

ICE_y
Interference and Compatibility Evaluation System
Handbook V2.5 r698

Schmid & Partner Engineering AG

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General

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About

The ICE y Professional Handbook contains the following parts:

General: This part containing general and legal information about this manual, the ICE y and other SPEAG products.

System Description and Installation: A general description of the ICE y hardware and software system components, their installation, service and maintenance.

Software Reference: Reference information about the functionalities of the ICE y control software.

System Operation: A step-by-step introduction in the use of the ICE y hardware and software components.

Application Examples: Application notes featuring the unique capabilities of your ICE y .

Troubleshooting: System Error Codes and Messages, Frequently Asked Questions and Instructions how to troubleshoot your ICE y system.

If you have any questions related to matter beyond the scope of this handbook, do not hesitate to contact us by email (support@speag.com).

Declaration of CE Conformity

Part I

**System Description and
Installation**

Chapter 1

Overview

This chapter provides a brief "at a glance" introduction to ICE y . More detailed information on the individual system components, their functions, user-interfaces and service and maintenance of the system can be found in the following chapters.

1.1 System Components

Figure 1.1 shows a typical setup of the ICE y (Interference and Compatibility Evaluation System) with the system operator workplace on the right and the ICE y Test Chamber and the Support and Equipment Rack on the left. A more detailed schematic overview of ICE y is shown in Figure 1.2. ICE y is an integrated testbed composed of a shielded, anechoic chamber where the actual near-field scans are performed, which sits on top of an equipment rack containing all necessary control and measurement equipment. The positioner system consists of linear motion stages allowing the positioning of the probe in a Cartesian coordinate system. In addition, the system allows the probe to be rolled around its axis. The positioner system contains a LASER triangulation and camera system fixed to the z-axis that allows photographs of the device under test (DUT) to be taken as well as reconstruction of the elevation profile of the DUT before the actual scans are performed. Based on the profile of the DUT, scans can be performed conforming to the surfaces of arbitrary electronic components without the need for CAD data. In the post-processing software, the photographs of the DUT can be projected onto the profile and the measured field results can be displayed as a direct overlay to the DUT.

1.1. SYSTEM COMPONENTS



Figure 1.1: Interference and Compatibility Evaluation System (ICEy) setup. Shown is a typical system setup of ICEy with the system operator workplace on the left and the ICEy Test Chamber and the Support and Equipment Rack on the right.

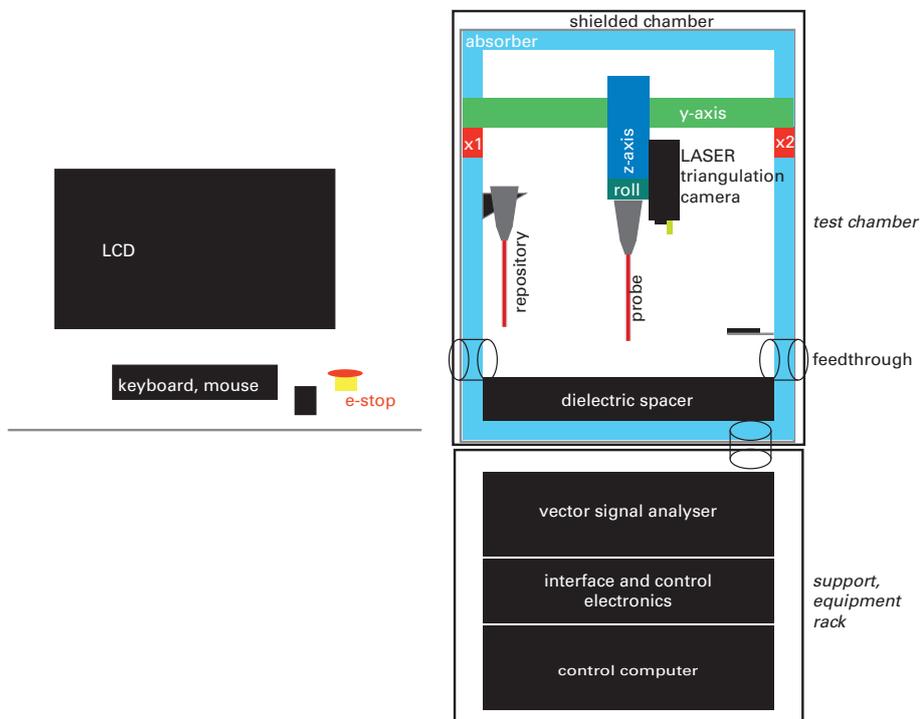


Figure 1.2: ICEy schematic setup.

1.2. SYSTEM DIAGRAM

1.2 System Diagram

The full, detail system and wiring diagram of the ICEy is shown in Figure 1.3.

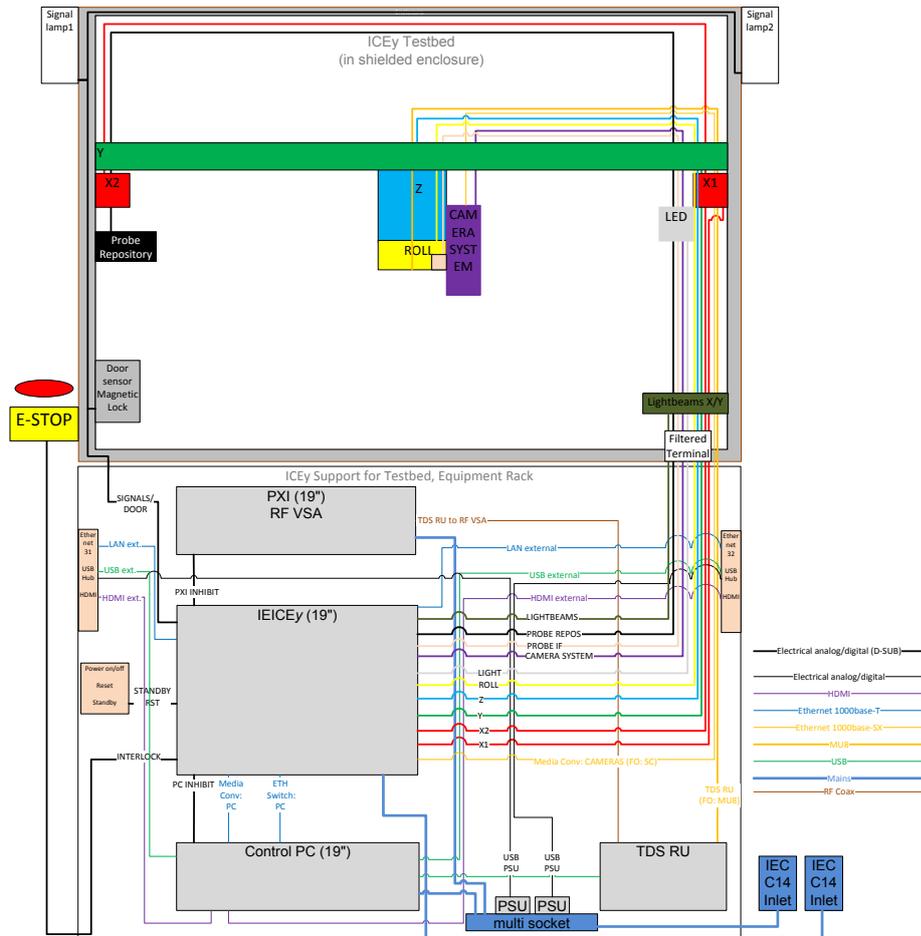


Figure 1.3: Complete system block and wiring diagram.

1.3 System Specifications

1.3.1 Positioning System

Axis Travel (x,y,z,roll)	600×500×120 mm ³ , 360 degrees
Scanning Volume (x,y,z)	450×450×115 mm ³
Absolute Positioning Unc.	< ± 50 μm, 1 degree
Relative Positioning Unc.	< ± 12 μm, 0.1 degree
Probe Alignment	2 orthogonal fork LASER light barriers

1.3.2 Test chamber

Probe Repository	holds up to 4 probes, automatic exchange
RF Shielding	fully shielded test chamber, with shielded door
RF EM Test Environment	anechoic using ECCOSORB FHY-NRL around scanning area, optional metallic ground plane (included)
Cable Feedthroughs	customizable feedthrough inserts on either side of the chamber; fiber-optics feedthrough (cut-off waveguide) in the rear left corner - towards equipment rack
Ventilation	air inlet in chamber door, fan and air outlet at on the rear side

1.3.3 DUT Detection

DUT Image Acquisition	1296×966 pixels, 16 mm lens, resolution: 0.07×0.07 mm ² /pixel
DUT surface detection	LASER triangulation system with sub-pixel LASER line recognition
Detection limit	< ±20 μm

1.3.4 RF M&T Equipment / Probes

1.3. SYSTEM SPECIFICATIONS

H1TDSx ICEy (H-field radial):	Tip size: $4 \times 4 \text{mm}^2$, Sensor size: $2 \times 2 \text{mm}^2$, Sensitivity: $0.4 \mu\text{A}/\text{m}/\sqrt{\text{Hz}}$ @ 2 GHz, f-range: 10 MHz - 6 GHz
H1TDSz ICEy (H-field axial):	Tip size: $4 \times 4 \text{mm}^2$, Sensor size: $2 \times 2 \text{mm}^2$, Sensitivity: $0.4 \mu\text{A}/\text{m}/\sqrt{\text{Hz}}$ @ 2 GHz, f-range: 10 MHz - 6 GHz
E1TDSx ICEy (E-field radial):	Tip size: $4 \times 4 \text{mm}^2$, Sensor size: 2.8mm, Sensitivity: $0.15 \text{mV}/\text{m}/\sqrt{\text{Hz}}$, f-range: 10 MHz - 6 GHz
E1TDSz ICEy (E-field axial):	Tip size: $4 \times 4 \text{mm}^2$, Sensor size: 2.8mm, Sensitivity: $0.15 \text{mV}/\text{m}/\sqrt{\text{Hz}}$, f-range: 10 MHz - 6 GHz
Remote Unit	1RU1TDS (PXI module)
Vector Signal Analyzer	NI PXIe-5665: frequency range: 20 Hz to 14 GHz noise floor: -165 dBm/Hz @ 1 GHz 3dB bandwidth: 50 MHz amplitude uncertainty: $\pm 1 \text{dB}$ (typical)

1.3.5 Equipment Rack / Scanner Support Table

19" Rack Dimensions	$3 \times 4\text{U}$
Control, Post-Processing PC	3U 19", Intel i7, $\geq 16\text{GB}$ RAM, Win7, inside Rack
Interface and Control Electronics	3U 19", inside Rack
PXI Chassis	18 slots, 3U 19", inside Rack

1.3.6 External Peripherals

USB	4 ports on both sides of scanner support
Ethernet	1 port on either side of scanner support
HDMI	1 port on either side of scanner support
Peripherals	1 Mouse 1 Keyboard 1 24" LCD Screen 1 Desktop E-Stop

1.3.7 Validation and Calibration Sources

TDSVDV2	Wideband TDS Validation Device V2: 2-channel microstripline (500 MHz - 6 GHz validation source) with USB power and control
CALB4LC	Calibration Body for LASER and Camera System
CALB4FLB	Calibration Body for LASER Fork Barrier

1.3.8 Overall System

Electrical power	2x 110...230 V IEC C14 power inlets, with 10 A max @110 V each
Thermal load	0.75 kW
Operating temperature	$22 \pm 2^\circ C$
Relative humidity	$45 \pm 5\%$
Storage temperature	$0 \dots 40^\circ C$
Acoustic Noise	$< 70 \text{ dB(A)}$
Dimensions	$1.16 \times 1.16 \times 2.0 \text{ m}^3$, 900 kg
Door	the door is hinged on the right side
Minimum access and ventilation margins	$\geq 20 \text{ cm}$ on rear, left and right hand sides, 1.1 m on the front
Operator Station	it is recommended to allow at least $1 \times 1 \text{ m}^2$ for a table to host the Operator Station on either the left or right side of ICEy

1.3. SYSTEM SPECIFICATIONS

Chapter 2

Testbed

2.1 Test Chamber



The ICE y Test Chamber is located on top of the equipment rack. It is a fully RF shielded chamber with a door that opens to the right side. Inside the test chamber the positioning system which performs scanning is located. A LED light strip is located on the right side the probe repository holding up to 4 probes on the left side. Feedthroughs are available on the left and right sides as well as in the rear left corner.

2.1. TEST CHAMBER

2.1.1 DUT Workbench



The ICE y Test Chamber contains a platform made from laminated glass. This platform is called DUT Workbench. That is where the DUT can be placed. The glass platform has a thickness of 10 cm and is backed with an RF absorber.

2.1.2 Positioning System



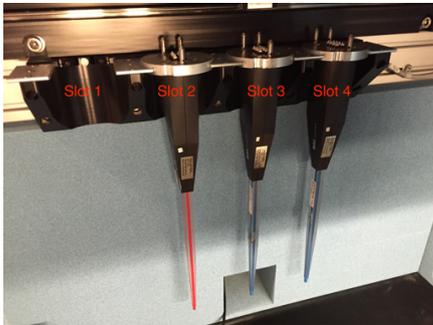
The positioning system is a Gantry-type system. With two x-stage, one y-stage, one z-stage and one roll stage to roll the probes around their axis. The camera system is suspended on the z-axis.

2.1.2.1 Axis Referencing & Lubrication Movement

The referencing of the position system is performed automatically after startup of the ICE y software or based on a user-request. The axis referencing takes place in the top, rear, right corner, just above the fork light

barriers. At the end of the axis referencing the system uses the fork light barrier to detect if a probe was connected. If no probe is detected the system will perform a lubrications movement. During this movement all x,y,z and roll stages move through their full degrees of freedom in order to lubricate the movement stages.

2.1.3 Probe Repository



ICEy can hold up to four probes in its repository. The parking slots are numbered as indicated from the front to the rear side of the chamber.

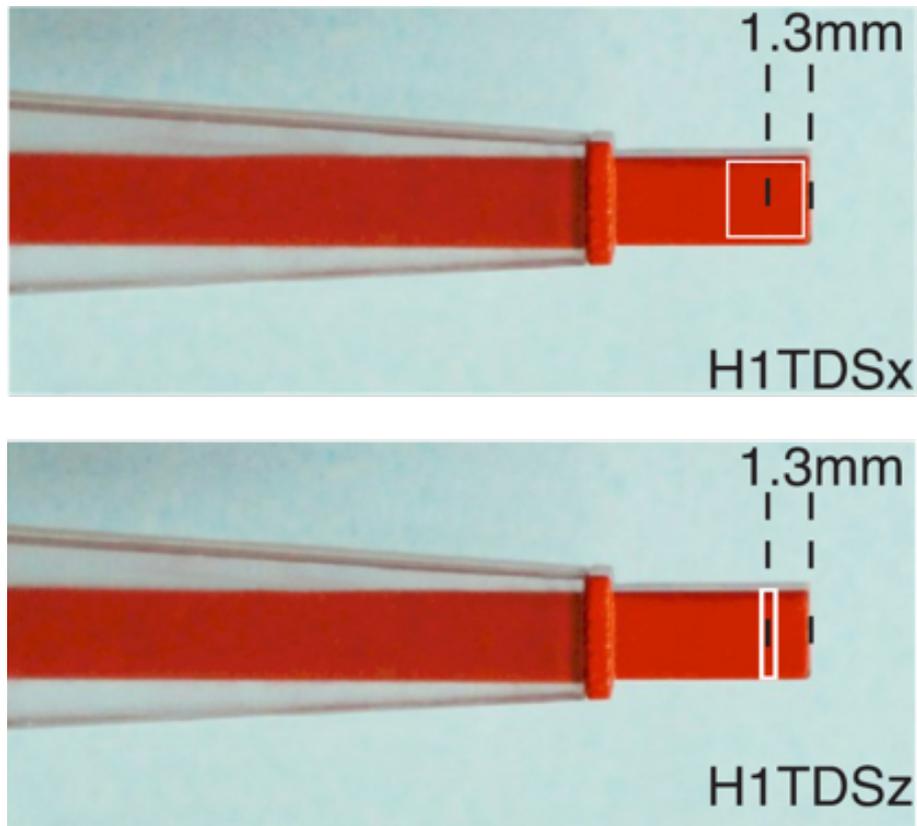
2.1.4 Probes

Four types of TDS probes are available, four full-sized TDS probes (E1TDSx, E1TDSz, H1TDSx and H1TDSz). In addition for millimeter wave safety evaluation the EUmW probe is available. The details of the probes are described in the sections below.

2.1.4.1 H-Field Probes

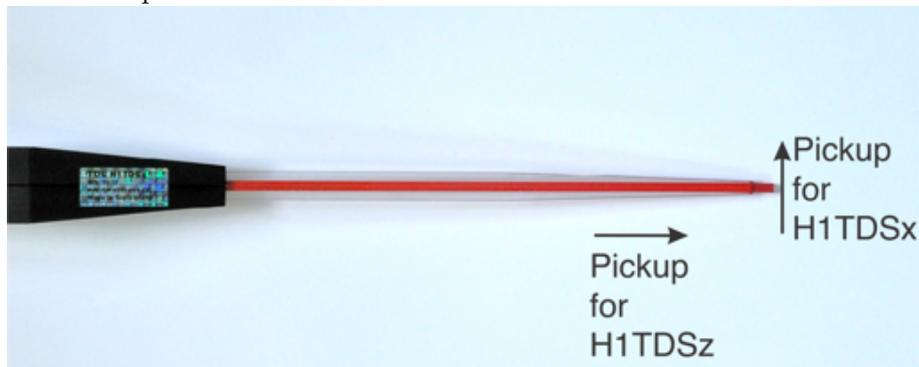
TDS H-field probes can be identified by a probe tip coloured in red. The below figure illustrates the location of the miniature loop sensors with respect to the tip of the TDS H-field probes:

2.1. TEST CHAMBER



The loop of the H1TDSz sensor is just a visualisation as it is actually oriented orthogonal to the viewing plane. Both loop types are centred in the TDS probe tip centre. The tip to loop sensing centre distance is 1.3mm in both cases.

The picture below illustrates the pick-up directions for H1TDSx and H1TDSz probes. Note the orientation of the label with the serial number of the TDS probe:



2.1.4.2 E-Field Probes

TDS E-field probes can be identified by a probe tip coloured in blue. The below figure illustrates the location of the miniature dipole sensors (in white) with respect to the tip of the the TDS E-field probes:



The dipoles of the E1TDS sensors are centred in the TDS probe tip centre. The tip to dipole centre distance is in both cases 1.55 mm.

The picture below illustrates the pick-up directions for E1TDSx and E1TDSz probes. Note the orientation of the white TDS label and the SPEAG logo:



2.1. TEST CHAMBER

2.1.4.3 EUmmW Probe and DAE4ICEy

The EUmmW is a two-axis pseudo-vectorial¹ probe for millimeter wave safety evaluations up to 110 GHz. The probe comes with a transparent protective cover as shown below. Please, remove this cover after installation on the DAE4ICEy just before putting the probe and DAE4ICEy inside the ICEy probe repository.



The sensors of the EUmmW probe are centred in the probe tip. The tip-to-sensor centre distance is 1.5 mm.

DAE4ICEy is used to read out the detector voltages from EUmmW probes in ICEy. The below photographs show the important elements of the DAE4ICEy :

¹pokovic2000novel.



DAE4ICEy is a battery powered device and can be charged via the USB-C connector. Pressing the power button once will enable the DAE4ICEy and disable once pressed again. The LED will light up approximately 2s after activation and whenever the DAE4ICEy communicates with the TDS Remote Unit .

2.1. TEST CHAMBER

When connecting the EUmW probe to the DAE4ICEy use the probe cup delivered with probe to minimize the eccentricity of the probe. First slide the cup over the rear end of the probe:

Note: Do not slide the cup over the probe tip! This operation might break it.



Align the notch and pin of the probe and DAE4ICEy connectors and carefully mate the probe connector with the DAE4ICEy connector. Make sure the probe body is straight and fasten the retainer nut carefully (not too tight). In the end screw on the probe cup and make sure the rubber seam is uniformly pointing upwards around the probe. Remove the protective cover before putting the probe inside the ICEy probe repository.



2.1.5 Probe Referencing



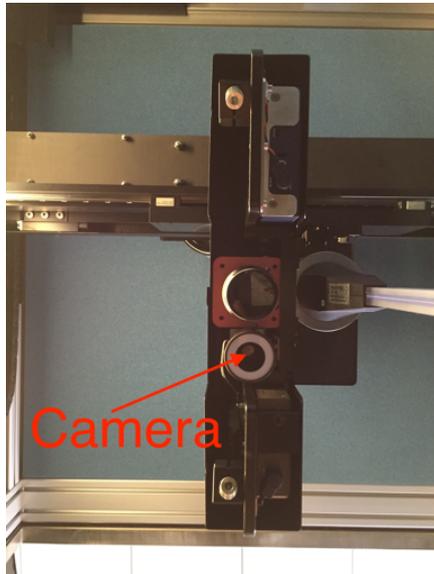
The probe tip location is reference in the fork light barriers. After *ICEy* picked up a probe its tip location is automatically referenced in the fork light barriers. During the reference also the repeatability of the light-barrier location is validated. The *ICEy* will warn the user if the repeatability is worse than 0.1 mm. A probe referencing can also be forced by the user from the *ICEy* GUI.

2.1.6 Camera System



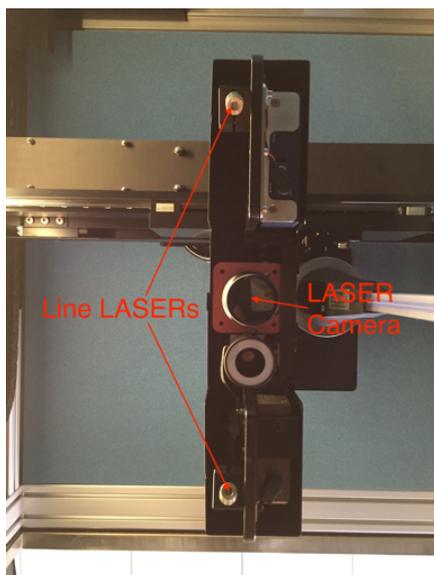
The camera system is suspended on the z-axis of the positioning system. In this way the camera system can scan across the workbench improving the the resolution of the scanning and allows direct correlation to the probe position.

2.1.6.1 DUT Image Acquisition System



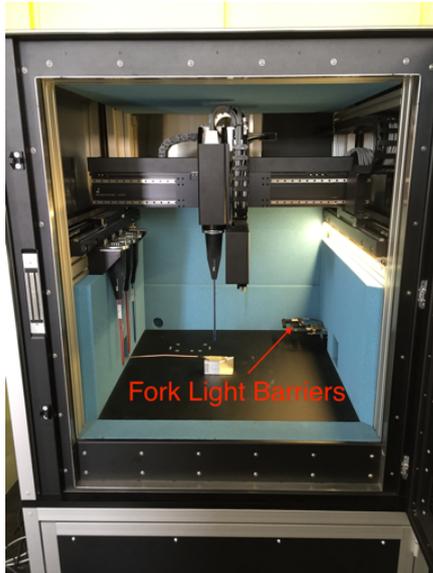
On the left a bottom view of the camera system is shown. The DUT color camera is located as indicated. The camera is equipped with an additional LED ring-light for additional illumination if required. During a camera scan the camera is scanned over the workbench. Based on the synthetic aperture and stereo-vision principles a rough height map is reconstructed after each camera scan. This height map is for instance used to optimise the distance between the DUT and the camera in subsequent LASER scans.

2.1.6.2 LASER Triangulation System



On the left a bottom view of the camera system is shown. The LASER Triangulation System consists of two line LASERs and a high dynamic range black and white camera. During a LASER scan the system is scanned over the evaluation area, at each position both LASER lines are subsequently illuminating the work-bench and the camera takes a picture of the line projection. Based on this the algorithms reconstruct the DUT surface with a precision of better than $25\ \mu\text{m}$.

2.1.7 Fork Light Barriers



The fork light barriers are located the in the rear right corner of the system. The light barriers are suspended at a height of 9 cm above the chamber floor. In this way DUT with a very large surface area can be placed also below the light barriers.

2.1.8 Chamber Illumination



The ICEy Test Chamber can be illuminated by a LED light strip on the right hand side. As soon as the GUI starts up, the light is switched on. The light is switched off when the user exits the GUI. The light is also switched off during LASER scans.

2.1. TEST CHAMBER

2.1.9 Signal Lights

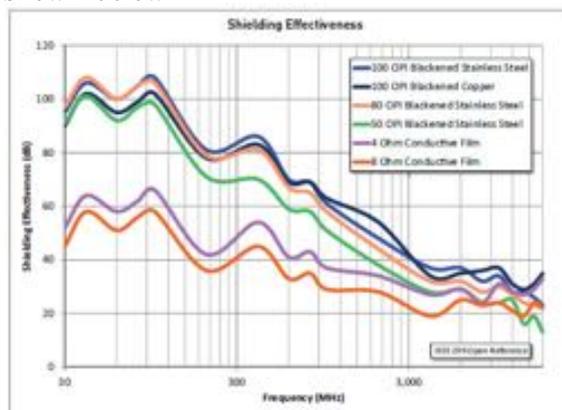


There is a signal light on either side of the chamber, indicating the system status to the user:

- **green:** system is powered up, axes are unpowered
- **orange:** system is powered up, axes are powered
- **red:** system is powered up, axes are moving

2.1.10 Chamber Shielding and Radio-Frequency Absorbers

The test chamber is fully shielded to attenuate environmental signals. The door employs a shielded window (100 OPI stainless steel) that forms the weakest part of the shielding. The shielding effectiveness of the window is shown below:

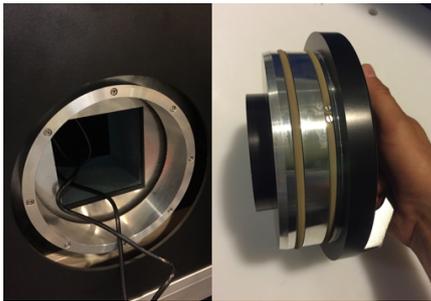


2.1.11 Door



As mentioned above the door is equipped with an RF shielded window. In addition the door employs a (green) LASER safety window to attenuate the LASER radiation from the line LASERs. The chamber door is hinged on the right-hand side and can be opened using a handle on the left side.

2.1.12 Feedthrough Plugs



Both sides of the chamber have a feedthrough plug. The plug can be removed in order to feedthrough cable directly. Note, that this will greatly impair the shielding effectiveness of the chamber. The plugs can also be customized with feedthrough cable connectors.

2.1. TEST CHAMBER

Chapter 3

Support Rack

3.1 Support Rack Mechanics



The support rack contains 4 adjustable feed. The feed can be adjusted and secured using a 19 mm wrench.



The equipment rack has a door on the rear and front side for easy access to the rack equipment and wiring. Open the door by lifting the handle as indicated on the picture on the left.

3.2. INTERFACES AND PERIPHERALS



The 19 inch rack equipment is located in drawer for easier access for installation and maintenance. To move the equipment drawer out, fully open the front door, unlock the drawer by lifting the green lever (see photograph) and pull on the drawer handle.

3.2 Interfaces and Peripherals

3.2.1 Power Inlet



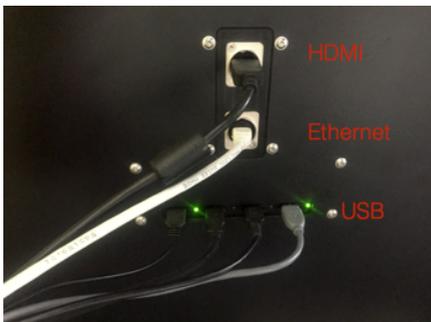
From the rear bottom of the equipment rack extend two power inlet cables, one for the PXI chassis and one for the rest of the system. These cables are IEC C14 types and can be easily customised with location specific IEC C13 power cords.

3.2.2 Main Power Switch, Standby Button, Reset



The system power button, standby switch, and controller reset are located on the front door of the system rack. Switching on the power button, enables all system components, i.e., the controller, PC and vector signal analyser. Switching off the power button will power down the controller, and the vector signal analyser. The PC will remain on for post-processing purposes. Please note: that in the power down state the PC will not have a network connector. The system controller can be reset using a needle as shown on the left. This will also reboot the vector signal analyser. Note: after a restart of the vector signal analyser the PC has to be restarted to connect to the vector signal analyser again.

3.2.3 Control PC Peripheral Interfaces



On either side of the rack there are 1 HDMI, 1 Ethernet, and 4 USB ports for connecting peripheral devices (mouse, keyboard, LCD) to the control PC.

3.3. RACK COMPONENTS

3.2.4 Rack Fan



Like the test chamber, the rack has a fan providing ventilation to the equipment on the rear side. The fan is integrated inside the rear door and the fan speed is controlled by the rack temperature.

3.3 Rack Components



The ICEy rack drawer contain 3 19inch devices, the PXI Chassis with the Vector Signal Analyser, the IE-ICEy Interface Electronics and the Control PC.

Chapter 4

Hardware Installation

4.1 On-Site Requirements

The electrical, thermal and space on-site requirements for the ICE y system are summarized in Table 4.1. The system footprint is shown in Figure 4.1. **Please make also sure that the place of installation can be reached with either a pallet jack or a crane transporting the pre-assembled ICE y , i.e., if using a pallet jack to move the system in place, doors must be at least 1.16 m \times 2.0 m wide and no major obstacles on the floor preventing the pallet jack from rolling the system in place.** Please refer to Section 4.3 for details about transporting the ICE y to the installation site.

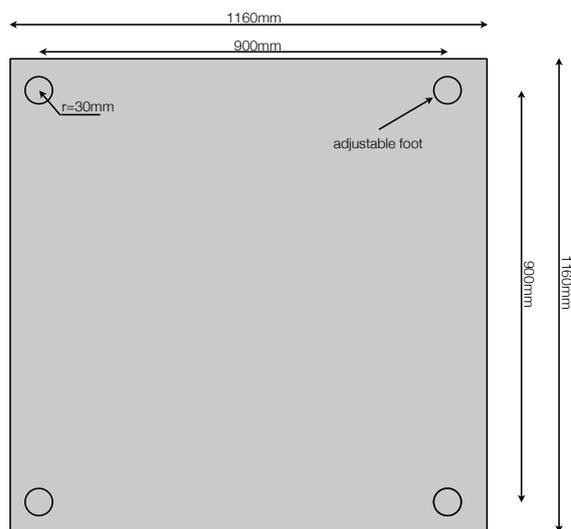


Figure 4.1: Bottom view and footprint of the ICE y system

4.1. ON-SITE REQUIREMENTS

Table 4.1: ICE y On-Site Requirements

Electrical	AC power	3x 110...230 V IEC C14 power inlets with 10 A max @110 V each 3 region specific power cords
	Ethernet	left & right side of ICE y Support
	USB	left & right side of ICE y Support
	HDMI	left & right side of ICE y Support
Environmental	Thermal Load (typical)	0.75 kW
	Operating Temperature	22±2°C
	Relative Humidity	45±5%
	Storage Temperature	0...40 °C
	Acoustic Noise	<70 dB(A)
Dimensions	System	1.16 × 1.16 × 2.0 m ³ , 900 kg
	Door	the door is hinged on the right side of the ICE y
	Minimum access and ventilation margins	≥20 cm on rear, left and right hand sides, 1.1 m on the front
	Operator Station	it is recommended to allow at least 1 × 1 m ² for a table to host the Operator Station on either the left or right side of ICEy

4.2 On-site Tool Requirements

The following list describes the set of tools required for unpacking and installing the ICE y system on-site:

- Electric screwdriver including metric bit set (mainly *Philips* required)
- Wire cutters
- Box knife
- Metric allen key set (1.5, 2, 2.5, 3, 4, 5, 6, 8, 10)
- Crane or forklift to lift the test chamber onto the support rack (min. height reach > 2.7m, payload >1000 kg, see 4.3). In case of fork-lift: min. fork length = 1.15 m.
- Pallet jack: min. fork length = 1.15 m, max. fork height from ground (when in low position) = 10 cm.
- Public internet access (during time of installation).

4.3 Unpacking, Setup & Transport to Installation Site

4.3.1 Unpacking and Installing the ICE y Test Chamber on the ICE y Support

This section describes the process of unpacking the ICE y system and installing the ICE y Test Chamber on the ICE y Support:



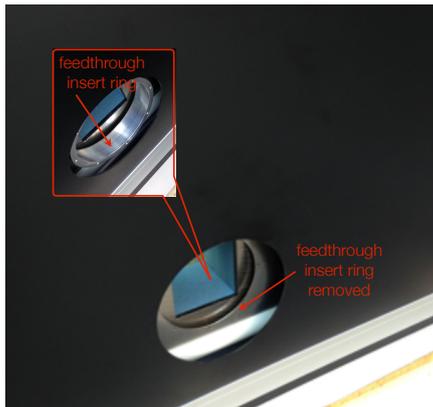
The ICE y system is shipped in 3 boxes: 1 cardboard box on a pallet containing the electronic and accessory components and 2 wooden boxes containing the ICE y Test Chamber and the ICE y Support. At this point in time only the contents of the 2 wooden boxes are required. To unbox the wooden boxes, place them in an area with sufficient space for assembly. First open the locks holding the top panel and remove the top panel on both boxes, then open the locks holding the side-panels and remove the side panels.



Remove the wooden planks securing the test chamber on the pallet base as shown on the left.



Remove the 4 grub screws at either corner of the decorative housing, securing it to the aluminium base of the ICEy Test Chamber as shown on the left using an Allen key.



Remove the feedthrough plugs on both sides of the chamber. Then undo all 8 Allen screws fixing the feedthrough receptacle ring to the shielded chamber on both sides of the chamber and remove the feedthrough receptacle rings completely as shown on the left.



The JST connectors for the signal lamps are located at the frontal, top inner sides of decorative housing. In order to remove the housing, the connectors for the signal lamps as well as the connector for the door electronics (top, front, left) have to be opened. There is excess wiring on the connectors to pull them out from the space between the test chamber and the decorative housing. In order to open the connectors press the connector unlocking mechanism as shown on the picture and pull the connectors apart.

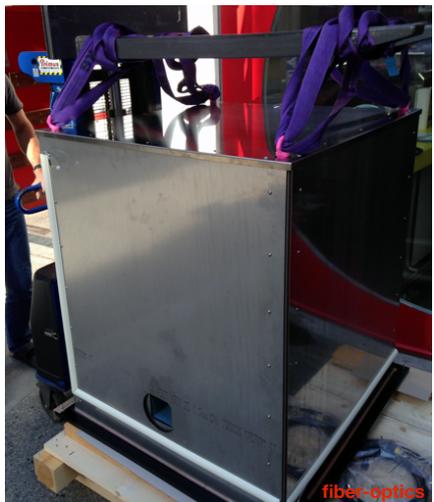
4.3. UNPACKING, SETUP & TRANSPORT TO INSTALLATION SITE



Lift the decorative housing (with 3 persons) sufficiently such that it is released from the locking pins shown on the left. Make sure not to lift the housing much further as it might otherwise not be possible to reverse with it. After lifting the housing from the locking pins, reverse with it and put it aside for later re-installation.



Remove the front and rear panels of the ICE y Support as shown on the picture on the left. Place the Support on a flat surface such that the ICE y Test Chamber can be mounted on top of it in the next step. **Ascertain that the feet are high enough to later get below the Support with the fork of a pallet jack.**



Install the lifting hooks on the top of the test chamber, if not installed yet. Use a forklift or a crane and appropriate lifting gear rated for the mass of the system to lift the ICE y Test Chamber off the pallet base of the transportation box. **While doing so, make sure that none of the fiber-optics extending from below the Test Chamber rear, right connector terminal is damaged when lifting and moving the system.**



Locate the guide pins on the ICE y Support. These pins will help to install the ICE y test chamber, which has conical holes in its aluminium base, mating with the pins.



Use the crane or fork-lift to position the Test Chamber over the ICE y Support. Slowly, lower the Test Chamber onto the Support and manually guide the Chamber into the guide pins.



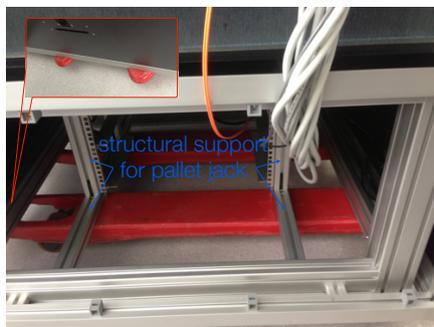
Now re-install the decorative housing as shown on the left. Also re-install the feed-through receptacle rings and close the JST connectors to the signal lamps and the door electronics again.

4.3. UNPACKING, SETUP & TRANSPORT TO INSTALLATION SITE



If you are planning to put the ICEy with its rear side against a wall, or the rear side may otherwise not be accessible, please follow the steps described in Section 4.3.3. If the rear side of the system is accessible at the installation site, please continue with the next step.

4.3.2 Transport to Installation Site



The system is now ready to be lifted and transported to the installation site using a standard pallet jack. Insert the pallet jack laterally only, never from the rear or front sides of the ICEy. It is important that the fork of the pallet jack is long enough to extend below structural supports of the ICEy Support. Ideally, the fork should extend even below the full width of the system, i.e., >1.1 m as shown on the picture on the left.



Use the pallet jack to move the entire ICEy to its destination. At the installation site use the adjustable feet to level the system and put it in place by lowering the pallet jack.

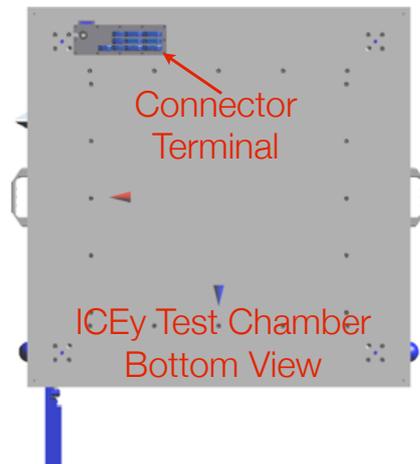
4.3.3 Cables to Test Chamber Terminal

In the rear, right corner below the base of the ICEy Test Chamber the connector terminal is located. The terminal provides all connections between

the Test Chamber and the electronics in the Support. The section describes the on-site assembly of the electrical and optical connections at the terminal.



The ICEy Support is delivered pre-wired with all cables in place to connect to the connector terminal in this step as shown on the right.



The connector terminal is located below the ICEy Test Chamber in the rear, left corner (when viewing from the rear side).



All connectors are individually labelled as shown on the left. Simply connect the connectors of all cables attached to the left side of the DIN rail on the rear side of the ICEy Support to the Test Chamber terminal according to the connector diagram shown in Figure 4.2

4.3. UNPACKING, SETUP & TRANSPORT TO INSTALLATION SITE

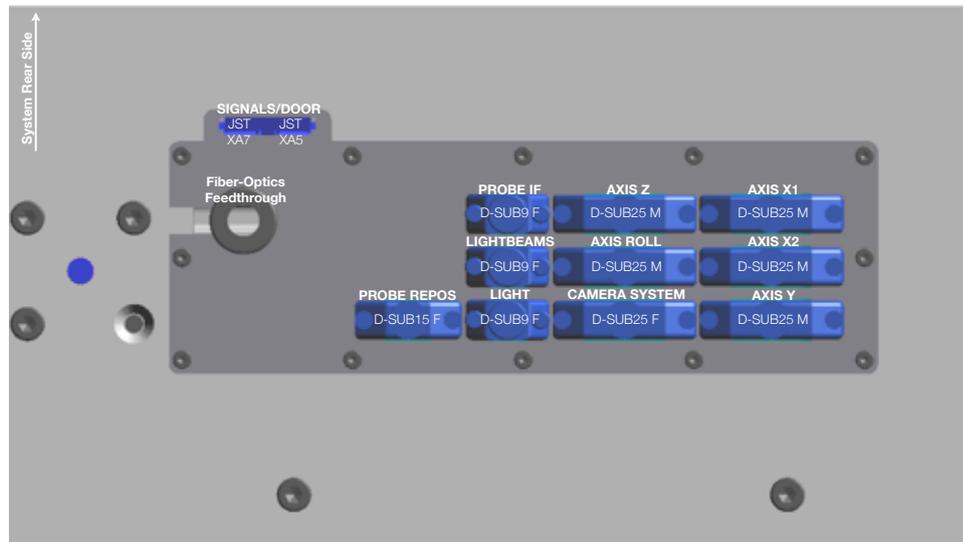


Figure 4.2: Connector allocation of the terminal on the rear, right, bottom side of the ICE_y Test Chamber.

4.3.4 Installing Rack Components

This section describes the installation of the 19" rack components and the TDS Remote Unit in the ICE y Support rack (see Figure 4.3). There are two options for connecting up the 19" chassis: 1) from the front or 2) from the rear side of the ICE y Support. Option 2 is the easier method if the rear side of ICE y is accessible, all rear chassis connectors can then be connected from behind the system. Option 1 should be taken if the rear-side of the system is not accessible, in this case the cables can be pulled to front of the system and connected while the 19" components are only partially inserted into the system.

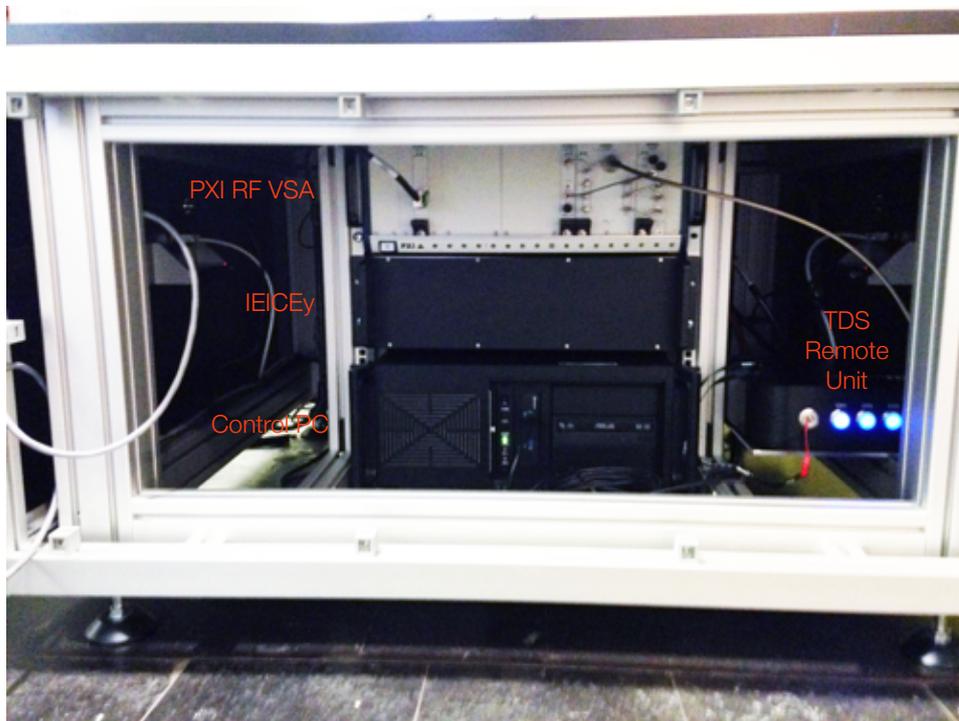


Figure 4.3: ICE y 19" rack components: the PXI radio-frequency vector signal analyser (PXI RF VSA), the ICE y interface electronics (IEICE y), the Control PC and the TDS Remote Unit installed in the ICE y support rack.

Start the installation of the 19" chassis with the Control PC. The connector layout of the Control PC is shown in Figure 4.4. Connect the below cables, either while the PC is partially inserted from the front side or when it is fully inserted from the rear side system:

4.3. UNPACKING, SETUP & TRANSPORT TO INSTALLATION SITE

Cable Source Type	Destination PC Connector
AC Power	AC Power
USB from left side peripheral connector terminal	any USB2 or USB3
USB from right side peripheral connector terminal	any USB2 or USB3
Ethernet cable (green) from camera system media converter (inside IE-ICEy)	ETH to CAMs
HDMI cable from left side peripheral connector terminal	HDMI connector
HDMI cable from right side peripheral connector terminal	DVI connector using DVI to HDMI adapter
Ethernet cable (yellow) from motion controller (inside IEICEy)	ETH to Motion Ctrl
Ethernet cable (red) from Ethernet network switch (inside IEICEy)	ETH to Network
LEMO push pull 4pin cable (from IE-ICEy, PC INHIBIT)	PC INHIBIT
PXI extension cable	PXIe

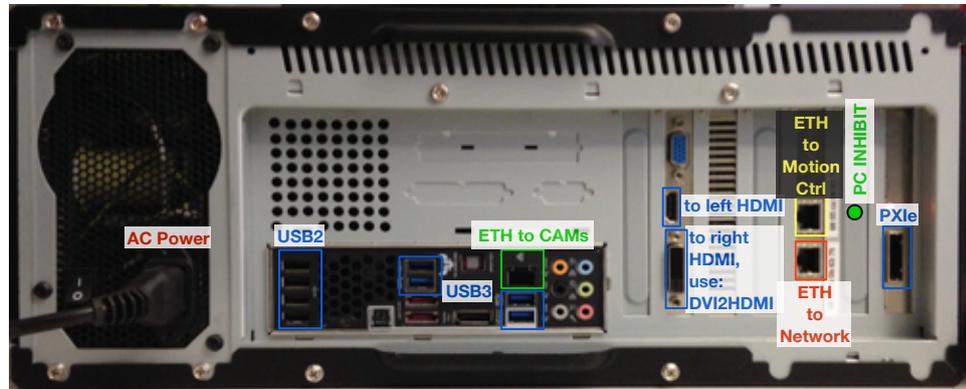


Figure 4.4: Connector allocation of the ICEy Control PC.



If the cable connectors had been mounted from the front side of ICEy slot the PC into the bottom most mounting rails of the rack and fix it using screws. Note: that the screws should go into 6 cm extenders. Also make sure that the rear mounting rails are positioned correctly before inserting the PC.



In the next step install the IEICE y in the centre mounting rail of the rack. Again this 19" chassis can be wired from the front and then inserted as shown on the picture in the left.

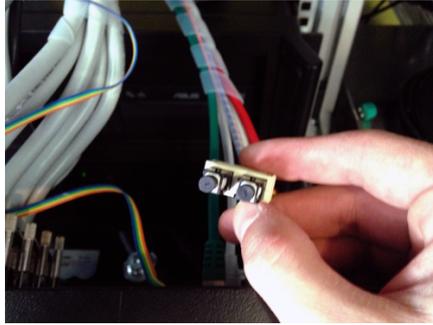
The connector layout on the rear side of the ICE y Interface Electronics (IEICE y) is shown in Figure 4.5. All cables with D-SUB type connectors are labelled on the connector housings. The following unlabelled connectors/cables have to be connected as well:

Cable Source Type	Destination IEICE y Connector
AC Power Cable IEC C15	IEICE y AC Power Connector: IEC C14
PWR (Inhibit)	IEICE y Power Inhibit Connector: MOLEX 51110 - 8 Pin (see below)
Ethernet cable (green) from PC	IEICE y Media Converter, RJ45 Connector: CAMSYS/PC
Ethernet cable (red) from PC	IEICE y 5x Switch, RJ45 Connector: PC
Ethernet cable (yellow) from PC	IEICE y Motion Controller, RJ45 Connector: CTRL
Fiber Optic Cable, SC-Connector	IEICE y , SC-Duplex Connector: CAMERAS (see below)

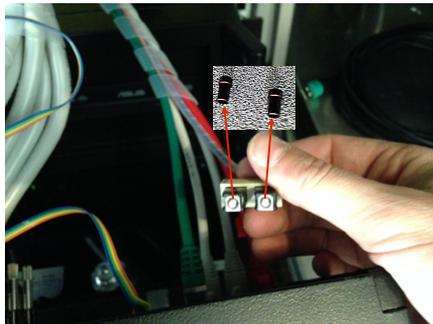


The IEICE y power inhibit ribbon cable is connected using the small 8 pin power inhibit MOLEX 51110 connector on the rear-side of the IEICE y close to the AC power inlet. Carefully, connect the small connector. When removing the connector, avoid pulling on the ribbon cable. The other end of the ribbon cable is connected inside the STANDBY/RST D-SUB cable connector, that should be connected to the IEICE y before the MOLEX 51110.

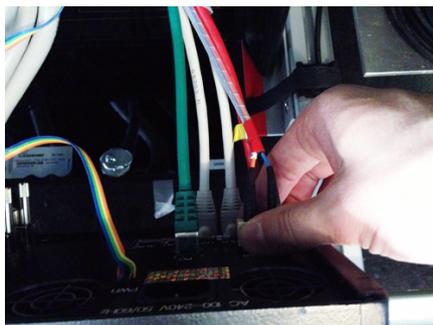
4.3. UNPACKING, SETUP & TRANSPORT TO INSTALLATION SITE



Special care has to be taken when connecting the SC-duplex fiber-optics to the IEICE_y. When the system is delivered the ferrules of the fiber optics are equipped with protective covers as shown on the right. Never try to mate the connector with the covers on.



Remove the protective covers as shown on the left. Make sure to retain the protective covers for future use. Fiber-optics are extremely sensitive to dust and should always be properly covered as shown in the image above when not mated within a connector.



Before mating the SC-duplex connector as shown on the left always make sure the fiber-optics are cleaned properly.

The following IEICE_y connectors remain unconnected to any cables:

Cable Source Type	Destination IEICE _y Connector
not connected	IEICE _y SMB connector: RU RDY
not connected	IEICE _y SMB connector: RU TRG
not connected	IEICE _y SMB connector: PXI RDY
not connected	IEICE _y SMB connector: PXI TRG
not connected	IEICE _y USB type B connector: USB MON



When the wiring is complete slot the IEICE_y in the centre mounting rail of the rack as shown.

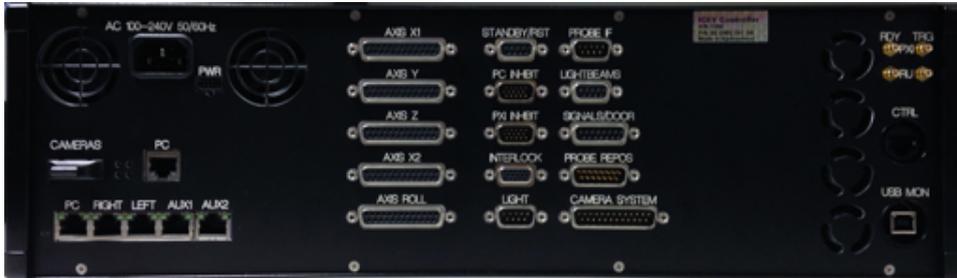
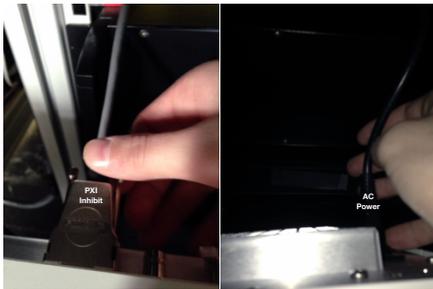


Figure 4.5: Connector allocation of the ICE y Interface Electronics (IE-ICE y).



Secure the IEICE y with screws inside the rack as shown on the left.

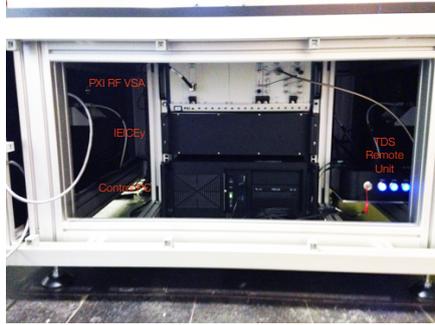


The last 19" rack component to be installed is the PXI Chassis with the radio-frequency vector signal analyser modules. On the rear side of the PXI only 2 cables have to be connected: 1) the AC power cord on the right and 2) the PXI Inhibit D-SUB from the IE-ICE y on the left.



Fix the PXI inside the rack and connect the PXIe extension cable (from the Control PC) on the front side of the PXI chassis as shown.

4.3. UNPACKING, SETUP & TRANSPORT TO INSTALLATION SITE



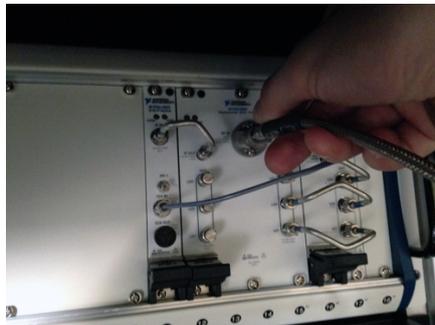
Place the TDS Remote Unit on the platform on the right side of the 19" rack as shown in the picture.



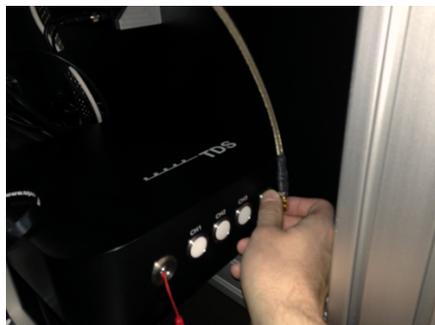
Align the connector of the fiber-optic patch-cord as shown in 1. Then insert the key pins into the shutter (against spring load) and rotate the connector clock-wise when viewed from the front of the Remote Unit (2). When rotated against the touch position, insert the connector in the shutter (3).



In the next step connect the USB Type B connector on the rear side of the TDS Remote Unit (1) and connect the other side of the USB cable, type A connector, to the front panel of the Control PC.

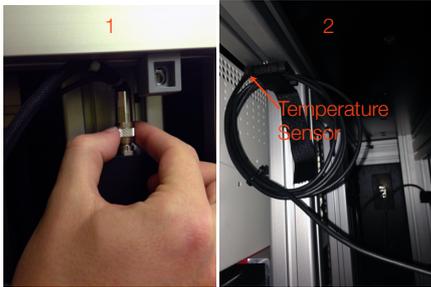


Connect the PC 3.5 mm cable male connector to the RF input of PXI RF VSA. Use an SMA, PC3.5 torque wrench to fasten the PC3.5 connector screw.



Connect the female end of the PC3.5 mm cable to the RF output of the TDS Remote Unit. Hand-tighten the NMD-3.5 screw to carefully fix the RF coaxial cable. This step concludes the installation of the rack components.

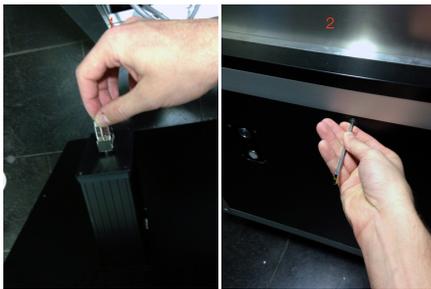
The front and rear panels of the ICEy Support can now be closed again:



Connect the fan integrated in the rear-panel as well as the temperature sensor to the fan controller as shown in (1). Then place the temperature sensor as shown in (2) at the top right of the ICE y support, close to the PXI chassis.

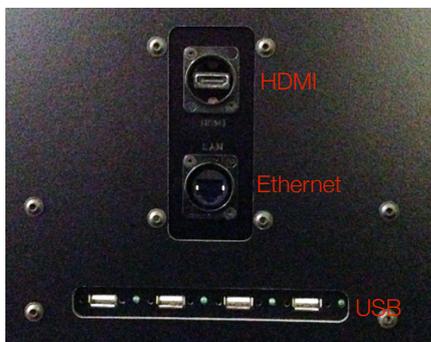


Place the rear panel inside the ICE y Support frame (1). Make sure that the fan power cable is completely inside the system. Fix the rear-panel with the Allen screws provided from the outside (2).



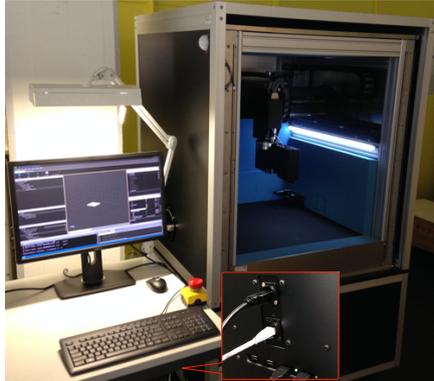
On the rear side of the front panel connect the D-SUB connector on the housing for the system power, standby and reset buttons to the D-SUB cable attached on the left side of the ICE y Support (1). Then place the front panel inside the ICE y Support frame and fix it with the Allen screws provided (2).

4.3.5 Connecting PC Peripherals



On the left and right side of the ICE y Support are terminals to connect external PC peripherals. On each side there are: 1 HDMI connector for an LCD screen, 1 Ethernet RJ45 connector for network access of the Control PC, 4 USB connectors for USB peripherals like mouse and keyboard.

4.3. UNPACKING, SETUP & TRANSPORT TO INSTALLATION SITE



PC peripherals on the operator station can be connected in a simple way (as shown on the left).

Chapter 5

Software Installation

5.1 Operating System Requirements

The ICEy software and driver have been tested under the following operating systems:

- Windows 7 Professional or Enterprise 64 Bit
- Windows 10 Professional or Enterprise 64 Bit

Other operating systems are currently not supported. ICEy requires a highly performant PC. We strongly discourage from installing any third party software on the control PC especially anti-virus, disk encryption and endpoint protection.

5.2 Driver Installation

We strongly recommend the use of a pre-installed control PC from SPEAG . In case you still have to re-install the control PC please always request the latest driver support package for your system by contacting *support@speag.com* . The below installation instruction refer to content of this driver support package. Were not other-wise note run "typical" installations.

5.2.1 Basler DUT Camera

The imaging camera requires the installation of:

- \ImagingCamera\Baslerpylon5.0.0.6150.exe

5.2.2 Photonfocus LASER Triangulation Camera

The LASER triangulation camera requires the installation of (please adhere to the below order):

- \LASERtriangulationCamera\ebus_sdk_3.1.14.3284.exe
- \LASERtriangulationCamera\PFInstaller_2_45_Win64.exe

5.2. DRIVER INSTALLATION

5.2.3 National Instruments PXI Vector Signal Analyzer

If your system is equipped with a PXIe-1075 chassis ensure that the latest firmware is installed. Older version of the firmware cause conflicts with the latest PC drivers of National Instruments that may cause PXI chassis malfunction. Please update the firmware before installing any other drivers on the working system. In order to update the firmware run:

- `\NI\PXI_firmware\PXIe-1075_1082_Firmware_Updater.exe`

As some PC may not correctly support PCI bus enumeration install the NI MXIe Bios Compatibility Software:

- `\NI\NIMXIECmpt150.exe`

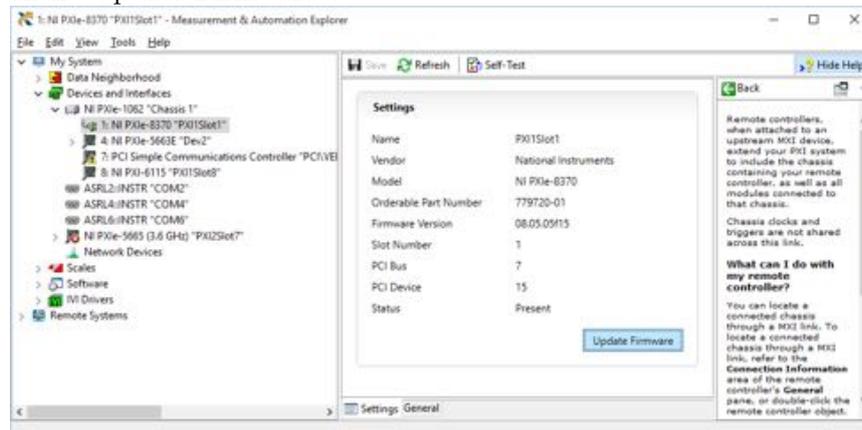
Install the NI PXI Support package and NI VISA:

- `\NI\NIPXIPS1502.exe`
- `\NI\NIVISA1550runtime.exe`

Reboot the PC. Update the MXI card firmware using NI MAX (Measurement and Automation Explorer). The firmware is located in:

- `\NI\MXI_firmware\PXIe-8370_fw_12071010.bin`

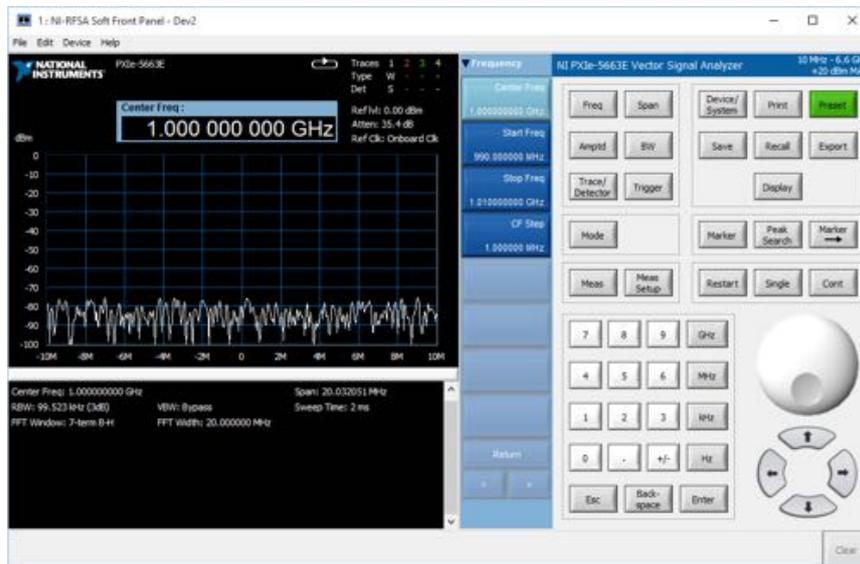
Type "MAX" in the Windows Search pane and Launch NI MAX. Expand Devices and Interfaces, and the PXI Chassis, select the NI PXIe-8370 and click "Update Firmware":



Finally, install the NI RFSA toolkit:

- `\NI\NIRFSA1502.zip`

Reboot the PC. Type "RFSA" in the Windows Search pane and Launch the NI-RFSA Front Panel and verify the vector signal analyser is working. If not contact support@speag.com.



5.2.4 Motion Controller Driver

Install the Galil tools including drivers from:

- `\Galil\GalilTools-1.5.0.398-Win-x64.exe`

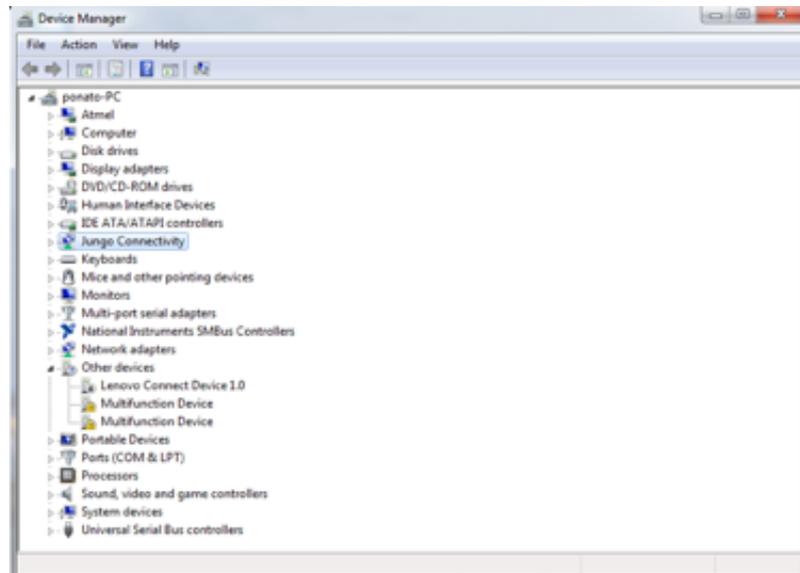
5.2.5 TDS Remote Unit

5.2.5.1 Windows 7

The following procedure describes the driver installation under Windows 7:

1. Mount the Remote Unit PXI inside an NI PXI Chassis. Connect the NI PXIe with your PC and start up all devices.
2. Open the MS Windows Device Manager. The device manager can be found under Control Panel - System of your PC:

5.2. DRIVER INSTALLATION

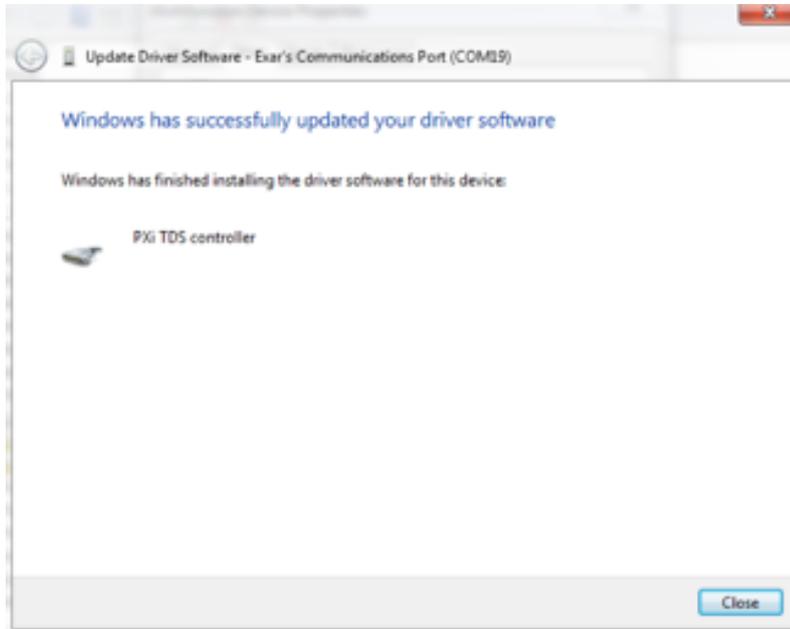


3. Identify two devices called Multifunction Device under Other Devices. Right-click on the devices and select Update Driver Software.
4. Select Browse my computer for driver software:

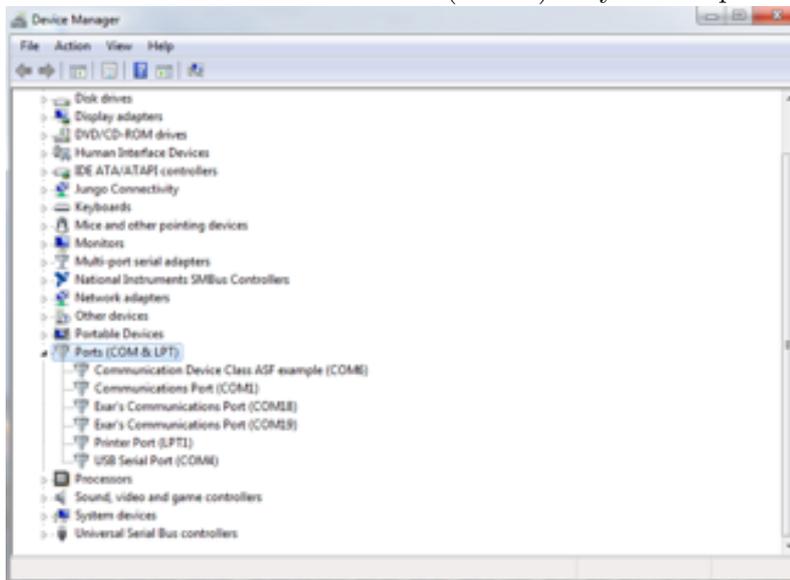
How do you want to search for driver software?

- ➔ Search automatically for updated driver software
Windows will search your computer and the Internet for the latest driver software for your device, unless you've disabled this feature in your device installation settings.
- ➔ Browse my computer for driver software
Locate and install driver software manually.

5. Navigate to the location of NextFreePort_14.7 (`\RemoteUnit\PXI\PCIVEN_1c0d&DEV_0001TDSEXAR\NextFreePort_14.7-1c0d0001`) and install the driver:



6. Repeat these steps for the second Multifunction Device.
7. After the successful installation the TDS PXI Remote Unit will be available as a new COM interface (Exar's) on your computer:



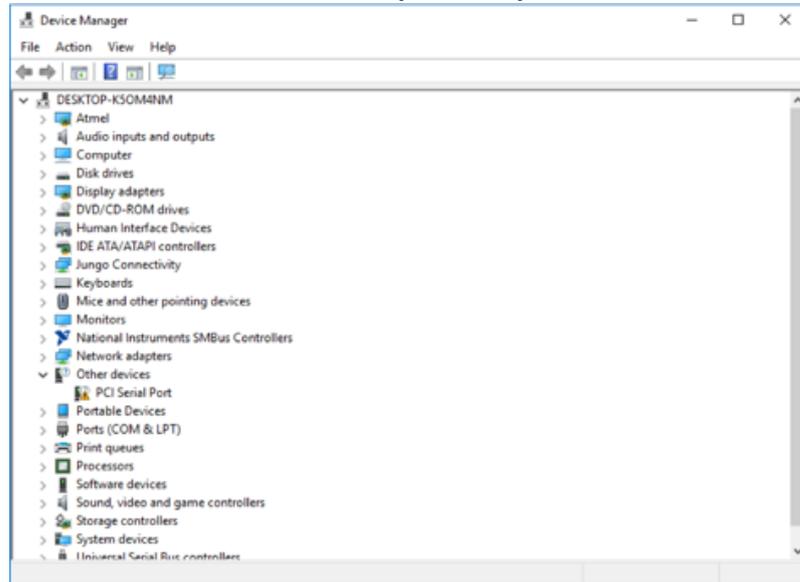
5.2.5.2 Windows 10

The following procedure describes the driver installation under Windows 10:

1. Mount the Remote Unit PXI inside an NI PXI Chassis. Connect the NI PXIe with the your PC and start up all devices.
2. Open the MS Windows Device Manager. The device manager can be

5.2. DRIVER INSTALLATION

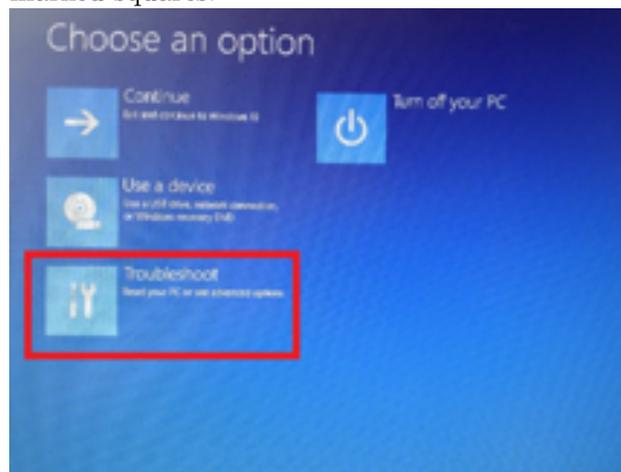
found under Control Panel - System of your PC:

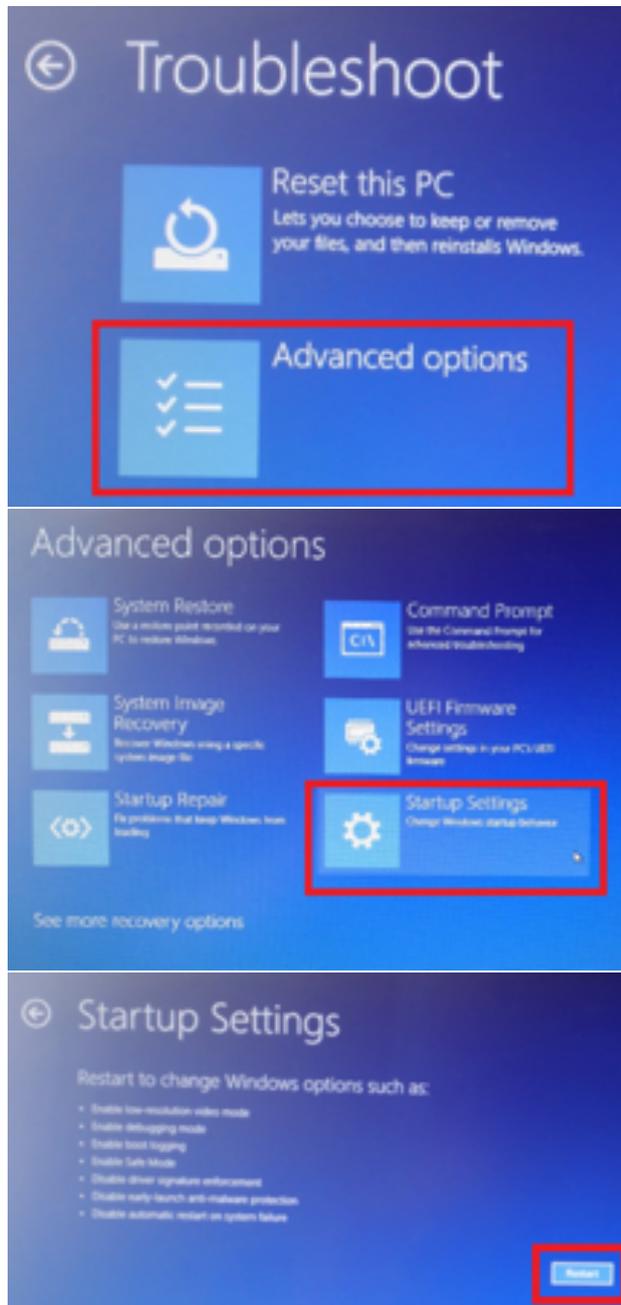


3. Press and Hold the Shift-Button on the Keyboard and restart the Computer:

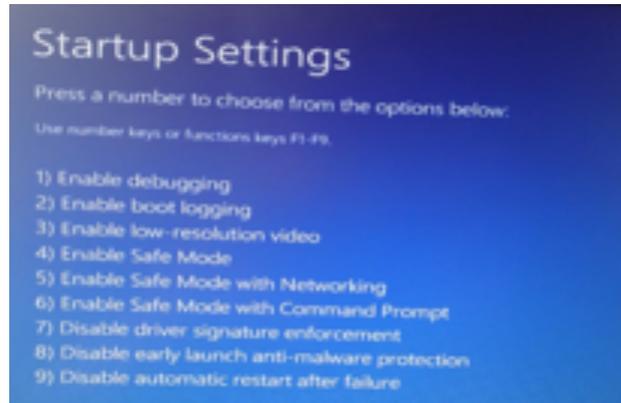


4. The Computer boots now to the boot options menu. Follow the red marked squares:

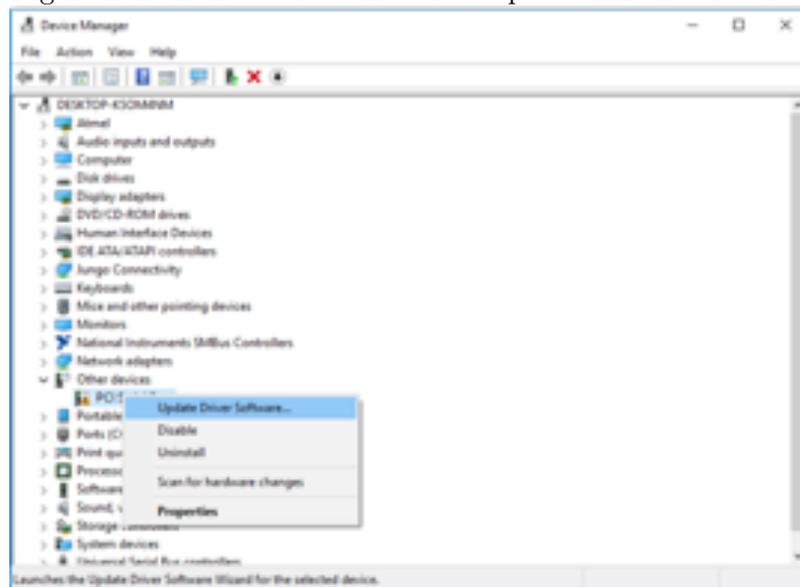




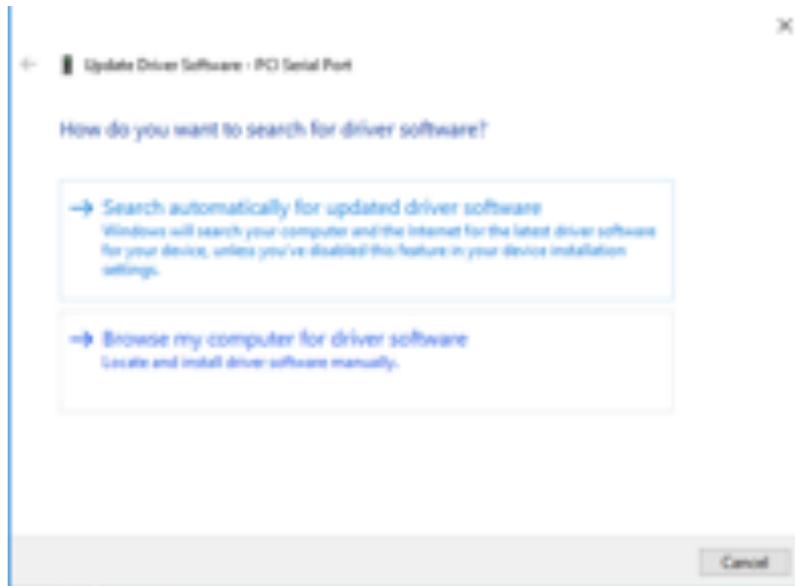
5.2. DRIVER INSTALLATION



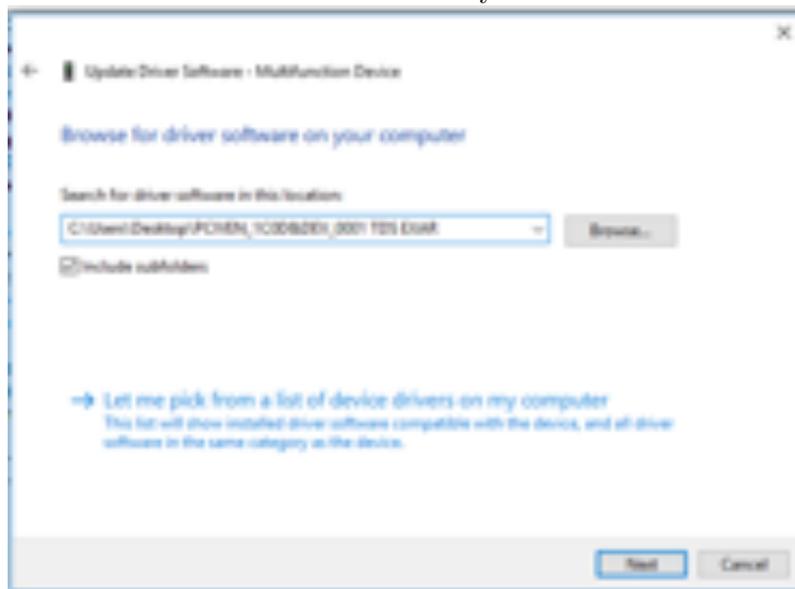
5. Press F7 on the keyboard and the computer will restart
6. Open the MS Windows Device Manager. The device manager can be found under Control Panel - System of your PC.
7. Identify two devices called Multifunction Device under Other Devices. Right-click on the devices and select Update Driver Software:



8. Select Browse my computer for driver software:

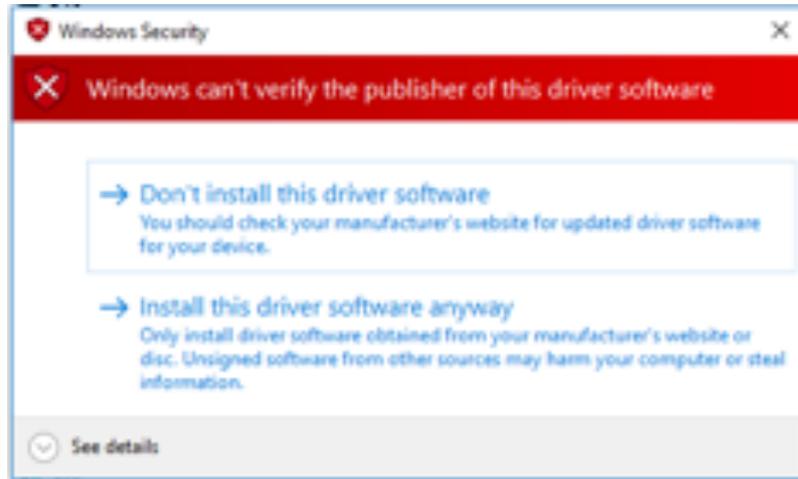


9. Navigate to the location where you downloaded and extracted the NextFreePort_14.7. This is rovided by SPEAG. Press Next.

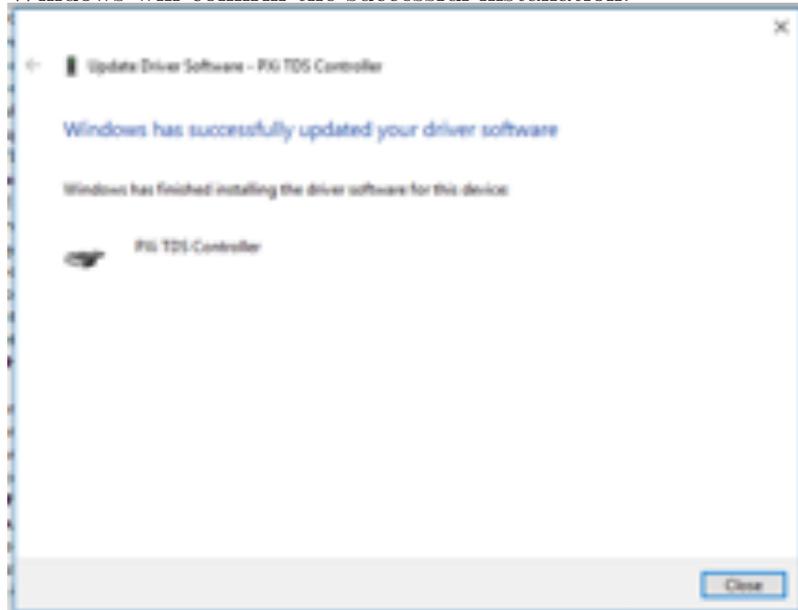


10. Windows will ask to install the Driver. Press "Install this driver software anyway".

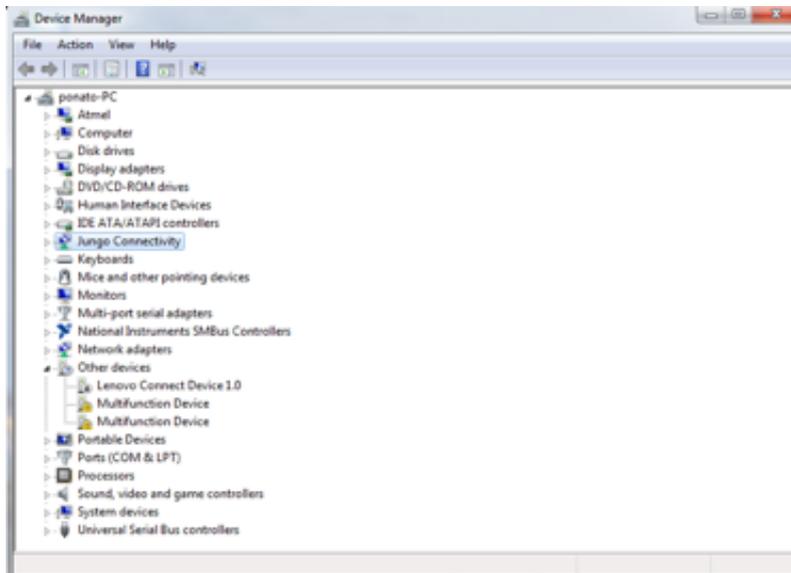
5.2. DRIVER INSTALLATION



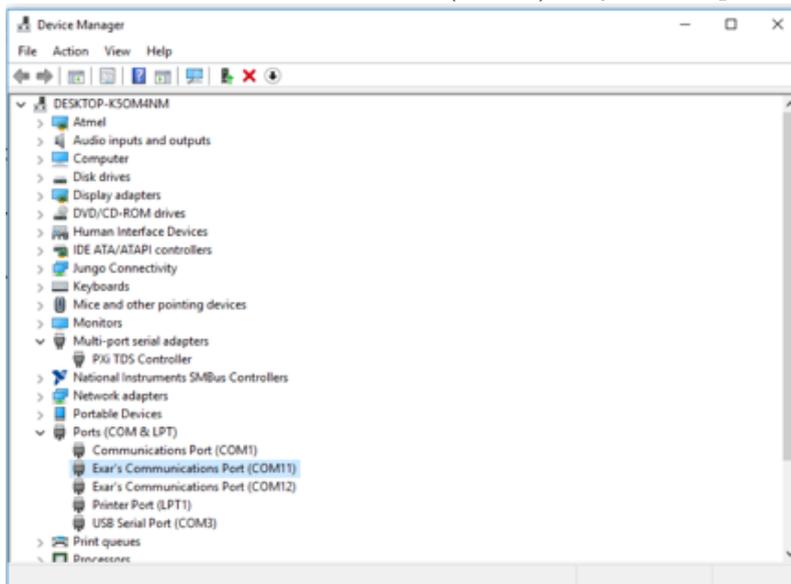
11. Windows will confirm the successful installation.



12. Now there are two new Devices visible in the Device Manager. (Multifunction Device). Repeat the steps 1 to 6 for both Devices:



13. After the successful installation the TDS PXI Remote Unit will be available as a new COM interface (Exar's) on your computer:



5.3 Ethernet Interface Configuration

This section explains the setup of the Ethernet local area network ports (5.1) on the ICEy Control PC. The PC has 3 Ethernet ports in total. Depending on your system configuration the rear layout of the control PC may be different, however all specific ports will be labeled by SPEAG.

ETH to CAMs This ethernet port connects the PC to the Ethernet fiber-optic media converter inside the IEICEy. The fiber-optics are then

5.3. ETHERNET INTERFACE CONFIGURATION

used to connect the camera system inside the ICE y Test Chamber.

ETH to Motion Ctrl This ethernet port connects the PC to the Motion Controller inside the IEICE y .

ETH to Network This ethernet port connects the PC to the ethernet switch inside the IEICE y , from there the signal are distributed to the peripheral connector terminals on both sides of the ICE y Support rack. This link is used to connect to Control PC to a local area network.

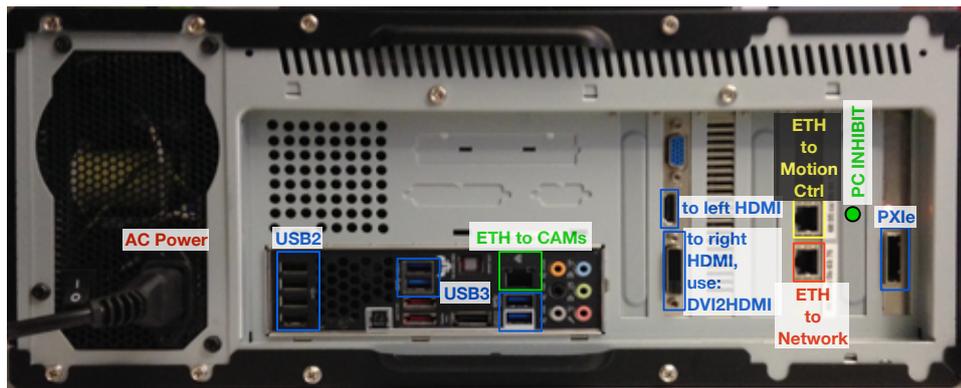


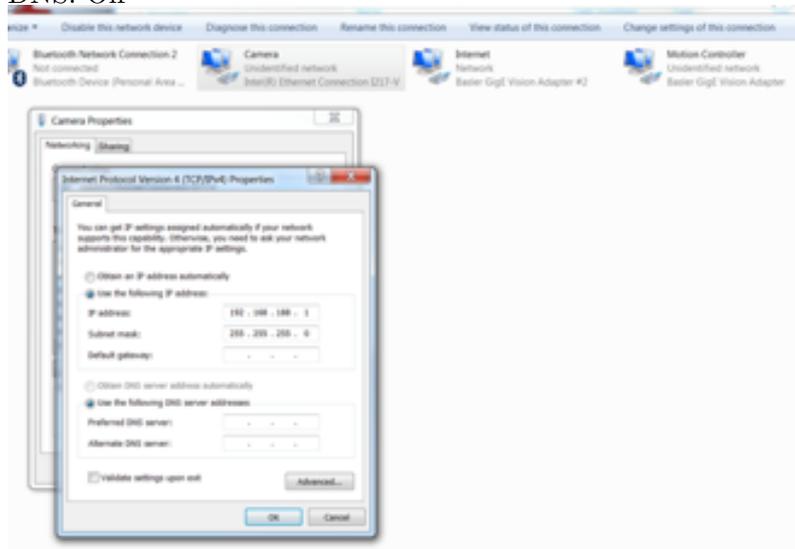
Figure 5.1: Connector allocation of the ICE y Control PC.

5.3.1 Ethernet to Camera System

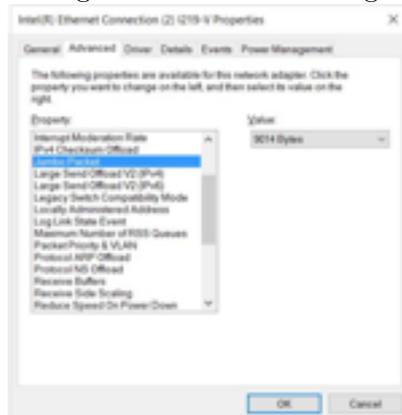
Select one Gigabit Ethernet Port (use onboard port) to connect the camera system via the Ethernet media converter (located in the ICEy Controller).

Configure this Ethernet interface:

- IP: 192.168.188.1
- Subnetmask: 255.255.255.0
- Default Gateway: 192.168.188.1
- DNS: Off

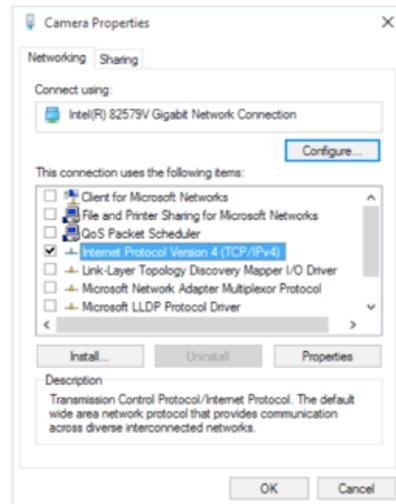


- Configure: Advanced Settings: Gigabit MasterSlaveMode Force Slave Mode, 1Gbit/s
- Configure: Advanced Settings:JumboPacket Value 9014 Bytes



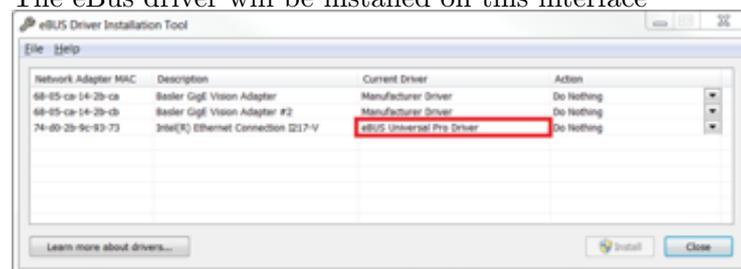
- Ensure that any service except IPV4 is disabled:

5.3. ETHERNET INTERFACE CONFIGURATION

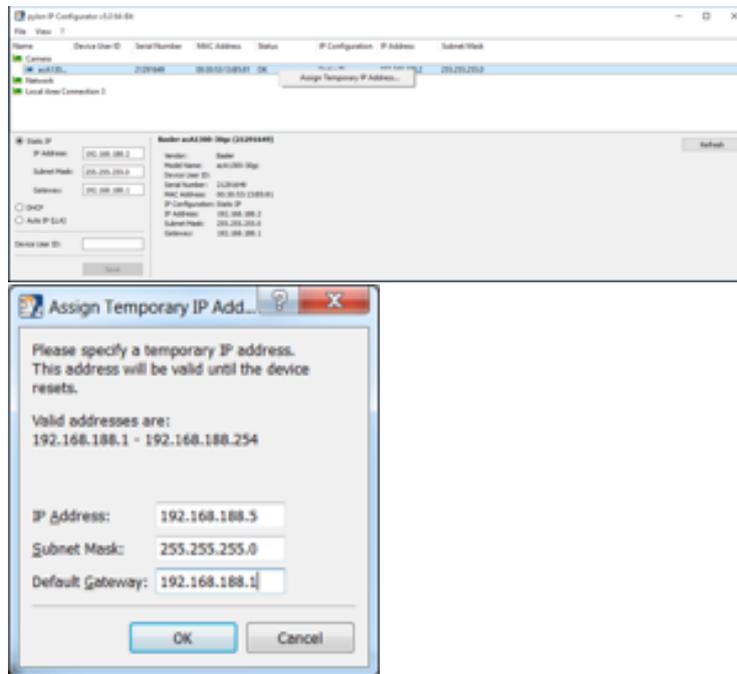


- Make sure both Ethernet Media Converters (on scanner z-axis and inside ICEy Controller) are set to "Force" (Note: This is only accessible to SPEAG and pre-configured.)
- Install the eBus Driver on this interface:

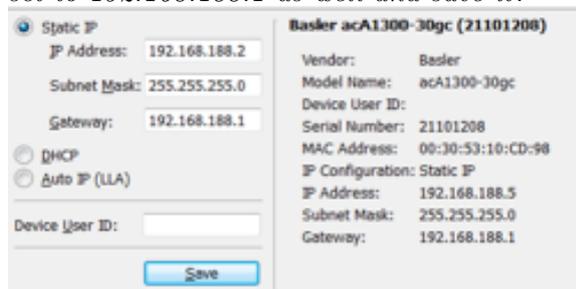
- Open: Start — Programs — Pleora* — Tools — eBus Driver tool
- Select the 192.168.188.1 interface and "Action" install eBus Driver & "OK"
- The eBus driver will be installed on this interface



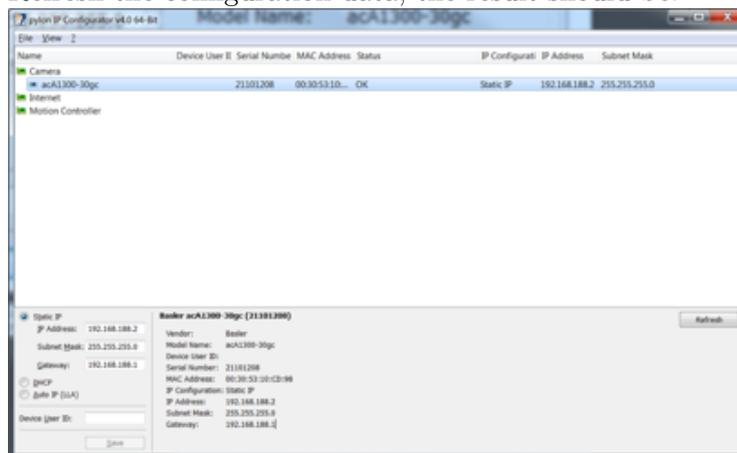
- Fix the IP Address of the Basler Camera:
 - Open: Start — Programs — Basler — pylon 4 Camera Software Suite — pylon IP Configurator (x64). *Make sure to also allow public network access in the firewall popup!*
 - Assign a temporary IP address to the basler camera (192.168.188.5). *Default gateway must be set to 192.168.188.1 as well*



- Set static IP address to: 192.168.188.2. *Default gateway must be set to 192.168.188.1 as well and save it:*

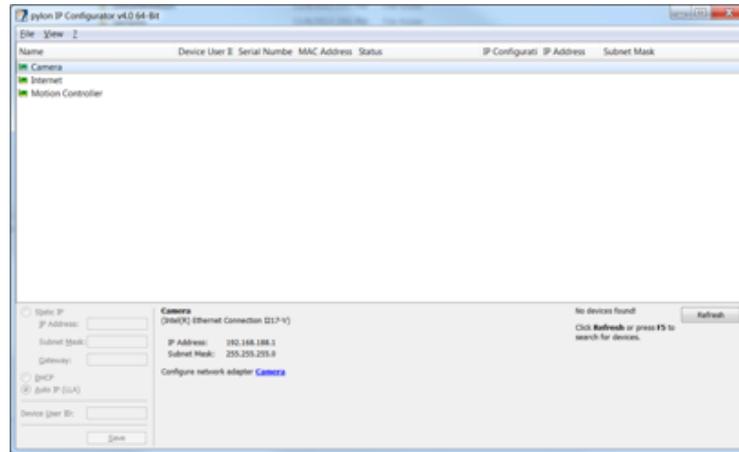


- Refresh the configuration data, the result should be:

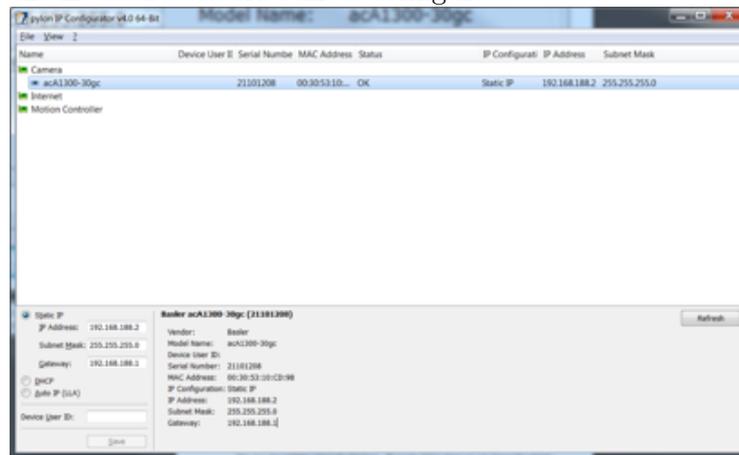


- Switch off camera system (CB47), refresh:

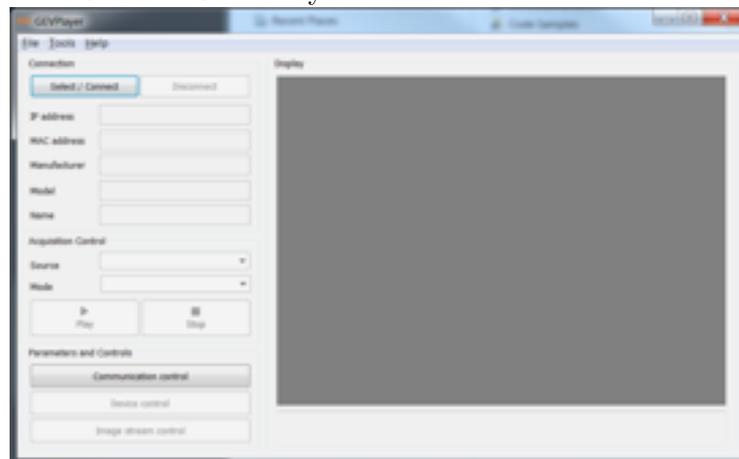
5.3. ETHERNET INTERFACE CONFIGURATION



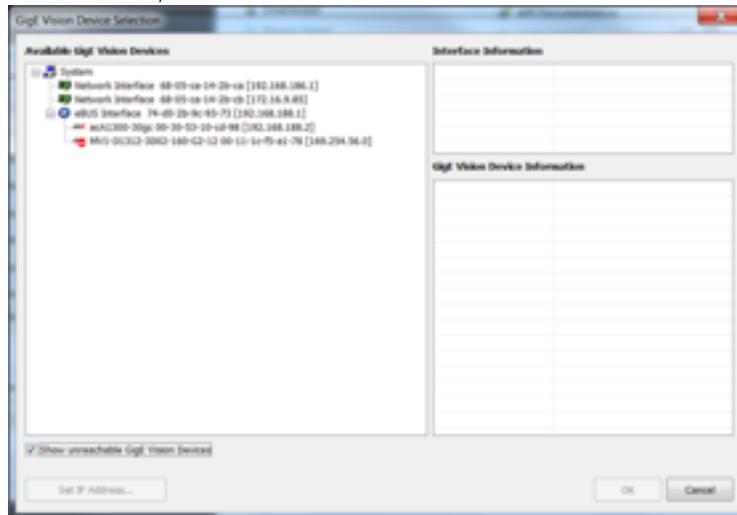
- Switch on camera system again (SB47), refresh and make sure the IP addresses are still as configured:



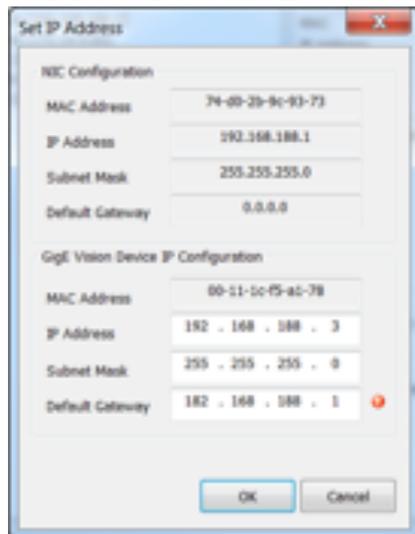
- Fix the IP address of the LASER camera:
 - Open: Start — All Programms — Pleora Technologies Inc. — eBus SDK — GEV Player:



- Click Select/ Connect and tick “Show unreachable devices”

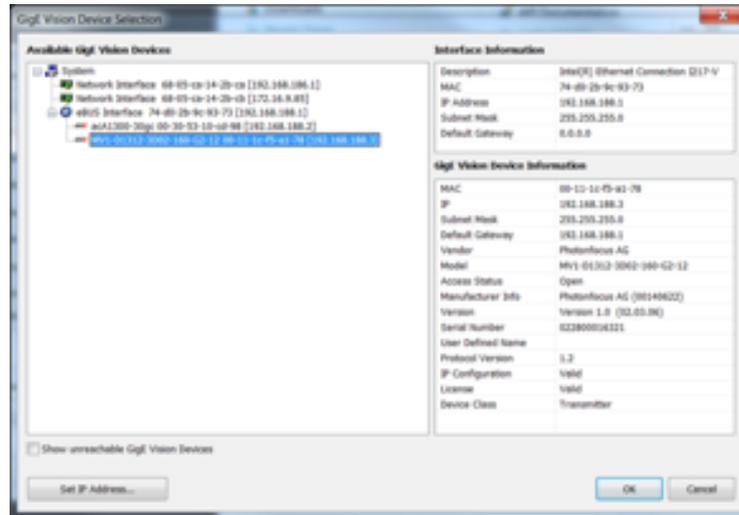


- Select MV1-D1312 and click “Set IP Address?.”, set IP Address to 192.168.188.3 and Default Gateway to 192.168.188.1:

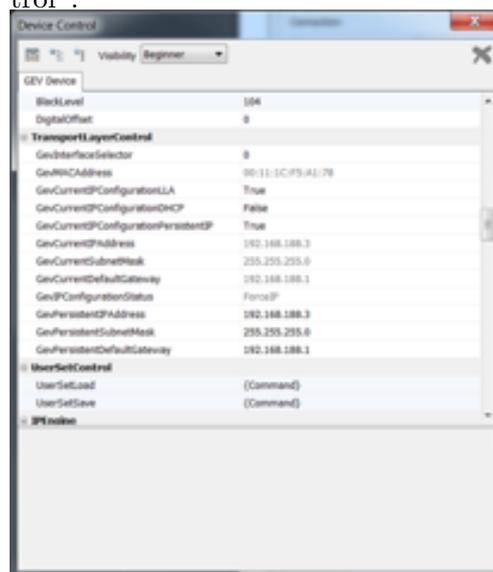


- The camera is now reachable, click OK to exit

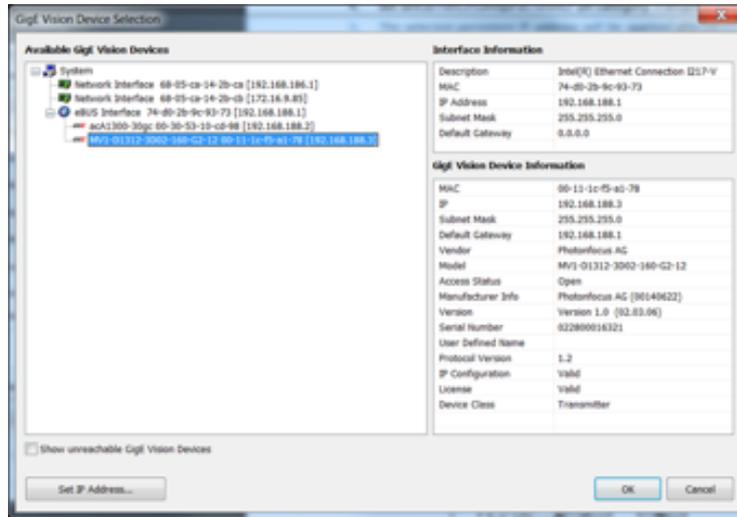
5.3. ETHERNET INTERFACE CONFIGURATION



- Click “Device Control” and scroll down to “TransportLayerControl”:



- Make the following changes:
 - * `GevCurrentIPConfigurationDHCP` ⇒ `False`
 - * `GevCurrentIPConfigurationPersistenIP` ⇒ `True`
 - * `GevPersistentIPAddress` ⇒ `192.168.188.3`
 - * `GevPersistentSubnetMask` ⇒ `255.255.255.0`
 - * `GevPersistentDefaultGateway` ⇒ `192.168.188.1`
 - * Click `UserSetSave`
- Close `GEVPlayer` and reboot the camera (CB47, wait 1minute, SB 47, wait 1 minute on the motion controller)
- Open `GEVPlayer` again and validate that the `LASERcamera` comes up with the pre-configured IP-address:

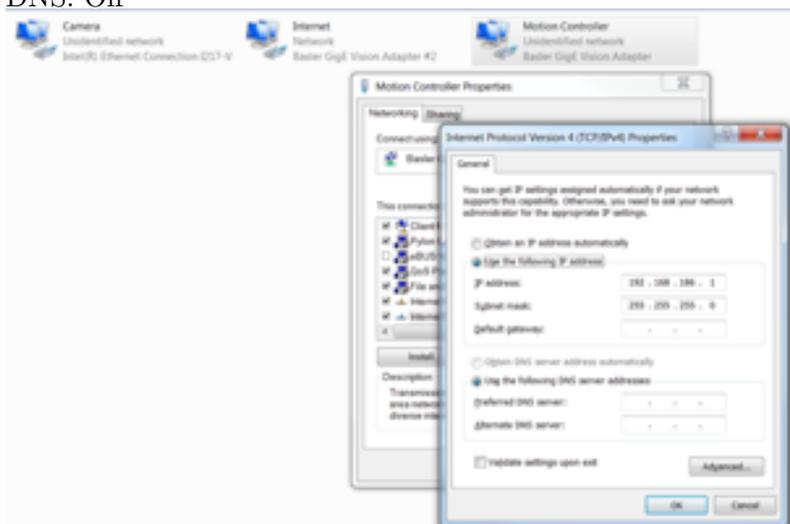


5.3.2 Ethernet to Motion Controller

Select one Gigabit Ethernet Port (upper port on the extension card) to connect the motion system via and Ethernet cable to the ICE_y controller.

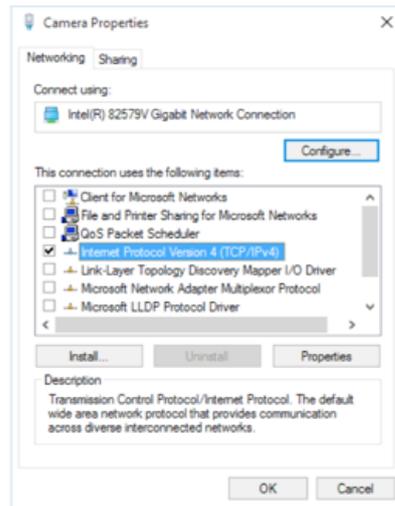
Configure this Ethernet interface:

- IP: 192.168.186.1
- Subnetmask: 255.255.255.0
- Default Gateway: 192.168.186.1
- DNS: Off



- Ensure that any service except IPV4 is disabled:

5.3. ETHERNET INTERFACE CONFIGURATION

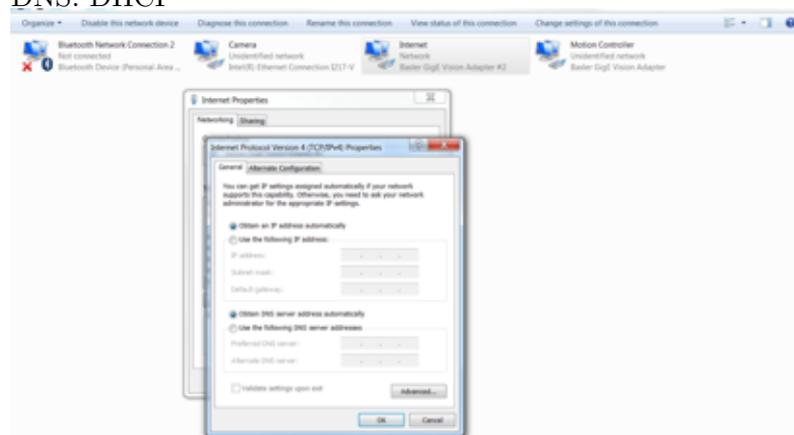


5.3.3 Ethernet to Local Area Network

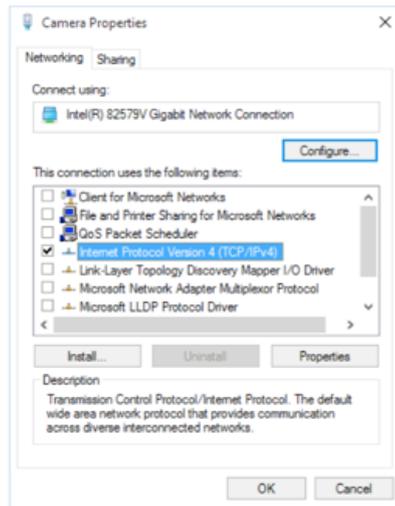
Select one Gigabit Ethernet Port (lower port on the extension card) to connect the PC via an Ethernet cable to the Ethernet Switch located in the ICE_y controller.

Configure this Ethernet interface:

- IP: DHCP
- Subnetmask: DHCP
- Default Gateway: DHCP
- DNS: DHCP



- Ensure that any service except IPV4 is disabled:



5.4 ICEy Software Installation

Install the ICEy software using the installer supplied by SPEAG. To install the software simply double click the installer executable, accept the license term and run through the default installation setting. On a newly setup PC you might also want to install the Visual Studio Runtime redistributables.



After the installation you will find two newly create icons on the desktop. To start up the ICEy software always start up ICEy RT first and then the ICEy graphical user interface.

5.5 License setup

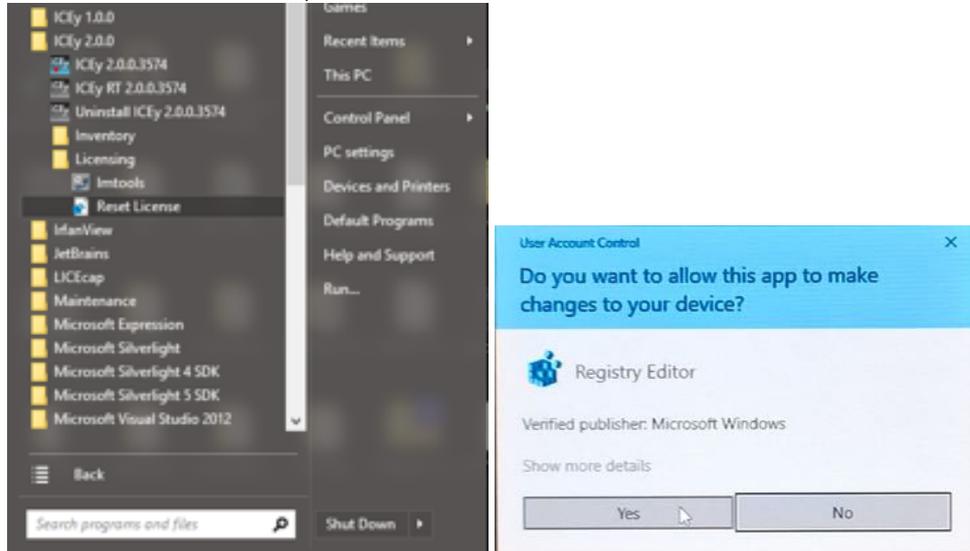
The ICEy software is protected by a dongle-based license. The dongle drivers are automatically installed by the application software. The first time the software is started, the user will be asked to specify a license file location. The path is stored in the software and it expects to find a valid license in this location. If the user gets a new license file from SPEAG, the old one can be renamed/deleted and the new one can be placed in the same location.

5.5.1 Reset License Location

If the message "No valid license found!" appears when starting the software, make sure that the license dongle is connected to a USB port on your computer. If this does not resolve the issue, it is likely that the license file is in a different directory than what the program expects. To reset the license location, run the Reset License program by choosing *Start : All Programs : ICEy 2.x.x : Licensing : Reset License*. This will run a script which modifies

5.6. CONFIGURATION FILES AND PREFERENCES

the registry and resets the path to the license file. Windows will pop up few warnings. Please click **Yes/OK** on all of them.



When the ICEy software is restarted, it will run the FLEXnet License Finder. The user will have to select *Specify the License File* and then Browse to the location containing the license.



If all is successful, the application will start after clicking *Finish* in the FlexNet License Finder window.

5.6 Configuration Files and Preferences

The ICEy software shares the same configuration files among all users on the system. The configuration files therefore are located under `C:\Users\Public\Documents\Speag\ICEy`. The following file and directory structure is used:

`.\ICEy\ICEy_*_LOG.txt`

Contains all log files and further subdirectories.

`.\ICEy\Camera\Calibration`

- Contains calibration results of the camera system.*
- `.\ICEy\Camera\Configuration`
Contains the configuration file of the DUT camera.
- `.\ICEy\EvaluationLibrary`
Contains all evaluation templates that an ICEy user creates.
- `.\ICEy\Inventory\Probes`
Contains all installed probe calibration files.
- `.\ICEy\Inventory\TDSRemoteUnit`
Contains the currently installed remote unit calibration file.
- `.\ICEy\LaserTriangulation\Calibration`
Contains calibration results of the laser triangulation system.
- `.\ICEy\LaserTriangulation\Configuration`
Contains the configuration file of the laser triangulation camera.
- `.\ICEy\License`
Contains the license file
- `.\ICEy\Preferences`
Contains the GUI preferences.
- `.\ICEy\Scripts`
Contains user Python™ scrips.
- `.\ICEy\UserDUTSetupScripts`
Contains all DUT setup hook scripts.

5.6.1 Probe and Remote Unit Configuration Files

Probe and remote unit calibration files are provided to the end-user by SPEAG. These files must be installed within the ICEy GUI. Copying the files manually in the aforementioned directories will cause conflicts.

5.7 Calibration and Parametrization

This section explains the calibration and the parameters used for setting up the ICEy system. Calibration and editing of parameters can be done in the calibration tool. To start it, the user must be switched: in the menu bar, select **Users** and switch to **ICEy Calibrator**. On successful login, the icon **Start Calibration** should appear in the **Scanner Tab** (Fig. 5.2). Click it to start the calibration tool.

5.7.1 Motion System

The motion system calibration tool (Fig. 5.3) allows editing of the motion system parameters and calibration of the lightbeam position. It can also detect the surface of a (hard) object by lowering a probe until the surface is hit.

5.7. CALIBRATION AND PARAMETRIZATION



Figure 5.2: Log in as ICEy Calibrator to start the calibration tool.

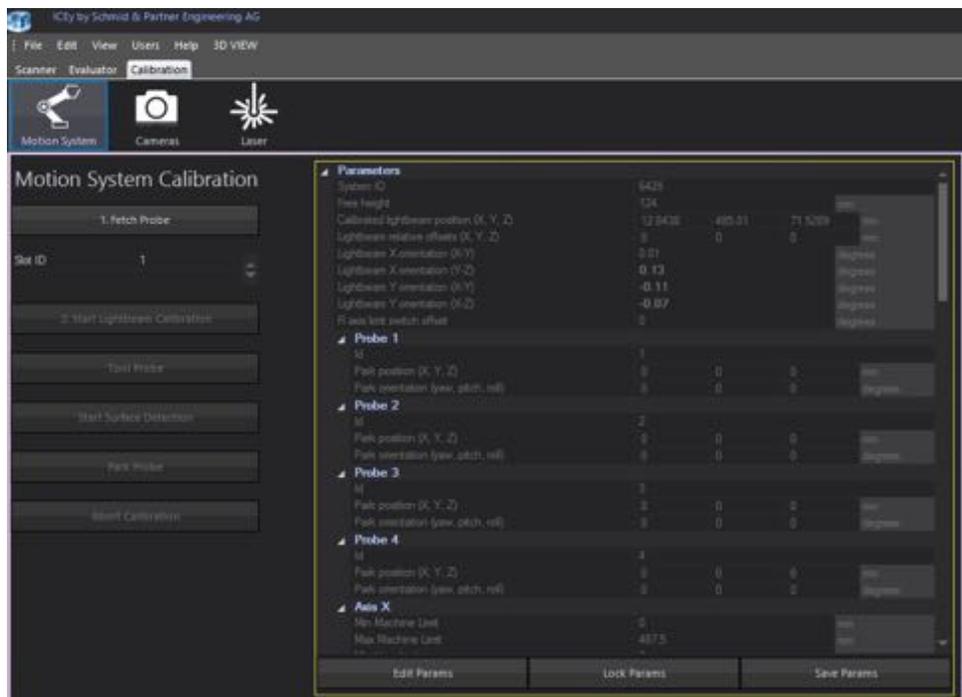


Figure 5.3: Motion system calibration tool.

5.7.1.1 Parameters

The parameters only need to be set once during system installation. To edit the parameters, press the **Edit Params** button below the parameter list (in the calibration tool).

The parameters describing the system are shown in the following table:

System ID	Serial number of the controller.
Free height	Defines the position of the z-axis when the system moves, to avoid collisions with objects in the workspace.
Calibrated lightbeam position	Before any calibration is performed, this should contain the approximate position of the lightbeam (intersection of the two lightbeams). After lightbeam calibration, this will contain the calibrated position.
Lightbeam relative offsets	Position that defines the offsets between the two lightbeams. This differs for different cabinet types.
Lightbeam X orientation (X-Y)	Is determined during lightbeam calibration and is currently unused.
Lightbeam X orientation (Y-Z)	Is determined during lightbeam calibration and is currently unused.
Lightbeam Y orientation (X-Y)	Is determined during lightbeam calibration and is currently unused.
Lightbeam Y orientation (X-Z)	Is determined during lightbeam calibration and is currently unused.
R axis limit switch offset	Is internally determined for the R-axis during tooling.

For each probe, the position and orientation of the parking slots need to be defined:

Park position	Components x, y, z for the probe parking slot position.
Park orientation	Components yaw, pitch, roll for the probe parking slot orientation.

Before any operation is possible, the following parameters must be adjusted: **System ID**, **Free height**, **Calibrated lightbeam position**, **Lightbeam relative offsets**, **Park position** and **Park orientation** 1-4.

The axis parameters should already contain the correct defaults. Each of the five axes (X, X2, Y, Z, R) is configured by the parameters in Table 5.1.

Parameter	Default value for axis					
	X	Y	Z	R	X2	
Min Machine Limit	0 mm	-105 mm	0 mm	5°	0 mm	
Max Machine Limit	487.5 mm	500 mm	127 mm	355°	487.5 mm	
Min User Limit	0 mm	0 mm	0 mm	5°	0 mm	
Max User Limit	487.5 mm	500 mm	125 mm	355°	487.5 mm	
Reference Direction	false	false	true	false	false	
Reference Mark Position	487.5 mm	-105 mm	127 mm	0°	487.5 mm	
After Reference Position	20 mm	-80 mm	125 mm	0°	20 mm	
Reversal Position	0 mm	0 mm	0 mm	0°	0 mm	
Increments per mm	1600 1/mm	1600 1/mm	4000 1/mm	66.6667 1/°	1600 1/mm	
Inverted	false	true	false	false	false	
Rotational	false	false	false	true	false	
Default Speed	20 mm/s	20 mm/s	20 mm/s	50°/s	20 mm/s	
Default Acceleration	100 mm/s ²	100 mm/s ²	100 mm/s ²	250°/s ²	100 mm/s ²	
Max Speed	70 mm/s	70 mm/s	70 mm/s	70°/s	70 mm/s	
Max Acceleration	350 mm/s ²	350 mm/s ²	350 mm/s ²	350°/s ²	350 mm/s ²	

Table 5.1: Axis parameters

5.7.1.2 Lightbeam Calibration

To calibrate a reference point that can be used both for the probes and for the lasercamera, the lightbeams are used. Calibration must be performed once when the system is installed. Once the parameters are set up (including the approximate lightbeam position entered in the field `Calibrated lightbeam position`) enter the slot from which you want to fetch the probe that is used for lightbeam calibration and press `Fetch Probe`. The probe must be configured in the probe repository (see Section 9.1.1). When the probe is fetched press `Start Lightbeam Calibration` to start the calibration process. When the process is finished, you will be asked if you want to store the calibrated parameters in the preferences.

5.7.1.3 Surface Detection

To validate agreement of laser triangulation scan and probe, a surface detection using a probe can be performed. The robot will slowly lower the probe until a (hard) surface is found. To perform a surface detection, fetch a probe, and tool it (use the corresponding buttons in the motion system calibration tool). Then use the `MotionSystemRemoteControl.py` script to move the probe above the surface you want to detect. Bring the probe above the surface within a few millimeters, then press the `Start Surface Detection` button. When finished, the software will show you a popup window with the results. The found user coordinates of the surface can then be compared to the results of a laser triangulation scan.

5.7.2 Cameras

The camera calibration tool (Fig. 5.4) determines camera lens parameters, such that lens distortion can be compensated. It also determines focal length and offset between normal camera and laser camera, and distance to the workbench surface. To use the tool, a *camera calibration body* is required.

During the first installation, it is necessary to calibrate the normal camera, the laser camera, and then their offsets. For all these actions, the *camera calibration body* needs to be placed in the center of the ICEy workbench.

To calibrate the normal camera, select it in the drop-down list in the upper left, and press `Start Image Acquisition`. The robot will look at the checkerboard patterns and take images from different positions. A dialog will appear when image acquisition is done. Select `Show Checkerboard` in the lower right corner of the calibration tool, and go through the images to see if the checkerboard is detected on most of the images. Do NOT delete individual images. Make sure that `Calibration Target Height` is set correctly (40 mm for the shipped calibration targets), and then press `Compute & Save Calibration`. Computation of the parameters will take a couple of minutes. During that time you can already start image acquisition of the

5.7. CALIBRATION AND PARAMETRIZATION

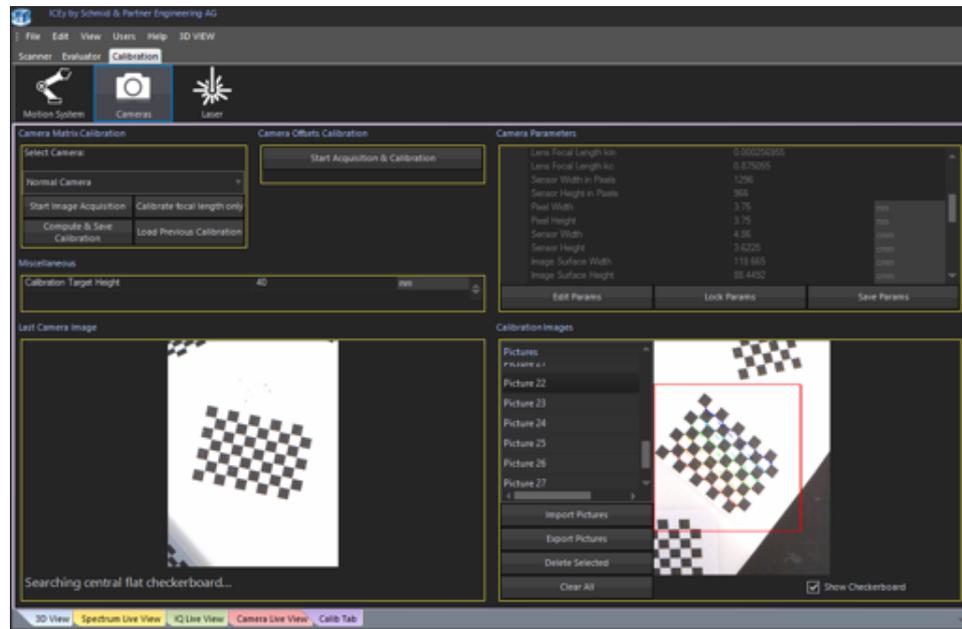


Figure 5.4: Camera calibration tool.

laser camera. A pop-up window will inform you when the computation is done and you can save the parameters to the preferences. The lens calibration file is automatically generated and selected as the current calibration.

To calibrate the laser camera, follow the same procedure as for the normal camera, but select **Laser Camera** in the drop-down list.

After both cameras are calibrated, their offset needs to be determined. The parameter **Calibration Target Height** normally is set in the previous step, if not, make sure it is correct. Press **Start Acquisition & Calibration** in the **Camera Offsets Calibration** Field.

After offset calibration, a camera scan in the ICEy scanner should not be performed until the software was restarted.

5.7.3 Laser

The laser calibration tool calibrates the reference point and the parameters of the laser triangulation system. A *lightbeam calibration body* is required. Note that the camera calibration (see above) needs to be performed prior to laser calibration.

First, the lightbeam calibration needs to be performed. Press **Lightbeam Calibration** and insert the *lightbeam calibration body* into the lightbeams as shown in the pop-up window, then press **OK** to start the calibration. After a few minutes, you will be asked to turn the *lightbeam calibration body* (remove

it, turn it by 90 degrees, and put it back between the lightbeams as shown in the pop-up window). Close the pop-up when you are done. After a few minutes, a pop-up window will inform you that the lightbeam calibration is completed.

Next, calibrate the laser parameters. For this, make sure the ICE y workbench is empty (at least 300 x 300 mm in the center), and press **Laser Parameters Calibration**. After about a minute a pop-up window should inform you that the laser calibration is finished and you can save the parameters to the preferences.

5.7. CALIBRATION AND PARAMETRIZATION

Chapter 6

Service and Maintenance

6.1 Maintenance

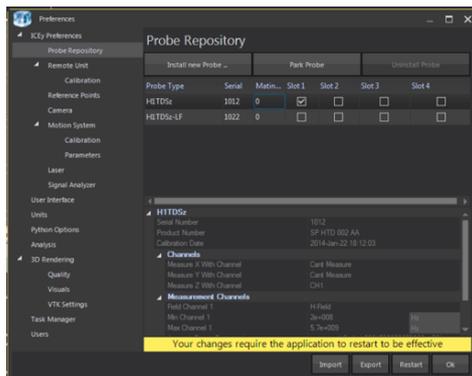
6.1.1 Maintenance Schedule

6.1.2 NI PXI Vector Signal Analyzer Air Inlet Filters

Please contact support@speag.com or your local National Instruments representative to purchase a new air inlet filter if your current filter shows signs of wear.

6.1.3 Fiber-Optical Connectors

6.1.3.1 Probe Fiber-Optical Connectors



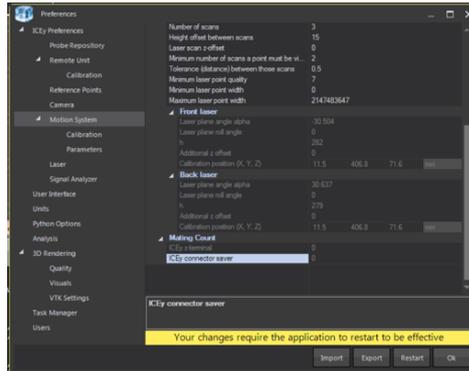
The MU fiber optical connectors (savers) of TDS -ICEy probes support 500-1000 mating cycles. The current mating count of any ICEy probe is visible under probe preferences as shown on the left. ICEy TDS probes include a connector saver which can be replaced. This adds another 500-1000 times - greatly increasing the total mating count.

We suggest to execute this connector saver exchange as soon as the probe mating count reaches 500 or the ICEy software reports problems with the fiber-optical connection quality. As this exchange is critical with respect to LASER safety and probe calibration the probe connector saver can only be exchanged by SPEAG. Please contact support@speag.com before returning a probe for connector saver exchange.

6.1. MAINTENANCE

6.1.3.2 Z- and Roll Axis Fiber-Optical Connectors

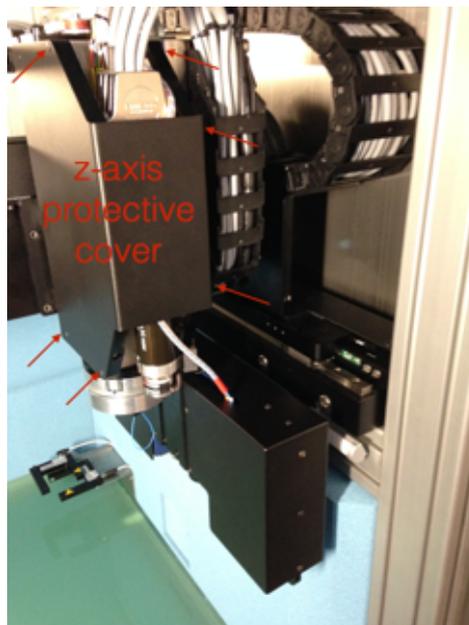
TDS ICEy probes mate with an MU8 fiber optical connection located in the roll axis of the ICEy system. This fiber optical connection supports 500- 1000 mating cycles.



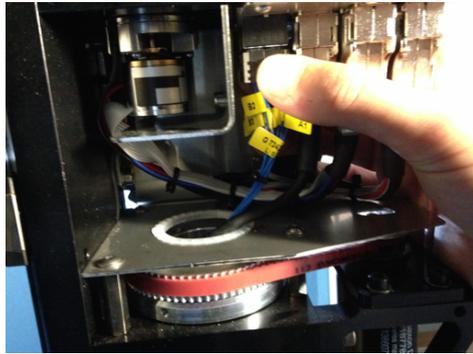
The current mating count of the ICEy z-axis connector is visible under Motion System, Mating Count preferences as shown on the left. ICEy's z-axis includes a connector saver formed by an MU8 connector and 275 mm MU8 fiber-optics which can be replaced by the user, adding another 500- 1000 mating cycles. In the following procedure the exchange of this connector saver is described.

Start with locating the ICEy z-axis connector saver delivered with your system. The connector saver consists of 275 mm MU-type fiber-optics and an MU8 adapter. If you can not locate the connector saver or already used the one delivered with your system previously, please contact info@speag.com to purchase connector savers.

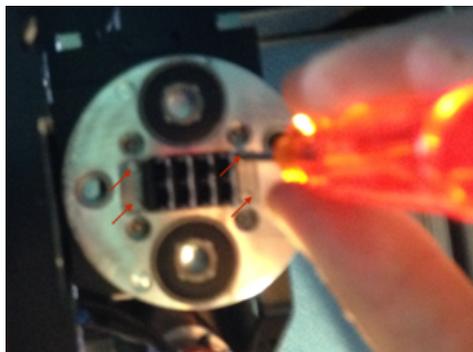
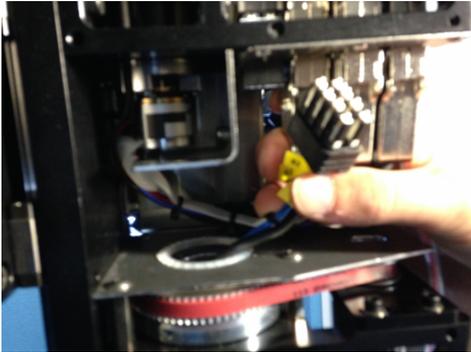
Initially, you will have to remove the currently installed connector saver following the steps below.



Use the ICEy motion control script to move the ICEy axis to a front center position with the z-axis all the way down ($x=400$ mm, $y=300$ mm, $z=0$ mm) Then remove the protective cover from the ICEy system z-axis by taking out the screws indicated by arrows.



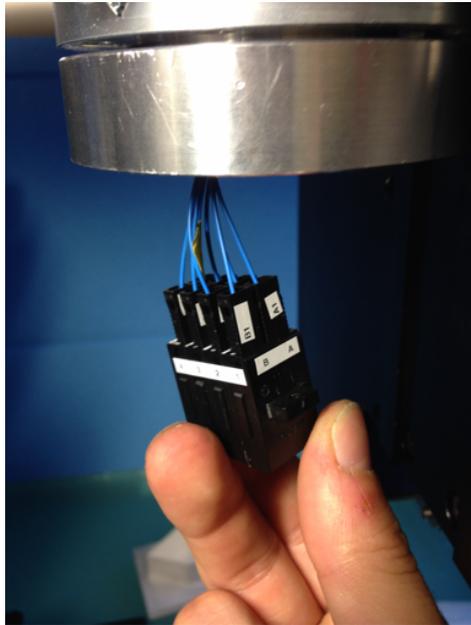
Disconnect the connector saver fiber-optics at the top of the z-axis terminal.



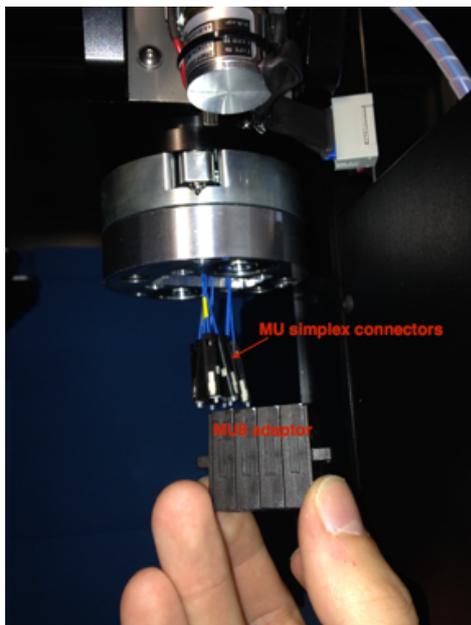
Undo the 2 plates holding the MU8 connector in the roll axis by unscrewing 2 screws each.



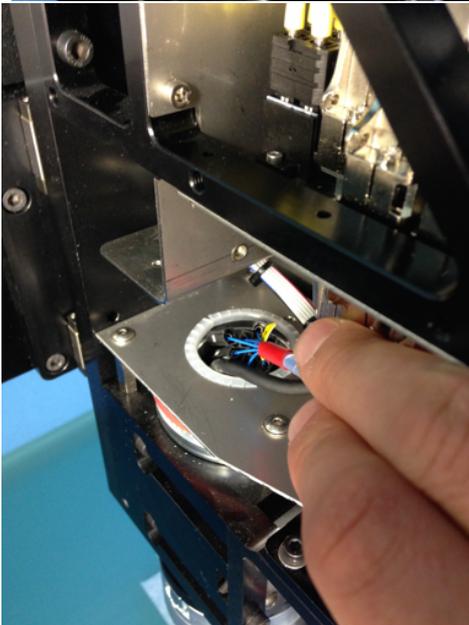
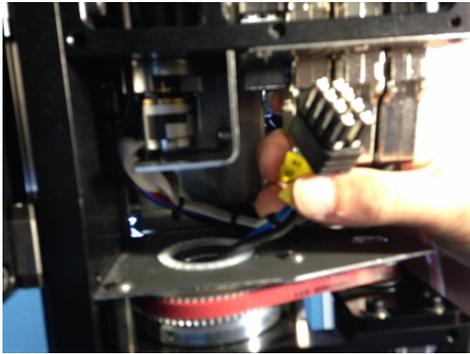
6.1. MAINTENANCE



Now you can pull down (by about 30-40 mm) the fiber-optics by pulling the roll-axis MU8 connector.

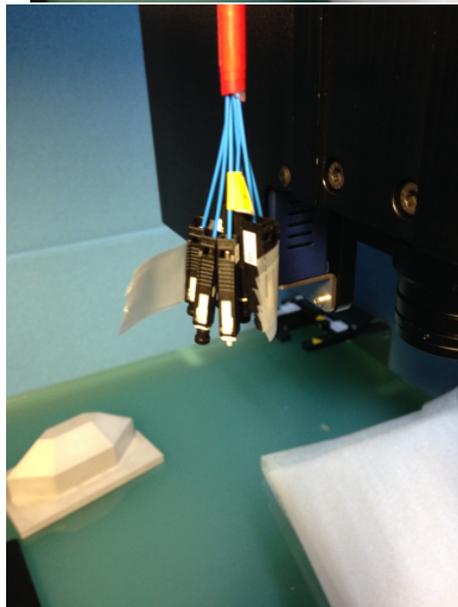


Now disconnect all MU-simplex fiber-connectors one by one from the MU8-adaptor until the adaptor is free.

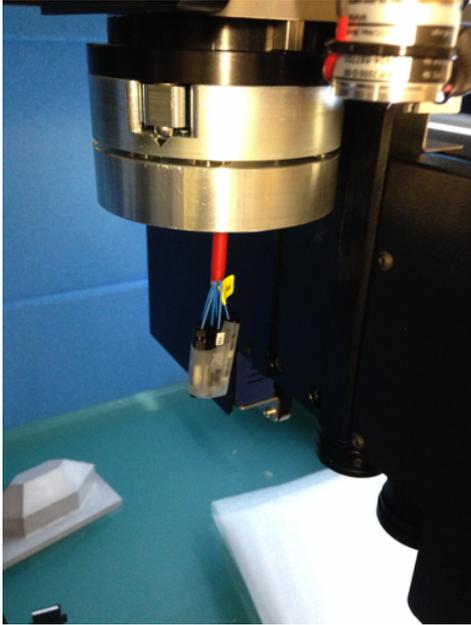


Remove the connector saver fiber optics by pulling carefully the top MU8 connector.

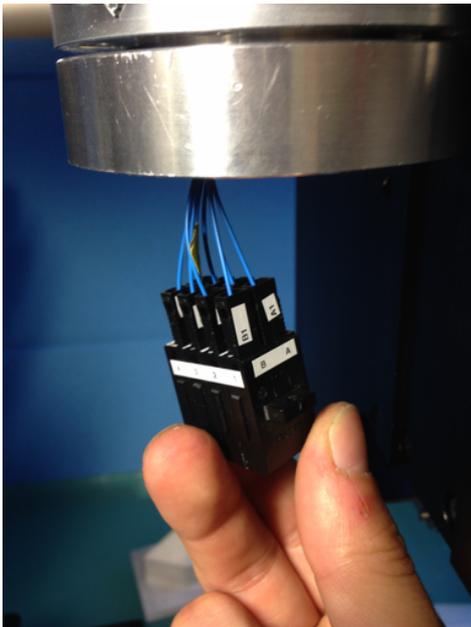
6.1. MAINTENANCE



Prepare the new connector saver fiber optics by taping the 8 separate MU-simplex connectors together as shown. It is recommended not to remove the protective caps from the connectors.

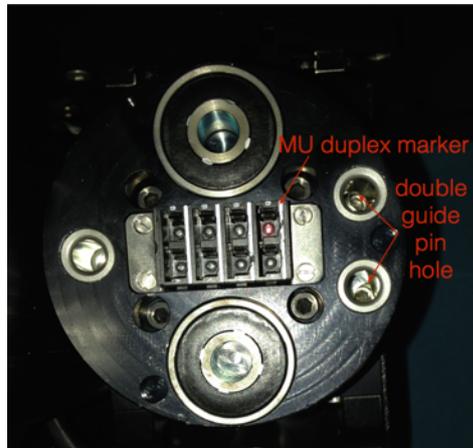


Re-insert the MU-simplex side of connector saver fiber optics from the top.

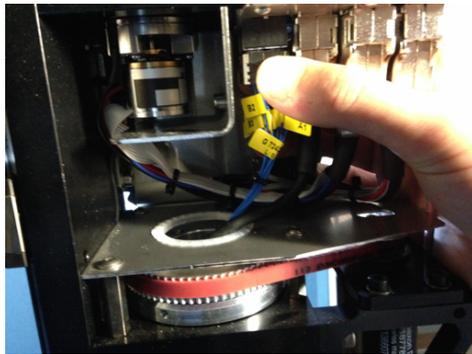


Re-connect the MU-simplex connectors to the MU8-adaptor (remove the protective caps beforehand). Make sure the labelling on MU8 matches the individual labels on the MU-simplex connectors.

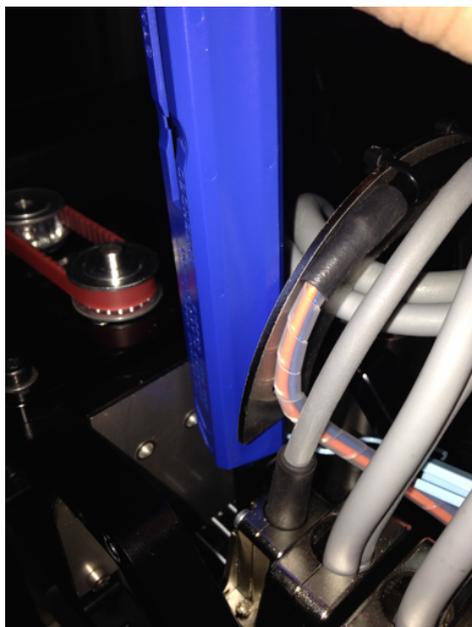
6.1. MAINTENANCE



Verify that the white marks on the MU8 adapter are oriented with respect to the probe guide pins as shown on the left and then re-install the MU8-adapter holder plates.



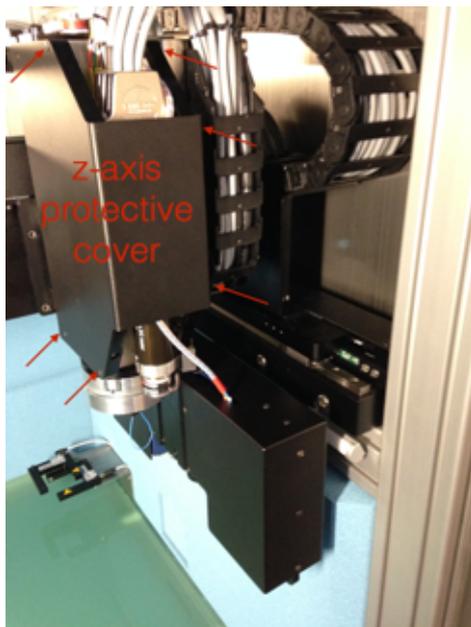
Reconnect the fiber optic connector saver at the top of the z-axis terminal.



Disconnect the MU8 fiber optics coming from the drag chain (counter part to the connector saver fiber optics) and clean the connector using the click-cleaner as shown on the left (remove the blue tip-cover from the click-cleaner for this). Also clean the fiber optics from the drag chain side and reconnect the connector.



Clean the bottom (roll axis) MU8 adaptor using the click-cleaner (remove the blue cap again).



Finally, re-install the protective cover.

6.1.4 Test Chamber Door

6.1.4.1 Small Maintenance

Use a scour pad to remove residue and clean the knife blade on the door. Clean the knife blade with a soft cloth soaked with acetone or similar solvent. Lightly spray the knife edge with silicon lubricant.

6.1.4.2 Large Maintenance

Do not slide the trowel and cloth across the finger stock when performing these steps.

1. Lightly dampen a soft cloth with solvent.
2. Completely cover a trowel blade with the cloth.
3. Remove built-up dirt from the contact fingers of the door.
4. Allow the solvent to evaporate, and then repeat the entire procedure.

6.1.5 Cleaning the Workbench

The glass platform of the workbench is coated with NEXTEL[®] or mate edged glass on version 2 ICE_y systems.

- Dust and finger marks can be removed by means of a soft brush, moist cloth or sponge. Removal is facilitated by using aqueous detergents, washing-up liquid or methylated spirit.
- Stains caused by mineral oils, lubricants, vegetable fats, can be removed with a cloth, sponge or brush together with methylated spirit or isopropyl alcohol.
- Stains caused by water-soluble agents such as jam, tea, coffee, fruit juice etc. can be removed with a cloth, sponge or brush together with aqueous detergents, washing-up liquid, or a light scrubbing with a moist SCOTCHBRITE pad.

In all cases, a regular cleaning schedule will prevent the build-up of stains, which may, in time, prove difficult to remove.

6.1.6 Cleaning Accessible Metal, Glass or Plastic Surfaces

6.1.7 Maintenance Schedule

The following maintenance (to be carried out by SPEAG or the end-user) is recommended:

maintenance interval	maintenance activity	maintenanced by
500-1000 cycles	fiber-optic connector saver	end-user
weekly	test chamber door and feedthrough sealing small maintenance	end-user
monthly	test chamber door and feedthrough sealing large maintenance	end-user
as needed	cleaning of work-bench and components	end-user
750 h	clean-out of all filters (PXI), vents, air inlets and outlets (vacuum cleaner)	end-user

6.2 Service

6.2.1 Wearing Parts, Service and Repair

The system does not contain any wearing parts. For your own safety, do not attempt to service or repair the system yourself.

For maintaining LASER product safety, maintenance other than described above must be performed by the manufacturer of the ICE y system (*Schmid & Partner Engineering AG, Zurich, Switzerland*). The product does not require any scheduled maintenance to maintain compliance with Class 1 LASER safety. If the system is damaged, especially the housings of the probes, the remote unit or the sleeving of the fibre optics, or needs service or repair it has to be returned to Schmid&Partner Engineering AG, Zurich, Switzerland. Do not attempt any service or repair yourself. Do not open the housings or sleeves of any of the components of the ICE y and TDS systems at any time.

6.2.2 Service Schedule

The following services (to be carried out by SPEAG only) are recommended:

service intervall	service activity	serviced by
15000 h	lubrification of movement stage	SPEAG
30000 h	cleaning, adjustment and lubrication of movement stage	SPEAG
30000 h or 25000 cycles	main fiber-optic patchcord replacement	SPEAG

6.2. SERVICE

Chapter 7

Safety

The customer must provide the following minimum requirements for safe robot operations:

- Only instructed persons should operate the system.
- If local regulations prohibit the access to the movement stages during computer-controlled operation, properly installed safeguarding equipment must be added to the system with respect to the safety guidelines.

7.1 Electrical Safety

Mains voltages of $>50\text{ V}$ are available for the following parts:

- PC
- PXI Chassis
- IEICEy
- Fan Controller

Their cabinets must only be opened by trained personnel and after the mains is interrupted. Follow the respective manuals when doing so. Fuses may only be replaced by units with the proper rating. Wiring and cabling shall not be exposed to chemical agents.

7.2 Positioning System Safety

Do not operate the system with open door (if configured with door-override option). Do not reach into the system through the feedthrough plugs. **Failure to adhere to the above instructions may result in hazardous situations due to moving stages inside the system.**

7.3 LASER Safety

The Time-Domain Sensor (TDS) system is a LASER product designated as Class 1 during all procedures of operation. The TDS system internally

uses a CW power LASER capable of Class 3B operation. An internal safety circuit shuts down the power LASER within 0.1 ms if the optical link from the remote unit to the sensor is interrupted which allows the system to operate as a LASER Class 1 device. The TDS system is easy to use device but as the system is internally operating with powerful invisible LASER radiation it is strongly recommended to read the following instructions before unpacking and first operating the system.

- Permit only experienced personnel to operate the system.
- Do not override the safety optical safety return links by external bias (electrically or optically).
- Under no circumstances do attempt to defeat the connector interlocking mechanism (shutter and mating probe connector).
- Do not switch on the remote unit with the activation pin before the fiber optics (probe) have been connected.
- Do not leave the key of the key switch attached to the remote unit if not in use.
- Immediately shut down the system (remove activation pin) if an optical link error occurred. Inform support@speag.com about the error for further instructions.
- Under no circumstances operate a defective unit or a unit with broken or damaged cover seals.
- Do not open the remote unit, fiber optics housing, sleeves or the sensors at any time. It is dangerous and will cause system failure if one opens the cover of the remote unit, fiber or the sensor.
- In case of mechanical damage of the remote unit (in particular the shutter), the fiber-optical patch-cord or the TDS probe, immediately deactivate the system by removing the activation pin. Inform "support@speag.com" about the damage and await further instructions.
- The system does not contain any user serviceable parts. Do not attempt any service or repair to the TDS system yourself. For service or repair the system has to be returned to SPEAG.

Failure to adhere to the above instructions may result in hazardous exposure. Caution: the use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

7.3.1 Accessible LASER Radiation

During operation the accessible radiation from the TDS system is limited to LASER Class 1. Even in the event of a failure of the protective covers or sleeves the radiation from a TDS system is limited to LASER Class 1 using an internal automatic power down mechanism of the LASER sources based on a continuous monitoring of the optical return link quality.

7.3.2 Non-Accessible Internal LASER Parameters

The TDS system uses embedded Class 3B lasers with no human access. Inside the Remote Unit up to 3 mutually exclusively activated near-infrared power LASER sources to energise the TDS sensors heads when a probe is connected:

Wavelength	808 nm
LASER power for classification	≤ 100 mW (≤ 55 mW calibrated)
Mode of operation	CW (continuous wave): automatic shutdown after link failure: $\leq 100 \mu\text{s}$
Transverse Beam Mode	multi-mode

Inside the Remote Unit 1 near-infrared LASER source to energise the TDS probe serial number when a probe is connected:

Wavelength	845 nm
LASER power for classification	≤ 5 mW (calibrated)
Mode of operation	CW (continuous wave): automatic shutdown after link failure: ≤ 1000 uSec
Transverse beam mode	multi-mode

Inside the TDS probe 1 near-infrared LASER source (VCSEL) is present:

Wavelength	850 nm
LASER Power for classification	≤ 2 mW
Mode of operation	CW (continuous wave): automatic shutdown after link failure: ≤ 100 uSec
Transverse beam mode	multi-mode

7.3.3 LASER Labeling

The below figures show the positions of the LASER safety relevant labelling of the TDS Remote Unit. The following labels are present on every Remote Unit:

1. Manufacturer Identification Label Part 1 (Remote Unit identification, Serial number, Part number and Manufacturing date)



7.3. LASER SAFETY

2. Manufacturer Identification Label Part 2 (Manufacturer address)

**Schmid & Partner Engineering AG,
Zeughausstrasse 43, CH - 8004 Zurich**

3. Certification Label

**Complies with FDA performance standards for laser products except for
deviations pursuant to Laser Notice No. 50, dated June 24, 2007**

4. Hazard Warning Symbol



5. Explanatory Label



7.4 Disposal

Safety installations must only be removed if the system will be taken out of operation permanently. This has to be done by removing the mains supply from the system. The state of the disposed system must be such that it cannot be put into operation without using tools.

If the system needs to be disposed of, it can easily be disassembled and recycled using state of the art recycling technology and following current disposal regulation.

Part II

Software Reference

Chapter 8

Overview

The ICEy Software has been designed to acquire and evaluate large datasets quickly and with ease.

The ICEy Software has also been designed to facilitate in troubleshooting problems that users may have. In doing so it aims to give users an increasing understanding with time of how the system works as the system is used more.

8.1 GUI Concept

The ICEy GUI consists of three modes:

- Calibration,
- Measurement,
- Evaluation.

Calibration is done at system installation thus it is not within the scope of this document.

8.1.1 Measurement

Measurement Mode allows one to manage and configure all of the measurements that can be done in ICEy.

This mode of operation has been designed to answer the following questions:

What can I do now?

Why can I not do what I would like to do?

What is the current status?

What is currently being done?

When one physically stands in front of the ICEy *Test Chamber* and opens the door, the ICEy *Workbench* is accessed. *DUTs* are physically placed on

8.1. GUI CONCEPT

the ICEy Workbench. Configuration of all measurements performed on the actual *DUT* are thus performed in the *Workbench* view of the *Measurement* sub-window.

The *Measurement* sub-window also contains the *Evaluation Library*, as well as a multi-purpose *Properties* editing view .

The *3D view* simply looks very cool, and visualizes the results of workbench and DUT scanning, as well as the current *Scan Area's* current scan positional state. It does not allow visualization of field results. For this you should use *Evaluation Mode*. It also provides docked views on current real-time results of *image scans, time and frequency domain scans*.

The *System Statuses* sub-window displays all of the system.

The *Ribbon Bar* provides allowed contextual actions.

8.1.1.1 How are ICEy measurements related?

All ICEy measurements are presented in the GUI in a tree based on the relation of each measurement type to the others.

This relation follows the measurement dependency: *Camera Scan->Laser Scan->Field Evaluations*.

There can be several *Laser Scans* done for each *Camera Scan*. And there can be several *Field Evaluations* performed for each *Laser Scan*. Further more, *Field Evaluations (Scan Area)* may contain several separate E and H-Field Evaluations, and these in turn may contain several separate Time/Frequency Domain Scans.

A *Camera Scan* combines several separate sub-images of the ICEy *Workbench* to form a single composite image, along with stereo-vision based height information. *This height information is not highly precise and is used only in fine-tuning the following steps.*

Thereafter one can see a flat version of the *Workbench* in the ICEy *3D View* of what one sees when standing at the *Test Chamber* and looking at the physical *Workbench*, and thus one can configure the desired *Evaluation Regions*. An *Evaluation Region* is a precise 3D model (accuracy $<25\ \mu\text{m}$) of what is currently at that region on the *Workbench*, acquired using the ICEy *Laser Triangulation System*. *Alternately, if one has a device of known geometry whose top surface is parallel to the workbench floor, this step can be skipped all together by using a **Freeheight Region**.*

Once an *Evaluation Region's* 3D model is known, it is texture mapped to the *Workbench* image. This gives an exact 3D model in geometry and appearance to the actual region, and is visualized in the *3D View*. *Scan regions (Point, Surface, Area and Volume)* can now be configured in this region.

These are also visualized in the *3D View*. You now have a real model that correlates to the physical device. The *ICEy Positioning System* is now able to safely move probes to within μm precision of your *DUT* in acquiring field data.

The limitations of measurement geometric placement are dependency based ->a *Scan Area* can not be placed outside of an *Evaluation Region*, and an *Evaluation Region* can not be placed outside of the *Workbench* in the *ICEy GUI*.

8.1.1.2 ICEy Project files

ICEy Projects store the configuration and state of the entire *Workbench* in the *ICEy GUI*.

Workbench Camera Scan results and *Laser Triangulation Scan* results for *Evaluation Regions* are also stored in *ICEy* Projects.

Field results however can be in the order of TB in size, and thus are not stored in the *ICEy* Project themselves, and may be distributed across several files. However, each *Evaluation Region* in the project knows where its results are. *Once a project is complete and it is desired to localize all data to one place (a folder) it is imperative to **Migrate** the project to that folder, and thereafter not alter the project file system in any way. At this point, this folder can be considered a separate entity that can be treated as such. It can be moved to a desired location without breaking integrity.*

ICEy Projects have a **iceproj** file extension and can be imported directly into the *Evaluator*.

8.1.1.3 Evaluation Library files

The *Evaluation Library* follows a configure-once-and-use-repeatedly strategy. It takes time to set up scan parameters and measurement strategies as desired. This library is intended to ease the process.

It allows the creation of several libraries that are stored separately on disk and reloadable via the GUI.

Items in the libraries are simply cloned into scans for use.

It is recommended to spend time thinking about your own scanning needs in order to configure your libraries correctly. Thereafter scan set up becomes very quick and easy.

Evaluation Library files are stored in the *Public User SPEAG ICEy* directory and have a **icevallib** file extension. All files found in this directory are presented for selection in the *ICEy GUI* when configuring scans.

8.1.1.4 ICEy Results Files

ICEy Field results file form a separate file system of their own that correlates to the configuration of the projects workbench.

All results initially reside in the *File System Root* directory as configured in the *ICEy Preferences*. Due to the size and amount of results files that can be generated from certain scan configurations, this drive is monitored. If you run out of space, you will be notified. Migration moves them to the desired location.

Each *Scan Area* configured in the *Workbench* has a results folder. Within this folder is a *Master File*, as well as several sub-folders containing positional information, vision information, other miscellaneous information and scan data for several scans and field evaluations configured for the *Scan Area*. The *Master File* knows of all other files within this system and as such is logically seen as one file (even though it may be 100), and thus it is imperative never to modify anything in these folders.

Master Files have a **icevsaresm** file extension and can be imported directly into the *Evaluator*.

8.1.2 Evaluation

Evaluation Mode has been designed to conform to how post-processing is done in **SEMCAD**. If you are familiar with this concept in **SEMCAD** you will be familiar with this concept in ICEy, and vice versa.

As such the ICEy software binaries have been created in such a way that the entire *Evaluation* process can be done in **SEMCAD** by simply copying some *DLL's* into your **SEMCAD** installation directory. For more information, please send a mail to support@speag.com.

Evaluation Mode has a 3D view for viewing Field results, an *Algorithm Explorer* for configuring how to evaluate, and a *Properties* area for configuring individual algorithm parameters.

8.2 GUI Components

8.2.1 Measurement Mode

What can I do now? The actions presented in the ribbon bar in this mode answer this question. Depending on what you select, and what is currently happening and allowed to happen in the system, you are only allowed to execute the following actions. *It is thus context based.*



Figure 8.1: Context based actions of the *Ribbon Bar*.

The configurable parts of the measurement process are found in the *Measurement* sub-window.

The detailed system information is displayed in several sub-views of the *System Status* sub-window.

The *3D view* visualizes the results of workbench and DUT scanning, as well as the current *Evaluation Region* positional state. It also provides docked views on real-time results if *image scans*, *time* and *frequency domain scans*.

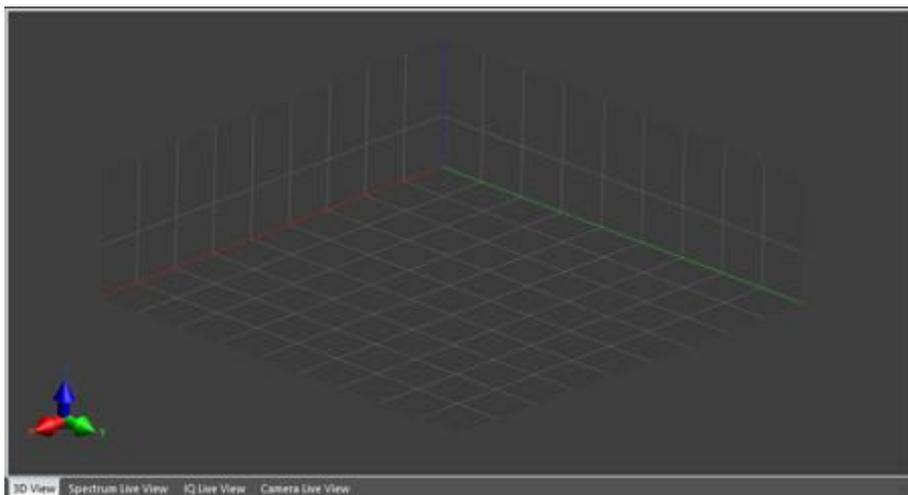


Figure 8.2: The 3D View with tabs for Spectrum, IQ and Camera Scan data.

8.2. GUI COMPONENTS

8.2.1.1 Measurement Sub-Window

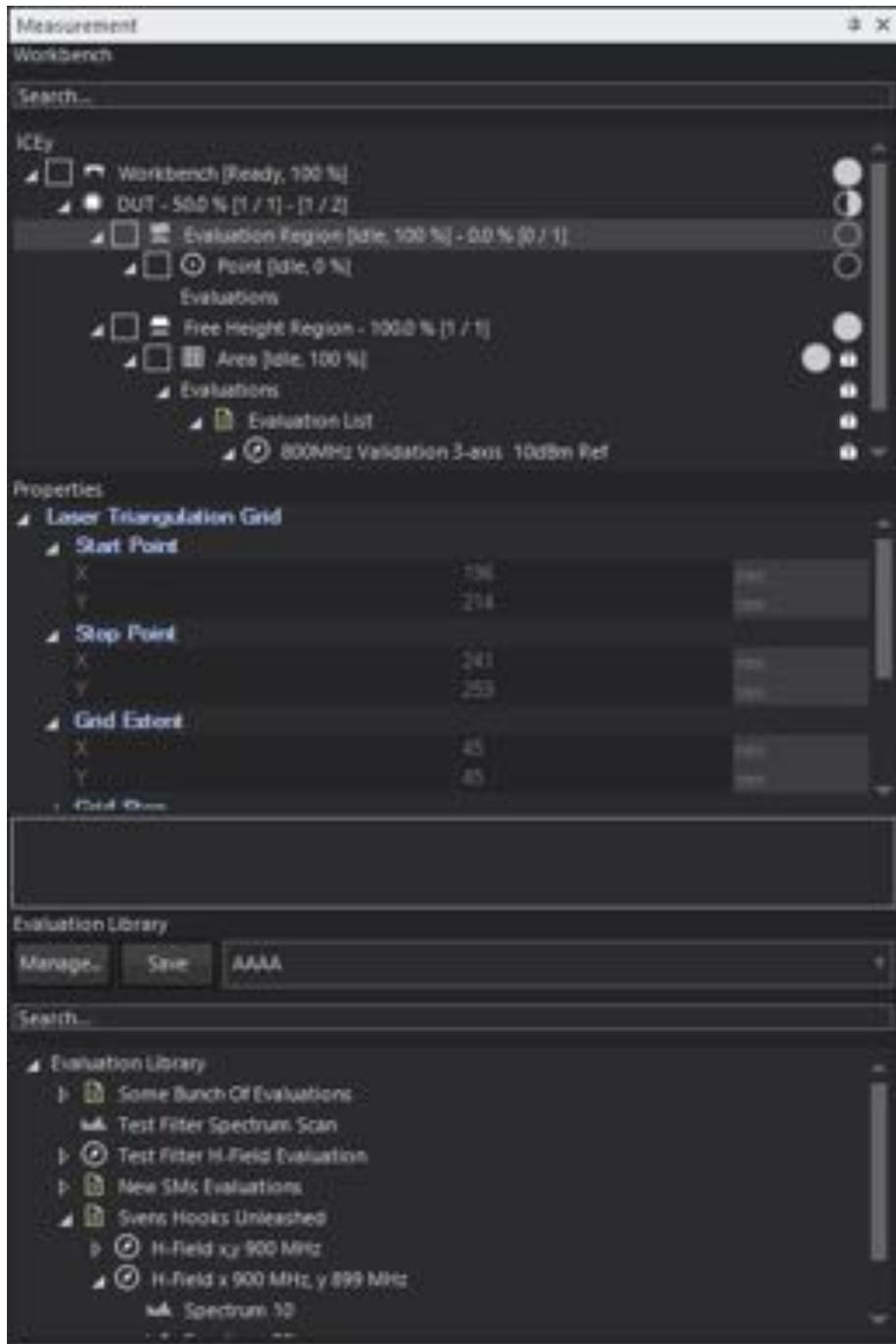


Figure 8.3: All three parts of the Measurement sub-windows.

This window contains three parts.

Workbench Sub-View

The *Workbench Sub-View* has the following functions.

You can search for items by name.

You can see progress via a progress wheel.

You can see the visual state of the item in the 3D View (presence of an 'eye' means visible).

You can see the editable state of the item in the Properties View (presence of a lock means uneditable).

You can see the queued status of an item (presence of a circle with a triangle indicates 'engueued' state).

You can select an item to get a context menu for that item.

The item currently being run will have a spinning wheel, as well as a status text (e.g. 'scanning') along with the current percentage complete appended to its description.

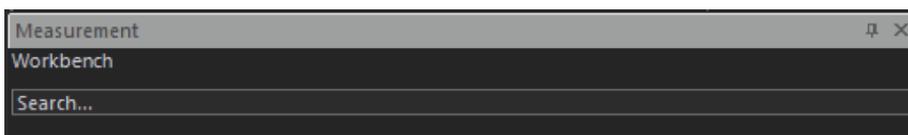


Figure 8.4: Item Search Bar.



Figure 8.5: Status information.

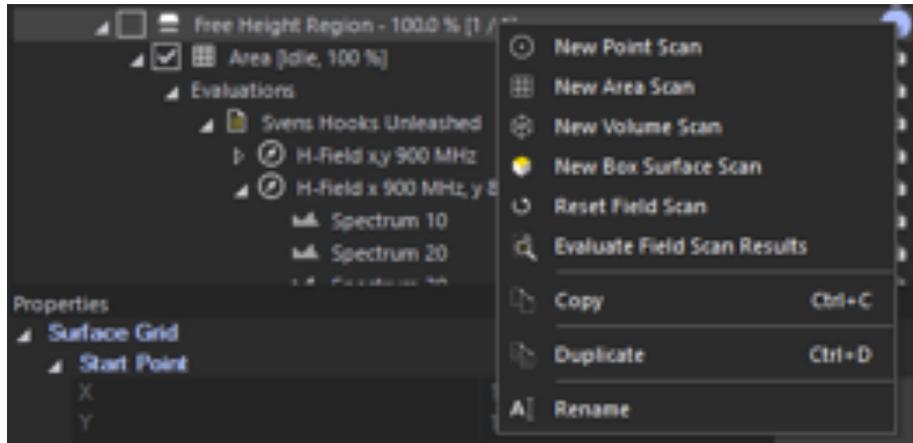


Figure 8.6: Item context actions.

Properties Sub-View

The *Properties Sub-View* is a simple property editor window that allows context based editing of properties selected in either the *Workbench Sub-View* or the *Evaluation Library Sub-View*. Items in the *Workbench Sub-View* that are uneditable will also be uneditable here.

Evaluation Library Sub-View

The *Evaluation Library Sub-View* has the following functions.

You can see manage/save/select your Evaluation Libraries (**iceevallib** files in the *Public User SPEAG ICEy* directory).

You can search for items by name.

You can select an item to get a context menu for that item.

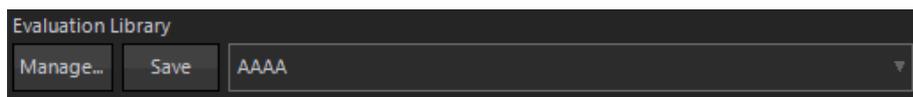


Figure 8.7: Evaluation Library Management functionality.

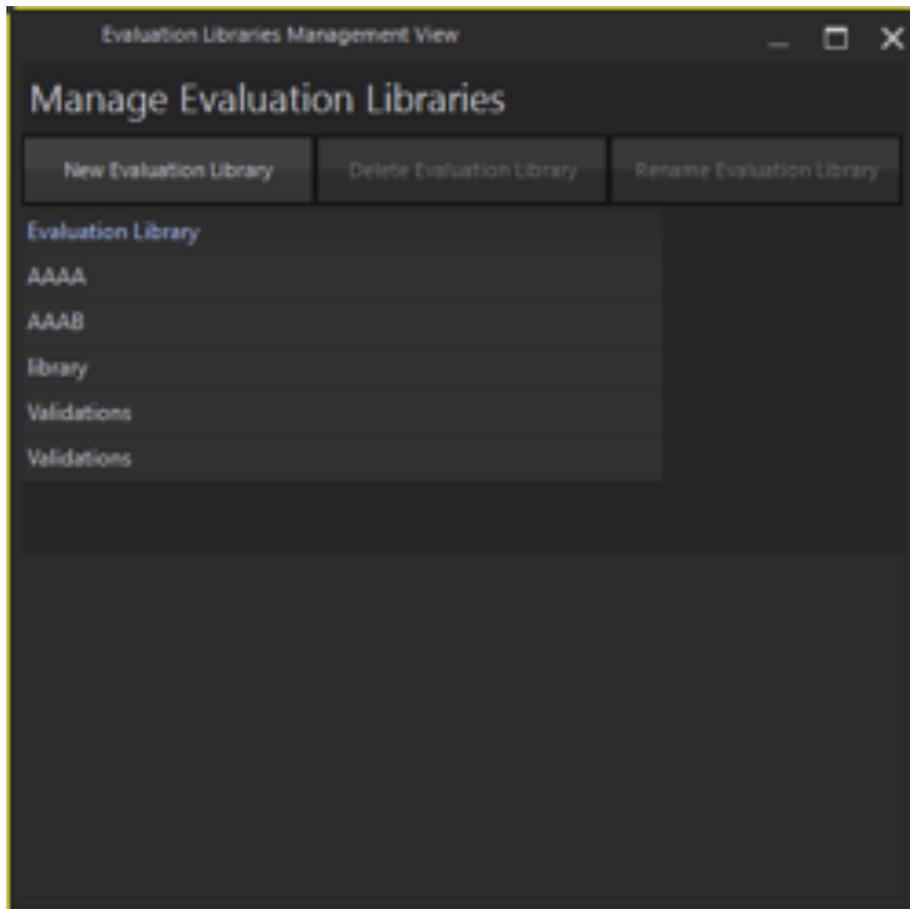


Figure 8.8: Evaluation Library Management Dialog.

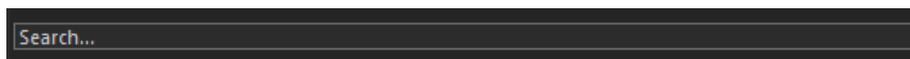


Figure 8.9: Item Search Bar.

8.2. GUI COMPONENTS

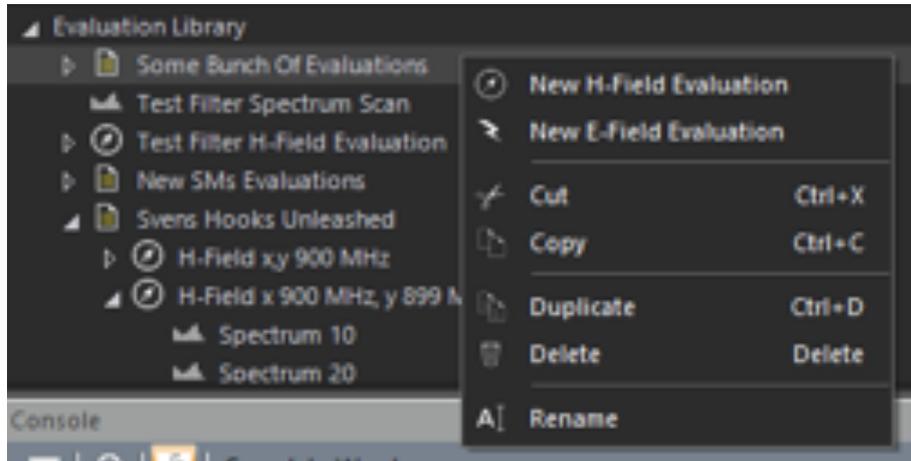


Figure 8.10: Item context actions.

8.2.1.2 System Statuses Sub-Window

This window contains eight selectable parts.

Position

When a probe is attached, this status is the position of the probe tip.
When no probe is attached, this status is the position of the Z-Axis.

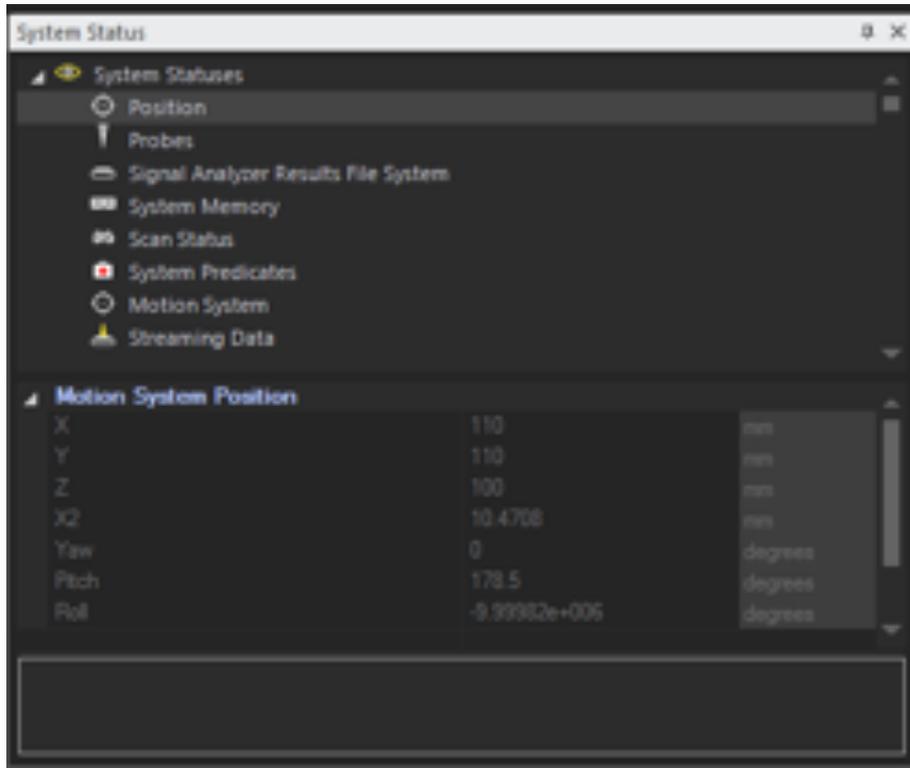


Figure 8.11: Positioning system status.

Probes

For each of the four physical probe parking slots, this status indicates:

- is a probe parked or not for that parking slot,
- the GUI-configured name/serial number of the probe for that parking slot,
- whether that probe is currently connected or not.

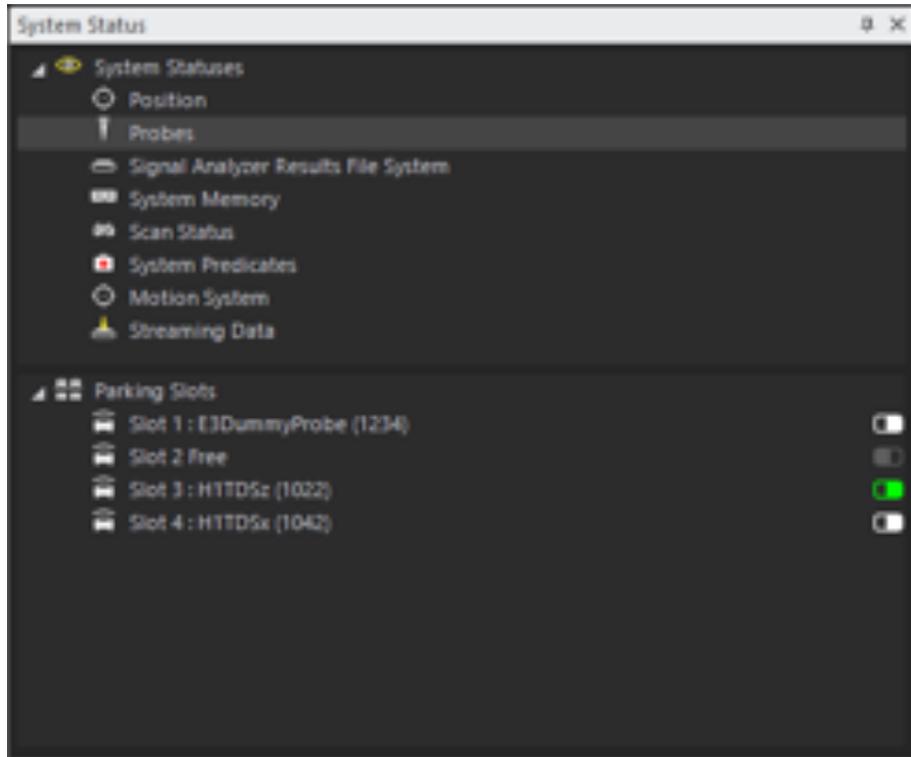


Figure 8.12: Probes status.

Signal Analyzer Results File System

For the currently configured *File System Root* directory for all ICE y Results Files, this status indicates:

- the configured path and percentage of hard disk capacity utilized,
- the used space of that hard disk (in bytes),
- the free space of that hard disk (in bytes),
- the total space of that hard disk (in bytes).

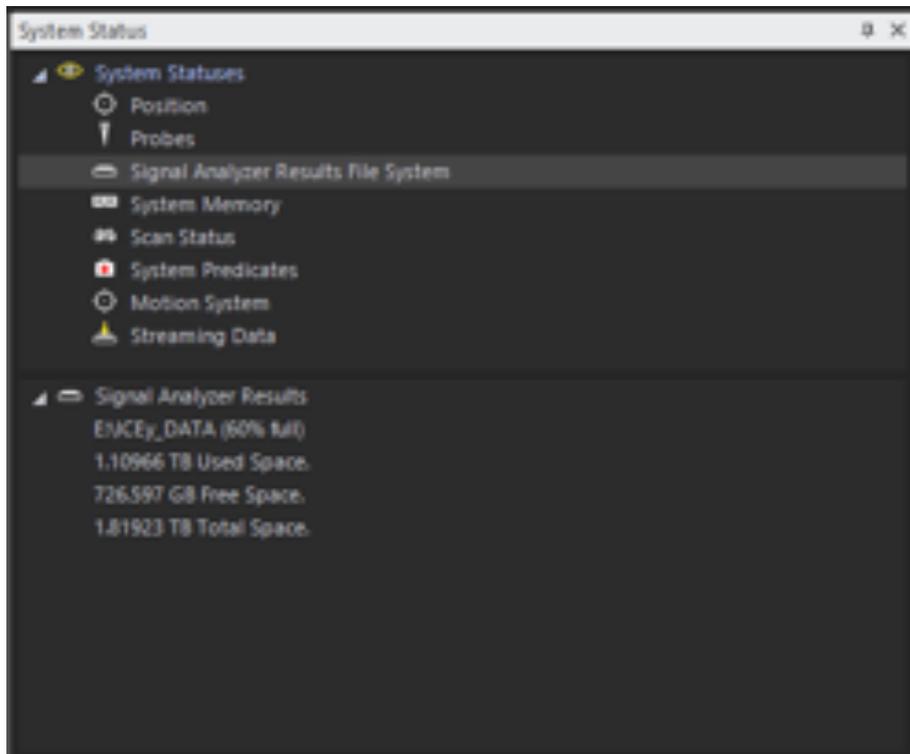


Figure 8.13: Results File System Status.

System Memory

For your System Memory (PC RAM):

- the ICE y used RAM (in bytes),
- the Peak used RAM (in bytes),
- the Total System RAM (in bytes),
- the Free System RAM (in bytes).

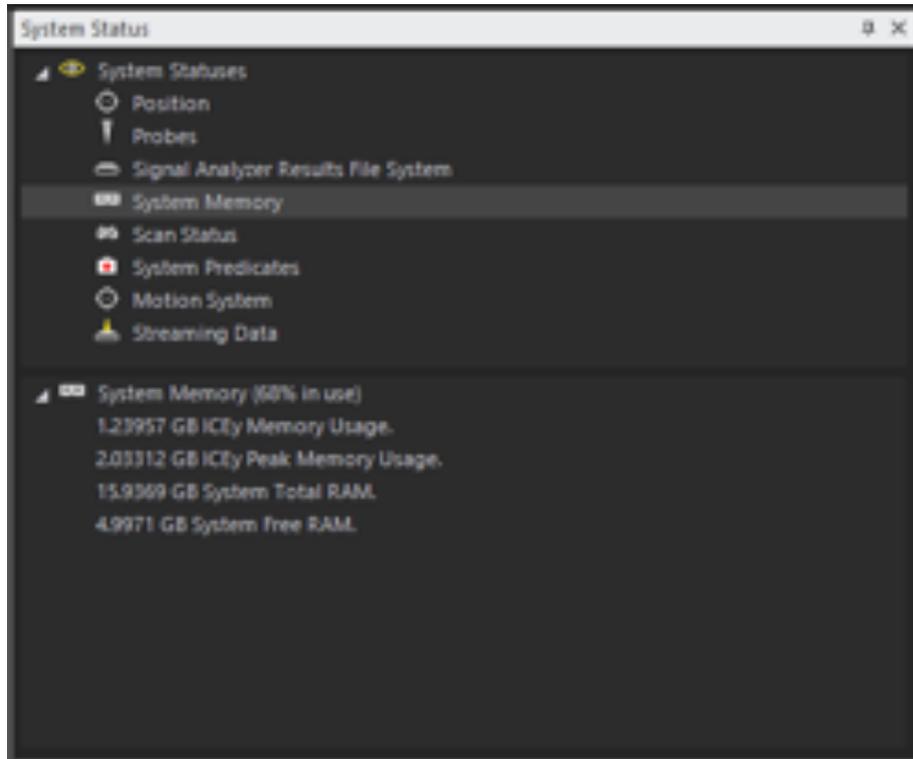


Figure 8.14: System Memory Status.

Scan Status

For the current *Scan Area* being scanned:

- the scan state,
- the accumulated results size on hard disk (in bytes),
- the estimate results size on hard disk (in bytes),
- the estimated time remaining (in HH:MM:SS).
- the elapsed time (in HH::MM::SS),
- the currently used probe,
- the currently scanned field,
- the currently scanned vector component.
- the current scanned grid position (in grid indices),
- the current scanned grid position (of total points),

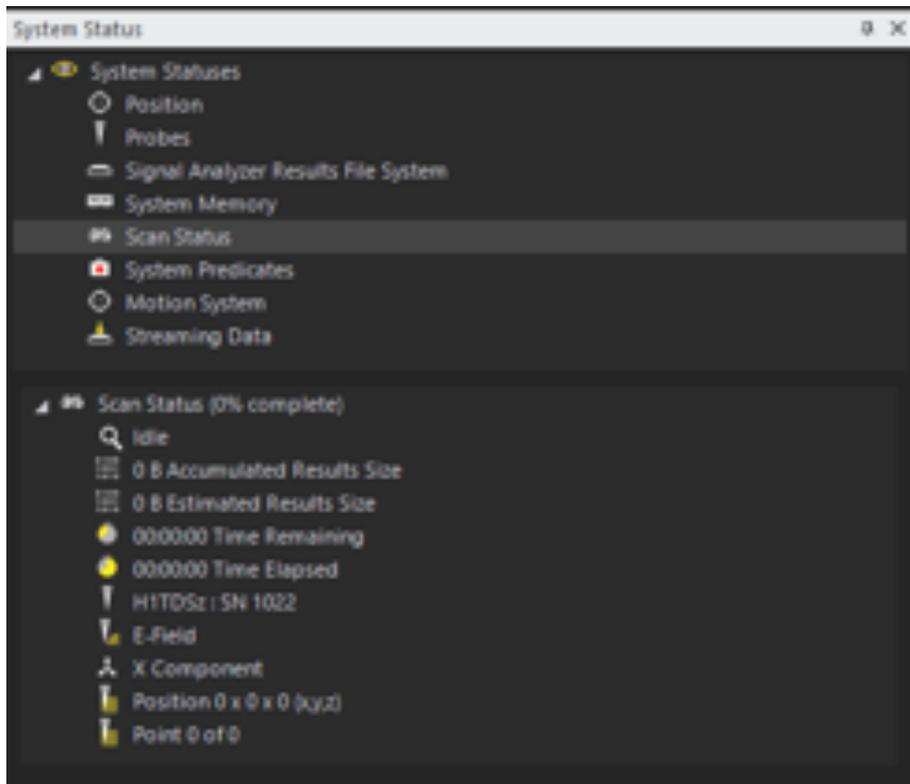


Figure 8.15: Current Scan Status.

System Predicates or *Why can I not do what I would like to do?*

For the ICEy system to work smoothly and error free, certain things can not be allowed in certain situations, and certain things can only be allowed in certain situations. *This yields a set of rules, or predicates.* Without being able to visualize these rules and seeing the composition and state of their conditions it is impossible to understand what is going on or why certain things can not happen, after all ICEy is a complex and novel system. Luckily these rules are visualised, and the state of the conditions for these rules too, and thus, with a bit of thinking, it becomes easy to understand what is wrong, or *why I can not do what I would like to do.* With time, the system can be learned. Or if not, simply knowing where to look can be of benefit.

This status is split into two parts. The first part, *System Predicates*, is the answer to a question (or rule). Selecting that rule (*when 'Context Based Condition Filtering' is enabled*), then displays the states of the conditions that make up that rule in *Conditions*, the second part.

Usually the prompt for looking at the *System Predicates* is when you expect

8.2. *GUI COMPONENTS*

to be able to do something, and the context-based-action is nowhere to be found.

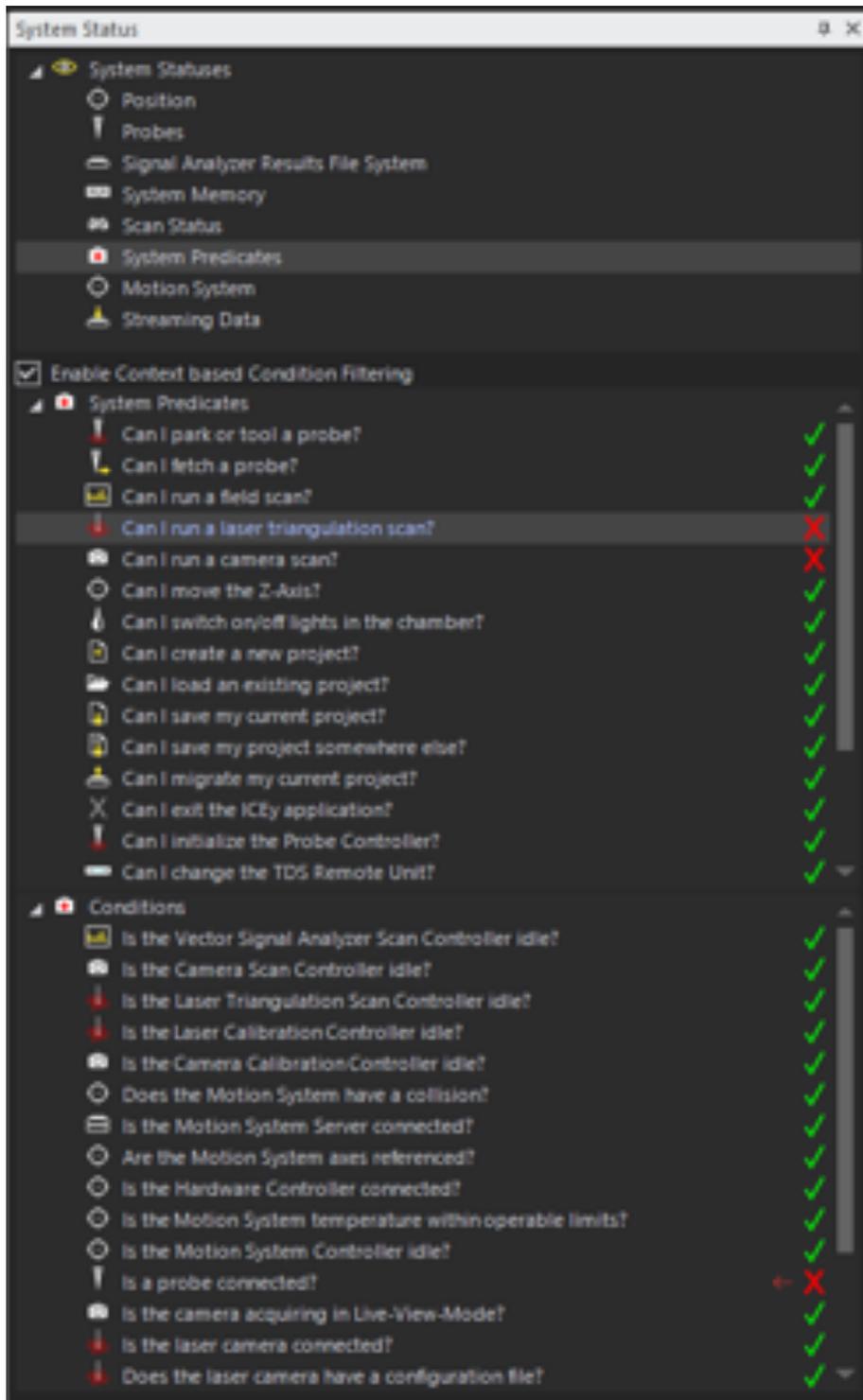


Figure 8.16: System Predicates Status.

Motion System

This status displays the status bits for the various motor controllers of the the separate ICEy Positioning System axes as well as door open state, cabinet temperature and abort request. *This status is of little interest to end users of ICEy and is something we may request from time to time.*

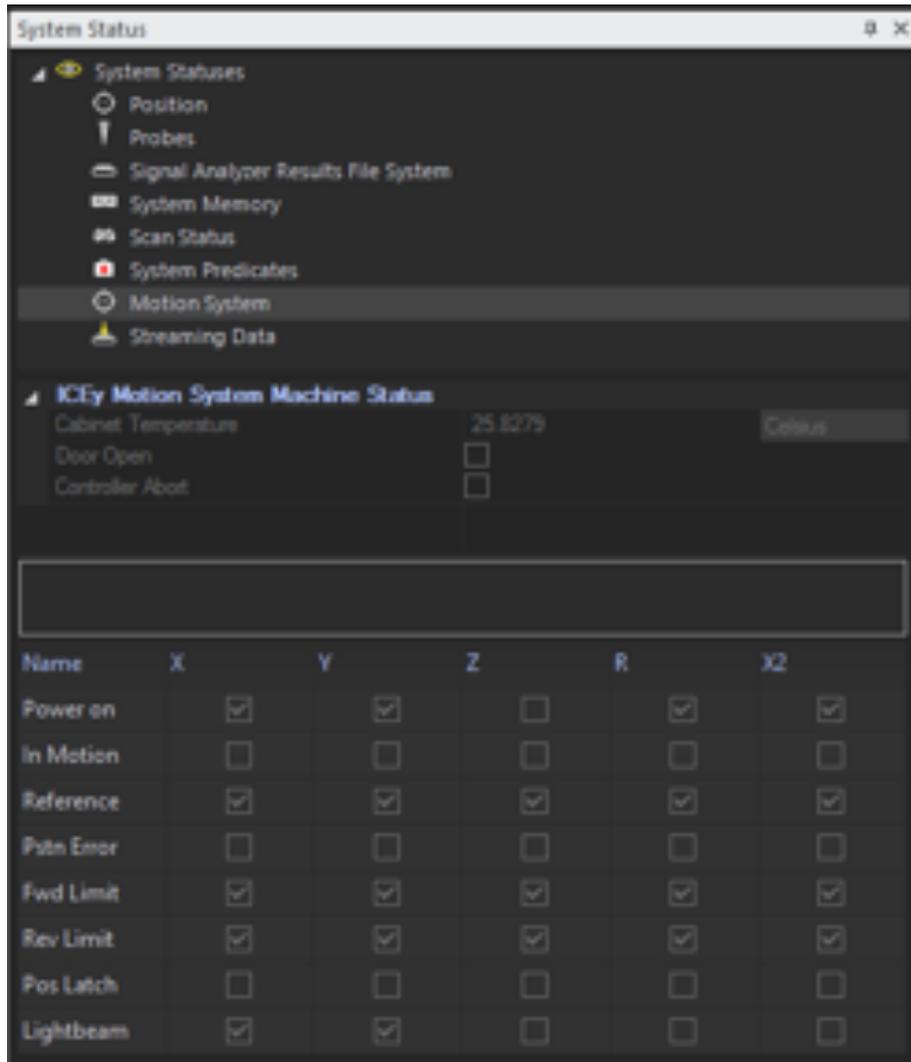


Figure 8.17: Motion System Status.

Streaming Data

Scan configuration can generate many files, and lots of data, and this data has to be stored to a single disk. This data can not be stored at the same

rate it is acquired, which mainly depends on the user configuration (i.e. number of samples x number of points, for example) and to a lesser degree depends on the disk involved, and so this data is managed in RAM. This task is handled by streamers.

Certain scan configurations may make streaming orders of magnitude slower than scanning, and thus system RAM is also monitored. If current RAM usage exceeds a certain *threshold* (*configured in Preferences*), the scanner will simply pause, until RAM usage is again below this threshold, at which point it continues. You may see a warning if this happens, but there is no action (other than awareness) required on your behalf.

This status displays:

- the estimated streaming remaining time (in HH:MM:SS),
- the data buffered in RAM (in bytes),
- the hard disk IO Data Rate (in bytes/second),
- the files being actively streamed to,
- the streamers current present in ICEy.

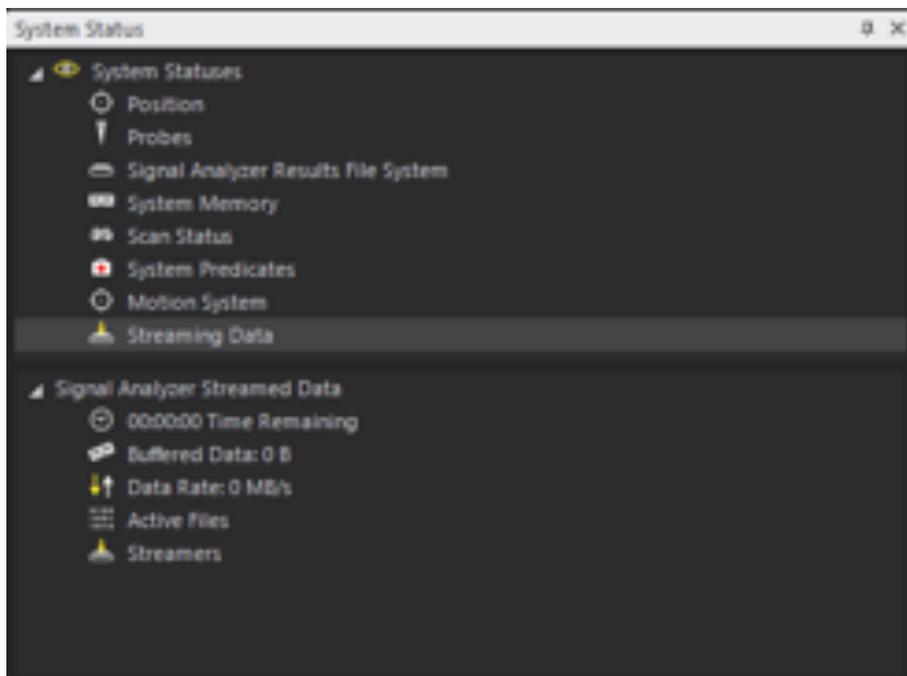


Figure 8.18: Streaming Status.

8.2.2 Evaluation

What can I do now? The actions presented in the ribbon bar in this mode answer this question. Depending on what you select, and what is currently happening and allowed to happen in the system, you are only allowed to execute the following actions. *It is thus context based.*

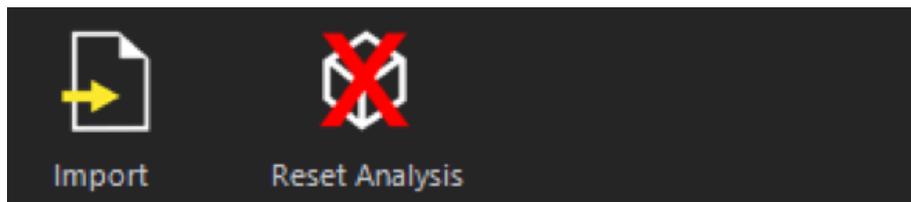


Figure 8.19: Context based actions of the *Ribbon Bar*.

The configurable parts of the *Evaluation* process are found in the Algorithm *Explorer* sub-window.

This window also displays the progress of the algorithms as an overlaid progress bar directly in the tree. It also contains search functionality, for text based searching of items.

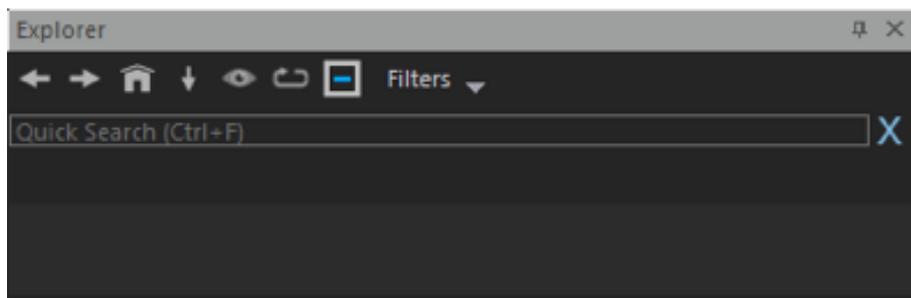


Figure 8.20: Algorithm Explorer sub-window.

The configurable parts of each algorithm is found in the Algorithm *Properties* sub-window.

The availability of properties is contextually based to the selected algorithm. *This includes locked/unlocked state of properties.*

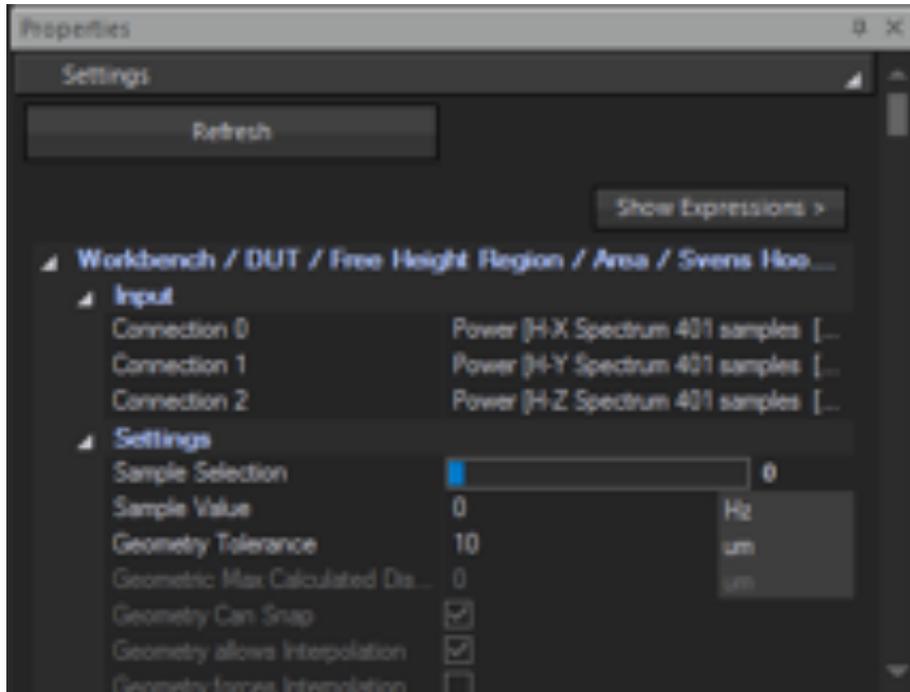


Figure 8.21: Algorithm properties sub-window.

The *3D view* visualizes the results of workbench and DUT scanning, as well as the results (via *Viewer* algorithms) of your customized Evaluation setup.

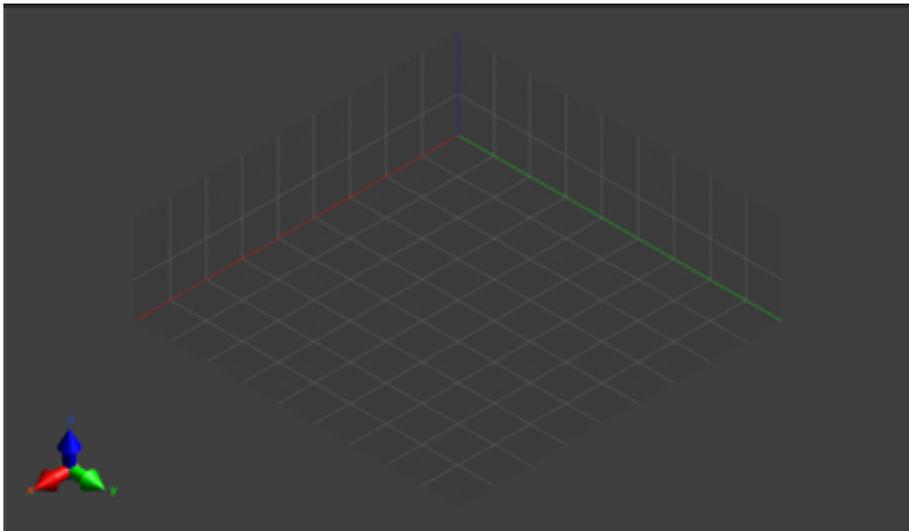


Figure 8.22: The 3D View.

8.2.3 Python

For all modes of GUI operation, *Python* interaction is achieved with the *Python Interpreter Console*, the *Script Editor* and the *API Browser*.

The *Python Interpreter Console* and *Script Editor* are not much different to what one gets with a default *Python* installation.

The *Python Interpreter Console* is used also for miscellaneous messages, warnings and errors in ICEy.

The *API Browser* simply gives help and a list of the current ICEy *Python* API.

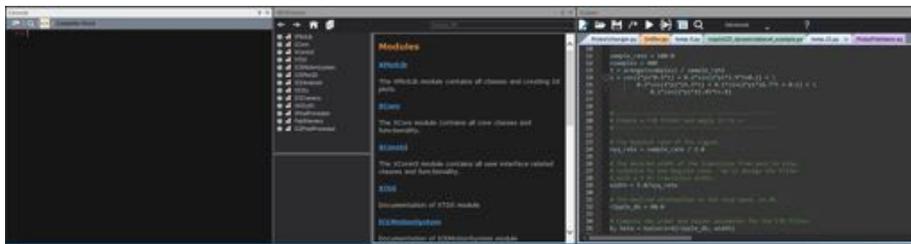


Figure 8.23: All three *Python* sub-windows.

8.2.4 Status Bar and Task Manager

The *Status Bar* displays the current ICEy software version, the current ICEy Realtime software version as well as the current GUI *status*.

The *status* is indicated by a change of colour of the *Status Bar*, the text displayed, as well as the wheel icon, which will spin when something is happening.

The wheel icon is also a button which can be pressed to display the *Task Manager*.

The *Task Manager* displays the current system state, the progress of all tasks executing in the ICEy software and a log with less information than the *Python Interpreter Console*.

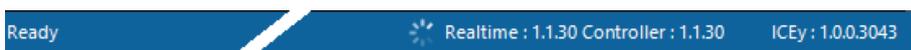


Figure 8.24: An idle *Status Bar*.



Figure 8.25: The *Task Manager* pop-up dialog.

8.2. GUI COMPONENTS

Chapter 9

Preferences

The preferences can be accessed using the *File* menu in the main application menu bar.

9.1 ICEy Preferences

The root of the ICEy preferences (Figure 9.1) contains the the *File System* preferences:

File System Root When a scan is started, ICEy will stream the results to the "File System Root" directory defined here. This location is independent of the location of the project file, until the project is migrated (in the Save As dialog) and project file and results can be moved to the same location.

Laser lines dump Directory If "Dump laser lines" is enabled (see Subsection 9.1.4), the raw 3D scan laser data is written in this directory. This is useful for debugging.

The rest of the file system preferences are set during calibration and should not be touched by the user.

The root of the ICEy preferences also contains the *Safety Mode* preferences. The safety mode is activated when the memory consumption exceeds the given threshold to prevent measurement data loss. The default is 90%.

The *Physical Limits* defined here are the following:

Workbench Volume The default is X : 450 mm, Y : 450 mm, Z : 125 mm. It should not be changed unless you have a customized ICEy chamber.

Camera Offset This is automatically calculated during calibration.

Safety Height This is the height at which the robot generally will move when not performing a measurement. It is recommended to leave it at the default of 120 mm.

Collision detection safety margin The system will not move the probe tip closer to the DUT than the height detected by the 3D surface scan plus this safety margin. The default is 0.1 mm.

Probe collision detection factor (x/y) This is the factor applied to the probe mesh that is used for collision detection in horizontal direction. It is recommended to leave it at the default of 1.5.

Finally, *Hide disabled actions* will hide actions or commands in the menu bar that are not available in the current context. It is recommended to enable this option.

9.1.1 Probe Repository

The probe repository is used to manage the probes that may be used in your ICEy. Always make sure that the probes that are physically installed in your system match the mapping here in the probe repository. If the probe you are trying to use is not yet in the list, you may have to install the probe calibration file by pressing *Install new Probe ...* and selecting the corresponding file, which will then be copied to your preferences folder.

The slot numbers are defined such that Slot 1 is the one closest to the door, and Slot 4 is in the back of the system (see Subsection 2.1.3). To assign a slot number to a probe, the probe must be physically inserted in the respective slot.

9.1.2 Remote Unit

This section is used to configure your Remote Unit. In case of problems you can hit the "+" buttons next to *Test COM Port* and *Test Remote Unit* to get more status information.

9.1.2.1 Calibration

This defines the calibration file for the Remote Unit in the system. This needs to be changed when the Remote Unit in your system is changed.

9.1.3 Motion System

This defines basic motion system settings that should be left at their default settings (IP Address: 127.0.0.1, Port: 4711, Maximum Operating Temperature: 55°, Simulate Laser Triangulation: disabled).

9.1.3.1 Calibration

Some of these items may be useful if something was wrong with your setup: **Axis Reference** If you experience a collision the motion system may lose the axis reference (indicated by the check box here). This can be solved by pushing the *Axis Reference* button.

Initialize Probe Controller In case the probe inventory (Subsection 9.1.1) was not defined correctly, the probe exchange controller may not be

able to initialize. In this case, fix the entries in the probe repository and then push the *Initialize Probe Controller* button.

9.1.3.2 Parameters

These parameters are set during initial installation and calibration of your system and should not be touched by the user.

9.1.4 Laser

Most of the settings here are set during calibration of your system, except the following:

Dump laser lines If enabled, raw 3D scan laser data is written in the directory defined in Section 9.1. This is useful for debugging.

Laser scan z-offset If you have high DUTs (greater than approximately 80 mm), this setting can be used to offset the laser camera during 3D scanning. Normally the camera scan should be able to get a rough estimate of the height using stereo vision, so this setting is usually not required and can be left at its default value of 0.

If *dump laser lines* is enabled (see Subsection 9.1.4), the raw laser data is written in this directory. This is only useful for debugging.

9.1.5 Signal Analyzer

The signal analyzer installed in your ICEy can be configured here.

9.1.6 System Information

This contains some information about the motion system controller in your system.

9.1.7 Camera

Many parameters in this dialog are automatically computed during calibration. The others are the following:

Simulated If checked, the physical camera is disabled. This is useful for debugging.

Display Projected Image in UI Previews the position of the camera images in the 3D View.

Display Sensor Grid in UI Displays the positions where the camera will take images in the 3D View.

Camera Scan z-Position The robot position at which the camera will take images (in robot coordinates). The default is 120 mm.

- Height from surface** The approximate distance of the camera from the workbench surface when the robot is doing a camera scan. Unless you have a customized ICEy, leave it at the default of 380 mm.
- Image Overlap Ratio** The amount of overlap for the individual camera images. Generally, stitching of the workbench image is improved with larger overlap, but the camera scan will take longer. The default is 30 %.
- Image Cutoff Ratio** The amount of crop of each individual image. This should be smaller than the amount of overlap. The default is 25 %.
- Use Stereo Vision** It is recommended to enable stereo vision, which will give the system some idea about the DUT dimensions, which is used to avoid collisions and for more accurate laser scans.
- Use Single Shot** Generally it is not recommended to use this. If enabled, only one image will be taken, at the position defined by the following two parameters *Single Shot Position X* and *Single Shot Position Y*.
- Camera Trigger Mode** This must be set to *Software* unless you are using some customized camera trigger hardware.

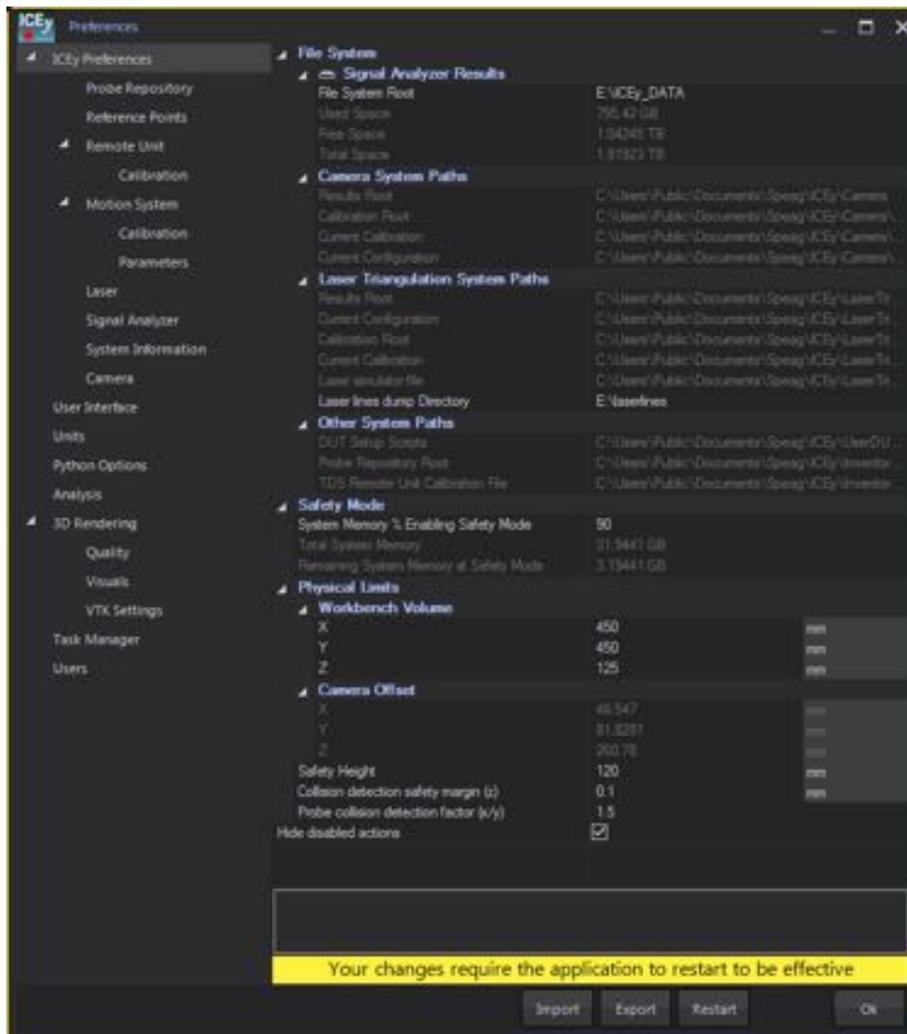


Figure 9.1: ICEy preferences dialog.

9.1. *ICEY PREFERENCES*

Chapter 10

Measurement Mode

In this chapter, the individual items are explained in more detail. For a quick measurement example, please check Chapter 18.

10.1 Measurement Elements

This sections describes the different elements that are available in the tree in the *Measurement* dockable window.

10.1.1 Workbench

The *Workbench* represents the space inside your ICEy chamber. Usually the first action that is done on a workbench is a camera scan, where the camera is moved inside the chamber to generate a preview of what is in it. For a description of the parameters for the camera scan, see Section 9.1.7. One workbench represents one configuration and can, therefore, have one camera scan. On one workbench, there can be multiple *DUTs*. You can create multiple workbenches inside a project if you wish to group multiple workbench configurations within a single project.

The following actions are available for a *Workbench*:

- *Start Camera Scan* to start a camera scan
- *Check Camera Scan* checks whether a camera scan can be performed
- *Reset Camera Scan* if there was a camera scan that you want to discard
- *New DUT* to create a new DUT on this workbench
- *New Workbench* to create a new workbench besides this workbench
- *Common Actions* like Rename, Duplicate, Copy, Paste, when you right-click on the workbench

10.1.2 DUT

A *DUT* is used to group different *Evaluation Regions* (Laser Scans) or *Free Height Regions* together. Commonly, one DUT is created for one device,

and *Evaluation Regions* are created over the areas of interest. You can also create one big *Evaluation Region*, but laser scan time will be longer and more system resources will be used.

The following actions are available for a *DUT*:

- *New Evaluation Region* to create a new Evaluation Region (Laser Scan)
- *New Free Height Region* to create a new Free Height Region
- *Start Laser Scan* start all the laser scans below this *DUT* if there are Evaluation Regions attached that can be started
- *Check Laser Scan* to check whether there are laser scans below this *DUT* that can be started
- *Start Field Scan* to start all the field scans (Point Scan, Area Scan and Volume Scan) below this *DUT*
- *Check Field Scan* to check whether there are field scans (Point Scan, Area Scan and Volume Scan) in the attached Evaluation Regions or Free Height Regions that can be started
- *Reset Field Scan* to delete the results from all field scans below this *Evaluation Region* (if available)
- *Evaluate Field Scan Results* to load the results from all field scans below this *Evaluation Region* in the Evaluator mode (if available)
- *Common Actions* like Rename, Duplicate, Copy, Paste, when you right-click on the *DUT*

The status of each *DUT* can be quickly seen in the *Measurement* dockable window (see Figure 18.24). You can read it as follows:

DUT Name - Overall Progress [No. of laser scans complete / Total no. of laser scans] - [No. field scans complete / Total no. of Field scans]

10.1.3 Evaluation Region

An *Evaluation Region* defines a region over which a laser surface detection will be performed. The selection of the area is commonly done based on the camera scan. To set up the area, either use the Move/Resize commands in the ribbon bar and the 3D View, or modify the properties (Figure 10.1).



Figure 10.1: Properties of an *Evaluation Region*.

An *Evaluation Region* has the following properties:

Start Point, Stop Point, Grid Extent Used to set up the position and the size of the laser scan.

Grid Step defines the horizontal laser scan resolution in μm . It is recommended to set it between 100 and 500 μm for a good trade-off between accuracy and speed.

Texture Mapping After the laserscan is complete, a texture will be generated (if there is a camera scan). When the texture becomes available, this property determines whether the texture should be displayed or not.

Laserline Grid Visibility If enabled, grid lines in the spacing of the *Grid Step* are displayed in the 3D View. It will be disabled by default after the laser scan is complete.

Once the laser scan is complete, one or more field scans (Point Scans, Area Scans and Volume Scans) can be added to the *Evaluation Region*. In case more than one field scans are added, all scans below the *Evaluation Region* are started by clicking *Start Field Scan* while the *Evaluation Region* is selected. Because ICEy will try to minimize probe exchanges given these scans, you cannot add more scans, delete scans, or start individual scans from this *Evaluation Region* that you started at first, at least not until all scans are complete.

The following actions are available for an *Evaluation Region*:

- *Move/Resize Selection* to move/resize the region on the workbench (if the laser scan has not been started yet)
- *Start Laser Scan* if the laser scan can be started
- *Check Laser Scan* to check whether the laser scan can be started
- *New Point Scan* to create a new scan on a single point
- *New Area Scan* to create a new scan over a 2D-grid
- *New Volume Scan* to create a new scan over a 3D-grid

- *Start Field Scan* to start all the field scans (Point Scan, Area Scan and Volume Scan) below this *Evaluation Region*
- *Check Field Scan* to check whether there are field scans (Point Scan, Area Scan and Volume Scan) attached that can be started
- *Reset Field Scan* to delete the results from all field scans below this *Evaluation Region* (if available)
- *Evaluate Field Scan Results* to load the results from all field scans below this *Evaluation Region* in the Evaluator mode (if available)
- *Common Actions* like Rename, Duplicate, Copy, Paste, when you right-click on the *Evaluation Region*

The status of each *Evaluation Region* can be quickly seen in the *Measurement* dockable window (see Figure 18.24). You can read it as follows:

Region Name [Laserscan-Status, Laserscan-Progress] - Fieldscan-Progress
[No. field scans complete / Total no. of Field scans]

10.1.4 Free Height Region

A *Free Height Region* can be used instead of an *Evaluation Region* to omit the laser scan. This is NOT recommended, as it can easily generate collisions between a probe and a DUT, thereby destroying probe and DUT.

Except for the parts of the laser scan, a *Free Height Region* has the same functionality as the *Evaluation Region*.

10.1.5 Volume Scan

A *Volume Scan* defines the grid of points at which the field will be measured. To set up the grid, either use the Move/Resize commands in the ribbon bar and the 3D View, or modify the properties, which are the following:

Start Point, Stop Point, Grid Extent Used to set up the position and the size of the grid.

Grid Step defines the grid resolution in μm , which can be different for each coordinate axis.

Grid Orientation Allows you to rotate the grid if it should not be aligned with the ICE y coordinate axes.

Conformance Criteria:

3D surface conformity If set to *absolute positions*, the grid is defined exactly as set up with the *Start Point* and *Stop Point* (or *Grid Extent*) properties. Points that cannot be measured due to predicted collisions between probe and DUT will be skipped.

If set to *Conform to surface*, the z -position of each column in the grid (a column being a row of points with the same x - and y -position) will be shifted such that the lowest point in the column is the *Distance* away from the laser scan surface that is defined with the next parameter. The distance to the surface will be

greater than the conformance distance if a collision between probe and DUT would occur otherwise (i.e. the columns are "pushed up" such that no collision occurs).

See Figures 10.2 and 10.3 for an illustration of what *Conform to surface* means.

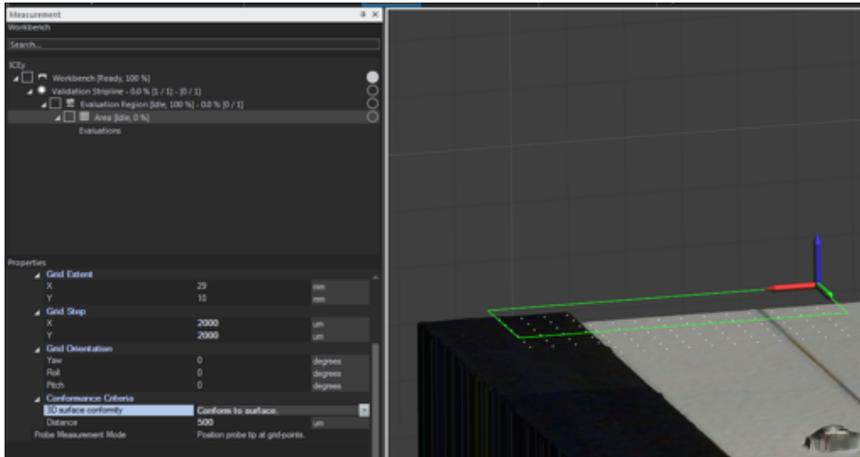


Figure 10.2: Grid Points conforming to surface.

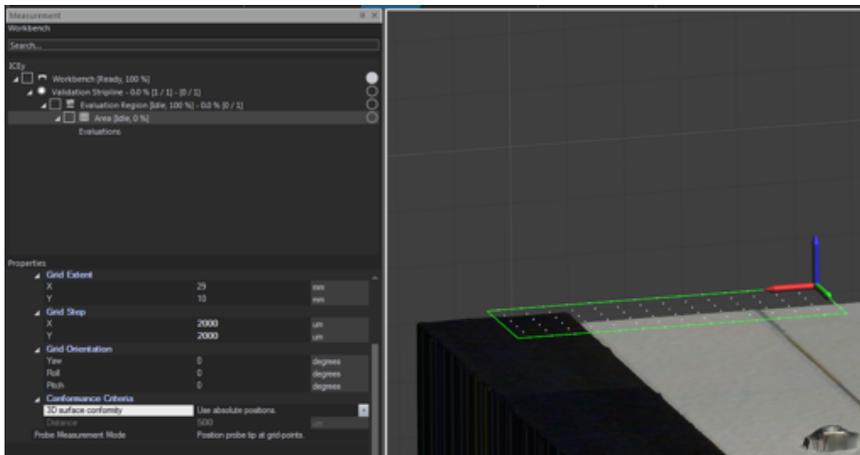


Figure 10.3: Grid Point at absolute positions.

Distance The conformance distance of the grid points from the laser scan surface (in z -direction).

Probe Measurement Mode If set to *Position probe tip at grid-points*, the physical tip or end of the probe is placed at the grid points. Therefore, the sensor, which is placed 1 to 1.5 mm from the tip (depending on the probe), will be placed higher than the actual grid points. If set to

Position probe sensor at grid-points, the sensor will be placed at the grid points. Therefore, the probe tip will be lower than the actual grid points.

Note that grid points that lie outside of the *Evaluation Region* or *Free Height Region* that this *Volume Scan* is attached to, are not measured. Once the grid is set up, an *Evaluation List* or an *Evaluation* can be added to the scan by drag and drop from the *Evaluation Library*. If multiple evaluations should be performed at each point in the grid, they must be grouped in an *Evaluation List*.

The following actions are available for a *Volume Scan*:

- *Move/Resize/Rotate Selection* to move/resize/rotate the grid on the workbench (if the field scan has not been started yet)
- *Snap To Evaluation Region* moves the *Start Point* of the grid to the *Start Point* of the *Evaluation Region*
- *Start Field Scan* to start this field scan
- *Pause Field Scan* to pause this field scan (when the scan is running)
- *Check Field Scan* to check whether this field scan can be started
- *Reset Field Scan* to delete the results from this scan
- *Evaluate Field Scan Results* to load the results of this scan in the Evaluator mode
- *Overwrite Field Evaluation Parameters* is only used in rare cases when a probe calibration file is changed and the results should be evaluated again with this new calibration
- *Common Actions* like Rename, Duplicate, Copy, Paste, when you right-click on the *Volume Scan*. Note that duplicating a *Volume Scan* will only duplicate the grid and evaluations, not any results files.

10.1.6 Area Scan

This is the same as a *Volume Scan* with an extent of 0 in the *z*-coordinate (only a plane is left).

10.1.7 Point Scan

This is the same as a *Volume Scan* with extents of 0 in all 3 coordinates (only one point is left).

10.2 Evaluation Library

Evaluation libraries are stored separately to the project and contain the settings for the field measurements such as the center frequencies, bandwidth and so on.

10.2.1 Managing evaluation libraries

To create, rename or delete an evaluation library, click *Manage...* in the *Evaluation Library* section of the *Measurement* dockable window (Figure 10.4).

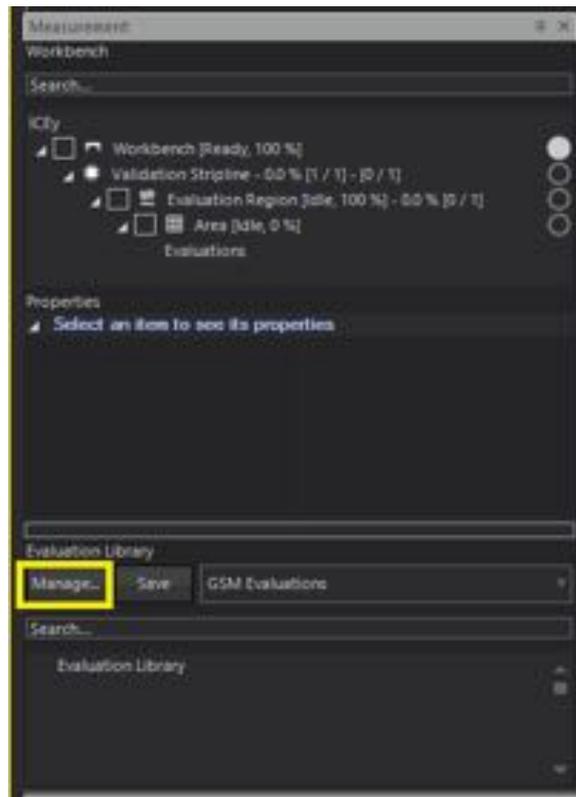


Figure 10.4: Manage your Evaluation Libraries.

You will be presented with a window where you can manage your evaluation libraries. To create a new one, click on *New Evaluation Library*, and give it a name, for example *Common Validations*. Once created, close the *Manage Evaluation Libraries* window and select the created library in the drop-down list in the *Evaluation Library* section of the *Measurement* dockable window (Figure 10.5). You can now add new evaluation lists or single evaluations to this library, as described in the following subsections.

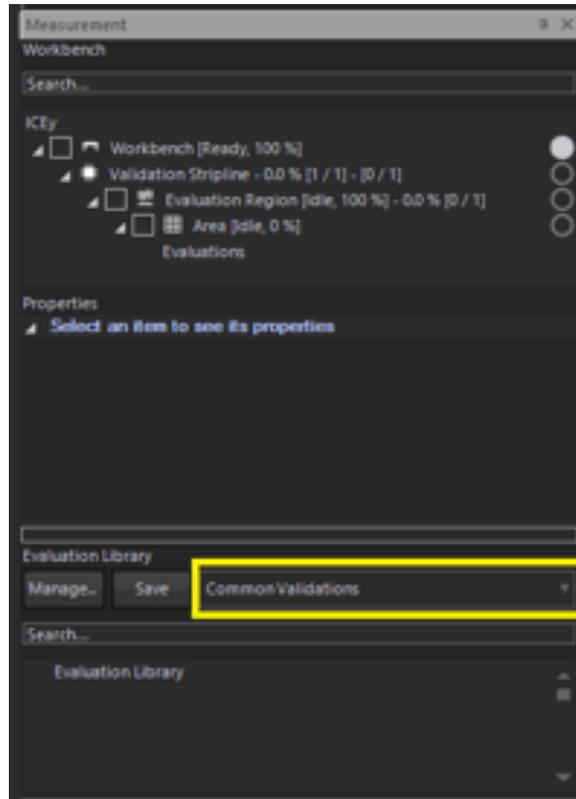


Figure 10.5: Select your desired Evaluation Library.

When the evaluation library is selected, the ribbon bar will present you with the possibility to create new *Evaluation Lists*, *H-Field Evaluations*, *E-Field Evaluations*, *Spectrum Scans* or *Time Domain Scans* (Figure 10.6), which are explained in the following subsections.



Figure 10.6: Create new entries in your Evaluation Library.

10.2.2 Evaluation List

An *Evaluation List* is a set of different evaluations that are performed at each grid point of your scan. It can hold different H-Field Evaluations and E-Field Evaluations. Note that the evaluations in the list are run in arbitrary order.

An Evaluation List has only two properties:

Pre Job DUT Setup Hook A python script can be selected that is executed each time a new pass of this scan is started. A new pass is started for each X, Y or Z component that is scanned.

Post Job DUT Shutdown Hook A python script can be selected that is executed each time a pass of this scan is completed (i.e. one X, Y or Z component has been completed).

10.2.3 H-Field and E-Field Evaluations

H-Field and *E-Field* Evaluations contain the same properties, but ICEy will use different probes depending on which one is used. An *H-Field* or *E-Field* Evaluation can contain different *Spectrum Scans* and/or *Time Domain Scans* (I/Q Scans). The only properties directly belonging to the *H-Field* and *E-Field* Evaluations are which field components (X, Y, Z) should be measured in this evaluation (Figure 10.7).

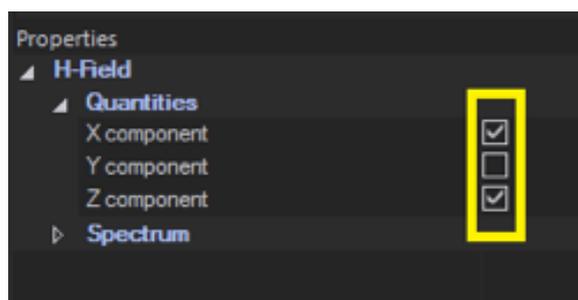


Figure 10.7: Properties of the H-Field and E-Field Evaluation.

10.2.4 Spectrum Scan

Spectrum Scans are frequency domain sweeps that can be assigned to *Field Evaluations*. A *Spectrum Scan* provides the following configurable properties and functionalities, though they might differ slightly for different Vector Signal Analyzer modules:

Pre Scan DUT Setup Hook A python script can be selected that is executed in advance of this *Spectrum Scan*. This can for example be used to set up a signal generator (see Chapter 20).

Reference Level of the Vector Signal Analyzer module. The reference level represents the maximum expected power of an input RF signal and thus the upper ADC sampling limit.

Center, Span, Min. / Max Frequency Set up the width of the frequency domain sweep, where either min/max frequency or center and space can be set. $f_{center} = f_{min} + 0.5 \cdot (f_{max} - f_{min})$ and $f_{span} = (f_{max} - f_{min})$

FFT Window Type Specifies the FFT Window Type. For optimal performance in typical EMC applications we recommend the use of a *7-term Blackman-Harris* window. Details to the various window types can be found under: NI Zone RFSA FFT Window Type

Resolution Bandwidth Type For typical EMC application we recommend the use of either *Auto* or *Configurable Display resolution*. More details on *Resolution Bandwidth Types* can be found under NI Zone RFSA Resolution Bandwidth Type.

Resolution Bandwidth Sets up the RBW in Hz.

Averaging Modes:

RMS Averaging RMS averaging reduces signal fluctuations and averages the energy, or power, of the signal.

Peak Hold Averaging Peak-hold averaging hold the RMS peak levels of every frequency domain sample for the number of averaging sweeps configured.

Vector Averaging Perform a complexed valued averaging of the signal vector. For this type of averaging a synchronous signal has to present.

No. Averages Number of frequency domain sweeps an averaging is performed over.

Probe Noise Floor Filtering If this function is enabled for a *Spectrum Scan* the noise floor from the probe is removed before storing the scan data, i.e., data below the probe's noise floor will be removed before storage.

Lift filter by 'n' dB If noise floor filtering is enabled all data below:

$V_{n_{probe}} \frac{V}{\sqrt{Hz}} \cdot \sqrt{RBW Hz} \cdot 10^{n/20}$ is considered noise and hence not stored. The probe's noise floor is represented by a polynomial fit to the probe's DANL ($\frac{V}{\sqrt{Hz}}$) when using a 10x RMS averaging. A value of $n = 6dB$ typically removes most of the noise floor samples for 10x RMS averaging.

Store only measured data points If this is enabled, data will only be stored for points that are actually measured, rather than all points in the scan. It is recommended to leave this at the default. This option is automatically enabled if *Probe Noise Floor Filtering* is enabled.

Store only one time/frequency vector for all measured points This can only be enabled in combination with *Store only measured data points*. If enabled, only one frequency vector will be stored for all the points. This can save storage space.

Clocking:

Clock Source Select the clock source. Options vary depending on the Vector Signal Analyzer Module.

Clock Rate (Hz) Specifies the Reference clock rate in hertz.

Triggering:

Trigger Mode For most Spectrum Scans, *No Trigger* will be used, unless you want to trigger from an external device.

10.2.5 Time Domain Scan

Time Domain Scans or *I/Q Scans* are time domain acquisitions that can be assigned to *Field Evaluations*. Note that for phase-resolved time domain scans, there must only be one E-Field and one H-Field Evaluation with exactly the same settings in your evaluation list, so only one frequency can be measured at a time. Furthermore, a reference clock from your radiation source is needed, which can be configured as described below. A *Time Domain Scan* provides the following configurable properties and functionalities, though they might differ slightly for different Vector Signal Analyzer modules:

Pre Scan DUT Setup Hook A python script can be selected that is executed in advance of this *Time Domain Scan*. This can for example be used to set up a signal generator (see Chapter 20).

Reference Level of the Vector Signal Analyzer module. The reference level represents the maximum expected power of an input RF signal and thus the upper ADC sampling limit.

Carrier Frequency Configures the carrier frequency, in hertz (Hz), of the RF signal to acquire an I/Q acquisition. The carrier frequency is the center frequency of the I/Q acquisition.

Carrier Rate (Samples/s) Specifies the I/Q rate for the acquisition. The value is expressed in samples per second (S/s).

No. Samples Configures the number of samples per record for a finite acquisition.

Clocking:

Clock Source Select the clock source. For phase-resolved time domain scans, you need a reference clock from your radiation source.

Clock Rate (Hz) Specifies the Reference clock rate in Hertz.

Triggering:

Trigger Mode For Time Domain Scans, it is recommended to use *Software Trigger*. This will keep the Vector Signal Analyzer phase-locked to the reference clock and issue a software trigger at each scan point.

Probe Noise Floor Filtering This is not supported for *Time Domain Scans*.

Lift filter by 'n' dB This is not supported for *Time Domain Scans*.

Store only measured data points If this is enabled, data will only be stored for points that are actually measured, rather than all points in the scan. It is recommended to leave this at the default.

Store only one time/frequency vector for all measured points This can only be enabled in combination with *Store only measured data*

10.2. EVALUATION LIBRARY

points. If enabled, only one time vector will be stored for all the points. This can save storage space.

Chapter 11

Evaluator Mode

11.1 Introduction

Once a job or job list has been completely scanned, the Evaluator Mode can be initiated by context sensitive command on the job/job-list in *Measurement Mode*. Alternately, the **Evaluator** tab can be selected and data imported.

ICEy measurement results are presented as a single algorithm combining voltage extraction (from persistent *Snapshots* on disk) and field evaluation, per scan in a scanlist of a job, as a *Field Evaluator* algorithm. This algorithm uses all jobs' measured directional component voltage datasets, measured spatial location datasets and probe parameters to provide electric or magnetic field data.

The *Evaluator* uses the concept from *11.2 Pipeline* for custom evaluation and analysis of several ICEy *Field Evaluator*'s field data.

The *Explorer* is a tree-like representation of all loaded *Pipelines* facilitating fine-tuning and algorithm parameter customization during post-processing analysis.

Selection of each algorithm in the *Explorer* yields context sensitive actions available on the selected algorithm's output in the *Context Sensitive Tool Bar*. Right-clicking on the selected algorithm also yields a context sensitive menu.

The selected algorithm will also have its own unique set of properties/information, configurable/viewable in *Properties*.

Algorithms that display results in 3D will have their results superimposed in the *3D View*. For those algorithms that display results in 2D their results will have their own 2D Plot in *2D View*.

Other miscellaneous results that are not directly related to evaluation of field data of interest to you may be also presented as extractor algorithms. These are of interest to us, and may be asked of you from time to time.

Vision results might also be present, if the corresponding camera or

*DUT surface scans were performed. This is presented in the Evaluator for result overlay, as well as for the case where results are imported into **SEM-CAD**.*

11.2 Pipeline

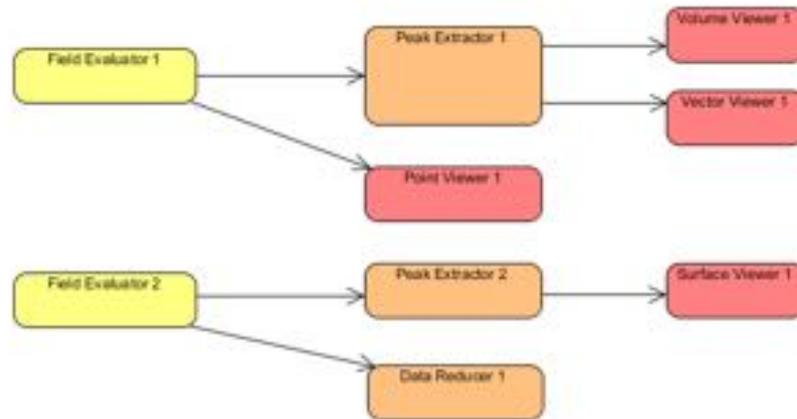


Figure 11.1: Example Pipelining processes.

A **Pipeline** provides an easy and easily-customizable way of post processing data.

Data flows from the source (e.g. results of a measurement) through the pipe to an image rendered on screen. At the start of every pipeline is a data source, usually a field evaluator, or a data cache extractor. Typically, a user will process fields further, e.g. by iterating over the full dataset to extract peak information, visualizing the spectra at a single grid point, or reducing the size of stored data by filtering. The sink or end of a pipeline is often a viewer which takes a result and renders it either in 3D or 2D. It may also be an exporter.

Data flows as *Snapshots* through *Pipeline*.

*It is also possible to create custom algorithms and insert them before a viewer in a **Pipeline** via the Python API. For more information, please email support@speag.com.*

11.3 Snapshot

A **Snapshot** is the description of data that flows through *Pipelines*.

For sample \mathbf{M} of a spectrum scan of N samples over P number of grid points, a **Snapshot** is the dataset consisting of sample value $\theta > \mathbf{M} > N$ at each point θ to $(P-1)$.

11.4 Context Sensitive Tool Bar

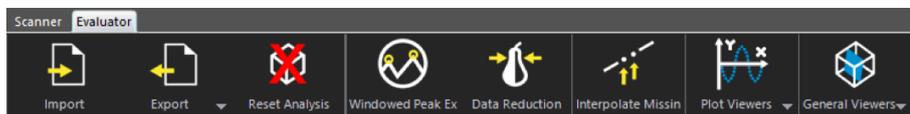


Figure 11.2: Evaluator Mode Context Sensitive Tool Bar.

The **Context Sensitive Tool Bar** provides easy access to algorithms that can be added to the current selection in the *Explorer*. The desired analysis can be achieved by modifying a *Pipeline* in this way. The *Context Sensitive Tool Bar* is populated with the following actions in context of the currently selected algorithm in the *Explorer*. These are:

1. Import
2. Export
 - (a) Data Cache Exporter (*and Importer*)
 - (b) MATLAB Exporter
3. Reset Analysis
4. Windowed Peak Extractor
5. Data Reduction
6. Plot Viewers
 - (a) Measurement Point Viewer
7. General Viewers
 - (a) Surface Viewer
 - (b) DASy Viewer
 - (c) Volume Rendering Viewer
 - (d) Slice Viewer
 - (e) Vector Field Viewer
 - (f) Streamline Viewer

11.5 Explorer

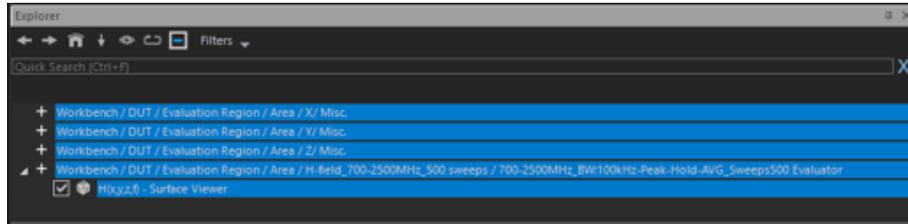


Figure 11.3: Explorer Window with a typical *Pipeline*.

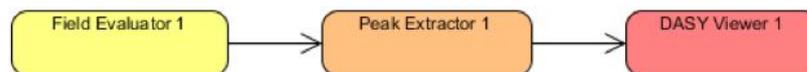


Figure 11.4: *Pipeline* equivalent of the Explorer Window in Figure 11.3.

The **Explorer** provides a tree-like representation of the current evaluation session. For each job's results, a separate *Pipeline* is presented for modification in the Explorer. Each level of nesting represents a connection of the data output of the parent algorithm to the data input of the *nested* child algorithm, from data extraction to viewing on screen.

Each algorithm's progress is displayed inline in the **Explorer**.

Double-clicking on a **viewer** algorithm in the **Explorer** will automatically zoom to fit the viewer in the *3D View*.

Hovering over a *Field Evaluator* algorithm in the **Explorer** will display temporarily all grids related to the algorithm in the *3D View*.

If the algorithm has an associated *2D View*, then its tab will be brought to focus in *2D View*.

Each item of camera, laser and field scans in *Measurement Mode* can be renamed as desired, in order to give meaning to scanning and evaluation. **It is thus strongly recommended to develop a good naming convention when configuring measurements in ICEy.** For scan job correlation, the names from the following items in all three scan types are applied to the corresponding result *Field Evaluator* as a **path** using the '/' path delimiter in the following order:

1. Device Under Test Name
2. Evaluation Region Name
3. Volumetric Grid Name

4. Job List Name
5. Job Name
6. Evaluated Field Name
7. Scan Name

When an evaluation session has several algorithms, for convenience the **Explorer** provides *Quick Search* and *Filters* (amongst others) to aid you in the search of algorithms based on the names you provided.

Figure 11.4 illustrates the equivalent *Pipeline* for the tree as in Figure 11.3.

11.6 Properties

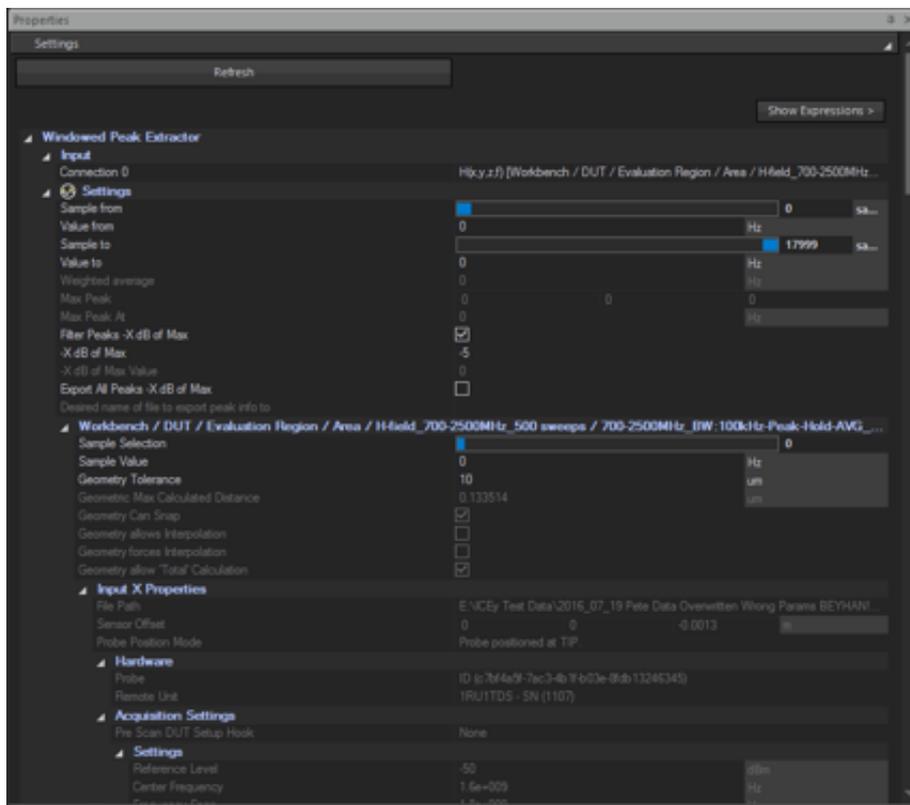


Figure 11.5: Example of selected algorithm properties.

The **Properties** Windows provides an editable list representation of the configurable properties of the currently selected algorithm in the *Explorer*.

In some cases, information is displayed here. These properties will not be editable, and will be greyed out to indicate that they are not for editing, but for information.

11.8 3D View

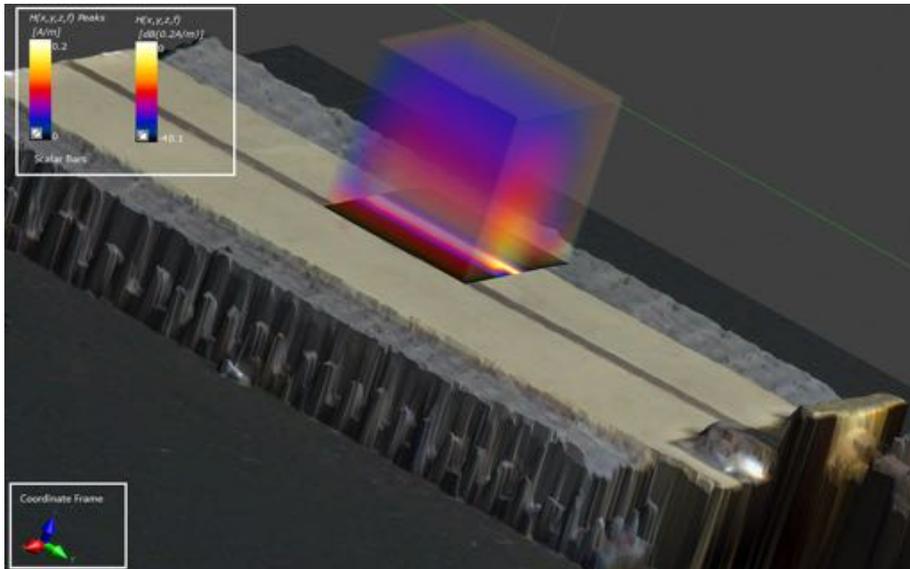


Figure 11.7: Example of the *3D View* with multiple viewers displaying field overlaid on imaging and triangulation results from *Measurement Mode*.

In *Evaluator Mode* the **3D View** provides a novel mechanism for analysis and visualization of real-world devices by combining all results of all scans in ICEy: one can see the device constructed via combined imaging and laser triangulation alongside the measured fields in 3D space.

To visualize the device under test, its visibility needs to be enabled in *Measurement Mode*.

Each viewer in the **3D View** contains a *scalar bar*, which indicates the legend, and alternative options for visualization.

Decibel scaling in the *scalar bar* can be enabled by the checkbox in the lower left corner.

Scale of the *scalar bar* can be modified by editing the values directly on screen.

By dragging the *scalar bar*, it can be repositioned.

By right-clicking the *scalar bar*, more visualization options are available.

The *coordinate frame control* works as it does in *Evaluator Mode*, that is, to indicate the coordinate system of the **3D View**, as well as to align the view by clicking on the desired axis.

11.9 Actions and Algorithms

11.9.1 Import

The **Import** action can be used to add additional projects' results to the current evaluation session.

Please note: only 3D and imaging information from the currently loaded project in Measurement Mode is applicable.

Importing via this mechanism is for field data only.

The following items are importable:

1. ICEy project (*.iceproj*) : all jobs' master results files of a project.
2. Job Master Result File (*.icevsaresm*) : all field component results from a single job of a project.
3. Result File (*.icevsares*) : results from a single field component of a job.
4. Data Cache File (*.cache*) : algorithm output data captured from a previous analysis *Pipeline*.

11.9.2 Export

Export exports the results of a *Pipeline* to a file on disk. Further analysis can be done in  MATLAB.

For extremely large results, evaluation might take a long time, or one might want to keep the end result of several variations on a *Pipeline*'s configuration, in which case the *Pipeline* output can be cached.

11.9.2.1 Data Cache Exporter (*and Importer*)

The **Data Cache Exporter** can be used to export the results (and spatial information) of one or several selected *Pipelines*' algorithms, or the intermediate results, to a *.cache* file on disk.

This can be done by:

1. in *Explorer*, selecting the desired algorithms whose outputs should be persisted to disk, then,
2. Selecting **Export** from the *Context Sensitive Tool Bar/Context Menu*,
3. Selecting **Data Cache Exporter**,
4. in *Properties* (Figure 11.8) choosing the desired file name and path (*again, a good naming convention that has relevant meaning is highly recommended*) by pressing the grey **'...'** button of the *File Path* property to bring up a file dialog, or manually entering the *File Path* correctly,
5. Pressing *'Refresh'* (Figure 11.8).

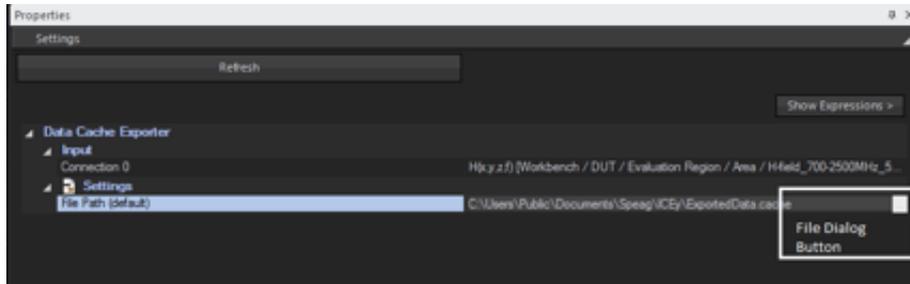


Figure 11.8: Data Cache Exporter *Properties* with multiple algorithm results to export. **Input** connection 0 5 indicate all outputs from *Pipelines'* algorithms that will be persisted to disk.

Importing a *.cache* file from disk will create a **Data Cache Extractor** *source algorithm* as a *Pipeline* in the *Explorer*. Attaching a viewer to that will give access to extract / view all data previously exported by switching the *Input Connection*, as illustrated in Figure 11.9.

A *MATLAB Exporter* could also be attached to a **Data Cache Extractor** to export cached results to  MATLAB.

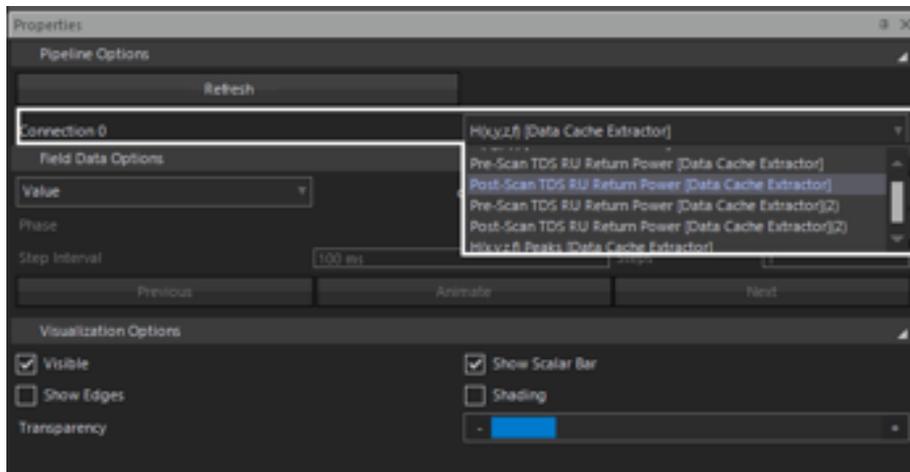


Figure 11.9: Data Cache Importer with (with multiple algorithm results) as a source in *Properties* to a connected algorithm in a *Pipeline*. **Input connection 0 through 5** indicate all inputs that were exported.

11.9.2.2 MATLAB Exporter

The **MATLAB Exporter** can be used to export the results (and spatial information) of one selected *Pipeline's* algorithm, or the intermediate result,

to a *.MAT* file on disk. This data can then be imported into MATLAB.



This can be done by:

1. in *Explorer*, selecting the desired algorithm whose output should converted to *.MAT* file and persisted to disk, then,
2. Selecting **Export** from the *Context Sensitive Tool Bar/Context Menu*,
3. Selecting **MATLAB Exporter**,
4. in *Properties* (Figure 11.10) choosing the desired file name and path (*again, a good naming convention that has relevant meaning is highly recommended*) by pressing the **grey '...'** button of the *File Path* property to bring up a file dialog, or manually entering the *File Path* correctly,
5. Pressing *'Refresh'* (Figure 11.10).

When opening the file in  MATLAB, there will be four arrays, each correlated by 1D index:

1. **data** : exported field values.
2. **x** : spatial locations in x (mm), relative to the origin of the ICEy workbench.
3. **y** : spatial locations in y (mm), relative to the origin of the ICEy workbench.
4. **z** : spatial locations in z (mm), relative to the origin of the ICEy workbench.

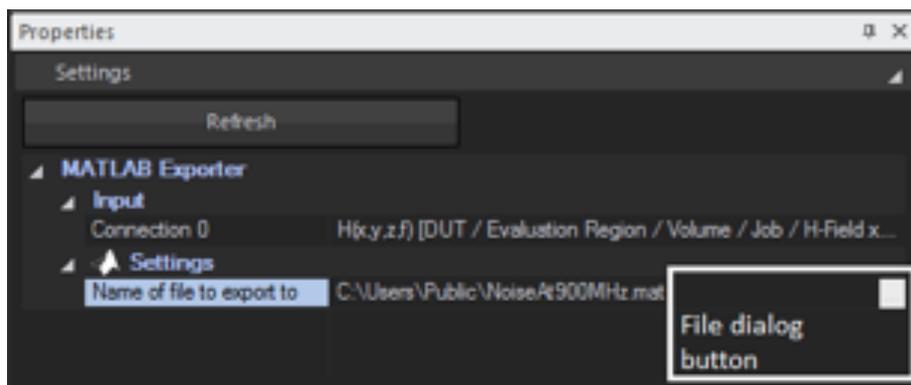


Figure 11.10: MATLAB Exporter *Properties* selected algorithm result to export. **Input** connection 0 indicates the output from the selected *Pipeline* algorithm that will be converted and persisted to disk.

11.9.3 Reset Analysis

The **Reset Analysis** action will completely clear all *Pipelines* from *Evaluator Mode*. Synonyms are *Clear All*, *Remove All* and *Delete All*.

11.9.4 Field Evaluator

11.9.4.1 Description

An ICEy **Field Evaluator** algorithm is presented as a single data source algorithm to the user.

Internally however, it contains its own dynamic *Pipeline* combining voltage extraction, geometric analysis, interpolation, field evaluation and field combination of all associated jobs' measured directional component voltage result datasets, measured spatial location datasets and probe parameters to provide electric or magnetic field data.

When each separate field components' field data is valid at the same spatial location as every other field components' data, no interpolation is necessary and a simpler evaluation pipe makes field evaluation very fast, regardless of the sample count and spatial area size. *When this is not possible, field evaluation is interpolated to common spatial locations first, and thus the evaluation processing time is orders of magnitude slower. The order is roughly equivalent to the product of*

- *the number of samples,*
- *the number of field components,*
- *an interpolation factor*
- *the number of points in measurement grids.*

The larger the number of samples and spatial areas, the higher the processing time.

The criterion for 'field data is valid at the same spatial location' (or **Geometry Can Snap**) is defined by a maximum **Geometry Tolerance**. For the **Field Evaluator**, the worst case distance over each scanned field component's grid compared to each other scanned field component's grid is used to pass or fail this criteria. *Failure implies a different (interpolating) Pipeline internally, and processing will be significantly slower.*

Distances are calculated along vectors parallel to surface normals, and at the centre of surface triangles, thus a 'tightest fit' approach is followed. The geometry criteria also accounts for overlap and the type of surface analysed (point, line, surface, or volume) accordingly. In processing this worst-case distance, the following criteria can also be determined:

- **Geometry Allows Interpolation** : e.g. two non-overlapping surfaces can not be interpolated to a common space (but two volumes with overlap can).
- **Geometry Forces Interpolation** : e.g. points are not at the same spatial location, and the only way one can combine component fields

11.9. ACTIONS AND ALGORITHMS

is via interpolation,

- **Geometry Allow 'Total' Calculation** : e.g. final results will be at the same spatial location, allowing a vector sum.

11.9.4.2 Properties

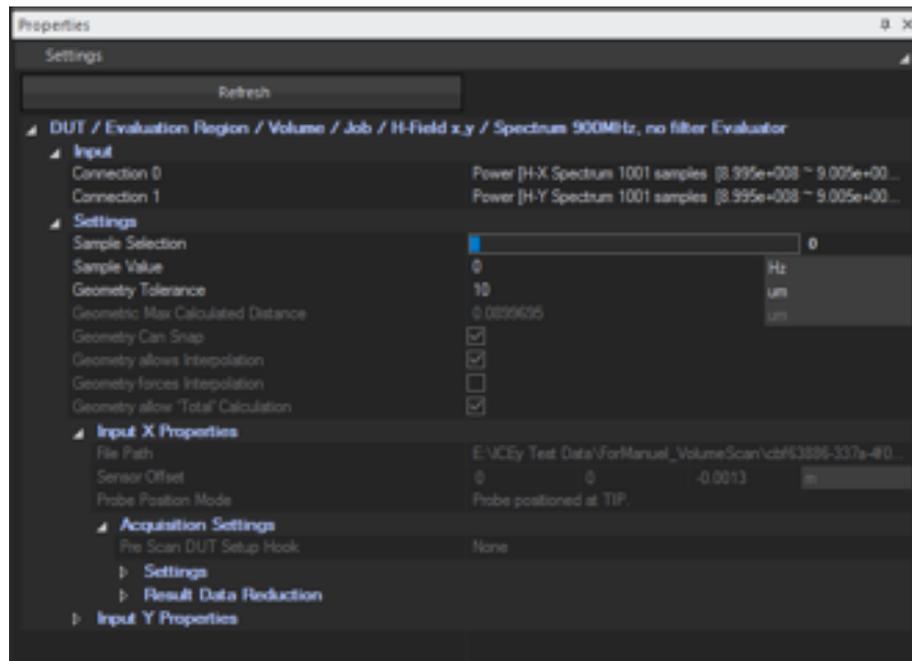


Figure 11.11: ICEy Field Evaluator properties.

The following are configurable properties:

- *Sample Selection* : Slider or Value editable : The sample from 0 to N number of samples of the data output of this algorithm. This will adjust the sample value accordingly.
- *Sample Value* : The value in Hz or s of the data output of this algorithm. This will adjust the sample selection accordingly.
- *Geometry Tolerance* : As described in *11.9.4.1 Description*, in μm .

The following are informational properties:

- *Geometric Max Calculated Distance* : Worst case distance between all grids, in μm .
- *Geometry Can Snap* : as described in *11.9.4.1 Description*.
- *Geometry Allows Interpolation* : as described above.

- *Geometry Forces Interpolation* : as described above.
- *Geometry Allow 'Total' Calculation* : as described above.
- *Input X/Y/Z Properties (when X/Y/Z present)* : Composed of
 - *File Path* : component voltage source data path on disk.
 - *Sensor Offset* : Cartesian geometric offsets of the probe sensor (relative to the probe coordinate system of the probe sensor used in data acquisition).
 - *Probe Position Mode* : Position mode of the probe used in data acquisition.
 - *Acquisition Settings* : Full set of scan parameters as configured in *Measurement Mode* used in data acquisition.

11.9.4.3 Use

1. Edit *Sample Selection* or *Sample Value*.
2. Press *Refresh*.

In special cases, **Geometry Tolerance** might require editing. See Figure 11.11.

11.9.5 Data Reduction

11.9.5.1 Description

Data Reduction is a data-slimming algorithm for the *Field Evaluator*. It is not available to any other algorithm.

ICEy is designed to scan millions of samples over thousands of spatial locations in a very short time. As a result accumulated result data can quickly reach the order of GB or TB in size on disk. When the samples of interest lie above a threshold, or only at certain spatial locations, the amount of data stored can be greatly reduced by using this algorithm.

Data Reduction uses the scanned probe sensor noise floor function over the configured response range, with an optional **dB lift** parameter to raise or lower the function, as a *filter-pass* criterion.

Data Reduction can be applied iteratively, meaning data can be trimmed bit by bit, until an acceptable file size (without undesired information loss) has been reached.

Data Reduction is visually aided in the form of an **accumulated max for each sample over the entire volume** and **noise-floor-filter 2D View** visualization. One can thus see what one is doing.

Data Reduction works the same as the in-scan feature in *Measurement Mode*.

Data Reduction also has the effect of increasing analysis speed thereafter. *However, if the filter is set too low (and the filtered data is thus extremely large) this may have the adverse effect.*

Data Reduction modifies persistent data on disk. *Once this algorithm has been applied, any filtered data is not recoverable. This is irreversible, and the only way to recover data thereafter is to re-scan.*

11.9.5.2 Properties

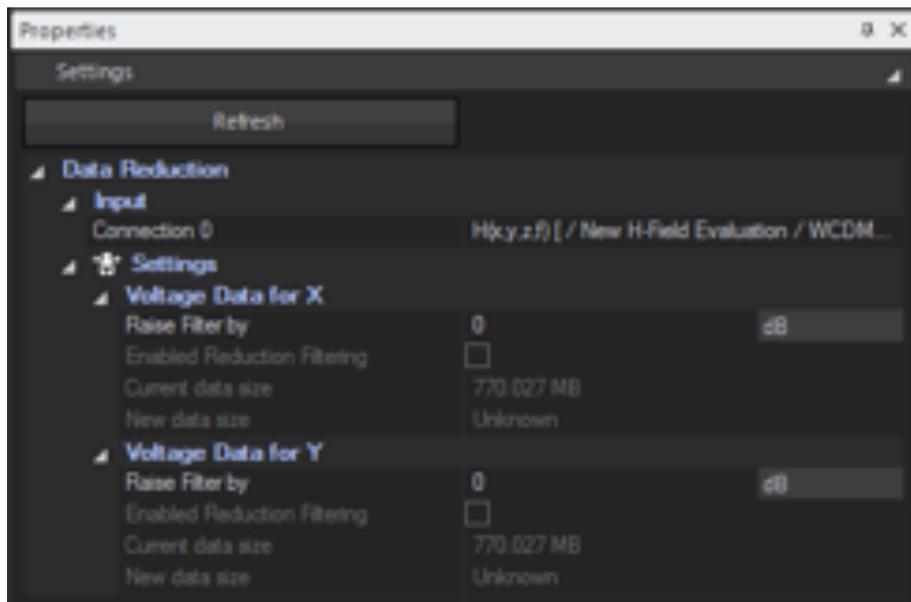


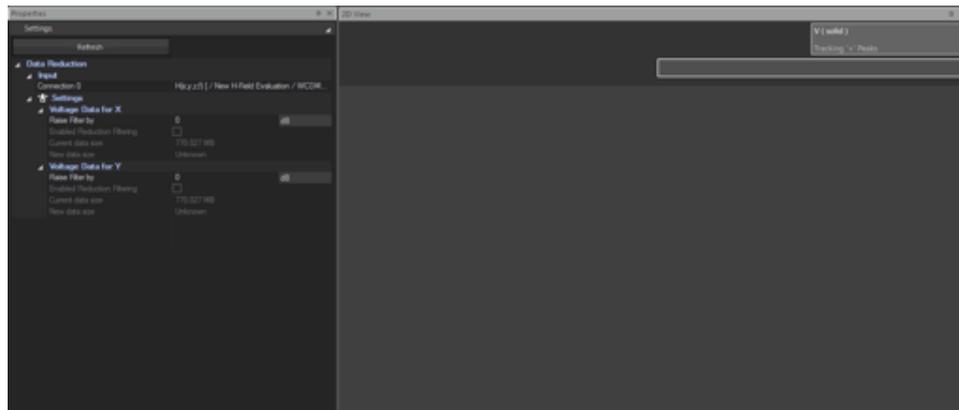
Figure 11.12: *Data Reduction* properties for X and Y scan.

- *Voltage Data X/Y/Z (when X/Y/Z present)*
 - Configurable properties
 - * *Raise Filter By (dB)* : Lifts the probe noise floor pass-filter function by the desired dB.
 - * *Enable Reduction Filtering* : Enabled or disables processing for the current X/Y/Z component. Thus each individual scan component's data can be managed separately.
 - Informational Properties
 - * *Current data size* : Size of data on disk.
 - * *New data size* : Size of the new filtered data on disk, **before applying**.

11.9.5.3 Use

1. **Accumulated max value of each sample over the entire scanned volume.**

Initially this algorithm is empty. **Enable Reduction Filtering** is read-only. *Press 'Refresh'*.



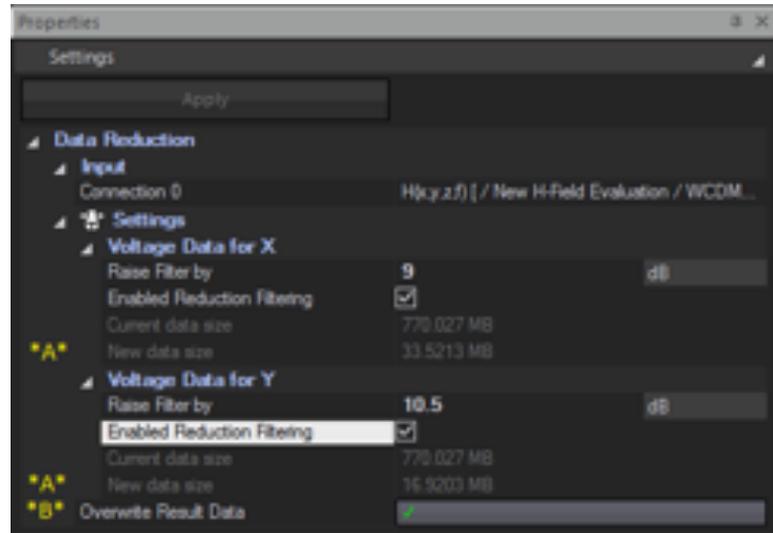
2. **Configure filters.** Each components filter, data processing and visualization can be configured separately.

Once the visual pass criteria is satisfactory, **Enable Reduction Filtering** becomes modifiable. Enable it. *Press 'Refresh'*.



3. **Is this satisfactory?** *A* *New data size* fields will be populated.

If not, redo 2, If so, press *B* **Overwrite Result Data**. *This is irreversible.*



4. The algorithm will be reloaded. At this point, data can be iteratively reduced by resuming from 2.

To visualize each component's accumulated max and filter separately :

- Move the mouse cursor to the header-legend in the *2D View*.
- Right-click on the data of interest (1,2...) to bring up its context menu.
- Use the **Visibility** sub-menu.

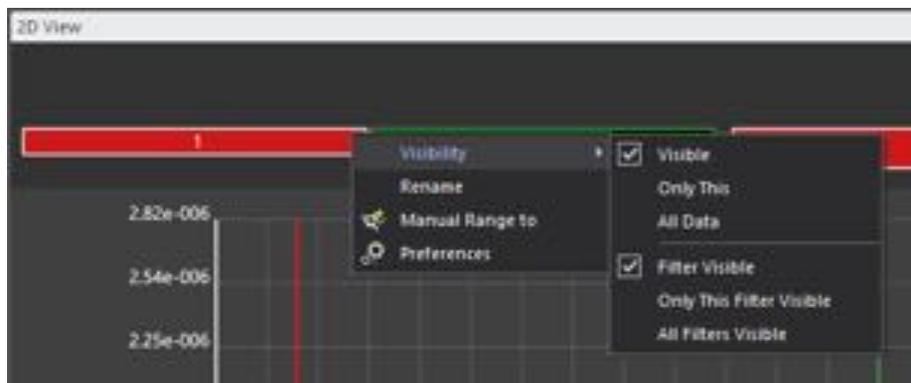


Figure 11.13: Visibility control of max data and related filters in **Data Reduction**.

11.9.6 Windowed Peak Extractor

11.9.6.1 Description

When used in conjunction with *Measurement Point Viewer*, **Windowed Peak Extractor** identifies spurious or abnormal signal data as well as the

spatial location thereof, on scanned devices.

Windowed Peak Extractor accumulates the maximum signal value for each measured point's spectrum and therefore provides a *Snapshot* of maxima over the entire scanned volume.

Windowed Peak Extractor is filtered to a configurable stimulus window. The entire stimulus response (default setting), or only a portion thereof, can be inspected.

Windowed Peak Extractor is not limited to maximum peaks, but can extract all peaks within a configurable amplitude (in dB) of the maximum peak. *These peaks are visualized when used in conjunction with **Measurement Point Viewer**. These peaks can be located, with probe tip, or for further higher resolution analysis, using **Move To Peak**.*

11.9.6.2 Properties

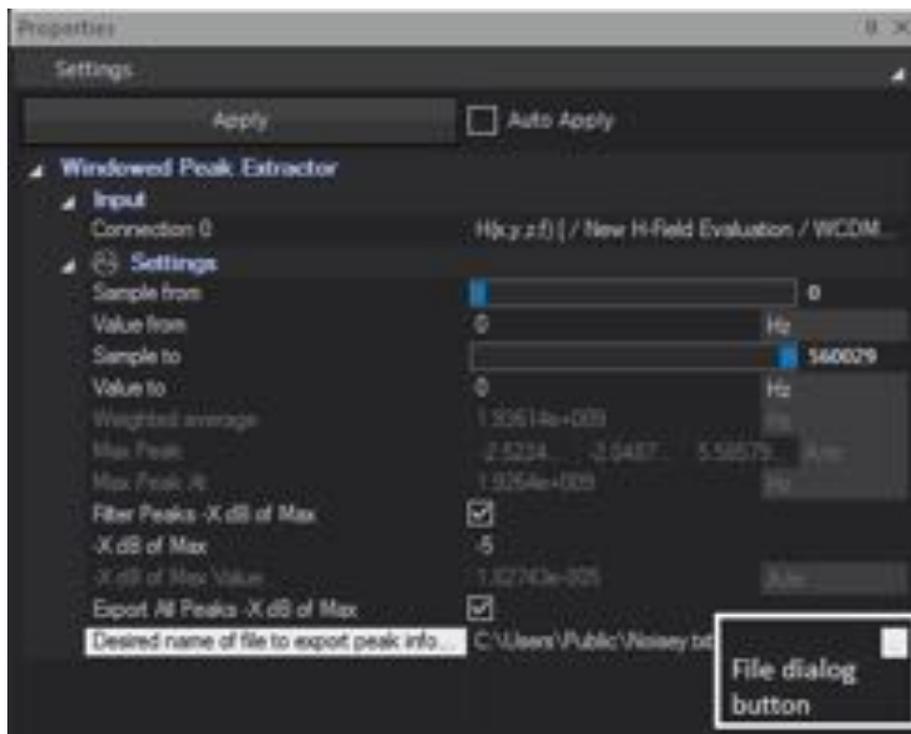


Figure 11.14: *Windowed Peak Extractor* properties.

The following are configurable properties:

- *Sample From* : Slider or Value editable : The sample from 0 to M number of samples of the start of the window for this algorithm. This

will adjust the *Value From* accordingly.

- *Value From* : The value in Hz or s of the start of the window for this algorithm. This will adjust the *Sample From* accordingly.
- *Sample To* : Slider or Value editable : The sample from N to Z (where $N > M$) number of samples of the end of the window for this algorithm. This will adjust the *Value To* accordingly.
- *Value To* : The value in Hz or s (where $Value To > Value From$) of the end of the window for this algorithm. This will adjust the *Sample To* accordingly.
- *Filter Peaks -X dB of Max* : Will pass all peaks of amplitude greater than -XdB of Max found peak.
- *-X dB of Max* : Filter pass criterion.
- *Export All Peaks -X dB of Max* : Enabling this will export all found peaks to a text file.
- *Desired name of file to export peak info* : File to export peaks to, when *Export All Peaks -X dB of Max* enable. Use the '...' button to access the file dialog.

The following are informational properties:

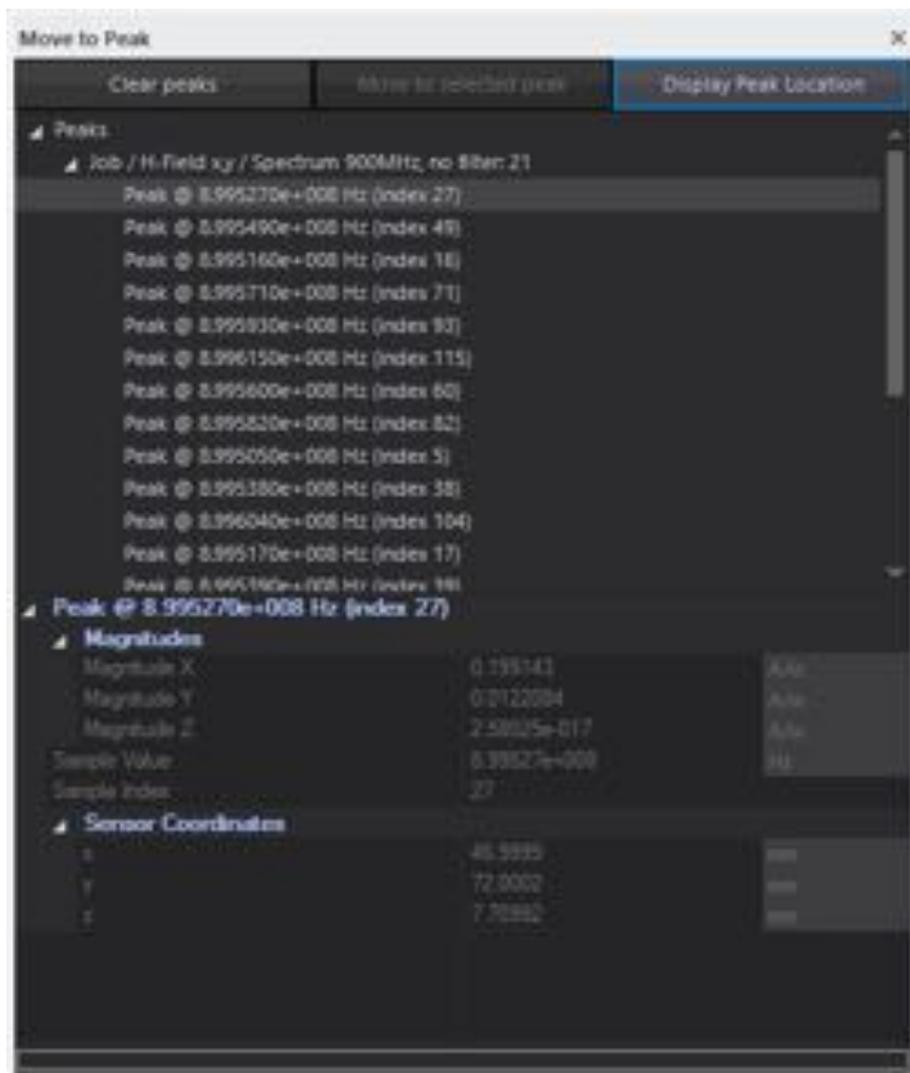
- *Weighted average* : The weighted stimulus average in Hz or s based on the stimuli values and the amplitude weights of found peaks.
- *Max Peak* : Vector field value of the max peak as [X, Y, Z] field components.
- *Max Peak At* : Stimulus value of *Max Peak* in Hz or s.
- *-X dB of Max Value* : Equivalent field value of configured *-X dB of Max* when the max peak is known.

11.9.6.3 Use

1. Edit *Sample From* or *Value From*.
2. Edit *Sample To* or *Value To*.
3. Edit *Configure -X dB of Max* or disable the filter if all peaks within this amplitude threshold are not of interest.
4. Press *Refresh*.

Naturally, a viewer is required to fully utilize this functionality.

11.9.6.4 Move To Peak

Figure 11.15: *Move To Peak* properties.

Peak information from *Windowed Peak Extractor* can be utilized by using **Move To Peak**:

1. *Selection* : Detailed information for all peaks available (Figure 11.15).
2. *Display Peak Location* : When enabled, selection will be indicated in *3D View*



3. *Move to selected peak* : If ICEy is not in *Evaluator Only Mode*, a connected probe can be moved to the selected peak location (Figure 11.15).

11.9.7 Measurement Point Viewer

11.9.7.1 Description

Measurement Point Viewer allows for the visualization of data orthogonally to *Snapshots*, that is, all *samples/entire spectra* for a scanned point in a volume can be display with this viewer.

When a **Measurement Point Viewer** and a *Windowed Peak Extractor* are in the same *Pipeline*/connected to the same *Field Evaluator* as illustrated in Figure 11.18, signal analysis is simple. **Measurement Point Viewer** then has access to all peak information from *Windowed Peak Extractor*, and peaks are thus marked accordingly in *2D View*. The peak search window of *Windowed Peak Extractor* is also displayed in **Measurement Point Viewer** when the range is within the data range, and when all fields are enabled.

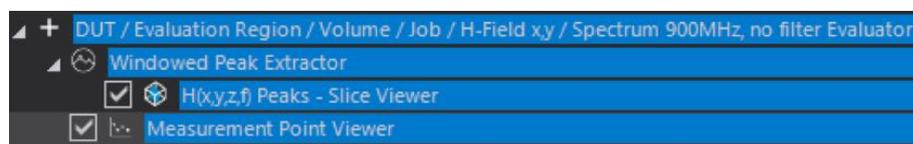


Figure 11.16: Recommended signal analysis pipeline using *Measurement Point Viewer* and *Windowed Peak Extractor*.

The spatial location of **Measurement Point Viewer** is displayed in *3D View* as illustrated in Figure 11.17.

When overlaying this locator to hotspots from *Windowed Peak Extractor*, it is trivial to view entire spectra at these locations. Cross-hairs matching axis color of available field components are rendered at its centre.

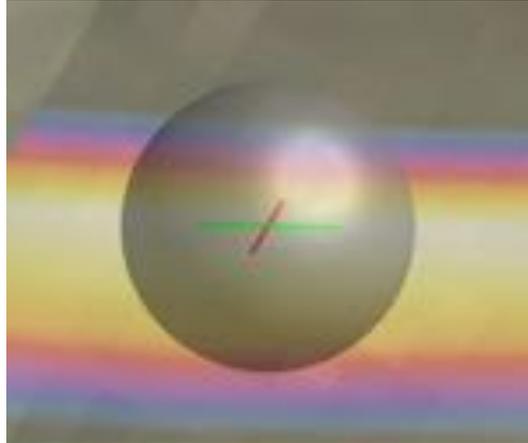


Figure 11.17: *Measurement Point Viewer* spatial indicator.

11.9.7.2 Properties

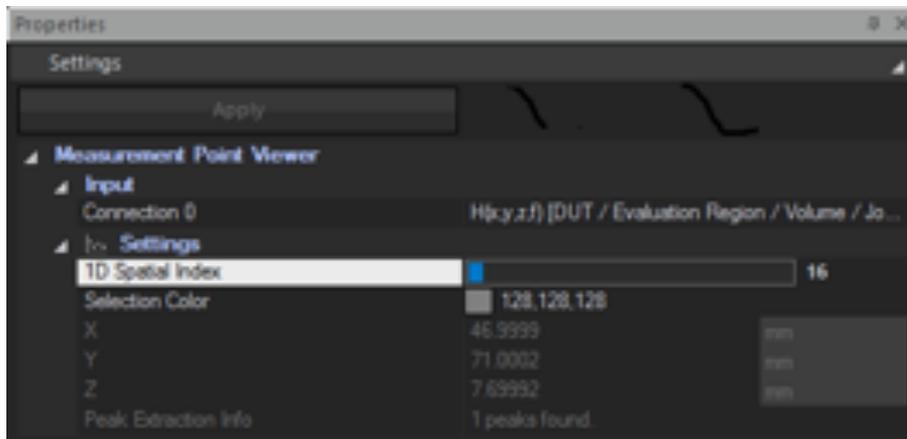


Figure 11.18: *Measurement Point Viewer* properties.

The following are configurable properties:

- *1D Spatial Index* : Slider or Value editable : Positions the spatial locator to grid point from 0 to P number of points in the scanned grid whose full set of data is to be visualized. The actual X, Y and Z spatial positions are updated accordingly.

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- *Selection Color* : The color of the spatial locator can be modified in case it is not clearly visible (for example due to the presence of background in a similar color).

The following are informational properties:

- *X* : spatial position in *mm*.
- *Y* : spatial position in *mm*.
- *Z* : spatial position in *mm*.
- *Peak Extraction Info* : Total number of peaks found, at current spatial location, for all field components.

11.9.7.3 3D Use

To visualize point data in 2D

1. Edit/Move *1D Spatial Index* whilst *looking at* the spatial locator in *3D View*, to the desired location.
2. Press *Refresh*.

Figure 11.19 illustrates positioning of the spatial locator at a hotspot, viewing the spectrum at that hotspot, and the peaks(found) that have passed the search criterion at that hotspot.

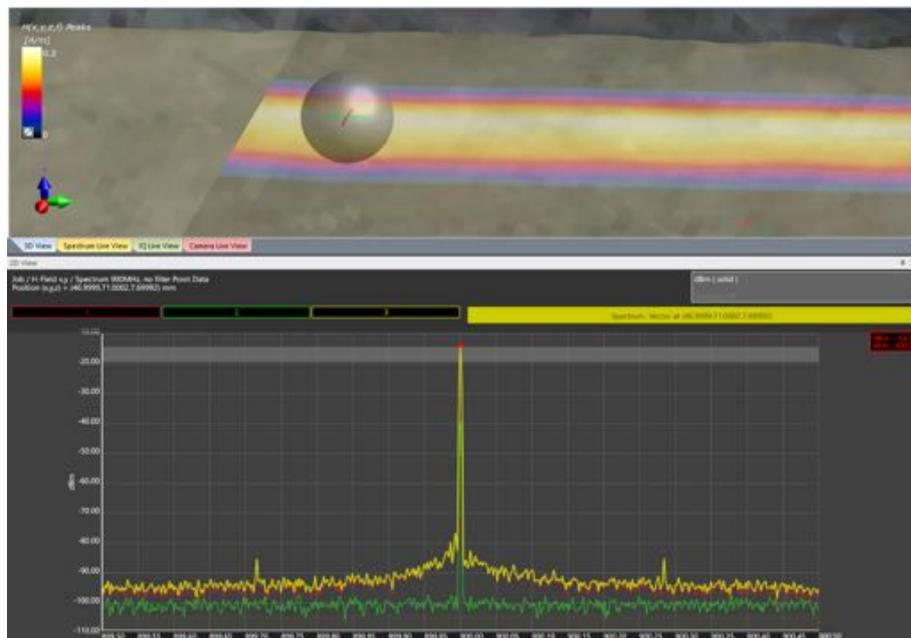


Figure 11.19: *Measurement Point Viewer* and *Windowed Peak Extractor* positioned at hotspot and displaying spectra and peaks.

11.9.7.4 2D Use

All functionality described in *2D Plots* is applicable.

To toggle the visibility of *noise floors*, the following custom commands are available in the visibility context menu of the data, accessible via *right-click* in the *2D Plots* header (as illustrated in Figure 11.20):

- *Noise Floor Visible* : Enables/disabled visibility of the probe noise floor related to this data.
- *Only This Noise Floor Visible* : Disabled all other probe noise floor and enabled only that which is related to this data.
- *All Noise Floors Visible* : Enables visibility of all noise floors.
- *All Noise Floors Invisible* : Disabled visibility of all noise floors.

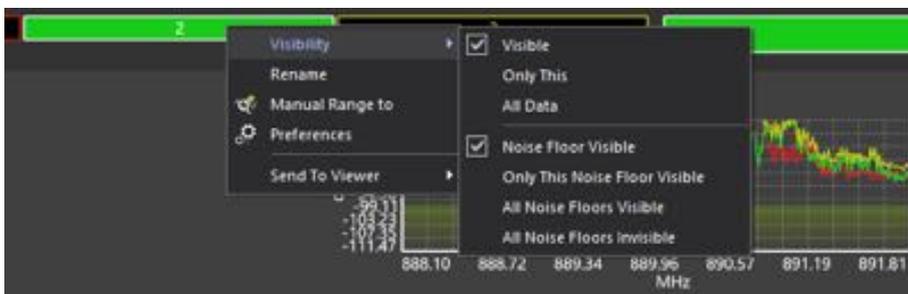


Figure 11.20: *Measurement Point Viewer* noise floor visibility.

Individual datasets can also be sent to a separate viewer (as illustrated in Figure 11.21). For any viewers already created this way, data can be sent to them via a new entry in this submenu.

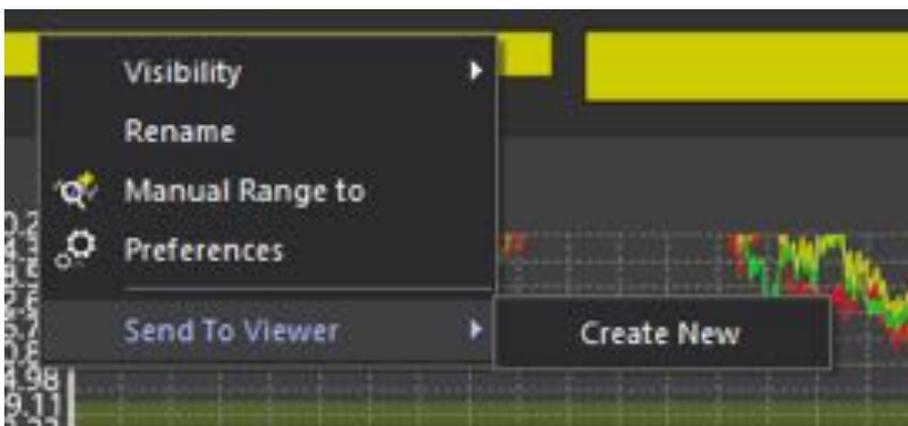


Figure 11.21: *Measurement Point Viewer* sending data to new viewer.

11.9.8 Slice Viewer

As shown in Figure 11.22 the *Slice Viewer* allows to visualize 3D field data in an arbitrarily located plane. In its default setup, the plane is oriented normal to one of the Cartesian axis.

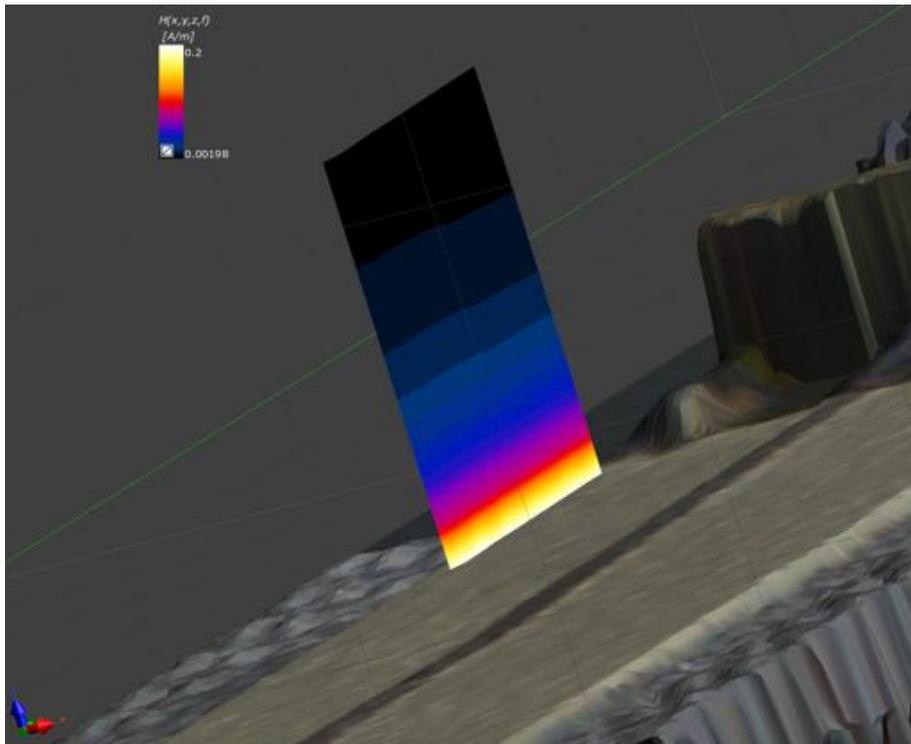


Figure 11.22: *Slice Viewer* showing a slice in the YZ plane.

The *Properties* and their meaning can be outlined as follows:

- **Pipeline Options**

- Specify if property changes are applied automatically (checkbox) or manually, by clicking the Refresh button.
- Define which quantity is shown.
- The pipeline options are the same for all viewer types.

- **Snapshot Options**

- When multiple time-steps or frequencies are available, the field data options are shown. Here the visualized time step or frequency can be chosen and animated (button).

- **Slice Options**

- Use a plane which is aligned to the Cartesian axis for visualization; the plane can be specified through a *Slice Index* or by the *Slice Coordinates* controls: there is a one-to-one cor-

respondence between Index and Coordinates, in such a way that every time one of them changes the other one will be updated accordingly. The *Go To Max* button also enables to visualize the slice that corresponds to the maximum field location.

- If the *Cutter* slice view is applied, the user can specify the origin and normal location of the plane (via edit fields or interactive positioning).
- To select the slice, the mouse wheel can be used when having clicked in the edit field.

- **Field Data Options**

- Select which field component or if the vector shall be shown.
- Specify if RMS or Real Magnitude, or Real, Imaginary or Phase shall be shown.

- **Visualization Options**

- Determine if the field itself and the scalar/color bar should be shown.
- Specify rendering options like transparency, shading of the field, or smooth to display cell centered field on the dual grid..

11.9.9 Surface Viewer

As shown in Figure 11.23 the *Surface Viewer* allows display of 3D data on the surface of the scanned volume.

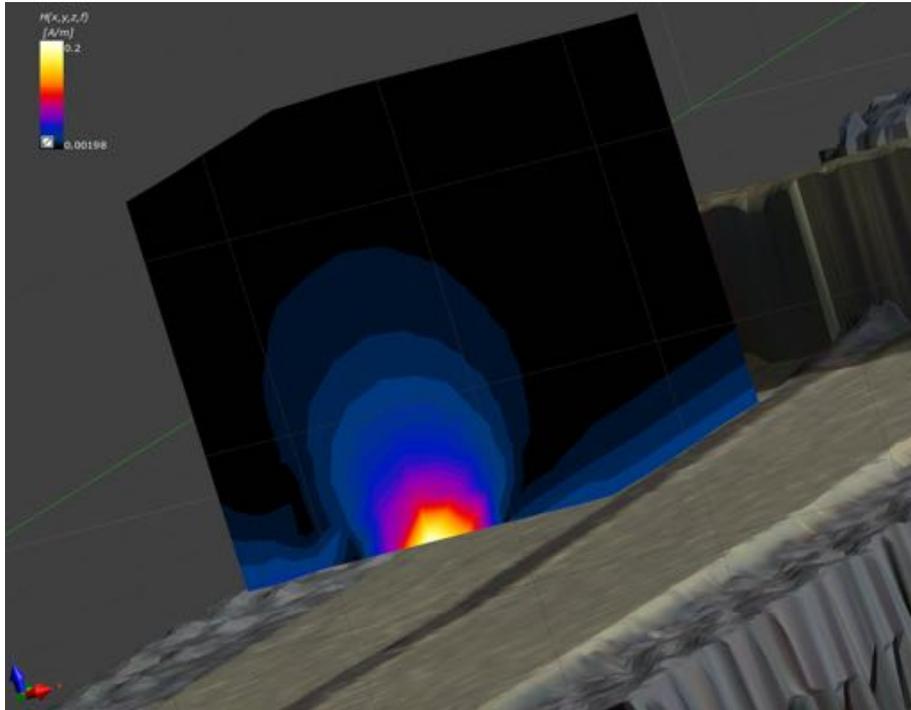


Figure 11.23: *Surface Viewer* showing a 3D surface.

The Properties and their meaning can be outlined as follows:

- **Pipeline Options**
 - The pipeline options are the same for all viewer types (as described in *Slice Viewer*).
- **Field Data Options**
 - The data options are the same as for the *Slice Viewer*.
- **Snapshot Options**
 - When multiple time-steps or frequencies are available, as for the *Slice Viewer*.
- **Visualization Options**
 - The visualization options are the same as for the *Slice Viewer*, but in addition allow to show edges of the underlying grid/mesh.

11.9.10 DASY Viewer

As shown in Figure 11.24 the *DASY Viewer* allows display of 3D data on a honey-comb like structure of the scanned volume.

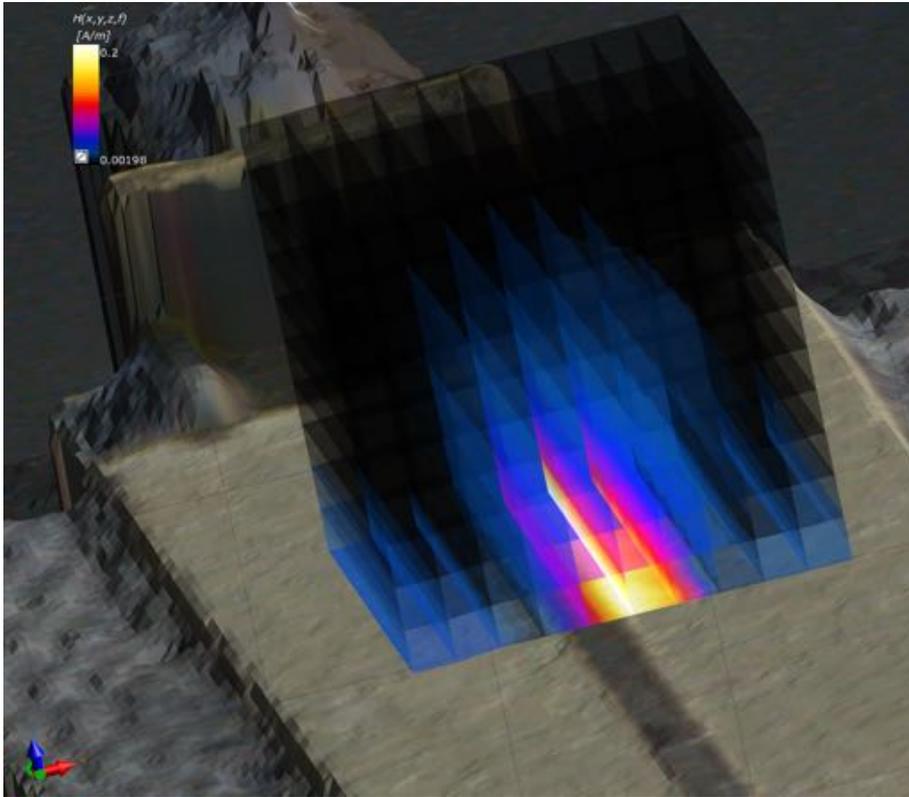


Figure 11.24: *DASY Viewer* showing a 3D honey-comb structure oriented to the XZ plane.

The Properties and their meaning can be outlined as follows:

- **Pipeline Options**
 - The pipeline options are the same for all viewer types (as described in *Slice Viewer*).
- **Field Data Options**
 - The data options are the same as for the *Slice Viewer*.
- **Snapshot Options**
 - When multiple time-steps or frequencies are available, as for the *Slice Viewer*.
- **Visualization Options**
 - The visualization options are the same as for the *Slice Viewer*, but in addition allow to show edges of the underlying grid/mesh.
- **Slice Options**
 - The slice options are the same as for the *Slice Viewer*

11.9.11 Volume Rendering Viewer

As shown in Figure Figure 11.25 the *Volume Rendering Viewer* allows to visualize scanned 3D data as a 3D “cloud” distribution within a 3D volume.

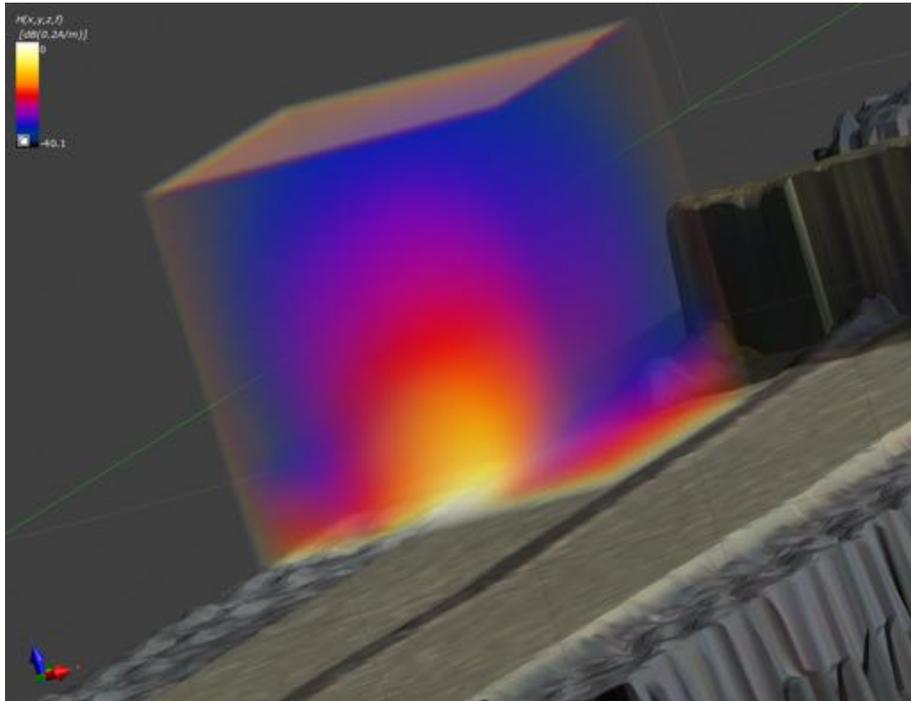


Figure 11.25: *Volume Rendering Viewer* showing a field cloud in a scanned volume.

The Properties and their meaning can be outlined as follows:

- **Pipeline Options**
 - The pipeline options are the same for all viewer types, as described in *Slice Viewer*.
- **Volume Rendering Options**
 - Volume rendering performs much faster when the field is sampled on a uniform grid.
 - Determine the resolution in X,Y and Z direction.
 - It is possible to clip the rendered field (checkbox) interactively, using the box tool. Drag the arrows to modify the clipping planes.
- **Field Data Options**
 - The data options are the same as for the *Slice Viewer*.
- **Snapshot Options**
 - When multiple time-steps or frequencies are available, as for

the *Slice Viewer*.

- **Visualization Options**

- The opacity transfer function used for volume rendering has a large impact on the visualization. To edit the opacity curve (or the color map), double click on the scalar bar in the 3D window.
- Determine the opacity by clicking on the red curve and dragging the handles (squares).

11.9.12 Vector Field Viewer

As shown in the animation snapshot in Figure 11.26 the *Vector Field Viewer* allows to visualize scanned 3D data in an arbitrarily located plane, through a vector field representation. In its default setup, the plane is oriented normal to one of the Cartesian axis.

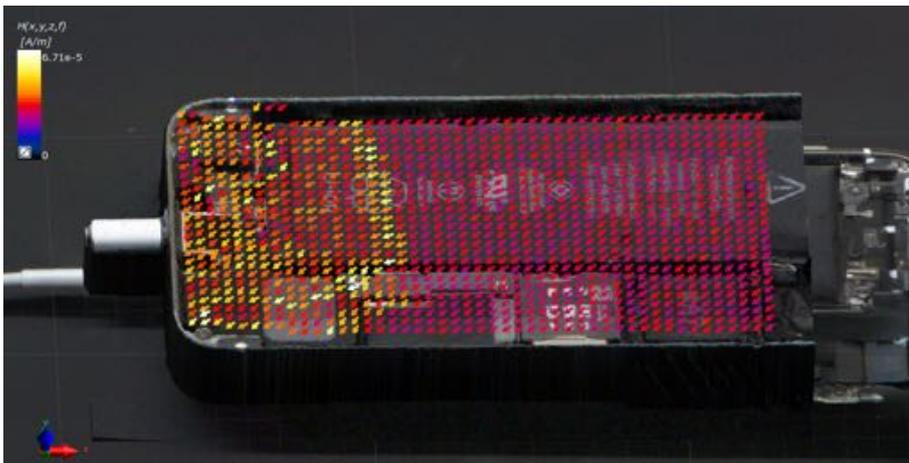


Figure 11.26: *Vector Field Viewer* showing a vector field.

The *Properties* and their meaning can be outlined as follows:

- **Pipeline Options**

- The pipeline options are the same for all viewer types.

- **Vector Field Options**

- *Arrow Size* is a scaling factor that allows the user to specify the size of the arrows. It usually scales on the basis of the resolution, but the user can also choose to have the size locked by clicking the lock icon next to it.
- *Scale Arrows*, *Simple Arrows* and *Interactive* are three checkboxes the user can use to customize visualization: *Scale Arrows* allows to visualize arrows having their size proportional to field intensity in that point; *Simple Arrows* switch the

arrows to be represented by a simple cone, while *Interactive* allows the user to interactively specify the visualization plane.

- *Seed Source* allows the user to switch between a plane and a line source, having the possibility to enter in the first case plane center and plane normal coordinates, while in the second case, start and end point coordinates; in both cases also the resolution (number of arrows per line/plane side -1).

- **Field Data Options**

- The data options are the same as for the slice viewer.

- **Visualization Options**

- The visualization options are the same as for the surface viewer.

11.9.13 Streamline Viewer

As shown in Figure 11.27 the *Streamline Viewer* allows to visualize scanned 3D data in the form of streamlines.

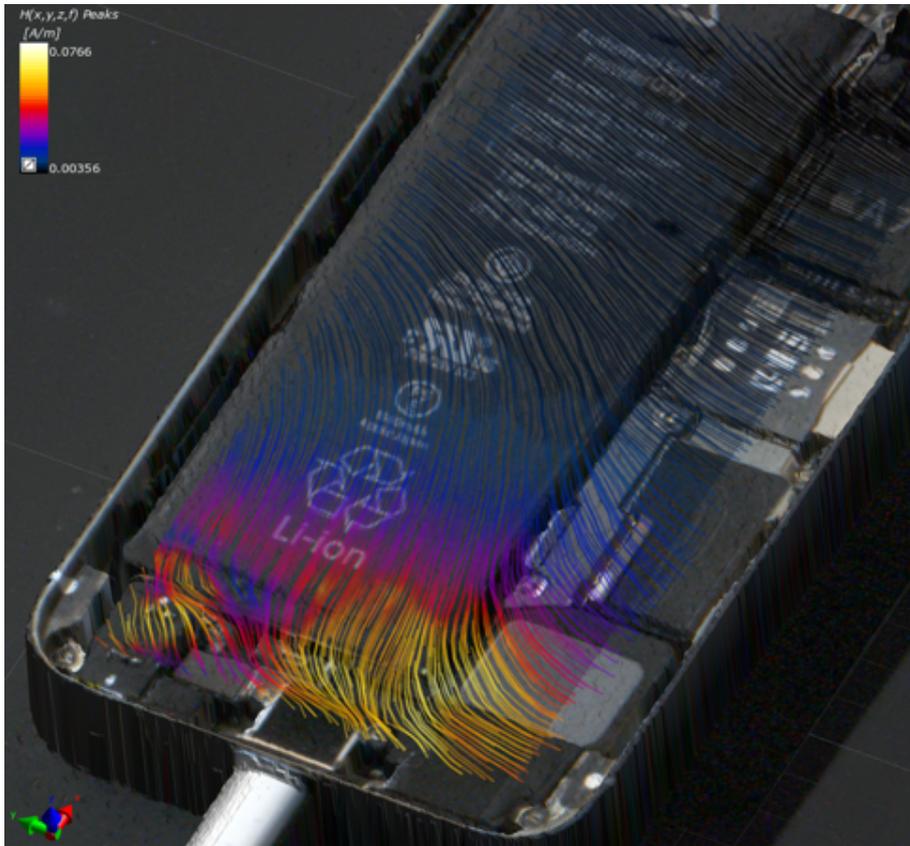


Figure 11.27: *Streamline Viewer* visualizing Magnetic Field as streamlines.

The Properties and their meaning can be outlined as follows:

- **Pipeline Options**

- The pipeline options are the same for all viewer types.

- **Stream Line Options**

- Streamlines are a family of curves that are instantaneously tangent to a vector field. The lines are obtained via pseudo time-integration along the vector direction.
- The integration direction can be chosen (forward/backward/both). The number of samples influences how accurately the lines follow the field. The length corresponds to a pseudo integration time (higher values result in longer streamlines).
- The streamlines are generated from a variety of seed points, sampled in space. The user can choose between seed points along a line, a plane or within a box. The parameters of the line/plane/box can be set via interactive (checkbox) tools. In addition, there is an option to generate seed points on the surface of a model entity, via picking the model (Seed source

set to Model, interactive=ON).

- The lines can be visualized as tubes. This process is slightly more time consuming.

- **Snapshot Options**

- When multiple time-steps or frequencies are available, as for the slice viewer.

- **Visualization Options**

- Choose if the seed points should be shown.
- Specify rendering options, as for the slice viewer.

Chapter 12

2D Plots



Figure 12.1: Example 2D plot.

A *2D Plot* consists of:

- a *Header*,
- a *Marker List*,
- a *Display*,
- some *Context Menus* and
- configurable *Preferences*.

12.1 Header



Figure 12.2: Example 2D plot header.

A *Header* consists of:

- a *Plot Descriptor*,
- a *Data Buffer Selector*,
- a *Data Legend*.
- and a *Display Legend*.

12.1.1 Plot Descriptor

This is an optional 3 line description of the current plot.

In Figure 12.2 it is 2 lines:

- *iPhone 5s GSM900...*,
- *Position (x,y,z)...*,

12.1.2 Data Buffer Selector



Figure 12.3: Header data buffer selector, with 3 datasets. The second is currently selected. The second also has 2 markers.

Data buffers are labelled from 1 to N.

The **Data Buffer Selector** allows for the selection of a data buffer using the mouse cursor.

Data buffers can also have *Markers*, and so this mechanism also allows for the selection of *Markers* attached to the selected data buffer.

Marker selectors are positioned directly below the data buffers, also labelled from 1 to N, which corresponds to their labelling in *Display*. *Markers are limited to 15 per dataset*.

Hovering over the data buffer will temporarily display the hovered-over dataset name in the *Data Legend*.

Hovering over the *Marker* selector will:

- temporarily display the hovered-over *Marker* information in the *Data Legend*,
- temporarily highlight the *Marker* in the *Display*,
- temporarily highlight the *Marker* in the *Marker List* (when enabled).

A single left-click with the mouse cursor selects the data buffer. *When data is selected, it is visually emphasized by being plotted in a thicker line above all other data in the **Display**.*

A single right-click with the mouse cursor on the data buffer enables the selected buffer's *Data Context Menu*.

A single right-click with the mouse cursor on the *Marker* selector enables the selected marker's *Marker Context Menu*.

12.1.3 Data Legend



Figure 12.4: Header Data Legend showing the name of the currently selected data.

The **Data Legend** displays the name of the data in the buffer currently selected or hovered-over.

It also displays the *Marker* information when the *Marker* selector is hovered over.

A single right-click with the mouse cursor enables the selected buffer's *Data Context Menu*.

12.1.4 Display Legend



Figure 12.5: Header Display Legend.

The Header *Display Legend* displays:

- the *left Y-axis* quantity currently described by the data represented on the *left Y-axis*. This data is rendered as a **solid** line in the *Display*.
- The *right Y-axis* quantity currently described by the data represented on the *right Y-axis*. This data is rendered as a **stippled** line in the *Display*.
- The current *Tracking Modes*.

A single right-click with the mouse cursor on each one of these items enables the items context menu for easy modification.

12.2 Marker List



Figure 12.6: 2D Plot marker list.

When configured from the *Marker Context Menu*, the **Marker List** can:

- be disabled,
- display selected dataset *Marker* values,
- display all dataset *Marker* values.

Hovering over a *Marker* selector in the list will:

- temporarily display the hovered-over *Marker* information in the *Data Legend*,
- temporarily highlight the *Marker* selector in the *Data Buffer Selector*.
- temporarily select the marker's associated dataset in the *Display*,
- temporarily highlight the *Marker* in the *Display*.

A single right-click with the mouse cursor on the marker selector will bring up the *Marker Context Menu*.

12.3 Display

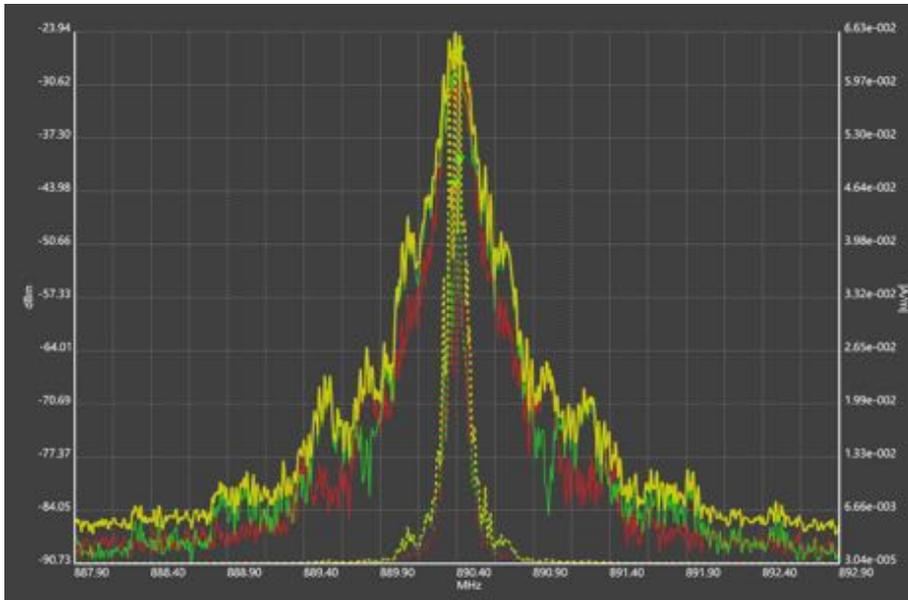


Figure 12.7: Example 2D Plot display.

The **Display** can render three quantities of data simultaneously, including *Markers*.

The *left Y-axis* indicates range for quantities in *Y* rendered with **solid** lines. The *right Y-axis* indicates range for quantities in *Y* rendered with **stippled** lines. The *X-axis* indicates range for all quantities in *X*.

Selection is achieved via the mouse cursor as described in *Selection*.

Tracking is achieved via mouse cursor as described in *Tracking Modes*.

The *Display Context Menu* provides the following functions (enabled via *right-clicking* anywhere on the **Display**):

- *Axes Quantity Selection.*
- *Marker placement.*
- *Zoom Rubber Band.*
- *Manual Range Rubber Band.*
- *Tracking Modes.*
- *Log Scale.*
- *Save to Image.*
- *Preferences.*

12.3.1 Marker

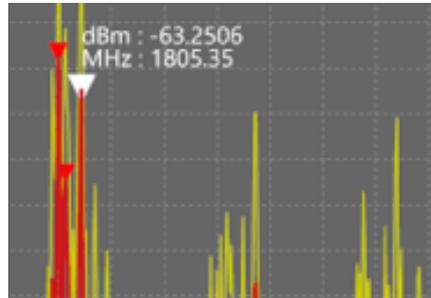


Figure 12.8: Marker #2.

A **Marker** marks a position of data in a dataset in the *Display*, based on the currently tracked XY value of the tracker. Each quantity for the data at that position is marked. This is evident when switching quantities in the *Display*.

The current **Marker** quantities are rendered in the *Marker List* (when enabled).

To place a **Marker**, track the selected dataset using one of the *Tracking Modes*, then right-click with the cursor to enable the *Display Context Menu*, and select *place marker*. A **Marker** is then placed at the desired position on the desired dataset.

12.3.2 Cursor

12.3.2.1 Selection

Positioning the cursor nearest the data followed by a **single left-click** will select the data. All functions related to that particular dataset can now be accessed.

Positioning the cursor on the *Marker* center followed by a **single right-cursor-press** will select the marker **as long as the cursor is kept pressed**. Markers can be **moved by cursor** this way, until the button release. The release will then signal the complete right-click, at which point the *Marker Context Menu* appears at the current cursor position in the *Display*.

12.3.2.2 Panning & Zooming

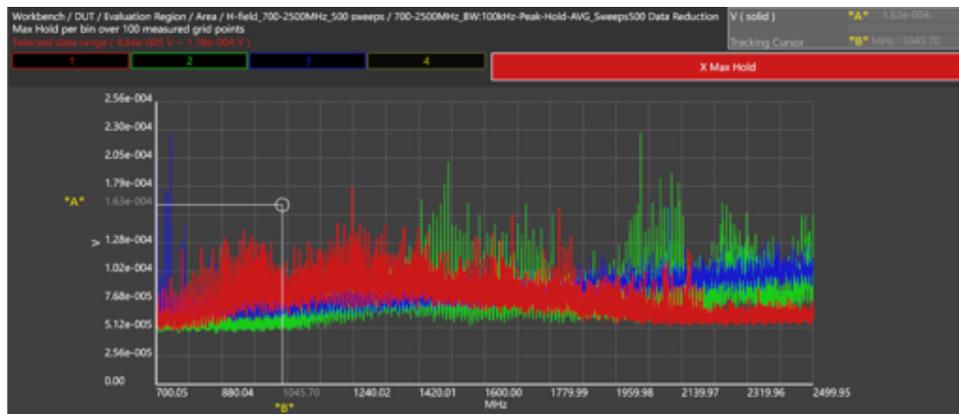
Panning of the display can be initiated by *mouse wheel press*. Keeping the mouse wheel pressed whilst *moving* the cursor will pan the *Display* with the cursor.

Zooming of the display can be done by *scrolling the mouse wheel* forward and backward.

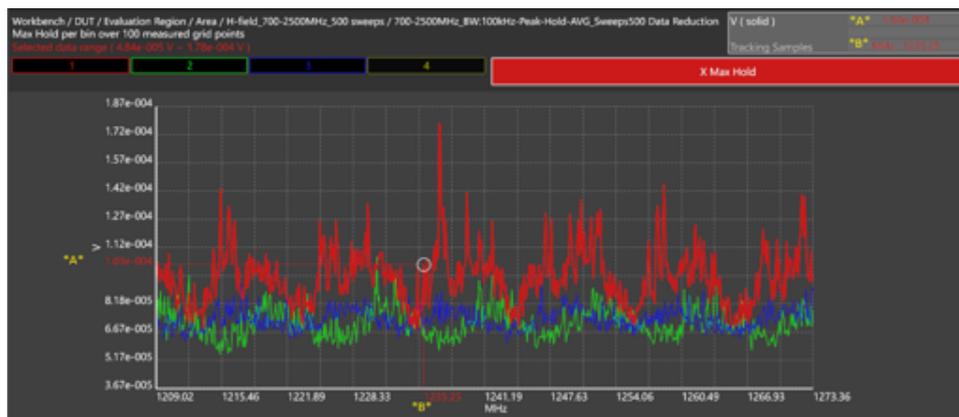
12.3.2.3 Tracking Modes

The *Display* supports the following cursor **Tracking Modes** on the currently selected dataset:

Cursor displays the X and Y value at the cursor position of the *Display*. No selected dataset is required. *A* and *B* represent the tracked values of the Y and X axes respectively, with the center of the circle representing the actual point.



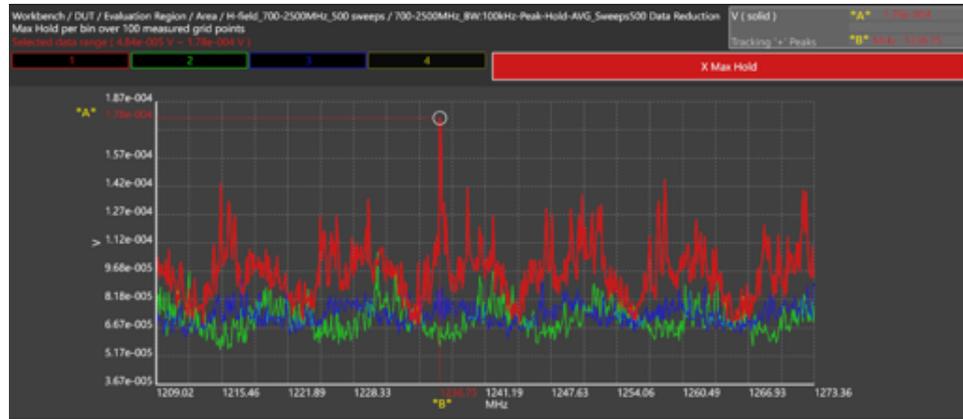
Sample snaps to the data sample closest to the mouse cursor with respect to x-axis *of the selected dataset*. *A* and *B* represent the tracked values of the Y and X axes respectively, with the center of the circle representing the actual point



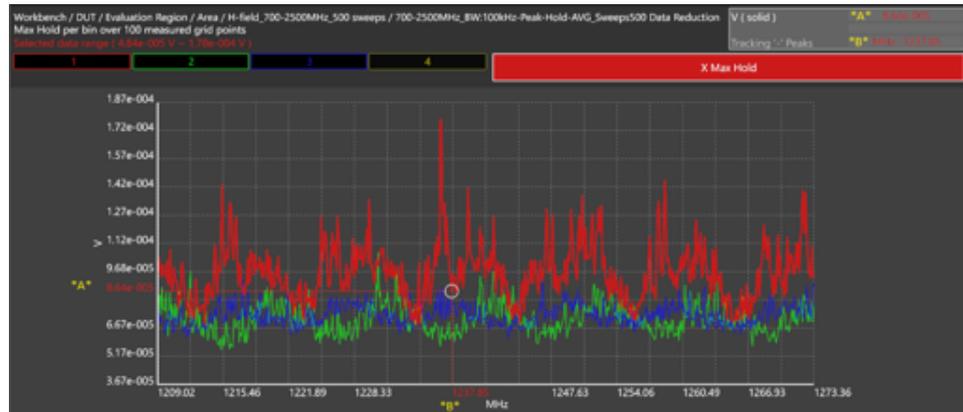
Positive Peak snaps to the closest local peak to the mouse cursor's x-axis coordinate *of the selected dataset*. *A* and *B* represent the tracked

12.3. DISPLAY

values of the Y and X axes respectively, with the center of the circle representing the actual point



Negative Peak snaps to the closest local minimum to the mouse cursor's x-axis coordinate *of the selected dataset*. *A* and *B* represent the tracked values of the Y and X axes respectively, with the center of the circle representing the actual point



12.3.3 Quantity Selection

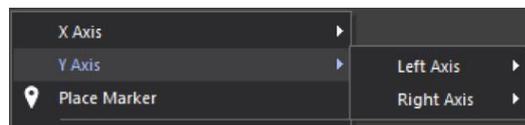


Figure 12.9: Axes Quantity Selection

Figure 12.9 illustrates how quantities are selected for all axes in *Display*.

Alternately, the Y-axes can also be configured as described in *Display Legend*.

12.3.4 Zoom Rubber Band

The **Zoom Rubber Band Tool** zooms the *Display* using rubber band selection to an approximate selected area.

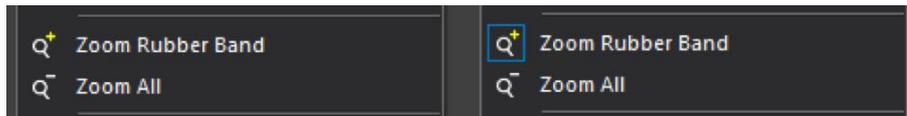


Figure 12.10: *Zoom Rubber Band* tool disabled (left), enabled (right).

The **Zoom Rubber Band Tool** has the following controls:

- *Enable/Disable* by right-clicking **Zoom Rubber Band**, as illustrated in Figure 12.10.
- *Reset* by right-clicking *Zoom All*.
- **Alternately Reset** by double-left-clicking anywhere in the display when the plot is not manually ranged.

When enabled, the mouse cursor will be in **Zoom Rubber Band Mode**. Right-press the mouse cursor on the desired starting point, drag until the rubber band covers the area to zoom to, then release. The effect is illustrated in Figure 12.11.

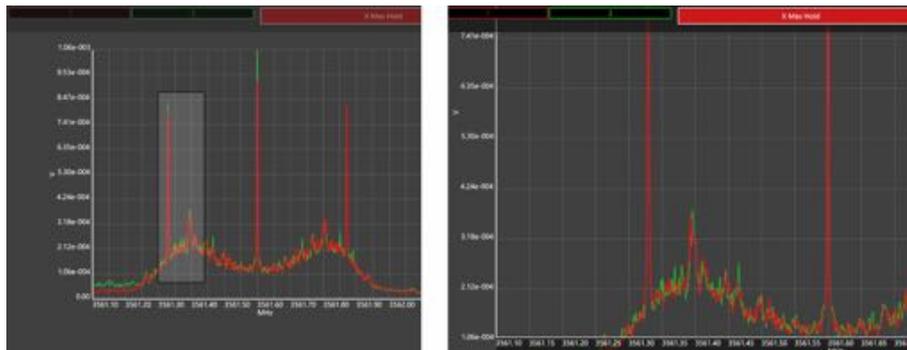


Figure 12.11: Zoom selection (left), zoomed result (right).

12.3.5 Manual Range Rubber Band

The **Manual Range Rubber Band Tool** sets the *Manual Data Ranges* of all axes of the *Display* using rubber band selection.



Figure 12.12: *Manual Range Rubber Band* tool disabled (left), enabled (right).

The **Manual Range Rubber Band Tool** has the following controls:

- *Enable/Disable* by right-clicking **Manual Range Rubber Band**, as illustrated in Figure 12.12.
- **Alternately Enable** by left-press the cursor on the start location, followed by dragging the cursor to the desired release location, followed by releasing the cursor.
- *Reset* by right-clicking *Range All*.
- **Alternately Reset** by double-left-clicking anywhere in the display when the plot is not manually ranged.

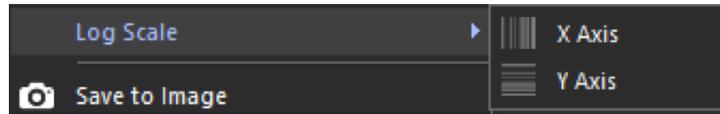
When enabled, the mouse cursor will be in **Zoom Rubber Band Mode**. Right-press the mouse cursor on the desired starting point, drag until the rubber band covers the area whose values should be applied to *Manual Data Ranges*, then release. The effect is illustrated in Figure 12.13.



Figure 12.13: Axes Range selection (left), Axes Range result (right).

12.3.6 Log Scale

The X and Y axes can display data scaled in base-10 logarithm form. These can be enabled as illustrated in Figure 12.14.

Figure 12.14: *Log Scale* and *Save to Image*.

12.3.7 Save to Image

The current *2D Plot Window* can be saved in its current state to an image file on disk. Figure 12.14 illustrates this function.

12.4 Context Menus

12.4.1 Data Context Menu

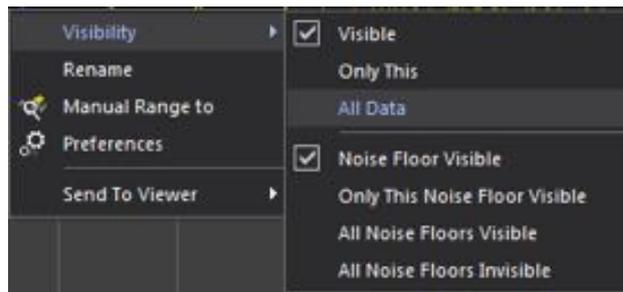


Figure 12.15: Context menu for data.

Visibility acts on datasets in the following way:

Visible Enable/disable visibility of selected dataset.

Only This Only this dataset is made visible, all others are made invisible.

All Data All datasets are made visible.

Noise Floor Visible Enable/disable visibility of selected dataset's noise floor.

Only This Noise Floor Visible Only this dataset's noise floor is made visible, all others are made invisible.

All Noise Floors Visible All datasets' noise floors are made visible.

All Noise Floors Invisible All datasets' noise floors are made invisible.

Rename allows one to rename the selected dataset.

Manual Range to sets the *Manual Data Ranges* of all axes of the *Display* to the range of the selected dataset.

12.4. CONTEXT MENUS

Preferences pops up a dialog that allows editing of preferences for the selected dataset only, as illustrated in Figure 12.16.

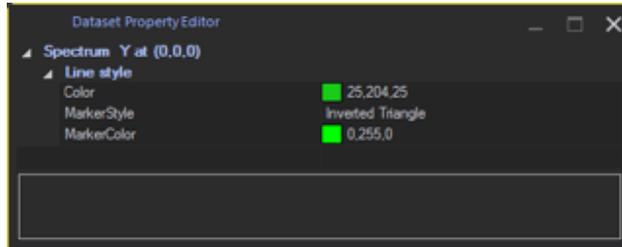


Figure 12.16: Selected data preferences.

12.4.2 Marker Context Menu

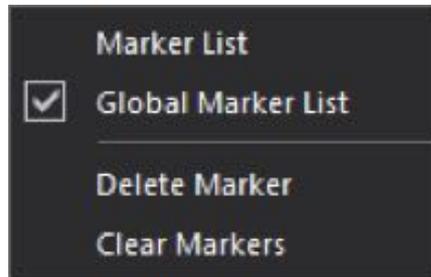


Figure 12.17: Context menu for a *Marker*.

As described in *Marker List*, the state of the *Marker List* can be configured with this menu.

Delete Marker will delete the currently selected *Marker*.

Clear Markers will delete all *Markers* present.

12.4.3 Display Context Menu



Figure 12.18: Context menu for *Display*.

The **Display Context Menu** provides the following functions (enabled via *right-clicking* anywhere on the **Display**):

- *Axes Quantity Selection.*
- *Marker placement.*
- *Zoom Rubber Band.*
- *Manual Range Rubber Band.*
- *Tracking Modes.*
- *Log Scale.*
- *Save to Image.*
- *Preferences.*

12.5 Preferences

Preferences allow preferred settings for a number of items in the *2D Plots*. The most important of these include:

- *Axes Manual Data Ranges*, for all available quantities.

- *Use Center/Span display for X.*
- *Show Full Values when Tracking.*
- All dataset preferences, as illustrated for the selected dataset in Figure 12.16.

12.5.1 Manual Data Ranges

For a displayed quantity, these include:

- *Min* : Minimum value of axis.
- *Max* : Maximum value of axis.
- *Enabled* : If enabled, the *Min* and *Max* are used. If disabled, the auto-range is used.

Part III

System Operation

Chapter 13

ICEy-mmW: Walkthrough

This chapter contains a step-by-step measurement example millimeter wave measurement of a DUT (horn antenna) operating at 60 GHz. It includes only the minimum needed for performing a measurement. Further details are given in the other chapters.

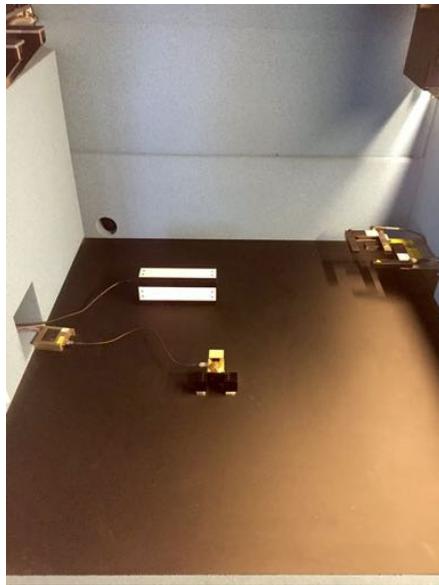
13.1 Probe and DUT Setup

Install the DUT in the scannable area on the workbench (see Figure 13.1a) and install the EUmmW probe connected to the DAE4ICEy as shown in Figure 13.1b. Activate the DAE4ICEy as shown in Figure 13.2

13.2 Application Start and Workbench Acquisition

Please consult Chapter 18, Sections 18.1 to 18.2.2 on how to start the ICEy application and setup the work bench and DUT.

13.2. APPLICATION START AND WORKBENCH ACQUISITION



(a) Millimeter wave horn antenna positioned on the ICEy workbench.



(b) The EUmmW probe positioned in slot 1 of the ICEy system.

Figure 13.1: DUT and probe setup inside the ICEy testbed.



(a) Identify the button on the front side of the DAE4ICEy .



(b) Press and release the button.



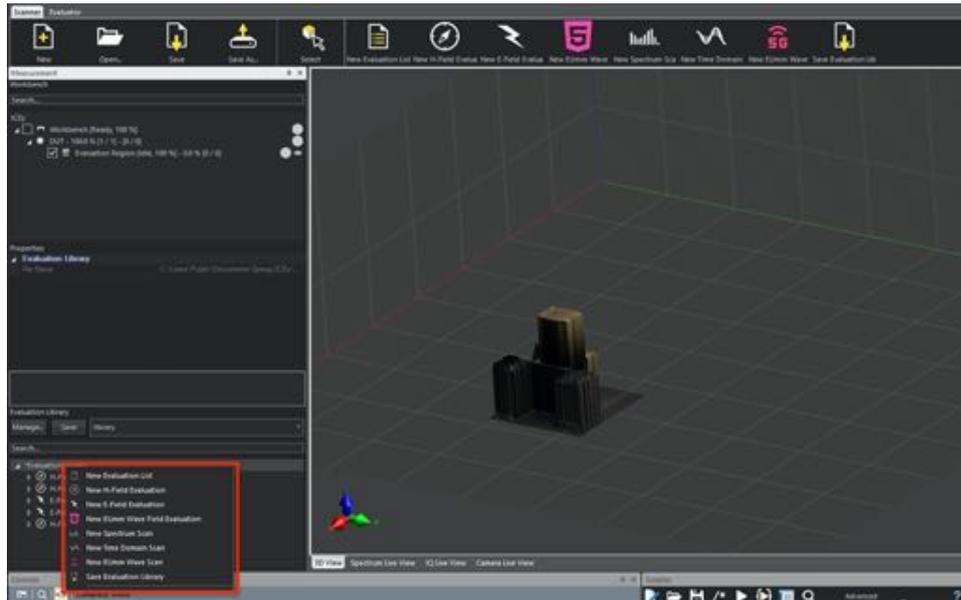
(c) After approximately 2 seconds the LED will light up shortly. Now the DAE4ICEy is activated. Note: the LED will be disabled again as the DAE4ICEy enters a power-saving standby mode.

Figure 13.2: Switching the DAE4ICEy on

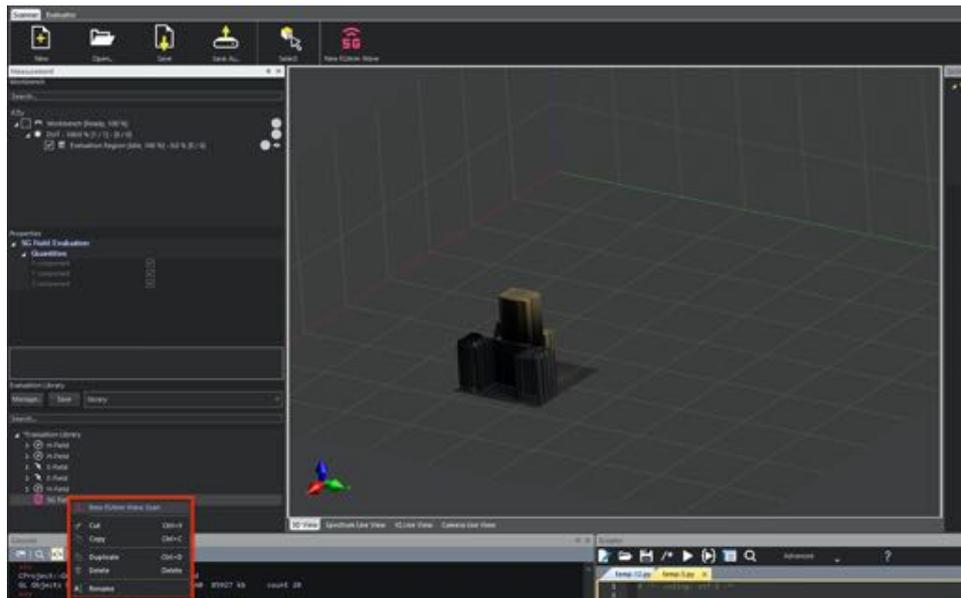
13.3 Millimeter Wave Measurement

13.3.1 Evaluation Setup

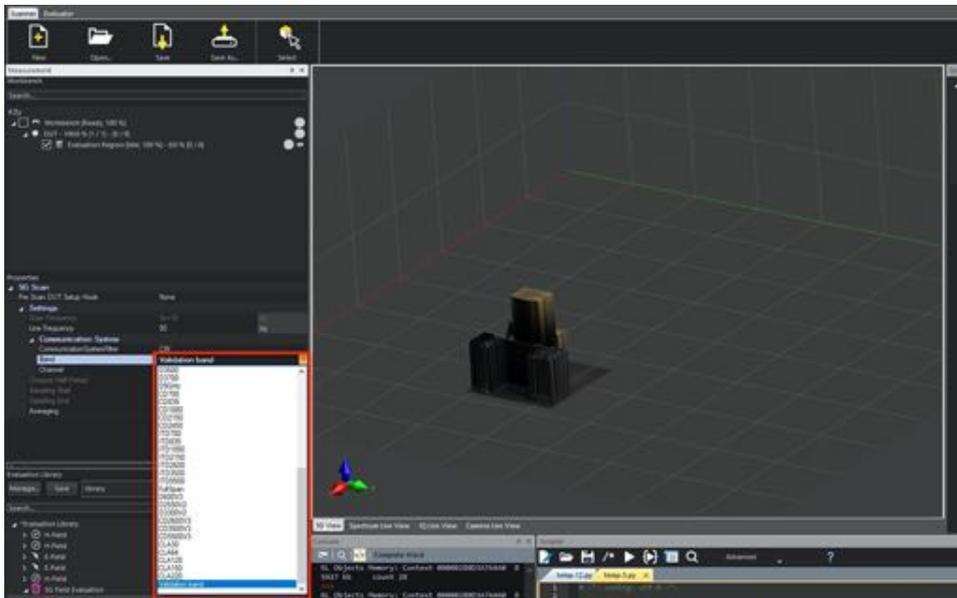
The evaluation library setup has to be performed only once as evaluation libraries can be stored for later use. In order to add a new 5G millimeter wave evaluation to the library right-click on the evaluation library root and select New EUmm Wave Field Evaluation:



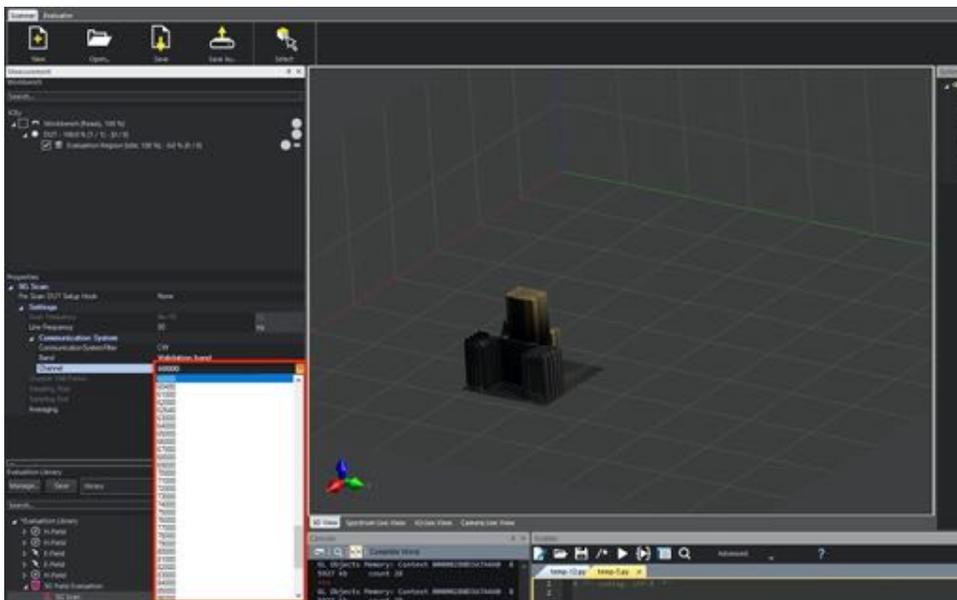
Now you can add a New EUmm Wave Scan to the evaluation:



Configure the scan properties, by selecting the communication system (in this example CW) and selecting a band (Validation Band):



In the validation band, select the desired frequency (60000 corresponds to 60000 MHz, 60 GHz.):

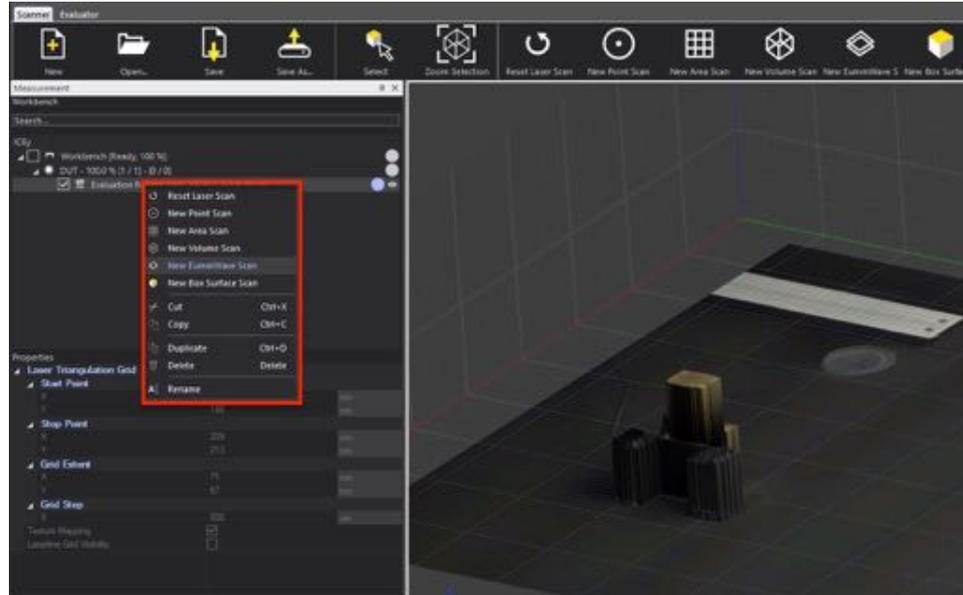


As a last step save the evaluation library to re-use the evaluation at a later point in time.

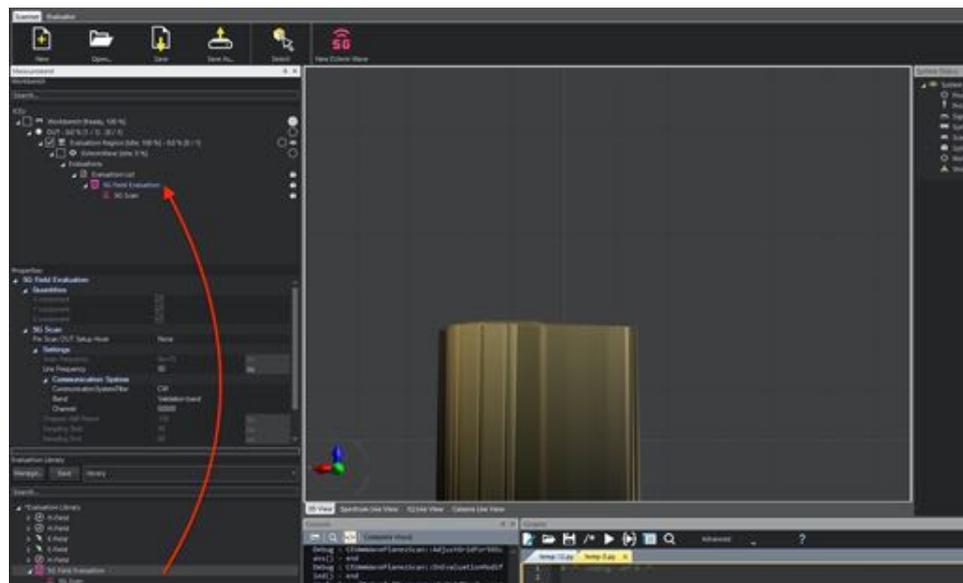
13.3. MILLIMETER WAVE MEASUREMENT

13.3.2 Scan Setup

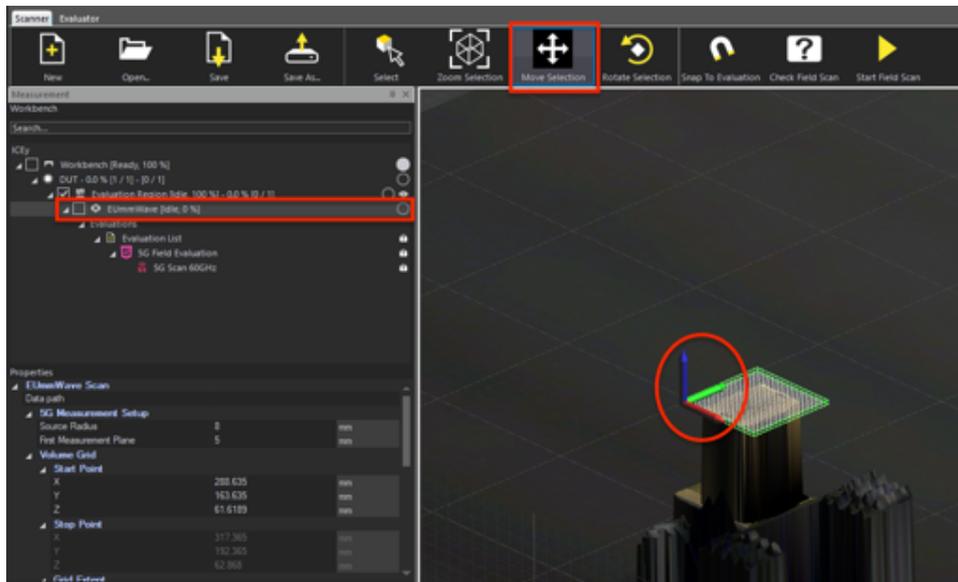
In the Workbench right-click on the completed 3D reconstruction LASER scan of the DUT and select New EummWave Scan:



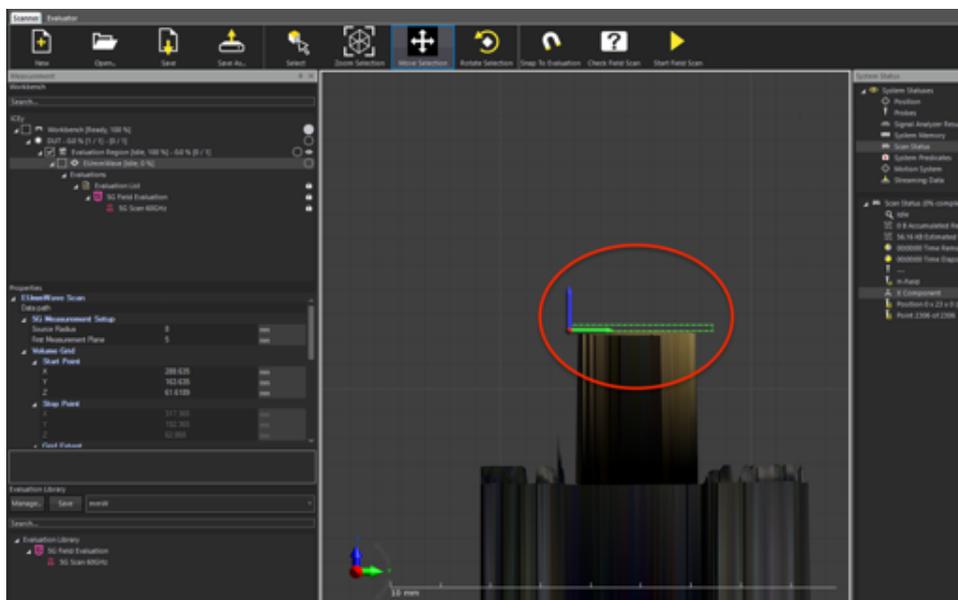
Drag the 5G Evaluation from the Evaluation Library into the Evaluations branch of the scan. It is important to complete this step now as the evaluation setting influence the grid generation.



Select the scan and move the scan using Move Selection to cover the entire emitting region. You may increase the Source Radius in the properties of the EUMmWave Scan to increase the scan grid:

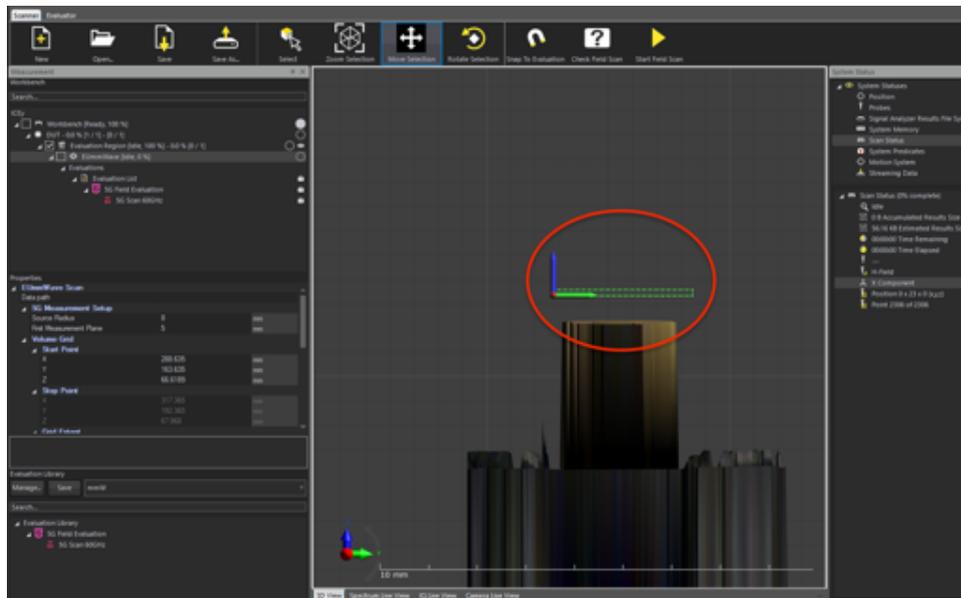
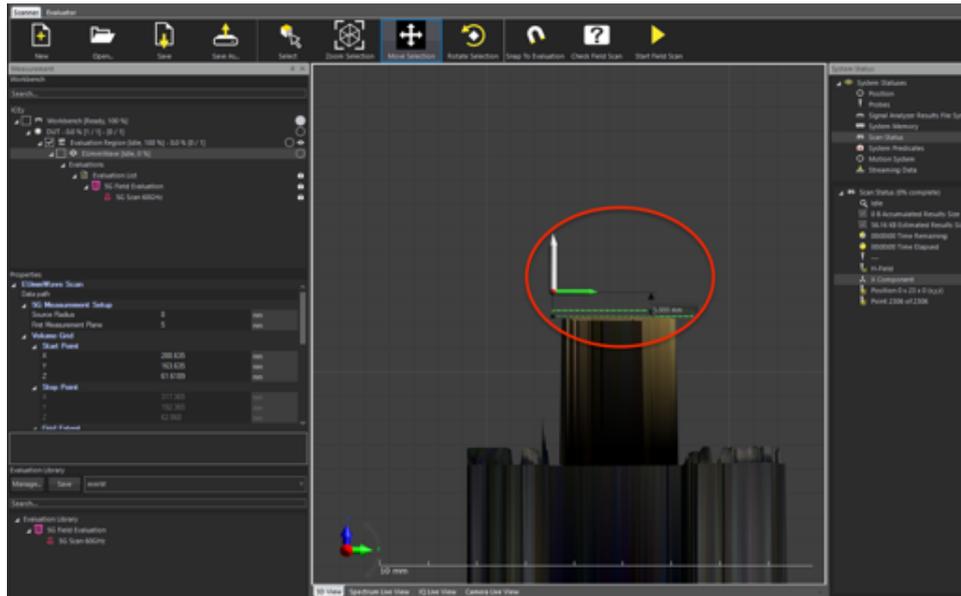


Select an x,z or y,z-view to modify the z-distance of the scan such that it touches the transmitter surface:

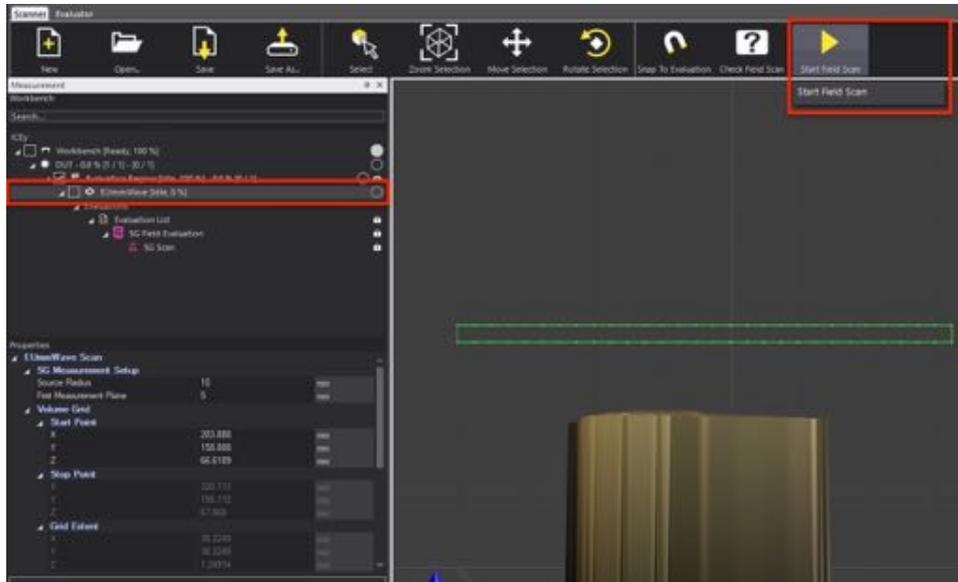


13.3. MILLIMETER WAVE MEASUREMENT

Move the scan up in z by ≥ 2 mm (the minimum reconstruction distance). Set the property **First Measurement Plane** to approximately the distance between the transmitting structure and the first measurement plane. If the transmitter is placed on the surface of the DUT this corresponds to the distance you moved the scan up in the previous step. If the transmitting structure is inside the DUT, then add the buried distance as well.



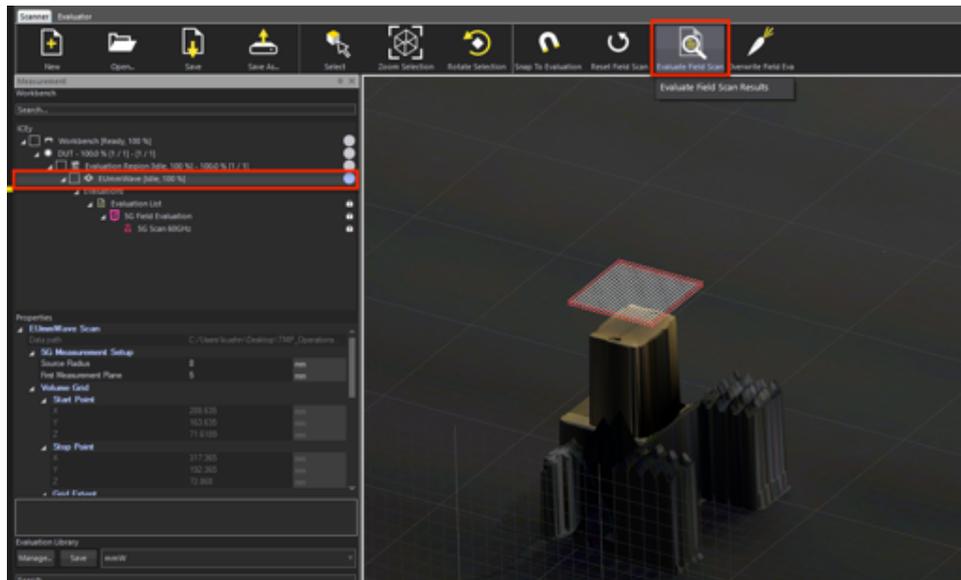
Select the scan and start it:



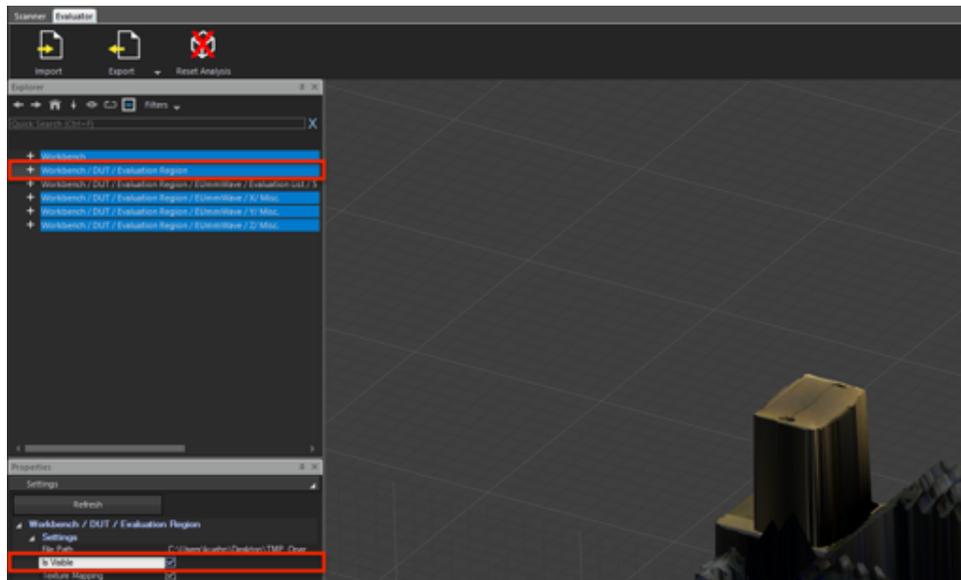
13.3. MILLIMETER WAVE MEASUREMENT

13.3.3 Post-Processing

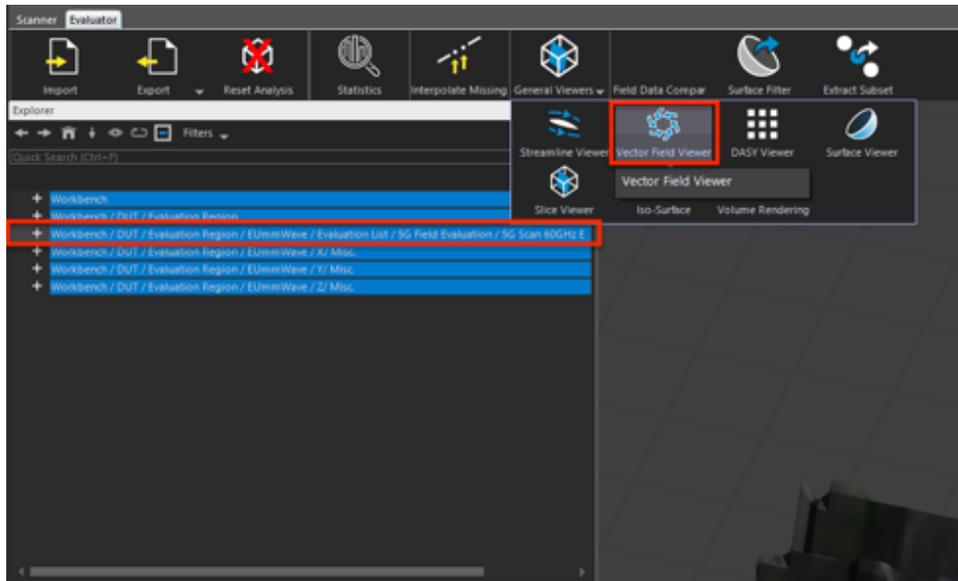
To start the post-processing of the data, select the EUmW Scan in scanner mode and click Evaluate Field Scan Results.



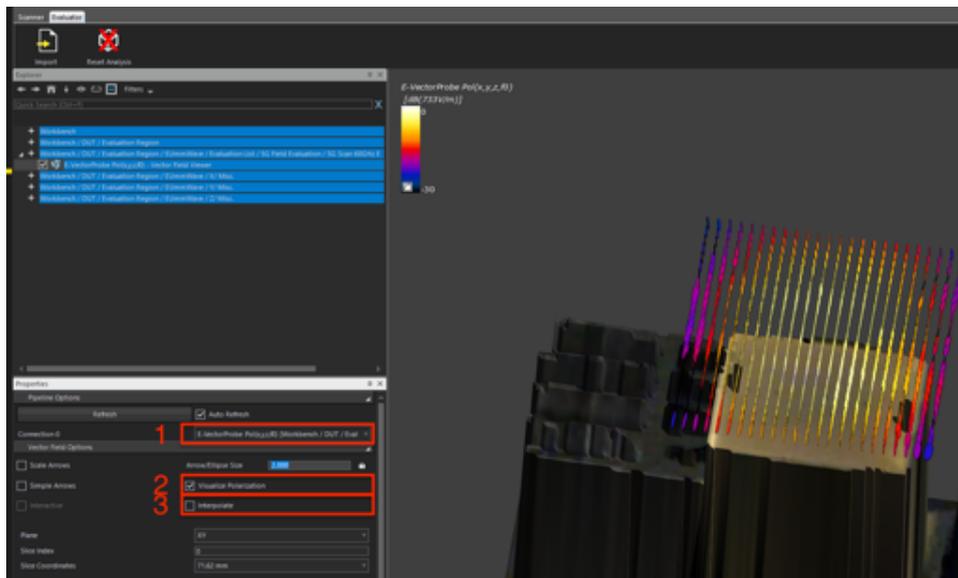
Switch to post-processing mode and select the Evaluation Region and activate Is Visible to permanently show the 3D model of the DUT.



Select the EUmW evaluation in the Explorer and attach a Vector Field Viewer to it:

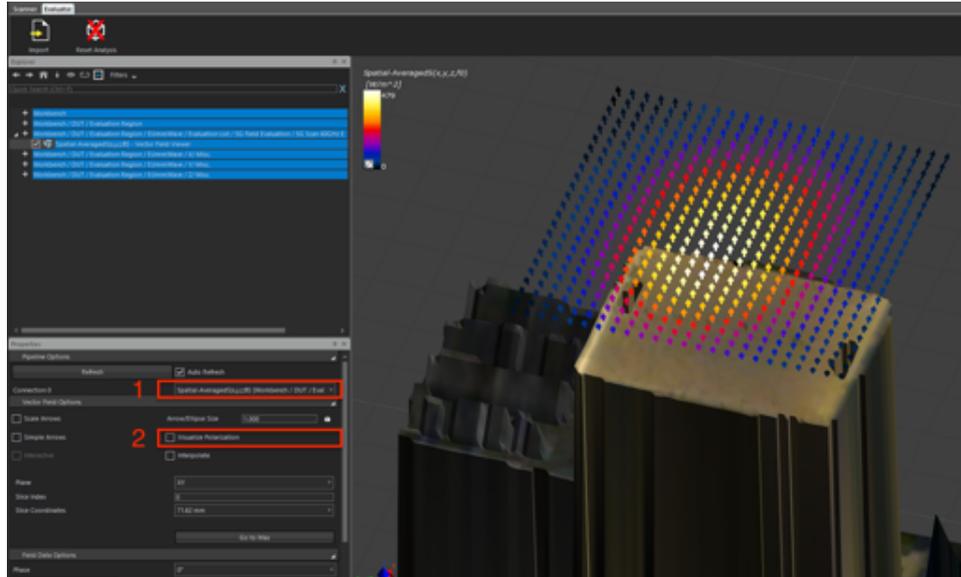


You can now visualize the reconstructed polarization field by selecting E-VectorProbe Pol(x,y,z,f0) as input connection (1). Untick Interpolate (3) and enable Visualize Polarization (2):

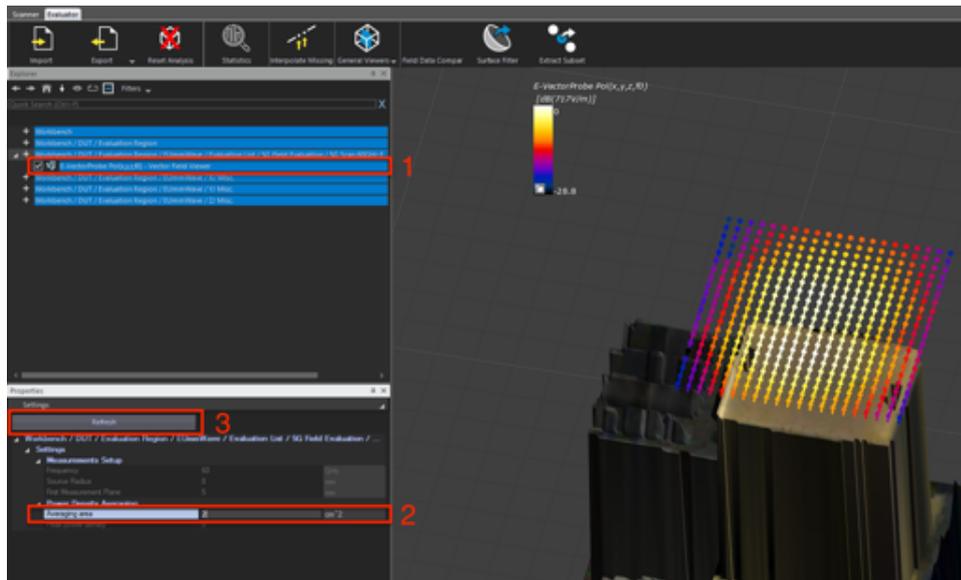


13.3. MILLIMETER WAVE MEASUREMENT

In order to view the surface averaged power density select $\text{Spatial-AveragedS}(x,y,z,f_0)$ as input connection (1) and untick $\text{Visualize Polarization}$ (2) to see the Poynting Vector:



You can change the averaging area by selecting the EUmmW evaluation in the Explorer (1) and then modifying the Averaging area (2) and updating the Viewer by clicking Refresh:



Chapter 14

ICEy-mmW: Verification

This chapter contains a step-by-step measurement example of a millimeter wave measurement of SPEAGs 30 GHz Verification Source. It includes only the minimum needed for performing a measurement. Further details are given in the other chapters.

14.1 Probe Setup

Please consult chapter 13 on how to setup and install the probe.

14.2 Application Start and Workbench Acquisition

Please consult Chapter 18, Sections 18.1 to 18.2.2 on how to start the ICEy application and setup the work bench and DUT.

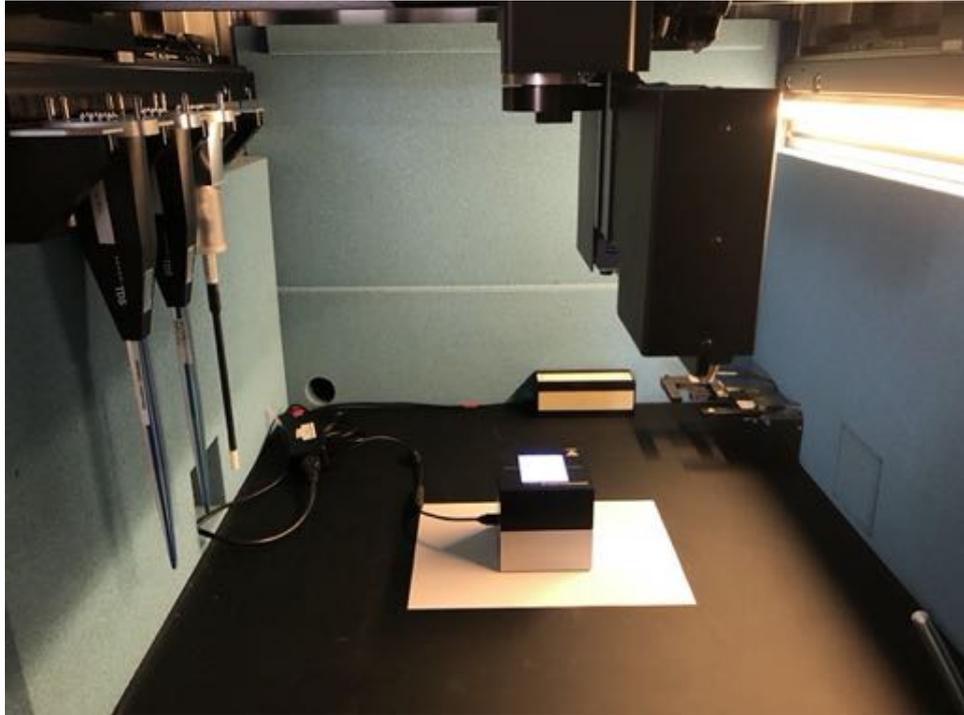
14.3 30 GHz Millimeter Wave Verification Source Measurement

14.3.1 Evaluation Library Setup

Please consult chapter 13 for the setup of the evaluation library.

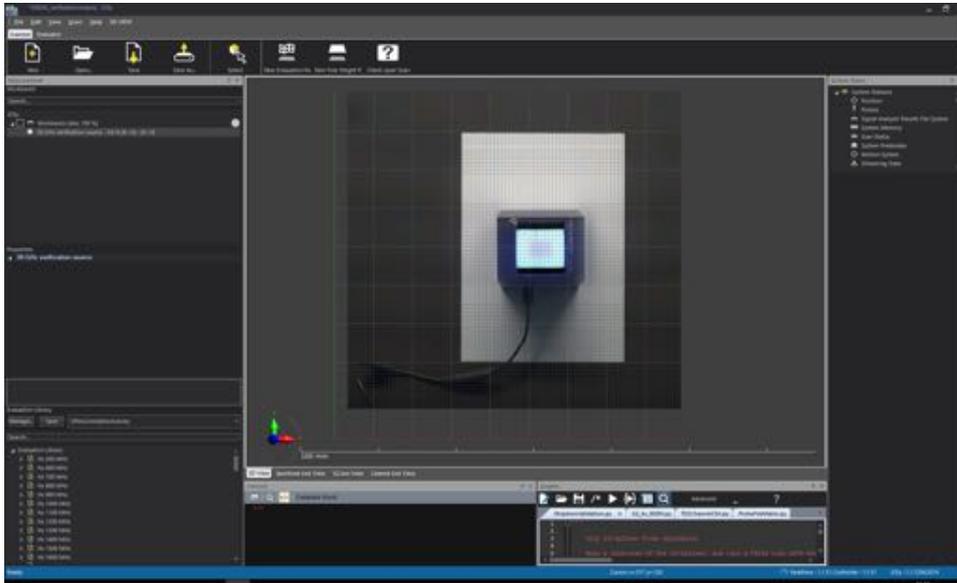
14.3. 30 GHZ MILLIMETER WAVE VERIFICATION SOURCE MEASUREMENT

14.3.2 Source and Measurement Setup

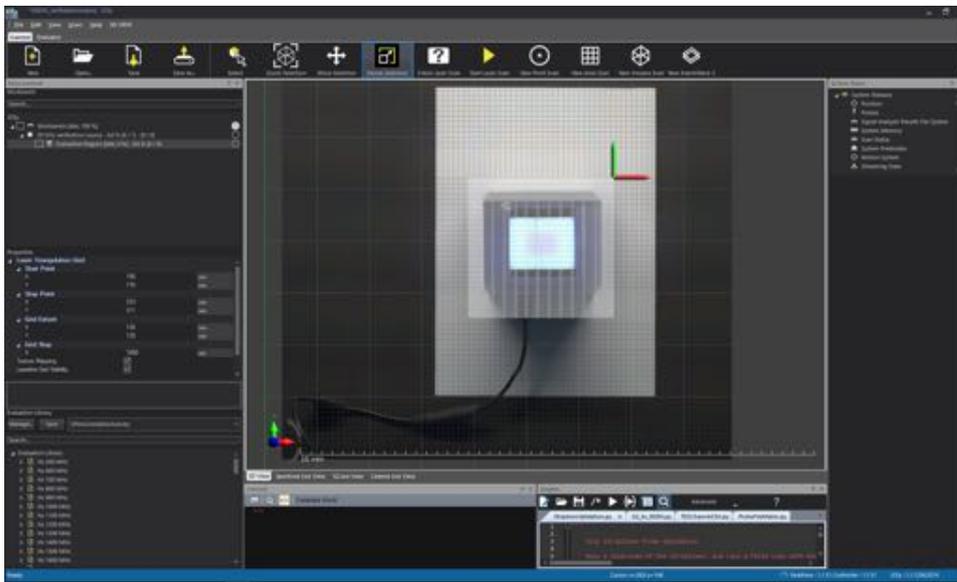


Place the verification source approximately in the center of the workbench and align it with the x,y-coordinate system of the scanner. It is recommend to put a sheet of white paper below the source in order to differentiate it better in the camera scan from the black workbench floor.

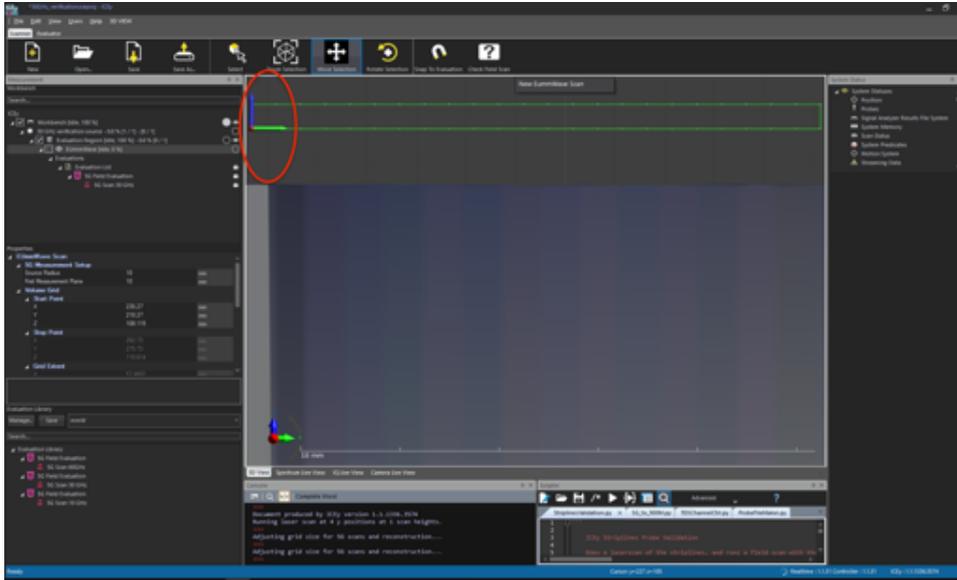
14.3.3 Scan Setup



Perform a camera scan and create a New DUT named 30 GHz Verification Source.



Setup a new Evaluation Region covering the entire verification source and start the 3D reconstruction using Start LASER Scan.



Move the grid up in z by 5.55 mm. To do so, select the blue arrow (for z) and type 5.55 mm in the numeric box next to it. This ensures that the first measurement plane is at 10 mm from the horn inside the source, corresponding to the plane during the calibration. You can now select the scan and start it.

*14.3. 30 GHZ MILLIMETER WAVE VERIFICATION SOURCE
MEASUREMENT*

14.3.4 Post-Processing

Please consult chapter 13 on how to post-process the data.

Chapter 15

ICE y -mmW: Measurement Uncertainty Budget

15.1 Uncertainty

The uncertainty budget shown in Table 15.1 for ICE y -mmW has been adapted from the IEC62209 standard series and is consistent with the current draft of the IEC106 WG10 report. The budget is preliminary estimated on current knowledge. A more substantiated uncertainty budget will be developed over the next couple of months. It is assumed to be applicable for all laboratories using ICE y -mmW provided the following requirements are met:

- the system is used by an experienced engineer who follows the manual and the guidelines taught during the training provided by SPEAG,
- the probe has been calibrated including probe modulation response parameters for the systems under test within the requested period,
- the corresponding system verification source has been calibrated within the requested period and the system performance check has been successful,
- the DAE unit has been calibrated within the requested period,
- the evaluation distance to the antenna is $> \lambda/2\pi$. If smaller, a greater uncertainty needs to be applied for the reconstruction,
- the reflection and noise has been confirmed to be below 0.21 dB,
- if the EUT is connected to a power supply, the EUT has been properly grounded.

Preliminary ICE_y-mmW Uncertainty Budget Evaluation Distances to the Antennas $> \lambda/2\pi$ Based on the 62209 Standard Family						
Error Description	Uncertainty Value (\pm dB)	Probability Distribution	Div.	(c_i)	Std. Unc. (\pm dB)	(v_i) v_{eff}
Measurement System						
Probe Calibration	0.49	N	1	1	0.49	∞
Hemispherical Isotropy	0.50	R	$\sqrt{3}$	1	0.29	∞
Linearity	0.20	R	$\sqrt{3}$	0	0	∞
System Detection Limits	0.04	R	$\sqrt{3}$	1	0.02	∞
Modulation Response	0.40	R	$\sqrt{3}$	1	0.23	∞
Resource Block Offset	0.1	R	$\sqrt{3}$	1	0.06	∞
Readout Electronics	0.03	N	1	1	0.03	∞
Response Time	0	R	$\sqrt{3}$	1	0	∞
Integration Time	0	R	$\sqrt{3}$	1	0	∞
RF Ambient Noise	0.04	R	$\sqrt{3}$	1	0.02	∞
RF Ambient Reflections	0.21	R	$\sqrt{3}$	1	0.12	∞
Probe Positioner	0.04	R	$\sqrt{3}$	1	0.02	∞
Probe Positioning	0.15	R	$\sqrt{3}$	1	0.08	∞
S _{avg} Reconstruction	0.60	R	$\sqrt{3}$	1	0.35	∞
Test Sample Related						
Power Drift	0.10	R	$\sqrt{3}$	1	0.06	∞
Input Power	0.27	N	1	0	0	∞
Combined Std. Uncertainty					0.73	∞
Expanded Std. Uncertainty					1.45	

Table 15.1: Preliminary uncertainty budget for ICE_y-mmW based on the IEC 62209 standard family and in compliance with the WG10 draft report. The budget is valid for evaluation distances $> \lambda/2\pi$. For specific tests and configurations, the uncertainty could be considerably smaller.

15.2 Probe Calibration Uncertainty

SPEAG conducts the probe calibration in compliance with international and national standards under ISO/IEC 17025. The probe is calibrated in the far-field over horn antennas. Each antenna is characterized for the E-field at the calibration distance. The field is determined by means of a three-antenna method with identical horns at different distances, evaluating the power over

a fine frequency raster, thereby reducing ripple caused by mismatches and reflections in the setup. In addition, the sensitivity factors are typically determined every 5 GHz and fitted to a 5-parameter-probe-sensor model by a least square technique. This further reduces the calibration uncertainty and provide a continuously valid calibration from 750 MHz to 110 GHz. The probe calibration uncertainty as stated in the calibration certificate does not exceed ± 0.49 dB ($k=1$) for any frequency between 750 MHz and 110 GHz.

15.3 Isotropy Uncertainty

The deviation from hemispherical isotropy is assessed during probe calibration and is typically below ± 0.5 dB.

15.4 Linearity

The probe dynamic response is a function of the diode RF voltage response which has been linearized over the specified dynamic range for CW, the uncertainty of which is evaluated during calibration. It is typically $< \pm 0.20$ dB. Please note that this uncertainty is part of the modulation uncertainty for modulated signals at therefore set to zero here.

15.5 System Detection Limits

System detection limit uncertainties may arise when the measured field strength is too close to the detection limit of the probe (i.e., probe sensitivity) and the associated system instrumentation. The uncertainty of detection limits is estimated to < 0.04 dB for the required minimal power density assessment level, i.e., $> 20\%$ of the applicable power density limits.

15.6 Modulation Response

The linearization as function of modulation has been determined using SPEAG's comprehensive SMC calibration method, the uncertainty of which is < 0.4 dB (i.e., 9.6%).

15.7 Readout Electronics Uncertainty

SPEAG DAE4ICEy is calibrated in its ISO/IEC 17025 laboratory. All uncertainties related to the probe readout electronics (DAE4ICEy unit), including the gain and linearity of the instrumentation amplifier, its loading effect on the probe, and accuracy of the signal conversion algorithm, have

been assessed accordingly to Clause 4 and Annex A of [IEEE]. The combination (root-sum-square RSS method) of these components results in an overall maximum error of ± 0.03 dB.

15.8 Response and Integration Time

The probe time response corresponds to lowpass filter of typically 30 Hz. The measurement protocol shall be selected that the uncertainty is negligible.

15.9 RF & ELF Ambient Noise

The probes are sensitive to ELF noise that needs to be carefully managed. In case of EUT connected to the mains supply, the EUT needs to be grounded to the shielding of the ICE y . RF noise should be avoided. The ambient noise can be evaluated by performing measurements using the same equipment setup as used for testing the EUT, with the main supply connected but the RF power source switched off. Ambient noise of less than 0.21 dB of the minimal required power density assessment level should be easily achievable.

15.10 RF Ambient Reflections

Reflections from the environment should be kept low, i.e., < 0.21 dB. For small separation distances from the EUT, this is easy achievable using the tools delivered from SPEAG and keeping possible reflectors in larger distances. At larger separation distances, i.e., > 50 mm, the effect on reflections needs to be carefully determined by a z-scan or measuring on at least two planes with $\lambda/4$ separation.

15.11 Probe Positioner

The mechanical tolerance of the field probe positioner can introduce probe positioning uncertainties. The uncertainty of ICE y for relative probe positioning is ± 25 μm resulting in an uncertainty of lower than 0.04 dB.

15.12 Probe Positioning

The probe positioning and surface reconstruction procedures affect the tolerance of the separation distance between the probe tip and the DUT surface. The error contribution for an accuracy of positioning of 0.1 mm at mm-Wave frequencies is estimated to be 0.3 dB/mm, i.e., 0.15 dB at 2 mm. At distances > 10 mm, this contribution is negligible.

15.13 Power Density Reconstruction Uncertainty

Reconstruction uncertainty for a given E-field input at measurement distances from source of $> \lambda/2\pi$ [pfeifer], [qbalzano] is less than 0.6 dB. In the far-field, the uncertainty contribution is negligible.

15.14 Power Drift

The power drift of the DUT may occur during the test. Typical value for SPEAG's verification sources is less than 0.1 dB (rectangular distribution). In case of EUT measurements, the drift shall be characterized by a point measurement before and after the test. It can also be monitored by a second probe or other sensor.

15.15 Input Power

Input power measurement from a source involves power measurement, power drift and power sensor noise. The coupling to the source is affected by the connector repeatability, the insertion loss of the adapter and variations due to the mismatch. Contribution to the uncertainty budget has been assessed to be 0.27 dB with a normal distribution. However for general EUT with integrated power source, this contribution is zero.

15.15. INPUT POWER

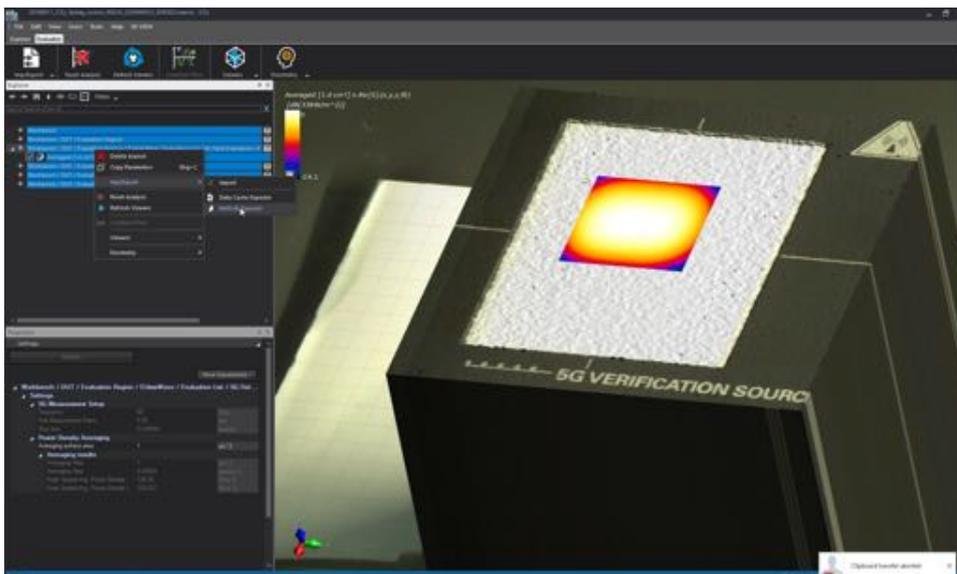
Chapter 16

ICE y -mmW: Result Export to Matlab and Python Import

This chapter contains a step-by-step description how to export mmW results to a MATLAB data format file and import such a data file in Python

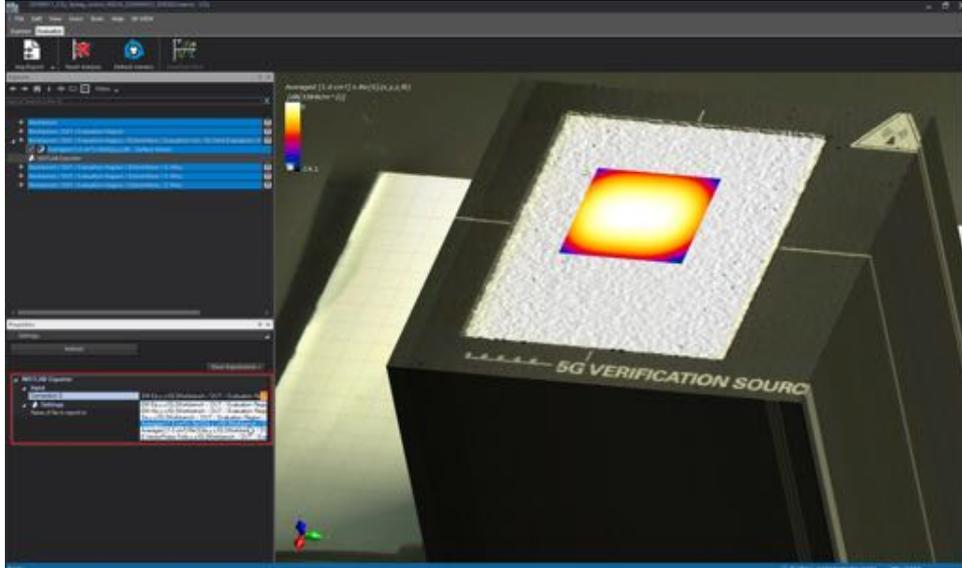
16.1 Export in ICE y Evaluator

To export to MATLAB right-click on the EUmW Scan in the Explorer of the ICE y Evaluator, navigate to Imp/Export and then to MATLAB Exporter:

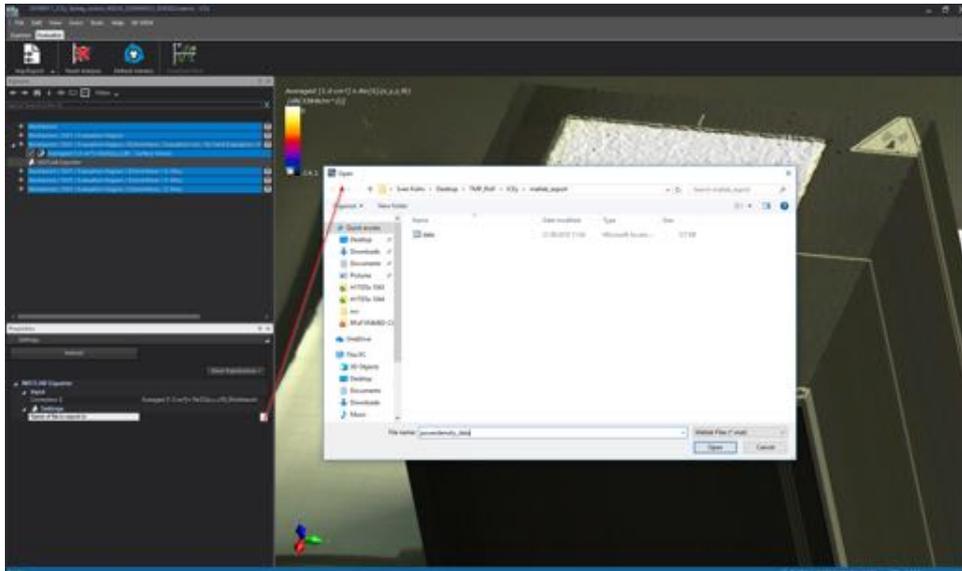


16.1. EXPORT IN ICEY EVALUATOR

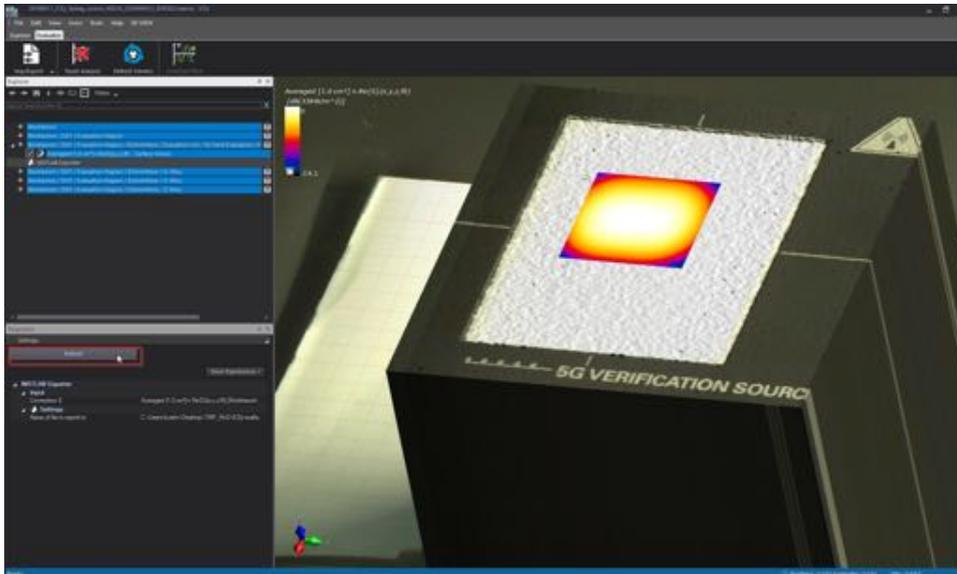
Select the newly created Explorer entry MATLAB Exporter. Under Properties select the quantity you want to export. (Surface Averaged Power Density in this example)



To define the export destination and file name click on ... and navigate in the dialog window to the destination folder and enter the export filename. Finally, click on Open



Note: the file is only actually written to disc once you click Refresh as shown below:



16.2 Import and plot ICEy MATLAB data in Python

The below Python script shows how to import and plot the exported ICEy data in Python using numpy, scipy and matplotlib. To use the example simply change the file path in the loadmat statement to point to your exported file.

```
import numpy as np
import scipy.io as sio
from matplotlib.mlab import griddata
import matplotlib.pyplot as plt

#change to point to exported file:
data=sio.loadmat('///Users//kuehn//Desktop//
    mmWmatlabExport//powerdensity_data.mat')

#extracting x,y and Pd data
x_vec=np.array(data['x'], dtype=np.float_).flatten()
y_vec=np.array(data['y'], dtype=np.float_).flatten()
Pd_vec = np.array(data['data'], dtype=np.float_).flatten
    ()

#interpolate to rectilinear grid
x_min = np.min(x_vec)
x_max = np.max(x_vec)
y_min = np.min(y_vec)
y_max = np.max(y_vec)
```

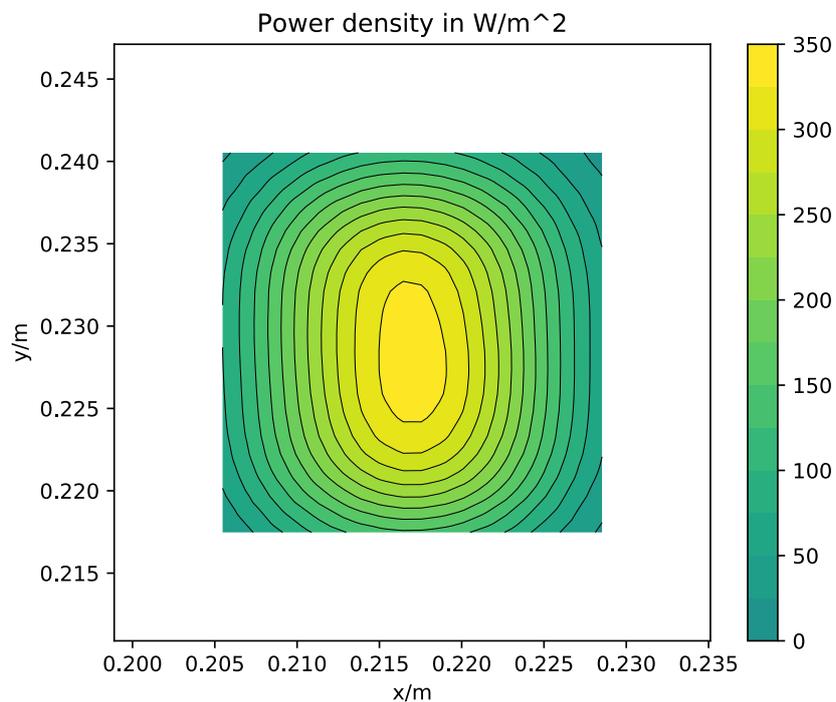
16.2. IMPORT AND PLOT ICEY MATLAB DATA IN PYTHON

```
xi = np.linspace(x_min,x_max, 100) #100 are the gridsteps
yi = np.linspace(y_min,y_max, 100) #100 are the gridstep
Pdi = griddata(x_vec, y_vec, Pd_vec, xi, yi, interp='
    linear')

#plotting
CS = plt.contour(xi, yi, Pdi, 15, linewidths=0.5, colors=
    'k')
CS = plt.contourf(xi, yi, Pdi, 15,
    vmax=abs(Pdi).max(), vmin=-abs(Pdi).
    max())

plt.colorbar()
plt.xlim(x_min, x_max)
plt.ylim(y_min, y_max)
plt.xlabel('x/m')
plt.ylabel('y/m')
plt.title('Power density in W/m^2')
plt.show()
```

Running the above Python script will generate a plot as shown below.



Chapter 17

ICEy-mmW: Vertical Measurement Planes

This chapter contains a step-by-step measurement example of a millimeter wave measurement of SPEAG's 30 GHz Verification Source with the measurement plane set up vertically. It includes only the minimum needed for performing a measurement. Further details are given in the other chapters.

17.1 Probe Setup

Please consult Chapter 13 on how to setup and install the probe.

17.2 Application Start and Workbench Acquisition

Please consult Chapter 18, Sections 18.1 to 18.2.2 on how to start the ICEy application and setup the work bench and DUT.

17.3 30 GHz Millimeter Wave Verification Source Measurement

17.3.1 Evaluation Library Setup

Please consult Chapter 13 for the setup of the evaluation library.

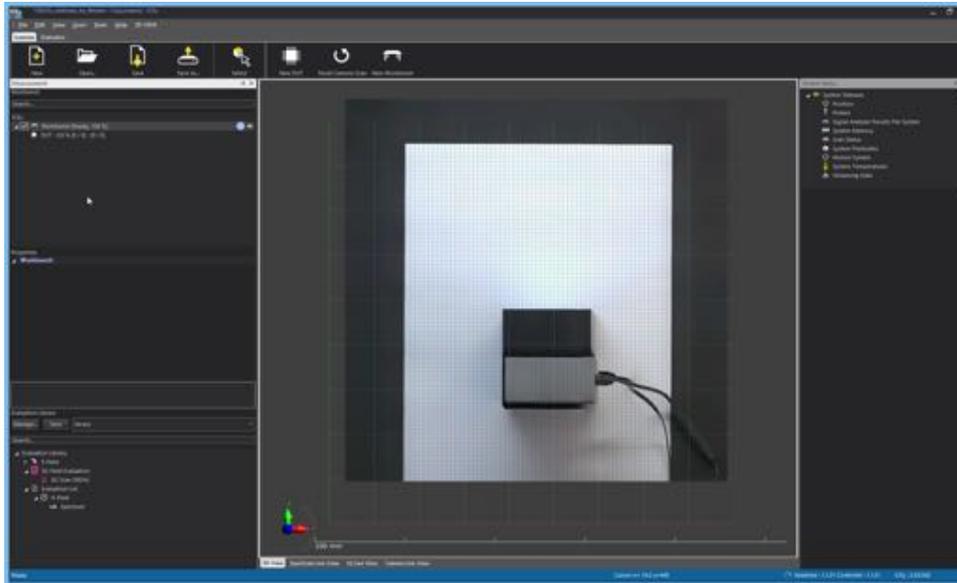
17.3. 30 GHZ MILLIMETER WAVE VERIFICATION SOURCE MEASUREMENT

17.3.2 Source and Measurement Setup

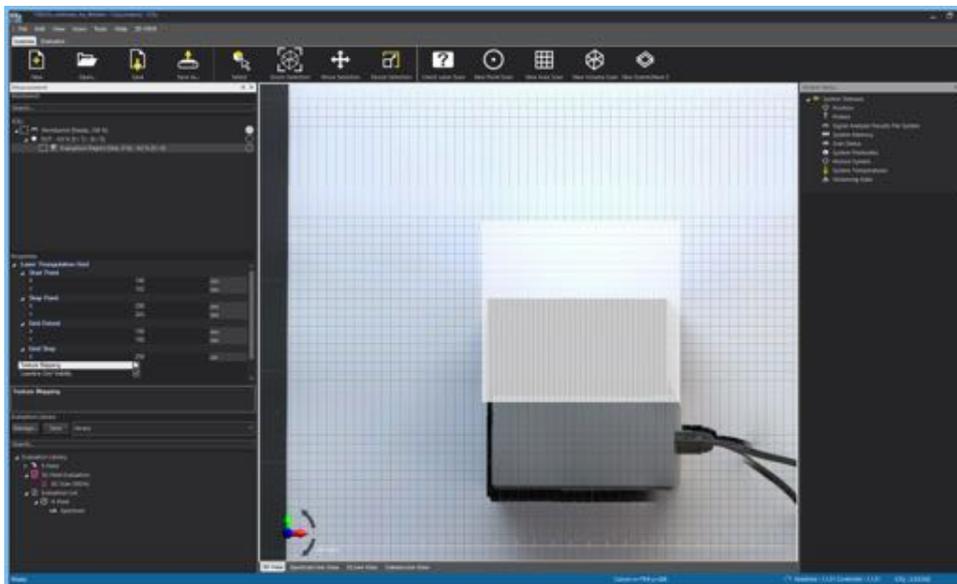


In this setup the verification source has been put on its side, radiating against the right side of the ICE y test chamber. As the measurement plane will later be aligned in the x-z-plane of the system, we recommend to align the source parallel to the x-axis of the ICE y system. It is also recommended to put a sheet of white paper below the source in order to differentiate it better in the camera scan from the black workbench floor.

17.3.3 Scan Setup

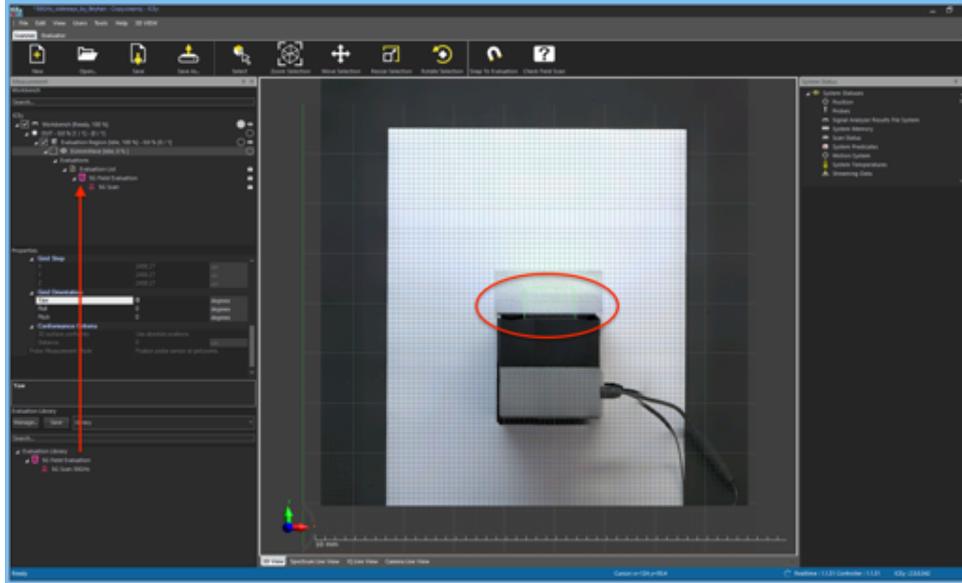


Perform a camera scan and create a New DUT.

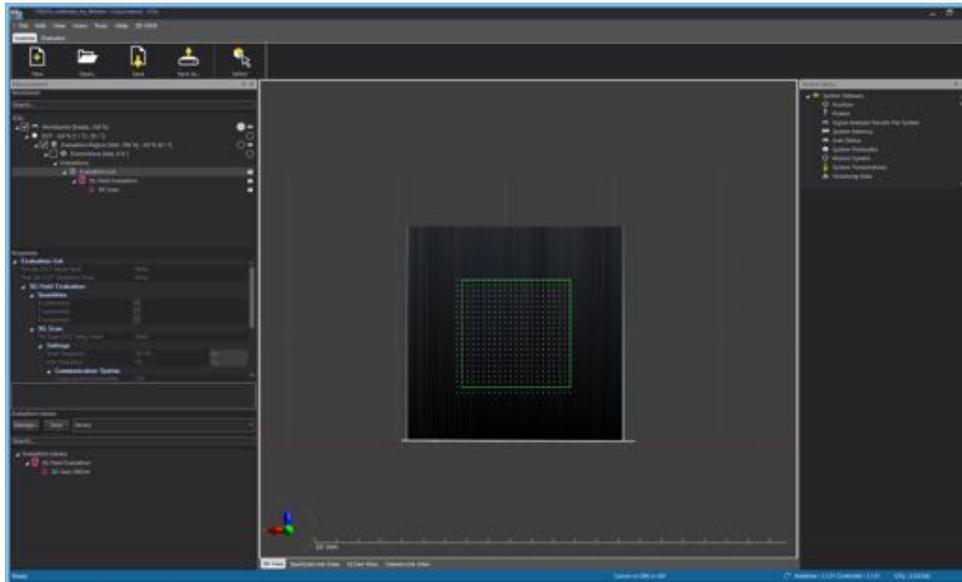


Setup a new Evaluation Region covering the verification source as well as a few centimeter of the chamber floor in front of it and start the 3D reconstruction using Start LASER Scan.

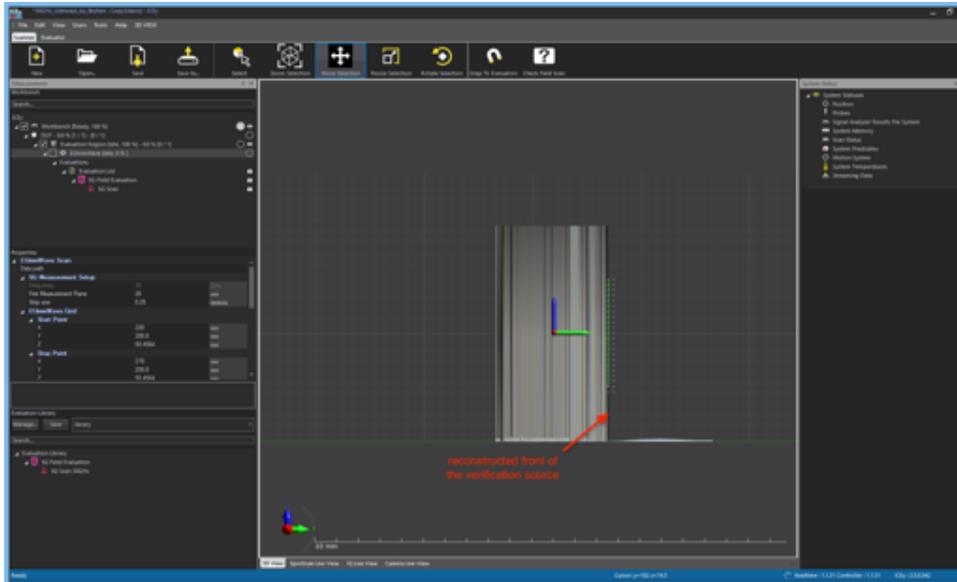
17.3. 30 GHZ MILLIMETER WAVE VERIFICATION SOURCE MEASUREMENT



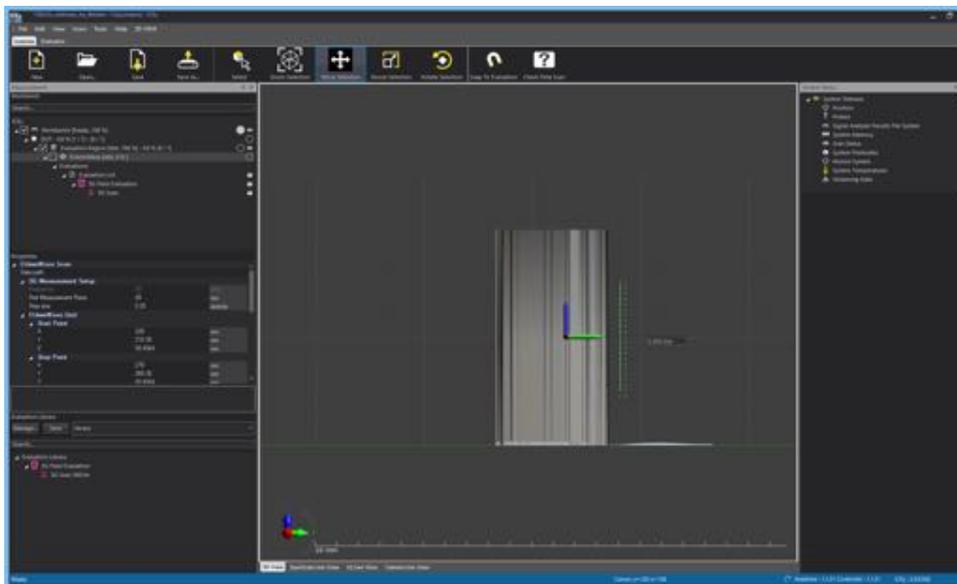
Attach an EUmW Scan to the Evaluation Region. Drag the 5G Evaluation from the Evaluation Library into the Evaluations branch of the scan. It is important to complete this step now as the evaluation setting influences the grid generation. Then approximately center the grid in front of the x,z-center of the verification source (best use a view from y-direction to do so.)



Switch to the z- or x-view and move the grid right against the reconstructed surface of the verification source.



Move the grid away in y by 5.55 mm. To do so, select the green arrow (for y) and type 5.55 mm in the numeric box next to it. This ensures that the first measurement plane is at 10 mm from the horn inside the source, corresponding to the plane during the calibration. You can now select the scan and start it.



Note: per default ICEy limits the first measurement plane to ≥ 6 mm from the closest lateral obstacle. Please contact SPEAG support for instructions how to lower this limit at the risk of probe collisions with your equipment under test.

*17.3. 30 GHZ MILLIMETER WAVE VERIFICATION SOURCE
MEASUREMENT*

17.3.4 Post-Processing

Please consult Chapter 13 on how to post-process the data.

Chapter 18

ICEy-EMC: Measurement Quick Start Walkthrough

This chapter contains a step-by-step measurement example of a DUT (small amplifier) operating at 835MHz. It includes only the minimum needed for performing a measurement. Further details are given in the other chapters.

18.1 Start of the application

After a successful installation of ICEy two icons will appear on the desktop. One is for the ICEy RT realtime control, the other one is the ICEy application itself. The starting order of these is important. Double-click on the ICEy RT first and then on the ICEy. Note that if the ICEy RT is not running, you will not be able to perform any measurements - only evaluation of previously performed measurements will be possible.



Figure 18.1: ICEy and ICEy RT icons on the desktop.

18.2 Measurement

To start a measurement, make sure you are in the *Scanner* mode, which can be selected in the mode tab (Figure 18.2).

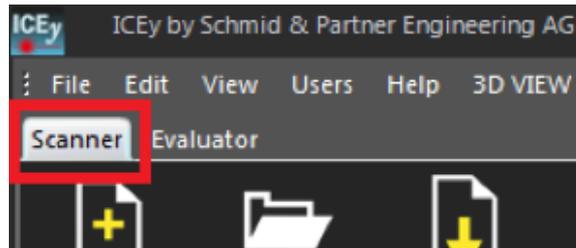


Figure 18.2: Scanner mode.

In case you don't see the mode tab, right click in the menu bar and make sure *Mode Bar* and *Measurement* are enabled (see Figure 18.3).

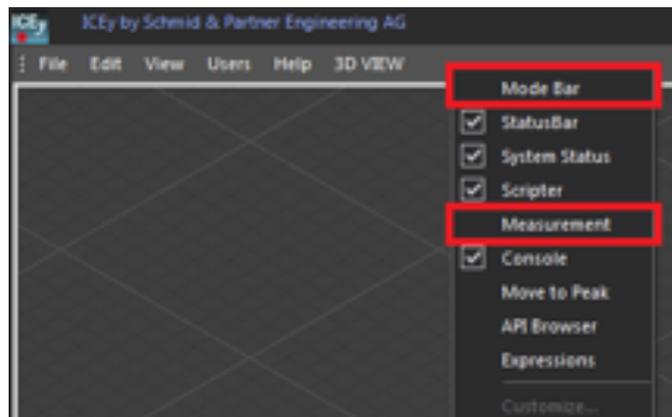


Figure 18.3: Enable measurement and Mode Bar.

As a first step of the setup, a camera scan of the workbench is done. After this, a laser triangulation scan is required. The information from these scans is used to create a 3D model of the DUT. Later, the user can define different scans (for example, area, volume, point scans, etc.) with respect to this 3D model.

18.2.1 Camera Scan

A camera scan is performed by right-clicking the Workbench item in the Workbench tab of the Measurement dockable window (Figure 18.5). Al-

ternatively, the Start Camera Scan button from the toolbar, can be used too.

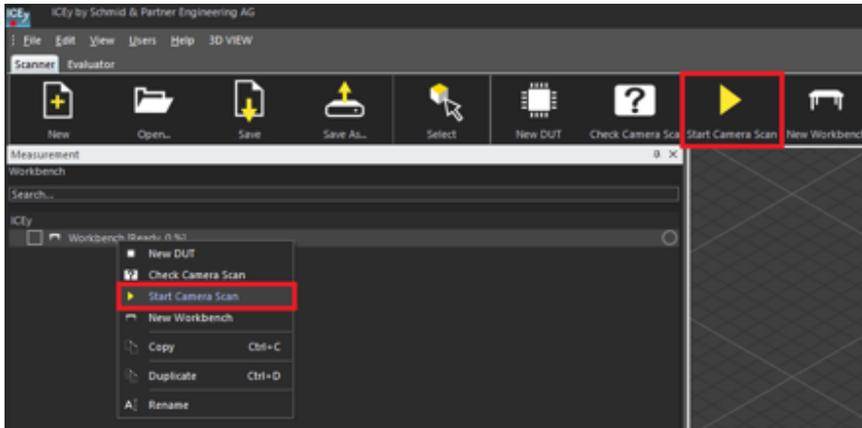


Figure 18.4: Start Camera Scan.

Note: If a probe is still attached to the scanner from a previous measurement, the Start Camera Scan button is not available in the toolbar and a camera scan cannot be initiated. In this case, the user has to park the probe first, using the corresponding button on the toolbar.

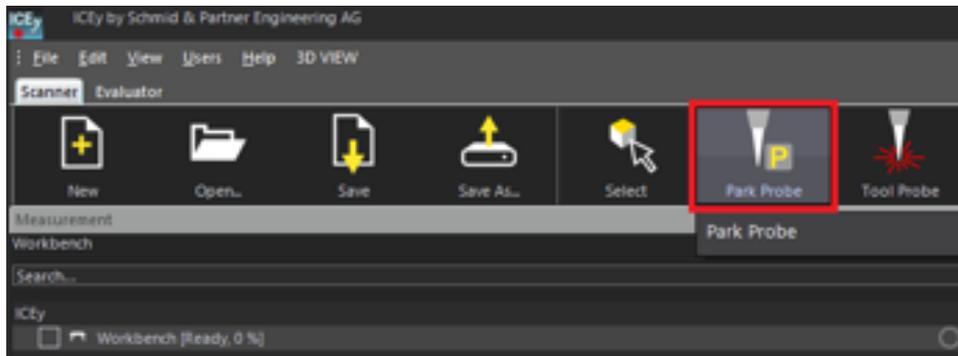


Figure 18.5: Parking a probe.

In case the Start Camera Scan button does not appear after parking the probe, you can check the system predicates in the *System Status* dockable window and select *Can I run a camera scan?* to see why this is not possible at the moment (Figure 18.6), .e.g. when your system is currently moving. If the *System Status* dockable window is not visible, enable it the same way as the Mode Bar (Figure 18.3).

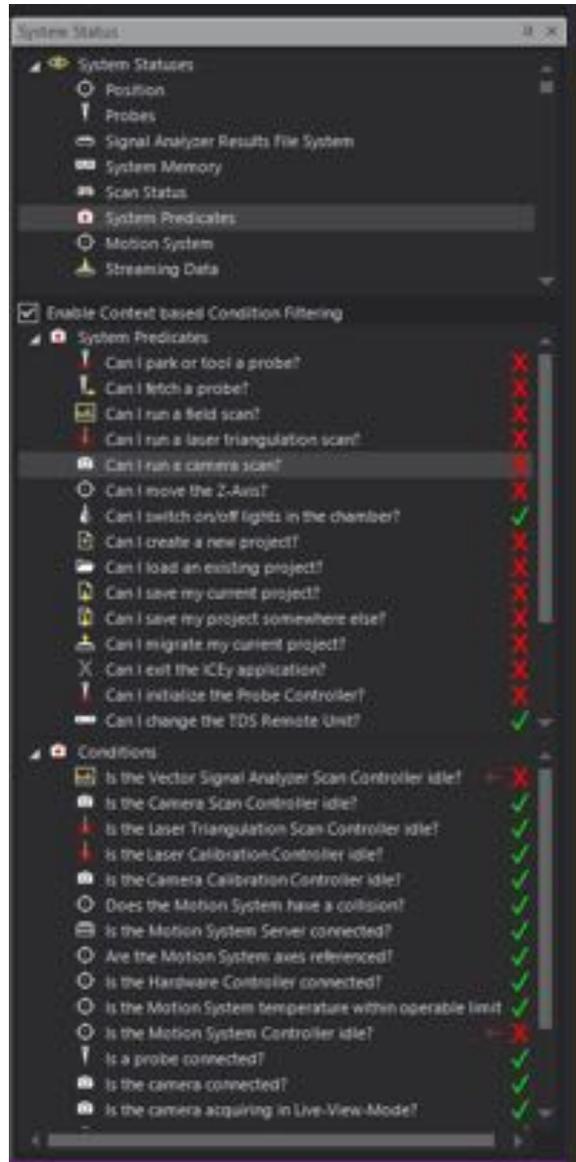


Figure 18.6: System Predicates.

Once the Camera Scan is started, it takes few moments to complete. While it is running, the snapshots from the camera are transferred one by one to the 3D View tab building the full workbench view.

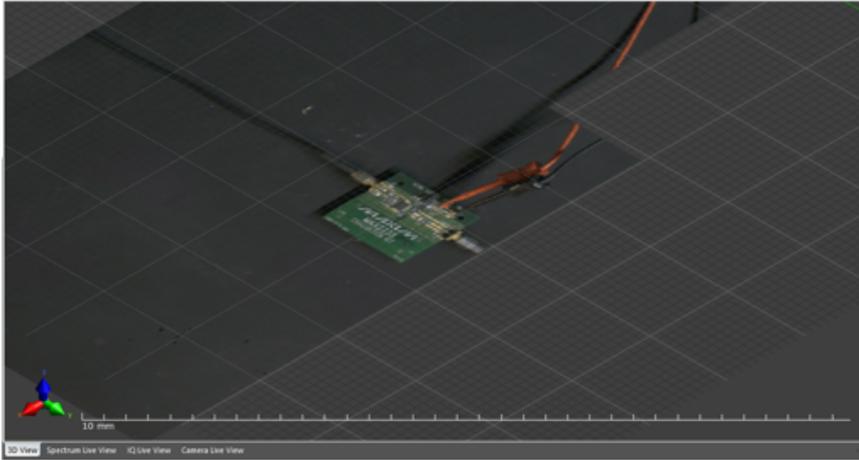


Figure 18.7: 3D View of the workbench showing the camera scan in progress.

At each snapshot location two pictures are taken. There is a slight x-offset between them. Using this redundant information the approximate height of the workbench objects is determined with stereo-vision techniques.

18.2.2 Laser Scan

Once the Camera Scan is complete, the 3D view should show a preview of what is inside the ICEy chamber. Now, the user can define the new DUT by right-clicking on the Workbench, or by using the corresponding toolbar button. The default name can be changed by right-clicking the DUT in the *Measurement* dockable window and selecting *Rename*.

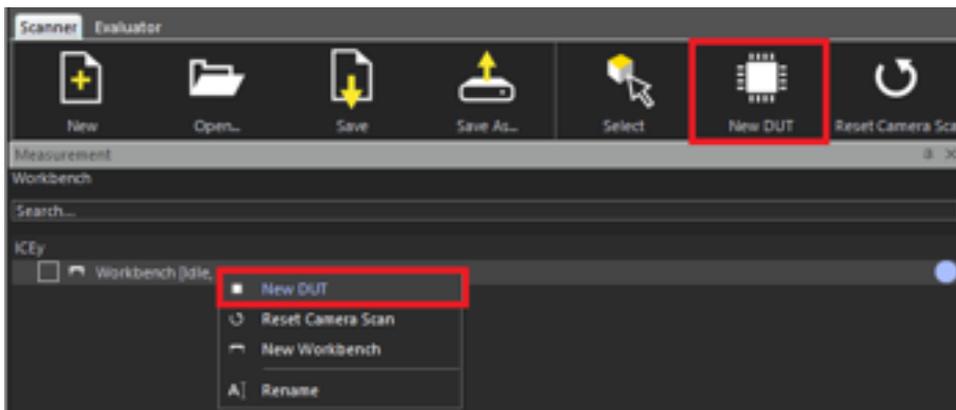


Figure 18.8: Create a new DUT.

Next, the user can define the evaluation region. This tells the software

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which part of the workbench is of interest. Based on this definition, a laser triangulation will be performed as a next step. The user can select the DUT in the *Measurement* dockable window and click on *New Evaluation Region* in the ribbon bar to set up the laser surface detection (Figure 18.9), or right-click on the DUT and select *New Evaluation Region* there.

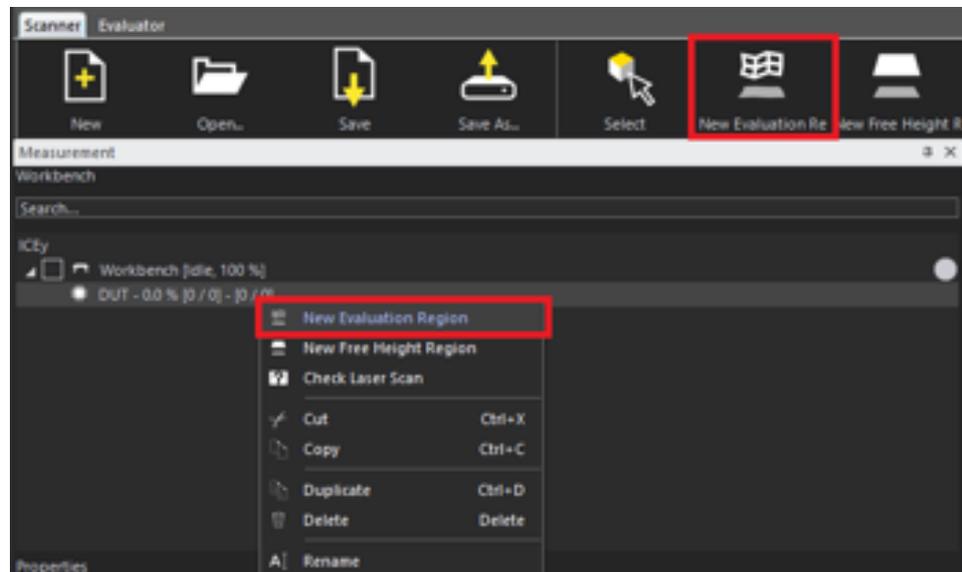


Figure 18.9: Create a new Evaluation Region.

The newly created Evaluation Region is visible as a grid in the 3D View. Now, the user can modify the position and size of this region using the Move and Resize Selection buttons from the toolbar. The red and green arrows can be used for modifications in X- and Y- direction. Please note, that big evaluation regions will result in longer laser triangulation scans.

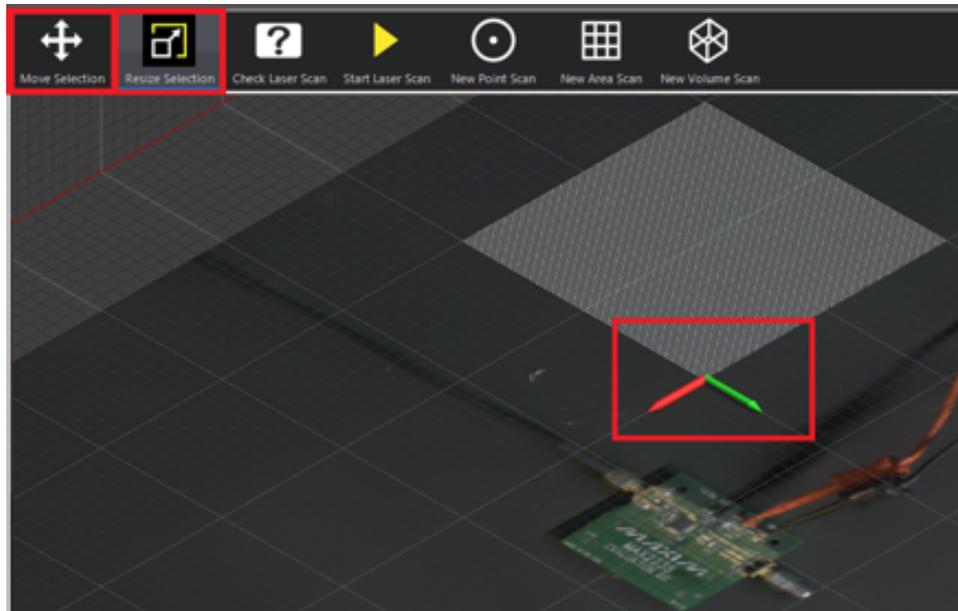


Figure 18.10: Moving and Resizing the Evaluation Region

The position and the size of the evaluation region can be defined using the Properties window too. Here, the user can specify the stepsize in X-direction, which is related to the resolution of the laser scan. The smaller stepsize, will result in finer laser triangulation, but will take more time. It is recommended to set it between 100 and $500\mu\text{m}$ for a good trade-off between accuracy and speed. In this example, we use $500\mu\text{m}$.

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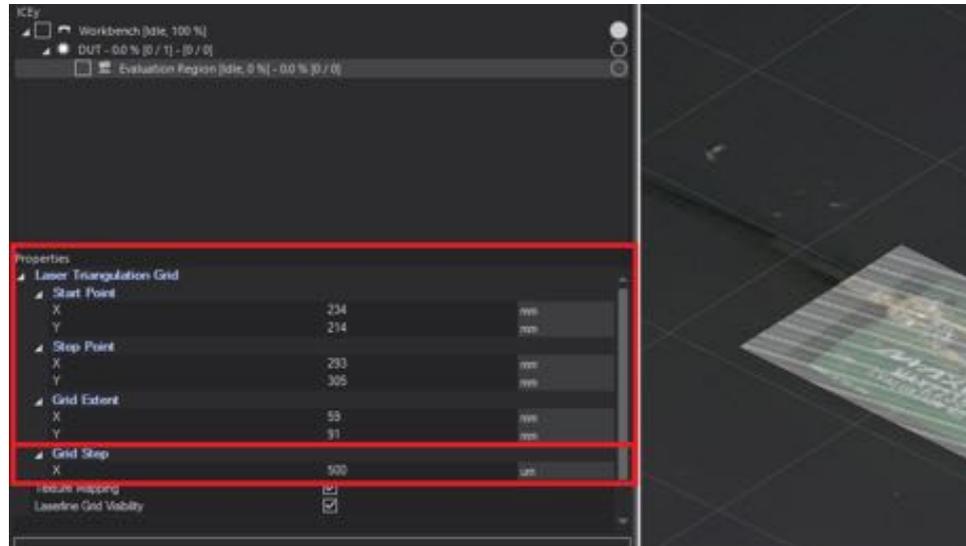


Figure 18.11: Properties of the Evaluation Region.

Once the Evaluation Area settings are complete, the laser triangulation scan can be initiated by pressing the Start Laser Triangulation button from the toolbar. In case this is not available, check the system predicates.

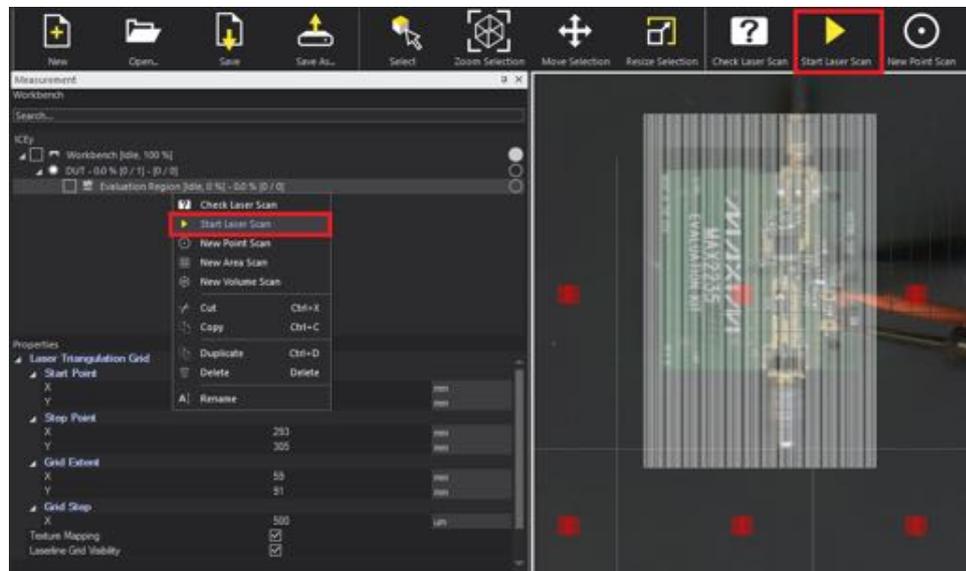


Figure 18.12: Starting a Laser Scan.

Once the scan is started, the progress is shown in the *Measurement* dockable window (the number inside the square bracket is the progress of

the laser scan, Figure 18.13), or you can select the *Scan Status* in the *System Status* dockable window which will display an estimate of the remaining time (Figure 18.14).

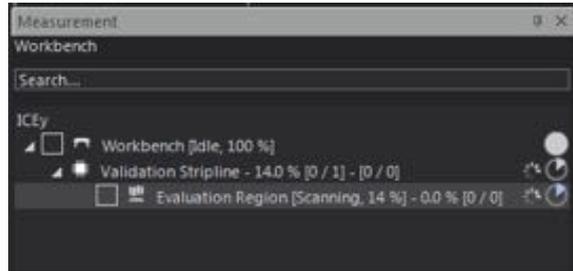


Figure 18.13: Progress of the laser scan.

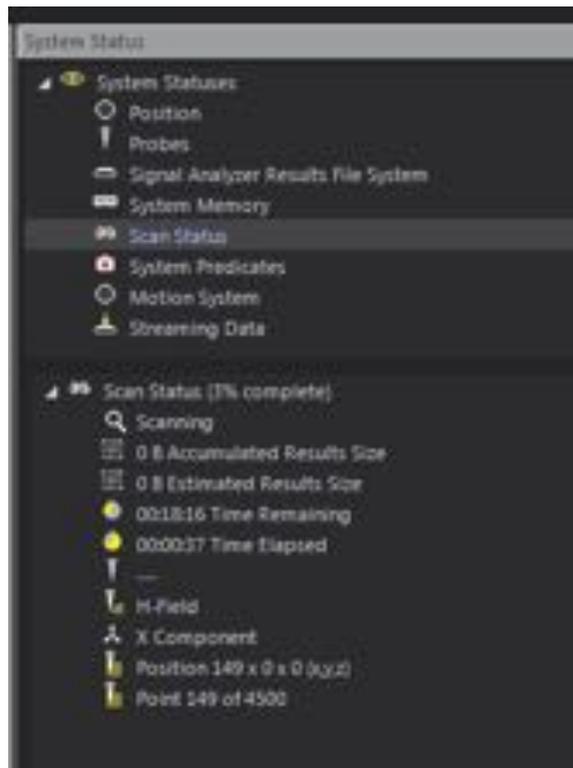


Figure 18.14: Detailed status of the laser scan.

Depending on the size and resolution of the scan, it may take some time for the texture to be generated. At the end of the Laser Triangulation and 3D model of the DUT is created. The user can define the desired scan based

18.2. MEASUREMENT

on this model. This is done by right-clicking on the Evaluation Region. Three different scans are available: *New Point Scan* (for a single point), *New Area Scan* (for a 2-dimensional grid) or *New Volume Scan*. In this example, we take an Area Scan. Note that only points that lie within the evaluation region area can be measured.

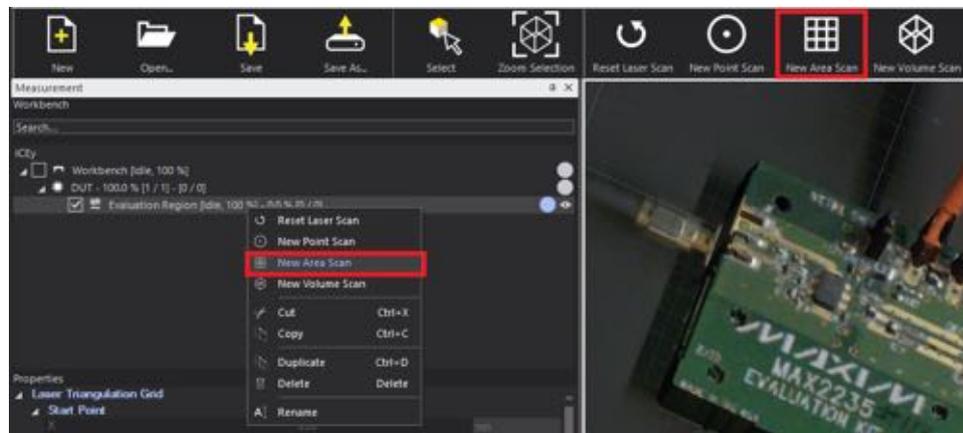


Figure 18.15: Creating a new Area Scan.

The Area Scan is marked with a green rectangle. Here, the user can modify the size and the position again with the Move and Resize Selection buttons from the toolbar. The properties of the area scan are available from the Properties window. The grid step is an important setting here - this defines what will be the physical spacing between the measurement points. Same as in the Laser Scan case, the smaller stepsize will result in finer scan, but will take longer time.

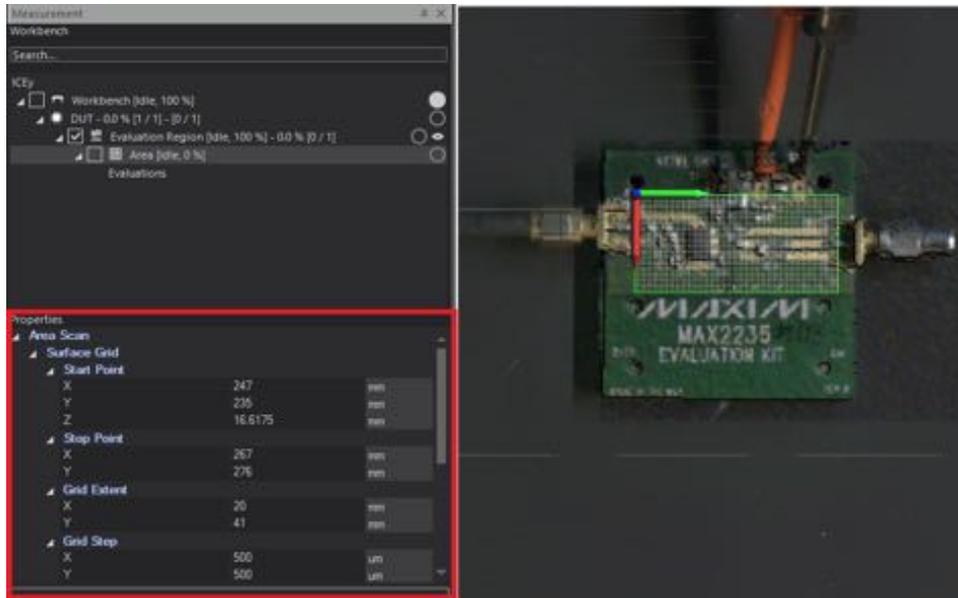


Figure 18.16: Area Scan Properties.

Another important setting is the conformance type and the conformance distance. The *3D surface conformity* determines whether the points are measured at a given distance to the laser scan result (the absolute height of each point may vary, or at the absolute position of where the grid is placed, all points at exactly the same height).

In this example, we create an area scan conformal to the surface of the DUT with spacing of $1000\mu\text{m}$. The user can define this spacing. Furthermore, two different measurement modes are available. *Position probe tip at grid-points* places the end of the probe at the grid positions. The measurement point will be above the grid position, because the sensor is placed 1 to 1.5 mm above the probe tip inside the probe (depending on the probe). *Position probe sensor at grid-points* places the sensor at the grid positions. Note that the probe tip will be lower than the grid points in this case. So, if the grid point is 0.2mm from the surface, and *Position probe sensor at grid-points* is enabled, this position cannot be measured because a collision would occur. When a point cannot be measured because it would cause a collision, it behaves differently depending on the *3D surface conformity* setting. If surface conformance is enabled, the z-position of the point will be altered such that no collision occurs, i.e. the surface conformance distance is respected. If surface conformance is disabled, the points that would cause a collision will not be measured. For this example, we place the tip of the probe at the grid points.



Figure 18.17: Conformance Criteria selection.

18.2.3 Field Evaluation Definition

Now, it is time to define the details of the desired field scan using the Evaluation Library tab. By right-clicking on the Evaluation List, the user can create new H- or E-field evaluation. This is possible through the corresponding buttons from the toolbar too. In this example, we select H-field.

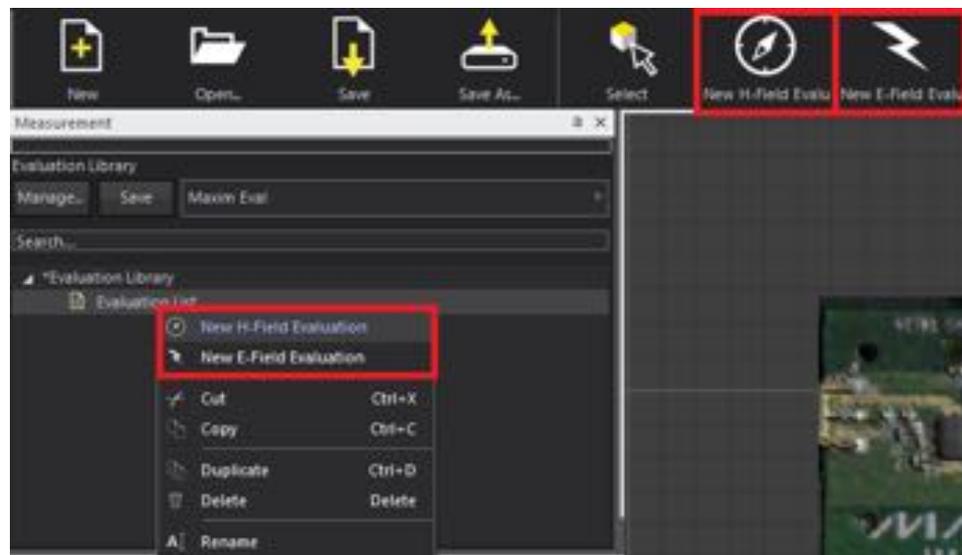


Figure 18.18: New E- or H-field evaluation.

In the Properties section, the user can select the field component of interest. In this example, for simplicity we only pick the X-component.

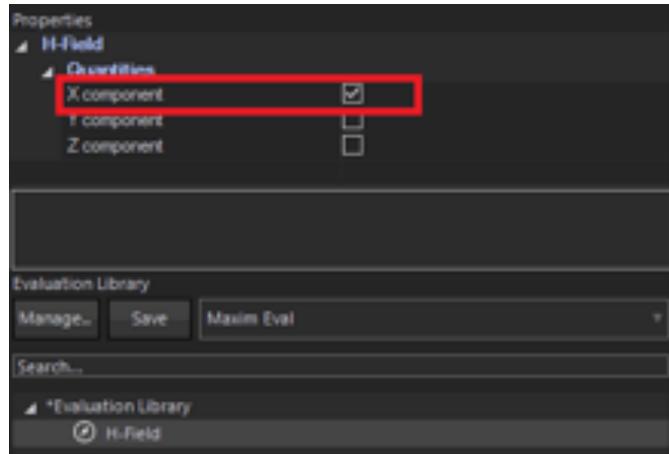


Figure 18.19: Selection of the desired field components.

As a next step, the user can select a Spectrum or a Time Domain scan by right-clicking on the already defined H-field evaluation. In this example, we select New Spectrum Scan.

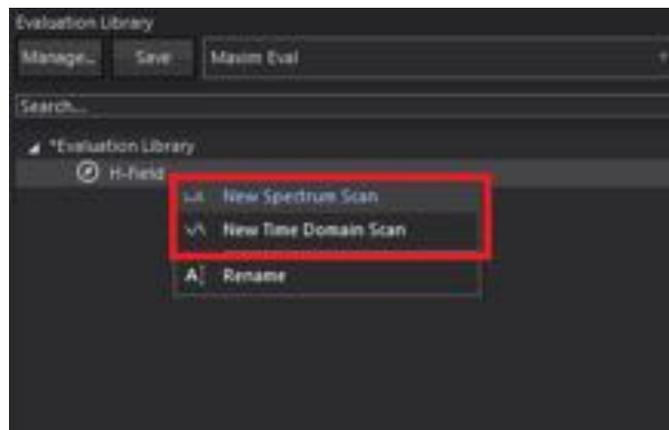
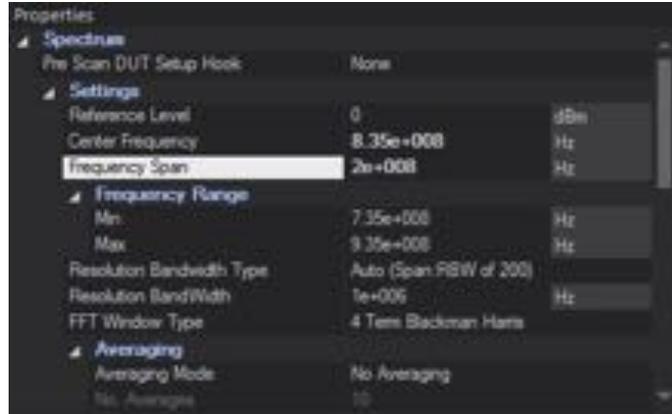


Figure 18.20: New Spectrum or Time Domain Scan.

The spectrum analyzer settings for the scan can be done in the Properties window. These include center frequency, resolution bandwidth, reference level, averaging etc.

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This concludes the scan settings. As a next step, we will assign these settings to the already defined area scan. This is done by dragging and dropping the created Evaluation Library to the Evaluation section of the Area Scan. Multiple scans can be added to the same Evaluation.

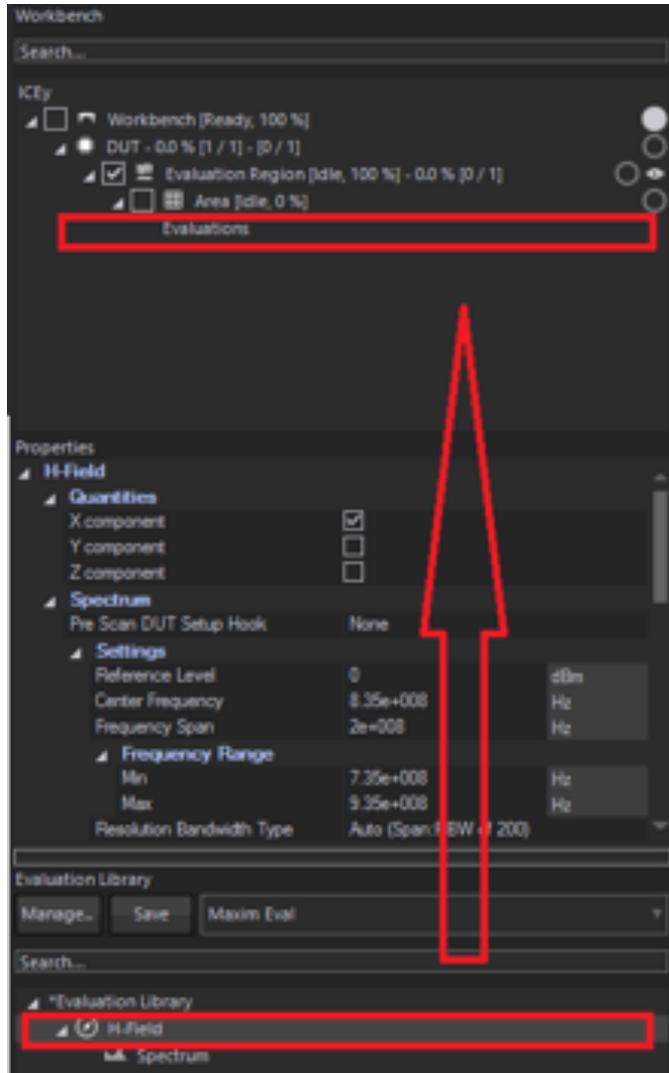


Figure 18.21: Evaluation of the results.

At this point, we are ready with all settings and it is time to save the project. This is performed with the corresponding toolbar button.

18.3. PERFORMING A MEASUREMENT

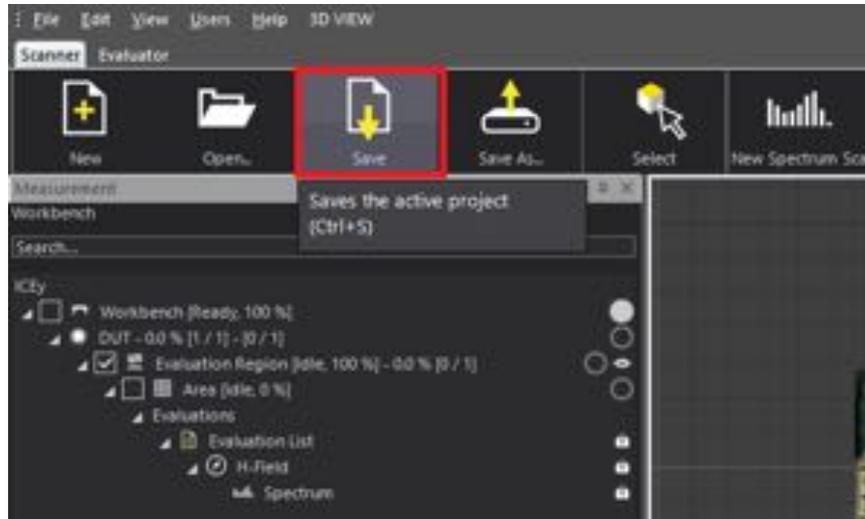


Figure 18.22: Saving the project.

18.3 Performing a Measurement

The measurement can be initiated by pressing the Start button in the toolbar. The scanner will pick up the right probe from the probe repository, tool it and perform the defined scan. From this point the scanner will measure without any operator interaction. The duration of the measurement depends on the size of the defined scans, number of field components, field types, etc.

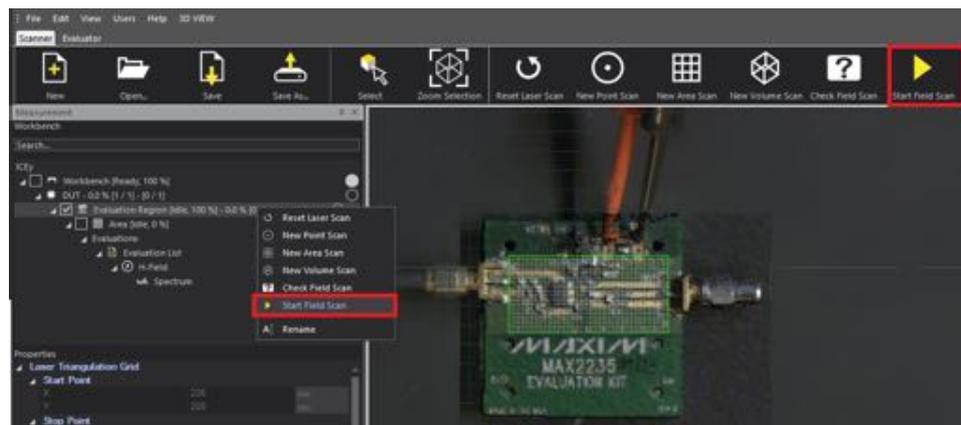


Figure 18.23: Start a measurement.

The progress of the scan is shown in the *Measurement* dockable window

next to the Area Scan (Figure 18.24). The Evaluation Region and the DUT show the overall progress in case there are multiple scans.

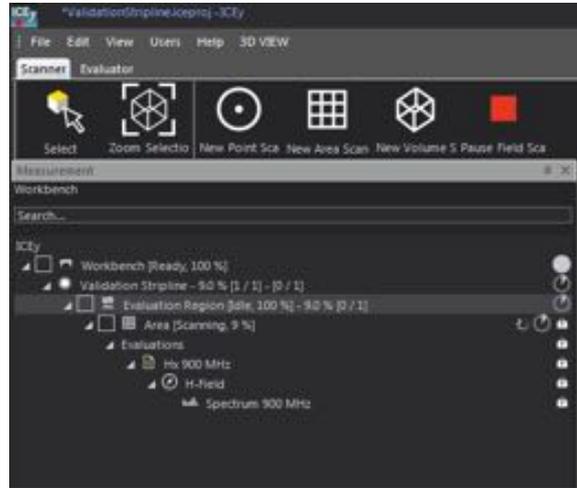
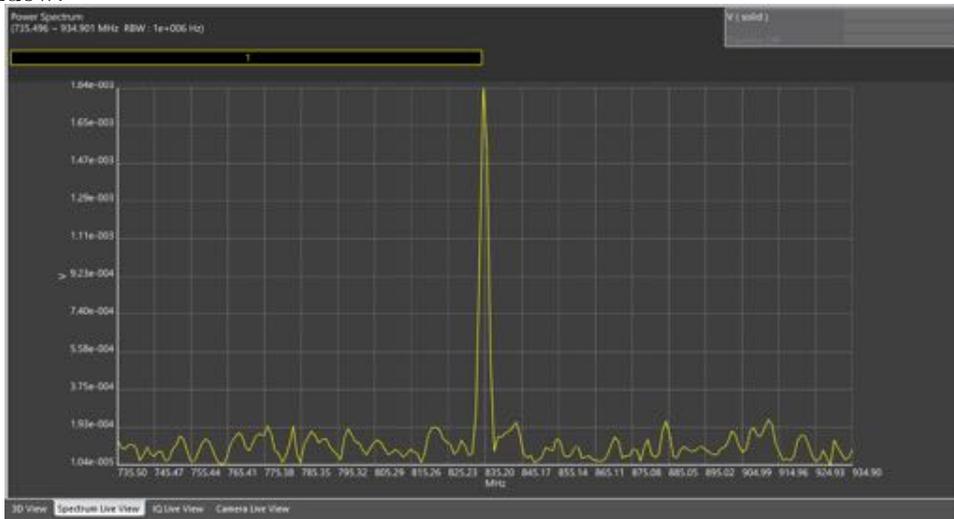


Figure 18.24: Progress of the field scan.

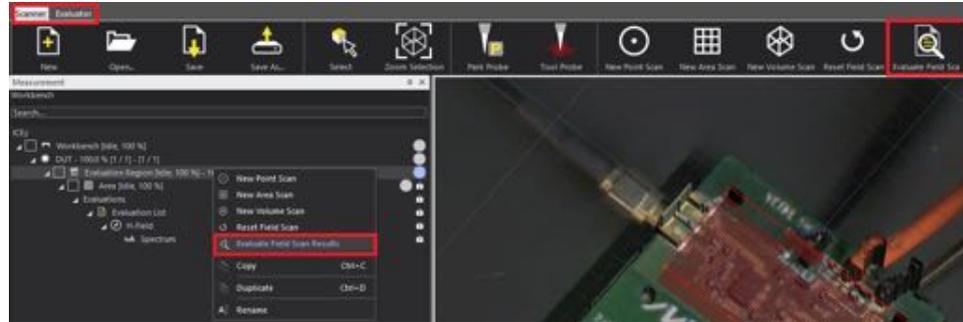
While the measurement is running, the user can see the spectrum for the current measurement point from the Spectrum Live Tab in the visualization window.



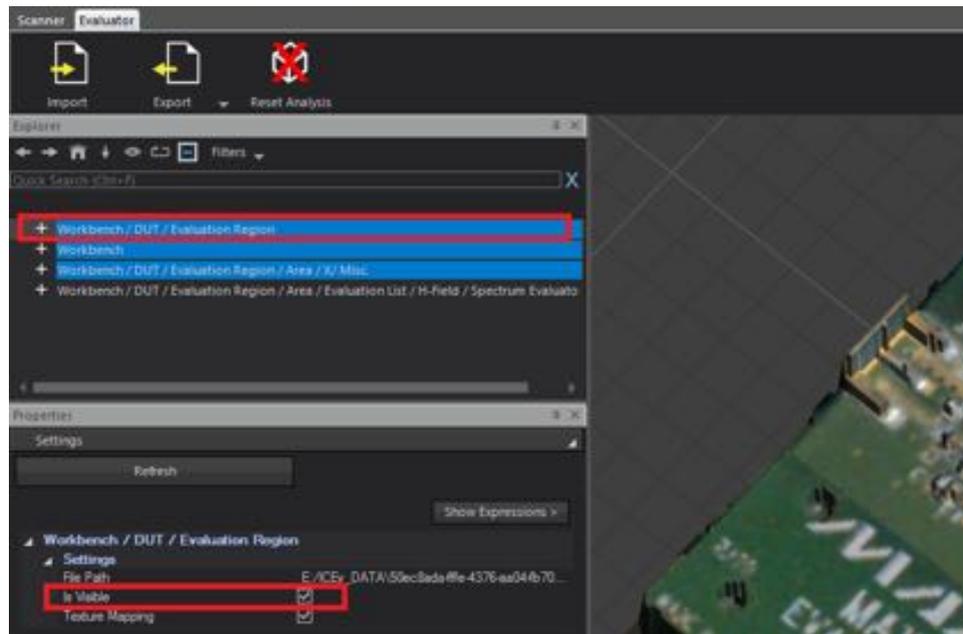
18.4 Evaluating a measurement

Once the measurement is completed, the results can be evaluated by pressing the Evaluate Field Scan Results button. Make sure that the actual Evaluation Region is selected (as shown in the picture below).

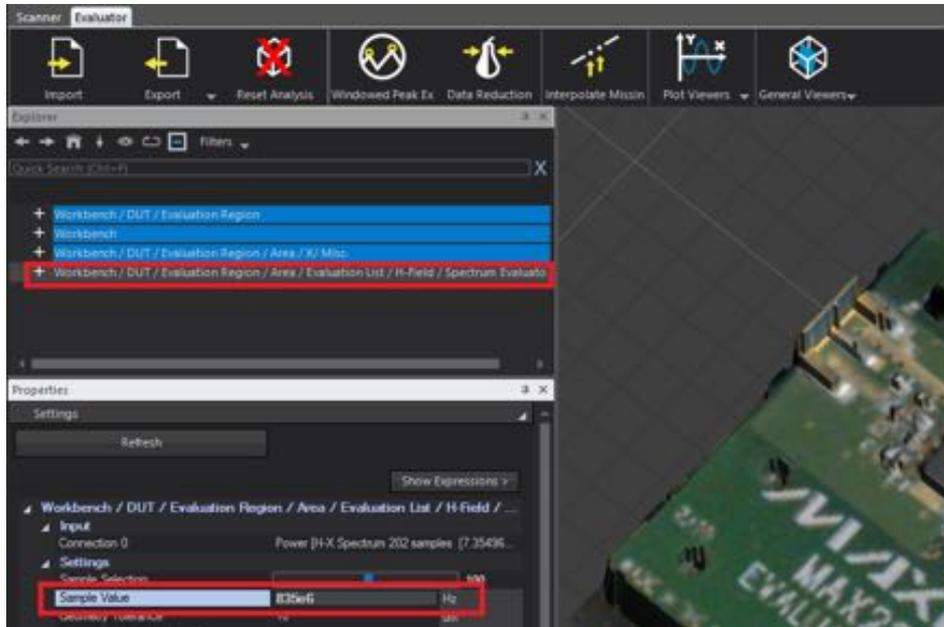
18.4. EVALUATING A MEASUREMENT



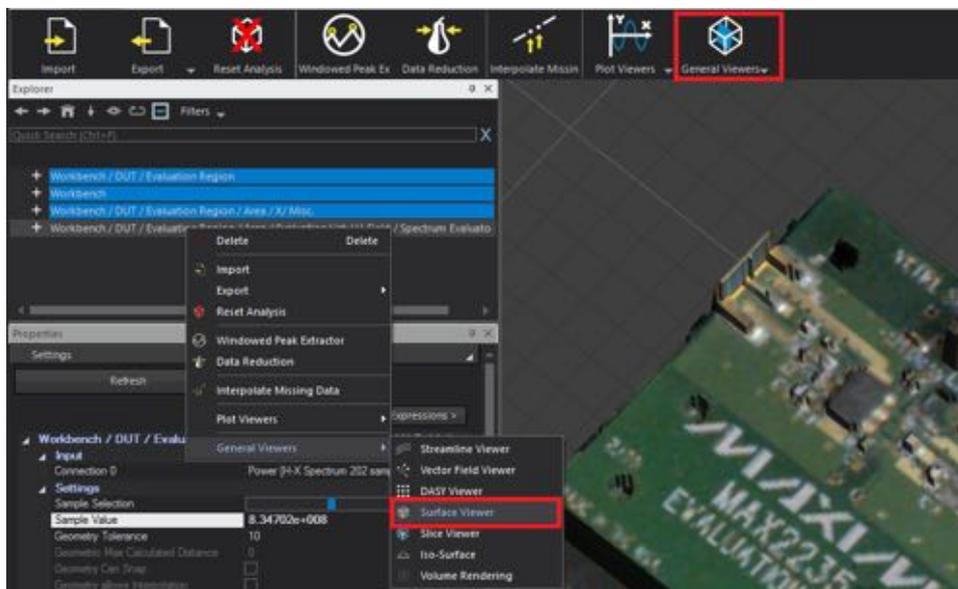
Pressing this button switches the ICEy software from Scanner to Evaluator mode - seen in the tabs above the toolbar. The measurement data is in the Explorer window. First, we want to show the 3D model of the evaluation region on the workbench. Click on the first node and check-mark *Is Visible* from the Properties.



Now, we will use the last node. Click on it and select the correct frequency from the sample value. Our DUT operates at 835MHz, so we put 835e6 in this field. Note, that due to the finite number of frequency points, 835MHz might not be available. In this case, the software will pick the closest available frequency.

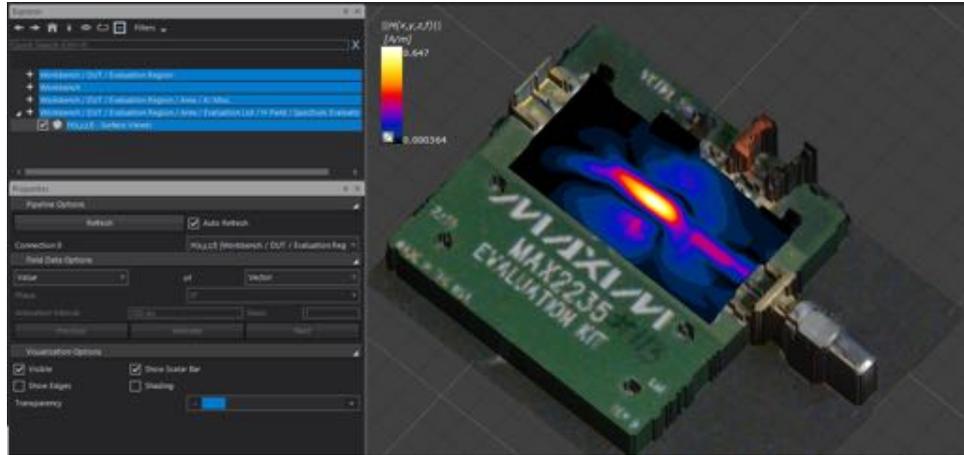


Right-click on the H-field/Spectrum Evaluator node and select the desired General Viewer. In this example, we will use Surface Viewer.

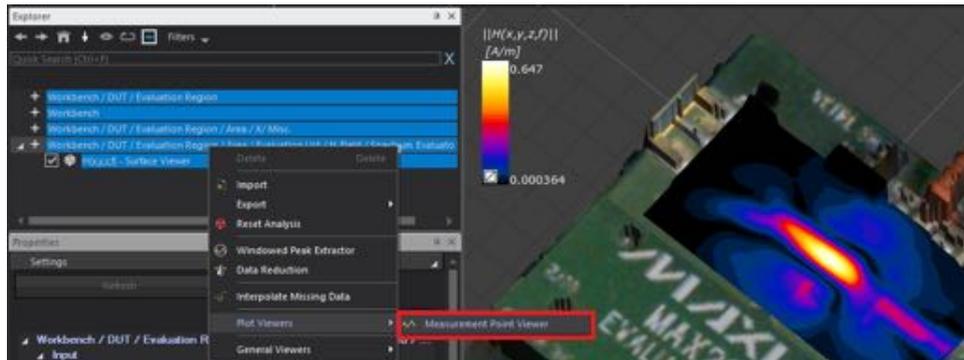


This creates a surface view of the field and places it on top of the DUT in the 3D View tab of the visualization window. Now, we can see the higher field on top of the actual amplifier and above the stripline connected to the output of the amplifier.

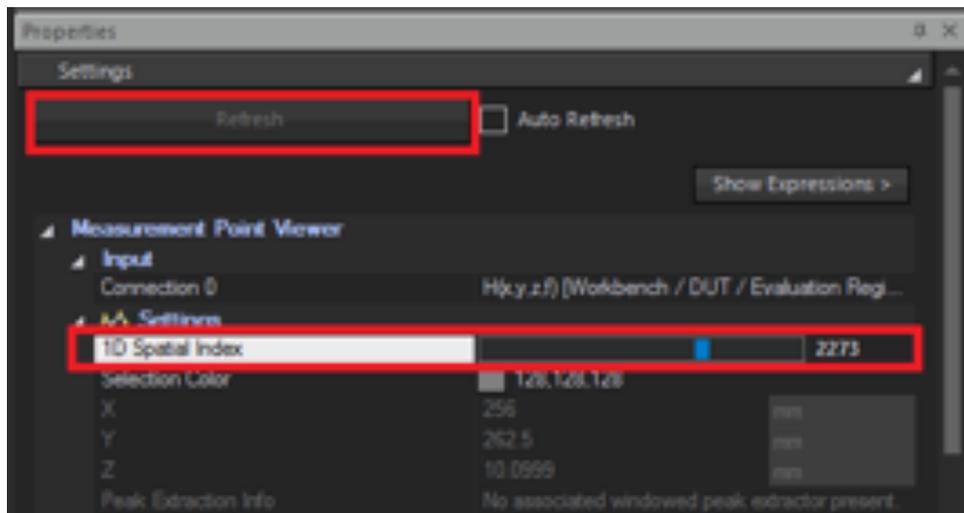
18.4. EVALUATING A MEASUREMENT



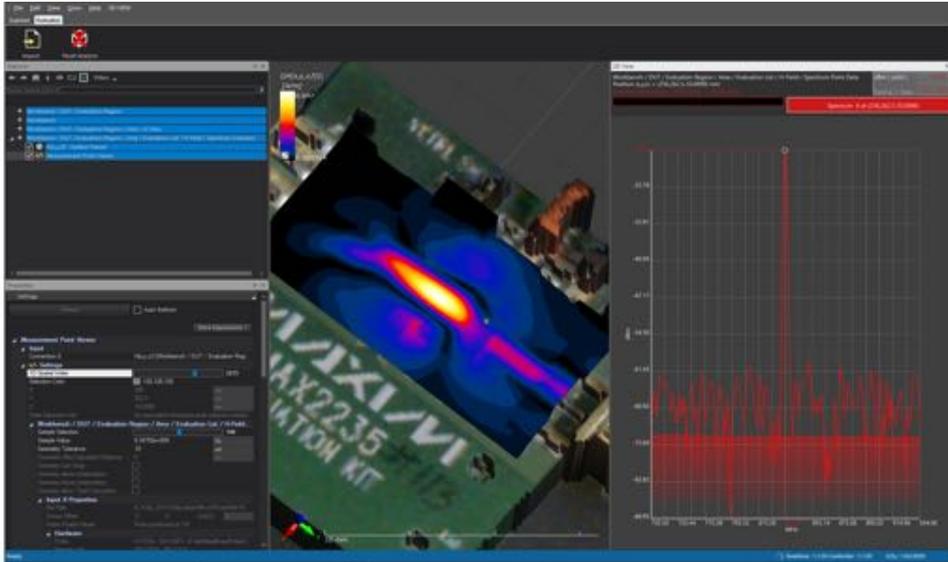
At this point, we can also take a look at the spectrum for single measurement points. Right-click on the H-field/Spectrum Evaluator node and select Plot Viewers –> Measurement Point Viewer.



The actual point is indicated with a small sphere in the 3D View. It can be moved around by changing the 1D Spatial Index in the Settings window.



The 2D spectrum plot is shown next to the 3D View. If the view is not automatically updated, press the Refresh button.



That concludes this basic measurement example. Further details on how to perform more advanced measurements are given in the other chapters of this manual.

18.4. *EVALUATING A MEASUREMENT*

Chapter 19

ICEy-EMC: Verification Walkthrough:

19.1 Verification Device

The easiest way to run verification measurements with ICEy is by using the Verification Device. It has a two striplines. When placed inside the ICEy chamber such that the USB port faces right, one stripline faces up, and one towards you, the upper stripline will be called *horizontal stripline* and the one facing you will be called *vertical stripline*.



Figure 19.1: Verification Device.

The status LED next to the USB port is white when the device has power over the USB, and will turn green when the RF power is switched on. The device is controlled using visa commands from the ICEy Python™ interface.

19.2 Hardware Setup

Place the device inside the ICE y chamber such that the striplines are parallel to the Y-axis of the system, the USB port is facing right, one stripline is facing upwards and the other one towards you.

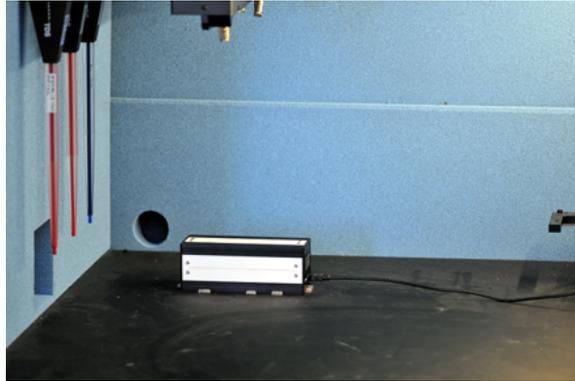


Figure 19.2: Recommended placement of verification device inside the ICE y chamber, make sure the striplines are parallel to the system Y-Axis.

Connect the USB cable to the ICE y computer. You can use the USB ports on the side of the system for this purpose.



Figure 19.3: Connecting the device to the ICE y computer.

19.3 Driver Setup

First, make sure that the device is detected correctly by your system. To do this, open Windows Device Manager.

If the driver is not installed yet, there will be an entry *Other devices* with an item *Unknown Device* or *COMX* with a yellow triangle with and exclamation mark next to it.

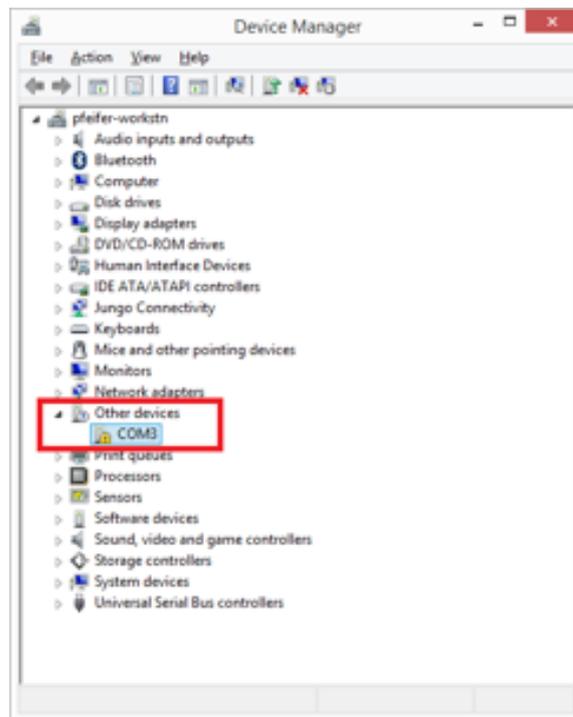


Figure 19.4: Driver not installed.

If this is the case, install the driver from the ICEy driver package called *AtmelStudioUSB-7.0.31.exe*. During installation you may be asked if you want to install the driver package, where you have to click on *Install*.



Figure 19.5: Security warning that might occur during installation. Make sure to select *Install*.

19.3. DRIVER SETUP

After installation, the device should be listed under the entry *Ports (COM & LPT)*. The name can be either *Communication Device Class ASF example (COMX)* (Figure 19.6) or *USB Serial Device (COMX)* (Figure 19.7).

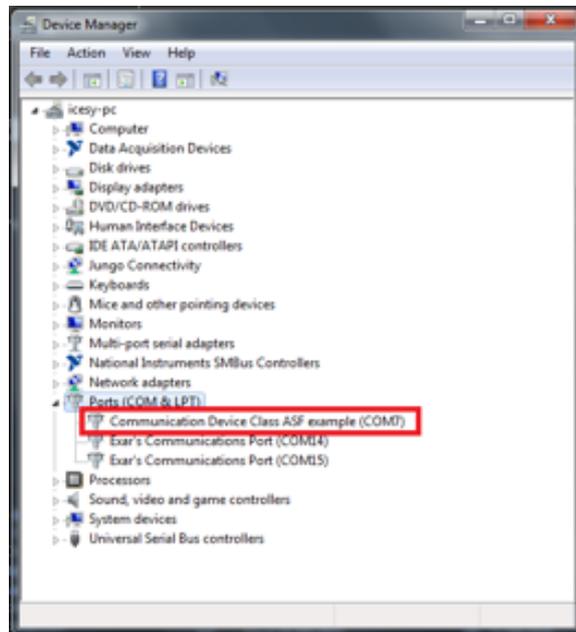


Figure 19.6: Driver name on Windows 7.

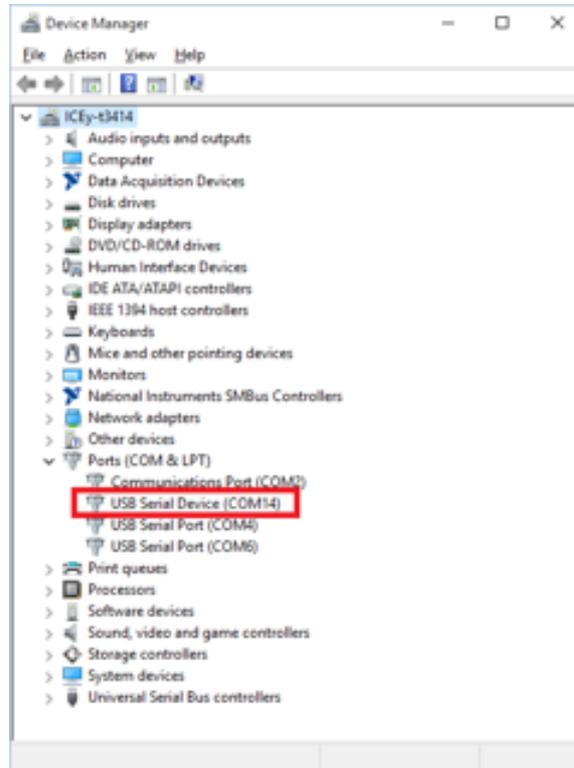


Figure 19.7: Driver name on Windows 10.

19.4 Calibration File Setup

Copy the verification device calibration file `VSS_SN1XYZ.icevsscal` (must match the verification device serial number) to the folder `C:\Users\Public\Documents\Speag\ICEy\Inventory\VerificationDevice\`. Create the folder if it does not exist yet. There should exactly one calibration file there with the correct serial number, otherwise the verification cannot be run.

19.5 ICEy Scripts Setup

Once you have installed the drivers and verified that the verification device is detected correctly, the Python™ scripts need to be installed. These are so-called *Scan Hooks* that are executed automatically before or after a scan (see Chapter 20 for details). To use these scripts, make sure they are inside your `UserDUTSetupScripts` folder in the `ICEy` preferences folder.

Copy the scripts `VerificationStriplines_Setup_CH1_Top.py`, `VerificationStriplines_Setup_CH2_Side.py` and `VerificationStriplines_TurnOff.py` from your `ICEy` installation directory. In this example this

19.6. EVALUATION LIBRARY

means copying them from `C:\SPEAG\ICEy_1.0.0.3050\scripts\examples\XICEy` to `C:\Users\Public\Documents\Speag\ICEy\UserDUTSetupScripts`.

19.6 Evaluation Library

There should be an Evaluation Library called `SPEAGVerificationLibrary` installed in your system (located in `C:\Users\Public\Documents\Speag\ICEy\EvaluationLibrary\`) that contains a range of frequencies for verification with the verification device. If there is no such Evaluation library, contact SPEAG to obtain the file.

19.7 Running the Verification Measurement

Make sure you have an H1TDSx and a H1TDSz probe set up in your system and in your probe repository. See Section 9.1.1 if you are unsure how to do this.

Then, run a *Camera Scan*, as described in Chapter 18.

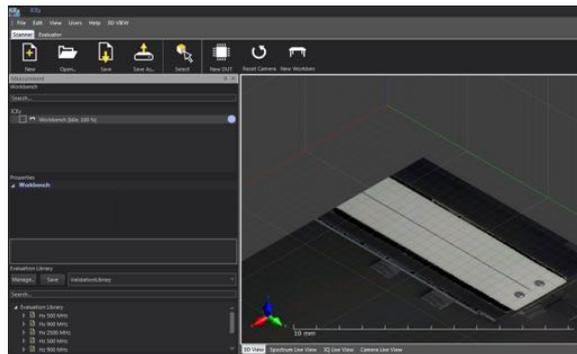


Figure 19.8: Camera Scan of the Verification Device.

Once the camera scan is complete, you need to find the approximate position of the device on the workbench. You can use the grid and ruler to find this (Figure 19.9).

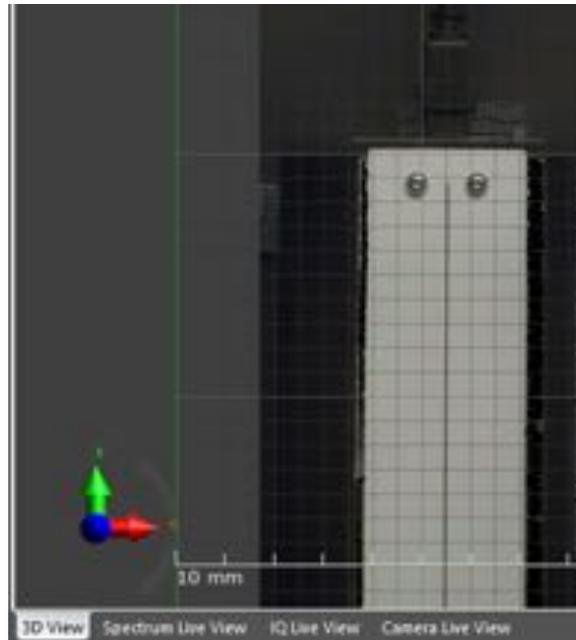


Figure 19.9: Find the approximate position of the Verification Device.

If you are unsure, you can use a small workaround: Create a DUT, and an Evaluation Region (see Chapter 18), and position the evaluation region on the stripline (Figure 19.9). Make sure you delete it again after you found the position.

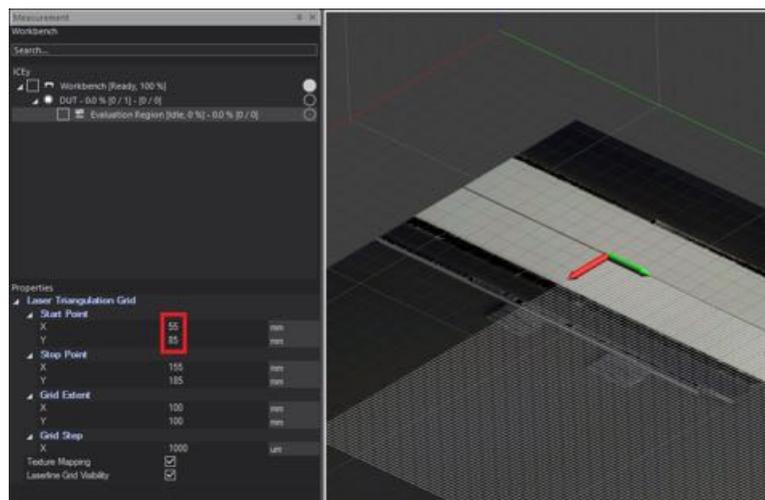


Figure 19.10: Find the position of the Verification Device using a temporary Evaluation Region.

19.7. RUNNING THE VERIFICATION MEASUREMENT

Alternatively, you can click on the z-axis in the 3D-window, and move the cursor to the center position of the stripline. The cursor X and Y positions are displayed in the status bar at the bottom of the window.

In this example, the approximate position is (X: 55 mm, Y: 85 mm). Once this position is known, start the verification script. For this open, the *Scripter*. Right click on the menu bar and select *Scripter* in case it is not visible.

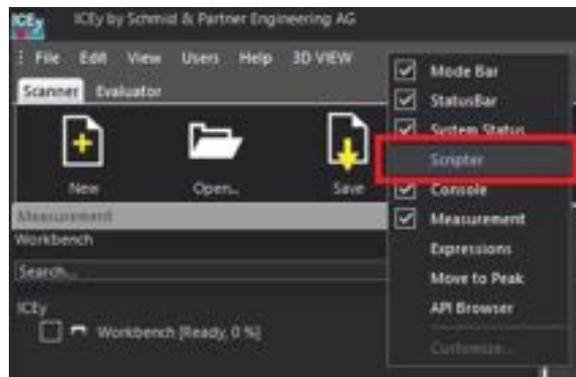


Figure 19.11: Open the scripter in ICEy.

In the *Scripter*, open the file `StriplinesVerification.py` from your ICEy installation directory (in this example: `C:\SPEAG\ICEy_1.0.0.3050\scripts\examples\XICEy`).

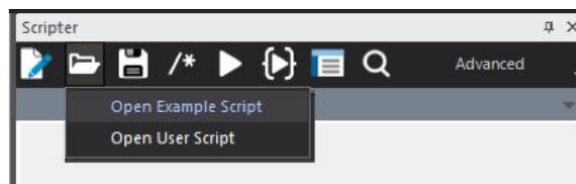


Figure 19.12: Open the script `StriplinesVerification.py`.

Once opened and selected, press the play button or hit F5 on your keyboard.

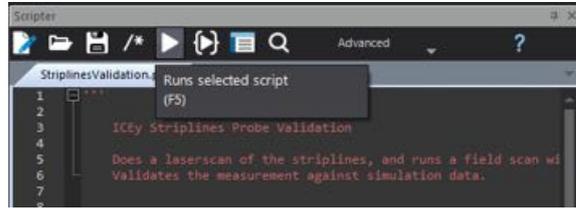


Figure 19.13: Run the script StriplinesVerification.py.

A new window should occur to control the verification measurement. Enter the device position that you determined before in the fields *Approximate device center X* and *Approximate device center Y*.

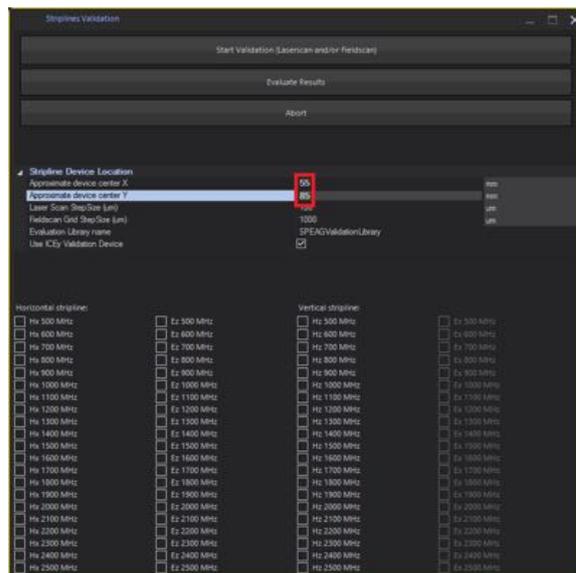


Figure 19.14: Enter the approximate device position.

Next, select which evaluation lists you want to run on which stripline. Select the lists with the X-Component (Hx 900 MHz and Hx 2500 MHz) for the horizontal stripline, and the ones with the Z-Component (Hz 900 MHz and Hz 2500 MHz) for the vertical stripline.

19.7. RUNNING THE VERIFICATION MEASUREMENT

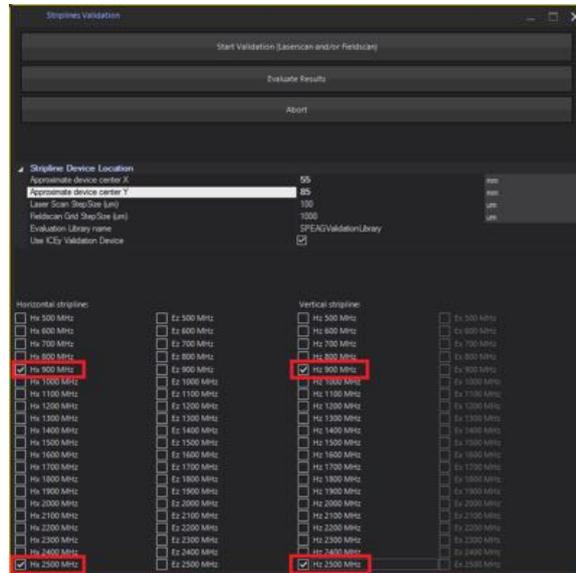


Figure 19.15: Select which Evaluation Lists to run for which stripline.

Then press the top button in the verification script GUI: *Start Verification (Laserscan and/or Fieldscan)*. In this case, the laser scan will run first, and a field scan afterwards. In case you have stored a laser scan created with this script and this project is open, only the field scan will be performed, saving the time for the laser scan. When you hit the button you should see the laser grid in the 3D View as shown in Figure 19.16.

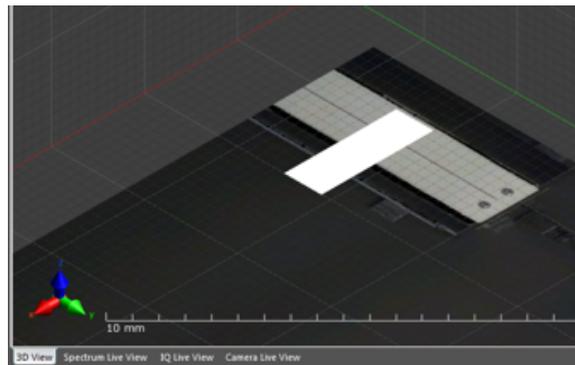


Figure 19.16: Laser grid lines over the striplines.

The laser scan will take around 15-20 minutes if you left the laser scan resolution at 100 μm . Once complete, a 3D model should become visible in the 3D View.

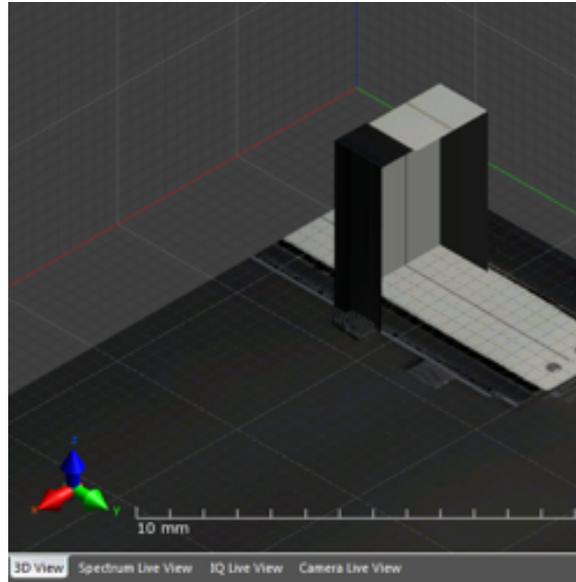


Figure 19.17: Laser scan result.

The field scans with the selected Evaluation Lists will be automatically set up and started. The scan will take around 30 minutes in total for all the four selected Evaluation Lists. When completed, you should see a pop-up window informing you of the completion.

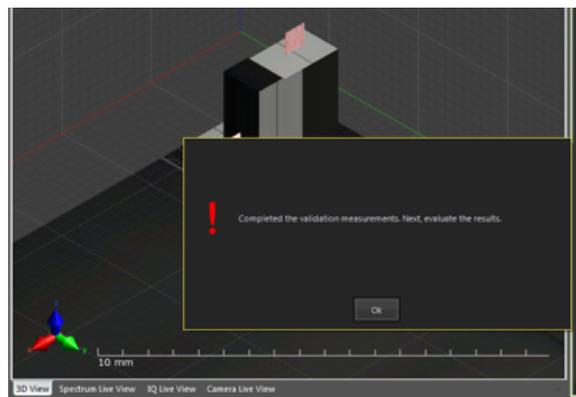


Figure 19.18: Completion of the verification measurement.

19.8 Evaluate the Results

Now the measurements can be evaluated. Press *Evaluate Results* in the verification script GUI.

19.8. EVALUATE THE RESULTS

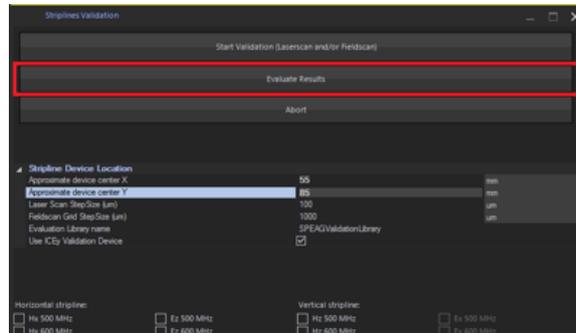


Figure 19.19: Evaluate the verification measurement.

This will switch the software to *Evaluator Mode* and compare the measurement data against simulation data. Plots will be created to show the results. It is possible that these plots are created behind the main application window, so you might have to minimize the main application window or use the Windows task bar, or Alt-Tab on your keyboard to see the result plots.

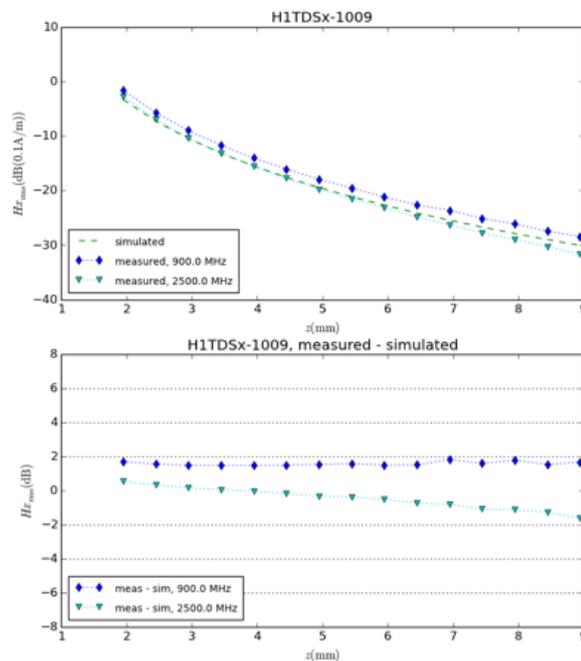


Figure 19.20: Verification results for the H1TDSx probe.

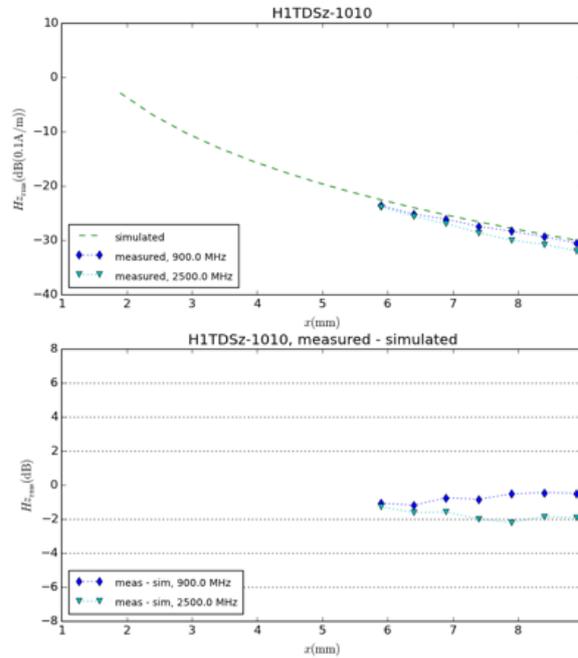


Figure 19.21: Verification results for the H1TDSz probe.

The results of the example are shown in Figure 19.20 and Figure 19.21. It shows the magnetic field at different distances to the striplines and compares it to simulation data. The upper sub-plot shows the absolute field in dB (referenced to 0.1 A m^{-1}), and the lower sub-plot shows the difference between measurement and simulation. As you can see, the probe cannot get as close to the vertical stripline as it can to the horizontal stripline. This is due to the geometry of the probes.

19.9 Verification Source Example Measurement Uncertainty

The overall expanded measurement uncertainty ($k = 2$) was found to be $< 5.0 \text{ dB}$. Table 19.1 details the uncertainty budget taken into account. The system can be considered verified, if the results of the above verification measurements are within the specified expanded measurement uncertainty.

19.9. VERIFICATION SOURCE EXAMPLE MEASUREMENT
UNCERTAINTY

	unc. dB	distr.	div.	ci.	std. unc. dB	
TDS Probe System					2.3	
1	Probe Calibration	1.72	norm $k = 1$	1	1	1.72
2	Axial Isotropy	2.00	rect $k = 1.73$	1.73	1	1.16
3	Linearity	1.20	rect $k = 1.73$	1.73	1	0.69
4	Frequency Response	1.00	rect $k = 1.73$	1.73	1	0.58
5	Fiber-optics Repeatability	0.60	rect $k = 1.73$	1.73	1	0.35
6	Connector Repeatability	0.80	rect $k = 1.73$	1.73	1	0.46
RF Receiver					1.1	
7	Absolute Accuracy (VSA)	0.92	norm $k = 1$	1	1	0.92
8	Missmatch VSA/Remote Unit	0.80	U-shape	1.41	1	0.57
Positioning					0.1	
9	Surface Reconstruction	0.21	rect $k = 1.73$	1.73	1	0.12
10	Probe Positioning	0.07	norm $k = 1$	1	1	0.07
Verification Source					0.6	
11	Absolute Power Accuracy	0.30	norm $k = 1$	1	1	0.30
12	Source Manufacturing	0.60	norm $k = 1.73$	1.73	1	0.35
13	Numerical Model	0.45	norm $k = 1$	1	1	0.45
RSS					2.65	
Coverage Factor for 95%					1.87	
Expanded Uncertainty					5.0	

Table 19.1: Detailed verification source measurement uncertainty.

Chapter 20

ICEy-EMC: Use of DUT Setup Hooks

This chapter is to illustrate a use case of DUT setup hooks to control an external signal generator during an ICEy measurement.

20.1 Signal Generator Control Script

The below script is an example how to control remotely a signal generator via GPIB. A requirement is that the following scripts (available from SPEAG) are installed in `c:\Users\Public\Documents\Speag\ICEy\lib`:

- `Instrument.py`
- `SignalGenerator.py`

This script uses the external module `SignalGenerator` to control an external signal generator via the VISA interface. In this case the generator is connected via GPIB using address "GPIB0::15::INSTR". In case your signal generator is connected via another interface/address please modify the variable `GPIBaddress` accordingly (you can simply access and copy this string within NI MAX or Keysight IO Suite). The second variable that requires customization is `dB_per_Hz`. This Python™ dictionary has the following structure: *frequency in Hz : output power in dBm* of the signal generator. The best is to run a calibration with a power meter connected to the end of your cable from the signal generator and calibrate the output power at all the desired frequencies. In the below example the output power of the signal generator has been determined such that the power at the end of the cable is exactly 0 dBm at all frequencies, e.g., at 6.8 MHz the signal generator has to be set to 3.5 dBm to deliver 0 dBm into the matched DUT. Make sure to calibrate all frequencies that shall be measured with ICEy later on. All the rest of the script can remain unaltered. Also ensure that the script is installed in `c:\Users\Public\Documents\Speag\UserDUTSetupScripts`

20.1. SIGNAL GENERATOR CONTROL SCRIPT

```
import SignalGenerator
import sys
import datetime

dB_per_Hz = {6.8e6 : 3.5, 500e6 : 0.45, 900e6 : 0.7, 1800
             e6 : 1.212, 1900e6 : 1.24, 2500e6 : 1.59} # =0dBm
             thru calibration (using uStrip, cable, SMU200) to VSA
GPIBaddress = "GPIB0::15::INSTR" #to be defined

myfile = None
sg = None

if '__fc_Hz__' in locals() or '__fc_Hz__' in globals():
    if dB_per_Hz.has_key(__fc_Hz__):
        try:
            print str(datetime.datetime.utcnow()) + "\t" + "
                \t Pre Item Hook - Start Hz: " + str(
                    __fstrt_Hz__) + "\t Stop Hz : " + str(
                    __fstp_Hz__) + "\t Centre Hz : " + str(
                    __fc_Hz__) + "\n"

            sg =SignalGenerator.SignalGenerator(GPIBaddress)
            sg.setFreq(__fc_Hz__)
            sg.setP(dB_per_Hz[__fc_Hz__])
            sg.setOutput(True)

            sg.instrHandle.clear()
            sg.instrHandle.close()
        except:
            if myfile != None:
                myfile.close()
            if sg != None:
                # EG : Make certain all visa resources are
                #       cleared before the next thread tries to
                #       create new handles etc...
                sg.instrHandle.clear()
                sg.instrHandle.close()
            print "Unexpected error in _SG_SETUP.py:", sys.
                exc_info()[0]
        else:
            print "dB_per_Hz[__fc_Hz__] NOT defined. Is the
                power-per-frequency definition correct?"
    else:
        print "'__fc_Hz__' NOT defined. This script requires '
            __fc_Hz__', meaning it is a pre-scan hook only
            script."
```

20.2 Usage of the Signal Generator Control Script in ICEy

The usage of the signal generator control script in ICEy is very simple (see Figure 20.1). When you set up your evaluation lists just select `_SG_SETUP.py` in **each** spectrum scan. This script is then executed before every spectrum acquisition and sets up the signal generator based on the frequency setting for the center frequency of your spectrum acquisition. For example if the center frequency of the spectrum acquisition is 6.8 MHz, the entry for 6.8 MHz is selected in `_SG_SETUP.py` and the signal generator set to 6.8 MHz with an output power of 3.5 dBm.

This way you can run various spectrum acquisitions at every grid point and automatically tune the signal source to the right frequency and output power.

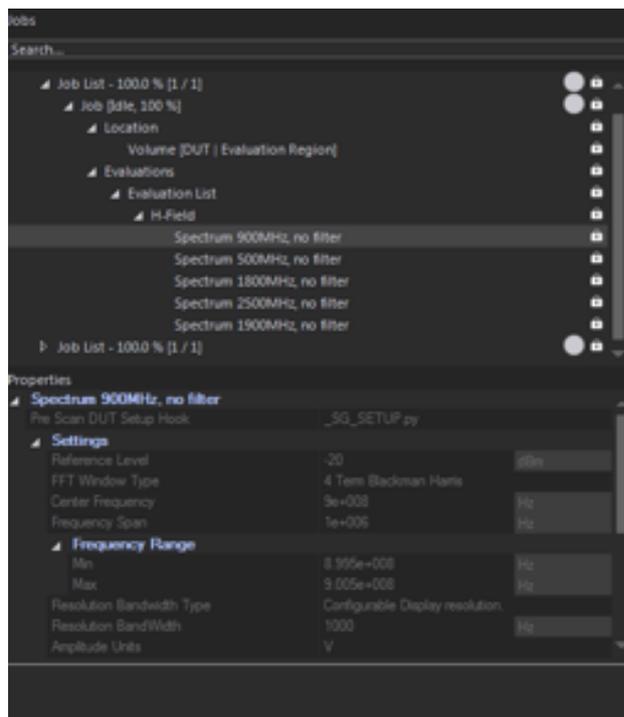


Figure 20.1: Scan job with multiple frequency domain scans and the signal generator control script selected as Pre Scan DUT Setup Hook.

20.2. *USAGE OF THE SIGNAL GENERATOR CONTROL SCRIPT IN
ICEY*

Chapter 21

ICEy-EMC: Move to Peak Measurement Walkthrough

This chapter contains a step-by-step measurement example of peak signal detection of a DUT, followed by automatic positioning of the ICE y probe in the peak location. The procedure can be used to identify spurious or intermittent emissions from a device and to analyze their spectral components.

21.1 Scanning the device

In this example, a 900 MHz transmitter device has been scanned in ICE y (see Figure 21.1), with an E1TDSz ICE y probe, according to the step by step procedure described in Chapter 18.

21.2. EVALUATING THE RESULTS

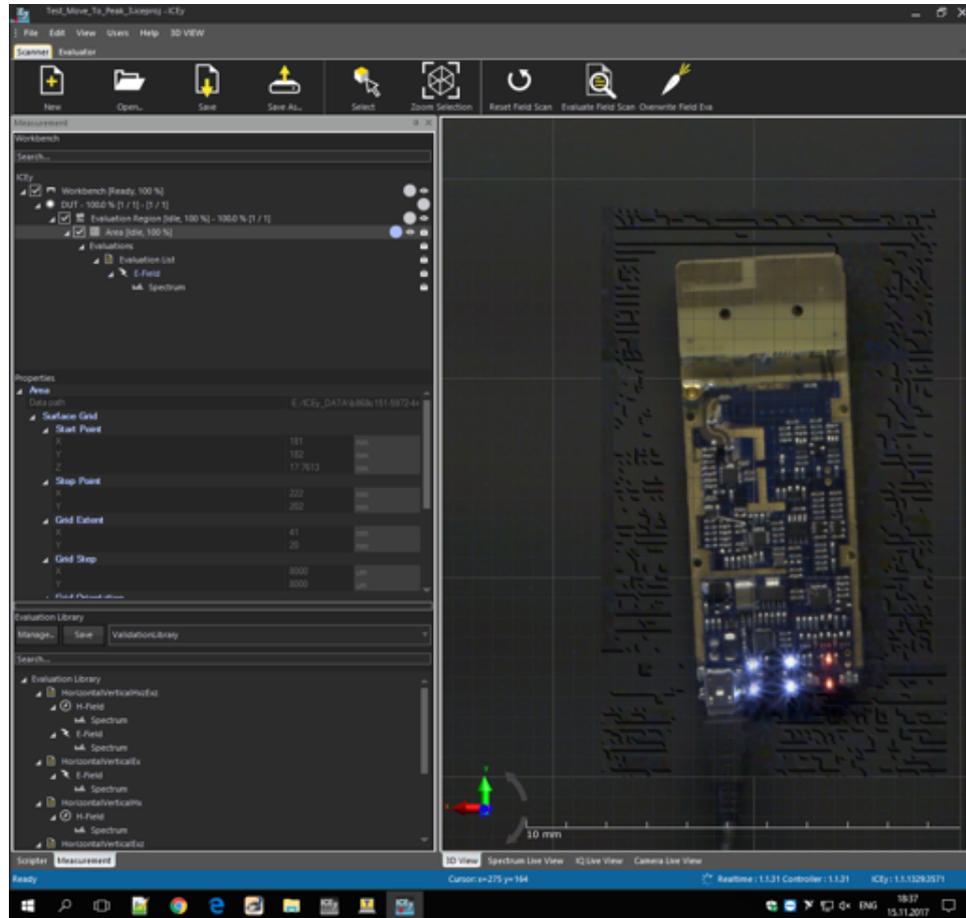


Figure 21.1: 3D View of the workbench showing the DUT.

21.2 Evaluating the results

Once the device has been scanned, the measurements can be evaluated by clicking the *Evaluate Field Scan* icon on the toolbar. A list of the measurements is visible in the *Explorer* window (see Figure 21.2)

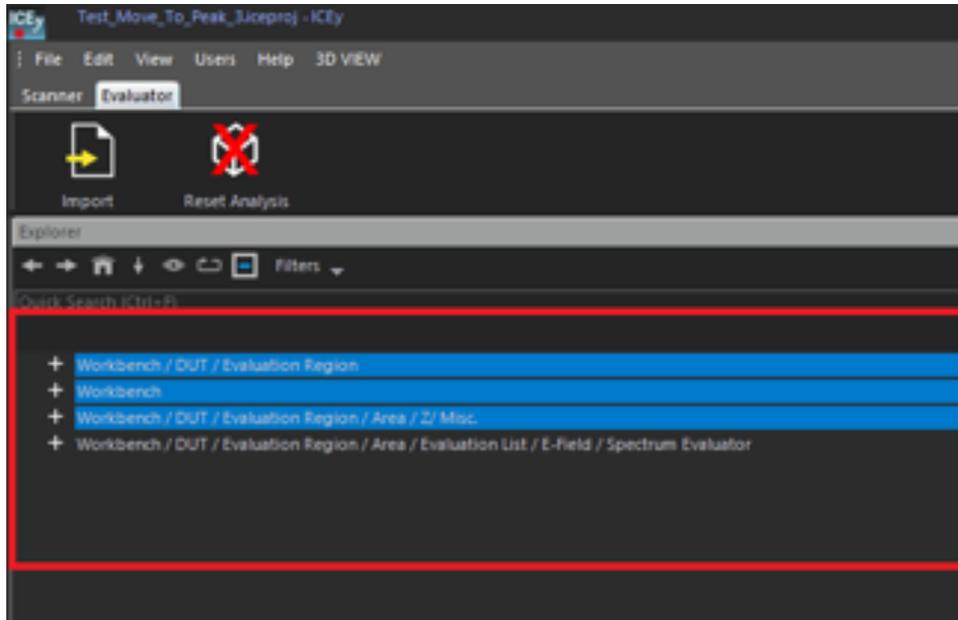


Figure 21.2: Evaluation Results

To perform a peak analysis and get an overview of the peak locations, the *Move to Peak* window must be visible. It can be selected right-clicking on the menu bar (see Figure 21.3). For a full description of the *Move to Peak* window, please take a look at the subsection 11.9.6.4.

21.2. EVALUATING THE RESULTS

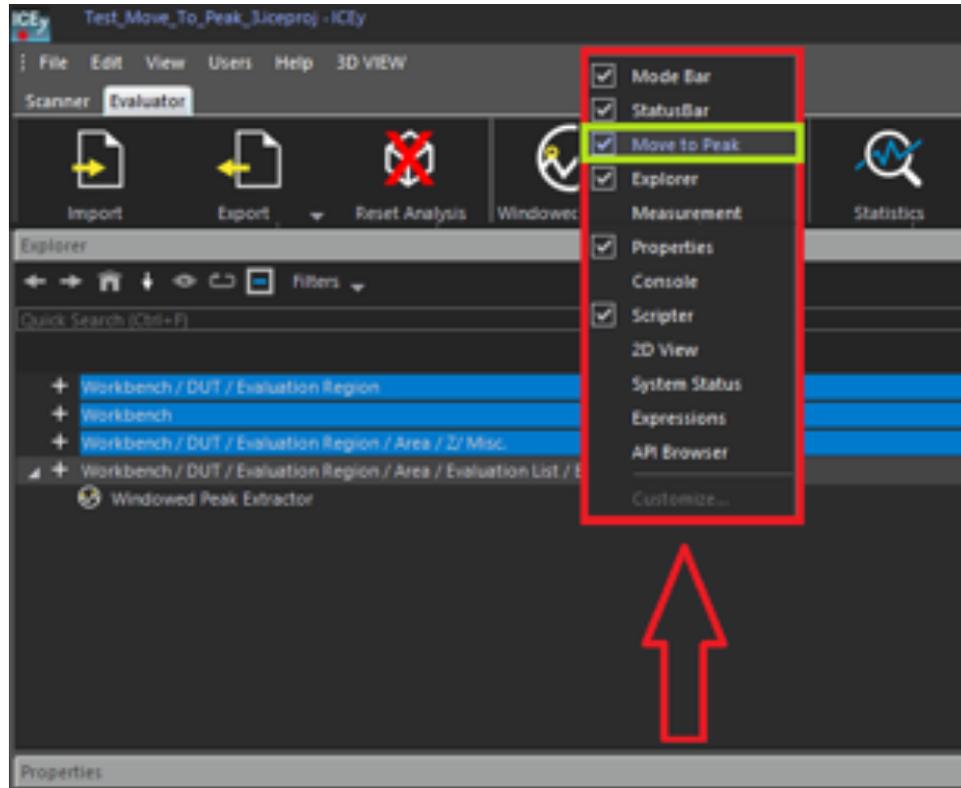


Figure 21.3: Enabling the Move to Peak window

In order to perform a peak analysis, the frequency window of interest has to be defined first. This can be done with the *Windowed Peak Extractor* tool. Right-click on the the field *Workbench/DUT/Evaluation Region/Area/EvaluationList/E-Field/Spectrum Evaluation* and a context menu containing the *Windowed Peak Extractor* will show up (see Figure 21.4).

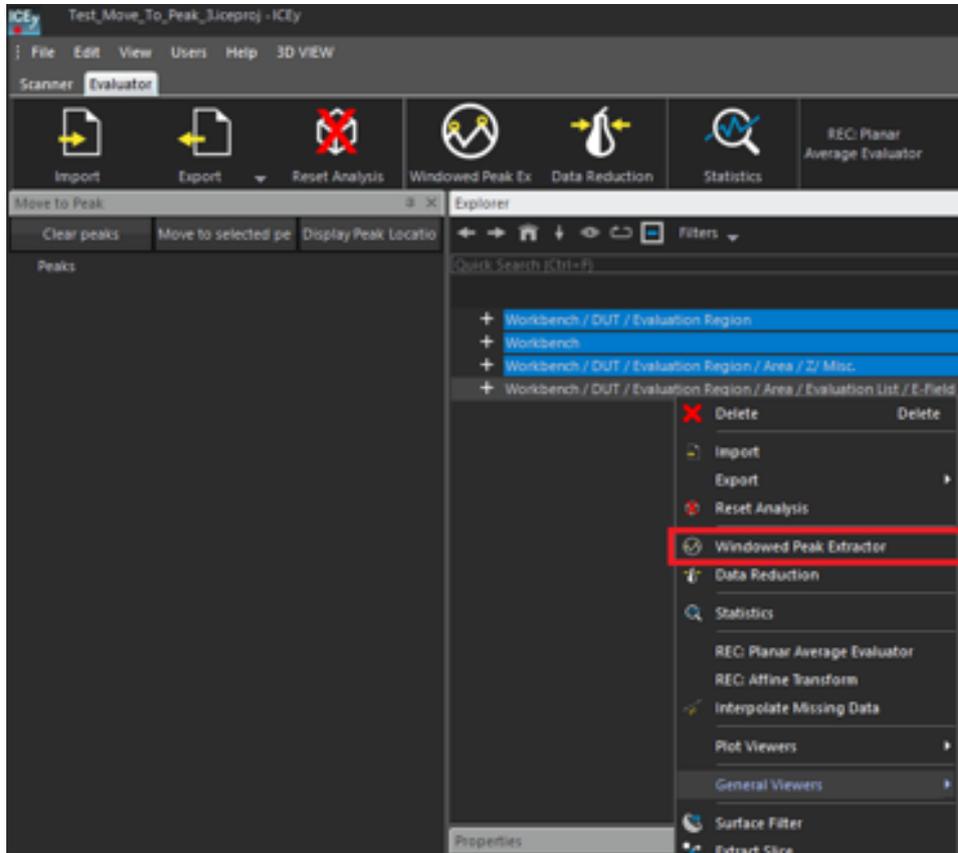


Figure 21.4: Context Menu of the Evaluation Results

21.2.1 Peak Extraction

The *Windowed Peak Extractor* window (see Figure 21.5) defines the frequency range of the peak analysis and allows a peak filtering as described in subsection 11.9.6.4.

21.2. EVALUATING THE RESULTS

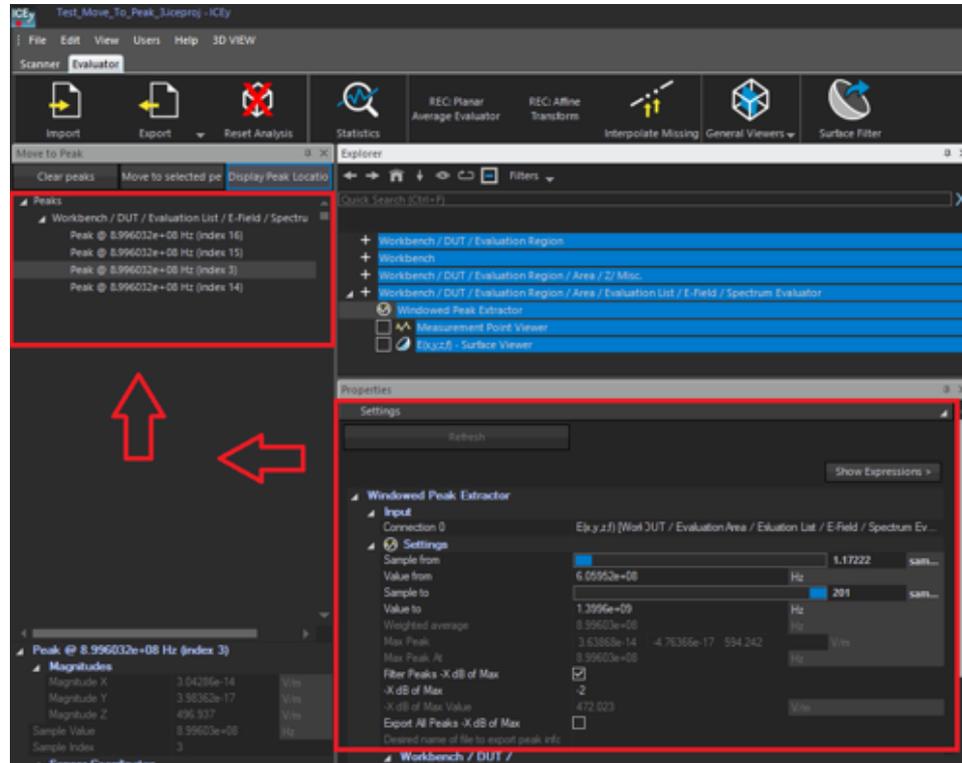


Figure 21.5: The Windowed Peak Extractor Window

To complete the *Evaluation Results* analysis, two further functions, namely *Measurement Point Viewer* (see Figure 21.6) and *Surface Viewer* (see Figure 21.7), allow, respectively, spectral and spatial visualization of the results.

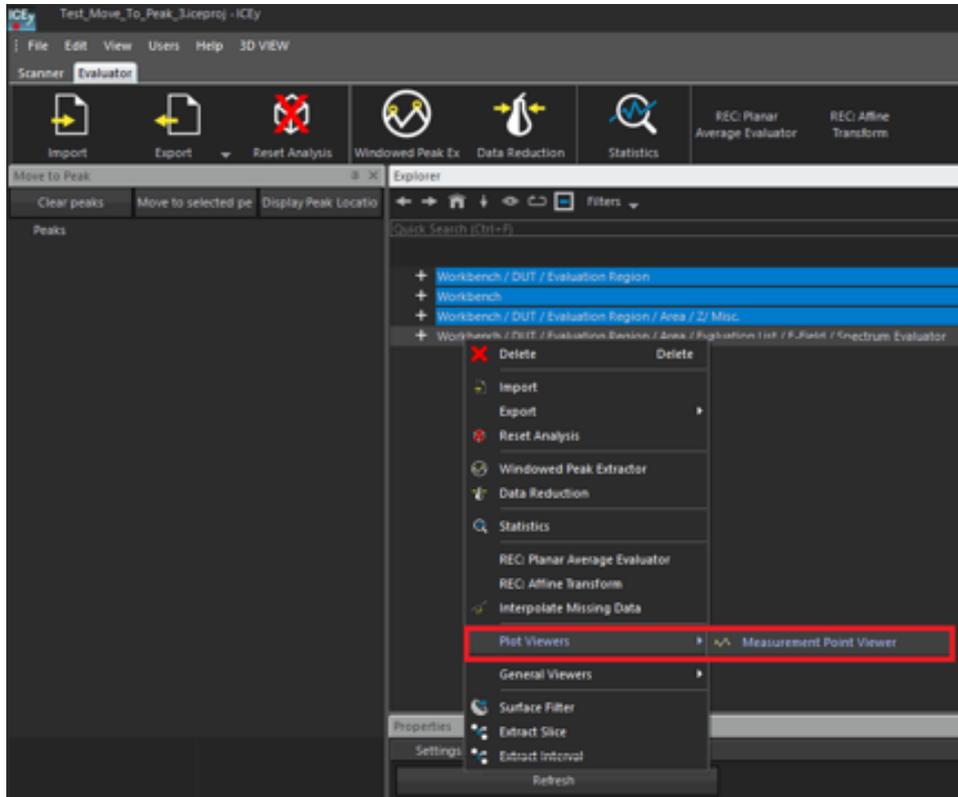


Figure 21.6: The Measurement Point Viewer Location

21.2. EVALUATING THE RESULTS

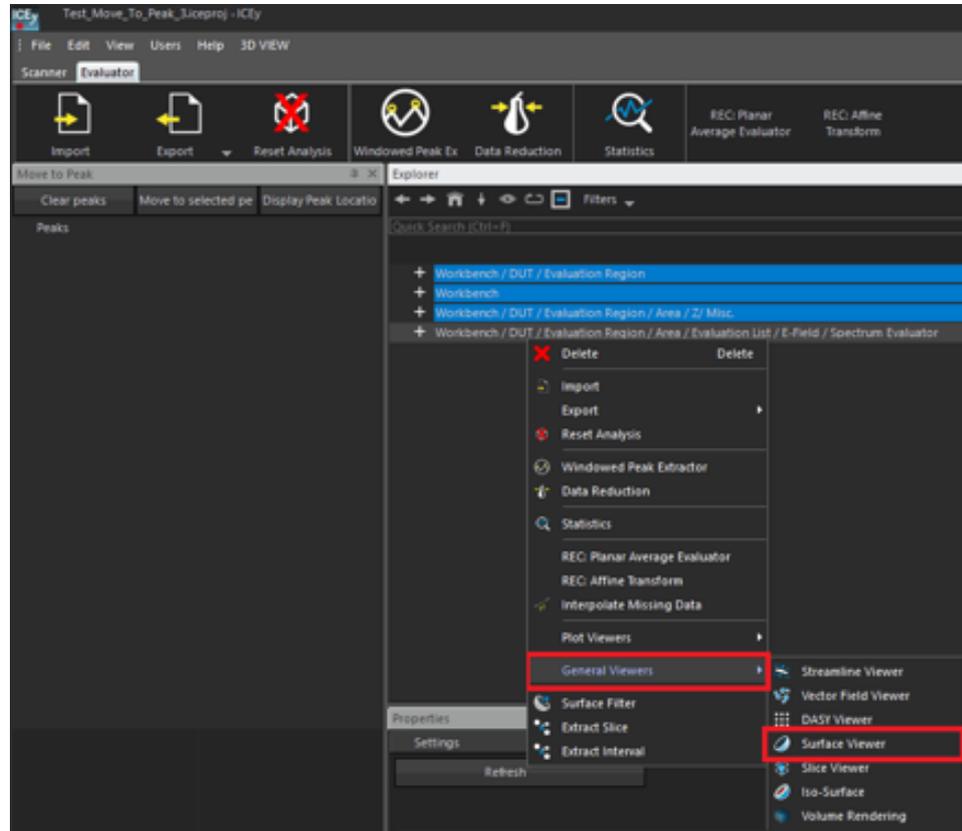


Figure 21.7: The Surface Viewer Location

The *Evaluator Workbench* shown on Figure 21.8 contains the windows *Move to Peak*, *Measurement Point Viewer* and *Surface Viewer*. It provides full information of the scanned device's peaks space and frequency location. By clicking *Display Peak Locations* in the *Move to Peak* window, the spatial locations of the peaks appear. A small sphere identifies the position of the selected peak on the *Surface Viewer* window. The coordinates and field values of the peak are displayed next to this sphere. The *Measurement Point Viewer* window provides the frequency domain data at the assigned position, identified by a *spatial index*. The spatial index (16 in the proposed example) is shown in the Properties window. Please do not forget to refresh both the *Measurement Point Viewer* and the *Windowed Peak Extractor* windows by clicking on the *Refresh* button, or checking on the *Auto Refresh* check-box, in order to update the peak locations and amplitudes.

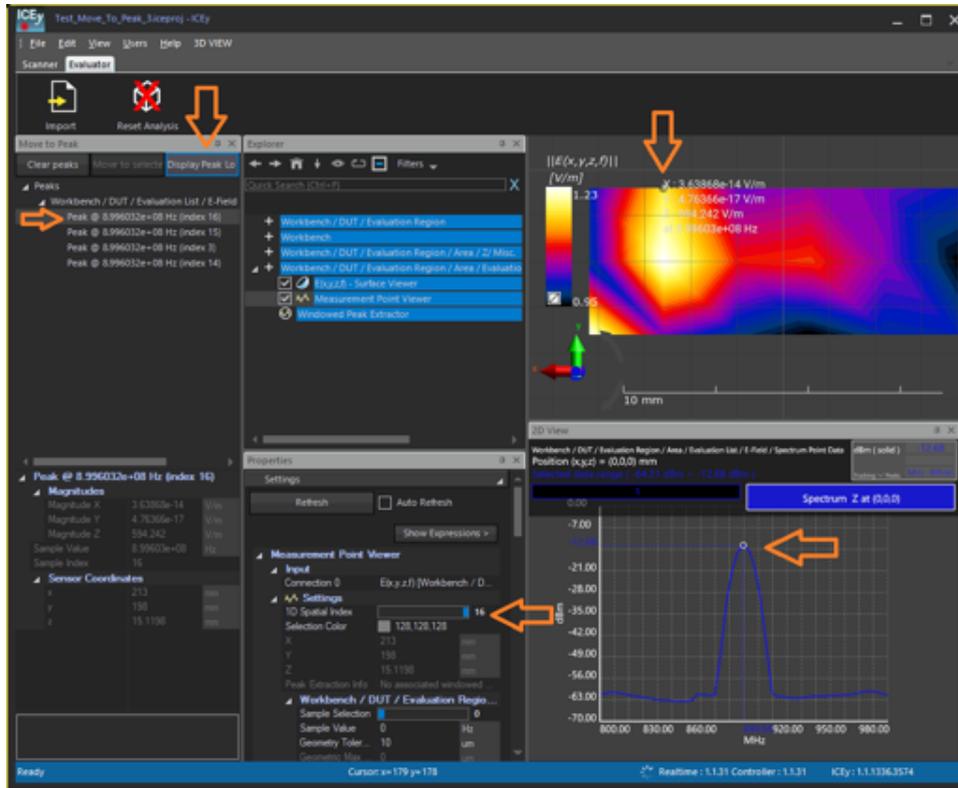


Figure 21.8: The whole Evaluator workbench

21.2.2 Move to Peak Option

Once the full spatial information about the peaks' locations and amplitudes has been extracted in the *Evaluator* workbench, ICEy offers the possibility to move the field probe to a selected peak location and to perform a detailed amplitude and frequency analysis at that hot spot. This can be achieved by clicking *Move to selected peak* in the *Move to Peak* window (see Figure 21.9). Once the *Move to selected peak* button has been pushed, the probe moves to the peak location selected in the *Move to Peak* window (see Figure 21.10).

21.2. EVALUATING THE RESULTS

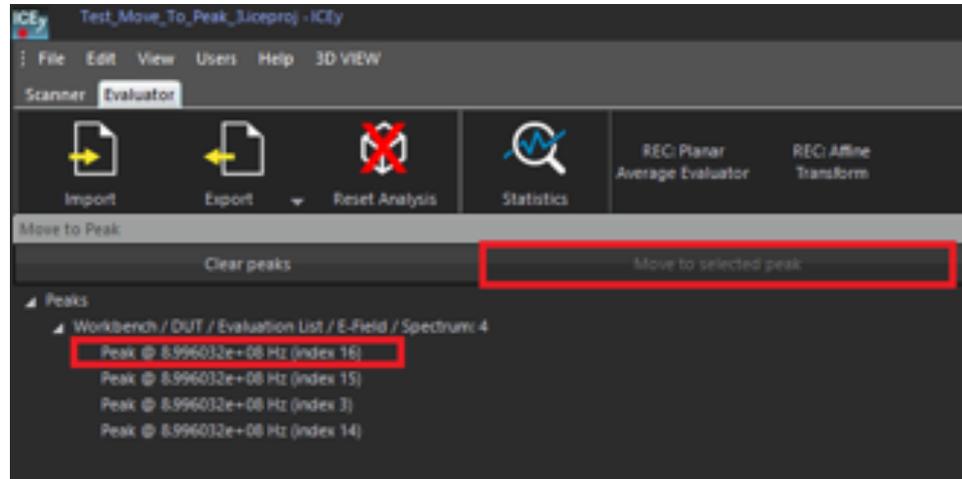


Figure 21.9: Peak selection and Move to Peak button

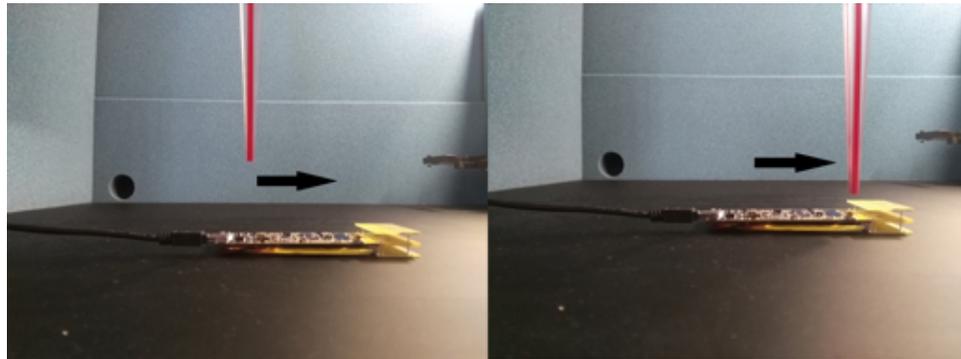


Figure 21.10: Sensor movement on the selected peak position

21.2.3 Switch to the NI RFSA

Once the probe is positioned on the selected peak by using the *Move to Peak* function, it may be interesting to analyze the peak signals with the NI Vector Spectrum Analyser (NI VSA). To activate the NI RFSA soft panel directly from the PC start menu (see Figure 21.11), ICEy must release the control of the instrument. For this purpose, the *VSA Simulator* has to be selected in the *Signal Analyzer* field of the *File - Preferences* menu (see Figure 21.12).

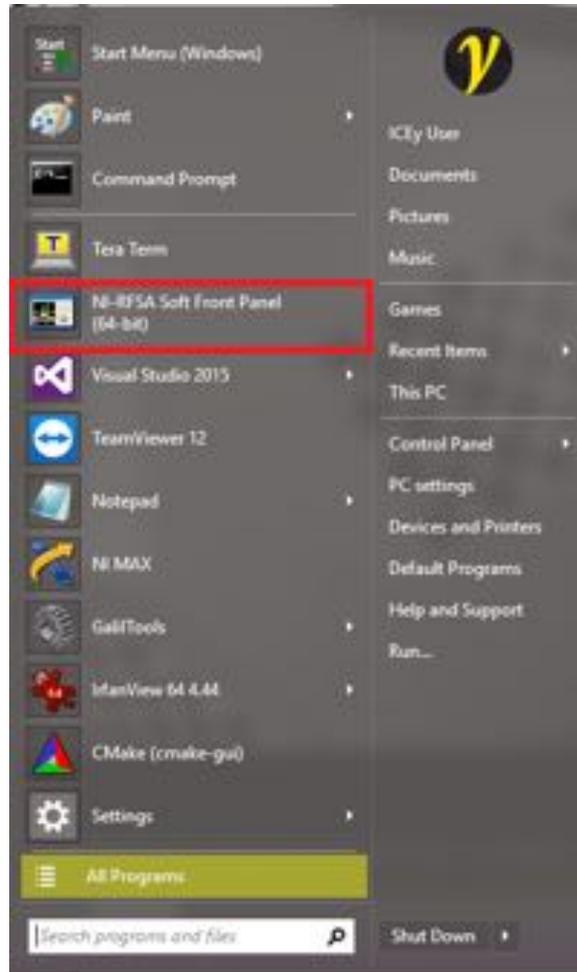


Figure 21.11: NI-RFSA soft panel selector on the start menu

21.2. EVALUATING THE RESULTS

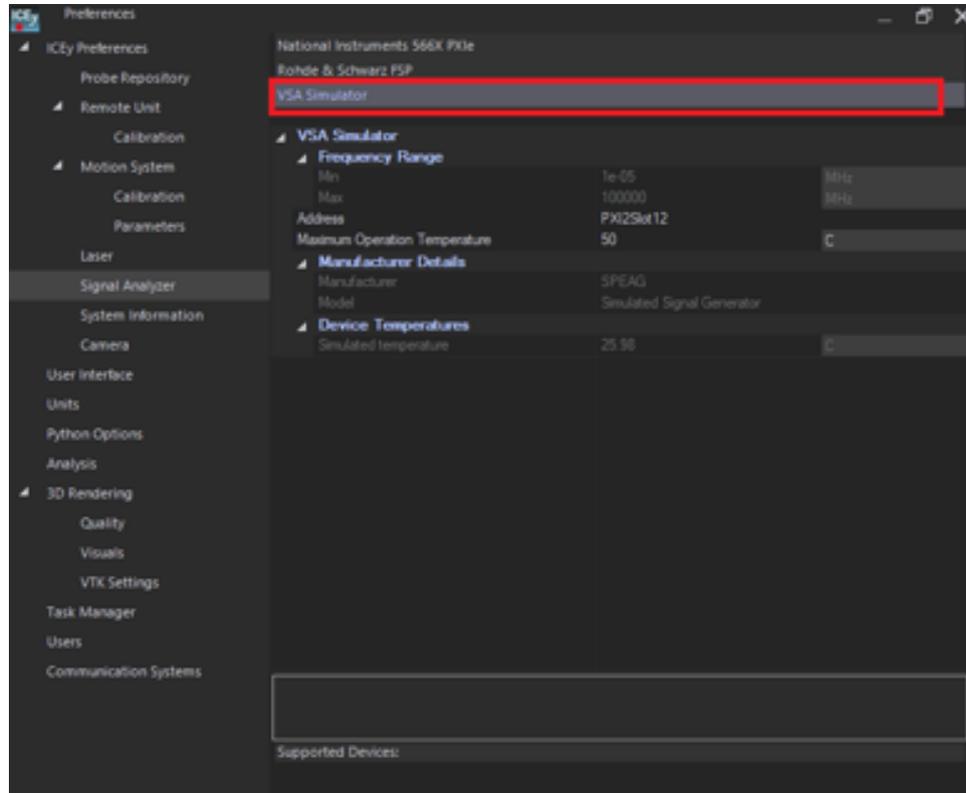


Figure 21.12: When the Signal Analyzer is configured in simulator mode, ICEy releases the control over the NI VSA

Before looking at the signal with the NI-RFSA, it is first necessary to activate the probe. This can be done by running the python script *TD-SCChannelCtrl.py* and activating the channel 1 (see Figure 21.13). This is done in the *Scripter* window, which can be activated by right-clicking on the Menu Bar. The *TDSCChannelCtrl.py* python script can be found in the ICEy release folder, in the path *scripts\examples\XTDS*.

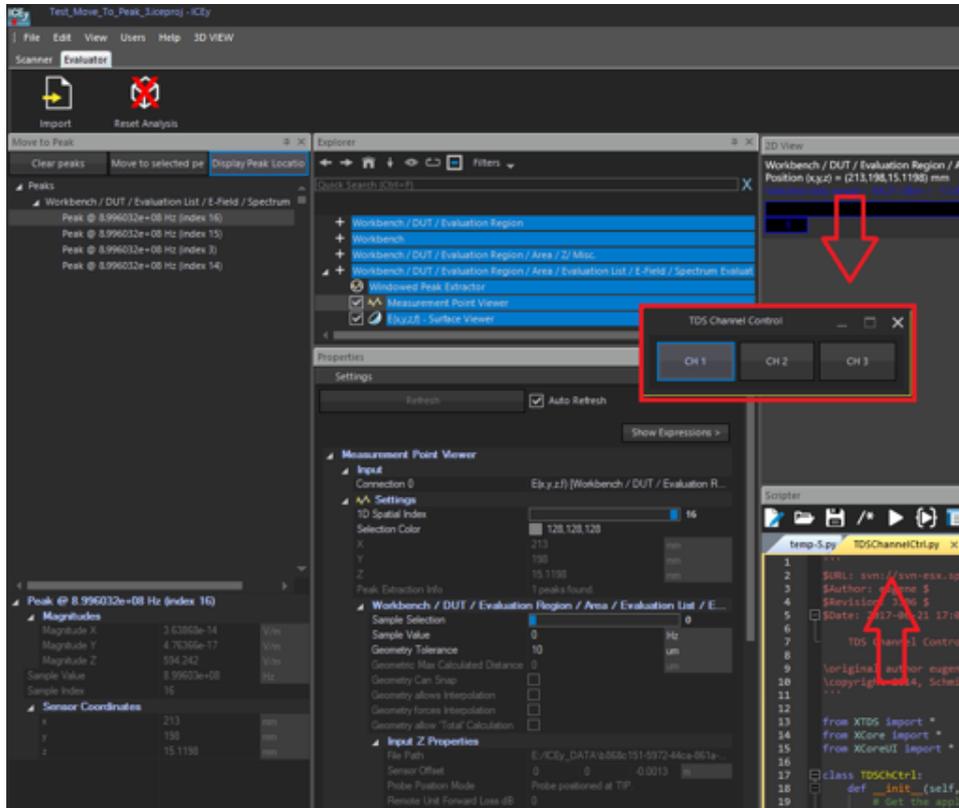


Figure 21.13: *TDSChannelCtrl.py* - the GUI used for activating the probe channel

The NI-RFSA spectrum analyzer can be set in *Local Mode* by clicking on the *SFP Control* button (see Figure 21.14) and then can be manually configured in the frequency range where the peak signal is present (see Figure 21.15).

21.2. EVALUATING THE RESULTS

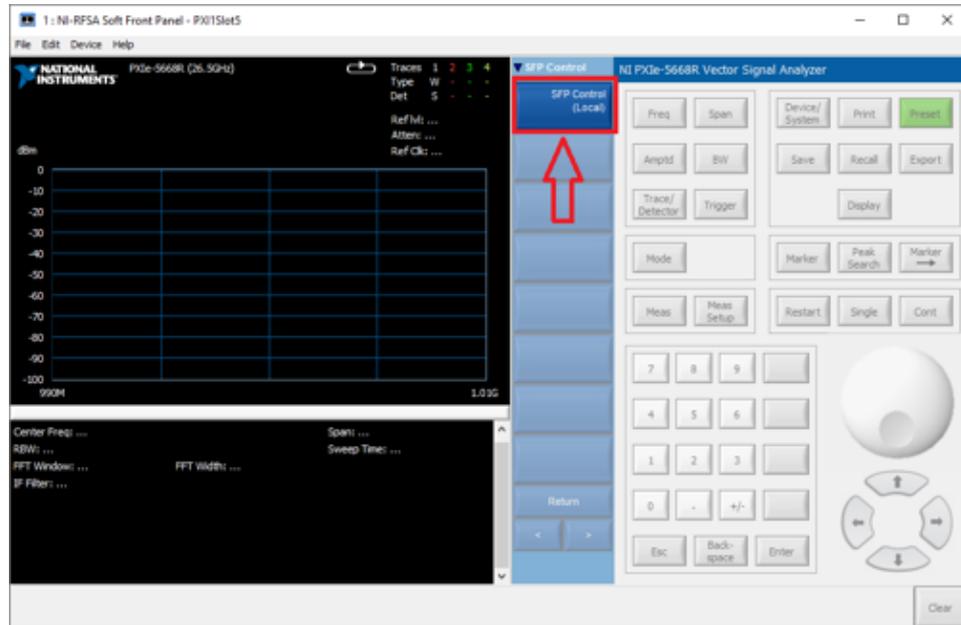


Figure 21.14: NI-RFSA soft panel selector on the start menu

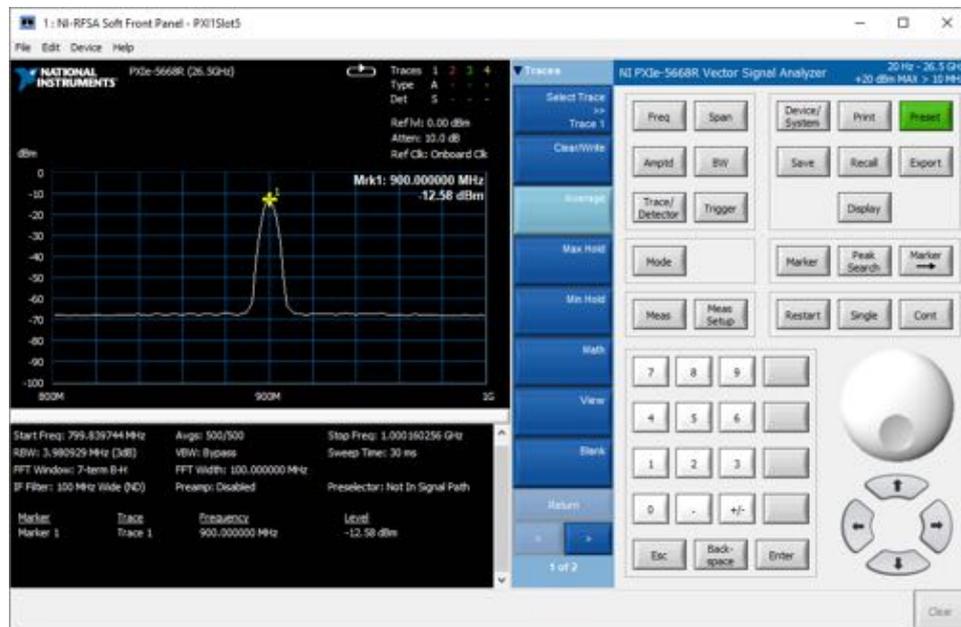


Figure 21.15: NI-RFSA peak signal spectrum

Once the spectrum of the peak signal has been carefully analyzed with

the NI-RFSA, ICEy can receive back the control of the NI-RFSA instrument, by configuring it in access mode (see Figure 21.16).

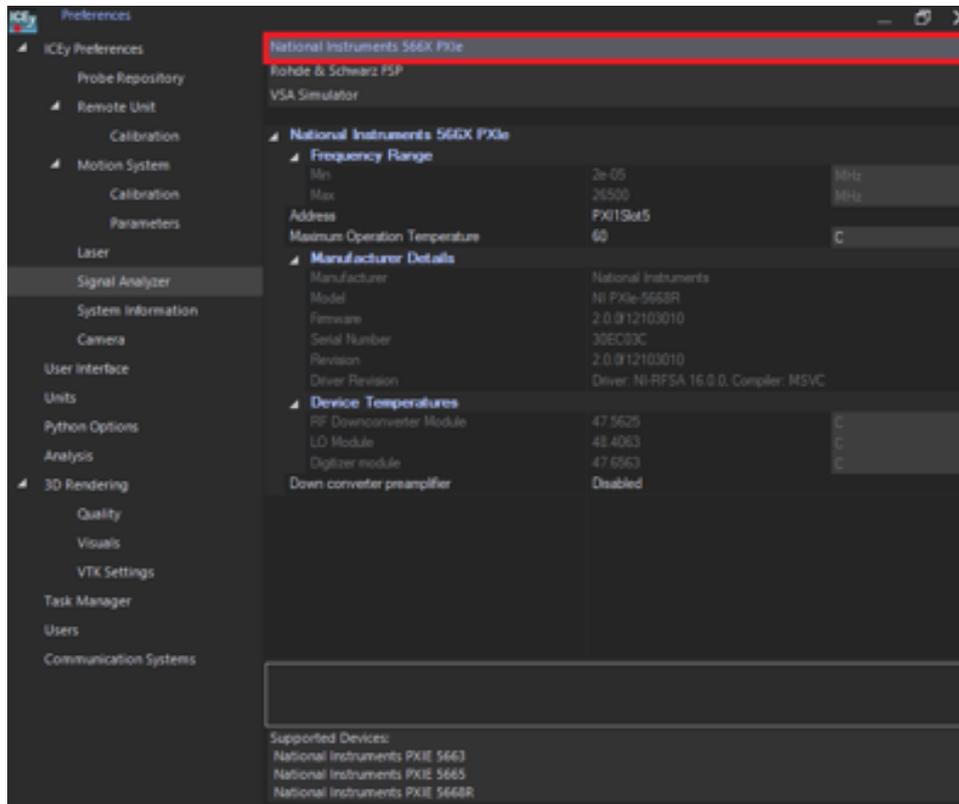


Figure 21.16: When the NI-RFSA is configured in access mode, ICEy is controlling it

That concludes this peak signal measurement example. Further details on how to perform more advanced measurements are given in the other chapters of this manual.

