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SWISS MADE

MFCTOOL V10

MAGNETIC FIELD CAMERA SOFTWARE

USER'S MANUAL

Version 3.0

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ISO17025 ACCREDITED

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GETTING STARTED

1- INTRODUCTION

NOTICE
See the “Installation and Safety Manual,” delivered in printed form with your instrument, for safe installation and operation of the Magnetic Field Camera hardware. The most recent version of this manual is also available for download from the Metrolab website, *www.metrolab.com.*

One of the primary requirements for effective Magnetic Resonance Imaging (MRI) is sufficient uniformity of the main magnetic field. Spatial homogeneity within a few ppm is never obtained without sophisticated correction systems ("shims"). The shimming process requires a precise measurement and analysis of the magnetic field, which can be highly time consuming. Metrolab Magnetic Field Camera (MFC) system such as MFC3045 or MFC2046 offers a very quick and easy way to map MRI magnets with high precision. The precision and speed of these systems offers an inestimable advantage over all other existing mapping and analysis systems.

The Metrolab MFC systems rely on Nuclear Magnetic Resonance (NMR) as measurement technique. NMR is unique in magnetometry due to its unrivalled precision and accuracy, and practically total lack of drift. It is important to note that NMR magnetometry also has limitations. Most importantly, the magnetic field gradients in the volume to be measured must be close to zero. See chapter 6 for more details on NMR magnetometers.

The Metrolab MFC systems are suitable for all mapping applications: inhomogeneity analysis, shim coil characterization, superconducting magnet decay monitoring, quality control, etc. They are suitable for both solenoid and dipole magnets.

The MFCTool V10 Software allows the user to display and control all functions and parameters of Metrolab MFC3045 and MFC2046 systems. It allows magnetic field strength measurements in different operating modes and enables the recording of these measurements in files. The user can quickly obtain information about field homogeneity and stability of the magnet under test.

The contents of this Software User Manual are as follows:

- Chapter 2- “Quick Start Guide” and Chapter 3- “Overview” provide information to get started;
- Chapter 4- “Software User Interface” explains how to use the software;
- Chapter 5- “MFCTool Specifications” lists the software characteristics;

Updates to the software and documentation are posted on the Metrolab website, *www.metrolab.com*, and can be downloaded free of charge.

We hope the MFCTool will help you perform your magnetic field measurements easily and accurately. If you have problems and your reseller cannot help you further, the Metrolab team is ready to help. Even if you don’t have problems, we are always interested in knowing more about how our instruments and software are used. Feel free to contact us at any time at *contacts@metrolab.com.*

2- QUICK START GUIDE

This chapter describes the installation, start-up and shut-down of the MFCTool V10 software.

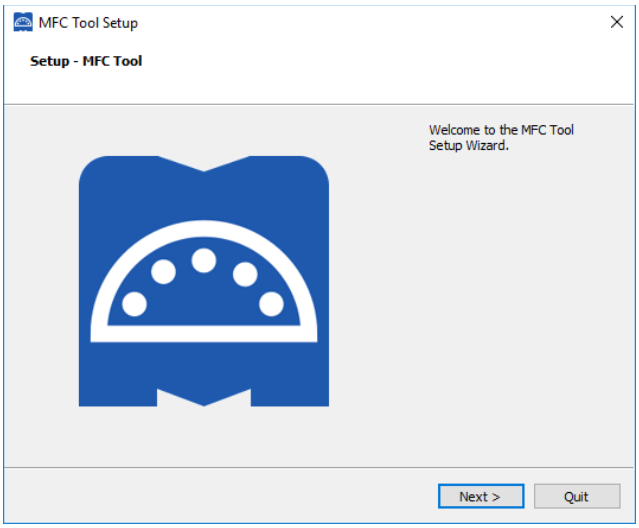
2-1 SOFTWARE PRE-REQUIREMENTS – WINDOWS

Before installing MFCTool you need to install the following software:

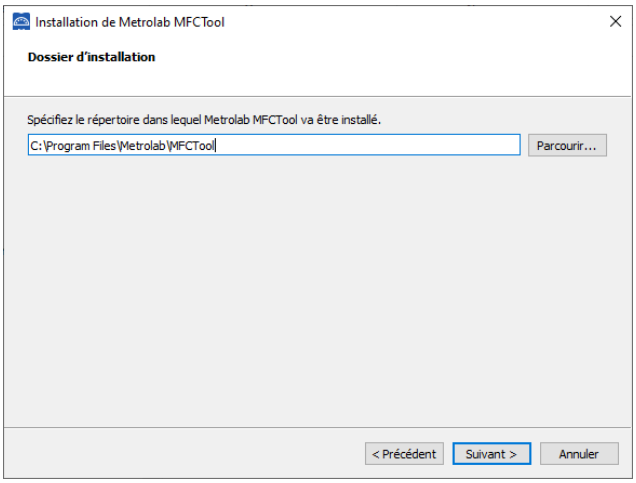
- Download and install the latest *NI-VISA Run-Time Engine* from the National Instruments web site. Use the full edition. MFCTool supports NI_VISA Run-Time 15.5 release or higher.

2-2 MFCTOOL SOFTWARE INSTALLATION – WINDOWS

- Insert the installation CD, or download the MFCTool installer from our website (*www.metrolab.com/downloads/*)
- Execute the MFCTool installation program:
  Metrolab-MFCTool-v10.x.y-Installer.exe , with x.y the release number.
- Click Next to proceed with the MFCTool installation process.



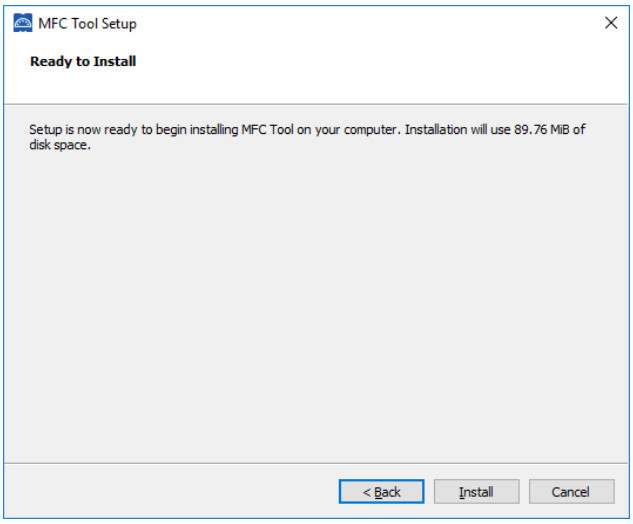
- Select the destination folder path for MFCTool installation if you do not want to use the default one:



Click Next to proceed with the installation.

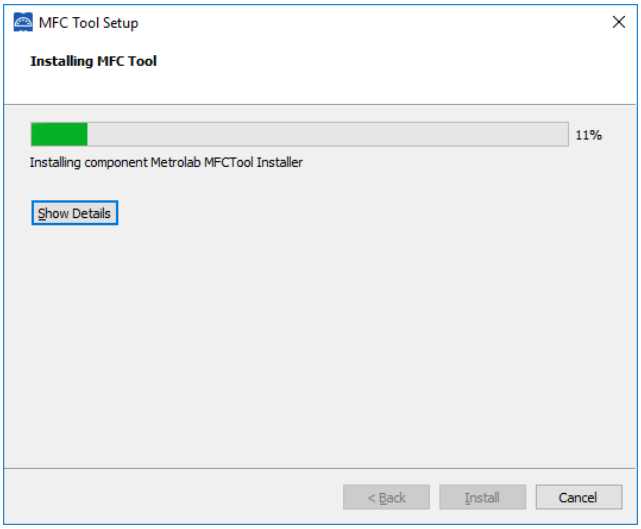
Note: If an older MFCTool V10 version already exists in the installation folder, quit the installer, and uninstall the older version before to proceed further.

- You will now see the installation summary:

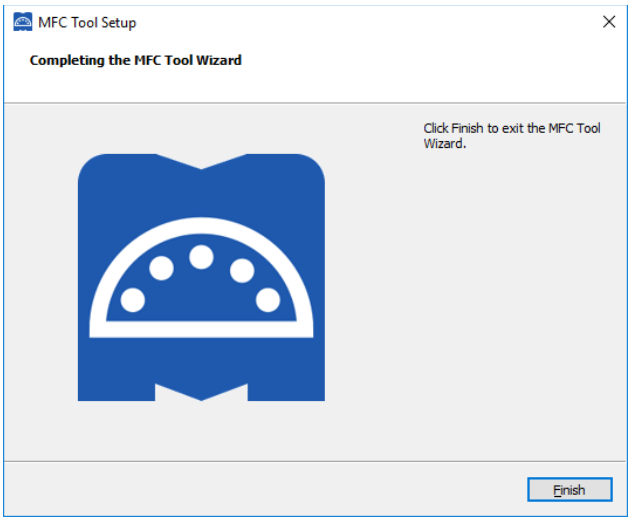


Click “Next” to start the installation of MFCTool on your computer.

- Wait for the installation to complete:



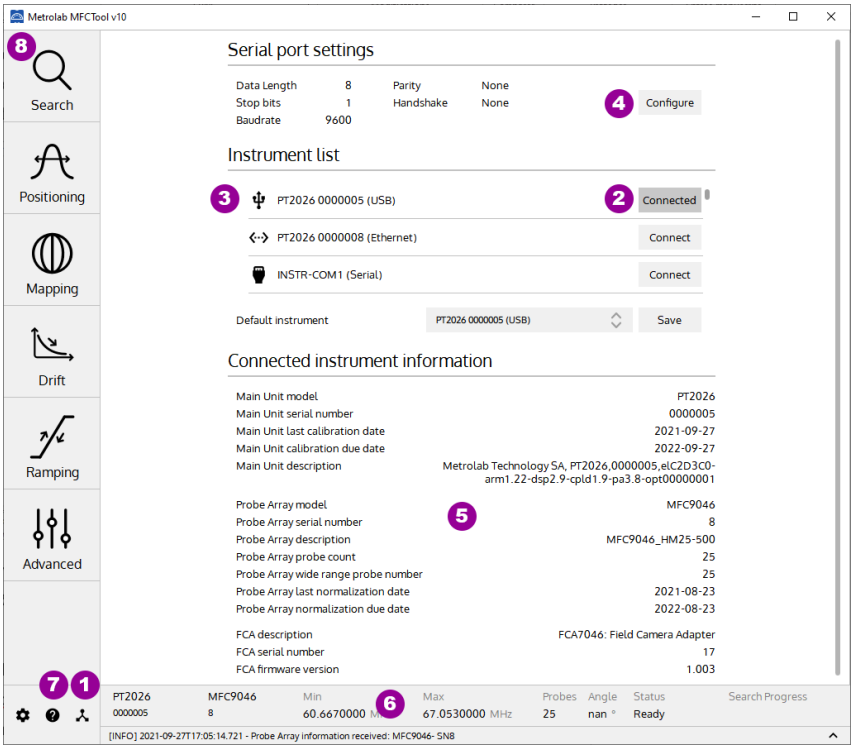
- Click “Finish” to exit the installer.



- MFCTool is ready to be used.

2-3 START-UP

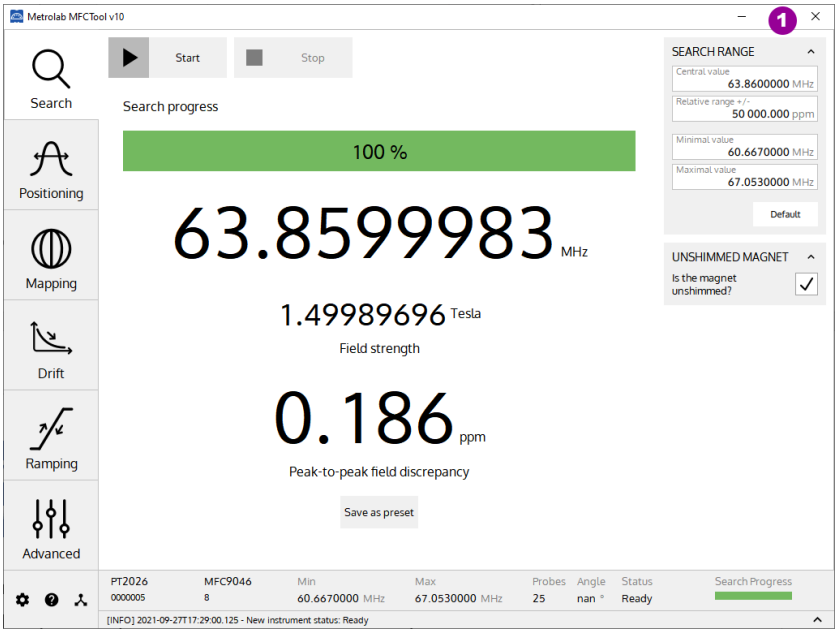
- Connect your Magnetic Field Camera system to your computer as described in the “Instrument’s Installation and Safety Manual” (MFC3045; MFC2046).
- Power on your instrument.
- Start the Magnetic Field Camera software from the Windows Start Menu:
  Metrolab MFCTool
- In the MFCTool software window, click on the “Connection” icon (see item 1 in the illustration below) to access the Connection settings page. Select the MFC system to connect to in the instrument list (see item 2). The instrument name (see item 3) should be “Instrument Model” + “Instrument Serial number”. This name is preceded by an icon representing the instrument connection type (Ethernet, USB, Serial). If the instrument uses a serial connection, configure the Serial port settings (see item 4) before connecting to the instrument.
  Verify that the software has successfully connected to your instrument. The “Connect” button should have changed to “Connected”. Information about the connected instrument should be displayed (see item 5 & 6). For more information about the connection page, press the help icon “**?**” in your software window (see item 7), or read section 4-2 of this manual.



- Select the Search operating mode (see item 8) to do a field strength search. See section 4-5 for more information about the Search operating mode.
- Then select another desired operating measurement mode on the left of MFCTool window. See section 4-1 for general information on operating modes and press help “**?**” icon on each operating mode page to see more details.

2-4 SHUT-DOWN

- To quit the software, close the MFCTool window (see item 1):



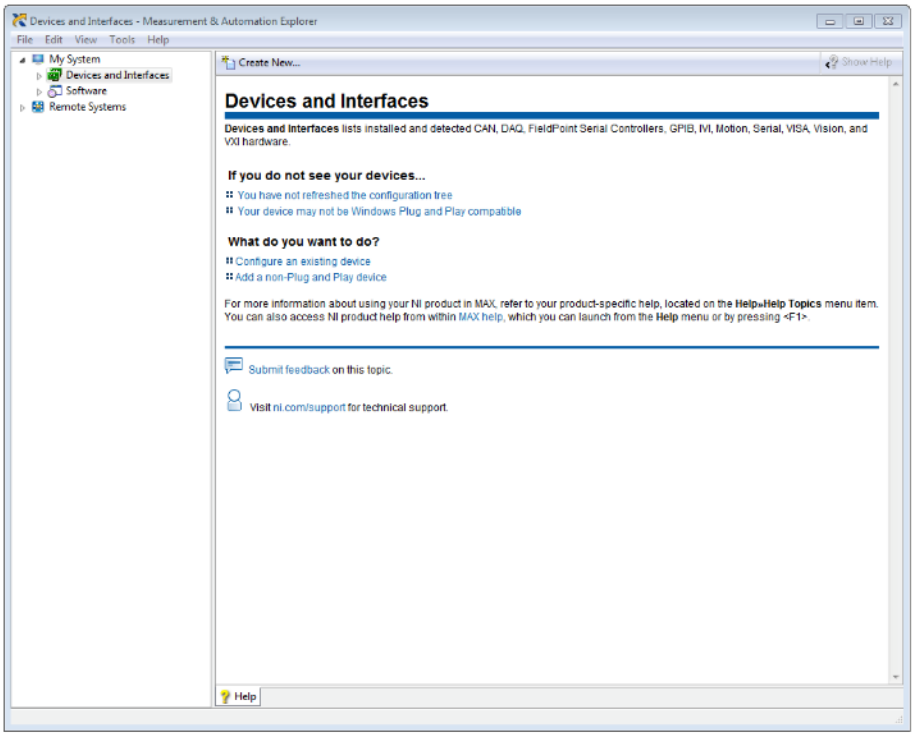
- Power off the Instrument.

2-5 CONNECT INSTRUMENT VIA ETHERNET

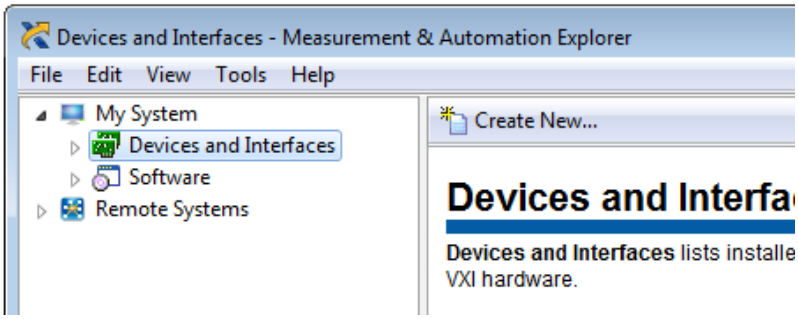
To connect to your instrument (PT2026) via Ethernet, you must first create a network instrument entry in the VISA database.

Use the National Instruments utility, “Measurement & Automation Explorer” (MAX) to do this:

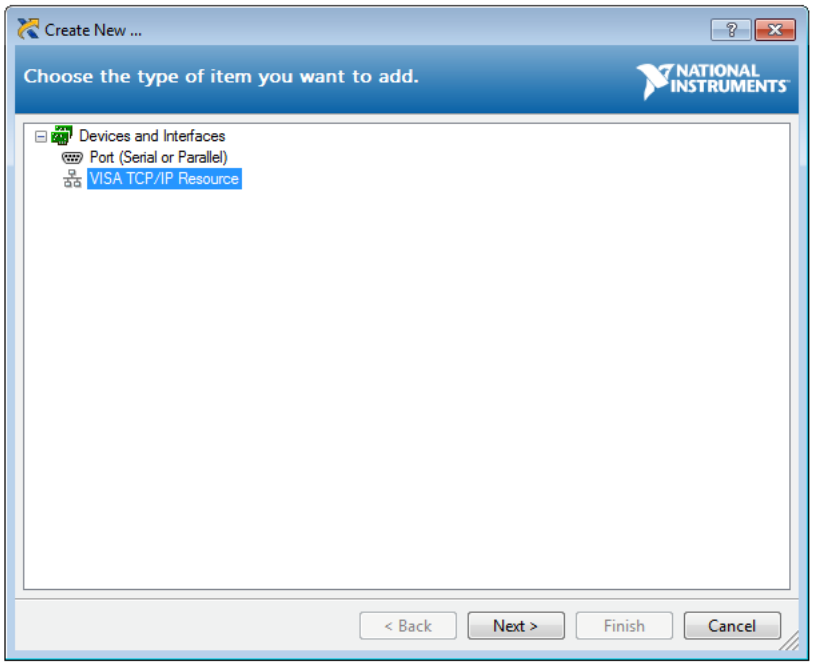
- Launch MAX: Windows Start Menu > All Programs > NI MAX:



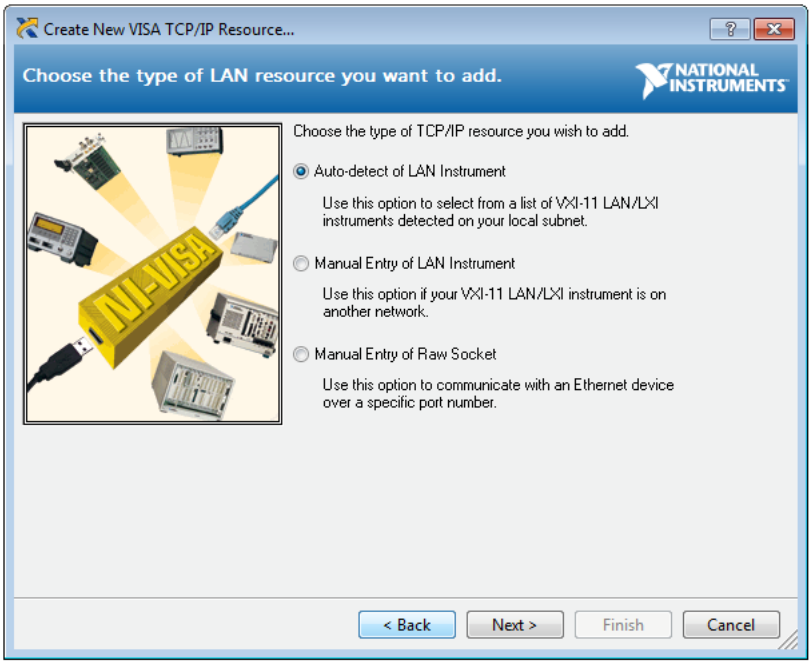
- Select “System > Devices and Interfaces” in the left-hand column, and click on “Create New…”:



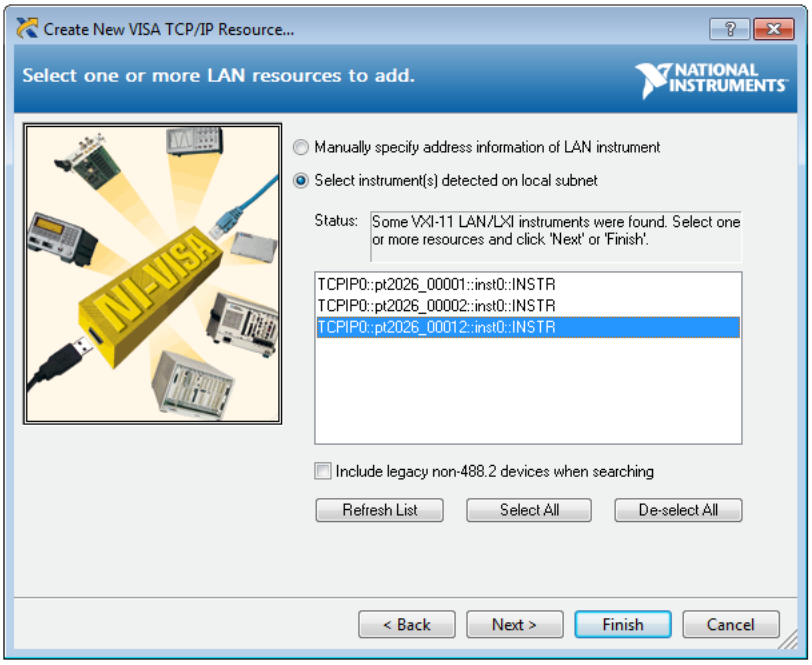
- In the resulting dialogue window, select “VISA TCP/IP Resource” and click “Next”:



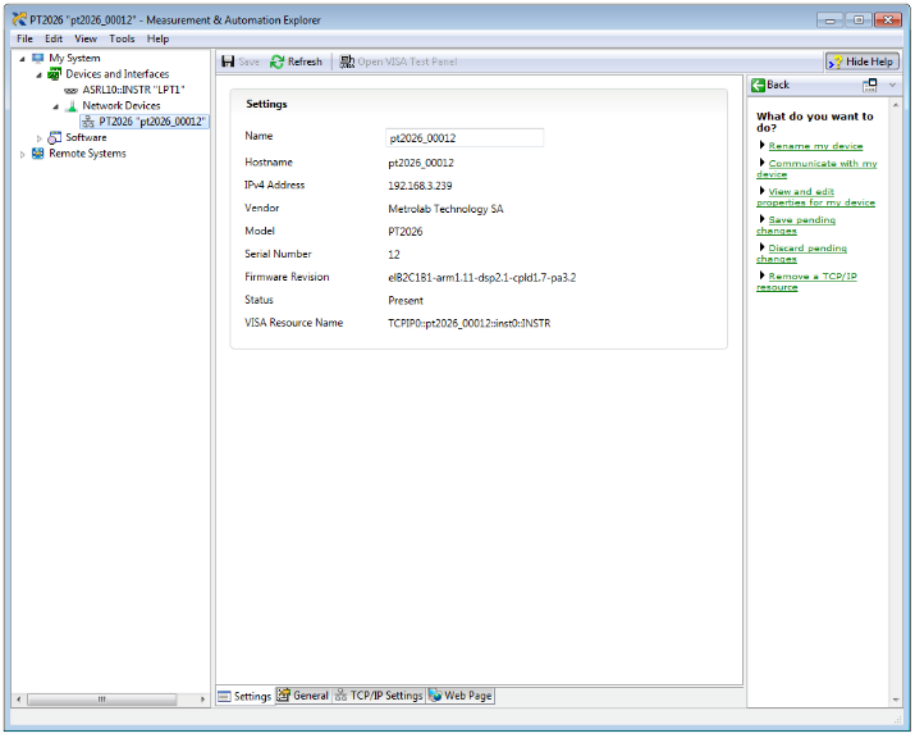
- In the subsequent dialogue, select “Auto-detect of LAN Instrument” and click “Next”:



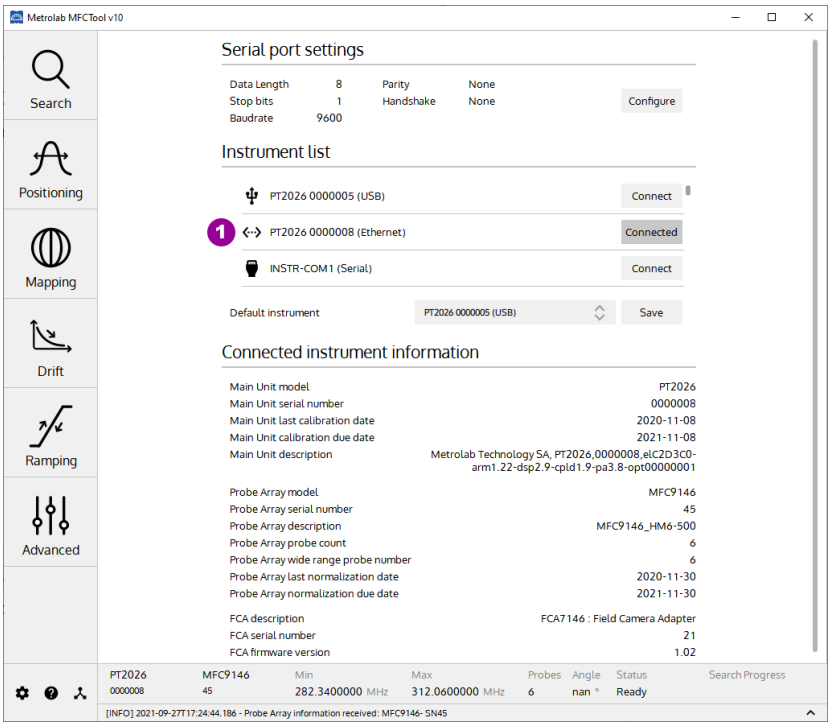
- In the last dialogue, select the entry that corresponds to your instrument, and click “Finish”:



- In the main MAX window, if you expand the item “Devices and Interfaces”, then the subjacent item “Network Devices”, you will now see an entry for your instrument. Click on the entry to reveal the Settings panel for your network device:



- Now, in the Connection panel of the MFCTool, you will see the entry for your instrument to connect with Ethernet (“<···>” icon, see item 1):



Press the Connect button and go!

MAGNETIC FIELD CAMERA

3- OVERVIEW

This chapter provides a quick overview of what you can do with a Magnetic Field Camera system and the MFCTool Software. Additional details are provided in subsequent chapters. Note that the contextual help in the MFCTool software is very useful; in fact, it is exactly the same as Chapter 4- “Software User Interface”.

The MFCTool Software allows the user to access all the usual commands and instrument parameters and to achieve all the measuring sequenced needed to characterize magnet field strength for MRI.

3-1 OPERATING SYSTEM

MFCTool V10 software runs under Windows 7 (64bit) or later.

Linux and OSX versions will be soon available.

3-2 MAGNETIC FIELD CAMERA SYSTEM

The Metrolab Magnetic Field Camera systems offer a quick and precise way to map MRI magnets. The MFCTool v10 software can manage Metrolab MFC2046 and MFC3045 models.

Metrolab Magnetic Field Camera systems:

- MFC2046 (pulsed wave NMR). Including devices:
  - PT2026: Main unit
  - FCA9046: Main Unit to Probe-Array adapter
  - MFC9046 or MFC9146: Probe-Array
  - RB8045, RB8046: Remote box
- MFC3045, (continuous wave NMR). Including devices:
  - MFC3045: Main Unit
  - MFC3048: Probe-Array
  - MFC3045-RB, RB8045: Remote Box

3-3 MEASUREMENT

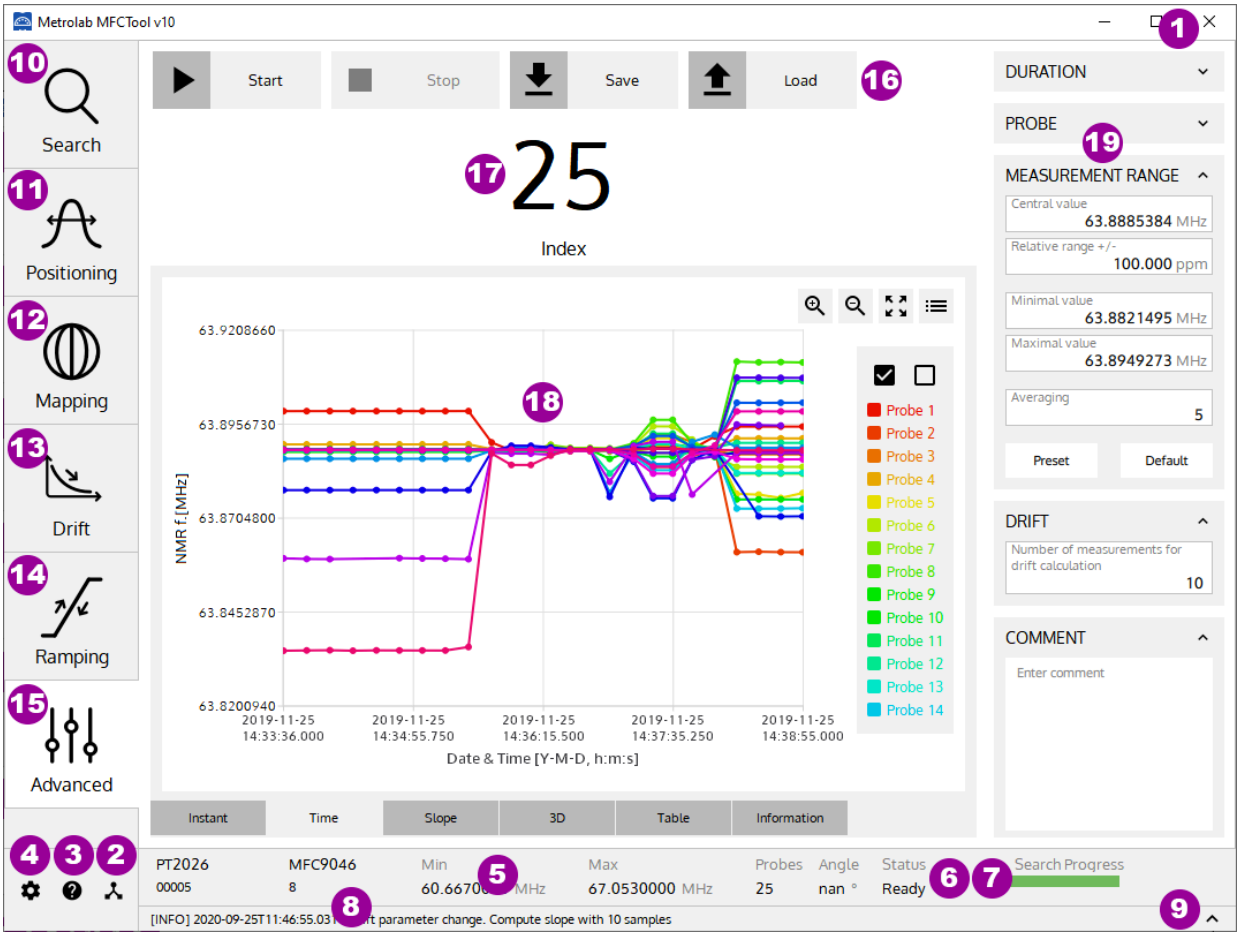
- To help facilitate your measurements, the MFCTool software offers several operating modes:
  - **Search**: This operating mode allows you to find the exact field strength of a magnet. If the magnetic field value is somewhere in the Probe-Array range, it will be measured. By default, the search range covers the Probe-Array's entire sensitive range; however, you can restrict the search parameters to a narrower range. This mode should be used before starting other operating modes. You can save the measured field as a preset for other operating modes.
  - **Positioning**: This operating mode helps position the Probe-Array in a magnet by viewing an instantaneous measurement of the magnetic field in a plot with persistent traces.
  - **Mapping**: This operating mode is suited for mapping the field strength on a sphere or cylinder. During a 360° rotation, it guides you in placing the Probe-Array at each step angle and performing the measurement.
  - **Drift**: This operating mode permits measuring the field drift of your magnet, by measuring it repeatedly during hours and computing the field decay slope.
  - **Ramping**: This mode is used when establishing the current in a superconducting magnet, to determine when the field reaches the nominal value. It monitors the field value in real time, over the entire range of sensitivity of the Probe-Array.
  - **Advanced**: This operating mode is used to measure field strength in an advanced way, with access to all types of available measurement parameters. It allows you to choose your own way to configure and operate your measurements.
- You can measure magnetic flux density with a precision of parts per million (10^{-6}) or even better.
- MFCTool can display measurements in Tesla or MHz (see section 4-1). The gyromagnetic ratio (MHz/T) used as the conversion factor between these two units is stored in the Probe-Array's EEPROM, and is set according to the NMR sample material used in the Probe-Array.
- If for some reason the MFC system is unable to measure an NMR signal, a "NAN" (Not A Number) value is returned.
- You can record your measurements in an xml file. If needed, measurement files can be reloaded to review the plots and data tables. The default MFCTool measurement file name is constructed as "ProbeArrayType_ProbeArraySerialNumber_DateTime_OperatingMode.mxr.xml".

USING MFCTool

4- SOFTWARE USER INTERFACE

This chapter provides a detailed explanation of the operation of the MFCTool software. The same information is available online, by clicking the Help button (see Section 4-1).

4-1 GENERAL INFORMATION



4-1-1 Controls and indicators

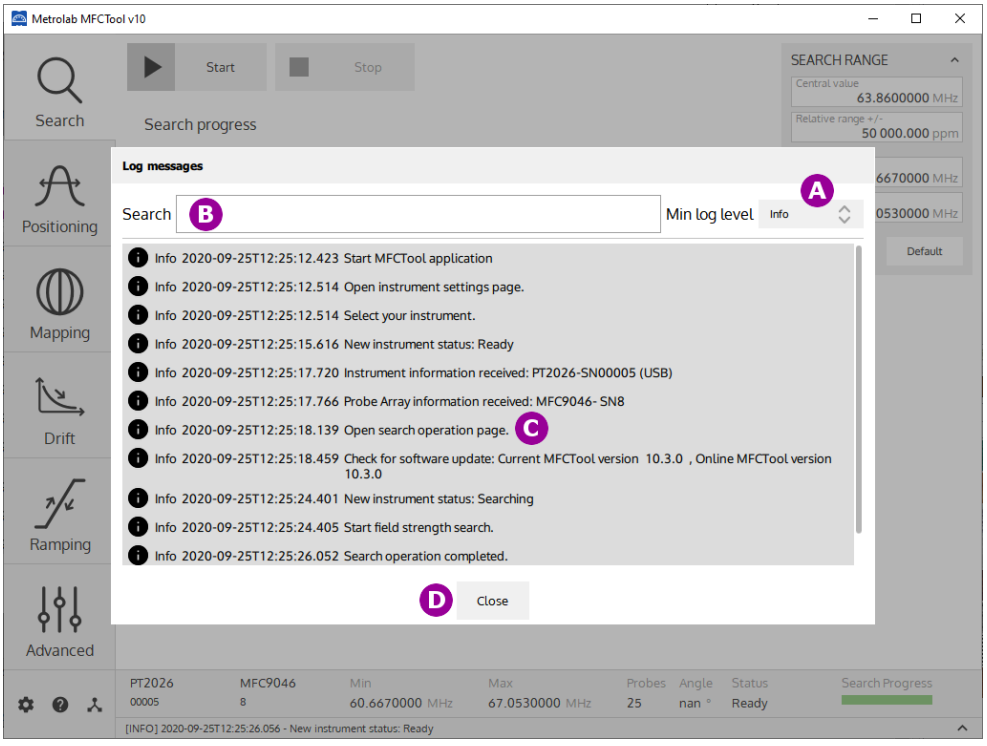
On most of the MFCTool windows, the controls and indicators are arranged as follows:

- On the left side are the different measurement operating modes (items 10, 11,12, 13, 14, 15) to use with your connected Magnetic Field Camera.
- Along the top are the action button controls (item 16) for the current operating mode.
- On the right side are the parameters (item 19) to configure the measurement of the current operating mode.
- In the center, the results and other information about the current measurement are displayed (items 17, 18).
- Along the bottom are settings and information (items 2, 3, 4, 5, 6, 7, 8, 9) about MFCTool and your instrument.

Details on the general controls and indicators:

1. **Quit** the application.

2. Display the instrument's **Connection** page, to set up the Magnetic Field Camera connection.
3. Display contextual **Help** for the current page.
4. Display the **Settings** page, to configure the MFCTool user settings and access the maintenance (**Normalization**) page on MFCToolPro edition only.
5. Display **information** about the currently connected Magnetic Field Camera:
   - Instrument model and serial number,
   - Probe-Array model and serial number,
   - Minimal and maximal operating range (NMR frequency or Tesla),
   - Number of probes in the Probe-Array,
   - Angular sensor's value of the Probe-Array. "nan" (not a number) is displayed if the sensor is not implemented on the Probe-Array (option not implemented yet).
6. Provide the overall **instrument status**.
7. The **Search progress bar** shows the status of the NMR signal search.
8. Provide MFCTool's **last log message**.
9. Display the MFCTool's **history log messages** window.



A. **Filter** the message type to display. Select the minimum desired log message level between Info, Warning, Critical error and Fatal error.

B. Write to **search** a specific message in the history log.

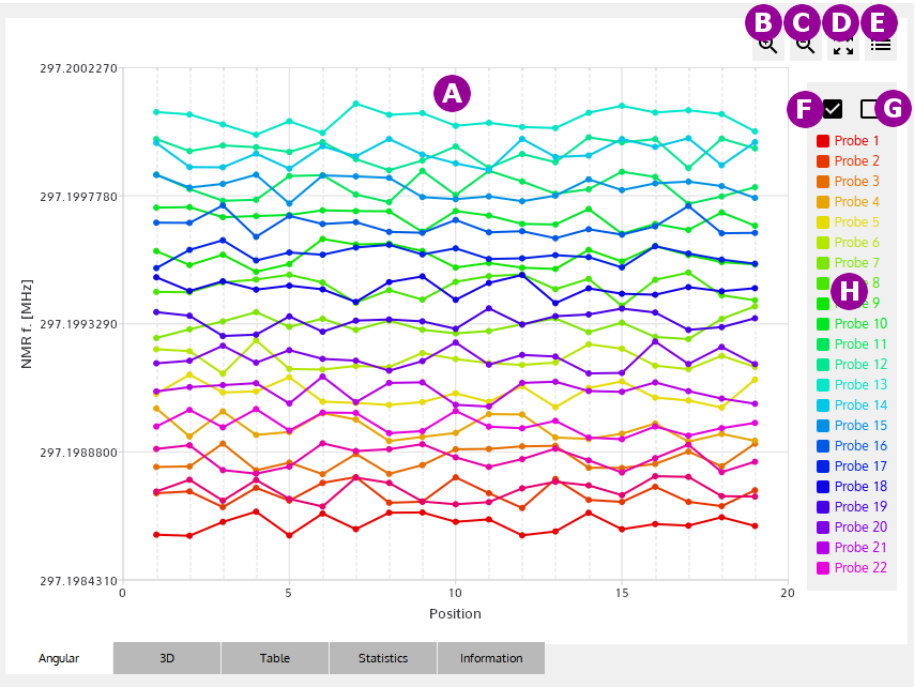
C. Display log messages.

D. **Close** the history log window. Selecting out of the window will close the history log as well.

10. Display the **Search** operating mode page, to search for the exact magnetic field of a magnet.
11. Display the **Positioning** operating mode page, to facilitate positioning the Probe-Array in a magnet.

12. Display the **Mapping** operating mode page, for measuring a magnetic field map.
13. Display the **Drift** operating mode page, for drift measurements.
14. Display the **Ramping** operating mode page, for tracking the magnetic field strength up to a target value.
15. Display the **Advanced** operating mode page, for advanced measurements.
16. Select the **button control** to perform an action (Start, Stop, Save file, Load file) according to the current operating mode.
17. Display the **current measurement number** or position according to the operating mode.
18. Display the NMR field measurement **results** in different plots and tables according to the current operating mode:

- Measurement results in a 2D plot:



A. Display measurement results as a **2D plot**. The X and Y axes are defined in the section describing the operating mode that uses this type of plot. Each trace on the plot corresponds to one probe's measurements. You can zoom into a portion of the plot by using the mouse to select a rectangle in the plot area. To restore the original view, click on the right mouse button or select item D.

B. **Zoom into** the plot view.

C. **Zoom out of** the plot view.

D. **Restore** the original plot view.

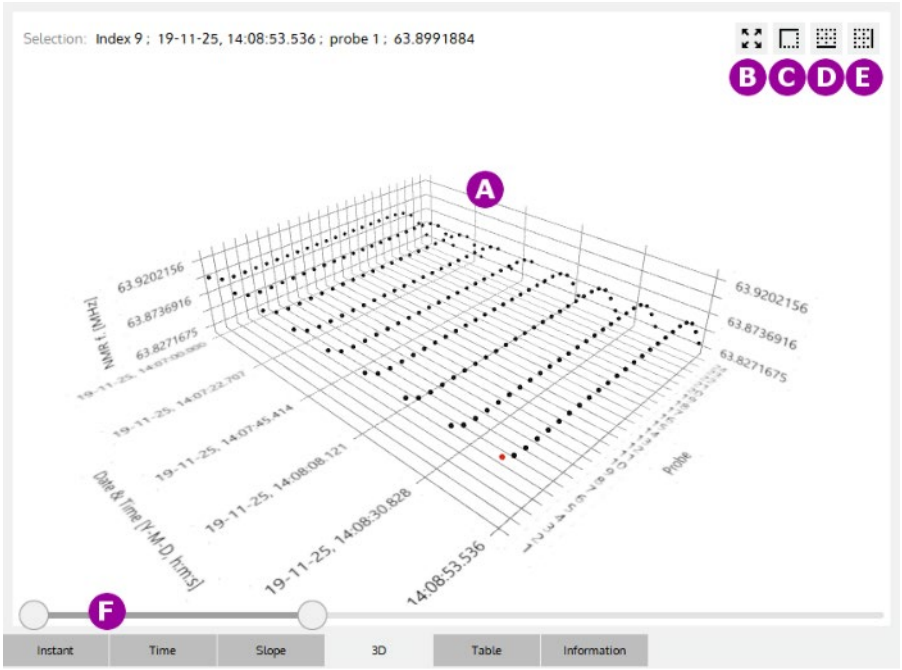
E. Show or hide the **legend**.

F. **Show** all probe **traces** on the plot.

G. **Hide** all probe **traces** on the plot.

H. Display a legend for the probe traces. Click on an entry to show or hide an individual probe trace. When you pass the pointer over a probe legend without clicking it, the probe trace is highlighted.

- Display measurement results in a **3D plot**:



A. Display measurement **results** as a 3D plot. Depending on the operating mode, the X axis can be time or position. The Y axis is probe number. The Z axis is the NMR measurement result in MHz or Tesla. See the information on a specific operating mode using this kind of plot for more details on X-Y-Z.

   The view orientation can be changed by clicking the right mouse button while moving in the 3D plot area. The mouse wheel can be used as a zoom control. If you click on a probe position in the 3D plot, information appears for the selected measurement.

B. **Restore** the original plot view size.

C. Display the 3D plot in an **isometric** (45°) view.

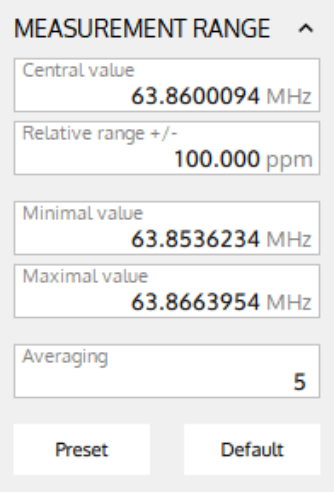
D. Display the 3D plot in a **front view** (Position axis as the base axis).

E. Display the 3D plot in a **side view** (Probe axis as the base axis).

F. **Time** slide bar. Move the two cursors to zoom the 3D plot on a portion of the Time axis.

19. Display and configure the **Parameters** (e.g. Duration, Drift, Probe, Measurement Range, Search Range, …) for the current operating mode. In each operating mode, only the relevant parameters are displayed. Depending on the MFCTool window size, you may not see all the parameters; you can scroll with your mouse wheel to see hidden boxes.

The general case of the **Measurement Range** parameters is described here. These parameters configure, for a specific operating mode, the measurement limits.



The Measurement Range parameters are:

- **Central value**: The central measurement range value in MHz or T.
- **Relative range +/-** : The +/- relative range in ppm referenced to the central value used for measurement. (In relation to older WMFCTool versions used with MFC3045, the relative range is related to the old modulation amplitude parameter MDA by: Relative Range = MDA * PCF*1e-7 / (2 * Central value). With PCF the Probe-array central frequency).
- **Minimal value**: The minimal limit value in MHz or T used for measurement.
- **Maximal value**: The maximal limit value in MHz or T used for measurement.
- **Averaging**: Set the number of NMR acquisitions used to compute the average returned as one measurement result. For a MFC3045 instrument it corresponds to the number of measurement cycle (NCY).

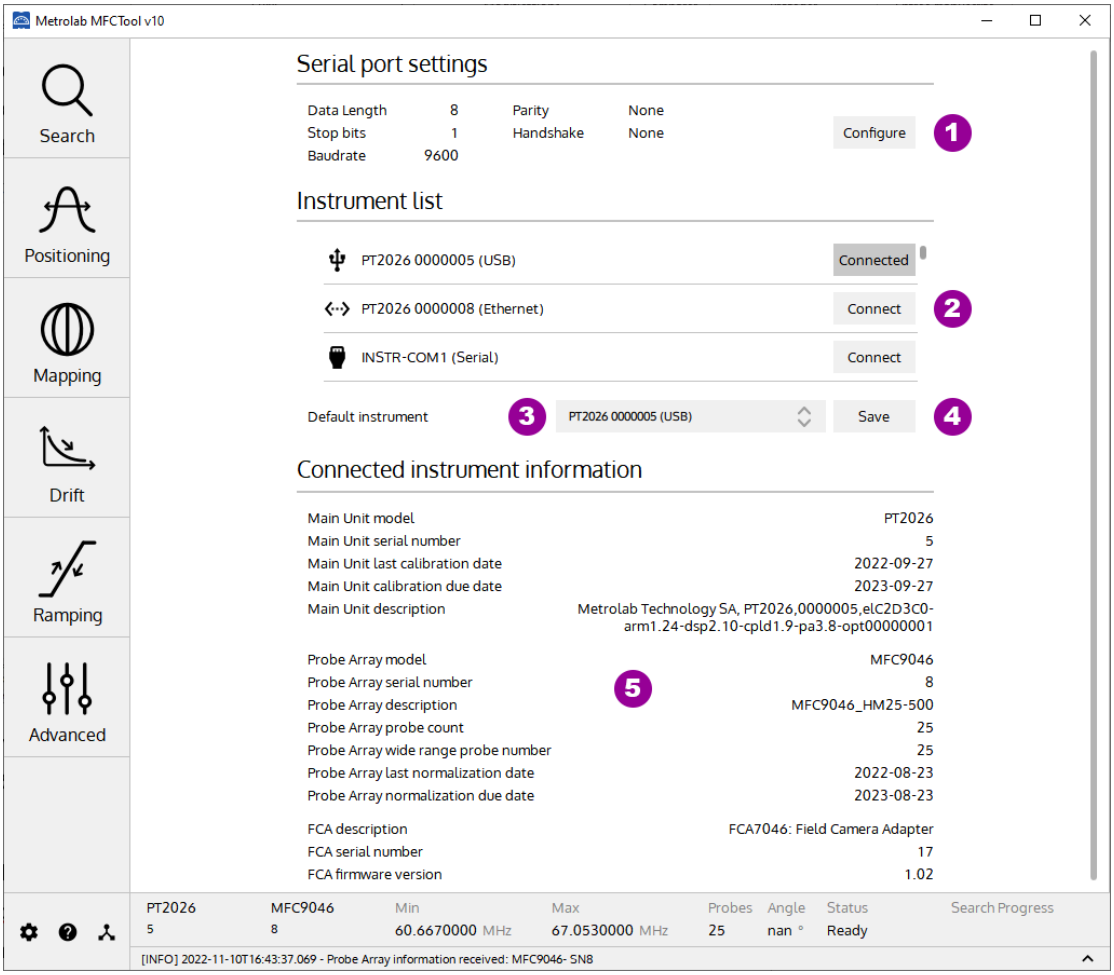
The measurement limits are configured either by the central value and relative range, or by the minimal and maximal values. The unit types (MHz or Tesla) are configured in the **Settings** page (see section 4-3). The range values are limited to the Probe-Array's specifications.

The "**Default**" button restores the Probe-Array's or the selected Probe's default Measurement Range.

The "**Preset**" button restores the Probe-Array's Measurement Range saved in **Search** operating mode (see section 4-5).

For the other specific parameter descriptions, see the information pages about the desired operating mode.

4-2 INSTRUMENT CONNECTION SETTINGS

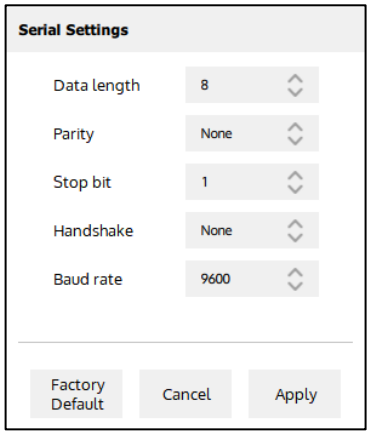


4-2-1 Purpose

Configure Instrument (Magnetic Field Camera) Connection settings.

4-2-2 Controls and indicators

1. Configure the **serial port** settings for MFC3045 instrument using an RS232 connection.



If a MFC3045 instrument is connected in MFCTool, new serial settings are directly applied to instrument when pressing "Apply". Wait few seconds for the MFC3045 to be reconfigured and restarted.
If MFCTool fails to communicate with the instrument due to a settings mismatch between them, you can restore the factory default settings on the instrument and MFCTool. In this case, follow this procedure:

- Press “Factory Default” on MFCTool and then “Apply” to set these settings
- On MFC3045 remote box:
  - Press on “Start” button and hold it.
  - Press briefly on “Reset” button.
  - Wait the “Busy” led to blink (about 8 sec) and turn off.
  - When the “Busy” led is off, you can release the “Start” button. The default serial settings are restored in the MFC3045 instrument.

The factory defaults in MFC3045 serial settings are:

- Serial Baud rate = 9600
- Serial Parity = 0
- Serial Stop bits = 1
- Serial Data bits = 8
- Serial Handshake = 0

2. Select which instrument in the list to **connect** to for field measurements. Only the instruments detected by the computer are present in the list.
   The instrument name is composed of the Instrument Model followed by the Instrument Serial number. This name is preceded by an icon representing the instrument connection type:


USB


Ethernet

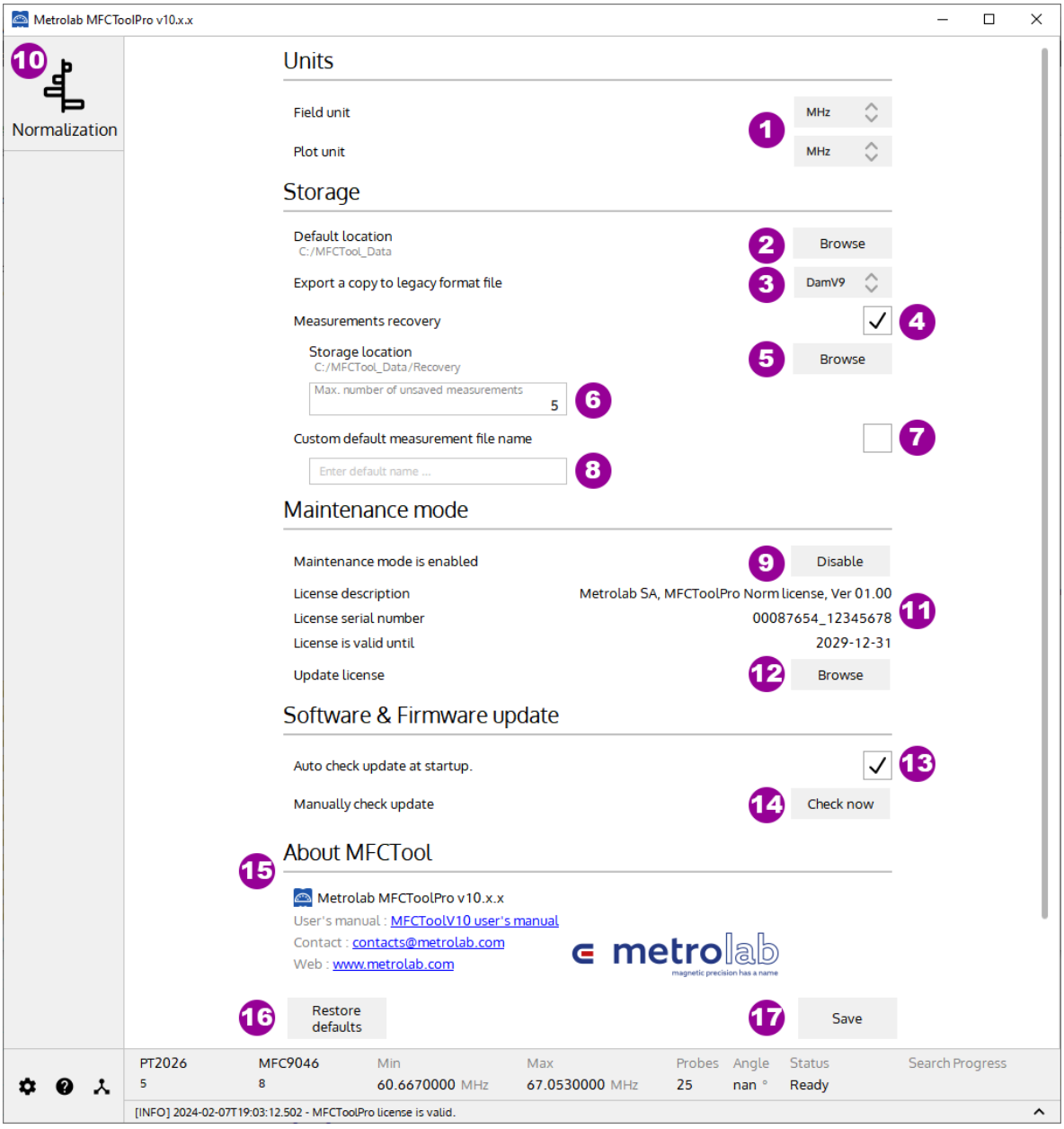

Serial

   The button for the connected instrument changes from Connect to Connected.
3. Set a **default** instrument to connect to automatically when MFCTool starts up. The instrument must be present in the list.
4. **Save** the instrument to connect by default.
5. Display **information** about the connected Main Unit, peripheral and Probe Array.

4-2-3 Notes

For general information about MFCTool, see Section 4-1 .

4-3 SETTINGS



4-3-1 Purpose

Set up the user settings and access the maintenance mode (Probe-Array normalization; see section 4-4). Maintenance mode is only available in MFCToolPro edition with a valid license.

4-3-2 Controls and indicators

1. Select the units to display for text fields and plots:

   T: Tesla

   MHz: NMR frequency (depends on gyromagnetic ratio of sample material used in probe heads)

2. Choose the default storage location for saving measurement result files. In MFCTool V10 the default file type for measurement results is ".XML". (The path is written in URI format).

3. Select the legacy DAM file format (WMFCTool V9, V8, 3035) to save a copy of the measurement results. Select "None" to disable this option.

4. Check the box to save measurement results in a temporary file for recovery use.
5. Choose the default storage location for the recovery measurement files. (The path is written in URI format).
6. Enter the maximum number of recovery measurement files to be kept.
7. Check the box to use a custom default measurement file name instead of the default MFCTool name. (The default MFCTool measurement file name is constructed as "ProbeArrayType_ProbeArraySerialNumber_Date_OperatingMode.mxr.xml").
8. Enter the desired custom default file name without the file extension.
9. Enable or disable the maintenance operating mode. Available in MFCToolPro edition.
10. Displays the Normalization operating mode page to normalize the Probe-Array. Available only in MFCToolPro edition.
11. MFCToolPro license information. Only displayed in MFCToolPro edition.
12. Choose the update file to update the license of MFCToolPro. Only displayed in MFCToolPro edition.
13. Check the box to look at available MFCTool software update at startup.
14. Check for available MFCTool software update now.
15. Information and contacts about Metrolab and MFCTool release
16. Restore factory default user settings.
17. Save user's settings to apply modified settings. If you quit the page without saving, the modified settings won't be applied.

4-3-3 Notes

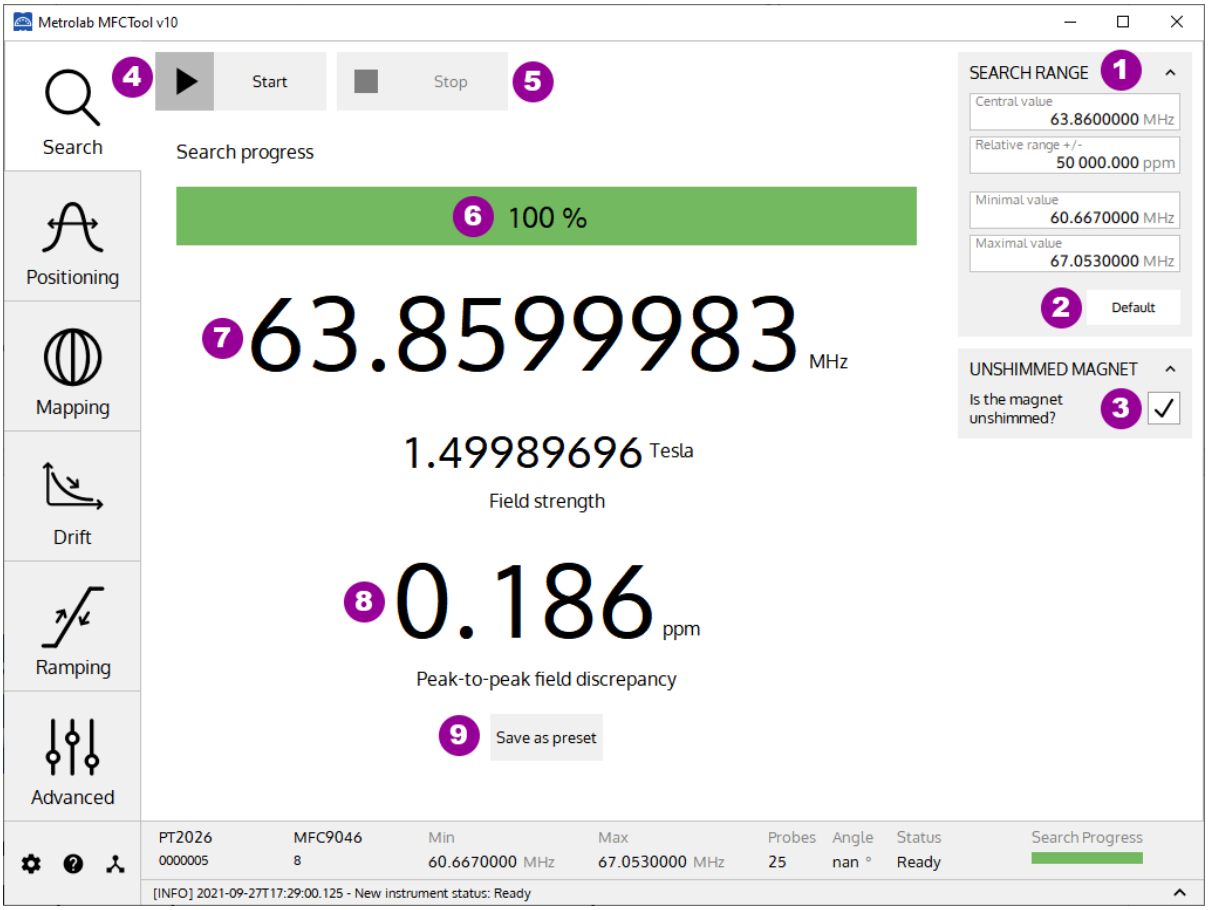
To have access to Measuring operating mode, don't forget to disable the Maintenance mode in the User settings page (see item 9).

For general information about MFCTool, see Section 4-1 .

4-4 NORMALIZATION

Each probe of the Probe-Array measures the magnetic field with a small discrepancy due to paramagnetic materials surrounding the probe. The purpose of the Normalization process is to reduce these discrepancies to a few tenths of ppm. (*contacts@metrolab.com* for additional information).

4-5 SEARCH OPERATING MODE



4-5-1 Purpose

The Search operating mode allows you to find the exact field strength of a magnet. If the magnetic field value is somewhere in the Probe-Array range, then it will be measured. By default, the search range includes the entire sensitivity range of the Probe-Array; however, you can restrict the search parameters to a narrower range. This mode should be used before starting other operating modes. You can save the measured field as a preset for other operating modes.

4-5-2 Controls and indicators

1. Set the **Search Range** parameters used for the Search operating mode.

   The Search Range parameters are:

   - **Central value**: The central search range value in MHz or T.
   - **Relative range**: The +/- relative range in ppm referenced to the central value used for the search.
   - **Minimal value**: The minimal limit value in MHz or T used for the search.
   - **Maximal value**: The maximal limit value in MHz or T used for the search.

   The search limits are configured either by the central value and relative range, or by the minimal and maximal values. These parameters are linked. The unit types (MHz or Tesla) are configured in the Settings page (see section 4-3). The range values are limited to the Probe-Array's specifications.

2. Set the **default** Probe-Array specification in the "Search Range" parameters.

3. If your magnet is **unshimmed**, enable this box to increase, in the saved preset (see item 9), the value of the "Relative range" measurement parameter for other operating modes.

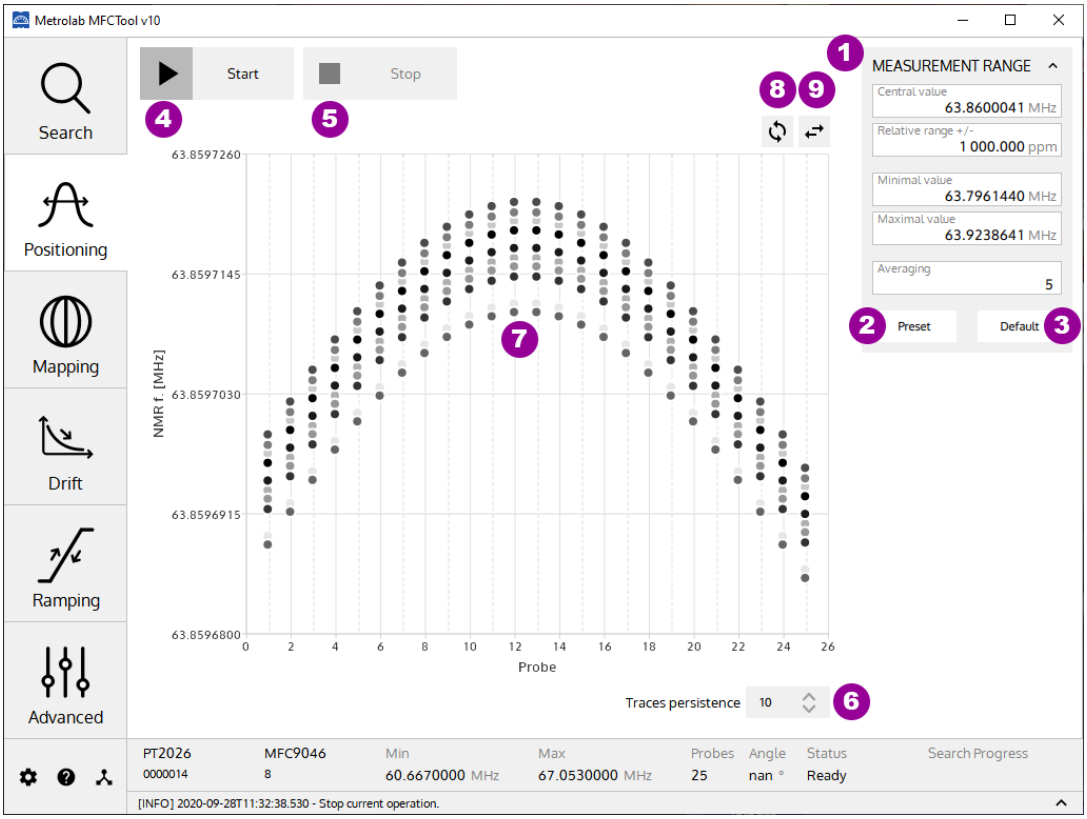
4. **Start** Search field measurement.

5. **Stop** Search field measurement.
6. The Search **progress bar** shows the status of the NMR signal search; to be precise, it shows the current frequency within the selected range.
7. Display the Field strength measurement **result** (in MHz and T) after a search operation. This measurement result is the mean measurement value of all NMR probes in the Probe-Array.
8. Display in ppm the **Peak-to-peak field discrepancy**. This is the difference between the minimum and maximum frequencies measured by the different probes in the Probe Array.
9. **Save** search measurement results as a measurement **preset** in the Measurement Range parameters for other operating modes (Positioning, Mapping, Drift, Ramping, Advanced).

4-5-3 Notes

For general information about MFCTool, see Section 4-1 .

4-6 POSITIONING OPERATING MODE



4-6-1 Purpose

Help to position the Probe-Array in a magnet by viewing an instantaneous plot of the magnetic field measurements, with persistent traces.

4-6-2 Controls and indicators

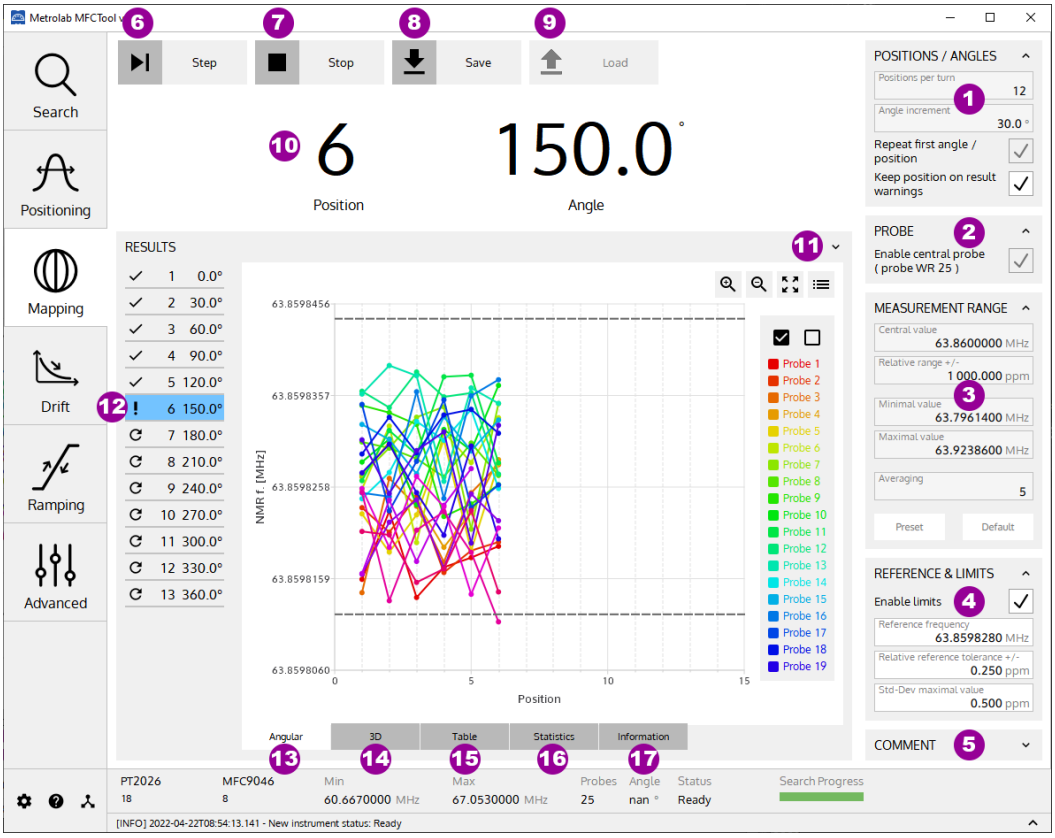
1. Set **Measurement Range** parameters used for the Position mode. See section 4-1 for more details.
2. **Preset** the last saved Search result as Measurement Range. When you pass the cursor over the button without pressing it, the preset values are displayed.
3. Set the **default** Probe-Array specification as Measurement Range. When you pass the cursor over the button without pressing it, the default values are displayed.

4. **Start** measurement in positioning mode.
5. **Stop** measurement in positioning mode.
6. Set value for trace **persistence** on plot. The newer the measurement, the darker the points in the plot.
7. Continuously display the probe measurements in a **2D plot,** in MHz (NMR frequency) or in Tesla (see Section 4-3).
8. **Swap** the X and Y axes.
9. **Mirror** the X axis.

4-6-3 Notes

For general information about MFCTool, see Section 4-1 .

4-7 MAPPING OPERATING MODE



4-7-1 Purpose

The mapping operating mode is used to measure and map field strength on a sphere, ellipsoid, or cylinder (depending on your Probe-Array) by rotating the Probe-Array in the magnet.

4-7-2 Controls and indicators

1. Configure step **position parameters** for the mapping measurement. Edit only one of the following two parameters to set the step position. Editing one of these parameters automatically updates the other.
    - **Positions per turn**: Set the number of measurement positions in a 360° Probe-Array rotation.
    - **Angle increment**: Set the angular step for measurement around a 360° Probe-Array rotation. The precision of the angle increment is one decimal, but the value is rounded to have a whole number of measurements in 360°.

The "**Repeat first angle / position**" box allows you, if enabled, to do an extra measurement in the first measurement position at the end of the whole Probe-Array rotation.

The "**Keep position on result warnings**" box allows you, if enabled, to stay after a measurement on the current position if measurement has a NaN (not a number) result or does not have 100% valid acquisition or if some result is out of limits (see item 4). If the box is disabled, the next position is automatically selected after a measurement.

2. The "**Enable central probe**" box allows you to enable or disable the measurement results of the wide range probe located at the Probe-Array's magnetic center. This probe is optional in the Probe-Array.
3. Set **Measurement Range** parameters used for the Mapping mode. See section 4-1 for more details.
4. The "**Enable limits**" box allows you, if enabled, to activate warning notifications on out of limits measurements. Editing the following parameters set the frequency and standard deviation measurement results limits.
    - **Reference frequency**: Set the central value of the limits, in MHz or T, to apply on frequency measurement.
    - **Relative reference tolerance +/-** : Set the limits frequency in relative range, in ppm, referenced to the "Reference frequency".
    - **Std-Dev maximal value**: Set the limit, in ppm, to apply on standard deviation measurement result.
5. Write personal **Comments** to add to the saved measurement file.
6. **Start** mapping operation with a measurement on the first angular position. After a measurement, the next angle increment is automatically shown. Before starting a measurement, rotate your Probe-Array to the corresponding angle. Press again the **Step** button to measure the next selected position (see item 8). To manually select a specific angular position, select it in the small table (item 10). It is possible to repeat a measurement on an angular position as many times as desired.
7. **Stop** the current mapping operation. A stopped mapping operation cannot be restarted.
8. **Save** the mapping results to an XML file. (The default MFCTool measurement file name is constructed as "ProbeArrayType_ProbeArraySerialNumber_DateTime_OperatingMode.mxr.xml").
9. **Load** a mapping XML file to review the results.
10. Shows the **currently selected** measurement position index and angle in degrees.
11. Click on the arrow to view the **current probe number bigger** by hiding the result window.
12. Display the **selection** and state **mapping table**. The blue line indicates the current angular position. After measuring a position, the next position is automatically selected. However, you can manually select to measure a specific angular position with this table.

    This table has three columns:

    - The first column contains icons indicating the measurement state:

    
    Angular position to be measured.

    
    Angular position measured, but with at least one NAN (Not A Number), or out of limits probe result, or valid acquisition < 100%.

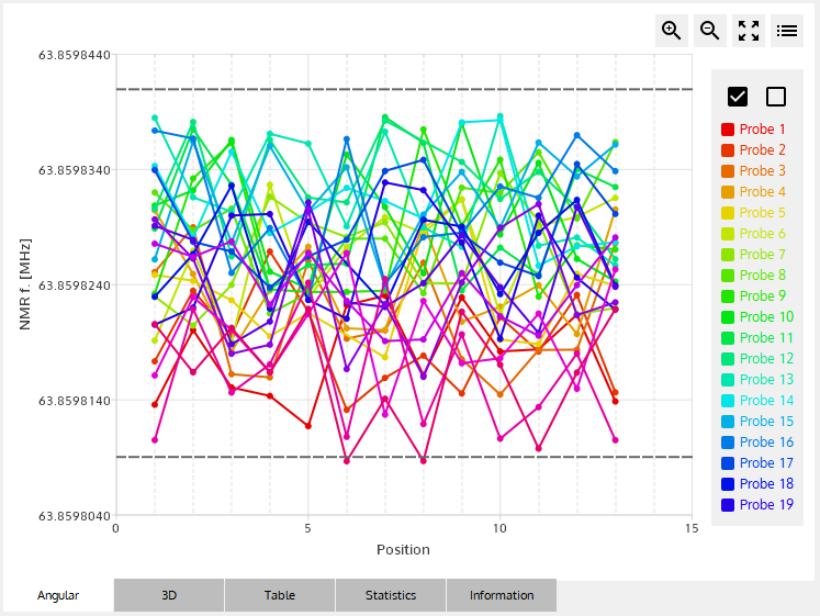
    
    Angular position fully measured (inside limits).

    - The second column displays the position number.
    - The last column displays the angular position in degrees.
13. Display the mapping results in a **2D plot**.

    Axis X: Probe-Array Position number [-]

    Axis Y: NMR measurement results [MHz] or [T]

    Frequency limits, if enabled, are displayed in dashed lines.



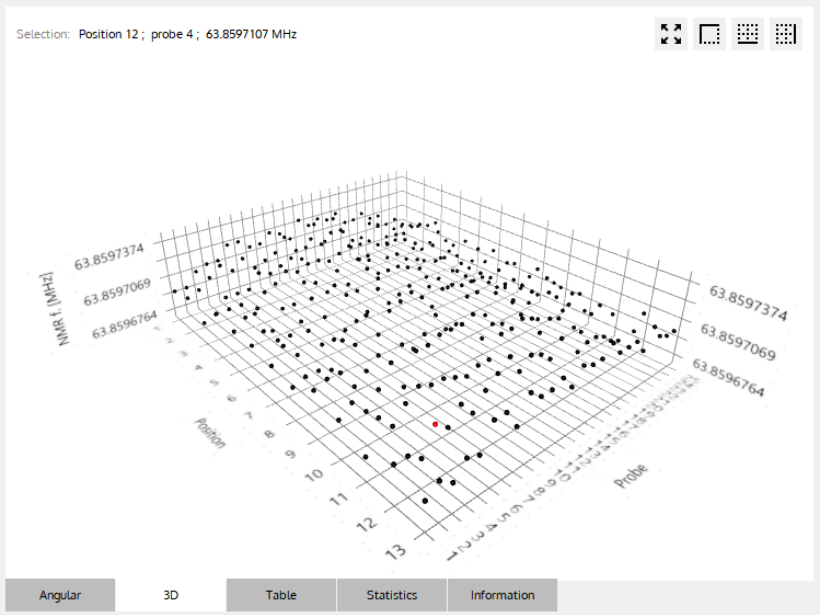
See section 4-1 for more details on 2D plot.

14. Display the mapping results in a **3D plot**.

    Axis X: Probe-Array Position number [-]

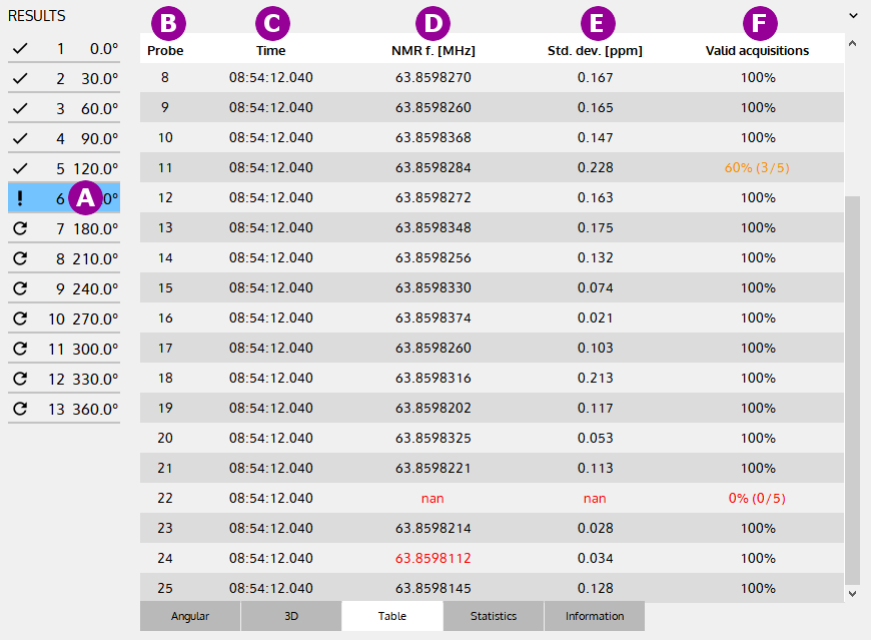
    Axis Y: Probe number [-]

    Axis Z: NMR measurement results [MHz] or [T]



See section 4-1 for more details on the 3D plot.

15. Display mapping results in **data tables** (one table for each angular position).



A. **Select** the angular position measurement table to display.

B. Shows the **Probe number**. Each line of the table displays the measurement for a probe at a Probe-Array's angular position.

C. Shows the measurement **time**, in hh:mm:ss.

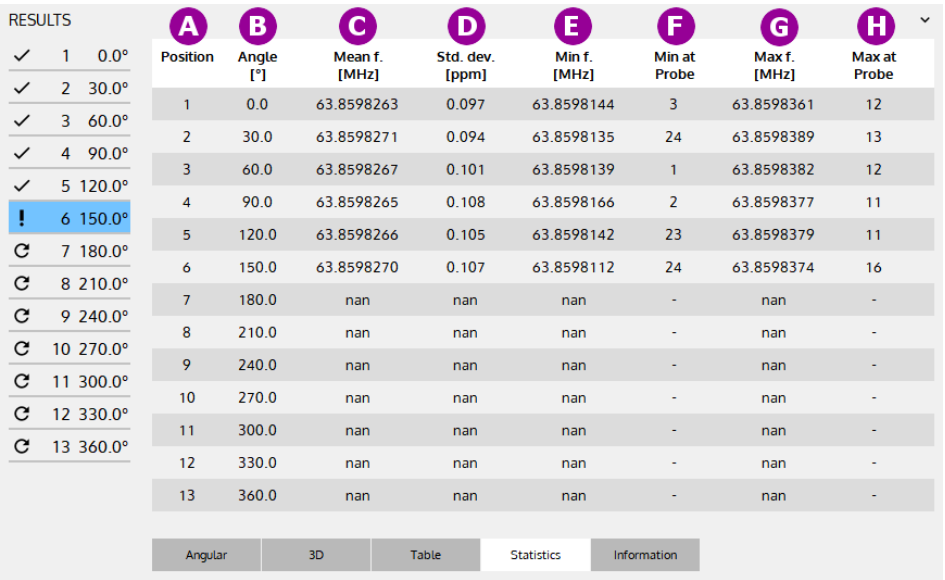
D. Shows the measurement **result** in MHz (NMR frequency) or Tesla. The unit is configured in the settings page (see section 4-3). The result is an average of N acquisitions as defined in the Measurement Range parameter box (see section 4-1). Nan (not a number) or out of limits values are shown in red.

E. Shows the **standard deviation** of the measurement, in ppm. Nan (not a number) or out of limits values are shown in red.

F. Shows the number of **valid acquisitions** for a measurement. Only the valid acquisitions are taken into account to compute the average measurement result.

Warnings about measurement results are colored. Such as nan results (not a number), out of limits results (see item 4), and results with less than 100% valid acquisitions.

16. Display **statistics** on mapping results in a **data table**.



A. Shows the **position** number.

B. Shows the probe array's **angular position value** in degree.

C. Shows the **mean NMR frequency** value on all valid measurement probe for each position in MHz or Tesla.

D. Shows, for each position, the **standard deviation** of all valid probe measurements, in ppm.

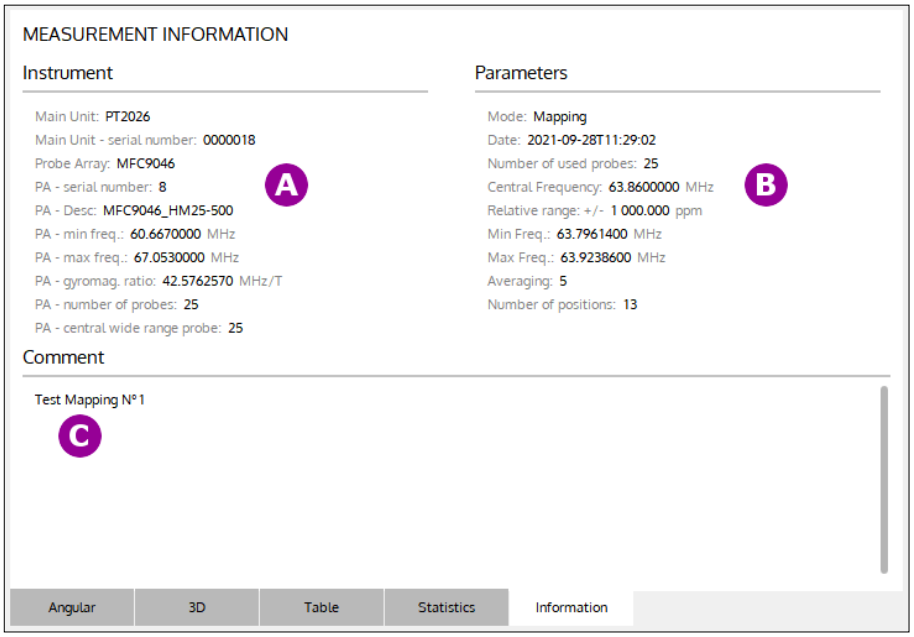
E. Shows the **minimum NMR frequency** for each position, in MHz or Tesla. The unit is configured in the settings page (see section 4-3).

F. Shows the **probe number** with the minimum NMR frequency for each position.

G. Shows the **maximum NMR frequency** for each position, in MHz or Tesla. The unit is configured in the settings page (see section 4-3).

H. Shows the **probe number** with the maximum NMR frequency for each position.

17. Display measurement information.



A. Shows information about **instrument** (Main unit and Probe Array) used for this measurement.

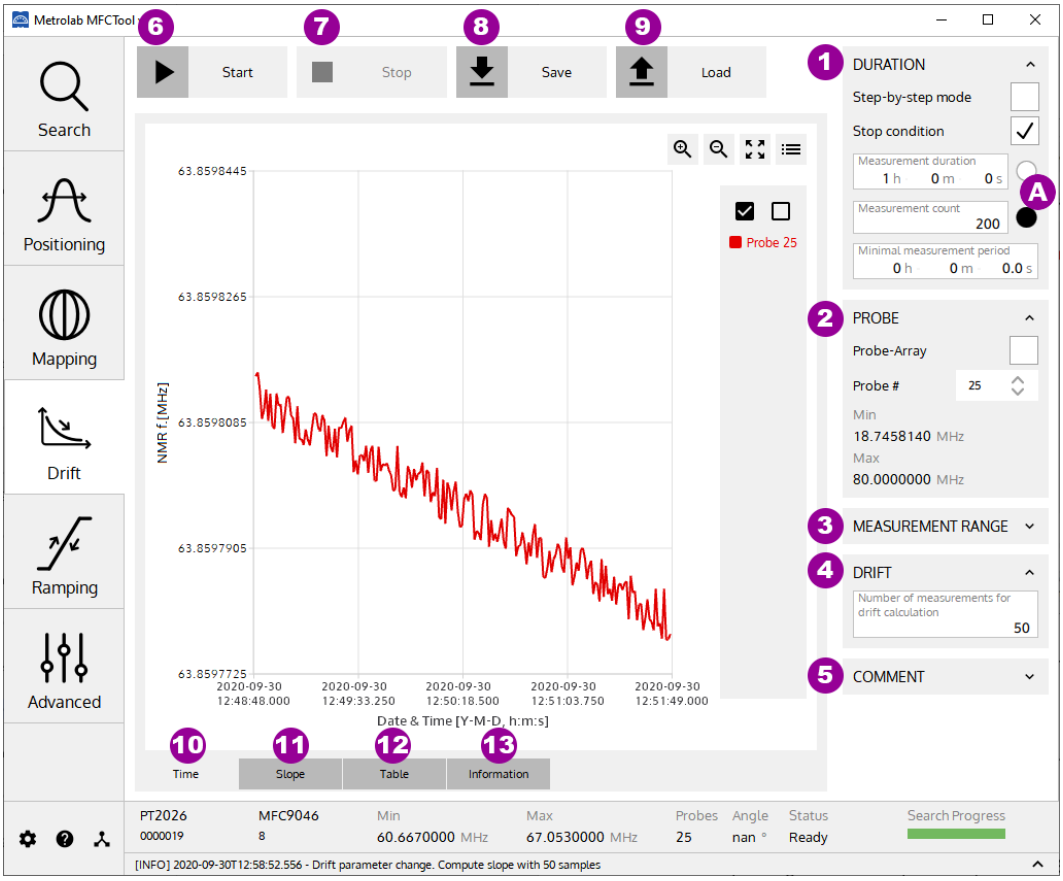
B. Shows information about **parameters** used for this measurement.

C. Shows written **comment** for this measurement.

4-7-3 Notes

For general information about MFCTool, see Section 4-1 .

4-8 DRIFT OPERATING MODE



4-8-1 Purpose

The Drift operating mode is used to measure the drift of a magnetic field in a magnet.

4-8-2 Controls and indicators

1. Configure **Duration parameters** for Drift measurement.

   The Duration parameters are:

   - Step-by-Step mode:

     When enabled, the drift measurement is done manually, or step-by-step, by pushing the Start/Step button (see item 6). When disabled, the drift measurement is performed continuously according to the minimal period parameter.

   - Stop condition:

     When enabled, the “Measurement duration” and the “Measurement count” parameters are activated to set a stop time or count condition for the measurement process.

   - Measurement **duration**:

     Set the measurement duration stop condition in hours, minutes and seconds. This parameter is only available when “Stop condition” is enabled and “step-by-step mode” is disabled. When enabled with the right button (see item **A**), the duration stop condition overrides the count stop condition.

   - Measurement **count**:

     Set the measurement count stop condition. This parameter is only available when “Stop condition” is enabled. When enabled with the right button (see item **A**), the count stop condition overrides the time stop condition.

   - Minimal period:

Set the minimal desired period for measurement in hours, minutes and seconds. This parameter is only available when “step-by-step mode” is disabled. If, for technical reason, the Magnetic Field Camera cannot measure as requested, the measurement will be done as fast as its specification allows it.

2. Set **Probe-Array or single probe** use for drift measurement.
   - Probe-Array:

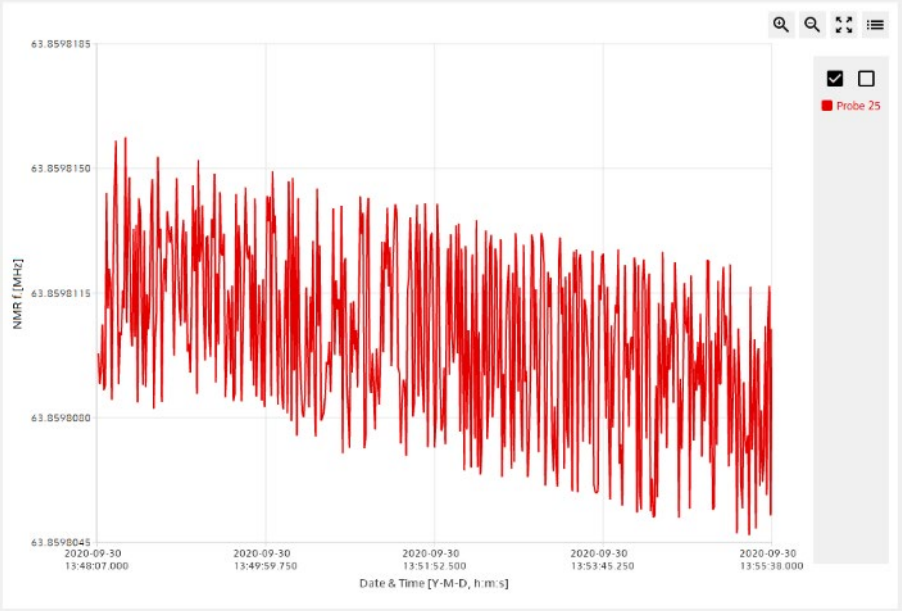
     When enabled, the whole Probe-Array is used for measurement. When disabled, the measurement is done on a single probe head of the Probe-Array.
   - Probe#:

     Select the single probe number to use for the measurement. This parameter is only available when “Probe-Array” parameter is disabled.
   - Min & Max:

     Display information about minimal and maximal measurement capabilities of the selected Probe or the Probe-Array.
3. Set the **Measurement Range** parameters used for the Drift mode. See section 4-1 for more details.
4. Set the number of measurement results to calculate the **drift**. The calculated drift slope is shown in the Slope Graph (see item 11).
5. Write personal **Comments** to add to the saved measurement file.
6. **Start** Drift measurement. If the “Step-by-step mode” parameter is enabled, the start button changes to Step after the first measurement and needs to be pushed again for a new measurement.
7. **Stop** Drift measurement operation. A stopped drift measurement cannot be restarted from where it has been stopped.
8. **Save** drift measurement results to an XML file. (The default MFCTool measurement file name is constructed as “ProbeArrayType_ProbeArraySerialNumber_DateTime_OperatingMode.mxr.xml”).
9. **Load** a drift measurement XML file to review the results.
10. Display the drift measurement results in a time **2D plot**.

    Axis X: Date & Time [Y-M-D, hh:mm:ss.xxx]

    Axis Y: NMR measurement results [MHz] or [T]



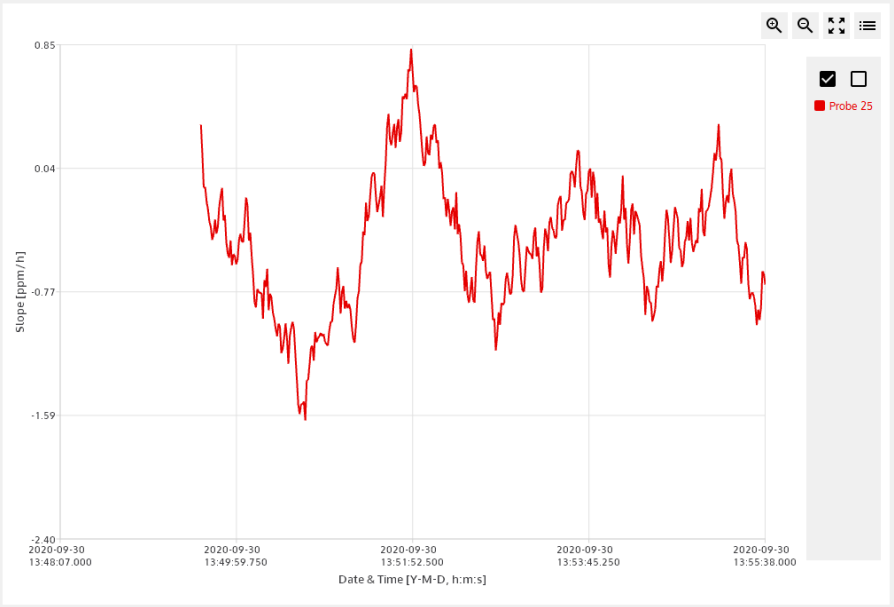
See section 4-1 for more details on 2D plot.

11. Display the **drift slope** calculation for each probe of the Probe-Array in a **2D plot**.

    Axis X: Date & Time [Y-M-D, hh:mm:ss.xxx]

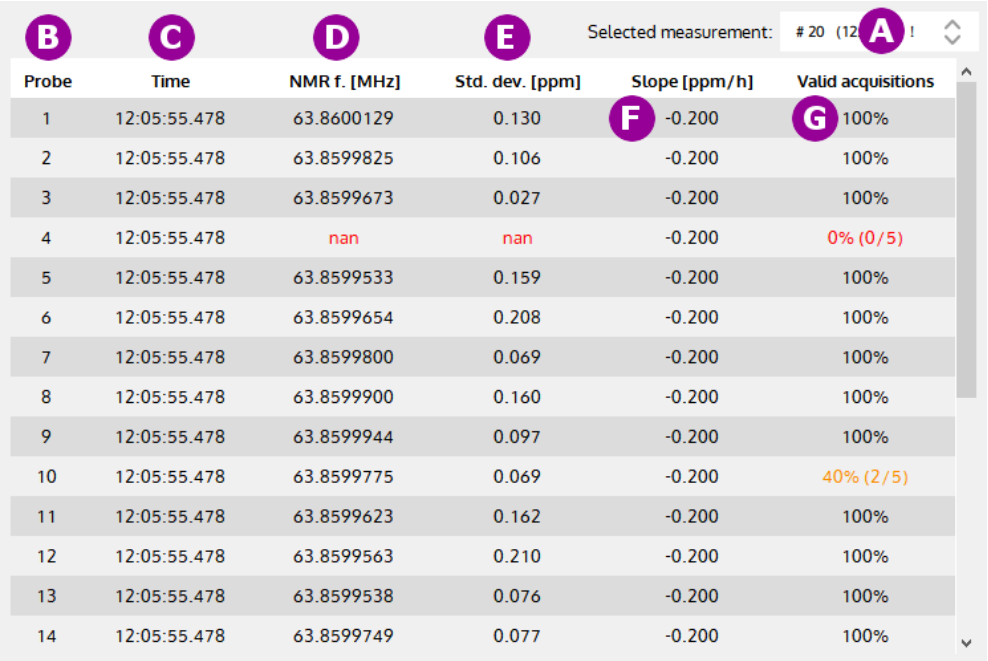
    Axis Y: Slope of NMR measurement results [ppm/h]

    Each slope value is calculated by a simple linear regression of the NMR measurement results in a moving window whose length is defined by the “drift” parameter (see item 4). The slope values, in ppm/h, are relative and referenced to the first measurement result. Be aware to have a valid first measurement, otherwise slope values will be “Not A Number” (NAN).



See section 4-1 for more details on 2D plot.

12. Display the drift measurement results in **data tables**.



A. **Select** in the list the measurement table number to display. This selection is available if whole Probe-Array is used for measurement.

   If an exclamation mark "!" is displayed in the "selected measurement" identification, it indicates that a nan (not a number) measurement value or less than 100% of valid acquisition are present in the table.

B. Shows **Probe number**. Each line of the table displays the measurement for a probe of the Probe-Array. Available if whole Probe-Array is used for measurement.

C. Shows the measurement **time** in hh:mm:ss.xxx.

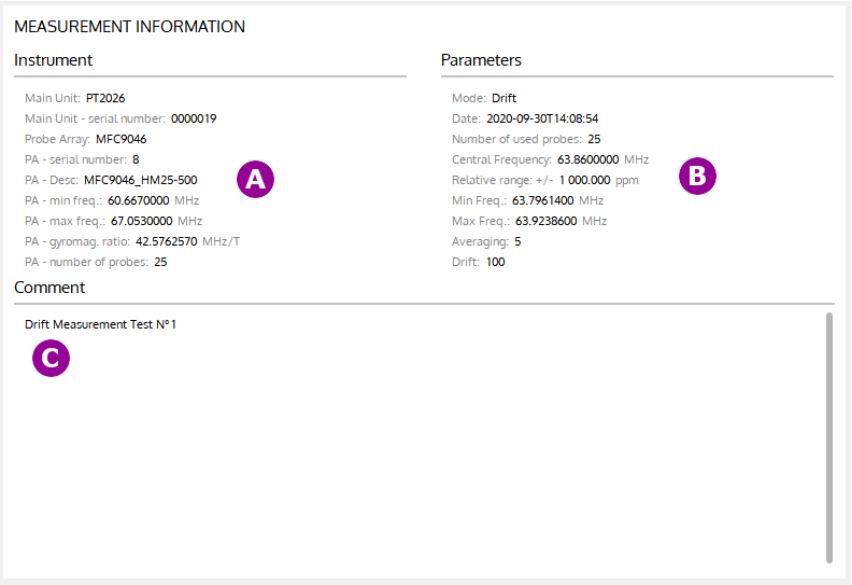
D. Shows the **NMR measurement results** in MHz (NMR frequency) or Tesla. The units are configured in the settings page (see section 4-3). The result is an average of X acquisitions as defined in the Measurement Range parameter box (see section 4-1).

E. Shows the measurement **standard deviation** in ppm.

F. Shows the NMR measurement **slope** values in ppm/h, referenced to the first drift operation's measurement. Be aware to have a valid first measurement, otherwise slope values will be "Not A Number" (NAN).

G. Shows number of **valid acquisitions** for a measurement. Only the valid acquisitions are taken into account to compute the average of the measurement result.

13. Display measurement information.



A. Show information about **instrument** (Main unit and Probe Array) used for this measurement.

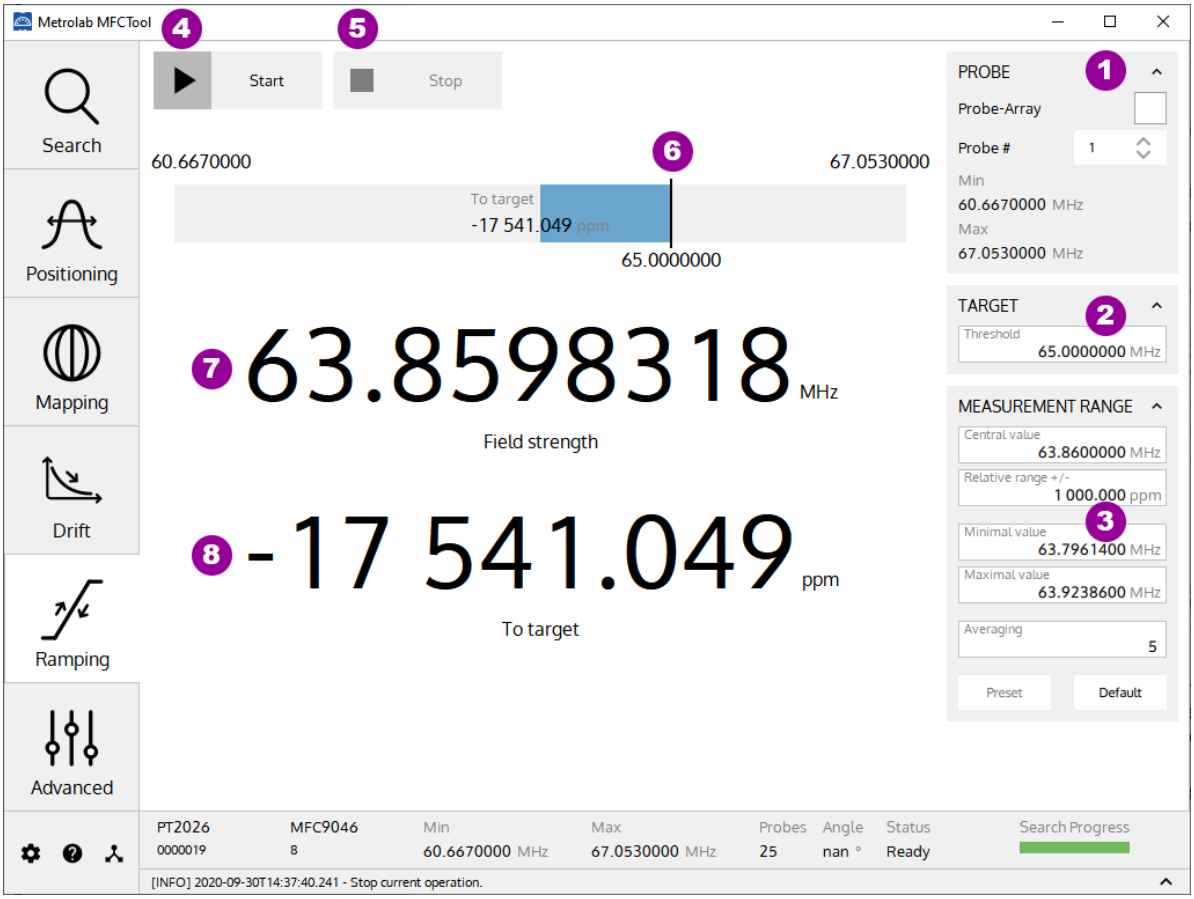
B. Show information about **parameters** used for this measurement.

C. Show written **comment** for this measurement.

4-8-3 Notes

For general information about MFCTool, see Section 4-1 .

4-9 RAMPING OPERATING MODE



4-9-1 Purpose

The Ramping operating mode is used to track the magnetic field up to a target field in a specific measurement range. You can choose to process the measurement on one single probe or on the whole Probe-Array. In this last case the average of the values measured on all NMR probes is returned.

The measurement range parameters are limited to the sensitivity of the selected Probe (a specific Probe number or the complete Probe-Array).

4-9-2 Controls and indicators

1. Set Probe-Array or single **probe use** for measurement.
   - Probe-Array:

     When enabled, the whole Probe-Array is used for measurement. When disabled, the measurement is performed with a single probe head of the Probe-Array.
   - Probe#:

     Select the single probe number to use for measurement. This parameter is only available when “Probe-Array” parameter is disabled.
   - Min & Max:

     Displays information about minimal and maximal measurement capabilities of the selected probe or Probe-Array.
2. Set the **Target field strength** in MHz or Tesla. The field units are configured in the Settings page (see section 4-3).

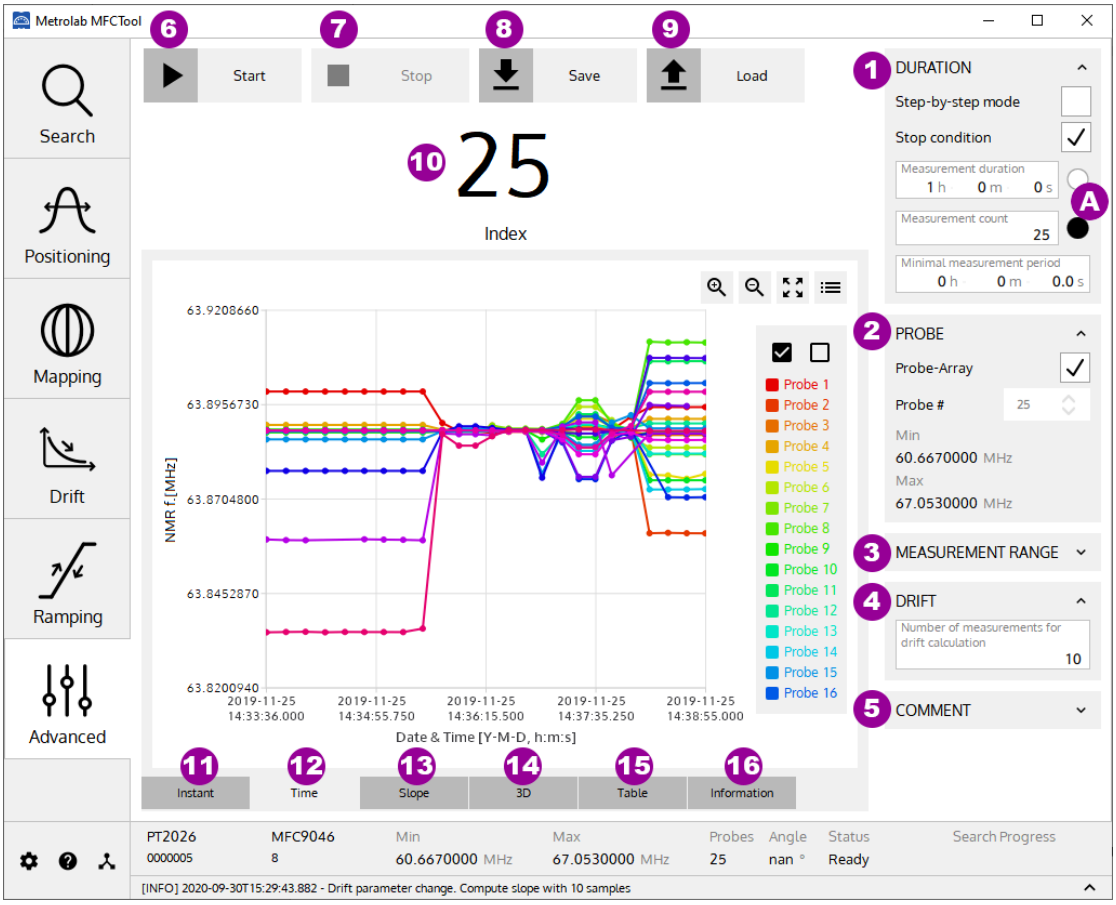
3. Set **Measurement Range** parameters used for the Ramping mode. See section 4-1 for more details. We recommend setting.
4. **Start** Ramping measurement.
5. **Stop** Ramping measurement.
6. The vertical line indicates the **target field strength** in the Measurement range.
7. Displays **actual field strength** measurement value in MHz or Tesla. The field units are configured in the Settings page (see section 4-3).
8. Displays the difference between the **measurement and the target** field strength in ppm.

4-9-3 Notes

To improve the tracking of a ramp up or down of the magnetic field, we recommend using an average of 1 for the MFC2046 and 2 for the MFC3045 and selecting a single probe. Furthermore, if a wide range probe is equipped in the probe-array, we recommend selecting it. Depending on the speed of the field ramp up/down, and the parameters you have set, the instrument may not be able to track the field.

For general information about MFCTool, see Section 4-1 .

4-10 ADVANCED OPERATING MODE



4-10-1 Purpose

The Advanced operating mode is used to measure field strength with access to all available measurement parameters. It allows you to choose your own way to configure and operate your measurements.

4-10-2 Controls and indicators

1. Configure **Duration** parameters for measurement.

   The Duration parameters are:

   - Step-by-Step mode:

     When enabled, the measurement is performed manually, step-by step, by pushing the Start/Step button (see item 6). When disabled, the measurement is performed automatically according to the minimal period parameter.

   - Stop condition:

     When enabled, the “Measurement duration” and the “Measurement count” parameters are activated to set a stop time or count condition on the measurement process.

   - Measurement **duration**:

     Set the measurement duration stop condition in hours, minutes, and seconds. This parameter is only available when “Stop condition” is enabled and “step-by-step mode” is disabled. When enabled with the right button (see item **A**), the duration stop condition overrides the count stop condition.

   - Measurement **count**:

     Set the measurement count stop condition. This parameter is only available when “Stop condition” is enabled. When enabled with the right button (see item **A**), the count stop condition overrides the time stop condition.

- Minimal period:

  Set the minimal desired period for measurements in hours, minutes and seconds. If, for technical reason, the Magnetic Field Camera is not able to measure as requested, the measurement will be done as fast as its specification allows.

2. Set **Probe-Array or single probe** to use for measurement.

   - Probe-Array:

     When enabled, the whole Probe-Array is used for measurement. When disabled, the measurement is performed with a single probe head of the Probe-Array.

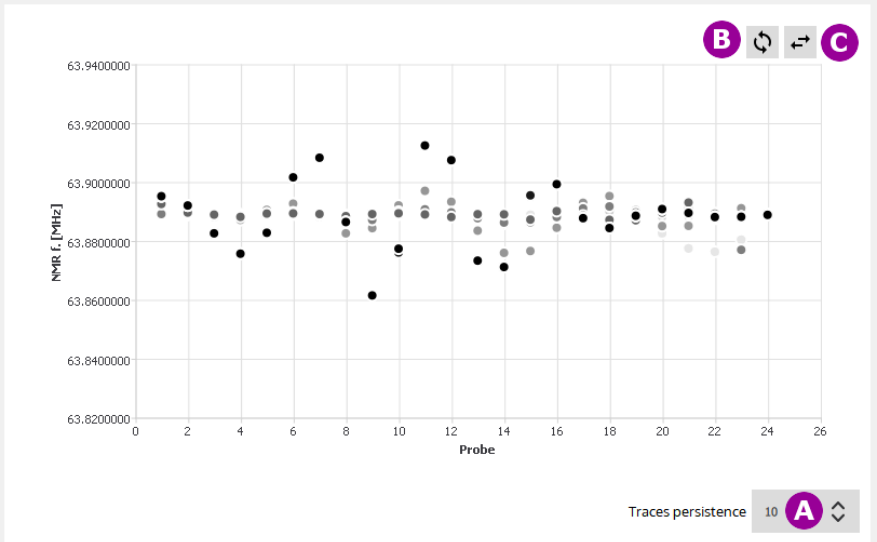
   - Probe#:

     Select the probe number to use for measurement. This parameter is only available when “Probe-Array” parameter is disabled.

   - Min & Max:

     Display information about minimal and maximal measurement range of the selected Probe or the Probe-Array.

3. Set the **Measurement Range** parameters used for the advanced operating mode. See section 4-1 for more details.
4. Set the number of measurement results used to calculate the **drift**. The calculated drift slope is shown in the Slope plot (see item 13). Changing the drift parameter after a measurement session will compute again the drift slope results.
5. Write personal **Comments** to add to the saved measurement file.
6. **Start** measurements in advanced operating mode. If the “step-by-step” mode is enabled, the start button changes to Step after the first measurement and needs to be pushed again for the next measurement.
7. **Stop** measurements in advanced operating mode. A stopped measurement cannot be restarted from where it has been stopped.
8. **Save** measurement results to an XML file. (The default MFCTool measurement file name is constructed as “ProbeArrayType_ProbeArraySerialNumber_DateTime_OperatingMode.mxr.xml”).
9. **Load** a measurement XML file to review the results.
10. Displays current measurement number.
11. Displays the **continuous** probe measurements in a **2D plot**, in MHz (NMR frequency) or in Tesla.



A. Set the trace **persistence** in the plot. The newer the measurements, the darker the points in the plot.

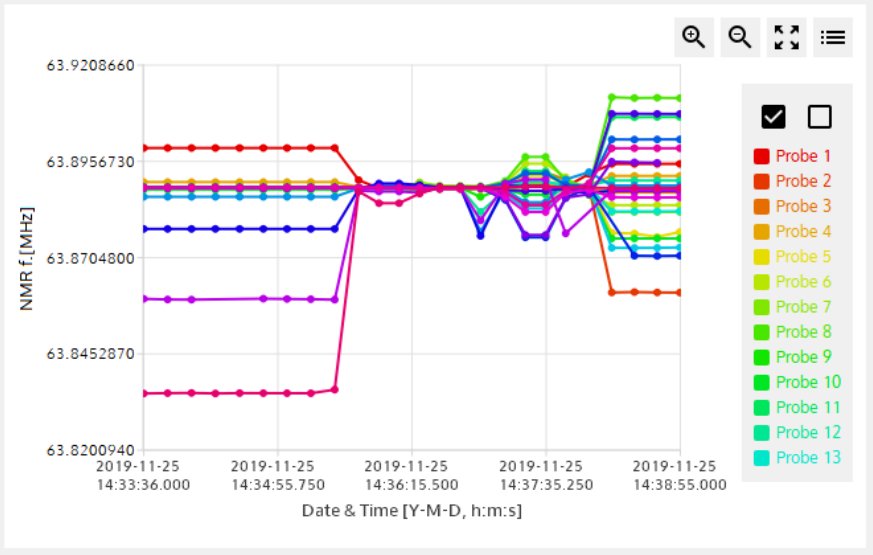
B. **Swap** the X and Y axes.

C. **Mirror** the X axis.

12. Display the measurement results in a **2D plot**.

Axis X: Date & Time [Y-M-D, hh:mm:ss.xxx]

Axis Y: NMR measurement results [MHz] or [T]



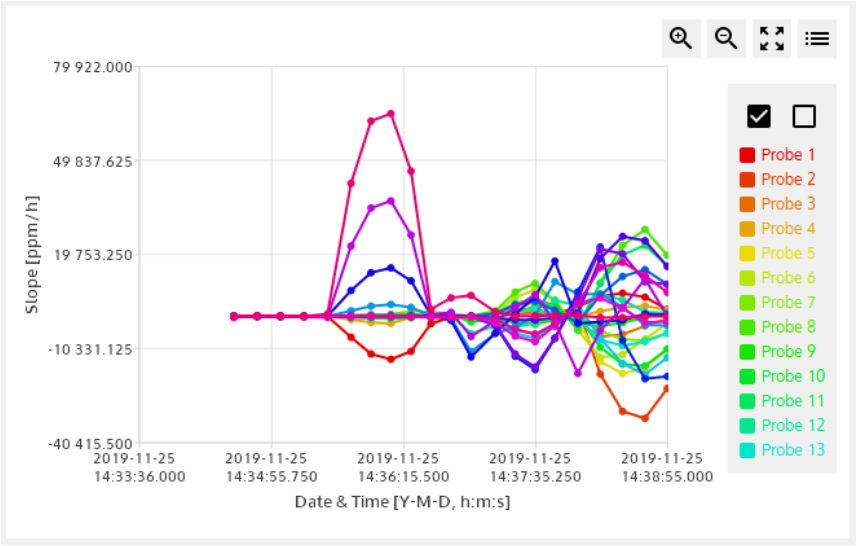
See section 4-1 for more details on the 2D plot.

13. Display the **drift slope** calculation for each probe of the Probe-Array in a **2D plot**.

    Axis X: Date & Time [Y-M-D, hh:mm:ss.xxx]

    Axis Y: Slope of NMR measurement results [ppm/h]

    Each slope value is calculated from a simple linear regression of the NMR measurement results on a moving window whose length is defined by the “drift” parameter (see item 3). The relative slope values, in ppm/h, are referenced to the first measurement result. Be aware to have a valid first measurement, otherwise slope values will be “Not A Number” (NAN).



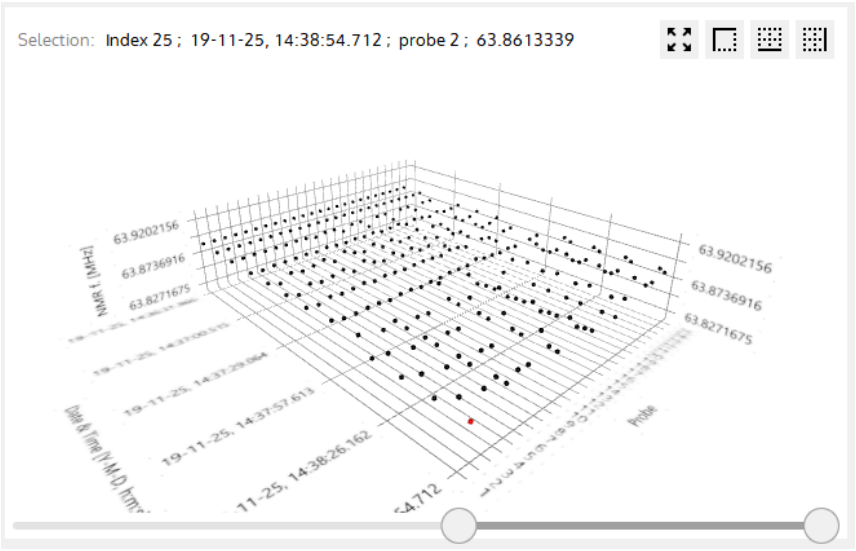
See section 4-1 for more details on 2D plot.

14. Display measurement results in a **3D plot**.

    Axis X: Date & Time [Y-M-D, hh:mm:ss.xxx]

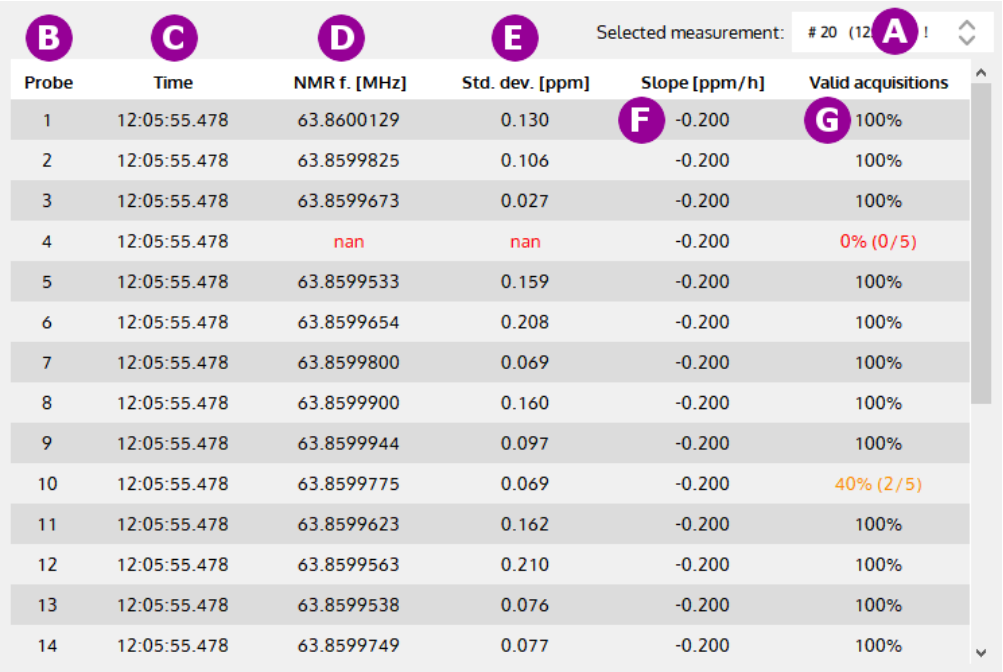
    Axis Y: Probe number [-]

    Axis Z: NMR measurement results [MHz] or [T]



See section 4-1 for more details on 3D plot.

15. Display measurement results in **data tables**.



A. **Select** in the list the measurement table number to display. This selection is available if whole Probe-Array is used for measurement.

   If an exclamation mark "!" is displayed in the "selected measurement" identification, it indicates that a nan (not a number) measurement value or less than 100% of valid acquisition are present in the table.

B. Shows **Probe number**. Each line of the table displays the measurement for a probe of the Probe-Array.

C. Shows the measurement **time**.

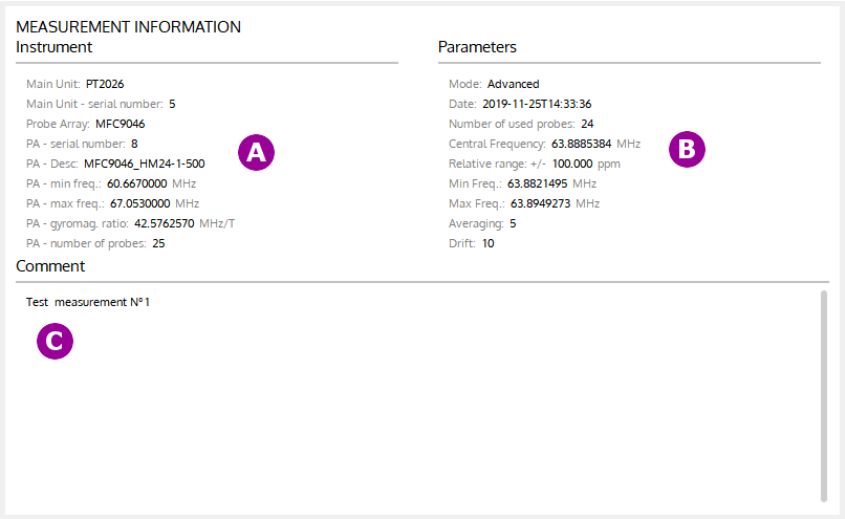
D. Shows **NMR measurement result** in MHz (NMR frequency) or Tesla. The units are configured in the settings page (see section 4-3). The result is an average of N acquisitions as defined in the Measurement Range parameter box (see section 4-1).

E. Shows the **standard deviation** of the measurement, in ppm.

F. Shows the NMR measurement **slope** values, in ppm/h referenced to the first measurement. Be aware to have a valid first measurement, otherwise slope values will be "Not A Number" (NAN).

G. Shows the number of **valid acquisitions** for a measurement. Only the valid acquisitions are taken into account to compute the average measurement result.

16. Display measurement information.



A. Show information about **instrument** (Main unit and Probe Array) used for this measurement.

B. Show information about **parameters** used for this measurement.

C. Show written **comment** for this measurement.

4-10-3 Notes

For general information about MFCTool, see Section 4-1 .

4-11 DLL UTILITY

To export automatically, at your convenience, measurement results, instrument information and status, you can developpe a DLL that can be loaded at MFCTool's startup.

To enable MFCTool to use your DLL, edit the MFCToolApplicationSettings.ini file. This file is located (in Windows) at

C:\ProgramData\Metrolab\MFCTool_V10.x.y\MFCToolApplicationSettings.ini

, with "x.y" as the MFCToolV10 release number

You must edit two parameters in the file:

- ExternalLibrary=

  You must enter the DLL path in this field. The path can be absolute or relative to the application execution binary (defaults to C:\Program Files\Metrolab\MFCTool).

  You can leave the extension empty, as the application will automatically try to find the correct extension depending on the architecture (.dll, .lib, ...)

  Note: Leave this field empty when no external dll is required.

- ExternalLibraryTimeoutSeconds=

  You must enter the timeout value in seconds in this field. This timeout corresponds to the time the MFCTool software will wait for the DLL to initialize or terminate before continuing startup or shutdown.

4-12 PT2026 CUSTOM CONFIGURATION FILE

When connecting with MFCTool v10 to a MFC2046 system, the PT2026 main unit is automatically configured by default.

When special PT2026 configuration is needed for a specific Probe Array, it's possible to call a "Custom Instrument Configuration" xml file.

"Custom Instrument Configuration" file must follow these rules:

- A custom configuration file use for a specific Probe-array must conform with the following naming rule:

  MMMM_NNNNNNNN.cic.xml

  with:

- MMMM = Probe Array **model** number on 4 digits (e.g. 9046, 9146).
- NNNNNNNN = Probe Array **serial** number on 8 digits.
- .cic.xml = Extension for the "Custom Instrument Configuration"xml file.

  For example, the corresponding configuration file name for a Probe Array MFC9046-HM24-1-450 with the serial number 101 will be: 9046_00000101.cic.xml

- A custom configuration file must be placed in the following directory:

  C:\Users\<username>\AppData\Roaming\Metrolab\MFCTool\CustomPAScripts

Information on content of a configuration file can be obtained by contacting Metrolab at *contacts@metrolab.com*

REFERENCE

5- MFCTOOL SPECIFICATIONS

5-1 SOFTWARE MFCTOOL

Software name	MFCTool V10.3.5, or MFCToolPro V10.3.5
Supported platforms	Microsoft Windows 7 (64bit) or higher.
Licenses	Qt 5.15.2 GPL 3-Clause BSD See license information file enclosed in the MFCTool application directory for more details.

5-2 RELEASE NOTES

5-2-1 MFCTool V10.3.5

1. New Features

- In MFCToolPro (normalization operation) only:
    - Add check box to keep position on warnings about measurement results.

2. Updates

- In Search operation, the search process has been improved for an unshimmed magnet.
- In MFCToolPro (normalization operation) only:
    - The normalization report file has been modified to add the initial measurements.
    - The value of the range parameters can be modified during the process.

3. Bugs Fixed

- Mapping to 32 positions (11.25 degree steps) is now supported.
- Fixed EEPROM write failure after normalization process that could occur on some MFC3045 main unit.
- Resolved issue on MFC3045 remote box not working properly if the probe-array was unconnected and reconnected from the main unit.
- When editing the average measurement parameter, the maximum value of the main unit is taken into account.

5-2-2 MFCTool V10.3.4

1. New Features

- Add exclamation mark in selected measurement list to indicates the presence of NAN or less than 100% valid acquisition.
- Add an option in the settings page to use a custom default measurement file name.
- Add FCA information in measurement xml file.
- In MFCToolPro only:
    - Add update license option for MFCToolPro.

2. Updates

- Update the PT2026 driver (version change to 0x0106) to remove the incompatibility with older PT2026 ARM firmware version < 1.23 and to manage new PT2026 FW version.

- Replace the custom Probe-array Script file (.scs) by a custom instrument configuration file .cic.xml.
- In MFCToolPro (normalization operation) only:
    - Change default normalization tolerance to 0.2ppm for field < 0.5T

3. Bugs Fixed

- Display only two digits for the minor FW version of the FCA7046. Remove the third digit “0”.
- First measurement done in continuous and single probe measurement is not displayed as a dot in 2D plot.
- Minor other bugs fixed

5-2-3 MFCTool V10.3.3

1. New Features

- Check if a new firmware version is available for the connected main unit.
- In mapping operation, add check box to keep position on warnings about measurement results.
- Add parameters "DefaultUserFileName" and "UseDefaultUserFileName" in MFCToolUserSettings.ini file to allow default user file name while saving measurement results in a file.
- In MFCToolPro only:
    - manage license for normalization operation
    - add plots in normalization operation
    - add default relative limit check box in normalization operation

2. Updates

- QT version upgraded to 5.15.2 and MSVC2019 64 bit.
- Update MFC3045 driver (version change to 0x0101) to improve measurement speed
- Update PT2026 driver (version change to 0x0105)
- Remove pre-extension ".mxr" in the legacy dam file extension. Instead of "XXX.mxr.dam", legacy file is saved as "XXX.dam".
- Serial port COM settings: When "factory default" is pressed, it doesn't close anymore the popup window. The new settings are sent to the connected MFC3045 only when the button "Apply" is pressed.
- In MFCToolPro (normalization operation) only:
    - change default normalization tolerance to 0.1ppm for MFC3045
    - unit are always in Hz (never in Tesla)

3. Bugs Fixed

- Qt5.15 has resolved microsoft screen display bad zoom factor interpretation in Qt while using High dpi screen resolution.

5-2-4 MFCTool V10.3.2

1. New Features

- Adding, in the setting page, a link to “MFCToolUsersManual” Metrolab web page.
- Checking calibration and normalization due date and notifies expiration while connecting to instrument.
- Adding "Reference & Limit" parameters in mapping operating mode. It provides warning notices on measurement if it's outside the limits.
- Adding a parameter, in mapping operating mode, to remove from measurements the central wide-range probe (if equipped on Probe-Array).
- Adding a parameter, in search operating mode, to indicate if the magnet is unshimmed. MFCTool increases the saved preset of measurement range parameter tolerance.

2. Updates

- QT version upgraded to 5.12.11.
- Adding element "paWrPrChannel" to xml record and service files. The xml body “tMXR_BODY_MFCTOOL" is incremented to version 1.2

3. Bugs Fixed

- When selecting 3D graphics view right after selecting another view tab, the MFCTool could sometimes crash. The bug is fixed.

5-2-5 MFCTool V10.3.1

1. Updates

- Instrument measurement Timestamp in measurement xml file is normalized to 0 for the first measurement.
- Remove in DAM file data for unmeasured positions in mapping operating mode

2. Bugs Fixed

- Averaging parameter modification was not anymore updated after edition (in MFCTool V10.3.0). The default value was always used. This bug has been fixed.

5-2-6 MFCTool V10.3.0

1. New Features

- MFC3045 instrument support
- Add export measurement file to legacy file format .dam V8, V9 and MFC4035
- Use local date and time in table and plot results
- Add FCA7046 information in connection page
- Add statistics table in Mapping operation mode
- Add time information in measurement index table selector
- In single probe measurement, the “default” button in “Range Parameter” loads the default single probe limit.

2. Updates

- Update to Qt 5.12.9.
- Use openGL on 2D chart to accelerate data loading when in continuous measurement mode or with lot of data.
- In duration parameter, the time stop condition and minimal duration period is set in hour, minute, second.
- Move about Metrolab information in Settings page.

3. Bugs fixed

- Resolve problem when editing text number with some thousand and separator character according to local regional settings.
- Disable position selection capability while measuring in mapping operating mode. Result could have been affected to the new selected position.
- Resolve a communication error with PT2026 instrument that could occurred in some special case.
- Some other small bug fixed

5-2-7 MFCTool V10.2.1

1. Update

- Change body version in xml record file and service file to 1.1.

5-2-8 MFCTool V10.2.0

1. New Features

- Script file reading to configure PT2026 main unit parameters.
- Measurement information (instrument and parameters).
- Predefined name and extension on saving file.
- Range parameters loaded from user's preferences or last modified value.
- Log messages history (warning, error, info).
- Check on MFCTool software version update.
- Button to reload Probe Array corrections value in normalization table.
- Information on selected instrument and Probe Array in connection page.
- Post measurement slope compute on drift sample parameter change.
- Support remote RB8045 connected directly to FCA7046.
- More parameters and instrument information in normalization report file.
- Warning icon in the mapping measurement status to inform on a NaN (not a number) probe measurement.

2. Updates

- Include VS C++ redistributables (VC_redist.x64.exe) in MFCTool installation.
- Change installation default repository from Program Files (X86) to Program Files.
- Change MFCToolApplicationSettings.ini file path from C:\ProgramData\Metrolab\MFCTool\ to C:\ProgramData\Metrolab\MFCTool_V10.2.0\
- Don’t truncate precision of Gyromagnetic ratio value in measurement report file.
- Show search result in both MHz and Tesla unit.

3. Bugs fixed

- In Normalization operation: button Edit is now available if the PA information comes after being in the Normalization Page.
- Change NAN value to 0.0 in DAM file.
- HDPI representation text issue.
- In Connection page: Correct empty name for default instrument if it exists in the list.
- in Normalization report file, always use MHz unit title like measurement value, and never Tesla.

5-2-9 MFCTool V10.1.1

1. New Features

- Add Clear Error Message button to clear last message.
- Add version in application title name.

2. Updates

- Update Help Online and User's Manual.
- Remove viewing Point label value in 2D Charts.
- Sort ascending Probe Measurement list.
- Change default storage location folder name.
- Change view in Ramping operating mode.
- Set default font to text button.
- Update font to have fixed size number.

3. Bugs fixed

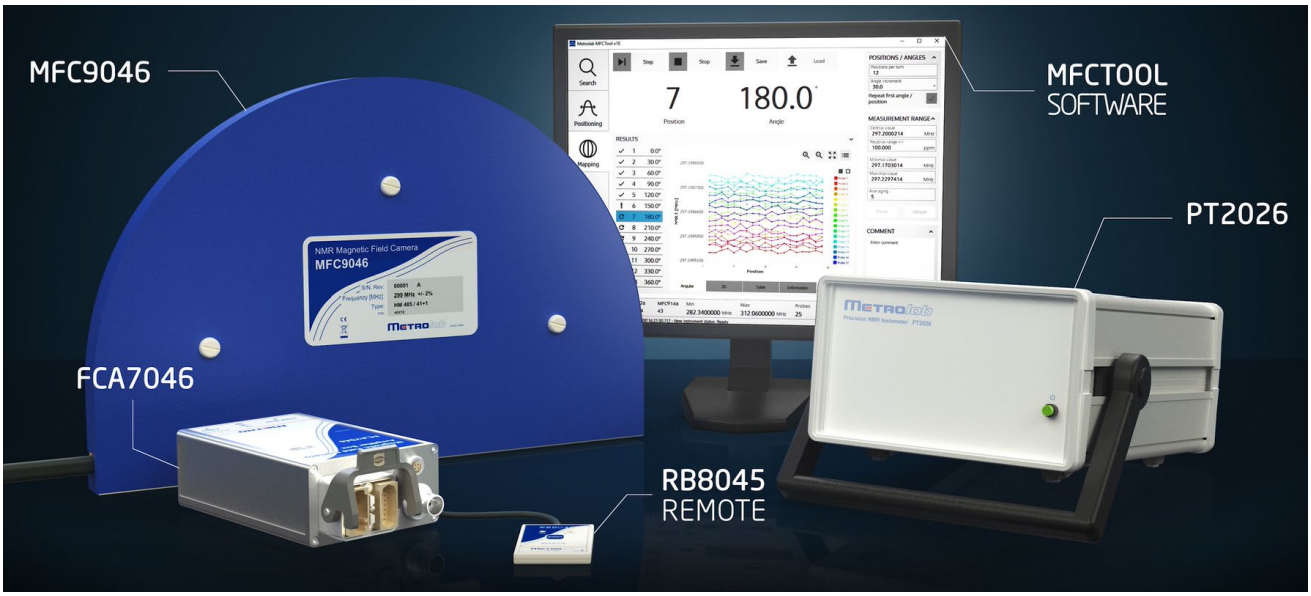
- In Probe Parameters box, updates Probe List on new Probe-Array information.
- In 3D Chart corrects bug measurement view if probe measurement list has a missing probe number.
- In Normalization Mode, detects new Probe-Array information and updates parameters.
- In all Parameters field, update in range test value when selecting a single probe or Probe-Array.

6- KEY SPECIFICATIONS

Warning: for safety precautions, see the MFC2046 Installation and Safety Manual

6-1 DIMENSIONS

PT2026 Main Unit	210 X 125 X 324 mm
FCA7046 Amplifier Box	210 X 61 X 112 mm
MFC9046 Probe-Array	Depends on the customer's request, see below
MFC9146 Probe-Array	Depends on the customer's request, see below



6-2 MEASUREMENT

Measurement principle: pulsed wave Nuclear Magnetic Resonance

Frequency range	1 MHz – 1.1 GHz
Resolution	± 0.1 Hz (stable field, low gradient, no averaging) < 0.01 ppm (10 ppb) in uniform 3 T field
Accuracy	± 5 ppm, independent of temperature
Max gradient	> 1000 ppm/cm
Measurement rate	Up to 33 Hz
Trigger modes	Immediate, Timed, Bus, External

6-3 PT2026 MAIN UNIT RATINGS

PT2026 MFC ready	Basic PT2026 made MFC ready by firmware upgrade
Power	55 VA, 100 – 240 VAC, 50-60 Hz
Overvoltage	Accepts temporary overvoltage occurring on the mains supply—transient overvoltage up to overvoltage category ll levels
Fuse	3.15 A (T), 5x20 mm, 250 V
Environment	Indoor use; no air inlet (IP 50)
Operating temperature	10 – 40 °C
Storage / transport temperature	-25 – 80 °C
Altitude	≤ 2000 m
Relative humidity	Maximum 80 % for temperatures up to 31 °C, decreasing linearly to 50 % relative humidity at 40 °C
Pollution	Pollution degree 2: only non-conductive pollution occurs, except that occasionally a temporary conductivity caused by condensation is to be expected
Magnetic environment	< 0.2 T
Electromagnetic environment	Equipment intended to be used in an industrial electromagnetic environment, class A

6-4 FCA7046 AMPLIFIER BOX RATINGS

Environment	Indoor use; IP 50
Operating temperature	10 – 40 °C
Storage / transport temperature	-25 – 80 °C
Altitude	≤ 2000 m
Relative humidity	Maximum 80 % for temperatures up to 31 °C, decreasing linearly to 50 % relative humidity at 40 °C
Pollution	Pollution degree 2: only non-conductive pollution occurs, except that occasionally a temporary conductivity caused by condensation is to be expected
Magnetic environment	< 1 T
Electromagnetic environment	Equipment intended to be used in an industrial electromagnetic environment, class A
Fixing lugs available upon request	

6-5 MFCTOOL SOFTWARE

Supported platforms	Microsoft Windows 7 or higher
API	Access to all system features; LabVIEW® 2015 SP1
Licenses	Metrolab (including source code for API) National Instruments (LabVIEW® and NI-VISA run-times) Qt 5.12 under GPL and 3-Clause BSD

7- PROBE-ARRAY SPECIFICATIONS

7-1 MFC9046 PROBE-ARRAY RATINGS

Frequency	1 MHz- 1.1 GHz Depends on the magnetic field requested, probe tuning dedicated to one frequency
Magnetic Field Range	Nominal probe-array value ±3% (typical)
Probes on the periphery of the half-moon	Example: 1.5 T probe-array: range => 1.455 T to 1.545 T Sample Ø 2.9 mm, height 3.0 mm, Hydrogen, Synthetic rubber
Sample geometry and material	3.0 T probe-array: range => 2.91 T to 3.09 T Sample Ø 2.9 mm, height 3.0 mm, Hydrogen, Synthetic rubber
Probe-array normalization	The discrepancy between probes placed in the exact same field ≤ ±0.2 ppm Probe-array normalization recommended every 12 months
Magnetic Field Range	Dynamic range of x3 below the nominal probe-array value
Central wide-range probe	Example: 1.5 T probe-array: wide-range probe => 0.5 T to 1.5 T Sample Ø 4.3 mm, height 4.0 mm, Hydrogen, Synthetic rubber
Sample geometry and material	3.0 T probe-array: wide-range probe => 1.0 T to 3.0 T

	Sample Ø 2.9 mm, height 3.0 mm, Hydrogen, Synthetic rubber
Dimensions	DSV from 150 mm up to 600 mm, See below for details
Geometry	Standard sizes and geometries available, customizable on request
Measurement points	Theoretically, up to 255 probes
Position accuracy	Better than ±0.3 mm
Cable Length	4 meters
Environment	Indoor use
Operating temperature	10 – 40 °C
Storage / transport temperature	-25 – 80 °C
Altitude	≤ 2000 m
Relative humidity	Maximum 80 % for temperatures up to 31 °C, decreasing linearly to 50 % relative humidity at 40 °C
Pollution	Pollution degree 2: only non-conductive pollution occurs, except that occasionally a temporary conductivity caused by condensation is to be expected
Electromagnetic environment	Equipment intended to be used in an industrial electromagnetic environment, class A

7-2 MFC9046 PROBE-ARRAY DIMENSIONS

Standard probe-array design

MFC9046 type	DSV (mm)	Number of peripheral probes	Central wide range probe	Dimensions
HM24-300	300	24	✗	237.4 x 29.4 x 324.4 mm
HM24-1-300	300	24	✓	237.4 x 29.4 x 324.4 mm
HM24-400	400	24	✗	287.4 x 29.4 x 424.4 mm
HM24-1-400	400	24	✓	287.4 x 29.4 x 424.4 mm
HM32-400	400	32	✗	287.4 x 29.4 x 424.4 mm
HM32-1-400	400	32	✓	287.4 x 29.4 x 424.4 mm
HM24-450	450	24	✗	312.4 x 29.4 x 474.4 mm
HM24-1-450	450	24	✓	312.4 x 29.4 x 474.4 mm
HM32-450	450	32	✗	312.4 x 29.4 x 474.4 mm
HM32-1-450	450	32	✓	312.4 x 29.4 x 474.4 mm
HM24-500	500	24	✗	337.4 x 29.4 x 524.4 mm
HM24-1-500	500	24	✓	337.4 x 29.4 x 524.4 mm
HM32-500	500	32	✗	337.4 x 29.4 x 524.4 mm
HM32-1-500	500	32	✓	337.4 x 29.4 x 524.4 mm

Other geometries are available on request.

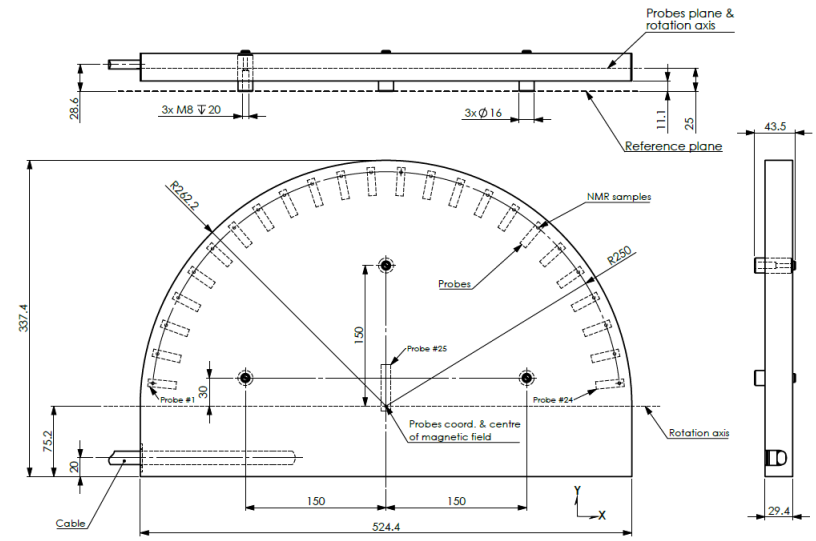
Examples:

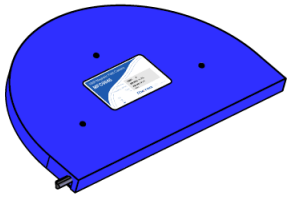
Probe-Array - MFC9046, model (HM24-1-500)

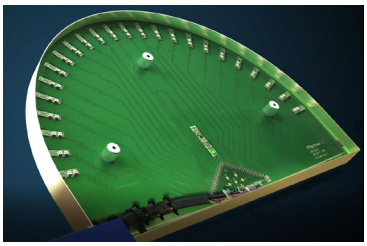
337.4 x 29.4 x 524.4 mm

DSV = 500 mm

24 probes + 1 central wide-range probe





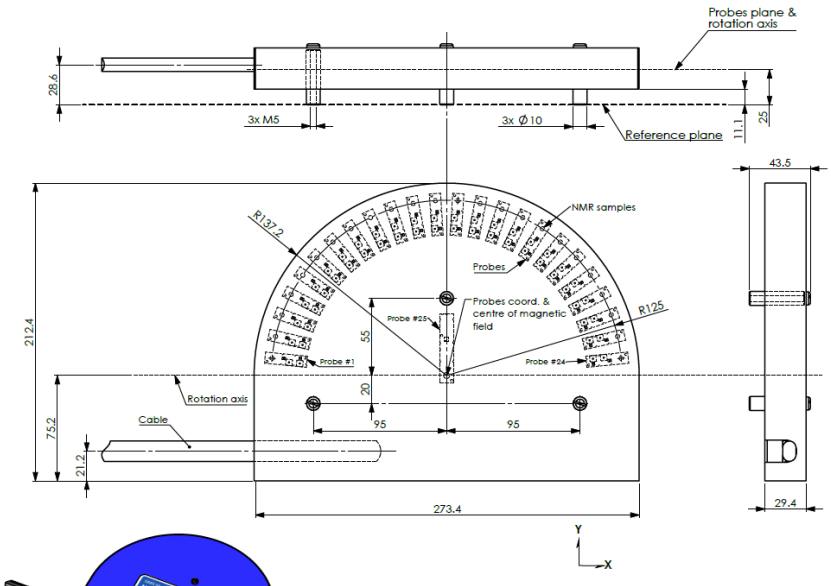


Custom Probe-Array - MFC9046, model HM24-1-250

212.4 x 29.4 x 273.4 mm

DSV = 250 mm

24 probes + 1 central wide-range probe



7-3 PROBE ARRAY MFC9146 RATINGS

Frequency	1 MHz- 1.1 GHz Depends on the magnetic field requested, probe tuning dedicated to one frequency
Magnetic Field Range	Nominal probe-array value ±3% (typical) Example: 1.5 T probe-array: range => 1.455 T to 1.545 T 3.0 T probe-array: range => 2.91 T to 3.09 T
Probe-array normalization	The discrepancy between probes placed in the exact same field ≤ ±0.2 ppm Probe-array normalization recommended every 12 months
Magnetic Field Range Central wide-range probe	Not available
Dimensions	Target cylindrical volume from 10 mm (diameter) X 28 mm (length)
Geometry	Custom geometries No standard sizes
Measurement points	Theoretically, up to 255 probes
Position accuracy	Better than ±0.3 mm
Cable Length	4 meters
Environment	Indoor use
Operating temperature	10 – 40 °C
Storage / transport temperature	-25 – 80 °C
Altitude	≤ 2000 m
Relative humidity	Maximum 80 % for temperatures up to 31 °C, decreasing linearly to 50 % relative humidity at 40 °C
Pollution	Pollution degree 2: only non-conductive pollution occurs, except that occasionally a temporary conductivity caused by condensation is to be expected
Electromagnetic environment	Equipment intended to be used in an industrial electromagnetic environment, class A

Example:

MFC9146 manufactured for HTS-110 400 MHz NMR spectrometer magnet:

https://www.metrolab.com/bringing-a-cryogen-free-400-mhz-hts-nmr-spectrometer-into-a-chemistry-lab-a-discussion-with-maria-silva-elipe/