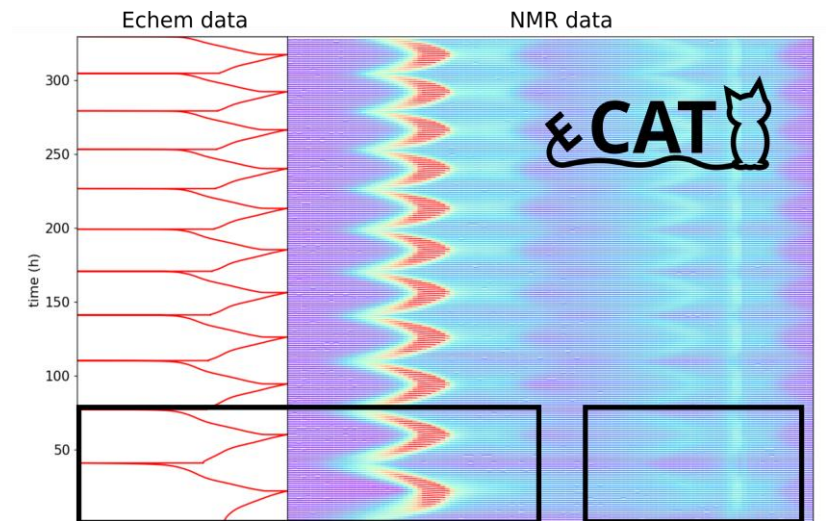


## Probes, accessories, and services



Find all information and the latest updates on:  
<https://eprobe.tech/>

ePROBE

BATTERY ANALYSIS TECHNOLOGY SOLUTIONS

The screenshot shows the homepage of the ePROBE website. The header includes the ePROBE logo and navigation links for PRODUCTS, SERVICE, PROJECTS, and CONTACT. Below the header, there is a welcome message: "Welcome to ePROBE GmbH (Erfurt, Germany)". The main content area is divided into three sections: "PRODUCTS", "Service", and "PROJECTS". Each section contains a brief description of the services and a small image. The footer includes copyright information for 2025 ePROBE GmbH and links to Imprint/Impressum, Privacy Policy, and Datenschutz/Zeichnung.

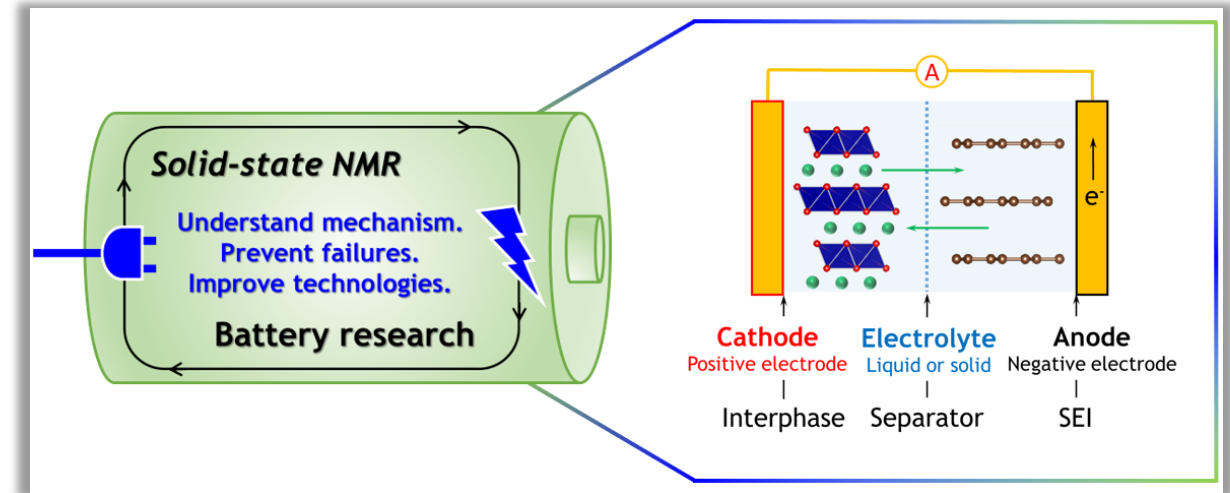
The screenshot shows the product page for "STATIC-X IN SITU NMR PROBES". The header includes the ePROBE logo and navigation links for PRODUCTS, SERVICE, PROJECTS, and CONTACT. Below the header, there are sub-navigation links for Probes, Controller, Setup, Cells, Tools, and eCAT. The main content area is divided into three sections: "STATIC-X IN SITU NMR PROBES", "STATIC H-X IN SITU NMR PROBES", and "STATIC F-X IN SITU NMR PROBES". Each section contains a brief description of the product and a list of features and options. The footer includes copyright information for 2025 ePROBE GmbH and links to Imprint/Impressum, Privacy Policy, and Datenschutz/Zeichnung.

The screenshot shows the service page of the ePROBE website. The header includes the ePROBE logo and navigation links for PRODUCTS, SERVICE, PROJECTS, and CONTACT. Below the header, there are sub-navigation links for Consulting, Partner, Outreach, Paper, and Download. The main content area is divided into three sections: "Webinar: Advancements in Operando NMR Analysis of Lithium-Ion Batteries", "Specialty Solids Probes for Battery Research and Manufacturing", and "Battery research probes for Li-ion technologies (and beyond)". Each section contains a brief description of the service and a small image. The footer includes copyright information for 2025 ePROBE GmbH and links to Imprint/Impressum, Privacy Policy, and Datenschutz/Zeichnung.

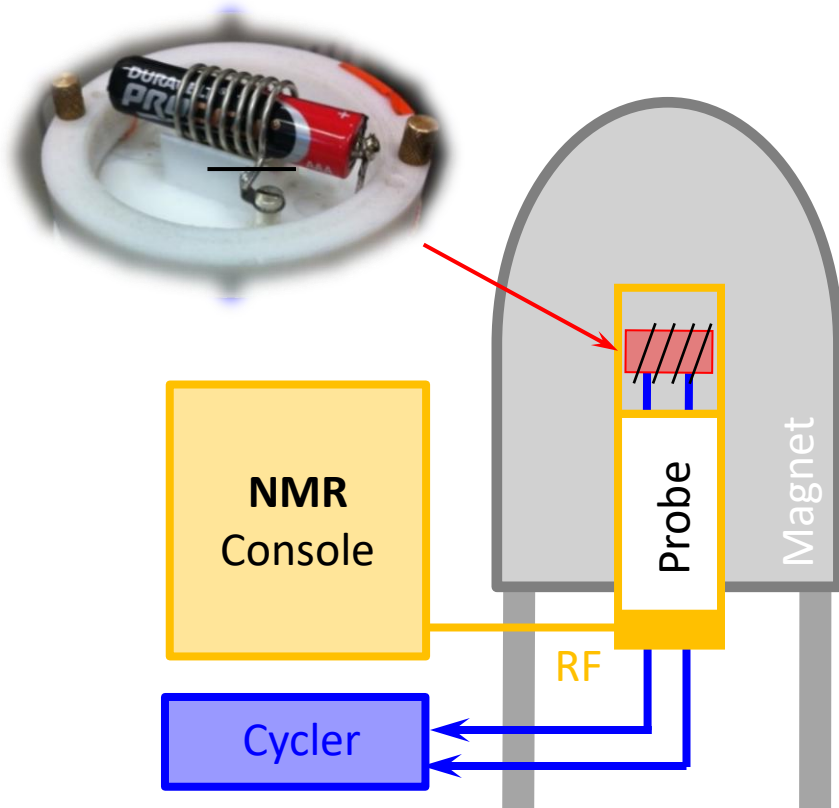
<https://eprobe.tech/>

# NMR on energy storage materials

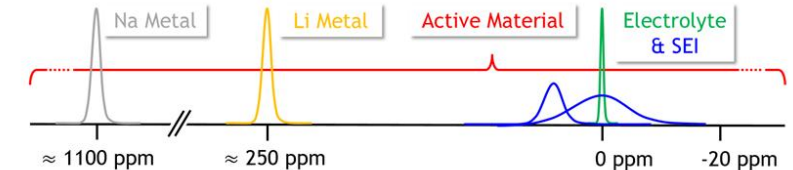
- Battery = complex system
  - Liquid and solid components
  - Various interfaces (solid-electrolyte-interface, SEI)
- **Ex situ NMR** – static and MAS
  - Cycle. Stop. Extract. Measure data.
- **In situ NMR** – static (and MAS)
  - Cycle. Pause. Collect data. Restart.
- **Operando NMR** – static
  - Cycling. Collect data during cycling.



# In situ NMR on energy storage materials

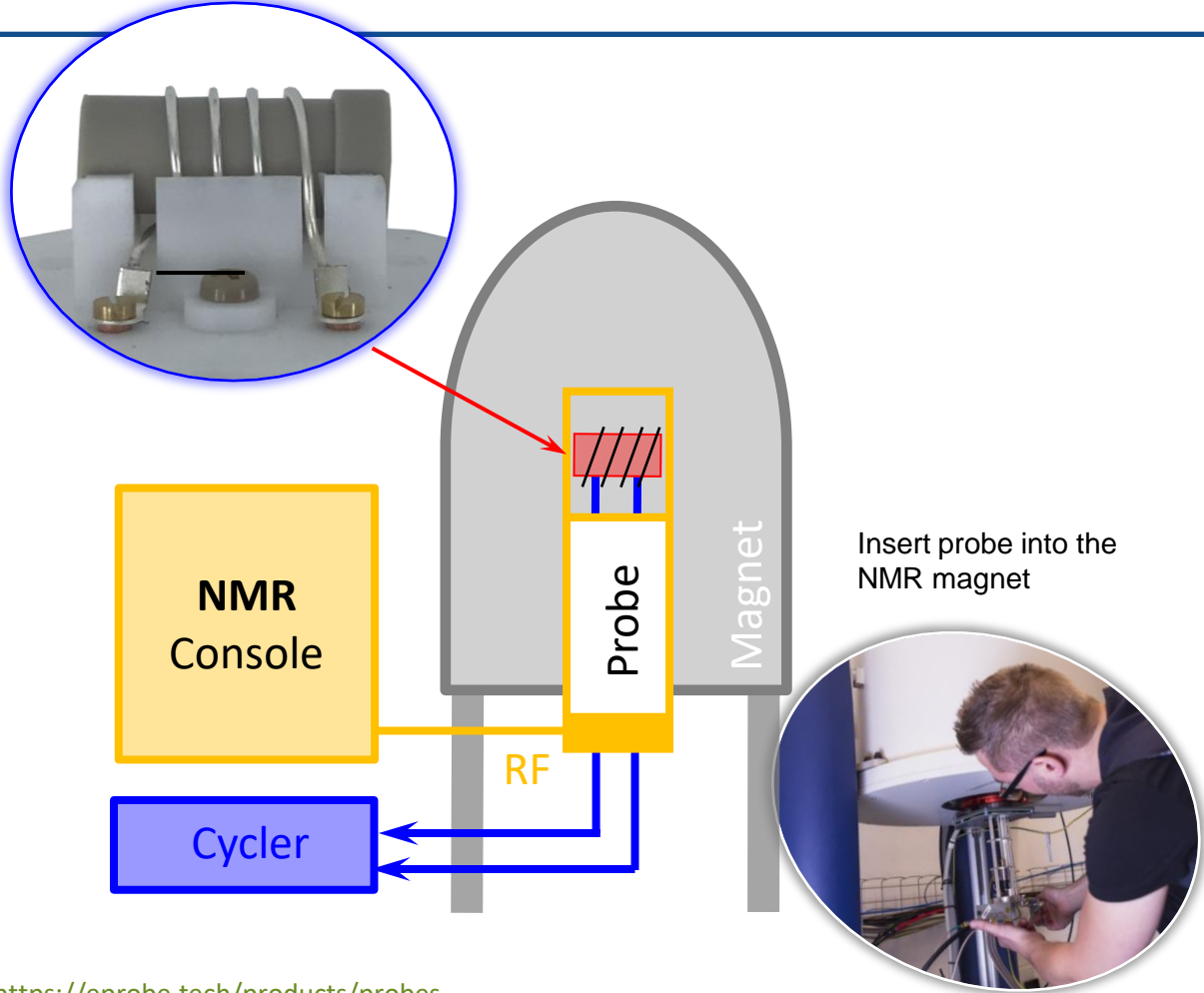


- Bypass self-relaxation ☺
- High chemical specificity ☺
- Dynamical processes ☺
- Metastable and short-lived phases ☺
- Crystalline and amorphous species ☺
- Shift ranges ☹
- Changing sample conditions ☹
- NMR signal broadening ☹
- NMR—EC circuit interferences ☹



F. Blanc et al. Acc. Chem. Res. 2013, 46, 1952. N. M. Trease et al. Solid State Nucl. Magn. Reson. 2012, 42, 62. L. Zhou et al. J. Magn. Reson. 2013, 234, 44. OP et al. J. Magn. Reson. 2016, 265, 200. B. Key et al. J. Am. Chem. Soc. 2009, 131, 9239. OP, J. Caretero-González, K.J. Griffith, C.P. Grey, Chem. Mater. 2017, 29, 213. OP and DMH et al. J. Magn. Reson. 2017, 275, 127.

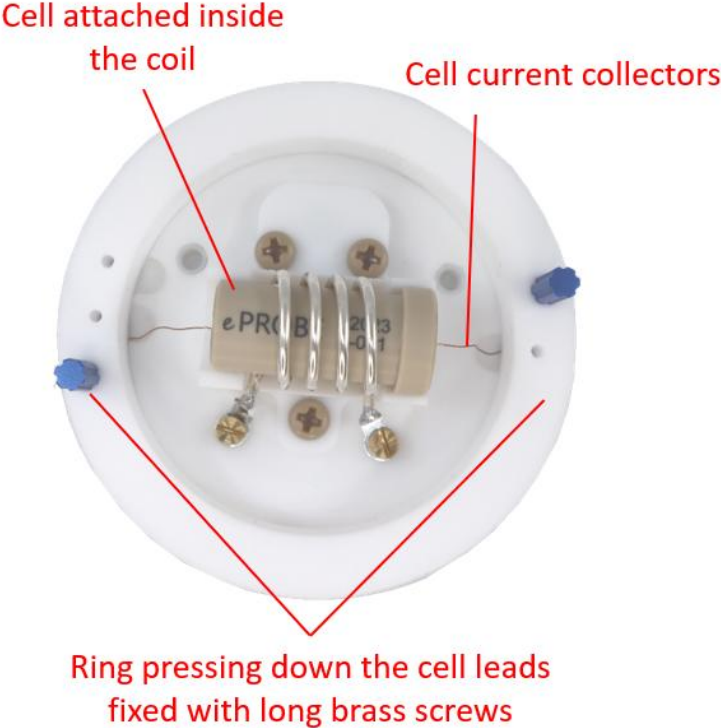
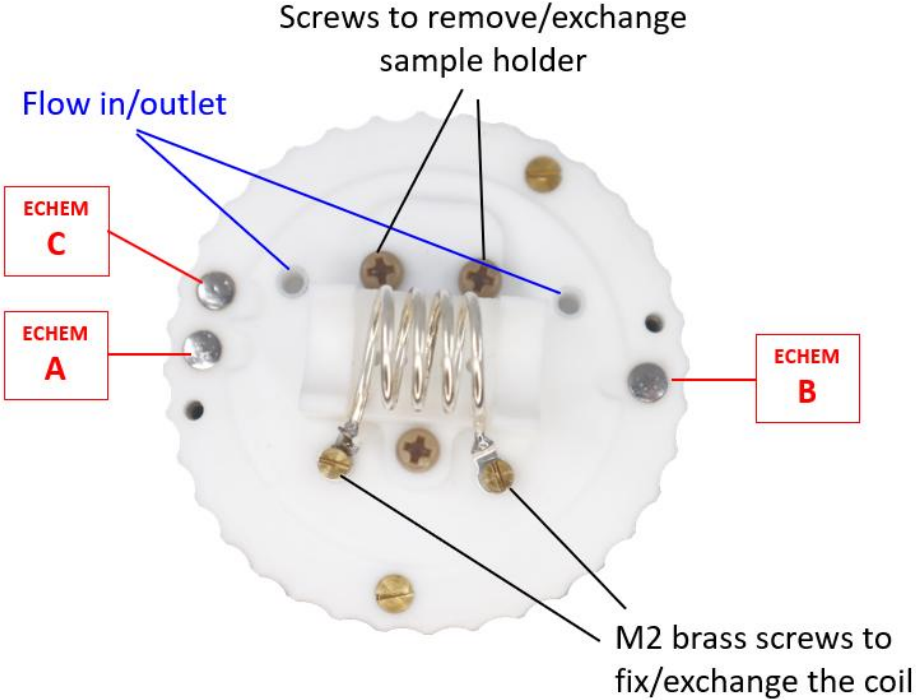
# In situ NMR on energy storage materials



<https://eprobe.tech/products/probes>



# In situ NMR probe: cell connections and features



<https://eprobe.tech/products/probes>

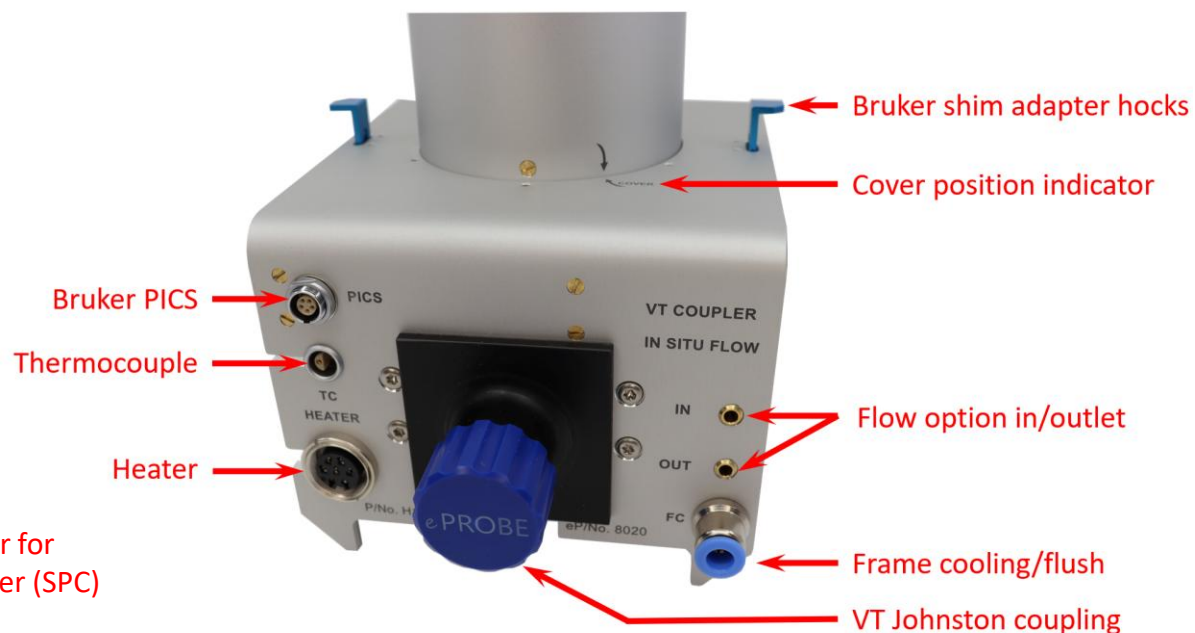
# In situ NMR probe: connections



SMA electrochemistry ports

N-type adapter for RF X-channel

Smart probe autotune (SPA) adapter for connection to Smart Probe Controller (SPC)



Bruker shim adapter hocks

Cover position indicator

Bruker PICS

Thermocouple

Heater

Flow option in/outlet











































Frame cooling/flush

VT Johnston coupling

<https://eprobe.tech/products/probes>

# Which in situ system best fits my needs?

- What are my **magnet/ console** specifications?
- Which **nuclei** do I want to analyse?
- Which **cell** geometry is best suited for my chemistry?
- Do I need **automatic tuning** and matching?
- Do I need efficient **data processing** options?

Options	STATIC—X	STATIC H—X	STATIC F—X
<b>NMR/RF</b>			
Wide-bore			
Narrow/standard-bore			
200 – 500 MHz			
600 – 700 MHz			
<sup>13</sup> C – <sup>31</sup> P + <sup>6</sup> Li			
Automatic tune/match		 + eATM ROBOT	 + eATM ROBOT
All NMR systems			
<b>Electrochemistry options</b>			
Three e-chem ports			
Flow option			
Impedance spectroscopy (EIS)			
Suitable for all cyclers			
<b>Available cell types</b>			
Plastic cell capsules (2 or 3 electrodes)			
Solid state cell			
Plastic pouch cells			
Coin cells			
<p><b>Watch this space for your customised solution.</b> Please do not hesitate to contact us.</p>			




















<https://eprobe.tech/products/probes>

<https://eprobe.tech/products/cells>



# Magnet/console specifications and nuclei wish-list

- **Wide-bore vs. narrow/standard-bore (WB vs. NB/SB)**
  - Less options on H/F for SB
  - Automatic tune/match possible via eATM ROBOT
- **Magnetic field strength**
  - 600+ MHz fields reduces H/F—X options
- **Talk to us on your customised solution!**

Options	STATIC—X	STATIC H—X	STATIC F—X
<b>NMR/RF</b>			
Wide-bore			
Narrow/standard-bore			
200 – 500 MHz			
600 – 700 MHz			
$^{13}\text{C} - ^{31}\text{P} + ^6\text{Li}$			
Automatic tune/match		 + eATM ROBOT	 + eATM ROBOT
All NMR systems			

<https://eprobe.tech/products/probes>

<https://www.bruker.com/en/products-and-solutions/mr/nmr/solid-state-nmr/specialty-solids-probes.html>

# Static X vs. H/F—X in situ probes



<https://eprobe.tech/products/probes>

# Example: Data sheets of H—X and X 400 MHz WB probes



## PRODUCT DATA SHEET

### Double-Resonance (H/X) Static *In Situ* NMR Probe for Battery & Energy Storage Materials Research

A specialized double-resonance (H/X) static *in situ* NMR probe for researching energy storage materials including batteries/electrochemical cells, using a 400 MHz wide-bore system. The tuning range covers  $^6\text{Li}$  (low-frequency mode) and  $^{13}\text{C} - ^{31}\text{P}$  (high-frequency mode) on X with a manual switch for low/high-frequency mode and manual tuning and matching. In addition, the probe is equipped with a  $^1\text{H}$  high-power decoupling channel. Automatic tuning/matching is optional and possible via an additional external automatic tune/match (eATM) robot. The probe is optimized for *in situ* plastic capsule cells including solid-state cells but is also compatible with plastic bag and home-built *in situ* cells. The probe is equipped with three current collector ports next to the RF coil, through which an electrochemical cyclers can be connected to the sample/cell to perform *in situ / operando* NMR experiments. Integrated channels for optional gas or liquid flow through the cell enable redox flow, metal-air, or similar battery chemistries research.

#### Model:

PH0951\_BB  
400 MHz (Length: W1), Bruker Material Number: H1884072, ePROBE Material Number: EA0204

#### Specifications:

<b>Coils</b>	Two exchangeable 11 mm ID solenoid coils for low- and high-frequency mode
<b>Compatible Samples/Cells</b>	<i>In situ</i> plastic cell capsule cells (OD 11 mm) Solid-state <i>in situ</i> cells (OD 11 mm) <i>In situ</i> plastic-bag cells and home-built/customized <i>in situ</i> cells
<b>Temperature Range</b>	-50 / +100 °C
<b>Electrochemistry Ports</b>	Three current collector ports: working electrode, counter electrode and reference electrode (reference electrode is used for customized cells only)
<b>Flow Ports</b>	Flow in- and outlet ports to the left and to the right of the RF coil; accessible via built-in extension to the probe base.
<b>Tuning Ranges</b>	X Channel: $^6\text{Li}, ^{13}\text{C} - ^{31}\text{P}$ H Channel: $^1\text{H}$

Specifications are valid as of 2024.09.13 with an Avance NEO spectrometer with a current BOSS shim system. Technical data and specifications subject to change without notice.

<sup>1</sup> RF power handling capabilities (verified at production; not installation):  $^1\text{H}$ ,  $^{13}\text{C}$ ,  $^{23}\text{Na}$ ,  $^7\text{Li}$ ,  $^{31}\text{P}$ , and  $^1\text{H}$  up to 300 W with 10  $\mu\text{s}$  pulses and 200 ms delay time; pulse width determination via the respective standard reference compounds, e.g. dried LiCl powder for  $^7\text{Li}$ .

<sup>2</sup> Recommended amplifiers:  $^1\text{H}$ : 500 W; X: 500 W.



## PRODUCT DATA SHEET

### Single-Resonance (X-channel) Static *In Situ* ATM-X NMR Probe for Battery & Energy Storage Materials Research

A specialized single-resonance (X-channel) static *in situ* NMR probe for researching energy storage materials, including batteries/electrochemical cells, using a 400 MHz wide-bore system. The tuning range covers  $^{13}\text{C}$  to  $^{31}\text{P}$ . The probe features an automatic tuning and matching unit. The probe is optimized for *in situ* plastic capsule cells including solid-state cells but is also compatible with plastic bag and home-built *in situ* cells. The probe is equipped with three current collector ports next to the RF coil, through which an electrochemical cyclers can be connected to the sample/cell to perform *in situ / operando* NMR experiments. Integrated channels for optional gas or liquid flow through the cell enable redox flow, metal-air, or similar battery chemistries research.

#### Model:

PA0950\_SR/BB  
400 MHz (Length: W1), Bruker Material Number: H1869020, ePROBE Material Number: EA010401

#### Specifications:

<b>90° Pulse Width<sup>(1, 2, 3)</sup></b>	$^7\text{Li}$	$\leq 2.5 \mu\text{s}$
<b>Coils</b>	Standard: Solenoid coil made of Ag-coated Cu wire (1.5 mm); 5-turns coil ID 11 mm <sup>3</sup> Exchangeable coils include 3, 4, 5, and 6-turn coils ID 11 and 15 mm	
<b>Compatible Samples/Cells</b>	<i>In situ</i> plastic cell capsule cells (OD 11 mm and OD 15 mm) Solid-state <i>in situ</i> cells (OD 11 mm) <i>In situ</i> plastic-bag cells and home-built/customized <i>in situ</i> cells	
<b>Temperature Range<sup>(1)</sup></b>	-50 / +100 °C	
<b>Electrochemistry Ports</b>	Three current collector ports: working electrode, counter electrode and reference electrode (reference electrode is used for customized cells only)	
<b>Flow Ports</b>	Flow in- and outlet ports to the left and to the right of the RF coil; accessible via built-in extension to the probe base.	
<b>Tuning Range</b>	X Channel	$^{13}\text{C} - ^{31}\text{P}$

Specifications are valid as of 2024.09.13 with an Avance NEO spectrometer with a current BOSS shim system. Technical data and specifications subject to change without notice.

<sup>1</sup> Specification verified at production, not at installation.

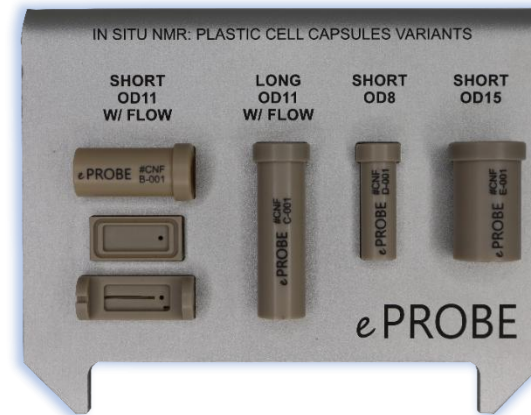
<sup>2</sup> The pulse width is determined with dried LiCl powder.

<sup>3</sup> Recommended amplifier: X: 500 W.

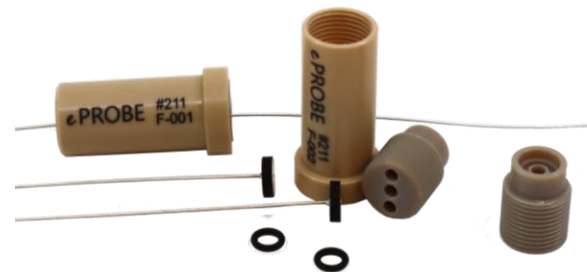
<https://www.bruker.com/en/products-and-solutions/mr/nmr/solid-state-nmr/specialty-solids-probes.html>

# Available cell geometries

- **Standard in-situ plastic capsule cells:**
  - Various sizes
  - Flow option available
- **Solid-state cells**
- **More applications (existing and under development):**
  - Coin cells
  - High temperatures (< 300 °C)
  - High pressure
  - Optical excitation
  - ...
- **Open to collaborations about new applications!**



New 2025 : 3- electrode cell

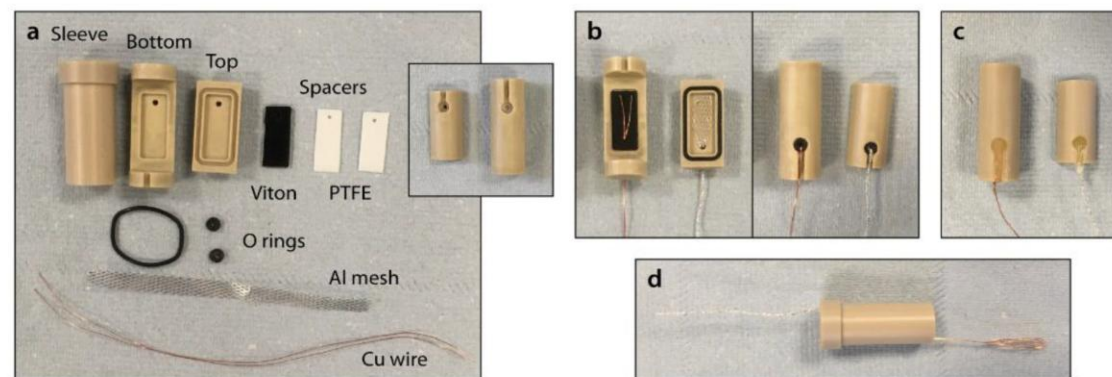
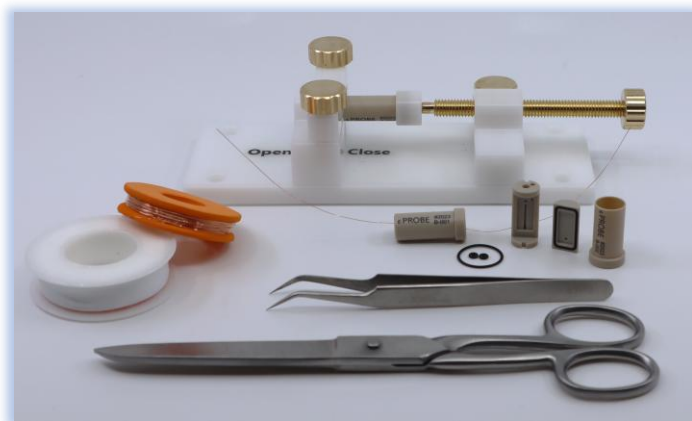


New 2025 : EIS option

<https://eprobe.tech/products/cells>

<https://eprobe.tech/projects/collaborators>

<https://eprobe.tech/projects/current-projects>



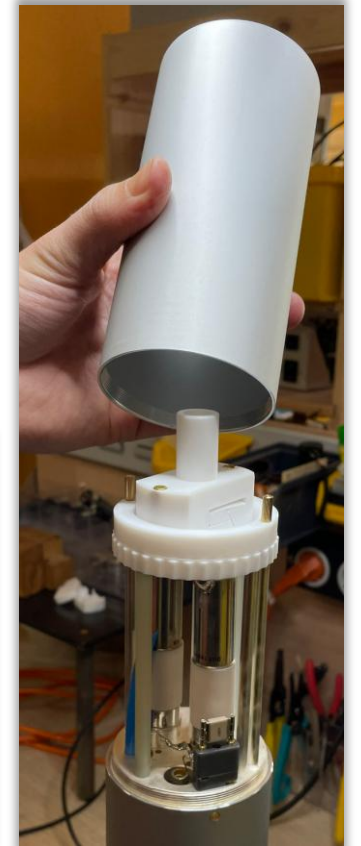
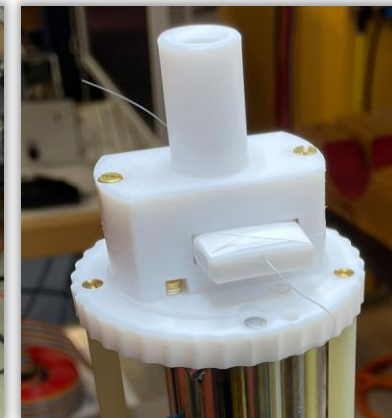
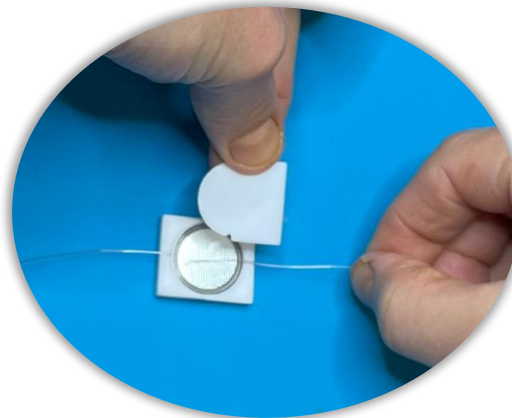
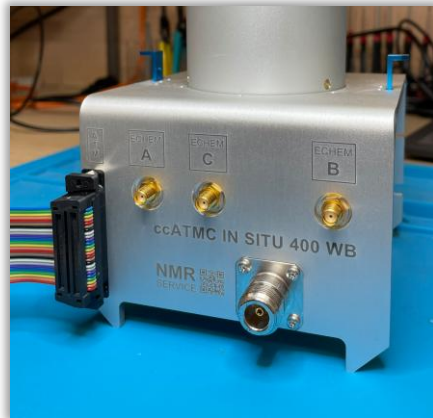
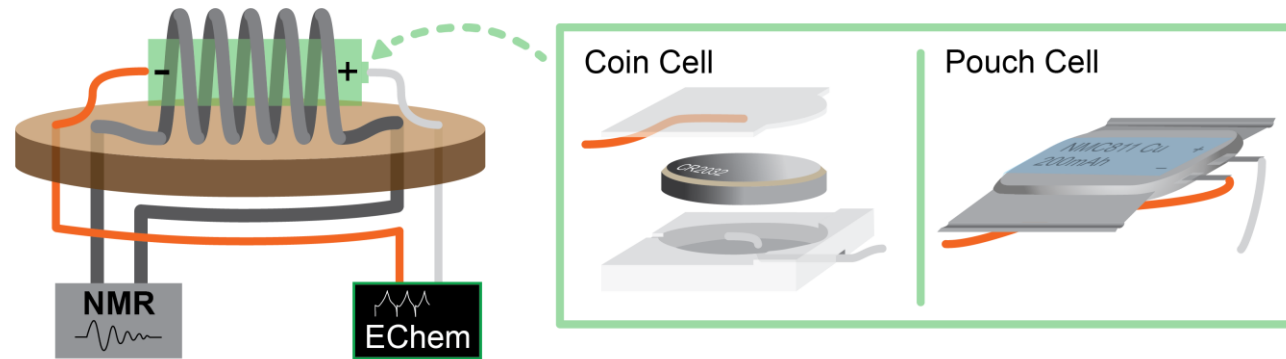
**Figure S1.** Photos of an *in situ* NMR capsule cell as used in this work. (a) Capsule cell and additional components, the small inset shows the other side of the top and bottom pieces. (b) The bottom piece is fitted with spacers and two thin copper wires; the top piece is fitted with an O ring and Al mesh (left photo). Small O rings are inserted in the current collector holes (right photo). (c) The current collector holes are sealed with epoxy glue. (d) Complete cell after assembly in a glove box.

K. Märker et al. JACS 2020, 142, 17447 (<https://dx.doi.org/10.1021/jacs.0c06727>).  
<https://eprobe.tech/products/tools>  
<https://eprobe.tech/service/download>

**Instructions In Peer-Reviewed Journals  
and Handout Downloads (ePROBE)**

# New in 2025: Operando NMR on coin and pouch cells

**Utilising the  
"Coin Cell In Situ NMR Probe"  
Est. September 2022**



In collaboration with Prof. Lauren E. Marbella and Dr. Asya Svirinovsky Arbeli Columbia University, NYC, USA)

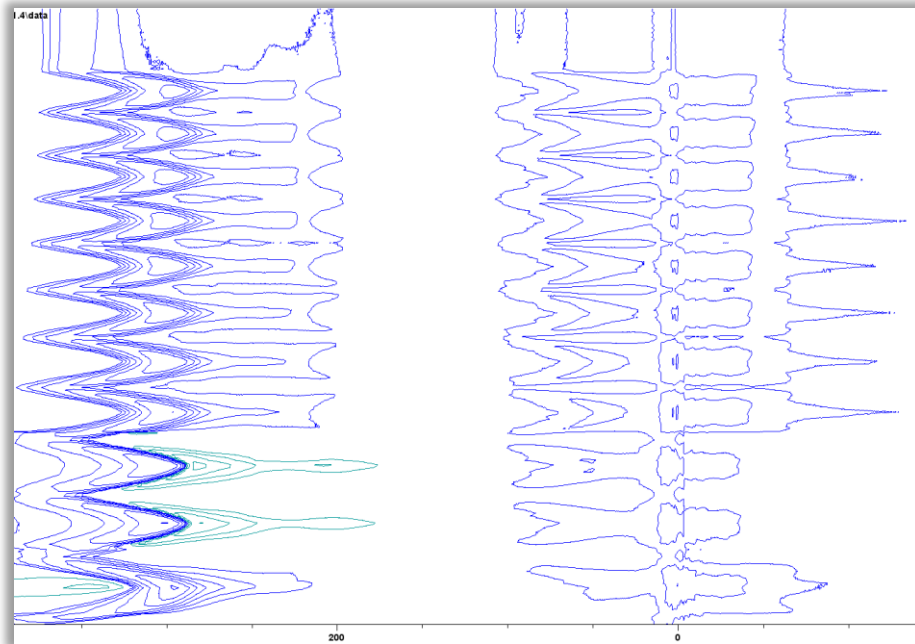
# Smart probe controller (SPC) for automatic tune/match

- Smart probe controller (SPC)
- Direct connection between probe and SPC
  - Available for X & H/F—X WB, as well as X NB/SB probes
- eATM ROBOT
  - Needed for H/F—X NB/SB probes
  - Can be connected to any type of probe (static, MAS, ...)



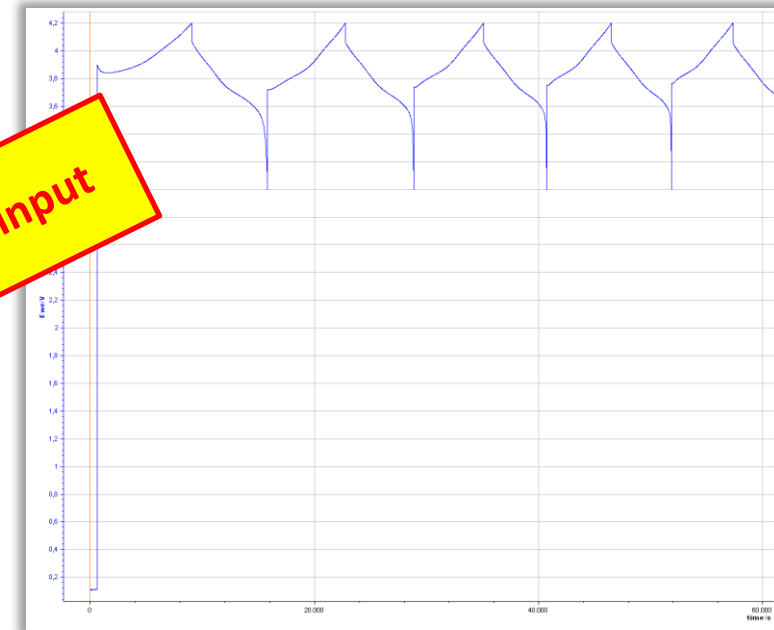
<https://eprobe.tech/products/controller>

- NMR data



- Cyclor data

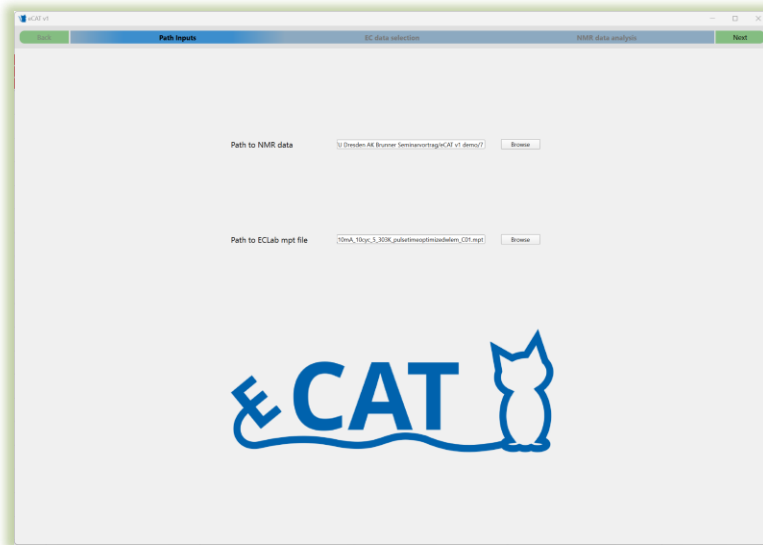
**RAW data input**



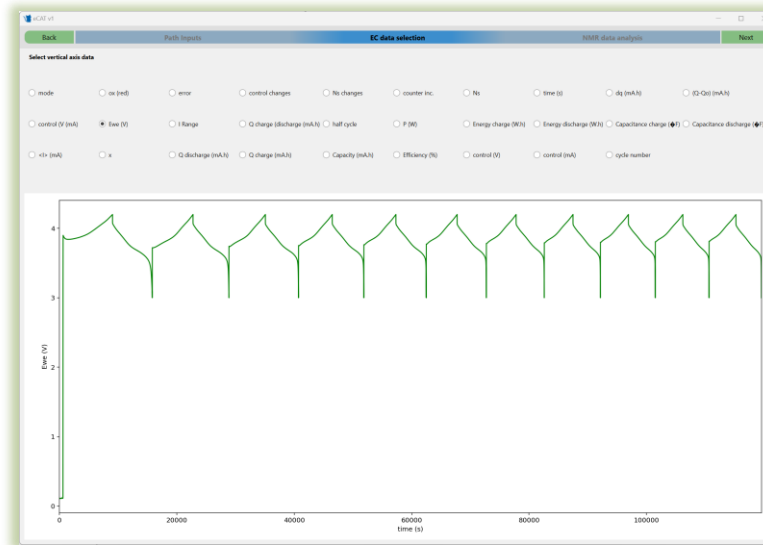
<https://eprobe.tech/products/ecat>  
eCAT automatic e-chem/NMR (raw) data data processing and visualisation tool | optional postprocessing



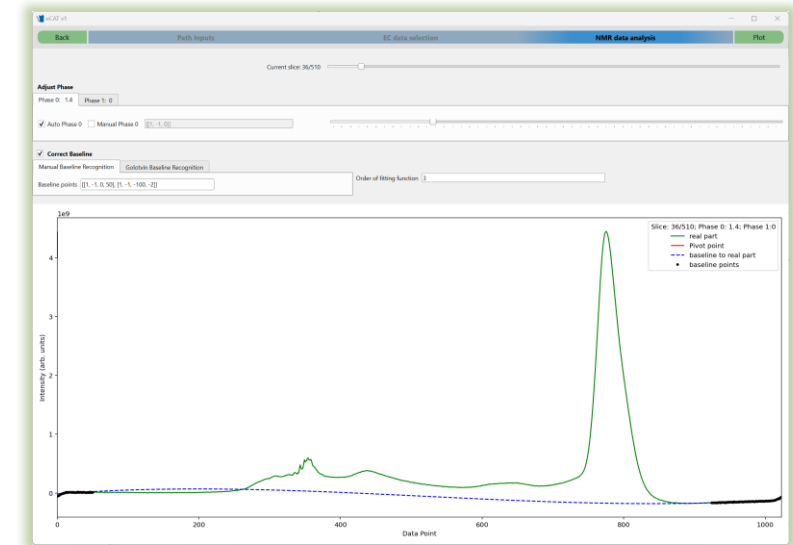
# Efficient data processing - eCAT



**Choose Data Paths**

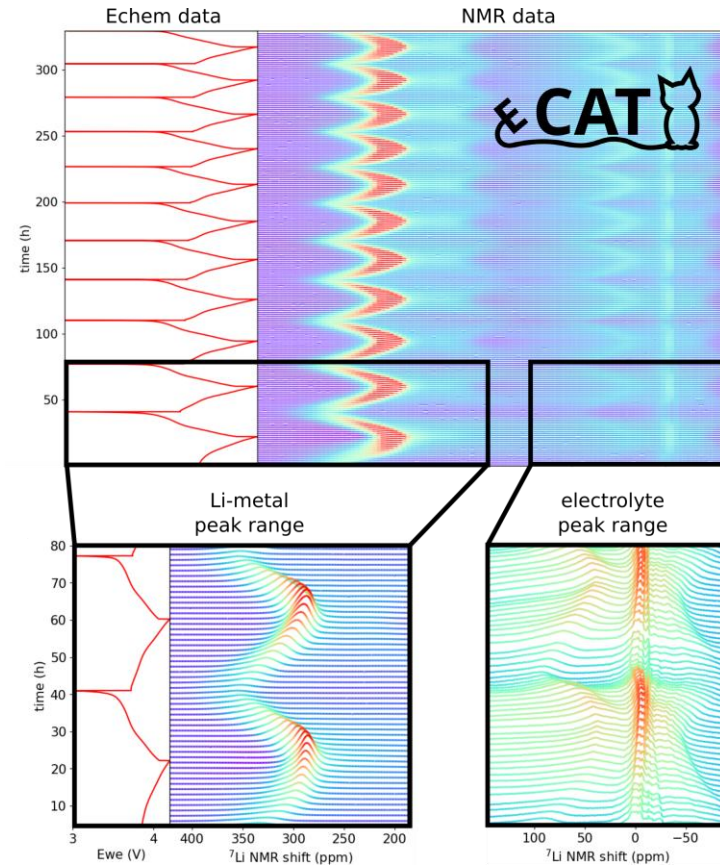


**Choose Data Presentation**



**Automatic or Manual Data Processing (Individual)**

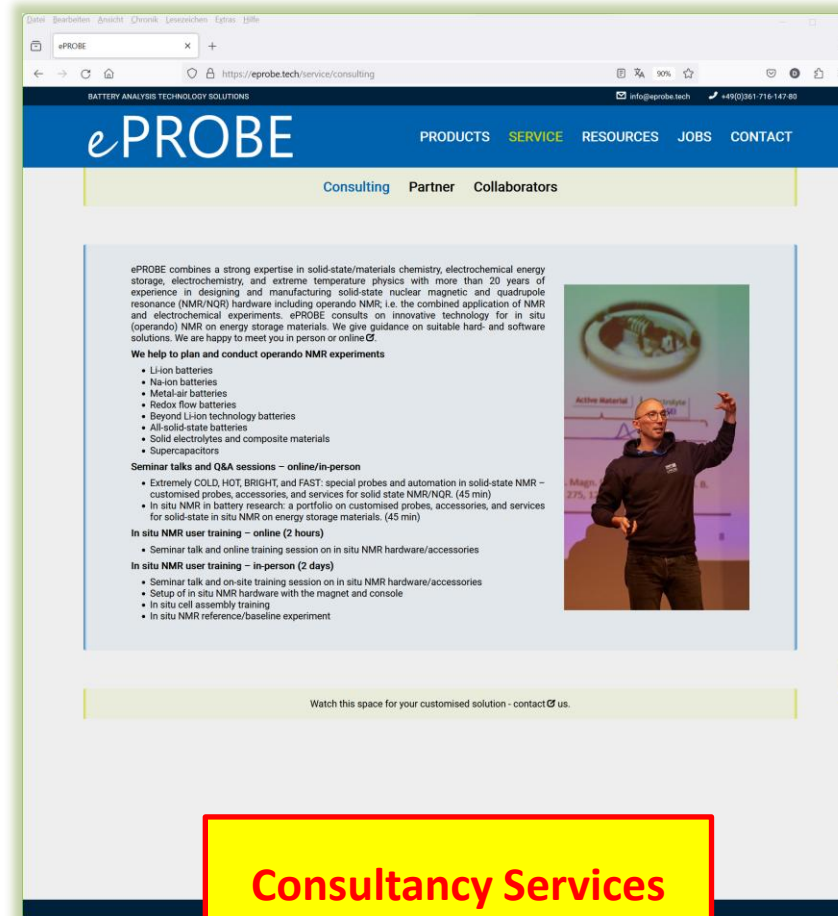
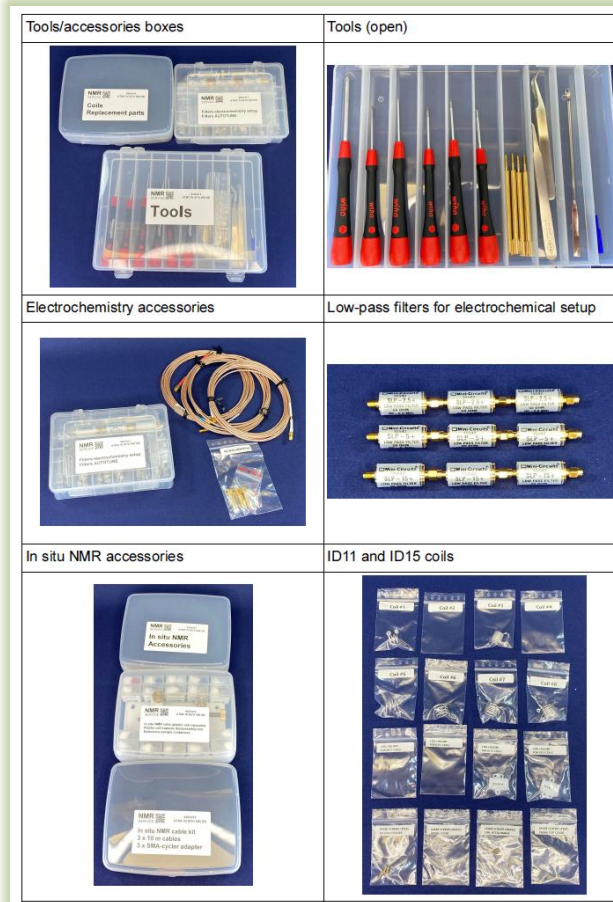
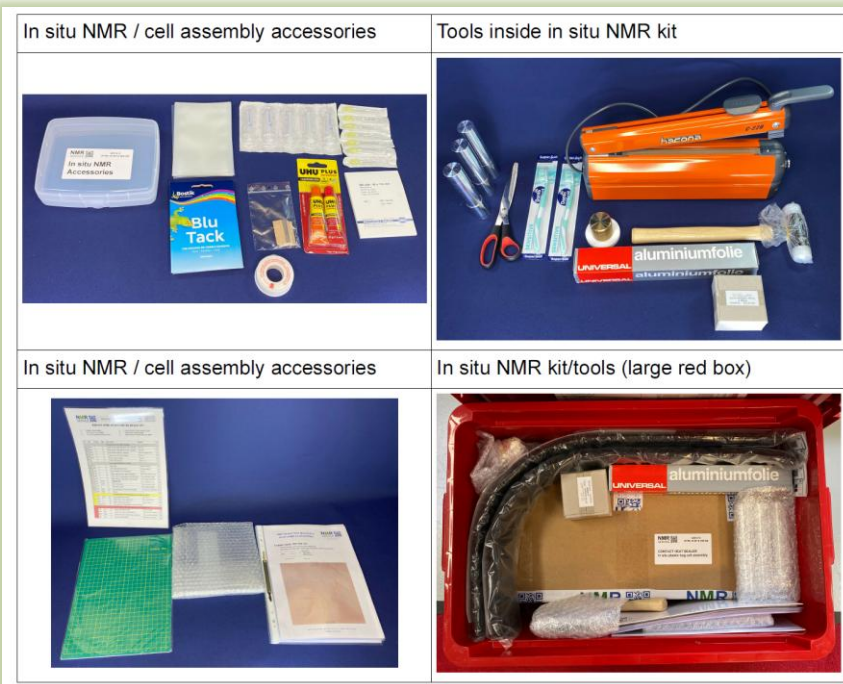
<https://eprobe.tech/products/ecat>  
eCAT automatic e-chem/NMR (raw) data data processing and visualisation tool | optional postprocessing



**Quick Graphical Presentation  
In Various Data Outputs**

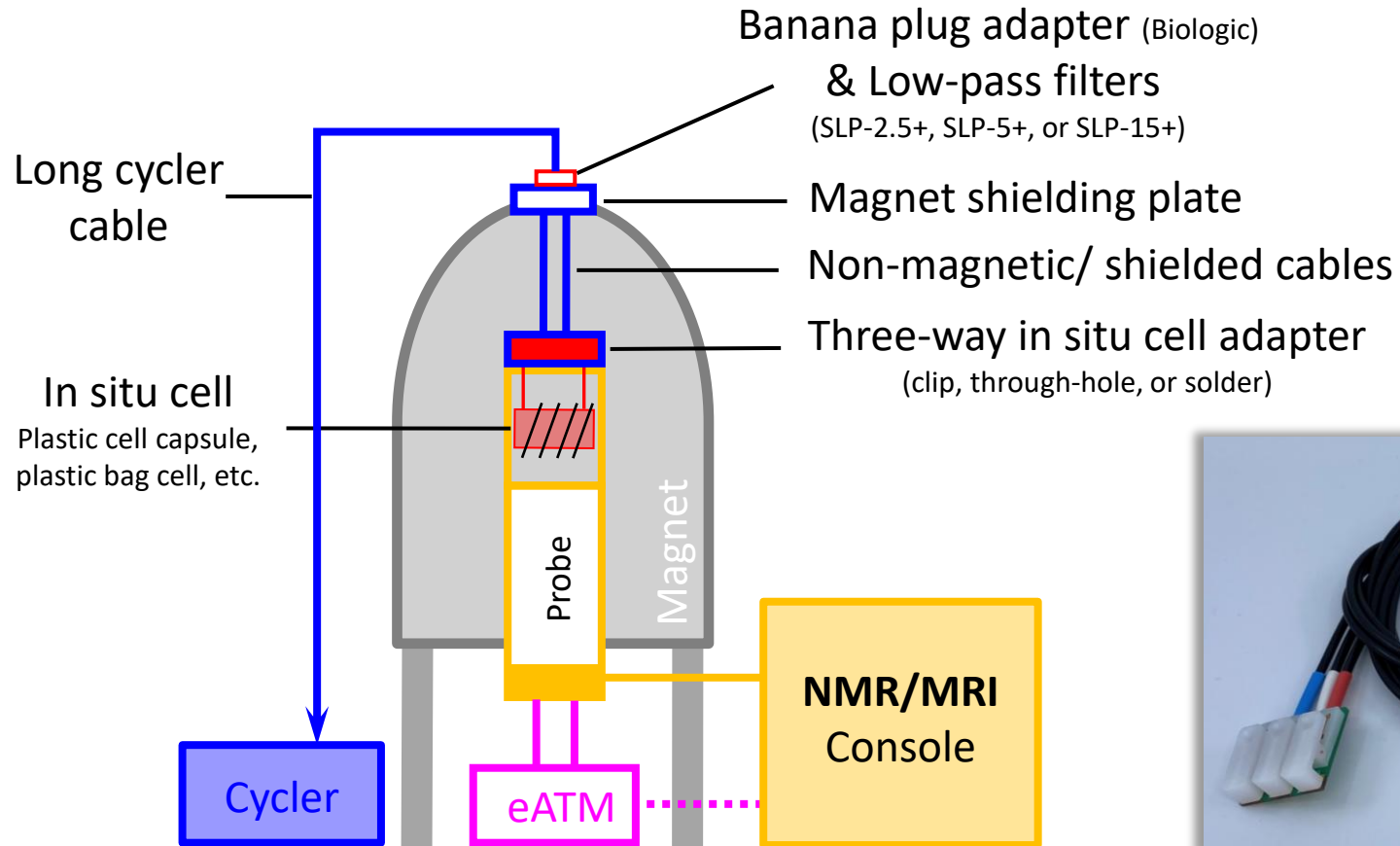
<https://eprobe.tech/products/ecat>  
eCAT automatic e-chem/NMR (raw) data data processing and visualisation tool | optional postprocessing

# In situ NMR accessories and consultancy



<https://eprobe.tech/products/tools>  
<https://eprobe.tech/service/consulting>

# In situ setup for static NMR/MRI probes



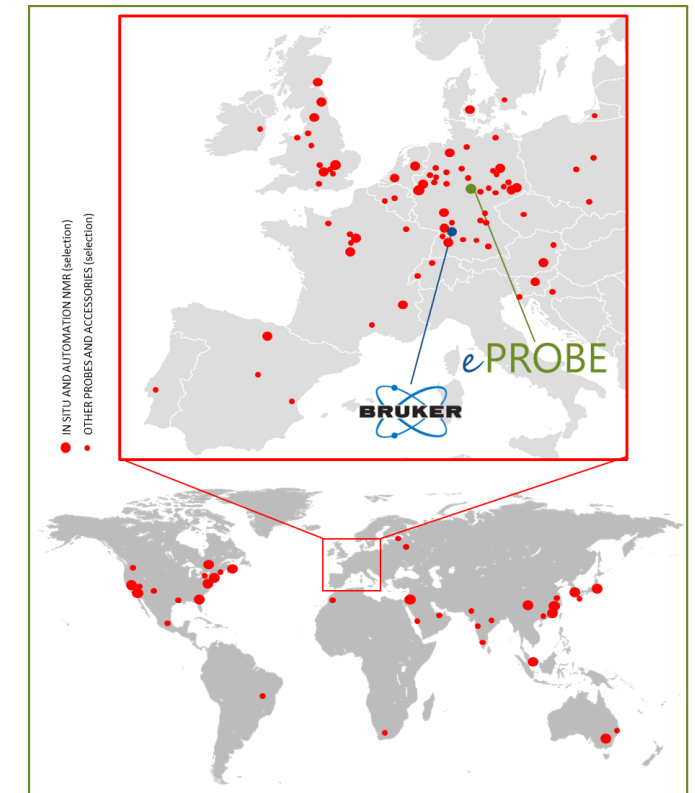
<https://eprobe.tech/products/setup>

Thank you very much for your attention



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Please do not hesitate to contact us.