I.FAST – WP7- Task 7.3

"Variable Dipole for the upgrade of the ELETTRA storage ring"

Meeting

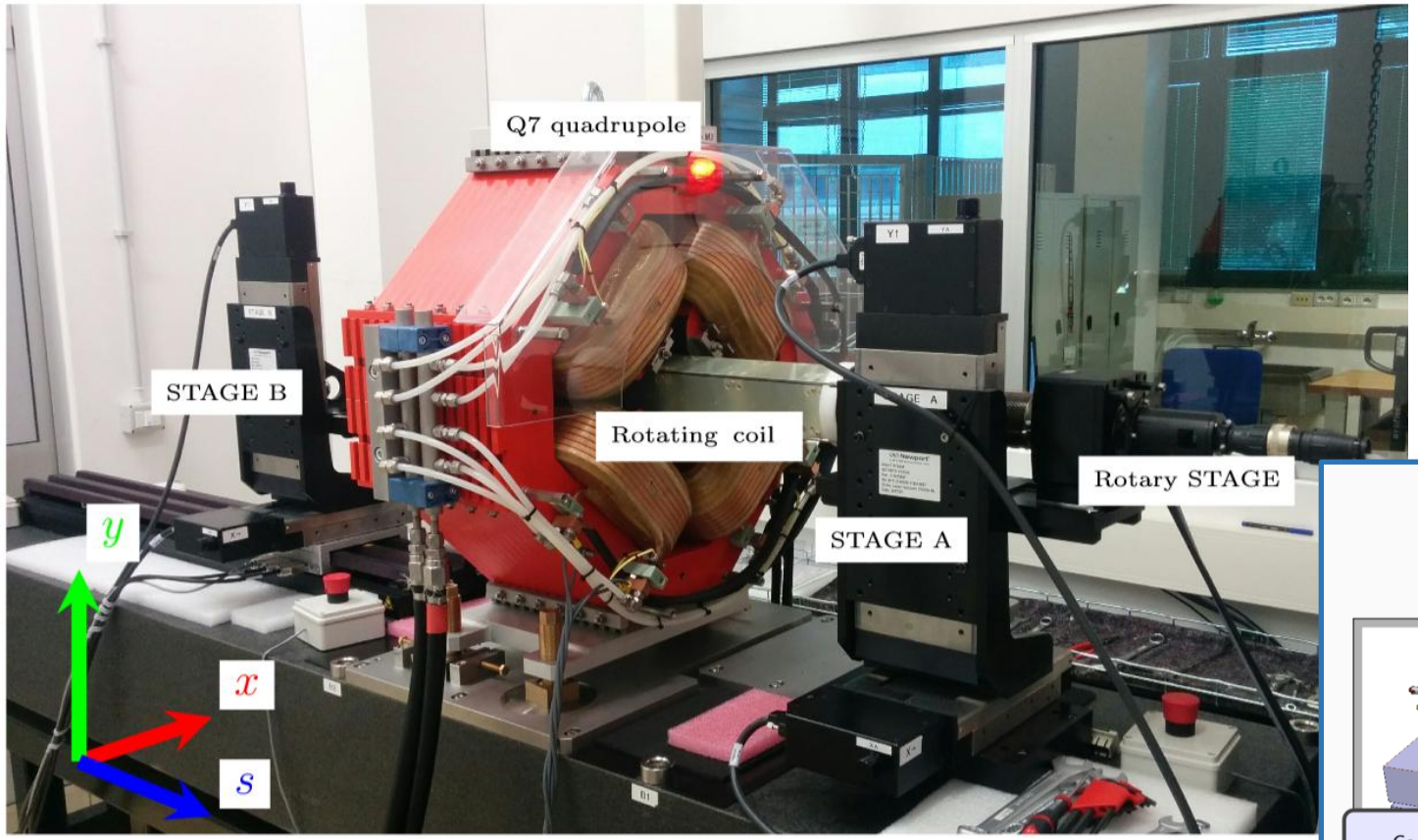
Madrid, 07.10.2022

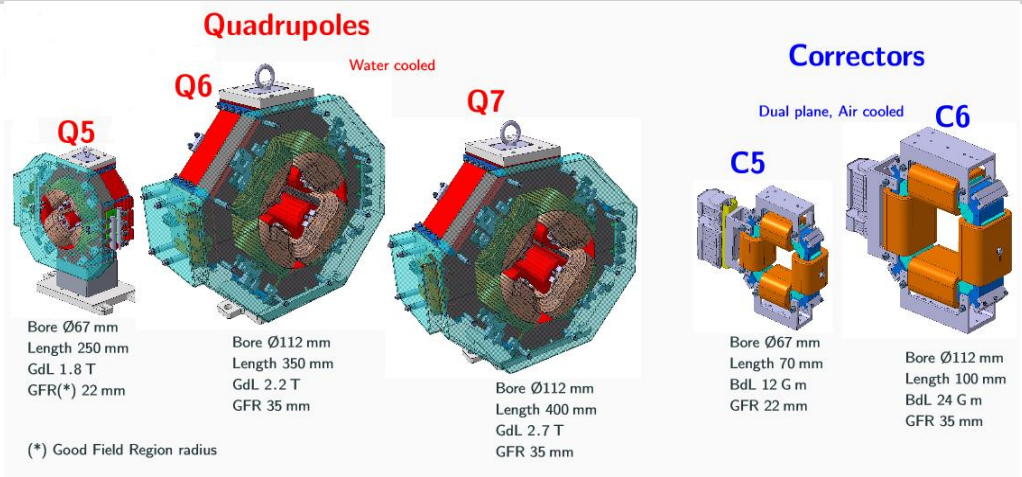
Hall Probe Mapper for accelerator magnets at Elettra

Magnetic Measurements at Elettra

- An early magnetic measurement laboratory was dismissed in middle 90's, after the construction of **Elettra**'s storage ring
- Conversely, the insertion device laboratory has been kept functioning since then
  - Flip coil system and hall probe mapper for undulator measurement
- In 2017 Elettra, INFN and CNR were committed to the realization of the Italian *in-kind contribution* for the construction of the European Spallation Source (ESS)
  - Among others, one of the work packages focuses on design, construction and testing of the ***Magnets for ESS linac ... (E4ESS Project)***
  - … *back to magnetic measurements with a new laboratory*
  - *… to expand as measurements are required for Elettra's upgrade*

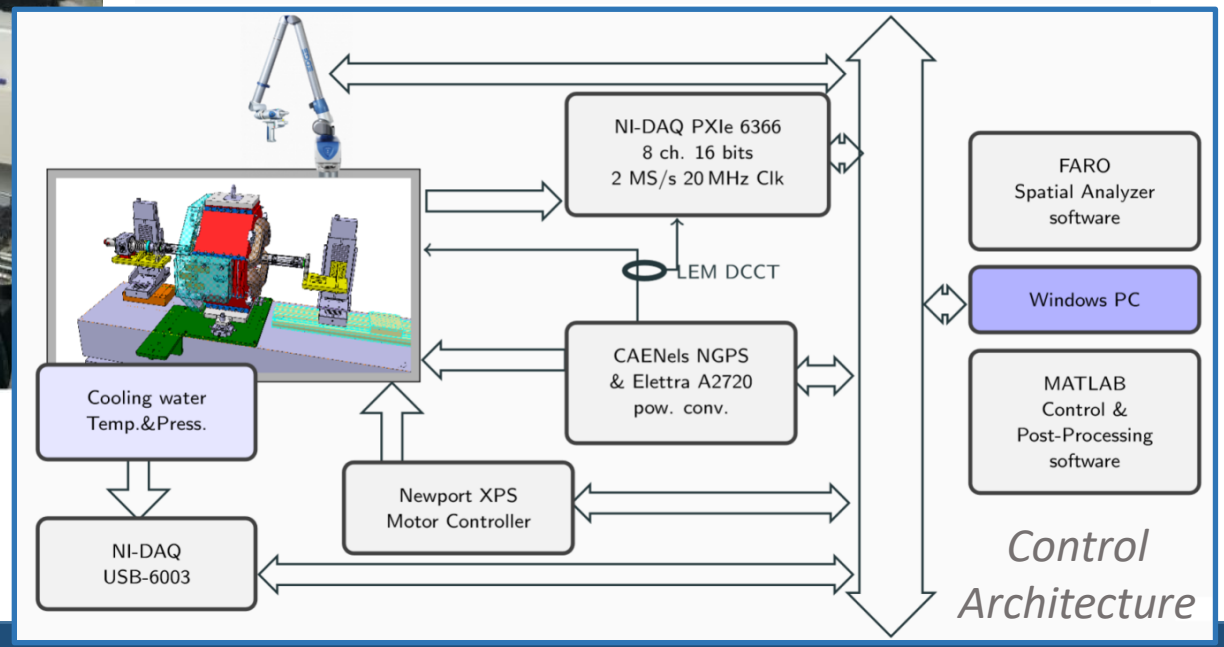
Measurement System for E4ESS Project





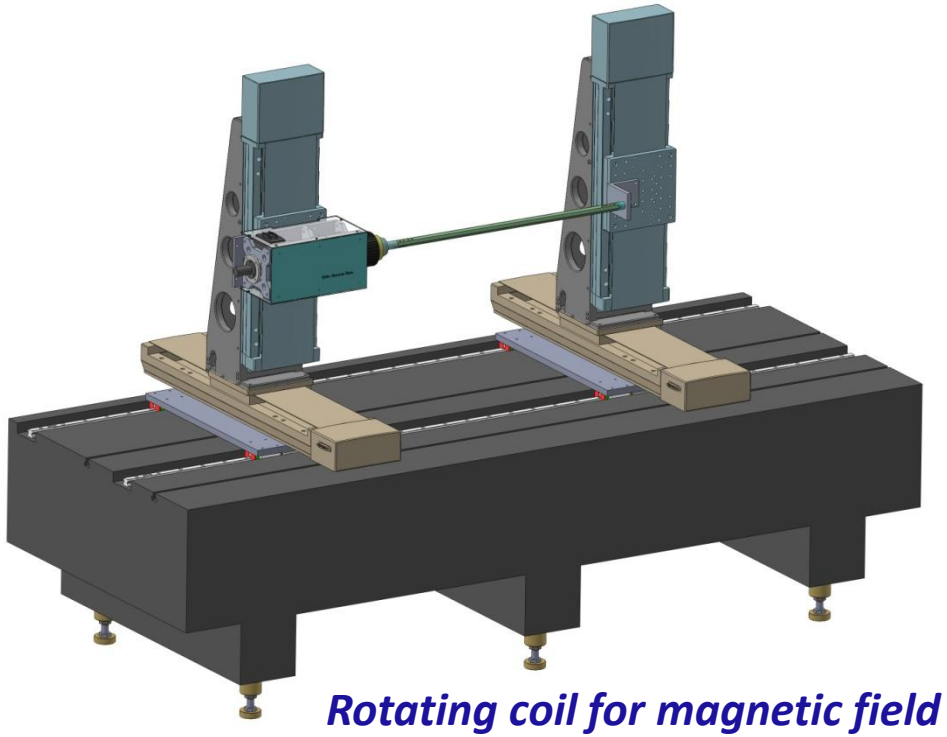
Rotating coil magnetometer

- Setup carried out in 2018
- 213 magnets characterized between Mar. – Aug. 2019

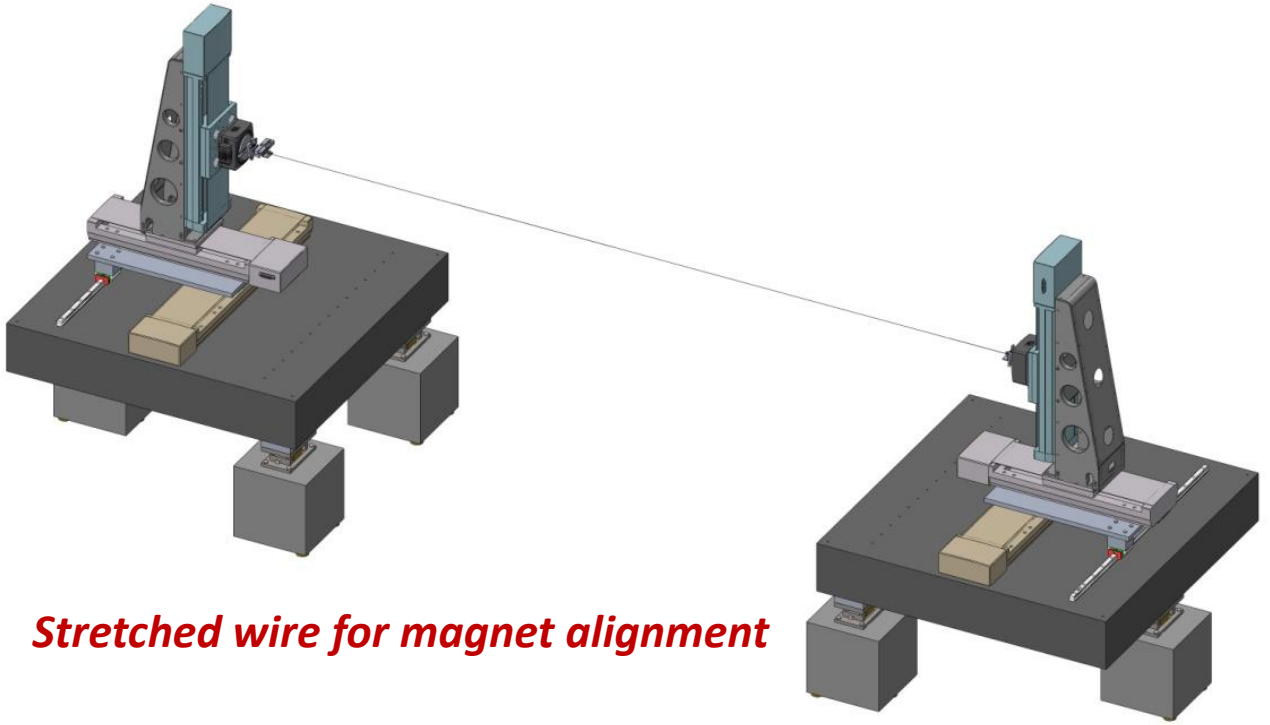


Elettra's upgrade (Elettra 2.0): new requirements

- **2 Rotating Coil Benches** for field quality of quadrupoles, sextupoles, octupoles and dipole correctors
- **1 Stretched Wire Bench** for magnet alignment on girder
- **1 Hall Probe Mapper** for Elettra's bending magnets

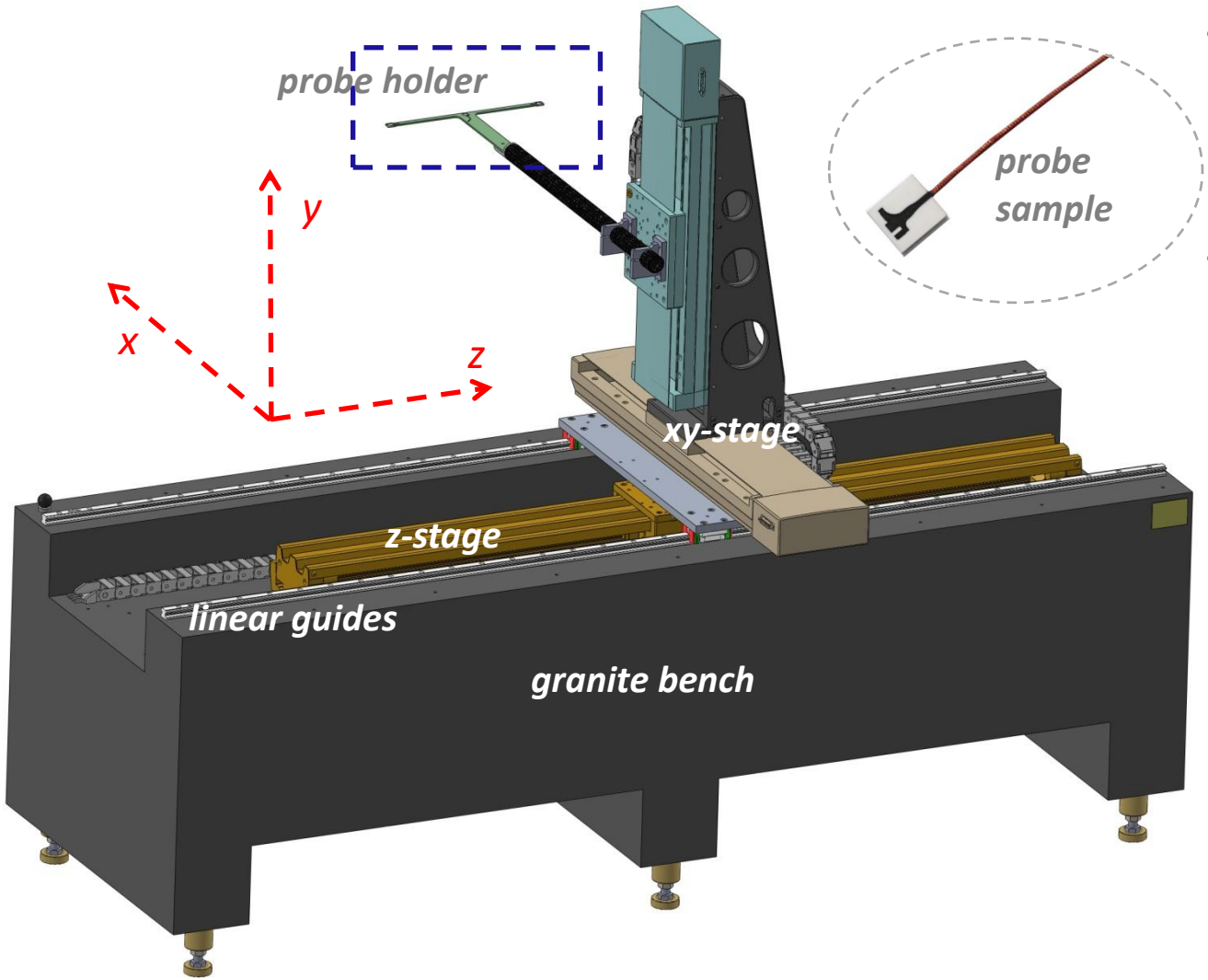


Rotating coil for magnetic field quality

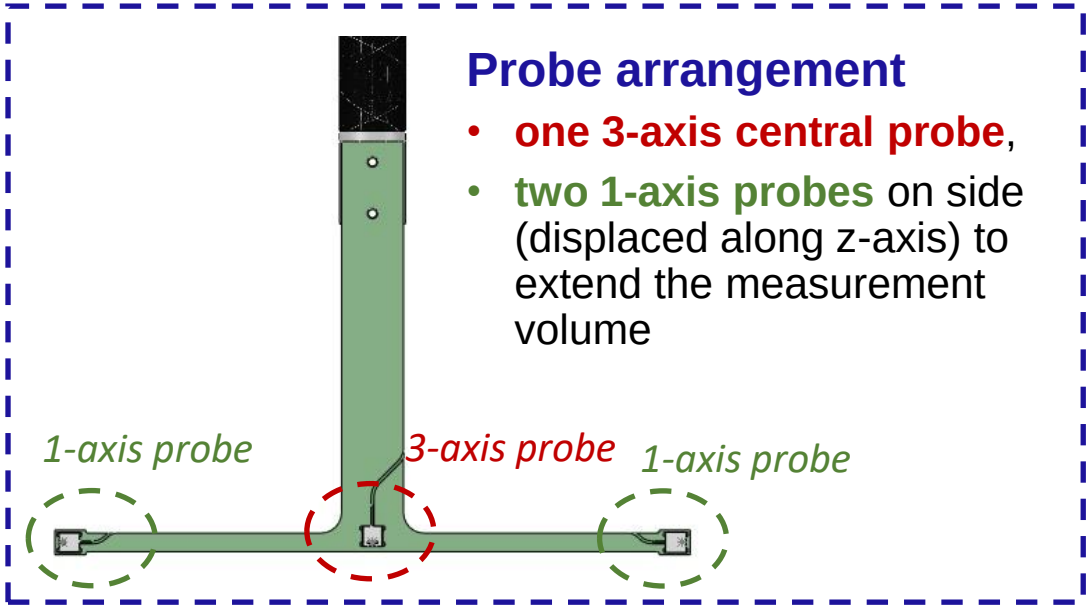


Stretched wire for magnet alignment

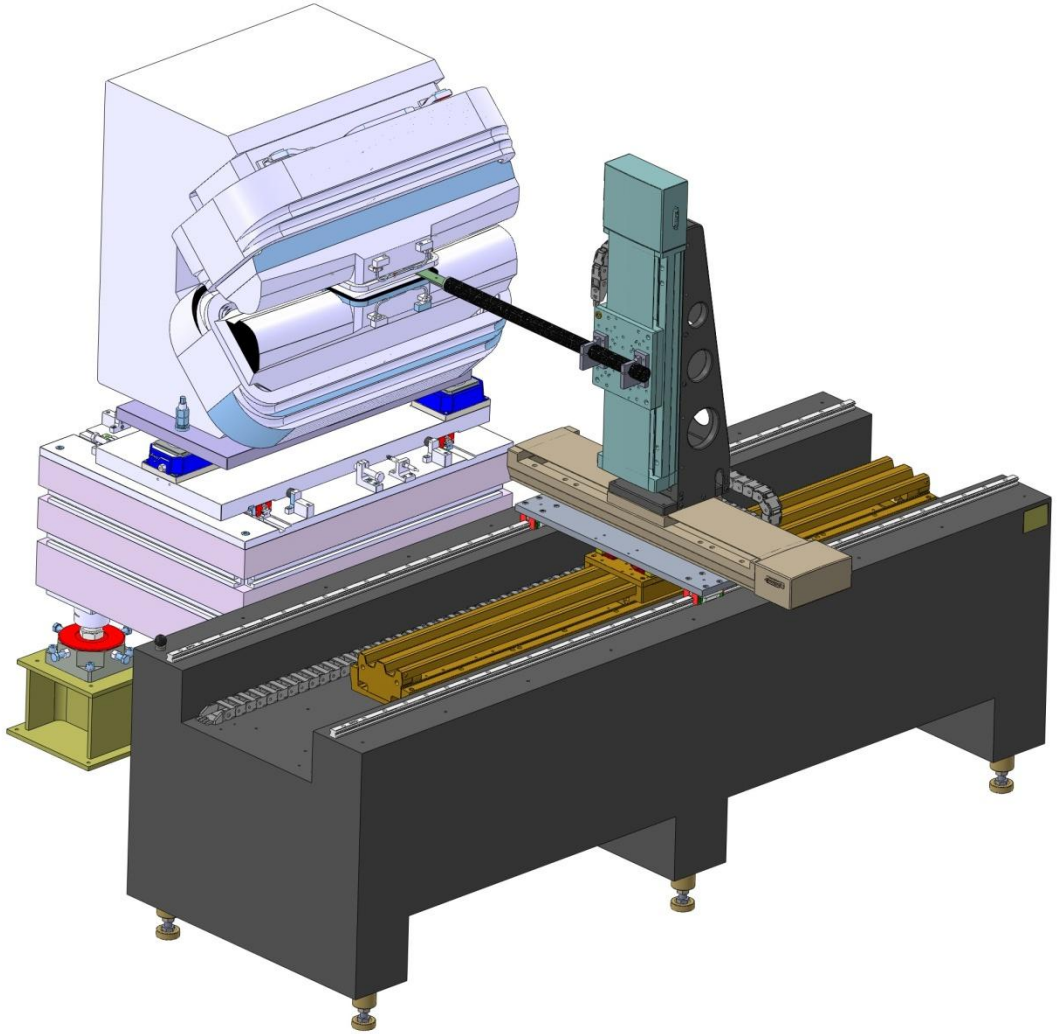
Hall Probe Mapper (1/2)

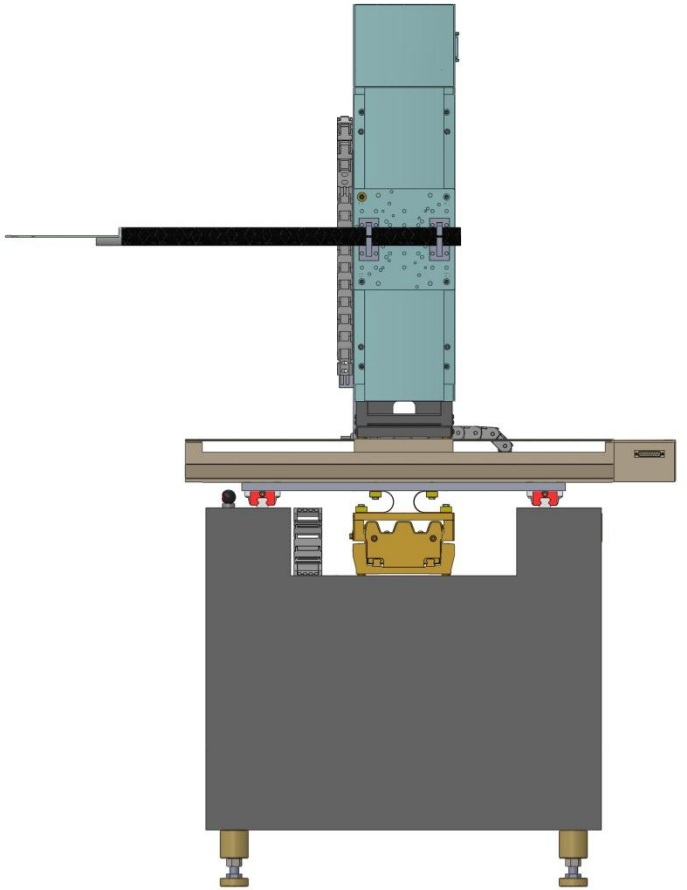


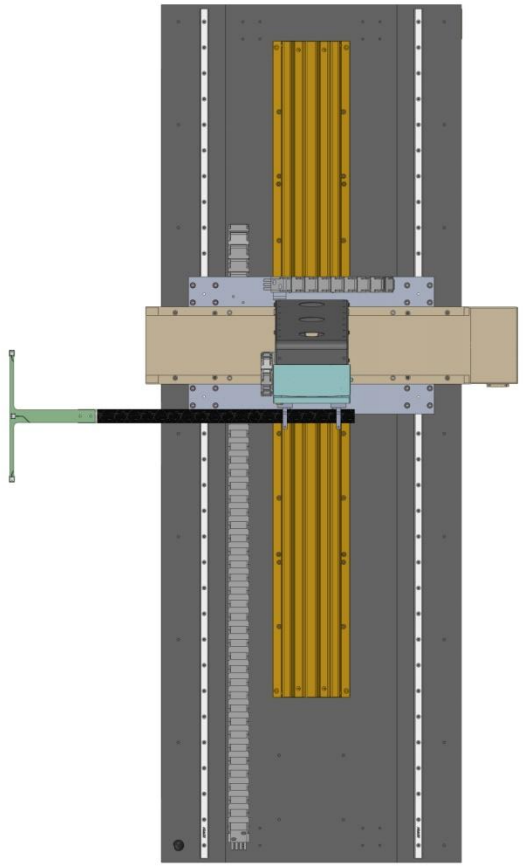
- **3D measurement range**
  - 500mm x 300mm x 1200mm *xyz*-stroke by **motorized stages**
  - the effective measurement stroke along z is 1500mm
- **Automatized** control, data acquisition and processing



Hall Probe Mapper (2/2)







Components

- 3-axis hall probe - **Senis**

Model	Accuracy	Range	Notes
H3A model	±0.25%	±2 T	calibrated by the constructor

Senis 3axis S-probe

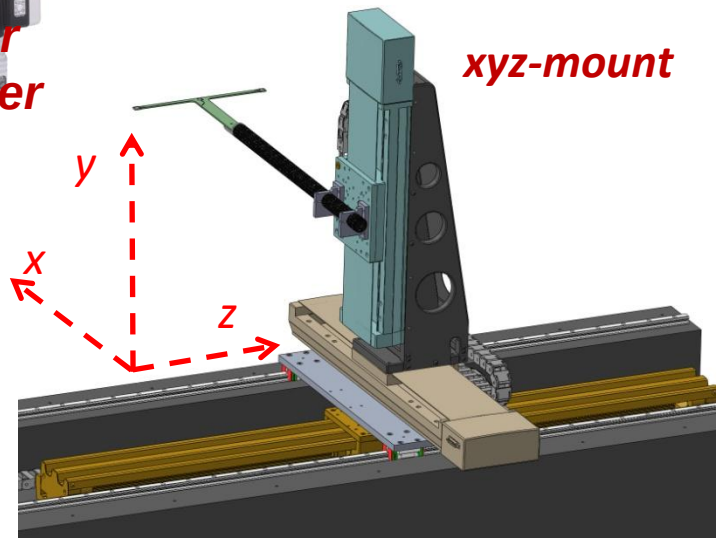
PXIe6289

- Acquisition card - **National Instruments**

Model	Resolution	Selectable range	Others
PXIe6289	18 bits	±0.1 V, ±0.2 V, ±0.5 V, ±1 V, ±2 V, ±5 V, ±10 V	Digital I/O channels for triggered acquisition

laser tracker

xyz-mount



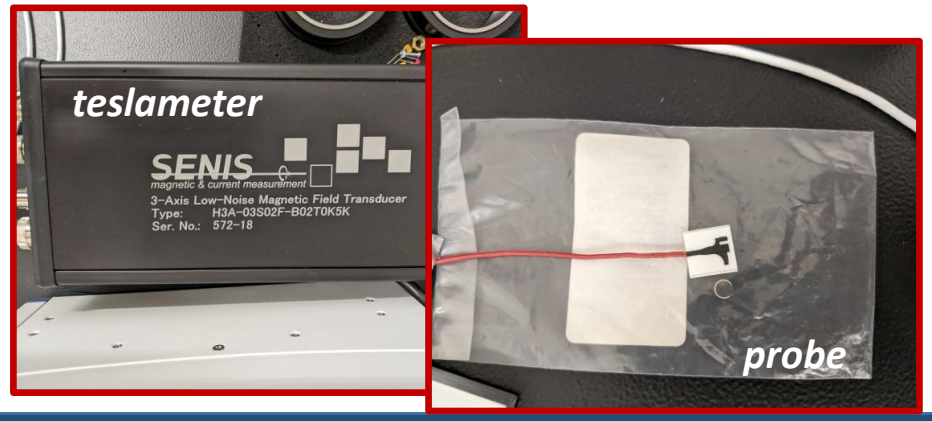
- Motorized translation stages - **Newport**

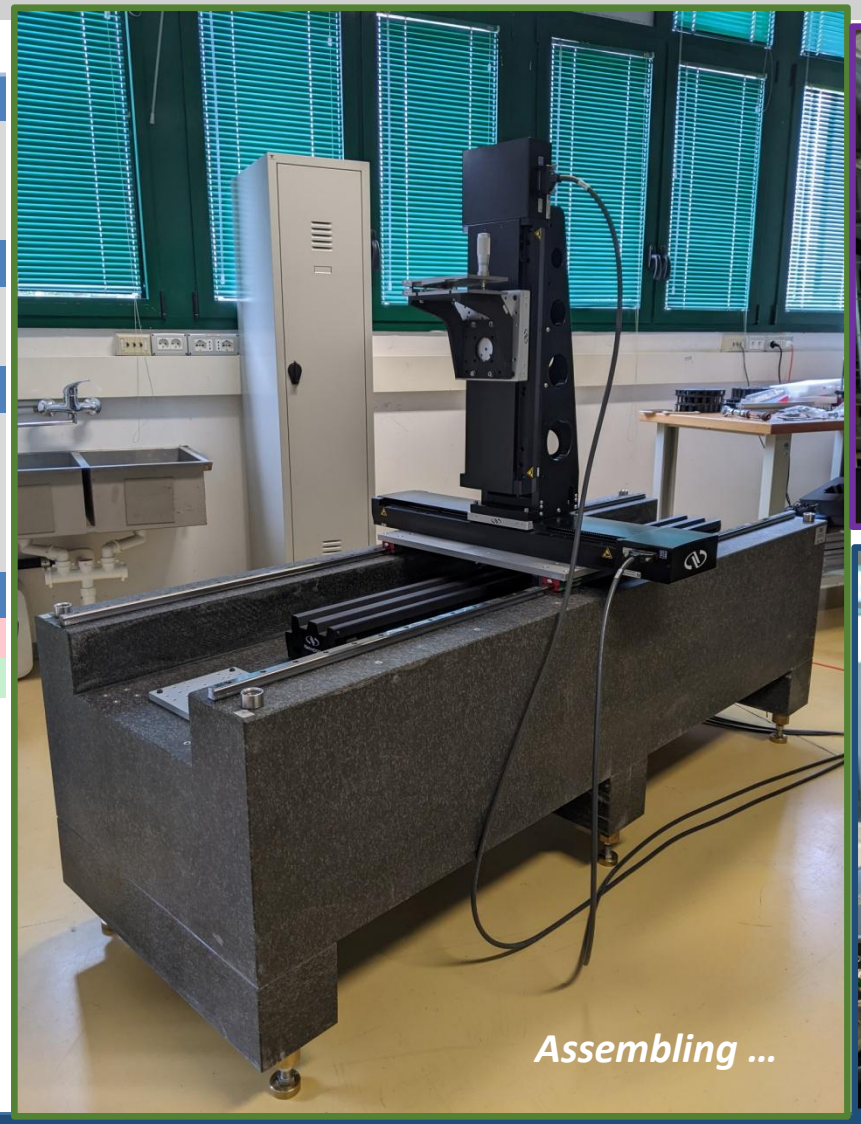
Function	Model	Description	Accuracy	Repeatability	Travel range
xy-translation	IMS500CCHA IMS300V	DC motor, linear encoders	±5.0 µm (±2.5 typ.)	±0.5 µm	500 mm *x*, 300 mm *y*
z-translation	IMS-LM1200	Linear motor	±9.0 µm (±5.0 µm typ.)	±0.5 µm	1200 mm

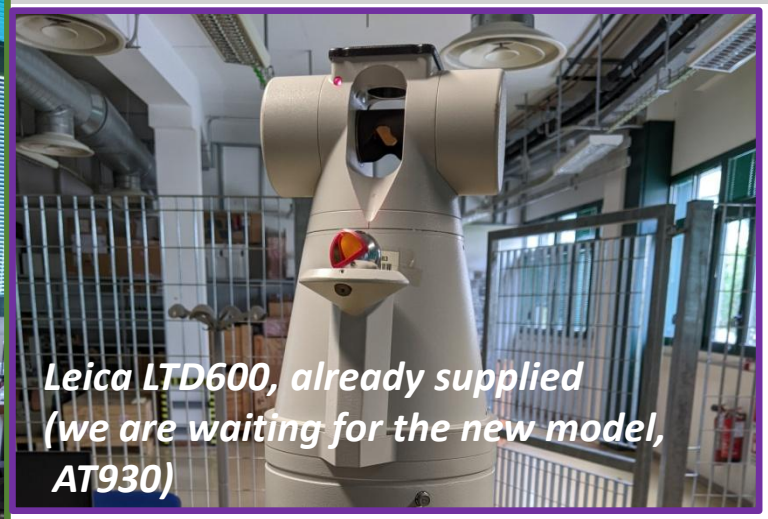
N: assembling of the axes is carried out in Elettra by the aid of our **laser tracker** to ensure axis orthogonality

Status

Item	Type	Status
Acquisition		
Voltage signals from probes	NI6289 (18 Bit, 16chs)	procured
PXIe chassis	NI1073	procured
Electronic clinometers signals	Frederick	procured
Motion Control		
Linear stages	Newport IMSCCHA, IMS-LM	procured
Motor controller	Newport D8	procured
Mechanics		
Marble bench	Zali	procured
Linear guides for Z-axis		procured
Hall plate supports	in-house	being built
Magnet Support		missing
Remote control		
PC + Monitor		to procure
Rack		procured







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SPARES …

Expected performance

- **Uncertainty sources**
  - Probe **positioning uncertainty** leads to **±40 µm** estimation (worst case)
    - Contribution from the **single stage accuracy** (±9 µm in *z*, ±5 µm for *x*,*y*)
    - **Stage mount orthogonality error** (laser tracker accuracy): 90 µrad
    - Positioning uncertainty more relevant in gradient fields:
      e.g., Elettra's **B80** bending with 20 T/m sector leads to 0.8 mT error, i.e. **5x10^{-4}** of the peak field
  - **Hall sensor accuracy**, **0.25%** of reading (for B > B_{LR})
  - **Voltage acquisition error:** **[1-2]**x**10^{-4}** for reading of about 5 V
- Thus, absolute field uncertainty in **single point measurement** will lays within **[25-30]** x **10^{-4}** w.r.t. the measured field
- **Integral properties** extraction from field map
  - Uncertainty will not degrade because of averaging effects ($u_I \sim 1/\sqrt{N}$)
    It will reasonably stay within **[20-40]** x **10^{-4}** w.r.t. the extracted property value
- Estimation of relative properties (e.g. **longitudinal harmonics** for **field homogeneity**) relies on **sensitivity** and actual **noise floor**
  - Expected resolution: **0.2** x **10^{-4}** w.r.t. main field component