Design of a new measurement system for closed insertion devices and magnets

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Local magnetic field measurements

- "punctual" measurements of Bx, By, Bz distributed in a 2D or 3D grid

- Requirements:
  - Accurate spatial positionning
  - On-the-fly measurements -> synchronization between position and voltage measurements

- Easy way to implement: lateral access

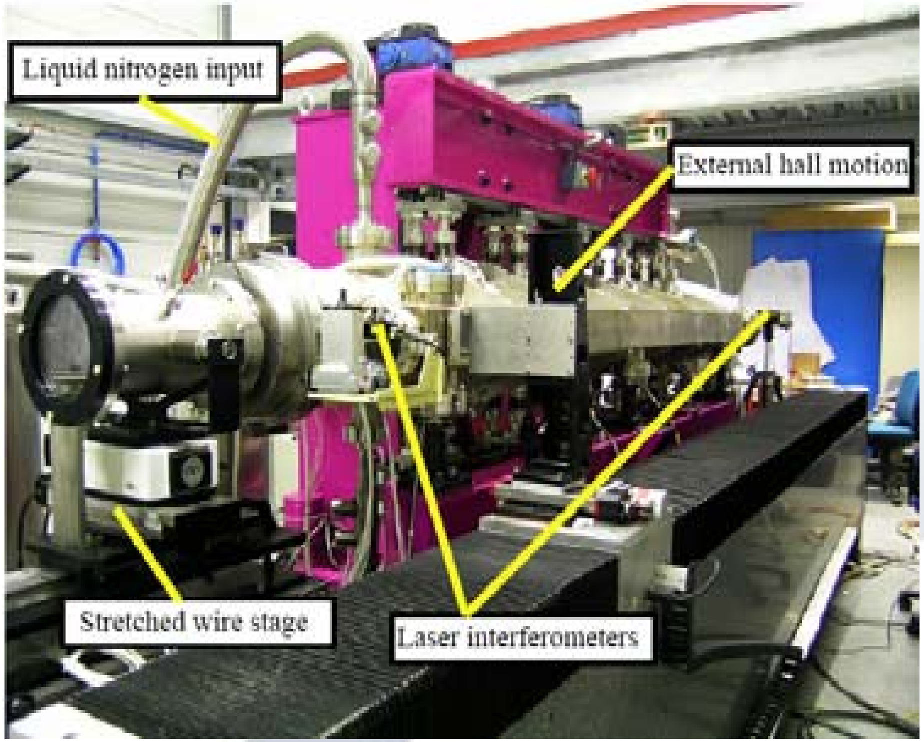
Usual arrangements for Hall benches

The challenge of "closed" structures

- Small gap magnets
- H magnets
- In-vacuum undulators
- Cryoundulators
- Any structure that cannot be accessed lateraly

Solutions:

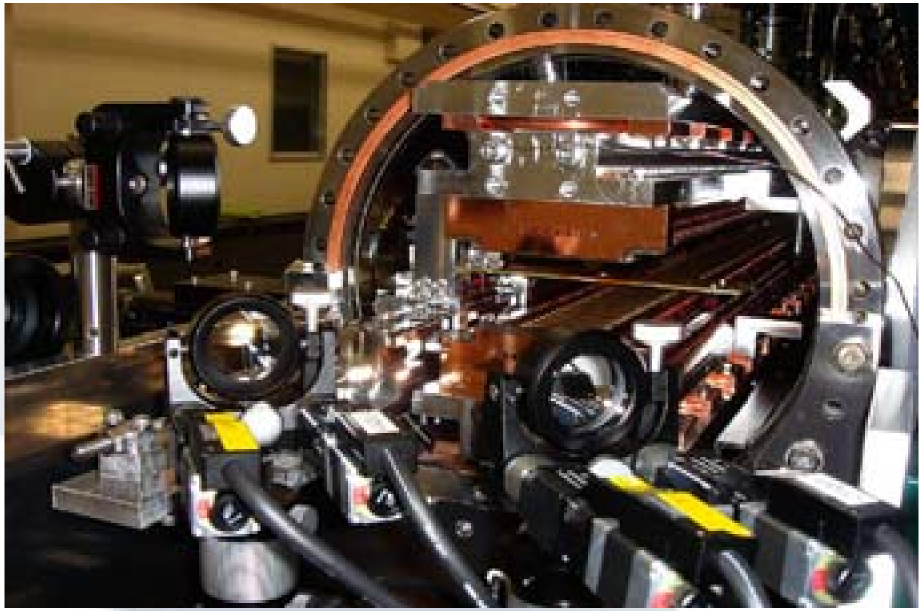
ESRF



J.Chavanne, M. Hahn, R.Kersevan, C.Kitegi, C.Penel, F.Revol, **Construction of a cryogenic permanent magnetundulator at the ESRF**, EPAC'08 Proceed., p. 2243.

Spring-8 (SAFALI)

Self-Aligned Field Analyzer with Laser Instrumentation



Takashi Tanaka, **Undulator Development for SPring-8 XFEL**, The 142nd Eastern Forum of Science and Technology, Shangai, 2009, http://www.sinap.ac.cn/meeting/EFST2009/142nd-EFST/EFST_TTanaka.pdf

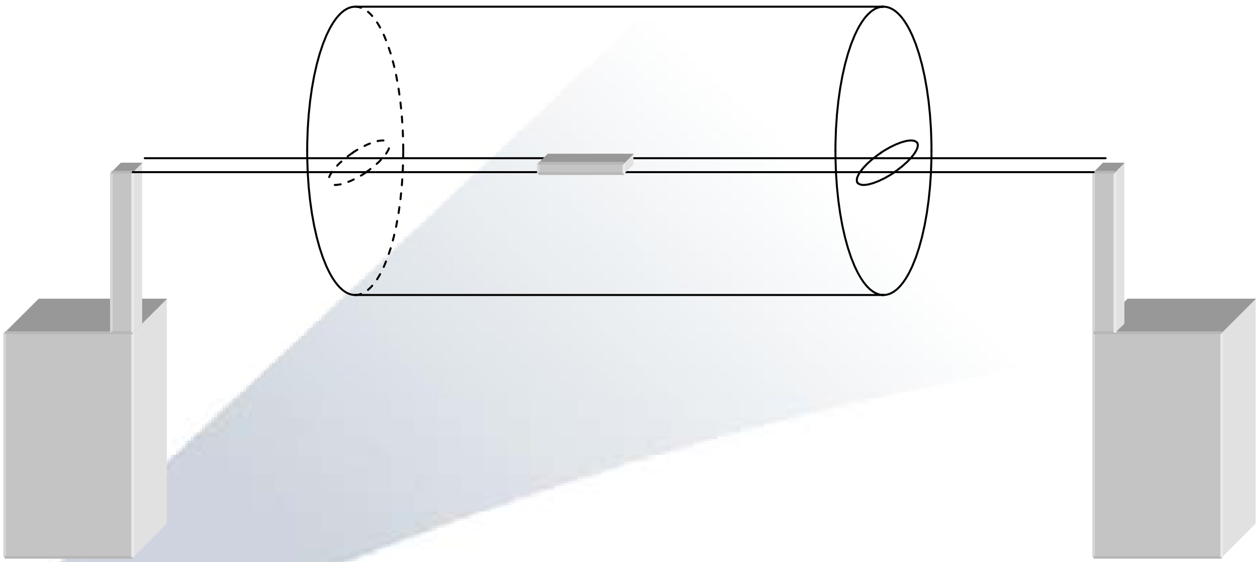
More developments:

- Brookhaven Nat. Lab -> T. Tanabe talk IMMW17
- ANKA -> A. Grau talk IMMW17
- Jefferson Lab. -> K. Bagget talk IMMW17
- NSRRC -> C. S. Wang talk IMMW17
- ...and many other places

Our proposal

- Small and compact 3D Hall probe
  - 13.9 mm Wide, 4 mm High, 100 mm long
  - Temperature measured with accuracy ±0.01° C
  - 3 Bell sensors assembled ortogonally
- Sliding on two hanging rails. Rails are rigid, and can be attached and dettached from the frame.
- Whole sistem running into a squared tube that can be introduced into a vacuum chamber through the flanges

The basic concept



Critical points:

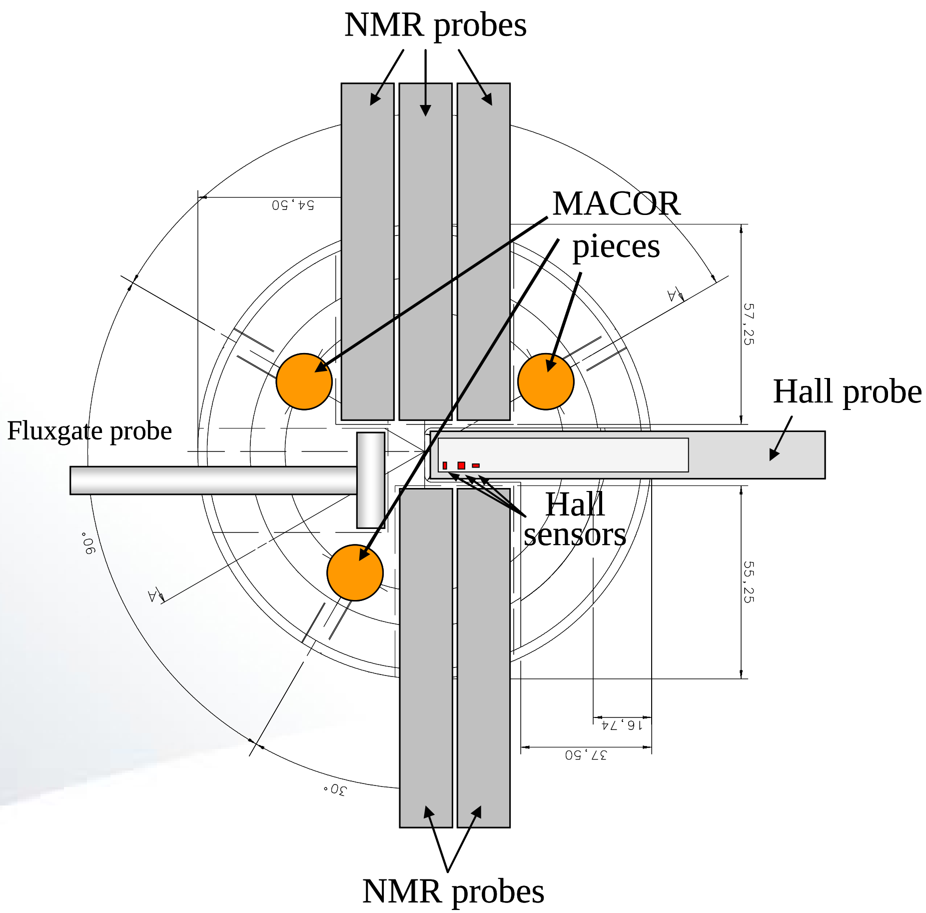
- Calibration (magnetic as well as geometric and thermal) of 3D Hall head
- Errors in the alignment of hanging rails
  - Sag
  - Rougness of rails
  - Alignment of the system (roll, yaw, pitch)
- Motion system – longitudinal positioning system
- Hall probes current input and extraction of signals

Some solutions to critical points
Hall probe head

- Magnetic calibration will be done using NMR probes and calibrating whole 3 Hall sensors (IMMW-15 talk)
- Temperature will be recorded at same time than voltages in order to correct off-situ the temperature dependence of voltages.
- Relative positions of 3 Hall sensors will be calibrated measuring an inhomogeneous field and using the properties of Maxwell equations (IMMW-15 talk)
- Extraction of signals and current supply: needs of a connector with 10 pins minimum. Semi-rigid thin cable.

Calibration system:

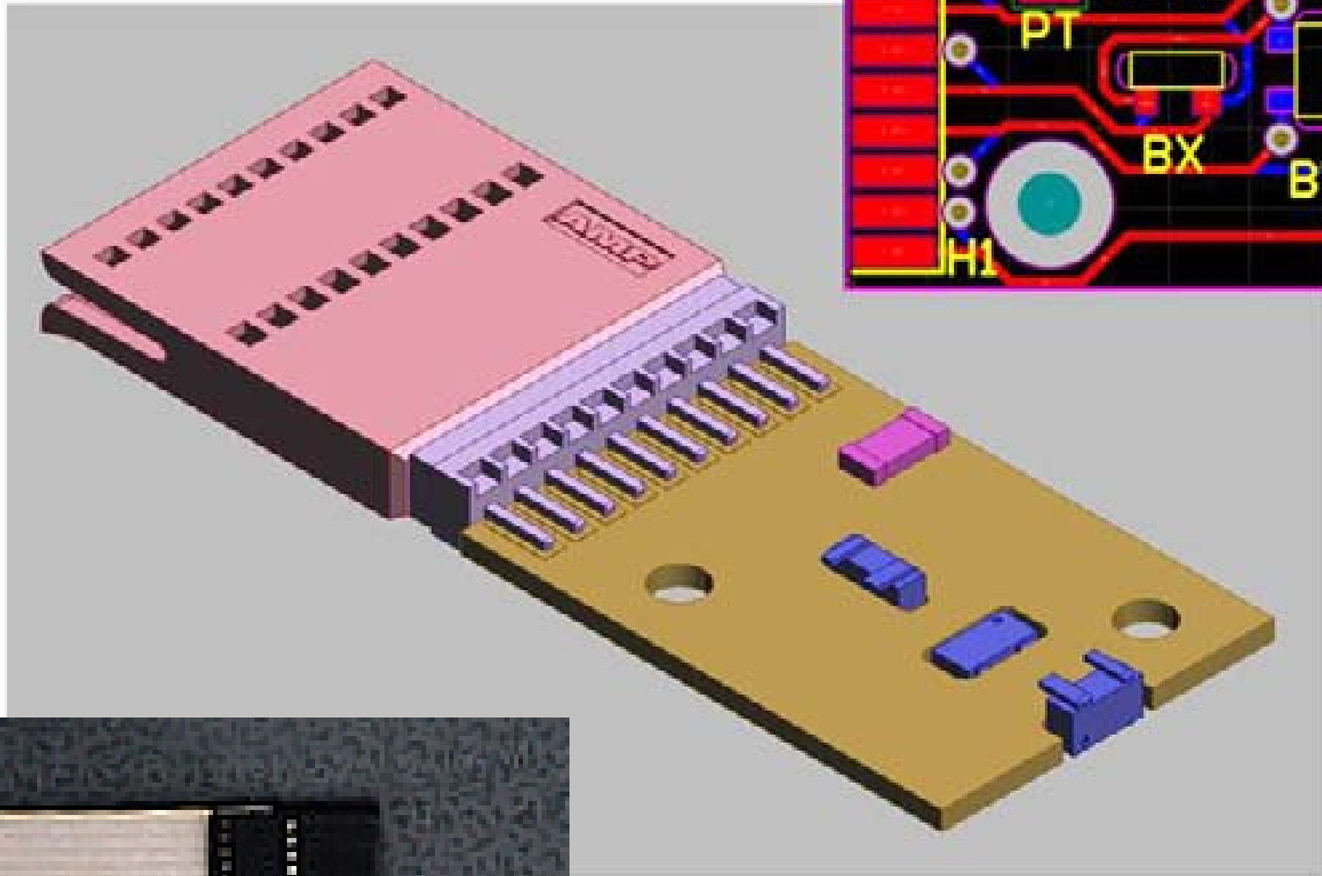
- Dipole Magnet *GMW 3473-50 150 MM*
- Power supply *Danfysik 858*
- RMN magnetometer *Metrolab PT 2025*
- Fluxgate magnetometer *Bartington Mag-01*

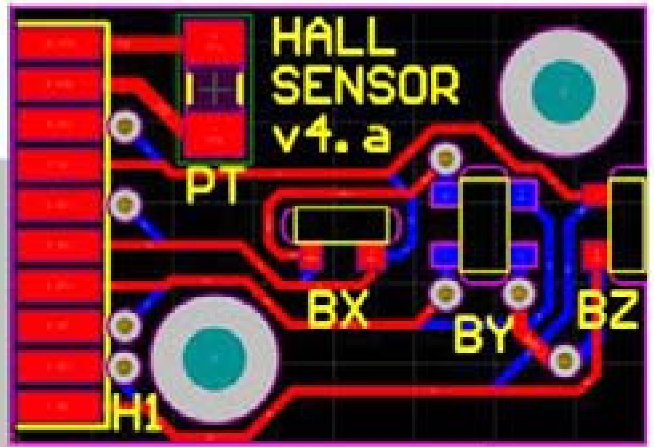


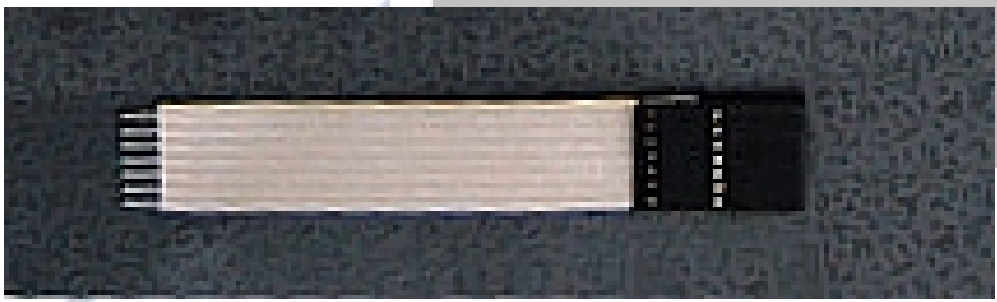
Magnet's air gap: 15mm	
5 NMR probes:	|B|= 500 Gauss–2.1 Tesla
Fluxgate probe:	|B|< 150 Gauss

J. Campany, J. Marcos, V. Massana and Z. Martí, ***Construction & Commissioning of a 3D Hall probe bench for Insertion Devices measurements at ALBA Synchrotron Light Source***, IMMW-15.

Hall probe head & cable

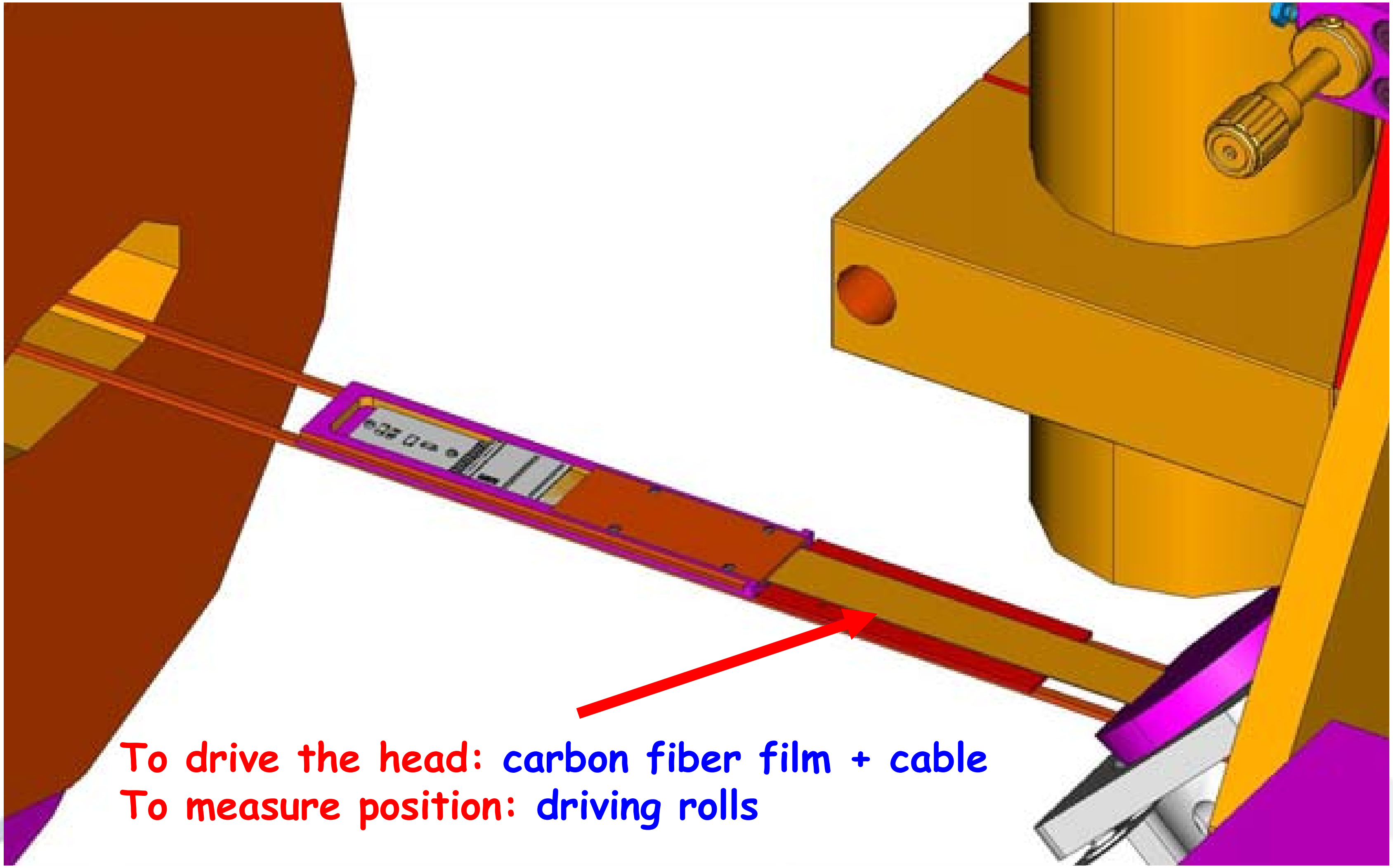




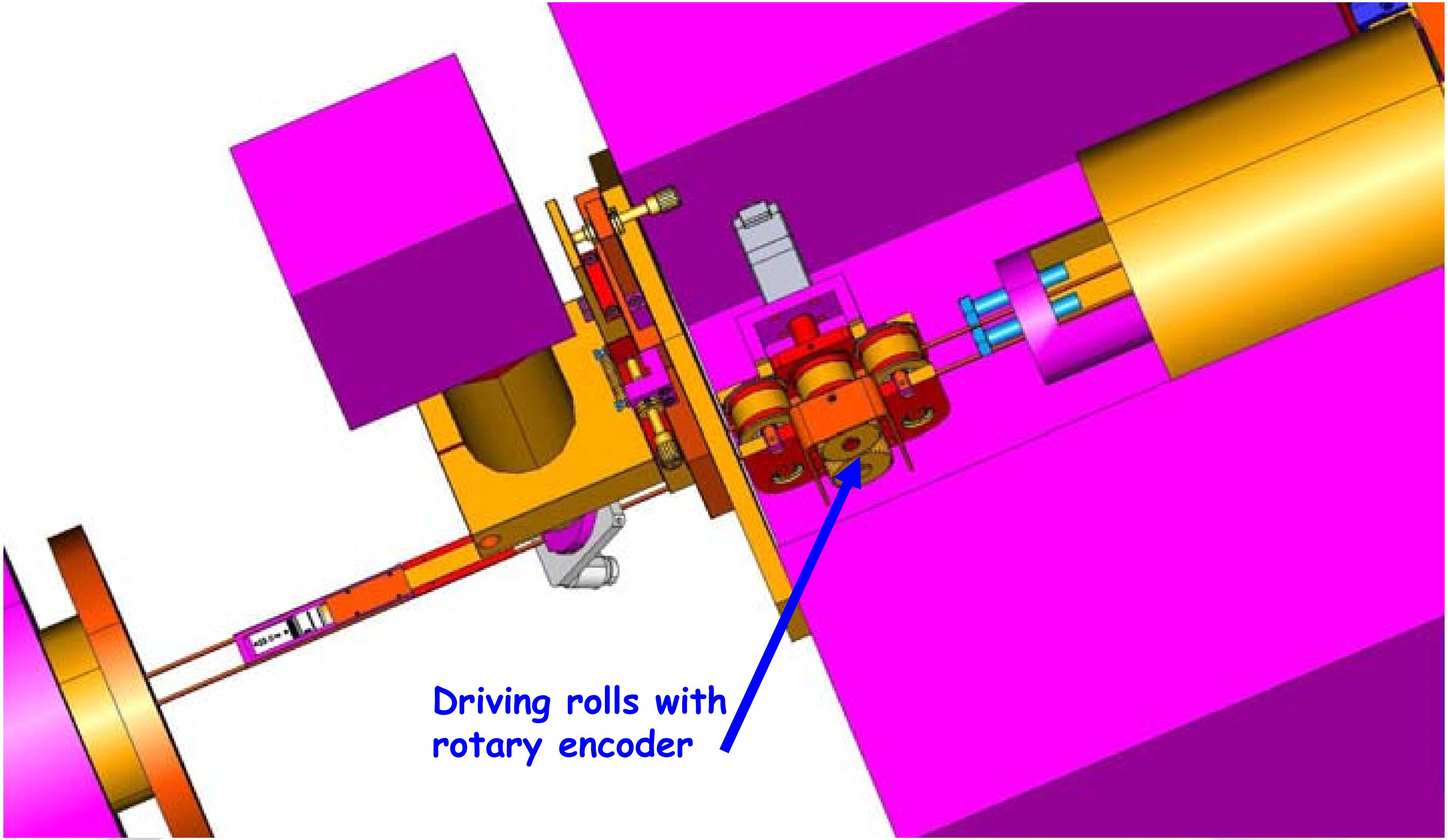


Open option: radiotransmission of signals + power supply through rails

Detail of the assembly



To drive the head: carbon fiber film + cable
To measure position: driving rolls



Driving carbon fiber and cable will be rolled on top of pedestal.

Hanging rails – requirements:

- Vertical position tolerance: ±25 um
- Horizontal position tolerance: ±25 um
- Longitudinal position resolution: 1 um

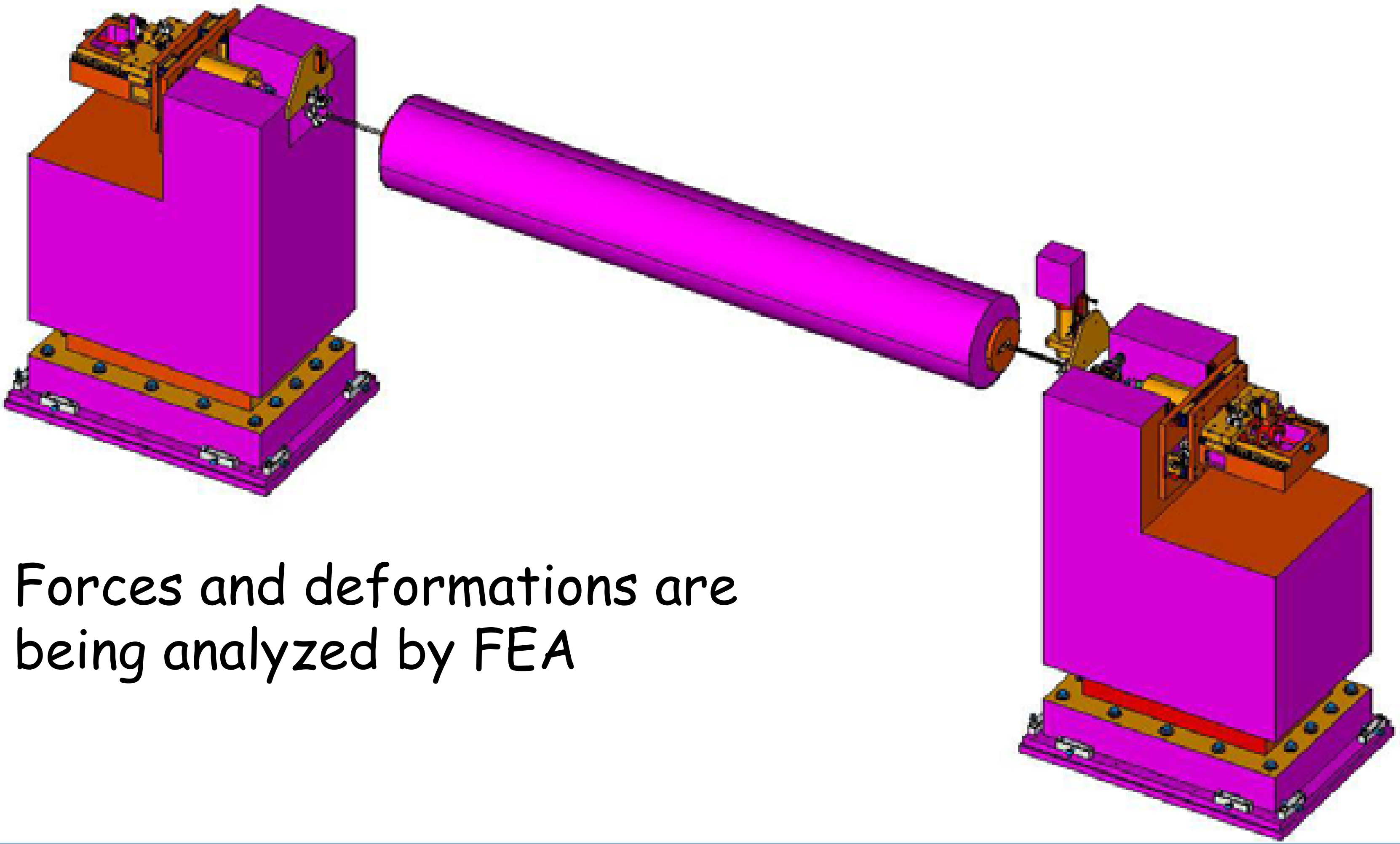
- Roll tolerances: ±50 urad
- Yaw tolerances: ±100 urad
- Pitch tolerances: ±50 urad

Hanging rails – critical points:

- Sag < 25 um applying a longitudinal tension in the rails between $1 \cdot 10^4$ to $5 \cdot 10^4$ N. Hall probe head weight < 10 g
- Rails will be made of carbon fiber
- Carbon fibers will be shimmed to a flatness < 20 um
- Hall probe head will slide on the rails
- Motion system will be a carbon fiber belt on top of which the signal & supply cable will be attached.
- Yaw error (estimated): 0.1 mrad
- Pitch error (estimated): 0.05 mrad
- Roll error (estimated): 1 mrad

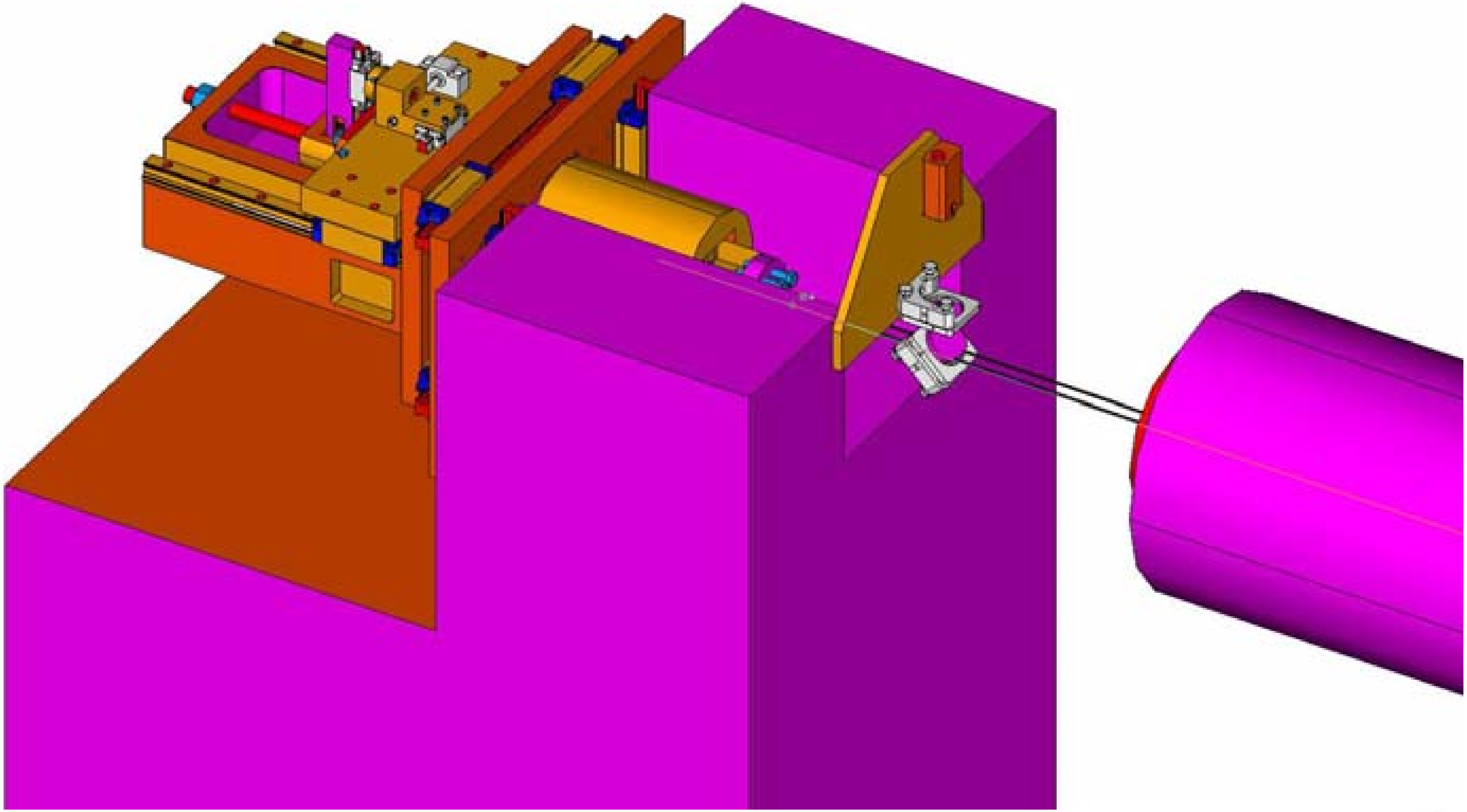
-> Roll error should be addressed

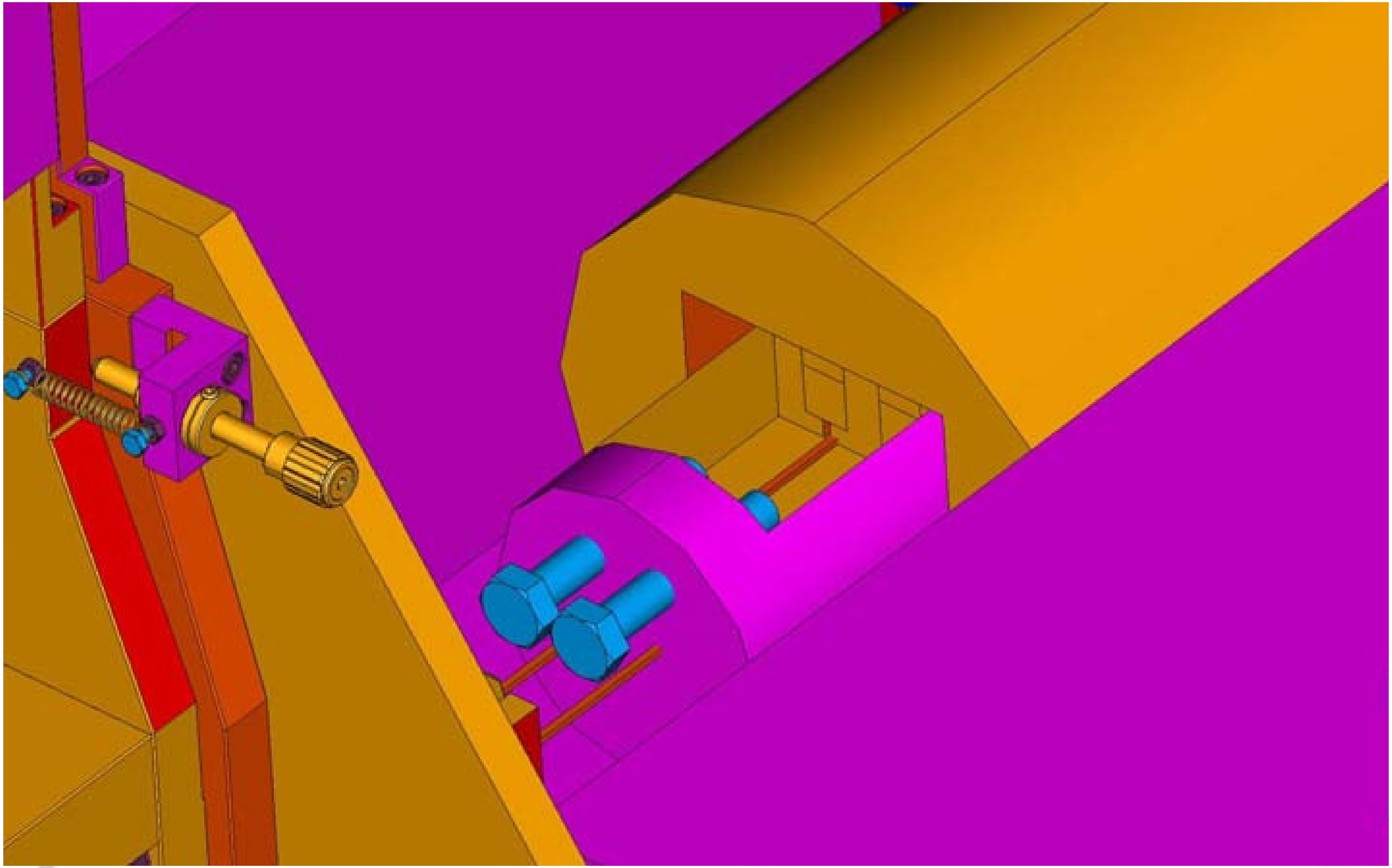
Full 3D model



Forces and deformations are being analyzed by FEA

Details





Correction of roll angle:

- Off-situ solution: Roughness of rails will be calibrated using a reference magnetic field and then correction will be applied.

- In-situ solution: real-time closed loop with motors allowing the roll of the rails according the real position of sliding Hall probe head. This implies:

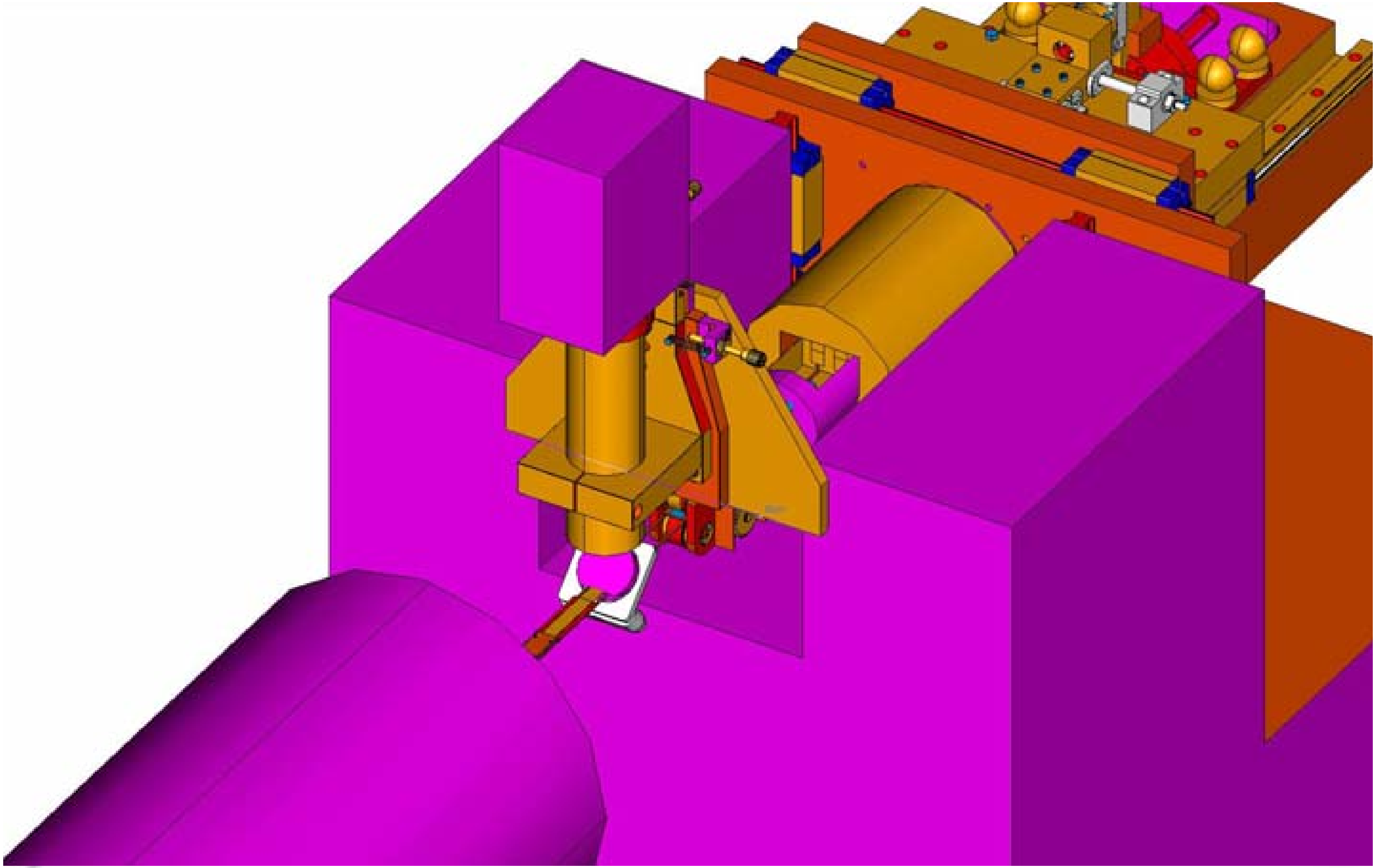
  - System **to measure the roll** along the rails

  - System **to act in the rails** to compensate the roll

-> Proposal inspired in "SAFALI"

In-situ solution:

- Roll will be measured using two pinholes at the edges of the Hall probe head container.
  - A cross pattern will be projected from one side through each pin-hole
  - The image will be collected by a CCD camera at the exit
  - Mathematical algorithm to calculate the vertical position of the pin-hole.
- Roll will be corrected using motors to move the rails.
  - Rails will be attached to mobile stands.



Other features:

- Fieldmap measurement: possibility to displace the rails lateraly ±10 mm
- Horizontal alignment: possibility to displace the rails vertically ±2 mm

Status of the project:

- Hall probe head is designed. Manufacturing will start in October
- Optical systems performance are being tested at ALBA Optical Laboratory
- Mechanical prototype without closed loop motors for correcting roll error has been designed to test the 3D model. Detailed desing expected to be finished on Nov. 30th
  - The objective of this prototype is to check the feasability of the roll measurement system using two pin-holes.
  - It involves the use of mirrors, lasers and CCD sensors.

Thank you for your attention