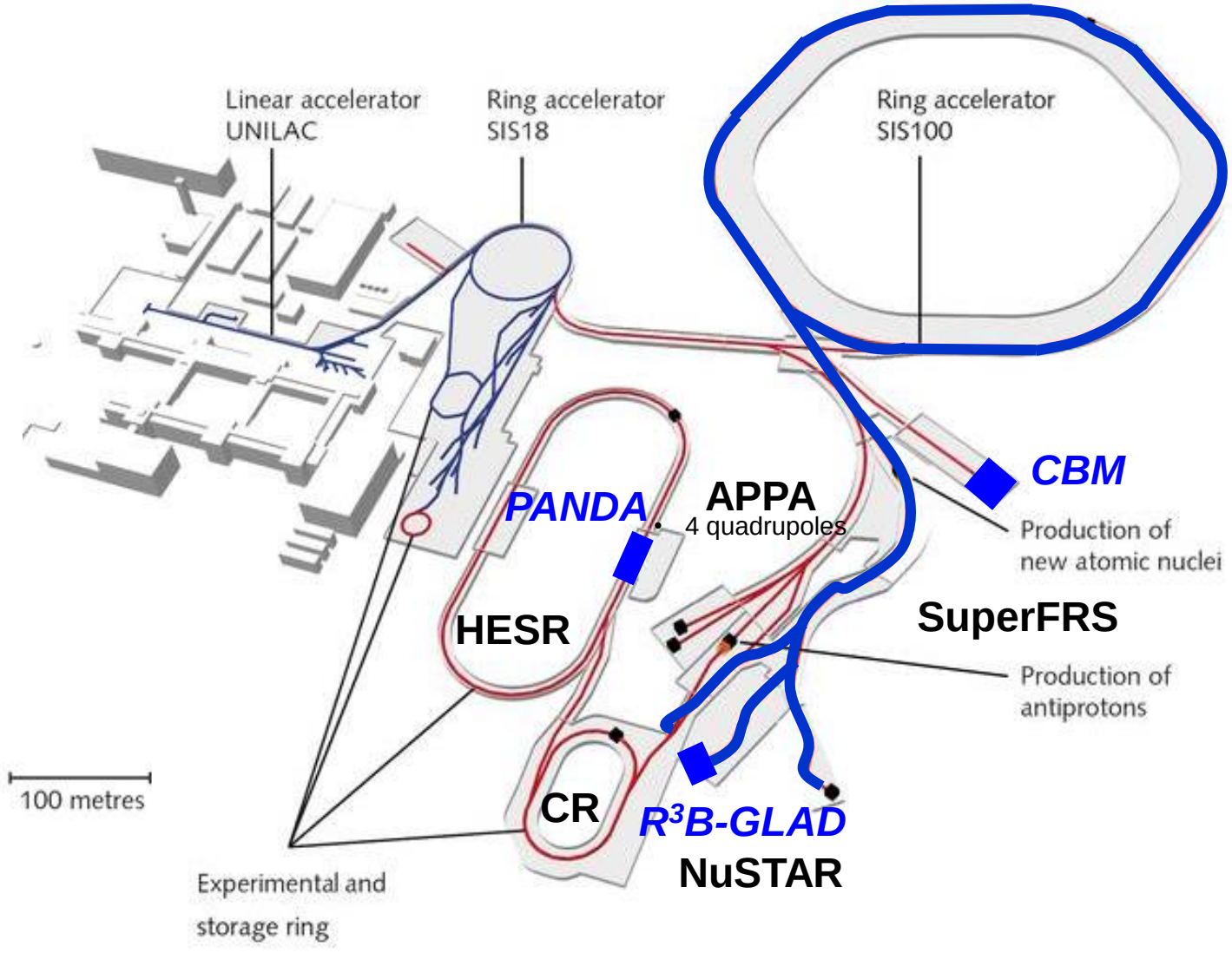
FAIR's first SIS 100 Accelerator Quadrupole Doublet Module – Manufacturing update and Test

Anna Kario,
A. Szwangruber, A. Bleile, K. Sugita, J.P. Meier, J. Ketter,
A. Waldt, E. Fischer, C. Roux, P. Spiller, S. Lindner,
R. Blümel, T. Winkler, J. Macavei, F. Garnica-Buenaver,
T. Eberl, L. Bozyk, P. Kowina, S. Wilfert, I. Pongrac,
H. Kollmus, C. Schroeder, B. Streicher @ **GSI**

M. Breitenbach, J. Amend, A. Kramer, S. Curelli, K. Heyn
@ **Bilfinger Noell**

Superconductivity at FAIR - Facility for Antiproton and Ion Research



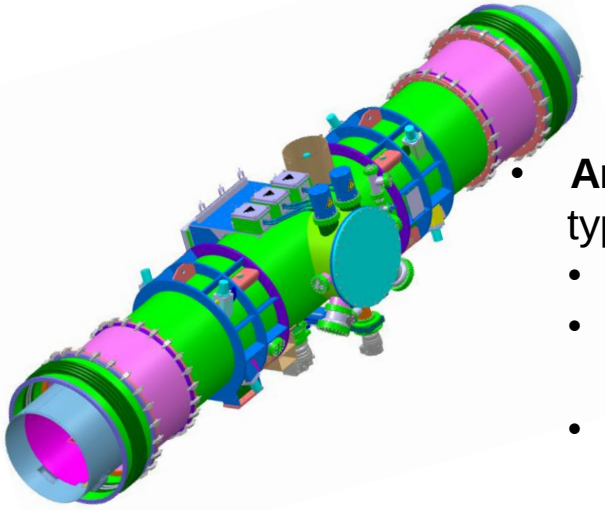
- 108 dipoles
- 303 quadrupoles, sextupole and corrector magnets assembled with UHV and beam diagnostic into **Quadrupole Doublet Modules**

JINR Dubna:
- quadrupole and corrector magnets production and testing

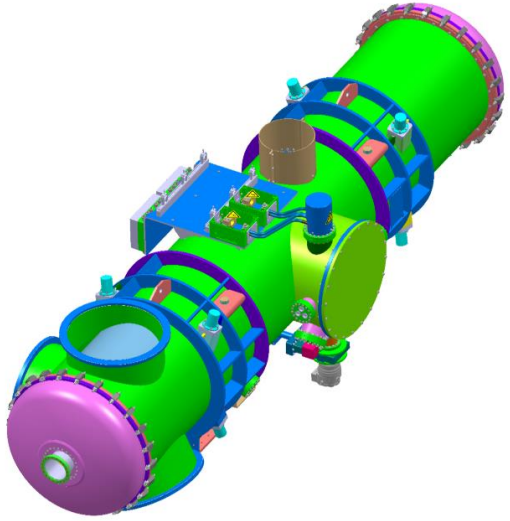
Bilfinger Noell:
- integration of magnet units, UHV system and beam diagnostic into QDM

INFN Salerno:
- QDM testing

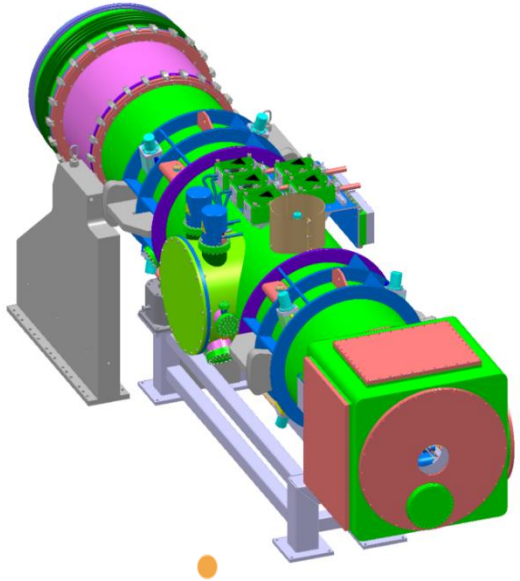
SIS100 Quadruple Doublet Module configurations



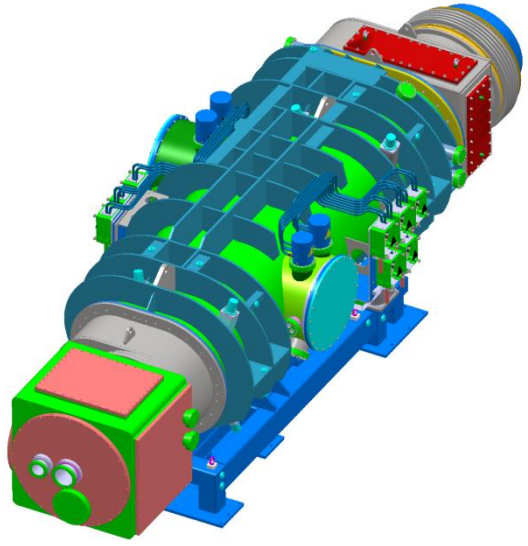
- **Arc section modules**
  types 2.5 to 2.9D
  - **54 modules**
  - Arc section module type incline of the arc-section
  - Cryogenic supply in line of the arc section



- **Straight section modules**
  types 2.123 and 2.13s
  - **17 modules**
  - Stand-alone module types are in between two warm sections
  - Cryogenic supply through attached by-pass line

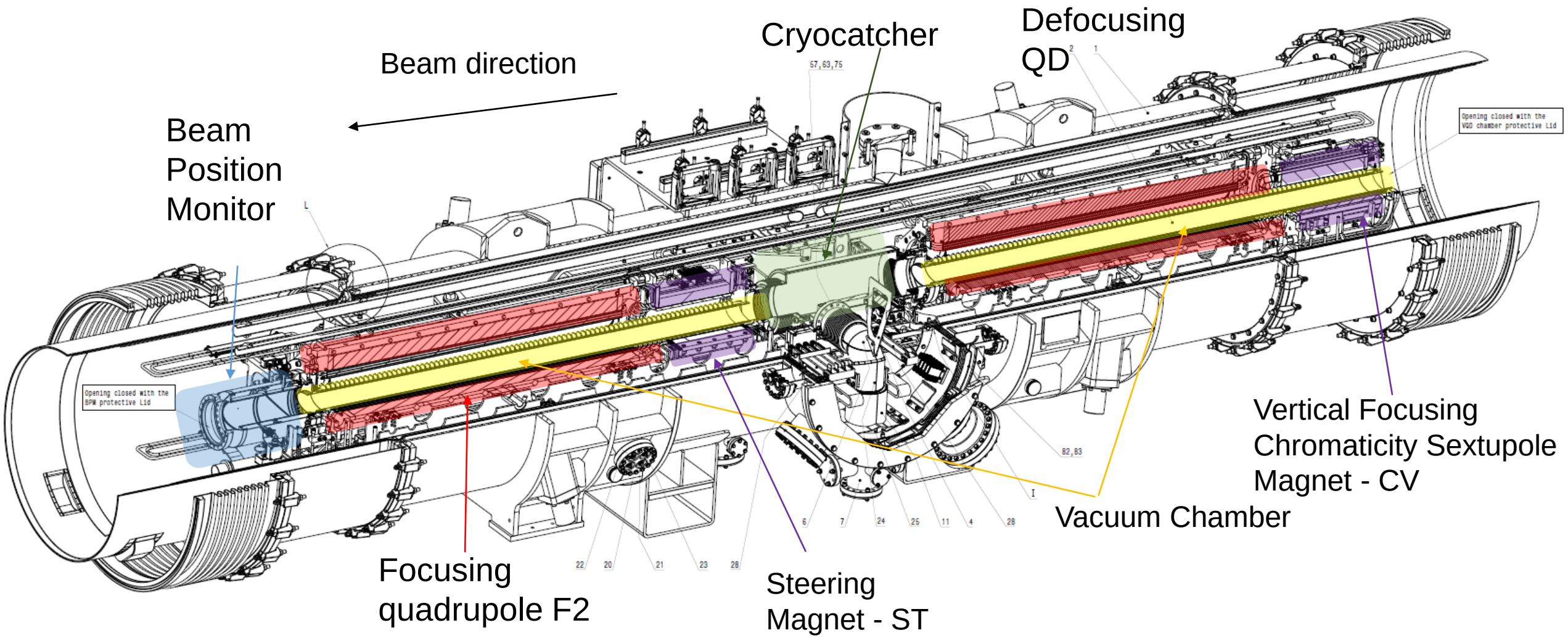


- **Arc termination modules**
  types 2.4 and 1.E
  - **10 modules**
  - US- and DS-termination of the arc section of SIS100
  - Cryogenic supply by attached by-pass line
  - Additional support for vacuum forces



- **Special modules**
  types 2.4x and 1.Ei
  - **2 modules**
  - US- and DS-terminations of sector 5 in SIS100
  - Additional Injection- and extraction QP-doublets separately supported
  - Cryogenic supply by attached by-pass line

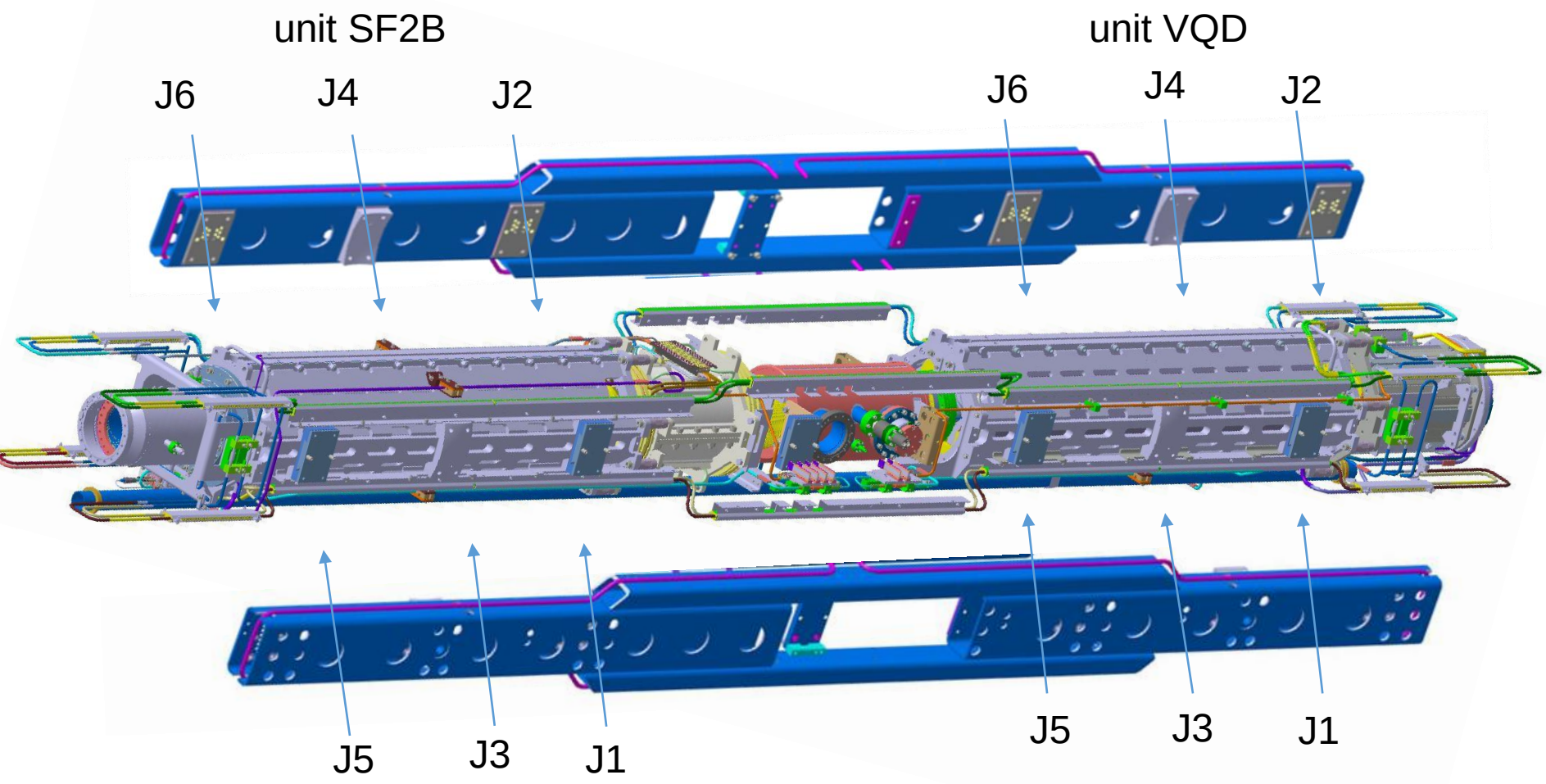
First of Series Quadrupole Doublet Module - 2.5

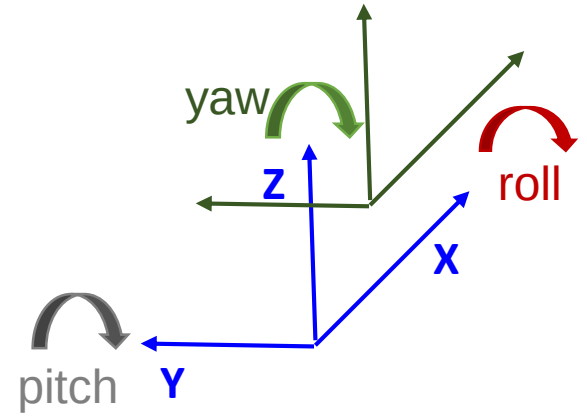


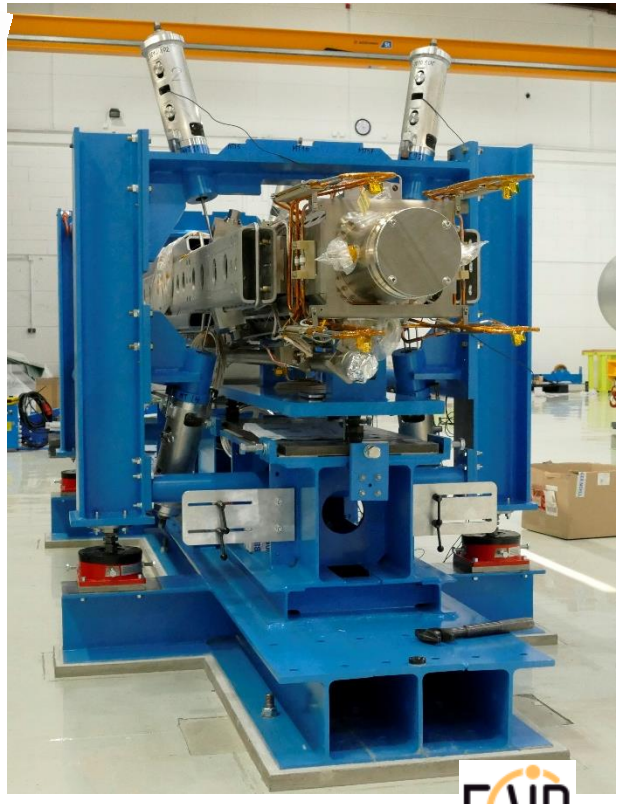
Downstream unit SF2B (F2 + steerer)

Upstream unit VQD (QD + sextupole)

Quadrupole module mechanical correction of the magnetic field:

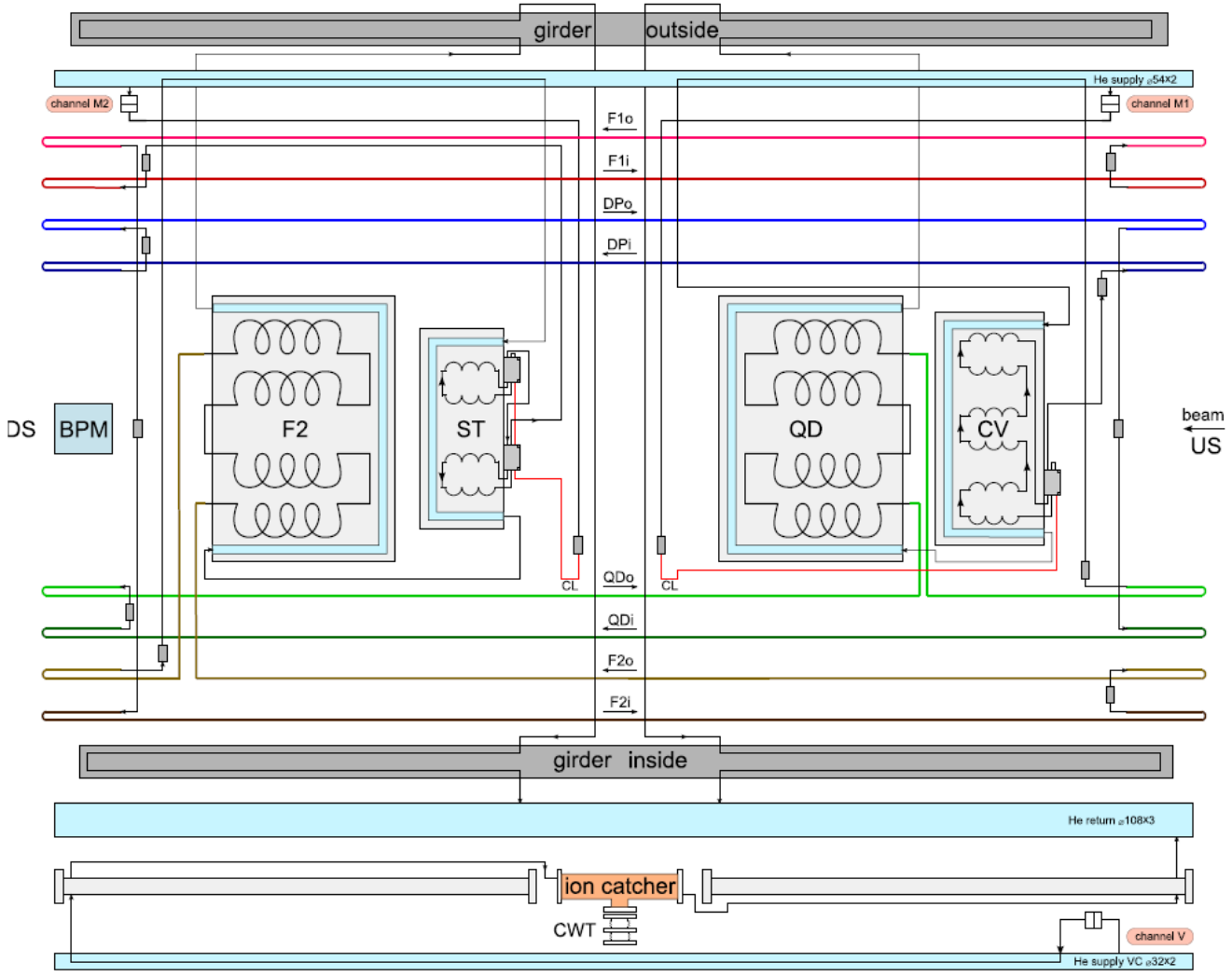


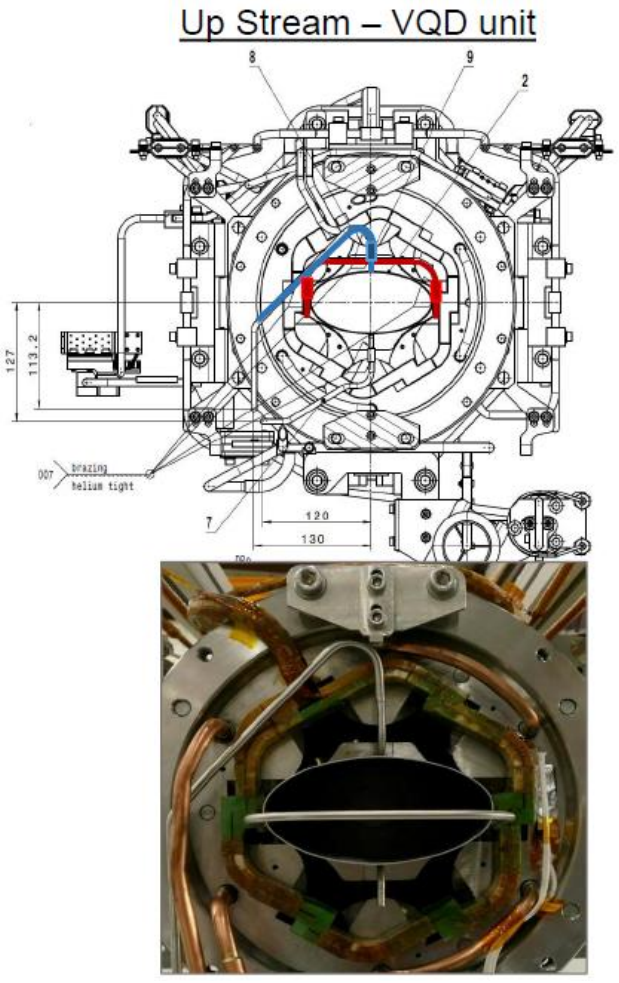




- existing system of plates with variable shape, thickness and pin connection system allows for correction of the magnetic axis mechanically.

Qualification of the hydraulic connections:

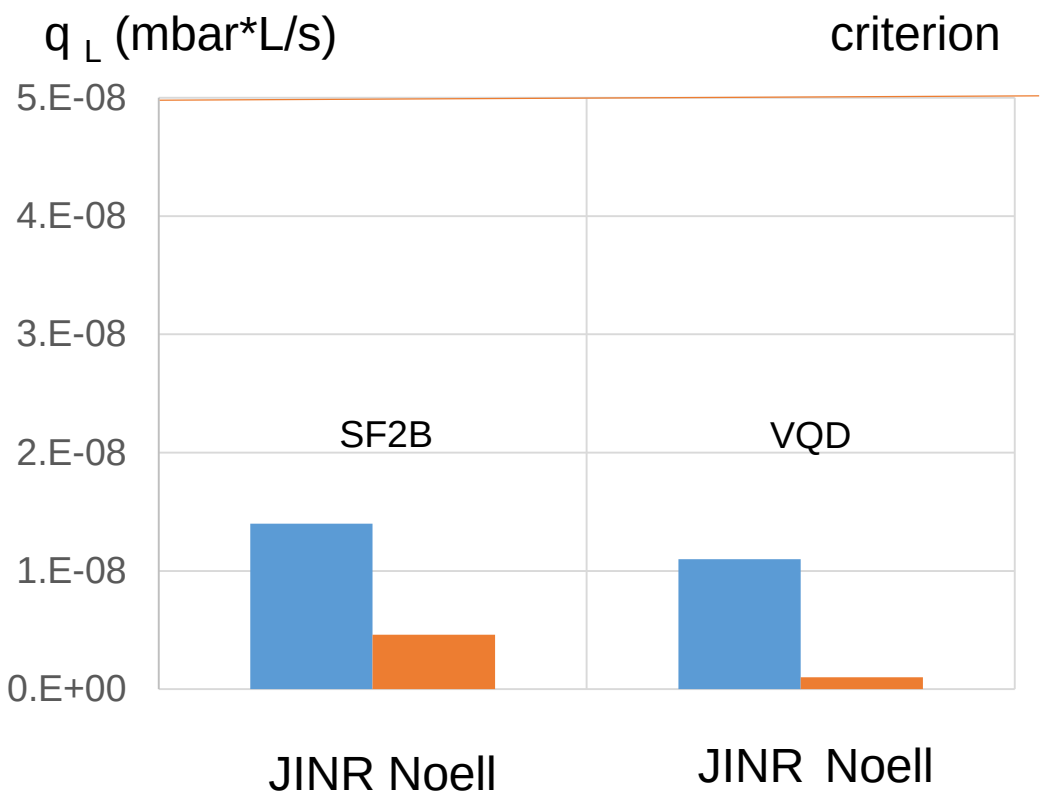


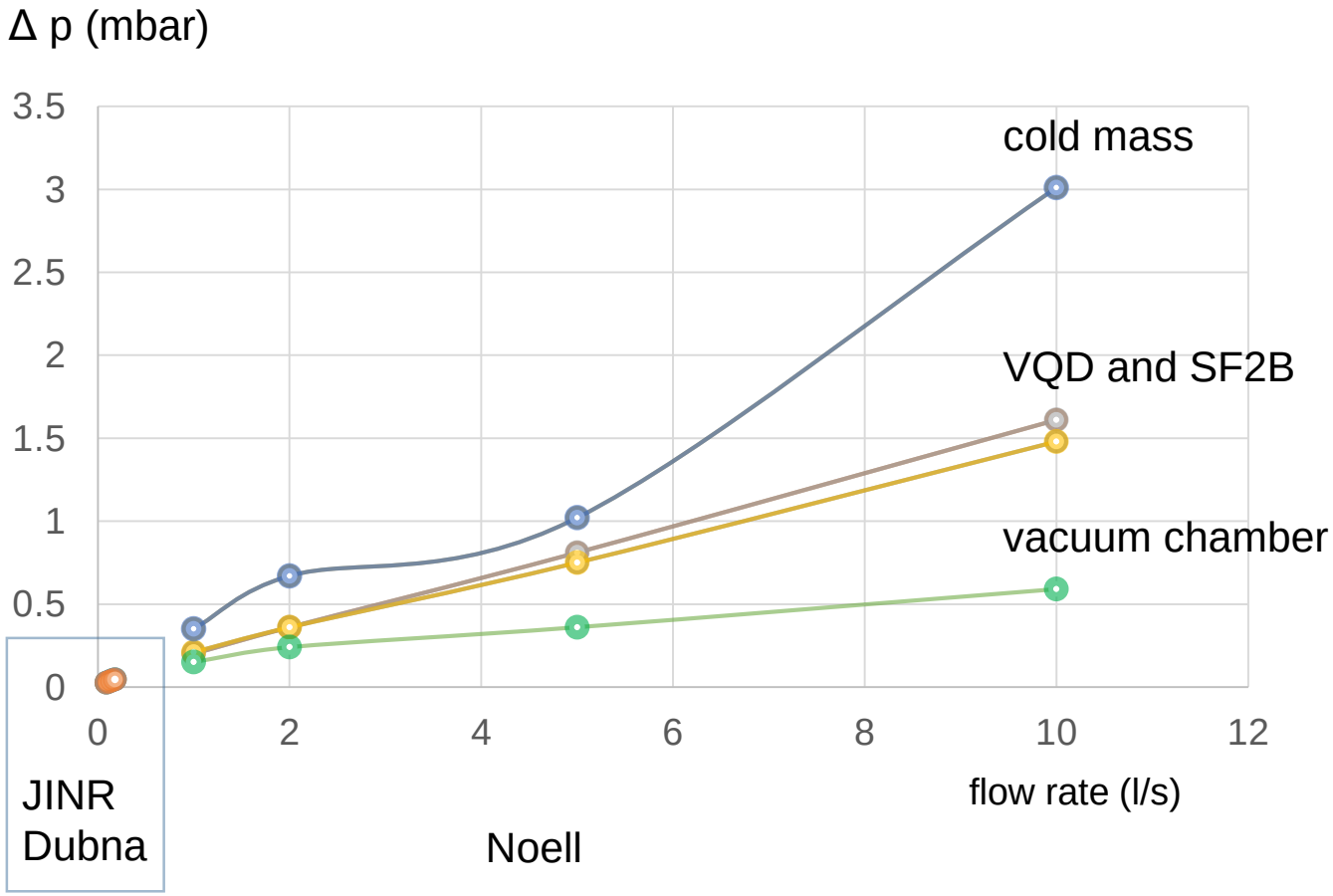


2.9E-09 mbar*L/s

1.1E-08 mbar*L/s

Process lines leak level in cold mass and flow rates





Entire Cold Mass Leak level:

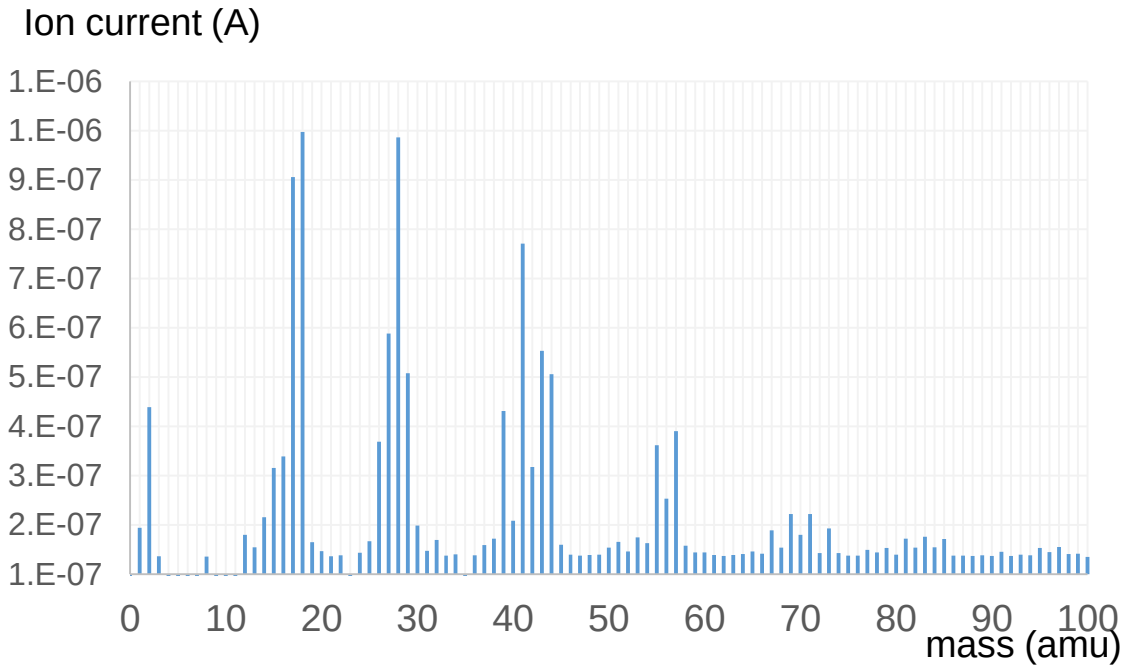
@ 15 bar 1.80E-06 mbar*L/s

@ 20 bar **1.10E-06 mbar*L/s**

- results should be compared with calculations (20% agreement)

Ultra High Vacuum Residual Gas Analysis

unit SF2B



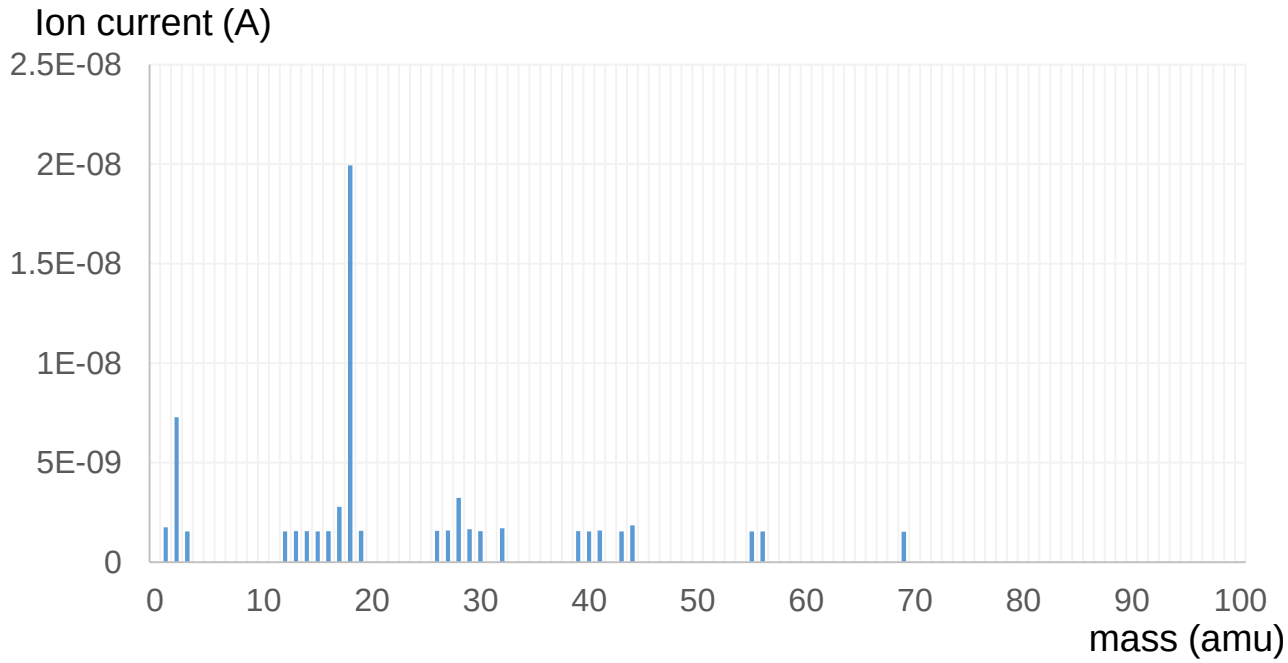
p = 5.04*10^{-4}

t = 22°C

$$\frac{\sum_{n=41}^{100} In - I44}{\sum_{n=1}^{40} In + I44} \leq \mathbf{0.62}$$

(required ≤ 0.15)

integrated UHV system

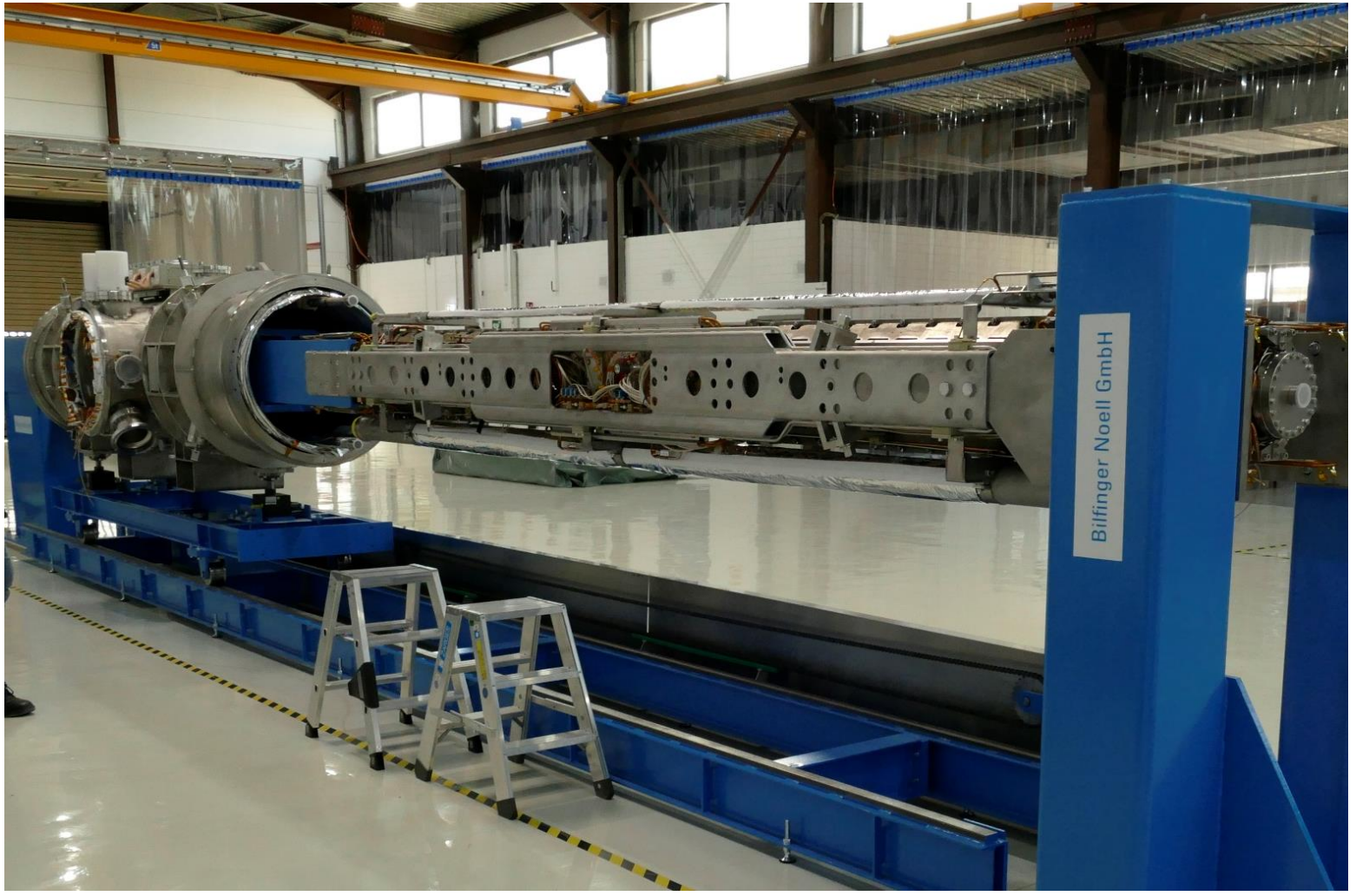


p = 1*10^{-3}

t = 22°C

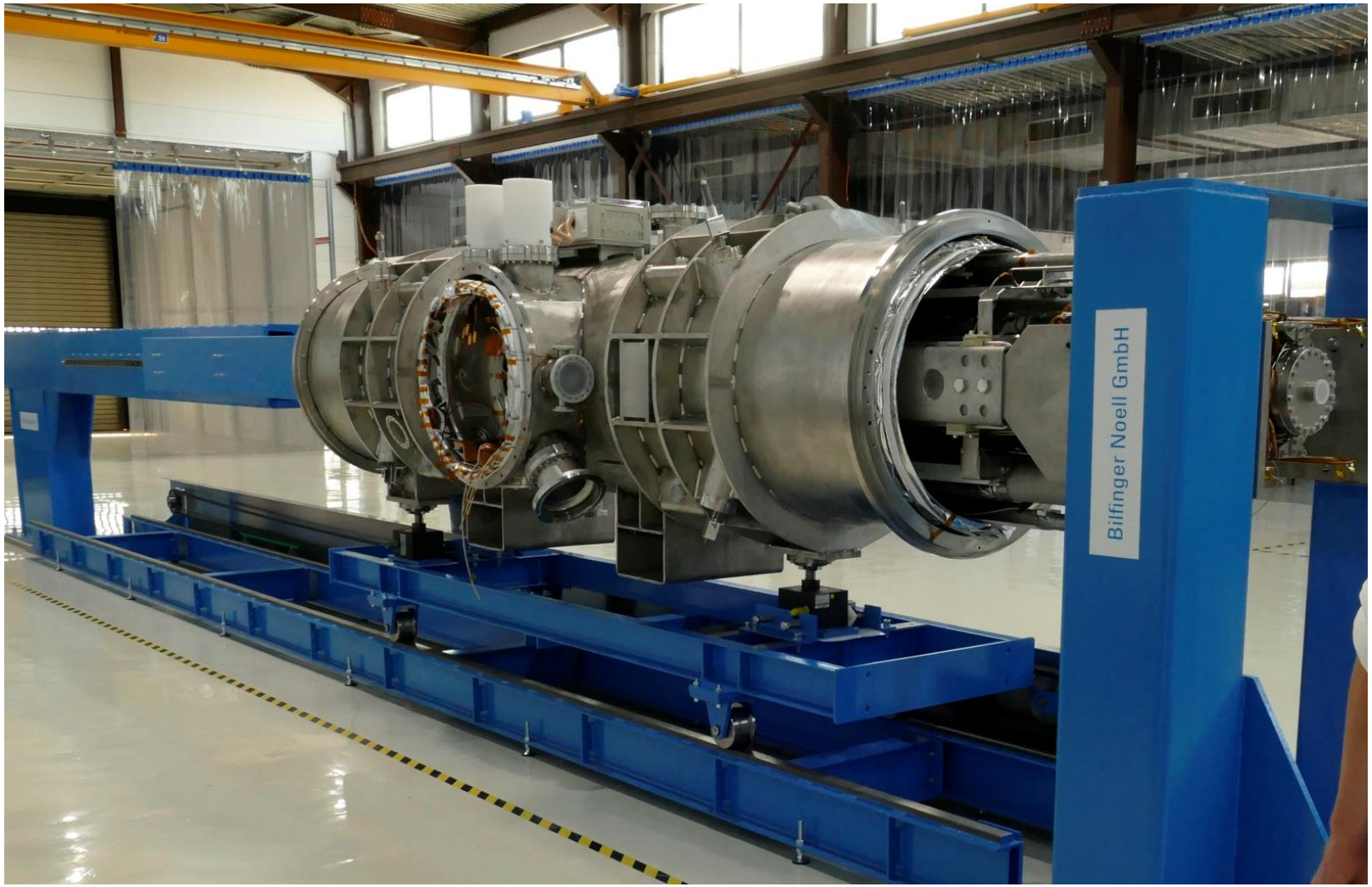
$$\frac{\sum_{n=41}^{100} In - I44}{\sum_{n=1}^{40} In + I44} \leq \mathbf{0.03}$$

Integration of the cold mass into cryostat



- mechanical connections
- Beam Position Monitor and cryocatcher installation
- hydraulic connections for process lines
- Ultra High Vacuum connections
- extended prototype instrumentation (temperature sensors, heaters, voltage taps, quench detection, strain gauges)

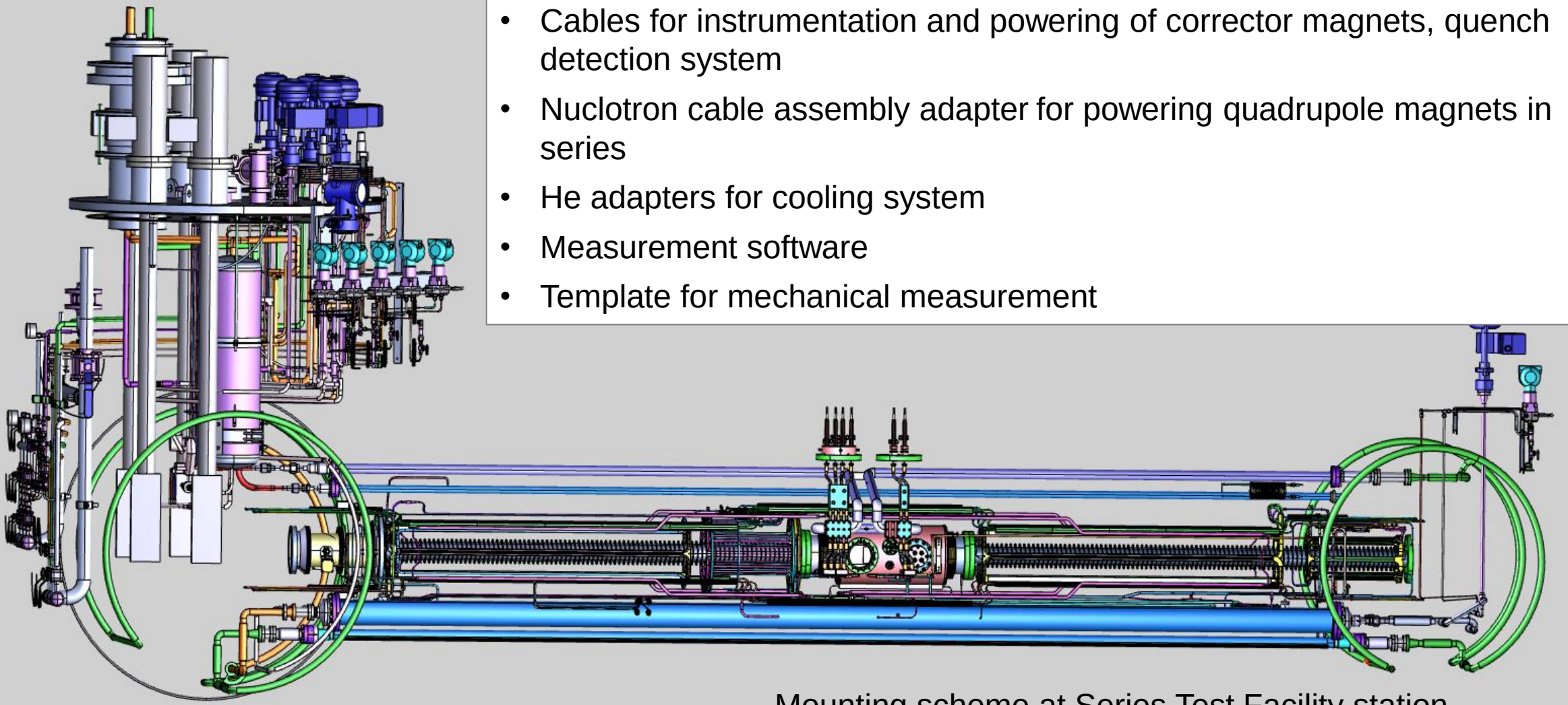
Successful integration of the cold mass into cryostat



- cryostat leak free
- merging cryostat with thermal shield (MLI, thermal connections, Aluminium body)
- thermal shield with thermalisation connections and MLI
- collisions between thermalisation and suspension system
- successful merging of cold mass and cryostat system

Prototype module testing at GSI

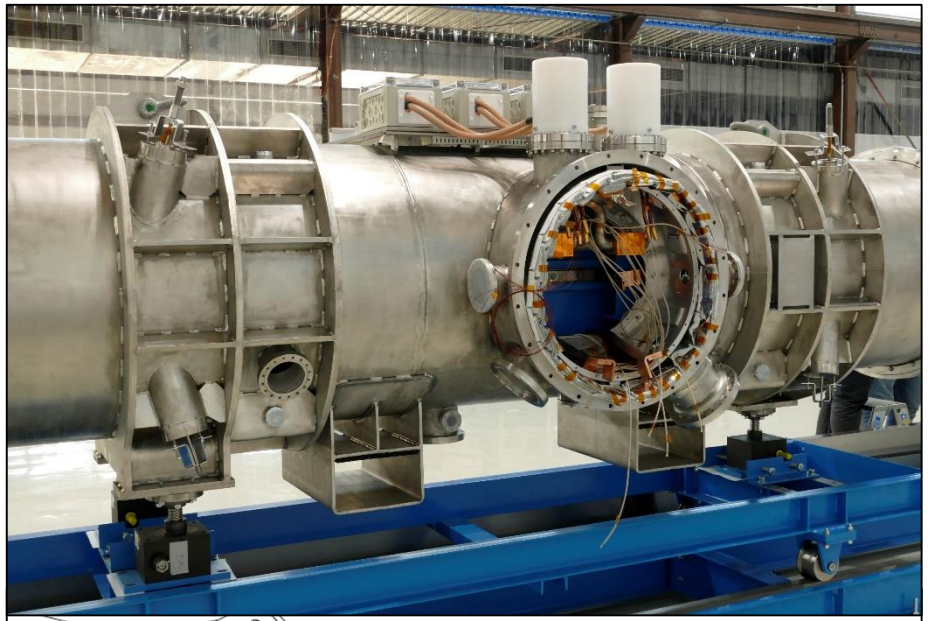
- Cables for instrumentation and powering of corrector magnets, quench detection system
- Nuclotron cable assembly adapter for powering quadrupole magnets in series
- He adapters for cooling system
- Measurement software
- Template for mechanical measurement

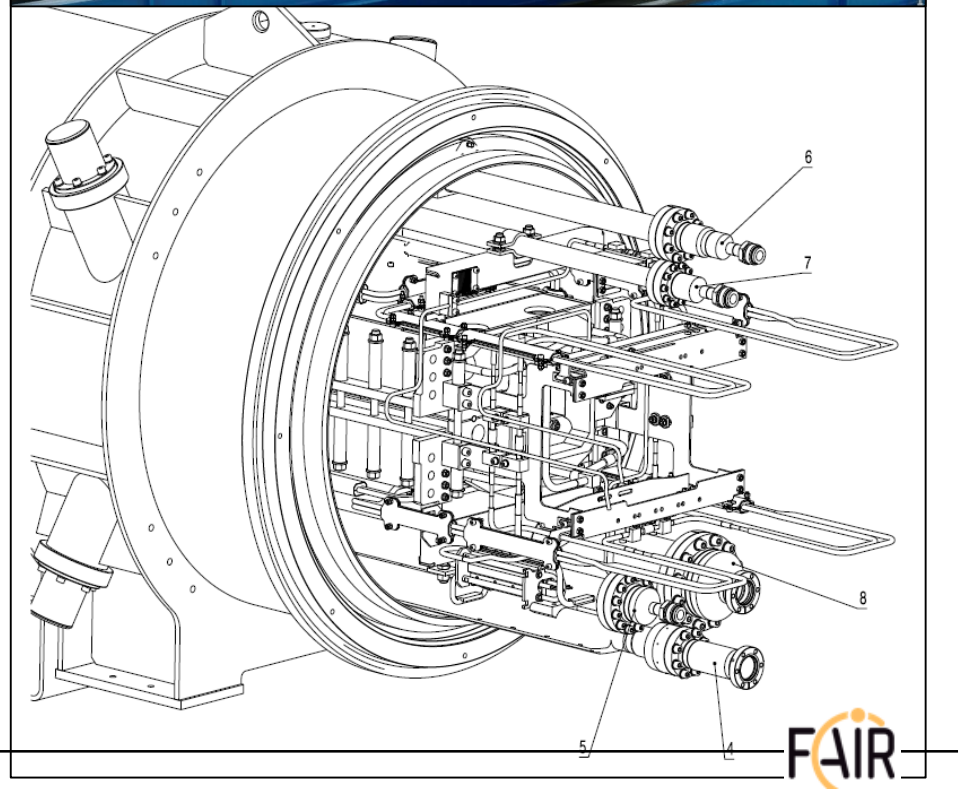


Mounting scheme at Series Test Facility station

Prototype module testing at GSI at warm

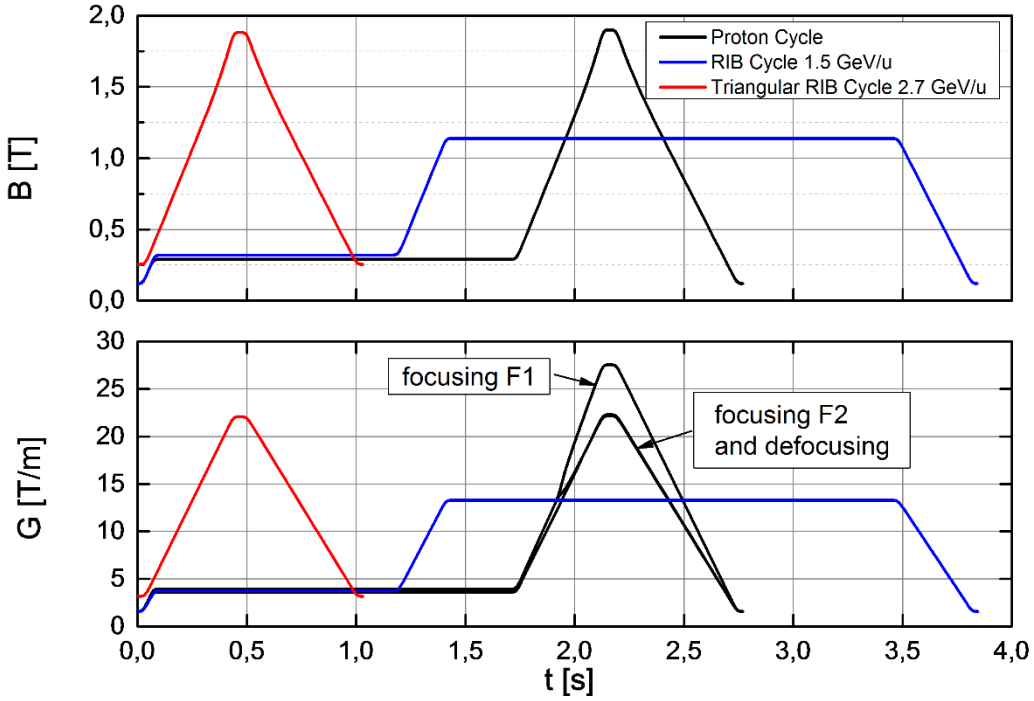
- Measurement of the cold mass and cryostat by laser tracker
- Functional tests of sensors, insulation tests for low and high voltage circuits
- Leak tests of the process lines
- Leak tests of the ultra high vacuum system
- Instrumentation tests: temperature sensors with calibration curves
- Checking the power circuits for electrical integrity (voltage taps)
- Leak tests of the cryostat vessel
- Integral leak test of the process lines during pump and purge process
- Functional tests of instrumentation

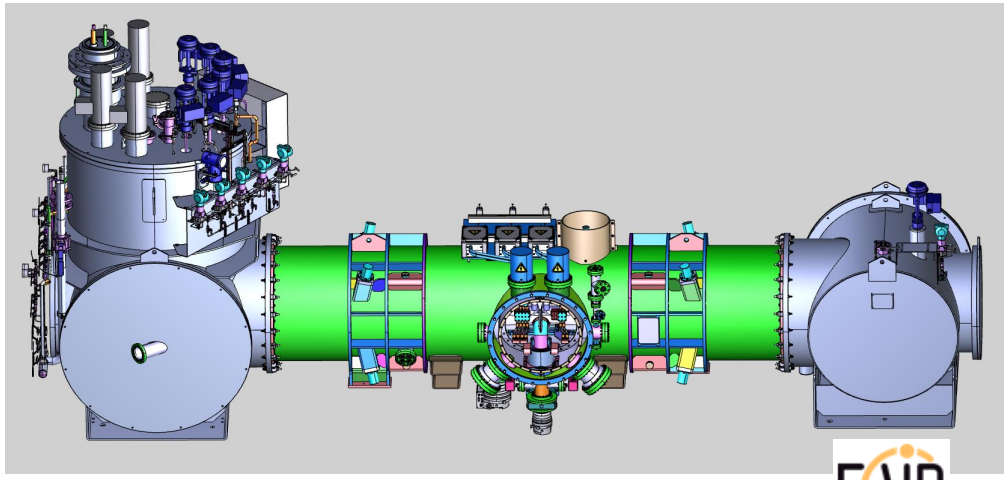




Prototype module testing at GSI at 4.5 K

- Measurement of the helium mass flow rates of the static heat load
- High and low voltage tests at cold conditions
- Validation of the voltage taps over cool down
- Measurement of cold mass position via. laser tracker
- Test of the quench detection system for corrector magnets
- Powering of the main quadrupole magnets
- Powering of the corrector magnets and testing the functionality of the Local Current Leads
- Measurement of the helium mass flow rates of the dynamic heat load
- Measurement of the Ultra High Vacuum system
- Functional test of the Beam Position Monitor and cryocatcher





Summary:

1. Magnet units, vacuum chambers, beam diagnostic and other module components available at Bilfinger Noell for prototype assembly.
2. Integration of QDM prototype advanced, module will be delivered in October 2019 to GSI.
3. Testing campaign of the magnet module is planned and will start in November 2019 at GSI series test facility.