



## News From IMP Magnet Test Stand

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3<sup>rd</sup> International Magnet Test Stand Workshop, Uppsala University, 11-12 June 2019

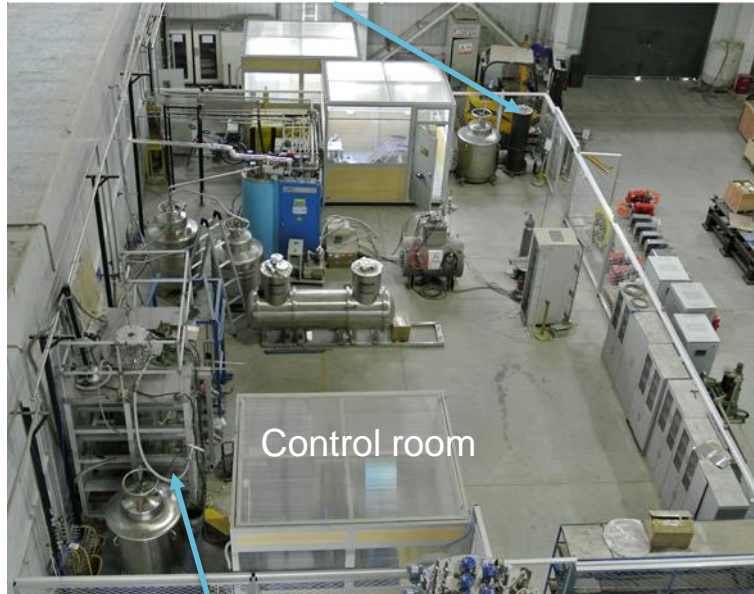
# Outline

- Overview of the test stand
- Test requirements of the MCBRD in China
- Upgrade project of the test station
- Field measurement & Data acquisition & Quench protection
- Test stand for HIAF project
- Summary

# Overview of the IMP Magnet Test Stand

Helium Liquefier	39L/h
Helium Dewar	500L
Buffer Tank	100m <sup>3</sup>
Liquid Nitrogen Tank	50m <sup>3</sup>
Recovery Compressor	23m <sup>3</sup> /h
Gas Bag	100m <sup>3</sup>
Impure Helium Tank	5m <sup>3</sup> @15MPa

300mm Test Cryostat



700mm Test Cryostat

Buffer Tank & Impure Gas Tank & Liquid Nitrogen



23m<sup>3</sup>/h Recovery Compressor



2 × 50m<sup>3</sup> Gas Bag



TCF10 Liquefier Unit



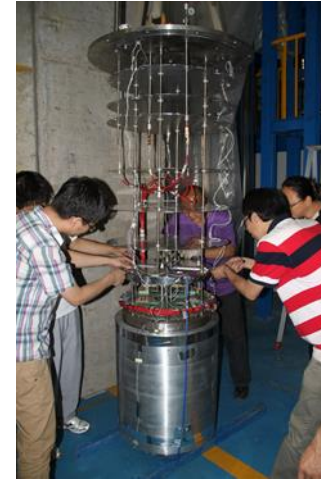
# Magnets Tested at IMP



SuperFRS



3T Solenoid



SECRAL II

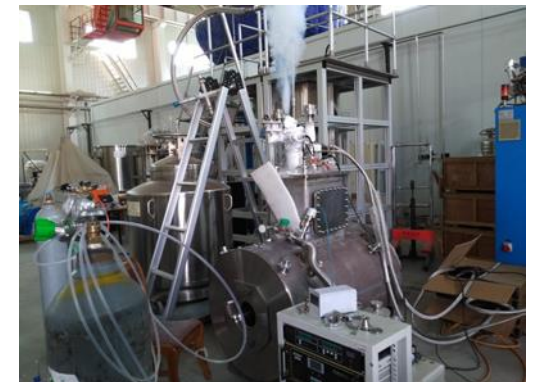


CIADS Solenoids

Type	Quantity
SuperFRS Dipole Prototype	1
CIADS solenoids	31
FRIB Solenoids	37
Others	>10



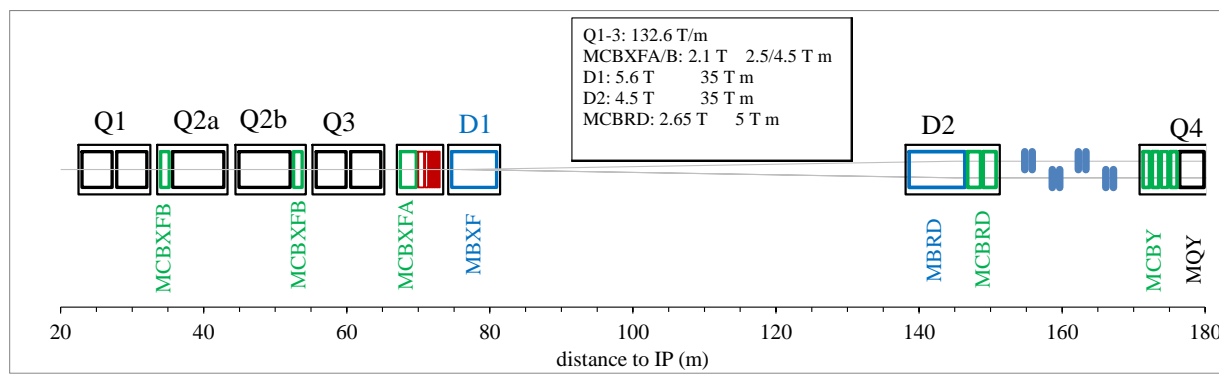
FRIB Solenoids



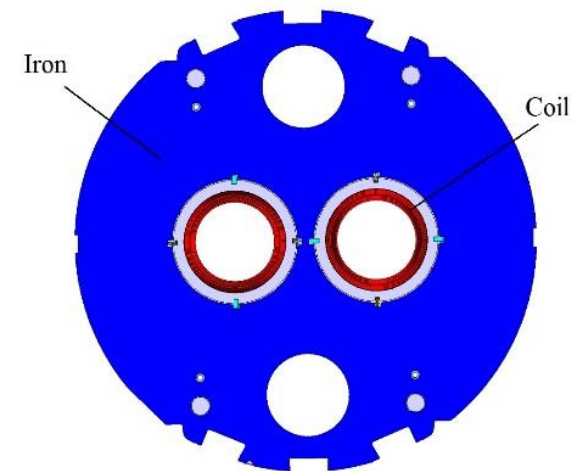
7T Penning Trap

# Test Plan of the MCBRD

- China will provide **12 units** of MCBRD before **2022**.
- First two magnets for integration in D2 series are needed for **mid 2021**.
- China makes a **0.5m long prototype** and a **full size prototype**.
- The full size prototype is needed for integration in the prototype D2 cold mass in **mid 2020**.
- Training and the integral multipoles measurement of the magnets will be processed at 4.5K in China.



E. Todesco



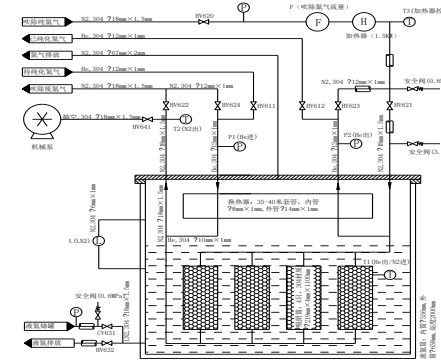
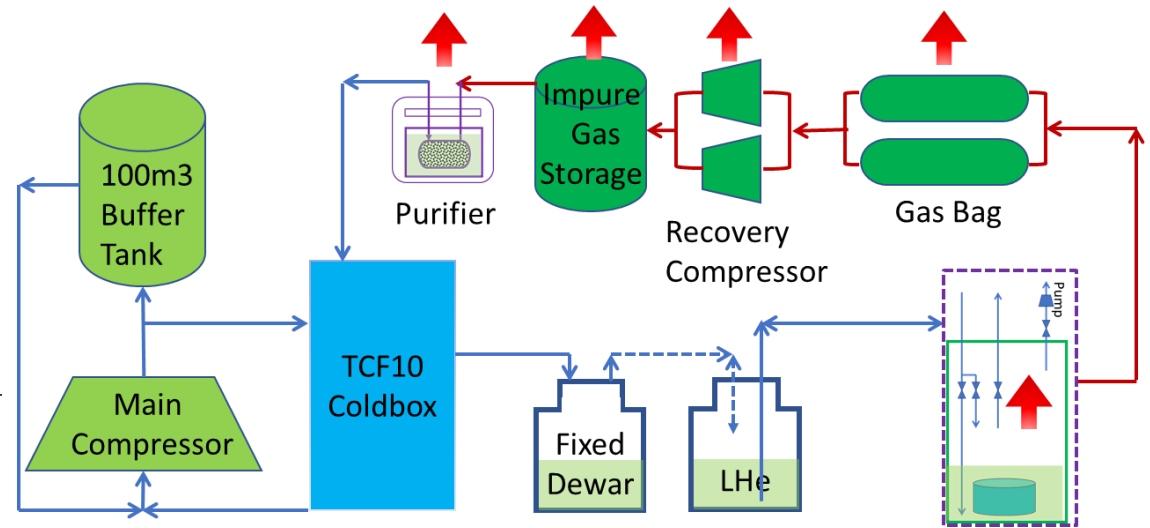
# Upgrade Project

## First Stage

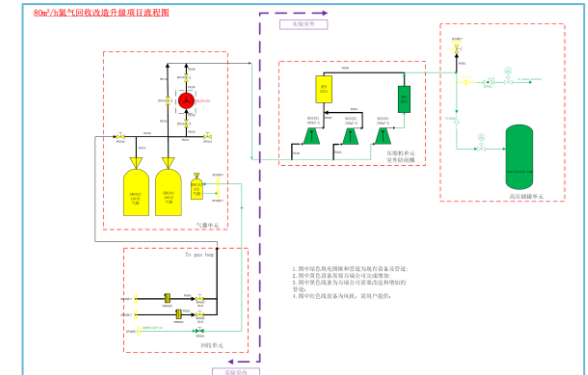
- Gas bag → 200m<sup>3</sup>
- Recovery compressor → 80m<sup>3</sup>/h
- Impure Gas Storage → >10m<sup>3</sup>@15MPa
- External Purifier → 35m<sup>3</sup>/h
- Vertical Test Dewar → Φ800mm L3800mm

## Second Stage

- + Valve box for Vertical Test Dewar
- + Pre-cooler system for cooling down & warm up



Scheme of the purifier



Scheme of the Recovery System

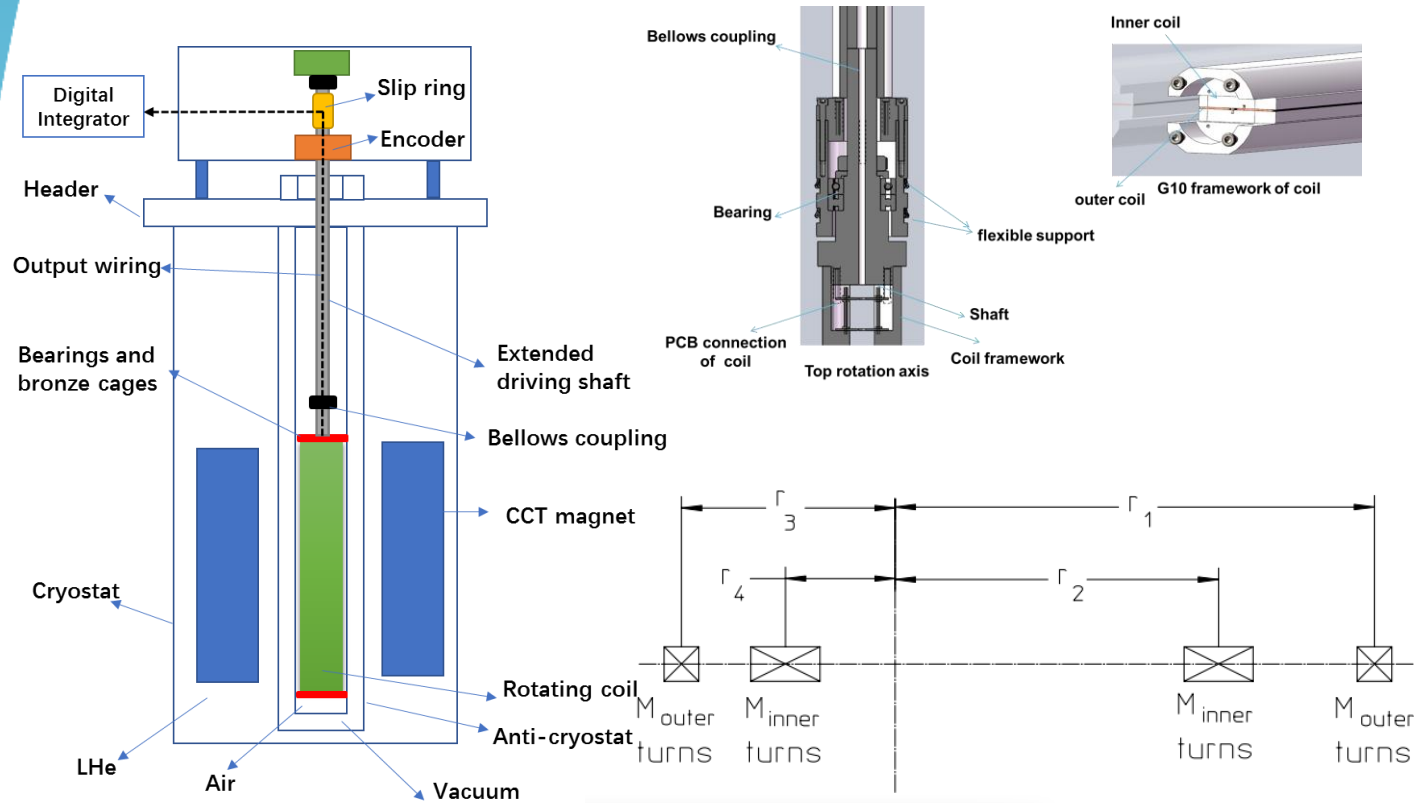


# Status of the Upgrade

- The Helium Recovery System is under construction, will finished in two weeks.
- External purifier is waiting for Factory Acceptance Tests.
- 800mm dewar has been installed, hanging system is under manufacture.
- All upgrades in stage 1 will be finished before July.



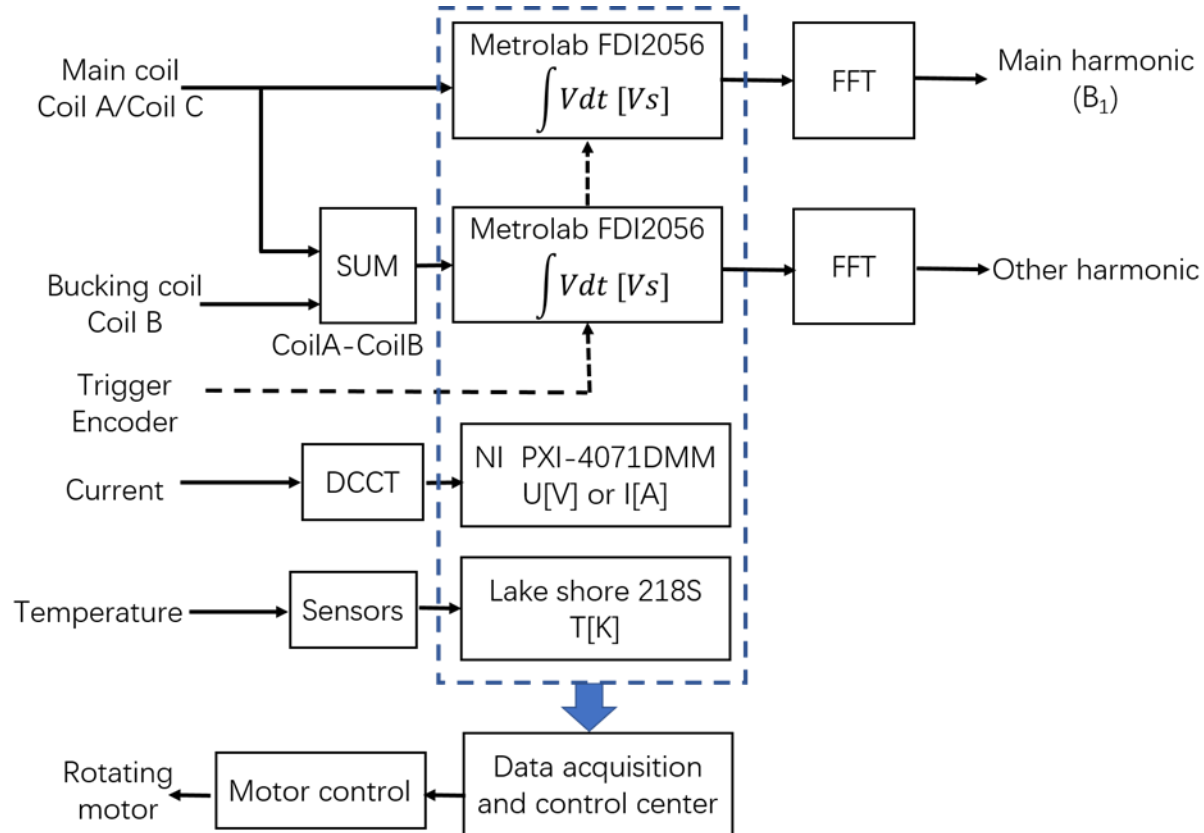
# Field Measurement



- Magnetic field measurements are performed by the rotating coil.
- The rotating coil contains two radius coils, the outer one measures the main component and the inner one for bucking improves the sensitivity for the high-order multipole components.
- Typical accuracy of the system : $10^{-4}$ .
- The rotating coil is positioned in the Anti-cryostat.
- The rotating coil is connected via a long stainless steel shaft to a rotation motor.
- The rotating shaft of the coil is coupled to an angular encoder and a slip ring.

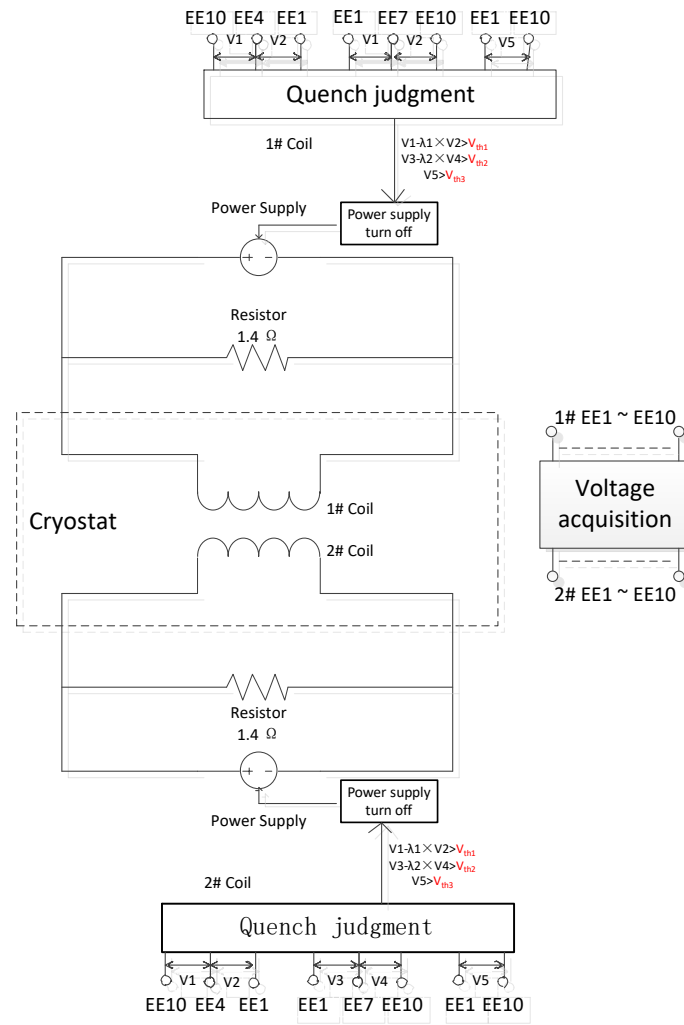
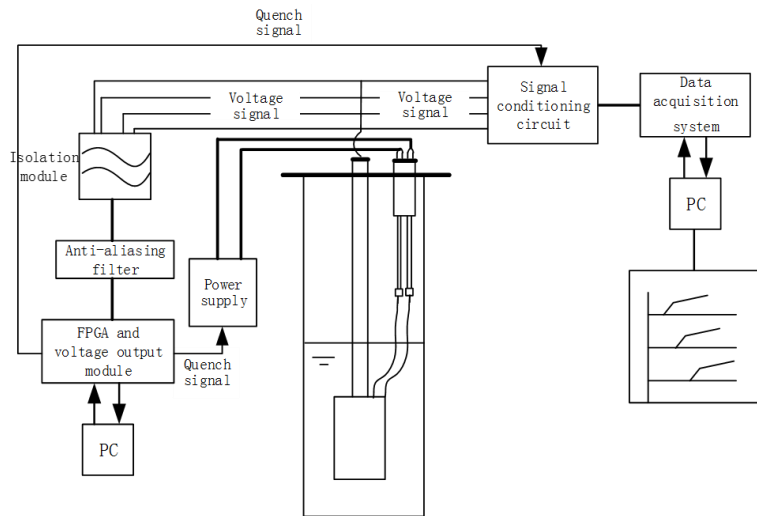
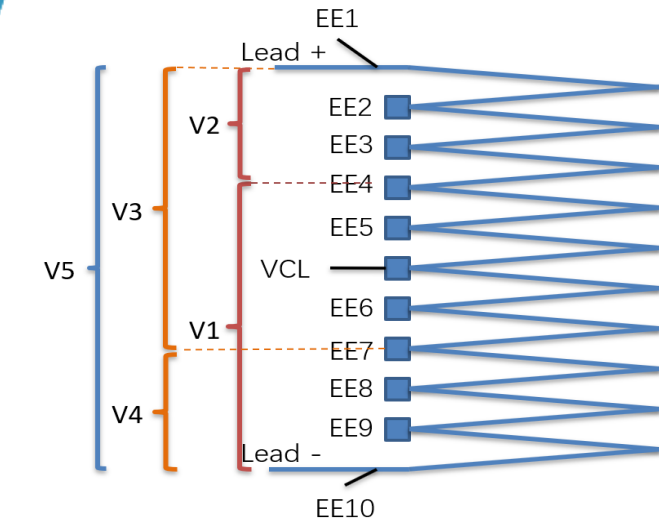


# Data Acquisition



- The inductive voltage of the rotating coil is fed into digital integrator (MetroLab, FDI2056).
- The integrators are triggered by the angular encoders.
- Results are obtained from the average of the forward and backward revolutions.
- The harmonic amplitudes and phases are calculated by a Fast Fourier Transform (FFT) of the acquired data.
- The magnet current is measured in real-time by a digital multimeter (NI PXI-4071).

# Quench detection

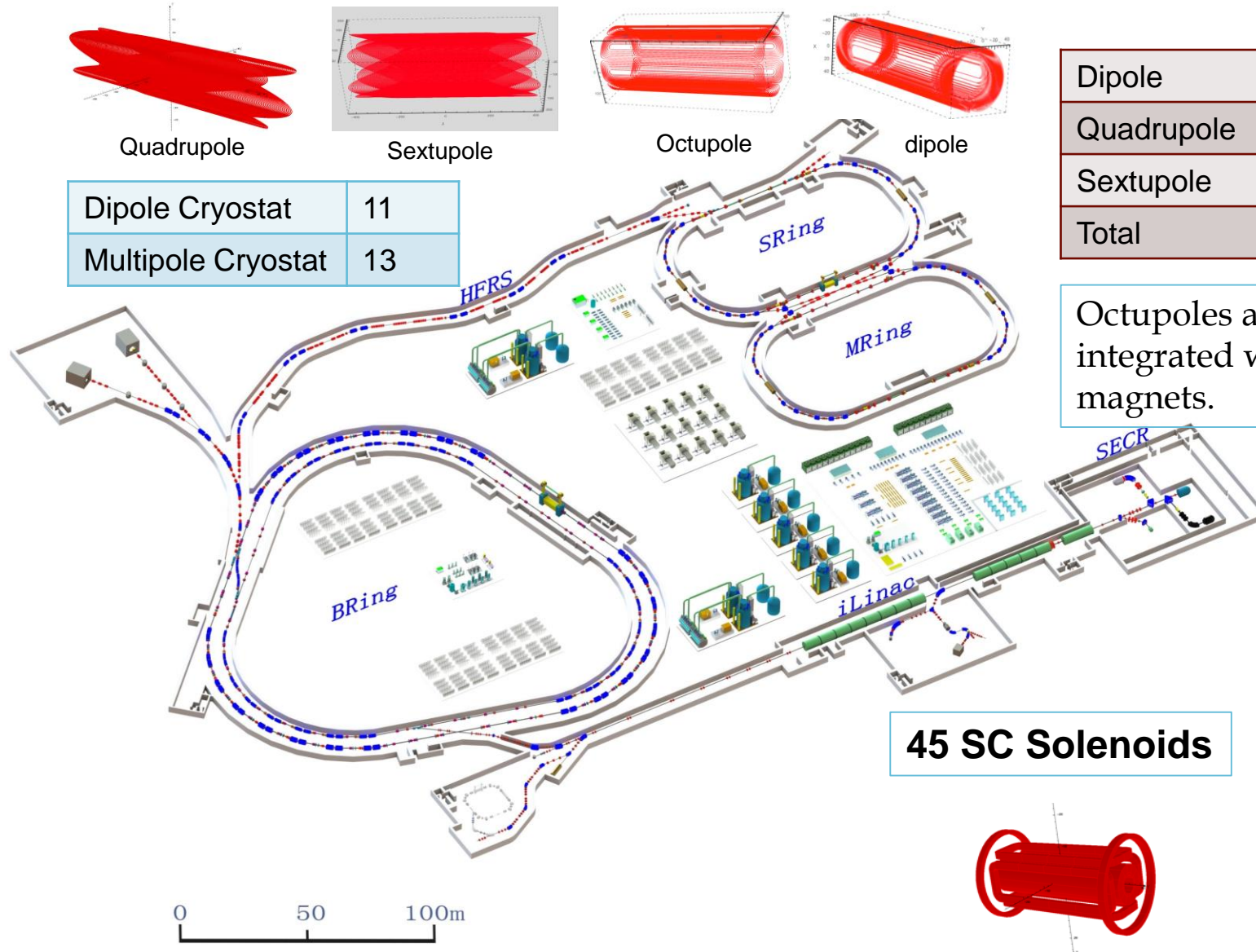


- The quench detection system is based on the NI-cRIO platform.
- The outlet voltages of SC coils are used as judgement signal.
- The logical calculus is carried out by FPGA.
- The isolation module is used to protect the electronic equipment.
- When the quench is detected, a 24V quench signal will be sent to the power supply and the data acquisition system.

# Future plan for HIAF project

- 300-500W refrigerator is required.
- 1 horizontal test bench is required.
- 2 vertical test bench
- 10g/s recovery and purifier system
- Plan to start testing in 2022.

Total coldmass ~100 tons.



Dipole Cryostat	11
Multipole Cryostat	13

Dipole	11
Quadrupole	39
Sextupole	21
Total	71

Octupoles and Correctors are integrated with other magnets.

**45 SC Solenoids**

# Summary

- Cryogenic system: Capability will be improved.
  - The capability of helium recovery system will be improved.
  - The vertical dewar for MCBRD has been installed.
- Measurement and data system: Has been modified or tailor made.
  - Quench detection system and data acquisition system are available.
  - Magnetic field measurement system is under construction.
- The whole system will be ready in July and then the 0.5m prototype will be tested.
  
- Wish we will perform the test of MCBRDs with high quality.
- Wish the test stand for HIAF project will go on well step by step.

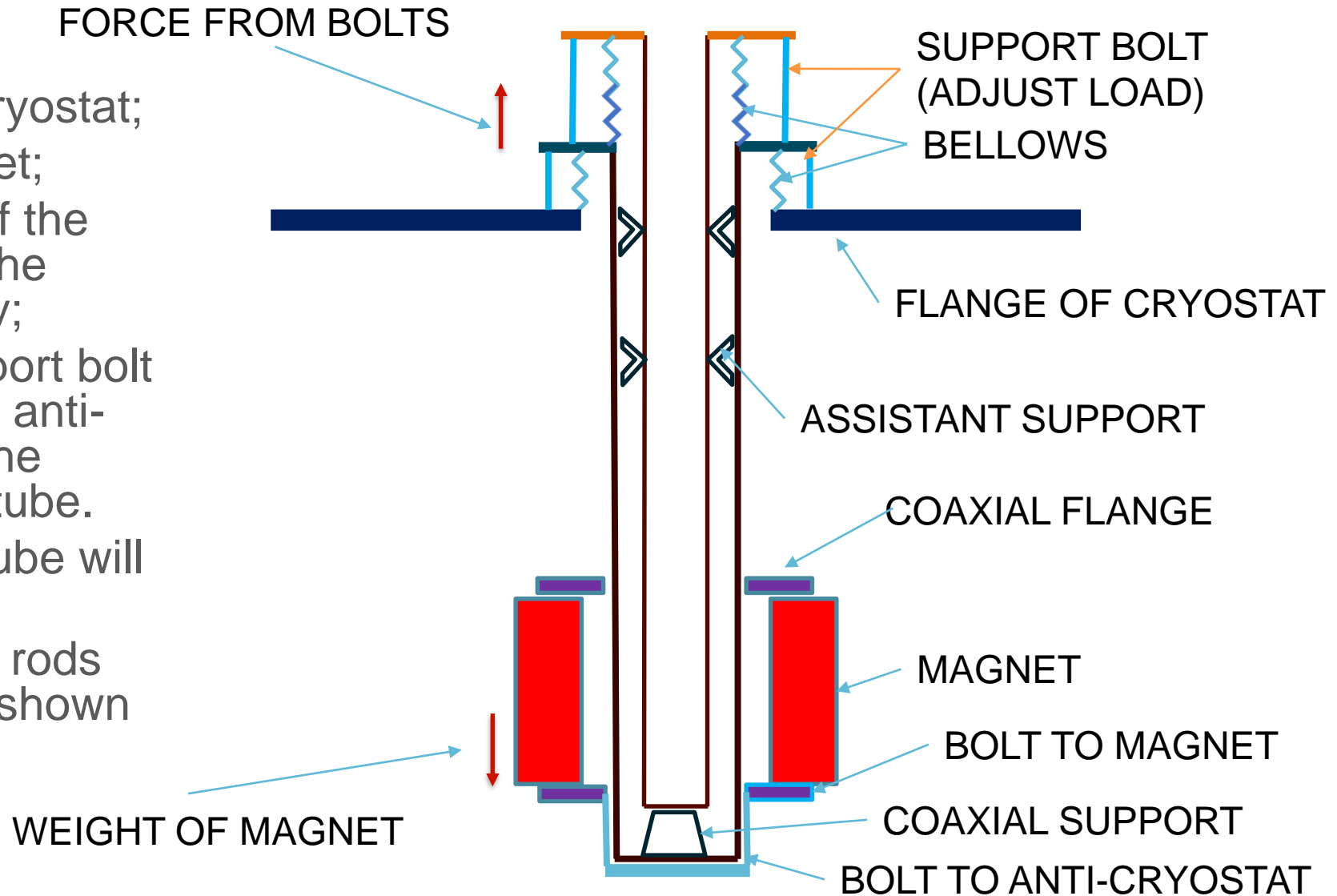




***THANKS FOR YOUR ATTENTION***

# Conceptual design of the Anti-Cryostat

1. Install the anti-cryostat;
  2. Install the magnet;
  3. Fix the bottom of the anti-cryostat to the magnet coaxially;
  4. Tighten the support bolt on the top of the anti-cryostat to pull the inner and outer tube.
- The bend of the tube will be minimized.
  - The main support rods for magnet is not shown here.



# Test Circuit

- Five voltages,
  - V1 between EE4 and EE10,
  - V2 between EE1 and EE4,
  - V3 between EE1 and EE7,
  - V4 between EE7 and EE10,
  - V5 between EE1 and EE10
 are used for the quench detection.
- Three threshold voltages,  $V_{th1}$ ,  $V_{th2}$  and  $V_{th3}$  are applied to the quench judgement,
  - when  $V1 - \lambda_1 * V2 > V_{th1}$  or  $V3 - \lambda_2 * V4 > V_{th2}$  or  $V5 > V_{th3}$  with three times respectively, the coil is considered quench and the power supply will be turned off.
  - $\lambda_1$  and  $\lambda_2$  are adjustment coefficients.  $V_{th1}$  and  $V_{th2}$  are usually set for 20~50 mV.  $V_5$  is not used during charging and discharging since the inductance is uncertain and  $V_{th3}$  is usually set for 50~100 mV.  $V_5$  is also monitored by the quench detection system built in the power supply.
  - All the voltage taps are connected to the voltage data acquisition device to obtain the wire voltage on each layer.

