Preparation of the cold test for MCBRDP2 at IMP

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Contents

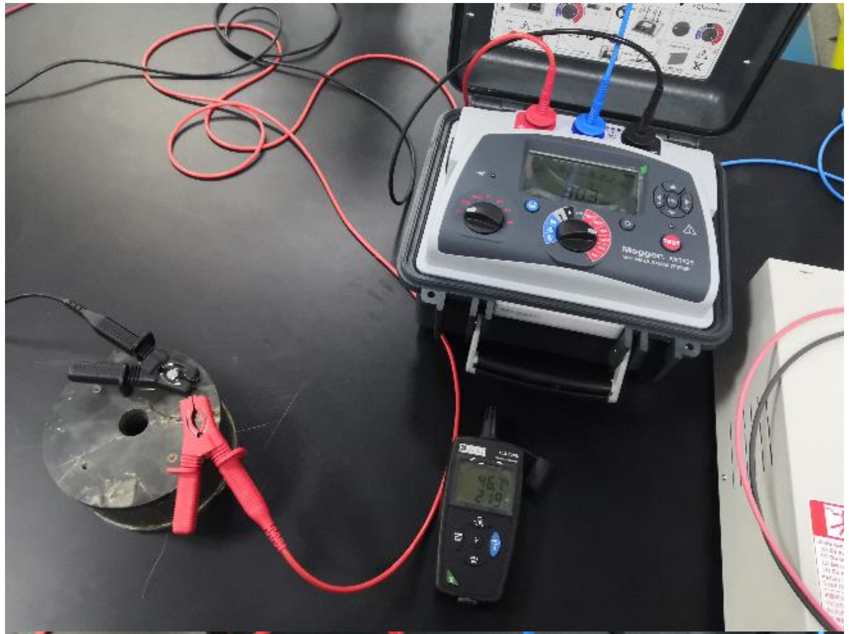
- Vertical installation and electrical test
- Field measurement at room temperature.
- HTS current lead and feedthrough
- CCS and other temperature sensors
- LHe tank
- Final checkout before cooling
- Schedule of cold test
- Cold test plan

Make the magnet vertically

- First, use the special tool to lift the magnet slowly and horizontally.
- Then, transfer the magnet on the turnover machine, and with the bridge crane's help to place the magnet slowly from horizontal to vertical
- Finally, the magnet was moved to the assemble area and connect to the insertion

The first HV test – New tester

- **We received the new High Voltage Insulation Tester MIT 525, and did the insulation test up to 2kV with five steps as suggested by CERN.**
- **First, we performed a functional test of the new tester on a room temperature coil which has passed 3000V test, and the tester works well.**
- **Then, we did the insulation test of the coil to ground with five steps as 500V/1000V/1500V/2000V/2200V.**
- **The Test Time is 30s, the temperature is 23.1℃, and the relative humidity is about 38.9%.**
- **The insulation test was carried out according to the *Final* test content of WST.**
- **All the tests were passed.**
- **At this point, the first electrical test was completed.**



The first HV test – New tester

- **Test results – coils:**

Equipment	Object	Function	Voltage/Leakage Current	Test Time	Resistance/ GΩ
MIT 525	Aperture V1 to ground	IR	512V/6.38nA	30s	80.3
		IR	1014V/12.8nA	30s	79.2
		IR	1530V17.5nA	30s	87.4
		IR	2044V/26.4nA	30s	77.4
		IR	2245V/27.8nA	30s	80.7
	Aperture V2 to ground	IR	512V/5.13nA	30s	99.8
		IR	1015V/10.5nA	30s	96.4
		IR	1531V/15.4nA	30s	99.5V
		IR	2045V/20.7nA	30s	98.8
		IR	2245V/22.1nA	30s	101.7

The first HV test – New tester

- **Test results – temperature sensors:**

Equipment	Object	Function	Voltage/Leakage Current	Test Time	Resistance/ TΩ
MIT 525	CCS 1158 to ground	IR	510V/0.37nA	30s	>1
	CCS 1158 to ground	IR	1015V/0.45nA	30s	>2
	CCS 1159 to ground	IR	512V/0.43nA	30s	>1
	CCS 1159 to ground	IR	1020V/0.65nA	30s	1.574
	Aperture V1 to CCS 1158	IR	512V/0.34nA	30s	>1
	Aperture V1 to CCS 1158	IR	1015V/0.47nA	30s	>2
	Aperture V2 to CCS 1159	IR	512V/0.31nA	30s	>1
	Aperture V2 to CCS 1159	IR	1015V/0.41nA	30s	>2
	CCS 1160 to ground	IR	512V/0.31nA	30s	>1
	CCS 1160 to ground	IR	1015V/0.57nA	30s	1.794
	CCS 1161 to ground	IR	512V0.35nA	30s	>1
	CCS 1161 to ground	IR	1015V/0.55nA	30s	1.836
	Aperture V1 to CCS 1160	IR	512V/0.26nA	30s	>1
	Aperture V1 to CCS 1160	IR	1015V/0.40nA	30s	>2
	Aperture V2 to CCS 1161	IR	512V/0.32nA	30s	>1
	Aperture V2 to CCS 1161	IR	1015V/071nA	30s	1.422

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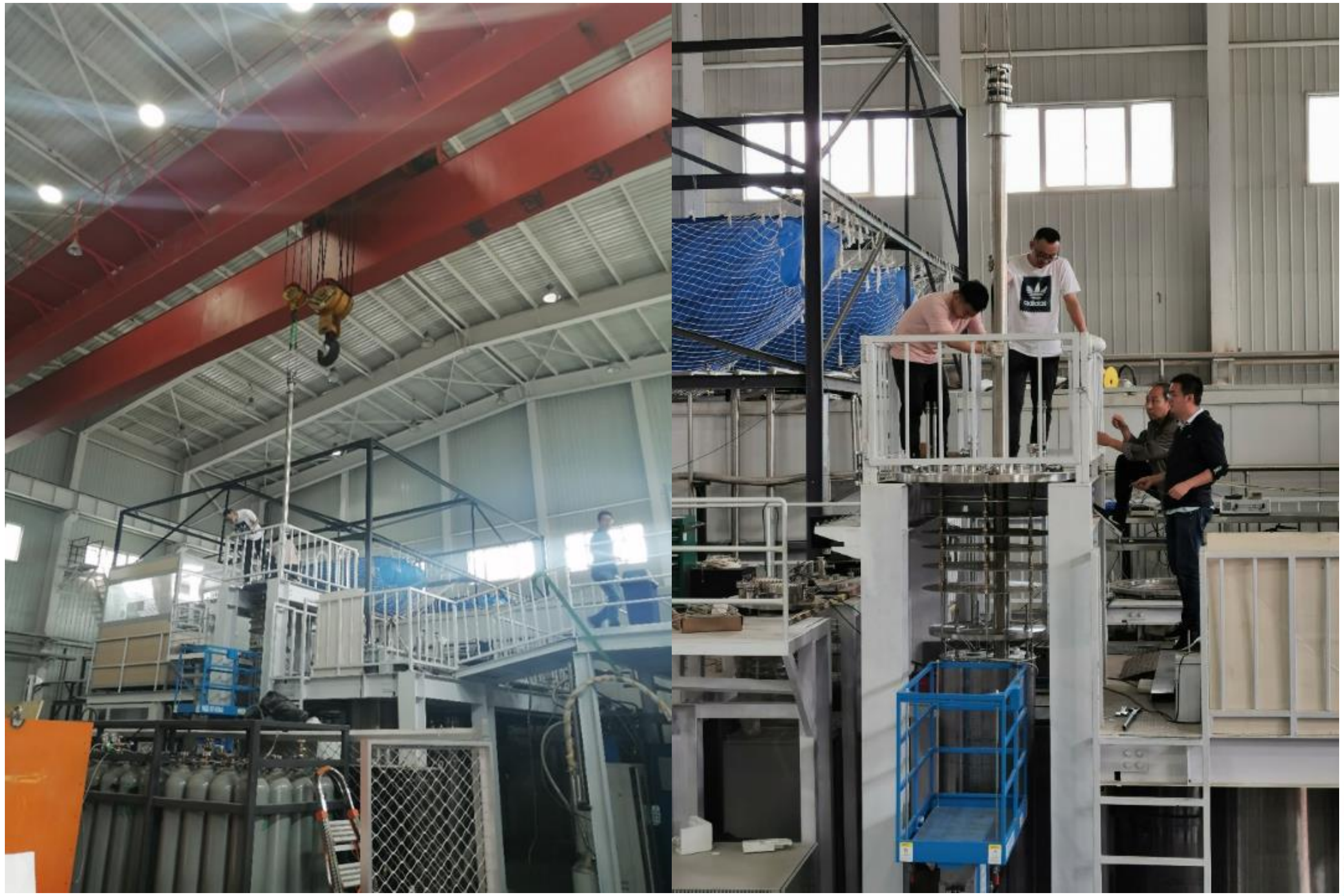
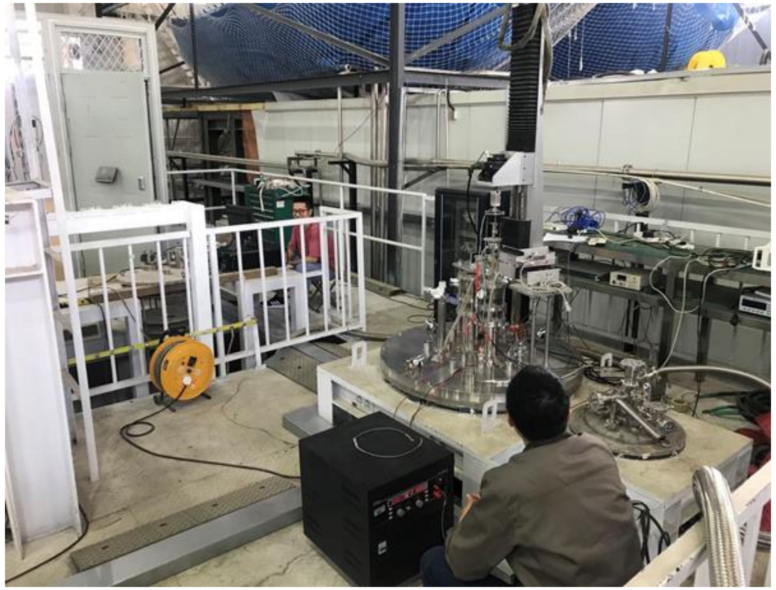
Assemble the anti-cryostat

- The anti-cryostats are very long that more than 4 meters, there are some difficulties in assembling them into the Aperture V1 and Aperture V2 smoothly.
- First, the bridge crane lifts the anti-cryostat vertically.
- Then, slowly moved the anti-cryostat to the upper of the insertion.
- Finally, slowly assembled the anti-cryostat into the Aperture.



Field measurement at room temperature-1

- The room temperature measurement was setup vertically and use the 2.3m long rotating coil.
- Averaging more than 60 measurements to reduce the random errors.
- Positive and negative polarities are measured respectively to reduce system errors
- Field repeatable within 2 units



Field measurement at room temperature-2

B1/Tm	0.25A	0.5A
AP1	0.003148	0.006295
AP2	-0.003152	-0.006286

AP1 0.25A			AP1 0.5A		
n	bn	an	n	bn	an
2	5.195	25.082	2	5.343	0.223
3	2.715	1.068	3	1.015	-0.133
4	-0.022	9.284	4	-0.062	1.712
5	-0.960	0.340	5	0.607	0.637
6	1.709	2.511	6	0.433	0.754
7	-4.074	0.339	7	0.264	0.022
8	-0.369	2.902	8	0.336	0.450
9	-0.069	1.048	9	0.151	0.184
10	1.688	-0.878	10	0.876	0.310

AP2 0.25A			AP2 0.5A		
n	bn	an	n	bn	an
2	2.360	-2.083	2	2.202	4.348
3	3.426	-1.167	3	0.035	-0.664
4	-0.831	1.136	4	0.195	1.466
5	-0.222	0.827	5	-1.692	0.540
6	-0.914	-0.454	6	1.228	-0.221
7	-0.459	0.861	7	-0.634	-1.291
8	0.917	0.639	8	0.806	1.299
9	0.737	-2.907	9	0.900	-0.293
10	2.312	-1.484	10	-0.109	-0.991

Insulation test of the feed-through

- We made a feed-through of the voltage taps that using the LEMO high voltage connector.
- The HV test is up to 3055V.
- The insulation of *wire to wire* and *wire to flange* is very good, all of them are more than 1 TΩ.
- The test temperature is 21.5℃, and the relative humidity is about 37.5%.
- The sealing performance of the feed-through is very good.

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Insulation test of the HTS current leads

- We did the HV test of the HTS current leads in an empty Dewar.
- First, we did the HV test in the air, and the test voltage is up to 2547V.
- Then, we replaced the air in the Dewar with room temperature helium gas, and the test voltage is up to 1531V.
- The insulation of *leads to ground* is very good, all of them are more than 1 TΩ.
- The sealing performance of the HTS current leads also very good.

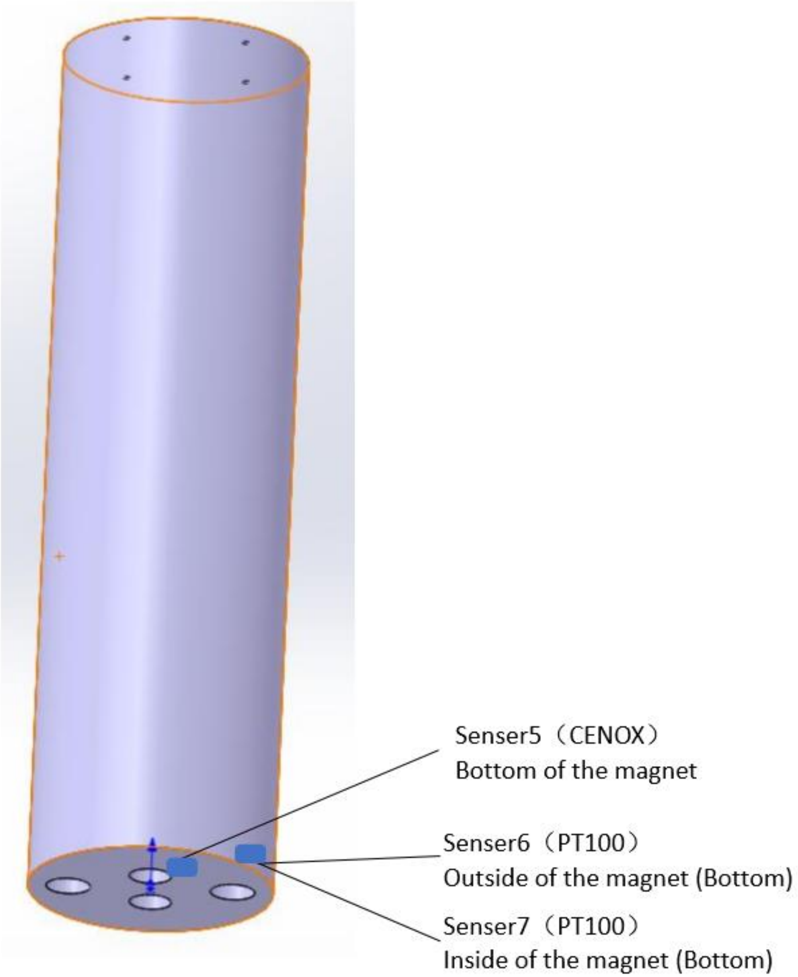
In the air @ 2547V

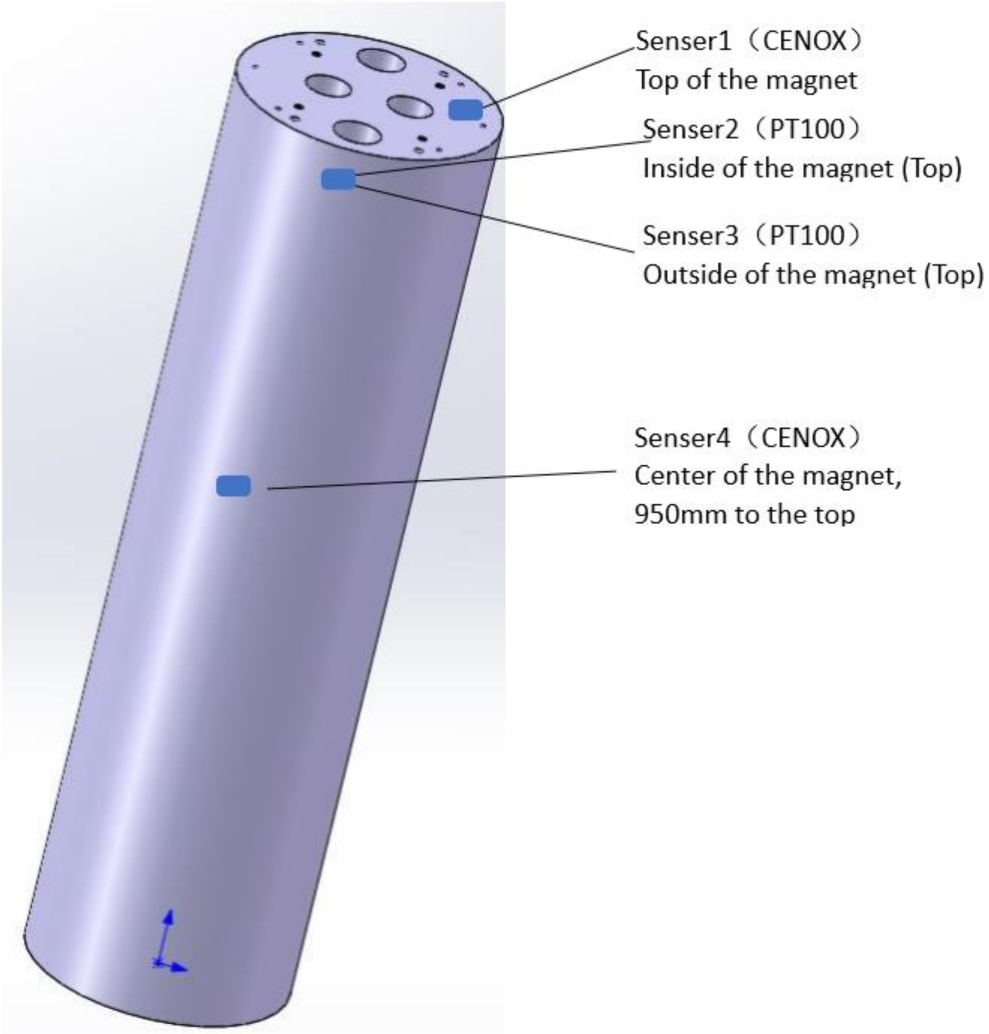
In the helium gas @ 1531V

Produce LHe and develop CCS monitoring system

- Began to run the Linde TCF10 helium liquefier and produce LHe. This process will continue until the test finish.
- Select suitable device to develop the CCS monitoring system. At present, *it's Lake Shore Model 218.*
- For this device, the sensor excitation is constant current *@10μA +0.05%* and the input range is *0-7500Ω*.
- After testing, the CCS monitoring system that based on *Lake Shore Model 218* is suitable and the system works well.

Other temperature sensors





Assemble the LHe tank

- The tank will be used for reducing the consumption of liquid helium.
- The material is non-magnetic stainless steel.
- After the tank is installed, the magnet was put into the cryostat.

Final checkout before cooling

- The magnet was inserted into the cryostat.
- We did the insulation test of the coil to ground with five steps as 500V/1000V/1500V/2000V/2200V, all passed.
- The maximum test voltage is 2245V, and the resistance is more than 10 GΩ.
- The Test Time is 30s, the temperature is 23.5℃, and the relative humidity is about 34.7%.

HV test of Aperture V1

HV test of Aperture V2

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Final checkout before cooling

Other tests:

- Power the Aperture V1 and Aperture V2 with 0.05A, and measure the continuity of the magnet's voltage taps.
- Turn on the QPS, and then give the QDS an artificial signal to trigger quenching, the QDS works well.
- Turn on the DAQ system to check the signals that from CCS sensors, other temperature sensors, liquid level monitors, etc. All sensors and the DAQ system are working well

Checkout of the continuity

	Summary of the checkout	
Items	HV test	√
	QPS	√
	DAQ System	√
	Magnet-field Measuring System	√

Schedule of cold test

June															
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T
warm preparation		First cooldown max dT=30K					First cold powering					warm up			

July															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T
re-instrumentation			Second cooldown max dT=30K				Second cold powering					warmup			

Cold test plan-1 （First cool down）

- 1. **Electrical insulation test in air**
  - V1 to ground: 500V, 1000V, 1500V, 2000V, 2200V
  - V2 to ground: 500V, 1000V, 1500V, 2000V, 2200V
  - Leak current and duration: 10 uA after 30 s
- **2. Continuity**
  - Measure the continuity of the magnet’s voltage taps at 50 mA
  - All temperature sensors

Cold test plan-2 （First cool down）

- **Cool down**
  - ✓RRR measurement： Current: 10 mA.
    Segments: V1 and V2, and each third of V1 and V2
  - ✓Temperature monitoring
    Max dT<30k
- **Electrical insulation test in LHe**
  - ✓Coils to ground: 500, 1000V

Cold test plan-3 （First cool down）

- **Cold powering tests, low current verification, aperture V1 and V2 respectively.**
  - ✓ Protection verification and splice measurement
  - ✓ Connect the EE units in series with R_dump (2 Ω)
  - ✓ Power V1 or V2 to 10, 50 and 100 A , 200 A ,300A@ 2A/s with plateaus of 300 s, then manually trigger QPS
  - ✓ Analysis of quench hot spots

Cold test plan-4 （First cool down）

- **Sensors installation and I-B curve measurement**
  - ✓ V1 or V2: The Hall probe shaft in the center of the anti-cryostat
  - ✓ Check the location of and angle of the Hall probe
  - ✓ Get magnetic field and field direction of V1or V2 respectively with the current
  - ✓ DTM151(Digital teslameters)+MPT141(Hall probe)

    Accuracy is 0.01% of reading + 0.006% of full scale

    Resolution of 0.01 Gauss

    Maximum field 3 Tesla

Cold test plan-5 （First cool down）

- **Cold powering tests, high current training , aperture V1 and V2 respectively.**
  - **Protection studies and training to Nominal Current (393 A)**
  - **Training and holding current to Ultimate Current (435 A)**

    Power V1 and V2 respectively to 393 A @ 4 A/s

    Verify that QI and V_max are in limits

    (QI from trigger < 23-25 kA2s, V_max < 900 V)

    If there is a quench, note and repeat.

    If there is no quench, hold the current for 0.5 h
  - **I-B curve measurement**

    The Hall probe shaft

    Get magnetic field and field direction with the current during the training

Cold test plan-6 （First cool down）

Splices and inductance measurement, aperture V1 and V2 respectively to Nominal Current (393 A)

- ✓ Connect DMM and measure current and voltage of the coils V1 and V2, and each third of V1 and V2 (1HZ~10HZ)
- ✓ Power V1 or V2 from 0 to 393 to 0 A @ 2A/s or 4A/s wait 0.5 hours
- ✓ The plateaus for splices measurement
- ✓ Estimate inductance from the ramp and decay signals （1KHZ）

Cold test plan-7 （First cool down）

- **Magnetic measurements to Nominal Current (393 A) ,aperture V1 and V2 respectively.**
- The power supply is Unipolar
- Rotating coil installation
- Individually powered apertures test of V1(0 current in V2)
- Crosstalk test of V1(I_{nom} in V2, –I_{nom} in V2)
- Individually powered apertures test of V2(0 current in V1)
- Crosstalk test of V2(I_{nom} in V1, –I_{nom} in V1)

Cold test plan-8 （First cool down）

- **Final electrical tests at cold**
  Coils to ground: 500, 1000V

- **Warm up**

Thank you !!

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