Short Model, Prototype and Series Program of MCBRD in China

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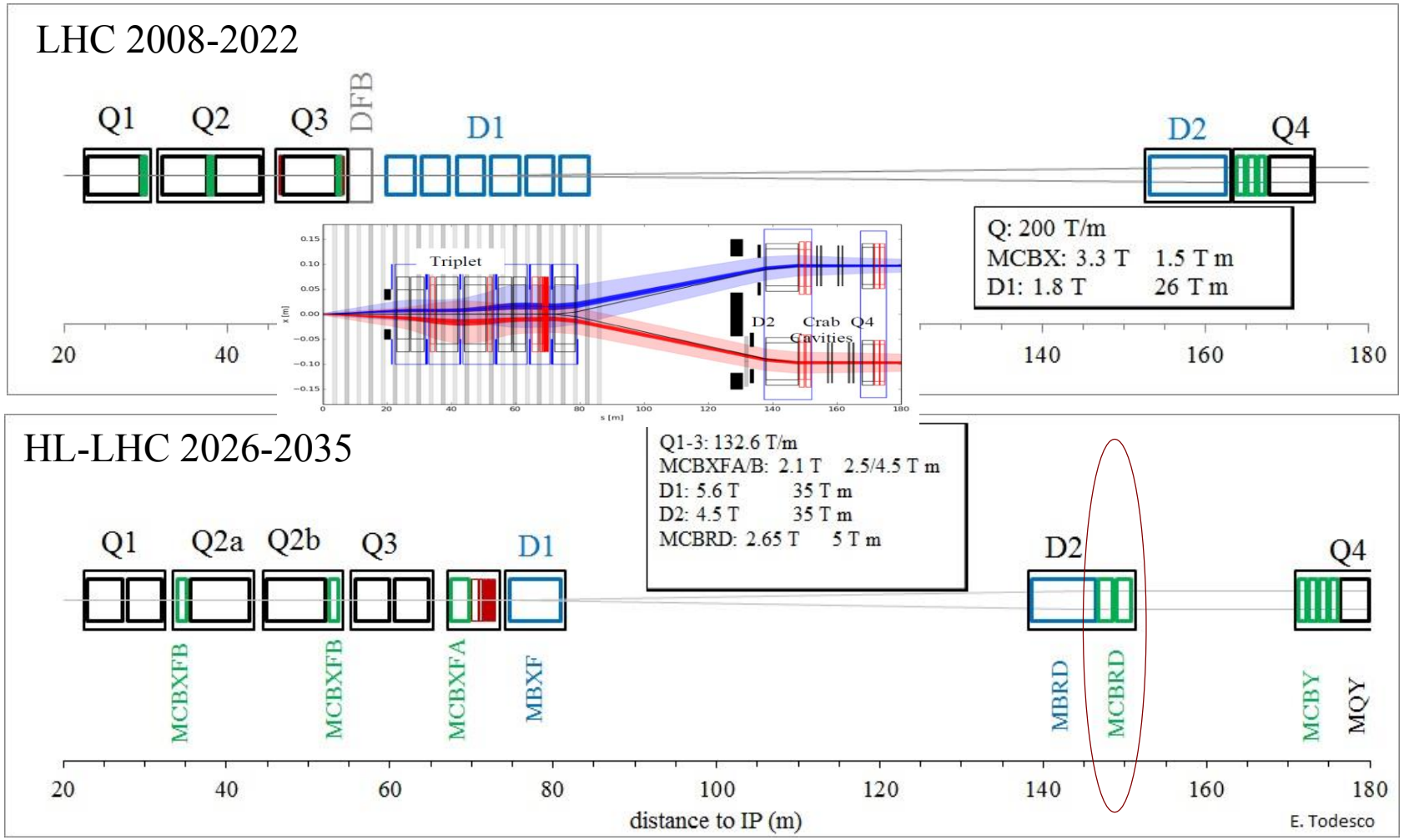
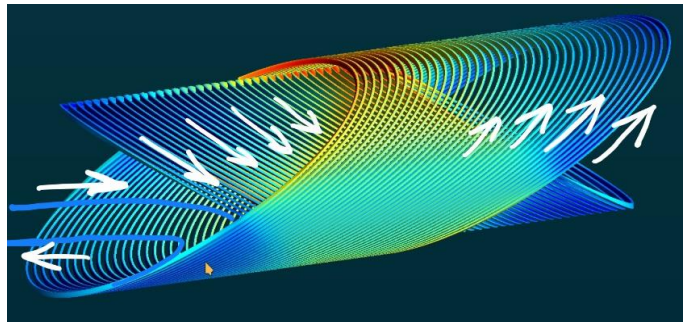
Outline

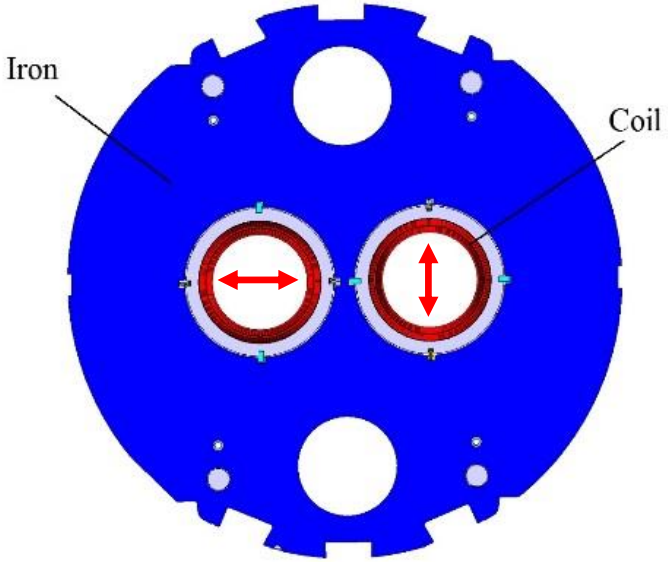
- MCBRD: orbit corrector magnets for HL-LHC

  Main requirements and parameters from CERN
- CERN-China Collaboration for HL-LHC: Start from CCT
- Development of the 0.5-m Model in China
- Schedule of the 2.2m Prototype and Series
- Technology transfer from CERN to China
- SC Magnet Experiences of Chinese Team
- Summary

MCBRD: the HL-LHC orbit correctors close to recombination dipole MBRD, providing a maximum 5 Tm integrated field in two apertures, vertical in one and horizontal in the other.

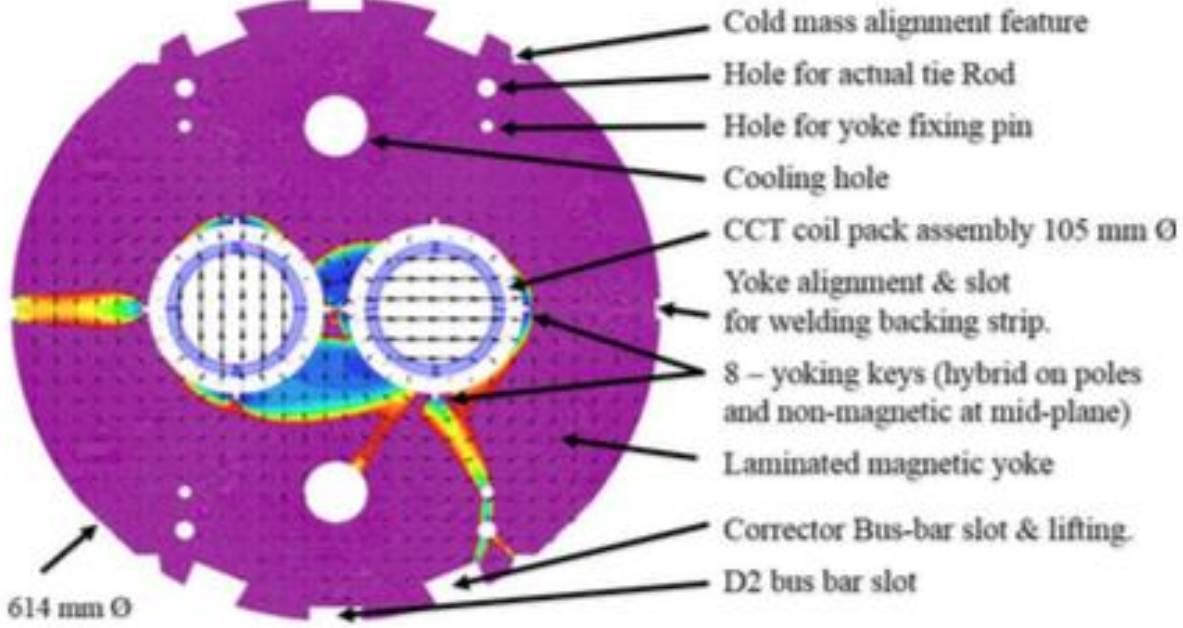


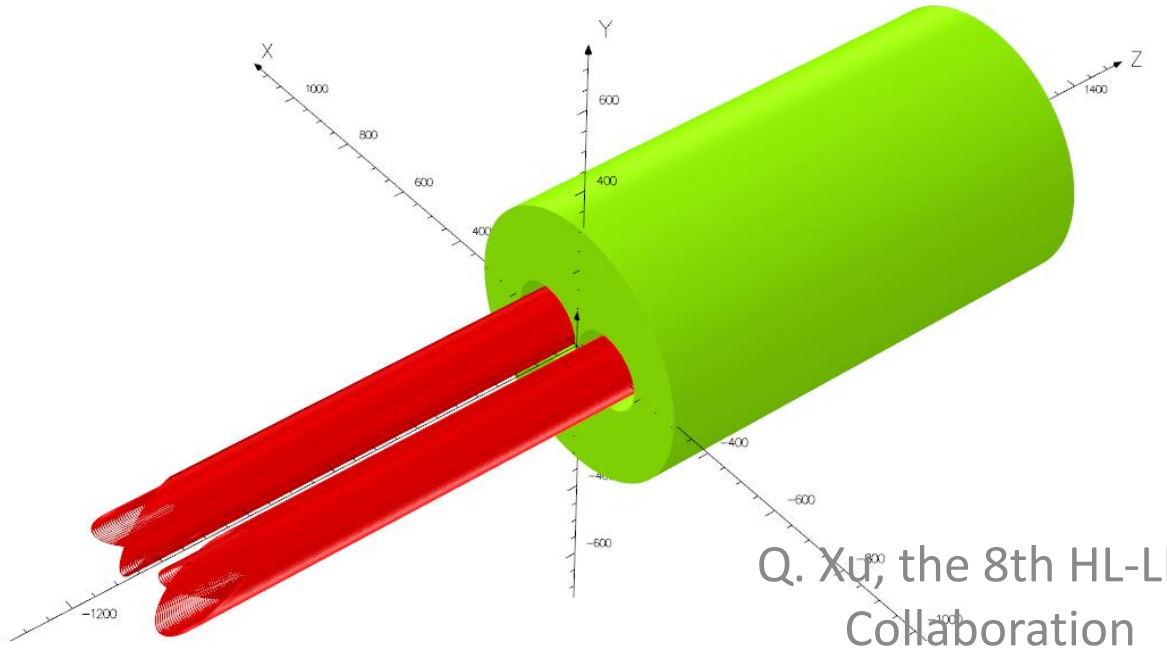




Requirements of MCBRD Corrector Magnets

- Yoke outer diameter of 614 mm to fit with the MBRD envelope.
- Operational current lower than 500 A to fit with the existing LHC power converters.
- Must be able to reach the ultimate field, 8% more than nominal integrated field.
- Physical length smaller than 2.2 m to fit in the layout.
- Load line not more than 55% at 1.9 K to guarantee adequate margin for this corrector type.
- Wire diameter 0.825 mm to reuse the wire used for the LHC inner layer cable.
- Wire insulation withstands 1200 V for coil to ground.
- Sustain 50 warm-up / cool-down cycles
- Resistant to a dose of 10 MGy.
- Multipoles less than 10 units in all operational conditions with 35 mm reference radius.





Structures and Main Parameters of MCBRD Magnets

Nominal current	A	435
Physical length	m	2.19
Peak field on the conductor	T	3.06
Loadline fraction3	%	55
Stored energy per aperture at nominal current	kJ	72.7
Inductance per aperture at nominal current	mH	820
Wire diameter	mm	0.825
Wire insulation thickness	mm	0.0875
Max filament diameter	mm	0.050
Minimum Ic at 5 T, 4.2 K	A	450
Minimum Cu/No Cu		1.5
Wire length per coil	m	2200
Total wire length per magnet (two apertures)	m	8800
CCT skew angle	degrees	30

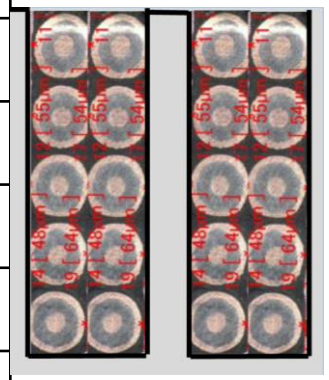
Q. Xu, the 8th HL-LHC Collaboration Meeting, CERN, Oct.

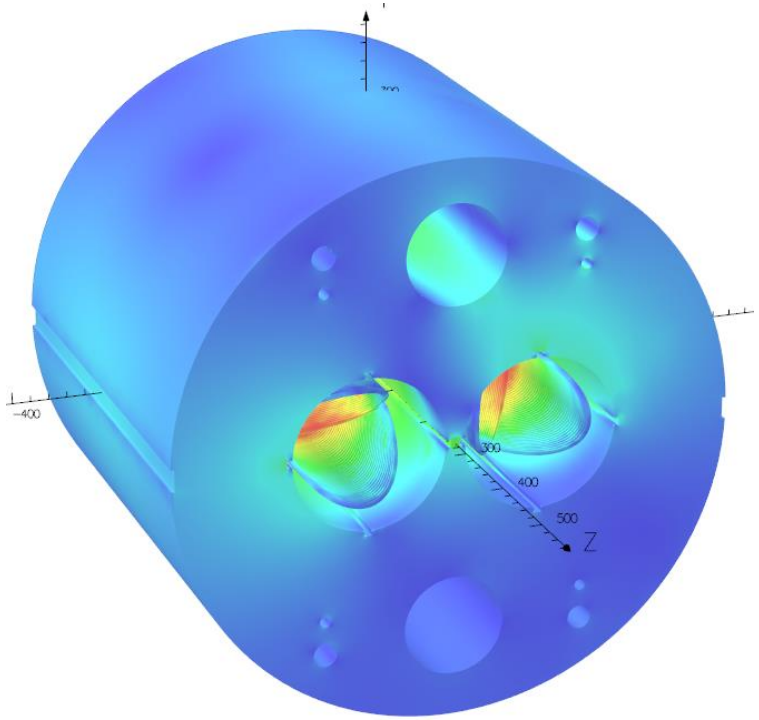
CERN-China Collaboration for HL-LHC

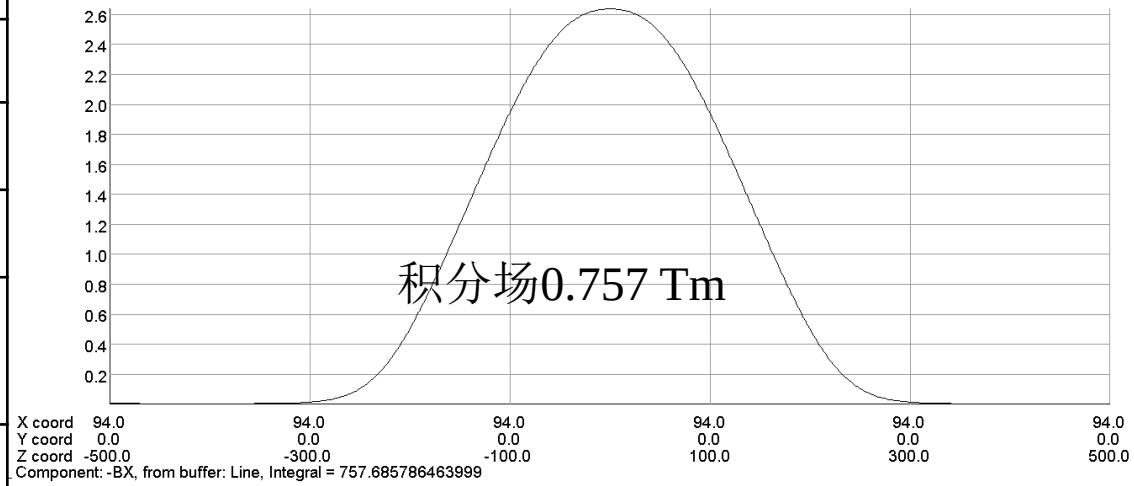
- MoU formally signed for CCT magnets in September 2018
- China will provide 12 units of CCT magnets for HL-LHC before 2022
- A 0.5m model is under construction, and 2.2m prototype to be fabricated and tested by June 2019

Development of the 0.5-m Model in China

Bore field / T	2.64
Current / A	422
Layers	5+5
CCT angle /°	30
Turn width /mm	5.2(0.6)
Turns per layer	55
Integrated field / Tm	0.757
Peak field / T	3.1
Io/Ic	55%
Slot size in former	2 mm*5 mm,0.6 mm for rib
Iron yoke size/mm	Φ614/539.4
Inside and outside the former/ mm	The first layer: 105 /1119 ; The second layer: 119 /133
Dia of wire / mm	0.825(767A@3T 700A@4T) 0.99(with insulation)

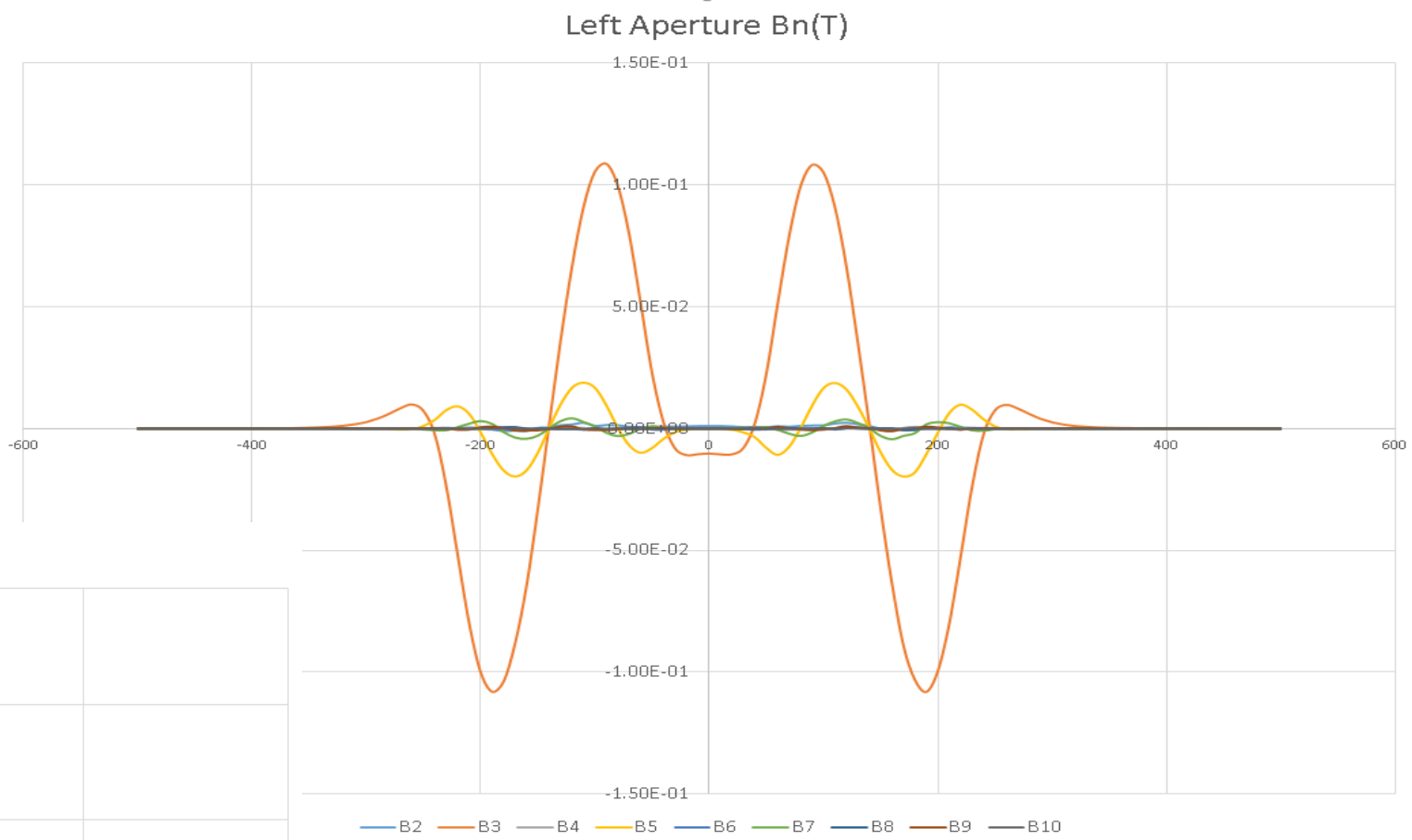


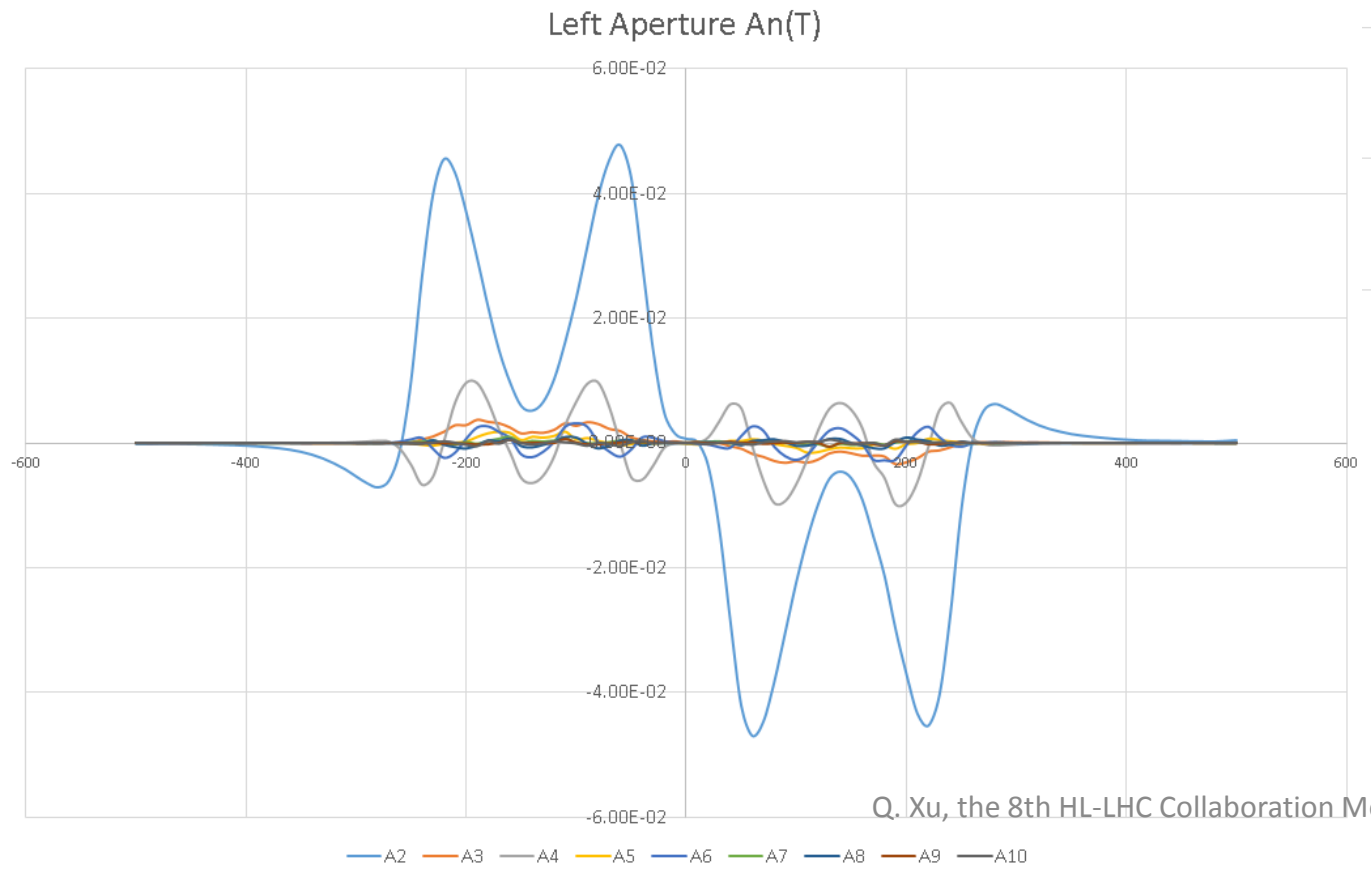


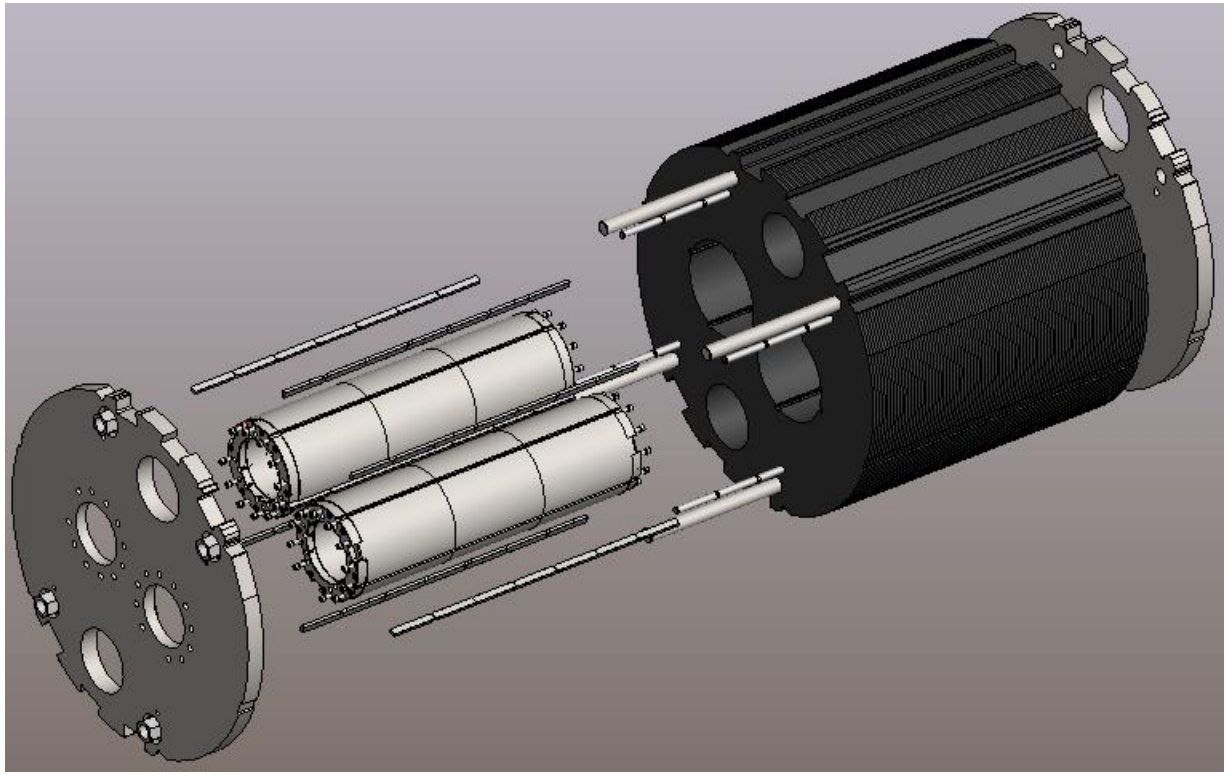


B_x along the axial direction (right aperture)

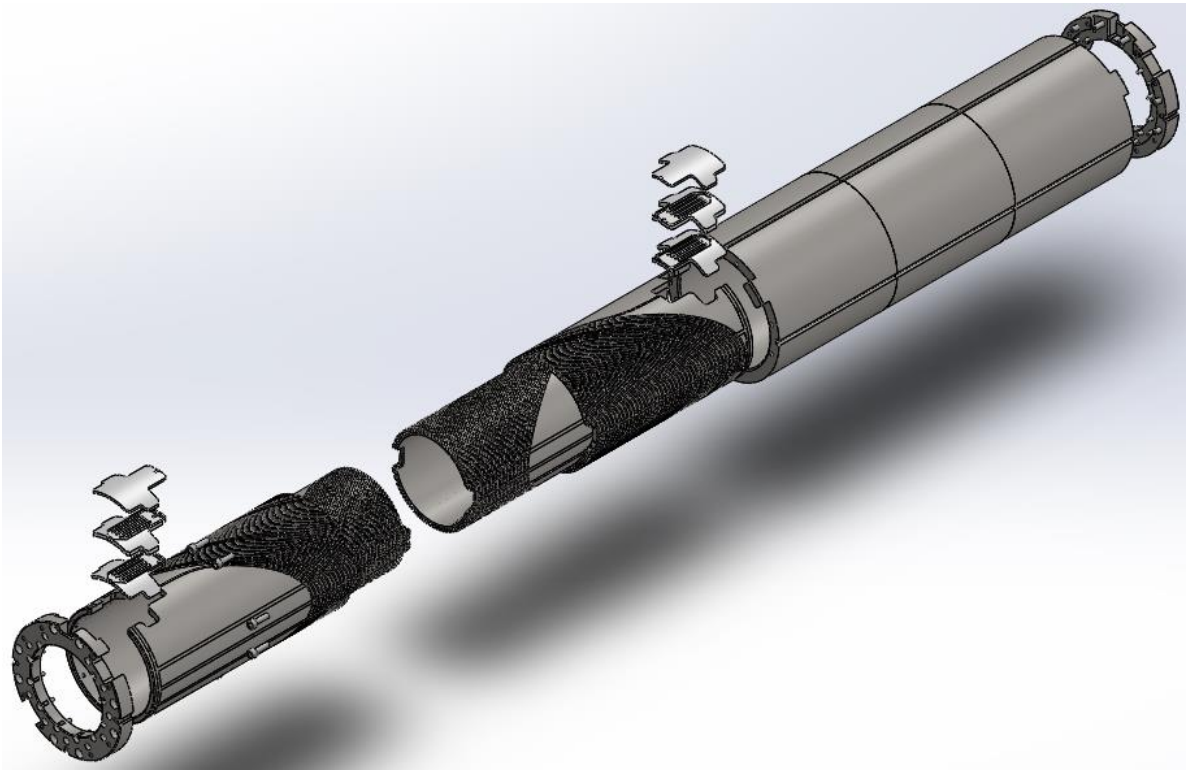
High Order Multiples of the 0.5m Model
(simulation results)







The whole structure



The coil structure

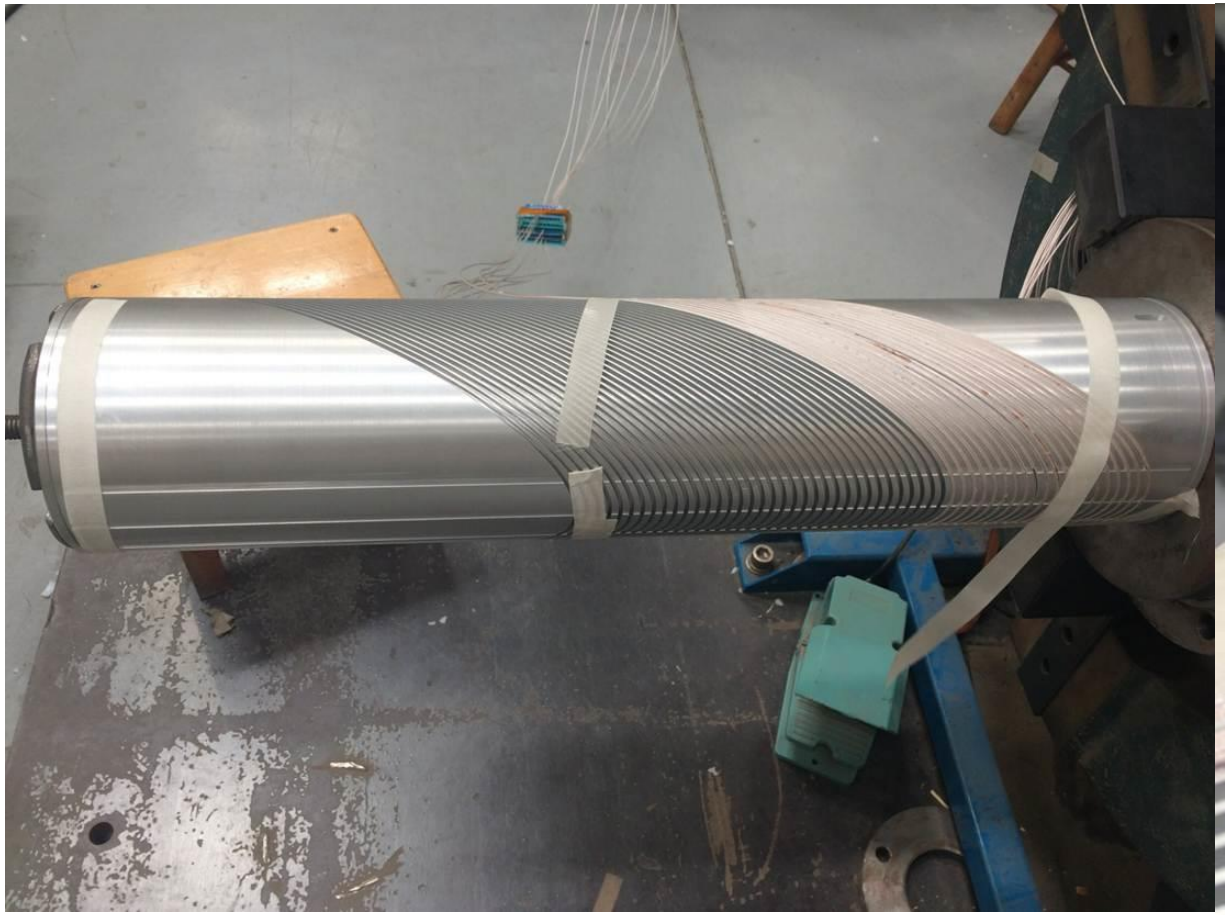
Parameters of superconducting wire

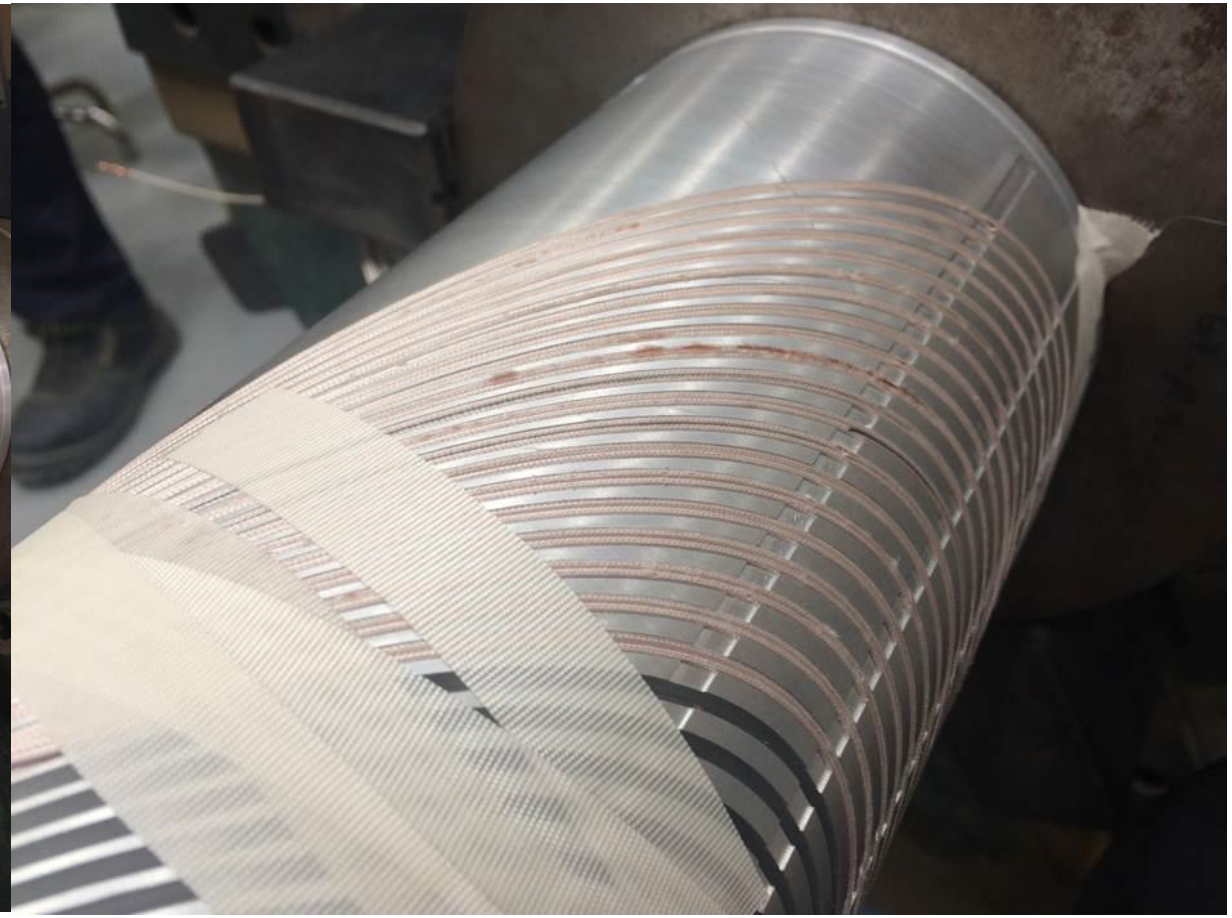
Insulated size (mm)	Insulation meterial	Number of filament	Cu/non-Cu ratio	Critical current@4.22K (A)	RRR(273K/ 10K)
Φ0.99±0.01	Kapton+S glass	≥192	1.3±0.13	>767@3T, >700@4T	>100
Insulation voltage >2500V					

Three-coordinate Measurement of the Outer Former

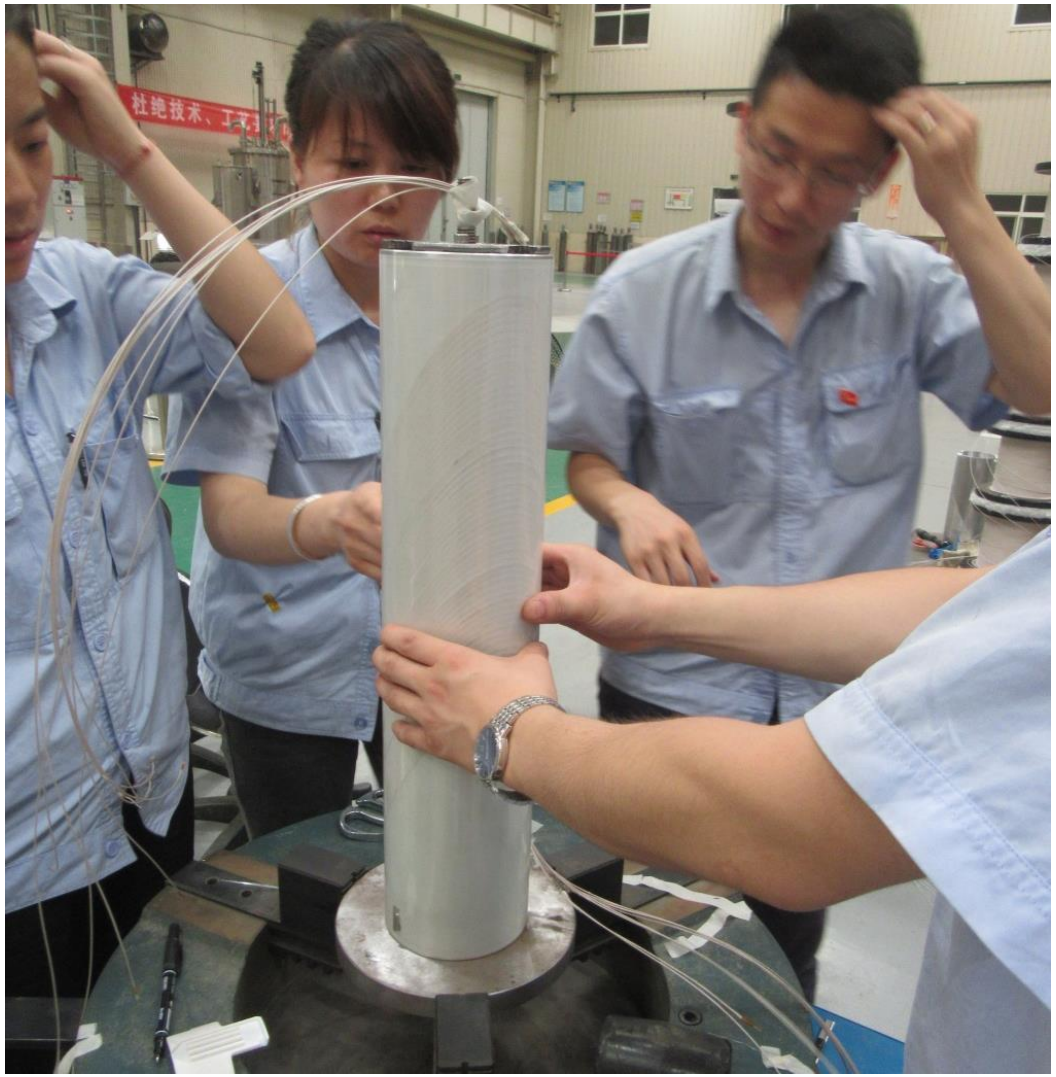
	1# outer former1	2# outer former1	1# outer former2	2# outer former2	Criterion
Groove bottom size（different grooves）	-0.0239	-0.0437	-0.0983	-0.0442	122.6-123
Groove bottom size（same groove）	-0.0218	-0.0377	-0.0415	-0.0121	122.6-123
Inner circle size	-0.0214	-0.0118	-0.0066	Qualified	118.98-119.035
Outer circle size	0.0029	Qualified	Qualified	Qualified	132.97-133.028
Groove width	Qualified	1.9965	Qualified	Qualified	2-2.04
Groove profile	Qualified	Qualified	Qualified	Qualified	0.05
Inner circle roundness	Qualified	Qualified	Qualified	Qualified	0.03
Outer circle roundness	Qualified	Qualified	Qualified	Qualified	0.03
Coaxially	Qualified	Qualified	Qualified	0.0329	0.03

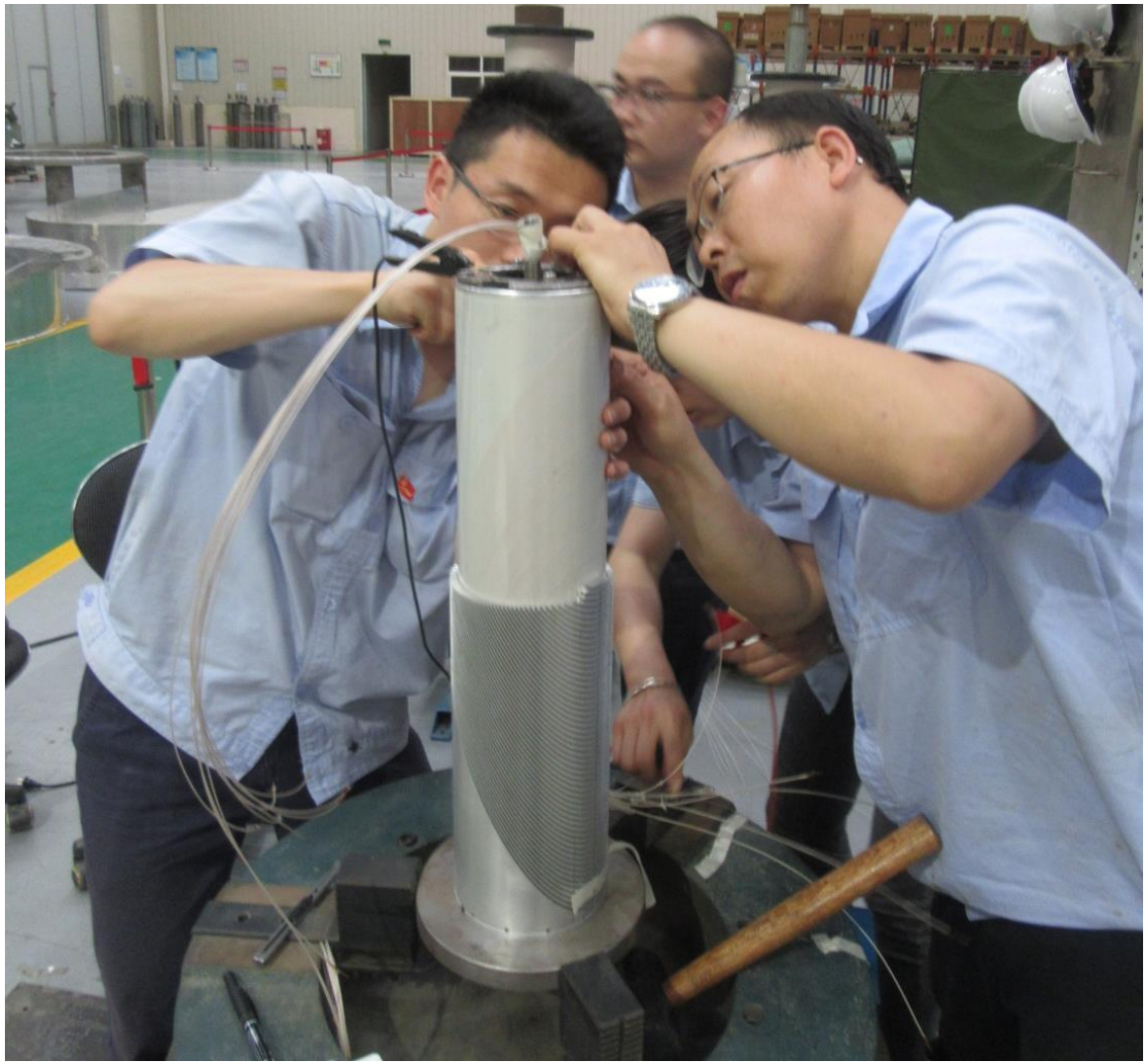
Coil Winding



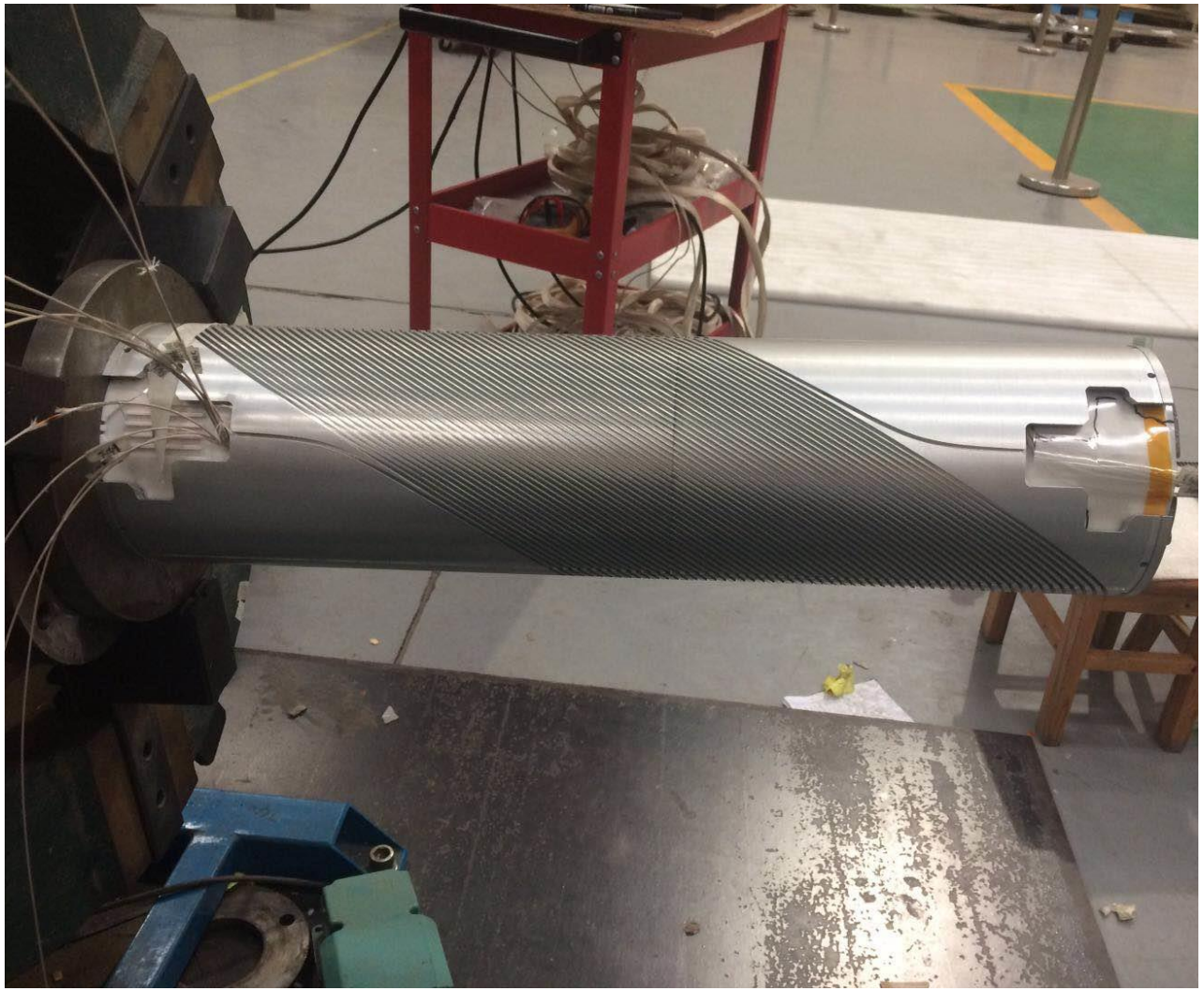


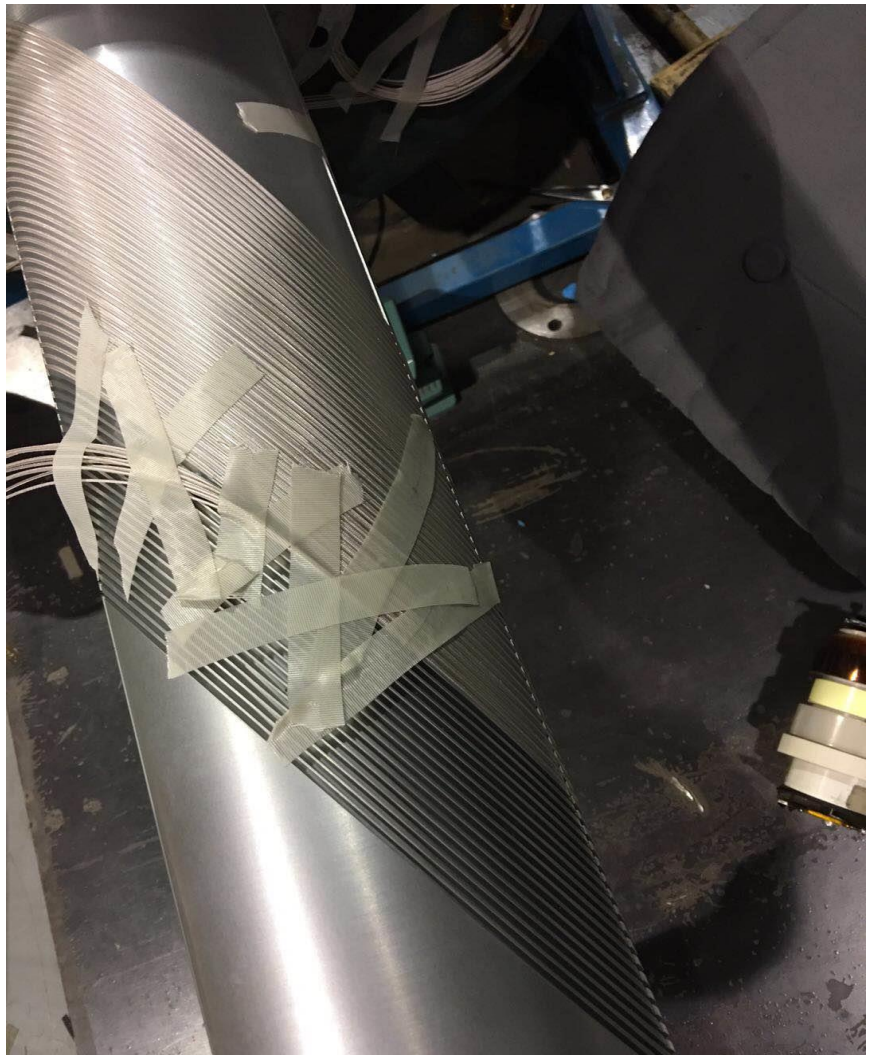
Coil Winding



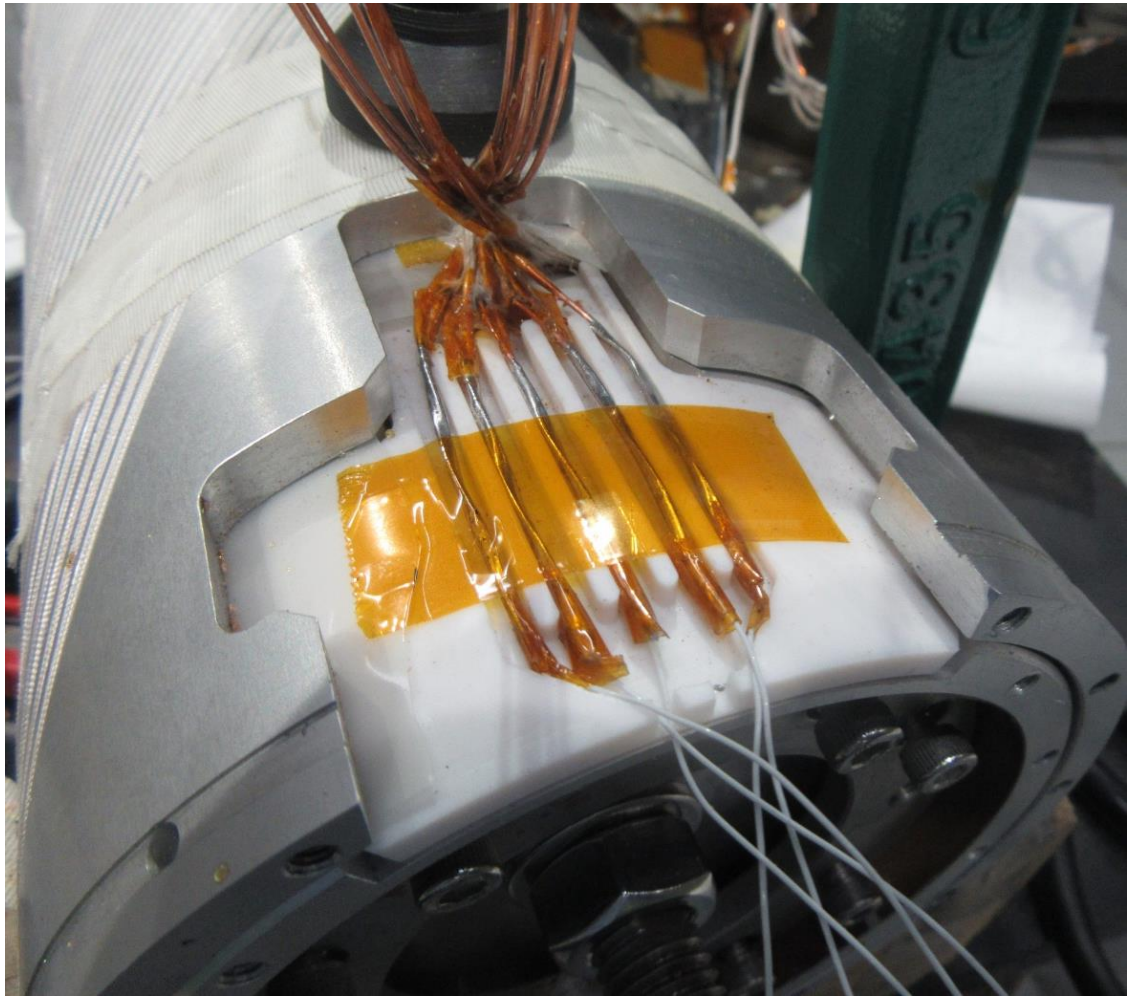


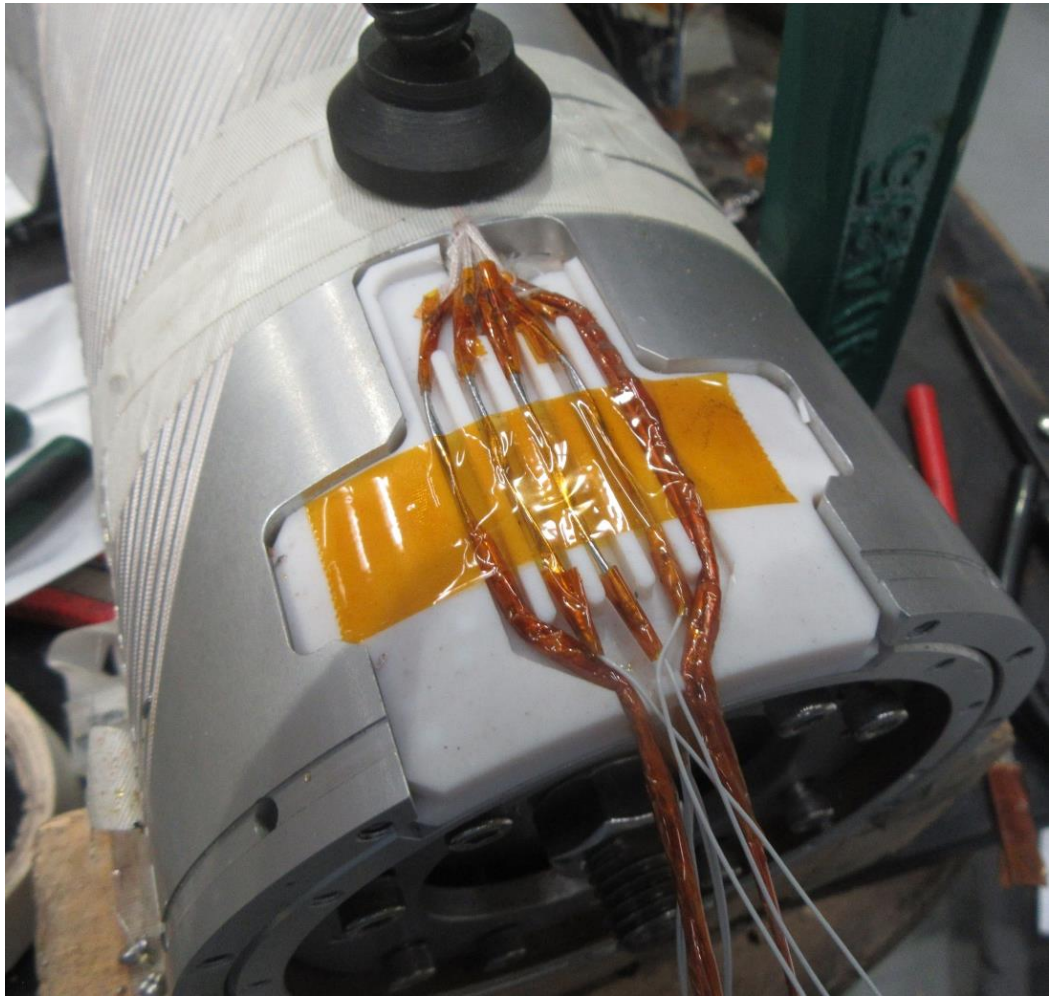
Coil Winding





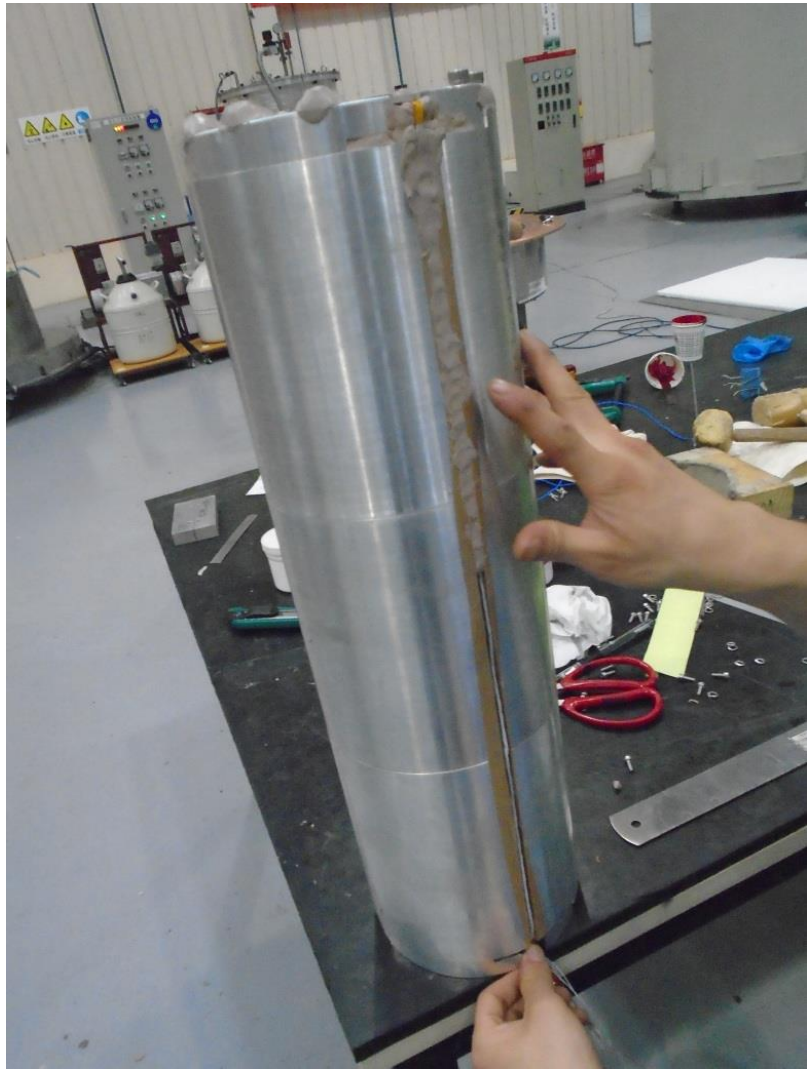
Splicing



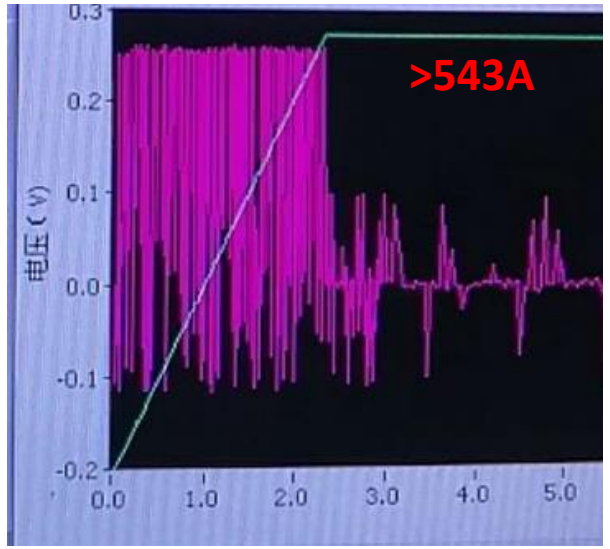


Assembly of the Coil Pack

Vacuum Impregnation tools

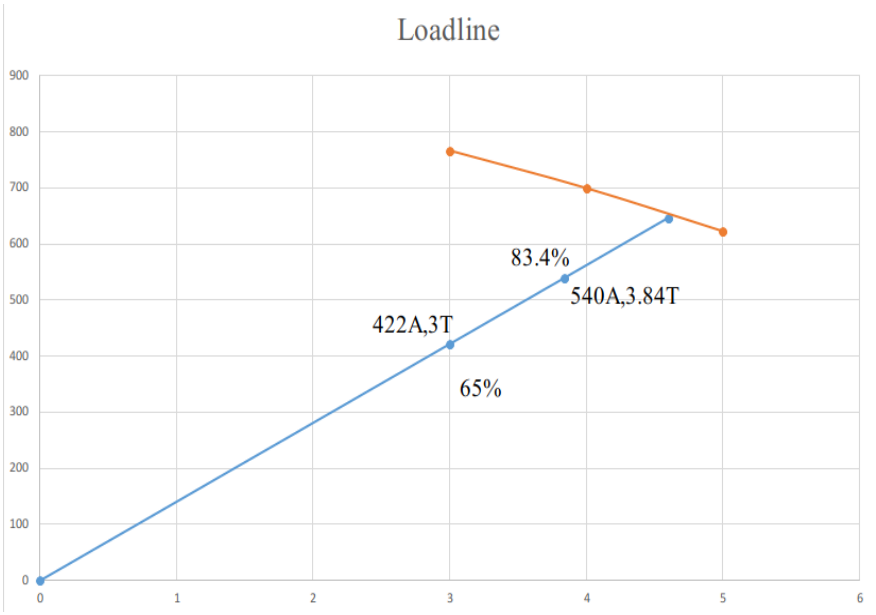


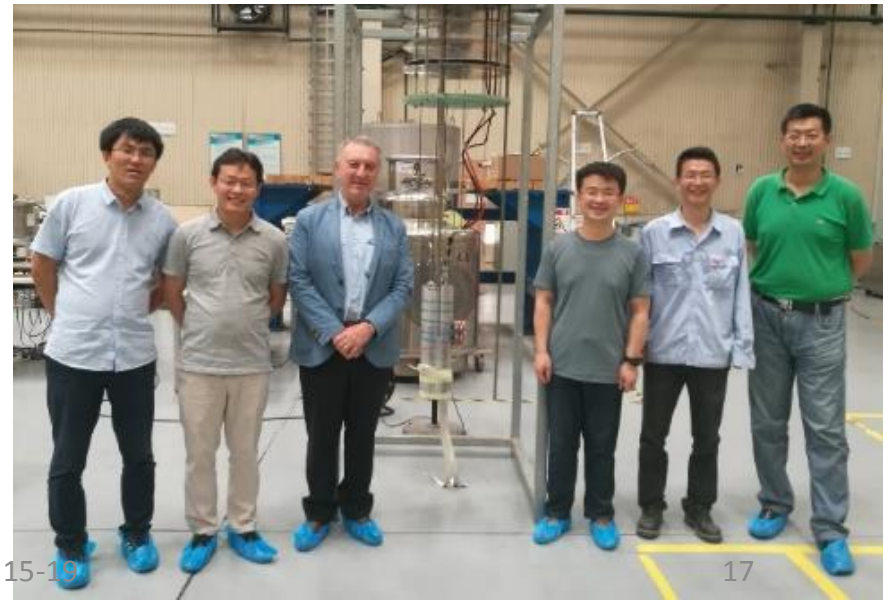
Test of the 1st Model Coil



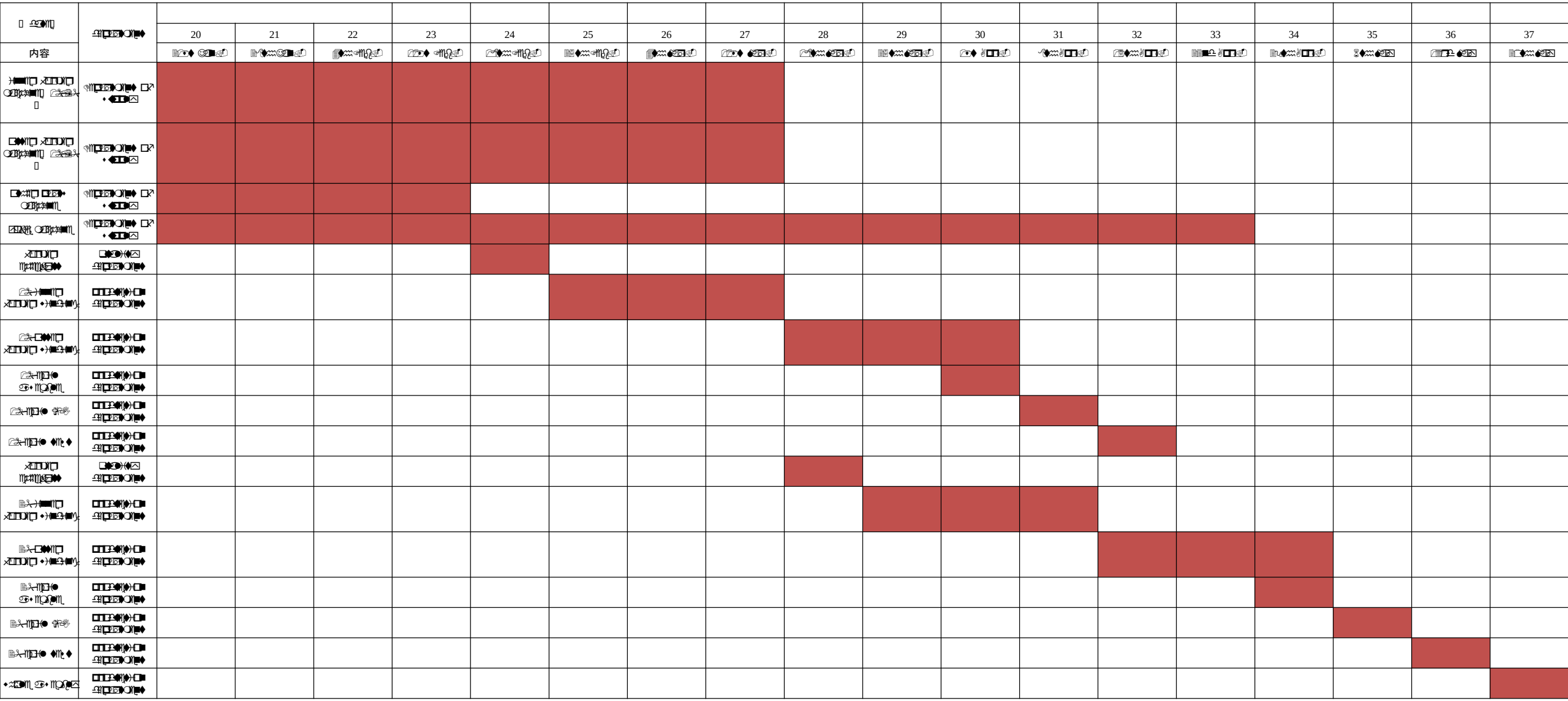
Test Procedures

data	time	details	comment
2018/7/14	8:40	cooling by LN2	check
2018/7/14	9:20	cooling by LN2	76K, 75k
2018/7/14	10:05	discharge of LN2	77K.76k
2018/7/14	11:00	dry under nitrogen	98K,88K
2018/7/14		dry with heating	
2018/7/14	12:20	cooling by LHe2	102K ,95k
2018/7/14	13:50	cooling by LHe2	41cm
2018/7/14	14:05	excitation 1A/s	
2018/7/14		excitation 2A/s	483A quench
2018/7/14	15:10	excitation 3A/s from 0 to 460A, 1A/s from 0 to 470A, pause，excitation	471A quench
2018/7/14	15:18	excitation 4A/s	469.4A
2018/7/14	15;28	excitation 4A/s	529A
2018/7/14	15:44	excitation 4A/s	543A
2018/7/14	15:49	excitation 4A/s	520A last 20 min, 551A quench





Schedule of the 2.2m Prototype

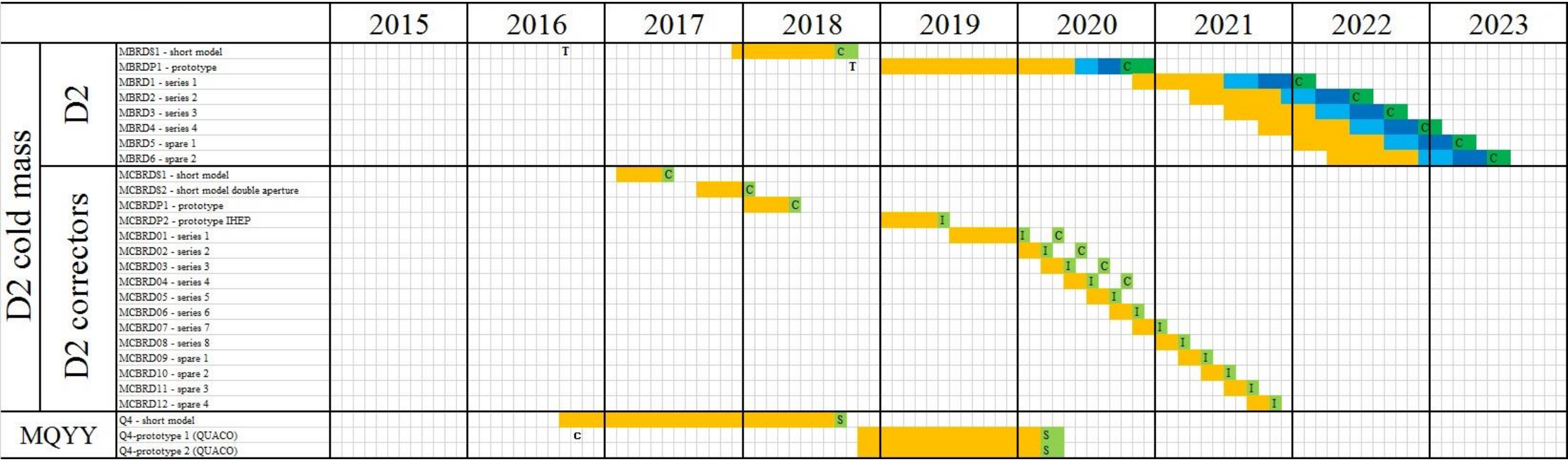


CERN SCHEDULE for D2 coldmass

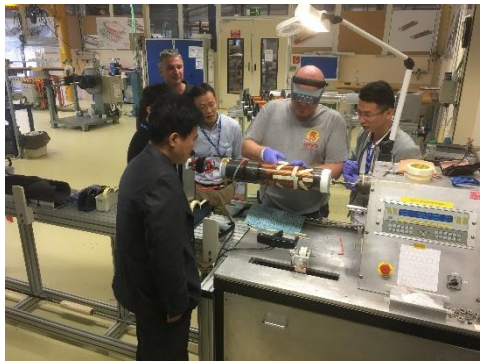
	Magnet construction
	Vertical test
	Cold mass assembly
	Cryostating
	Horizontal test

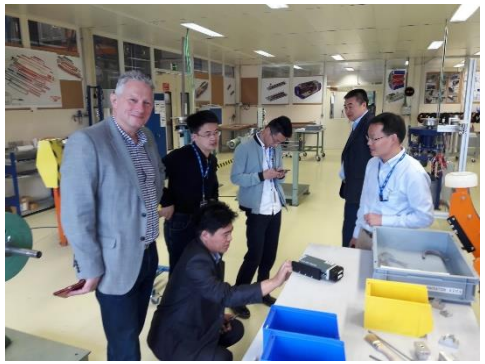
M	Mirror or single coil test
S	Slice (mechanical model)
T	Contract signed (ext. Contr.)
F	Finance committee

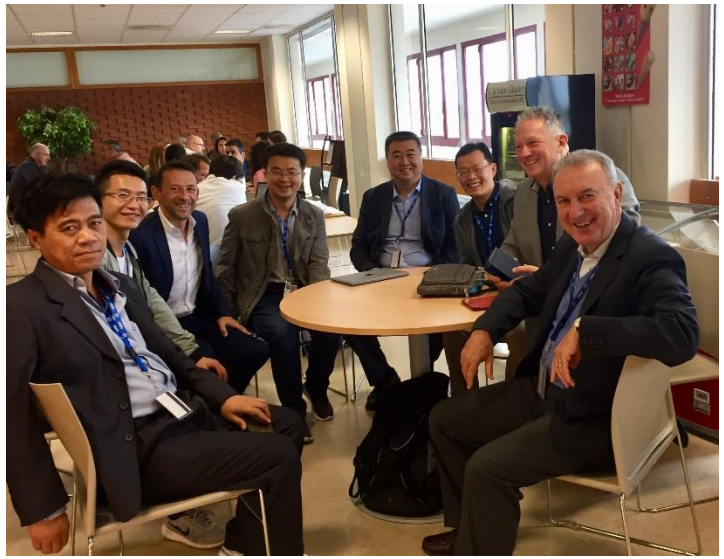
C	Test at CERN
B	Test at BNL
F	Test at FNAL
S	Test at Saclay
L	Test at LASA
K	Test at KEK
N	Test at FREIA
I	Test at IMP



Technology transfer from CERN to China







Monday 8th
- 14:00 to 14:30 Welcome and presentation of the Model Magnet Laboratory (Ezio, JCP & Glyn)
- 14:30 to 16:00 Presentation of the 3D model & drawings (Luca & Mathieu in 927 meeting room)

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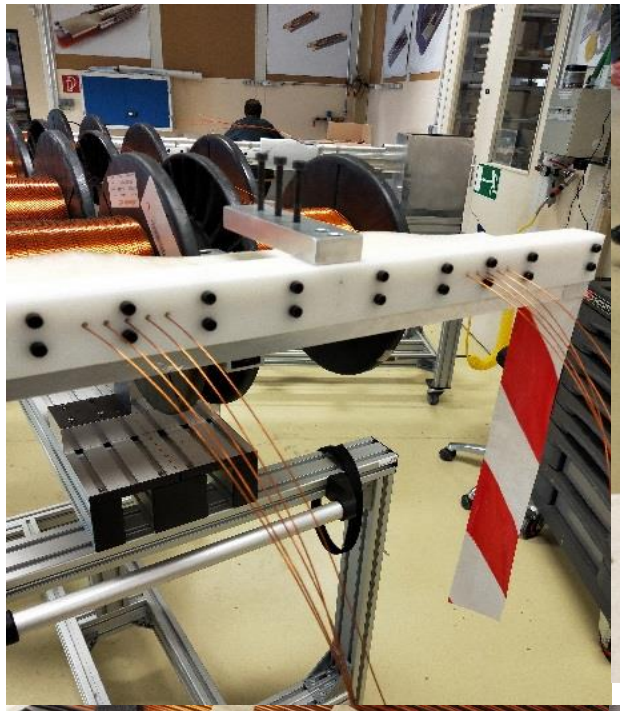
Tuesday 9th
- 08:30 to 09:00 Impregnation process (Remy)
- 09:00 to 11:45 Coil winding (Jacky)
- 12:00 to 13:45 Official lunch (Luca & Ezio)
- 14:00 to 15:00 Seminar in Building 30 (Qingjin)
- 15:00 to 16:00 Coil winding & Impregnation mould assembly (Jacky) Ezio's seminar
- 16:00 to 16:30 Presentation on Quench calculation by Matthias (room TBD)

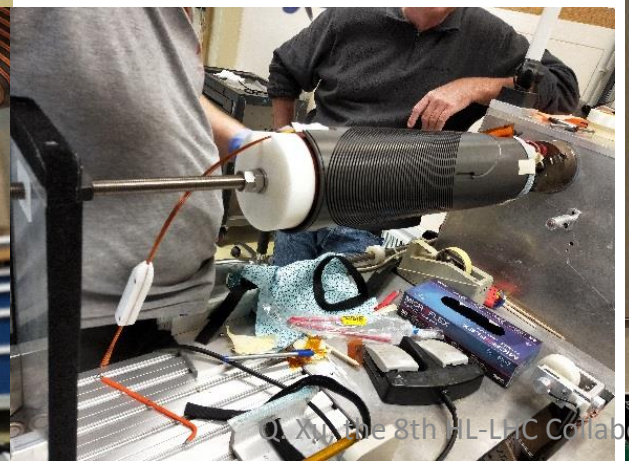
Wednesday 10th
- 08:30 to 12:00 Magnet instrumentation and splicing (Francois-Olivier)
- 13:30 to 16:30 Magnet assembly (Francois-Olivier)

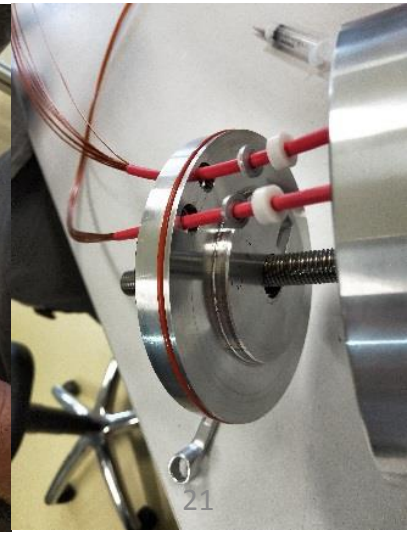
Thursday 11th
- 09:00 to 10:00 MDT engineering seminar in 927 meeting room (Ezio)
- 10:00 to 12:00 Electrical tests and documentation (Francois-Olivier)
- 13:30 to 16:00 Training on HL-LHC project documentation (Isabel & team)

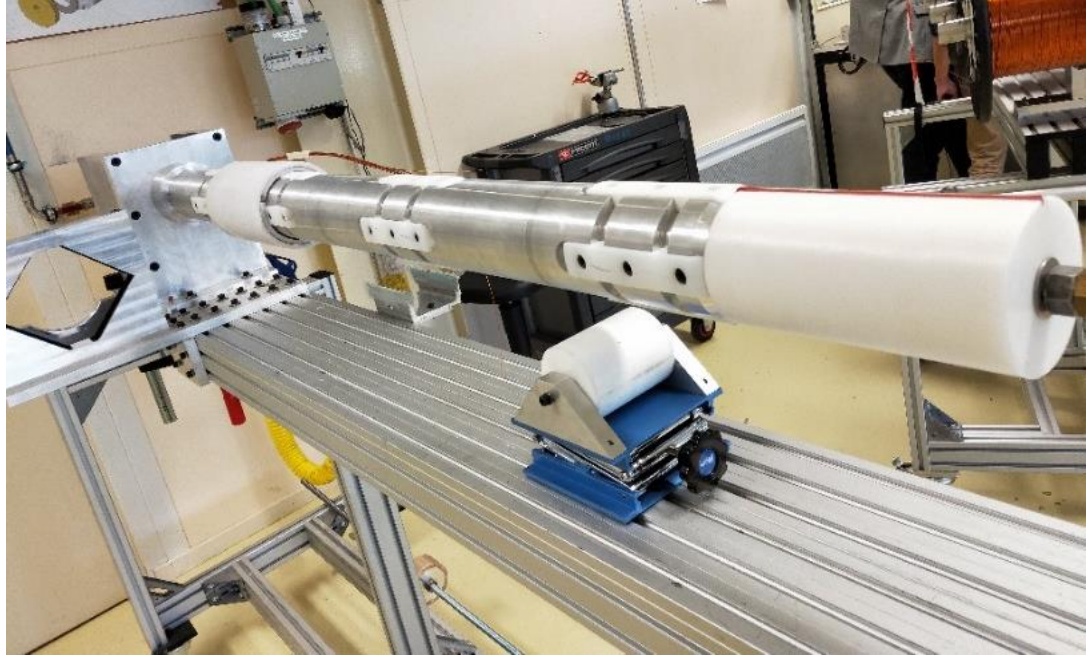
Friday 12th
- 10:30 to 12:00 Time for discussion with MDT team on open points (Ezio, Juan, Glyn & all)
- 14:00 to 15:30 specific QA/QC (Rosario)

Technology transfer from CERN to China

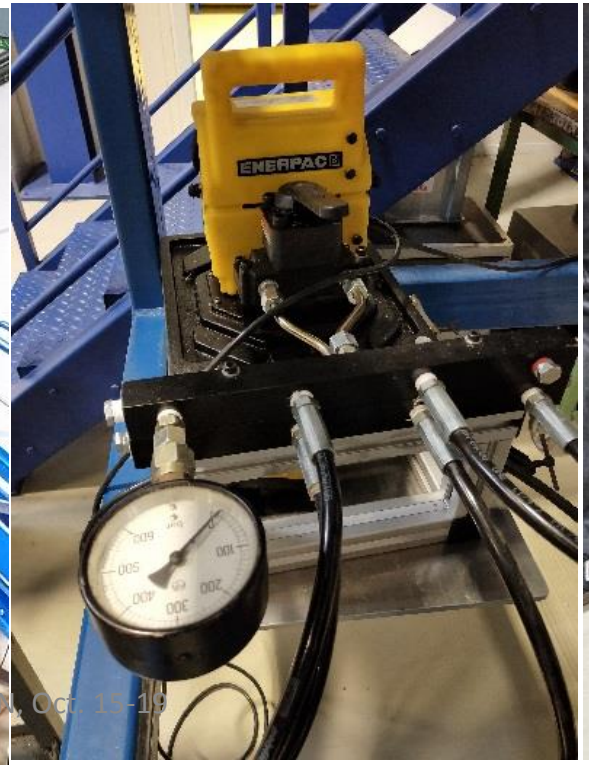


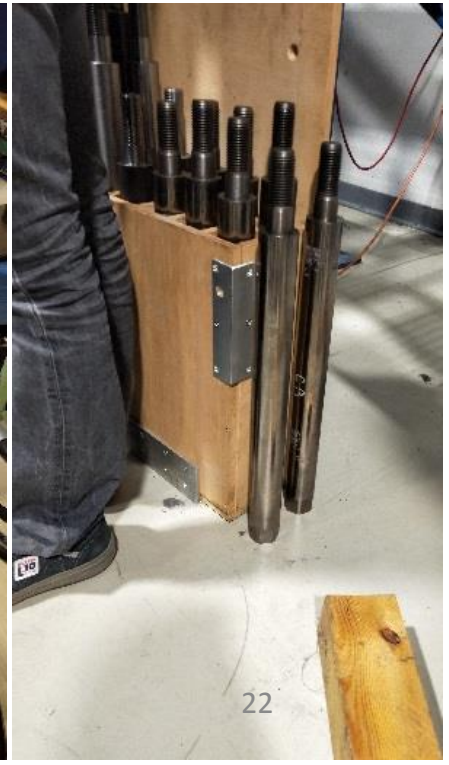






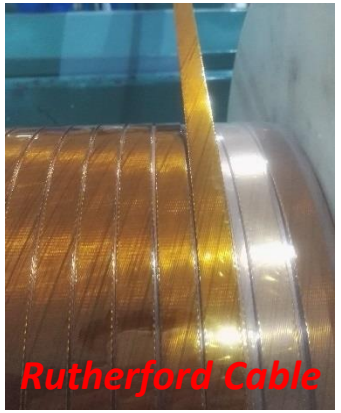

MQY27

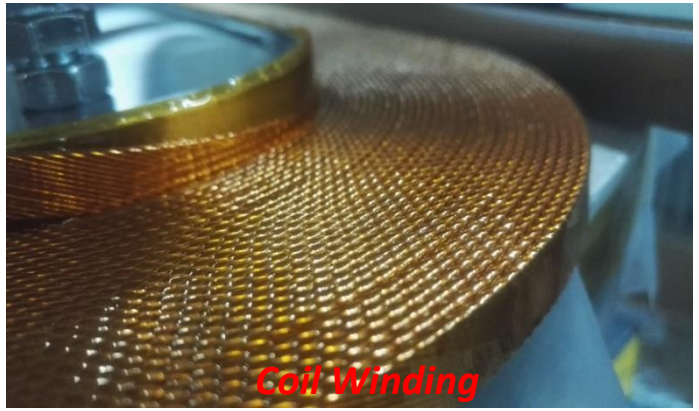

ENERPAC

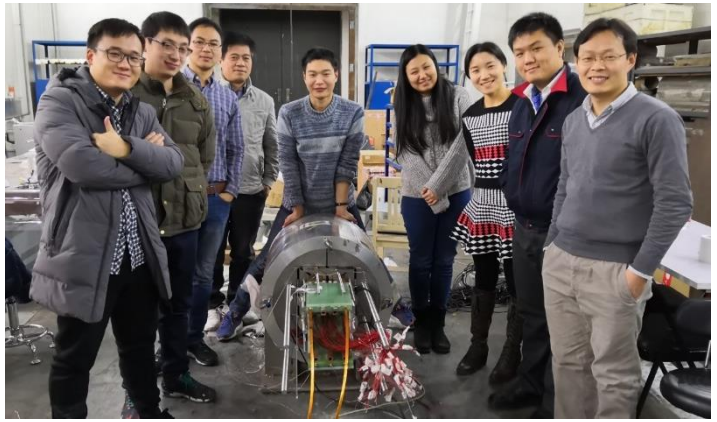


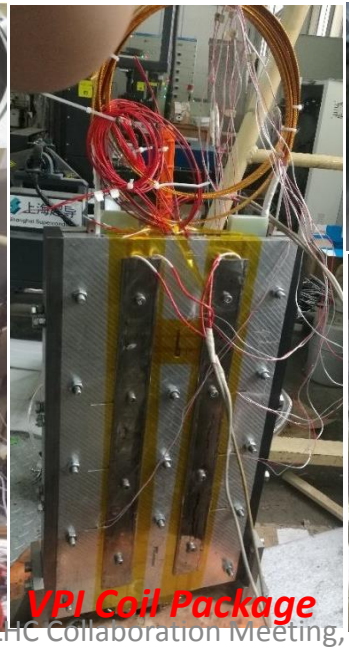
SC Magnet Experiences of Chinese Team

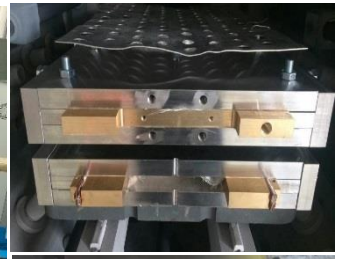
High field twin-aperture dipole magnet R&D: 10.2T @ 4.2K

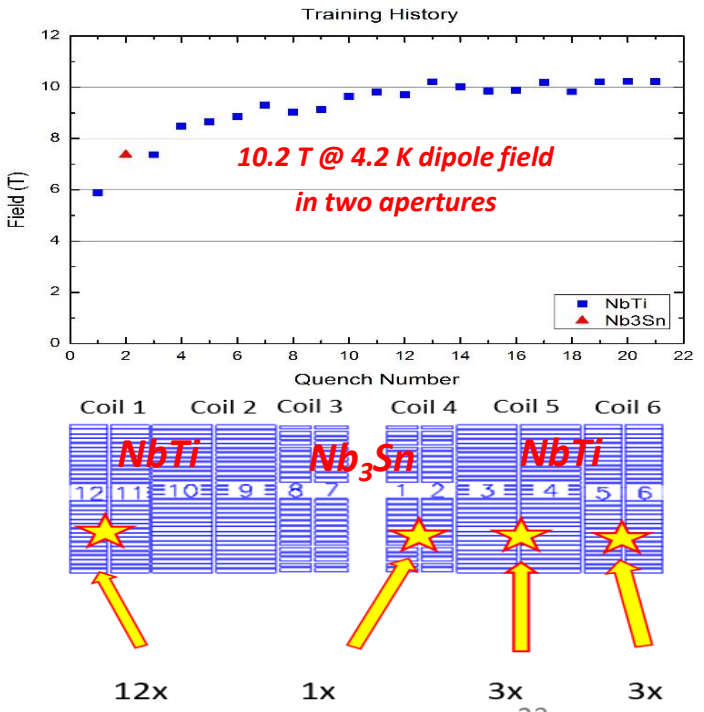








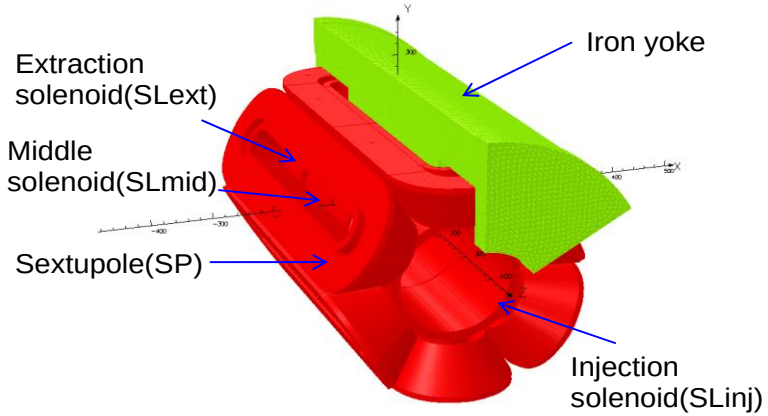




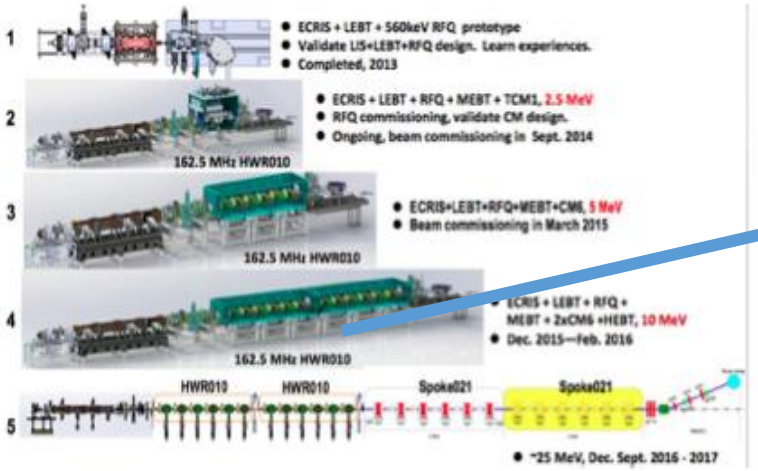
SC Magnet Experiences of Chinese Team

Super-FRS dipole prototype for FAIR

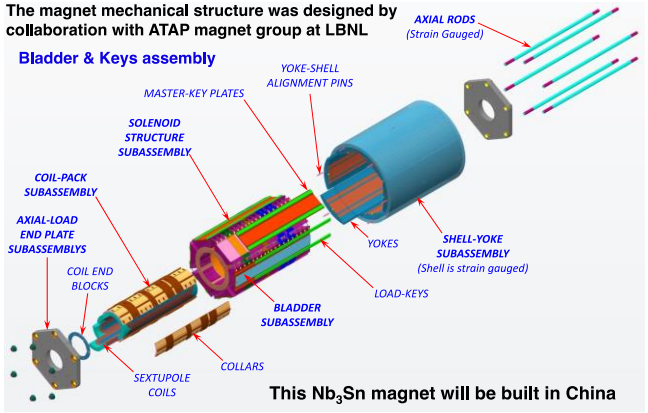
7T magnet for Penning trap



28 GHz ECRIS



Focusing solenoids for ADS SC Linac



45 GHz ECRIS (Nb_3Sn)

CCT magnet R&D

Summary

- *CERN-China Collaboration for HL-LHC has started with CCT magnet development*
- *The 1st 0.5m model coil has been fabricated and tested successfully in China*
- *The 2.2m Prototype will be fabricated and tested before next June, and the series will follow the CERN schedule*
- *Technology transfer from CERN to China has just been done*

Thanks a lot for everything and

Let's work together to do it well and in time!