Advancement of HL-LHC CCT Prototype and Schedule of Series in China

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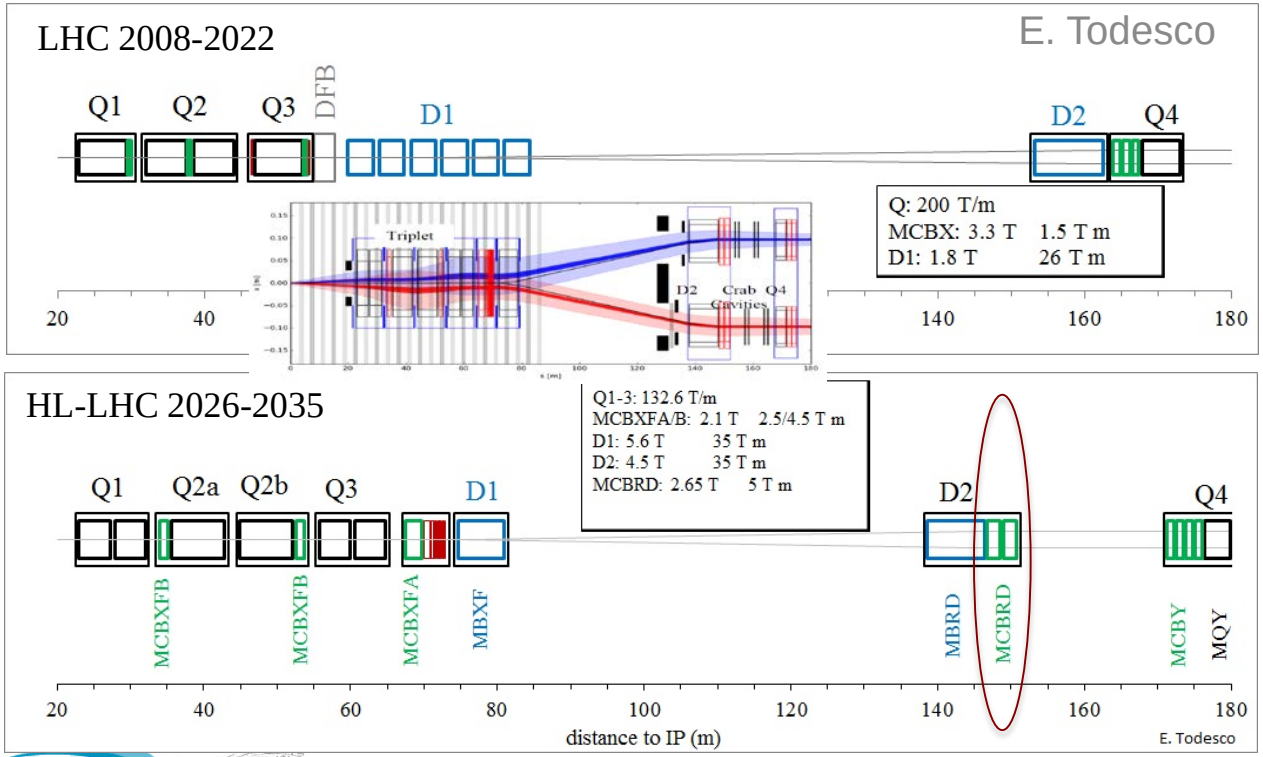
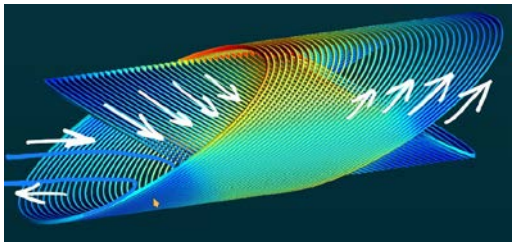
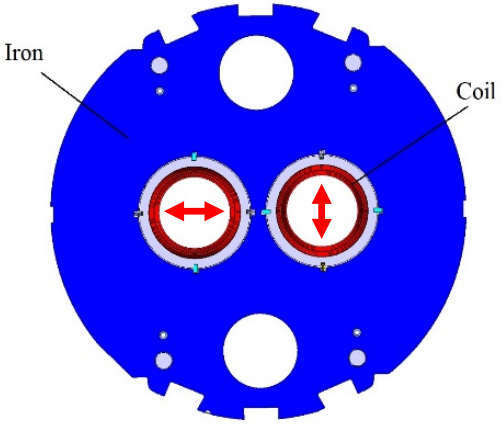
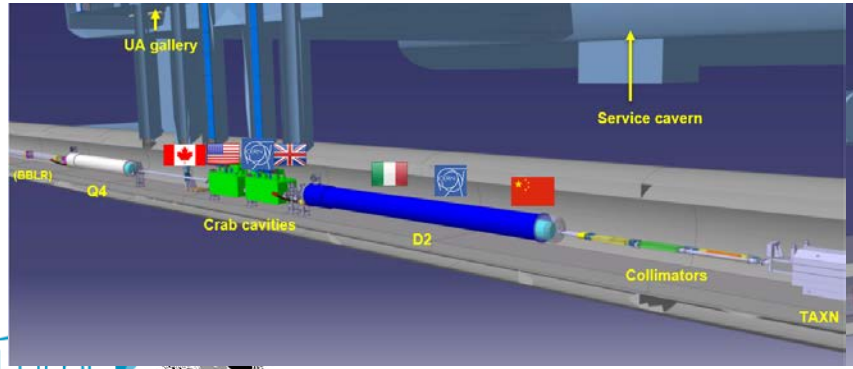
MCBRD: the HL-LHC D2 orbit correctors, providing a maximum 5 Tm integrated field in two apertures, vertical in one and horizontal in the other.

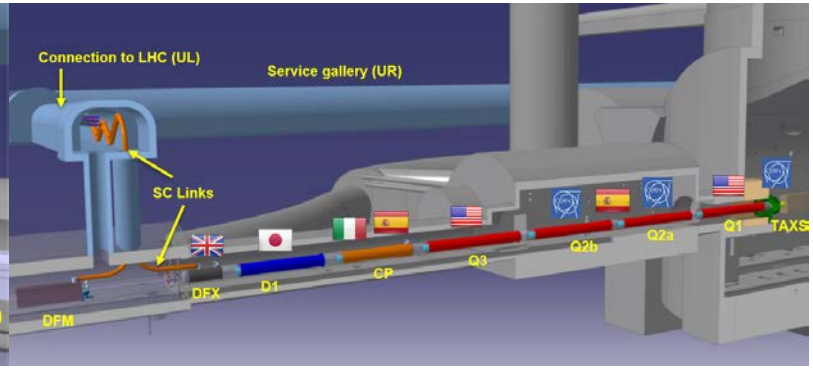


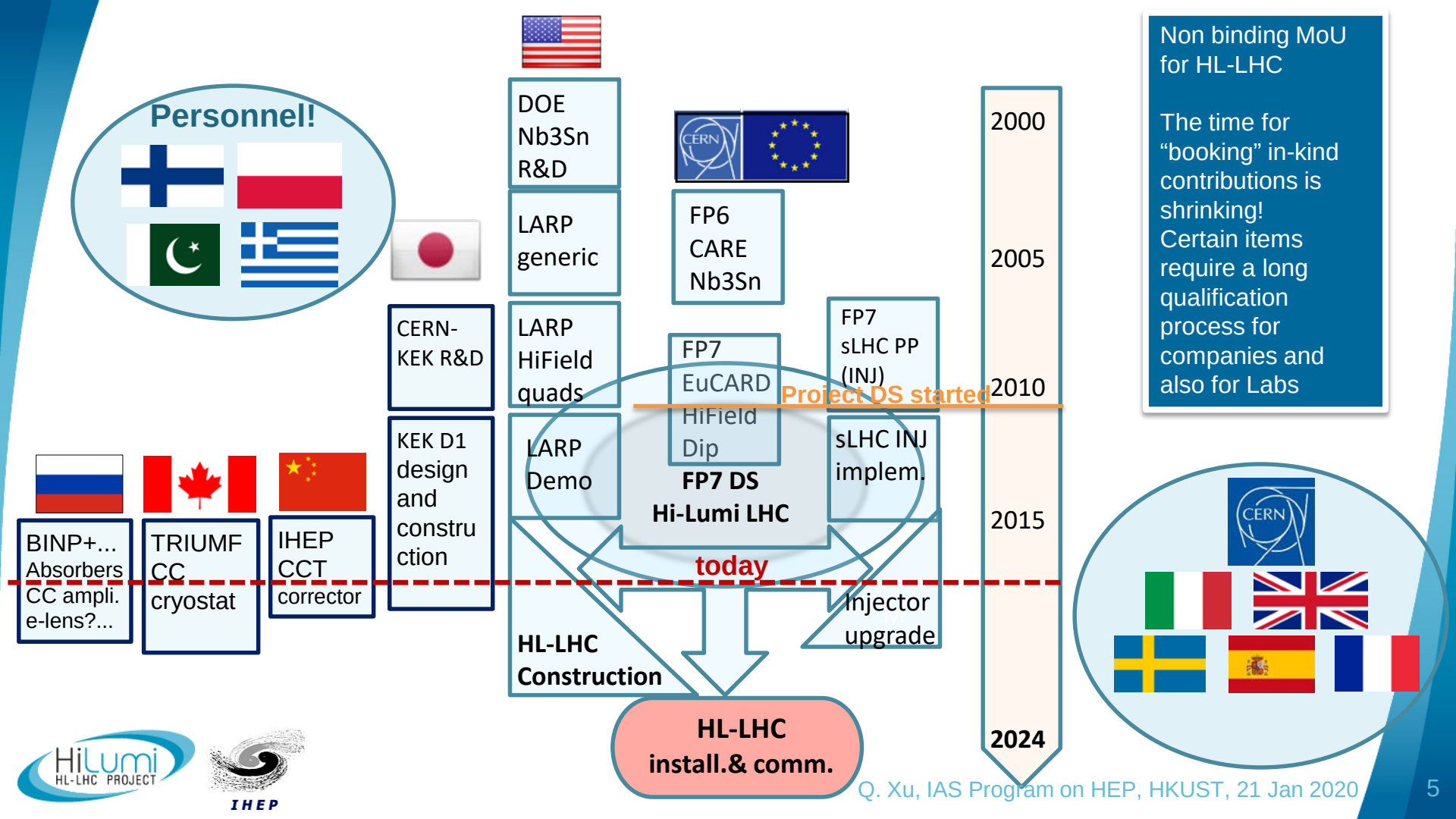




Agreement For HL-LHC CCT magnets signed in September 2018






Personnel!
DOE Nb3Sn R&D
LARP generic
LARP HiField quads
LARP Demo
FP6 CARE Nb3Sn
FP7 EuCARD HiField Dip
FP7 DS Hi-Lumi LHC
FP7 sLHC PP (INJ)
sLHC INJ implem.
CERN-KEK R&D
KEK D1 design and construction
BINP+... Absorbers CC ampli. e-lens?...
TRIUMF CC cryostat
IHEP CCT corrector
Project DS started
today
HL-LHC Construction
Injector upgrade
HL-LHC install.& comm.
2000
2005
2010
2015
2024
Non binding MoU for HL-LHC
The time for "booking" in-kind contributions is shrinking!
Certain items require a long qualification process for companies and also for Labs

Reminder of collaboration scope and deliverables

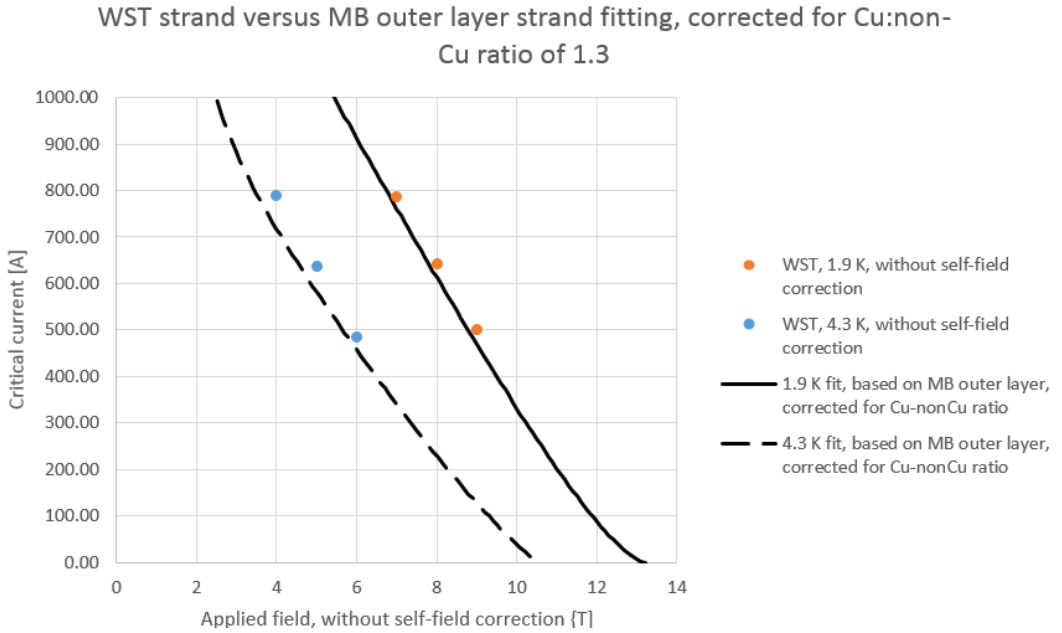
IHEP's contribution in general

- A Quality Assurance (QA) and a Quality Control (QC) plan in accordance with CERN and HL-LHC guidelines,
- A full-size prototype of the MCBRD orbit corrector magnet;
- A series of twelve MCBRD orbit corrector magnets (8 plus 4 spares);
- The room temperature magnetic measurements of all the magnets to validate the quality of the assembly:
- The vertical test at 4.2 K of the prototype and of the series magnets;
- The documentation relative to the production of the MCBRD corrector magnets in due time for review and acceptance by CERN;
- The documentation relative to the results of performance evaluation tests of each MCBRD orbit corrector in due time for review and acceptance by CERN; and
- All tooling agreed between the Parties as necessary for the maintenance and repair at CERN of each series production MCBRD orbit corrector magnet over the HL-LHC operational life

Status of work - Superconducting Wires

- NbTi bare wire for the 1st 2.2m prototype from WST China.
- The insulation done by CGP France. No Jc decay after insulation.

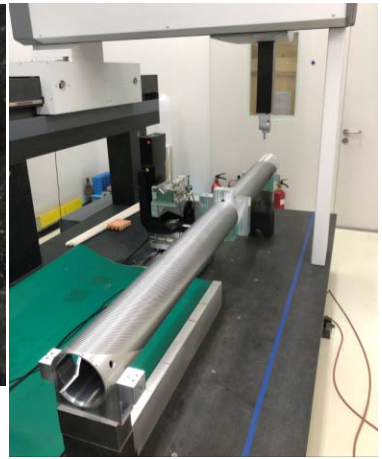
"After correcting for the higher Cu:non-Cu ratio the WST strand is about 7% more performance than the MB outer layer strand."-Matthias



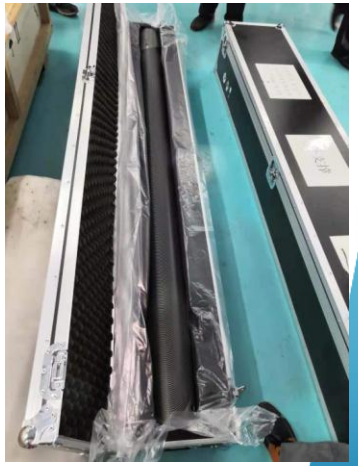
Status of work - Coil Formers

- Formers for the 2.2m Prototype (HE-Racing China)
  - Inner former, outer former and former assemblies for the two apertures completed and delivered to WST.
  - The anodized thickness of formers is 40-50 μm.

Former assemblies

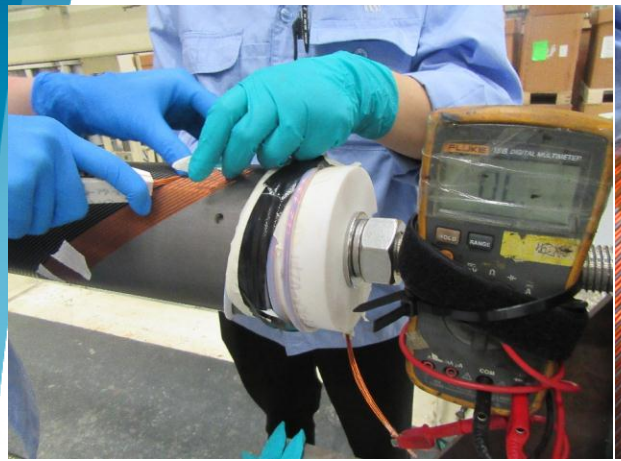
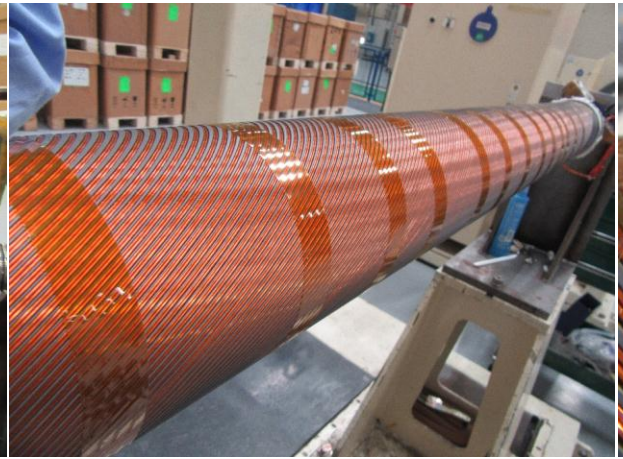
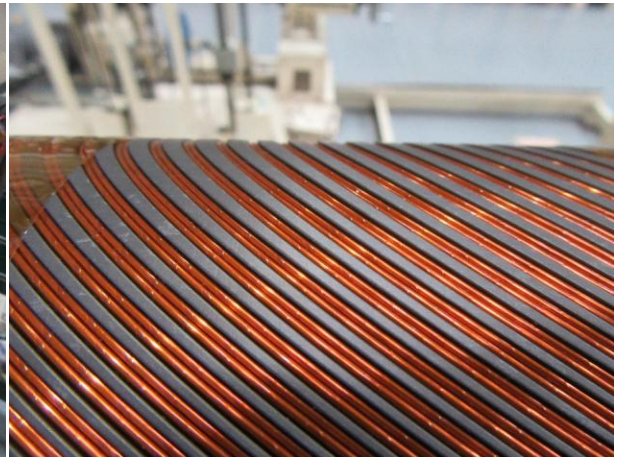


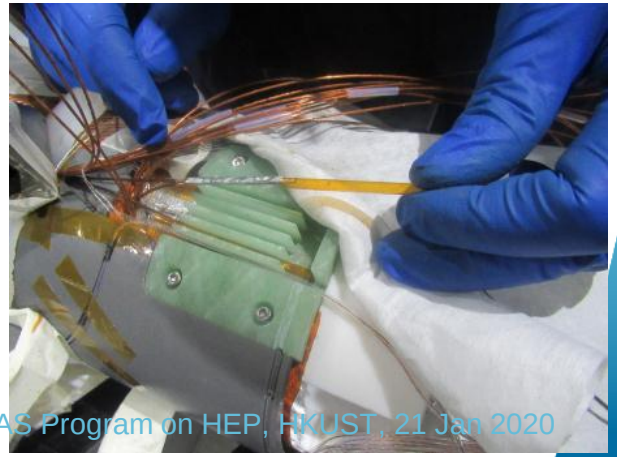
Dimension measurement



Anodized former and external support tube

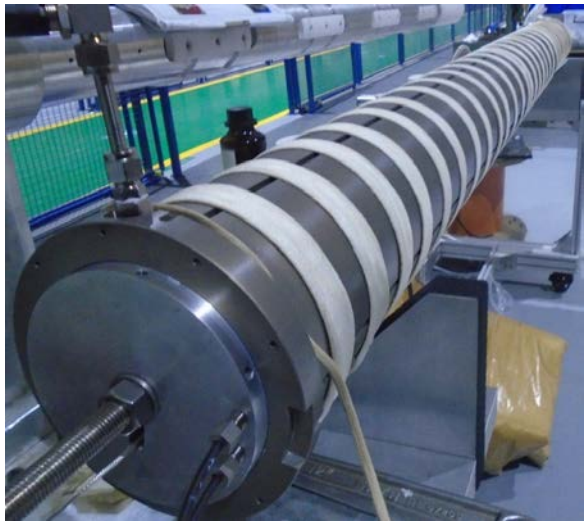
Status of work - CCT Coils

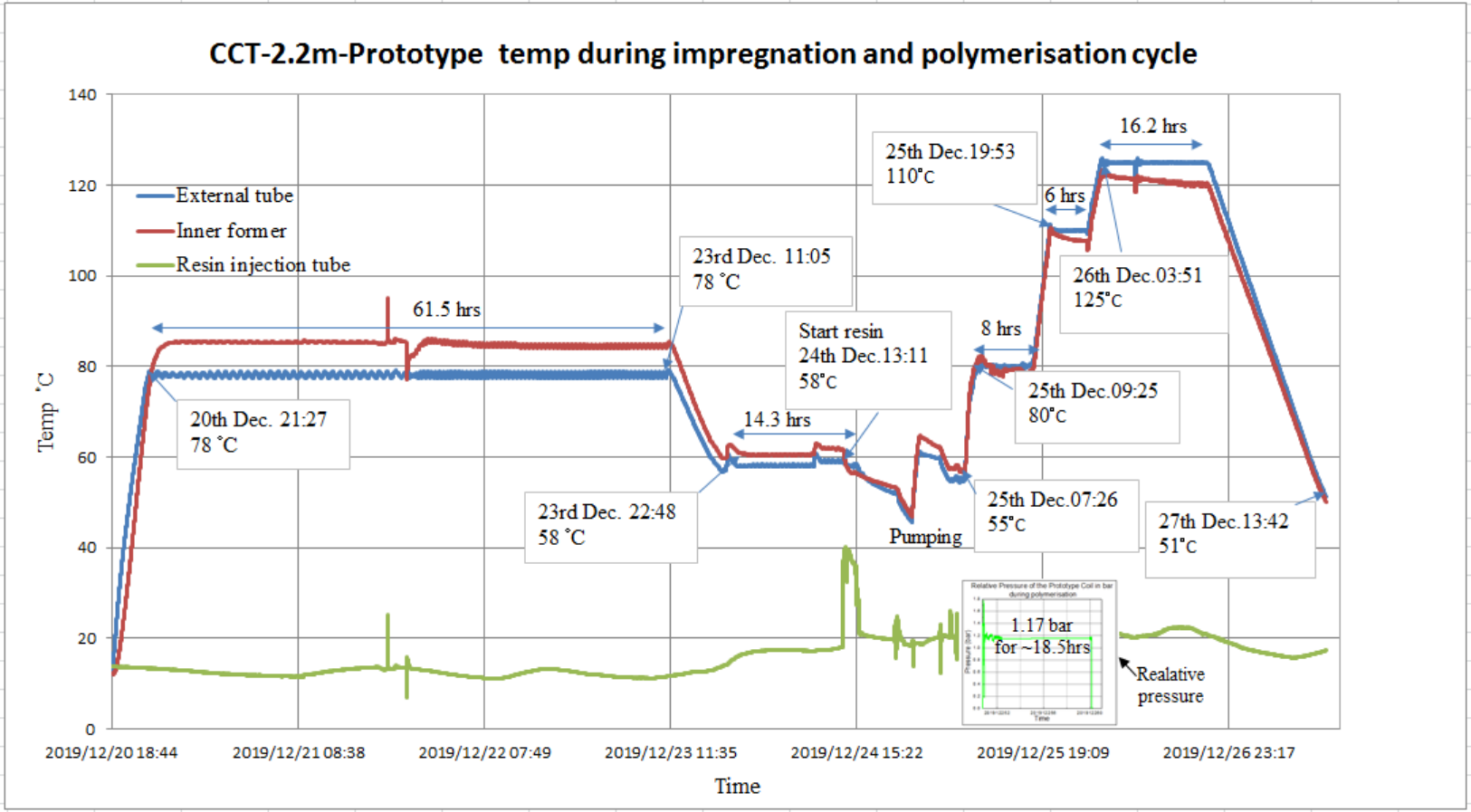
Advancement of VPI for Aperture V

- Coil VPI for aperture V and H completed
  - ✓ Baking coil before vacuum impregnation at 80°C for 3 days.
  - ✓ Electrical test before and after VPI procedure



Aperture V coil after VPI

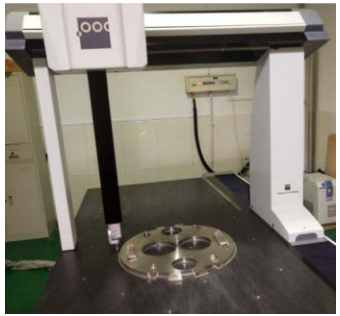
VPI for Aperture V



Status of work - Yoke

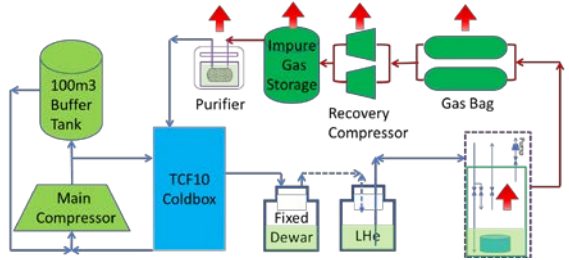
- Yoke Steel Delivery
  - 1st : About 10 tons yoke steel for the 1st 2.2m prototype have been received in February 2019.
  - 2nd : 40 tons yoke steel has been received in December 2019.
- Yoke laminations (KEYE, Anhui, China)
  - End plates machining and dimension measurement → completed
  - Yoke lamination machining and dimension measurement → completed

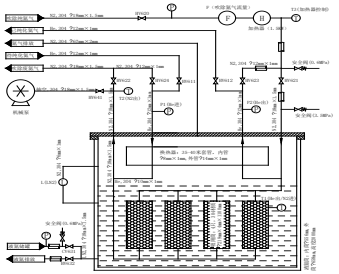




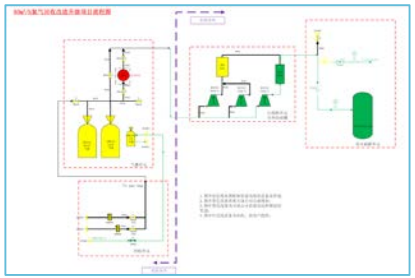

Status of work – Preparation of Test station

- LHe recovery
  - Gas bag → 200 m^3
  - Recovery compressor → 80 m^3/h
  - Impure Gas Storage → > 10 m^3 @ 15MPa
  - External Purifier → 75 m^3/h
  - Vertical Dewar → Φ 800 x 3800 mm
- Test Dewar
  - + Valve box for Vertical Test Dewar
  - + Pre-cooler system for cooling down & warm up

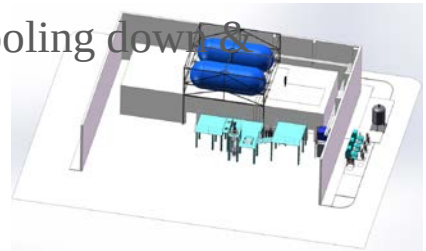


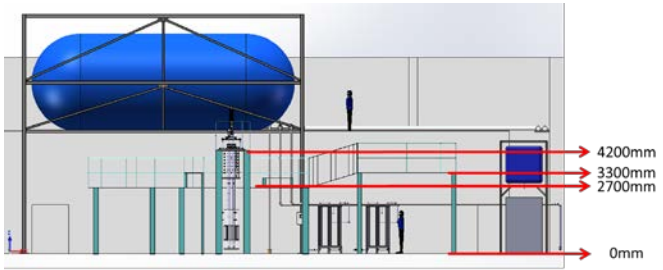


Scheme of the purifier



Scheme of the Recovery System



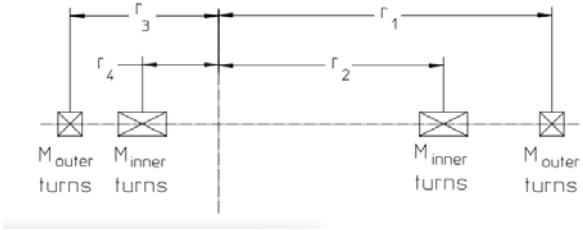


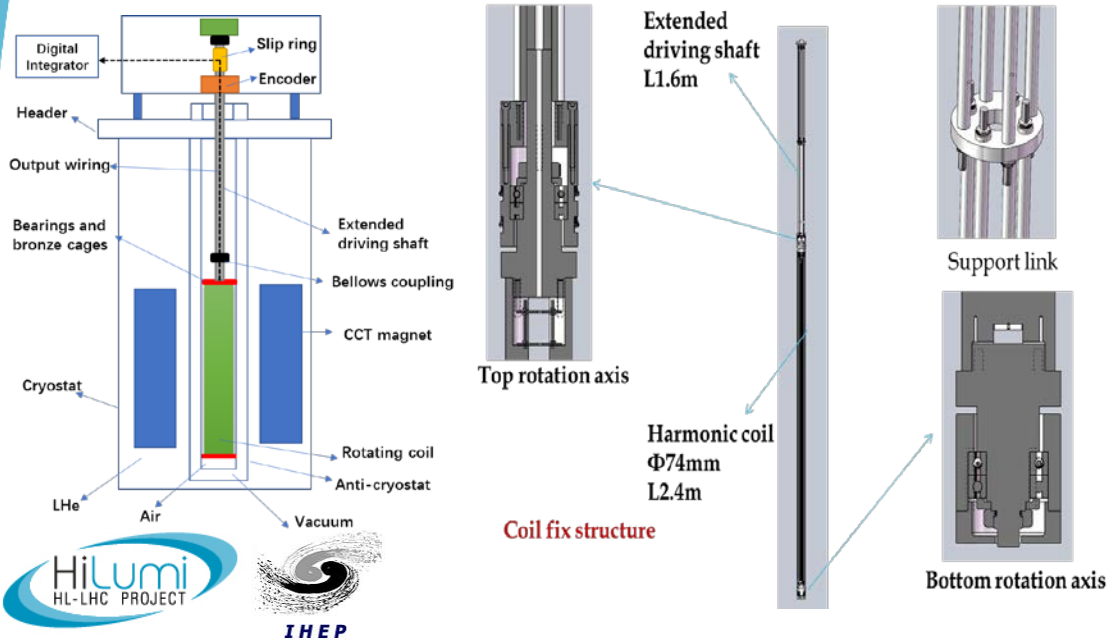
Lay out of the test stand

Status of work – Preparation of Test station

Field Measurement System

Harmonic coil parameters						
r1/mm	r2/mm	r3/mm	r4/mm	Mout/turns	Min/turns	Rref/mm
35	23	-25	-17	80	120	35



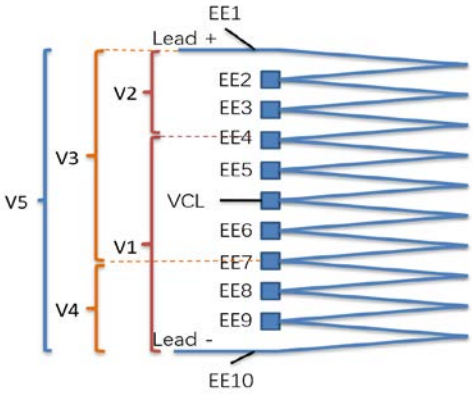


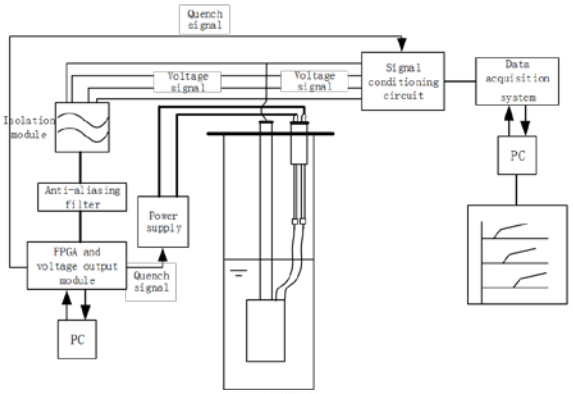
- ✓ Mainly by the rotating coil.
- ✓ Subsidiarily by Hall probe and NMR probe.
- ✓ The field measurement system is ready.

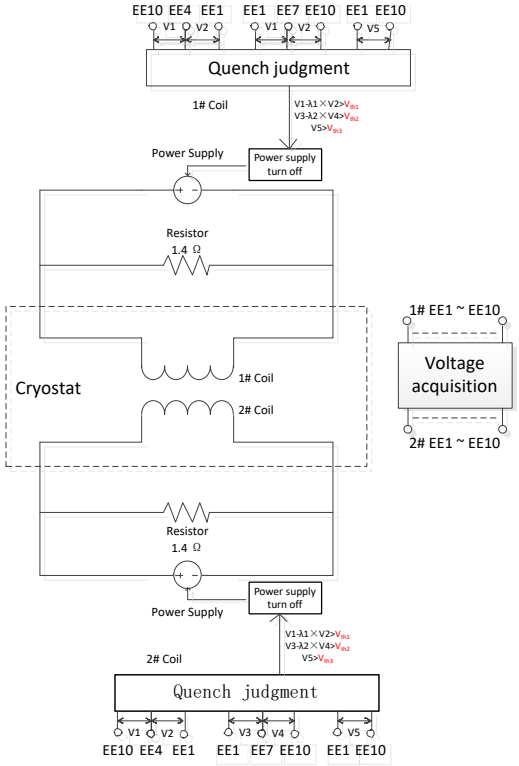
- Two radius coils symmetric to the axis;
- Outer Coil :main winding
- Inner Coil :dipole bucking which cancel the dipole component: V_A− V_B
- Typical accuracy of the system :10^{-4}.
- The rotating coil is positioned in two anti-cryostats.

Status of work – Preparation of Test station

Quench Detection System







- TheTwo asymmetry voltage bridges are used as the judgement signals to avoid possible symmetry quench.
- Quench detection system is based on the NI-cRIO platform.
- 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 trigger the quench protection switch and the data acquisition system.

Steering Committee meetings: Main outcome

The 1st steering committee meeting held in Oct. 7 2019.

Schedule of series magnets The successful test of the prototype is necessary before giving the green light to start the production of the series; for this reason, the beginning of the manufacturing for the series should be shifted by 6 months.

Wires insulation planning The bare wire will be insulated by CGP company (FR). IHEP will agree with them a detailed schedule of deliveries in order to fit with the current planning and communicate the result to CERN.

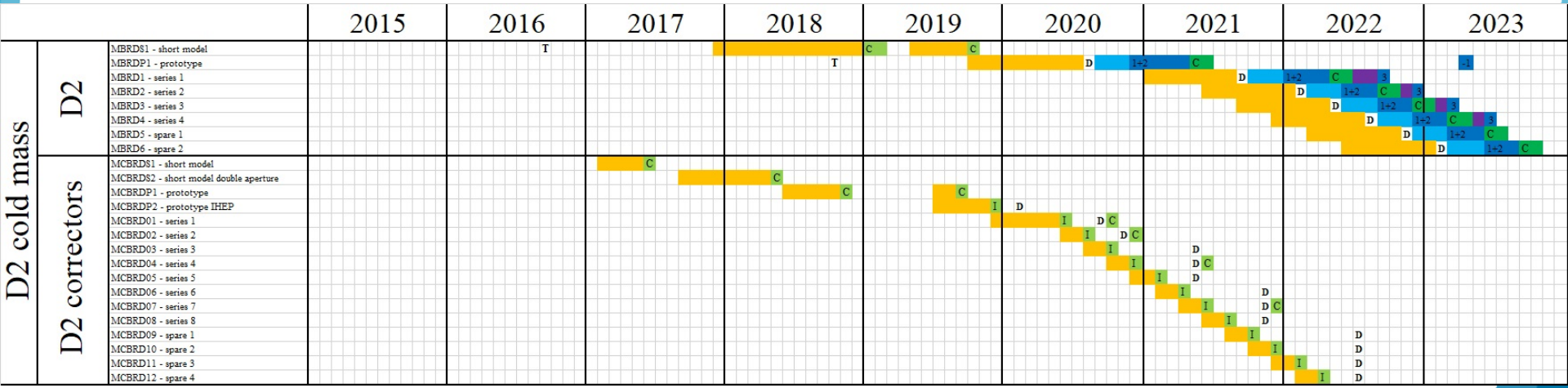
Prototype delivery The delivery of the prototype to CERN might be shifted to Feb. 2020.

The ST COM takes notes of the delay, not critical for HL-LHC project, and commends the IHEP and all Chinese teams for the increased effort on the prototype and for launching the definition and procurement of important components.

The QA/QC plan has recently been improved in a considerable way, with mutual satisfaction.

Schedule

- Production rate assumption: 1 magnet each 2 months
- Series starts after test on prototype



Schedule

Prototype delivered at CERN (MCBRDP2)	February 2020
1st series magnet test delivered at CERN (MCBRD01)	September 2020
2nd series magnet test delivered at CERN (MCBRD02)	November 2020
1st batch delivered at CERN (MCBRD03-05)	May 2021
2nd batch delivered at CERN (MCBRD06-08)	November 2021
3rd batch delivered at CERN (MCBRD09-12)	July 2022

Manpower

	2019	2020	2021	2022
Scientific (FTE)	8	8	8	8
Technicians (FTE)	8	8	8	8
Total (FTE)	16	16	16	16

Structure

HL LHC WP3: MCBRD

Q. Xu,

S. Wei (deputy)

July 2019

Design
S. Wei, Y. Liang (deputy)

Contract follow-up
J. Wang, D. Ni (deputy)

QA
L. Gong, S. Wei (deputy)

Production
C. Li

Construction
M. Li, Z. Ge (deputy)

Contract
C. Li

QA
Y. Wang, M. Li (deputy)

Test
W. Wu

Room temperature test
Q. Peng, L. Gong (deputy)

4.5 K test
W. Yang, D. Ni (deputy)

QA
Y. Liang, W. Yang (deputy)

Risks, impact, mitigation measures

- **Technical risks**

  Electrical insulation (quality control)

  Field quality (Further minor optimization to reduce the field error?)

- **Resource risks**

  Stable supply of Helium for the cold test

- **Schedule**

  No serious potential obstacles foreseen presently

Thanks for your attention

IHEP