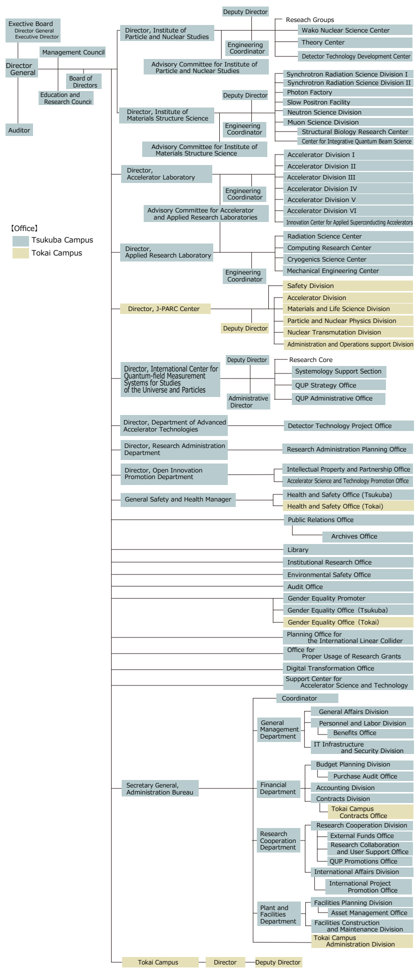
Status of Superconducting Magnet Projects and R&D at KEK

Toru Ogitsu
On be half of KEK Cryogenics Science Center
and
J-PARC Center Cryogenics Section

KEK Cryogenics Science Center and J-PARC Center Cryogenics Section



Scientists

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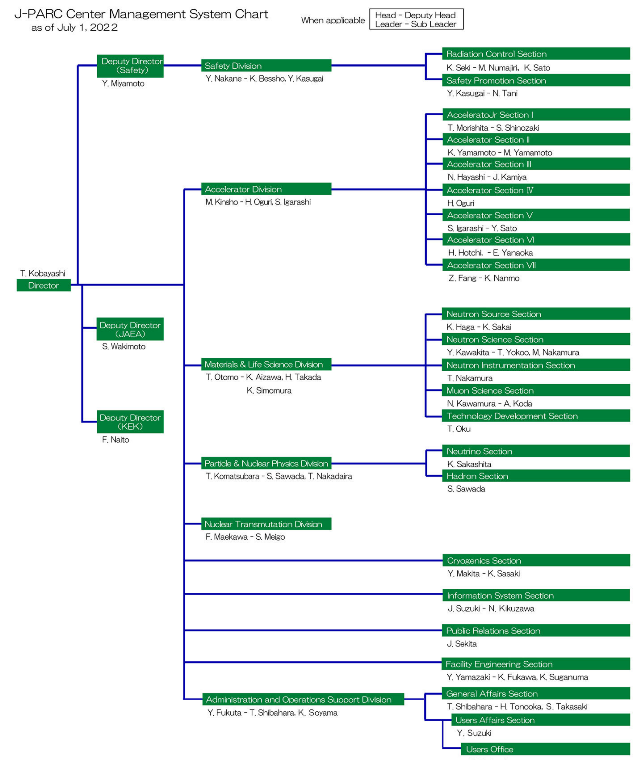

Contents

- On going Projects
  - HL-LHC D1
  - COMET
  - g-2/EDM
- Future R&D
  - High Field Magnet
  - Radiation Hard Magnet
- Issue on Detector Magnet
- Summary

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- **On going Projects**
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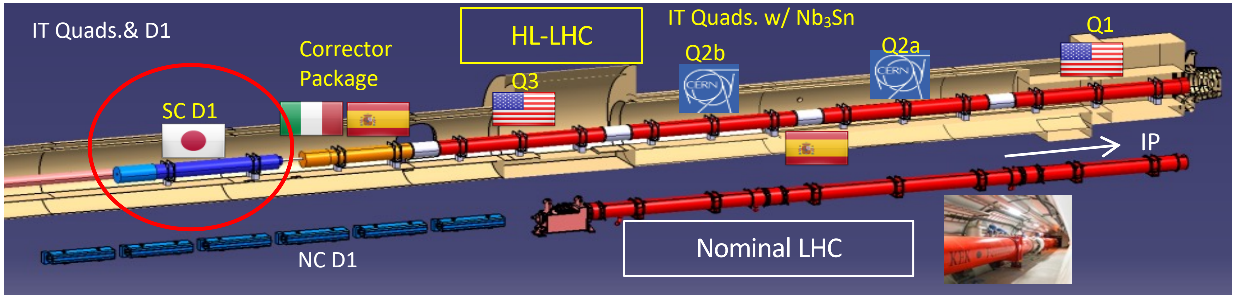
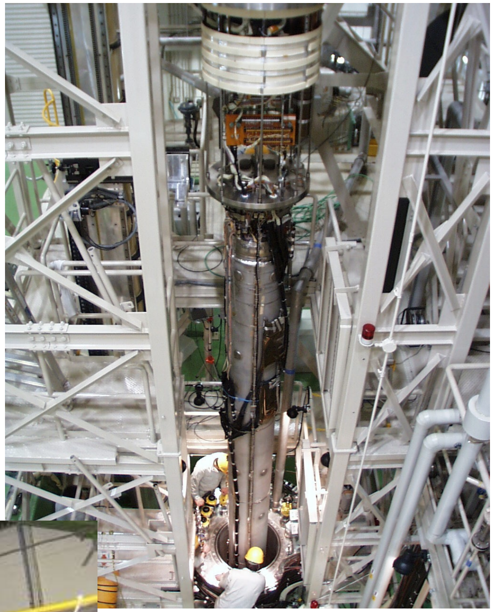
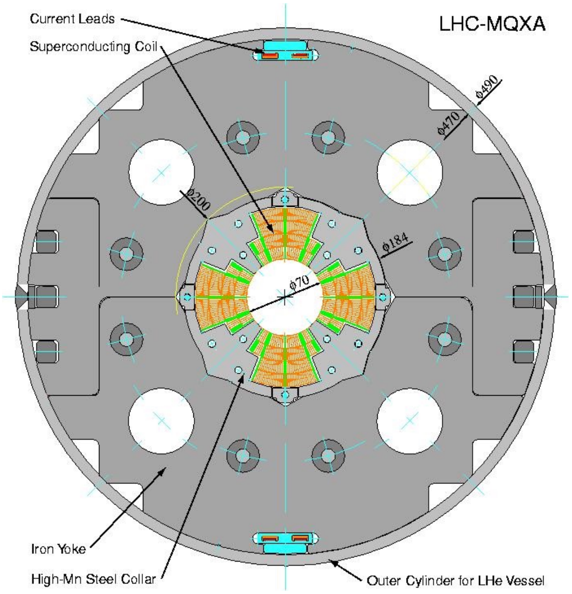
HL-LHC D1 Magnet

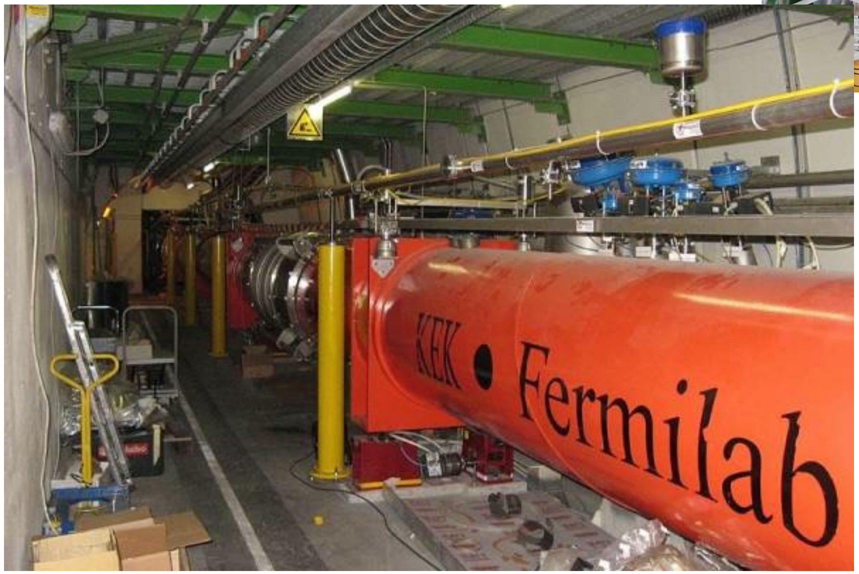


Japanese Contribution to LHC MQXA: Interaction Quadrupole

- **Focus Beam at Interaction Region (Increase Luminosity)**
  - Field Gradient 280T/m, Maximum Field 8.7 T

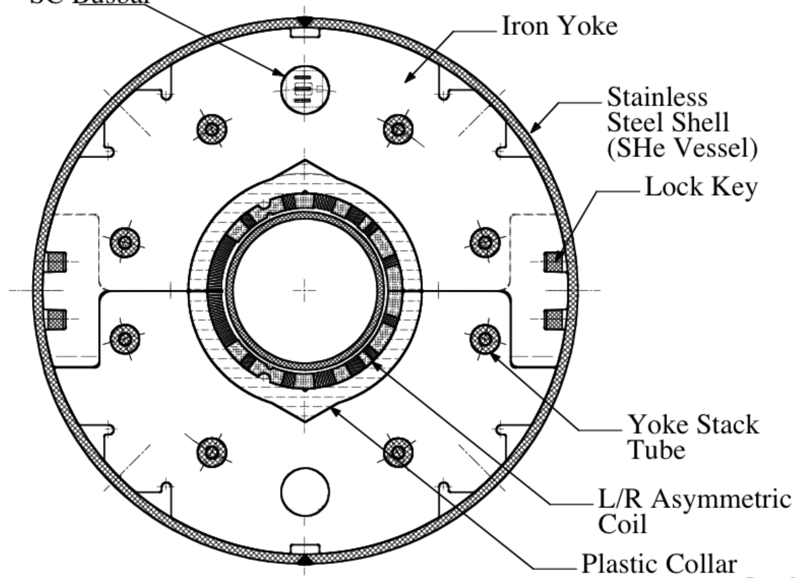


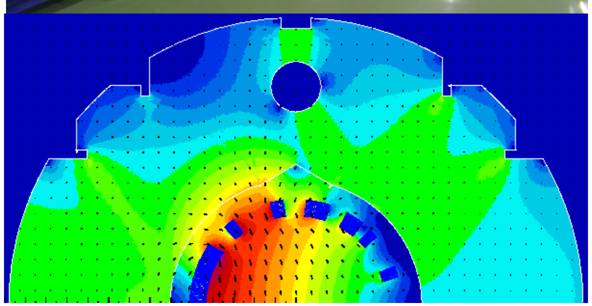




KEK SC Magnets J-PARC Neutrino Facility

- Neutrino Facility needed SC magnets due to space limitation

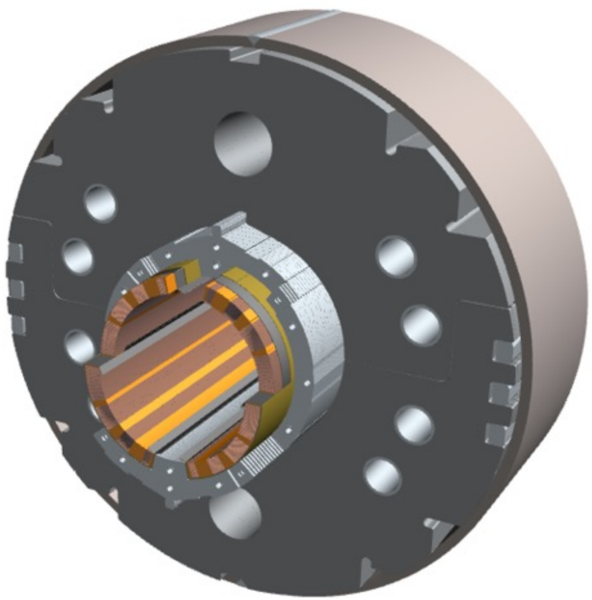




Combined Function MagnetS（2.6T+19T/m, 28 Magnets）
Optimize Cost and Schedule

Beam Separation Dipole
KEK Contribution to HL-LHC

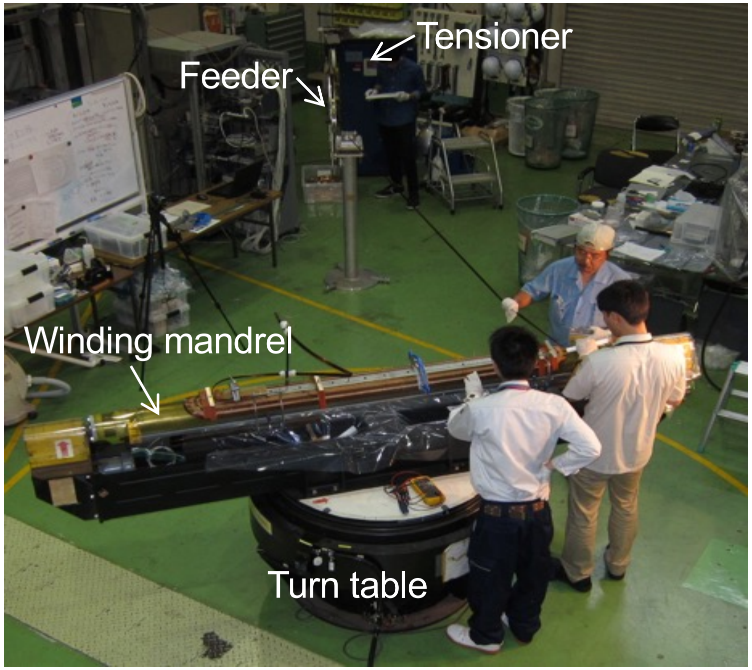
- Large Aperture 150mm, 6T Dipole

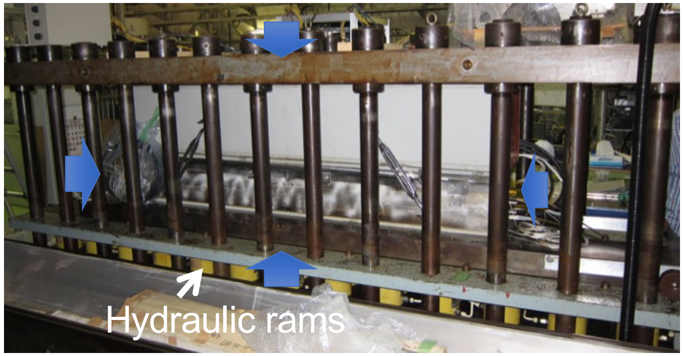


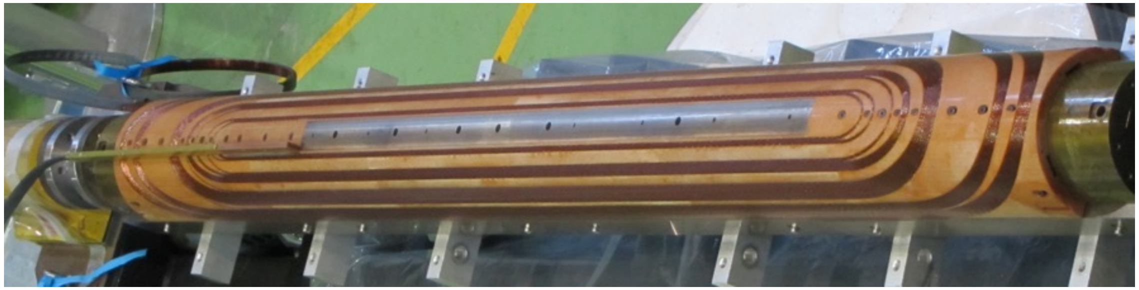
HL-LHC D1 Magnet

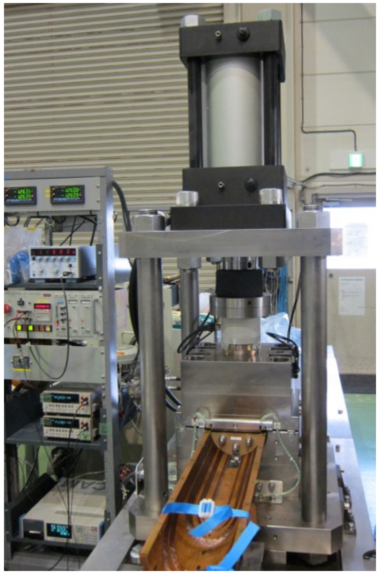
Sigh of MOU between CERN and KEK

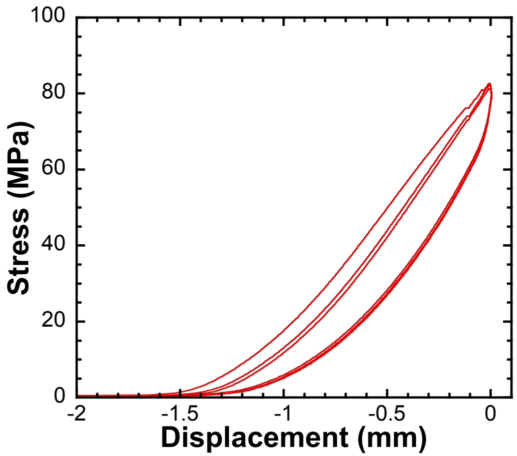
2m Model Magnet Assembly: Coil winding and Curing

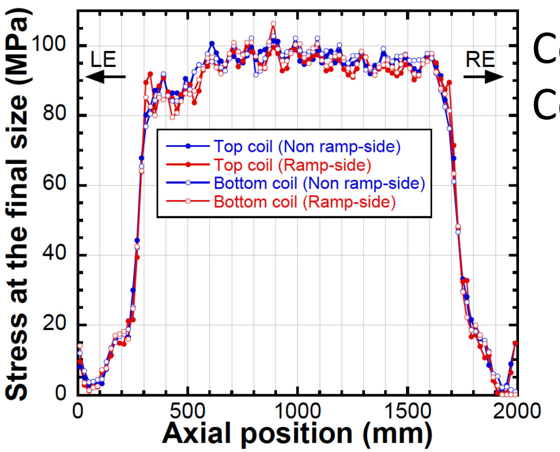






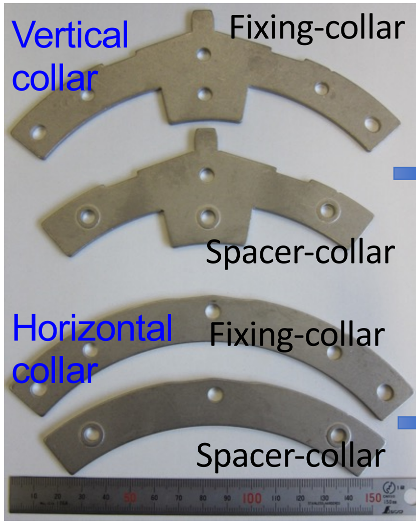


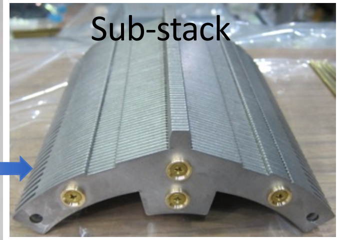


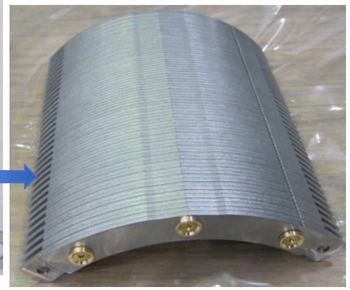


Coil Size Control:
Control Pre-stress

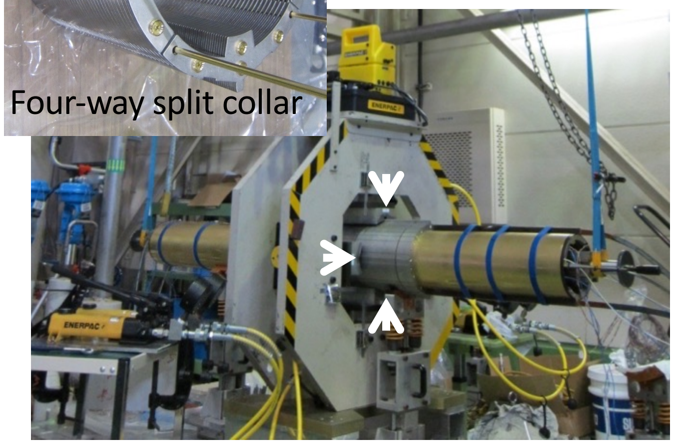
2m Model Magnet Assembly: Collaring & Yoking







Collar plates fabricated by fine-blanking

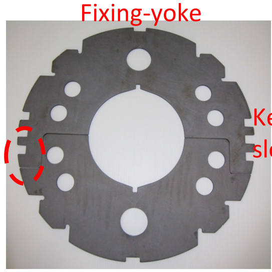


Collaring press

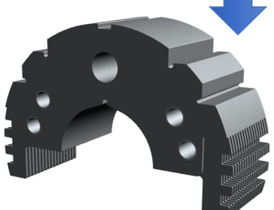
- Collar plates were fabricated by fine-blanking.
- Good size accuracy in the critical parts: ±10 µm
- Four-way split collar even for a dipole
- Alternate lamination of Fixing- and Spacer-collar

  (t2.3 mm, t2.6 mm)
- Embossing to control PF to be 96%

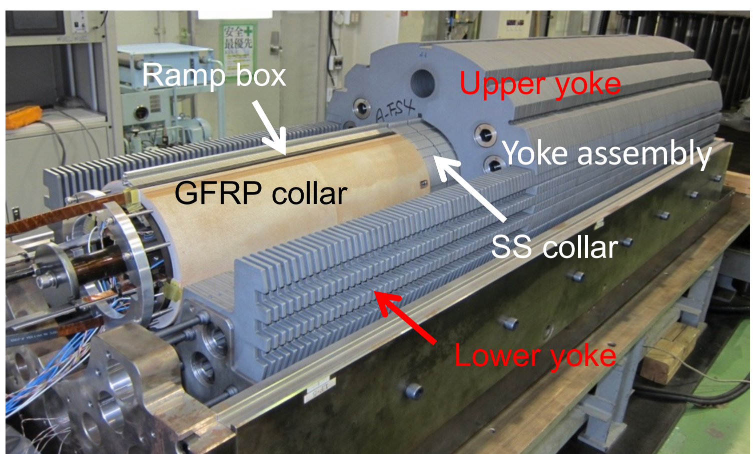
Fixing-yoke

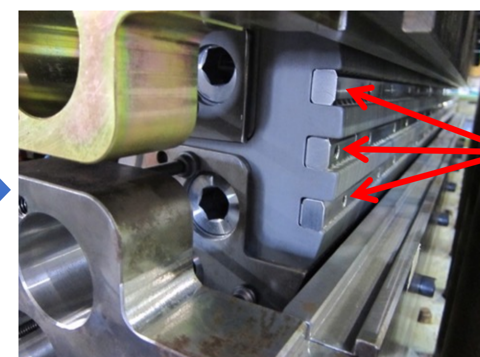


Spacer-yoke



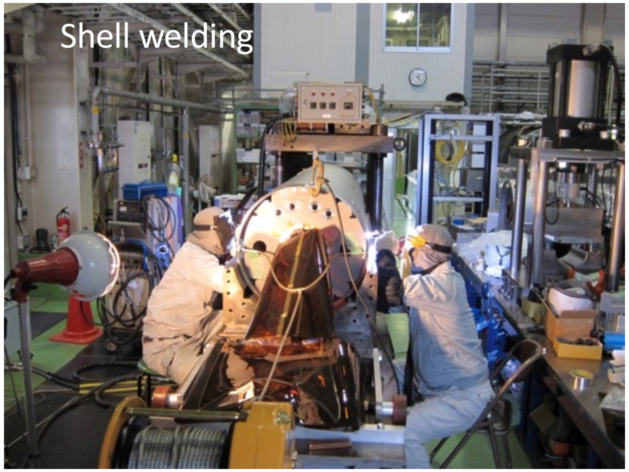
Yoke sub-stack

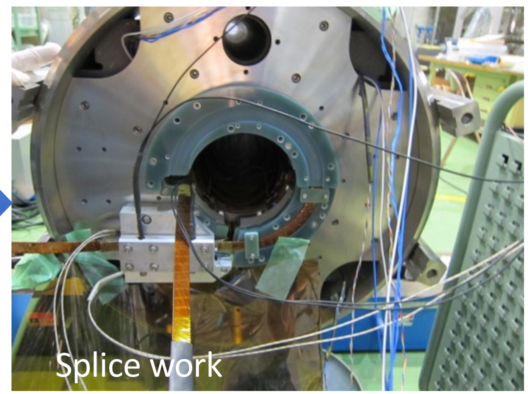


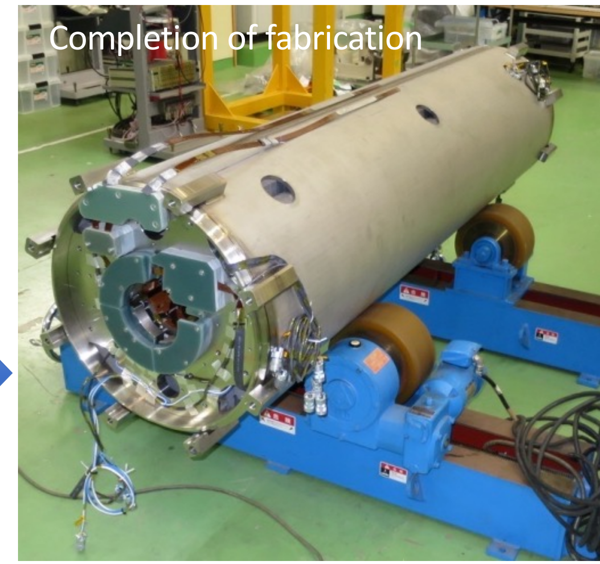


2m Model Magnet: Final Assembly and Tests

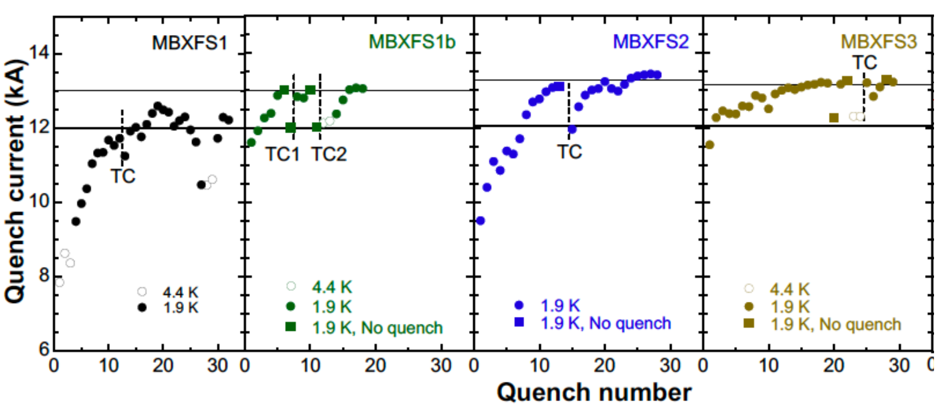
- 2 m long half shells were longitudinally welded.
- Magnet assembly was completed after end ring welding and splice work.







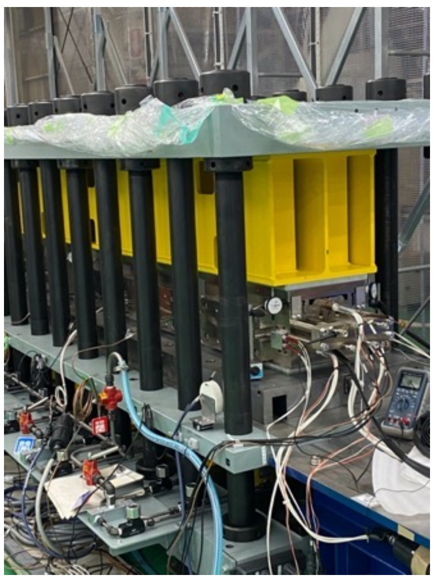
Magnet Test Results



Quench Performance: Good Enough
> Proceed to 7m Prototype

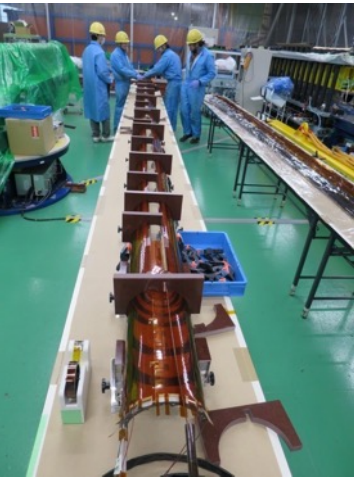
Manufacturing of D1 Prototype

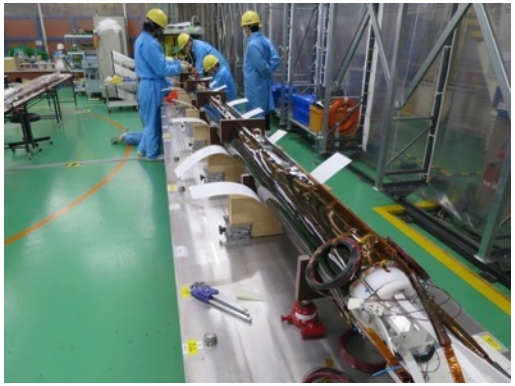
- Coil fabrication (LPT-1 and LPB-1 coils) started October 2, 2020.



- Azimuthal coil size measurement (evaluated as σ_{pole}) Target: 115 MPa
  - Top: L 113 MPa, R 112 MPa
  - Bottom: L 109 MPa, R 111 MPa
- The prototype coils achieved the coil size consistent with the model magnets and the sufficient pre-stress at the assembly can be expected.
- Dimension check: OK
- Electrical test: OK

Manufacturing of D1 prototype

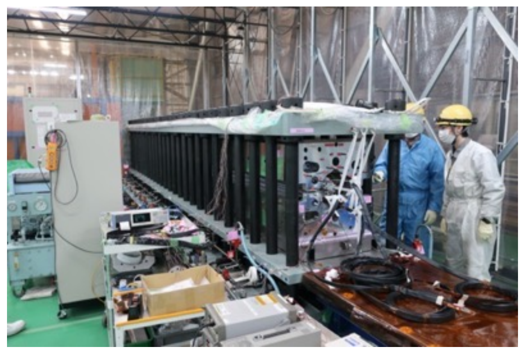

QPH, ground insulation wrapping

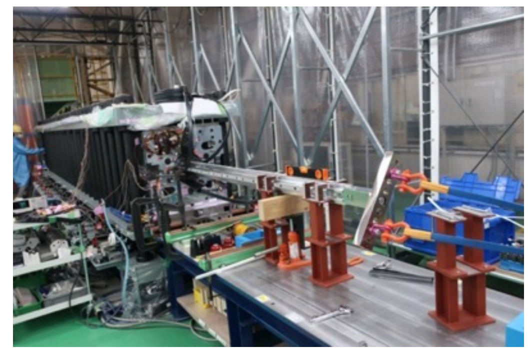

Top/bottom coil assembly


Brass shoe assembly

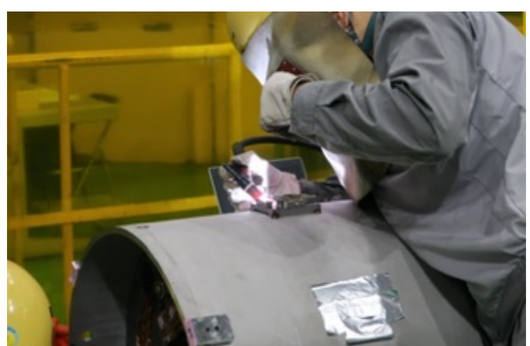

Collaring


Collared coil on bottom yoke


Yoking


Removal of collaring mandrel

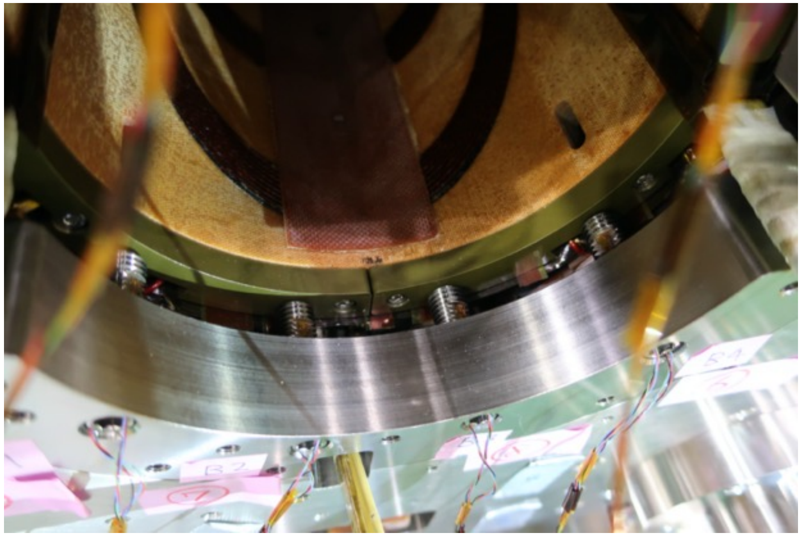

Shell welding


Welding of alignment markers

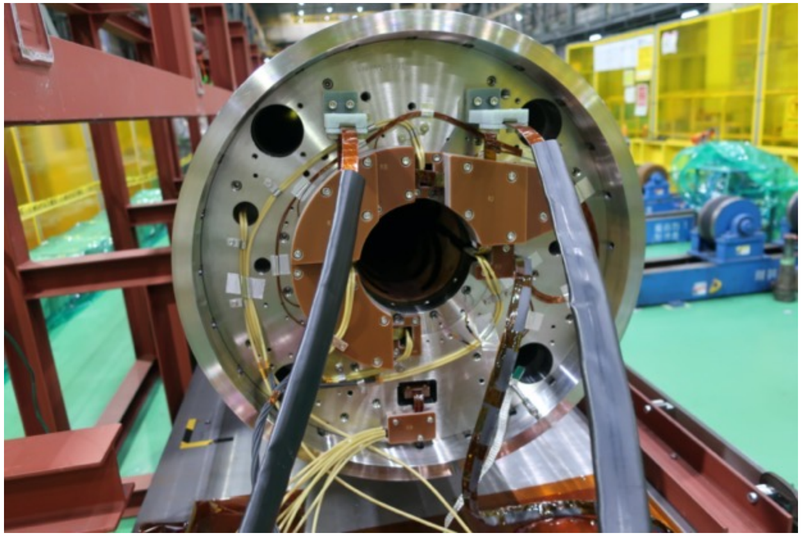

End ring welding

Manufacturing of D1 Prototype

- Axial compression on SC coils



- Splice work and bus-leads

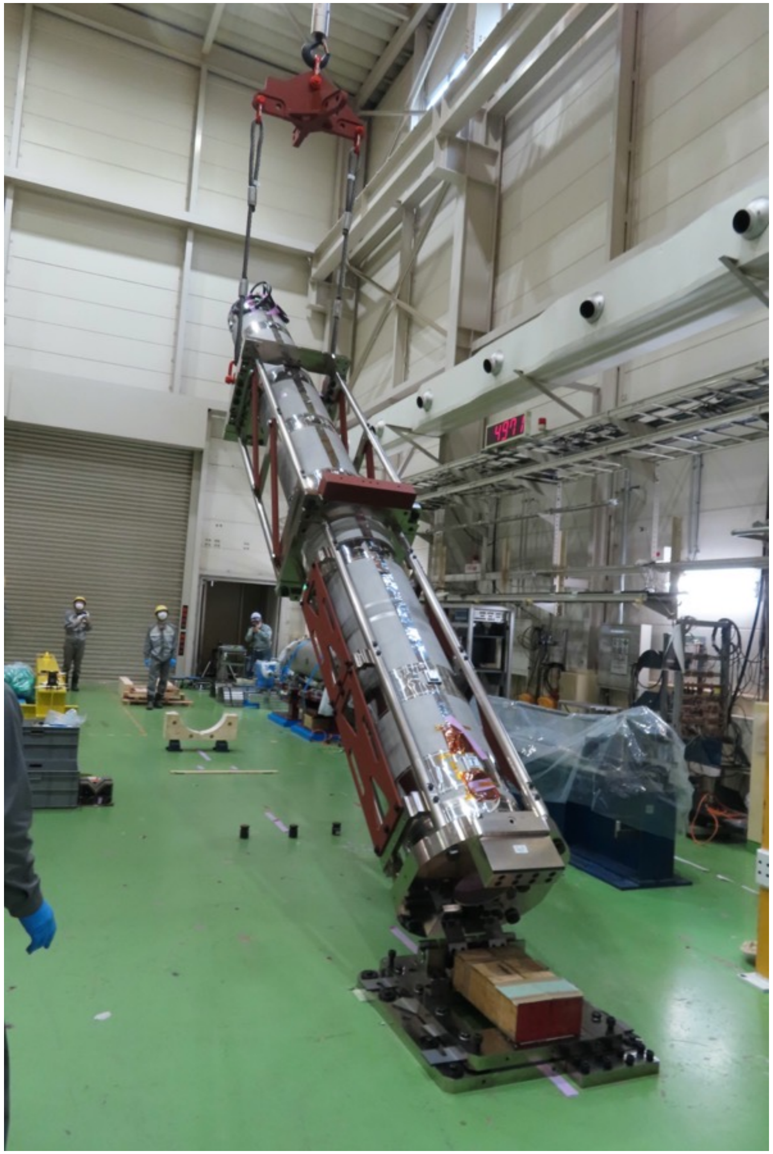


Manufacturing of D1 Prototype

- Completed D1 prototype magnet

Testing of D1 Prototype at KEK

- Lifting up the D1 magnet



- Insertion into vertical cryostat

Issue: Evaporated Gas and Voltage Limit

1st test cycle

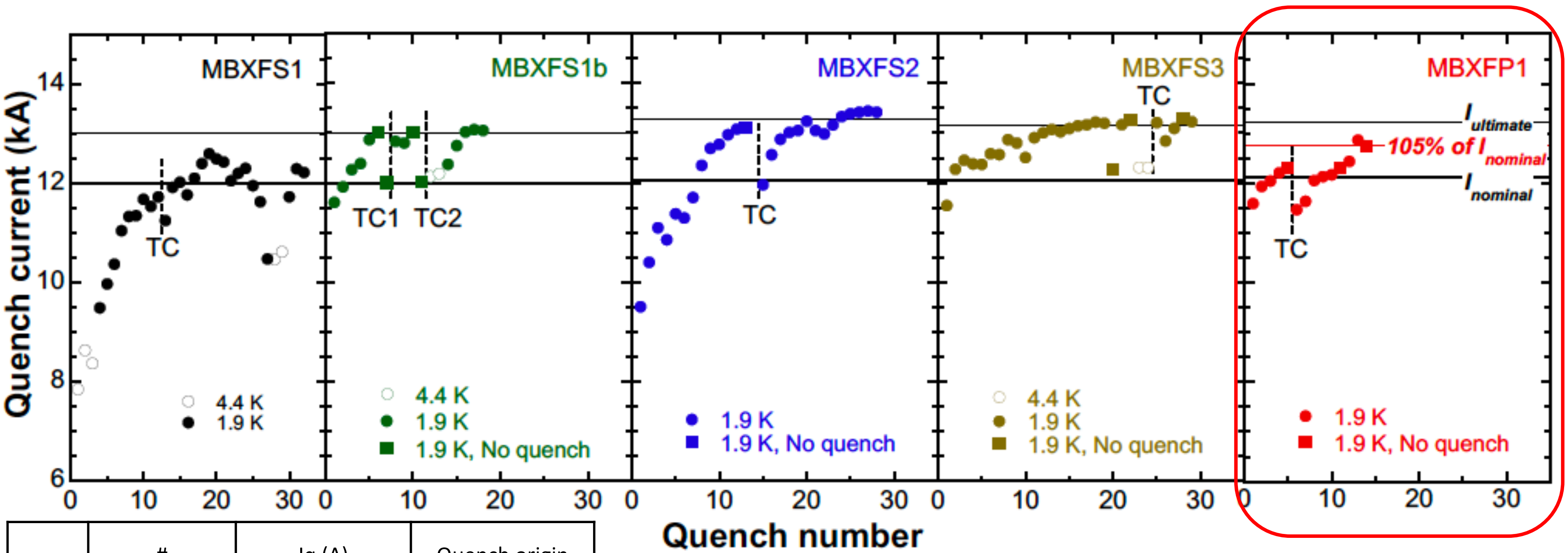
- R_{dump} of 25 mΩ for training quench was determined by voltage limit of DCCB.
- Due to a large energy dissipation in the cryostat and limited capacity of helium gas bag, it was impossible to recover the whole evaporated gas even at the nominal current.

2nd test cycle

- R_{dump} was increased to 50 mΩ for training quench to enhance the energy extraction.
- Thanks to that, the magnet was able to be energized up to **12.87 kA** while the helium gas was mostly recovered. But, the terminal voltage reached the DCCB limit and **we decided NOT to go beyond**.

Countermeasures: New dump resistor (~~~40 mΩ or~~ Metrosil varistor) will be implemented in the energy extraction

Training Performance



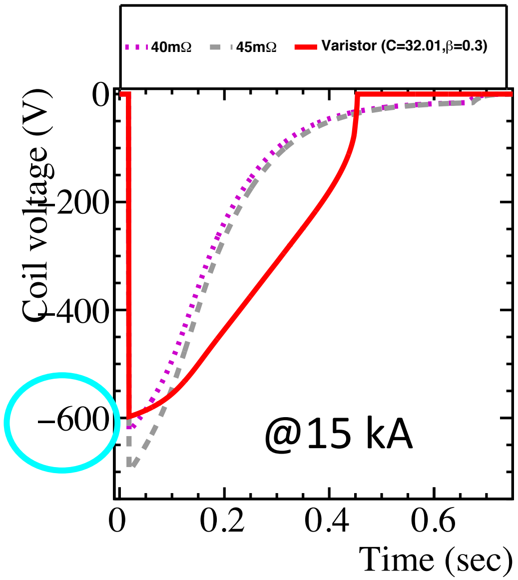
	#	Iq (A)	Quench origin
1st	1	11589	Top coil
	2	11934	Top coil
	3	12042	Bottom coil
	4	12209	Top coil
	5	12310	No quench
2nd	1	11466	Top coil
	2	11634	Bottom coil
	3	12052	Top coil
	4	12132	Bottom coil
	5	12169	Top coil
	6	**12310**	**No quench**
	7	12436	Bottom coil
	8	12866	Bottom coil

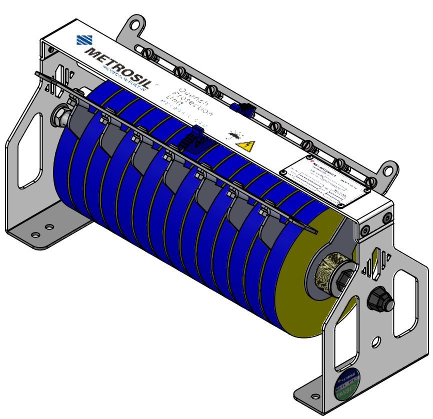
- The magnet needed 3 training quenches to reach the nominal (12.11 kA).
- The maximum current was 12.87 kA which was limited by allowable terminal voltage of DCCB.
- The magnet safely operated at 12.75 kA (105% nominal) for 4 hours.

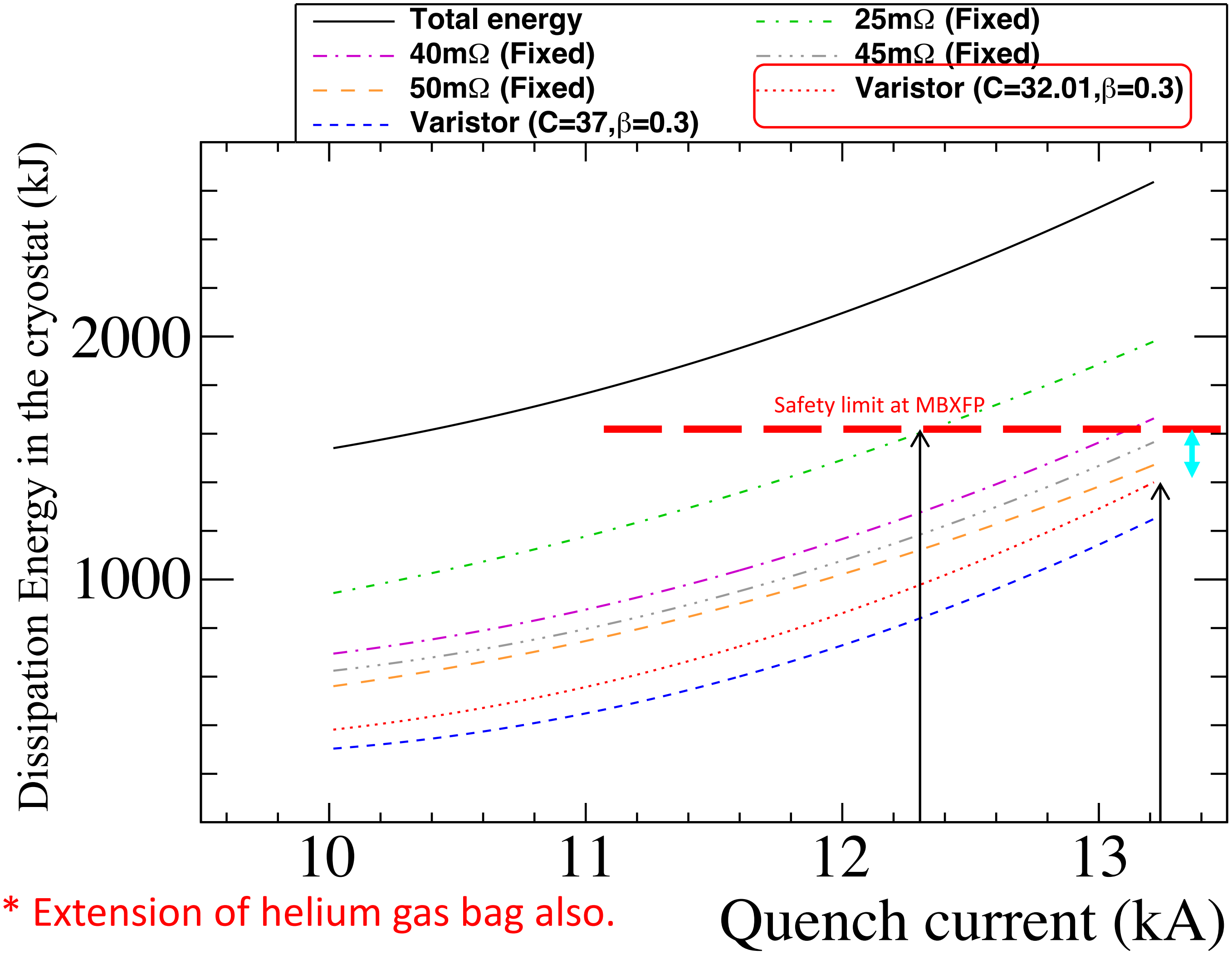
While the ultimate was not demonstrated, good performance in training behavior.

NCR: MBXFP1 Quench Performance EDMS2632162

Implementation of Varistor in EE system for the series magnets testing



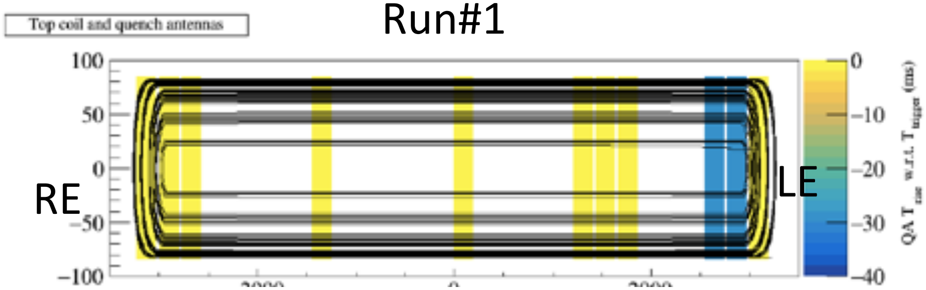




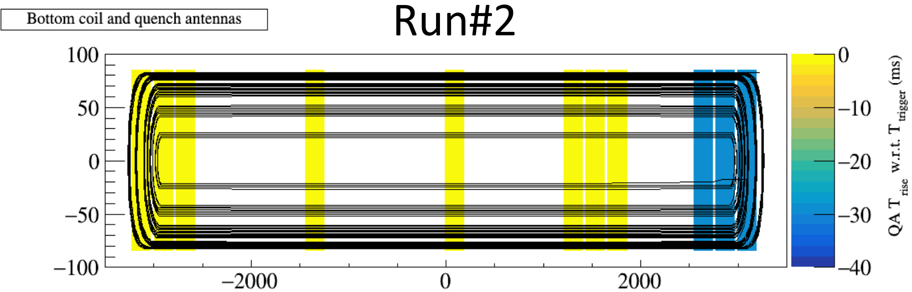
* Extension of helium gas bag also.

Quench location identified by antennas

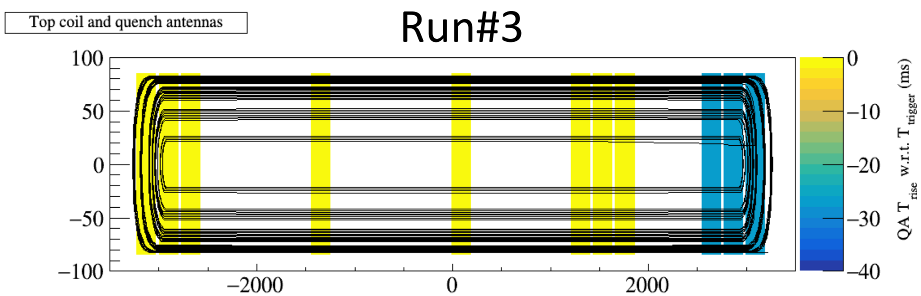
Run#1



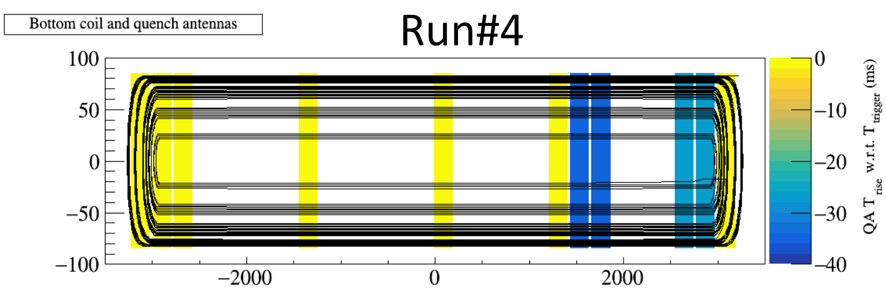
Run#2



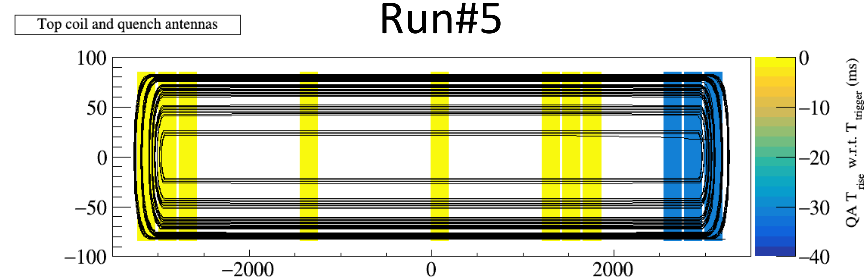
Run#3



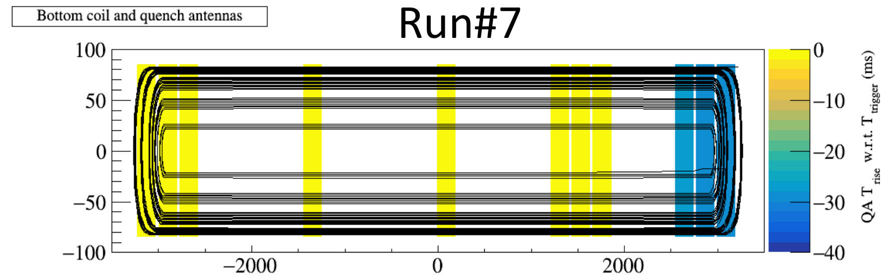
Run#4

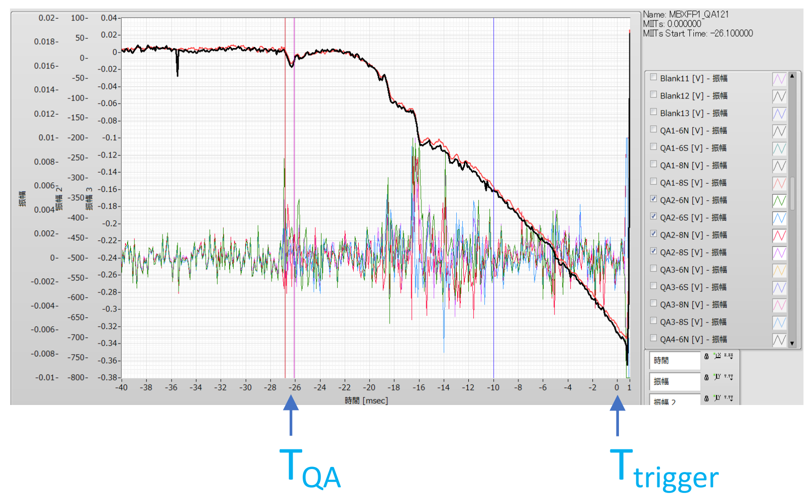


Run#5



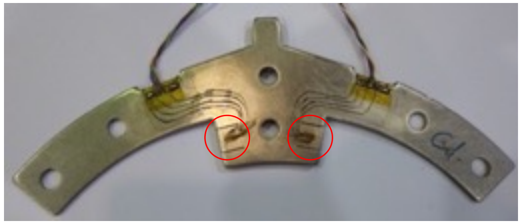
Run#7





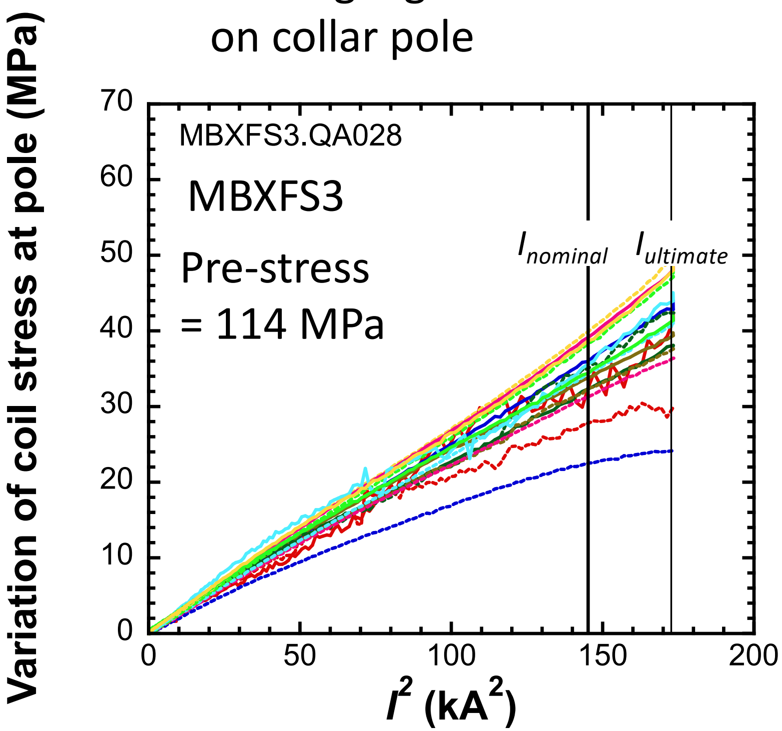
All the quench locations are confirmed to be around the LE region.

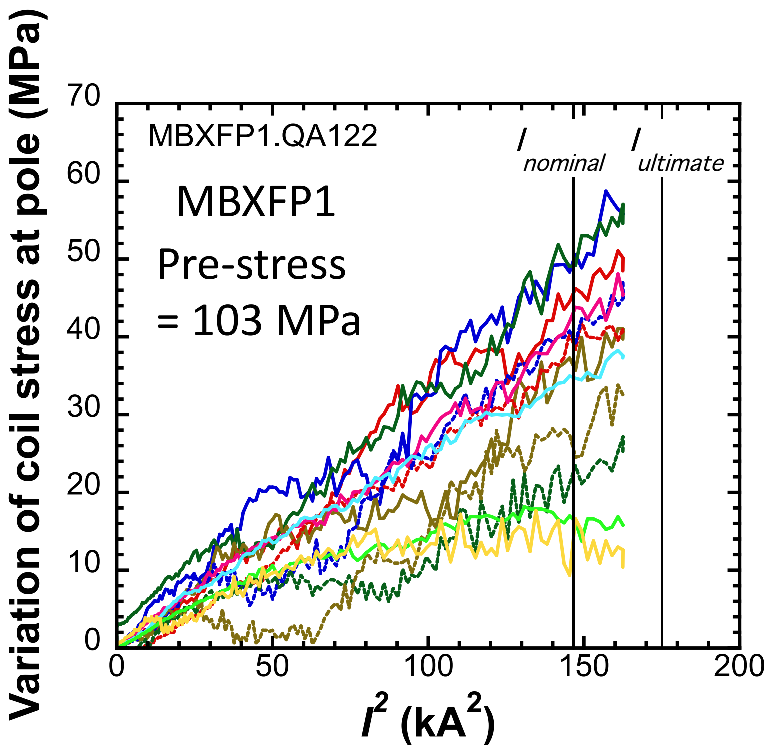
Coil stress at pole during excitation



Strain gauges on collar pole

Pre-stress is defined as azimuthal coil stress measured at collar pole after yoking.





- Coil stress in a straight section was measured at 12 points at collar pole.
- Coil stress at pole continues to change at most of the measured points up to 105% of the nominal current suggesting that pre-stress still remains.

Summary of MFM at the Magnet Center

(Units)

	MBXFS2		MBXFS3		MBXFP	
	3 kA*	12.05 kA*	3 kA*	12.05 kA*	**3 kA***	**12.11 kA**
b_3	20.84	35.94	24.05	37.28	**-3.06**	**-8.51**
b_5	-1.98	1.61	-1.82	2.01	**3.03**	**6.68**
b_7	-0.16	-0.83	0.03	-0.58	**1.24**	**0.98**
b_9	0.05	0.40	0.08	0.50	**0.79**	**1.35**
b_{11}	0.20	0.21	0.21	0.23	**-0.02**	**-0.06**
b_{13}	-0.50	-0.53	-0.51	-0.52	**-0.90**	**-1.03**
b_{15}	-0.96	-1.02	-1.01	-1.10	**-1.31**	**-1.52**

Large offset was significantly reduced.

Induced by the unexpected cross section change of MBXFP1 due to increased cable thickness.

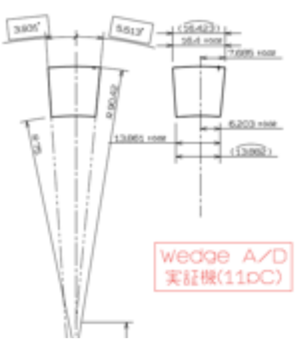
(*) Average of ramp-up/down

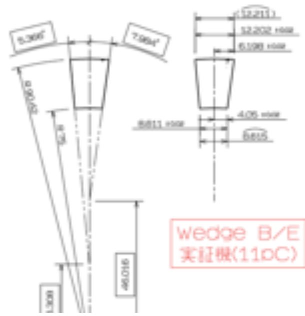
Change of the wedge size

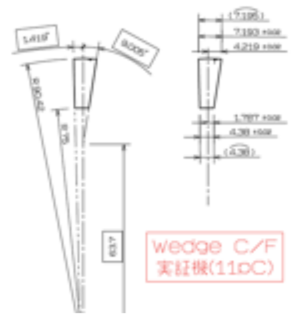
EDMS 2612909

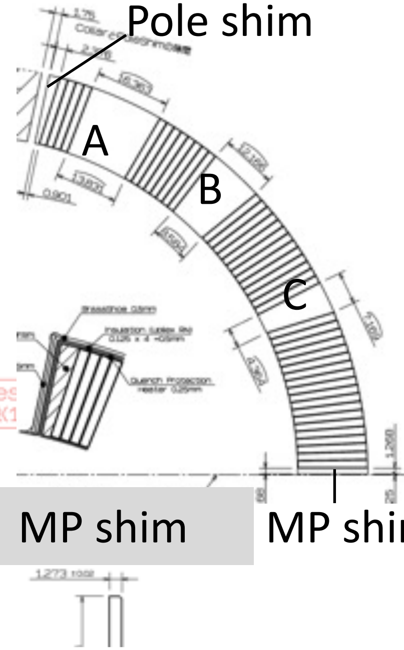
Wedge used in MBXFP

Wedge A	Wedge B	Wedge C	Pole shim	MP shim
R_{in} : -170um R_{out}: +145um	R_{in} : -151um R_{out}: -143um	R_{in} : -294um R_{out}: -253um	R_{in} : +554um R_{out}: +179um	+58um





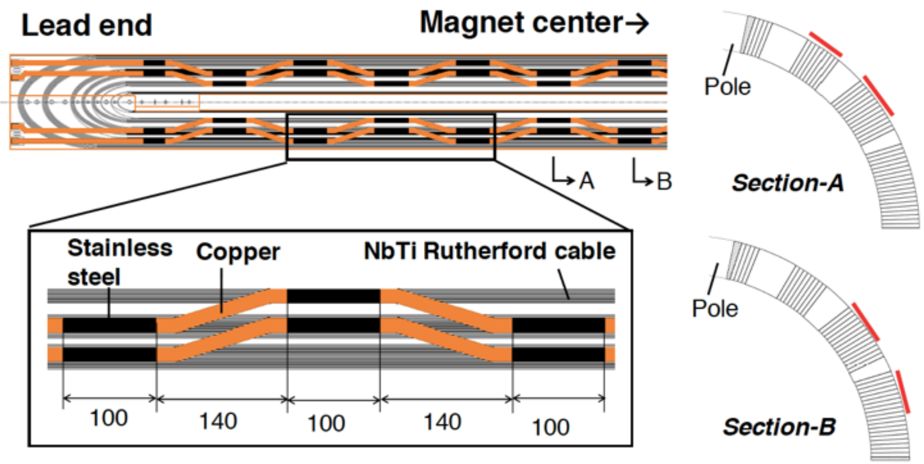


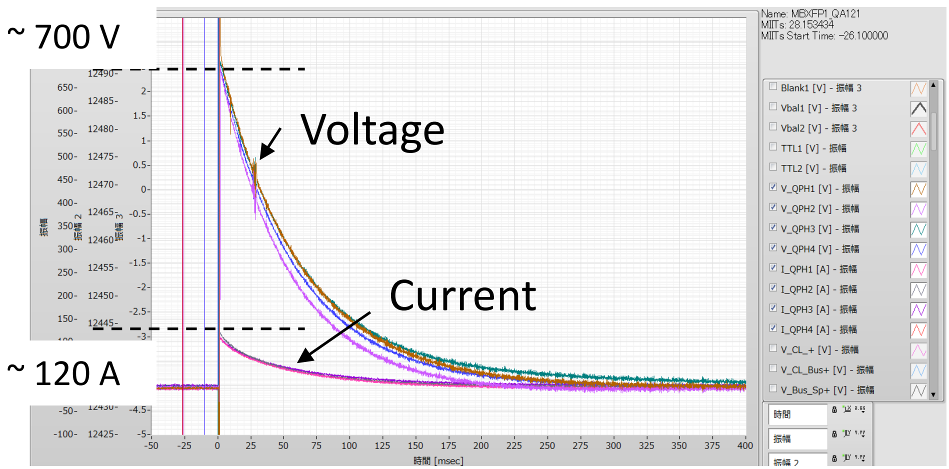


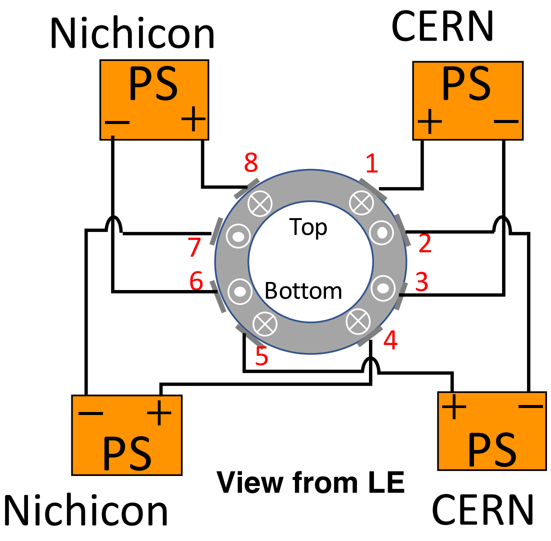
Wedge for MBXF series

Quench Protection of D1 magnet

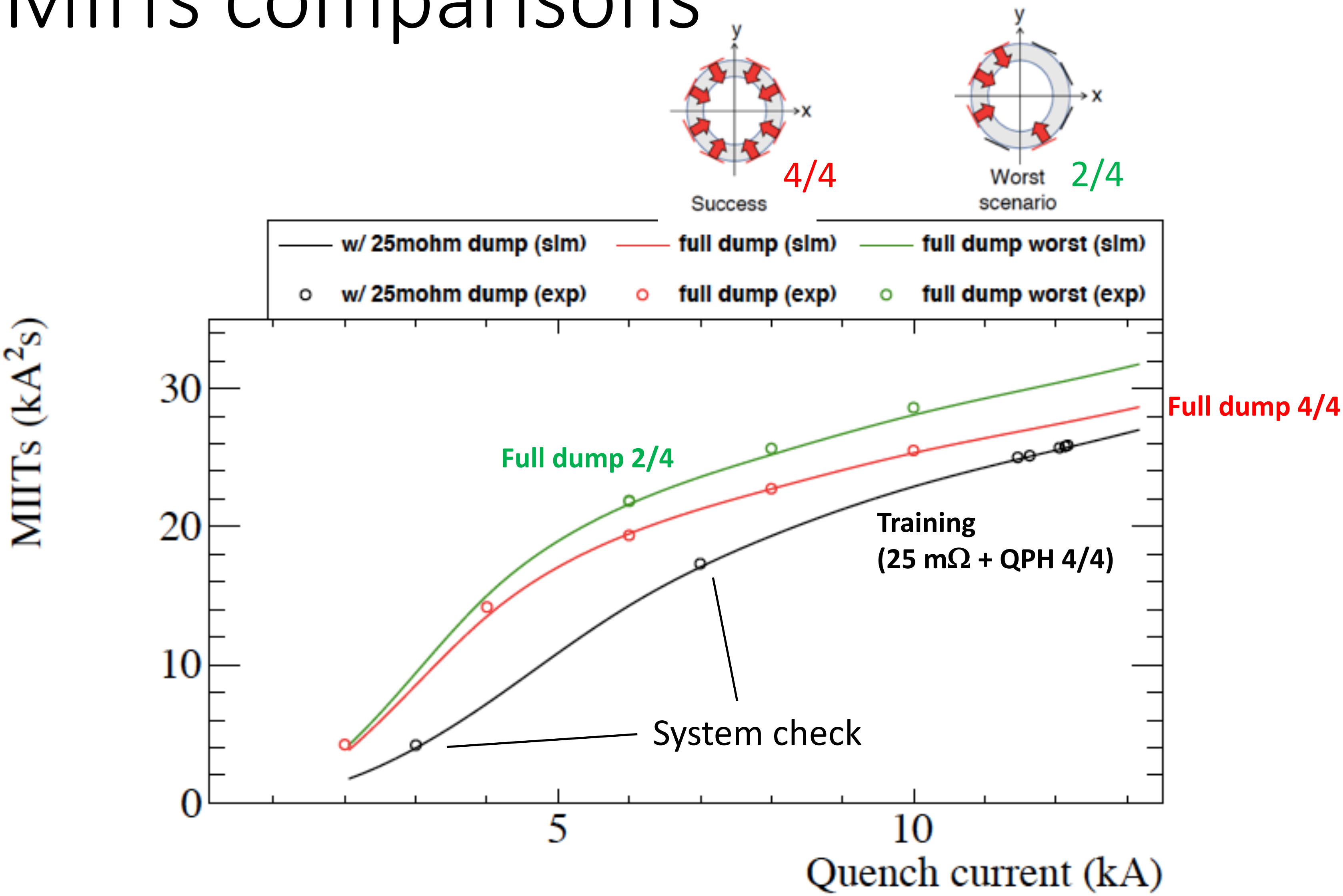
- MIITs (Quench Integral): index to evaluate peak temperature in the quenched coil.
- Baseline of the D1 magnet protection in case of quench: Quench Protection Heaters
  - ➢ Designed by the KEK's simulation code.
  - ➢ Verified with 2-m long model magnets so far.
- **First validation with a 7-m long full-scale magnet.**







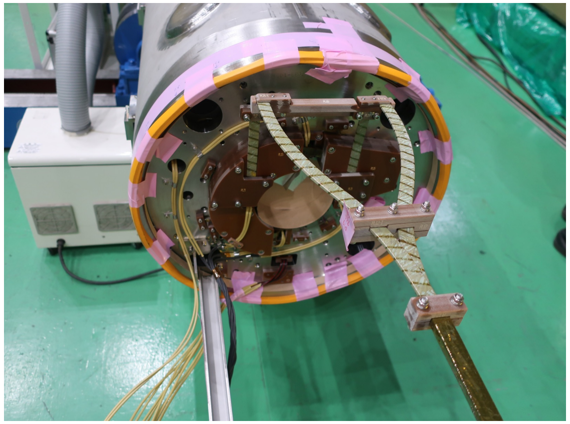
MIITs comparisons



- Measured MIITs are in good agreement with simulated ones

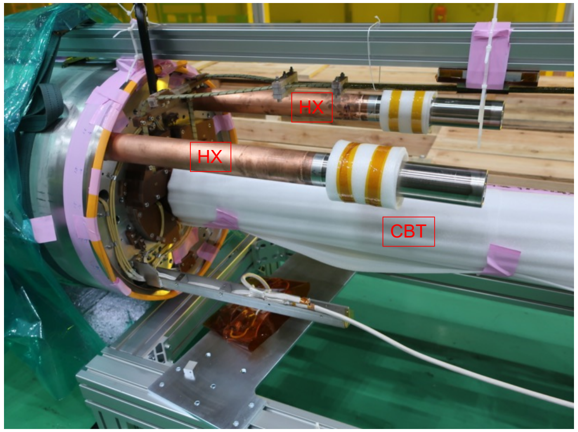
Validating both D1 heater performance and KEK's simulation code

D1 Final Assembly at Hitachi



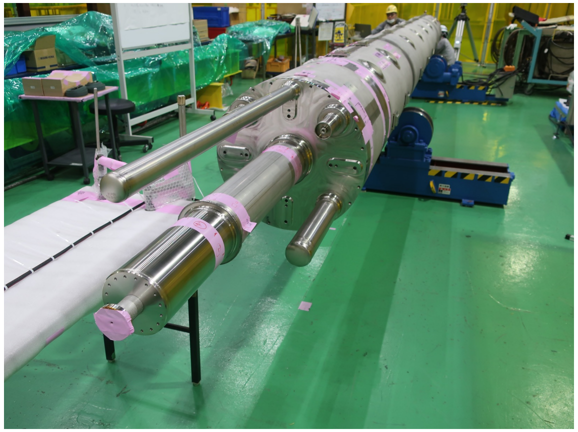
Splice Work

Beam Tube Insertion

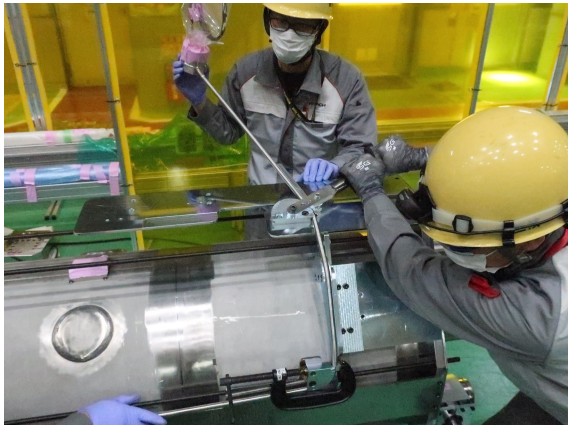


Heat Exchanger Insertion

End Dome Welding



After Welding



Capillary Tube Assembly

Now Welding Support Saddle and Preparing final leak tests

Summary

- Model Magnet (since early 2010s)
  - 3 Model Magnets
    - 1st model rebuilt due to insufficient preload
    - 1st rebuilt and 2nd,3rd showed good training performance
    - Field qualities are not good > modified for Prototype
- Prototype Magnet (since 2018)
  - Quench performance were good enough
    - Test stand needed to be upgraded
  - Field quality needed to be optimized for production
    - Small change in wedges
- Production Magnet (since 2021)
  - 5 production started to be built
  - 1st one come this winter

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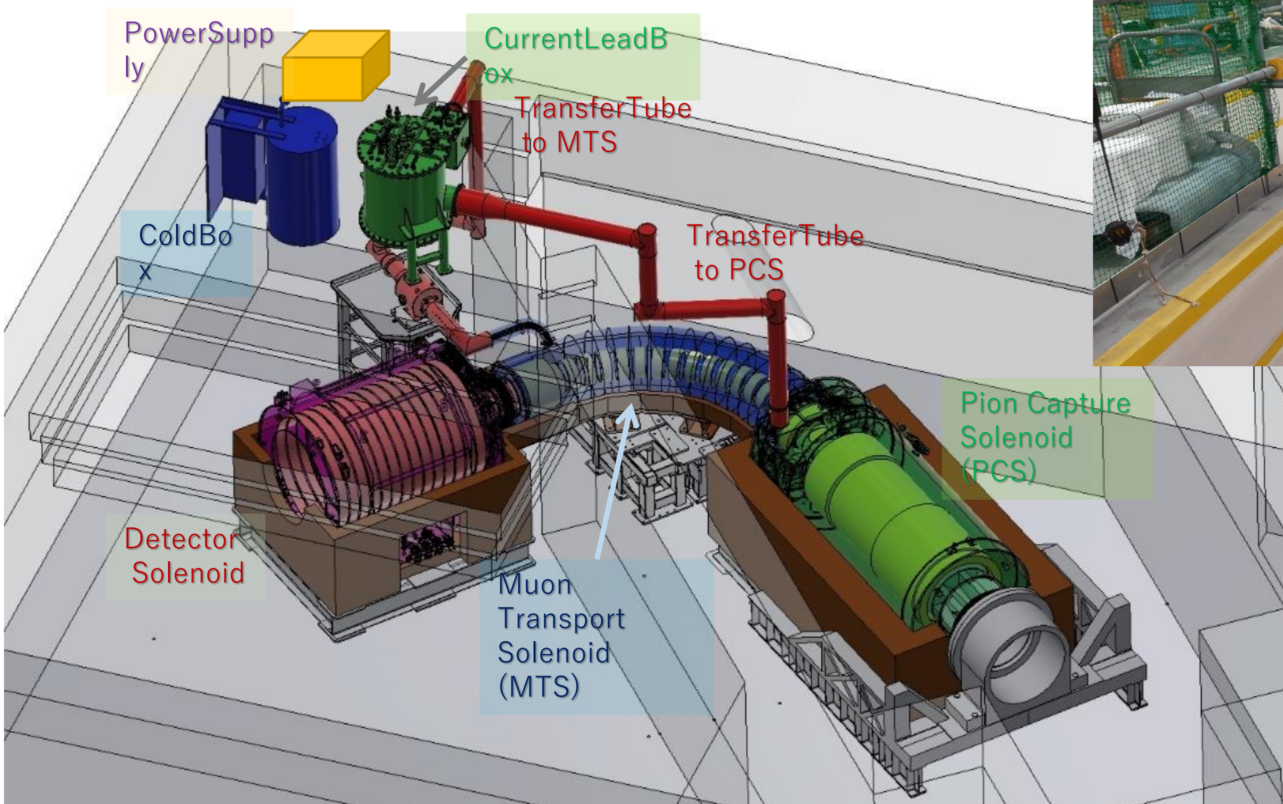
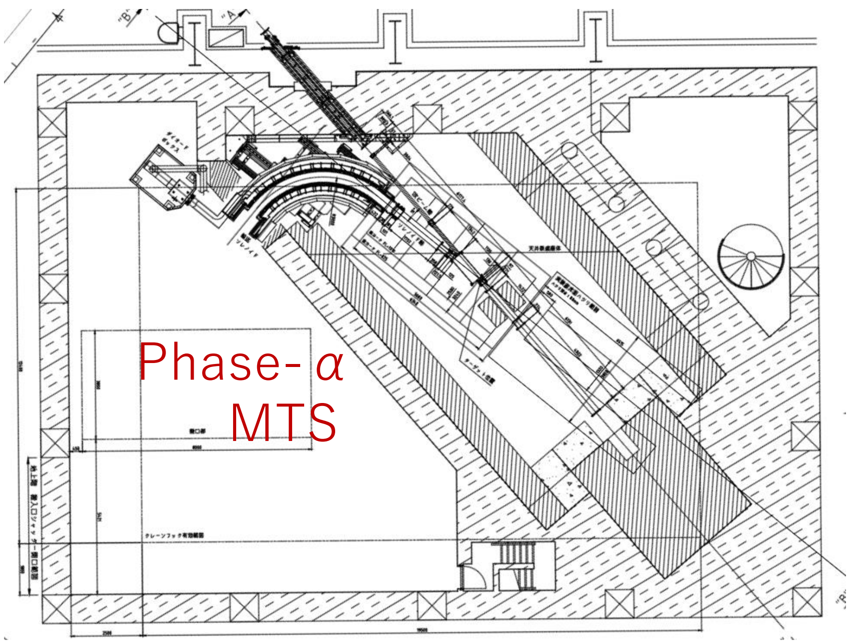
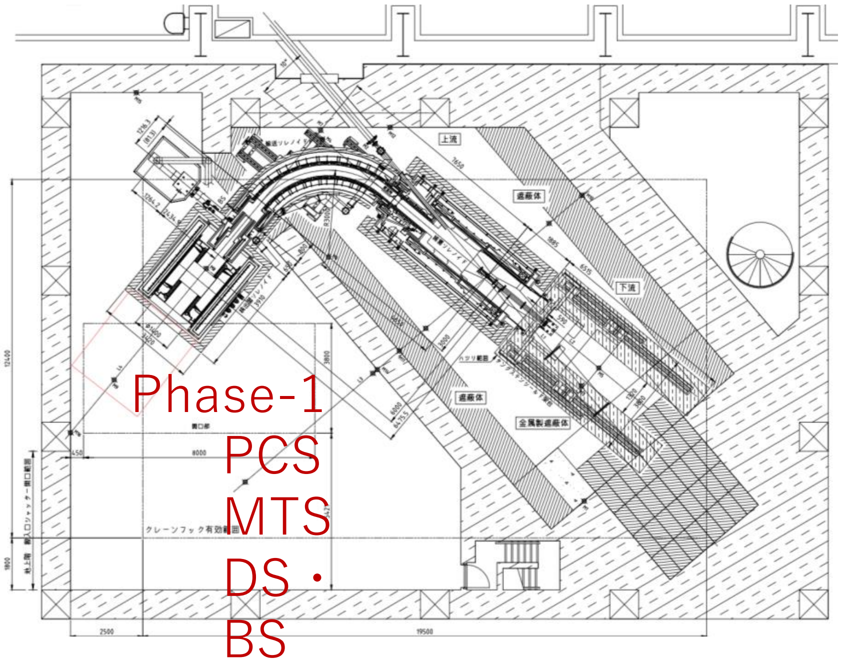
Superconducting Magnet System (COMET Phase-1)



Commissioning of Muon Transport Solenoid





2022/Mar-Apr Insert G10 warmbore in MTS, vacuum tests

2022/May-July MTS commissioning

Cool down, Qeunch test, Field measurement.

Magnet group request the colleagues to stand clear of downstair floor in the period of the first cool down and quench tests for SAFETY.

Status of PCS Main Unit

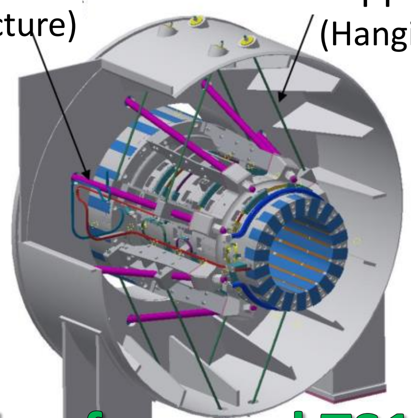
- **PCS main unit has been in production since 2020 at the factory of Mitsubishi Electric in Kobe.**

Annual milestones

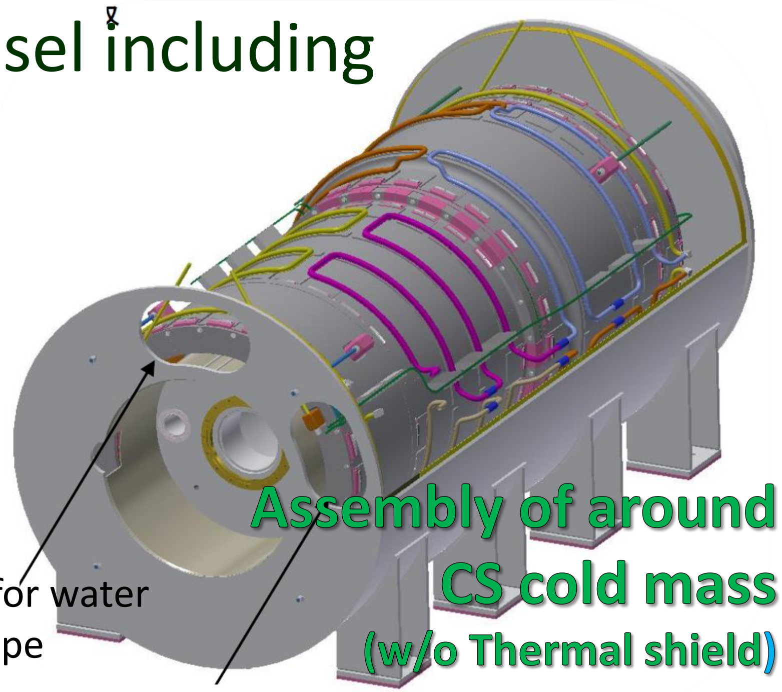
- FY2020: CS & TS1 cold masses: Completed
- **FY2021: Cooling objects conforming to High Pressure Gas Safety Act**
- FY2022: Main unit (cold masses, thermal shields, Part of vacuum vessel)

Working Items

- 4.5 K liquid He piping for CS and TS1 cold masses
  (Application of High Pressure Gas Safety Act)
- Design and production of thermal shields for cold masses
- 60 K gas He piping for thermal shields
  (Application of High Pressure Gas Safety Act)
- Partial production of vacuum vessel including built-in radiation shield.



Assembly of around TS1 cold mass
(w/o Thermal shield)



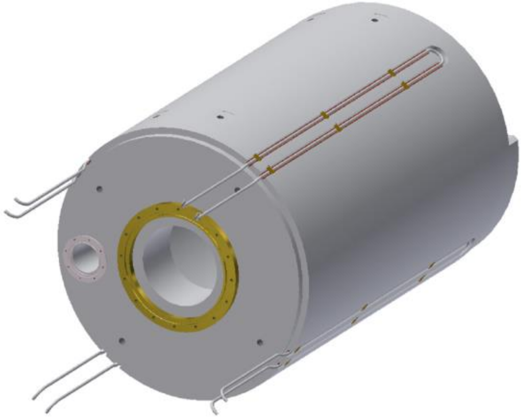
Assembly of around CS cold mass
(w/o Thermal shield)

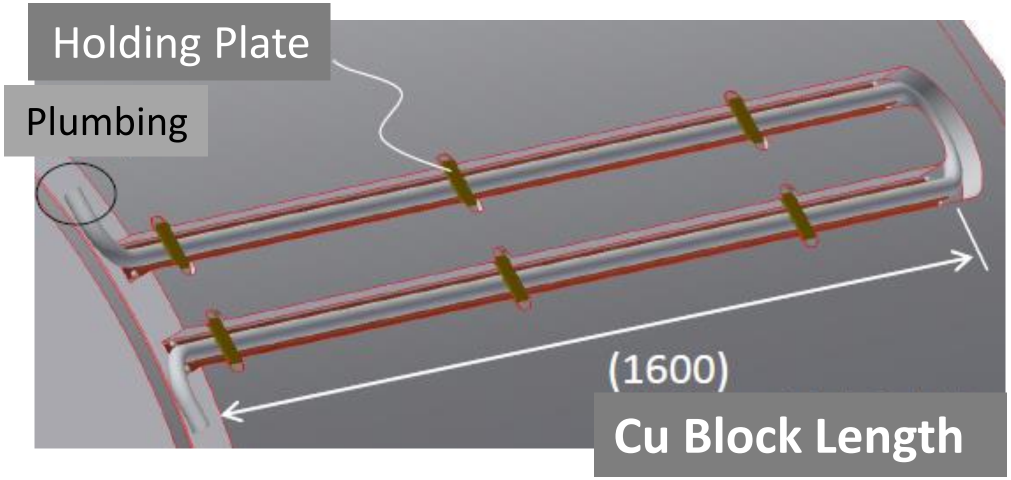
Built-in Radiation Shield

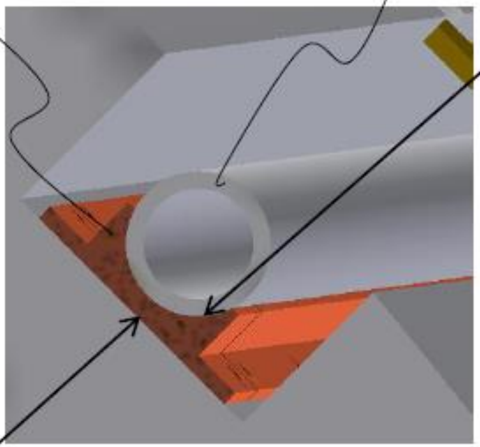
The built-in radiation shield also requires a cooling structure.

Nuclear Heating: **479 W@56kW**, **26 W@3kW**
(Water cooling) (Air cooling)

1. SS pipe is brazed to copper block
2. The copper blocks integrated with the SS pipe are soldered to the groove of the shield.
3. Holding plates are welded to the shield (just in case)







Production Plan of Return Yoke

Return yoke has been in production with great contribution of Hirose-san since April 2021.

- Production of components: Completed
- Assembly test at the factory: Completed

Summary

- The production of PCS main unit is underway at Mitsubishi Electric's factory .
- The production of cooling objects conforming to High Pressure Gas Safety Act is in progress. The production of built-in radiation shield and vacuum vessel parts is also progress in parallel.
- The PCS main unit will be delivered at the end of September 2023. And it will be installed in the beam room in Phase-I construction after temporary storage at the J-PARC site.
- Construction of a return yoke is in progress with the strong contribution of the Hadron Beamline Group.
- All parts of the return yoke will be delivered by mid-March 2022.

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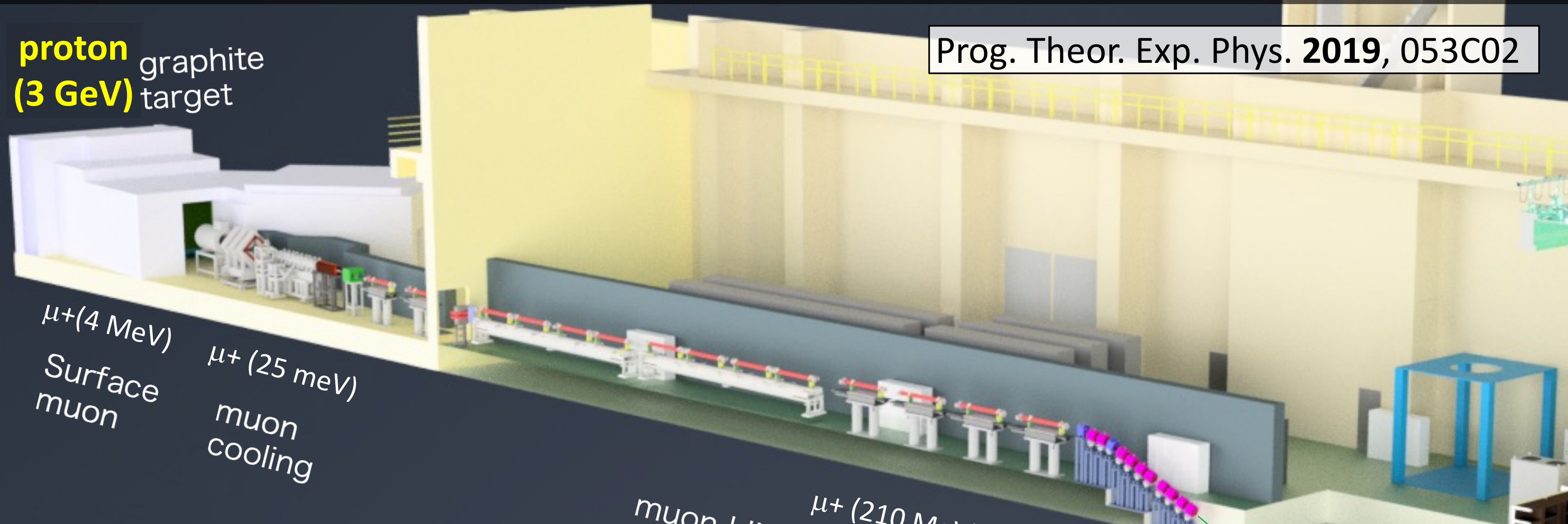
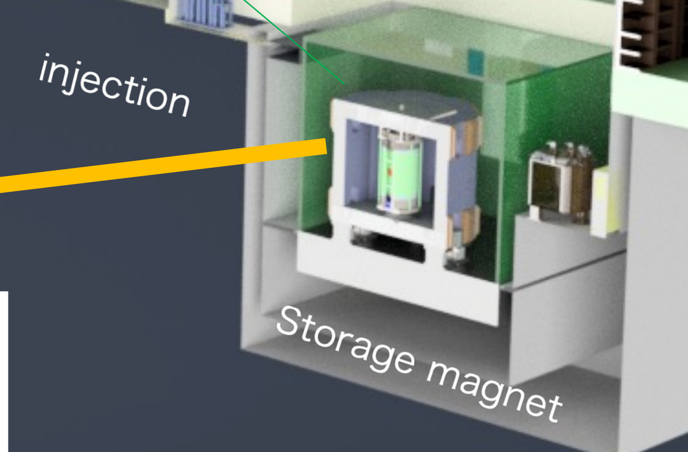
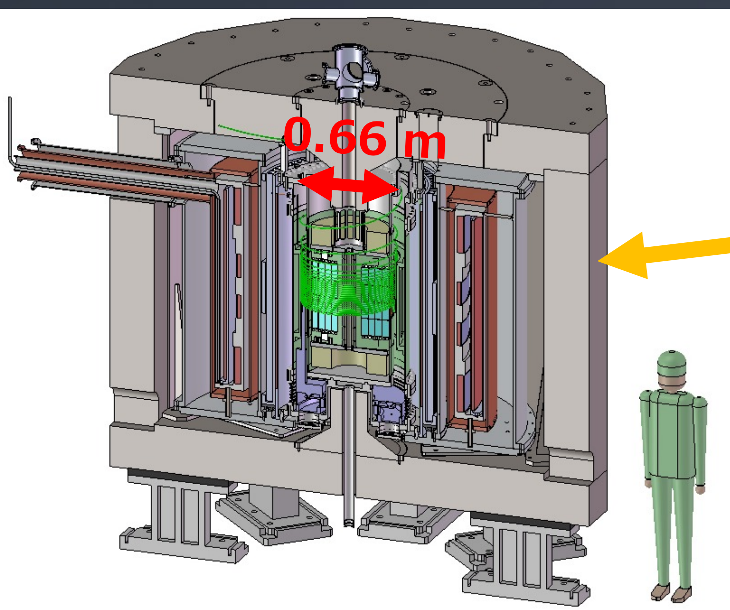
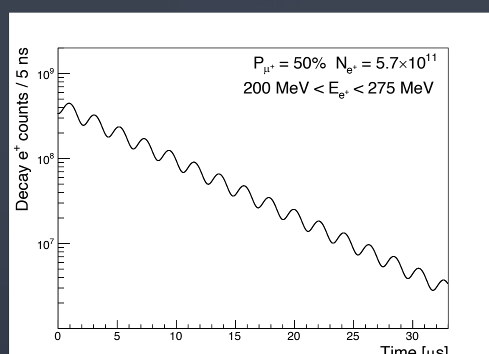
Muon g-2/EDM experiment at J-PARC







muon storage magnet



Goals:

g-2 450 ppb (~ BNL/FNAL run 1)

EDM 1.5 x 10^{-21} e・cm (x70 better)

History

Date	Events
July, 2009	LOI submitted to PAC8
Jan, 2010	Proposal submitted to PAC9
Jan, 2012	CDR submitted to PAC13, Milestones defined.
July, 2012	Stage-1 status recommended by PAC15, granted by the IPNS
May, 2015	TDR submitted to PAC
Oct, 2016	Revised TDR submitted to PAC and FRC
June, 2016	**Selected as a KEK-PIP priority project**
Nov, 2016	Focused review on technical design
Dec, 2017	Responses and Revised TDR submitted to PAC
Nov, 2018	**Stage-2 status granted by the IPNS director**
Jan, 2019 **Mar, 2019**	**Stage-2 status granted by the IMSS director** **KEK-SAC endorsed the E34 for the near-term priority**
June, 2020	**Grant-in-aid "specially prompted research" (2020-2025)**
April, 2022 **(June, 2022)**	**KEK allocated a budget for preparation for construction** **Funding request to MEXT**

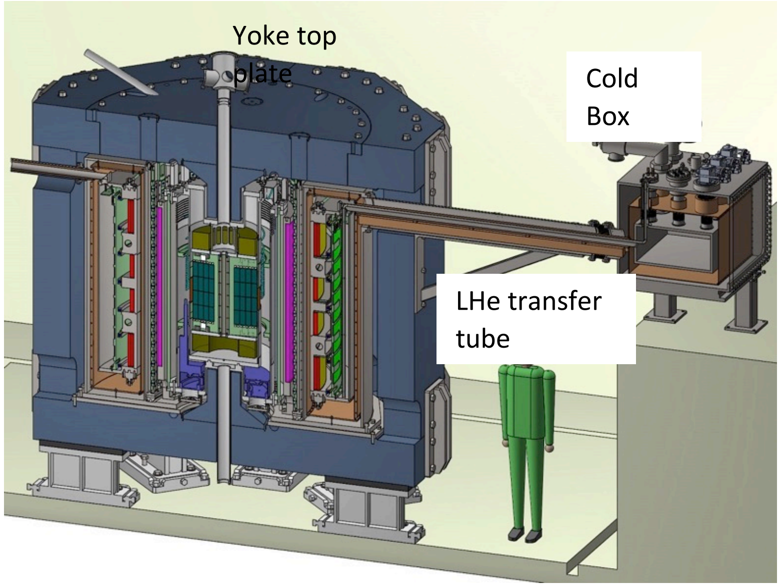
The Magnet

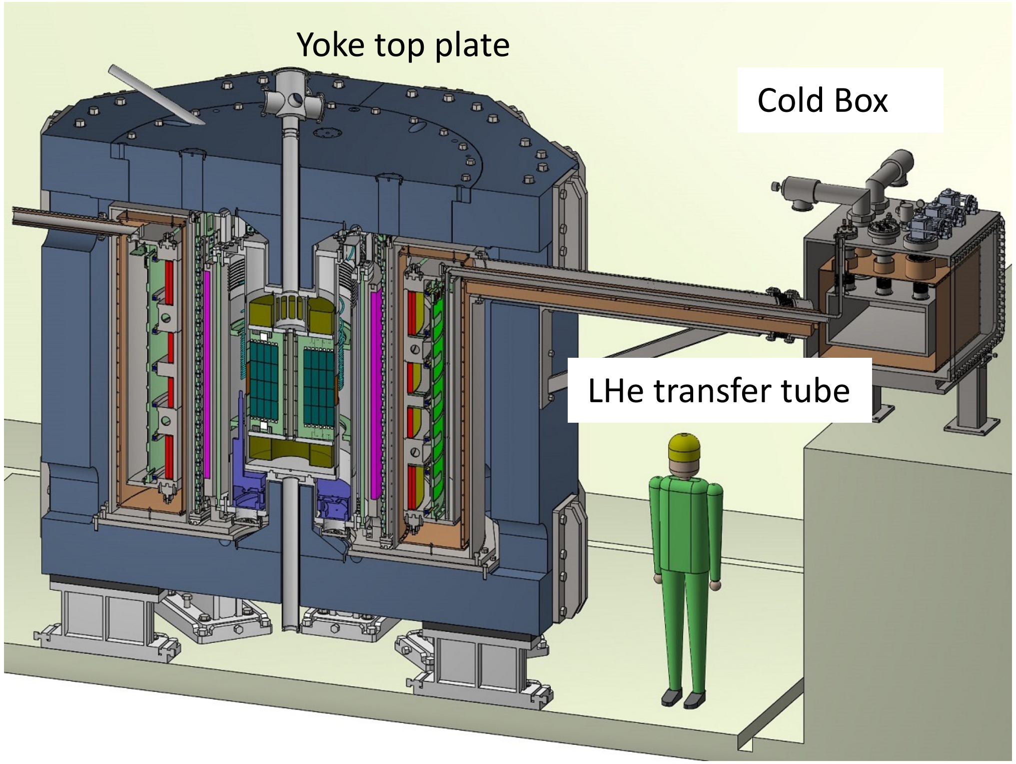
- Storage region :
  - radius : 33.3 ± 1.5 cm
  - height : ± 5 cm
  - Field strength : 3T
  - Uniformity : 0.1 ppm (Azimuthal integral)
- Injection region :
  - Smooth field for beam injection
- Weak focus field: -5e-4 T/m of Br at maximum

Adopt MRI technology

Superconducting solenoid system

- Current model of the magnet



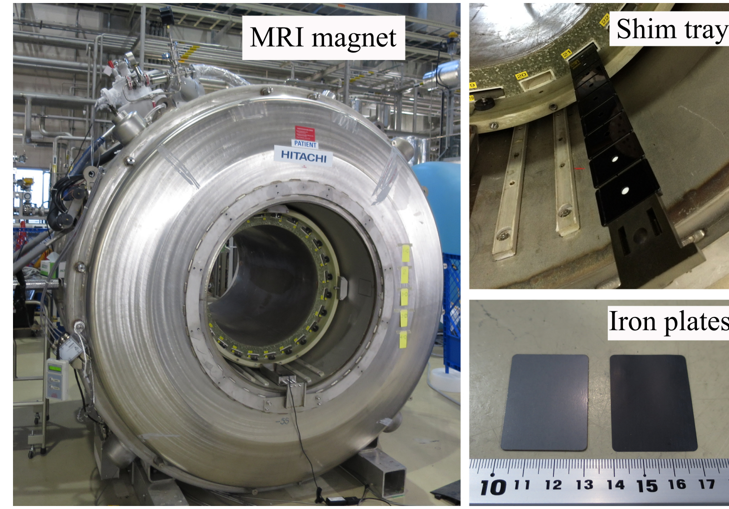


- Mag. field monitoring system
  - CW-NMR probe : < 0.1 ppm accuracy
    - Mapping probe
    - Drift monitoring probe
    - Standard probe

- Superconducting coils : NbTi
  - Main solenoid coil
    - Persistent current operation
  - Weak focusing coil
    - Power supply operation
  - Shim coils
    - Power supply operation
- Cooled by liquid Helium
  - Cryocoolers to recondense LHe
- Separated cold box from magnet cryostat
  - Isolate vibration
- Vibration isolation/control system
- Iron yoke
  - Adjust field shape
- Field tuning system using iron pieces

Study on shimming scheme

- Studying the shimming scheme : MuSEUM magnet
  - Different magnet
    - Developed process can be applied to g-2



- Simulation study
  - Optimum area for shimming calculation
  - Effect of error field due to massive iron outside the magnet
  - Accuracy of magnetic field interpolation
  - Effect of random measurement error

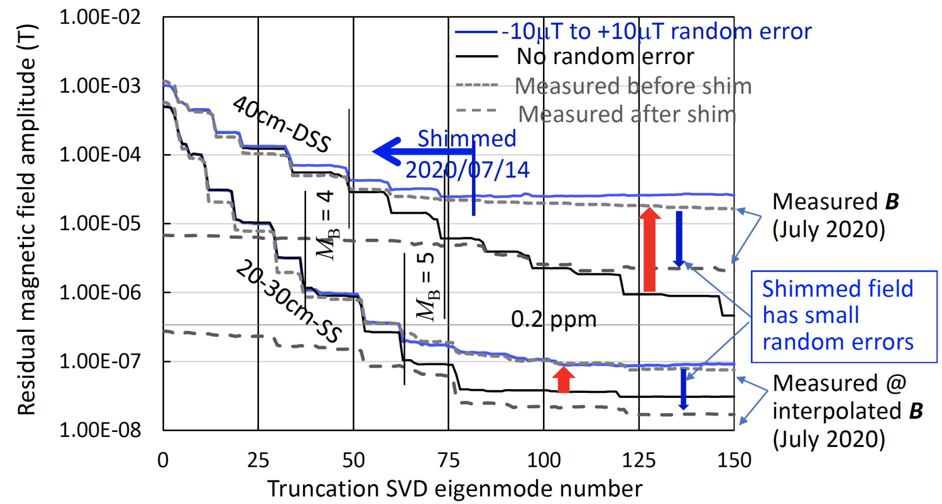
✓ Random error

  ✓ result in worse homogeneity

➢ Require

  ➢ precise measurement

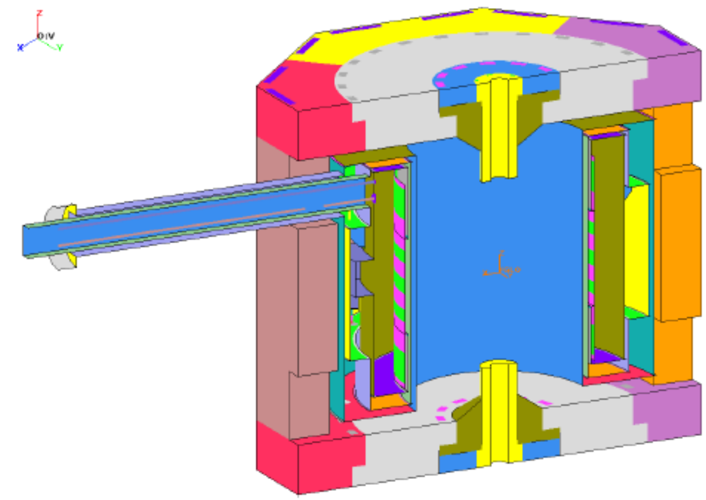
  ➢ previous rough shimming



- Continue the study to explore the best shimming process

Study of cryocooler vibration effect

- Vibration source
  - Ground vibration
  - GM cryocoolers

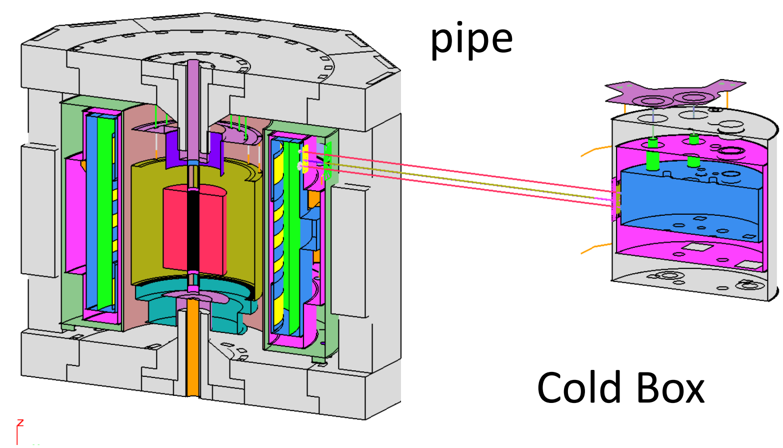


- Ground vibration
  - Magnet : 2019
    - With practical mechanical design
    - Apply measured <u>ground vibration</u>

expect : ~ 0.33 ppm@14.3 Hz

Need vibration isolation system

- GM cryocoolers
  - Cold box : 2020
  - Overall : 2021



Study of cryocooler vibration effect

- Frequency response analysis with ANSYS

Normal vibration modes
1) 20.48 Hz
2) 21.48 Hz
3) 41.67 Hz
4) 53.38 Hz
5) 53.68 Hz
6) 60.74 Hz
:

10 N each

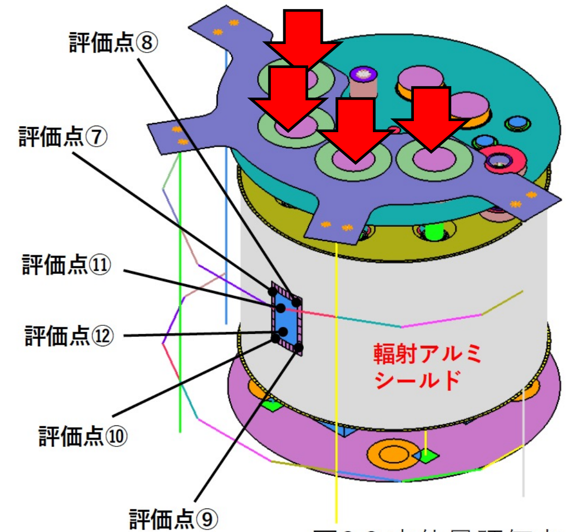
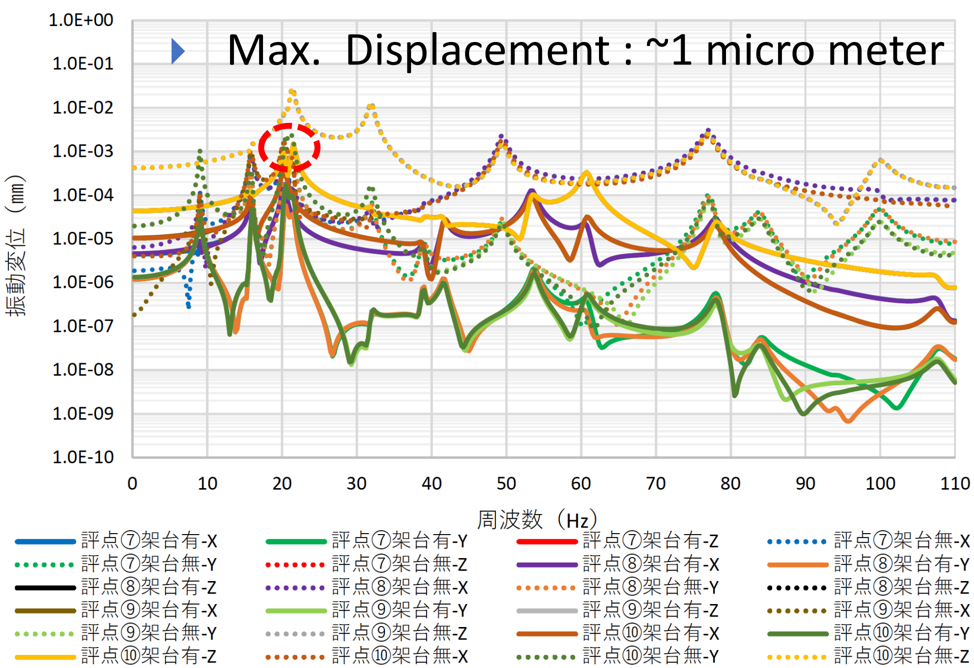
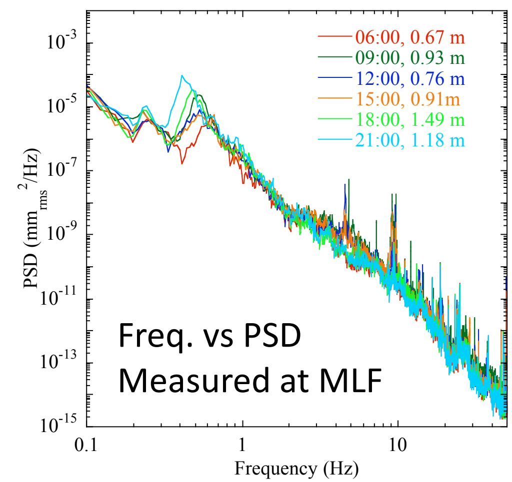


図2.2 変位量評価点

- Max. Displacement : ~1 micro meter

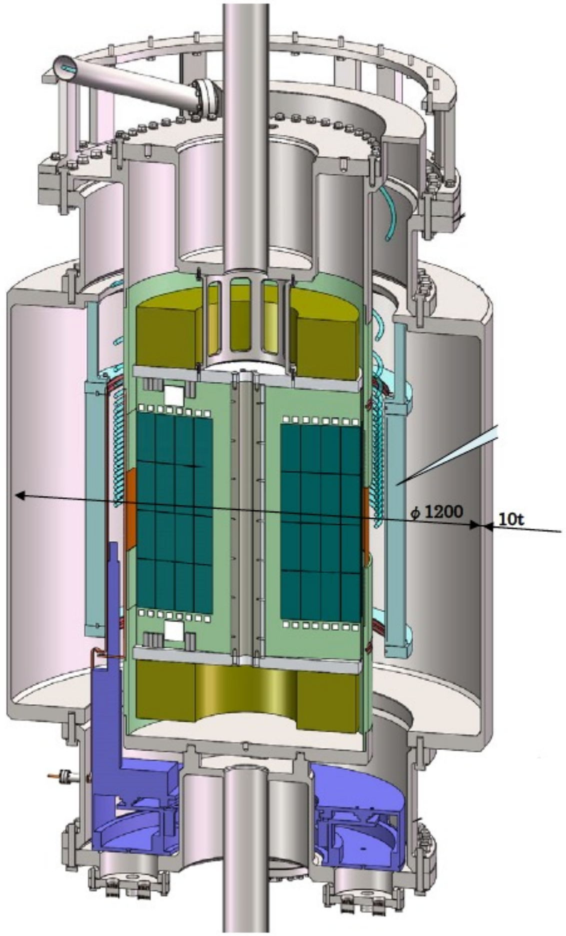




- Max. Displacement : small enough
- Ground vib. : off resonant

R&D of moving stage

- 3D moving stage
  - to get field map in the muon storage region

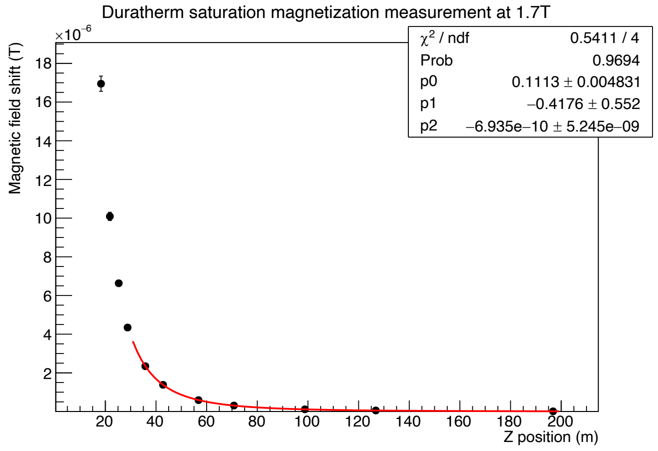


- Need azimuthal moving stage with large diameter
  - Non-magnetic -> Low-magnetic
- Discuss with German company (FRANKE)

✓ Crossed roller bearings

Magnetization check

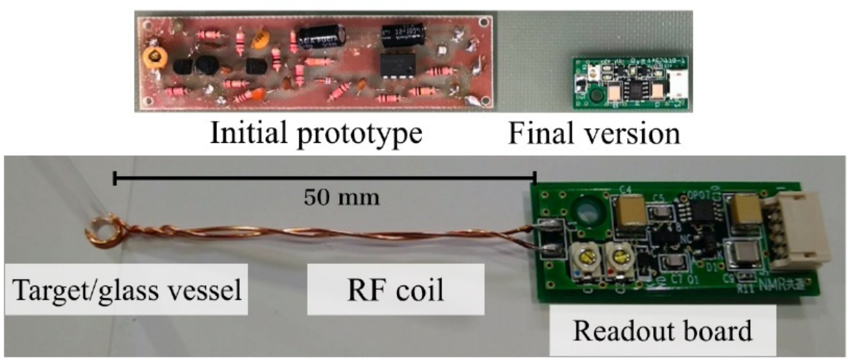
	Magnetic moment (Am^2/g)
Duratherm	0.00316092
Ni	0.05468 (measured)
SUS304[*1]	~0.01



Magnetic field mapping system ~ 1ch

by H. Tada & S. Oyama

- Study of probe configuration
  - Material of RF coil
    - Cu wire, Non-mag. wire
  - Diameter of Glass tube
    - 3 mm or 5 mm
  - NMR sample
    - Water or MgCl2 Solution



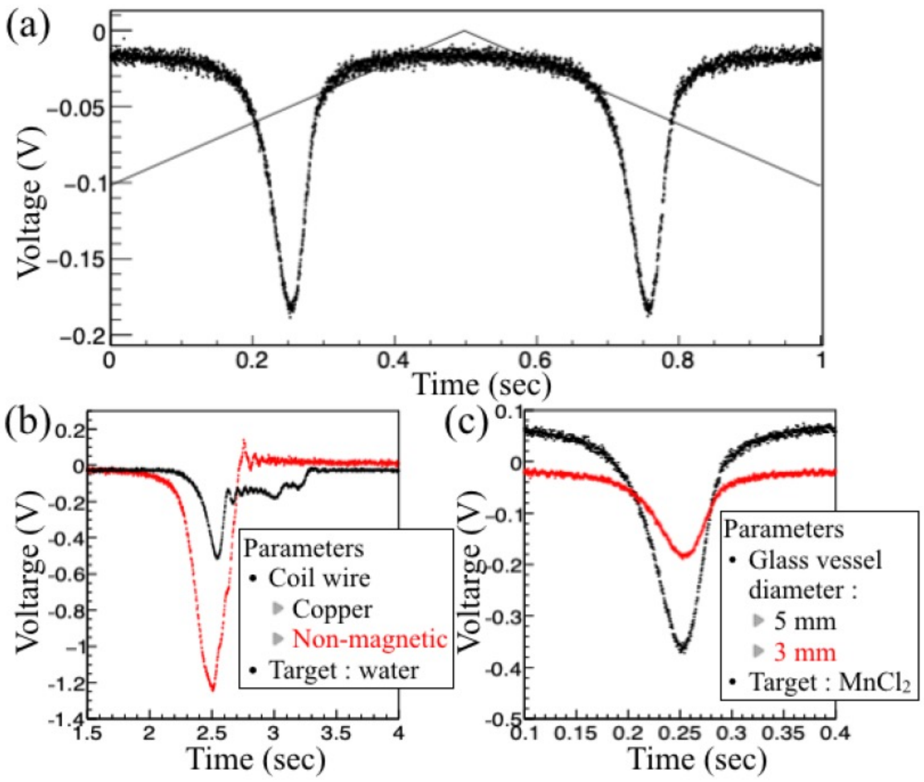


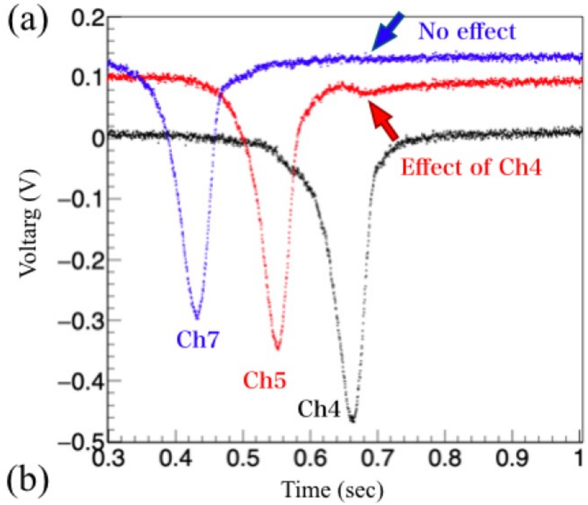
Fig. 4. (a) Data sample: The RF frequency is swept with the triangular frequency modulation. (b) Comparison of coil wires (sample: water), (c) Comparison of glass tube diameters (sample: manganese chloride solution). The blue line indicates the same frequency sweep range.

✓ Non-mag. wire
✓ ϕ 3 mm tube
✓ Use water and solution properly according to the homogeneity

Magnetic field mapping system ~ 8 ch

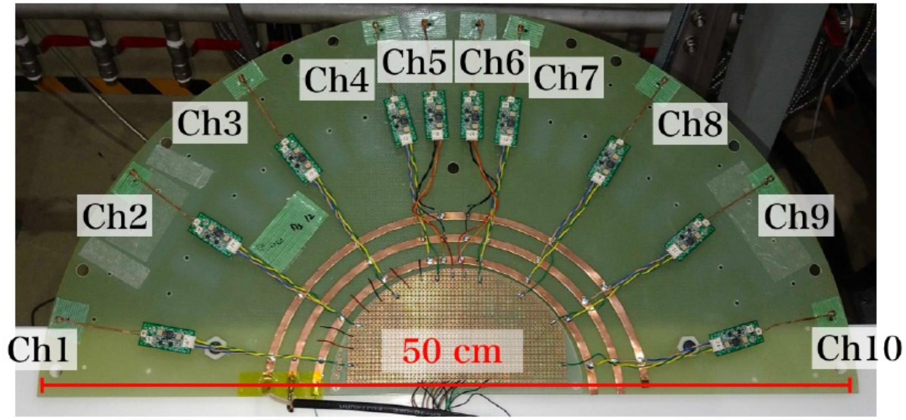
- Goal : 24 ch probe system
  - prototype : 10 ch system
    - verify the multi-ch. operation

✓ Cross talk btw channels



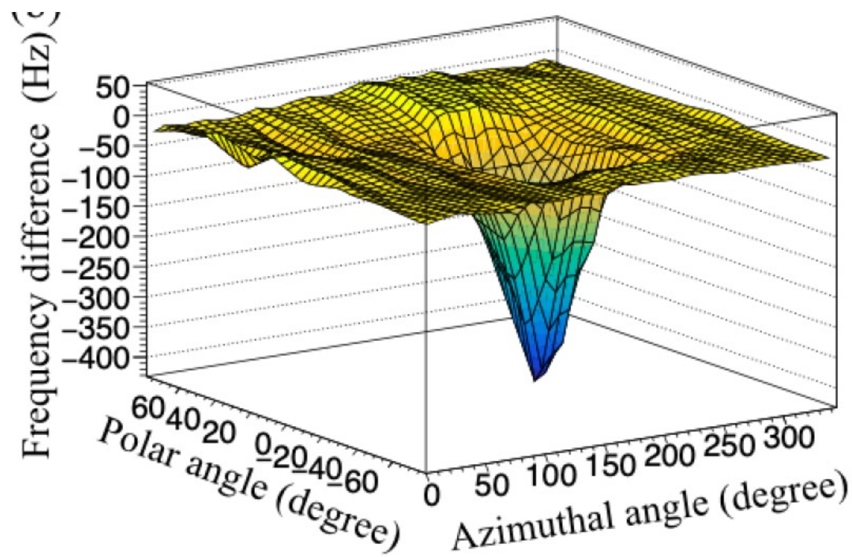
◆ Measurement sequence test

✓ Signal peak due to iron
- ✓ Meas. : -430 +/- 10 Hz
- ✓ Calc. : -467 Hz



✓ Estimate uncertainty due to the crosstalk
- ➢ ~2 ppb

＊Depends on the magnitude of crosstalk

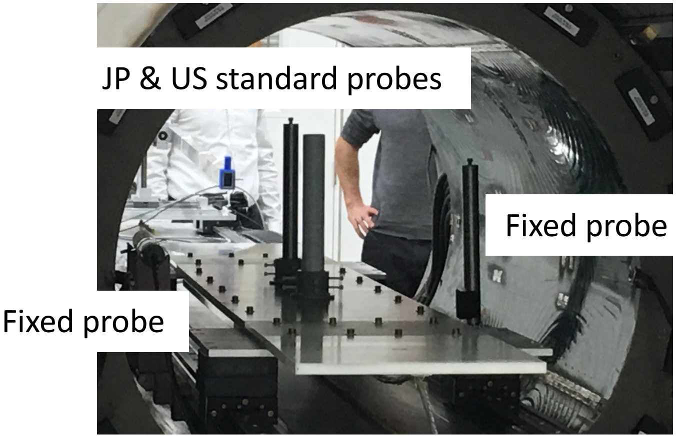


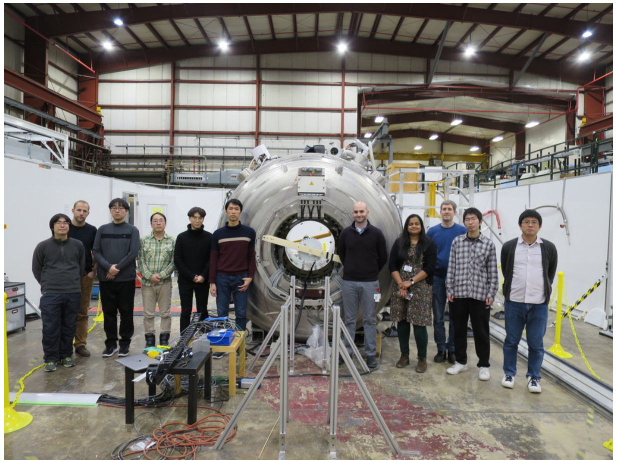
Cross calibration in US-JP collaborative framework

- Check consistency btw J-PARC and FNAL probes
  - increase the robustness of magnetic field measurement
  - collaboration with ANL and UMass group
  - at 1.45, 1.7 and 3.0 T

✓ measure magnetic field of single magnet at the same location with different probes

- Performed tests at 1.45 and 1.7 T in 2019





- planned 3 T test in 2020 <- postponed
- Analyzed the data at 1.45 T and 1.7 T with blind offset

Summary

- Updates of magnet design
  - Optimized main coil size
  - Systematic and statistical study of manufacturing error on the magnetic field error -> on going
  - Study of shimming scheme -> on going
  - Study of magnet system vibration -> on going
- Field monitoring system
  - R&D of moving stage
    - material study of rotating bearing
  - Multi channel probe system
    - made 10 ch. prototype, checked cross-talk and meas. scheme
  - Cross calibration analysis
    - found the difference : 40 ~ 55 ppb -> further study is underway
  - He3 probe
    - made cells, checked discharge performance
    - preparing laser room to do the test in J-PARC

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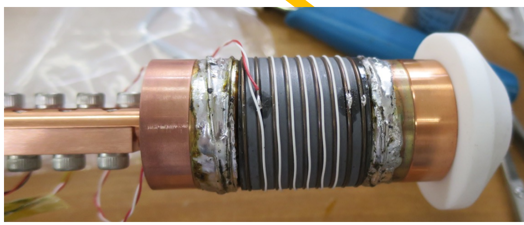
Nb3Sn conductor R&D structure

Design and Characterization

KEK



- Evaluation of J_c, B_{c2}
- Mechanical property

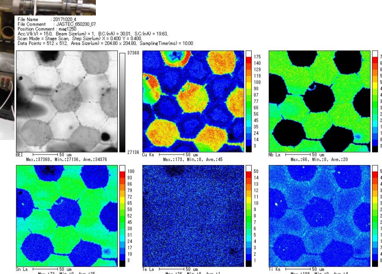
CERN

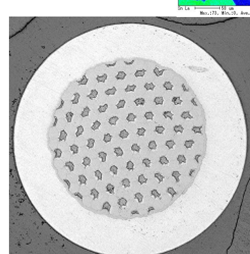
- In-depth characterization HT, J_c, composition, d_{eff} ...

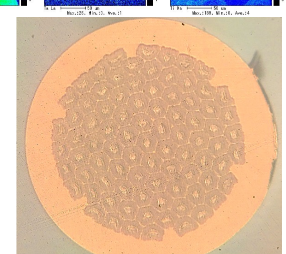
- **Program coordination**
- **Defining specification**
- **Conceptual design**

Tokai University

- Optimization of HT condition
- Microstructure observation
- Compositional analysis



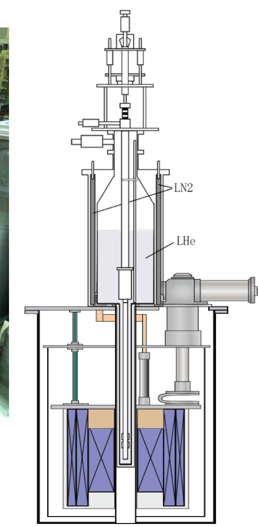




Tohoku University

- High field magnet facility
- Evaluation of d_{eff}

28 T HM



Spec, design

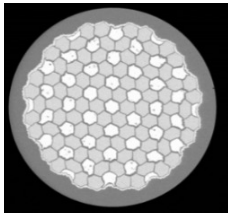
R&D billets

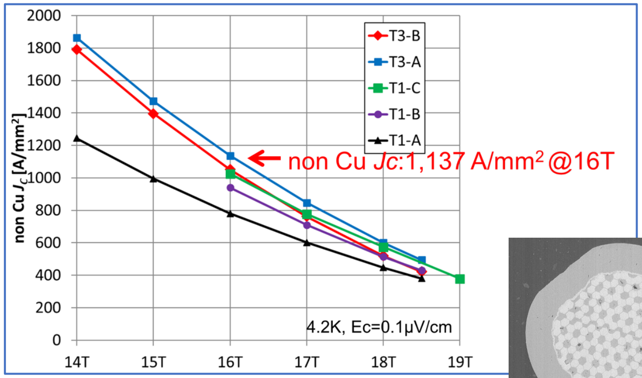
Fabrication

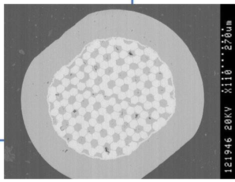
Kobe Steel / JASTEC

Furukawa Electric

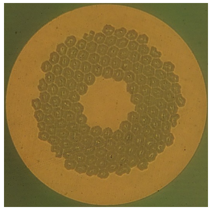
Status of Nb3Sn conductor R&D

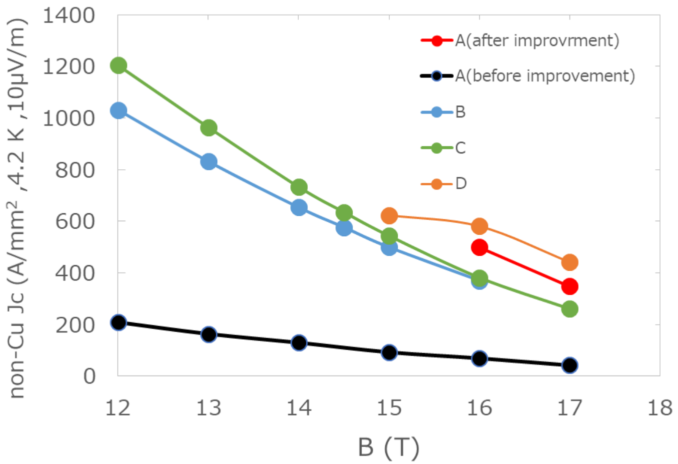




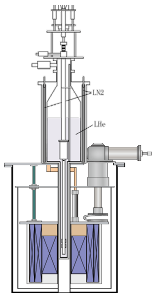


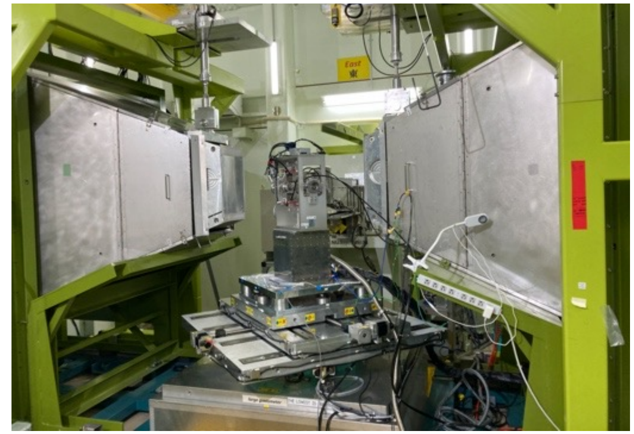
- DT wire
  - non Cu J_c @16T 1,100 A/mm²
  - reasonable results in d_{eff} (~50μm)
  - and rolling test (Ic/Ic0>95%, RRR>100 @ 10% roll)
  - Production of 10km wire is on going.
- Nb tube wire
  - Non-Cu Jc of 580 A/mm² @16 T
  - Further improvement in progress

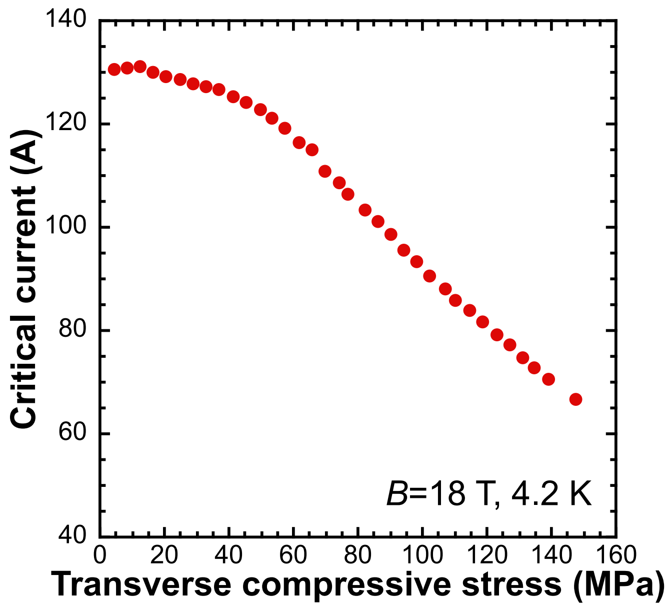




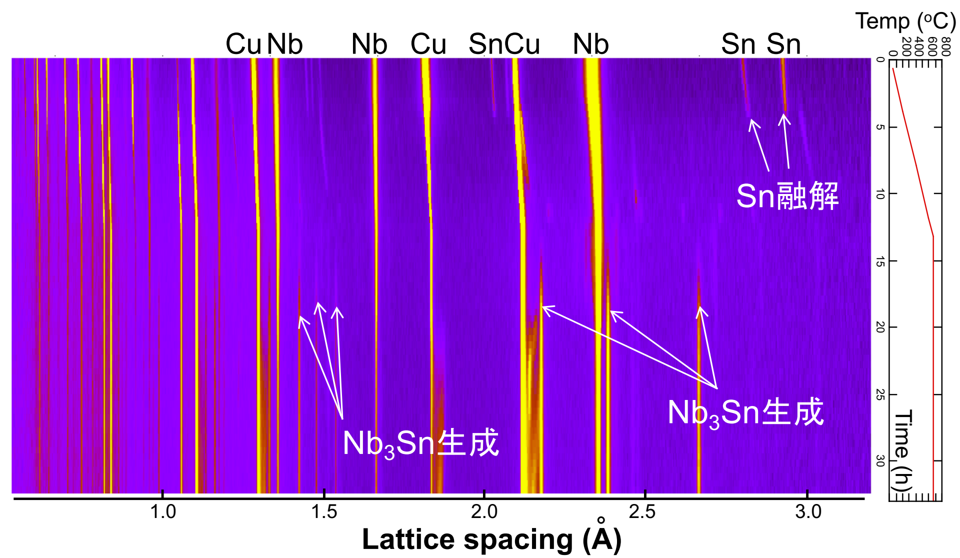
Nb_3Sn Recent Progress







Ic Measurement with Transverse Stress at Tohoku U.



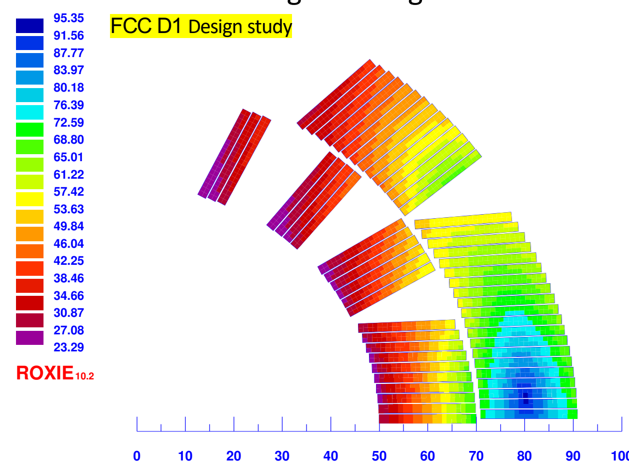
In-situ Material Analysis during Heat Treatment at J-PARC Neutron Beam Line

Future Magnet Development with Large Funding (Dream..)

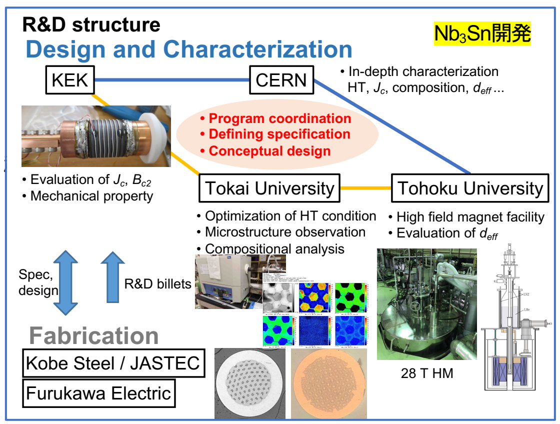
Magnet Manufacturing Experience

Infrastructure

Magnet Design



Advanced Conductor Development



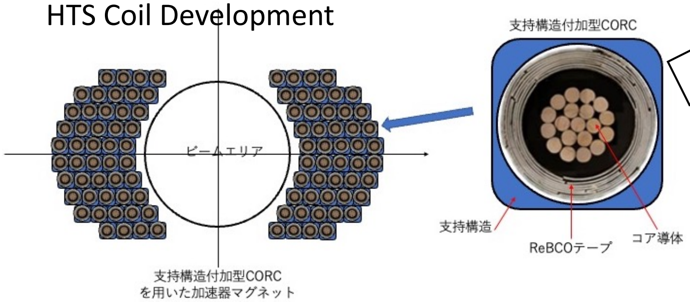
Large Aperture 12T Magnet

16-20T Magnet

4-8T Insert Coil

High Field Magnet for Future Accelerator

HTS Coil Development



New JSPS Funding with Tohoku and Kyoto

Contents

- On going Projects
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- **Future R&D**
  - High Field Magnet
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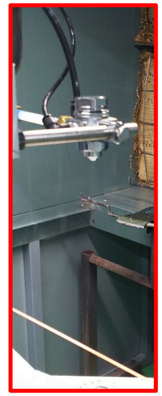
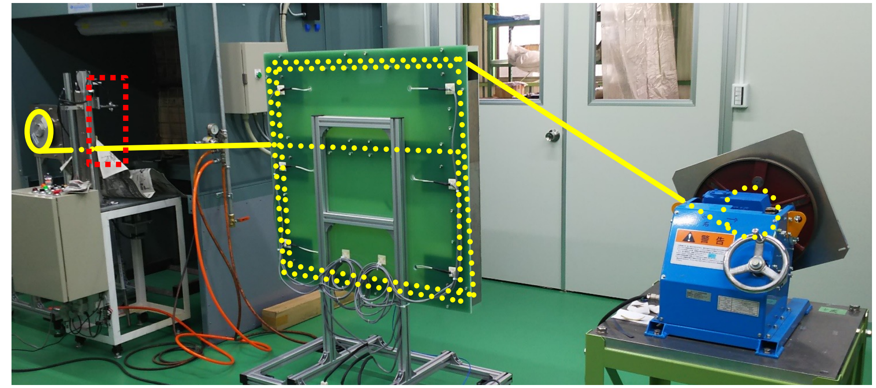
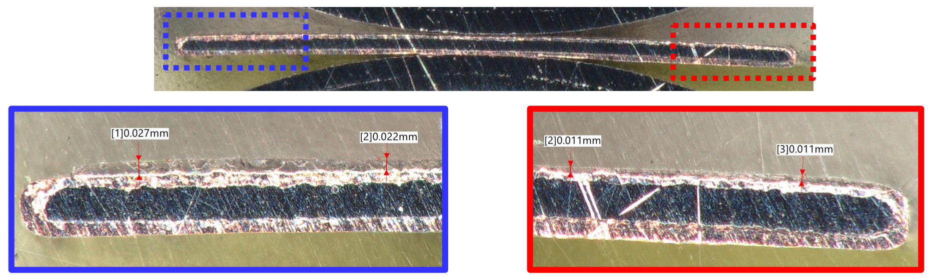
Inorganic Insulation HTS coil

R&D of continuous coating on long tapes by real to real insulation machine is in progress.

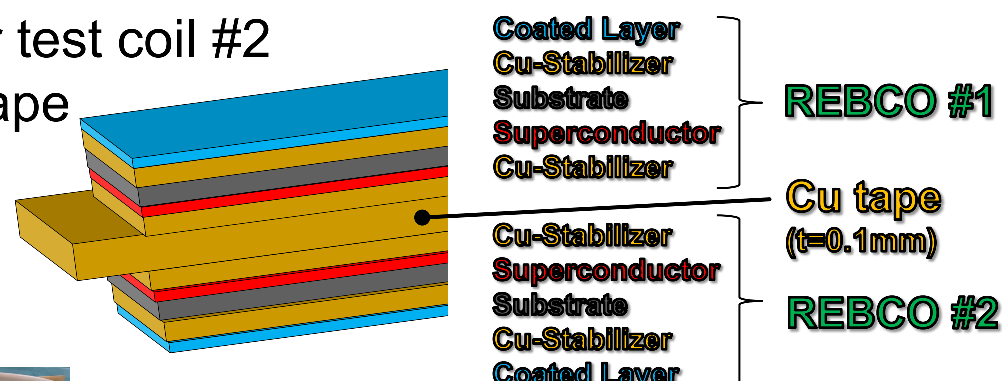
Although continuous coating is successful, difference in thickness of ~16 μm in the width direction is confirmed.

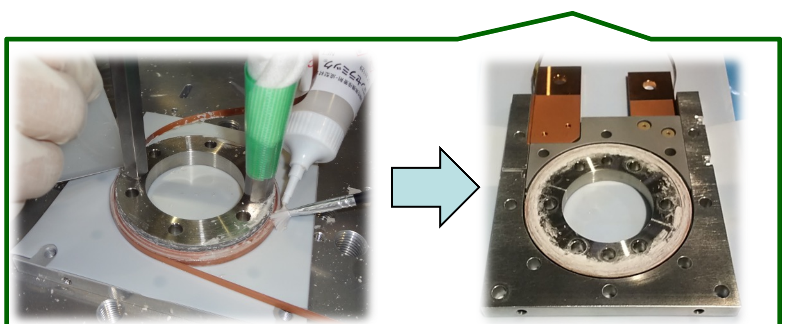






Preparing the winding of the circular test coil #2 with co-winding 2 REBCO and Cu tape (same shape as <u>Test coil #1</u>)



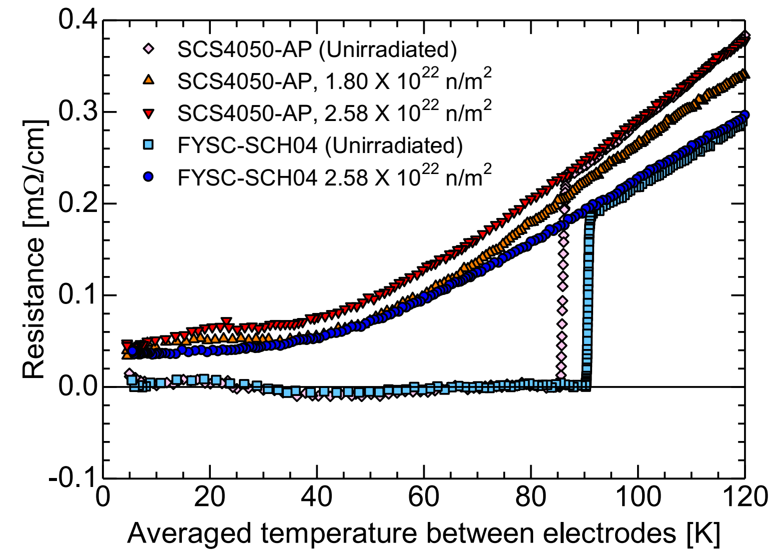


Wires identified and shipped from LBNL to KEK for testing KEK's new ceramic coating insulation on Nb_3Sn and Bi-2212 wires.

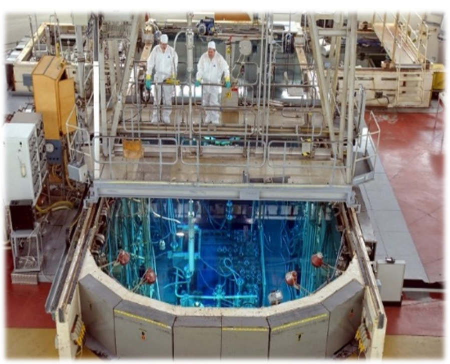
BERKELEY LAB

Neutron Irradiation to HTS

- Neutron Irradiation
    - Belgium BR2 (Also plan at JR3 at JAEA)
        - ReBCO (Re = Gd or Eu or Y)
- Post Irradiation Experiment (PIE)
    - Hot Labo at Tohoku Univ. Oarai Center



BR2 @Belgian nuclear research center

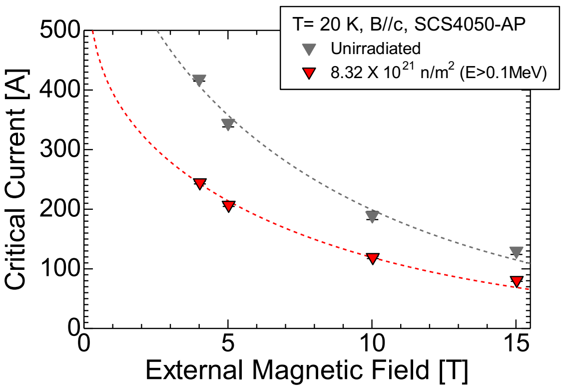


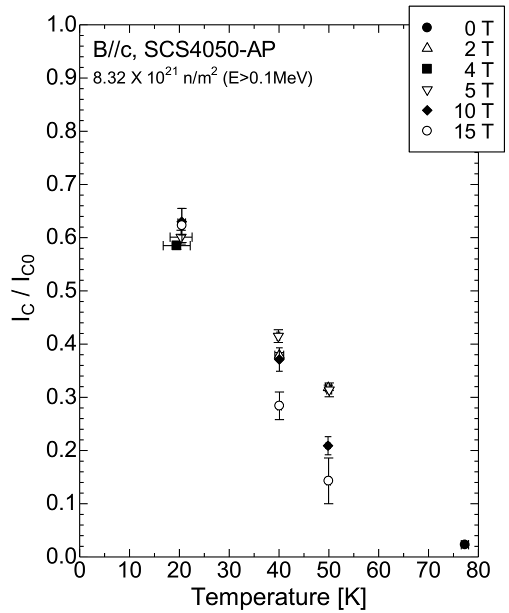
PIE Sample preparation

Ic Measurement
Magnet

Neutron irradiation to HTS

PIE of GdBCO samples with neutron flux of 1.80, 2.58x10^{22} n/m^2

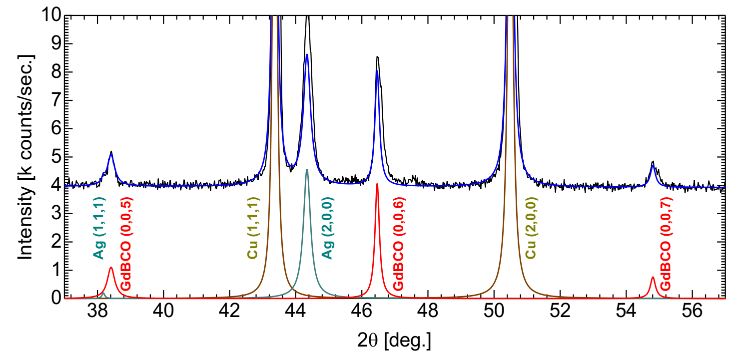




Neutron irradiation effect on Tc
***influence of Cd foil for SuperPower SCS4050**

D. X. Fischer, et al., Supercond. Sci. Technol. 31 (2018) 044006

- **No significant degradation in shielded HTS tape at 0.6 x 10^{22} n/m^2.**
- **But, reduction of Tc by 5 K in unshielded sample.**



X-ray diffraction patterns of the unirradiated GdBCO tape as a preliminary study.

□ **Degradation is confirmed**

Further study

- **PIE of GdBCO samples of target fluence 1x10^{21}, 5x10^{21} n/m^2**
- **Fast neutron irradiation by shielding of samples with Cd foil**
- **Irradiation of EuBCO & YBCO samples to confirm the contribution of Gd**
- **Materials analysis of irradiated samples at UC Berkeley**

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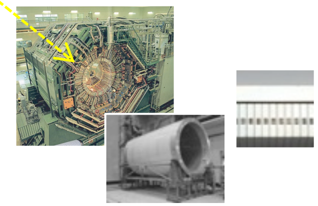
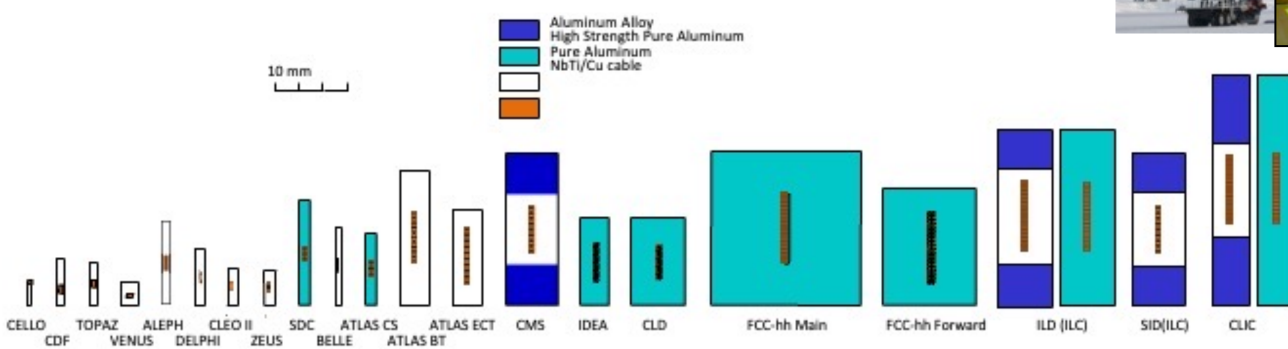
History of Detector Solenoids

Experiment	Laboratory	R (m)	B (T)	I (kA)	X (X_0)	E/M (kJ/kg)	E (MJ)	Year
PLUTO	DESY	0.75	2.2	1.3	4.0	2.3	4.1	1972
ISR point 1	CERN	0.85	1.5	2	1.1	1.8	3.0	1977
CELLO	Saclay/DESY	0.85	1.5	3	0.6	5.0	7.0	1978
PEP4/TPC	LBL/SLAC	1.1	1.5	2.27	0.83	7.6	11	1983
CDF	KEK/FNAL	1.5	1.6	5	0.84	5.4	30	1984
TOPAZ	KEK	1.45	1.2	3.65	0.70	4.3	19	1984
VENUS	KEK	1.75	0.75	4	0.52	2.8	11.7	1985
AMY	KEK	1.2	3	5	N/A	N/A	40	1985
CLEO-II	Cornell	1.55	1.5	3.3	2.5	3.7	25	1988
ALEPH	Saclay/CERN	2.75	1.5	5	2.0	5.5	136	1987
DELPHI	RAL/CERN	2.8	1.2	5	1.7	4.2	110	1988
ZEUS	INFN/DESY	1.5	1.8	5	0.9	5.2	10.5	1988
H1	RAL/DESY	2.8	1.2	5	1.8	4.8	120	1990
BESS	KEK	0.5	1.2	0.38	0.2	6.6	0.25	1990
WASA	KEK/Uppsala	0.25	1.3	0.9	0.18	6	0.12	1996
BABAR	INFN/SLAC	1.5	1.5	6.83	0.5	N/A	27	1997
D0	FNAL	0.6	2.0	4.85	0.9	3.7	5.6	1998
BELLE	KEK	1.8	1.5	4.16	N/A	5.3	37	1998
ATLAS-CS	KEK/CERN	1.25	2.0	7.8	0.66	7.1	38	2001
BESS-polar	KEK	0.45	1.0	0.48	0.156	9.2	0.34	2005
CMS	CMS/CERN	3.0	4.0	19.5	N/A	12	2600	2007
BESIII	IHEP (China)	1.45	1.0	5	N/A	2.6	9.5	2008
CMD-3	BINP	0.35	1.5	1	0.085	8.2	0.31	2009





Aluminum Stabilized Conductor: Last production COMET & Mu2e

Now all company stop producing Al stabilized conductors

Issue: Revive the current technology and create new technologies (HTS Al stabilized?)

Workshop on Superconducting Detector Magnets for Future Colliders and Physics Experiments

- Together with KEK, CERN is organizing a workshop on present and future superconducting detector magnet projects, to be **hosted by CERN, September 12-14, 2022**, with aluminum-stabilized conductors as topic of particular interested

- Meant for:
  - Institutes working on the design and construction of superconducting detector magnets
  - Industry working on all aspects of superconducting detector magnets, especially the present and future production of aluminum-stabilized conductors in all its constituents.
  - Other interested parties

- For the purpose of:
  - Addressing the issue of unavailability of aluminum-stabilized conductor technology for future superconducting detector magnets
  - Informing the community of on-going projects
  - Fostering collaboration, the exchange of ideas, concepts, and best practices, and to advance superconducting detector magnet technology

Workshop held on **12 – 14 September 2022,** and hosted by **CERN**, in hybrid style

- **Co-chairs :** Matthias Mentink (CERN) and Toru Ogitsu (KEK)

- **Local Organizing Committee:** Nikkie Deelen and Connie Potter (CERN)

- **Program Committee:**
  - EU: Benoit Cure (CERN) and Lionel Quettier (CEA)
  - US: Renuka Rajput-Ghoshal (JLab/BNL) and Vadim Kashikhin (Fermilab)
  - AS/JP: Ken-ichi Sasaki, Yasuhiro Makida, and Akira Yamamoto (Chair, KEK)

  - Ex: Matthias Mentink (CERN) and Toru Ogitsu (KEK)

Summary

- On going Project
  - HL-LHC D1
  - COMET
  - g-2/EDM
  - Also some user experiments at J-PARC
  - Too many projects for not enough resources
- For future projects
  - We still need R&D for new technologies (Nb3Sn, HTS…)
  - Can we make it?
    - Collaboration!: Universities (Tohoku, Kyoto, Berkeley), Laboratories (LBNL, CERN..)
  - Need Funding
    - Collaboration!: US-JP, CERN-KEK, Joint Proposal with Physics Group and/or Universities
- Endangered Technologies
  - Detector magnet with Aluminum stabilized conductor
  - Search for applications? Collaboration with private sector?

- For survival: widen collaborations and applications