Multi-National Partnership Project MNPP-02

Title of the project:
Novel superconducting magnet technologies towards the applications in future high-intensity accelerators

Proposed by
Toru Ogitsu (Project Manager)
KEK, Cryogenics Science Center

Aim:

1. Low electric power consumption
2. Insusceptibility to large heat load
3. Low yield of radioactive materials
4. Low construction cost of the system including cryogenics

Possible Applications:

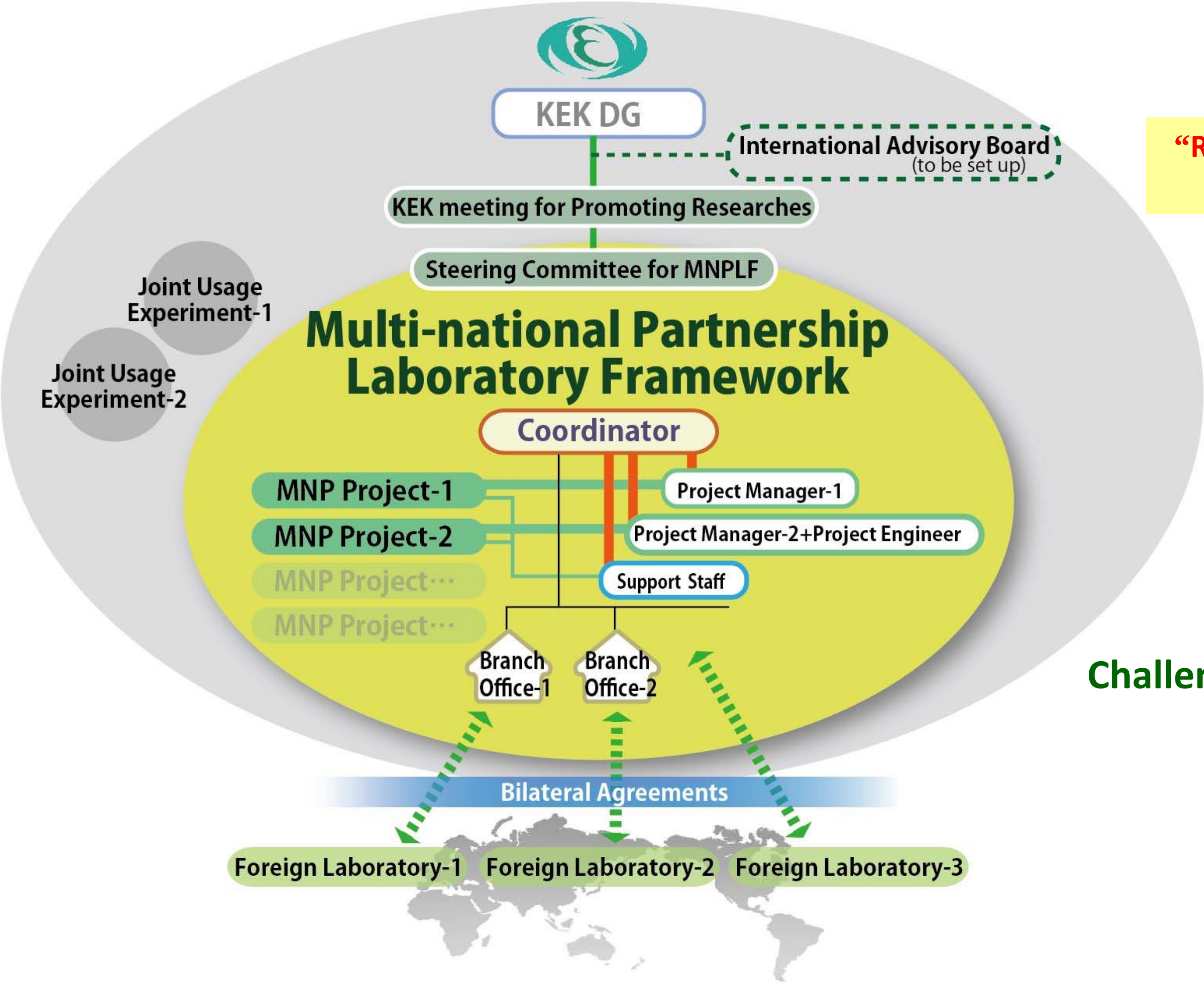
1. Accelerator Ring or Beam Line (High efficiency magnets)
2. Muon Beam Line (High efficiency muon production solenoids)
3. Future Hadron Collider (High field magnets for high radiation environments)
4. Neutrino Super Beam (DC horn or high field solenoid)

Cryogenics Science Center

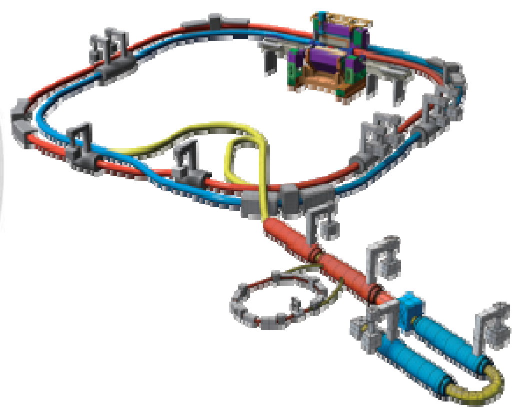
Research Administration Department, International Cooperation Office
Multi-national Partnership Laboratory Coordinator
Junji Urakawa

HL Accelerator Project (MNPP-01) , SC MG Project (MNPP-02)

Activity of Multi-National Partnership Laboratory (MNPL) at KEK and its Approved Project (MNPP-01)



"R&D for high luminosity colliders" Project (MNPP-01)



Challenge to highest luminosity at SuperKEKB

$2x10^{34} \Rightarrow 8x10^{35}$

Approved Project (MNPP-01) by KEK DG

,which is described in the Annex-1 of bilateral MoU , Appendix under umbrella MoU or simple agreement.

Title: R&D for high luminosity colliders (MNPP-01)

"Project Manager": Makoto Tobiyama

Following 4 R&D tasks are set-up to realize the performance:

1. **Development of IP feedback systems,**
2. **Development of advanced bunch feedback systems,**
3. **Minimization of gap transients,**
4. **Beam commissioning of the SuperKEKB accelerators.**

SLAC , CERN, LAL, Jefferson Lab, California Polytechnic State University, IHEP

Project period: from November 2017 to April 2021

Many Bilateral MoUs were necessary to proceed this project, which took time after the approval of KEK DG.

Project (MNPP-02) under final approving process:

Organization of MNPP-02 includes KEK (JP), TRIUMF (CA), CERN (CH), Robinson Research Institute of Victoria University of Wellington (NZ) and Kyoto University (JP).

Above institutes are interested in this project.

This is the project of five years.

We are trying to obtain special budget from Japanese funding agency and will get KEK DG sign if we will get the funding. After this, we will make necessary bilateral MoUs.

Concept of Multi-National Partnership Laboratory (MNPL)
Institution-based Partnership of World Accelerator Laboratories

Categories of KEK experiments

Joint Usage Experiments **For examples: Belle II, T2K**

1) **Invite application for experiments using KEK facilities.**
2) **Form collaboration.**
3) **Apply proposal.**
4) **Judge by Program Advisory Committee (PAC).**
5) **KEK user registration**

International Joint Research (New MNPP has to make many bilateral MoU with the explanation regarding the project)

- **KEK takes initiatives to form international joint research programs using KEK facilities or improving/creating facilities.**
- **Based on agreements (MoU) between KEK and participating Institutes (bilateral MoU or Appendix or simple agreement)**
- **Call it "MNP-Project"**

Purpose of MNPL:

- **Offers a framework to coordinate the MNP-Projects and to support the participating researchers from abroad.**
- **Integrates the bilateral cooperation to form a unified framework for partnership.**

Novel superconducting magnet technologies towards the applications in future high-intensity accelerators

The Project (MNPP-02) was recently recommended by steering committee for MNPLF and KEK research promotion meeting.

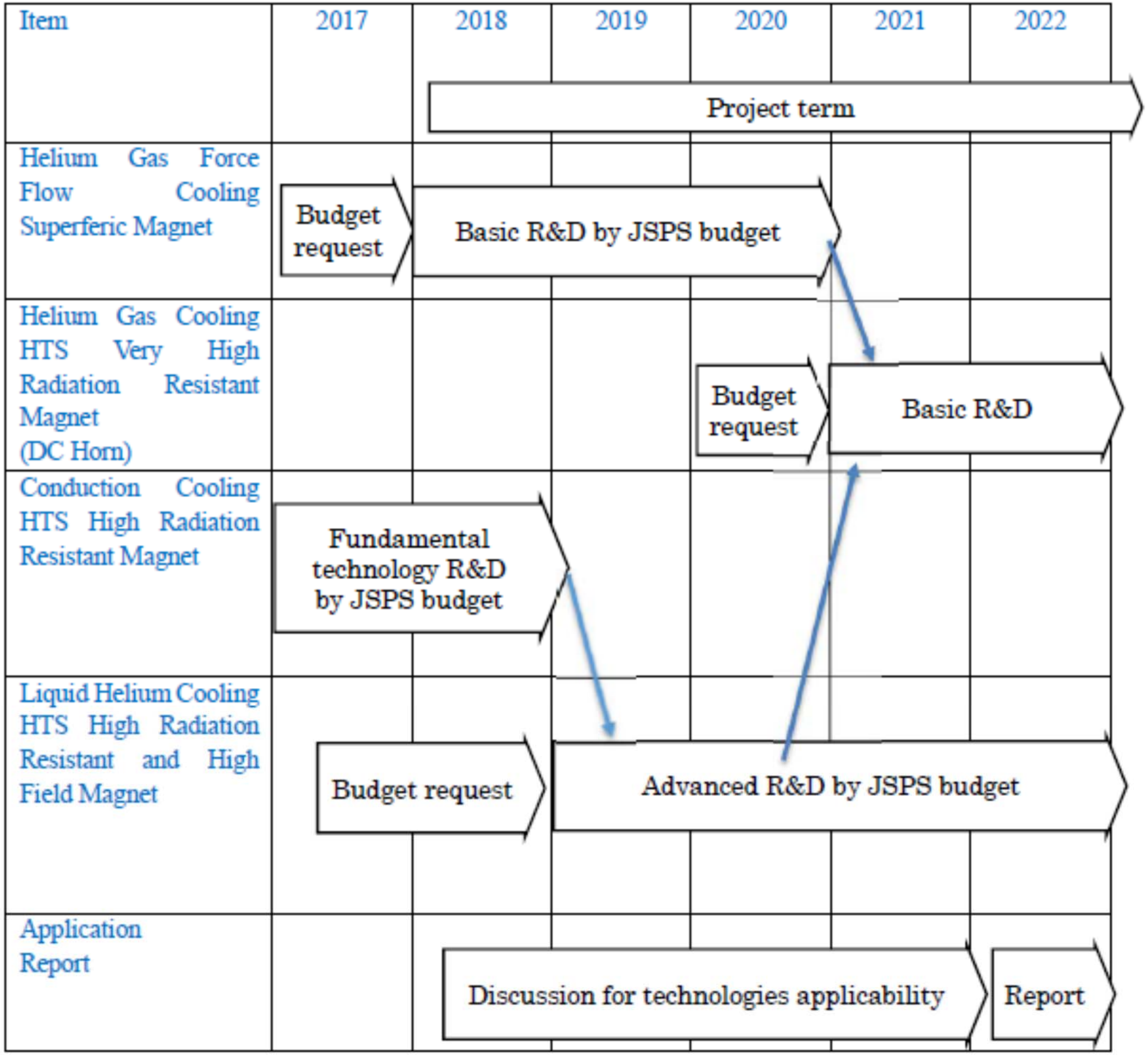
Issues with High Intensity Accelerator

1. High electric power consumption, (NC)
2. Susceptibility to large heat load due to radiation and/or AC-loss, (SC)
3. Radiation resistance of the system, (NC, SC)
4. Production of radioactive materials in the accelerator system, (NC)
5. High construction cost of the system including cryogenics. (SC)

Solutions with HTC (MgB_2, YBCO)

1. An operation at 20K to 50K, achievable with a recently developed superconducting materials such as MgB_2 (Tc~40K) or YBCO (Tc~90K), improves the efficiency of a refrigerator by a factor of 10 to 30,
2. The heat capacity of the material is generally higher at higher temperature and the temperature rise due to heat load is suppressed,
3. The heat conductance is maximum at around 30K for copper and aluminum, both of which are often used as a heat conductor to release heat load,
4. A simpler design of a cryostat is possible by avoiding an intermediate heat shield while keeping the system efficiency high.

Rough schedule for this project



Transmission Line and Related Technologies in Accelerator

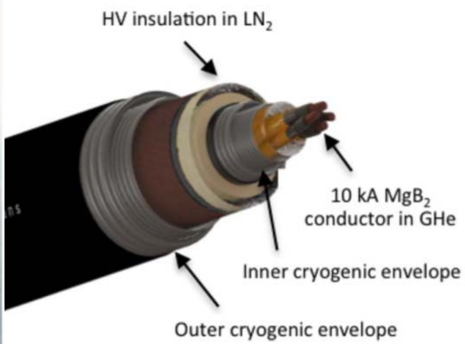
Location	Length [m]	Capacity [MVA]	Schedule
Long Island/USA	600	574 (138 kV AC, 2.4 kA)	In operation since 2008
Essen/Germany	1000	40 (10 kV AC, 2.3 kA)	Start of operation 01/2014
Amsterdam/NL	6000	250 (50 kV AC)	Proposed
St. Petersburg/Russia	2500	50 (20 kV DC, 2.5 kA)	Start of operation 2015
Ishikari/Japan	2000	100 ($\pm$ 10 kV DC, 5 kA)	Start of construction spring 2014
Icheon/Korea	100	154 (154 kV AC, 3.75 kA)	Operating since 11/2013
Jeju Island/Korea	1000	154 (154 kV AC, 3.75kA)	Operation 2015
Jeju Island/Korea	500	500 (80kV DC)	Operation 2014
Westchester county/USA	170	96 (13.8 kV AC/4 kA)	Start of construction early 2014
Yokohama/Japan	250	200 (66 kV AC, 5kA)	Operation stopped December 2013, continuation planned with new high-performance refrig-erator 2015.
China	360	13 (1.3 kV DC, 10 kA)	Operation since 2011
Chicago/US	5 km	to be specified	Planning since 2014
New Mexico/US		750/5000	Postponed

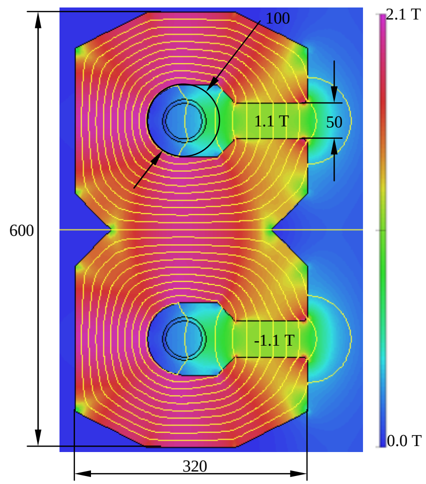
IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY, VOL. 26, NO. 3, APRIL 2016 5401705

The BEST PATHS Project on MgB_2 Superconducting Cables for Very High Power Transmission

Amalia Ballarino, Christian E. Bruzek, Nico Dittmar, Sebastiano Giannelli, Wilfried Goldacker, Giovanni Grasso, Francesco Grilli, Christoph Haberstroh, Stéphane Holé, Frédéric Lesur, Adela Marian, José M. Martínez-Val, Luciano Martini, Carlo Rubbia, Delia Salmieri, Frank Schmidt, and Matteo Tropeano

Photo of a superconducting cable composed of 24 MgB_2 wires and a copper core, and with a diameter of only 11 mm. Such cables can carry currents of 10 kA and more.



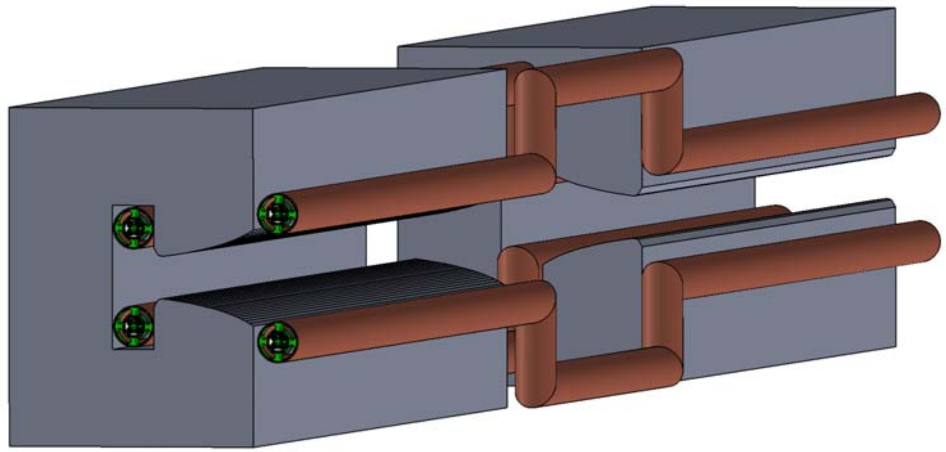


Transmission line magnet proposed at CERN

R&D Plan

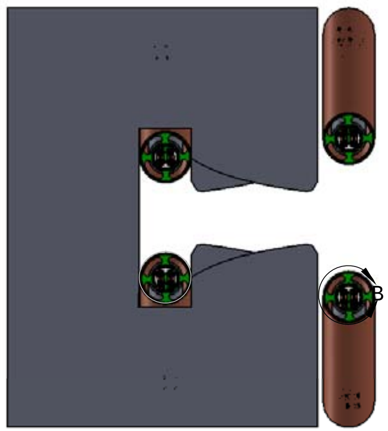
1. High Efficiency Superferric Magnet R&D – MgB_2 with Helium Gas Cooling
2. HTS Solenoid for High Radiation Environments – YBCO with Conduction Cooling
3. HTS Magnets for Higher Radiation – YBCO with Helium Gas Cooling
4. HTS High Field Magnets for High Radiation – YBCO with Liquid Helium Cooling

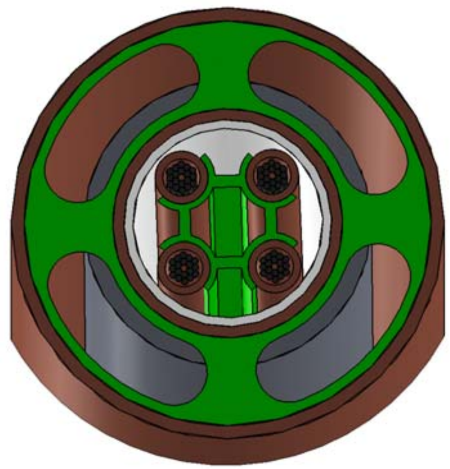
High Efficiency Superferric Magnet R&D



Use transmission Line Technology

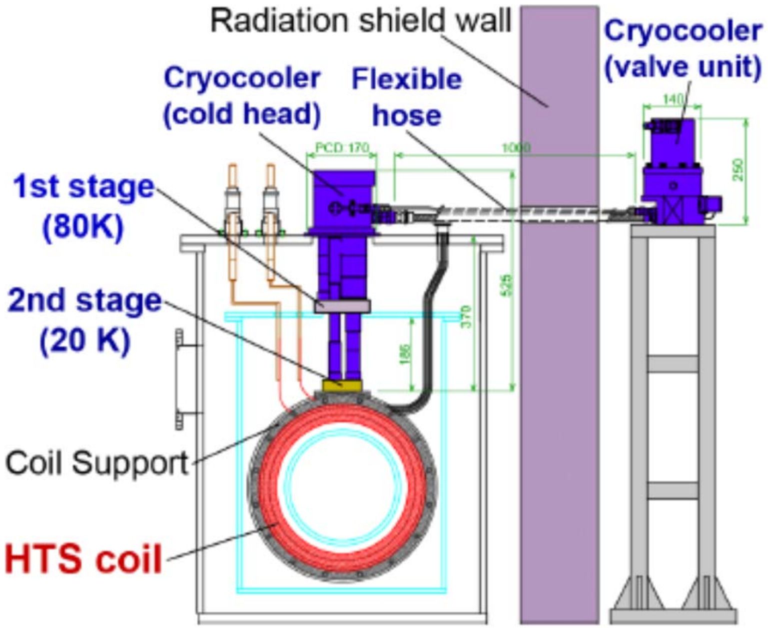
- MgB_2 with 20K
- Forced Flow Helium Gas Cooling

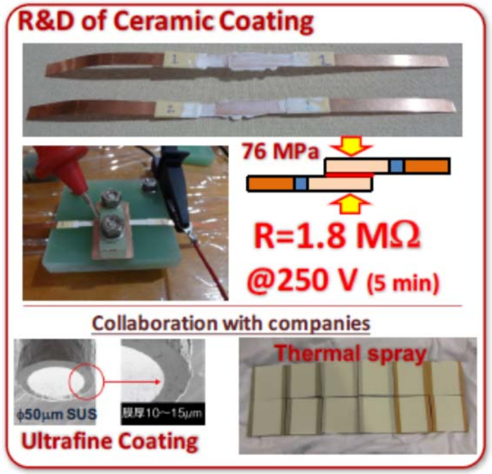


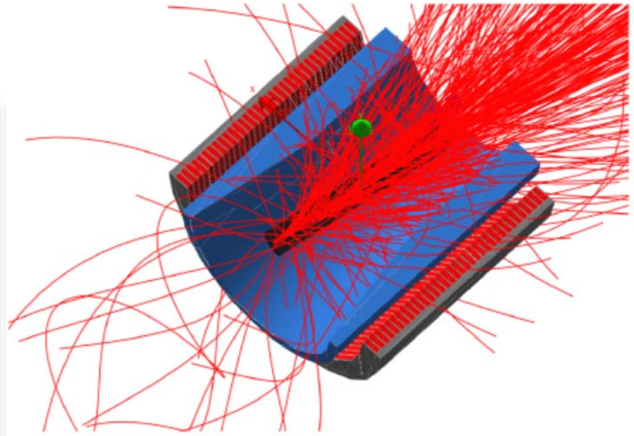


HTS Magnets for High Radiation Environments

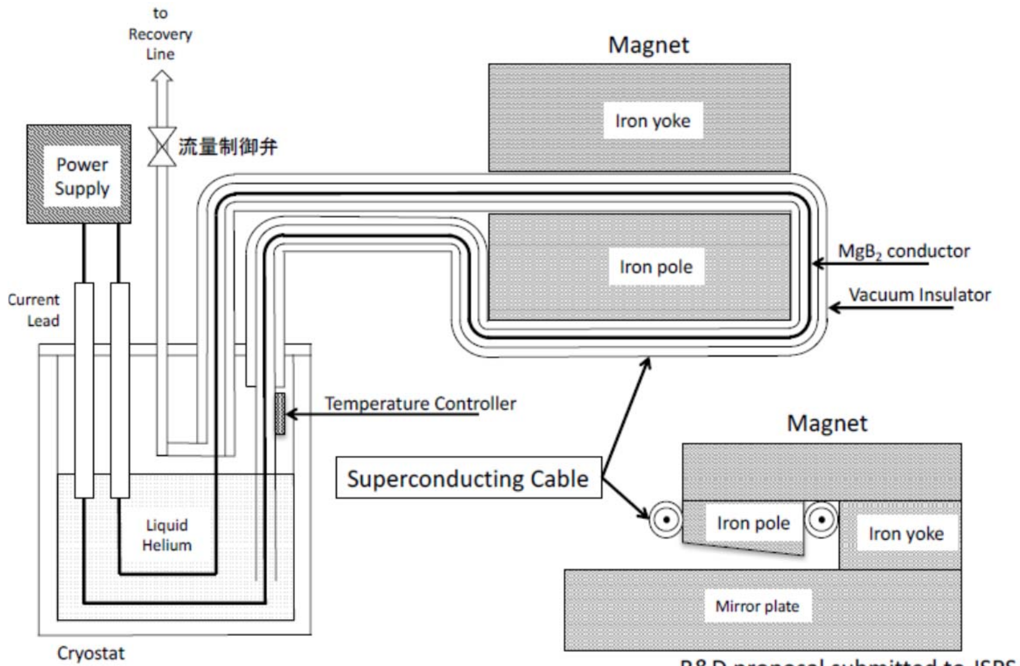
Computational model study indicates HTS magnets can sustain very high radiation environments.







Experimental plan and Mini-model magnet proposal



R&D proposal submitted to JSPS

KEK

Toru Ogitsu, Tatsushi Nakamoto, Ken-ichi Sasaki, Michinaka Sugano, Masami Iio, Masahito Tomizawa, Ryotaro Mutoh, Kento Suzuki, Mukesh Dhakarwal

Develop MgB_2 based superferric magnet.

Develop high radiation resistant superconducting magnet.

TRIUMF

Oliver Kester, Akira Konaka, Marco Marchetto

Study influences of radiations on superconducting magnet materials based on the availability of irradiation stations.

Discuss possibility of beam test for a high radiation resistant superconducting magnet.

CERN

Thank you for your attention!

Amalia Ballarino

Develop MgB_2 transmission line system.

Study applicability of transmission line to superferric magnet.

Robinson Research Institute

Nick Long, Zhenan Jiang

Research and develop high current HTS Roebel Cable.

Study on AC loss of Roebel Cable.

Kyoto University

Naoyuki Amemiya

Study on HTS based transmission line magnet system.

Study on AC loss of HTS transmission line.

Study applicability to accelerators for ADSR.