13th IPAC 2022 @ Bangkok, Thailand, June 12th -17th, 2022

THOYSP2

The new Eddy current type Septum magnet for upgrading of fast extraction in Main Ring of J-PARC

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2022/06/16 (Thu.)

Outline & simple Summary

1 What is Septum Magnet ? **Eddy Septum Magnet** !?

Both of them are **Simple!**

2. **J-PARC** and **Upgrade** of **MR**

Toward High Power Beam of **1.3 MW !!**

3. **Upgrade** of **Septum Magnets for Fast Extraction** in MR.

Completed in last month.

What was **important task about Eddy septum ?**

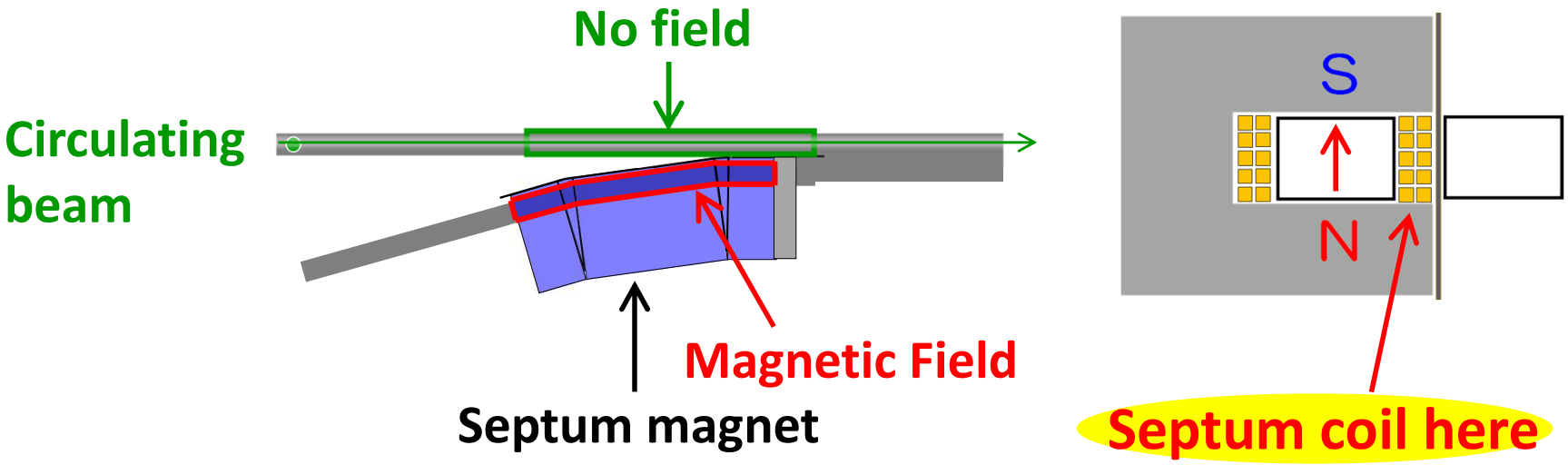
Higher Stability & **Lower leakage field !!**

4. **Summary again**

What is Septum Magnet ?

A **septum magnet** is used at a intersection of **≥2 beam lines**

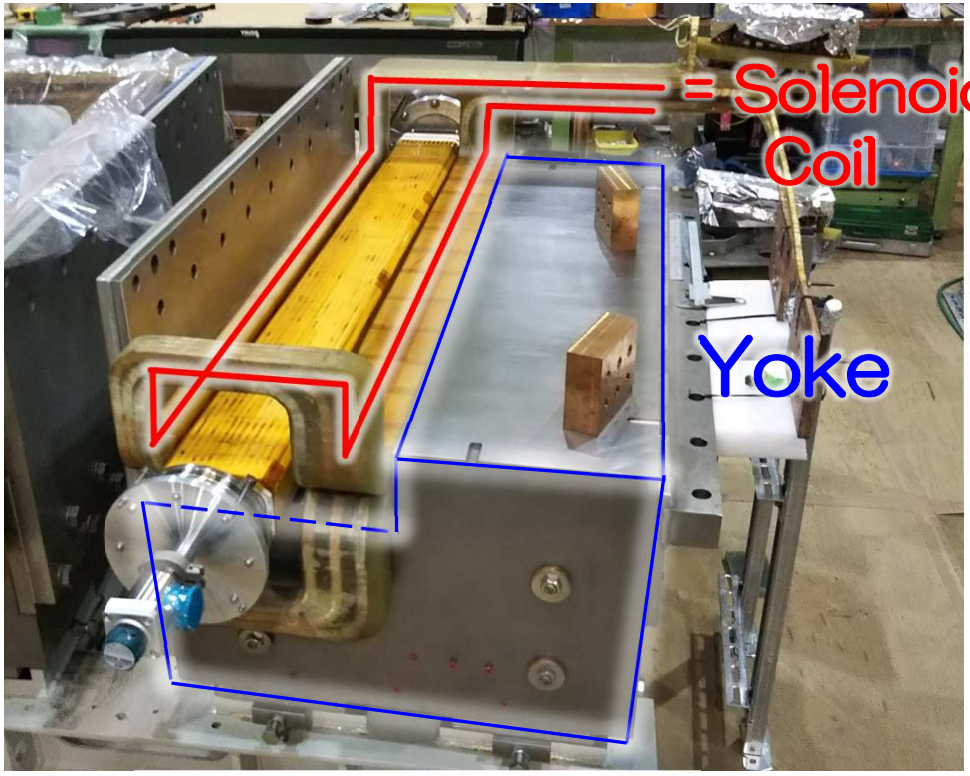
No magnetic field in **One of the beam lines**

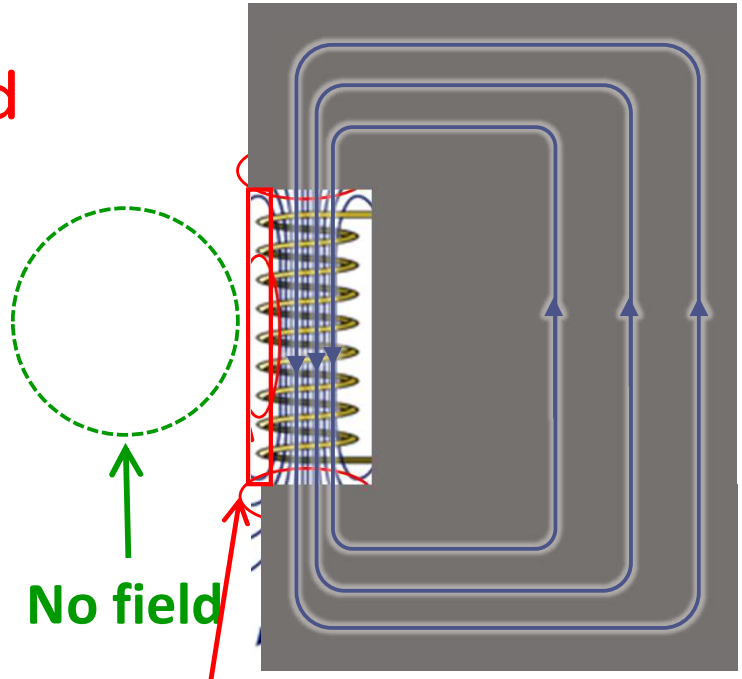


Why no field outside the magnet ?

Why no field outside the magnet ?

Actual Septum Magnet (under assembly)

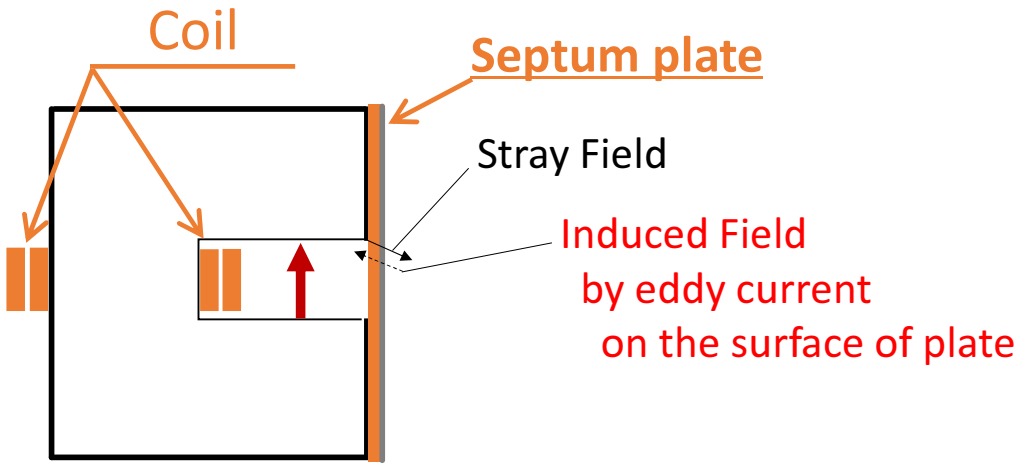




What is Eddy Septum Magnet ?

Eddy septum magnet is also simple, but principle is difference.

Base on ordinary C-type dipole



Stray field is cancelled by induced field.

Only **Short-Pulse Current** can be used

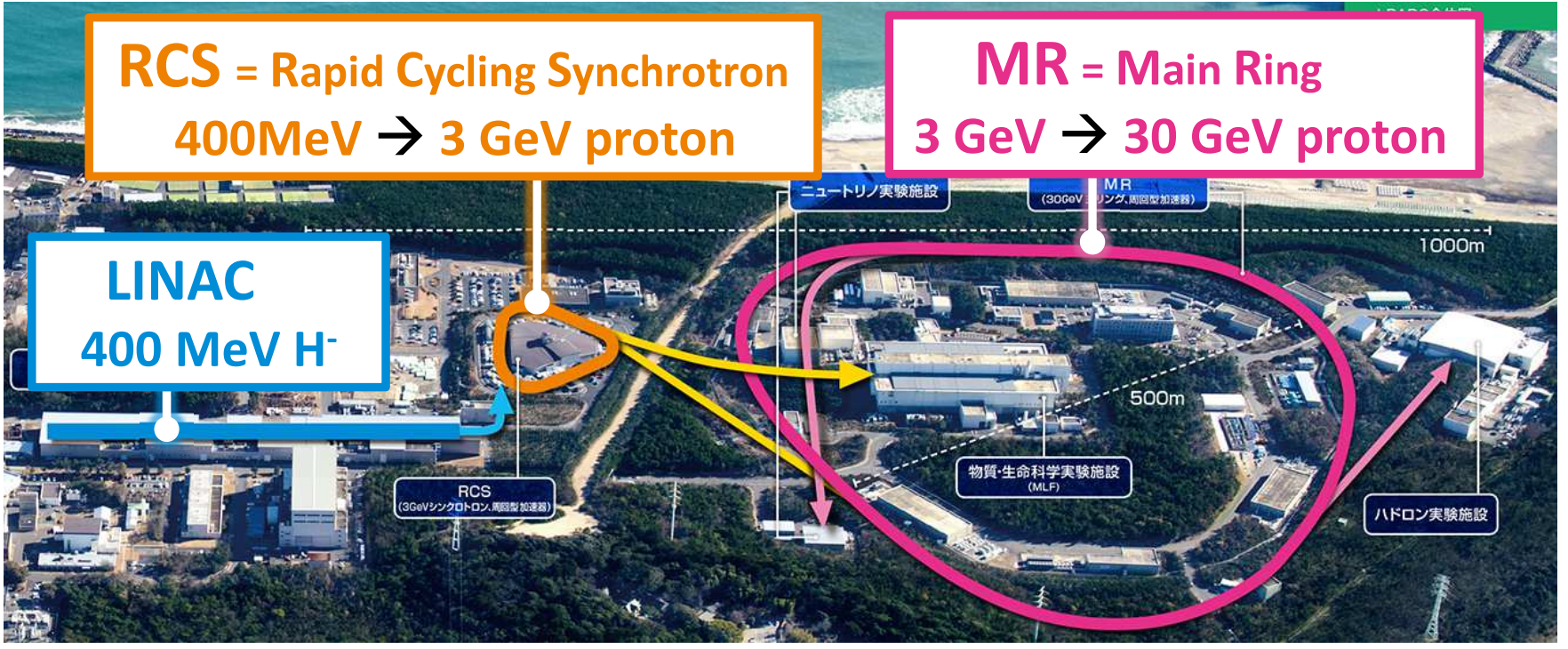
For example ; Sin-wave

J-PARC and Upgrade of MR

J-PARC

Japan - Proton Accelerator Research Complex

In Tokai, Ibaraki, Japan

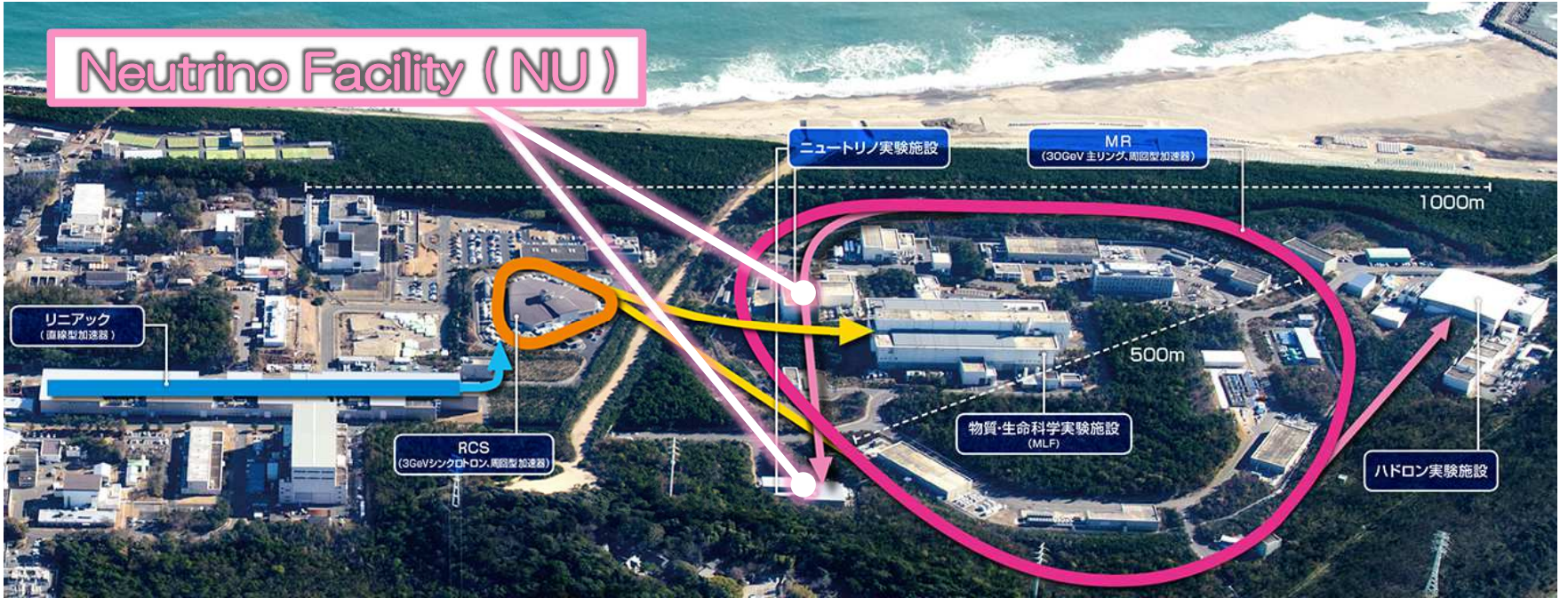


Fast Extraction (FX) in MR

= Beam extracted during 1 turn, and sent to NU

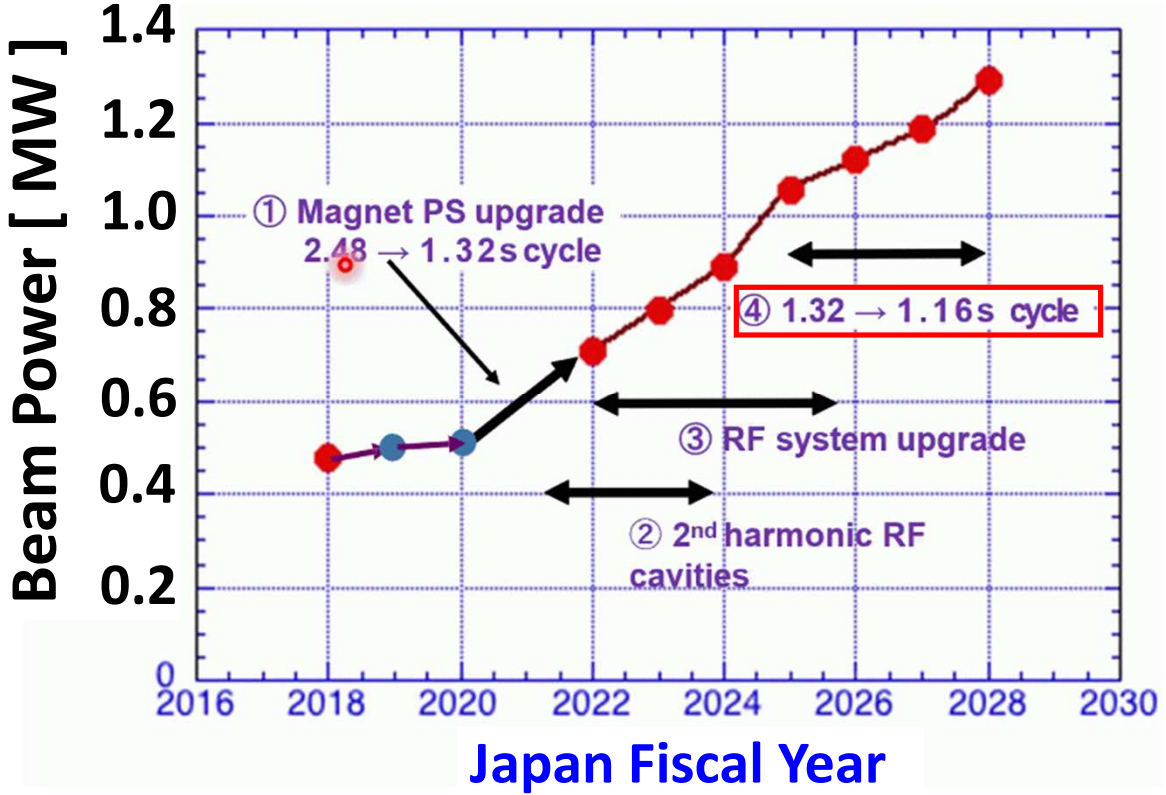
～5.2μsec

Beam cycle until last summer was **2.48 sec**



Plan to Upgrade MR beam power

1.3 MW by 2028

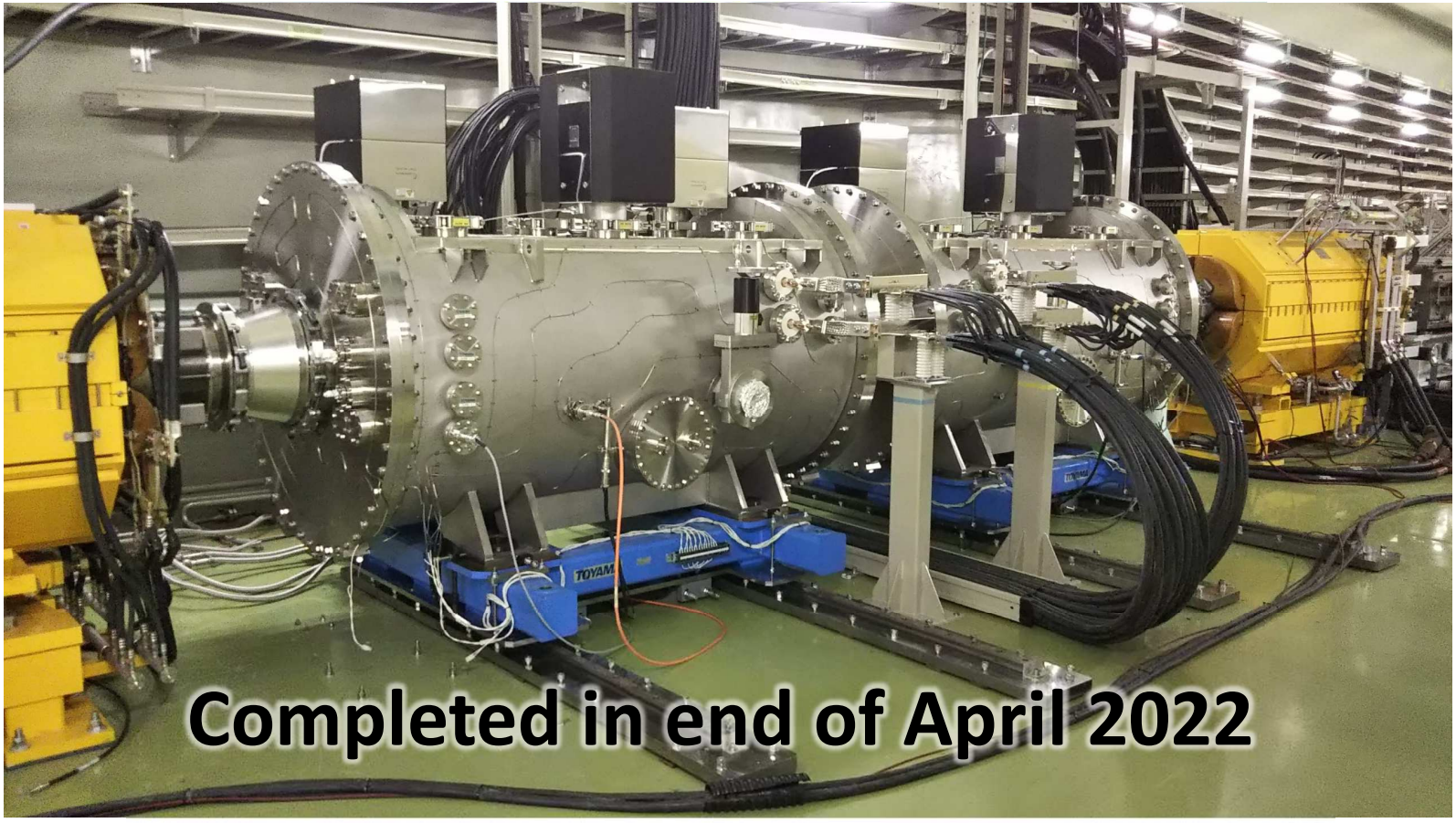


Upgrade of Septum Magnets for FX in MR.

I focus on EDDY Septum

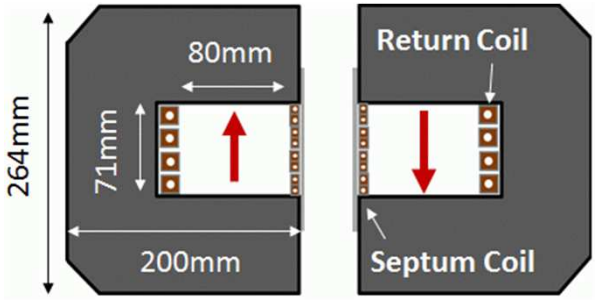

Replacement with EDDY Septum

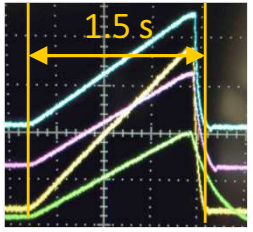
Replacement of Low-Field Septum Magnets



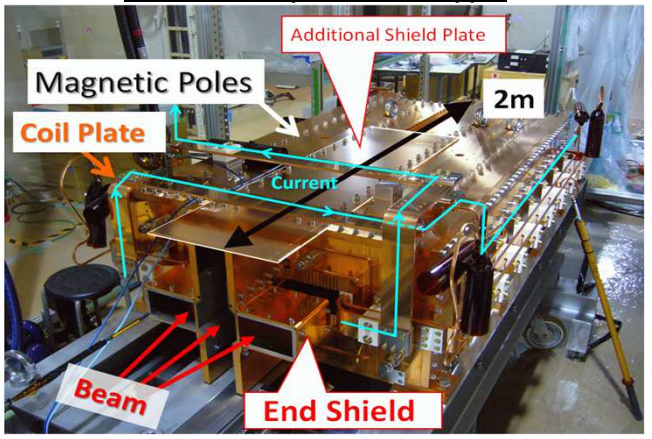
Comparison of Old and New Septum Magnet

Old = Conventional Type





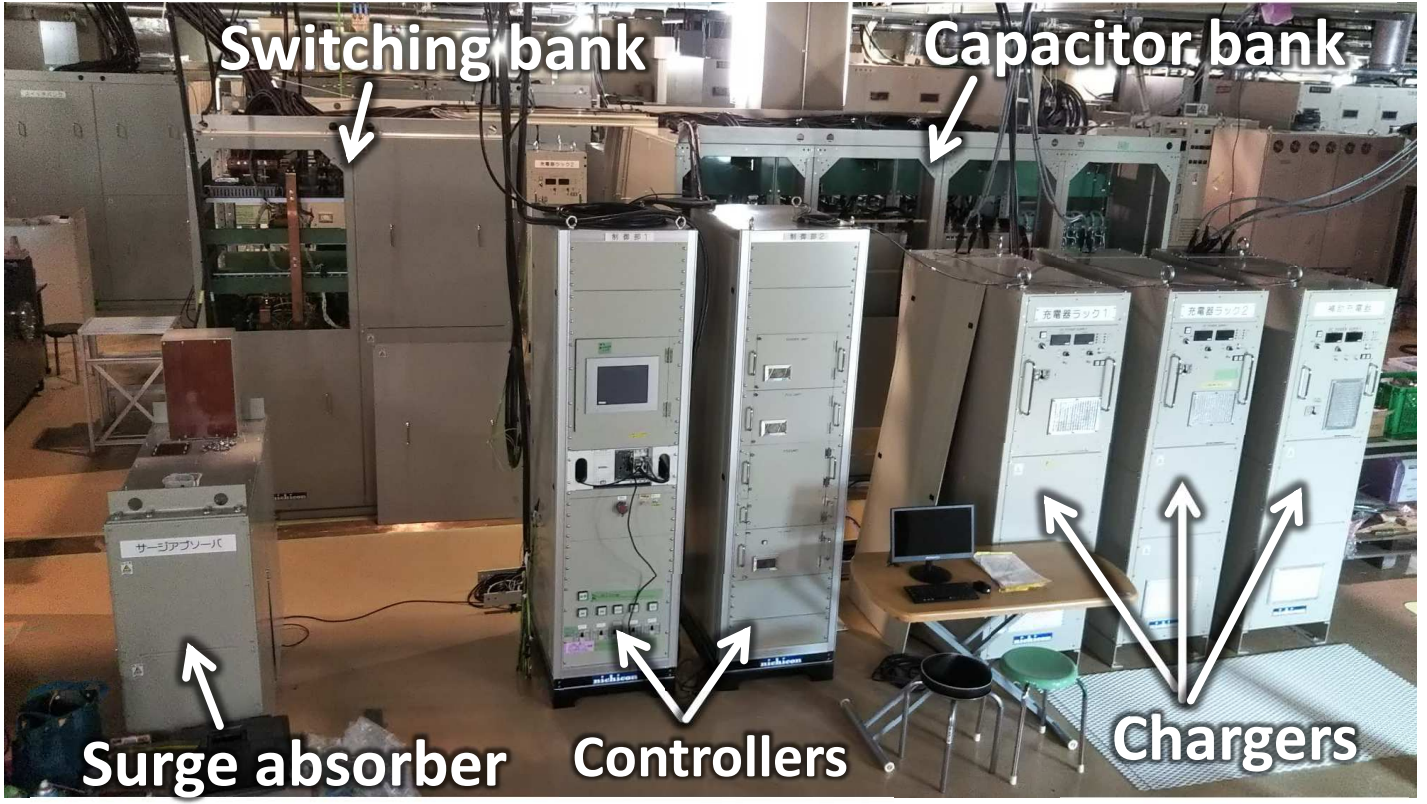
New = Eddy Current type



Magnetic Coil	**Hollow conductor** (4mm thickness)	→	Copper **Plate** (7mm thickness) No damage from self-vibration
Horizontal Aperture	80mm	→	**140 mm** No septum coil in gap
Output Current (width)	**Long-** Pattern (1.5 sec)	→	**Short**-Pulse (**1msec**) Low joule heating
Leakage Field	~ 2 gauss・m/cm, max 50 Gauss @ Core Edge	→	**< 1gauss, ～10 gauss @ Core edge No leakage during injection. Acc.**

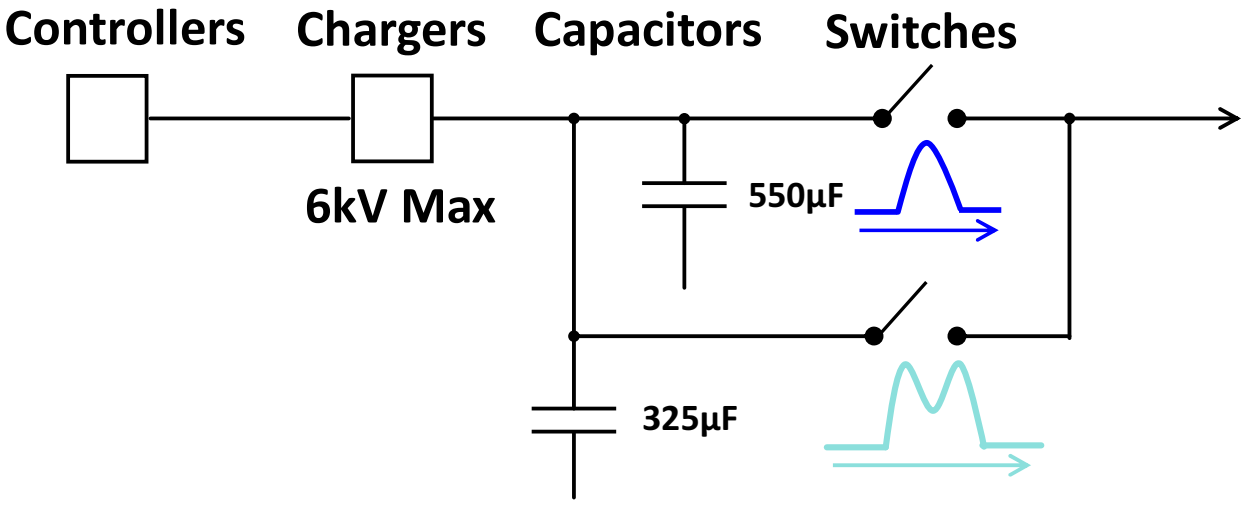
Power Supply installed in MR in 2022

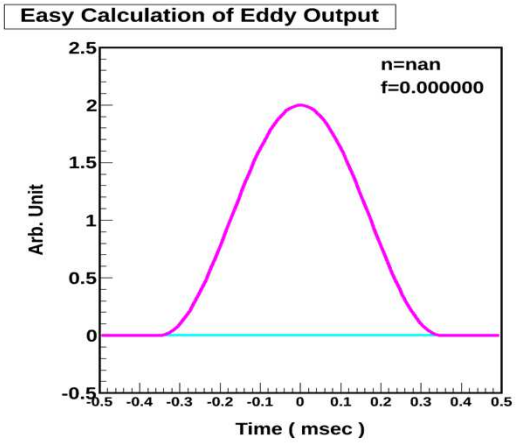
Pulse Power Supply



New Power Supply for Eddy Septum

The circuit diagram of Power supply





To obtain
good Flatness

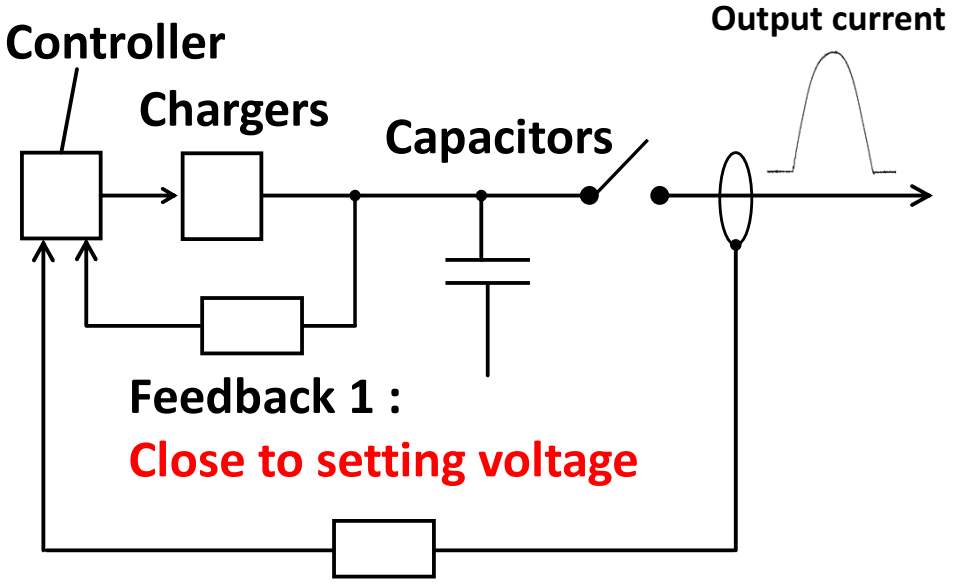
Most important task

High Shot-to-shot Stability, and Long-term Stability

The stability of Output Current

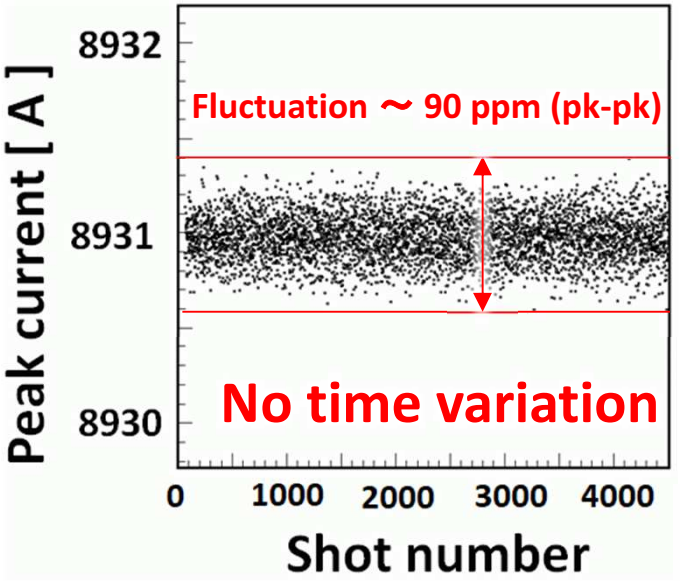
Shot-to-Shot stability

1. Realtime Feedback
   in Charging Voltage



Long-term stability

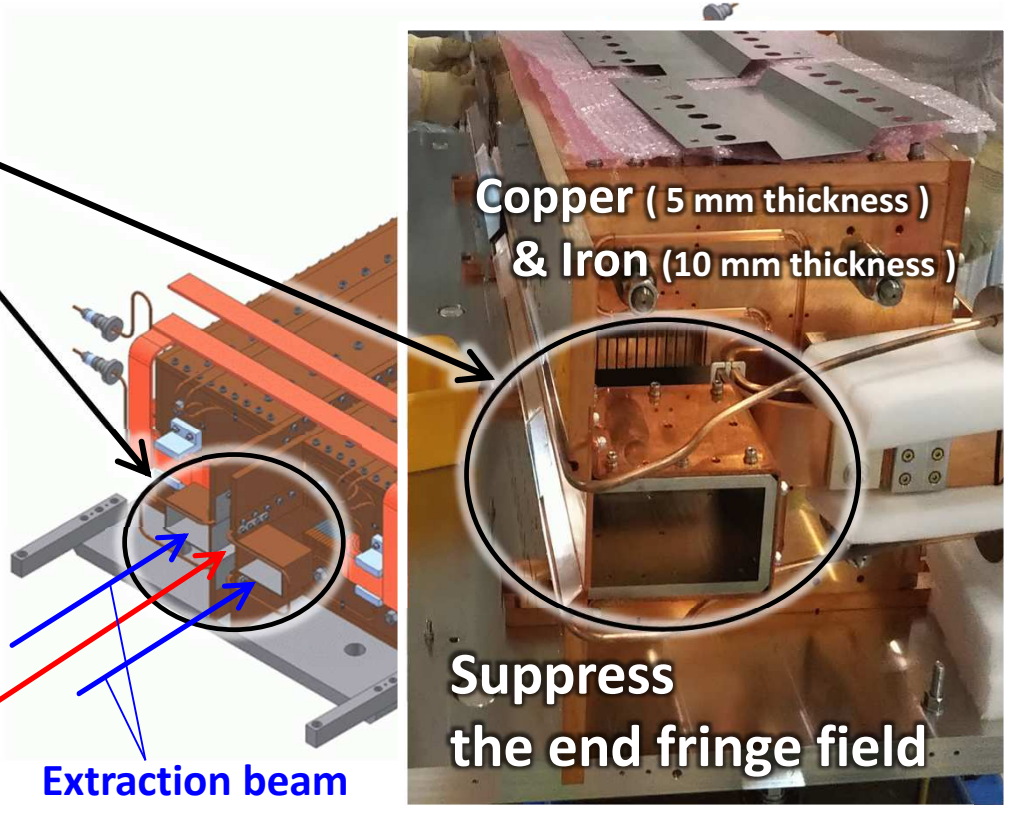
2. Shot-by-shot Feedback
   using Output Pulsed Current



Low Leakage Field

Low leakage field in the circulating line

① End field clamp

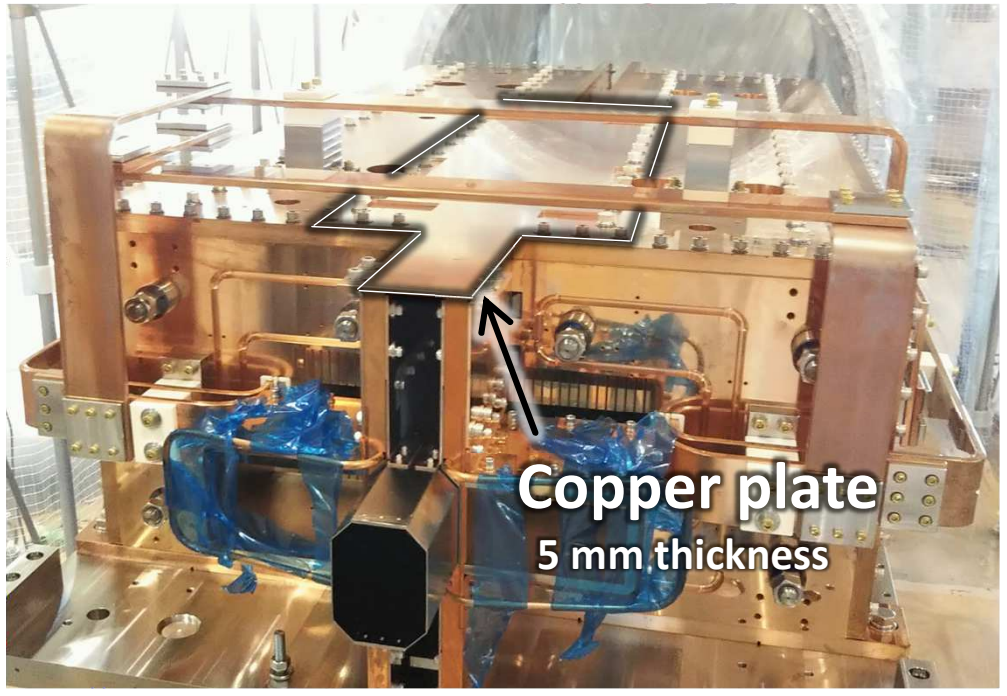


Low Leakage Field

Low leakage field in the circulating line

① End field clamp

② Ceiling shield



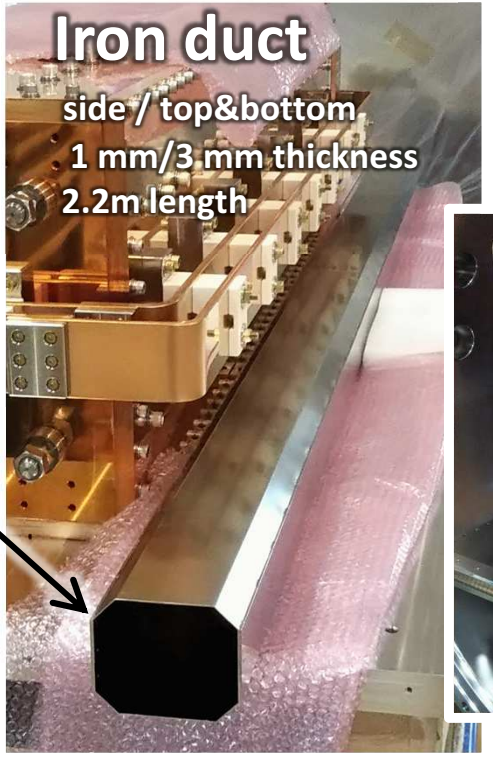
Low Leakage Field

Low leakage field in the circulating line

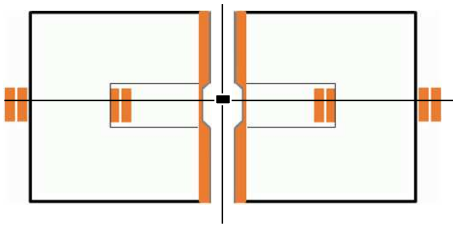
① End field clamp

② Ceiling shield

③ Duct shield

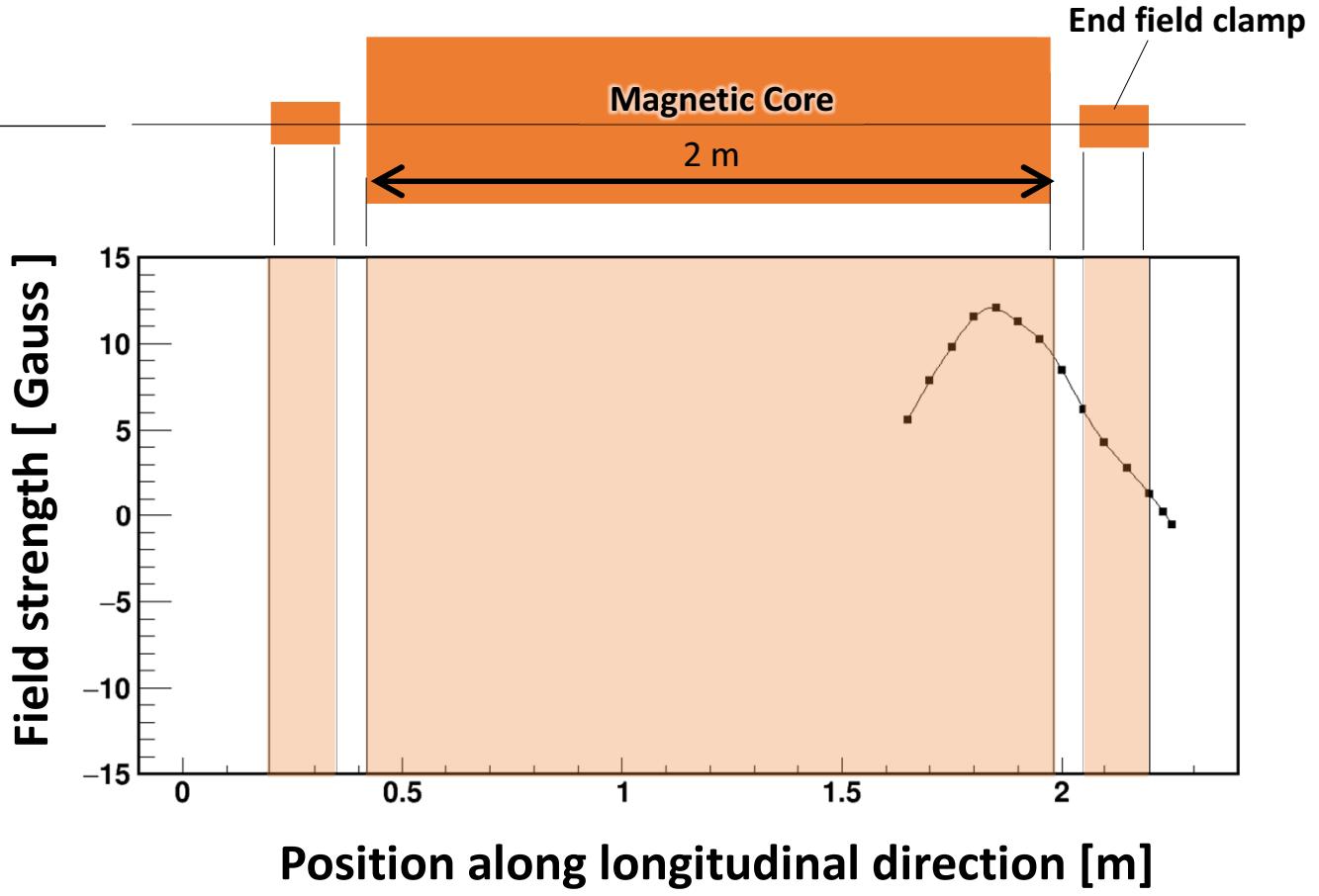


Measurement of Leakage field

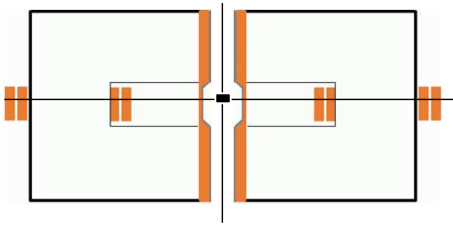


Measured at center position
Applied current = 9kA

- ○ **End field clamp**
- × Ceiling shield
- × Duct shield



Measurement of Leakage field



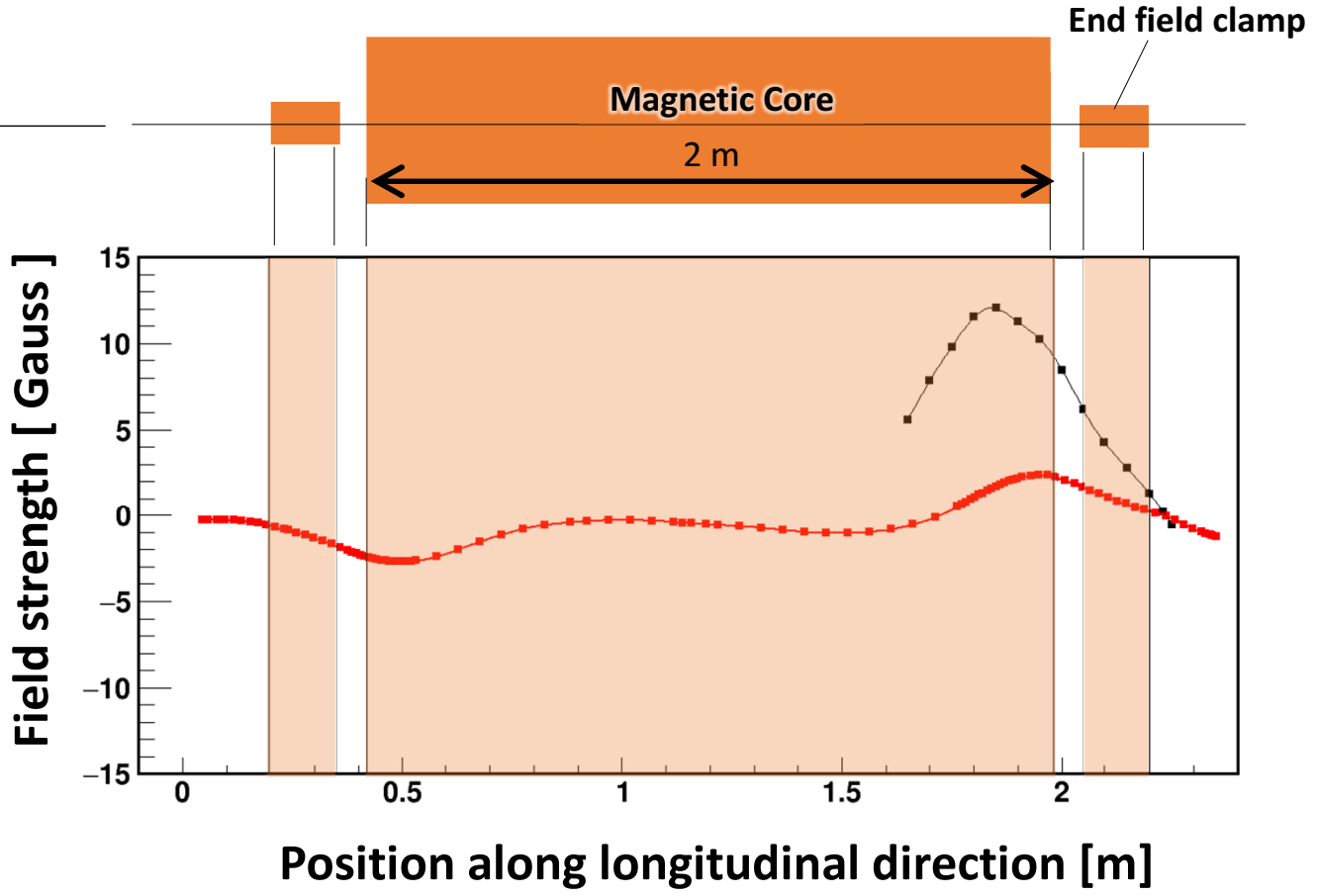
Measured at center position

Applied current = 9kA

○ End field clamp

○ Ceiling shield

× Duct shield



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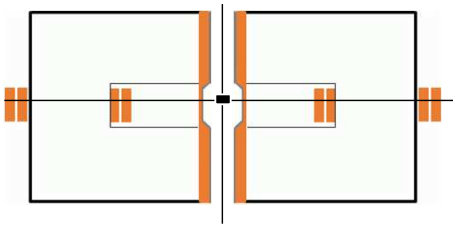
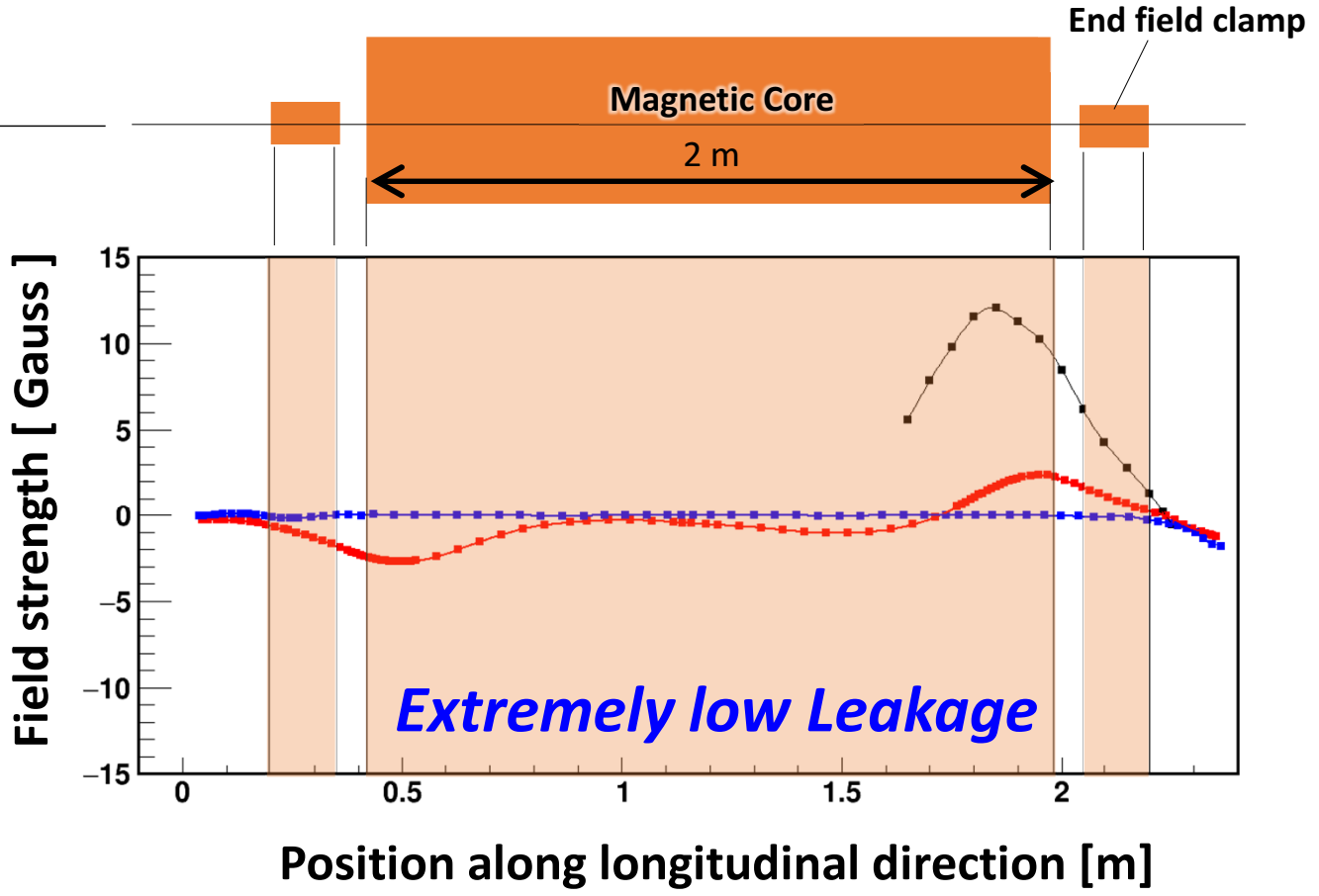


Measured at center position

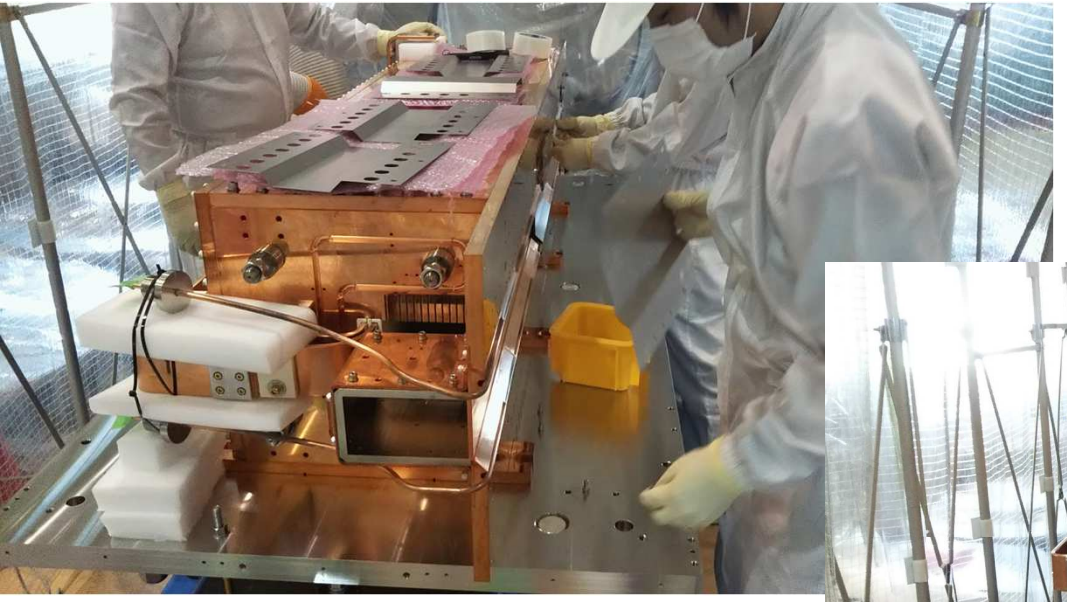
Applied current = 9kA

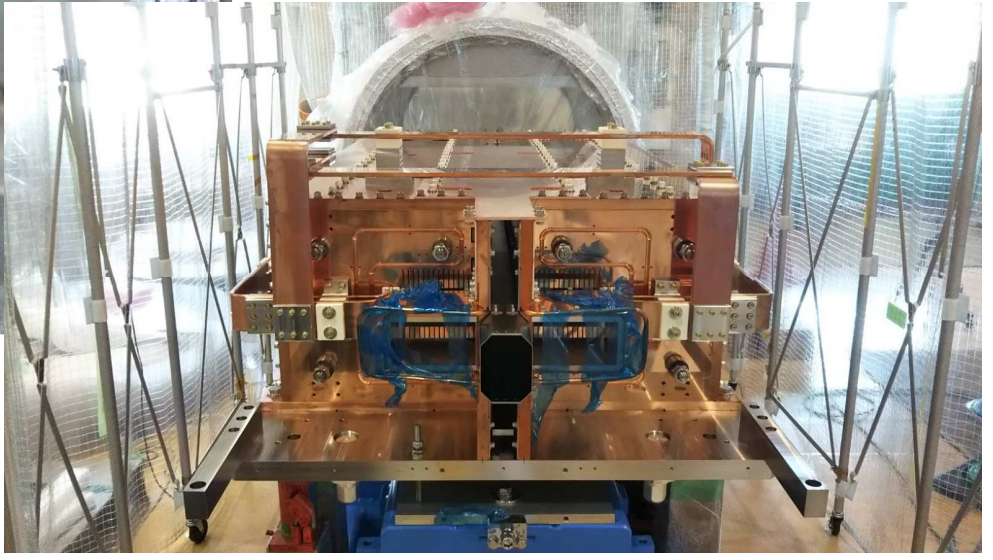
- End field clamp
- Ceiling shield
- Duct shield



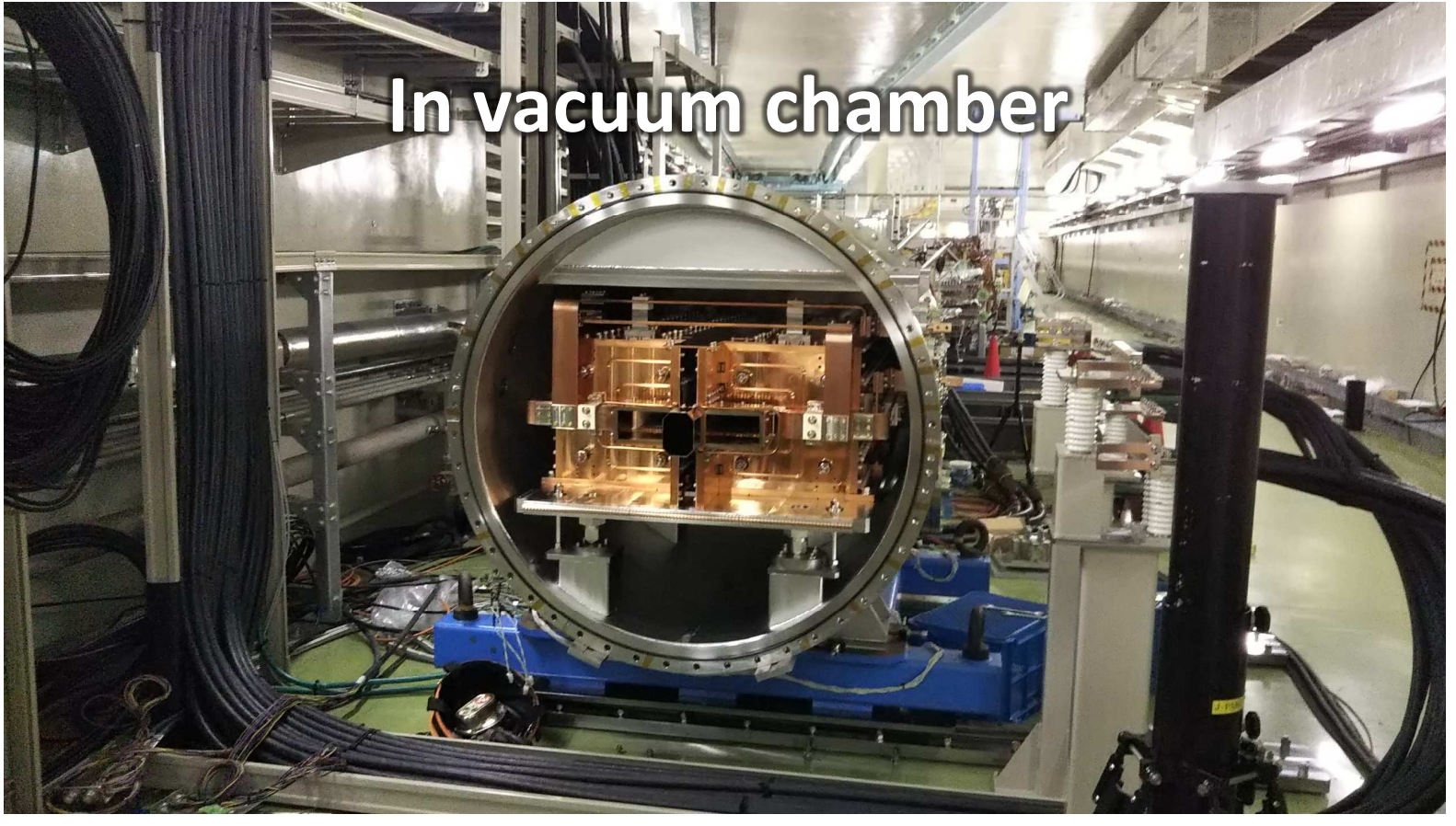
Assembly of the Eddy Septum in a Clean Booth

For Installation into a Vacuum chamber





Eddy Septum mounted in the Vacuum chamber



Replacement of other Septum Magnets

New Fast Extraction 2022

Summary

■ *Eddy Current Septum is very useful*

have many advantage rather than conventional type.

■ *Developed New Eddy Septum for FX*

Shot-to-shot Stability ～100 ppm (pk-pk) with 3kV ×9kA

Long-term Stability of No time variation by feedback

Very Low leakage field by several shields.

■ *Installation into MR was completed in 2022.*

The Beam Operation of MR

with the Eddy Septum magnets was started !