# 3GeV synchrotron to Neutron target Beam Transport facility (3NBT)

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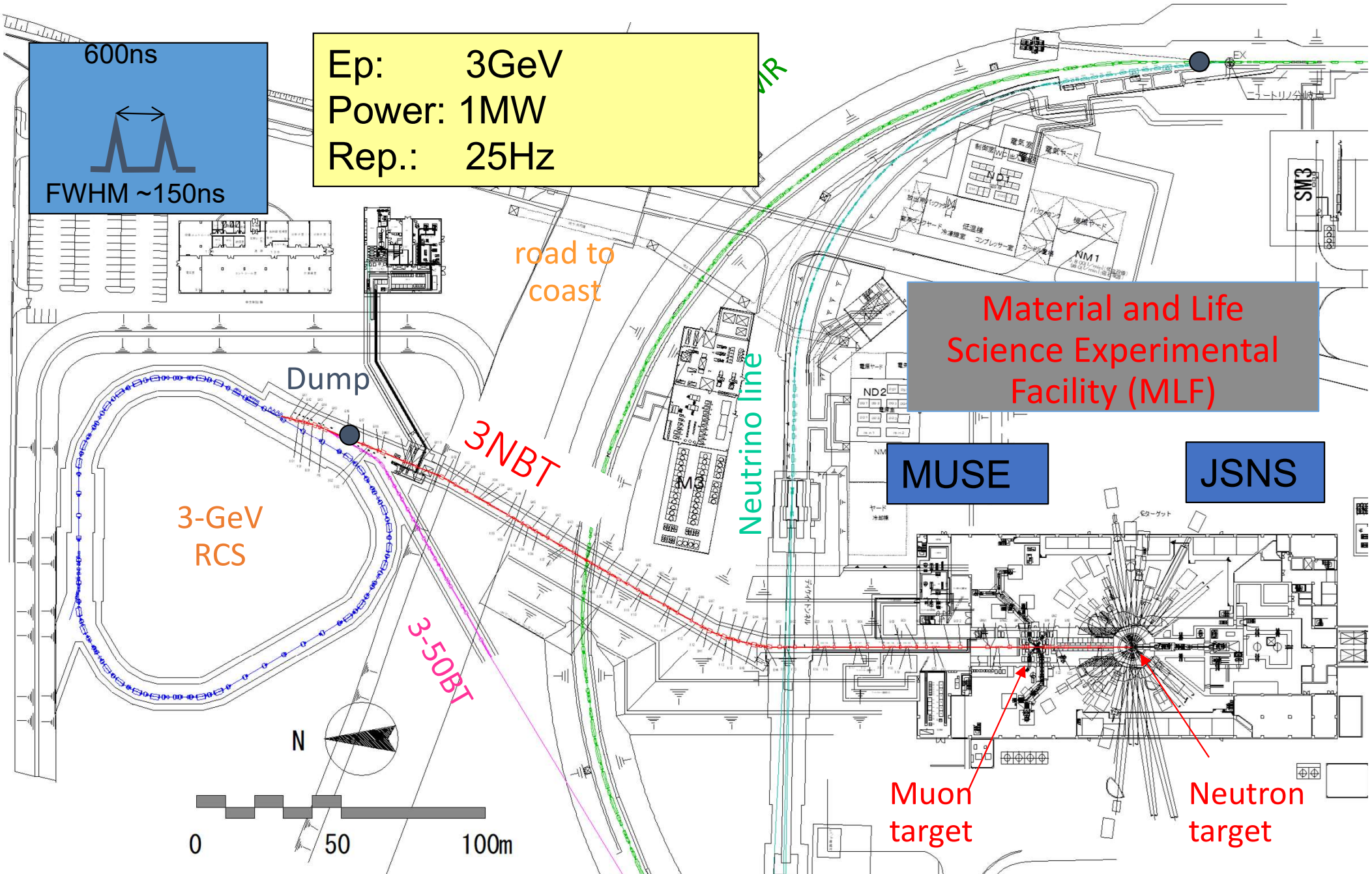
# Outline

- About 3GeV proton beam transport facility (3NBT)
- Beam transport
- Troubles

# Beam transport to MLF (3NBT)

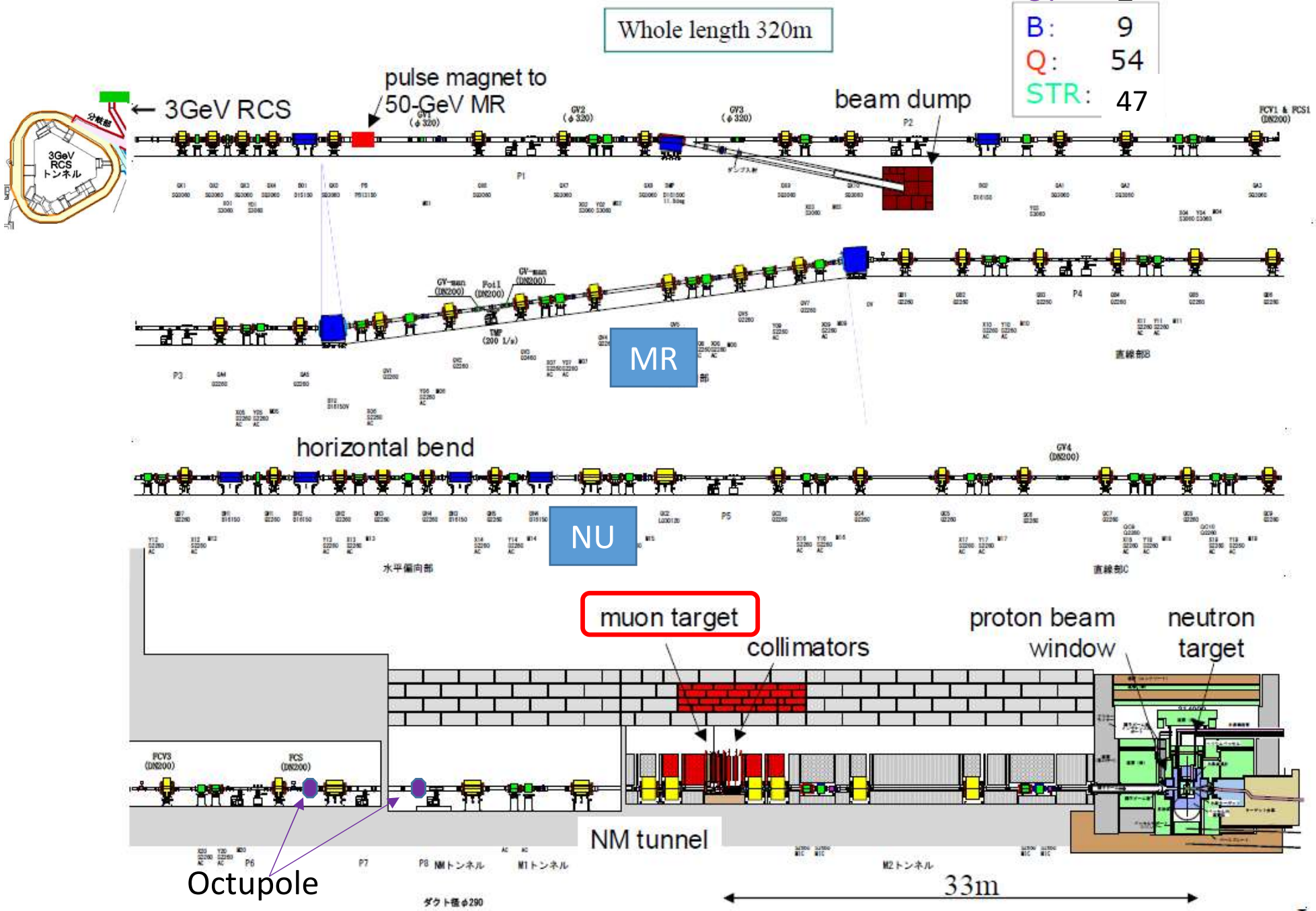
Length: 320 m from RCS to MLF



# Cross section of 3NBT

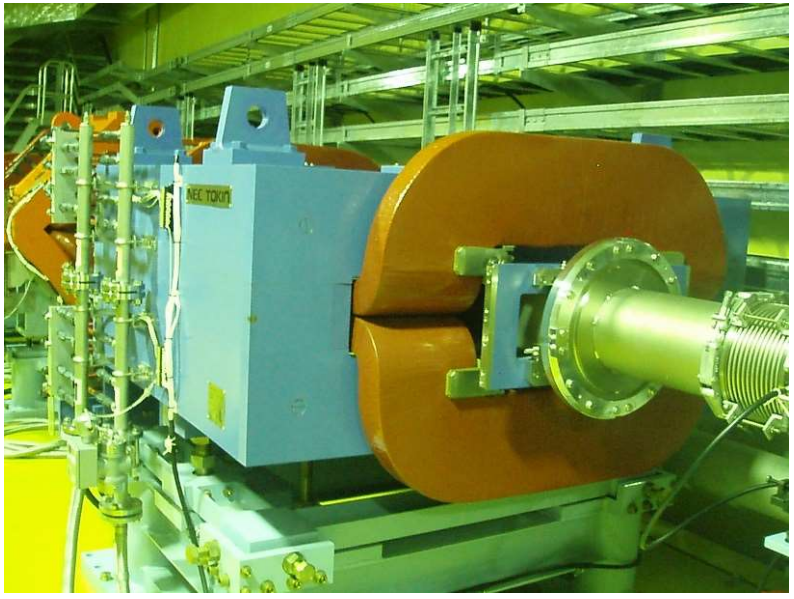
Number of Magnets

| | |
|---|---|
| O: | 2 |
| B: | 9 |
| Q: | 54 |
| STR: | 47 |



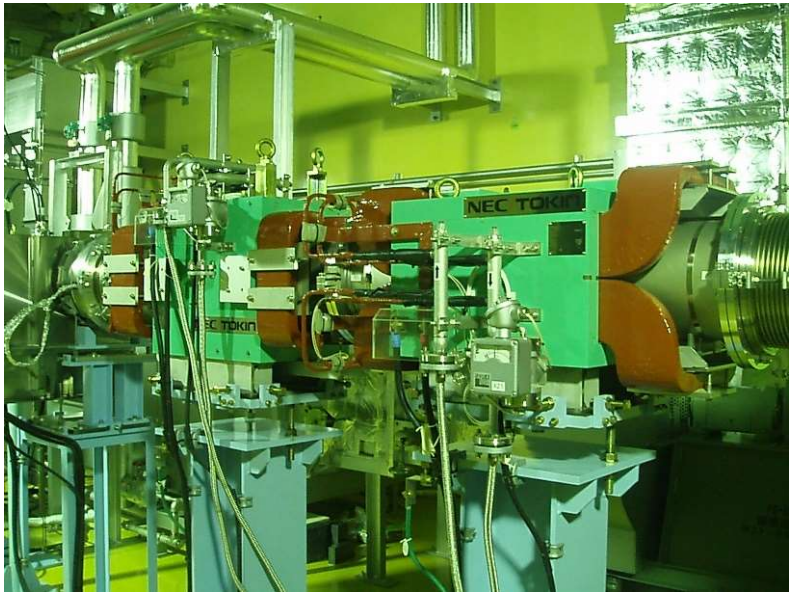
# Magnet in 3NBT

Bending magnet

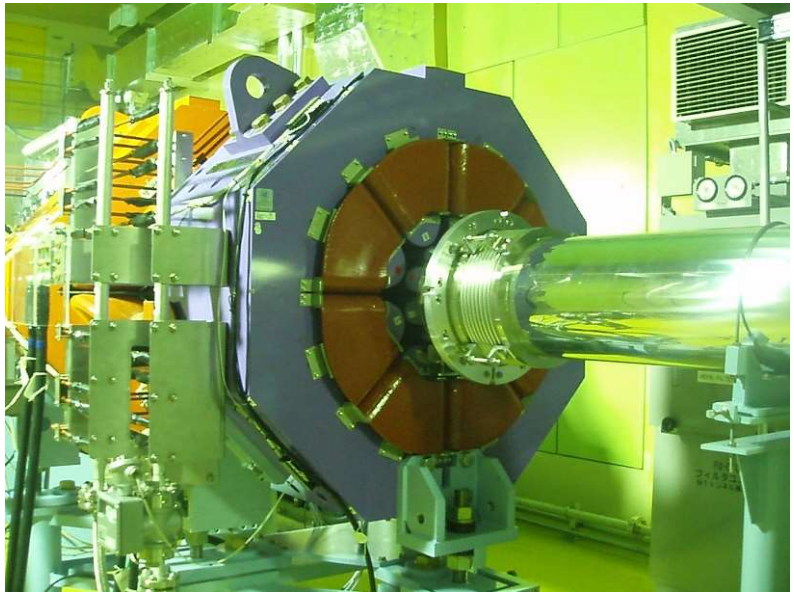


Quadra pole magnet

Steering magnet



Octupole magnet



# Beam monitors

- 16 multi wire Profile Monitor (PM)
  - Measure beam width and beam position
- 10 Current Transformer (CT)
  - Measure beam current
- 16 Beam Position Monitor (BPM)
  - Measure beam position
- 54 beam Loss Monitor (LM) proportional counter
  - Measure beam loss at Q-magnet
- 16 beam Halo Monitor (HM)
  - Measure beam halo around PM
- 5 additional loss monitor, scintillator & photomultiplier

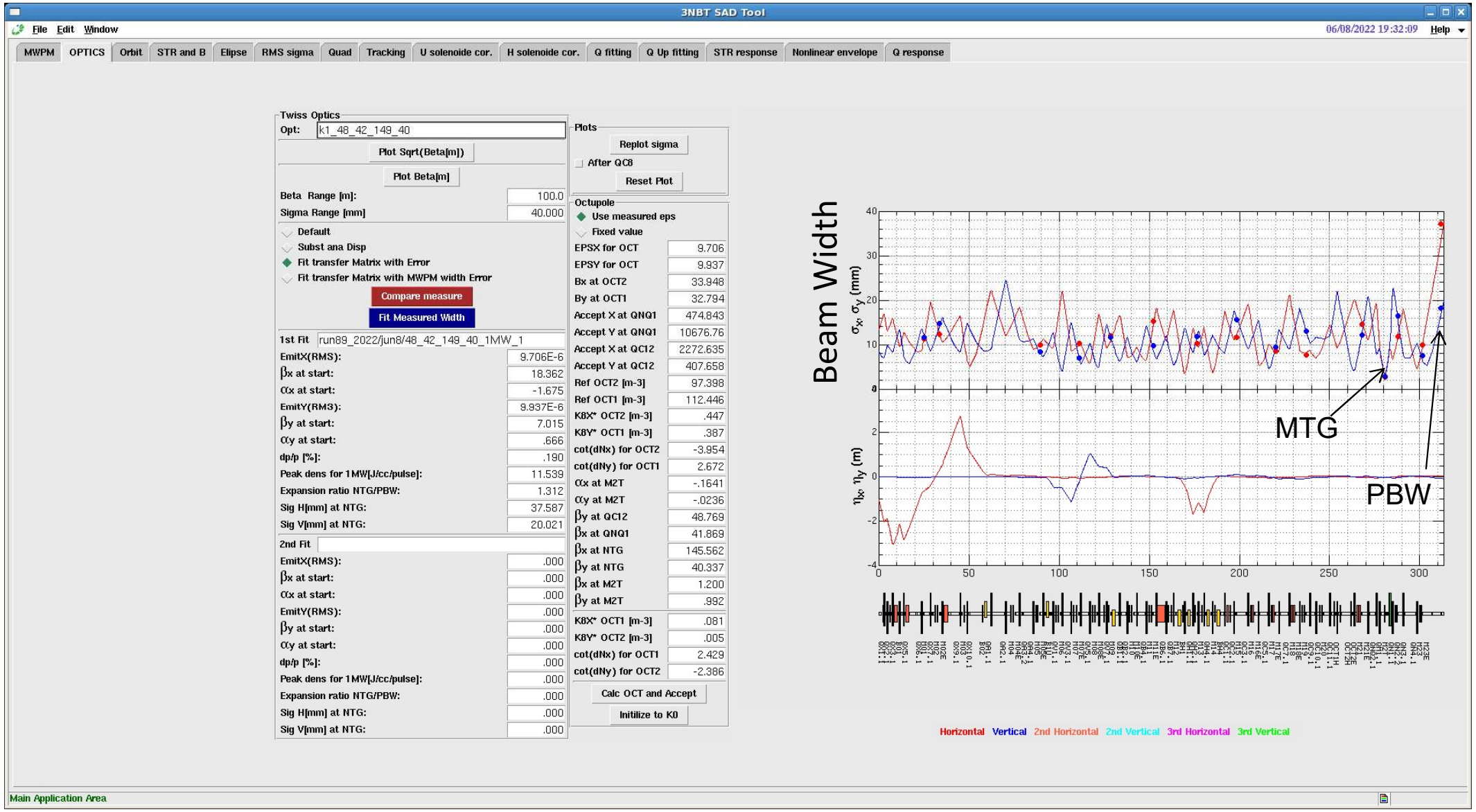
**Detail is shown in Meigo's presentation.**

# Operator interface & beam optics

- SAD code (operator interface)
  - Expert operation interface with SAD code. Auto fitting and auto magnet adjustment.
- Octupole magnet
  - This technique is used for flattening of the beam profile to the current density reduction at neutron target. For target pitting reduction.

# Beam tuning with SAD code

SAD : Strategic Accelerator Design



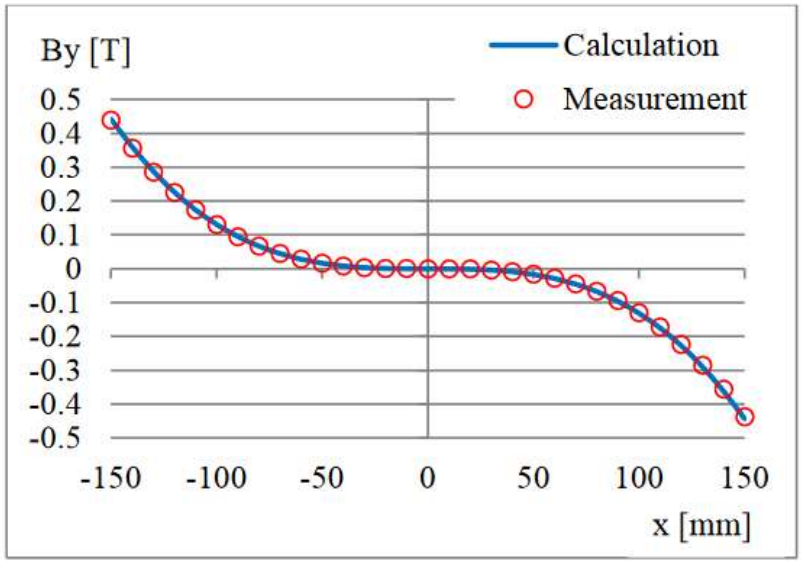

**Detail is shown in Meigo's presentation.**

https://acc-physics.kek.jp/SAD/

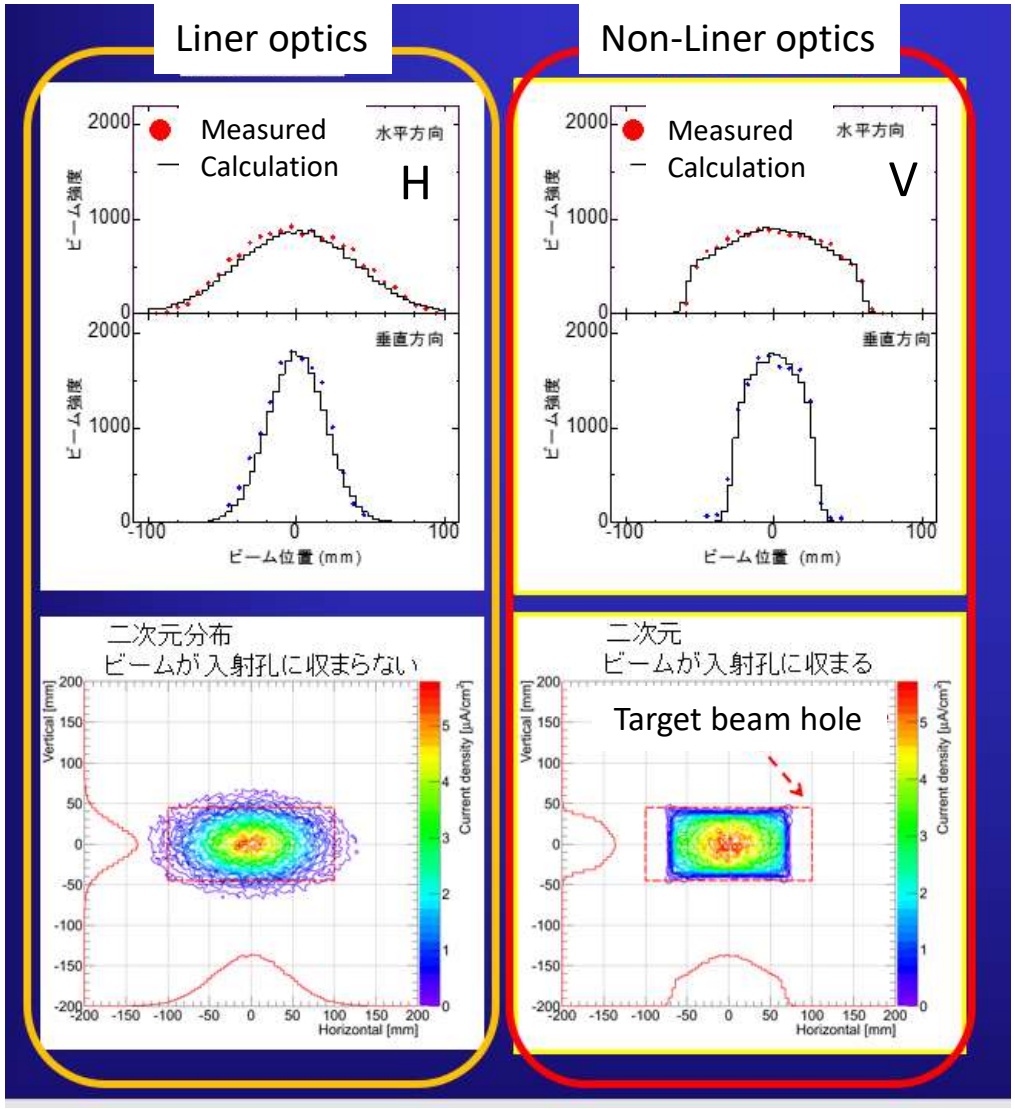
# Octupole magnet

- Effect of octupole magnet

  Beam flattening to reduce target pitting.




Magnetic field of octupole magnet



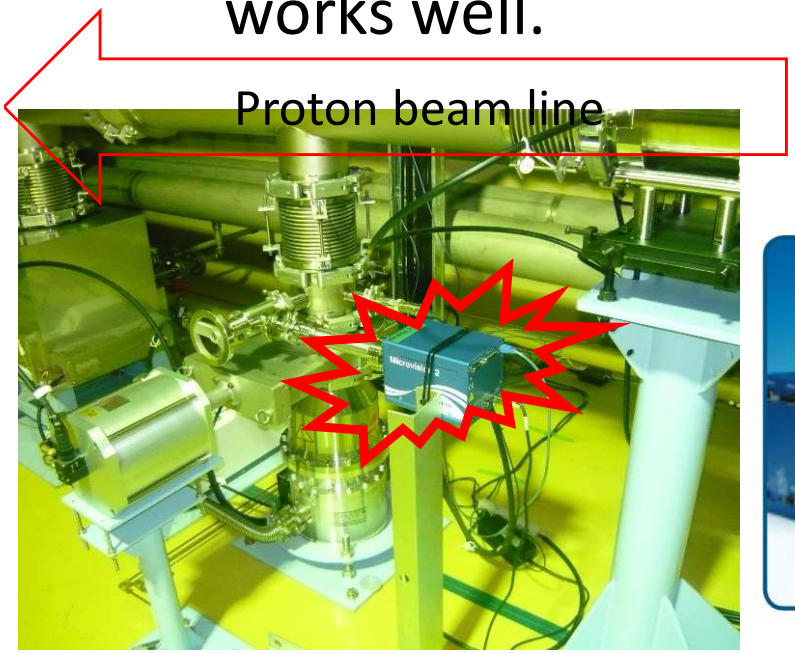

8極電磁石の効果

# Troubles in 3NBT

- Q-mass failure
- Corrosion of the magnet coil
- Broken of vacuum clamp
- Coil layer short

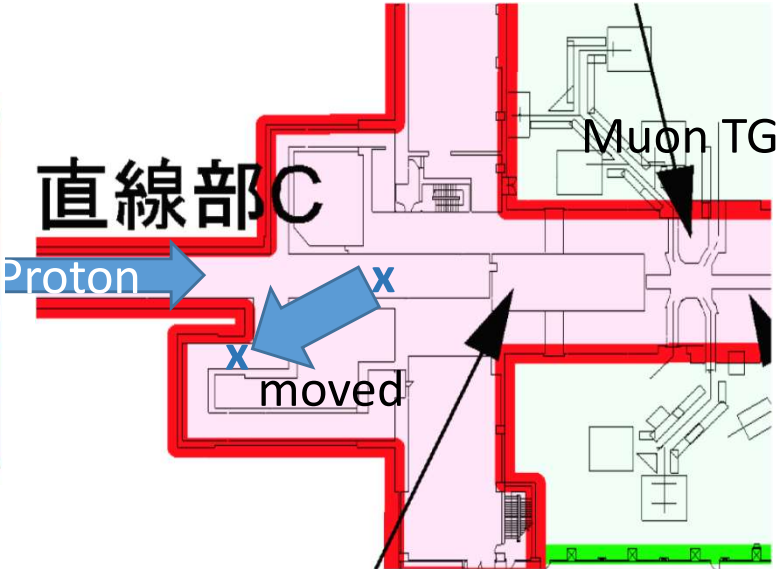
# Gas monitoring in 3NBT beam line

- In order to detect abnormal event in the proton beam line, we installed Q-mass in the proton beam line.
- Q-mass is shielded with lead and polyethylene blocks but due to the radiation damage, it was frequently stopped and sometime broken during the beam operation.
- Long wired Q-mass was installed in the cranked cave and it works well.



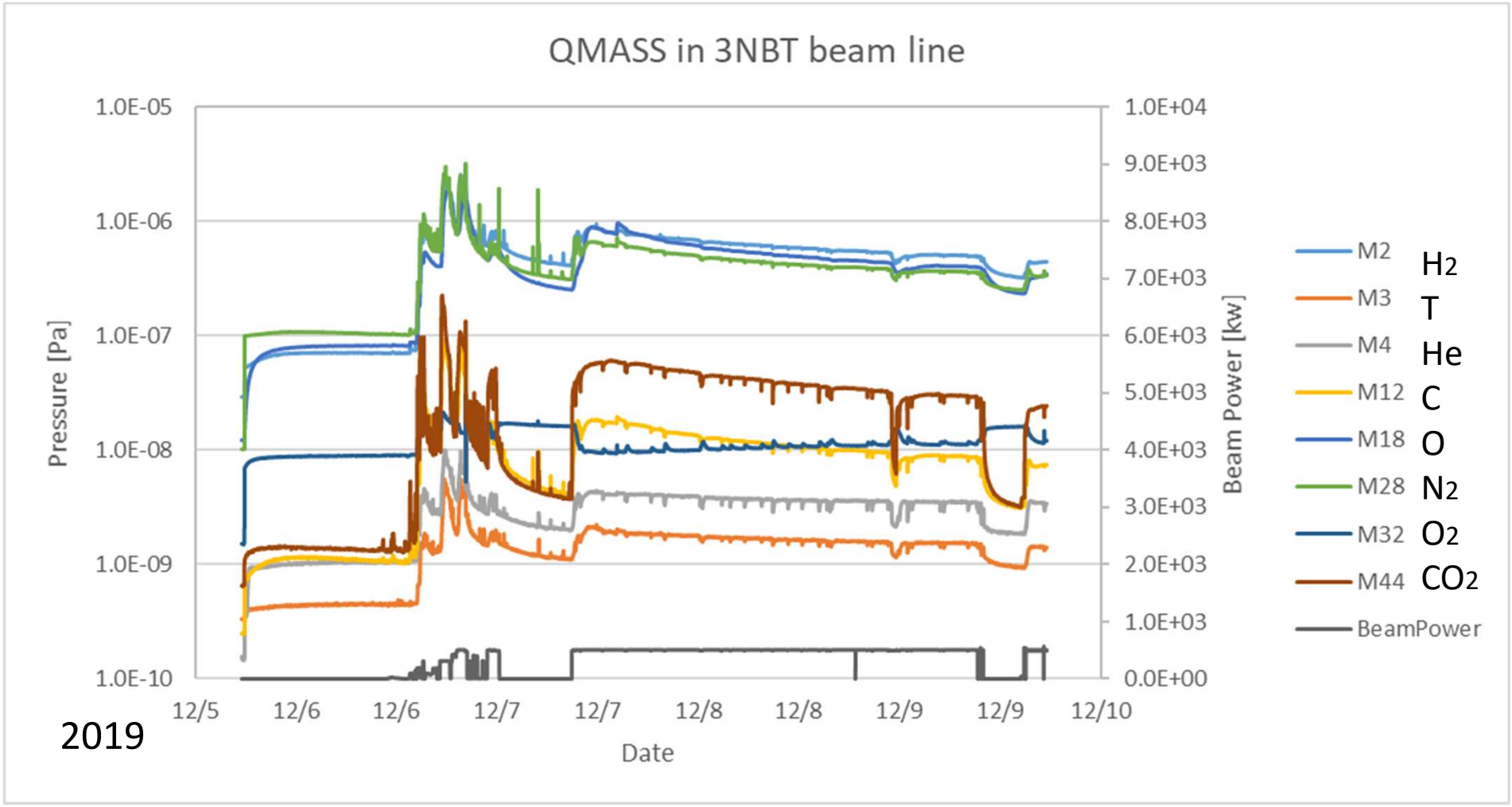

Long wired Q-mass


15m length



# Example of Q-mass data

Muon target was replaced before this beam operation.




Gas emissions from muon target decreases with beam operation.

# Oxygen in the cooling water

・The oxygen concentration in the cooling water affects copper corrosion.
・In the early days, corrosion of the copper caused dielectric breakdown of the insulated pipe.

・In 2016, degassing system was installed, and the cupper corrosion was reduced.

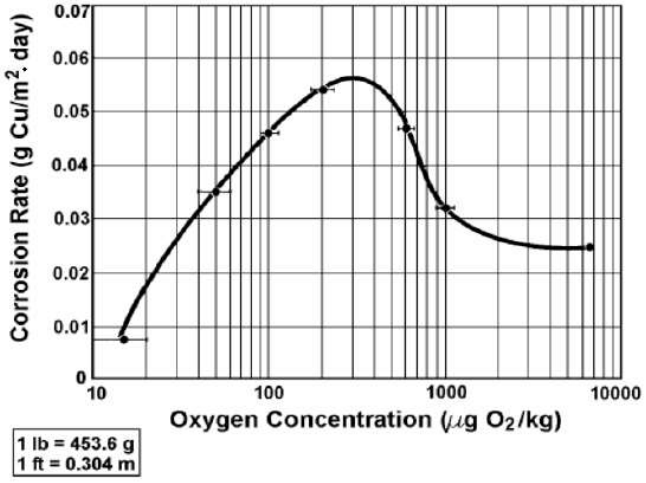
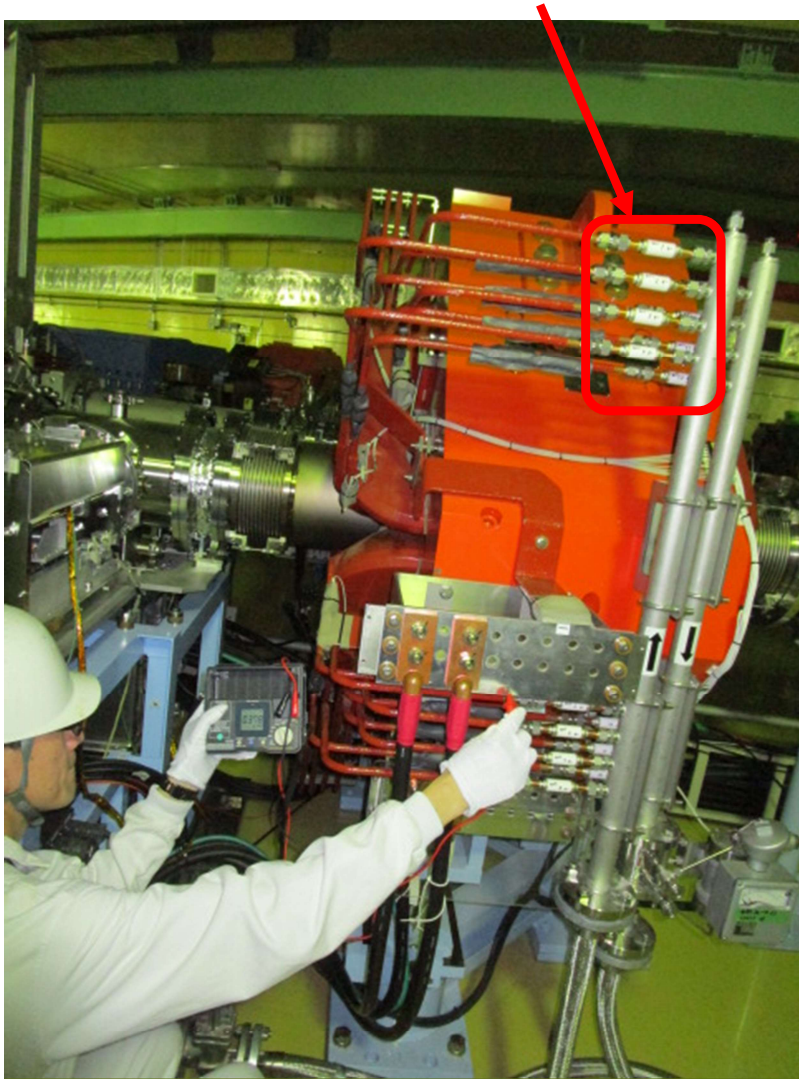



**Figure 8. Corrosion rate as a function of oxygen concentration.** Source: P. H. Effertz and W. Fichte, "Beeinflussung der Kupferkorrosion in hochreinem Wasser" ("Influencing Copper Corrosion in High-Purity Water"), *Jahrbuch Vom Wasser,* 1974.

Water Filter in magnet


Insulating pipe

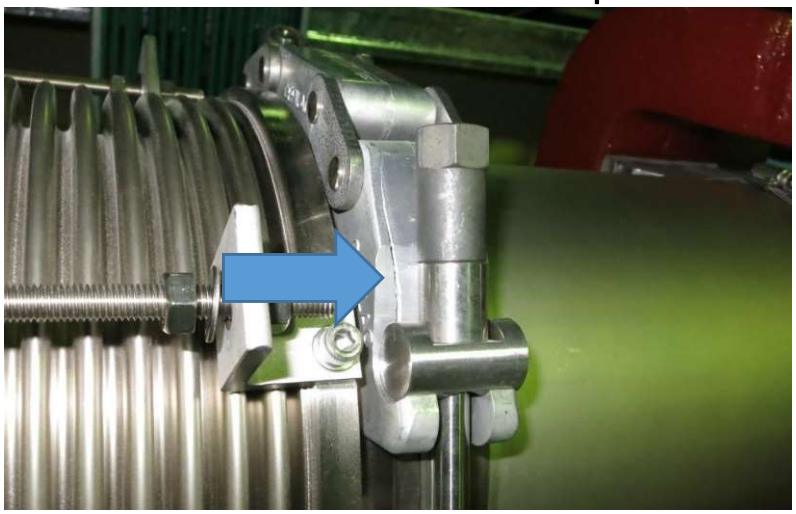


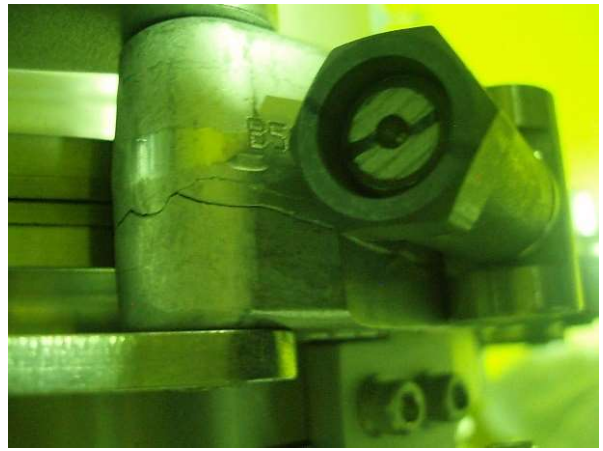
# Brake of the vacuum crump

We used aluminum chain clump on the beam duct.
A few clumps were broken every year and sometime beam operation was stopped.

we replaced these clumps to Al separate clump and SUS chain clump

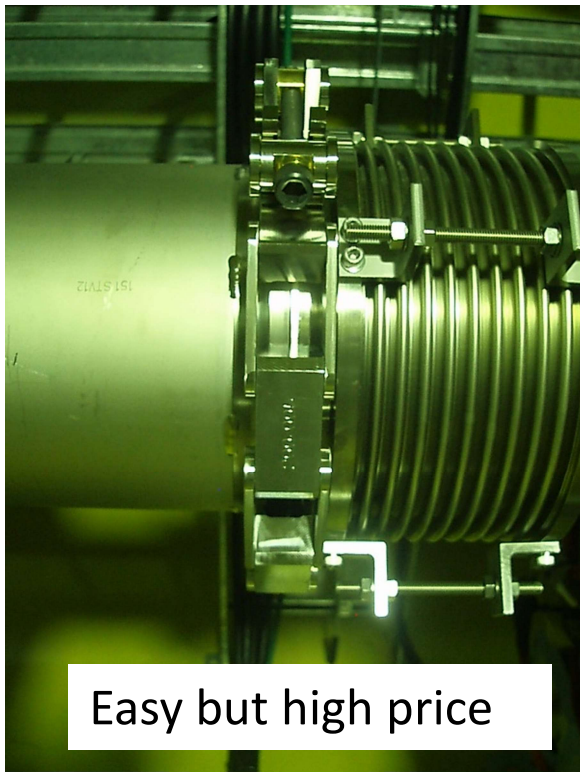
Broken chain clump





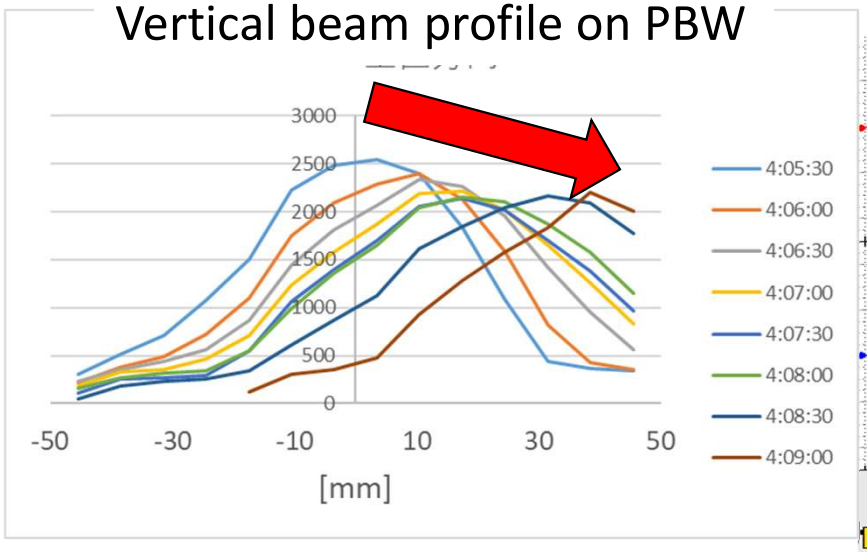
Al separate clump

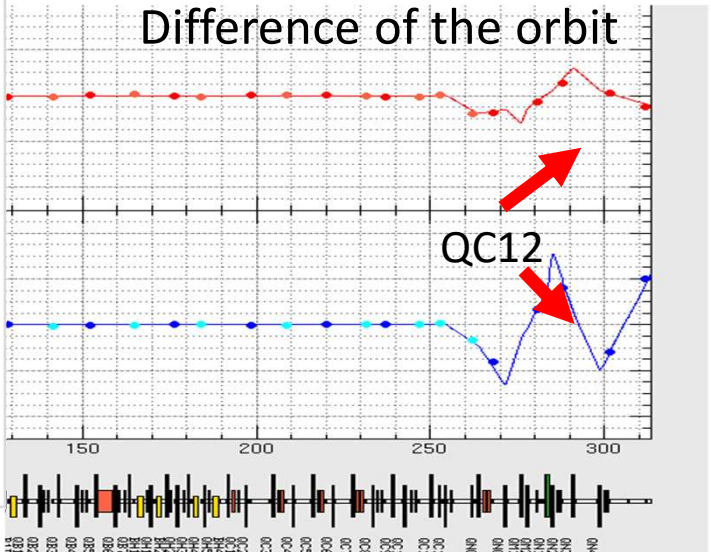

SUS chain clump

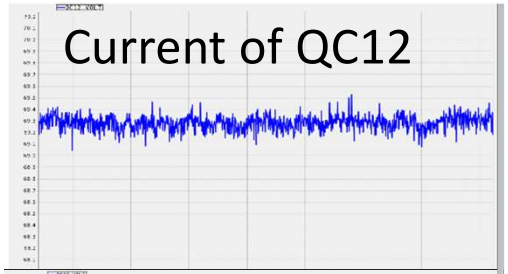


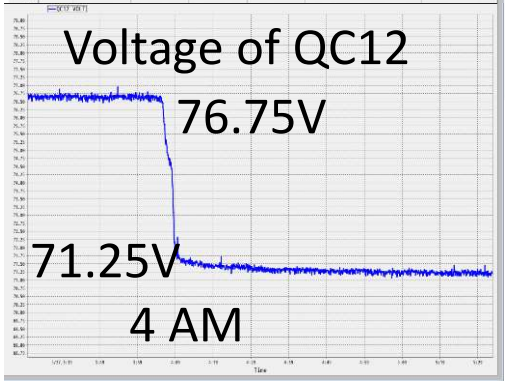
# Trouble of Q magnet in 3NBT

- May 27 2018, Beam position on the PBW moved and beam operation was stop due to MPS of PBW temperature.
- Beam orbit was changed after QC12 (Q magnet).
- Magnet field center was shifted 7mm and beam was kicked 1.7mrad.
- Layer short was occurred in QC12.



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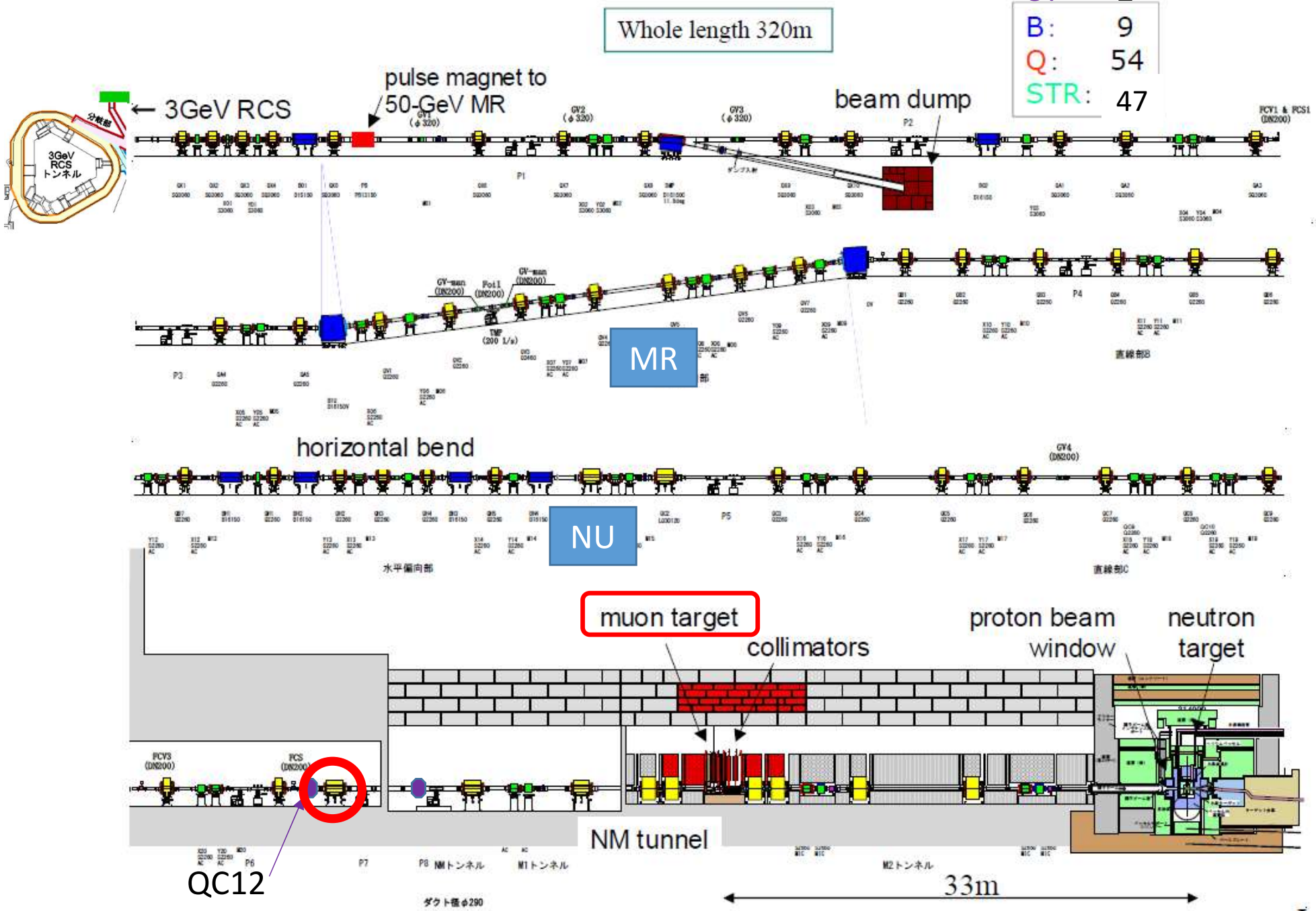


# Recover from the layer short

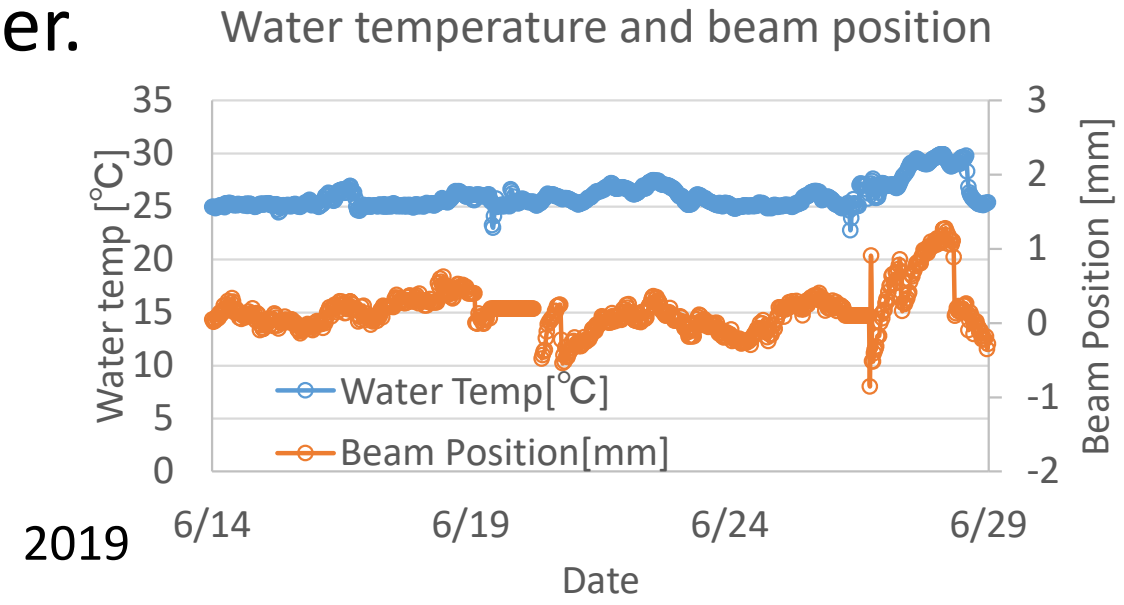
- Fast action (within 2 hour)
  - Beam orbit was corrected by S-magnet
- Second action (next beam study)
  - Beam tunning without QC12 was performed
- Final action (next summer shutdown)
  - The layer shorted coil was replaced to now one.

Study assuming a coil failure will lead to early restart of operation.

In 3NBT, some of the Q-magnet

# Water temperature and beam position

- We detect beam orbit is changing with the water temperature.
- With the temperature of 5 degrees, beam position was shifted by 1.4mm at maximum in MLF.
- During summer shutdown of 2021, cooling tower is replaced to chilled tower.



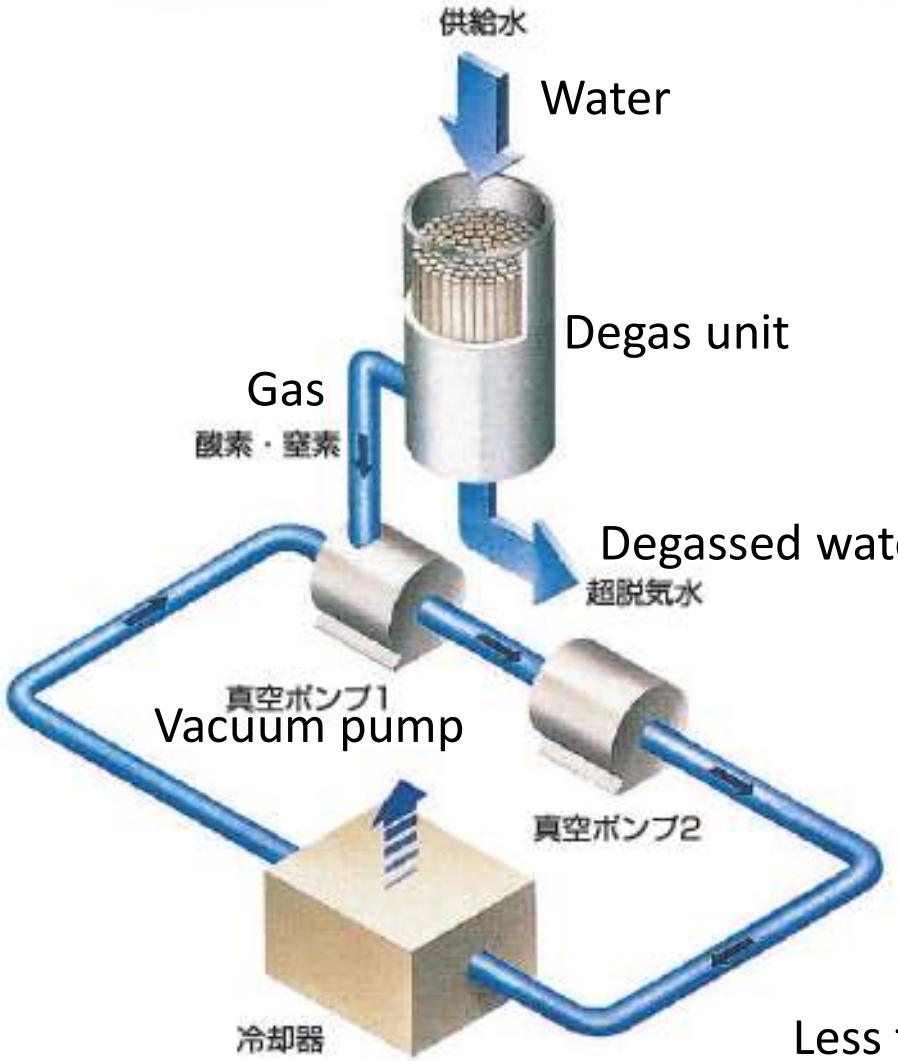

2019

# summary

- We use SAD code as operator interface.
- Octupole magnet was installed to reduce the beam current density on the target.
- It is recommended to be prepared for electromagnet troubles.
- Oxygen concentration should be controlled for corrosion protection.
- Some electronic devices are damaged by radiation, so it is necessary to evacuate them from the beamline.

# 超脱気装置

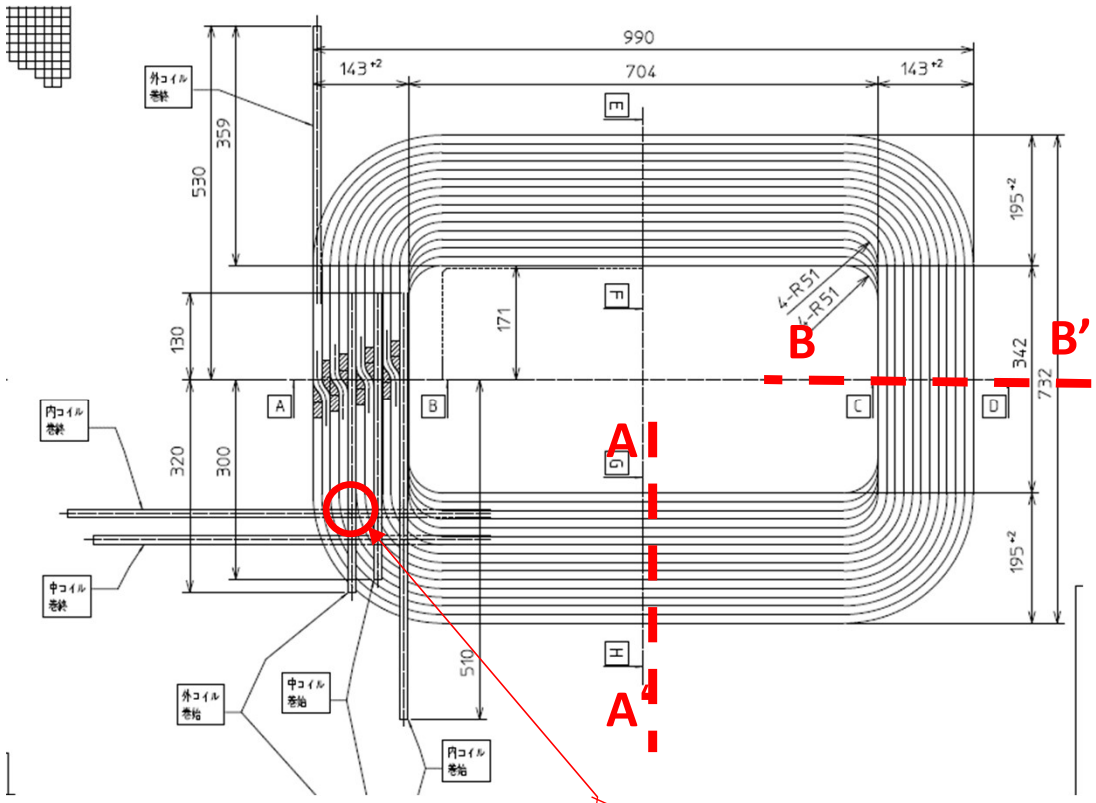
## 超脱気システム



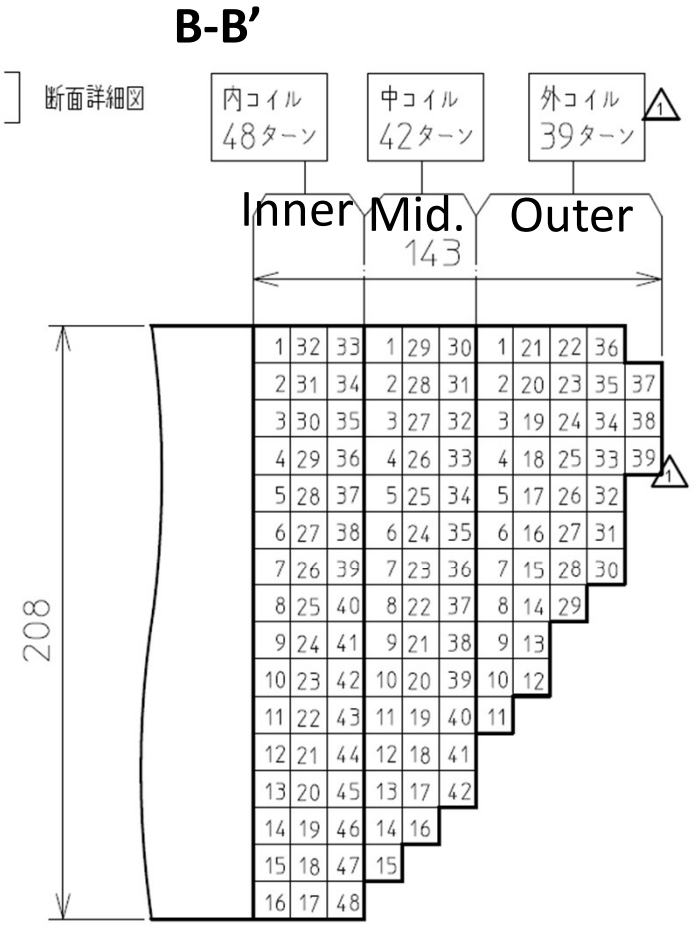

Less than 5 ppb is available

特殊脱気モジュールとミウラ独自の真空システムで5μg/ℓの超脱気性能を実現しました。
ミウラの真空技術と膜利用技術の結晶です。

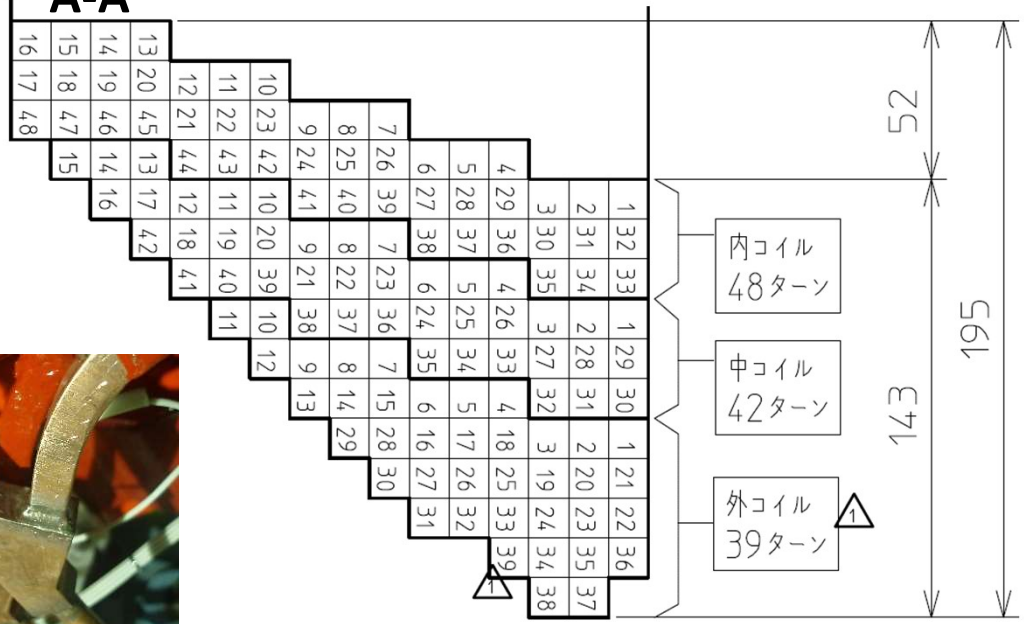
# QC12 coil



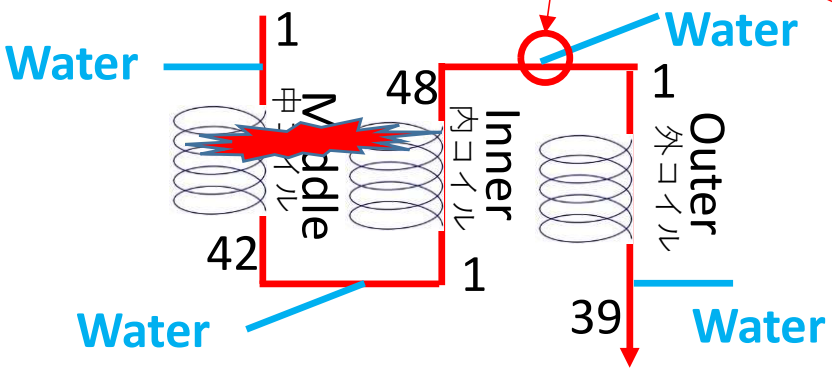

B-B'




A-A'



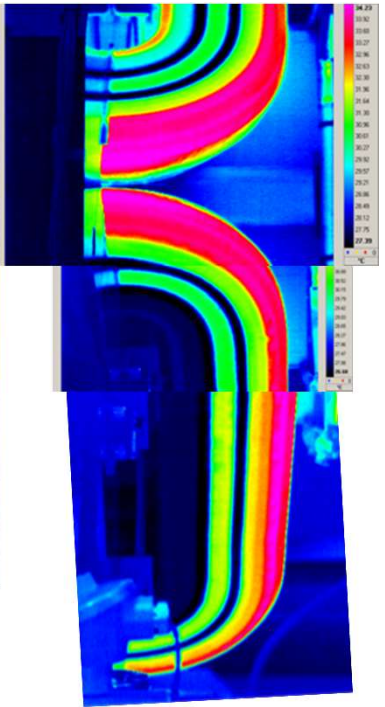

Electric flow




# Recover

- During the summer shut down, QC12 coil was changed to the another one and recovered.
- In the IR image of the QC12, we can see the shorted zone.

IR image

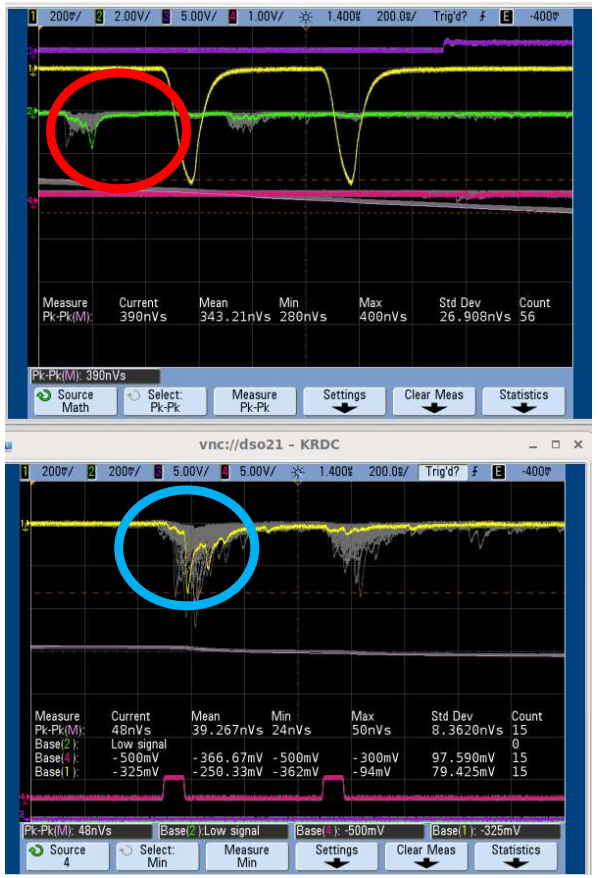


# Beam loss monitor (scintillator)

Scintillation monitor is installed as a beam loss monitor.

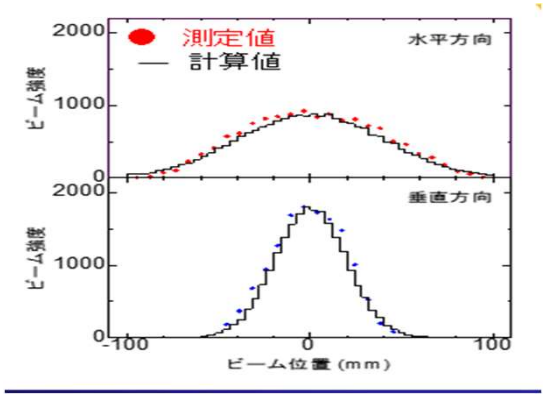
3NBTでは、ミュオン標的の有無によって、トンネル内の線量が変化する様子見られる。

**Without muon TG**

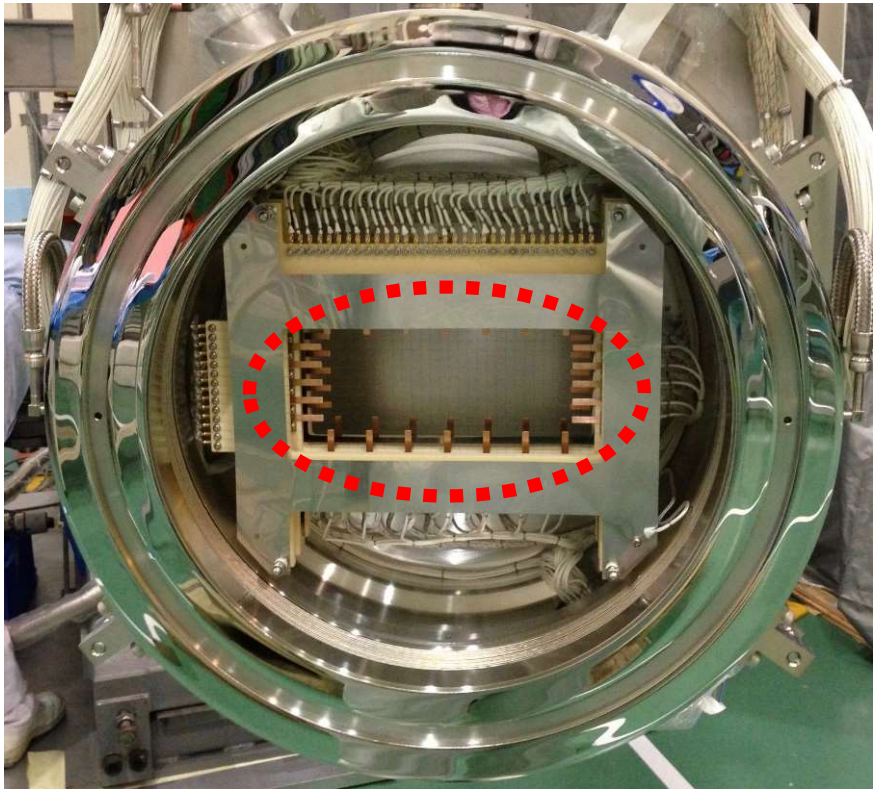


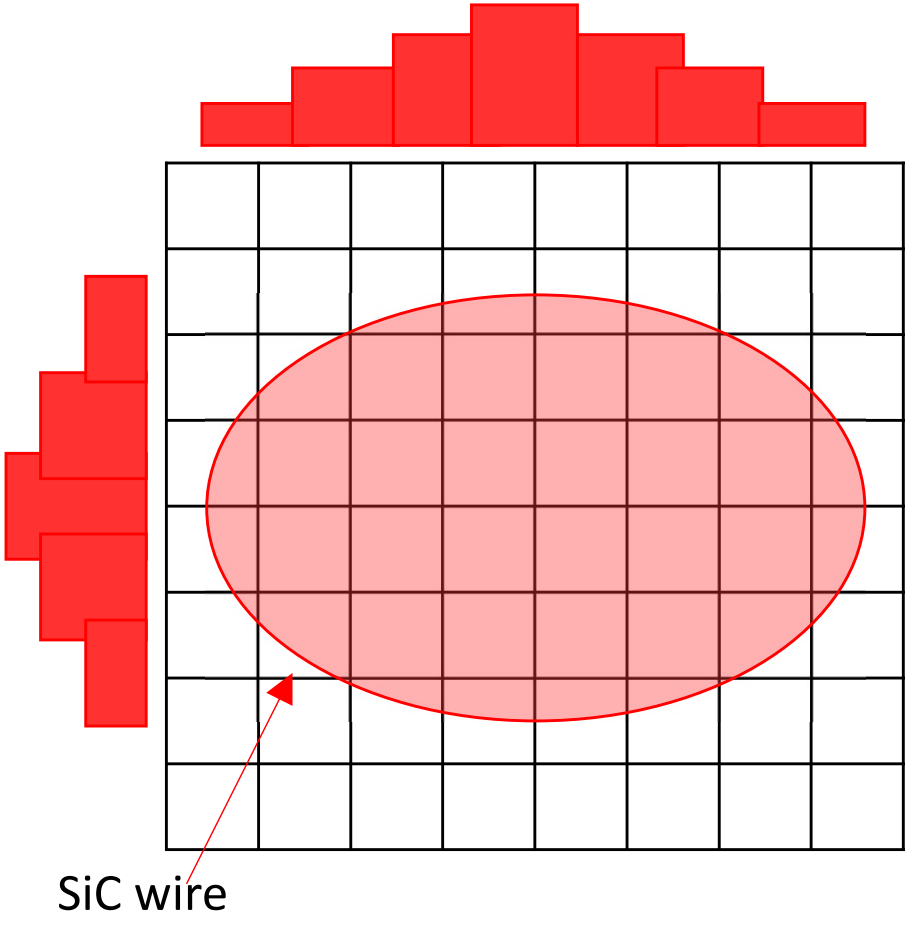

**With muon TG**

# Multi wire profile monitor




When the proton beam hit the grid-like SiC wire monitor, electric signal is generated. The beam shapes are measured by the magnitude of the signal.

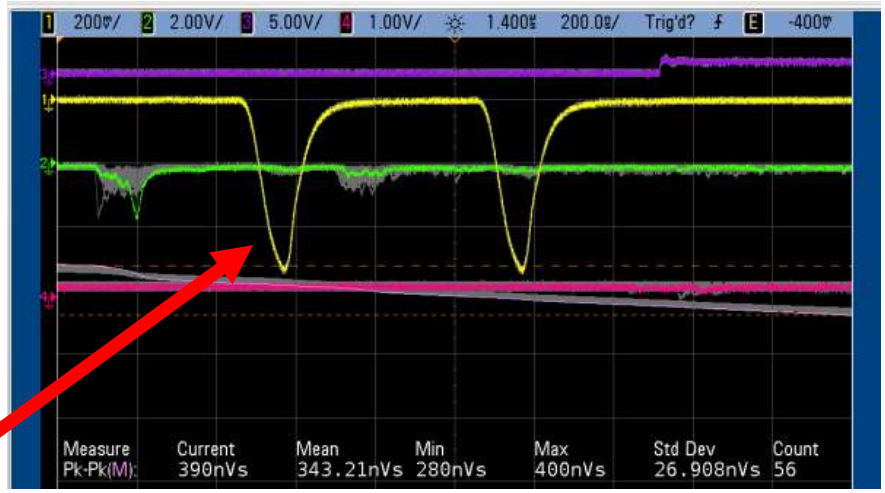


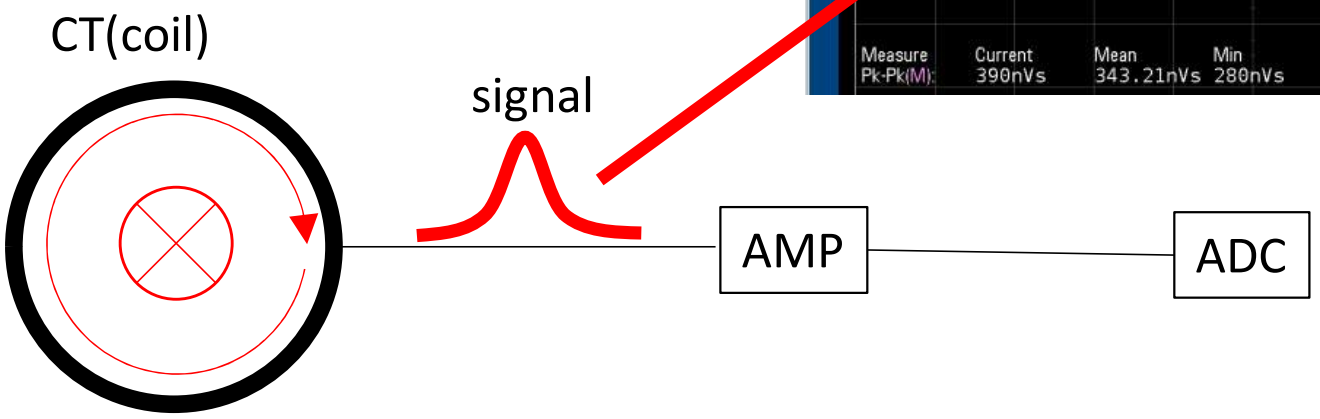


# Current Transformer (CT)

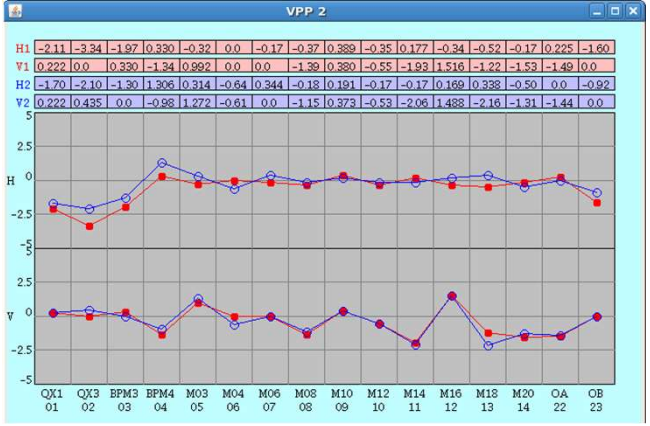
When Proton beam passing through the coil, electric signal is generated.

Signal is integrated in the ADC

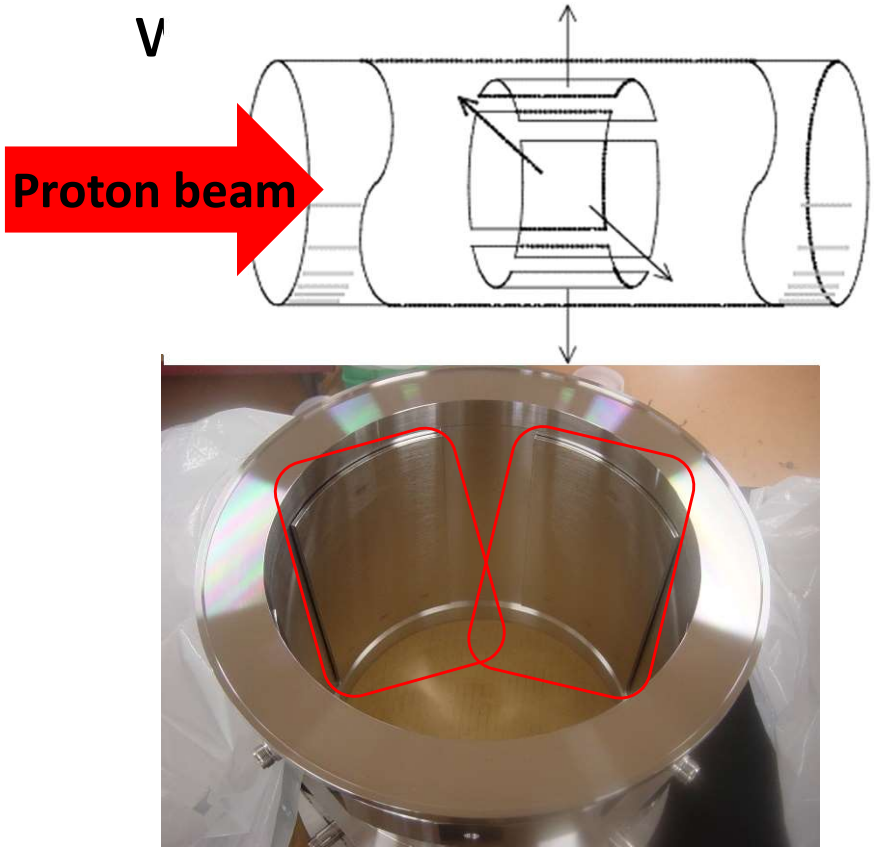


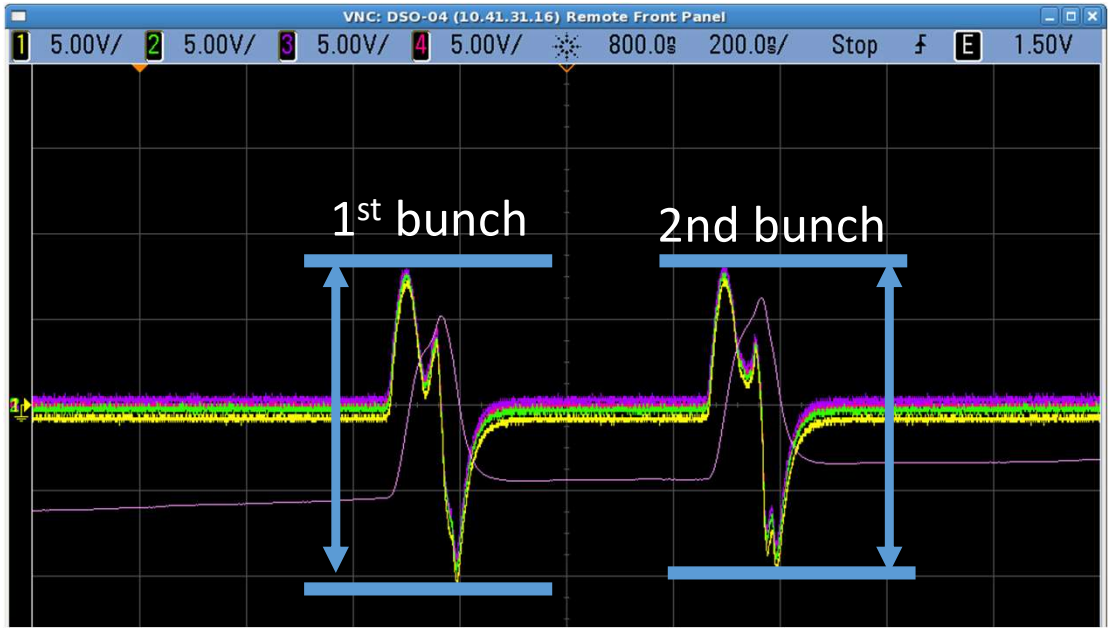



# Beam Position monitor




- Four antennas are installed on the beamline.
- The position of the beam is determined from the difference in the magnitude of the signal generated v



# Beam loss reduction with star duct

Beam width becomes large horizontally or vertically around the Q-magnet.

By using the star duct, we can use more dynamic orbit rather than a round duct.

The star duct is installed near the muon target.