

# Status and plan of testbeam line at KEK

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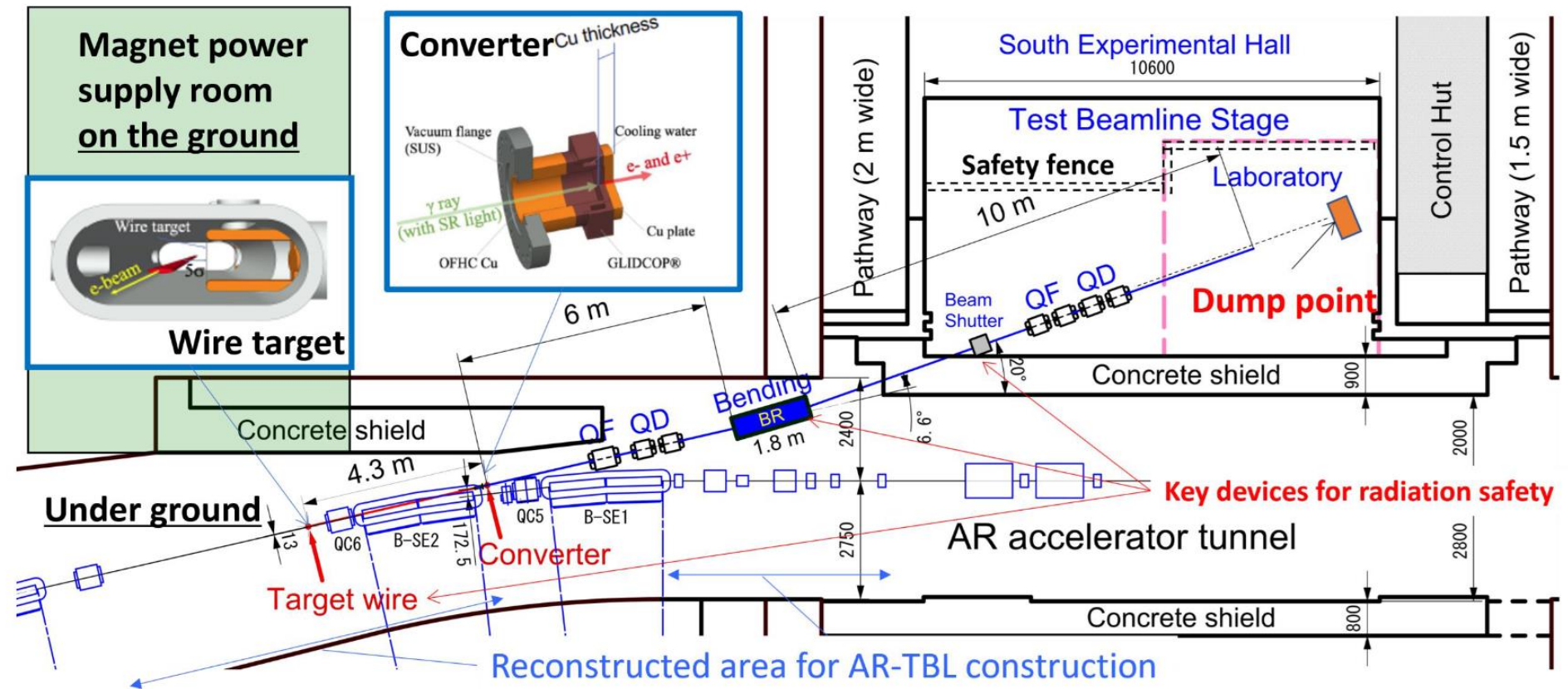
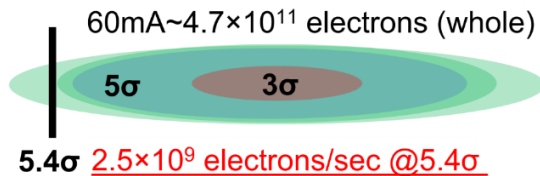


測定器開発センター  
Instrumentation Technology Development Center

# Electron test beam from PF-AR

## Electron in AR ring

$\beta_x = 20.6$  [m],  $\epsilon_x = 290$  [nmrad]  
beam size  $1\sigma_x = 2.4$  [mm]  $1\sigma_y = 0.1$  [mm]



- Photon emission by wire target (Graphene)
- Inject photon to a converter (16 mm Copper plate) to make pair creation.
- Transfer electron with Di-pole and Quadra-pole magnets to the test stage.



# How does it look like?

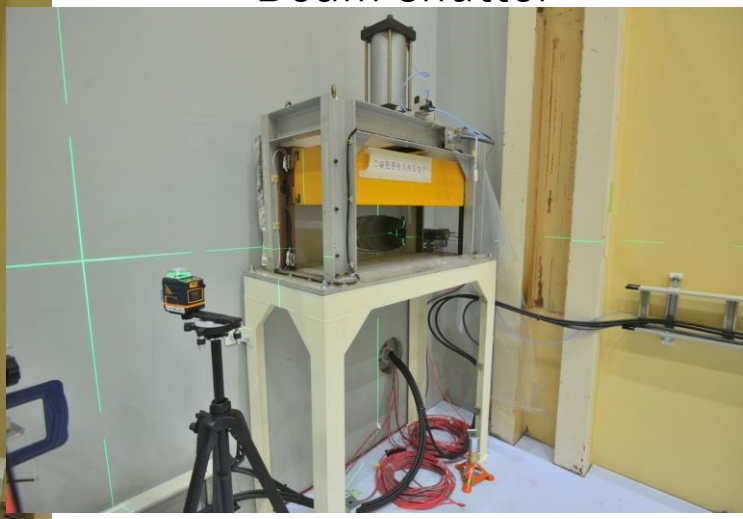
Counting room



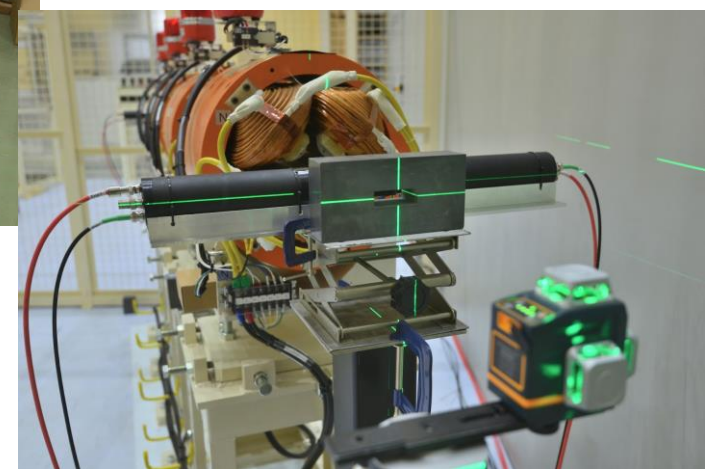
Sensor Stage



Beam shutter

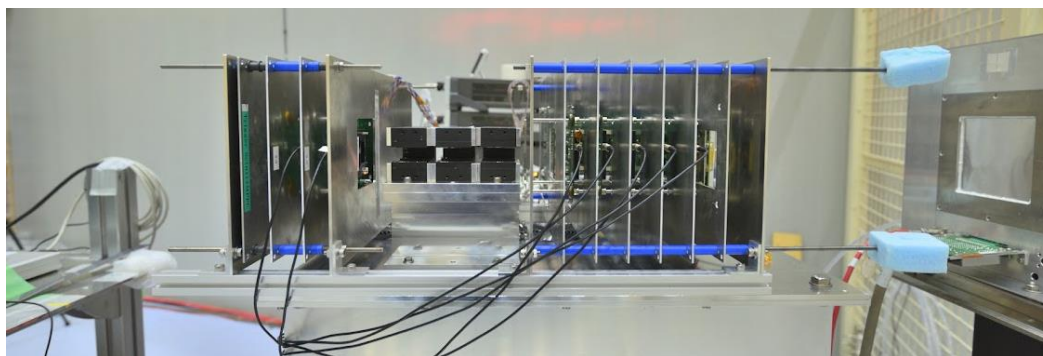
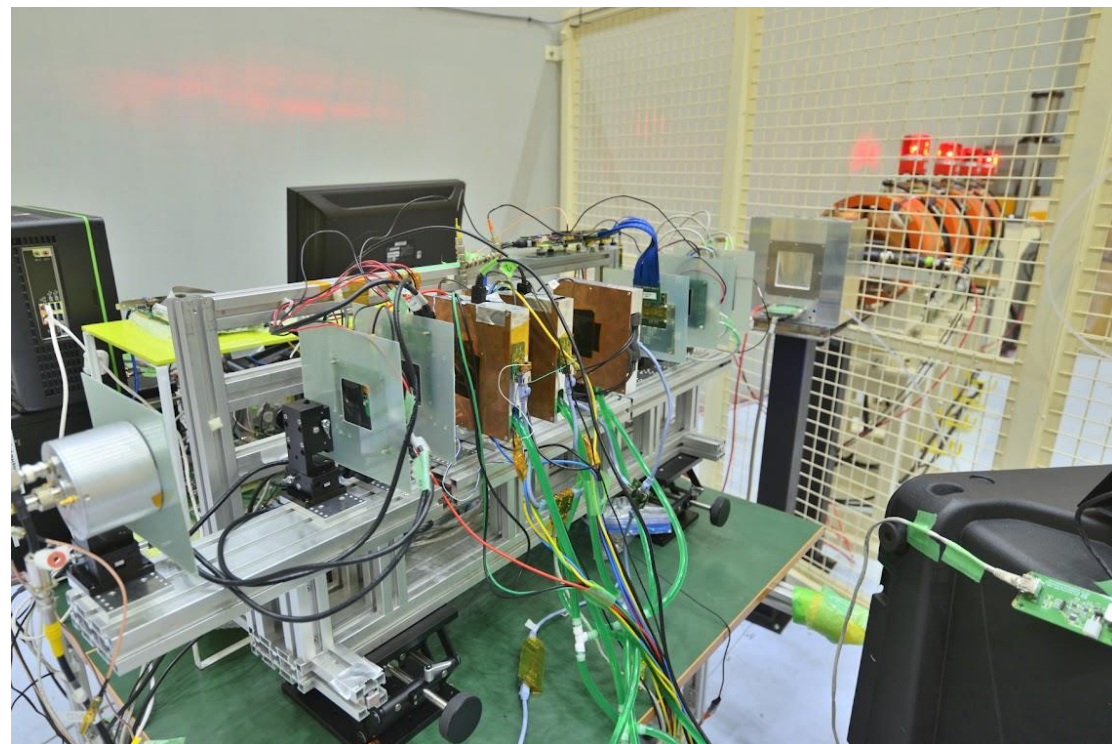
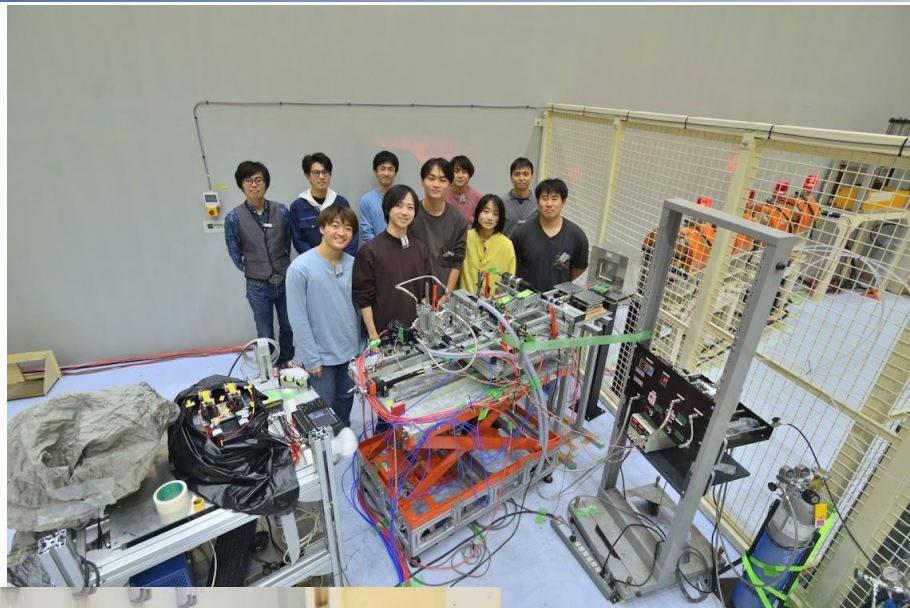


Trigger counters





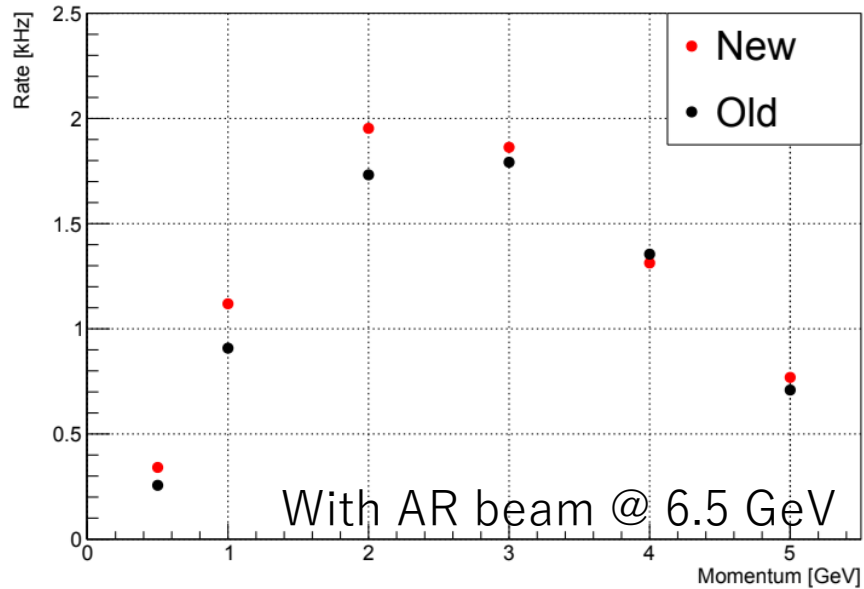
# Use cases...



# Test beam rate and profile

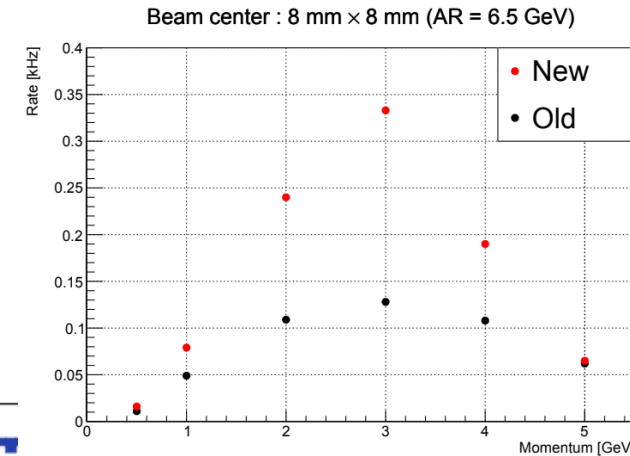
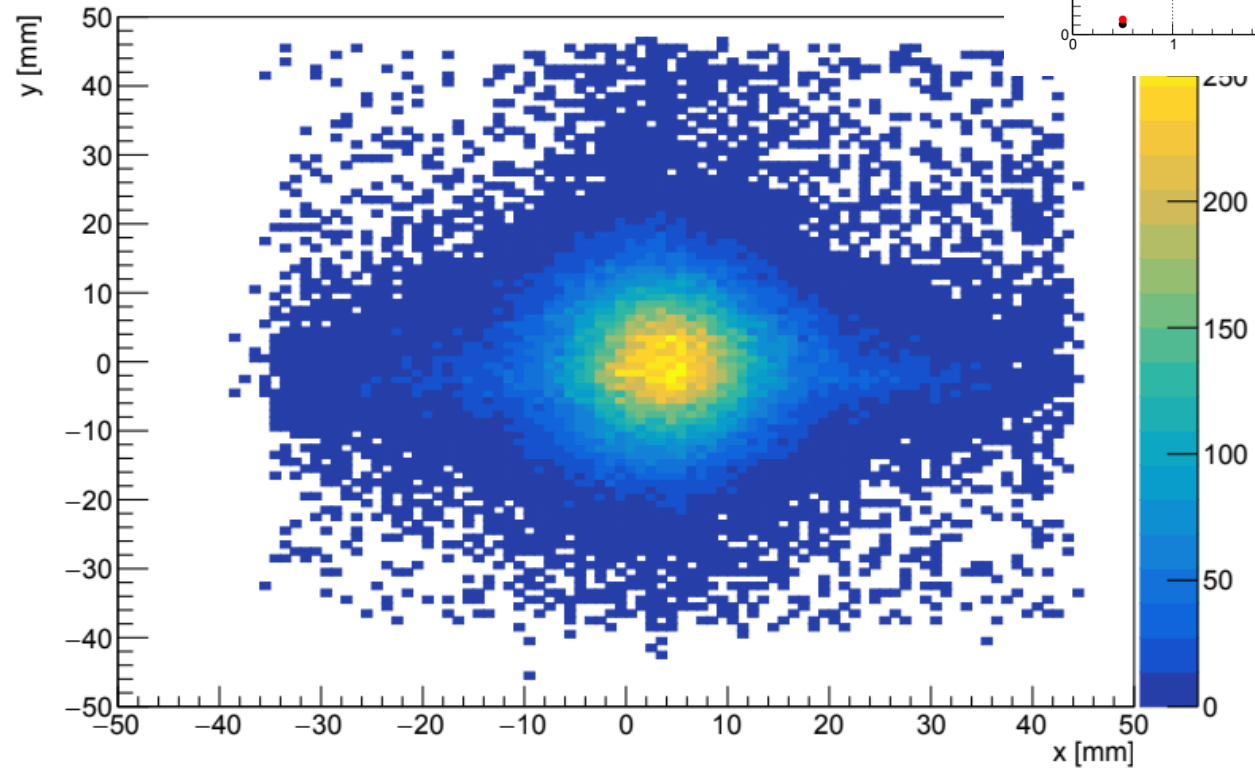
## Rate:

Overall rate is 2~2.5 kHz  
Highest rate ~ 3 GeV.



Recently we optimize Q-magnet  
New: after optimization.  
 $\Delta p/p \sim 10\%$ .

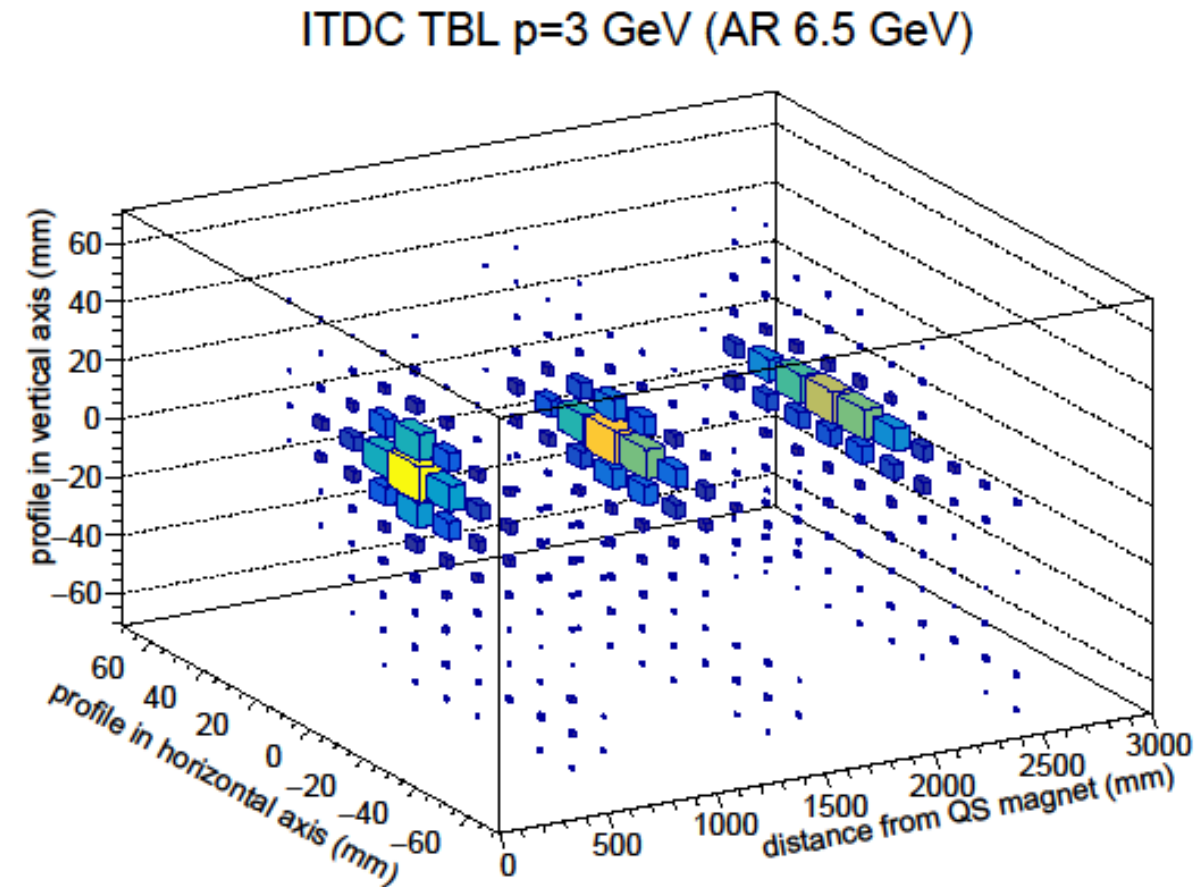
- Beam profile at 3 GeV
  - ~ 4 mm in sigma
  - Wide in x direction.
- Beam rate with 8mm x 8mm:  
~ 350 Hz.



# Beam profile in beam axis direction

Beam width in sigma (gaussian fit) in beam axis direction  
 $Z=0$  is at the edge of the last quadrupole magnet.

Momentum and AR operation Beam energy	Direction	Z = 0.65 m	Z= 1.50 m	Z=2.50 m
3 GeV @ AR 6,5 GeV	Horizontal	10.0 mm	12.9 mm	14.8 mm
3 GeV @ AR 5.0 GeV	Horizontal	10.2 mm	12.8 mm	----
3 GeV @ AR 6,5 GeV	Vertical	8.9 mm	7.1 mm	5.2 mm
3 GeV @ AR 5.0 GeV	Vertical;	8.9 mm	7.0 mm	----

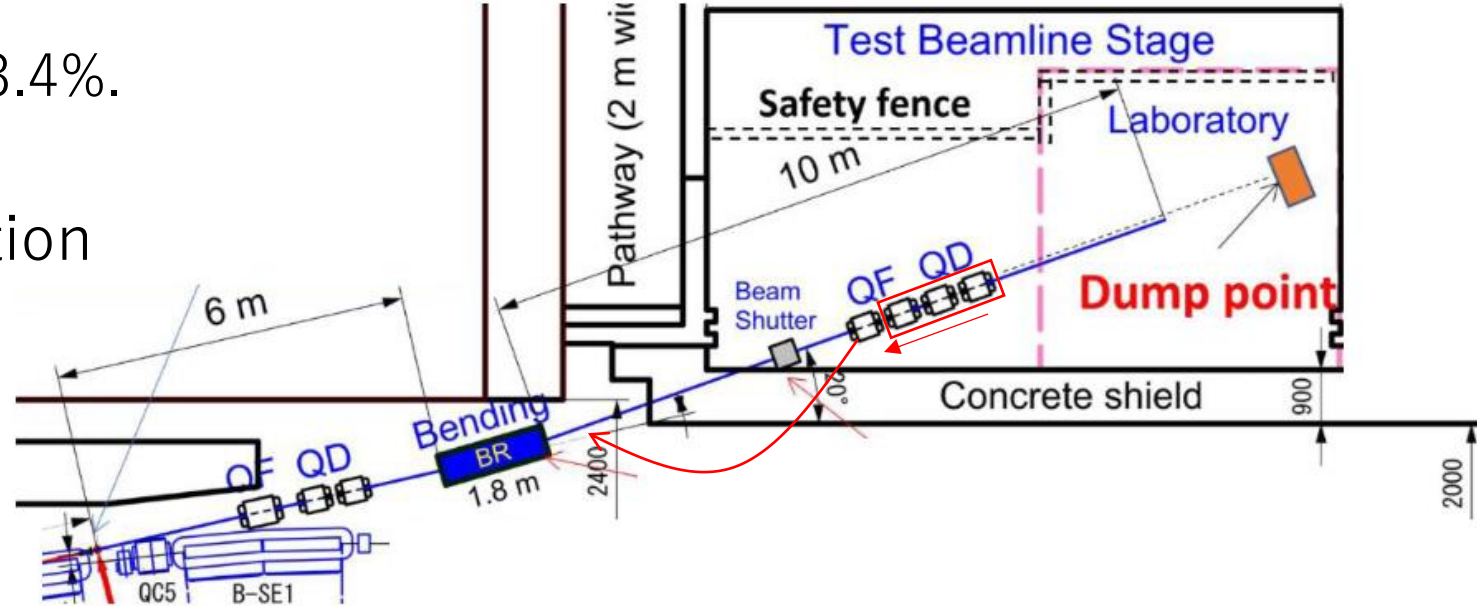
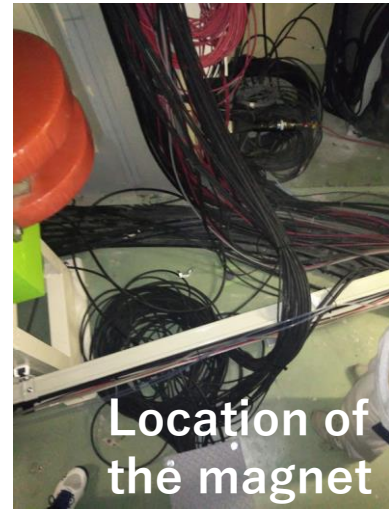
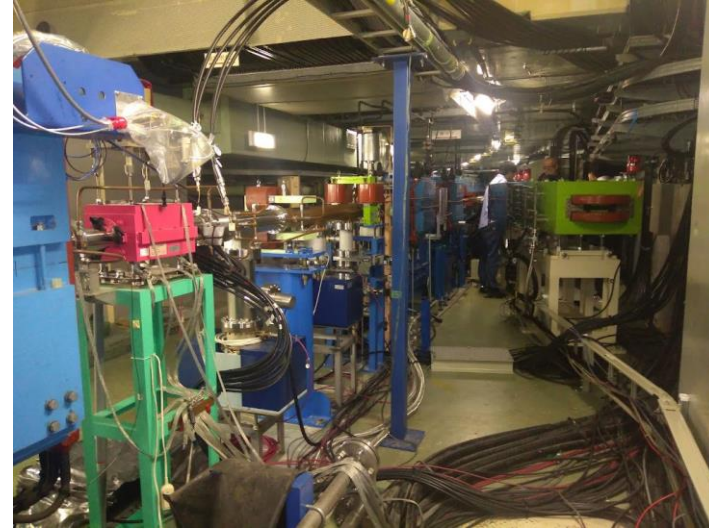




# To have higher rate

- Position of Quadrupole magnets can be improved.
  - Set them upper stream side.
    - Move one of QF just after Dipole magnet
    - Move forward rest of Quadrupoles by 1 m.
- The rate increased by 1.9  
momentum spread: 2.8% → 3.4%.

Plan to proceed this modification  
in Summer 2025

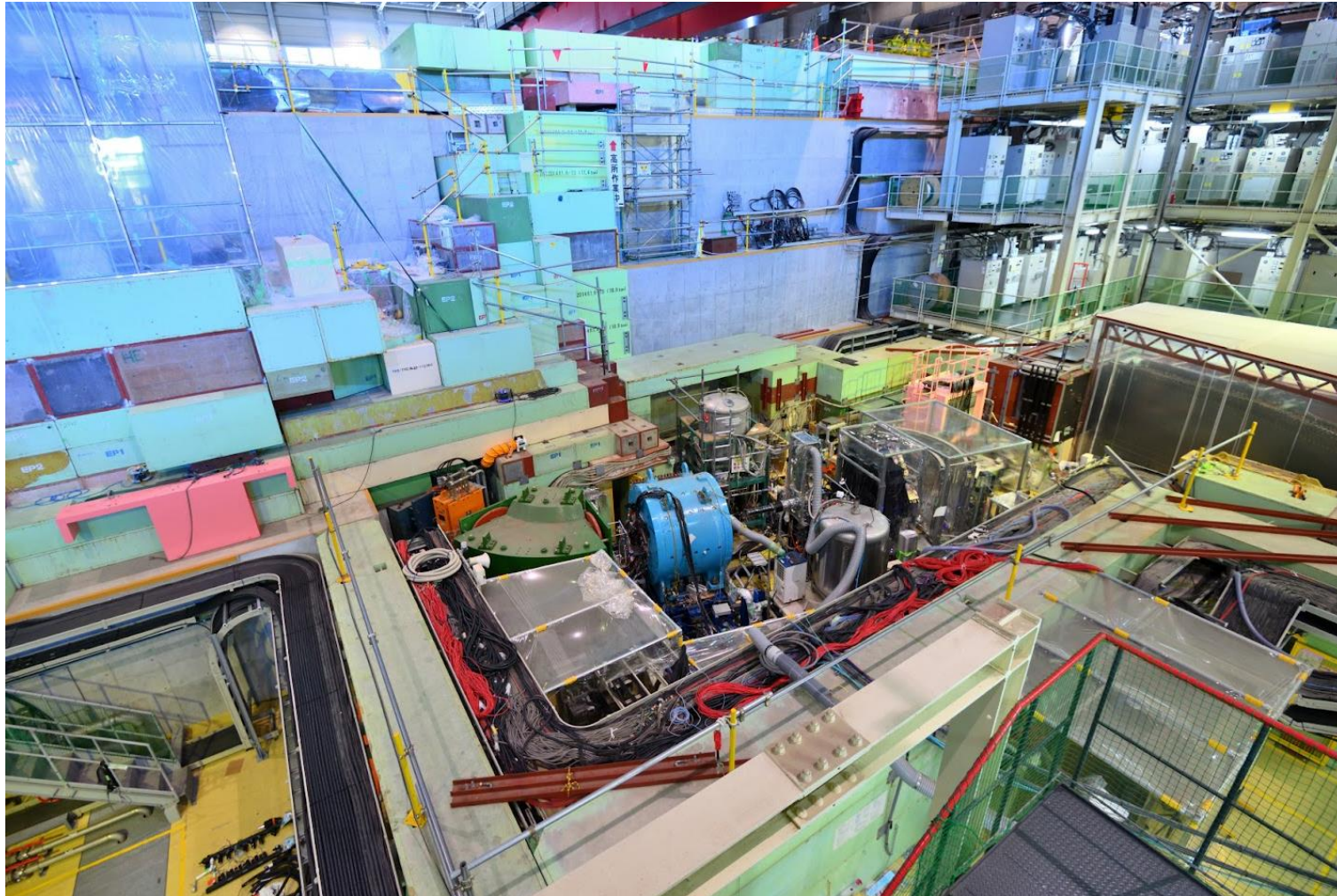


# Beam Time in 2025

- Beam time for electron test beam line:
  - 2025 Mar 03 ~ Mar 24
  - 2025 May 13 ~ July 07
  - 2025 Oct 14 ~ Dec 26
- Beam time for a group is typically 1 week
  - Wed 17:00 ~ Wed 9:00.
  - Often Wednesday is machine time.
  - PF-AR is operating with top-up mode
    - No down time for injection.
- If you would like to use the beam, let me know.  
([yuji.enari@cern.ch](mailto:yuji.enari@cern.ch))
  - <https://itdc.kek.jp/en/testBeamLine/index.html>
  - [https://www2.kek.jp/uskek/eng/apply/ar\\_tbl\\_eng.html](https://www2.kek.jp/uskek/eng/apply/ar_tbl_eng.html)

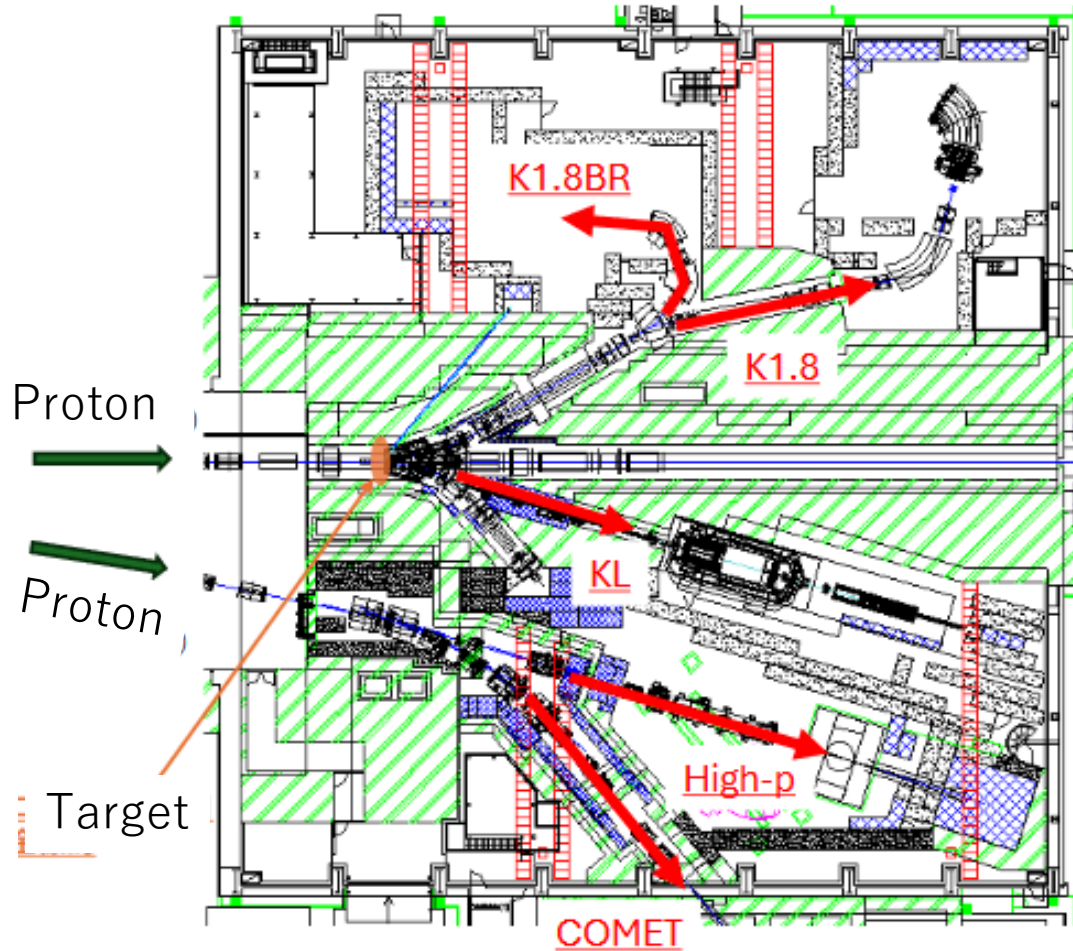


# A plan for a hadron test beam in J-PARC



J-PARC Hadron experimental hall @ KEK Tokai campus

# J-PARC Hadron experimental hall



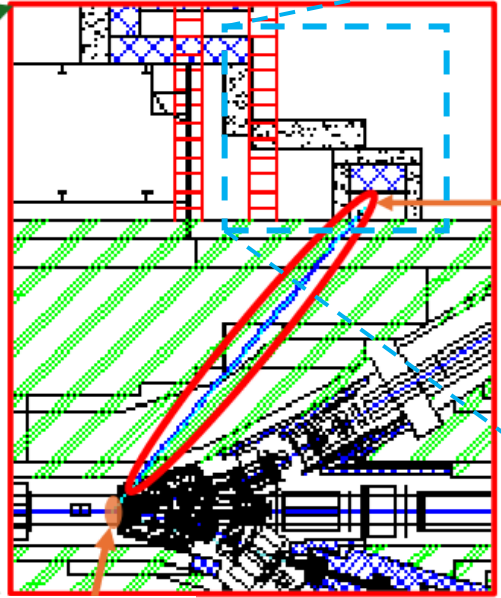
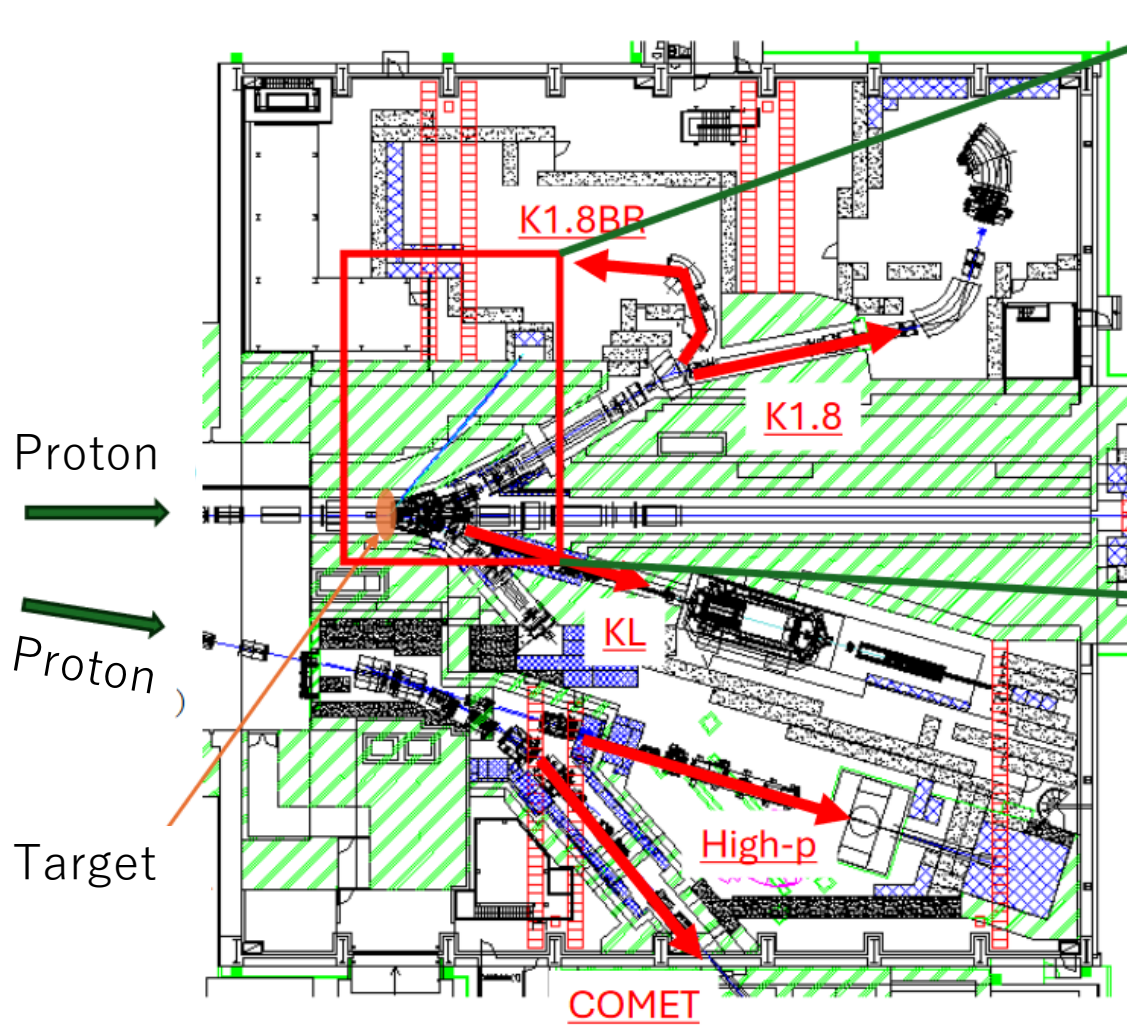
- 30GeV protons are injected to gold target
- Using secondary particles
  - Max beam intensity : 115kW (4.2s cycle)
  - Record of beam intensity: 65kW
  - target : Gold 66mm thickness
- There is high momentum line

Name	Species	Mom./Energy	Intensity
K1.8	$\pi^\pm, K^\pm$	< 2.0 GeV/c	$\sim 10^5$ Hz for $K^+$
K1.8BR	$\pi^\pm, K^\pm$	< 1.0 GeV/c	$\sim 10^4$ Hz for $K^+$
KL	$K_L$	2.0 GeV/c (Ave.)	$\sim 10^7$ Hz for $K^0$
High-p	Proton	30 GeV	$\sim 10^{10}$ Hz
COMET	Proton	8 GeV	$6.2 \times 10^{12}$ /shot*

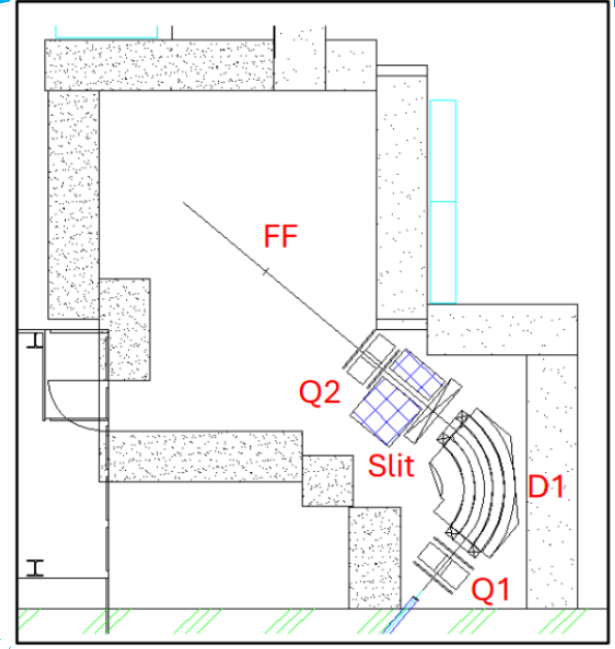
\*Phase 1



# A plan for a Hadron Test beam line



Target

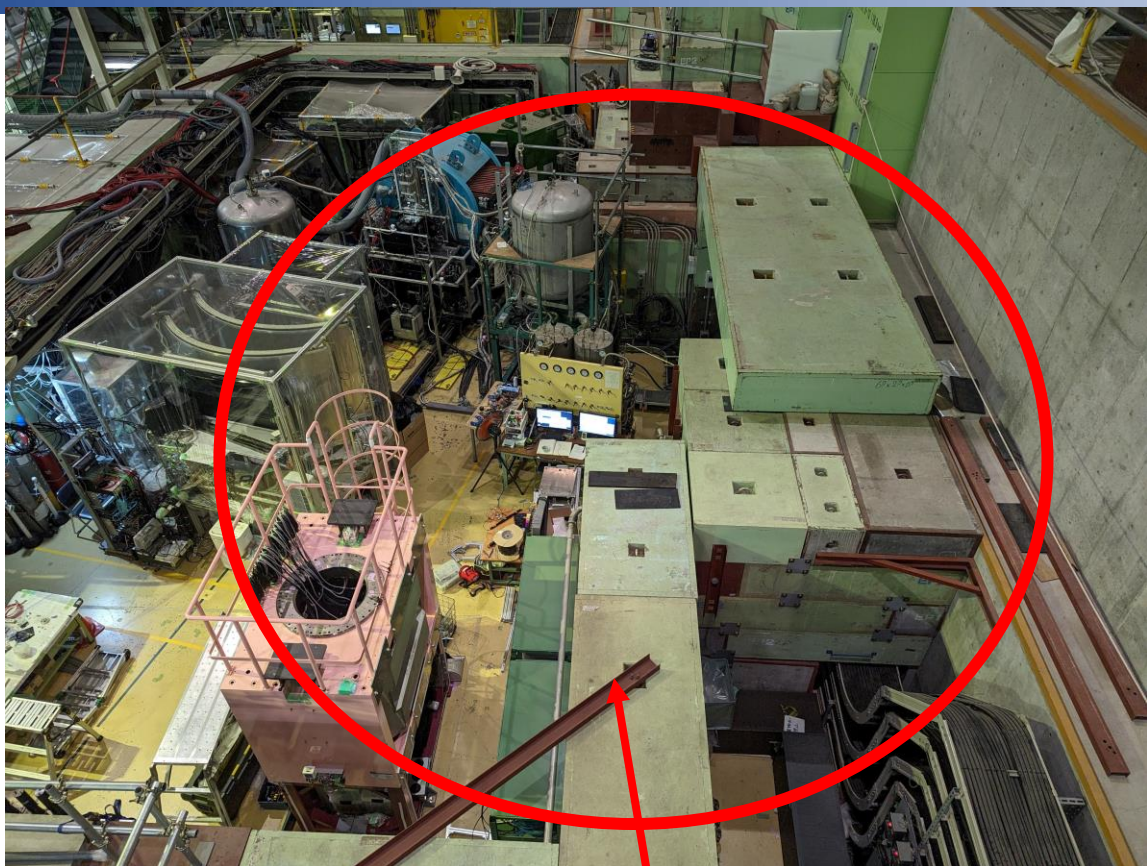


Plan for hadron TBL

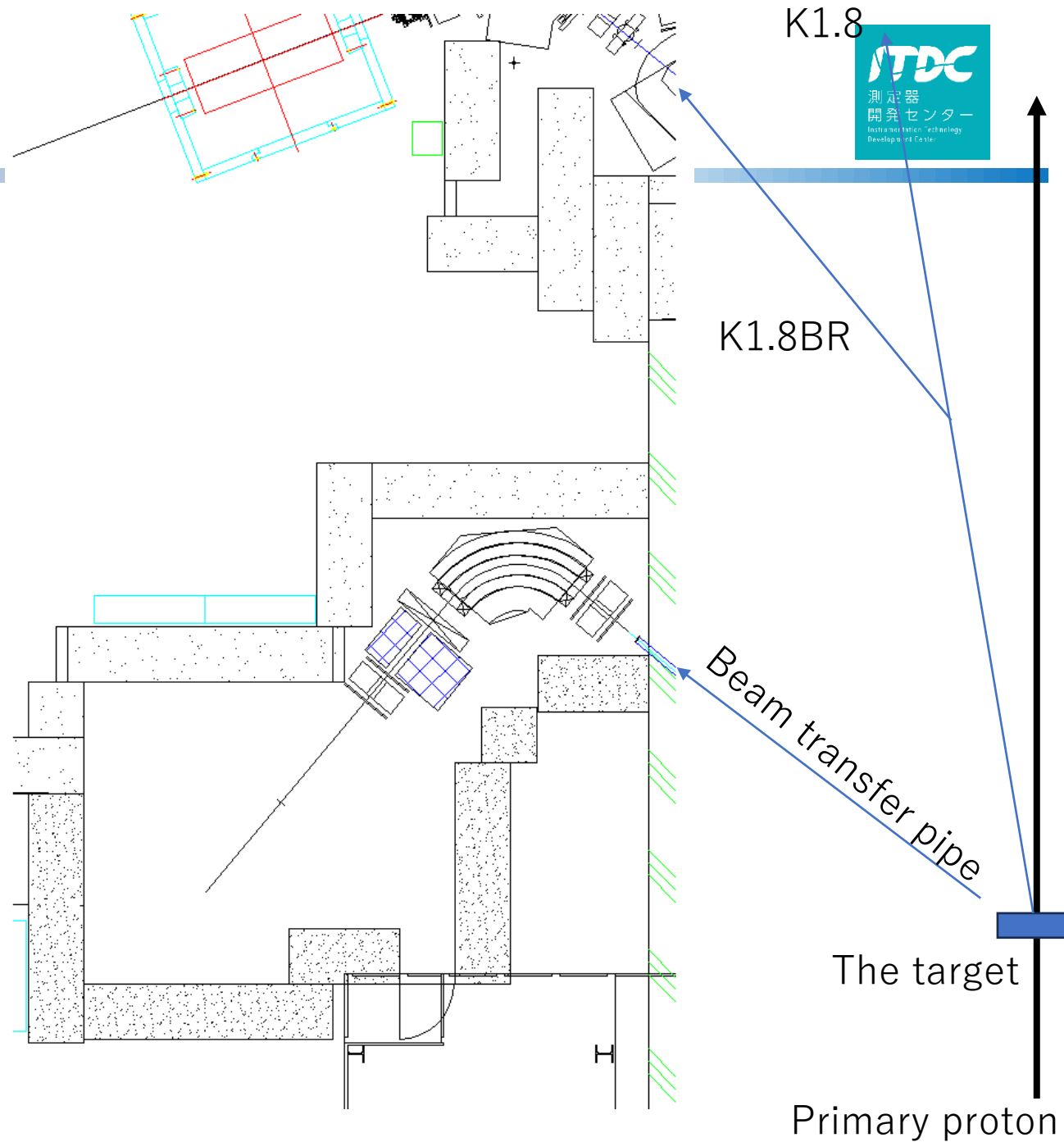
- Beam pipe is allocated from the target at 50 degree
- This beam pipe can be used for test beam line.
- Modify area and place magnets.
  - open slit :  $\Delta p/p = 5\%$ , beam full width : 15cm (full width)
  - 1cm Slit :  $\Delta p/p = 0.5\%$ , beam full width : 2cm (full width)



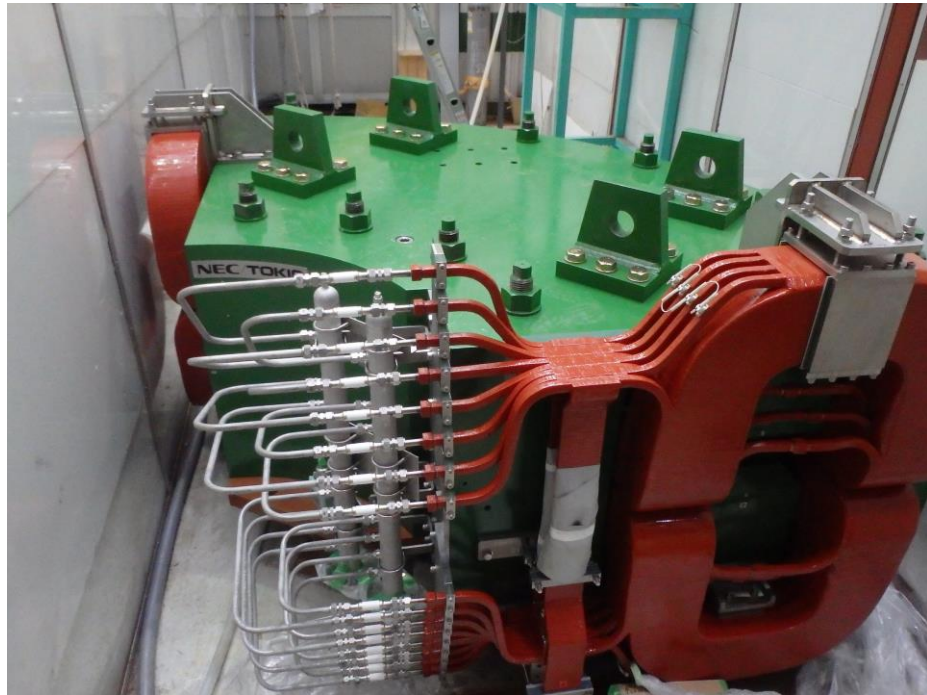
# 現状の実験エリア



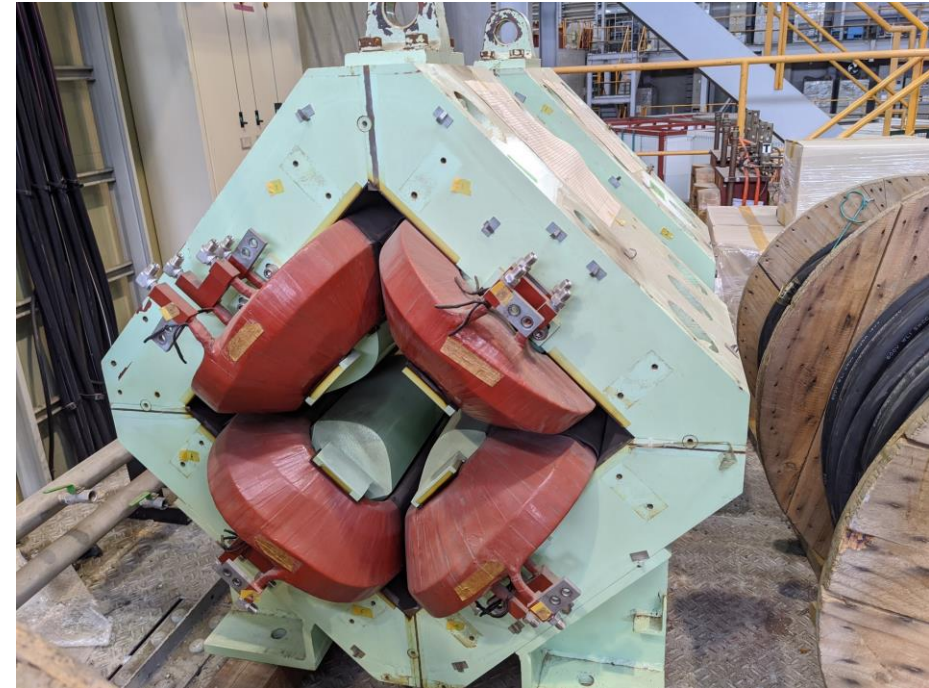
Modify this area as the plan on right side



# Magnets are reserved!



Dipole magnet



Two quadrupole magnets



Need to buy the power supply  
(400kW)



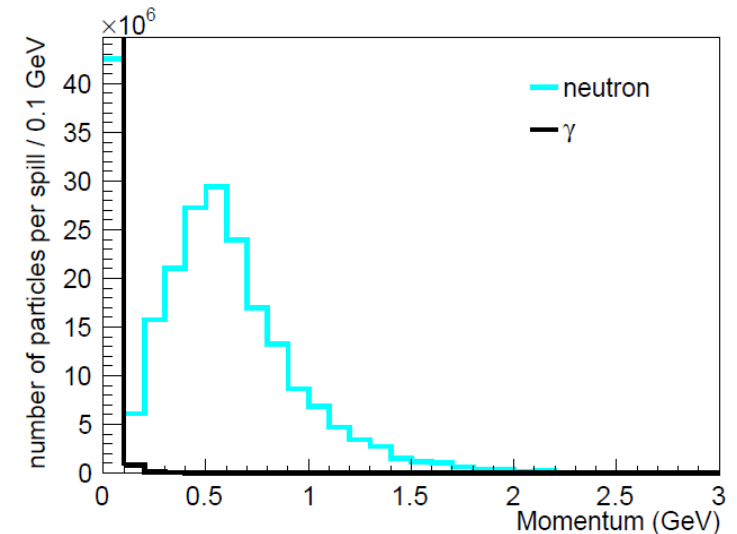
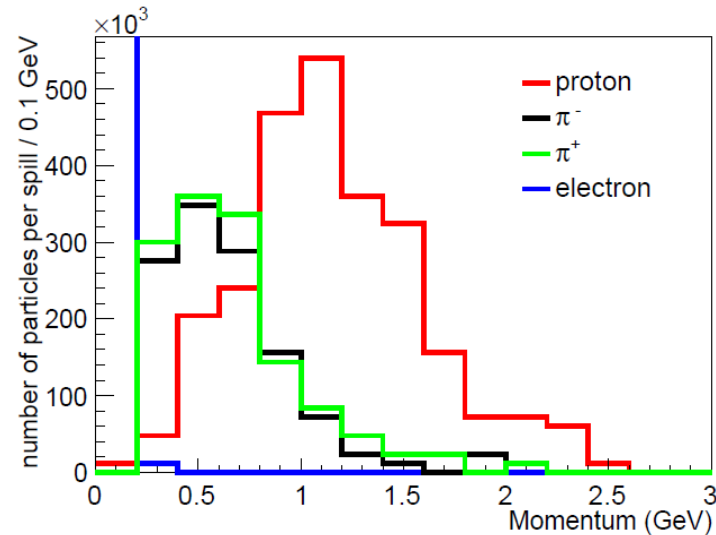
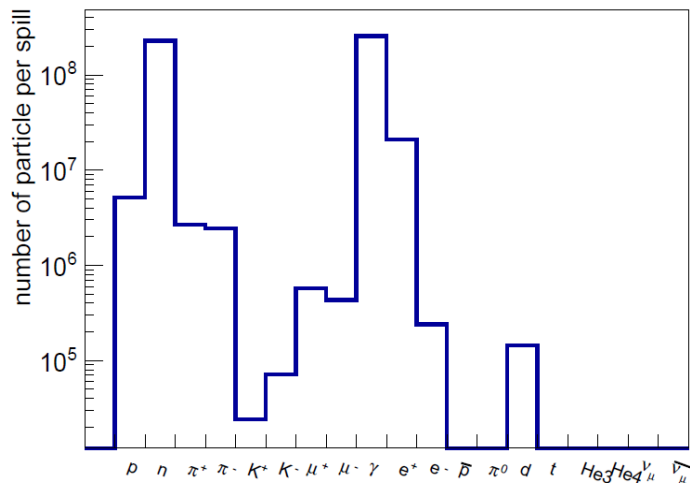
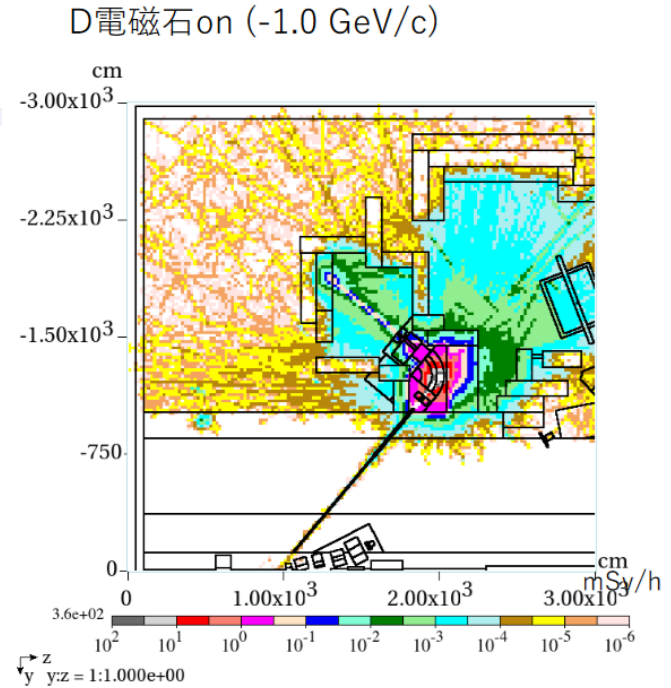
2 x 50kW



# Expected rate at the hadron TBL



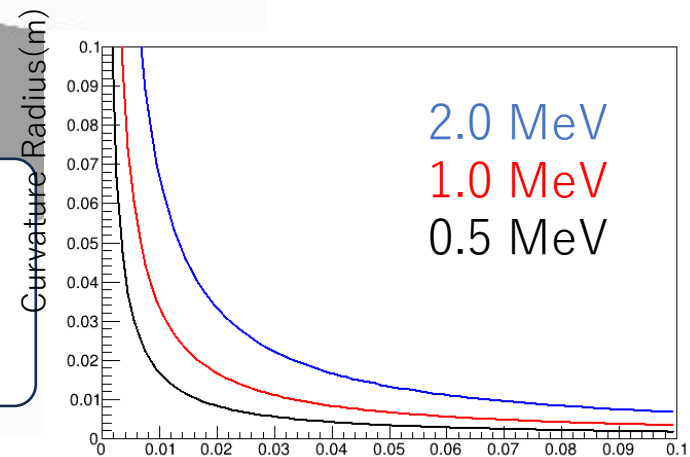
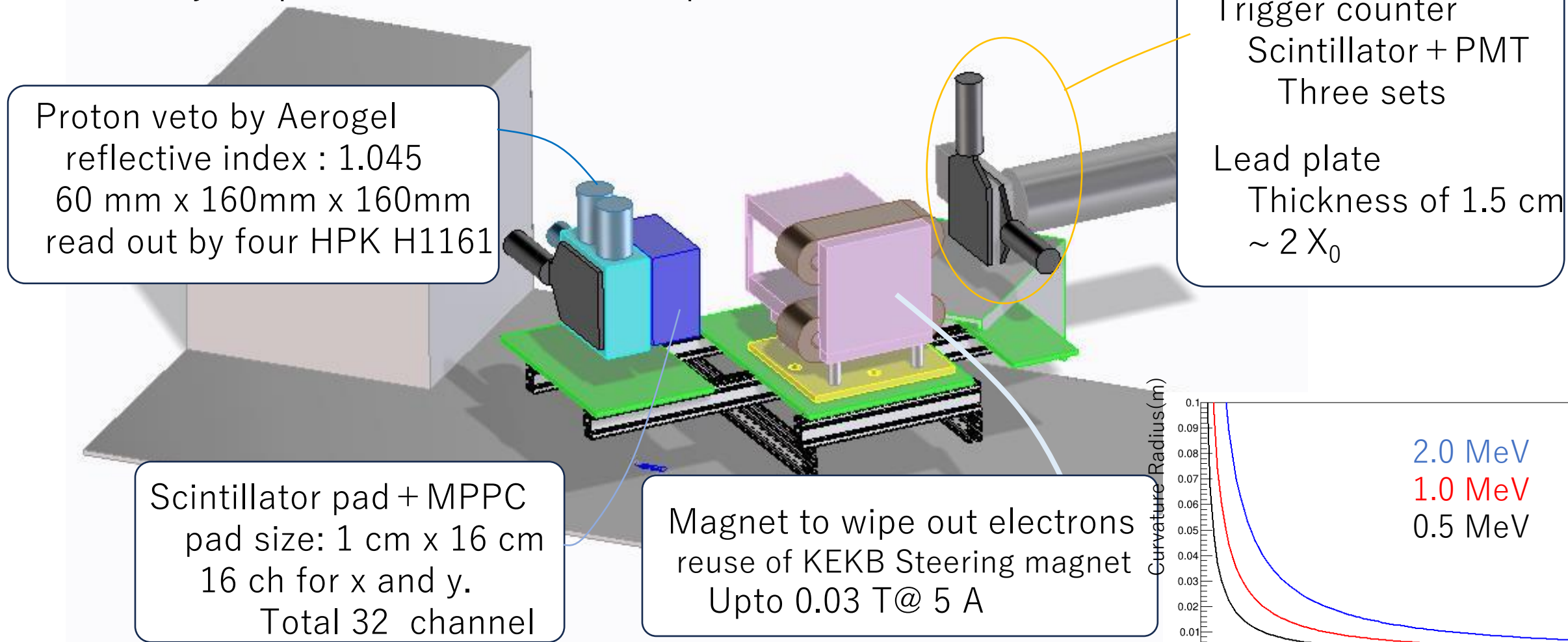
- Simulated by MARS
  - Take into account for Target system and transfer hole
  - Total rate is roughly consistent with simple measurement
    - With Ion chamber including low ET photon and electron.
  - Expected charged pion rate
    - The bin of 0.9-1.0 GeV: 120 k / spill.
      - 1 spill ~ 4 sec
    - Need to confirm by measurement!





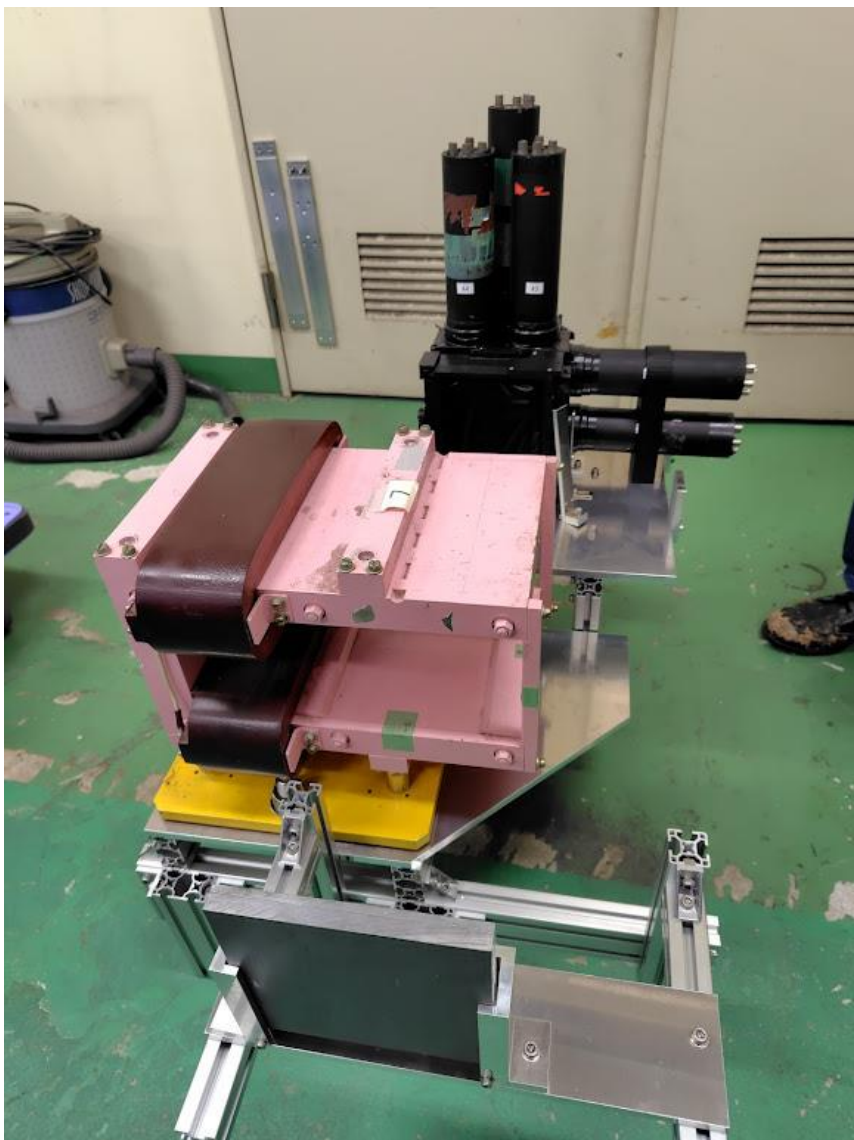
# Setup for the rate measurement

Need to reject photon, electron and proton!

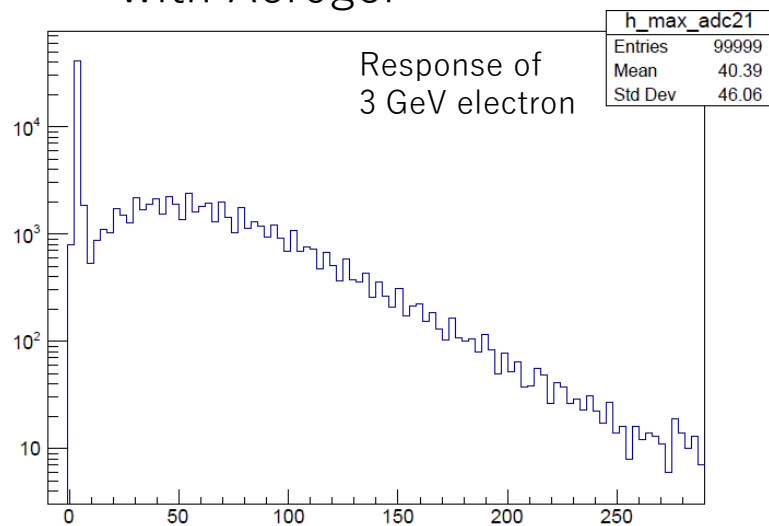


Magnetic field (T)

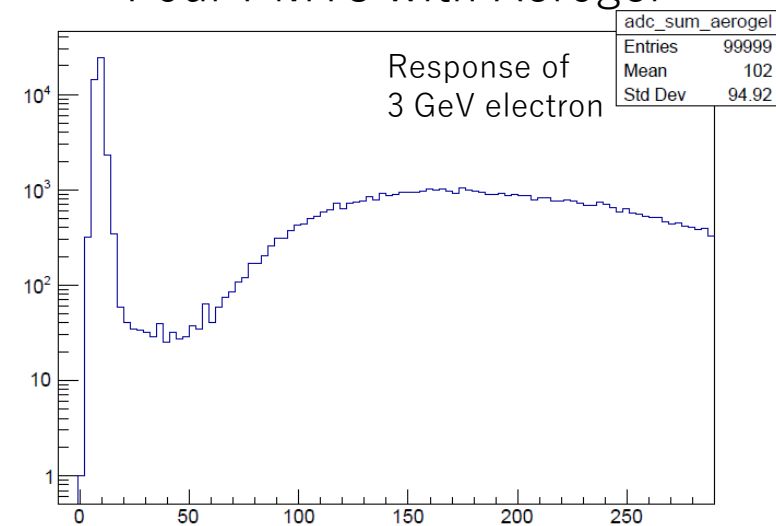
# Status of each component and plan



ADC distribution of PMT  
with Aerogel



Sum of ADC of  
Four PMTs with Aerogel



- Install the setup next week.
- Waiting for the beam.
- Scheduled from 2025 Jan 17<sup>th</sup>

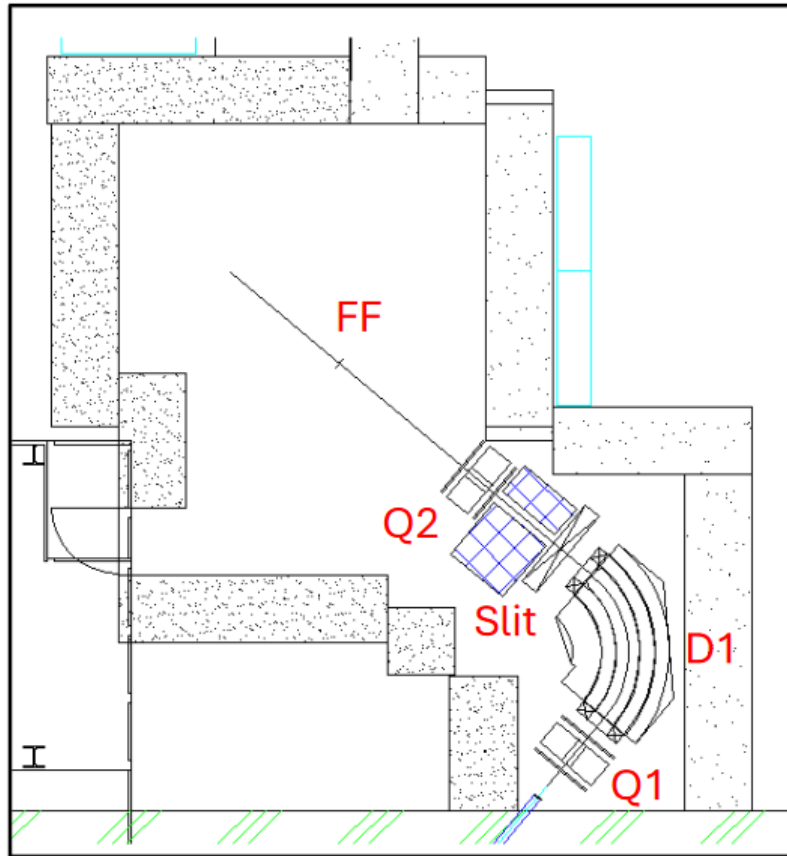
# Summary

- The PF-AR electron test beam line
  - Stably running as scheduled.
  - Plan to make modification on magnet configuration next Summer
    - Rate will be increased by a factor of 1.9
  - Next year schedule: Mar, May-July, Oct-Dec
    - To request beam time, please contact YE ([yuji.enari@cern.ch](mailto:yuji.enari@cern.ch)).
- Plan for a Hadron test beam line
  - KEK J-PARC hadron hall
  - Up to 2 GeV
  - Beam rate measurement will be performed early next year.



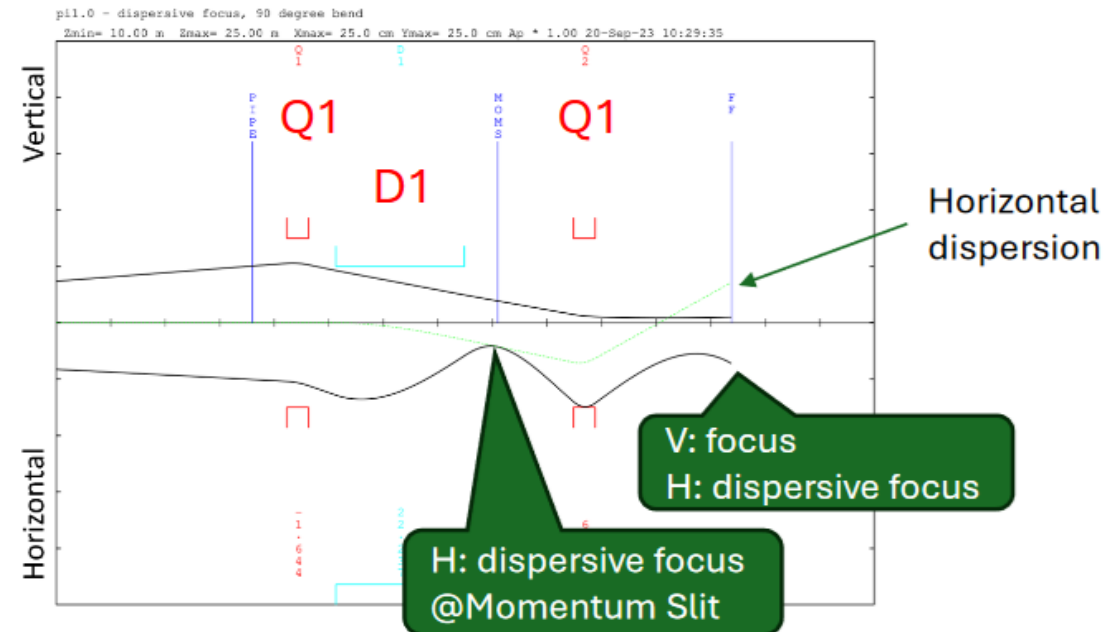
# Plan of the hadron test beam line

改造後のテストビームエリア ( $\pi 1.0$ )



生成標的から  
(Q1入口まで14m)

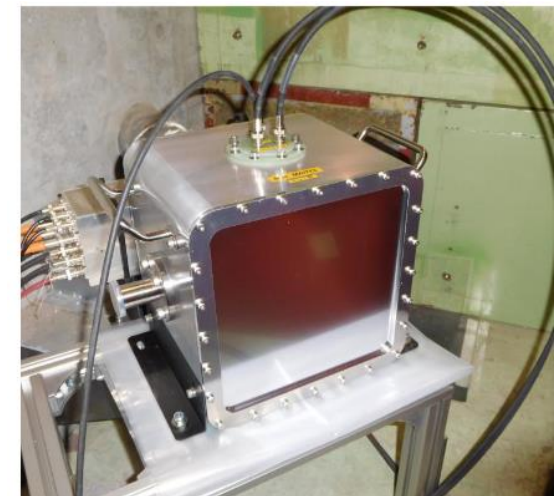
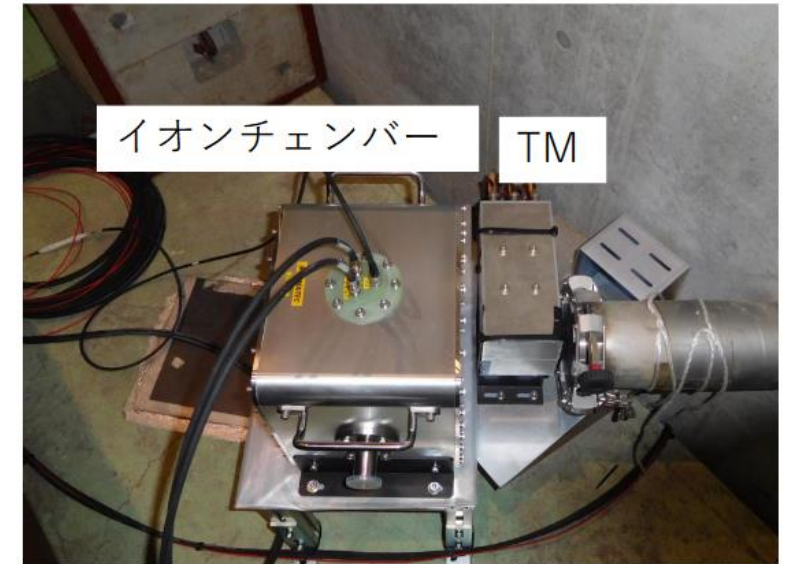
- Dipole and quadrupole configuration
  - Length of beam line 22.4 m
  - Momentum selection
    - Full open slit :  $Dp/p \pm 5\%$ , beam width :  $\pm 15\text{cm}$
    - Slit with 1 cm :  $Dp/p \pm 0.5\%$ , beam width  $\pm 2\text{cm}$



Estimation on the Beam Envelop

# Last measurement on the particle rate

- Target monitor:
  - 1cm × 1cm × 2mm scintillator + PMT
    - 3 hold considnece
  - $5.34 \times 10^{-7}$ sr
  - 90-100 k/spill (2024.6, 82 kW, 4.2 s cycle)
- Ion chamber installed in 2019.
  - 15 cm × 15 cm
  - 22M/spill (50.5kW, 5.2 s cycle)

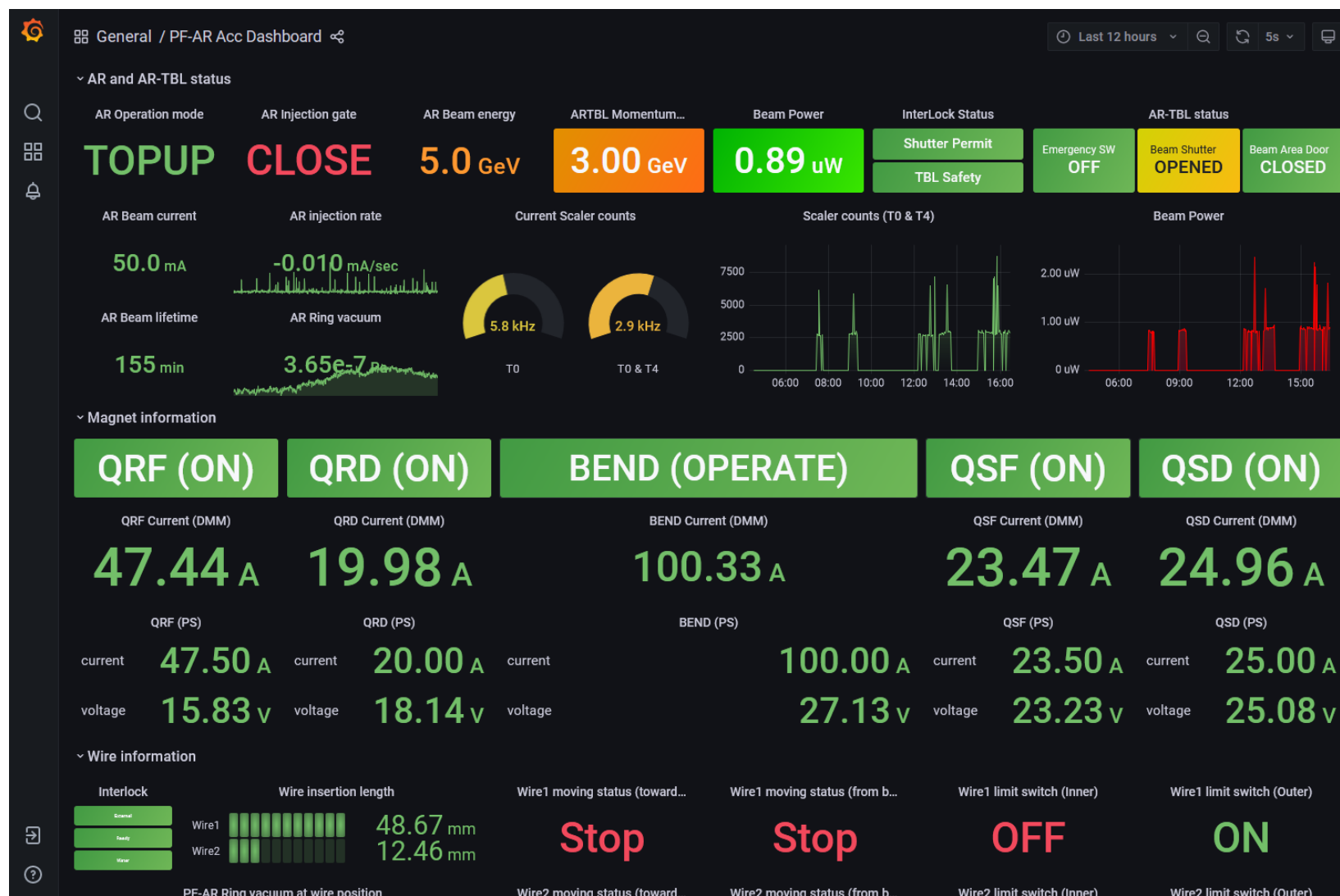


Materials for PF-AR TBL

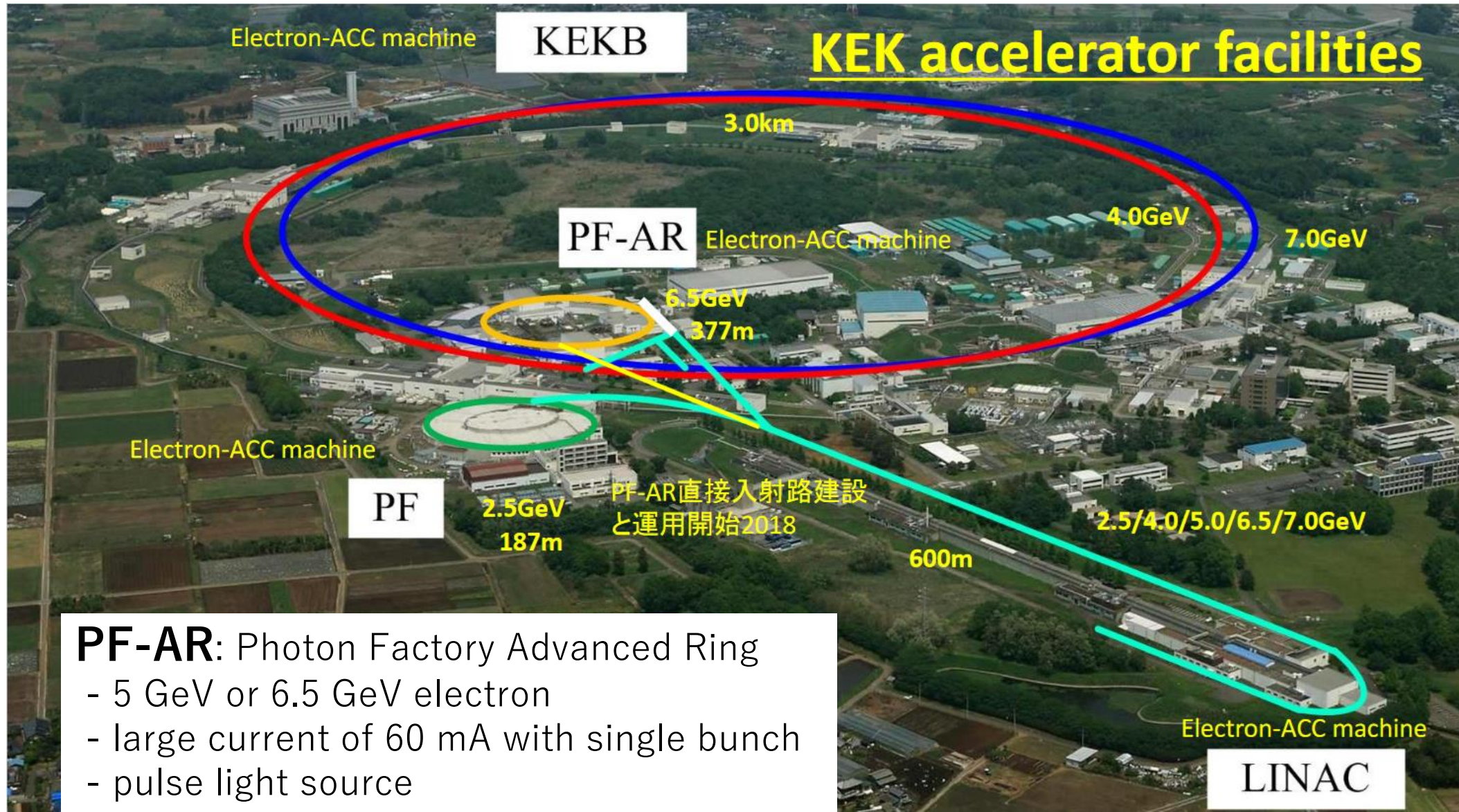


# TBL control and monitoring

- Magnets currents can be changed with script.
  - User can change.
- Shutter is hard switch with inter-rock.
- Graphana is set up for monitoring



# KEK accelerators and PF-AR ring



- PF-AR:** Photon Factory Advanced Ring
- 5 GeV or 6.5 GeV electron
  - large current of 60 mA with single bunch
  - pulse light source



# Tools at TBL

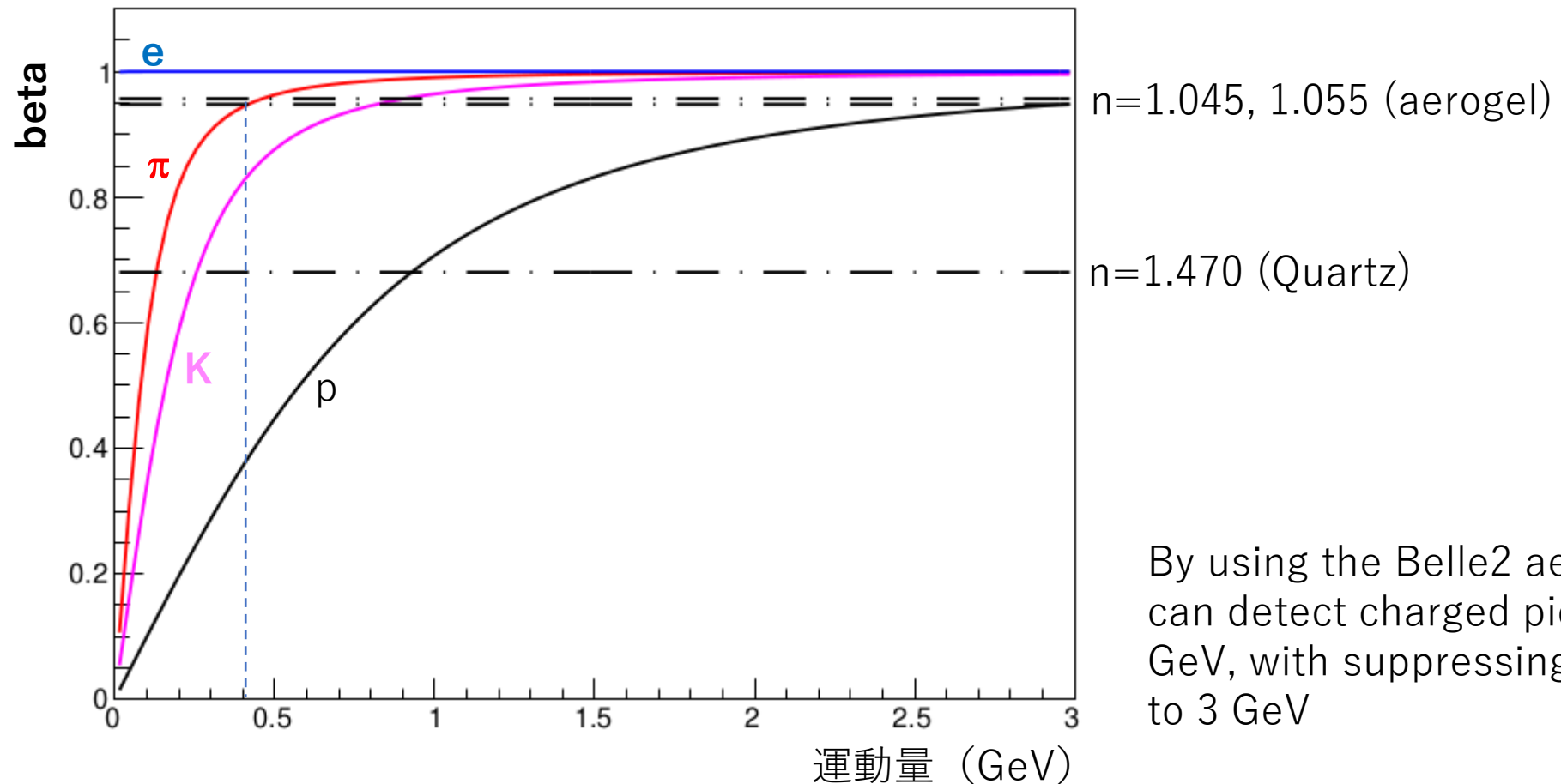
- Trigger, beam clock, veto signals
  - NIM level signals can be provided
    - Injection period may need to be vetoed.
  - NIM create, basic modules, oscilloscope are available.
- Tele-scope is not available
  - May be able to organize to set it up
- There is no common DAQ, no dedicated PCs.
  - User needs to prepare.
- Cooling / any specific infrastructure
  - Need to prepare by user.
- Room for preparation can be provided.
  - In another building (2 min on foot).





# Cherenkov light emission on Aerogel

- $\beta$  and momentum



By using the Belle2 aerogel, we can detect charged pion  $p > \sim 0.5$  GeV, with suppressing proton up to 3 GeV