Introduction of Instrumentation Technology Development Center (ITDC)

Kazunori Hanagaki (KEK)

2024.2.15

from April 2023

KEK

IPNS

Accelerator

IMSS

Applied Research

Collaborative operation of test beam line

QUP

Theory Center

Wako Nuclear Physics Center

Support Grp.

safety

computing

Experiment Grp.

Across groups

Energy Frontier

Belle

Neutrino

Hadron

CMB

μ・n

Collaboration within KEK

Instrumentation Technology Development Center (ITDC)

International Hub for instrumentation development with diversity

- Test beam line → More efficient, faster development
- Training for young researchers

Inter-University Research Devision

seamless cooperation

Electronics

Cryogenics

Mechanics

Cutting Edge Technology Development Devision

Collaborative development of next generation key technologies

- New idea by interdisciplinary communication
- Education by OJT

Researcher Community

Across organizations

- Universities
- Communities for
  - high energy physics
  - nuclear physics
  - cosmic ray

Industry and more wide range of research fields

Across fields

- Solid state physics
- Life science
- Material science
- Accelerator physics

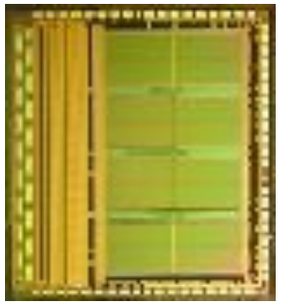
Research Member

	Physicist	Physicist/Engneer	Engneer/Technician
ITDC proper	2→3 (from Apr)		
IPNS/ITDC	5		
Electronics		6	7
Cryogenics		3	7
Mechanics			5→6 (from Apr)

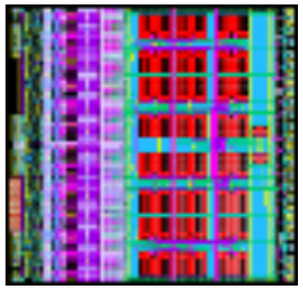
◉ It's still evolving…

Electronics, Cryogenics, and Mechanics group
~Supporting various IPNS projects~

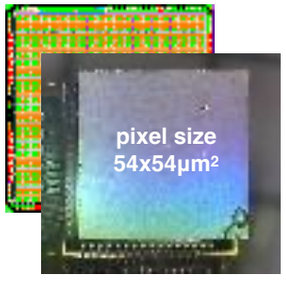
◉ Electronics group



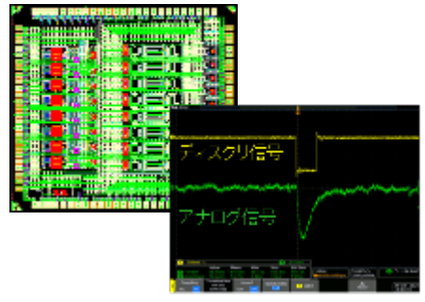
Belle II SVD upgrade ASIC @2020



J-PARC g-2/EDM 128ch ASIC @2020



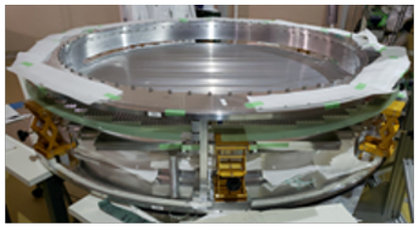
COMET muon monitor @2021



Digitizer for Belle II Drift Chamber

◉ Cryogenics group constructs and/or supports operation of
- Belle solenoid
- COMET and neutrino beam line magnets
- Dilution refrigerator

◉ Mechanics group contributions to
- Belle II vertex detector
- COMET shields and calorimeter
- g-2/EDM silicon detector design

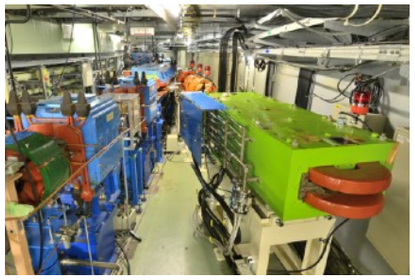


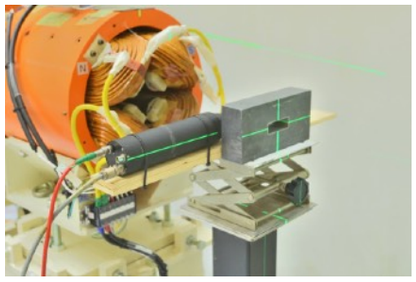
Instrumentation Technology Development Center

International Hub for instrumentation development
Promotion of Innovation and Young researches

Inter-University Research

- **Extension of inter-university research functions**
- More efficient and faster development

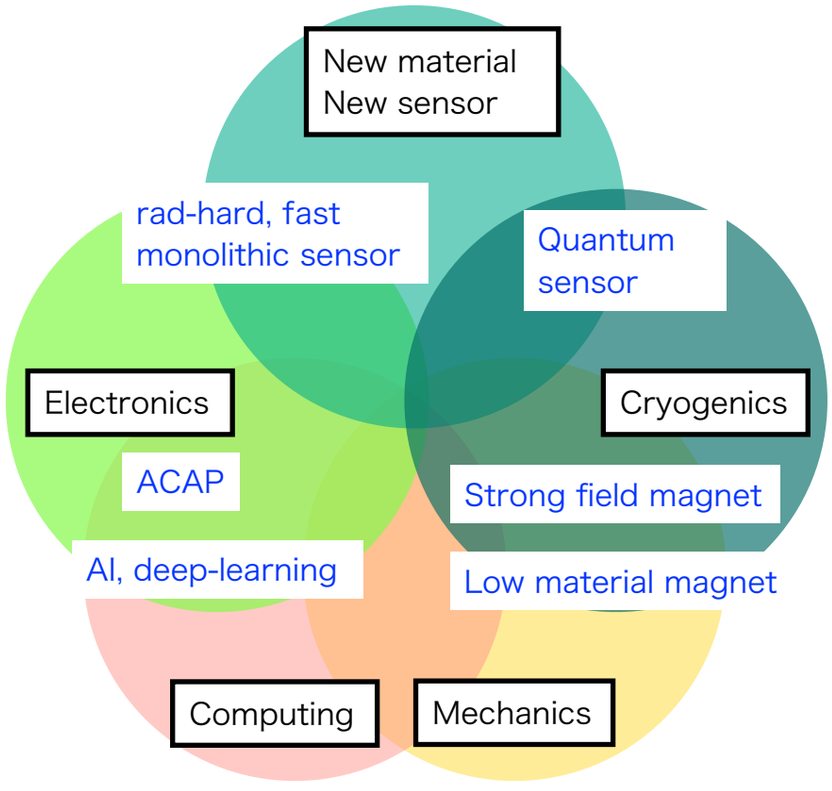




- Wider users by simpler system for use
  → Young researchers such as student can easily use
  → Education

Cutting Edge Technology Development

- **Continue to support IPNS project in both development and operation**
- **Support bottom-up research : some R&D platforms**
  - works also as the interface to the community
- **Common/Core technologies for next generation projects led by ITDC**
  - **Cryogenics and superconducting technology**
  - **Monolithic semiconductor pixel sensor**



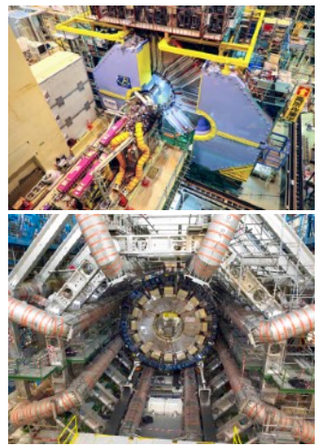
Technology Development Platforms

- Cryogenics
- Mechanics
- Sensor
  - Light sensor
  - semiconductor
  - gas & active medium
- Electronics
  - System integration
  - Collider Electronics
- SPADI alliance
- Computing

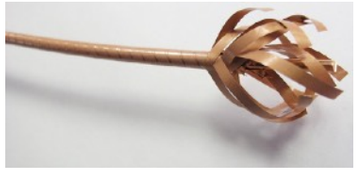
Platform Organization flexible, always ready to start new one

Researcher Community

IPNS projects



KEK projects

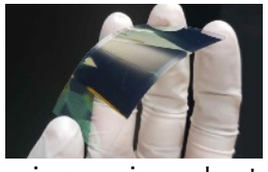


REBCO for HL-LHC

Education

HEP school

Industry



organic semiconductor

ITDC Roadmap

time

Sensor

Electronics

Cryogenics

Mechanics

Rad-hard new material sensor

Rad-hard CMOS MAPS

Fast sensor LGAD

ATLAS group

CMOS MAPS

Belle

High speed
CMOS MAPS

High speed elec.
BiCMOS

High speed data transmission, ASIC, FPGA

Elec. under low temperature

Cryogenics towards quantum computer

Super low temperature cryogenics

Low material superconducting magnet

cooperation

Cryogenics
Science Center

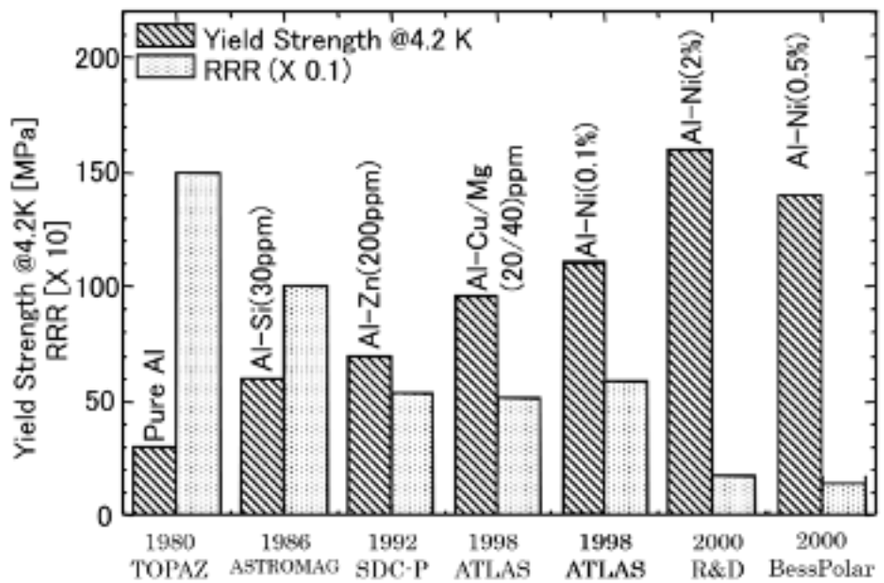
Superconducting material research,
High field superconducting magnet

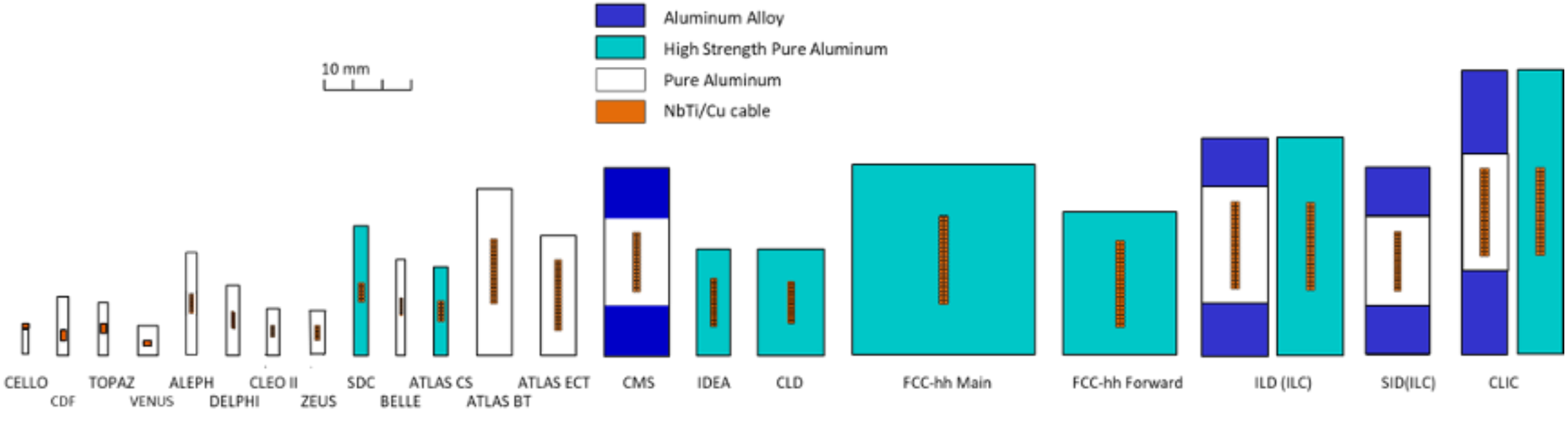
Operation of test beam line,

Construction of hadron test
beam line

Revival of Al stabilized NbTi superconductor

- Al stabilized superconductor is critical to construct detector solenoid due to its transparency to particles
- Lack of industrial provider will cause serious trouble in next generation projects
- Started cooperative work with CERN to revive this technology
  - We have expertise with strong industrial partnership
- Can be applied to cutting-edge new material superconductor instead of NbTi

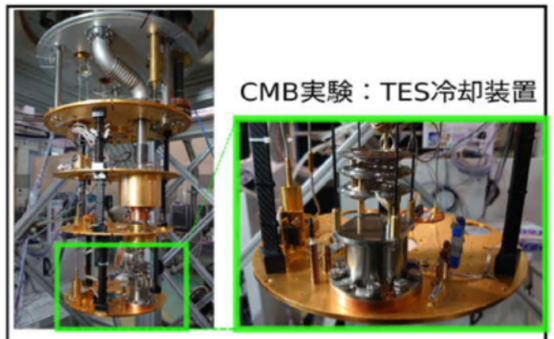




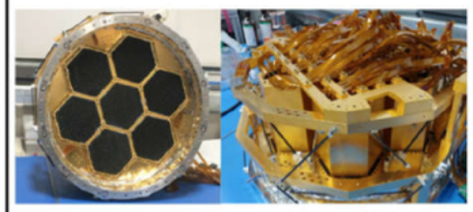
KEK Cryogenics Experience

3He ＋（4He）　　**4He**（superfluid, normal）

No experinece (~ 100mK)　　**Experience including maintenance and operation（0.3 K ~ 5K）**

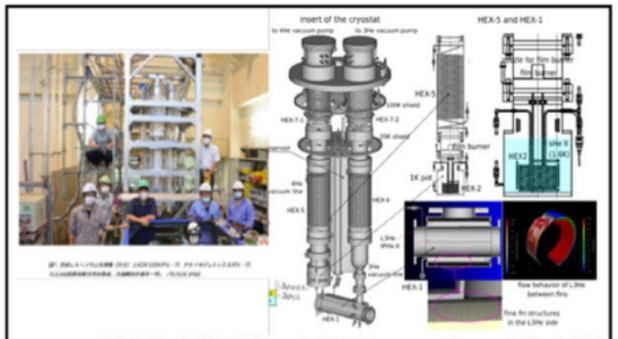


■偏極標的冷却（大学と共同）
100mK, 2000uW,
希釈冷凍機　2021- 現在開発中
■LiteBIRD実験　現在開発中
■CMB実験：Al-Mn TES冷却装置

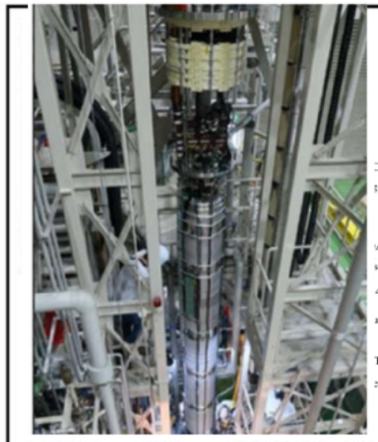


POLARBEAR-2 レシーバー
超伝導検出器・大型低温光学系

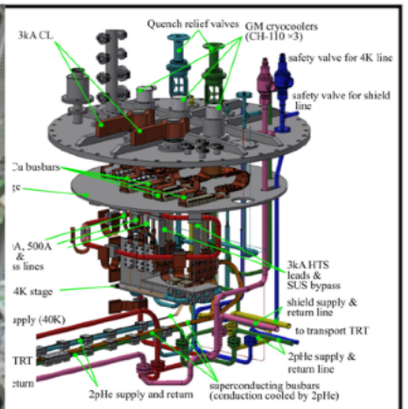
ソープション冷凍機システム
300mK, 200uW
ソープション冷凍機
ボロメーター冷却装置
2012-2014製作終了



UCN（超冷中性子）実験用ヘリウム3冷凍機
＊0.8K, 10W
＊この温度領域で世界最大
2017-2020 製作～冷却試験終了
カナダ（TRIUMF）へ輸送済



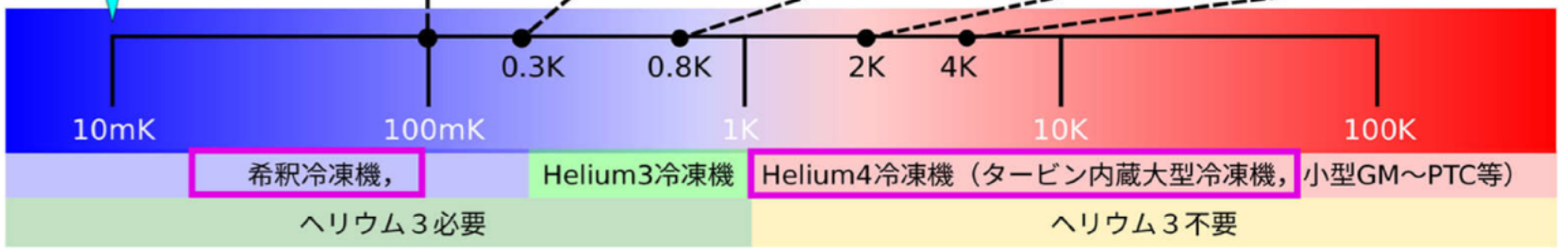
LHCアップグレード超伝導電磁石
冷却装置
1.8K-2K 加圧超流動ヘリウム

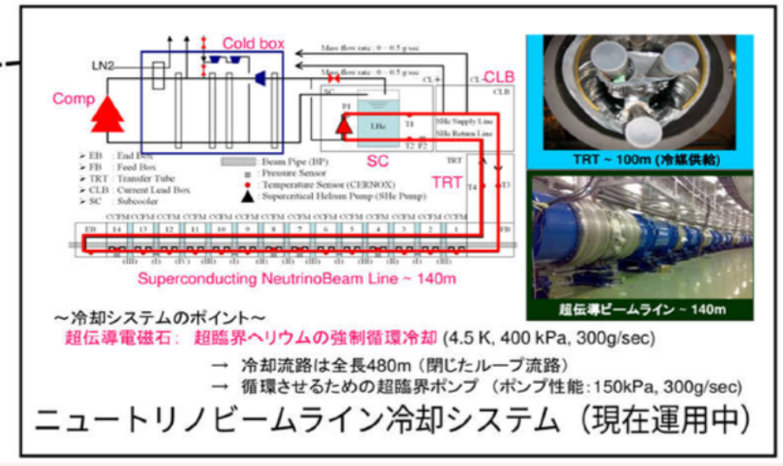


・ COMET用CLB（KEK設計）

冷却系付帯設備
CLB

量子コンピューター冷却





ニュートリノビームライン冷却システム（現在運用中）

実績　極低温～100mKに至るまでの冷却システムを多数構築

- Large load due to beam
  → not only refrigerator but also associated cooling system is needed

Facility
- Large scale cooling system
- Infrastructure especially He available widely

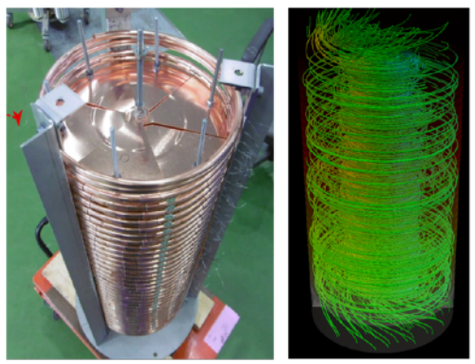
Ultra Low Temperature Cryogenics

A. Technology Development for below 1K

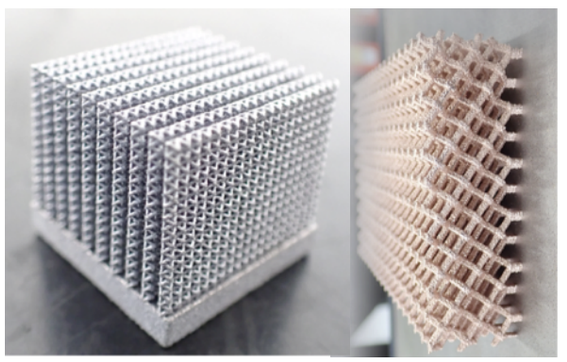
He³ Refrigerator, Enlarge capacity of dilution refrigerator大容量化

Goal

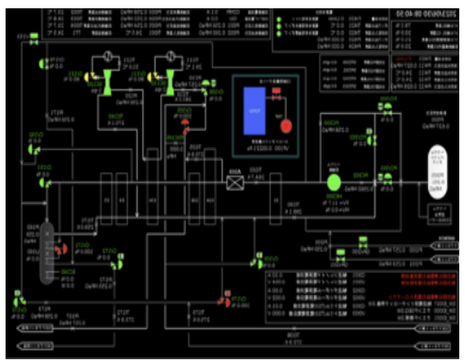
P1. 2mW@100mK
P2. Distributing technology



HEX development



金属積層造形技術の適用



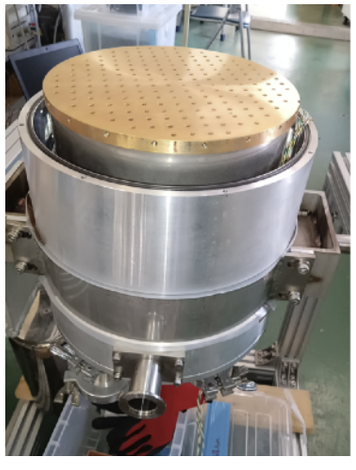
Automatic control

- Maximize refrigerator performance
- Accumulate expertise/technology applicable to particle physics experiment using cryogenics
- Maintenance and Operation of refrigerator

→ Higher expertise, cost reduction

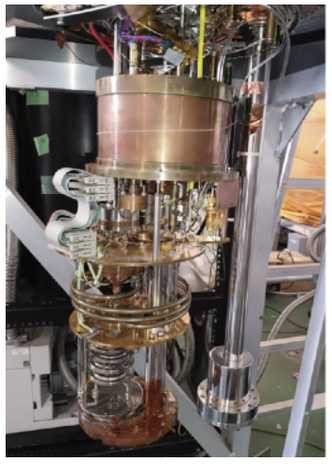
B. Support of low temperature detector development

- **Lequid Nitrogen temperature ~ 4k**
- **detector cooling technology**



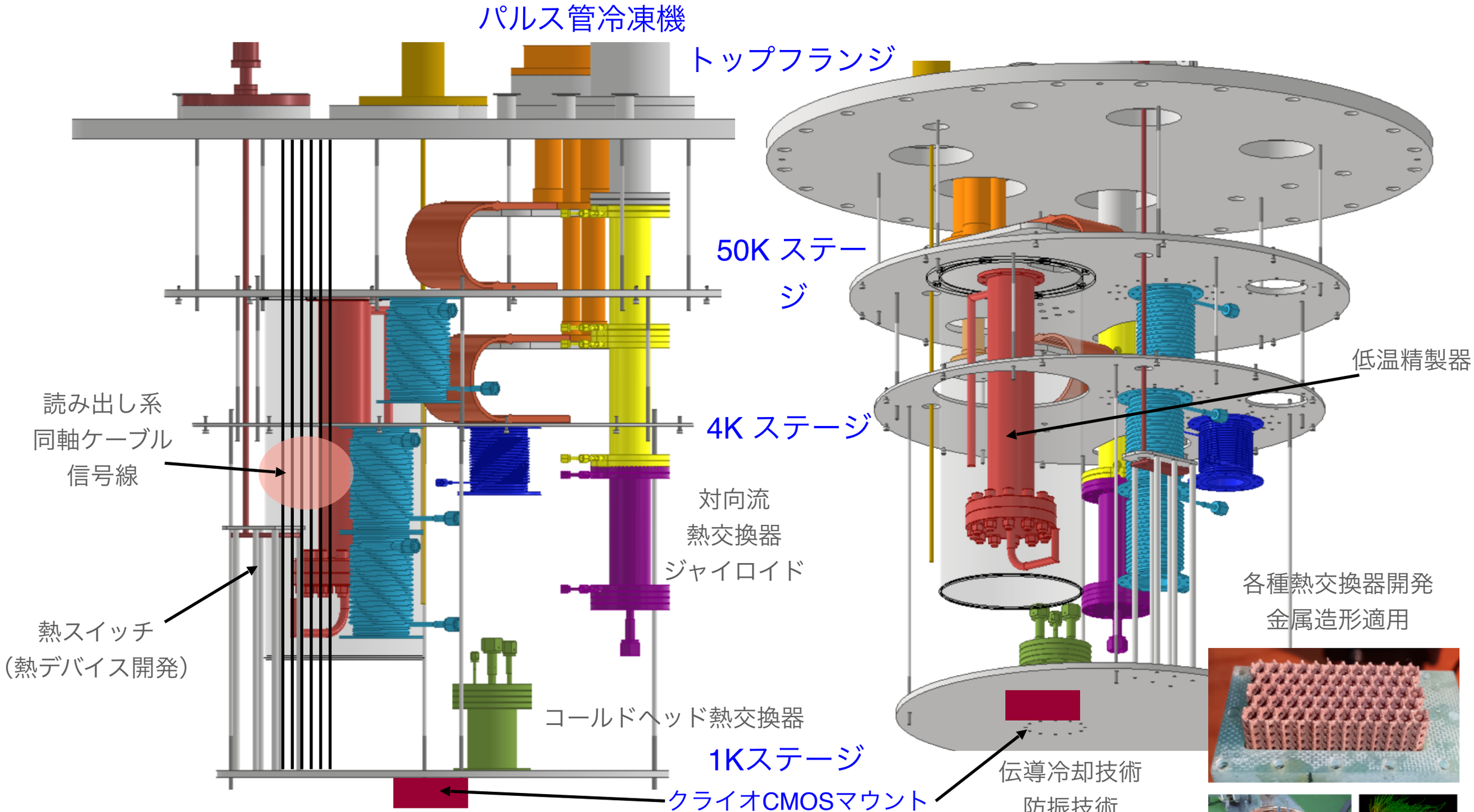
existing equipment→

1.5K-4K cooling system



Dilution refrigerator

1K 冷凍機設計状況（設計中）



希釈冷凍機の要素技術と共通　（3Heはないが・・）

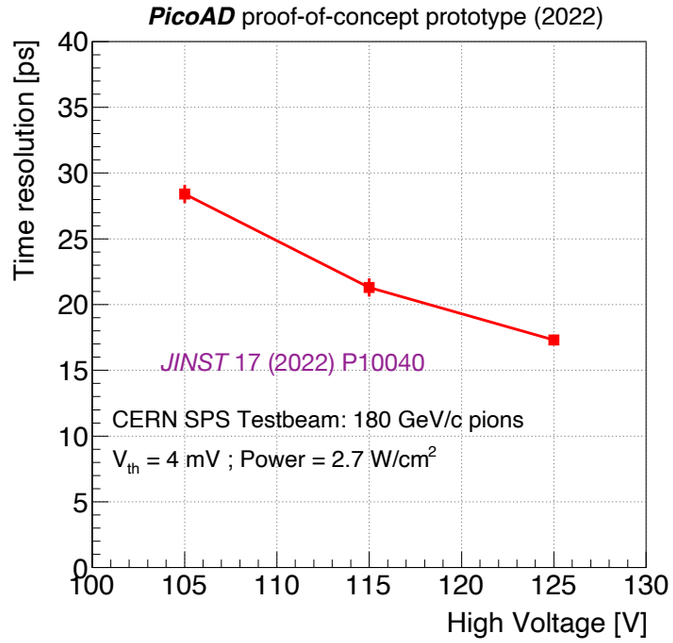
- チャレンジ：4Heでサブケルビンを目指す
  → 頑張れば、4Heで0.5 Kが出せる (@ 冷凍能力 mW）。
  原理：量子渦を使ったボルテックスクーラー　＋　循環系強化
- 超低温技術：金属3D造形熱交換器、防振、精製器、熱スイッチ等熱デバイス開発
- 測定器開発：クライオCMOSを実装した測定器開発。素子・読み出し系との共存（次頁）

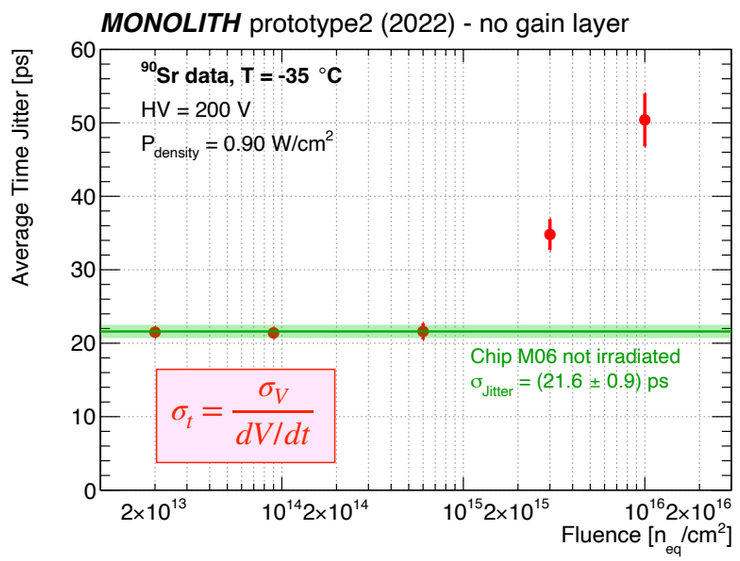
CMOS MAPS

- Belle group
  - Started collaboration with Strasbourg
    - TJ Monopix2 testing
    - OBELIX
  - ITDC ASIC designer joined this activity
    - Strong interest in 65nm technology

- Energy Frontier group
  - CERN MALTA ?
  - Geneva SiGe
    - Evaluation of radiation hardness

- Main target is future collider
  - ECFA DRD3
  - Always open to other application

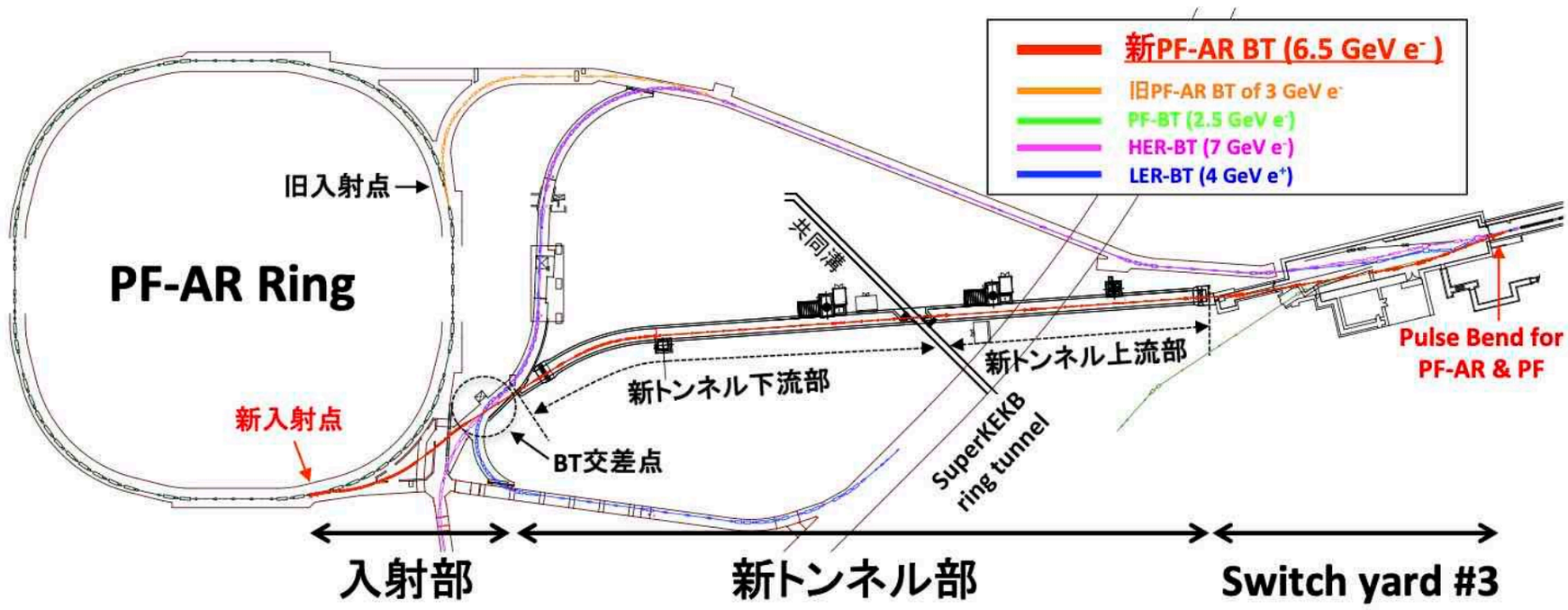




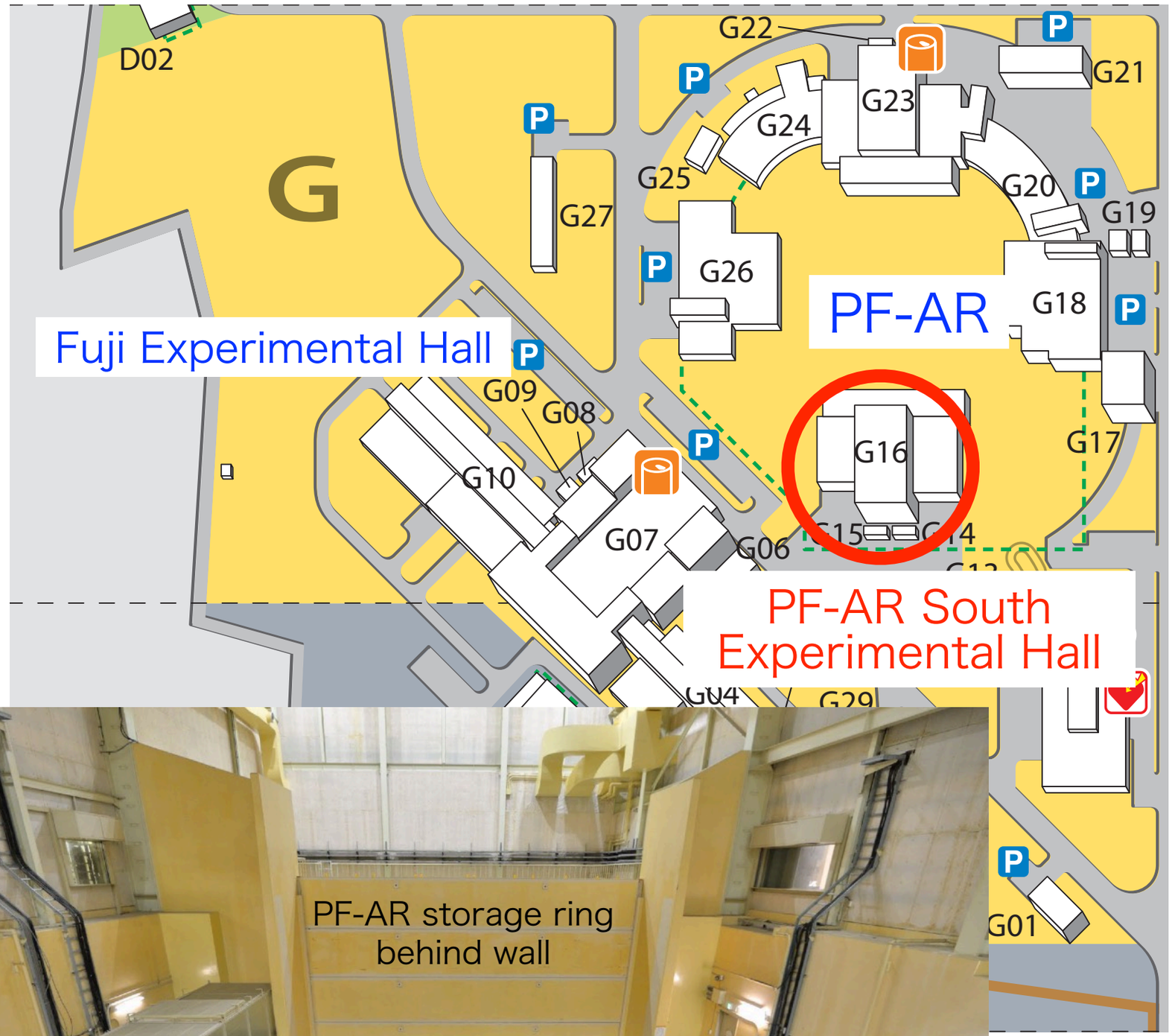
Test beam line

PF-AR

- One of the synchrotoron photon source operated by Photon Factor Facility in IMSS
  - PF　2.5GeV
  - Photon Factory Advanced Ring (PF-AR)
    6.5GeV or 5GeV electron beam as a light source
- Single bunch beam with its revolution frequency of 1.257 μs
- Beam current ~50mA
- Top-up injection is possible



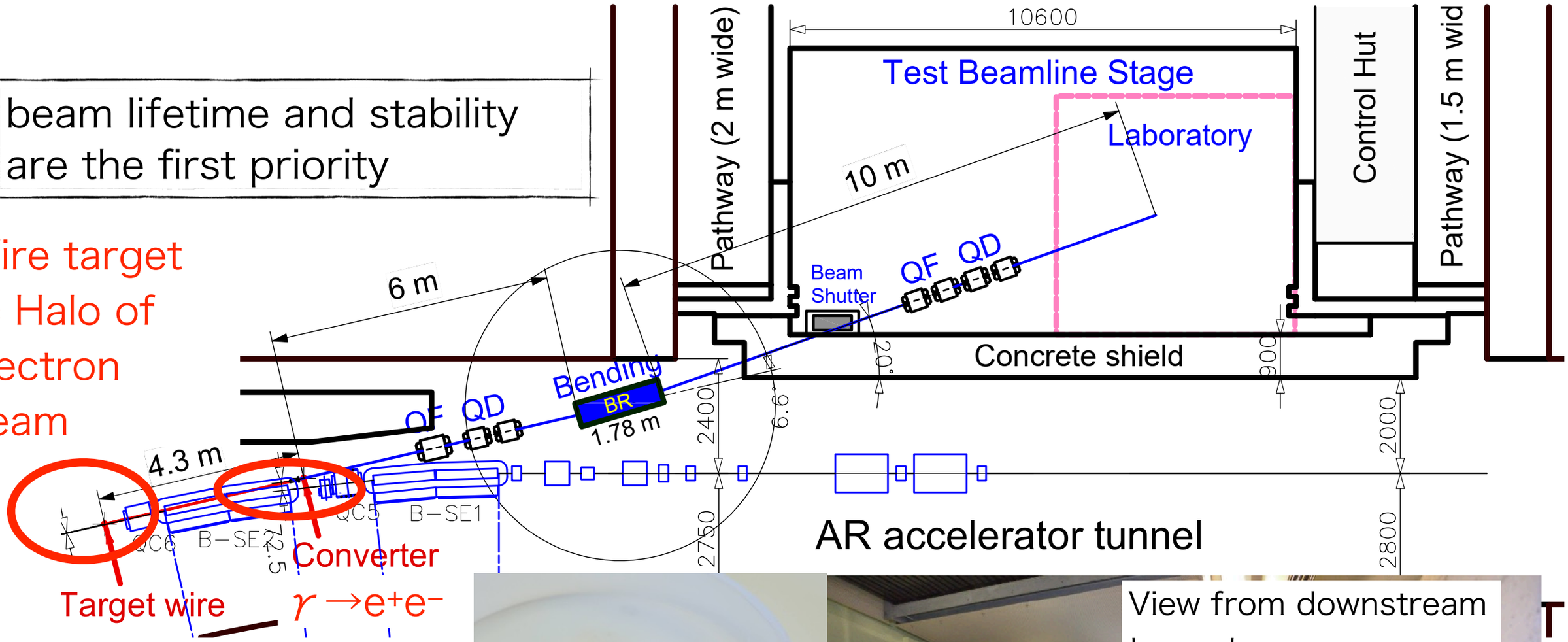
Test Beam Line at PF-AR

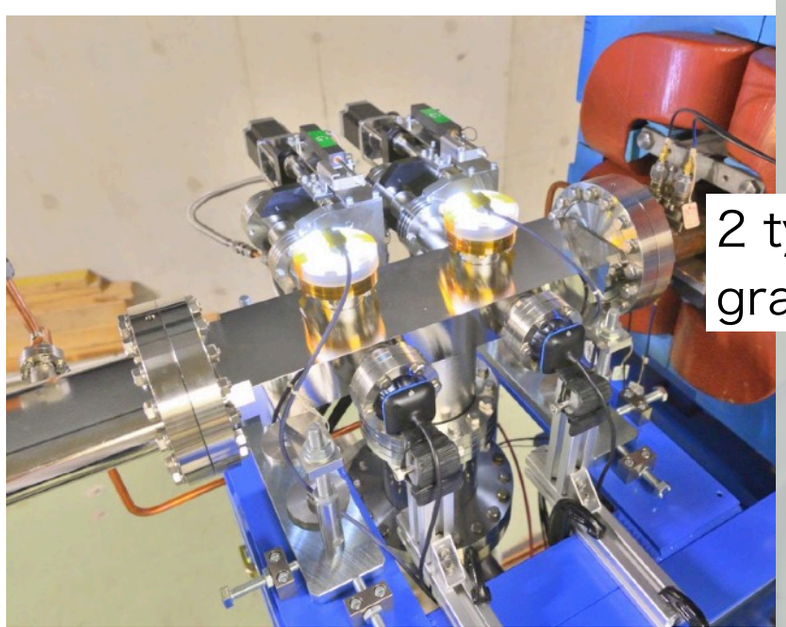


Overview of test beam line

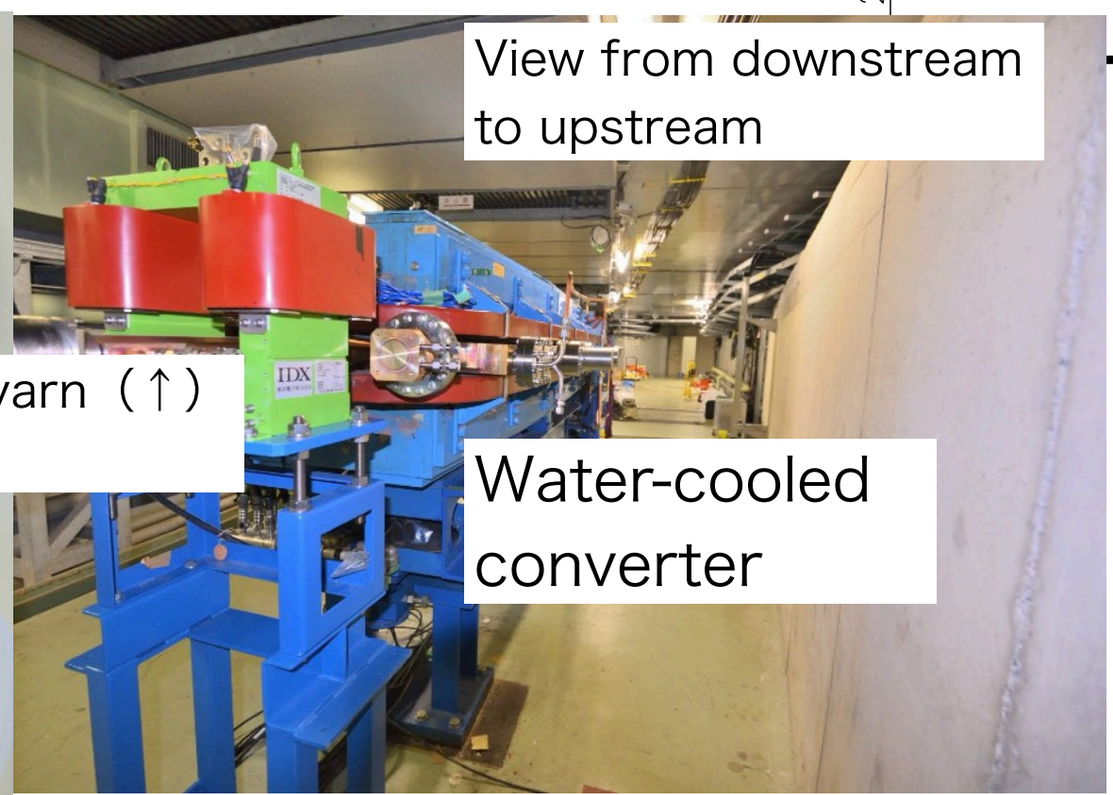
beam lifetime and stability
are the first priority

Wire target
to Halo of
electron
beam





2 types of target : CNT yarn（↑）
graphite sheet（↓）



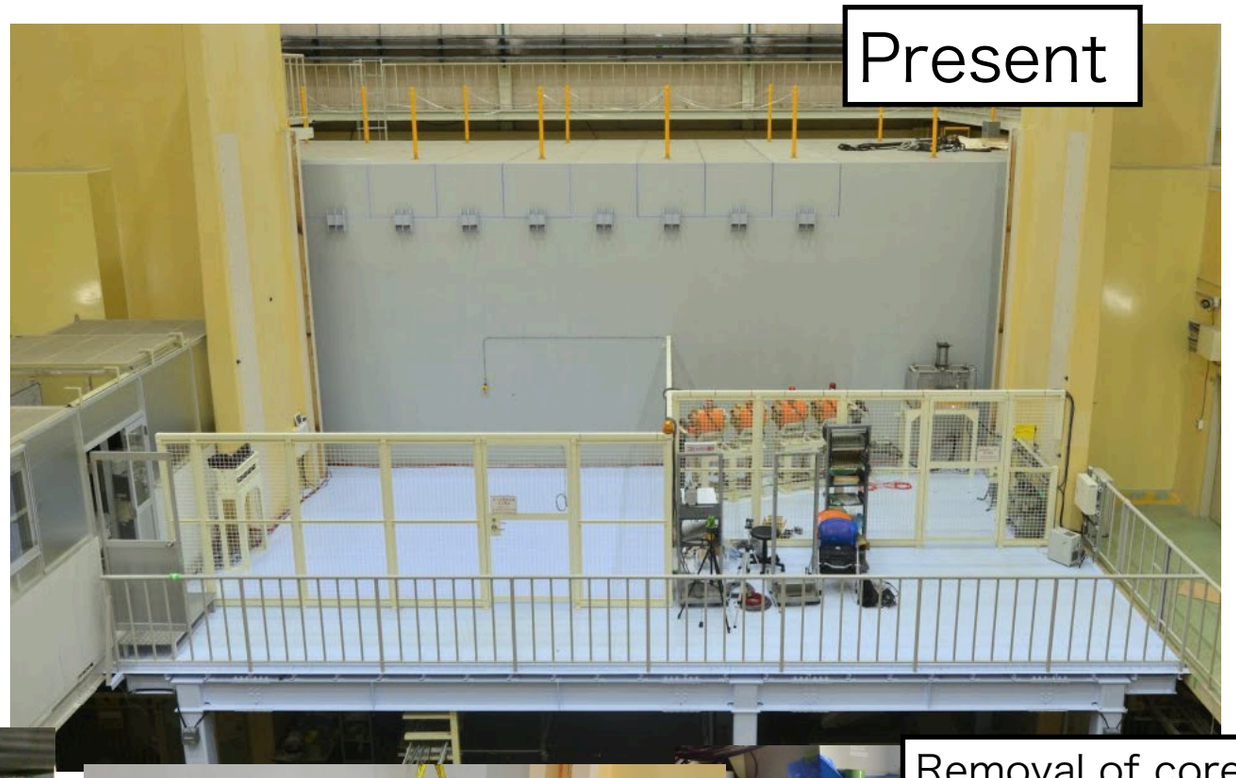
View from downstream
to upstream

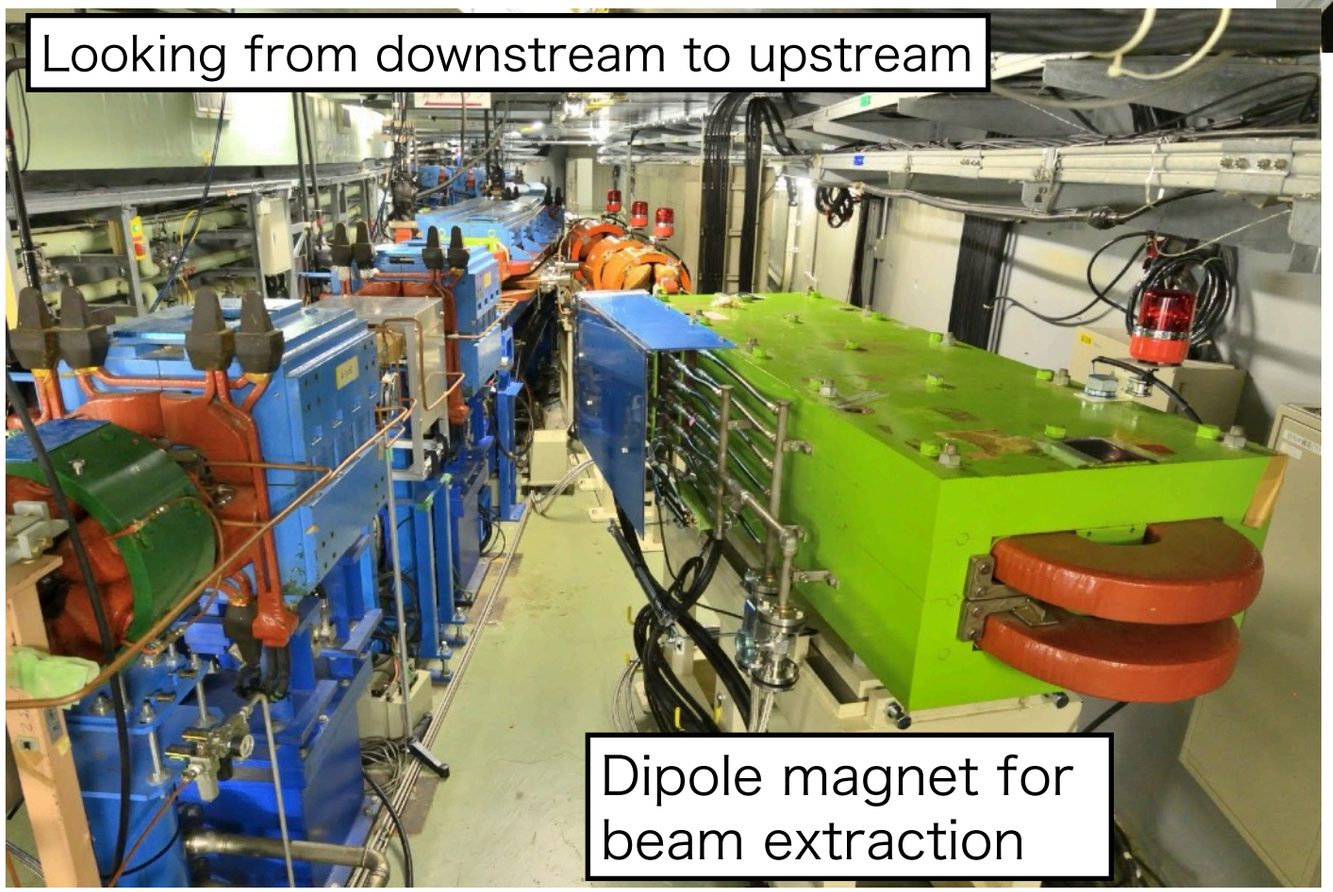
Water-cooled
converter

Construction scene


beam line scribing


Transfer and installation of dipole magnet

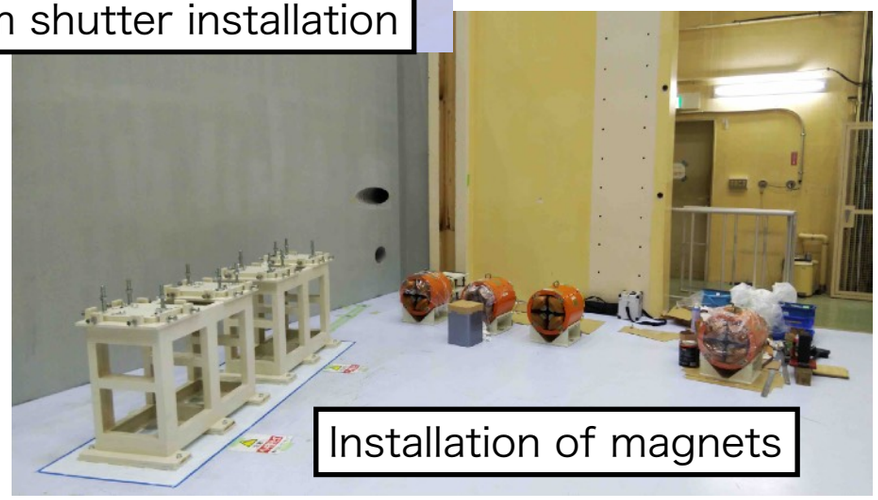

Present


Looking from downstream to upstream

Dipole magnet for beam extraction

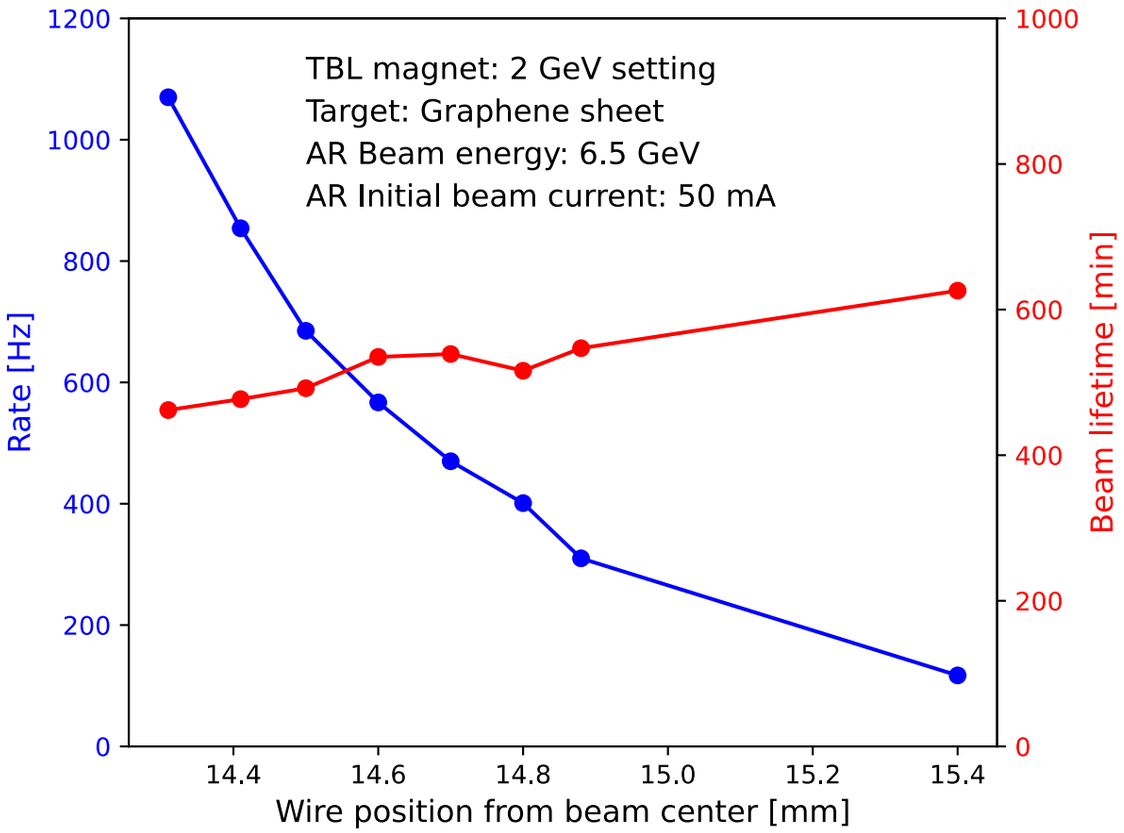

Beam shutter installation

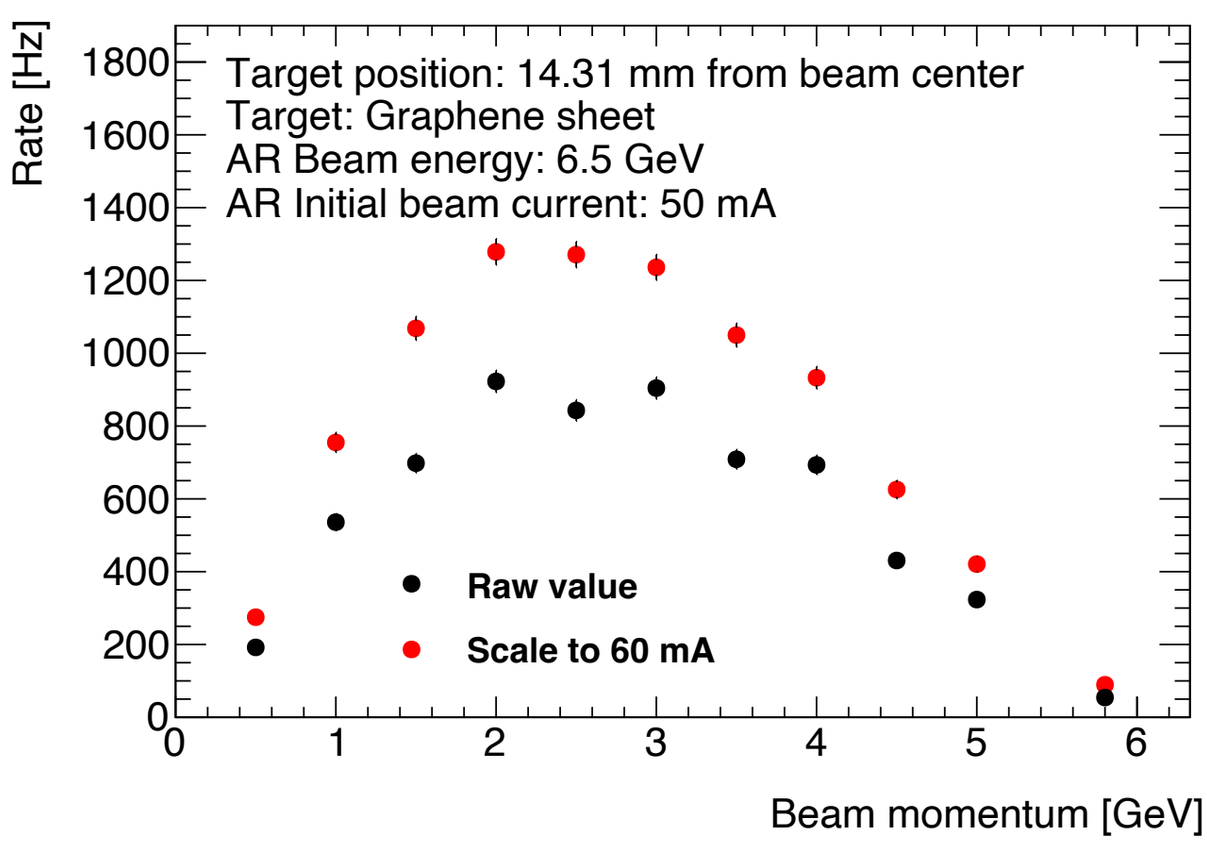

Removal of core

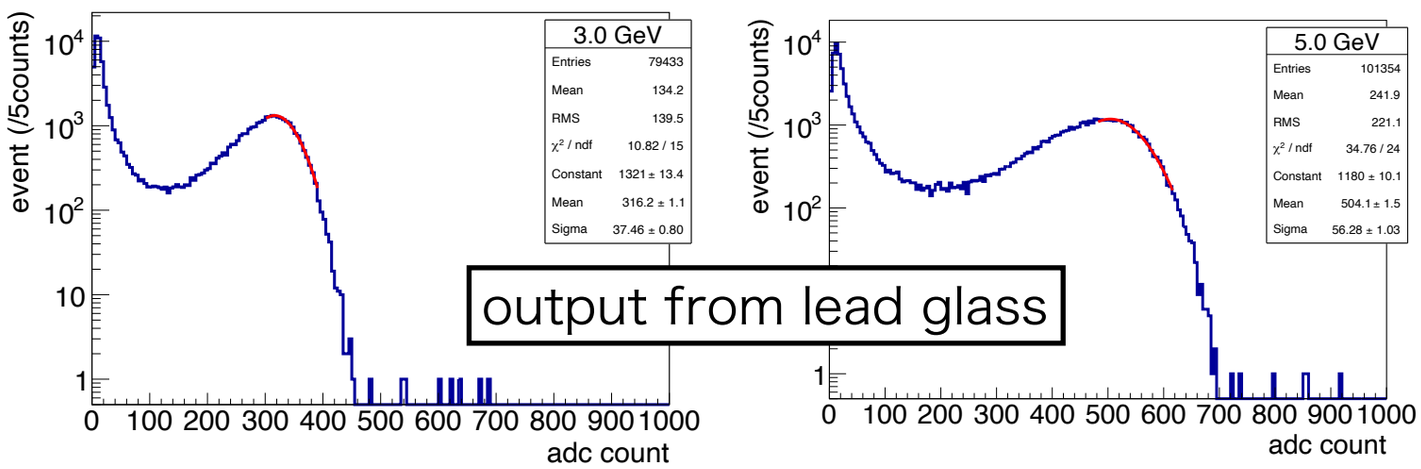

Installation of magnets

First Beam Extraction on March 2022

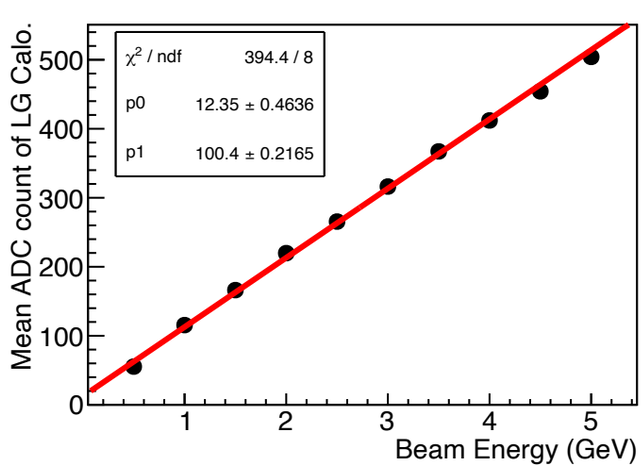
- Rate measurement by scintillators plus PMT's
  - Strongly depends on how deep we can insert target
    ← subject of negotiation with Photon Factory







output from lead glass



Start of Test Use

- Despite of still we are in beam commissioning, test use started on November 2022
- Official use started in 2023