

E21: COMET

the 39th J-PARC PAC Meeting

KEK / J-PARC
Yoshinori Fukao
for the COMET Collaboration

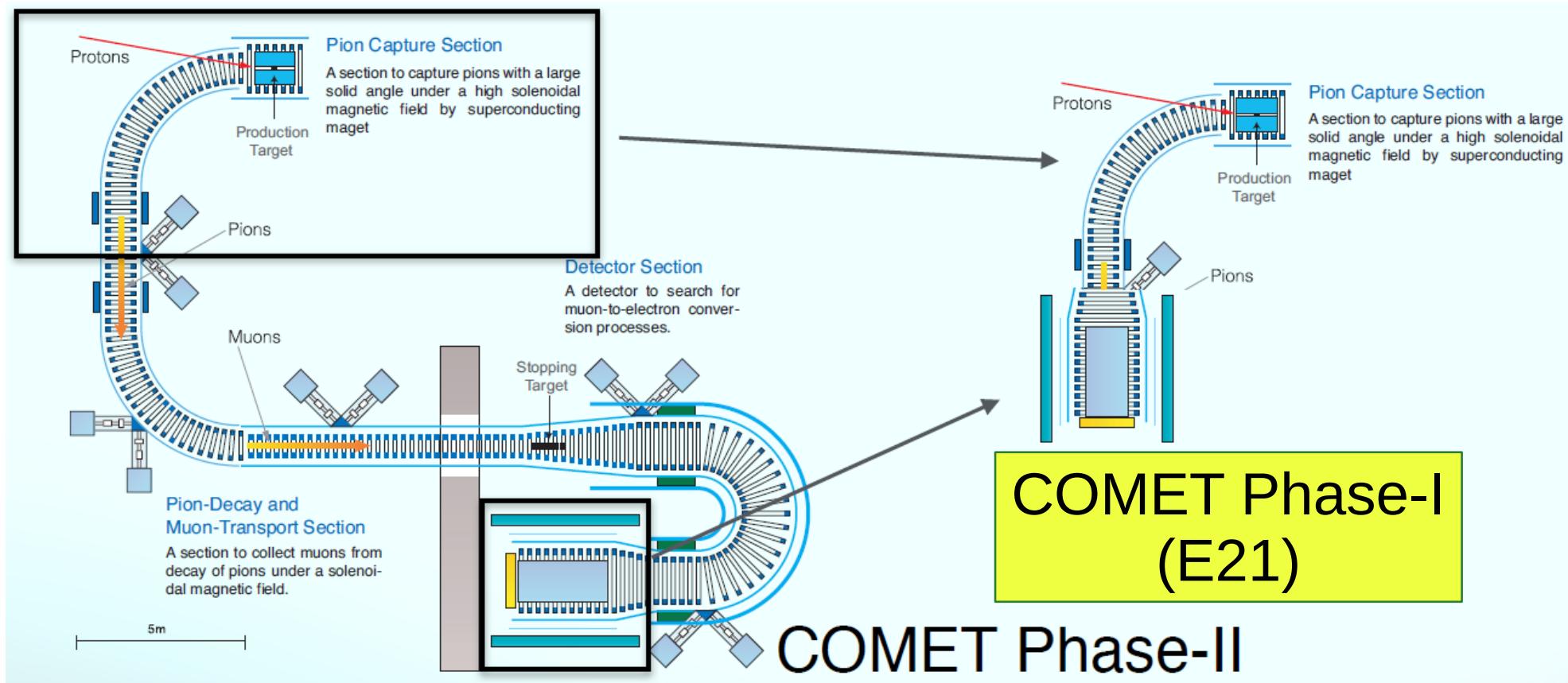
μ
COMET

e

Pion Capture Solenoid Shows Up at J-PARC !!



Introduction

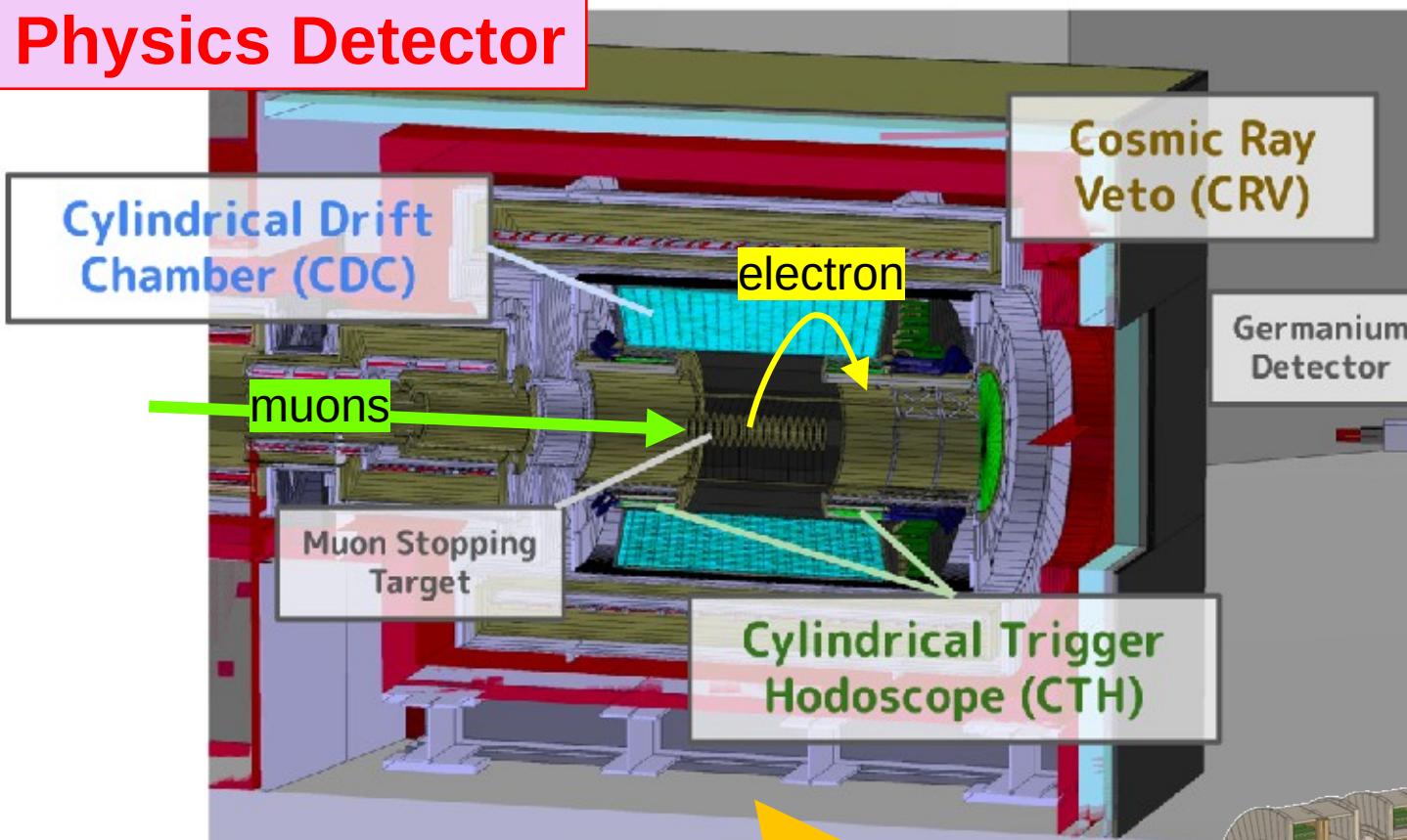


	Sensitivity	Beam Power	
Phase-I LI (*)	3×10^{-13}	0.32kW	E21
Phase-I	3×10^{-15}	3.2kW	
Phase-II	$< 10^{-16}$	56kW	

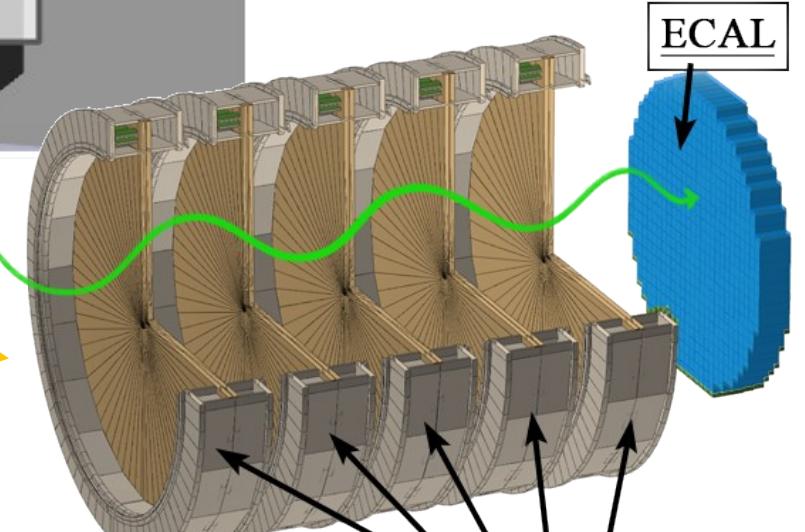
(*) For the earliest start of the physics data taking with minimum radiation shield, then upgrade to increase the beam power.

COMET Detector System

Physics Detector



Exchange
Inner Detectors



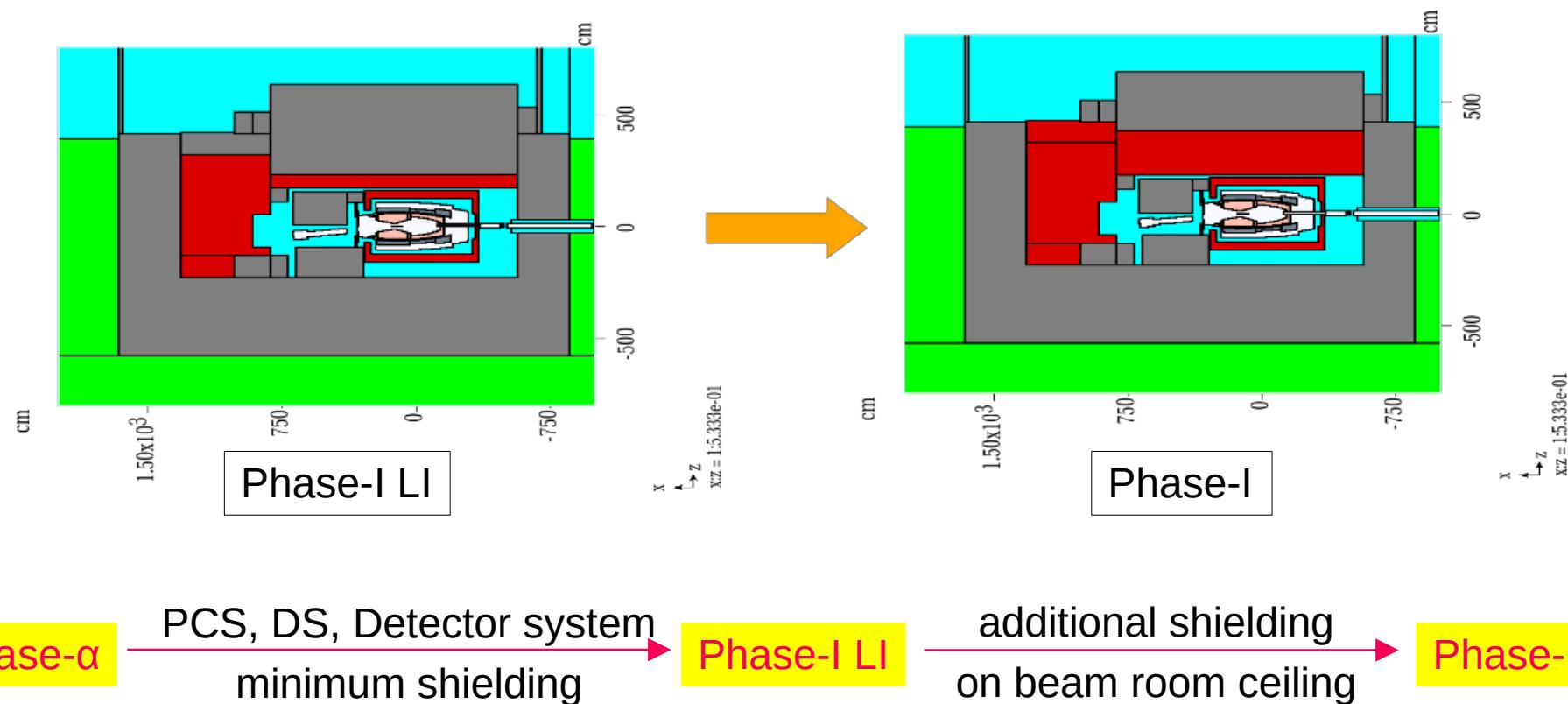
Beam Measurement Detector

Reply to the Previous PAC

- Output of the review in July
 - Optimization of the facility design
 - Management structure improvement
 - Funding

Minutes from J-PARC PAC38

The PAC agrees that taking data at a reduced intensity in Phase-1 LI as early as possible is the correct strategy at this point. Subsequent COMET Phases will be discussed in future PAC meetings. The PAC also agrees with the Review recommendations as specified above, in particular that the collaboration and the laboratory should continue to work together to ensure that the necessary funding for Phase-1 LI is quickly secured. The PAC encourages COMET to continue their efforts towards the timely realization of Phase-1 LI.



Review in July

- Members
 - Augusto Ceccucci (CERN, Chair),
 - Hans Danielsson (CERN), Junji Haba (KEK), Mika Masuzawa (KEK), Shoji Uno (KEK), Akira Yamamoto (KEK)
- Detector Session(19 July)
- Magnet Session(22 July)
- Main Session(26 July)
 - Interviews
 - for three different groups: Senior, mainstay, ECR
- The final Report is open to us in 5th Sep. 2024.

Output of Review in July

3. It is felt that the communication within the collaboration has to be improved in order to be sure that each collaborator, including the youngest, is aware of the objectives and can contribute coherently to the completion of the experiment and the achievement of the physics goal
5. It is important to note that many young physicists are involved in the experiment since a long time and that they need data to show how good they are

→ Management structure improvement

6. Operation conditions for the early stage COMET system, including the pion capture solenoid (PCS) strength, the production target, the PCS inner shield, and other external shields etc. should be optimised with all the wisdom of the collaboration. The impression is that this optimisation process has not been completed yet

→ Facility design optimization and update

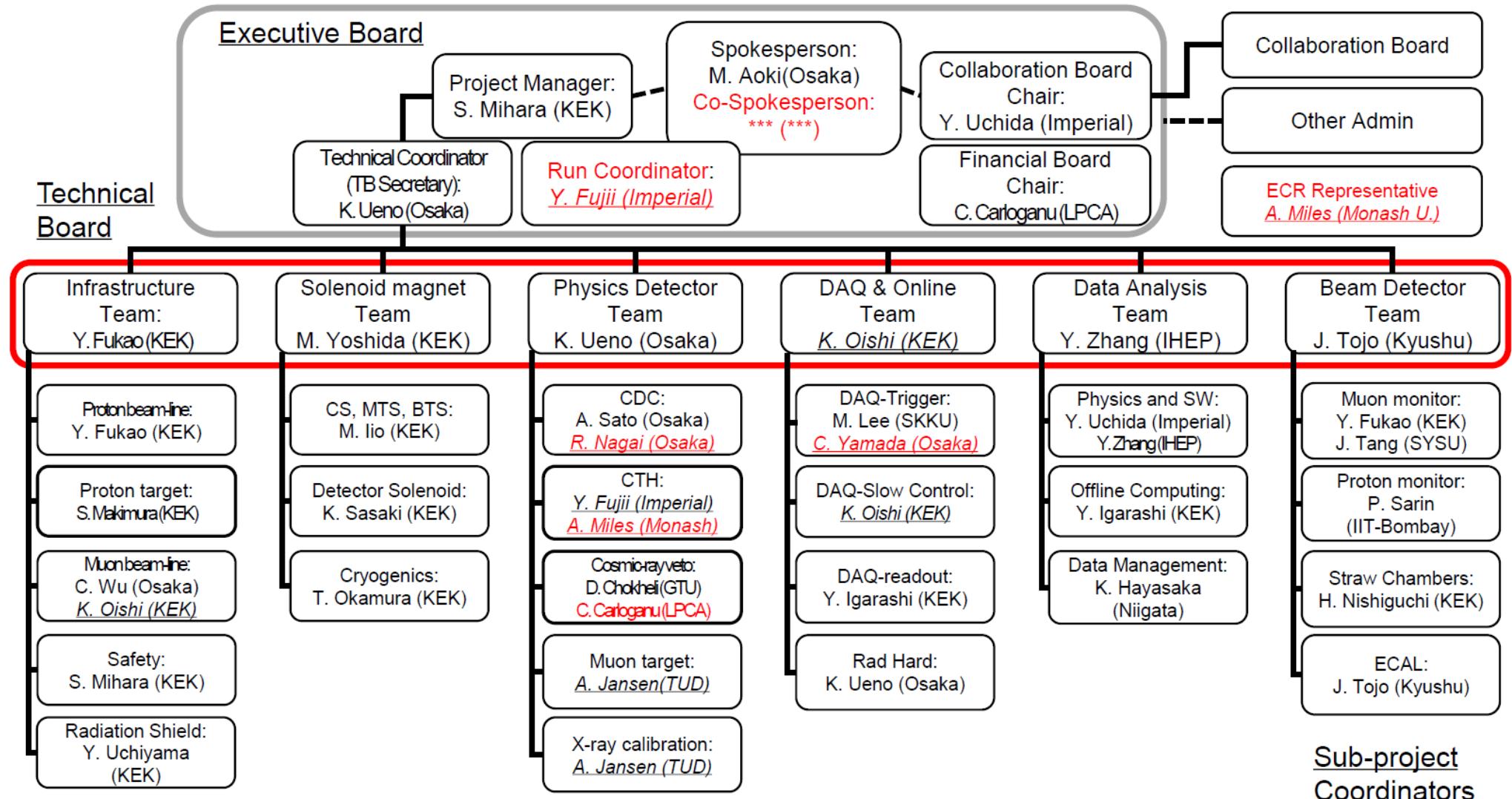
10. It is pointed out that there are still parts of the detector unfunded, notably the Cosmic Ray Veto (CRV)

→ Status of CRV preparation

2. The collaboration and the laboratory should work together to secure the 2.8 OKU Yen required to complete the shielding needed for low intensity (LI) running

→ Effort to secure funding

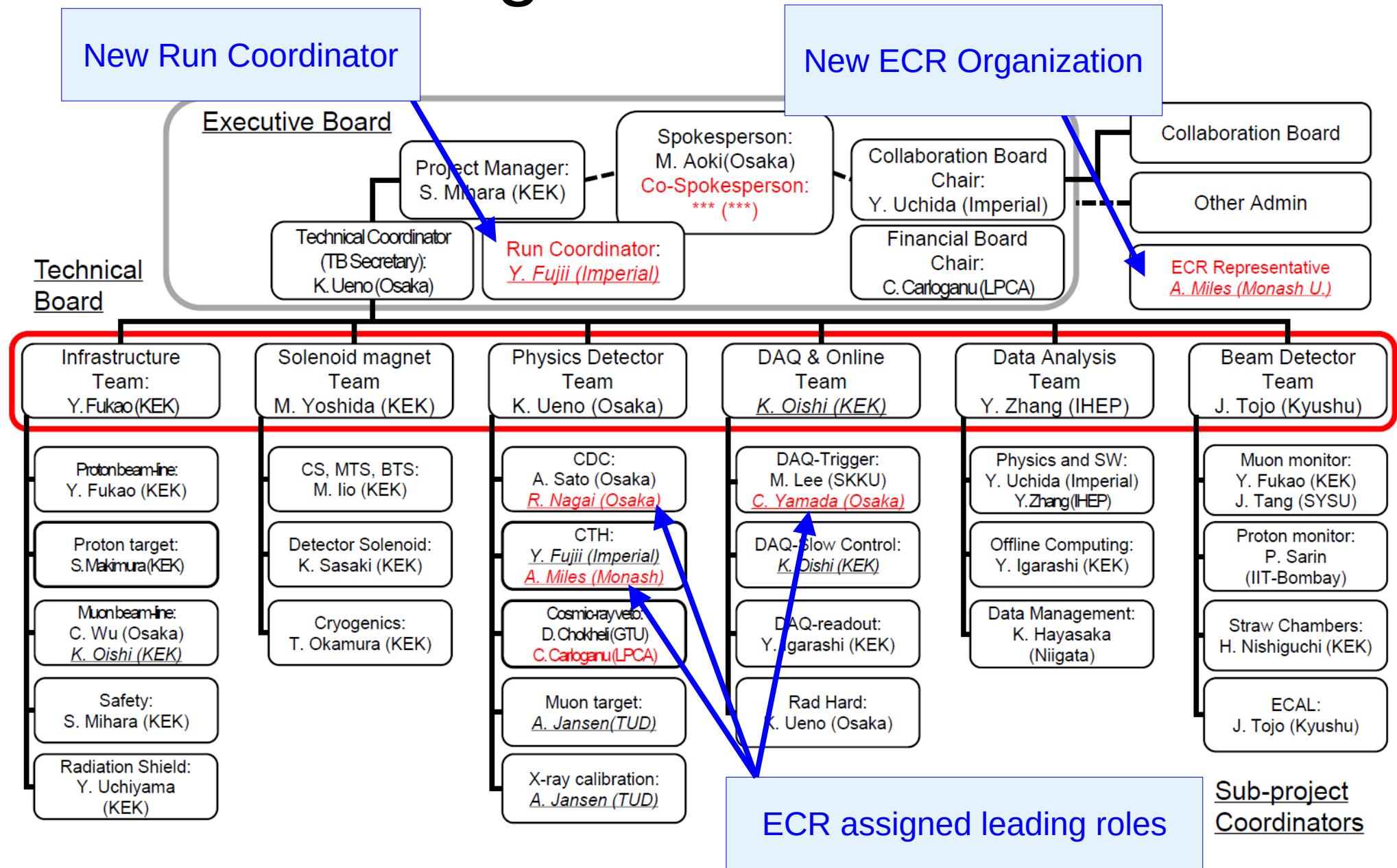
Management Structure



Text in red: new

Text with Underline: ECR (Early Career Researcher)

Management Structure



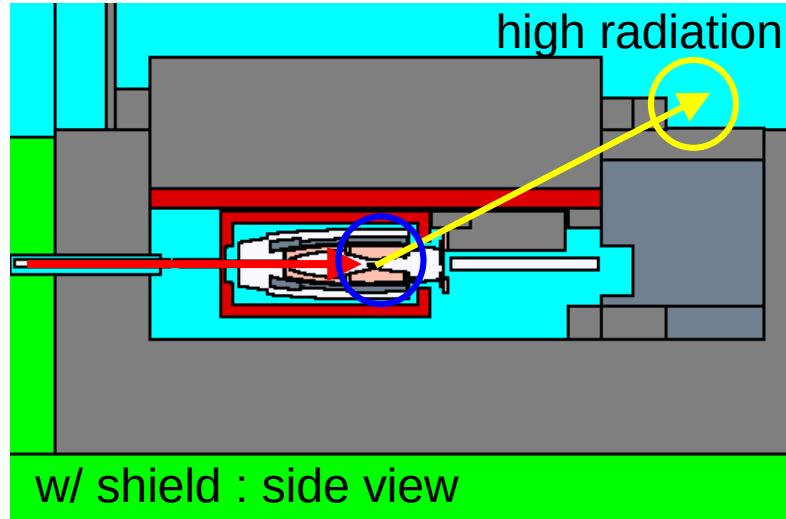
ECR assigned leading roles

Steps to improve communication within the collaboration

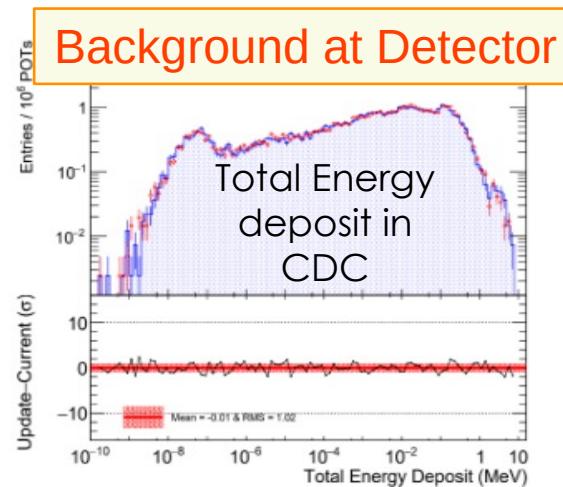
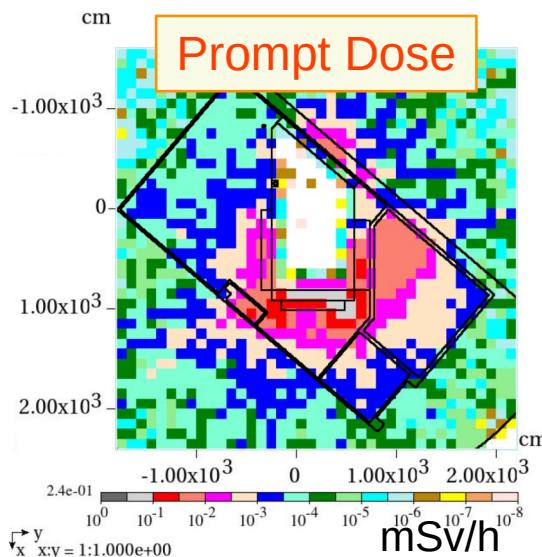
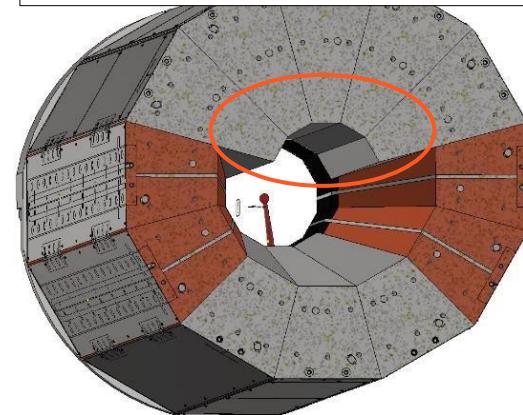
- An intermediate “Team” structure stimulates communication between detector sub-projects.
- The Technical Coordinator (a leader of the Teams) invited to the EB mediates efficient communication between the COMET management and collaborators.
- The frequency of the EB meeting is doubled than in the past.
- Significant increase of Rocket.Chat (a SNS tool like Slack) use
 - teams have channels for COMET-wide discussions
- Renewal of Communication Group Membership
 - an update of the Internal Web Pages is ongoing

Shape Change of PCS Inner Shield

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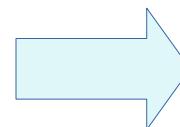
Make aperture narrower



Effect of the new shape of the PCS Inner Shield

- Outside radiation reduced by 40%
- Permanent coil damage increased by 5%
- Stable background in the detector region

1. Proposal from facility
2. Background estimation by each detector team
3. Quick decision in Technical Board meeting.



Manufacturing is ongoing with modified shape.

Updates from the Previous PAC

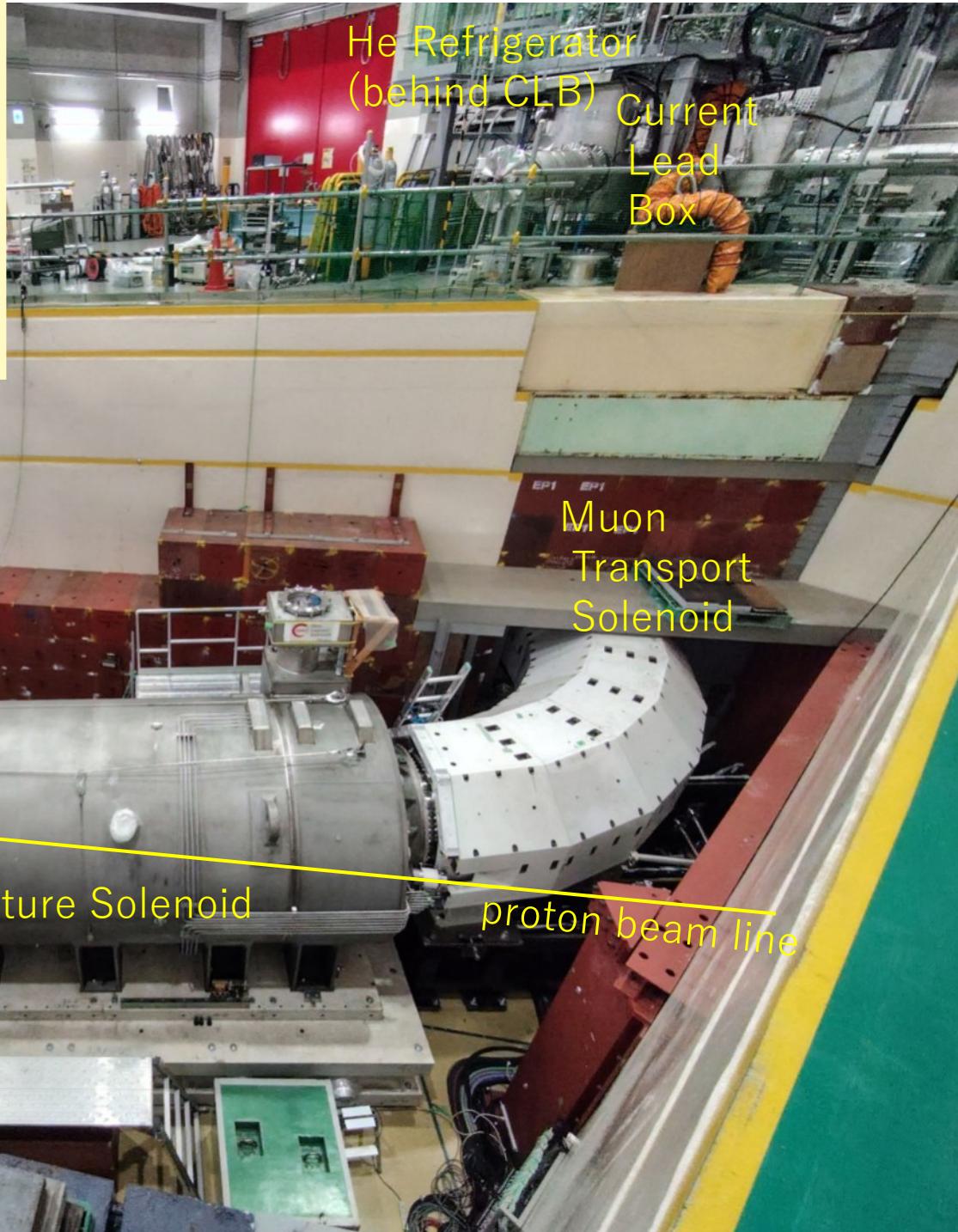
- Pion Capture Solenoid (PCS)
- Physics Detector : CDC, CTH, CRV
- Beam Measurement Detector
- DAQ System
- Schedule
- Publications

COMET

Superconducting Magnet System

as of Dec.2024

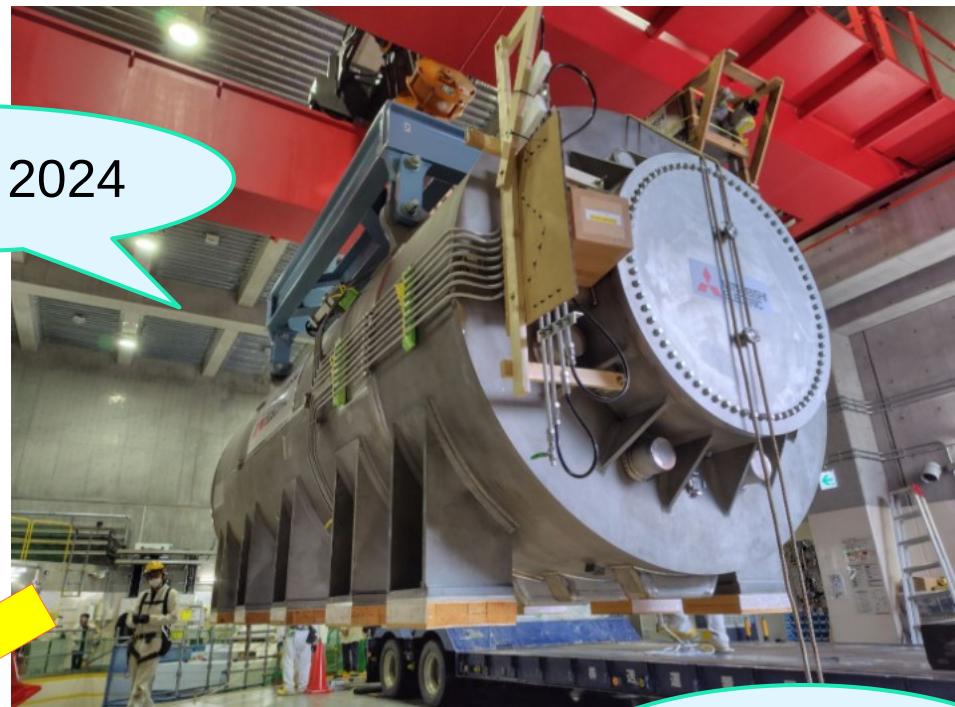
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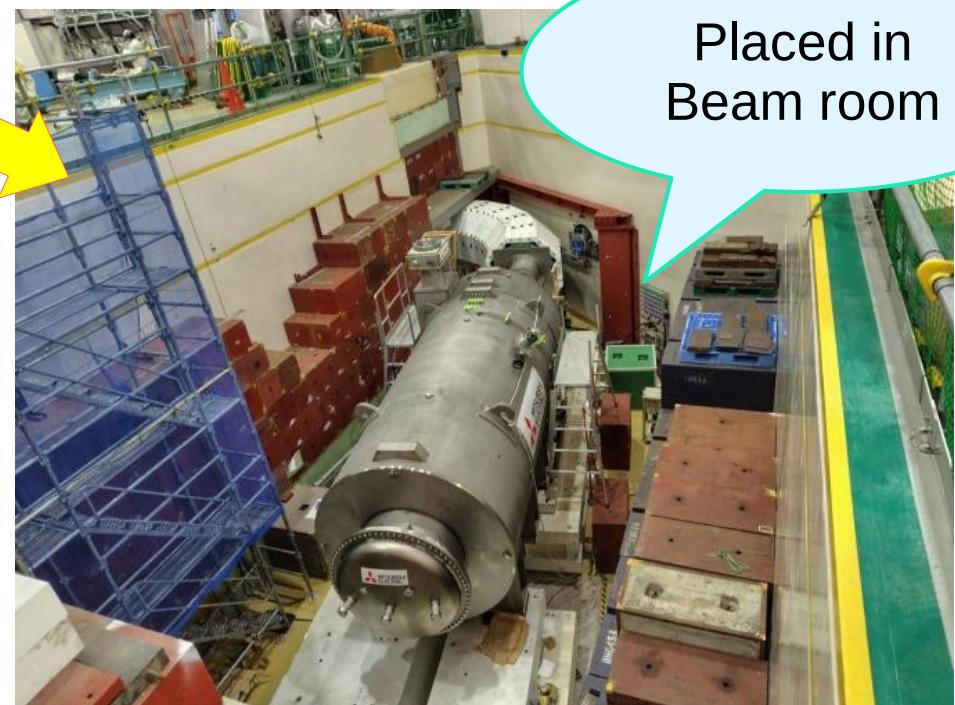
Delivery of PCS

30th Oct. 2024

Lifted by crane



Placed in
Beam room



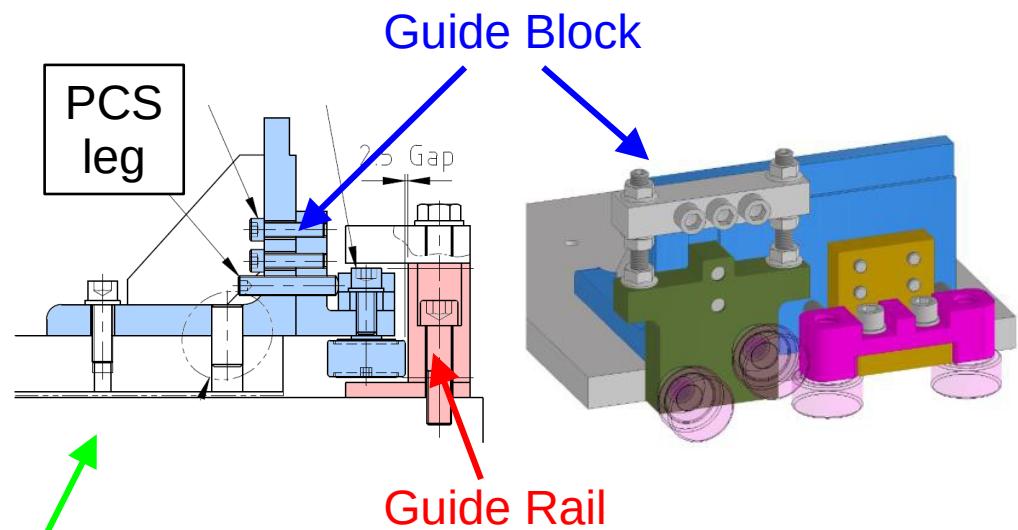
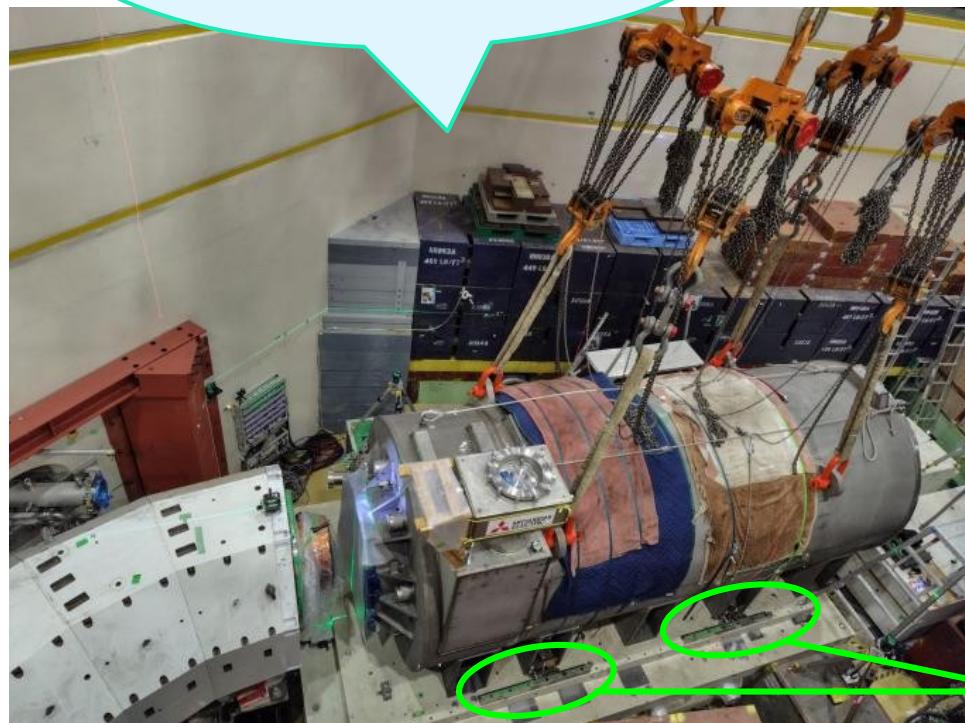
Acceptance tests finished.
• No leak
• Coil resistance is OK.

PCS Installation

Aligned to beamline



Connected to Muon
Transport Solenoid
in December



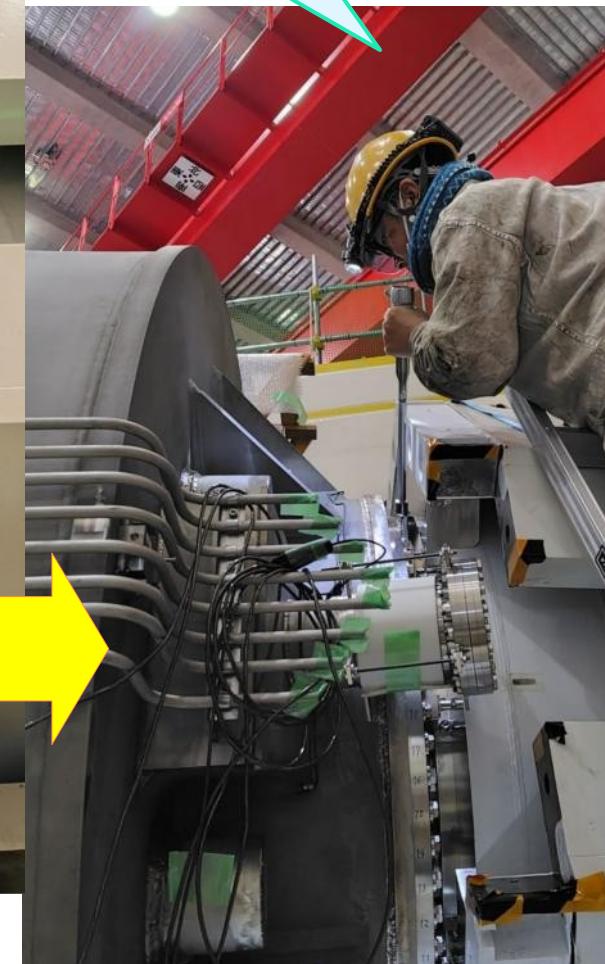
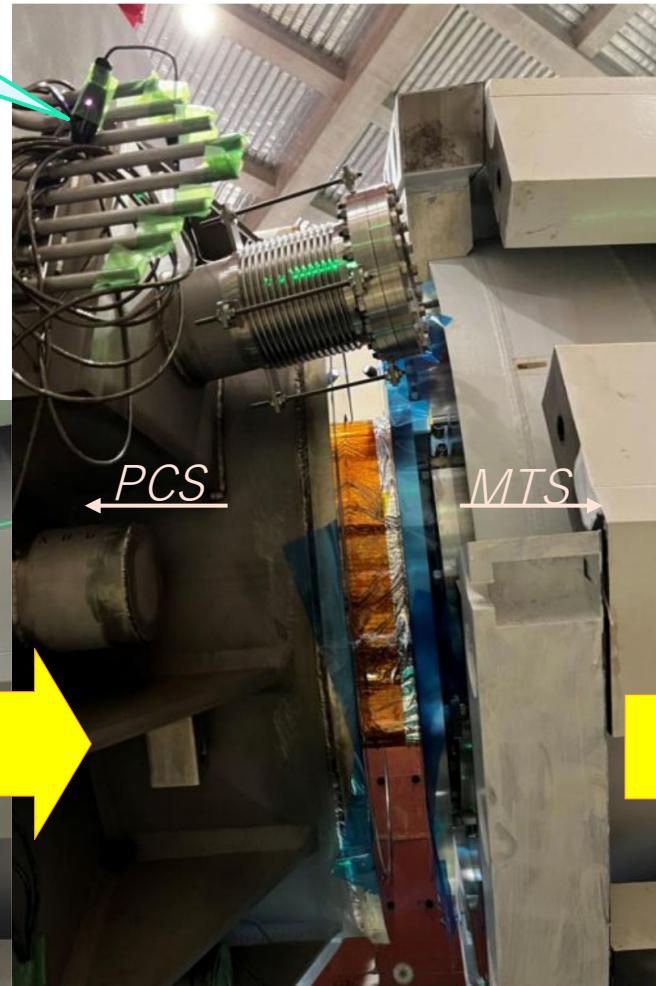
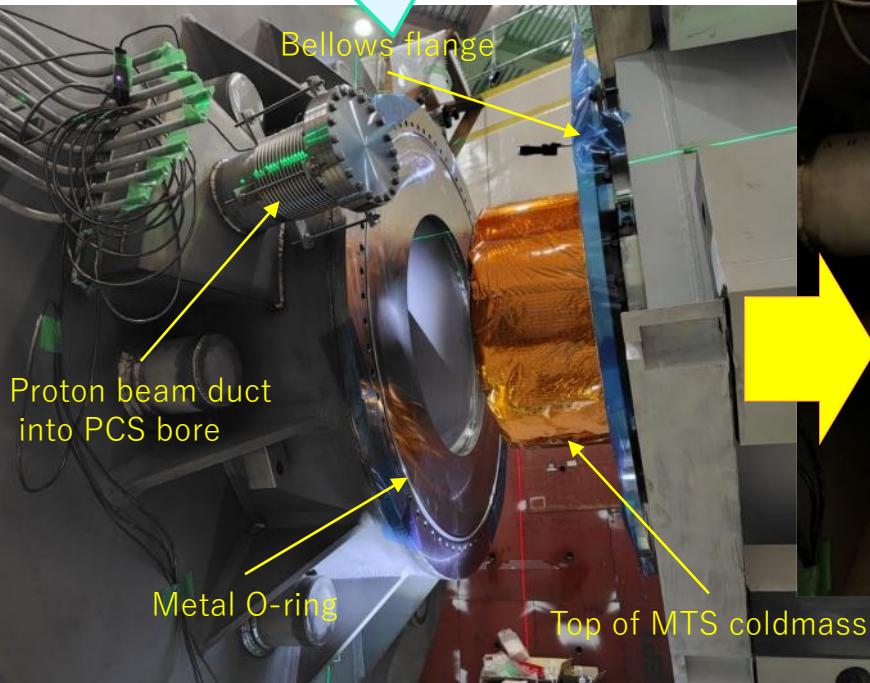
Guide block and rail were utilized based
on the preliminary test.

Connection of PCS and MTS

Very slowly slid towards MTS

Bellows flange was connected.
Evacuation is underway.

Clearance <10mm.



Detector Solenoid, Bridge Solenoid

- DS was delivered at KEK Tsukuba in Sep. 2024.
- BS was delivered at J-PARC in Mar. 2022.
- All magnets are ready to install.



	Bridge Solenoid	Detector Solenoid
Conductor	NbTi/Cu monolith wire Cu/NbTi = 4	
Strand dimensions	$\phi 1.2$ mm (without insulation) $\phi 1.3$ mm (with insulation)	
Cable insulation	PVF	
Coil inner diameter	460, 620 mm	2140 mm
Total coil length	1.4 m	2.9 m
Operation current	155 A	189 A
Magnetomotive force	1.9 MAT	2.5 MAT
Field on axis	3 T - 1 T	1 T
Inductance	29.1 H	236 H
Stored energy	0.35 MJ	4.2 MJ
Refrigeration	conduction cooling by GM $2 \times 1.5W$	conduction cooling by GM $3 \times 1.5W$
Quench protection	external dump resistor	semi-active quench back heater



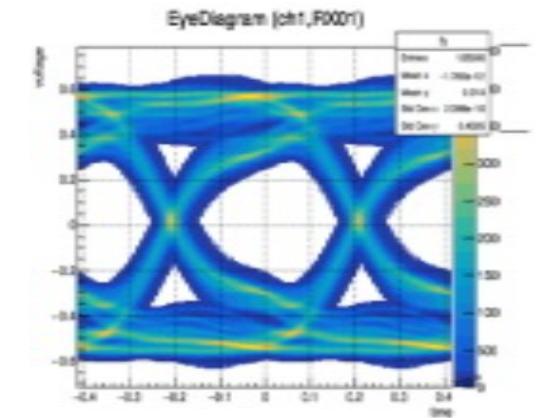
Physics Detector : CDC

Hardware almost completed.

- **All the readout boards** were installed.
- Network communication test ongoing.
- DAQ/slow control test is ongoing.

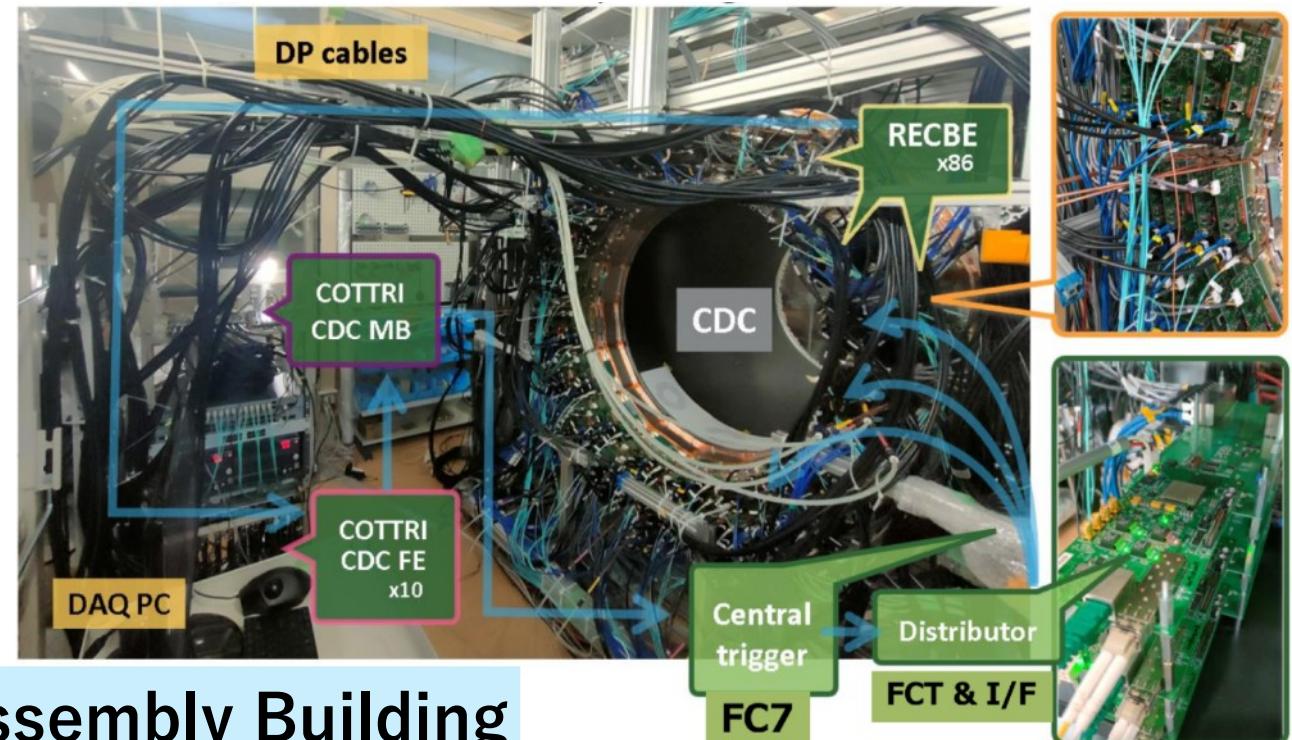
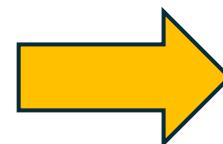
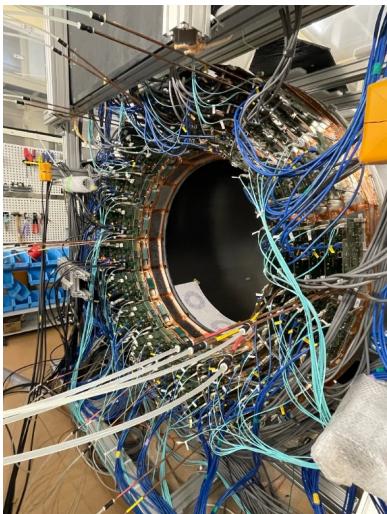
Preparation of gas circulation system started.

Example of Eye diagram
on trigger signal



Jun. 2024

Oct. 2024



@J-PARC Hadron Assembly Building

Physics Detector : CTH

- **Scintillator quality control :**
 - Procedures defined, test bench operational.
 - Mass testing foreseen in the first quarter of 2025.



- **MPPC quality control :**

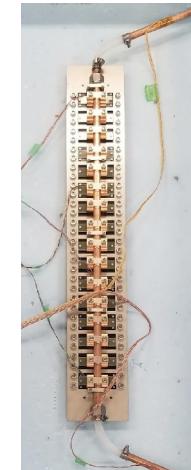
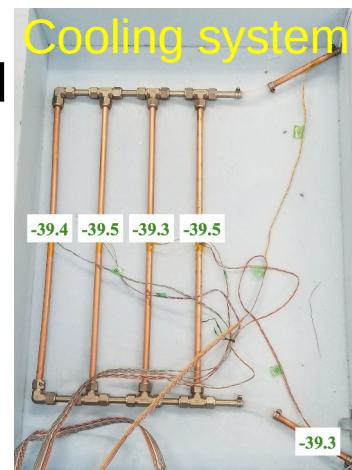
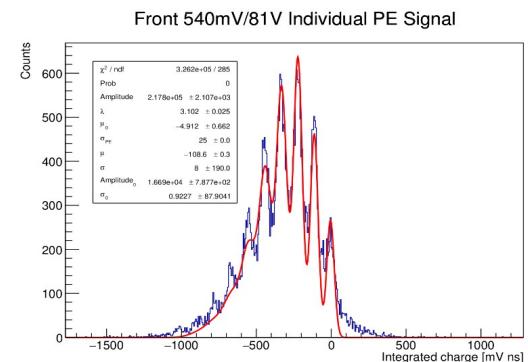
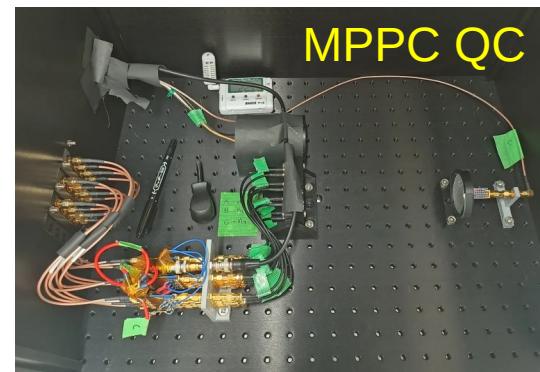
- Calibration data ongoing

- **Cooling system :**

- Final design almost ready.
Construction started.

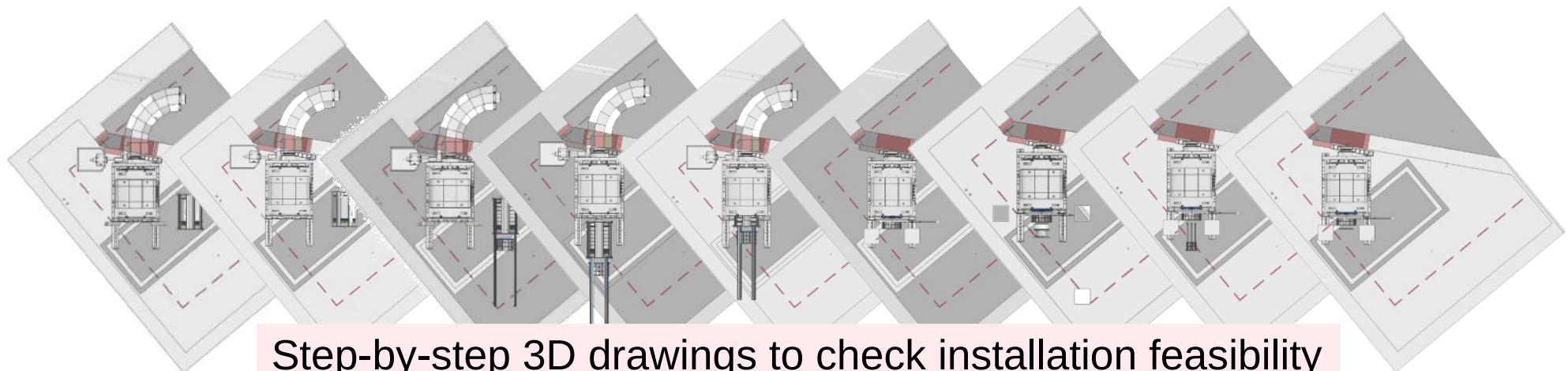
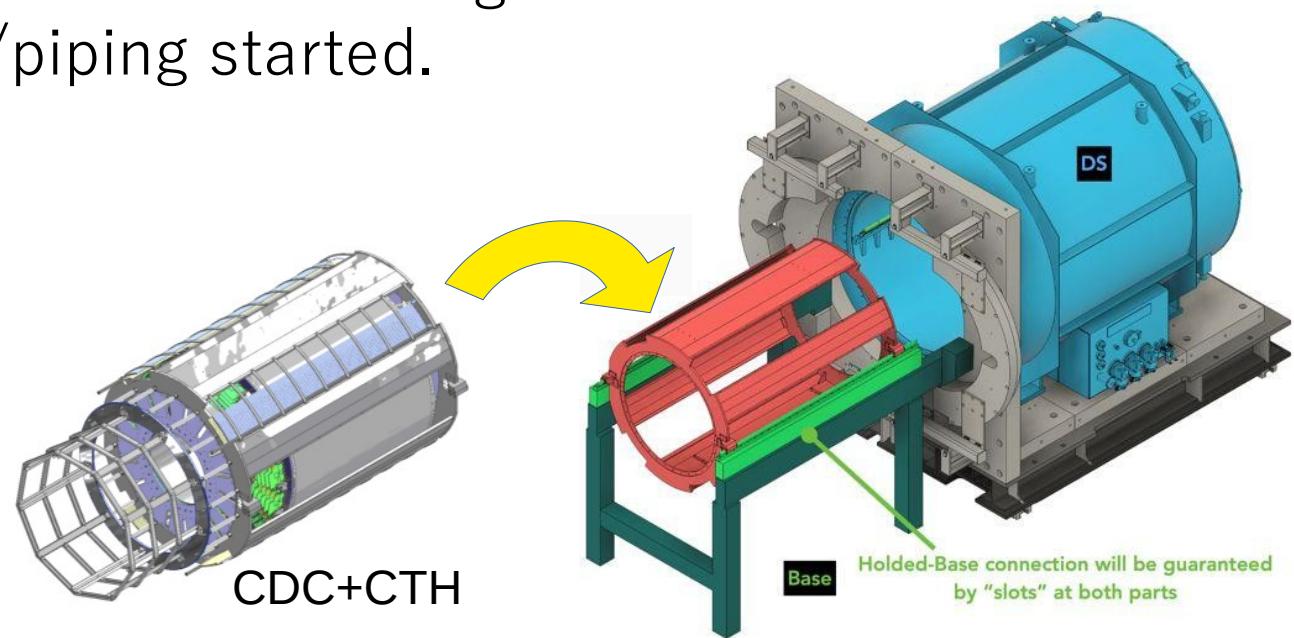
- **Fibre winding system :**

- Conceptual design made and proven with a table size prototype
- Expect to complete 256 fiber bundles within a few weeks



Physics Detector : Integration

- Detailed installation scheme has been defined.
- Design of the support structure is being finalised.
- Discussion on cabling/piping started.



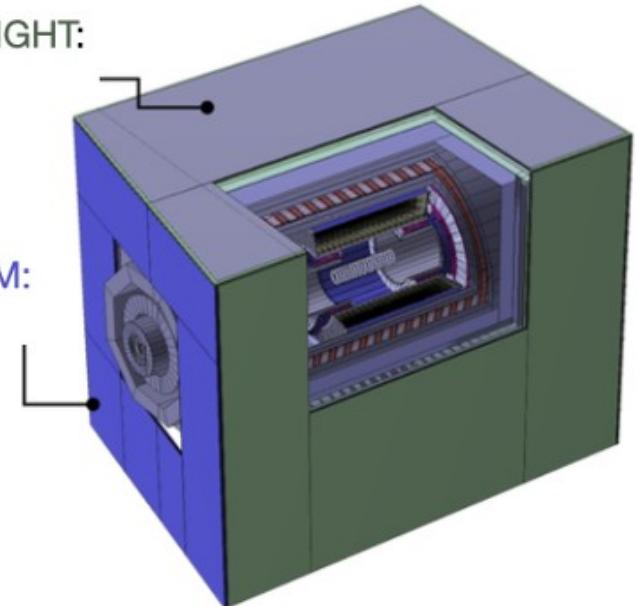
Physics Detector : CRV

Current design:

- Scintillators on top, left and right sides : partially funded;
- Bakelite RPCs following the iRPC design from CMS for the areas with large neutron flux (upstream and downstream) : French funding requested for electronics and DAQ, expect answer in the beginning of 2025.

TOP, LEFT, RIGHT:
Scintillators

UPSTREAM:
▫ RPCs



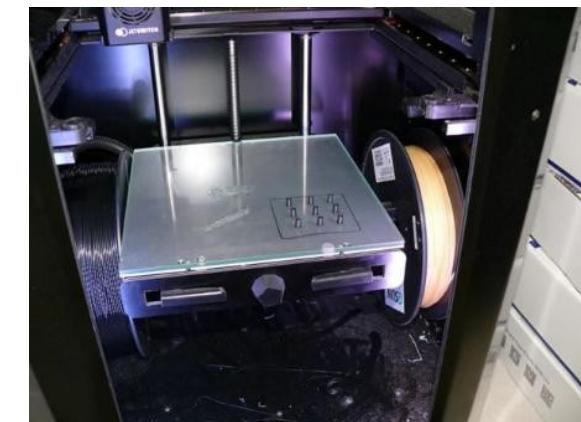
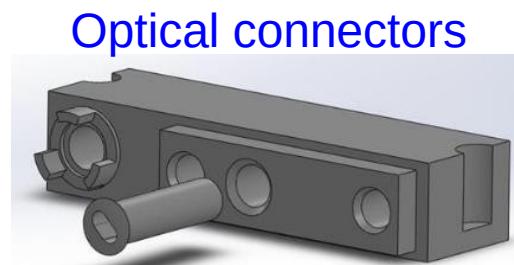
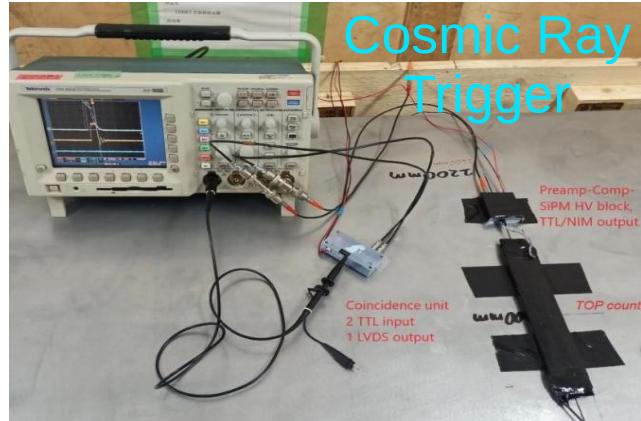
We are currently investigating if RPCs from the ARGO-YBJ experiment can be used to improve CRV coverage for Phase-I-LI.

- up to 2700 m² available
- test of a chamber at GIF++ at CERN is being discussed to check the behaviour of these RPCs at high rates

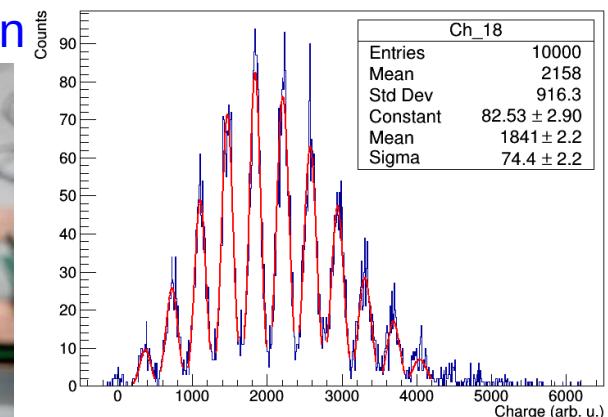


Physics Detector : CRV

- Prototype of CRV was shipped to J-PARC about one year ago. Cosmic ray measurements are ongoing at Tokai-2 gokan.
- The blanks for scintillation strips have almost been manufacture.
- Optical connectors are being produced using CNC machine / 3D printer.
- LED Calibration System has been implemented.

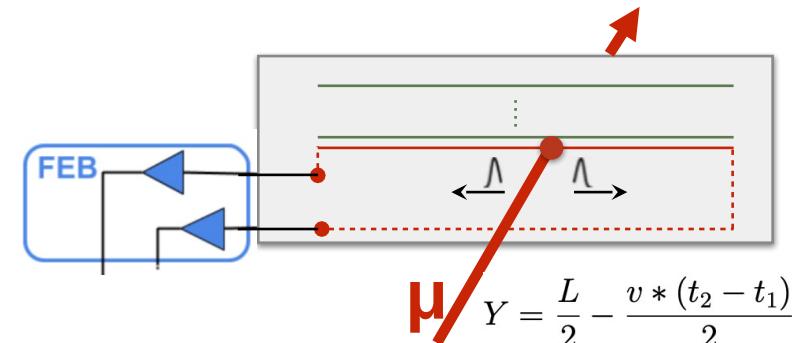
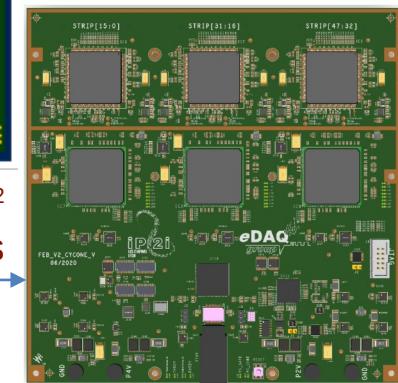
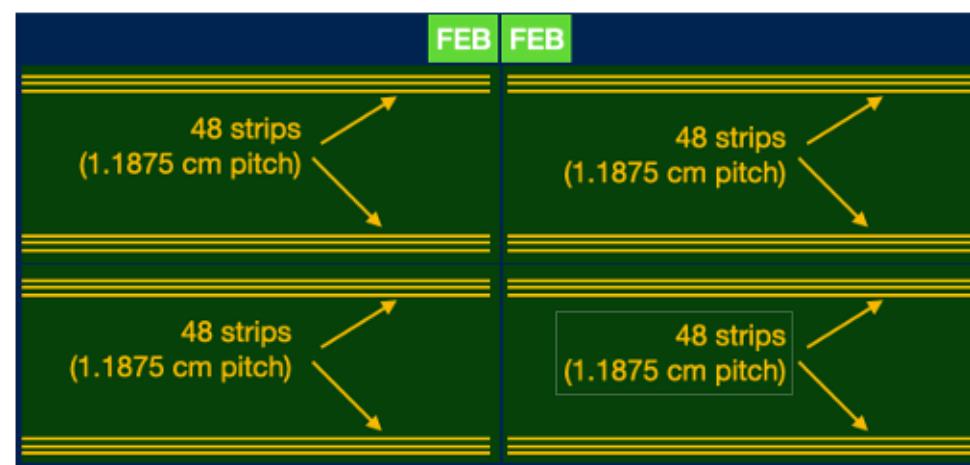
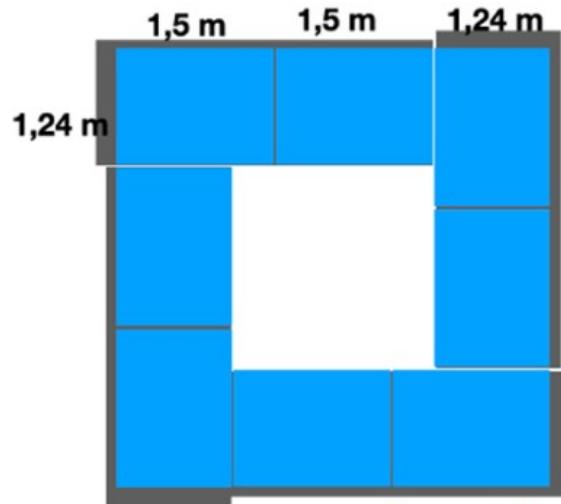


Connector for LED calibration



Physics Detector : CRV (iRPCs)

- Front End Boards ready to be produced
- Design of the readout PCB, customised for COMET geometry almost finished
- RPCs and readout electronics already tested by CMS at rates similar to those expected for COMET Phase-I.



2D readout : both sides of the strip are read with 20 ps time resolution on Δt

Beam Measurement Detector

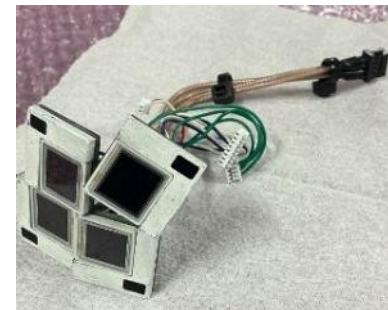
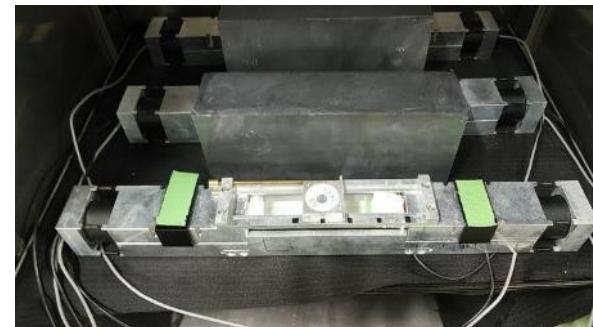
Straw Tube Tracker

- #1 : Performance test is ongoing
- #2 : Stringing of 320 wires (out of 480) was completed.
- #3 : Straw installation is ongoing.
- DAQ and Gas operation was finished.



EM Callorimator

- Fabrication of the module support frame was completed.
- QA / QC of the crystal is ongoing.
- APD test is ongoing



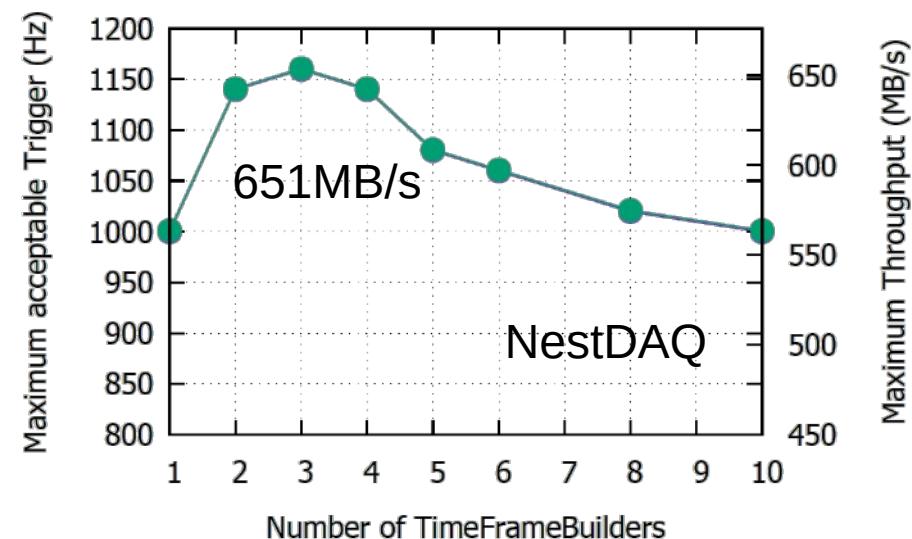
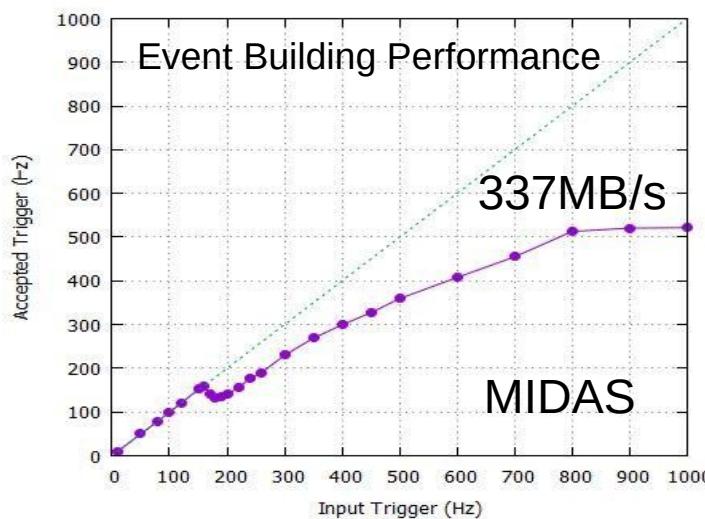
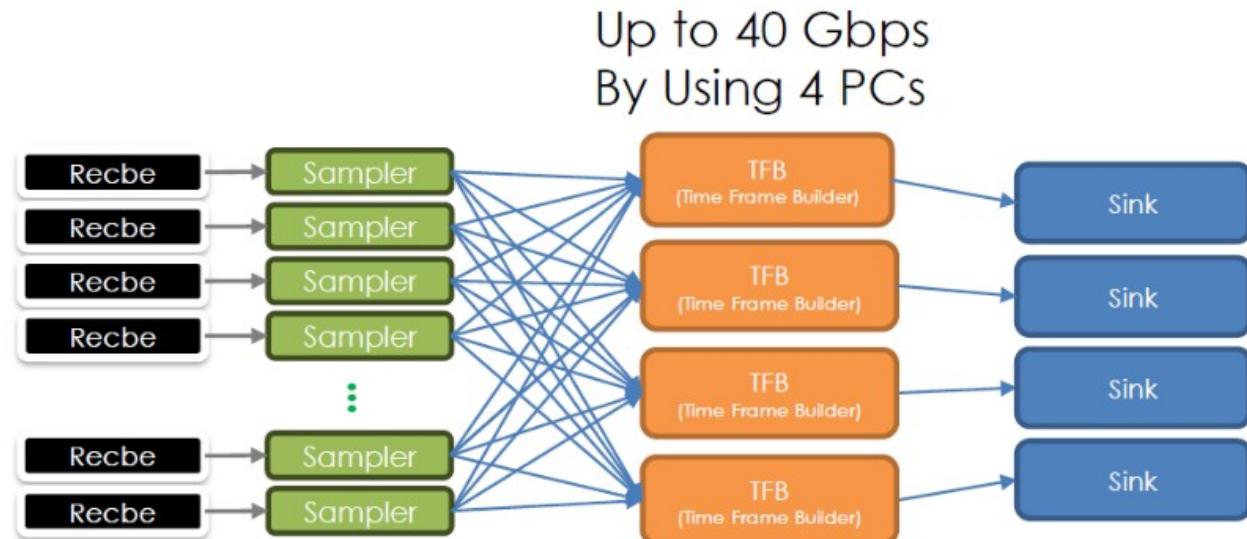
DAQ System

COMET DAQ : MIDAS → NestDAQ

- **Scalable system** : Performance can be improved by adding multiple computers.
- **Software trigger** : Originally designed to include the software trigger.

Improvement has been confirmed

- with CDC readout electronics.
- with single PC



List of Publication and Presentation after the previous PAC

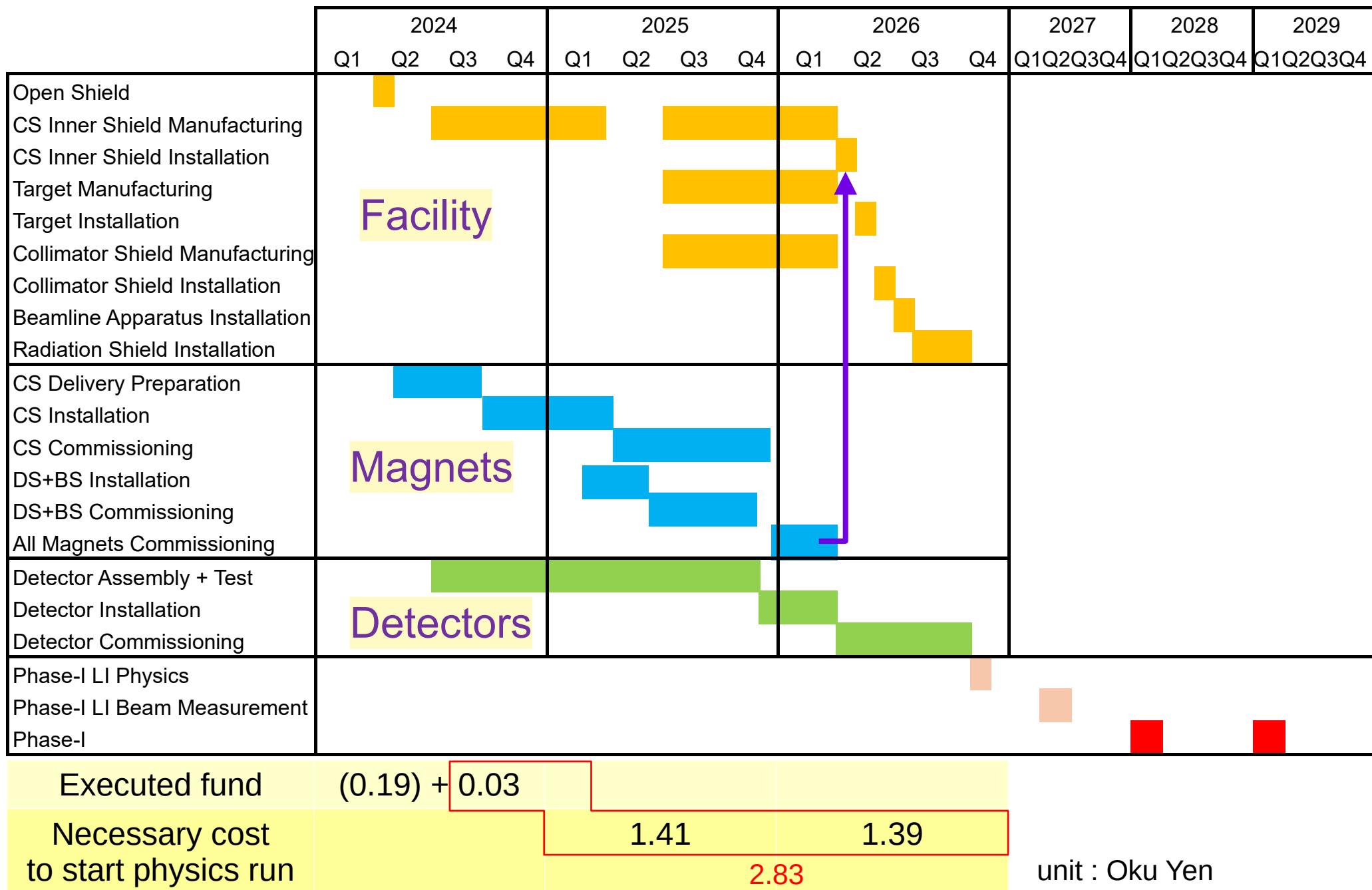
Journal Publication

- A Hybrid Scrubber Based on the SEM and the PicoBlaze for Artix-7 FPGAs in the COMET Read-out Electronics
E. Hamada et al., IEEE Transactions on Nuclear Science (2024)
- Design and Construction of the Cylindrical Drift Chamber for the COMET Phase-I Experiment
A. Sato et al., NIM Phys. Res.A vol.1069, 169926 (2024)
- Particle identification using plastic scintillators in the COMET Phase-I experiment
Y. Fujii et al., NIM Phys. Res. A 1067, 169665 (2024)

Oral / Poster Presentation at Conferences

- Neural network-based event selection on FPGA for COMET Phase-I
M. Miyataki et al., IEEE NSS MIC RTSD 2024, 2024.10.28-11.2
- Neural network-based event selection on FPGA for COMET Phase-I
M. Miyataki et al., IEEE Edge Computing Workshop, 2024.10.27
- The COMET Experiment to Search for μ -e Conversion at J-PARC
K. Oishi et al., The 4th J-PARC symposium, 2024.10.14-17
- Status of the COMET Cylindrical Drift Chamber at J-PARC
R. Nagai et al., The 4th J-PARC symposium, 2024.10.14-17
- CyDet Trigger System for COMET Phase-I
C. Yamada et al., The 4th J-PARC symposium, 2024.10.14-17
- Performance test towards the construction of Cylindrical Trigger Hodoscope in COMET Phase-I
R. Sasaki et al., The 4th J-PARC symposium, 2024.10.14-17
- Quality Control of Multi-Pixel Photon Counters for the COMET Experiment
A. Miles et al., The 4th J-PARC symposium, 2024.10.14-17
- Construction and Beam Commissioning for the COMET Experiment
Y. Fukao et al., The 4th J-PARC symposium, 2024.10.14-17
- Performance evaluation of SiC muon beam monitor for COMET experiment
K. Okabe et al., The 4th J-PARC symposium, 2024.10.14-17
- Recent upgrade on muon target at J-PARC
S. Makimura et al., The 4th J-PARC symposium, 2024.10.14-17
- Radiation Shielding System for the COMET Pion Capture Solenoid
Y. Uchiyama et al., The 4th J-PARC symposium, 2024.10.14-17

Schedule



Funding

- The 38th PAC: “in particular that the collaboration and the laboratory should continue to work together to ensure that the necessary funding for Phase-1 LI is quickly secured.”
 - Regular COMET propulsion meetings
- **In-kind contribution to the construction**
 - **Radiation shielding by JINR and IHEP**
- A **Common Fund** is being implemented
 - **It could contribute to the construction cost.**
- to complete the detector construction
 - LPCA participation in CTH
 - IN2P3 and IHEP contribution to CRV
 - Thanks to KEK-DG Prof. Asai, IHEP-DGs Prof. Y. Wang and Prof. J. Cao.
- MoUs between foreign institutes and KEK are needed.

Summary

- E21 aims to search for μ -e conversion at a single-event sensitivity level of 10^{-15} .
- Considering the nature of the “rare decay” experiment, we plan to start the physics run with low intensity (LI) mode and quickly move to the full-power Phase-I to compete against Mu2e.
- The review report was delivered in the last September. It positively supports the project.
- Facility construction funding in 2024 was not as hoped. However, we finally received the pion-capture solenoid (PCS). We have all magnets: PCS, MTS, BS, and DS.
 - We can meet the facility construction schedule to start LI in 2026.
 - The installation must be started immediately.
- Restructuring of the management for much better collaboration performance is ongoing:
 - run coordinator, ECR representative, and co-spokesperson;
 - the outstanding performance of the new technical-board system well proved.
- Detector construction is going well with 100% user-side funding (DS and BS included).
- We are working with the laboratory for the early start of physics data taking.
 - Possible in-kind contributions to the radiation shielding,
 - Common Fund that can be used for the construction.