PRESENT DESIGN STATUS OF COMET TARGET AT J-PARC

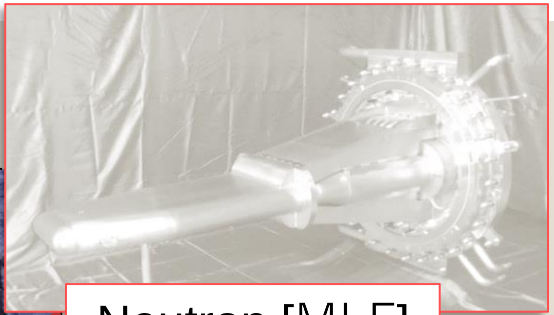
J-PARC, KEK
Shunsuke Makimura

COMET Phase alpha target from pion transport beamline

COMET target at J-PARC

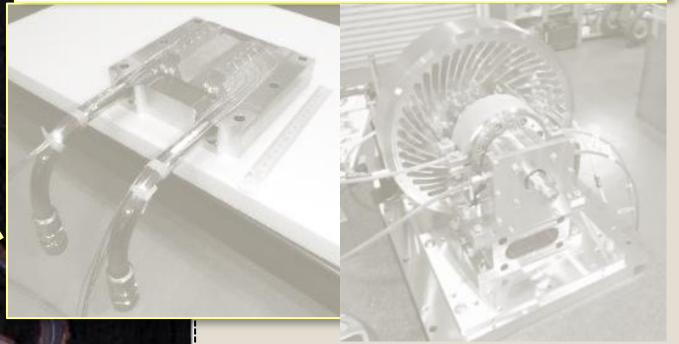
Muon [MLF-MUSE]
Rotating Graphite

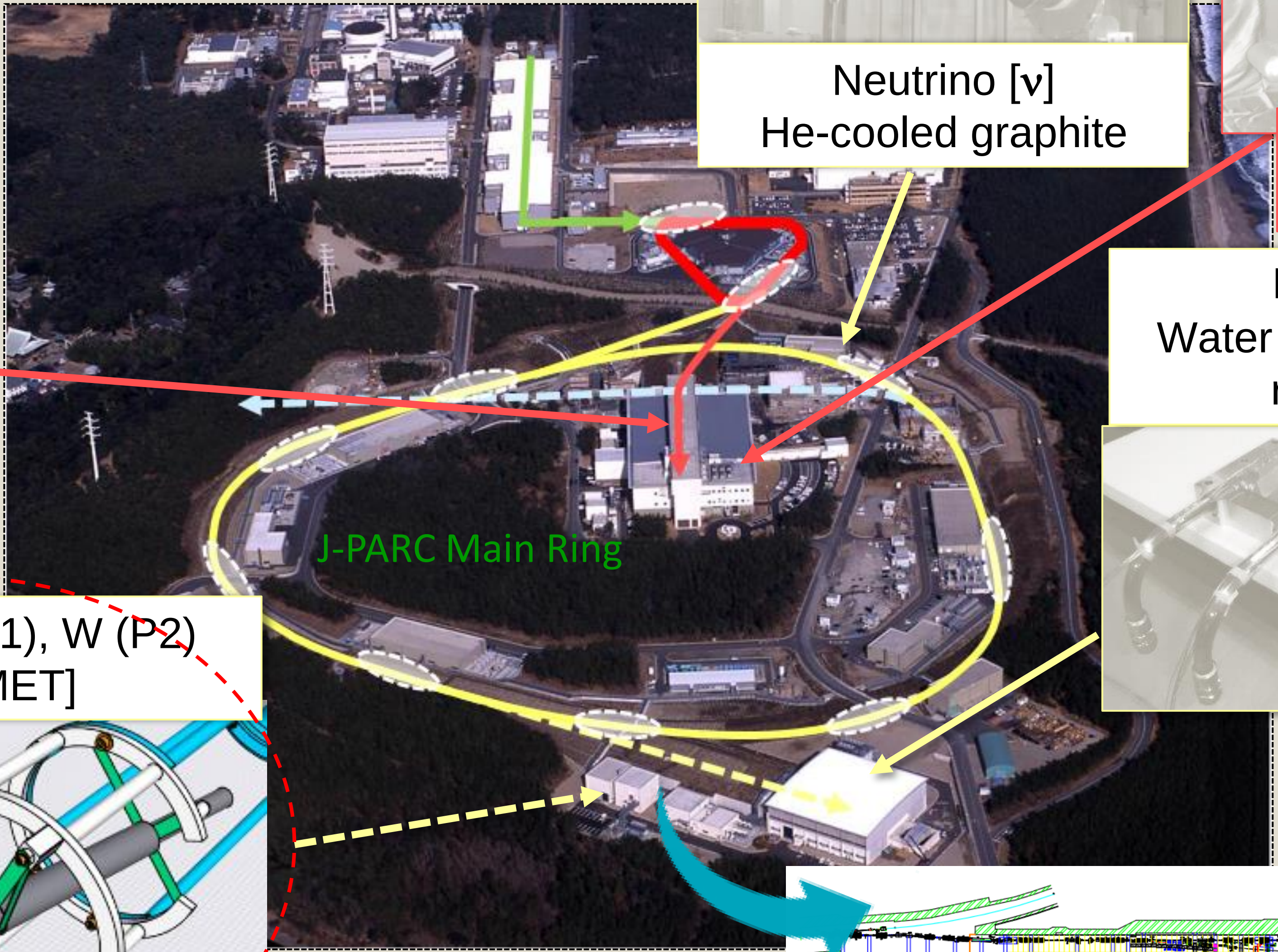
Neutrino [ν]
He-cooled graphite



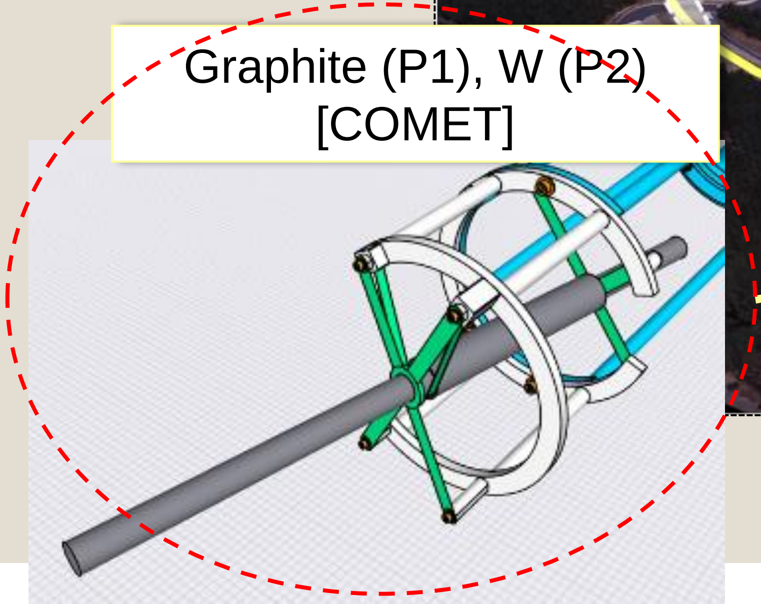
Neutron [MLF]
Liquid Mercury

Hadron [HEF]
Water cooled gold/ high-Z rotating target

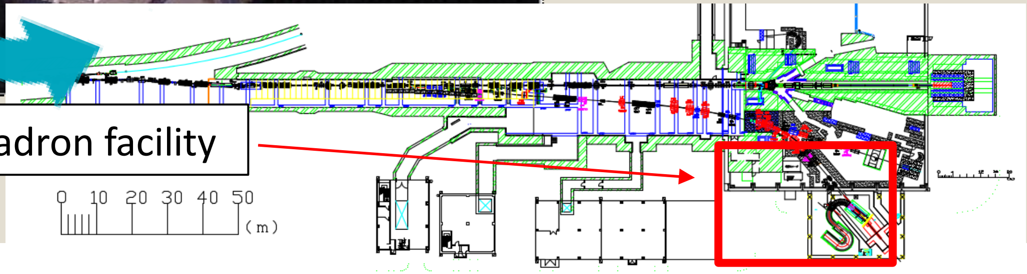




Graphite (P1), W (P2)
[COMET]



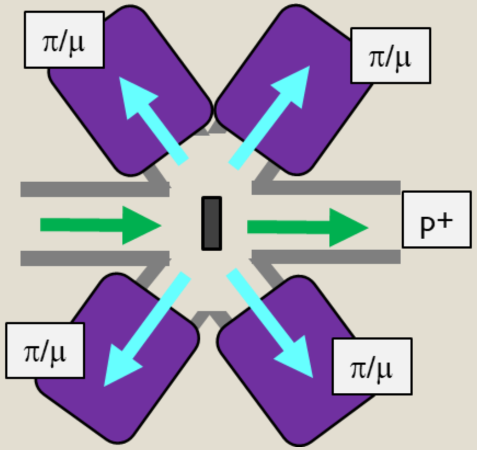
South experimental hall in Hadron facility



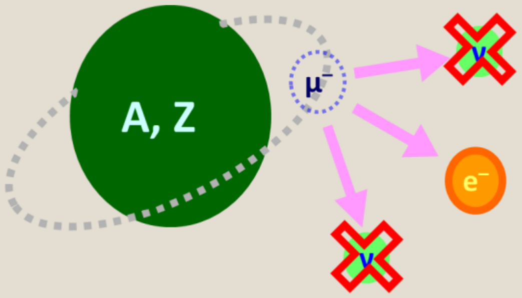
COMET target & MLF muon target
(MLF: Materials and Life Science experimental Facility)

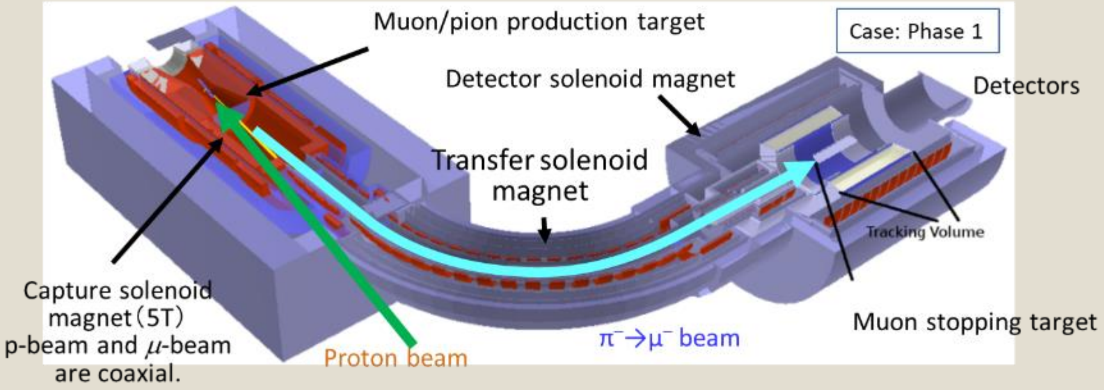
COMET facility: Y. Fukao ⟶ Oral session

	MLF target (Conventional)	COMET P1	COMET P2
Proton beam	3 GeV, 1 MW	8 GeV, 3.2 kW	8 GeV, 56 kW
Beam sigma	3.5 mm	H: 2.3 mm, V: 2.3 mm	(H: 2.3 mm, V: 2.3 mm)
Target material	graphite	graphite	Tungsten
Target thickness	20 mm	700 mm	160 mm
Beam loss on target	3.3 kW	110 W	7 kW
Time structure	25 Hz, Double Pulsed, 110 ns	0.5 s. extraction in 2.5 s.	-



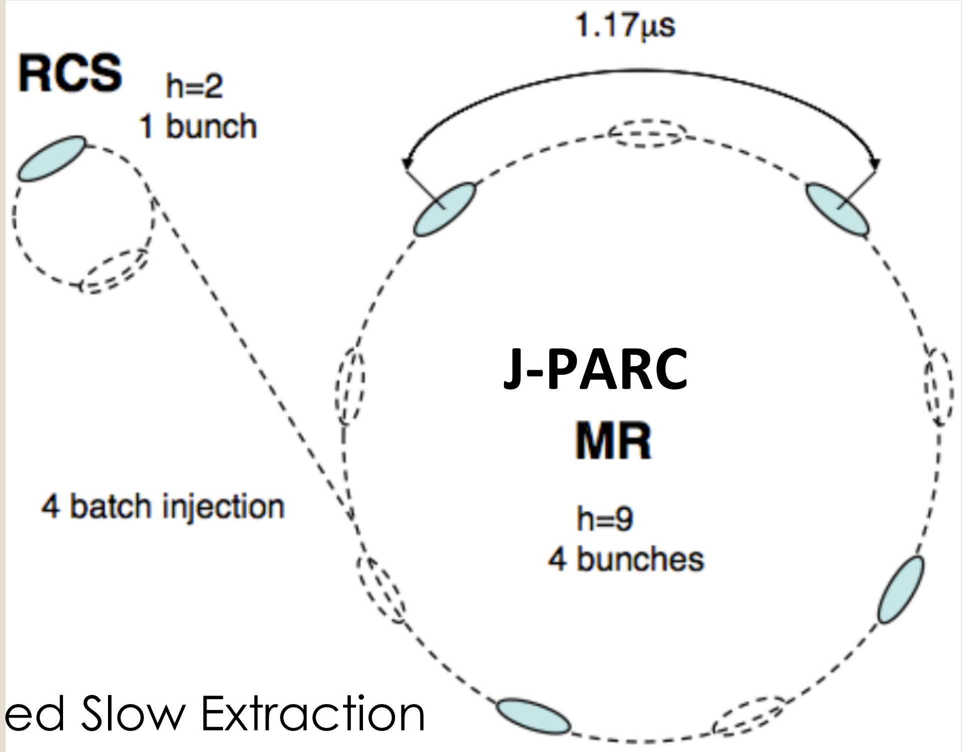
MLF muon target:
Multipurpose use



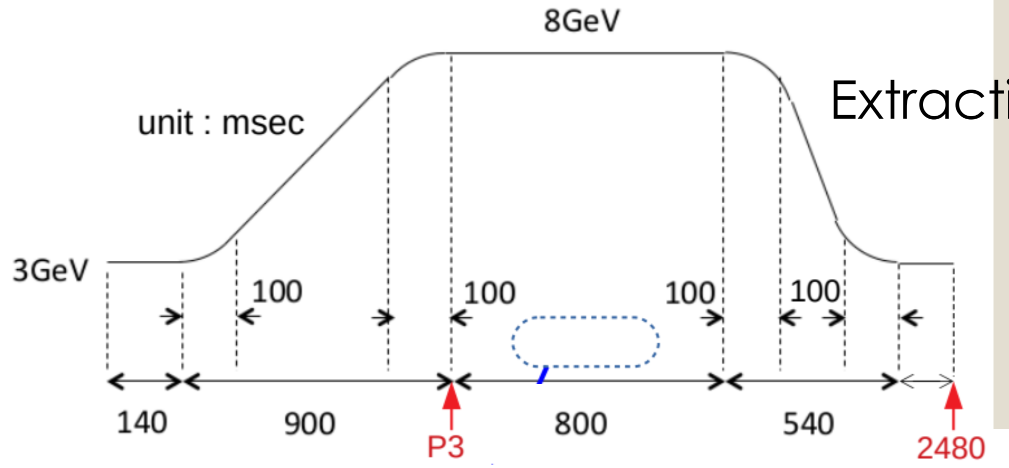


COMET target: Search for mu-e conversion
Located in high magnetic field to transport as large number of pions/muons as possible. Large Acceptance. Difficult to disperse the beam loss.

Time structure in COMET Phase 1



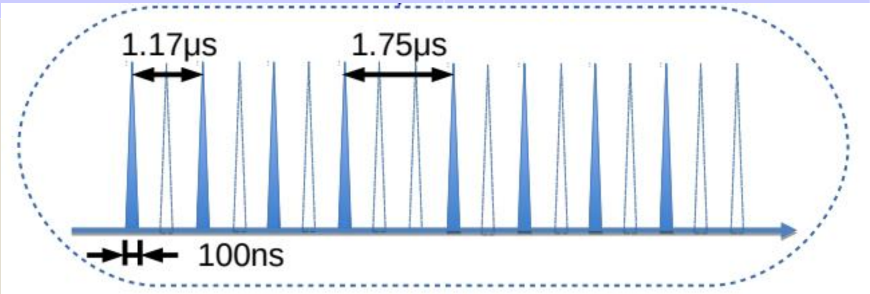
Bunched Slow Extraction

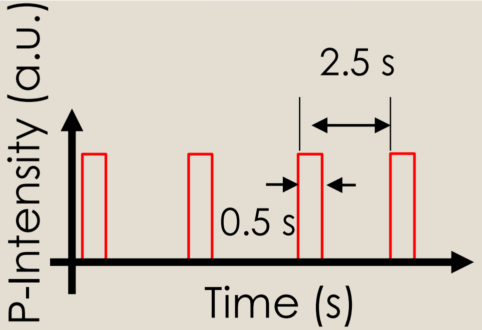


Extraction: 0.5 sec.

Case: COMET Phase1

energy	8GeV
power	3.2 kW
proton / bunch proton / spill	1.6×10^7 6.2×10^{12}
<u>cycle</u> <u>extraction</u>	<u>2.5 sec.</u> <u>0.5 sec.</u>



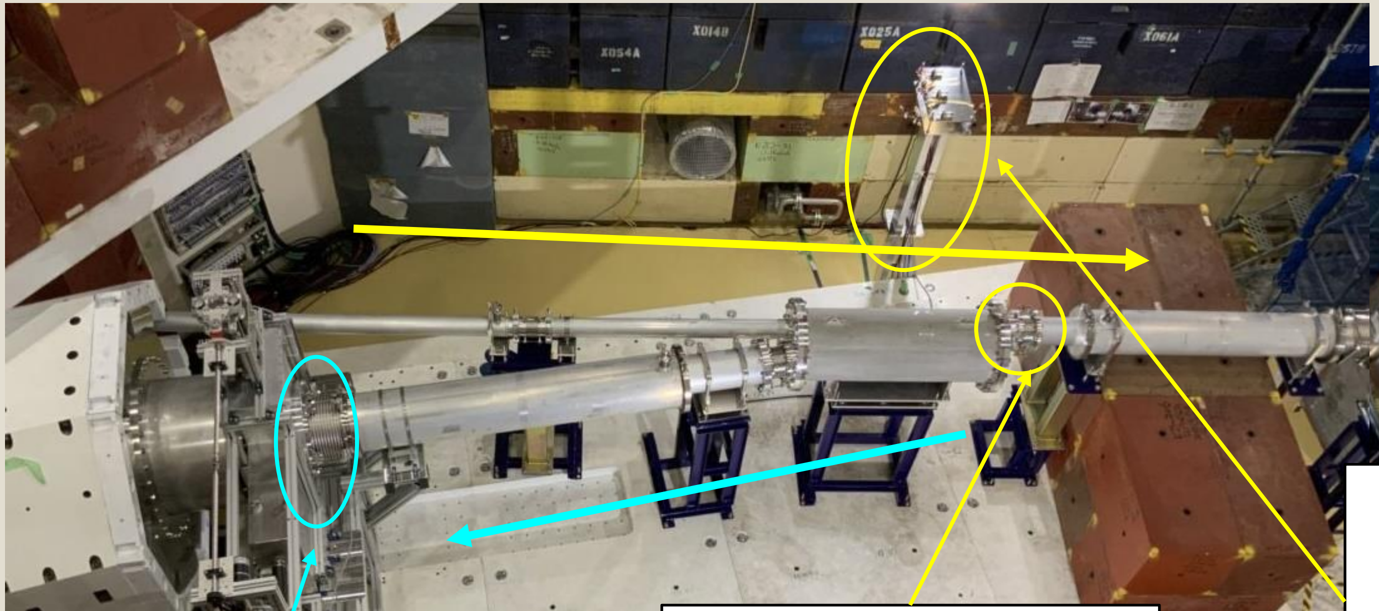


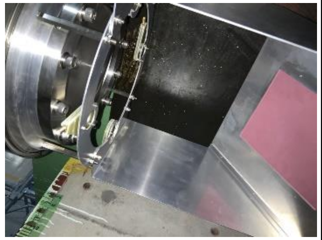
Case: Phase2
Proton beam intensity: 56 kW

Engineering Run: Phase alpha

Operation in Feb. 2023

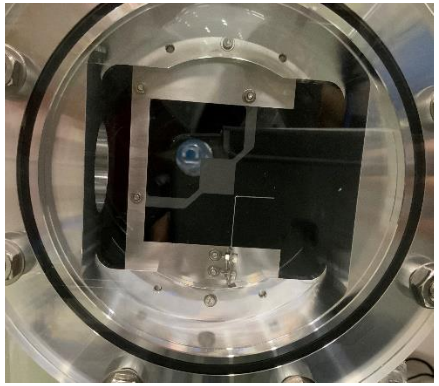
- Transport of Proton beam w/o the capture solenoid magnet
- Studies for secondary particles transport & detection



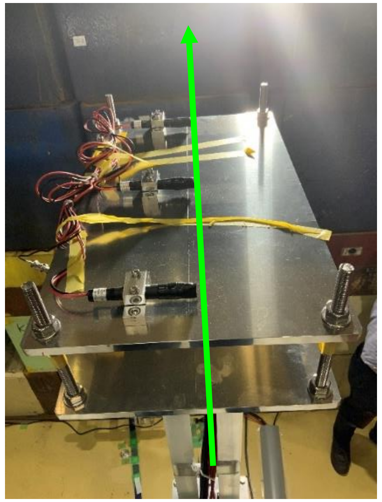


Extinction monitor & beam window

3D-printed beam window
Y. Nagasawa in poster session



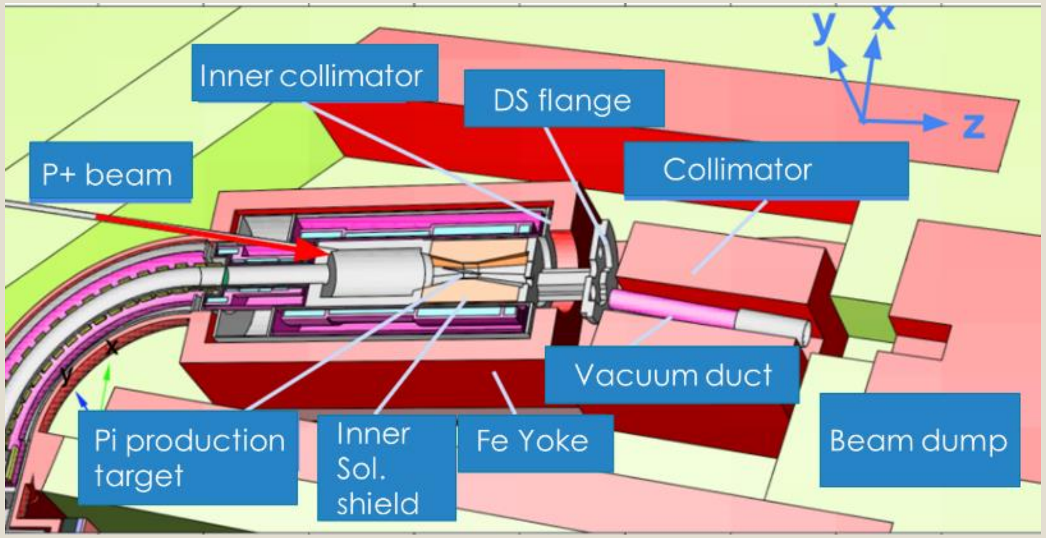
Pi - production target
C/C composite, t=1.1 mm

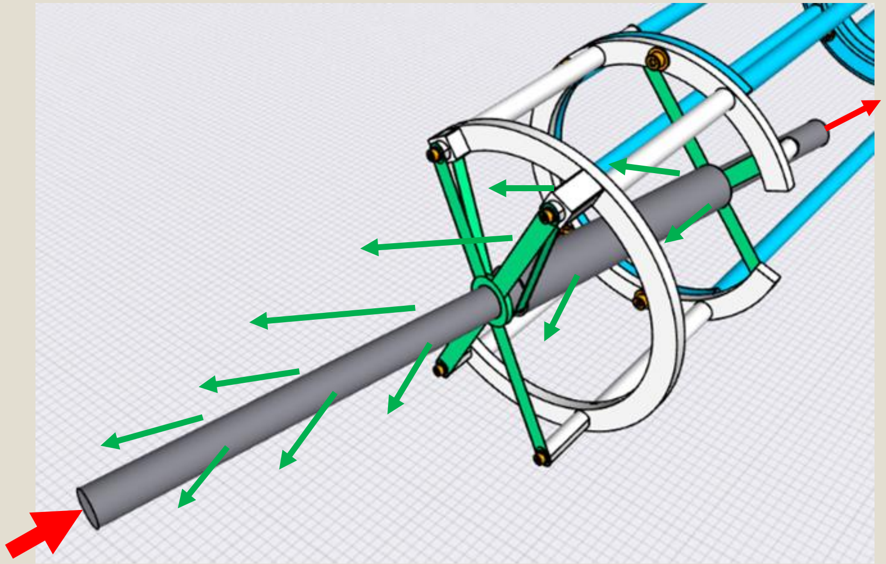


Beam loss monitor
Coincidence measurement

Phosphor plate & imaging tube camera

Pion production target for phase 1





The objective is to collect as many muons as possible.

Graphite rod, L=700 mm, is floating on the center of superconducting solenoid magnet.

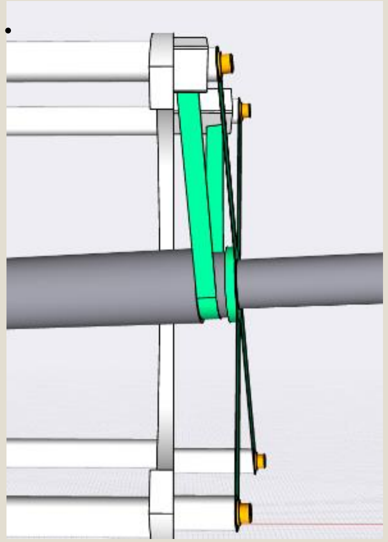
<u>Target support</u>

- Should not disturb the pion transport
- Will be irradiated by proton beam

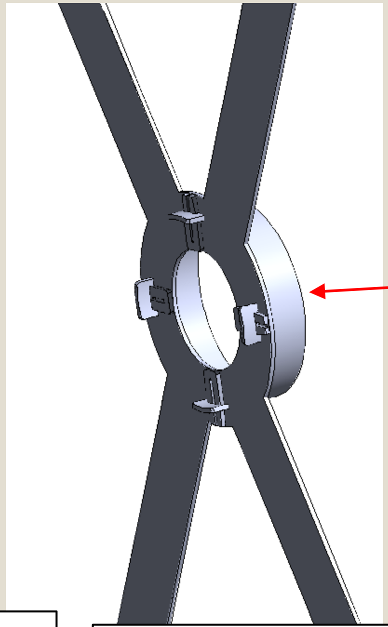
<u>Material & Structure</u>

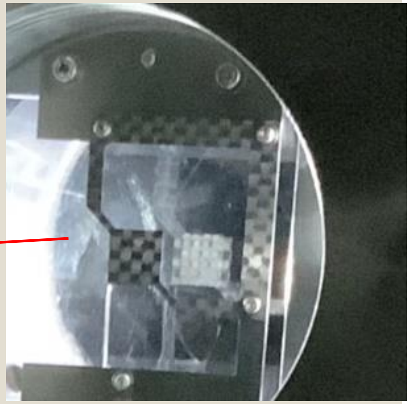
- Refractory material
- Not-bulk material
- Low-density is preferable

- C/C composite
- SS304, 64Ti, Inconel



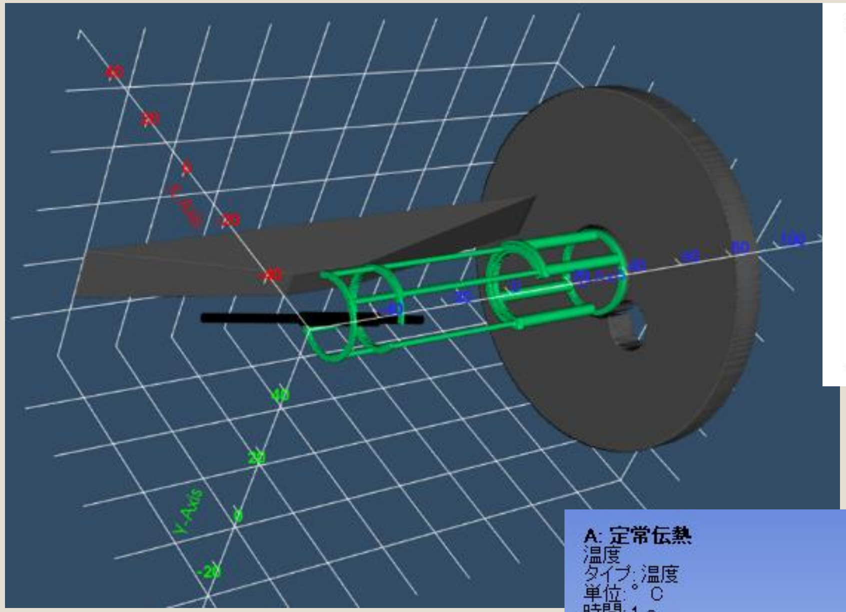
Reinforcement of target support for the axial direction

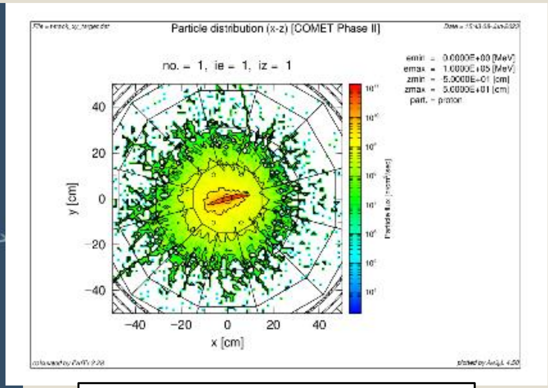




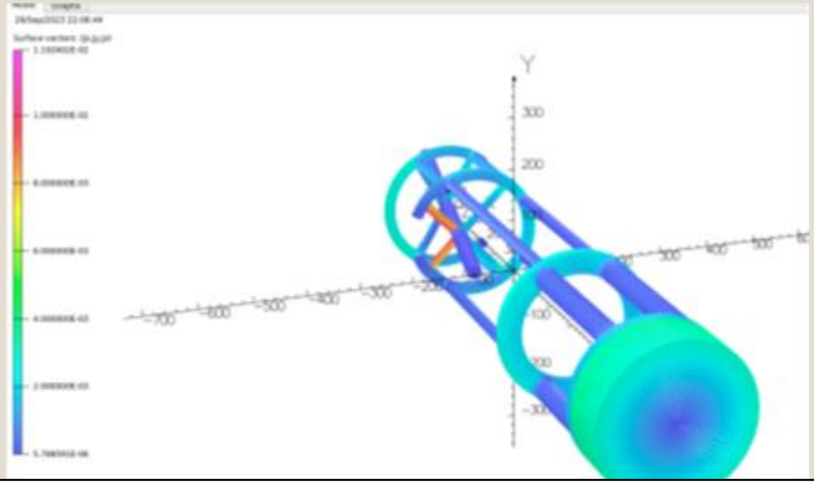
Manufacturing of target support by C/C composite

Dose analysis, Thermal analysis & Eddy current analysis

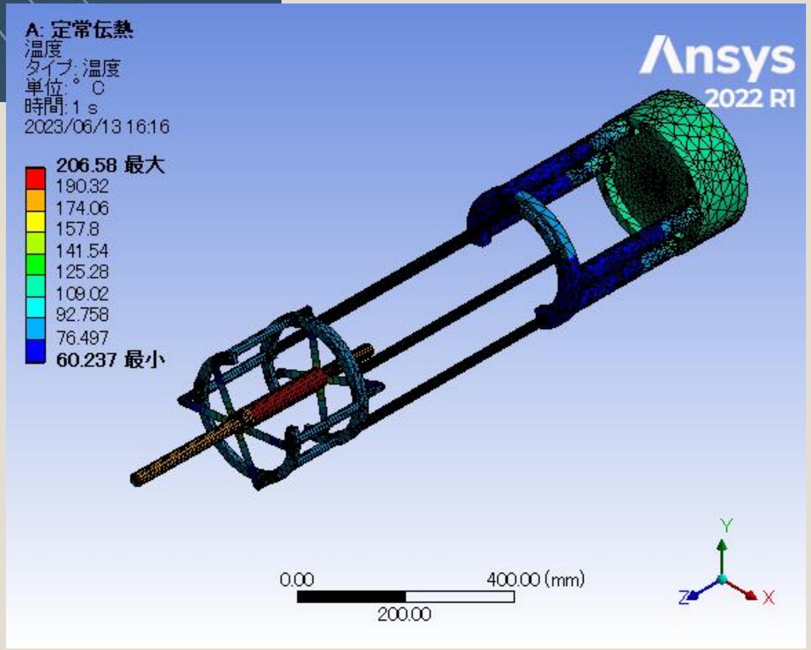




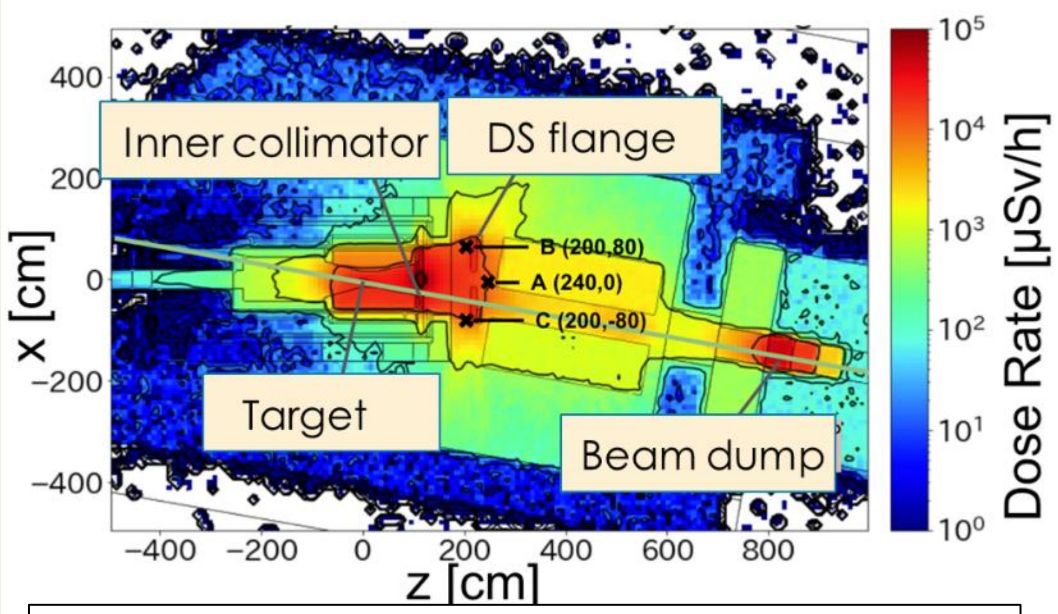
Proton distribution
on upstream view



Eddy current analysis when the quench occurs by
Sumi in Cryogenic section

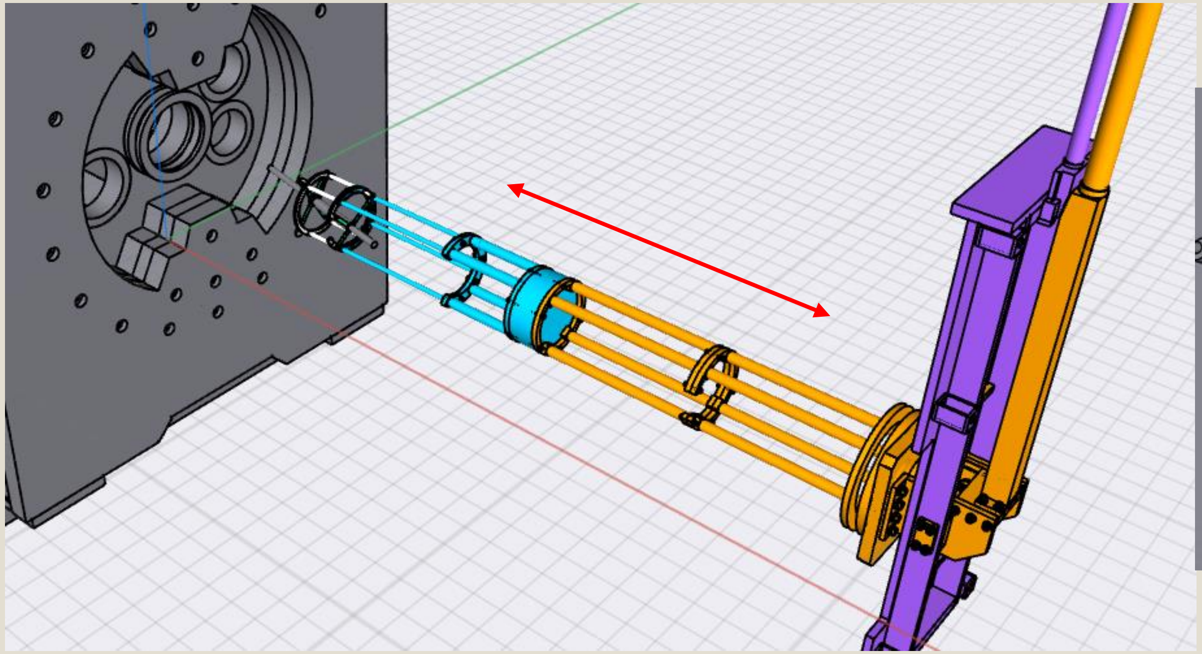


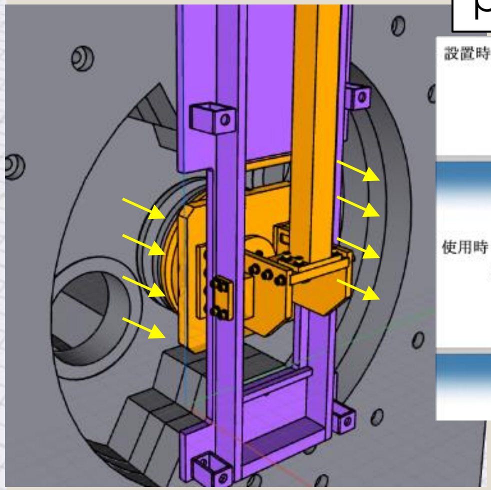
Max. temperature: 200 °C
PHITS & ANSYS simulation by
Metal technology Co., LTD.



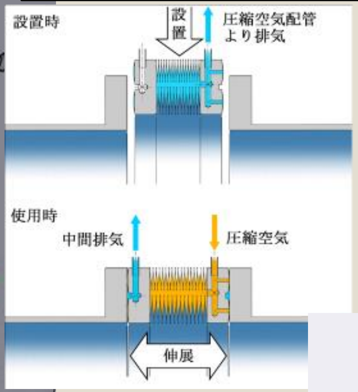
Residual radiation dose analysis by Kyusyu University

Target assembly in phase 1





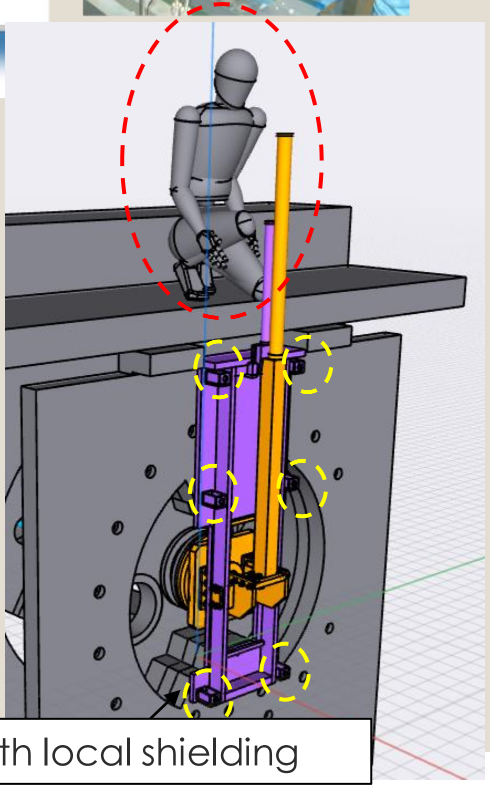
3000 kgf of load by the air-pressure of pillowseal must be considered.



The target assembly is inserted into the solenoid shield by semi-remote-handling.

We must consider

- How the structural strength is guaranteed.
- How the accuracy is guaranteed.
- How it is maintained in the high radiation area.

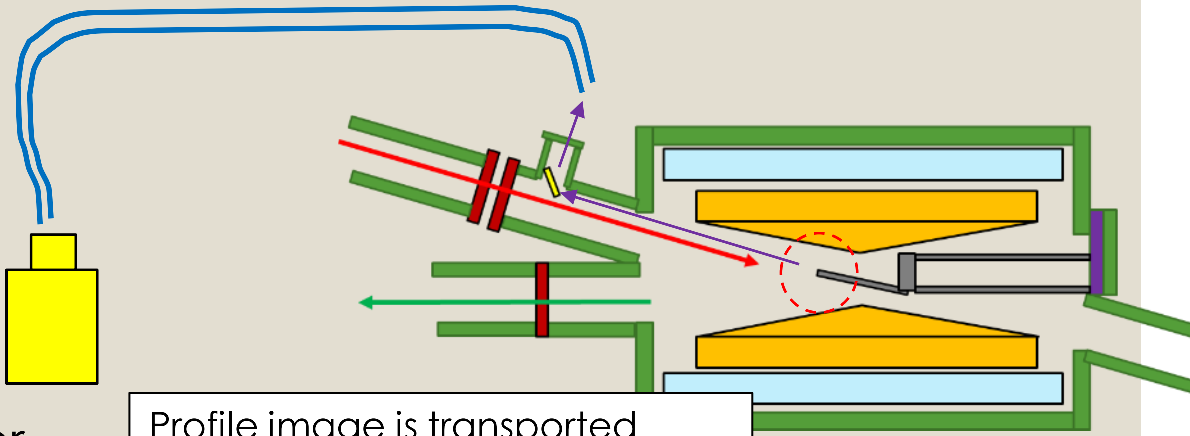


Maintenance with local shielding

Beam profile monitor on target position

- Proton beam twines around the axis of solenoid magnetic field.
- Downward 40 cm on the dump position
- Difficult to align the beam position on target

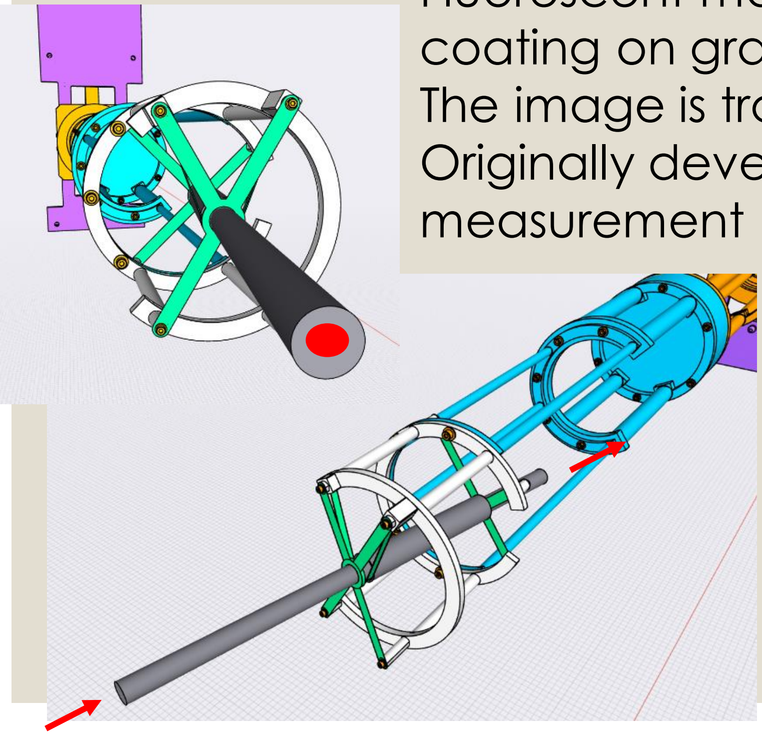
Collaboration with Hong Ming & Liang Wen in Institute of Modern Physics in China

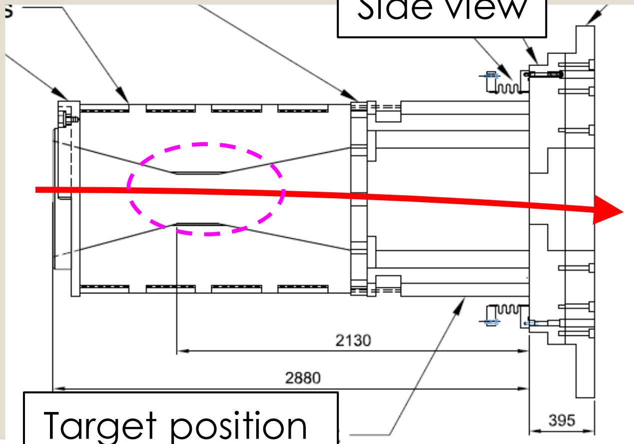


Profile image is transported through mirror and optical fiber.

<u>Importance of beam profile monitor on target position.</u>

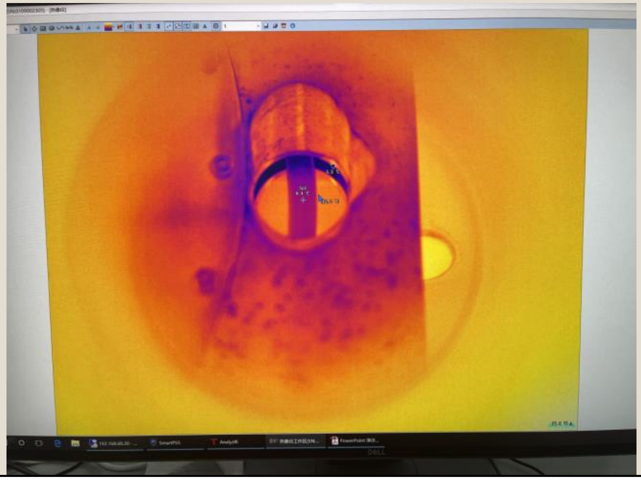
Fluorescent material, Al2O3+Cr2O3 coating on graphite.
The image is transported by optical fiber.
Originally developed at ORNL for SNS measurement





Side view

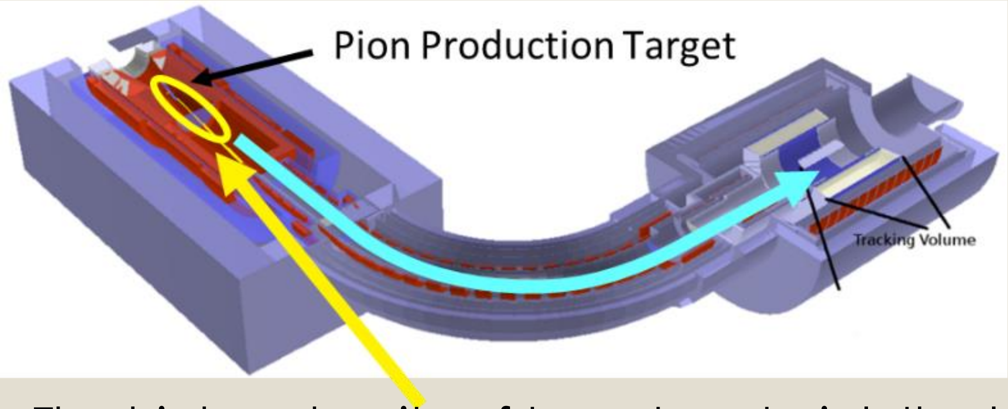
Target position



Profile measurement @CAFÉ Linac, IMP

COMET Phase 2 target

TFGR tungsten: S. Makimura
He-embrittlement: T. Sakamoto } Poster session
Water-cooling target: N. Kamei → Oral session

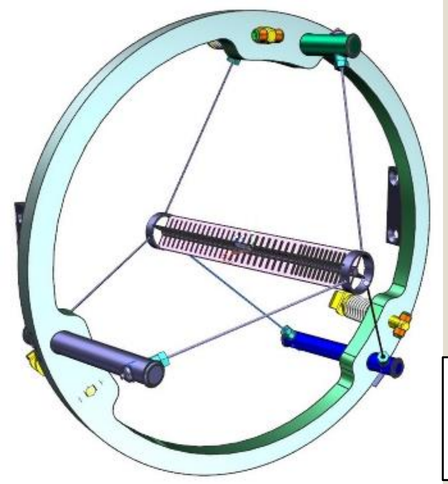


	graphite	tungsten
Density (g/cc)	1.82	19.2
Transport efficiency	1	3

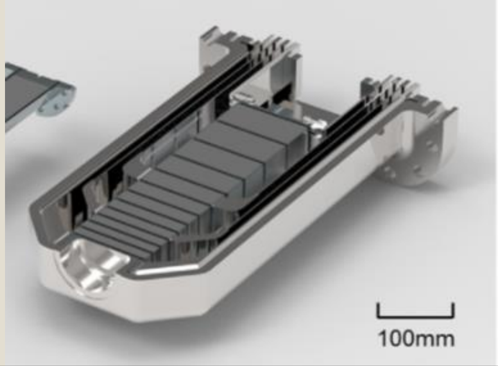
- The higher density of target material, the lower spatial volume of muon source
- The lower spatial volume, the higher capture and transport efficiency of muon

COMET	Proton beam power	Target material	Cooling
Phase 1	3.2 kW	Graphite	Thermal radiation
Phase 2	56 kW	Ta-clad Tungsten	Water cooling

Mu2e@ Fermi	Proton beam power	Target material	Cooling
Phase 1	8 kW	Tungsten	Thermal radiation



Thermal radiation cooling tungsten target at Mu2e



Water cooling Ta-cladding tungsten target at RAL

Design & Fundamental Research: US-JP collaboration with Fermi-lab is under discussion.

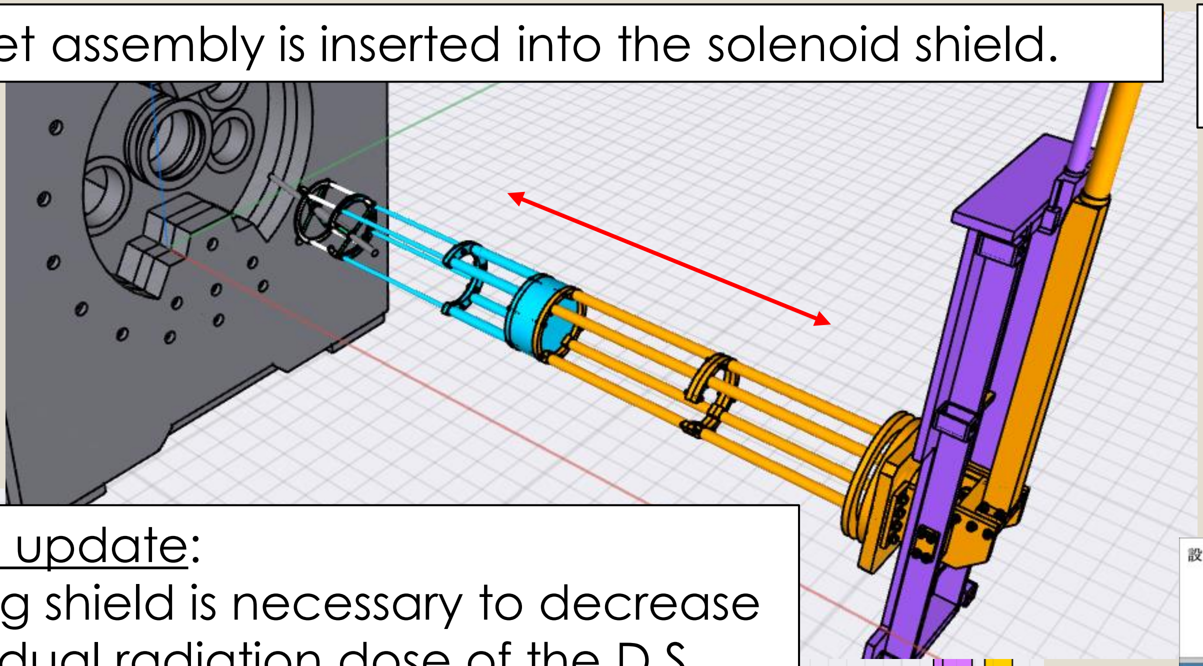
Summary

- The developments of the COMET target, located on the center of solenoid magnetic field.
- Phase alpha operation in Feb, 2023
- Design of Phase 1 is on going.
- Development for Phase 2 will start soon.

Thanks for your attention

Target assembly in phase 1

The target assembly is inserted into the solenoid shield.



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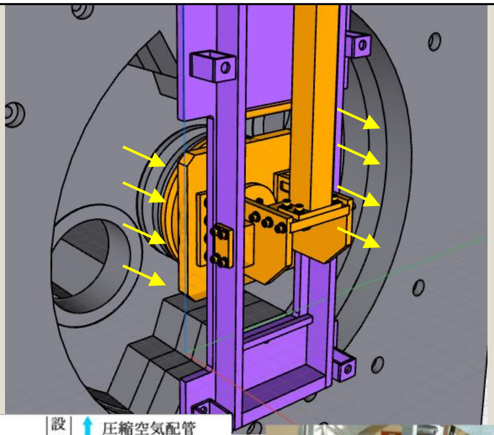
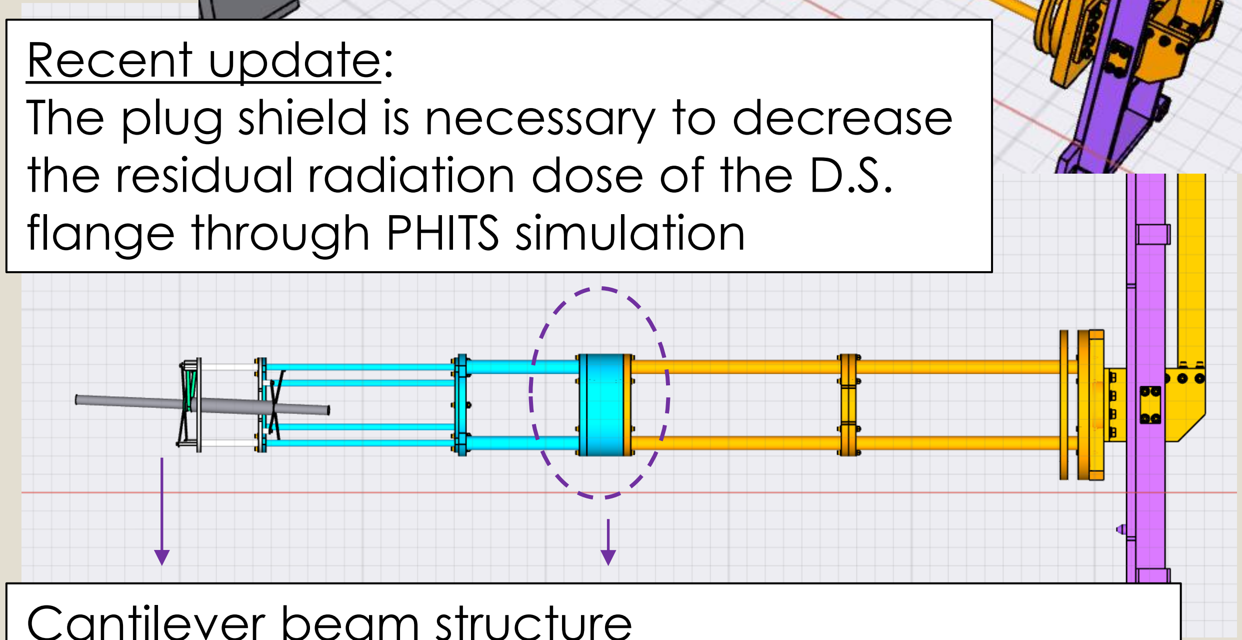
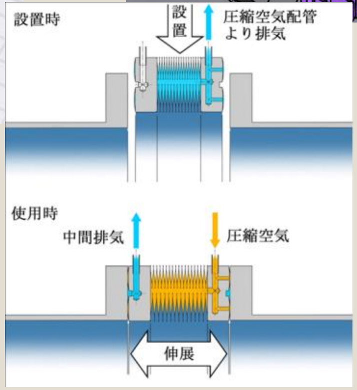


Recent update:
The plug shield is necessary to decrease the residual radiation dose of the D.S. flange through PHITS simulation



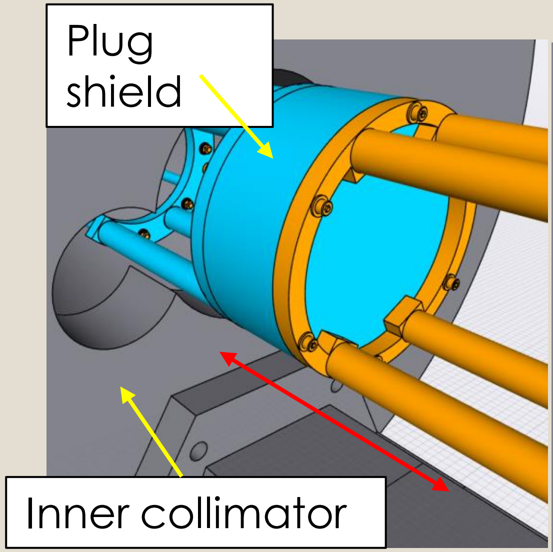
Cantilever beam structure
The distortion of the target position is 2-3 mm due to the weight of the inner collimator, 50 kg.

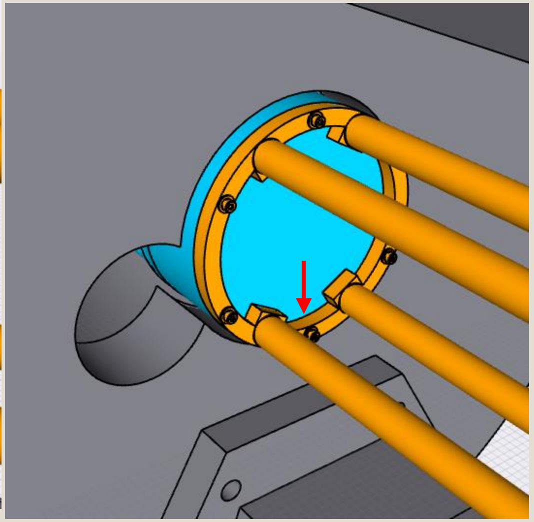


We must consider

- How the structural strength is guaranteed.
- How the accuracy is guaranteed.
- How it is maintained in the high radiation area.

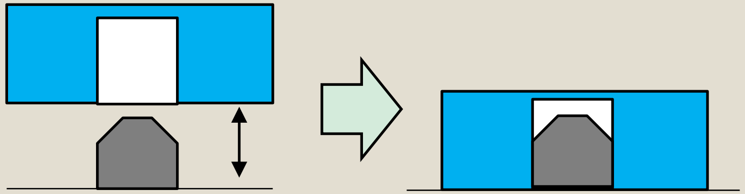
Accuracy and precision

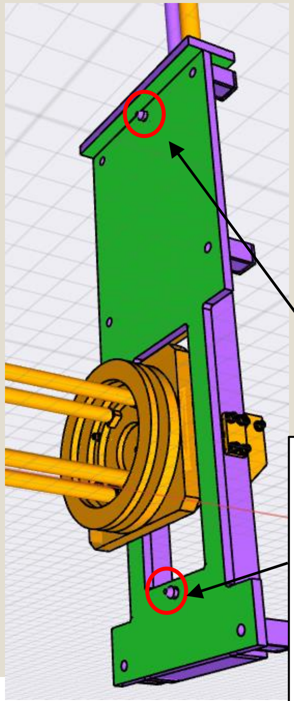


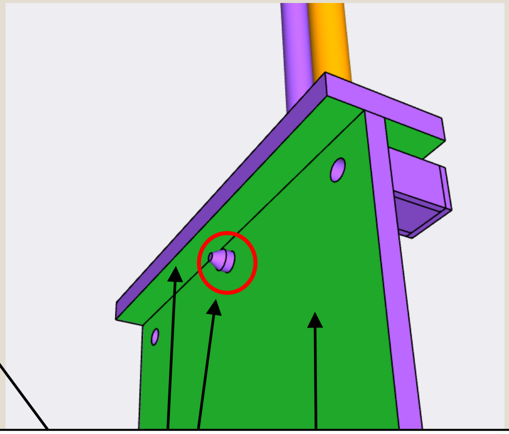


Difficult to use guide pins because of the limitation of the space and the risk of the stuck here.
The weight of the plug shield is just supported by the inner collimator.

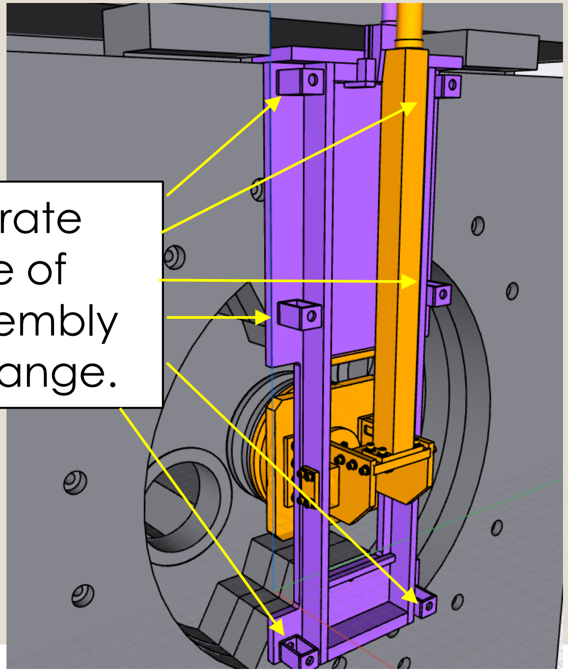
Need the space for guide pins





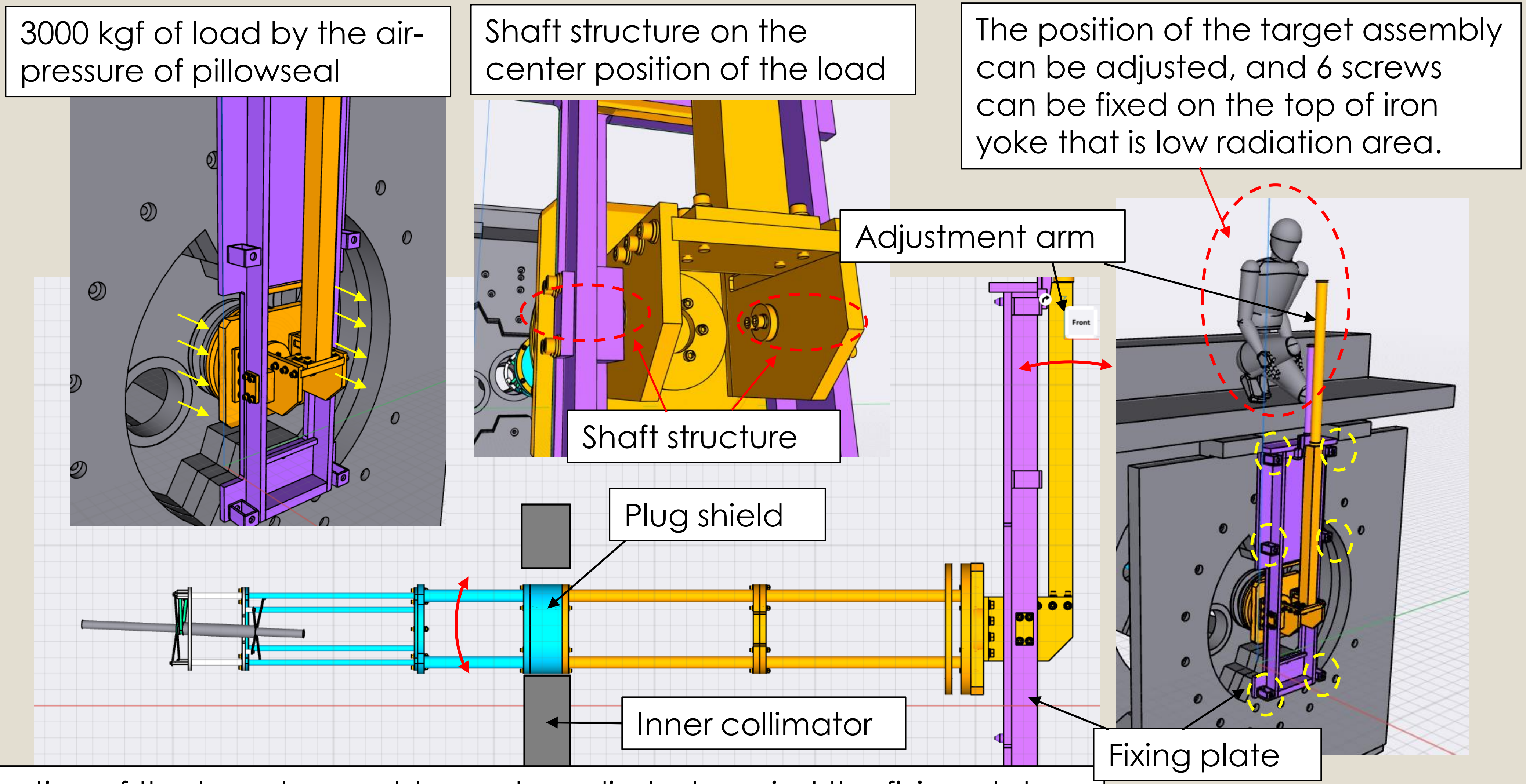


Two horizontal guide pins and two planes determine the accuracy and precision.
Two long holes against the pins on D.S. flange.



6 screws integrate the fixing plate of the target assembly with the D.S. flange.

structure Against load of pillowseal and semi-remote maintenance



The location of the target assembly can be adjusted against the fixing plate by the adjustment arm. The plug shield is just supported by the inner collimator.