The Commissioning Workshop of ESS-J-PARC collaboration

10-12 October 2022
European Spallation Source ERIC

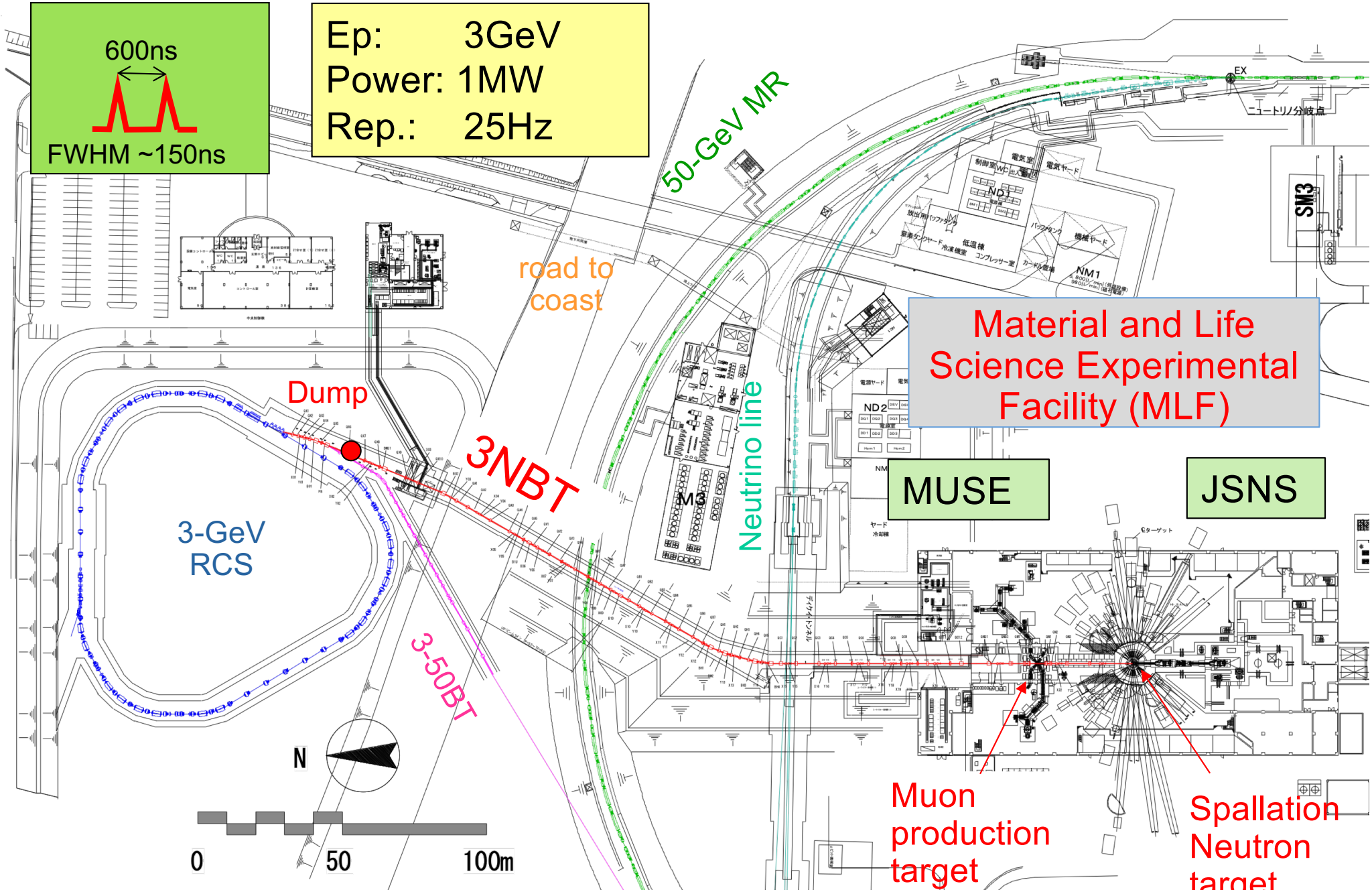
Beam commissioning at the MLF target station

(J-PARC/JAEA) Shin-ichiro Meigo

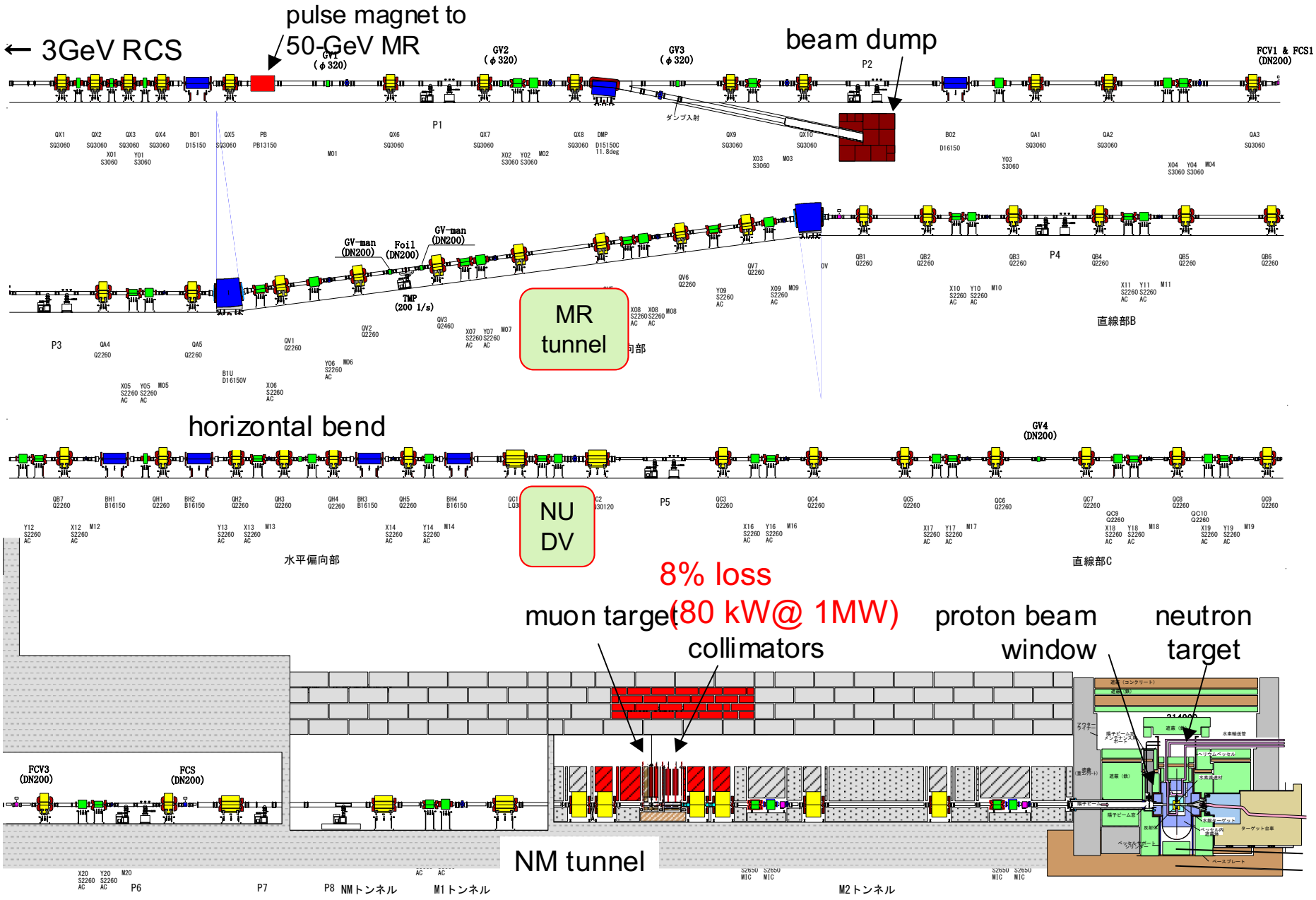
Contents

- Beam transport from 3-GeV rapid cycling synchrotron (RCS) to neutron target (3NBT)
- Day-1 beam commissioning status at MLF
- Current beam commissioning status at MLF

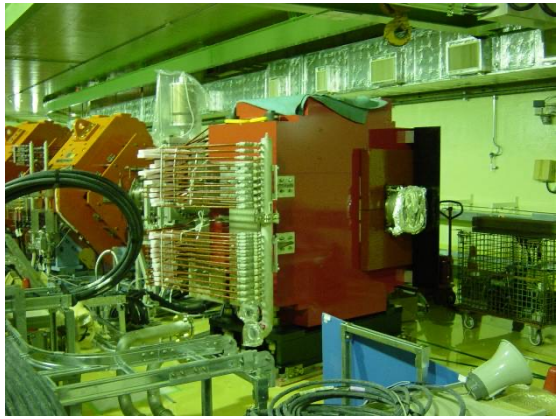
Beam transport to MLF (3NBT)



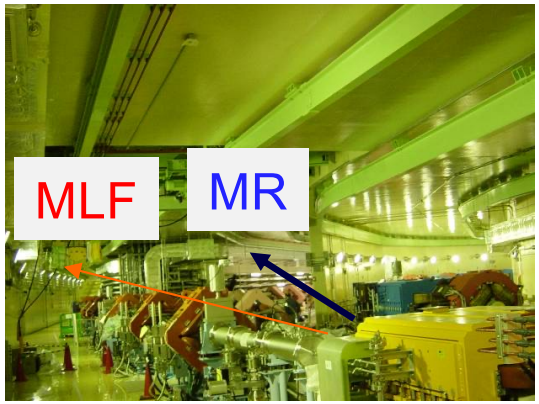
Vertical view of 3NBT



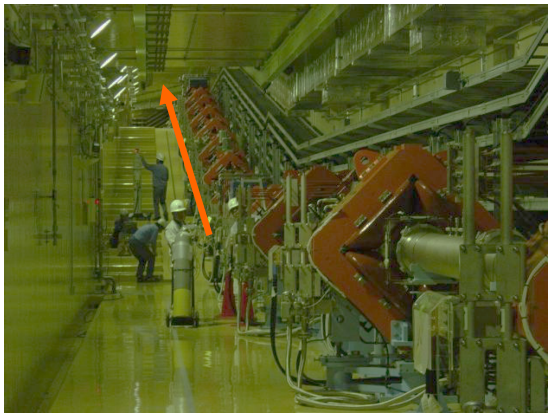
Inside beam tunnel



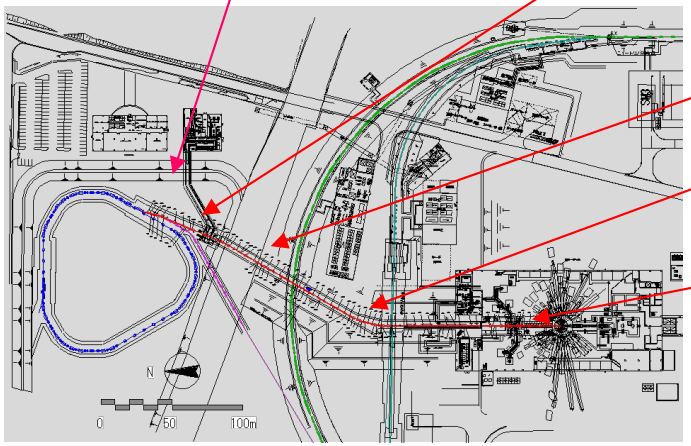
Extraction septum



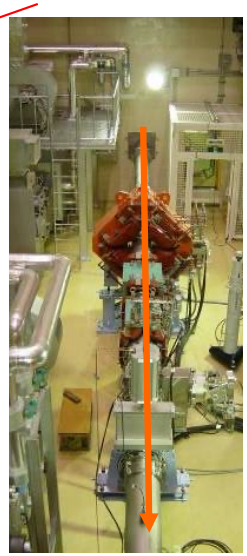
Ext and BT for MR



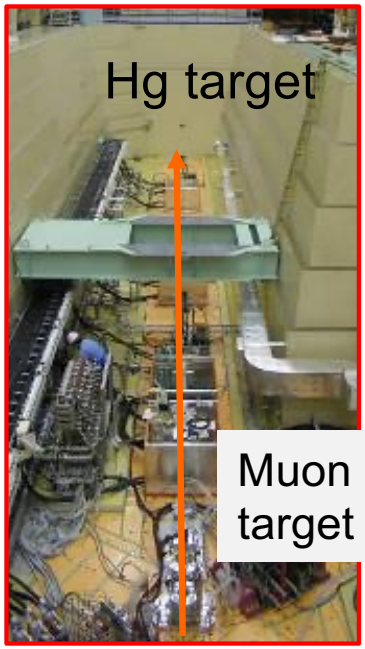
Vertical bend section



Horizontal bend section



M1 section

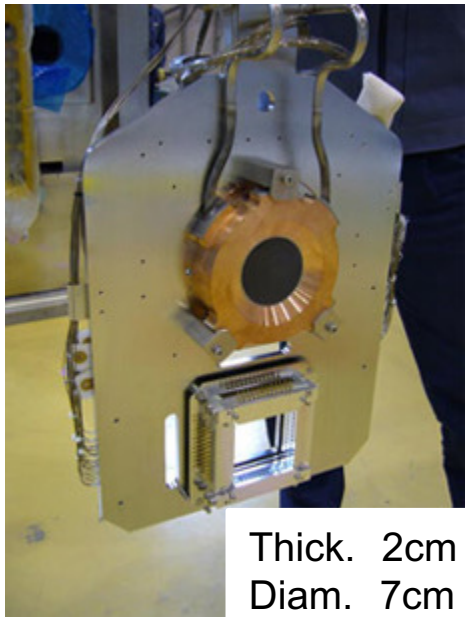


M2 section

NIMA.2006.02.076

Targets located at MLF

- Muon prod. target
  - Carbon graphite (IG430)

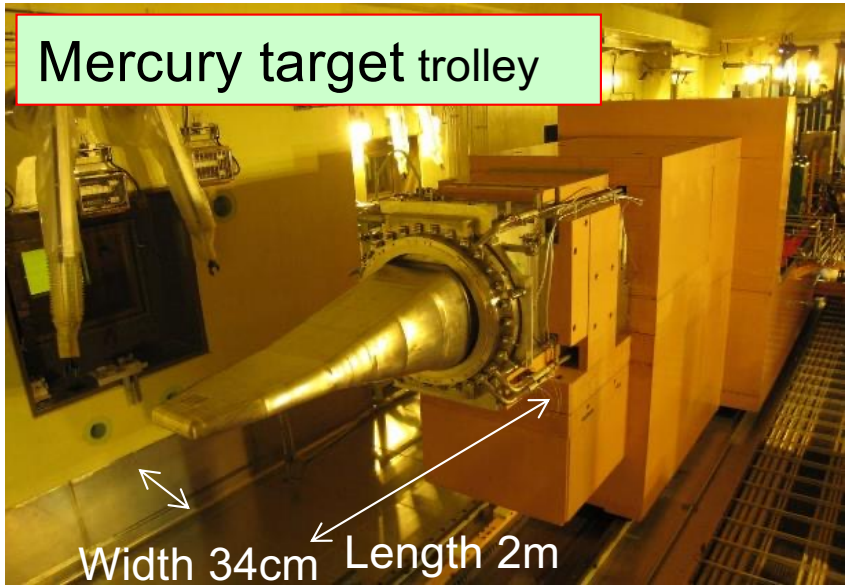


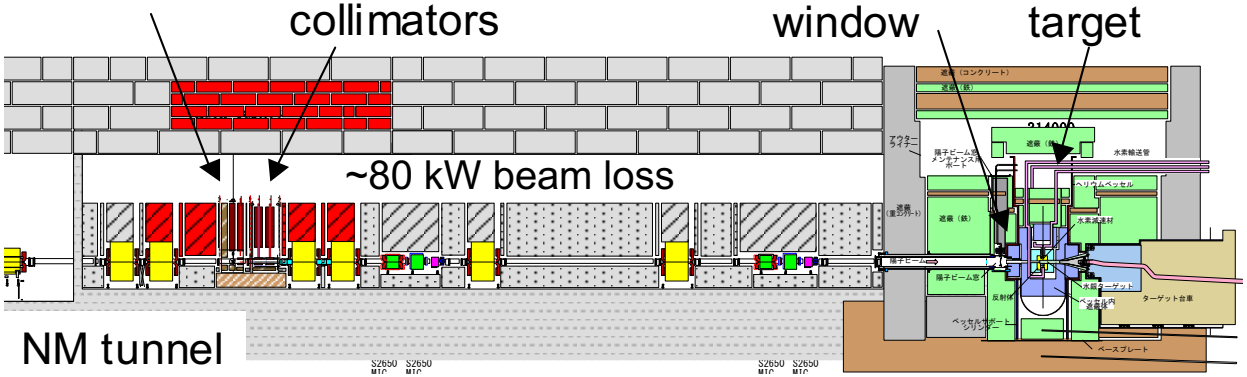
Thick. 2cm
Diam. 7cm

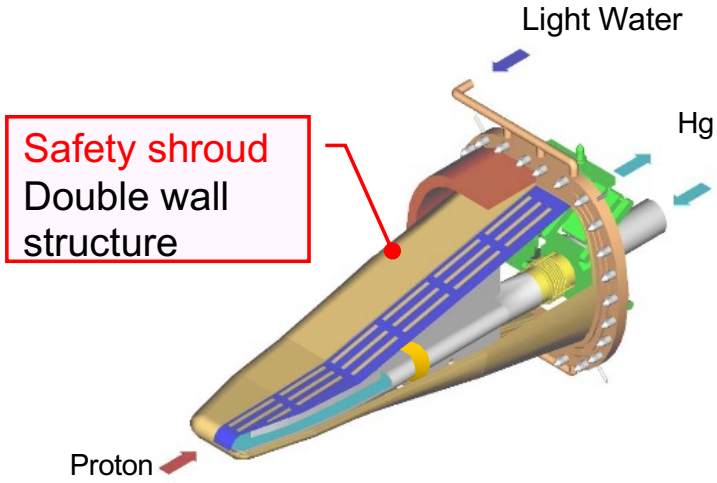
Rotating type
(60 rpm)

Makimura et al.

- Neutron prod. target
  - Mercury
  - Highest pulse intensity in the world

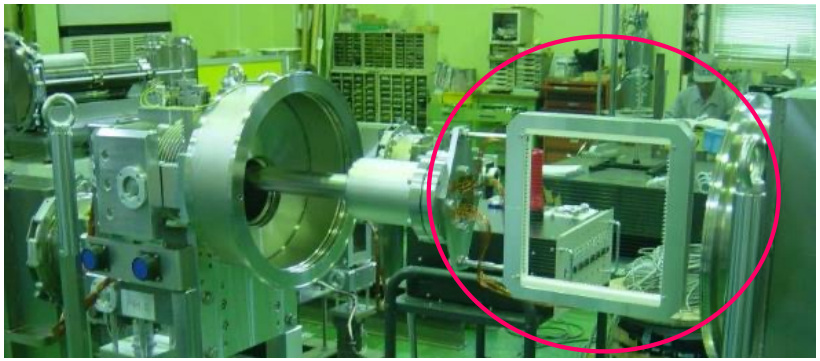


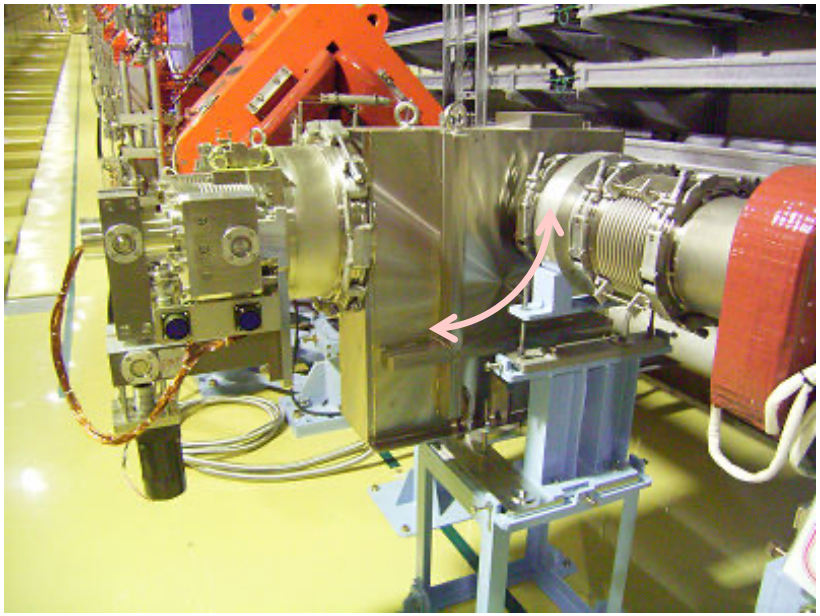


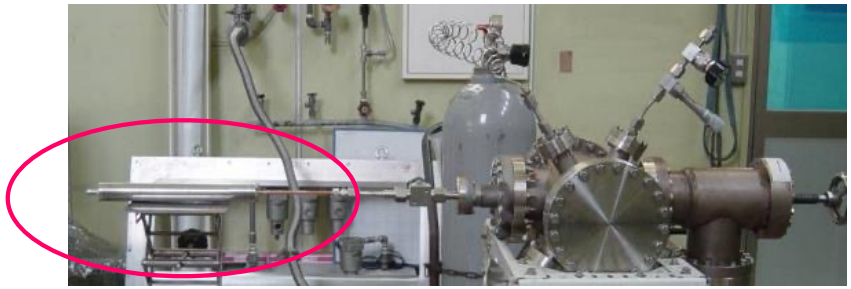


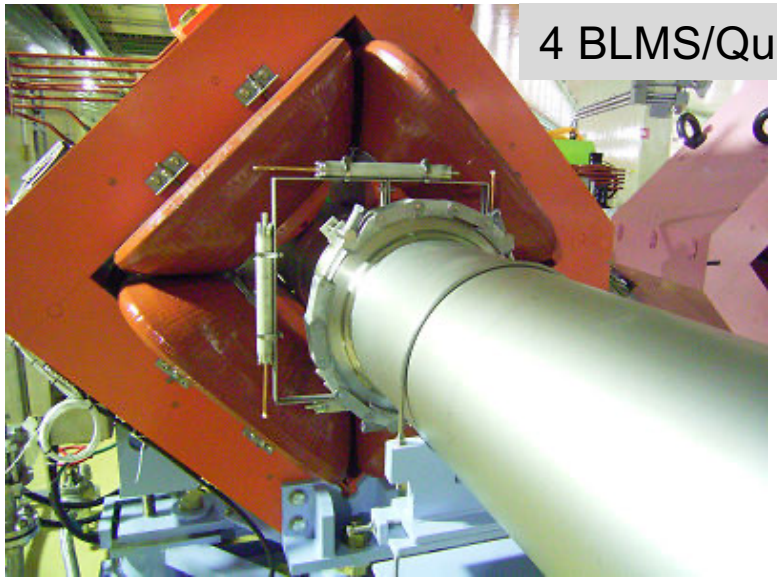
Beam monitors

HB2018-TUP1WE03









4 BLMS/Quad

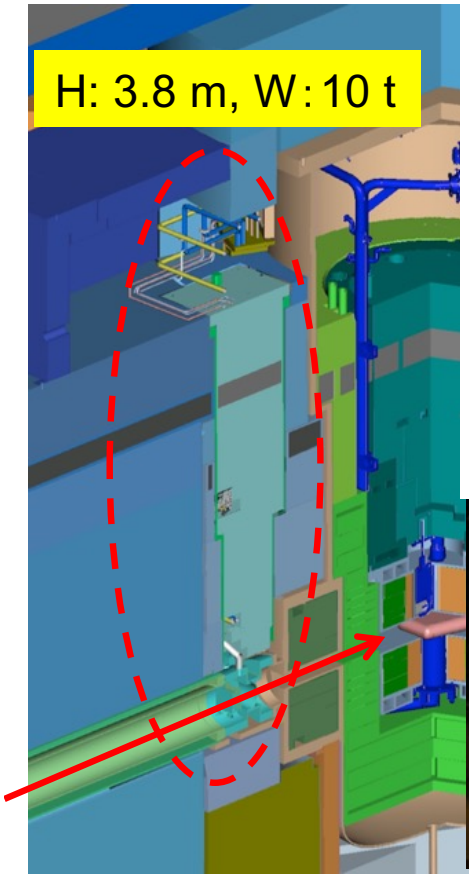
- Multi wire profile monitor
  SiC ϕ0.15mm(H 32 x V 32 chan.)

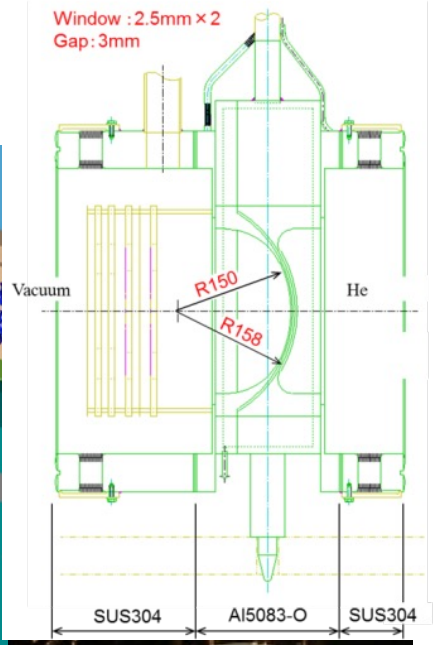
- Beam loss monitors (BLMs)
  $ArCO_2$ (0.1MPa)

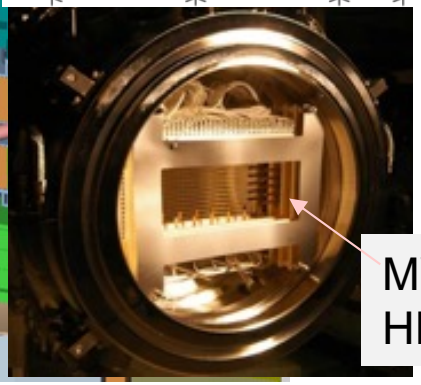
BPMs were installed, as well.

Proton Beam Window at MLF

- Beam profile (MWPM) and halo monitors (HM) are implemented at Proton Beam Window (PBW) made of Al-alloy (A5083).
- Lifetime estimation*: Post Irradiation Examination (PIE) for safety shroud (AlMg3) at SINQ in PSI



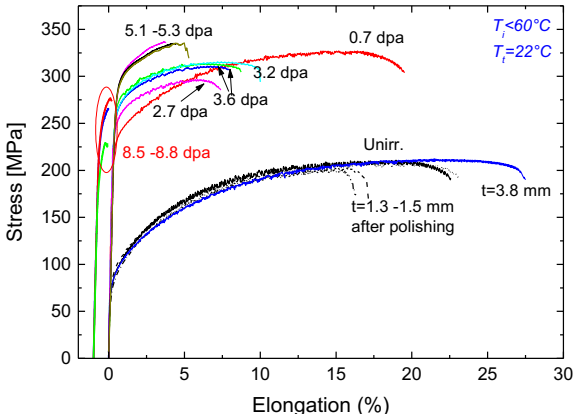


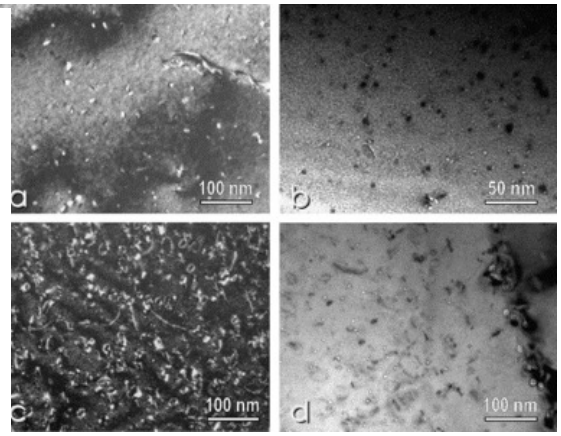


MWPM,
HMs (SEC, TC)

Result PIE at SINQ for 0.6-GeV protons

Y. Dai, et al, J. Nucl Mat. 343 184 (2005)





Lifetime of PBW: Determined by He gas production (1200 appm) 2 years*

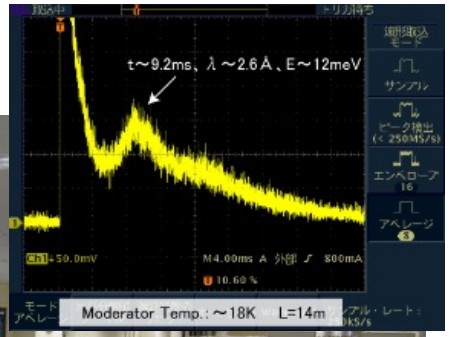
New PIE result at the SINQ (2400 apmm), lifetime may apply ~3 years.

* S. Meigo, et al, J. Nucl Mat. 450 141 (2012)

1st beam commissioning at MLF

- For the first beam, easily irradiation ~5 kW beam on the target (just one shot of beam required for both beam transport and neutron production confirmation.
- Almost beam tuning was made with single shot mode.
- User operation started with 5 kW on Sept. 2008 with muon production. User operation 20 kW and 100 kW started on Dec. 2008 and Nov. 2009, respectively. (and then, see next page)

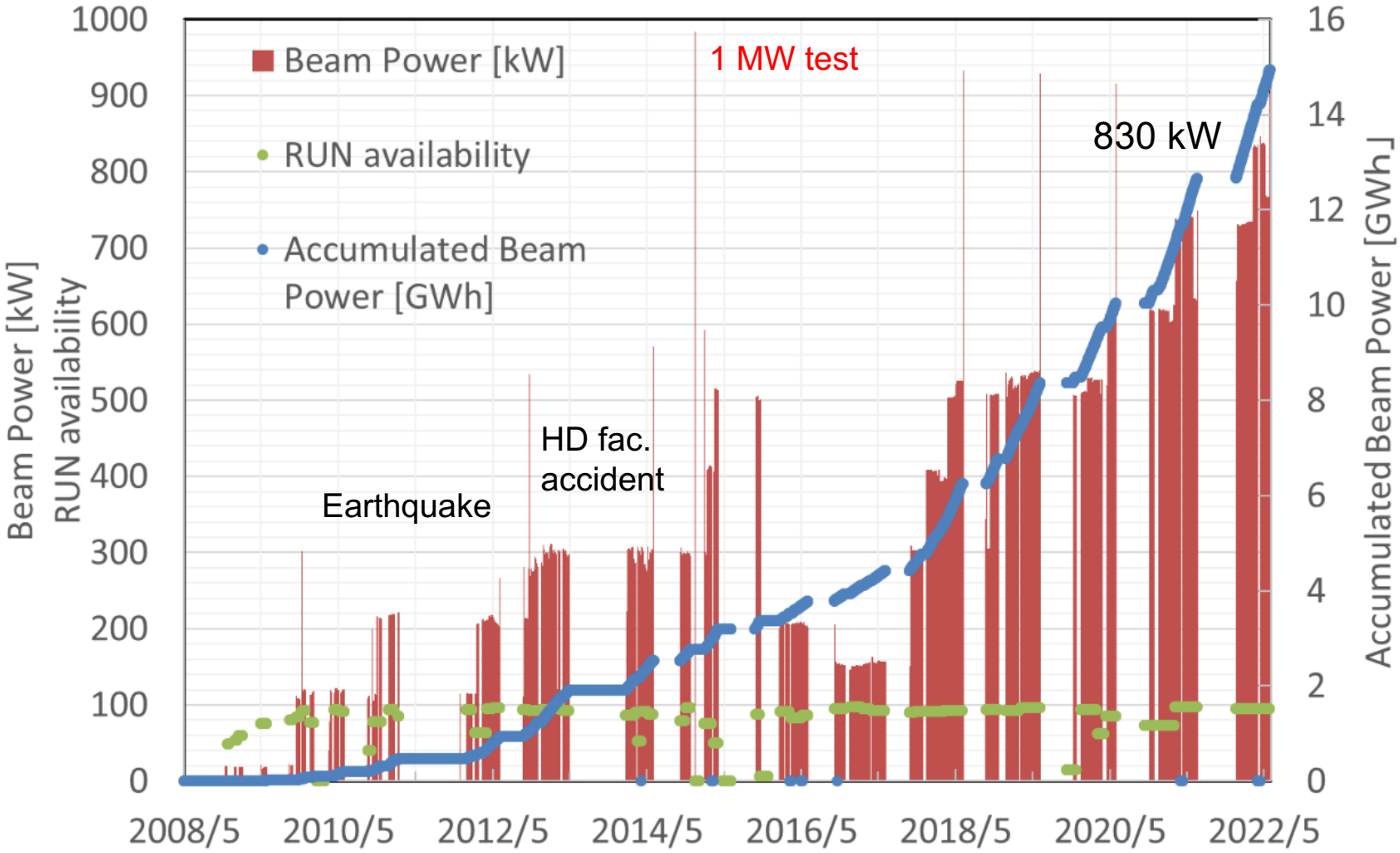
CTOF: JNST 37 2000



1st neutron beam May 30 2008

1st muon beam Sept 26 2008

Beam power trend for MLF

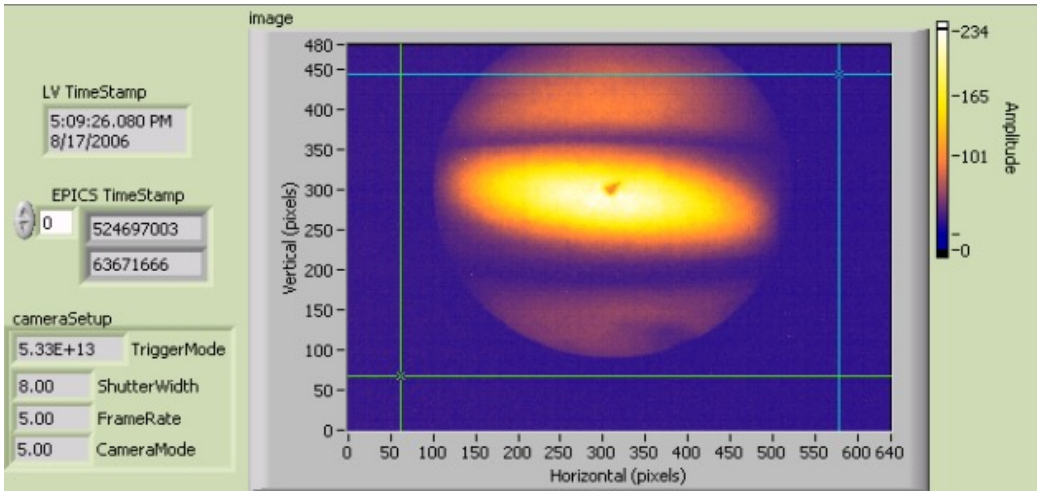


- After day 1, the beam power was rumped 800 kW for continuous operation with high availability.
- Each year, the beam power has been increased by ~100 kW.
- The 1-MW operation has been successfully done for a short period (< 3 days).

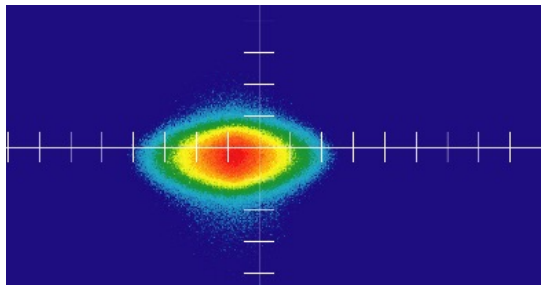
Beam profile on the target

- Damage due to pitting on the target
  - Forth power of peak density
  - Accuracy of profile is required.
- Ordinary profile measurements
  - Profile projection on horizontal and vertical axes
- SNS result
  - Skew of the beam was observed by target imaging system, which is not implemented at MLF
- Activation imaging technique was applied by placing aluminum foil in front of the target.

Skewed profile at SNS

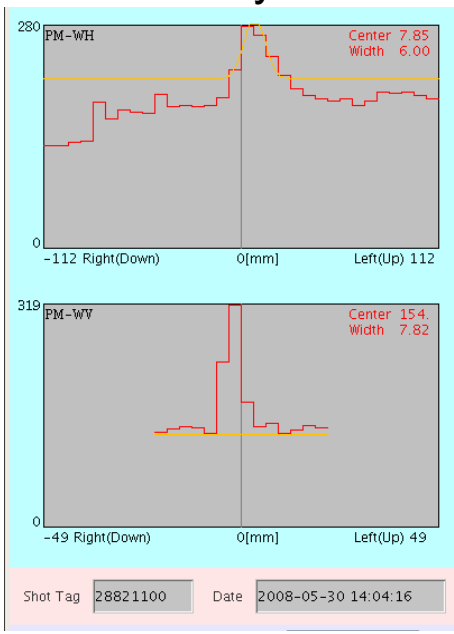


2D image at MLF

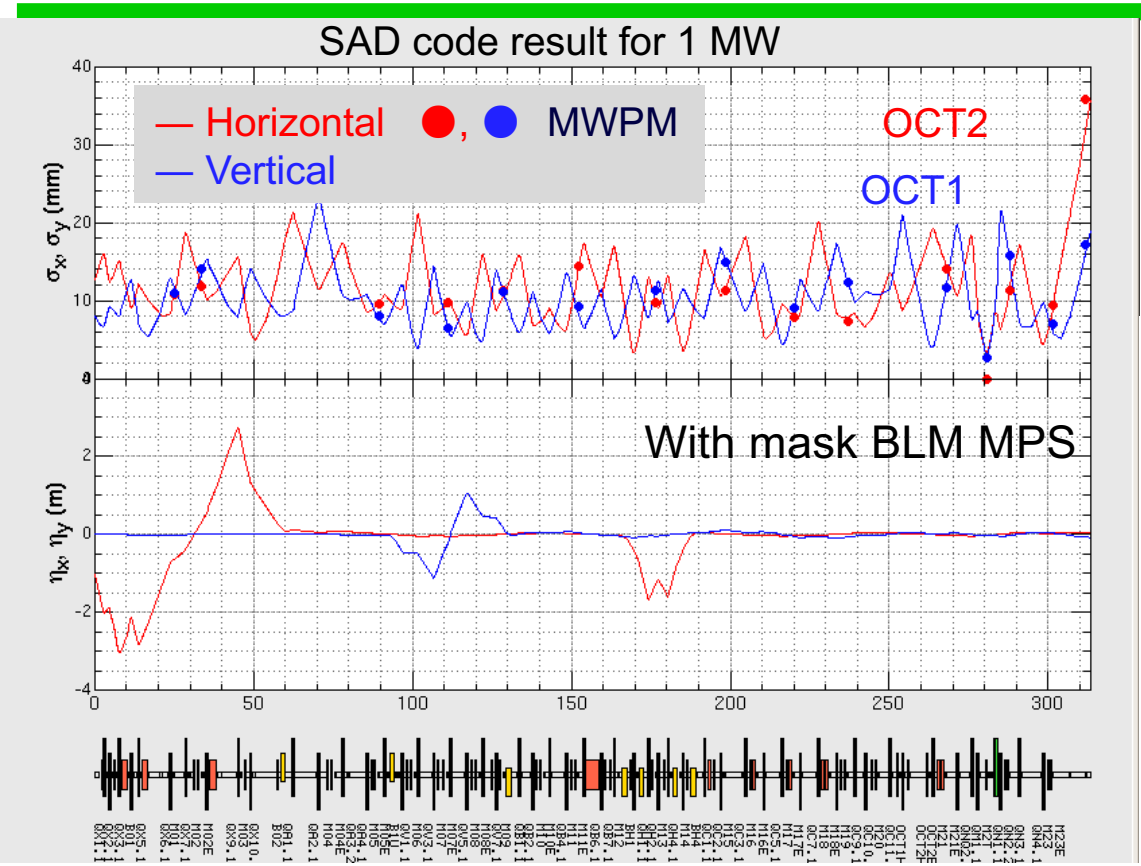


Result of activation of Al foil with Imaging Plate at MLF (No skew found)

Observed by MWPM



Beam optics



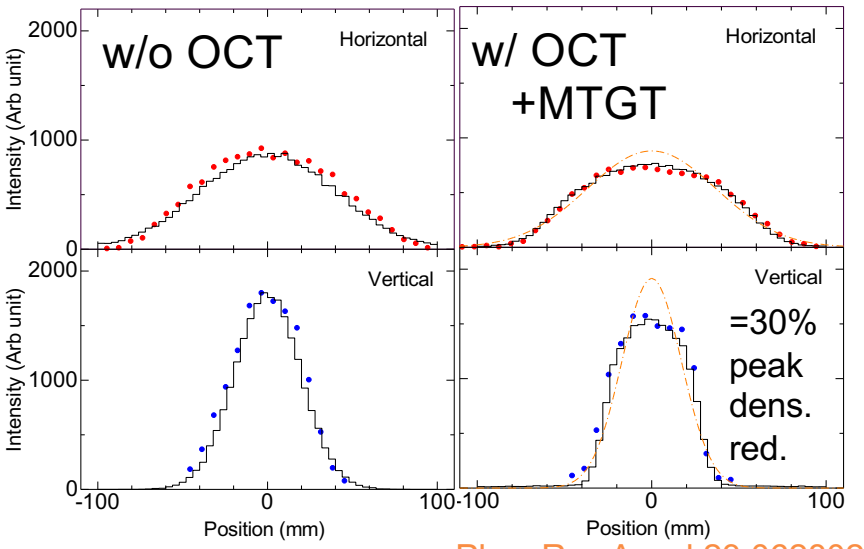
•Beam emittance

Design:

Core&Halo: 81, 324 π mm mrad

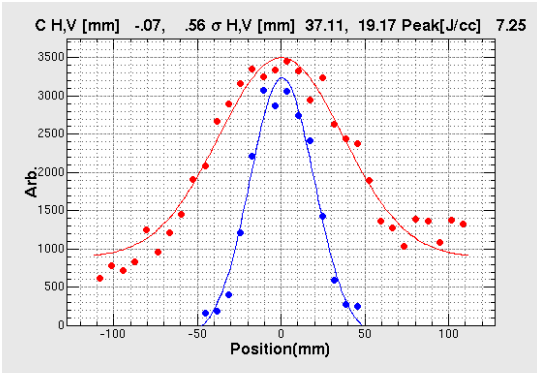
Actual: ~10 π mm mrad

for 1 MW at 1σ (accuracy <4%)



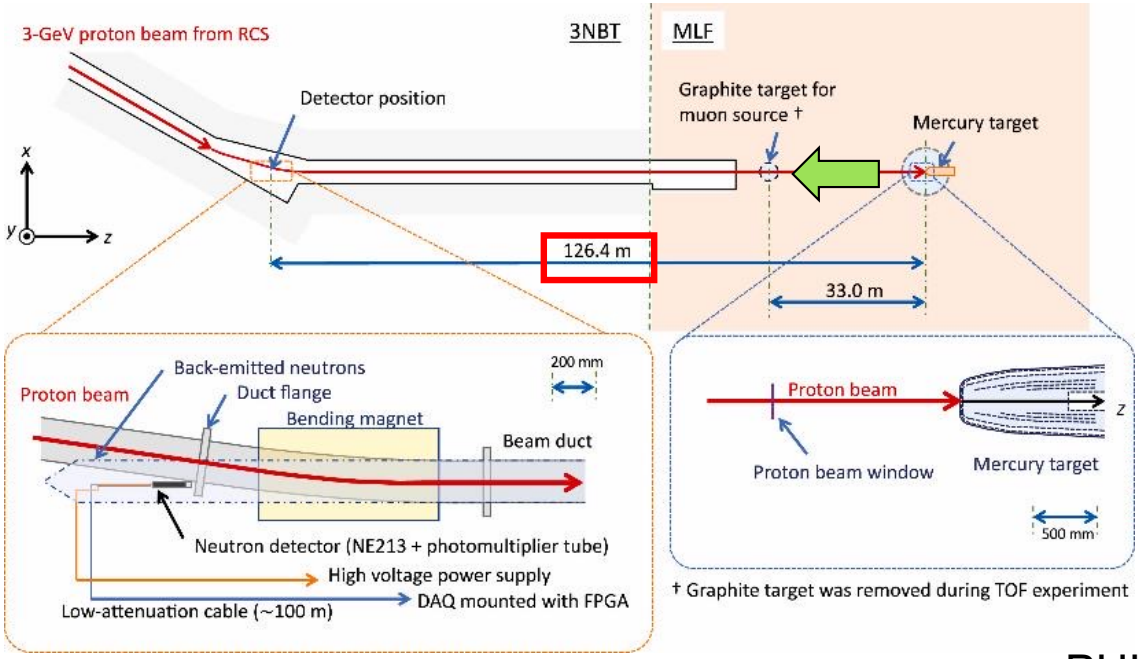
Phys Rev Accel.23.062802

Beam profile at PBW

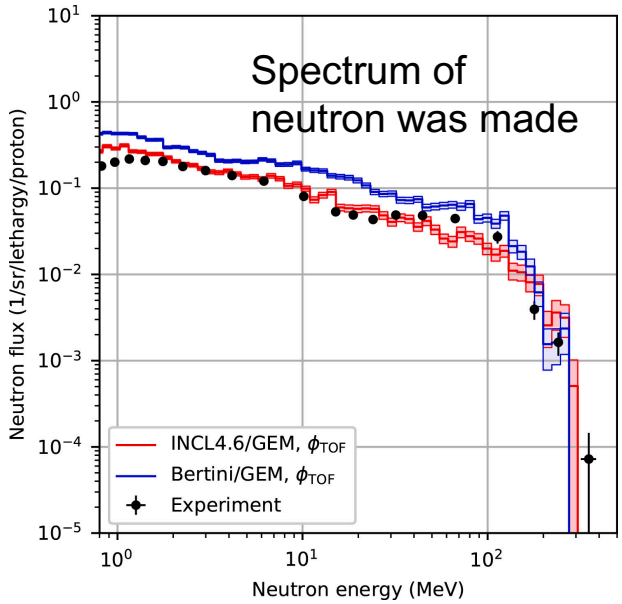


- One shot of beam is enough for the orbit correction.
- To decrees the beam peak current density on the target, octupole magnets were installed.
- Although slight change of emittance due to LINAC and RCS condition, the widths at target conserved (H: 37, V 19 mm at 1σ with confirm amount of beam halo by it monitor at PBW.
- MPS stops the anomaly beam (day-1 not implemented)

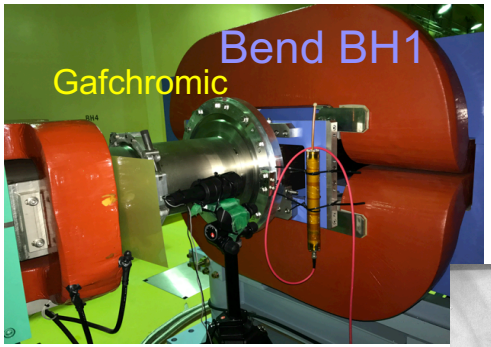
Neutron coming through beam duct



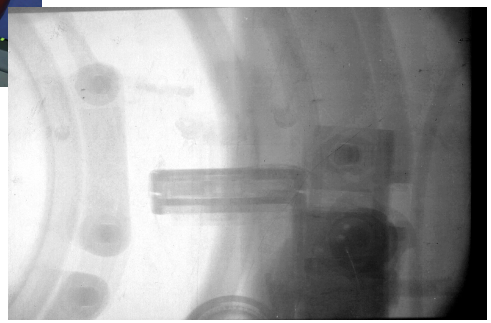
NIMB.2020.09.012



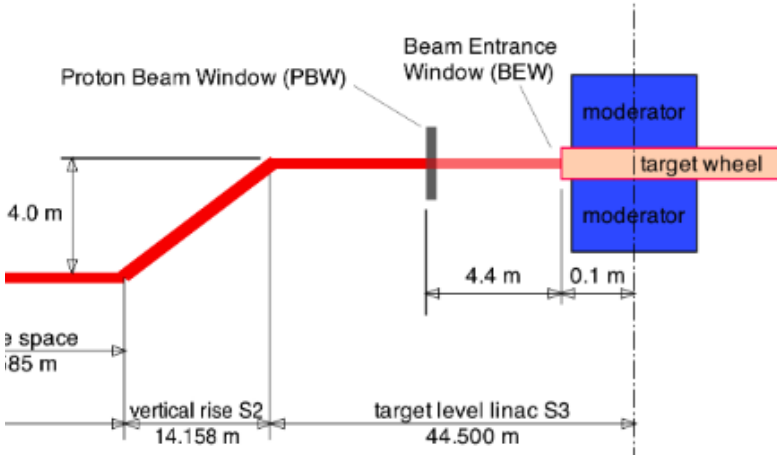
PHITS with new model of INCL predicts well.
Neutron flux: 6×10^6 n/cm^2/s at 1 MW



Well collimated neutrons beam came out



Radio activity found at flange



ESS beam transport (at 44.5 m from target)
Flux × 8 of MLF (i.e., 2×10^8 n/cm^2/s at 5 MW)

Those neutrons may be used for many sciences.

Summary

- MLF day-1 commissioning:
  - Succeeded beam transport by only one shot of beam
  - Succeeded neutron production confirmed by only one shot of beam
  - Succeeded obtain 2-D beam profile by Al-foil activation
    - No skew was found
- Current status of 3NBT and MLF:
  - Beam rump up to 1 MW successfully
  - User operation 850 kW with high reliability (April 2023 ~0.9 MW)
  - Constraints of 1 MW : Safety regarding the target (pitting erosion)
- ESS beam monitor test was made at 3NBT.

Thank you!


Successfully completed 1 MW beam test!
1MW安定運転に成功！
2018 July 3rd
平成30年7月3日
J-PARC
J-PARC MLF