The Commissioning Workshop of
ESS-J-PARC collaboration
October 10-12, 2022, ESS ERIC

J-PARC Neutron-Muon facility construction, commissioning and operation of Target, Moderator and Instruments

October 10, 2022

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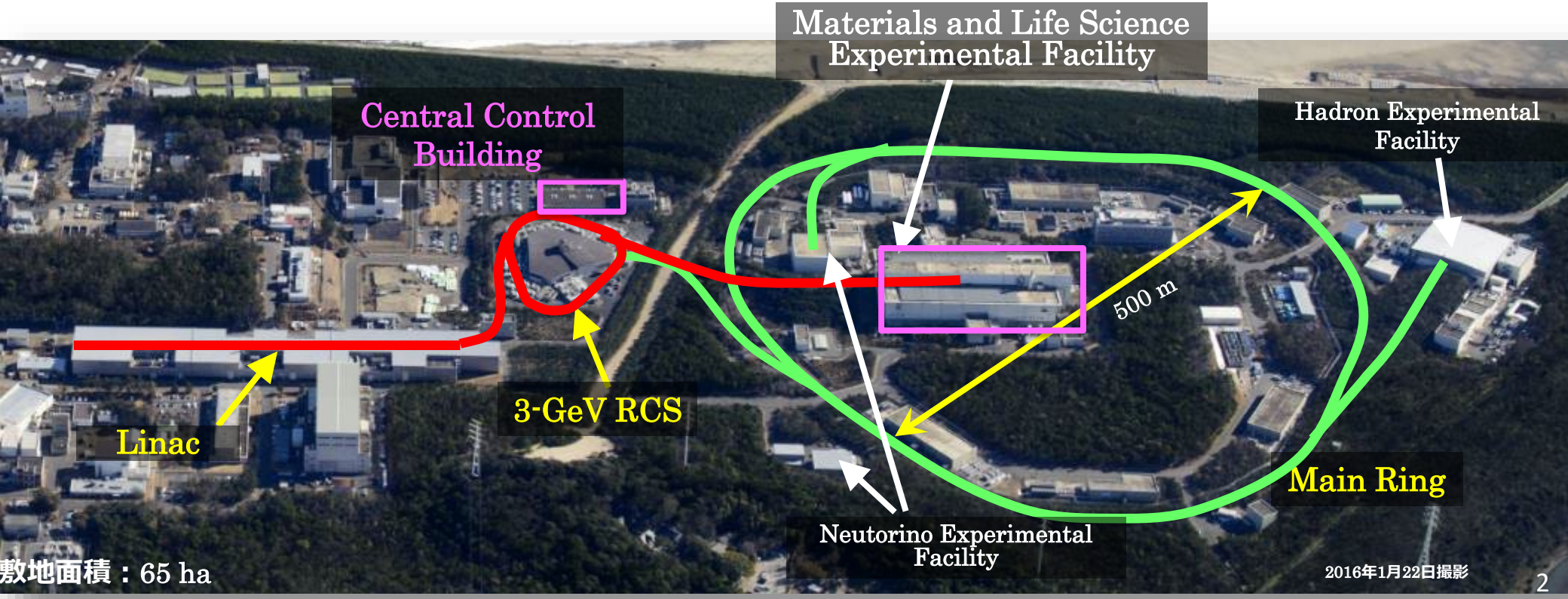
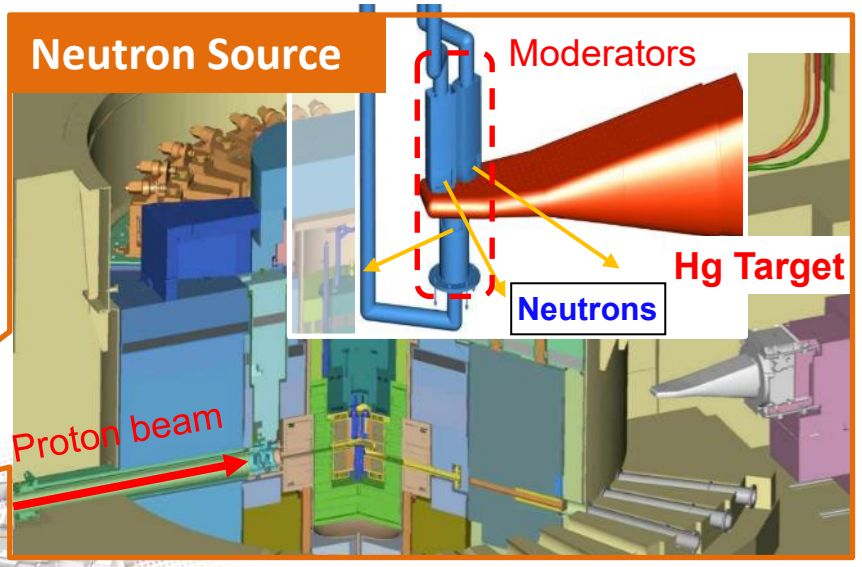
Operations of MLF in J-PARC

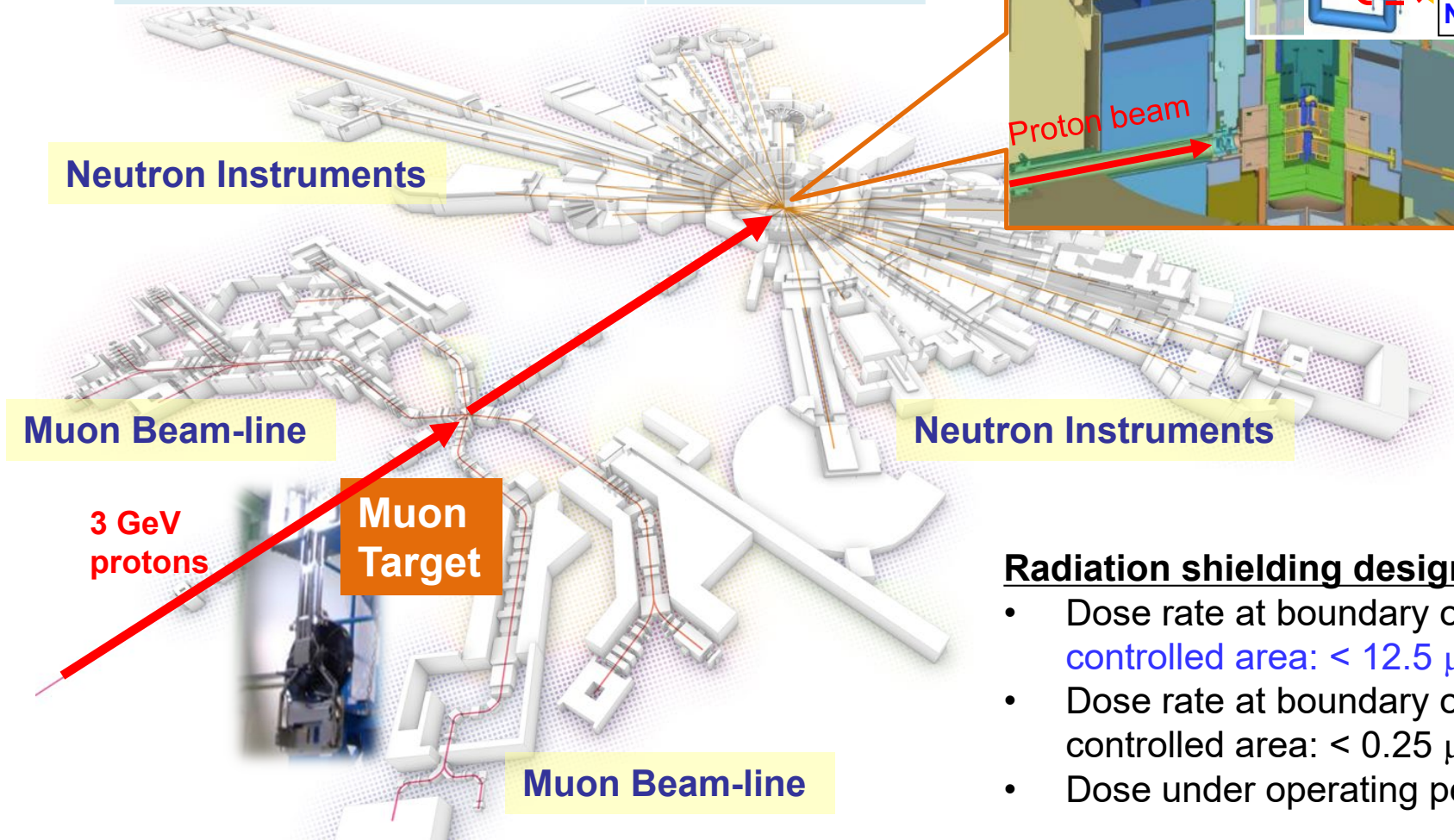
- Operations and control of accelerators are conducted at central control building.
- Operations and control of Neutron Source, Muon target and beamlines are conducted at MLF.
- Interlock signals (PPS, MPS, etc.) of MLF are transferred to accelerator control system to stop beam .



Outline of Materials and Life Science Experimental Facility MLF

Neutron production target	Hg
Moderator	LH_2 (para 100%)
Reflector	Be/Fe
Number of neutron beamline	23
Number of neutron shutter	23

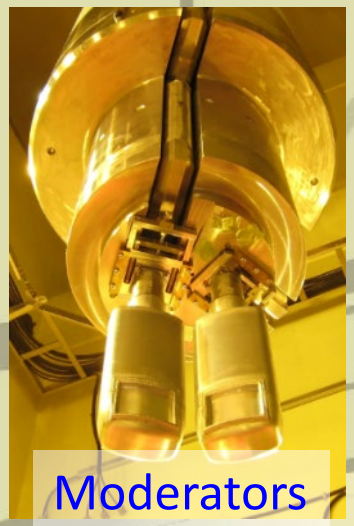




Radiation shielding design criteria

- Dose rate at boundary of radiation controlled area: < 12.5 μSv/h
- Dose rate at boundary of non-radiation controlled area: < 0.25 μSv/h
- Dose under operating period 25 μSv/h

Pulsed spallation neutron source of MLF



Moderators

Proton beam window

Neutron shutter

Shielding

Shielding

Outer liner

Cryogenic hydrogen system

Mercury target system

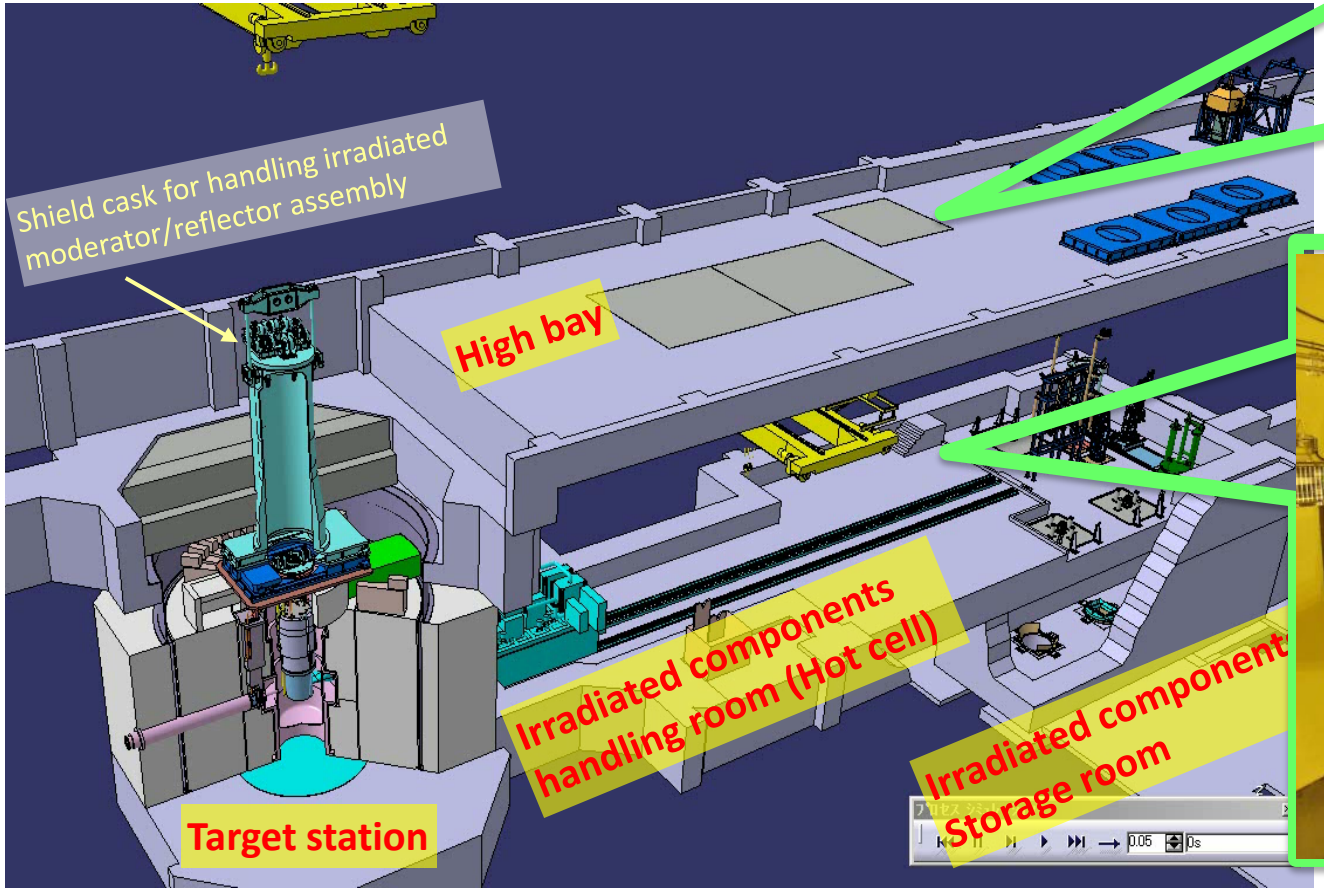
neutron

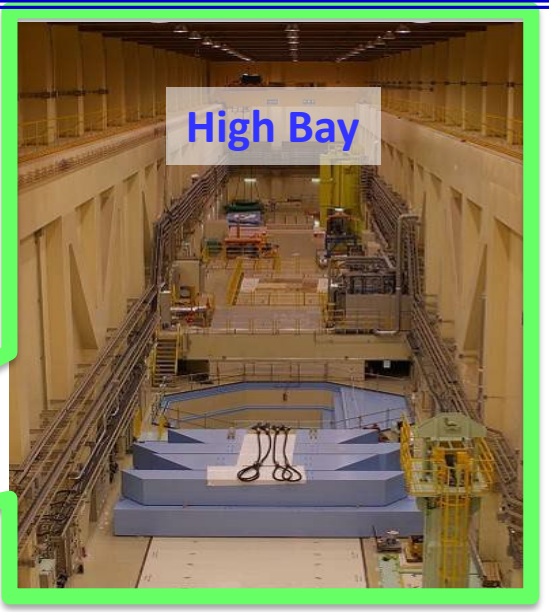
Proton beam
3 GeV, 1MW, 25 Hz

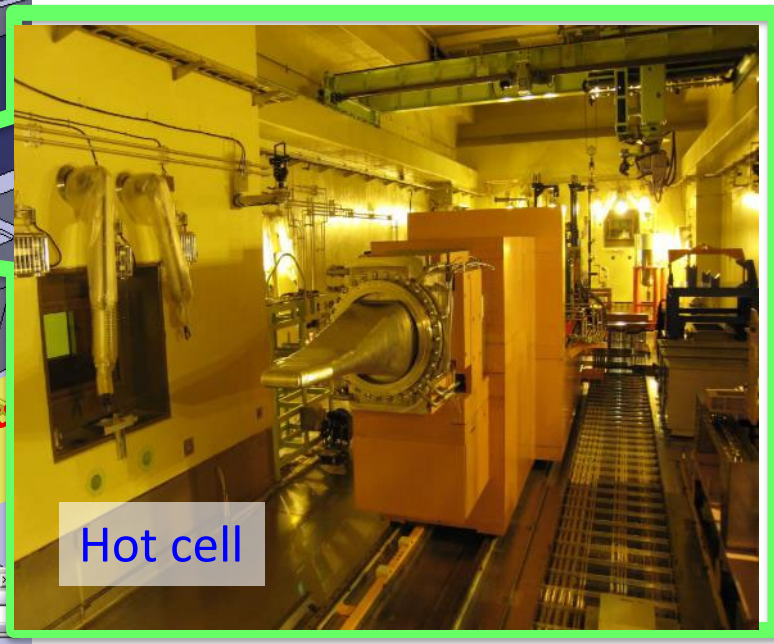
5m

Pulsed spallation neutron source facility

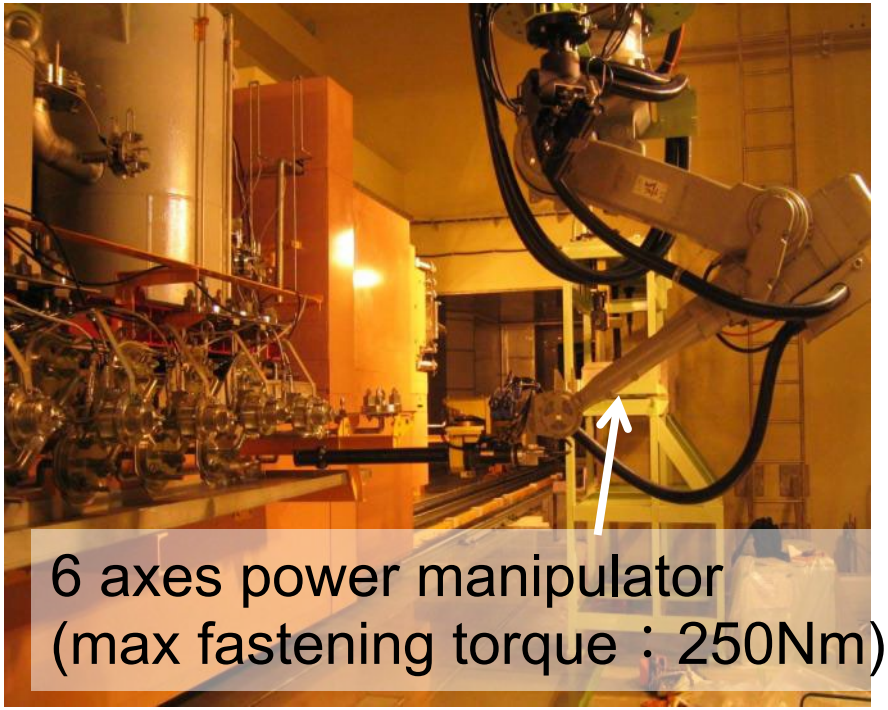
- Clear separation of the user area from the source components operation/ maintenance area
- Appropriate and effective facility layout considering components maintenance;
  - Hot-cell for handling highly irradiated components
  - High bay structure







Remote handling devices in hot cell



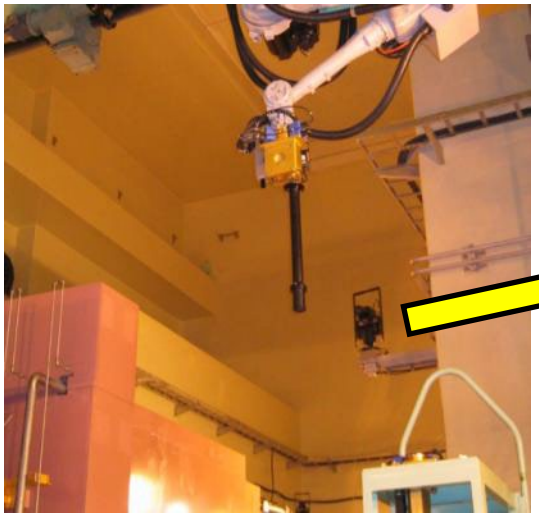
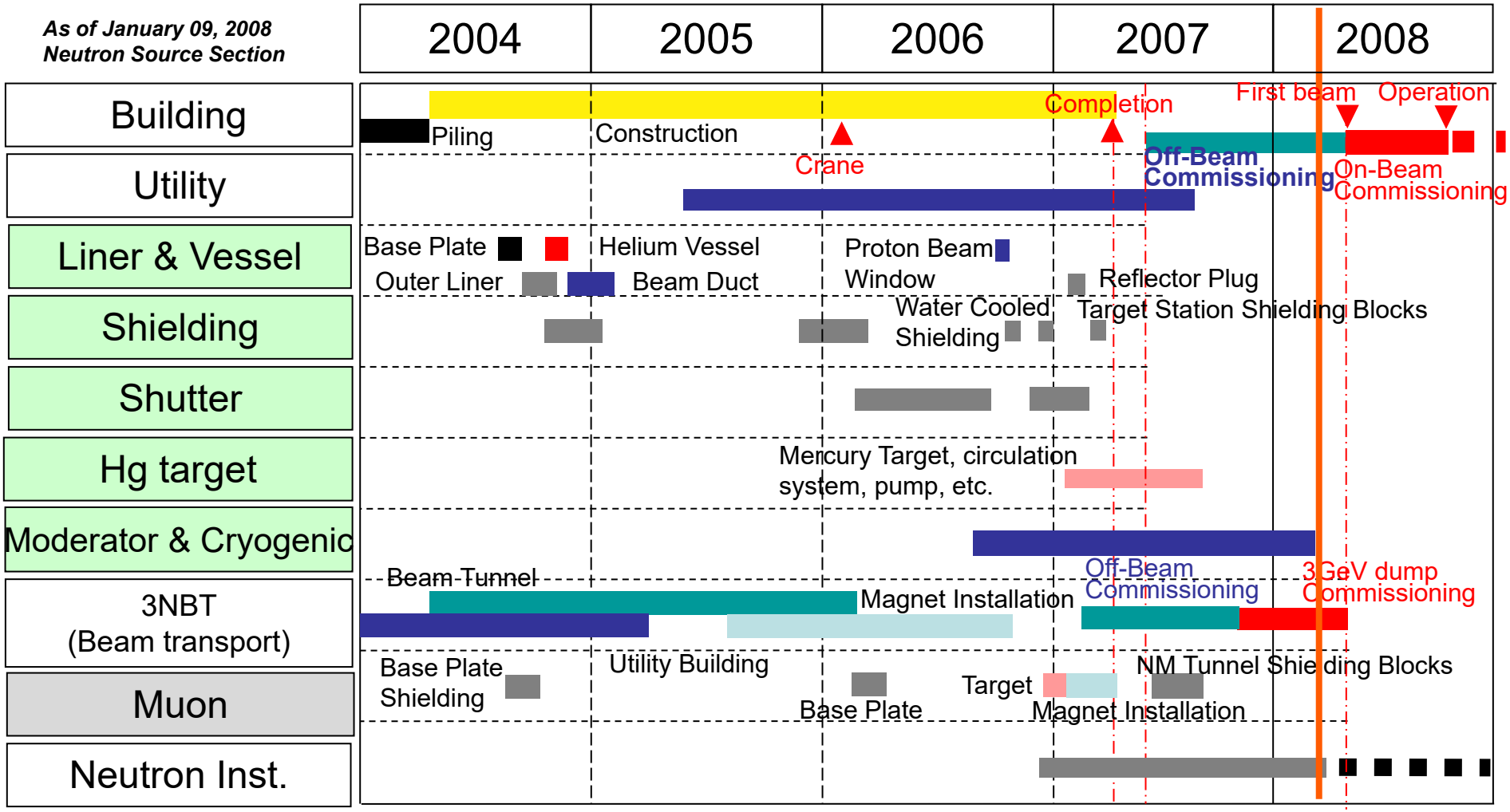
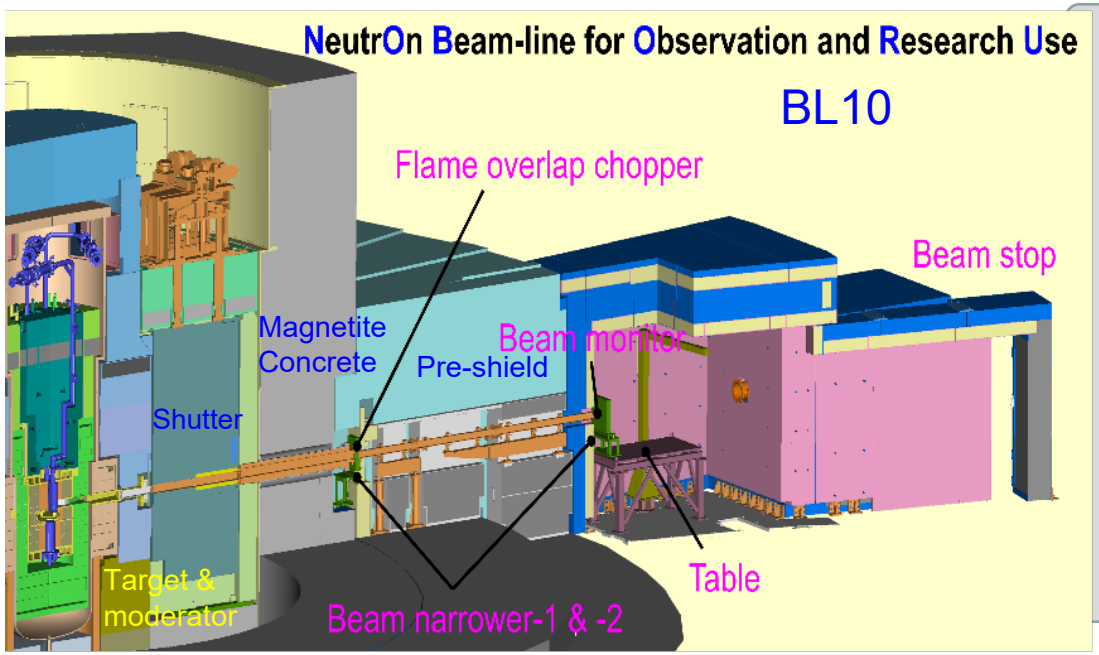


Image tube
camera

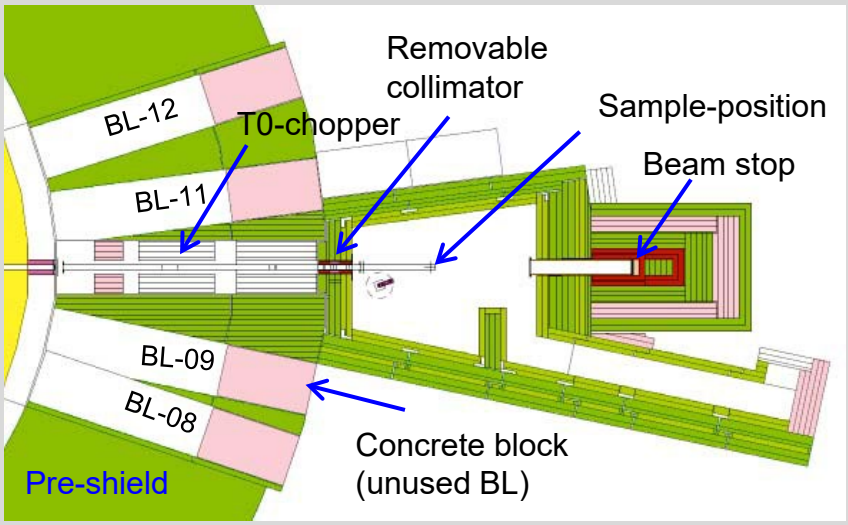
Construction Schedule of MLF
-- Neutron and Muon Sources --



Example of beamline shielding design

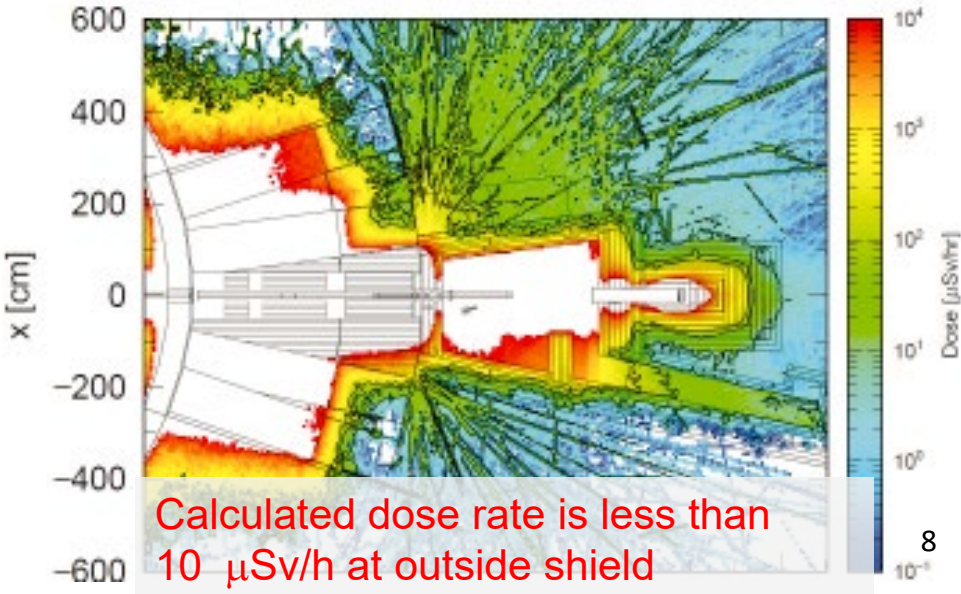


Plane section of calculation model for BL10



- 3-D Monte Carlo calculation with PHITS code
- Neutrons generated at moderator surface with directional cosine viewing inside beam duct are considered as source spectra.
- Design target is less than12.5 μSv/h.
- Safety margin of factor 2 is considered in PHITS calculation.
- When a neutron beamline is increased, shielding calculation is carried out with modelling all beamlin and source spectra.

Calculated dose rate in case of using steel sample

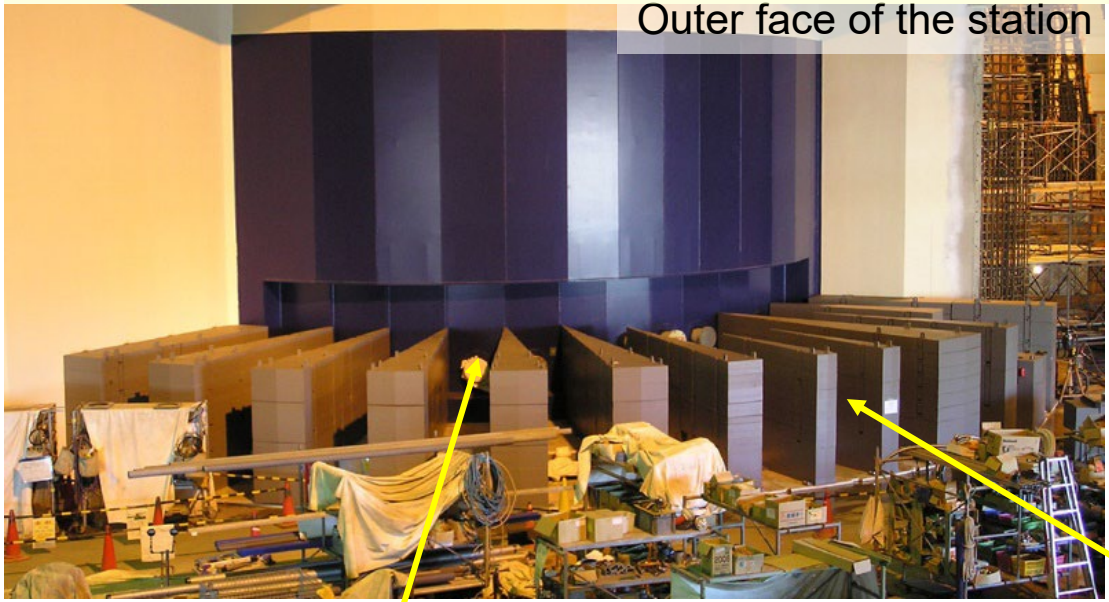


Calculated dose rate is less than 10 μSv/h at outside shield

Ref.) M. Harada, et al. Progress in Nucl. Sci. Technol., Vol. 1, pp. 94-97 (2011)

View of outside of neutron source station

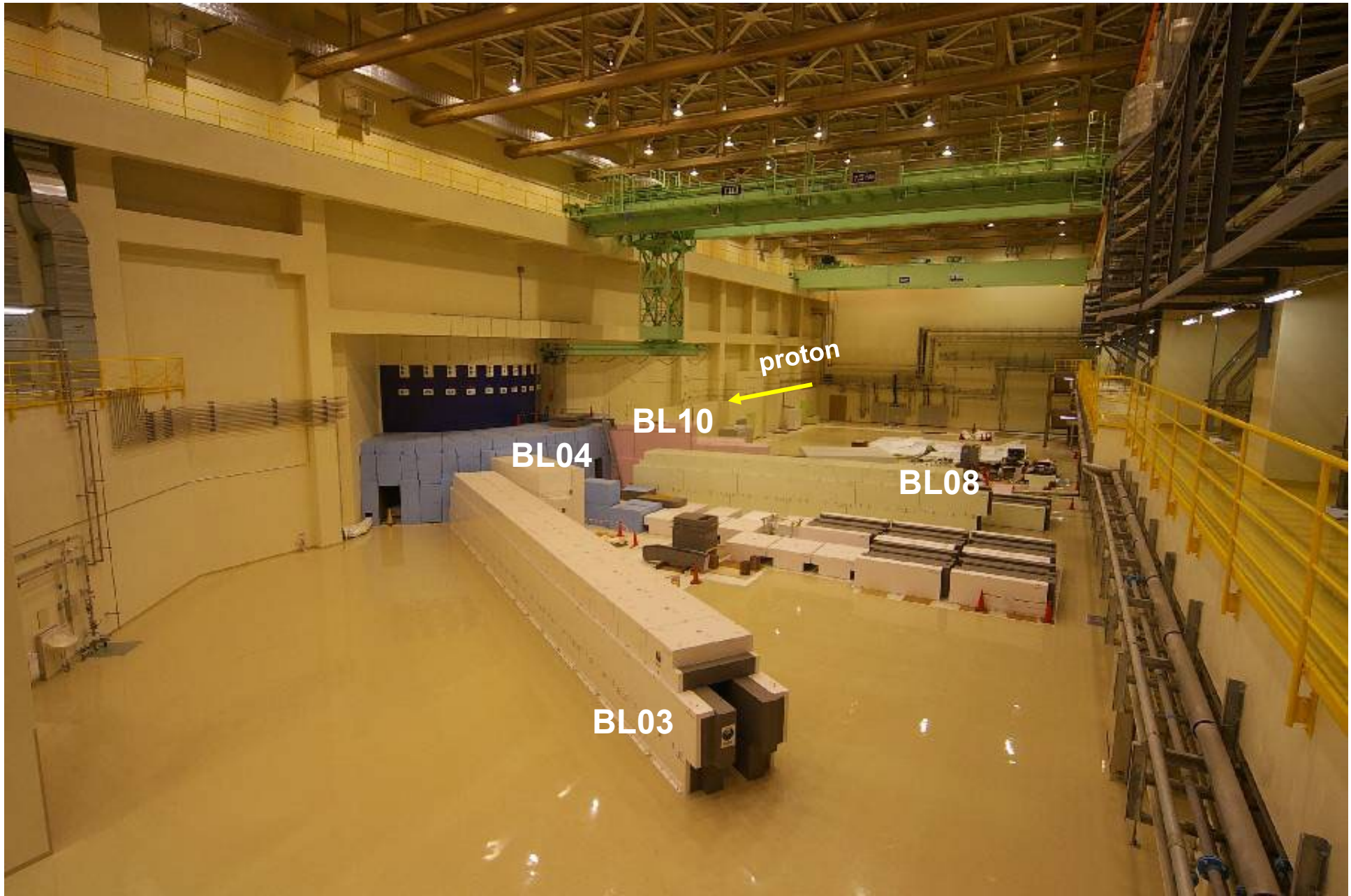
Pre-shield installation along each beam lines in 2007



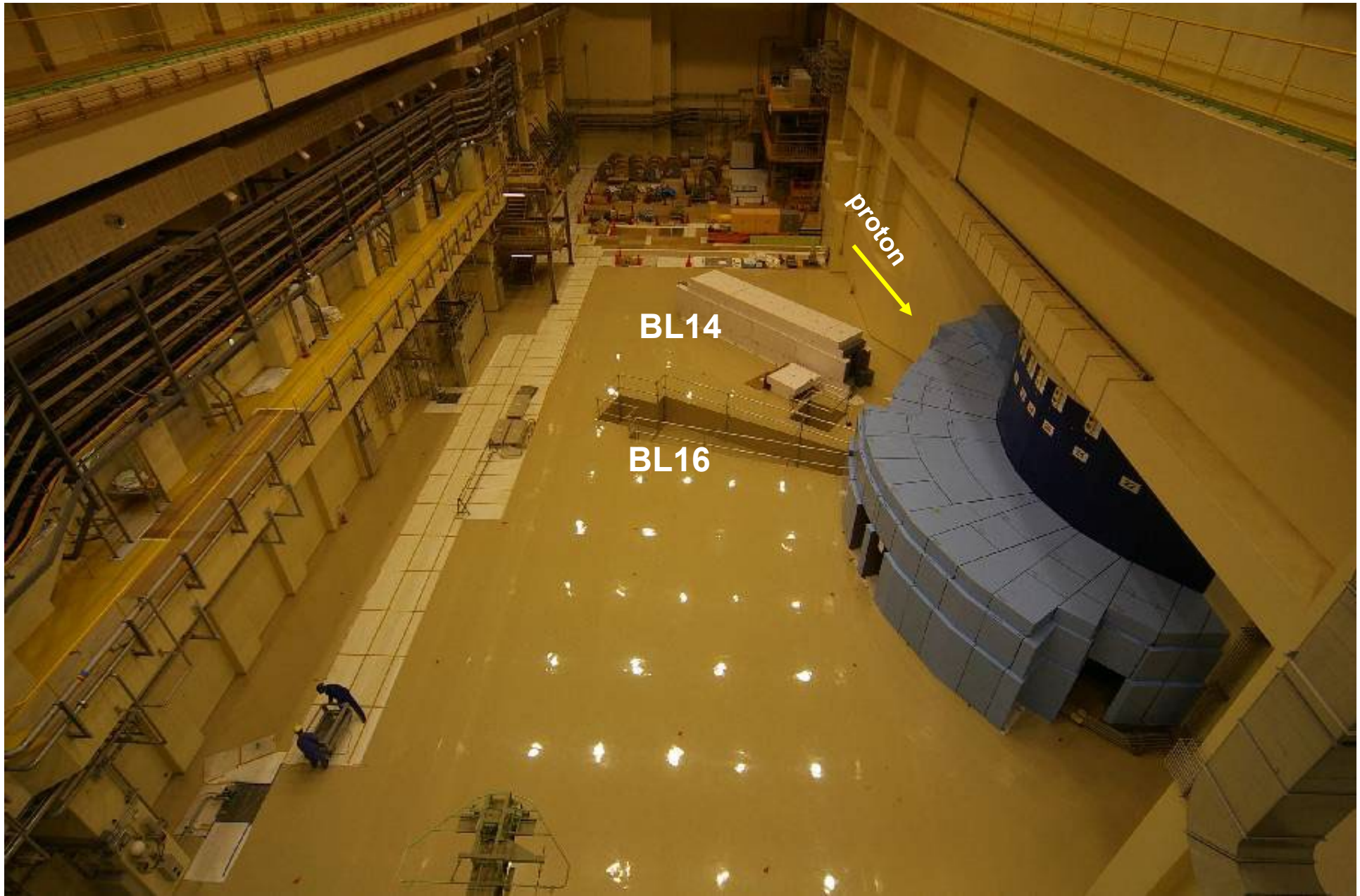
Shield plug for unused beamline

Neutron beam collimator shield installation

MLF experimental Hall #1 in 2007

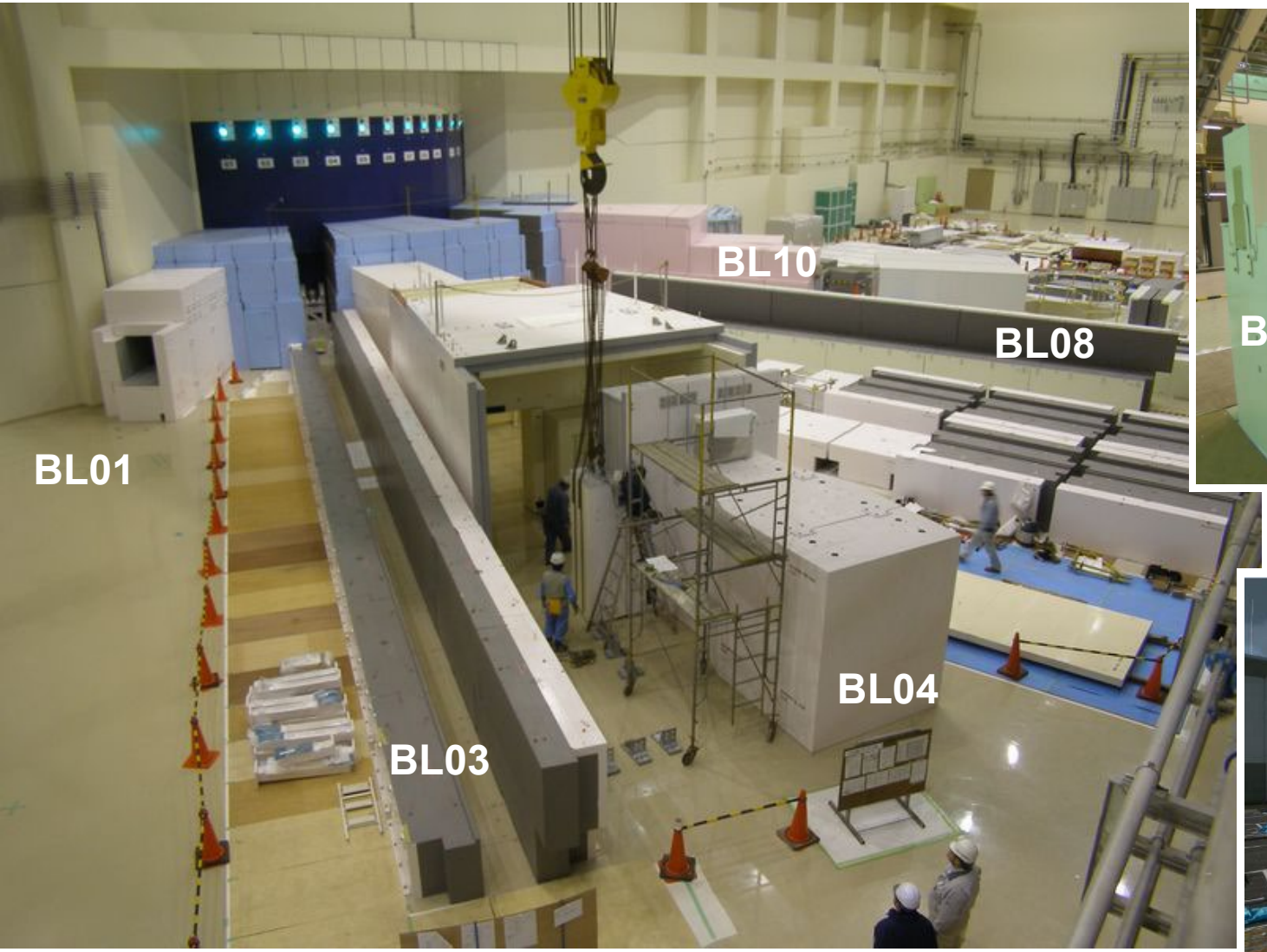


MLF experimental Hall #2 in 2007



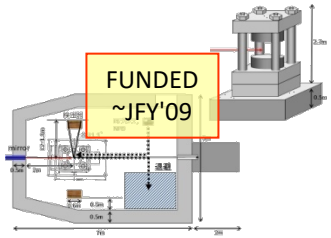
Neutron beam line construction in FY2007

Experimental Hall #1

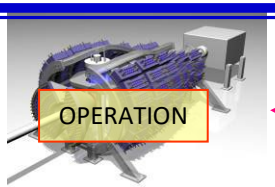


Experimental Hall #2

Status of neutron instruments in 2008 - 1st year of operation

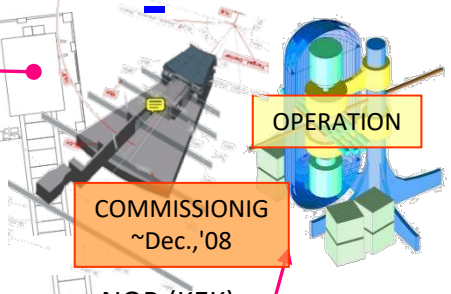


High-Pressure Diffraction Station (U. of Tokyo, JAEA)



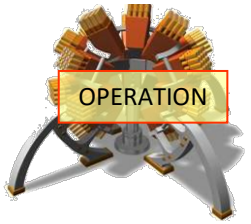
SHRPD (KEK)

NOBORU (JAEA)



NOP (KEK)

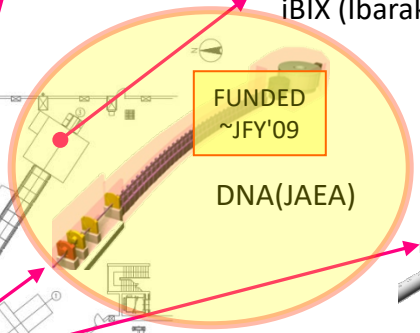
NNRI （Tokyo Tech. U., JAEA, Hokkaido U.)



iBIX (Ibaraki Pref.)

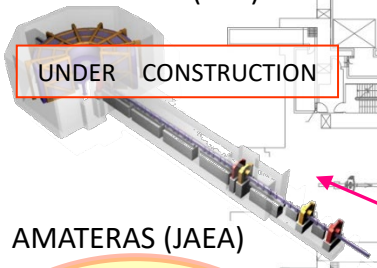
HRC (KEK)

1st Experimental Hall



DNA(JAEA)

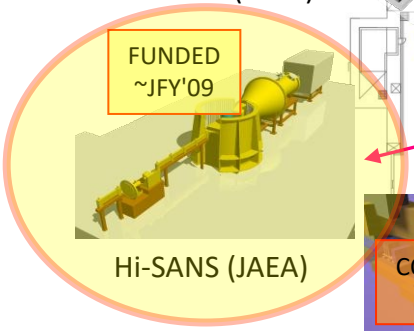
4SEASONS
（JAEA, KEK, Tohoku U.）



AMATERAS (JAEA)

2nd Experimental Hall

NOVA （NEDO, KEK）



Hi-SANS (JAEA)

Reflectometer (KEK)

TAKUMI (JAEA)

iMATERIA (Ibaraki Pref.)

- **7 Instruments are open for user program.**
- **4 Instruments have been working from Dec. '08.**
- **1 Instrument is under construction.**
- **3 Instrument are newly funded (two for JAEA and 1 for U. Tokyo & JAEA).**

Flow of neutron source component construction

Design of neutron source system by MLF construction team with Building construction department of JAEA

Design and fabrication of each component by procurement

Subsystem and integrated tests of a component by a vendor

On-site integration tests and commissioning by MLF construction team

Example: Mercury target system

Procurement items

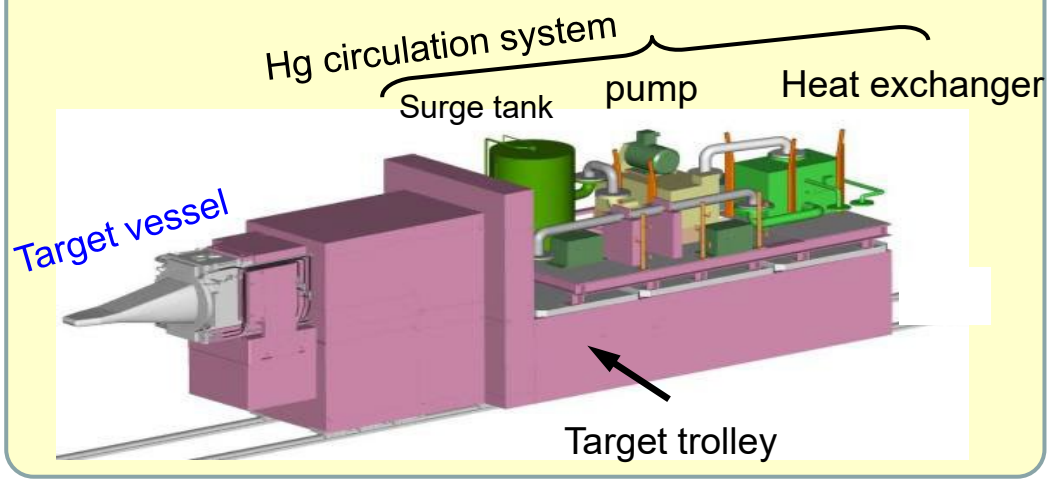
- ✓ Target vessel
- ✓ Hg circulation system with target trolley

Subsystem and integrated test of component:

- ✓ Remote handling test using crane,
- ✓ Seal performance test, etc.

On-site integration tests and commissioning:

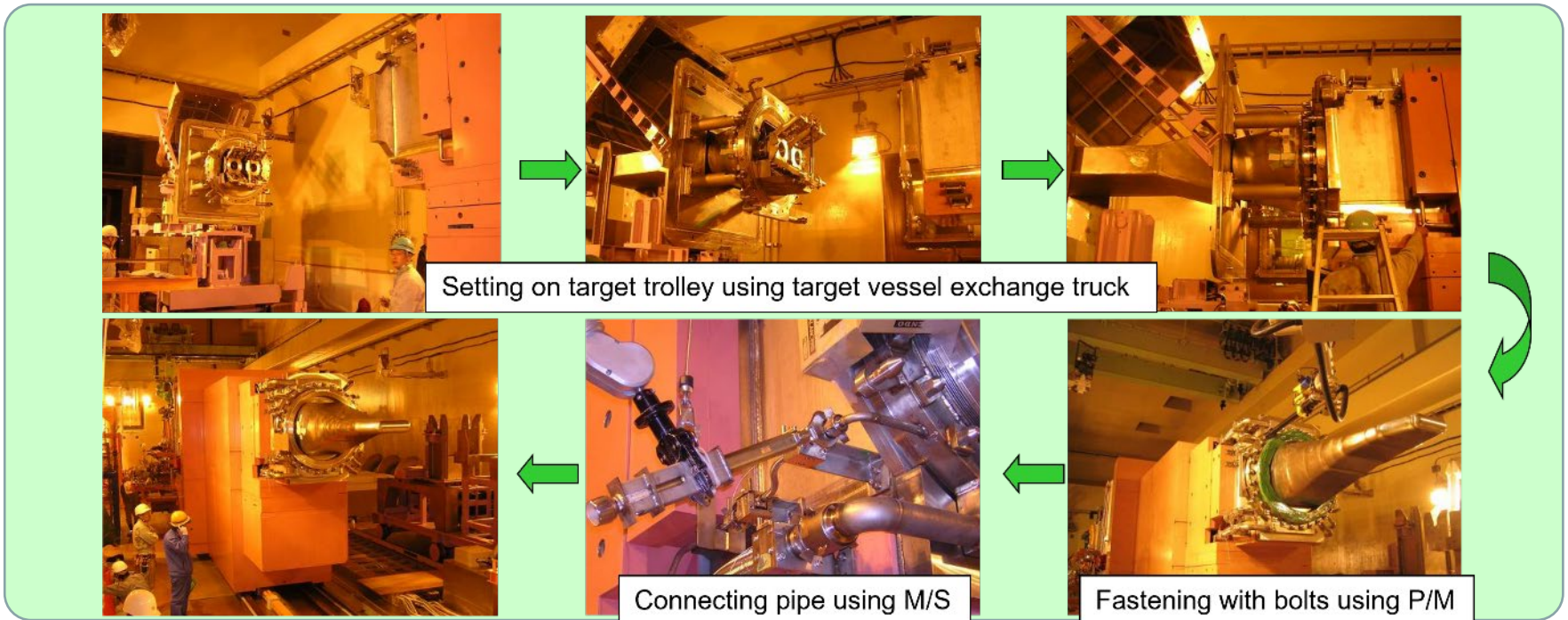
- ✓ Remote handling test with manipulators,
- ✓ Seal performance test,
- ✓ Water loop test, Hg loop test, etc.



Integration tests and commissioning

- Integration tests from April 2007 to March 2008
  - Target installation and Hg circulation
  - Moderator installation and Liq. H_2 circulation
  - Water cool, gas insulation, ventilation, etc.
  - BT commissioning (Dump mode Sept. 2007)
  - Remote handling and control system validation
- On beam commissioning; May 2008
- 20 kW beam operation; Oct. 2008
  - With seven Day-one instruments

Remote handling tests : 2007.03 -



Control system validation for neutron shutter and beamline

Procedure to access to sample room of neutron instrument

Shutter CLOSE ⇒ Pull off **two safety keys** from key panel and insert one of keys into Door Controller

⇒ Unlock the door and enter to sample room

Procedure to use neutron beam

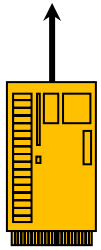
Sweep all users out of sample room ⇒ Lock the door

⇒ Release the key from Door controller

⇒ Return it to key panel

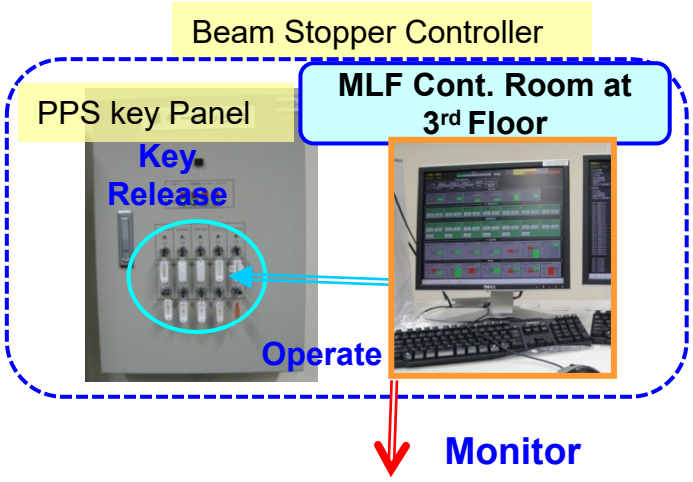
⇒ Shutter open permission

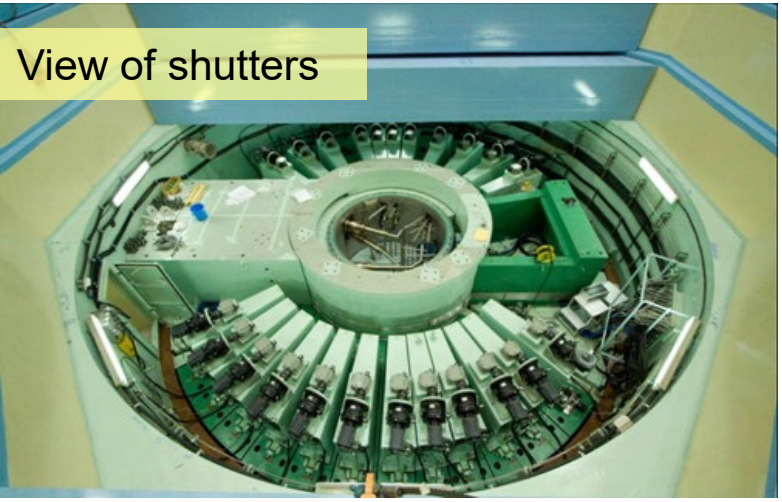
It is designed that shutter is never opened unless all keys are returned to the key panel

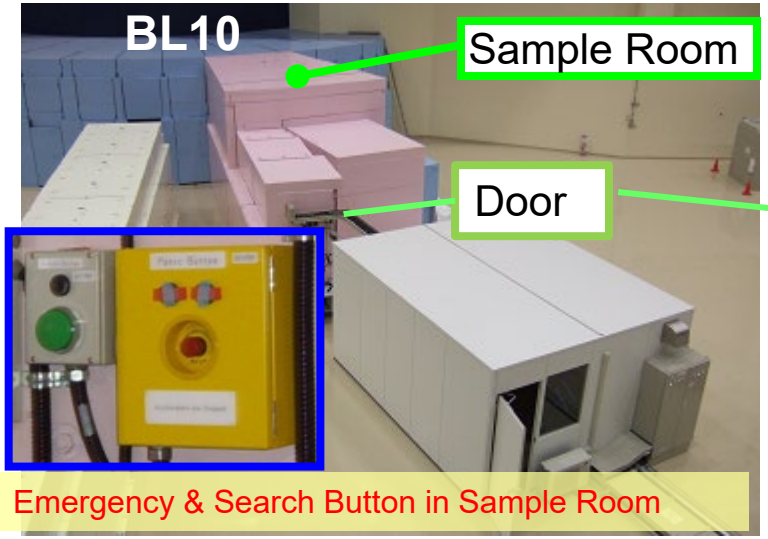


"**Safety**", "**Emergency**" beam stop

PPS-MP







Readiness checklist

- Objectives to check readiness

  to list all necessary conditions which are needed to be completed before the beam acceptance, and

  to share the checklists among those who are in charge of neutron source construction and operation for mutual confirmation.

- This procedure is effective

  to avoid forgetting to do something important before the beam acceptance, and

  to make acceptance criteria clear.

Total 700 items are included in readiness checklist for all MLF components.

Example of readiness sheet

Component: Moderator

Last modified: Jan. 04, 2008

General item	Detailed item	Acceptance Criteria	Confirmation methods (Name of document)	Necessity A: Indispensable by Day-1 B: Preferable by Day-1	Status A: Completed B: Conditionally Completed C: Not yet Completed
1.1 Functions	Moderators have been installed at the right positions. Pressure proof and leak tests have been passed after connecting to the hydrogen circulation system.	Hydrogen region Pressure proof test: 1.5 MPa Leak rate: not detectable by He-leak test Vacuum region Leak rate: not detectable by He-leak test He-blanket region Leak rate: not detectable by He-leak test Cooling water region	Off-beam commissioning report	A	C
	Stable operations of hydrogen, vacuum, He-blanket and cooling water systems at the nominal conditions have been confirmed.	Hydrogen system: OK Vacuum system: OK He-blanlet system: OK Cooling water system: OK	Off-beam commissioning report	A	C
	Integrity of cryogenic temperature region has been confirmed.	Unexpected contact between cold and room temperature regions: No	Off-beam commissioning report	A	C
	Arrangement with the process control system has been completed.	NA	NETH transmission list Console display pages	A	C

Format of Readiness

1st column: General items

functions, process operation, maintainability, measures for off-normal events, *etc.*

2nd column: Detailed items

3rd column: Acceptance criteria for each detailed item.

- Only major acceptance criteria are described in this checklist while detailed and many other acceptance criteria are dropped for simplification.
- Other documents such as documents prepared by manufacturer and technical reports can be referred in the checklist if needed.

4th column: Confirmation method to satisfy the acceptance criteria

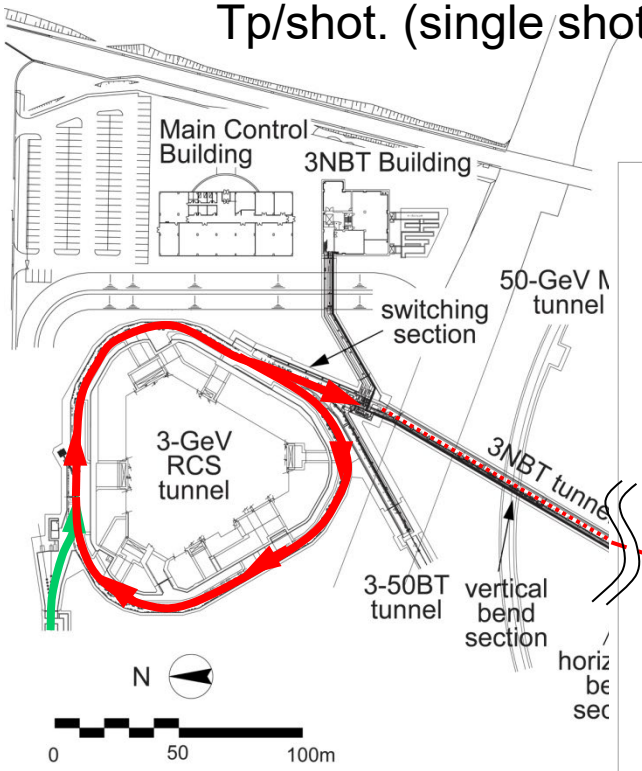
- The confirmation should rely on documents as much as possible that are accessible by any interested persons of JSNS in order to be checked by third persons from an objective point of view.

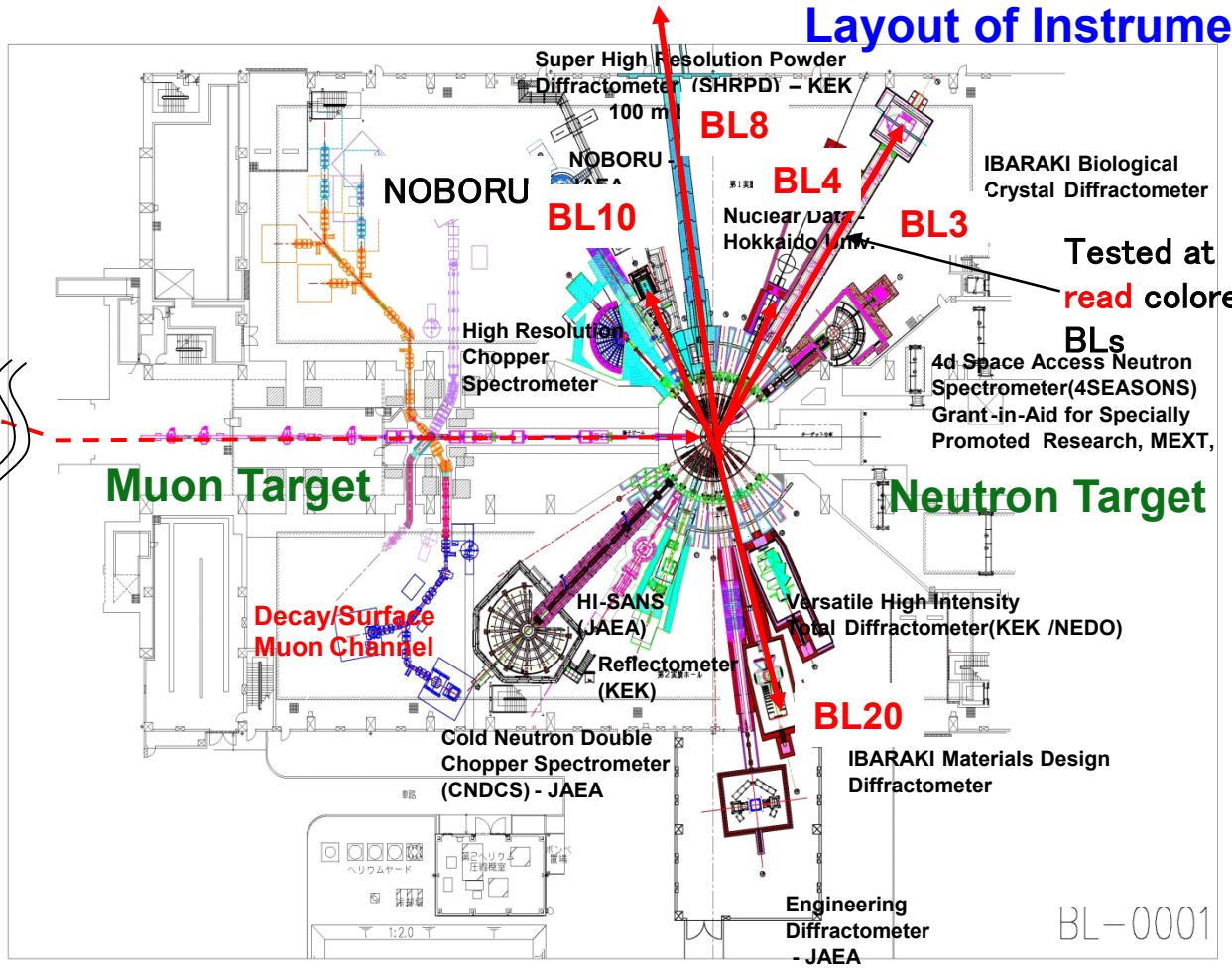
Examples of the documents:

documents prepared by manufacturer, technical reports, papers, etc.

The first neutron production at JSNS

May 30, 2008,14:25 at BL10(NOBORU) the first neutron beam was observed. Right after on May 30 and May 31, BL3、BL4、BL8,BL20 were tested with 0.4 Tp/shot. (single shot mode) in total 2,500 shots.

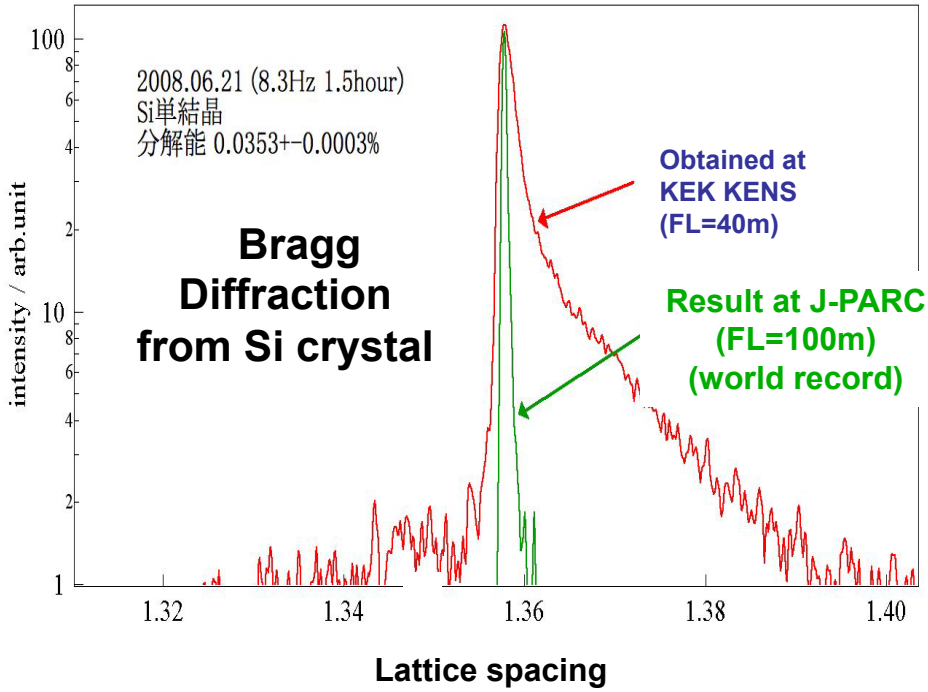




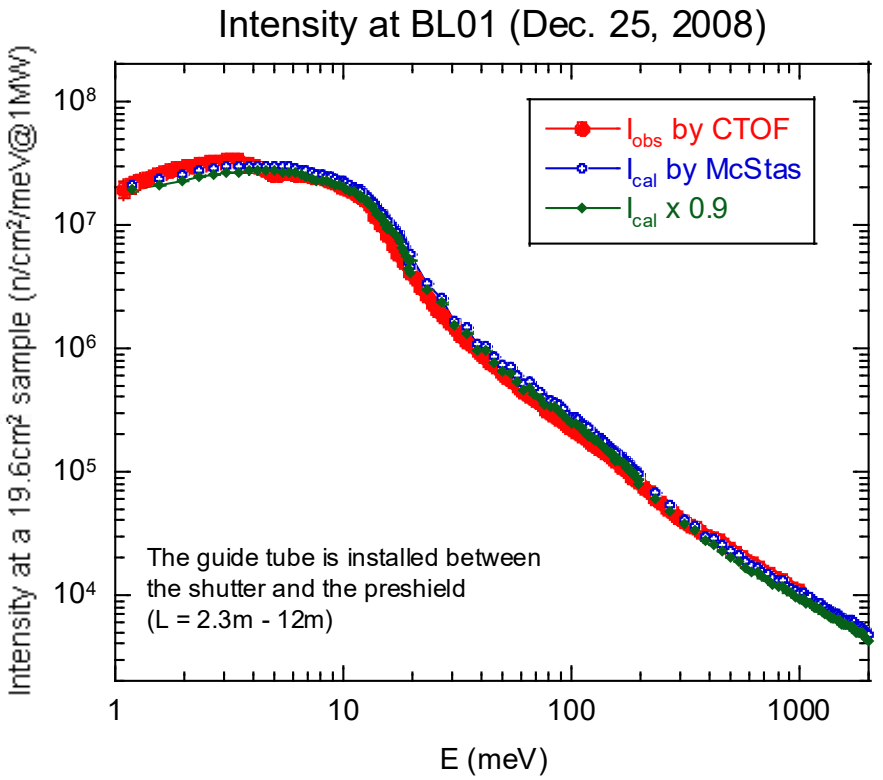
Example of on-beam commissioning results

Resolution and intensity at neutron instruments were measured, resulting that source performance was confirmed as what is expected.

SuperHRPD(BL08) :Δd/d = 0.035 %



Neutron pulse shape measured at sample position of Super High Resolution Powder Diffractometer (BL08) which is provided by poisoned moderator with a Cd plate



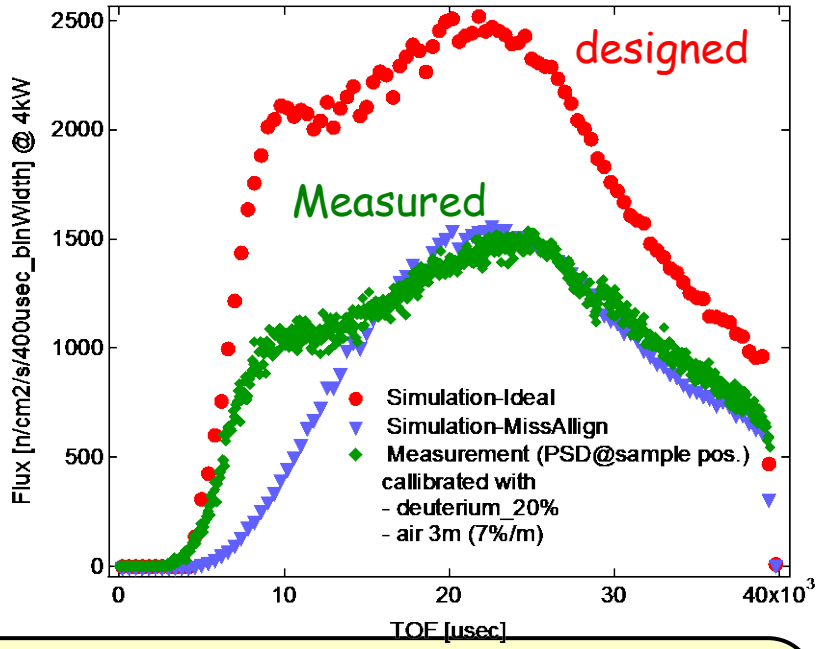
Neutron intensity at sample position of BL01 which is provided by coupled moderator

Validation of neutronic performance of beamline

Once a beamline is completed and/or realigned, neutron flux and intensity are measured with PSD and foil activation for validation.

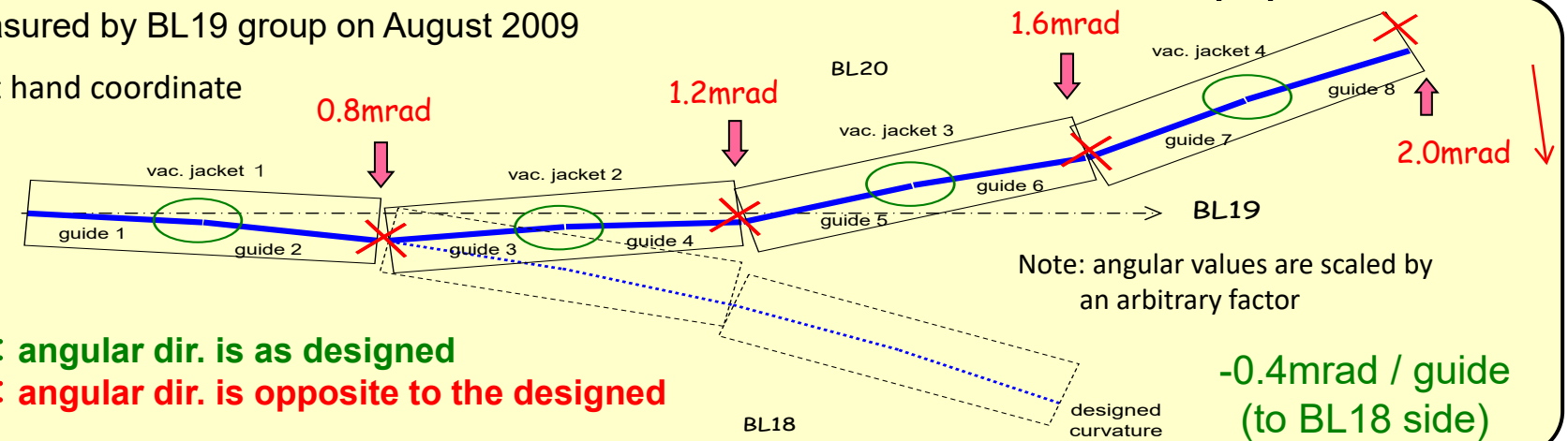
Experience at BL19 having curved guides

- Measured neutron flux was lower than the estimated one by about 50-60%, indicating that beamline was mis-aligned.
- As a matter of fact, the vaccum jackets had been aligned to opposite direction.



measured by BL19 group on August 2009

right hand coordinate



Note: angular values are scaled by an arbitrary factor

○ : **angular dir. is as designed**

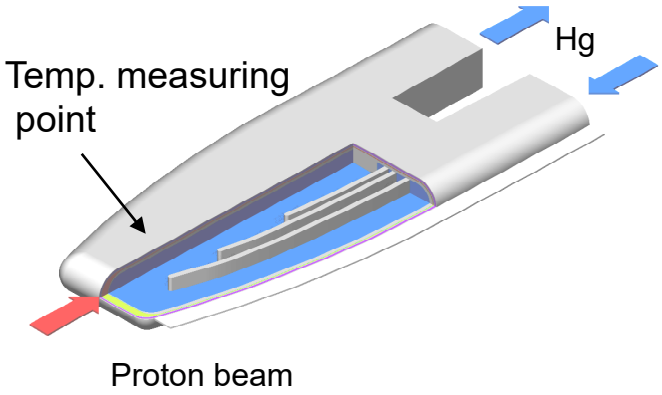
× : **angular dir. is opposite to the designed**

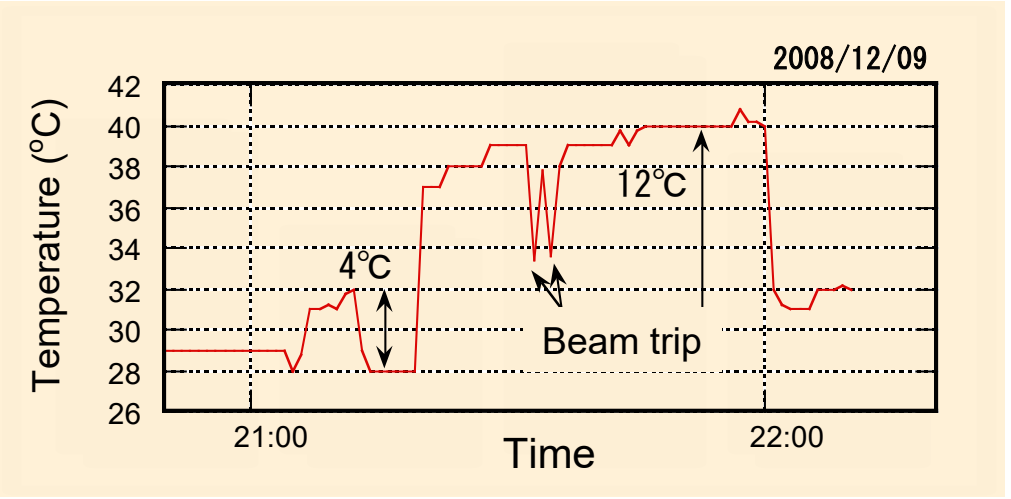
-0.4mrad / guide (to BL18 side)

Example of on-beam commissioning results

Target design confirmation at 120 kW

- Temperature rising at mercury vessel by 120 kW beam power agreed with the design estimation.
- As results, it was confirmed that the mercury circulation system; EM pump, heat exchanger, etc., were operated sufficiently as expected in the design.

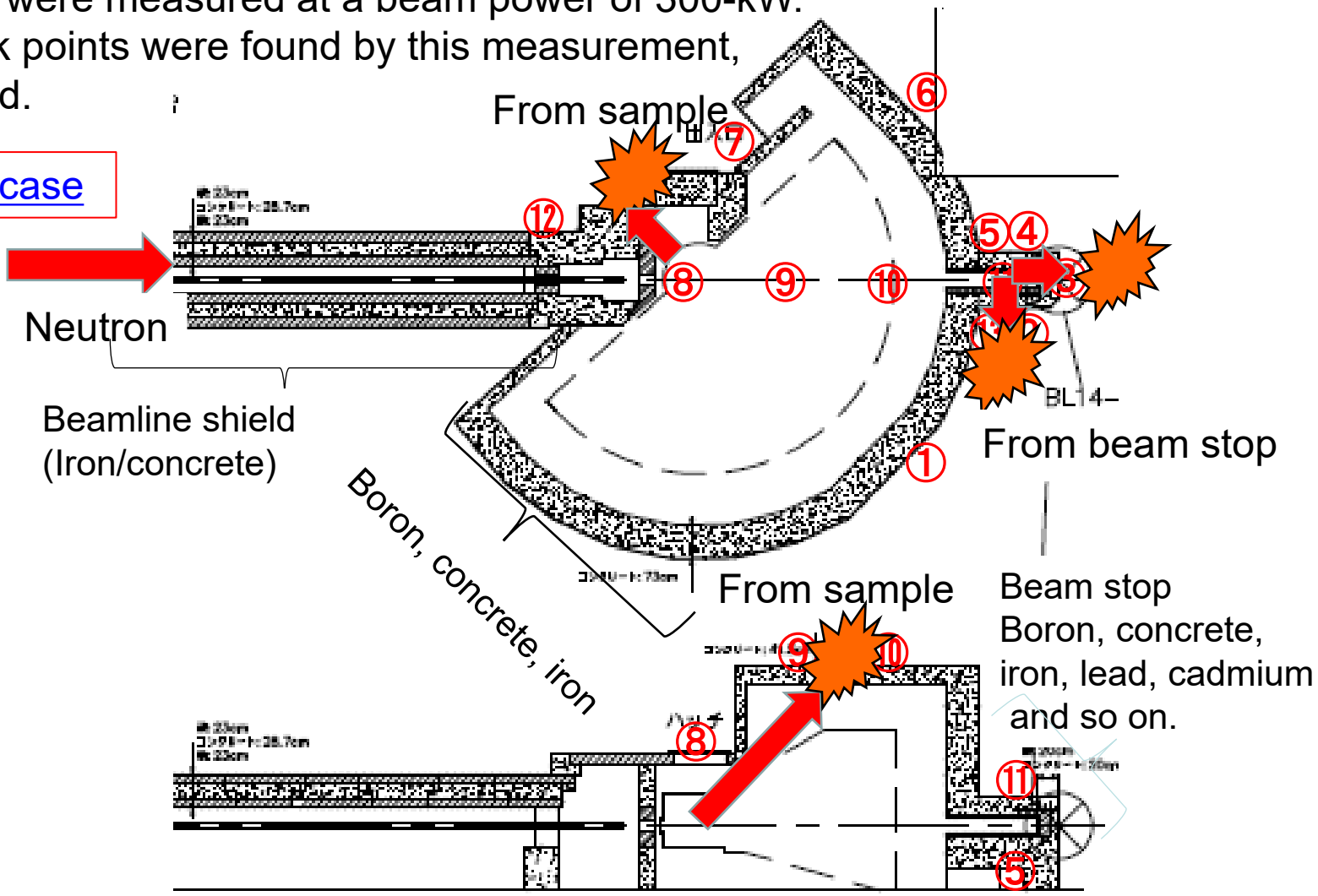




Validation of Neutron Beamline Shield

- In 2014, dose rates outside shields at neutron source, muon source, and all beam lines were measured at a beam power of 300-kW.
- Some week points were found by this measurement, and repaired.

Example: BL14 case



Summary

- Pulsed neutron source components of MLF was designed and fabricated to receive 1-MW proton beam.
- On-site integration tests and commissioning were carried out from 2007 to May 2008 during which items to be completed up to Day-1 were specified using readiness checklist.
- Intensity and pulse shape of neutron beam provided by the neutron source was validated at each neutron beam line during on-beam commissioning, resulting that neutron performance was what as it expected.
- On-beam test was useful to find misalignment of a neutron beam component and confirm shield performance around sample room of a neutron instrument.