2nd International Advisory Committee of
J-PARC March 10,11, 2003

Material & Life Science Experimental Facility (MLF) Progress report since March 2002

Yujiro Ikeda
JAERI

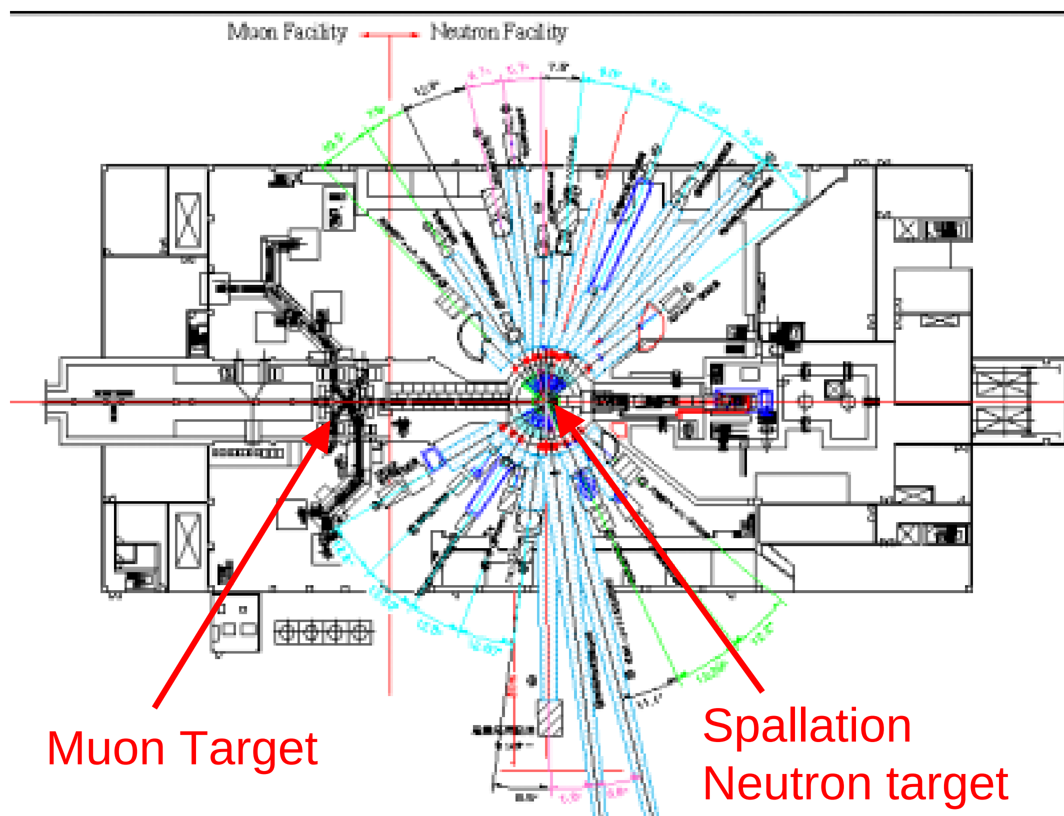
- MLF component design and construction with emphasis of JSNS*
- Report of 1MW Neutron Source Technical Advisory Committee
- Mercury target pitting problem and R&D

* The framework of development neutron beam line will be reported by Prof. Fujii

MLF Mission

is to construct a user experimental facility aiming at new scientific breakthrough with pulsed neutrons and muons in material&life sciences, fundamental physics, industrial applications, etc.

Layout of instrument suits



MLF Parameters

1MW proton beam power
(3GeV, 0.33 mA, 25Hz, 1μs pulse width)
Hg Spallation neutron target
(1MW, Flowing mercury, 1 m/s)
Carbon muon production target
(60 kW, Edge cooling with Cu support ring)
Long Proton Beam Transport Line
(340 m long from 3GeV RCS ring extraction)
125m x 70 m x 30 m Large Building
(Two sided experimental halls
130 ton central crane,50 ton and 30 ton cranes for experimental halls)

Looking back over the past one year

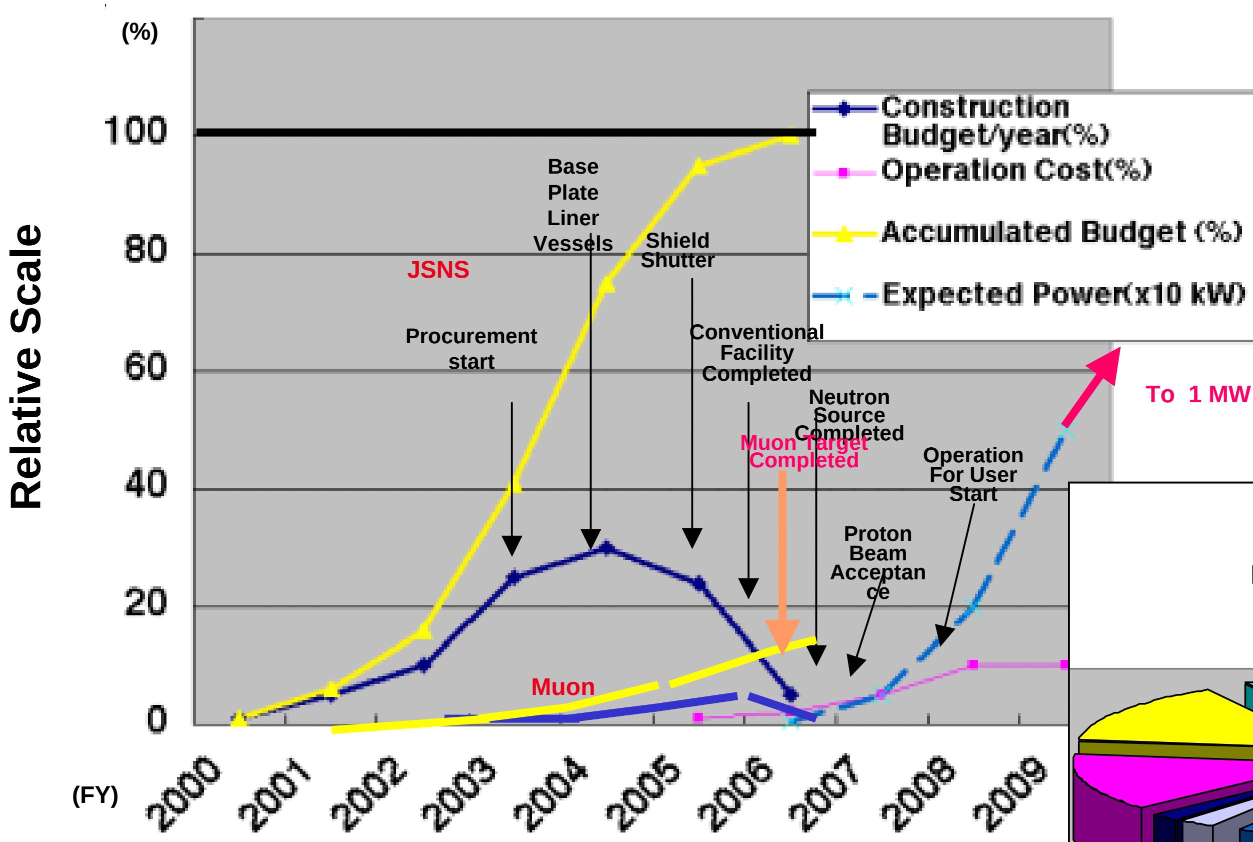
The 1st IAC	March 2002
Structural components design specification	Apr. ~ Aug. 2002
23 beam extraction was determined	May. 2002
Tenders for the first bids & awards,	Nov. 02~ Mar. 03
N-TAC	October 28~30, 2002,
10 neutron instrument project team proposals submitted to a committee as LOIs	Sept.12~Dec. 6, 2002

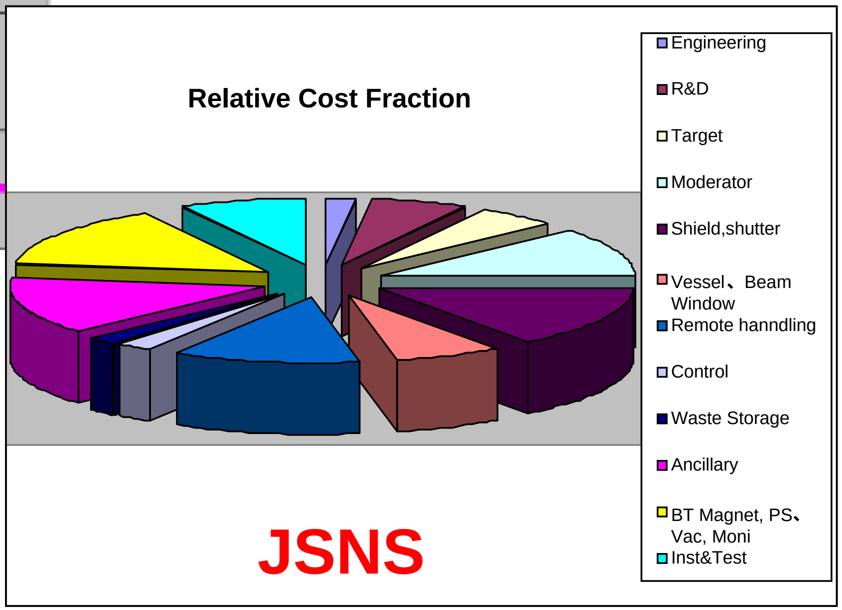
Mercury pitting issues (Target technology)

International Spallation Target Workshop	July, 2002
Specialist Meeting at SNS/ORNL	October, 2002
High Power Target technology Collaboration	January 2003

Detail design is on going for tender of the 2nd bids Jun.~ Sept., 2003.

Budget Profile and Major Milestone





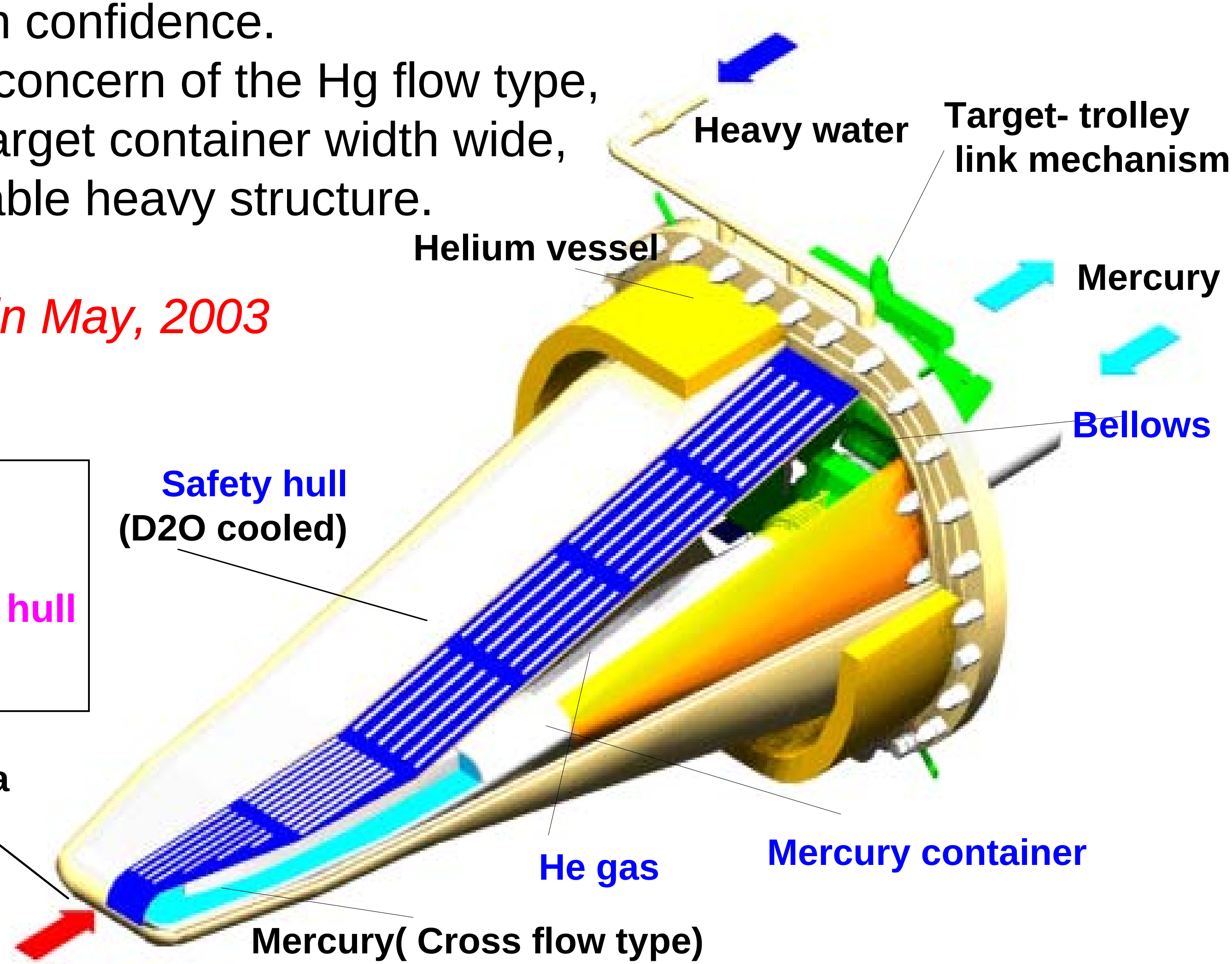
Mercury Target

Very close to the final design specification for order(tender)
Pitting damage issue remained to work further
till we have enough confidence.
N-TAC reported a concern of the Hg flow type,
which makes the target container width wide,
leading to undesirable heavy structure.

Tender of bit start in May, 2003

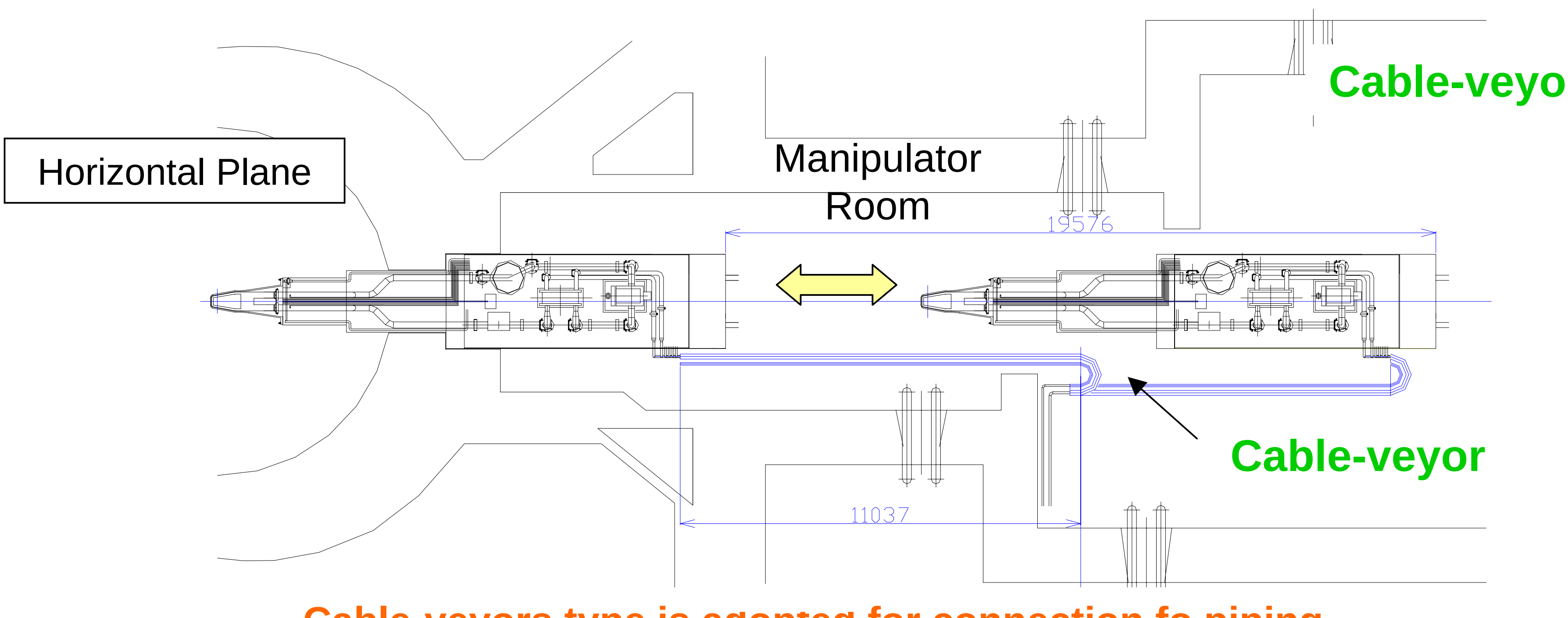
Multi-walled concept ;
A target Hg container
A water cooled safety hull

Lifetime is to 5dpa



Target Cart and Handling

The bit of the target cart will be awarded to a vender next week.
One of the most strong N-TAC comments is to establish more realistic remote handling scenario.
According to detailed dose mapping, maintenance requirements should be identified one by one. We have started actions.

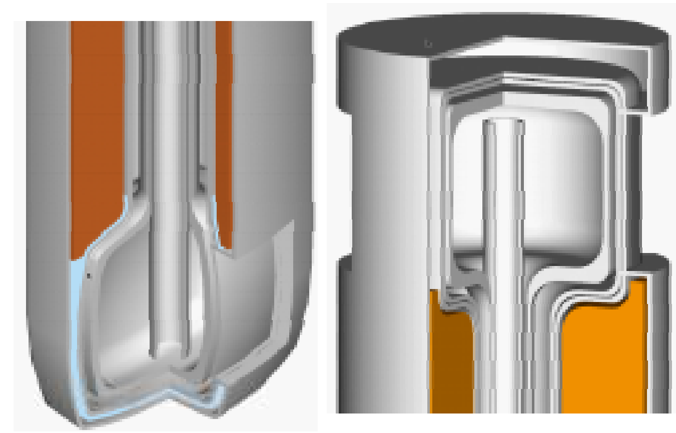


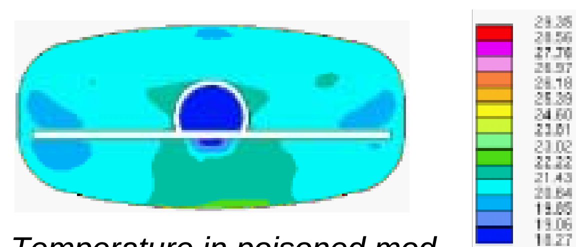
Cable-veyors type is adopted for connection fo piping

Moderator

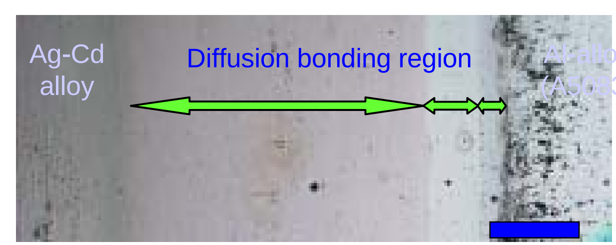
- Structure
  - detailed design has almost been completed.
  - two canteen-type decoupled moderators (poisoned & un-poisoned) and one cylindrical coupled moderator.
  - He-barrier layer at extraction window.
  - moderator wall thickness determination is in progress taking account of:
    - Design hydrogen pressure 2.0 MPa
    - Proof pressure testing by applying 4 times of the design pressure
- Hydrogen flow
  - Parallel hydrogen flow in all the three moderators were confirmed.
  - Maximum hydrogen temperature is well below 30 K.
- Neutron absorbing materials
  - Ag-In-Cd (AIC) decoupler for higher Ed (1 eV)
  - HIP testing for binding Al-alloy & AIC.
  - Cd poison for higher Ecut (0.4 eV)
  - Cd-Poison plate at an asymmetrical position
- Tender start: June 2003

Decoupled Moderator Coupled Moderator





Temperature in poisoned mod.

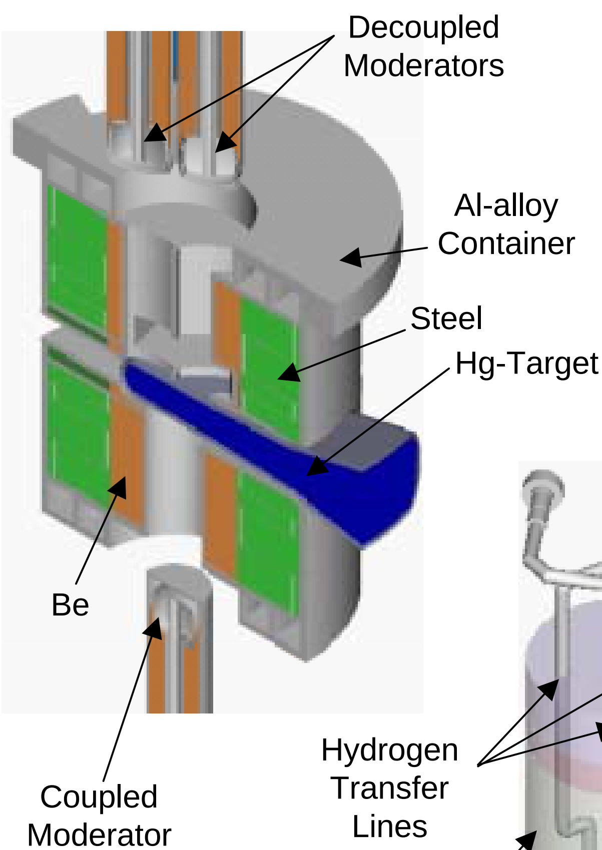


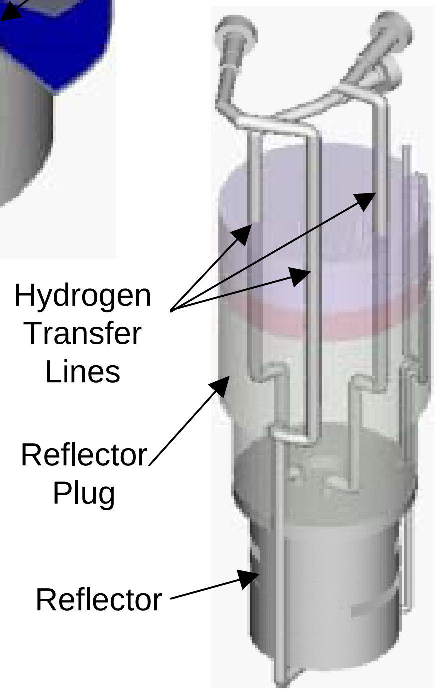
HIP test result 100 µm

Reflector

- Reflector
  - Be inner, Steel outer
  - Three one-path cooling channel (top, middle and bottom)
  - Mechanical strength design
    - Water pressure: 0.5 MPa
    - Max. deformation: 1 mm
  - Adequate water flow for heat removal Detailed thermo-hydraulic analysis for final design is in progress.
- Reflector plug
  - The previous polygonal shape was changed to cylindrical one for easy manufacturing & maintenance.

- Contract: December 2002

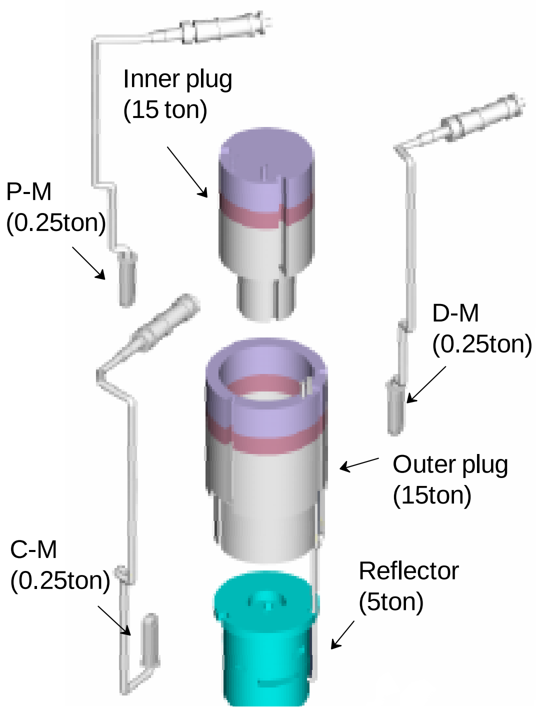


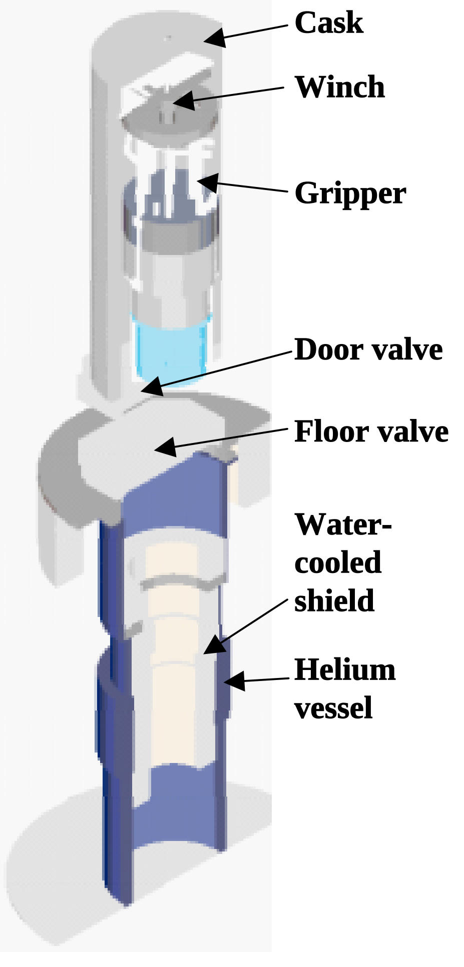


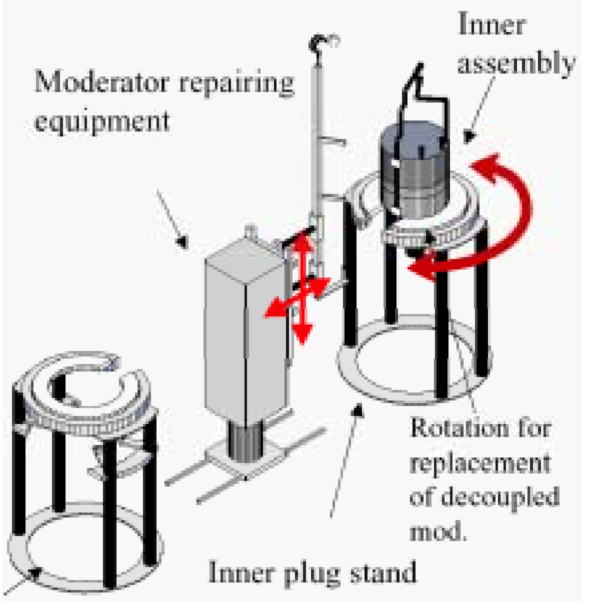
Remote Handling for Moderator & Reflector

- Remote handling scenario has been established.

Contract: December 2002







Elevation View of Target Station

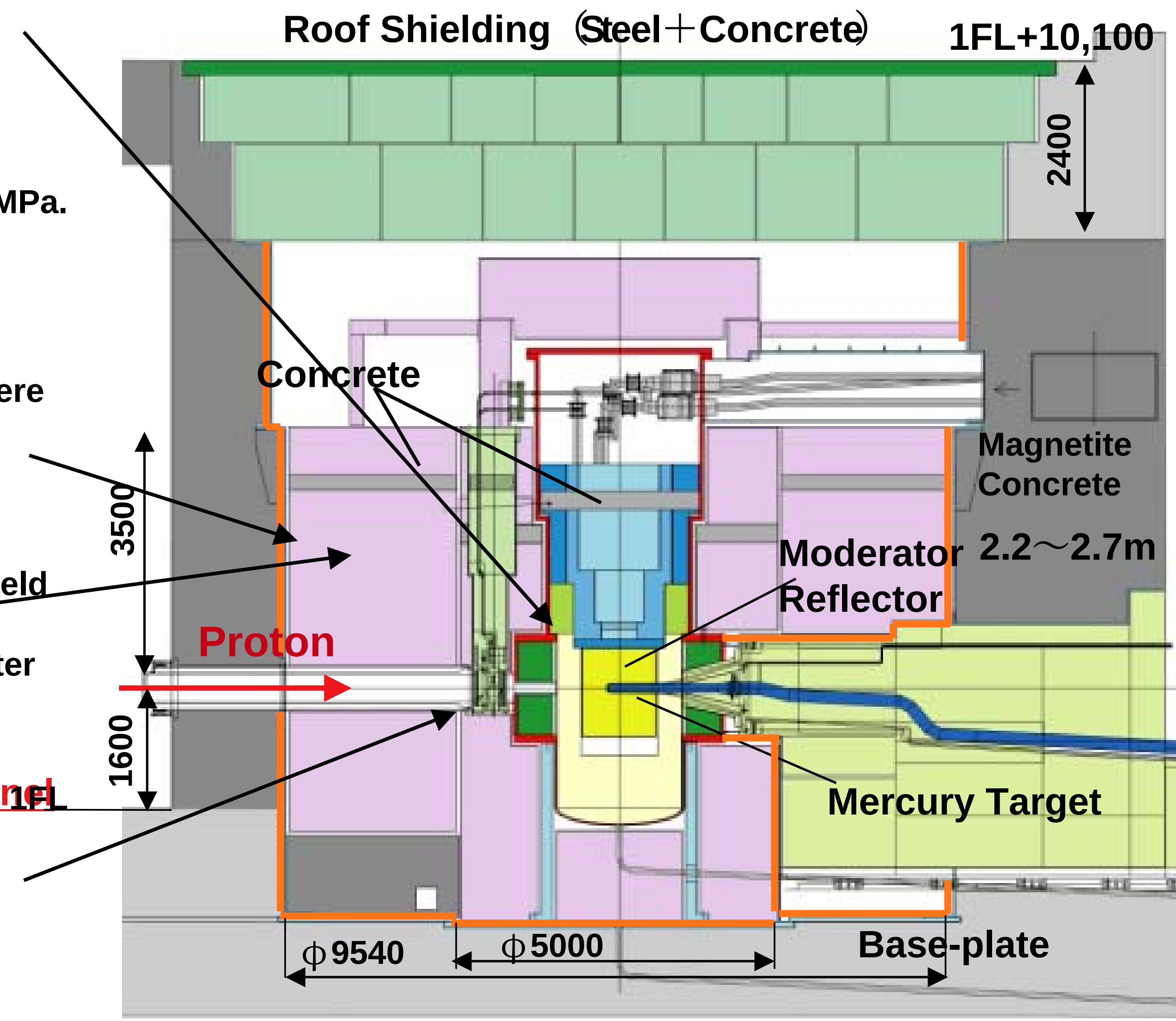
- **Helium Vessel（SS316L）**
  Water-cooled block region in middle section designed as
  Inner pressure : 0.3 MPa
  Inner pressure by water : 0.6 MPa.
  Containment of Helium inside.

- **Liners（SS）**
  Boundary from outer atmosphere
  Dry air ventilation inside.

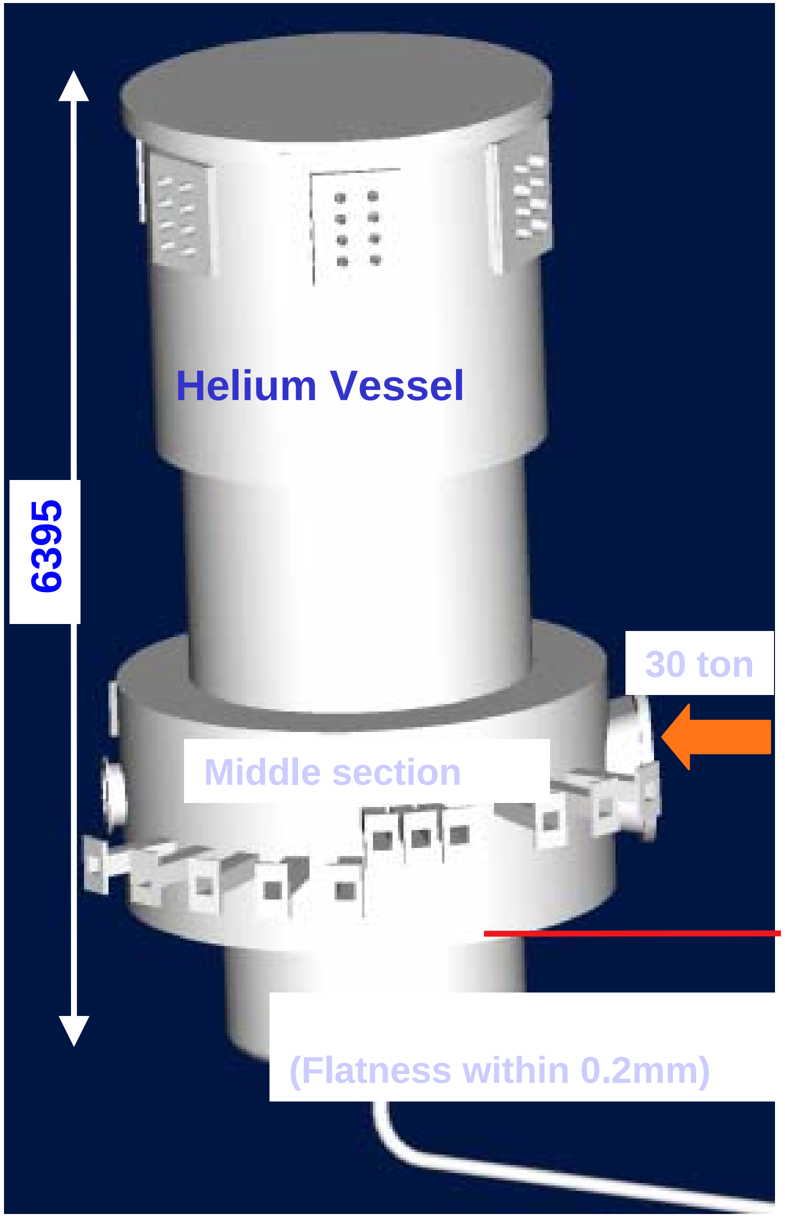
- **Shielding Blocks（Steel）**
  Concrete layer for effective shield of neutrons below 1 MeV

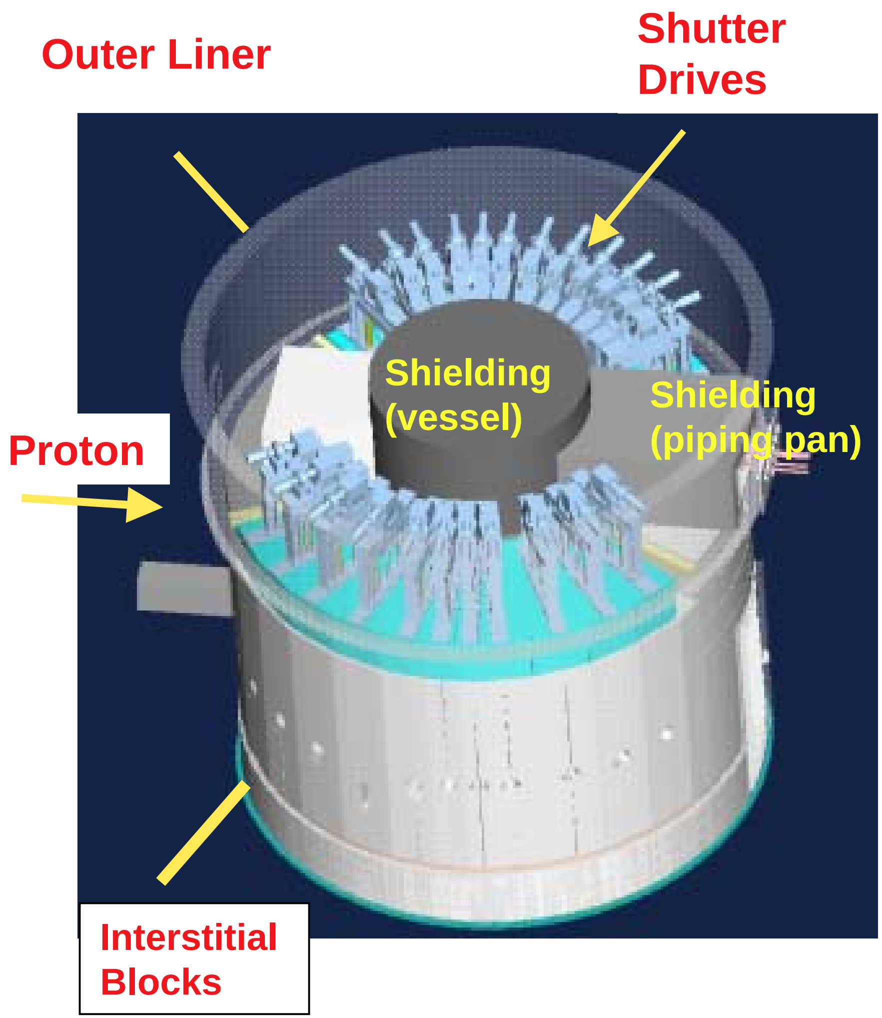
- **Magnetite concrete around outer liner**

- **Proton beam window（Inconel 718）**



Target Station
Shielding/Shutter/Helium Vessel

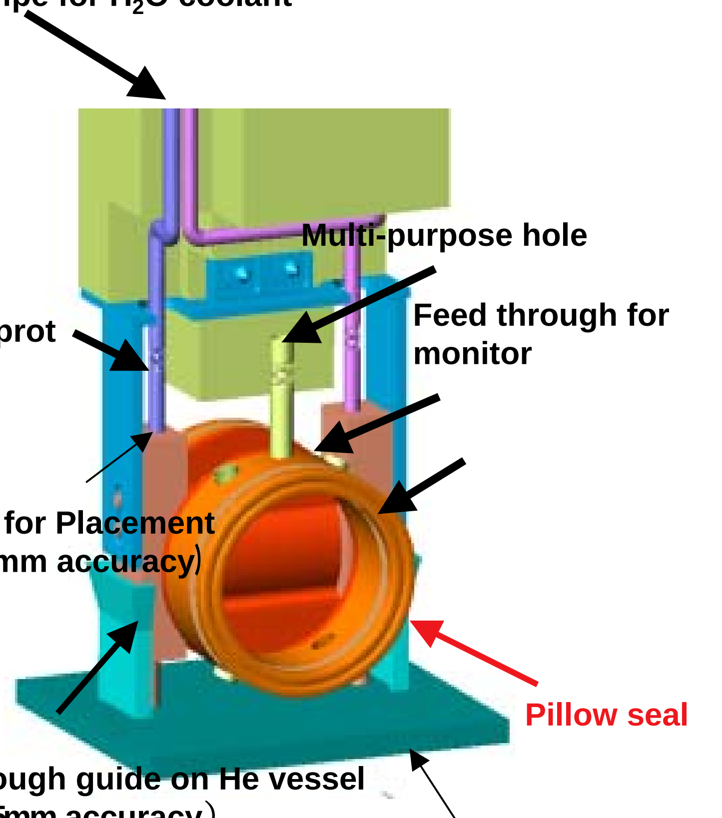




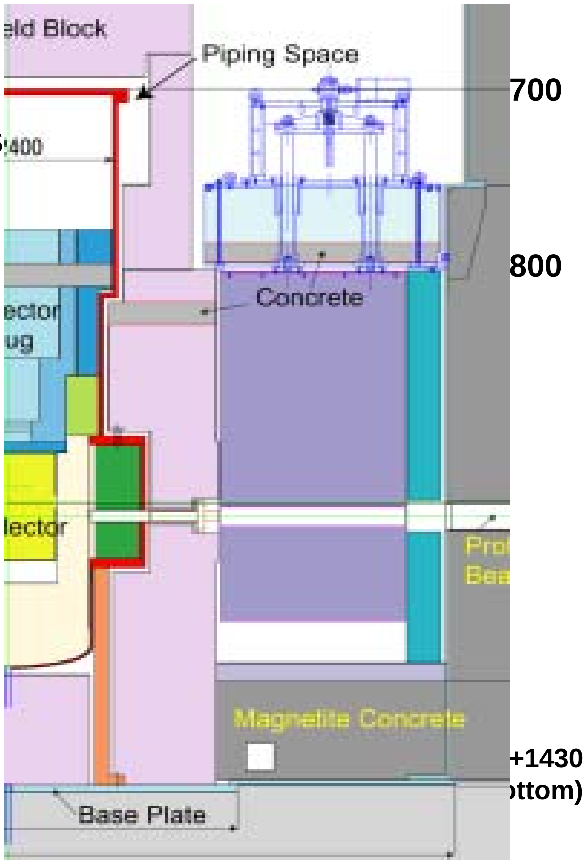
23 beam lines with independent shutters
Minimum angular interval of 6.7 °

Neutron Shutter and Proton Beam Window

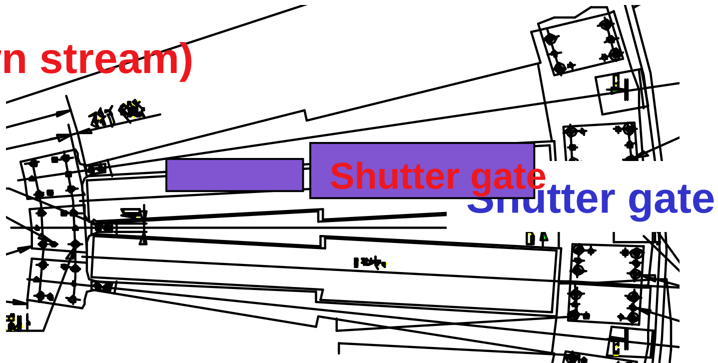
Proton beam window



- rigid connection by two guide rods
- shutter weight support by inner
- electrical motor drive
- Stroke : 400 mm
- open/close: <1 min
- positioning is 0.5 mm

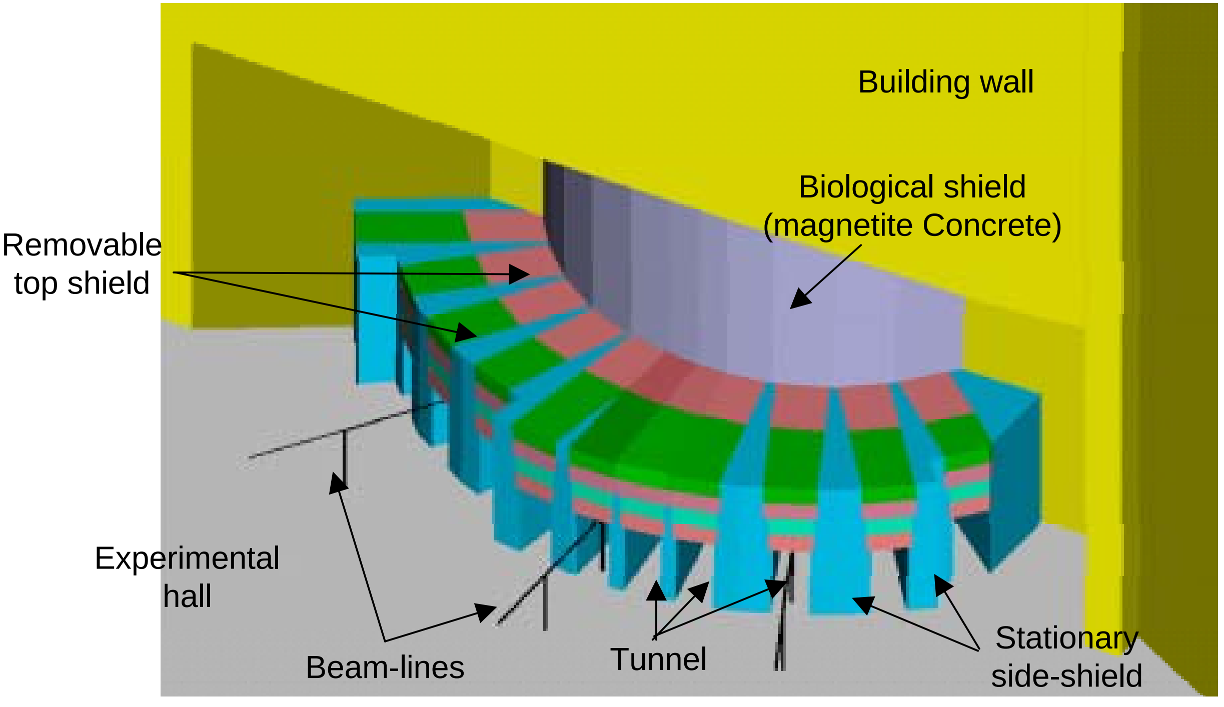


Gap : 12.5mm (side)
20 mm
(up/down stream)



Neutron-Beam-Line Shield

- A part of neutron-beam-line shield has been in tendering for award.
  - – Just outside of the biological shield made of magnetite concrete, and up to 12 m from the source center.
  - – 4,000 mm height from the floor level
    - Beam-line heights: 1,437 & 1,758 mm
  - – A 1,000 mm wide & 2,000 mm height tunnel for each beam line
    - Choppers, guide tubes, beam ducts, shield: to be installed
  - – Basically steel, and a layer of ordinary concrete of 200 mm
  - – 4,400 ton



Cryogenic System of Cold Moderators

Cryogenic system conceptual design has been completed to satisfy the cryogenic moderator design requirements. And followings were achieved.

- Flow diagram design
- Conceptual specifications for the main components
- Process flow diagram
- Pressure behavior analysis when applying disturbance

Issues to be perform

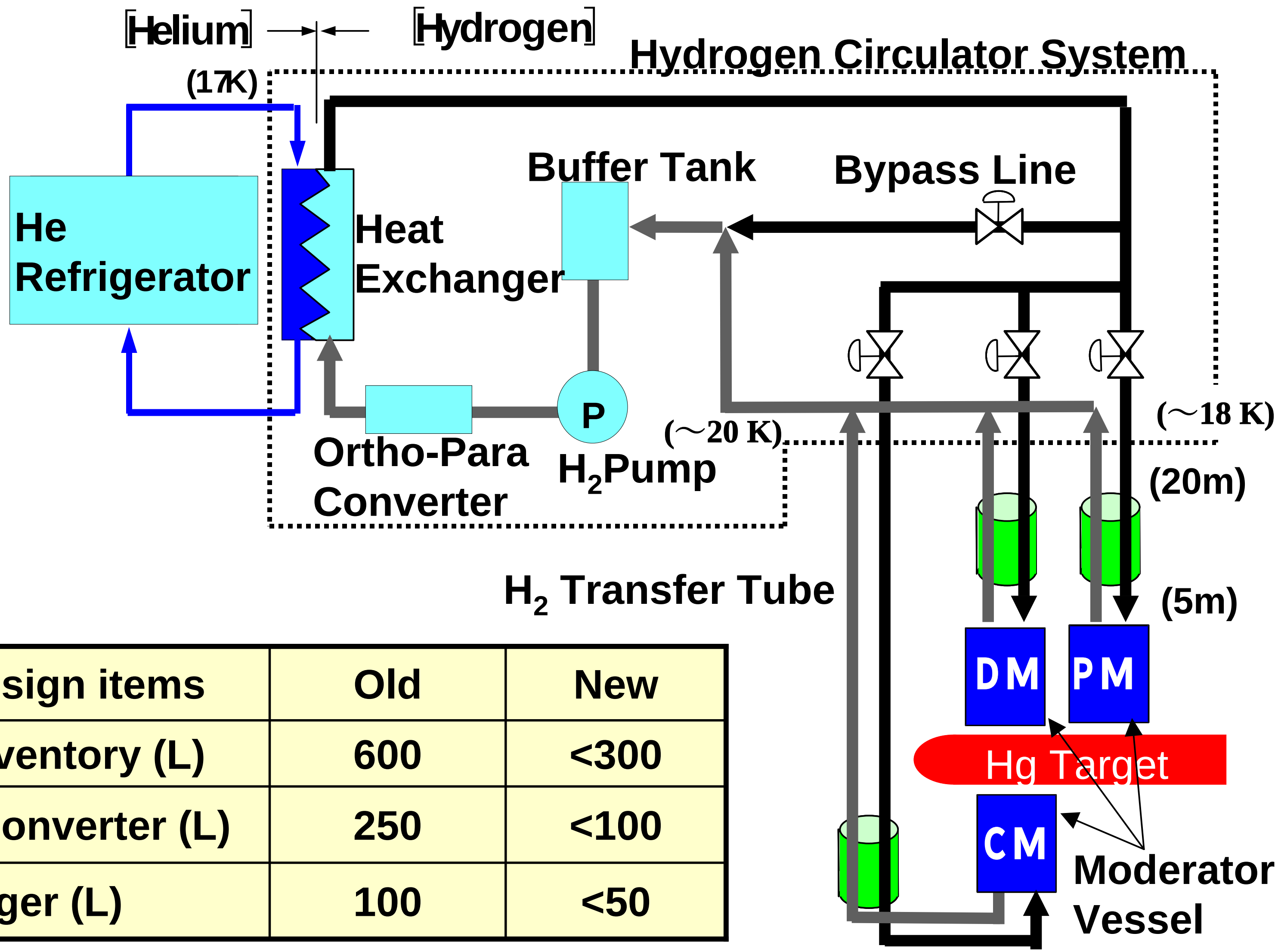
- Detail specification and cost estimation (Almost finished)
- Study and analysis of safety issues (on going)

Conceptual Flow Diagram

Design Press.
: 2MPa

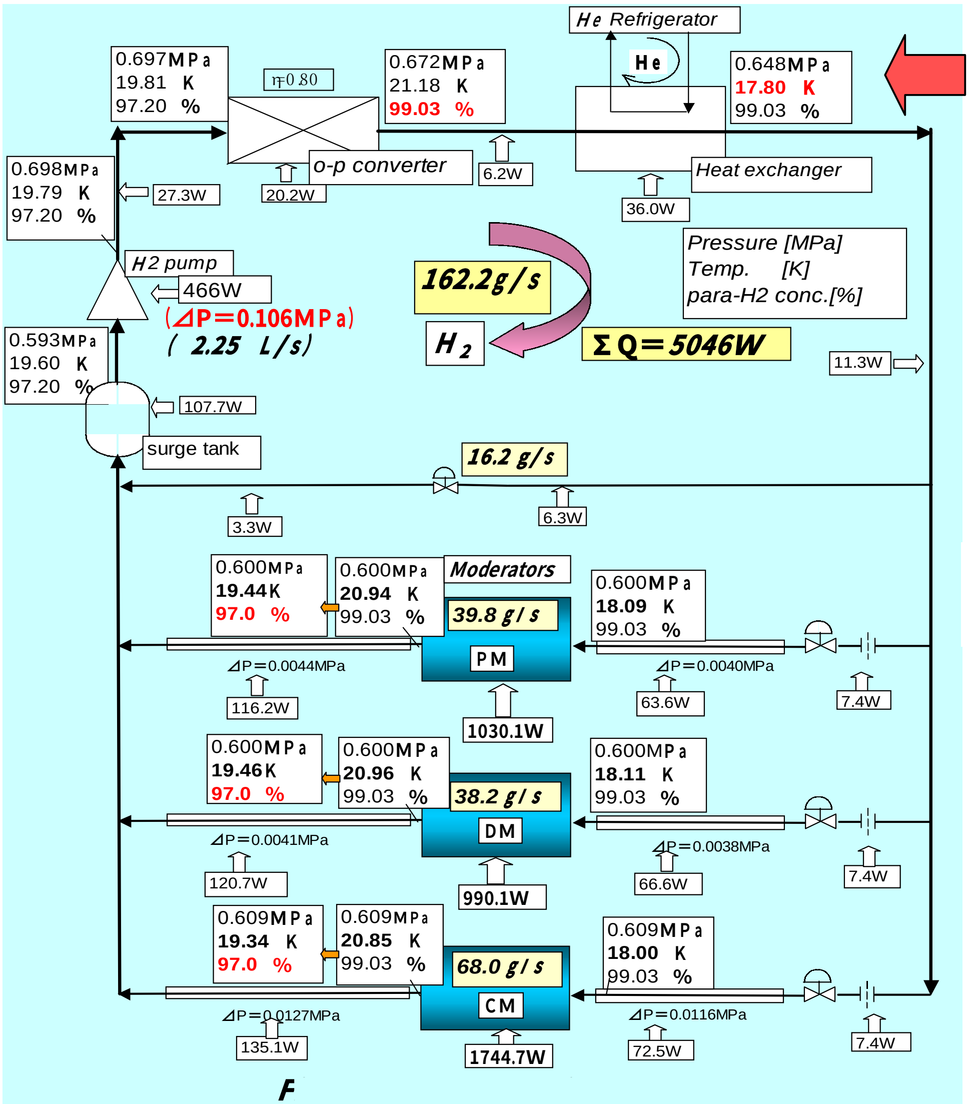
Temperature
:～ 20K

Flow Rate
: ～2.3L/s



Reviewed design items	Old	New
Hydrogen inventory (L)	600	<300
Ortho-Para converter (L)	250	<100
Heat exchanger (L)	100	<50

Process Design at the Rated Condition



Completion of process design

- ✓Satisfaction of design requirements
- ✓Optimization of process design

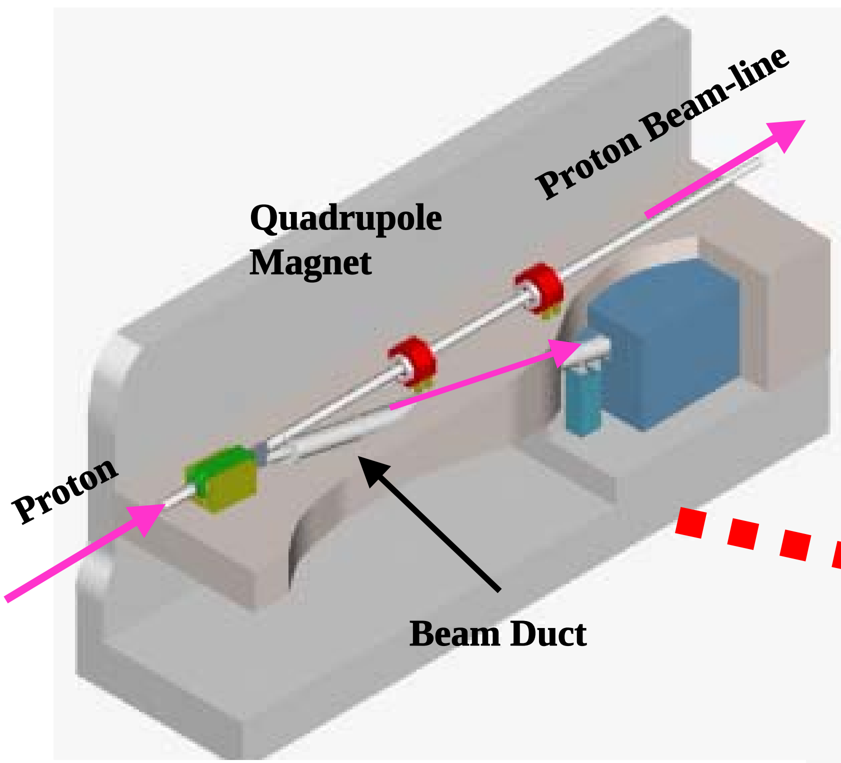
Reference heat loads

Moderator nuclear heating	Vessel	1896W
	Hydrogen	1855W
Heat load of circulator		466W
Heat load of hydrogen loop		254W
Heat load of transfer tubes		575W*
Total		5046W

*: The design review could reduce the heat load of 420W.

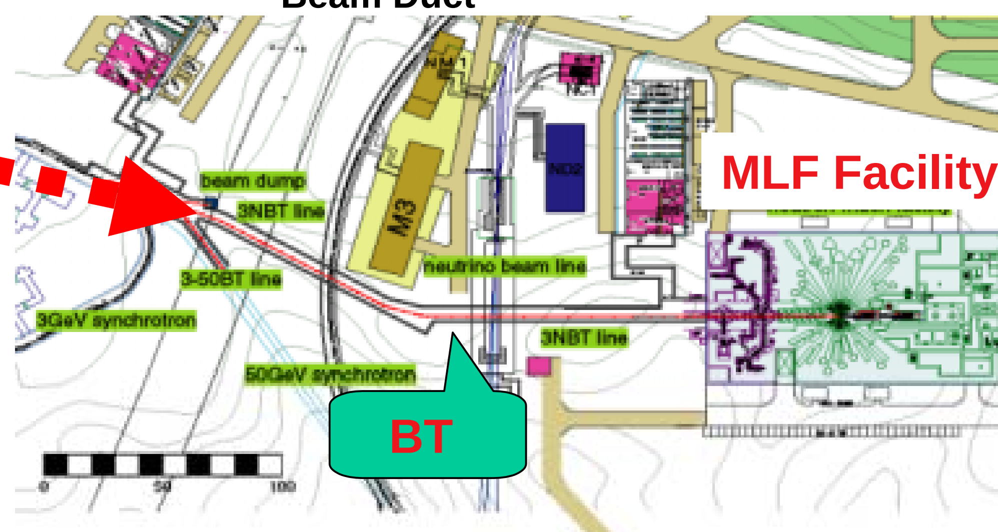
3 GeV proton beam-line and beam dump

- Final adjustment of beam optics at just after the 3GeV extraction point is underway.
- Parts of magnets and power supplies are under procurements. Design of the beam dump is in progress for manufacturing

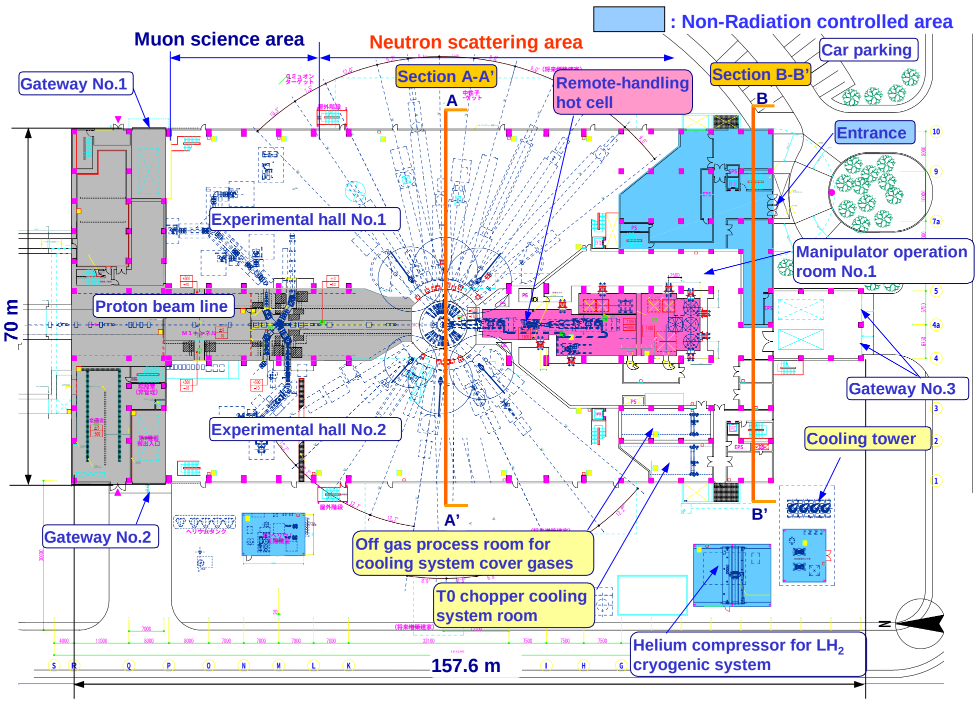


Beam dump is placed underground of the proton beam transport(BT) line.

Beam Dump
- **Proton Beam**
  - **3 GeV, 4 kW**
- **Structure**
  - **Steel：3.5m×3m×3m**
  - **SUS Liner**
  - **Concrete ：Thickness ~2m**
  - **Beam Duct**

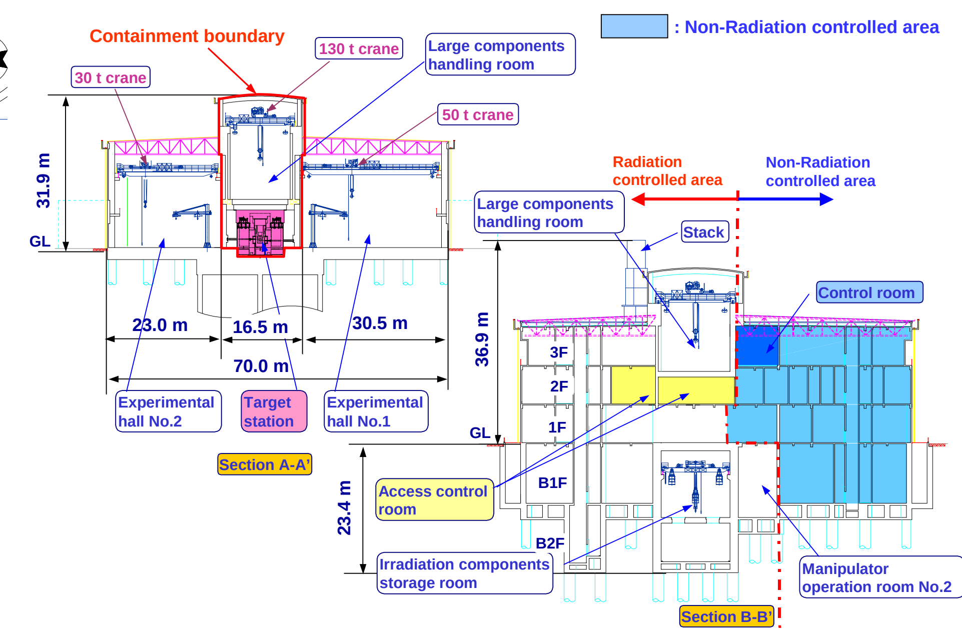


Conventional facility design



The first floor drawing

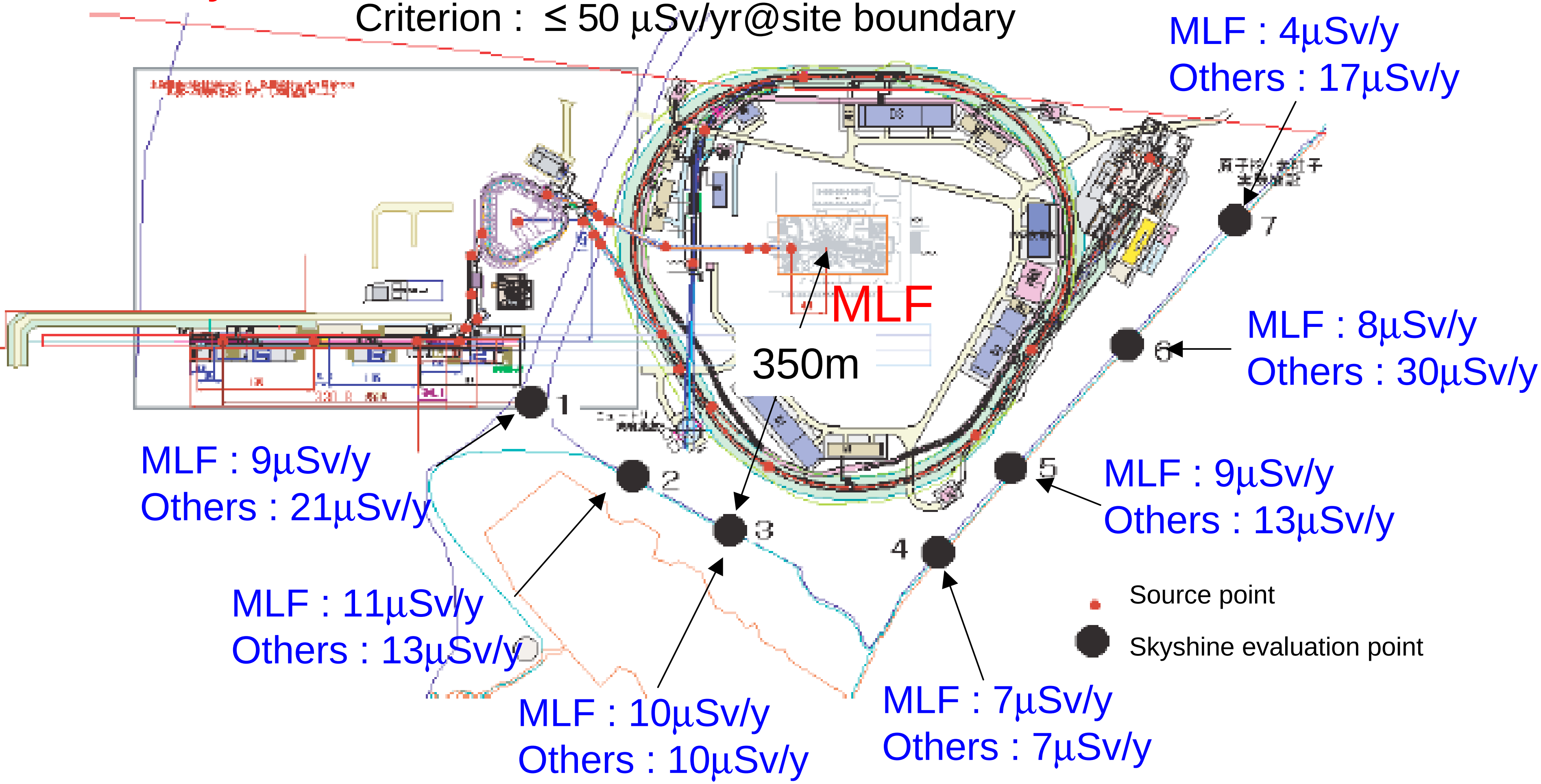
Elevation Views across the source/ across the storage area



Radiation Safety Design

Skyshine dose

Criterion : ≤ 50 μSv/yr@site boundary



Application to the local governments (Ibaraki prefecture and Tokai village) is underway. They will permit construction of MLF facility soon.

Project-team Instrument Proposal

1. Conceptual Design of Day-one Instruments
2. Evaluate requirements for

   Moderators (Ed 1eV, poisoning depth), Utilities & Facility

   Instrument components (Detector, Mirror etc.)
3. Instruments arrangements to evaluate required beam ports(number and separation) and requirement on engineering design of target station including moderator structure, etc.

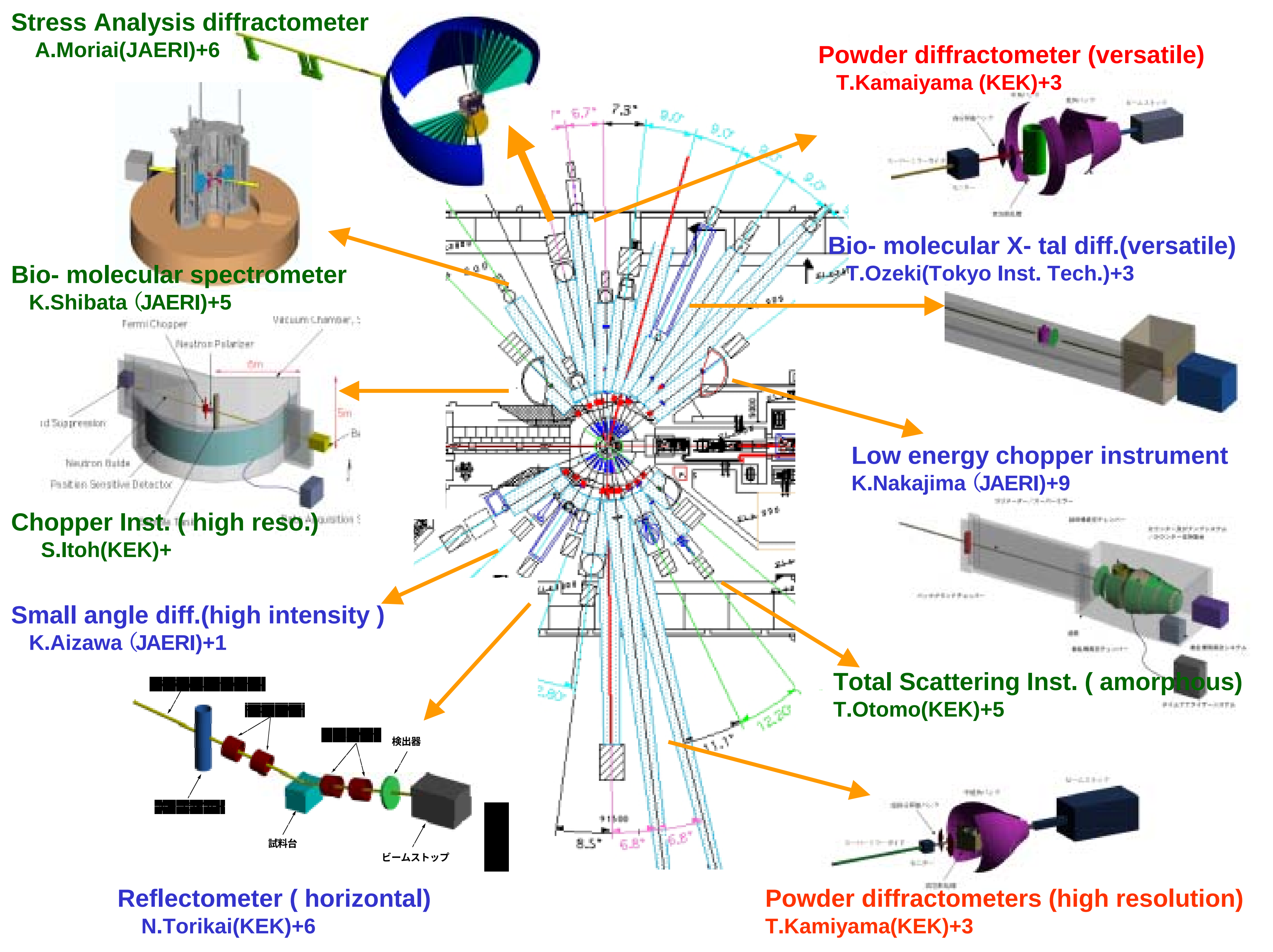
   --->23 beam port were established.

1999-2000 Instruments Discussion Group :40 instruments proposed

2000-2002 Instrument Project Team was established

Pre-selection of instruments to proceed to a concrete design of neutron target station (Beam hole, viewing moderator etc.)

Project-team Proposed 10 day-one instruments from a view Point of that Whole Q-E space should be covered by instrument suits so that various science can be applied.



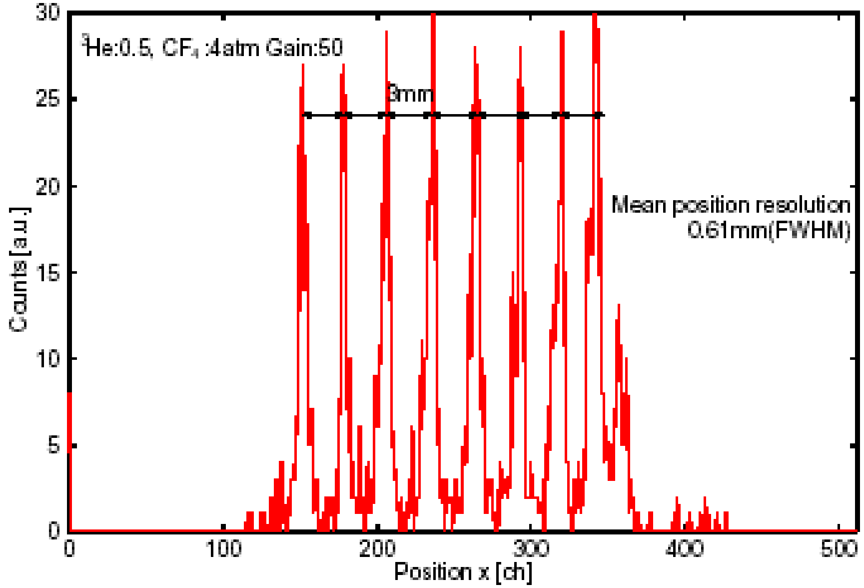
Stress Analysis diffractometer
A.Moriai(JAERI)+6
Powder diffractometer (versatile)
T.Kamaiyama (KEK)+3
Bio- molecular X- tal diff.(versatile)
T.Ozeki(Tokyo Inst. Tech.)+3
Bio- molecular spectrometer
K.Shibata (JAERI)+5
Fermi Chopper
Neutron Polarizer
Neutron Guide
Position Sensitive Detector
Low energy chopper instrument
K.Nakajima (JAERI)+9
Chopper Inst. (high reso.)
S.Itoh(KEK)+
Small angle diff.(high intensity)
K.Aizawa (JAERI)+1
検出器
試料台
ビームストップ
Total Scattering Inst. (amorphous)
T.Otomo(KEK)+5
Reflectometer (horizontal)
N.Torikai(KEK)+6
Powder diffractometers (high resolution)
T.Kamiyama(KEK)+3

Device development

I. Detector development

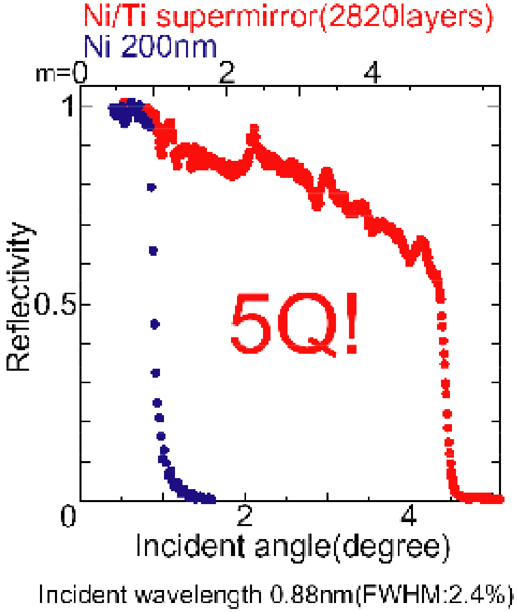
- Grid-type micro-strip gas-counter (MSGC),
  ASIC development
  - 0.6mm positional resolution,
  - Charge integration method:
    10^8-10^9 cps/s/mm^2
- Micro-Pin type gas-counter
  - Development just started.
- WLSF scintillation detector
  - 0.4mm positional resolution
- Direct-coupling scintillation detector with multi-anode PMT
  - Development just started.

MSGC: 0.6mm resolution
(Takahashi)



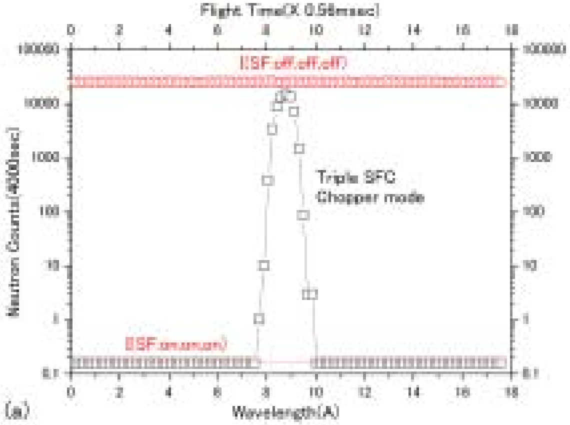
Device Development - continued

- II. Optics
  - Pulsed-sextupole magnet development for TOF SANS
  - Ion polishing for high-reflectivity
  - 5 Qc mirror
- III. He-3 Polarizing filter
- IV. Spin-flip chopper, Drabkin energy-filter

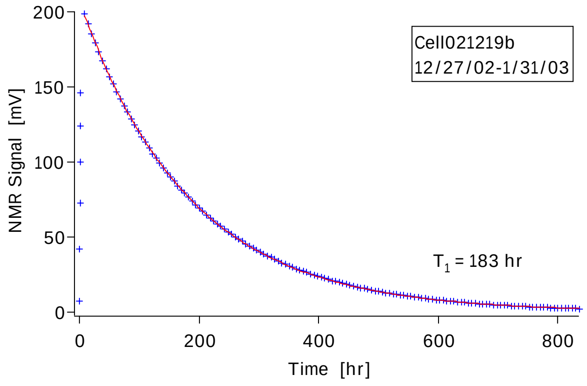


Hino, preliminary result.

Triple SFC, S/N ratio 1.6 x 10^5



He-3 polarization: T_1 = 183 hrs



1MW Pulse Spallation Neutron Source Technical Advisory Committee (N-TAC)

Date: October 28-30, 2002

@Japan Atomic Energy Research Institute, Tokai Research Establishment

- **Organization:**
  - under the International Advisory Committee (IAC) of the High Intensity Proton Accelerator Project (J-PARC)
- **Organizer:** Project Director, Prof. Shoji. Nagamiya

Objectives and introductory guidance for

The project recognizes indispensable merits to have a technical review of the design by professional scientists comprising international specialists world wide, giving critical advice on how to meet the goal for the completion of the 1MW pulse spallation neutron source, JSNS:

in terms of overall performance, technical soundness, timeframe, budgetary rationality, and other important points.

The N-TAC Committee members:

Dr. Günter S. BAUER (Chair)	ESS, Forschungszentrum Juelich GmbH, Germany
Dr. Timothy A. BROOME	ISIS, Rutherford Appleton Laboratory UK
Dr. John M. CARPENTER	Argonne National Laboratory USA
Dr. Hajo HEYCK	SINQ, Paul Scherrer Institute CH
Prof. Hiroaki KURISHITA	Tohoku University, Japan
Dr. Thomas J. MCMANAMY	SNS Project Oak Ridge, USA

Executive Summary and Main Recommendations

- The Committee was impressed by the amount and quality of work done by the Project Team since Phase 1 of the J-PARC project was approved and by the well thought through overall concept of this endeavour of highest scientific importance.

- Continue active participation in the *International Collaboration on High Power Target Development* with the goal to find a method to mitigate pressure wave build-up in liquid metal targets under pulsed operating conditions.

- Carefully reassess the benefits of a cross flow configuration with a permanently fixed outer shroud for the mercury target system in terms of;
  technical and manufacturing complexity
  overall cost and handling
  flexibility to incorporate a pressure pulse mitigation system.

- Reassess the required size of the ortho-para hydrogen converter by confirming the anticipated conversion rate in the moderators. --> less than 1/2 in total H2 inventory

Executive Summary and Main Recommendations-2

- Re-examine the purpose and specifications of the proton beam dump (currently 4kW)to ensure efficient accelerator commissioning and development without relying too heavily on the mercury target being in service.

- Consider making available at least limited funds for instrument planning at the present point in time to fund a few full time scientists for this task. This is important to guarantee that instrumentation needs get sufficient attention in the planning process and the needs of the instruments are fully taken into account in the design of the target station.

- Develop procedures and make suitable provisions for recovery from abnormal operating conditions and equipment failure and for post mortem and after service examination of components in order to improve continuously the system performance and availability. All documentation should take this into account.

The Committee noted in particular:

- The design presented for the (now) JPARC 1MW Spallation Source is generally well developed with good technical solutions for all major target station requirements and appears technically feasible.

- In accordance with a growing importance of long wavelength neutrons, emphasis has been placed on cold neutron performance. Along these lines innovative features for moderator design have been developed which hold a promise for significant improvements of long wavelength neutron performance.

- Well developed neutronic shielding analysis has led to cost optimisation by reducing the amount of machined steel shielding required in the monolith.

- The design presentations focused on normal operations with little discussion of the design requirements for off-normal events or the level of quality assurance required for the equivalent of safety significant or safety class systems.

In general, the review material presented did not permit an evaluation of design features for off-normal events or accidents.
This may have far reaching consequences as experience shows that the design is often significantly influenced by the requirements for containing and recovering from such events. This should be a prominent subject in future reviews.

Schedule and integration

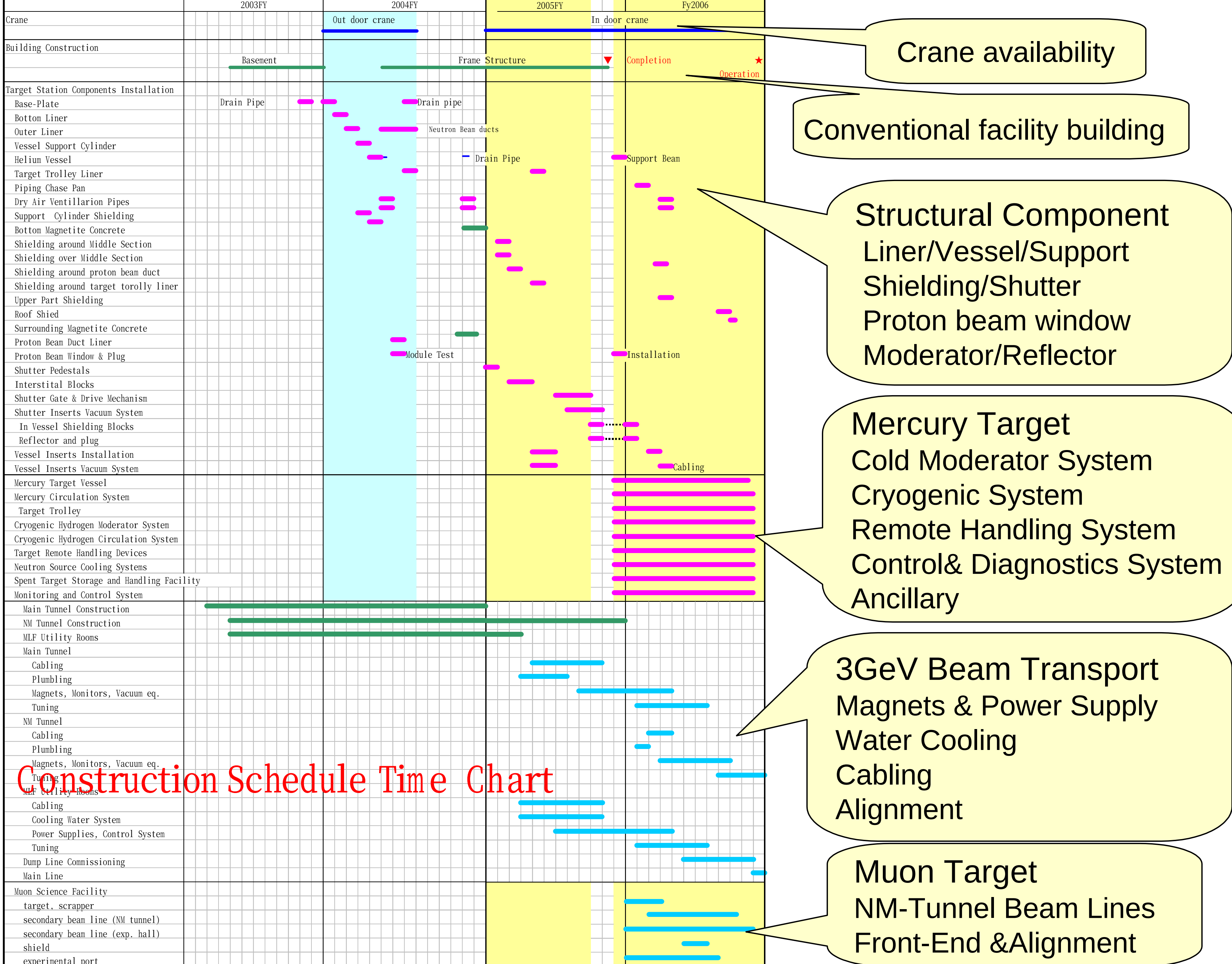
- *The schedule for the whole project is extremely ambitious.* It is the understanding of the Committee that this is dictated in part by a funding profile which is beyond the Project's control. This affects the procurement sequence and requires difficult decisions to be made at a very early point, making sure that there remains enough flexibility to adjust to arising needs.

- The Committee anticipates problems to arise if deliveries come in at times when the site is not ready for the installation of the components.

- Significant amounts of space must be provided for receiving, acceptance testing and storage of parts and components.

- Simultaneous construction activities on all project units in a rather limited space will require special measures and tight organisation.

- It is particularly important to ensure adequate testing time and provisions to demonstrate remote handling systems.


Construction Schedule Time Chart
2003FY
2004FY
2005FY
Fy2006
Crane
Out door crane
In door crane
Building Construction
Basement
Frame Structure
Completion
Operation
Target Station Components Installation
Base-Plate
Bottom Liner
Outer Liner
Vessel Support Cylinder
Helium Vessel
Target Trolley Liner
Piping Chase Pan
Dry Air Ventillarion Pipes
Support Cylinder Shielding
Bottom Magnetite Concrete
Shielding around Middle Section
Shielding over Middle Section
Shielding around proton beam duct
Shielding around target torolly liner
Upper Part Shielding
Roof Shied
Surrounding Magnetite Concrete
Proton Beam Duct Liner
Proton Beam Window & Plug
Shutter Pedestals
Interstital Blocks
Shutter Gate & Drive Mechanism
Shutter Inserts Vacuum System
In Vessel Shielding Blocks
Reflector and plug
Vessel Inserts Installation
Vessel Inserts Vacuum System
Drain Pipe
Drain pipe
Neutron Beam ducts
Drain Pipe
Support Beam
Module Test
Installation
Cabling
Mercury Target Vessel
Mercury Circulation System
Target Trolley
Cryogenic Hydrogen Moderator System
Cryogenic Hydrogen Circulation System
Target Remote Handling Devices
Neutron Source Cooling Systems
Spent Target Storage and Handling Facility
Monitoring and Control System
Main Tunnel Construction
NM Tunnel Construction
MLF Utility Rooms
Main Tunnel
Cabling
Plumbling
Magnets, Monitors, Vacuum eq.
Tuning
NM Tunnel
Cabling
Plumbling
Magnets, Monitors, Vacuum eq.
Tuning
MLF Utility Rooms
Cabling
Cooling Water System
Power Supplies, Control System
Tuning
Dump Line Commissioning
Main Line
Muon Science Facility
target, scrapper
secondary beam line (NM tunnel)
secondary beam line (exp. hall)
shield
experimental port
Crane availability
Conventional facility building
Structural Component
Liner/Vessel/Support
Shielding/Shutter
Proton beam window
Moderator/Reflector
Mercury Target
Cold Moderator System
Cryogenic System
Remote Handling System
Control& Diagnostics System
Ancillary
3GeV Beam Transport
Magnets & Power Supply
Water Cooling
Cabling
Alignment
Muon Target
NM-Tunnel Beam Lines
Front-End &Alignment

Mercury Spallation Target Issue

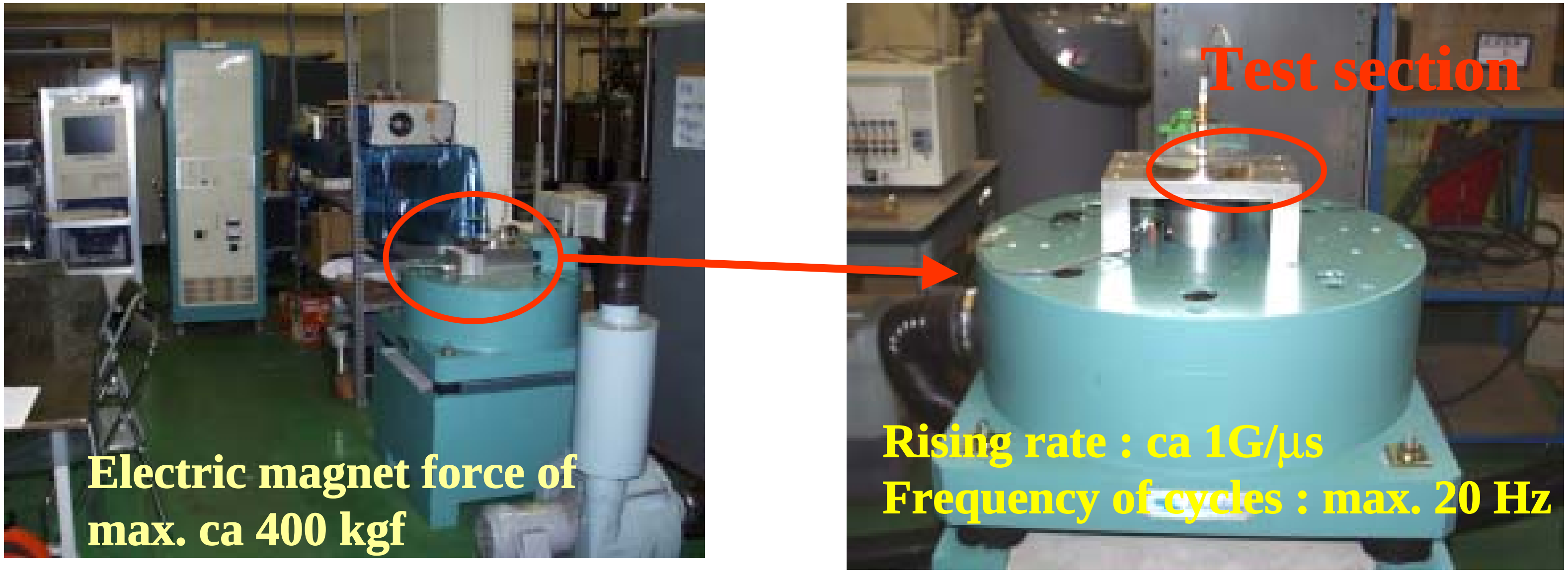
Pitting damage and erosion on a Hg target container inner surface induced by high power pulse injection.
It has been recognized a serious problem for assurance of the target lifetime.
Since the first observation of the pitting by SHPB test at JAERI,
studies have been extensively carried out both with on- and off-line impact test by SNS and JSNS project teams, respectively:

LANSCE/WNR using proton pulse

MIMTM high cycle offline test.

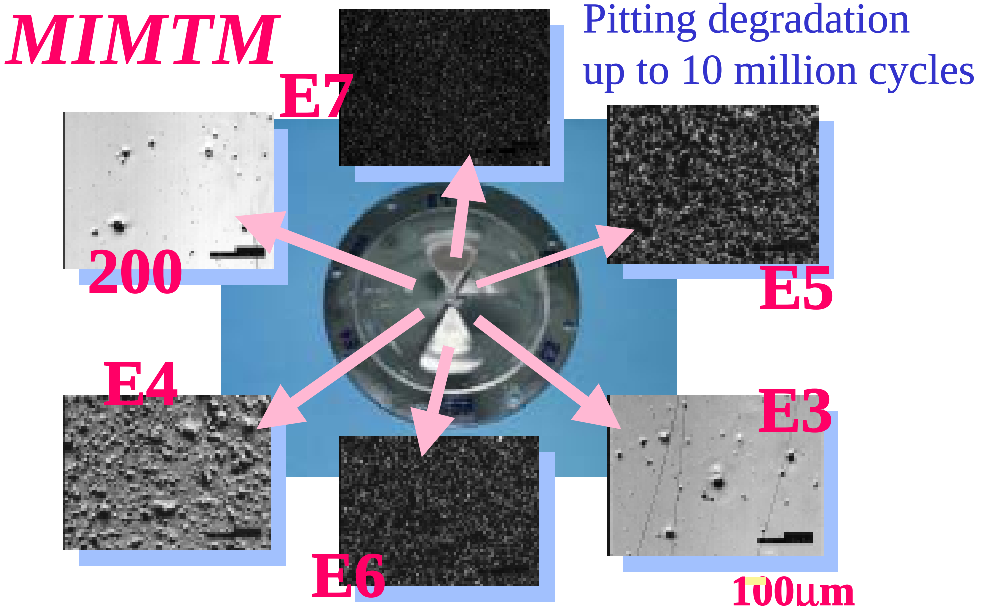
Magnetic IMpact Testing Machine(M I M T M)

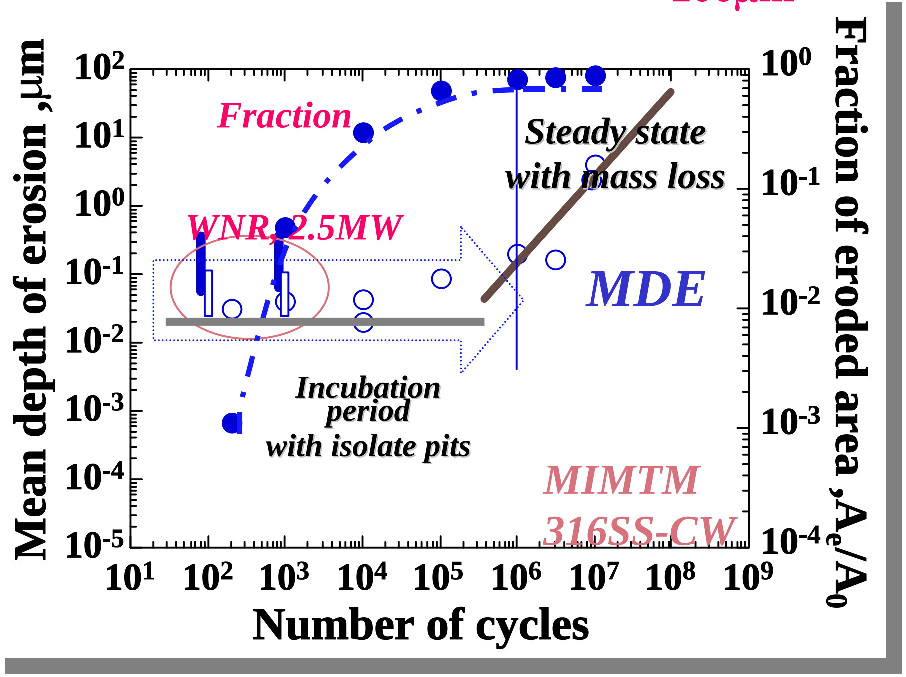
to estimate high cycle pitting damage up to 10 million



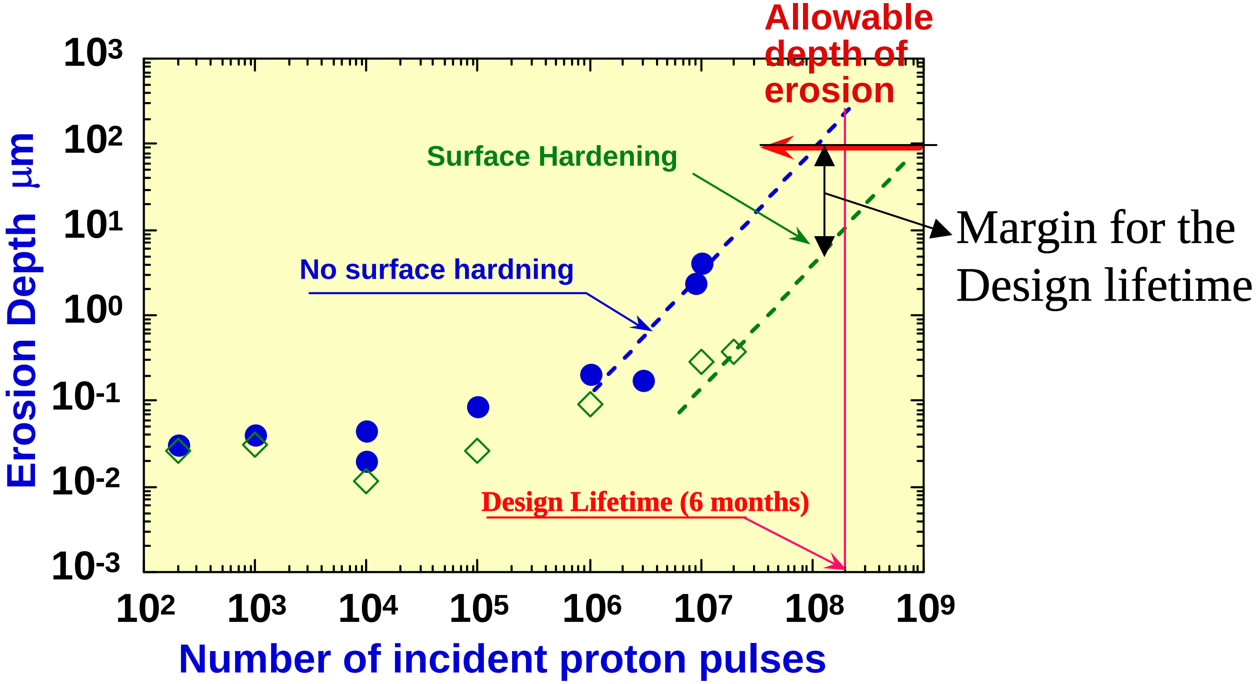
What we have known so far from Off-line tests

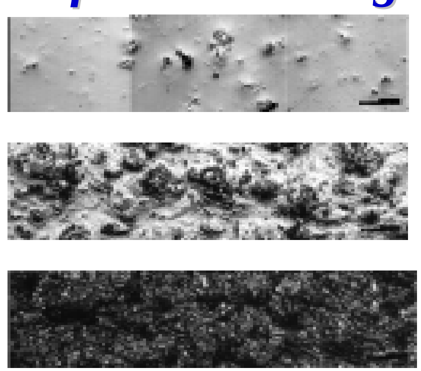
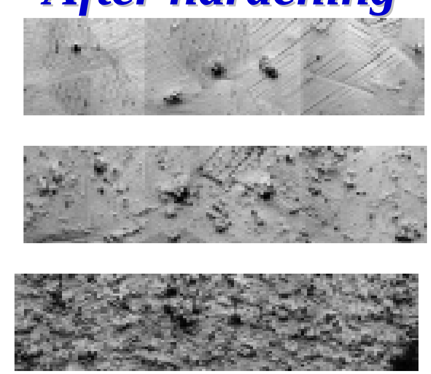
1) Kolsterising (Hardening surface treatment) is effective for reducing pitting damage.
2) Understandings: the damage is characterized by two steps, an incubation period and steady increase of mass loss with the number of cycles to approximately the 1.27 power.
3) Three phases of pitting damage could be categorized in terms of the number of loading cycles (for 316SS):
   Phase 1($<10^4$): Individual pits
   Phase 2(10^5 to 10^6): Pits combine and over lapped.
   Phase 3($>10^6$): Homogeneous erosion with mass loss begins





Comparison of pitting damage erosion of SS316 before and after surface hardening



No. of cycle	*Before hardening*	*After hardening*
10,000		
100,000		
1,000,000		

It is clearly observed that the pitting damage is suppressed by the hadning

We have set up further R&D programs on pitting issues in mercury target for design continuation consistently.

Items & Schedule

2002 MPY:5, 20MYen 2003 MPY:5, 25MYen

	Items	Apparatus	Collabo.	2003 1/4	2003 2/4	2003 3/4	2003 4/4	2004 1/4	2004 2/4	2004 3/4	2004 4/4	2005	2006
Off-line test	Data up to 2E8 Hardening & Coating	MIMTM	Private co. SNS,ESS										
	Pressurised Hg	MIMTM											
	Stressed specimens	MIMTM											
	Monitering system	MIMTM	Tohoku Univ.										
	Fatigue (Hg,Pitting)	New Machine MIMTM											
	Flowing Hg effect Mitigation system	Hg-LOOP	ESS										
On beam test	Data up to E5		SNS,ESS										
	Mitigation		ESS,SNS										
	Hardening & Coatings		SNS,ESS										
	Monitering system												
Simulation	Dynamic response Cavitation intensity		Tokyo Univ.										
Hg-Target	Design Trial fabrication Fabrication Installation												

We are in a high time:

Bids of structural components have been awarded by multiple venders. As components are mutually intricate structures, a stringent coordination and precise adjustments are essential.

In addition, even more critical accordance with the conventional facility building construction is required in a limited timeframe.

Designs of the mercury target system and the supercritical hydrogen cold moderator/cryogenic system are going to be finalized and almost all line items are to be submitted to tenders for bids.

Very close to the No Return Point.