Material and Life Science Experimental Facility

Project Overview

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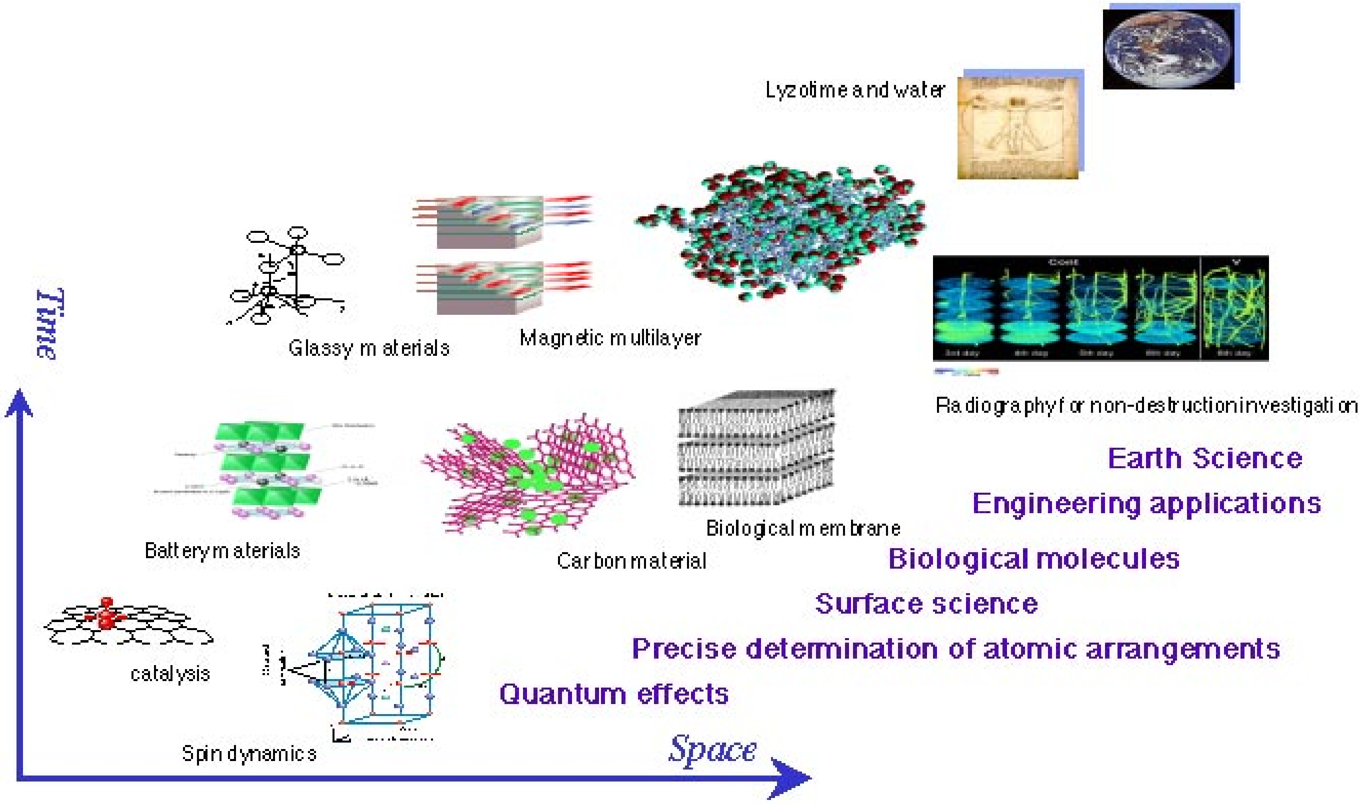
Japan Atomic Energy Research Institute

MLF Mission

Construction of a user facility providing advanced MW pulse neutron and muon sources for various experiments of materials and life sciences.
One of large regional centers in the world.

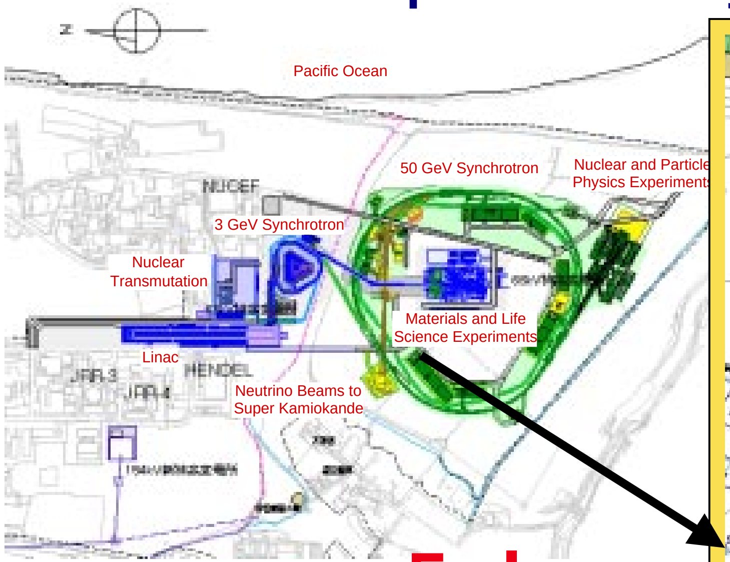


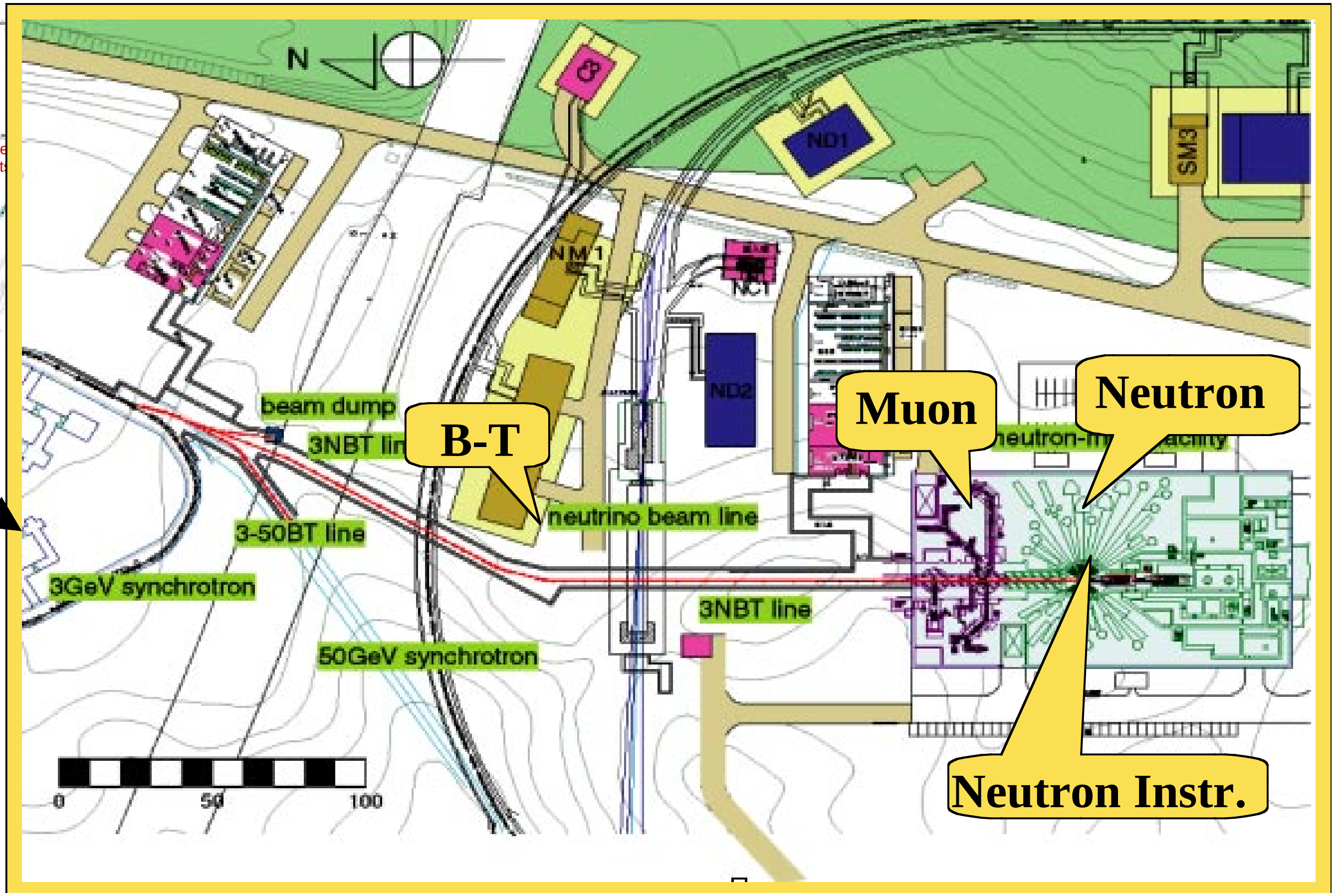
Neutron sciences in a wide time-space

MLF Facility Layout

Consists of four major areas

3GeV Proton Beam Transport System
Pulsed Spallation Neutron Source System
Neutron Instruments Systems
Muon Experimental Systems

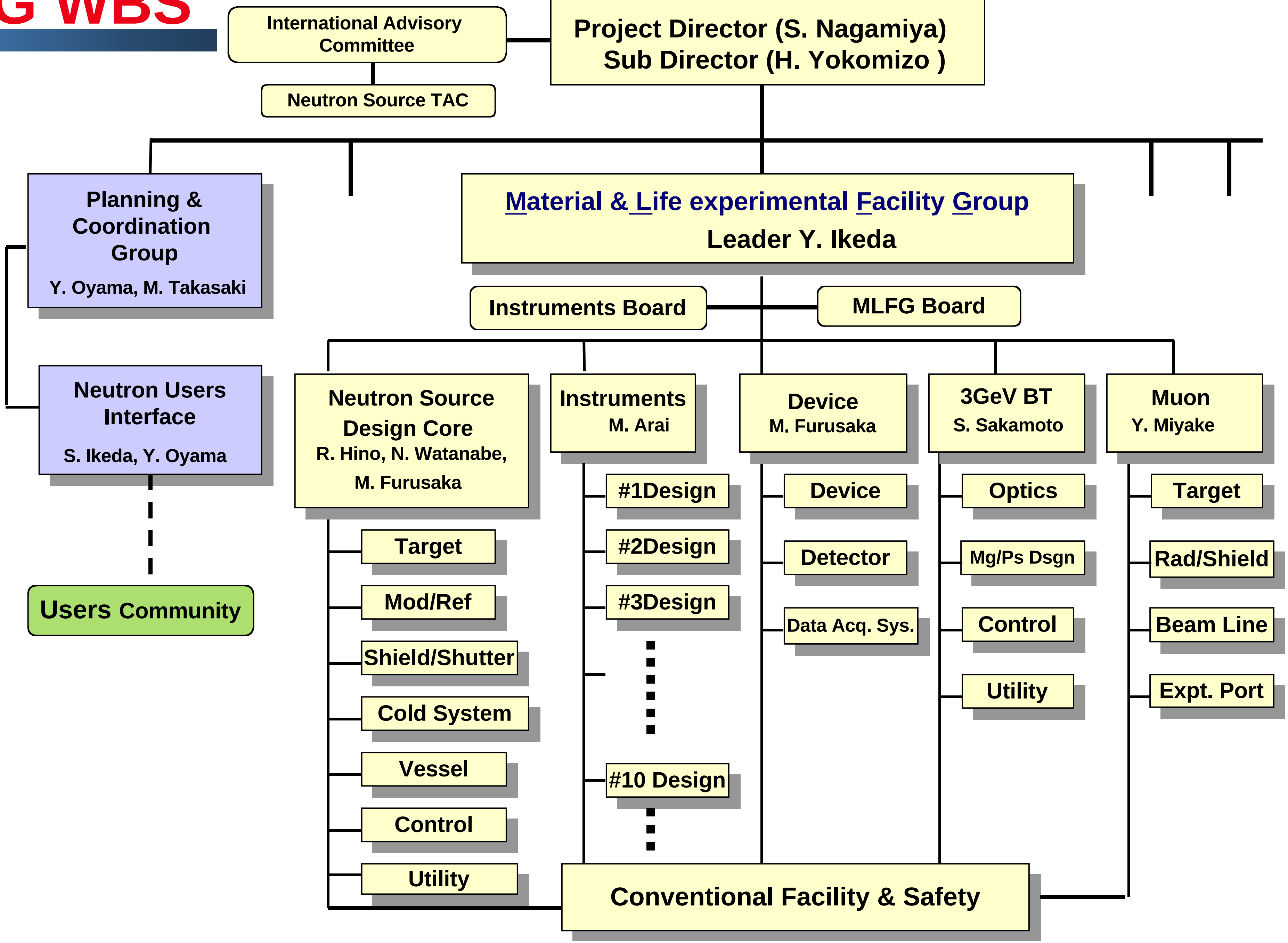




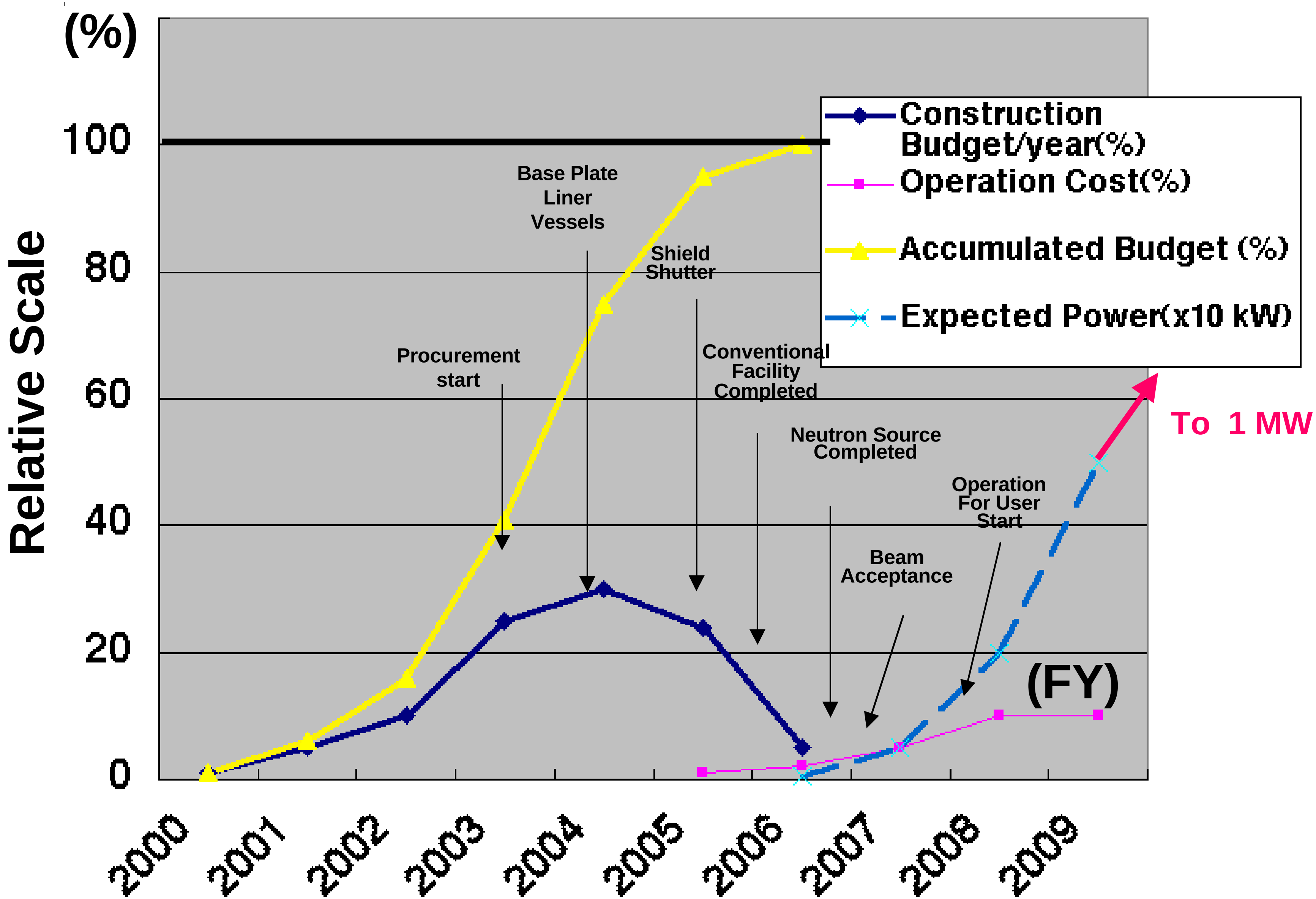
Major Parameters

- **1MW (3GeV, 0.33 mA) proton beam power**
- **25 Hz Repetition, < 1 ms Pulse width**
- **Long 3GeV p B-T line ~300 m: 1W/m beam loss -BT**
- **Mercury spallation target -N**
- **20mm carbon muon production target -M**
- **Proton beam cascade configuration through M-N in one building sharing the experimental hall and utilities**
- ****Note that 5pulses/3.4 sec are delivered to 50GeV ring***

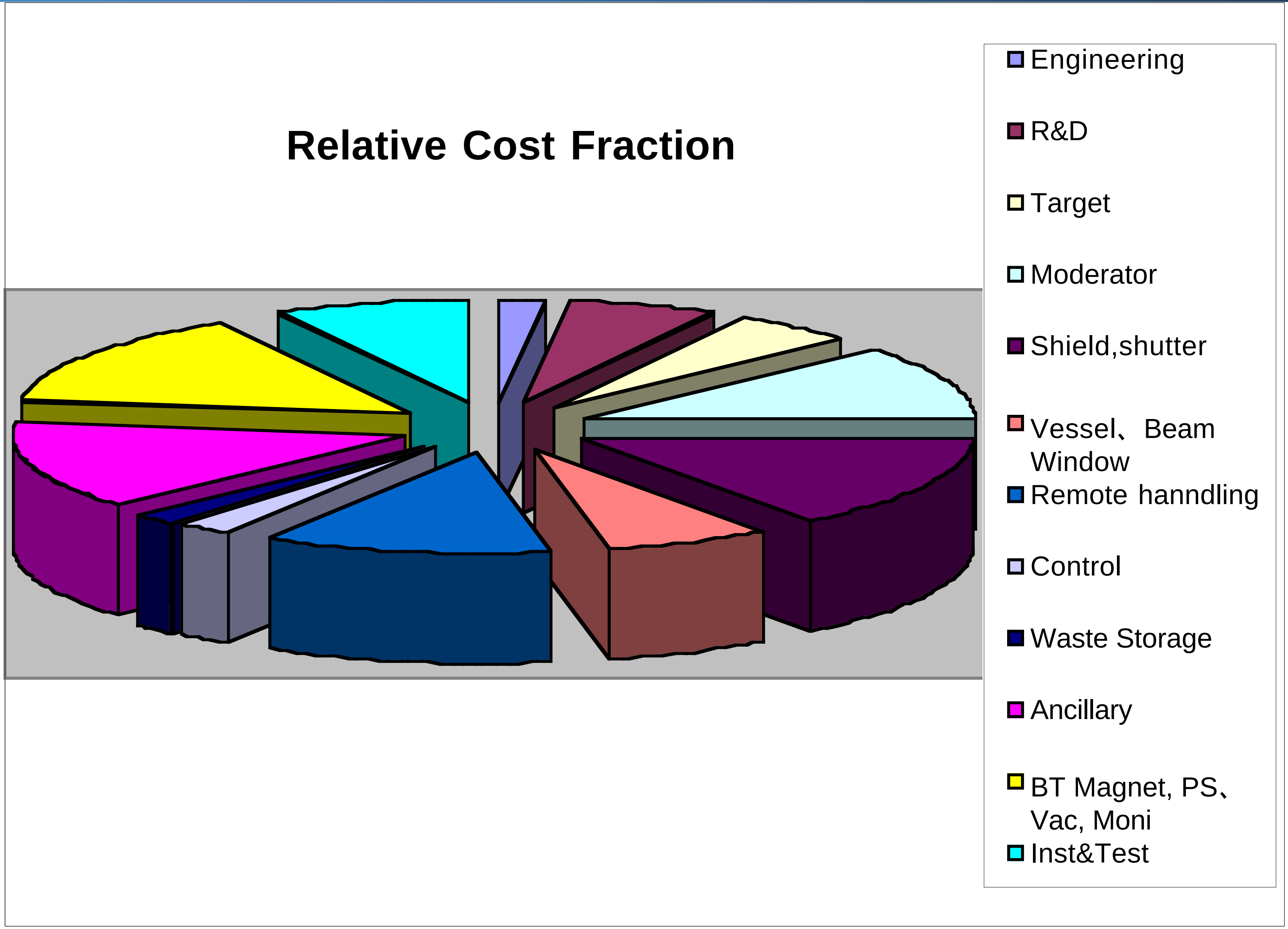
MLFG WBS


International Advisory Committee
Neutron Source TAC
Project Director (S. Nagamiya)
Sub Director (H. Yokomizo)
Planning & Coordination Group
Y. Oyama, M. Takasaki
Neutron Users Interface
S. Ikeda, Y. Oyama
Users Community
Material & Life experimental Facility Group
Leader Y. Ikeda
Instruments Board
MLFG Board
Neutron Source Design Core
R. Hino, N. Watanabe, M. Furusaka
Target
Mod/Ref
Shield/Shutter
Cold System
Vessel
Control
Utility
Instruments
M. Arai
#1Design
#2Design
#3Design
#10 Design
Device
M. Furusaka
Device
Detector
Data Acq. Sys.
3GeV BT
S. Sakamoto
Optics
Mg/Ps Dsgn
Control
Utility
Muon
Y. Miyake
Target
Rad/Shield
Beam Line
Expt. Port
Conventional Facility & Safety

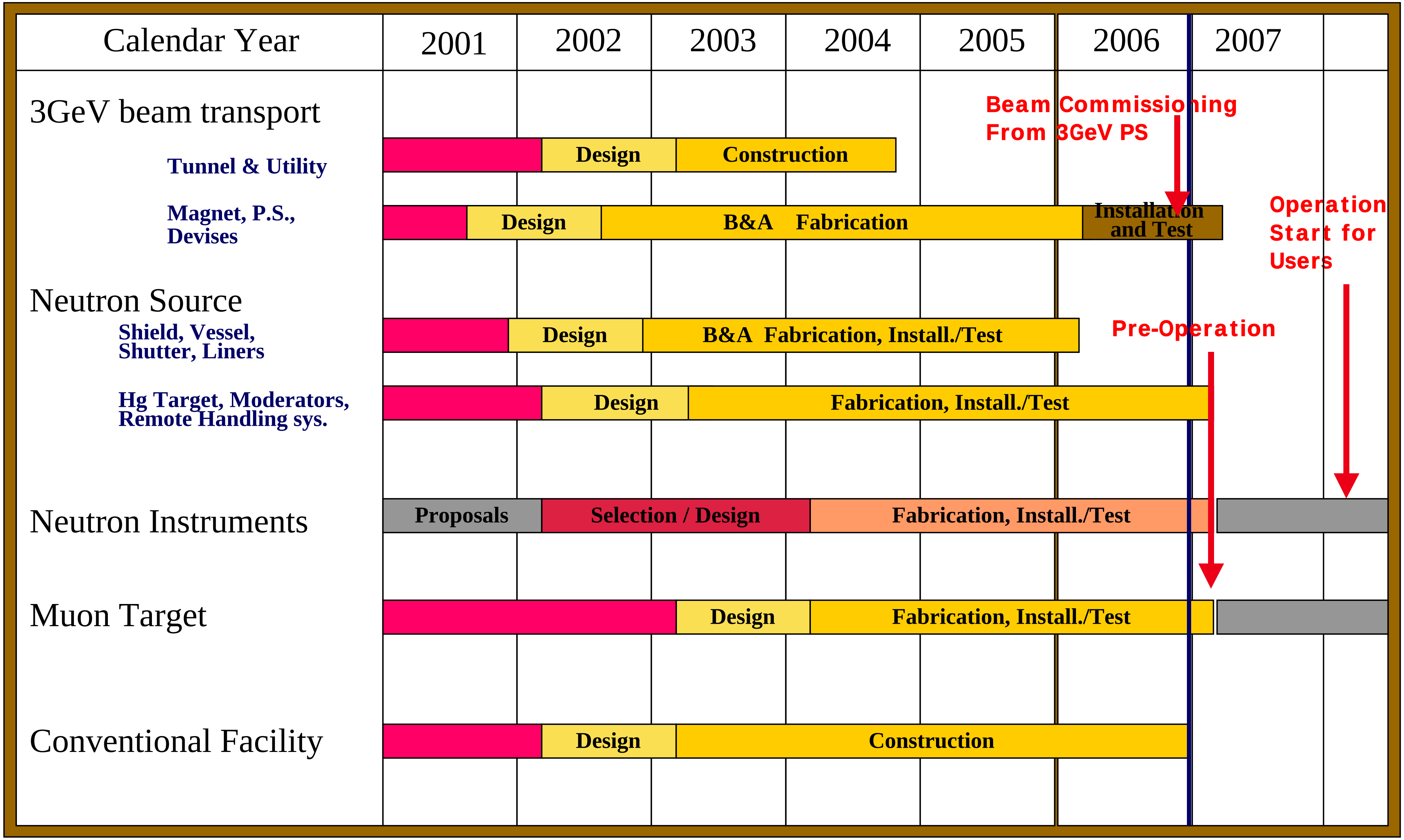
Budget profile for JSNS and major milestones



Relative Cost Fractions of Major Components of JSNS



MLF Construction Schedule



Design principle

*As many beam lines as possible (Max. 23 lines with independent shutters)
*Simple and robust structure
*High neutron performance of target/moderator system based on detailed neutronics design
*Competitiveness with other major sources with full advantages of the repetition rate of 25 Hz and the 1MW beam power

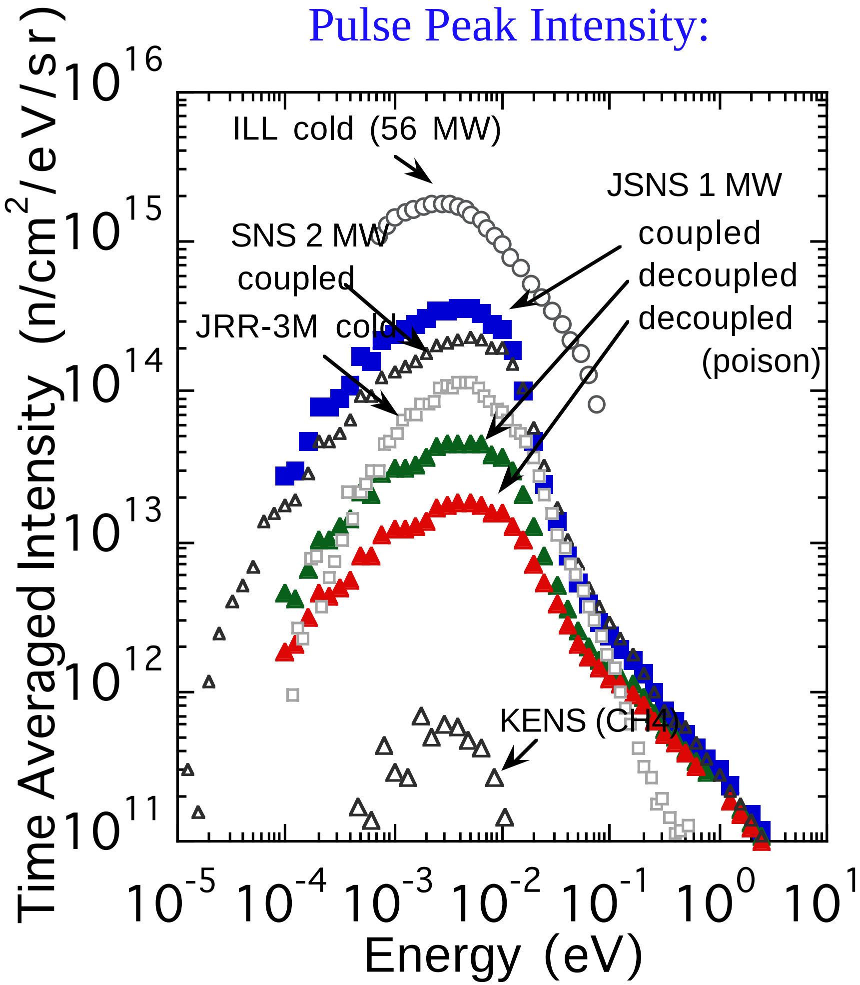
Minimizing cost and maximizing overall facility performance

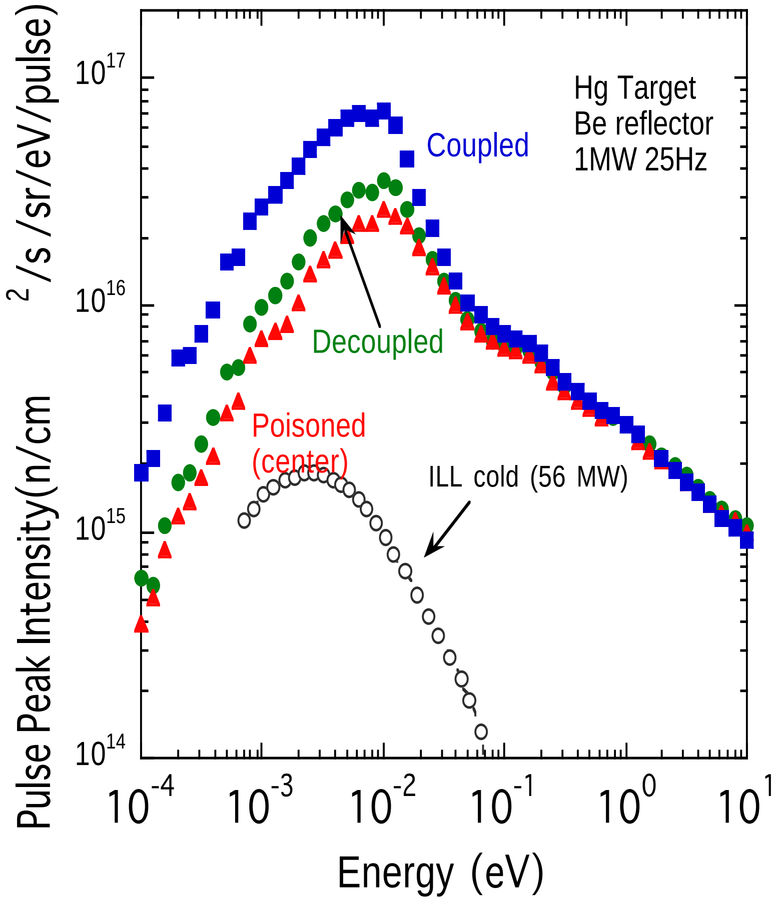
Performance of neutron source

Unique Neutron Flux of JSNS

Time Averaged Intensity: Coupled Moderator 1/4 of ILL's cold

Pulse Peak Intensity: 100 of ILL's cold



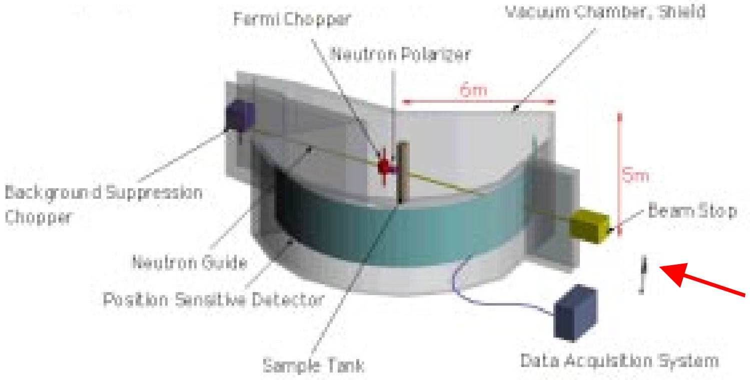


Neutron instrumentation and users

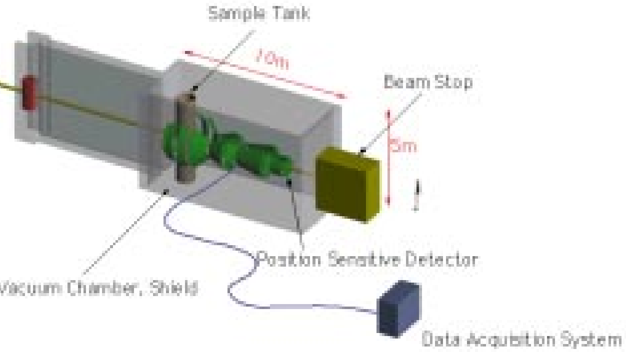
- Instruments design team in the project consisting mainly of the Instrument group of MLFG was organized and started an active work.
- The project team identified 10 important instruments to be installed at an early stage of the facility operation.
- User instrumentation group has been organized besides the instruments design team in the project to encourage the external proposals.
- The advisory committee to the project director was organized , in which the priority of neutron instrument and a general rule for adopting the proposals has been discussed.
- Call for LOI was announced out.

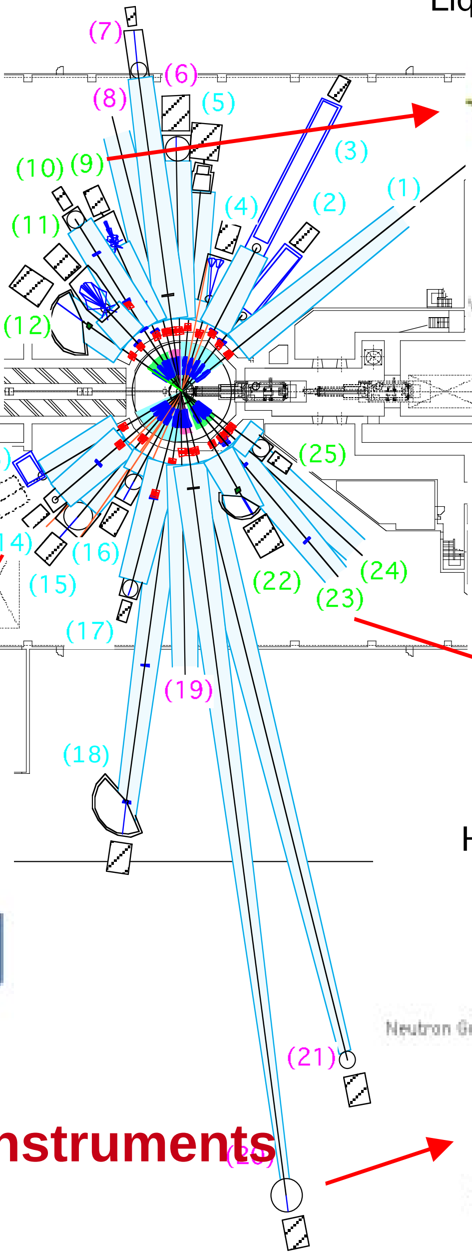
23 beam lines with Independent shutters

High-Resolution Chopper Spectrometer

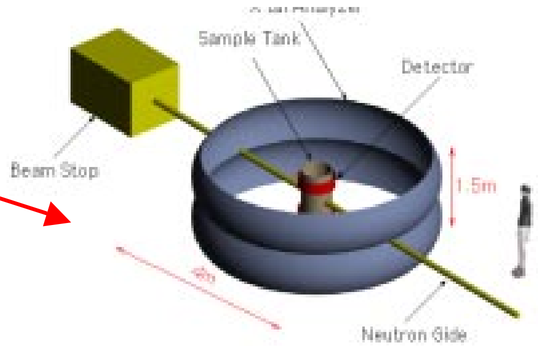


Liquids Total Scattering Diffractometer

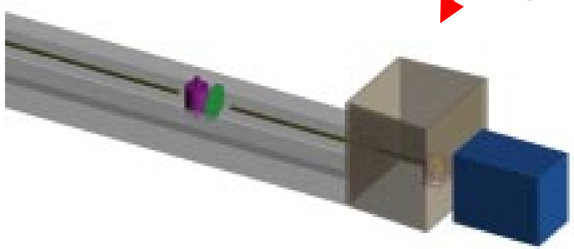




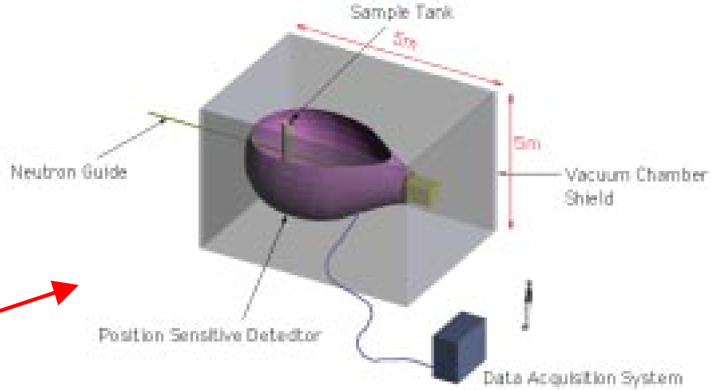
Inverted Geometry Spectrometer for Biological Macromolecules



Versatile Single Crystal Diffractometer for Biological Macromolecules



High-Resolution Powder Spectrometer



Preliminary Layout of JSNS Instruments

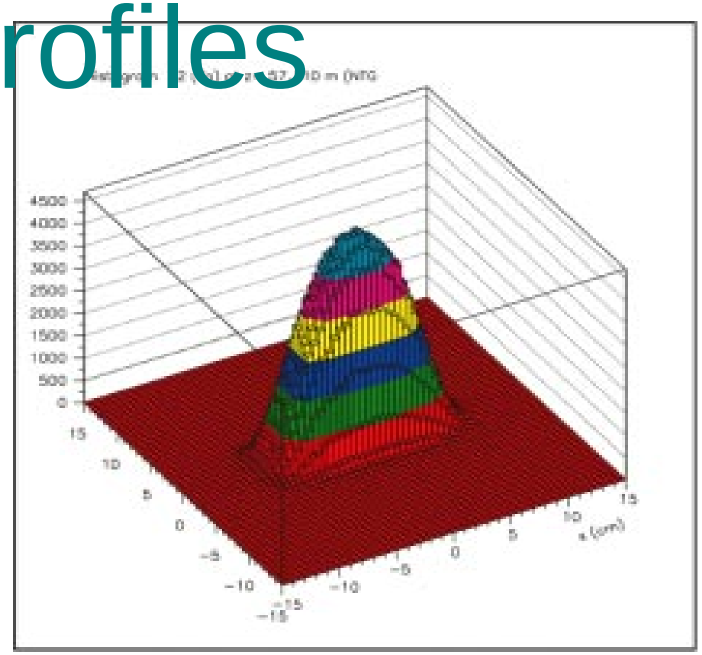
Proton beam transport line

- **long and complicated beam line**
  - **264 m long main tunnel and 4.8 m elevation**
  - **56 m long beam line in experimental facility**
- **cascade target system**
  - **muon production target in proton beam line upstream of neutron source**

Beam optics and profiles

- beam emittance (*e*) = 81p mm.mrad (beam core) 324p mm.mrad (max. beam halo)

  D*p*/*p* < ±1.0 %
- strong focusing on muon production target and rectangular beam profile on neutron source

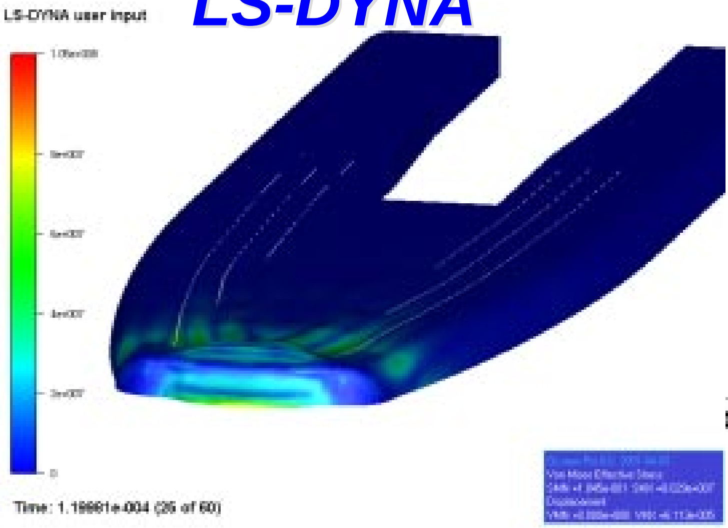


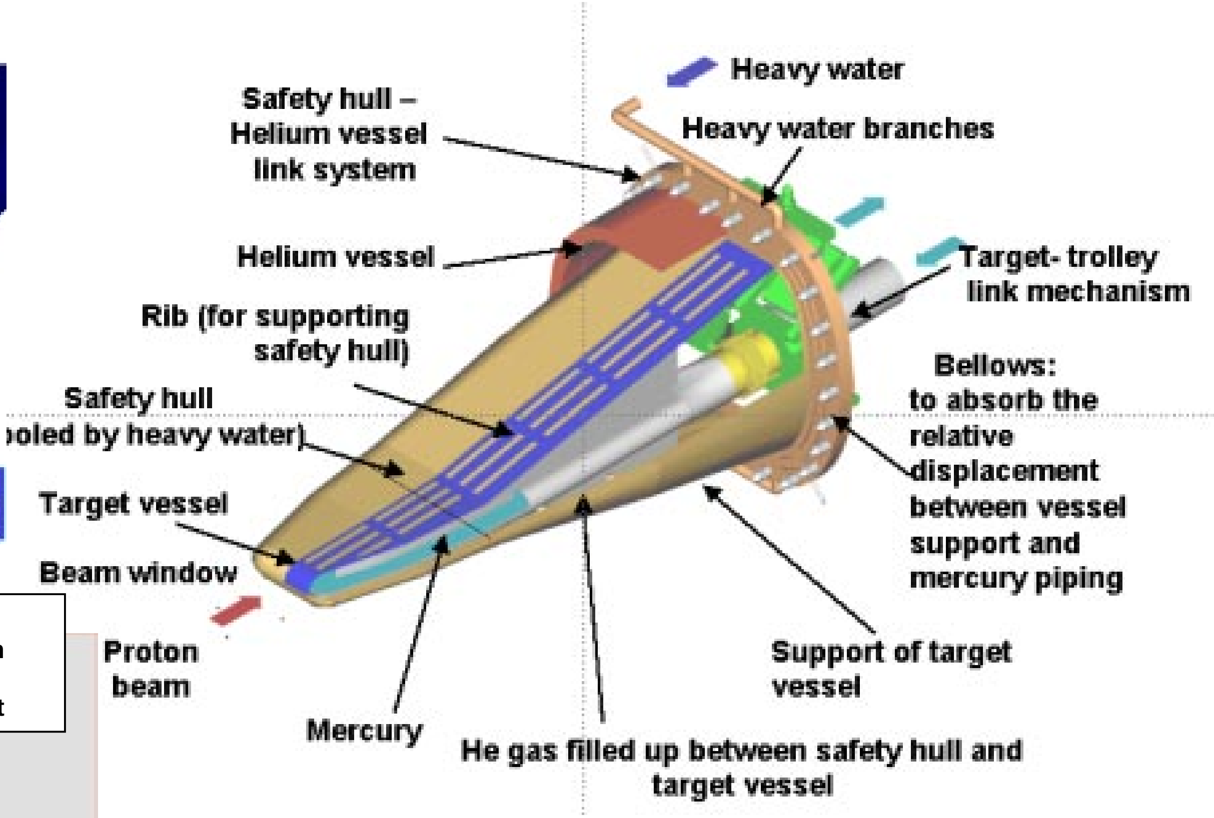
Highlights of the facility design

1 MW mercury target system (Cross flow, safety hull).
Three supercritical hydrogen cold moderators (assuming 100 % para state of H2).
Parallel H2 flow with a bypath channel using one circulator.
Independent moderator remote handling with an inner and an outer reflector plugs.
Wide extraction angle coverage of the coupled moderator for 11 instruments.
1eV decoupling energy with AIC de-coupler and AIC liners
High resolution poisoned moderator with Cd poisoning material.
Minimized iron materials with positive use of magnetite heavy concrete shielding, resulting in cost saving.(Precise Model Calc.)
23 independent neutron shutter systems

Mercury target design

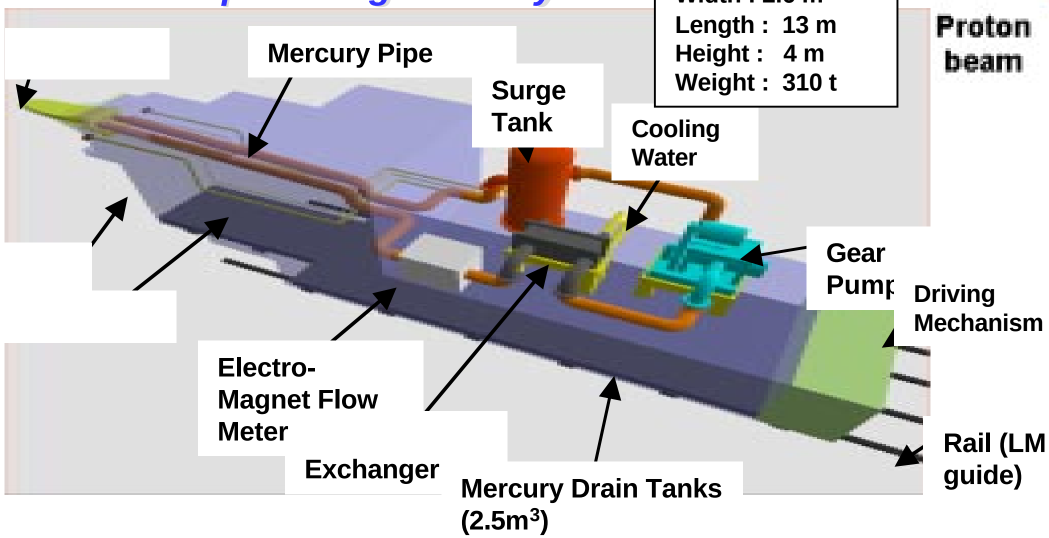
LS-DYNA





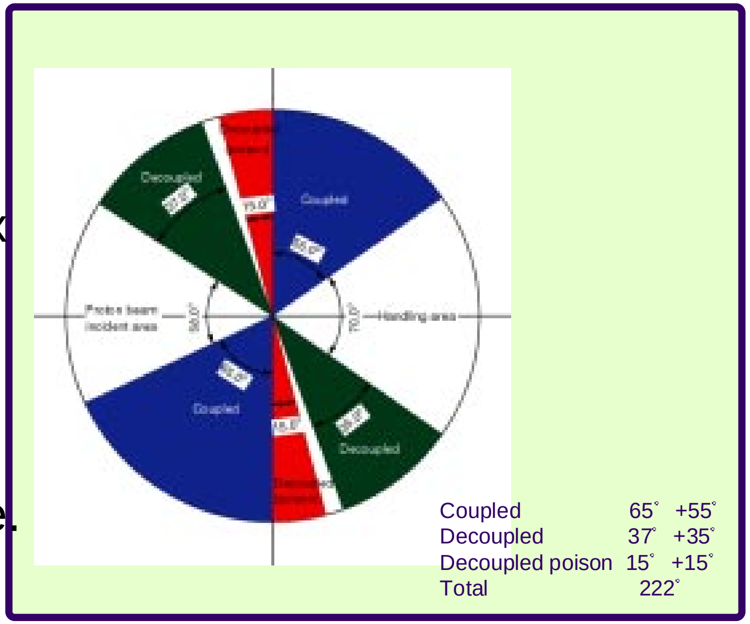
Concept of Target Trolley

Width : 2.6 m
Length : 13 m
Height : 4 m
Weight : 310 t



Characteristic Advantage of 1MW Pulse Neutron Source and Strategic Utilization

1. New, challenging idea to realize the most powerful coupled cold moderator in terms of the time integrated neutron flux and peak intensity, which are superior to those of SNS of (2MW, 60Hz) by factors of 1.5 and 3, respectively
2. One coupled, and two decoupled moderators are located separately, below and above the Hg target to avoid interference of each, resulting in high neutron performance.
3. To meet requirements from users, a wide and high efficient neutron beam extraction from the coupled moderator is designed.

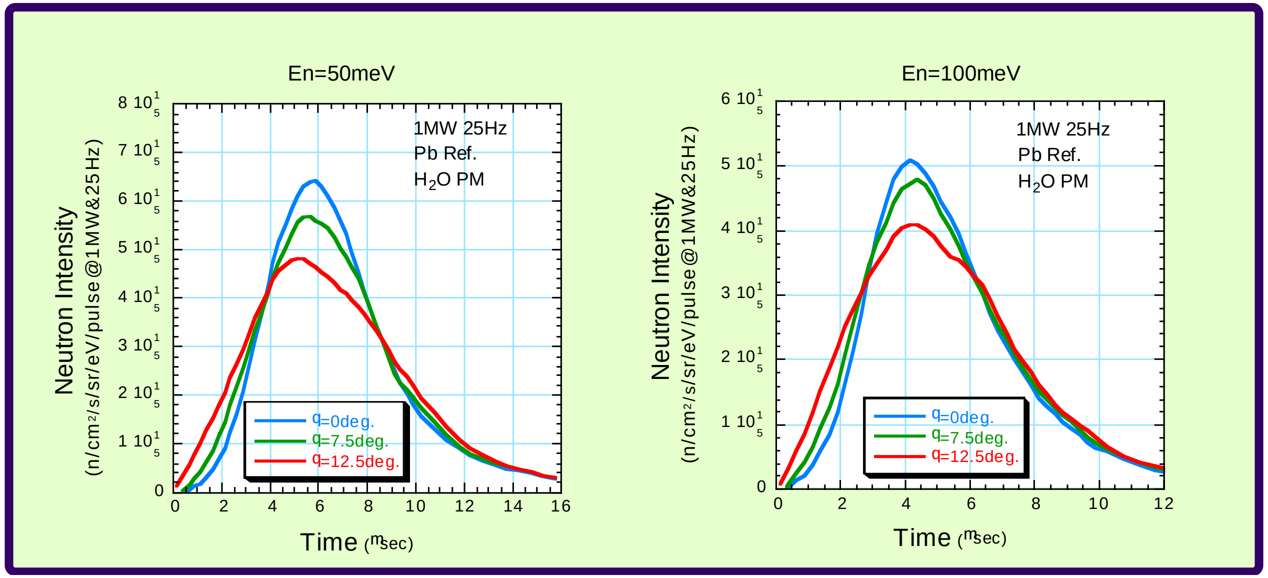


Angle sharing scheme

4. Long-lived decoupler material (Ed=1eV), small tail pulse peak

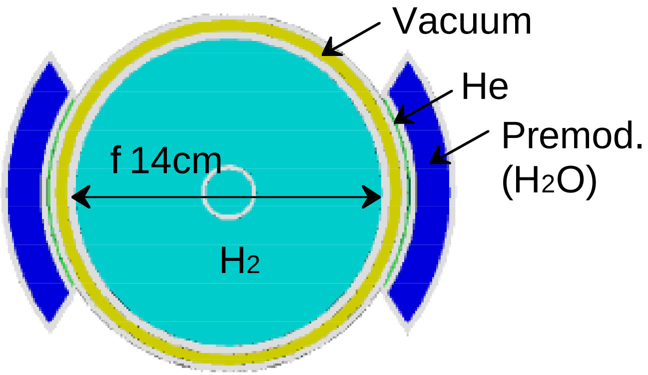
5. Optimizing moderator shapes, and reflector configuration to mitigate effects at large angles.

The angle is within 7.5° for poised moderator.

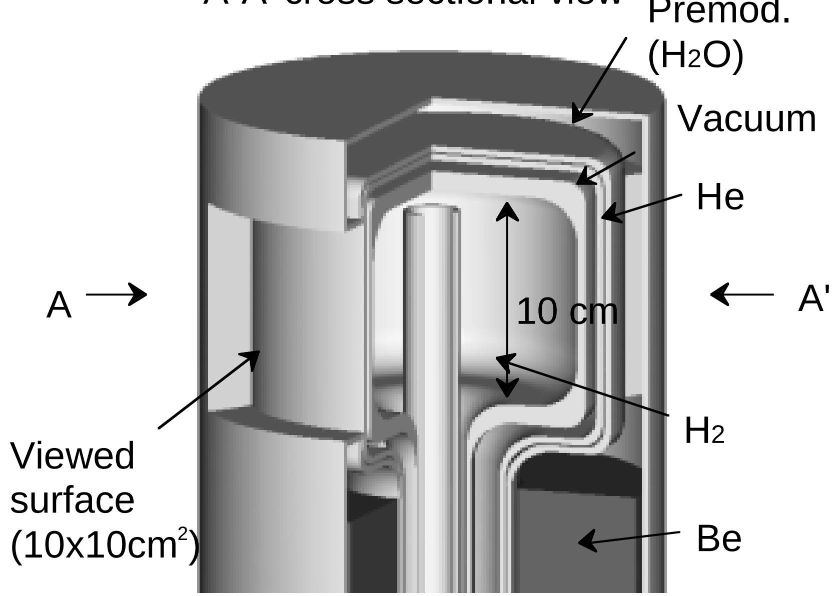


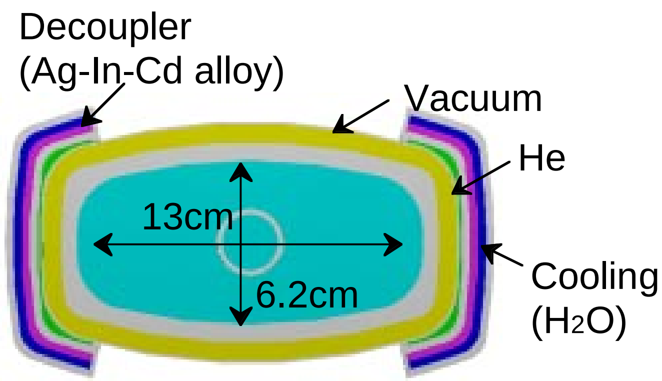
Moderator Design

Three supercritical H2 moderator systems (coupled, de -coupled, de-coupled poisoned)

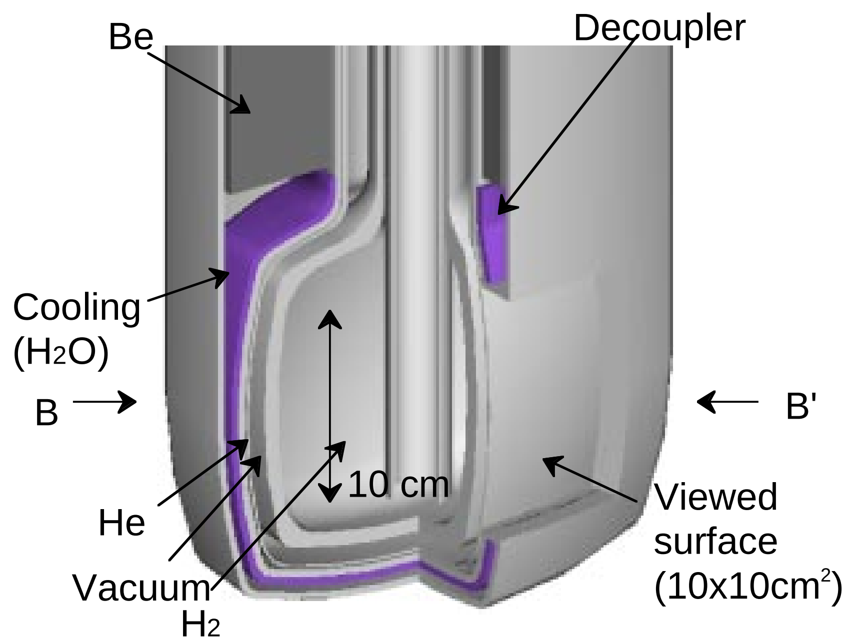


A-A' cross sectional view





B-B' cross sectional view



Hydrogen Circulation System

Design Conditions for Hydrogen Loop

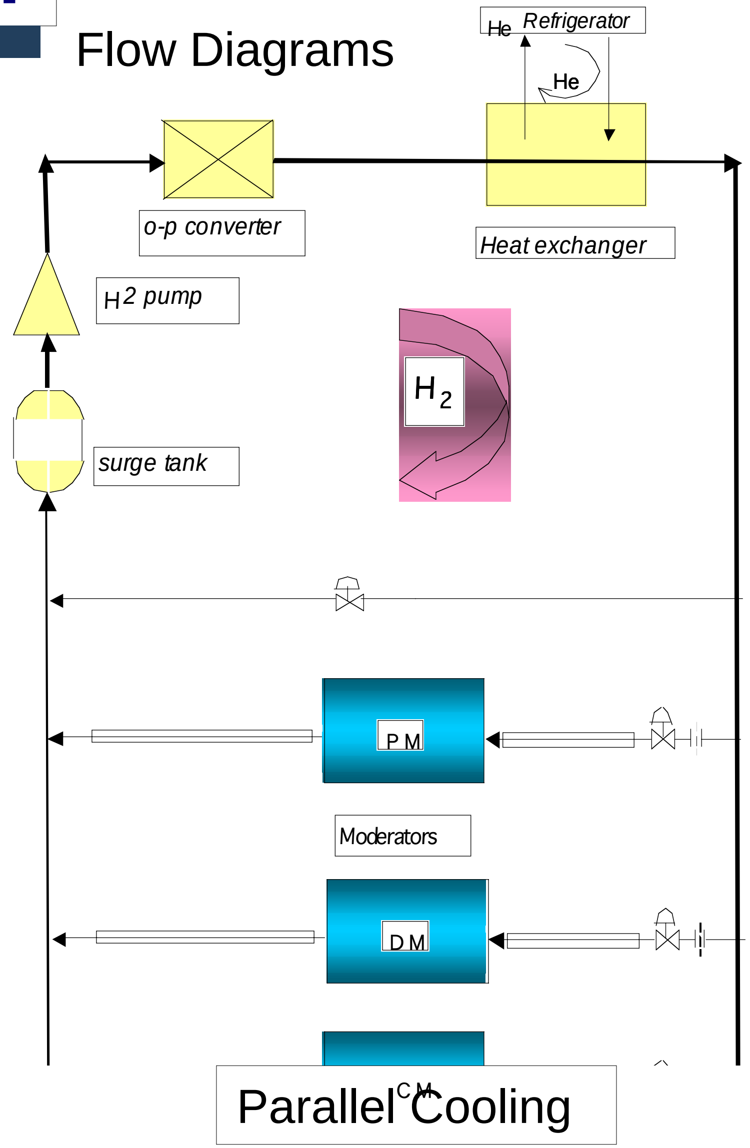
H_2 pressure in moderators : ~ 1.5 MPa

Temperature increase through the moderators :
less than 3 K

Moderator outlet temperature :
less than 21 K

Para-H_2 concentration at the moderator inlet :
more than 99 %

Flow Diagrams



Reflector Assembly Design

Independent removal of moderator

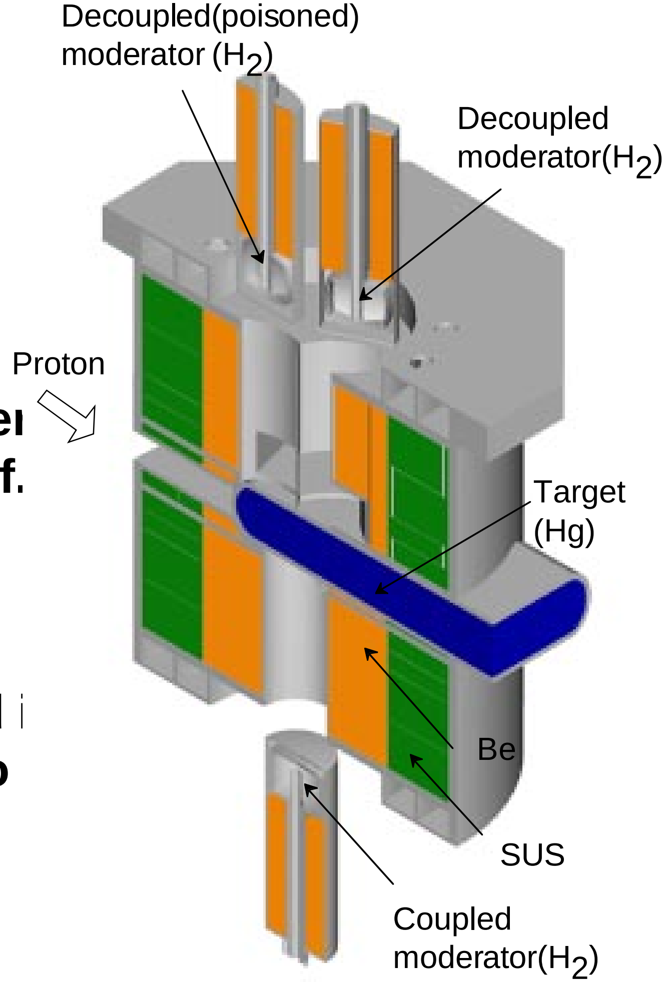
Parallel circulation of H2 cryogenics

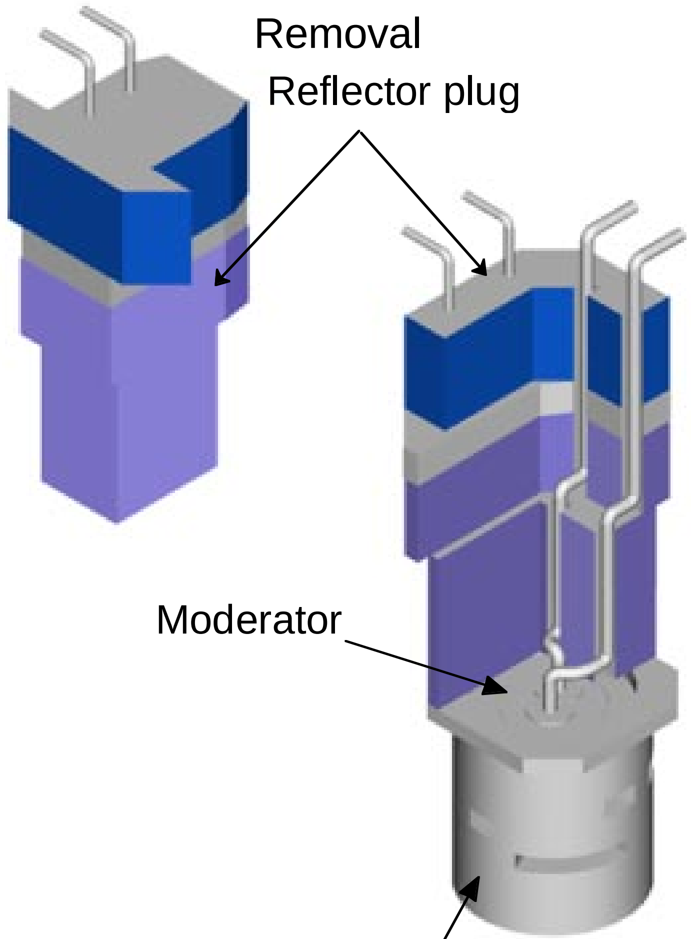
Beryllium inner and SS outer reflectors instead of lead ref.

Heavy water cooled

Be reflectors are embedded in the moderator containers to reduce reflector missing

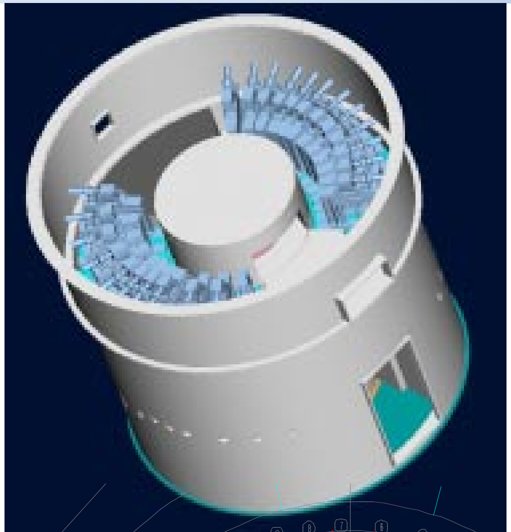
Light water pre-moderator.

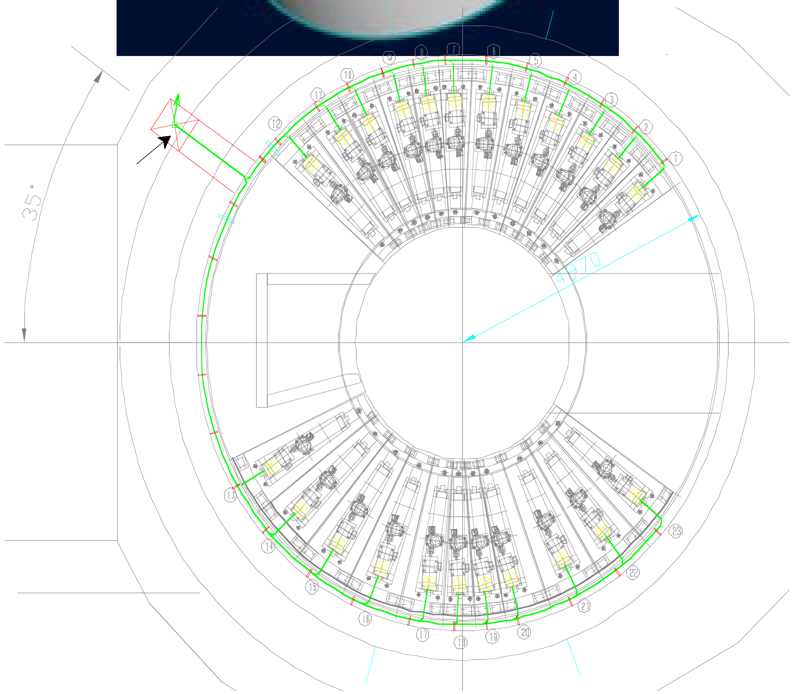




Each moderator is removed separately.

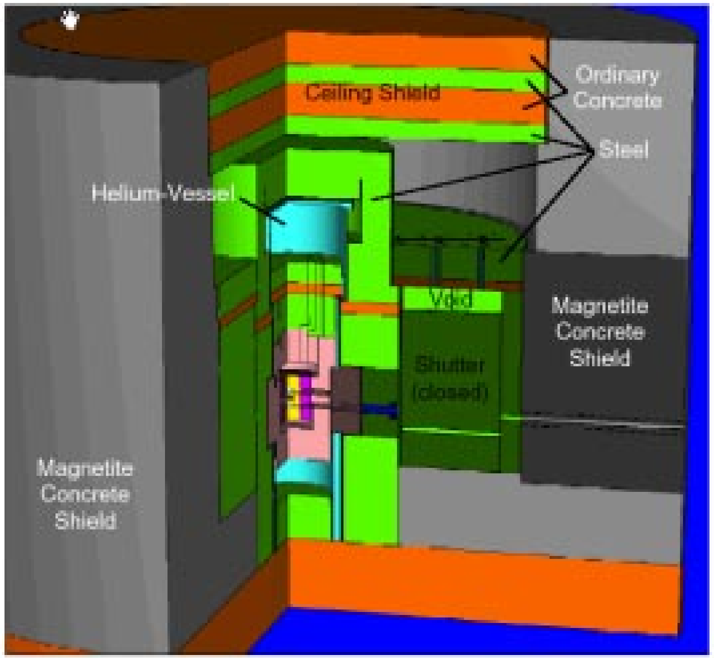
Neutron target station design

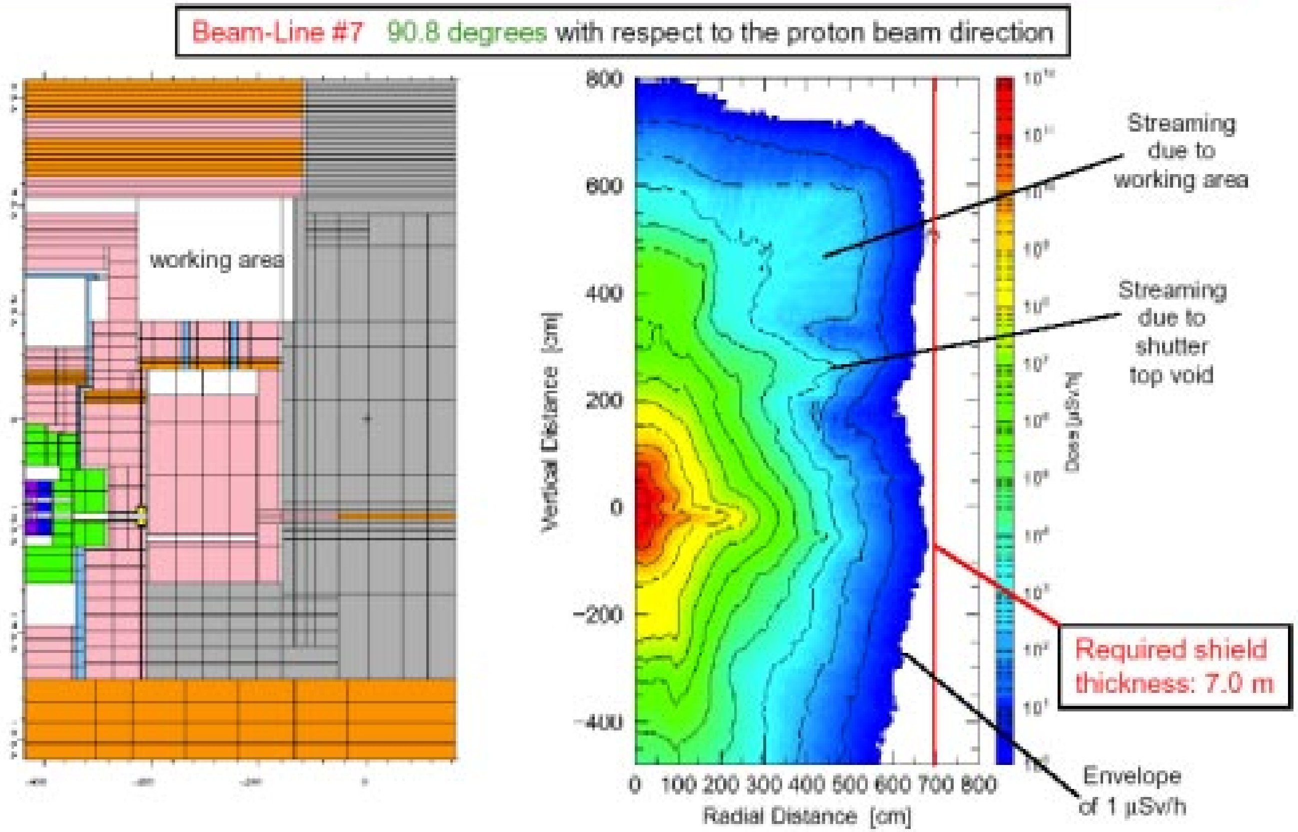




Shielding performance evaluation by MCNPX

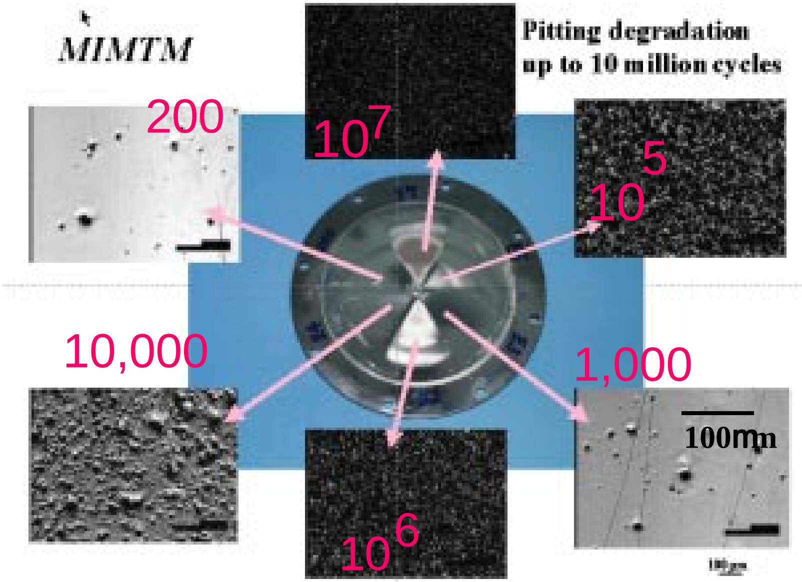
Biological Shield (3-D): Model-1



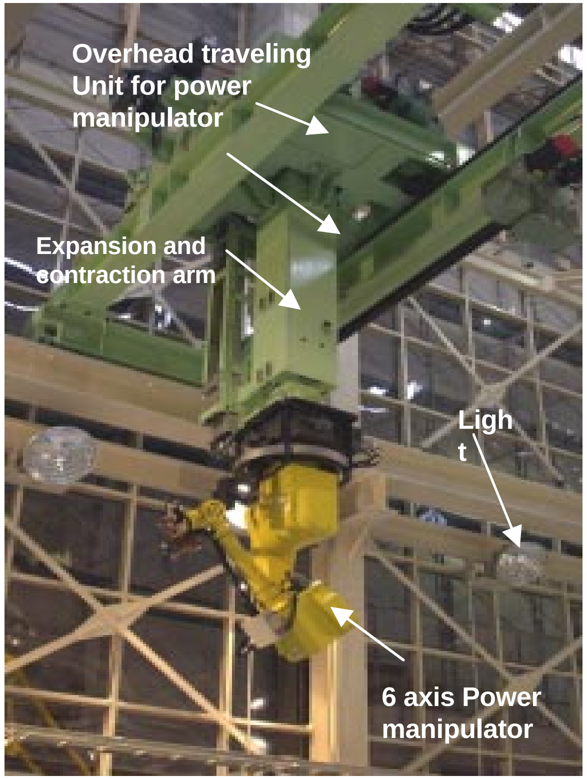


R&Ds

Hg pitting damage issue



AIC HIP test

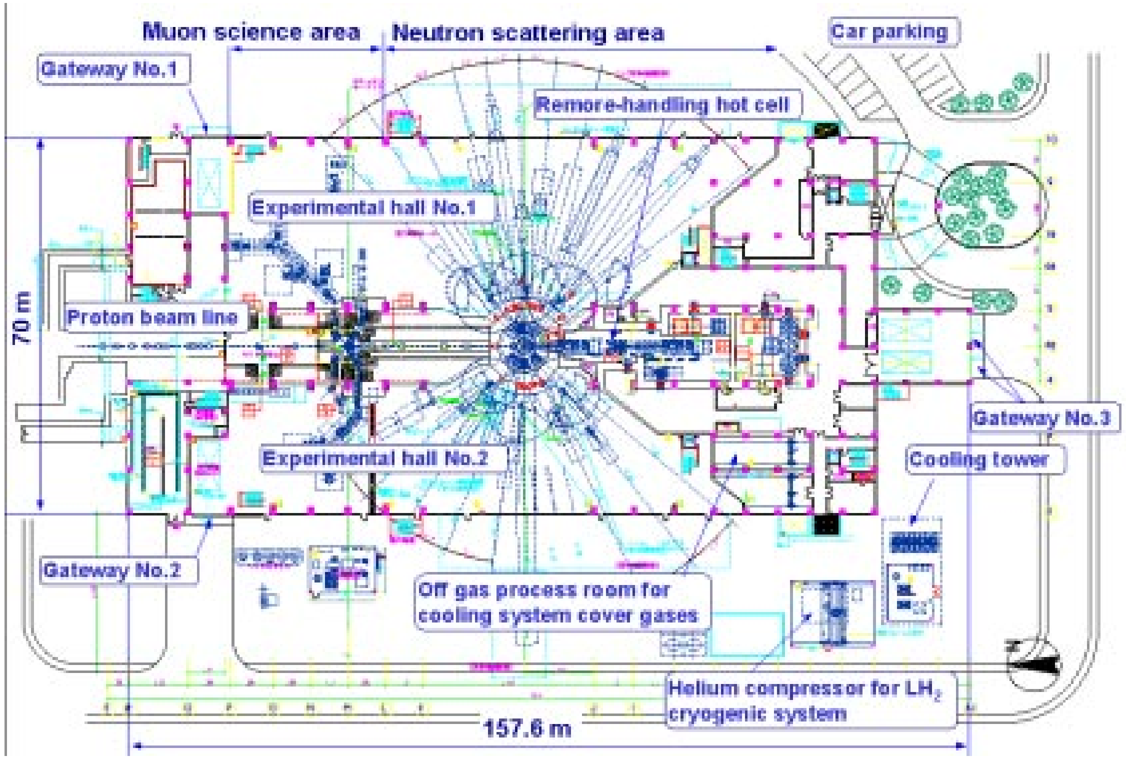


Remote-handling Test Facility

ASTE Collaboration at AGS/BNL
- **Mercury Target Pressure Wave**
- **Cavitaion Damage**
- **Bulk Shielding**
- **Spallation Neutron Production**

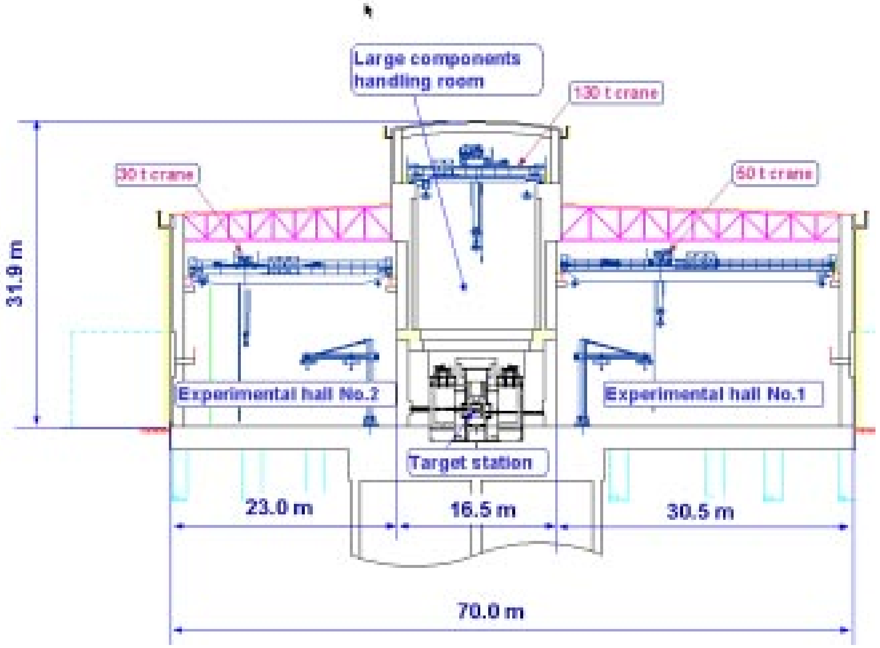
JAERI-USDOE Collaboration at LANSCE/LANL
- **Beam-Line Shielding Experiments**

Conventional facility design



The first floor drawing

Elevation View acrossing the source



Facility safety

To observe the Japanese regulations

Law concerning Prevention from Radiation Hazards due to Radio-Isotopes, etc.	Public exposure : ・Skyshine < 50 mSv/yr ・Radioactive gas and liquid release Worker radiation **< 12.5 mSv/hr (~1 mSv/hr)** Radiation waste (Target, Moderator, etc.)
High Pressure Gas Safety Law	Hydrogen safe
Building Standard Law	Earthquake-resistant construction

Radiation protection	ALARA, Defense in Depth
Hazard material protection	Confinement of radioactive mercury
Public exposure	Source term analysis of
Others	Human factor (Procedure and training) Maintenance Quality assurance

Accidental scenario for release of radioactive mercury
Preliminary results of public exposure at site boundary

5.8 mSv (Recovery from accident in 10 days)

Major milestones

Design Manual:	~ Dec. 2002
Detailed Design:	~ Mar. 2003
Safety Report:	~ Dec. 2002
Technical Review:	Oct. 2002
The first B&A:	Nov. 2002
Fabrication and Procurement:	Dec. 2002 ~ Dec. 2006
Installation and Testing:	Apr. 2006 ~ Mar. 2007
Beam Acceptance of MLF:	Mar. 2007

Conventional Facility Design:	Mar. 2003
Construction Start:	Apr. 2003
Completion of CF:	Mar. 2006
First beam acceptance:	Mar. 2007

Summary

Designs have been extensively in progress.

Specific technical designs are to be presented.

Comments, advises,and recommendations which will be generated in the N-TAC, are to be factored into the design and construction scheme of the JSNS.