The Fundamental Neutron Physics Beamline
at the
Spallation Neutron Source

Update

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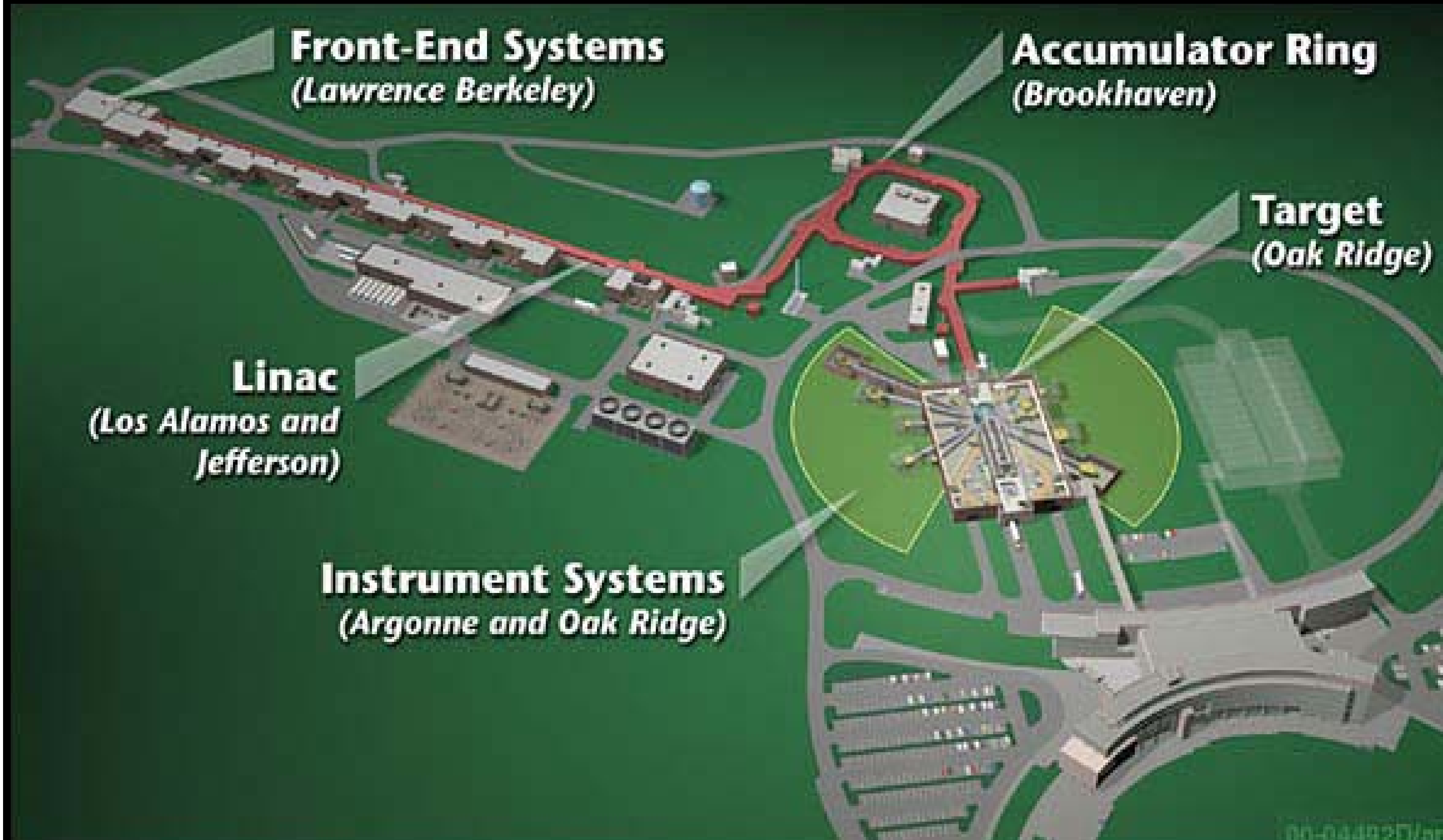
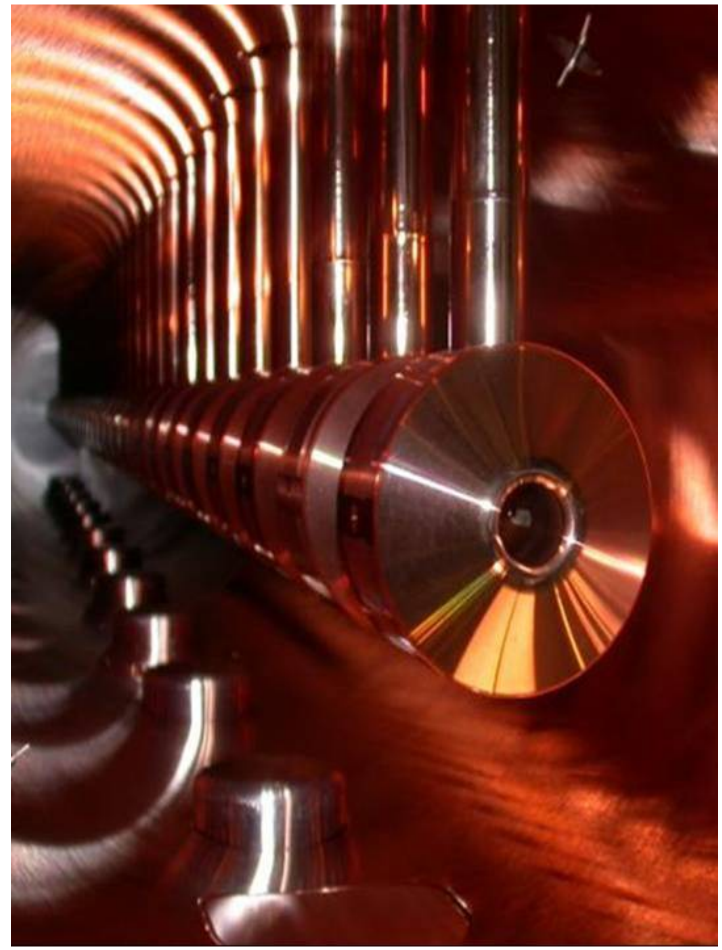
The Spallation Neutron Source at ORNL
www.sns.gov

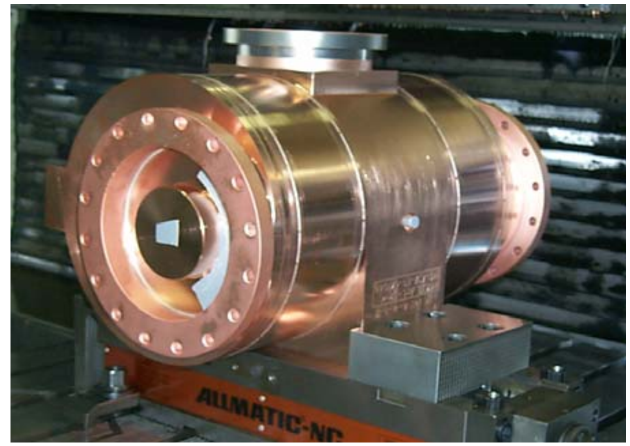

Front-End Systems
(Lawrence Berkeley)
Accumulator Ring
(Brookhaven)
Target
(Oak Ridge)
Linac
(Los Alamos and
Jefferson)
Instrument Systems
(Argonne and Oak Ridge)

Drift Tube Linac

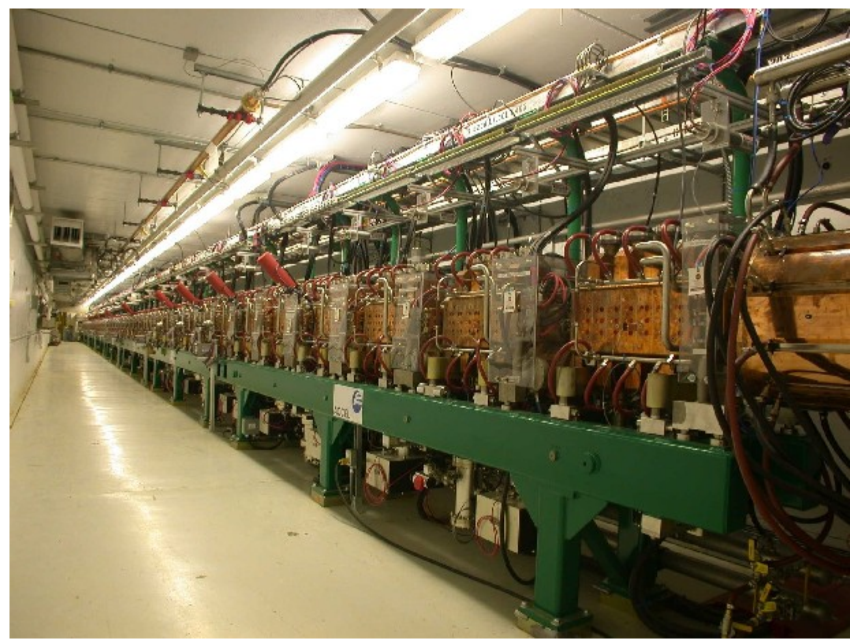
- ***System includes 210 drift tubes, transverse focusing via PM quads, 24 dipole correctors, and associated beam diagnostics***



Coupled-Cavity Linac



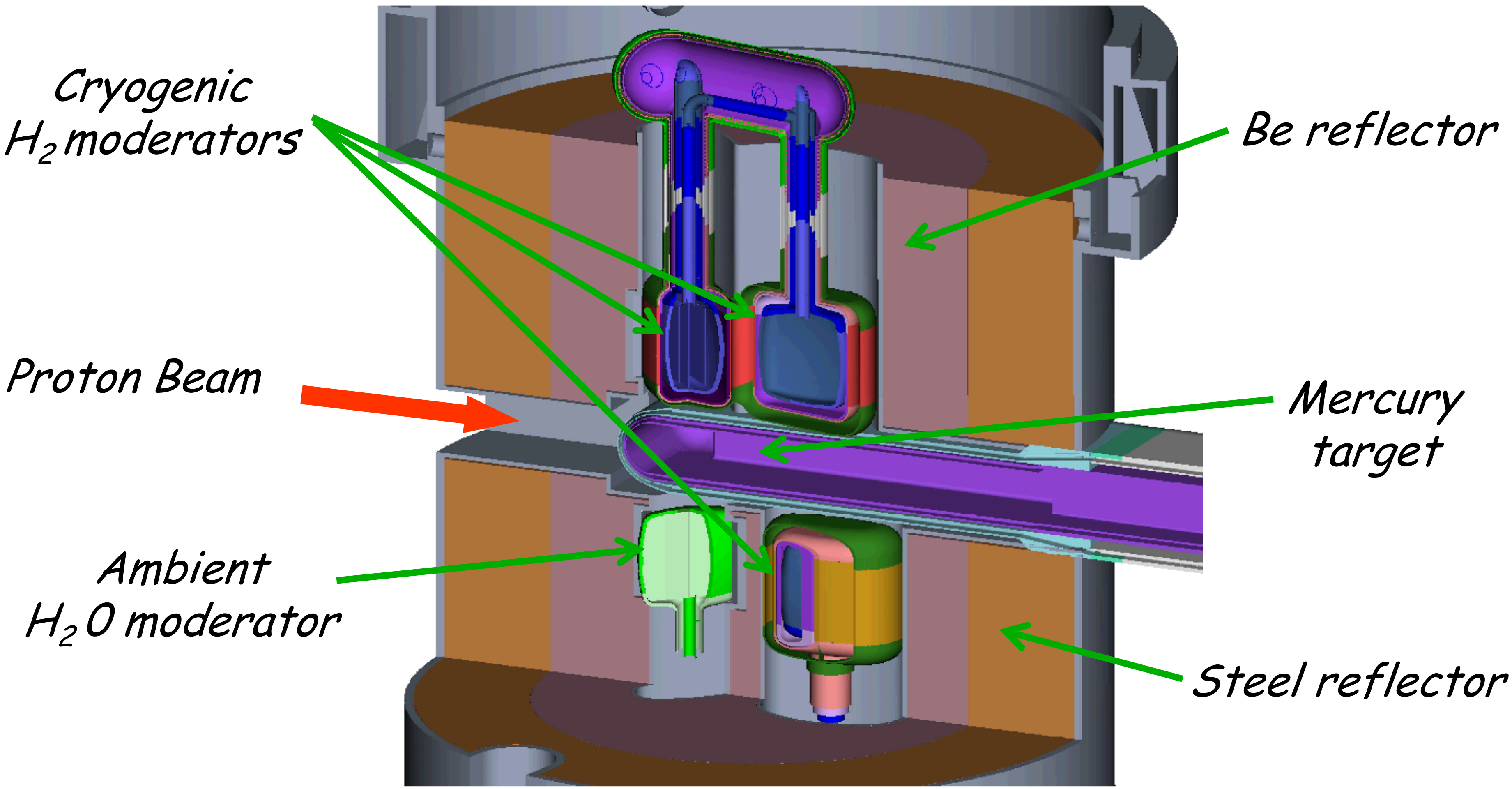
- *System consists of 48 accelerating segments, 48 quadrupoles, 32 steering magnets and diagnostics*

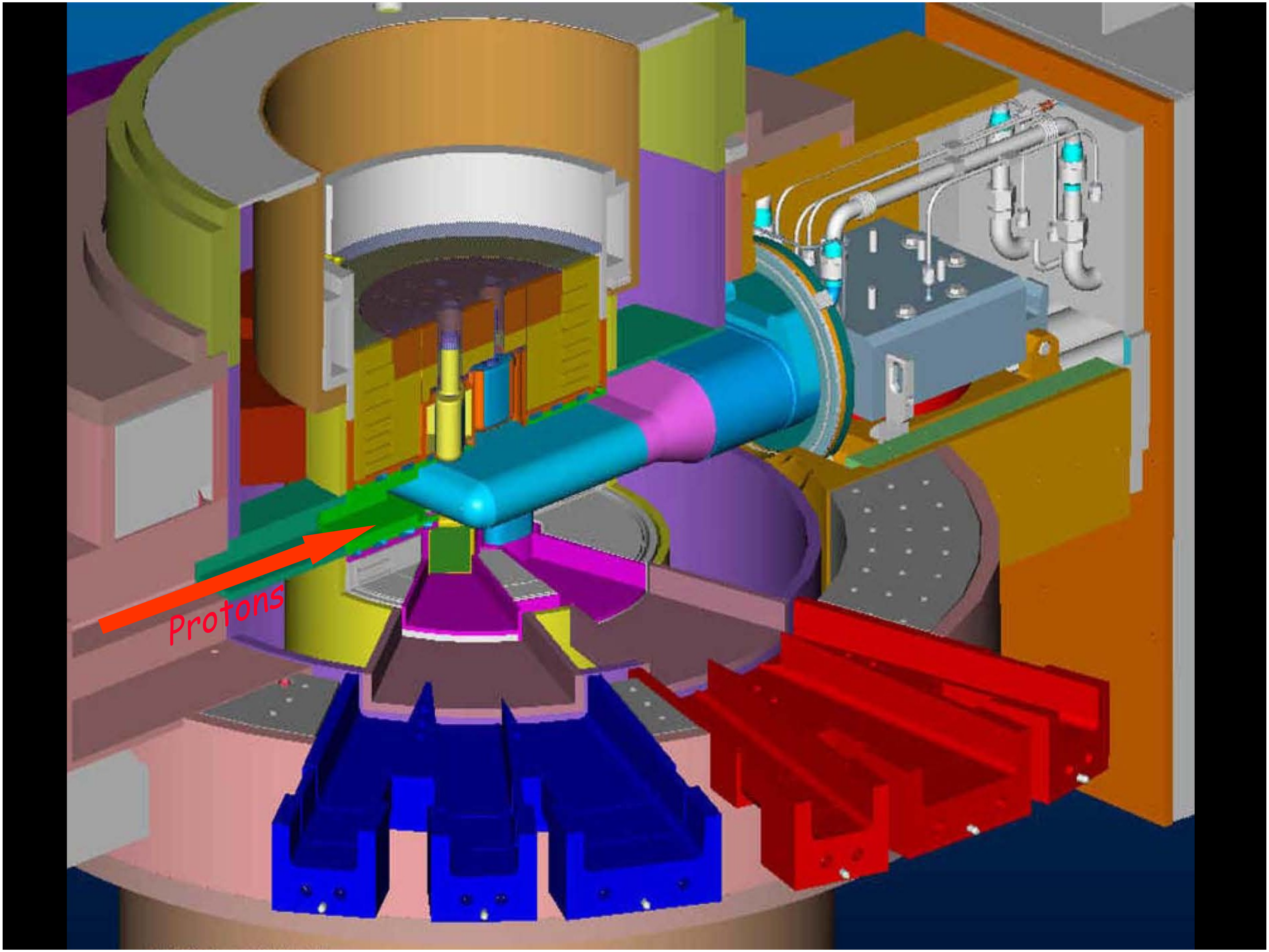


Superconducting Linac

- ***11 Medium - β cryomodules***
- ***12 High - β cryomodules***
- ***Cavities exceed gradient specifications***

Target, Reflectors, and Moderators

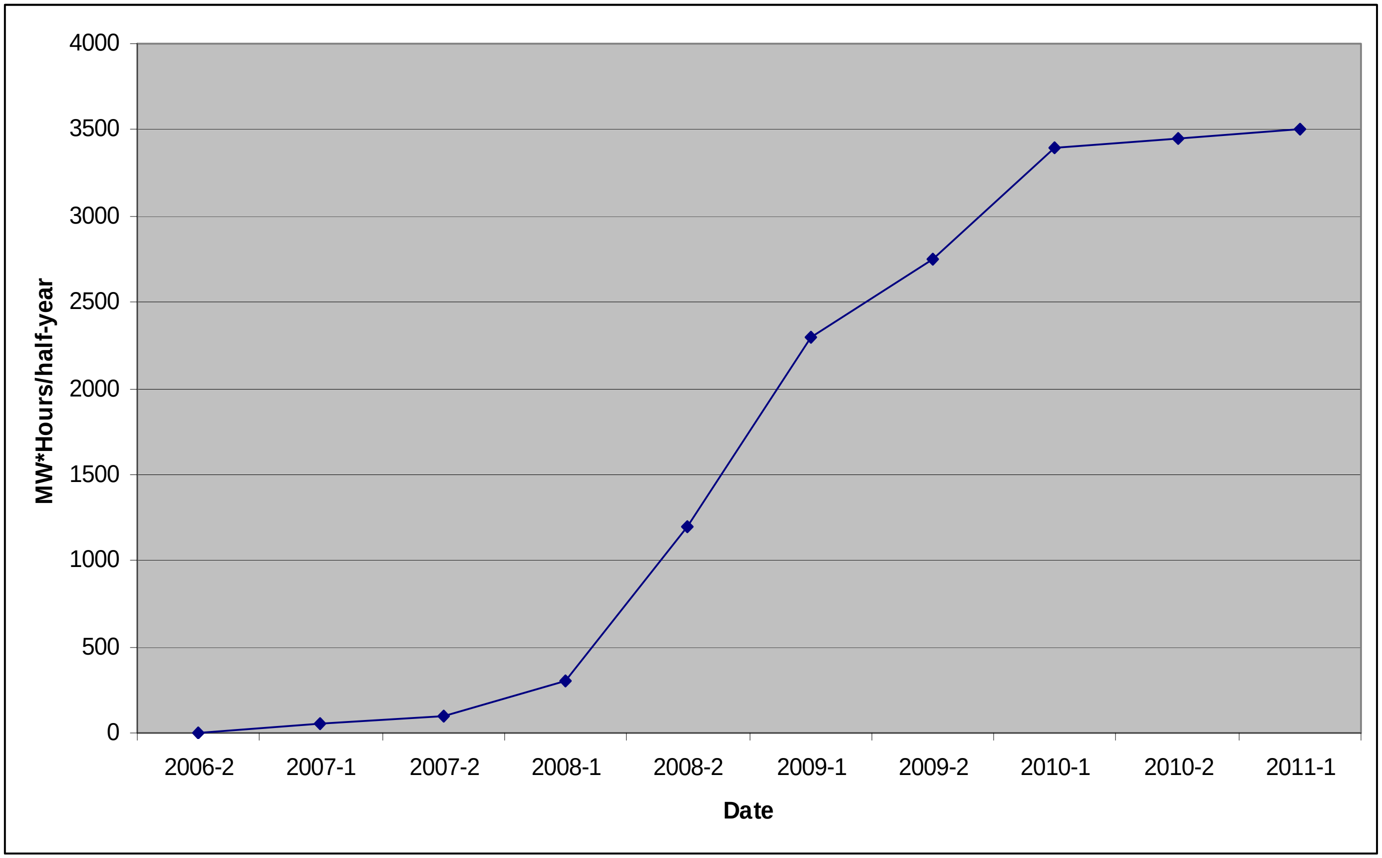



Protons

Spallation Neutron Source Primary Parameters

Proton beam power on target	1.4 MW
Proton beam kinetic energy on target	1.0 GeV
Average beam current on target	1.4 mA
Pulse repetition rate	60 Hz
Protons per pulse on target	1.5×10^{14} protons
Charge per pulse on target	24 μC
Energy per pulse on target	24 kJ
Proton pulse length on target	695 ns
Ion type (Front end, Linac, HEBT)	H minus
Average linac macropulse H- current	26 mA
Linac beam macropulse duty factor	6 %
Front end length	7.5 m
Linac length	331 m
HEBT length	170 m
Ring circumference	248 m
RTBT length	150 m
Ion type (Ring, RTBT, Target)	proton
Ring filling time	1.0 ms
Ring revolution frequency	1.058 MHz
Number of injected turns	1060
Ring filling fraction	68 %
Ring extraction beam gap	250 ns
Maximum uncontrolled beam loss	1 W/m
Target material	Hg
Number of ambient / cold moderators	1/3
Number of neutron beam shutters	18
Initial number of instruments	5

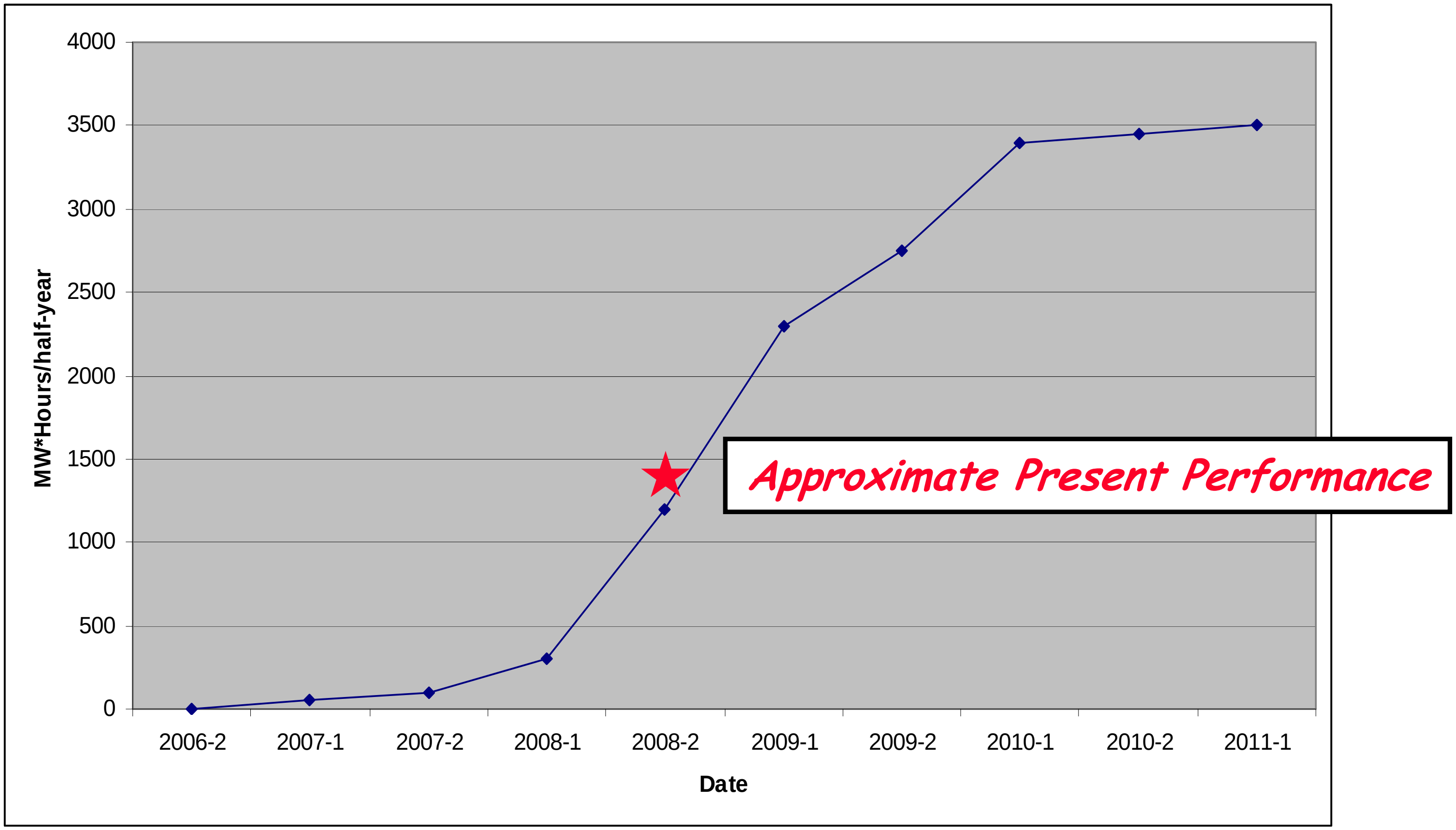
Originally Projected SNS Operational Ramp-Up



Source: SNS Project

First SNS beam on target – April 2006

Originally Projected SNS Operational Ramp-Up

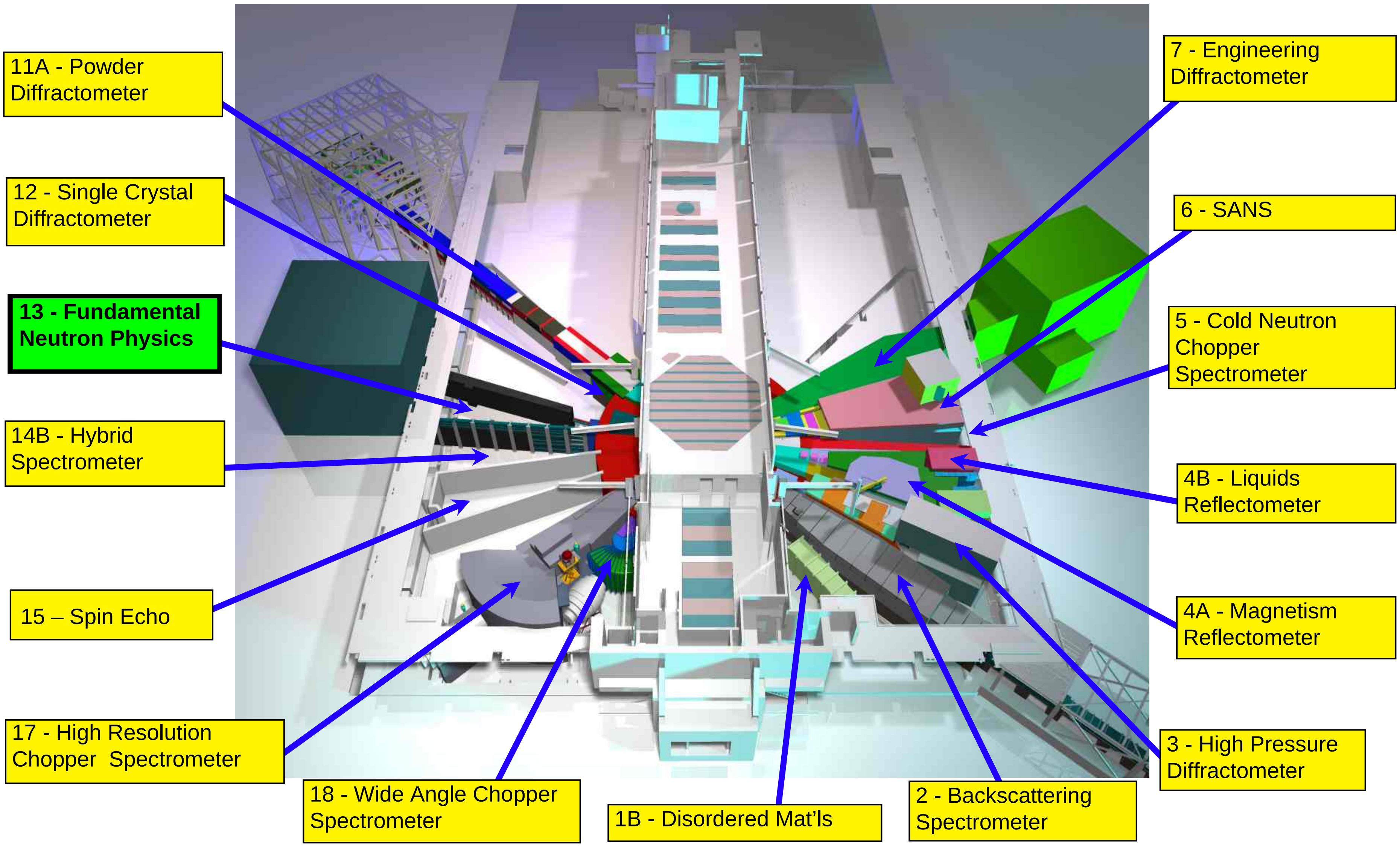


Source: SNS Project

SNS ran at ≥500kW during 2nd half of FY2008

SNS is the Highest Power Pulsed Neutron Source in the World.

One Beamline has been allocated for Nuclear Physics



Brief FNPB Project History

1989-2002		*Three successive NSAC Long Range Plans identify research with Cold and Ultracold Neutrons as important opportunities.*
Nov	*1999*	*DOE begins construction of SNS*
April	*2002*	*Proposal for a nuclear physics beamline submitted to SNS.*
April	*2002*	*Proposal for funding submitted to DOE NP.*
Oct	*2002*	*SNS Science Advisory Subcommittee (Peoples) Review*
March	*2003*	*Formal Allocation of Beamline by SNS for FNPB.*
April	*2003*	*NSAC Sub-Committee (Tribble)*
May	*2003*	*NSAC Sub-Committee recommends construction of Fundamental Neutron Physics beamline at the SNS.*
Aug	*2003*	*DOE Issues Critical Decision 0 (Mission Need)*
Nov	*2003*	*DOE NP project review*
Dec	*2003*	*DOE Issues Critical Decision 1 (Cost Range)*
May	*2004*	*Preliminary Design Review*
Jun/Jul	*2004*	*External Independent Review (EIR)*
Aug	*2004*	*DOE Issues Critical Decision 2 (Performance Baseline).*
Aug	*2004*	*DOE Issues Critical Decision 3a (Long lead Procurement).*
Feb	*2004-8*	*Annual DOE Project Review*
April	*2006*	*Completion of SNS Construction Project.*
Dec	*2007*	*NSAC Long Range Plan reiterates interest in Fundamental Symmetries…*
Sept	*2008*	*Completion of "Cold Beamline" (projected)*
June	*2010*	*Completion of "UCN Beamline" (baseline)*

Red indicates substantive review

The DOE-NP Investment in the FNPB is "Heavily Leveraged"

The FNPB M.I.E. is a \$9.2M DOE construction project.

DOE Basic Energy Sciences invested \$1.4G for the construction of the SNS.

DOE Basic Energy Sciences pays for the operation of the accelerator and the neutron production target ~\$120M/y

Averaged over a period of 10-15 years and over 15-20 beamlines, this represents an investment of >\$100M (≥\$10M/y) by BES for nuclear physics at the SNS.

FNPB Project includes only the Neutron Beam Facility

The Fundamental Neutron Physics Beam M.I.E. includes only the construction of the neutron beams and the infrastructure that allows the installation of experiments.

Funding for experiments is done independently of the Beamline Construction Project.

Individual experiments are selected by a proposal driven, peer review process operated by ORNL Physics Division under the auspices of the SNS.

The FNPB has its own Proposal Review and Advisory Committee* to advise Physics Division and SNS Management on programmatic issues.

*B. Filippone, J. Nico, M. Ramsey-Musolf, A. Steyerl, R. Tribble (chair), F. Wietfeldt

SNS Fundamental Neutron Physics Program

1. Accurate measurement of parameters that describe the beta decay of the free neutron (i.e. Lifetime, Decay Correlations)
   - Universality of the Weak Interaction (Unitarity of CKM Matrix)
   - Extensions to the Standard Model (RH currents, new couplings,..)
   - Big Bang Nucleosynthesis and Cosmic Elemental Abundances
   - Stellar Astrophysics
   - …

2. Precision measurement of parity violation in the interaction low energy neutrons with "simple" nuclear systems (i.e. n-p, n-d, n-α)
   - Quark-Quark Weak Interaction
   - QCD in the strongly interacting limit

3. Search for a non-zero permanent neutron electric dipole moment
   - Origin of CP and T violation
   - Cosmic Baryon Asymmetry
   - ….

Two Classes of Fundamental Experiments

1. ***Cold Neutron, Broad Band (beta decay, hadronic weak studies)***

   Optimal Beam:

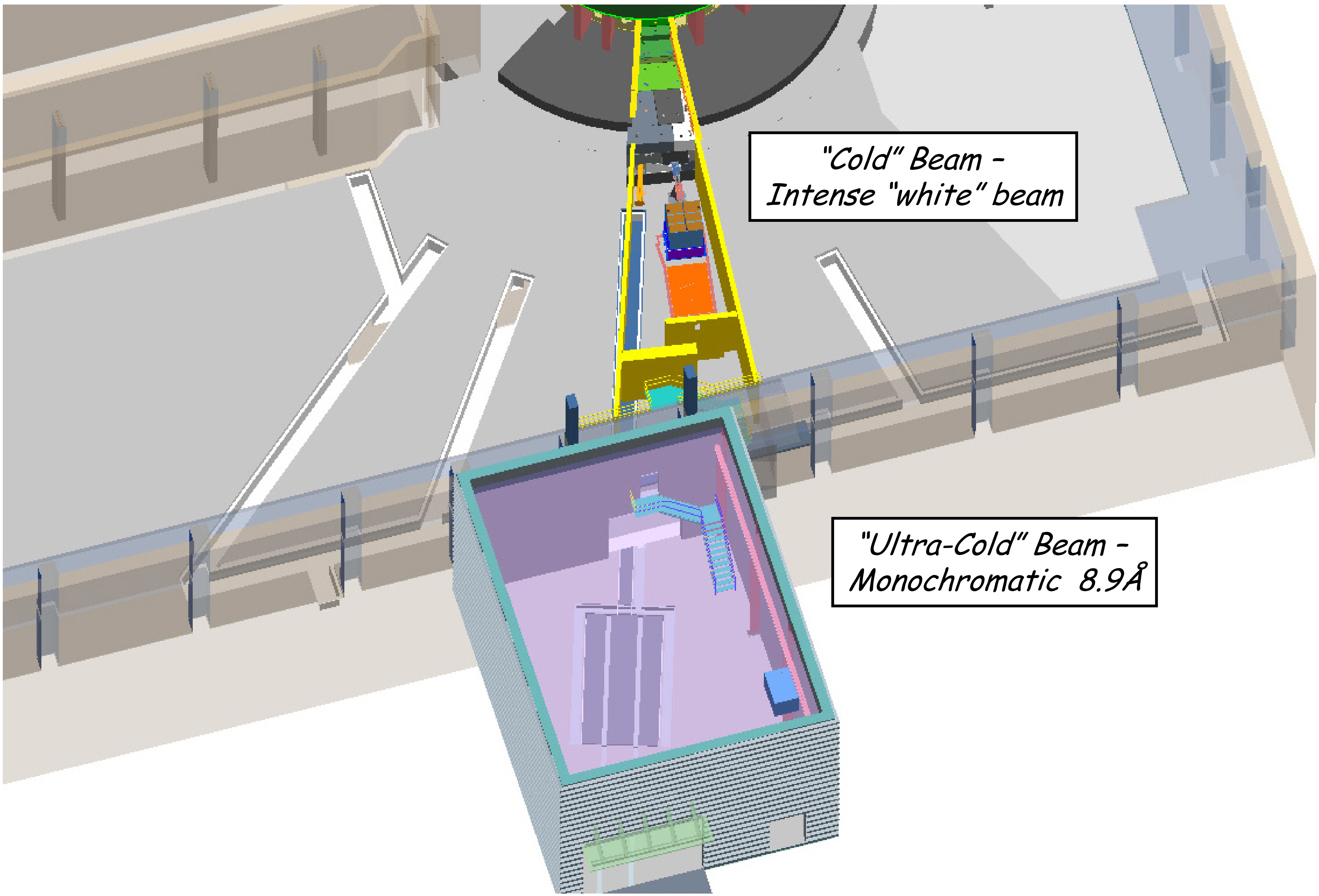
   Large X-section (10x12 cm^2),
   Large Divergence (> m=3 supermirror)
   Broad Wavelength Band (short flight path ~15m)

2. ***Monochromatic Beam at 8.9Å for Ultra Cold Neutrons (EDM)***

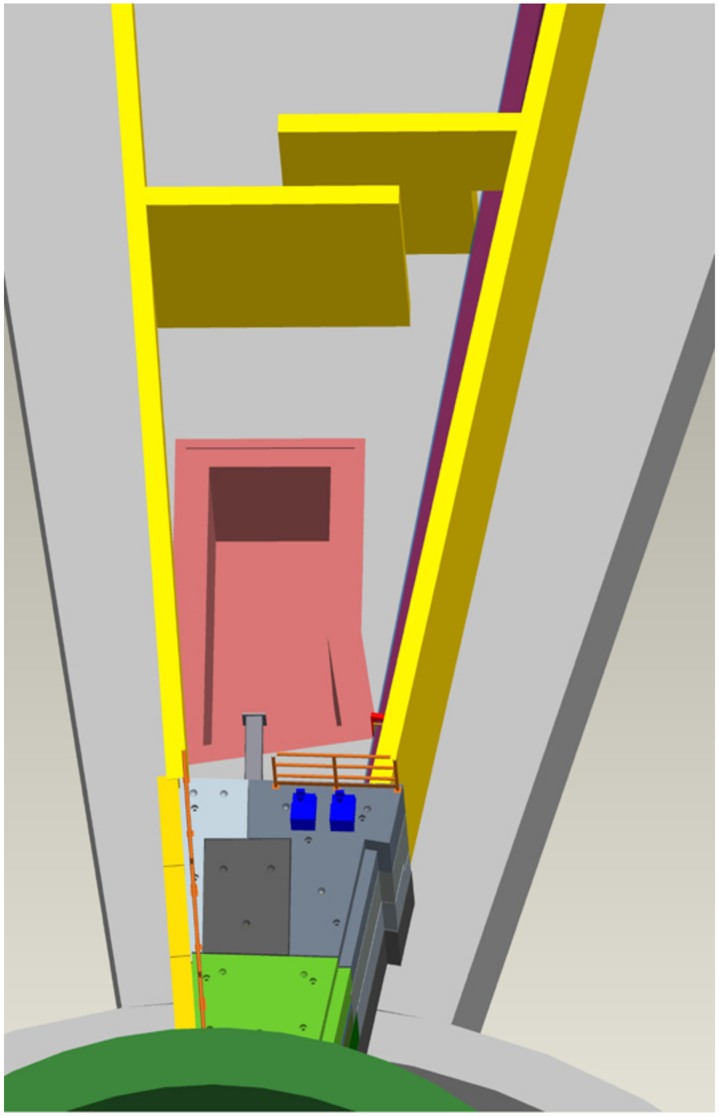
   Optimal Beam:

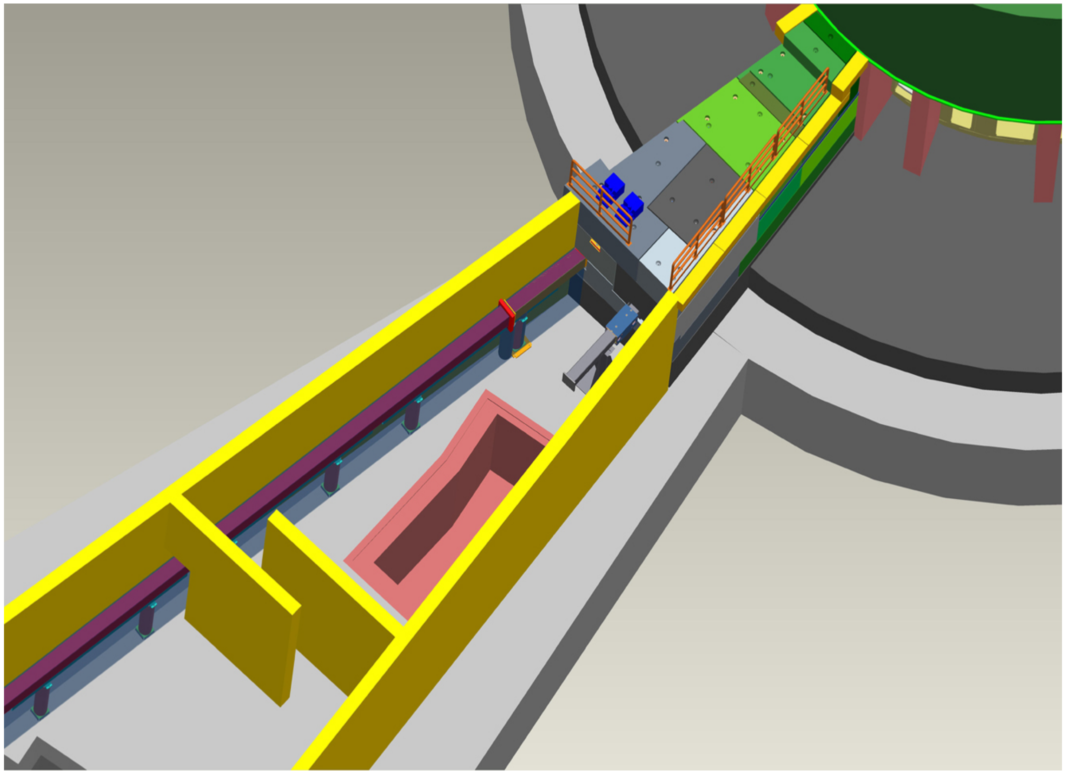
   Large X-section (~10x12 cm^2),
   Large Divergence (> m=3 supermirror)
   Long Flight Path (~40m)
   Low Background Experimental Area

The FNPB has two independent neutron beamlines

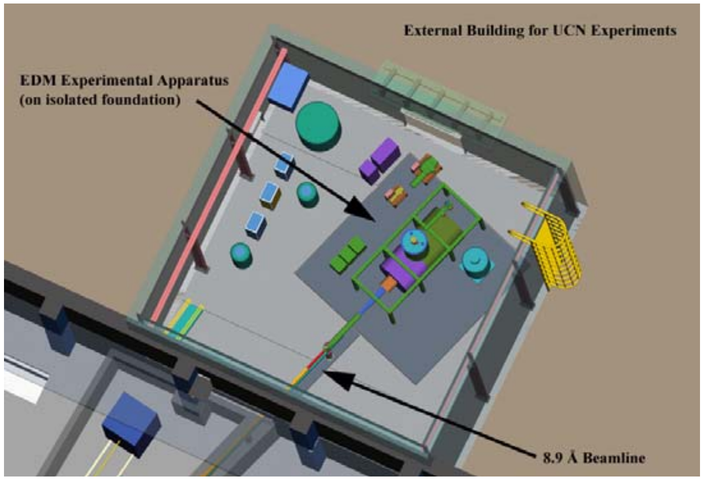


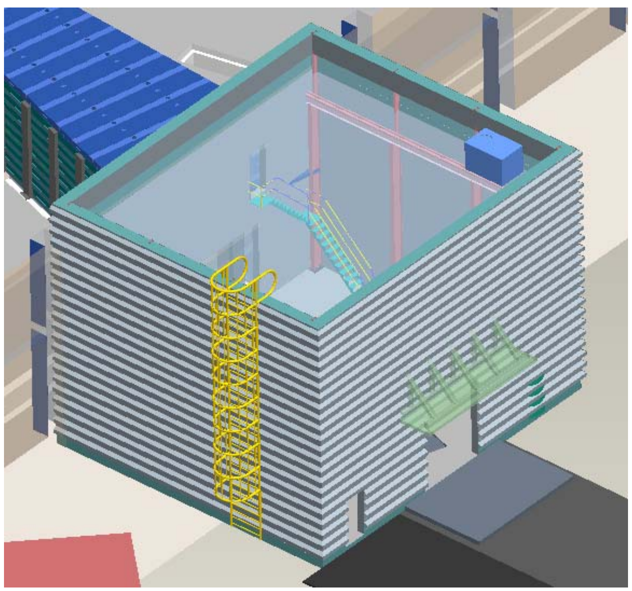
FNPB Cold Beam experimental Area





FNPB Ultra Cold Beam External Building





Beamline 2 external building

Ten proposals have been received and reviewed

FNPB Beamline Characterization and Commissioning
(SNS, ORNL, LANL, IUCF, NCSU,…)

Determination of τ_n Lifetime Using Magnetically Trapped UCN
(Harvard, NIST, NC State)
Measurement of "a" & "b" Correlations in Neutron Beta Decay
(U of Va., ORNL, LANL, Indiana, UNH, Tennessee…)
Measurement of "a,b,B,A" Correlations in Neutron Beta Decay
(LANL, Indiana, Michigan, NIST, ORNL, UNH, Tennessee…)
Measurement of "A+B" Correlation in Neutron Beta Decay
(Michigan, Indiana, NIST, ORNL, UNH,…)

Measurement of Parity Violation in n-p Capture
(LANL, Indiana, Manitoba, ORNL, Kentucky, Tennessee…)
Measurement of Parity Violation in n-d Capture
(LANL, Indiana, Manitoba, NIST, Berkeley, ORNL,…)
Precise Measurement of Neutron Spin Rotation in H_2 and He
(Indiana, Washington, NIST, NC State, Indiana, ORNL,…)
Proton Asymmetry in n+3He capture
(Indiana, Washington, NIST, NC State, Indiana, ORNL,…)

New Search for an Electric Dipole Moment
(LANL, Caltech, Berkeley, ORNL, NC State, Illinois, MIT, BU…)

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(LANL, Indiana, Michigan, NIST, ORNL, UNH, Tennessee…)
Measurement of "A
(Michigan, Indian

Measurement of Par
(LANL, Indiana, Manitoba, ORNL, Kentucky, Tennessee…)
Measurement of Parity Violation in n-d Capture
(LANL, Indiana, Manitoba, NIST, Berkeley, ORNL,…)
Precise Measurement of Neutron Spin Rotation in H_2 and He
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New Search for an Electric Dipole Moment
(LANL, Caltech, Berkeley, ORNL, NC State, Illinois, MIT, BU…)

>100 Distinct Participants
>30 Different Institutions

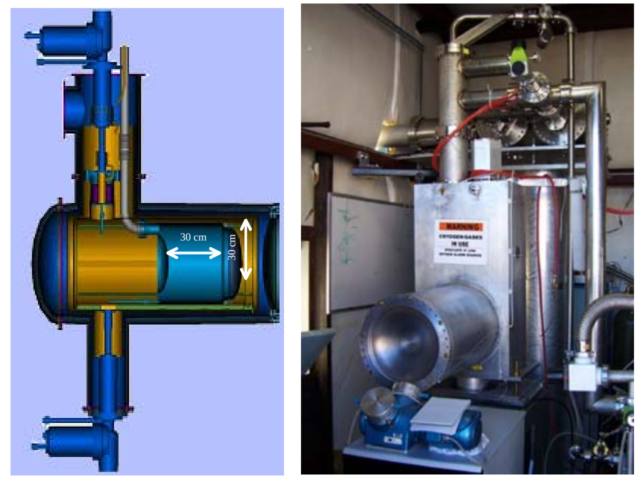
Ten proposals have been received and reviewed

FNPB Beamline Characterization and Commissioning	*Approved*
(SNS, ORNL, LANL, IUCF, NCSU,…)	
Determination of τ_n Lifetime Using Magnetically Trapped UCN	*Approved*
(Harvard, NIST, NC State)	
Measurement of "a" & "b" Correlations in Neutron Beta Decay	*Approved*
(U of Va., ORNL, LANL, Indiana, UNH, Tennessee…)	
Measurement of "a,b,B,A" Correlations in Neutron Beta Decay	*Deferred*
(LANL, Indiana, Michigan, NIST, ORNL, UNH, Tennessee…)	
Measurement of "A+B" Correlation in Neutron Beta Decay	*Deferred*
(Michigan, Indiana, NIST, ORNL, UNH,…)	
Measurement of Parity Violation in n-p Capture	*Beam Allocated*
(LANL, Indiana, Manitoba, ORNL, Kentucky, Tennessee…)	
Measurement of Parity Violation in n-d Capture	*Deferred*
(LANL, Indiana, Manitoba, NIST, Berkeley, ORNL,…)	
Precise Measurement of Neutron Spin Rotation in H_2 and He	*Deferred*
(Indiana, Washington, NIST, NC State, Indiana, ORNL,…)	
Proton Asymmetry in $n+{}^3He$ capture	*Approved*
(Indiana, Washington, NIST, NC State, Indiana, ORNL,…)	
New Search for an Electric Dipole Moment	*Approved UCN Beam*
(LANL, Caltech, Berkeley, ORNL, NC State, Illinois, MIT, BU…)	

The NPDGamma Experiment

The n+p→d+γ completed data collection at LANSCE in 2006.

Polarizer, Field Coils, Spin Flipper, & Detector

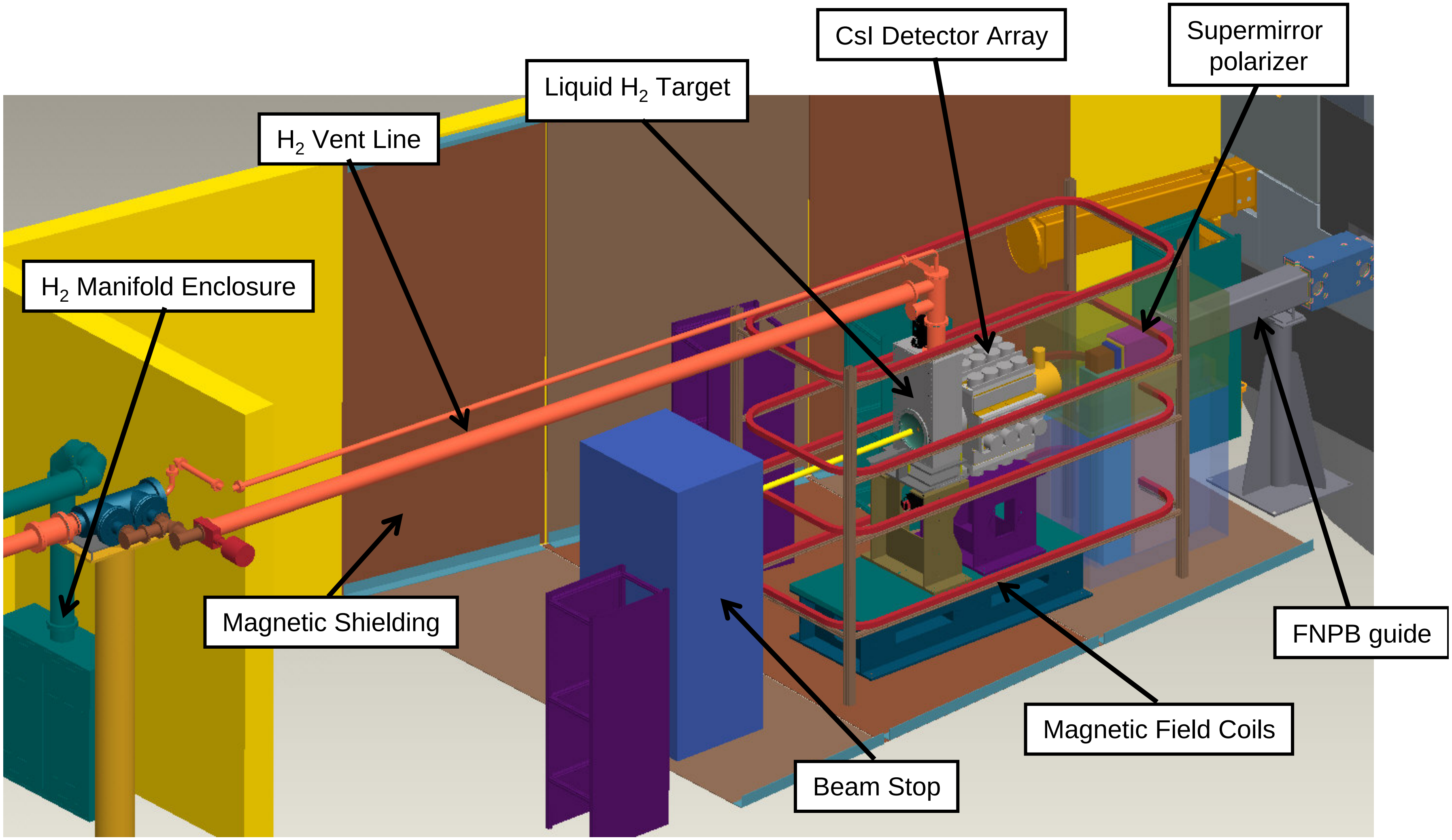


Liquid H_2 Target

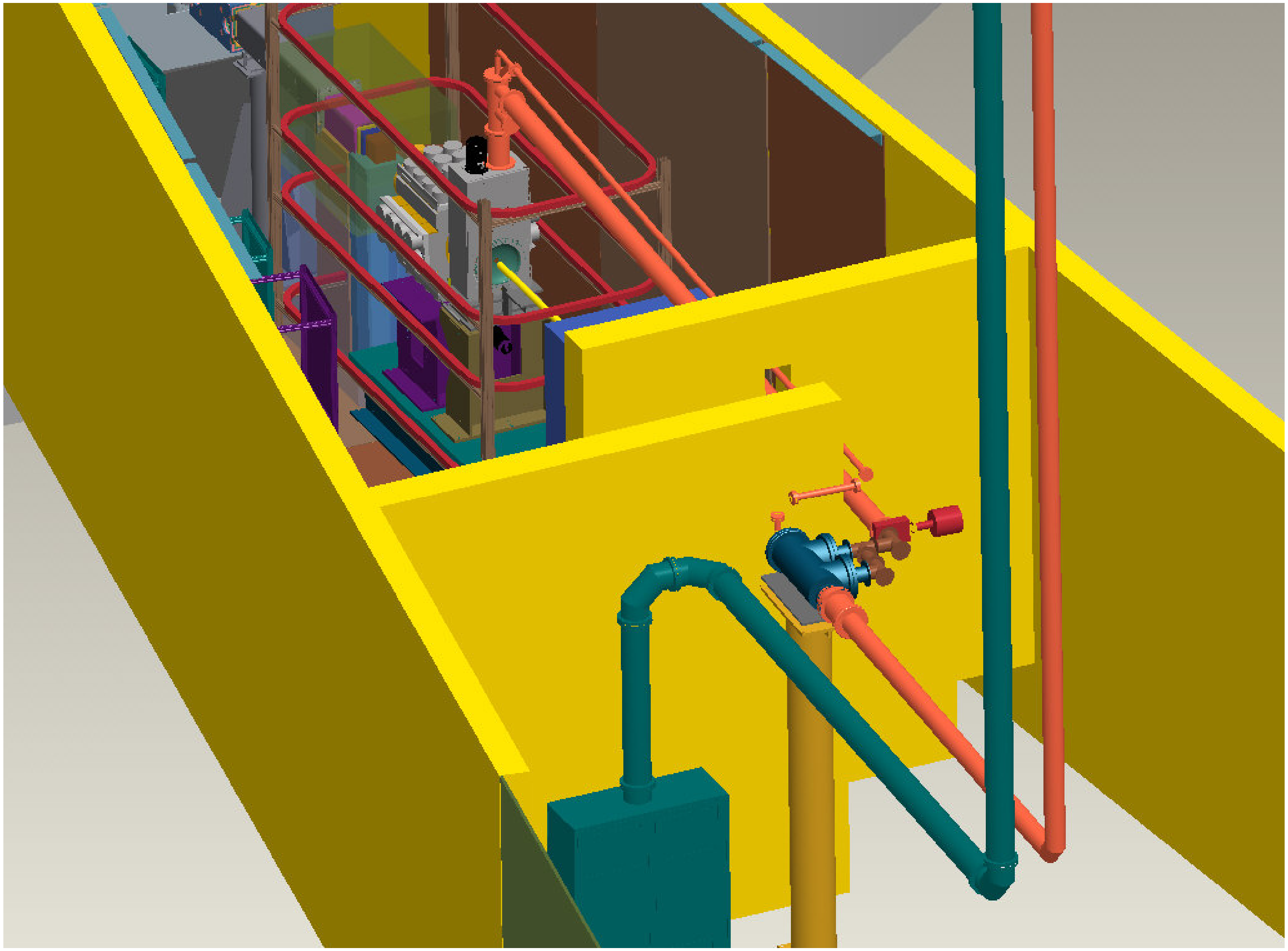
H_2 Safety System

H_2 Vent Stack

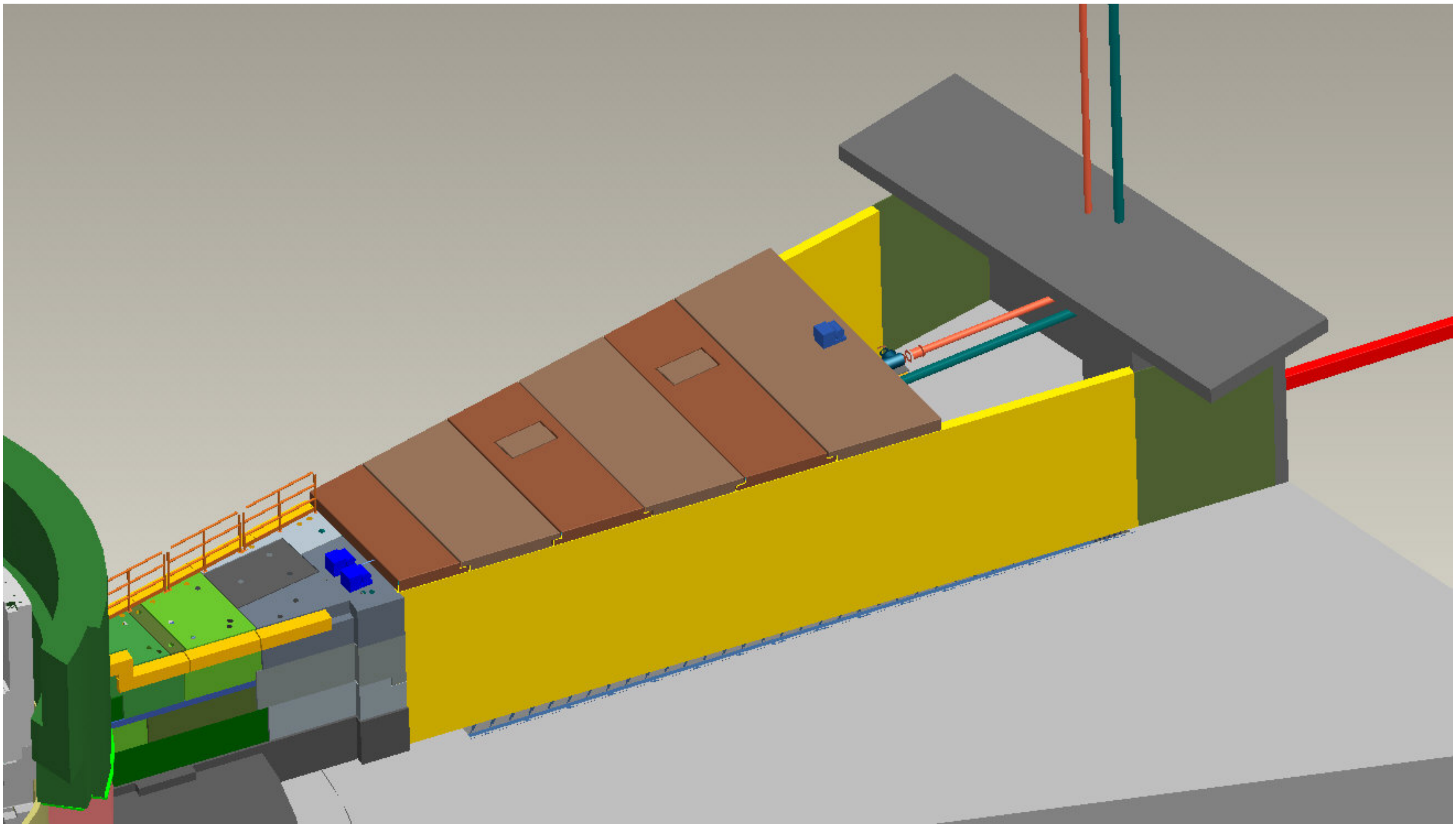
The NPDGamma Experiment



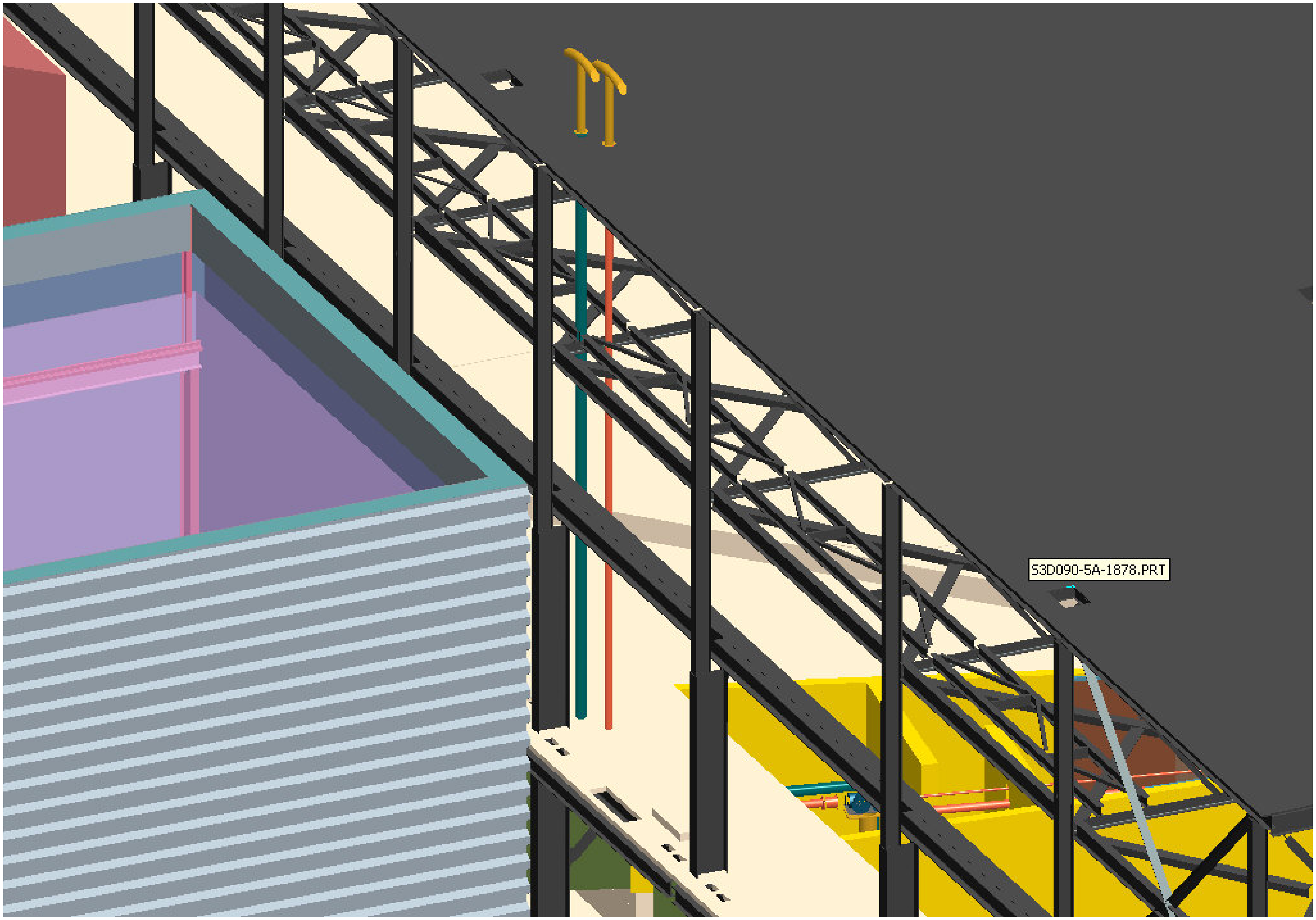
The NPDGamma Experiment – Vent System



The NPDGamma Experiment – Shield Roof and Mezzanine

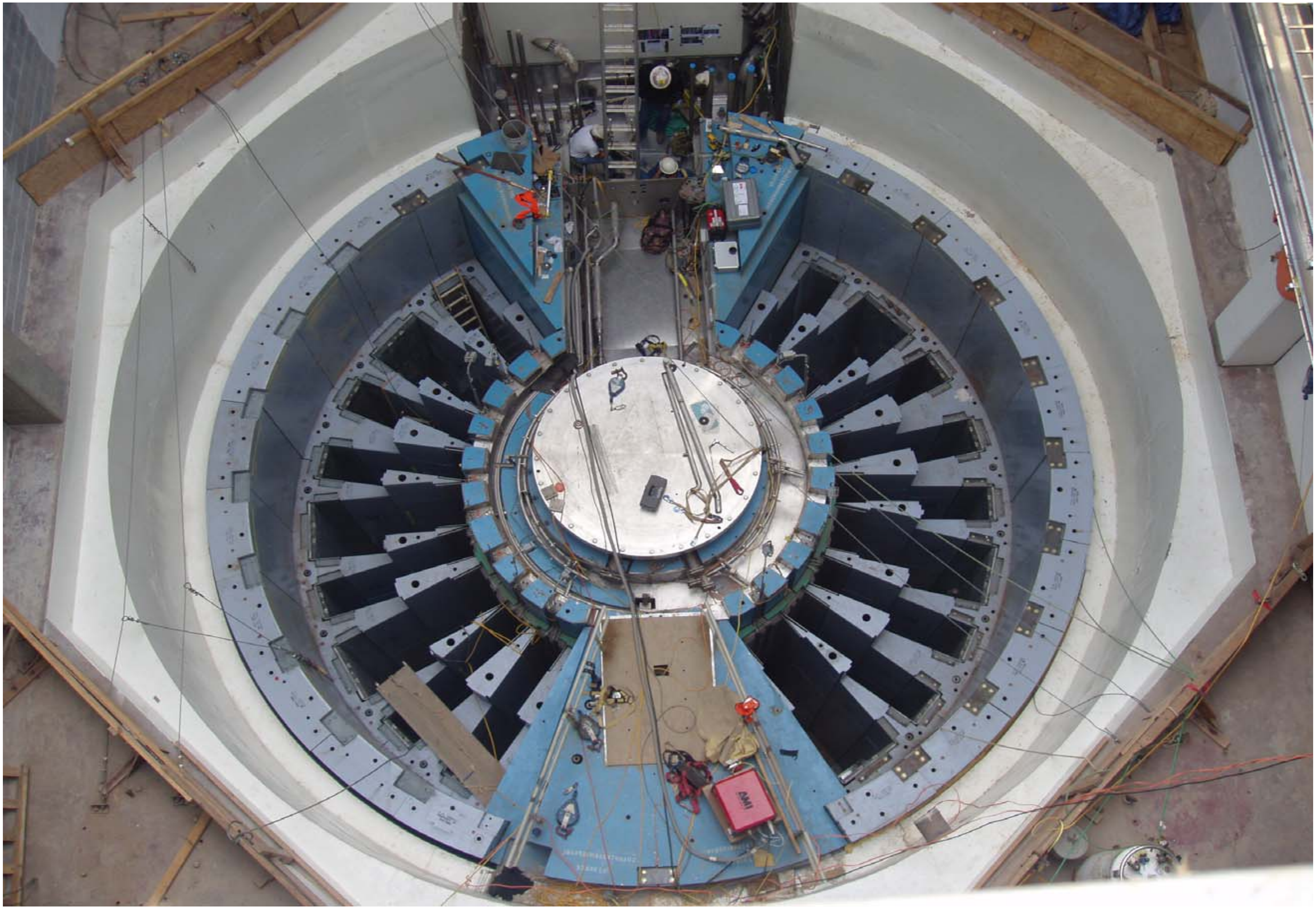


The NPDGamma Experiment – Vent Line Routing

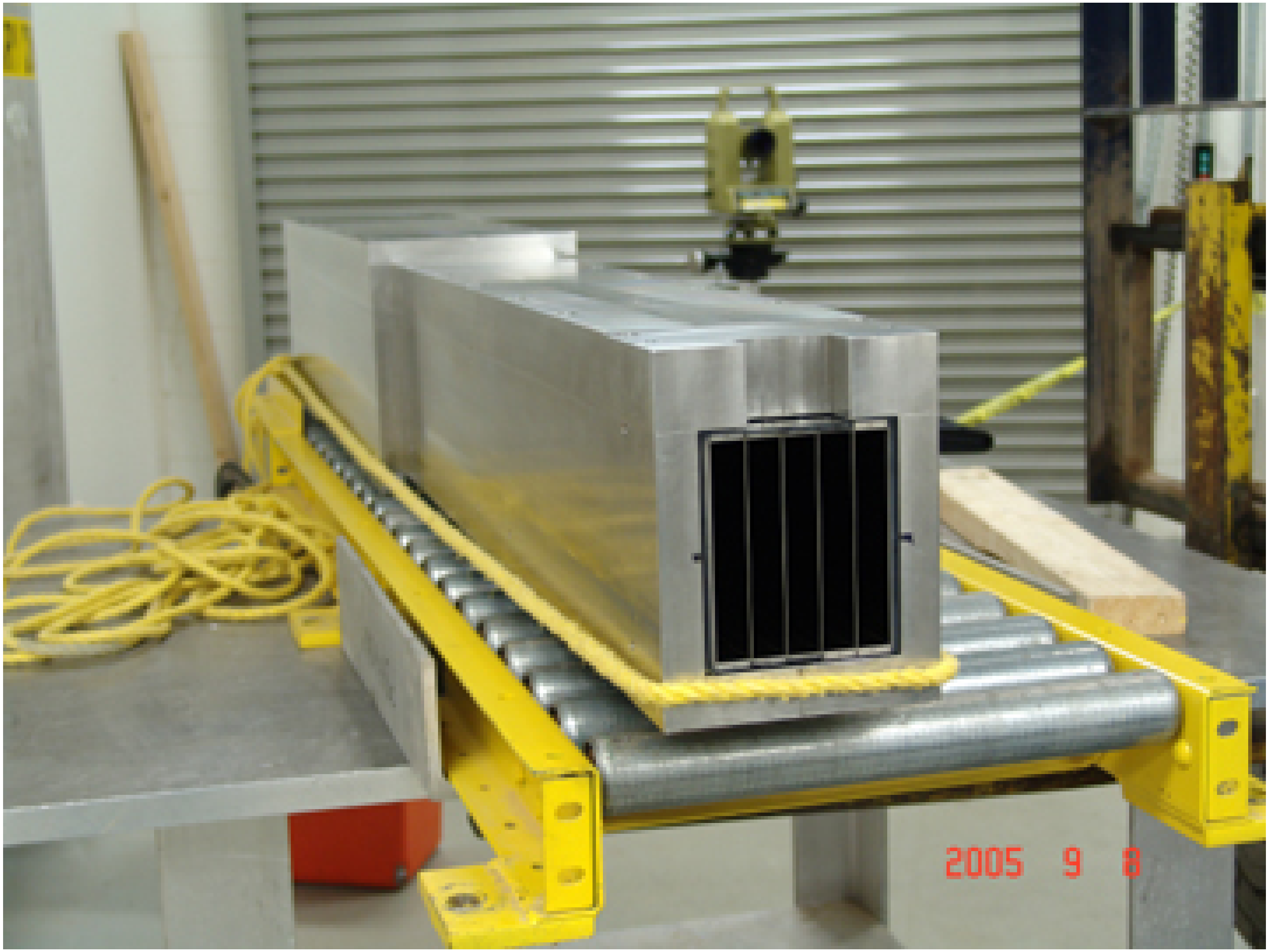


FNPB Construction

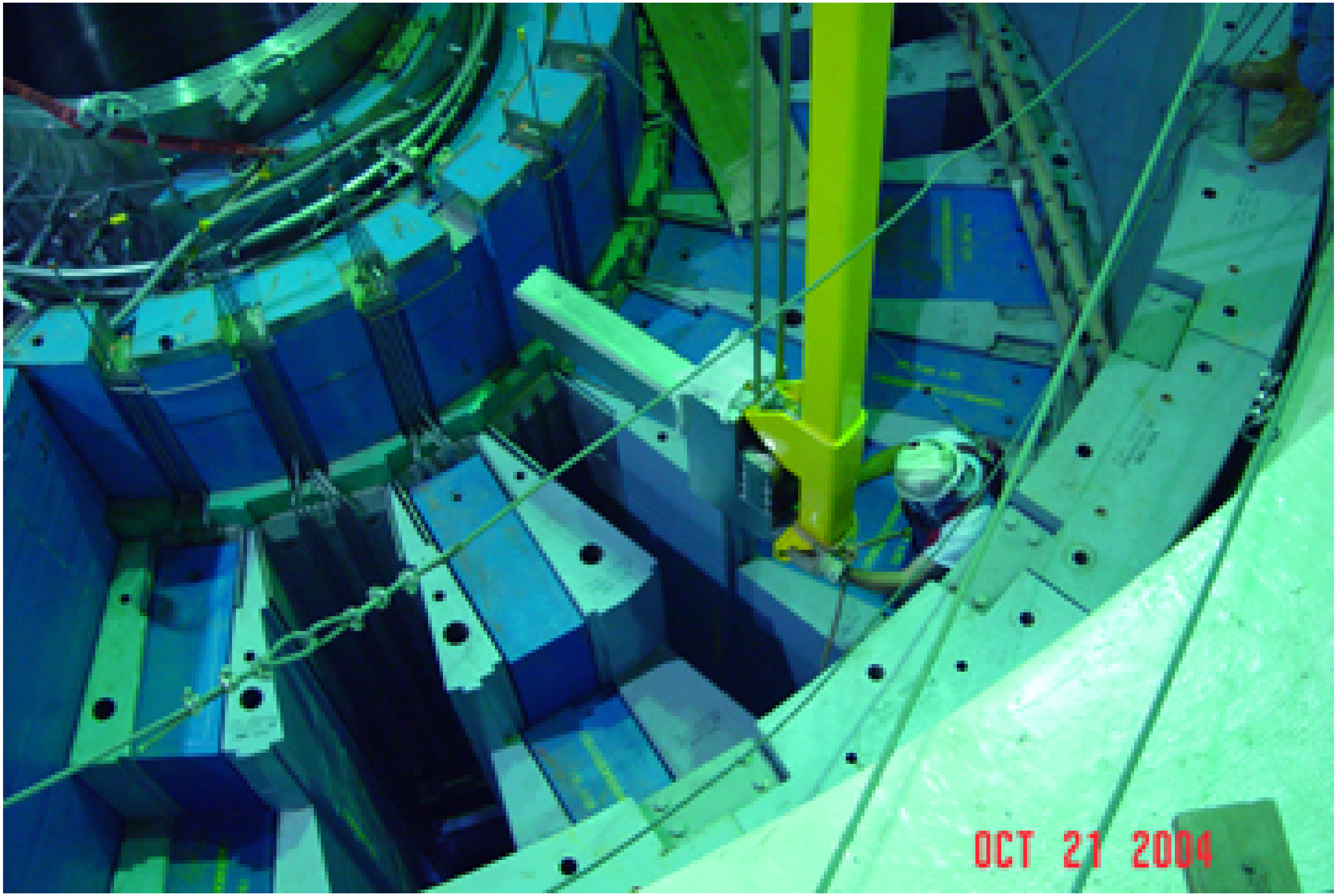
SNS Target "Monolith"



FNPB Neutron Guide (Shutter)



Insertion of Upstream Neutron Guide



SNS Experimental Hall

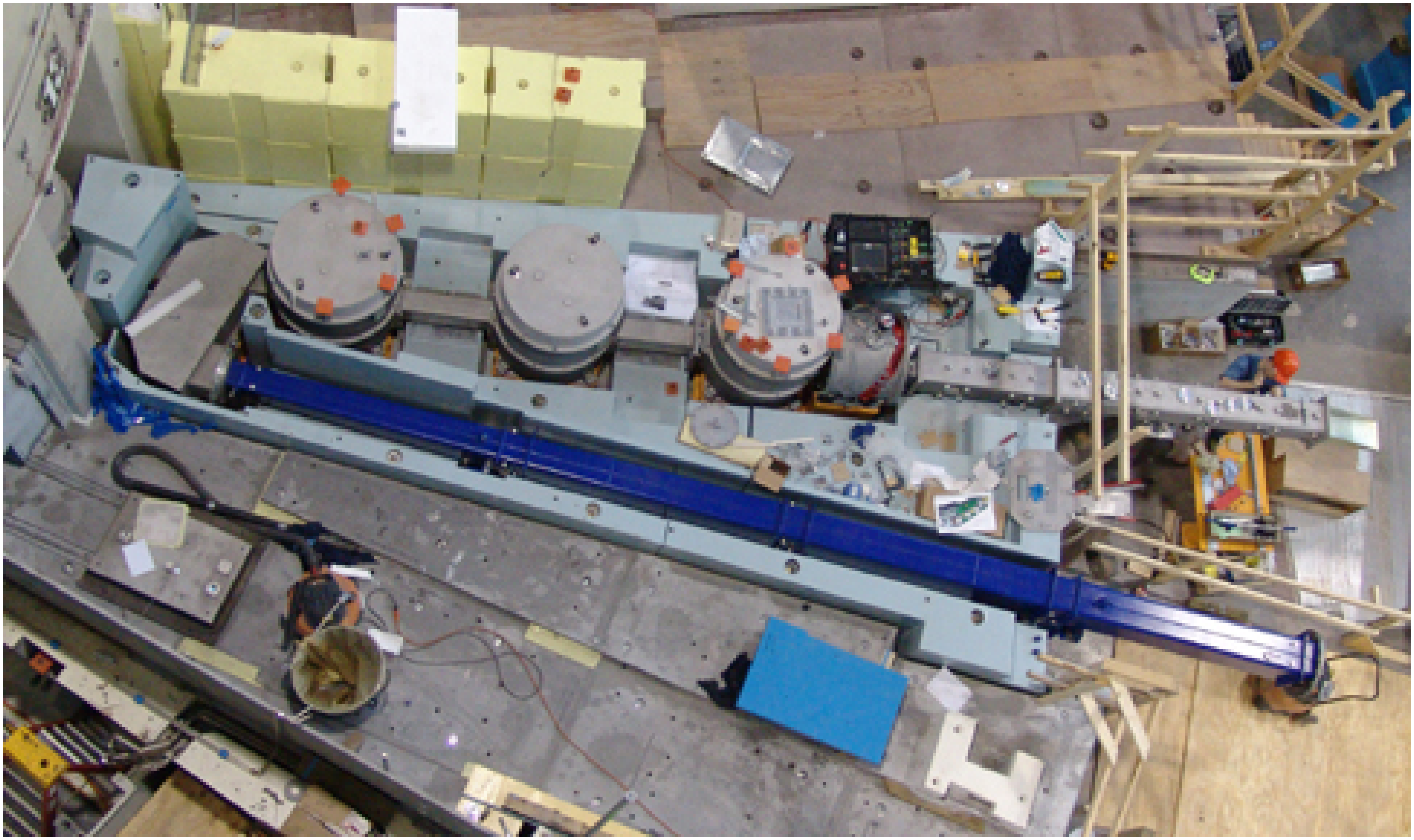
FNPB Chopper Housing #1

Shielding Seismic Tie-Downs

FNPB 1st Level Shielding

FNPB 2nd Level Shielding

FNPB Cold and Ultra Cold Beam Line Installed



FNPB Cold Neutron Beamline

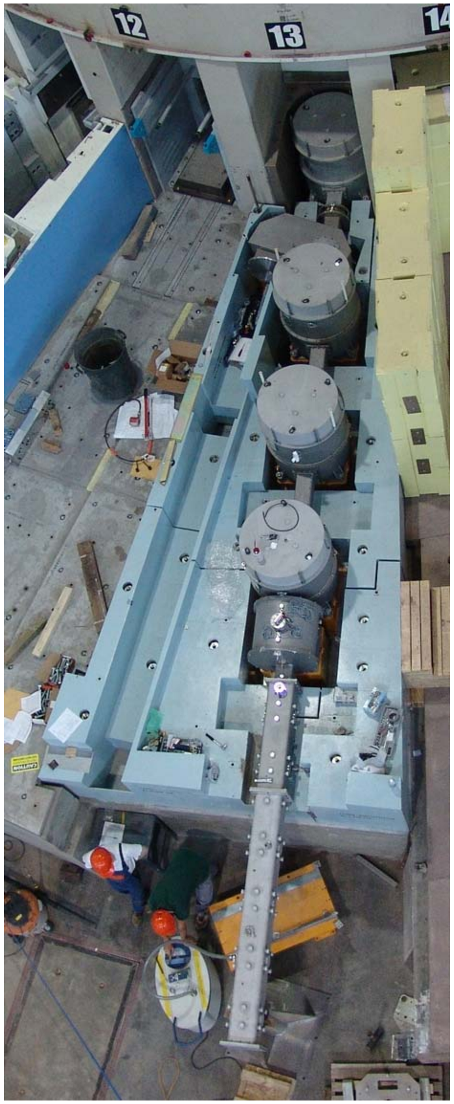
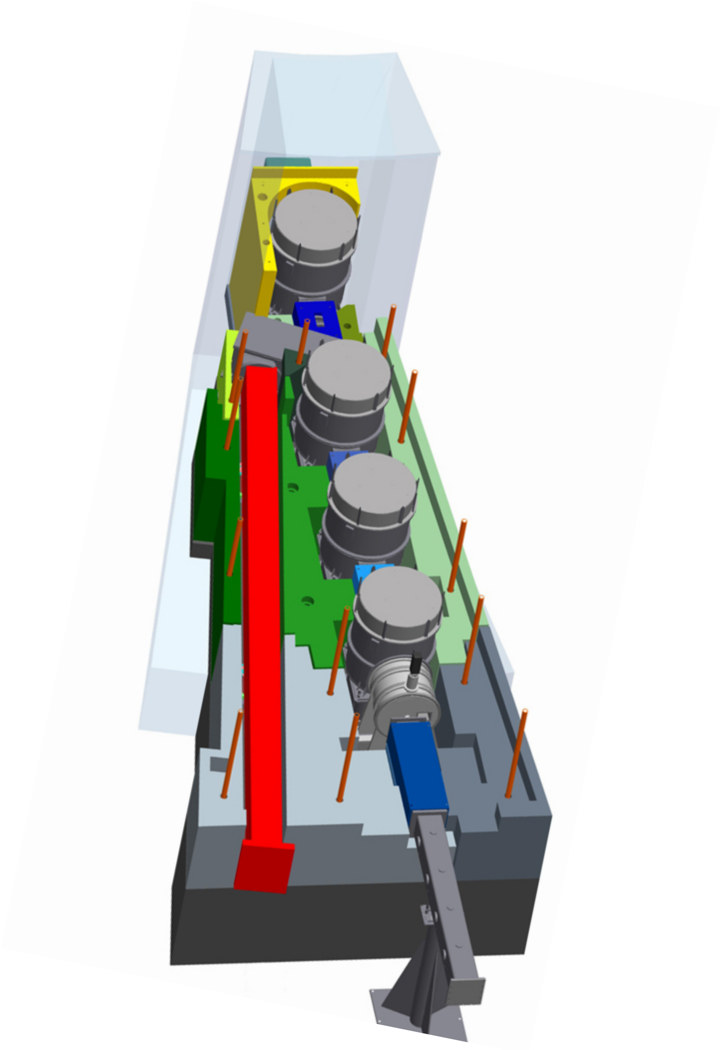
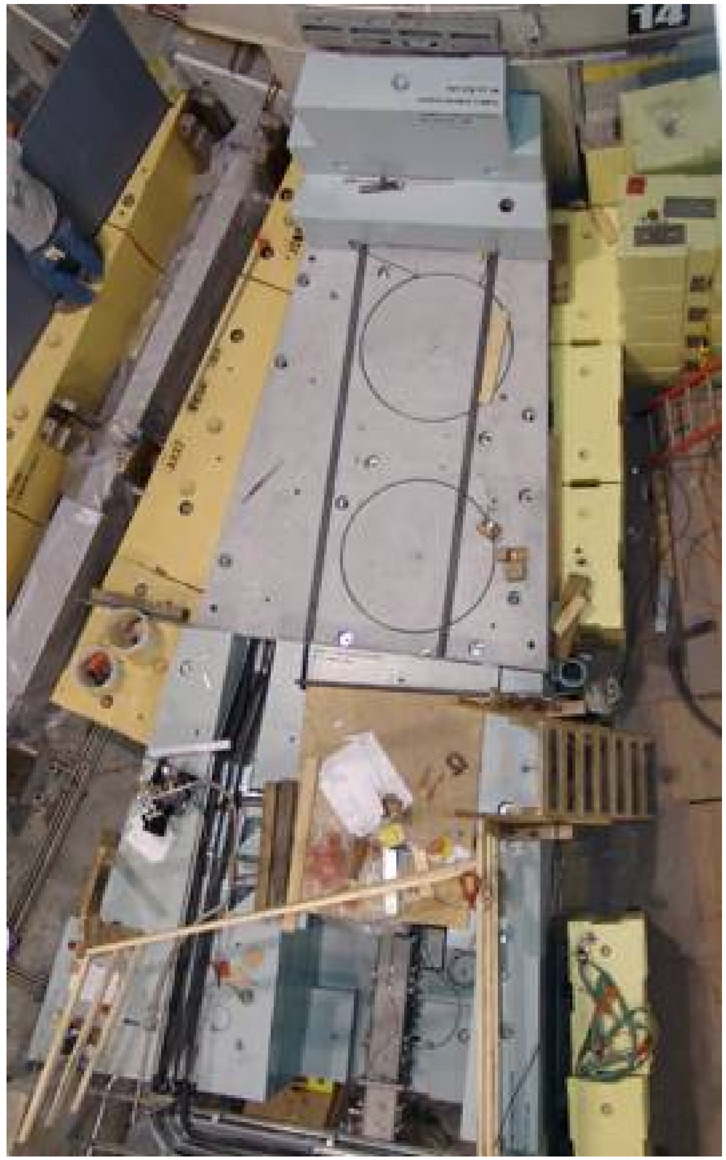


Photo – Feb 2007



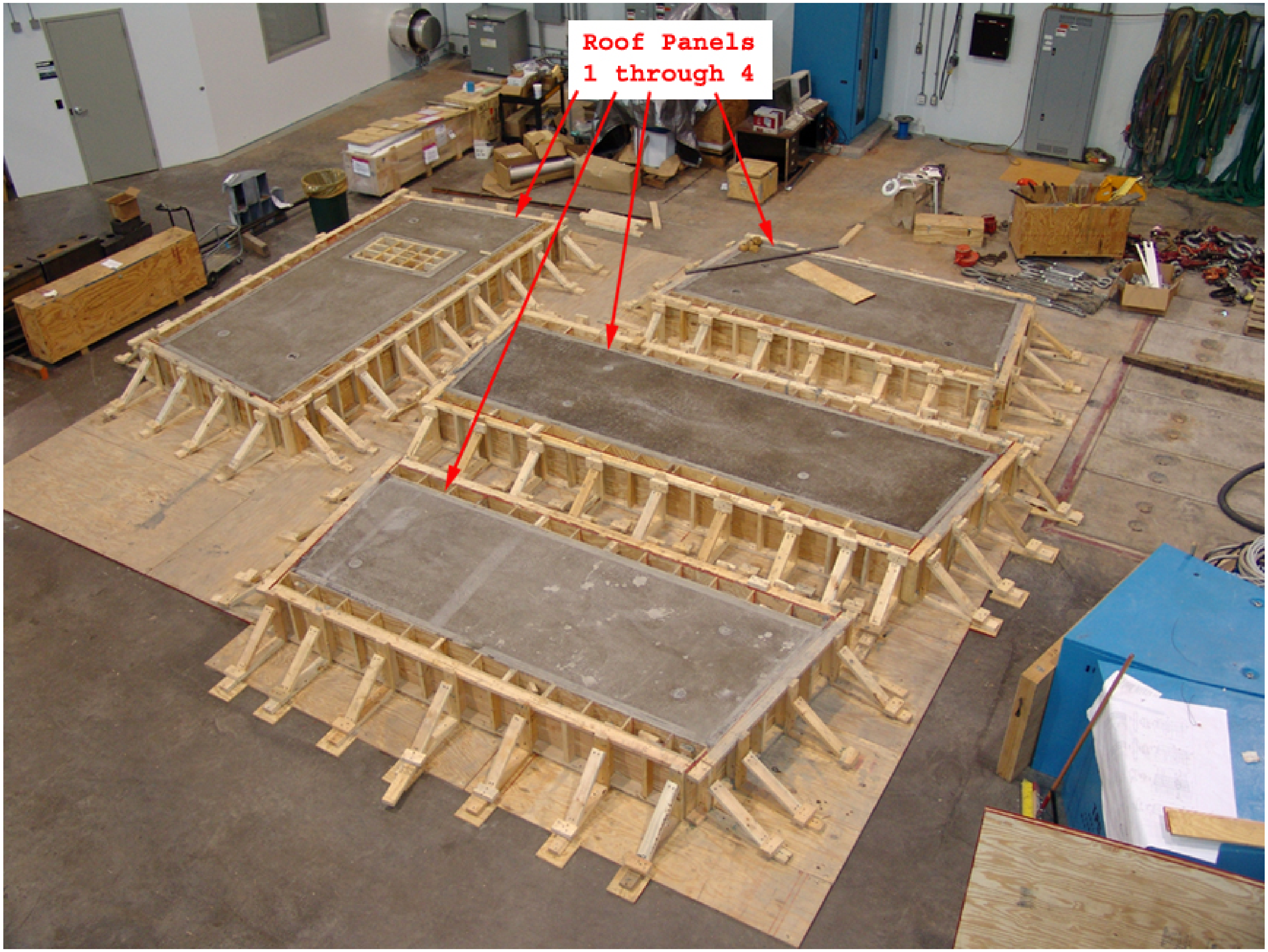
FNPB 3rd Level Shielding Installation



Chopper Installation

Shield Walls

Roof Panels



Excavation of Magnet Pit

Magnet Pit Non-Magnetic Rebar

FNPB Magnet Pit

Anticipated Schedule

Commissioning of FNPB Cold Guide	Sept	2008
1st beam to npdgamma	Spring	2009
Cold Beam Operation with LH2	Summer	2009
UCN (EDM) Building available	Late Summer	2009

End of Presentation