The Spallation Neutron Source

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The Spallation Neutron Source

- The SNS will begin operation in 2006
- At 1.4 MW it will be ~8x ISIS, the world's leading pulsed spallation source
- The peak thermal neutron flux will be ~50-100x ILL
- SNS will be the world's leading facility for neutron scattering
- It will be a short drive from HFIR, a reactor source with a flux comparable to the ILL

SNS - Guiding Principles

- SNS will provide high availability, high reliability operation of the world's most powerful pulsed neutron source
- It will operate as a User Facility to support peer reviewed research on a Best-in-Class suite of instruments
  - Research conducted at SNS will be at the forefront of biology, chemistry, condensed matter physics, materials science and engineering
- SNS will have the capability to advance the state of the art in spallation neutron source technology. This includes:
  - R&D in accelerators, target, and instruments to keep SNS at the forefront
  - Planned enhancement of SNS performance through upgrades of the complex and ongoing instrument development as part of the normal operating life of the facility

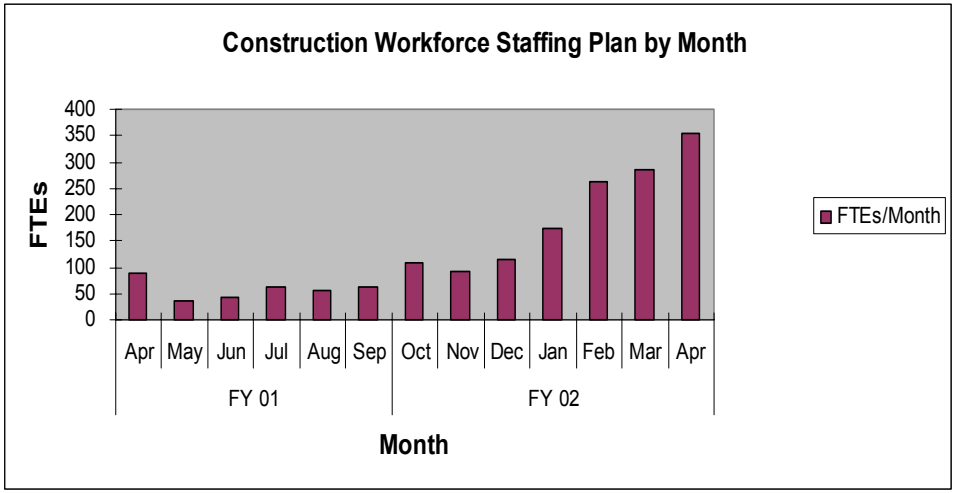
Project Status

- The FY 2002 request was $291M, fully funded
- The FY 2003 request is $225M, as anticipated
- Overall project design is 78% complete
- Overall the project is 42% complete (through April 2002) and within budget and schedule constraints
  - $1.4B and June 2006 completion
- Significant site construction activities are underway
- There is good progress on all of the technical components: front end, superconducting linac, ring, target & instruments
- We continue to have excellent ES&H performance
  - >700,000 construction site work hours without lost workday injury
- Post-handoff MOAs signed with LBNL, BNL, draft LANL – others to follow, partner lab relations good
  - Working through issues

Recent Accomplishments

- Site construction activities have ramped up considerably and safety performance has been maintained
  - Target building foundation, ring tunnel foundation and general construction, CHL, electrical substation, klystron gallery, & CUB underway, progress is good
  - Installation of technical components has begun
- New XFD Director – Ian Anderson (ILL) 03/11/02, Thanks to Tony Gabriel!
- New Ring Senior Team Leader – Jie Wei 03/01/02, Thanks to Bill Weng!
- Across the whole project we continue to award significant $ in procurements of technical systems and are staying within the cost envelope
  - Cumulative awards through the month of March totaled $323.2M against a baseline budget of $311.6M. Over 60% of the project's total procurements have been placed
- The baseline was revised using the Estimate to Complete (ETC) and it is holding up well, contingency remains adequate (but tight)
- On track for Front End commissioning fall of this year!
  - 2.5 MeV through the RFQ and MEBT at LBNL with good beam properties
  - Installation in Oak Ridge underway

SNS Construction

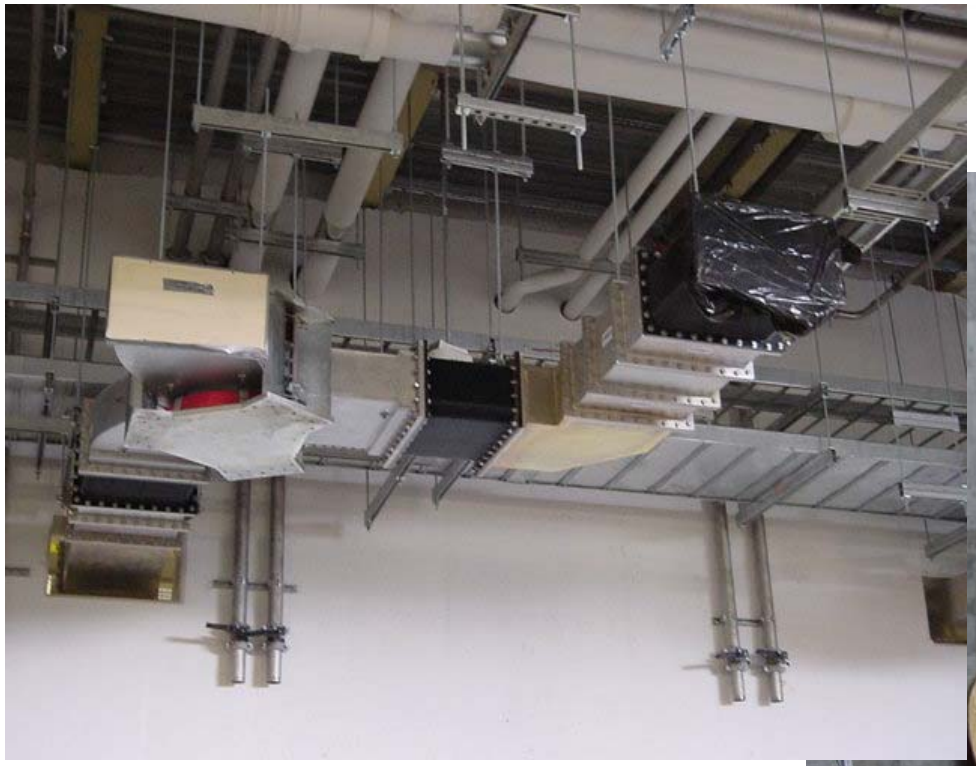


From April 01-April 02

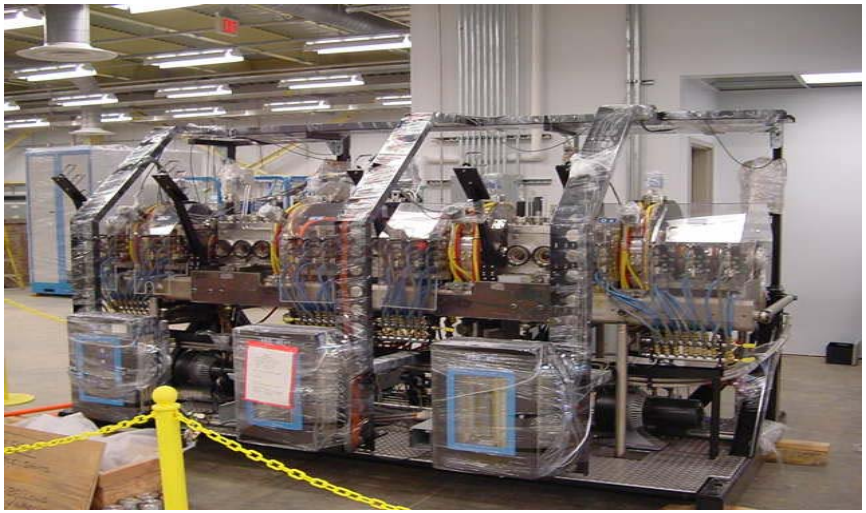
- >750,000 safe hours
- 1 LWC at SNS-ORNL
- 4 minor RIIs at site; 3 RIIs at SNS-ORNL

SNS Construction

Installation of Technical Components



LBNL: First Beam through Full RFQ on 1/25/2002, MEBT 4/4/2002



- Installation of the front end has begun – commissioning this fall
- Exceeds performance goals (50 mA demonstrated – 38 mA required)

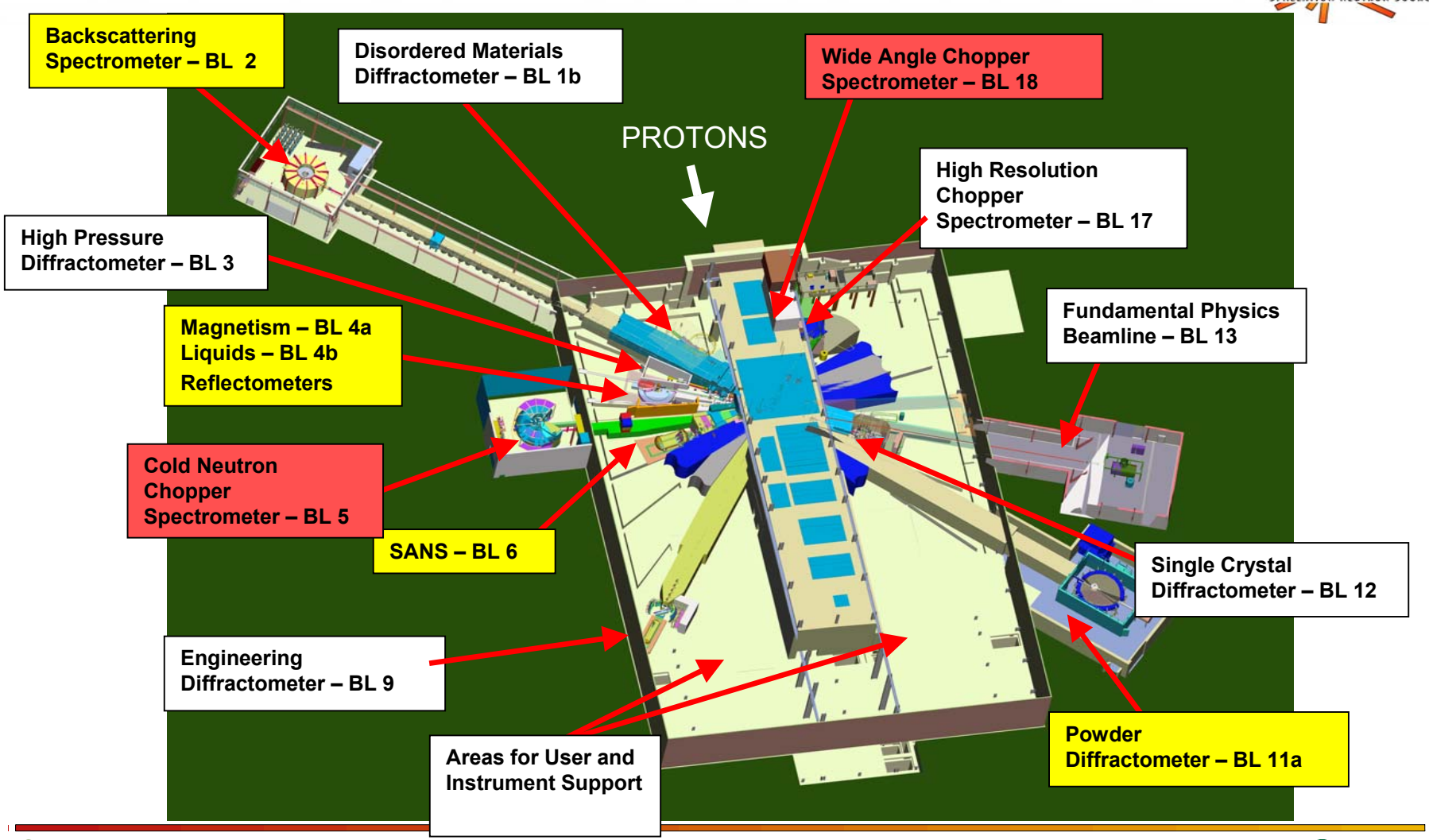
Drift Tube Linac Fabrication and Assembly is Underway

- Re-assembling DTL tank #3 in Oak Ridge
  - Supports schedule for tunnel installation (June 2002)

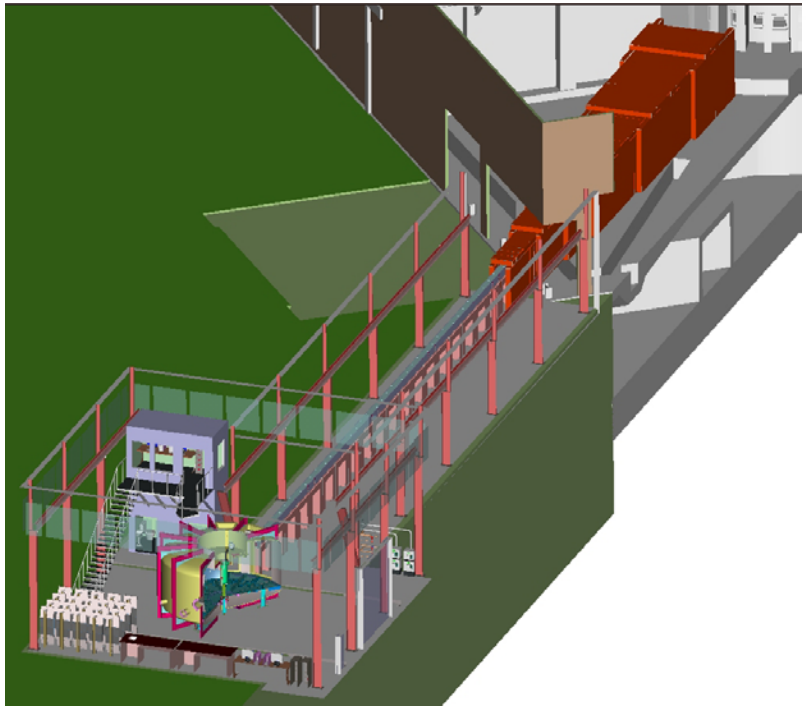
JLab: Superconducting Linac Highlights

- **Prototype cryomodule testing has begun**
- **Initial results very promising – exceeding specifications for accelerating gradient**

Instrument Status



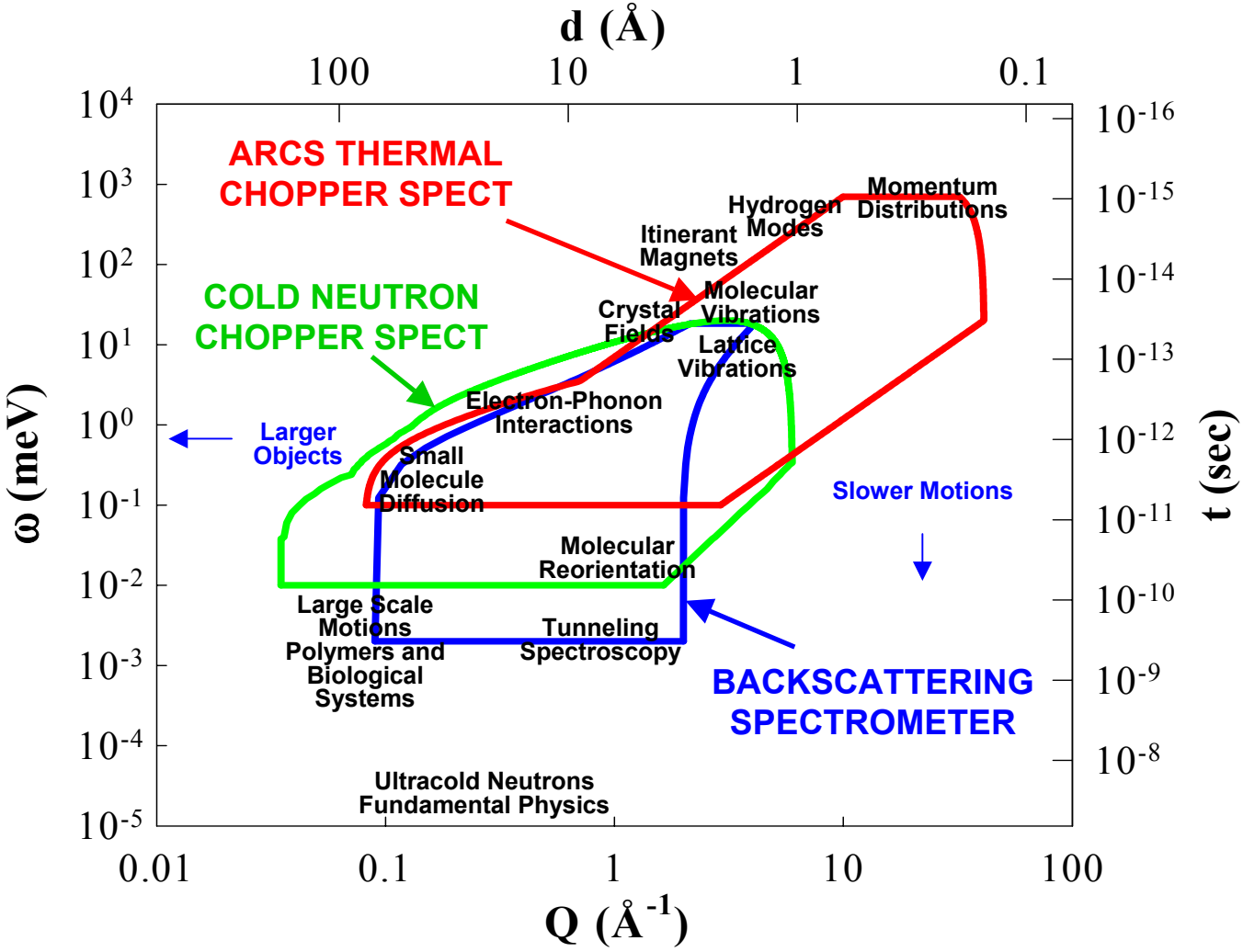
High Resolution Backscattering Spectrometer



- Crystal analyzer (Si) with 84 m incident flight path
- Achieves 2.2 μeV resolution at the elastic position with 250 μeV bandwidth
- Can operate up to 18 meV energy transfer with 10 μeV resolution
- Unprecedented capabilities

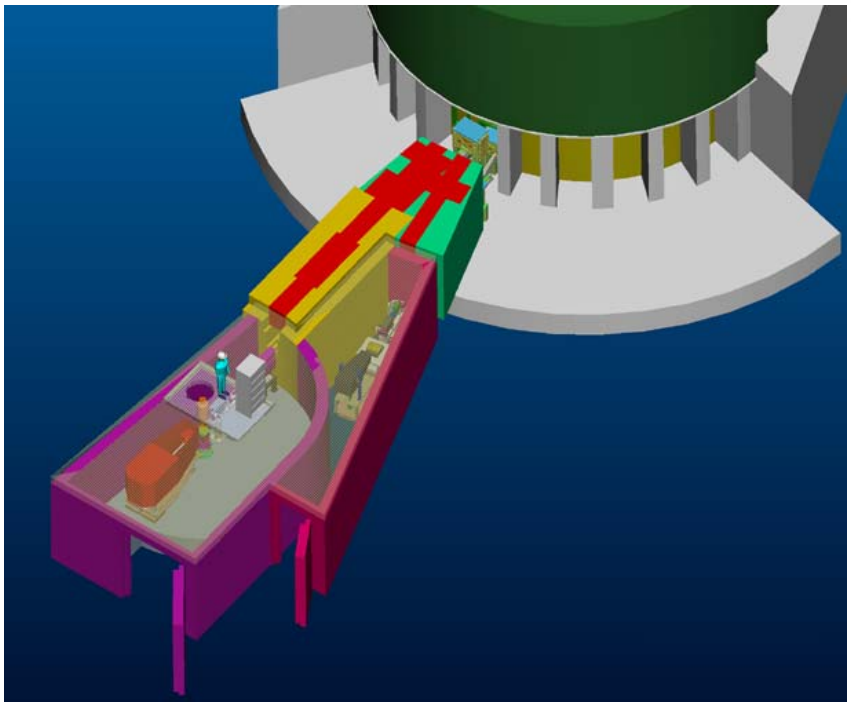
- Performance gains over comparable reactor backscattering instruments >100 (depending on bandwidth needed)
- High-Q option (with Si 311) 500x IN13 and 18x IRIS (with 3 times Q range and better resolution!)

Q-ω Diagram for Inelastic Instruments



adapted from "Neutron Scattering Instrumentation for a High-Powered Spallation Source" R. Hjelm, et al., LA0-UR 97-1272

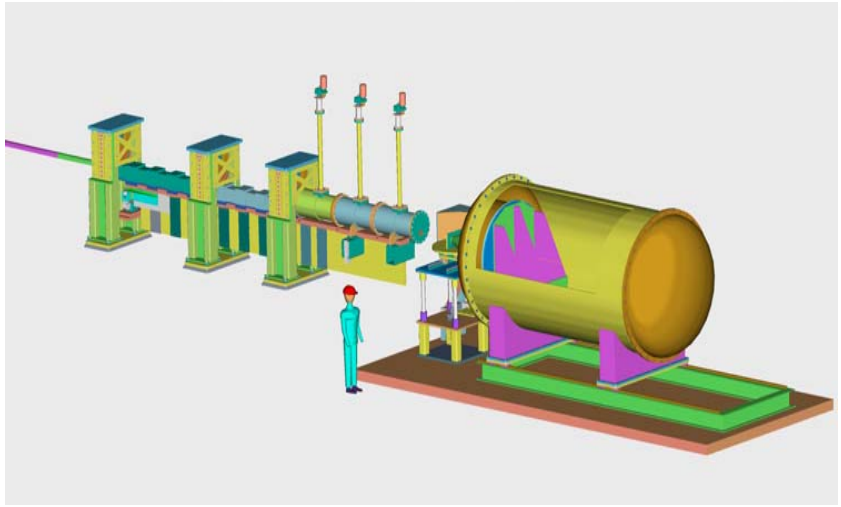
Reflectometers



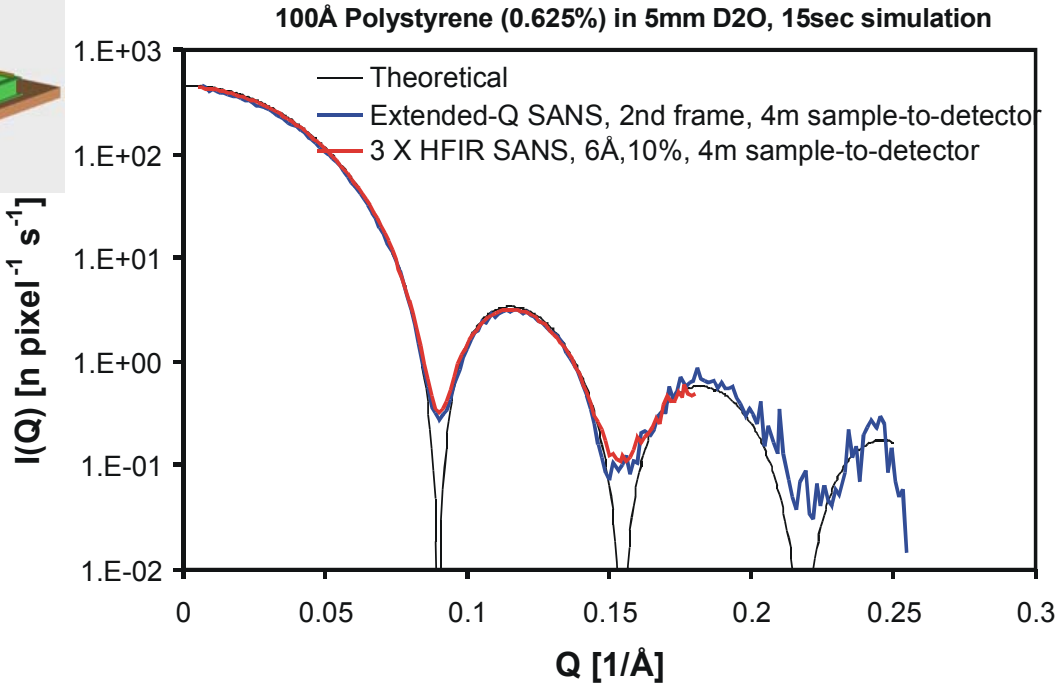
- 2 reflectometers sharing a single beamport
- Requires new multi-channel shutters in the target station
- Allows for both vertical sample (magnetism) and horizontal sample (liquids) studies

- Novel beam bender optics allows multiplexing and reduces background
- Reflectivities $<10^{-9}$, 10-50 times faster than any existing instrument

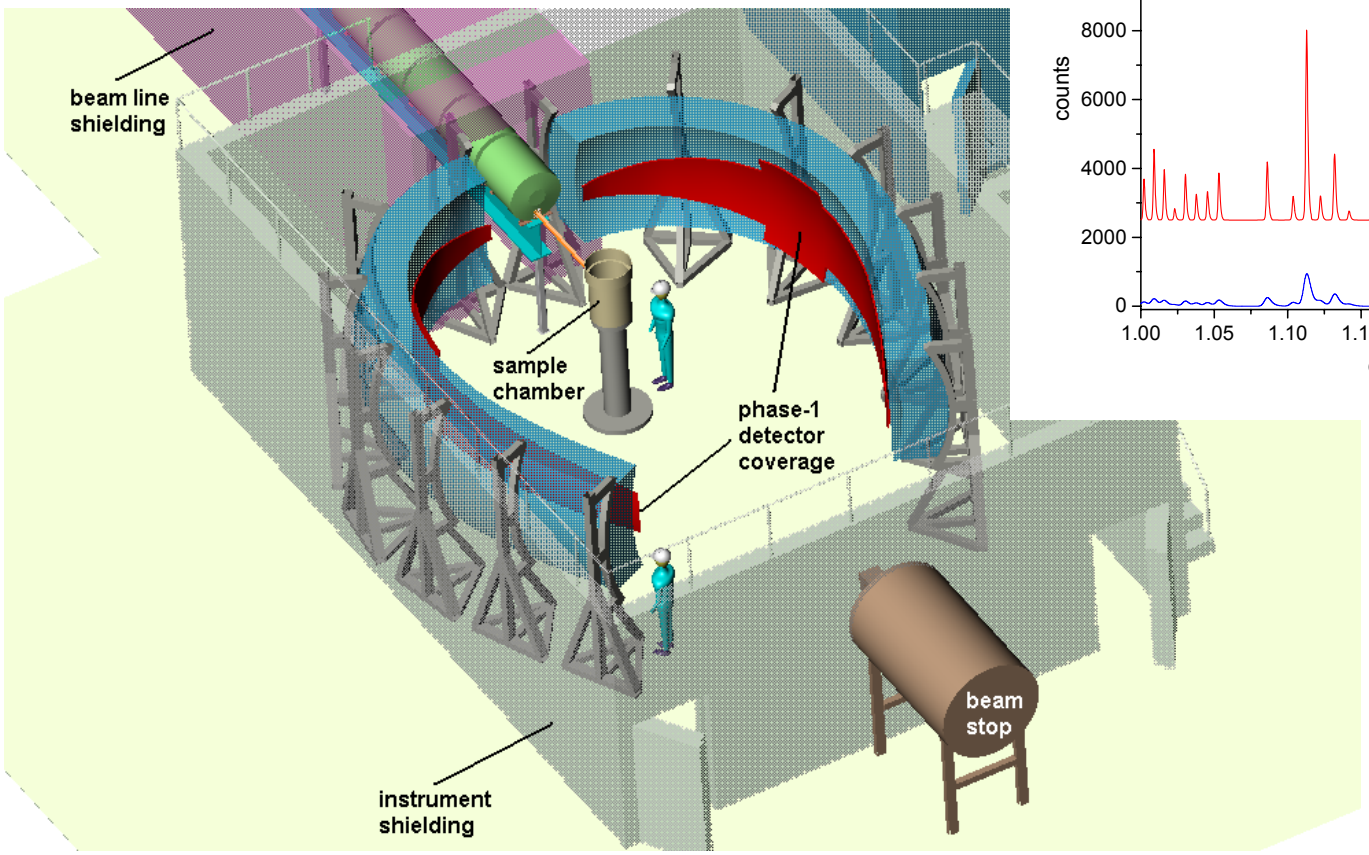
SNS SANS

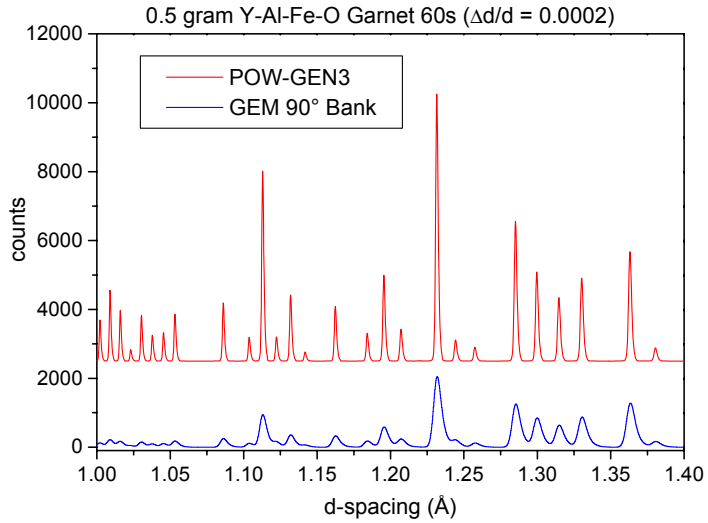


- Extended Q-Range 0.001-12 $Å^{-1}$
- Moderate resolution
- Performance ~3-5 x D22 (ILL) & HFIR, ~30-100 x ISIS

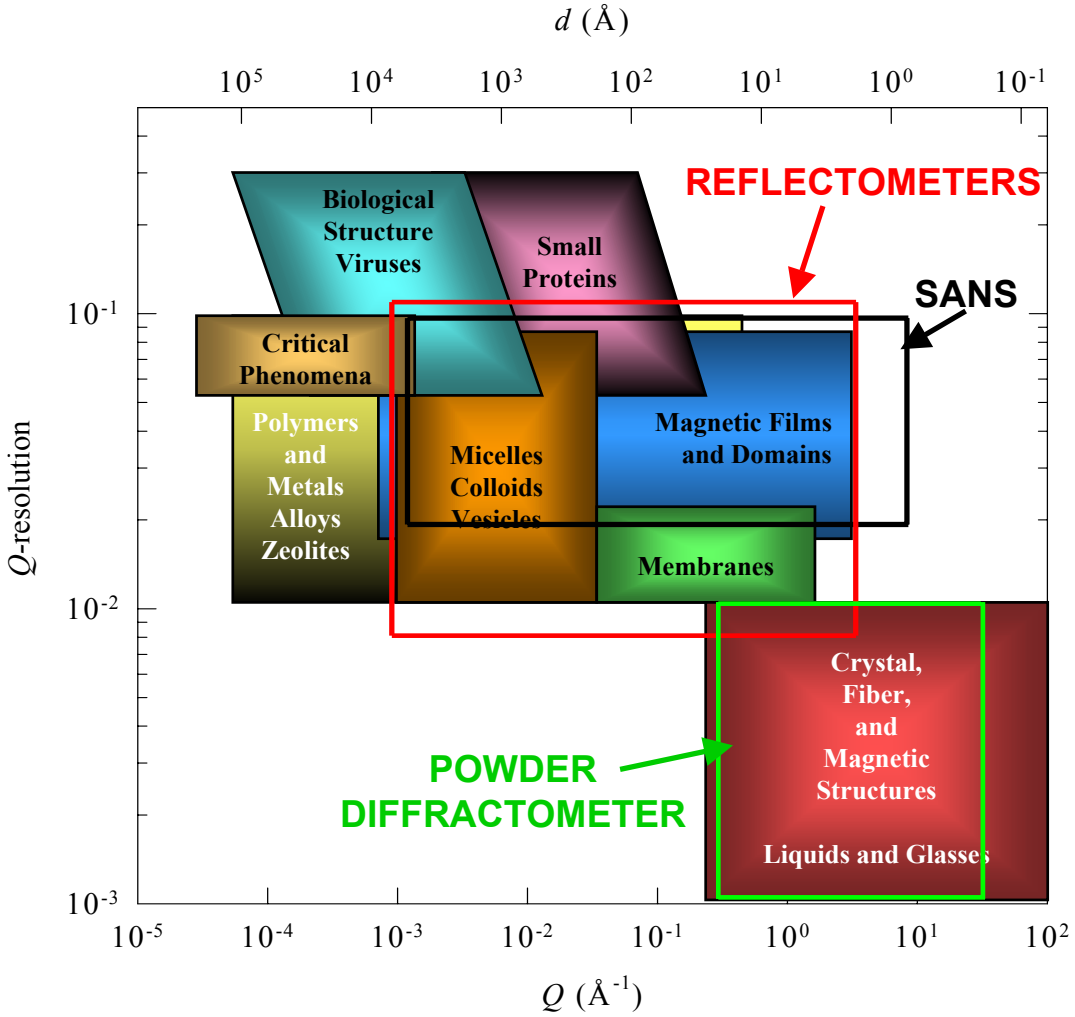


Powder Diffractometer





Q-Resolution Diagram for Elastic Instruments



Instrument Development Teams

- Currently 2 funded IDTs with additional teams in various stages of maturity:
  - Proposal for High pressure diffractometer (to BES) imminent
  - Proposal for Engineering diffractometer submitted to Canadian Foundation for Innovation (CFI) as part of partnership with ORNL/Universities that also includes second thermal chopper spectrometer
    - Reviewed in May by CFI
  - German team carrying out R&D for Spin echo spectrometer
  - DOE has indicated in FY03 budget plans an additional $5M for SNS instruments built by DOE labs
- Guidelines governing IDTs have been issued (www.sns.gov under users) incorporating input from advisory committees, users group executive, workshops and users meetings and are being used to implement agreements with the 2 funded IDTs (CNCS and ARCS)
- Guidelines will be updated once this is done using template established by ARCS and CNCS

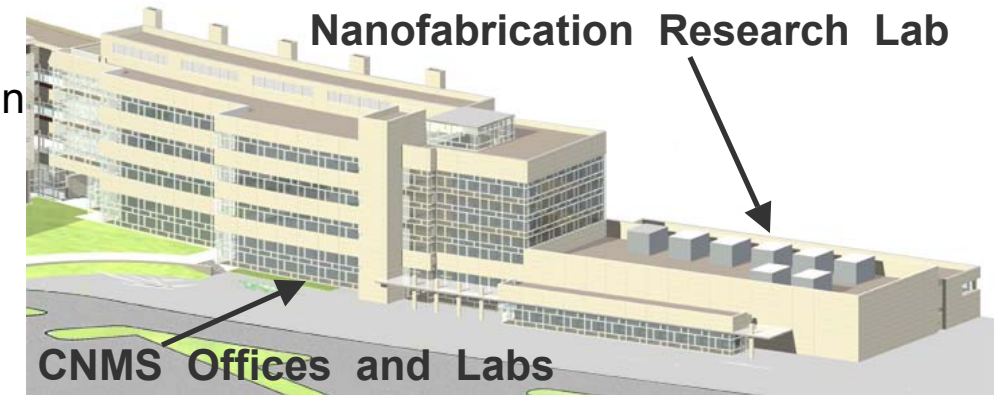
Scientific Scope and Vision for CNMS

Center for Nanophase Materials Sciences

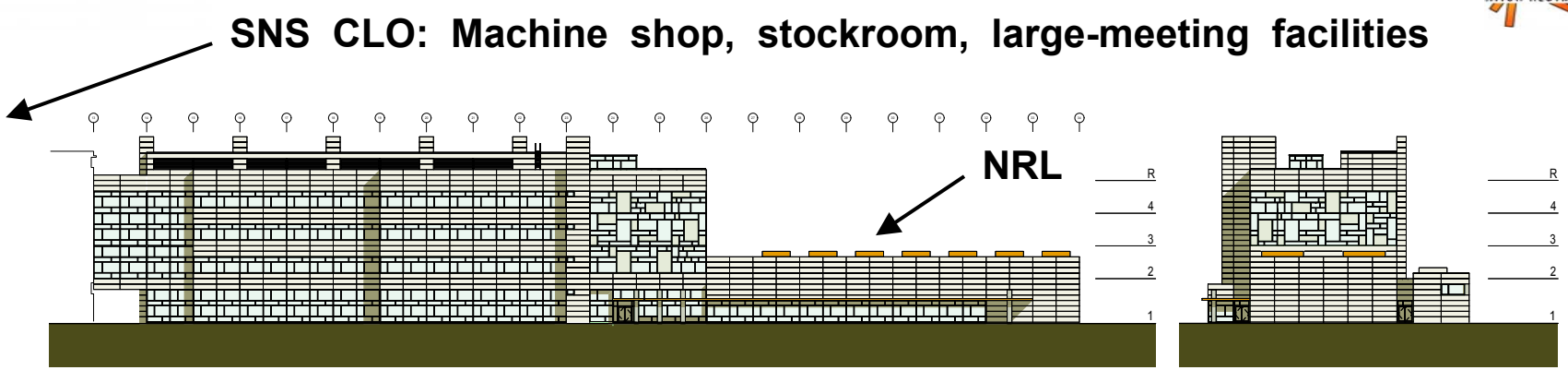
- A highly collaborative and multidisciplinary research center
- Co-located with the Spallation Neutron Source (SNS) and the Joint Institute for Neutron Sciences (JINS) on ORNL's "new campus"
- JINS: Housing and dining facilities, auditorium, classrooms, for research visitors and students
- SNS: Will provide access to unique neutron scattering capabilities for nanoscience
- CNMS: Provides urgently needed capabilities for materials synthesis, nanofabrication, and modeling

The CNMS Concept:

Create scientific synergies to accelerate discovery in nanoscale science



Building and Support Facilities

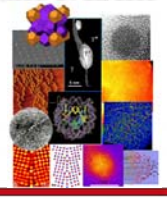


- 80,000 sf: Four levels + Nanofabrication Research Lab (NRL)
- "Wet" and "dry" materials synthesis and characterization labs
- Office space for staff and visitors: *Immediately opposite labs to maximize collaborative, multidisiplinary, and educational interactions*
- Nanomaterials Theory Institute: Labs to access terascale computing facilities / expertise of ORNL Center for Computational Sciences (CCS)
- NRL: Clean and environmentally controlled rooms; electron microscopes; nanoscale patterning (e-beam writer / lithography); facilities for manipulation and integration of soft & hard materials
- CNMS 1st floor (adjacent to NRL): High-resolution scanning probes

CNMS Projected Impacts

- CNMS will be THE world leader in using neutron scattering to make broad classes of nanoscale phenomena accessible to fundamental study
- Leadership in science-driven synthesis—via synergy with Theory, Modeling, and Simulation—will accelerate both discovery and understanding of advanced materials
- Nanomaterials Theory Institute
  - A world leader for designing new functional materials, and for investigating pathways for nanomaterials synthesis
  - Stimulate and support the understanding of nanoscale phenomena
- Nanofabrication Research Laboratory (facilities and expertise)
  - Understand and direct nanoscale self-assembly
  - Functionally integrate use of “soft” and “hard” materials
- CNMS: A leading Center for multidisciplinary NSET research and education and—through strong university collaborations—an intellectual and operational focal point for the southeastern U.S.

Nanophase Materials Sciences Workshop
October 24-26, 2001



SNS
SPALLATION NEUTRON SOURCE

Results of First CNMS Planning Workshop

Candidate Research Focus Areas

Soft Materials

- *Synthetic Polymers and Bio-Inspired Materials*
- *Systems Dominated by Organic-Inorganic Interconnections*
- *Interfacing Nanostructures to Biological Systems: From Synthesis to Signal Transduction*
- *Electronics on a Molecular Scale*

Complex Hard Materials

- *Magnetism in Nanostructured Materials*
- *Nanoscale Manipulation of Collective Behavior*
- *Nanoscale Interface Science (Nanoparticles and Nanograins)*
- *Electromagnetic Fields in Confined Structures*

Hybrid Soft/Hard Materials

- *Carbon-Based Nanostructures*
- *Characterization of Active Sites in Catalytic Materials*
- *Nanoporous Membranes and Nanomaterials for Ultra-Selective Catalysis*

Theory/Modeling/Simulation

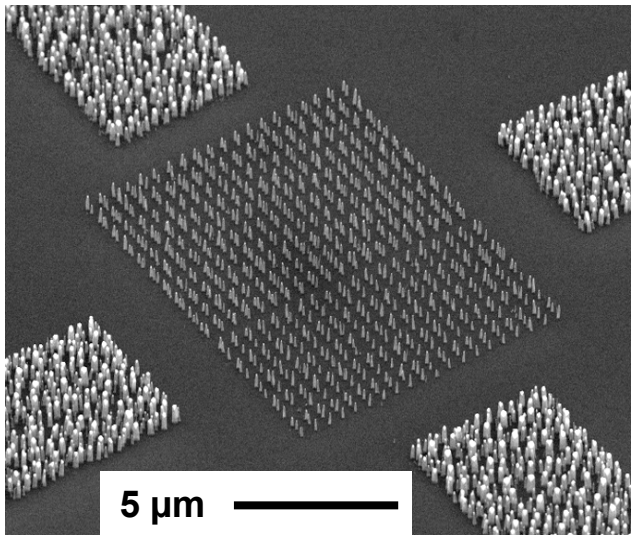
- *Virtual Synthesis and Nanomaterials Design*
- *Theoretical Nano-Interface Science*

Nanofabrication Research Laboratory

Equipment & Clean Room Spaces (Class 100 / 1,000 / 10,000)

- Electron Beam Lithography (E-beam writer) [EVA]
- Focused Ion Beam / Scanning Electron Microscope (FIB / SEM) [EVA]
- Metrology FE-SEM [EVA]
- STEM / TEM and SEM / EDX [EVA]
- E-Beam Resist Processing [EVA]
- Photolithography & Photoresist Processing [EVA]
- CVD / PECVD / PVD / Sputtering
- LPCVD
- Soft Materials / Thin Films Research Integration
- Wet Etch
- Dry Etch & Chemical Mechanical Polishing (CMP)
- Thin Film Metrology
- Gowning entrance; equipment move-in aisle; viewing and office corridor

EVA = Free of Electromagnetic, Vibrational, and Acoustic Interference



Early Operations

- A white paper has been drafted (in part stimulated by ASAC) to describe the expected operational mode in the early years of operation following project completion (CD-4)
  - Intended to stimulate discussion on the topic and following dialog between accelerator/experimental systems and users (plus ASAC, EFAC, DOE, etc.) form a basis for:
    - Planning
    - Decisions on spares, designs, budget, etc. that impact reliability
    - Setting user expectations
  - Breaks operations into six-month segments following CD-4 with a goal to have user mode operation after two years
    - User mode is defined by reliability with respect to schedule >90% with power level and availability (total number of hours) as variables to be maximized subject to that constraint
    - White paper lays out possible goals for the latter two segments

Evolution of performance

- Goal is to optimize scientific performance which depends on power, reliability, availability, number and performance of instruments, quality of staff, etc. in a non-linear way
- The first six months following CD-4 the facility is under regulatory constraint to stay below Hazard Category 3 inventory threshold (until ORR is complete)
  - This implies low power (<10 kW) and duty factor
  - Suitable for accelerator commissioning and instrument tests with beam
    - No reliability requirement – XFD would like warning of when beam may be expected based on ca. 1 week working schedule
- Following completion of ORR the facility will be able to proceed toward higher power operation

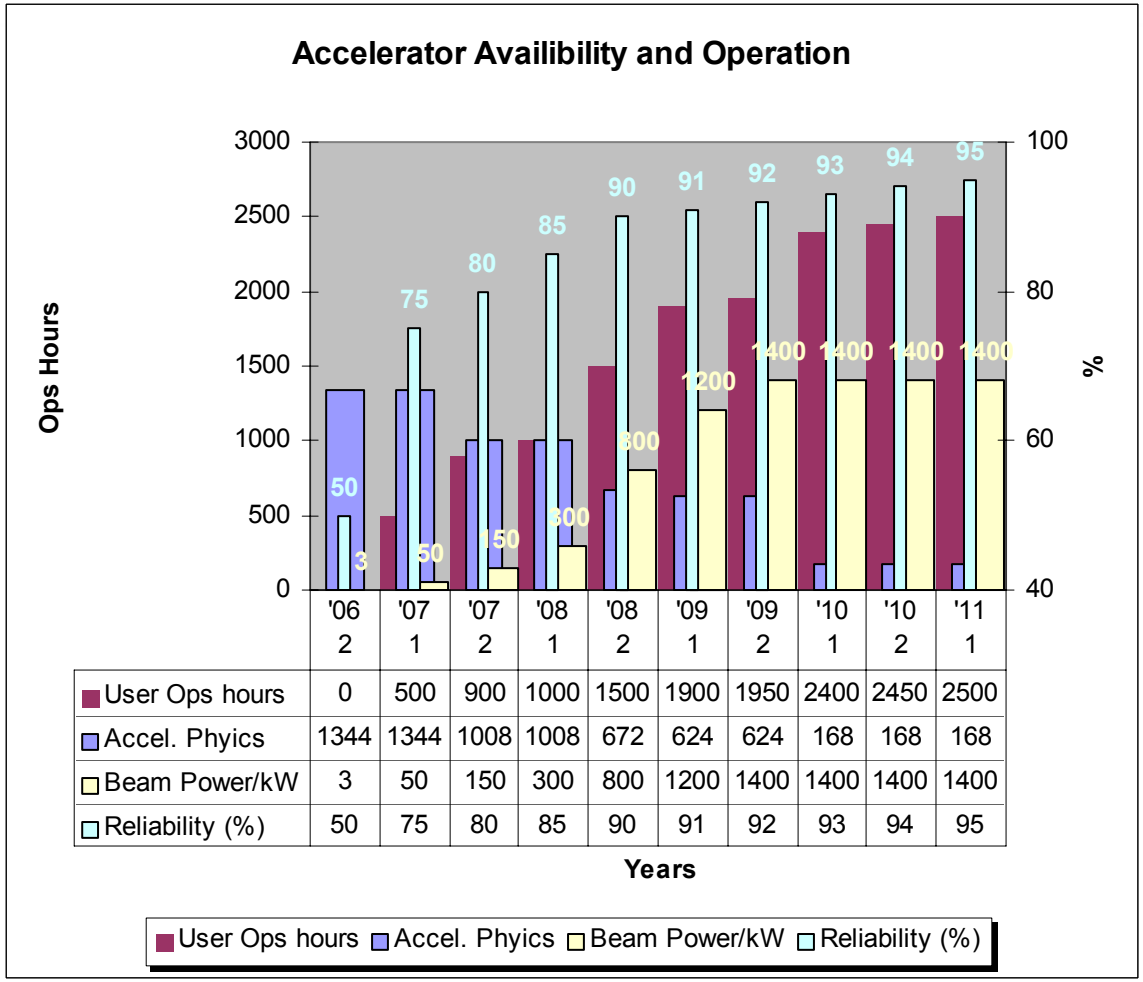
High(er) Power Operations

- The second six-month segment should see operation at a power level sufficient to test all operational modes of instruments (including inelastic scattering) and debug control and analysis software, no external users
  - 75% reliability, ~50 kW for ~500 hours
- At the start of year two of operations some instruments will be ready for scientific commissioning with some “friendly user” experiments, ISIS-class performance
  - 80% reliability, ~150kW for ~900 hours
- By the end of year two power level should be world class with improving reliability
  - 85% reliability, ~300 kW for ~1000 hours

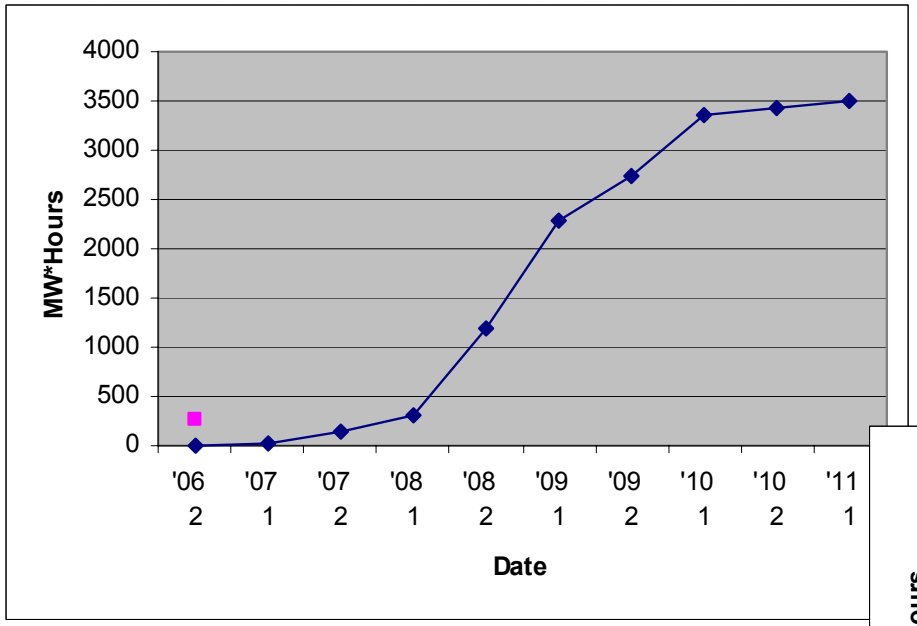
User Mode Operations

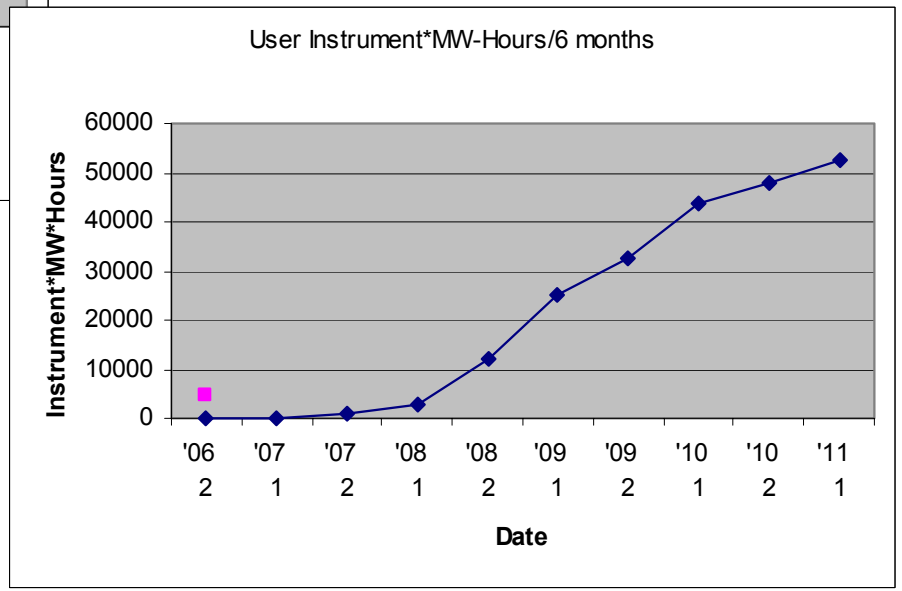
- The third year of operations should see a transition to user mode operation on the initial instrument suite with the peer review proposal system in place, MW-class performance
  - 90% reliability, ~800 kW for ~1500 hours over six months
- In subsequent years the reliability, power level, availability should all approach the ultimate goals
  - 95% reliability, 1.4 MW for 2500 hours over six months
  - Longer-term goal is to increase rated power and buildout instrument suite

Timeline for Operations



Timeline for scientific productivity





Summary

- SNS is well positioned to deliver the world's leading facility for studies of structure and dynamics of materials
  - Contingency is adequate (21%)
  - Early finish schedule has 6 months of float
  - Current baseline reflects results of recent Estimate to Complete
    - The performance of the baseline facility meets the needs and expectations of the scientific community and exceeds the initial CDR goals
      - Capable of >1 MW beam power (1.4 MW +)
      - Five Best-in-Class instruments with room for an eventual suite of 24 (vs. 18 in CDR)
      - Sufficient laboratory and office space to support world class facility operations and user needs
      - Flexible and upgradeable superconducting linac