The Status of US Neutron Sources

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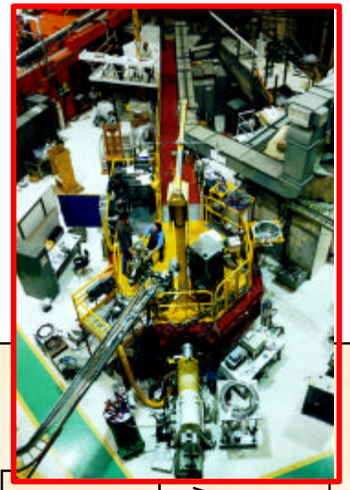
Neutron Scattering Facilities 2002

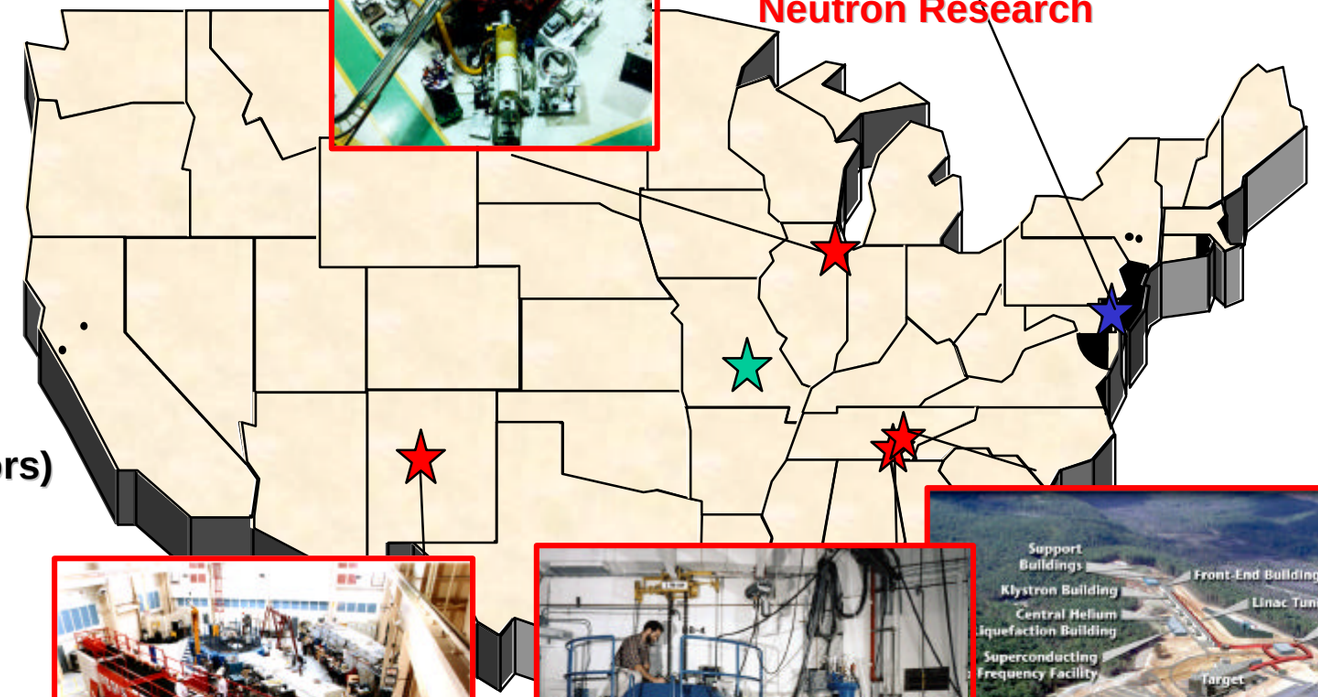
Intense Pulsed Neutron Source



NIST Center for Neutron Research

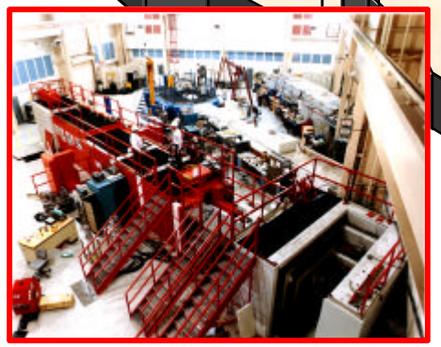
National User Facilities

HFBR 1965-1999
HFIR 1966 –
NCNR 1969 –
IPNS 1981 –
Lujan 1985 –



Local/Regional Facilities (University Reactors)

MIT
Missouri
Michigan
…



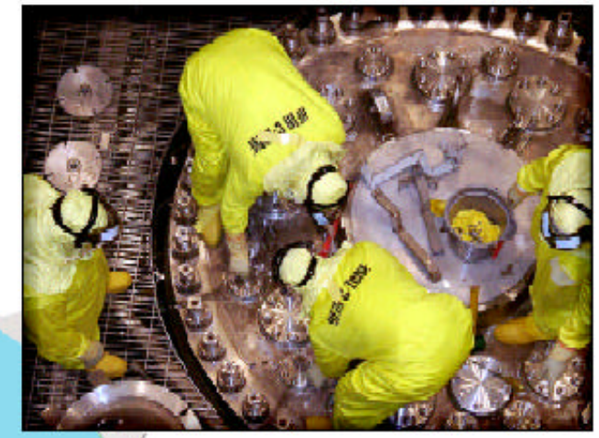
Manuel Lujan Jr. Neutron

High-Flux

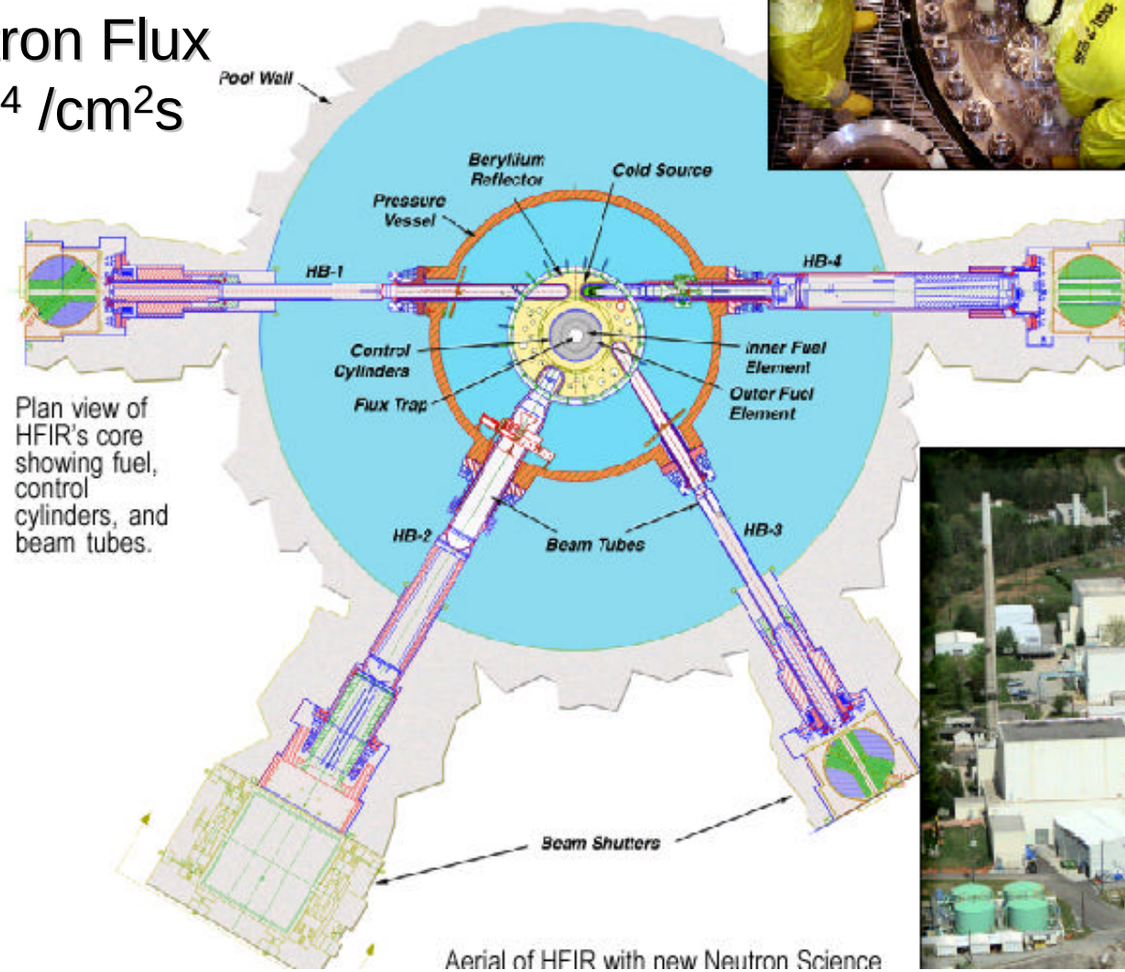
Spallation Neutron

High Flux Isotope Reactor

- Oak Ridge, Tennessee
- BES, Department of Energy
- Started Operation:1966
- 85 MW Light Water Reactor
- Peak Core Neutron Flux
  - 12×10^{14} /cm^{2}s
- 10 Instruments



The reactor was disassembled and the beryllium reflector replaced.



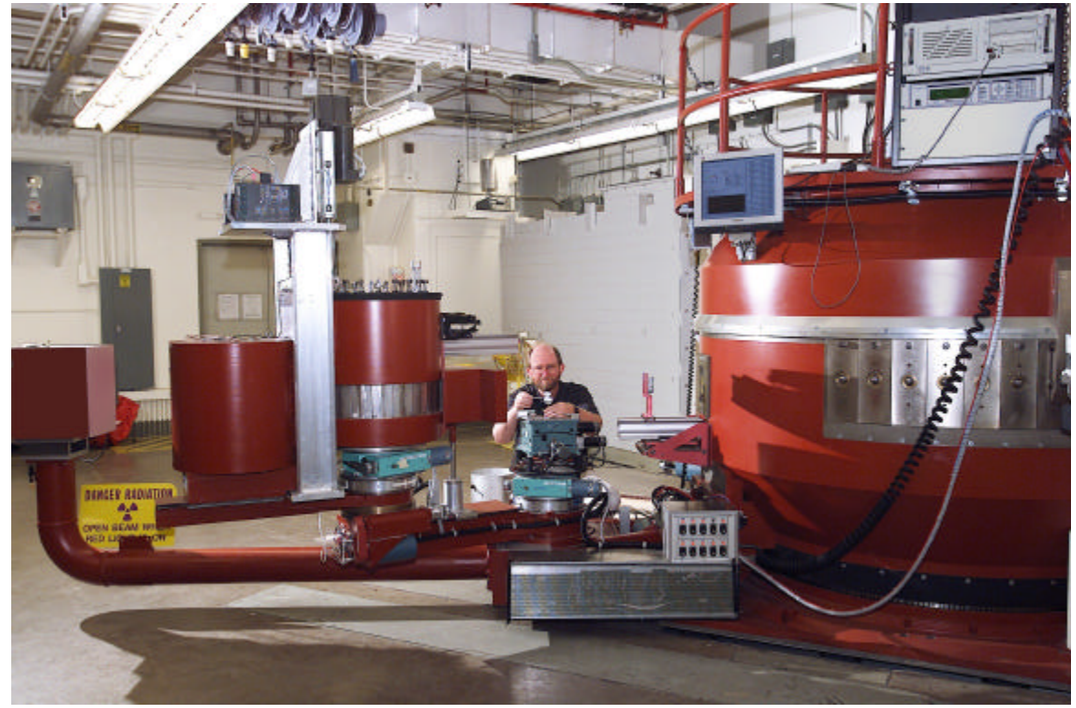
Plan view of HFIR's core showing fuel, control cylinders, and beam tubes.

Aerial of HFIR with new Neutron Science

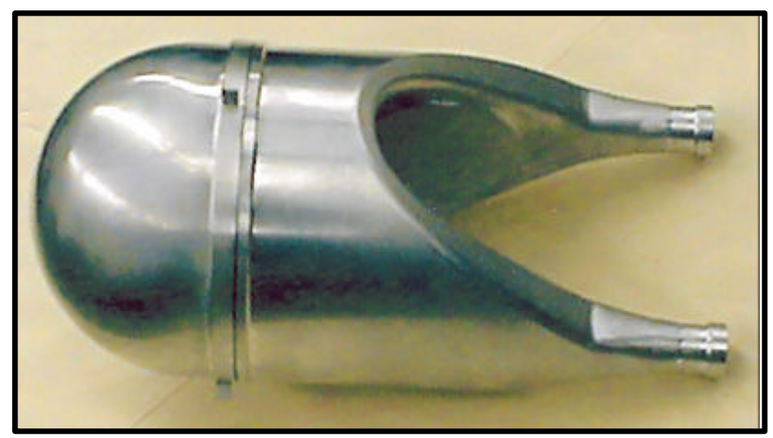
New Instruments

Rebuilt HB1 3-Axis

- New Design
  - Instrument is a device
  - All electronics on board
  - Single Ethernet connection



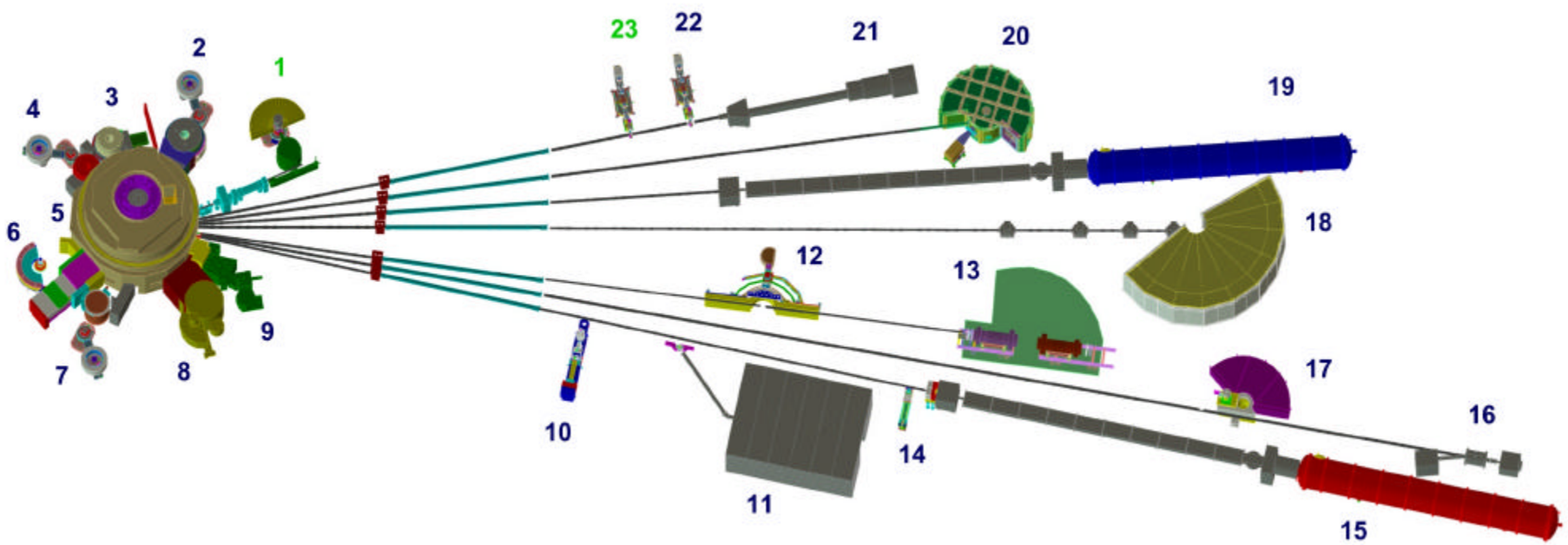
Cold Source Moderator Vessel



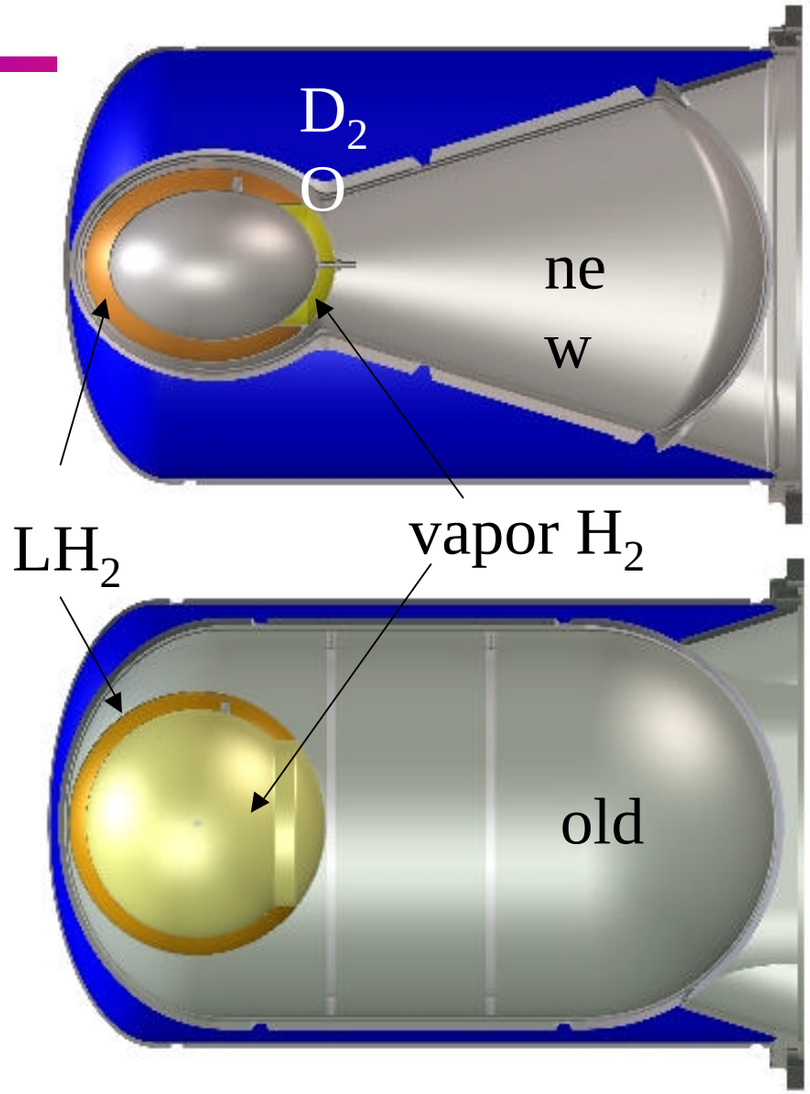
NIST Center for Neutron Research

- Gaithersburg, Maryland
- NIST, Department of Commerce
- Started Operation:1969
- 20 MW Split Core Research Reactor
- Peak Core Neutron Flux – 4 x 10^{14} /cm^2s
- Cold Source, Guide Hall
- 17 Instruments

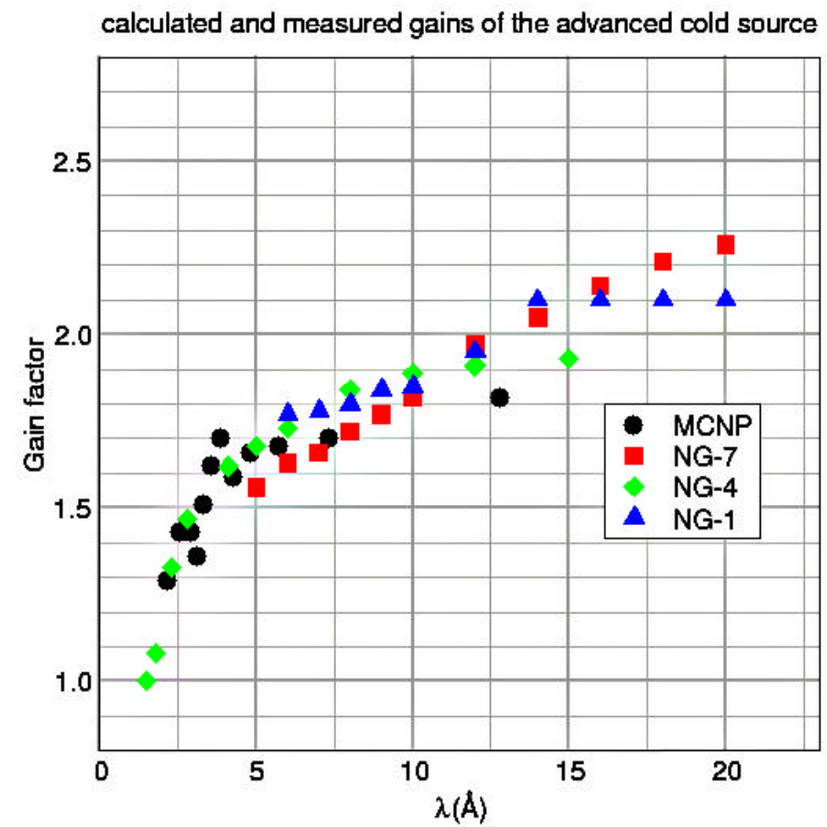
Recent Additions
2000 Disk Chopper TOF Spectrometer
2001 Neutron Spin Echo Spectrometer
Filter Analyzer Spectrometer
Double Perfect Crystal Ultra-high resolution SANS



The NCNR Advanced Cold Neutron Source



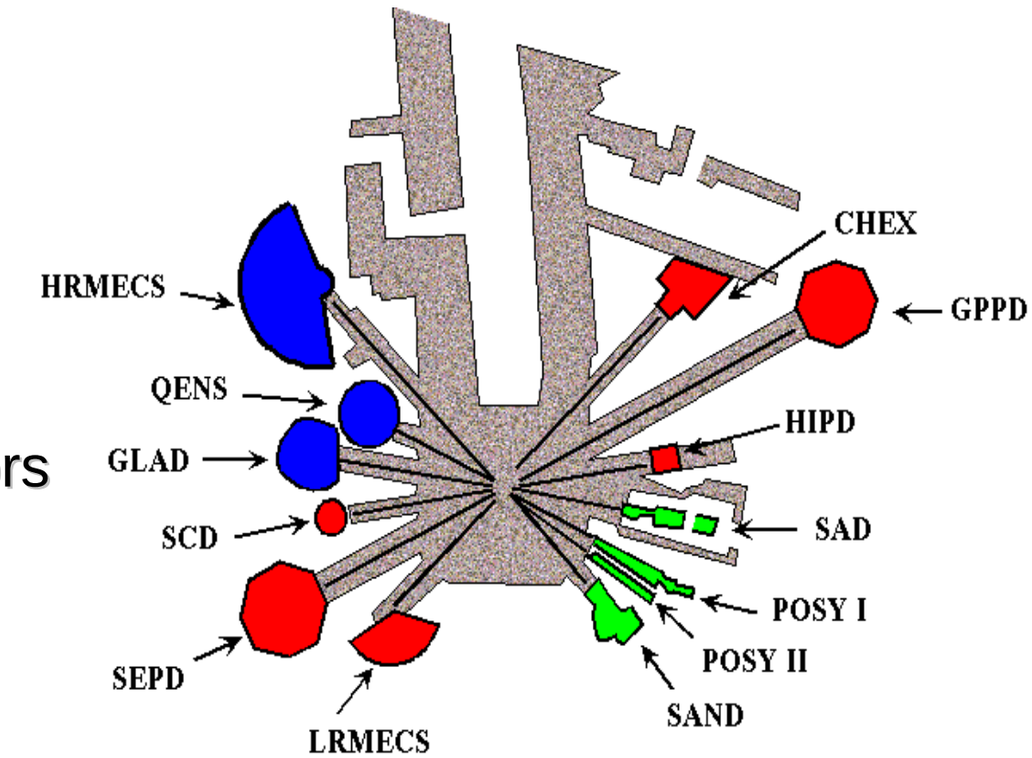
New source: additional D_2O acts as a neutron reflector. LH_2 thicker near source. Inner ellipsoid



Overall gain: 40 % at 2.4 Å to slightly more than 100 % for $\lambda > 15$ Å. Excellent agreement with MCNP.

Intense Pulsed Neutron Source

- Chicago, Illinois
- BES, Department of Energy
- Started Operation:1981
- 7 kW Spallation Source
- Peak Flux – 5 x 10^{14} /cm^2s
- Cold and Thermal Moderators
- 12 Instruments



www.ipns.anl.gov

IPNS – The first user-dedicated accelerator-based neutron source in the world, commissioned in1981. The 7 billionth pulse was delivered to target in December of 2001

Improved Instruments

QENS

Expanded analyzer/detector coverage (installation June 2000)

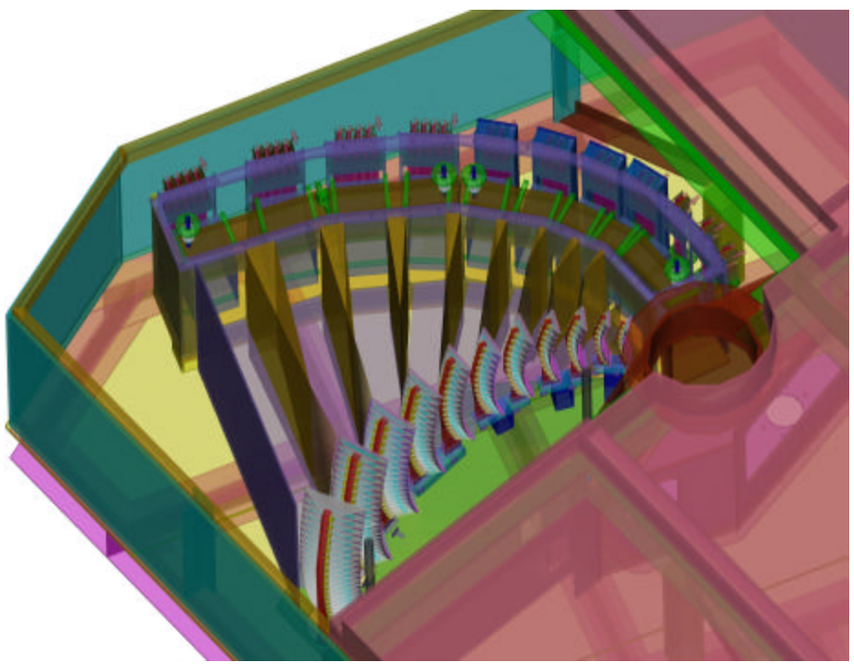
- Improved E resolution (70 μeV elastic, 3-4% inelastic), expanded Q range (x3)
- Higher data rate (x5)

LN_2 Be filter cooling (completed late 2000)

- Additional factor of x2 data rate (total gain x10)

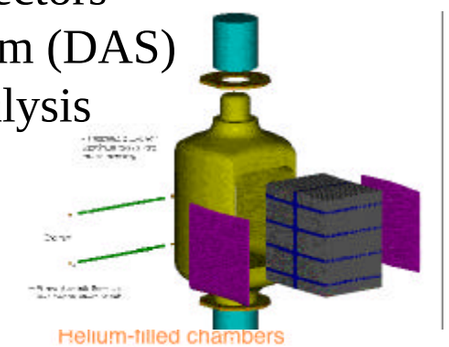
Future prospects

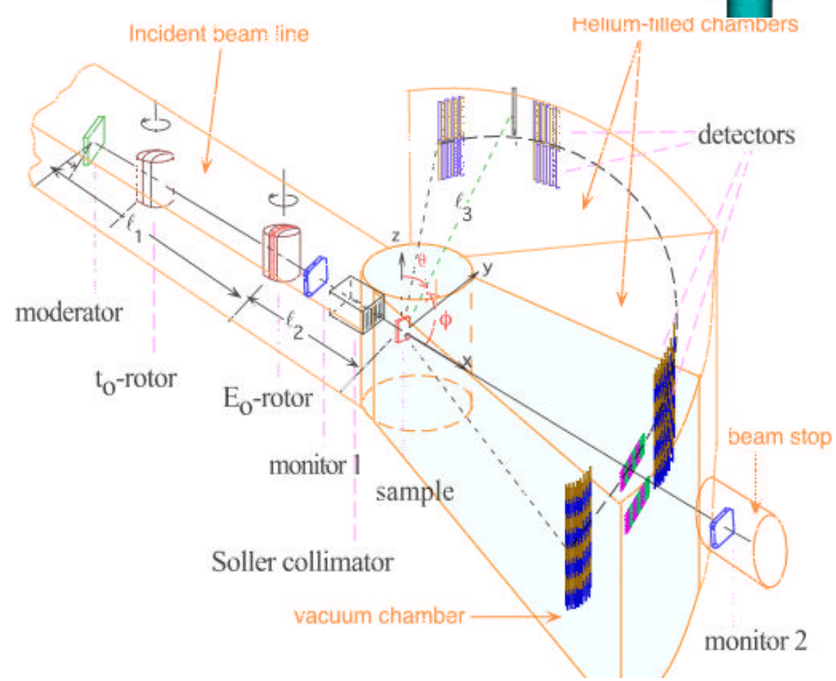
- Neutron guide and focussing optics (additional x3)



HRMECS

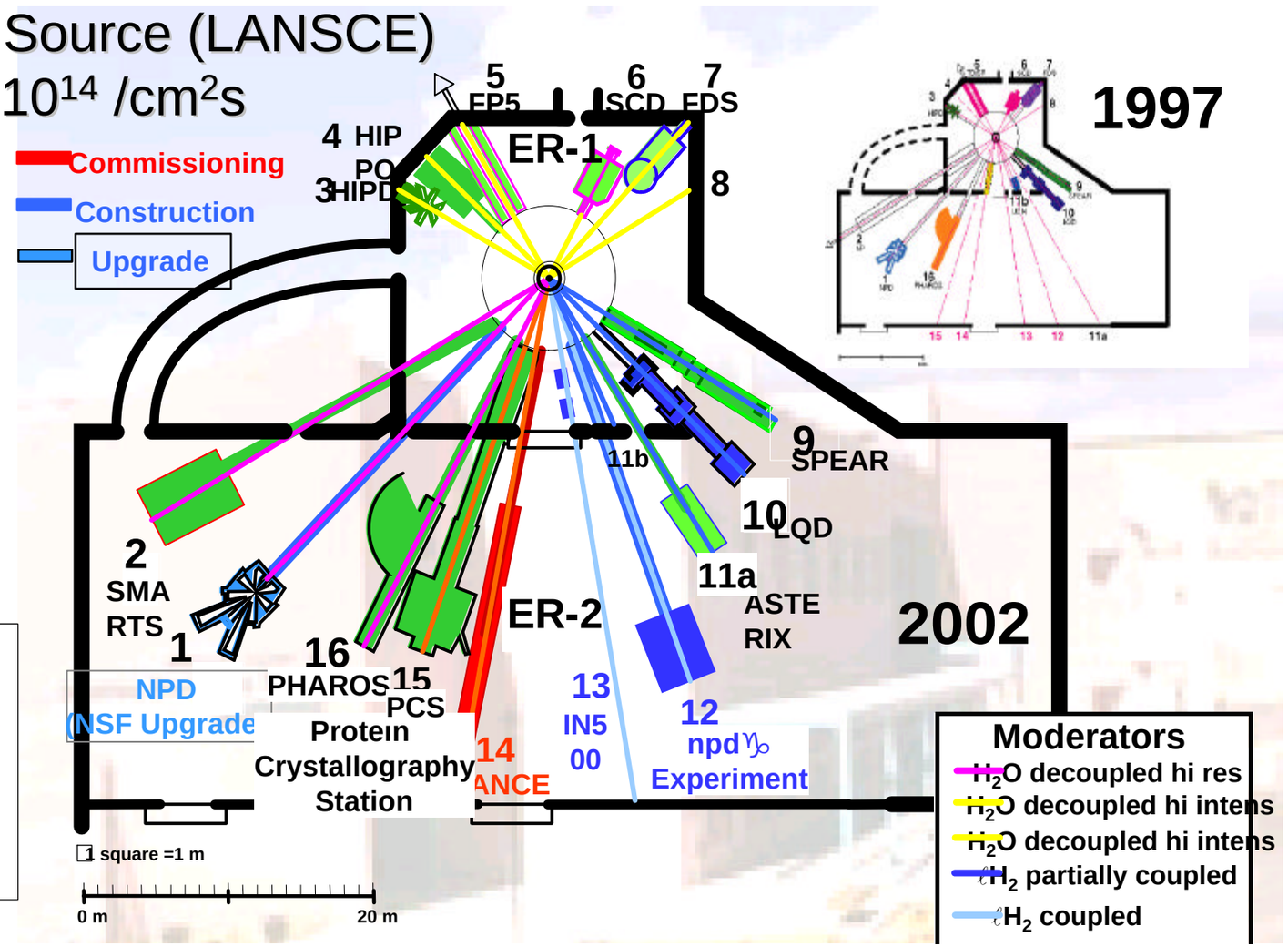
- New linear position-sensitive detectors at low angles (<20°) to increase Q resolution
- New electronics for all detectors
- New data acquisition system (DAS)
- New data visualization/analysis software, ISAW
- New fast choppers

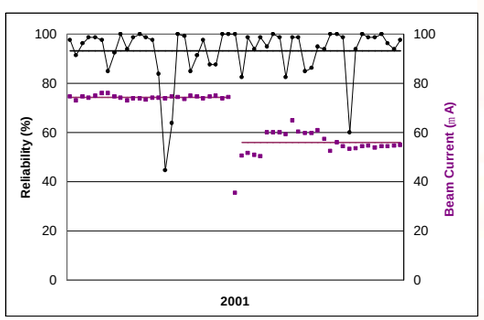




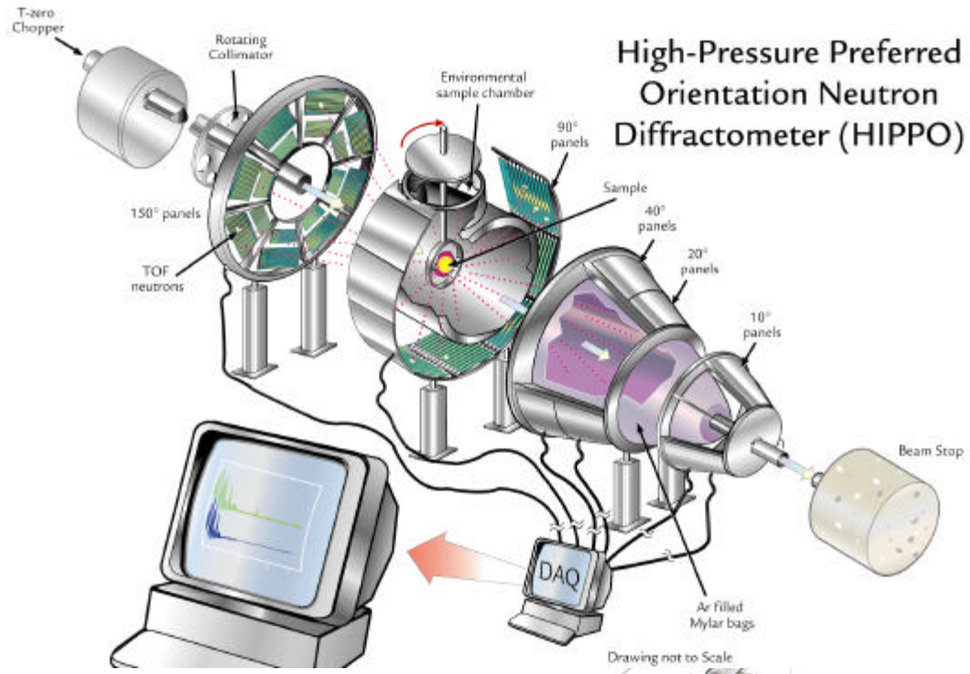
Lujan Center

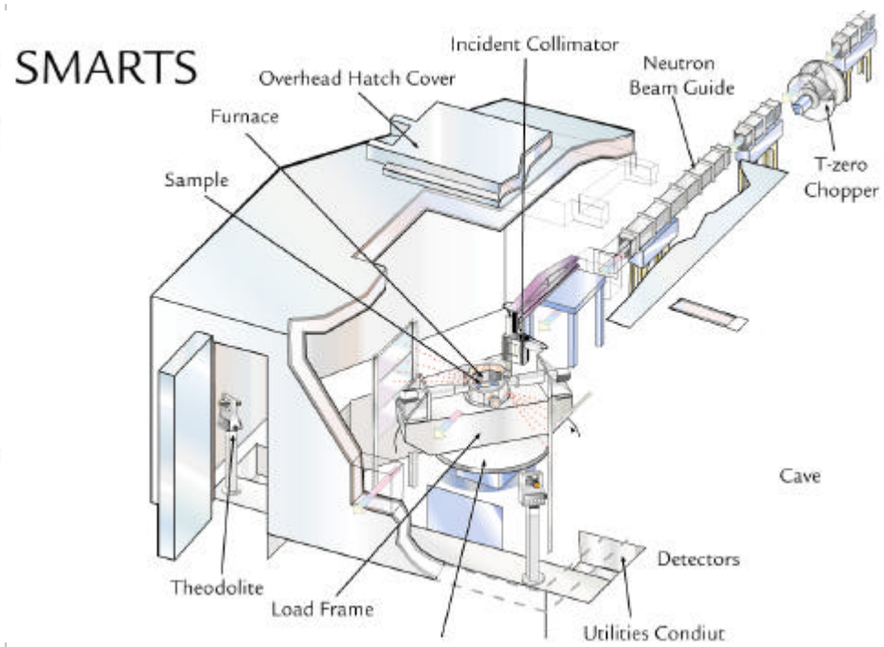
- Los Alamos, New Mexico
- BES/NNSA, Department of Energy
- Started Operation:1985
- 85 kW Spallation Source (LANSCE)
- Peak Flux – 30 x 10^{14} /cm^2s
- Cold Source
- 7 Instruments

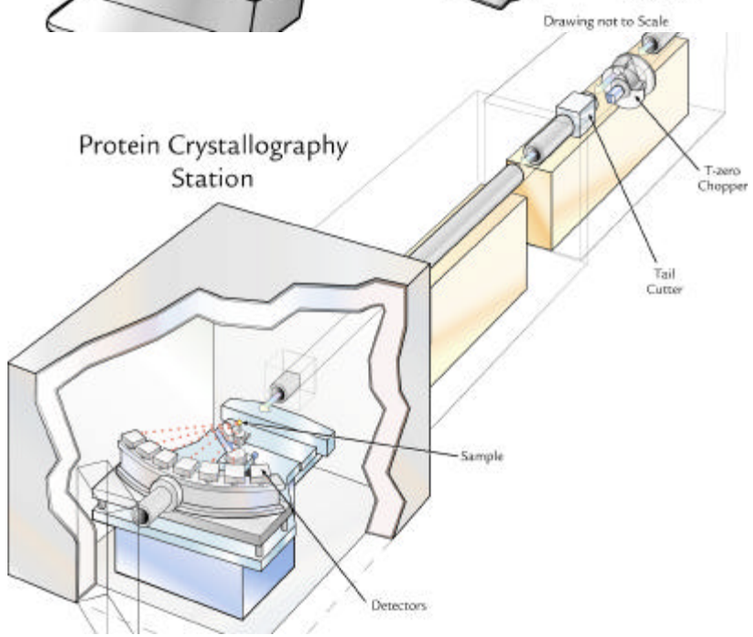


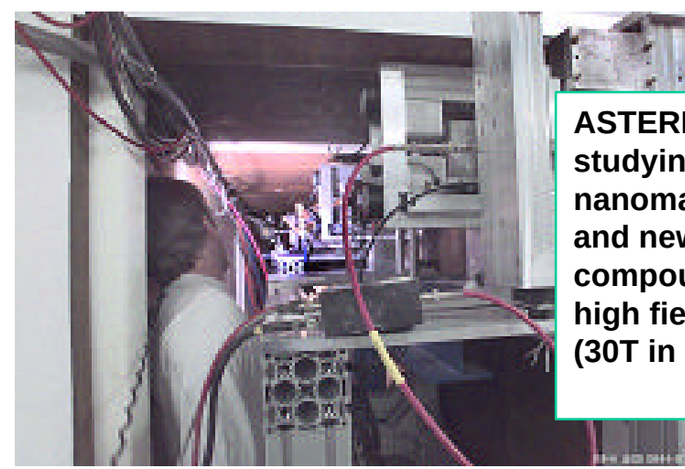


New LANSCE Instruments









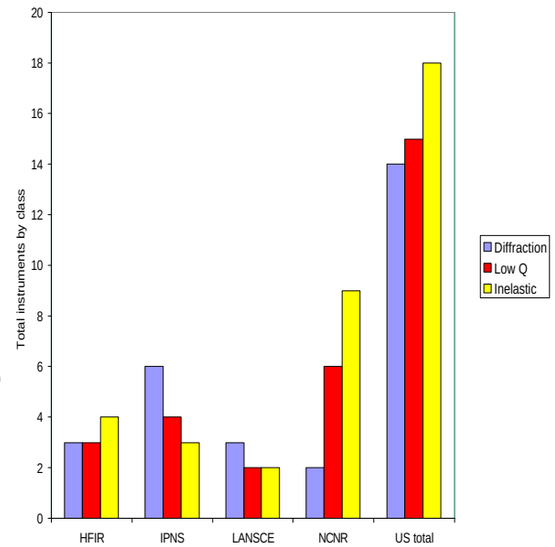
ASTERIX is for studying nanomagnetism and new magnetic compounds at high fields to 11T (30T in future)

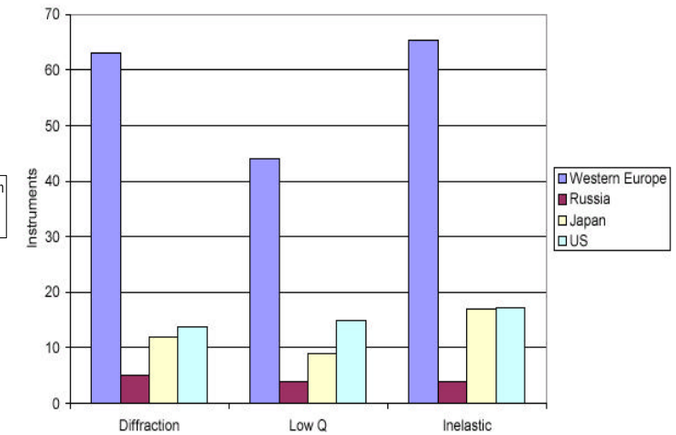
Reports

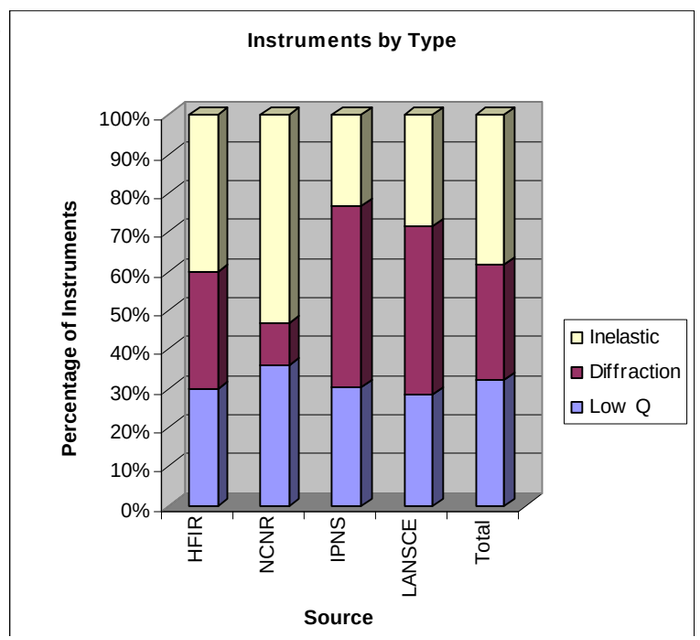
- *Neutron Source Upgrades and Specifications for SNS* (1996)
  - Research Reactor Upgrades, Robert Birgeneau, Chair
  - Spallation Neutron Source Upgrades, Gabriel Aeppli, Chair
  - Technical Specifications for the Next Generation Spallation Source, Thomas Russell, Chair
- *Review of the High Flux Isotope Reactor Upgrade and User Program* (October, 1998; Jack Crow, Chair)
- *Neutron Scattering* (February, 2000; Martin Blume, Chair)
- *Review of IPNS/LANSCE* (March, 2001; Ward Plummer, Chair)
- *Report on the Status and Needs of Major Neutron Scattering Facilities and Instruments in the United States* (June 2002; Patrick Gallagher, Chair)

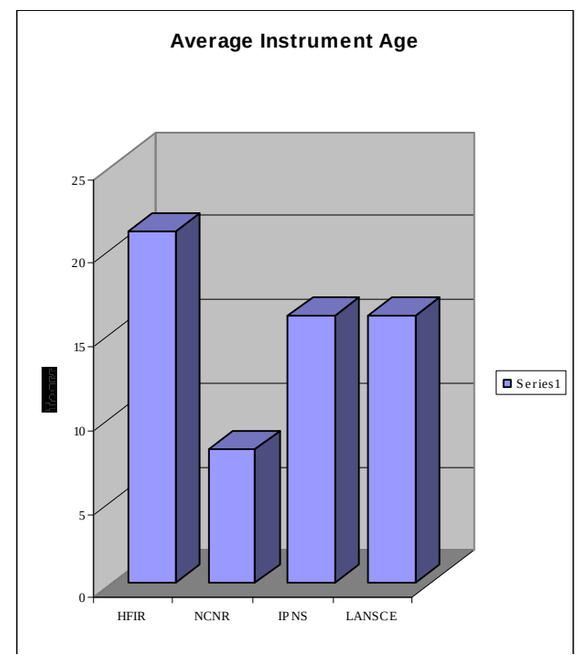
The National Instrument Suite

- Neutron Diffraction
  - Single Crystal
  - Powder
  - Liquid/Amorphous
  - Diffuse
  - Residual Stress/Texture
- Low-Q Diffraction
  - Small Angle Scattering
  - Reflectometry
- Inelastic Scattering
  - Triple Axis
  - Time-of-Flight
  - Backscattering
  - Spin-Echo

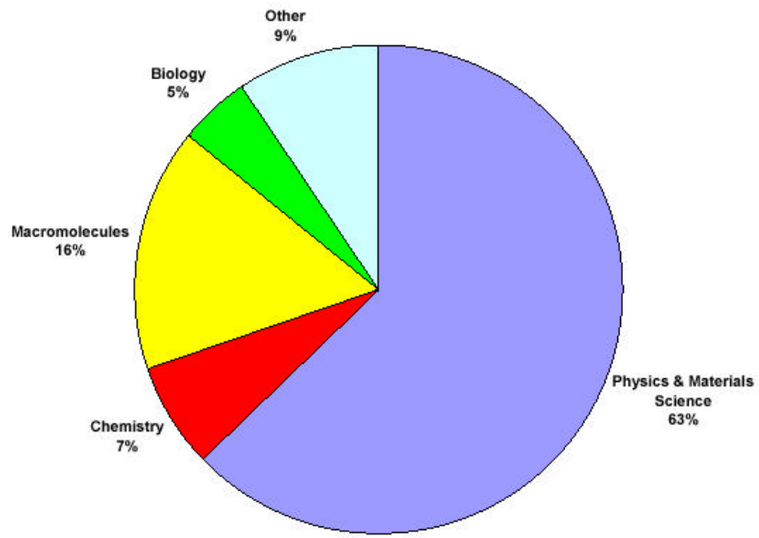


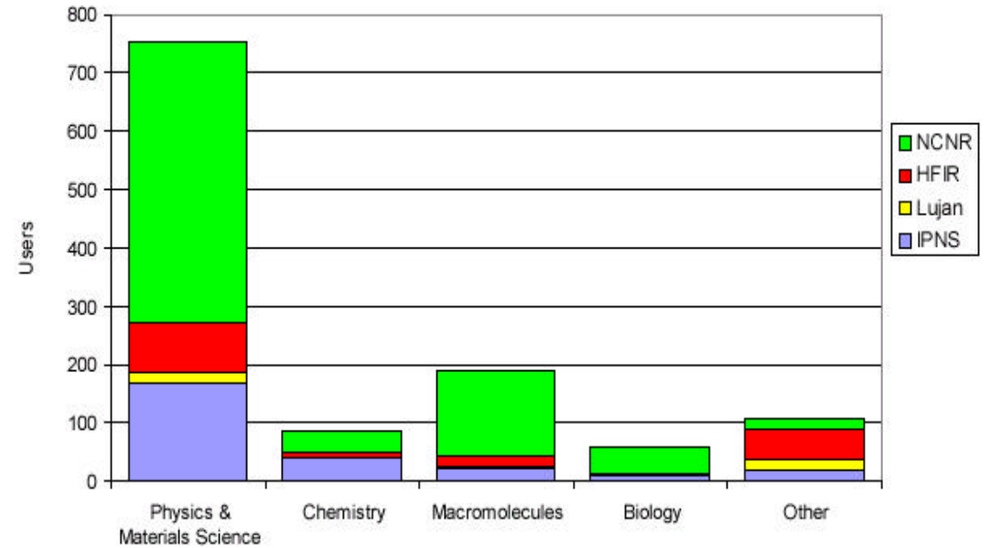


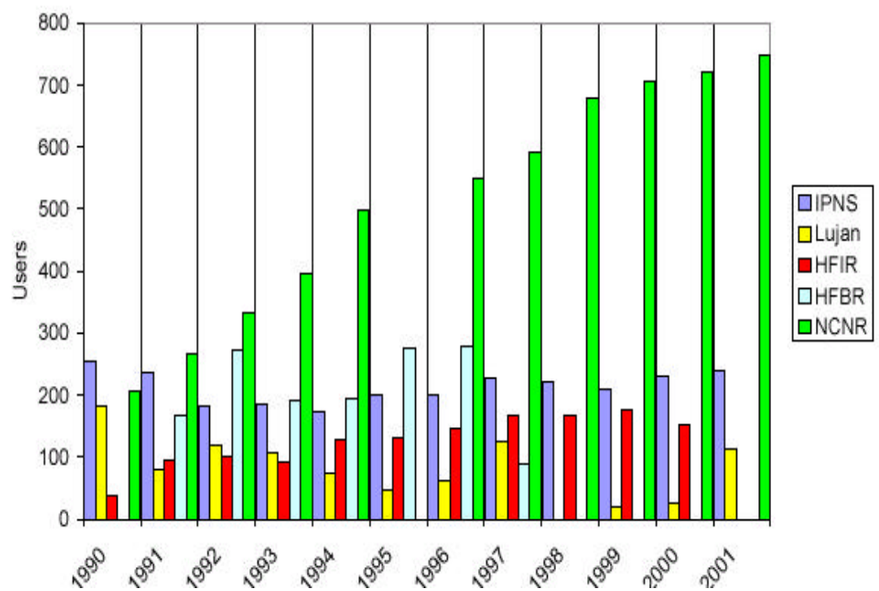


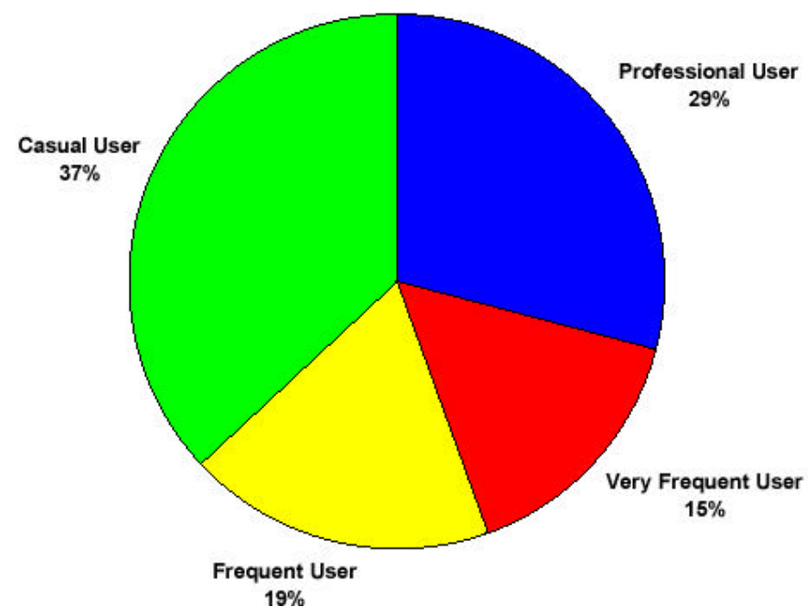


The Community







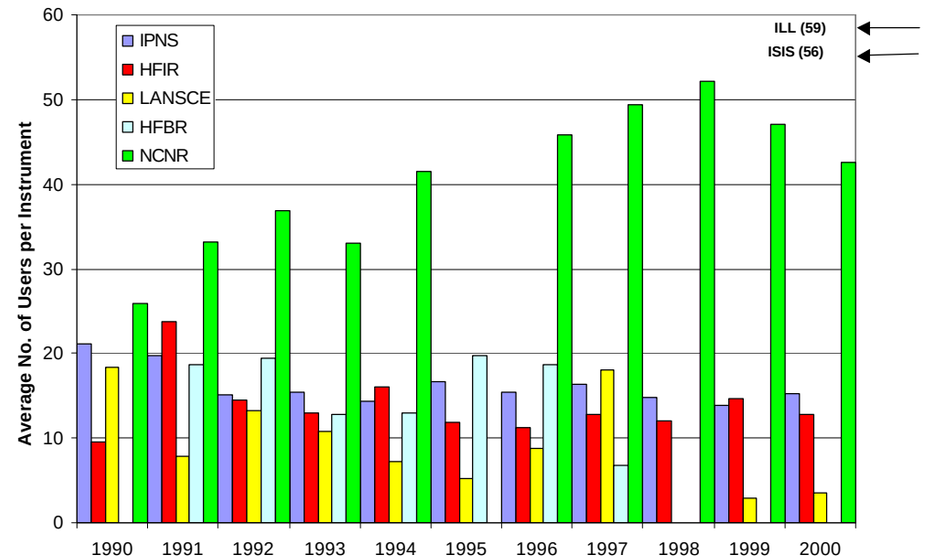


Community Development

- Neutron Schools
  - IPNS
    - Hands on Experience for 60 students/year
    - Neutron and X-ray scattering (joint with APS)
    - Since 2000
    - Funded by DOE
      - no charge to students or institutions
  - NIST
    - Hands on Experience for ~35 students/yr
    - Neutron scattering only (Inelastic/Low Q)
    - Since 1995
    - Funded by NSF and NIST
      - no charge to students or institutions
- Undergraduate Fellowships
- Graduate Fellowships

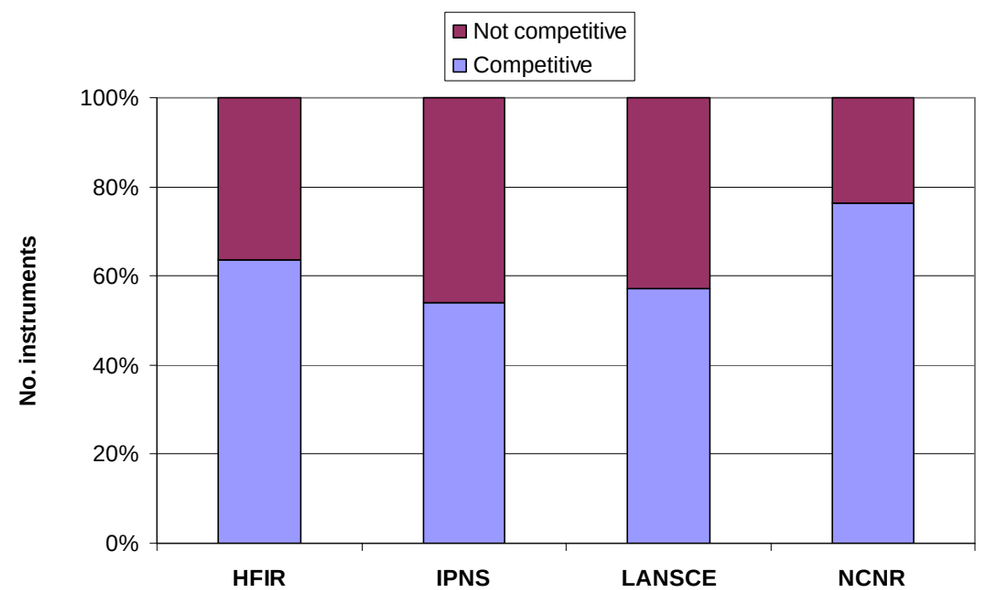
How Competitive are we?

Not all instruments are nationally and internationally competitive



Instrument competitiveness can be judged based on usage

Average ~65%

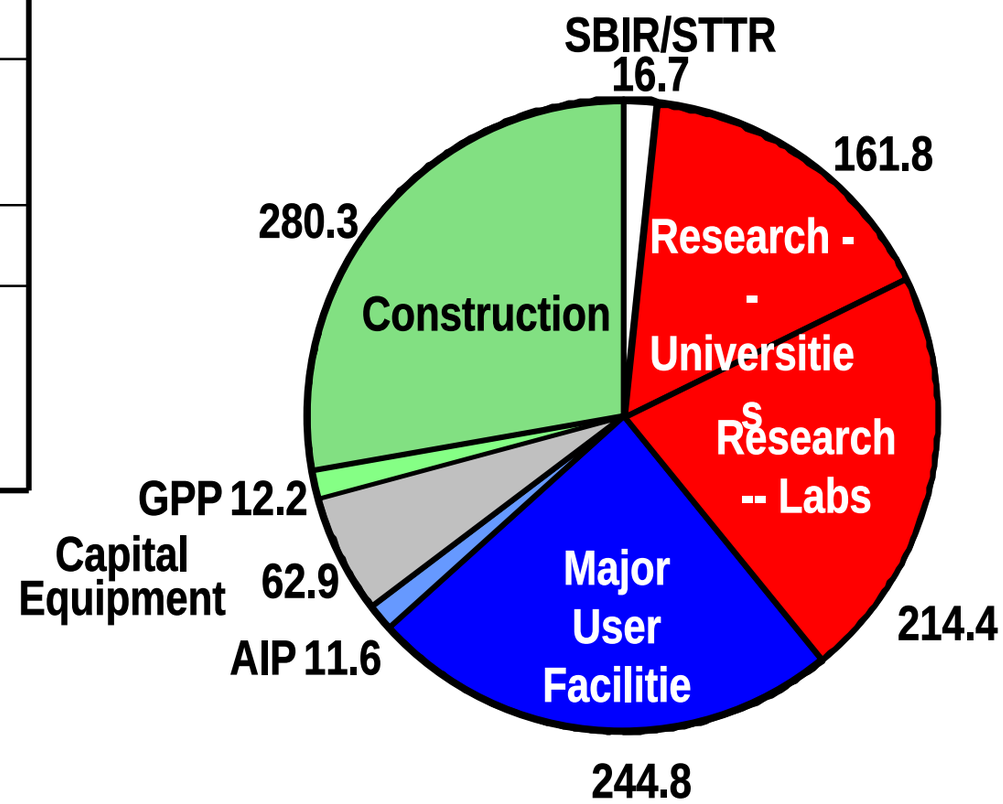


Funding

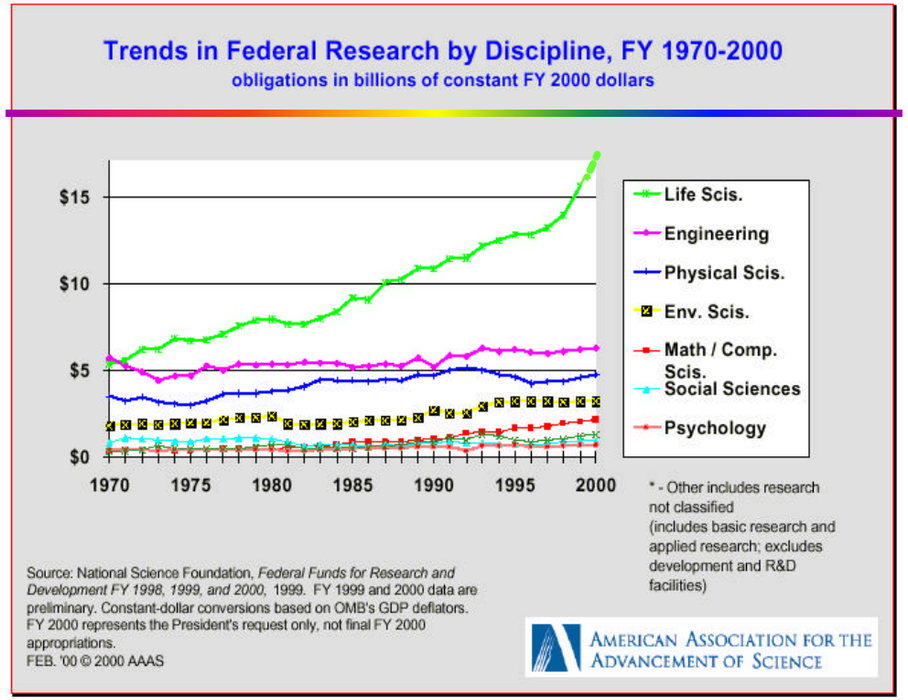
Facility Operation

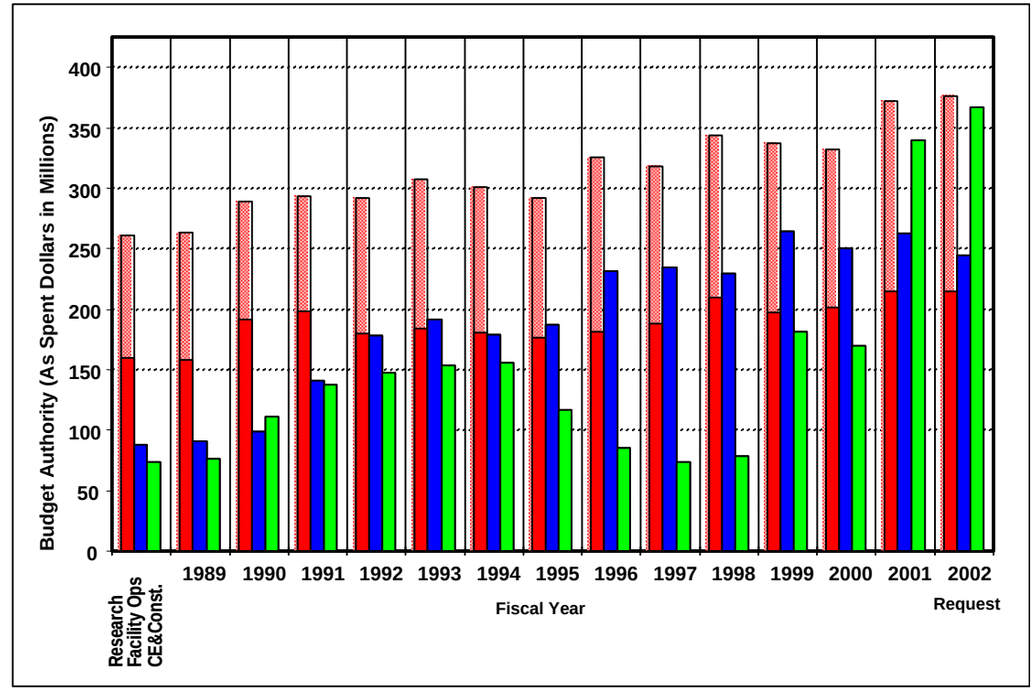
HFIR	$38 M	DOE (BES)
NIST	$15 M $3.2 M	DOC NSF
IPNS	$13 M	DOE (BES)
Lujan (LANSCE)	$9 M ($45 M)	DOE (BES) DOE (NNSA)

- Note: Funding is difficult to compare
  - Depends on Agency
  - Depends on Usage of Facility



$ 1,004.7 M
FY 2002 President's Request





User Experiments

- Travel
  - Airfare $500
  - Lodging $300
  - Meals $400
- Total $1200

Current – 1000 Users/yr

User Experiments - $1.2 M

SNS – 2000 Users/yr

User Experiments - $2.4 M

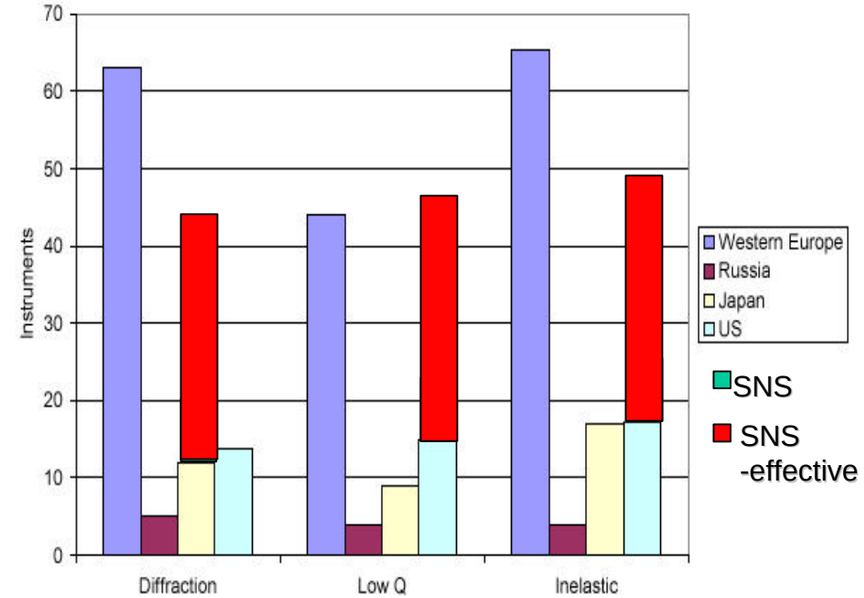
The Future

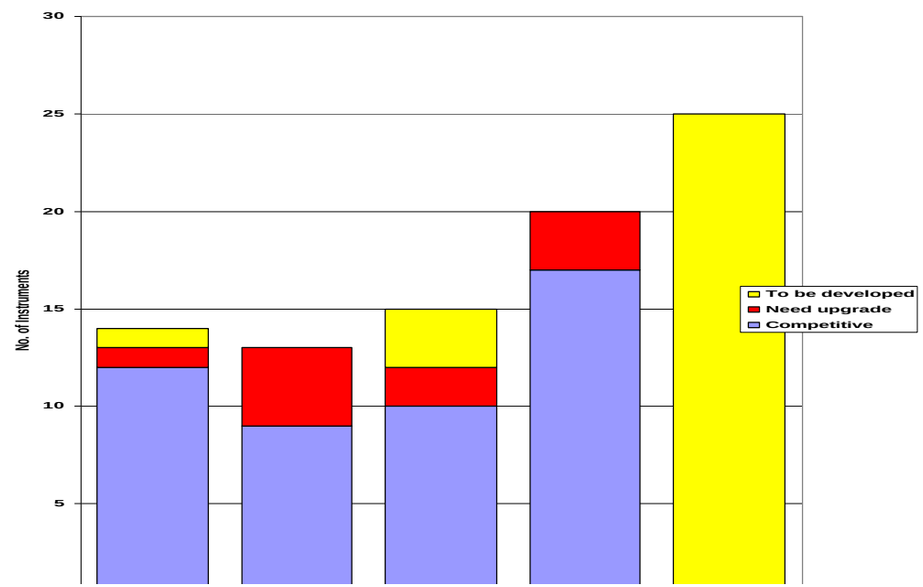
The Spallation Neutron Source

~8X ISIS

SNS can't do it all!

Exiting facilities, and instruments, must be fully utilized

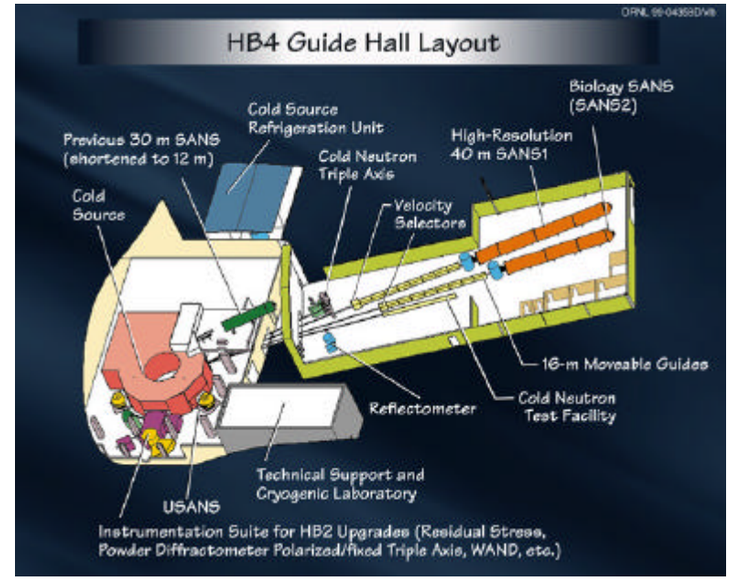




Instrument Upgrades

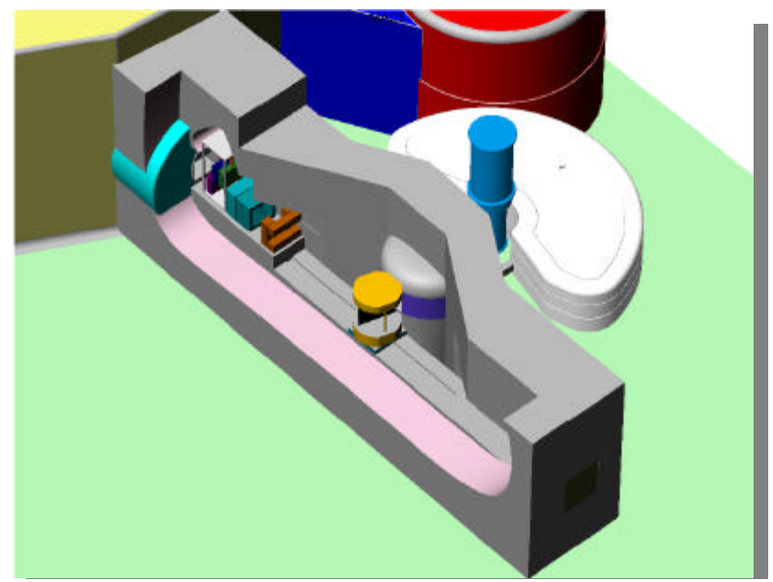
HFIR

- New
  - 40 m SANS
  - 35 m biology SANS
  - Cold Neutron Triple Axis
- Upgrades
  - Reflectometer
  - Double crystal spectrometer
  - Polarized triple axis
  - High intensity diffractometer
  - High resolution powder diffractometer
  - Residual stress diffractometer
  - Triple axis spectrometer
  - 4 circle single crystal diffractometer



NCNR

- New
  - Cold Neutron Triple Axis
  - Biology Reflectometer
  - 9 m SANS
- Upgrades
  - Triple Axis (2)
  - 30 m SANS
  - Spin polarized triple axis
  - 30 m SANS



Instrument Upgrades

IPNS

- New
- Upgrades
  - Target 14-28% flux increase
  - Accelerator – 30% current increase
  - Instruments
    - Date rate 2x-10x
    - SANS and reflectometer
    - 2.5x from moderator

- **Guide, choppers, longer flight path (resolution), allowing flexibility of operation**
- **5x for high resolution studies**
- **18x for parametric studies**
- **Improved resolution (Dd/d=.2%)**

Lujan

- New
  - IN500
  - SABER
  - Mark II Target
- Upgrades
  - Pharos
  - LQD
  - SPEAR
  - NPDF
  - Data Acquisition System
  - Sample Environment

Conclusions

▪***Report on the Status and Needs of Major Neutron Scattering Facilities and Instruments in the United States*** (June 2002; Patrick Gallagher, Chair)

The highest priority for federal investments in neutron scattering is to fully exploit the best US neutron source capabilities

- Fully develop 85% of the beam lines available
- Maximize the amount of beam time available to the broad scientific community
- Provide additional support for research using neutron scattering techniques

I would like to thank the following for providing information and helpful comments:
Ronald Cappelletti , Charlie Glinka, Pat Gallagher, Alan Hurd, Dan Neuman, Jim Rhyne, Lee Robertson and Ray Teller