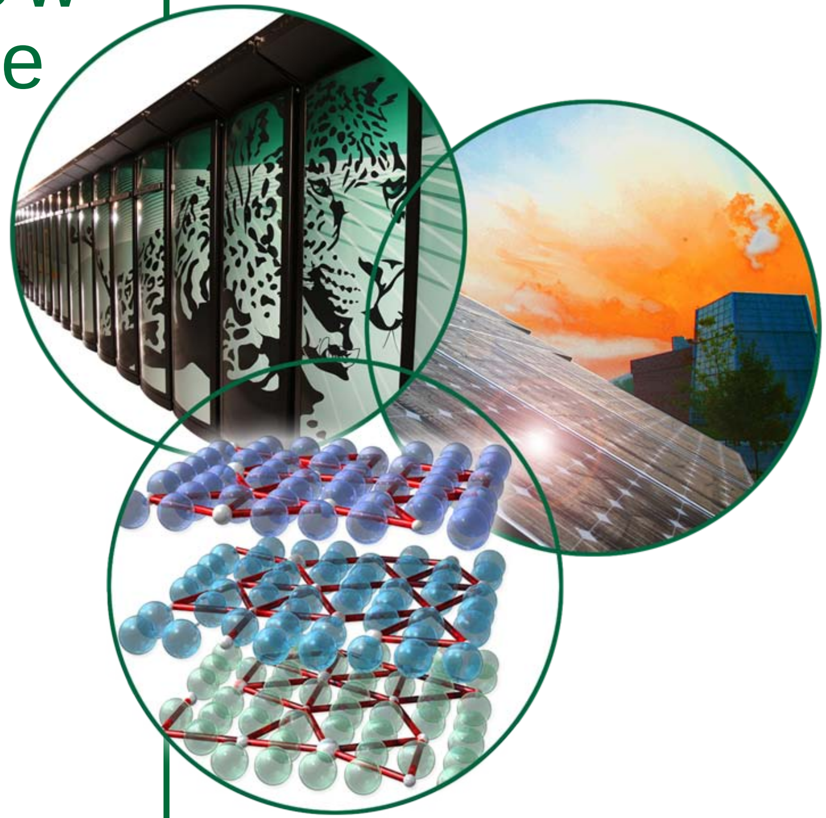
SNS Neutron Source Development at the Low Energy Neutron Source



Presented at:

The Second Meeting of the Union of Compact Accelerator-Driven Neutron Sources (UCANS-II)

Phil Ferguson

July 6, 2011

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Why is SNS source development important?

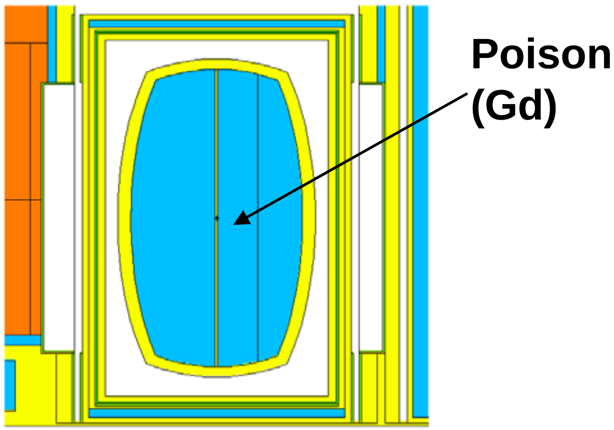
- SNS moderator poisons determine the lifetime of the inner reflector plug (IRP)
  - Time, money, and personnel dose could all be saved if this issue is addressed
- Substantial improvements in moderator performance are possible
  - 10% to a factor of 4 or more
- Success of the Second Target Station (STS) requires strong neutronic performance
  - Without excellent moderator performance, the STS is just a lower power neutron source

Source development at Lens

- Efficiently using the neutrons produced is much more cost effective than increasing neutron production
  - Increasing SNS beam power by 30% costs ~$100M
- Experimental program must:
  - Calibrate theory
  - Identify issues with implementation
- Examples
  - Past
    - Poison plate study
  - Present
    - Advanced moderator development
  - Future

Alternative moderator poison

Where is the poison and what does it do….



Top upstream hydrogen moderator

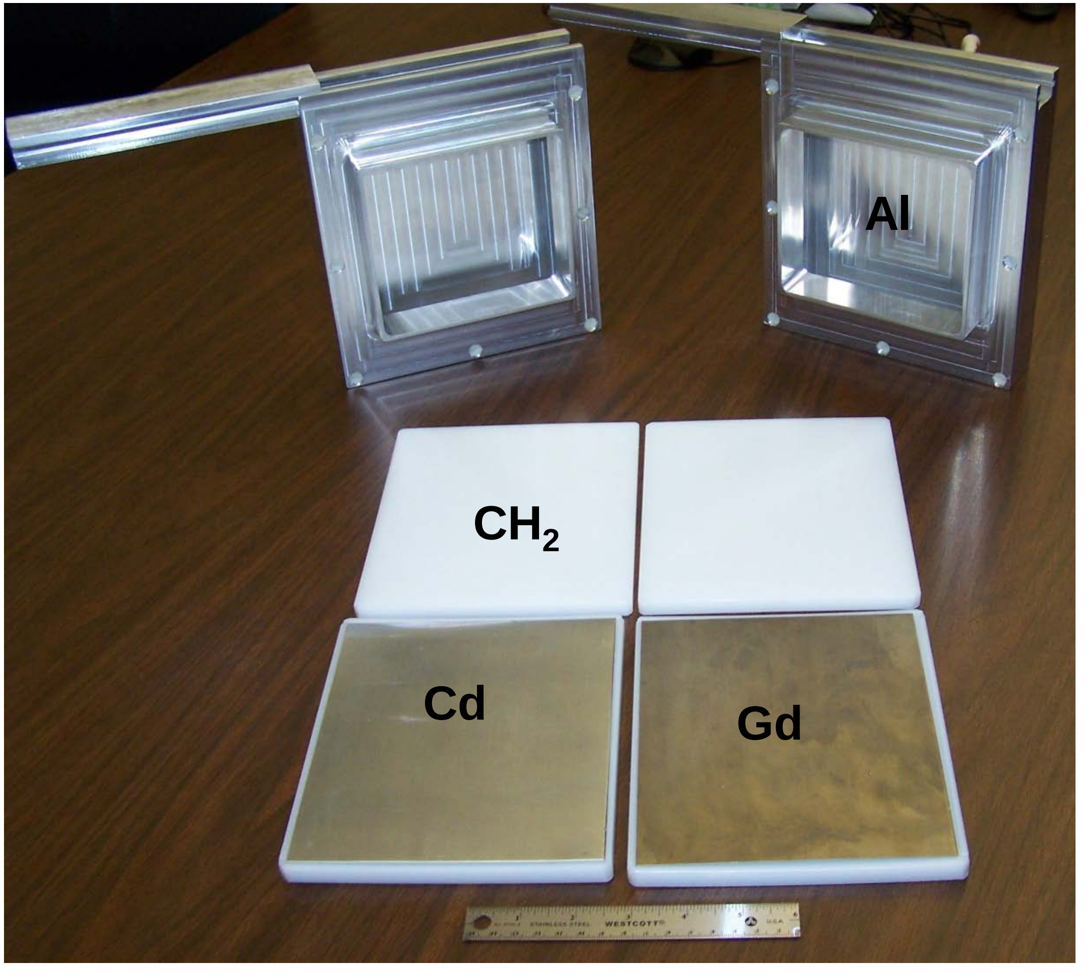
- **The moderator poison defines the active moderator volume and the time response of the moderator**
- **Typical poisons are made of Gd and are ~50 µm thick**
- **The two neutronically significant nuclides in Gd are Gd-155 (14.8%) and Gd-157 (15.65%)**

At SNS, the two upstream moderators, serving 2/3 of the beamlines, are poisoned.

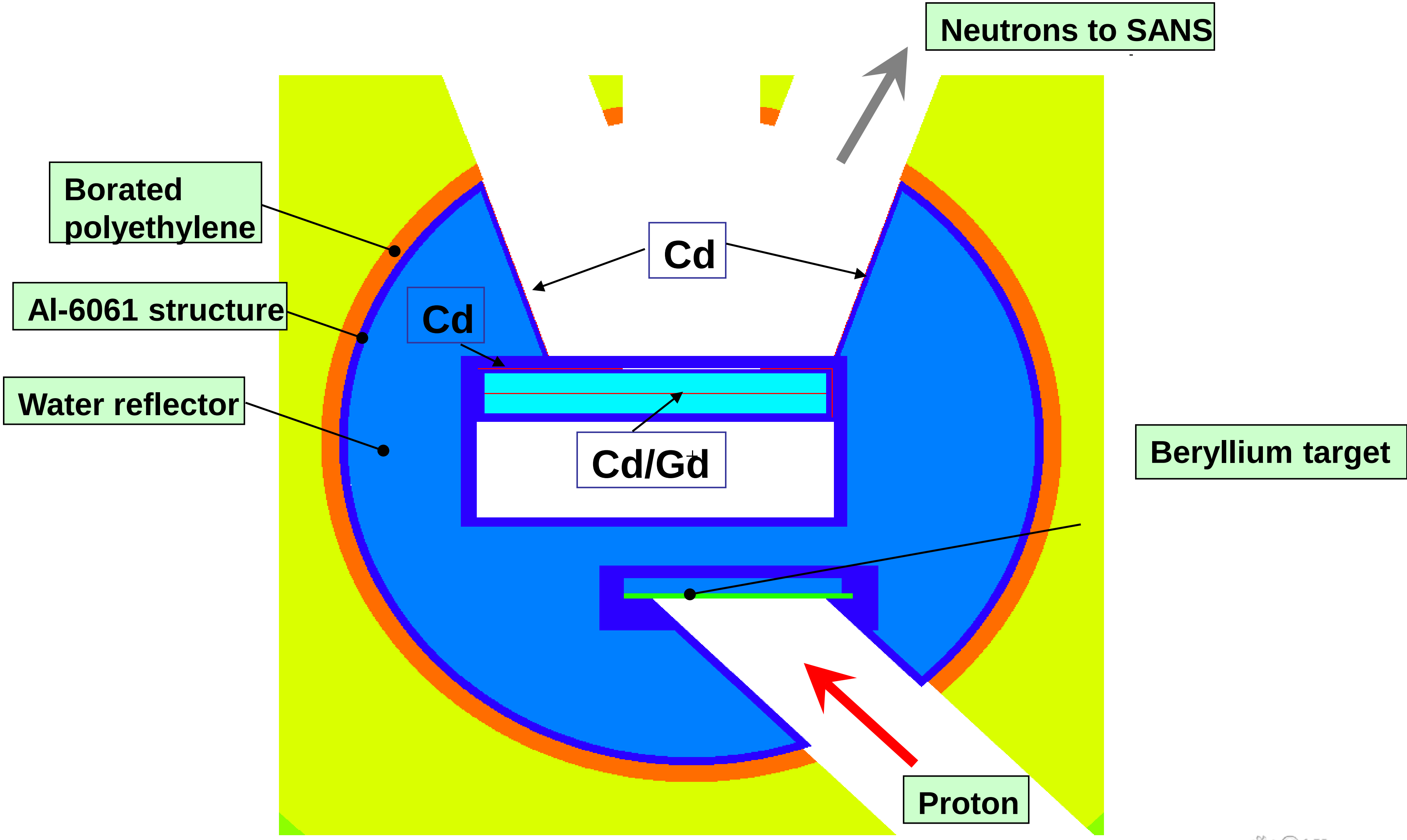
Poison plate material change

- Current moderator poison plate
  - Thick Gd sheets
    - 0.8 mm for the decoupled hydrogen moderator, 20 K
    - 1.0 mm for the decoupled water moderator, 273 K
  - Lifetime of 3 SNS yr at 2 MW (6 MW-years)
  - ~20% loss of moderator performance
- Can increase lifetime and performance
  - Change to Cd poison plate
  - Lifetime increases to 8 MW-years
  - Performance improves slightly (few percent)
- *Can not risk a ~$5M change without testing*
  - Perform comparison at LENS (Indiana University)

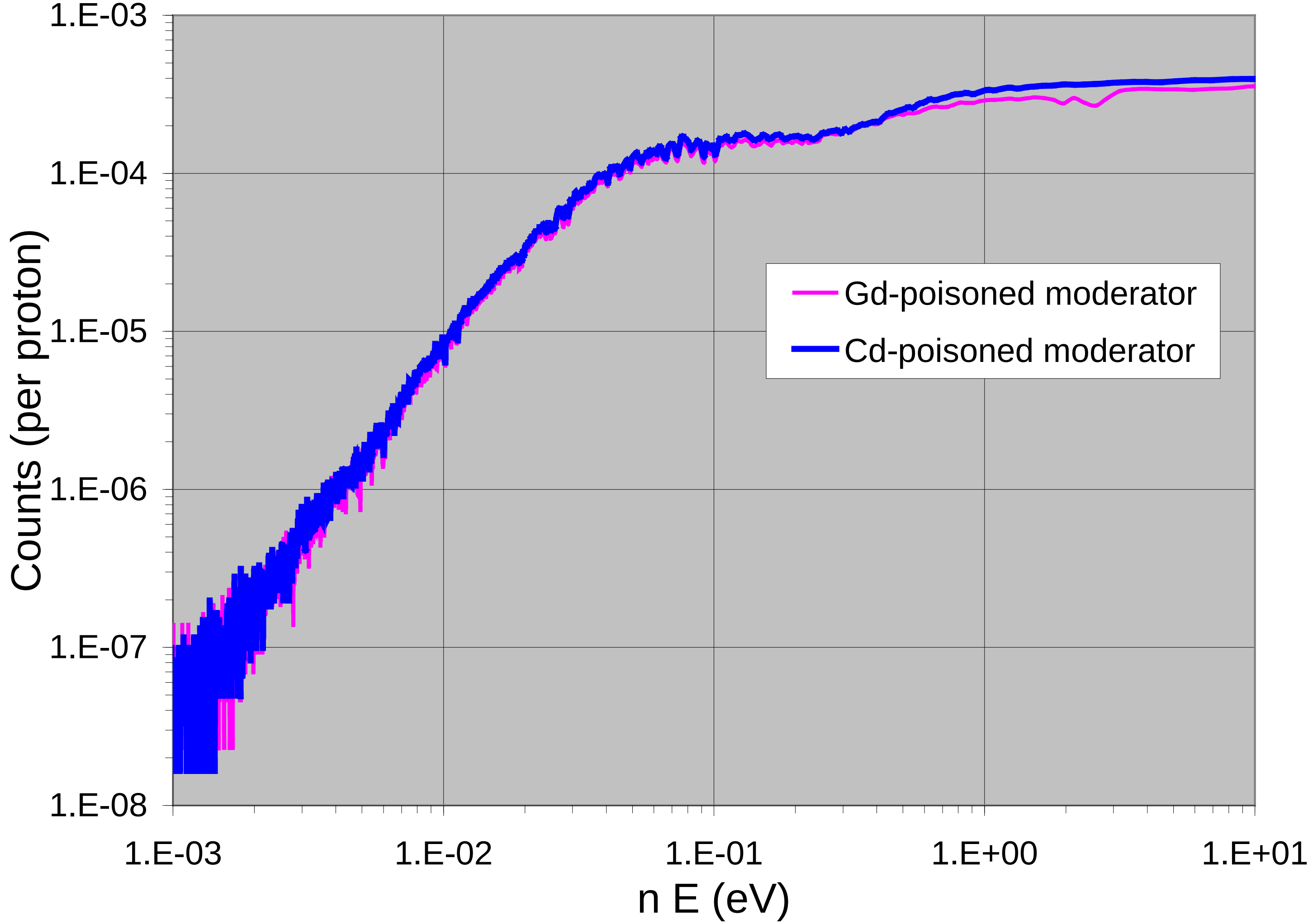
Test moderators before assembly



Experiment set-up

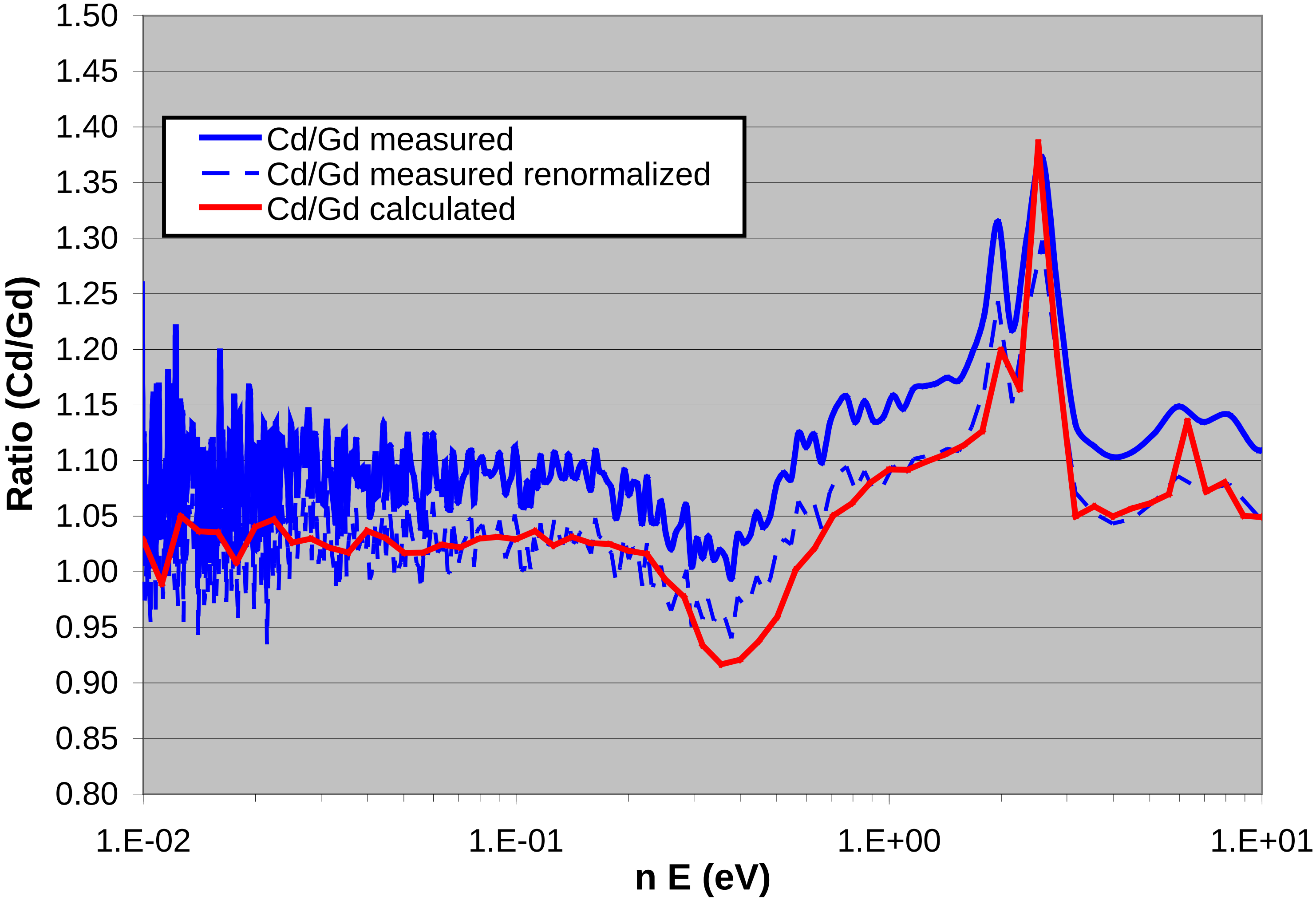


Measured spectra



Measured spectra of Gd- and Cd- poisoned moderator

Ratio of spectra



Brightness of Cd poisoned moderator is ~7% higher than Gd poisoned moderator

Advanced moderators

Why do we need advanced moderators?

SNS target system neutron balance

Systems	Production (n/p)	Capture (n/p)	Leakage (n/p)
Target Module	21.7	5.1	---**
Moderator System	0.1	2	1.3
Inner Reflector Plug	2.4	8.8	---
Outer Reflector Plug	1	5.9	1.7*
Proton Beam Window Assembly	0.4	0.4	0.4
Total	25.6	22.2	3.4

~5%, or 1% per viewed surface

If guides start at 2 m, another factor of 2.5E-05

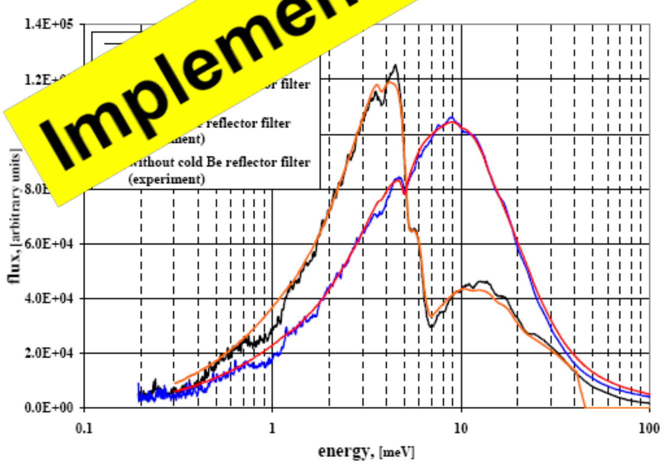
Directional moderators

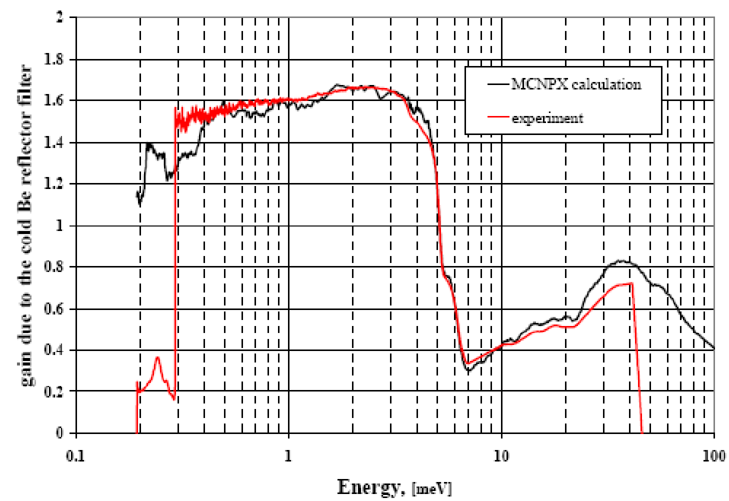
- More neutrons in the direction of the beamline (or guide)
- Active program with Lens
- ILL effort on diamond nanoparticles may be combined with crystals
  - Working on collaboration to perform joint experiment at Lens

Beryllium reflector/filter

Implemented at Lujan with great success

- A small piece of cold (~77 K) high purity beryllium is adde in the line of sight of the coupled hydrogen moderators
  - For λ >4 Å, a gain of ~50% in intensity is seen, wh in intensity occurs for λ <4 Å
  - The filter can be tailored to allow more with λ <4 Å through for one instrument
- Collaborations with LAN ENS
- High purity ber need to be purchased and machined (~$40K)



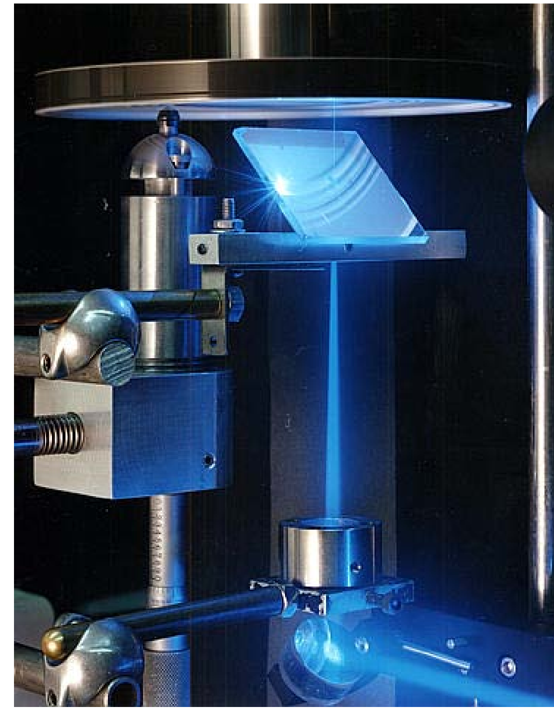


Substitute for beryllium reflector

- *Beryllium is expensive and isn't getting cheaper*
  - Metal hydrides (titanium, zirconium, etc.) may be a suitable replacement for some/all for the beryllium in the IRP
  - Desire to reduce the cost of the IRP without sacrificing performance
  - Currently we can not estimate the performance of metal hydrides because we lack suitable scattering kernels
  - If a suitable material is found, an experiment will need to be conducted to verify the calculations
    - Can we perform various reflector studies at LENS?

Understanding ortho/para hydrogen under irradiation

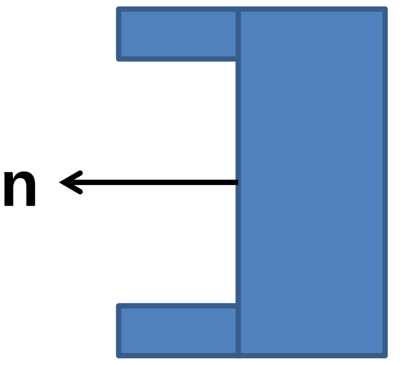
- Moderator performance depends on ortho/para hydrogen concentration
- Currently SNS avoids this issue, using less than optimal coupled moderators
  - Unacceptable going forward
- Need a system to measure hydrogen spin state
  - Do pulse to pulse variations matter at high power?
- Must demonstrate performance/reliability (at Lens?)



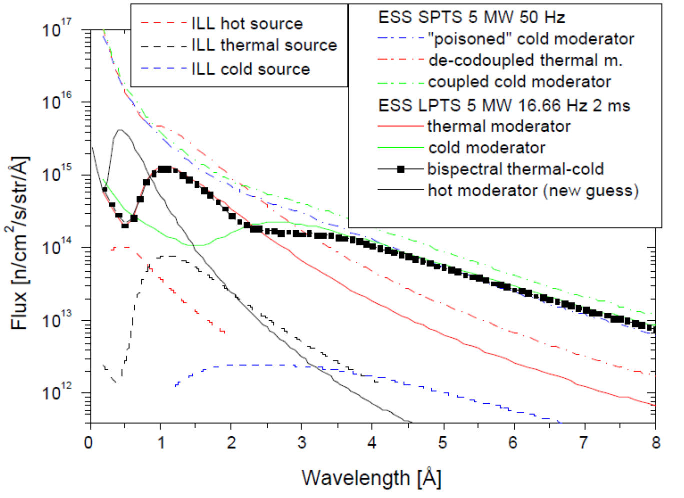
COTS Raman spectroscopy system

Enhanced beam extraction

- Can we more efficiently fill the guide?
  - Re-entrant moderators
  - Guides (bi-spectral moderators)
- Requires more detailed modeling (angular dependent) of moderator source term
  - More closely coupled MCNPX/McStas efforts



(Watanabe/Kiyanagi)



(Mezei)

Summary

- Neutron source development is a vital part of the future of SNS
  - Not only the first target station, but the second target station as well
- Efforts so far will impact the design of the next IRP
  - Poison plate material change alone reduces cost, improves availability
- Goal is to improve source performance by a factor of 10 over the next 10-20 years

Vision without action is merely a dream.
Action without vision just passes the time.
Vision with action can change the world!

~Joel Arthur Barker

ICANS – XX
hosted by Centro Atómico Bariloche, CNEA, Argentina

The International Collaboration on Advanced Neutron Sources (ICANS) was founded in 1977 by a group of scientists, as a forum to promote discussions and collaborative work, and to share information on three main topics: Accelerators, Targets and Moderators, and Instruments.

Throughout nearly 35 years, nineteen (or 19-1/2 according to Capt. Jack Carpenter!) ICANS meetings were hosted worldwide by many of the laboratories that compose this informal collaboration network. Its 20th meeting, ICANS-XX, will be held for the first time in the Southern Hemisphere, during March 11 -16, 2012 in Bariloche, Argentina. We are very proud and excited for such a distinction, and eagerly hope that you will be joining us.

We will make our best effort to continue the ICANS tradition of promoting the cooperation and synergism among the participating laboratories, within an atmosphere that will combine good neutron science and a beautiful natural environment.

Following the trend started in the last meeting in Grindelwald, Switzerland, besides the traditional emphasis on large scale facilities ICANS-XX will also encourage contributions related to developments at smaller neutron sources and their complementary role as a cradle for new ideas and a school for new generations of neutron users. Along with this expectation, a special feature that we wish to recover in this meeting is the workshop format for the last few sessions, to discuss on recent experiences, either successful ones or the others.

TOPICS

1. Facility reports:

- **Status report**
- **New projects**

2. Accelerator:

- **Intense-beam accelerator development**
- **Intense-beam accelerator commissioning and operation**
- **Accelerator and target interface**

3. TMR systems

- **High power target and target materials**
- **Neutronics**
- **Moderators and reflectors**
- **Target/Moderator/Reflector engineering and experiments**

4. Instruments:

- **Fundamental Physics**
- **Optics**
- **Detectors and data collection**
- **Instruments design (especially for long-pulse neutrons)**

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The conference Web site will be up in a few weeks, but a First Announcement will be sent in the next days.