LENS Facility: 2015 report

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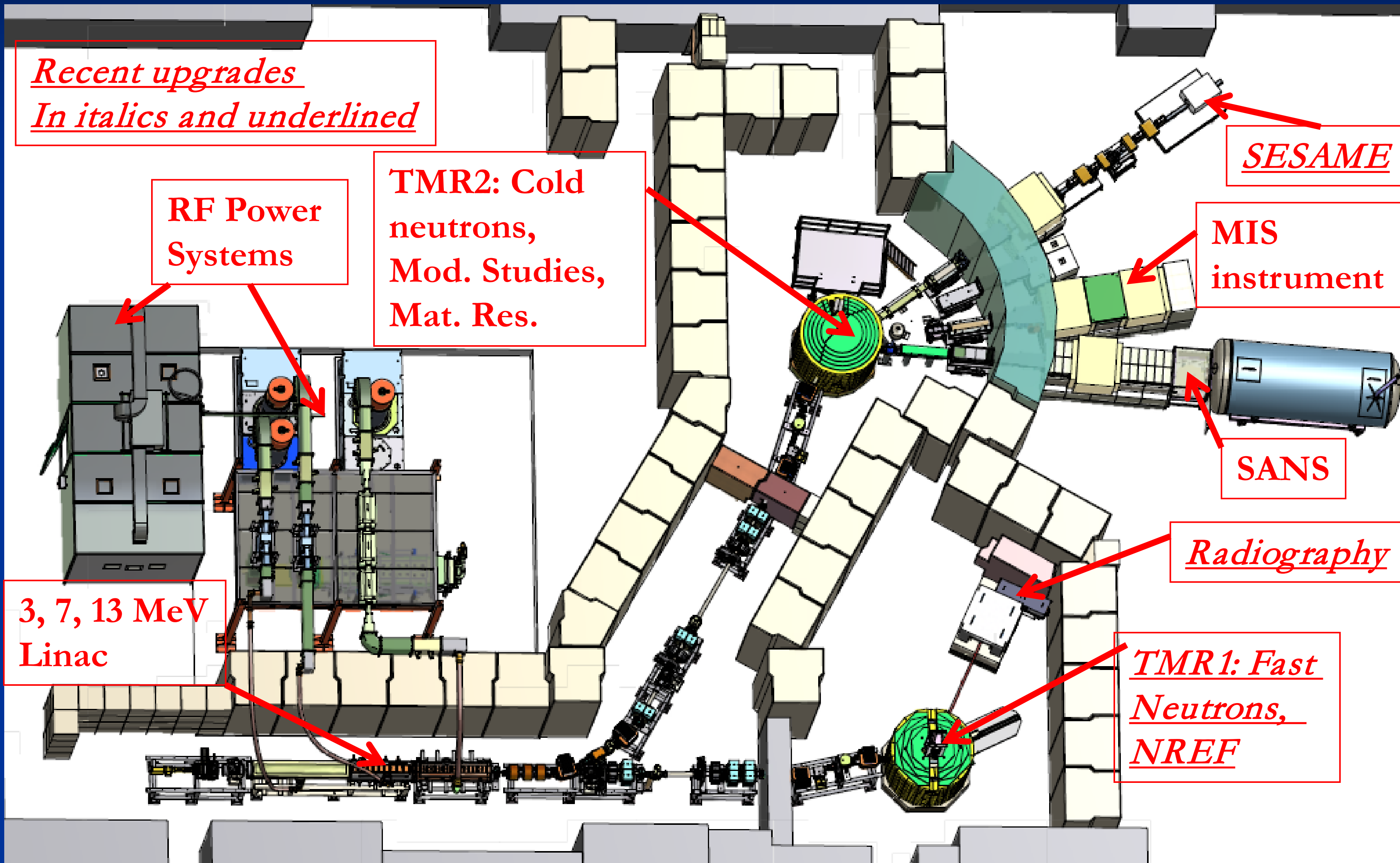
OUTLINE

- LENS Overview:
  - Operational details
  - Education and connections
  - Target Update
- Research Activities
  - Materials Research
  - Instrumentation Development Activities
- Conclusions

LENS: 2014



Recent upgrades
In italics and underlined
RF Power Systems
TMR2: Cold neutrons, Mod. Studies, Mat. Res.
SESAME
MIS instrument
SANS
Radiography
3, 7, 13 MeV Linac
TMR1: Fast Neutrons, NREF

LENS OPERATIONS

- Total funding for research ~ $1-2M/yr (DOE, DOC, NSF, other)
- LENS Operations
  - Annual operating budget ~$300K
  - ~3 staff members ~½ time, electricity, supplies, equipment
  - Lots of support from graduate students and academic staff
  - Ran for approximately:
    - ~ 2700 hours in 2012 (~75-90% reliability, RF trips and target issues)
    - ~1700 hours in 2013 (reliability limited mainly by target issues)
    - ~ 1300 hours in 2014
- In coming years we expect to:
  - Expand instrumentation development (spin manipulation, moderators, radiography with novel contrast, …)
  - Expand use of TMR1 (radiography, radiation effects).
  - Increase connections to National facilities: Advanced Radiography, transfer of spin-manipulation technology, moderators …

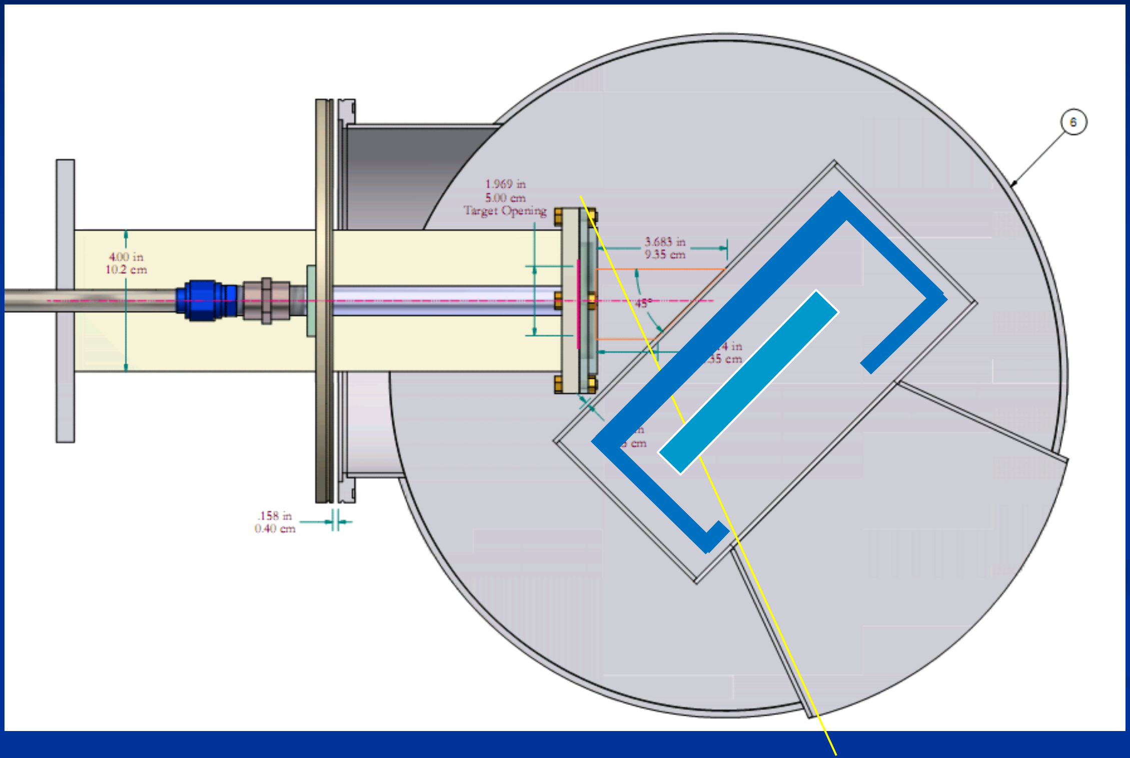
Operational issues

- RF power systems (lots of help from LANL has kept us going).
- Target (more on this later)
- We have partnered with the SNS on data acquisition systems. This has good and bad points:
  - Good for training students for experiments at SNS
  - System is far more powerful than what we could have produced ourselves (complicated, black box)
  - Maintaining compatibility is an issue
- Budget strains:
  - We had been sharing staff with another facility (ALPHA) on site that facility has now been terminated.
  - Federal budget cuts (sequester) limits grant income

LENS Connections to the International Neutron Community

- Technological:
  - Instrumentation development (more on this later)
- Education [PDF (9+1), PhD (11+7), UG (11+2); (past+current)]
  - IGERT: neutron graduate education program with an emphasis on hand-on instrumentation exposure and project-based learning in the classroom. (with U. Missouri and SNS).
  - Joint convening of workshops on neutron education (ORNL) and instrumentation development (NIST)
  - Lectures at summer schools
- Financial/programmatic
  - Pynn joint appointment between IU/ORNL
  - LENS/NCNR collaborative agreement
  - Joint research projects/proposals in areas such as ^{3}He neutron polarizer development (NIST/SNS), instrument upgrades (LANL), and moderator development (SNS,LANL,ESS), looking at novel radiography (NIST/ORNL)…

2010 Target Configuration



Thinner target gave longer life (initially), but slightly reduced primary neutron production. Increased water between the target and moderator improves coupling; no significant drop in cold flux was seen.

SANS instrument no longer views the illuminated portion of the target directly! Beam dose-rate fell from 1.6 R/hr.kW to 1.0 R/hr.kW after this change. This reduces the fast-neutron contribution to instrument background.

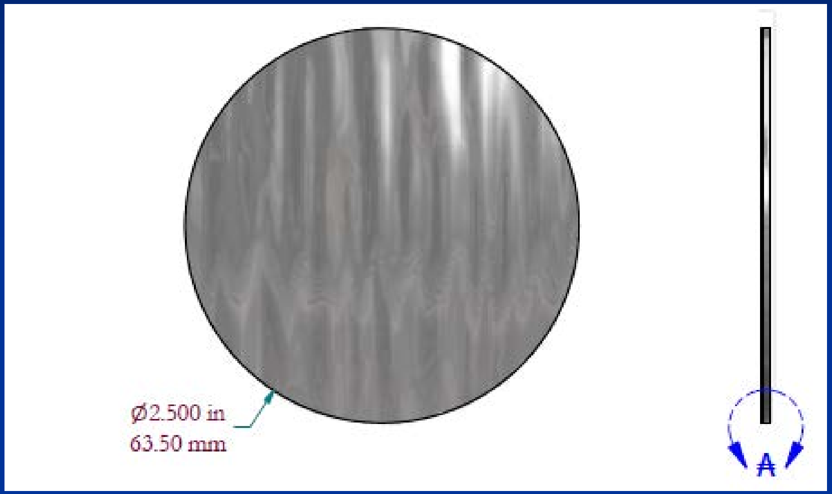
Target experience

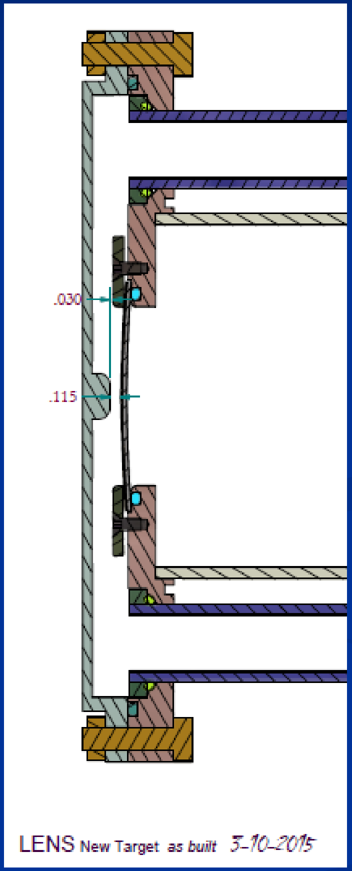
- Targets (TMR2):

#	date failed	kW-Days	failure-mode
1	1-July-11	75	O-ring leak
2	1-Mar-12	95	O-ring leak
3	19-July-12	78	O-ring leak
4	5-Nov-12	112	Changed before failure
5	2-Apr-13	98	Target cracked.
6	10-jul-14	>81	Target cracked
7	21-jul-14	<6	Target cracked

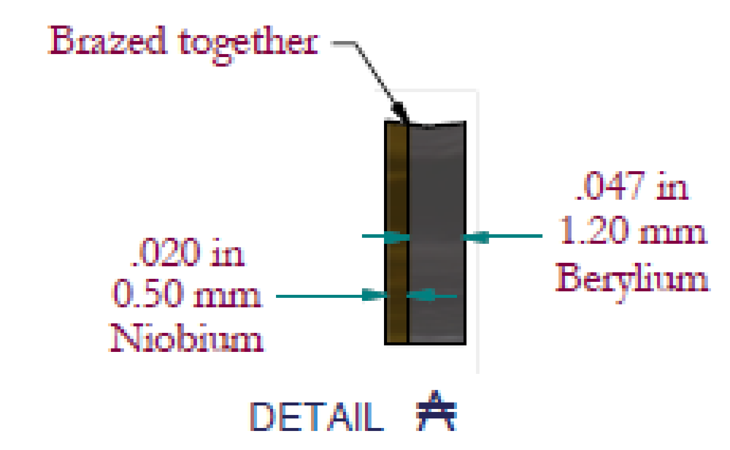
- NOTE targets 1 and 2 used Viton O-rings, 3,4 and 5 use E740 O-rings (latter are recommended in terms of ease of maintenance).
- Recent target cracking failure mode still a mystery!!? We were hoping that a modified Riken design would fix this.

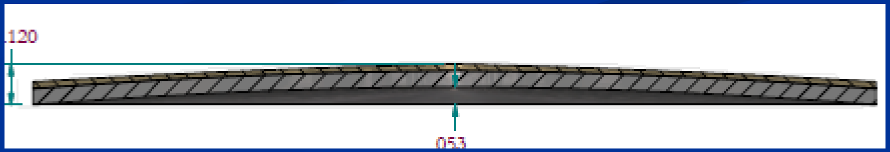
Mark III target design (March, 2015)





In an attempt to avoid the cracking we have experienced recently, we are testing a design in which a backing layer of 0.5mm V is brazed to the Be. The target comes out of the brazing process with a bow (convex to the water side).





New target: post use

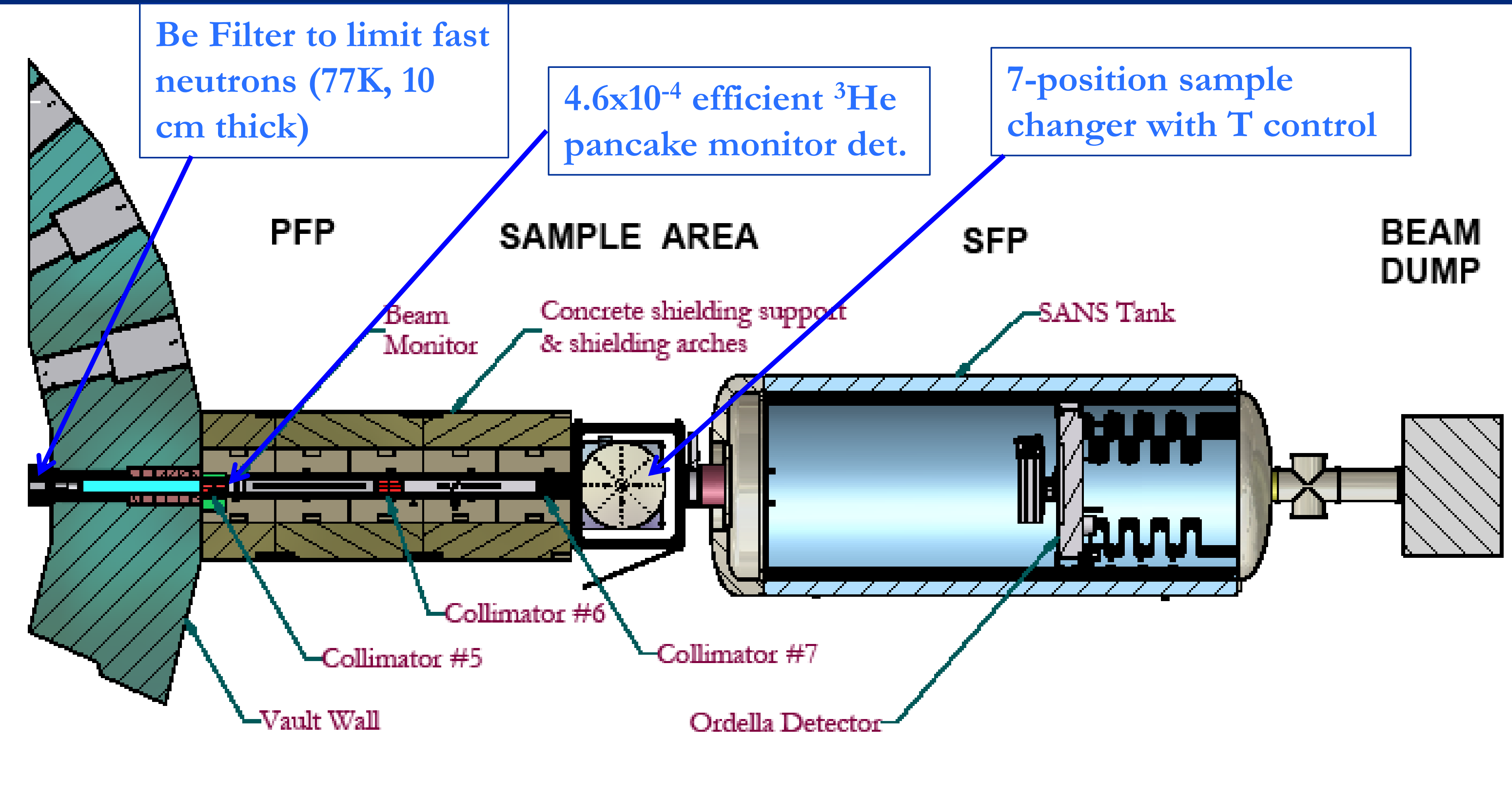
Water-cooled side

We were surprised by the amount of build up on the target, the water quality stayed remarkably high compared to the thinner Be target. There appears to be a small crack, and the backing prevented a water leak, but vacuum still softened.

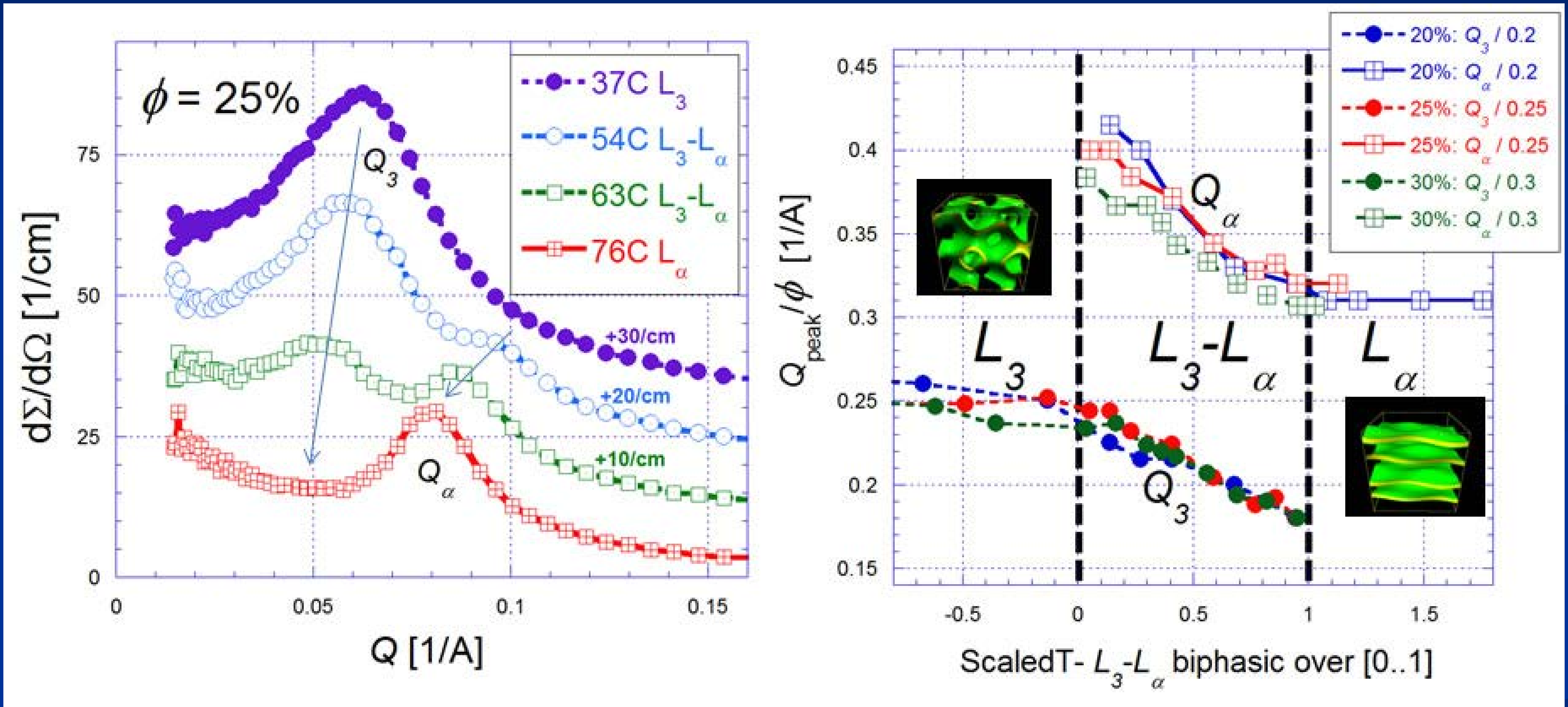
Vacuum side

This target again failed after a short time, but failure did not introduce water into the vacuum system.

SANS instrument



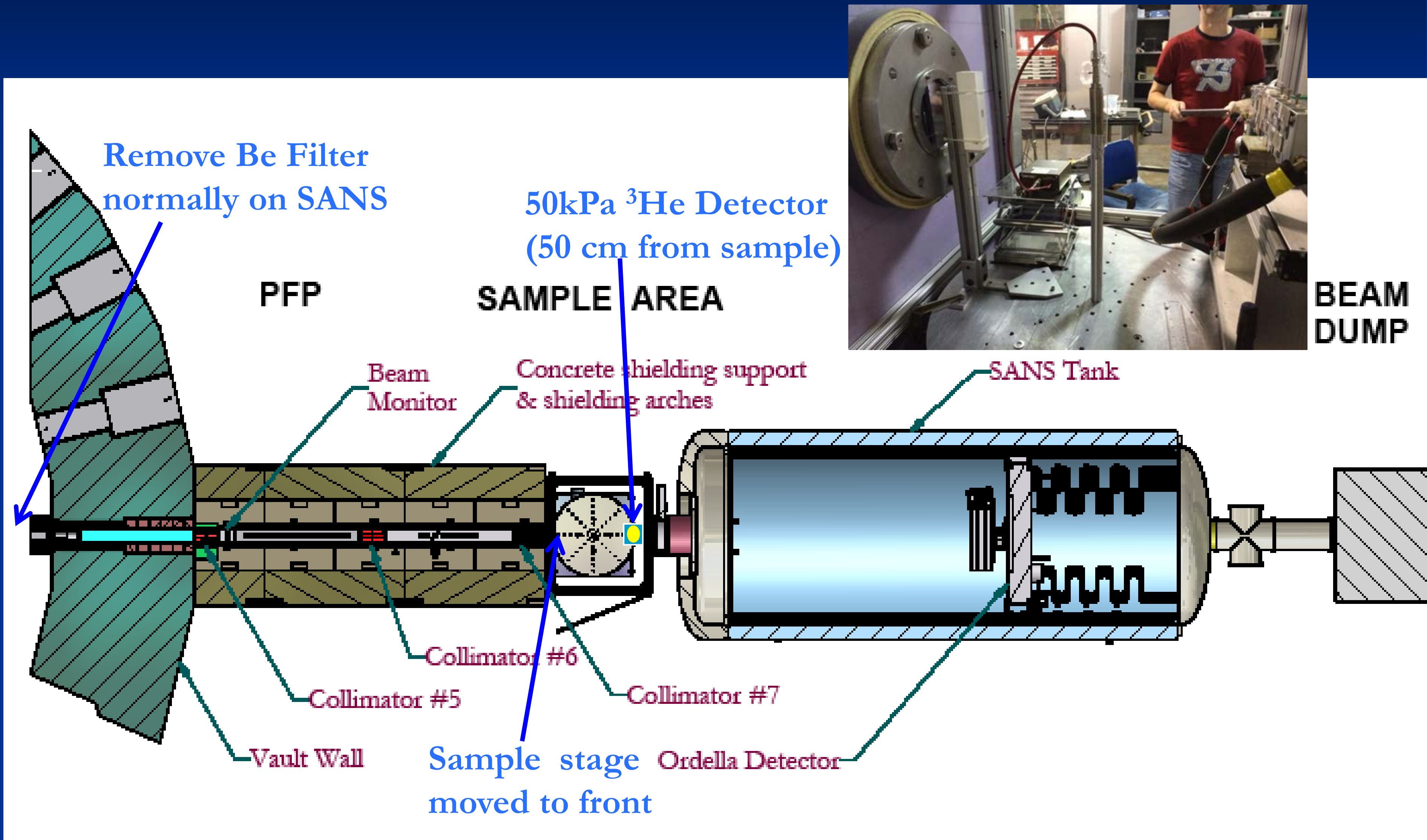
Miscibility gap in AOT



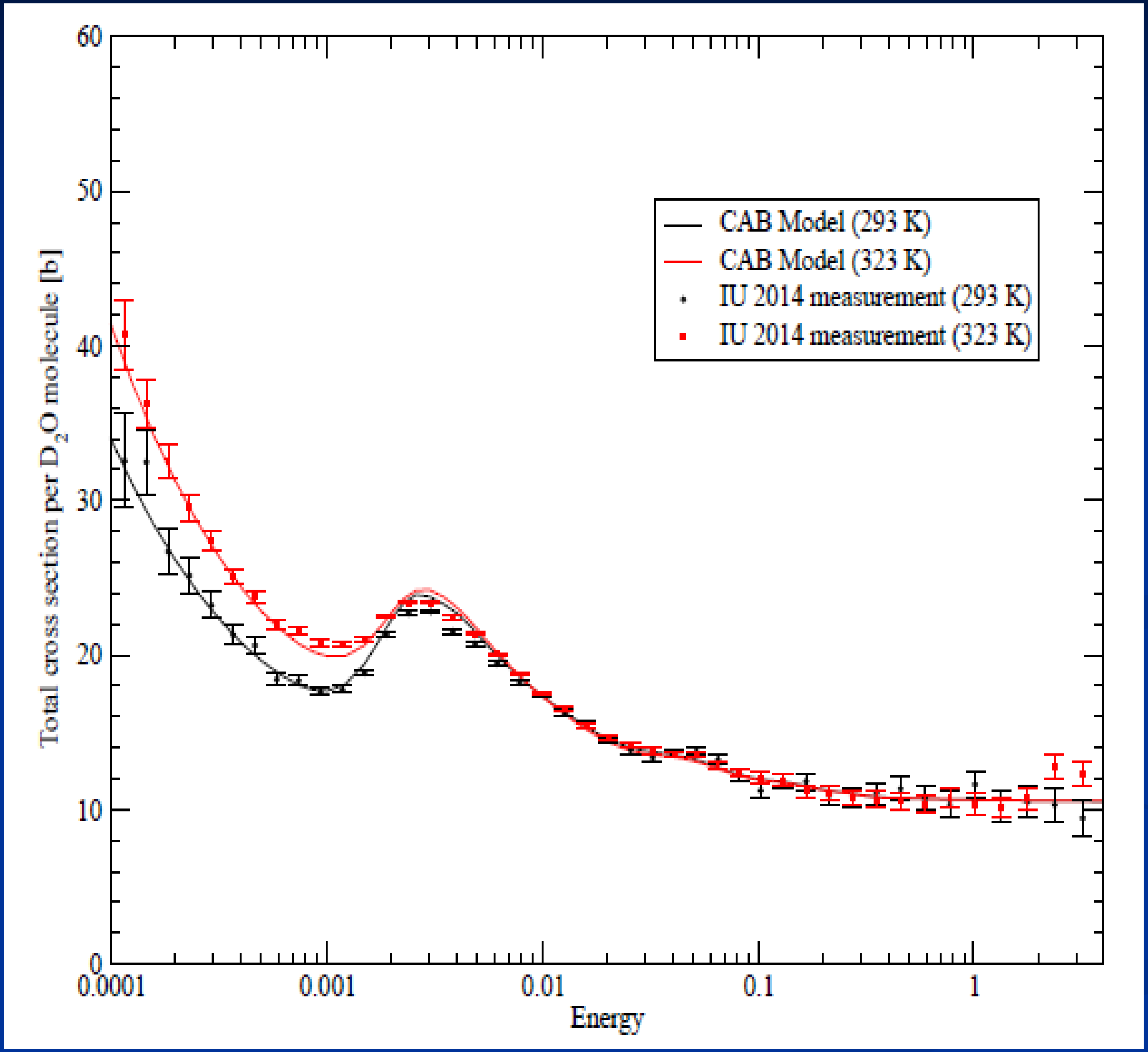
Data from the LENS SANS instrument. 20 minutes per temperature.
Instrument has also provided seed data for runs at ISIS, ILL, and NIST

W. A. Hamilton and S. R. Parnell (2015)

Total Cross-Section Expt. Setup



Total Cross section of D_2O



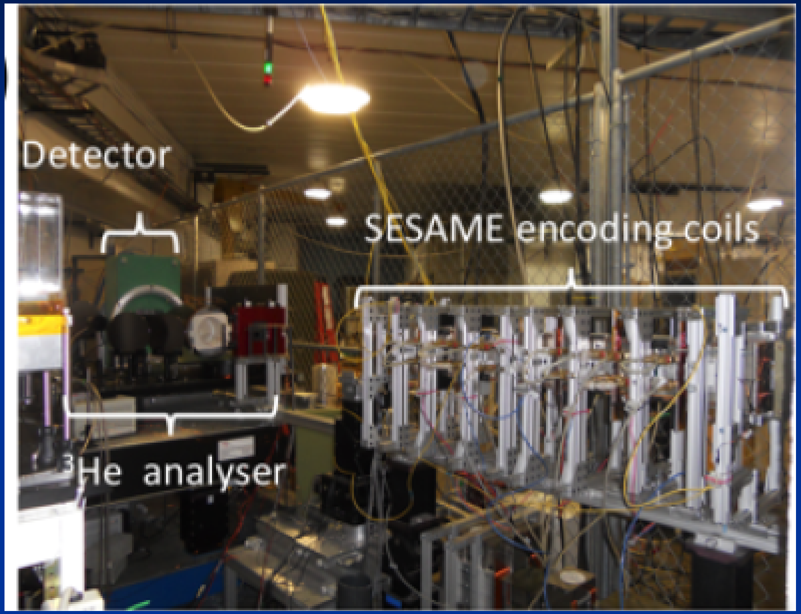
Data collected at 10Hz with 0.15ms pulse width for full energy range.
12 hour data collection(6 hour sample in, 6 hour sample out).

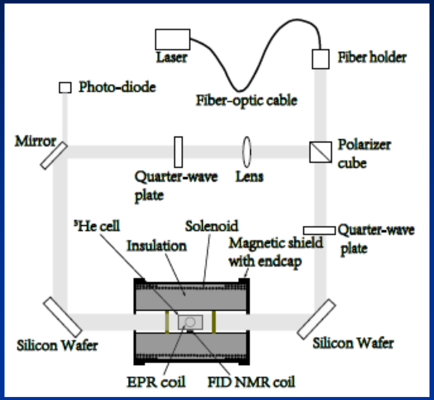
Statistics could be improved by using different accel. settings for large and small energy portions of the data.

Background rate in the ^3He detector is very small.

J. I. M. Damian et al.,UCANS-V

SESAME Instrument

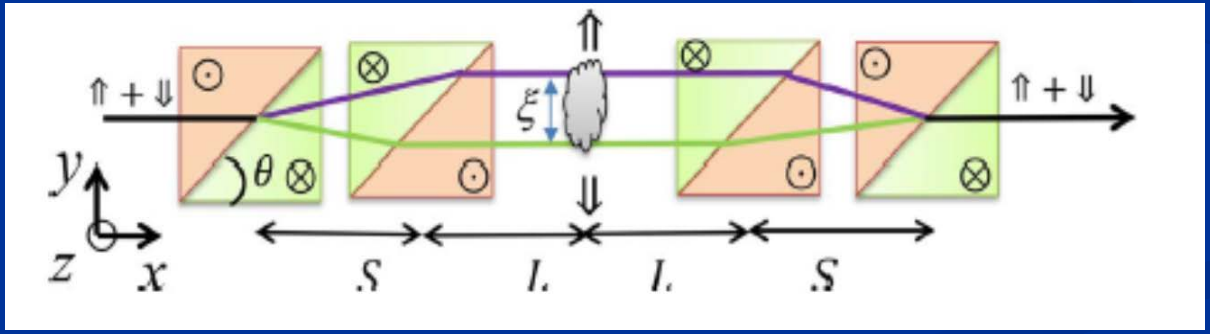




On-line ^{3}He polarization (SEOP) analysis

$$P_s(\xi)/P_o(\xi)=\exp(\Sigma_t[G(\xi)-1])$$

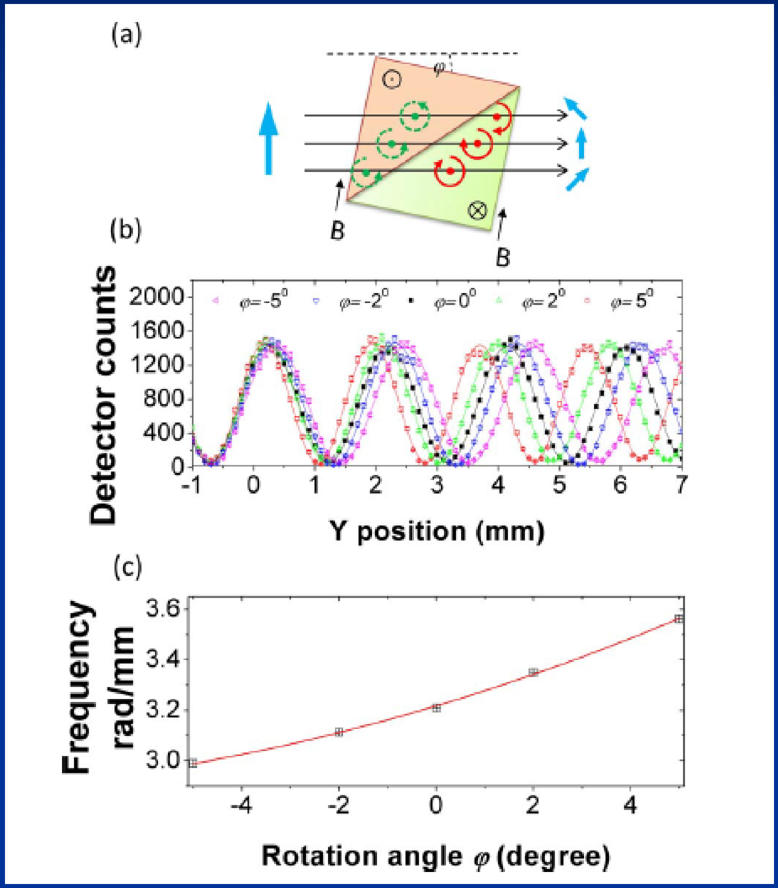
$$\xi = cBS\lambda^2B\cot(\theta)\ ;\ \ c=2.476\times10^{14}\ T^{-1}\ m^{-2}$$

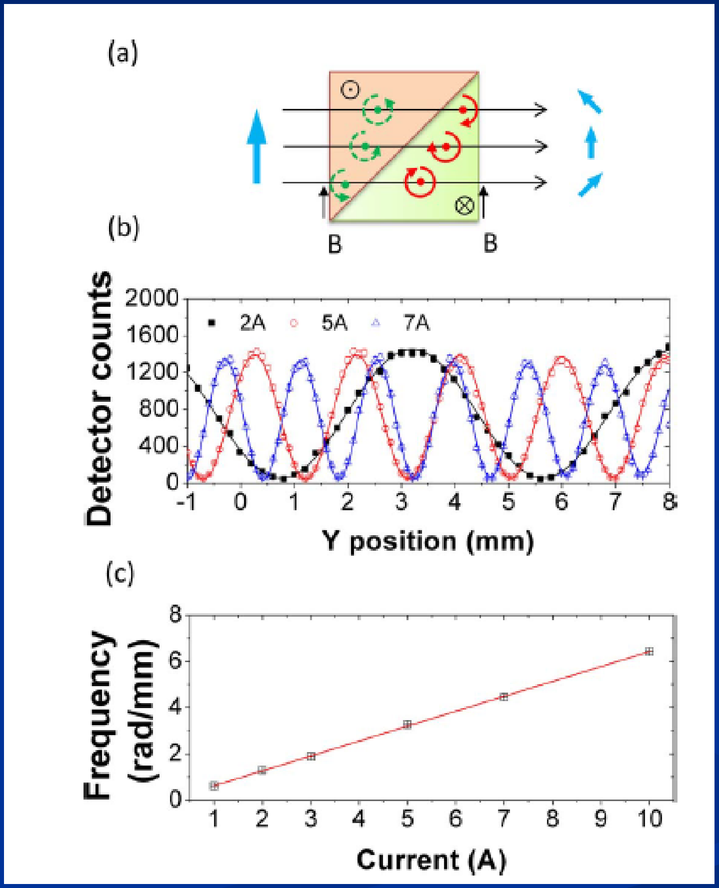


Real space correlations are determined directly from measuring the normalized polarization of the outgoing beam.

S. R. Parnell et al., Rev. Sci. Inst. (2015)

Magnetic Wollaston Prisms

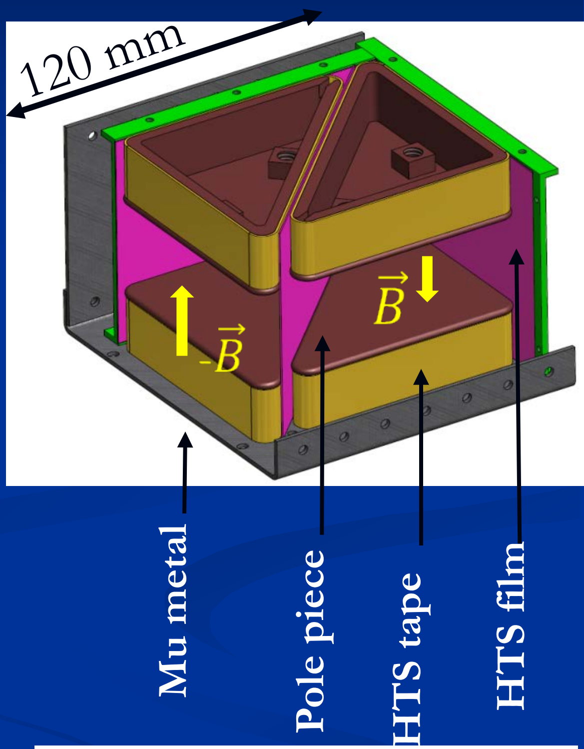


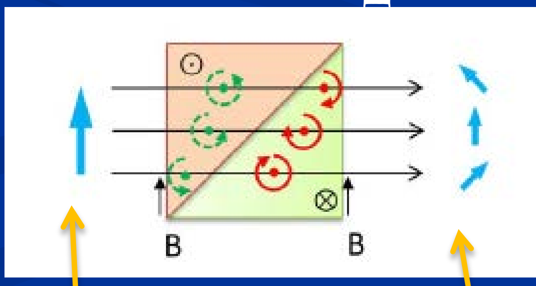


Have gone through several generations of such coils. Now have working superconducting prototypes functioning up to 20 A, expect to have the next generation working to 60A (SESAME to 5 μm or more, phase contrast radiography/ SEMSANS with 200 μm spatial resolution, phonon focusing…)

HTS Magnetic Wollaston Prisms

- A neutron WP allows you to encode neutron trajectory information into the neutron phase (spin orientation). With this you can decouple momentum resolution from neutron intensity facilitating:
  - Increased energy resolution in neutron scattering
  - Spin-echo approaches to real-space correlations in materials
  - New contrast mechanisms to neutron radiography
  - Introduction of entangled spin states into neutron scattering
- NSF funding was used to develop the concept and first prototype (by 2 NSF-supported grad students).
- Experimental tests at NCNR verify performance calculated using simulation software (MagNet©)
- Will be deployed at National Facilities (SNS, HFIR, NCNR) using follow-on funding from DOC, ORNL.
- A follow-on DOE STTR is leading to commercialization

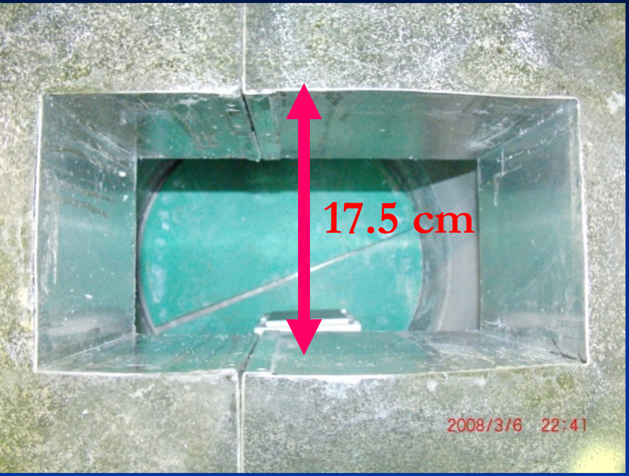




Neutron spin orientations

See Li et al. Rev. Sci. Inst. **86**, 023902 (2014), Li and Pynn, J. Appl. Cryst, **47**,1849 (2014) & perspective by F. Mezei, J. Appl. Cryst **47**,1807 (2014)

TMR1



TMR 1 has undergone a couple of upgrades over the last two years. SEE POSTER: 5

New dumb-waiter access allows us to accommodate larger circuits and ease access at NREF.

Radiography system has been resurrected to complement our collaborative efforts with NIST.

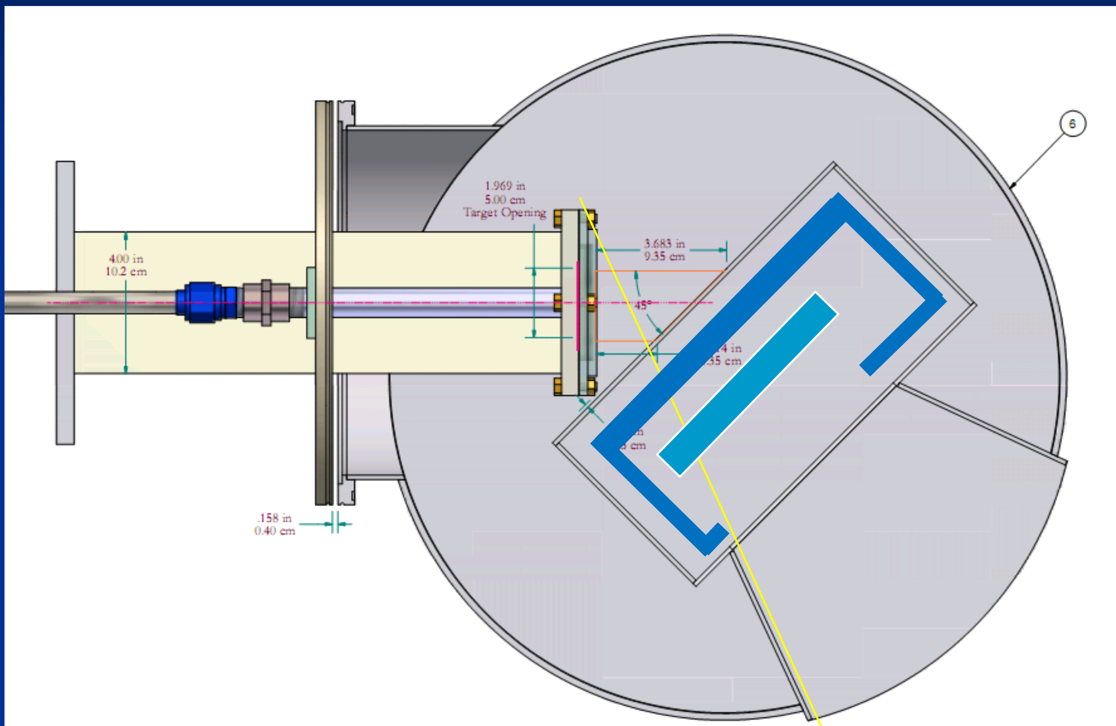
NREF

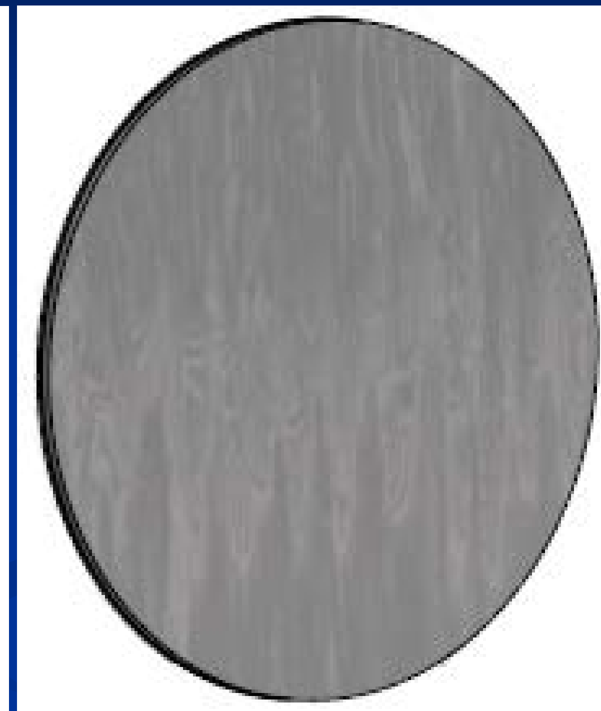
- Neutron-induced Single Event Effects (SEE) are a concern:
  - Cosmic-ray induced effects on commercial electronics
  - "harsh environments" for military electronics
- Military testing traditionally performed at fast burst reactors; these are becoming a dying breed!
- SEE involve processes over a large range of time scales (<ns to months).
- QUESTIONS
  - Can CANS provide equivalent information to reactors?
  - Can CANS provide extra information on time scales from <ms to minutes?

CONCLUSIONS

- LENS is now 13 years old (as a project, 10+ years old as a source)!
- LENS is continuing to advance Education, Innovation, Materials Research
- Key developments:
  - SANS+SESAME producing science
  - YBCO-based spin manipulators
  - Expanding NREF and neutron imaging
- Keys to the future are increased connections to major facilities and broadening of the user base (but not in a traditional user-facility mode).

2015 Target Design





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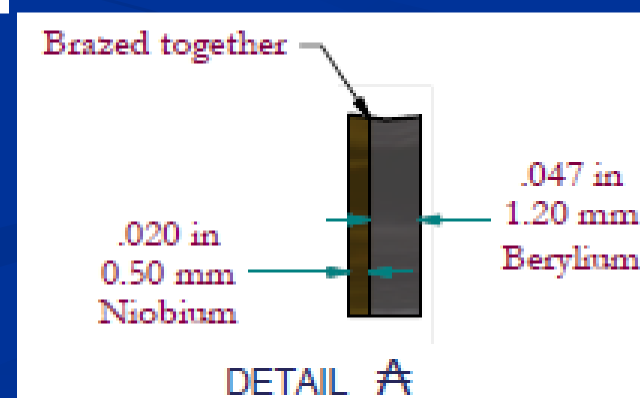

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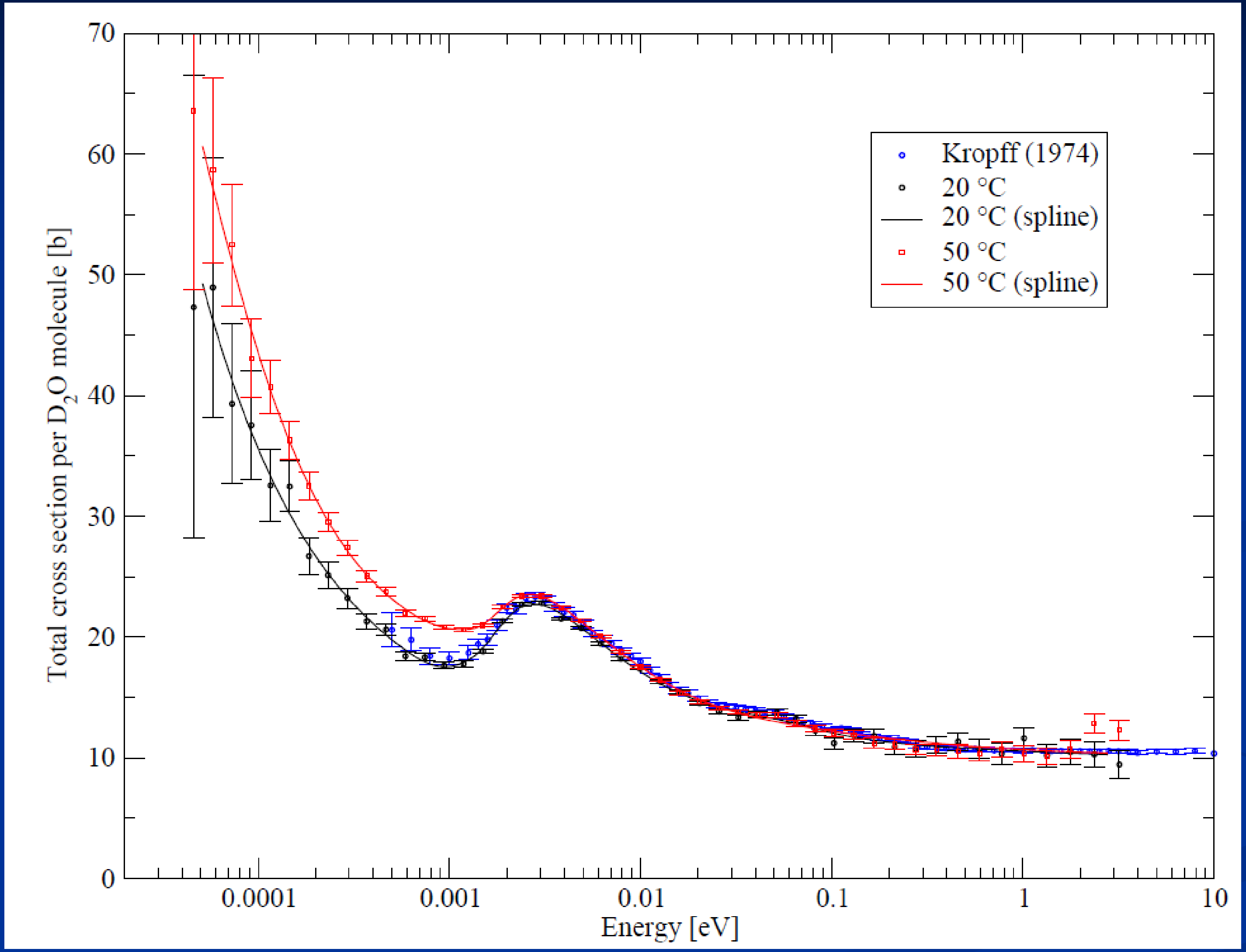

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12 hour data collection(6 hour sample in, 6 hour sample out).

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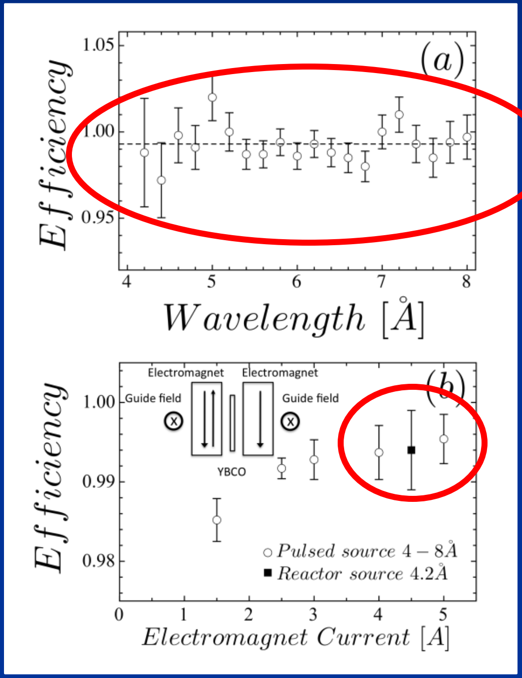
Background rate in the ^{3}He detector is very small.

Preliminary results,
J. I. M. Damian et al. (2014),UCANS-V

Spin Manipulation - Results

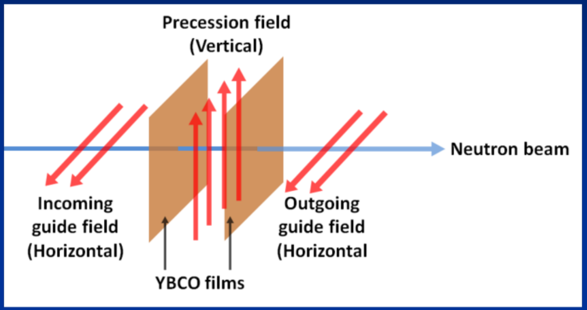
Cryoflipper: Uses Meissner effect to create abrupt non-adiabatic transition between magnetic field regions



Uniform wavelength efficiency

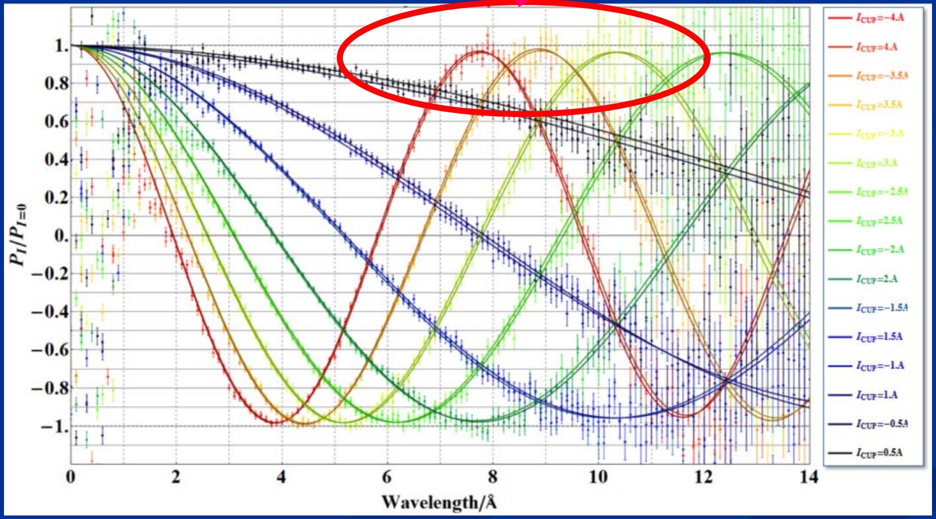
Optimisation gives 99.5% efficiency
Tested at LENS and HFIR

Cryo-Cup: Compact spin precession device -



- Tested at LENS
- Key component of full SNP

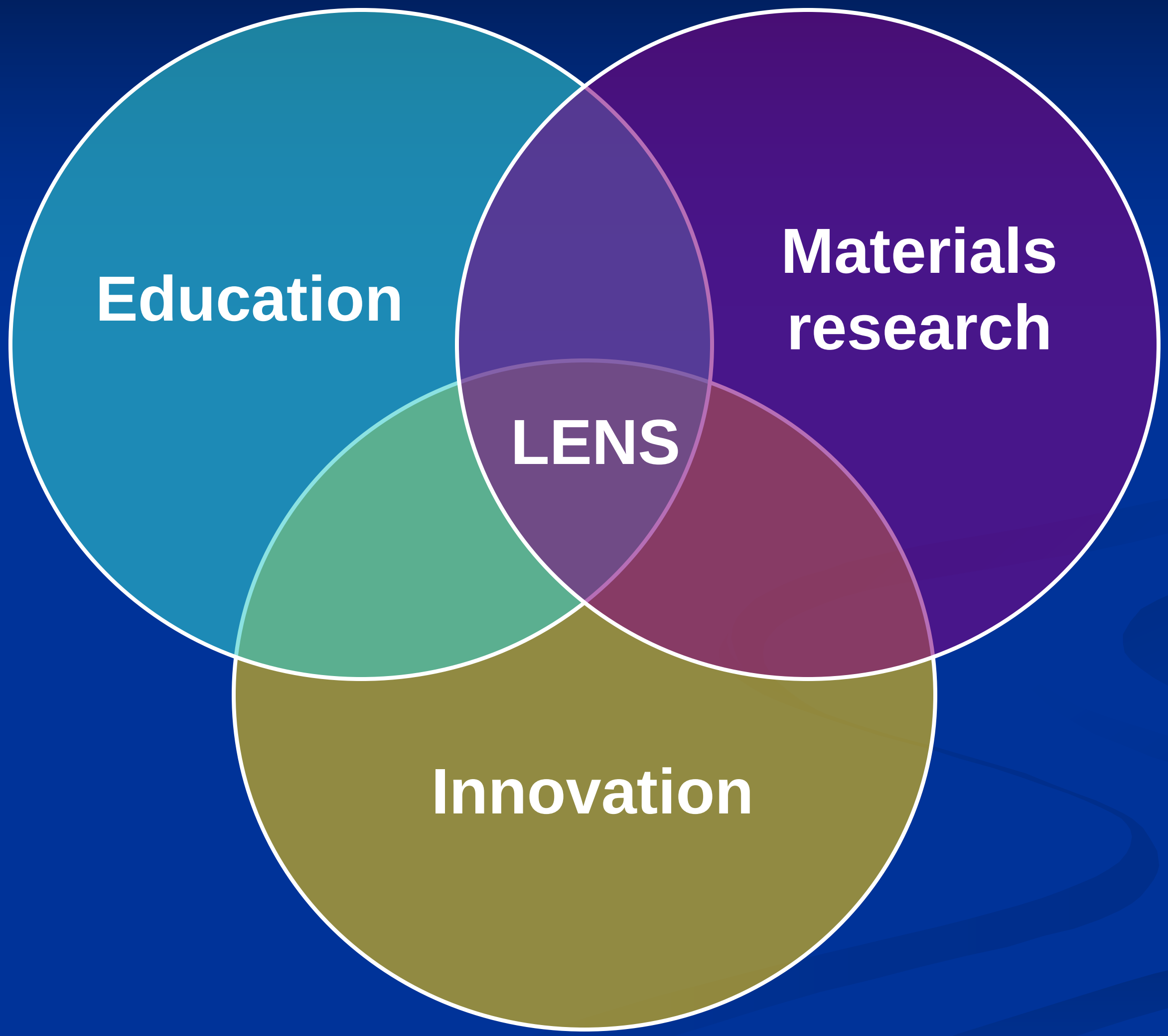
Low depolarisation



- Above plot shows P/Po as a function of λ for various coil currents (up to 4 A).

S. R. Parnell et al., NIMA **722**, 20 (2013),
Phys. Procedia **42**, 125 (2013)
Rev. Sci. Instr. **85**, 053303 (2014)

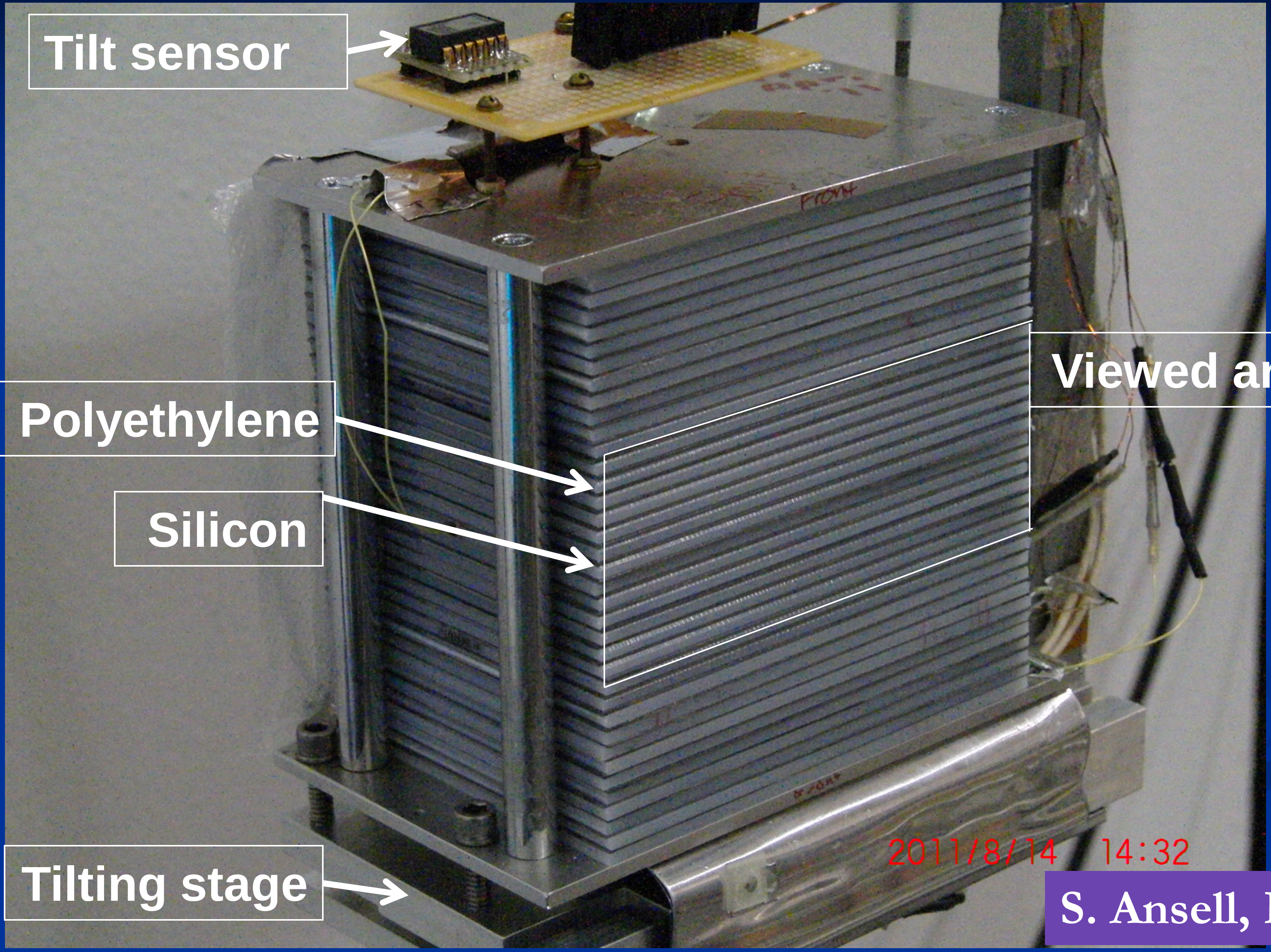
LENS Missions



LENS Education (since 2005)

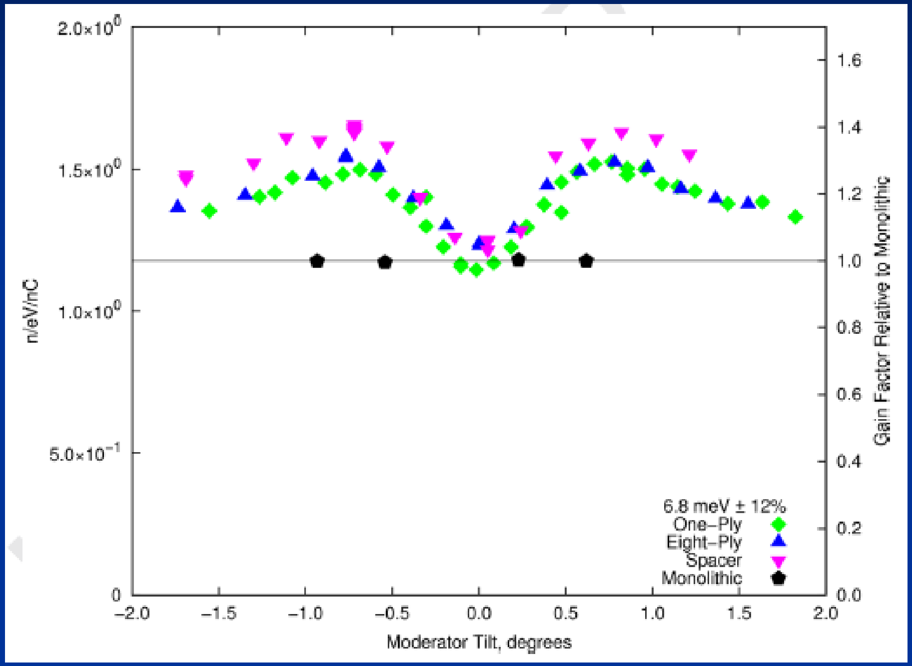
- Post Doctoral Fellows:
  - **Past (9)** Bogdanov, Panteli, Shah, Kilburn, Lee, Cao, Das, Lin, Yan
  - **Current (1)**: Parnell
- Graduate Students:
  - **PhD's defended (11)**: Chen, Lavelle, Remmes, Shin, Ashkar, Stonaha, Washington, Prisk, Halstead (AFIT, 2014), and 2@UIUC-NE during construction.
  - **Current: (7**) Bryan, Cao, Evans, Feng, Li, T. Wang, B. Wang
- Undergraduate Students
  - **REU (6)**: Nelson, Raguse, Stienbach, Leung, Carpenter, Jenkins
  - **IU: (5)** Nicholson, Schevitz, Hunt, Lesh, Ewing

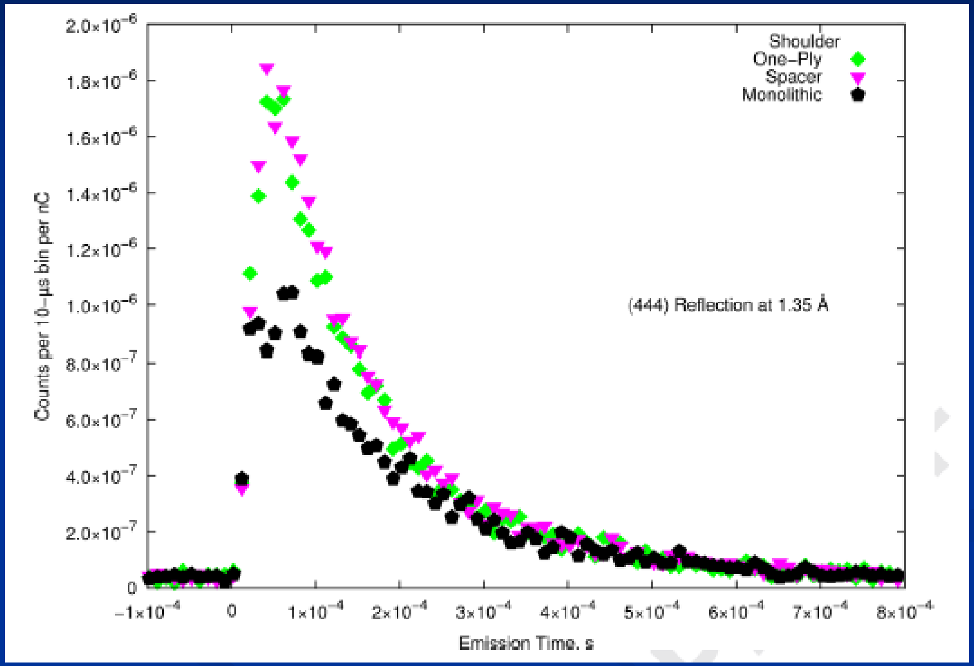
PE/Si Convoluted Moderator



S. Ansell, ISIS

Convoluted moderator (moderator at room temperature)





Presence of the Si vanes provides an easy escape route for cold neutrons from deep within the moderator volume, this leads to a remarkable directional dependence (left) and increased PEAK intensity. More work still needed to understand how this carries over to a comparison of individually optimized designs (7meV for angular dependence, 45 meV for emission time).

Iverson et al., NIMA **762**, 31 (2014)