Neutron Moderator Studies at the Low Energy Neutron Source

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OUTLINE

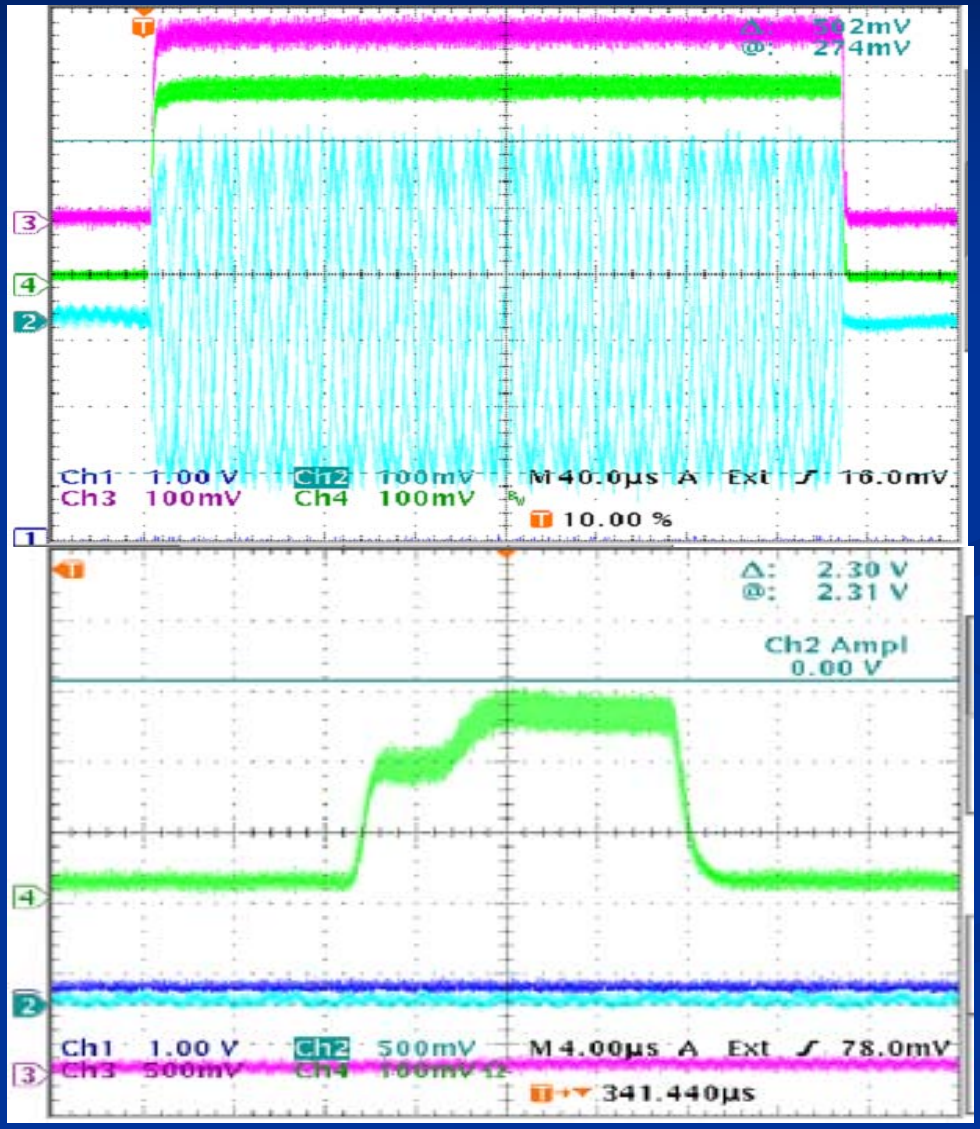
- Important LENS Design features
- Total Cross section measurements
  - Water and ZrH_2 : groundwork for VCN modeling
  - Confined methane: extra modes??
- Whole moderator tests (interaction with major sources):
  - Poisson plate
  - Hydrogen
  - The concept of vanes for moderator design: a possible breakthrough!
- Conclusions

Facility Layout: 2009

Target Moderator Reflector (TMR)

- Replaceable moderator
- Low heat load
- Low radiation load
- Direct view of moderator possible
- Low activation

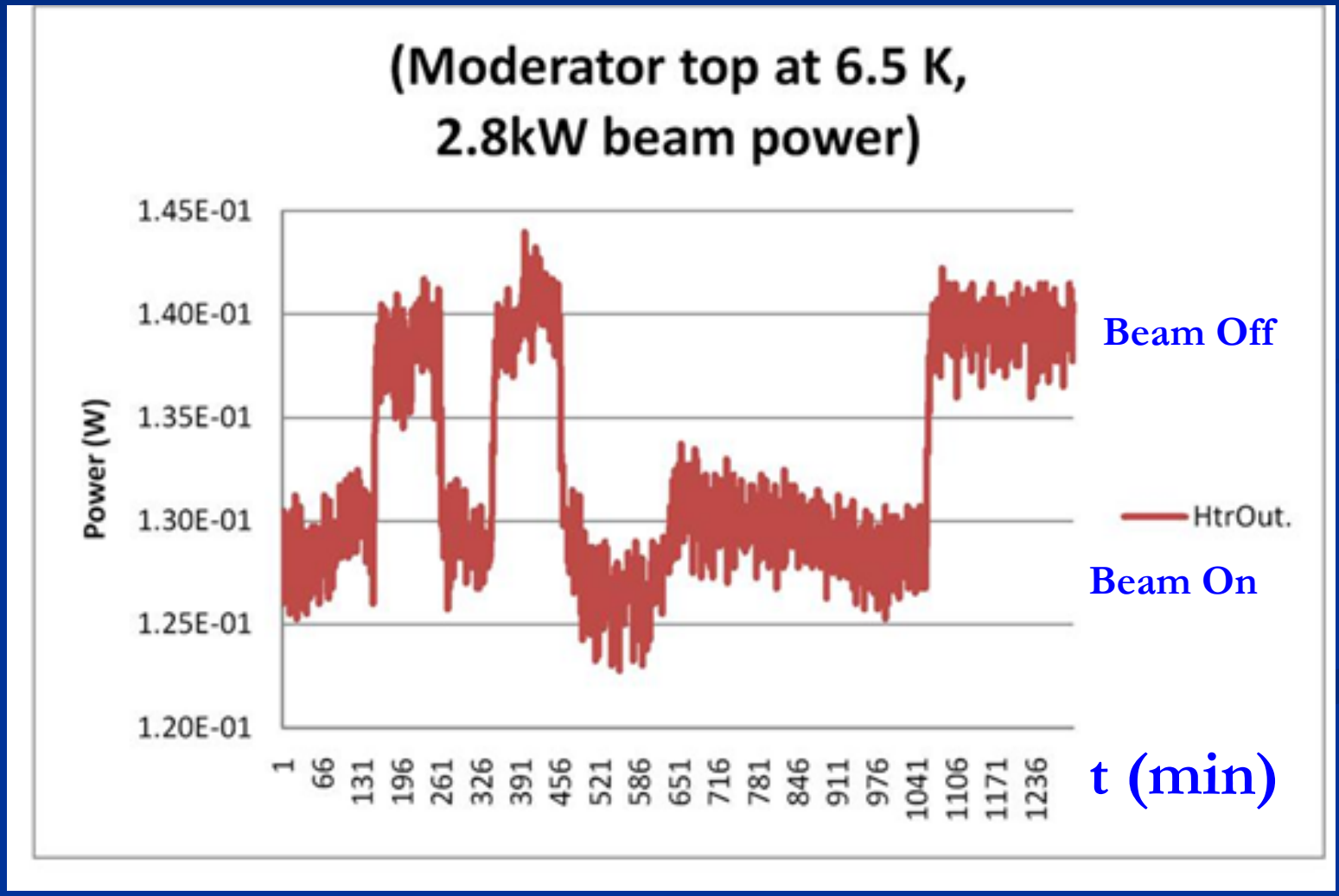
Instrumentation Research: Variable Proton Pulse Structure



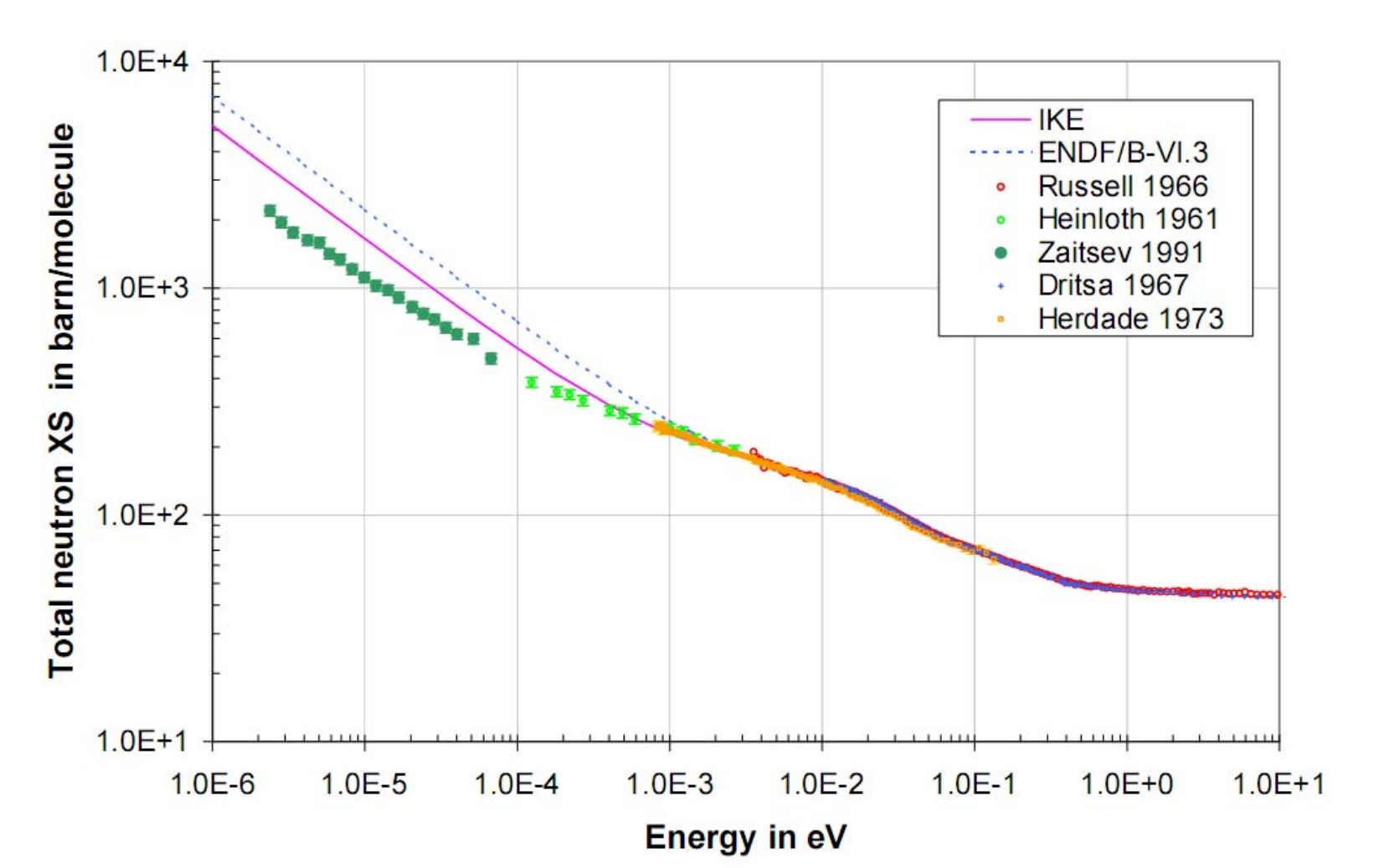
Long proton pulses:
(300-800 µsec at 20 Hz)

Short proton pulses:
(14 µsec at 40 Hz)
Needed for emission time measurements

Moderator Thermal load (~25μW/ml.kW)

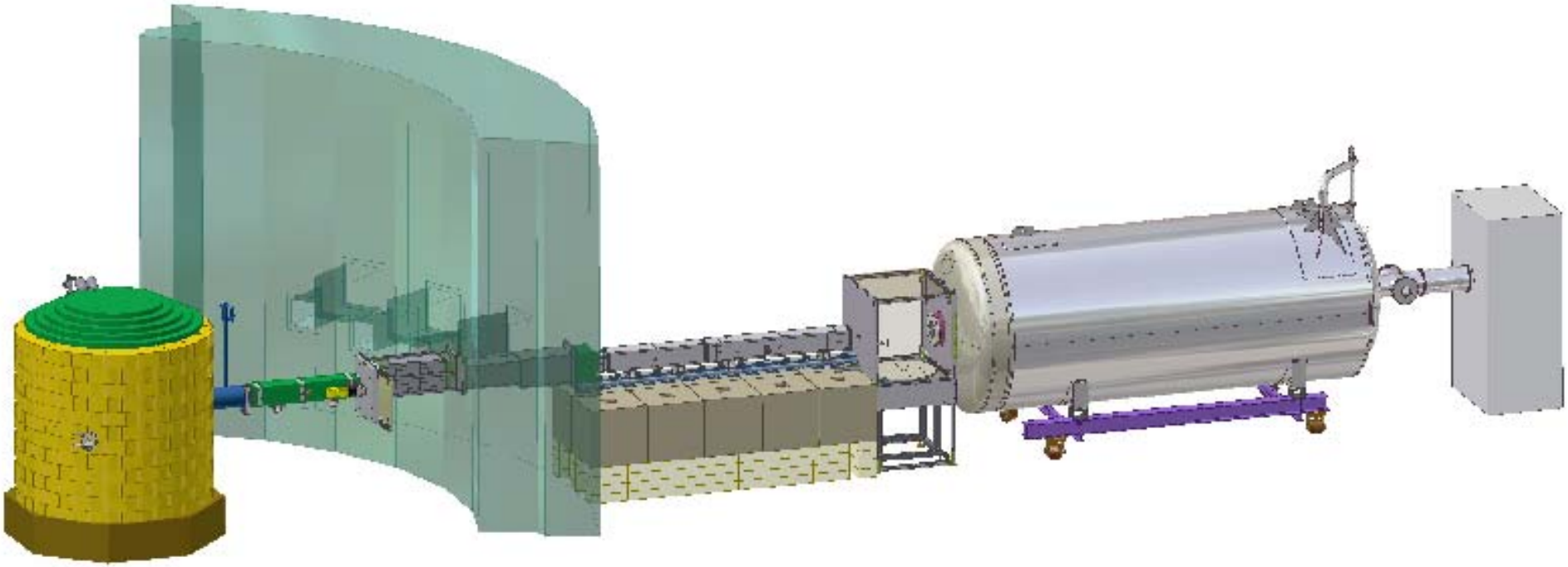


VCN Kernel development: H_2O

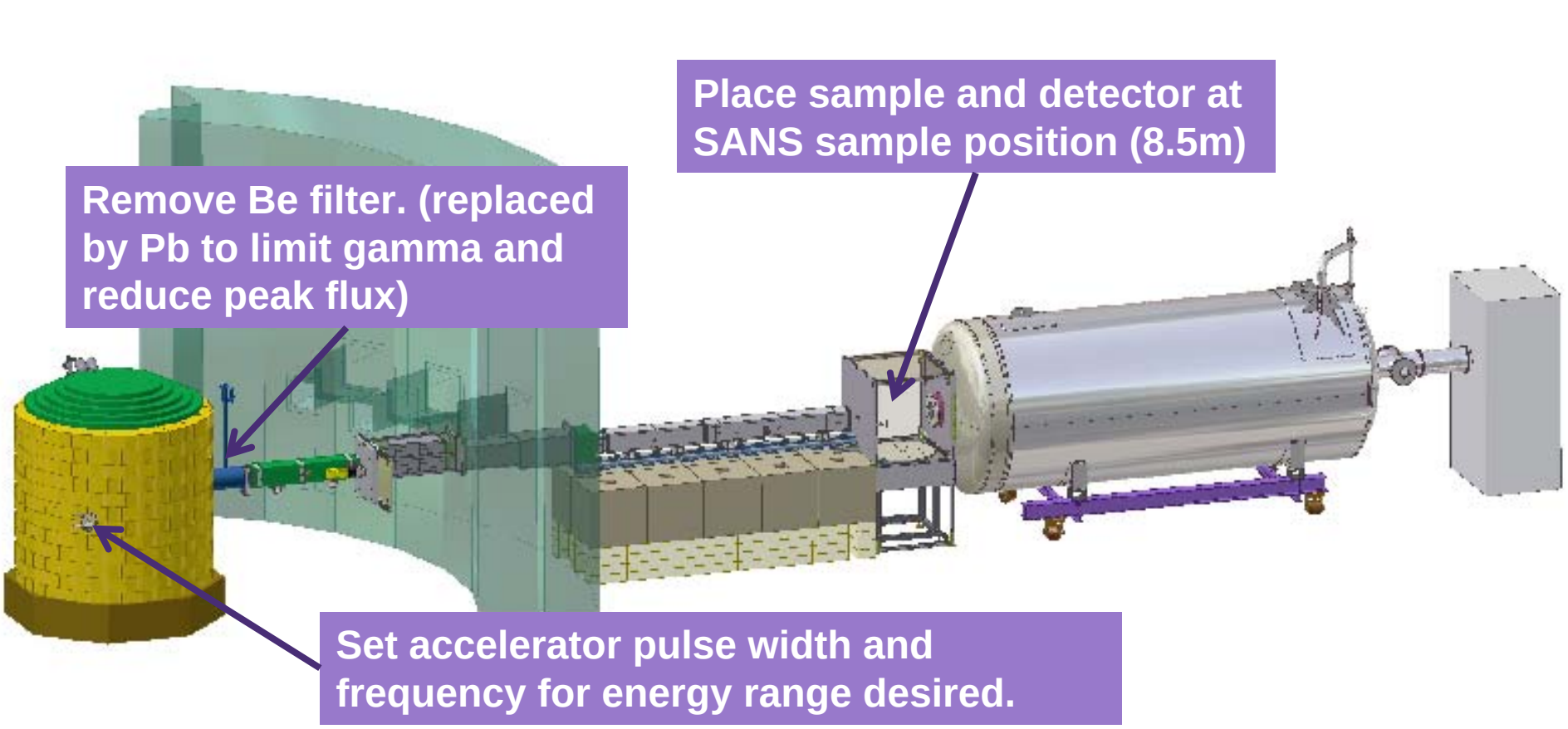


IAEA report: INDC(NDS) -0470

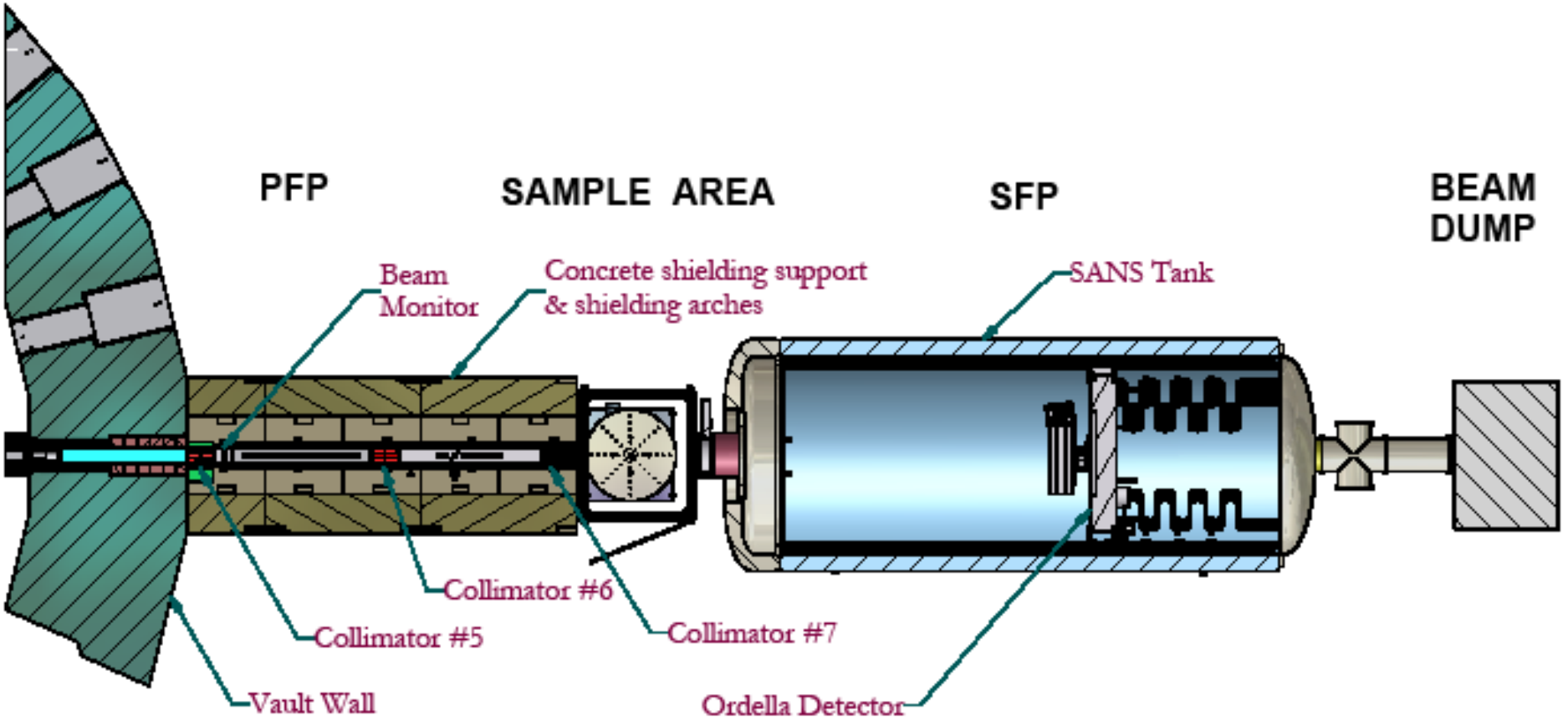
SANS Layout



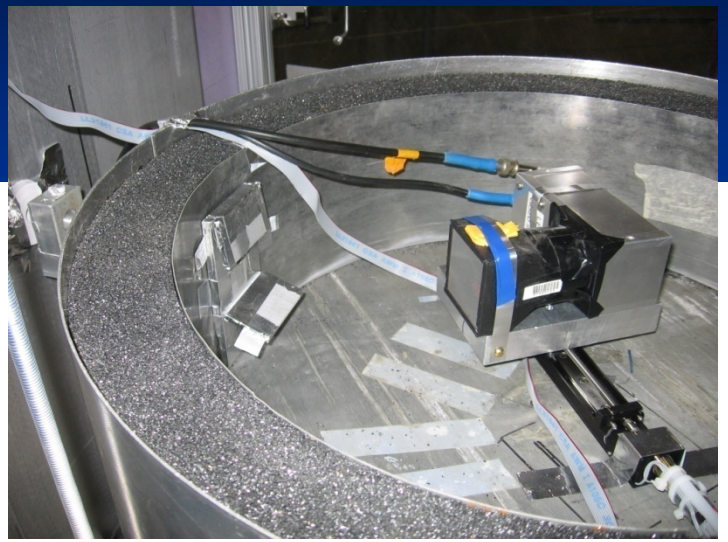
Σ_{tot} measured at SANS



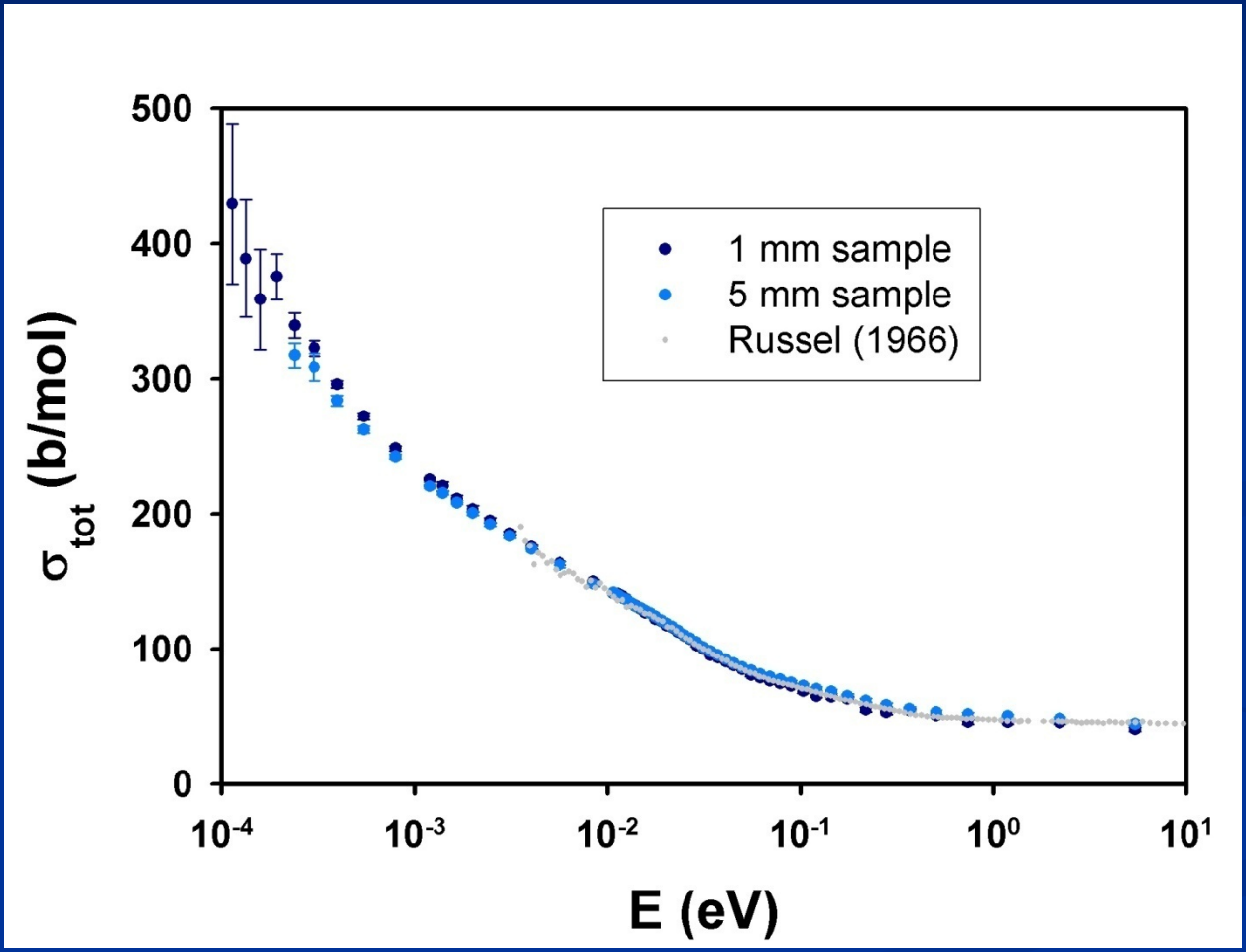
SANS Instrument



SANS Instrument

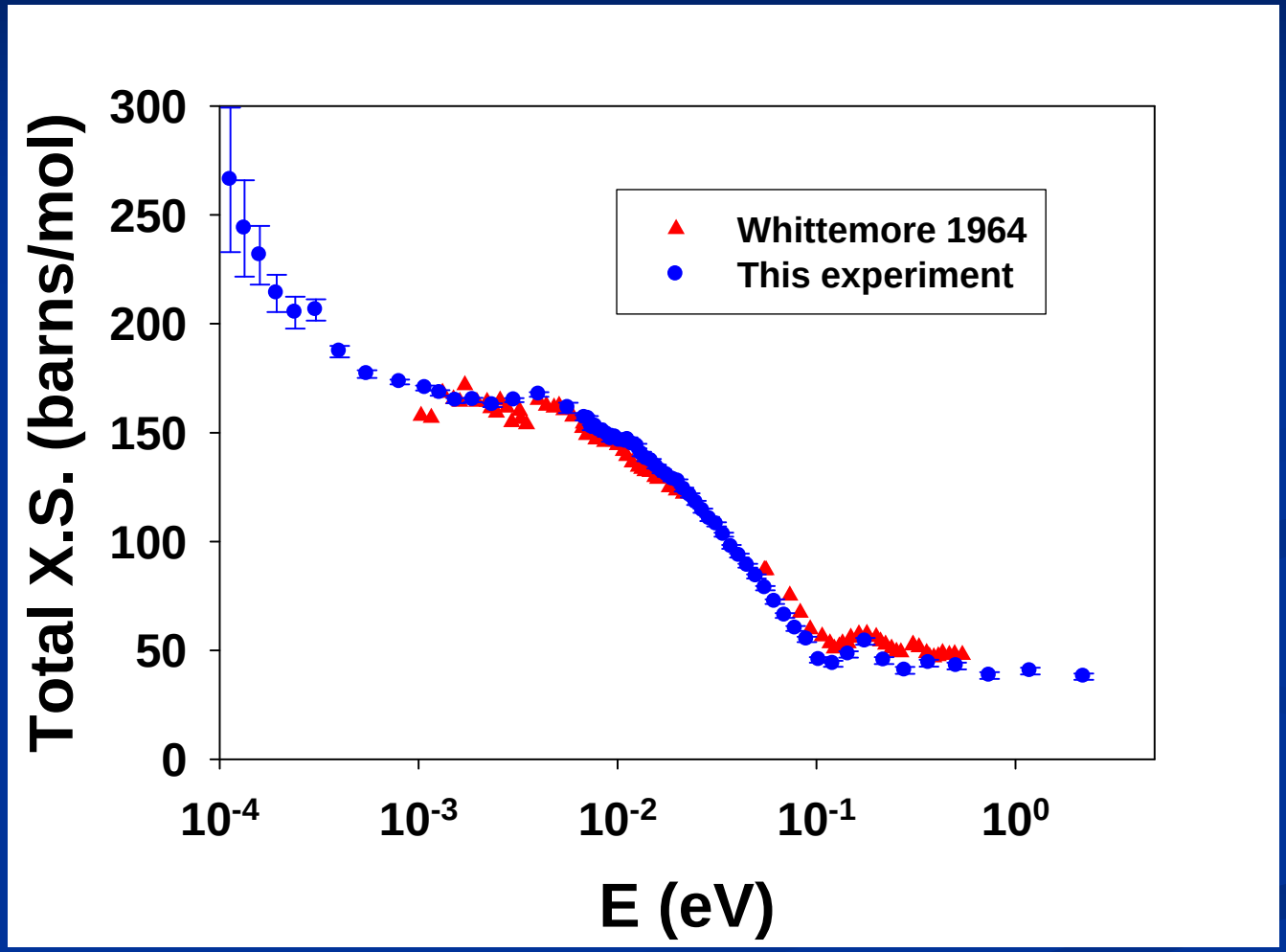


Σ_{tot} for H_2O



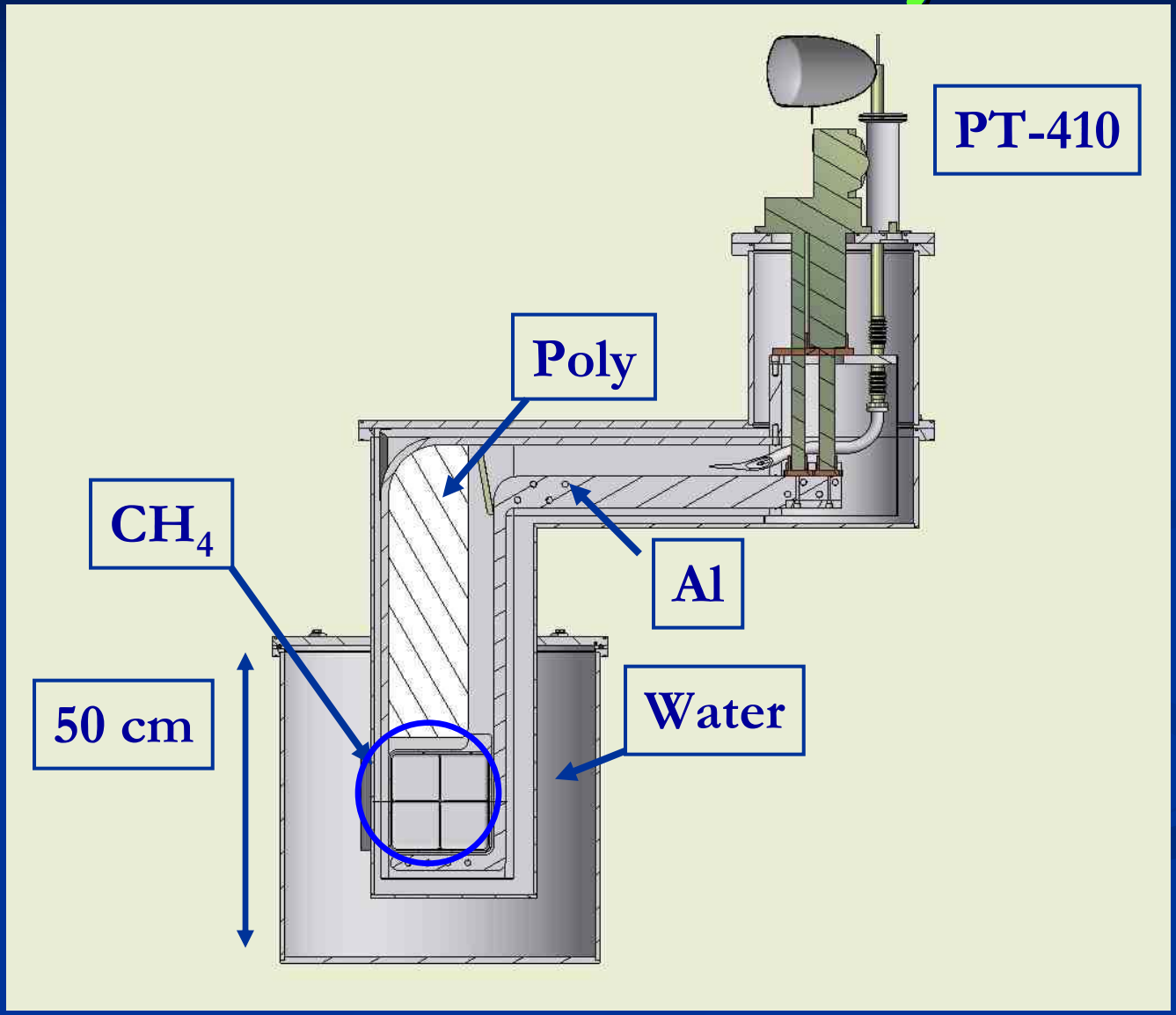
2 hour for 1mm
5 hour for 5 mm
(0.5kW beam power)

Σ_{tot} for ZrH_2

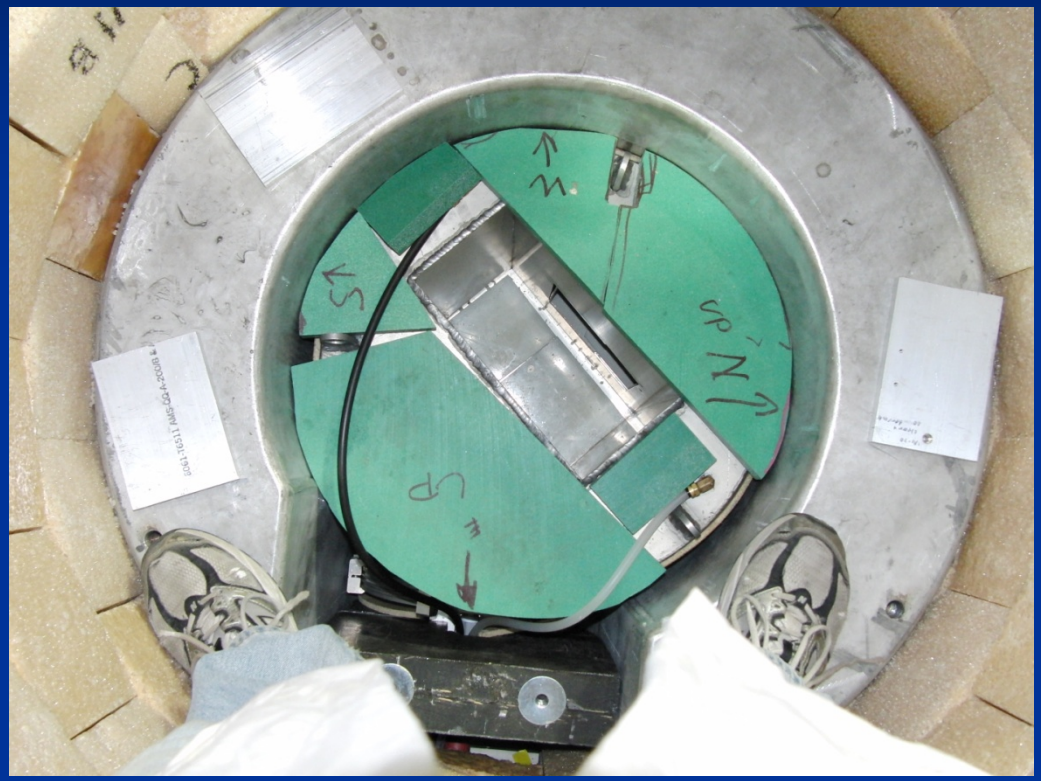


10 hour data collection
1mm sample thickness

Moderator Assembly



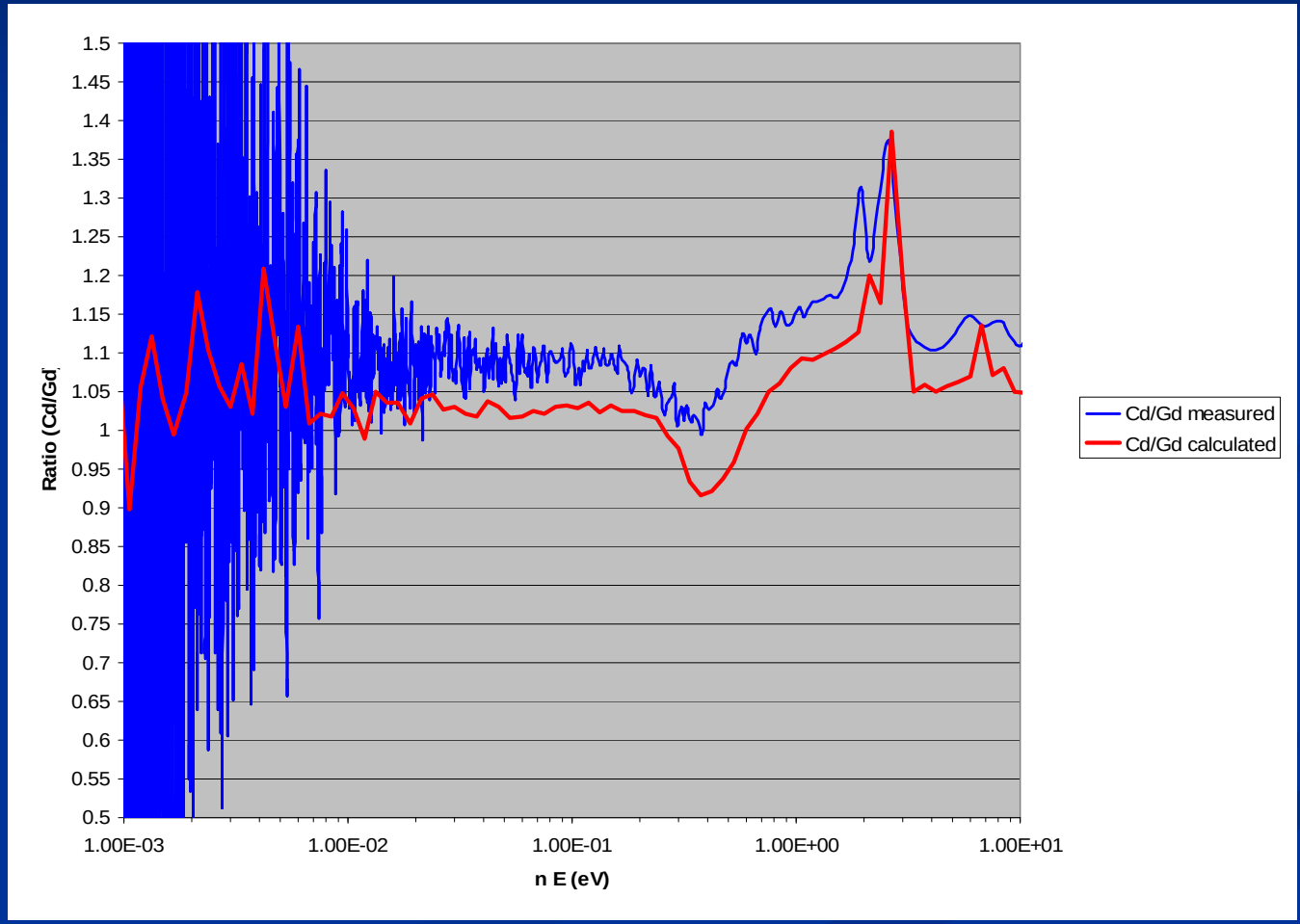
Research on prototype Moderators



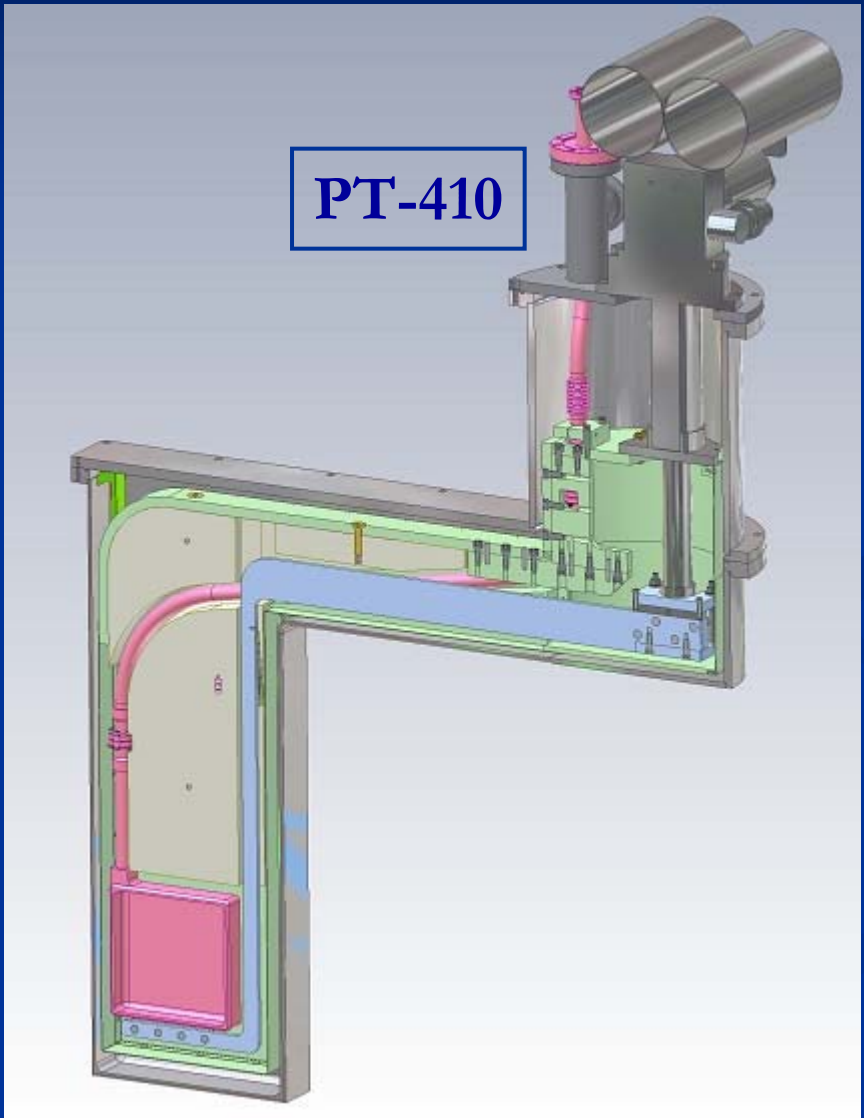
View of the reflector (inside a lead cask to shield gammas) and the cavity available for test moderators. On right is shown the opening to the beam lines, into which we insert Cd-coated liners to reduce interference from the reflector. The proton beam enters from bottom of left-hand image.

Neutronic experiments (SNS Poison Plate measurements Cd vs. Gd)

"Poison Plate"

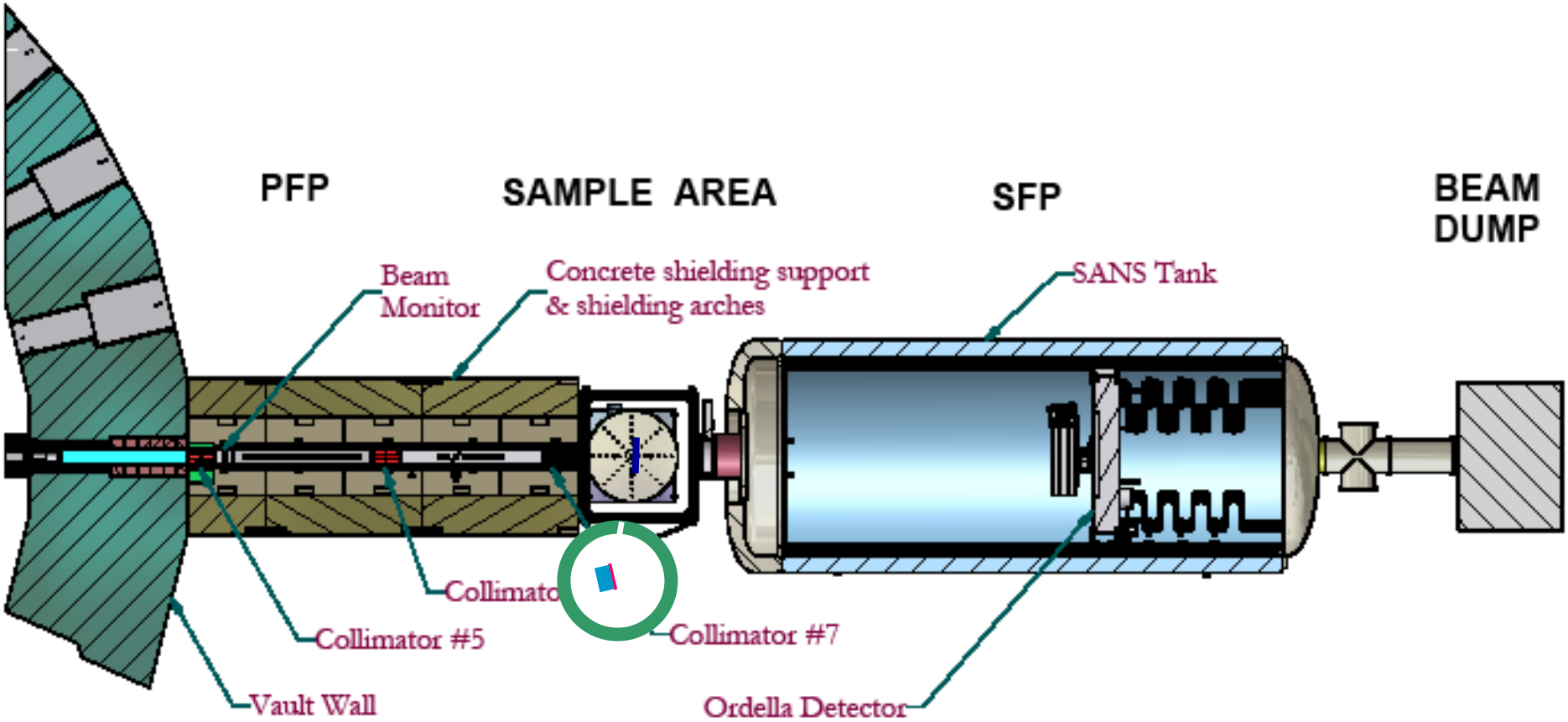


Test bed Assembly

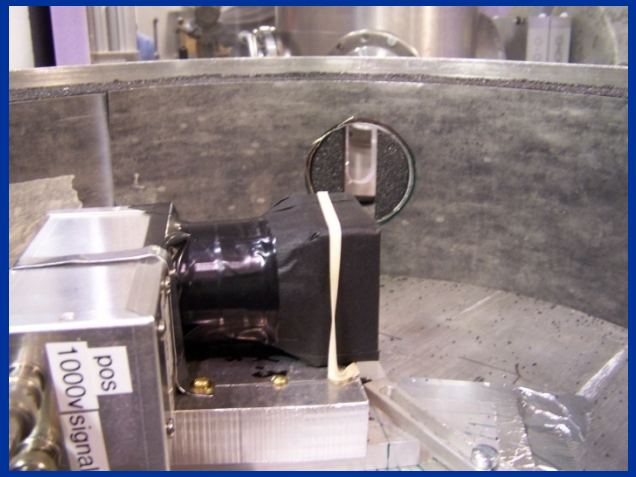


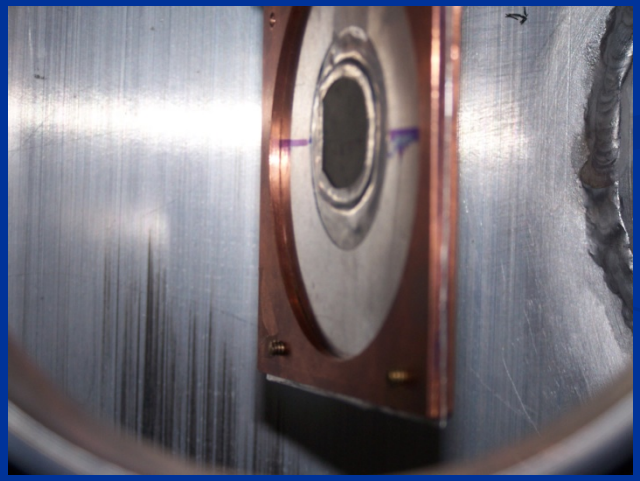
We have built a second moderator insert with some added features (e.g. second gas line) to facilitate ancillary measurements on cryogenic prototypes (e.g. H_2, CH_4 and alloys, pellets, etc.)

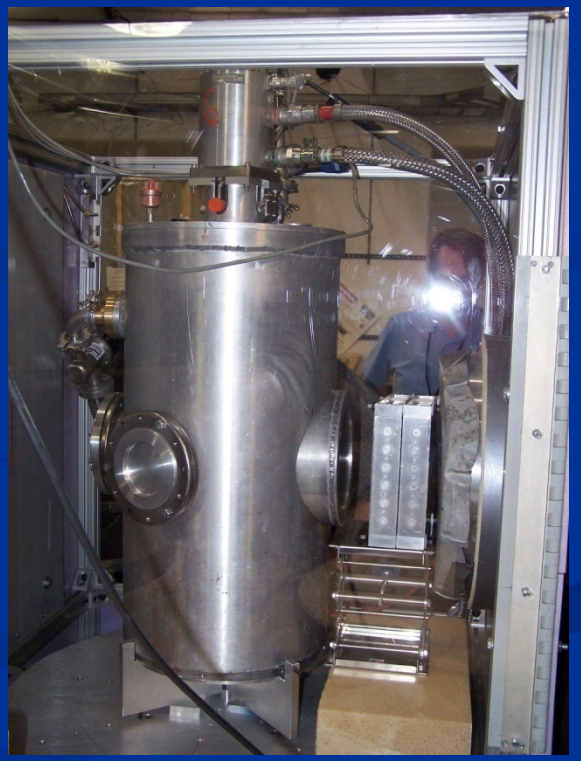
Emission Time measurements



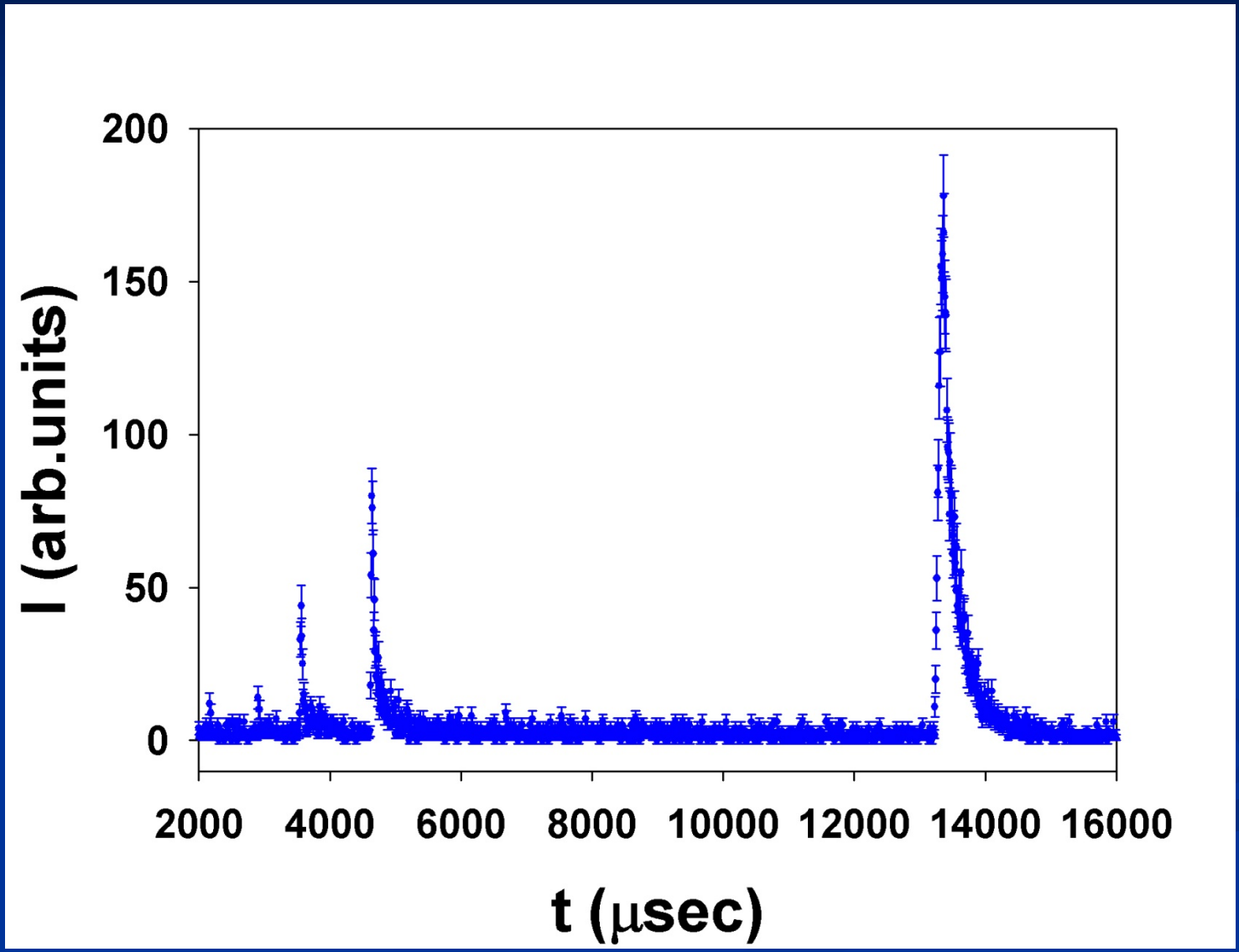
Emission time Expt.



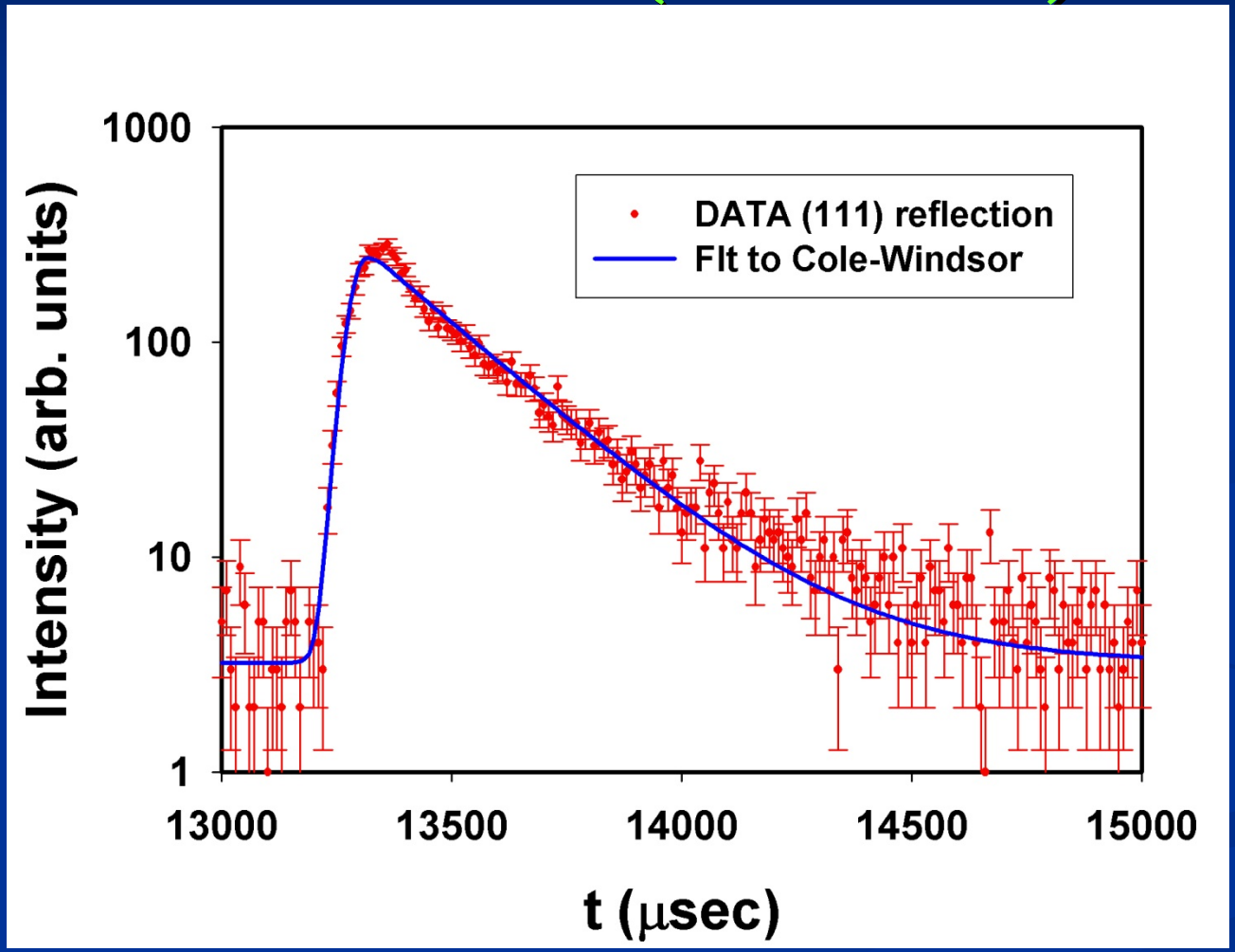




Emission time (H_2; 25 μsec pulse)



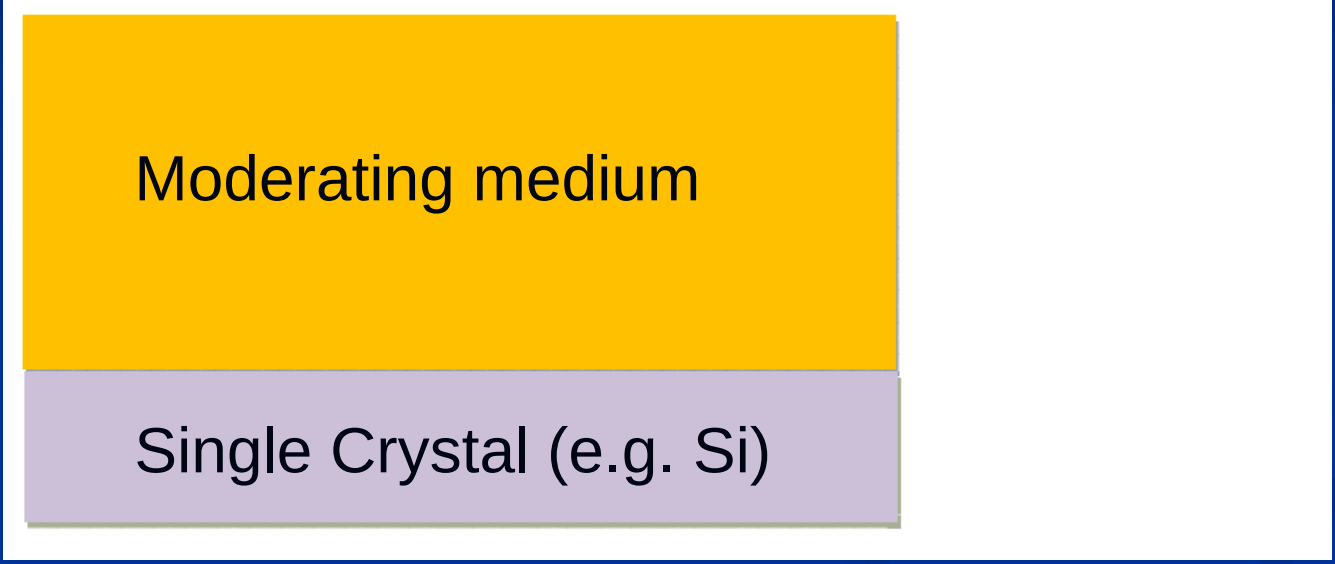
Emission time distribution (2.3 meV)



Parallel fits to simulated data suggest that this moderator was more than 95% para).

We are developing in-situ techniques for independent measurement of O/P ratios to facilitate this line of research.

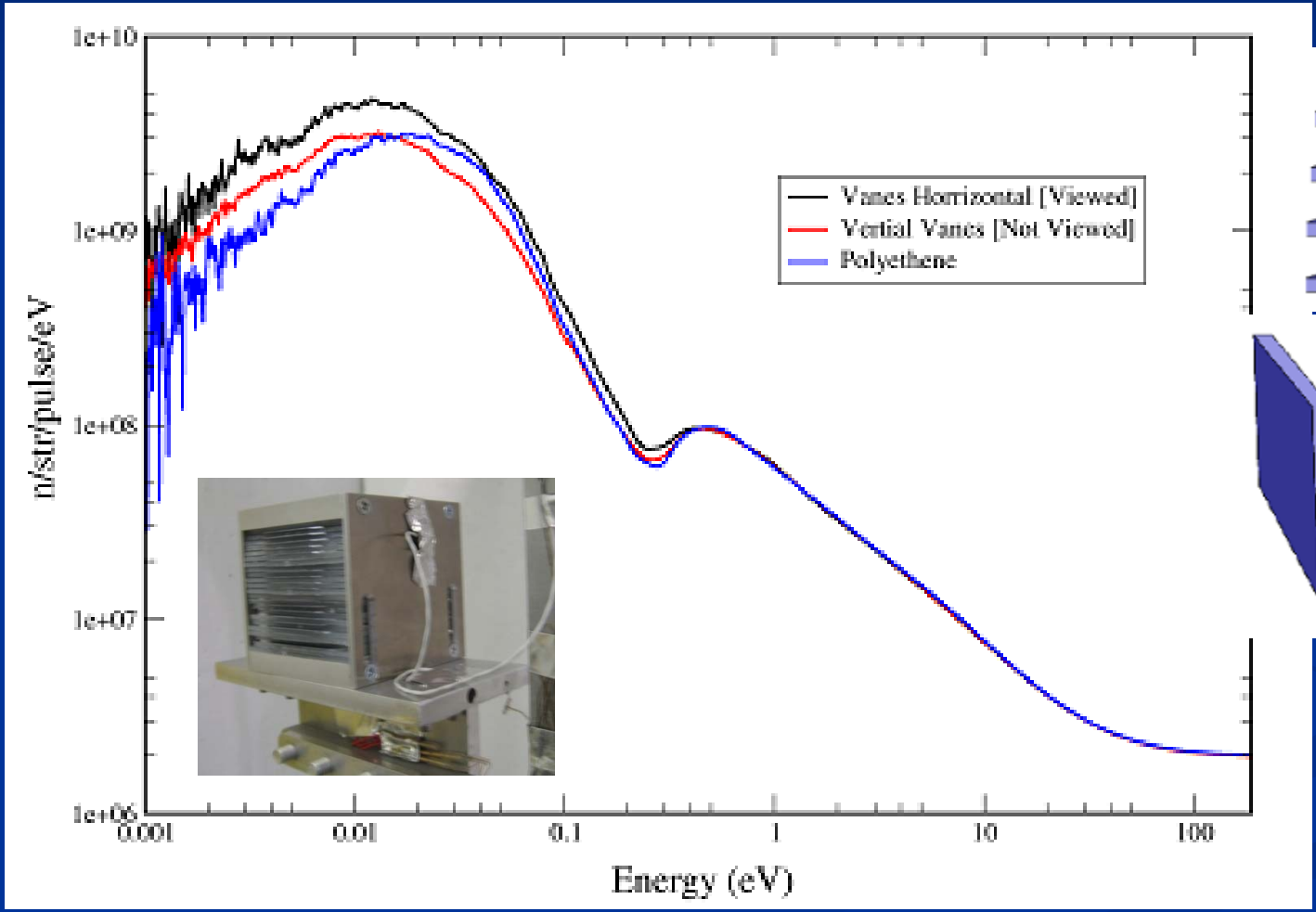
Inhomogeneous Moderators
(a new concept to increase efficiency: S. Ansell)

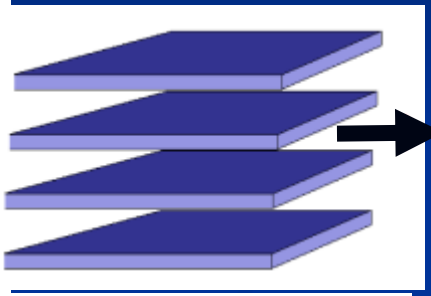


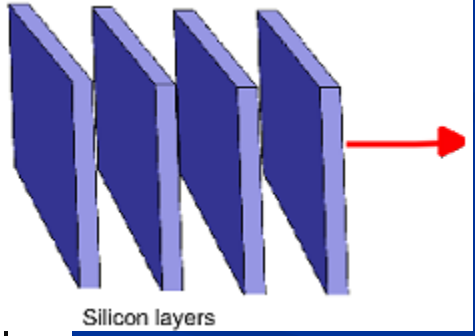
What if you include a single crystal vanes (say Si) inside a moderator (say PE). For cold enough neutrons, the crystal is essentially transparent and provides alternative exit paths from deep within the moderator for neutrons moving roughly in the plane of the vane. It is SELECTIVELY transparent to the neutrons you want in your instruments!

Directional Moderators: Si/PE

(the future?)

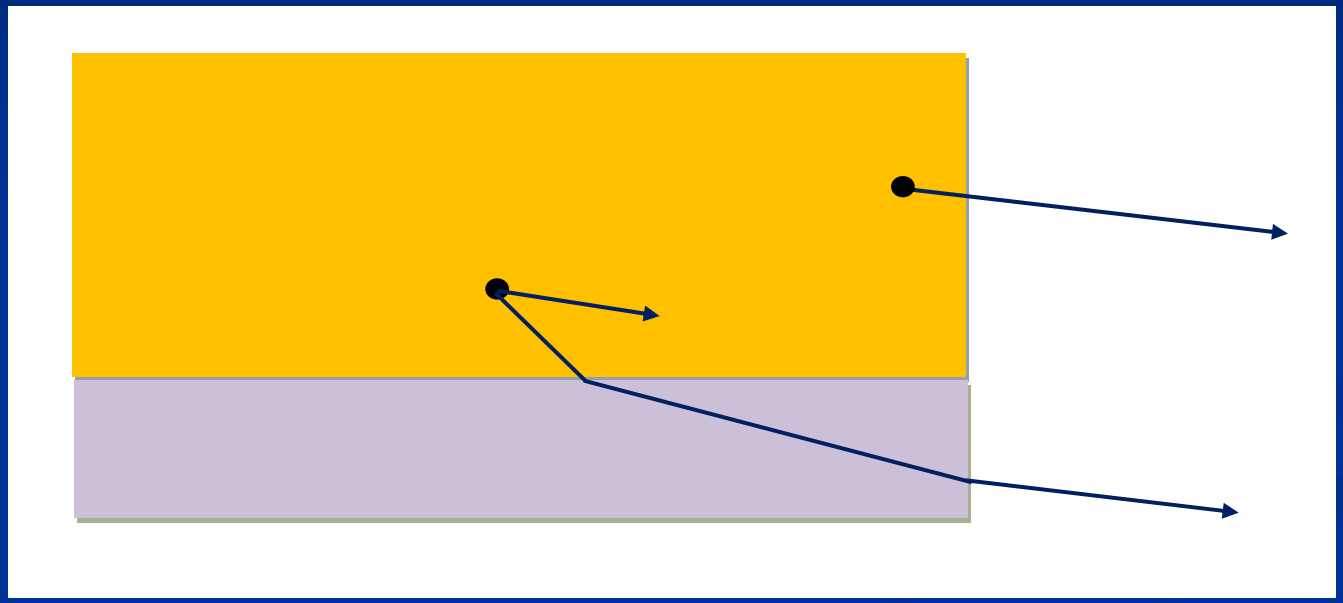






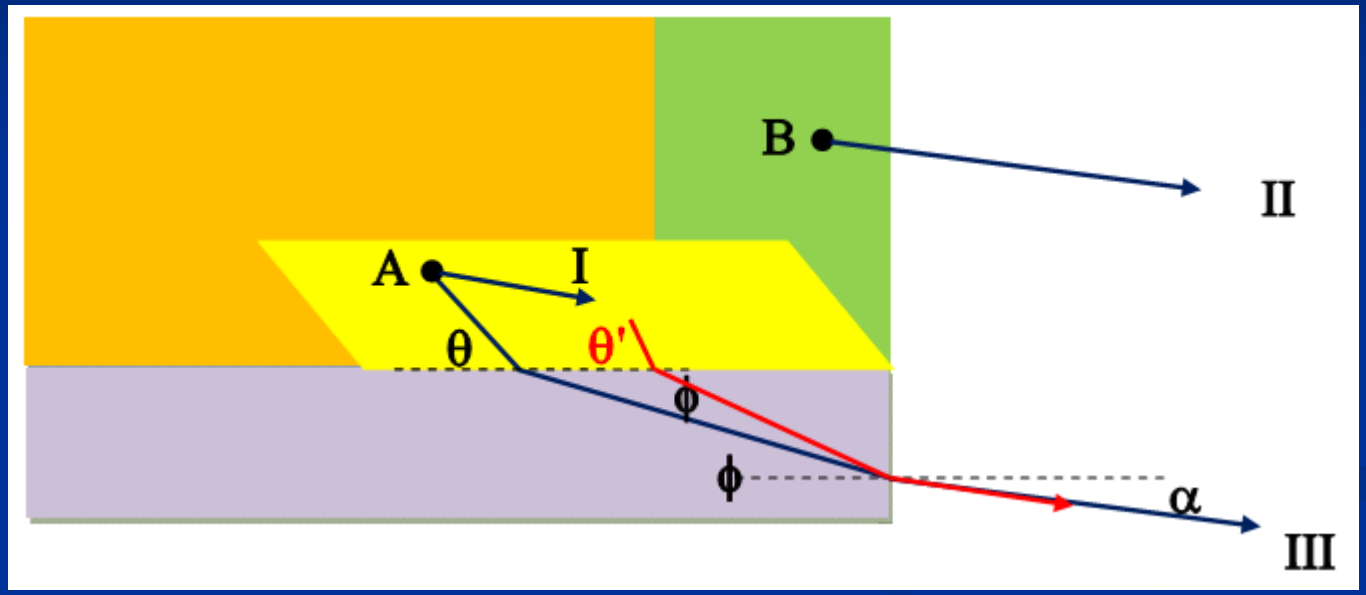
Ansell et al. in preparation.

What is going on?



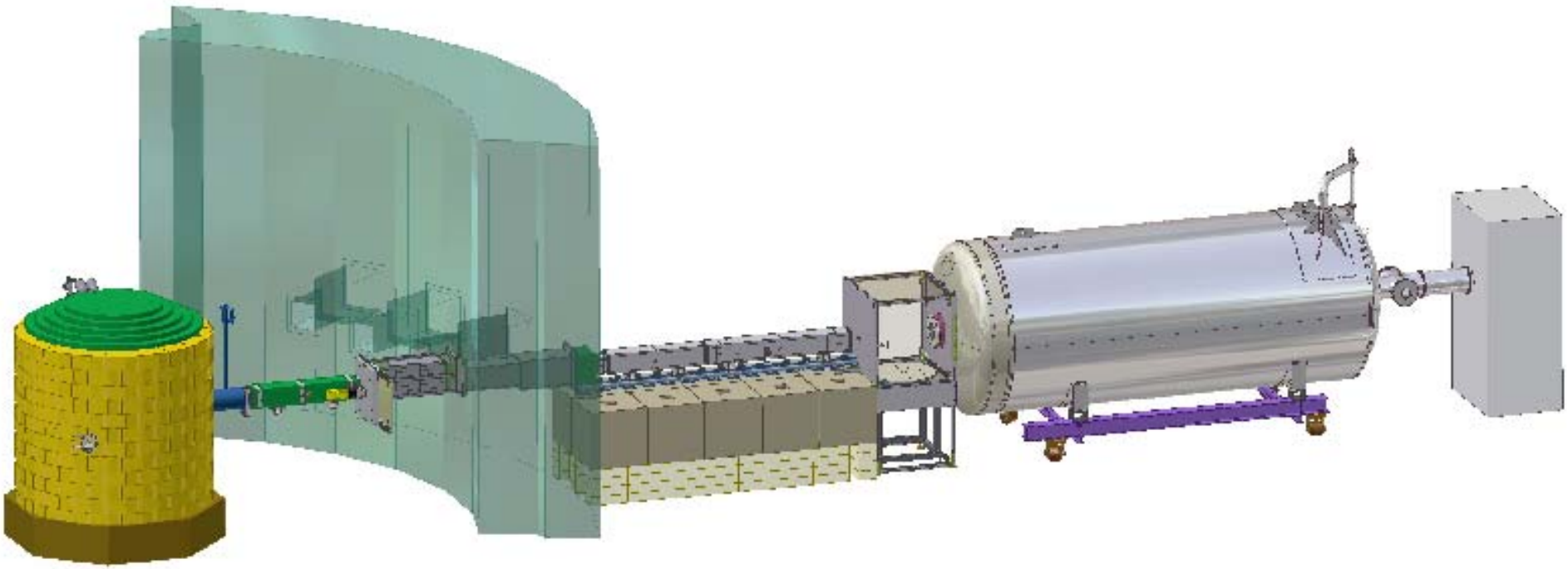
What if you include a single crystal vanes (say Si) inside a moderator (say PE). For cold enough neutrons, the crystal is essentially transparent and provides alternative exit paths from deep within the moderator for neutrons moving roughly in the plane of the vane.

What is going on?



What if you include a single crystal vanes (say Si) inside a moderator (say PE). For cold enough neutrons, the crystal is essentially transparent and provides alternative exit paths from deep within the moderator for neutrons moving roughly in the plane of the vane. Moreover, you can get several different angles of incidence contributing to a given exit angle (top face meets hydrogenous material, end meets air).

Effect of vanes on SANS?



We have yet to confirm this effect for a methane moderator, but we see potential for increasing the effective flux at the SANS sample by a factor of 4 or more while simultaneously increasing its Q-range. A factor of 2-3 gain from the moderator (perhaps less, perhaps more), plus another gain of 2, and reduced λ_{min}, as a result of eliminating the Be filter.

Directional Moderators
(the future?)

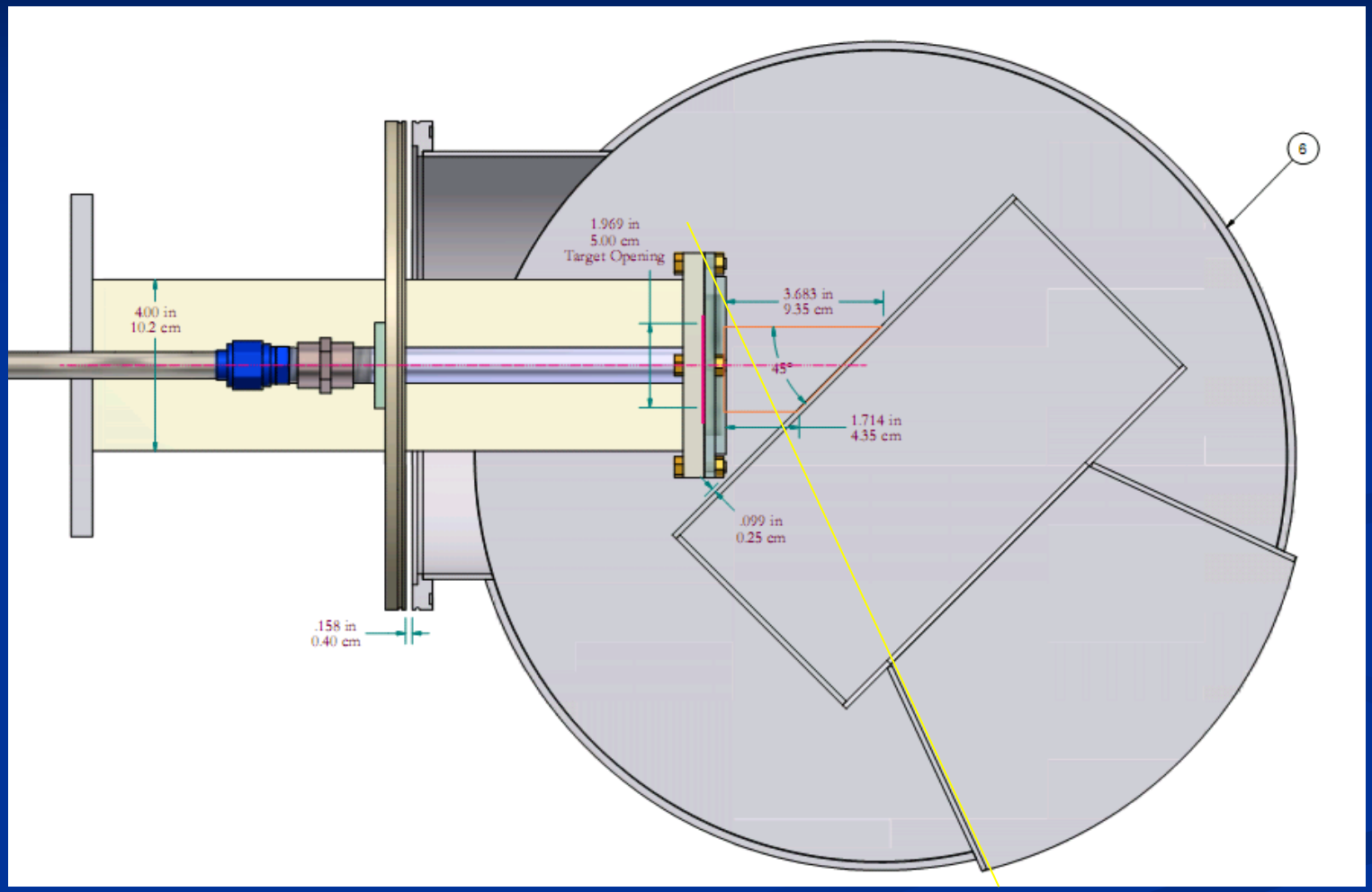
- A gain of as much as a factor of 2 is seen by 6 A for polyethylene
- Even greater gains should appear at longer wavelengths.
- FOR SANS, the gain could be a factor of 5 or more in effective flux AND we would get an expanded Q range.

- One caveat: the optimal thickness for the vaned and monolithic cases will probably be different, our measured ratio is for the same thickness, so the real "gain" may somewhat smaller.

CONCLUSIONS

- LENS has demonstrated a number of capabilities for moving moderator research forward (modeling, prototyping, materials characterization).
- Our simple approach to moderator exchange without remote handling has been clearly validated in several prototyping experiments.
- The vaned moderator concept holds promise for improving the performance of instruments like our SANS by a factor of from 3 to 5 and should be considered for any small neutron source.

New Target Configuration



SANS instrument no longer views the illuminated portion of the target directly! Together with a thicker moderator, this should obviate the need for the Be filter