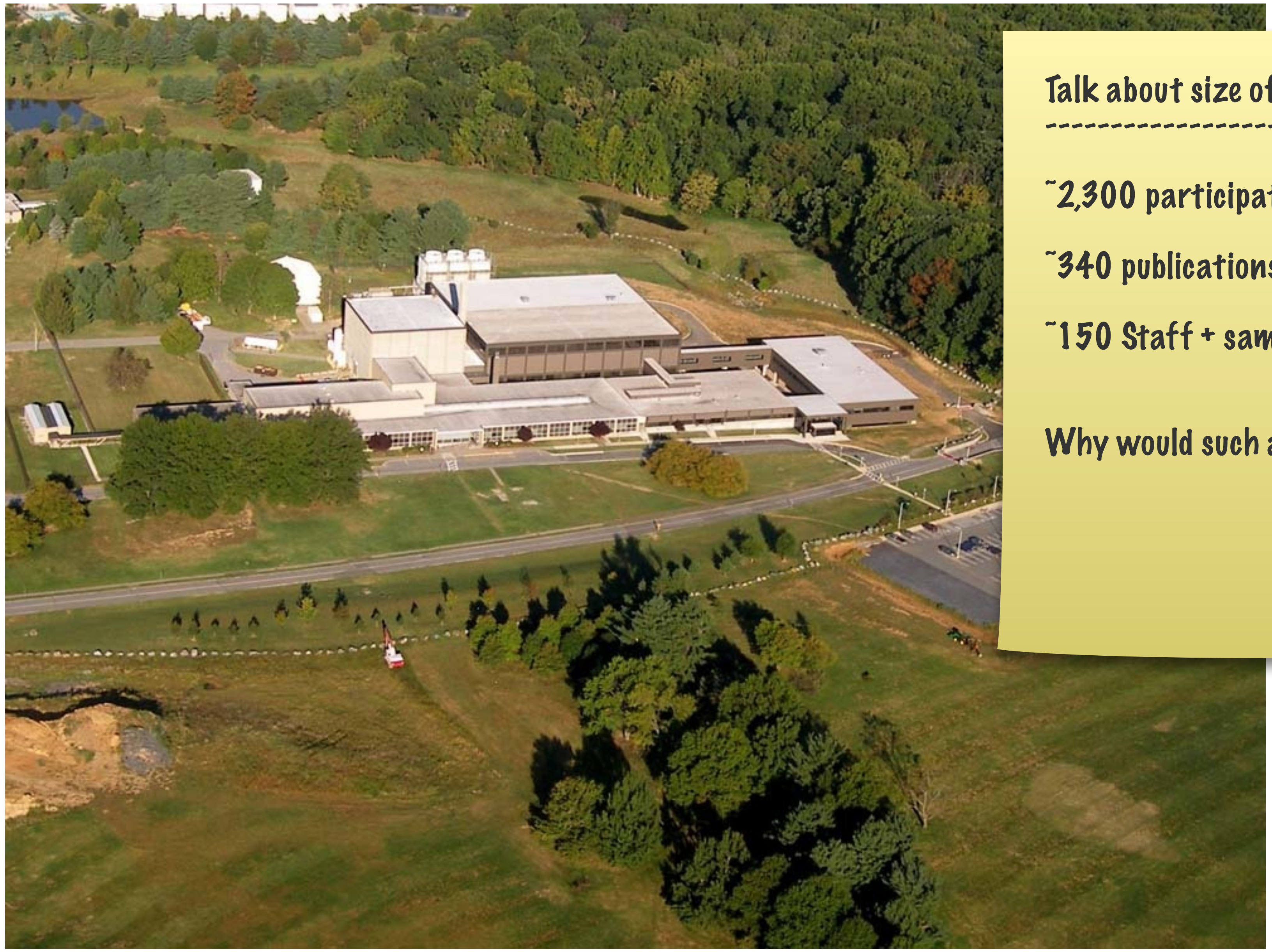
Opportunities at the National Institute of Standards and Technology



Talk about size of NCNR

~2,300 participates /year

~340 publications/ year

~150 Staff + same postdocs

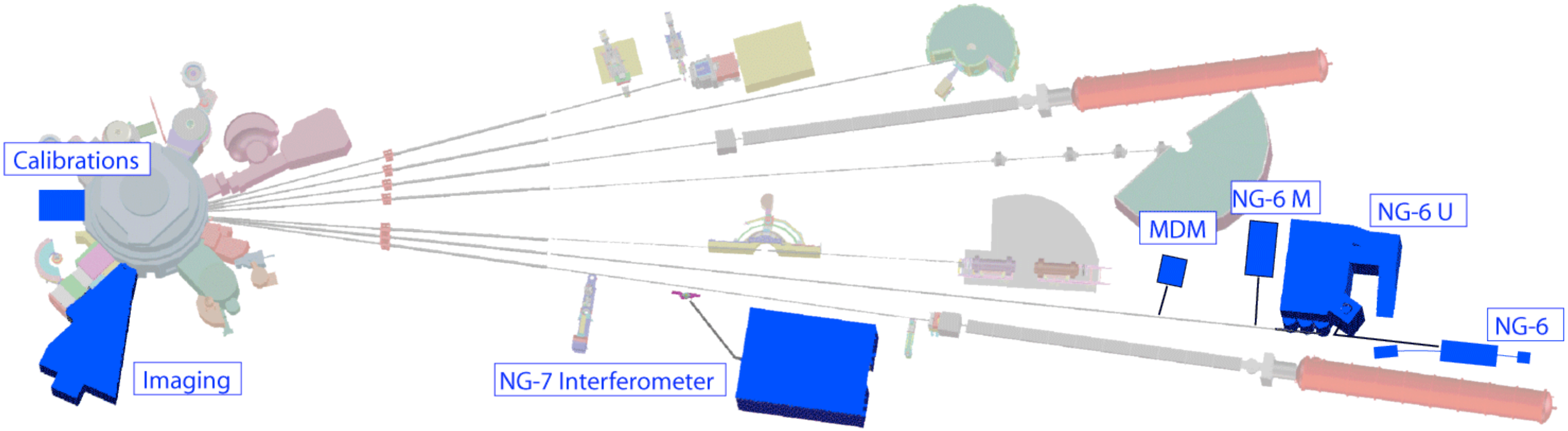
Why would such a facility exist?

Pieter Mumm
National Institute of Standards and Technology

NIST Center for Neutron Research

NIST

Neutron Nuclear/Particle Physics at the NCNR



Current Facilities (9 Neutron Beam lines)

NG-6U	UCN neutron lifetime
NG-6	Radiative decay of Neutrons
NG-6M	Absolute neutron fluence (τ_n)
	n-Beam for ^{3}He polarization
NG-6A	Magnetic dipole moment
	LAND Detector
NG-7	Neutron charge radius
	n-^{3}He scattering length
	QIP
Laser Labs	^{3}He Research and Cell

Fabrication (2)

BT-2	Neutron Imaging (Thermal)
TC3	Device calibrations (3 Thermal Beams)
^{252}Cf	Homeland Security
Mn Bath	n-Source Calibrations

Then my group....

9 Staff
9 beamlines

Who We Are.

- Nine scientists and two technicians
- Typically about twenty resident guest researchers, post docs, and students at any given time
- Extensive outside collaborations

Major collaborators

Universities

University of California – Berkeley
DePauw University
George Washington University
Valparaiso University
Hamilton College
Harvard University
University of Hawaii
Indiana University
University of Maryland
MIT
University of Michigan
North Carolina Central University
North Carolina State University
University of N. Carolina – Wilmington
University of Notre Dame
University of Tennessee
Tulane University
University of Washington
University of N. Carolina – Chapel Hill
Georgia State University
Arizona State University

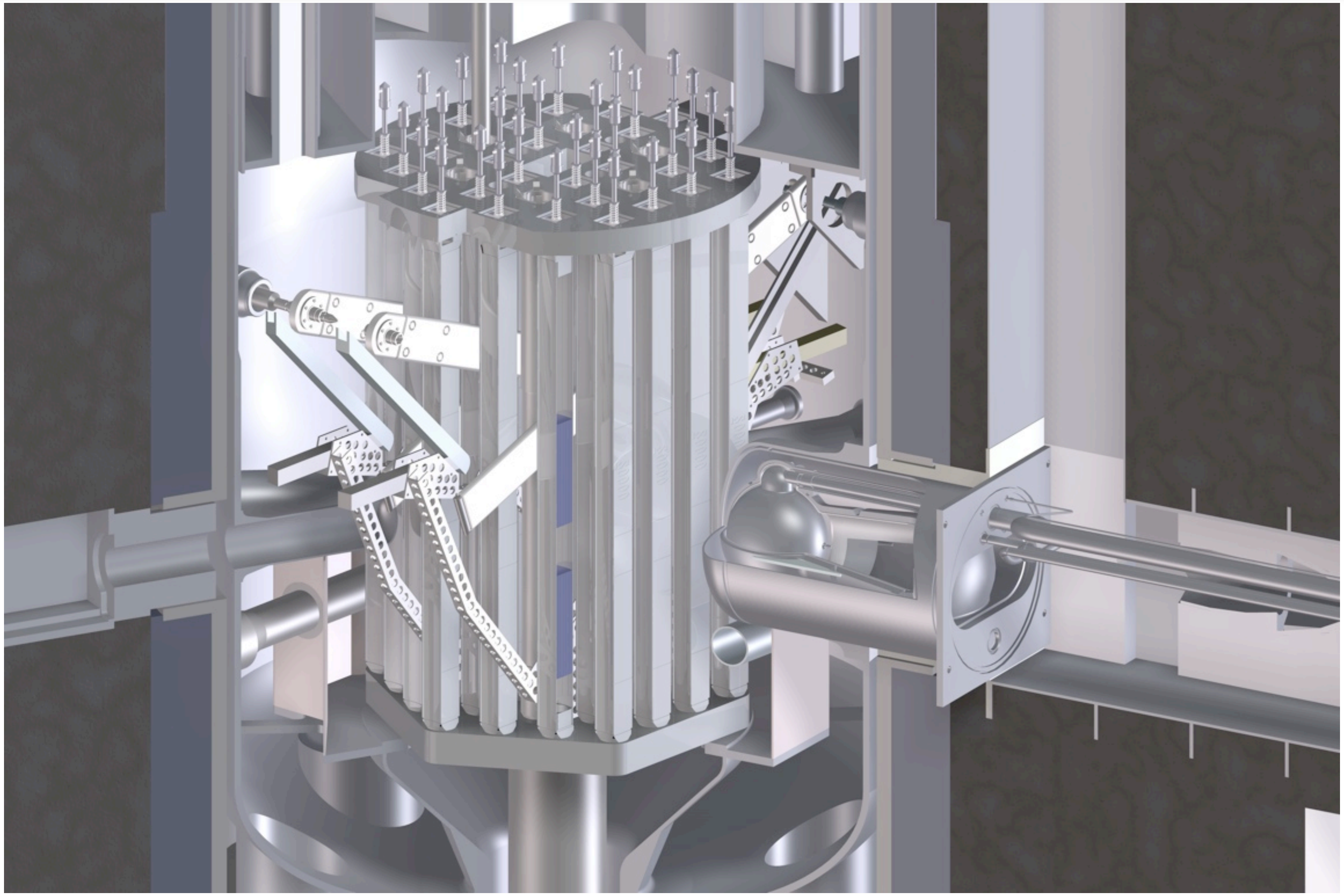
Foreign

Institute Laue Langevin – France
Hahn-Meitner Institute – Berlin, Germany
IRMM – Belgium
Kurchatov Institute – Russia
University of Melbourne – Australia
Nuclear Physics Institute of CAS – Czech Republic
Petersburg Nuclear Physics Institute – Russia
Scottish Universities – UK
Technical University Munich – Germany
University of Sussex – UK
Institute for Nuclear Research – Moscow, Russia

National Labs

Argonne National Laboratory
Lawrence Berkeley National Laboratory
Los Alamos National Laboratory
Oak Ridge National Laboratory

Cold Neutron Beams at the NIST Center for Neutron Research (NCNR)



20 MW heavy water reactor dedicated to neutron research

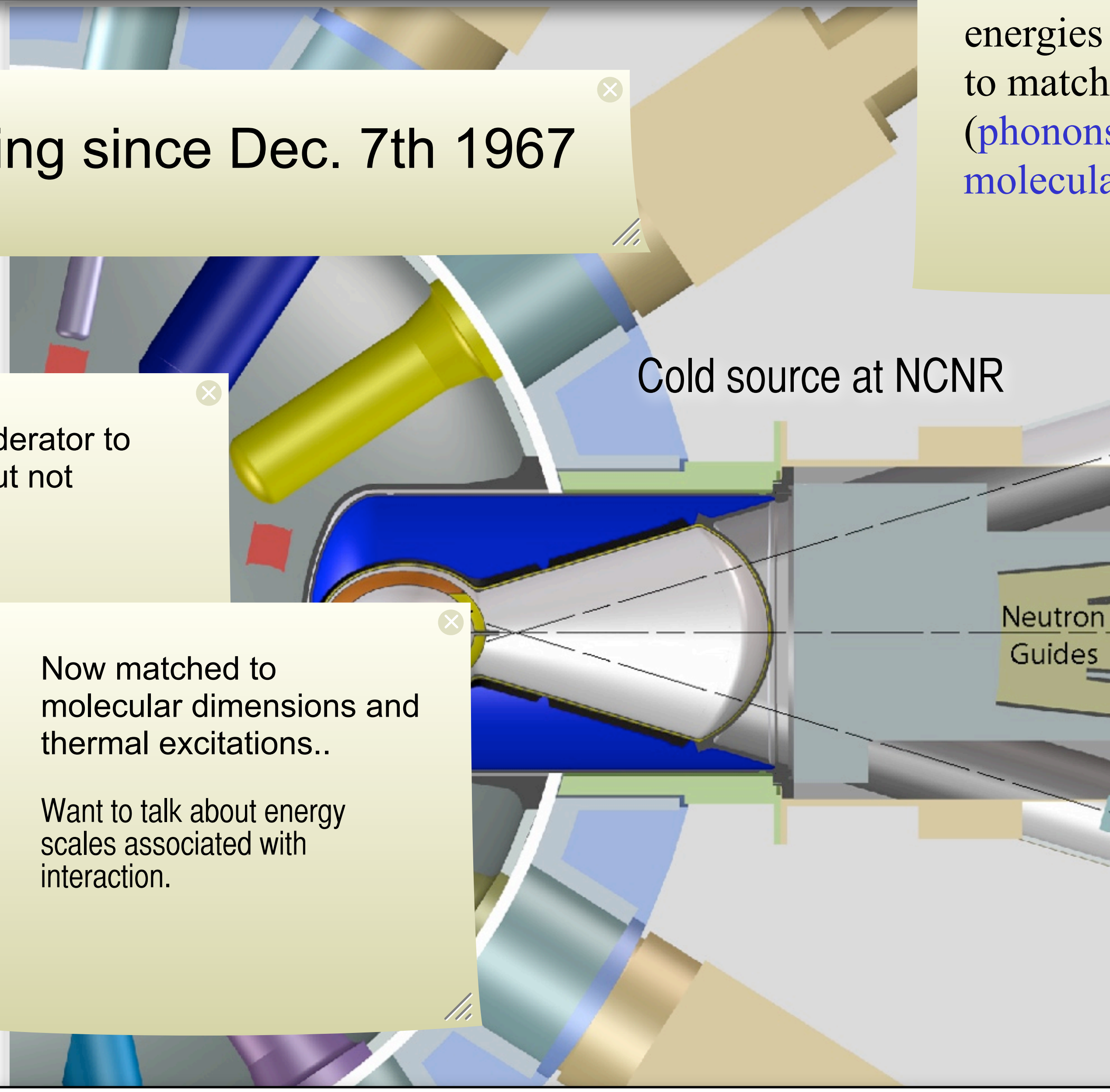
7 Reentrant neutron guides

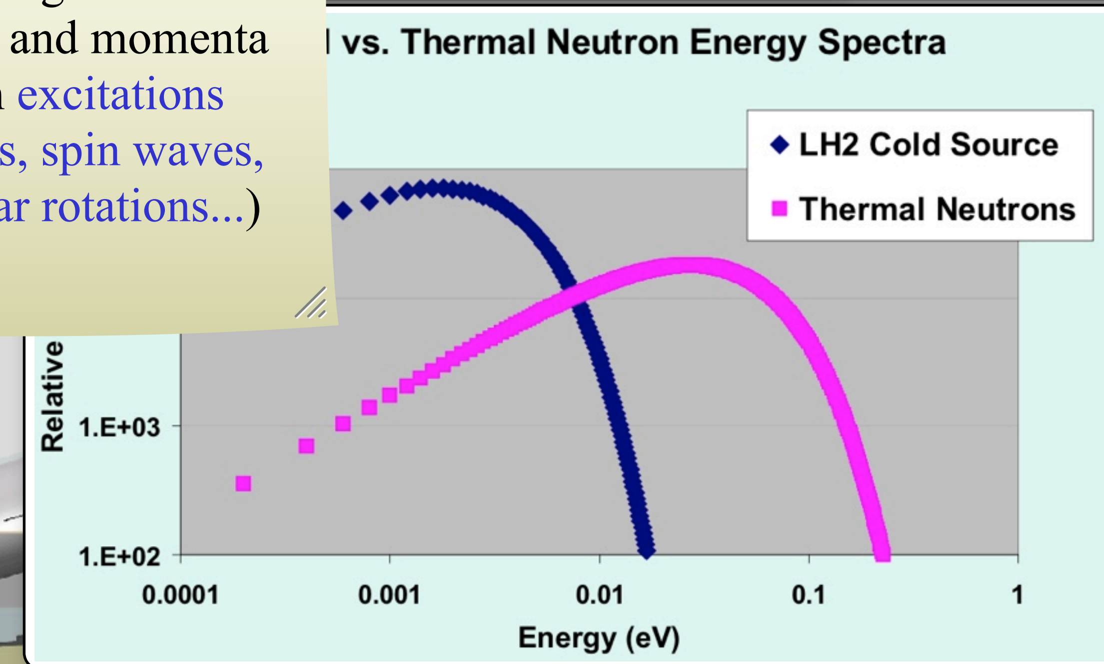
Core density: 3.5 x 10^{14} neutrons s^{-1} cm^{-2}

Why Neutrons? Why/How Cold?

Operating since Dec. 7th 1967

Thermal neutrons have the right energies and momenta to match excitations (phonons, spin waves, molecular rotations...)





Pick your moderator to slow down, but not absorb.

Now matched to molecular dimensions and thermal excitations..

Want to talk about energy scales associated with interaction.

1.6 A
versus
6 A

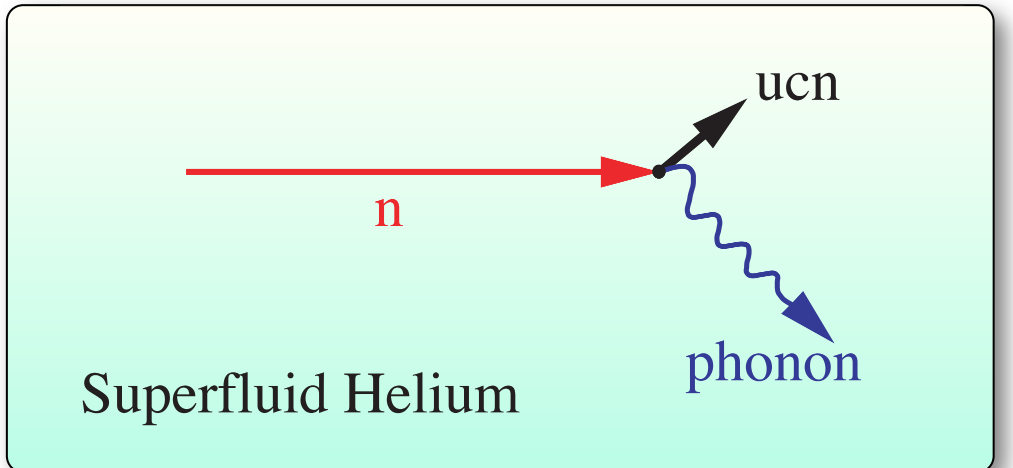
2 meV vs 30 meV

Neutrons partially thermalize in a cold source

- NCNR, liquid hydrogen (~ 20K)

- neutron temp ≈ 40 K
- neutron energy ≈ 3.4 meV
- neutron velocity ≈ 800 m s^{-1}
- neutron flux (typ. ≈ 10^9 s^{-1} cm^{-2})

Superthermal Production

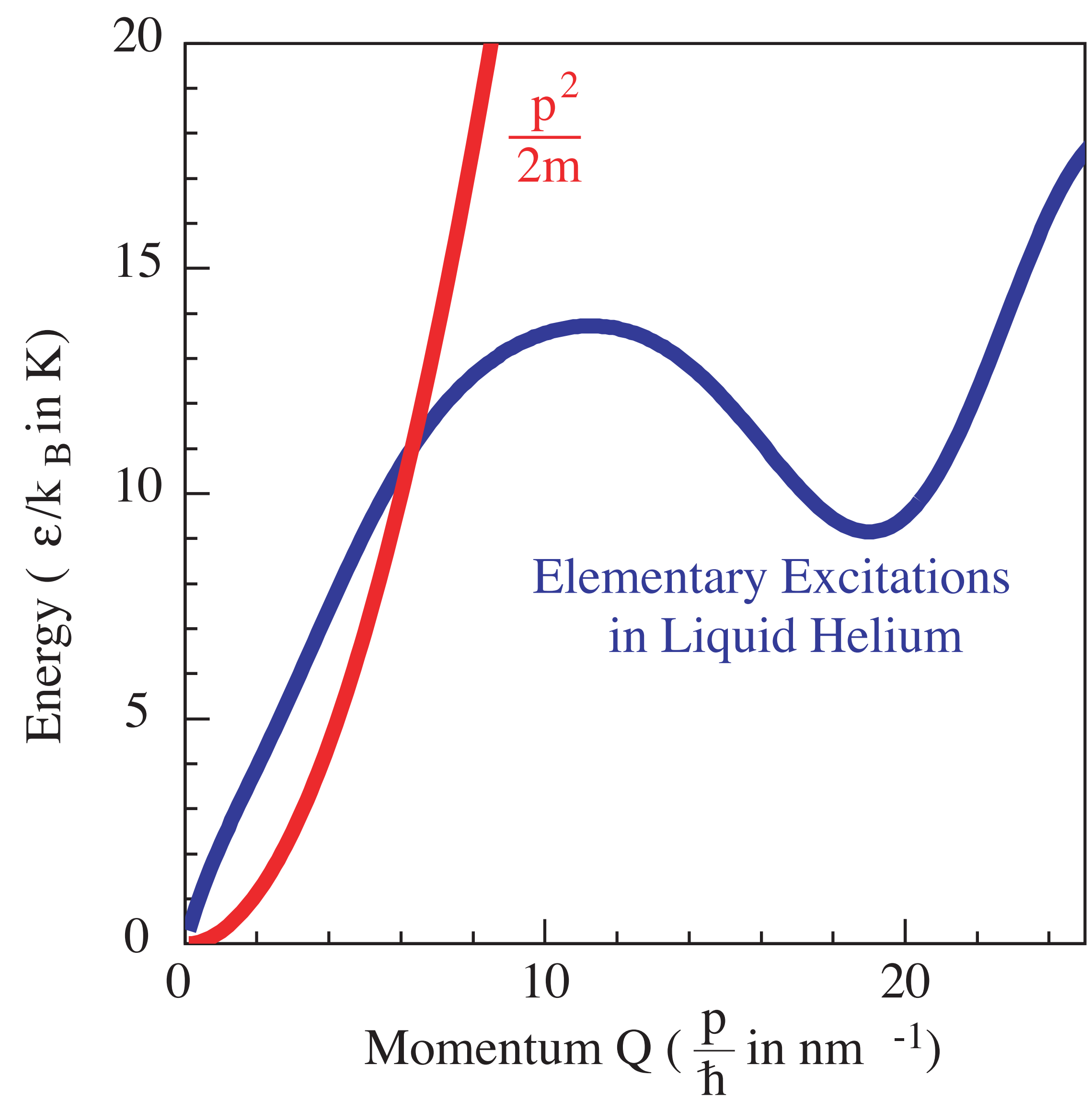


$$\vec{p}_{UCN} = \vec{p}_n - \vec{q}_{phonon}$$

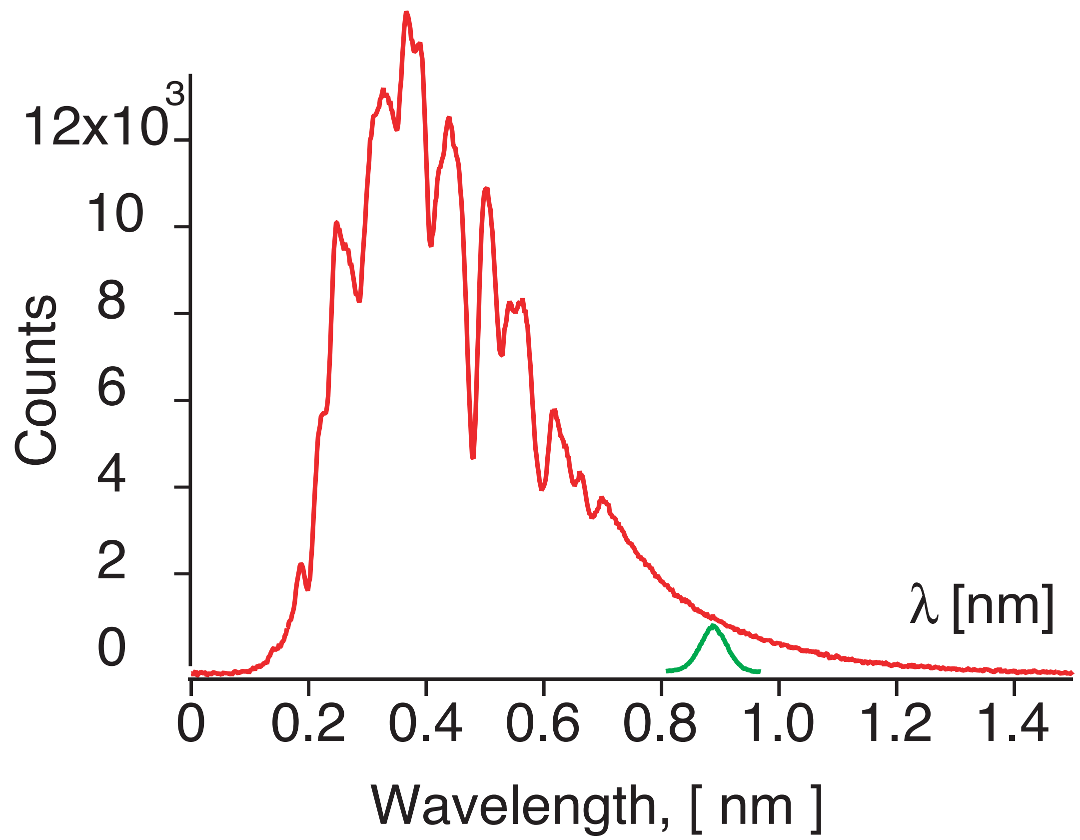
$$E_{UCN} = E_n - E_{phonon}$$

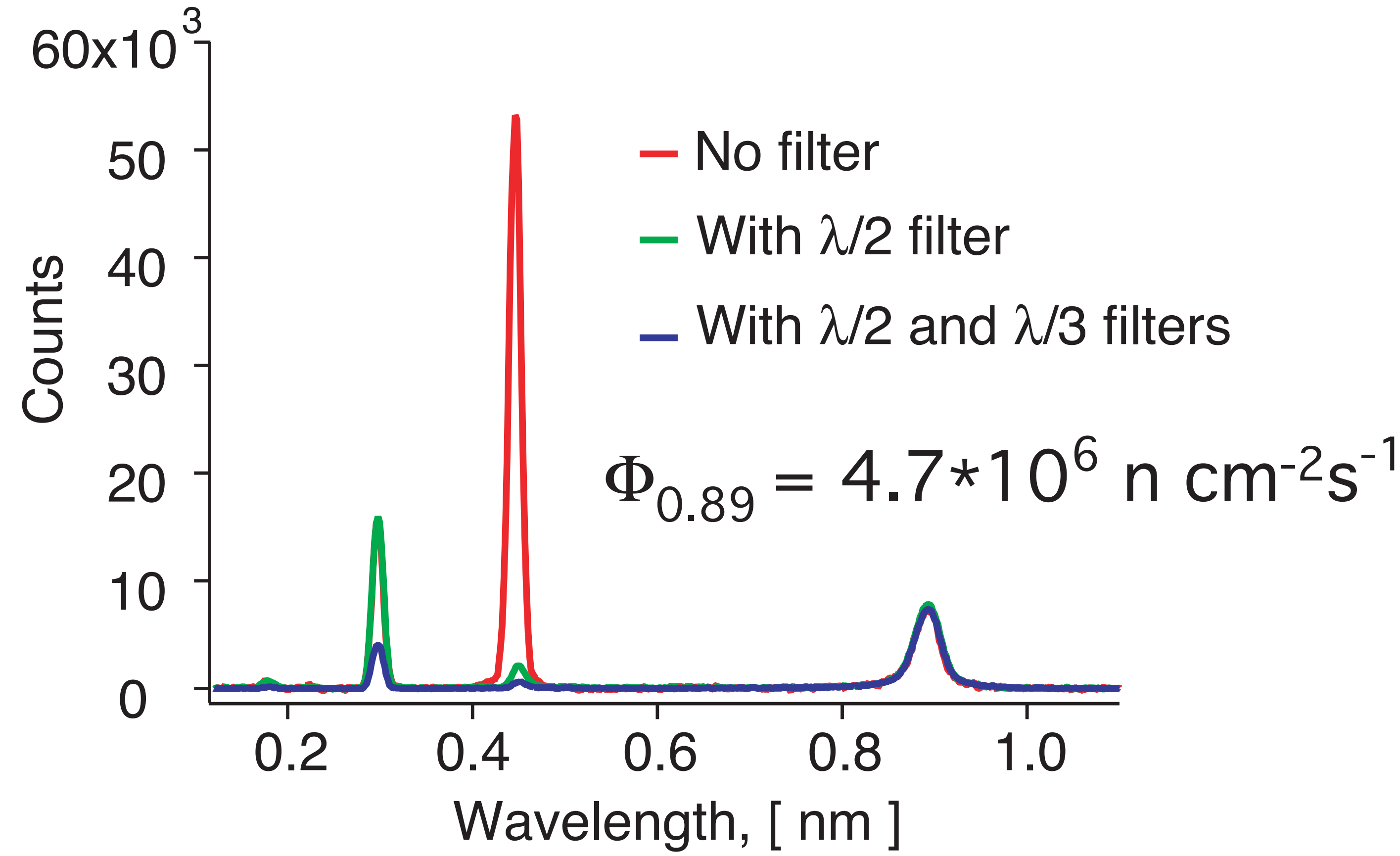
- ~0.95 meV (12 K or 0.89 nm) neutrons can scatter in liquid helium to near rest by emission of a single phonon.

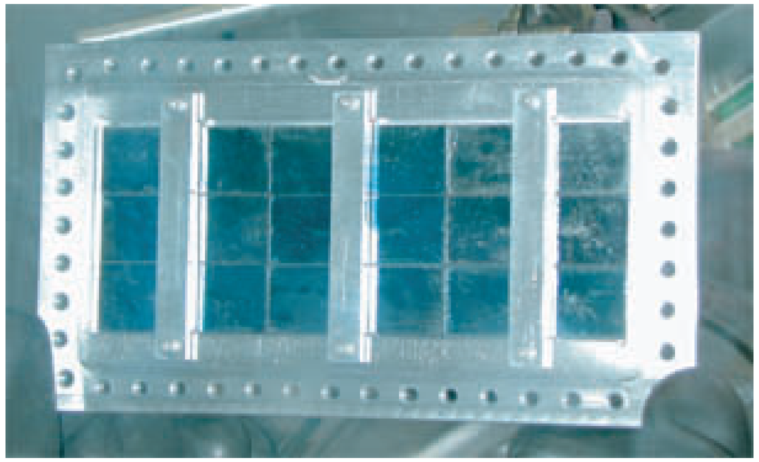
- Upscattering
(by absorption of an 12 K phonon)
∝ Population of 12 K phonons ~ $e^{\frac{-12K}{T_{bath}}}$

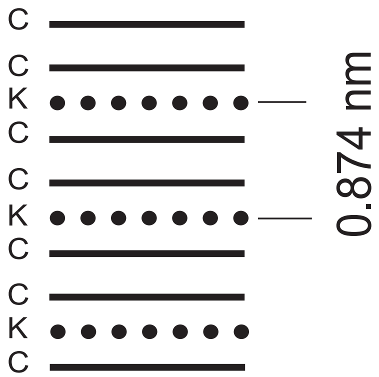


0.89 nm Monochromator

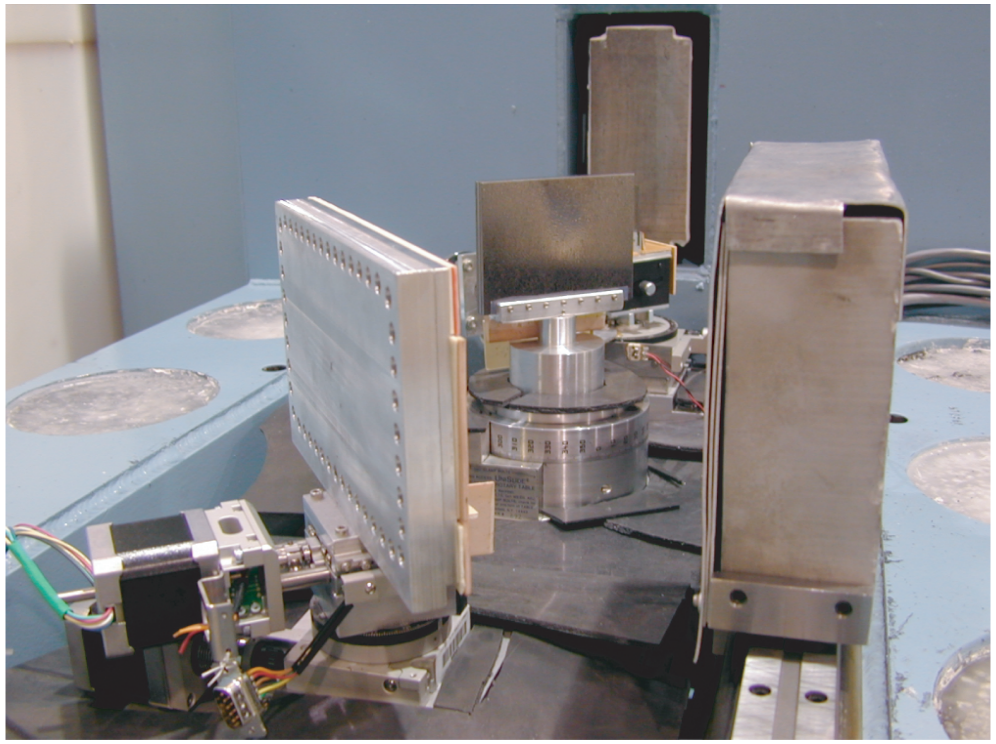




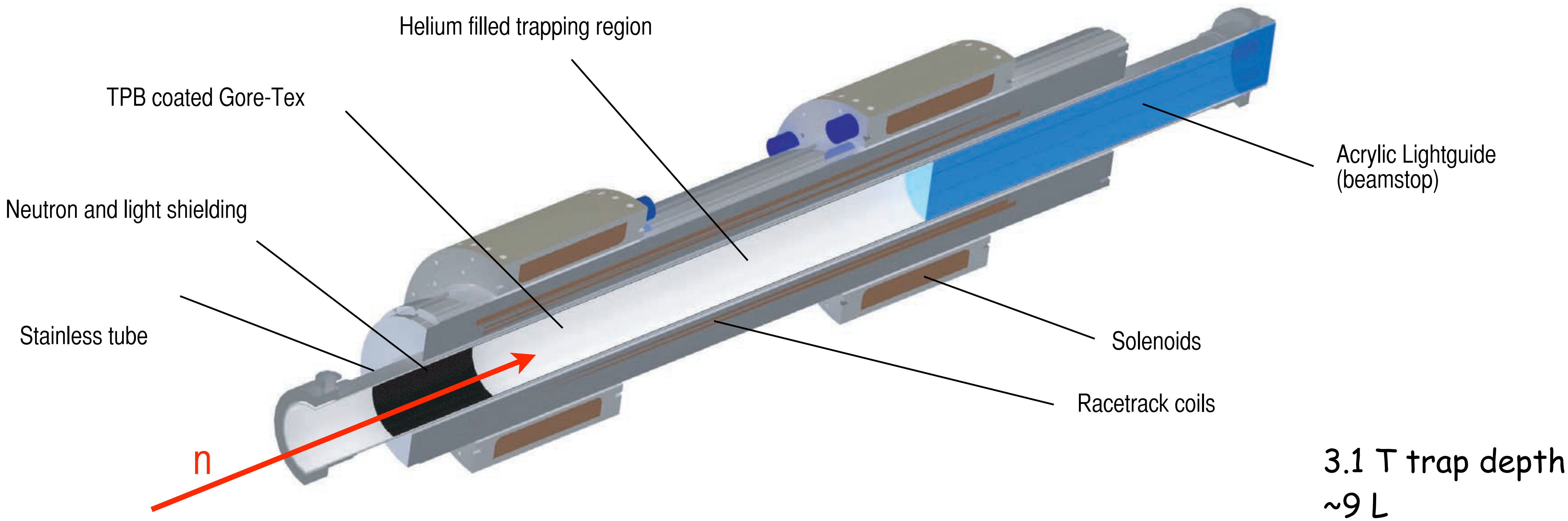


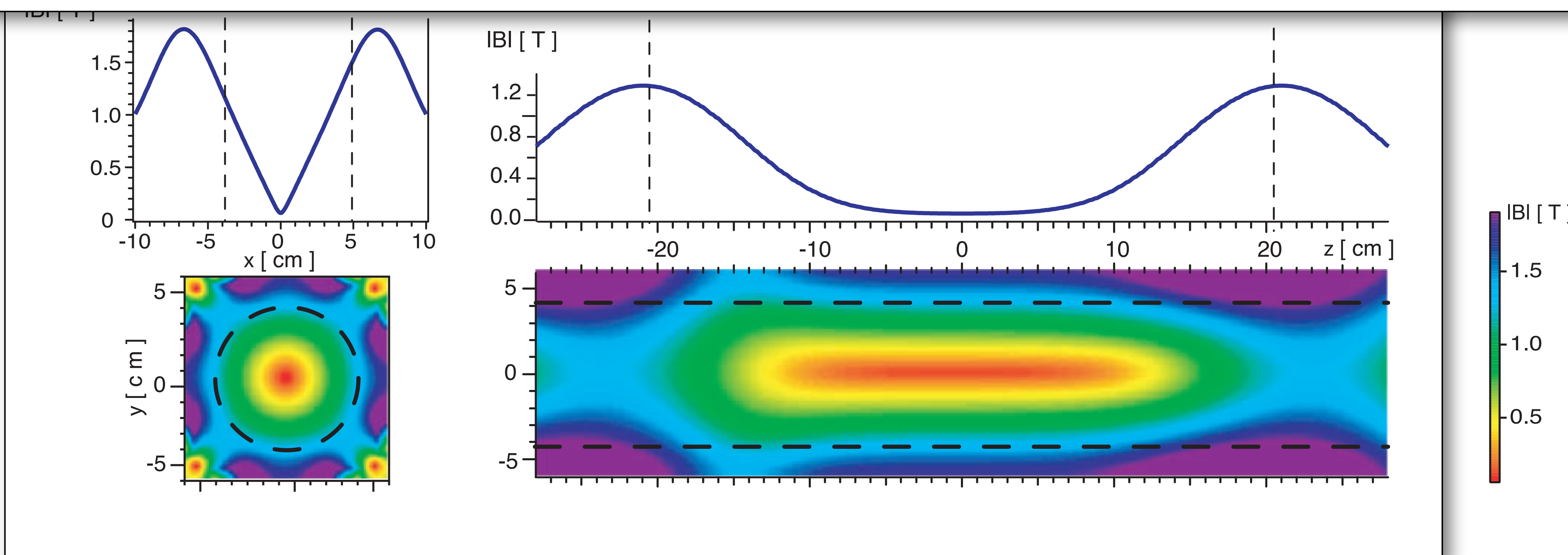


KC_{24} structure

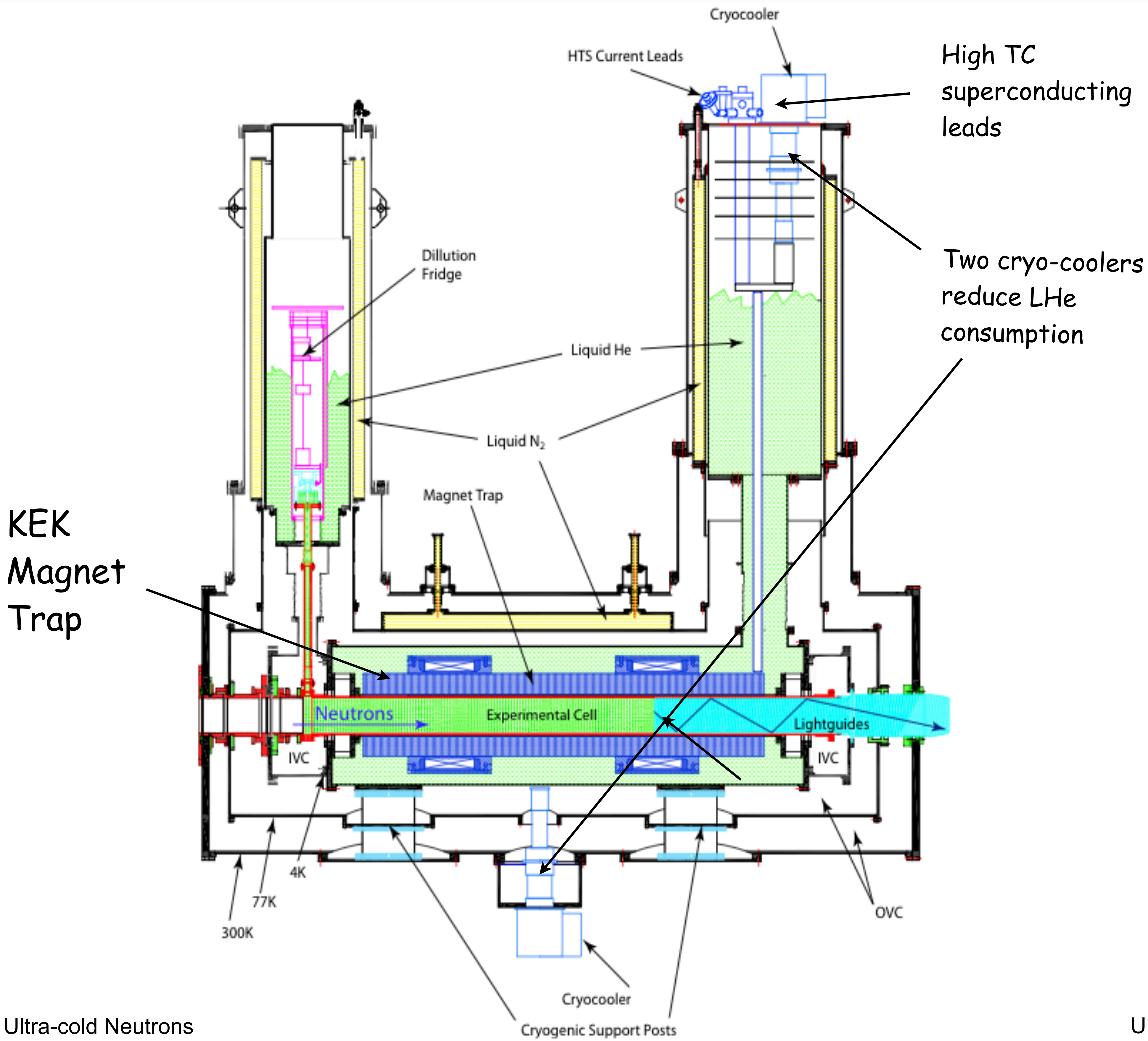


Neutron Lifetime (using an Ioffe magnetic trap)

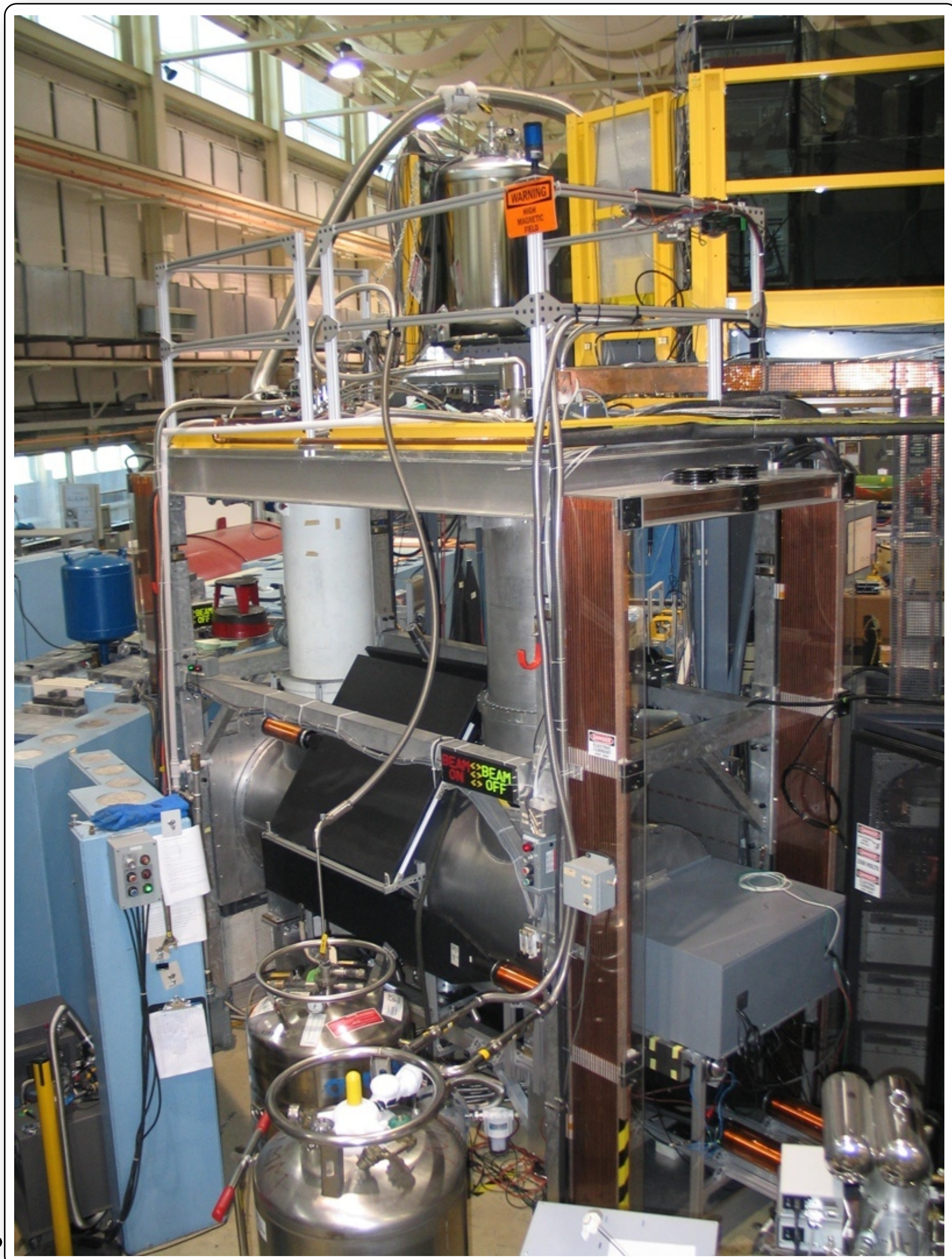


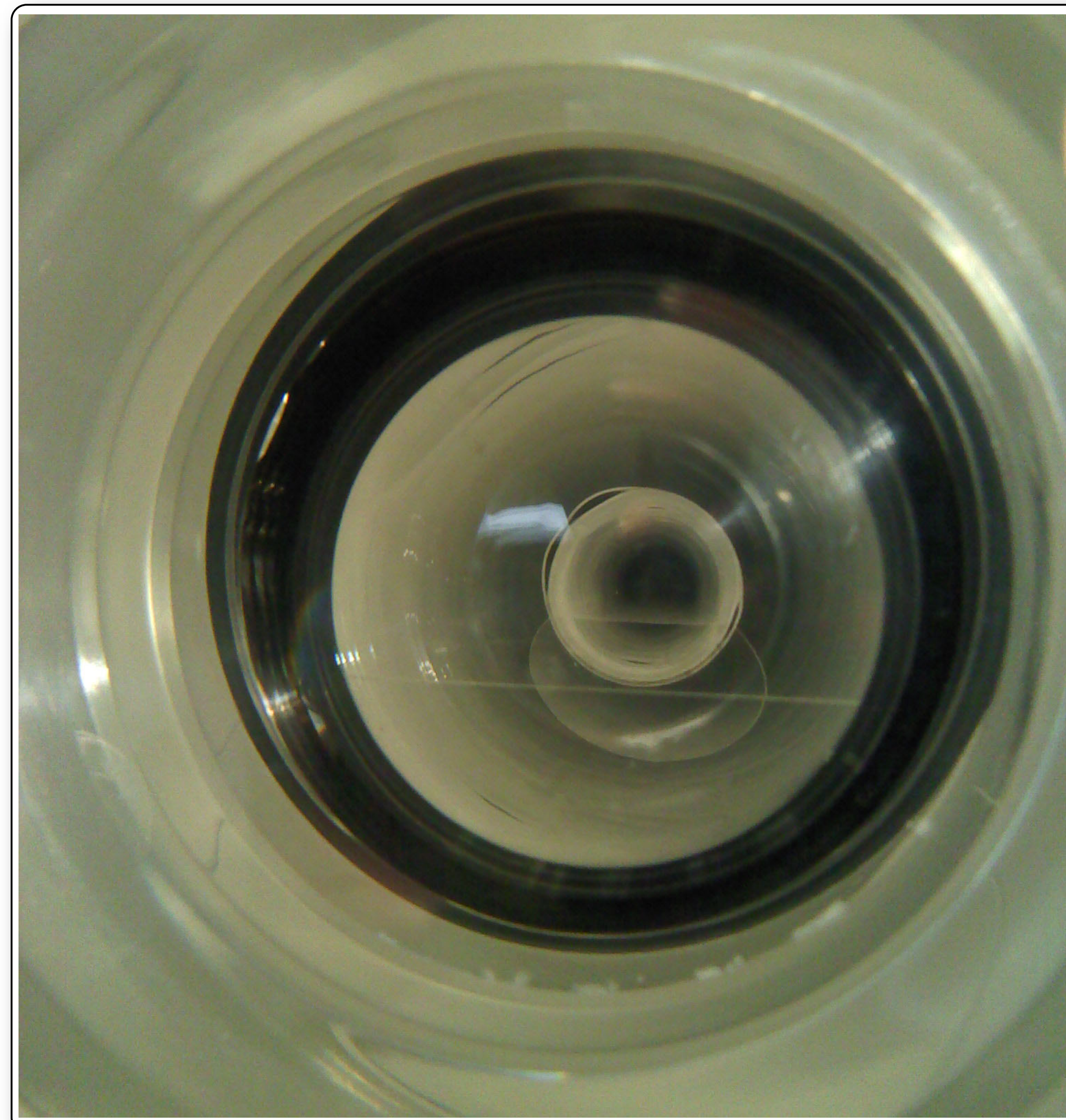


Neutron Lifetime Apparatus



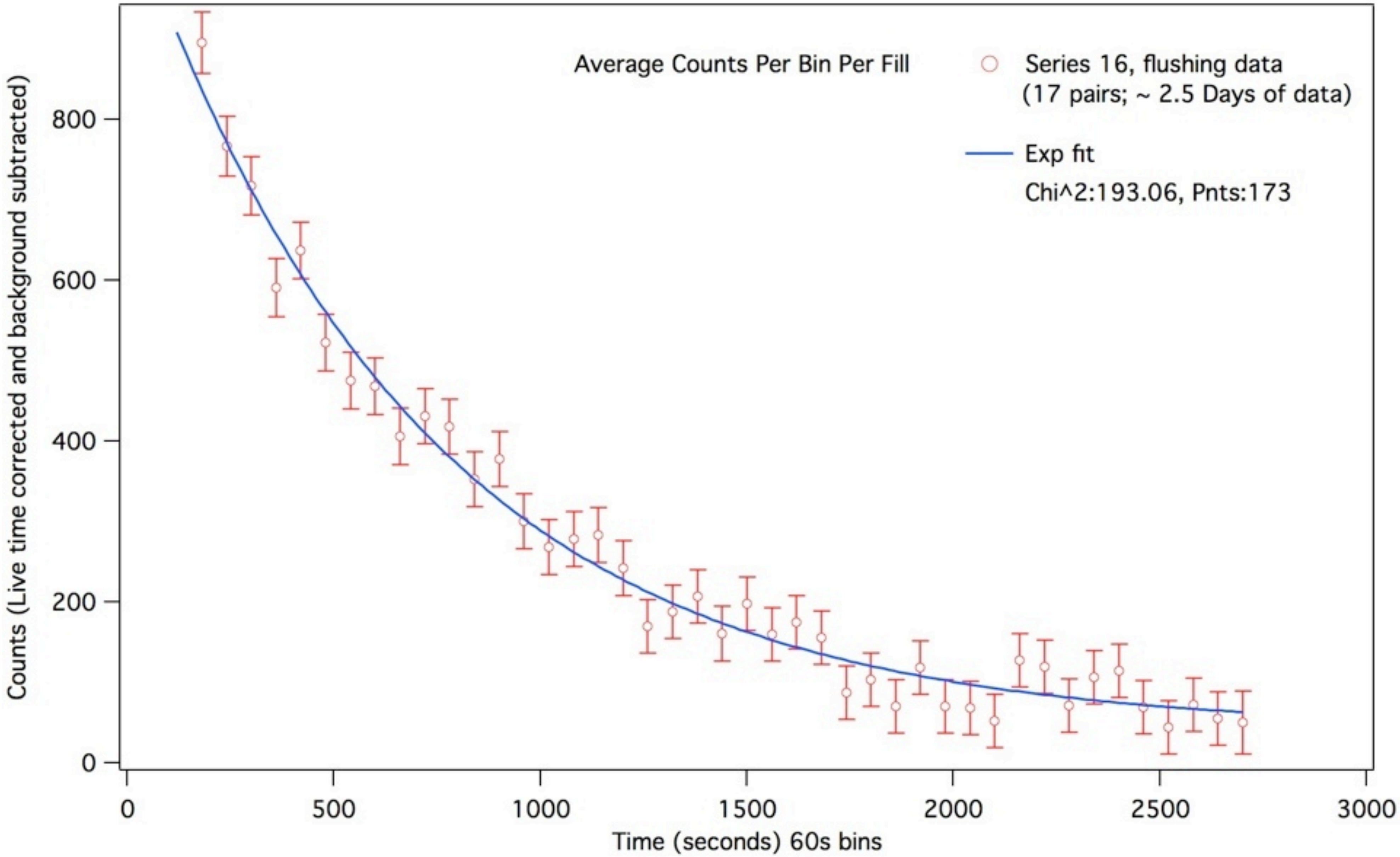
Lifetime Apparatus as it Looks at **NG-6** at NIST





- Ultra-pure Helium in cell

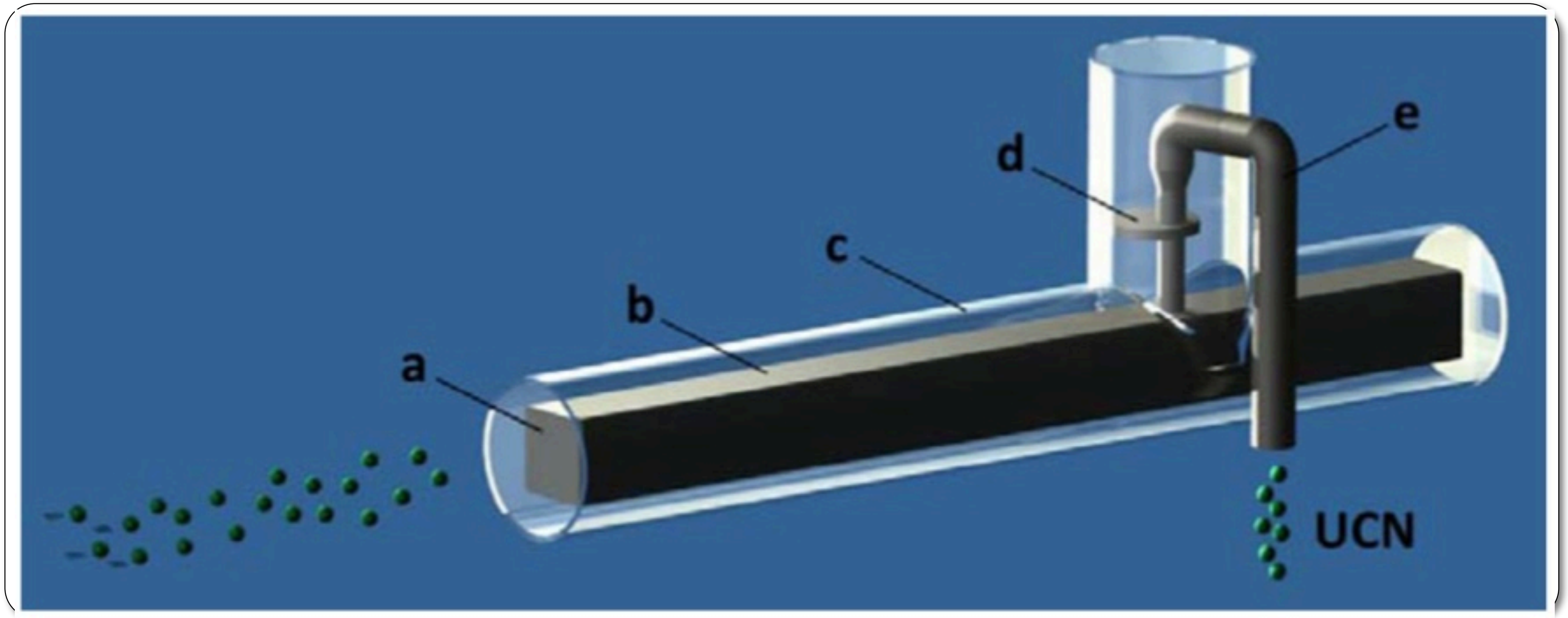
Preliminary Data For UCN Lifetime Expt.



Shown is live-time & gain corrected data for 17 run-pairs

9600 ± 700 decays per fill (within a factor of 2 of expectations)

Institute Laue-Langevin Helium UCN Source

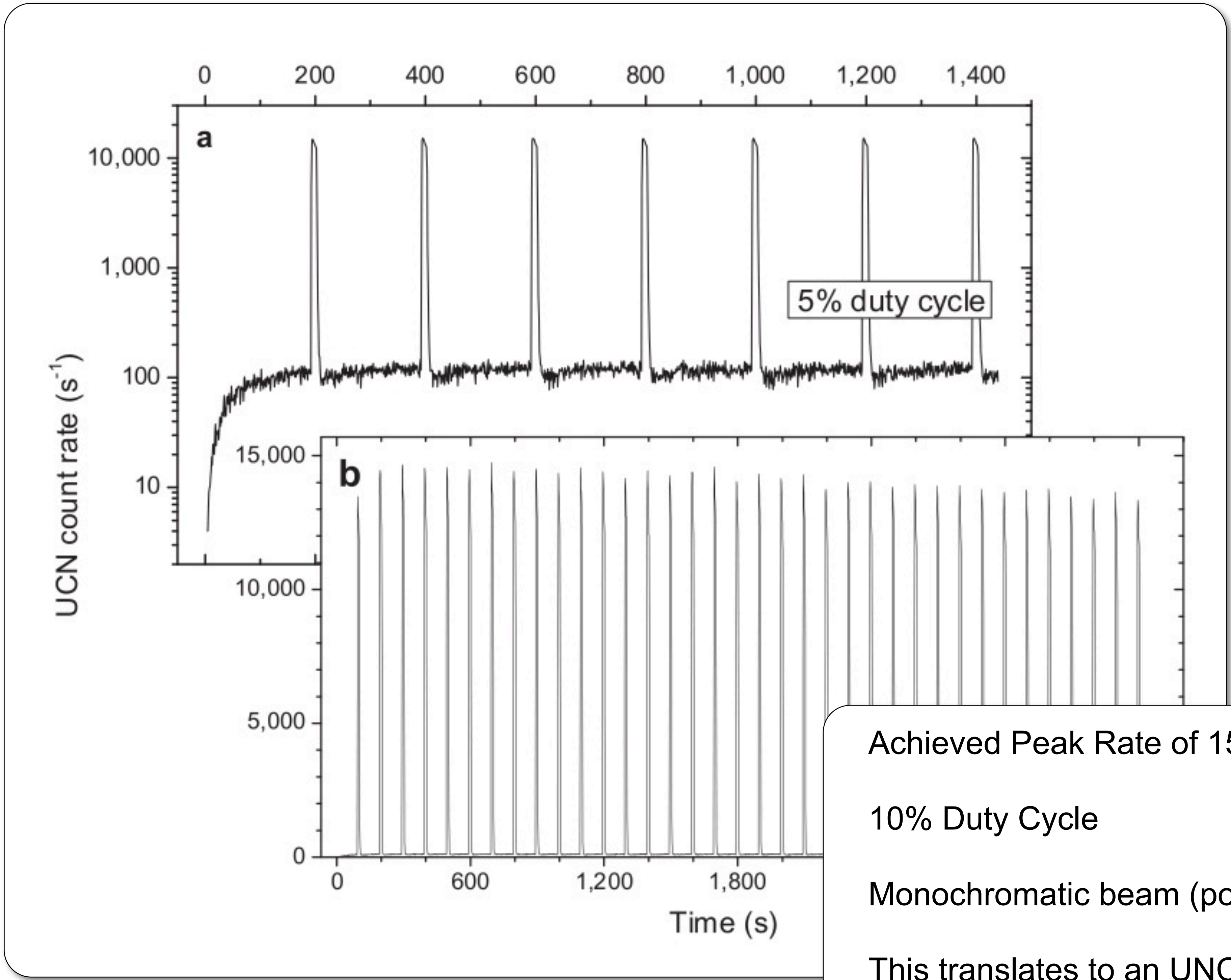


a) Beryllium window
b) Helium vessel (beryllium oxide ceramics, 7 cm x 7 cm x 1m)
d) UCN Valve
e) Stainless extraction guide

9×10^8 n cm^{-2} s^{-1}

DOI: 10.1103/PhysRevLett.107.134801

Recent Upgrade



Achieved Peak Rate of 15,000 UCN/s

10% Duty Cycle

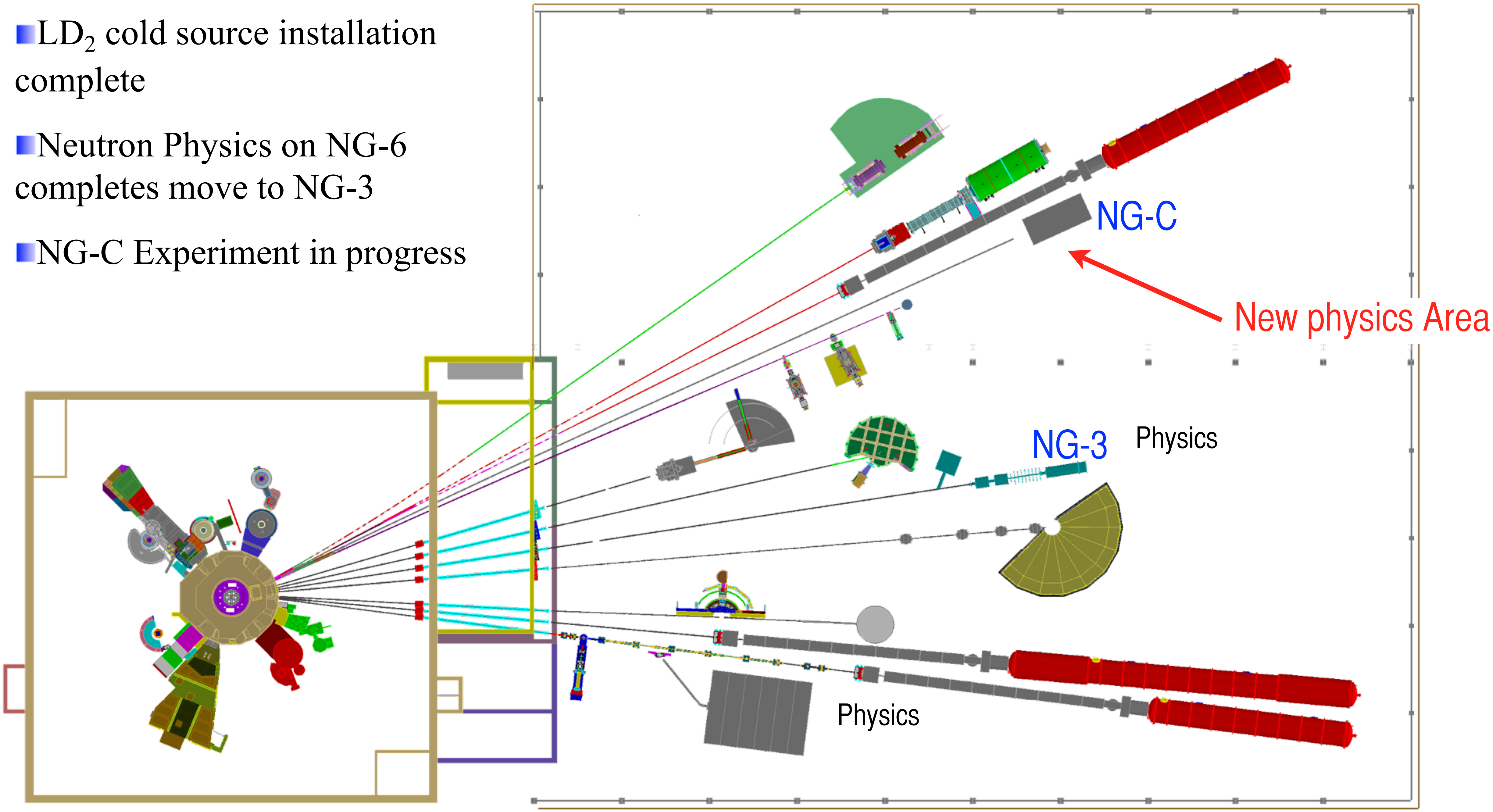
Monochromatic beam (polychromatic is about 2 x)

This translates to an UNC density of 55 cc (usable)

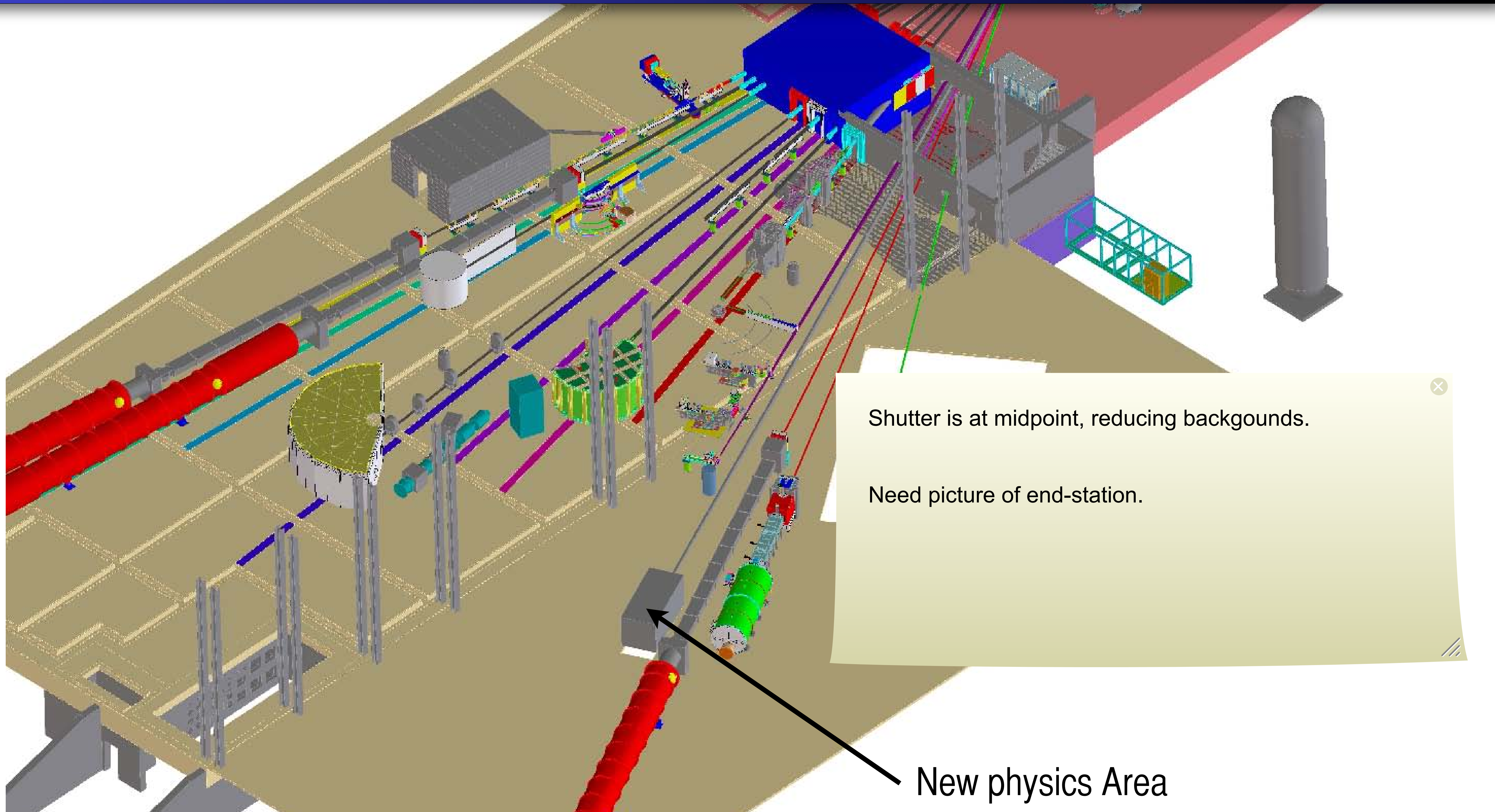
DOI: 10.1103/PhysRevLett.107.134801

Upgrade Complete December 2014

- LD_2 cold source installation complete
- Neutron Physics on NG-6 completes move to NG-3
- NG-C Experiment in progress



NCNR Expansion: Significant Increase in Capability



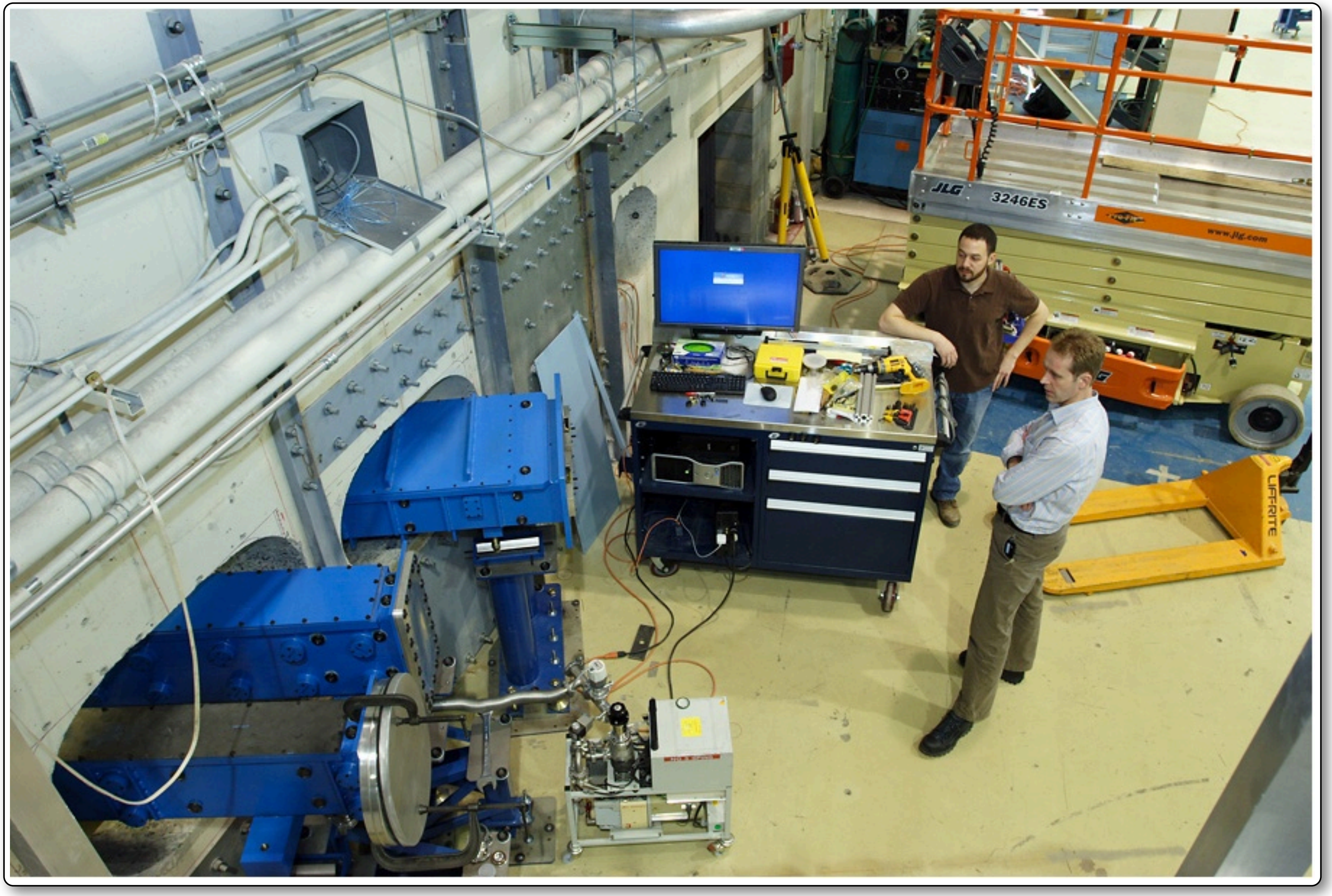
Shutter is at midpoint, reducing backgounds.

Need picture of end-station.

- Full Suite of Power/ air / chilled water (provided)
- Helium recovery system (reduces helium costs slightly/mitigates price fluctuations)
- NIST beamline responsible

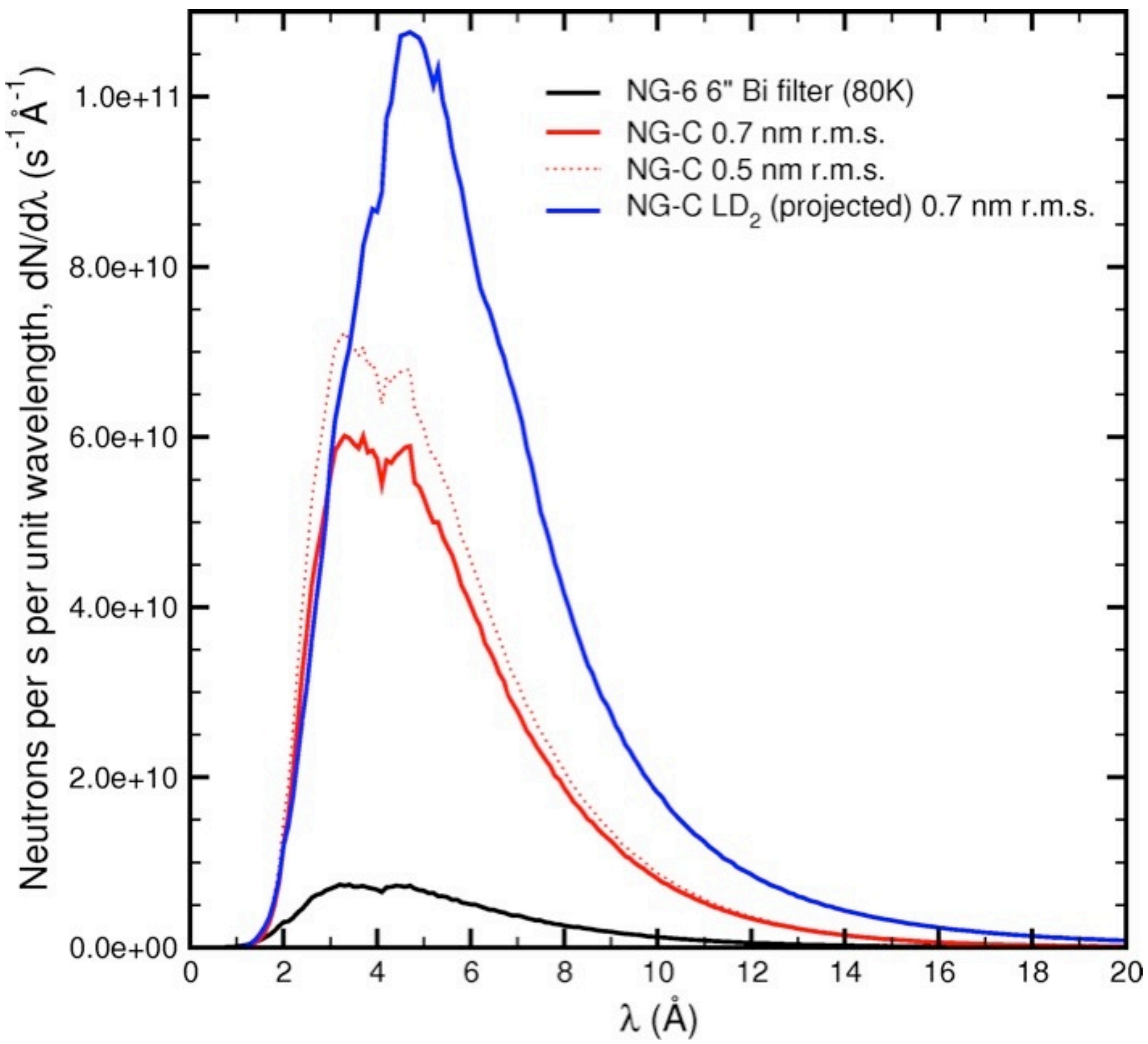
The New Guide Hall (to the south)

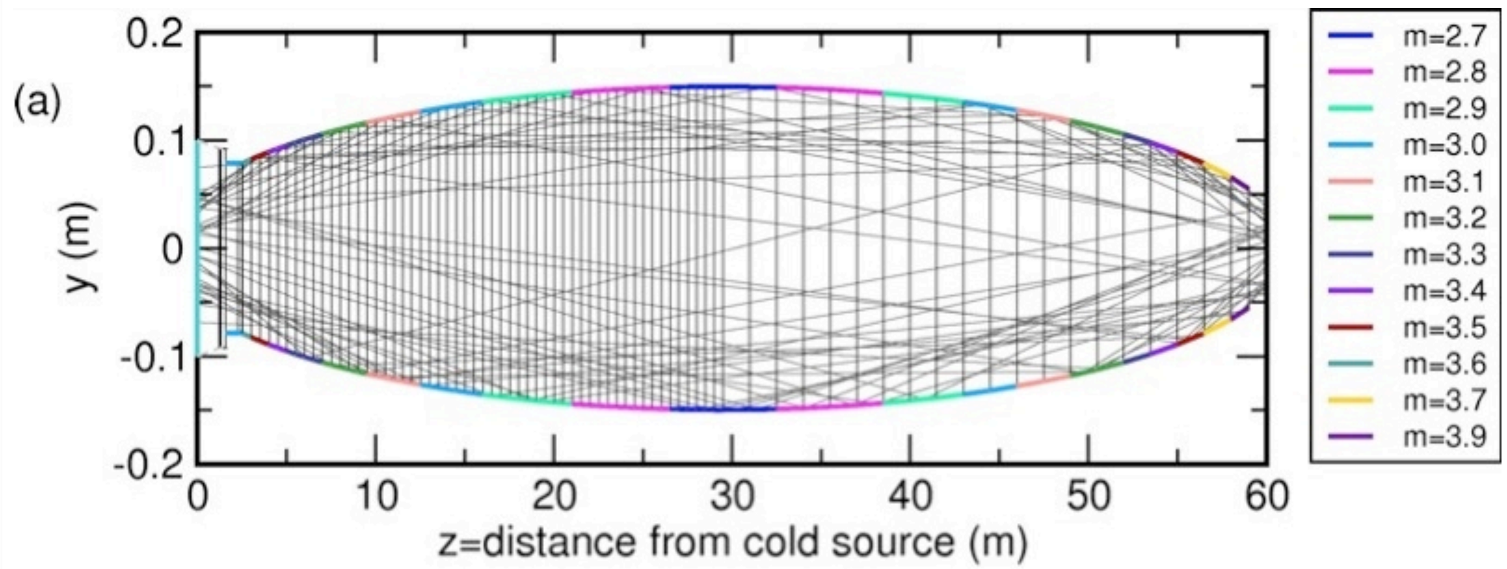
New Guides Penetrating Outer Confinement Wall



NG-C Being Installed Through Outer Confinement

NG-C Characteristics





Guide/position CTW (LH_2 cold source) CTW (projected LD_2 cold source) Existing NCNR guide reference	Phase space tailoring?	Capture flux, φ_c ($cm^{-2}s^{-1}$)	Integral flux, φ_{int} ($cm^{-2}s^{-1}$)	Neutrons/s	Mean wavelength (Å) $\langle\lambda\rangle \approx 1.8\varphi_c/\varphi_{int}$
NG-C 11cm×11cm guide exit	Yes, but with under-illumination	7.64×10^{9} 1.57×10^{10}	2.49×10^{9} 4.47×10^{9}	3.01×10^{11} 5.41×10^{11}	5.51 6.29
NG-6 guide exit at fundamental physics station (6" Bi filter)	No	1.39×10^{9}	4.48×10^{8}	4.03×10^{10}	5.56

Focusing guide

Peak Fluence: 1 x 10^{10} n $cm^{-2}s^{-1}$

Shutter at midpoint - low backgrounds

NG-C Expected Schedule

- NG-C will come online Dec. 2012.

- The first experiment, aCORN, will run for roughly 1 year.
  (an experiment to measure the neutrino asymmetry in beta decay, a)

- Dec. 2013 the beam will be available.

- Possible other experiments.
  Neutron Lifetime
  Neutron Spin Rotation in Liquid Helium.

- BTAC (based on readiness and scientific merit).

NG-6 could be available in Dec. 2012 (short term)
NG-3 could be available 2014 (longer term)

NIST BTAC Charge

Charge Overview:

"The Beam Time Allocation Committee (BTAC) is charged with the task of recommending the allocation of time on the NG-6 neutron beam line, which is located in the guide hall at the NIST Center for Neutron Research (NCNR). NG-6 is operated and managed by the Neutron Interaction and Dosimetry (NI&D) Group within the Physics Laboratory. The recommendation will be given to the NI&D group leader who will make the final decision regarding the use of NG-6. As part of the allocation process, the BTAC will be responsible for assessing

- the scientific motivation of the experiment
- feasibility of accomplishing the goal
- state of readiness
- manpower resources
- funding
- beam time request

A critical goal of the committee is to help facilitate, insofar as is possible, the ability of experiments to succeed and the NG-6 beam line to operate efficiently. It includes making an assessment that the collaboration has realistic plans and goals."

NIST BTAC Review Mechanics

- Once a year, the NI&D group will send a formal email solicitation to potential users of the *physics* beam lines.

- Persons or collaborations wishing to operate at the beam must submit a proposal for review by the BTAC. It is not a request for beam time.

- The proposal is submitted online at the NCNR website.

- The content of the proposal should be minimal. It should contain aspects like the physics motivation, the basic experimental concepts, the collaboration members, an estimate of the time scale, etc.

- The proposal is sent to the BTAC, and the review should be completed in approximately two weeks.

NIST BTAC Review Mechanics

- BTAC reviews the charge.

- BTAC hears presentations on the status of the current and past experiments, the experiment requesting beam time, and those experiments who may request beam time in the future.

- The presentations are open sessions. All may ask questions, but the BTAC has the prerogative to keep the sessions focused.

- The final executive session is designed to allow the BTAC to discuss any issues among themselves.

- Close-out comments are optional. Additional requests may be made of proposers. Presentations can be made available.

- Concise reviews are submitted individually to group leader.

Conclusions

- NIST could be a very attractive option for optics/guide/source testing.
- Likely to be beamlines and support available on a relevant timescale.

Technical Review

• Experiments with positive reviews can request beam time in this forum.

• Guidelines for review are outlined in the BTAC Charge document of March 2008.

• The written recommendation should include an assessment of the physics justification, state of readiness of the experiment, and reasonableness of the requested time and duration of beam time.

• Reviews are seen by NI&D Group leader and NCNR Director. The director defers decisions to the unless there are unusual circumstances.

• Beam time is allotted (or not).