

*The Fundamental Neutron Physics Beamline
at the
Spallation Neutron Source*

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Project X meeting, FNAL
March 2012

1. Project background

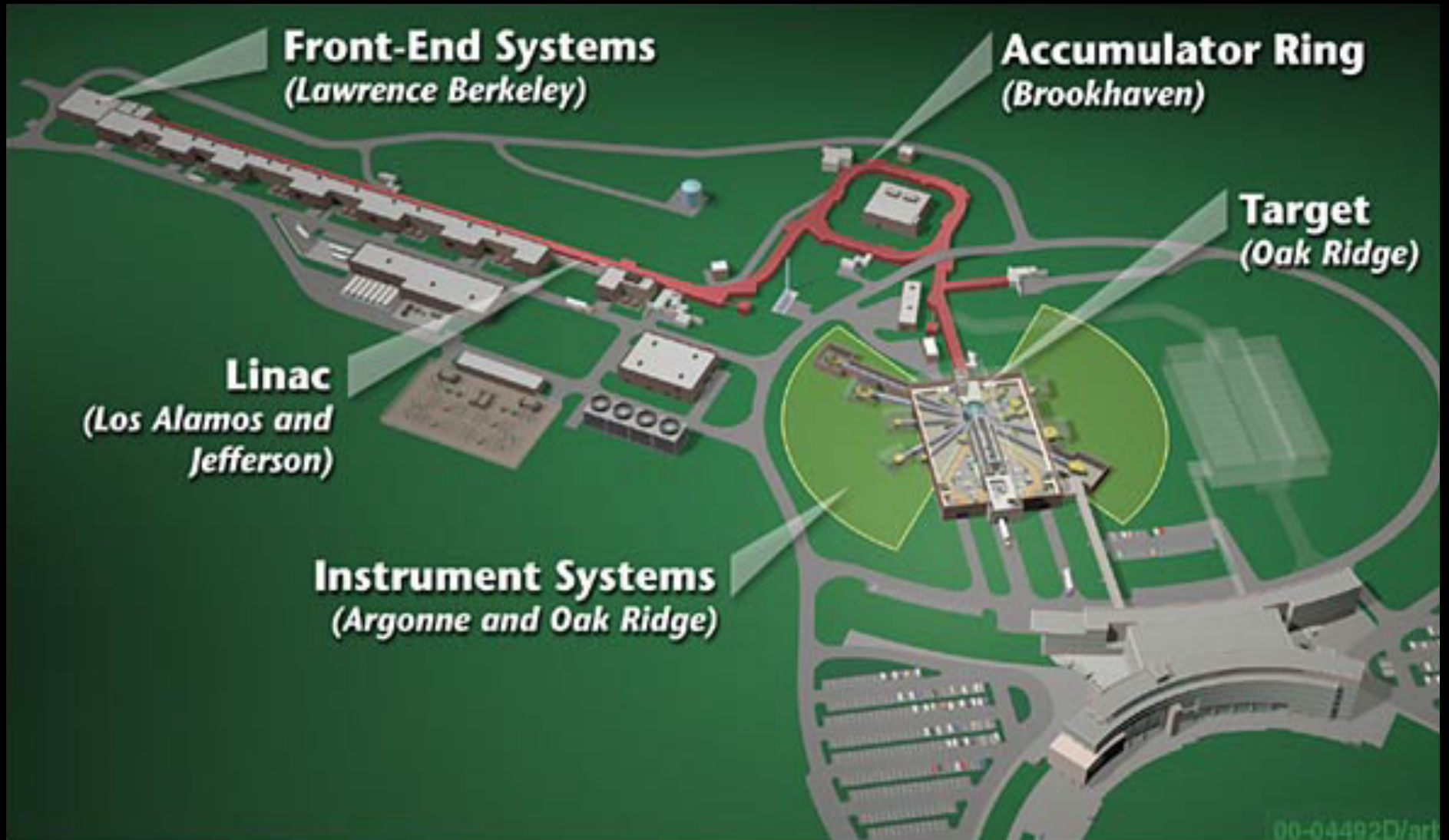
2. Scientific goals

3. Scientific Program

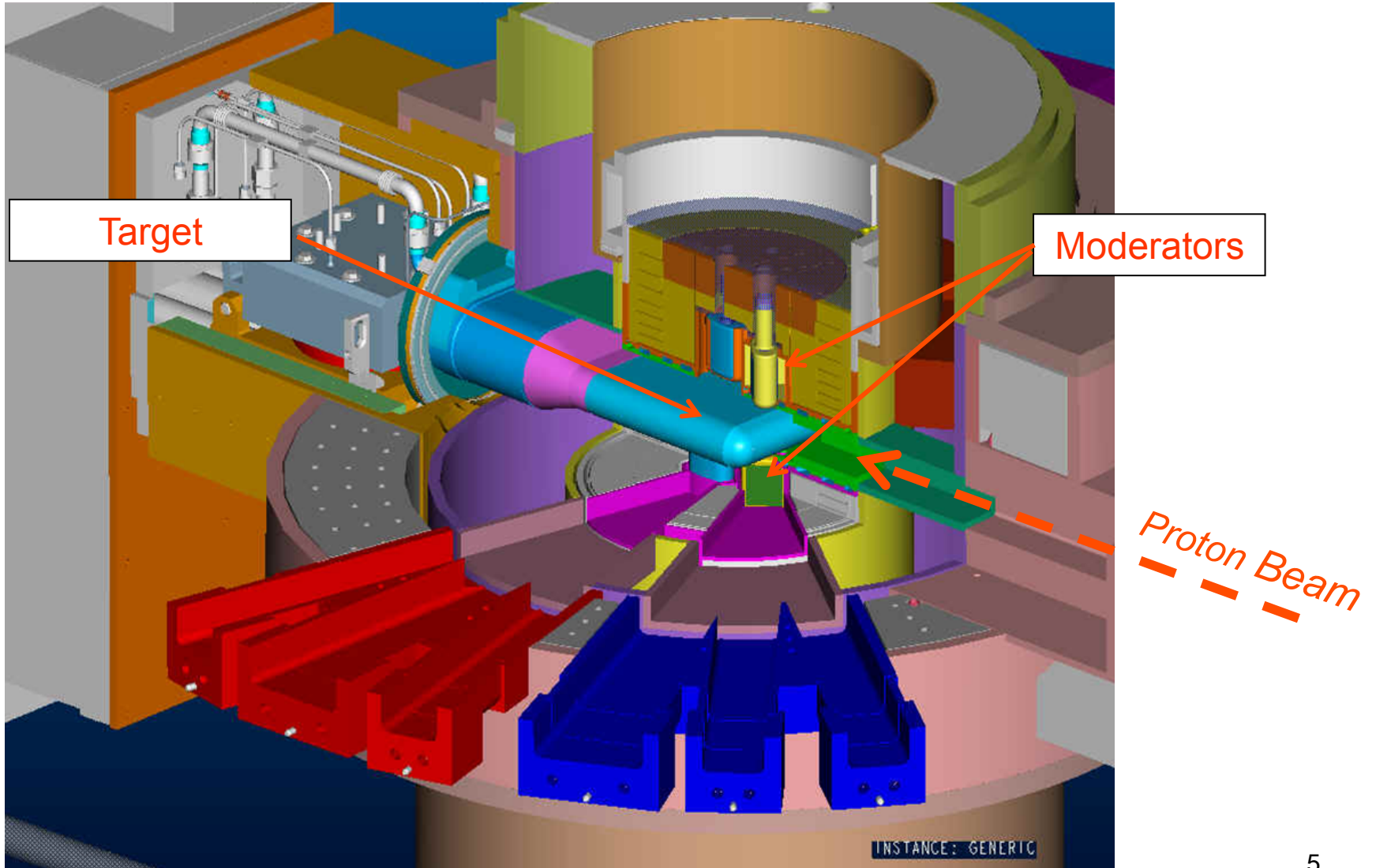


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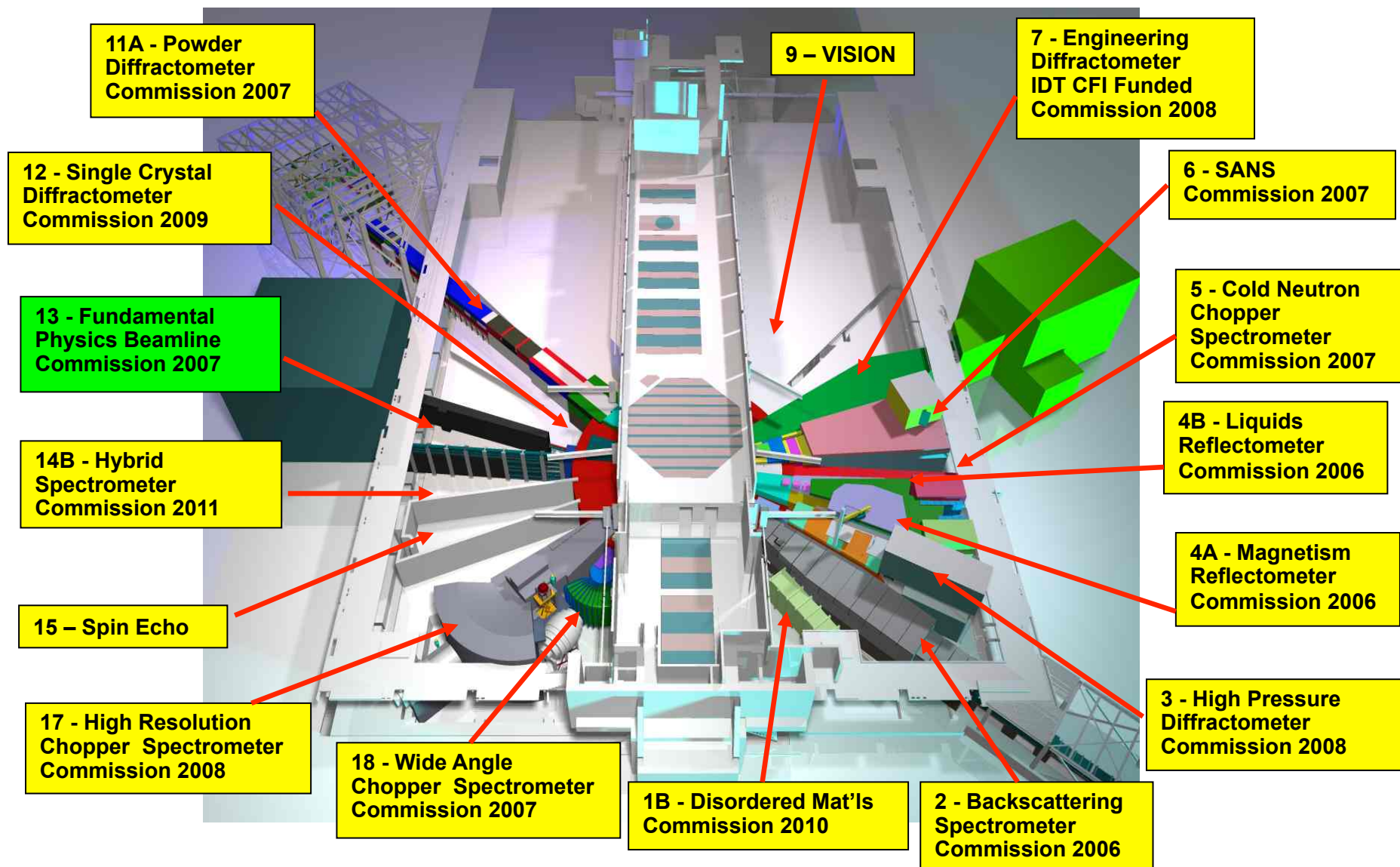
The Spallation Neutron Source at ORNL
www.sns.gov



STARTING POINT



Beamline 13 Has Been Allocated for Nuclear Physics



IMPORTANT NOTE

- *The SNS Fundamental Neutron Physics Beamline is part of a facility built by DOE BES.*
- *The SNS was designed to support 24 beamlines that were designed for "generic" neutron scattering experiments (Focus of science is on condensed matter studies)*
- *There was no opportunity to optimize the target moderator for nuclear/particle physics research*
- *In particular, there was no opportunity to establish a dedicated Ultracold neutron source.*
- *The FNPB was designed to use the existing capabilities of the SNS to best serve a variety of fundamental physics experiments.*

SNS Fundamental Neutron Physics Program

1. Search for a non-zero permanent neutron electric dipole moment

- *Origin of CP and T violation*
- *Cosmic Baryon Asymmetry*
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2. Precision measurement of parity violation in the interaction low energy neutrons with "simple" nuclear systems (i.e. n-p)

- *Quark-Quark Weak Interaction*
- *QCD in the strongly interacting limit*

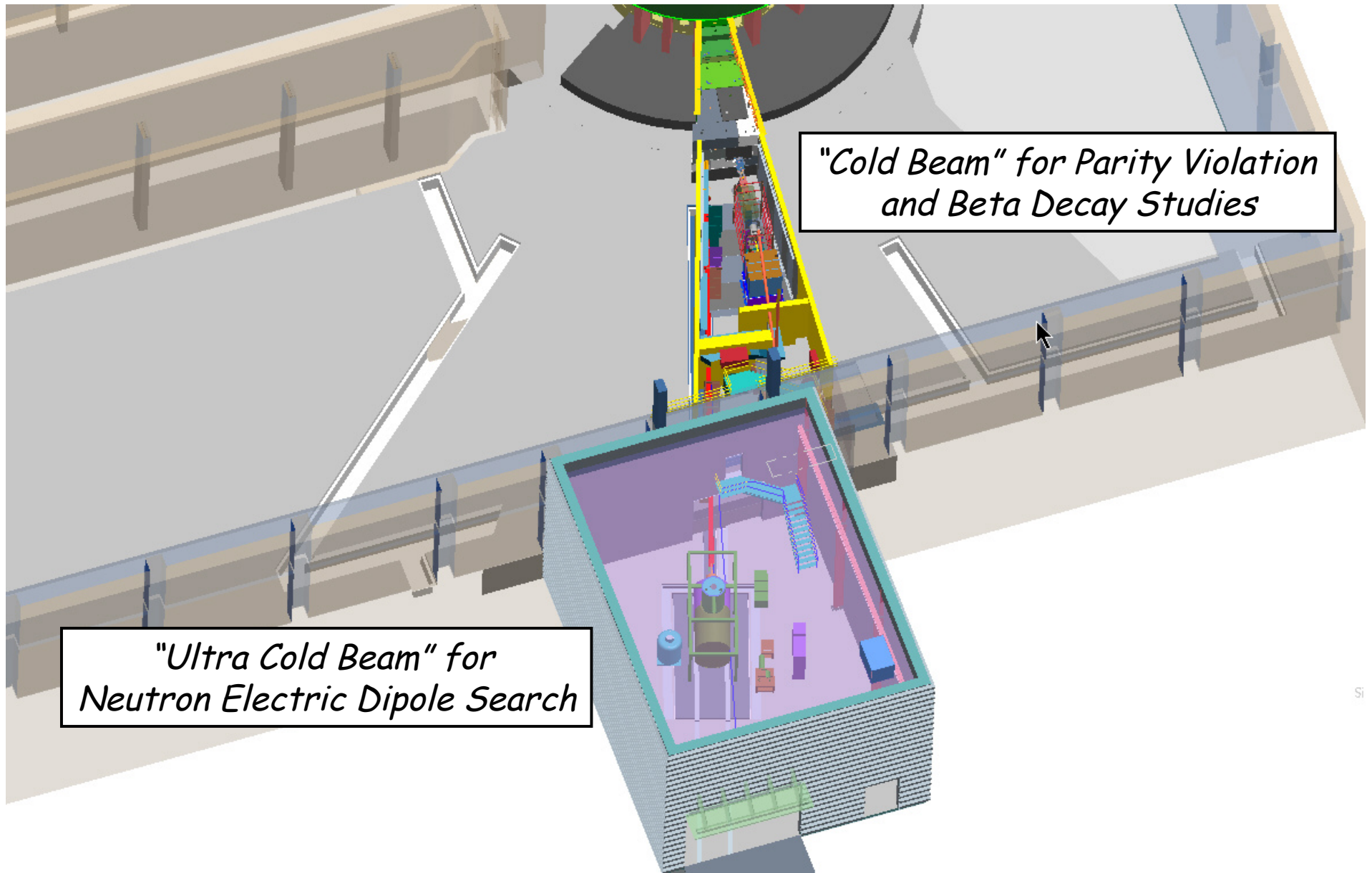
3. Accurate measurement of parameters that describe the beta decay of the free neutron (i.e. Lifetime, Decay Correlations)

- *Universality of the Weak Interaction (Unitarity of CKM Matrix)*
- *Extensions to the Standard Model (RH currents, new couplings, ...)*
- *Big Bang Nucleosynthesis and Cosmic Elemental Abundances*
- *Stellar Astrophysics*
- ...

Two Classes of Experiments

- 1. Cold Neutron, Broad Band, Short Flight Path (~15m)
Hadronic Parity Violation and Neutron Beta Decay*
- 2. Monochromatic Beam at 8.9\AA for Ultra Cold Neutrons
Long Flight Path (~50m), Low Background Area
neutron EDM, neutron lifetime*

The Fundamental Neutron Physics Beamline at the SNS



Ten proposals have been received and reviewed

FNPB Beamline Characterization and Commissioning (SNS, ORNL, LANL, IUCF, NCSU,...)	Completed
Determination of τ_n Lifetime Using Magnetically Trapped UCN (Harvard, NIST, NC State)	Deferred
Measurement of "a" & "b" Correlations in Neutron Decay (nab) (U of Va., ORNL, LANL, Indiana, UT, Tennessee...)	Approved
Measurement of "a, b, B, A" Correlations in Neutron Decay (abBA) (U of Va, LANL, Indiana, Michigan, ORNL, UT,...)	Approved
Measurement of "C" Correlation in Neutron Decay (PANDA) (Michigan, Indiana, NIST, ORNL, UNH,...)	Deferred
Measurement of Parity Violation in n-p Capture (ORNL, Indiana, LANL, Manitoba, U of Va, Kentucky, UT,...)	In Progress
Measurement of Parity Violation in n-d Capture (LANL, Indiana, Manitoba, NIST, Berkeley, ORNL,...)	Deferred
Precise Measurement of Neutron Spin Rotation in H₂ and He (Indiana, Washington, NIST, NC State, Indiana, ORNL,...)	Deferred
Proton Asymmetry in n+³He capture (Kentucky, Manitoba, Indiana, ORNL,...)	Approved
Search for an Electric Dipole Moment (LANL, Caltech, ORNL, NC State, Illinois, MIT, Berkeley, BU...)	Approved

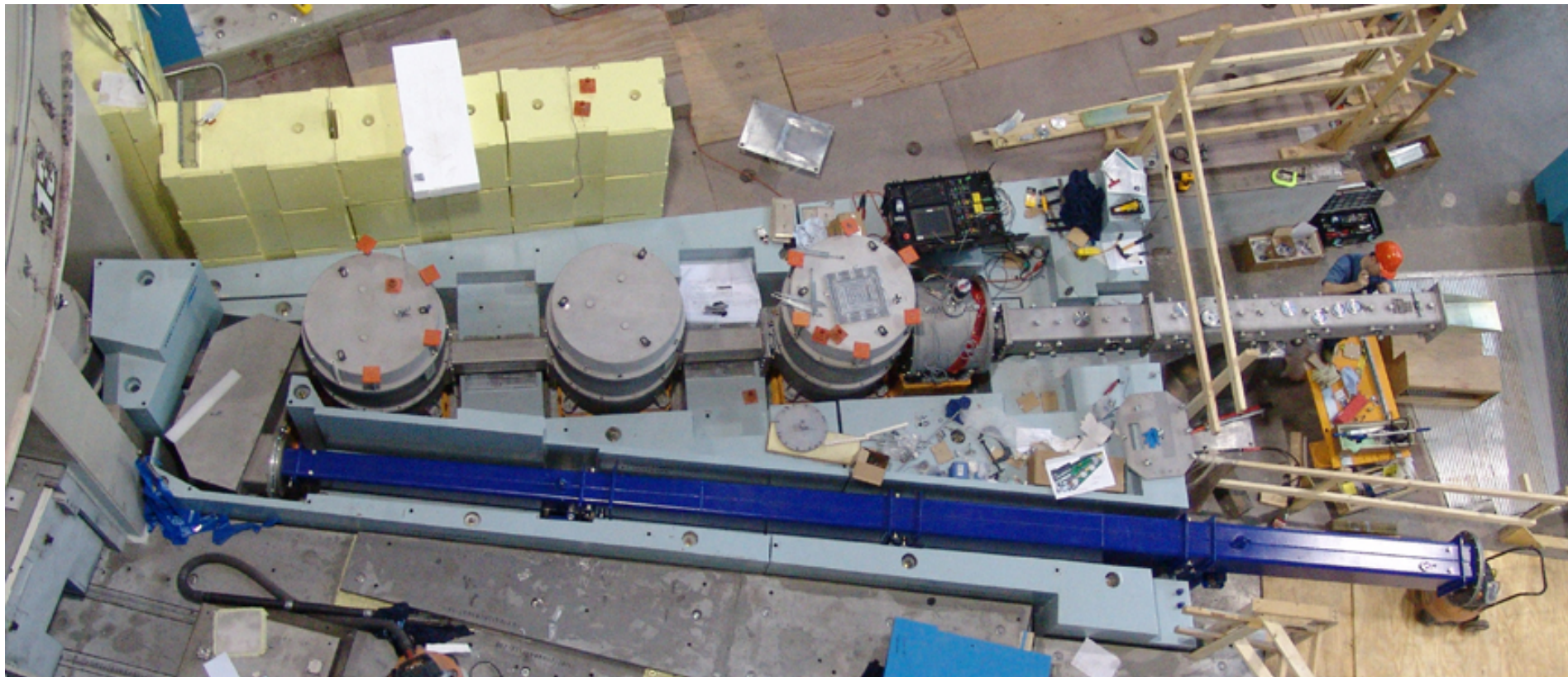
Goals of SNS Fundamental Neutron Physics Program

- 1. Accurate measurement of parameters that describe the beta decay of the free neutron (i.e. Lifetime, Decay Correlations)**
 - *Universality of the Weak Interaction (Unitarity of CKM Matrix)*
 - *Extensions to the Standard Model (RH currents, new couplings,...)*
 - *Big Bang Nucleosynthesis and Cosmic Elemental Abundances*
 - *Stellar Astrophysics*
 - ...
- 2. Precision measurement of parity violation in the interaction low energy neutrons with "simple" nuclear systems (i.e. n-p, n-d, n- α)**
 - *Quark-Quark Weak Interaction*
 - *QCD in the strongly interacting limit*
- 3. Search for a non-zero permanent neutron electric dipole moment**
 - *Origin of CP and T violation*
 - *Cosmic Baryon Asymmetry*
 -

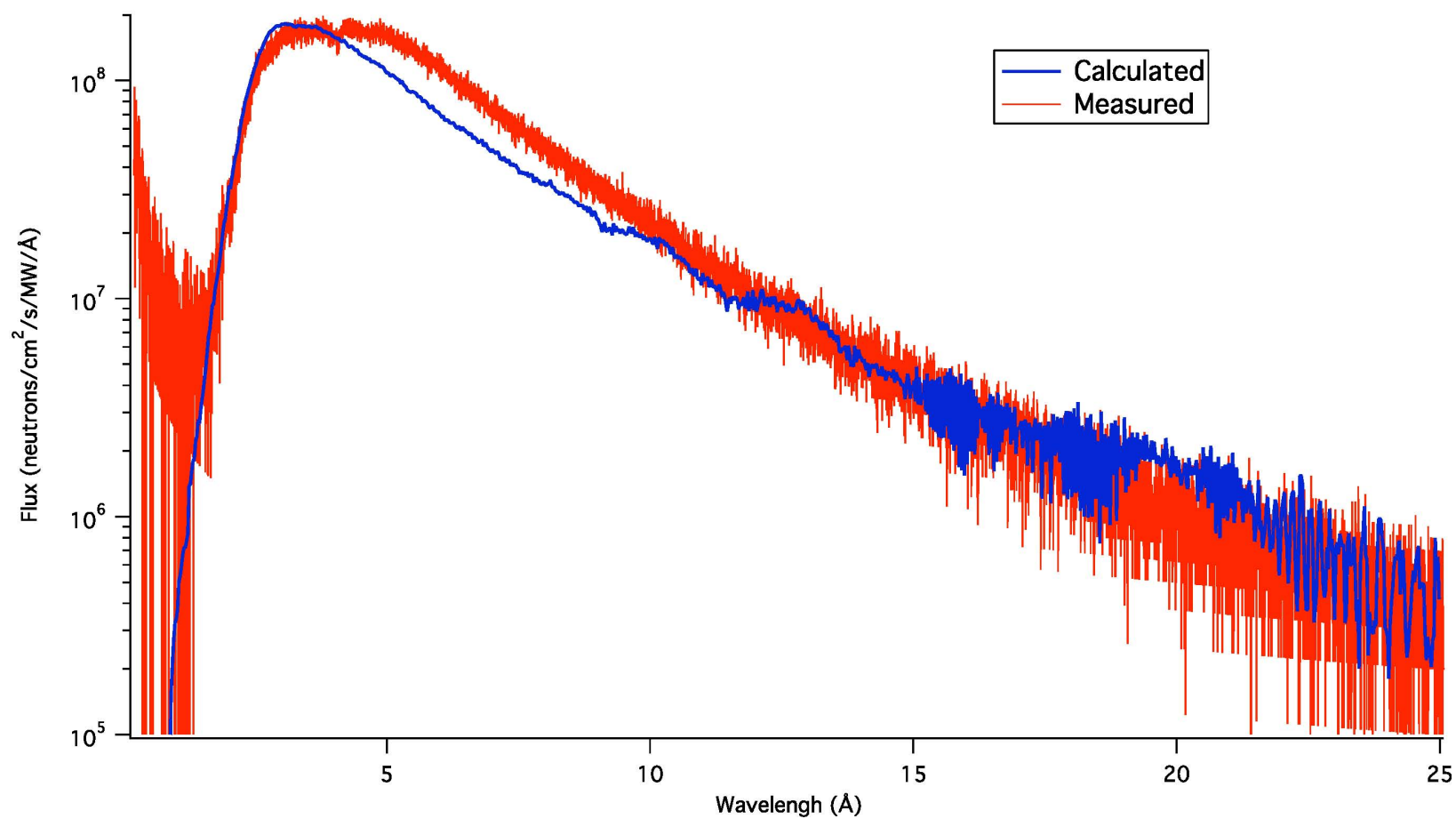
Broad Spectrum

8.9Å

The FNPB Neutron Guide System

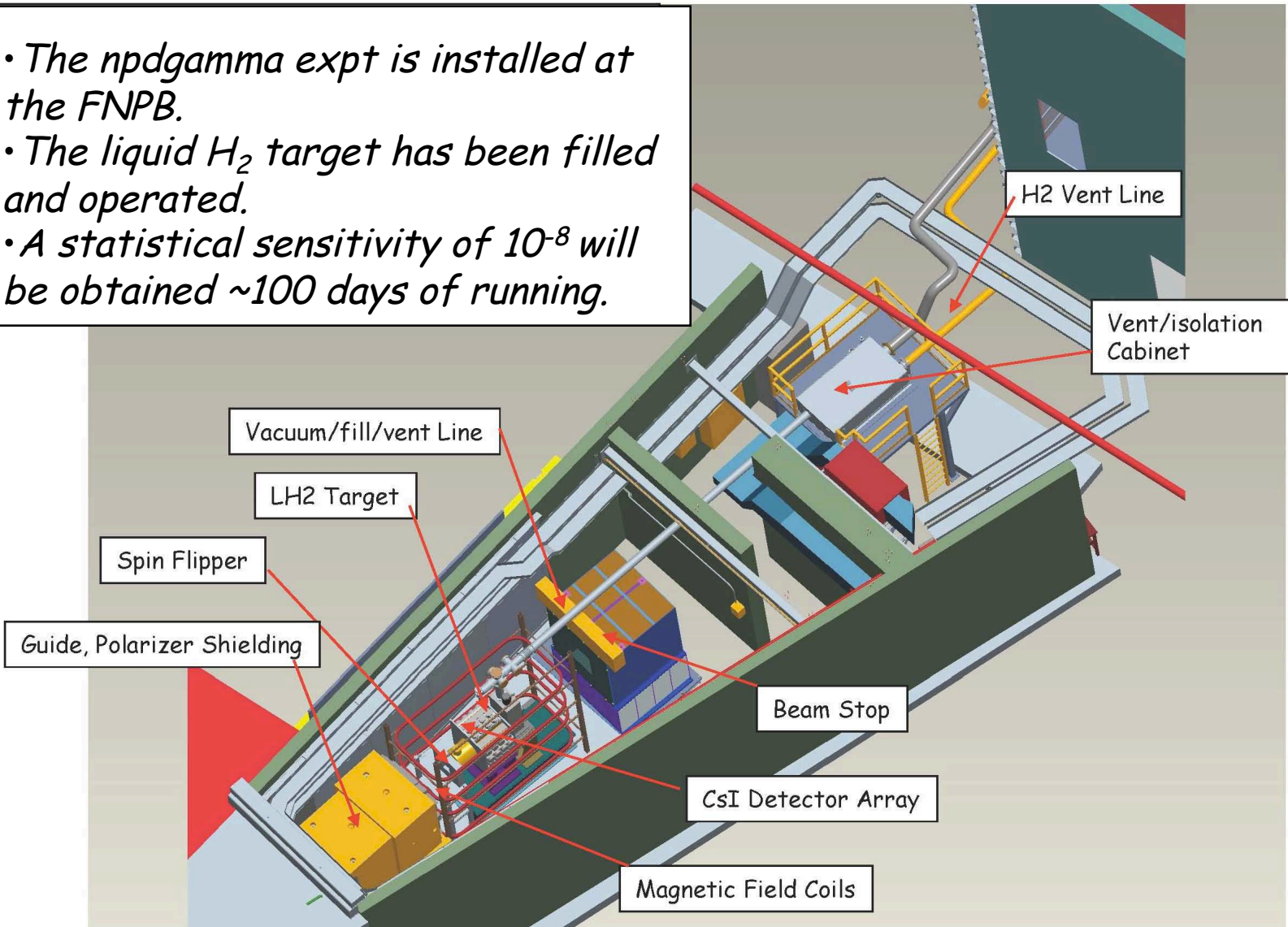


Detailed FNPB Cold Beam Flux Measurements

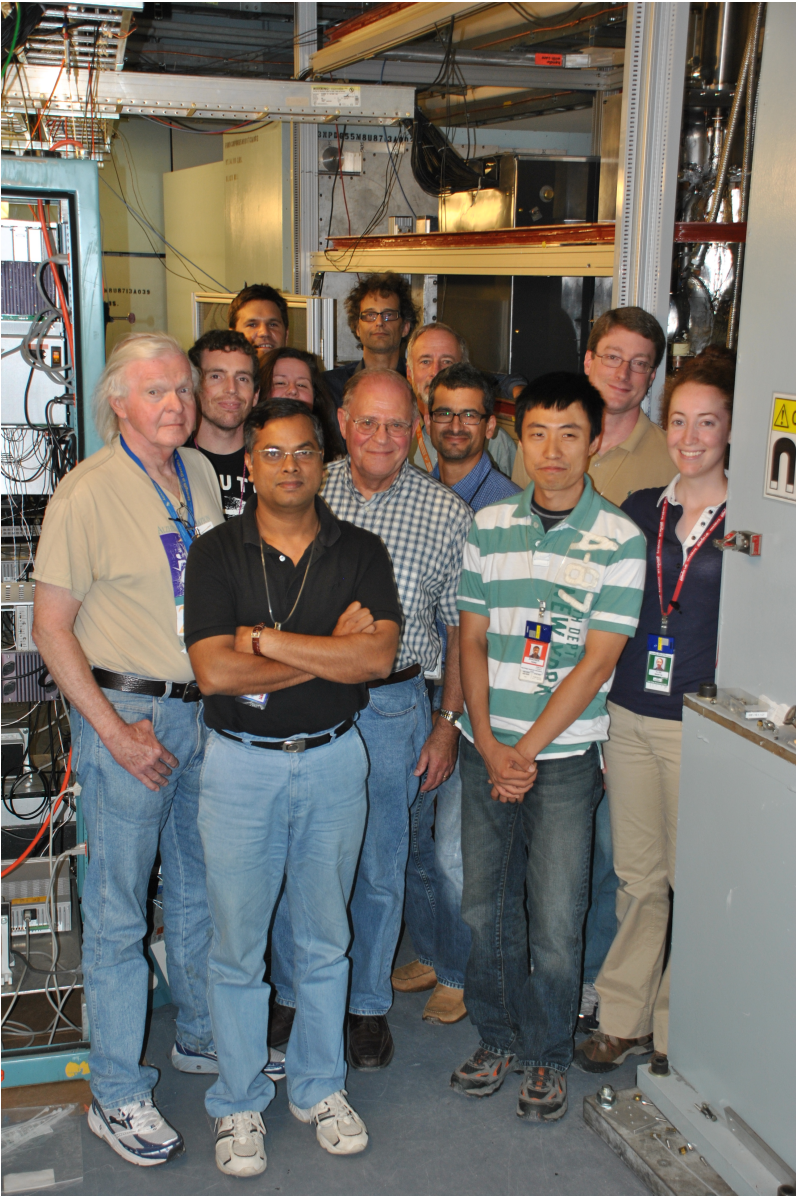


The npdgamma experiment at the SNS

- The npdgamma expt is installed at the FNPB.
- The liquid H_2 target has been filled and operated.
- A statistical sensitivity of 10^{-8} will be obtained ~ 100 days of running.



Typical Experiment is of Modest Size



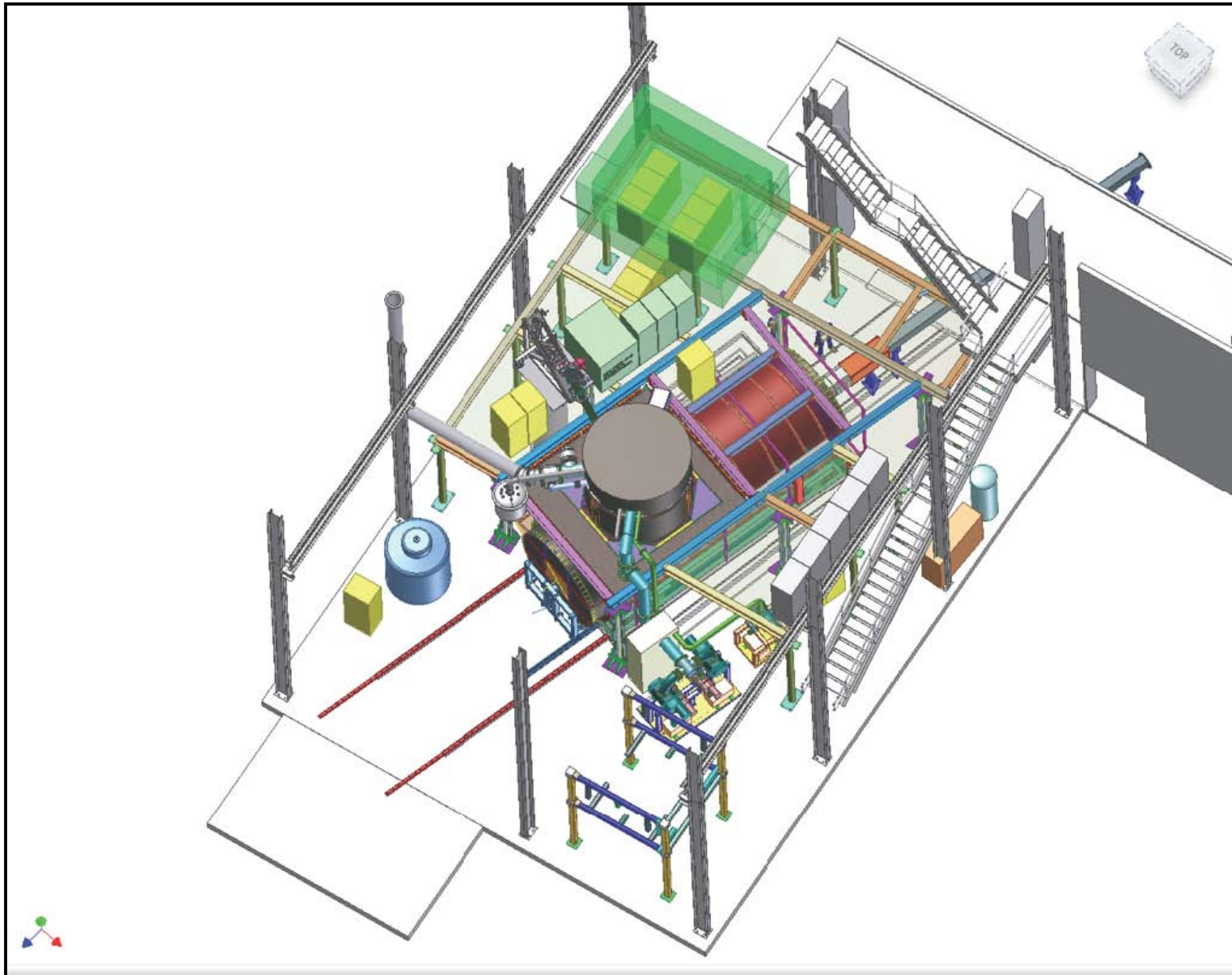
npdgamma experiment

- ~30 collaborators on site during first run cycle 2011
- >30 participants at collaboration meeting in July 2011
- 5 graduate students and 2 post docs in residence at Oak Ridge.

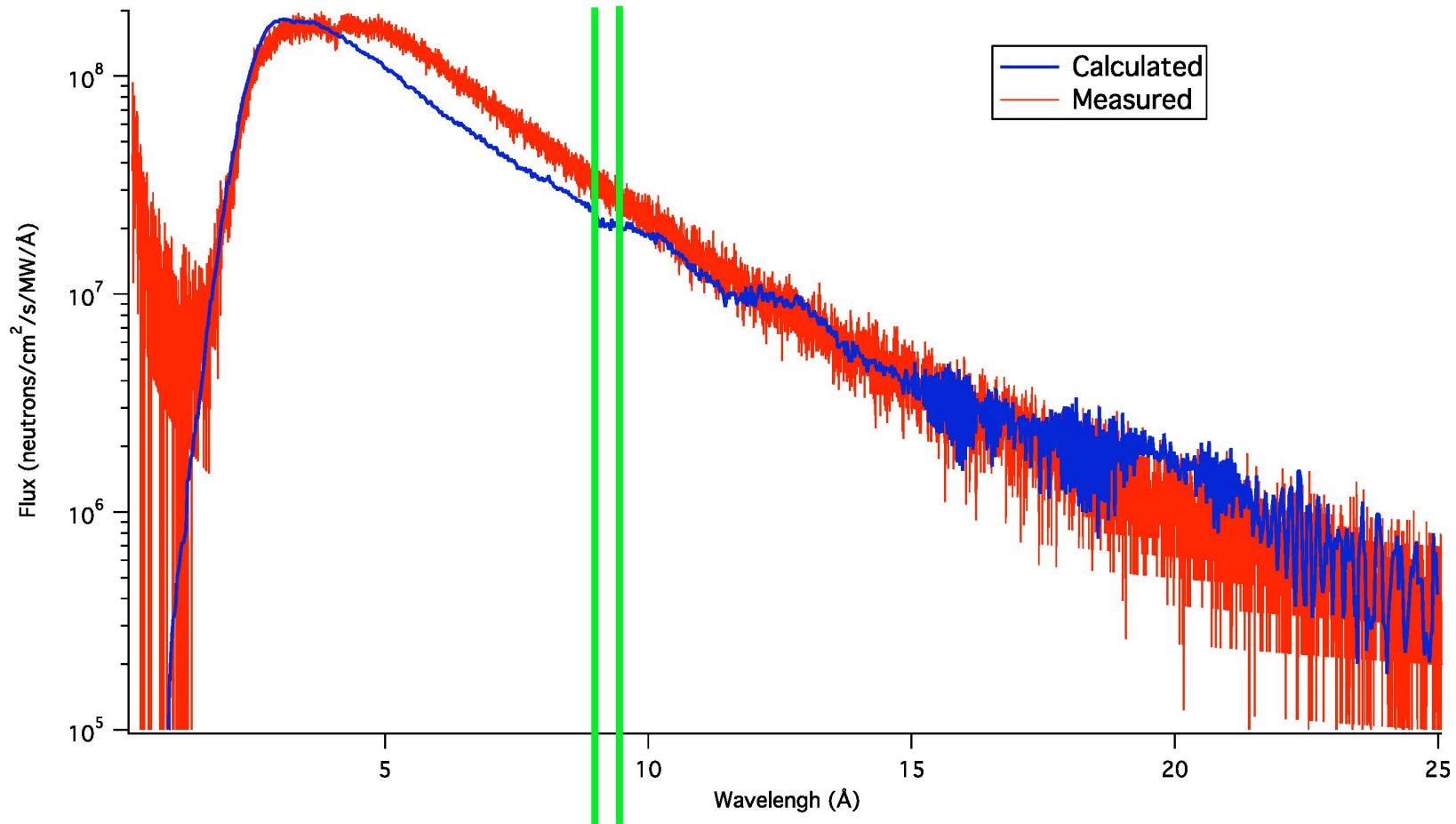
External Building for the nEDM



The nEDM experiment as planned in the external bldg



nEDM requires a very narrow wavelength slice at 8.9Å



*Only neutrons in this band are efficiently
down-scattered by superfluid ⁴He to give UCN*

Comments from Recent NSAC review

Priorities

- Subfield is vibrant; many excellent initiatives proposed
 - *But there is neither the money, people or time to do everything*
- Highest priorities spelled out below in rank order

1. nEDM is the highest priority for neutron science

- *specific set of recommendations (#1 thru #6) crafted; goals and timelines specified*

2. continue UCNA to its logical end i.e. achieve original design goals (#8)

- *build on existing investments and expertise*

3. complete NPDGamma and ensure the design precision is reached (#9)

- *the beamline is ready and preparations for the experiment are progressing well*

4. invest in Nab (**only project needing new funding**) (#8)

- *next precision instrument for neutron beta decay; several years of development*

5. complete modest lifetime effort (NIST cold beam): poised for 1 s precision (#7)

- *Measurements worldwide inconsistent; NIST cold beam effort is very mature*
- *the future goal is 0.1 s, likely with UCNs, but US initiatives still in R&D stage*

- **The program above fits into a funding scenario of constant effort**
- **2 thru 5 are part of the numbered recommendations 7, 8 and 9**

Further Comments from Recent NSAC review

Neutron Electric Dipole Moment

“The successful completion of an nEDM experiment, the initiative with the highest scientific priority in US neutron science, would represent an impressive scientific and technical achievement for all of nuclear physics, with ramifications well beyond the field”

Hadronic Parity Violation - the npdgamma experiment

“We recommend strong support for the NPDGamma experiment as the highest priority measurement in hadronic parity-violation, and urge that every effort be made to reach the design goal, an asymmetry determination of one part in 10^8 .

Neutron Beta Decay - the nab experiment

“We further recommend parallel R&D to develop the experiment to measure the a-coefficient with the Nab spectrometer, with a sensitivity of 0.1%.”

End of Presentation