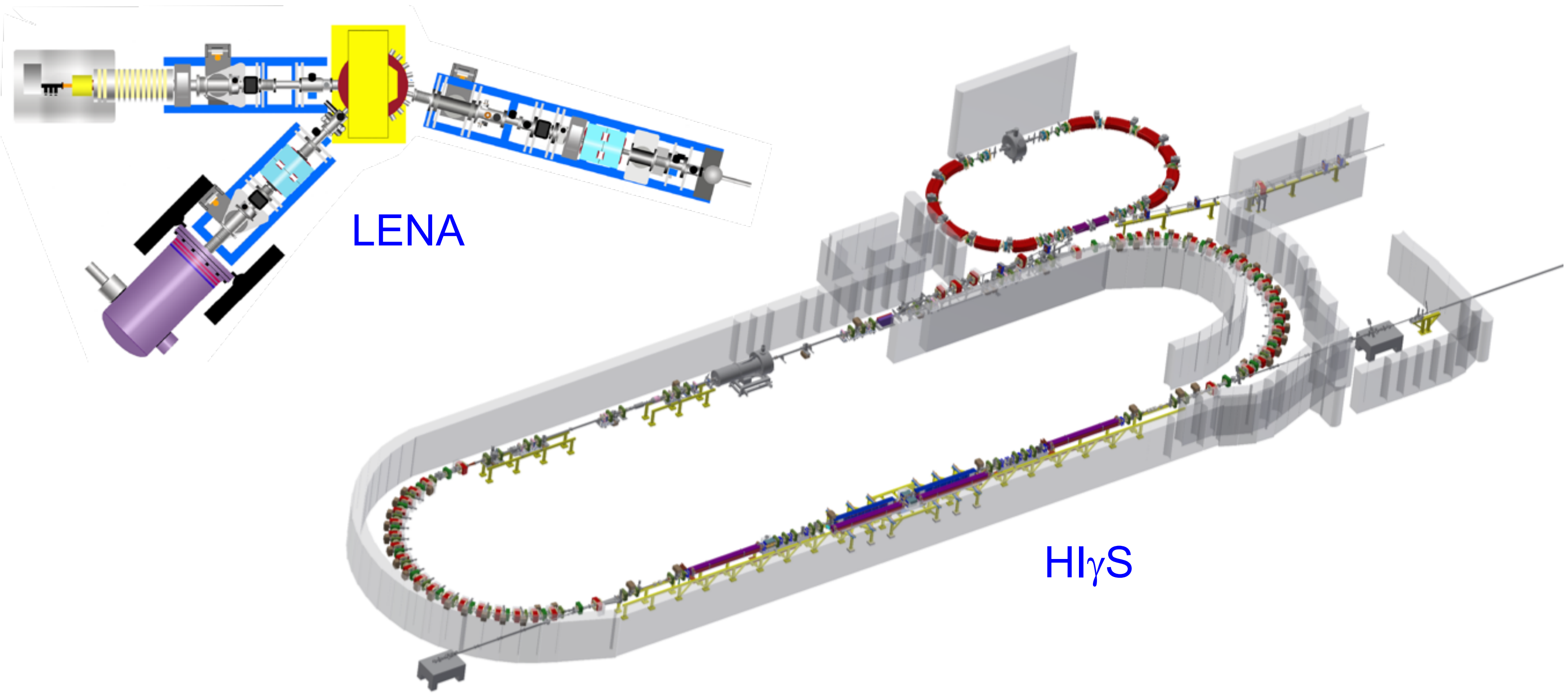
Laboratory Portrait: TUNL

TUNL



Tandem

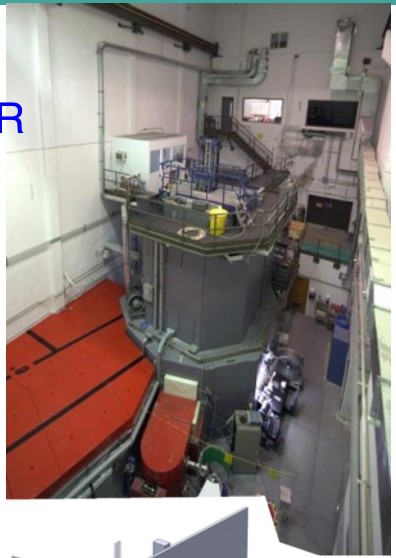
A·R·U·N·A

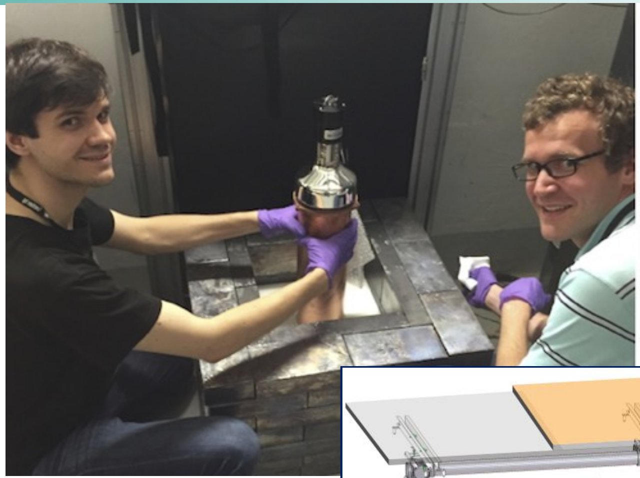
Duke University | North Carolina Central University | NC State University | The University of North Carolina at Chapel Hill

Laboratory Protrait: TUNL

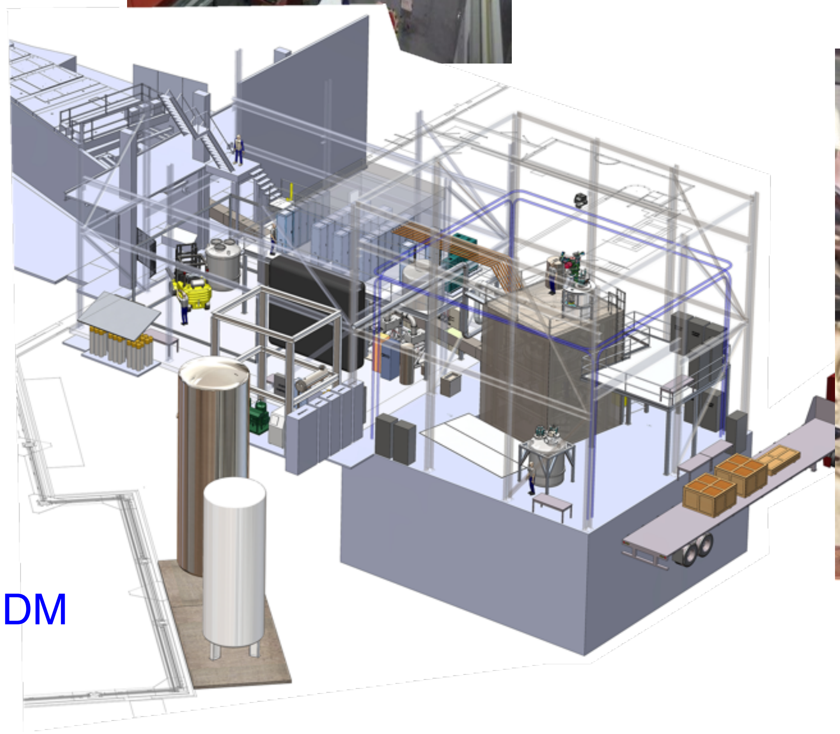
TUNL

PULSTAR

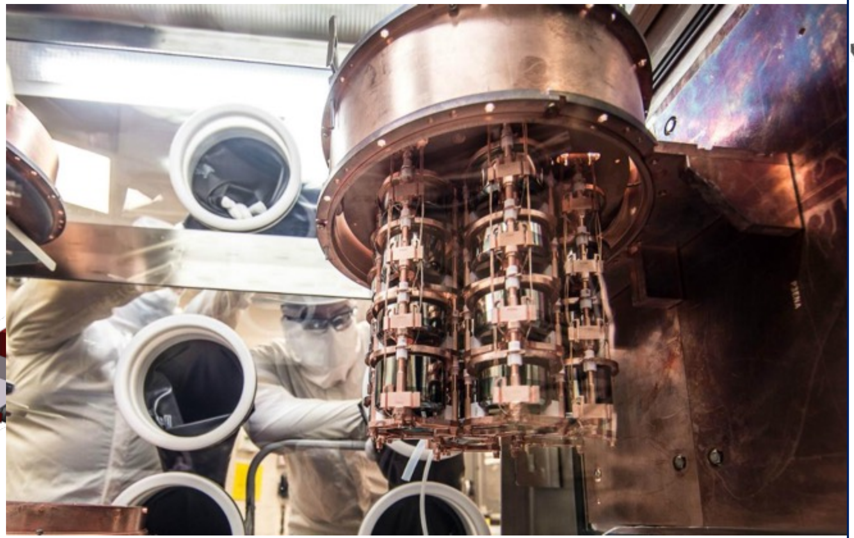




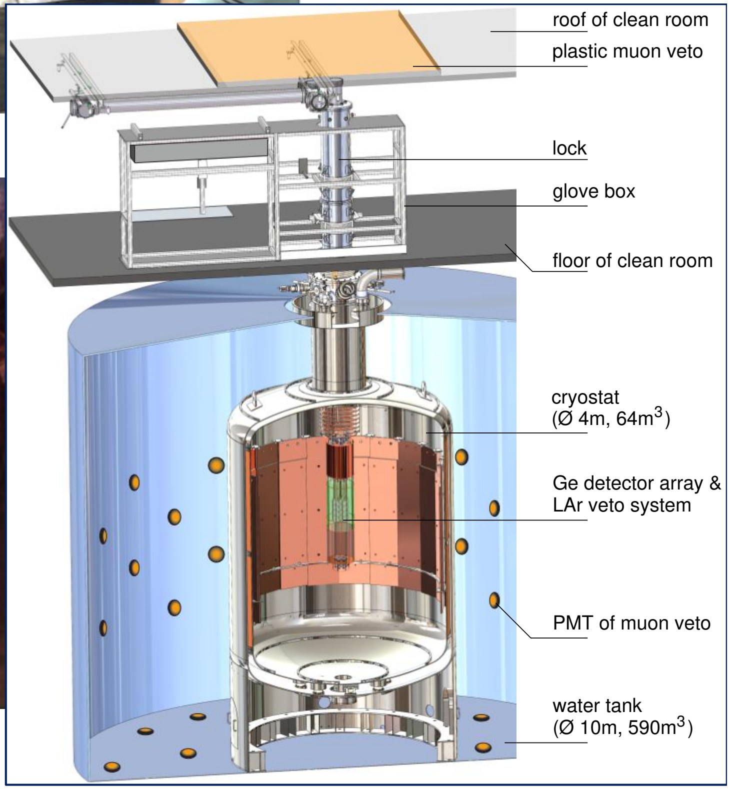
COHERENT



nEDM



MAJORANA DEMONSTRATOR



LEGEND-200

NC Central University Joins TUNL – Jan. 29, 2018

TUNL

TUNL

TUNL Code of Conduct

The American Physical Society (APS), in its Policy on Equal Professional Opportunity encourages the enactment of comparable policies at home institutions and workplaces. Thus, the Triangle Universities Nuclear Laboratory (TUNL) adopts the basic principles endorsed by the APS as detailed below.

Principles

As part of its goal of advancement and diffusion of the knowledge of nuclear physics, the Triangle Universities Nuclear Laboratory (TUNL) affirms a policy of equal opportunity for all who work at the laboratory. This policy requires that all members of TUNL as well as all visitors conduct their professional activities without discrimination or harassment in regard to personal factors irrelevant to the purposes of the laboratory, including (but not limited to) gender, gender identity, race, national origin, age, religion, marital status, political views, sexual orientation, or disability. Because respect for individuals is integral to achieving this goal, it is the policy of TUNL that harassment of colleagues and co-workers in the professional environment, including sexual or racial harassment, is unacceptable behavior.

Professional Conduct

TUNL endorses the APS Guidelines for Professional Conduct. All TUNL personnel and all visiting researchers should be familiar with these guidelines.

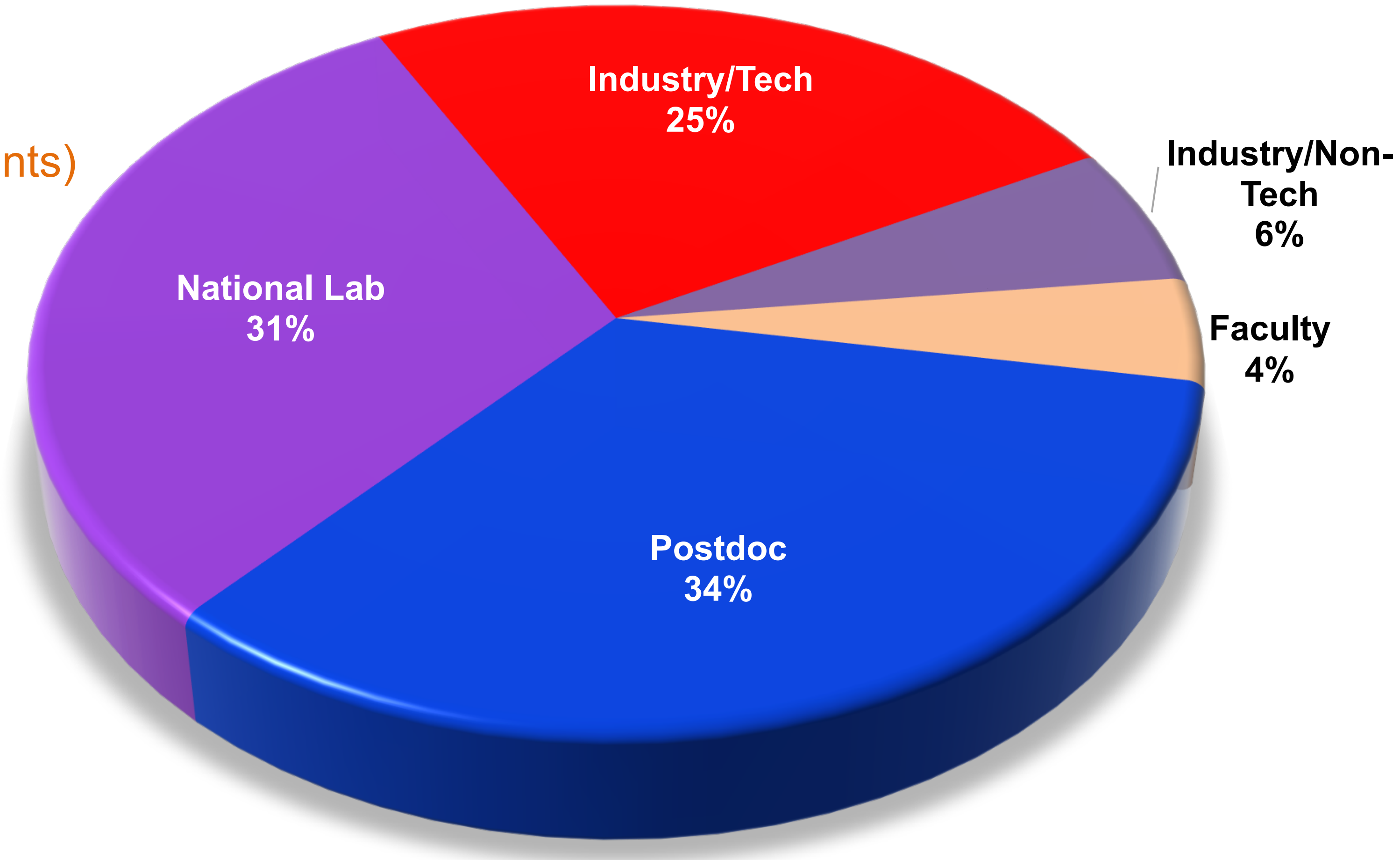
Guidelines for Authorship

All collaborations at TUNL independent of size must follow the authorship guidelines of the APS. Details specific to research at TUNL are described in a separate policy.

Who We Are

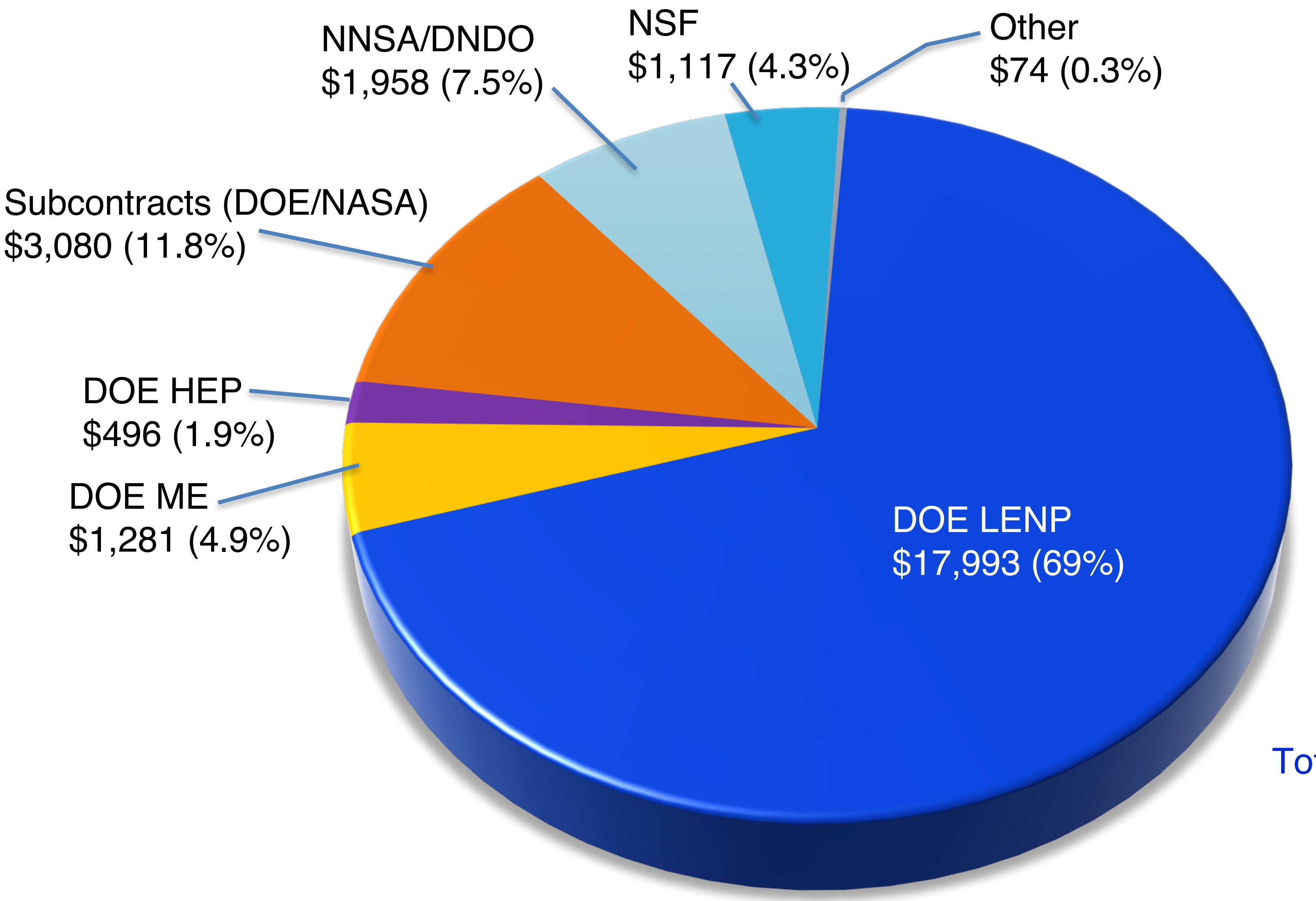
2008-present: 66 PhDs
(about 8% of PhDs in experimental nuclear physics nationwide)

18 faculty
14 postdocs
~40 graduate students
~23 undergraduates (including 8 REU students)
2 high school students
7 research scientists
3 administrative staff
4 R&D Engineers
5 technicians
2 accelerator operators/technicians
1 electronics supervisor



Total Funding: FY'15 – FY'17 (k$)

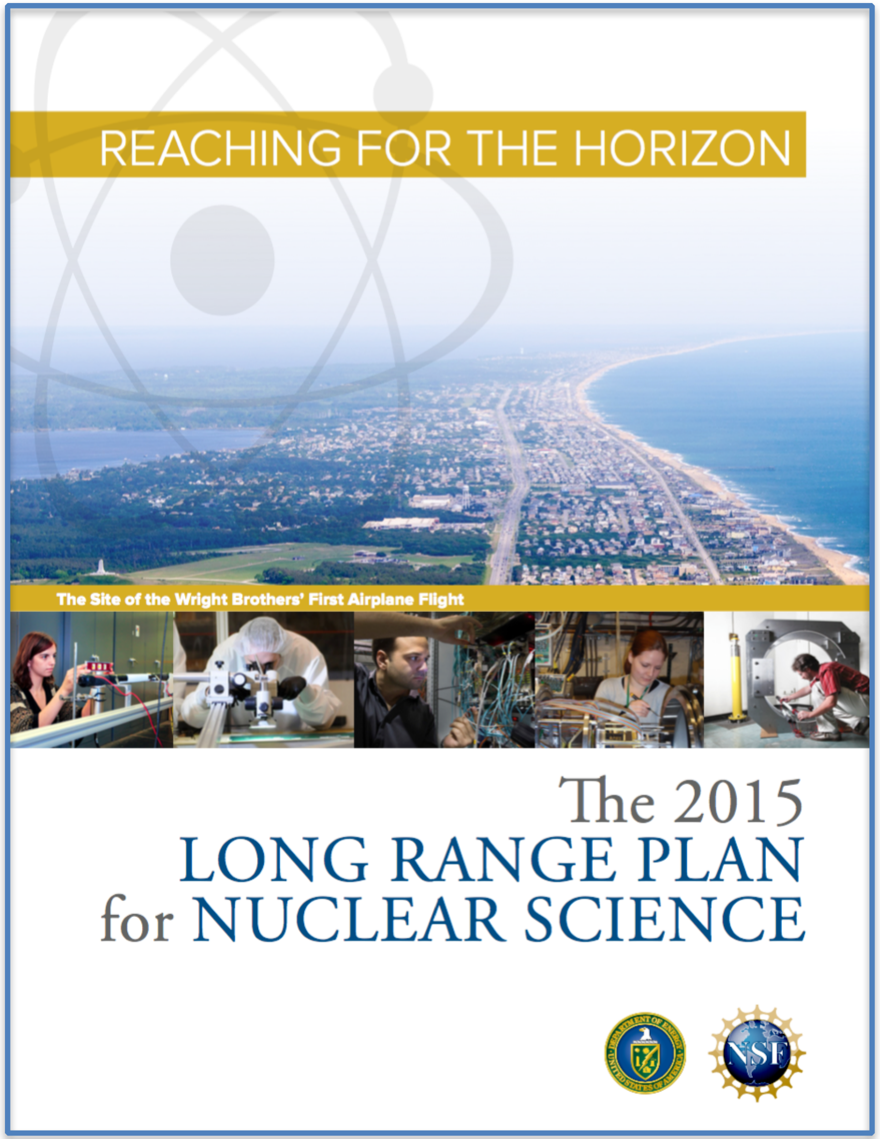
TUNL



Total Funding = $25.99 M

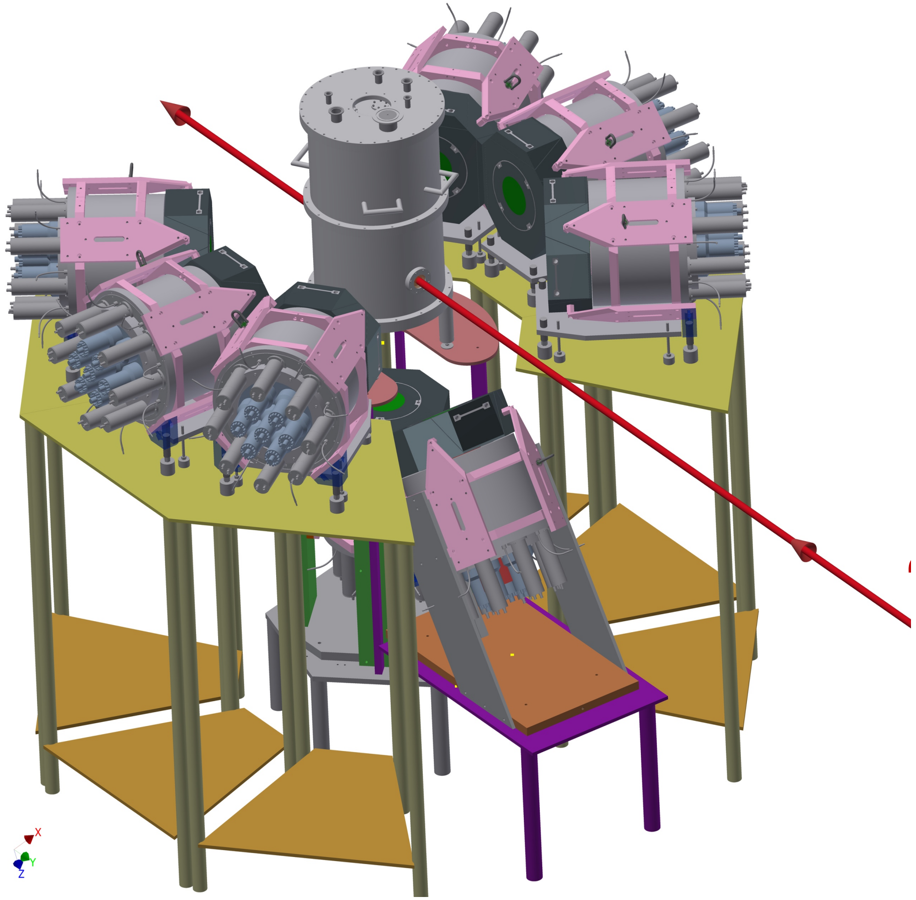
Research Program

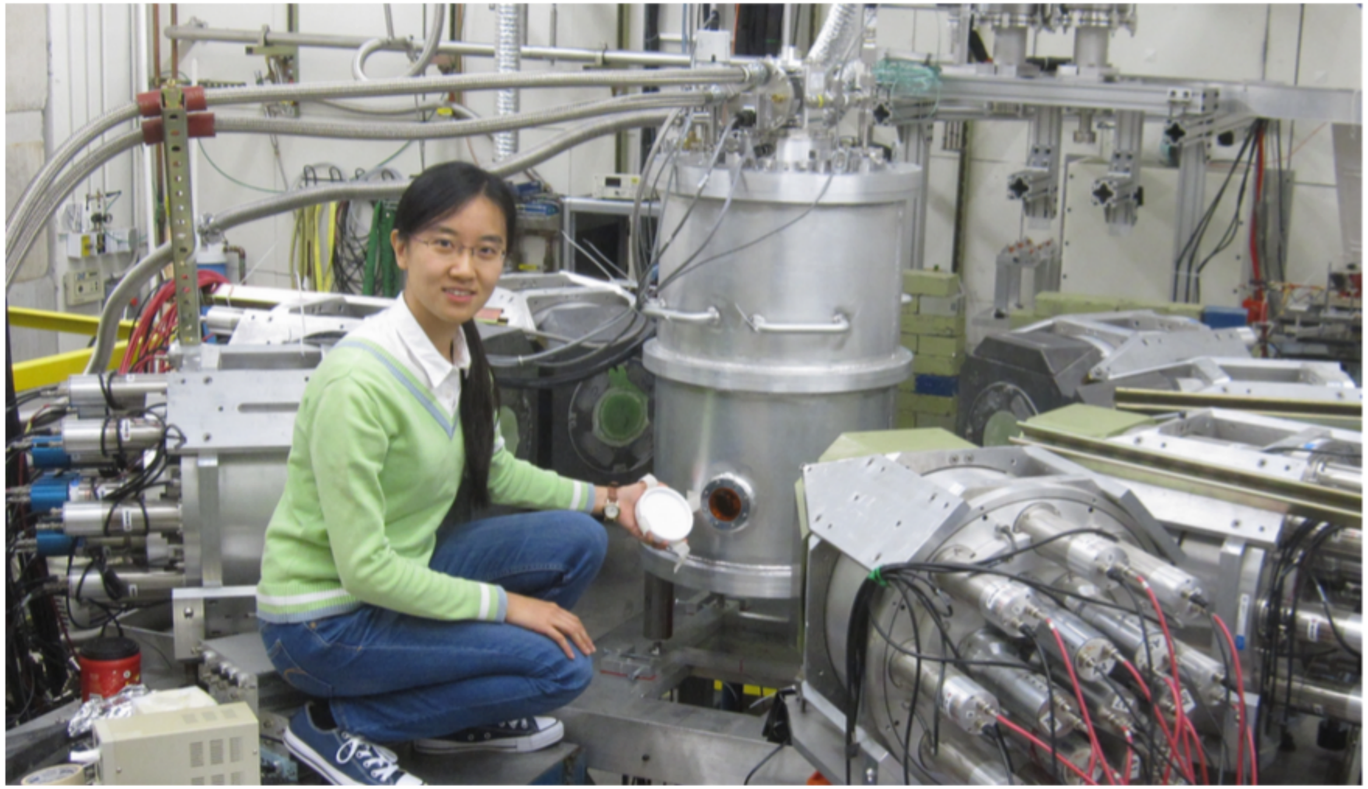
- *(Low-energy) QCD*
  (NCCU, Duke, UNC, NCSU)
- *Nuclear Structure and Reactions*
  (UNC, Duke)
- *Nuclear Astrophysics*
  (UNC, NCSU)
- *Fundamental Symmetries*
  (NCSU, UNC, NCCU, Duke)
- *Neutrino Physics*
  (UNC, Duke, NCSU, NCCU)
- *Nuclear Data*
  (NCSU, Duke)
- *Applied*
  (Duke, UNC, NCSU, NCCU)



Electric and magnetic dipole polarizabilities:

Bridging the gap between nuclear phenomenology and quark-gluon structure via Compton scattering



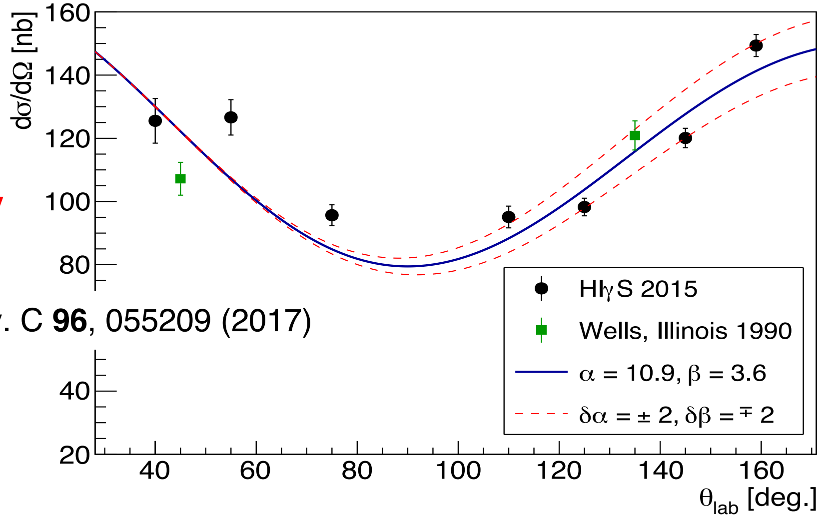


Duke Graduate student Xiaqing Li

Compton Scattering Measurements

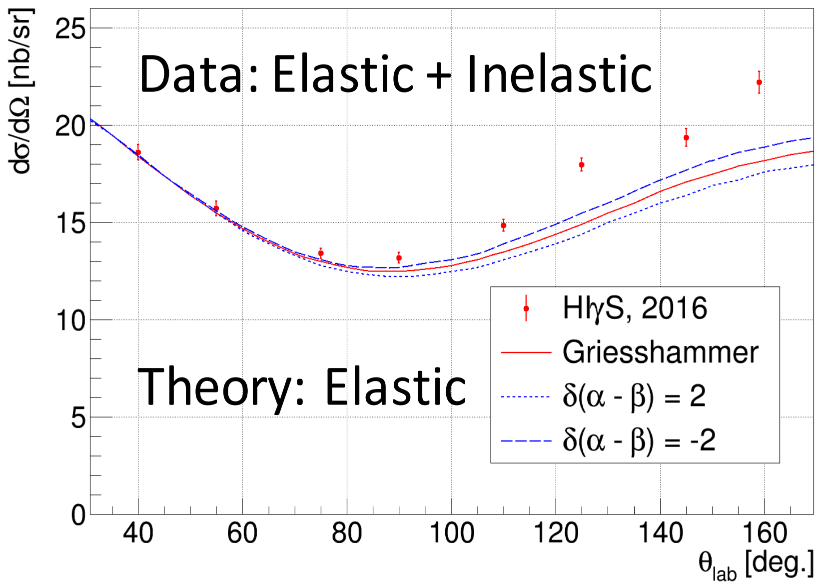
TUNL

^{4}He @ 61 MeV

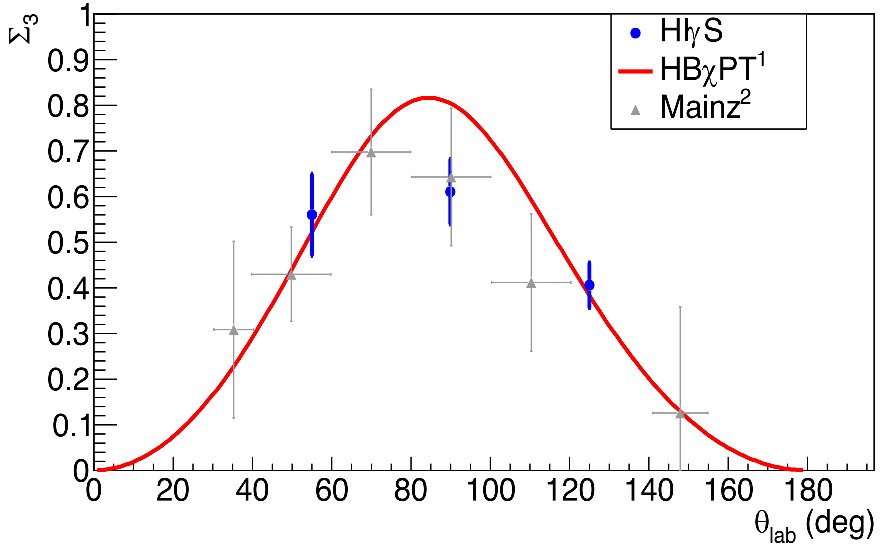


M.H. Sikora *et al.*, Phys. Rev. C **96**, 055209 (2017)

^{2}H @ 65 MeV



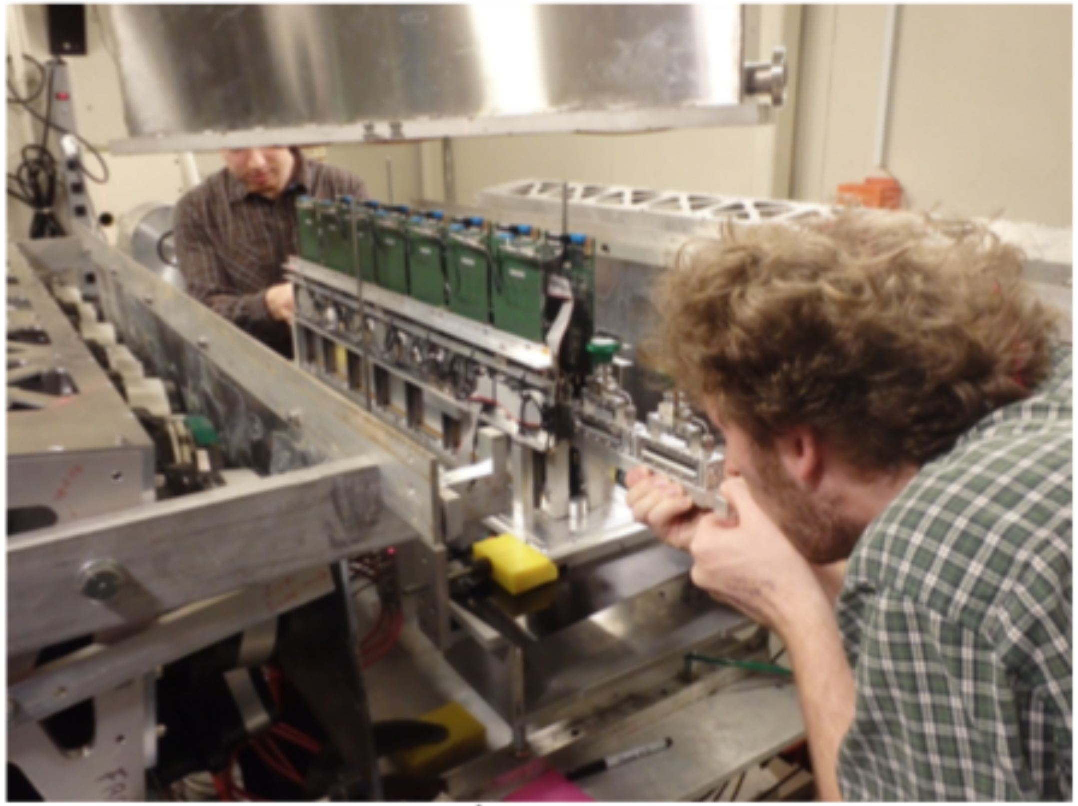
^{1}H @ 85 MeV – linear polarization

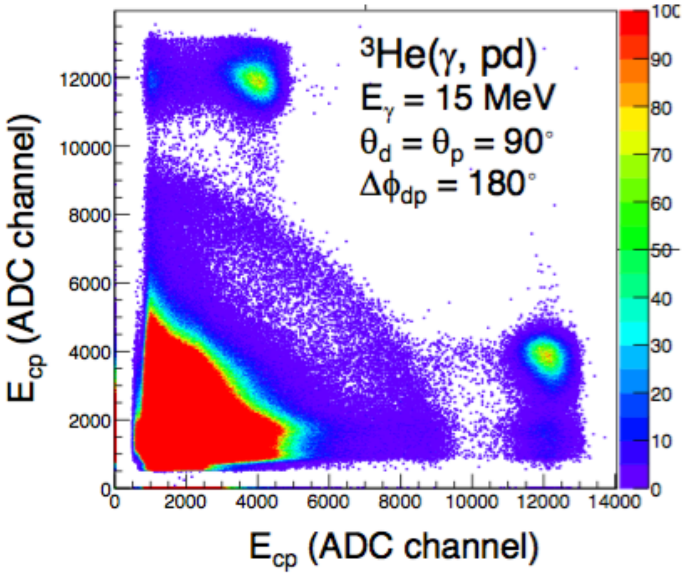


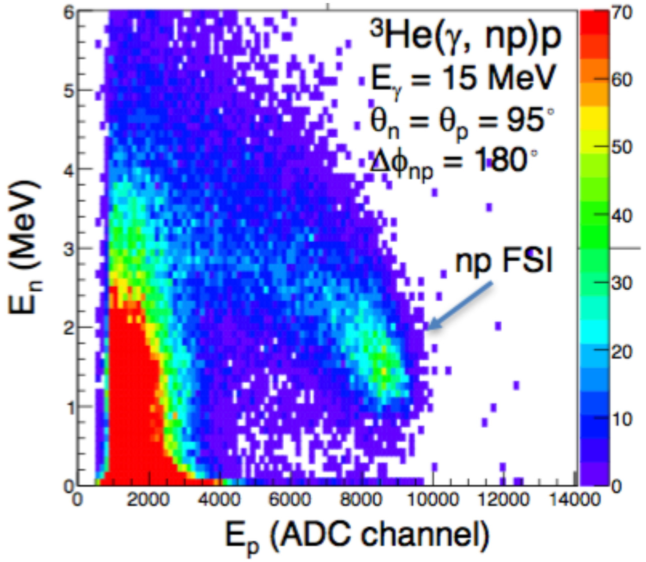
[1] J.A. McGovern, D.R. Phillips, H.W. Griesshammer, Eur. Phys. J. A, **49**, 12 (2013).

TUNL

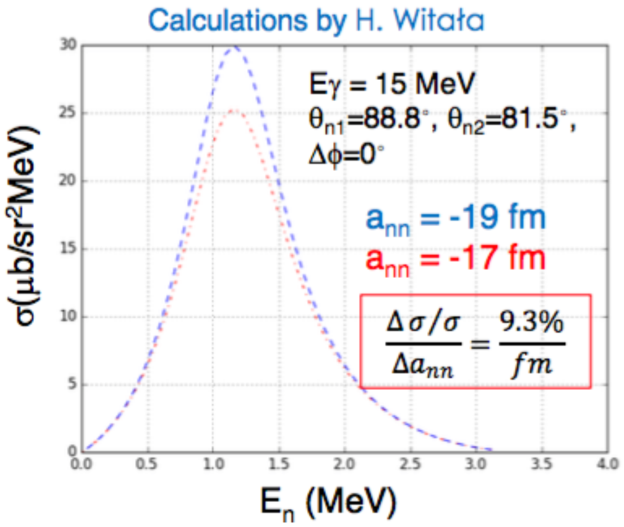
Photodisintegration of ^{3}He and ^{3}H at HIγS
n-d breakup in tandem lab



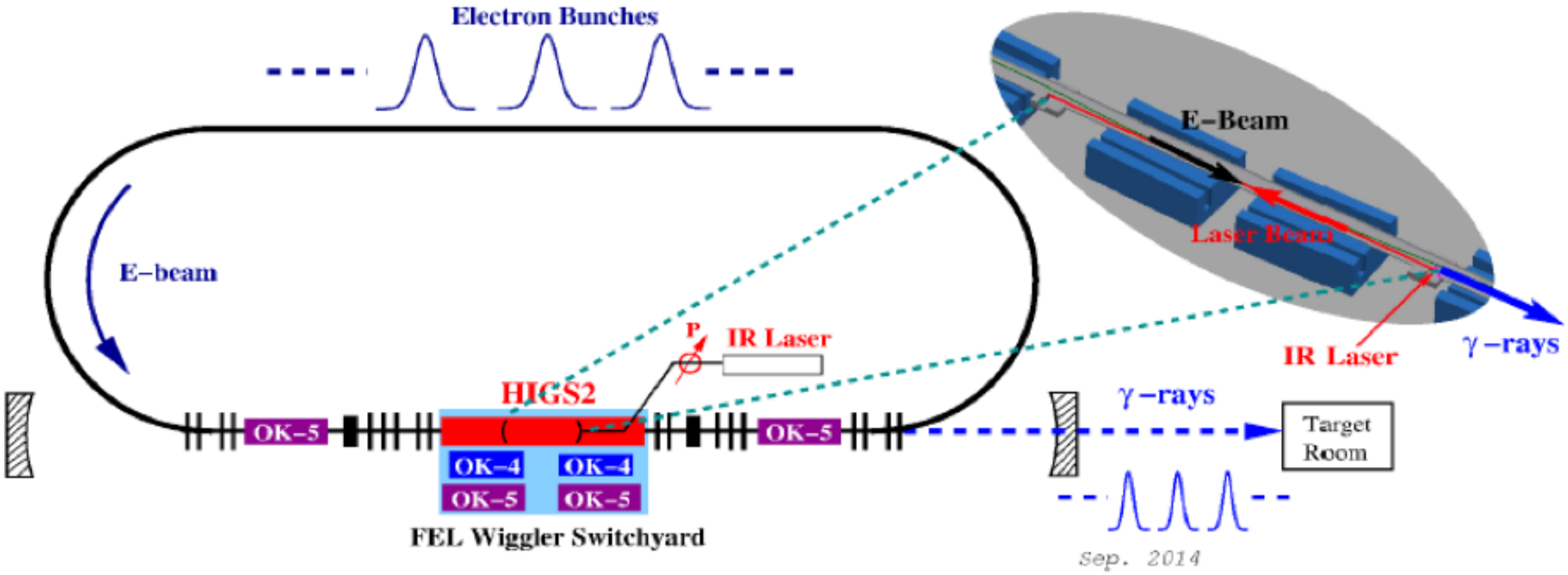


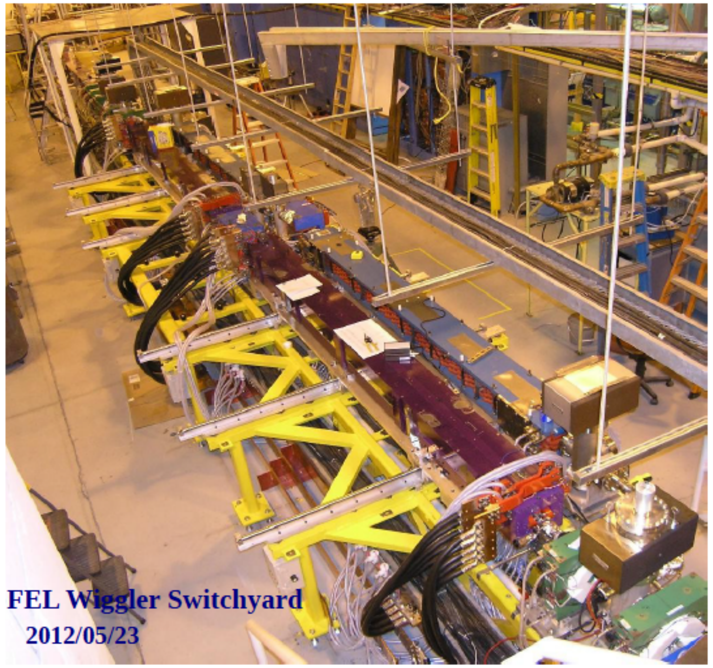


^{3}H(γ,nn)p



HIγS2 Concept

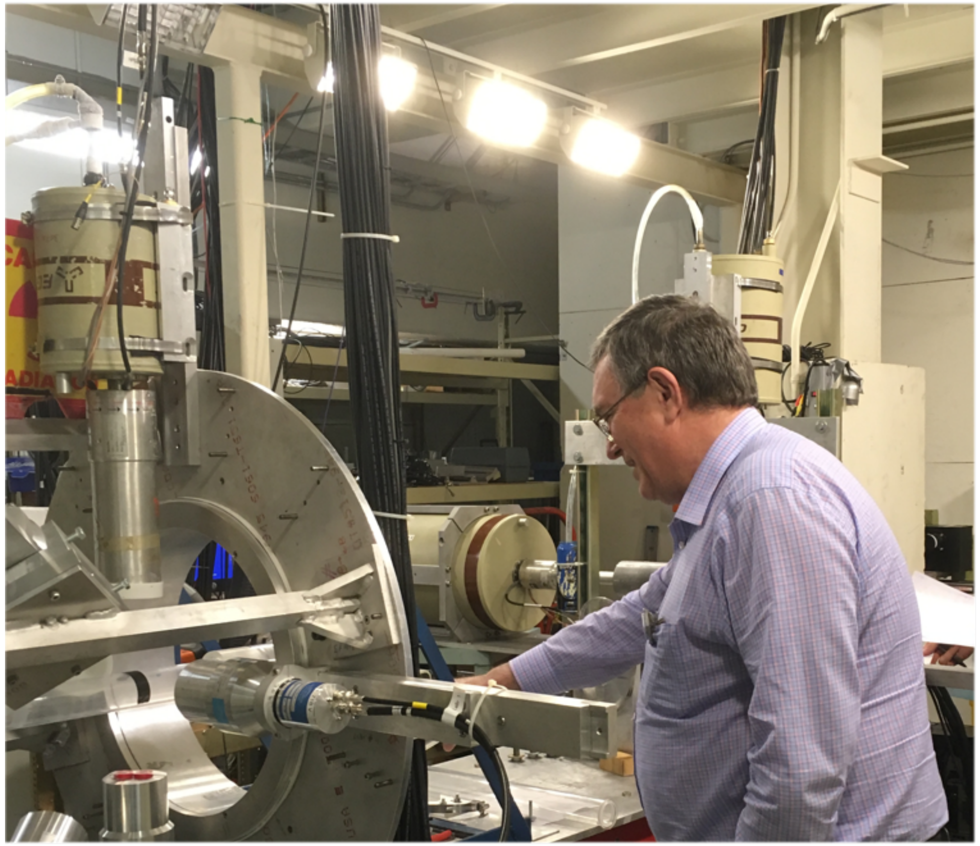


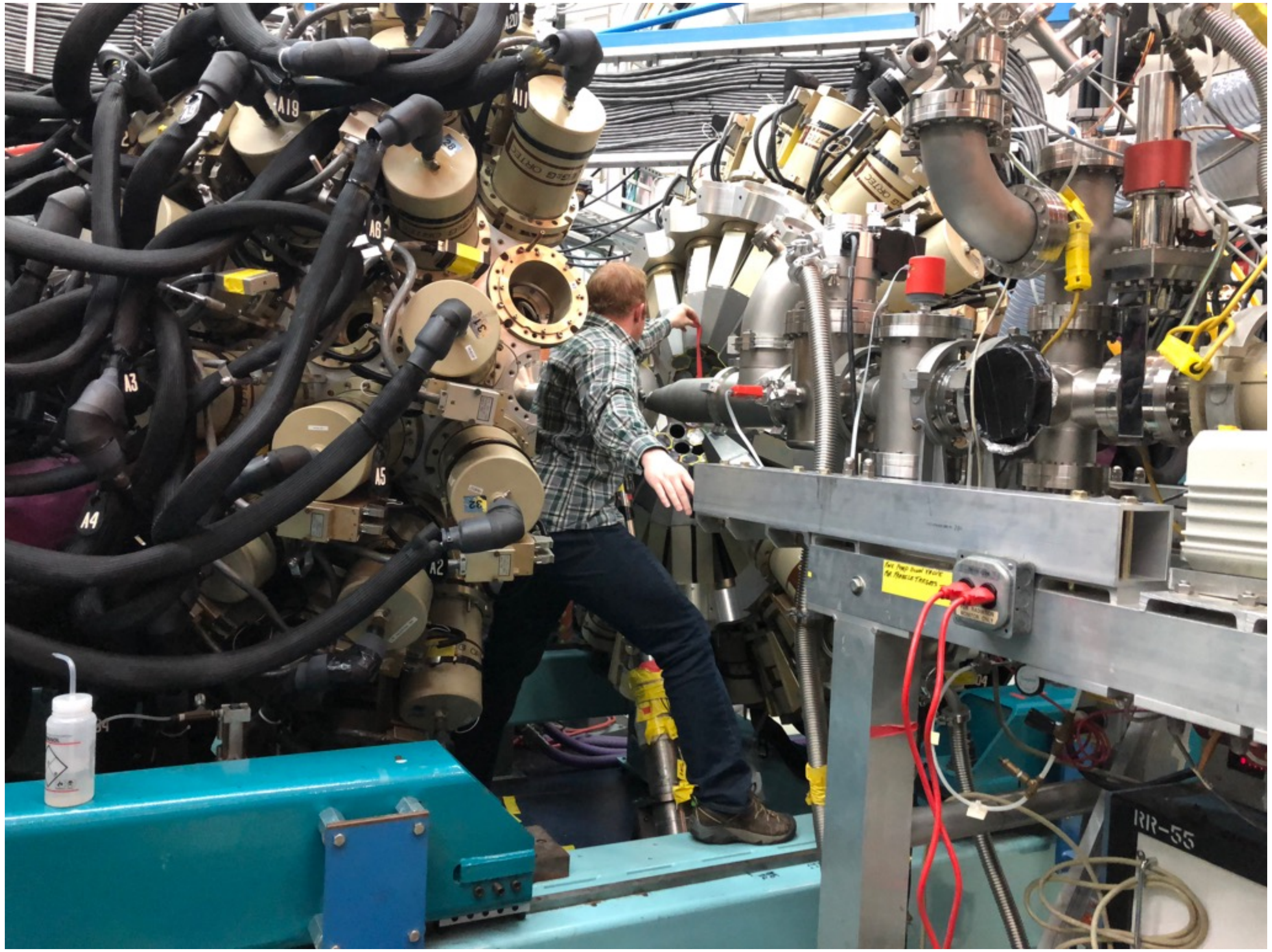


Fabry-Pérot laser cavity:
E_{γ} = 2 – 20 MeV
Increase in total flux by factor of 500 – 167 (larger increase in flux on target, e.g. gain of 1,600 - 5,000 at E_{γ} = 2.56 MeV, $\Delta E/E$ = 5%)
Estimated cost: $7 M

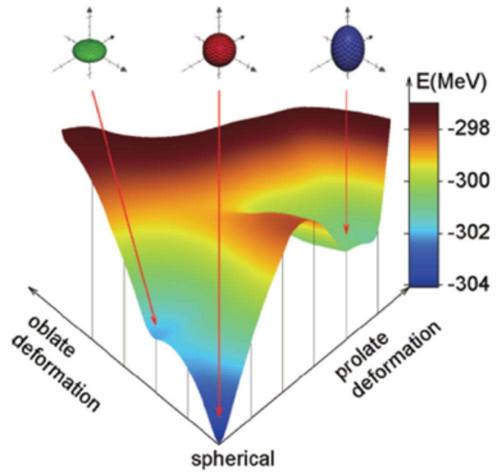
Research Highlights – Nuclear Structure

TUNL

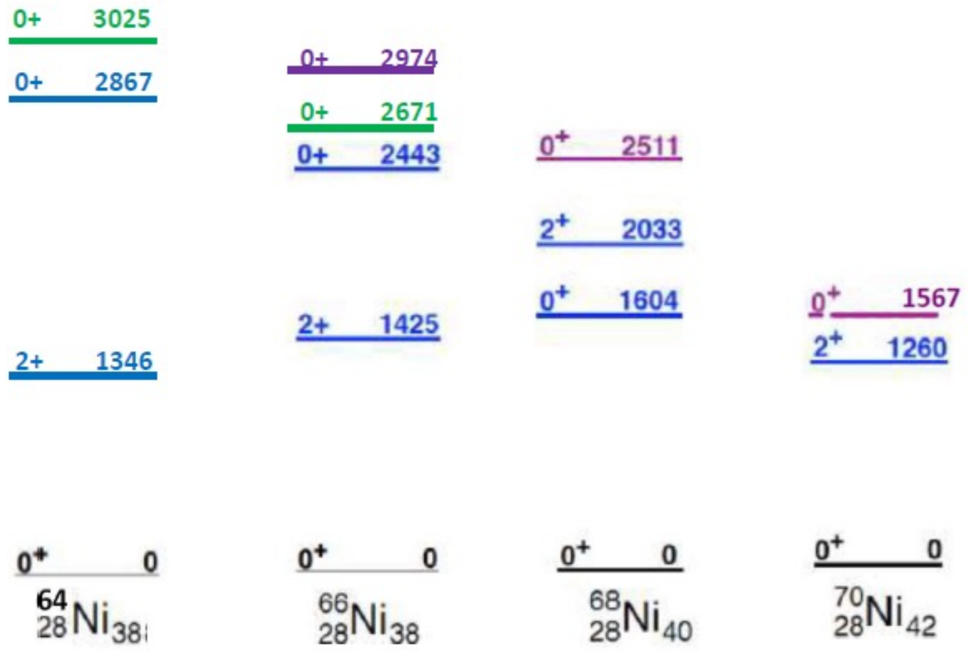




- Shape Coexistence is present in Ni with N = 38, 40, 42
- The 0_3^+prolate state is understood as dominated by a proton excitation
  - → it could/should be present in ^{64}Ni
  - → test effective interactions at stability



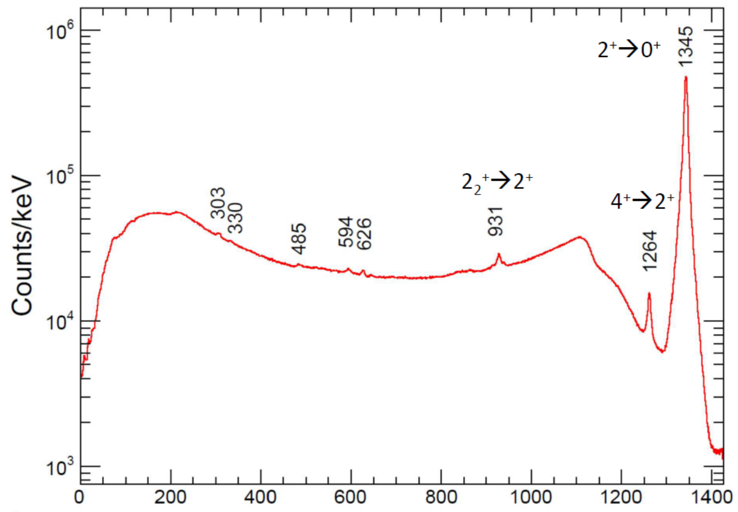
Y. Tsunoda *et al.*, PRC 89, 031310(R)

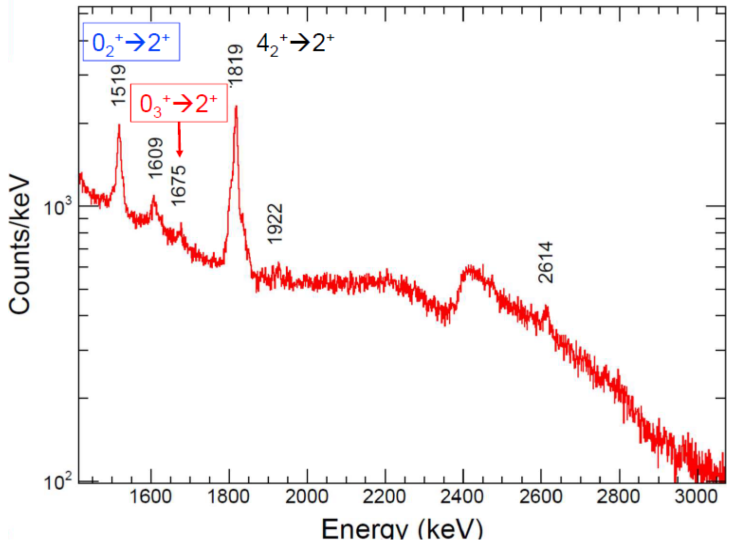


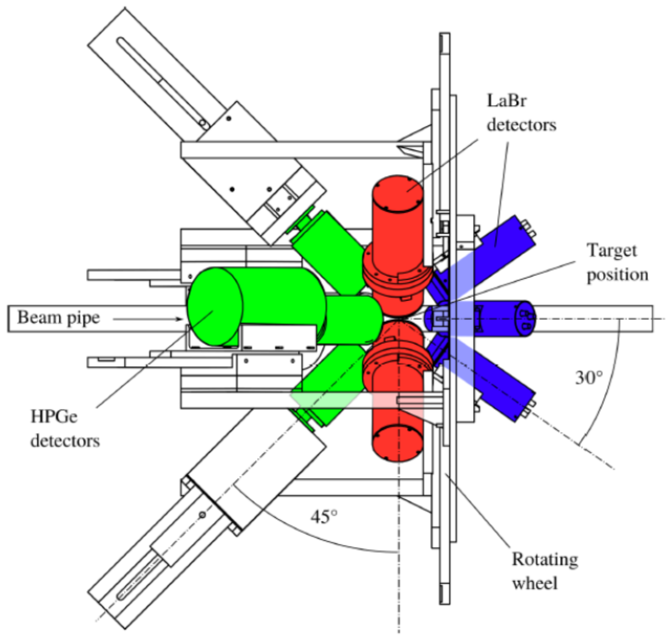
ATLAS & HIγS

ATLAS & NSCL

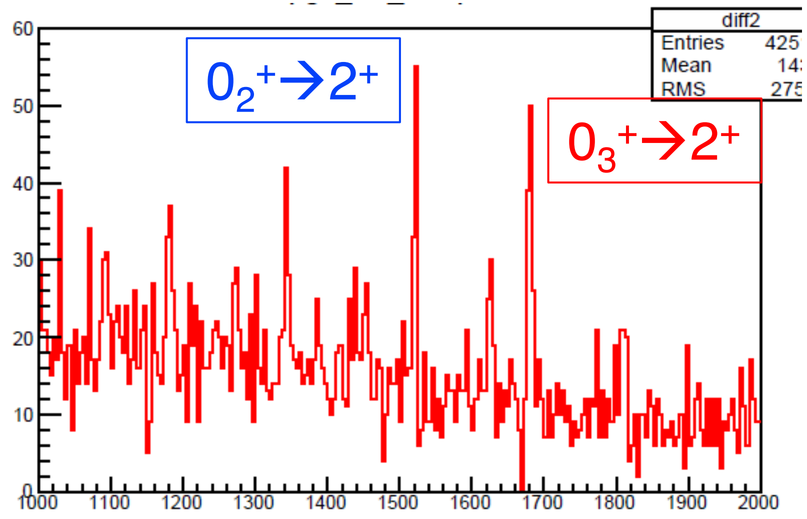
GRETINA & CHICO-2

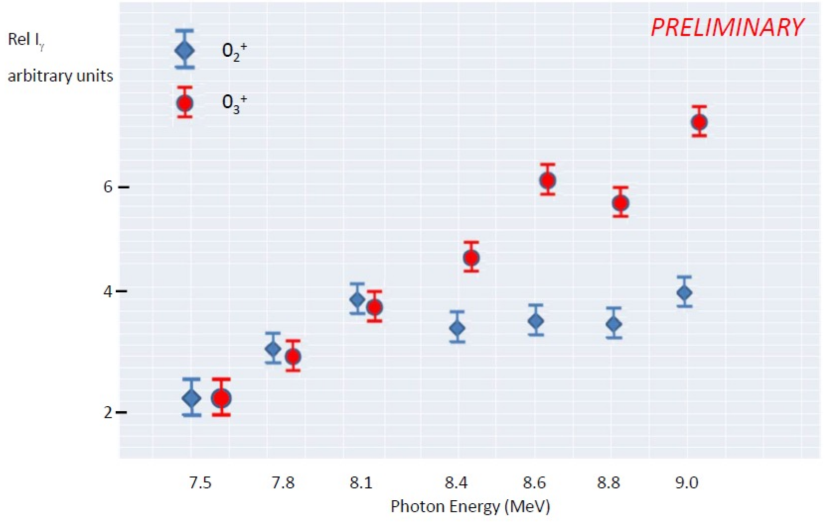






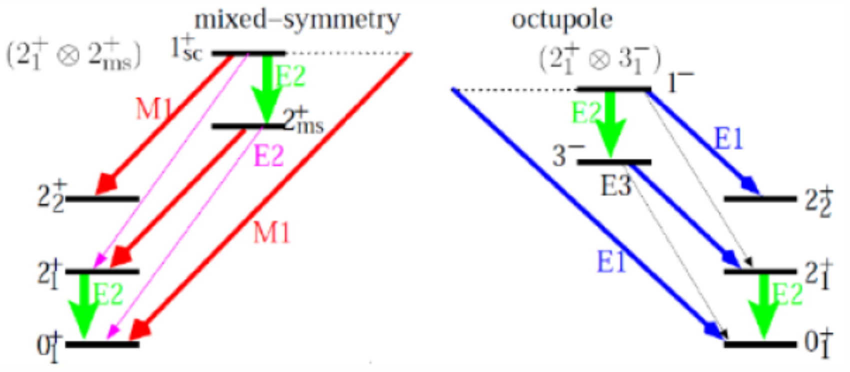
Current γ^3 setup



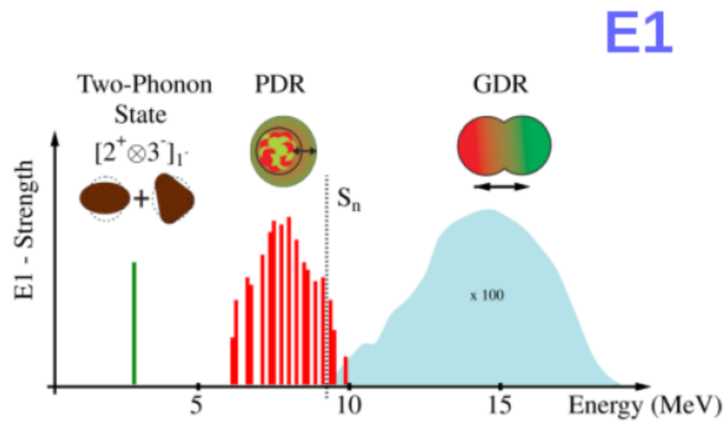


1. Multi-phonon states & coupling to rotational states

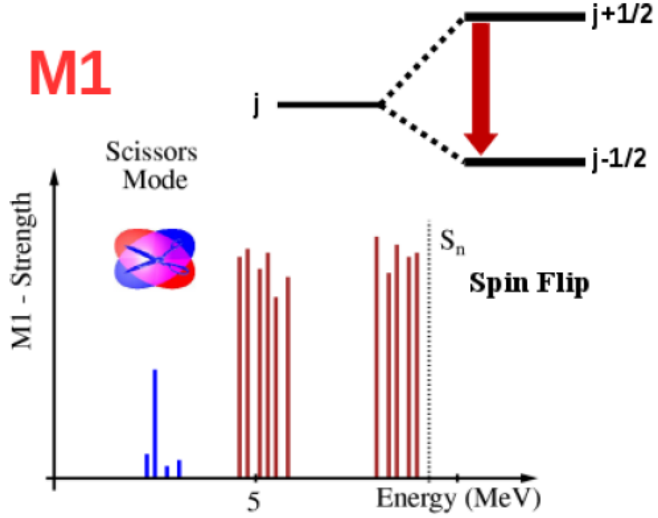
2-Phonon
J=1 States

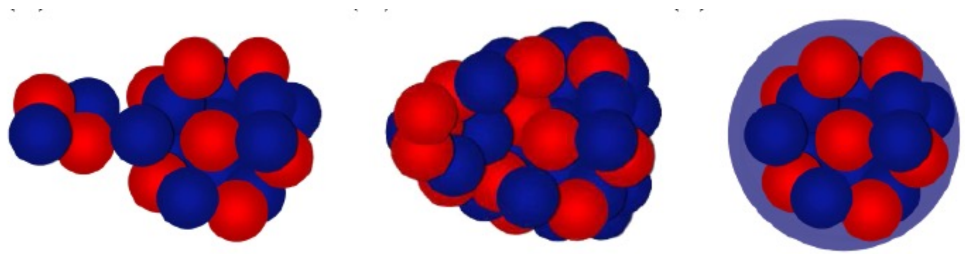


2. The E1 Pygmy Dipole Resonance



3. The M1 Spin-Flip Mode

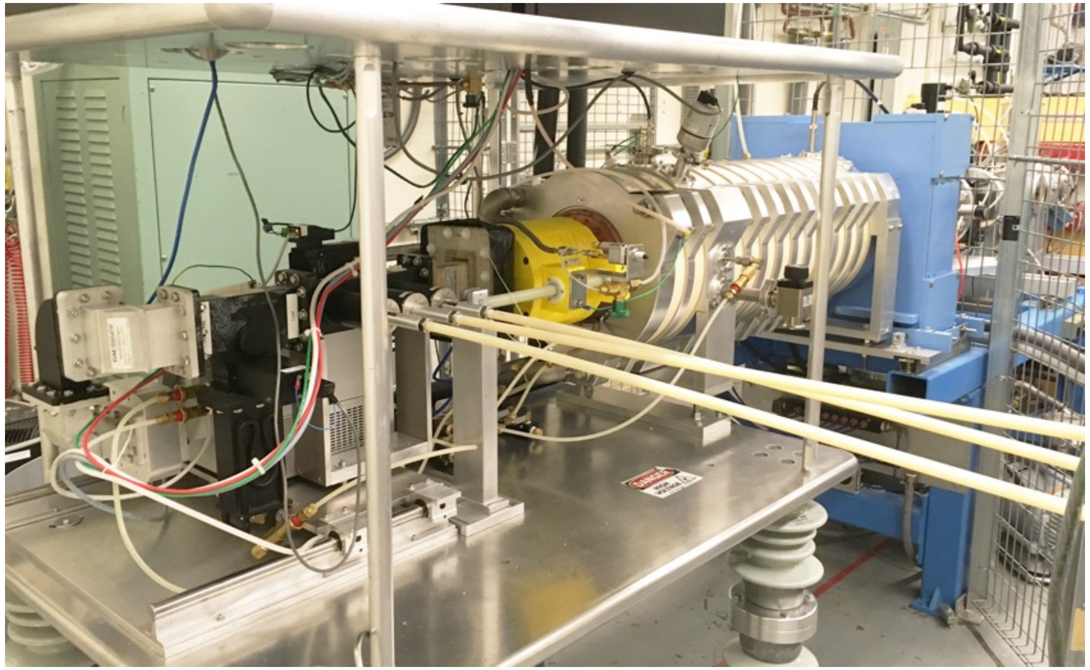




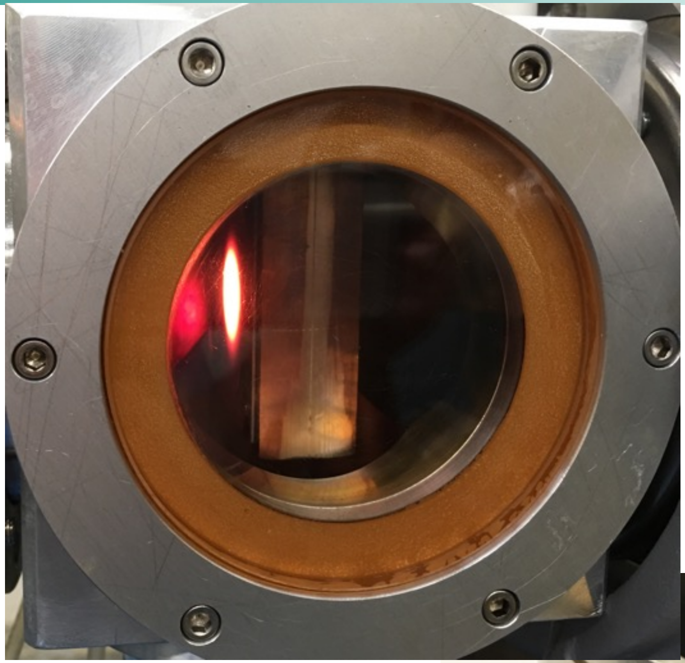
α clustering mode octupole mode PDR

M. Spieker *et al.*, PRL 114, 192504 (2015)

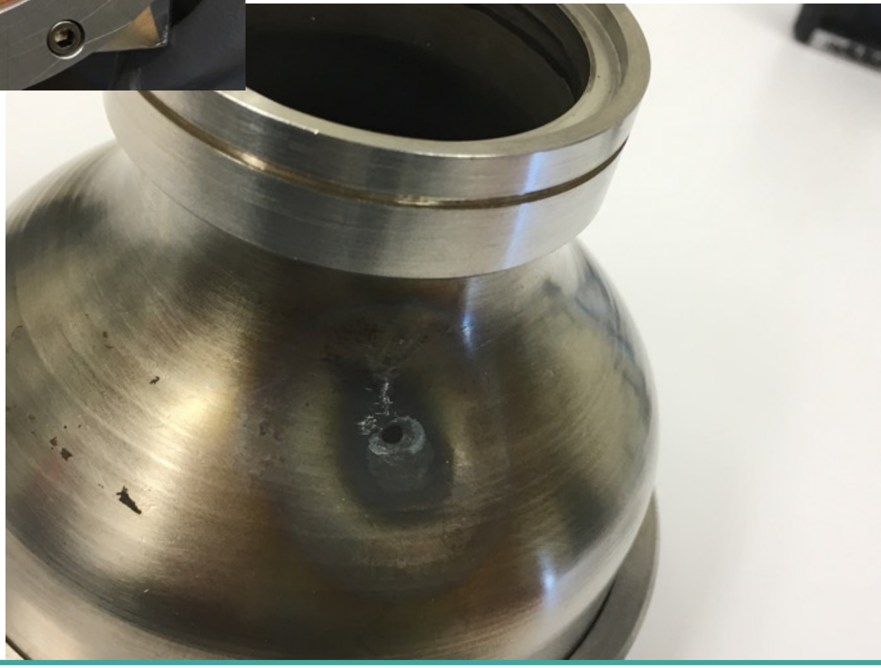
LENA 240-keV ECR accelerator



Magnet upgrade planned, late 2018

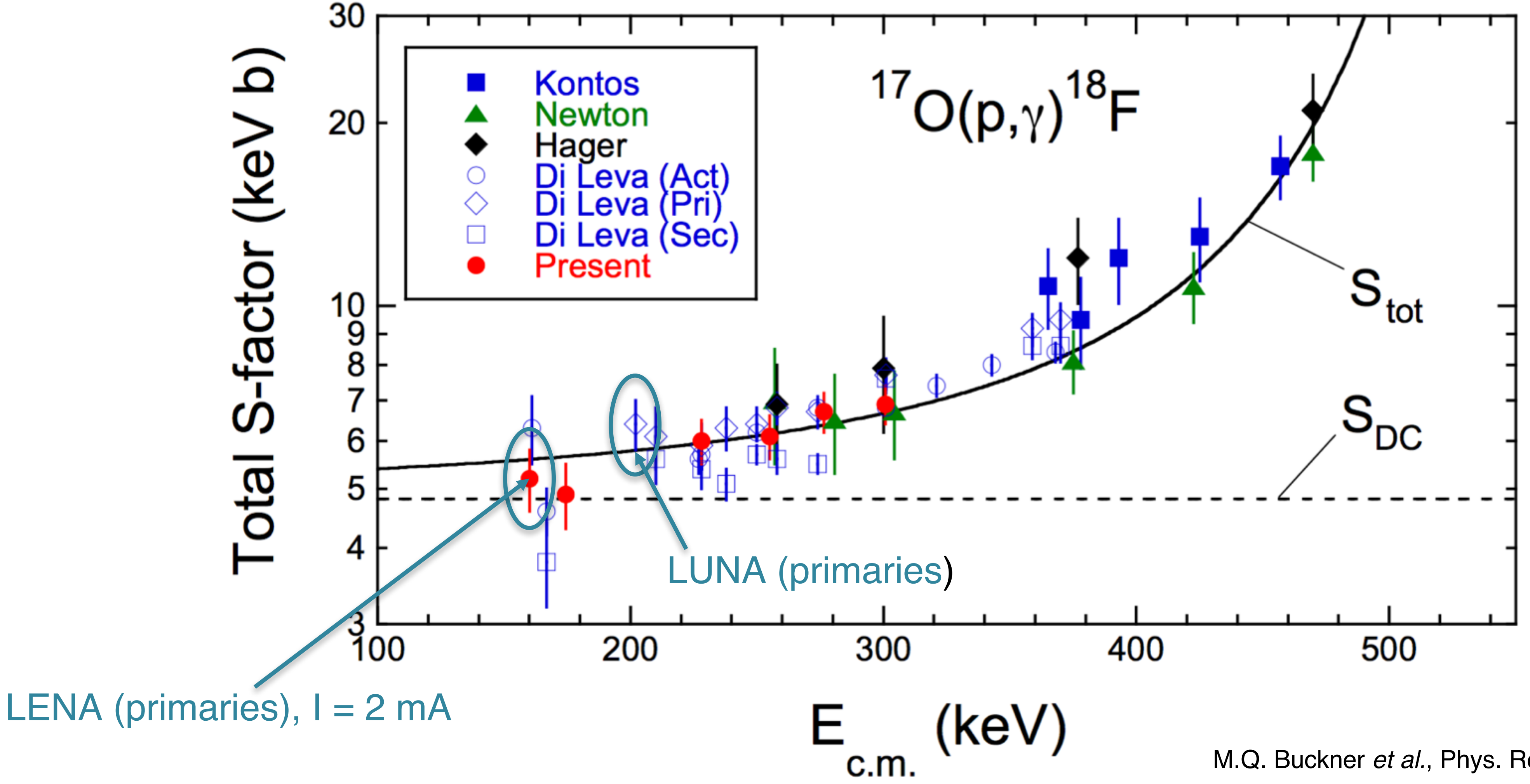


H+ beam on target:
~ 5.2 mA @ 200 keV



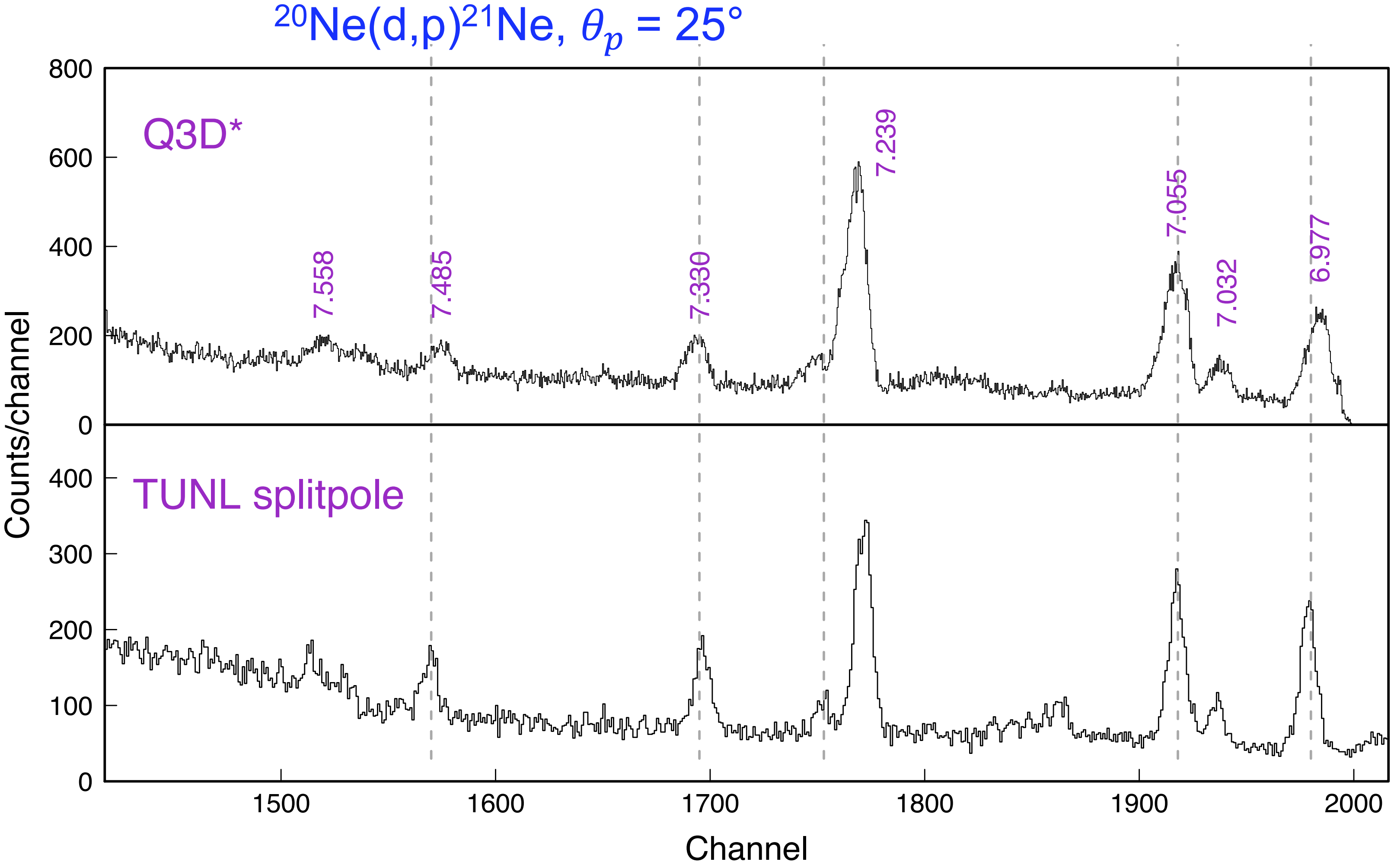
See:
https://m.phys.org/news/2018-08-renovations-big-nuclear-astrophysics-lab.html

Recent Results from LENA



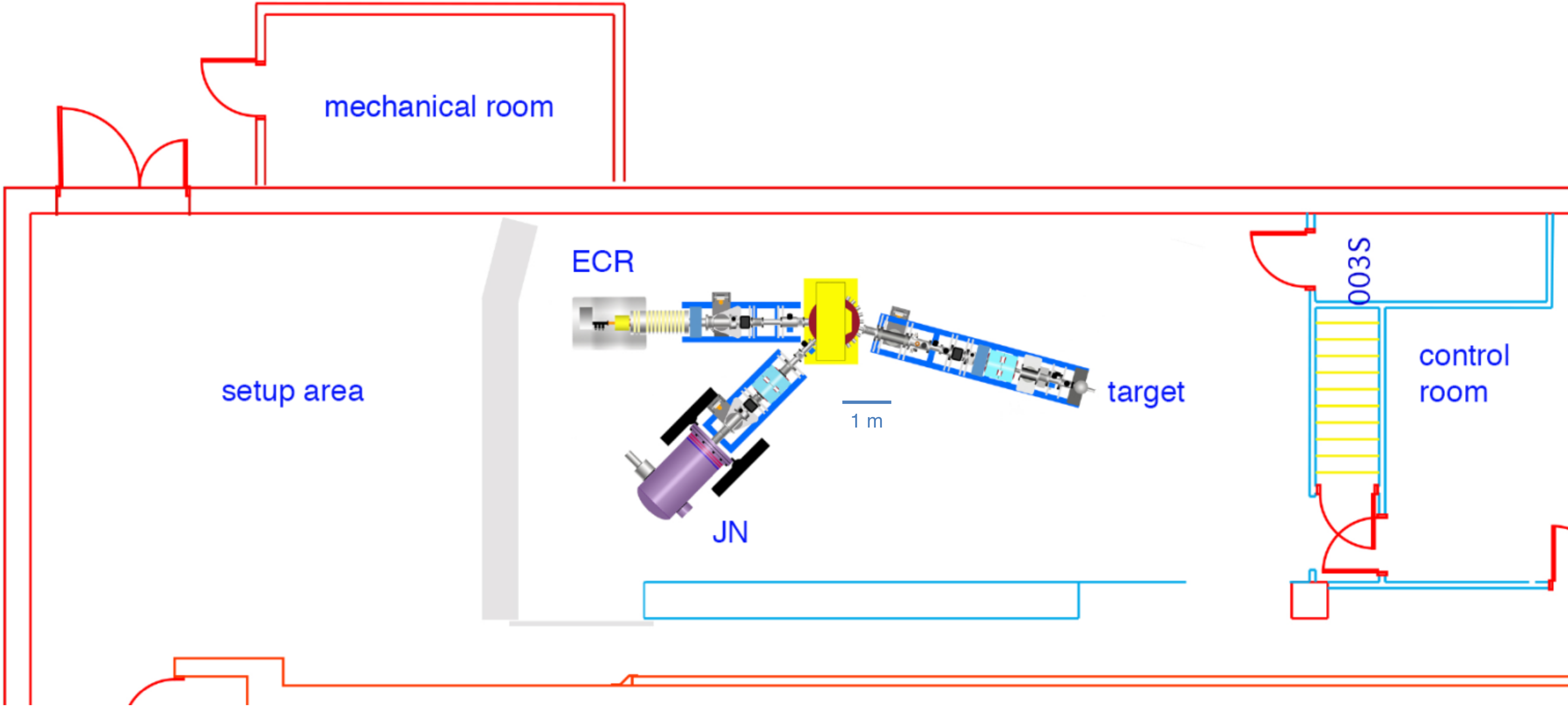
M.Q. Buckner *et al.*, Phys. Rev. C **91** 015812 (2015)

Enge split-pole spectrometer

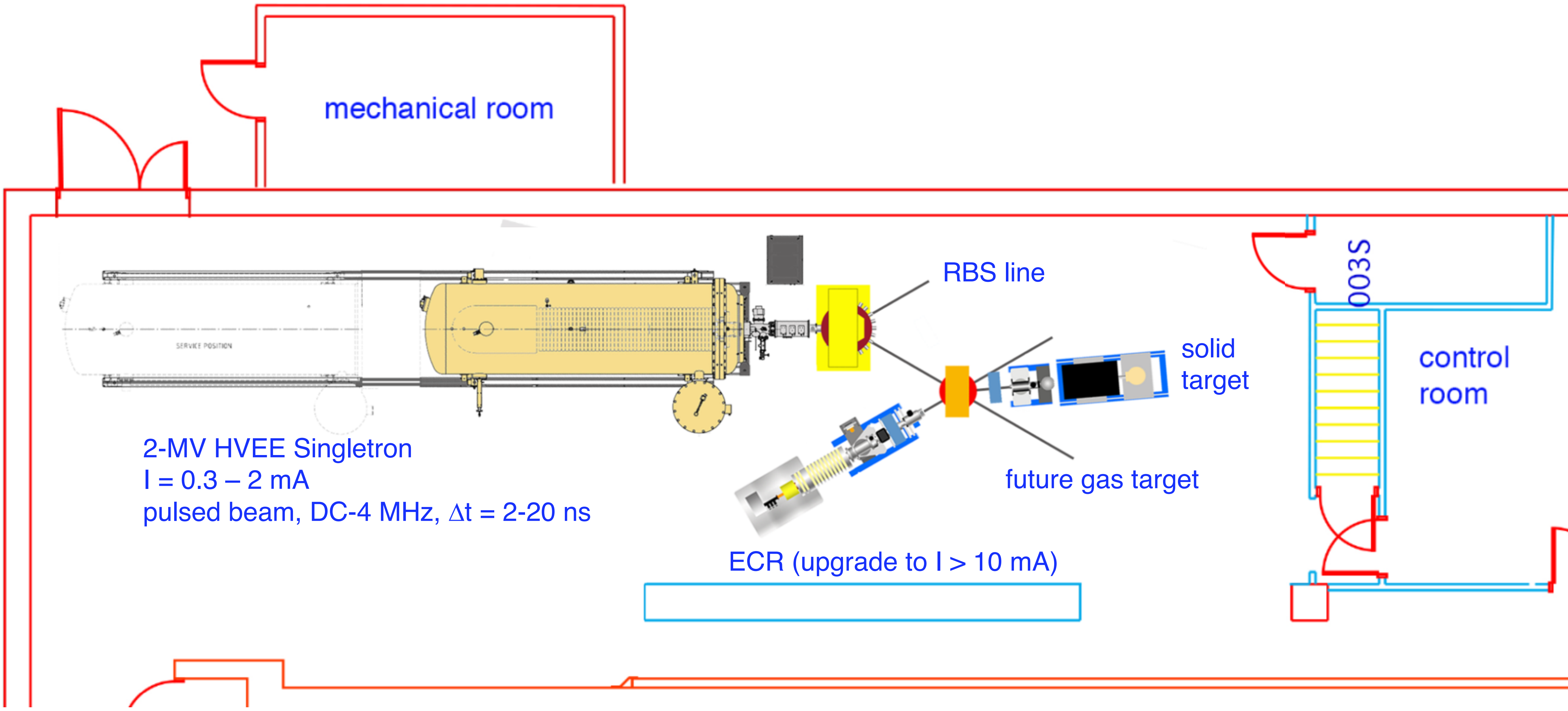


*C. T. Nsangu *et al* 2016 *J. Phys.: Conf. Ser.* **665** 012026

LENA - Current

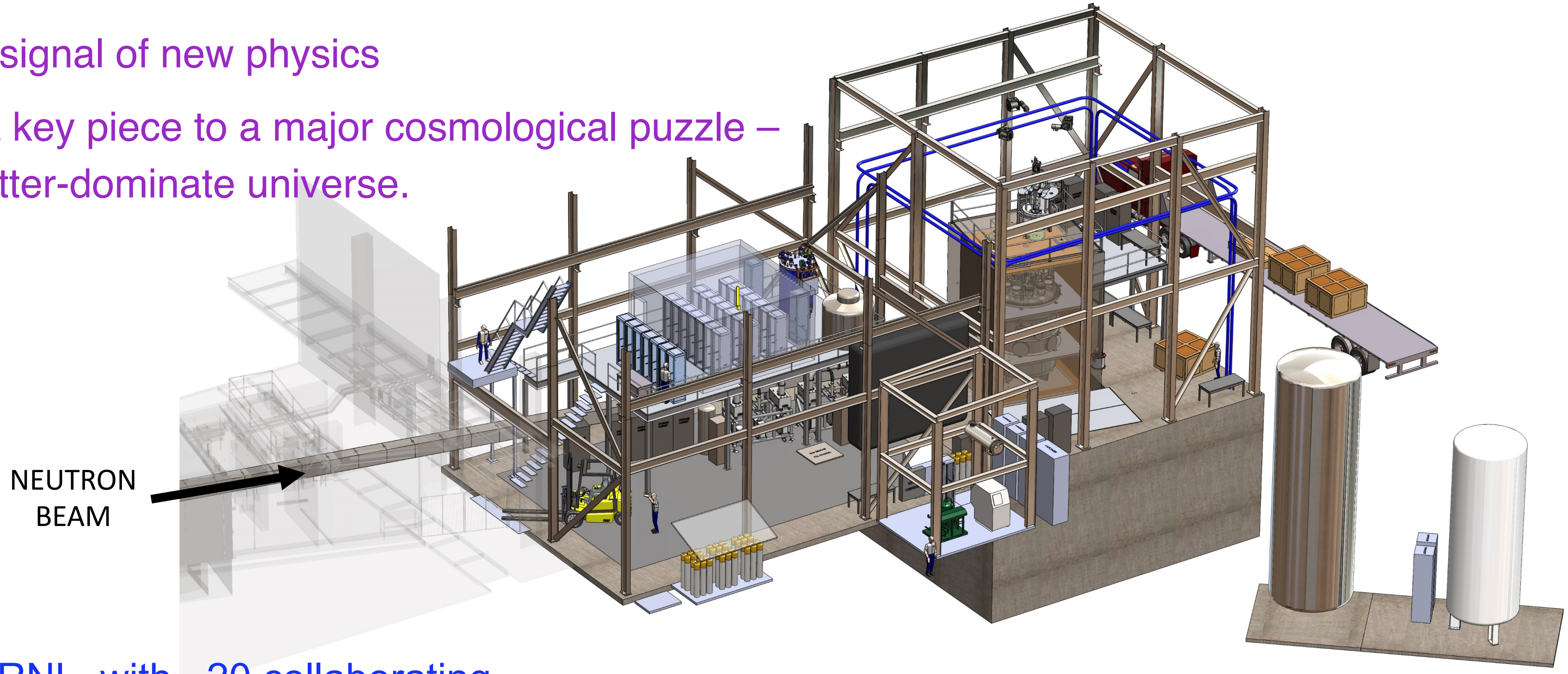


TUNL


mechanical room
SERVICE POSITION
RBS line
solid
target
003S
control
room
2-MV HVEE Singletron
I = 0.3 – 2 mA
pulsed beam, DC-4 MHz, Δt = 2-20 ns
future gas target
ECR (upgrade to I > 10 mA)

nEDM is moving from R&D phase to construction

- Goal is to measure the neutron EDM with a sensitivity of $d_n < 5 \times 10^{-28}$ e•cm (90%)
- Seeks to discover a new source of CP-Violation
- Would be a dramatic signal of new physics
- Potentially provides a key piece to a major cosmological puzzle – why we live in a matter-dominate universe.



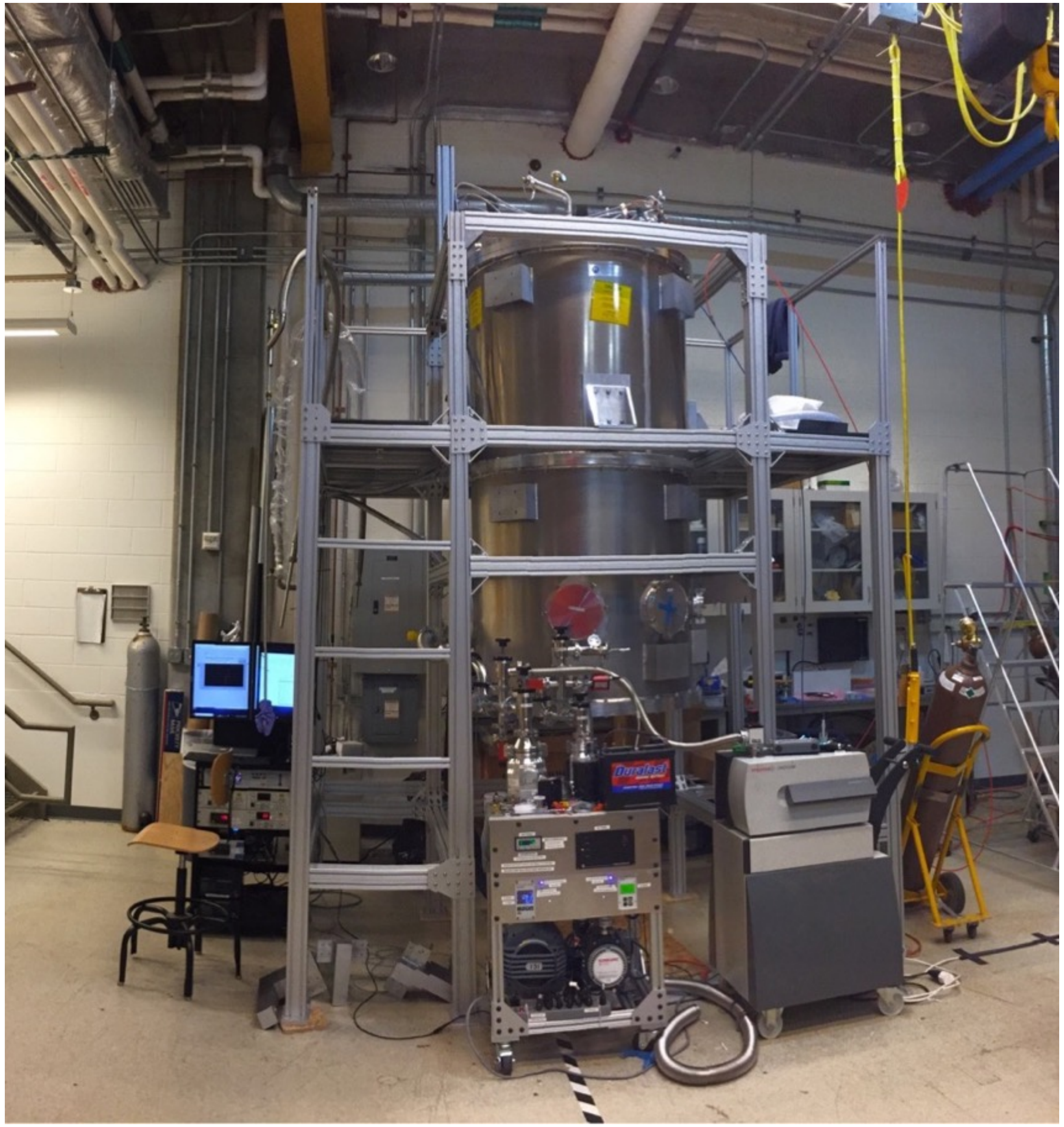
Based at the SNS at ORNL, with ~20 collaborating institutions across the U.S. and Canada.

Cryovessel Arrival at Caltech

TUNL

Systematic study apparatus:

- Neutron and ^{3}He motional correlation functions
- Measurements of the neutron-to-^{3}He gyromagnetic ratio
- Development of the precise simultaneous manipulation of neutrons and ^{3}He spins with AC fields
- Studies of the critical spin-dressing and spin-dressing modulation techniques
- Studies of the pseudomagnetic field that is aligned with the ^{3}He spins and generated by the spin-dependent n-^{3}He scattering length
- General measurement cell characterization

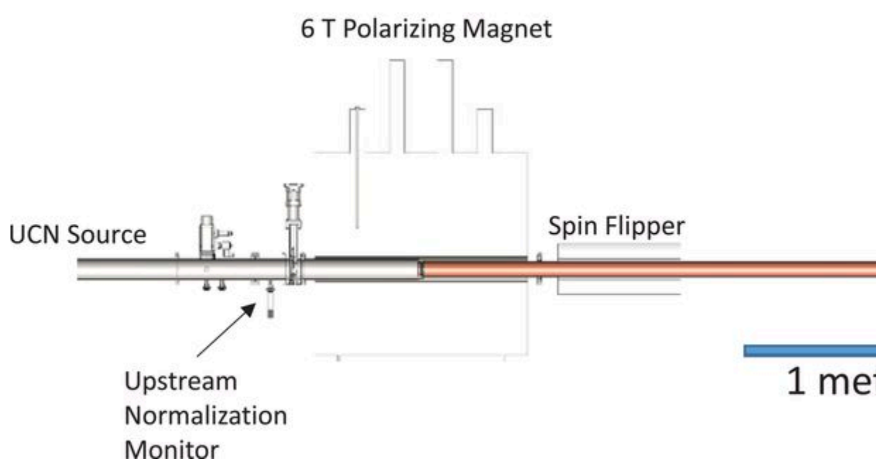


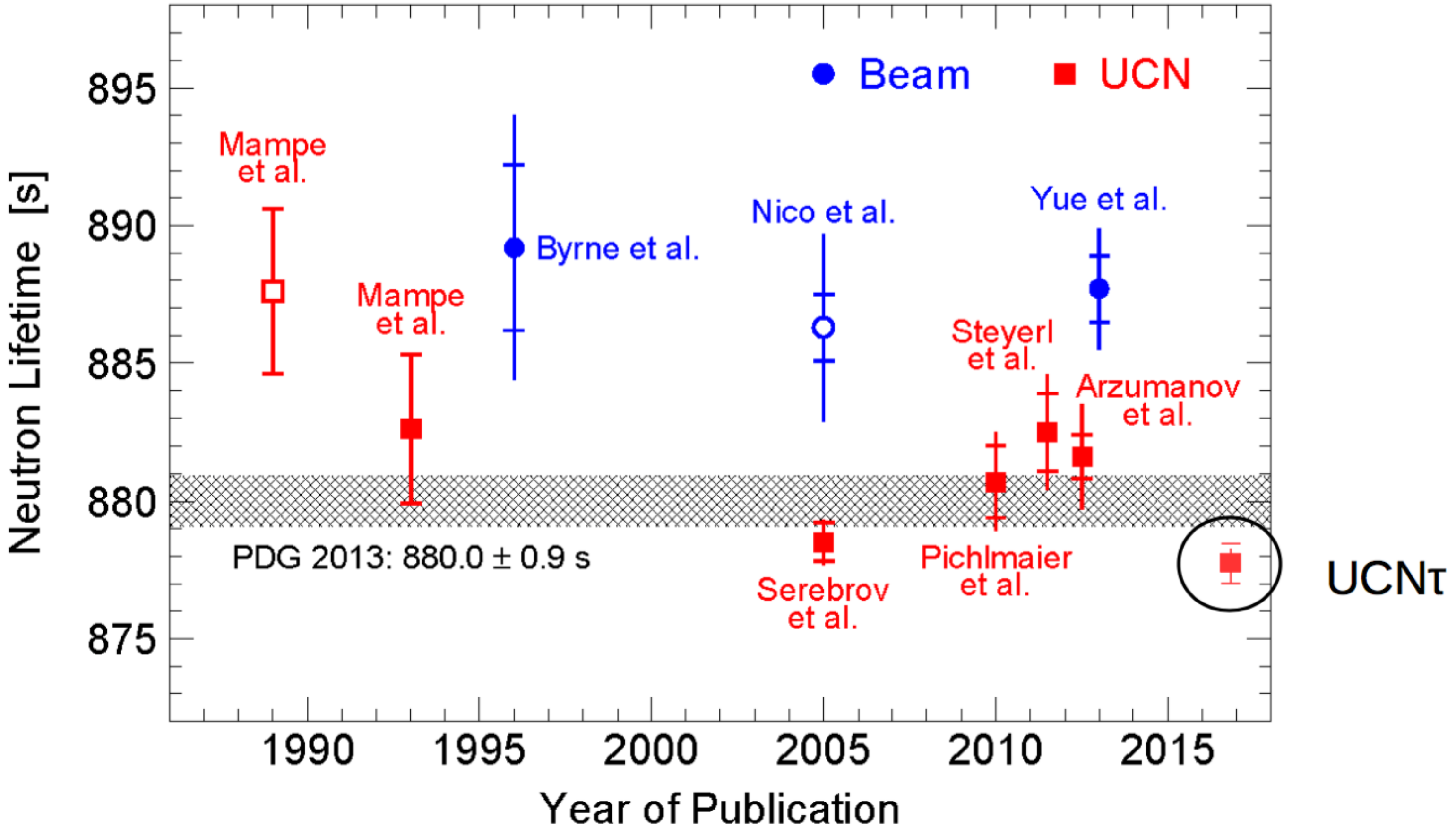
Neutron β-decay

Lifetime of the neutron from UCNτ*

R. W. Pattie Jr. et al. Science 2018;360:627-632

$\tau = 877.7 \pm 0.7_{stat}\ {}^{+0.4}_{-0.2}{}_{sys}$ s

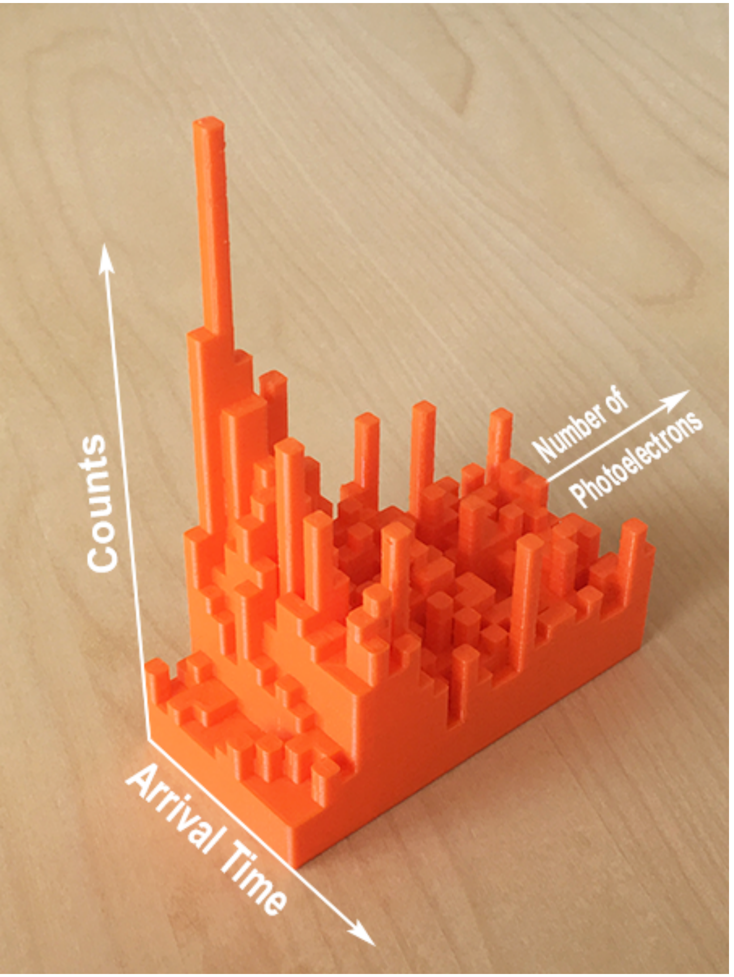




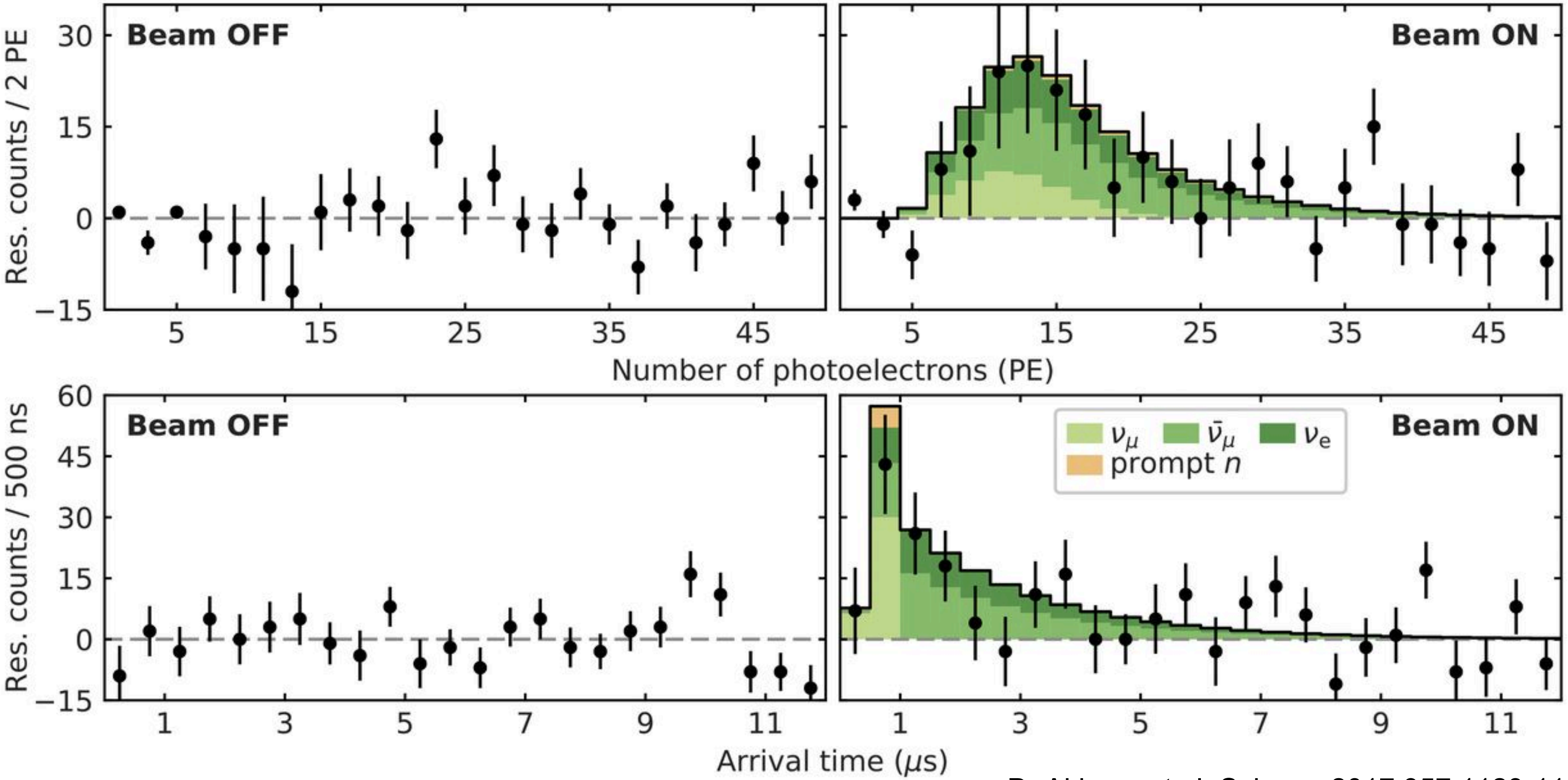
Also: UCNA
Nab
NIST interferometry

*based at LANL with 12 collaborating institutions

TUNL



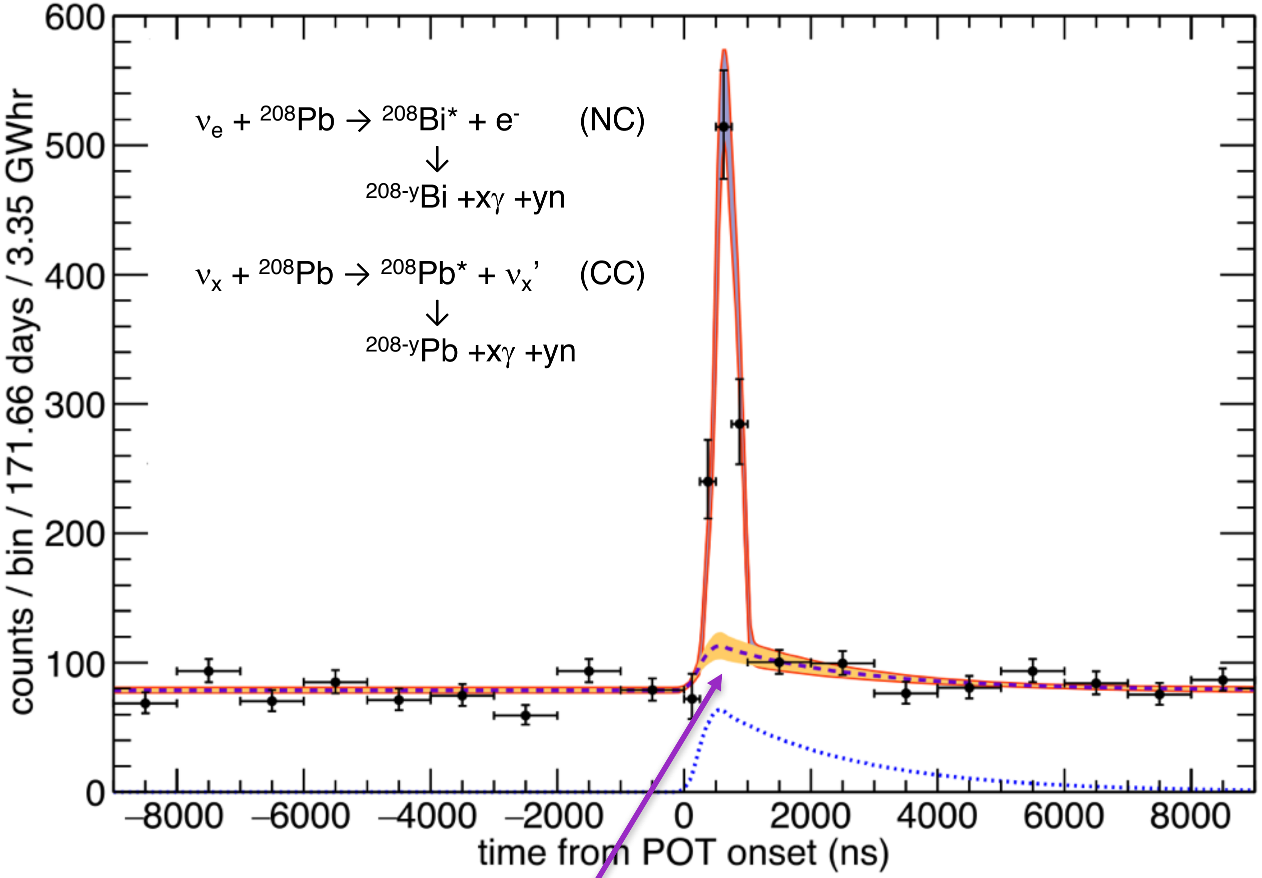
First observation of coherent elastic neutrino-nucleus scattering!



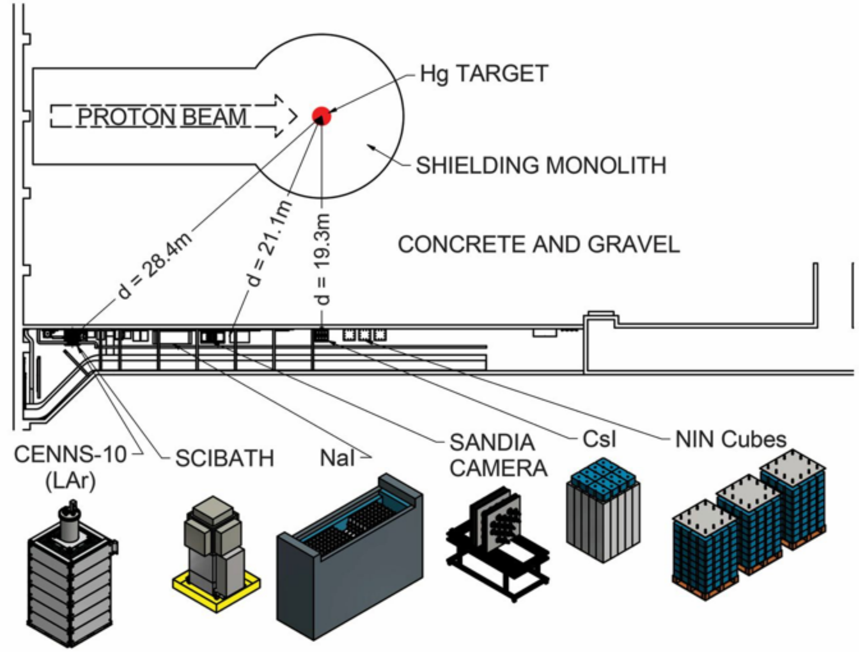
D. Akimov et al. Science 2017;357:1123-1126

Located at the SNS, ORNL, 21 collaborating institutions

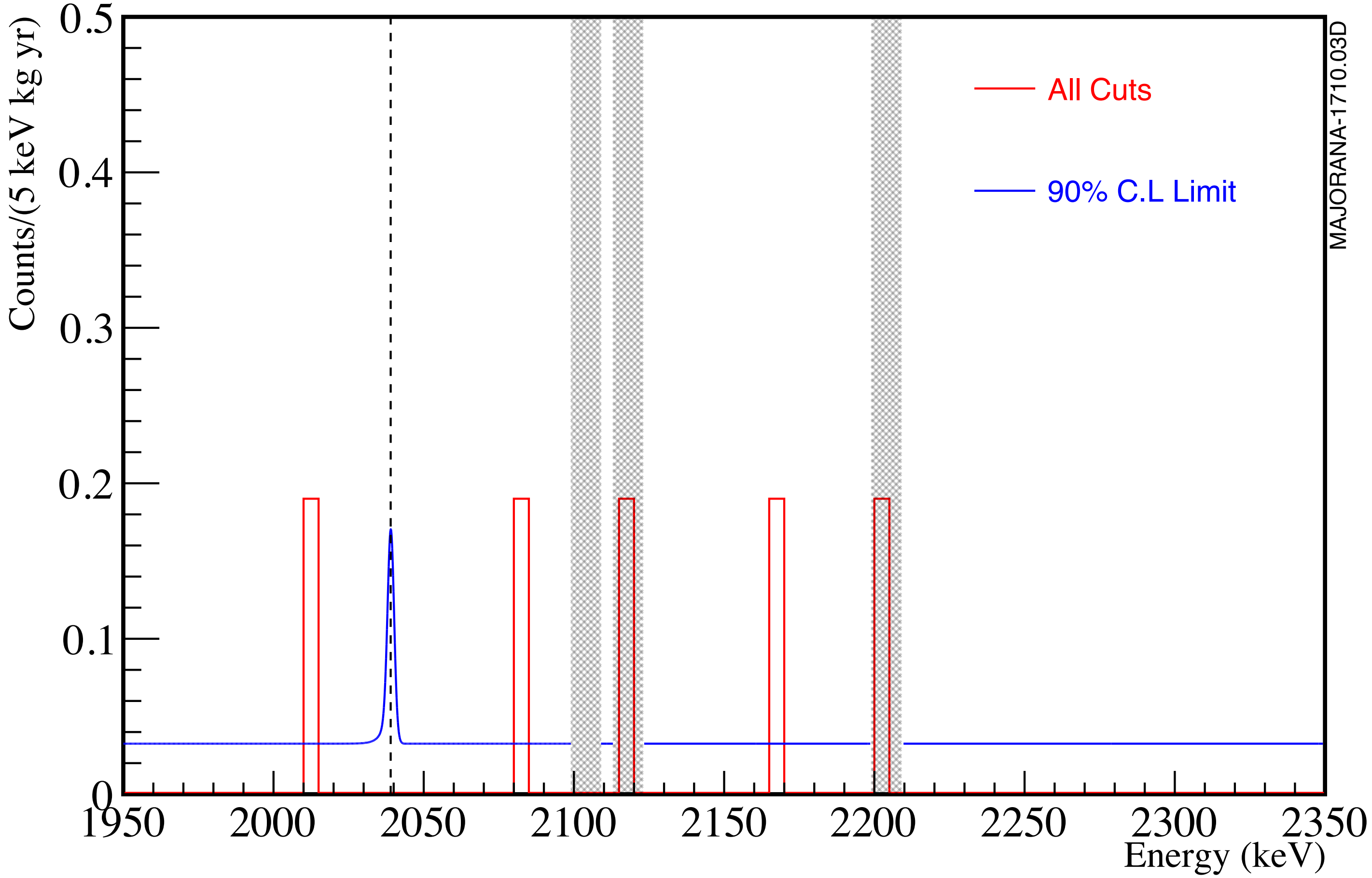
TUNL



factor of 1.7 less than theory



quenching factor measurements using n-beams from the tandem →



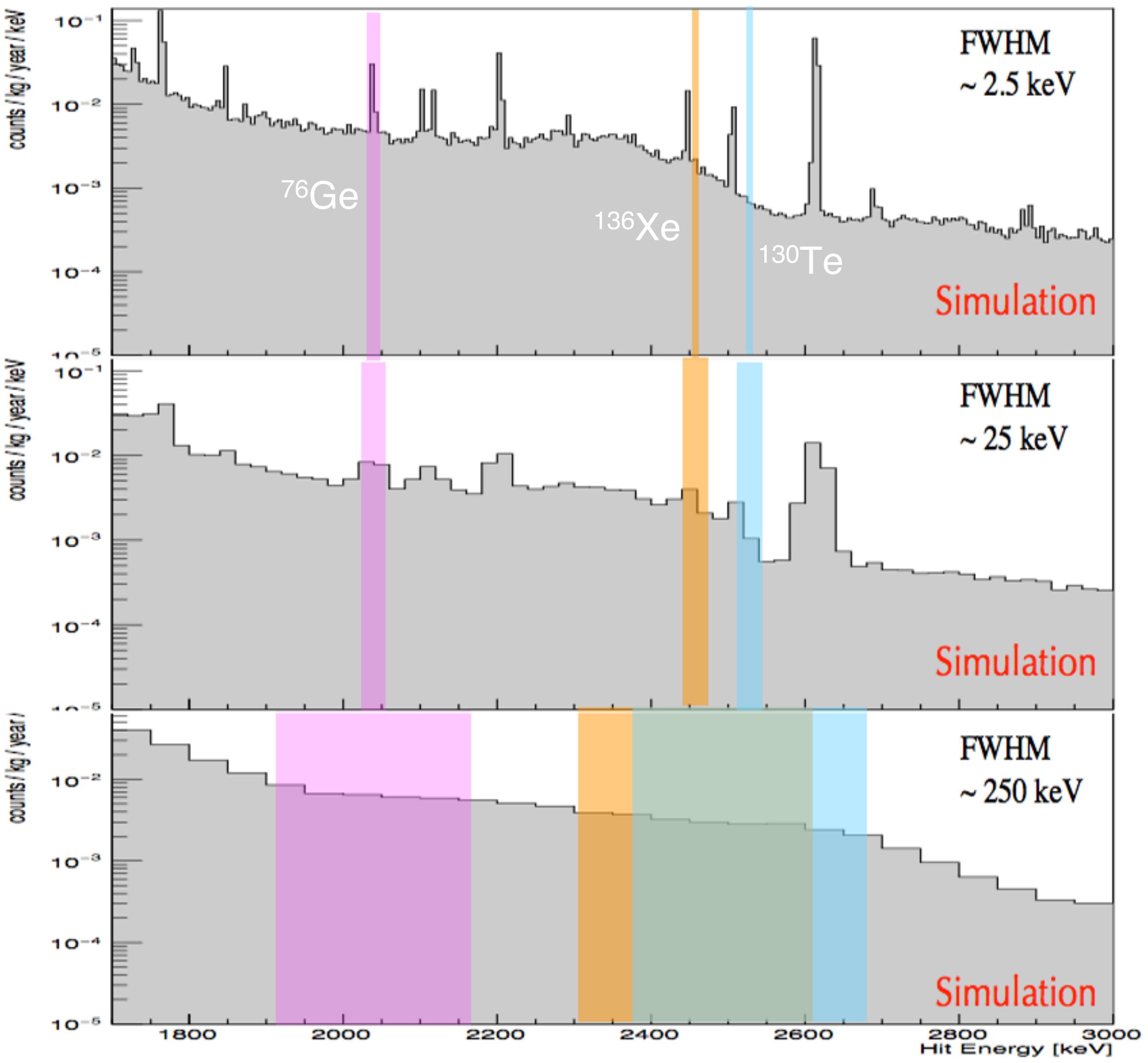
9.95 kg・yr exposure:

$T_{1/2}^{0\upsilon} > 1.9 \times 10^{25}$ yr (90% CL)

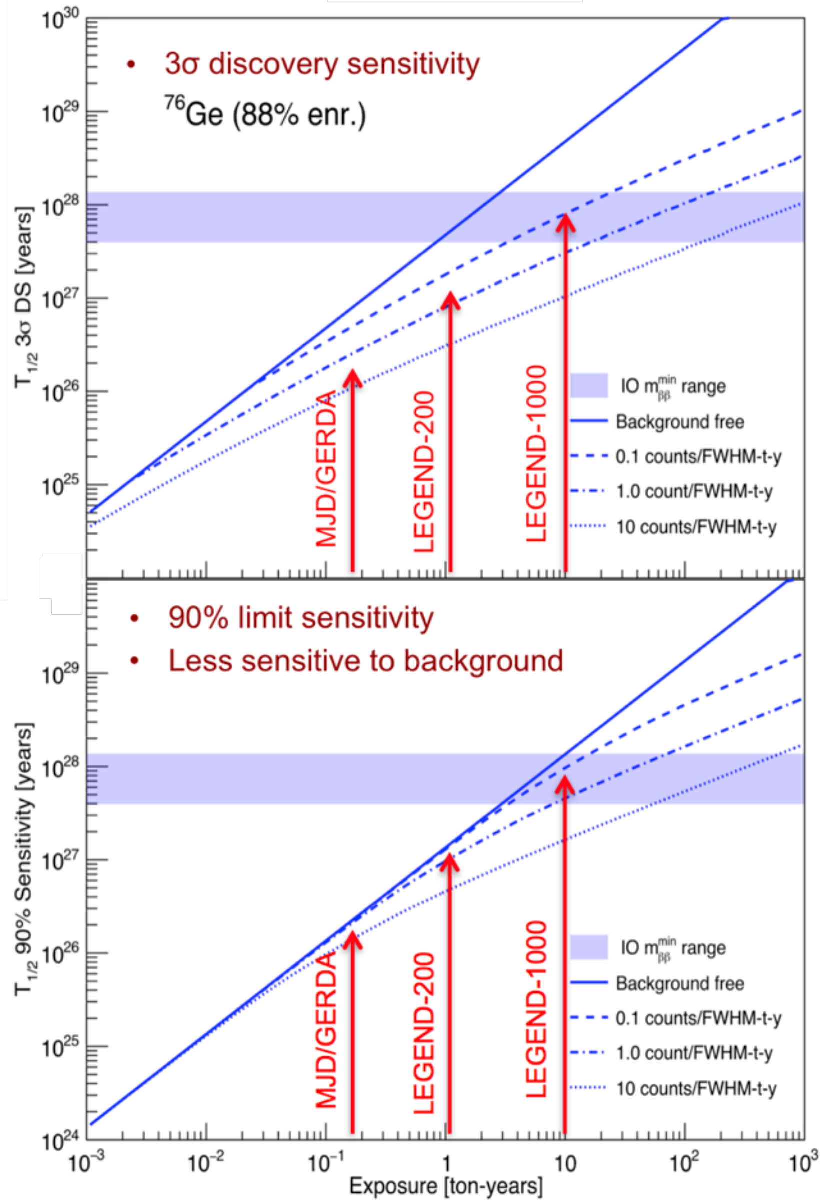
$1.6^{+1.2}_{-1.0}$ cts/(keV/t yr)

C. E. Aalseth *et al.* (Majorana Collaboration), Phys. Rev. Lett. **120**, 132502 (2018)

Discovery Potential



M. Buuck



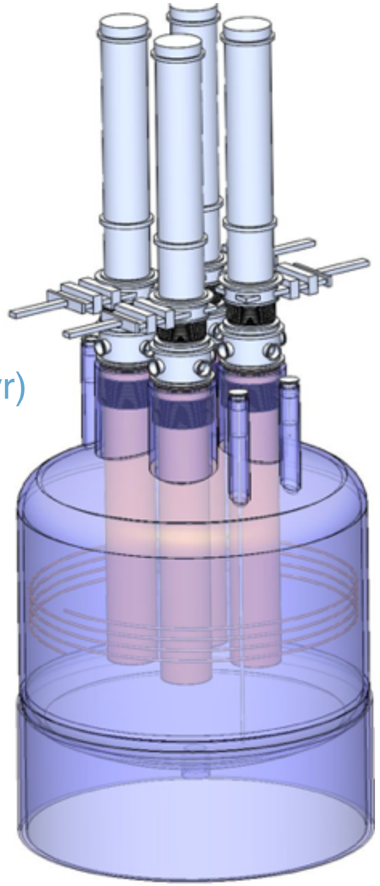
LEGEND mission: “The collaboration aims to develop a phased, ^{76}Ge based double-beta decay experimental program with **discovery potential** at a half-life beyond 10^{28} years, using existing resources as appropriate to expedite physics results.”

First Stage:

- (up to) 200 kg ^{76}Ge in upgrade of existing infrastructure at LNGS
- BG goal: 0.6 cts/(FWHM t yr)
- Data start ~2021
- Will use Majorana & GERDA detectors
- Proposal submitted to LNGS in March 2018
- Funding for 130 of the 200 kg in place.

Subsequent Stages:

- 1000 kg ^{76}Ge (staged)
- Timeline coordinated with first Stage
- BG goal: 0.1 cts/(FWHM t yr)
- Location tbd
- Required depth (Ge-77m) under investigation



Summary

Synergistic use of accelerators and non-accelerator techniques to tackle complex problems
(a flexible, highly-trained workforce in service of society)