The Notre Dame Nuclear Science Laboratory

Dan Bardayan

Association for Research at University Nuclear Accelerators

The NSL Laboratory

10 MV FN Tandem

St. GEORGE Recoil Separator

5U Pelletron

AMS spectrometer

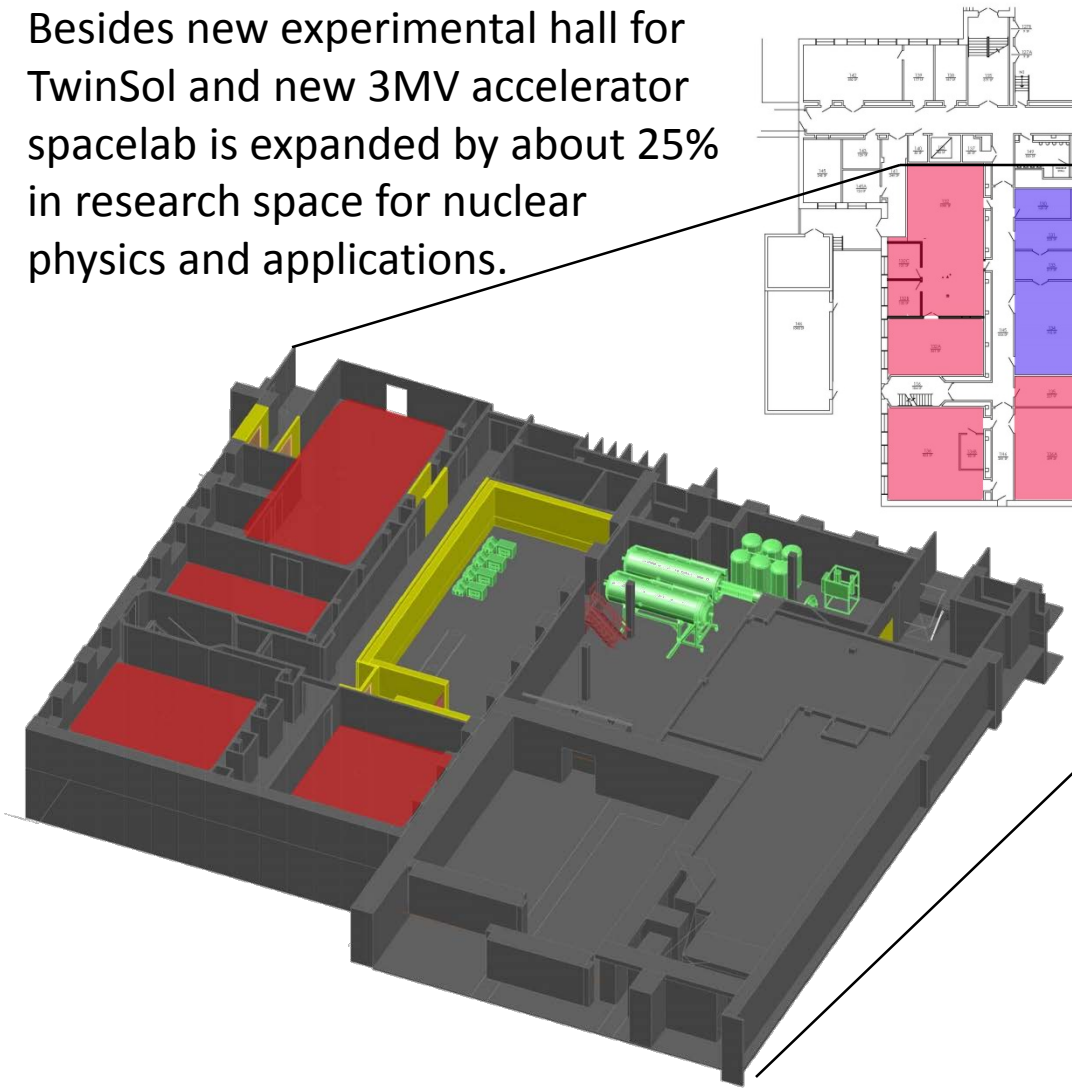
TwinSol

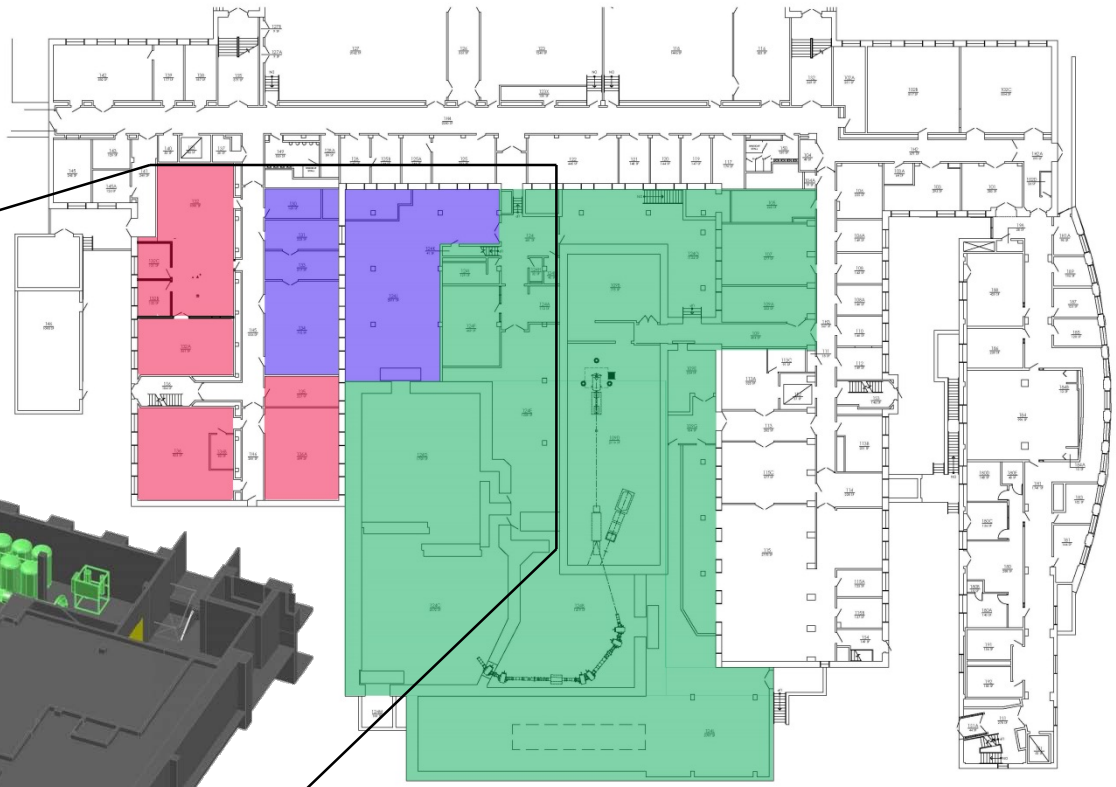
250 kV I

3MV Tandem Pelletron

NSL Expansion

Besides new experimental hall for TwinSol and new 3MV accelerator spacelab is expanded by about 25% in research space for nuclear physics and applications.



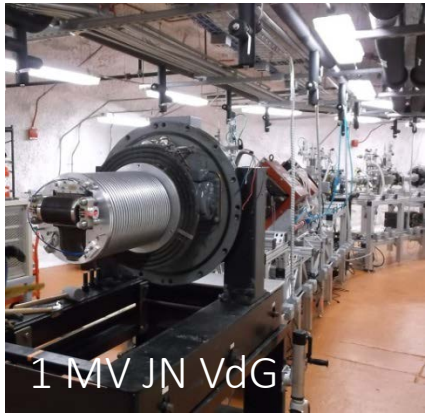


Chemistry for AMS and applications
Detector development
Experiment Preparations
General research group space
Possibly new experimental hall for FN

The NSL Accelerators

^{1}H, ^{4}He, ^{14}N, ^{16}O, ^{20}Ne, ^{40}Ar

Three accelerators for basic research,
one accelerator for applied research,
TwinSol as radioactive beam facility



^{1}H, ^{4}He

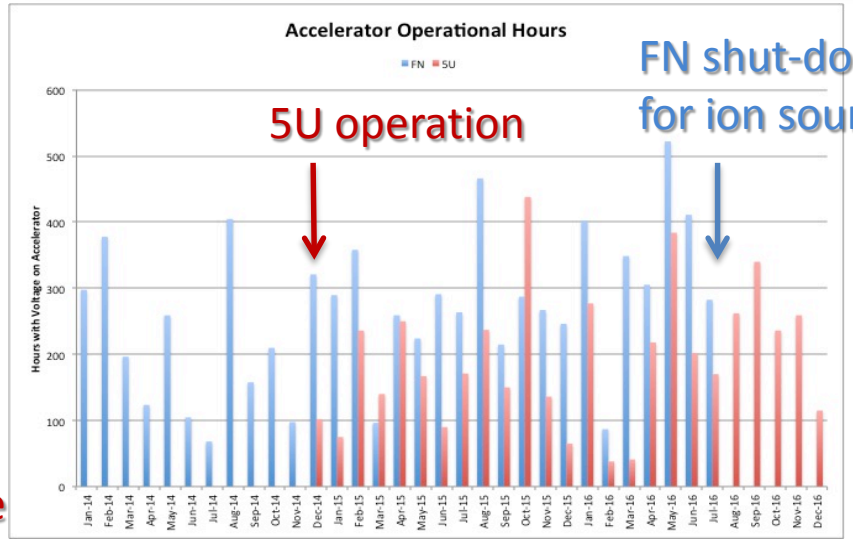
^{7}Be, ^{10}Be, ^{12}B, ^{10}C, ^{11}C, ^{12}N, ^{14}O, ^{15}O, ^{17}F,
^{19}Ne, ^{23}Mg, ^{25}Al, ^{26}Al: 10^{3}-10^{7} pps

Accelerator Operation

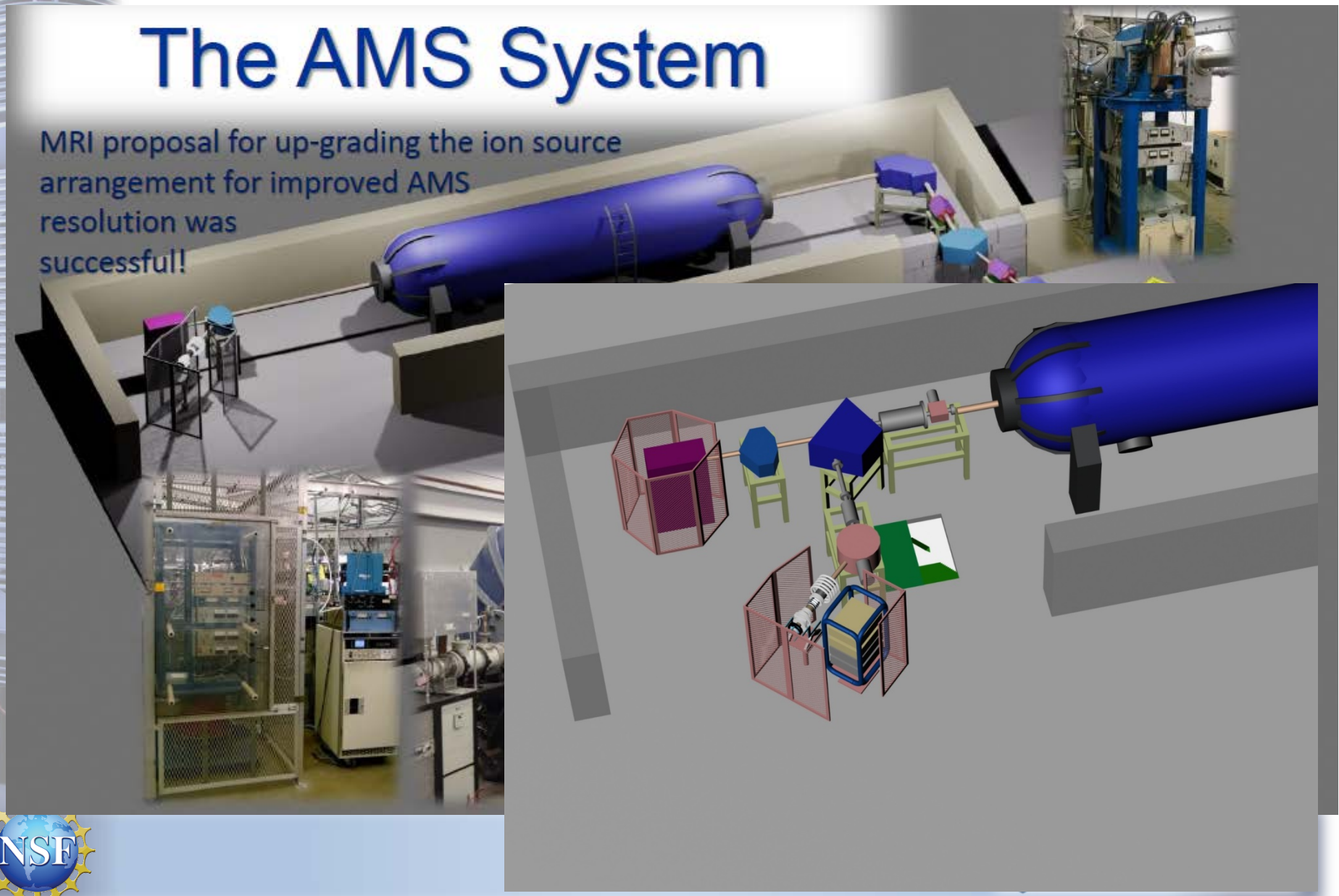
	2014	2015	2016	Avg
FN	2617	3236	2359	2746
5U		2155	2542	2349

Voltage on Terminal

On average: 40% user operation;
40% local groups, 20% maintenance



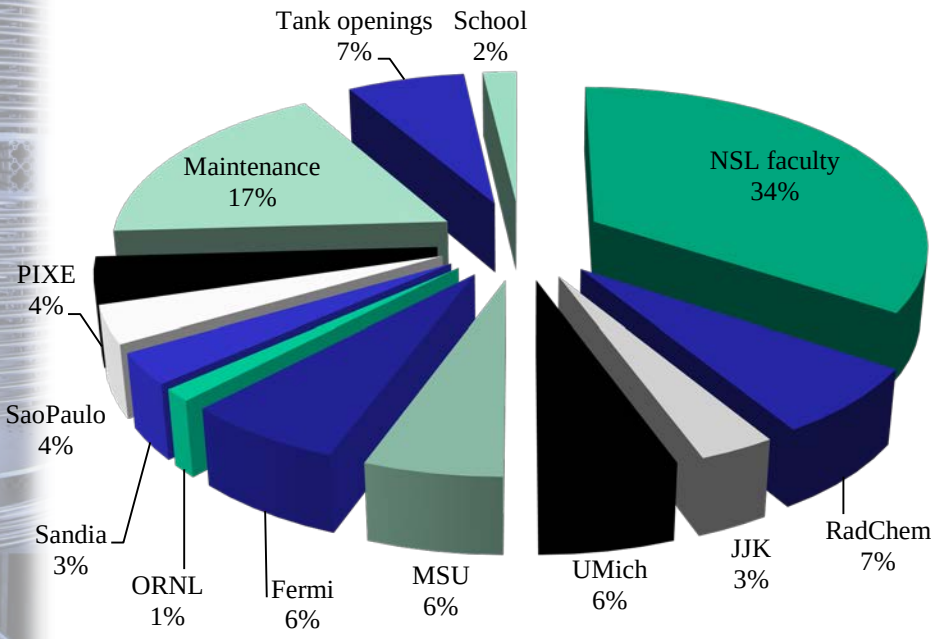
Upgrade to FN Injection System



The NSL User Community

In 2014-2015:

FN accelerator: 40% users
36% NSL programs
24% Maintenance



In 2015-2016: FN accelerator: 40% users
40% NSL programs
20% Maintenance

Users: ANL, U. Birmingham (UK), Fermi-Lab, Hebrew U. (Israel), ININ (Mexico), LSU, U. of Michigan, NSCL/MSU, Ohio U., ORNL, Princeton, U. of Richmond, Rutgers U., U. of Sao Paulo (Brazil), Sandia Natl. Lab, Stanford U., U. of Tennessee, U. Vienna (Austria), U. of Wisconsin-La Crosse.

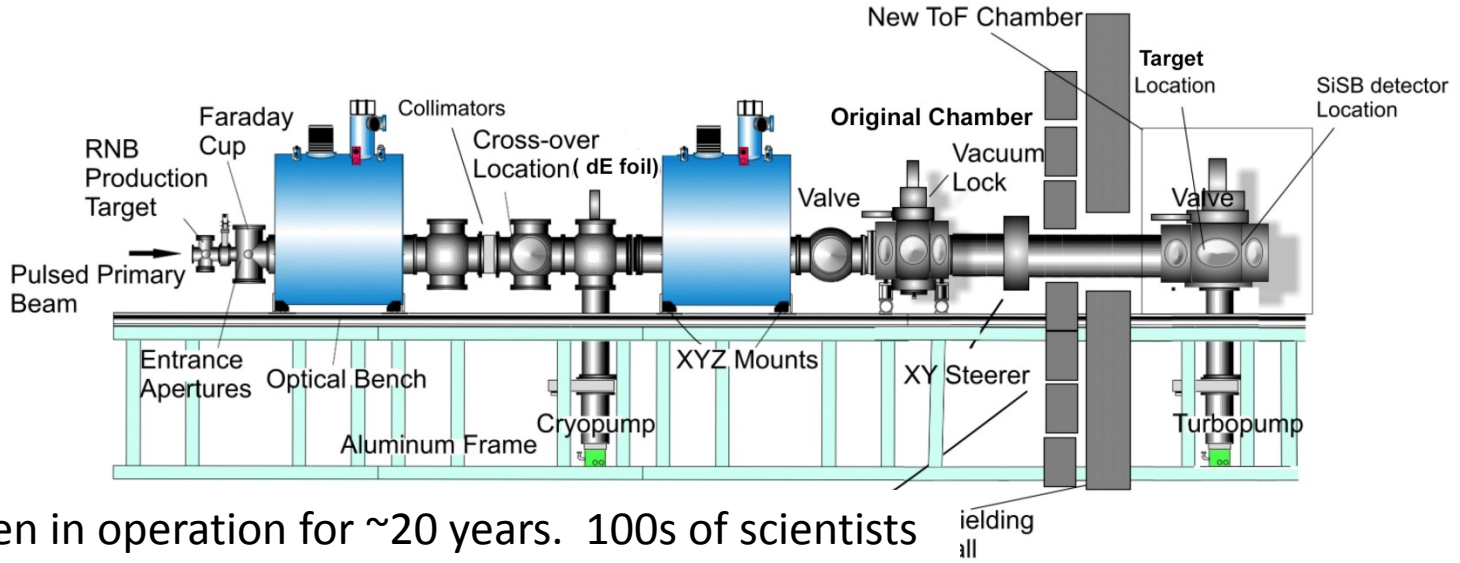
5U accelerator: 30% users
50% NSL programs
20% Maintenance

Users: ANL, Hope College, U. Illinois Chicago (UIC), INFN Gran Sasso (Italy), LANL, LLNL, U. of Michigan, U. Naples (Italy), NSCL/MSU, ORNL, Rutgers U., South Dakota School of Mines, U. of Tennessee.

The NSL Science Program

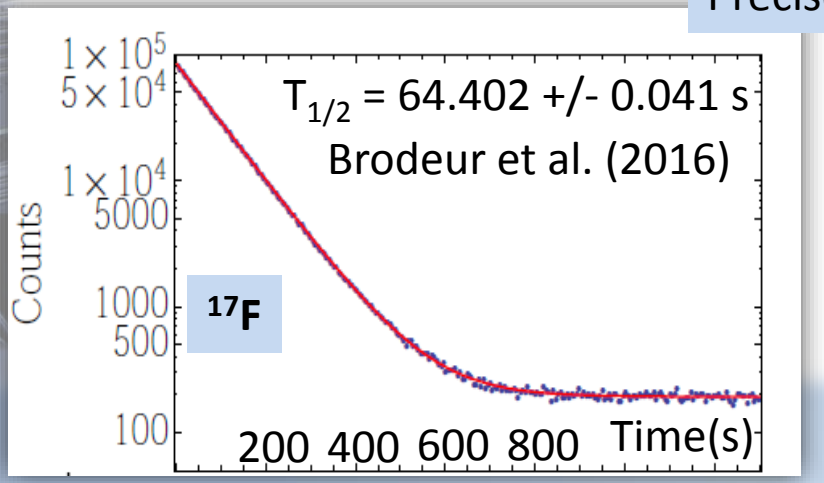
- Nuclear astrophysics
  - Low energy reactions, fusion reactions, late stellar evolution, explosive hydrogen burning, s-process nucleosynthesis, r-process nucleosynthesis, p-process nucleosynthesis
- Nuclear structure physics
  - Vibrational modes in nuclei, nuclear incompressibility, E0 transitions, alpha cluster structure in light nuclei, γ-strength functions, nuclear life times, reaction theory (R-matrix, HF method)
- Radioactive ion beam physics
  - Elastic scattering, transfer reaction measurements with radioactive beams
- Accelerator mass spectrometry
  - Nuclear reaction studies, analysis of geological, astrophysical, cultural samples
- Fundamental symmetries
  - super-allowed mirror transitions with light nuclei in ion traps
- Applied nuclear physics
  - AMS, PIXE, PIGE, reaction analysis

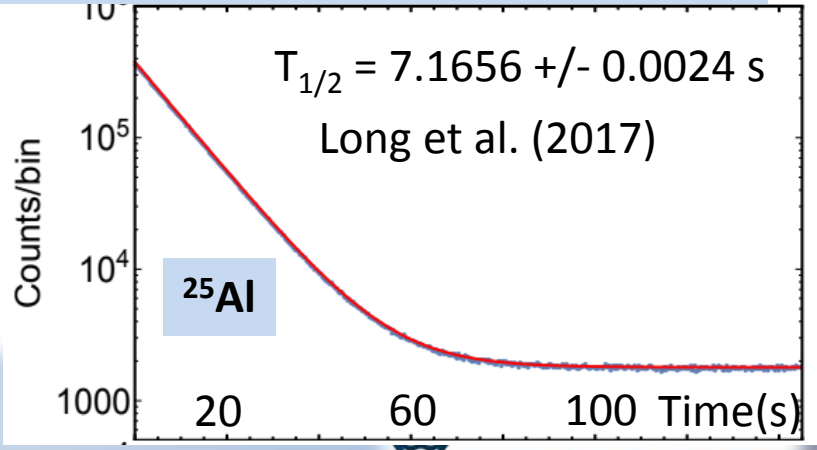
FN Highlight



TWINSOL has been in operation for ~20 years. 100s of scientists from 10s of countries have participated in TWINSOL experiments

Precise $t_{1/2}$ need to extract V_{ud} from β decay.



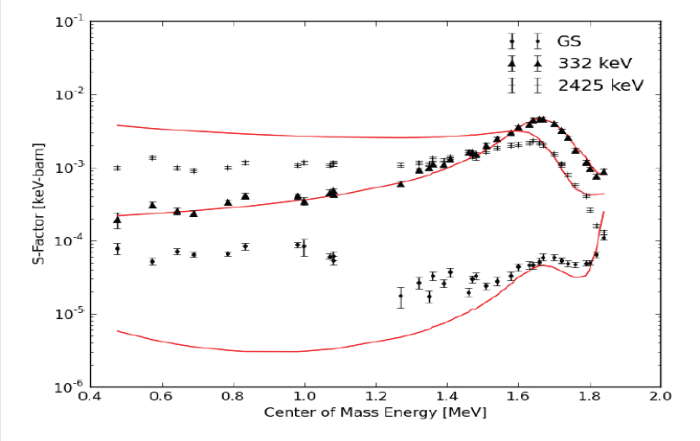


5U cross section measurements

High beam currents from 5U allow for precise and complete data sets to be taken.

$^{20}Ne(p,\gamma)^{21}Na$ – S. Lyons, Ph. D. Thesis

BEFORE



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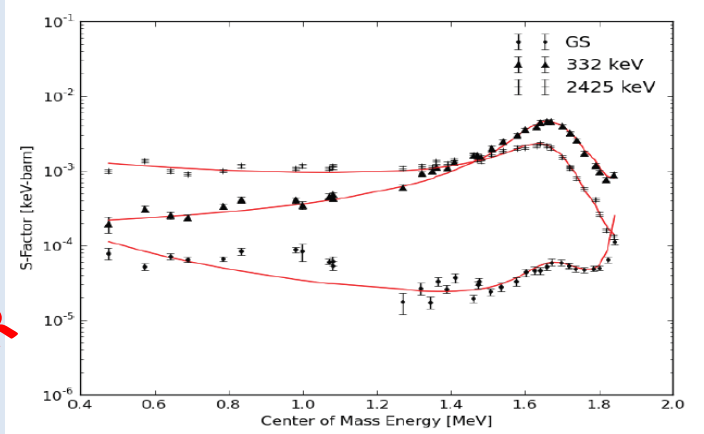
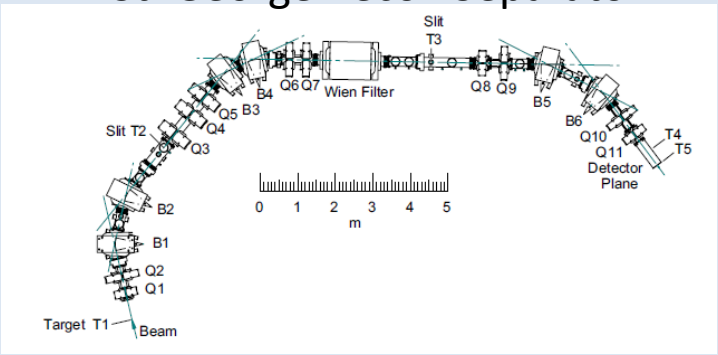


St. George Recoil Separator



Coupling of 5U to St. George in unique in the world.

NSL Applications

AMS Dating of materials
(U. Vienna, Hebrew U.) (P. Collon, D. Robertson)

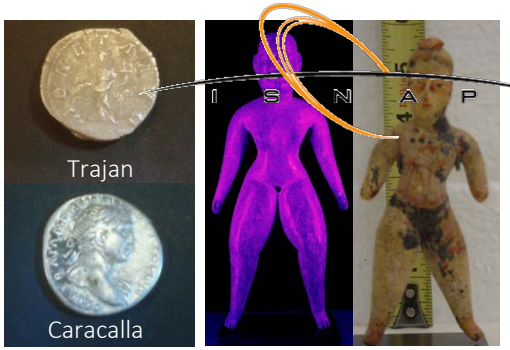
PIXE/XRF on historical artifacts
(Architecture, Anthropology, Chemistry, Snite, Library) (K. Manukyan, G. Peaslee, E. Stech, M. Wiescher)

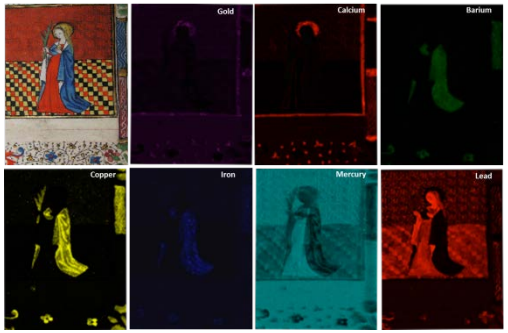
PIGE water pollution and aerosol analysis
(Hope College) (G. Peaslee, D. Robertson, E. Stech)

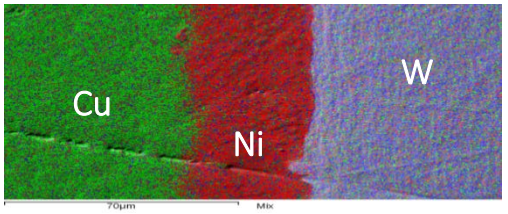
Nanomaterial modification & explosion under beam
(ND Engineering, John Hopkins U., MIT, I. Moscow) (K. Manukyan)

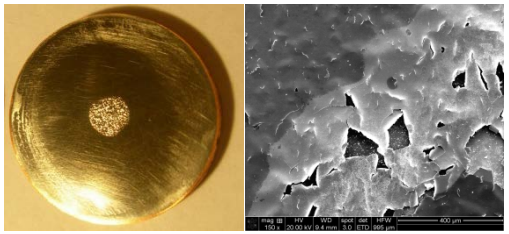
Radiation chemistry for long term storage, nuclear reactor material, and nuclear medicine
(ND RadLab, U. Manchester, UK) (J. LaVerne, D. Robertson)

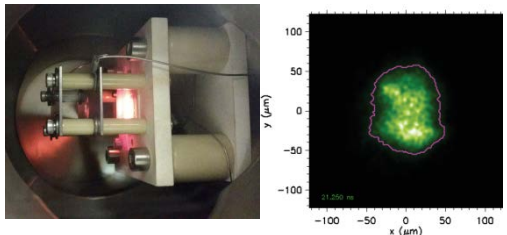
Nuclear diagnostics for forensic analysis
(LLNL) (M. Couder, G. Peaslee, M. Wiescher)











Applied Nuclear Physics Accelerator – New 2016

Perfluorinated Compounds

Environmental Science & Technology Letters

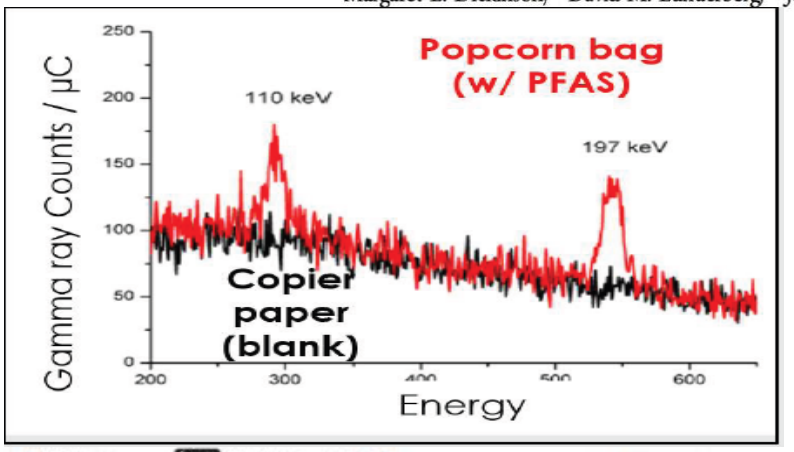
Published online 1 February 2017
Open Access

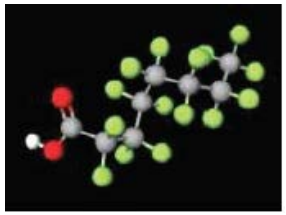
Letter

pubs.acs.org/journal/estlcu

Fluorinated Compounds in U.S. Fast Food Packaging

Laurel A. Schaider,[*,†] Simona A. Balan,[‡] Arlene Blum,[§,∥] David Q. Andrews,[⊥] Mark J. Strynar,[#] Margaret E. Dickinson,[▽] David M. Lunderberg,[▽] Johnsie R. Lang,[○] and Graham F. Peaslee[@]





215 major news stories in 7 days in print, television, radio and internet format.

The research paper was downloaded **4,000** times in a single week from the ACS Environmental Science & Technology Letters site, a result of the collaboration between co-authors and their institutions to distribute coordinated releases

NSF

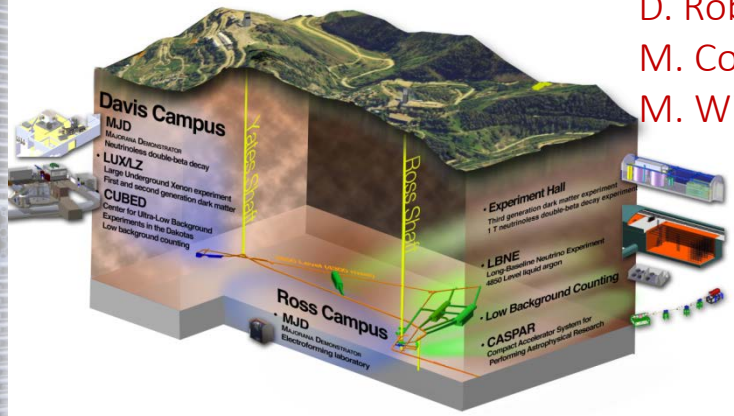
UNIVERSITY OF NOTRE DAME

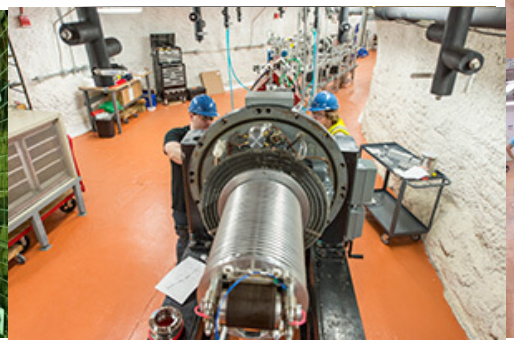
CASPAR Status

DIANA project on hold; DIANA demonstrator project being initiated with NSF, ND, CSM, SDSM&T & SURF funding

CASPAR (**C**ompact **A**ccelerator **S**ystem for **P**erforming **A**strophysical **R**esearch)

D. Robertson
M. Couder
M. Wiescher





First beam accelerated July 2017. Data taking begins Fall 2017.
$^{13}C(\alpha,n)$ and $^{22}Ne(\alpha,n)$ are key experiments.

UNIVERSITY OF NOTRE DAME

T&R Faculty Members

ISNAP

The AOV program doubled the number of faculty

Michael Wiescher,
Nuclear Astrophysics
Nuclear Applications

Ani Aprahamian,
Nuclear Astrophysics &
Nuclear Structure Physics

Dan Bardayan, Nuclear
Astrophysics

Maxime Brodeur,
Nuclear Astrophysics &
Fundamental Symmetries

Umesh Garg,
Nuclear Structure Physics

Philippe Collon,
Nuclear Astrophysics
& Nuclear Applications

Manoel Couder,
Nuclear Astrophysics
& Nuclear Applications

Anna Simon,
Nuclear Astrophysics

Graham Peaslee,
Nuclear Applications

Tan Ahn,
Nuclear Physics &
Cluster Structure

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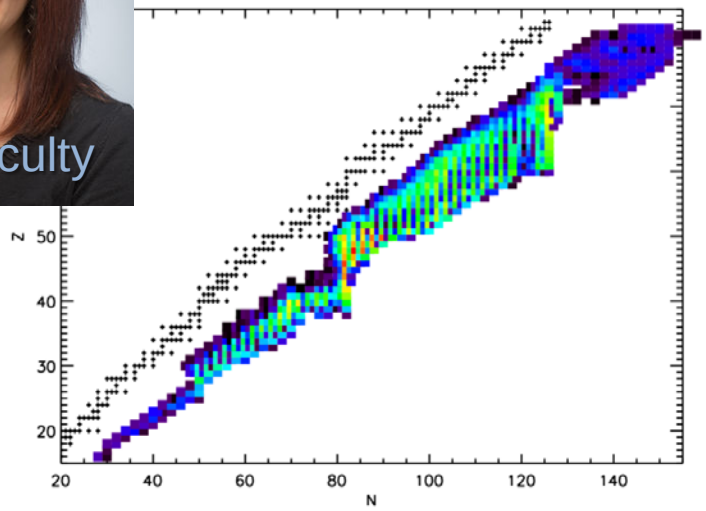
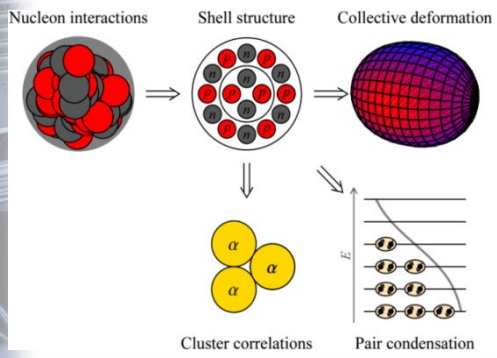
The Notre Dame Nuclear Theory Group

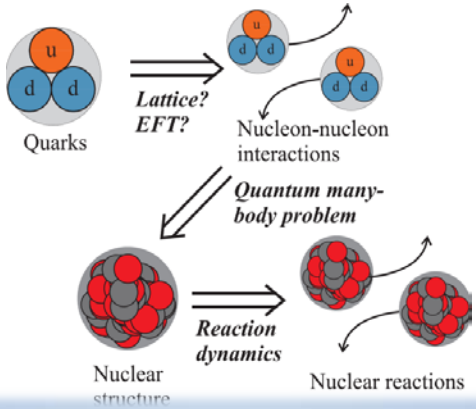
Dr. Stefan Frauendorf

Dr. Mark Caprio

Dr. Rebecca Surman







Close collaboration with the experimental group on nuclear structure and astrophysics!

The NSL research faculty

JINA support

James DeBoer
R-matrix development

Micha Kilburn
NSL Outreach

NSF support

Ed Stech
NSL Operation

Daniel Robertson
CASPAR Development

Project based DOE support

George Berg
SECAR

Jay Laverne
Rad. Chemistry

University support

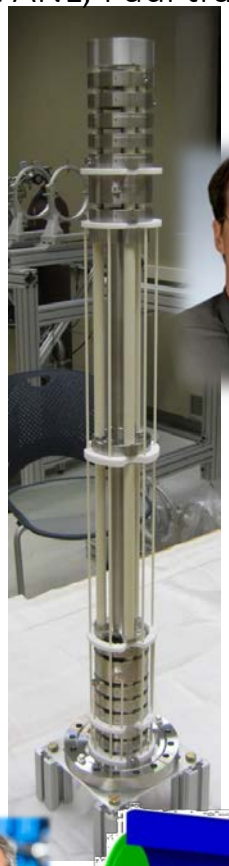
Joachim Görres
Research Support

Khachatur Manukyan
Materials & Applications

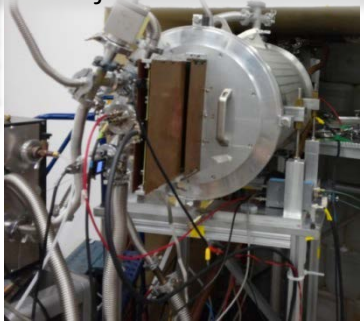
Wanpeng Tan
User Support

New Equipment developments

Multi-Reflection-Time-of-Flight mass spectrometer at ANL; Paul trap for TwinSol



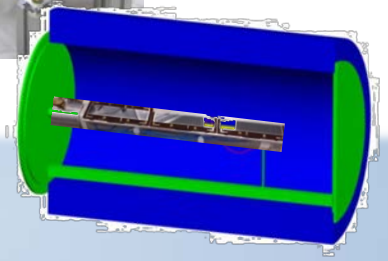
Prototype Active Target Time-Projection Chamber



Gamma Summing Detector Array: HECTOR
(High EffiCiency TOtal absorption spectrometeR)

St. Andre for Nuclear Applications

Enge Split-Pole Separator



Solenoid-Spectrometer for Nuclear Astrophysics

NSF

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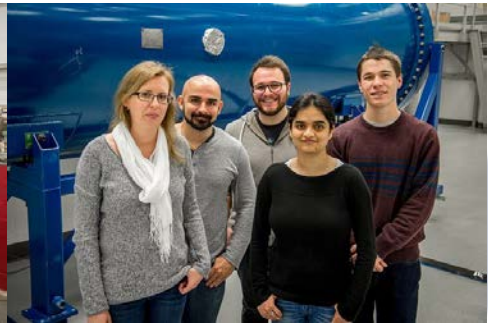
NSL students

20% female

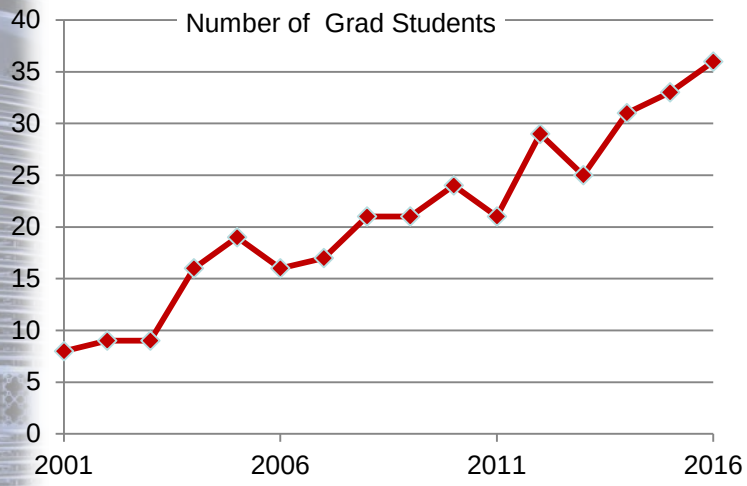
Allen, Jacob	Bardayan
Anderson, Tyler	Collon
Blankstein, Drew	Bardayan
Burdette, Daniel	Brodeur
Casarella, Clark	Aprahamian
Chen, Yingying	Wiescher
Clark, Adam	Collon
Frentz, Bryce	Aprahamian
Hall, Matthew	Bardayan
Henderson, Samuel	Ahn
Howard, Kevin	Garg
Huestis, Patricia	Couder/LaVerne
Kelly, James	Brodeur
Lamere, Edward	Couder
Li, Xuyang	Ahn
Liu, Qian	Wiescher
Long, Jacob	Brodeur
Morales, Luis	Couder
Moran, Michael	Wiescher
Moylan, Shane	Couder
Nelson, Austin	Collon
Reingold, Craig	Simon
Sensharma, Nirupama	Garg
Seymour, Christopher	Wiescher
Siegl, Kevin	Aprahamian
Skulski, Michael	Collon
Smith. Mallory	Aprahamian
Strauss, Sabrina	Aprahamian
Vande Kolk, Bryant	Wiescher

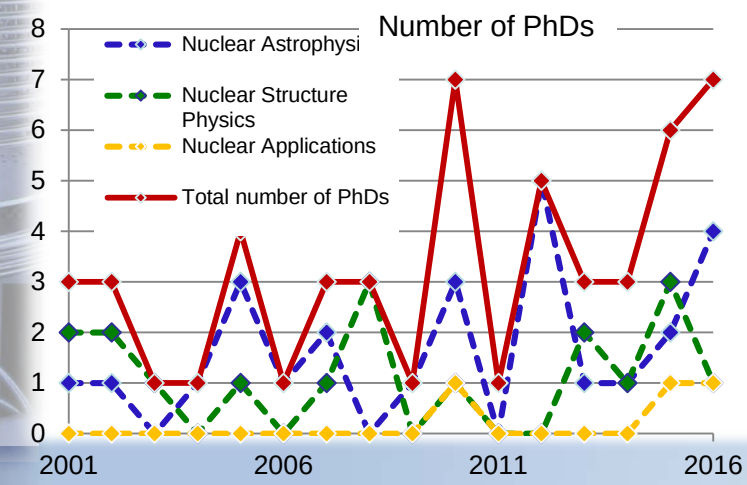
NSF grant, TA support (University),
Other grants (DOE NSF) & fellowships (NSF&NNSA)



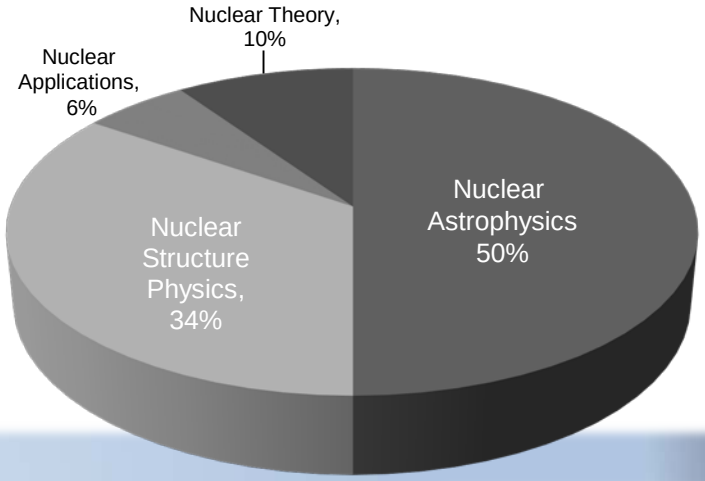
Graduate Student Development





Presently 30 + graduate students at Notre Dame do their research project in Nuclear Physics, five have graduated in 2016. Since 2001, 52 students have received their PhD at Notre Dame on average 3.3/year.

PhD topics from 2001 to 2016

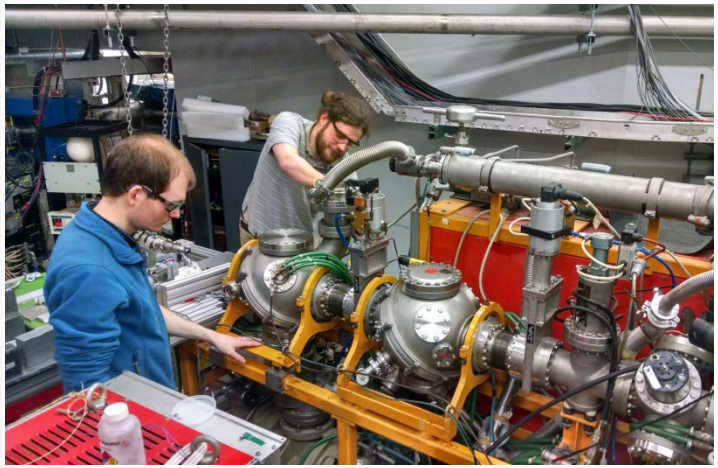


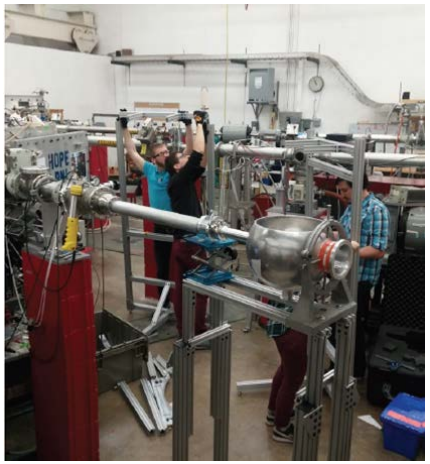
NSL postdocs

20% female

Axel Boeltzig	5U, Caspar experiments	JINA/ND
Jianping, Lai	Nuclear Structure Physics	Ahn/ND
Kevin Macon	Heavy Ion Fusion Program	NSF
Farheen Naqvi	Nuclear Astrophysics	Simon/NSF
Patrick O'Malley	Nuclear Astrophysics	Bardayan/ND

Typically 1-2 postdocs paid by NSF grant, with rotating assignments to research groups






The NSL Long Range Plan

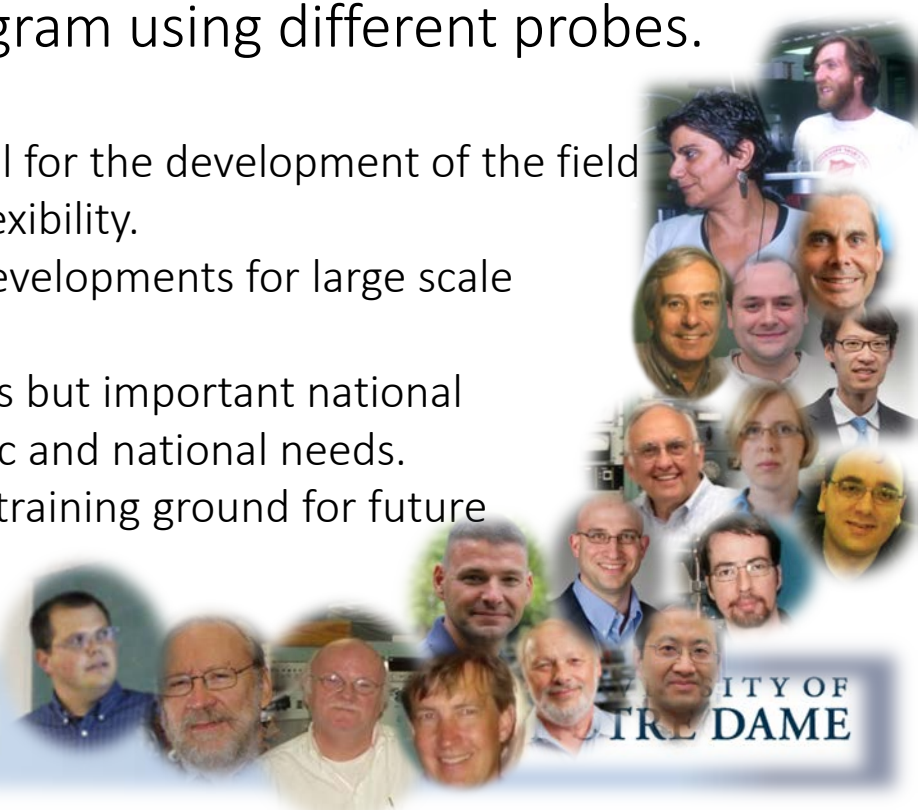
Maintain an innovative and competitive research program in nuclear structure and nuclear astrophysics.

- Focus on reactions and structure near particle thresholds.
- Expand on light radioactive beams and trapping light isotopes.
- Capitalize on new instruments/people working at the intensity frontier.

Broaden the scientific program by using new low energy probes

Grow nuclear application program using different probes.

- ARUNA university facilities are crucial for the development of the field due to their unique versatility and flexibility.
- They provide innovative ideas and developments for large scale facilities.
- They are not only cheap test benches but important national resources serving important scientific and national needs.
- Last not least they are an important training ground for future generations of nuclear scientists.



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