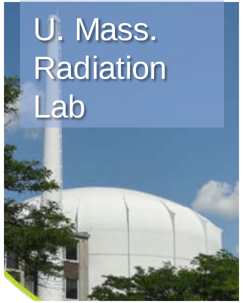
ARUNA:
Advancing Science, Educating Scientists, Delivering for Society

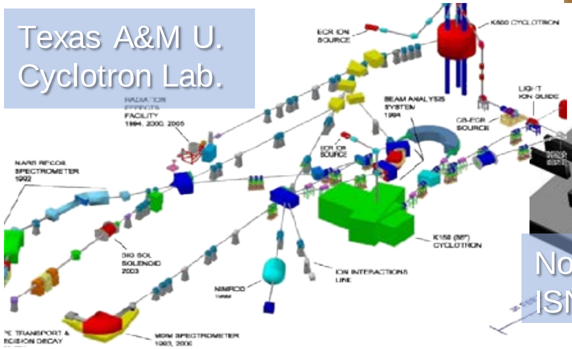
NSAC - LE-Nuclear Science Town Meeting

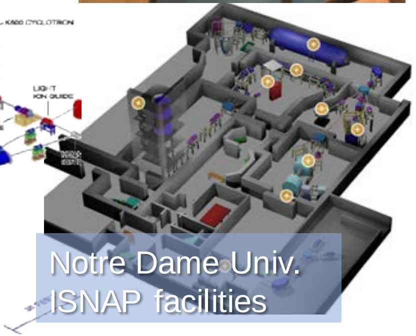
2022 White Paper available at https://aruna.physics.fsu.edu

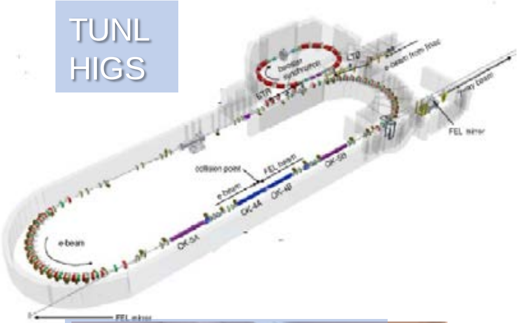
Interconnected Association of 12 laboratories
187 registered users
https://aruna.physics.fsu.edu/

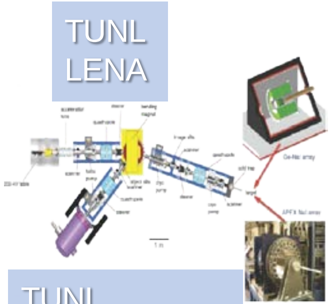
ARUNA: The facilities

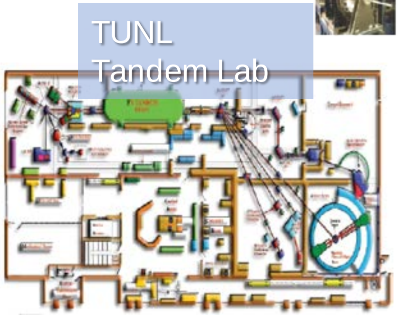








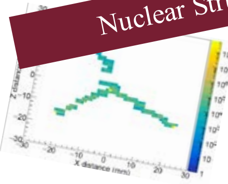


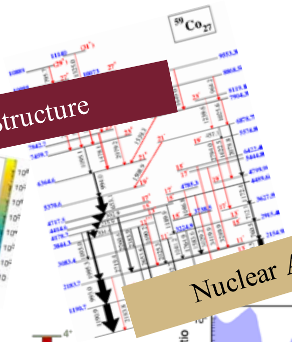


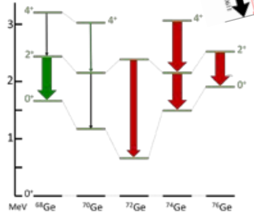
Association for Research at University Nuclear Accelerators

Interconnected Association of 12 institutions

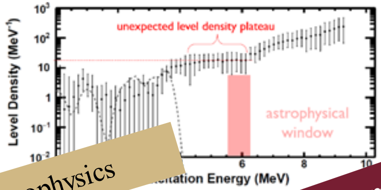
Nuclear Structure

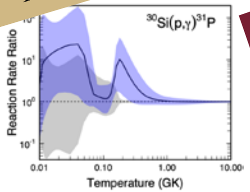




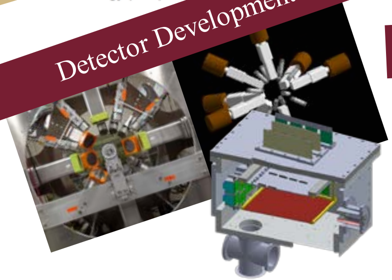


Nuclear Astrophysics

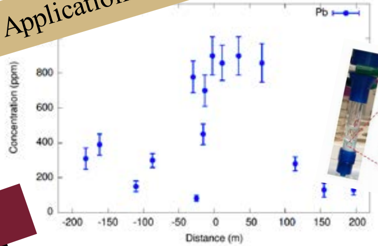


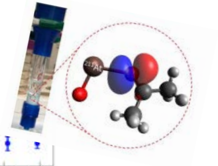


Detector Development

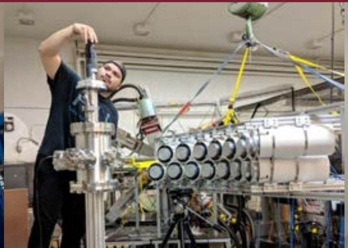


Applications & Society





Workforce Development



NSAC - LE-Nuclear Science Town Meeting

A) Scientific Focus on Nuclear Astrophysics

"Direct" Experiments: Astrophysical reactions at the relevant energies

- Solar ν-sources, n-sources, CNO-cycles, Helium and C-burning:
  (p,γ) and (α,γ) , (α,n) reactions on stable isotopes,
  Unique set of low-energy high-intensity accelerators @UND, @TUNL-LENA

- Big-Bang nucleosynthesis, 3α-reaction "upscattering", hot-CNO, (α,p)-process
  (α,p) reactions on RIB, Investigation of $^{12}C(n,n')$ with
  RIB, unique active-target Detectors: ANASEN, TexAT: @FSU-LSU, @TAMU & OU

"Indirect" Experiments: Data to guide reaction rate calculations

- Explosive rp-process nucleosynthesis, (p, γ), (α,γ) resonant reactions

  RIB & transfer reactions measuring resonance strengths
  Specialized detector systems, @UND, @FSU

  SIB & indirect p and α-resonance spectroscopy, high-resolution n-spectroscopy
  High-resolution spectrographs @TUNL-Tandem, @FSU
  Unique: long-baseline neutron time-of-flight facility @OU

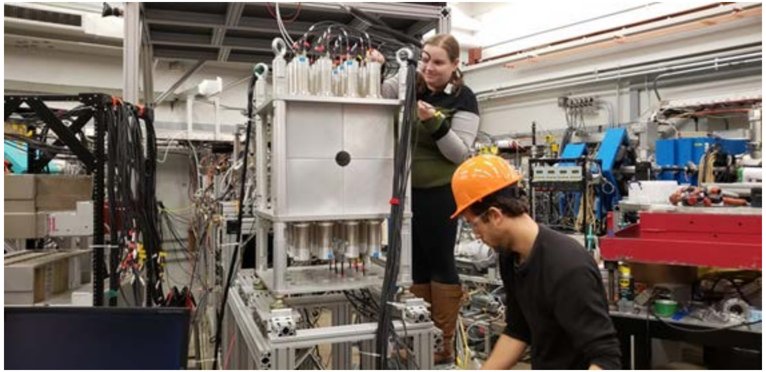
Unique Facility: Notre Dame experiments @ CASPAR

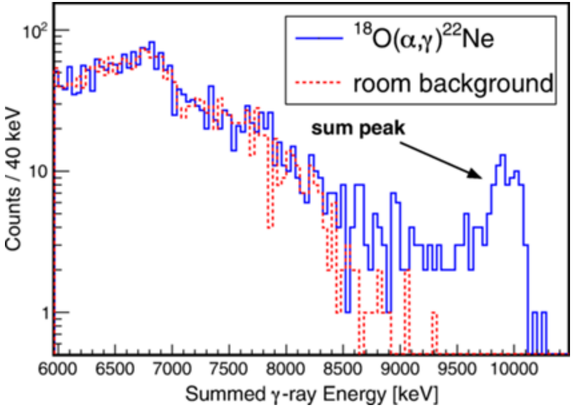
Underground lab in (under?) South Dakota

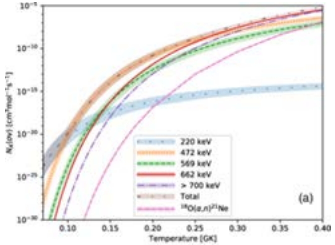
HECTOR, a summing array, has now been commissioned using the ^{27}Al(p,γ) reaction - EPJA 58 57 (2022)

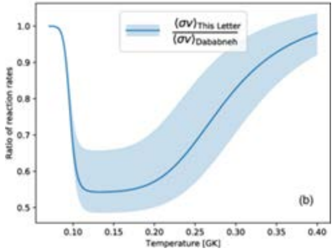
Direct measurement of ^{18}O(α,γ) reaction with HECTOR which produces ^{22}Ne, a source of neutrons for the s-process

Dombos *et al.*: Phys Rev Lett 128 162701 (2022)

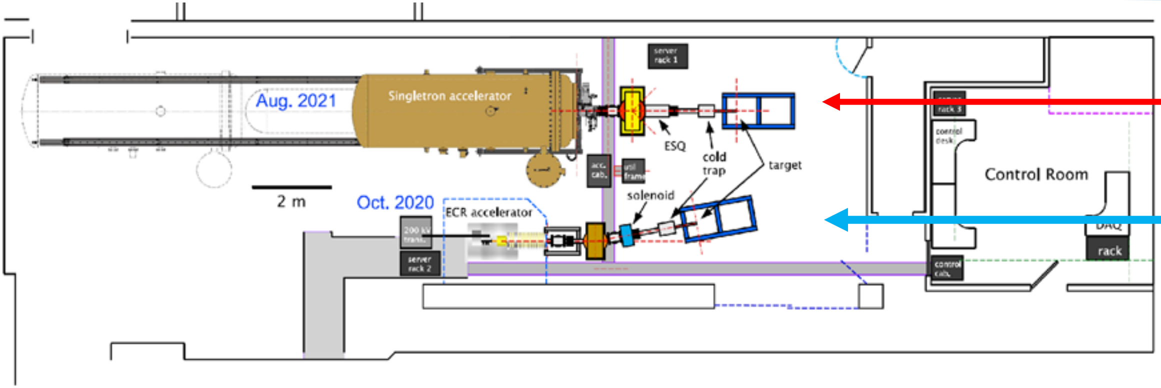








Unique facility: upgraded LENA



2-MV Singletron accelerator with new 2.45 GHz ECR ion source

Refurbished ECR on HV platform with pulsing capabilities

Installation of ECR accelerator in renovated laboratory space

Singletron accelerator properties

Terminal voltage	0.1 – 2 MV 2.2 MV actual
Terminal stability	200 V
DC beam current at 250 kV	0.4 mA (H), 0.3 mA (He) 0.54 mA (H), 0.41 mA (He)
DC beam current at 1 - 2 MV	2 mA (H and He) 2 mA
Pulse frequency	0.125, 0.25, 0.5, 1, 2, 4 MHz
Pulse width	2 – 20 ns 2 ns (H), 2.5 ns (He)

Singletron accelerator

Unique Detectors: Measurement of ^{18}Ne(α,p)^{21}Na with ANASEN at FSU

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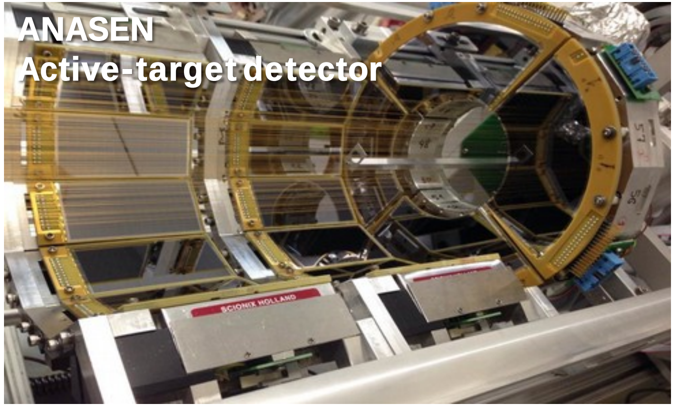
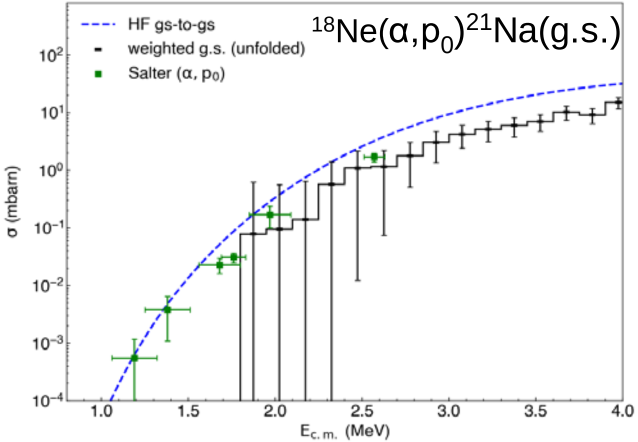


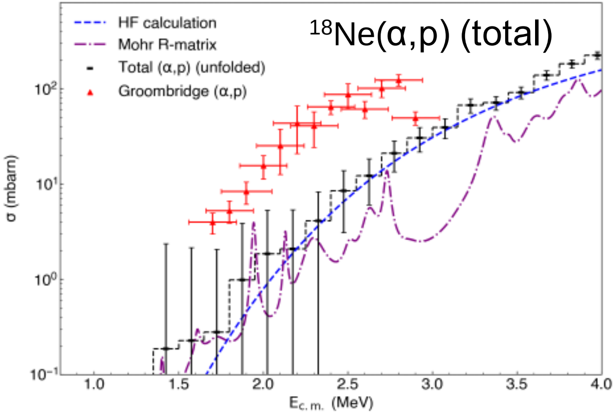
^{18}Ne(α,p)^{21}Na: Key reaction for breakout from hot-CNO cycles.

- ANASEN Active-target detector developed at FSU with LSU, capable of high beam rates
- Experiment with ^{18}Ne beam delivered by RESOLUT RIB facility with ~2000 pps
- Distinguish ^{21}Na ground state vs excited-state contributions.

M. Anastasiou *et al.*: PRC 105, 055806 (2022)

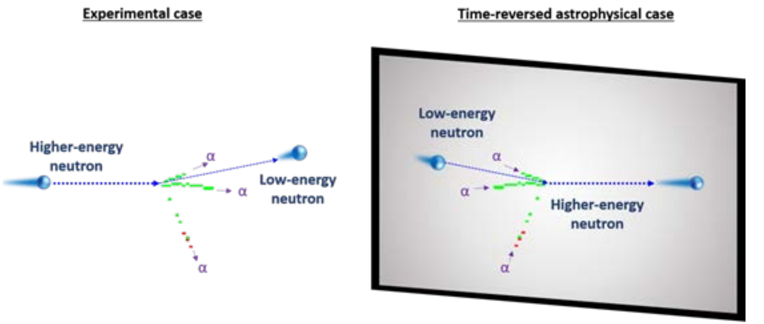
- ^{18}Ne(α,p_0)^{21}Na(g.s.) cross section consistent with "reverse" ^{21}Na(p,α) of Salter *et al. (2012)*
- Total cross section much lower than Groombridge et al. (2002)
- Cross sections larger than theoretical R-matrix analysis (Mohr et al.)
- Cross sections generally consistent with Hauser-Feshbach calculation
- Next step: repeat experiment with more beam ANASEN at Triumf (2023)





Unique Detectors: TexAT active-target

Enhancement of triple-alpha reaction rate via upscattering



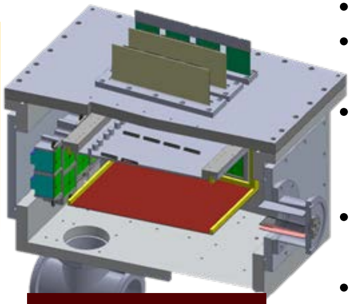
Measurement of $^{12}C(n,n_2)3\alpha$ XS with TexAT at Edwards Accelerator Lab, OU in astrophysically-relevant region (E_n = 8.3-10 MeV)

First neutron-induced reactions with an active target TPC!

Time-reversal mirror comparing experimentally-measured reaction and the neutron upscattering reaction in stars – enhancing Hoyle radiative width!

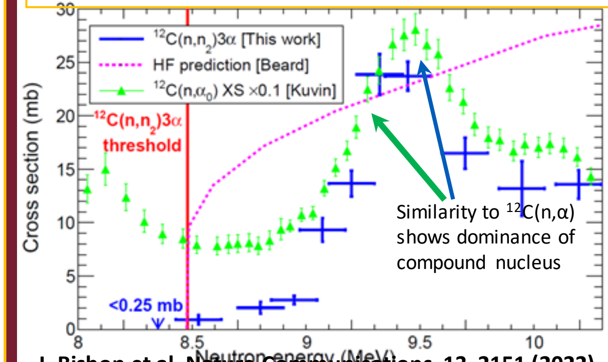
TAMU, WashU, OU collaboration

TexAT TPC

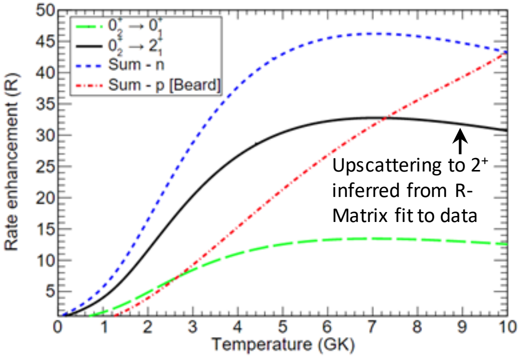


- Versatile TPC
- Micromegas readout
- Single GEM avalanche stage
- GET system used
- Nuclear structure/astrophysics studies

E. Koshchiy et al. NIMA 957, 163398 (2020)



$^{12}C(n,n_2)3\alpha$ XS smaller than expected (particularly near threshold) ⍰ neutron upscattering enhancement **smaller** than expected (particularly at low T) – no suitable astro sites?? Settles longstanding question of importance of neutron upscattering



J. Bishop et al. Nature Communications, 13, 2151 (2022),
Carbon Conundrum: Experiment Aims to Re-create Synthesis of Key Element – Scientific American article (2020)

B) Scientific Focus on Nuclear Structure and Reactions

Spectroscopy with diverse probes

- Open Systems, and Clustering
  RIB and scattering, transfer react. TexAT@TAMU, @FSU, @UND
- Shell Evolution, cross-shell excitations
  Gamma-spectroscopy with Clarion-2 @FSU
  Transfer-reactions SE-SPS high-resolution spectrograph @FSU
- Collectivity and Structure for (0υββ) decay
  Unique Gamma-beams @TUNL-HIGS
  Unique Neutron-beams @UK

Reaction-studies with diverse probes

- Light-nuclear wave functions as a probe for ab-initio theories
  Few-body reactions @TUNL-Tandem
- Symmetry energy and density-dependence EOS @TAMU
- Statistical Nuclear Physics: Light-ion reactions @OU

Texas A&M: TexAT active-target detector with ^{14}O beam from MARS

Methods:

- Thick target Inverse kinematics technique **TTIK**
- **Active target**, TexAT
- **^{14}O** radioactive **beam** at MARS (TAMU)
- **R-matrix** analysis

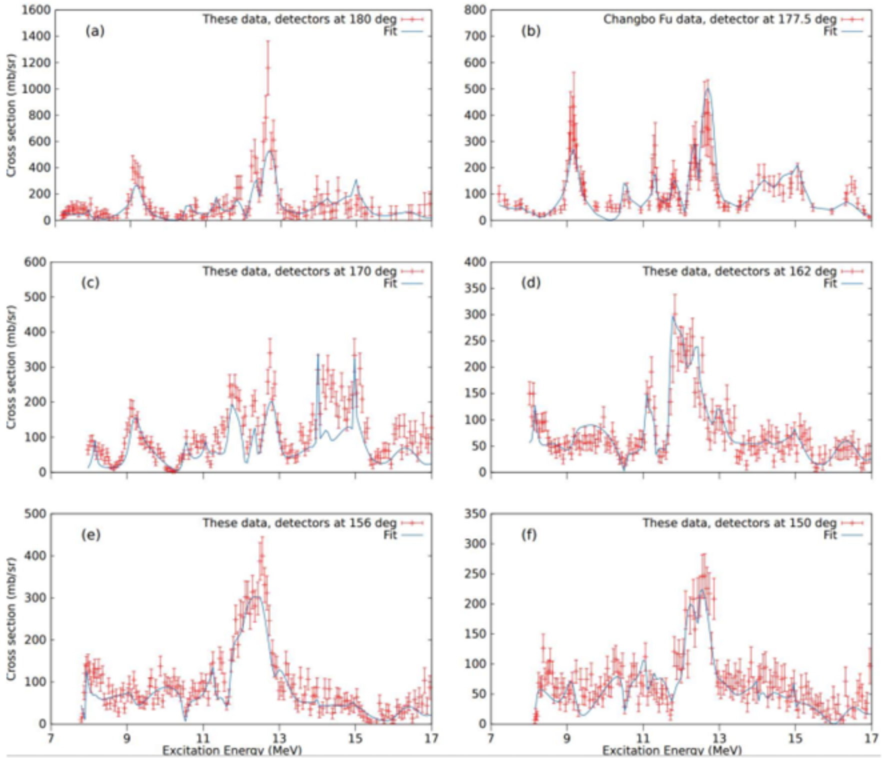
Data Analysis:

- **Excitation function** of **^{18}Ne** in the excitation energy range **8-17 MeV**.
- R-matrix analysis **starting form the parameters** listed in [PRC 90, 024327 (2014)] for the mirror nucleus **^{18}O**.
- **Comparison** of the α-cluster states in **^{18}O and ^{18}Ne**
- **Comparison** with a **shell-model** calculation [PRC 100, 034321 (2019)]

Conclusions:

- **α-clustering is strong** in ^{18}O and ^{18}Ne, with good correspondence of the mirror levels.
- At high excitation energy the observed **states are more clustered than predicted**. This can be due to the limitations of the model. However, the fact that, in the experiment, on each J^{π} group, one or two levels for each configuration absorb all the alpha strength going in that reaction channel suggests that these could be **superradiant states.**
- More experimental and theoretical studies are required to understand the role of superradiance in α-cluster states

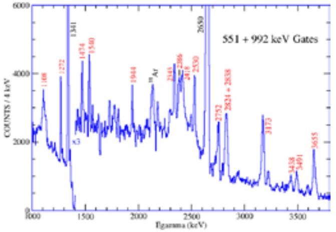
α-cluster structure of ^{18}Ne



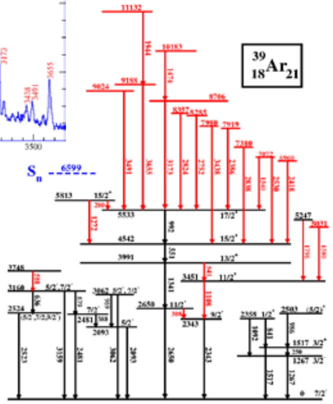
M. Barbui et al. **Phys. Rev. C 106, 054310 (2022)**

Gamma-spectroscopy at FSU: calibrating shell-evolution for exotic nuclei

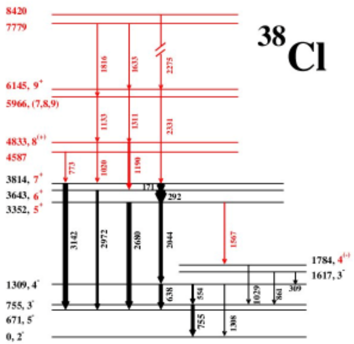
Experiments @ FSU + new FSU S.M. interaction



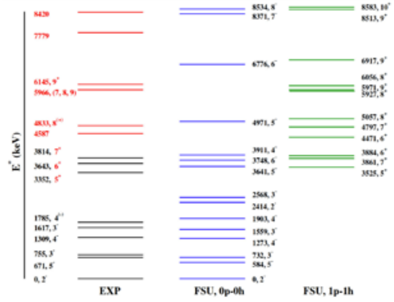
γ-γ spectrum for Ar using the FSU γ detector array
Red --> new



Ph.D. Thesis (2019) Brittany Abromeit
PRC 100, 014310 –16 July 2019

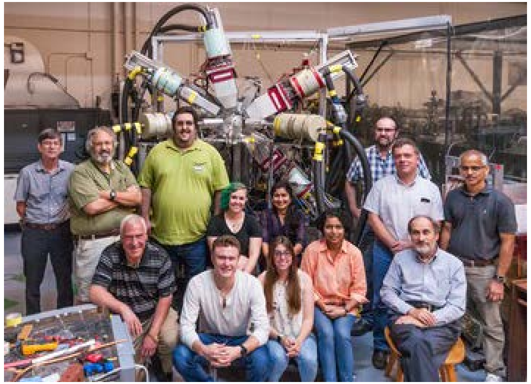


Ph.D. Thesis (2019) Rebeka Lubna
arXiv:1905.10646v2 [nucl-ex]



Cl compared with the new FSU shell model interaction

FSU particle-γ array and group

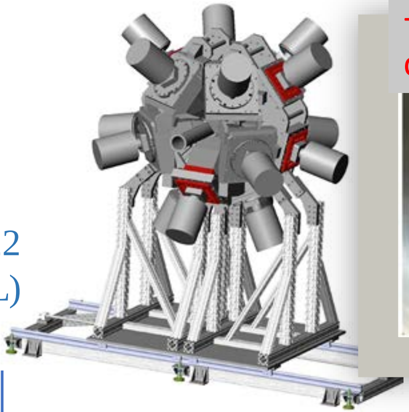


Examples of nuclear structure investigations at FSU
Particle- γ-γ experiments
Upgrade: Clarion 2 coming 2022 to FSU for campaigns
Development of a comprehensive shell model interaction for intruder configurations,
in collaboration with the FSU nuclear theory group.

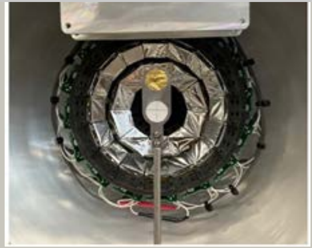
CLARION2@FSU

& Oak Ridge National Laboratory

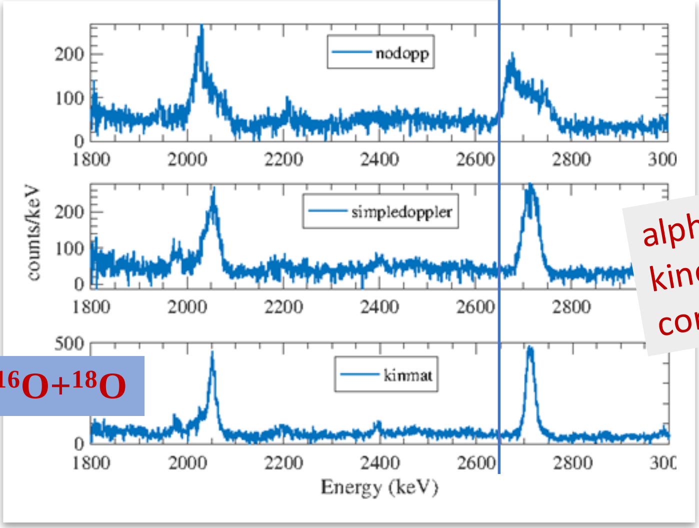
- γ-ray detection with up to
16 Compton suppressed CLOVERs
- Charged particle detection
  TRINITY: 5 rings of GAGG+ Si
- Commissioned in Dec 2021
- First experiments: Jan-March 22
- Safe Coulex of ^{48,49,50}Ti (ORNL)
- ^{16}O+^{18}O, ^{7}Li + ^{64}Ni (FSU)



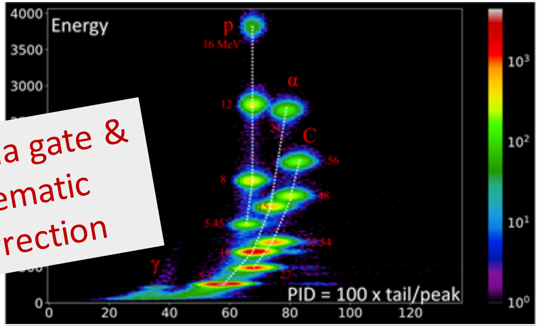
+ TRINITY GAGG det.



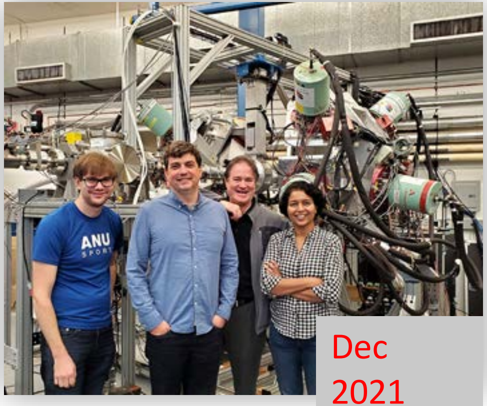
Sept 2021



alpha gate & kinematic correction



PID capability of TRINITY



Dec 2021

NSAC - LE-Nuclear Science Town Meeting

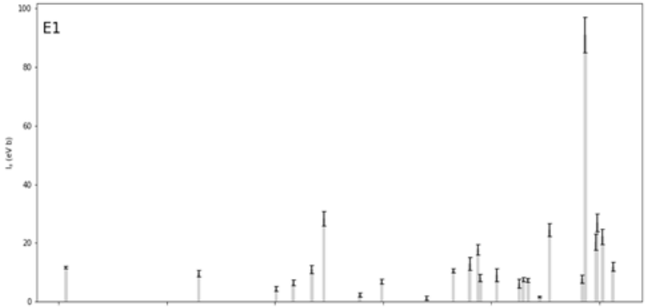
New Information on ^{74}Ge from combining 3 techniques

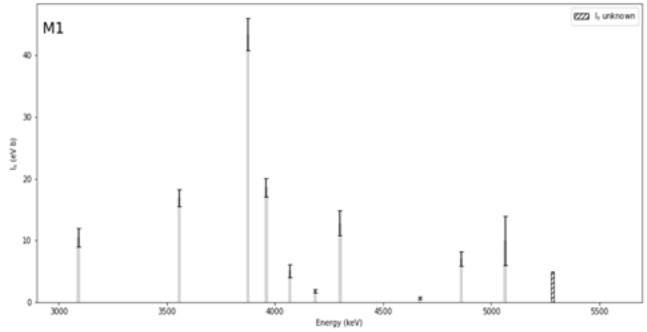
Motivation

Advances in computational techniques indicate that a better understanding of neutrinoless double beta decay ($0\nu\beta\beta$) can be achieved by expressing the nuclear matrix elements governing the decay in terms of a summation over states in the (A – 2) nucleus. Thus, in the case of $^{76}Ge \xrightarrow{0\nu\beta\beta} {}^{76}Se$, an extensive ^{74}Ge study provides constrains for $0\nu\beta\beta$ calculations.

New structure information on ^{74}Ge was obtained by combining results from Coulomb Excitation, NRF and (n,n'γ) carried out at three U.S. laboratories (HIGS at TUNL, ATLAS at ANL and the 7-MV neutron scattering facility at U. Kentucky).

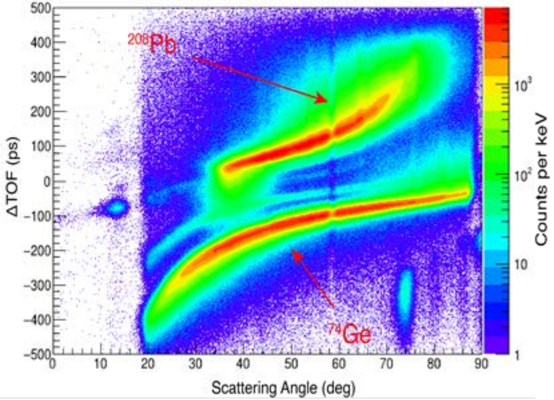
NRF study of ^{74}Ge at HIγS

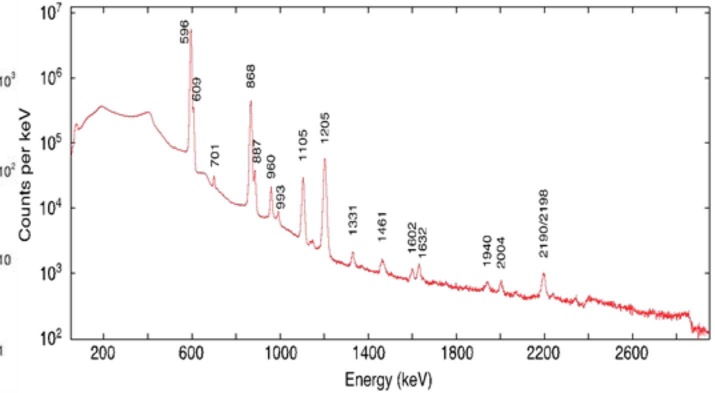




Experimentally determined integrated scattering cross section and energy of $J^\pi = 1^-$ (top) and $J^\pi = 1^+$ (bottom) states in ^{74}Ge.

Coulomb excitation of ^{74}Ge at ATLAS





Samantha Johnson, PhD thesis UNC

C) Science Focus: Tests of Fundamental Symmetries in Nuclear Systems

- Unitarity Tests of CKM Matrix
  Couder (U. Notre Dame) Test super-allowed decay in mixed (Fermi & GT) decays. Upgrade: ν-β angular correlation measurements with St. Benedict

- Search for Scalar Currents in T=2 β-decay
  Melconian (Texas A&M) TAMUTRAP setup for ν-β angular correlations
  in T=2 nuclei

- Search for Tensor Currents
  Garcia (UW) with Argonne, Mainz, NCSU, PNNL, Texas A&M, Tulane
  Magento-Laser trap
  Development of cyclotron-radiation electron spectroscopy (Similar to Project-8)
  Use of UW tandem to produce ^{6}He, ^{19}Ne and ^{14}O.

CENPA at U. of Washington

Tandem Van de Graaff for production of ^{6}He and ^{19}Ne for Fundamental Symmetries studies

Developing precision beta spectroscopy via Cyclotron Radiation Emission Spectroscopy (CRES)

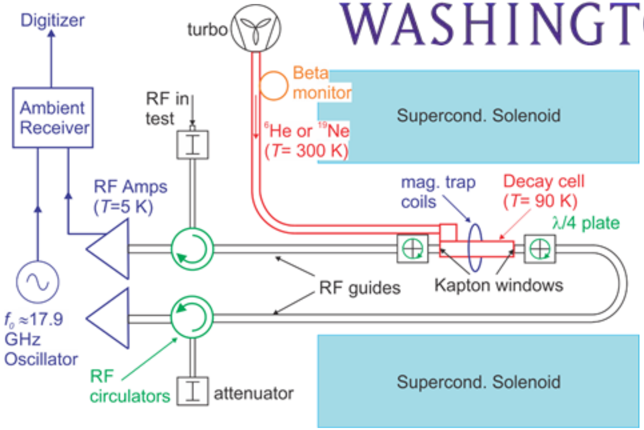
- **Searching for chirality-flipping interactions in ^{6}He and ^{19}Ne**
- **Technique could be used at FRIB with ion trap for beta spectroscopy from many nuclei**

Cyclotron Radiation Emission Spectroscopy (CRES)

Measure beta energy by frequency of cyclotron radiation:

$$E = \frac{qB\,c^2}{2\pi\, f}$$

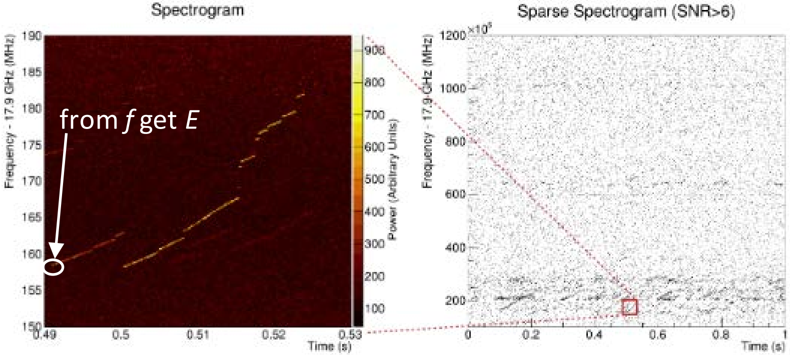
with $E \approx 1$ MeV, $B \approx 1$ T → $f \approx 15$ GHz



Recently observed CRES events from ^{6}He and ^{19}Ne

Collaboration with:
Argonne, Mainz, NCSU, PNNL, Texas A&M, Tulane

Below: example of frequency extraction for electron

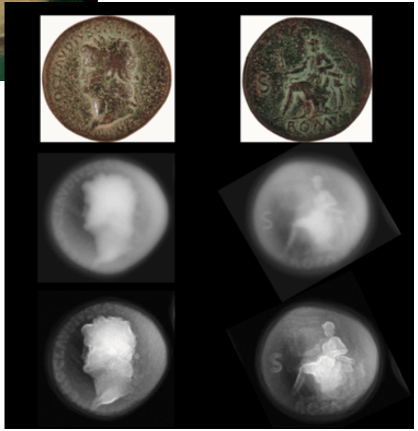


Delivering for Society: Application of Nuclear Methods

Many ARUNA laboratories support research applying nuclear methods.

- Analytical Techniques for elemental or structural analysis: PIXE, PIGE, RBS (UMass, UND, TAMU)
- Accelerator-Mass Spectrometry is a focus program at UND
- Neutron Beams: Unique opportunities for measurements with relevance for advanced reactor design, nuclear stockpile stewardship (UMass, UK)
- Production of Medical Isotopes: The TAMU cyclotron is developing production mechanism for the Targeted Alpha Therapy Isotope At-211
- Radiation effects: Heavy-Ion beam testing of radiation effects in Semiconductors for Space technology at TAMU and testing of superconducting materials at UWM
- Detector Development: Many Aruna Laboratories develop detector technologies, which take significant hours of beam time to perfect and benefit national lab programs (FSU, UND, TAMU, Umass)

PIXE analysis of Artwork at UND



X-ray Imaging at JMU

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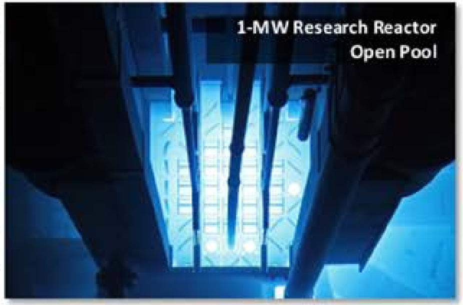
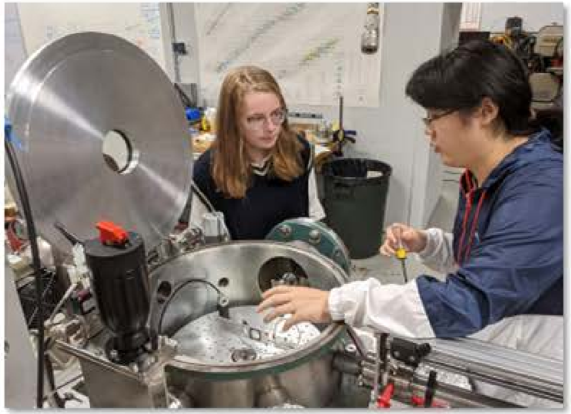
Research Highlights Radiation Lab

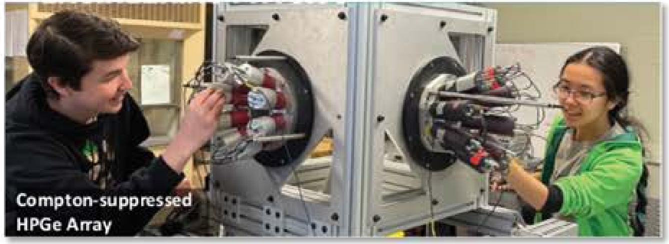


Main Facilities: 5.5-MV Van de Graaff
1-MW Research Reactor
6 graduate students, ~6-8 undergrads, 1-2 postdocs



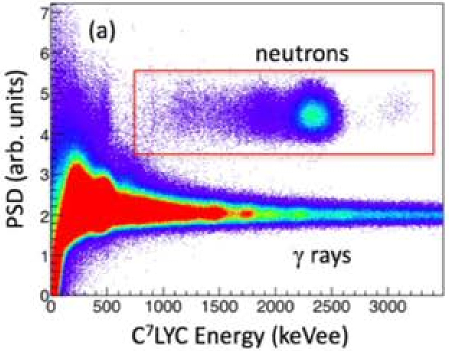
Implanted targets and characterization

- Well characterized H and He implanted targets are important in both nuclear structure (precision DSAM) and astrophysical (reaction rate) measurements.
- High current (> 1 μA) Deuteron and Alpha beams are implanted within the first μm of a heavy target foil using energy-degraded and low-voltage plasma sources.
- Implantation depth and number of implanted ions is determined via Elastic Recoil Detection Analysis (ERDA).



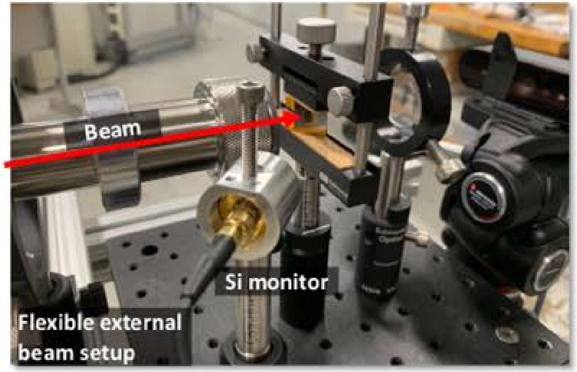
C^7LYC development

- Characterization of several new detectors.
- Exploring new geometries.



External-beam development

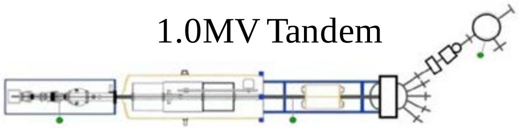
- Cell death studies in collaboration with UML Biomedical Engineering using proton irradiation for space physics applications.
- PIGE for identifying and quantifying total ^{19}F found in PFAS samples.



UNION COLLEGE
FOUNDED 1795

Ion-Beam Analysis of Environmental Pollution

1.0MV Tandem

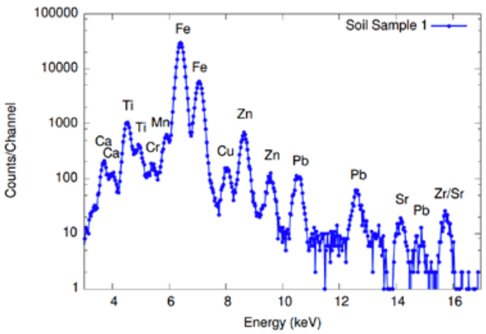


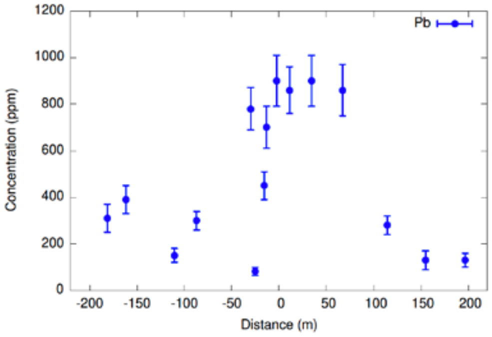
NASA NEW YORK Space Grant Consortium

Source: United States Environmental Protection Agency (EPA)

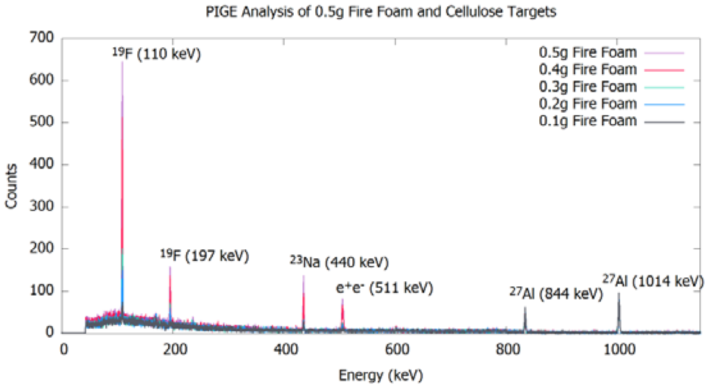
Per- and polyfluoroalkyl substances (PFAS) are a group of man-made chemicals that have been in use since the 1940s, and are (or have been) found in many consumer products like cookware, food packaging, and stain repellants.

- Lead Contamination in Soil Around Bridges





- PFAS Contamination From Fire-Fighting Foam



At-211 Production at Texas A&M

Production
$^{209}Bi(\alpha,2n)^{211}At$ at 28.8 MeV, 4-8 μA

↓

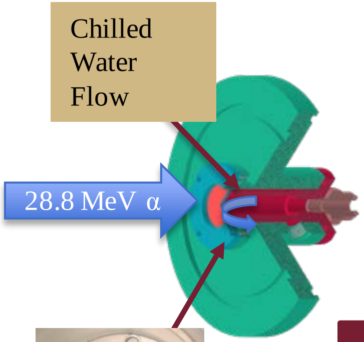
Dissolution of Target
6–12 M HNO_3 (nitric acid)

↓

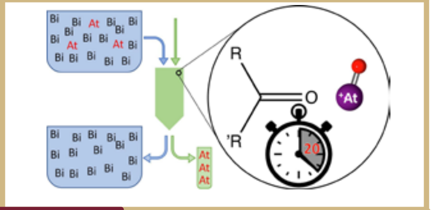
Experimental Chemistry
Separations and Fundamental

↓

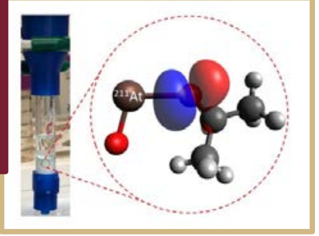
Radiolabeling for Targeted Alpha Therapy



Rapid recovery of At-211 by extraction chromatography



New purification method results in larger At-211 yields faster than previous methods.



Purification based on newly discovered chemical interaction of At-211 with ketones.

Background: Targeted Alpha Therapy

- Potential to be a curative treatment for patients after primary cancer treatment
- ^{211}At is the only α-decaying isotope fulfilling the criteria for nuclear medicine applications
  - → $T_{1/2} > 1h$
  - → No serial decay (which could contribute to toxicity *in vivo* from daughters), one alpha

J.D. Burns, *et al.*, *Chem. Commun.*, **56**, 9004-9007, 2020.
J.D. Burns, *et al.*, *J. Sep. Pur.*, **256**, 117794, 2021.

NSAC - LE-Nuclear Science Town Meeting

11/2022 U.S. DOE Nuclear Science Highlights

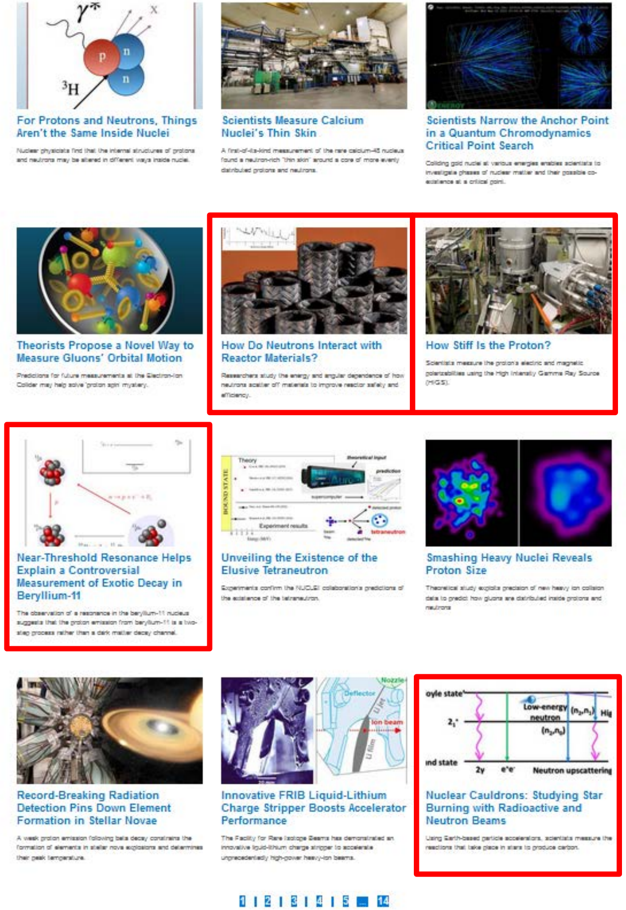
Fun Fact: 4 of the current 12 DOE Nuclear Physics Highlights are ARUNA-projects

1) UK: How do Neutrons Interact with Reactor Materials

2) TUNL-HIGS: How Stiff is the Proton ?

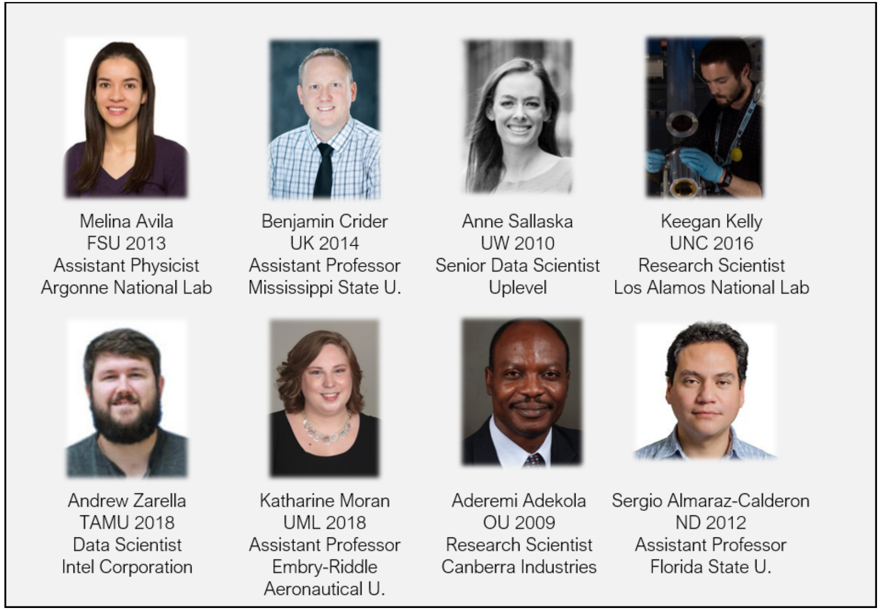
3) FSU: Near-Threshold Resonance Helps Explain a Controversial Measurement of Exotic Decay in Beryllium-11

4) TAMU & OU: Nuclear Cauldrons: Studying Star Burning with Radioactive and Neutron Beams



Educating Scientists: Workforce Development Ph.Ds

- ARUNA labs attract talent in many places and on many levels: with a “wide net”.
- ARUNA labs provide a hands-on, immersive research experience, fostering multiple skills from machine-shop, electronics and detector technology, to coding, AI and complex “large data” analysis
- ARUNA groups educate 20% of all experimental nuclear Ph.D.s in U.S.
- Many Ph.D. include projects combining ARUNA labs and user labs.
- Most find excellent jobs at National labs, data science firms and institutions of higher education.



Ph.D. Graduates from ARUNA institutions (2015-2019)

2015

Mason Anders (Shlomo,TAMU)
Jessica Baker (Wiedenhoever,FSU)
Matteo Barbarino (Bonasera,TAMU)
William Bauder (Collon,ND)
Richard Behling (Melconian,TAMU)
Joseph Belarge (Wiedenhoever,FSU)
Amila Dissanayake (Kayani,WMU)
Sean Finch (Tornow,Duke)
Graham Giovanetti (Wilkerson,UNC)
Emily Jackson (Lister,UML)
Sean Kuvin (Wiedenhoever,FSU)
Georgios Laskaris (Gao,Duke)
Jacqueline MacMullin (Wilkerson,UNC)
James Matta (Garg,ND)
Larry May (Yennello,TAMU)
Dmitriy Mayorov (Folden,TAMU)
David Mc. Pherson (Cottle,FSU)
Mike Mehlman (Melconian,TAMU)
Scott Miller (Riley,FSU)
Vikram Prasher (Chowdhury,UML)
Sarah Shidler (Wiescher,ND)
Rashi Talwar (Wiescher,ND)
Justin VonMoss (Tabor,FSU)
Brittany VornDick (Young,NCSU)
David Zumwalt (Garcia,UW)

2016

Shamim Akhtar (Brune,OU)
Marisa Alfonso (Folden,TAMU)
Anthony Battaglia (Aprahamian,ND)
Johnathan Button (Youngblood,TAMU)
Zilong Chang (Gagliardi,TAMU)
Murat Dag (Tribble,TAMU)
Sushil Dhakal (Brune,OU)
Rutger Dungan (Tabor,FSU)
Ben Fenker (Melconian,TAMU)
Kyong Han (Ko,TAMU)
Nathan Holt (Rapp,TAMU)
Ran Hong (Garcia,UW)
Min Huang (Gao,Duke)
Keegan Kelly (Champagne,UNC)
Feng Li (Ko,TAMU)
Alexander Long (Wiescher,ND)
Wenting Lu (Collon,ND)
Stephanie Lyons (Wiescher,ND)
Karen Ostdiek (Collon,ND)
Cody Parker (Brune,OU)
Yuan Qiu (Chowdhury,UML)
Jack Silano (Karwowski,UNC)
Mallory Smith (Aprahamian,ND)
Sidharth Somanathan (Fries,TAMU)
Pei-Luan Tai (Tabor,FSU)
David Ticehurst (Howell,UNC)
James Trimble (Henning,UNC)
Tyler Werke (Folden,TAMU)
Kevin Wierman (Wilkerson,UNC)
Jun Yan (Wu,Duke)

2017

Laurie Cumberbatch (Howell,Duke)
Craig Huffer (Huffman,NCSU)
John J. Parker IV (Wiedenhoever,FSU)
Shuai Liu (Rapp,TAMU)
Graham Medlin (Young,NCSU)
Grayson Rich (Barbeau,UNC)
Benjamin Shanks (Wilkerson,UNC)
Alexandra Spiridon (Tribble,TAMU)
Kristopher Vorren (Henning,UNC)
Xuefei Yan (Gao,Duke)

2018

Nadyah Alanazi (Voinov,OU)
Bilal Amro (Lister,UML)
Jonathan Barron (Riley,FSU)
Miguel Bencomo (Hardy,TAMU)
Clark Casarella (Aprahamian,ND)
Dustin Combs (Young,NCSU)
Patrick Copp (Lister,UML)
John Dermigny (Iliadis,UNC)
Brent Fallin (Turkington,Duke)
Xiao Fang (Wiescher,ND)
Lauren Heilborn (Yennello,TAMU)
Ed Lamere (Couder,ND)
Mike Moran (Couder,ND)
Katherine Moran (Lister,UML)
Chao Peng (Gao,Duke)
Austin Reid (Huffman,NCSU)
Andrea Richard (Crawford,OU)
Nabin Rijal (Wiedenhoever,FSU)
PathirannehelageNuwan
Sisira Kumara (Tanis,WMU)
Yifeng Sun (Ko,TAMU)
Andrew Zarrella (Yennello,TAMU)
Yang Zhang (Gao,Duke)

2019

Brittany Abromeit (Tabor,FSU)
Maria Anastasiou (Wiedenhoever,FSU)
Yelena Bagdasarova (Garcia,UW)
Chelsea Bartram (Henning,UNC)
Giacamo Bonasera (Shlomo,TAMU)
Yingying Chen (Wiescher,ND)
Roman Chyzh (Tribble,TAMU)
Andrew Cooper (Champagne,UNC)
Eric Dees (Young,NCSU)
Xiaojian Du (Rapp,TAMU)
Katrina Elizabeth Koehler
(Famiano,WMU)
Forrest Friesen (Howell,Duke)
Gwenaelle Gilardy (Couder,ND)
Thomas Gilliss (Wilkerson,UNC)
Rekam Giri (Brune,OU)
Matt Hall (Bardayan,ND)
Benjamin Heacock (Young,NCSU)
Josh Hooker (Rogachev,TAMU)
Sean Hunt (Iliadis,UNC)
Shahid Iqbal (Kayani,WMU)
Heshani Jayatissa (Rogachev,TAMU)
James Kelly (Brodeur,ND)
David La Mantia (Tanis,WMU)
Rebeka Lubna (Tabor,FSU)
Kalisa Villafana (Riley,FSU)
Merinda Viola (Folden,TAMU)
Zhidong Yang (Fries,TAMU)
Bryan Zeck (Young,NCSU)

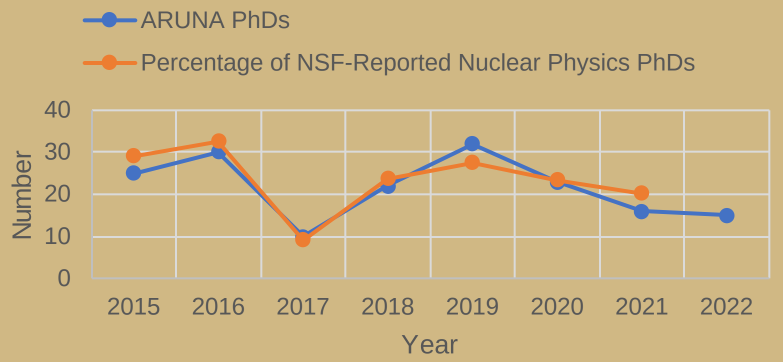

Ph.D. Graduates from ARUNA institutions

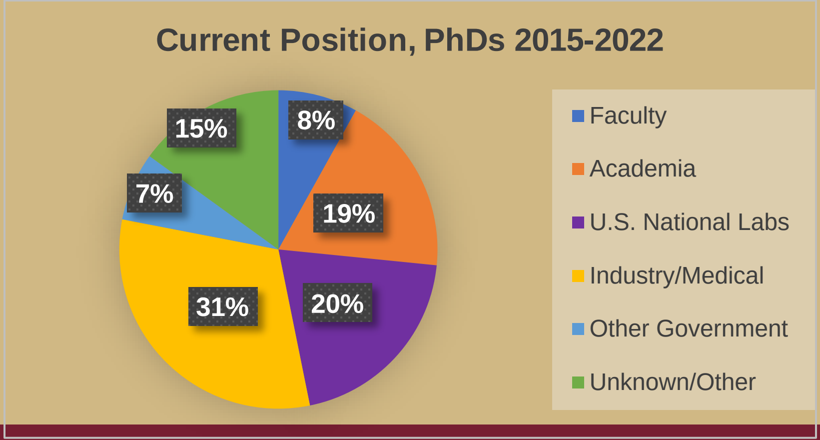
2020
Hasna Abdullah M Alali (Kayani,WMU)
Tyler Anderson (Collon,ND)
Eames Bennett (Christian,TAMU)
Lori Downen (Iliadis,UNC)
Kevin Glennon (Folden,TAMU)
Kevin Howard (Garg,ND)
Patricia Huestis (LaVerne,ND)
Andrea Jedele (Yennello,TAMU)
Xiaqing Li (Gao,Duke)
David Little (Janssens,UNC)
Qian Liu (Wiescher,ND)
Jacob Long (Brodeur,ND)
Ronald Malone (Howell,Duke)
Prashanta Mani Niraula (Kayani,WMU)
Caleb Marshall (Longland,NCSU)
Som Paneru (Brune,OU)
Craig Reingold (Simon-Robertson,ND)
Elizabeth Rubino (Tabor,FSU)
Kevin Siegl (Aprahamian,ND)
Michael Skulski (Collon,ND)
Sabrina Strauss (Aprahamian,ND)
Sriteja Upadhyayula (Rogachev,TAMU)
Weizhi Xiong (Gao,Duke)

2021
Eric Aboud (Rogachev,TAMU)
Ben Asher (Almaraz-Calderon,FSU)
Nathan Gerken (Almaraz-Calderon,FSU)
Gula Hamad (Meisel,OU)
Samuel Hedges (Barbeau,Duke)
Samuel Henderson (Ahn,ND)
Curtis Hunt (Rogachev,TAMU)
Sean McGuinness (Peaslee,ND)
Luis Morales (Couder,ND)
Gulden Othman (Henning,UNC)
Jesus Perello (Almaraz-Calderon,FSU)
Nirupama Sensharma (Garg,ND)
Doug Soltesz (Meisel,OU)
Shiv Subedi (Meisel,OU)
Bryant Vande Kolk (Wiescher,ND)
Taylor Whitehead (Holt,TAMU)

2022
Derek Anderson (Mioduszewski,TAMU)
Joseph Atchison (Rapp,TAMU)
Connor Awe (Barbeau,Duke)
Om Bhadra Khanal (Chajecki,WMU)
Daniel Burdette (Brodeur,ND)
Bryce Frentz (Wiescher,ND)
August Gula (Wiescher,ND)
Khushi Jayeshbhai Bhatt (Famiano,WMU)
Long Li (Barbeau,Duke)
Collin Malone (Howell,Duke)
Orlando Olivas-Gomez (Simon-Robertson,ND)
Federico Portillo Chaves (Longland,NCSU)
Chris Seymour (Couder,ND)
John Wilkinson (Peaslee,ND)
Vera Zakusilova (Folden,TAMU)

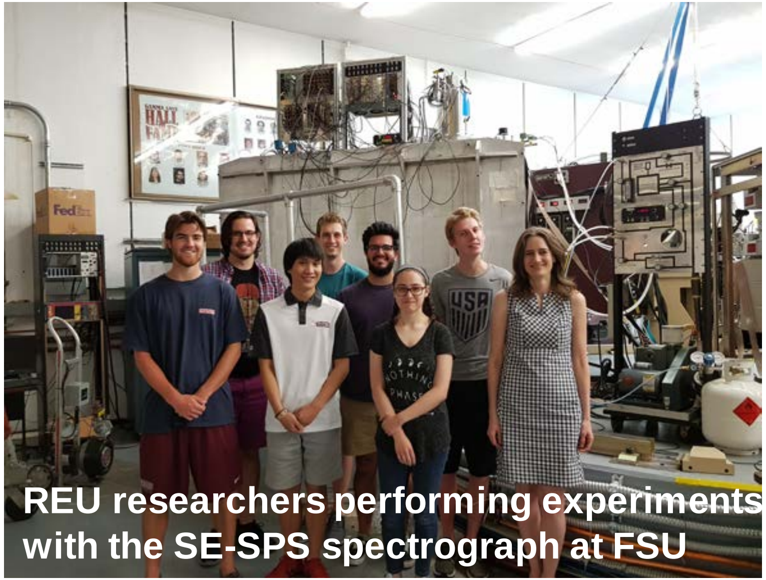
(ain't over yet….)





Educating Scientists:
Workforce Development: Undergraduate Research

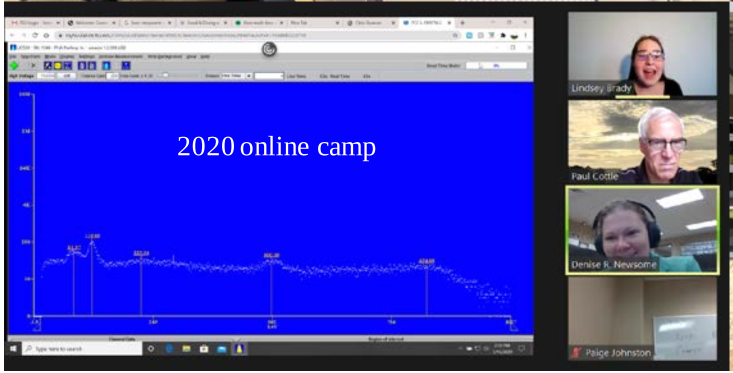
- Undergraduate research is a hallmark of ARUNA laboratories
- The flexible scheduling at ARUNA facilities allows for a meaningful participation of undergraduate researchers in actual experiments
- Many Aruna Laboratories have / participate in Research Experience for Undergraduates (REU) programs. (ND, TAMU, TUNL, FSU)
- Three ARUNA laboratories are located at undergraduate institutions: Hope College, Union College and James Madison University, flagship research programs at their respective colleges.


REU researchers performing experiments with the SE-SPS spectrograph at FSU

An Outreach Example: Inspiring the next generation

2020 online camp

2021 in-person camp



2020 online camp

2020 online camp

CENTER FOR EXCELLENCE
CENTAUR
IN NUCLEAR TRAINING AND UNIVERSITY-BASED RESEARCH

Observations

1. ARUNA facilities do first rate science in areas aligned with the long-range plan and a diverse set of probes
2. ARUNA facilities provide unique opportunities for new developments and testing that is not possible at big facilities.
3. ARUNA facilities attract students and help nuclear science compete for talent at universities.
4. ARUNA facilities are flagships at their universities and generate a lot of leverage support.
5. Scientists from ARUNA facilities are a major part of the user community of large facilities.
6. Scientists from ARUNA facilities are an intellectual resource, if not a motor for the field.

Resolution

In order to ensure the long-term health of the field and the education of the next generation of scientists, it is critical to maintain balance between the ARUNA facilities and the major national user facilities, in science, operations and new initiatives. Under this condition the ARUNA laboratories will continue to flourish and provide a diversity of approaches for forefront science while nurturing the scientists of the future.

(Passed unanimously 10/28/2022 at the ARUNA@DNP Town Meeting)