

From the TUNL Director by Robert Janssens



Welcome to the 2nd TUNL Newsletter! The newsletter is the brainchild of the Climate Committee and it is meant to keep our entire community informed about major developments affecting TUNL.

At this time, members of TUNL are closely involved in two important activities which will, without a doubt, impact the future of the laboratory in major ways. First, NSAC, the Nuclear Science Advisory Committee, has been mandated by the DOE and NSF to prepare a new Long Range Plan (LRP) for nuclear science. As a first major step in this endeavor, three Town Hall meetings were held where the entire community was asked to (1) articulate its accomplishments since the 2015 LRP, and (2) provide a prioritized list of initiatives that will keep the national nuclear science enterprise at the forefront of the field in the next decade. Many members of the TUNL community have played major roles in these Town Hall meetings. In fact, the meeting on Fundamental Symmetries, Neutrons and Neutrinos was hosted by TUNL and held on Dec. 13-15 at the Friday Center in Chapel Hill. All three meetings have resulted in input to the LRP process through white papers with significant TUNL contributions. Furthermore, our efforts continue as three members of TUNL are part of the ad-hoc committee in charge of writing the LRP. We wish them the very best.

While the LRP process continues, TUNL is also preparing for the renewal of its major research grant. This activity is just getting underway and, here as well, TUNL staff are challenged to take note of past accomplishments while defining future directions. We have a strong case to make with many initiatives currently underway such as the completion of LENA, the ongoing injector upgrade for the Tandem, the development of new mirrors at HILS to increase to photon energies to 150 MeV, the success of MAJORANA and the successful launch of LEGEND-200, continued steady progress in the neutron EDM project and in beta-decay research, and many more. A retreat by TUNL faculty later this month will kick off in earnest our efforts towards the best possible proposal.

While all these activities are important for TUNL's future, one cannot lose sight of the fact that recent successes and accomplishments, some of which are outlined in this newsletter, are all due to the dedication and the many contributions by everyone, from students to postdocs, and from technical and administrative staff to scientists and faculty. Because of everyone's efforts, we can look forward with optimism to the future. So, yes, stay tuned: there is much more to come...

TUNL Climate Committee by Reyco Henning

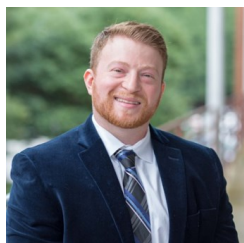
The TUNL Climate Committee (TCC) is now in its second year and would like welcome Brogan Thomas as our newest member. We are continuing to monitor initiatives such as TUNL days, graduate student pizza lunches with the Director, this newsletter, and other efforts to foster a greater sense of community. We also would like to thank everyone who filled out the recent Climate survey. After we review the results, we will draft a report to release to the TUNL community. We are especially interested to see how this survey compares to the previous one.

Our major initiative for the coming months will be to develop the Promoting Inclusive and Equitable Research Plan for the TUNL Renewal proposal. This will be based on greater outreach to faculty members from smaller colleges and community colleges in central NC and beyond. Please contact us if you would like to participate or have ideas to share!

Graduate Student and Postdoc Achievements

PhD Dissertations

- **Adam Lipman** (NCSU, advisors Robert Golub and Paul Huffman) defended his dissertation entitled “Development of Simulations Framework to Study Trapped Particle Spin Dynamics Regarding the Search for an nEDM”. Adam works now as Assistant VP of Global Risk and Valuation, Model Validator at Citibank.
- **Collin Malone** (Duke, advisor Calvin Howell) successfully defended his dissertation, “Photodisintegration of ^3H and Supporting Experiments” and is now employed as a postdoctoral fellow at Savannah River National Lab.
- **Long Li** (Duke, advisor Phil Barbeau) defended his dissertation entitled “A Measurement of the Response of a High Purity Germanium Detector to Low-Energy Nuclear Recoils”. Long is now teaching high school physics in the International Department at Beijing National Day School.
- **Peibo An** (Duke, advisor Phil Barbeau) successfully defended his PhD thesis, “Studies of the Electron Neutrino Charged-current Interaction on ^{127}I ”. Peibo will start a position as Senior Data Scientist at Prudential Financial in the near future.
- **Federico Portillo Chaves** (NCSU, advisor Richard Longland) defended his thesis entitled “ ^{19}Ne States and Resonances in the $^{18}\text{F}(p, \alpha)^{15}\text{O}$ Reaction in Classical Novae”. Federico is currently a Lecturer at NCSU.
- **Danula Godagama** (U. Kentucky, advisor Michael Kovash) defended his research thesis, “Elastic and Inelastic Compton Scattering from Deuterium at 61 MeV”. This project was performed at the HlyS facility as part of the Compton@HlyS program. Danula is now a postdoctoral associate at Duke working with Calvin Howell.



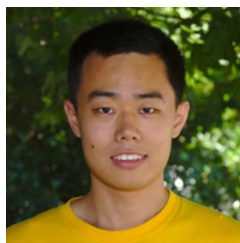
Adam Lipman



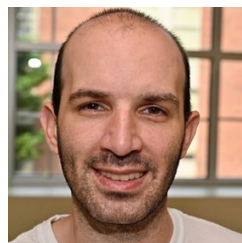
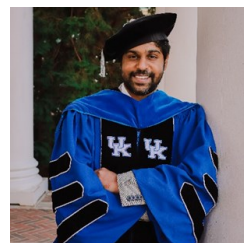
Collin Malone



Long Li



Peibo An

Federico Portillo
Chaves

Danula Godagama

Preliminary Exams and Master's Theses

- Duke graduate students **Aitor Bracho**, **Ryan Bouabid**, **Charlie Prior** and **Emma Van Nieuwenhuizen** passed their preliminary exams this year.
- UNC graduate student **Jackson Waters** successfully defended his Master's Thesis entitled “A low-energy background Model for the LEGEND-1000 Experiment”.
- UNC graduate students **Erin Engelhardt**, **Andrew Gavin**, **Kevin Bhimani**, and **Esteban Leon** passed their preliminary exams.
- NCSU graduate student **Matt Morano** passed his preliminary exam in June 2022.

Graduate Student and Postdoc Achievements (continued from p. 2)

Awards and Fellowships

- **Charlie Prior** was accepted into the Public Policy & Nuclear Threats class of 2022. Charlie also attended the Carnegie Nuclear Policy Program.
- **Ryan Bouabid** was awarded an Office of Science Graduate Student Research Fellowship to attend LANL and work with Steve Elliott and Ralph Massarczyk on LEGEND. He was also awarded a 3-year applied antineutrino fellowship with the consortium for Monitoring, Technology and Verification (MTV) for the development of more sensitive germanium-based CEvNS detectors.
- **Aitor Bracho** was awarded 3 years of funding as part of the ACT-UP award at LLNL, to measure fission product yields from neutrons on U and Th. Aitor has also recently received an internship offer from Terrapower for the summer of 2023.
- **Tyler Johnson** received best poster at this year's MTV conference for his work on building a neutrino-induced fission detector at the SNS. Tyler also served on the Provost's committee to select a new Dean of Arts & Sciences for Duke, the UCEM Advisory Board, and the Duke Board of Trustees Strategic Engagement Program.
- **Peibo An** spent the summer of 2022 in New York as part of very competitive internship with META.
- **Innocent Tsorxe** received a Best Poster Award at the 2023 Stewardship Science Academic Programs (SSAP) Annual Symposium.
- **Esteban Leon** was awarded an Outstanding Poster Award at the 7th Symposium on Neutrinos and Dark Matter in Nuclear Physics (NDM22).
- **Morgan Clark** was named a DOE Office of Science Graduate Student Research Program (SCGSR) Fellow at ORNL.
- **Guadalupe Duran** was awarded the prestigious NSF Graduate Research Fellowship.
- **Tyler Kowalewski** was selected for and awarded partial funding to attend the 4th GOSIA Workshop at the Heavy Ion Laboratory of the University of Warsaw.
- **Nirupama Sensharma's** Ph.D. thesis, titled "Wobbling motion in nuclei: Transverse, Longitudinal, and Chiral" has been published as a book by the well-known science publisher Springer under the "Springer Theses" series (<https://link.springer.com/book/10.1007/978-3-031-17150-5>)
- **Aobo Li** received a Postdoctoral Award for Research Excellence (PARE) from UNC in 2022. Aobo also was the recipient of the 2023 APS DNP Dissertation Award "For the invention of a novel machine learning algorithm that broke down significant technological barriers with monolithic liquid scintillator detectors and, in turn, delivered the world's most sensitive search for neutrinoless double beta decay."
- In addition, **Aobo Li** was the recipient of a Machine Learning: Science and Technology Paper Award at the 2022 Conference on Neural Information Processing Systems.



Aobo Li

Research Highlights

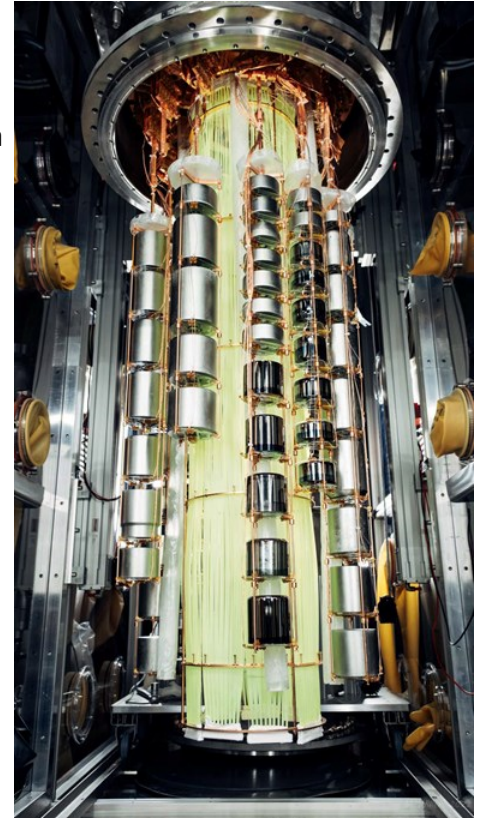
- UCN τ and UCN τ^+ :** UCN τ is an experiment which exploits Ultracold Neutrons (UCN) stored in a magnetic trap formed by the surface of an asymmetric bowl paved with permanent magnets in a Halbach array. The top of the bowl is 50 cm above its lowest point, permitting the trapping of “weak-field seeking” spin states with energies up to about 50 neV. The trap is loaded from the bottom through a removable section of the bowl using UCN produced by the Area B source at the Los Alamos Neutron Science Center. In 2021, the UCN τ collaboration reported the most precise measurement of the mean neutron lifetime, $877.75 \pm 0.28_{\text{stat}} \pm 0.22 / -0.16_{\text{sys}}$ seconds in Physical Review Letters ([Gonzalez et al., Phys. Rev. Lett. 127, 162501, 2021](#)). The UCN τ experiment completed its final “production” run in December of 2022, with a substantial increment in available statistics and new systematics tests from the 2019 through 2022 run-cycles at LANSCE. TUNL graduate student **Rifet Musedinovic** is performing one of the independent analyses for these data. The TUNL team is also involved in the development of the next generation experiment UCN τ^+ , scheduled for prototype testing during the 2023 LANSCE run-cycle. UCN τ^+ will employ the same magnetic array as UCN τ , but will utilize a detector system optimized for higher rates and new loading system involving adiabatic transport of UCN into the magnetic trap from a very large volume storage vessel. UCN τ^+ targets a factor of two or more improvement to the precision of UCN τ .
- Nab:** The Nab experiment is designed to determine the axial coupling constant in neutron decay from a measurement of the angular correlation between the emitted electron and antineutrino following beta decay. This correlation produces a distortion in the predicted time of flight (TOF) for recoil protons which is measured by Si detectors situated at either ends of the detector, using the decay electron as “start” for the proton timing measurement. These detectors are very thick (1.5 to 2.0 mm), large diameter (~12 cm), thin dead-layer (~100 nm) Si detectors, which are segmented into 127 active pixels. A TUNL team led by Assistant Professor **Leendert Hayen** and graduate students **J. Choi** and **R.J. Taylor** developed a very complete analysis and simulation package for the Nab detector signals, which incorporated detailed modelling of the (hexagonal) pixel boundaries, undepleted detector regions, updated pair creation energy and implanted contact models and more. This work is currently submitted to Physical Review C ([ArXiv:2212.03438](#)).
- nEDM:** For the neutron EDM experiment, a small “mini-nEDM” apparatus is being developed with one measurement cell and no electric field to study systematic effects related to the larger-scale experiment that will run at Oak Ridge National Laboratory. The systematic studies apparatus is in the final commissioning stage (expected to be fully commissioned in the coming year). Most recently, a helium re-liquefier has been installed and is fully operational. We are on track to begin the first phase of ^3He systematic studies by the end of 2024.



“Mini-nEDM” apparatus located in French 1127 high-bay lab

Research Highlights (continued from p. 4)

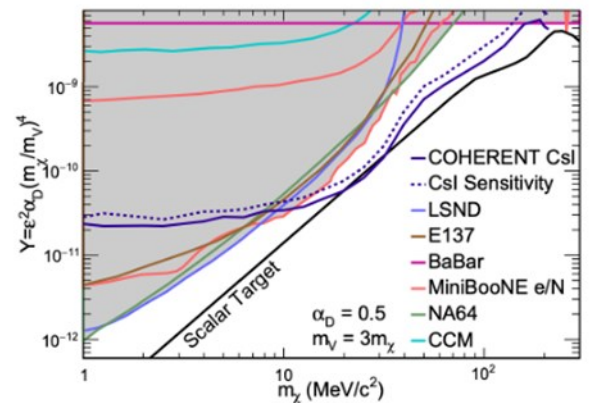
- LEGEND:** This is an exciting time for the LEGEND collaboration. In October 2022 the collaboration deployed 101, ^{76}Ge enriched, high purity germanium (HPGe) detectors in a liquid argon cryostat deep underground at the INFN Gran Sasso National Laboratory (LNGS) in Italy. After a four-month commissioning period, the collaboration started production data-taking in February of this year. This phase of LEGEND, called LEGEND-200, is poised to become the most sensitive search for neutrinoless double-beta decay, with a projected half-life discovery sensitivity of 10^{27} years. TUNL members have played major roles in simulations and analysis, machine learning studies, detector procurement and characterization, cable production, engineering, data acquisition, electronics testing, commissioning, and operations. We are also ramping up our analysis efforts and anticipate many exciting student projects in the coming years in analyzing the L200 data. Looking beyond LEGEND-200, we are also actively pursuing the next generation tonne-scale double-beta decay experiment called LEGEND-1000. After a successful portfolio review in 2021, the collaboration's currently priority is preparing for CD-1/3A. The TUNL group has a wide variety of important roles in the L1000 project ranging from engineering and infrastructure, project management, simulations and analysis, electronics, germanium detector production, cabling, and data acquisition. In February we submitted an NSF MRI proposal for a test setup that will perform many science and technical studies with HPGe detectors submerged in liquid argon. We are also developing an NSF Mid-scale RI-2 Proposal for a part of L1000 that will be submitted via UNC.
- MAJORANA DEMONSTRATOR:** Though the MAJORANA DEMONSTRATOR completed operations in 2022, the collaboration published many new technical papers and searches for physics beyond the standard model using the Demonstrator data. One, led by previous UNC postdoc **Wenqin Xu**, made the cover of PRL ([Arnquist et al., Phys. Rev. Lett. 129, 081803, 2022](#)). The collaboration also published its final neutrinoless double-beta decay limit based on 65 kg-yr of exposure, which was $T_{1/2} > 8.3 \times 10^{25}$ yr (90% C.L.) using a frequentist analysis. All these results have been presented at numerous conferences.
- Nuclear Astrophysics News:** (1) NCSU graduate student **Kaixin Song's** research with the Longland group was featured in APS News ([December 2022, Volume 31, Number 11](#)) in an article entitled "Scientists Investigate Salty Stellar Recipes". (2) UNC graduate student **David Gribble** was first author on a publication for his work "Investigation of ^{11}B and ^{40}Ca Levels at 8–9 MeV by Nuclear Resonance Fluorescence" with the Iliadis group ([Gribble et al., Phys. Rev. C 106, 014308, 2022](#)). (3) **Christian Iliadis** is heading a working group on Solar Fusion cross sections. The workshop took place in Berkeley, CA during July 2022. Work by the 60+ member collaboration is ongoing and a publication is planned in Rev. Mod. Phys.



The LEGEND-200 array of germanium detectors and light readout

Research Highlights (continued from p. 5)

- KamLAND:** KamLAND (Kamioka Liquid Anti-Neutrino Detector) is a monolithic liquid scintillator detector experiment in Kamioka Observatory, Japan. During its construction phase, the TUNL group played a vital role in building the KamLAND outer detector, a key facility that helps rejecting cosmic muon backgrounds and is still running today. The first data-taking of KamLAND began in 2002, with the primary goal of measuring neutrino oscillations using reactor antineutrinos. As a result, it directly observed two full oscillation cycles and, in turn, determined that LMA-MSW was the solution to the solar neutrino problem. This result was endorsed by the 2016 Breakthrough Prize in Fundamental Physics. KamLAND was also the first experiment that discovered geoneutrinos. In 2011, the KamLAND experiment evolved into KamLAND-Zen, shifting its primary goal to searching for neutrinoless double beta decay ($0\nu\beta\beta$). This decay, if discovered, will be the first lepton number violation signal and prove neutrinos are Majorana particles. In 2022, KamLAND-Zen released its new $0\nu\beta\beta$ search result ([Phys. Rev. Lett. 130, 051801](#)). This result is the world's most sensitive search for Majorana neutrinos and marks the first $0\nu\beta\beta$ search in the inverted mass ordering region. It arrived exactly 20 years after KamLAND's first data taking, and the fantastic journey of KamLAND-Zen is still ongoing. The TUNL KamLAND-Zen group contains four current members: **Hugon Karwowski**, **Aobo Li**, **Diane Markoff**, and **Werner Tornow**. **Chris Gould** was involved in the construction of the outer detector. Aobo Li received the 2023 APS [Dissertation Award in Nuclear Physics](#) because of his contribution to the KamLAND-Zen new result.
- COHERENT:** The COHERENT collaboration had their paper constraining Sub-GeV Dark Matter accepted by PRL ([Phys.Rev.Lett. 130, 051803, 2023](#)). The result uses the data from the Csl deployment, and strongly hinges on the precision of the quenching factor measurement that was produced using the tandem accelerator at TUNL.
- Barbeau Group News:** **Phil Barbeau**, **Diane Markoff**, and their graduate students have been extremely busy with detector deployments to the SNS at ORNL. These systems include (1) Nv-Thor, which looks for neutrino-induced fission events, (2) GeMini, a mini-array of Ge detectors complete with shields and muon vetoes, and the first module of (3) NalvE-Te, which will be a multi-tonne Nal[Tl] detector looking for coherent elastic neutrino-nucleus scattering (CEvNS) off of ^{23}Na .
- Phil Barbeau** wrote two articles that will appear in the Annual Review on Nuclear and Particle Sciences in 2023. The first with COHERENT Collaborators Kate Scholberg and Yuri Efremenko is on the current neutrino program at the SNS; and the second with fellow Quenching Factor aficionados Jingke Xu and Ziqing Hong describes the calibration of low-energy nuclear recoils in neutrino and dark matter detectors.



Constraint of Dark Matter parameter space for COHERENT Csl data compared to other experimental data

Join the TUNL Slack workspace. Contact Matt Green (mpgreen2@ncsu.edu) to be added. This is a great tool for collaboration or just staying in touch.

Accelerator Updates

LENA II Upgrade: The new 2-MV Singletron accelerator from HVEE was delivered to Durham on October 5, 2022, and has been installed in the Laboratory for Experimental Nuclear Astrophysics (LENA II). The Singletron features intense beams of H and He which can be pulsed to provide good background rejection for experiments. The newly refreshed laboratory will also include an upgraded 230-kV ECR accelerator. Both accelerators are currently being tested with hopes of starting measurements this summer.

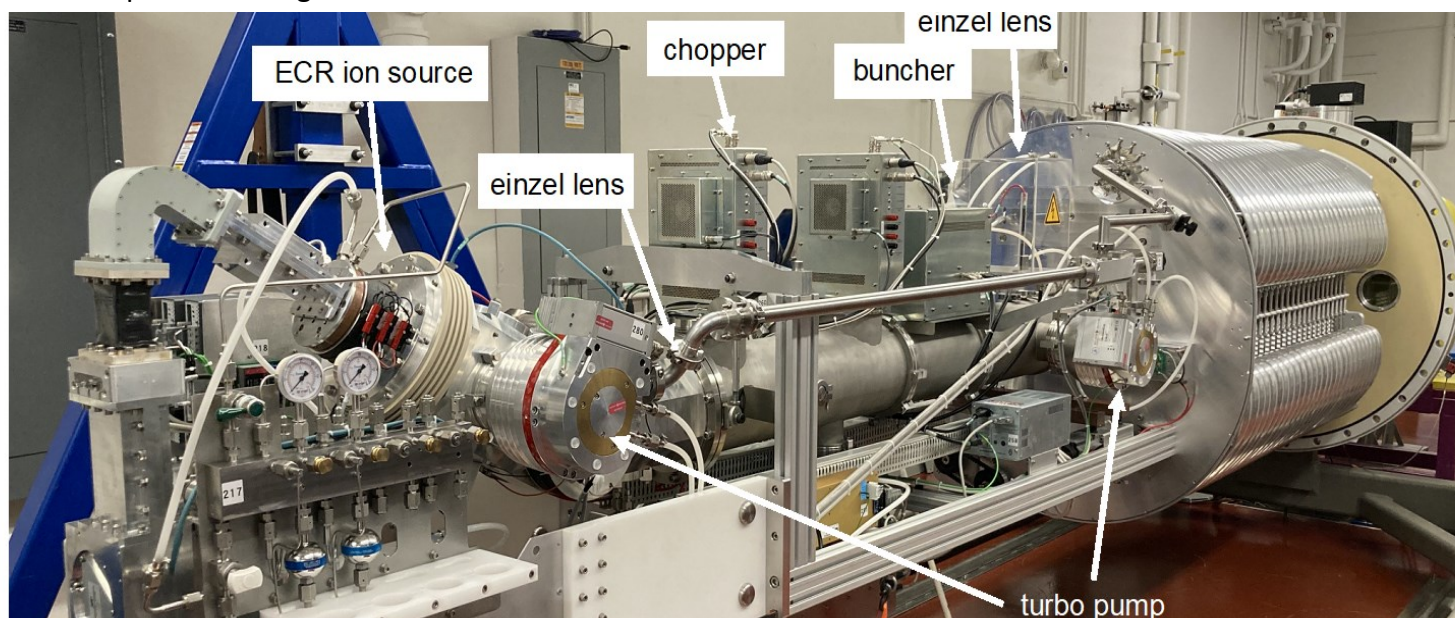


Photo of the LENA II 2-MV Singletron showing its ion source components.

Tandem Injector Upgrades: In summer 2022, TUNL received a grant of \$1.5M from DOE to upgrade the sources that produce ions for the tandem Van de Graaff accelerator. The current Direct Extraction Negative Ion Source (DENIS II) and helium source will be replaced by a Toroidal Volume Ion Source (TORVIS) and a Source of Negative Ions by Cesium Sputtering (SNICS-II). The TORVIS will produce H and He beams with 5 times the current that is available from the present ion sources. The SNICS-II will enable the production of heavier ion beams, increasing the variety of particle beams available to researchers and creating new research opportunities in nuclear astrophysics and nuclear structure. The TORVIS has been ordered from NEC and is expected to be delivered in Spring 2024. The SNICS-II source will arrive later and installation of both sources is expected in Spring 2025.

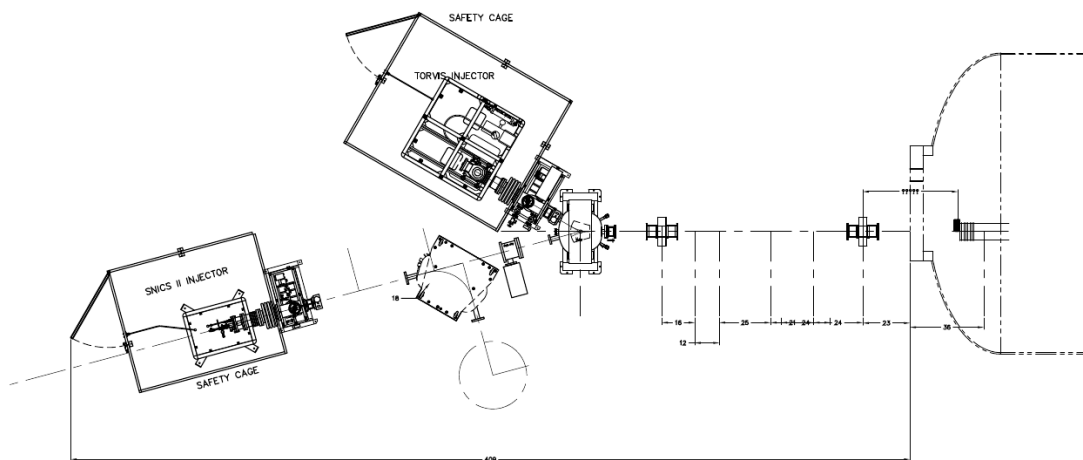
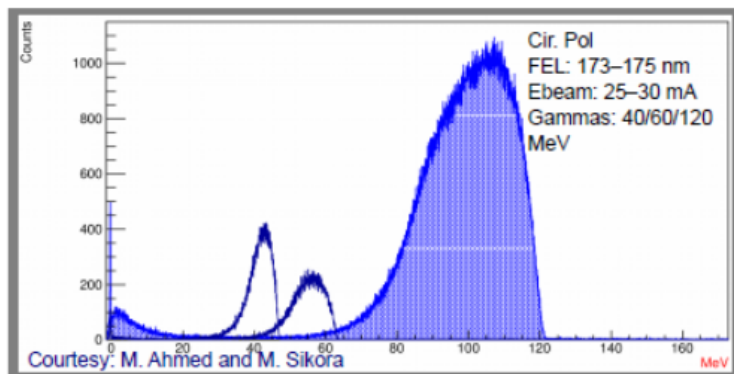


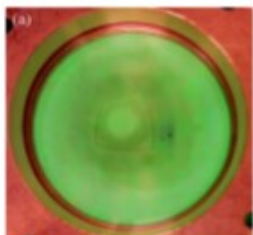
Diagram of the new planned tandem low-energy injector system showing the TORVIS (upper center) and SNICS-II (lower left).

Accelerator Updates (continued from p. 7)

HlyS Mirror Development: Development and testing of new fluoride-based VUV mirrors in the 170-175 nm range have continued at DFELL in the last year. These mirrors have enabled production of stable γ -ray beams at energies up to 120 MeV at a flux comparable to what has previously been achieved with 190 nm mirrors. Post-lasing measurements by the German company LZH has shown only mild degradation with little reflectivity change at the lasing wavelength. The expected lifetime of these mirrors is over 70 hours.



γ -ray spectrum with new 175 nm mirrors



Downstream 175 nm mirror
post-lasing

Future low-energy QCD measurements at HlyS, especially the spin-polarizability research program, will require even higher energy γ -ray beams, necessitating even lower wavelength FEL mirrors. Funding has been obtained from DOE for a 3-year project to develop robust, high-reflectivity 155 nm mirrors which would enable gamma-ray beam production in the 120-150 MeV energy range.

Welcome to our new TUNL Postdocs!

- **Danula Godagama**

Danula did his dissertation research with Mike Kovash at the University of Kentucky on the Compton@HlyS project. He recently joined the Howell group and is focused on the tritium photodisintegration project. Danula is also involved in the Compton and photon-induced fission experiments. When not in the HlyS counting house, you can find him in DFELL 219.

- **Caleb Marshall**

Caleb is a returning TUNL alum, having done his dissertation research on the TUNL Enge Split-pole spectrograph as an NCSU graduate student with Richard Longland. He then worked on the commissioning of the recoil separator SECAR located at FRIB as a postdoctoral scholar with Ohio University. Caleb is working with the Iliadis group and can be found in TUNL 323.



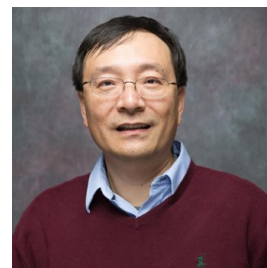
- **Thannasis Psaltis**

Thannasis is a new NCSU postdoc in the Longland group. He did his dissertation work with Alan Chen at McMaster University and followed that with a postdoc at Technische Universität in Darmstadt, Germany, working with Almudena Arcones. When he isn't working on the Enge, you can find him in TUNL 322.



Faculty and Staff News

- **Robert Janssens**, TUNL Director and Bilpuch Distinguished Professor at the University of North Carolina at Chapel Hill (UNC-CH), received the 2022 Division of Nuclear Physics Distinguished Service Award. The citation reads: "For his exemplary service to the DNP, particularly his extended leadership in the chair line and the nuclear physics community, including as the Director of the Physics Division at Argonne National Laboratory and as Director of the Triangle Universities Nuclear Laboratory."
- **Ying Wu**, Professor at Duke University and Associate Director for Light Sources at TUNL, is the co-winner of the 2022 FEL prize as announced during the 40th International Free Electron Laser Conference (FEL2022). The citation for the prize reads as follows: "Prof. Wu has made important contributions to both theoretical and experimental FEL science. He has distinguished himself with the use of storage ring FELs to produce gamma-ray beams for nuclear physics research. Going far beyond just the production of the highest intensity Compton gamma-ray source in the world, he has created a new research field by modifying the FEL to produce new types of gamma rays for experiments. The facility can now produce polarized gammas with varying polarization and two-color gammas by operating the FEL as a two-color laser".
- **Mohammad Ahmed**, Professor of Physics and Mathematics at North Carolina Central University (NCCU) and Associate Director at TUNL, has been appointed as Dean of the College of Health and Sciences at NCCU effective July 1, 2022. His research is in the field of low-energy quantum chromodynamics and is performed primarily at the HfS facility.
- **John Wilkerson**, the John and Louise S. Parker Professor of Physics at UNC-CH and Associate Director at TUNL, was named to the American Physical Society Board of Directors starting January 1, 2023.
- **Diane Markoff**, Professor of Mathematics and Physics at NCCU, was appointed as an Adjunct Professor of Physics at Duke University.
- **Phil Barbeau**, Associate Professor at Duke, spent part of July 2022 in Seattle as the Instrumentation Frontier Co-Convener for SNOWMASS 2022.
- **Leendert Hayen**, Research Assistant Professor at North Carolina State University, has accepted a tenure-track position at the University of Caen Normandy in France.
- **Chris Westerfeldt**, Assistant Director of Operations, was recognized for **45 years** of service at Duke University.



Ying Wu



Mohammad Ahmed



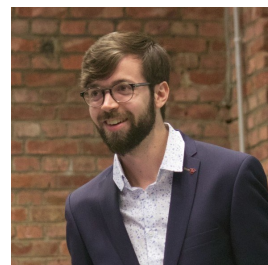
John Wilkerson



Phil Barbeau



Diane Markoff



Leendert Hayen



Chris Westerfeldt

Summer 2022 Undergraduate Research Programs

This past summer TUNL hosted a large group of undergraduate students who participated in research projects with faculty, staff, and graduate students from the four consortium universities. Twelve students from institutions across the country were part of TUNL's NSF-sponsored REU Program which has been running continuously since 2000. An additional six students from Fisk University, Florida Memorial University, and NCCU were members of the inaugural class of DOE-sponsored Traineeships in Nuclear Physics. In addition, undergraduates from Duke, UNC, and NCSU were engaged in TUNL research at sites both local and off-campus.



As part of the summer research experience, students had the opportunity to attend lectures on nuclear and particle physics, to participate in career workshops, and to hone their skills in scientific communication. The undergraduates were able to learn about TUNL's research enterprise through weekly seminars and during informal talks over pizza where graduate students shared what they were working on. A number of social events including a welcome reception, ice cream social, and the TUNL BBQ allowed stu-

dents to meet and engage with members of the TUNL community outside of their research group.

A big thanks to everyone for welcoming and including these students as members of the TUNL community this summer!

TUNL Seminars

The TUNL Seminar series moved to a hybrid format in Fall 2022 and has continued into Spring 2023. Speakers in the fall included Carlos Bertulani (Texas A&M-Commerce), Johann Isaak (TU Darmstadt), Brad Sherrill (MSU), and Charlotte Hulse (U. of Paris-Saclay). This spring we have had a SURF webinar on final results from the Majorana Demonstrator and talks by Matt Mumpower (LANL), Augusto Machiavelli (ORNL), and Ingo Wiedenhoever (Florida State). We have a full slate of talks scheduled for the rest of the semester which are listed below. The TUNL seminars this semester are held on Thursdays at 3:30 PM in LSRC B101 (Love Auditorium) on the Duke campus and are also broadcast via Zoom. If you have ideas for speakers for the fall, please contact a member of the seminar committee: Julieta Gruszko (Chair), John Kelley, Sean Finch, Anselm Vossen, and Albert Young.

April 6, 2023	Ben Jones	U. of Texas at Arlington
April 13, 2023	Yutian Feng	Duke U.
April 20, 2023	Sanjana Curtis	U. of Chicago
April 27, 2023	Bob Runkle	PNNL
May 4, 2023	Amy Nicholson	UNC Chapel Hill