Center for Experimental Nuclear Physics and Astrophysics

December 2020

CENPA 2020 Newsletter

INSIDE THIS ISSUE:

Thanks to University of Washington, Physics Dept., DOE, NSF, DOE-HEP, and DOE-NP for continued support.

Forward

One can't help but to notice that the CENPA 2020 Annual Report back page reflected an interruption of the many decades tradition of the springtime outdoor group photo. Of course, this was related to the ongoing COVID-19 crisis. At this time, our hearts go out to the many critical workers who have maintained our health, our safety, our food supply, and our internet! Those of us working at CENPA, and in general throughout the physics community, are relatively lucky. Most of us are able to work, study, and teach profitably, even if inconveniently, while at home. Progress is being made on data analyses, paper preparations, experimental simulations, and instrument designs. However, almost all of our in-lab work has stalled. A notable exception is the ADMX axion search experiment, which continued to take data with minimal in-person efforts, mainly for cryogenic maintenance. Several CENPA technical staff members have been deemed essential workers by the University of Washington, which allows them to maintain the safety of critical systems and to carry out some work in isolation from others. Most work has slowed and some critical experimental efforts are on pause. The same is true of our external efforts; for example, the muon g−2 Run-3 at Fermilab was stopped when the accelerator complex went into standby mode. But the good news is Run-4 has just started, with major efforts from CENPA group members, both locally at Fermilab and remotely here "at CENPA."

Jens Gundlach, who leads the Gravity/LIGO group, also heads a separate high-profile NIH program in DNA sequencing technology; this biophysics group is conducting research on the enzymes of SARS-CoV-2 to develop antiviral drugs. Their work – truly essential COVID-19 science – has gone on unabated, under very special safety rules. Beginning in March, Charlie Hagedorn was a key member of the team behind FindTheMasks.com, an open-data project mapping more than 4,000 healthcare institutions for personal-protective-equipment donations. The small numbers CENPA had in inventory were donated to local medical staff.

Our CENPA teaching faculty experienced an abrupt transition to all online-classes in the last 2 weeks of Winter quarter, followed by the entire online-only Spring and Fall quarters. This has been a significant challenge, leading to issues such as, how does one administer a remote introductory physics exam to 1000 students? Our lab has maintained weekly Monday Meetings, where students and postdocs give presentations on their research status. This important community-building event has gone on uninterrupted over Zoom, as have occasional seminars, General and Final Ph.D. exams, and group, staff, and faculty meetings. A number of CENPA members gave remote talks at the recent APS meetings, and others at various online conferences and workshops.

It is now early December and campus research is ongoing albeit under a set of evolving safety workplace guidelines. Peter Kammel is the Chair of the Physics Department Safety Committee. He worked tirelessly to establish protocols to permit researchers back into Physics and CENPA laboratories. Through adherence to well defined safety policies, most of our onsite, experimental efforts are running again, although still not at full strength. For those of us who can work from home, we have been directed to do so for the indefinite future.

– David Hertzog –

CENPA - Introduction

The Center for Experimental Nuclear Physics and Astrophysics, CENPA, was established in 1998 at the University of Washington as the institutional home for a broad program of research in nuclear physics and related fields. Research activities — with an emphasis on fundamental symmetries and neutrinos — are conducted locally and at remote sites. In neutrino physics, CENPA is the lead US institution in the KATRIN tritium beta decay experiment, the supportive local tritium decay experiment TRIMS, the site for experimental work on Project8, a collaborating institution in the MAJORANA ^{76}Ge and LEGEND-200 neutrinoless double beta decay experiments, and in the COHERENT neutrino-nucleus scattering experiment. The Muon Physics group developed and completed the MuSun experiment to measure muon capture in deuterium at the Paul Scherrer Institute in Switzerland. The muon group has a major leadership role in the measurement of the muon's anomalous magnetic moment at Fermilab, which aims to even higher precision than it is presently known from our previous work at Brookhaven. The fundamental symmetries program also includes "in-house" research on the search for a static electric dipole moment in ^{199}Hg, and an experiment using the local Tandem Van de Graaff accelerator to measure the electron-neutrino correlation and Fierz interference in ^{6}He decay. Looking to the future, we have a new program in next generation $0\nu\beta\beta$ decay with the SELENA experiment.

In addition to the research directly supported by DOE's Office of Nuclear Physics through the CENPA core grant, other important programs are located at CENPA, forming a broader intellectual center with valuable synergies. The "Gravity" group carries out, with both DOE and NSF support, studies of the weak and strong Equivalence Principles, fundamental precepts of General Relativity, as well as searches for non-Newtonian forces such as those predicted by theories with extra dimensions. In addition, they participate in LIGO with unique instrumentation that aids the functioning and stabilization of the interferometers. The DOE Office of High Energy Physics supports the unique ADMX axion search experiment. The NSF supports the DAMIC experiment that looks for light dark matter.

CENPA is home to a large number of faculty, research faculty, postdoctoral scholars, graduate, and undergraduate students. The core professional engineering and technical staff provide diverse capabilities and skills such as state-of-the-art detector development, fabrication of custom electronics, large-scale computing, and design engineering. New advancements, capabilities, and ideas are regularly shared at seminars by CENPA members and visitors alike.

Ryan Roehnelt – Mechanical Engineer

We welcome Ryan Roehnelt to the CENPA team, who was hired as a senior Mechanical Engineer after John Amsbaugh retired after 40 years of service. This position is critical for CENPA workflow and for keeping our competitive edge in state-of-the-art hardware projects. Thus, we performed an extensive search, screening more than 100 applicants. The interview of the short-listed candidates included presentations by the candidates as well as by our faculty which showcased real life problems in two projects, providing the candidates the opportunity to suggest solutions on the spot. Ryan was unanimously ranked highest by the Search Committee and we are excited that he joined CENPA.

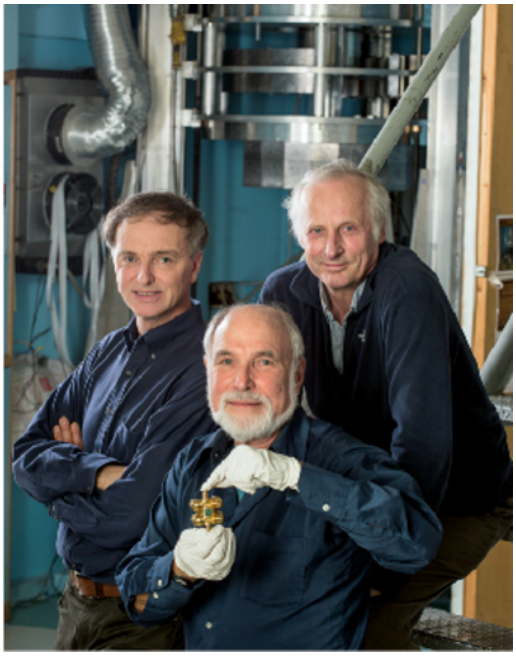
Ryan obtained his B.S. and M.S in Material Sciences at Oregon State and has a broad and diverse engineering experience over 16 years working in unconventional environments with unconventional materials. His institutional experience spans small startups to a DOE National Laboratory, and defense and space industry, always holding serious mechanical engineering positions. He is already engaged in the DAMIC project and Project-8 at CENPA and shares our excitement about fundamental science. While working in the Bay Area he lived on a 36' sailing Trimaran, and in Seattle settled into a more conventional home with his wife and two of his children, while his eldest daughter is living in Budapest.

2021 Breakthrough Prize

The Eöt-Wash Group, made up of UW physicists Adelberger, Gundlach and Heckel, was recognized for precision fundamental measurements that test our understanding of gravity, probe the nature of dark energy and establish limits on couplings to dark matter is.

The equivalence principle — the observation that objects, whatever they are made of, fall with the same acceleration — inspired Albert Einstein's relativistic theory of gravity. Motivated by the unexplained phenomena of dark matter and dark energy that hint towards new physics, as well as theoretical attempts to develop unified quantum theories of gravity that inherently predict violations of the equivalence principle and additional curled-up space dimensions, the UW Eöt-Wash team decided to probe the fundamental properties of gravity with a new generation of instruments.

They took the two-century-old torsion balance concept and developed it into a supremely sensitive 21st-century instrument to look for new fundamental physics. They tested the equivalence principle, the inverse square law, and measured the gravitational constant with unprecedented precision and sensitivity. For example, their latest inverse-square law test probed gravity at ultra-short distances, establishing that any extra dimension must be curled up with a radius less than one-third the diameter of a human hair. (Text excerpt by Victor Balta - UW News)



News and Awards

Jason Detwiler elected Fellow of the American Physical Society (APS), 2020. For outstanding contributions to key measurements by the Sudbury Neutrino Observatory, Kamioka Liquid Scintillator Antineutrino Detector (KamLAND), KamLAND-Zen, COHERENT, and the Majorana Demonstrator that have advanced our understanding of neutrino properties and fundamental interactions. Nominated by: Division of Nuclear Physics

David Sweigart wins 2020 URA Thesis Award. For his Cornell Ph.D. dissertation, Sweigart analyzed the first year of data from Fermilab's Muon g-2 experiment, collected in 2018.

ADMX Postdoc **Tatsumi Nitta** was awarded the Young Scientist Award of the Physical Society of Japan, 2021.

CENPA Visitors and Community

CENPA offered educational group tours to interested schools and organizations adapted for a range of grade levels to inspire interest in experimental physics, especially in young visitors. The photo below shows Scout BSA Troop 90 of Everett visit CENPA as part of earning their Nuclear Science Merit Badge. Historically, tours have encouraged visiting students to get further involved in CENPA research activities— notably visitors from the Conference for Undergraduate Women in Physics2 (CUWiP, January 2019) have since joined CENPA research collaborations.

Developing New Directions in Fundamental Physics (DND) 2020

The meetings on November 4-6th represent the first in a planned series of workshops aimed at identifying the most promising avenues going forward to explore fundamental physics with new experimental campaigns located at TRIUMF and CENPA. The first meeting focused on the current status of the field of nuclear and particle physics, the potential ideas that can be carried out with midscale sized initiatives, and the theoretical motivation necessary to justify the efforts.

Working Groups and Convenors included:
New Physics with Nucleons & Molecules (EDMs, etc.): Beatrice Franke & Adam Ritz Pions, muons, & New Physics: David Hertzog & Peter Kammel
New Physics with Radioactives: John Behr & Alejandro Garcia
New Technologies and Ideas: Alvaro Chavarria, Makoto Fujiwara, Gray Rybka, & Oliver Stelzer-Chilton
Electron Linac Opportunities: David McKeen

CENPA Seminar Series

The CENPA Seminar Series was run by postdoctoral scholars Elise Novitski, Walter Pettus and currently Clint Wiseman. This series has been enormously successful and well attended locally and remotely. Speakers, covering a wide range of topics of interest to the Center, are invited.

In 2019, there were a total of 28 speakers, 8 of which are from the UW.
In 2020, there was a total of 7 speakers, 1 of which is from the UW.

Research Highlights

- The KATRIN experiment made the transition to nominal tritium operation, with data from the first 30 days resulting in a new neutrino mass limit of 1.1 eV, an improvement by a factor of approximately 2.
- A comprehensive analysis of the data from the TRIMS experiment has been carried out. The results are in strong contradiction to earlier experiments, and, in contrast, support the current theoretical model that is used to calculate the final-state spectrum in KATRIN for extracting neutrino mass. A paper on the HT data was published in Phys. Rev. Lett., and another is in preparation on the T2 data.
- The second phase of Project 8 is a “microtritium experiment” that has now completed a three-month-long run. Preliminary analysis shows the expected spectrum shape and extremely low backgrounds, one of the anticipated features of the Cyclotron Radiation Spectroscopy (CRES) method. This completes Phase II, and attention now focuses on the demonstrators required for the design of a research-scale Project 8 experiment.
- The first stage of an atomic-tritium source demonstrator for Project 8 has been completed and is undergoing commissioning. It includes a thermal dissociator for ‘cracking’ molecular hydrogen and a mass spectrometer for analyzing the beam. Studies of dissociation and cooling will be carried out with hydrogen and deuterium.
- The Majorana Demonstrator recently presented preliminary results on its back- ground model, two-neutrino double-beta decay to excited states, and low-energy rare event searches. Soon, all enriched detectors will be removed and sent to LNGS for use in the LEGEND-200 apparatus.
- The LEGEND Collaboration has entered the construction phase for the LEGEND-200 apparatus at LNGS in Italy. Procurement of detectors, fabrication of hardware components, and software development are proceeding. Preparations continue to complete key design and critical R&D work for LEGEND-1000 prior to the DOE downselect process.
- The 21Ne(p, γ) experiment was successfully run over 3 months during the summer of 2019. This involved setting up 12 Ge detectors for angular distribution measurements, switching the accelerator to run in terminal-ion source mode, a dedicated program to optimize implantation of 21Ne targets, and a data-taking campaign with 24/7 running for 3 months. Data analysis is under progress.
- The data analysis on extraction of little-a from laser-trapped 6He continued to completion during 2019. We are presently working on a publication.
- We are mounting the experiment to search for tensor currents using the CRES technique to search for little-b from 6He, 19Ne. We have installed the superconducting solenoid and built a helium recovery system using the ADMX compressor. The magnet was cooled down and biased successfully. We installed a cryocooler unit and set up the cooling distribution for our RF system. The DAQ system is running and presently undergoing tests of noise levels. Tests with an 83Kr source are expected soon.
- We designed and tested production from a 19Ne source built on the style of the Berkeley/Princeton design. While production is below expectations (≈ 109 instead of 1010 19Ne atoms/s), it is adequate for our needs.
- The Muon g − 2 collaboration continues to analyze the Run-1 data set and completed Runs 2 and 3. In total, we envision the statistical harvest of these three data sets to exceed that obtained by BNL E821 by at least a factor of 6. The experiment will continue for several more years.
- The lifetime results from the μ+ datasets collected in MuSun were unblinded and compared with the free muon lifetime measured with high precision in our previous dedicated MuLan experiment. The good agreement found verifies essential aspects of MuSun’s technique and is encouraging towards the ongoing final analysis of the ten- times higher statistics of the negative muon data, which determines the muon capture rate in deuterium.
- The ADMX G2 experiment increased its mass coverage in the search for the QCD Axion Dark Matter by fourfold.
- The ADMX G2 experiment achieved sensitivity to the “DFSZ” axion, a decades-long goal of the dark-matter axion community. ADMX is by far the only experiment with this sensitivity. Over the last year, ADMX increased its mass-scanning rate by fourfold in the most compelling axion-mass region. ADMX finally has the mass-reach and sensitivity reach to be able to detect dark-matter axions, and ADMX could find the axion at any time.
- DAMIC released world-leading exclusion limits on the scattering of dark matter particles with masses smaller than 5 MeV. Further analysis of the dark matter search data is ongoing, with results from the search for GeV-scale weakly-interacting massive particles (WIMPs) in preparation.
- The first prototype DAMIC-M charge-coupled device (CCD) sensors were successfully packaged and tested at CENPA. Single-electron response was demonstrated with a 24- megapixel CCD. This is the most-massive, lowest-noise CCD ever tested, a milestone for the DAMIC-M program.
- Selena completed the first experimental measurements with a single-pixel amorphous selenium sensor. The charge generation and transport properties of amorphous selenium were measured, and results are being prepared for publication. We started collaboration with Berkeley Lab to interface amorphous selenium with the Topmetal-II CMOS sensor.
- The Eöt-Wash “Gravity” group published a test of Newton’s 1/r2 law at Yukawa ranges down to 39 micrometers. They are presently conducting a search for dark matter using a torsion balance.
- The CENPA LIGO Group deployed ground rotation sensors at LIGO that are detecting ground deformation due to wind and built a gravitational calibrator for LIGO.

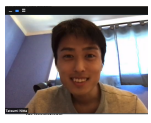
2020 Group Photo

New RAs and Postdocs

New RAs:
Kellie McGuire (DAMIC)
Grace Song (SELENA)
Winston DeGraw (DAMIC)

New Postdocs:
Zachary Hodge (g-2)
Tatsumi Nitta (ADMX)
David Sweigart (Project 8/LEGEND)
Michael Ross (Gravity)



McGuire Song DeGraw Nitta Sweigart Ross

Holiday Party!

- CENPA Holiday Celebration – Wine and Cheese (Virtual!) December 18th 4PM!
- We will send an email with the Zoom information.

Transitions

This past year has been one with an enormous number of transitions as we have seen post-doctoral scholars move to more permanent research positions, many Ph.D. students complete theses, and various milestones and departures in the CENPA technical staff.

Charlie Hagedorn left in September after many years of dedicated research and leadership in the Gravity group. He is currently spending time with family while exploring experimental options.

In the late summer of 2019, Research Assistant Professor Martin Fertl (Project 8 / Muon g−2) began a tenured Associate University Professor appointment at the Johannes Gutenberg University Mainz, Germany. Martin has started a new group and continues to be involved in both projects.

In autumn 2019, postdoctoral scholar Kim Siang Khaw (Muon g −2) began a tenure-track Associate Professor position at the School of Physics and Astronomy (SPA), Shanghai Jiao Tong University (SJTU), with a joint a position as a T. D. Lee Fellow. Kim Siang is helping to lead the growing Shanghai group in many Muon g − 2 efforts.

Postdoctoral scholar Walter Pettus is now a tenure-track Assistant Professor position at Indiana University. Walter will launch a new research group at IU and continue his involvement in Project 8 and LEGEND-200.

Senior postdoctoral scholar Krishna Venkateswara (LIGO) accepted a research position at Paroscientific Inc. in Redmond.

ADMX postdoctoral scholar Nicole Crisosto, an expert in low-temperature cryogenics, is now working in the Microsoft quantum group.

Postdoctoral scholar Menglei Sun, who contributed significantly to the first KATRIN analysis, has taken a position at Synopsys Inc. in Seattle.

PNNL postdoctoral scholar Ben LaRoque, who has been permanently stationed at CENPA on Project 8, accepted a staff position at PNNL.

Junior Research Engineers Seth Kimes and Joben Pederson were both lured to Microsoft where they will provide their cryogenic skills to the developing quantum computing there.

Senior Engineer Doug Will celebrated more than 38 years of service to CENPA and continues to be a role model for junior engineers and a leader in our cryogenics efforts.

Mechanical Engineer John Amsbaugh retired in March 2020 after more than 40 years of service to CENPA. John was central to the design and realization of many of the innovative detector systems

Ph.D. Theses

Rachel Ryan (MuSun), after a short post-defense extension with our group, accepted a research Fusion Scientist position at Helion Energy.

Ian Guinn (Majorana Demonstrator), is presently a postdoctoral scholar at UNC Chapel Hill / TUNL working on LEGEND-200.

Micah Buuck (Majorana Demonstrator), is presently a postdoctoral scholar at SLAC working on the LZ experiment.

Yelena Bagdasarova (He-6) is a Research Scientist in the Dept. of Ophthalmology at the University of Washington.

Rachel Osofsky (Muon g−2) has taken a position at the Johns Hopkins Applied Physics Institute.

Ying-Ting Lin (TRIMS) returned to Taiwan to undertake his national service tour of duty there.

John Lee (Gravity) defended his Ph.D. on the new 1/r2 gravity limit. His future plans are developing.

Michael Ross (Gravity) defended his Ph.D. on “Precision Mechanical Rotation Sensors for Terrestrial Gravitational Wave Observatories” and is now a postdoc at CENPA.

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