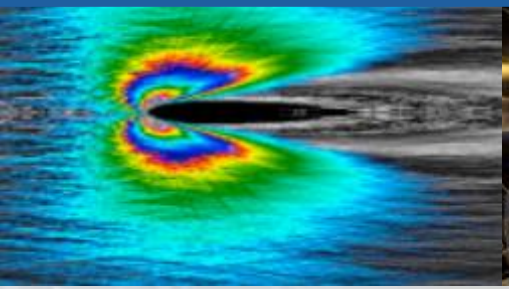
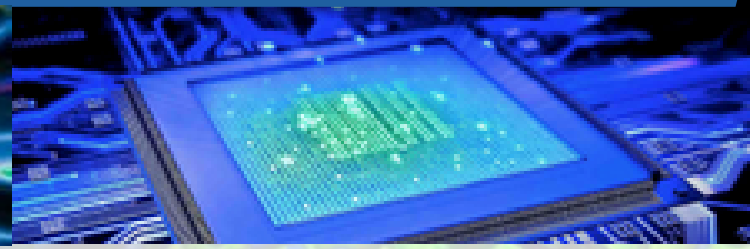
The High Energy Density Science Center: 2022 A Year in Review




Frank Graziani and Felicie Albert
October 6, 2022





Tracy Baldwin
Jim Emig
Paul Grabowski
Jessica Karlton
Caitlin Menniti
Bruce Remington
Ronnie Shepherd

LLNL-PRES-841039

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC


FY23
Deputy Director
Director
C.KROHG
1893

Who are we?

Director

Frank Graziani

Deputy Director

Felicie Albert

Seminar Series

Paul Grabowski

Outreach

Ronnie Shepherd

Administrator

Jessica Karlton

Administrator

Caitlin Menniti

Discovery Science

Bruce Remington

Technology Facility

Jim Emig

Budget

Tracy Baldwin

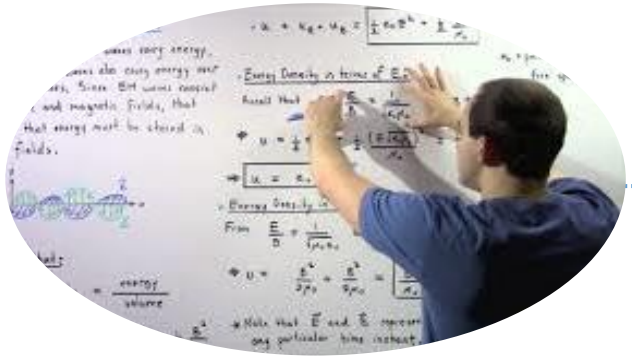
Director Diversity Equity and Inclusion

Tony Baylis

Strategic advisor

Camille Bibeau

The HEDS Center is building a worldwide community in HED by integrating academic and national laboratory efforts

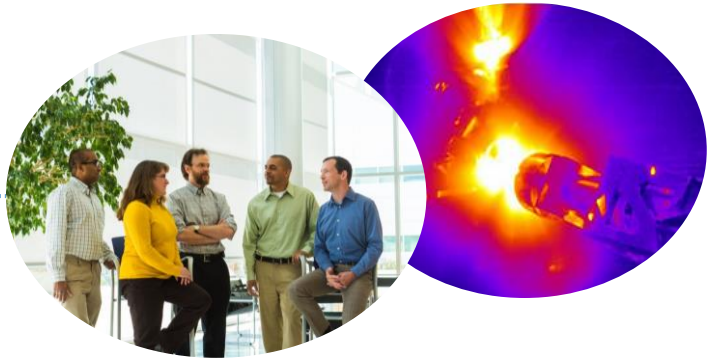


Education

Educating the next generation of researchers

HEDS

High Energy Density Science Center



Bridge to the Programs

Focus on HED areas of interest to the programs — driving a workforce pipeline

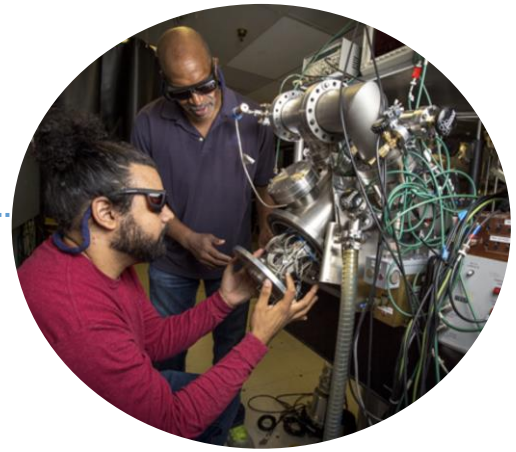
Bridge to the HED Community

Seminars, Workshops and Outreach

Strengthening communication ties within the HED community

Enabling Research in Relevant Areas

Providing the links to HED research collaborations

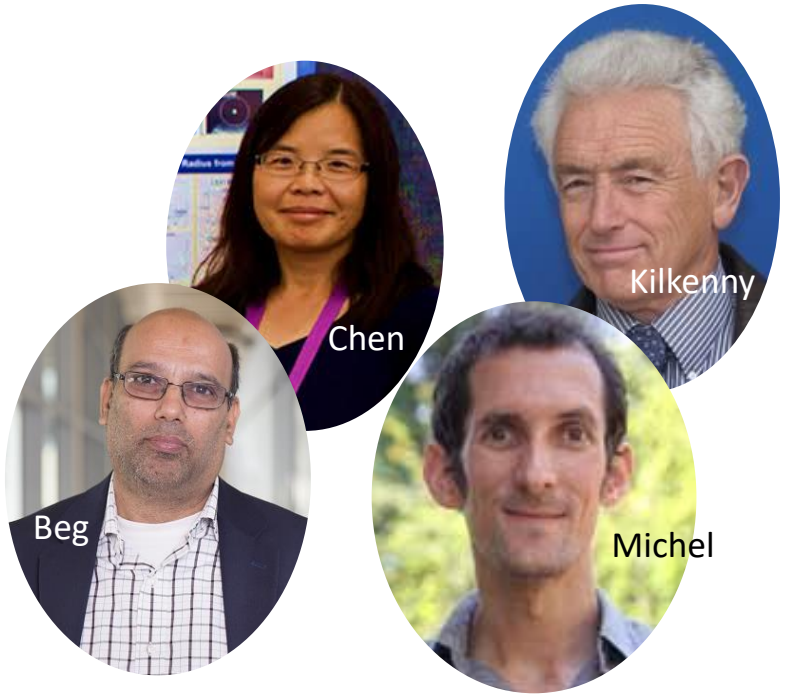


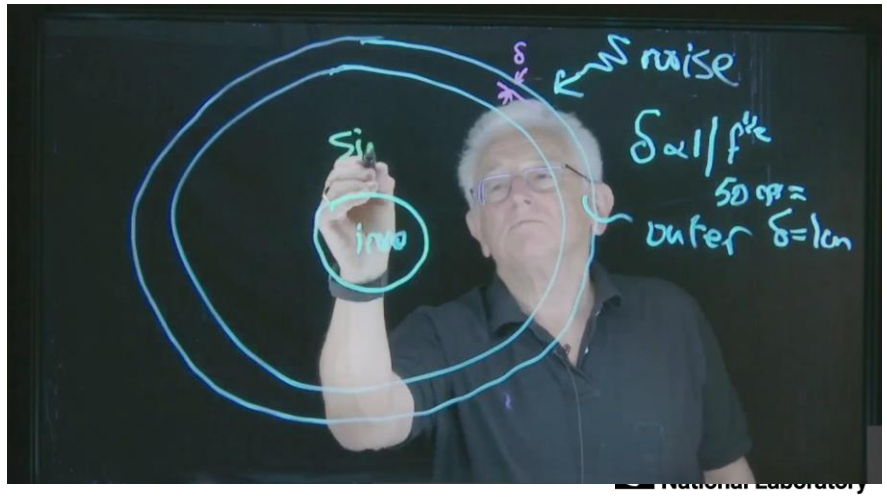
https://heds-center.llnl.gov/

EDUCATION

Educating the next generation of HED scientists is important to maintaining a healthy and vibrant field

- Since 2017, the Center has worked with universities to offer courses in HEDS
  - Short (6-8 lectures) and long courses (~10 weeks)
  - Introduction to HEDS, X-ray matter interactions, diagnostics
  - Strong collaboration with UCSD and UR
  - Long courses in HEDS diagnostics offered in 2020 and 2021
- We continue to explore new avenues in education
  - P. Michel LPI book is almost complete
  - We have invested in lightboard technology
  - UCLCC (University of California Livermore Collaboration Center) as an education resource for distance learning

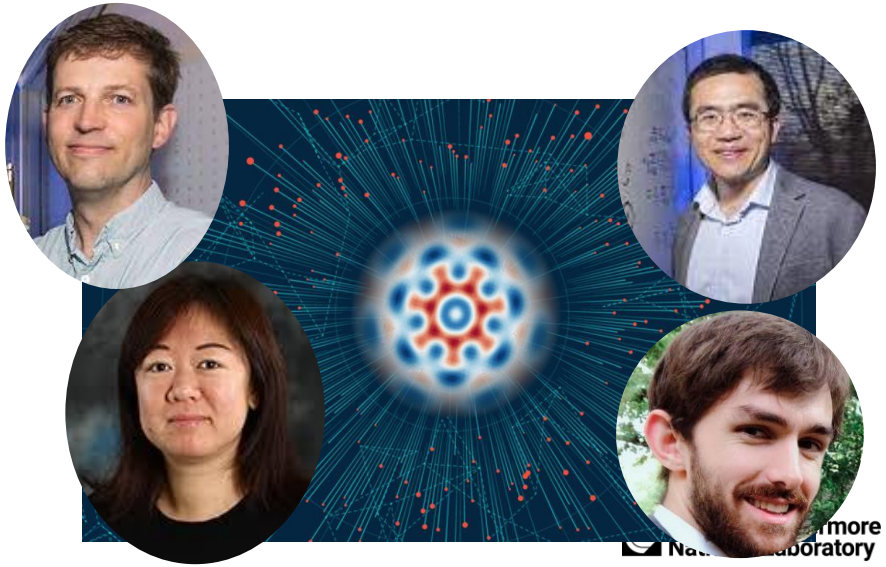




In 2022 a survey class in HEDS and a quantum computing summer school were offered

- Collaboration with the WCI Designer Training Program
  - Topics- Overview, Atomic physics, EOS, hydrodynamics and mix, shock physics, kinetic theory, radiation, radiation hydrodynamics
  - LLNL, SNL, UR, MSU lecturers
  - Modular format (M. Aikin), archived and aimed at the advanced undergrad level for staff and students

- Quantum Computing and Scientific Applications summer school was offered
  - Two phases: Tutorials and Applications
  - LLNL, UC Berkeley, ORNL, UC Merced
  - 32 hours of lectures in modular form and archived



We welcomed on-site and off-site summer interns in 2022

Multi-Species magnetized plasma simulations in LAPD geometry

Quantum computing and radiation diffusion

Laser driven ion acceleration

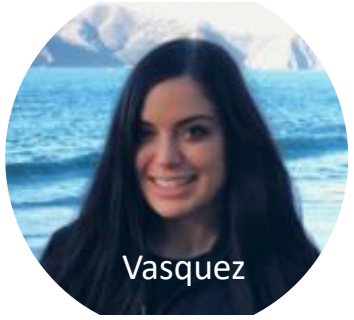
1D simulations of high intensity laser heated nanotubes

Quantum computing and spin chains

Visualizing magnetic fields using machine learning

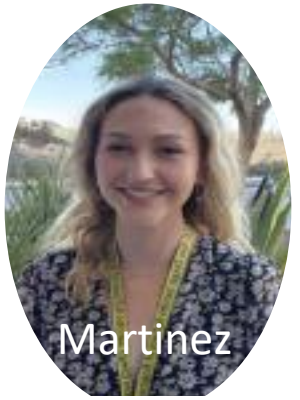
Merging Encoded Data from Experiments and Simulations through Machine Learning

Electron beams in orbital angular momentum laser driven magnetic fields



A high-pressure study of iron meteorites

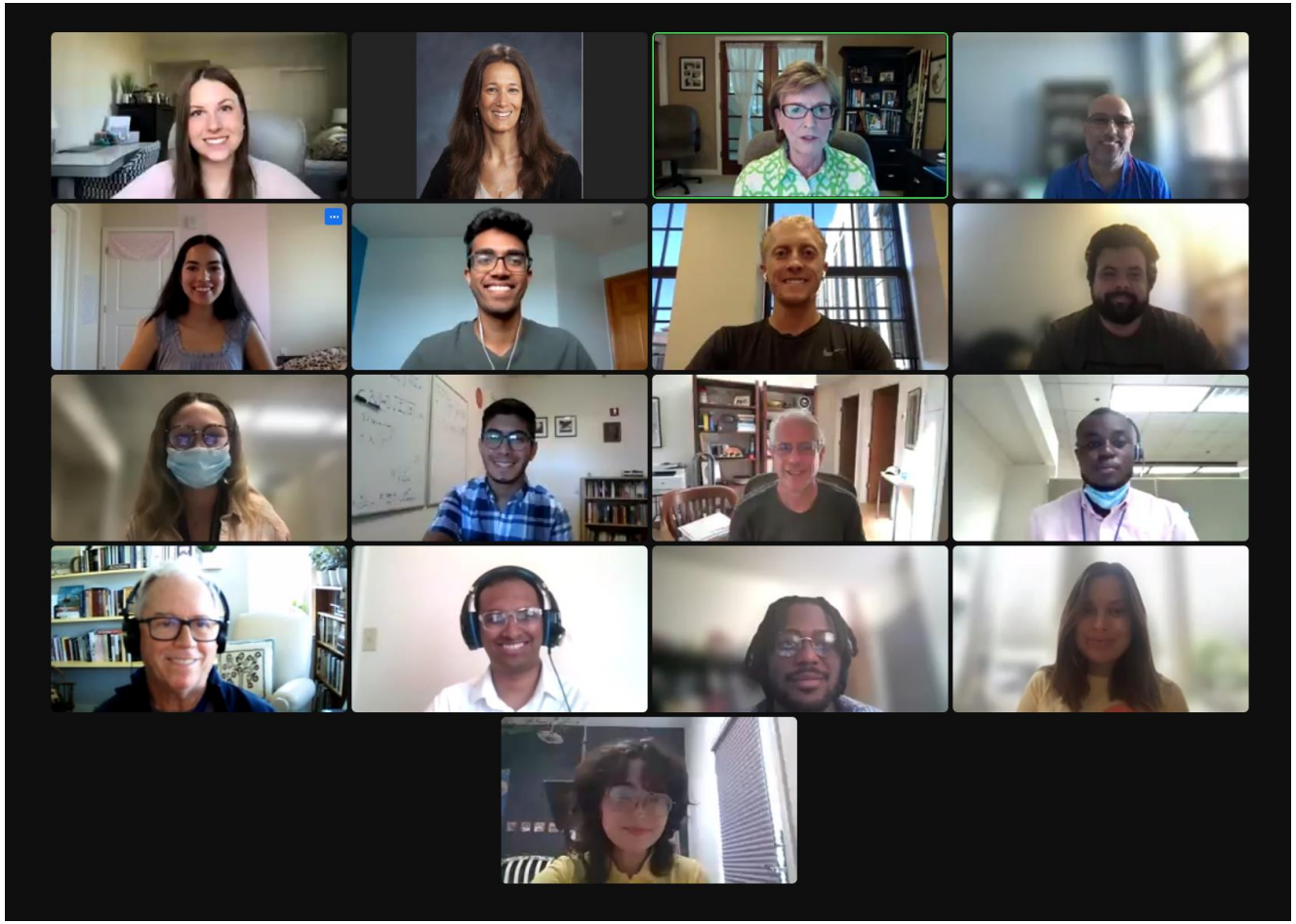
Shock physics in QHD



One-Dimensional Atomic Models for Opacity

The Livermore Lab Foundation has once again in FY22 helped our HEDS Center students

- Livermore Lab Foundation has provided additional support to our students
  - Students submitted applications for funding for support and HEDS staff determined need and amount on a case-by-case basis
  - Funds were used for rent, computers, desks, food, …

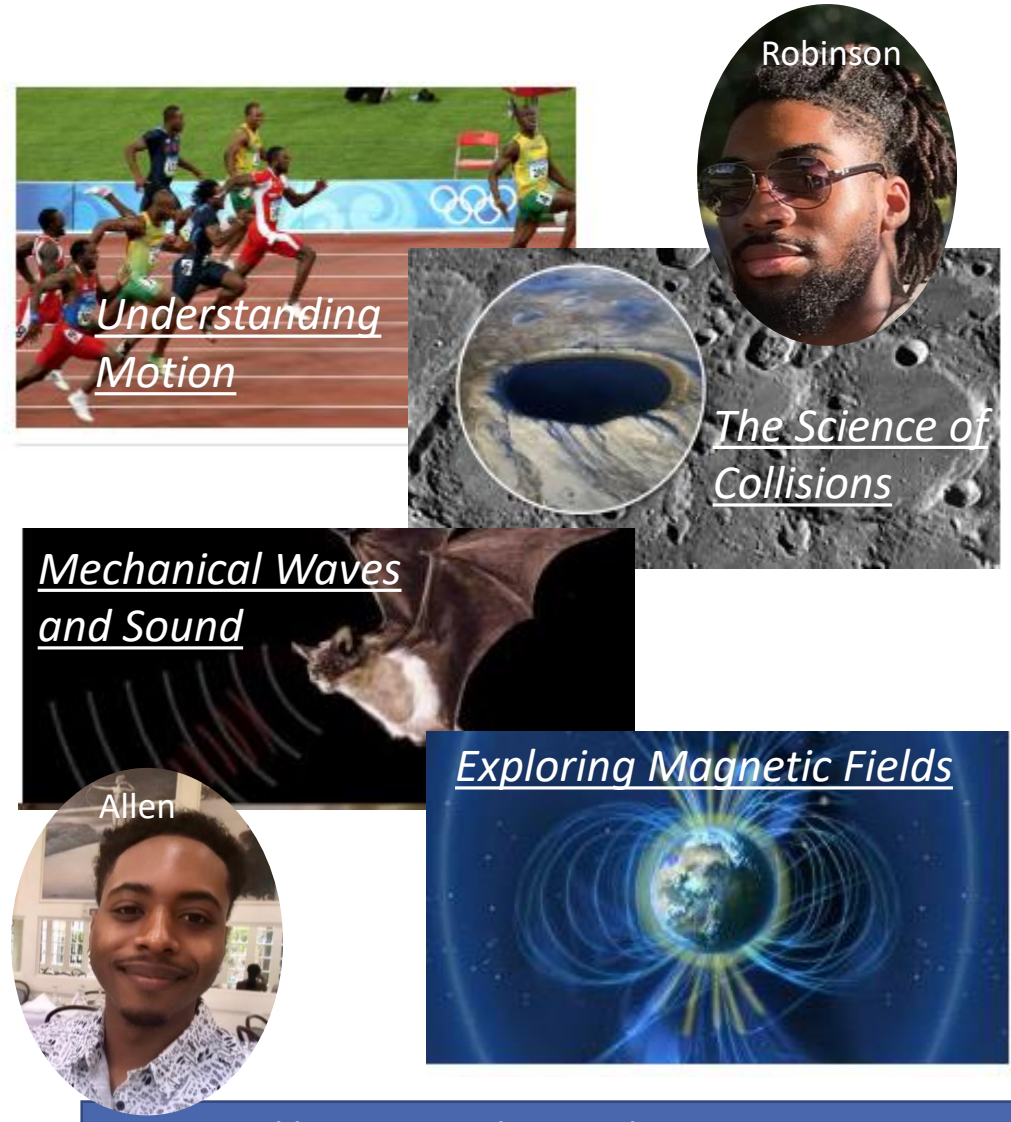


Dave Rakestraw mentored summer interns working on the development of physics curriculum using the sensors in phones

Students helped develop, test and refine a series of physics experiments that make use of the sensors in phones which include:

- 3-axis accelerometer
- 3-axis gyroscope
- 3-axis magnetometer
- Pressure transducer
- Microphones and speakers
- GPS system
- High resolution video camera
- High resolution timer

The material is available on the LLNL website and is being used in high school and college classes across this country this fall.



https://st.llnl.gov/sci-ed/distance-learning

Dave Rakestraw hosted an on-site workshop for LLNL staff and students on the use of Phones for physics

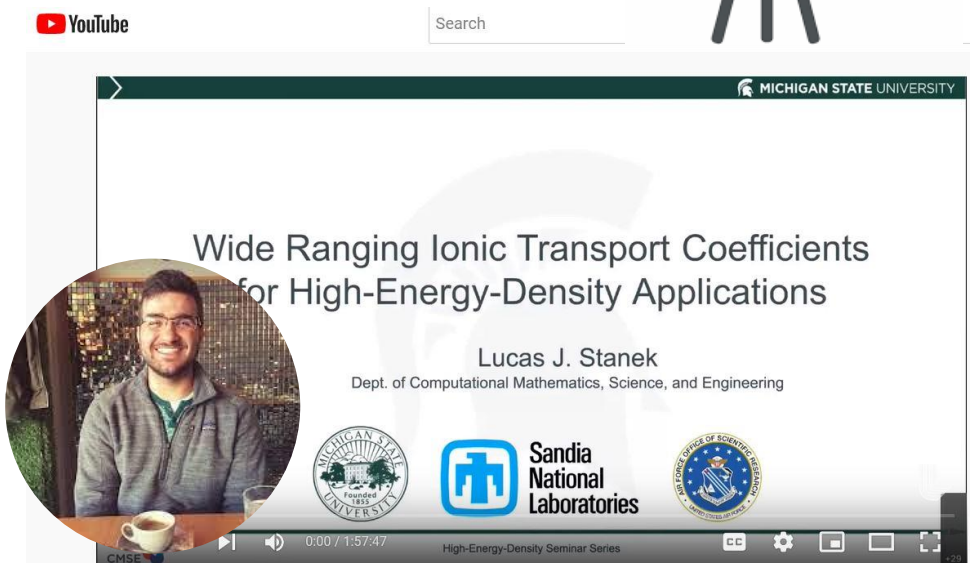
https://phyphox.org/

https://st.llnl.gov/sci-ed/Physics-with-Phones

Bridge to the HEDS Community

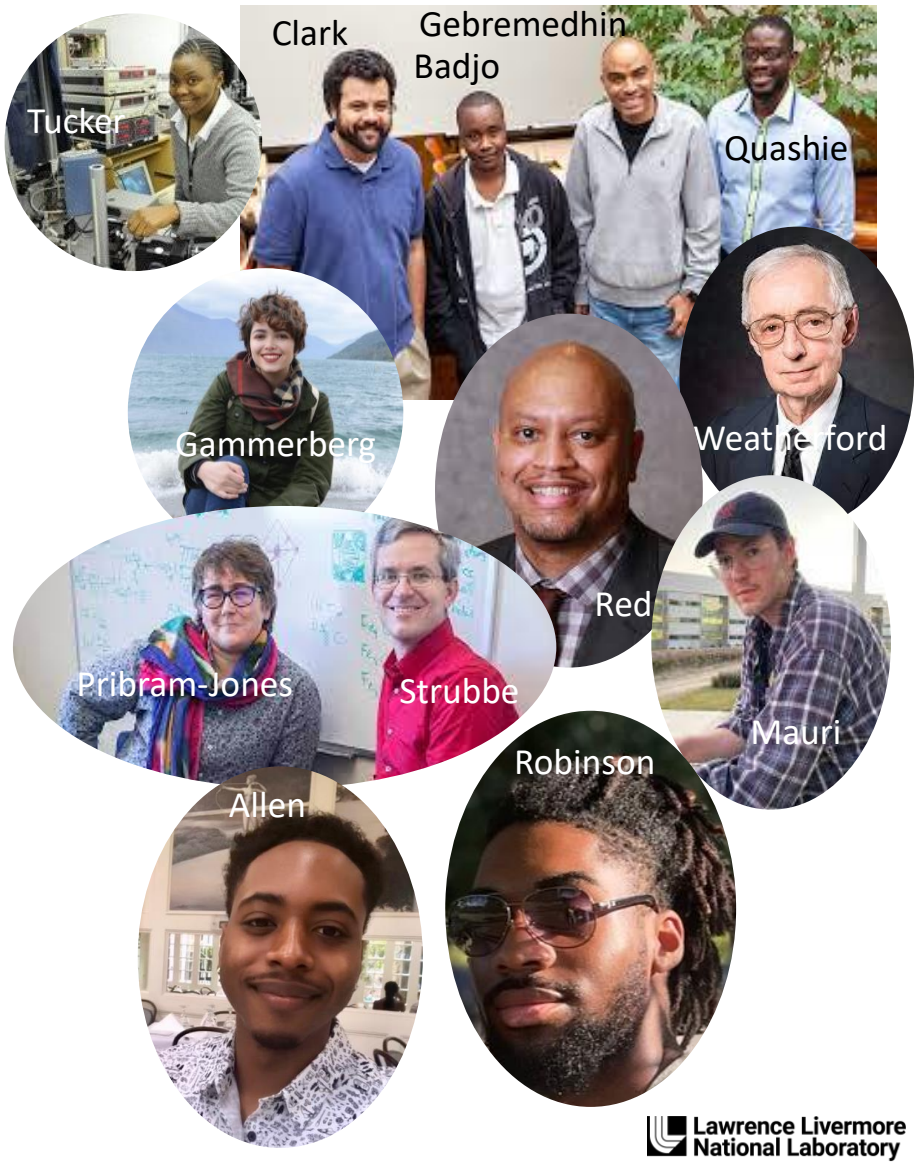
The Center provides outreach through seminars, workshops and campus interactions

- "Weekly" HED seminar series
  - Process that includes both established and early career scientists
  - *https://heds-center.llnl.gov/education/seminars*
  - Seminars are now in hybrid mode to accommodate LLNL staff and our external colleagues – CHALLENGING TASK
- Videos are on the YouTube channel
  - https://www.youtube.com/watch?v=eLvN6215M9U&list=PLy9rIbGDXrG3noqQ4wkG6DoMACYoKiulr&index=19
- Support for workshops and outreach
  - High Pressure Gordon Conference (S. Pascarelli)
  - New interaction with CSUN (MSI), assisting with NSF proposal on science at extremes



The Center is the focal point for facilitating and fostering research opportunities for Minority Serving Institutions

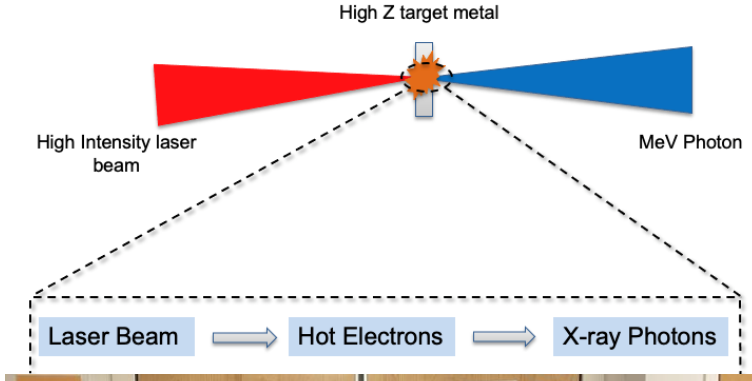
- MSIPP-NNSA Consortium for High Energy Density Science
  - FAMU, UC Merced, Morehouse and LLNL
  - Dense plasma effects on ionization
  - CfHEDS students were students interns and participated in physics with phones over the summer
  - Two-day CfHEDS workshop at LLNL in August
    - *Morehouse students Mitchell Allen and Aaron Robinson*
- Graduate students and postdoc are in residence at Center
  - J. Clark: PhD student working with R. Shepherd (PhD in December)
  - J. Tucker: Quantum computing working with J. Dubois (2023)
  - D. Gebremedhin : PD from FAMU in residence at the Center
  - A. Aghedo: FAMU graduate student working with D. Rusby



FAMU student Adeola Aghedo is pursuing his PhD in residence at LLNL

Adeola Aghedo, Florida A&M
Mentored by Dean Rusby

Model of Bremsstrahlung x-ray emission from short-pulse high-intensity laser interaction on various metal targets



Adeola won best student poster award at the annual LaserNetUS meeting

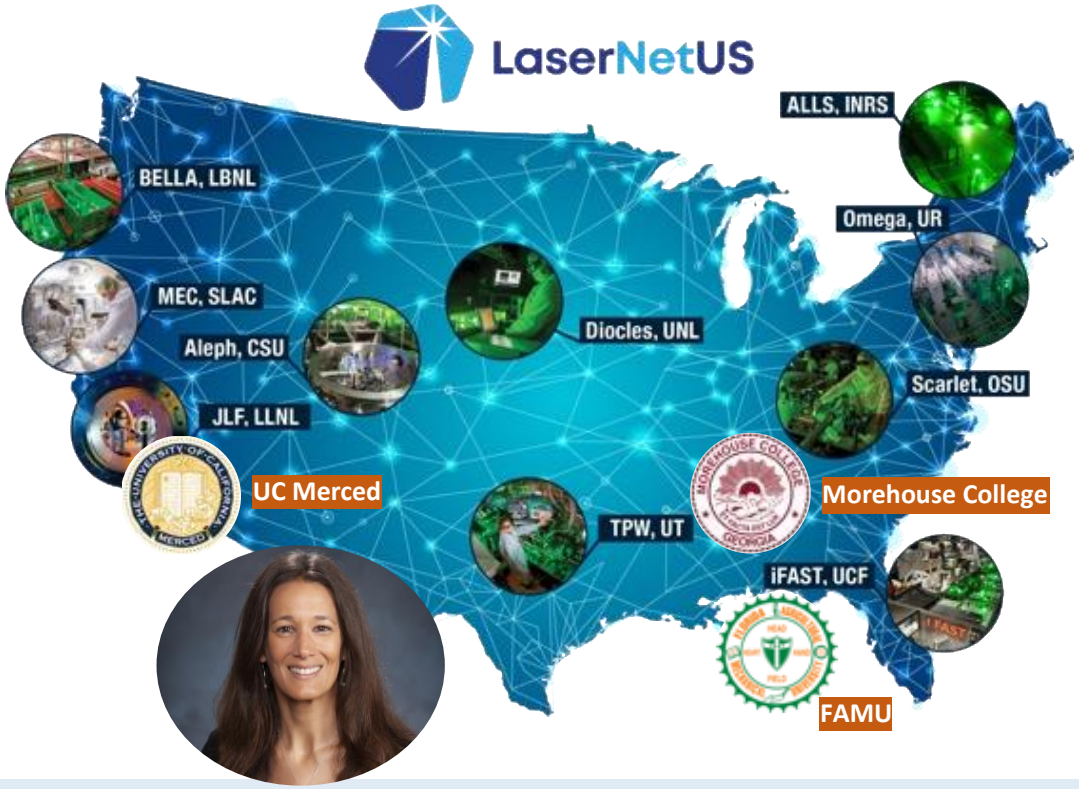
Lawrence Livermore National Laboratory

We coordinated a proposal submitted to FES-RENEW for LaserNetUS

Reaching a new science energy sciences workforce

We are leveraging our CfHEDS connections to create this program that will help attract and train undergraduate students from underrepresented populations on LaserNetUS facilities.

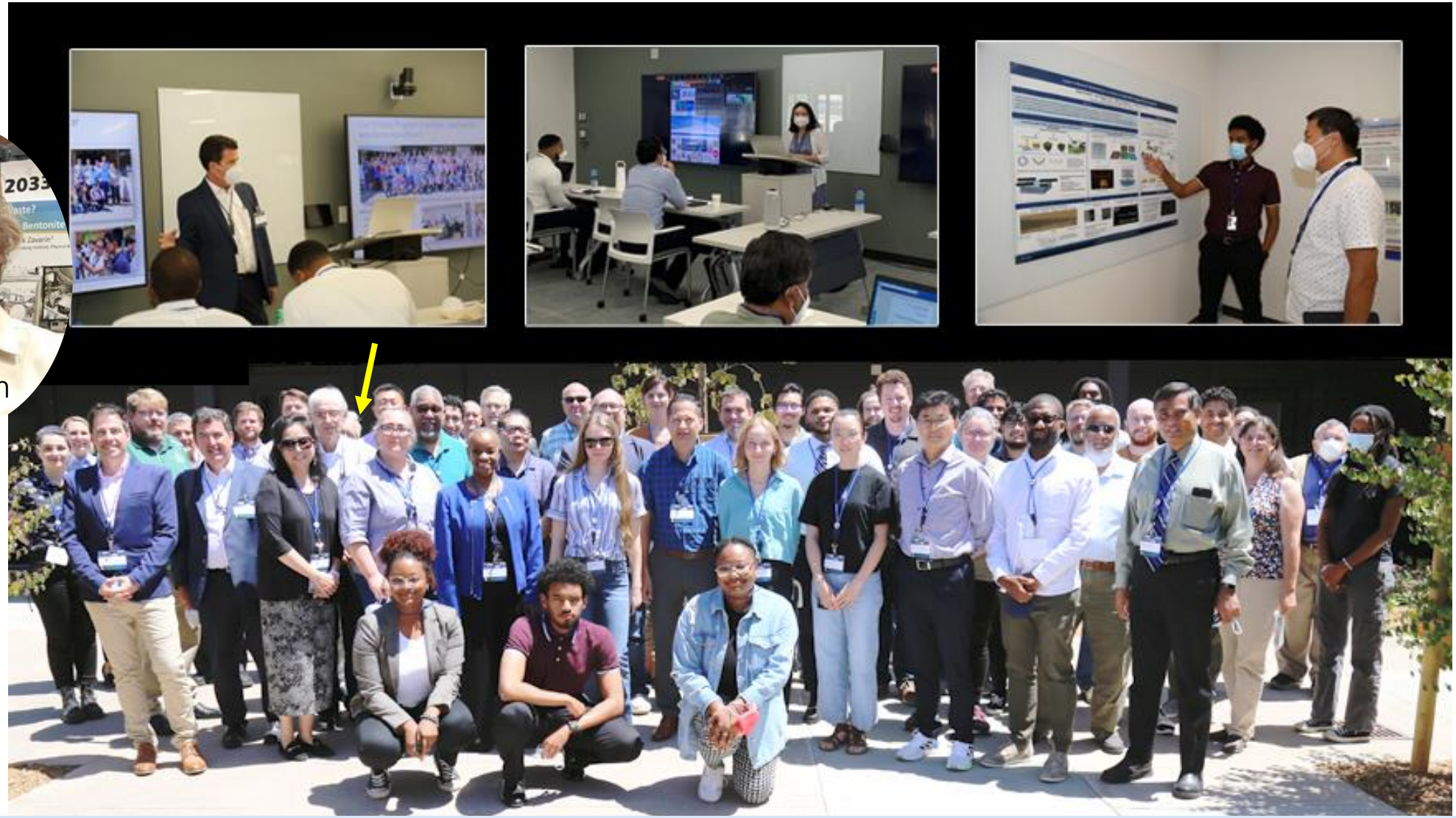
1. Expose and train MSI students and faculty to LaserNetUS Science
2. Host cohorts of MSI undergrads and faculties at LaserNetUS
3. Support ongoing engagement with students to bring them into the field
4. Develop capabilities and expertise at MSIs to create new programs



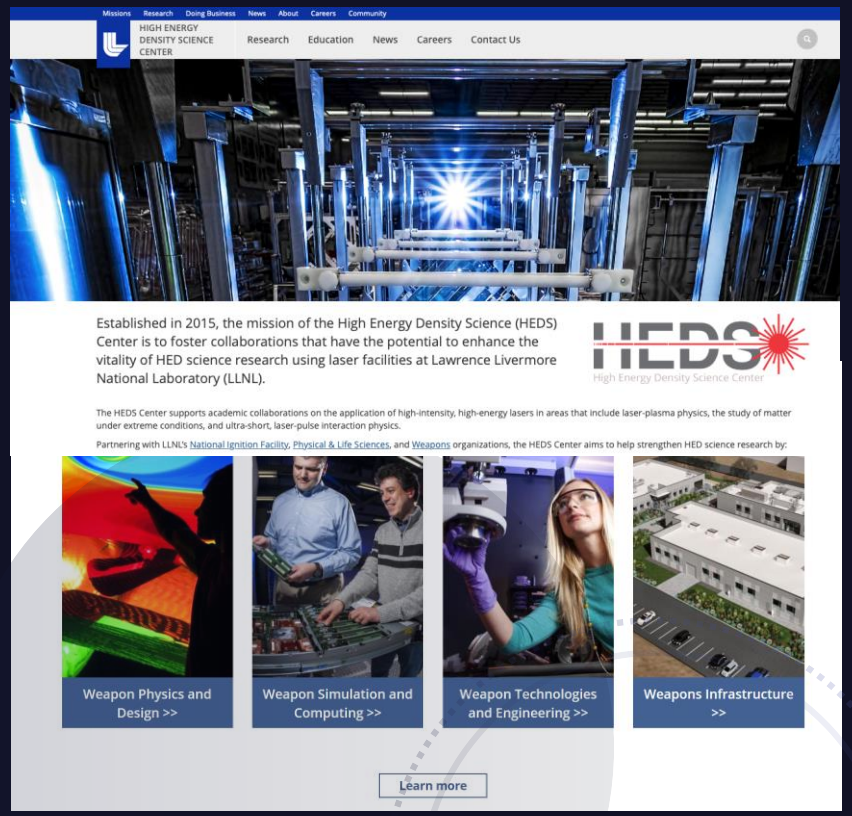
Providing a welcoming and supportive environment to MSI students at our facilities to increase retention of underrepresented students in our field

Workforce Development for Teachers and Scientists was held Aug 3-4 at UCLCC

Zavarin



Opportunity for LLNL's institutes and centers to engage with Minority Serving Institutions and highlight research areas and internship and collaboration opportunities



The center is working with PLS communication teams to improve the website

Education
- Courses
- Workshops

Outreach
- Seminars
- Summer student program
- HEDS videos

Collaborations
- Consortia
- MSIPP
- Japan
- Israel

Career opportunities
- Students
- Postdocs
- Faculty

HEDS @LLNL
- Project highlights
- People

News

Contacts

A sabbatical program and a HEDS Center Postdoctoral Fellow, will continue in FY23

- Sabbatical stays at the HEDS Center
  - Mini-sabbatical sponsored by A. Kersting
    - F. Beg of UCSD developed a spectroscopy course for spring quarter of 23 and advised on the HEDS survey course
  - F. Delmotte (University of Paris) gave a series of lectures on laser optics
- HEDS Center Postdoctoral Fellow
  - Opportunity for an early career researcher to work at LLNL, while promoting HEDS to a larger audience
  - We have hired three Fellows (one each year)
  - Application package and review process is coordinated with the Lawrence Fellowship and Foster and Brown Fellowships

The HEDS postdoctoral fellowship continues, supported by WCI/ICF/WPD

1st HEDS center Fellow
Andrew Longman, PhD University of Alberta
"Coupling of Structured Light to Plasma for Magnetic Field Generation, Particle Guiding, and Control of Laser-Plasma Interactions"
LLNL Mentor: Pierre Michel (Since January 2021)

2022 Selection commitee

- Tilo Doeppner (NIF)
- Paul Grabowski (PLS)
- John Moody (NIF)
- Peter Celliers (PLS)
- Amy Jenei (PLS)
- Josh Kallman (WCI)

2nd HEDS center Fellow (now at Meta)
Ka Wai (Karry) Wong, PhD University of California Davis
"3D Electron Temperature Measurement of Inertial Confinement Fusion Hotspots using X-Ray Emission Tomography"
LLNL Mentor: Benjamin Bachmann (October 2021 – May 2022)

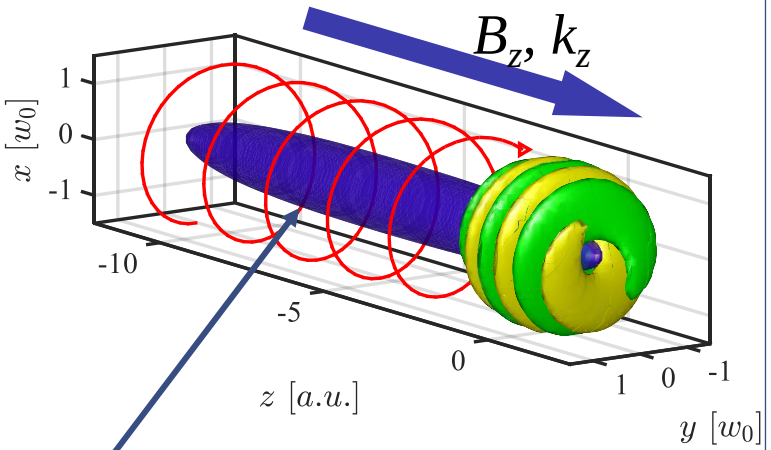
2023 applications in review
Coordination with Lawrence and WCI fellowships

3rd HEDS center Fellow
Elizabeth Grace, PhD Georgia Institute of Technology
"Single-Shot Spatiotemporal Electron Density Characterization"
LLNL Mentor: Tammy Ma (Starting January 2023)

Lawrence Livermore National Laboratory

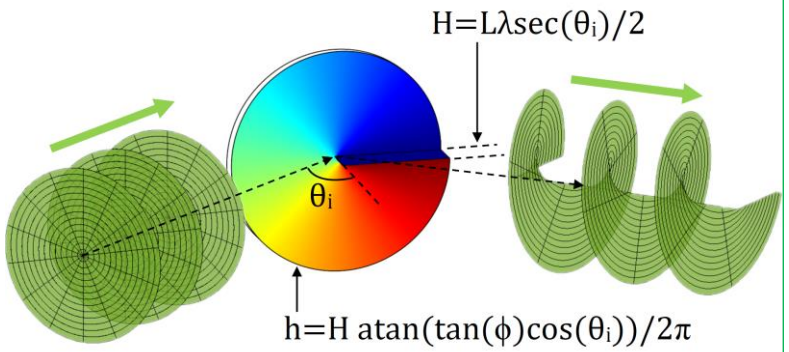
Andrew Longman has executed his research proposal and broadened his scope to include NIF and OMEGA EP

- Developed new model and simulations for Relativistic inverse Faraday driven magnetic fields
- Published 2 papers in the last year on the theory and simulations.



$$B_{max} \approx 10 \frac{P[TW]\lambda^3[\mu m]}{w_0^4[\mu m]}\ kT$$

- Manufactured spiral phase mirrors using the NIF MRF polishing machine



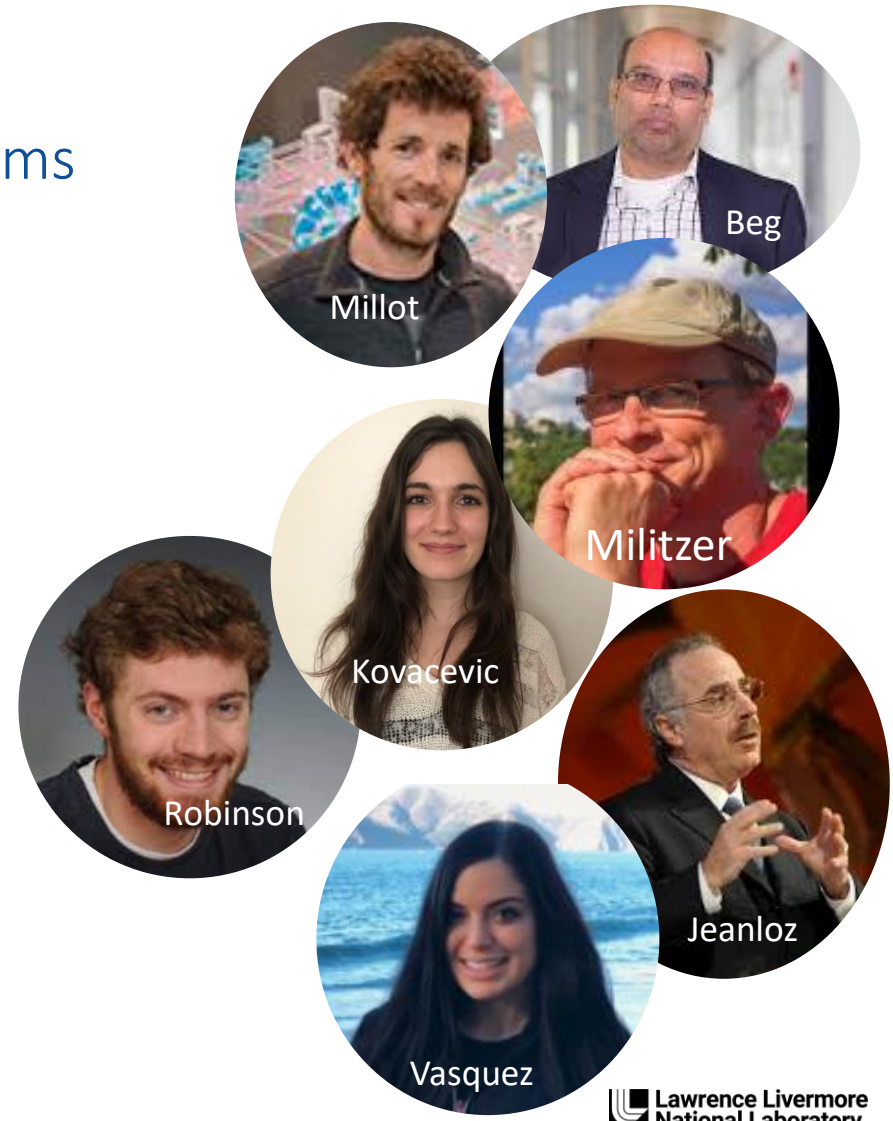
- Mirrors will be used in upcoming experiments at the COMET laser at JLF, and the BELLA laser at Berkeley
- Gave an invited talk at APS DPP in 2021 on applications of high intensity OAM

- Working on Near Backscatter Imager/Full Aperture Backscatter Station diagnostic on NIF
- Ran an OMEGA EP campaign in May investigating microwires on the surface of gold targets
- Will be heavily involved in the FSBS hohlraum predictive capability campaign on NIF next May.
- Hosted a summer student who also participated on campaign at OSU.

Enabling Collaborations : Connecting LLNL scientists and external researchers

The Center is the focal point for facilitating and fostering research opportunities for academic and LLNL staff

- **NNSA HED Center for Matter at Extreme Conditions**
  - Energy transport, material properties, in magnetized systems Host students at LLNL
  - HEDS curriculum development for spectroscopy
  - Support for experiments at Jupiter Laser Facility
  - Introducing students to HEDS
- **High pressure research at Berkeley and Davis**
  - HEDS Center continues to support HiP work
  - M. Vasquez member of Jeanloz group
  - T. Kovacevic member of Militzer group
  - V. Naden Robinson of Militzer group



A proposal was submitted to the UC Multi-campus Research Programs and Initiatives (MRPI) call

- California Initiative for Solid-to-Plasma Dynamics for Fusion Energy
  - Understand the solid to plasma transition under high-power lasers
  - Combined multiscale simulation and time-resolved experiments
- Multi-institutional with both research and education as a focus
  - Hands-on research training for students and postdocs
  - Undergraduate research
  - Undergraduate and graduate education

We have continued the Japan-US HEDS seminar series and we are looking forward to re-start paused activities in 2023

- Quarterly meetings between ILE and LLNL
- Monthly HED seminar series
  - https://heds-center.llnl.gov/education/seminars
- New activities in a post-COVID environment
  - Core-to-Core proposal to government of Japan
  - Japan-US summer schools
  - Student internships
  - Research collaborations (NIF DS)
    - Professor Natsumi is collaborating on a NIF DS proposal

Japan Speaker:

Professor Yasuhiro Kuramitsu
Graduate School of Engineering, Osaka University

"Particle acceleration in space and laboratory plasma"

US Speaker:

Dr. Ronnie Shepherd
Lawrence Livermore National Laboratory

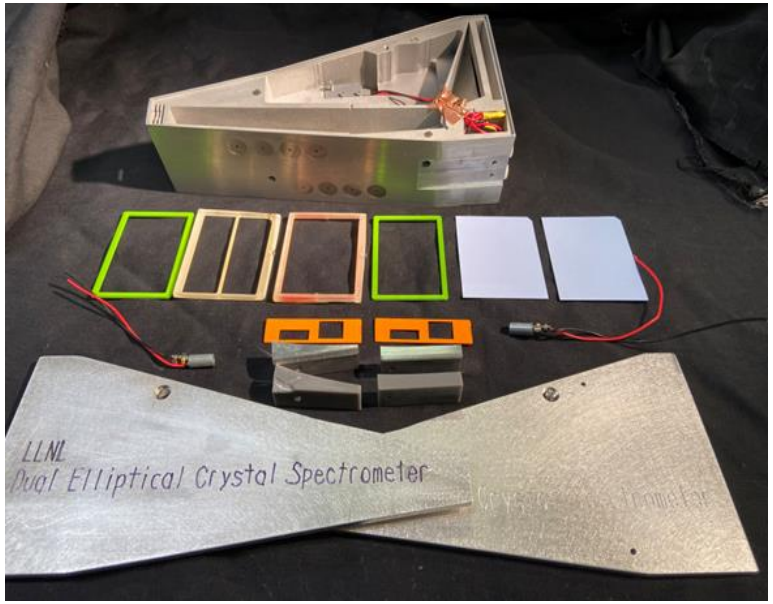
"Utilizing ultrashort pulse laser heated matter to study fundamental properties of high energy-density plasma"

Bridge to the programs

The HEDS Center helps provide support for the HEDS B161 technology center

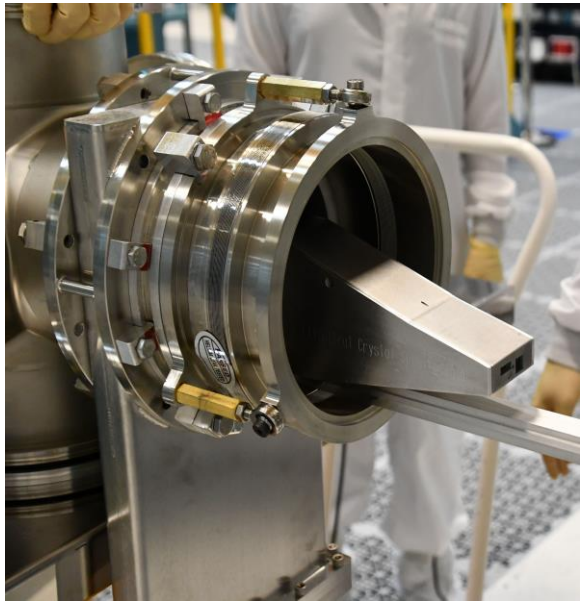
The Building 161 technology facility is a multi use facility, managed by PLS, for researchers to design, build and deliver targets and diagnostics.

Dual Elliptical Crystal Spectrometer 3D printed Aluminum and 3D printed internal components used in Israel



Spectrometer installed on alignment station

Spectrometer installed on chamber

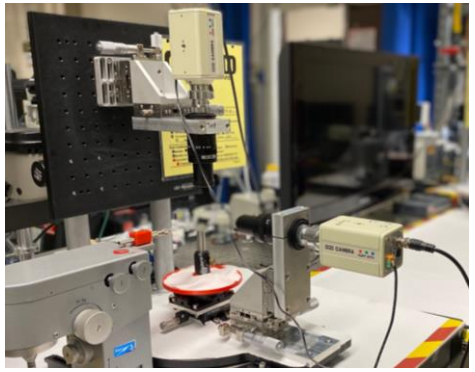


Spectrometer inserted to target chamber center

HEDS B161 technology design, fabrication and assembly

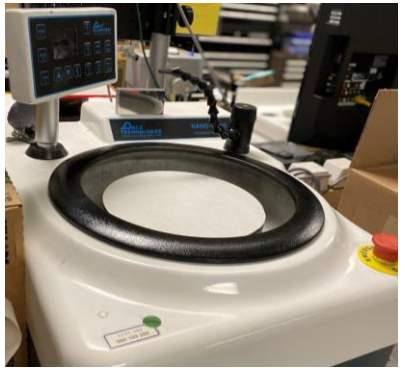
3D printing with
2 different style platforms

Precision assembly stations

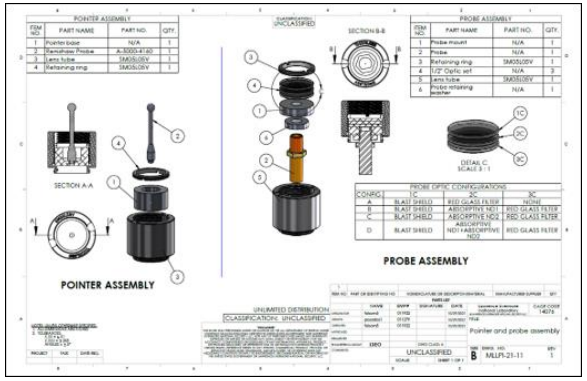


Mechanical assembly
Thin filters for NIF

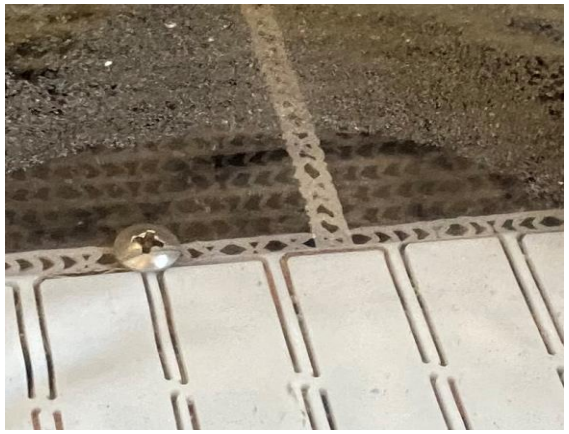
Precision polishing



CAD design expertise



Water Jet cutting stainless steel

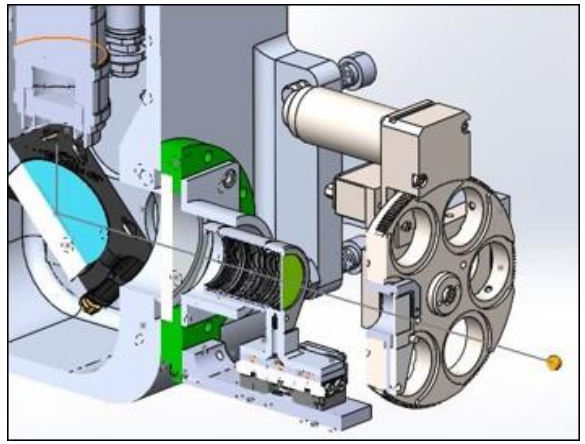


Innovative ideas to print

Expert micro assembly

Precision polishing

CAD design expertise up to full assemblies



WCI has introduced the Academic Collaboration Team (ACT) and the Foster-Brown Fellows as a way of fostering LLNL-academic interactions

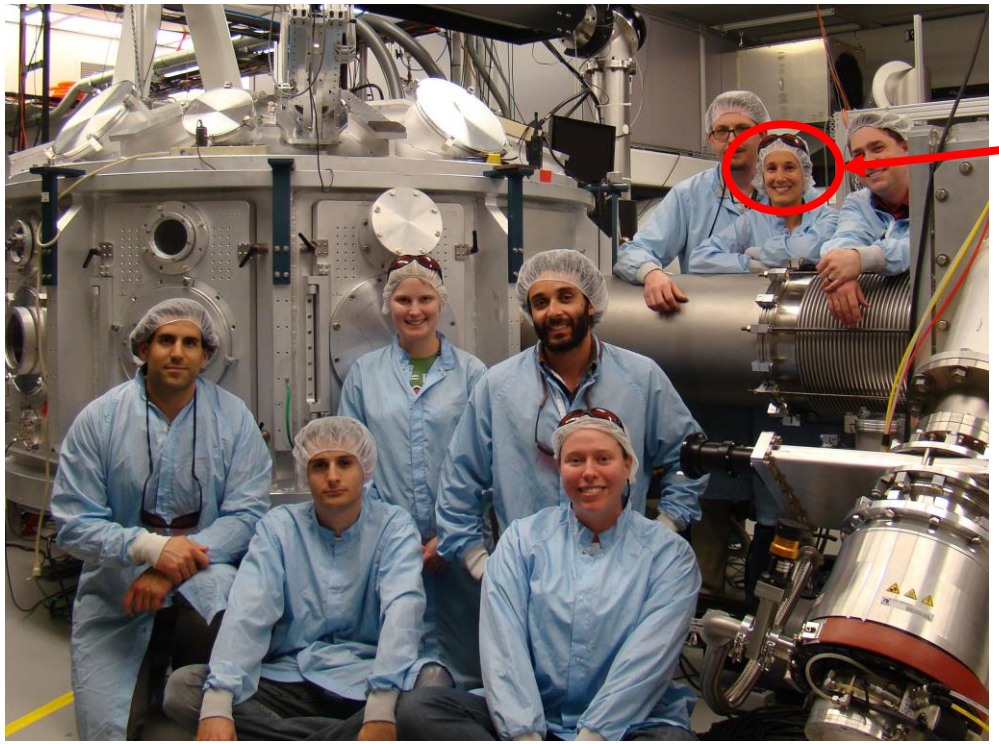
- WCI is developing university relations in support of its programs
  - Innovation, basic science, an informed independent perspective
  - Product is data, technology, methods
  - Hiring pipeline and workforce education
- ACT roles and responsibilities
  - Luc Peterson of WCI is coordinating ACT
  - Proposals consist of PI's from academia and LLNL
  - Selection process is based on a "blind" review by a committee
- Foster and Brown Fellows
  - Coordinated with Lawrence and HEDS Fellow selection process

Chris Hartmann led a diverse team of scientists to address how investments in S&T has been critical to SSP

A cross-laboratory team developed a classified slide set and unclassified white paper that took a fresh look at the role S&T has played in stockpile stewardship and what it means for the future of the nuclear deterrent.

What's new for FY23?

In FY 2023 the center will be exploring new partnerships with the Jupiter Laser Facility



The JLF deputy

JLF has attracted many students and postdocs to LLNL and enables collaborations with academia

We are currently exploring new partnerships:

- Possible common use of 161 facility for JLF users for targets, diagnostics, storage
- A HEDS/JLF summer intern at the facility, to help the facility while training a student on laser and diagnostic technology

The University of California Livermore Collaboration Center will provide capabilities for workshops, educations, and meetings

UCLCC Meeting and Classrooms

- UCLCC offers a suite of flexible meeting rooms and classrooms
- Moveable/modular furniture designed to allow maximum flexibility for users
- Rooms are equipped with modern AV equipment and IT setup
- Classrooms setup for remote teaching and conferences
- Flex-labs allow for dry-lab setup

We are welcoming Nuno Loureiro from MIT and we will be working again with Farhat Beg of UCSD

- Nuno Loureiro is at LLNL on October 4th
  - Sponsored by the mini-sabbatical program
  - Lectures on the uses of quantum computing for plasma physics
  - Lectures on transport processes in fusion plasmas

- Farhat Beg has been a strong partner of the HEDS Center and NNSA Labs
  - Atomic spectroscopy course for spring Q of 2023
  - 7 students and 3 postdocs to NNSA Labs
  - 1 LLNL staff member is pursuing a PhD program at UCSD with another following

We will work with IFE team to explore how the HEDS Center can support Inertial Fusion Energy activities

- Seminars
  - Devote a block of the HEDS Seminar series to colloquia on fusion energy
- Workshops
  - Assist the IFE effort in organizing and planning workshops
- Student internships
- Education

Re-engaging the IAEC-NNSA collaboration, Post-COVID, in HEDS builds upon existing relationships and points to new ones

Continue to advance the understanding of HEDS in areas of mutual interest

- A two-day meeting between NNSA and IAEC (Israel Atomic Energy Commission) scientists occurred in September
  - Out briefs and discussions on topical areas (HEDS)
  - Highlighting on-going collaborations-Kruse, Marley, Waxman, Remington, Malamud
  - Utilize existing forms for collaborations (e.g., LaserNetUS, NIF DS)
  - What is next?

- Areas in HEDS of ongoing research interest in simulation, theory, and experiment have been identified
  - Hydrodynamic instabilities and turbulence
  - Atomic physics and opacity
  - Plasma physics

- A HEDS meeting is being planned in spring 2023
  - Discuss code-to-code comparison test problems
  - Discuss on-going and new experiments of mutual interest
  - Sabbatical, students, education, workshops

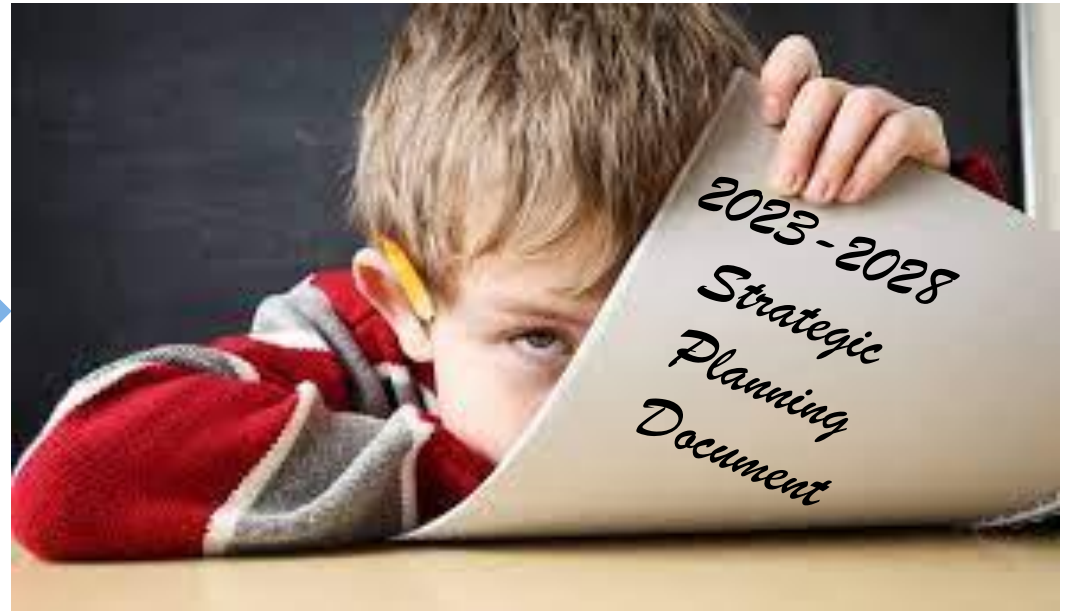
In FY23 we will be starting the process to develop a new 5-year Strategic Plan

Sabbaticals

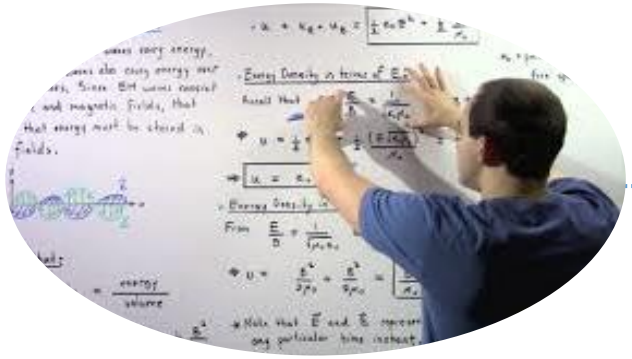
HEDS distance learning

HEDS Postdoc

Students from MSI's transitioning to postdoc positions

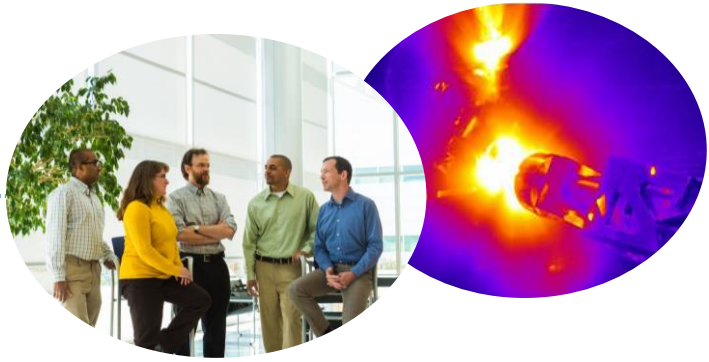


Thank you for your interest and your time !



Education

Educating the next generation of researchers



Bridge to the Programs

Focus on HED areas of interest to the programs — driving a workforce pipeline

HEDS

High Energy Density Science Center

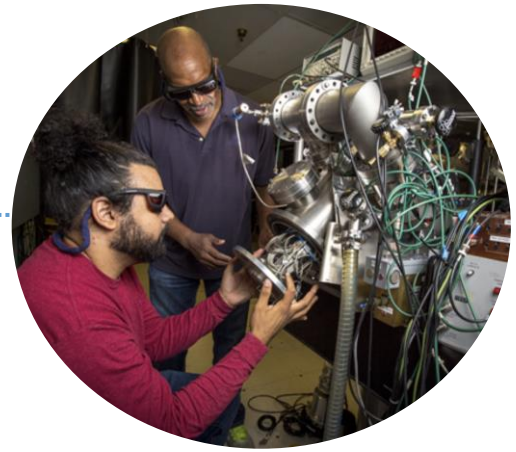
Bridge to the HED Community

Seminars, Workshops and Outreach

Strengthening communication ties within the HED community

Enabling Research in Relevant Areas

Providing the links to HED research collaborations



https://heds-center.llnl.gov/