

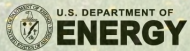
SNOWMASS-SEATTLE 24 JULY 2022



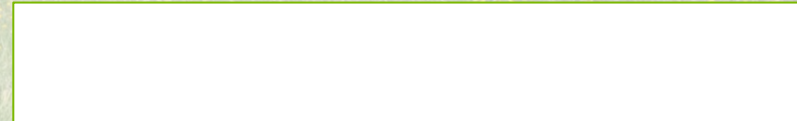
ARGONNE NATIONAL LABORATORY HIGH ENERGY PHYSICS DIVISION



RIK YOSHIDA
HEP DIVISION DIRECTOR
ARGONNE NATIONAL LAB

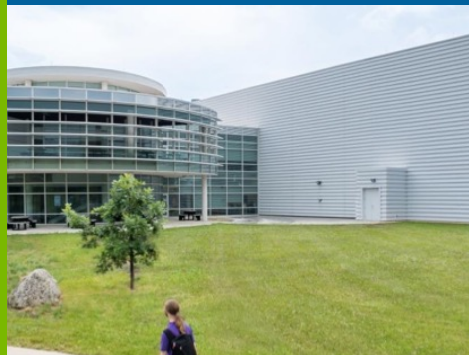


Argonne National Laboratory is a
U.S. Department of Energy laboratory
managed by UChicago Argonne, LLC.



Argonne: 3500 Staff, 500 Joint Faculty, 500 PD and Students, 800 visiting scientists+6700 users

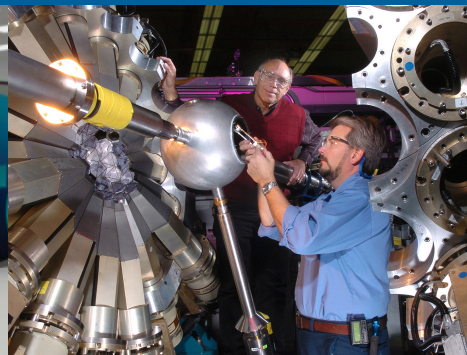
ARGONNE AND ARGONNE HEP



Materials, Nanoscience



Leadership Computing



Nuclear Physics



Photon Science

AN ENVIRONMENT WITH MANY OPPORTUNITIES FOR SYNERGIES

“ARGONNE High Energy Physics division (HEPD) will carry out cutting edge research in Energy, Intensity and Cosmic Frontiers while becoming a hub of innovation in the utilization of the new developments in computing, detectors and accelerator technologies for HEP science”. Argonne HEP Vision Document submitted to DOE-HEP March 2021

HEP Division
~100 members
~40 core staff

Division Main Research Thrusts

- Cross-cutting
 - Computing
 - AI/ML
 - QIS



Intensity Frontier

- Muon Program
- Neutrino Program



Particle Theory

- Beyond the Standard Model
- Precision QCD



Cosmic Frontier

- Cosmic Theory and Computing
- Experimental Cosmology
- CMB and Dark Energy



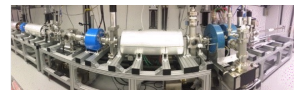
Detector R&D

- Superconducting Detectors
- Novel UV Sensitive Materials



Energy Frontier

- ATLAS at LHC



Advanced Accelerator Development

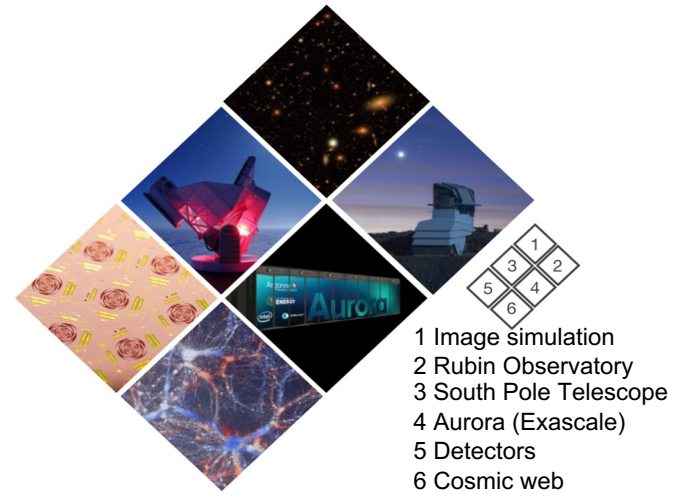
- Argonne Wakefield Accelerator (AWA)

Many connection between thrusts:
Also, many connections with the larger Argonne Laboratory

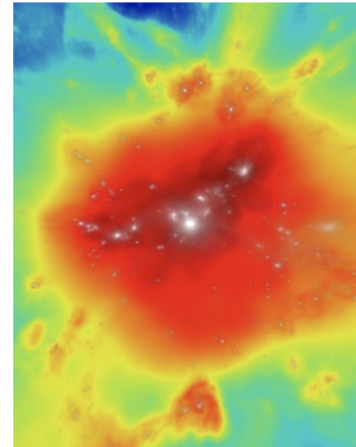
Cosmic Frontier

- Program combines theory, computing and experiment
- Leading role in computational cosmology
- Part of Exascale Computing Project to prepare for first exascale supercomputers in the U.S. in 2022/23
- Delivery of world-leading simulations to the DOE-supported cosmology surveys with the Hardware/Hybrid Accelerated Cosmology Code (HACC)
- Leading roles in optical surveys (LSST-DESC)
- Advancing CMB science (SPT-3G, CMB-S4)
 - South Pole Telescope-Operations and Science
 - CMB-S4 Project
 - Detector Fabrication
 - South Pole Site Infrastructure
 - Large-scale superconducting technologies (Synergy with Detector R&D)

Close Collaboration with Computing and Mat. Sci



- 1 Image simulation
- 2 Rubin Observatory
- 3 South Pole Telescope
- 4 Aurora (Exascale)
- 5 Detectors
- 6 Cosmic web



Zoom-in on a cluster in a 1.1Gpc box, CRK-HACC run (white peaks track gas density, colors track temperature)

Intensity Frontier

Science, hardware, operations and leadership with muons & neutrinos

Muon g-2



Magnetic field analysis



Significant roles in operations



Leadership roles in collaboration

Mu2e



Background simul. & analysis



Cosmic Ray Veto & Field Mapping



Leadership roles in Mu2e Project

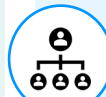
DUNE



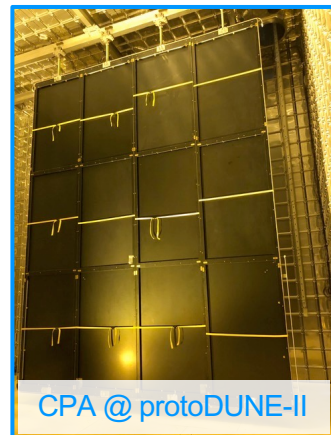
protoDUNE and DUNE analysis & simul.



Near and Far Detector roles



Leadership roles in DUNE Project



Infrastructure for large scale construction

Long Term for DUNE: VUV detection being explored (Mat Sci) in Detector R&D

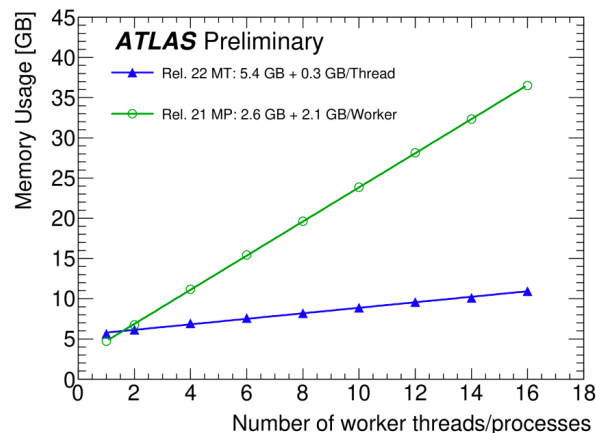
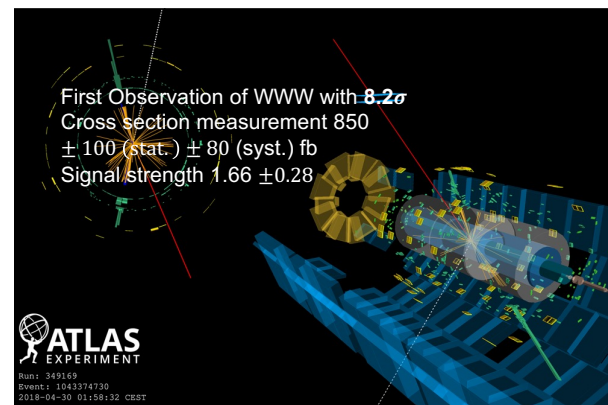
Transpacific cross-calibration of magnetic probes to ~50 ppb. Working with KEK and J-PARC

Energy Frontier (ATLAS)

- BSM searches and precision SM measurements.
- Support for ATLAS detector operations, software and computing.
- Critical upgrades for both Phase-I and the HL-LHC
- AI/ML and High-Performance Computing (HPC)

Deploying HPC for HEP. Also see Center of Computing Excellence

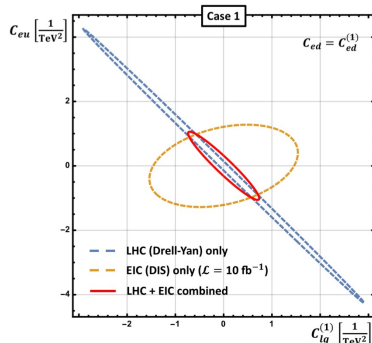
- Collaboration with universities via ANL ATLAS Center (ATC) University students spend time at Argonne for analysis and hardware work
- R&D activities for future experiments such as the Future Circular Collider (FCC) and International Linear Collider (ILC).



Argonne Microfabrication Facility

Particle Theory

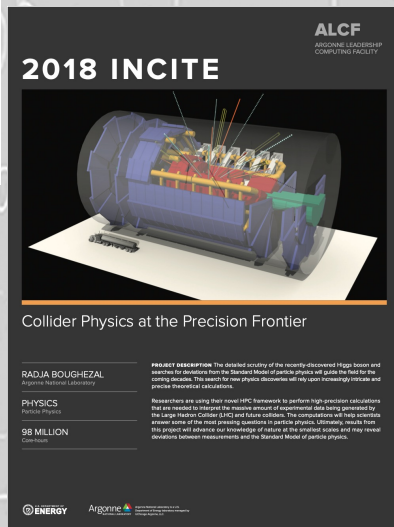
Boughezal, Petriello, Wiegand PRD 101 (2020)
Editor's Suggestion



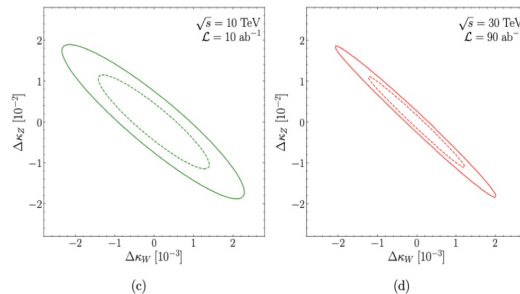
How EIC with LHC adds significant constraints

Joint Appointments
with Northwestern
and UChicago

Strong
Connections to
Experiment and
Computing

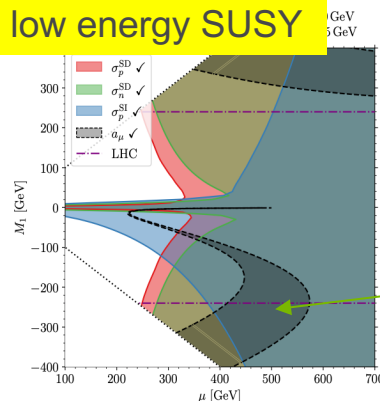


Using HPC for precision QCD



D. Liu, T. Han, **I. Low** and X. Wang: 2008.12204

g-2 and low energy SUSY



Allowed
regions in
parameter
space

S. Baum, M. Carena, N. Shah and **C. Wagner**, arXiv:2104.03302

Accelerator Science at Argonne

User Facilities

Advanced Photon Source (BES)



Accelerator
Science
Division

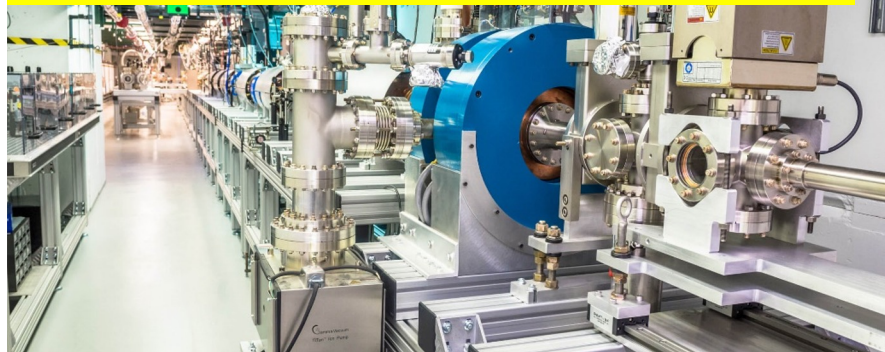
Argonne Tandem Linac Accelerator System (NP)



Heavy Ion
Accelerator
(10's of MeV/u)

Argonne Accelerator Institute (AAI): Gateway
to Collaboration (both internal and external)

Argonne Wakefield Accelerator (HEP)



AWA RESEARCH THEMES

- Advanced Accelerator Concepts (THEME 1)
- Beam Manipulation (THEME 2)
- Beam Production (THEME 3)

AWA Recent Highlight

Ultra high-gradient, X-band RF cathode gun.

Demonstrated Gradient 3-4 times state-of-the-art

Demonstration of sub-GV/m Accelerating Field in a Photoemission Electron Gun Powered by Nanosecond X-Band Radiofrequency Pulses”, **Submitted to PRL** (arXiv: <http://arxiv.org/abs/2203.11598>)

A Major breakthrough

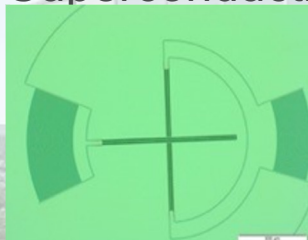
Potential to decrease emittance

- For LCLS 100 pC@68 nm → 30 nm
- **For future HEP linear collider, reduce the site power (and cost) by 30%.**
- For FEL, raise photon energy by 50%
 - $h\nu = 13 \text{ keV} \rightarrow 20 \text{ keV}$

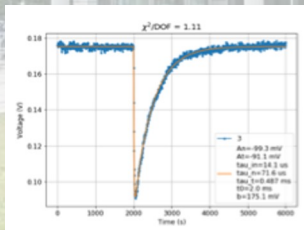
Supported in part by Argonne Accelerator Institute (AAI) as well as DOE HEP

Detector R&D

Superconducting Detectors

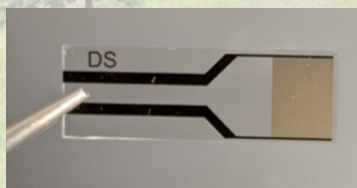


MKID fabricated at Argonne



Trace of a cosmic ray event in an Argonne low-Tc TES device

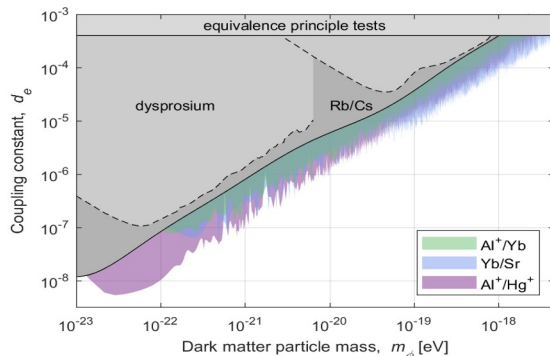
VUV Sensitive Materials and Detectors



Quantum Information Science

BSM Investigations with Atomic Clocks

Collaboration with NIST Boulder

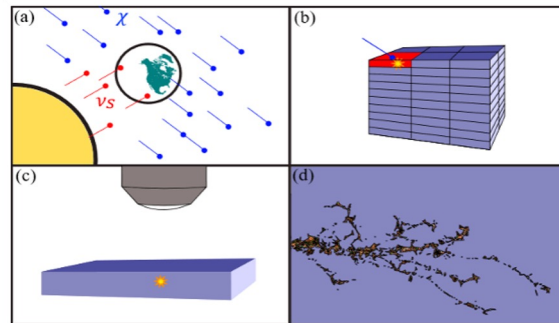


Constraints derived from optical clock data on the coupling constant d_e for ultralight dark matter

Lattice Field Theories with Bosons

Investigate methods for implementing bosonic field theories on quantum computers

Dark matter detection with nitrogen vacancy centers in diamond with UMd



Quantum Sensing for Axion Detection

Ultra-sensitive THz single-photon counting KIDs for wideband axion detection

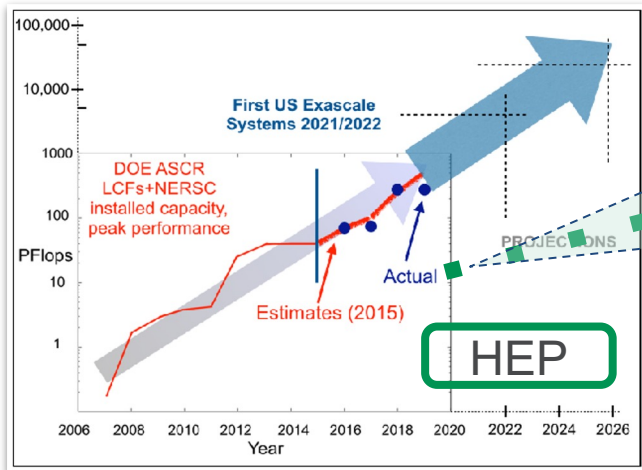
Strong collaboration with

- Computational Science Division
- Superconducting Detector/MSD
- NIST
- UMd

HEP-CCE

HEP Center for Computational Excellence

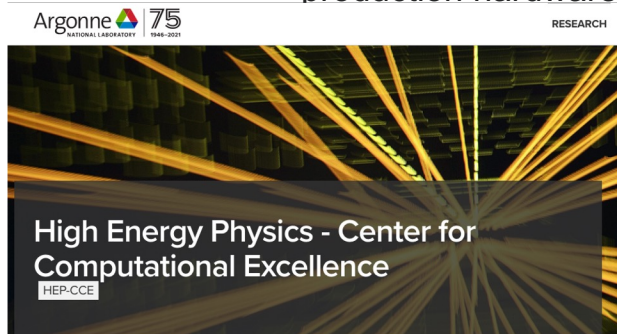
New HEP-CCE effort on porting HEP experiment codes to run on DOE supercomputers



DOE ASCR
computing resource
projection versus
HEP computing
resources
(estimated)

Argonne Roles in HEP-CCE

- Staff/postdoc roles in HEP division and **Computing directorate** for all aspects of the HEP-CCE project, collaborative work with 4 labs (**Argonne, BNL, Fermilab, LBNL**)
- Provide natural links to relevant **Exascale Computer Project** efforts
- Provide access to prototype and early production hardware to the HEP community



Helping members of the community connect to one another to share or engineer experiment-independent solutions.

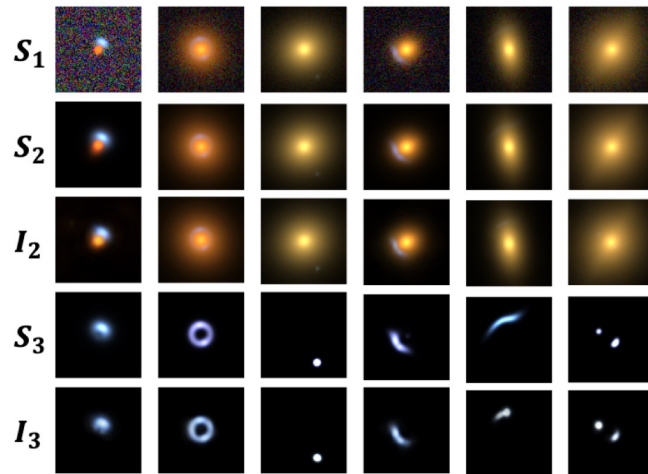
AI/ML

AI/ML: IMPORTANT PART OF ALL FROTIERS



Aurora: Argonne's first Exascale computer. Supports Machine Learning.

Example:
Identifying
Galaxy-
scale
strong
lensing



s_1 : noisy blended simulation, s_2 : noiseless blended simulation, I_2 : output from denoising module, s_3 : noiseless debended simulation, I_3 : output from debending model

HOW WE COLLABORATE OUTSIDE HEP at ANL

Several modes of cross-cutting Examples

Aims of HEP and other Divisions align closely (integration)

- *Computational Cosmology*
HEP (Aim: Cosmology Science) ASCR (Aim: Scientific HPC at Scale)
- AWA and the Argonne Accelerator Institute

Collaborating on Specific Research Topics

- HEP Neutrino effort and PHY(NP) Theory group that produce Nuclear models.
- AWA and NP accelerator program collaborating on AI/ML of acc. controls.

Extension of other Division's interests will serve HEP

- MSD-Superconductivity and Magnetism Group: collaborate for Superconducting Detectors.
- MSD-Novel Materials Group: collaborate for VUV sensitive materials.

All Modes of Collaboration are Exploited

Additional Slides



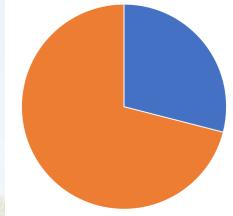
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75
1946–2021

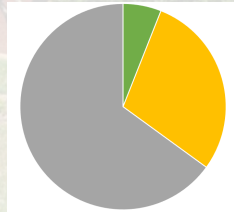
Scientific Staff Demographics (2022)

Gender



**Argonne HEPD
Physics Staff**
29% Female

Minorities



**Argonne HEPD
Physics Staff**
6% URM

Argonne HEPD 2018

