DOE High Energy Physics

Regina Rameika
Associate Director for HEP - US DOE Office of Science

Symposium of the US-Japan Science and Technology Cooperation Program
May 22-23, 2023
Honolulu, Hawaii

U.S. DEPARTMENT OF ENERGY | Office of Science

Energy.gov/science

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The Nation's largest supporter of basic research in the physical sciences

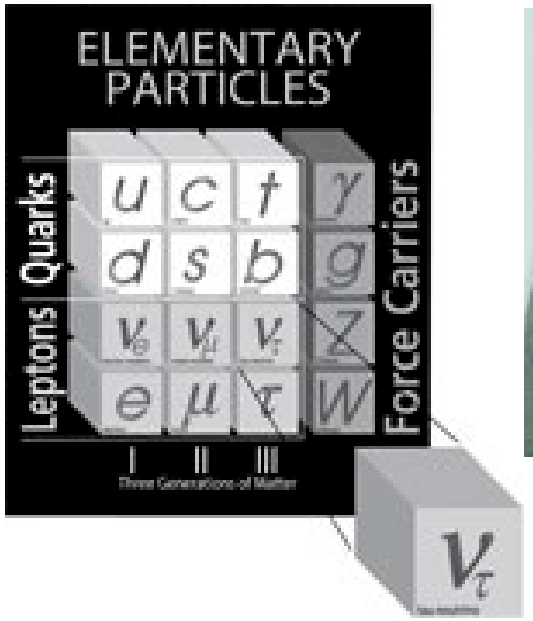
Principal roles:

- Direct support of scientific research
- Direct support of the development, construction, and operation of unique, open-access scientific user facilities that are made available for use by external researchers

Allow Me to Introduce Myself

- As Associate Director of the Office of High Energy Physics (HEP), I oversee all high-energy physics research activities in the United States at both national laboratories as well as universities
- I started this role on November 7, 2022
- Before coming to DOE I worked at Fermi National Accelerator Laboratory since 1982 as an experimental research scientist
  - Specialized in detector building and data analysis
  - Held numerous leadership positions in project management, laboratory administration, international experimental collaborations, etc.
- I am very excited to be serving in this new role, aiming to lead our office to enable ground-breaking discoveries in fundamental science and its applications.

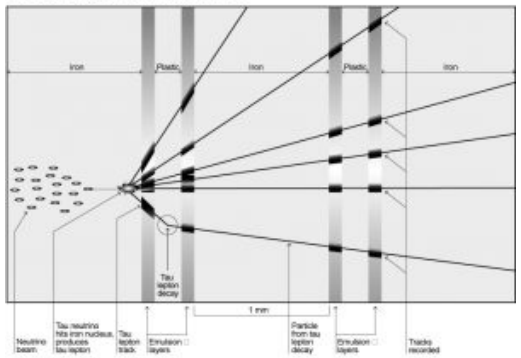
A personal acknowledgement to US-Japan Cooperation



Professor Niwa
Nagoya U.

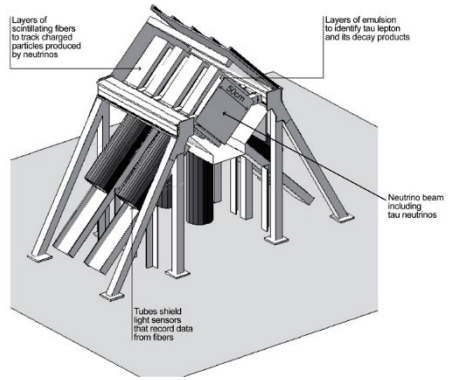
Scanning at Nagoya

Detecting a Tau Neutrino



Of one million million tau neutrinos crossing the DONUT detector, scientists expect about one to interact with an iron nucleus.

DONUT Target Station



DONUT Collaboration
K. Kodama[1], N. Ushida[1], C. Andreopoulos[2], N. Saoulidou[2], G. Tzanakos[2], P. Yager[3], B. Baller[4], D. Boehnlein[4], W. Freeman[4], B. Lundberg[4], J. Morfin[4], R. Rameika[4], J.C. Yun[4], J.S. Song[5], C.S. Yoon[5], S.H.Chung[5], P. Berghaus[6], M. Kubanstev[6], N.W. Reay[6], R. Sidwell[6], N. Stanton[6], S. Yoshida[6], S. Aoki[7], T. Hara[7], J.T. Rhee[8], D. Ciampa[9], C. Erickson[9], M. Graham[9], K. Heller[9], R. Rusack[9], R. Schwienhorst[9], J. Sielaff[9], J. Trammell[9], J. Wilcox[9], K. Hoshino[10], H. Jiko[10], M. Miyanishi[10], M. Komatsu[10], M. Nakamura[10], T. Nakano[10], K. Niwa[10], N. Nonaka[10], K. Okada[10], O. Sato[10], T. Akdogan[11], V. Paolone[11], C. Rosenfeld[12], A. Kulik[11,12], T. Kafka[13], W. Oliver[13], T. Patzak[13], J. Schneps[13]

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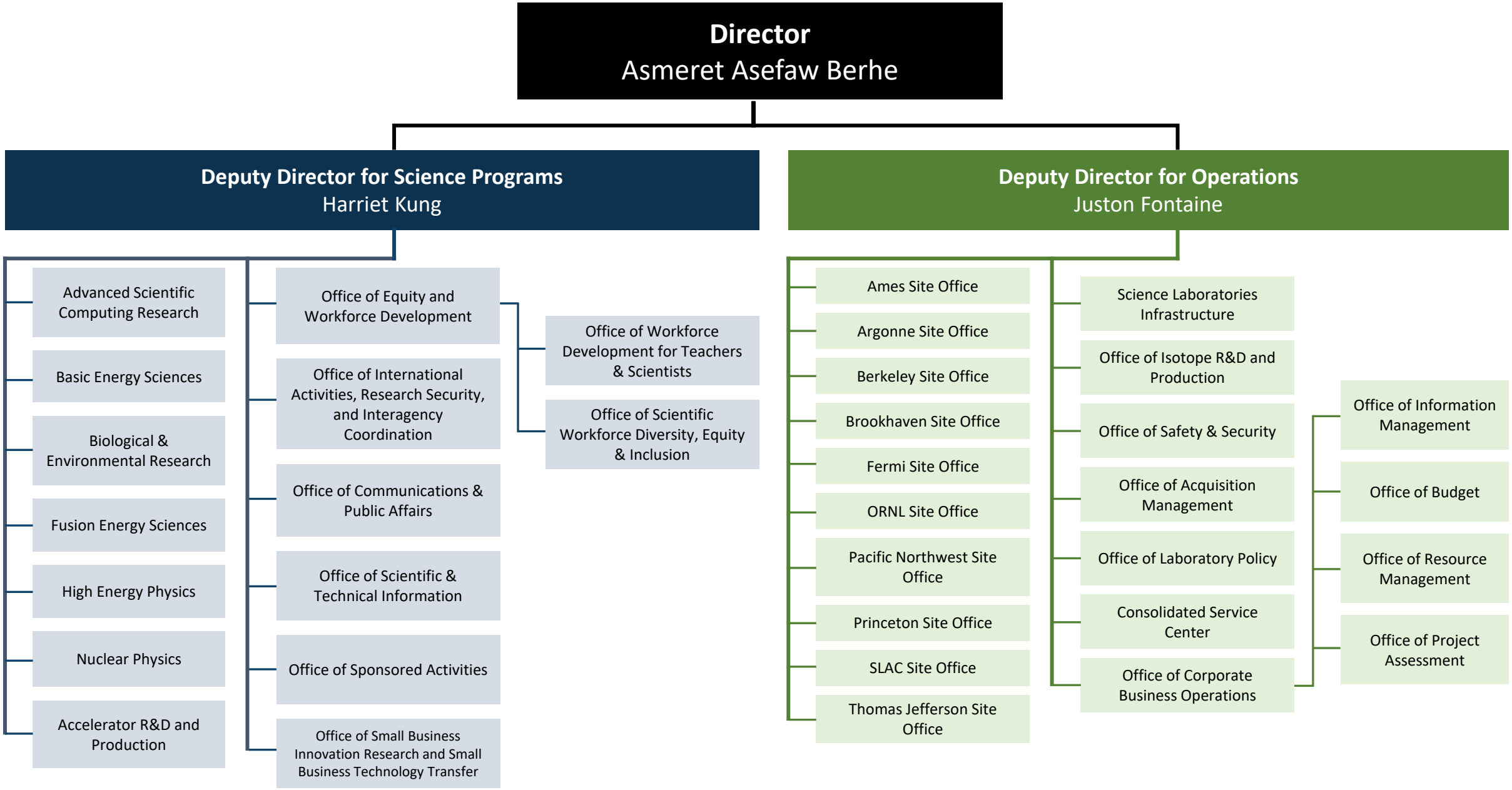
December 14, 2000

Abstract

The DONUT experiment has analyzed 203 neutrino interactions recorded in nuclear emulsion targets. A decay search has found evi-

1


Director
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Deputy Director for Science Programs
Harriet Kung
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Biological & Environmental Research
Fusion Energy Sciences
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Accelerator R&D and Production
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Office of Communications & Public Affairs
Office of Scientific & Technical Information
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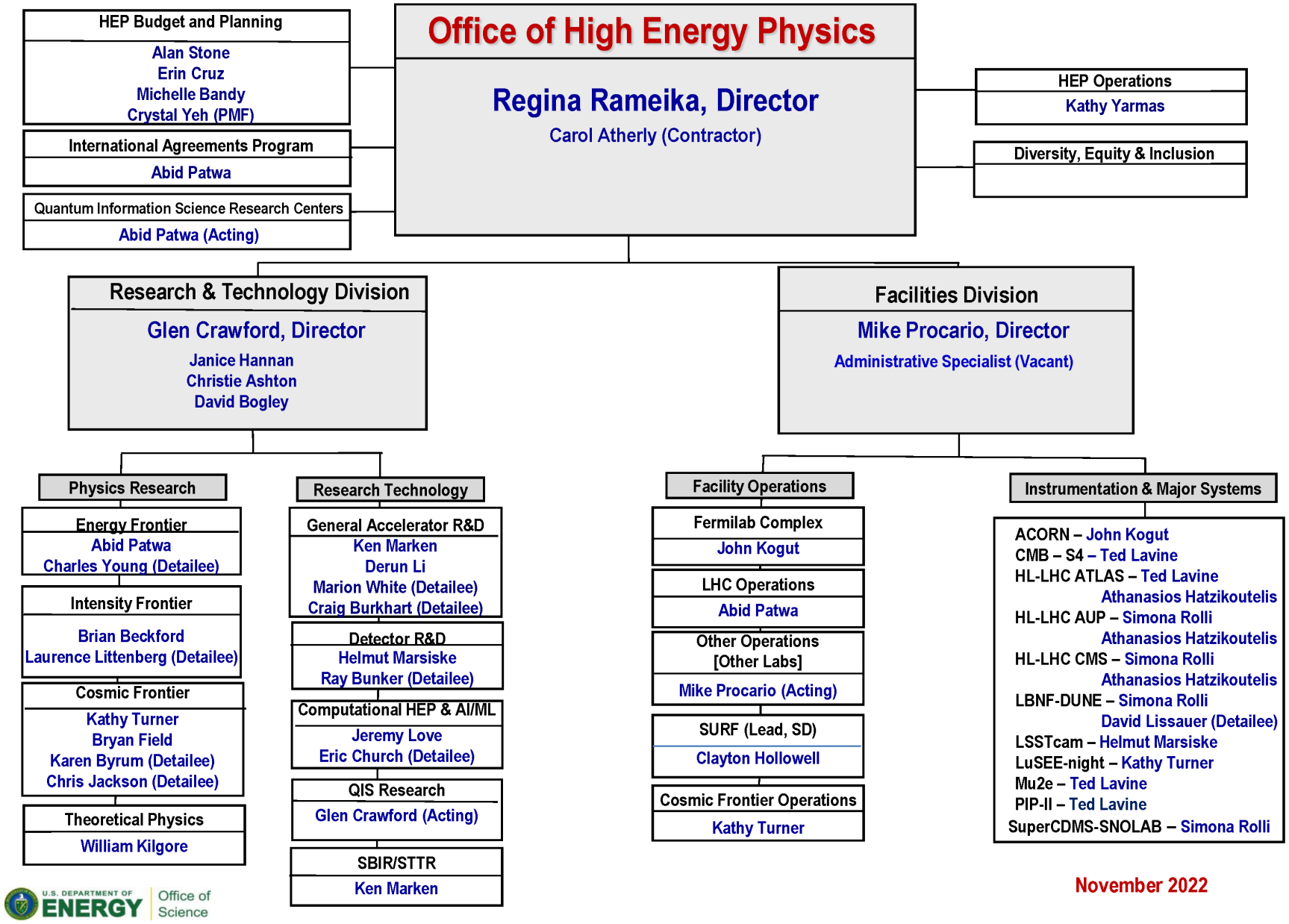
Office of Budget
Office of Resource Management
Office of Project Assessment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Administrative Specialist (Vacant)
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Charles Young (Detailee)
Intensity Frontier
Brian Beckford
Laurence Littenberg (Detailee)
Cosmic Frontier
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Bryan Field
Karen Byrum (Detailee)
Chris Jackson (Detailee)
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Craig Burkhart (Detailee)
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John Kogut
LHC Operations
Abid Patwa
Other Operations
[Other Labs]
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SURF (Lead, SD)
Clayton Hollowell
Cosmic Frontier Operations
Kathy Turner
Instrumentation & Major Systems
ACORN – John Kogut
CMB – S4 – Ted Lavine
HL-LHC ATLAS – Ted Lavine
Athanasios Hatzikoutelis
HL-LHC AUP – Simona Rolli
Athanasios Hatzikoutelis
HL-LHC CMS – Simona Rolli
Athanasios Hatzikoutelis
LBNF-DUNE – Simona Rolli
David Lissauer (Detailee)
LSSTcam – Helmut Marsiske
LuSEE-night – Kathy Turner
Mu2e – Ted Lavine
PIP-II – Ted Lavine
SuperCDMS-SNOLAB – Simona Rolli
November 2022
U.S. DEPARTMENT OF ENERGY
Office of Science

Office of High Energy Physics at a Glance

FY 2023 Enacted: $1.166B

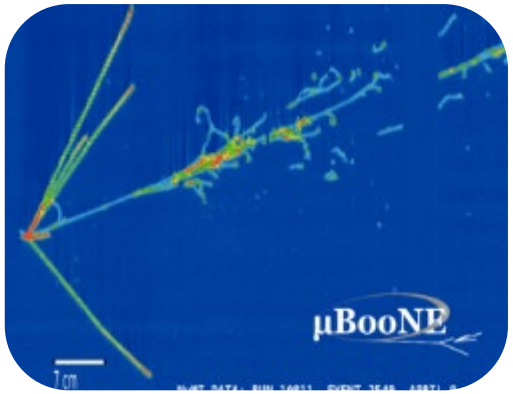
Largest Supporter (**~85%**) of Particle Physics in the U.S.

Funding at **>160** Institutions, including **12** DOE Labs

Over **1,175** Ph.D. Scientists and **525** Grad Students Supported

Over **2,325** Users at **2** SC Scientific Facilities

~30% of Research to Universities



Research:

39.8%, $464.4M

Facility Operations:

29.7%, $346.6M

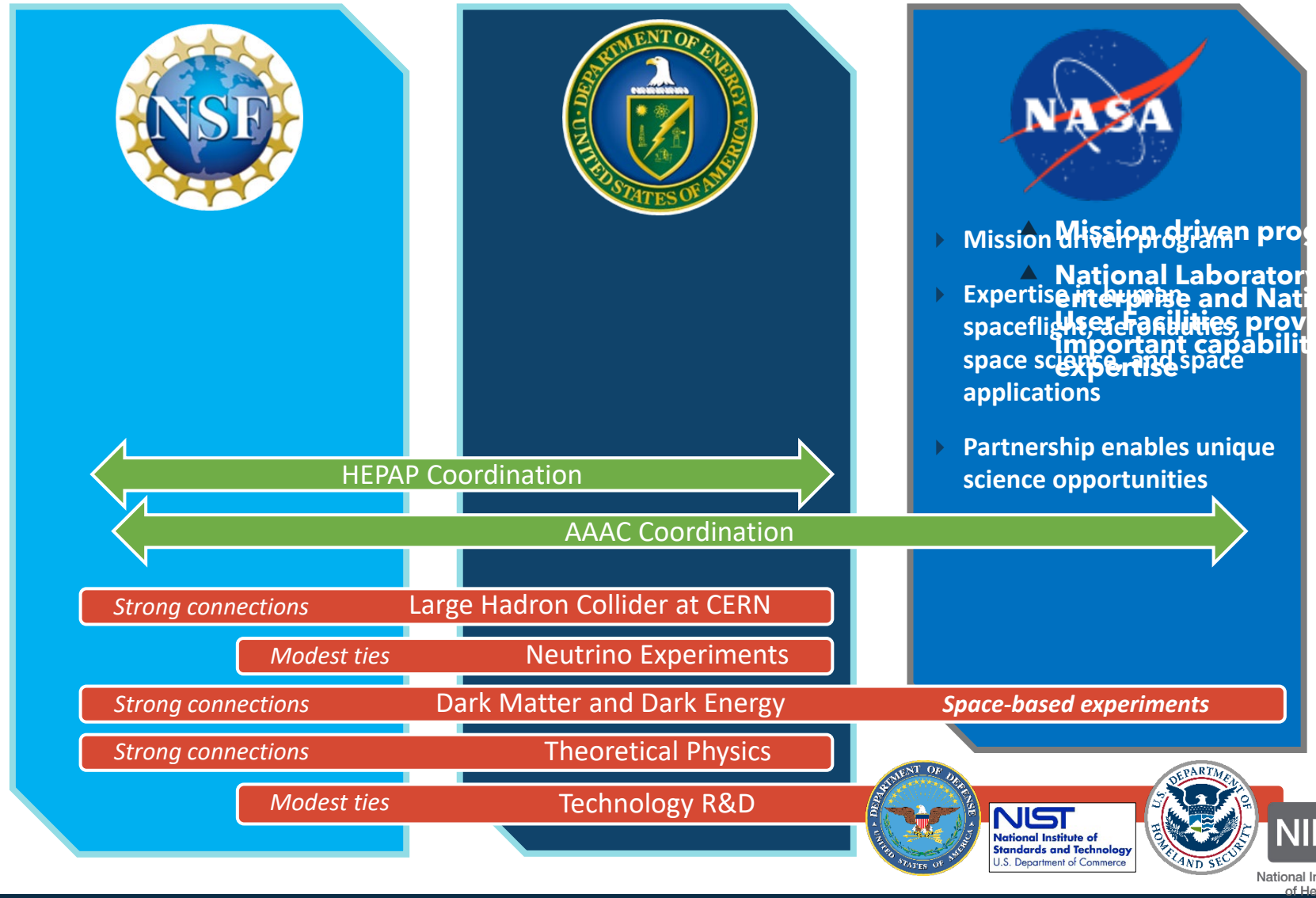
Projects:

30.4%, $355M

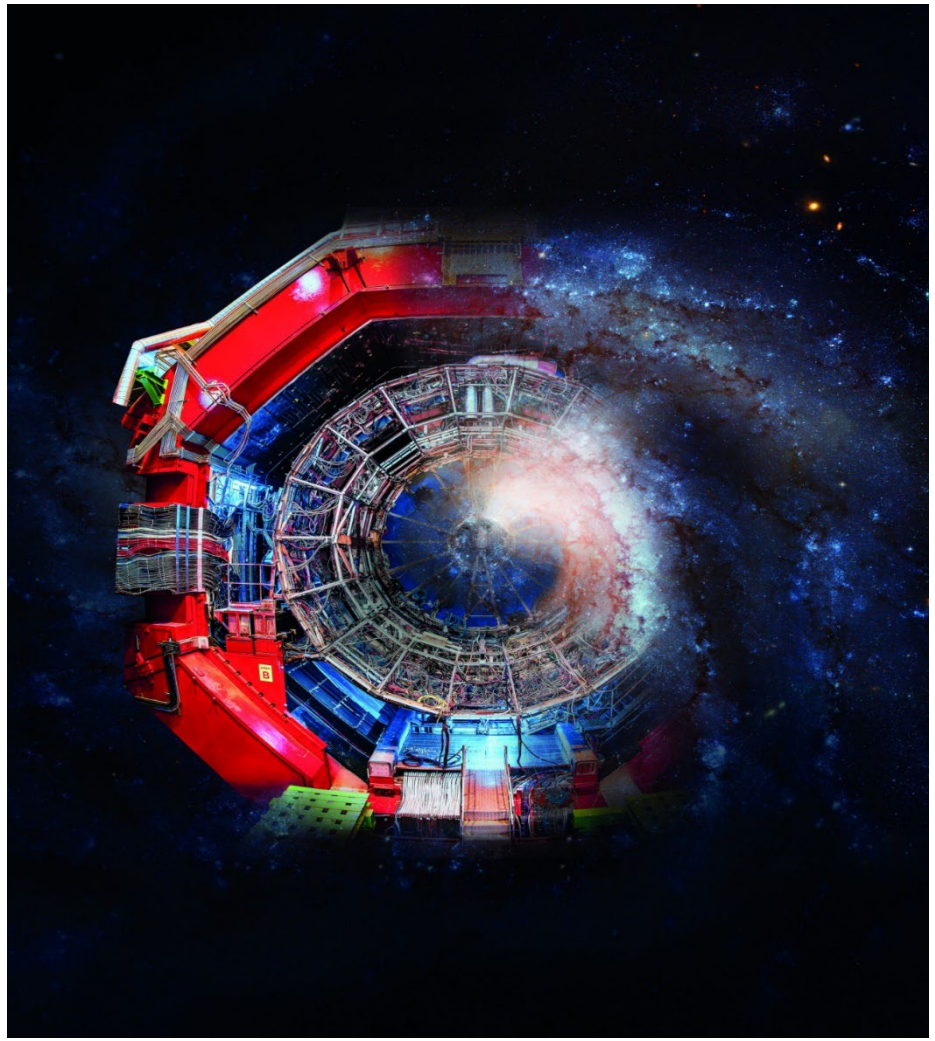
DOE Particle Physics Agency Partnerships

DOE is the central player in US particle physics, providing ~85% of annual resources & leveraging interagency partnerships

European Organization for Nuclear Research, known as CERN, is a European research organization that operates the largest particle physics laboratory in the world.

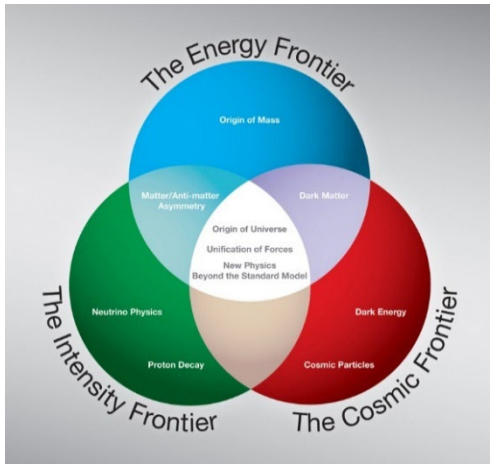


Our Research & Technology



Spans the breadth of three "frontiers":

- Energy Frontier
- Intensity Frontier
- Cosmic Frontier



2008 P5

Plus cross-cutting themes

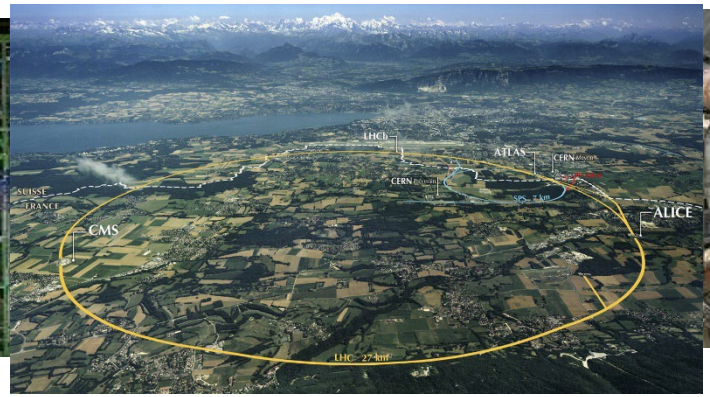
- Theoretical physics
- General Accelerator and Detector R&D
- Computational HEP and AI/ML
- QIS Research

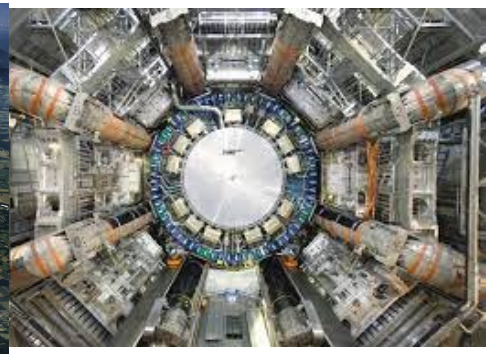
2014 Frontiers to Science Drivers

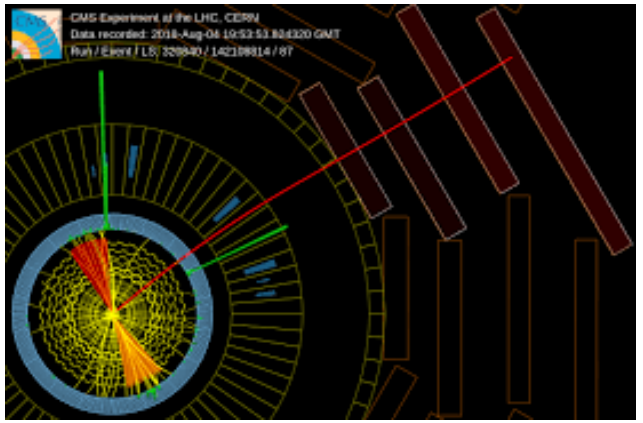
	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●

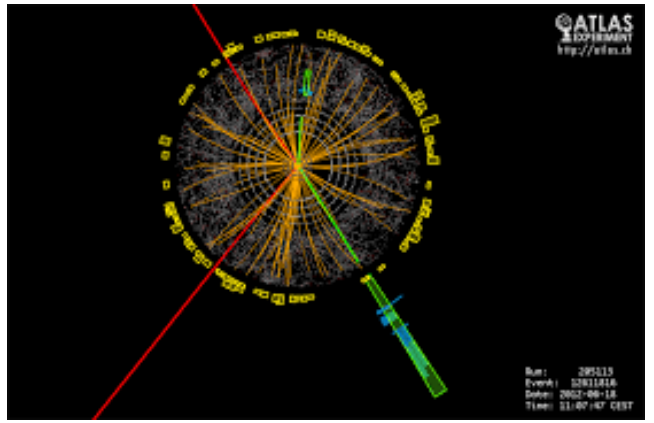
Energy Frontier: Large Hadron Collider experiments

	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●

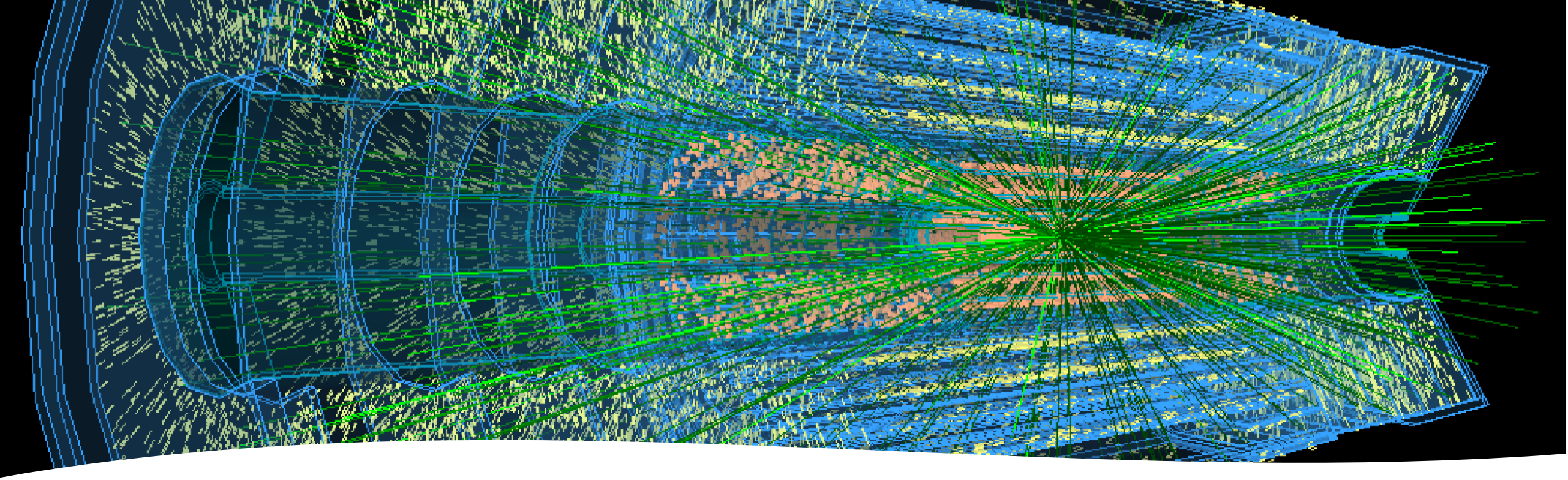








- CMS and ATLAS continue to drive HEP results
  - with over 2000 per year publications from Run 1 &2 since 2009 (LHC start),
  - a comprehensive measurements of the Higgs in journal *Nature* for the 10th anniversary of the Higgs discovery
- The LHC resumed stable Run 3 operations with proton beams colliding on April 20, 2023. The goal set by the LHC is to deliver a total of 75 fb^{-1} of data to the ATLAS and CMS experiments during calendar year 2023.



Energy Frontier

- High Luminosity ("HiLumi" of HL-LHC) program.
  - The LHC accelerator and the main detectors upgrade for Run 4 starting in 2029.
    - Goal: deliver 3000-4000 fb^{-1} to CMS and ATLAS upgraded detectors
  - The HL-LHC CMS is baselined (CD-2).
  - The HL-LHC ATLAS has begun full construction (CD-3).
  - The HL-LCH AUP (the accelerator upgrade) is in construction mode since 2020 and re-baselined after the pandemic.

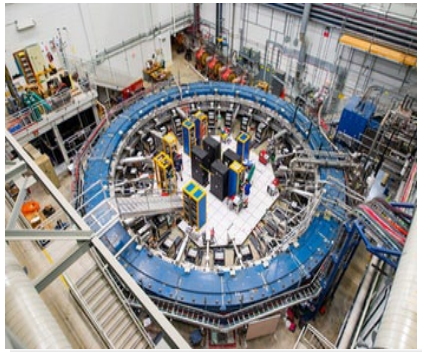
Intensity Frontier Experiments

	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●

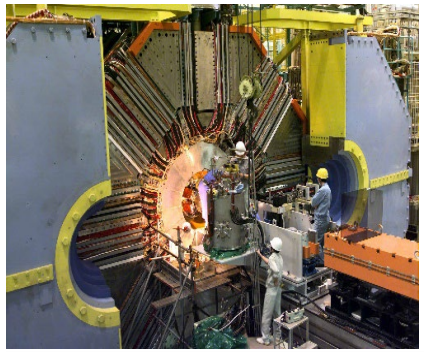
NOvA at Fermilab and Ash River

ICARUS at Fermilab

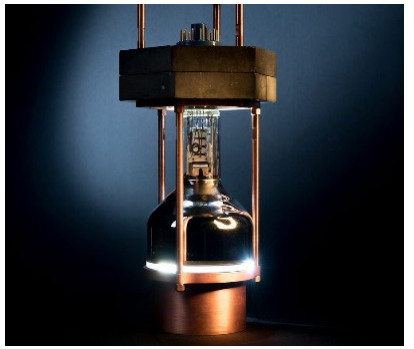
Mu2E at Fermilab



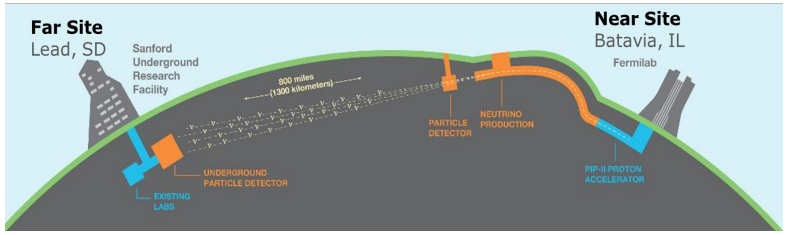
Muon g-2 at Fermilab



Belle II at KEK, Japan



COHERENT at ORNL

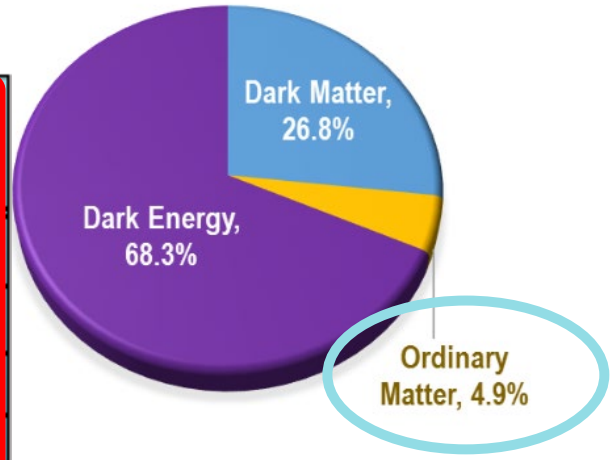


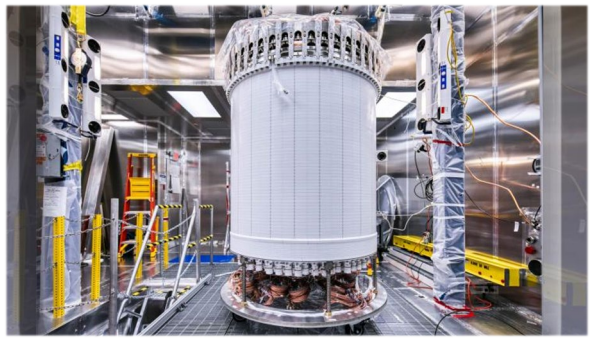
DUNE at Fermilab and Lead, SD

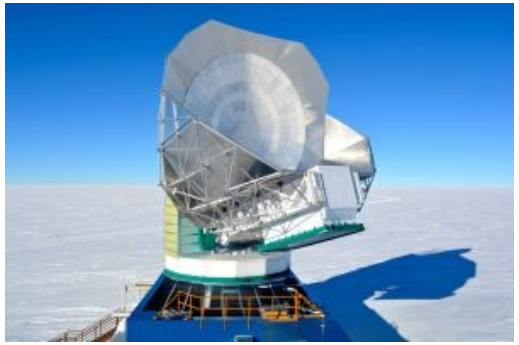
Cosmic Frontier Experiments

- **Cosmic Frontier experiments** address four of five science drivers
- They use naturally occurring sources to determine the fundamental nature of matter, energy, space and time.

	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●



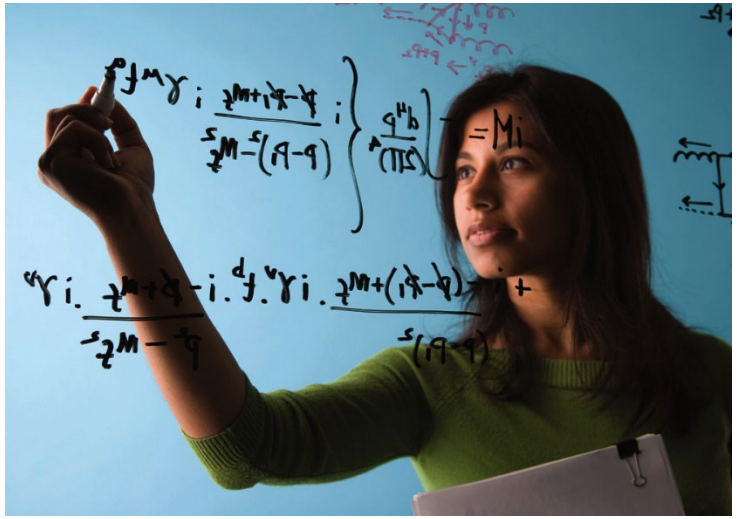




- Partnerships w/NSF (PHY, AST, OPP) NASA (AST, ISS, CLPS) are essential

HEP Theory Program

- A thriving HEP Theory program is necessary to provide the vision and the mathematical framework for understanding and extending our knowledge of particles, forces, space-time, and the universe



- Exciting areas seeing rapid development are:
  - Dark matter phenomenology, particularly light dark matter
  - The structure of black holes and the nature of quantum gravity
  - Cosmology and the nature of dark energy
  - Experimental puzzles like Muon *g*-2, the *W*-boson mass
- Planning for the future

- HEP Theory supports HEP Experiments by devoting resources to programmatic priorities
  - Computational resources to support lattice calculations advancing the experimental program
  - The Neutrino Theory Network provides theoretical support for our neutrino experiments

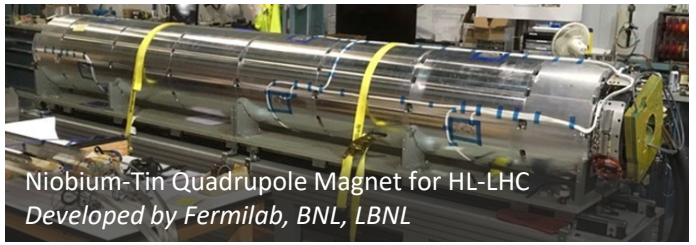
Advanced Detector and Accelerator Technology and R&D

Advanced detector technology

High-field magnets to enable future colliders

Superconducting radiofrequency (SRF) accelerators

Advanced accelerator concepts



Niobium-Tin Quadrupole Magnet for HL-LHC
Developed by Fermilab, BNL, LBNL

LCLS-II SRF Cavity Processing
Photo credit: Fermilab

Laser-driven Plasma Wakefield Channel *BELLA at LBNL*

AI/ML Initiative

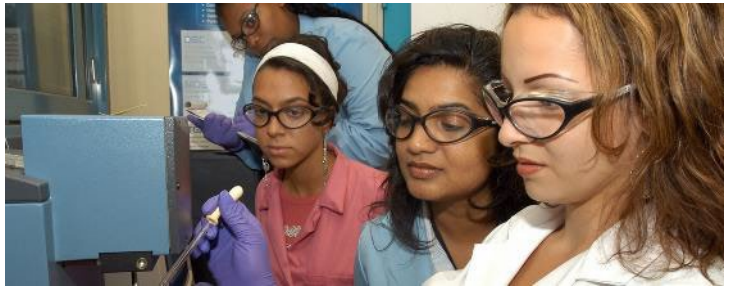
The Federal administration has placed a high priority on ensuring continued U.S. leadership in AI research and development

- Broad interest in AI/ML is being driven by the accumulation of large datasets and growing computational capacity for processing
- HEP has a long track record of successful AI/ML research and development across many decades and programs
- Core AI/ML research is supported through dedicated FOAs and targeted projects

Office of Science Initiatives towards workforce development

RENEW

Reaching a New Energy Sciences Workforce



FAIR

Funding for Accelerated, Inclusive Research

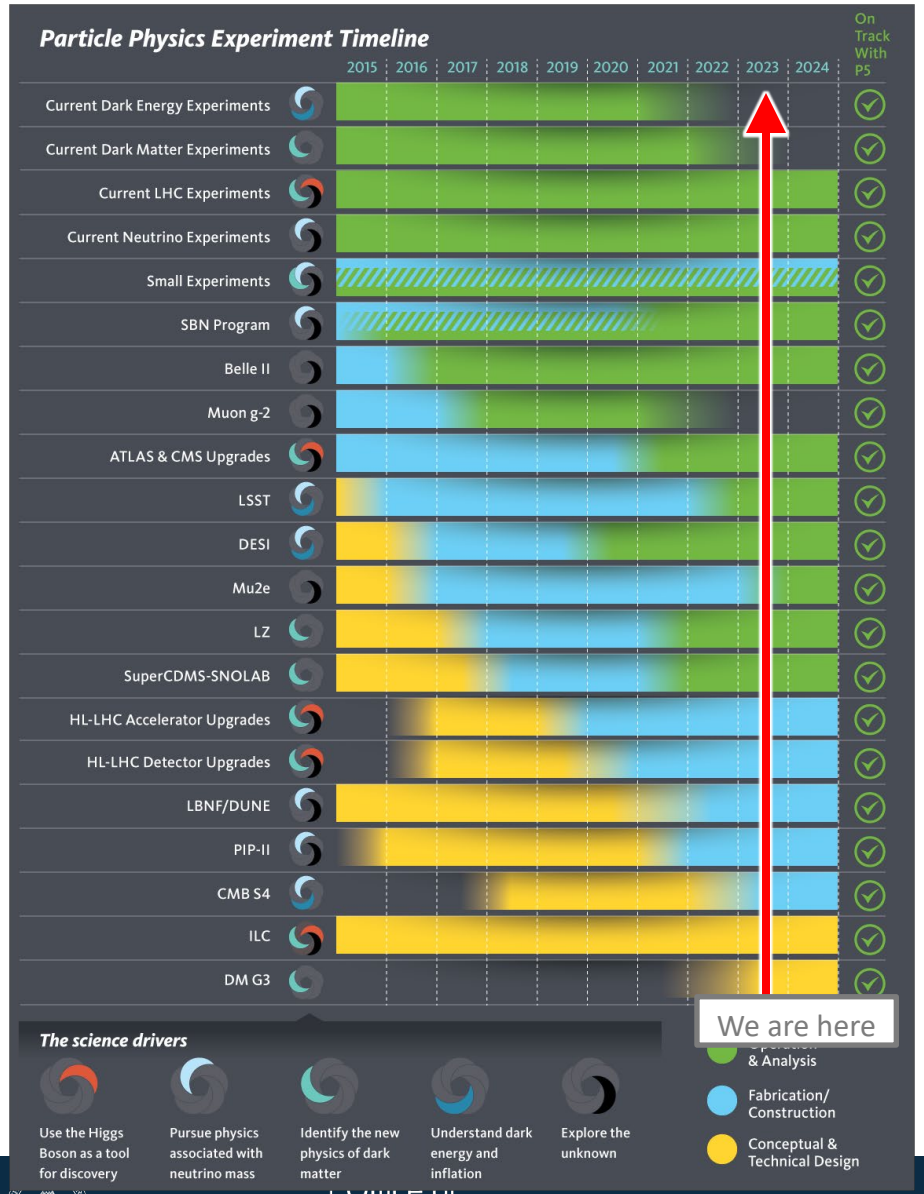
PIER Plans

Promoting Inclusive and Equitable Research

U.S. Particle Physics Strategic Planning Process

- The May 2014 U.S. P5 report was successful because it was **well informed by the science community**, including information from:
  - 2010 New Worlds, New Horizons in Astronomy and Astrophysics
  - 2012 Report of the Subcommittee on Future Projects of High Energy Physics (Japan)
  - 2013 Update of the European Strategy for Particle Physics Report
  - 2013 U.S. Particle Physics Community-driven "Snowmass" process
- Community **engagement continued during** the P5 process:
- P5 report **rollout included targeted engagement** with HEP community, science interested public, and decision makers
- Initial and continuing **community support for P5 strategy** has been critical to successful implementation

2014 P5 Implementation Status



Implementation of the 2014 P5 strategy continues

Continuous physics analyses and output throughout the "P5 envisioned" 10-year plan

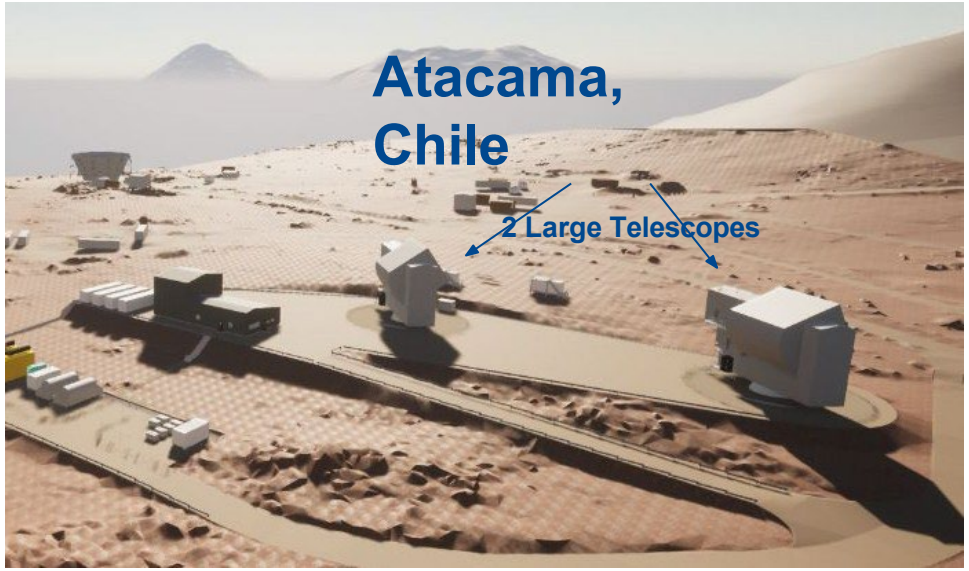
- HL-LHC accelerator and detector upgrade projects underway
- LBNF/DUNE & PIP-II schedules advanced due to strong support by the U.S. Administration & Congress
- DESI, LZ and LSSTCam (for Rubin Observatory) projects completed
- Broad portfolio of small projects running

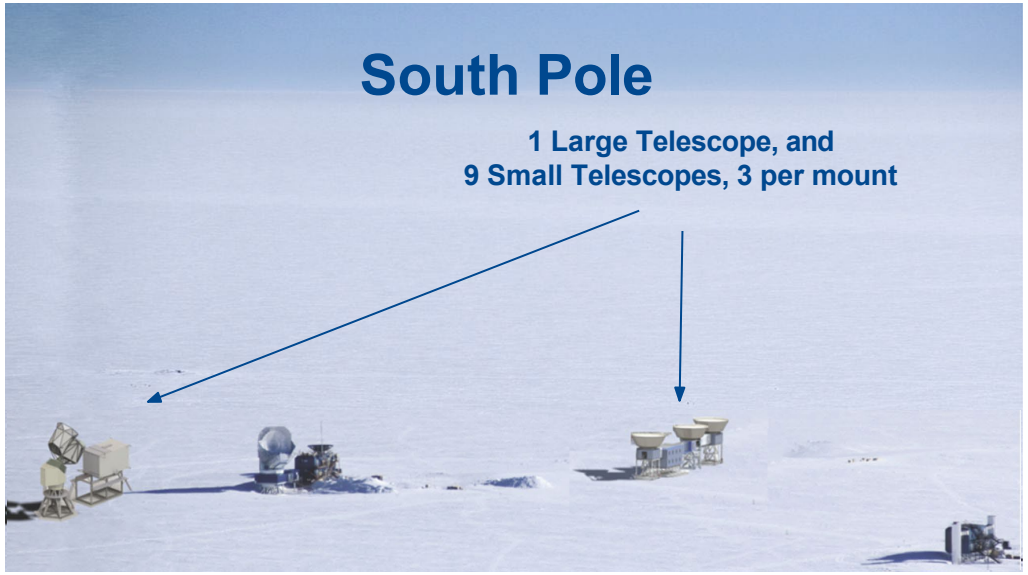
- General assessment – good progress, in spite of Covid delays

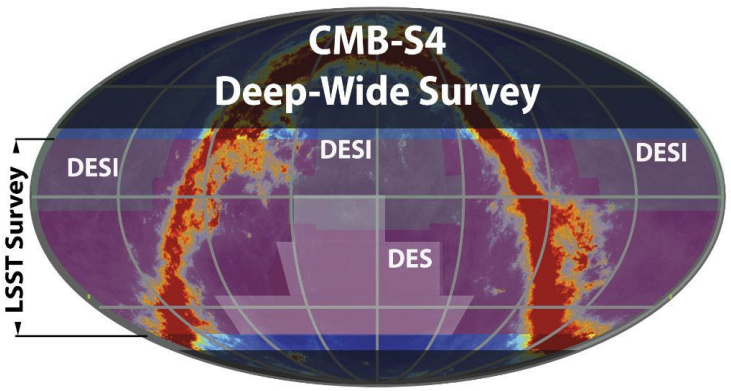
- LSST and Mu2e not yet operating
- CMB-S4 not yet in construction
- Direction for Future Colliders (beyond High Lumi-LHC) undetermined

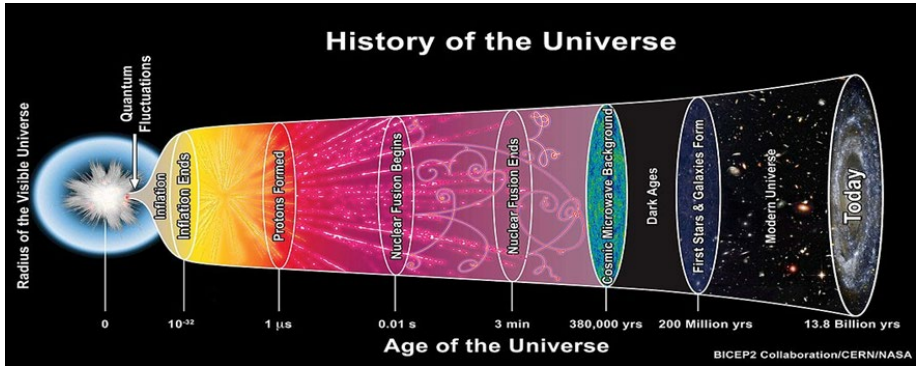
- **Time to update and refresh the plan…**

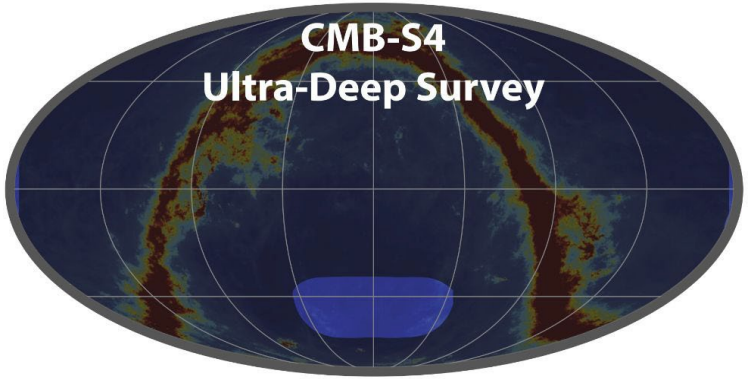
CMB-S4 remains an important component of the program



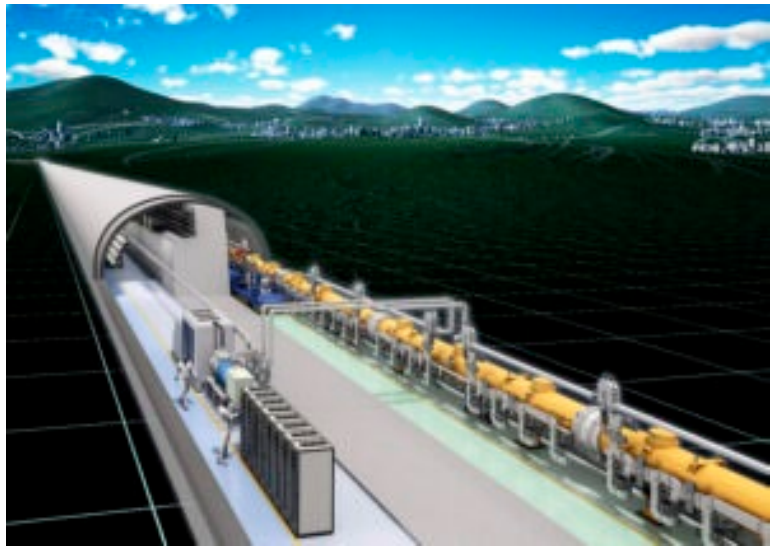


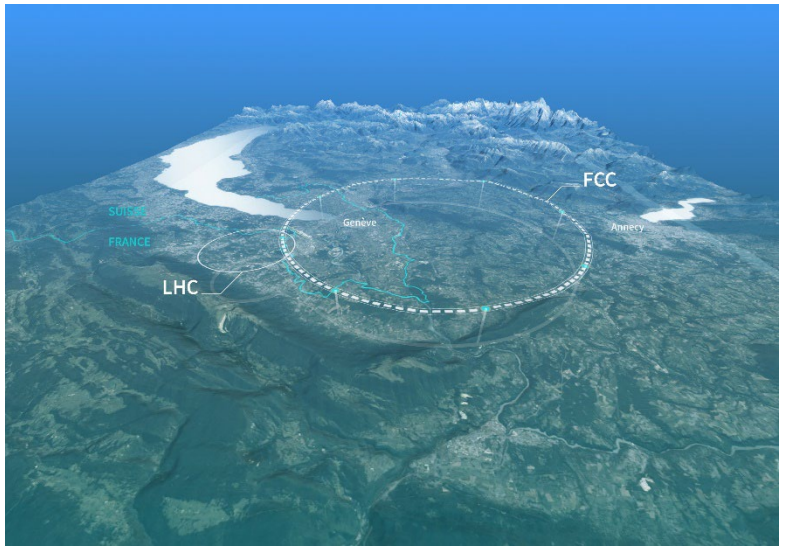


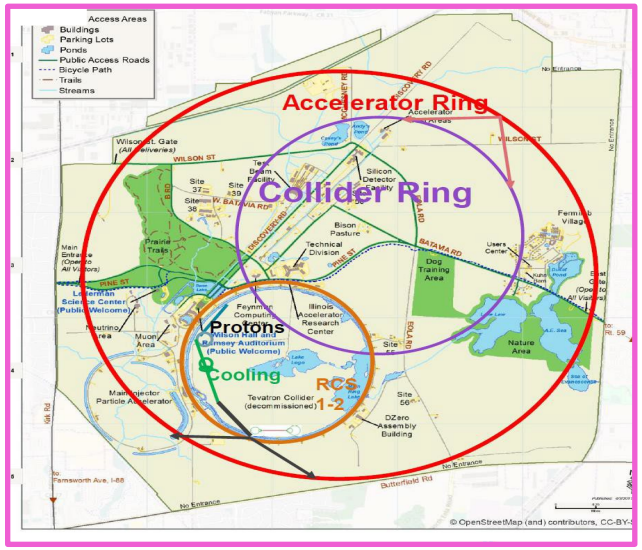


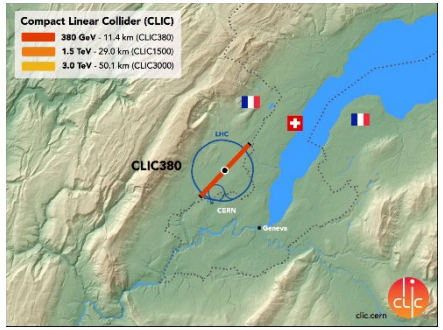


Future Colliders – many options and timelines to consider









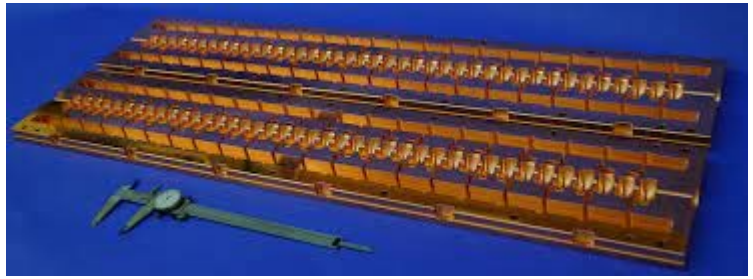
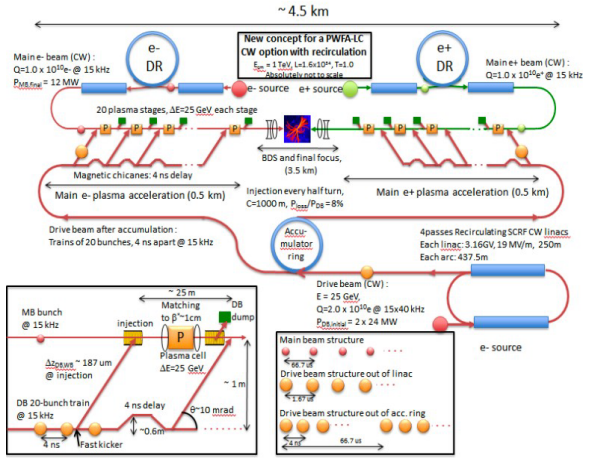
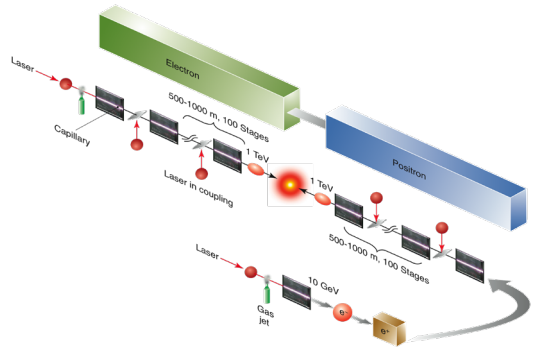


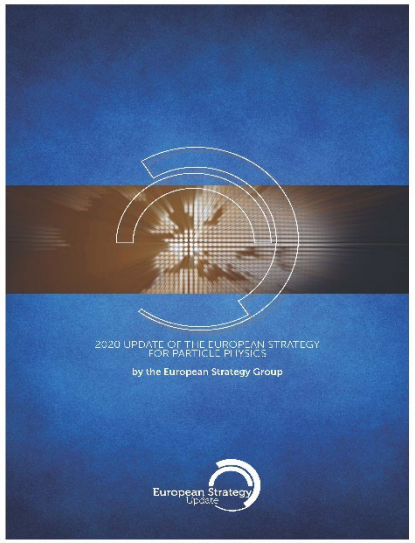
Figure 1: Layout of a 1 TeV PWFA Linear Collider

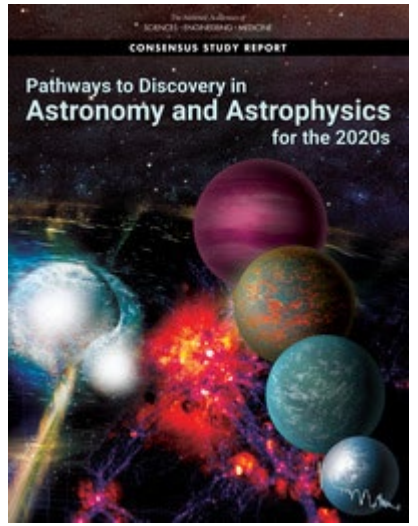


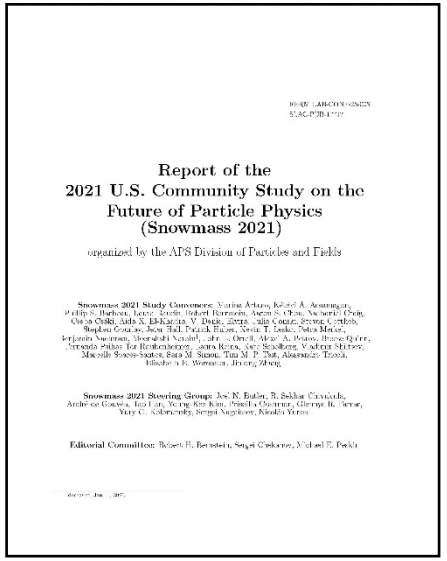


U.S. Particle Physics Strategic Planning Process

- Each of these processes provides important input to the next P5 strategic process
  - Updated 2020 European Strategy for Particle Physics
  - NAS Astronomy and Astrophysics Decadal Survey (2021)
  - 2021-2022 Community Snowmass Process
  - New NAS Decadal Survey in Elementary Particle Physics
  - Upcoming HEPAP Report on International Benchmarking
- The next P5 process is currently in progress
  - A P5 report by late 2023 will inform the FY 2025 U.S. budget formulation process






Report of the
2021 U.S. Community Study on the
Future of Particle Physics
(Snowmass 2021)
organized by the APS Division of Particles and Fields

Snowmass 2021

Outlook

- It is an exciting time in High Energy Physics
- We can look forward to a decade or more of exciting data at the Hi-lumi LHC
- The U.S. neutrino program is strong and growing; results from DUNE and Hyper-K should answer some important questions that we have been asking for a long time
- Experiments at the Cosmic frontier are unique, diverse and very exciting
- Our on-going long range planning process should inform our future directions and poise us to continue to answer the important questions about the nature of matter energy, space and time!

Thank you!!!

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