

Perspectives from the U.S. for a Higgs Factory

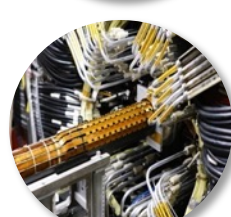
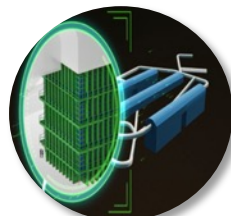
International Workshop on Future Linear Colliders
LCWS 2024 • University of Tokyo • July 8-11, 2024
<https://agenda.linearcollider.org/event/10134/>

Abid Patwa
U.S. Department of Energy
Office of High Energy Physics



U.S. DEPARTMENT OF
ENERGY

Office of
Science



- **DOE-HEP's mission-driven program**
- **Brief recap of the 2023 P5 process and recommendations**
- **Following the P5 rollout, DOE's initial response to recommendations related to a future Higgs factory**
- **DOE's approach to a nationally coordinated program for U.S. participation in an off-shore international Higgs factory**
- **Closing remarks**

What is the DOE HEP Program

DOE Program Model Science Mission-driven

DOE develops and supports a specific portfolio of projects ⇒ emphasis placed on planning, R&D, building experiments, operating, and publishing results

DOE High Energy Physics Mission

- **Discover** the fundamental constituents of matter and energy
- **Probe** the interactions between them
- **Explore** the basic nature of space and time

How do we do this?

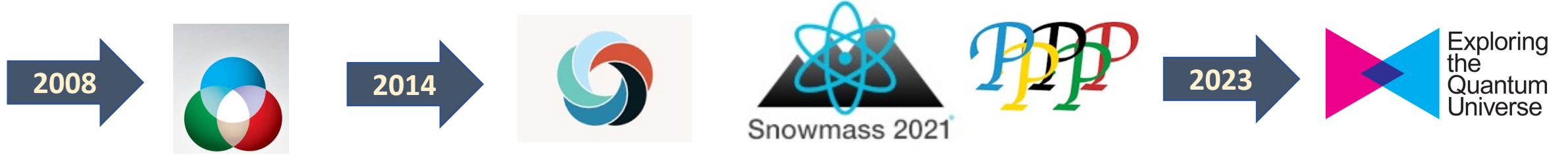
- Make significant, coherent contributions to global facilities/experiments (e.g., LHC/CMS and ATLAS, Rubin/LSST, ...), including project management under DOE project system
- Support science collaborations in all stages ⇒ leading to the best possible science results
- Support technology R&D to advance state-of-the-art particle accelerators and detectors leading to new capable facilities
- Form partnerships with other agencies (e.g., NSF, NASA) and organizations (e.g., CERN, KEK) to help deliver our mission

DOE supports about 80-85% of the U.S. HEP effort (in \$), including the U.S. national laboratories

HEP Program Guidance

- Federal Advisory Committee Act (FACA) panels – official advisory bodies to the U.S. government
- for e.g., High Energy Physics Advisory Panel (HEPAP) provides the primary advice for HEP program to DOE and NSF and includes subpanels for detailed studies (e.g., P5 and HEPAP’s “International Benchmarking Study” subpanel)

U.S. Particle Physics Strategic Planning Process



US Particle Physics:
Scientific Opportunities
A Strategic Plan
for the Next Ten Years

Report of the Particle
Physics Project
Prioritization Panel

29 May 2008

SNOWMASS CSS 2013
ON THE MISSISSIPPI
JULY 29 - AUGUST 6, 2013

FERMLAB-CONF-13-68
SLAC-PUB-1360

**Planning the Future
of U.S. Particle Physics**

Report of the 2013 Community Summer Study
of the APS Division of Particles and Fields

Study Conveners: M. Barden, W. Barletta, L. A. T. Bauerick, R. Brock,
D. Cromm-Hennsey, M. Denarreau, M. Dine, J. L. Feng, M. Gilchriese, S. Gottlieb,
J. L. Hewett, R. Lipton, H. Nicholson, M. E. Peskin, S. Ritz, I. Shipsey, H. Weerts

Division of Particles and Fields Officers in 2013: J. L. Rosner (chair), I. Shipsey
(chair-elect), N. Hadley (vice-chair), P. Ramond (past chair)

Editorial Committee: R. H. Bernstein, N. A. Graf, P. McBride, M. E. Peskin,
J. L. Rosner, N. Varelas, K. Yurkewicz

Building for Discovery
Strategic Plan for U.S. Particle Physics in the Global Context

Report of the Particle Physics Project Prioritization Panel (P5) May 2014

Community Summer Study
SNOWMASS
2022 July 17-26 Seattle

Summaries and
Conveners' Reports

Report of the
**2021 U.S. Community Study
on the
Future of Particle Physics**

Snowmass 2021

Organized by
the Division of Particles and Fields
of the American Physical Society

Edited by
Joel N. Butler
R. Sekhar Chivukula
Michael E. Peskin

Exploring the
Quantum
Universe

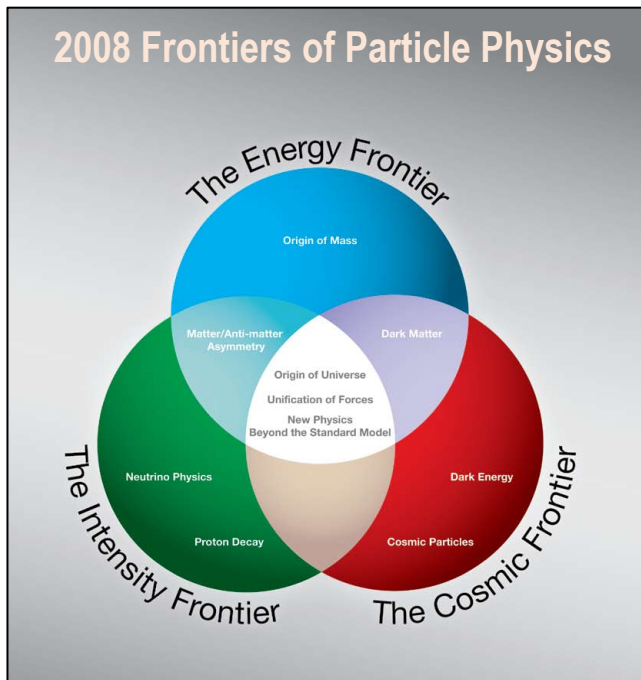
Pathways to Innovation
and Discovery
in Particle Physics

Report of the 2023 Particle Physics Project Prioritization Panel

2023p5report.org

Evolution of the Key Questions in Particle Physics

2008 Frontiers



2014 Science Drivers

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

2023 Science Drivers

Exploring the Quantum Universe

- Reveal the Secrets of the Higgs Boson
- Elucidate the Mysteries of Neutrinos
- Determine the Nature of Dark Matter
- Understand What Drives Cosmic Evolution
- Search for Direct Evidence of New Particles
- Pursue Quantum Imprints of New Phenomena

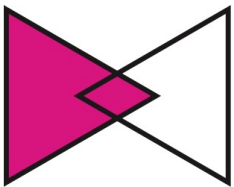
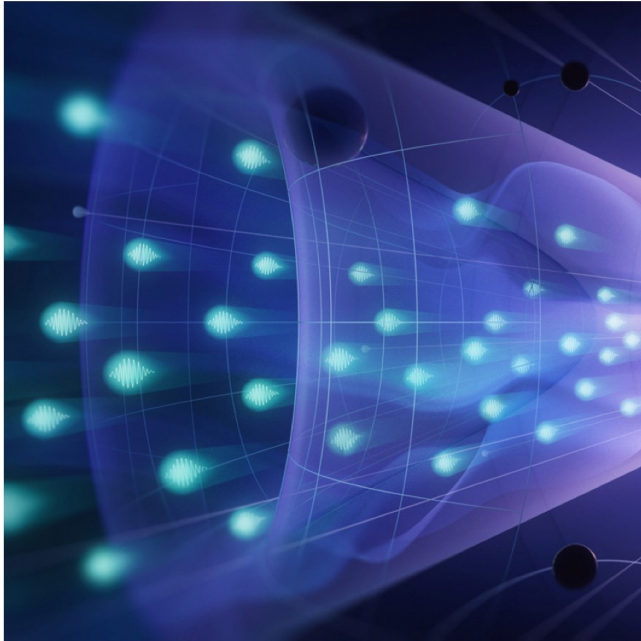
Icons and associated goals:

- Decipher the Quantum Realm
- Illuminate the Hidden Universe
- Explore New Paradigms in Physics

Ref.: [U.S. Particle Physics](#)

2023 P5 Strategy:

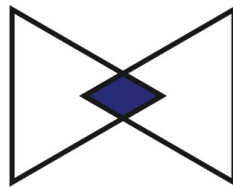
3 Science Themes and 6 Science Drivers or Focus Areas



Decipher
the
Quantum
Realm

Elucidate the Mysteries
of Neutrinos

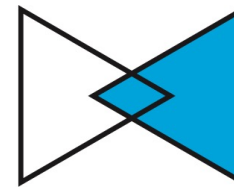
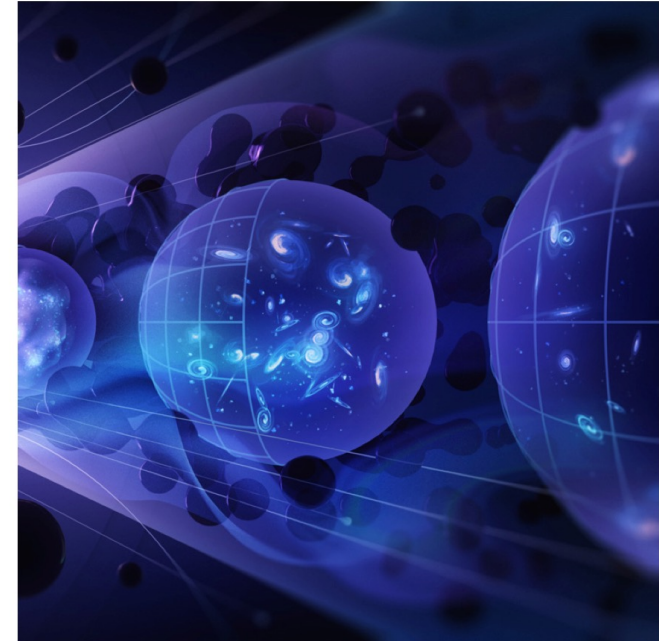
Reveal the Secrets of
the Higgs Boson



Explore
New
Paradigms
in Physics

Search for Direct Evidence
of New Particles

Pursue Quantum Imprints
of New Phenomena



Illuminate
the
Hidden
Universe

Determine the Nature
of Dark Matter

Understand What Drives
Cosmic Evolution

2023 P5 Strategy:

3 Science Themes and 6 Science Drivers or Focus Areas

- **Energy Frontier**
 - **Reveal the Secrets of the Higgs, Search for Direct Evidence of New Particles, Pursue Quantum Imprints of New Phenomena, and Determine the Nature of Dark Matter**
- **The U.S. is now transitioning from the 2014 P5 to the updated 2023 P5 strategy, which is to be executed over the next 10-year timeframe in the context of a 20-year, globally aware strategy for the field**
- **For Energy Frontier, the 2023 P5 re-affirmed 2014 P5's recommendation for the LHC and HL-LHC, including the HL-LHC ATLAS and CMS detector upgrades as well as the HL-LHC accelerator upgrade (Ref. Rec. 1a of the 2023 P5 report)**
- **Under any available budgets, DOE-HEP coordinating plans to implement a future Higgs factory portfolio (Ref. Rec. 2c and 6a; more next slides...)**

Reveal the Secrets of
the Higgs Boson

Pursue Quantum Imprints
of New Phenomena

Understand What Drives
Cosmic Evolution



From 2023 P5:

- **Recommendation 2, Priority #3 out of 5:** An **off-shore Higgs factory**, realized in collaboration with international partners, in order to reveal the secrets of the Higgs boson. **The current designs of FCC-ee and ILC meet our scientific requirements.** The U.S. should actively **engage in feasibility and design studies.** Once a specific project is deemed feasible and well-defined (see also P5 Recommendation 6), the U.S. should aim for a contribution at funding levels commensurate to that of the U.S. involvement in the LHC and HL-LHC, while maintaining a healthy U.S. on-shore program in particle physics (P5 section 3.2).
- **Recommendation 6:** Convene **a targeted panel** with broad membership across particle physics later this decade that makes decisions on the U.S. accelerator-based program **at the time when major decisions concerning an off-shore Higgs factory are expected**, and/or significant adjustments within the accelerator-based R&D portfolio are likely to be needed. A plan for the Fermilab accelerator complex consistent with the long-term vision in this report should also be reviewed. The panel would consider the following:
 - a) The level and nature of U.S. contributions in a specific **Higgs factory** including an evaluation of the associated schedule, budget, and risks once crucial information becomes available.
 - b) Mid- and large **test and demonstrator facilities** in the accelerator and collider R&D portfolios.
 - c) A plan for the **evolution of the Fermilab accelerator complex** consistent with the long-term vision in this report, which may commence construction in the event of a more favorable budget situation.

DOE does not envision a single panel to address Recommendation 6; rather we plan to work with NSF, the DOE national labs, and community-at-large to convene three separate panels that each will address one of the topics.

- Last year and earlier this year, KEK (Japan) requested that DOE support ILC development efforts through the ILC Technology Network (ITN)
- In February 2024, we discussed our approach with MEXT (Japan) to be “observers” in the ITN while considering, at some fraction, associated R&D efforts under our existing U.S.-Japan Cooperation Program in HEP
 - The U.S.-Japan Cooperation Program in HEP is codified under our bilateral DOE-MEXT Project Arrangement agreement, signed in 2015
 - Our current observer status in ITN is mainly due to fiscal budget constraints at DOE-HEP for 2024 and those foreseen for 2025
 - DOE-HEP and KEK met this past May for the U.S.-Japan Cooperation Program to identify and support a modest subset of proposals related to linear accelerator-driven technology efforts
- In March 2024, we presented DOE's view on participating in any potential FCC-ee to the CERN Council

- **Through interagency coordination in the United States – led by The White House Office of Science and Technology Policy (OSTP) – a Joint Statement of Intent was signed at The White House in April 2024 between the U.S. Government and CERN**
 - Interagency coordination by OSTP included the U.S. Department of State, DOE, the National Science Foundation (NSF), and NASA
- **Among the topics, the Statement expresses an intent for the United States to collaborate on the FCC-ee construction and physics exploitation should the CERN Member States determine it is likely to be CERN’s next major research facility following the HL-LHC**
- **It also reaffirms our continued collaboration with CERN and our international partners in the ongoing FCC feasibility study**

Joint Statement of Intent between The United States of America and The European Organization for Nuclear Research concerning Future Planning for Large Research Infrastructure Facilities, Advanced Scientific Computing, and Open Science

OTHER RELEASE

BUREAU OF OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS

APRIL 26, 2024

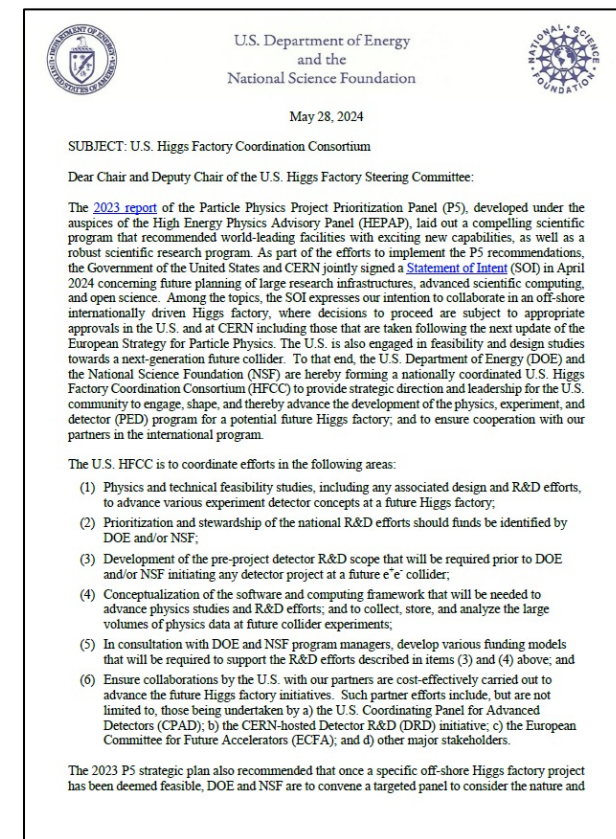
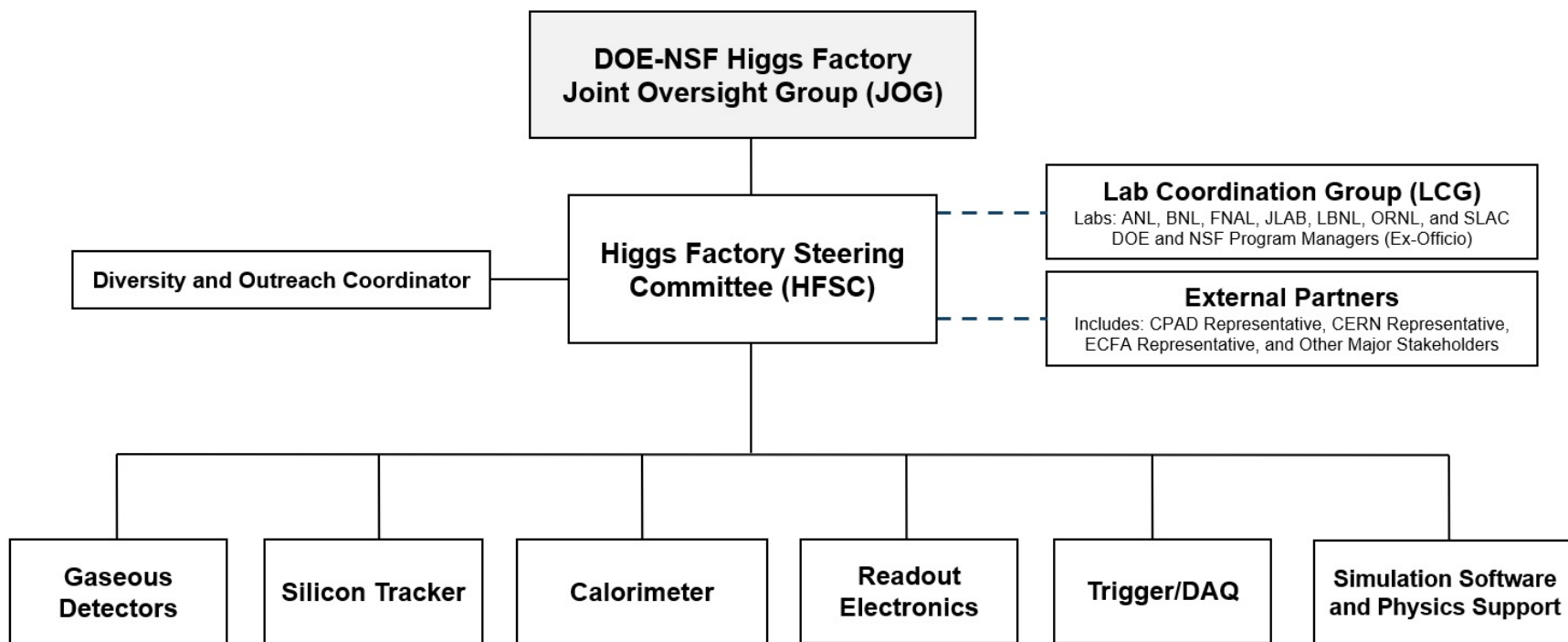


The text of the statement was released by the Government of the United States of America and the European Organization for Nuclear Research (CERN), an Intergovernmental Organization having its seat at Geneva, Switzerland. White House Office of Science and Technology Policy Principal Deputy U.S. Chief Technology Officer Deirdre Mulligan signed for the United States while Director-General Fabiola Gianotti signed for CERN.

- Text available at: [U.S. Department of State Remarks & Releases site](#)
- Statement aligned with P5: should FCC-ee receive a “green-light” following the next update of the European Strategy, the U.S. intends to collaborate; and the nature of the contributions to be discussed by the targeted panel prescribed in 6.a

U.S. Organization for Higgs Factory Coordination and Development – PED (I)

- Jointly, DOE and NSF recently issued a charge forming a **nationally coordinated U.S. Higgs Factory Coordination Consortium (HFCC)** to coordinate and develop the **physics, experiments, and detectors (PED) program**
 - U.S. HFCC includes: 1) Higgs Factory Steering Committee (HFSC); 2) a Lab Coordination Group (LCG); and 3) various detector systems that naturally map onto the CERN Detector R&D (DRD) initiative

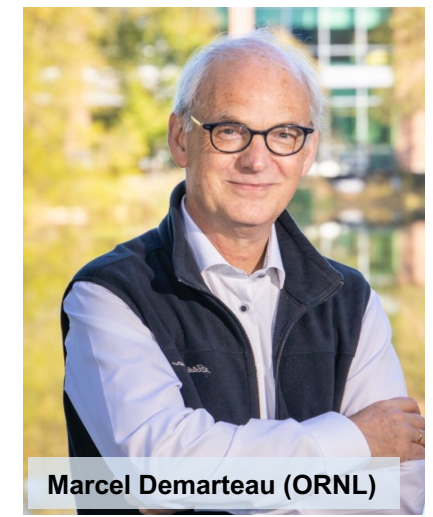


U.S. Organization for Higgs Factory Coordination and Development – PED (II)

- **The Consortium is to ensure that collaborative activities by the U.S. with our international partners are prioritized and cost-effectively carried out for Higgs factory initiatives**
- **The Lab Coordination Group (LCG) is an integral part of the Consortium and includes a representative from each of our DOE national labs:**
 - ANL, BNL, FNAL, JLAB, LBNL, ORNL, and SLAC
 - During the P5 process and soon after the P5 roll-out, these labs expressed an interest to participate in Higgs factory R&D efforts
 - Representatives for the LCG are being identified by the management of each lab
- **Representatives in the Consortium also include external partners and other major stakeholders**
 - Such as those from APS/DPF's Coordinating Panel for Advanced Detectors (CPAD) in the United States and the CERN-hosted Detector R&D (DRD) initiative
- **Various detector systems that report to the Steering Committee**
 - Nominations now progressing for Level-2 and Level-3 R&D coordinator roles

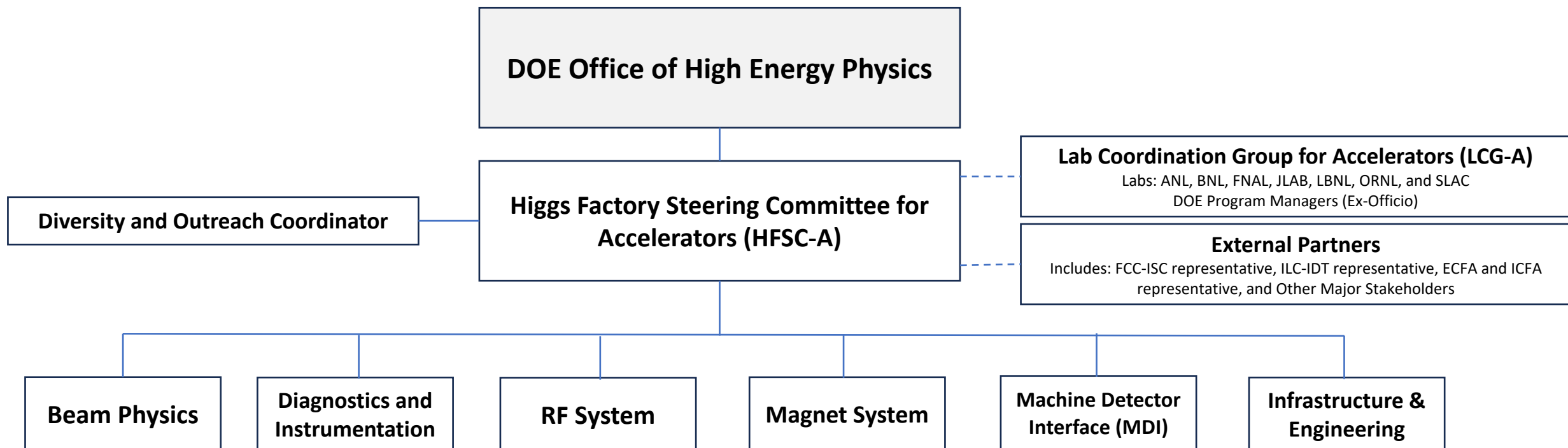
Higgs Factory Steering Committee – PED

- **Goals and tasks of the U.S. HFCC include:**
 - Coordinate U.S. community efforts, **bringing together** both the **linear** and **circular collider communities**
 - To be done during the phase which precedes the development of a specific future project
- **DOE and NSF selected members of the Steering Committee from the leadership of the community-driven FCC-ee P5 input group and the Americas' Linear Collider Community:**
 - Srinji Rajagopalan (*Chair*); Sarah Eno
 - Ritchie Patterson (*Deputy Chair*); Marcel Demarteau
- **No lead DOE laboratory is designated for this Consortium**
 - Each lab collaborating in Higgs factory efforts is represented through the Lab Coordination Group



U.S. Organization for Higgs Factory Coordination and Development – Accelerators

- DOE plans to issue a charge later this month [July] that forms a **nationally coordinated U.S. Higgs Factory Coordination Consortium (HFCC)** for developing the **accelerators program**
 - In general, similar structure as the U.S. HFCC for PED; includes appropriate partners and accelerator systems
 - Membership in the Higgs Factory Steering Committee for Accelerators (HFSC-A) is being finalized now, and leaders are to be identified soon.

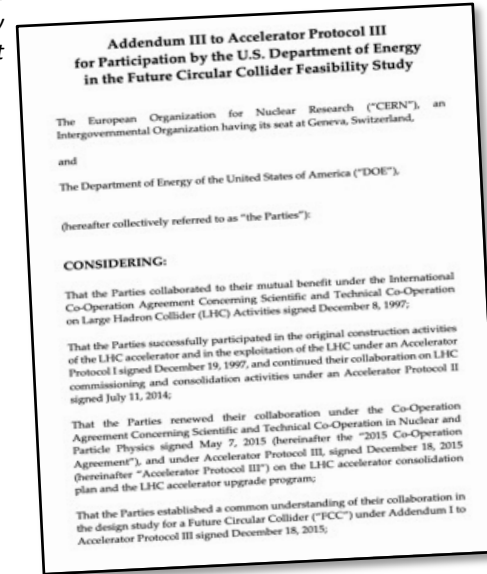


- **Efforts to be coordinated under each respective Consortia include:**
 - Physics and technical feasibility studies, including associated design and R&D efforts, to advance the accelerator (HFCC-A) and the various experimental detector concepts (HFCC-PED) at a future e^+e^- collider
 - Prioritization and stewardship of national R&D efforts under any available funding
 - Pre-project R&D prior to DOE (for PED and Accelerators) and/or NSF (for PED) initiating any associated detector or accelerator projects in the U.S.
 - Conceptualization of appropriate software and computing framework to advance the respective physics, experiments, and accelerator

- **Correspondingly, each U.S. HFCC – PED and Accelerators – will be positioned to inform deliberations of the future targeted panel envisioned by P5 (i.e., P5 Rec. 6a)**
 - One that will consider the specific nature of U.S. contributions in a future Higgs factory, and which is to convene following completion of the next European Strategy for Particle Physics update process

Some additional words on DOE advancing future colliders ...

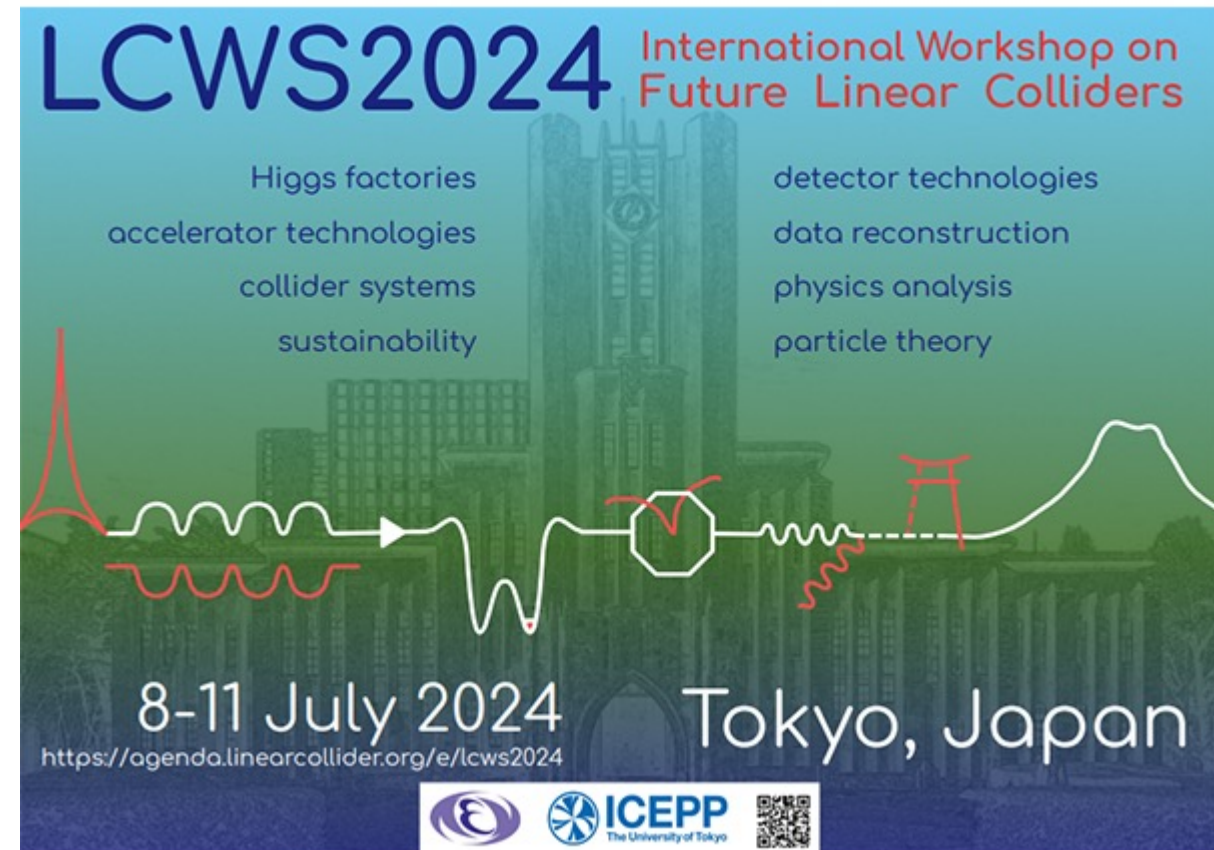
December 2020:
DOE-CERN FCC Feasibility Study
Agreement



- **Advancing colliders of the proposed size, scale, and complexity requires interagency, intergovernmental discussions and global coordination**
 - Continuing concerted U.S. Government interagency effort initiated ~8 years ago to support moving forward and advance a future collider
- **Following the 2020 European Strategy for Particle Physics update, DOE and CERN signed an FCC agreement to collaborate in the FCC feasibility study for the proposed 80-100 km collider in Swiss-French area**
- **DOE continues to coordinate with the ILC International Development Team, formed by ICFA in 2020, that is guiding the future of the ILC**
- **In the near-term – *i.e.*, this fiscal year and next – as DOE works to support nationally-coordinated R&D efforts towards future e^+e^- collider initiatives**
 - Key constraint is the FY 2024 and [foreseen] 2025 fiscal budgets, which currently are heavily constrained
 - Priority is to support LHC and HL-LHC efforts (*i.e.*, 2023 P5 Rec. #1a)
- **Should funds be available for design studies and targeted R&D efforts, DOE intends to rely on each U.S. HFCC (PED and Accelerators) for its prioritization and stewardship**

Closing Remarks

- **The U.S.-Japan Cooperation Program in HEP is long-standing and strong**
 - We will continue to work with our KEK colleagues to enhance support of proposed efforts that advance linear accelerator-related technology initiatives
- **The U.S. also has a strong and long-standing collaboration with CERN and plans to carry this partnership far into the future**
 - We look forward to continuing our discussions with CERN to advance the development and realization of the future collider hosted at CERN
- **The 2023 P5 report provides a strategic vision for an exciting path into the future of particle physics**
 - It reaffirms and recommends projects and programs undertaken in a globally aware collaborative context
 - Provides a long-term vision that will take long-term planning



LCWS2024 International Workshop on
Future Linear Colliders

Higgs factories
accelerator technologies
collider systems
sustainability

detector technologies
data reconstruction
physics analysis
particle theory

8-11 July 2024 Tokyo, Japan

<https://agenda.linearcollider.org/e/lcws2024>

ICEPP
The University of Tokyo

The poster features a background illustration of a city skyline with a particle detector and a red torii gate. It includes a list of topics, the event dates and location, a URL, and logos for the University of Tokyo and ICEPP.



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Prescriptive P5 Area Recommendations

P5 Recommendation	Funding/year (\$M)
ASTAE Initiative	35
Detector R&D	20
HEP Theory	15
General Accelerator R&D	10
Energy Frontier Detectors	20
Energy Frontier Accelerator	35
TOTAL	135

DOE Office of High Energy Physics (HEP)	
FY 2024 Enacted Budget (\$M)	1,200
FY 2025 President's Budget Request (\$M)	1,230
Initiative Fraction	11%

- The 2023 P5 Area Recommendations for budgets is >10% of the current DOE-HEP annual budget. At this moment, 10% increases in the budget look very unlikely.
- Our analysis shows the ASTAE (Advancing Science and Technology through Agile Experiments) funding can support a steady stream of one new project starting per year, so it looks quite appropriate.
- The other recommendations have not yet been fully studied.
- To prevent continued strain on the core DOE-HEP research budget and facility operations, DOE-HEP will need to build up to these levels as current projects ramp down.
- We need to emphasize that funding priorities will be towards the execution of P5's Recommendation #1.

Budget Scenarios Considered by 2023 P5 Panel

