NSF Perspectives on P5

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Division of Physics
National Science Foundation

HEPAP Meeting - May 9, 2024

First: Thank You, P5!

- For building on Snowmass input, and engaging broadly
- For thinking bold, and taking risks
- Although one of the "P" is for projects, for taking a holistic view of what it takes to deliver the science
- For delivering a map to the scientific opportunities during the next 10 years in a 20-year context

Exploring the Quantum Universe

August 2023. *Photo: Rowena Smith*

A First NSF Perspective on P5

- Today, will provide first NSF perspectives and reactions to the P5 report
- Since we are proposal-driven, the full "NSF response to P5" will be the set of proposals and projects we fund over the next 10 years
- Again, P5 is an opportunity map for us—and like in all maps, there are some destinations that are more difficult to reach than others
- But there are still many places to discover

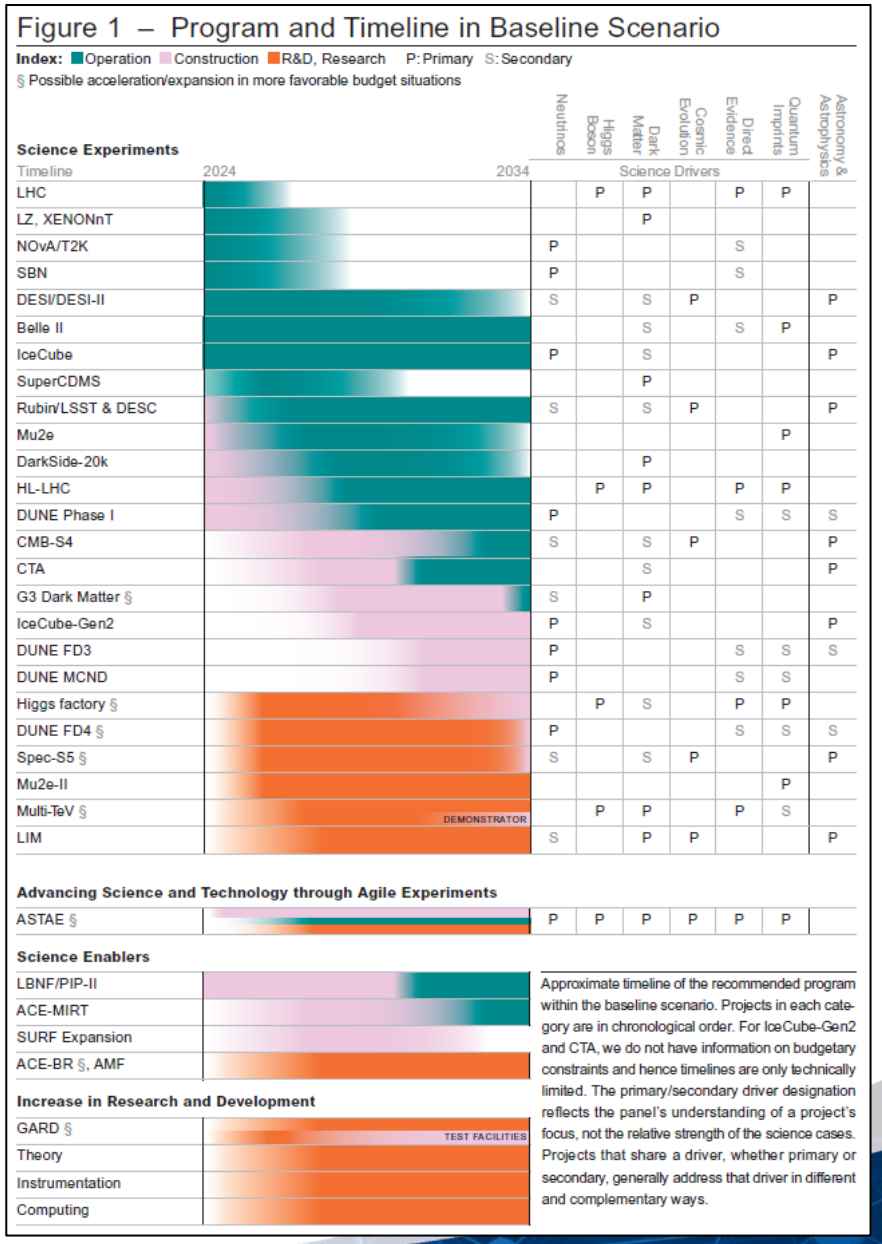


Figure 1 – Program and Timeline in Baseline Scenario

Index: Operation Construction R&D, Research P: Primary S: Secondary

§ Possible acceleration/expansion in more favorable budget situations

	Timeline	Neutrinos	Higgs Boson	Dark Matter	Cosmic Evolution	Direct Evidence	Quantum Imprints	Astronomy & Astrophysics
Science Experiments	2024–2034	Science Drivers						
LHC			P	P		P	P	
LZ, XENONnT				P				
NOvA/T2K		P				S		
SBN		P				S		
DESI/DESI-II		S		S	P			P
Belle II				S		S	P	
IceCube		P		S				P
SuperCDMS				P				
Rubin/LSST & DESC		S		S	P			P
Mu2e							P	
DarkSide-20k				P				
HL-LHC			P	P		P	P	
DUNE Phase I		P				S	S	S
CMB-S4		S		S	P			P
CTA				S				P
G3 Dark Matter §		S		P				
IceCube-Gen2		P		S				P
DUNE FD3		P				S	S	S
DUNE MCND		P				S	S	
Higgs factory §			P	S		P	P	
DUNE FD4 §		P				S	S	S
Spec-S5 §		S		S	P			P
Mu2e-II							P	
Multi-TeV §	DEMONSTRATOR		P	P		P	S	
LIM		S		P	P			P
Advancing Science and Technology through Agile Experiments								
ASTAE §		P	P	P	P	P	P	
Science Enablers								
LBNF/PIP-II								
ACE-MIRT								
SURF Expansion								
ACE-BR §, AMF								
Increase in Research and Development								
GARD §	TEST FACILITIES							
Theory								
Instrumentation								
Computing								

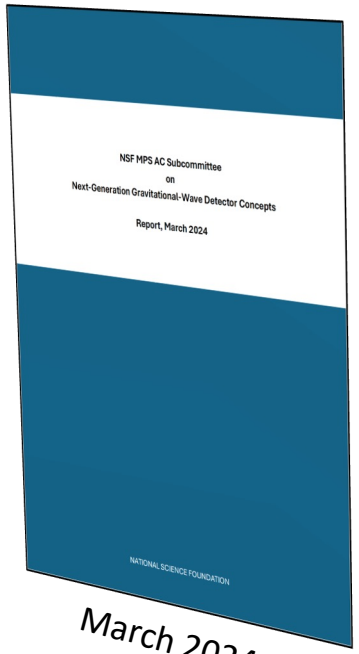
Approximate timeline of the recommended program within the baseline scenario. Projects in each category are in chronological order. For IceCube-Gen2 and CTA, we do not have information on budgetary constraints and hence timelines are only technically limited. The primary/secondary driver designation reflects the panel's understanding of a project's focus, not the relative strength of the science cases. Projects that share a driver, whether primary or secondary, generally address that driver in different and complementary ways.

Context: Particle Physics at the NSF Division of Physics

- Particle Physics within NSF is about 1% of research at the NSF (including research and facilities)
- Primarily funds individual investigators, postdocs, and students at U.S. universities and engineers, computing professionals, and technicians to develop new or maintain existing facilities
- Has strong links to the Astronomy Division, Office of Polar Programs, DOE, CERN
- Is part of a Division that supports many other areas in Physics such as Nuclear Physics, Plasma Physics, Atomic Molecular and Optical Physics, Gravitational Physics, Physics of Living Systems, and Quantum Information Science
  - Experimental and Theoretical approaches
- How do we set priorities? Community-driven in the context of Physics, MPS, and NSF priorities

Community Input to MPS and the Division of Physics

Gravitational Physics

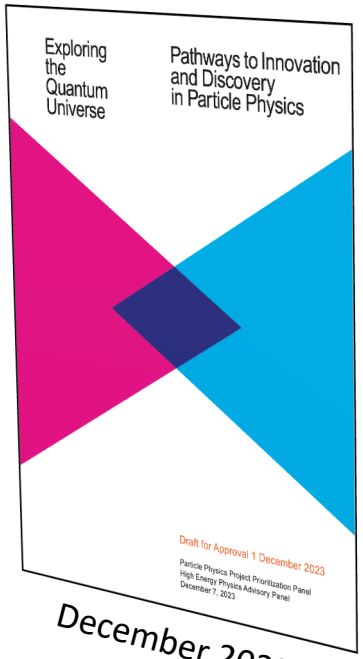


March 2024

Laser Technology

January 2024

Particle Physics

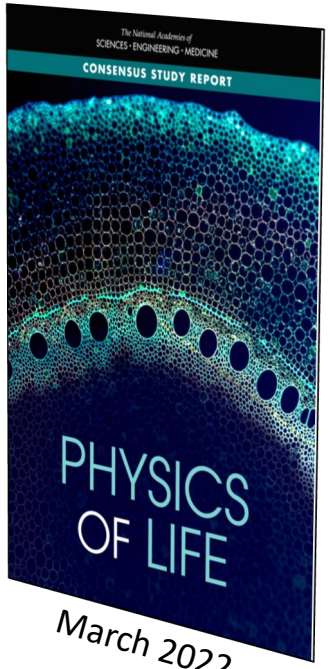


December 2023

Nuclear Physics

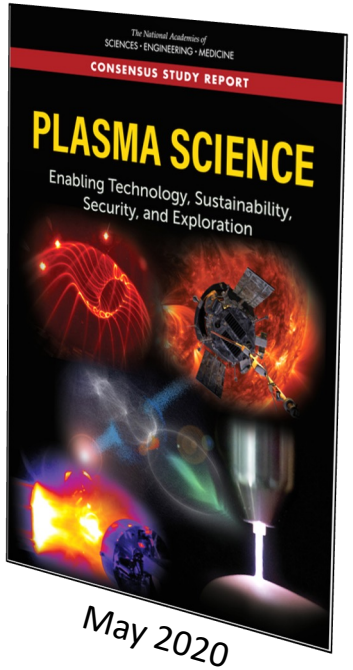
October 2023

Physics of Living Systems



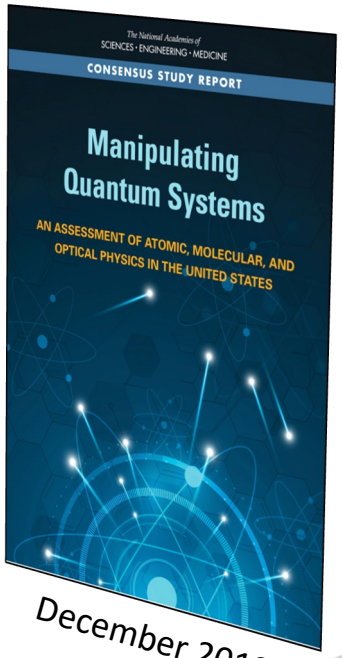
March 2022

Plasma Physics



May 2020

AMO Physics

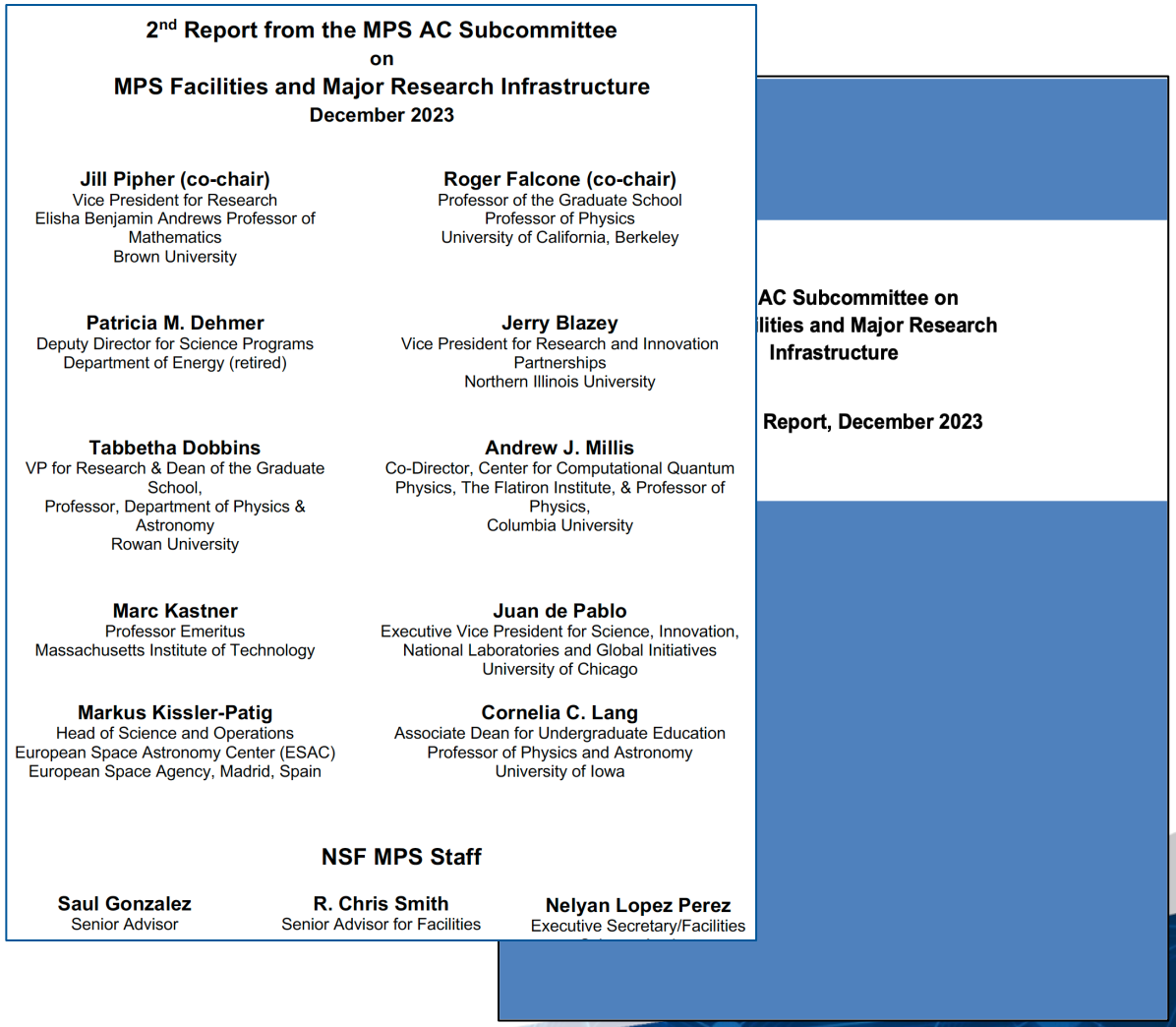


December 2019

Next: NASEM EPP2024

Physics and MPS Project Prioritization

- As the science disciplines push their respective frontiers, the aspiration for research facilities exceeds what budgets can accomodate
- There is thus a need to prioritize across disciplines
- Over a year ago, we charged our MPS Advisory Committee to develop a framework for prioritization.
- Recommendations fall in 3 categories:
  - Science & Technical need and impact
  - Readiness to Proceed
  - Alignment to Broader Missions



2nd Report from the MPS AC Subcommittee
on
MPS Facilities and Major Research Infrastructure
December 2023

Jill Pipher (co-chair)
Vice President for Research
Elisha Benjamin Andrews Professor of Mathematics
Brown University

Roger Falcone (co-chair)
Professor of the Graduate School
Professor of Physics
University of California, Berkeley

Patricia M. Dehmer
Deputy Director for Science Programs
Department of Energy (retired)

Jerry Blazey
Vice President for Research and Innovation Partnerships
Northern Illinois University

Tabbetha Dobbins
VP for Research & Dean of the Graduate School,
Professor, Department of Physics & Astronomy
Rowan University

Andrew J. Millis
Co-Director, Center for Computational Quantum Physics, The Flatiron Institute, & Professor of Physics,
Columbia University

Marc Kastner
Professor Emeritus
Massachusetts Institute of Technology

Juan de Pablo
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AC Subcommittee on
lities and Major Research
Infrastructure

Report, December 2023

Caveats for what follows

- Will provide you an NSF perspective on the recommendations that we are ready to provide comment.
- Will comment on the six main recommendations, including many of the sub-recommendations.
- But not all sub-recommendations—I will skip those not directly related to NSF or those we will comment on later, including the "Area recommendations"
- We will come back to other ones at a future HEPAP meeting
- This is the collective view of the Division.

P5 Recommendation 1

P5: *As the highest priority independent of the budget scenarios, complete construction projects and support operations of ongoing experiments and research to enable maximum science.*

a) through g): HL-LHC, DUNE, Vera C Rubin, IceCube, DarkSide-20k, LHCb…

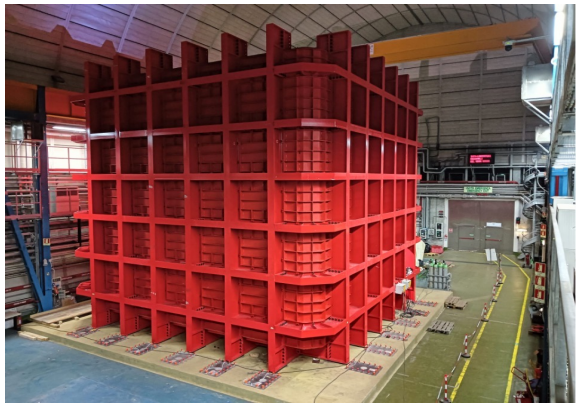
NSF perspective: Yes, absolutely. Let's complete ongoing projects and extract as much science as we can from existing or soon-to-start facilities

IceCube Upgrade

Image Credit: IceCube Upgrade

Vera C. Rubin

DarkSide-20k



The DarkSide-20k experiment (arxiv.org)

LHCb

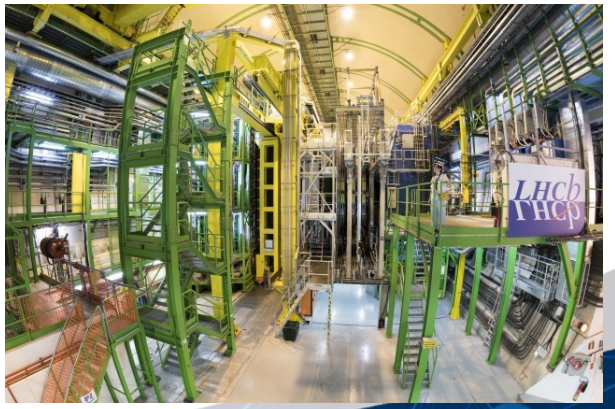


Image Credit: CERN

P5 Recommendation 2

P5: *Construct a portfolio of major projects that collectively study nearly all fundamental constituents of our universe and their interactions, as well as how those interactions determine both the cosmic past and future. [in priority order:]*

a) CMB-S4, which looks back at the earliest moments of the universe to probe physics at the highest energy scales. It is critical to install telescopes at and observe from both the South Pole and Chile sites to achieve the science goals

NSF perspective:

- NSF has decided not to move CMB-S4 forward to the Design Stage at this time. Therefore, recommendation 2a) cannot be currently implemented.
- NSF is prioritizing Antarctic infrastructure recapitalization projects, which are necessary to maintain the viability and safe operation of that important resource for future science projects.
- We are working with DOE and will work with the community to explore possible options for CMB science that do not depend on the Antarctic infrastructure.

P5 Recommendation 2 (continued)

P5: *Construct a portfolio of major projects that collectively study nearly all fundamental constituents of our universe and their interactions, as well as how those interactions determine both the cosmic past and future. [in priority order:]*

c) 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 US should actively engage in feasibility and design studies. Once a specific project is deemed feasible and well-defined (see also Recommendation 6), the US should aim for a contribution at funding levels commensurate to that of the US involvement in the LHC and HL-LHC, while maintaining a healthy US on-shore program in particle physics

NSF perspective:

- We agree and our intention is that NSF will play a role in detector development and science exploitation for a future Higgs factory
- We are in conversations with DOE and Higgs Factory community members to chart a joint way forward.
- Recently, USG signed a Statement of Intent with CERN

P5 Recommendation 2 (continued)

P5: *Construct a portfolio of major projects that collectively study nearly all fundamental constituents of our universe and their interactions, as well as how those interactions determine both the cosmic past and future. [in priority order:]*

e) IceCube-Gen2 for study of neutrino properties using non-beam neutrinos complementary to DUNE and for indirect detection of dark matter covering higher mass ranges using neutrinos as a tool

NSF perspective:

- There is currently no defined timescale for IceCube-Gen2, although we know that Antarctic infrastructure needs provides an important constraint.
- Currently, we are focused on completing the ongoing IceCube upgrade. Results from that upgrade will inform any future plans for IceCube-Gen2

P5 Recommendation 3

P5: *Create an improved balance between small-, medium-, and large-scale projects to open new scientific opportunities and maximize their results, enhance workforce development, promote creativity, and compete on the world stage.*

b) Continue Mid-Scale Research Infrastructure (MSRI) and Major Research Instrumentation (MRI) programs as a critical component of the NSF research and project portfolio.

NSF perspective:

- We agree. The FY 2025 President's Budget Request for NSF includes requests for MRI, MSRI-1, and MSRI-2. The Division has benefitted from these programs.

Photo Credits: University of Michigan

P5 Recommendation 3 (continued)

P5: *Create an improved balance between small-, medium-, and large-scale projects to open new scientific opportunities and maximize their results, enhance workforce development, promote creativity, and compete on the world stage.*

c) Support DESI-II for cosmic evolution, LHCb upgrade II and Belle II upgrade for quantum imprints, and US contributions to the global CTA Observatory for dark matter.

NSF perspective:

c) We acknowledge this recommendation (LHCb, CTA). Working with the respective communities, we will consider their plans in the context of budgets and priorities.

P5 Recommendation 4

P5: *Support a comprehensive effort to develop the resources--theoretical, computational, and technological--essential to our 20-year vision for the field. This includes an aggressive R&D program that, while technologically challenging, could yield revolutionary accelerator designs that chart a realistic path to a 10 TeV pCM collider.*

b) Enhance research in theory to propel innovation, maximize scientific impact of investments in experiments, and expand our understanding of the universe

d) Invest in R&D in instrumentation to develop innovative scientific tools

NSF perspective:

b) We acknowledge this recommendations and agree that theory propels the field forward. Enhanced research in theory and in other areas in the Division of Physics would be beneficial.

d) For instrumentation, we see leveraging opportunities in QIS, precision measurements, AI, and multimodal approaches.

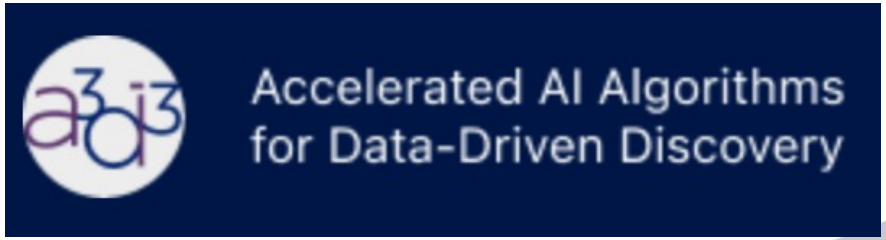
P5 Recommendation 4 (continued)

P5: *Support a comprehensive effort to develop the resources--theoretical, computational, and technological--essential to our 20-year vision for the field. This includes an aggressive R&D program that, while technologically challenging, could yield revolutionary accelerator designs that chart a realistic path to a 10 TeV pCM collider.*

f) Support key cyberinfrastructure components such as shared software tools and a sustained R&D effort in computing, to fully exploit emerging technologies for projects. Prioritize computing and novel data analysis techniques for maximizing science across the entire field

NSF perspective:

f) We agree and have been supporting several significant efforts in this area.



P5 Recommendation 5

P5: *Invest in initiatives aimed at developing the workforce, broadening engagement, and supporting ethical conduct in the field. This commitment nurtures an advanced technological workforce not only for particle physics, but for the nation as a whole.*

a) All projects, workshops, conferences, and collaborations must incorporate ethics agreements that detail expectations for professional conduct and establish mechanisms for transparent reporting, response, and training. These mechanisms should be supported by laboratory and funding agency infrastructure. The efficacy and coverage of this infrastructure should be reviewed by a HEPAP subpanel.

b) Funding agencies should continue to support programs that broaden engagement in particle physics, including strategic academic partnership programs, traineeship programs, and programs in support of dependent care and accessibility. A systematic review of these programs should be used to identify and remove barriers.

NSF perspective:

a) NSF Proposal Preparation Guide (PAPPG) outlines policies that address this both for conference proposals and safe and inclusive working environments for off-site or off-campus research.

b) We agree that broadening engagement and accessibility are important to Physics. We continue programs such as REU, PREP, Ascend fellowships, AGEP-GRS, PHY-GRS (NSF 21-065) and LEAPS. See PHY Broadening Participation. Across the Foundation, other programs such as FASED, etc.

P5 Recommendation 5 (continued)

P5: *Invest in initiatives aimed at developing the workforce, broadening engagement, and supporting ethical conduct in the field. This commitment nurtures an advanced technological workforce not only for particle physics, but for the nation as a whole.*

d) Funding agencies should strategically increase support for research scientists, research hardware and software engineers, technicians, and other professionals at universities.

e) A plan for dissemination of scientific results to the public should be included in the proposed operations and research budgets of experiments. The funding agencies should include funding for the dissemination of results to the public in operation and research budgets.

NSF perspective:

d) This is proposal-driven, budget-driven, and competes with other priorities.

e) We agree and this is generally included in NSF M&O proposals. (Also see https://new.nsf.gov/public-access)

P5 Recommendation 6

P5: *Convene a targeted panel with broad membership across particle physics later this decade that makes decisions on the US 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 US contribution in a specific Higgs factory including an evaluation of the associated schedule, budget, and risks once crucial information becomes available.

NSF perspective:

a) We will work with DOE to address this recommendation.

Conclusion: The View from NSF

- We must maximally exploit existing and new facilities
- There is a shift in the center of gravity of the field from collider techniques to cosmo/astro techniques. We heard that message and are thinking about how to follow that shift to these scientific opportunities.
    - This is healthy because it means the particle physics is dynamic, chasing the science, not the tools themselves. (see EPP2024 charge!)
- However, much community interest in Higgs factory and muon collider development
- There are opportunities for instrumentation development and cyberinfrastructure tools by leveraging emerging technologies and allied fields
- The neutrino sector is as intriguing and important as ever.
- There are budgetary constraints and technically-limited infrastructure constraints, so need to be realistic about what can be done when and where.
- We are excited about the future of particle physics!

Particle Astrophysics Permanent Position Vacancy at NSF: https://www.usajobs.gov/job/787468700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