



# U.S. High Energy Physics Program HEPAP View



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U.S. – Japan Collaboration  
April 2021

# Remembering Sandip Pakvasa



*Sandip Pakvasa  
1935 – 2020  
a hui hou*

Sandip was a distinguished theoretical physicist, an esteemed colleague and a treasured friend. He was a member of the Hawaii faculty for 46 yrs.

He made incisive contributions to neutrino physics and to the physics of flavor and CP violation, connecting theory to experiment and known for his mentorship of early career scientists.

# U.S. HEP Strategic Planning Process

The U.S. High Energy Physics program is guided by the strategic plan laid out in the 2014 P5 report

## Community Driven Strategic Process

- **“Snowmass” 2013**: a year-long community-wide study of science opportunities, organized by the Division of Particles and Fields of the American Physical Society
- **Particle Physics Project Prioritization Panel (P5) 2014**: High Energy Physics Advisory Panel (HEPAP) subpanel, prioritized scientific opportunities outlined in the Snowmass study within a budget framework

## Dovetailed with

- 2010 Astronomy & Astrophysics Decadal Survey
- 2013 European Strategy for Particle Physics

Process defines strategic plan for U.S. HEP for the decade

# Particle Physics Project Prioritization Panel (P5)



Scientific advisory panel (subpanel of HEPAP) tasked to develop a strategic HEP plan to be executed in 10-yr timeframe, in the context of a 20-yr global vision for the field

Examine current, planned and proposed research capabilities and assess

- Role & potential for scientific advancement
- Uniqueness & scientific impact in global context
- Time & required resources to achieve stated goals

Provided with 3 budget scenarios to work within

- Necessitated hard choices

Community “Snowmass” study served as invaluable input

# Signals that time was right for a new P5

## Physics landscape changed

- Higgs discovered at relatively low mass
- Key neutrino mixing angle measured to be large
- New technology & innovative approaches
- 3 Nobel prizes: CKM, Higgs, Dark Energy

These demonstrate importance of diversity of topics and scale

## Programmatic Changes

- Tevatron and B-Factor ceased operations
- Budgets more constrained than considered by last P5 (2008)
- International considerations

Success of 2013 “Snowmass”

Context important when considering next P5



# Principal Conclusions of Report

## Particle Physics is Global

- The U.S. and major players in other regions can together address the full breadth of the most urgent science questions if each hosts a unique world-class facility at home and partners in high-priority facilities hosted elsewhere
- Reliable partnerships are essential for the success of international projects

## Urgent science questions drive the field forward

- Vision for addressing the science drivers using a select set of prioritized experiments

Mix of projects of all scales

Balance Research, Operations & Projects

29 Recommendations in the report

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



# The P5 plan in one glance: Building for Discovery



## Centered on 5 Science Drivers

- Higgs Boson is a tool for discovery
- Physics Associated with Neutrino Mass
- Identify the Physics of Dark Matter
- Understanding Cosmic Acceleration
- Exploring the Unknown

Science drivers are not prioritized

They are intertwined and dependent on each other

Vision to address the science drivers represents the P5 plan



Blue Construction, Green Ops

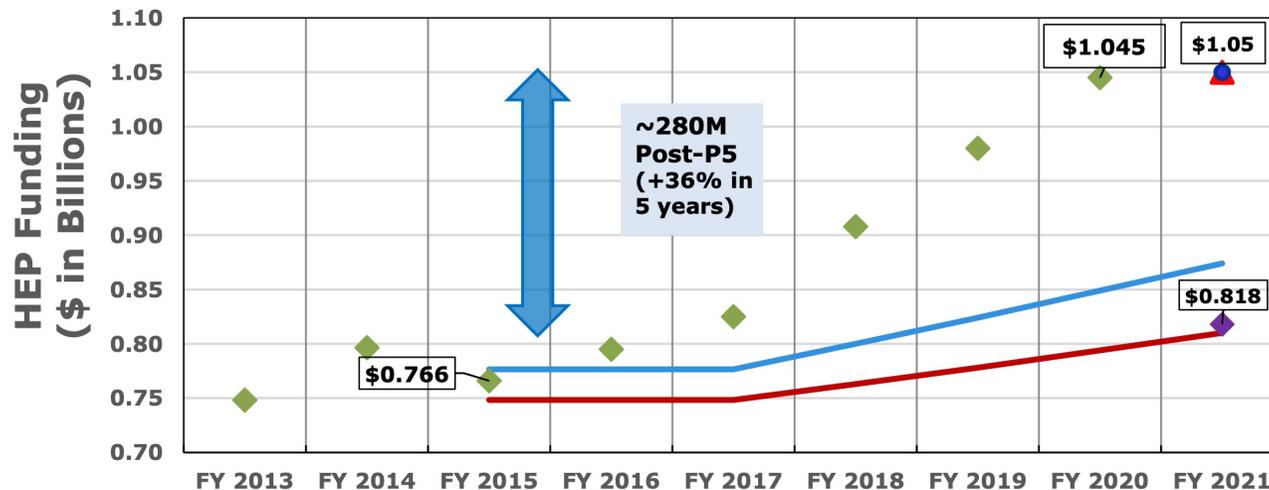
# U.S. Administration and Congress support the P5 Plan

## Spawned numerous U.S. International agreements

- U.S. – CERN Agreement, May 2015
- UK – U.S. Science & Technology Agreement, Sep 2017
- DOE-DAE Project Annex II on Neutrino Research, Apr 2018
- U.S. – Italy Neutrino Agreement, Jun 2018
- ...
- U.S. – CERN FCC and HL-LHC Agreement, Dec 2020



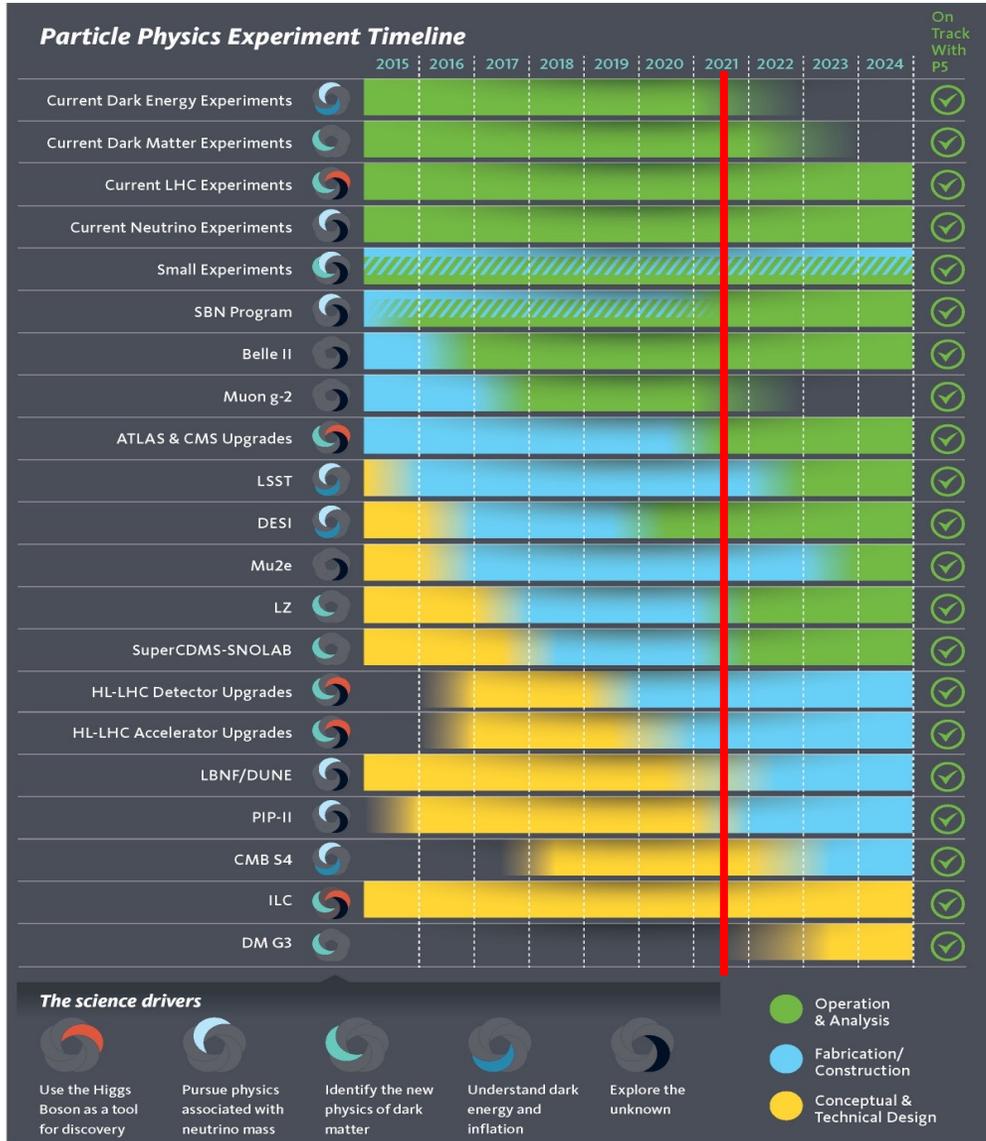
CERN – FNAL HL LHC Agreement, Mar 2021



## Strong Congressional Support

DOE HEP Budget has increased by 36% since 2014 P5 Plan

# P5 Plan in 2021: 7 yrs into the Plan



## P5 projects report card:

5 Projects have been completed (and transitioned to operations)

- Muon g-2, Phase I ATLAS, Phase I CMS
- CD-4 in 2020: DESI and LZ

5 Projects are past CD-3 (Readiness for transition to operations)

- CD-4 expected in summer 2021: FACET-II, LSSTCam
- HL-AUP, Mu2e, Super-CDMS

4 Projects past CD-1

- HL-ATLAS, HL-CMS – started on schedule
- LBNF/DUNE, PIP-II - schedules advanced due to strong support by Administration & Congress

2 Projects past CD-0

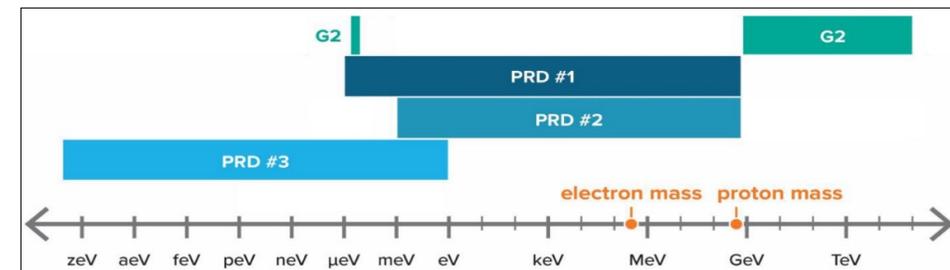
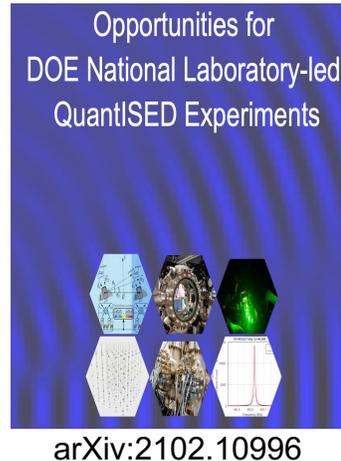
- CMB-S4 – LBNL named lead-lab
- Accelerator Control Operations and Research Network at FNAL

Broad portfolio of small projects from R&D phase to operations

# New Programs since P5: Science is Dynamic!

New programs envisioned by small projects portfolio in 2014 P5 report

- **Quantum Information Science**
  - 2018/2019 QuantISED program transitioning to stable research plan
  - 5 DOE National QIS Research Centers awarded in 2020 with strong HEP participation
  - Opportunities for DOE QuantISED experiments
- **Artificial Intelligence/Machine Learning**
  - Emergent new program
- **Dark Matter New Initiatives**
  - R&D Funded for 6 novel small-exp't concepts
  - 3 Priority Research Directions identified in 2018
  - **There is more to Dark Matter than WIMPS!**



# HEPAP 2019 Assessment on P5 Plan Progress

## Year-long evaluation of progress, halfway into plan's decadal horizon

- Status of the implementation of the P5 vision
- Status of the science drivers in 2019
- Checks and balances in carrying out the plan

## Criteria for Evaluation

- Realization of science impact
- Engagement of global partners
- Sustained productivity – science results and construction of projects
- Balance of project scales
- Balance of components: research, operations, & projects

## HEPAP Assessment of Progress on 2014 P5 Report

In 2019, halfway through the 10-year strategic plan for U.S. particle physics presented in the 2014 report of the Particle Physics Project Prioritization Panel (P5), the High Energy Physics Advisory Panel (HEPAP) evaluated the plan's implementation. The review concluded that the U.S. Department of Energy (DOE) and National Science Foundation (NSF) have successfully carried out the first five years of the plan, which focused on construction of experimental facilities. Going forward, reviewers said, it will be important to fully support plans for operating those facilities and provide adequate research support to the particle physics community for carrying out the remainder of the plan and achieving its scientific goals.

The 2014 P5 report, "Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global Context," presented a 10-year strategic plan for U.S. High Energy Physics (HEP). The plan emphasized the global nature of particle physics and recommended construction of projects both large and small, including a new international facility in the U.S. to study the nature of neutrinos. These projects would push the field forward by advancing discovery science in five intertwined areas of science that drive progress in the field.

Last year, HEPAP evaluated the implementation of this report to date. The panel heard presentations on the current High Energy Physics science landscape, including developments in each of the P5 science drivers; the status of each project; and how the agencies have been executing the plan.

### The assessment concluded that:

- ▶ The five P5 science drivers continue to describe the most urgent questions in our field.
- ▶ The DOE and NSF have closely followed the advice given in the P5 Report and have been successfully executing the plan. All the projects in the plan are

underway, with some projects nearing completion and the rest proceeding in a timely fashion. This suite of projects is expected to yield exciting discovery science for the next decade.

- ▶ Thanks to generous DOE Office of Science budgets, construction of the Long-Baseline Neutrino Facility and Deep Underground Neutrino Detector is farther along than envisioned by P5. Timely construction of this international facility is critical to achieving our national priorities.

- ▶ While investments over the past 5 years have focused on project construction, it will be fundamentally important to balance the components of the HEP budget to continue successful execution of the P5 plan. Operations of the newly constructed experiments require full support to reap their scientific goals. The HEP research program also needs strong support to fully execute the plan, throughout the construction, operations, and data analysis phases of the experiments, and to lay a foundation for the future.



**JoAnne Hewett**  
Chair, High Energy Physics Advisory Panel

### On behalf of the members of HEPAP:

—Timothy Alan Bolton  
—Janet Conrad  
—Priscilla Cushman  
—Rohini Godbole  
—Jordan Goodman  
—Michael Hildreth  
—Kent Irwin  
—Donatella Lucchesi  
—Alycia Marino  
—Meenakshi Narain  
—Fulvia Pilat  
—Soren Prestemon  
—Patrizia Rossi  
—Michael Syphers



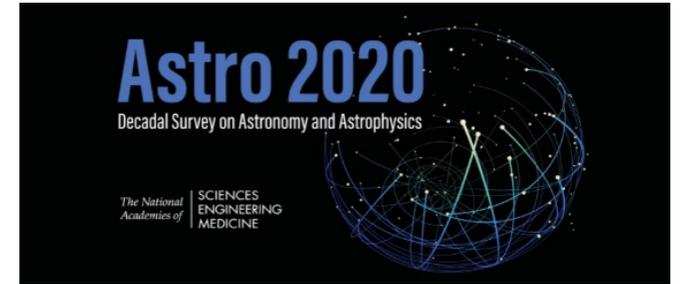
# HEPAP Assessment Conclusions

- Five science drivers continue to describe the most urgent questions in our field
- DOE and NSF have closely followed the advice given in the report and have been successfully executing the plan
- LBNF/DUNE construction is further along than envisioned by P5 thanks to generous DOE Office of Science budgets. Timely construction is critical to achieving our national priorities
- While investments over past 5 yrs have focused on construction, it will be important to balance. The components of the HEP budget to continue successful execution of the plan. Operations of newly constructed experiments require full support to reap their scientific goals and HEP research program needs strong support to fully execute the plan.

# U.S. HEP Strategic Planning Process: The Next Round has Begun!

## Astronomy & Astrophysics Decadal Survey: 2020-2021

- NCR & NAS
- Chaired by Fiona Harrison & Robert Kennicutt



## Community Study (“Snowmass”): 2020-2022

- Organized by Division of Particles and Fields of the American Physical Society
- Ideas for facilities & experiments bubble up from community
- Feasibility studies & physics reach evaluations

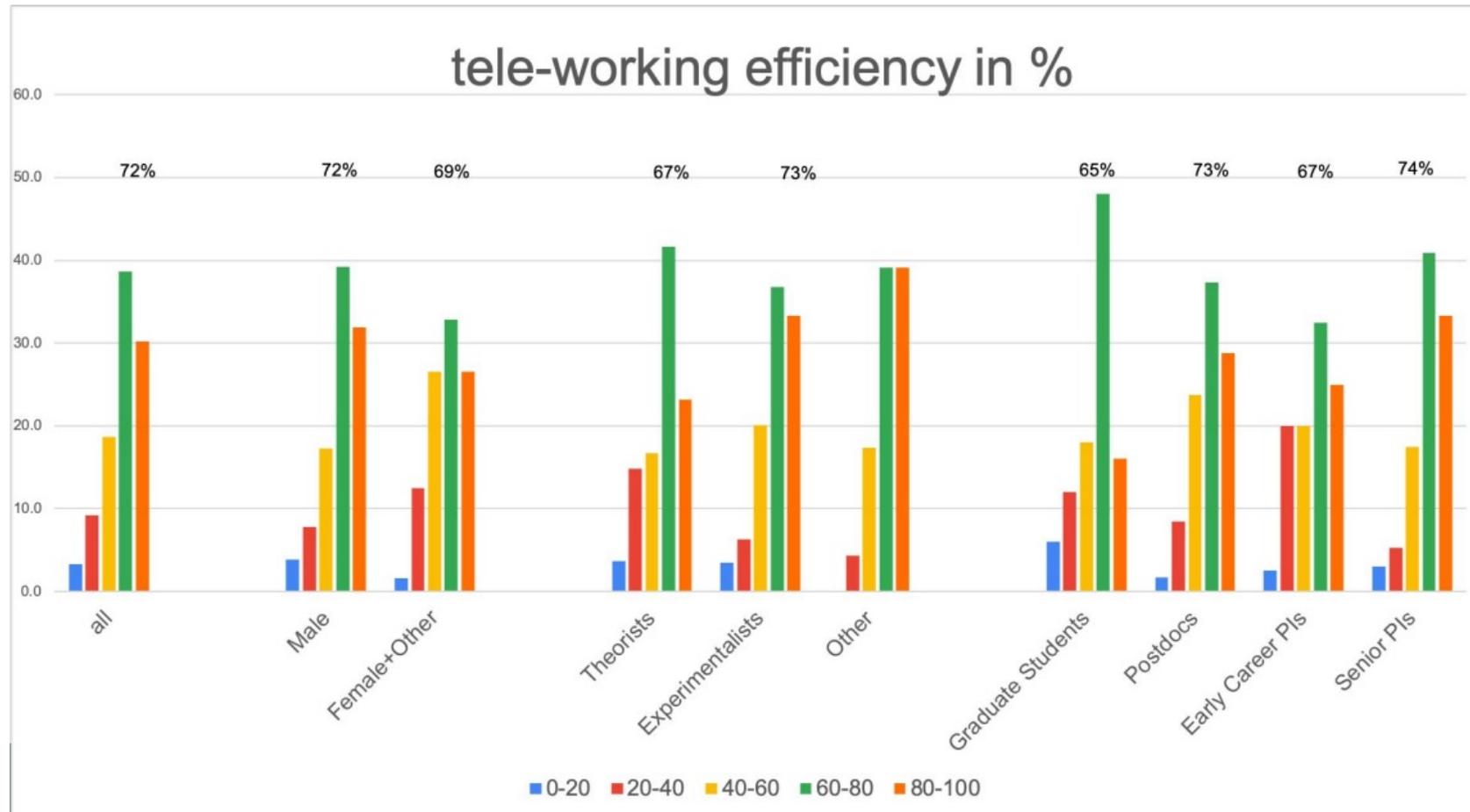


See T. Han’s presentation

## Particle Physics Project Prioritization Panel (P5): ~2022

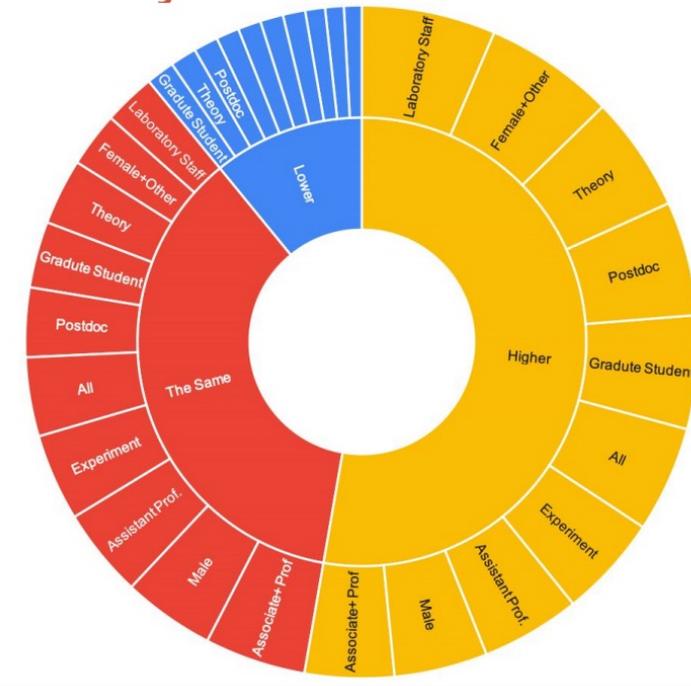
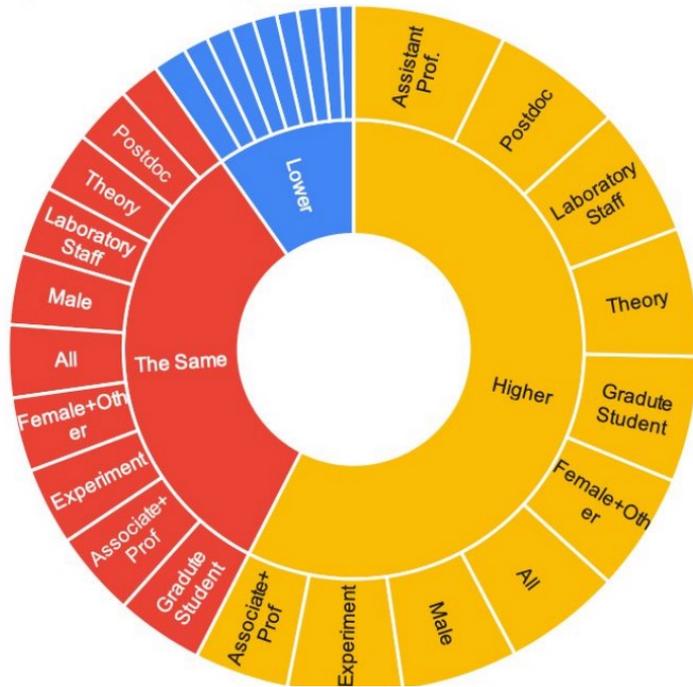
- Will begin after completion of Community Study
- HEPAP subpanel, prioritizes science within a budget framework

# HEPAP COVID-19 Impact Ad-hoc Survey: July 2020



# 2<sup>nd</sup> HEPAP COVID-19 Impact Ad-hoc Survey: December 2020

Level of stress, relative to April, 2020, is **HIGHER**  
Work, career, & work-life balance      Family and social situations



## Scientific Productivity

**Lower** relative to pre-pandemic productivity mostly in the range of 51-75%