The U.S. Particle Physics Planning Process

Sally Seidel, University of New Mexico
with thanks to Hitoshi Murayama for important slides
CEPC2023 Workshop
Friday, October 27, 2023

U.S. Decadal Process for Particle Physics Planning

The community of particle physicists write white papers on proposed future research topics and issues. This is called the:

"Snowmass"
Community Study

Organized by
American Physical Society / Division of Particles and Fields

The complete set of papers is at:
https://www.slac.stanford.edu/econf/C210711/

Snowmass 2021

Particle Physics Project Prioritization Panel (P5) is established by the High Energy Physics Advisory Panel (HEPAP).

P5 are 31 persons in the HEP community, including 5 international and 26 from US institutes.

P5 reports to HEPAP, and if the report is approved, it is transmitted to DOE HEP and NSF PHYS as the recommendations of the Community

The report is also circulated to the federal Office of Management and Budget (OMB), the Office of Science and Technology Policy (OSTP), and Congress

DOE HEP Office and NSF PHYS Division provide the Charge and mandatory budget scenario to P5

Key Elements of a Successful P5

- Well informed by the science community
- Set a grand long-range vision for U.S. particle physics
- Faced budget constraints realistically
  - "Community made tough choices."
- Balanced portfolio
  - Domestic and international
  - Small, mid-scale, and large projects
- Community engagement critical to success
  - "Bickering scientists get nothing."

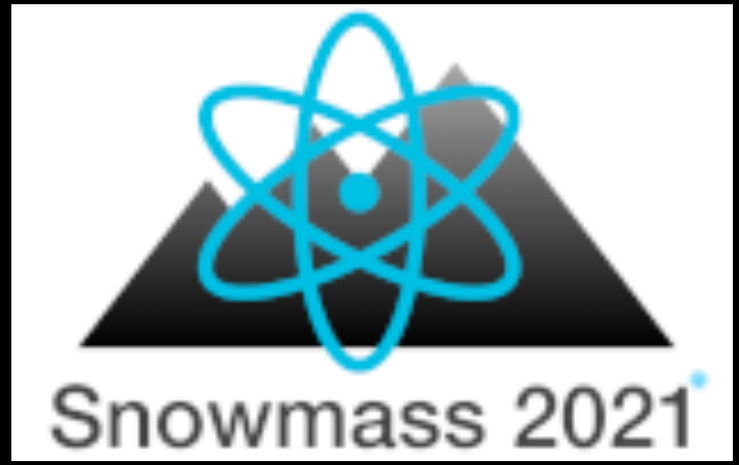
Harriet Kung,
Then interim director of HEP
Now deputy director for Science Programs

The Snowmass process concluded in 2021. This is the timetable for the process by which P5 gathered information and communicated with the community:

- Information Gathering phase
  - Open Town Halls
    - LBNL: Feb 22, 23. 513 registrants
    - Fermilab/Argonne: March 21, 22, 23. 797 registrants, overlapped with EPP
    - Brookhaven: April 12, 13. 666 registrants
    - SLAC: May 3, 4. 512 registrants
    - All with short remarks and talks on international programs
  - Virtual Town Halls
    - UT Austin: June 5. 159 registrants, exclusive session for Early Career Scientists
    - Virginia Tech: June 27. 119 registrants
  - All town halls offered live captioning and American Sign Language (ASL)
- Keeping the community informed
  - Session on P5 at the DPF Annual Meeting (April 15), at the Early Career Network Workshop (June 8,9), Accelerator Complex Evolution (ACE) Science Workshop (June 14, 15), CEPC Workshop (July 6), and ICFA (July 15)
  - Status broadcasts to the DPF & Division of Particles and Beams (DPB) mailing lists, and the Snowmass mailing list

The P5 report should take account of the ways that the physics landscape has evolved since the previous P5 (which was in 2014):

- 125 GeV Higgs does look like Standard Model
- Recognition that dark matter parameter space is *big*
  - Growing in interest in low-energy weakly coupled sector
- ΛCDM + inflation is the new Standard Model
  - But H_0, σ_8 tension
  - Inflation, cosmological constant vs swampland?
- DUNE and HyperK are both moving ahead
- Lattice vs g-2?
- Interesting anomalies in flavor physics?
- Gravitational waves. High-energy neutrinos.
- US National Initiatives: Quantum Information Science, AI/ML, microelectronics
- Field is more global than ever, yet geopolitical challenges, climate change



P5 Charge (dated November 2, 2022)  1/8

Dear Dr. Hewett:

The 2014 report of the Particle Physics Project Prioritization Panel (P5), developed under the auspices of the High Energy Physics Advisory Panel (HEPAP), successfully laid out a compelling scientific program that recommended world-leading facilities with exciting new capabilities, as well as a robust scientific research program. That report was well received by the community, the U.S. Department of Energy (DOE) and the National Science Foundation (NSF), and Congress as a well-thought-out and strategic plan that could be successfully implemented. HEPAP's 2019 review of the implementation of this plan demonstrated that many of the report's recommendations are being realized, and the community has made excellent progress on the P5 science drivers.

- The 2014 report was successful
- 2019 implementation review by HEPAP showed progress on the plan

As the landscape of high-energy physics continues to evolve and the decadal timeframe addressed in the 2014 P5 report nears its end, we believe it is timely to initiate the next long-range planning guidance to the DOE and NSF. To that end, we ask that you constitute a new P5 panel to develop an updated strategic plan for U.S. high-energy physics that can be executed over a 10-year timeframe in the context of a 20-year, globally aware strategy for the field.

- 2023 P5 to update strategic plan over 10-yr timeframe in 20-yr context

P5 Charge  2/8

A critical element of this charge is to assess the continued importance of the science drivers identified by the 2014 P5 report and, if necessary, to identify new science drivers that have the potential to enable compelling new avenues of pursuit for particle physics. Specifically, we request that HEPAP 1) evaluate ongoing projects and identify potential new projects to address these science drivers; 2) make the science case for new facilities and capabilities that will advance the field and enhance U.S. leadership and global partnership roles; and 3) recommend a program portfolio that the agencies should pursue in this timeframe, along with any other strategic actions needed to ensure the broad success of the program in the coming decades.

In developing the plan, we would like the panel to take into consideration several particularly relevant aspects of constructing a compelling and well-balanced portfolio:

- Re-evaluate the 2014 science drivers
- Evaluate ongoing projects
- Identify new projects
- Make science case for new facilities and capabilities
- Recommend program portfolio

P5 Charge  3/8

- A core tenet of the 2014 P5 Report is that particle physics is fundamentally a global enterprise. Thus far, the U.S. program has achieved high impact through U.S. researchers participating in the programs at world-class facilities outside the U.S. and international researchers working at world-class U.S. facilities. The recommendations developed for this report should carefully consider the current and future international landscape for particle physics. The panel's report should include an explicit discussion of the choices made in this context, including the extent to which it is necessary to construct, maintain, and/or upgrade leading U.S.hosted high-energy physics facilities so that our leadership position in the global scientific arena continues, while at the same time preserving the essential roles of, and contributions by, the National Laboratories and universities to global collaboration on large-scale initiatives.

- Remember HEP is a global field
- Support decisions to retain US leadership as a global parter
- Preserve essential roles of Universities and National Labs

- A number of the projects recommended by the 2014 P5 report are still being built, and the agencies take their commitments to complete them very seriously. Understanding the continued strength of the science case for these projects is quite valuable, and the panel should provide its assessment of these projects in this context.

- Assess science case for on-going projects

P5 Charge  4/8

- A successful plan should maintain a balance of large, medium, and small projects that can deliver scientific results throughout the decadal timeframe. We do not expect the panel to consider the large number of possible small-scale projects individually, but advice on research areas where focused investments in smallscale projects can have a significant impact is welcome.
- There are elements of DOE HEP-operated infrastructure that are a stewardship responsibility for HEP. Investments to maintain that infrastructure in a safe and reliable condition are an HEP responsibility and are outside the scope of the panel. Major infrastructure upgrades that create new science capabilities are within the scope of the charge and should be considered by the panel.
- Successfully exploiting a newly built project requires funding for the commissioning and operation of the project and to support the researchers who will use these new capabilities to do world-leading science. Funding is also needed for research and development (R&D) that develops new technologies for future projects. Scientists and technical personnel working in experimental particle physics often contribute to all these project phases, while theoretical physics provides both the framework to evolve our fundamental understanding of the known universe as well as the innovative concepts that will expand our knowledge into new frontiers. The panel should deliver a research portfolio that will balance all these factors and consider related issues such as training and workforce development.

- Maintain balance of large, medium & small projects
- Advise on science topics to focus small projects

- Assess infrastructure upgrades that create new science capabilities

- Remember costs of R&D, commissioning, and operations for future projects
- Remember that a balanced core research budget is paramount to producing science from current projects and developing ideas for new ones

P5 Charge  5/8

- Both NSF and DOE are deeply committed to diversity, equity, inclusion, and accessibility principles in all the scientific communities they support. Creating a more diverse and inclusive workforce in particle physics will be necessary to implement the plan that this panel recommends, and the panel may further recommend strategic actions that could be taken to address or mitigate barriers to achieving these goals.
- Broad national initiatives relevant to the science and technology of particle physics have been developed by the administration and are being implemented by the funding agencies. These include, but are not limited to, investments in advanced electronics and instrumentation, artificial intelligence and machine learning, and quantum information science. Potential synergies between these initiatives and elements of the recommended portfolio should be considered.

- Remember that a diverse workforce results in improved science

- Address synergies with broad national initiatives

P5 Charge - budget scenarios  6/8

We request that the panel include these considerations in their deliberations and discuss how they affect their recommendations in the report narrative.

The panel's report should identify priorities and make recommendations for an optimized particle physics program over 10 years, FY 2024–FY 2033, under the following budget scenarios:

1) Increases of 2.0 percent per year during fiscal years 2024 to 2033 with the FY 2024 level calculated from the FY 2023 President's Budget Request for HEP.
2) Budget levels for HEP for fiscal years 2023 to 2027 specified in the Creating Helpful Incentives to Produce Semiconductors and Science Act of 2022, followed by increases of 3.0 percent per year from fiscal years 2028 to 2033.

The recommended projects and initiatives should be implementable under reasonable assumptions and be based on generally accepted estimates of science reach and capability. Estimated costs for future projects and facility operations should be given particular scrutiny and may be adjusted if the panel finds it prudent to do so. Given the long timescales for realizing these initiatives, we expect the funding required to enable the priorities the panel identifies may extend well past the 10-year budget profile, but any recommendation should be technically and fiscally plausible to execute in a 20-year timeframe.

- Scenario A: 2% increase per year
- Scenario B: Budgets in Chips and Science Act, followed by 3% increase per year

- Evaluate projected project costs
- Plan should be executable in 20-yr timeframe

P5 Charge  7/8

In addition to articulating the scientific opportunities that can and cannot be pursued in the various scenarios, the panel may provide their opinions on the approximate overall level of support that is needed for core particle physics research and advanced technology R&D programs to be successful in the context of the science goals of the recommended plan.

We expect the "Snowmass" community planning reports and HEPAP's 2022 study on international benchmarking of scientific resources and capabilities will be useful inputs and that the panel will make efforts to maximize community input and participation in the overall process. Coordination and congruence with the National Academies of Sciences, Engineering, and Medicine's recent and ongoing decadal studies in astronomy, astrophysics, and particle physics are also important considerations.

- Evaluate level of core research budget and technology R&D programs

- Include Snowmass report and Benchmarking subpanel report in deliberations
- Strive towards coordination and congruence with EPP2024

P5 Charge 8/8

Finally, effective communication about the excitement, impact, and vitality of particle physics that can be shared with a general audience and other disciplines continues to be critical when advocating the strategic plan. It would be particularly valuable if the panel could re-state the key scientific questions that drive the field so that they are accessible to non-specialists and crisply articulate the value of basic research and the broader benefits of particle physics on other sciences and society.

We would appreciate the panel's preliminary comments by August 2023 and a final report by October 2023. We recognize that this is a challenging task; nevertheless, your assessments will be an essential input to planning at both the DOE and NSF.

Sincerely,

Asmeret Asefaw Berhe
Director, Office of Science
U.S. Department of Energy

Sean L. Jones
Assistant Director
Directorate for Mathematical and Physical Sciences
National Science Foundation

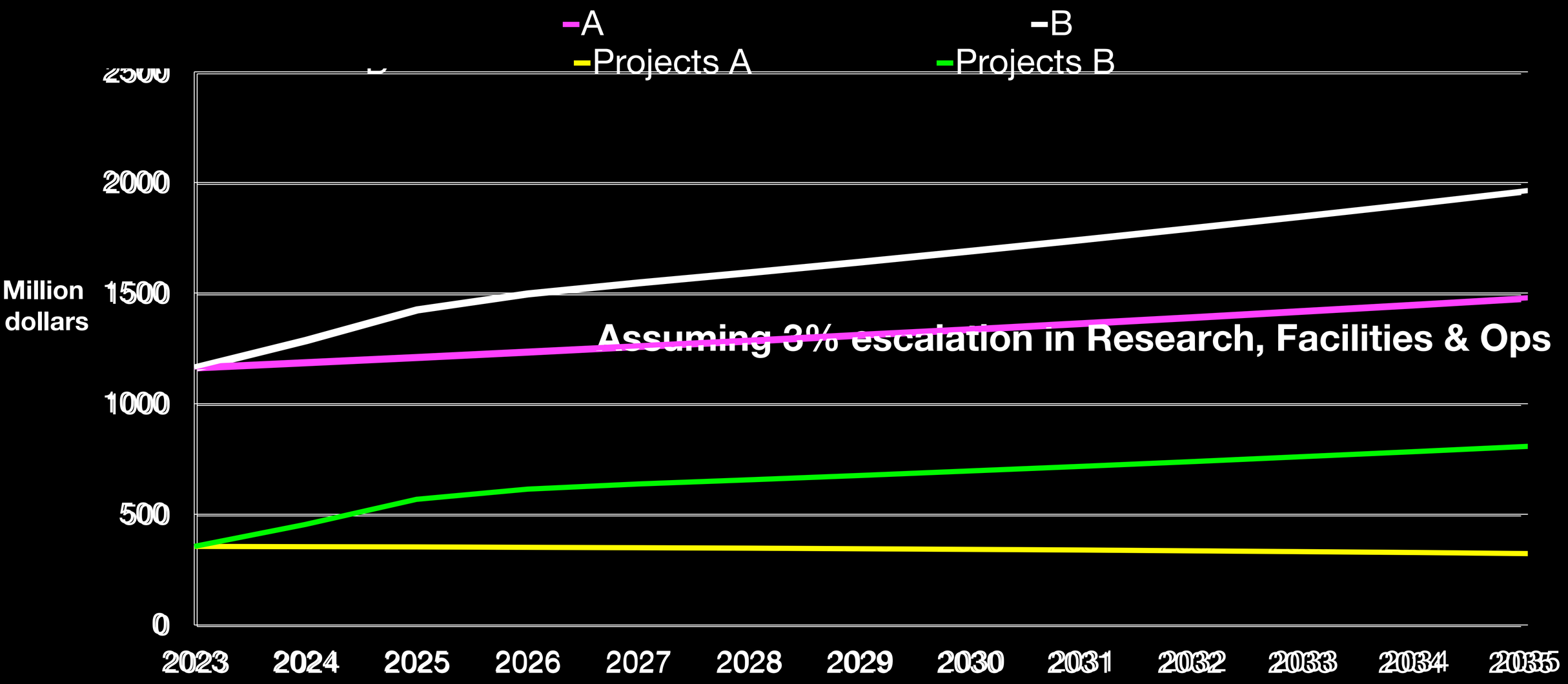
- Effectively communicate the 2023 P5 plan once it's finished
- Preliminary comments in August 2023
- Report due by October 2023

The P5 Report must balance many considerations:

- Project vs. research
- Large (>$200M), medium ($50-200M), small (<$50M) experiments
- Investments in future
  - Instrumentation, computing, theory
- National initiatives
  - AI/ML, microelectronics, QIS
  - How do we capitalize on them? How do we contribute?
- Respect and promotion of diversity, equity, and inclusiveness in the workforce

DOE only

These are the boundaries: the recommendations must fit within the Budget Scenarios



A special sub-sub-committee was established to assess costs, risks, and schedule of activities under consideration

The cost/schedule/risk subcommittee was asked to obtain and clarify the cost/schedule/risk information from the proponents of high cost (>250M FY23$) HEP projects funded or being considered for funding by the DOE and/or NSF. The subcommittee did not prepare its own estimates. The committee assessed this information at a high level, noting key assumptions, risks and cost and schedule uncertainties including the risk from non-DOE/NSF funding sources, international partners making in-kind contributions and collaborations and missing costly items, if any. The committee commented on the operation costs for projects both during commissioning and when the resulting facilities are in steady-state operation. This committee provided P5 with opinions on the uncertainty ranges for the projects that P5 needs to develop a strategy for the field within assumed budgetary constraints.

Principles and philosophy of the deliberations

- Optimize science within the boundary conditions
- Everything is "on the table” for consideration, nothing is off the table
- Attention to balance among
  - Different areas
  - Different sizes
  - Domestic vs. international
  - Project vs. Research
- The recommendations to improve diversity, equity, and inclusion must be actionable
- Decisions are based on consensus, not votes

Criteria for Prioritization

- Not all projects will satisfy all criteria, but high-priority projects will satisfy several of these criteria:
  - Discovery potential, transformative science
  - Leverages unique capabilities or facilities of the US
  - Supports international engagements
  - Enables US leadership in core areas of HEP science
  - Takes advantage of HEP’s unique role in National Initiatives
  - Develops a diverse workforce for the future
  - Opens and creates opportunities for the future of HEP
  - Risks
  - Costs

P5 criteria for compelling projects

- Addresses all science areas of our interest
- Big (>$250M)
  - Excellent discovery potential
  - World-leading
  - Unique
- Medium ($20-$250M)
  - Good discovery potential, development of major tools
  - World-class
  - Competitive
- Small (<$20M)
  - Some discovery potential or well-defined measurements or technology development
  - World-class
  - Excellent training grounds

Timetable for assessing the gathered information and developing the recommendations

- Deliberation Phase
  - Four closed meetings
    - May 1 to June 2, Austin
    - June 21 to 23, Gaithersburg
    - July 11 to 14, Santa Monica
    - August 1 to 4, Denver
    - Many meetings between them by various working groups
  - Communications and clarifications with the following groups:
    - Agencies: Asmeret Berhe, Harriet Kung, Sean Jones, Saúl Gonzalez, DOE/HEP, NSF/PHY, NSF/AST (Debra Fisher, Nigel Sharp), NSF/OPP (Jim Ulvestad)
    - Government: Cole Donovan (State, OSTP)
    - Community: International Benchmarking Panel, computing frontier, DPF leadership, previous P5 (Steve Ritz, Andy Lankford), CoV reports (Ritchie Patterson, Dmitry Denisov)
- Writing Phase
  - Weekly Zoom meetings
  - Professional editor, graphic design artists contributing
  - Preliminary recommendations communicated to agencies in September and November
  - Peer reviews
- Final report due December 7, subject to approval by HEPAP, then roll-out to the community (led by DPF)

The P5 leadership team

Sally Seidel
Interim HEPAP chair, ex officio
Professor of Physics, University of New Mexico

Hitoshi Murayama
P5 chair, Professor of Physics, University of California, Berkeley

Karsten Heeger
P5 Deputy chair,
Professor of Physics, Yale University


The P5 panel

The P5 report will be presented at a public meeting on December 7 in Washington DC. Again, the leading priority is to maximize science.

Backup Slides

Almost simultaneously, there is another US panel, called EPP2024

- EPP2024 is a separate panel constituted by the National Academies of Science, that looks into long-term vision, dreams
  - unconstrained by budget scenarios
- Some of the P5 leaders have participated in the EPP November 2022, December 2022, and July 2023 meetings
- We invited all EPP2024 members to P5 town halls to make sure we get the same inputs from the community
- We inform EPP2024 about our progress and vice versa
- What P5 recommends should smoothly connect to their longer-term vision

Background

- HEPAP advises DOE OHEP and NSF PHY
  - Current chair: Sally Seidel
  - Sunshine law requires such advisory panels are open
  - Impossible to discuss sensitive issues such as prioritization
- But HEPAP can create a “subpanel” whose meetings can be closed
  - HEPAP subpanels existed for a long time, discussed “big things”
- Individual projects used to be purview of lab Program Advisory Committees (PACs)
- Around Year 2000, it was becoming increasingly clear that “projects” have become too big to be handled by lab PACs
- Natalie Roe proposed establishment of a “national PAC” (which became Snowmass 2001):
  - A standing committee that handles decisions om mid-size and big projects in particle physics
  - This recommendation was included as a recommendation by the “Bagger & Barish" subpanel of 2001

HEPA subpanel 2001

- Bagger & Barish HEPAP subpanel followed Snowmass
  - It came out big on e^+e^- LC
  - Led to technology choice, GDE, too expensive for a US project
- Persis Drell proposed P5 = Particle Physics Projects Prioritization Panel
  - Became part of the recommendation
- "*The Science Ahead, The Way to Discovery*" Jan 2002
- "*Quantum Universe*" outreach document

Current Portfolio of medium to large projects

- Energy frontier
  - HL-LHC (AUP, ATLAS & CMS), LHCb
- Intensity frontier
  - Neutrinos: NOvA, SBND+Icarus, DUNE + PIP-II
  - Precision: Muon g-2
  - Flavor: Mu2e, Belle II
- Cosmic frontier
  - Galaxy surveys: DESI, Rubin
  - Dark matter: LZ, SuperCDMS, ADMX
  - CMB: Simons Observatory & BICEP/Keck