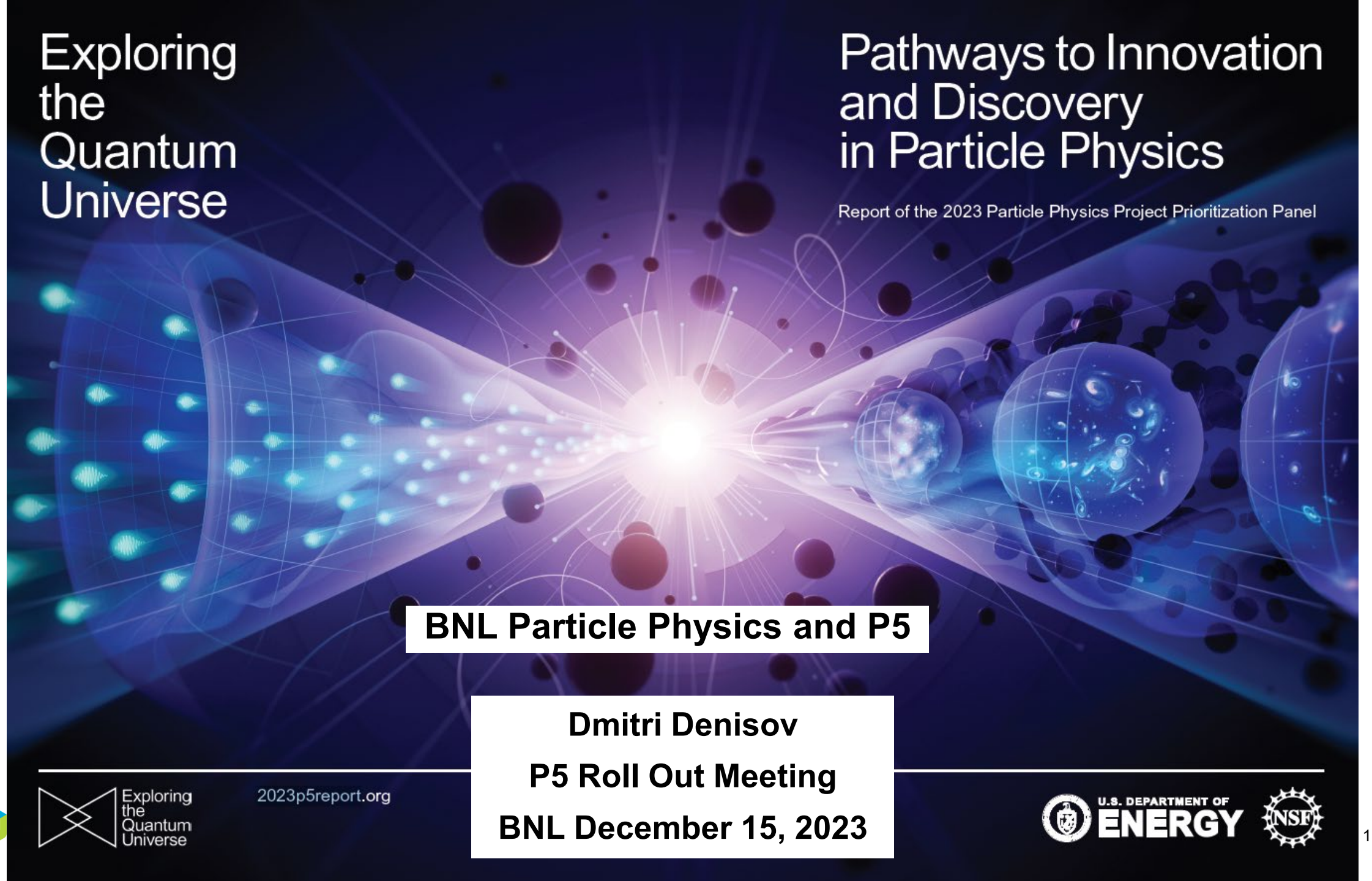
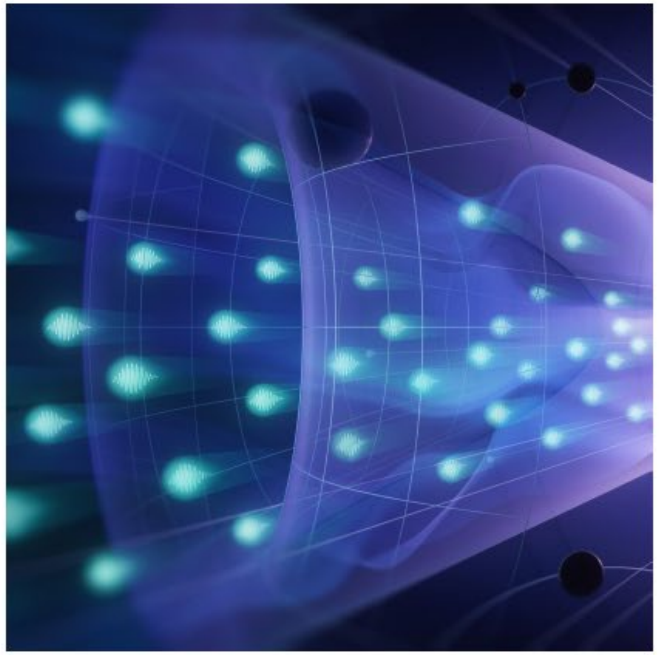

Exploring the Quantum Universe
Pathways to Innovation and Discovery in Particle Physics
Report of the 2023 Particle Physics Project Prioritization Panel
BNL Particle Physics and P5
Dmitri Denisov
P5 Roll Out Meeting
BNL December 15, 2023
Exploring the Quantum Universe
2023p5report.org
U.S. DEPARTMENT OF ENERGY
NSF

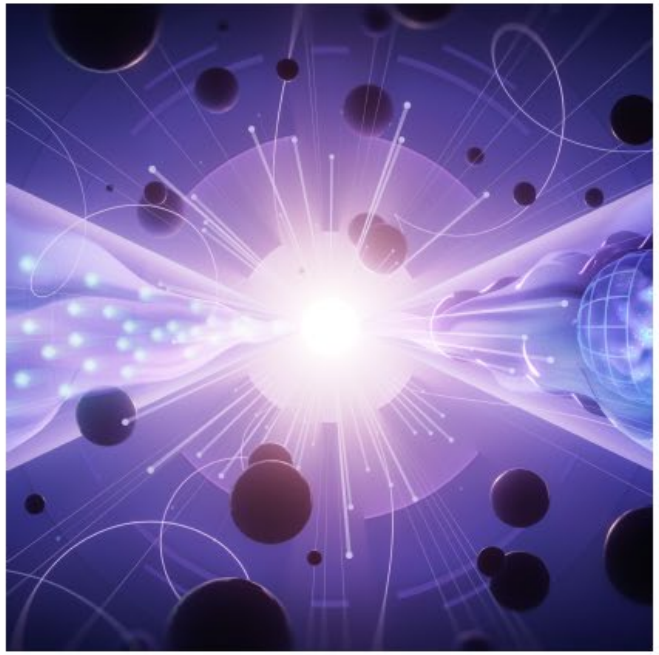
P5 Science Drivers



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

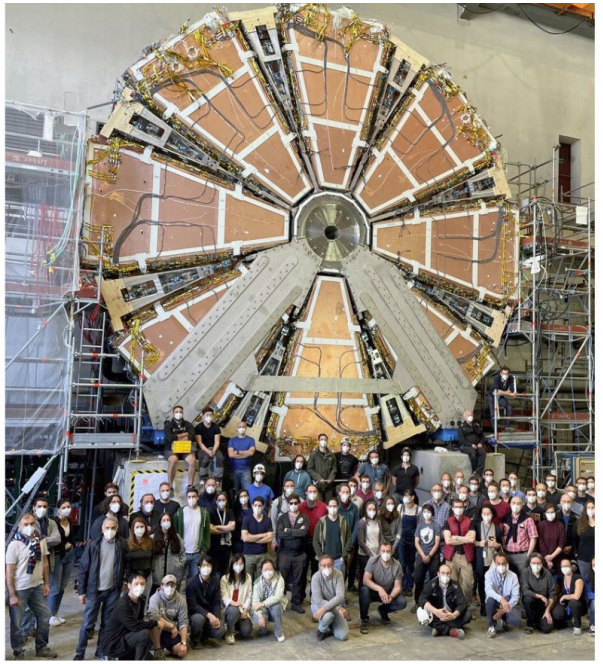
Brookhaven National Laboratory

BNL is involved in addressing all P5 science drivers!

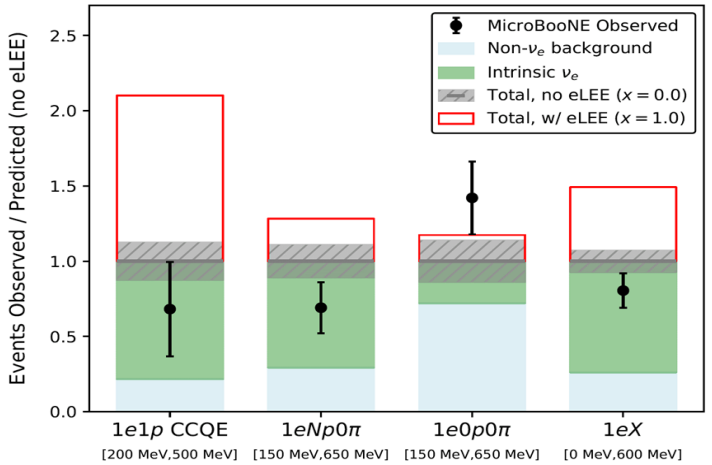
Strong Ongoing BNL Program Enables HEP Science

- **ATLAS experiment at CERN**
  - Lead Lab for U.S. ATLAS collaboration of ~800 US scientists
  - Leading US ATLAS Operations program and hosting Tier 1 computing center
- **Neutrino Program at Fermilab**
  - Proto-DUNE detector with BNL-developed cold electronics
  - Studying properties of neutrinos with short-baseline experiments
- **Belle II experiment at KEK**
  - Lead Lab for U.S. Belle II experiment in Japan
- **Rubin Observatory**
  - Commissioning the experiment in Chile
  - Developing computing and software for data analysis
- **Theory, Detectors and Accelerators R&D**

Assembly of ATLAS muon system at CERN



MicroBooNE sterile neutrinos



Brookhaven National Laboratory

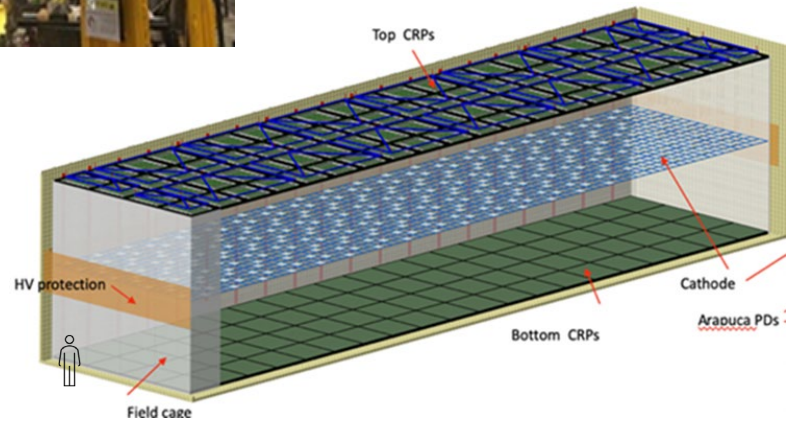
Implementing 2013 P5 Program

- **Energy Frontier**
  - Hosting project for $275M HL-LHC ATLAS upgrade
  - Building magnets for the HL-LHC
  - Developing HL-LHC computing and software
- **Intensity Frontier**
  - Strongly contributing to DUNE experiment
    - Leading DUNE far detector Module 2 activities
- **Cosmic Frontier**
  - Soon to analyze unique Rubin Observatory data
  - Building LuSEE-Night mission to the far side of the moon
- **Leading Technologies Developments for Particle Physics**
  - Computing and software
  - Detectors and electronics
  - Accelerators R&D including superconducting magnets
- **Actively participating in the field long term future planning**
  - BNL scientists submitted over 130 white papers to Snowmass and contributed strongly to P5 process

HL-LHC magnet testing at BNL

ATLAS silicon assembly at BNL

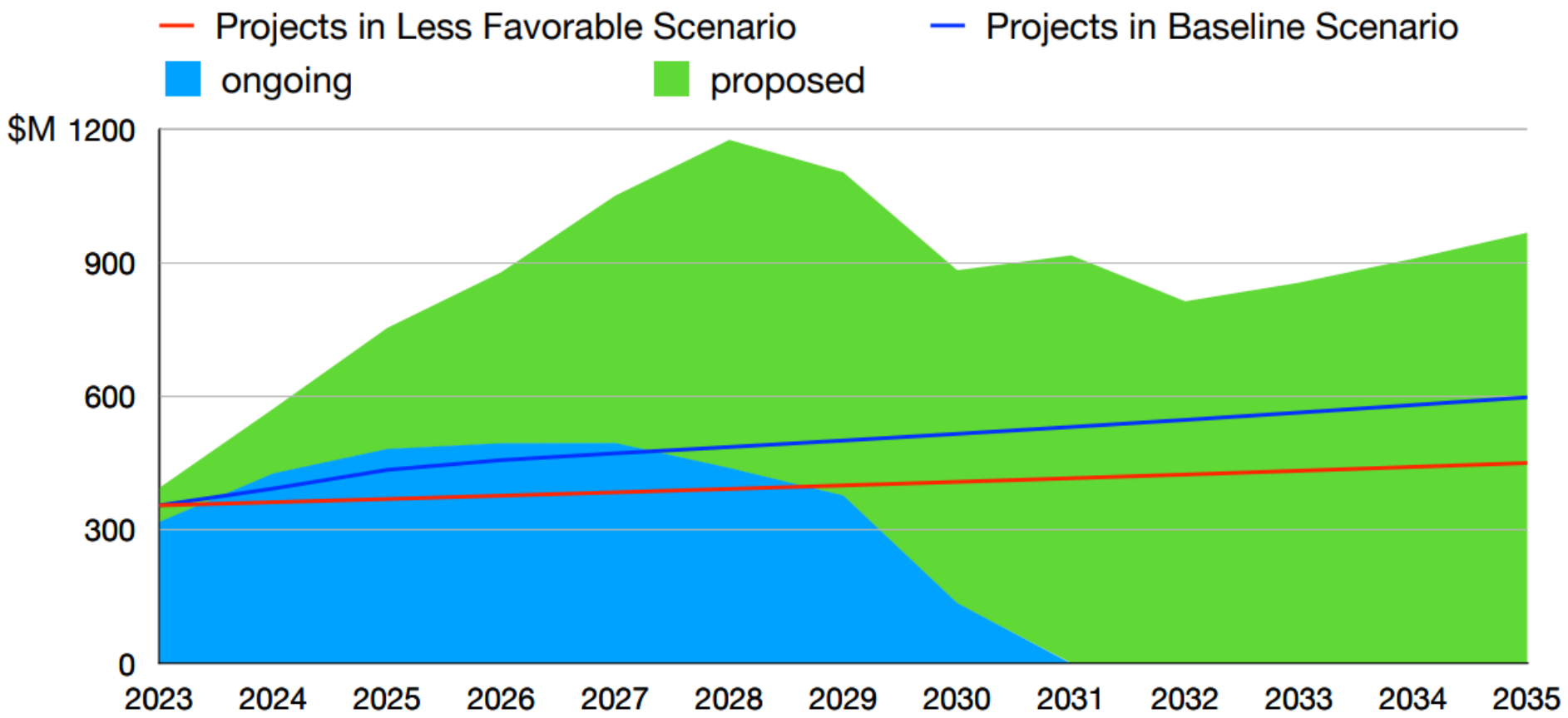
DUNE Module 2 design



Brookhaven National Laboratory

Large Number of Exciting Proposals

Budget Scenarios and Projects



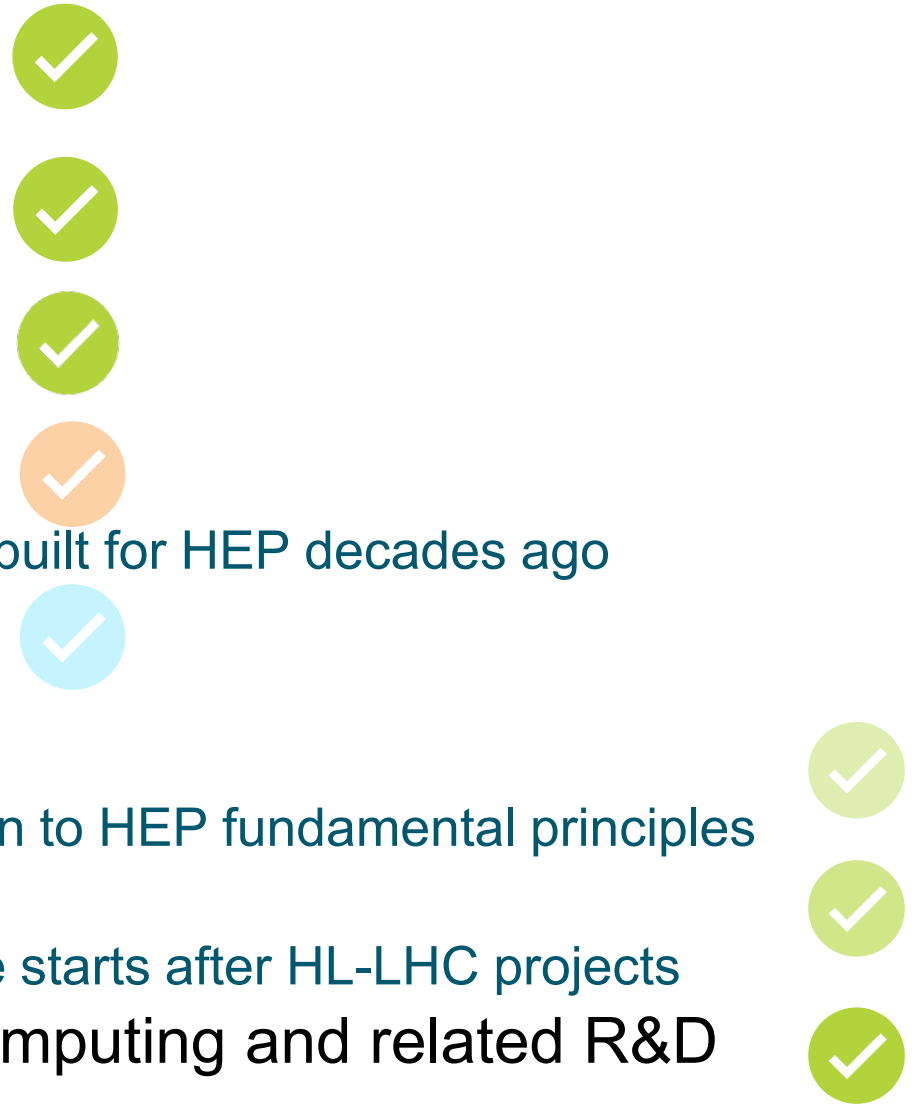
DOE only

2023 P5 Report

- Plan is for a decade with vision beyond
- Expect final version of the report before the end of 2023
  - No major changes expected
- Will take time to digest and adjust
  - And for funding agencies to consider *recommendations*
- Some of the recommendations are of the global context
  - Outcome depends on worldwide field developments
- Some adjustments might be needed, as stated in the report, even during the coming decade
  - Science results, technological developments, funding opportunities
- It is important for the US community to unite behind the report

P5 Proposals BNL is Deeply Engaged - April 2023 P5 Meeting at BNL Slide

- DUNE upgrades
  - Physics and modules 3 and 4 upgrade
- Higgs factory
  - FCC due to our close connections with CERN
  - ILC
- Muon collider
  - Unique expertise in accelerator and detectors
- Proton EDM experiment at BNL
  - Unique way for exciting science using infrastructure built for HEP decades ago
- Forward Physics Facility at CERN
  - Neutrinos and energy frontier
- PIONEER
  - Small scale experiment with deep science connection to HEP fundamental principles
- LHCb
  - Have experts in both physics and detectors, upgrade starts after HL-LHC projects
- Various proposals for accelerator, detectors, computing and related R&D



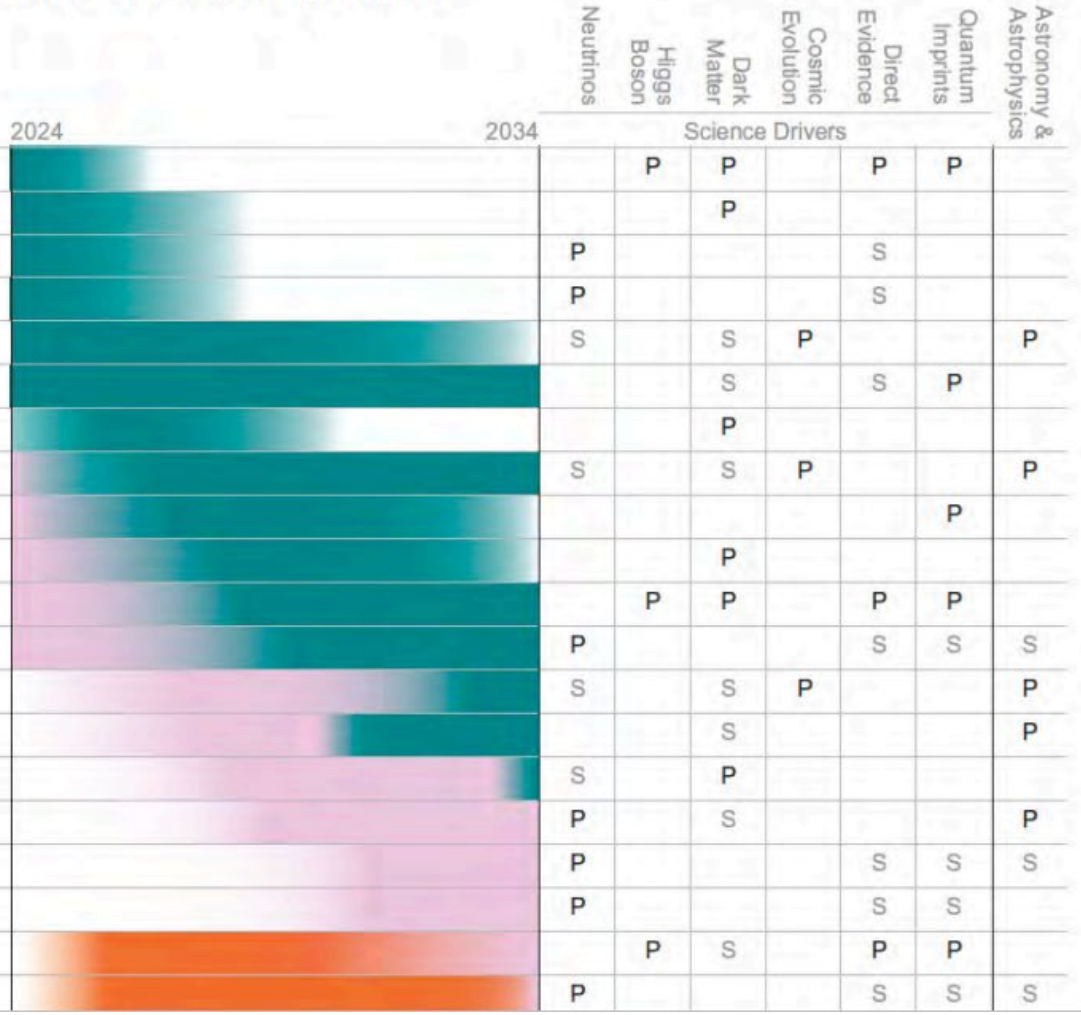
Timeline in Baseline Scenario

Exploring the Quantum Universe

Figure 1 – Program and Timeline in Baseline Scenario (B)

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

§ Possible acceleration/expansion for more favorable budget situations



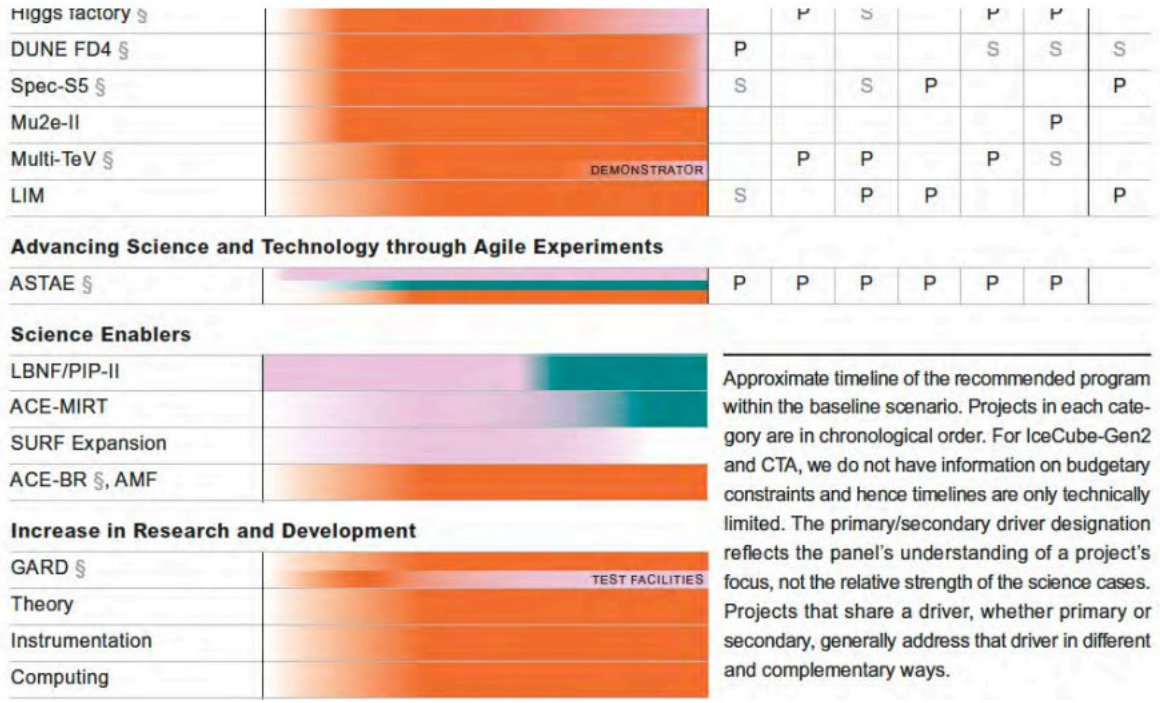
Brookhaven National Laboratory

Timeline in Baseline Scenario

Figure 1 – Program and Timeline in Baseline Scenario (B)

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

§ Possible acceleration/expansion for more favorable budget situations



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.

BNL is already deeply involved in many activities and there is an excellent potential for participation in new programs and experiments

Brookhaven National Laboratory

PEMP Notable and Planning

- PEMP Notable:
  - Submit a strategic response to the 2023 P5 Report for the lab by August 31, 2024. Identify which new initiatives recommended by P5 that the lab wishes to participate in and document the strengths the lab brings to those. Also identify existing efforts that will continue or strengthen. Identify efforts that will be reduced to enable this.

- We plan a series of meetings in early 2024 to discuss options
  - Like a series of meetings at BNL before Snowmass 2021

Vision for the Future

- Successfully **complete 2013 P5 program** and benefit from scientific potential created
  - International **HL-LHC program**
  - Execute **international DUNE program**
  - Uncover the mysteries of the universe with **Rubin observatory**
  - Execute array of **small and medium scale experiments**
- Develop strong **program for the future**
  - Develop strong foundations for an international **Higgs factory**
    - And develop accelerators to reach **next energy frontier beyond the LHC**
  - Re-envisioned second phase of DUNE
  - Perform upgrades and re-fill the pipeline of **small and medium scale experiments**
  - Develop participation in P5 recommended **experiments and facilities**
  - Lead **Accelerator, Detector and Computing R&D** efforts and **theory** initiatives
  - Develop a **balanced program of research, operations and construction** with strong participation of **universities, national labs and international partners**

Develop, train and support a diverse workforce

Thank you!