U.S. DEPARTMENT OF ENERGY | Office of Science

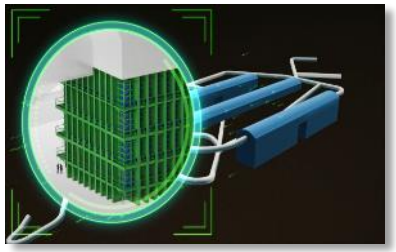
DOE Self-Assessment: P5 Implementation

HEPAP Meeting
May 30, 2019

Glen Crawford
Research & Technology Division Director
Office of High Energy Physics
Office of Science, U.S. Department of Energy

U.S. Strategy in High Energy Physics

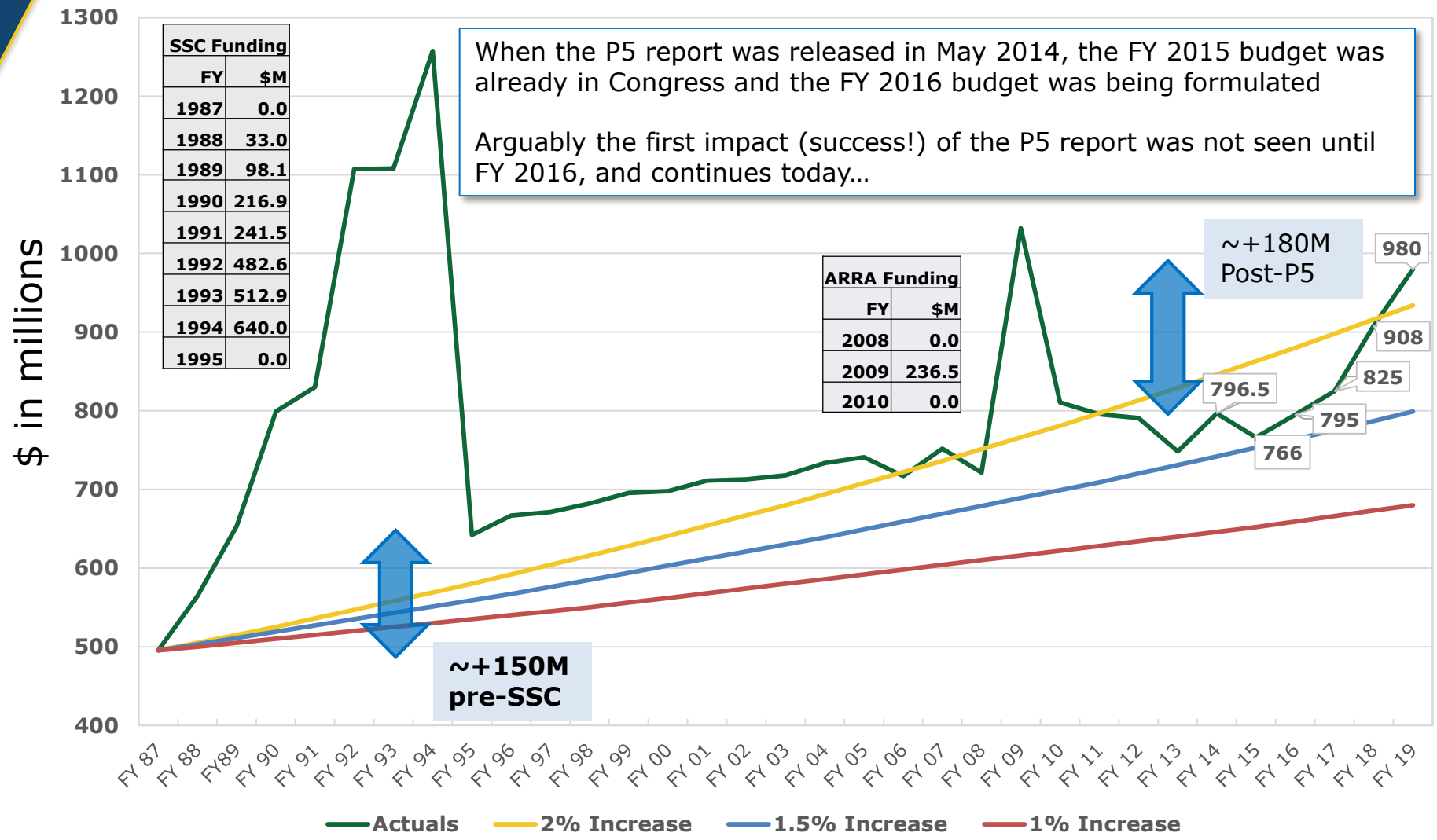
- The global vision presented in the 2014 Particle Physics Project Prioritization Panel (P5) report is the culmination of years of effort by the U.S. particle physics community
  - 2012 – 2013: Scientific community organized year-long planning exercise ("Snowmass")
  - 2013 – 2014: U.S. High Energy Physics Advisory Panel convened P5 to develop a plan to be executed over a ten-year timescale in the context of a 20-year global vision for the field
- P5 report enables discovery science with a balanced program that deeply intertwines U.S. efforts with international partners
  - **U.S. particle physics community** strongly supports strategy
  - **U.S. Administration** has supported implementing the P5 strategy through each President's Budget Request
  - **U.S. Congress** has supported implementing the P5 strategy through the language and funding levels in appropriations bills
  - **International community** recognizes strategy through global partnerships



Big Picture: Everything is Awesome!

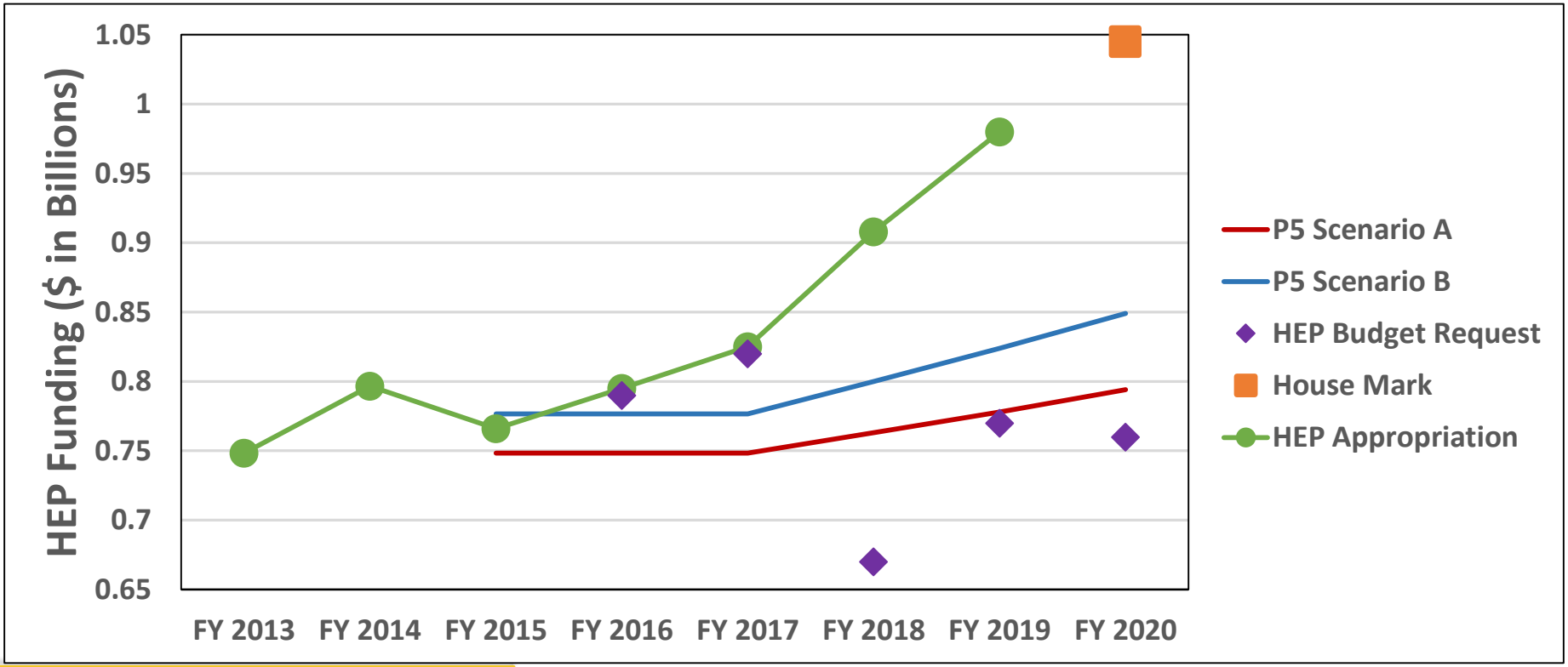
- In the last 3-4 years, HEP budget situation has changed dramatically
  - 20-25% growth in bottom-line
  - HL-LHC and LBNF/DUNE profiles ramping up
  - New DOE/SC initiative(s) for QIS (+ML/AI in FY20 Request) with real HEP roles
- Lots of Progress on P5 Implementation
  - International agreements starting to line up
  - Completion of "pre-P5" projects (Belle II, Muon g-2) and initial data-taking
  - 1st of the planned mid-scale P5 projects (LHC Phase I upgrades, DESI) are on schedule to complete soon. Several new Cosmic Frontier experiments, SBN, Mu2e in fabrication.
- Excellent opportunities for junior PI's and new ideas

FY 2019 HEP Funding in Historical Context

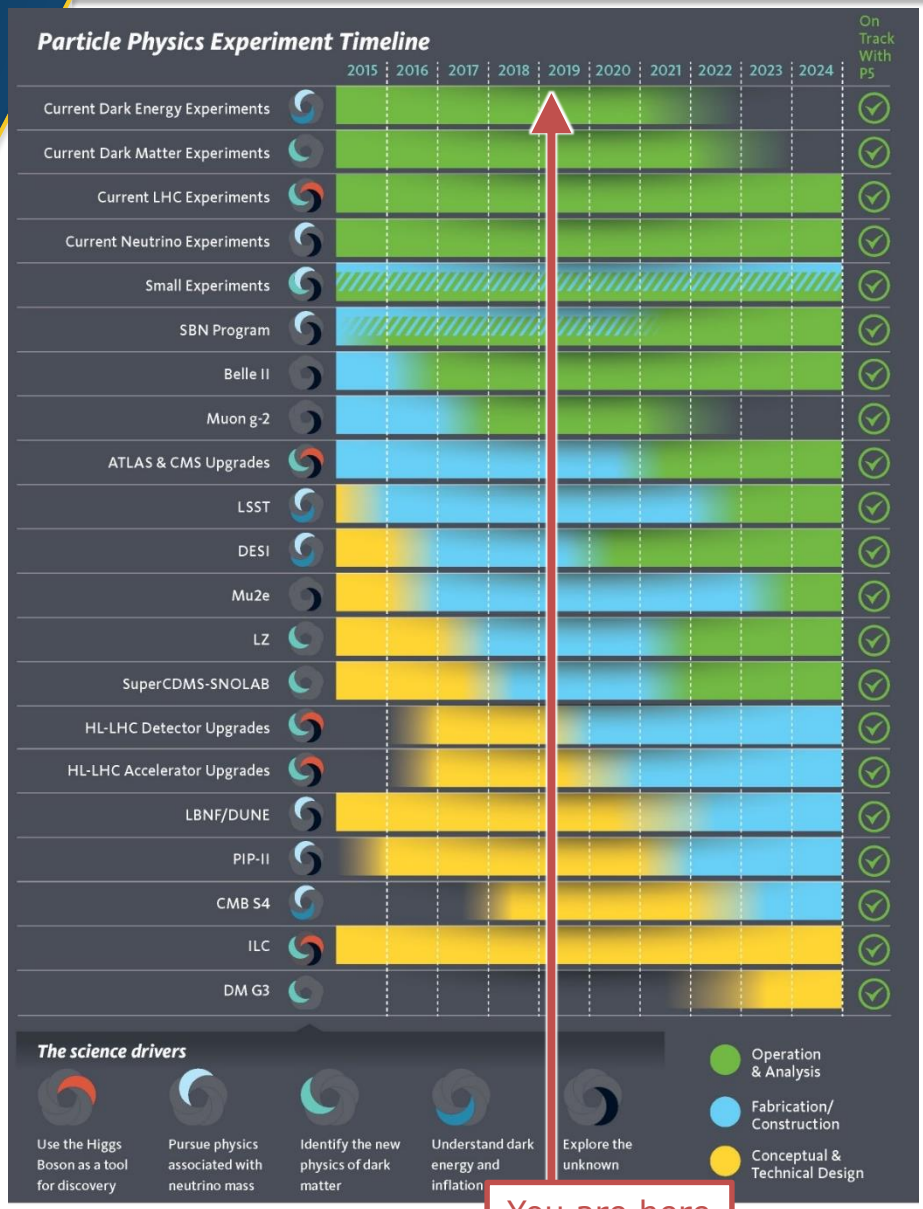


U.S. Congress Supports P5 Strategy

- Congressional appropriations reflect strong support for P5
- Language in appropriations reports have consistently recognized community's efforts in creating and executing the P5 report strategy



P5 Implementation Status – FY 2019



All projects on budget & schedule

- Projects fully funded as of FY19
  - Muon g-2: 1st beam 2017
  - LHC detector upgrades: on track for 2019/20 installation
  - Mu2e : 1st data in 2020
  - LSST: full science operations 2023
  - DM-G2 (superCDMS & LZ): 1st data 2020
  - DESI: 1st light on April 1, 2019
- HL-LHC accelerator and detector upgrades started on schedule
- LBNF/DUNE & PIP-II schedules advanced due to strong support by Administration & Congress
- CMB S4: developing technically-driven schedule to inform agencies, NAS Astro 2020 Decadal Survey
- DM-G3: R&D limited while fabricating G2
- ILC: cost reduction R&D while waiting for decision from Japan
- Broad portfolio of small projects running

P5 Project Scorecard

- Almost everything on the P5 menu (even "scenario C" items) underway or working towards CD-0
  - Existing experimental portfolio continues to produce exciting results.
  - Several new small experiments already producing data.
- Recall that these projects are
  - Scientifically compelling and technically challenging
  - One-of-a-kind or best-in-class experiments/facilities
  - Many with significant international partnerships
  - Diverse in scale and addressing all 5 physics drivers

HEP MIE Project Status

Subprogram	TPC ($M)	CD Status	CD Date
INTENSITY FRONTIER			
Long Baseline Neutrino Facility / Deep Underground Neutrino Experiment (LBNF/DUNE)	1,300 – 1,900	CD-3A	September 1, 2016
Proton Improvement Project (PIP-II)	653 – 928	CD-1	July 23, 2018
Muon g-2	46.4	CD-4	January 16, 2018
Muon-to-Electron Conversion Experiment (Mu2e)	273.7	CD-3	July 14, 2016
ENERGY FRONTIER			
LHC ATLAS Detector Upgrade	33	CD-3	November 12, 2014
LHC CMS Detector Upgrade	33	CD-4A	September 19, 2017
High-Luminosity LHC (HL-LHC) Accelerator Upgrade	208 – 252	CD-1/3A	October 13, 2017
High-Luminosity LHC (HL-LHC) ATLAS Detector Upgrade	125-155	CD-0	April 13, 2016
High-Luminosity LHC (HL-LHC) CMS Detector Upgrade	125-155	CD-0	April 13, 2016
COSMIC FRONTIER			
LUX-ZEPLIN (LZ)	55.5	CD-3	February 9, 2017
Super Cryogenic Dark Matter Search - SNOLAB (SuperCDMS-SNOLAB)	18.6	CD-2/3	May 2, 2018
Dark Energy Spectroscopic Instrument (DESI)	56.3	CD-3	June 22, 2016
Large Synoptic Survey Telescope Camera (LSSTcam)	168	CD-3	August 27, 2015
ADVANCED TECHNOLOGY R&D			
Facility for Advanced Accelerator Experimental Tests II (FACET-II)	25.6	CD-2/3	June 8, 2018

HEP Small Project Portfolio

"Small" (approx. 100 collab. Or less) projects currently HEP-supported (incl. new since P5):

Intensity Frontier:

- ANNIE
- CAPTAIN
- COHERENT
- EXO-200
- Heavy Photon Search (HPS)
- KOTO
- LArIAT
- NA61
- PROSPECT
- SBND
- WATCHMAN

Cosmic Frontier:

- ADMX-G2
- eBOSS
- HAWC
- SuperCDMS-SNOLab
- SPT-3G

Recently retired:

- BES-III
- DarkLight
- LUX
- MINOS+
- SuperCDMS-Soudan
- VERITAS

International Scorecard

- Since P5 report we have new international agreements or implementing arrangements concerning HEP with:
  - CERN
  - UK
  - India
  - Italy
- Several more "in the works"
- Active interagency working group

CERN

UK

India

Italy

The Challenges

Most of the recent HEP budget growth is in Projects, without similar increases in Operations and Research

- HEP-style Projects depend heavily on Research and Ops support for R&D, QA/QC, integration, installation, and commissioning
- Given that there is a lot of current Research and Ops effort committed to active experiments, this is not optimal for successful project execution
- Balancing Research and Ops with the needs of current and future projects will require careful prioritization

This is a complex interlocking problem with many contributing factors

- Cannot simply "trim the big projects" (or other "simple" solutions) without having impacts elsewhere
- HEP PMs work on this ~every day

Compounding Effects of Success

- A number of smaller issues have created a cumulative effect that impacts the Core Research program
  - Cost of doing business has increased significantly, year by year, reducing the buying power of research dollars
  - The community has grown, which adds more competitors to the pool for comparative review
  - Research efforts necessary to support large projects are increasing as the projects ramp up
  - Operations costs necessary for experiments are increasing as P5 projects are successfully completing and starting to take data
- These effects are tied to the high level of support received through appropriations based on the very successful execution of the P5 strategy so far
  - FY 2020 House Marks and Report language suggest that the message is getting through that healthy growth of the program requires Research and Operations growth in addition to Project support

HEP Research Priorities

- Broadly speaking, focus will be (not necessarily in priority order):
  - Research activities critical to executing the upcoming P5 projects;
  - Supporting initial data taking and analysis from new experiments coming on-line;
  - Continued analysis of ongoing experiments highly recommended to address the P5 science drivers; and
  - Supporting young investigators

A Thriving Theory Program

P5 called on HEP to maintain a "thriving theory program," and there are indications of success

- **Outstanding young people continue to enter the field**
  - Early Career is very competitive, with 2-3x more outstanding proposals than can be funded
  - Junior faculty are very successful in comparative review (> 70%)
- **The field is moving in exciting new directions**
  - Strong growth in Dark Matter / Dark Sectors
  - Application of modern effective field theory ideas to Electroweak theory, Dark Matter, etc.
  - Growing interest in cosmology and connections to astro-particle physics
  - New ideas in Quantum gravity, Black hole micro-structure, QIS, Emergent spacetime, …
  - New ideas in non-perturbative QFT (Conformal Bootstrap, Lattice investigations of near-conformal dynamics)
  - Continued development of Lattice QFT for precision calculations
  - Continued development of the Amplitudes program with possible applications to theories beyond QCD
- **These success come at a cost**
  - The movement toward DM has pushed many established researchers out of the center
  - Collider research using the Higgs as a tool for discovery remains a high priority, but general collider BSM has reduced

New Initiatives

- P5 also called for "the flexibility to support new ideas and developments"
  - Some of these have been realized through the Small Projects portfolio (mostly *ad-hoc*)

- Since P5 was wildly successful, we will also need plenty of new *mid- to large-scale* ideas, especially those that exploit current P5 investments (PIP-II, SURF,…) in new ways, e.g.:
  - Future Energy Frontier Colliders and Detectors
  - Underground HEP Science
  - Next-generation Dark Energy and Dark Matter experiments
  - PIP-II/PIP-III (non LBNF) program
  - Technology R&D demonstrators
  - Your best ideas for targeted Research initiatives

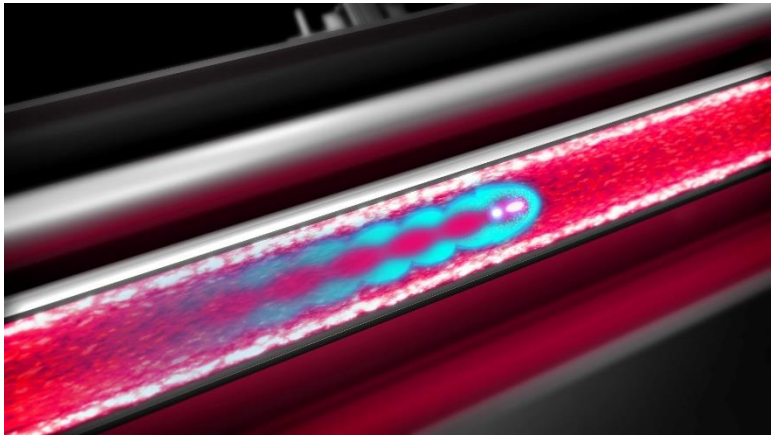
- There will be little resource available for this in the core HEP program in the next few years
  - Need to leverage *all other available sources* (LDRD, US-Japan, QIS, non-DOE,…)
  - A primary goal of the **Basic Research Needs Workshops** is to develop the case(s) for additional HEP funding to support such new initiatives in the future.

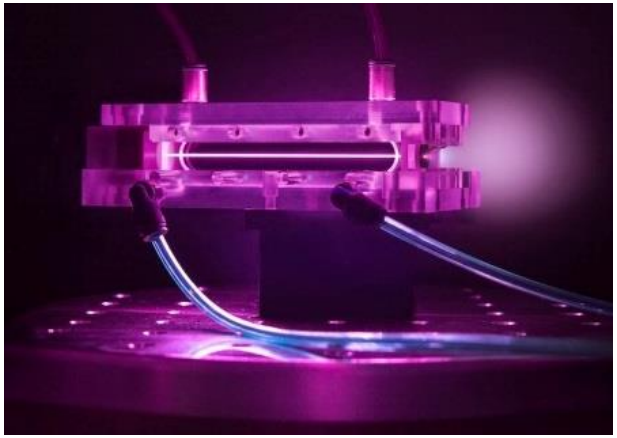
Adv. Tech. R&D: Research Roadmaps

- Following the release of the HEPAP Accelerator R&D Subpanel Report in April 2015, the General Accelerator R&D (GARD) Program has engaged its research community to address the Subpanel recommendations to develop research roadmaps for these thrust areas:
  - Superconducting High Field Magnets
    - Produced the U.S. Magnet Development Program Plan
  - Advanced Accelerator Concepts
    - Laser-driven plasma wakefield acceleration (LWFA)
    - Particle-beam-driven plasma wakefield acceleration (PWFA)
    - Dielectric wakefield acceleration (DWFA)
  - Radiofreqency Acceleration Technology
    - Superconducting RF
    - Normal Conducting RF
    - RF Sources
- Community-developed roadmaps include:
  - Pressing challenges to be addressed to move the field forward
  - Prioritized milestones aligned to the most compelling science

Technology R&D Progress

- Accelerator R&D Roadmaps are now guiding investments in the GARD program
  - Roadmaps are guiding GARD reviews
  - Last year's laboratory reviews noted that roadmaps are being followed successfully
- Investments are also being made in new accelerator R&D facilities: FACET-II, BELLA 2nd beamline
- Detector R&D plans to follow a similar roadmap strategy, starting with a Basic Research Needs workshop in late 2019





HEP Computing

- P5 recommended a program of challenging scientific experiments that have equally challenging computing needs
- The HEP Computing Infrastructure Working Group was formed in 2017 to develop a strategy for meeting the computing needs
  - **More details in Eric Colby's talk tomorrow**
- Successfully addressing computing challenges will require continued effort from the community and coordination with ASCR and NSF's IRIS-HEP

This is a great time for HEP!

- **Clear directions and priorities were provided by P5. Multiple program changes have been implemented.**
- Excellent progress on many fronts:
  - Budgets
  - Projects
  - International agreements
  - Lots of research highlights
  - Accelerator R&D roadmaps and upgraded facilities
  - **The future of U.S. HEP is bright!**

- Not everything is perfect:
  - Multiple projects trying to ramp up [fabrication, installation, ops, ...]
  - Research squeezed
  - More good ideas, and people, than we can support
  - **HEP is Actively working these issues**
- To maintain progress, continued support and engagement of the community is critical, not only for the P5 priorities and their execution; but also for development of new ideas, concepts and enabling technologies

U.S. DEPARTMENT OF
ENERGY

Office of
Science