Basic Research Needs Study
High Energy Physics
Detector R&D

BRN Workshop Workshop Rockville, MD
December 11-14, 2019

Helmut Marsiske
Program Manager for Instrumentation
Office of High Energy Physics
HEP Mission

- Understand how the universe works at its most fundamental level:
  - Discover the elementary constituents of matter and energy
  - Probe the interactions between them
  - Explore the basic nature of space and time

- HEP pursues its mission by:
  - Building Projects that enable discovery science
  - Operating Facilities that provide the capability to perform discovery science
  - Conducting a Research program that yields discoveries
HEP Program

- P5 Science Drivers identify the scientific motivation
- Research Frontiers are useful categorization of experimental techniques and serve as the basis of the budget process
- Research Frontiers are complementary
  - No one Frontier addresses all science drivers
  - Each Frontier provides a different approach to address a science driver
  - Enables cross-checking scientific results
- Detector R&D Program undergirds/overarches Research in all three Frontiers
1. Support research leading to fundamental advances in the science of particle detection, and develop the next generation of instrumentation for HEP

- Properly balanced between...
  - ...incremental, near-term, low-risk and transformative, long-term, high-risk R&D; i.e. Project-oriented vs. Generic R&D
  - ...universities and labs
- Focus on strategic areas
  - Future promise and U.S. leadership
- Engage researchers from other fields and from industry
2. Provide graduate and post-doctoral research training in instrumentation
   - Next generation of detector experts

Funding in FY 2019 is ~$24M, down from ~$30M earlier in the decade
- Research funding is ~2/3 of total, most of it at labs
- Facilities/test beam operations is ~1/3

Efforts at labs and universities:
- 50-60 FTEs at 7 labs: ANL, BNL, FNAL, LBNL, LLNL, PNNL, SLAC
- 20-30 FTEs at ~15 universities

Process to determine funding/effort:
- Labs: annual budget briefings, field work proposals (FWPs), and lab comparative review (last in 2016, next in FY 2021)
- Universities: annual funding opportunity announcement (FOA) and university comparative review (since 2012)
HEP Program Guidance

- FACA panels & subpanels provide official advice
  - High Energy Physics Advisory Panel (HEPAP)
    - Jointly chartered by DOE and NSF to advise both agencies
    - Provides the primary advice for the program
    - Subpanels for detailed studies (e.g. Particle Physics Project Prioritization Panel (“P5”) in 2008, 2014
  - Astronomy and Astrophysics Advisory Committee (AAAC)
    - Advises DOE, NASA, and NSF on selected issues in astronomy & astrophysics of overlap, mutual interest and concern
  - Formal Advice Also Provided by National Academy of Sciences (NAS)
    - Decadal Surveys in Astronomy & Astrophysics, Elementary Particle Physics
Other:
- Community-organized science studies and input
  - Snowmass, CPAD, DPF input
- DOE-organized science studies and exercises
  - Portfolio reviews
  - Lab optimization
  - Accelerator Technology Roadmap
  - Computing Infrastructure Working Group
- Basic Research Needs (BRN) Studies

Taken together these processes aim to
- Improve the effectiveness and efficiency of HEP research programs and supporting technology R&D/infrastructure
- Identify currently operating experiments that have the highest impact on P5 science drivers
- Identify research and technology R&D areas that are ripe for additional investments, informing future experiments
SC’s Office of Basic Energy Sciences initiated this approach with the *Basic Research Needs to Assure a Secure Energy Future* workshop in October 2002. This resulted in a comprehensive, 420-page report that identified 37 Proposed Research Directions.

Numerous (~20) subsequent topically-focused BRNs have helped to define directions and make the case for major new efforts such as Energy Frontier Research Centers and Innovation Hubs.

While there are some variations and there has been some evolution, many BRNs have involved:

- Production of a *Technology Perspectives Factual Document* prior to the workshop
- Definition of a set of *Science Grand Challenges* that, if solved, might result in transformational changes
- Definition of a set of *Priority Research Directions* that address the technology R&D challenges
Targeted topics defined, and workshop charge issued, by SC program office

Attendance is limited and by invitation only

Participants will have considerable work to do before, during, and after the meeting

Workshop co-chairs develop agenda and select panel leads (with program office input); panel co-leads develop agenda and select panel members

Typical structure: Opening plenary sessions, panel breakout sessions that develop Priority Research Directions, closing plenary session, and extended writing session – draft report completed before departure!

Prompt output: final report released typically 60-90 days after the workshop
BRN Impacts

- BRN reports are expected to serve as reference documents with a long shelf life, and to be readily accessible.

- Post-workshop outreach activities often include communication of the results to the broader community by co-chairs and the SC program, and briefings by federal staff to other interested federal parties (within and beyond DOE).

- **BRNs may, individually or collectively, serve as the basis for subsequent funding opportunities**
  - Many examples from BES
HEP Detector R&D BRN Study

DOE/HEP commissioned Study to engage the community in identifying Detector R&D priorities

- Assess the present status of the HEP technology landscape
- Identify key enabling capabilities and associated performance requirements in pursuit of the P5 Science Drivers
- Identify strategic technology areas, aligned with the strengths of the US community, that future long-term R&D efforts should focus on. Formulate Priority Research Directions in each area
- Formulate a small set of broad, high-impact instrumentation “Key Challenges” where technological breakthroughs could lead to game-changing experimental capabilities for HEP
- Study results will be described in a report delivered within two months following the completion of a workshop. DOE will use the study results to inform HEP Detector R&D program planning, which may include a call for proposals to support new technology developments and capabilities that address the study priorities
BRN Study, continued

- Study co-chairs: Bonnie Fleming (Yale) and Ian Shipsey (Oxford)
- Physics Working Groups reflecting the P5 Science Drivers
  - Elucidate capabilities and performance requirements to achieve physics goals
- Technology Working Groups
  - Identify specific technologies capable of achieving performance requirements and elucidate R&D efforts to get there
BRN Study WGs and Co-Conveners

The BRN website is:  http://doe-brn-hep-detectorrandd.physics.ox.ac.uk

- **Physics-focused WGs**
  - Higgs: Jim Hirschauer (FNAL), Gabriella Sciolla (Brandeis)
  - Neutrinos: Ornella Palamara (FNAL), Kate Scholberg (Duke)
  - Dark Matter: Jodi Cooley (SMU), Dan McKinsey (Berkeley)
  - Dark Energy and Inflation: Clarence Chang (ANL), Brenna Flaugher (FNAL)
  - Explore the Unknown: Monica Pepe Altarelli (CERN), Sarah Demers (Yale)

- **Technology-focused WGs**
  - Quantum Sensors: Andy Geraci (Northwestern), Kent Irwin (SLAC)
  - Noble Liquids: Roxanne Guenette (Harvard), Jocelyn Monroe (RHUL)
  - Photodetectors: Peter Krizan (IJS), Lindley Winslow (MIT)
  - Solid State and Tracking: Marina Artuso (Syracuse), Carl Haber (LBNL)
  - Calorimetry: Francesco Lanni (BNL), Roger Rusack (Minnesota)
  - T/DAQ: Darin Acosta (UFlorida), Tulika Bose (Wisconsin)
  - Readout and ASICs: Gabriella Carini (BNL), Mitch Newcomer (UPenn)

- **Cross-cut WG**
  - Marcel Demarteau (ORNL), Jim Fast (PNNL), Sunil Golwala (Caltech), Young-Kee Kim (Chicago), Abe Seiden (UCSC)
BRN Study, continued

- WGs have been working on
  - Engaging the broader community to gather input
  - Drafts of WG reports encapsulating Priority Research Directions (PRDs)

- Planning for workshop in the DC area
  - December 11-14, 2019
  - 60-70 participants, by invitation

- Complete final report by middle of February 2020
Summary

Thank You for contributing to this (second) HEP BRN

We look forward to the workshop discussions later this week and to the BRN final report.

DOE will use the study results to inform HEP Detector R&D program planning, which may include a call for proposals to support new technology developments and capabilities that address the study priorities.
DOE HEP Research Priorities: Snapshot

- **Energy Frontier**
  - Analysis of LHC Run 2 data
  - Contribute to operational responsibilities and complete “Phase I” upgrades
  - Scientific support for HL-LHC program

- **Intensity Frontier**
  - Neutrino Program
    - Support ProtoDUNE, LBNF/DUNE, and PIP-II
    - Implement Fermilab Short-Baseline Neutrino Program and Intermediate Neutrino Program
    - NOvA, T2K/SK, Minerva, MicroBooNE data analysis
  - Muon Program: Complete Mu2e, take data with Muon g-2
  - Heavy Flavor Program: take and analyze data with Belle-II

- **Cosmic Frontier**
  - Dark Matter: Scientific support for G2 experiments (in fabrication)
  - Dark Energy: DES analysis; scientific support for LSST and DESI (in fabrication)
  - Continue science and technology planning for CMB-S4

- **Accelerator R&D**
  - Focus on outcomes and capabilities that will dramatically improve cost effectiveness for mid-term and far-term accelerators
  - Hosting workshops to develop and implement R&D plan following P5 and GARD panels

- **Detector R&D**
  - Developing process to identify highest priority R&D activities for current phase of implementing P5
  - Aim to increase long-term “high-risk” R&D with potential for wide applicability and/or high-impact
    - “Blue-Sky” scientific research on innovative technologies not already in contention for implementation in future DOE HEP projects

- **HEP Theory**
  - Maintain an overall “thriving” program as per P5
Detector R&D Program Goals

1. Support research leading to fundamental advances in the science of particle detection, and develop the next generation of instrumentation for HEP
   - Properly balanced between...
     - ...incremental, near-term, low-risk and transformative, long-term, high-risk R&D; i.e. Project-oriented vs. Generic R&D
     - ...universities and labs
   - Focus on strategic areas
     - Future promise and U.S. leadership
   - Engage researchers from other fields and from industry
2. Provide graduate and post-doctoral research training in instrumentation
   ▶ Next generation of detector experts

Program Funding/Effort/Process

- Funding in FY 2019 is ~$24M, down from ~$30M earlier in the decade
  - Research funding is ~$17M, ~80% at labs
  - Facilities/test beam operations is ~$7M

- Efforts at labs and universities:
  - 50-60 FTEs at 7 labs: ANL, BNL, FNAL, LBNL, LLNL, PNNL, SLAC
  - 20-30 FTEs at ~15 universities

- Process to determine funding/effort:
  - Labs: annual budget briefings, field work proposals (FWPs), and lab comparative review (last in 2016)
  - Universities: annual funding opportunity announcement (FOA) and university comparative review (since 2012)
**Interim Summary**

- **Innovation in Instrumentation (historical) strength of HEP**
  - Need to strengthen/reinvigorate this core competency

- **Near-term focus has been on high-priority P5 projects**
  - LHC phase-II upgrades
  - Short- and long-baseline neutrino program
  - Dark Matter, Dark Energy (and CMB)

- **Need to strengthen long-term efforts: more Blue-Sky R&D**

- **Stewardship of instrumentation efforts has historically rested with national labs and a small number of university groups**
  - Need to establish new, effective and efficient collaborative models, and better engage universities in the R&D enterprise
  - Continue to examine raison d’être of existing detector facilities within the (changing) national HEP program

- **Community plays key role in identifying scientific and technological opportunities and in making them happen**
  - E.g., engaging CPAD for general- and special-purpose Detector R&D workshops