U.S. DEPARTMENT OF ENERGY | Office of Science

HEP Research Program Status

HEPAP Meeting
November 21, 2019

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

1st DOE SC Distinguished Scientist Fellows

Two of the first five DOE SC Distinguished Scientists are from HEP

- Sally Dawson, Brookhaven National Laboratory
  - "for seminal contributions to the discovery of the Higgs particle through theoretical predictions, and a leadership role in thoroughly exploring the Higgs Boson and electroweak physics in research at particle accelerators."

- Joshua Frieman, Fermi National Accelerator Laboratory
  - "for pioneering advances in the science of dark energy and cosmic acceleration, including leading the Sloan Digital Sky Survey-II Supernova Survey, co-founding the Dark Energy Survey and service as its Director."

FY 2019 Early Career Awards: Univ.

- Thomas Dumitrescu, UCLA
  - New Tools for Strongly Coupled Quantum Field Theories
- Cora Dvorkin, Harvard U.
  - Discovering Dark Matter Clumps and Primordial Particles with Galaxies
- Tim Eifler, U. Arizona
  - Multi-Probe Cosmology with DES and LSST
- Sowjanya Gollapinni, U. Tennessee
  - Development of a Laser Calibration System for the DUNE Far Detector
- Scott Hertel, U. Massachusetts, Amherst
  - Optimization and Calibration of a 4He-based Detector for Low-Mass Dark Matter
- Laura Jeanty, U. Oregon
  - Searches for New Long-Lived Particles and Upgrades to the ATLAS Inner Detector
- Elisabeth Krause, U. Arizona
  - Joint Analyses of Lensing, Clustering, and Galaxy Clusters with DES and LSST







FY 2019 Early Career Awards: Labs

- Viviana Cavaliere, BNL
  - Boosting New Physics Searches with Higgs Differential Cross-Section Measurements
- Diana Gamzina, SLAC
  - Mechanics of Materials' Interaction with Electromagnetic Waves in Accelerator Cavities
- Pedro Machado, FNAL
  - The Next Revolution in Neutrino Physics
- Peter Sorensen, LBNL
  - Tagging Radon Daughter Backgrounds in a Crystalline Xenon TPC: A Solid Future for the LZ Dark Matter Search Experiment
- Nhan V. Tran, FNAL
  - Deep Learning Acceleration of the Boosted Higgs Program and HEP Computing
- Jingke Xu, LLNL
  - Pursuing the Ultimate Power of Xenon Dark Matter Detectors
- Xingchen Xu, FNAL
  - Development of Next-Generation Nb_3Sn Superconductors for Energy-Frontier Circular Colliders

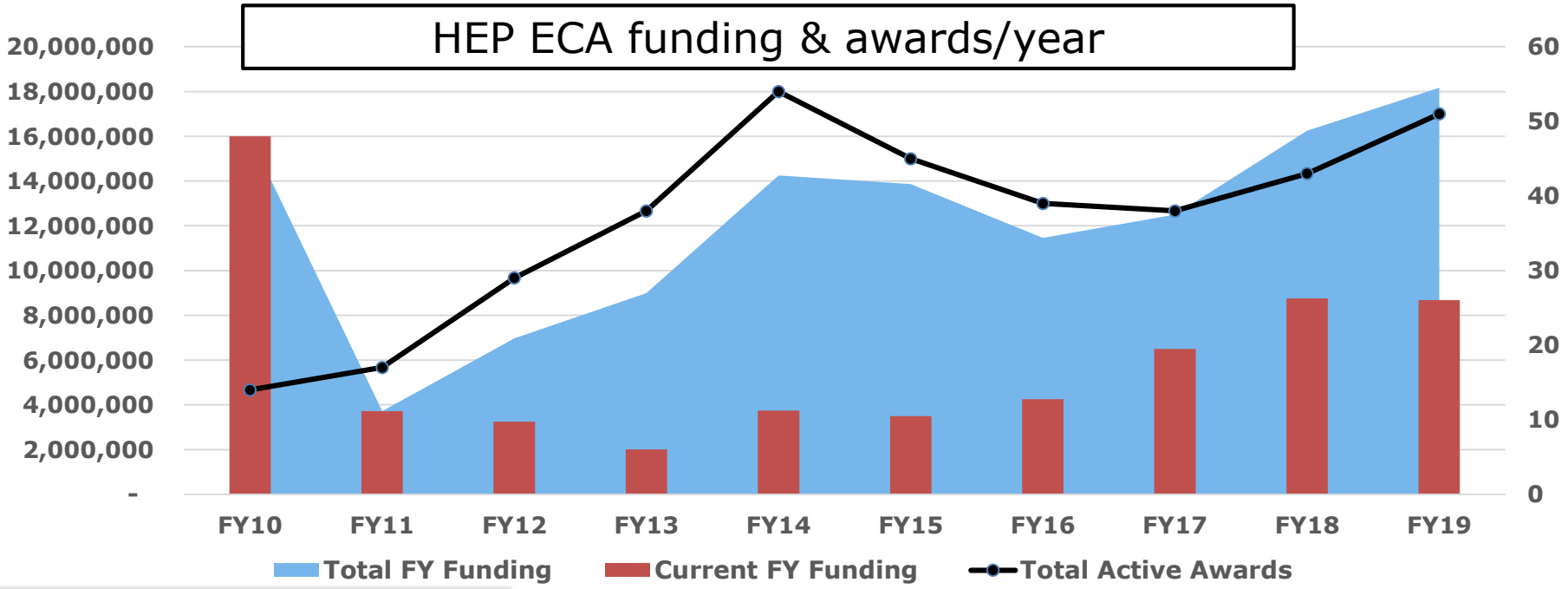






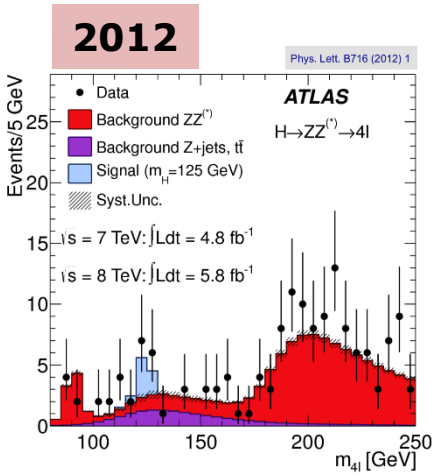
Increasing Investments to Early Career Research Program

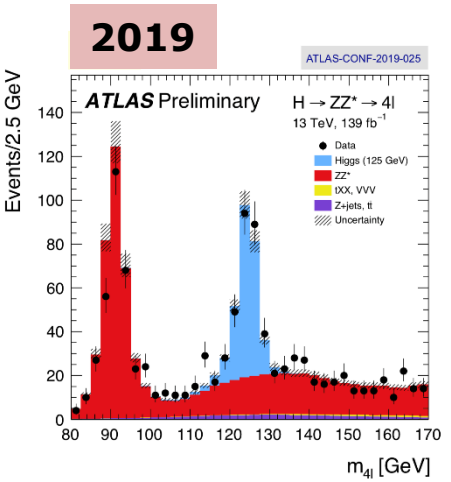
- Launched in FY 2010 with ARRA funding
- Established Program to Stimulate Competitive Research (EPSCoR) supported 1 Theory ECA in FY 2011 and 1 Intensity ECA in FY 2013
- Funding nadir was FY 2013, the first year impacted by sequestration
- Full-funding requirement took effect in FY 2014 (awards < $1M)
- 105 total awards to date: 61 University and 45 National Labs

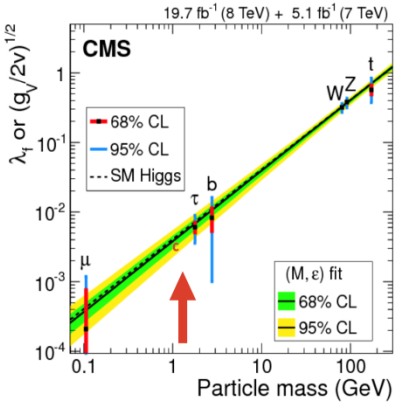


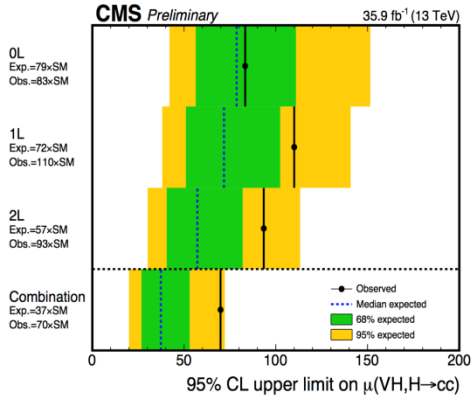
LHC Results

- LHC Physics program continuing successfully with **over 900 physics papers to-date by each experiment,** ATLAS and CMS. Recent results include:
  - ATLAS & CMS achieving unprecedented precision on Higgs mass since 2012 discovery; now within 0.1%
  - New results in Higgs search channels by ATLAS (H→μμ) and CMS (H→cc)



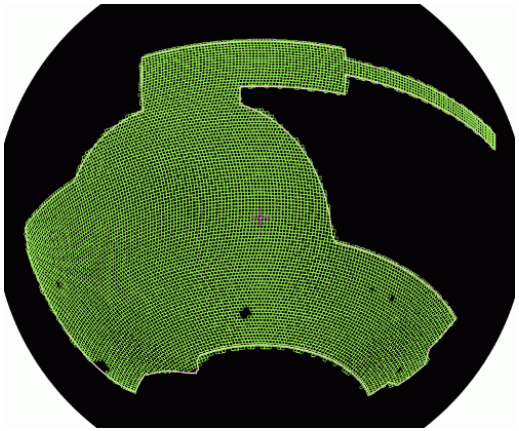




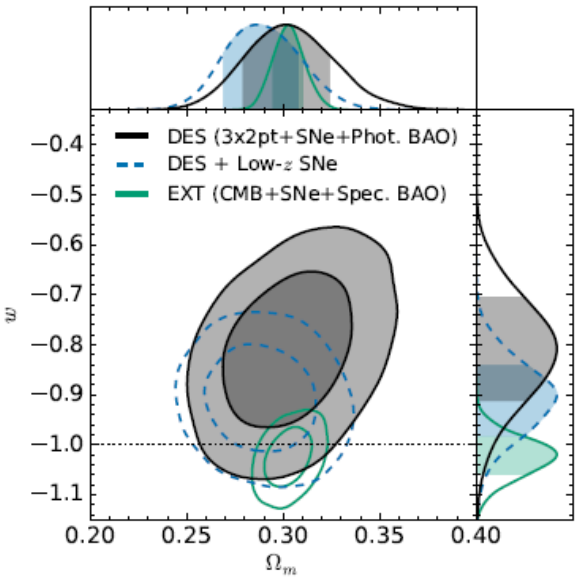


Dark Energy Survey

- DOE-HEP partnership with NSF-AST to create new camera and data systems on Blanco Telescope at CTIO
  - HEP provided Camera (DECam); NSF provided data system; both participate in operations, science
- Completed observations in January 2019 and met all survey metrics
  - Public Data Release "DR1" based on first 3 years data (Y1-Y3) has over 780 users, 10 TB data delivered
- Scientific results:
  - **250 scientific publications on range of topics as of November 2019**
  - New combined cosmology results from DES use Y1 Weak Lensing and Galaxy Clustering, Y1 Large Scale Structure, and Y1-Y3 Type 1a Supernovae
- Coming soon:
  - Y1 galaxy cluster & Y3 3x2pt WL cosmology, with Y6 cosmological results to follow



5085 sq. deg. in 5 filters each with ten 90 s exposures

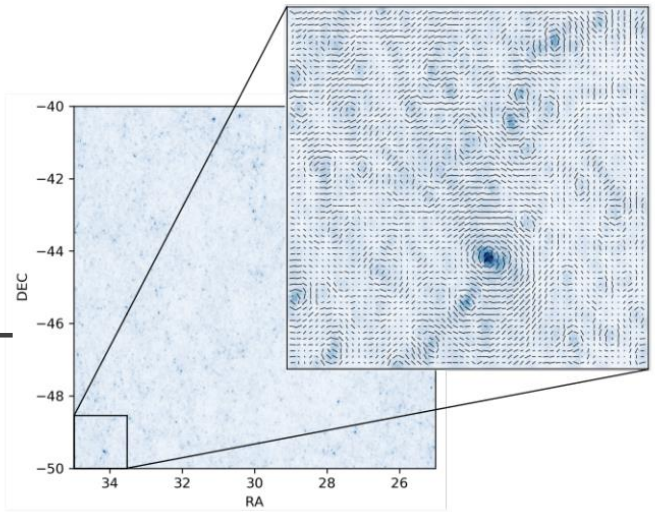


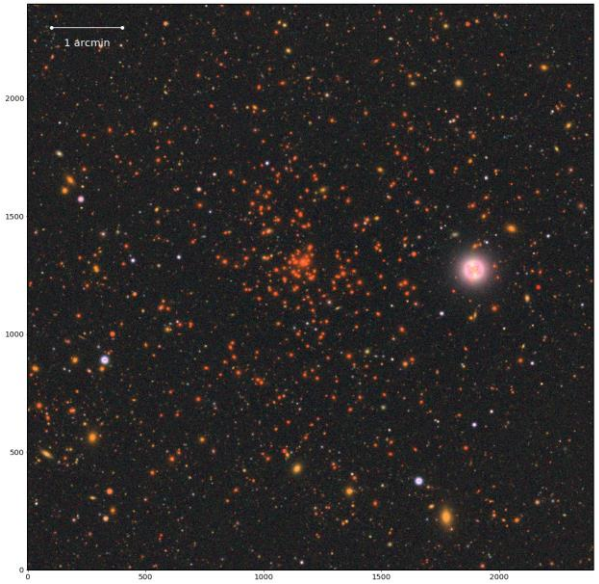
LSST Dark Energy Science Collaboration

- DESC produced state-of-the-art extragalactic catalogs and image simulations of the LSST survey
  - Used to test the dark energy analysis pipelines DESC is developing for LSST data
- DESC analysis software is under active development
  - Recent successes in weak lensing analysis pipeline development and the Core Cosmology Library

CCL release: https://github.com/LSSTDESC/CCL

https://arxiv.org/abs/1907.06530





DESC Spokesperson: Rachel Mandelbaum (CMU)
Deputy Spokesperson: Pat Burchat (Stanford)
The full DESC Management Team is listed at
https://lsstdesc.org/pages/contacts.html

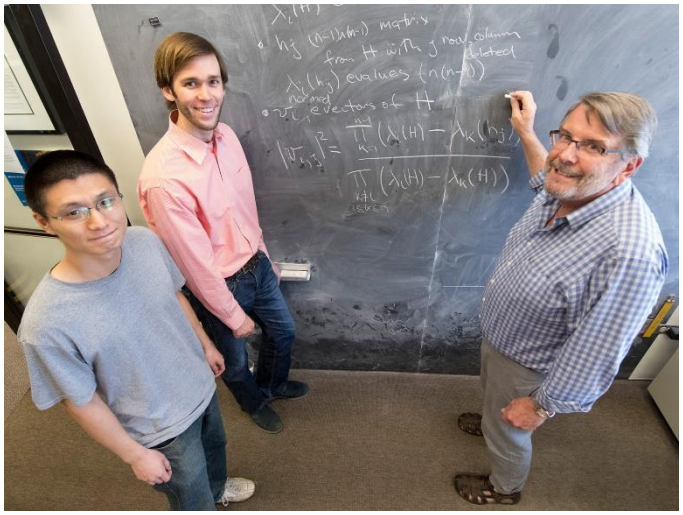
LSST DESC Dark Energy Science Collaboration

Neutrinos Lead to Discovery in Math

- Stephen Parke (FNAL), Peter Denton (BNL) and Xining Zhang (U. Chicago) were working on neutrino physics and discovered a curious mathematical identity
  - Identity relates the eigenvectors of the neutrino oscillation Hamiltonian directly to the eigenvalues of the Hamiltonian and its minors
  - They further discovered that this identity was a general property of Hermitian matrices (not just the 3x3 matrices of neutrino mixing) and that it did not seem to exist in the literature

https://arxiv.org/abs/1907.02534
https://arxiv.org/abs/1908.03795

- Reached out to Terence Tao (UCLA), who published a similar result in 2009
  - Tao did not previously know the new relation, but once informed of it was able to produce a mathematical derivation
  - The resulting paper, with Tao, Parke, Denton, and Zhang is under review
- Result should greatly simplify finding eigenvectors, a common problem in many physical systems



Zhang, Denton and Parke

QuantISED Awards & Updates

- FY 2019 Quantum Information Science Enabled Discovery (QuantISED) FOA and LAB call intended to complement and strengthen the current HEP- QIS portfolio
  - Cosmos and Qubits – *Connecting Cosmology, Information Theory & Qubits*
  - Foundational QIS-HEP Theory and Simulation – *field theory and qubits*
  - Quantum Computing for HEP – *experimental data analysis*
  - QIS-based Quantum Sensors – *for dark matter and new interactions*
  - Research Technology for QIST – *HEP tools for QIS technology*
  - Innovative HEP-QIS Small Experiments - *exploring P5 science drivers using QIS based tools and techniques*
- FY 2019 QuantISED Award Process:
  - 98 Letters of Intent were received (56 from FOA, 42 from LAB)
    - Represented about 45 institutions in 20 states; 48 LOIs encouraged to submit full proposals
  - 51 full proposals were received
  - 18 awards were recommended
    - 35% success rate; Awards list available at: https://science.osti.gov/hep
- QuantISED is coordinated with SC, other agencies, and OSTP

FY 2020 Planned Funding Opportunities

Funding Opportunity	Timeline	Funding Vehicles
FY 2020 SC Open Call (SC-wide)	Active	Funding Opportunity Announcement Only
U.S.-Japan Science and Technology Cooperation Program In High Energy Physics	Released October 15, Due December 16	DOE National Laboratory Announcement Only
FY 2020 Research Opportunities in High Energy Physics	Release soon. Proposals due ~late Jan.	Funding Opportunity Announcement Only
FY 2020 SC Early Career Research (ECR) Program (SC-wide)	Release in Fall 2019	Joint FOA/LAB Call
FY 2020 Research Opportunities in Accelerator Stewardship	Release in 2020	Joint FOA/LAB Call

- Dark Matter New Initiatives (FY19 call)
  - Some proposals from FY 2019 on hold for FY 2020 decision (more detail later)
- Quantum Information Science Enabled Discovery (QuantISED)
  - FY 2018 Lab awards and university consortia renewals to be considered for FY 2020 funding
- DOE Traineeship in Accelerator Science & Engineering
  - No new call expected in FY20.

Research Consortia

- Research consortia are a possible mechanism for funding where a single proposal is created by multiple institutions
  - One member of the consortium serves as the prime recipient/consortium representative (lead organization).
  - Consortia must provide a collaboration agreement which sets out the rights and responsibilities of each consortium member, including:
    - Management structure
    - Method of making payments to consortium members
    - Means of ensuring and overseeing members' efforts on the project
    - Provisions for members' cost sharing contributions
    - Provisions for ownership and rights in intellectual property developed previously or under the agreement
  - Note that a consortium is applied for in one application and results in one award with subawards to consortia members
- This mechanism allows research efforts with specific timelines and goals to provide the "big picture" for consideration, rather than "puzzle pieces" from separate individual institution proposals
  - Consortium option is available in the SC General Call for FY2020
  - May be available in other future HEP FOAs as appropriate

DOE SC Graduate Student Research Fellowships

- DOE SC Graduate Fellowship program has 2 calls per year, supporting student internships with DOE lab mentors in the summer (deadline previous Fall) and during the school year (deadline previous Spring).
- Fall 2019 solicitation just closed, next solicitation opens Feb 2020 for interns starting Fall 2020 or later. Internship period is flexible: 3-12 months
- This program has supported 15-20 HEP graduate students per year and has a high success rate for eligible applications. You can view the solicitation at https://science.osti.gov/wdts/scgsr/
- **New in 2019 solicitation are Convergence Research Topical Areas.** These are for research of interest to 2 or more SC offices and are treated somewhat differently in review. Please encourage likely candidates.
- Convergence Research Topical Areas

  (a)Microelectronics (ASCR, BES, HEP)

  (b)Data Science (ASCR, BES, BER, FES, HEP, NP)

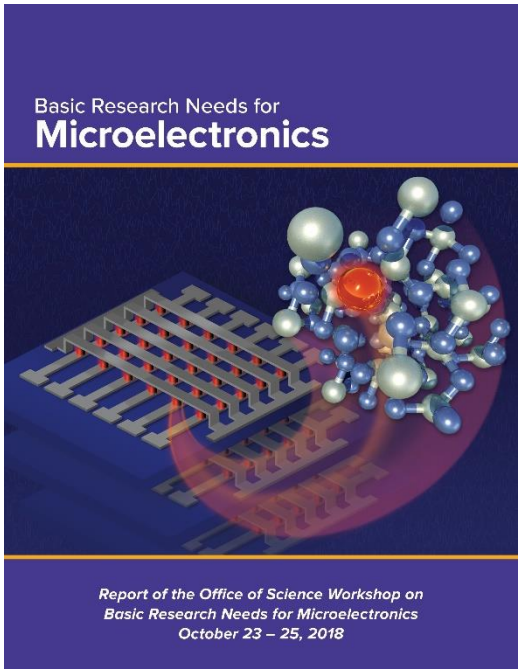
  (c)Fundamental Symmetries (BES, HEP, NP)

  (d)Accelerator Science (ASCR, BES, BER, FES, HEP, NP)

SC Microelectronics BRN

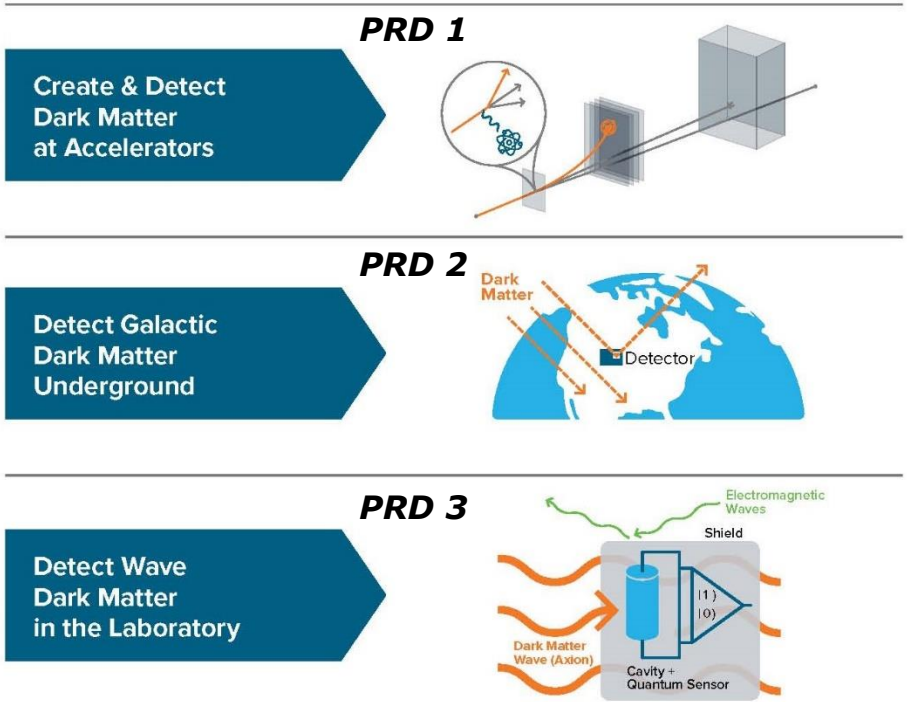
- Basic Research Needs Workshop for Microelectronics
  - Report now available: https://science.osti.gov/bes/Community-Resources/Reports

- This report is based on a workshop on Basic Research Needs for Microelectronics, which was held October 23–25, 2018, and sponsored by ASCR, BES, and HEP
- The goal of the workshop was to identify basic research needs associated with advanced microelectronics technologies for applications relevant to the DOE mission, including computing, power grid management, and science facility workloads



Dark Matter New Initiatives Process

- Dark Matter New Initiatives is motivated by recent theoretical advances and development of new technologies opened new avenues to explore dark matter
  - Input from 2017 Community Workshop
  - Basic Research Needs (BRN) Workshop led to 3 Priority Research Directions (PRDs) →
  - PRDs reflected in FY 2019 Funding Opportunity Announcement (FOA)



Dark Matter New Initiatives Awards

- In FY19, four proposals selected to develop concept and execution plans for potential small projects
  - Additional proposals may be awarded after FY20 appropriations
- In 2021 and beyond, aim to select concept(s) for fabrication (possibly in stages)
  - Continue to support theory studies, research efforts, tech. R&D needed to support project(s) as necessary & appropriate

PI Name	Institution	Proposal Title	PRD
Sonnenschein, Andrew	FNAL	ADMX Extended Frequency Range	3
Estrada, Juan	FNAL	Direct-Detection of Dark Matter with eV-to-GeV Masses with a low-background, multi-kilogram Skipper-CCD Array Sensitive to Single Electrons	2
Van de Water, Richard	LANL	Search for Dark Matter with an Improved Booster Beam Dump Experiment at FNAL	1
Irwin, Kent	SLAC	Dark Matter Radio Cubic Meter: Searching the QCD Axion Band Below 1 micro eV	3

Detector R&D BRN

- The Detector R&D BRN website is: http://doe-brn-hep-detectorrandd.physics.ox.ac.uk
- The Detector R&D BRN Study will:
  - Survey the present state of the HEP technology landscape.
  - Identify key capabilities and associated performance requirements to enable HEP science drivers.
  - Identify technologies to provide or enhance such capabilities.
  - Articulate long-term Priority Research Directions to push well beyond the current state of the art, potentially leading to transformative technological advances with broad-ranging applicability; flesh out the required R&D efforts with deliverables with notional timelines and key technical milestones along the way; and elucidate the technical infrastructure required to support these efforts.
  - Formulate a small set of instrumentation Key Challenges that could, if addressed successfully, result in game-changing experimental capabilities.
- The BRN Study structure consists of:
  - Five "physics working groups" based on the five P5 science drivers
  - Seven "technology working groups" plus a cross-cutting group:
    - Quantum Sensors, Solid State (including vertexing and tracking), Calorimetry, Photodetectors, Noble Liquids, TDAQ (including Machine Learning), and Readout & ASICs
- BRN Study members will attend CPAD in Madison, WI, December 8-10, 2019 https://wp.physics.wisc.edu/cpad2019/
  - There will be townhalls and other fora for community input and dialog with the BRN process
- Detector R&D BRN Workshop will be Dec. 11-14, 2019, in the DC area; report due in Feb. 2020
  - The Chairs of the BRN Study are **Bonnie Fleming (Yale) and Ian Shipsey (Oxford)**
  - The DOE BRN Study liaisons are Glen Crawford (DOE) and Helmut Marsiske (DOE)

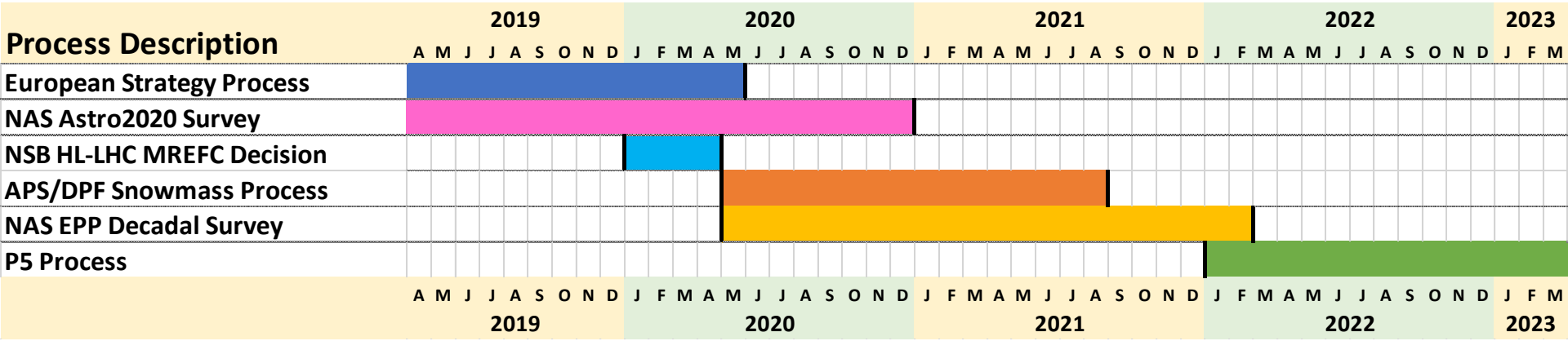
HEP Research Reviews in 2020

- Many reviews are scheduled in FY 2020!
  - This table shows some highlights, but does not include many of the "usual" activities (eg Comparative Review) or Project (OPA) Reviews. Dates subject to change.

Target Date	Activity
Dec-19	GARD Magnet Development Program
Jan-20	SLAC Sector 30 AIP, QuantISED panel
Feb-20	SBIR Phase I, SBN Ops Readiness
Apr-20	LSST Facility Operations, US-Japan FOA, LANL Institutional
May-20	Mu2e Prelim Ops
Jun-20	ANL Institutional, Accel Stewardship
Jul-20	Energy Frontier Comparative Lab Review, Belle II Ops
Aug-20	GARD Roadmap Reviews (TBC)
Sep-20	HEP Research and Technology Division Committee of Visitors
Oct-20	Cosmic Frontier Comparative Lab Review

Strategic Planning Timeline

- To provide timely input to the FY25 budget formulation, the next P5 report will be required by March 2023
- U.S. Community beginning Snowmass process with major meeting occurring in summer 2021
- Potential timeline for the next NAS EPP Decadal Survey could be mid-2020 through early-2022
  - Overlap with Snowmass could enable synergy with Snowmass processes and delivery of report as P5 process begins



Comings & Goings

- Incoming:
  - New Intensity Frontier IPA, early 2020
  - New HEP Computing Detailee TBD
- Outgoing:
  - IPA/detailees: Kevin Flood, Tom LeCompte (Aug)
  - AAAS Fellows: Claudette Rosado-Reyes, Andrea Peterson (Sep)
- DOE Federal Position for Intensity Frontier
  - Interviewing candidates now!
- DOE Federal Position for SURF Program Manager
  - Offer is out!
- Always looking for candidates to help with critical tasks
  - Interested parties should contact HEP Management!
  - Investigating alternate hiring opportunities beyond IPAs and Detailees

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