High Energy Physics Detector R&D

HEP PI Meeting @ DPF2019

July 31, 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 fulfills its mission by:
  - Building Projects that enable discovery science
  - Operating Facilities that provide the capability to perform discovery science
  - Conducting a Research program that produces discovery science
HEP Research 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
HEP Detector R&D Program
Detector R&D Program Goals

- 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
Provide graduate and post-doctoral research training in instrumentation
- Next generation of detector experts

Support “infrastructure”—technical personnel, equipment, “facilities”, and test beams—required for experimental detector R&D and fabrication
Funding in FY 2019 is ~$24M, down from ~$30M in FY 2014
  - 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’etre 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
Basic Research Needs (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 a small set of 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 the 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)
- In the process of laying out structure and timeline of the Study, and identifying co-conveners for the physics and technology Working Groups (WGs)
  - Chairs and conveners will identify WG members broadly balanced/representative of the community
BRN Study WGs and Co-Conveners

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: NN, NN
- 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 (Wisonsin)
- Readout and ASICs: Gabriella Carini (BNL), Mitch Newcomer (UPenn)
As the WGs are being assembled, start working on

- “Technology Perspectives Factual Document” using updated CPAD Report as input
- Interim Study report by the end of September to inform FY 2021 budget discussions with OMB

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

Complete final report by middle of February 2020
Budgets
Typically, three budgets are being worked on at any given time:

- Executing current Fiscal Year (FY; October 1 – September 30)
- White House Office of Management and Budget (OMB) review and Congressional Appropriation for next FY (FY+1)
- Agency internal planning for next-to-next FY (FY+2)

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<tr>
<th>FY 2019 Budget</th>
<th>Spend the Fiscal Year Budget</th>
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<tr>
<td>FY 2020 Budget</td>
<td>OMB Review</td>
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<tr>
<td>FY 2021 Budget</td>
<td>DOE Internal Planning with OMB and OSTP Guidance</td>
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<th>CY 2018</th>
<th>Calendar Year 2019</th>
<th>Calendar Year 2020</th>
<th>Calendar Year 2021</th>
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HEP BUDGET ALLOCATION BY FISCAL YEAR (THEN-YEAR $ IN K)

- Research
- Facilities
- Projects
- SBIR
- House Mark (1.045B)

FY 10, FY 11, FY 12, FY 13, FY 14, FY 15, FY 16, FY 17, FY 18, FY 19, FY 20 REQUEST

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Funding Opportunity Announcements
FY 2020 Research Opportunities in High Energy Physics – Comparative Review

- **DE-FOA-000xxxx** issued **TBD**
- Six HEP research subprograms
  - Cosmic, Energy, and Intensity Frontiers, HEP Theory, Accelerator Science and Tech. R&D, and Detector R&D
- Letter of Intent (strongly encouraged) due: **TBD**
- Final Proposal deadline: **TBD**

Please read the FOA carefully to comply with all requirements prior to submitting a proposal.

- In addition to the FOA, an FAQ is available and addresses topics on:
  - Registration and eligibility requirements
  - Proposal types and requirements;
  - Guidance for new faculty and those without current HEP grants
  - Guidance for PIs with existing HEP grants
  - Budget information and guidance on scope of request(s)
  - Letter of Intent
  - Information on overall scientific merit review process
  - Contacts for program- or system-related questions

Both the FOA and FAQ are planned to be available at: [http://science.osti.gov/hep/Funding-Opportunities/](http://science.osti.gov/hep/Funding-Opportunities/)
Key Items to Keep in Mind

- Read the FOA carefully and follow the requirements on content, length, etc.
- **Several requirements in the FOA are set from outside the DOE/HEP office**, and there is little to no flexibility to modify
  - **Non-compliant proposals submitted to the FOA will not be reviewed**
- **In recent years, ~10% of incoming proposals are declined without review.** Requirements most often missed or overlooked include: Data management plans, page limits, separate budget sheets (if needed) for each research subprogram or thrust, and inclusion of Personally Identifiable Information (PII)
Recent FOA Changes

- **All Research** proposals to DOE/SC must have a Data Management Plan (DMP)
  - Includes HEP comparative review and Early Career, but not conferences, workshops, operations, projects
  - Any research thrust in a proposal without a DMP will be declined without review

- **All Renewal** proposals must submit “proposal products” (publications, etc.) after the application is submitted
  - PIs will be notified by PAMS and have 5 days to respond
  - We cannot review incoming proposals until this step is completed
  - These will eventually be captured with your annual Progress Report, but must be entered by hand during the transition phase

- **Recurring Submissions** of Research Applications
  - “A previously declined application may be resubmitted to this FOA, but only after it has undergone substantial revision. An application submitted to this FOA that has not clearly taken into account the major concerns from prior DOE reviews may be declined without review and will not be considered for funding.”

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Non-compliant applications will not be reviewed, and therefore, will not be considered for funding. As a convenience and courtesy, DOE/HEP plans to provide a checklist in the FY 2020 FOA.

The list is not intended to be complete; applicants should review the FOA in-detail and follow all instructions.

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<tr>
<th>FY 2018 Comparative Review FOA – GUIDELINE FOR APPLICATION REQUIREMENTS</th>
<th>COMPLETED</th>
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<tr>
<td>Is the proposed research scope aligned with programmatic priorities of DOE-HEP?</td>
<td>✓</td>
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<tr>
<td>Personally Identifiable Information (PII): Do not supply any information, such as birth date or place, citizenship, home address, personal phone nos., etc., that should not enter into the merit review.</td>
<td>✓</td>
</tr>
<tr>
<td>A Data Management Plan is required for each research thrust (e.g., ATLAS, LSS T, lattice gauge theory, etc.). It must appear in Appendix 8 of the application and comply with page-limit requirements specified in the FOA.</td>
<td>✓</td>
</tr>
<tr>
<td>Project Summary/Abstract Page: contains the name(s) of the applicant, the project director/principal investigator(s) and the PD/PI’s institutional affiliation, and any Co-Investigators and their affiliations.</td>
<td>✓</td>
</tr>
<tr>
<td>DOE Cover Page: list each HEP research subprogram (e.g., Energy Frontier, HEP Theory) for which funding is requested. If there is more than one, be sure to attach the Cover Page Supplement.</td>
<td>✓</td>
</tr>
<tr>
<td>Page limits for each section comply with the FOA requirements (as defined in Section IV of the FOA).</td>
<td>✓</td>
</tr>
<tr>
<td>Biographical sketches carefully follow the FOA instructions and avoid PII.</td>
<td>✓</td>
</tr>
<tr>
<td>Current and Pending Support information completed, including an abstract of the scope of work.</td>
<td>✓</td>
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<tr>
<td>In addition to the budget information for the full proposal: separate budget and budget justification narratives for each HEP research subprogram in the proposal for each year in which funding is being requested and for the cumulative funding period has been provided in Appendix 7.</td>
<td>✓</td>
</tr>
<tr>
<td>Level of Effort Tables completed in Budget Justifications in Appendix 7: for each person for whom funding is requested in a research thrust, on the scope of activities during proposed project period.</td>
<td>✓</td>
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<tr>
<td>Post-submission of a ‘renewal’ application, timely submitted the Renewal Proposal Products (RPP) in PAMS.</td>
<td>✓</td>
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Supported HEP Research Activities

Research Efforts that are in direct support of HEP programs

- **Faculty support**
  - Up to 2-months faculty summer salary, and optimizing the number of research personnel supported
  - Summer support should be adjusted according to % time the faculty is on research effort

- **Research Scientists**
  - Support may be provided, but due to long-term expectations, need to consider case-by-case on merits: whether the roles and responsibilities are well-matched with individual capabilities and cannot be fulfilled by a term position
  - Efforts are related to research, not long-term operations and/or project activities

- **Support for technical personnel in the Detector R&D program**

- **What’s not supported by ‘Research’ grants**
  - Any significant HEP operations and/or project-related (past CD-0) activities:
    - Engineering (except Detector R&D), Major Items of Equipment, consumables for prototyping or production
    - Non-HEP related efforts; *e.g.* gravitational waves, heavy-ion, AMO
Comparative Review Considerations

- Generally very useful to have head-to-head reviews of PIs working in similar areas, particularly for large grants
  - Discussion of relative strengths and weaknesses of individual proposals and PIs

- Many factors weigh into final funding decisions
  - Compelling research proposal for next 1-4 years
    - Incremental? Implausibly ambitious? Poorly presented?
  - Significant recent contributions in last 3-4 years
    - Synergy and collaboration within group (as appropriate)
    - Contributions to the research infrastructure of experiments
  - Alignment with HEP programmatic priorities
  - Balanced program of R&D/design, support of construction or operations, data analysis

- Supportive of excellent research, including excellent research by new people, even when times are tough!
  - Corollary: Some proposals, including some from senior personnel, ranked below average may not be funded
HEP Detector R&D Program

- Proposed research will review best if broadly aligned with the DOE/HEP mission, its program, and the P5 strategy.
- “Generic” detector research that is not specific to a single HEP experiment but broadly applicable should be directed to the HEP Detector R&D program.

Proposals for “Blue-Sky” scientific research on innovative technologies not already in contention for implementation in future DOE HEP projects are specifically encouraged.
- **Multi-institutional (consortium) proposals** are strongly encouraged, to address significant technology R&D challenges beyond the scope of typical single-investigator awards

- Single proposal created by multiple institutions
  - One member of the consortium serves as the prime recipient/consortium representative (lead organization)
  - May result in one award to the prime recipient with subawards to the consortium members

- Consortia must provide a collaboration agreement which sets out the management structures and processes
Multi-thrust Proposals

- Applications where a PI is proposing to conduct research across multiple HEP research subprograms during the project period will be considered.

- PIs are encouraged to submit only one application, describing:
  - Overall research activity, including fractional time planned in each subprogram.
  - In proposal’s Budget Justification material (Appendix 7), include level of effort table for any transition of effort during project period, as appropriate.

- As part of their overview of the subprogram and review process, DOE PMs will provide the panel with details regarding such research plans across multiple HEP thrusts.

- Reviewers with appropriate topical expertise in the research area(s) will assess the full scope, relevance, and impact of the proposed research in the merit review process — e.g., merit review questions to consider:
  - Are the plans for such cross-cutting efforts reasonably developed and balanced; will the proposed activities have impact?
  - Does the scope of the full proposed program provide synergy or additional benefits to the HEP mission beyond the individual thrusts?
  - Will PI’s overall efforts across multiple thrusts add value to HEP program goals and mission?
Comparative Review and Award Process

Pre-review
- **August:** Letters of Intent (LOIs) received via DOE’s Portfolio Analysis and Management System (PAMS). Review planning at DOE-HEP.
- **September:** Proposals received. FOA compliance checks at DOE-HEP: scope, PI qualifications, page limits, budget pages, etc.

Panel Review
- **Sept-October:** Proposals assigned to at least three mail reviewers.
- **October-November:** Reviewers’ input written evaluations in PAMS.
- **November:** Panel discussion of all proposals and all senior personnel. Make comparative evaluation. Add panelist reviews in PAMS.

Post-review and award
- **December:** Assessment of each proposal and each PI by DOE-HEP using merit reviews, grant monitor input, programmatic priorities, and budget constraints.
- **Early-to-mid January:** Send prioritized budget guidance to PIs and request revised budgets and budget justifications.
- **End-January - March:** Route proposal’s procurement packages through DOE-SC and DOE Chicago Operations Office for award approval.
- **March-April:** Awards to university from DOE Chicago Operations Office.
Other Funding Opportunities

- **Workforce Development (WDTS) programs**
  - **Office of Science Graduate Student Research fellowships (SCSGR)**
    - Supports graduate student research at a DOE lab, 3 to 12 months
    - Two calls per year, usually Feb/Aug.
    - Applications typically due May/Nov for following Fall or Summer start
  - **Science Undergraduate Laboratory Internships (SULI)**
    - Supports undergraduate research at a DOE lab, 10 to 16 weeks
    - Three calls per year, for following Spring/Summer/Fall terms
    - Now accepting applications for Spring 2018, due Oct 2
  - **Visiting Faculty Program**
    - Summer research support for faculty/students from historically underrepresented institutions
    - One call per year, usually in Oct. Applications due in Jan.

- **Office of Science programs**
  - SC “Open Call” [DE-FOA-0001968]
    - HEP uses this primarily for supplemental proposals, experimental operations support, and conferences
  - **Early Career Research Program**
Early Career Research Program (ECRP)

- Plan to issue a FY 2020 Funding Opportunity Announcement for the next round of Early Career applications
- Stay tuned to https://science.osti.gov/early-career/ for further updates...
Preparing an ECRP Proposal

- In addition to the merit review criteria found in the FOA, the following guidance should be applied while preparing the proposal narrative:
  - What **challenges/problems** are you trying to solve? Communicate this!
  - Is **someone else** doing it already?
    - Alternatively, aren’t those research activities already being funded elsewhere?
    - If you carry-out these efforts, why are they unique and require ‘you’?
  - How does this research exploit/engage **unique capabilities** of your institution?
  - What **resources** are needed to complete the project?
  - Does your proposal outline a **5-year timeline**, with key **deliverables and personnel profiled** during this project period?
  - If funded, what will be the **outcome after 5-years**?
  - Have you previously **led the activities** that you are proposing?
  - **Why are you a future leader in HEP?**
    - Identify your leadership activities in Collaboration, HEP, or broader scientific community

- Reviewers/HEP look for **innovative, impactful** proposals
  - Can be speculative, but not implausible
  - Detector physics component is a plus

- Prior to submission, applicants may want to **seek guidance** from senior faculty/staff, and/or topical experts, and /or previous applicants while preparing proposals (including the budget materials)
Early Career Awards in Detector R&D

- **FY 2017**
  - Ahmed Zeeshan, SLAC
    - Multiplexing CMB detectors

- **FY 2018**
  - Aritoki Suzuki, LBNL
    - Producing CMB detectors
  - Javier Tiffenberg, FNAL
    - Skipper-CCD development

- **FY 2019 coming soon...**
HEP Detector R&D Summary

- Need to preserve/invigorate innovation in Detector R&D within constrained budgets and make a compelling case for growing the budget
- Near-term priority is to support P5 projects
- Long-term priority is to support research into transformational, broad-impact technology advances
- Need to optimize the program across the lab/university landscape using cost-effective, collaborative models—Consortia
- Community input for identifying strategic Detector R&D opportunities—Basic Research Needs Study
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
Office of Science Data Management Plan

- Focus of the SC Digital Data Management is the sharing and preservation of digital research data
  - Data management involves all stages of the digital data life cycle including capture, analysis, sharing, and preservation
  - See Dr. Laura Biven’s presentation on SC Digital Data Management, Sept. 2014 HEPAP meeting: http://science.osti.gov/hep/hepap/meetings/201409/
  - FOAs issued by HEP require Data Management Plan (DMP) compliance with the SC Statement
    - SC statement on DMPs: http://science.energy.gov/funding-opportunities/digital-data-management/
    - See Section IV, the subsection on Appendix 8 of the FOA, for requirements pertaining to DMPs that must be included in your application

- Most experiments have developed DMPs for their collaborations
  - When applying for financial assistance (universities) or submitting FWPs (labs), PIs can cite the DMPs for their experiments with the appropriate links
    - If DMP cited, PIs must briefly describe how proposed research relates to the experiment
  - Theorists need DMPs: explain how theoretical/simulated data can be accessed/validated
  - If there is no data of any sort generated by the proposed research, the DMP must state this. **A DMP that is blank or states “not applicable” is not acceptable**

Each research thrust in a proposal requesting DOE research support, including the FY 2020 Comparative Review FOA, require addressing the DMP requirements for it to be reviewed, and hence, to be considered for funding.
Proposal Project Narrative

- Project Narrative comprises the **research plan** for the project
  - Should contain enough background material in the introduction to demonstrate sufficient knowledge of the research
  - Devote main portion to a description and justification of the proposed project, include details of the methods to be used and any relevant results
  - Indicate which project personnel will be responsible for which activities
  - Include timeline for the major activities of the proposed project

- Must not exceed 9 pages per senior investigator when printed on standard 8 ½” x 11” paper with 1-inch margins (all sides). Font must not be smaller than 11 point.
  - Senior investigator ≡ active tenured or tenure-track faculty member **at sponsoring institution**
  - Non-tenure track faculty (e.g., research scientists) and staff with term appointments are not included in the 9-page limit per investigator unless they are the lead PI on the application
  - Faculty members at collaborating institutions listed on the proposal (if any) are not included

- Refer to Section IV of the planned FOA for useful information to prepare narratives
  - What to address for the Background/Introduction
  - Multiple Investigators and/or Multiple Research Subprograms or Thrusts
  - Common narrative with overview of each group’s activities in different research areas
  - Discussion of any synergies and connections between areas
  - Proposed Project Objectives, Research Methods, Resources
  - Timetable and Level of Effort of different activities, ...
Renewal Proposal Products

- ‘Renewal’ proposals plan to be accepted
  - Such proposals are appropriate where funds are requested for an award first awarded in 2012 or later with no change in
    - Recipient/applicant institution; research thrust(s) and research scope(s); and award’s lead-PI
  - See also, when available, FAQ Q&As for additional guidance

Renewal Proposal Products

- Since Feb 2015, PI must complete and submit ‘Renewal Proposal Products’ section in PAMS by entering each product created during the course of the previous project period
  - Types of products include:
    - Publications (for collaborators on large experiments, list those where you were primary)
    - Intellectual property, technologies or techniques
    - Databases or software (made public)

Renewal Proposal Products are to be submitted after the application submission

- DOE will assign the renewal proposal to a Program Manager, resulting in an automated email from PAMS to the PI with instructions ← watch for this email in your Inbox
- Navigate in PAMS to ‘Tasks’ and enter all products within 5-days after the proposal submission
- Application will not be considered complete and therefore cannot be reviewed until the product list has been submitted
Research Scientists (RS)

Panel will evaluate RS efforts where support is requested in a proposal

- Guidance to PIs given in Q&A of FAQ
  - Requests to support RS dedicated full-time (and long-term) to operational and/or project activities for an experiment will not be supported by respective frontier research areas
  - If RS conducting physics research-related activities, requests [scaled to % of time on such efforts] can be included

- Common [past] reviewer comments that result in unfavorable merit reviews:
  - “RS conducting scope of work typically commensurate at the postdoctoral-level…”
  - “RS involved in long-term ops/project activities with minimum physics research efforts…”
    - May review well in the operation/project program but not in a review of the experimental research program

- What are “physics research-related activities?”
  - Object reconstruction/algorithm development, performance studies, data taking and analysis, and mentorship of students & postdocs in these areas
  - Scientific activities in support of detector/hardware design and development

- From the research program, cases become an issue when operations/projects become the dominant activity in the long-term
  - A well-balanced portfolio that includes physics research-related activities is encouraged
  - Important to narrate complete plans in 2-page “appendix narrative” + provide 1-page bio
1. **Scientific and/or Technical Merit of the Proposed Research**
   e.g., What is the scientific scope and impact of the proposed effort? **How might the results of the proposed work impact the direction, progress, and thinking in relevant scientific fields of research?** What is the likelihood of achieving valuable results? How does the merit of the proposed research, both in terms of scientific and/or technical merit and originality, compare with other efforts within the same research area for a) applications submitted to this FOA and b) those in the overall HEP field? Is the Data Management Plan suitable for the proposed research and to what extent does it support the validation of research results? **Please comment individually on each senior investigator.**

2. **Appropriateness of the Proposed Method or Approach**
   e.g., **How logical and feasible are the approaches?** Does the proposed research employ innovative concepts or methods? Are the conceptual framework, methods, and analyses well justified, adequately developed, and likely to lead to scientifically valid conclusions? Does the applicant recognize significant potential problems and consider alternative strategies?

3. **Competency of Applicant’s Personnel and Adequacy of Available Resources**
   e.g., **How well qualified is each senior investigator and their team, and what is the likelihood of success in carrying out the proposed work?** Does the proposed work take advantage of unique facilities and capabilities? What is the past scientific performance of the team, including the dissemination of results? Are any proposed plans for recruiting any additional scientific and/or technical personnel including new senior staff, students and postdocs reasonable, justified, and appropriate? Are the environment and facilities adequate for performing the proposed effort, including any synergistic opportunities, institutional support, and/or infrastructure? Are the senior investigator(s) or any members of the research group that are being reviewed leaders within the proposed effort(s) and/or potential future leaders in the field? For senior investigator(s) proposing to work across multiple research thrusts, are the plans for such cross-cutting efforts reasonably developed and will the proposed activities have impact?

4. **Reasonableness and Appropriateness of the Proposed Budget**
   e.g., **Are the proposed budget and staffing levels adequate to carry out the proposed work?** If multiple research thrusts are proposed, is the balance of proposed efforts reasonable and well-matched to the proposed research goals? Are all travel, student costs, and other ancillary expenses adequately estimated and justified? **Is the budget reasonable, appropriate for the scope?**

5. **Alignment of the proposed research to the priorities established in the P5 report.**
Comparative Merit Review Criteria Use

For Reviewers/Panelists

- The merit review criteria and corresponding questions are given to all reviewers to input their reviews in DOE’s Portfolio Analysis and Management System (PAMS)
  - Serves as a guide for reviewers to address each review criteria for written reviews
- They are highlighted by DOE Program Managers at the beginning of panel deliberations
- These are presented and discussed by individual panelists for each proposal
- Other Program Policy Factors are also discussed with panelists.
  - For e.g., program alignment with respect to the P5 strategic plan, fostering development of diverse cadre of supported researchers, and opportunity for early-stage investigators and/or junior scientific personnel.

For Principal Investigators

- The merit review criteria and corresponding questions are given in Section V of the FOA
- Program Policy Factors are also given in Section V of the FOA
- Serves as an additional guide for PIs to address in their proposal’s project narratives
  - Do not just write an explicit paragraph answering each question-by-question, but instead, PIs should integrate and adapt these (as appropriate) when narrating the group’s activities and research plans