U.S. DEPARTMENT OF ENERGY | Office of Science

DOE Accelerator R&D

HEPAP Meeting
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Office of Science, U.S. Department of Energy

Advanced Technology R&D Strategy

- **P5 report recommended moving forward with a focused Advanced Technology R&D strategy:**
  - Play a leadership role in superconducting magnet technology focused on the dual goals of increasing performance and decreasing costs
  - Reassess the Muon Accelerator Program, in consultation with international partners
  - Pursue accelerator R&D with a focus on outcomes and capabilities that will dramatically improve cost effectiveness for mid-term and far-term accelerators
  - Focus resources toward directed instrumentation R&D in the near-term for high-priority projects

Accelerator R&D Program

- **Following P5, the Accelerator R&D Subpanel (ARDS) was charged to identify the most promising accelerator research areas to support the advancement of HEP**
  - **ARDS plan provides prioritization in an R&D roadmap towards the Next Steps and Further Future accelerators**
- **Workshops will continue to refine implementation**
  - **HEP-GARD Magnet Workshop held July 28, 2015**
  - **Advanced Accelerator Concepts workshop will be held in early 2016**

	Intensity Frontier Accelerators	Hadron Colliders	e^+e^- Colliders
Current Efforts	PIP	LHC	
	PIP-II	HL-LHC	ILC
Next Steps	Multi-MW proton beam	Very high-energy *pp* collider	1 TeV class energy upgrade of ILC*
Further Future Goals	Neutrino factory*	Higher-energy upgrade	Multi-TeV collider*

dependent on how physics unfolds

Status of General Accelerator R&D (GARD)

- **Multi-MW proton beam**
  - Priority is completion and commissioning of PIP and R&D for PIP-II
  - Progress has been slow due to overall funding constraints
- **Very high-energy *pp* collider**
  - Priority is basic technology R&D
  - Pursuing R&D in coordination with CERN study
  - Funding-limited
- **Mutli-TeV e^+e^- collider**
  - Plasma-wakefield technology, an element of the possible technology roadmap for a multi-TeV e^+e^- collider, has been identified as a priority by the DOE Office of Science due to broader science impacts
    - As noted in Jim's talk
  - Moving forward with R&D
- **Far future R&D**
  - This effort is ongoing at approximately a constant level of funding
  - This was incorporated into, e.g., university comparative review

- **GARD thrust areas:**
  - Advanced Acceleration Concepts
  - Accelerator and Beam Physics
    - Expanded to include beam instrumentation and controls
  - Particle Sources and Targetry
  - RF Acceleration Technology
    - Includes both RF sources, NCRF and SRF R&D
  - Superconducting Magnet and Materials

ARDS Recommendation Status by Thrust

- **Advanced Acceleration Concepts**
  - Support development of the most promising concepts toward far-term accelerators as envisioned by P5
  - Implementing: 7, 8, 9, 10
  - In progress: C1b
  - Deferring: C1
- **Accelerator and Beam Physics**
  - Maintain accelerator science core competence and support high intensity proton beam physics R&D
  - Implementing: 14, 15
  - In progress: 2, 3
- **Particle Sources and Targetry**
  - Develop plan to support high-power target for Intensity Frontier
  - In progress: 1
- **RF Acceleration Technology**
  - Support high-efficient RF source development and high-gradient research
  - Implementing: 11, 12
  - Deferring: 4, 6, 13
- **Superconducting Magnet and Materials**
  - Support a balanced portfolio magnet and materials efforts; LTS and HTS conductors
  - In progress: 5, 5a, 5b, 5d
  - Deferring: 5c, 5e, 5f, C1, C1a

ARDS: "Next Step" Accelerator Facilities

Multi-MW Proton Beam

- **Recommendation 1. Fund generic high-power component R&D at a level necessary to carry out needed thermal shock studies and ionizing radiation damage studies on candidate materials that are not covered by project-directed research. (p. 9, 19)**
  - **GARD thrust: Particle Sources and Targetry**
  - **Status: In progress**
- **Recommendation 2. Construct the IOTA ring, and conduct experimental studies of high-current beam dynamics in integrable non-linear focusing systems. (p. 9, 18)**
  - **GARD thrust: Accelerator and Beam Physics**
  - **Status: In progress**
- **Recommendation 3. Support a collaborative framework among laboratories and universities that assures sufficient support in beam simulations and in beam instrumentation to address beam and particle stability including strong space charge forces. (p. 9, 17)**
  - **GARD thrust: Accelerator and Beam Physics**
  - **Status: In progress**
- **Recommendation 4. Direct appropriate investment in superconducting RF R&D in order to inform the selection of the acceleration technology for the multi-MW proton beam at Fermilab. (p. 9, 22)**
  - **GARD thrust: RF Acceleration Technology**
  - **Status: Maintaining current level but deferring increase until more favorable budget scenario**

ARDS: "Next Step" Accelerator Facilities

Very High-Energy Proton-Proton Collider

- Recommendation 5. Participate in international design studies for a very high-energy proton-proton collider in order to realize this Next Step in hadron collider facilities for exploration of the Energy Frontier. Vigorously pursue major cost reductions by investing in magnet development and in the most promising superconducting materials, targeting potential breakthroughs in cost-performance. (p. 10, 25)
  - GARD thrust: Superconducting Magnet and Materials
  - Status: In progress
- Recommendation 5a. Support accelerator design and simulation activities that guide and are informed by the superconducting magnet R&D program for a very high-energy proton-proton collider. (p. 10, 25)
  - GARD thrust: Superconducting Magnet and Materials
  - Status: In progress
- Recommendation 5b. Form a focused U.S. high-field magnet R&D collaboration that is coordinated with global design studies for a very high-energy proton-proton collider. The over-arching goal is a large improvement in cost-performance. (p. 10, 25)
  - GARD thrust: Superconducting Magnet and Materials
  - Status: In progress

ARDS: "Next Step" Accelerator Facilities

Very High-Energy Proton-Proton Collider

- **Recommendation 5c. Aggressively pursue the development of Nb_3Sn magnets suitable for use in a very high-energy proton-proton collider. (p. 10, 25)**
  - GARD thrust: Superconducting Magnet and Materials
  - Status: Maintaining current level but deferring increase until more favorable budget scenario
- **Recommendation 5d. Establish and execute a high-temperature superconducting (HTS) material and magnet development plan with appropriate milestones to demonstrate the feasibility of cost-effective accelerator magnets using HTS. (p. 10, 25)**
  - GARD thrust: Superconducting Magnet and Materials
  - Status: In progress
- **Recommendation 5e. Engage industry and manufacturing engineering disciplines to explore techniques to both decrease the touch labor and increase the overall reliability of next-generation superconducting accelerator magnets. (p. 10, 25)**
  - GARD thrust: Superconducting Magnet and Materials
  - Status: Deferring until more favorable budget scenario
- **Recommendation 5f. Significantly increase funding for superconducting accelerator magnet R&D in order to support aggressive development of new conductor and magnet technologies. (p. 10, 25)**
  - GARD thrust: Superconducting Magnet and Materials
  - Status: Maintaining current level but deferring increase until more favorable budget scenario

ARDS: "Next Step" Accelerator Facilities

1 TeV ILC Upgrade

- **Recommendation 6. Increase funding for development of superconducting RF (SRF) technology with the goal to significantly reduce the cost of a ~1 TeV energy upgrade of the ILC. Strive to achieve 80 MV/m accelerating gradients with new SRF materials on the 10-year timescale. (p. 11, 22)**
  - **GARD thrust: RF Acceleration Technology**
  - **Status: Maintaining current level but deferring increase until more favorable budget scenario**

ARDS: "Further Future" Accelerator Facilities

Multi-TeV e^+e^- Collider

- **Recommendation 7. Vigorously pursue particle-driven plasma wakefield acceleration of positrons at FACET in the time remaining for the operation of the facility. Between the closing of FACET and the operation of a follow-on facility, preserve the momentum of particle-driven wakefield acceleration research using other facilities. (p. 11, 32)**
  - GARD thrust: Advanced Acceleration Concepts
  - Status: Implementing recommendation
- **Recommendation 8. Continue to support laser-driven plasma wakefield acceleration experiments on BELLA at the current level. (p. 11, 32)**
  - GARD thrust: Advanced Acceleration Concepts
  - Status: Implementing recommendation
- **Recommendation 9. Reduce funding for direct laser acceleration research activities. (p. 11, 32)**
  - GARD thrust: Advanced Acceleration Concepts
  - Status: Implementing recommendation

ARDS: "Further Future" Accelerator Facilities

Multi-TeV e^+e^- Collider

- **Recommendation 10. Convene the university and laboratory proponents of advanced acceleration concepts to develop R&D roadmaps with a series of milestones and common down-selection criteria towards the goal of constructing a multi-TeV e^+e^- collider. (p. 11, 32)**
  - GARD thrust: Advanced Acceleration Concepts
  - Status: Implementing recommendation (through a series workshops)
- **Recommendation 11. Continue research on high-efficiency power sources and high-gradient normal conducting RF structures. (p. 12, 21)**
  - GARD thrust: RF Acceleration Technology
  - Status: Implementing recommendation
- **Recommendation 12. Make NLCTA available for RF structure tests using its RF power and beam sources. (p. 12, 21)**
  - GARD thrust: RF Acceleration Technology
  - Status: Implementing recommendation
- **Recommendation 13. Focus normal conducting RF R&D on developing a multistage prototype based on high-gradient normal conducting RF structures and high-efficiency RF power sources to demonstrate the effectiveness of the technology for a multi-TeV e^+e^- collider. (p. 12, 21)**
  - GARD thrust: RF Acceleration Technology
  - Status: Deferring until more favorable budget scenario

ARDS: 2.4: Accelerator and Beam Physics

Support for Next Steps and Further Future Goals

- **Recommendation 14. Continue accelerator and beam physics activities and beam instrumentation and control R&D aimed at developing the accelerators defined in the Next Steps and the Further Future Goals. Develop coordination strategies, both nationally and internationally, to carry out these studies in an efficient manner. (p. 12, 16)**
  - GARD thrust: Accelerator and Beam Physics
  - Status: Implementing recommendation
- **Recommendation 15. To ensure a healthy, broad program in accelerator research, allocate a fraction of the budget of the Accelerator Physics and Technology thrust to pursue fundamental accelerator research outside of the specific goals of the Next Steps and Further Future Goals. Research activities at universities should play a particularly important role. (p. 12, 16)**
  - GARD thrust: Accelerator and Beam Physics
  - Status: Implementing recommendation

ARDS: Scenario B

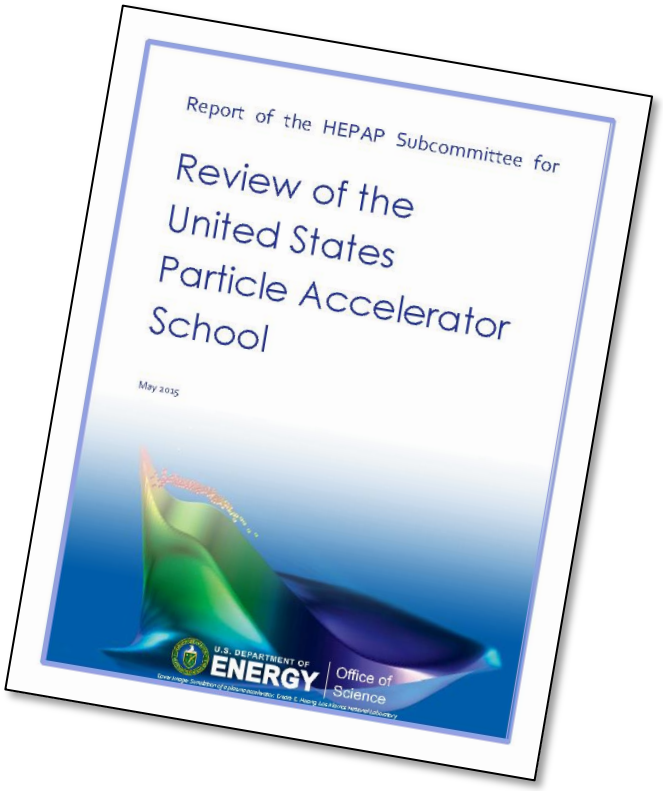
- **Recommendation B1. Increase base GARD funding modestly in order to open numerous critical R&D opportunities that do not fit in the current base, as well as to invigorate fundamental accelerator science research, and to step up development of the national accelerator workforce. (p. 13)**
  - **Status: Deferring until more favorable budget scenario**

ARDS: Scenario C

- **Recommendation C1. Hasten the realization of the accelerator of P5's medium-term vision for discovery: a very high-energy proton-proton collider, and the realization of the accelerator of P5's long-term vision for discovery: a multi-TeV e^+e^- collider. (p. 14, 26, 32)**
  - GARD thrust: Superconducting Magnet and Materials, Advanced Acceleration Concepts
  - Status: Deferring until more favorable budget scenario
- **Recommendation C1a. Ramp up research and development of superconducting magnets, targeted primarily for a very high-energy proton-proton collider, to a level that permits a multi-faceted program to explore possible avenues of breakthrough in parallel. Investigate additional magnet configurations, fabricate multi-meter prototypes, and explore low-cost manufacturing techniques and industrial scale-up of conductors. Increase support for high-temperature superconducting (HTS) materials and magnet development to demonstrate the viability of accelerator-quality HTS magnets for a very high-energy proton-proton collider. (p. 14, 26)**
  - GARD thrust: Superconducting Magnet and Materials
  - Status: Deferring until more favorable budget scenario
- **Recommendation C1b. Develop, construct, and operate a next-generation facility for particle-driven plasma wakefield acceleration research and development, targeting a multi-TeV e^+e^- collider, in order to sustain this promising and synergistic line of research after the closure of the FACET facility. (p. 14, 33)**
  - GARD thrust: Advanced Acceleration Concepts
  - Status: In progress

Accelerator Science Training

- Review of the United States Particle Accelerator School (USPAS)
  - Report presents a clear case that "USPAS effectively and efficiently serves the critical needs for accelerator workforce development and training in the U.S."
- HEP charged FNAL to prepare a new 5-year proposal for management of USPAS
  - Reviews were generally positive; iterating on management plan
- Request for Information on Strengthening U.S. Academic Programs in Accelerator Science
  - Sought community input on:
    - Increasing the academic recognition of acc. science
    - Integrating university and national laboratory roles
    - Mechanisms to strengthen academic acc. science
  - 21 responses received are available at:
    - http://science.energy.gov/hep/community-resources/reports/
  - Responses emphasized the central importance of USPAS to academic training in accelerator science



- It is clear that USPAS plays a central role in the training of accelerator scientists in the U.S., and we are investigating complementary ways to strengthen academic accelerator science

The Accelerator R&D Stewardship Program

The mission of the HEP long-term accelerator R&D stewardship program is to support fundamental accelerator science and technology development of relevance to many fields and to disseminate accelerator knowledge and training to the broad community of accelerator users and providers.

- **Strategies:**
  - **Improve access to national laboratory accelerator facilities and resources for industrial and for other U.S. government agency users and developers of accelerators and related technology**
  - **Work with accelerator user communities and industrial accelerator providers to develop innovative solutions to critical problems, to the mutual benefit of our customers and the DOE discovery science community**
  - **Serve as a catalyst to broaden and strengthen the community of accelerator users and providers**
- **Engages the entire U.S. accelerator R&D ecosystem in a coordinated manner to solve high-impact challenges at a scale well beyond the reach of the DOE Small Business Innovation Research (SBIR) program**

New Accelerator Stewardship Initiatives

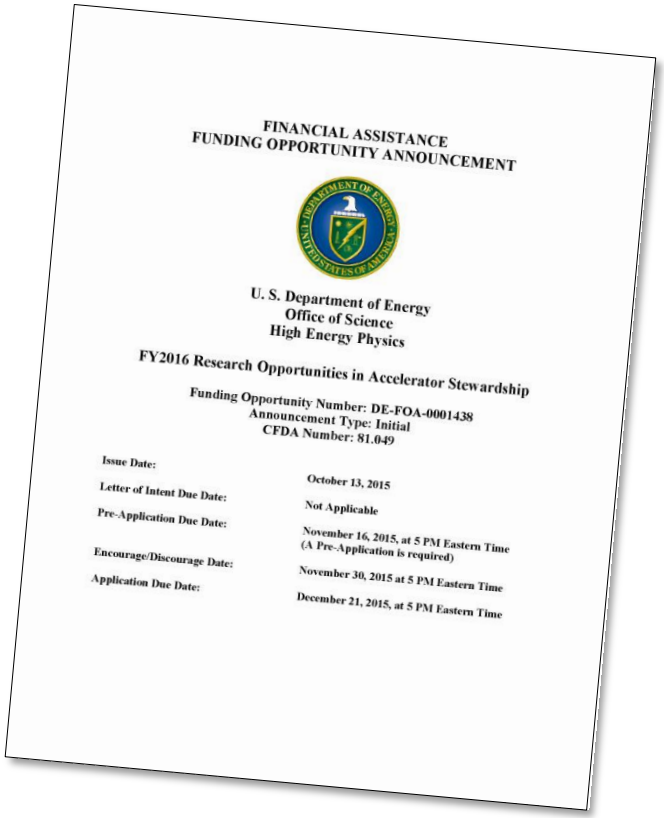
- The Accelerator Stewardship Test Facility Pilot Program has launched in FY 2015
  - Designed to enhance awareness of, and access to, accelerator test facilities and capabilities
  - Seven SC labs held public outreach events in spring 2015
    - Public events reached over 450 participants
    - More than 30 collaborative lab/business R&D opportunities were identified
    - 7 were awarded "seed" funds in FY 2015
  - Results of the Pilot to be assessed spring 2016, and a follow-on program formulated

- In preparation for the next FOA, an Energy & Environmental Applications of Accelerators Basic Research Needs workshop was held June 23-26 at ANL
  - Following up on input from a 2014 Request for Information, the workshop focused on accelerator technology R&D opportunities that, if developed, could enable high-impact solutions for current E&E challenges:
    - WG-1: Treating potable and waste water, removing pollutants from stack gases;
    - WG-2: Sterilization of sludges and solid wastes; mobile e-beam systems for environmental remediation;
    - WG-3: Wind generators, magnetic separation of material streams, and other industrial processes.
  - High-power (megawatt-class) accelerator technology was identified as cross-cutting, and would enable a wide range of industrial, environmental, and energy applications. It is also synergistic with Intensity Frontier needs.

- HEP assisted DNDO by hosting a workshop August 5-7 at FNAL on accelerator technology for active interrogation
  - Discussions at the workshop and with DNDO PMs indicated basic R&D areas that impact national security objectives

Accelerator Stewardship FOA

- **FY2016 Research Opportunities in Accelerator Stewardship (DE FOA 0001438) was posted on October 13, 2015**
  - Pre-Application Due Date: Nov. 16, 2015, at 5 PM Eastern Time *(now passed)*
    - Pre-Application was required
  - Encourage/Discourage Date: Nov. 30, 2015 at 5 PM Eastern Time *(now passed)*
  - Application Due Date: Dec. 21, 2015, at 5 PM Eastern Time
- **Track 1: Accelerator Stewardship Topical Areas**
  - Particle Therapy Beam Delivery Improvements
  - Ultrafast Laser Technology Program
  - Energy and Environmental Applications of Accelerators
- **Track 2: Long-Term Generic Accelerator R&D**



FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

U. S. Department of Energy
Office of Science
High Energy Physics

FY2016 Research Opportunities in Accelerator Stewardship

Funding Opportunity Number: DE-FOA-0001438
Announcement Type: Initial
CFDA Number: 81.049

Issue Date:	October 13, 2015
Letter of Intent Due Date:	Not Applicable
Pre-Application Due Date:	November 16, 2015, at 5 PM Eastern Time (A Pre-Application is required)
Encourage/Discourage Date:	November 30, 2015 at 5 PM Eastern Time
Application Due Date:	December 21, 2015, at 5 PM Eastern Time