
The DOE Office of Science Accelerator R&D Stewardship Program

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December 11, 2013

DOE Office of Science has long been the steward of Accelerator Science



The Accelerators for America's Future Workshop:

- Identified the importance of accelerator technologies to sectors of the US economy
- "...advocated [for] the creation of large-scale **demonstration and development facilities to help bridge the gap** between development and deployment of accelerator technologies"
- "...called for **greatly improved** interagency, interprogram, and industry-agency **coordination.**"
- "...strongly highlighted the value of expanded **training and education** of accelerator scientists and engineers..."

"The [Senate] Committee directs the Department to submit a ...

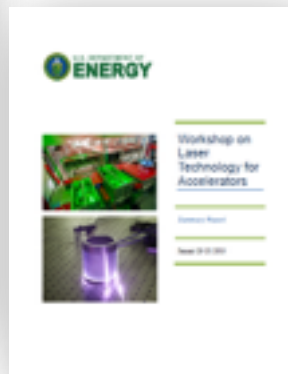
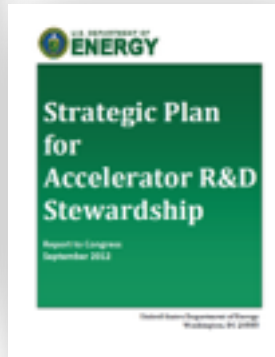
10-year strategic plan ... for accelerator technology research and development to advance accelerator applications in energy and the environment, medicine, industry, national security, and discovery science.

The strategic plan should be based on the results of the Department's 2010 workshop study, Accelerators for America's Future, ..."

Senate Report 112-075, p. 93. (Ordered to be printed September 7, 2011)

<http://science.energy.gov/~media/hep/pdf/accelerator-rd-stewardship/Report.pdf>

Formulating a National Accelerator Stewardship Program



2012 Holtkamp Accelerator Task Force

- Identified initial stewardship opportunities and potential impediments

2012 DOE Strategic Plan for Stewardship

- Articulated the need, initial program thrusts, evolution, and organization of the Accelerator R&D Stewardship Program.

2013 DOE/NIH Ion Beam Therapy Workshop

- Identified the role of accelerator technology and facilities in further cancer therapy

2013 DOE Laser Technology for Accelerators Workshop

- Identified high average power “ultrafast” lasers as key enabling technology for discovery and applied sciences

2014 Facilities Pilot Program Meeting

- Meeting of accelerator SC labs to discuss potential user community needs and making facilities more accessible

2014 RFI and Energy & Environment Workshop

- Will identify key accelerator R&D needed to advance energy and environmental applications of accelerators

Reports available at:

<http://science.energy.gov/~media/hep/pdf/accelerator-rd-stewardship>

2012: Mission of Accelerator Stewardship

- **Mission:**

- Support fundamental accelerator science and technology R&D for a broad range of applications
- Disseminate accelerator knowledge and training

- **Implementation:**

- **Facilitate access to national laboratory accelerator facilities and infrastructure**
- **Develop innovative solutions to critical problems, to the benefit of both the broader user communities and the DOE discovery science community**
- Serve as a catalyst **to broaden and strengthen the community** that relies on accelerators and accelerator technology



Strategic Plan for Accelerator R&D Stewardship

Report to Congress
September 2012

United States Department of Energy
Washington, DC 20585

Proposed Program Organization

- Accelerator Stewardship program is managed by the Office of High Energy Physics
- Close communication with other Offices of Science is in place
 - principally BES, NP
- Close communication with stakeholder agencies is also in place
 - DOE (-SC, -EERE, -NNSA), NIH-NCI, DoD, DHS, NSF, others
- Input on program formulation is sought through
 - Requests for Information
 - DOE-Sponsored Task Forces and Workshops
 - Meetings with stakeholder agencies

Elements of Accelerator R&D Stewardship

- **Near-term: facilitate access to test facilities**
 - 2012: Survey of national lab infrastructure
 - 2014: Follow-on Meeting on Accelerator R&D Stewardship Activities at test facilities; Pilot Program to follow
- **Mid-term (2-5 years): pursue goal-driven challenge areas**
 - Finite scope (e.g. 5-7 years) targeted tasks that solve important challenges
 - Challenge areas identified by the 2012 Accelerator Task Force:
 - Improve **particle beam delivery** for cancer therapy
 - Advance **ultrafast laser technology** for accelerators (e.g. x1000 pulse rate)
 - Innovate accelerator technologies for **energy and environment applications**
- **Longer Term (5-10 years)**
 - Identify and pursue additional challenges for focused work

Education and training will be an integral part of each activity. R&D will continue to involve students and collaboration with non-traditional users of accelerator technology.

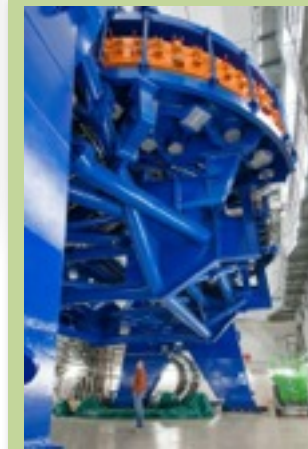
DOE/NIH Ion Beam Therapy Workshop

January 9-11, 2013, Bethesda, MD



Report highlights:

- Further studies of radiobiology and clinical efficacy are needed
- Identified opportunities for technology innovations to:
 - Reduce cost and size
 - Speed up scanning, beam control, and diagnostics
 - Reduce cost and size of gantries
 - Provide real-time range and dose verification



Technology developed for SC accelerators can significantly reduce the size and cost of gantries

Ion gantry at Heidelberg
600t, 5.6mx26m (RxL)

Using superconducting magnets:
~50t, 5.5mx13m (RxL)

http://science.energy.gov/~media/hep/pdf/accelerator-rd-stewardship/Workshop_on_Ion_Beam_Therapy_Report_Final_R1.pdf

Ultrafast Laser Technology for Accelerators

January 23-25, 2013 Napa, CA.

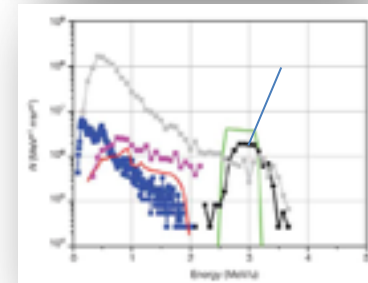
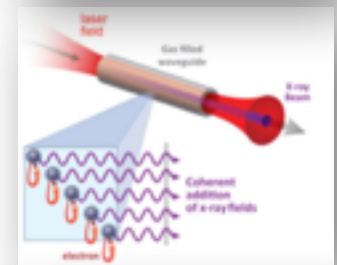
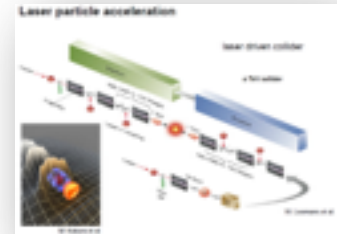


http://science.energy.gov/~media/hep/pdf/accelerator-rd-stewardship/Lasers_for_Accelerators_Report_Final.pdf

Report highlights:

- **Four primary application areas identified:**
 - Laser-plasma accelerators
 - High energy physics
 - Ultracompact sources
 - Synchronized sources of
 - THz, IR, & x-rays
 - Laser-driven sources of ions for medicine
 - Laser-driven sources of neutrons

- **ALL applications demand two technology advances:**
 - 1000x repetition rate or more
 - High power efficiency



Technology advances in this area have broad economic impact as articulated in the 2013 NAS report on Optics and Photonics. New SBIR/STTR topic targeted at accelerator-specific laser technology development drew a strong response.



Energy & Environmental Applications of Accelerators

- **Energy**

- Accelerator energy efficiency
 - EO13514 mandates 28% GHG reduction from FY08 to FY20; current DOE SC complex accelerator energy usage is ~1000 GW-h/yr
 - Initiative to increase accelerator efficiency will have broad impact across SC labs, and in industrial uses of accelerators
- Use of accelerators to deliver heat more precisely and controllably than conventional thermal processes

- **Environment**

- Pollution reduction NOX, SOX by flue gas treatment
- Waste water treatment
- Pesticide and endocrine disruptor reduction in domestic water supplies

- **Preparing a Request for Information**

Relationship between Accelerator Stewardship and the National Network for Manufacturing Innovation

DOE's
Accelerator R&D
Stewardship

DOC's
National Network for
Manufacturing Innovation

Work For Others

NATIONAL NETWORK FOR MANUFACTURING INNOVATION: A PRELIMINARY DESIGN

Table 1. Technology Readiness Levels and Manufacturing Readiness Levels, after [21]

TRL 1:	Basic principles observed and reported	MRL 1:	Manufacturing feasibility assessed
TRL 2:	Technology concept and/or application formulated	MRL 2:	Manufacturing concepts defined
TRL 3:	Analytical and experimental critical function and/or characteristic proof of concept	MRL 3:	Manufacturing concepts developed
TRL 4:	Component and/or breadboard validation in a laboratory environment	MRL 4:	Capability to produce the technology in a laboratory environment
TRL 5:	Component or breadboard validation in a relevant environment	MRL 5:	Capability to produce prototype components in a production relevant environment
TRL 6:	System/subsystem model or prototype demonstration in a relevant environment	MRL 6:	Capability to produce prototype system or subsystem in a production relevant environment
TRL 7:	System prototype demonstration in an operational environment	MRL 7:	Capability to produce systems, subsystems or components in a production relevant environment
TRL 8:	Actual system completed and qualified through test and demonstrated	MRL 8:	Pilot line capability demonstrated; Ready to begin Low Rate Initial Production
TRL 9:	Actual system proven through successful mission operations	MRL 9:	Low rate production demonstrated; Capability in place to begin Full Rate Production

3.3 IMI Funding, Revenue, and Sustainability

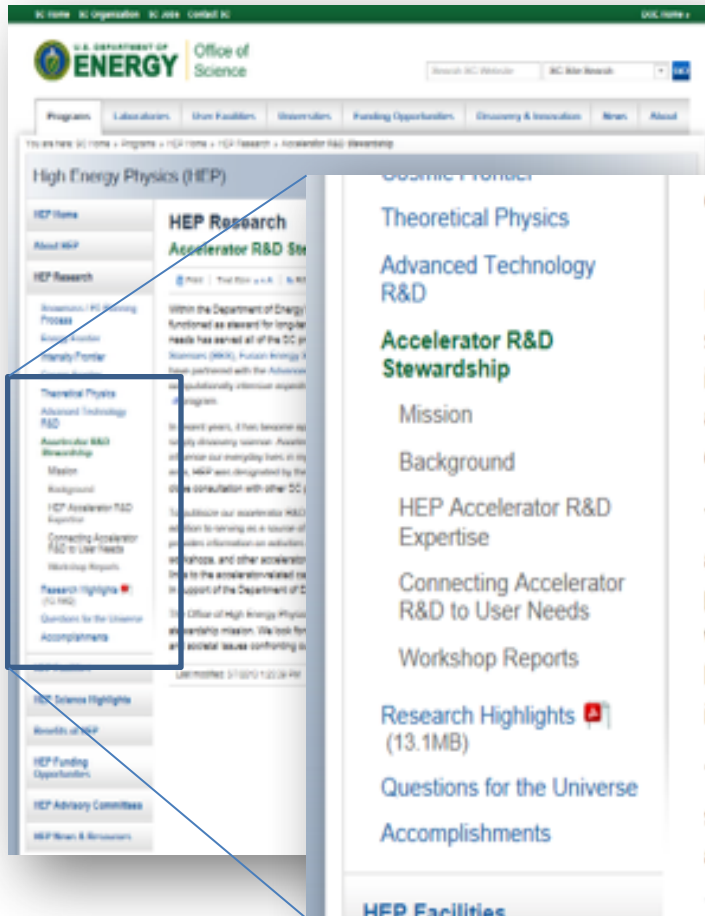
Each Institute should be of sufficient size and scope to have major national and regional economic impacts and to address the multidimensional challenges associated with the Institute's focus area. The amount of Federal funding should be appropriate to the Institute proposed. Federal funding to launch

National Network for Manufacturing Innovation: A Preliminary Design

Accelerator R&D Stewardship on the Web

Program Description on the Office of Science Portal

Public Portal to the National Labs



<http://science.energy.gov/hep/research/>



<http://www.acceleratorsamerica.org/>

Moving Forward

- A budget appropriation that includes funding for the major initiatives of Stewardship is essential.
 - HEP requested 9,931K\$ for Stewardship in FY 2014.
- Outreach to formulate the most promising stewardship activities in Energy & Environmental applications of accelerators
- Take steps towards the Pilot Program in Stewardship use of accelerator test facilities
- Inclusion of pieces of Stewardship topics in SBIR/STTR program

How DOE Accelerator R&D Connects to Science and to End-User Application Needs

Science Goal "Push"

Application "Pull"

Particle Beam Quality	Photon Beam Quality	Beam Intensity	Compact or High Energy	DOE R&D Program Thrust	Industry	Medicine	Energy and Environment	Defense and Security	Discovery Science
●	●	●	●	Superconducting RF	●		●	●	●
●	●	●	●	Accelerator, Beam, Computation		●	●	●	●
●	●	●	●	Particle Sources	●		●	●	●
		●	●	RF Sources	●		●	●	●
●	●	●	●	Beam Inst. & Controls		●	●	●	●
●	●		●	NC High-gradient Accel. Structures	●	●		●	●
			●	New Accelerator Concepts		●		●	●
●	●	●	●	Superconducting Magnets	●	●			●

2012: Facility Survey Results

- In addition to **broad expertise in accelerator and component design, specialized infrastructure exists**
- **Lab infrastructure falls mainly into these categories:**
 - **Beam test facilities**
 - electrons, neutrons, protons, light and heavy ions
 - includes particle sources, transport lines, diagnostics, laser-driven accelerators
 - **Superconducting cable/strand and cavity preparation and testing facilities**
 - cabling equipment, heat treatment ovens, clean rooms
 - Cavity polishing, chemistry, test dewars, etc.
 - **Magnet test facilities**
 - power supplies, cryogenic test stands, field mapping
 - **RF test facilities**
 - RF power sources, cryogenic test stands, processing capabilities, clean rooms
 - **High-performance computing expertise**
 - includes finite-element calculations, general accelerator design, nonlinear beam dynamics and beam transport, radiation shielding, electromagnetic modeling
 - **Fabrication and materials characterization facilities**
 - high accuracy NC machine tools, CMMs, e-beam welders, wire EDM, chemical cleaning, electro-polishing, SEMs, laser trackers, coating systems, remote handling,...

2014: Next Steps for Opening Lab Test Facilities

- **Inventory available accelerator facilities and competencies**
 - Each lab is asked to present a 20-minute synopsis of facility capabilities and availability
- **Discuss prospective stewardship uses for accelerator facilities**
 - Each lab is asked to present a 15-minute synopsis of potential user requests for facilities.
- **Discuss current business practices and operating models, and seek ways to improve efficiency and consistency**
 - **Streamlining the formal aspects of the process**
 - Each lab is asked to present a 20-minute synopsis of their business model for stewardship use of facilities
 - **Protection of IP and legal matters**
 - Each lab is asked to present a 15-minute synopsis of process and practice for IP protection and forming legal relationships with stewardship users
- **Discuss outreach strategy**
 - Each lab is asked to give a short verbal summary of outreach activities

DOE/NIH Ion Beam Therapy Workshop Charge

January 9-11, 2013, Bethesda, MD

• Prepared jointly by DOE-HEP and NIH-NCI

- **Identify a set of representative clinical applications** that span the range of expected future therapy requirements. These need to include capabilities for performing radiobiological experiments as well as human treatment protocols in order to explore the scientific principles underlying observed clinical results and point the way to promising protocol designs.
- **Assess the corresponding beam requirements** (e.g., energy range and energy spread, intensity range and pulse-to-pulse intensity jitter, spot size and pulse-to-pulse position jitter, repetition rate, ion species) for future treatment facilities and compare these with today's state-of-the-art.
- **Assess the corresponding beam delivery system requirements** (e.g., energy and position adjustability, time scale for adjustments, size of footprint, component mass, transverse and longitudinal acceptance) for future treatment facilities and compare these with today's state-of-the-art.
- **Identify R&D activities needed to bridge the gap between current capabilities and future requirements**; include an assessment of which R&D investments are likely to have the highest near-term performance gains.

Five Criteria for “Good” Accelerator R&D Stewardship Activities

- 1. The application must involve accelerators or accelerator-related technologies either as:**
 1. Accelerator Research that has synergy with and benefits the primary HEP mission
 2. Accelerator Development (but often this will be WFO)
- 2. There must be non-trivial intellectual involvement of the lab.**

Good: Build an accelerator technology component (NB: usually WFO)
Better: Design an accelerator technology component (WFO?)
Best: Design, build, and test an accelerator technology component (Stewardship)
- 3. The activity must be reasonably consistent with the mission of the lab, and minimally impact the primary SC program.**

Good: Activity maintains a
Better: Activity expands a
Best: Activity develops a new

} (again, this is usually WFO)
core skill or facility needed for the mission
- 4. The lab must arguably be the best provider* of the capability or service.**

Good: Lab’s capability is not unique, but lab is close to customer
Better: Lab’s capability is leading, and lab is close to customer
Best: Lab is the only possible provider
- 5. The customer benefiting from the stewardship activity must endorse the goals.**

Good: Customer participates in discussion of task definition, writes letter of support
Better: Customer and lab partner on research, some cost sharing from customer (e.g. 1:10)
Best: Customer and lab partner on research, significant cost sharing from customer (e.g. 1:1)

*and must not compete with an existing business

Stewardship, SBIR/STTR, and WFO

	Accelerator Stewardship	SBIR/STTR & TTO	WFO
Mission	<ul style="list-style-type: none"> • <i>Open Lab Facilities</i> • <i>Apply accelerators to solve challenging problems</i> 	<ul style="list-style-type: none"> • <i>Move technology towards market</i> • <i>Stimulate small businesses</i> 	<ul style="list-style-type: none"> • <i>Customer-defined, as consistent with lab's mission</i>
Technical & Manufacturing Readiness	<p><i>TRL 1-6</i> <i>MRL none</i></p>	<p><i>Phase I: TRL 2-3</i> <i>Phase II: TRL 3-4/MRL 1-4</i></p>	<p><i>TRL ~2 to 9</i> <i>MRL 1 to ~8</i></p>
Time Horizon	<i>Up to ~10 years</i>	<i>9 mos/24 mos</i>	<i>Customer-defined</i>
Topic Selection	<i>Stakeholder Boards</i>	<i>Lab input, DOE selects</i>	<i>Lab Selects</i>
Progress Review	<p><i>Community Workshops</i> <i>Grant Reports</i> <i>Contact with users (UECs)</i></p>	<i>Grant Reports</i>	<i>Customer-defined metrics</i>
Funding Mechanism	<i>Peer-reviewed FOAs</i>	<i>Peer-reviewed FOAs</i>	<i>WFOA/CRADA</i>
Intellectual Involvement of Lab	<i>Significant</i>	<i>(no requirement)</i>	<i>(no requirement)</i>

What Would Success Look Like?

- **Opening Access to Test Facilities**

- Co-investment from the customer (OFAs or industry)
- Publications, patents, new products/processes, positive feedback
- Facilities improve; new intellectual connections formed

- **Ion Beam Therapy**

- New components tested, industry partnerships formed, devices commercialized
- TFs enable radiobiology experiments
- Patient outcomes improved, treatment costs reduced
- Beam capability and technology improved generally

- **Laser Technology R&D**

- High power ultrafast laser technologies advanced, industry capability enhanced
- 1 kW test facility built, OFAs invest in science center based on the test facility
- Skilled ultrafast laser technology workforce trained for science and industry
- GeV-demonstrator built for potential HEP application

- **Energy and Environment Applications of Accelerator Technology**

- New accelerator technologies developed that focus on efficiency and power,
- New applications of accelerator technology conceived and tested
- Significant impact on GHG emissions in SC accelerator applications

Legend

Industrial Benefits
Science Benefits
HEP Benefits