Office of High Energy Physics

Report to DPF Executive Committee
May 4, 2009

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Office of Science, U.S. Department of Energy
Historically the U.S. has been the leader in HEP research
- Most major discoveries (many recognized by Nobel Prizes) were made in the U.S.
- Made possible by a continuous implementation of forefront accelerator facilities

At beginning of this decade the U.S. HEP program remained the leader
- The Fermilab Tevatron was the Energy Frontier facility
- The SLAC B-Factory was an Intensity Frontier facility
- U.S. HEP physicists were playing important roles at the Cosmic Frontier

The U.S. HEP program’s long range strategy was
- To participate at CERN Large Hadron Collider (LHC) when it became the Energy Frontier program
- To start construction of a next-generation lepton collider soon after the time LHC came into operations

Over the decade DOE OHEP started to implement this strategy
- Resources went into LHC program (accelerator & detectors) to allow US participation
- The number of U.S. HEP accelerator user facilities were reduced to one (Fermilab Tevatron/NuMi)
- Ramped up funding for R&D to position the U.S. to host the International Linear Collider (ILC)

Then the estimated cost of ILC increased and planned start of construction slipped
Current circumstances for the U.S. program are challenging!

- Reductions in FY 2008 DOE HEP funding (-8.4%) resulted in loss of
  - HEP’s scientific productivity and workforce
  - Momentum on planned activities (NOvA, SRF infrastructure, ILC R&D)
  - U.S. credibility as an interagency/international collaborator (BaBar, ILC)

- No realistic strategic plan that has dealt with
  - the increase in cost and the delay in possible start of an ILC
  - energy frontier moving to Europe in FY 2009
  - closure of B-Factory and imminent closure of Tevatron
  - Fermilab’s role in the future

- Competition for federal funding is fierce
  - HEP is not a priority of the Administration or Congress
  - HEP funding has eroded over the last decade
  - “Why does the U.S. have to be a leader in HEP (particle physics)?
Dealt with FY 2008 funding reduction
- Most serious impacts were mitigated
- Protected core activities and delivered science
- Supplemental funding at end of year – mitigated impact of 6-month Continuing Resolution

Developed (DOE/NSF with the scientific community) a new strategic plan for U.S. HEP
- Particle physics at three scientific frontiers
- A U.S. role that will deliver significant outcomes
- Realistic and robust with respect to funding scenarios and scientific discoveries

DOE HEP funding in FY 2009 supports the implementation of the plan
- FY 2009 Appropriation restores program to FY 2007 level
- Recovery Act funding accelerates / enhances research / infrastructure projects
FY 2008 Appropriations ($689M → 8.4% reduction compared to FY 2007)

- A productive program
  - Tevatron ran well – CDF/D0, MINOS, MiniBooNE
  - B-Factory completed a successful four month run
  - LHC circulated beam and ATLAS/CMS ready for beam
  - FGTS (GLAST) launched and collecting data
  - Many projects underway: Minerva, T2K, Daya Bay, EXO, DES, CDMS
  - DOE/NASA/NSF planning for joint projects

- There were significant impacts
  - Staff reductions at SLAC (76+100) and Fermilab (110)
  - B-Factory schedule was reduced from 10 months to 4 months
  - Work on NOvA stopped
  - ILC & SRF R&D supported at a minimal level

FY 2008 Supplemental
- $32M for HEP ($29.5M for Fermilab, $2.5M for SLAC)
DOE SC HEP
FY 2008 Science Highlights

Energy Frontier

- Operation of LHC
  (AIP Top Ten Story)
- Tevatron (Performance/Experimental Results)
  (AIP Top Ten Story)

Intensity Frontier

- BaBar discovery of bottomonium ground state
  (AIP Top Ten Story)
- Results from MiniBooNE and MINOS

Cosmic Frontier

- Pierre Auger
  (AIP Top Ten Story)
- Fermi (GLAST)
HEPAP (Particle Physics Project Prioritization Panel (P5)) seriously addressed the charge given by DOE/NSF:
- to examine the scientific opportunities and options
- for mounting a world class particle physics program
- at different funding levels

Grappled with the issue of how to mount a world-class program that addresses the highest priority scientific opportunities identified with the funding available

The result is a realistic vision whose priorities are consistent with the major findings that is robust and that should produce outcomes that justify the investment

Lays out what the nation will get with different investments
- Scenario A (FY 2008 Approp + COL) – unable to mount productive, world-class programs at all three frontiers
- Scenario B (FY 2007 Approp + COL) – productive programs at all three frontiers
- Scenario C (FY 2007 ACI level) – leadership programs – partner in TeV-scale facility
- Scenario D (additional above C) – the funding to host next TeV-scale facility

Progress in achieving the goals of particle physics requires advancements at the

- Energy, Intensity and Cosmic Frontiers.
- Each provides a unique window for insight about the fundamental forces and particles of nature
- The U.S. should have a strong, integrated research program at all three frontiers

Energy Frontier
- Continued support for the Tevatron Collider program for next 1-2 years
- LHC program has the highest priority, including US involvement in planned upgrades
- Accelerator and detector R&D program for next generation lepton collider

Intensity Frontier
- Recommends a world class neutrino program as core component
- Long term vision includes a large detector at DUSEL and high-intensity neutrino source at Fermilab.
- Program of rare decays (e.g.: muon to electron conversion – Mu2e)

Cosmic Frontier with an emphasis on dark energy and matter
- Joint Dark Energy Mission (JDEM) in collaboration with NASA
- Large Synoptic Survey Telescope (LSST) in collaboration with NSF
- Direct dark matter search experiments

HEP at its core is an accelerator based experimental science.
- Support accelerator R&D to develop technologies
  - that are needed by the field
  - The benefit the nation
It is a Plan that will deliver significant science

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Position U.S. with capabilities to:

- To be major player in discoveries at LHC
- Important neutrino-nucleus cross sections
- Important information on neutrino parameters
- LAr expertise for next generation detector
- CP and proton decay discoveries
- Needed to nail CP measurement
- Important rare decay measurement
- Measurement of $\theta_{13}$
- Stage III Dark Energy Measurement
- Stage IV Dark Energy measurement
- Stage IV space-based DE measurement
- Intermediate Dark Matter Experiments
- Large Volume Dark Matter Experiment
A Plan that will deliver new technologies for the Nation

The accelerator and detector technologies developed for high energy physics research in the past have had important impacts on the Nation’s economy, security, and society. (See [http://www.science.doe.gov/hep/benefits/index.shtml](http://www.science.doe.gov/hep/benefits/index.shtml))

- **Medicine**: Accelerators and detector technologies first developed for particle physics are now used throughout the nation to treat and diagnose patients.
- **Homeland security**: Similarly, detector technologies have found uses in cargo scanning and monitoring of nuclear waste and proliferation.
- **Computing**: To record and analyze the unprecedented volumes of data generated in particle collisions, particle physicists have developed cutting-edge computing technologies, including the www and grid strategies.
- **Sciences**: Many of the tools developed for particle physics have led to important scientific innovations, such as the synchrotron light source, that benefit other areas of science.

**Looking to the future**

- OHEP’s ongoing and future development of accelerator, detector, electronics and magnet technologies is anticipated to continue to have significant impact in medical treatment and diagnosis, homeland and national security, industry, the internet grid, and other scientific fields.
- OHEP will be sponsoring an Accelerator R&D Workshop in 2009 to make a more direct connection between fundamental accelerator technology and applications and obtain guidance on the needs of federal programs and the private sector.
A Plan that will deliver scientists to the Nation’s Workforce

- An important benefit to the Nation provided by the OHEP program is the recruitment and training of a highly motivated, highly trained scientific and technical work force.

  - About 80% of those completing doctoral degrees in particle physics or accelerator science ultimately pursue careers in outside high energy physics research: i.e.;
    - industry, national defense, information technology, medical instrumentation, electronics, communications, biophysics, etc.

  - These scientists are highly valued in employment where the workforce requires
    - highly developed analytical and technical skills,
    - the ability to work in large teams on complex projects
    - the ability to think creatively to solve unique problems
U.S. HEP program at a crossroad

U.S. has not made investments in onshore HEP research capabilities

- Number of U.S. accelerator user facilities has been reduced to one
- Investments have not implemented a sustainable U.S. program
  - Major investment over last decade has been offshore (LHC)
  - Proposed onshore initiatives have not materialized (BTeV, ILC, ...)

Foreign nations have made (are planning to make) investments in HEP research capabilities

- Europe → CERN/LHC (Phase I & II) Energy Frontier
- Japan → J-PARC / S-BELLE neutrinos / rare decay / e⁺-e⁻ collider
- China → BES-II / Daya Bay electron beams / neutrinos
- Italy → (Super-B) e⁺-e⁻ collider

If the U.S. wants to remain among the leaders investments need to be made

- A realistic strategic plan has been developed that will position the U.S. to play a leadership role
  - Develop research infrastructure in the U.S. that produces outstanding science and a technology foundation
  - Provides a role for U.S. scientists in campaigns at all three scientific frontiers
  - Positions the U.S. for a productive, sustainable program in the future

- Leadership in HEP is important to the Nation
  - Delivers new knowledge/discoveries about the world we live in - that have significant impact on other scientific fields
  - Attracts and trains a next generation of scientists for the Nation’s scientific workforce
  - Develops advanced technologies that are important for the Nation’s security and competitiveness
FY 2009 funding is (hopefully) a reversal of recent DOE HEP funding trend

- HEP funding has been eroded by inflation: FY 2008 / FY 1996 ~ 20% (OMB COL)
- HEP FY 2008 funding was a -8.4% reduction from FY 2007 (mitigated by supplement of $32M)

- HEP FY 2009 funding is +10% compared to FY 2008 and above Cost-of-Living (COL) from FY 2007
- HEP to receive >$200 million in Recovery Act funding
# U.S. DOE HEP Program Overview

## FIVE Subprograms

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<th>Budget Categories</th>
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<td>Electron Accelerator-Based Physics</td>
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<td>Non-Accelerator Physics</td>
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<td>Theoretical Physics</td>
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<tr>
<td>Advanced Technology R&amp;D</td>
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<td>High Energy Physics Total</td>
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## Research Statistics

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<td># Ph.D.’s awarded</td>
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## HEP Budget Overview

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<th>HEP Budget Categories</th>
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<th>vs FY 08</th>
<th>FY 2009</th>
<th>vs FY 08</th>
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## DOE SC HEP

### Budget Overview

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<td>751.8</td>
<td>721.3</td>
<td>74.4</td>
<td>795.7</td>
<td>10.3%</td>
<td>5.8%</td>
</tr>
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</table>
Advanced Technology R&D
Significant activities and issues

U.S. leadership in Accelerator R&D
- Historically the U.S. has been a leader in the development of advanced accelerators

- The developments have been largely driven by the HEP program, and supported by the DOE OHEP, in the quest for higher energies and intensities and more demanding beam properties.

- U.S. leadership in this area is being challenged by efforts in other regions and countries
  - Investments have been made and are being made in new forefront HEP accelerator facilities
  - There appears to be recognition by governments of the importance of accelerator competency and infrastructure
  - Industrial capabilities have been nurtured in Europe/Japan and are now preferred vendors for specialized accelerator components

- OHEP has begun to address this technology gap
  - Started in FY 2007 to nurture the development critical accelerator capabilities (e.g.; SRF cavities) in the U.S.
  - Participating in the international ILC and muon collider effort R&D effort
  - Significant Recovery Act funding is being directed towards accelerator R&D and in particular industrialization

- OHEP will be sponsoring an Accelerator R&D Workshop in 2009
  - to make a more direct connection between fundamental accelerator technology and applications
  - To obtain guidance on the needs of federal programs and the private sector