BOARD ON PHYSICS AND ASTRONOMY

THE NATIONAL ACADEMIES
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Revealing the Hidden Nature of Space and Time

Charting the Course for Elementary Particle Physics

EPP2010 at PLSC Meeting
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T.I. Meyer
Sr. Program Officer

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Physics 2010 – Guidelines

- Science is increasingly multidisciplinary
  - ⇨ *Broaden disciplinary study committees to include scientists from other fields*
- Science is increasingly multinational
  - ⇨ *Include scientists from Europe and Asia*
- Disciplines fail at communicating outside the field
  - ⇨ *Frame the science enterprise in terms of several questions or themes that are accessible to a broad audience. Don't construct an exhaustive catalog.*
  - ⇨ *Include policy experts familiar with the Washington S&T community in the makeup of the committee*
- Disciplines' analyses of themselves lack credibility in Washington
  - ⇨ *Include outsiders as listed above*
  - ⇨ *Set a small number of priorities for action and specify the actors*
- There must be a community consensus on the results
  - ⇨ *Reach out to the community through town meetings, web, etc*

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Genesis

- Last NRC report on Elementary Particle Physics (EPP) was published in 1998
  - Relatively little impact
- DOE/NSF FACA committee (HEPAP) published its long-range planning report in 2001
  - Relatively little impact
- Major sponsors of this field (DOE and NSF) approached the Academies informally in early 2004 about conducting a new assessment of the field
- BPA accepted the challenge, but recognized the need for innovation in all three areas
  - Task
  - Committee
  - Process (of deliberation)

Choosing the right task statement

- Charge to the committee
  - Identify, articulate, and prioritize the scientific questions and opportunities that define elementary-particle physics.
  - Recommend a 15-year implementation plan with realistic, ordered priorities to realize these opportunities.
- Key was to frame the analysis in a BROAD context
  - What does EPP offer and what strategy should the nation pursue with its investments?

Choosing the right people

- Membership of EPP2010 committee
  - Physicists from outside of particle physics
  - Scientists from outside of physics
  - Experts from outside science
  - Particle-physicists from outside the United States
- About half of the membership drawn from outside EPP
- Chaired by Harold T. Shapiro
  - Economist, bio-ethicist
  - IOM member
  - President emeritus of Princeton

Harold T. Shapiro, *Chair* Princeton University	Sally Dawson, *Vice Chair* Brookhaven Natl. Lab
Norman Augustine Lockheed Martin (retired)	Neal Lane Rice University
Jonathan Bagger Johns Hopkins University	Nigel Lockyer University of Penn
Philip Burrows Oxford University	Sidney Nagel University of Chicago
Sandra Faber University of California Observatories	Homer Neal University of Michigan
Stuart Freedman University of California, Berkeley	Ritchie Patterson Cornell University
Jerome Friedman MIT	Helen Quinn Stanford Linear Accel. Center
David Gross Kavli Inst for Theor. Physics	Charles Shank Lawrence Berkeley Natl. Lab
Joseph Hezir EOP Group, Inc.	Paul Steinhardt Princeton University
Norbert Holtkamp Oak Ridge Natl. Lab	Harold Varmus Sloan-Kettering
Takaaki Kajita University of Tokyo	Edward Witten Inst. for Advanced Study

Choosing the right process (1)

- First, examine the state of the science
  - Has this field run out of steam?
- Second, examine the state of the U.S. efforts
  - What are we doing? What is the rest of the world doing? What is the strategic vision?
- Third, frame strategic principles
  - What are the objectives? What are the overarching considerations?
- Fourth, set priorities going forward
  - Explicitly consider the consequences of different budget scenarios
- Fifth, sign and deliver…
- Some of these steps were new to the EPP community

Choosing the right process (2)

- Committee met at SLAC, Fermilab, Cornell, Washington
  - Six meetings as a full group
  - Dozens of small-group meetings, tutorials, visits, etc.
- Solicited input
  - Public web site
  - Town meetings at professional conferences
  - Public-comment sessions at every committee meeting
  - Written answers to committee queries
  - Lots of additional written input
- Visited Japan (KEK, JPARC) and Europe (DESY, CERN)
  - Additional meetings with INFN director, ECFA, ACFA, ICFA
- Non-particle physicists actively engaged every step of the way
  - Gather information, debate issues, rinse, and then repeat, again and again
- This process takes time
  - Committee formed in Aug 2004
  - Report release in April 2006

Nature of the Scientific Opportunities
(Does Particle Physics Still Matter?)

- As a committee of skeptics, outsiders, and insiders, how *exciting* were the scientific opportunities in particle physics?
- The committee concluded that particle physics continues to be a critical component of the physical sciences
  - Intellectual vitality and connectedness to many other fields
  - Inspiration to and attractor for young people
  - One of the drivers of technological frontiers
- The committee also concluded that the scientific agenda is especially ***exciting*** at the present time
  - Indeed, we are perhaps entering the most exciting era of particle physics in at least a generation
- In addition, particle physics is at a pivotal moment
  - Answers to long-standing questions are now within our technological reach
  - Convergence of separate lines of inquiries has special significance
- New tools such as the LHC and ***proposed*** ILC are poised to address these mysteries and make profound discoveries

Status of the U.S. Program

- Historical distinction
- Stagnating level of support for past 10 years
- Intellectual center of gravity moving abroad
- Major experiments are coming to the end of their scientifically useful lives

- ➔There is no clear follow-on plan in place
- ➔Significant risk of losing substantial (intellectual and financial) resources

- ➔However, there is a "silver lining"
  - As facilities close or change focus, resources are becoming available ***within the program*** to support and launch new initiatives

Is There a Leadership Strategy Going Forward?

- In the context of the global effort, to what role should the United States aspire?
  - Committee concluded that the scientific agenda has never been more compelling
  - Being among the leaders is critical for fully realizing the intellectual, economic, social, and cultural dividends from the investment of public resources
  - Without achieving a leadership role in the global effort, the U.S. program could not sustain its distinction and would become much smaller and less relevant

- Given the extraordinary scientific opportunities, the available human capital, and the current state of the U.S. effort, was there a path forward that could sustain (or regain) the United States' distinction in this field?

- YES! The committee articulated a strategic framework and evaluated several alternative strategies **aimed at leadership** and under different budget scenarios
  - Strategies with and without next-generation accelerators were considered
  - Clear priorities were proposed within this framework

International Linear Collider

- Scientific role
  - LHC will map out the territory, but a precision tool will be necessary for a comprehensive understanding
- Cost and schedule
  - Global scientific consensus has led to a world-wide planning activity (the Global Design Effort)
  - Key objective is determination of a credible design, cost, and schedule. However the committee proceeded under the assumption that the cost was 'like' the LHC and would require an international partnership.
- Relative timing
  - ILC would only become tenable after cost and initial LHC results complete the grounds for decision-making.
- Opportunity for the United States
  - Preliminary investment of ***risk capital*** is needed
  - A successful U.S. bid-to-host requires taking initiative now.

Findings & recommendations (1)

- Particle physics is at a special time: There is great theoretical and experimental evidence that a revolution could be in the making
  - The current theory, the Standard Model, has proven to accurately describe nature
  - New discoveries such as the mass of neutrinos, dark energy, and dark matter all point to new phenomena
  - Discoveries in particle physics have led to new insights about the cosmos, but the story has just begun
- The next step is not just a small step: it could be the next revolution
  - The convergence of interests in this energy range from particle physics, astrophysics, and cosmology indicate the potential for major scientific breakthrough
  - Discoveries are anticipated that will change how we think about particle physics, the universe, and the nature of space and time around us

Findings & recommendations (2)

- Particle physics in the U.S. is at a crossroads
  - Scientific discoveries are just within reach whose impact is likely to transform and even transcend particle physics
  - U.S. facilities are being closed or converted to other uses and federal investments have stagnated
  - Intellectual center of gravity is moving overseas with the construction of new facilities in Europe and Japan
- Without clear, decisive action in the next few years, the U.S. program will deteriorate
  - The United States should continue to support a competitive program in this key scientific field
  - The committee outlined a strategy that has the best chance to put the United States at the forefront of the field with a program of distinction and importance

Findings and recommendations (3)

- Particle physics is an important part of the national effort in the physical sciences
  - Key intellectual role in physics
  - Driver of scientific and technological frontiers
  - Inspiration and attraction for future generations
- The United States should aspire to a leadership role in the global program of particle physics
  - In the modern world, leadership does not mean singular dominance but rather taking initiative at the frontiers, accepting appropriate risks, and catalyzing partnerships both at home and abroad
  - We need to put greater emphasis on strategic international partnerships

Ordered Priorities

1. Exploit the opportunities offered by the LHC
2. Plan and initiate a comprehensive program to participate in the global effort to complete the necessary R&D to design and plan an international linear collider
3. Do what is necessary to mount an internationally compelling bid to build the international linear collider on U.S. soil
4. Seize the opportunities at the intersection of particle physics, astrophysics, and cosmology by coordinating and expanding domestic efforts
5. Pursue an internationally coordinated, staged program in the physics of neutrinos and proton decay
6. Pursue precision probes of physics beyond the Standard Model using available resources as a guide to overall level of effort while maintaining diversity

Paradigm shifts

- Outsiders brought three paradigm shifts to light that perhaps would not have been obvious with a different committee
  - Globalization
    - Working internationally means more than just collaborating and U.S. has an opportunity to usher in a new world order of global science
    - "The United States should move away from an almost certainly futile attempt to maintain dominance and toward an approach where leadership comes from developing and brokering mutual gains for partners"

    ➔PAST: "We're going to build this; will you help us?"
    ➔FUTURE: "What can we best build together?"
  - Intersection of particle physics with cosmology and astrophysics
    - Everyone "knows" that dark energy, dark matter, and so on have something to do with particle physics
    - The field is evolving
  - Changing landscape of national effort
    - Old paradigm of many labs competing with multiple good ideas is changing to an environment where a few labs must work together to identify their contributions to an overall coherent national strategy

Immediate attention (1)

- Advance courtesy briefings
  - Congress (Many staff, 4 members)
  - OMB (AD for Nat. Resources)
  - OSTP (Director, staff)
  - DOE (Secretary, Undersecretary for Science, AD for OHEP)
  - NSF (MPS AD, PHY division)
  - URA Board of Directors
  - NAS Physics Section (annual meeting)
- Within the first week, report was featured in articles in the New York Times, Chicago Tribune, Christian Science Monitor, even The Economist and one Chinese news agency and one Indian news agency
  - Coverage also immediately appeared in Nature, Science, Physics Today
- Electronic dissemination
  - Within 3 weeks, prepublication form of the report was downloaded more than 30,000 times from the NRC website
  - E-news articles appeared on AIP, PhysicsWeb.com, PhysOrg.com, Bob Park, and a half-dozen different "science" blogs

Immediate attention (2)

- Additional media coverage appeared later
  - Popular Science
  - CNN.com
  - symmetry magazine
  - IEEE Spectrum
  - Cornell Chronicle, Univ of Chicago Chronicle
- More than 20 different invited talks already
  - Major laboratories: SLAC, Fermilab, Cornell, Fermilab
  - U.S. advisory bodies: HEPAP, P5, NuSAG, SLAC SPC,
  - International bodies: ILC/GDE, ILCFOA, ECFA; Oxford, KEK
  - Professional society conferences: (many)
  - Other U.S. institutions

Longer-term Attention

- Op-eds in support of the report appeared in the New York Times, Chicago Sun-Times, APS News
- Invited op-eds from the committee were invited and published in News Day (Long Island), CERN Courier, Seed Magazine, Physics World, APS News
- Committee chair is still receiving invitations to speak on the topic
  - First speaker on the Fall 2006 colloquium schedule at Princeton physics department was Harold Shapiro
  - Univ of Chicago and Argonne Natl Lab have booked a Spring 2007 appearance
- Additional briefings are planned

Impact?

- The buzz is still alive
- APS Division sent open letter with sweeping praise & endorsement
  - Community advisory committees have embraced report and are adopting its language
- In Aug 2006, Norm Augustine and Harold Shapiro were invited to meet with Sen Domenici
- FY2007/8 budgets…time will tell

Back Up

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What Report Means for the National Laboratories

- Science program of the national laboratories is evolving
  - Fermilab will become the only laboratory primarily devoted to particle physics and this 'fact' will have implications for its scientific agenda
- Can a competitive, globally relevant national program be sustained without a major initiative to access Terascale physics (i.e., a major new accelerator facility, e.g., the ILC)?
  - The committee thought very hard about this possibility but could not see a long-term leadership role for the U.S. in this scenario
  - Thus, the committee recommends that the U.S. lead an international effort to consider how best to coordinate a long-term global effort with long-baseline neutrino experiments
- Fermilab will play a key role in mobilizing and working with the country's best talent and resources in implementing a national vision that has strategic importance in the global context
  - All national laboratories have unique roles to fill in this strategic vision
- Fermilab is a strong contender to have the ILC sited nearby
  - Final decision will involve some politics (both national and international)

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