

Informal Personal Observations

(Not approved by the NAS or the NRC!)

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Observations (1)

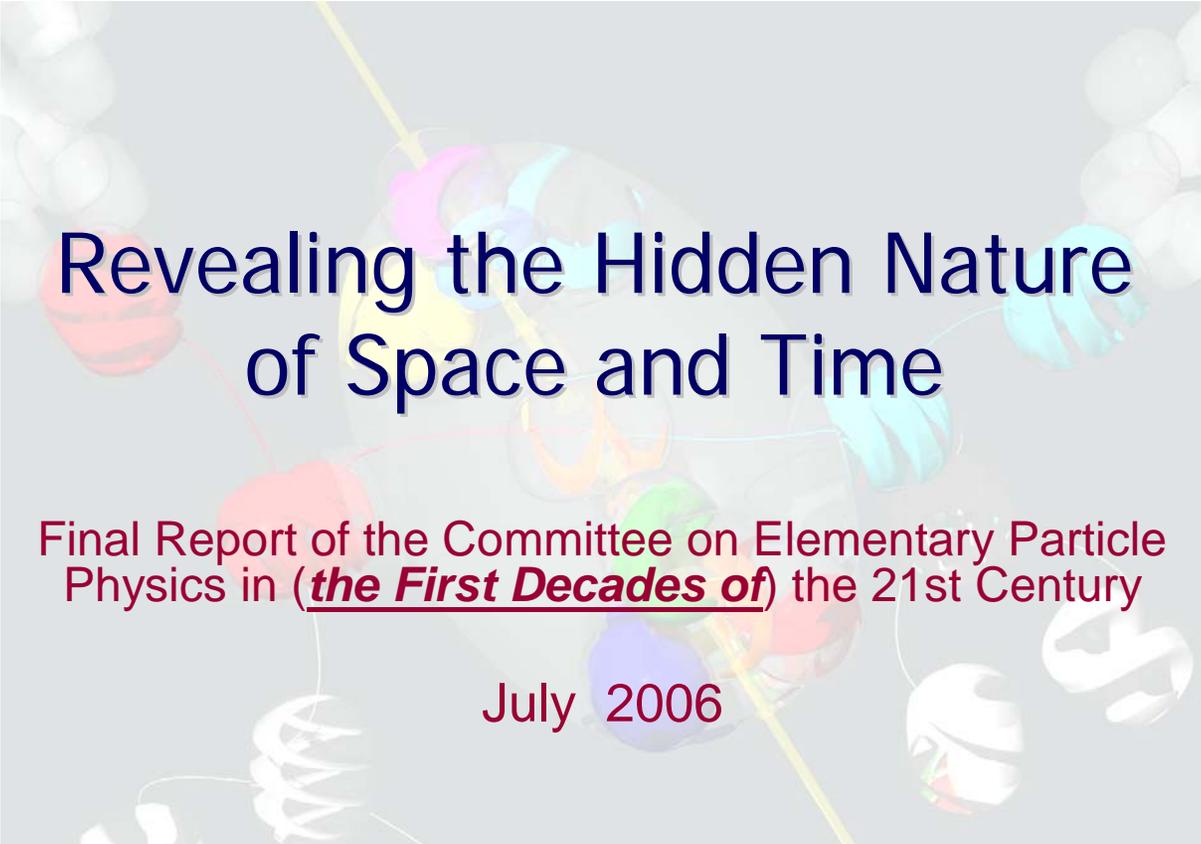
- Its been a quite remarkable intellectual journey for an “outsider”
- Grateful to the intellectual generosity of particle physicists, both here and abroad
- The ability to confront the current crisis in EPP is partly dependent on the views of the scientific community, but also on forces over which the scientific community has little or no control. [e.g. DoE’s other responsibilities, the congressional committee structure, the “energy crisis” etc.]

Observations (2)

- For the U.S. particle physics program it is hard to overestimate the critical nature of the next few years
- We need to reverse the momentum of the program which seems to be executing an exit strategy
- The longer we wait the worse our competitive position

Particle Physics and the “ACI”

- The current debate over the ACI initiative is a debate over who gets the money, although it is disguised as a debate over which activities most easily and quickly promote economic growth.
- Competitiveness is not won in a day, but in a generation. Understanding this may be the key to additional support for the physical sciences



Revealing the Hidden Nature of Space and Time

Final Report of the Committee on Elementary Particle
Physics in (*the First Decades of*) the 21st Century

July 2006

Harold T. Shapiro, Princeton University
on behalf of the full committee

Unusual Features of this “Moment” and this Committee

- Over the past 10 years, many committees have examined the future of elementary particle physics. What, if anything, makes this assessment by the National Academy any different?
- The current status of the U.S. program in a global context is changing
- A “different” and “scientifically pregnant” moment
- Committee membership was unusual in its breadth

Context of the Report

- The report examines and is framed by some initial conditions:
 - The nature of the scientific opportunities
 - The current status of the U.S. program
 - The current status of programs abroad

And a report structure characterized by:

- An articulation of a set of strategic principles
- Evaluation of alternative sets of priorities
- Reasonable budget assumptions [**at least inflationary adjustments**]
- Selection of ordered priorities
- (The ongoing national discussion of competitiveness, innovation, and the future position of U.S. science and technology)

We Worked Diligently [i.e. Hard]

- Committee met at SLAC, Fermilab, Cornell, Washington (multiple times)
- Solicited “Community” Input
 - “Town Meetings”
 - Web Site
 - Written Input
- Visited KEK, JPARC, DESY, and CERN
 - Met with INFN director, Brian Foster, ACFA chair, ICFA chair
 - Non-particle physicists actively engaged

Key Questions in Particle Physics (For The Uninitiated)

- Can all of the forces between particles be understood in a unified framework?
- What do the properties of particles reveal about the nature and origin of matter and the properties of space and time?
- What are dark matter and dark energy, and how has quantum mechanics influenced the structure of the universe?
- In the judgment of particle physicists these questions, together with accumulating experimental evidence, emerging technologies and experimental facilities (*actual and planned*), point to a potential transformation of particle physics

Nature of the Scientific Opportunities (For the “uninitiated” 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

Experimental Opportunities

- Particle physicists employ three general sets of tools for addressing these questions
- High-energy beams
 - Accelerators operating at higher energies create new particles and new patterns of interactions because they probe smaller scales of time and distance
- High-intensity beams
 - Effects of nature are often quite subtle and can require studying millions and millions of interactions to tease apart the underlying principles
- Nature's particle sources
 - Many of these particles occur “naturally” throughout the universe
 - Particles from the cosmos, the sun, and even natural radioactivity can provide key information

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.
- **Potential opportunity for the United States ?**
 - Preliminary investment of **risk capital** is needed
 - A successful U.S. bid-to-host requires taking initiative now.

Is There a Leadership Strategy Going Forward?

- In the context of the global effort, to what role should the United States aspire? In particular is leadership important?
 - Without achieving a leadership role within the global effort, the U.S. program could not sustain its distinction and would become a much smaller and less relevant effort
 - Being among the leaders is critical for fully realizing the intellectual, economic, social, and cultural dividends from the investment of public resources
- 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?
- The committee articulated a strategic framework and evaluated several alternative strategies **aimed at leadership** and under different budget scenarios
 - Clear priorities were proposed within this framework

Strategic Principles and Priorities

- The strategic principles are designed to set out the general framework or constraints within which particular priorities are selected.
- The priorities reflect both the long term aspirations of the program the necessary flexibility to adjust somewhat to the empirical facts that emerge from year to year.

Strategic Framework (1)

- 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*

Strategic Framework (2)

- A diverse portfolio of activities is crucial
- Need for vision, priorities, risk taking, flexibility, and responsible budgets
- To fully achieve the potential of particle physics, multi-year planning is required
 - Large-scale science requires long-term commitment
- The administration of U.S. program in particle physics is poised for change
 - With some national labs changing their focus, Fermilab will become even more central to the particle physics community
 - A new level of national and international planning is required to provide a full range of opportunities to physicists, to explore a wide range of approaches, to be good stewards of public funds and thus to increase the probability of important discoveries
 - Advisory and guidance processes for the field should be adjusted accordingly

Alternative Sets of Priorities

- Committee considered a broad array of strategies and scenarios
 - One set class of priorities rejected any consideration of a major commitment to new accelerator facilities here, while another set of priorities included investments aimed at the potential establishment of new domestically based experimental facilities to study Terascale physics under laboratory conditions *[i.e. the ILC]*
- The committee believed that only a strategy which included a major commitment to exploit the Terascale opportunities both at the LHC *and* with domestically based accelerator facilities would yield the highest risk adjusted return for the U.S. program and the best opportunity sustain (or regain) U.S. distinction in this area
 - Choosing not to pursue on a broad front the direct exploration of the Terascale would be equivalent to “folding our hands” and walking away from leadership in particle physics

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

Report in a Global Context

- The committee considered the U.S. role in the global effort at great length
 - The nation must “pull its own weight” in terms of hosting next-generation facilities and catalyzing the international partnerships required to make them possible
 - “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?”
- In articulating its priorities, the committee chose a strategy that leverages U.S. strengths for the global community and adds to the long-term vitality of the entire field

What the 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 if the major new initiative is an accelerator-based neutrino program at Fermilab?**
 - 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**
- **Fermilab is a strong contender to have the ILC sited nearby**

Take Home Message (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

Take-Home Message (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**

Take Home Message (3)

- Our Vision: That particle physicists, both here and abroad, and their students will be able to pursue which ever aspect of the field that they find intellectually exciting.
- To achieve this vision and be accountable for the responsible use of public resources requires that investments in new experimental facilities be “*internationally optimized*” and open to all scientists on an equitable basis. {Strategic Principle 2}

Take Home Message (4)

- I view the committee's work as an attempt to **start** an important process. As the U.S. program in particle physics evolves from this point many more decisions need to be made.
- In particular the particle physics community must come together on the strategic issues, on their aspirations and, equally important, must define the path forward in considerably greater detail.
- There is a lot for the particle physics community to do and little time to achieve it!

- **QUESTIONS**