NSF Elementary Particle Physics

The Present and Future of HEP:
The NSF Perspective and Partnerships

Presentation at the SLAC Users’ Meeting
July 6, 2004

Jim Whitmore
Marv Goldberg
Jim Stone
Gene Loh
Fred Cooper
INT is now an OFFICE
New SCI Div. in CISE
We work with SCI, ESIE in EHR on Project funding
MPS Structure

Directorate for Mathematical and Physical Sciences

Division of Astronomical Sciences
Division of Chemistry
Division of Materials Research
Division of Mathematical Sciences
Division of Physics

Office of Multidisciplinary Activities

***PHY + AST = Physics of Universe Initiative, Quarks to Cosmos, Quantum Universe

$ Help for EPP
NSF Division of Physics

I. Atomic, Molecular, Optical, and Plasma Physics
II. Biological Physics
III. Elementary Particle Physics (EPP)
IV. Gravitational Physics and LIGO
V. Education and Interdisciplinary Research
VI. Nuclear Physics
VII. Particle and Nuclear Astrophysics (PNA)
VIII. Theoretical Physics (TP)

Within TP are the subareas of:

Atomic Physics,
Elementary Particle Physics,
Mathematical Physics,
Nuclear Physics,
Particle and Nuclear Astrophysics
Program News

Successful Particle Astrophysics (in FY02)
Physics Frontier Center Program (in FY02)
(Next PFC competition will be in FY08)

NEW:

Biophysics Program (in FY04)

Physics at the Information Frontier Program:

Computational physics, information intensive physics, and quantum information and revolutionary computing

** BUT HAS BEEN DELAYED (to FY06?)**
NEW Funding Mechanism Statement FROM THE National Science Board


THE MRI-MREFC FUNDING GAP ($2M-$100M)

ADDRESS THE INCREASED NEED FOR MIDSIZE INFRASTRUCTURE. develop new funding mechanisms, as appropriate, to support midsize projects.

***Happening but without new money
Program News (cont)

PLANNED:

Accelerator Program:

Enhancing Accelerator Science and its Impact on Other Sciences: the Role of Universities;

and combined with mid-size projects

** BUT HAS BEEN DELAYED (in FY06?)**
## NSF FY 00-05 Budget Summary

<table>
<thead>
<tr>
<th></th>
<th>FY 2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
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<tr>
<td></td>
<td>($ millions)</td>
<td>(CP)</td>
<td>(Request)</td>
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<td>4,774.1</td>
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<td>5,577.8</td>
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<td>EPP BASE</td>
<td>60.64</td>
<td>66.99</td>
<td>70.80</td>
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“EPP BASE” : Theory + Astro + Accel. Based + Cornell

EPP has had an increase:
but we have been funding the LHC research program and RSVP
EPP Program at NSF

- **Science Highlights**
  - Physics at Energy Frontier \{ CDF, DO \}
  - (Extra Dim, Dark Energy, SUSY) \{ ATLAS, CMS \}
  - Physics at the Sensitivity Frontier \{ KOPIO, MECO \}
  - (Rare decays, LFV)

- Properties of Neutrinos \{ MINOS, MiniBooNE, K2K \}
- Heavy quark physics \{ CLEO-c, BaBar, BTeV \}
- QCD, proton and photon structure \{ ZEUS \}
- Accelerator physics
- Other \{ iVDGL, QuarkNet, PDG \}
### Experiment distribution

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Sr Phys</th>
<th>$</th>
<th>%</th>
<th>DOE%</th>
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<td>Tevatron</td>
<td>40</td>
<td>5,319K</td>
<td>20.9</td>
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<tr>
<td>Neutrino</td>
<td>12</td>
<td>2,128K</td>
<td>8.4</td>
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<td>LHC</td>
<td>39</td>
<td>5,697K</td>
<td>22.5</td>
<td>28</td>
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<tr>
<td>DESY/CERN</td>
<td>8</td>
<td>1,368K</td>
<td>5.4</td>
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<tr>
<td>BNL</td>
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<td>1,230K</td>
<td>4.8</td>
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<td>Other</td>
<td>14</td>
<td>1,173K</td>
<td>4.6</td>
<td>3</td>
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<td>Particle AstroPhys</td>
<td>70</td>
<td>6,475K</td>
<td>25.5</td>
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"Effective" Funding (>\$100M) for Particle Physics in FY02 - FY04:

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<th>FY02</th>
<th>FY03</th>
<th>FY04</th>
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<td>Accelerator-based activities w Cornell</td>
<td>$41.58 M</td>
<td>47.97</td>
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<td>Particle Astrophysics (SPINOFF)</td>
<td>9.05</td>
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<td>EP-Astro Theory</td>
<td>10.01</td>
<td>9.16</td>
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<td>Total Base</td>
<td>$60.64</td>
<td>66.99</td>
<td>70.80 M</td>
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**PLUS**

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<td>??</td>
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<tr>
<td>MRI</td>
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<td>ESIE</td>
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**MREFC**

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<th>FY04</th>
<th>FY05</th>
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<td>LHC construction</td>
<td>$16.90</td>
<td>9.69 M</td>
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<td>41.75</td>
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<td>RSVP</td>
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<td>30.00 M</td>
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<tr>
<td>Subtotal</td>
<td>$45.80</td>
<td>47.23</td>
<td>46.04</td>
<td>63.40 M</td>
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Good Advice
NSF and increasing involvement in large scale Projects

Energy vs Sensitivity Frontiers

Cornell/CESR EPP operations will phase out in FY08

LIGO

LHC: NSF Project Partnership at a European Laboratory.

RSVP: NSF Project Leadership at a National Laboratory

ICECUBE: NSF Project Leadership in a Harsh Environment.

NEXT STEPS

Underground Lab -- NSF LEAD

Linear Collider -- DOE LEAD

We will work with DOE on BOTH
The **LARGE HADRON COLLIDER (LHC)** will be the premier *Energy- Frontier* facility in the world, with vast discovery potential in elementary particle physics research.

A total of 34 international funding agencies participate in the **ATLAS** detector project, and 31 in the **CMS** Detector project.

The U.S. participants are ~20% of the collaboration.

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*U.S. Department of Energy and the National Science Foundation*
LHC Research Prog (M&O/SW&C)

LHC Funding, by Phase

- Concept/Development
- Implementation
- Operations & Maintenance

Fiscal Year

**DOE/NSF AGENCY AGREEMENT! More stable**
TRILLIUM UNIFIES
NSF (ITR)/DOE GRID PROJECTS

OASCR HEP
CISE EPP

LIGO-SDSS

EU

Trillium
Where we Are: Grid2003: An **Operational Grid**
- 28 sites (2100-2800 CPUs) and growing
- 400-1300 concurrent jobs
- 10 applications plus CS experiments
- Incl. CMS, ATLAS, SDSS, BTeV, LIGO, Biology
- Running since October 03 - Sharing Resources

http://www.ivdgl.org/grid2003
Grid 2003: DOES IT WORK?
US CMS Production

- With respect to previous year, almost double the number of events produced during first 25 days with half the manpower!
- Run production across Grid with 1 person working 50%
- Run 400 jobs simultaneously
- Compared to 200 previous year
DOES IT WORK? Feb 10 Panel Assessment Extract:

The [project] has to continue to succeed! It is important for the LHC (Large Hadron Collider), LIGO (Laser Interferometer Gravitational-Wave Observatory), and SDSS (Sloan Digital Sky Survey)...If grids do not work for HEP it is hard to see them working in other areas.

The SuperComputing2003 demo was a demonstration of a very successful first example of a persistent grid

The .. team should be more aggressive in publicizing their SC2003 grid demo success....establish procedures for outsiders to use the test bed.. (the latter statement was motivated by two panelists who wished to use the test bed.)

The potential for integrating both network monitoring and grid monitoring is a golden opportunity

Outreach activities have real teeth to them with demonstrable results.
Progress to date: Great

Teacher Satisfaction: High

Benefits: Teachers are respected and knowledgeable professionals.

Best Practices: Yes

Goals (excellent)

- Managed like EPP Experiment
- Through Teachers, impacts 100,000 H.S. Students Each Year
Educators’ Interests

Teachers are interested in and excited about the potential that Grid tools and techniques bring to data–based classroom projects. To use the Grid, teachers need a user–friendly site where inquiry–based projects are standards–based, visually appealing, use common tools and data formats, allow for levels and scale of use, and provide support materials for teachers and students.

Meeting at FIU, January 29-30, 2004
Building a Nationwide Laboratory for "Science of the Universe" Education and Outreach
WHY NATIONWIDE LABS?

National Labs: Focus on Directorate Science

*Resources for Experiments*

Nationwide Labs: Focus on Multi-Directorate E/O:

*Resources for E/O from Research to Deliverables*

*In the service of Integrating Research and Education*

*Program Coherence/Framework via Information Exchange*
Toward Defining a Broad Program Connecting to Quarks/Cosmos
Building on Existing Partnerships

Revolutionizing the way science is done through advanced cyberinfrastructure.

A basis for restructuring the integration of international research and education.

Empowering Universities in Research and Education

Empowering teachers as part of the research community

Bringing advanced cyberinfrastructure into the classroom by using distributed infrastructure supported for long times by Research programs.

A true symbiosis- MPS/CISE/EHR/INT
"LCPS Students Engage in Cosmic Ray Research"

School rooftops throughout Nebraska are becoming high-energy physics research stations as part of the **Cosmic Ray Observatory Project (CROP)**, a statewide effort administered by the Department of Physics and Astronomy at the University of Nebraska, Lincoln. The multi-year project aims to place detectors at all of the state's 314 high schools.
Open Science Grid -- Roadmap

• Build upon existing achievements towards a sustained US national production grid for the long term - past 2010
• US LHC will build and contribute their resources into a coherent infrastructure to provide the initial federation
• Develop the general Grid infrastructure to support other sciences
• Partnership between application scientists, technology providers and resource owners based on proven achievements as an effective strategy for success

From R. Pordes (Fermilab) June 2004 (DOE/NSF)
**Rare Symmetry Violating Processes**

- Complementary to **Energy Frontier** Science such as the Tevatron and LHC
- RSVP is Fundamental Physics at the **Sensitivity Frontier**
- Searching for **Very Rare Processes** that could indicate **New Physics** (i.e., beyond the Standard Model) and probe (via virtual processes) the highest energies beyond the accelerator frontier
- Many times **more sensitive** than past experiments
- RSVP is an **MREFC** project for two new AGS experiments that could profoundly change our understanding of physics

**NSF Project Leadership at a National Laboratory**
The **Rare Symmetry Violating Processes Project:**

**RSVP** is an NSF-supported, university-led particle physics project, using accelerator facilities developed by DOE

**KOPIO** aims to measure a rare decay of the neutral kaon that would be a major advance in the study of CP violation and the matter-antimatter asymmetry in the universe:

\[ K_L^0 \rightarrow \pi^0 \nu \bar{\nu} \]

**MECO** is a search for the “forbidden” conversion of muons to electrons that aims to discover new physics beyond SM up to 3000 TeV:

\[ \mu^- N \rightarrow e^- N \]
Quantum Universe Report

1. Are there undiscovered principles of nature: new symmetries, new physical laws?
5. Why are there so many kinds of particles?
9. What happened to the antimatter?

<table>
<thead>
<tr>
<th>Question</th>
<th>Unification</th>
<th>Particle World</th>
<th>Birth of the Universe</th>
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<tbody>
<tr>
<td>Mini-BooNE</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>MECO</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Reactor Experiments</td>
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<td>X</td>
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<td>CLEO-c</td>
<td>X</td>
<td></td>
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<td>K0PI0</td>
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<tr>
<td>Neutrinoless Double Beta Decay</td>
<td>X</td>
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<td>SDSS</td>
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<td>LSST</td>
<td>X</td>
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<td>Underground Dark Matter Detectors</td>
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<td>WMAP</td>
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<tr>
<td>Precision Gravity</td>
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RSVP FUNDING

- President’s FY2004 Budget put RSVP to start in FY2006
- Congress appropriated “$6M for continued advanced planning”

FY 2005 start shown, as in FY 2005 President’s budget.
Underground Science Laboratory Update

- NAS BOARD ON PHYSICS AND ASTRONOMY, DEC 2002 SUMMARY:
  “A deep underground laboratory can house a new generation of experiments that will advance our understanding of the fundamental properties of neutrinos and the forces that govern elementary particles, as well as shedding light on the nature of the dark matter that holds the Universe together. Recent discoveries about neutrinos, new ideas and technologies, and the scientific leadership that exists in the U.S., make the time ripe to build such a unique facility.” [http://www7.nationalacademies.org/bpa/Neutrinos_Sum.pdf](http://www7.nationalacademies.org/bpa/Neutrinos_Sum.pdf)

MPS/PHY is taking the lead for NSF, in partnership with the Directorates of Geosciences and Engineering, in working to implement a sequence of steps that might lead to the creation of such a laboratory.
Underground Science Laboratory Update

NSF had an open meeting on May 19-20, 2003. At this meeting: 3 Solicitations were announced:

1. Develop the scientific and engineering case for the range of potential experiments needing underground access (the Elements)
2. Describe the associated technical requirements on the infrastructure and instrumentation
3. Group the Elements with similar scientific motivation and associated technical requirements for infrastructure into Modules
Underground Science Laboratory Update

1. 04-595 (Deadline: September 15, 2004): The primary purpose of this solicitation is to establish the site-independent scientific and engineering benchmarks against which the capabilities of the candidate sites for an underground laboratory will be measured. (Expect 1-3 awards, each of up to $0.5M)

2. (No number yet; Deadline October 15, 2004): This solicitation will invite proposals to support development of the conceptual design for the infrastructure, and an initial suite of experiments, for a Deep Underground Science and Engineering Laboratory. (Expect 1-4 6-month awards, each of up to $0.5M, in FY05)
Physics Fall Target Date

- The target date for proposal submissions to the Division of Physics that are competing for FY2005 funds is September 29, 2004.

- The above date does not apply to proposals sent to the Physics Division in response to Foundation-wide solicitations, such as the Faculty Early Career Development (CAREER - July 22, 2004) or Research Experiences for Undergraduates (REU) programs.
Summary

- We are working with many partnerships to bring added value to EPP projects
- We are entering a new phase of operations with facilities (some with DOE)
- We hope to put more funds into LC R&D in FY05 (more coordination with DOE)
- We look forward to your next proposal(s)