

The Coming Particle Physics Revolution

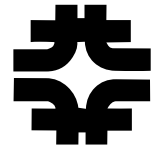
FNAL Long Range Plan:

Progress Report

Hugh Montgomery, stolen by R. Patterson

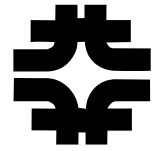
March 11, 2004

(From) Charge to the FNAL Long Range Planning Committee



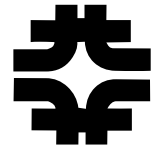
- **The committee should develop scenarios for each of the two cases spelled out by the HEPAP Subpanel.**
 - **A linear collider project will be built here, starting late in this decade with international support and organization.**
 - **The linear collider will be built offshore with substantial participation from U.S. High Energy Physics.**

Membership



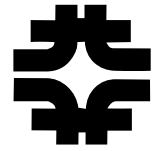
- **Hugh Montgomery (Chair)**
- **Steve Holmes (Deputy)**
- **Jeff Appel**
- **Joel Butler**
- **Marcela Carena**
- **Josh Frieman**
- **Steve Geer**
- **Chris Hill**
- **Bob Kephart**
- **Sergei Nagaitsev**
- **Jim Strait**
- **John Womersley**
- **Gary Feldman, Harvard**
- **Young-Kee Kim, Chicago**
- **Peter Meyers, Princeton**
- **Angela Olinto, Chicago**
- **Ritchie Patterson, Cornell**

Chronology



- **January, February, 2003**
 - **Committee approached, charge drafted and circulated**
- **Spring and Summer, 2003**
 - **Sub-committees formed, programs of presentations in committee and discussions**
 - **Layout of report discussed, space assigned**
- **Fall, 2003**
 - **Open Sessions**
 - **Drafts of sections of the report**
 - **Plenary Meetings**
- **January 9,10 ----**
 - **Retreat**
- **January- February 2004**
 - **Circulate Drafts of sections and complete report**
- **February-March 2004, converge, make presentations**
- **March-April , complete report (Exec Summary + Rep. ~75 pages)**

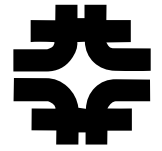
Current Fermilab Accelerator Complex



- **Present Local Accelerator Based Physics Program:**
 - Tevatron: CDF, D0 → BTeV
 - Booster: MiniBooNE
 - Main Injector: NuMI-MINOS
 - Main Injector: E907(MIPP), E906(Drell-Yan), (Kaons)
- **Energy Frontier, Discovery**
- **Strong Neutrino Component**
- **Strong Quark Flavor Component**
- **QCD**
- **Provides Basis for Future Flexibility**
- **Provides Ability to respond to Physics demands**

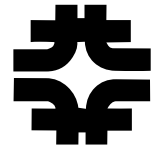
We are regularly receiving proposals
Program lasts into next decade

Coming Revolution in Particle Physics



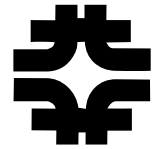
- The standard model is starting to give way to something new.
 - neutrinos have mass and mixing
 - window on a new phenomenon at the Grand Unification Scale?
 - Tevatron?, LHC, will pull back the curtain on the origin of mass, or electroweak symmetry breaking,
 - SUSY?
 - Extra Dimensions

Coming Revolution in Particle Physics



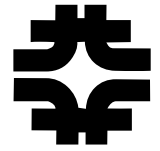
- new physics questions
- exploration of new worlds:
 - A new world of phenomena at the electroweak symmetry breaking scale and beyond;
 - A new world of neutrino masses and mixings, which may address the matter-antimatter asymmetry of our universe;
 - A new world of cosmological and particle astrophysics.
- new ways of working
- new connections

Vision I: FNAL hosting Linear Collider



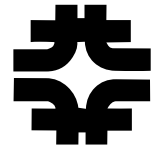
- **Linear Collider under construction near Fermilab**
 - **Fermilab at the center of future discoveries and understanding**
 - **Major part of Lab activity**
 - **Neutrino Program**
 - **Based on improvements to the accelerator complex and the experiments over the next ten years**
 - **Large Hadron Collider Program**
 - **Accelerator and experiment: Fermilab leading center for CMS physics**
 - **Other experiments at FNAL**
 - **As physics demands**
 - **Quark Flavor may still be key**
 - **Other programs**
 - **Astroparticle physics, Accelerator R&D**
 - **Non-particle science**
-

Vision II: FNAL with Linear Collider Offshore



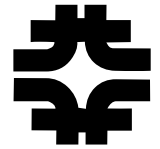
- **Fermilab Neutrino Program**
 - World leading long baseline program
 - New accelerator- Proton Driver
- **Linear Collider offshore**
 - Significant Lab resources in this activity
- **Large Hadron Collider Program**
 - Accelerator and experiment: Fermilab leading center for CMS physics
- **Other experiments at FNAL**
 - As physics demands
 - Quark Flavor may still be key
 - Other programs
- **Astroparticle physics, Accelerator R&D**
- **Non-particle science**

The Linear Collider



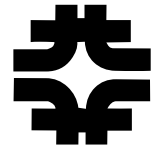
- **Physics of Electroweak Symmetry breaking**
 - **Elucidation of Higgs field/particle**
 - What are its couplings to different fermions
 - **New degrees of freedom**
 - SUSY
 - Extra Space Dimensions
 - **Precision discrimination between candidate descriptions**
 - **Detection and identification of dark matter**
- **A window to even higher energies**
- **Exciting Physics of the highest quality**

Linear Collider Status



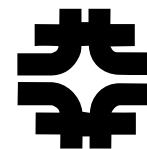
- **International Linear Collider Steering Committee under ICFA**
 - **Regional Committees**
- **Governance documents complete or in draft.**
- **US LC Accel Committee has completed study of Cold & Warm options “as if sited in US”, not yet released.**
- **Technologies**
 - **R1s supposed to be resolved this year**
 - **Power distribution was met in December for warm.**
- **Technology Choice**
 - **Committee in place,**
 - **1st Meeting in UK in January.**
 - **Report by end of 2004**

Linear Collider Actions



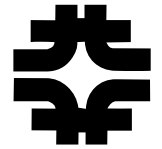
- Fermilab should initiate efforts to coordinate development of design studies for both warm and cold ETFs, in collaboration with international partners, with a goal of siting the ETF for the chosen technology at Fermilab.
- It is imperative that Fermilab prepare a bid to host the electron-positron Linear Collider
 - **With Broad US LC accelerator collaboration**
- The challenge is worthy of Fermilab.
- Fermilab planning should be based upon the host laboratory/international project model.

Neutrinos



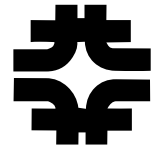
- **Neutrinos appear to mix, to have mass**
 - **Some explanations of light neutrino mass involve heavy states “ at the GUT scale”**
- **Pattern of observations is not understood**
 - **Intrinsically exciting**
- **Assume three flavors (doesn't fit the data but....)**
 - **Mass Hierarchy? CP Violation**
 - **Matrix Element θ_{13}**
 - ν_e appearance
 - Matter effects
 - **Different experiments have sensitivity to different aspects**
 - Reactor, JPARC to SuperK are sensitive to just magnitude of θ_{13}
 - NuMI baseline and energy \rightarrow sensitivity to
 - magnitude of θ_{13}
 - Mass hierarchy
 - CP violation

Neutrinos



- **Neutrinos**
 - Fermilab's capabilities provide unique opportunity
 - neutrino physics forms an exciting program
 - Fermilab should pursue vigorously.
- **Intense Neutrino Beams**
 - a superconducting linear accelerator or new synchrotron plus Main Injector improvements
- **Prepare CDR for SC LINAC + → Mission Need (CD0) for Proton Driver**

Proton Driver – SC Linac



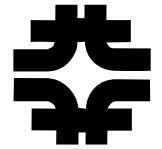
MI-30 Injection Point
Chosen for Design Study

Large Hadron Collider



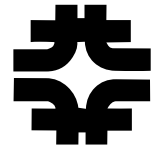
- **Role commensurate with the size of Fermilab**
- **CMS Physics Analysis Center**
 - **A (or perhaps The) place to do physics**
 - **Enhance US physics potential**
 - **Improve return on investment**
 - **(some) resources have been planned, the trick is to make it happen**
- **Phenomenology**
- **Detector Development for higher luminosity**
- **LHC Accelerator Research Program**

Accelerator R&D

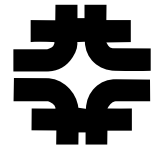


- **Most of our science is dependent on accelerator R&D done many years ago.**
- **The future of that science depends on the R&D we do today.**
- **Lots of the work is immensely interesting physics**
- **Committee would like to support an increase in resources**
- **Committee feels we could systematically improve the way we treat this part of the program.**

Particle Astrophysics



- **Already have strong astrophysics program (FNAL was the pioneer among HEP labs)**
 - **Dark Matter (SDSS, CDMS,SUSY searches)**
 - **Dark Energy (SNAP/JDEM nascent)**
 - **Ultra high energy cosmic rays (Auger)**
 - »
- **Current Discussions of new initiatives.**
 - **SDSS Program considering an extension.**
 - **Fermilab Technical Expertise significant (Focal Plane Arrays)**
 - **To list above, add CTIO/DECAM and LSST**
 - **PAC augmented to handle the discussion.**
- **Committee feels Astroparticle physics should grow.**
 - **Discussion of organization (center, institute??)**



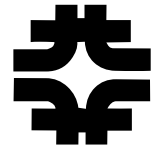
Interdisciplinary Science

- application of accelerators to the benefit of society.
 - for example, support the proposed Hadron Therapy Facility in DuPage Technology Park to the north of the site
 - R&D in Computing Science and Technology

Detector R&D

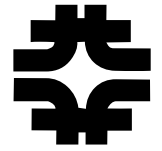
- Modest but focused program

Resources



-
- Start from 6 year model being used for discussions with DOE now.
 - G&A was included in each line.
 - Extend for a further few years to include 2017.
 - Use 2% increase per year to inflate individual items (if know no better)
 - Make a few intelligent moves, for example recognize that when BTeV stops there is a drop in the accelerator operation costs.
 - Add in a profile corresponding to the desired new initiative.
 - Linear Collider
 - Proton Driver
 - **Not well done**
 - Delve into the large parts of the operations, and the support to see what can be redirected.
 - Scrub for double counting between existing elements and elements added
 - **Balancing is only broad brush**
-

Conclusions



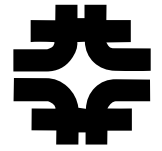
We expect a revolution in physics

We see an exciting future for Fermilab

If we work together, we can make it happen!

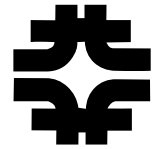
The work is of the whole committee, the MANY participants in the subcommittees, and of the many who have attended the open sessions.

Spares Follow



Linear Collider Governance:

(Kalmus Model; US Model is/will be similar)



- **The GLCP should be sited near an existing “Host” laboratory, from which it should be managerially wholly independent. This would:**
 - save much of the cost of establishing the infrastructure, support, and services that are needed by any large-scale project, while keeping the number of staff directly employed by the GLCP low;
 - provide the necessary academic and technical ambience from the outset;
 - reduce the cost of ultimate closure of the GLCP by ensuring that facilities owned by it are kept to a minimum.
- Relations between the GLCP and the Host Laboratory, and the role of the Host State, are considered in more detail in the full ECFA report

7

This struck a chord in sub-committee and in open session
