Particle Physics Project Prioritization Panel Report
A summary from Fermilab Director Michael Witherell

On Monday, September 29, 2003, at a meeting of the High Energy Physics Advisory Panel, the Particle Physics Project Prioritization Panel, P5, made public its first set of priorities and recommendations. All three of the projects reviewed by P5 in its initial effort are Fermilab projects funded by the Department of Energy's Office of Science, elements of the roadmap, the list of major projects that define the experimental program for the field of U.S particle physics in the years ahead.

In the discussion of the roadmap, P5 updated the collective vision of the U.S. particle physics community for the scientific program at the end of the decade. This portfolio of major experiments will advance our understanding of nature in dramatic ways while the community is preparing for additional breakthroughs at a linear collider. The most important message for the Fermilab community is that our laboratory will have a central role in every sector of the U.S. particle physics program in 2010. The P5 report solidifies Fermilab's position in the American physics program beyond Run II. We will continue in our role at the center of particle physics in the U.S. throughout this decade and into the next.

Background
P5 was formed in January 2002 to advise the Department of Energy and the National Science Foundation on the roadmap for particle physics in the United States. They make recommendations on projects that have already received endorsement from the appropriate peer-review advisory body and are ready to move into a construction phase.

From the report:
"This report presents the first such evaluation, based on a request to review three projects ready for construction:
1. the CDF and D0 detector upgrades for Run IIB of the Tevatron Collider,
2. the BTeV experiment that would carry out very high sensitivity studies of the decays of B hadrons, and
3. the CKM experiment, which has as its primary goal the study of the very rare decay $K^+ \to \pi^+ \nu \nu$.
In this particular case, it happens that all three of these projects would be supported primarily by the Department of Energy at Fermilab. However, it is the charge of P5 to consider them in the broader context of the overall U.S. program. Given the responsibility of P5 to all of U.S. particle physics, it is anticipated that in the future this panel, or a subsequent panel, will also be asked to consider projects whose major funding would come from the National Science Foundation. Such projects would most naturally be brought to P5 after mail and/or special committee review, but before consideration by the National Science Board."

The Roadmap

The P5 report described the panel's vision of the roadmap for U.S. particle physics in the intermediate term, the period around the end of the current decade, as laid out in the The High-Energy Physics Advisory Panel Long Range Plan for U.S. high-energy physics in the 21st century. P5 divided the experiments into four major areas of particle physics:

1) Physics at the highest energy scale, including Higgs physics, supersymmetry, and extra dimensions.
2) Quark flavor physics, including searches for the effects of new physics in decays of strange and bottom quarks.
3) Particle astrophysics and cosmology, including cosmic rays and explorations of dark matter and dark energy.
4) Neutrino physics and lepton flavor physics, including the effort to understand neutrino masses and mixing.

From the report:

"In the intermediate term the roadmap includes projects either in construction or that could soon be in construction and that would provide an exciting physics program later in this decade. These include, by primary physics category in the roadmap:

1) The LHC, which will be the energy frontier program, with potential impact on all major goals of the field.
2) BTeV, potentially the best quark flavor physics experiment into the next decade. CKM and KOPIO, which will study CP violation in the kaon system. We provide our recommendations regarding BTeV and CKM later in this report.
3) SNAP, which could map the dark energy content of the universe as it evolved. Along with GLAST, Ice-Cube, Pierre Auger and dark matter searches, it would provide new capabilities for studies of the cosmos.
4) The NuMI-MINOS program, the first high statistics accelerator based neutrino experiment able to carefully measure neutrino oscillations.

There are also likely to be additional opportunities in the area of neutrino physics, based on the discoveries of the last few years. In the charged lepton sector, MECO will search for lepton flavor violation.

This program is diverse, addresses the primary physics goals of the field, and has important connections to other fields. It would provide training in physics for a generation of scientists later in the decade. To fund such a program would require incremental funding, particularly for the construction of SNAP, which would be an interagency project involving NASA."

Fermilab and the Roadmap

Fermilab has a role that is central to the U.S. program in each of the four areas.

1. **CMS** is one of the two large experiments that will be exploring physics at the the Large Hadron Collider **(LHC)** being built at CERN, which will be the world's highest energy collider. Fermilab is the host laboratory for **US-CMS**, the

collaboration of 600 physicists at U.S. institutions working on CMS, and for **US-LHC**, the contributions of U.S. laboratories to the construction and operation of the LHC accelerator.

2. **BTeV** will be installed in the C0 interaction region of the Tevatron collider. It will be the primary experimental facility operating at the Tevatron from 2009, the completion date for the CDF/D0 program, until at least 2012. **CKM** would operate using a kaon beam produced by protons from the Main Injector.
3. **Pierre Auger Observatory** is being built in Argentina to observe the highest-energy cosmic rays. The goal of the **Cryogenic Dark Matter Search (CDMS),** just starting operation in the Soudan mine, is to observe the cosmological dark matter directly. For each experiment, Fermilab manages the construction and operation for a broad collaboration supported by several funding agencies. Fermilab is an institutional member of the **Supernova Acceleration Probe (SNAP)**, for which LBNL is the host DOE laboratory. The collaboration is designing a next-generation observatory to probe the nature of dark energy, which would be a collaboration between DOE and NASA.
4. The **NuMI** neutrino beam will start operation late in 2004, delivering neutrinos produced with Main Injector protons to the **MINOS** experiment, which is already observing atmospheric neutrinos in the Soudan mine in northern Minnesota. Fermilab operates the Soudan laboratory in collaboration with the University of Minnesota for both the MINOS and CDMS experiments. Other neutrino experiments are being proposed for the NuMI beam line, including a large "off-axis" long-baseline experiment which would be built in northern Minnesota or possibly Canada.

What the P5 Report Said

Run II

The P5 report gave high priority to Run II:

"The Tevatron is the world's highest energy accelerator and, until the LHC produces physics, it will have an unparalleled opportunity to address the major questions in elementary particle physics."

"The Tevatron is the forefront facility in high-energy physics, not just nationally, but worldwide, and it will continue to be the forefront facility for most of this decade."

The P5 report supported the decisions made recently by Fermilab on the detector upgrades:

"P5 strongly supports the Fermilab management's decision that the silicon detector upgrades not be constructed."

"P5 strongly endorses the upgrades of the trigger, DAQ and offline systems."

BTeV

The P5 report confirmed the positive evaluation of the BTeV project given by Fermilab and its PAC. The panel said that the project should be started soon so that it is ready to

start regular physics operation in 2009. P5 also urged Fermilab to include in the project the construction of new magnets for the C0 interaction region (C0 optics) to enhance the luminosity for BTeV.

The P5 evaluation and recommendation:
"The P5 supports the construction of BTeV as an important project in the world-wide quark flavor physics area. Subject to constraints within HEP budget, we strongly recommend an earlier BTeV construction profile and enhanced C0 optics."

CKM
The P5 report confirmed the positive evaluation of the CKM project given by Fermilab and its PAC. They did not recommend proceeding toward a construction start on CKM, however, because of funding constraints.

The P5 evaluation:
"CKM is an elegant world-class experiment, which would be able to produce important physics results. However, the committee assigns it a lower priority than the BTeV experiment. The main reason is that BTeV has a much broader physics program at a comparable cost."

The P5 recommendation:
"Based on current budgetary models, P5 does not recommend proceeding with CKM."

Fermilab Director's Response
The P5 report confirmed my judgment that the prospects for discovery in Run II will remain brighter than anywhere else in particle physics until the LHC produces major new results. The continuous string of new results at the energy frontier, stretching from the Tevatron today into the next decade at the LHC, will lead the way to a revolution in our understanding of nature.

P5's strong and unambiguous endorsement of BTeV is a critical step in establishing a strong future for U.S. particle physics at the end of this decade. BTeV had already received the highest marks at every stage of technical review and has now been ranked very highly by the national panel established to set priorities for the field. I agree with the judgment of P5 that BTeV can be built on time under realistic budget assumptions. Working together with the BTeV collaboration and the DOE, we can get construction of BTeV started late in 2004 and completed by 2009.

P5 confirmed the strong evaluation of the CKM experiment reached by the Fermilab PAC. P5 said, however, that construction of CKM could not be started now because of funding prospects. I agree with this assessment, given current budget assumptions. This sets a standard for starting experiments that is higher than ever – and too high for the good of the field. Over the next year we will take a critical look at the possible experimental program for the future, in addition to the future flagship experiments for

neutrinos and B physics, MINOS and BTeV. We will consider CKM carefully in this process, since its importance and feasibility are already demonstrated.