Wednesday, February 26, 2003

Director's Review of the Status of Fermilab Fixed-Target Experiment Analyses

The committee was unanimously impressed with the physics output of the fixed target experiments at Fermilab. These collaborations have produced and continue to produce world-class results of fundamental importance to High Energy Physics. In general, the Fixed Target program at Fermilab is broad, deep, and extremely productive, collectively accounting for about one-third of all publications from U.S. HEP facilities over each of the last ten years. It is worth noting that many of these datasets are unique and will not be superseded in the foreseeable future. All of these experiments have completed data taking and are in various stages of finalizing analyses of these data. The committee strongly recommends providing the resources required to fully exploit these data samples.

Our review (see attached agenda) revealed a broad program exploring many aspects of fundamental importance in High Energy Physics. Some of these experiments are designed primarily to search for one particle or phenomenon (e.g. search for the τ neutrino or Re(ε'/ε)). Others are exploring a whole sector (e.g. charm physics) and dominate the relevant PDG section. These experiments have much higher sensitivities than their predecessors, and have pioneered innovative detector and data acquisition technologies, as well as large scale processing and analysis techniques. Many precision measurements are world class; some are better than the world average by themselves. Others offer intriguing and, as of now, not fully understood deviations from the Standard Model.

All of the experiments have made good use of the data they collected, and are at various stages of analyzing it. Some are at the peak of their analysis-publication cycle while others are closer to completion. The birds-eye view is truly impressive:

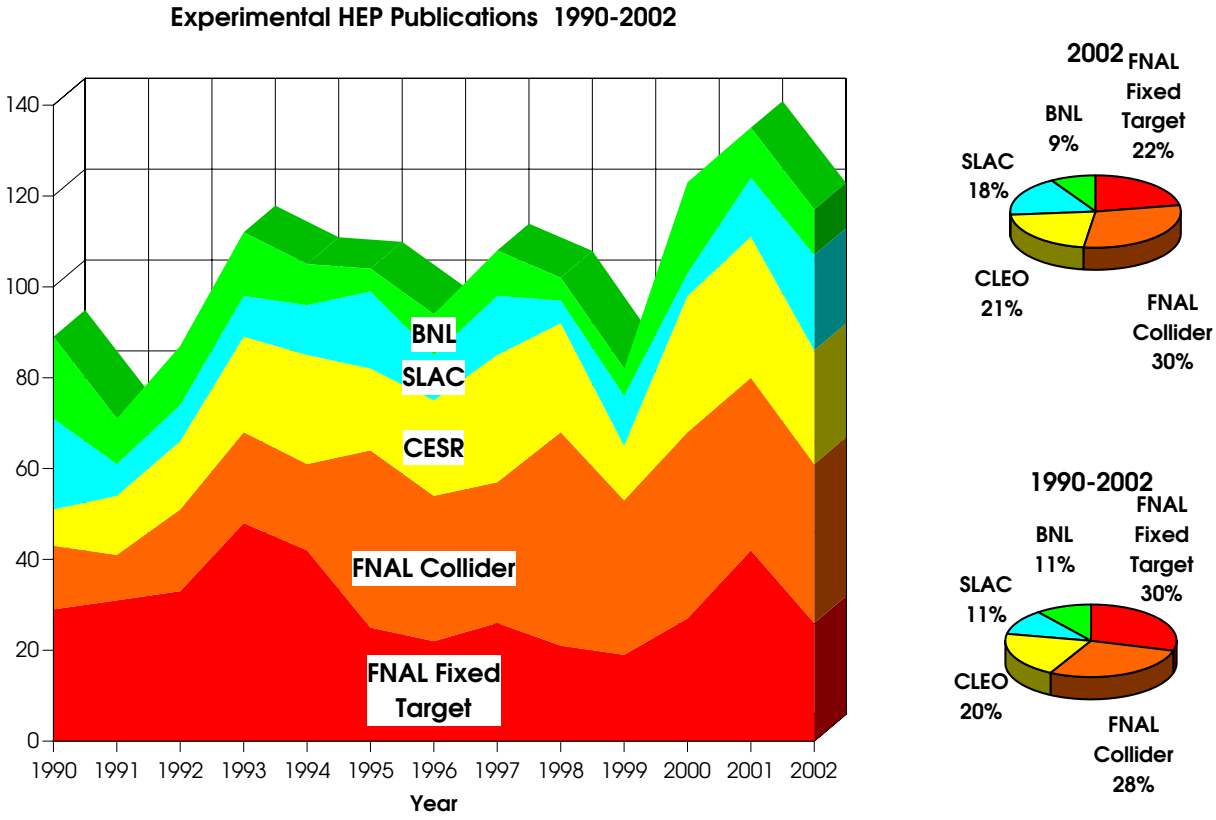
- 67 Masters & Laurea theses
- 95 PhD theses (expect additional 49)
- 129 Publications (expect additional 80-100)

For more details on individual experiments as well as comparisons with the rest of the field, see the attached figure and table.

Many of the datasets accumulated are unique and the committee would like to emphasize that the ongoing analyses are expected to yield additional interesting results over the next few years. It is important to think about preserving these data. This may require allocating resources for upgrading the storage media, and asking the groups involved to take some thought for long-term code maintenance and documentation of analysis procedures.

Several of the collaborations already have in place, and some have exercised, procedures for adding new collaborators for the purpose of increasing their analysis effort. This should be encouraged, as another way of ensuring that the physics legacy is preserved.

It is troublesome to hear that lack of resources may impede the ongoing effort to explore these data. They are the product of major investments on behalf of the funding agencies and the collaborations, and may contain additional valuable knowledge. It is irresponsible and shortsighted to artificially terminate the analysis of these data in favor of pursuing future projects (new-shiny-toy syndrome). The resources being requested are strikingly modest. Every effort should be made to allocate the necessary resources to ensure these investments are realized and the datasets fully exploited.



➔Data mining, color choices, and figures are courtesy of Peter Cooper.

Experiment Specific Comments

In the following section, we comment on the impact achieved or expected from each experiment's results, and also mention any issues that arose in the committee's mind regarding the experiment's status or needs.

NuTeV (E815)

This experiment is the culmination of the long-running neutrino program in Lab E. Its completed results include the measurement of the weak mixing angle away from the Z pole, which is of considerable interest since including this measurement in the global electroweak fit to the Standard Model lowers the confidence level substantially (from 14% to 1.7%), and the measurement of the di-muon production cross section, which is a useful addition to the suite of experimental constraints on PDFs. Both these measurements are possible only from this experiment. The determination of structure functions is still in progress – always the longest analysis from a neutrino scattering experiment. Its dataset represents the largest accumulation of neutrino scattering data with a high-energy beam.

DONUT (E872)

DONUT is one of the few experiments that can claim the distinction of being the first to observe one of the particles from the fundamental particle table: in this case, the ν_τ. Its emulsion detector represents one of the unique technologies in the Fixed Target program. The continuation of the scanning analysis through the two remaining, more difficult, topologies should expand the world's sample of identified ν_τ interactions by a factor of 2-4. The experiment confirms the existence of the ν_τ directly, at the correct Standard Model level (albeit with large statistical errors), and also sets a limit on the ν_τ magnetic moment, which would be an unambiguous indicator of new physics if observed to be non-zero.

HyperCP (E871)

This experiment has an extremely high-statistics data set of kaon and hyperon decays, including 300 x 10^6 polarized Ξ decays. They have preliminary results on the CP violation analysis that was the main focus of the proposal, and anticipate its completion this year. They have made the first observation of the decay $\Sigma^+ \rightarrow p\ \mu^+\mu^-$, and resolved a disagreement from previous experiments on the $K^\pm \rightarrow \pi^\pm\ \mu^+\mu^-$ branching ratio. They have a small number of active analyzers, and a very large dataset with a rather broad suite of possible analyses: CP violation searches, decay parameter measurements, and rare decay searches. Preserving this unrepeatable dataset with a second copy of the DSTs, on newer tape technology, is a modest request that we think should be supported. The time scale reported for analysis completion appears to be rather aggressive.

Charmonium Study (E835)

The experiment E835 has performed precision measurements of the masses and total widths of charmonium states with a precision of order 0.1 MeV, and in particular has the capability to produce and study spin-parity states inaccessible at e+e- colliders. The results published so far include detailed studies of the χ resonances, measurements of the branching ratios of the ψ', a search for the η' charmonium state, and a measurement of the magnetic form factor of the proton. On-going analyses include further charmonium spectroscopy studies related to the η, χ, and ψ' resonances, and various specific measurements such as the $\gamma\gamma$ branching ratios for η_c and χ_0. The support currently provided by the lab for this collaboration should be continued.

TPL Charm Studies (E791)

E791 finished taking data in 1992, and remains in this review by virtue of the fact that it is still producing interesting physics publications, more than ten years later. Its record is in fact the best illustration in the list of how to extract the maximum physics potential from a dataset by sustained and dedicated analysis effort. The experiment made important contributions to charm production and decay physics, as well as to new particle searches. One of the striking recent results is the identification of a broad isoscalar resonance, whose possible existence has been a long-standing puzzle, both from an experimental and theoretical perspective. Currently, partial wave analyses of scalar resonances are being performed, and studies of the branching ratios for the neutral D meson continue. The lab provides minimal support at this stage (office space for a visitor).

SELEX (E781)

The SELEX experiment (E781) was constructed to study production of charm hadrons with different beams, with expanded particle ID for the decays (using a RICH detector with multiparticle capability), and with good acceptance at large momentum transfer. Among the results obtained is the first measurement of a Cabibbo-suppressed decay of a charm baryon. Recently, the first observation of doubly-charmed baryon candidates has been made. Ongoing analyses include the study of isospin-singlet singly-charmed baryon decays, the production of the singly-charmed and doubly-strange baryons, and the systematics of charm hadroproduction from baryon and meson beams. The computing and office support provided by the lab is efficiently turned into robust scientific progress.

FOCUS (E831)

FOCUS completes the "suite" of FNAL experiments exploring charm physics and, in many regards, will dominate the world averages for charm decay parameters in the PDG. For example, their lifetime measurements by themselves, for both charmed mesons and baryons, are better than the current world averages. Their results have also substantially improved limits on D^0-mixing, where effects beyond the Standard Model may show themselves. Their dataset is of an impressive size and quality allowing them to explore charm decays with unprecedented precision. For example, they are the first experiment to

observe s-wave interference in the semileptonic decay of the D^+ to $K^-\pi^+\mu^+\nu$. The experiment's analysis efforts are in full stride, and while they have already published a wide and exciting array of physics results, it is expected that their rich data set will continue to yield interesting results for some while to come. The lab should help provide the necessary support from the computing division to ensure access to their data for the next several years. This may include providing backup disk space.

KTeV (E832)

This experiment is the culmination of a series of fixed target experiments at Fermilab and CERN whose principal goal was to observe direct CP violation in the K^0 system by measuring $Re(\varepsilon'/\varepsilon)$. This is an extremely challenging measurement. Their first result, using the first quarter of their data set, definitively established the existence of direct CP violation for the first time. The $Re(\varepsilon'/\varepsilon)$ parameter is now measured with a world average accuracy of about 10%. Their result from the full dataset is expected to be of comparable precision. They have additionally published results, which dominate world averages for kaon lifetimes and mass differences. Other notable results include their precise measurement of the semileptonic charge asymmetry in K^0_{e3} decays. They also have the possibility to improve the direct determination of $|V_{us}|$, which presently violates unitarity at the level of about three standard deviations. To reach the final precision on many of their measurements requires extreme attention to detail, which can only be efficiently achieved through a long, concerted effort. They are making steady and impressive progress and expect to finalize many of their results over the next few years. It is important for the lab to continue providing the necessary support from the computing division for KTeV hardware and PC farms as well as continued access to the data over this timescale.

KTeV (E799)

This experiment is the rare decay "sister" to E832, using the same experimental apparatus with some modifications and some dedicated beam time. It is a continuation of E799I, which itself was an upgrade of E832's predecessor, E731. Rare decays can be particularly sensitive probes of non-Standard Model physics since even small anomalous contributions can significantly affect the decay rate. As such, it is important to pursue experiments with ever increasing sensitivity to these decays. The E799 dataset corresponds to a total flux of about 6×10^{11} K_L decays, which affords sensitivity in the range of 10^{-10} for kaon decays – a significant improvement over previous experiments. They have already published results for a long list of rare K_L decays using the first half of these data. Their limits on K_L to $\pi^0e^+e^-$, $\pi^0\mu^+\mu^-$, and to the extremely challenging final state of $\pi^0\nu\nu$, are all at least an order of magnitude better than previous results. Their dataset includes over 5000 K_L to $\pi^+\pi^-e^+e^-$ decays, which had previously never been observed. This decay turns-out to be particularly interesting because it exhibits CP-violating T-odd asymmetries in its final state angular distributions. The data also include large numbers of hyperon decays. They are in the process of finalizing most of their results using the full dataset and expect to complete this over the next few years. They

will need continued support for their analysis cluster and access to the tape archive over this timescale.

Experiment	*Timescale*	*Longterm Uniqueness*	*Data Storage*	*Future Needs*	*Location in Lifecycle*	*Publications and Theses*
E815 - NuTeV	<2 years	Unique	Not very securely kept	None	Falling edge	Pubs. 12 (2) PhDs 7 (4)
E872 - DONUT	<2 years	Unique	Emulsion data on web	Travel funds	Falling edge	Pubs 5 (2?) PhDs 5 (2) Masters 7
E871 - HyperCP	<2 years	Unique	Single copy of full data in tapes	1 year of office space + PC farms + backup space	Peak	Pubs. 4(10) PhDs 4 (1) Masters 3
E835 - Charmonium	<2 years	Unique	Raw data on 8mm tape. Some Reco data in Enstore	Computing + video-conference	Falling edge	Pubs 8 (8?) PhDs 12 (5) Masters 18
E791 - TPL Charm	<1 year	Some overlap with Belle, Babar, Cleo C	Single copy of raw data exists (split 4 ways in US and Brazil)	One office	Falling edge	Pubs 35 (3?) PhDs 23 (2) Masters 7
E781 - SELEX	<2 years	Some overlap with Belle, Babar, Cleo C	On Enstore + 8mm tape	Office space + SGI computer support	Peak	Pubs 11 (6) PhDs 15 (5) Masters 3
E831 - FOCUS	>2 years	Some overlap with Belle, Babar, Cleo C	Full data set on disk @IU & 8mm tape @FNAL	Office and disk space + computers	Rising edge	Pubs 27 (30-40) PhDs 12 (14) Masters 29
E832 - KTeV	<2 years	Unique	On ~5000 DLTs @FNAL	PC farms	Peak	Pubs 9 (12?) PhDs 4 (8)
E799 - KTeV	<2 years	Unique	On ~5000 DLTs @FNAL	Archive data + computer support	Falling edge	Pubs 18 (8?) PhDs 13 (8?)

A Summary Table for the Fixed Target Experiments

Timescale – A very rough idea of the timescale to complete remaining analyses
Longterm Uniqueness – An idea of whether this dataset will soon be superseded or will remain unique for the foreseeable future
Data Storage – How securely is the data stored
Future Needs – A quick summary of the experiment's requests for support from Fermilab
Location in Lifecycle – Is the analysis process on the rising edge, peak or falling edge of the analysis activity curve
Publications – The total number of journal publications (including instrumental) and of PhD and masters theses awarded; numbers in parentheses are the experiments' estimate of the publications and theses still to come.

Review Agenda

8:45	Executive Session for Review Committee
9:00	Introduction - Mike Witherell
9:10	E815 - NuTeV (Donna Naples)
9:35	E872 - DONUT (Bruce Baller)
10:00	E871 - HyperCP (Kam-Biu Luk)
10:25	Coffee Break
10:40	E835 - Charmonium (Stephen Pordes)
11:05	E791 - TPL Charm (Milind Purohit)
11:30	E781 - SELEX (Jim Russ)
11:55	E831 - FOCUS (John Cumalat)
12:20	Lunch
1:20	E832 - KTeV (Ed Blucher)
1:45	E799 - KTeV (Tony Barker)
2:10	Executive Session
3:00	Review Close Out

Reviewers: Avi Yagil (Chair), Steve Brice, Bogdan Dobrescu, Doug Glenzinski, Wyatt Merritt