Particle Physics: CP Violation in Hyperon Decays

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Project Director: Michael J. Longo

The primary research activities under this grant were in E871 (Hyper*CP*) at Fermilab, a search for *CP* violation in hyperon decays which completed data taking in January, 2000. Hyper*CP* is an experiment designed to perform a sensitive search for direct *CP* violation in the decays of cascade (Ξ) and Λ hyperons by looking for an asymmetry between particle and antiparticle decay parameters. The experiment is expected to achieve a sensitivity $\approx 10^{-4}$ in the decay parameters. Standard model predictions for this *CP*-violating asymmetry range from 0.3 to 5 x 10^{-4}. A difference between the decay parameters for particle and antiparticle is direct evidence that *CP* symmetry is violated. A non-zero asymmetry would be the first evidence for *CP* violation outside of the K^0 system. Recent results from KTeV indicate a direct *CP* violation in K^0 decays, which suggests that *CP* violation will appear in other decays.

In addition, we will look at a number of rare hyperon decays involving muons. These probe important new physics topics such as Majorana neutrinos and lepton number violating processes. The latter are of great current interest because new evidence for neutrino oscillations indicate lepton flavor violation does occur. Our data will lead to an improvement in the limits on branching ratios for these processes typically by three to four orders-of-magnitude. The muon detector construction and data resulting from it have been the responsibility of the Michigan group. We are now leading the analysis of the rare muon-related decay modes, and were responsible for the muon system and beam monitor upgrades for the 1999 run.

The 1999 run began in June, 1999 and continued into January, 2000. We collected over twice as much data as we did in the 1997 run. The total data sample required approximately 30,000 Exabyte tapes. The data analysis is expected to continue for several years.

Our group currently consists of Principal Investigators M. J. Longo and H.R. Gustafson; postdoctoral scholar H. Park; and graduate student Alex Lehmann. H. Park is located at Fermilab and is working full-time on E871 analysis. Former graduate student Kael Hanson finished his thesis and took a postdoc position at the University of Pennsylvania.

Muon System and Beam Monitor Upgrades for 1999 Run

The Michigan group was responsible for the entire muon systems and, in addition, a new beam monitor that was installed for the 1999 run. The beam monitor consists of two scintillator hodoscope planes, one horizontal and one vertical with a total of 24 counters. This was designed by MJL, constructed mostly by an undergraduate, Josh Simon, and installed and tested by H.K. Park, HRG, and Alex Lehmann. This system has worked well.

A number of muon system upgrades were accomplished. These include:

- Separating horizontal and vertical muon hodoscope planes to decrease muon trigger rates.
- Installation of additional steel ahead of west side muon detector to reduce rates.

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- Changeover to "fast gas" for muon chambers (Ar-CH4-CF4)
- Changeover to "standard" readout electronics for muon system (the previous FEM electronics was no longer supported by Academia Sinica).

These upgrades went well, but the work and debugging turned out to be quite time-consuming.

TABLE 1. Summary of E-871 Runs

1997

Total Analysis Quality Tapes Vaulted = 9,376
Data Volume ~ 40 TB
Anti-Cascade Triggers on Tape: 24.5 Billion
Cascade Triggers on Tape: 15 Billion
Total Triggers on Tape: 63 Billion

1999

Total Analysis Quality Tapes Vaulted = 18,838
Data Volume ~ 71 TB
Anti-Cascade Triggers on Tape: 57 Billion
Cascade Triggers on Tape: 25 Billion
Total Triggers on Tape: 153 Billion