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RARE HYPERON AND KAON DECAYS FROM HYPERCP

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Over 120 terabytes of data were collected during the 1997 and 1999 runs of Fermilab E871 (HyperCP). From these data we expect to reconstruct more than 1 billion cascade hyperon decays, 100 million charged kaon decays, and 10 million omega hyperon decays. These data provide new sensitivity to lepton number violation in hyperon decays, and independent confirmation of the flavor changing neutral current decay of a charged kaon to a pion and two muons.

1. Introduction

We have recorded the world's largest sample of charged baryon decays, amounting to over 120 terabytes of data on tape. These data include over one billion fully reconstructable $\Xi^- \to \Lambda\pi^-$ decays, more than 100 million $\mathrm{K}^\pm \to \pi^\pm\pi^\pm\pi^\mp$ decays, and approximately 10 million $\Omega^- \to \Lambda\mathrm{K}^-$ decays. Though the main goal of HyperCP is the search for *CP* violation in the hyperon decays $\Xi^-(\overline{\Xi}^+) \to \Lambda(\overline{\Lambda})\pi^-(\pi^+)$, the large data-set makes it possible to perform a highly sensitive search for rare decay modes of hyperons and kaons.

Hyperons and kaons were produced by directing a beam of 800 GeV protons into a metal target. The secondaries were momentum selected by means of a 6 m curved magnetic channel set to 160 GeV/c with 25% FWHM momentum bite. After a 13 m evacuated decay pipe the decay products were detected in a high-rate magnetic spectrometer using small-pitch narrow-gap multiwire proportional chambers (MWPC's). There was also a muon detection system, consisting of proportional-tube planes interspersed with iron absorber, which provided sensitivity to rare decays with muons in the final state. Additional details can be found in the references.[1,2]

2. Search for Rare $|\Delta L| = 2$, $|\Delta S| = 2$ Decays

The conservation of total lepton number is not yet understood. New data[3] suggest that neutrino oscillations occur. If so, lepton family number is violated. It is therefore interesting to search as sensitively as possible for lepton-number-violating

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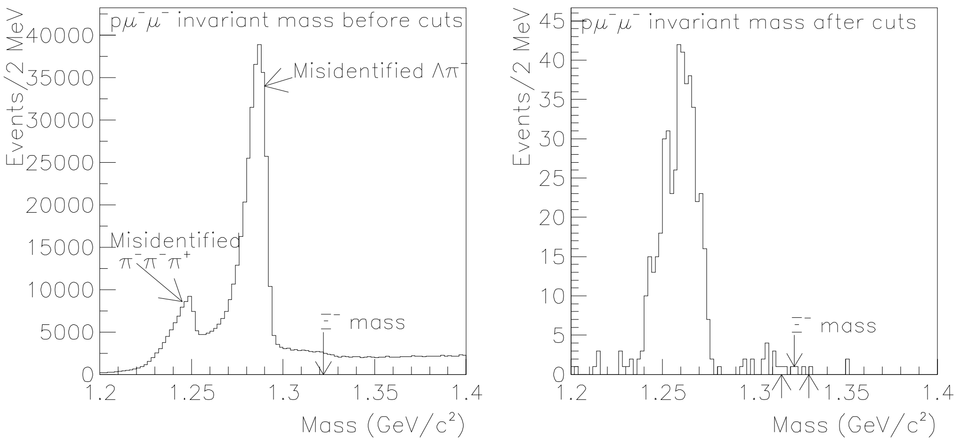

Fig. 1. Invariant mass distribution (assuming a p $\mu^-\mu^-$ final state) with muon identification (at left) and after selection criteria (at right).

processes. HyperCP has undertaken a search for the lepton-number-violating decay $\Xi^- \to p\mu^-\mu^-$ based on our 1997 data set. An observation of $|\Delta L| = 2$ decays could imply the existence of a Majorana-type neutrino. The current upper limit on the decay $\Xi^- \to p\mu^-\mu^-$ is $< 4 \times 10^{-4}$ at 90% CL.[4] We expect to improve upon this limit by a few orders of magnitude.

A particle track that produced hits in at least 2 of the 3 muon chambers in both the x and y views with corresponding in-time hits in the muon hodoscope is identified as a muon track. We have selected three-track events where both negatively charged tracks have been so identified. The total 3-track momentum must also be consistent with the momentum spread of the secondary beam. The invariant mass distribution (assuming a proton and dimuon final state) for these events is shown in Fig. 1. The dominant backgrounds are due to pion punch-through and $\pi^- \to \mu^-\nu_\mu$ in-flight decays from $\Xi^- \to \Lambda\pi^-$ and $K^- \to \pi^+\pi^-\pi^-$.

Figure 1 also shows the $p\mu^-\mu^-$ invariant mass distribution after application of kinematic and geometric selection criteria. We require the candidate tracks to originate from a common vertex within the vacuum decay region of the spectrometer. The combined 3-track momentum vector must extrapolate through the collimator and intersect the target region. The event must be inconsistent with both the $\Xi^- \to \Lambda\pi^-$ and $K^- \to \pi^+\pi^-\pi^-$ hypotheses. Furthermore, all 2-track combinations must be inconsistent with a $\Lambda \to p\pi^-$ hypothesis. We are left with a few events within the signal region, all consistent with background. A preliminary upper limit at 90% CL is < 5 signal events. After normalizing to the observed signal of $\Xi^- \to \Lambda^0\pi^-$ events and correcting for geometric acceptance and selection efficiencies, we obtain the preliminary upper limit $B(\Xi^- \to p\mu^-\mu^-) < 1.5 \times 10^{-7}$.

Table 1. Measured branching ratios for the decay $K^+ \to \pi^+\mu^+\mu^-$.

Source	Branching Fraction
BNL E787 [5]	$(5.0 \pm 1.0) \times 10^{-8}$
BNL E865 [6]	$(9.2 \pm 0.8) \times 10^{-8}$
PDG 2000 [4]	$(7.6 \pm 2.1) \times 10^{-8}$

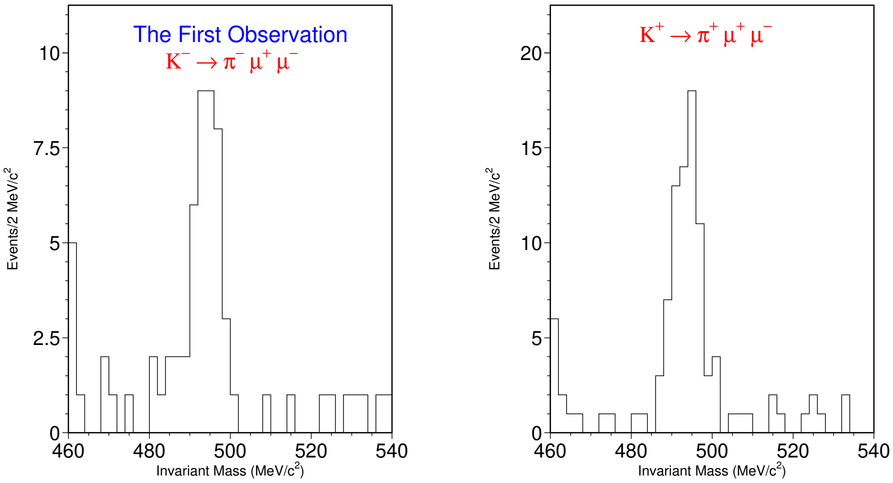

Fig. 2. Preliminary mass plots showing evidence for FCNC charged-K decays.

3. Observation of $\mathbf{K}^{\pm} \to \pi^{\pm}\mu^{\pm}\mu^{\mp}$

We have searched for Flavor Changing Neutral Current (FCNC) decays of charged kaons. Figure 2 shows our preliminary invariant-mass distributions. $K^+ \to \pi^+\mu^+\mu^-$ has previously been observed at Brookhaven;[5,6] however, this is the first observation of $K^- \to \pi^-\mu^+\mu^-$. The two previous measurements are shown in Table 1 along with the PDG 2000 value. The final HyperCP result will be competitive.

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