FERMILAB-EOI-1990-01 826

AN EXPRESSION OF INTEREST

TO CONTINUE HYPERON MEASUREMENTS

AT

FERMILAB

Submitted to the Fermilab Director's Office
October 8, 1990

K. Heller, University of Minnesota
K.Johns,University of Arizona
M. Longo, University of Michigan
R. Rameika, Fermilab

Hopefully, our upcoming experiment (E800) to make a precise measurement of the magnetic moment of the simplest accessible baryon, the Ω^-, will shed some light in this area.

Measurements of the weak decay parameters of the hyperons offer yet another avenue by which to investigate the strong interaction. Strong effects such as "penguin" diagrams dominate the detailed behavior. We have made precise measurements of non-leptonic decay parameters and shown that Fermilab is the ideal facility from which to launch a systematic attack on the weak radiative decays.[10] Generally the physics to be addressed in studies of hyperon decay and production is comparable in importance to that in studies of heavy quarks.

Hyperons are also a potential tool for the investigation of CP violation via the comparison of the weak decay asymmetry parameter to that of its anti-hyperon. In particular, the Ξ^- and Ξ^0 are potential candidates for this measurement.[11] One expects CP violation effects to be on the order of parts per thousand so that potential systematic errors must be under good control. To reach this goal of a new window on CP violation, it is important to maintain a continuously improving programmatic effort.

Such a program can be carried out in an era of large and complex fixed target "facilities" at Fermilab if one allows room for more than one approach to fundamental high energy physics research. Small experiments, focusing on well defined measurements, can uncover unexpected new physics using relatively simple spectrometers and quick and inexpensive reconfigurations. Bigger is not always better. The size and resources needed for a well supported experiment depend on the measurement to be made. Our basic spectrometer, although it is modified from experiment to experiment, is probably the smallest in the lab. At the same time, we have always been quick to develop or incorporate technical innovations so as to maximize our physics output. This group was a pioneer in the use of synchrotron radiation detectors for high energy electron identification[12] and were one of the early users of silicon microstrip detectors. For E-800 we have installed a high rate data acquisition system which utilizes modern techniques such as smart crate controllers, fast memories, and online processing with UNIX workstations. In fact, another of the many advantages of using a simple but flexible apparatus is that new ideas or technologies can be easily incorporated and tested under experimental conditions.

Finally, this type of experiment provides an ideal training ground for young physicists. Such experiments which can be set up, tested, run, and analyzed within the "lifetime" of a graduate student are rare. Our experiments have always stressed active, hands-on participation by graduate students allowing students a great deal of responsibility in the entire experimental process. Students gain hard-won experience and judgement to carry forward to their next endeavors. Our latest complete experiment, E-756, will produce 5 Ph.D's and the E-800 collaboration includes 4 fully involved graduate students.

THE PROGRAM

For the 1993 fixed target run we would like to propose to investigate directly two outstanding problems in the understanding the underlying mechanism(s) of high energy polarization due to the strong interaction. Both of these experiments would be carried out using a neutral beam. Since the anti-Ξ^- is polarized it is important to know whether the anti-Ξ^0 is also and whether the kinematic behavior of anti-hyperon polarization is really the same as that of the hyperons, specifically, the Λ and the Ξ^0. At the same time that we make this measurement, we would characterize the content and polarization of a high energy neutral beam produced by 800 GeV protons. The other outstanding question, which now has increased importance, is whether neutrons produced by high energy protons are polarized. This measurement has never been made because of the difficulty of measuring neutron polarization. We intend to exploit the work of E-704 and use a Primakoff polarimeter[13] to determine this. Both of these experiments require only modest rates of Tevatron energy protons on target and only modest changes in the E-800 spectrometer. If time allows we might also include a more precise measurement of the Σ^0/Λ transition moment.[14]

At this time we envision future work to include the exploitation of the high energy of the Tevatron to investigate the high p_T behavior of polarization as a test of perturbative QCD. Using Σ^+ hyperons, we can significantly increase the region probed by Λ measurements from about 4 to 6 GeV/c. We can also make a systematic study of the branching ratios and asymmetry parameters of the weak radiative decays, especially that of the Ω^- .In addition our continuing goal is a measurement of CP violation in hyperon decay.

THE QUESTION

This letter of intent has the purpose of asking whether Fermilab will support a physics program such as outlined above. From E-8 to E-800, 12 different experiments have been well supported by Fermilab with substantial physics results as a return. These experiments have had a high output of published results per physicist as well as contributing several "firsts" to the field. However, we see a trend for available targeting stations, including the one at which we have been running, to be occupied by complex and expensive spectrometers requiring large collaborations and considerable laboratory support to run. Other beamlines are busy with equipment tests for collider experiments. We are willing to work with the lab to find and adapt space to fit our modest requirements. We strongly believe we have an exciting physics program which attacks outstanding problems in high energy physics and has the potential to generate new ones. We need a reasonable assurance that there is the will and the resources to support this type of program at Fermilab.

REFERENCES

1. C. Y. Prescott et al., PL 77B, 347 (1978)
   C. Y. Prescott et al., PL 84B, 524 (1979)

2. J. Ashman et al., PL 206B, 364 (1988)

3. G. Bunce et al., PRL 36, 1113 (1976)
   K. Heller et al., PRL 41, 607 (1978)
   C. Wilkinson et al., PRL 46, 803 (1981)
   C. Ankenbrandt et al., PRL 51, 863 (1983)
   L. Deck et al., PR D28, 1 (1983)
   K. Heller et al., PRL 51, 2025 (1983)
   Y. W. Wah et al., PRL 55, 2551 (1985)
   R. Rameika et al., PR D33, 3172 (1986)
   B. Lundberg et al., PR D40, 3557 (1989)
   L. Trost et al., PR D40, 1703 (1989)

4. P. Kroll, High-Energy Spin Physics, Eighth International Symposium,
   K. Heller ed., AIP Conf. Proc. 187, V1, 48 (1989), and the references therein

5. K. Heller, 6th International Symposium on High Energy Spin Physics,
   J. Soffer ed., J. de Physique, C2, V46, 121 (1985), and the references therein.
   K. Heller, VII International Symposium on High Energy Spin Physics, Protvino (USSR), V1, 81 (1986), and the references therein

6. P. M. Ho et al., PRL 65, 1713 (1990)

7. See for example, T. DeGrand and H. Miettinen , PR D24, 2419 (1981)

8. B. L. Ioffe, Private communication

9. G. Bunce et al., PRL 36, 1113 (1976)
L. Schachinger et al., PRL 41, 1348 (1978)
G. Bunce et al., PL 86B, 386 (1979)
P. T. Cox et al., PRL 46, 877 (1981)
C. Ankenbrandt et al., PRL 51, 863 (1983)
L. Deck et al., PR D28, 1 (1983)
R. Rameika et al., PRL 52, 581 (1984)
Y. W. Wah et al., PRL 55, 2551 (1985)
G. Zapalac et al., PRL 57, 1526 (1986)
C. Wilkinson et al., PRL 58, 855 (1987)

10. S. Teige et al., PRL 63, 2717 (1989)
C. James et al., PRL 64, 843 (1990)

11. C. H. Albright , PRL 21, 1216 (1968)
M. Gronau, NCL 1, 209 (1969)

12. J. S. Dworkin et al., NIM A247, 412 (1986)

13. D. C. Carey et al., PRL 64, 357 (1990)

14. P. C. Petersen et al., PRL 57, 949 (1986)

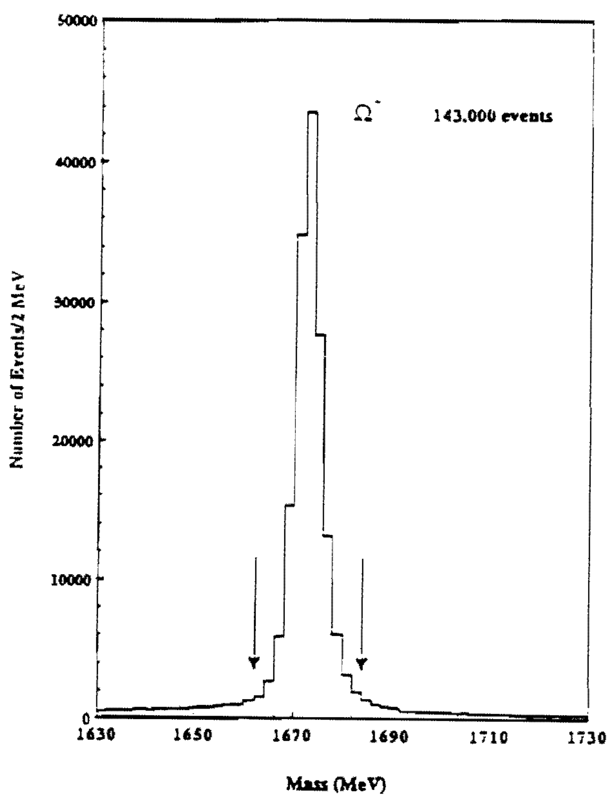


Fig. 1 . - A histogram of the Ω^- events as a function of the kinematic reconstruction of the $p\pi K$ mass . The $p\pi$ has been constrained to give the Λ mass.

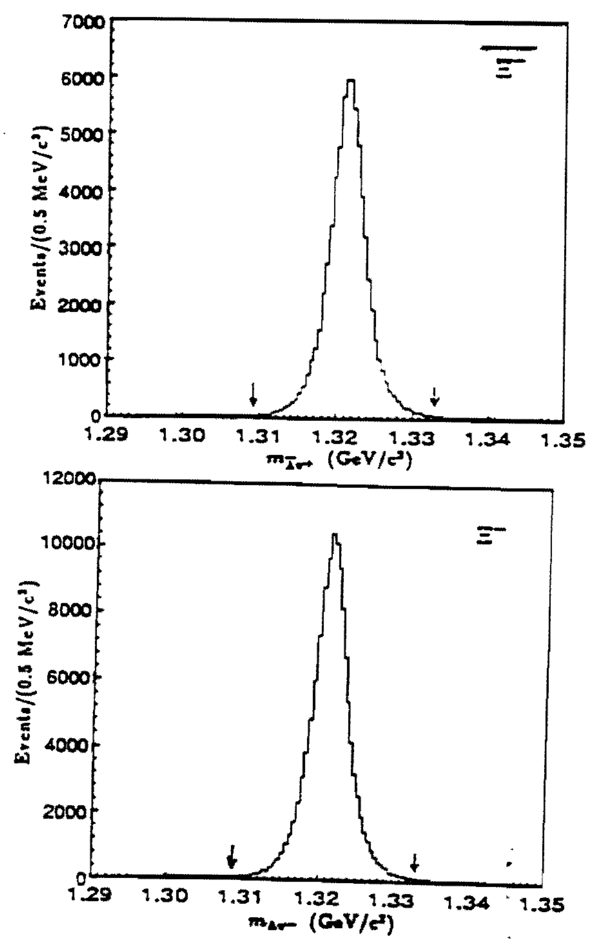
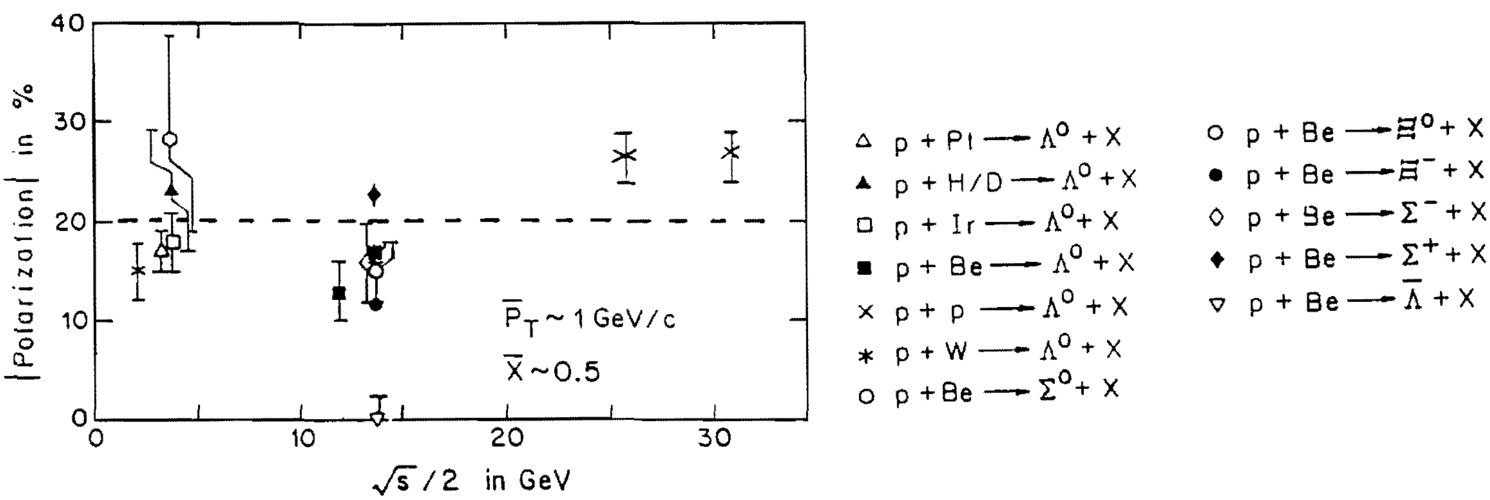


Fig. 2 - A histogram of the anti- Ξ^- events compared to a histogram of a subsample of the Ξ^- events as a function of the kinematic reconstruction of the $\bar{p}\,\pi^+\,\pi^+$ mass and the $p\,\pi^-\,\pi^-$ mass respectively. The $p\pi$ ($\bar{p}\pi^+$ has been constrained to give the Λ ($\bar{\Lambda}$) mass.



ig. 3 - Inclusive hyperon polarization magnitude as a function of collision energy for data ith p ~ 1 GeV/c and x ~ 0.5. The dashed line is drawn to provide a reference.

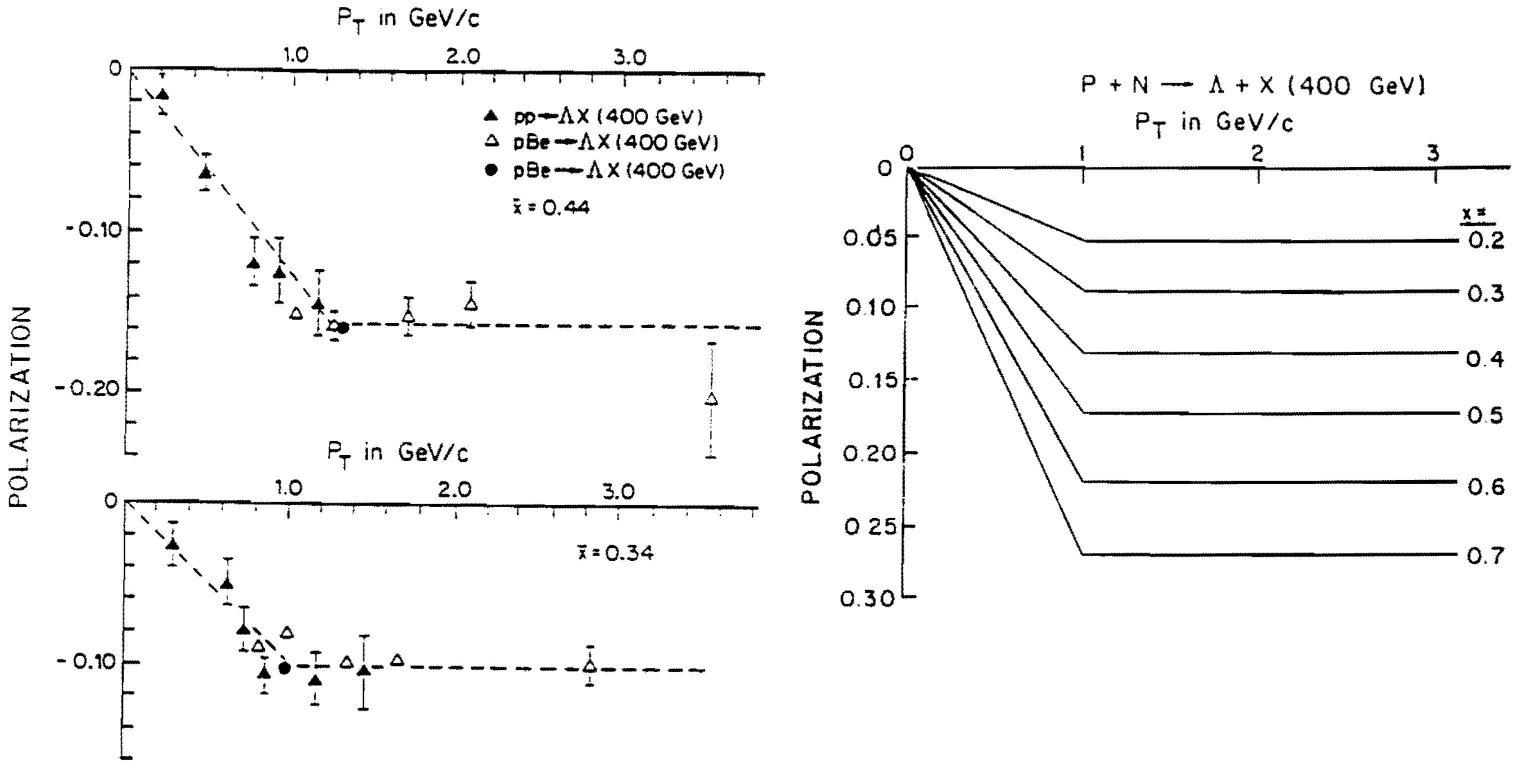


Fig. 4 - Polarization of Λ's produced by 400 GeV protons as a function of p_T for fixed x for two different values of x and a schematic consistent with all of the existing 400 GeV Λ data.

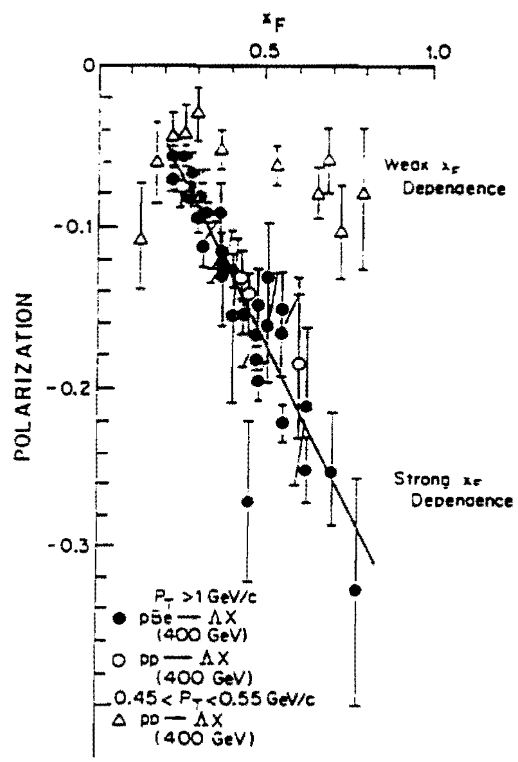


Fig. 5 - Polarization of Λ's produced by 400 GeV protons as a function of x for all p_T > 1 GeV/c. Also shown is lower p_T data ($p_T \approx 0.5$ GeV/c).