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ZGS Proposal

Measurement of Spin Rotation Parameters in Λ^0 Production at 12 GeV/c
Using the Polarized Proton Beam and the Effective Mass Spectrometer

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Measurement of Spin Rotation Parameters in Λ^0 Production at 12 GeV/c
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I. Summary

We propose to continue our study of the polarization properties of Λ^0 's produced in:

$$p + p \rightarrow \Lambda^0 + X$$

at the maximum ZGS energy of 12 GeV/c. Results from our recent 6 GeV/c experiment (E-336, submitted to PRL, see appendix) show some striking effects in the "induced" polarization ($P+P'$), the analyzing power ($P-P'$), and the depolarization parameter (D) for large values of the Feynman scaling variable X (Fig. 3(a), (b), (c) in appendix). We would like to study the behavior of these parameters at 12 GeV/c.

We request 50 shifts of polarized beam for data taking, during which we expect to obtain 45,000 usable Λ^0 events. This estimate is based on the following assumptions:

- 1 - Beam of 100K protons per pulse.
- 2 - ZGS repetition rate of 4.5 sec at 12 GeV/c.
- 3 - Flat-top of 700 msec.
- 4 - About 10% of our triggers will be used to acquire pp elastic scattering data, as a monitor of the beam polarization.

We request an additional 10 shifts for setup and tuning, for a total of 60 shifts.

The experiment requires the installation of the superconducting beam line (presently under design by the Accelerator Research Facilities Division) to bring the 12 GeV/c proton beam to the EMS.

II. Physics

For definitions of the spin rotation parameters, see the appendix.

A. Depolarization Parameter (D)

Theoretical expectations ^(1, 2) for the polarization of fast forward Λ^0 's coming from the fragmentation region of the beam in $p \uparrow p \rightarrow \Lambda^0 X$ have failed to match our 6 GeV/c data. The expectation was that forward Λ^0 's would to some degree "remember" the spin of the beam ($D \sim +1$). The data (Fig. 3(c) of appendix) shows that the D parameter for Λ^0 's is in fact negative for Feynman x near 1.0. The disagreement of our data with R. Field's prediction based on the triple-Regge formalism may not be surprising since 6 GeV/c is probably below the region of validity of triple-Regge arguments. Values of D between -.3 to -1.0 would result if most of the Λ^0 's at high x came from the decay of low-spin diffractively produced N^* 's. Data at 12 GeV/c would be useful in testing whether the effects predicted by the triple-Regge model become more prominent as the energy increases, and thus provide some clues as to the dominant mechanism at asymptotic energies.

B. Polarization and Analyzing Power

In inelastic processes like inclusive Λ^0 production the "induced" polarization is not required to be equal to the analyzing power ⁽¹⁾ as is the case for elastic scattering. The only previous observations of polarization-

analyzing power differences have been made in low energy nuclear reactions.⁽³⁾ Our data at 6 GeV/c represents the first observation of this inequality at high energy (Fig. 3(a), (b) of appendix). We believe that this effect merits further study at 12 GeV.

C. Polarized Hyperon Beam

We maintain our interest in polarized hyperon beams in view of the precise measurements that would be possible on the parameters of polarized Λ^0 -decay.⁽⁴⁾ This experiment will provide significant data for a feasibility study of using polarized protons to produce a polarized Λ^0 beam.

III. Experimental Method

We propose to use the Argonne Effective Mass Spectrometer in the same arrangement as in Experiment E-336 (see Fig. 1 of appendix). Two proportional chambers are inserted between the liquid hydrogen target and the first spectrometer wire spark chamber. These are used as multiplicity sensing hodoscopes to require two more charged particles at PWC2 than at PWC1, thus selecting Λ^0 's which decay between the two chambers. In the E-336 data, cuts on the quality and position of the production and decay vertices rejected $\sim 40\%$ of the Λ^0 's; however the surviving Λ^0 sample was very clean, with less than 1% background (see dashed histogram in Fig. 2 of the appendix).

The following considerations went into our rate calculations:

1. The inclusive Λ^0 production cross section is about a factor of two larger at 12 GeV/c than at 6 GeV/c (1.12 mb vs. 0.5 mb).⁽⁵⁾
2. The ZGS repetition rate is lower by a factor of two at 12 GeV/c than at 6 GeV/c.

3. The Λ^0 decay space will be 18", unchanged from E-336.
4. The overall acceptance for Λ^0 's is approximately a factor of two larger at 12 GeV/c than at 6 GeV/c. However the acceptance for Λ^0 's near $X = 1.0$ is only slightly better.

5. In E-336 we obtained 15,000 events in 35 shifts of production running. The above considerations give an event rate estimate for this experiment of $2(15,000/35) \approx 900$ events/shift, for a total of 45,000 events in 50 shifts.

The effective mass resolution (Fig. 2) was ≈ 1 MeV RMS at 6 GeV/c, and it will worsen to about 2 MeV at 12 GeV/c. This will have a negligible effect on our ability to identify $\Lambda^0 \rightarrow p\pi^-$ events. Backgrounds will remain small ($\sim 2\%$), though larger than for E-336.

We also expect about 1500 events of $p\bar{p} \rightarrow K_S^0 + X$ and about 1000 events of $p\bar{p} \rightarrow \Lambda^0 pK^+$.

IV. Data Analysis

We project that the experiment will produce ≈ 400 data tapes, which will contain 10% pp elastic triggers along with the inclusive Λ^0 triggers. The data analysis system exists and has already been used to process the 6 GeV/c data for E-336. Only minor software modifications will be necessary due to equipment changes in the EMS. The bulk of the computer analysis, namely the event reconstruction, will be done in parallel at Ohio State and at Argonne as it was for E-336. The physics analysis and the production of final summary tapes will be done with the Ohio State PDP-15 computer, using a few reduced tapes containing only good Λ^0 candidates. Since the analysis system will

require very little additional development, we anticipate being able to have results within six months after completion of the experimental run.

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