POLARIZATION and SPIN TRANSFER of Ω^- and Ξ^- HYPERONS at 800 GEV

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ABSTRACT

Fermilab experiment E756 has measured the polarization of W$^-$ hyperons produced by 800 GeV protons to be small compared to that of Ξ^- hyperons. When produced by a neutral beam containing polarized Λ and Ξ^0 hyperons, both the Ω^- and the Ξ^- have a significant polarization indicating a large spin transfer at high energies.

We report here preliminary results of Fermilab experiment E756 from the just completed fixed target run. The primary goal of E756 is to make the first measurement of the 8$^-$ magnetic moment. The Ω is the simplest of the "stable" baryons having 3 strange valence quarks with parallel spins. We hope this measurement will clarify the origin of the apparent inconsistency among the magnetic moments of the octet baryons.[1]

In order to measure the Ω magnetic moment using the precession technique, one needs to produce a polarized sample of Ωs. The standard technique is to produce the polarized sample at a p_T of about 1 GeV/c using a proton beam. This is the technique we have used for Λ, Ξ^0, Ξ^-, Σ^+, and Σ^- hyperons[2]. If the Ωs produced by protons were not polarized, we were prepared to attempt to produce a polarized sample by first producing polarized Λ's and Ξ^0's using protons and then producing polarized Ω's by spin transfer from the polarized neutral beam.

In order to produce a polarized Ω from a proton, the Ω must "remember" that it is a fragment of the incident proton to give the necessary correlation between production angle and polarization. One could imagine the Ω being produced by sequentially substituting one valence s quark at a time for the light valence quarks in a proton. We know that the Ξ's produced by protons (2 new valence s quarks) have approximately the same polarization as Λ's produced by protons (1 new valence s quark) On the other hand, one could argue that, since the Ω has no valence quarks in common with the incident proton, it carries no information about the proton spin direction and hence cannot be polarized. $\bar{\Lambda}$'s (3 new valence quarks) produced by protons are not polarized.[3]

Because it was easiest, we began by measuring the polarization of Ω's produced at 2.5 mrad by 800 GeV protons. We used the same basic spectrometer that has served us well since E8.[4] This apparatus, shown in Figure 4, also accepted Ξ^- events. The spectrometer was supplemented by 8 planes of 100μm pitch silicon strip detectors for tracking the Ω (Ξ^-) before it decayed into a ΛK^- ($\Lambda\pi^-$). At this time we have analyzed roughly 60% of our Ω data using a prelinary version of our reconstruction program. The 60,000 events in that sample are shown in Figure 2 (ΩK mass) and Figure 3 (Ω momentum). The signal is very clean with very little background under the mass peak. The sample peaks at a value of x_F greater that 0.5 and p_T greater than 1.0 GeV/c. This is the kinematic region where the polarizations of other hyperons were on the order of 20%.

From our 1987 run we will obtain 100,000 Ωs and 8 million Ξ^- events with an average momentum of 400 GeV/c, x_F of 0.5, and p_T of 1 GeV/c. Our detected Ξ^-/Ω^- ratio was about 80, giving us a yield of 5 Ω's and 400 Ξ's per 20 second spill of 2.5 x 10^{10} protons on a 1/4 interaction length Be target. Figure 4 shows our measured polarizations from about 10% of the Ξ^- data; the data agree well with our previously measured polarizations with 400 GeV protons from E620. The same figure also shows that the polarization of Ω's is small if not zero.

When our early data indicated that Ω's produced by protons were not sufficiently polarized, we reconfigured the targeting area to try the spin transfer technique. A 6 m sweeping magnet (B2) with a field of 1.8 T was added just upstream of our target. Inside the sweeping magnet was a collimator with a 3 mm x 3 mm limiting aperture to define a neutral beam. A 1 interaction length Cu target was just upstream of this sweeping magnet. The 800 GeV protons interacted in the copper target producing a neutral beam at 2 mrad. The neutral beam then interacted in a second copper target, also 1 interaction length, at 0 mrad to produce Ω's and Ξ's as shown in Figure 5. Scaling from our previous 400 GeV data, with 5x1011 protons on the upstream target. We expected a neutral beam consisting of 3x108 γ's, 2x10^8 n's, 5x10^7 polarized Λ's, 2x10^7 K0s, and 1x10^6 polarized Ξ^0s to be incident on the downstream target.[5] After interacting in the downstream target we estimated that the numbers of Ω's produced by n, Λ, and Ξ^0 would be in the ratio of 1:3:5, with those produced by γ and K^0 much smaller. In other words, we expected about 90% of the Ω's to be produced by polarized Λ's and Ξ's in the neutral beam.

Again the Ω sample has very little background (Figure 6). We obtained 20,000 Ω's and 1.5 million Ξ's with an average momentum of about 300 GeV/c from this part of E756. The ratio of Ξ^-/Ω detected was roughly the same as for proton production with a yield of 0.8 Ω and 50 Ξ^- per 20 second spill of 6x10^{11} protons. The polarization of the resulting sample is shown in Figure 7. About 15% of the Ξ data has been analyzed for this figure. It is clear that we have produced a neutral beam of polarized s quarks, and that there has been a large spin transfer to both the Ω's and the Ξ's.

In conclusion, we have found that the polarization of Ω's produced by protons at high energy is much smaller than that of other hyperons. We have produced a secondary polarized neutral beam which we have then used to produce a tertiary polarized charged hyperon beam. The spin transfer is large both to Ω's and to Ξ^-'s from a polarized neutral beam. This technique of "quark splicing" gives an inexpensive way to make polarized baryons at high energies. A very preliminary analysis of our data gives the Ω^- magnetic moment to be -2.0 ± 0.2 n.m. Our goal for the next run is to improve the precision to 0.03 n.m.

A high energy experiment is a team effort and there are many people who contributed to the success of this one. We would especially like to thank the many people at Fermilab, both management and staff, who helped us change from a polarization to a spin transfer experiment with a minimal loss of data taking time.

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REFERENCES

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5. A. Beretvas et al, PR D35 , 53 (1986).

FIGURE CAPTIONS

FIGURE 1. E756 apparatus.

FIGURE 2. Reconstructed mass of detected ΛK- showing the Ωs produced by protons.

FIGURE 3. Momentum spectrum of Ωs produced by protons and detected by the apparatus.

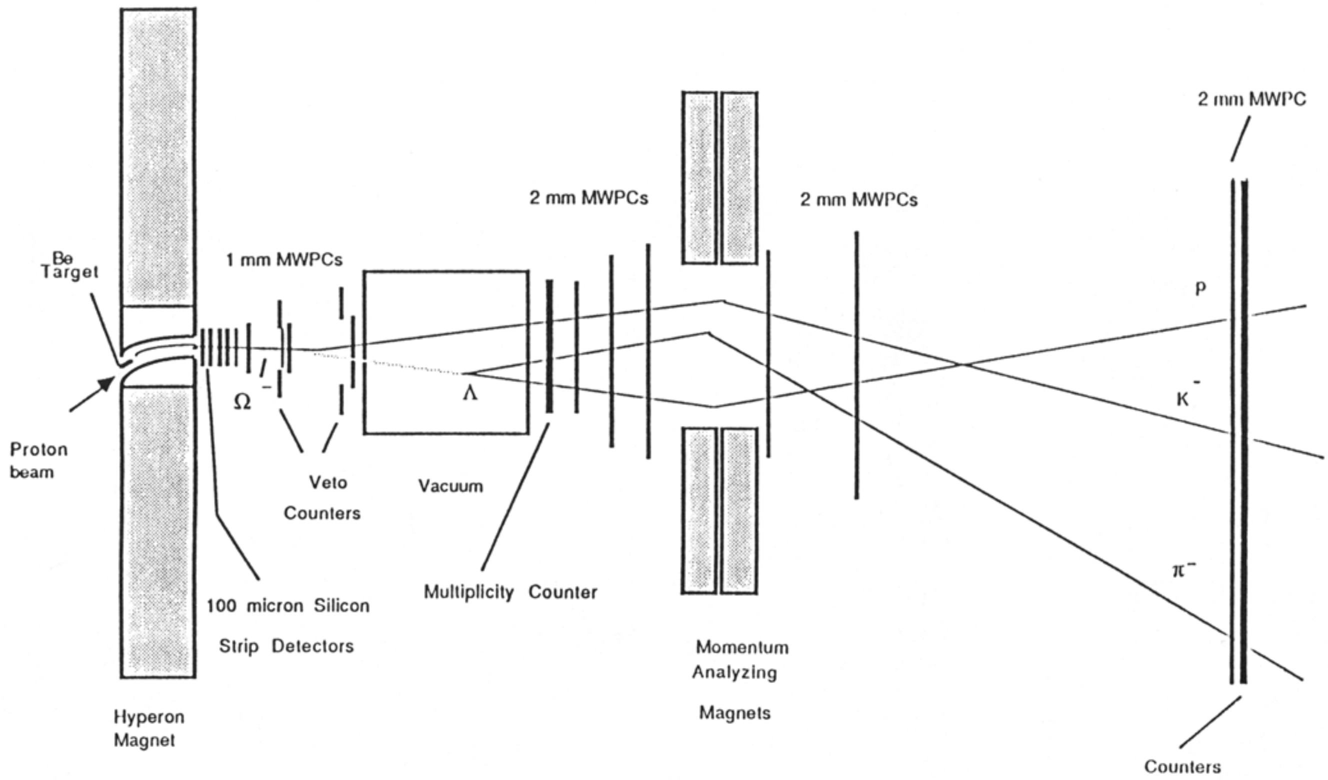
FIGURE 4. Polarization of Ξ^- and Ω produced by protons in E756 compared with previous 400 GeV results.

FIGURE 5. Upstream target area of E756 for producing a tertiary negative beam from a secondary neutral beam. The two targets and the neutral and charged collimaters are shown.

FIGURE 6. Reconstructed mass of detected $\Lambda\pi^-$ and ΛK^- showing the Ξ^- and Ωs produced by the neutral beam.

FIGURE 7. Polarization due to spin transfer of the Ξ^- and Ωs produced by the neutral beam at 0 mrad.

FIGURE 8. Momentum spectrum of Ws produced by the neutral beam and detected by the apparatus.



Plan View of E756 Spectrometer (not to scale)

FIGURE 1. E756 Apparatus.

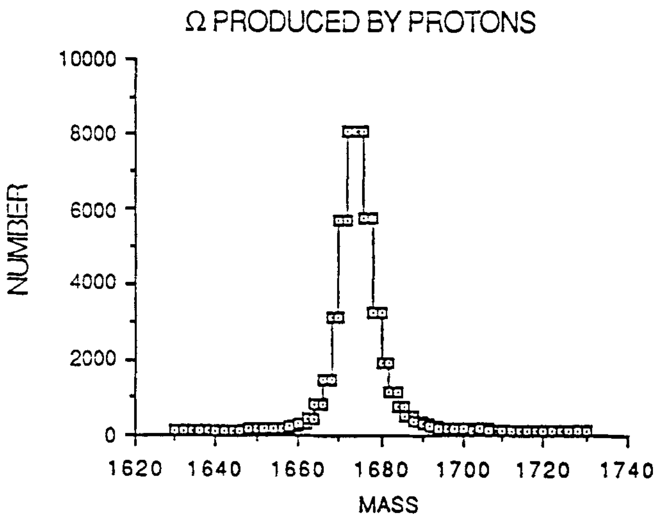


FIGURE 2. Reconstructed mass for Ξ^- on left and Ω^- on right. (produced by protons).

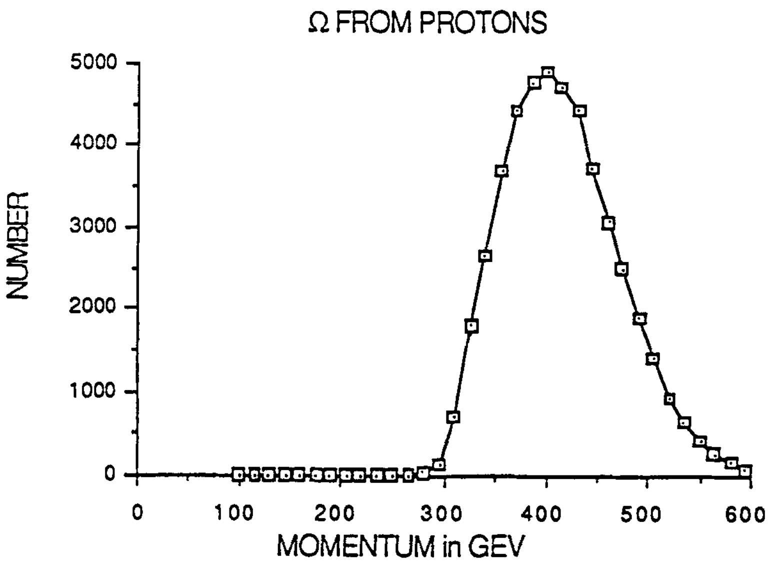


FIGURE 3. Momentum spectrum of Ω's produced by protons and detected by the apparatus.

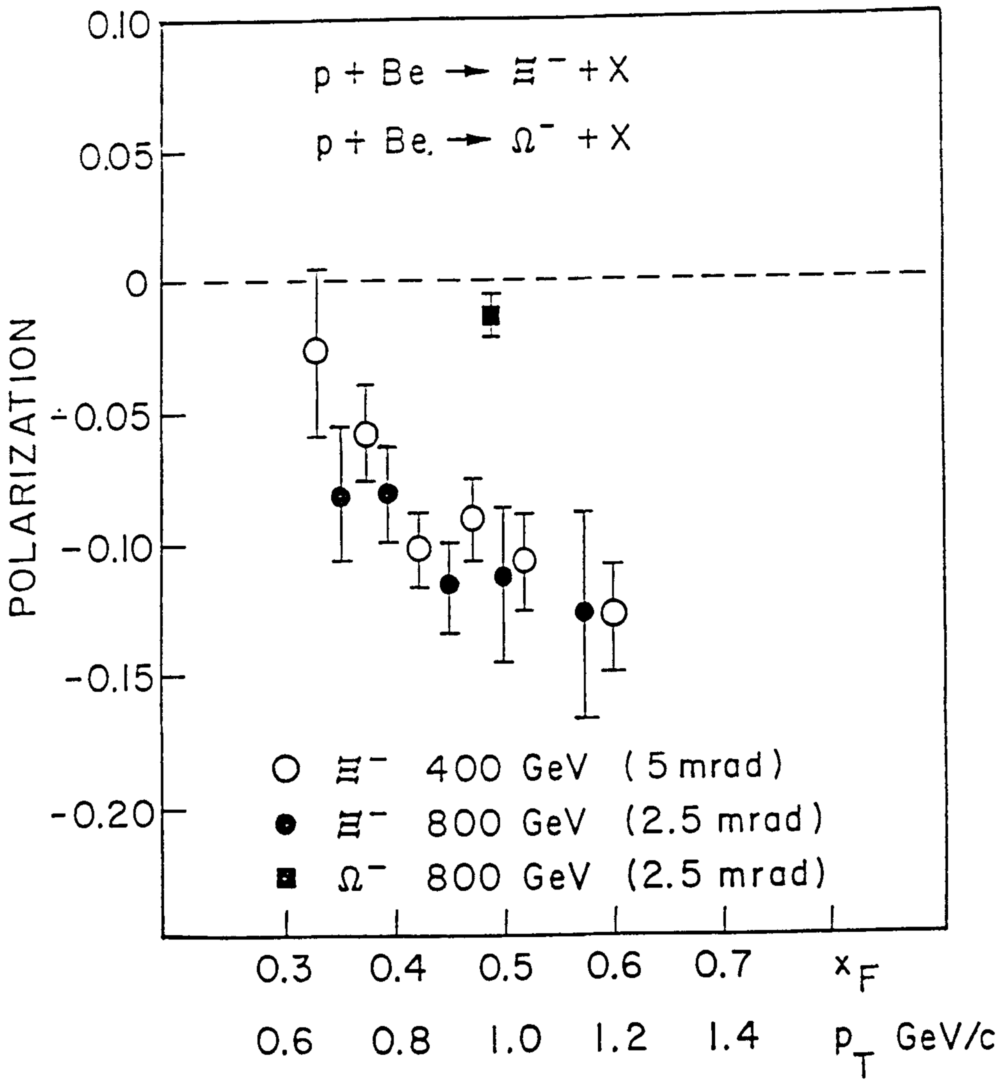


Figure 4. Polarization of Ξ^- and Ω produced by protons in E756 compared with previous 400 GeV results.

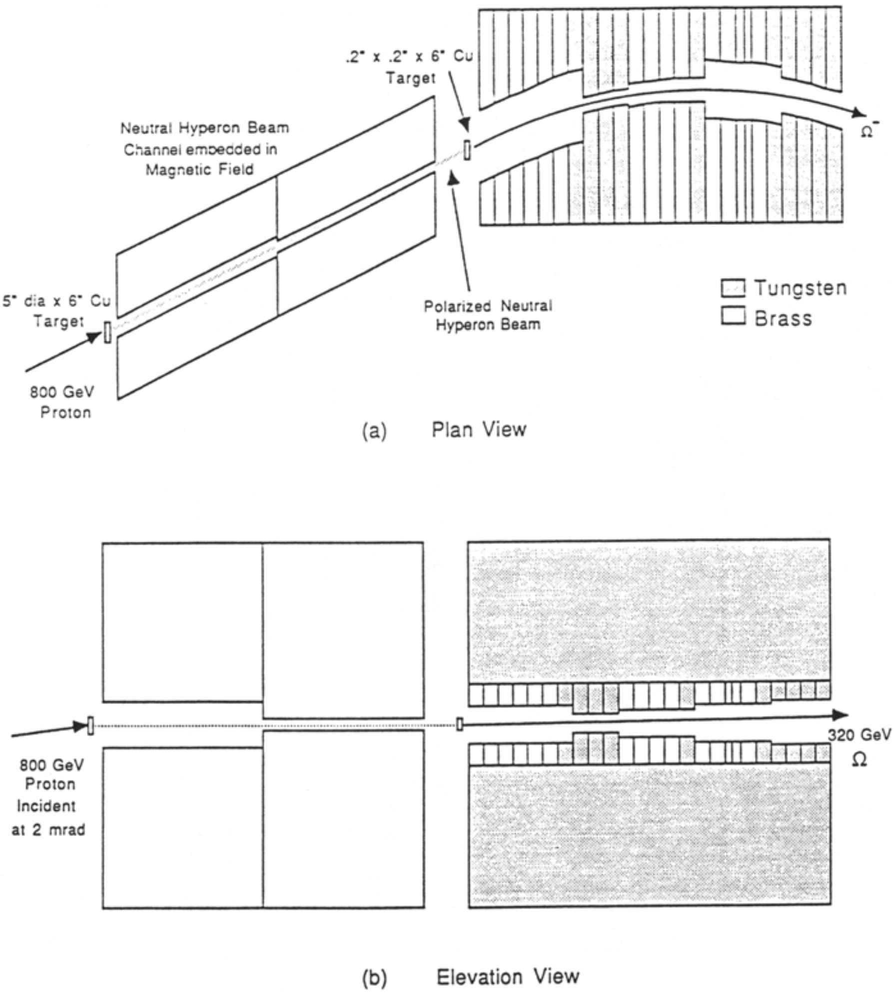
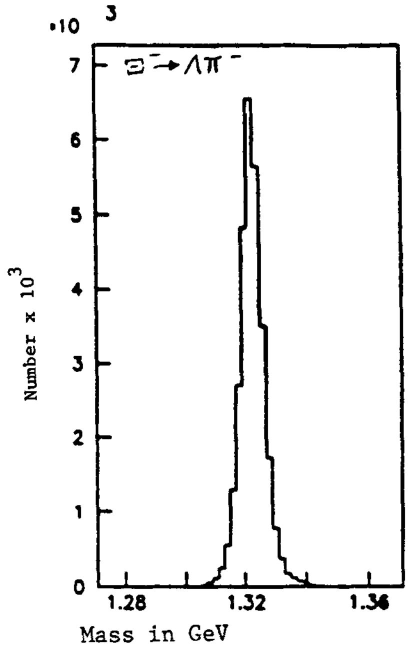


FIGURE 5. Upstream target area of E756 for producing a tertiary negative beam from a secondary neutral beam. The two targets and the neutral and charged collimaters are shown.


•10 3
Ξ⁻→Λπ⁻
Number x 10^3
7
6
5
4
3
2
1
0
1.28
1.32
1.36
Mass in GeV

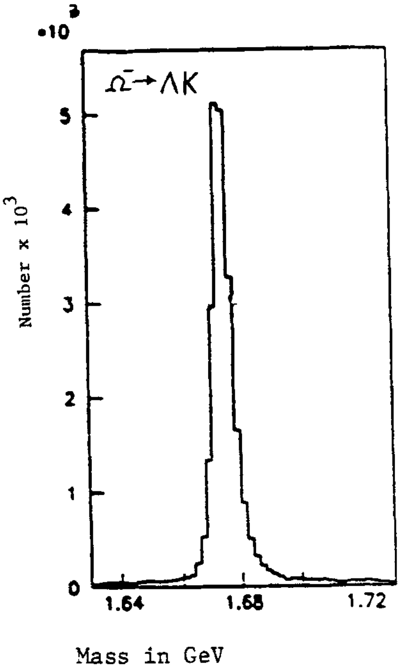

•10 3
Ω⁻→ΛK
Number x 10^3
5
4
3
2
1
0
1.64
1.68
1.72
Mass in GeV

FIGURE 6.

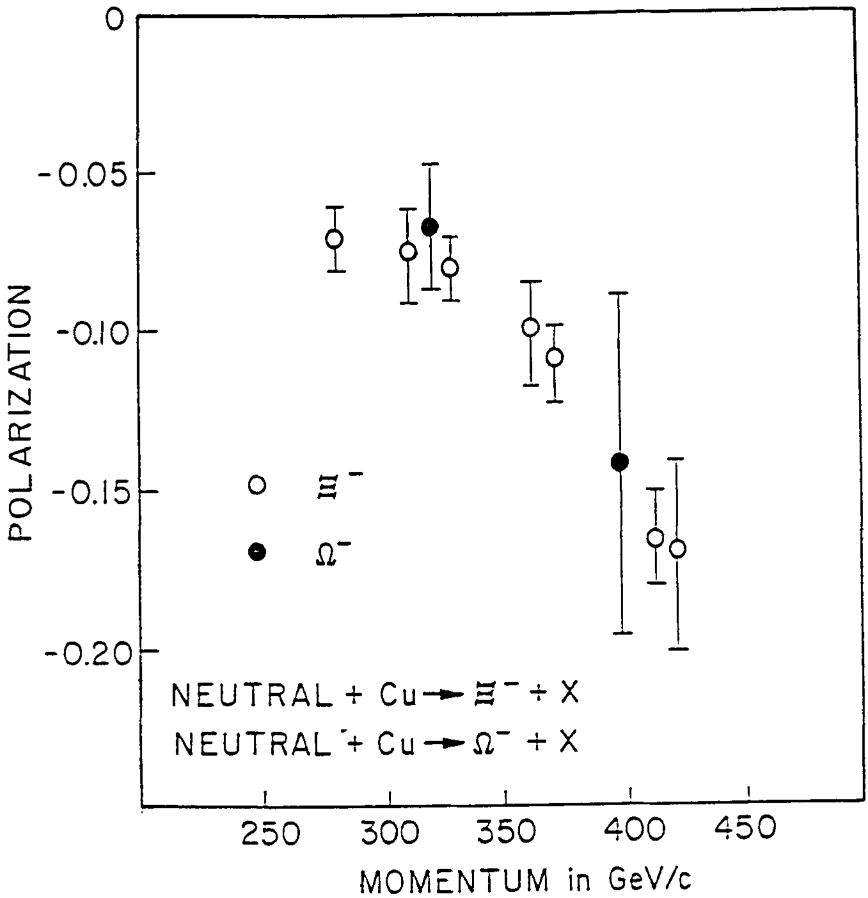


FIGURE 7. Polarization due to spin transfer of the Ξ^-s and Ωs produced by the neutral beam at 0 mrad.