

Two Polarization Studies

- Σ^+ Production Polarization
by 800 GeV Protons on Cu
and Be Targets

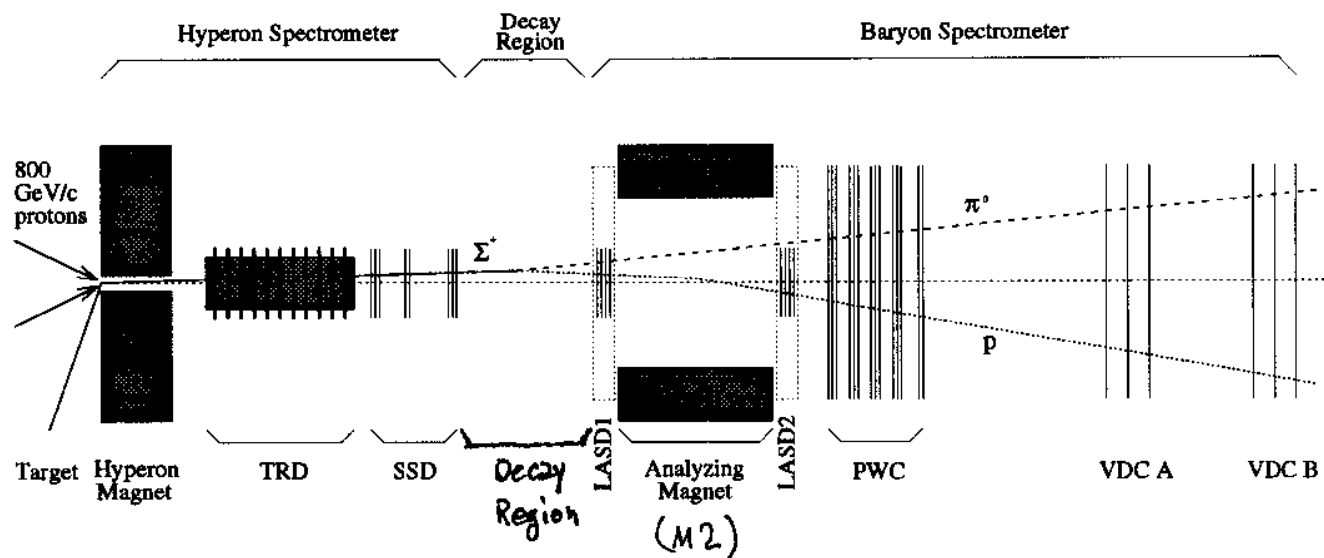
by
P. Pogodin
E. McCliment
& E781 Collaboration

- Polarization of Inclusively
Produced Λ^0 's by 600 GeV/c
 Σ^- on Cu and Carbon Targets

by
K. D. Nelson
E. McCliment
& E781 Collaboration

$$p(800 \text{ GeV}) + A \rightarrow \Sigma^+ + X$$

- Apparatus
- Data Selection
- Results
- Conclusion



Data Selection

TRD < 5 clusters (Remove Pions)

No reconst. Σ^+ segment

No reconst. proton segment

Vertex distance of closest approach

Y kink angle (to reduce proton background)

$\Rightarrow$ 2.2% Good Events

Further Refinements

$\theta > 0.2$ mrad (Eliminate proton background)

$0.64 < R < 0.88$ (Range for $\Sigma^+ \rightarrow p \pi^0$ decay)

$1.154 < m_\Sigma < 1.224$

$80 \text{ cm} < z_{\text{decay}} < 610 \text{ cm}$

Beam phase space

Loss 44.7%

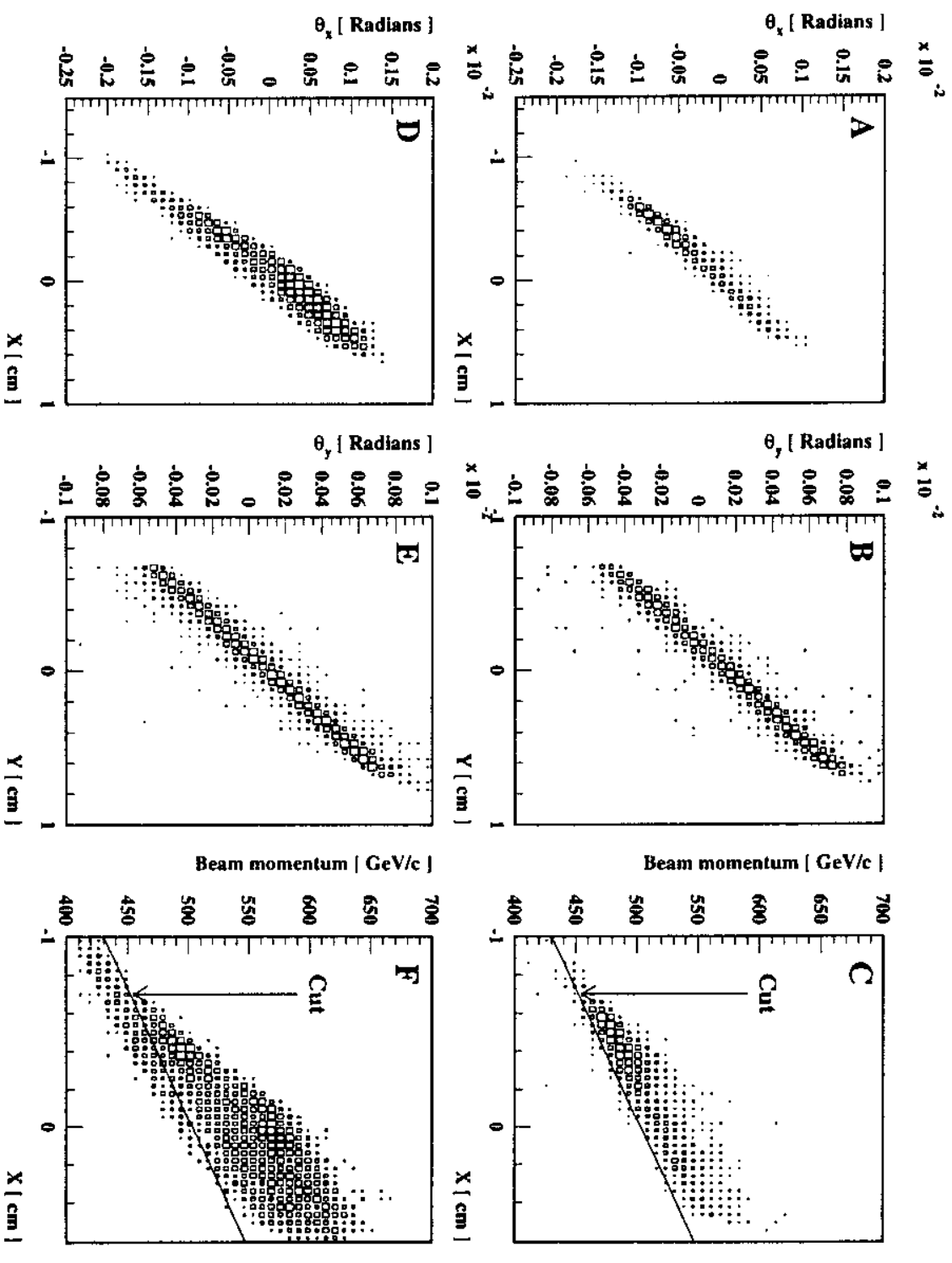


Figure 29: The phase space locations of the beam components with +4 mrad and -4 mrad targeting angles and beam momentum 572 GeV/c. Plots (A-C) correspond to +4 mrad primary beam targeting angle, Plots (D-F) to -4 mrad. Plots (A) and (D) show x_{Σ^+} vs. $\theta_{x\Sigma^+}$ distributions, Plots (B) and (E) show y_{Σ^+} vs. $\theta_{y\Sigma^+}$ distributions, and Plots (C) and (F) show p_{Σ^+} vs. x_{Σ^+} distributions.

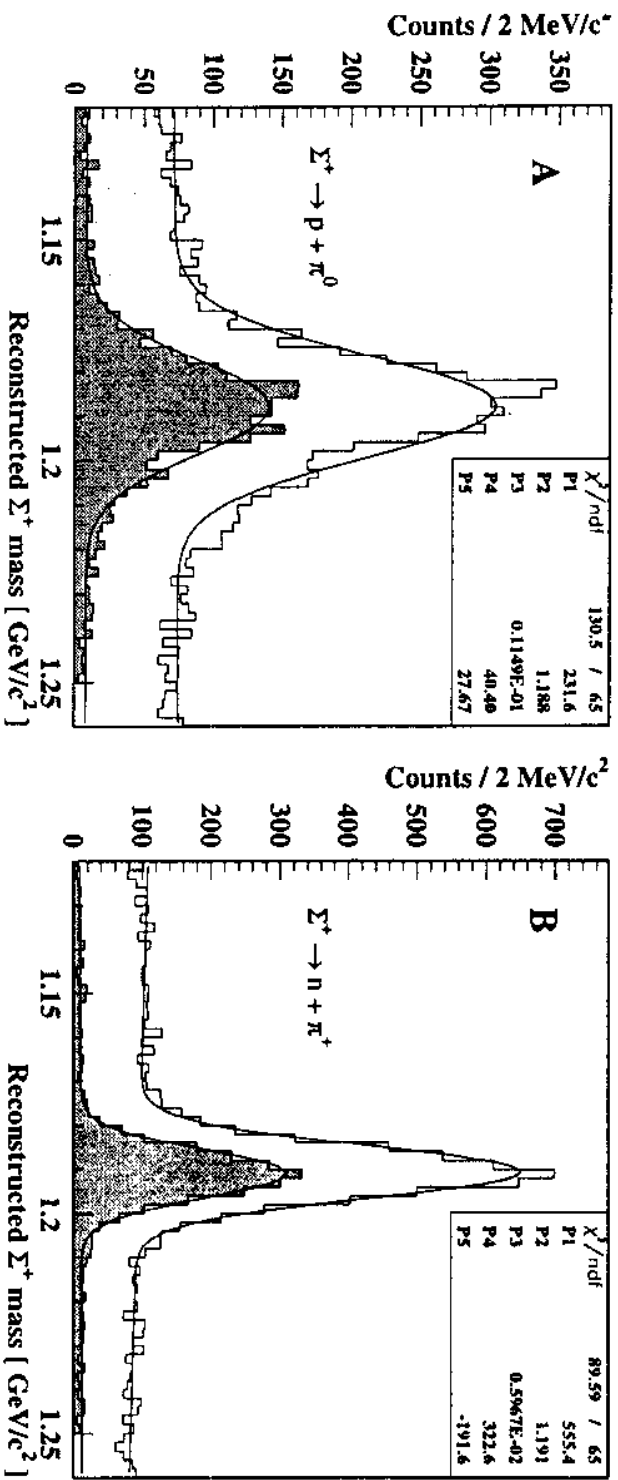


Figure 26: Σ^+ mass distributions calculated from the $\Sigma^+ \rightarrow p\pi^0$ decay (Plot (A)) and $\Sigma^+ \rightarrow n\pi^+$ decay (Plot (B)) (upper histograms). The lower histograms corresponds to the same mass distributions, but after selection cuts were imposed. Fit parameters P2 and P3 represent the center and the width of the Gaussian fit to the Σ^+ mass distribution, respectively.

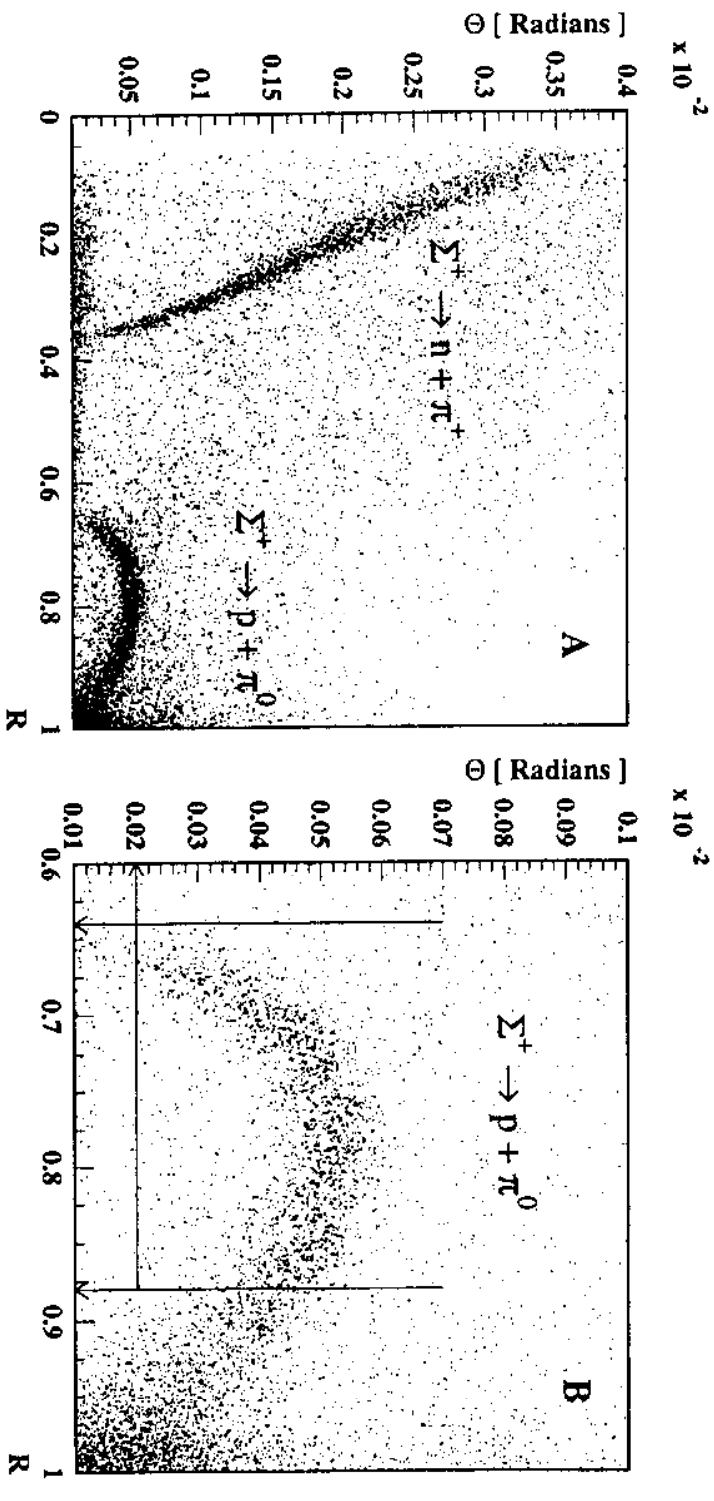


Figure 24: R vs. θ kinematic plot of the Σ^+ decay modes. Plot (A) shows both $\Sigma^+ \rightarrow p\pi^0$ and $\Sigma^+ \rightarrow n\pi^+$ decay modes. Plot (B) provides a closer view of the $\Sigma^+ \rightarrow p\pi^0$ region. $R = p_B/p_{\Sigma^+}$. θ is the decay angle.

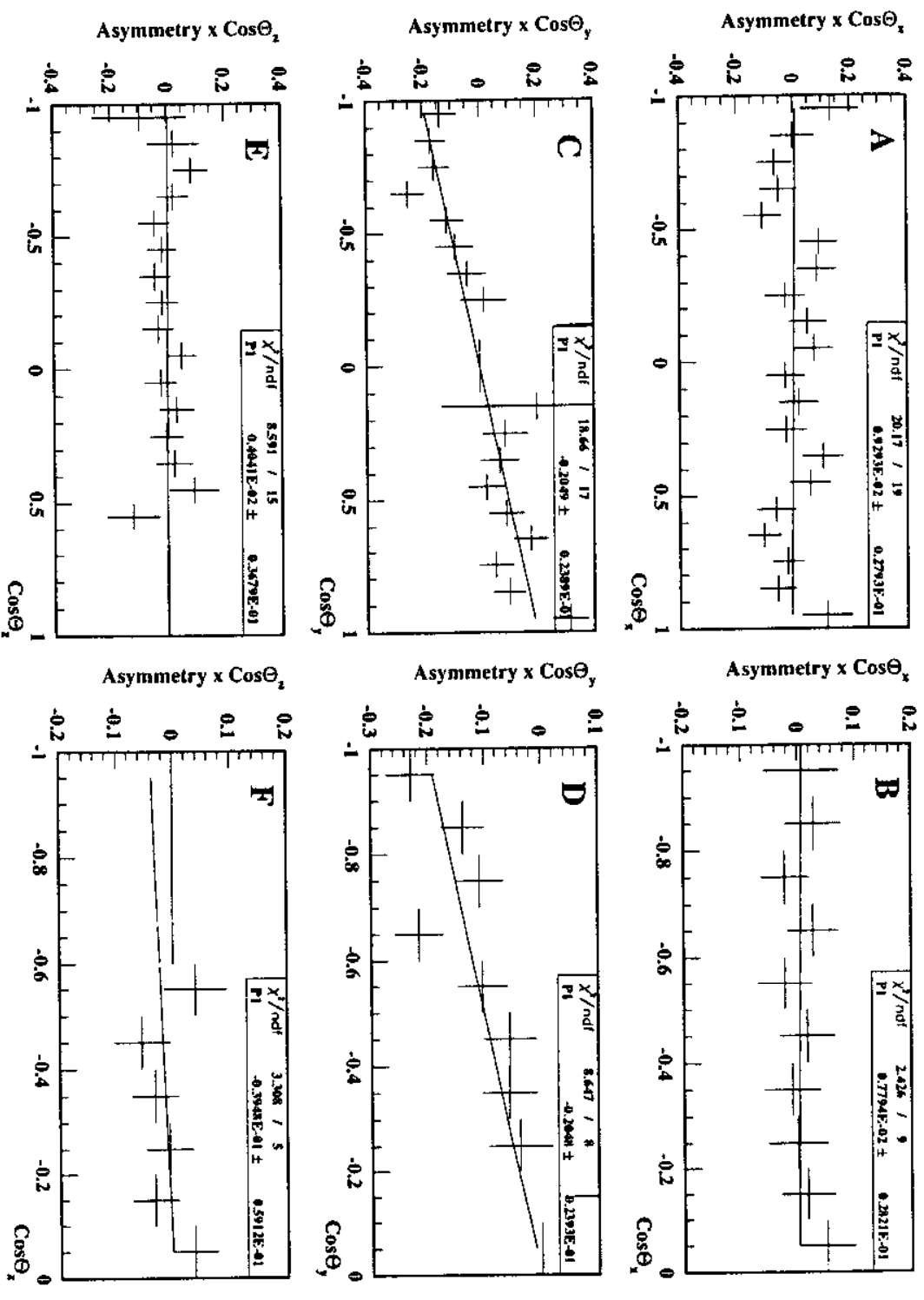


Figure 31: Asymmetries with respect to the cosines of the Σ^+ decay angles (proton angle) $\cos\Theta_x$, $\cos\Theta_y$, and $\cos\Theta_z$ in the center of mass frame of the decaying hyperon. Shon distributions correspond to Σ^+ momentum of 572 GeV/c. Plots (A), (C) and (E) show the asymmetries calculated using method of arithmetic mean. Plots (B), (D) and (F) show the asymmetries calculated using method of geometric mean.

Systematic Error

Cuts varied

Decay angle

Y kink angle

R parameter

Σ^+ Mass

Z decay range

Phase space binning

Result: Effects small compared to statistical error

Dominant effect phase space binning

False asymmetries

No Significant false asymmetries seen

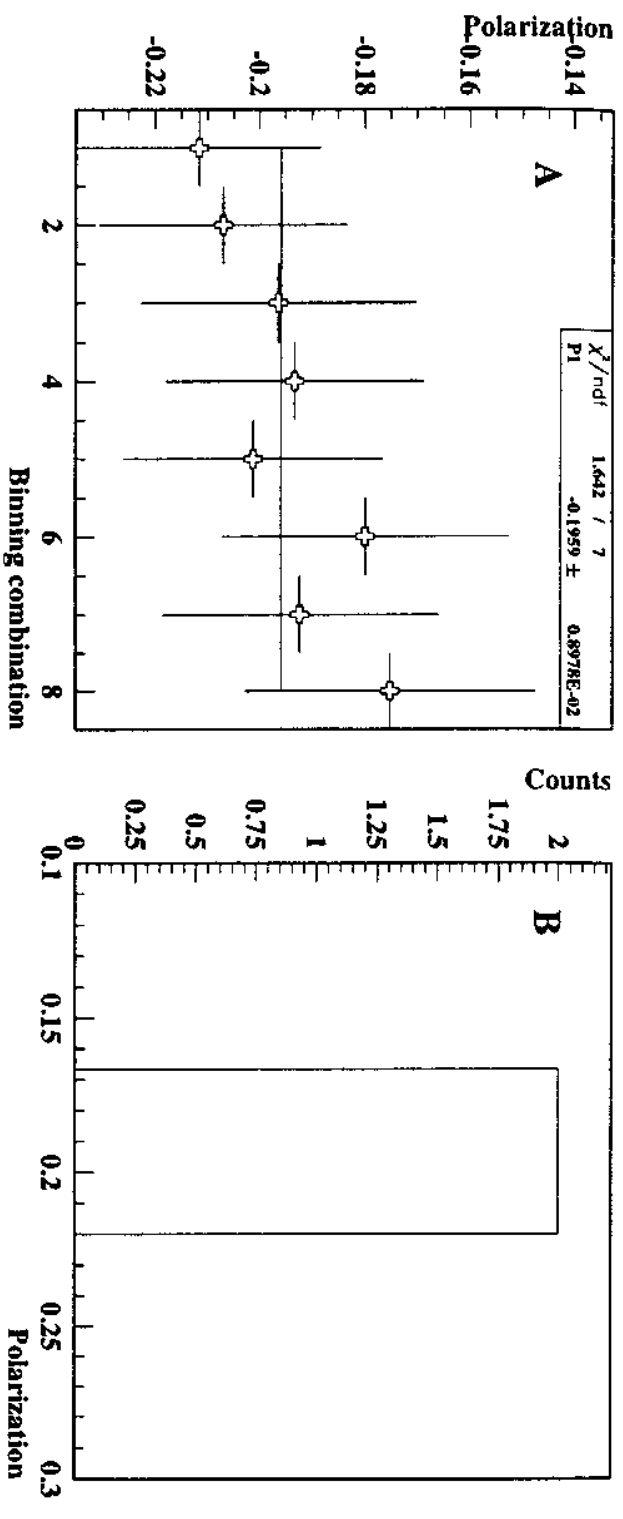


Figure 41: Average polarization magnitude. The result was obtained by averaging the polarization values corresponding to individual bins for binning combinations listed in Table 13 (Plot (A)), corresponding histogram of the average polarization values (Plot (B)).

Source of the contribution	Value of the contribution
Mismeasurement of the Θ_y	Negligible
Non-uniform beam phase space	0.009
Event selection	Negligible
Aggregate systematic error	0.009
Statistical error	0.023

Table 14: Various contribution to the systematic error in the measured polarization value.

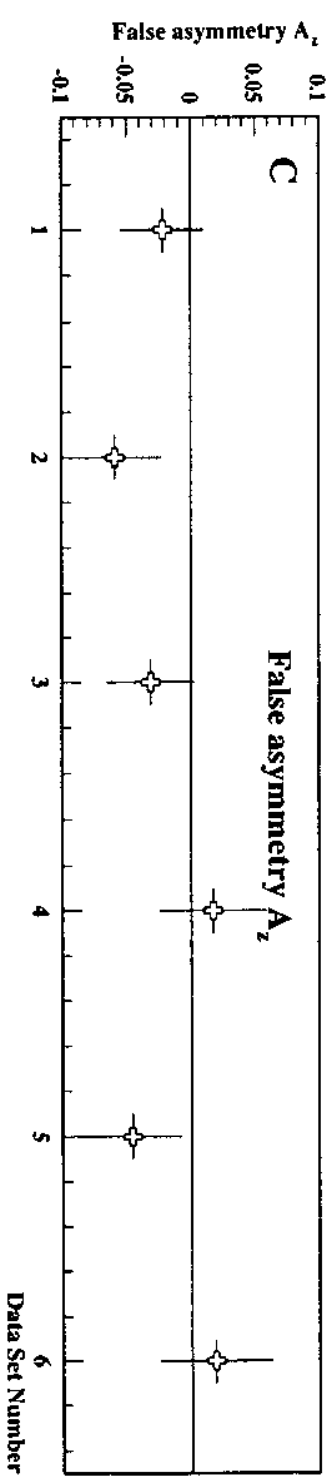
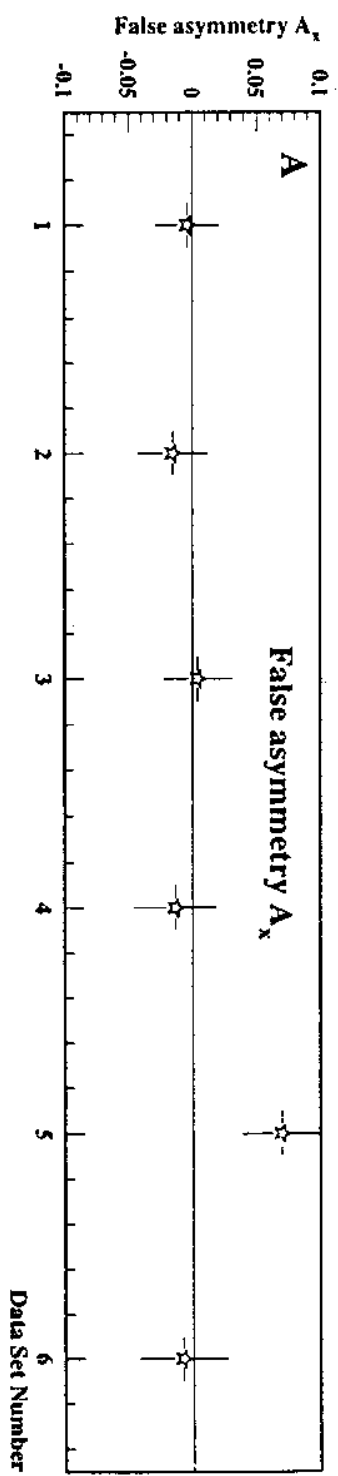


Figure 32: False asymmetries. Plots (A) and (C) show asymmetries of $\Sigma^+ \rightarrow p\pi^0$ decays with respect to $\cos \Theta_x$ and $\cos \Theta_z$. Plot (B) shows asymmetry of $\Sigma^+ \rightarrow n\pi^+$ decays with respect to $\cos \Theta_y$.

Data Set	P_{beam} [GeV/c]	P_t [GeV/c]	X_f	Number of events	Polarization [%]	Uncertainty [%]	
						Stat	Syst
Copper target							
1	366(24)	1.41(0.09)	0.46(0.03)	2723	-12.9	±3.3	±1.1
2	478(36)	1.85(0.14)	0.60(0.05)	2905	-18.2	±3.3	±1.1
3	540(39)	2.09(0.15)	0.68(0.05)	4575	-14.2	±2.9	±1.0
Beryllium target							
4	364(27)	1.41(0.10)	0.46(0.03)	3542	-17.8	±2.9	±1.0
5	473(39)	1.83(0.15)	0.59(0.05)	3933	-23.0	±2.8	±0.9
6	535(40)	2.07(0.15)	0.67(0.05)	5128	-19.2	±2.6	±0.9

Table 16: Data samples utilized to measure Σ^+ polarization. For each data sample, the table gives the value of the Σ^+ momentum, values of the corresponding P_t and X_f variables, number of the $\Sigma^+ \rightarrow p\pi^0$ decays used to measure the polarization, the polarization value and the uncertainty. Numbers in parentheses next to P_{beam} , P_t , and X_f represent the widths (σ of the gaussian fit) of the corresponding P_{beam} , P_t , and X_f distributions.

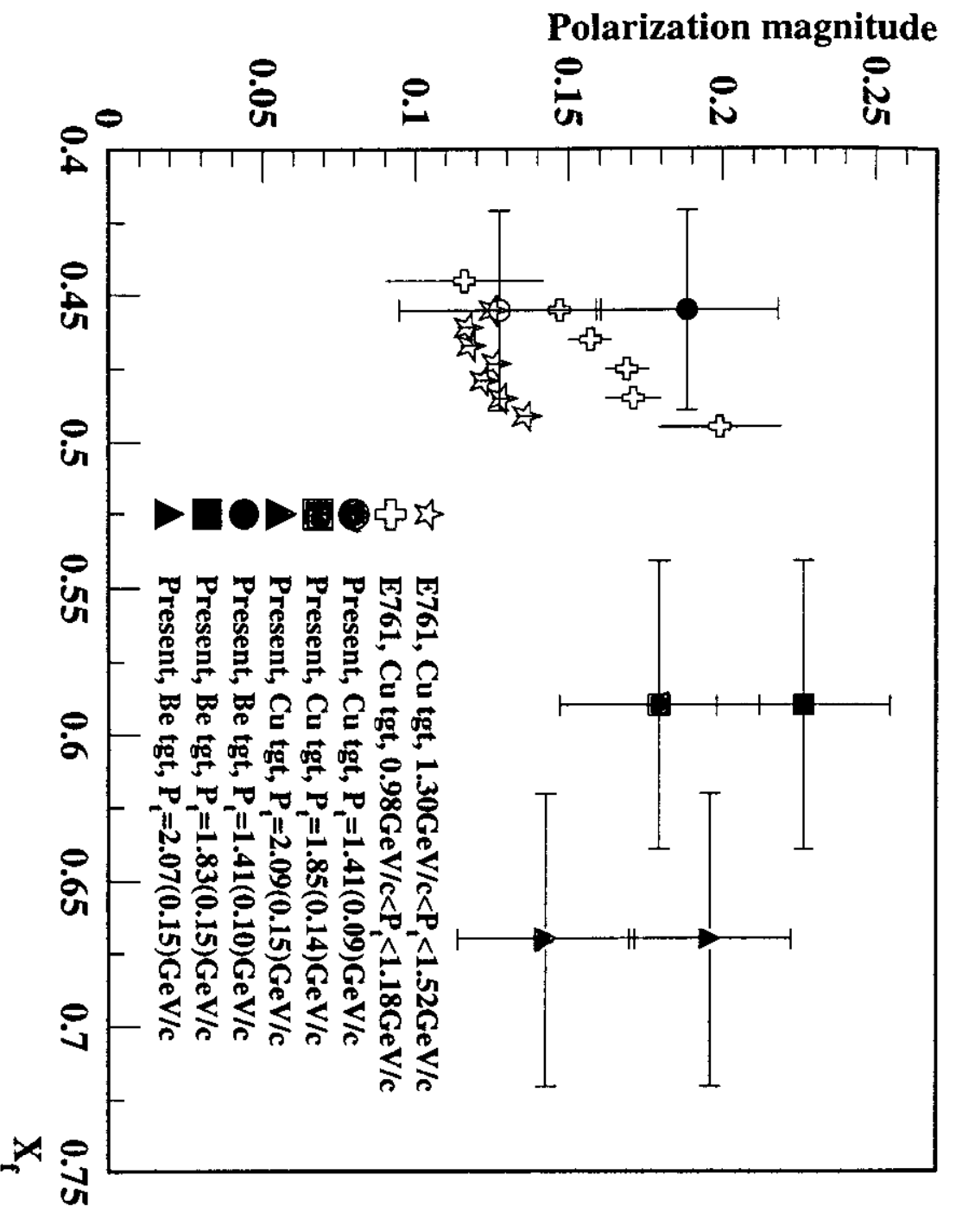


Figure 46: X_f dependence of the Σ^+ polarization (only statistical errors are shown). Open symbols correspond to the Cu production target, filled symbols – to the Be target. Open crosses and stars represent the E761 data [2] at $P_t \approx 1$ GeV/c and $P_t \approx 1.5$ GeV/c, respectively. Circles correspond to the present measurement at $P_t \approx 1.41$ GeV/c. Boxes correspond to the present measurement at $P_t \approx 1.84$ GeV/c. And, finally, triangles correspond to the present measurement at $P_t \approx 2.08$ GeV/c. Horizontal error bars represent the widths (σ of the gaussian fit) of the corresponding

Results

- **Polarization rises then falls as x_F (p_t) increases***
- **Significant difference between Cu and Be target**

$$P_{\text{Cu}}/P_{\text{Be}} = 0.71 \pm 0.08$$

*** This measurement performed at fixed targeting angles $\Rightarrow p_t$ and xf proportional to Σ^+ momentum**

Conclusion

**Results consistent with earlier E761 measurement
but here extended to higher x_F**

$$\Sigma^-(600 \text{ GeV}/c) + A \rightarrow \Lambda^0 + X$$

- Method
- Data Selection
- Results
- Conclusion

Data Selection

$\Delta(\text{mass}) < .005 \text{ GeV}/c^2$

beam pid

pion in M2 spectrometer*

proton id'd by rich

azimuth cut

360K “good” events

*** M2 momentum cutoff $15 \text{ MeV}/c \Rightarrow$ effective pi
momentum cut $\Rightarrow x_F \text{ cut} \geq 0.3$**

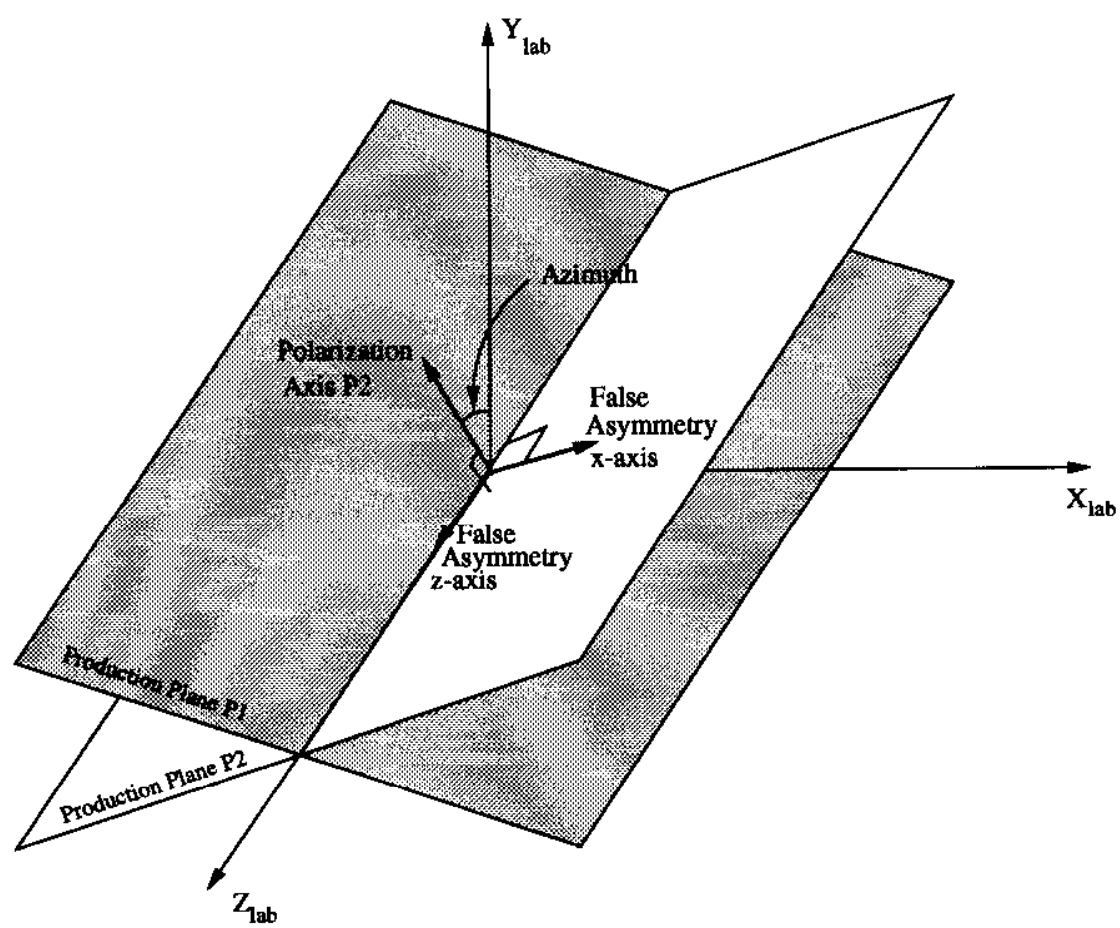
Comments on Method

- Λ^0 's produced at all azimuths

Bias cancelling still possible by exploiting up-down symmetry of apparatus

Checked with Monte Carlo and K_s sample

- **< 1 % False asymmetry in x, z directions at all x_F**
- **Systematic errors checked by varying cuts as in previous study**



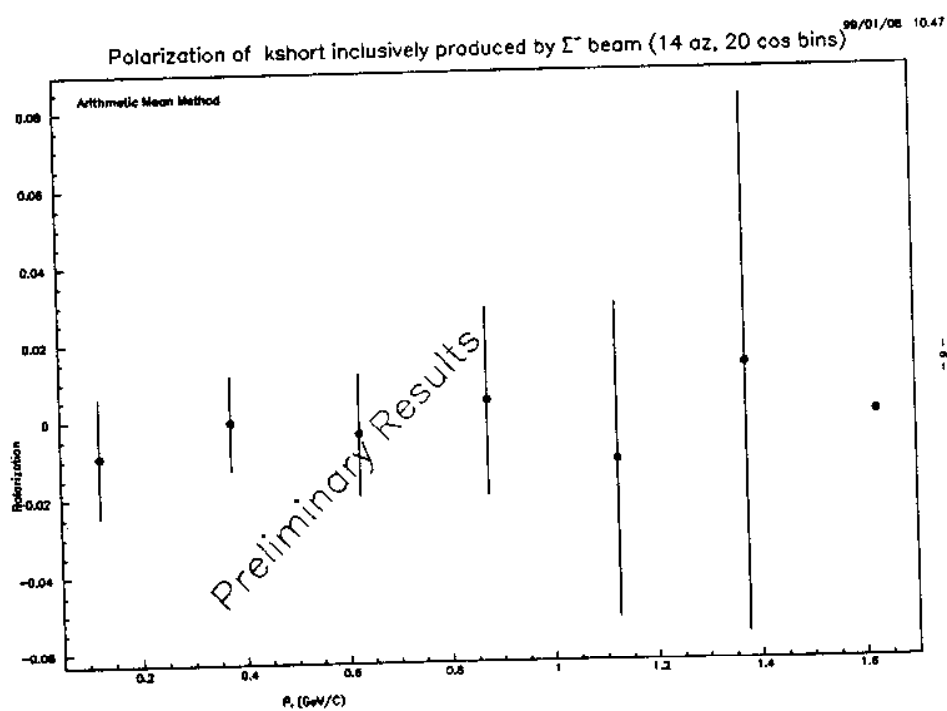
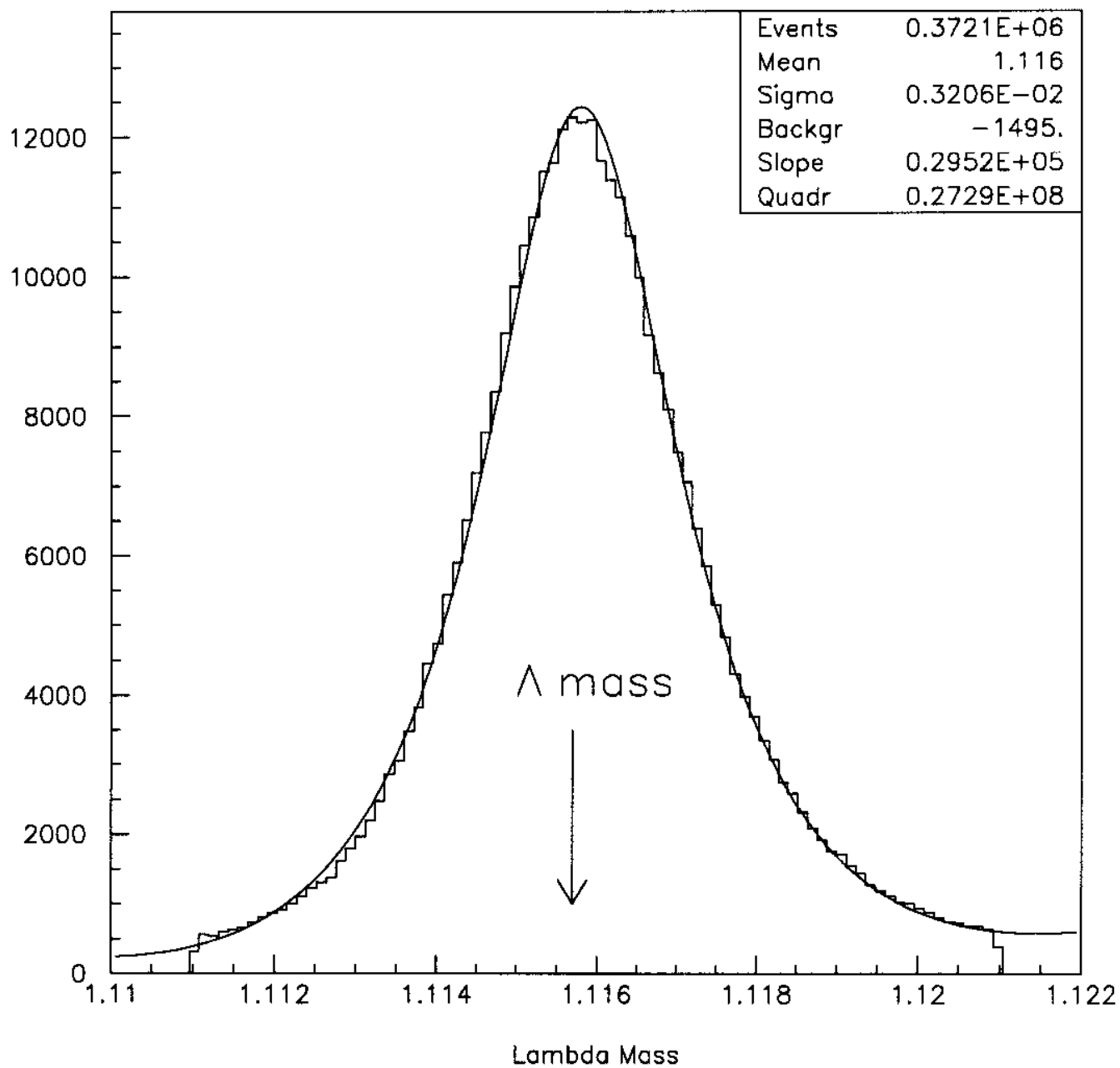
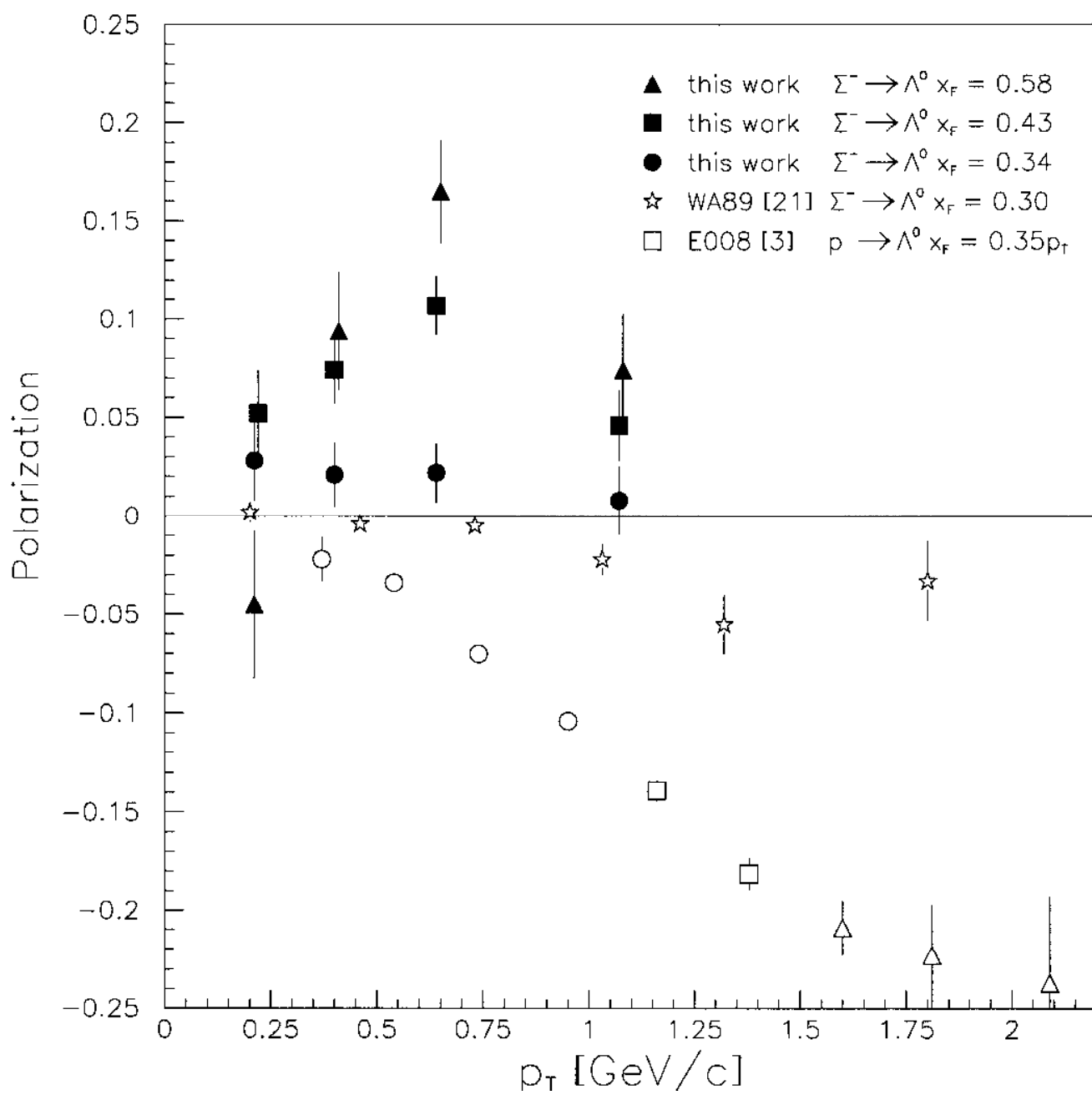
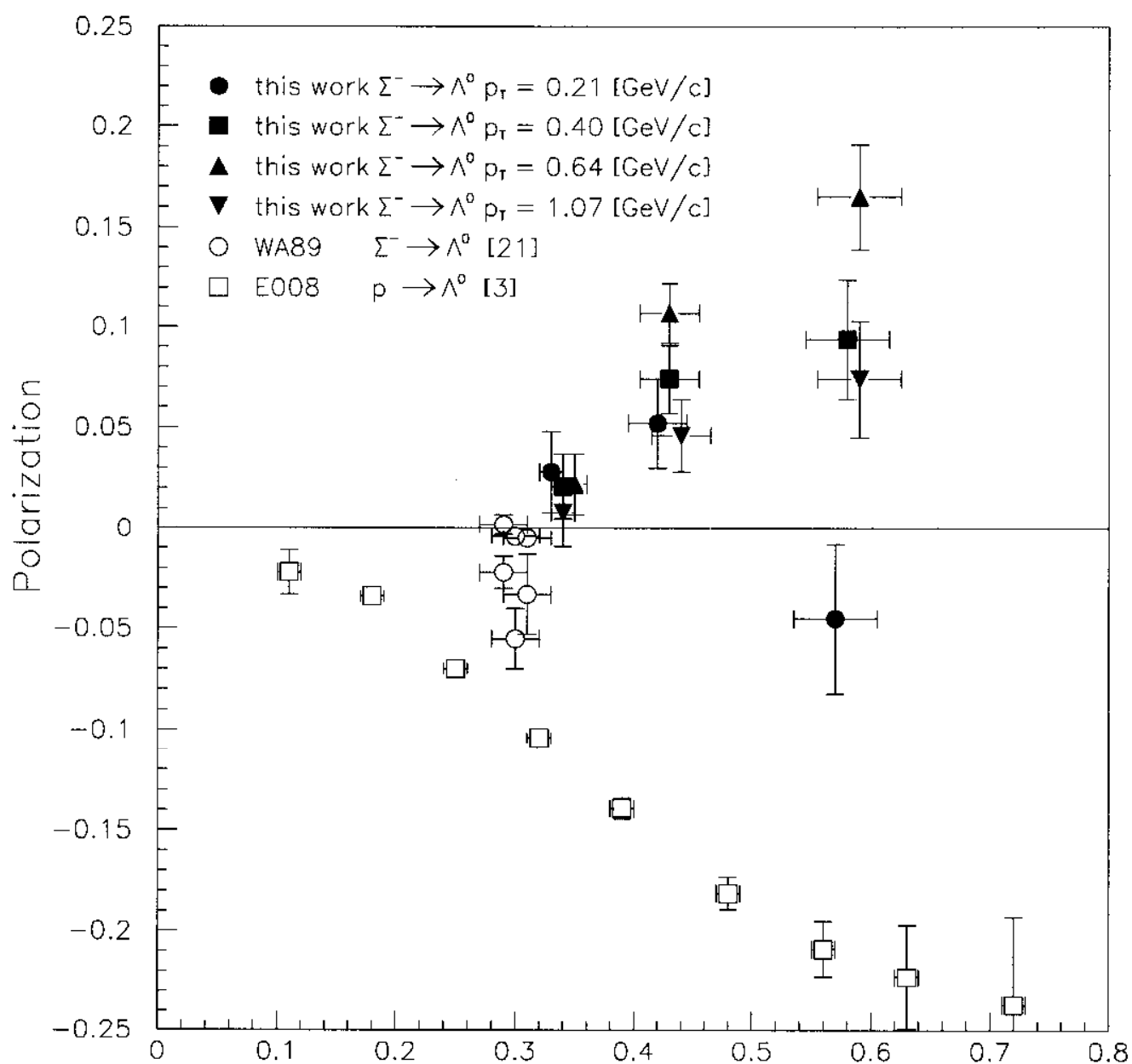


Figure 6.20: K-short polarization using the arithmetic mean method







Results

- **Positive polarization for $\Sigma^- + A \rightarrow \Lambda^0 + X$**
- **Linear dependence increasing in x_F**
- **p_t dependence which peaks between 0.8 and 1.0 then shows a tendency to decline**

Conclusion

- **Most striking feature of this measurement: the sign of the polarization is opposite to that of earlier measurements**