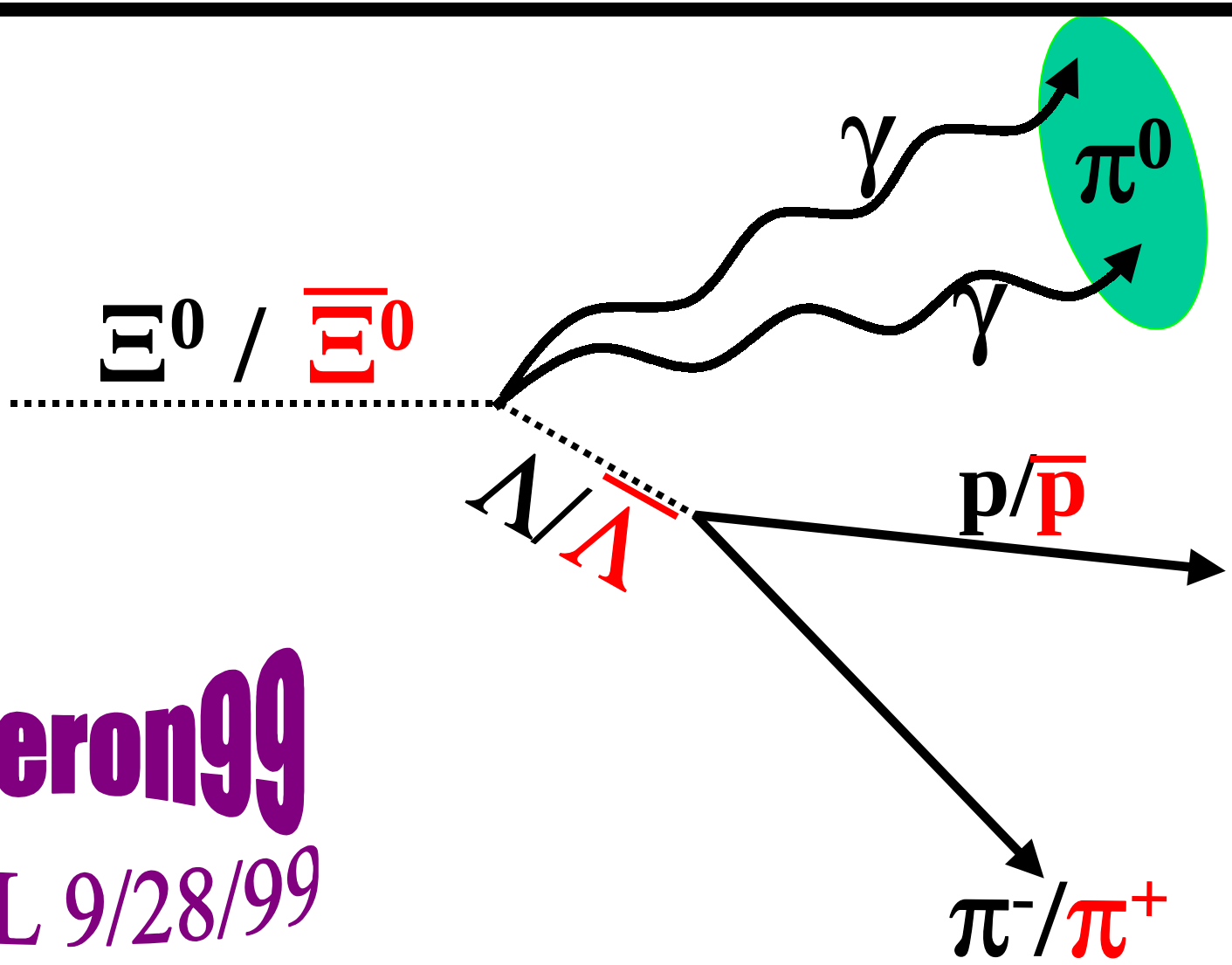
Ξ^0, $\overline{\Xi}^0$ Polarization at KTeV

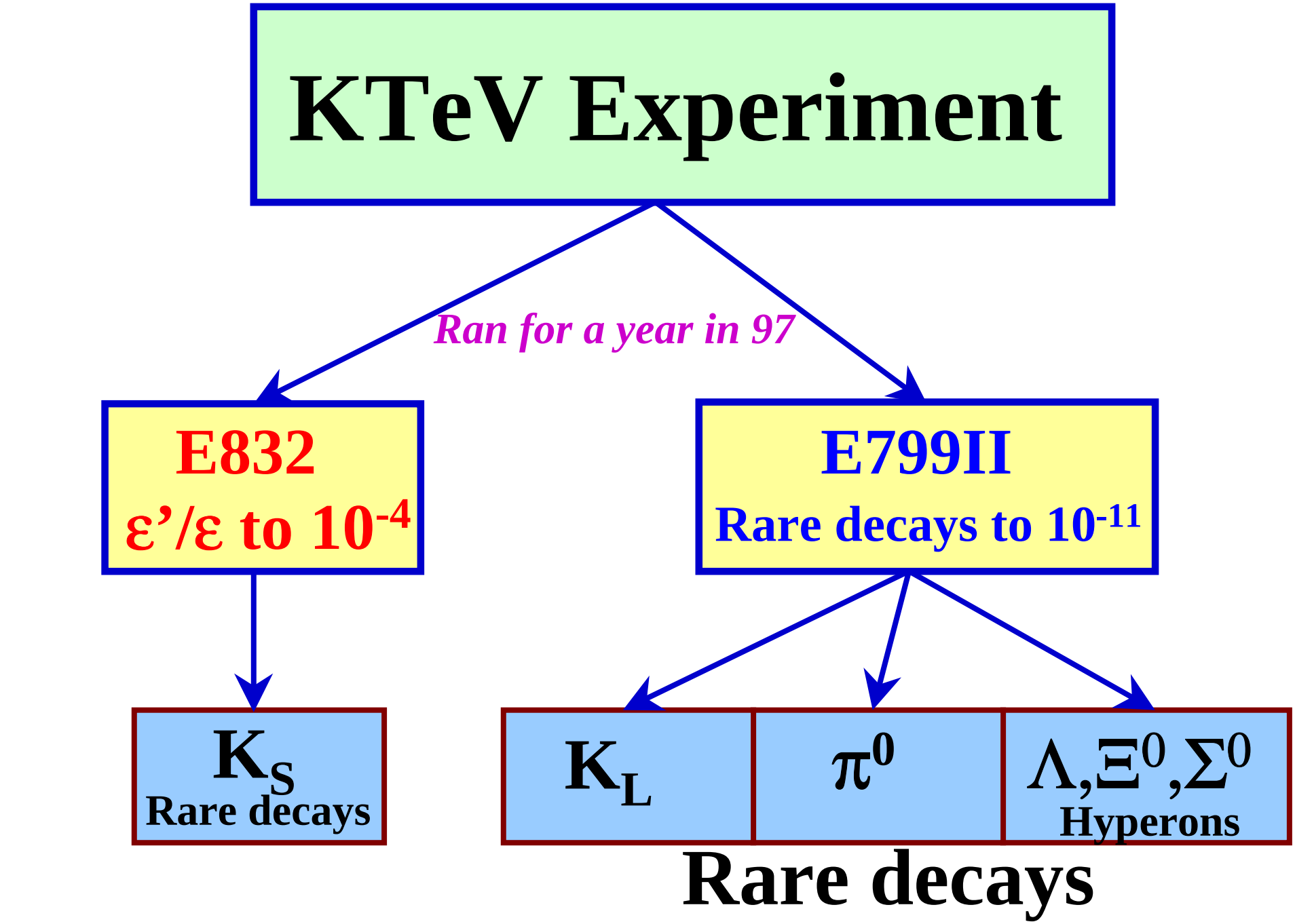
Albert R. Erwin
University of Wisconsin-Madison



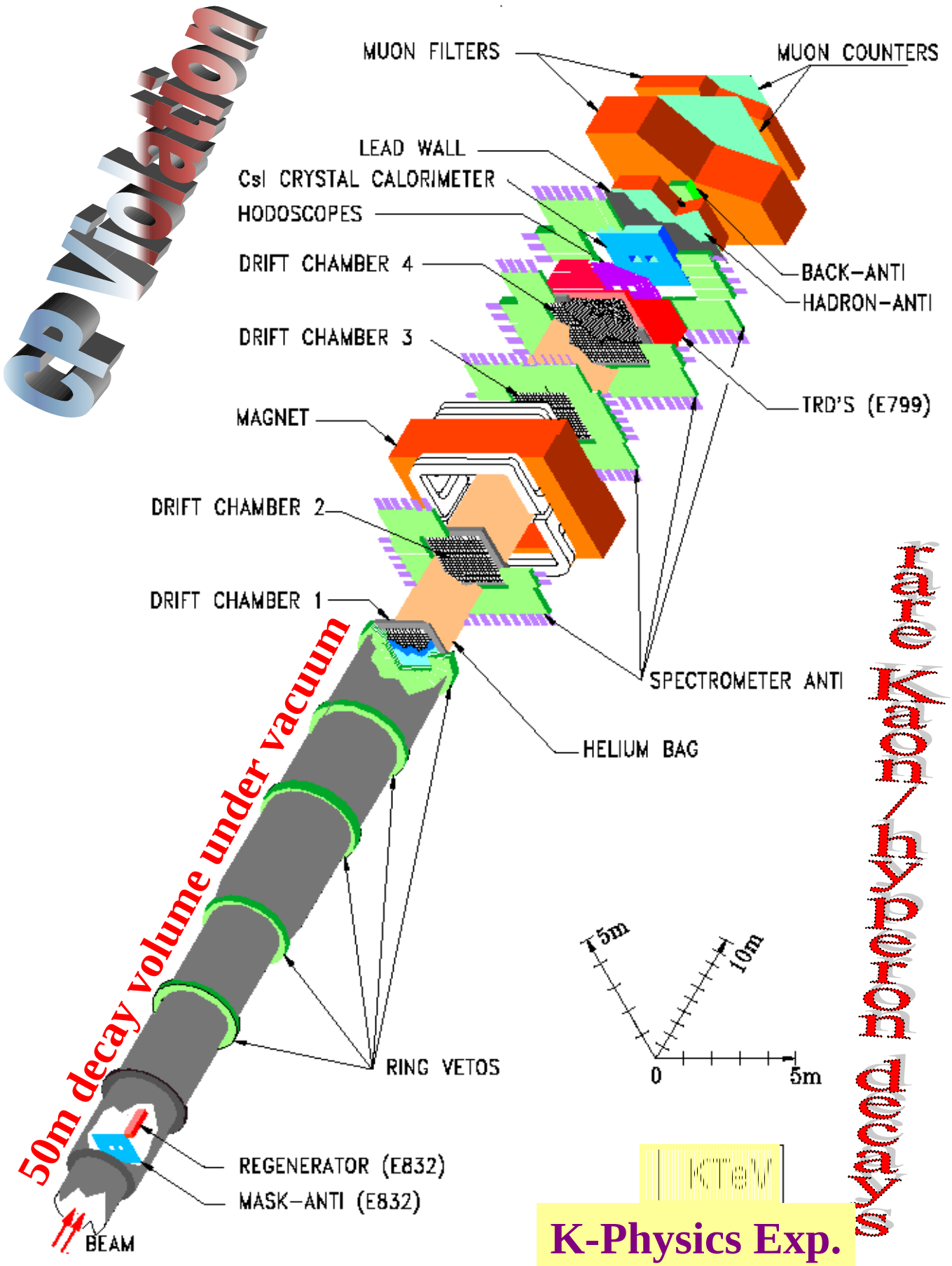
Hyperon99
FNAL 9/28/99

Outline

- ✓ **KTeV Experiment**
- ✓ **Description of Polarization**
- ✓ **Method of Measurement**
- ✓ **KTeV Polarization Results**
- ✓ **Summary**

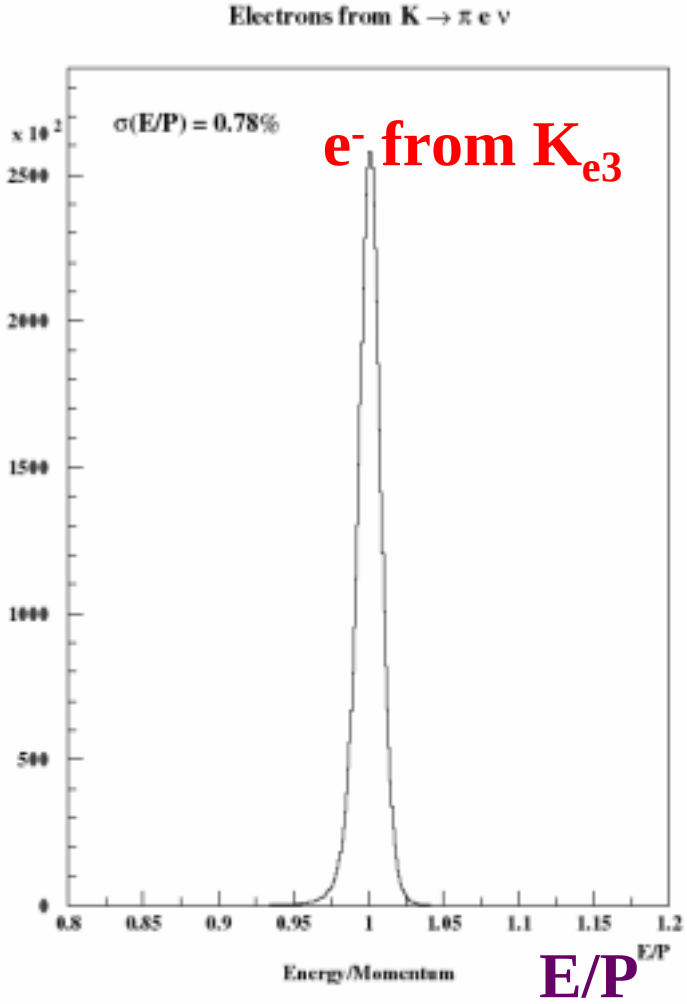


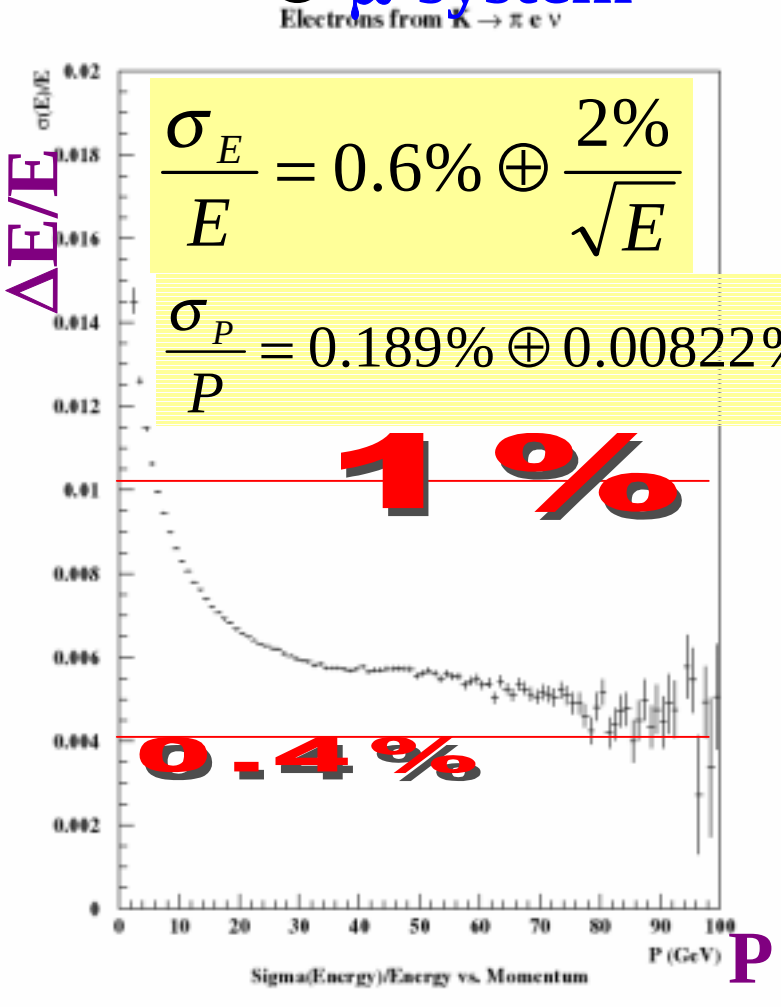
KTeV99 is running now until the end of the year


CP Violation
MUON FILTERS
MUON COUNTERS
LEAD WALL
CsI CRYSTAL CALORIMETER
HODOSCOPES
DRIFT CHAMBER 4
BACK–ANTI
HADRON–ANTI
DRIFT CHAMBER 3
TRD'S (E799)
MAGNET
DRIFT CHAMBER 2
DRIFT CHAMBER 1
SPECTROMETER ANTI
HELIUM BAG
50m decay volume under vacuum
RING VETOS
5m
10m
0
5m
REGENERATOR (E832)
MASK–ANTI (E832)
BEAM
Rare Kaon Decays
KTeV
K-Physics Exp.

Highlights of the KTeV Detector

- **Pure CsI EM Calorimeter**
  - Position resolution < 1mm
  - Energy resolution < 1.0%
- **Drift Chambers**
  - Position resolution ~ 100μm
- **Photon Veto system**
- **μ-system**





$$\frac{\sigma_E}{E} = 0.6\% \oplus \frac{2\%}{\sqrt{E}}$$

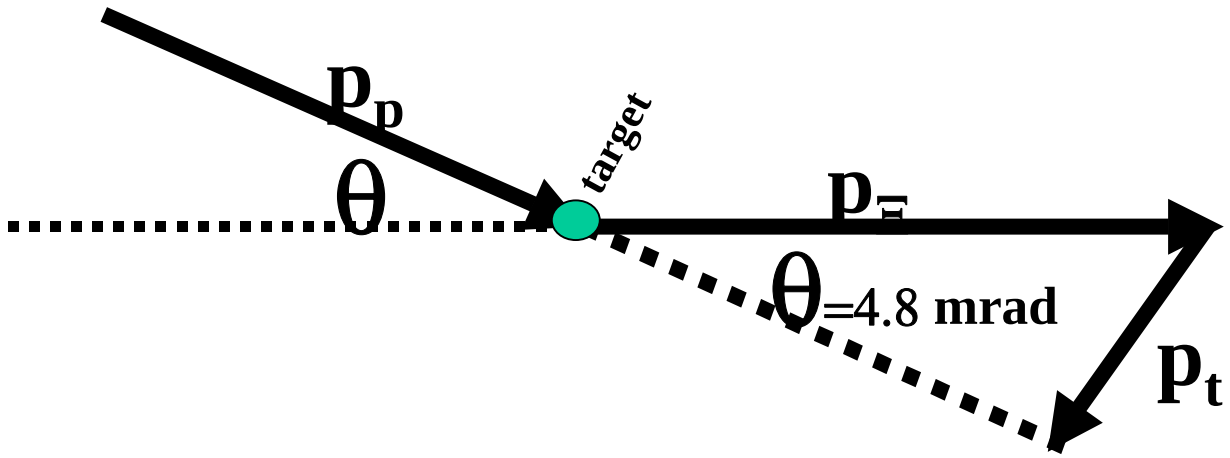
$$\frac{\sigma_P}{P} = 0.189\% \oplus 0.00822\% \text{ x P}$$

What Do We Know about Hyperon Polarization(1)?

Polarization depends on P_p, production angle/targeting angle, and material of the target.

➔Polarization reverses sign with production angle/targeting angle, and is zero at production angle $\theta=0$.

Polarization is expressed as a function of transverse momentum $p_t = p_\Xi \sin\theta$, & momentum fraction of produced Ξ, $x_F = p_\Xi/800$



What Do We Know about Hyperon Polarization(2)?

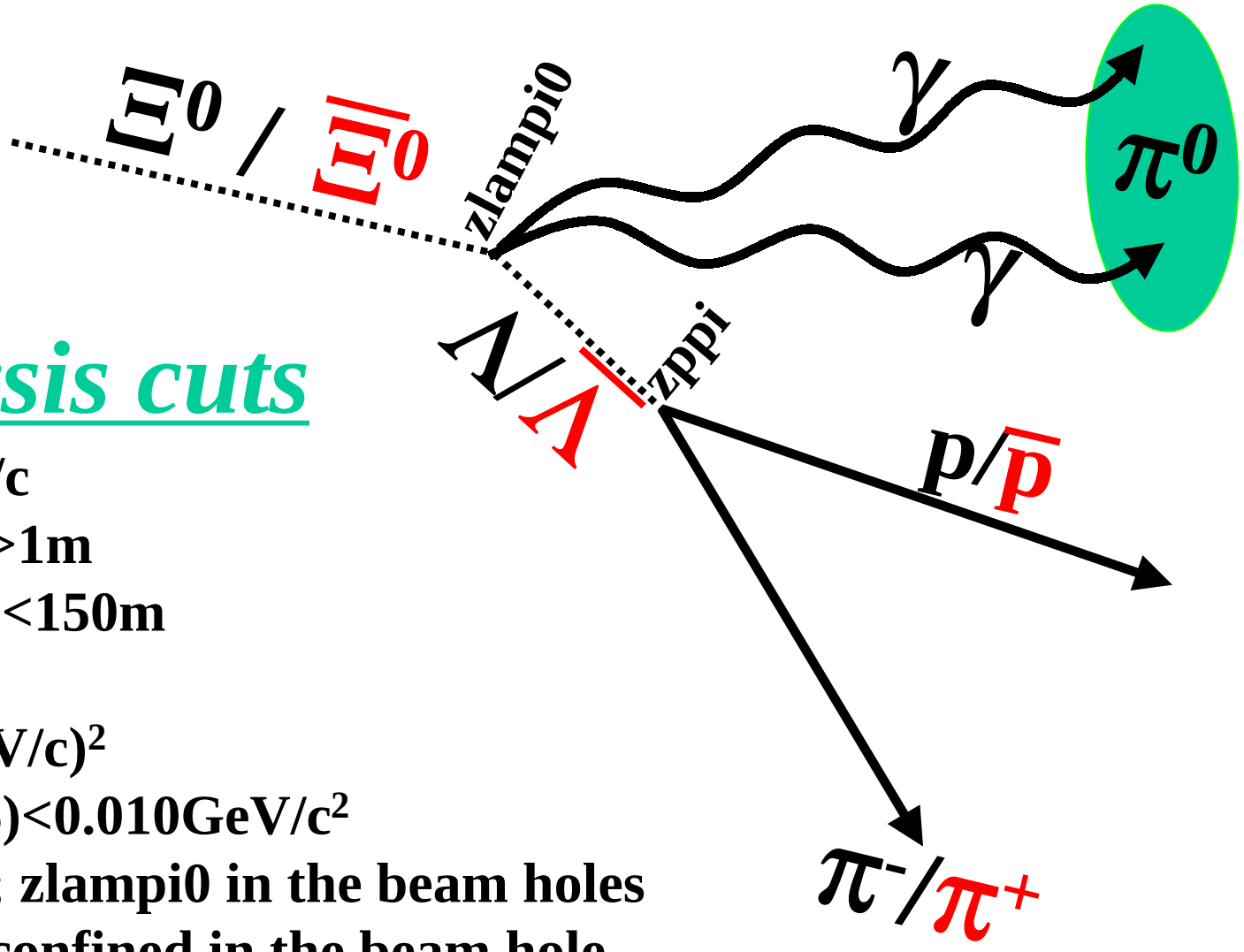
➔**Anti-Hyperons have not been observed to be produced polarized, except for $\overline{\Xi}^{+}$ and $\overline{\Sigma}^{-}$ in E756, E761, both with incident protons at 800 GeV/c.**

➔**Anti-Hyperons were produced with the same sign and magnitude as their hyperon counterparts.**

QCD/PQCD can't predict anything at small p_t .

Only prediction: P=0 for p_t>4GeV/c

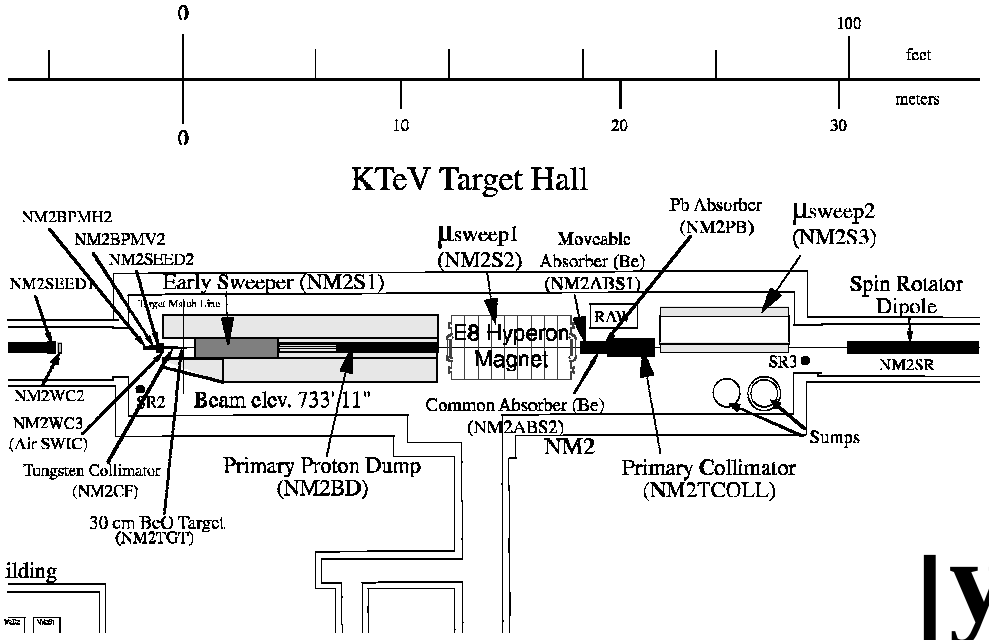
Ξ^0, $\bar{\Xi}^0$ Reconstruction

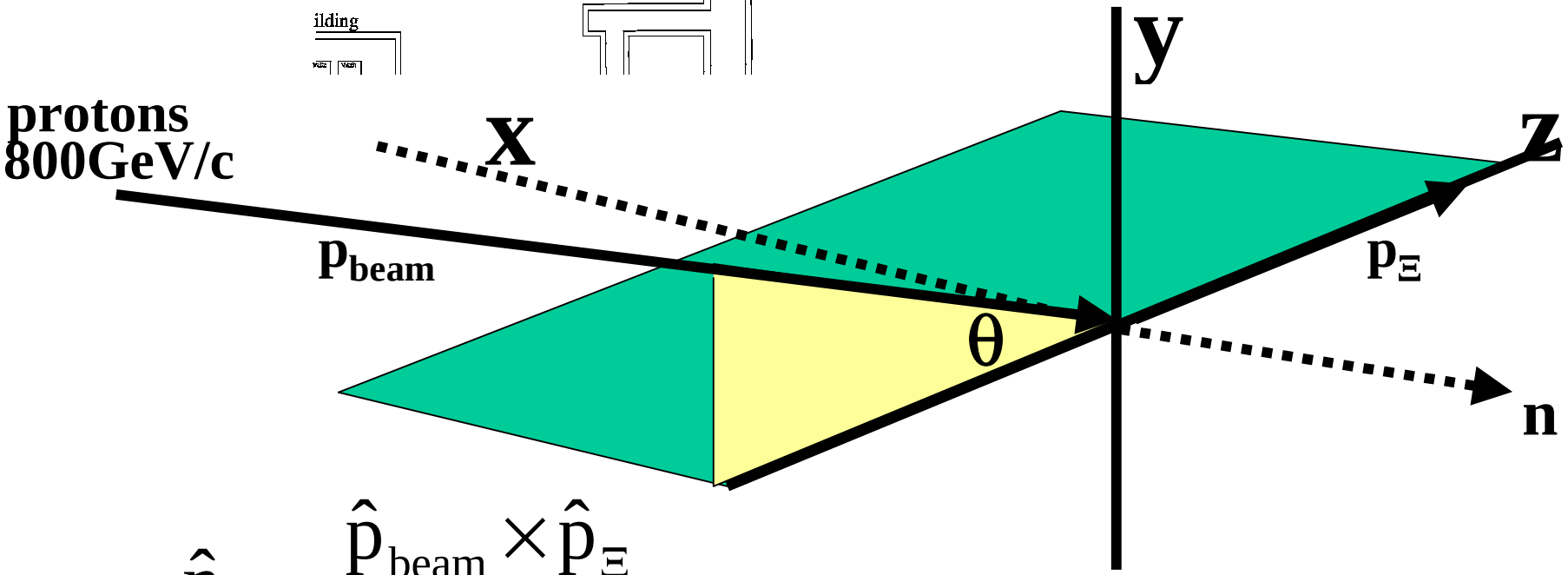


Analysis cuts

A) ppr>120GeV/c
B) zppi-zlampi0>1m
C) 95m<zlampi0<150m
D) d>25cm
E) pt^2<0.001$(GeV/c)^2$
F) (M(ppi)-1.116)<0.010GeV/c^2
G) Fiducial cuts; zlampi0 in the beam holes
H) proton to be confined in the beam hole
I) E/P (for pion) <0.8

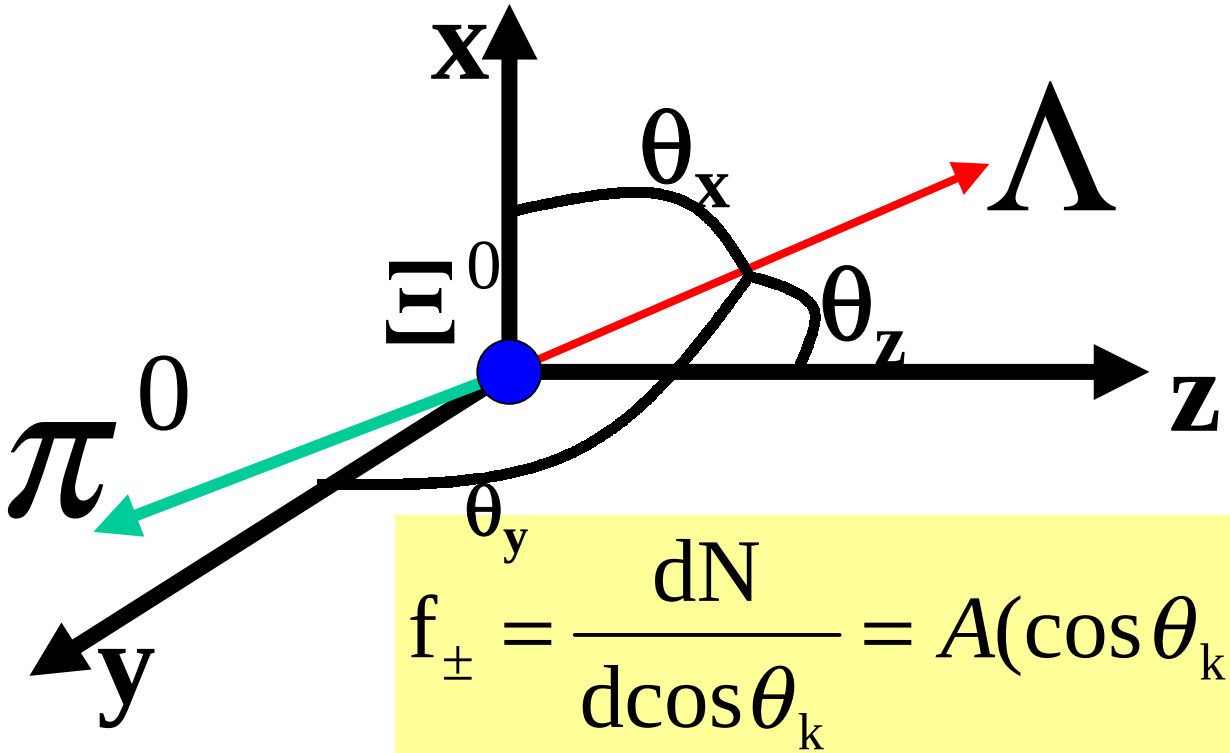
Hyperon production at KTeV





$$\hat{n} = \frac{\hat{p}_{beam} \times \hat{p}_{\Xi}}{|\hat{p}_{beam} \times \hat{p}_{\Xi}|}$$

Analysis Method



polarization

$$f_{\pm} = \frac{dN}{d\cos\theta_k} = A(\cos\theta_k)(1 \pm \alpha_{\Xi} P_k \cos\vartheta_k)$$

decay asymmetry $\alpha_{\Xi} = -0.411 \pm 0.022$

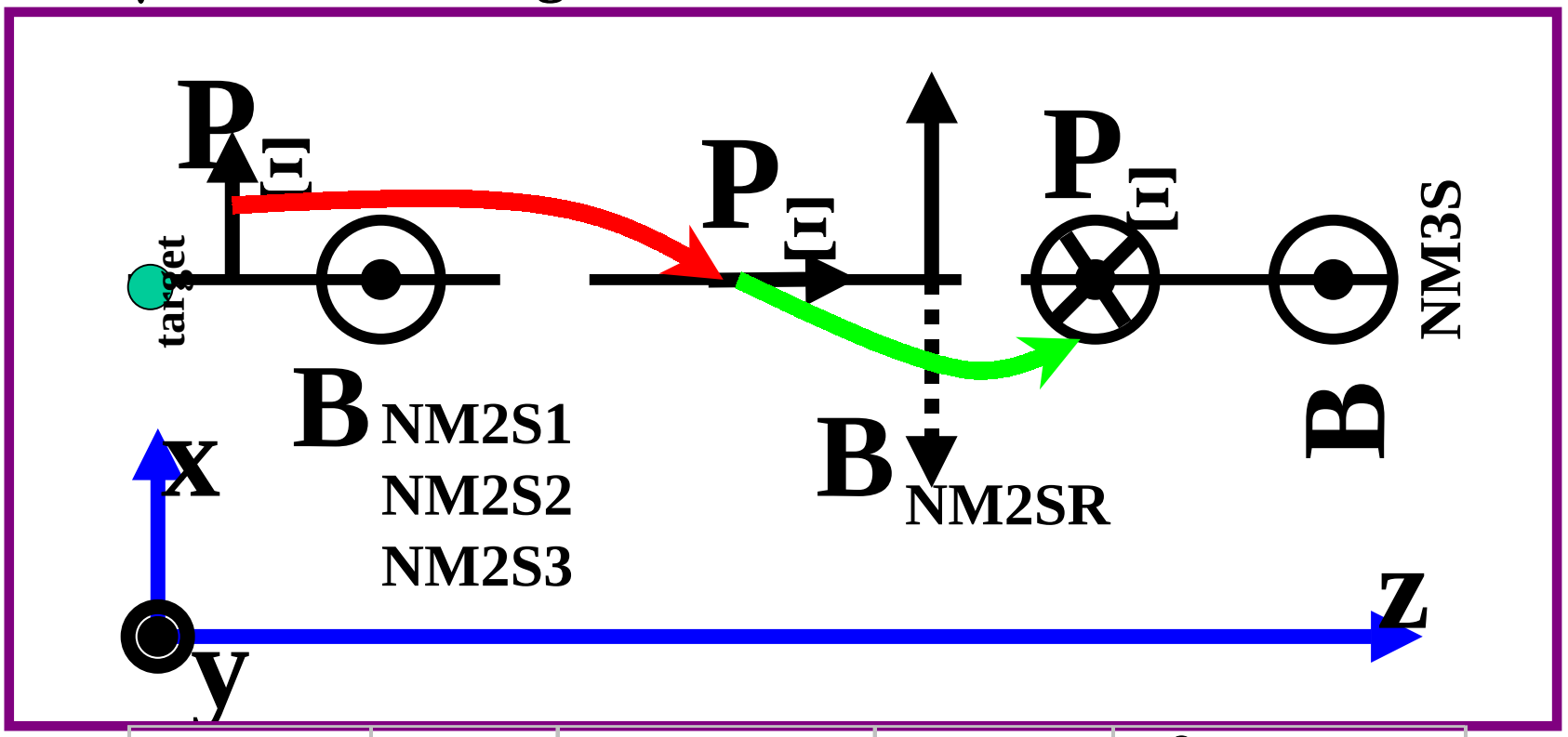
Method I: $$\frac{f_+}{f_-} \cong 1 + 2\alpha_{\Xi} P_k \cos\vartheta_k$$

Method II: $$\frac{f_+ - f_-}{f_+ + f_-} = \alpha_{\Xi} P_k \cos\vartheta_k \quad , k = x, y, z$$

Polarization Precession from sweeper Magnets

$$\varphi = \frac{2\mu}{hc\beta}\int \mathrm{Bdl} = (18.30)\mu\int \mathrm{Bdl}$$

Where μ in nuclear magnetons, for Ξ is -1.250 and for Λ -0.613



Magnet	B(T)	B*ΔL(T*m)	I(Amps)	Ξ° rot(deg)
NM2S1	0.41	1.583	536.649	36.221
NM2S2	2.17	11.905	1500	272.407
NM2S3	1.06	6.18	317	141.399
total				450.027
NM2SR	1.304	4	2652.52	91.523
NM3S	1.45	2.624	2000	No precess

Conclusions

➔ **Ξ^0 polarization at KTeV:**

Average Polarization:

$$P_y = 0.097 \pm 0.007_{(stat)} \pm 0.002_{(sys)}$$

➔ **$\overline{\Xi}^0$ polarization at KTeV:**

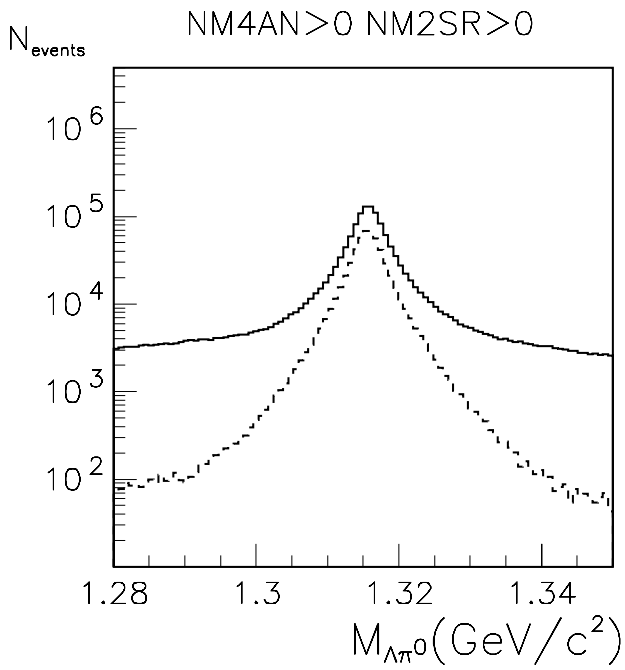
Average Polarization:

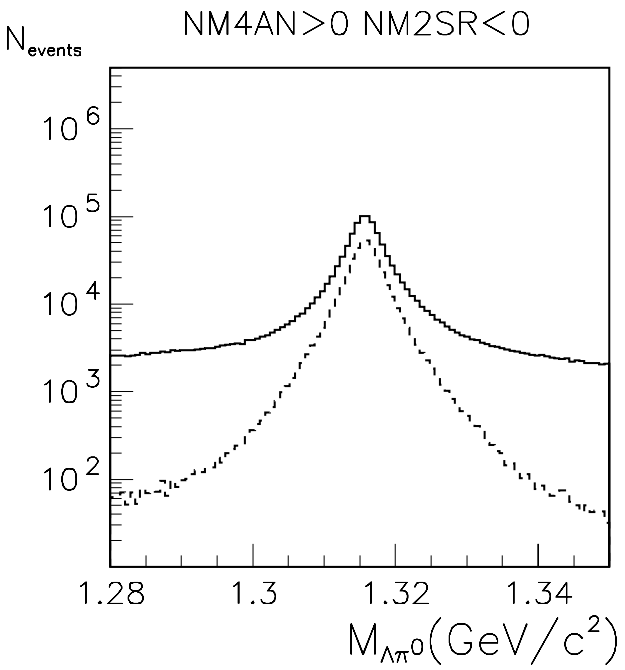
$$P_y = 0.000 \pm 0.013_{(stat)}$$

<u>This result is valid for:</u>

$$p_t = p \bullet \theta \,, \; x_F = p / p_{beam}$$

$$p_t = 3.84 \bullet x_F$$


NM4AN>0 NM2SR>0
N events
10 6
10 5
10 4
10 3
10 2
1.28
1.3
1.32
1.34
M Λπ0 (GeV/c 2)


NM4AN>0 NM2SR<0
N events
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10 5
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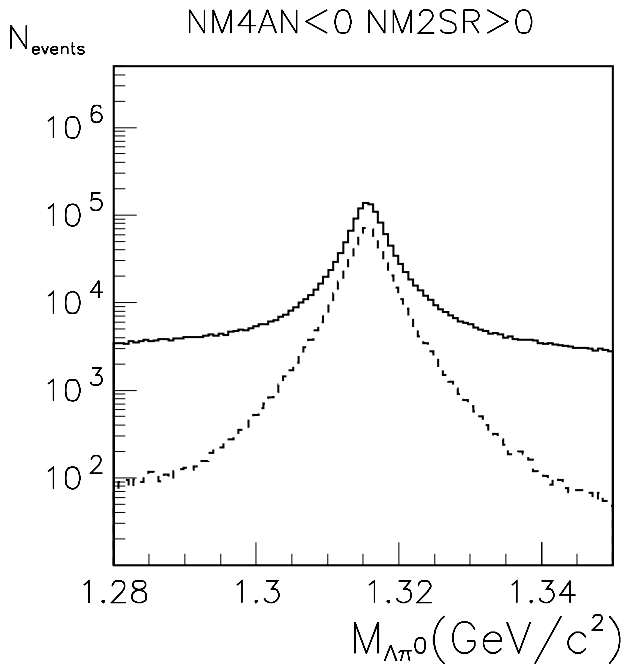
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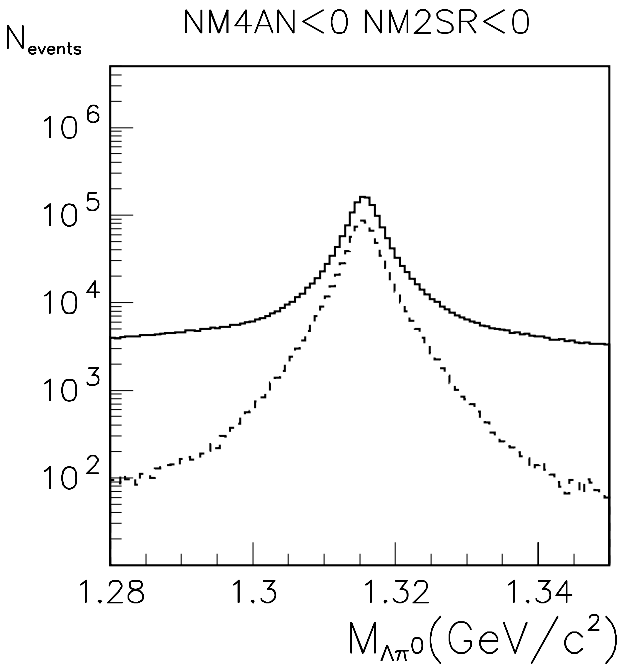
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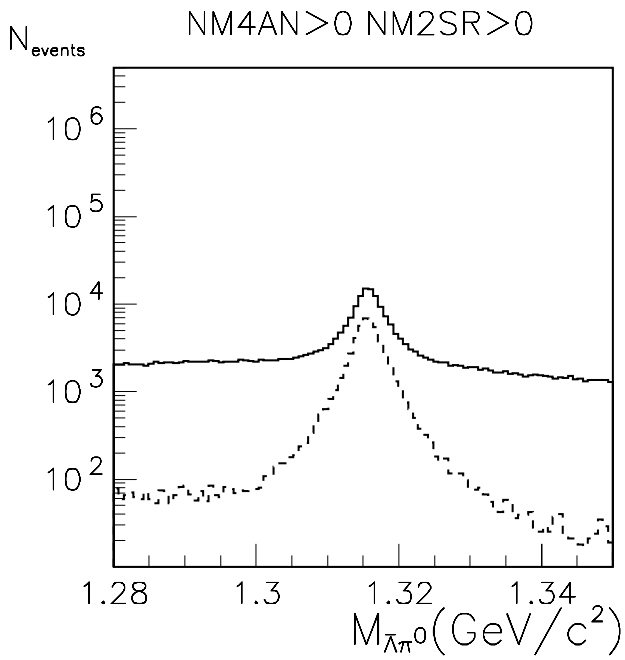
NM4AN>0 NM2SR>0
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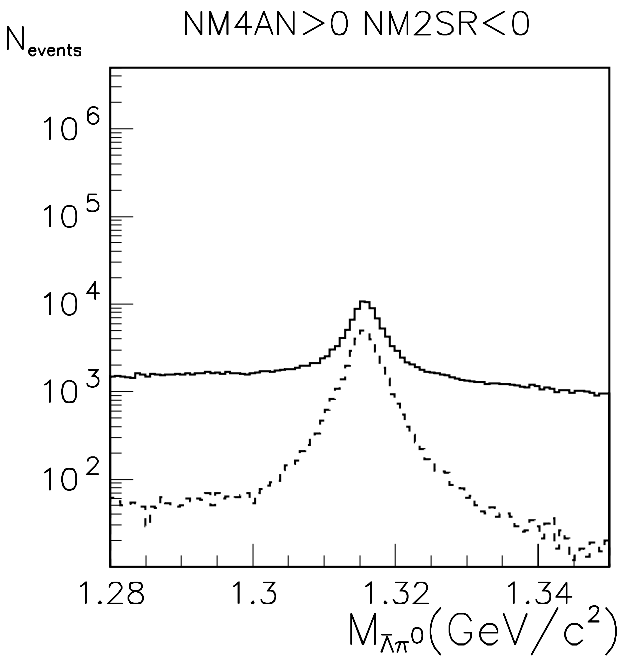
10^6
10^5
10^4
10^3
10^2
1.28
1.3
1.32
1.34
M_λ̄π0(GeV/c^2)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N events
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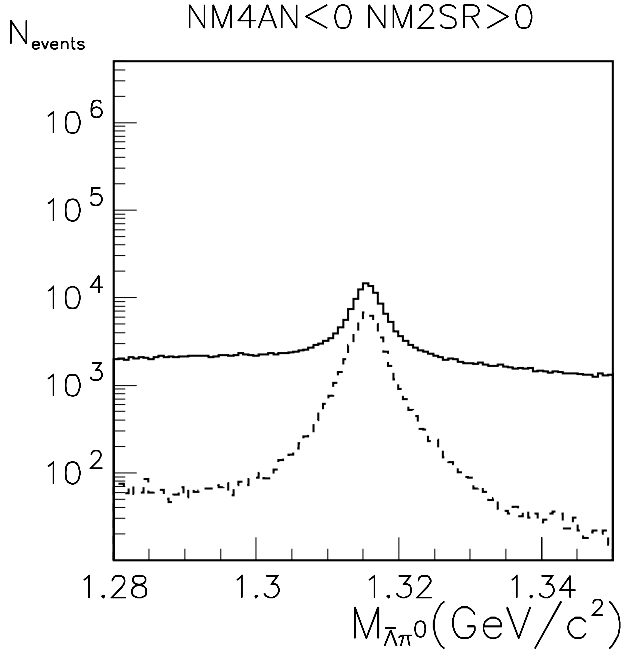
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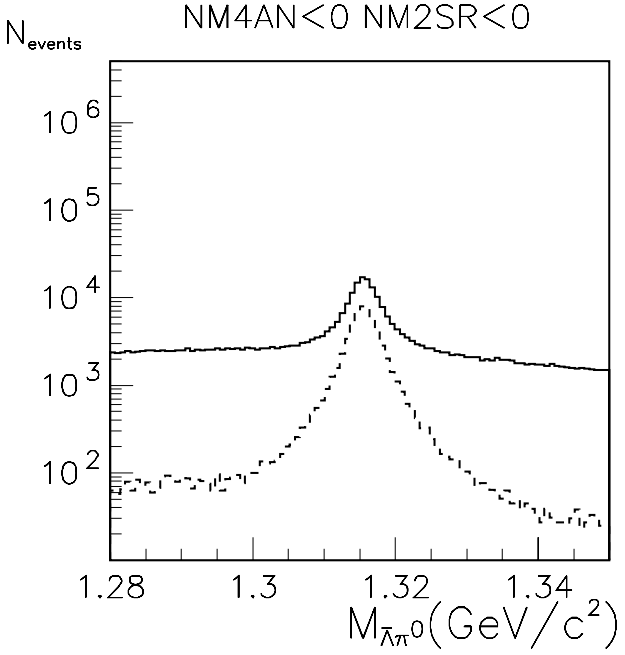
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N events
10^6
10^5
10^4
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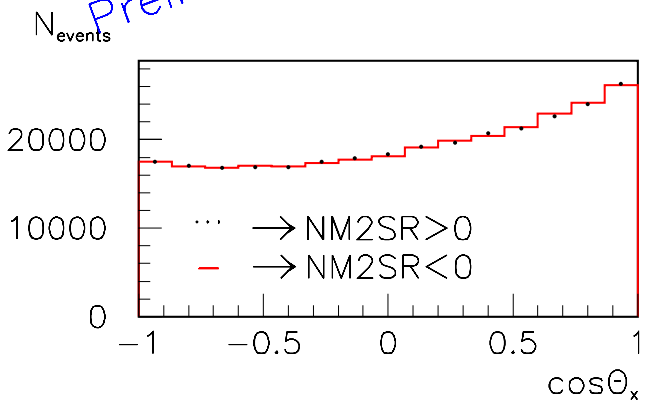
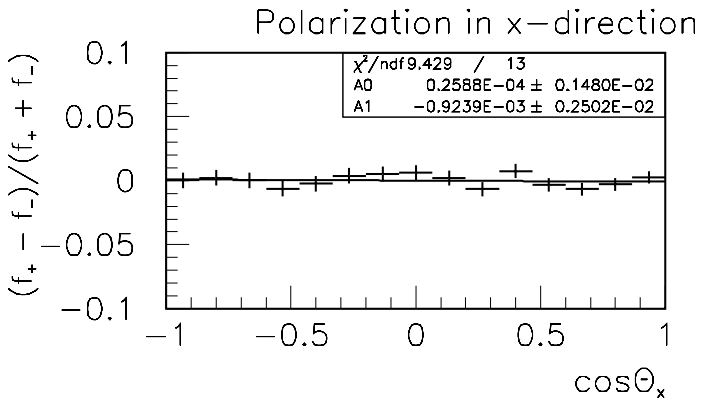
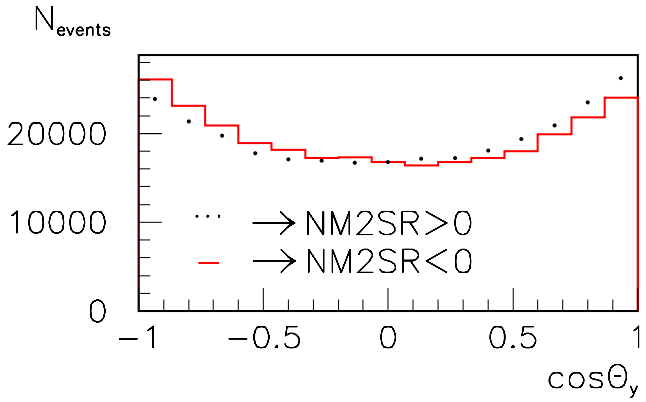
M_λ̄π0(GeV/c^2)

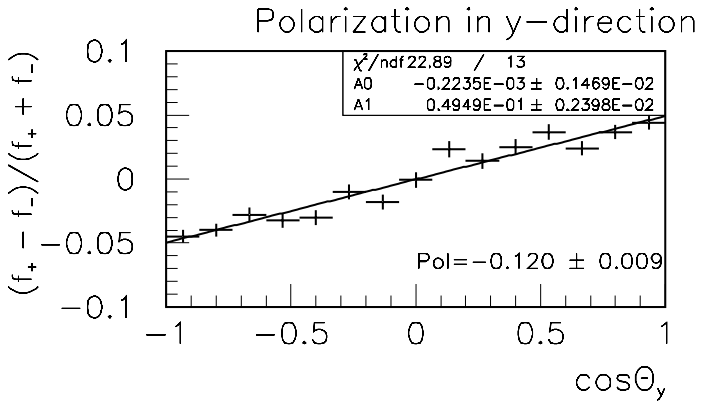
Analysis Magnet NM4AN>0

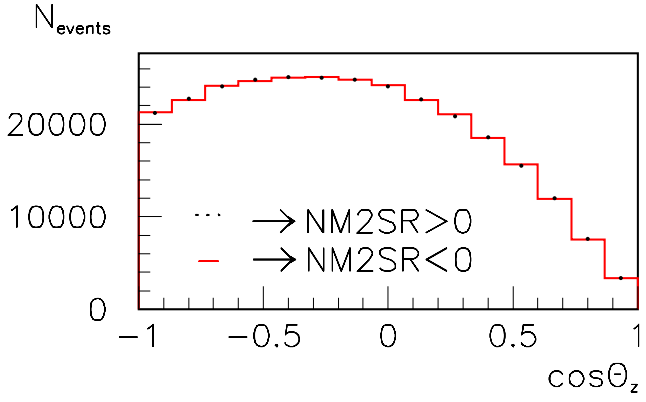
Preliminary

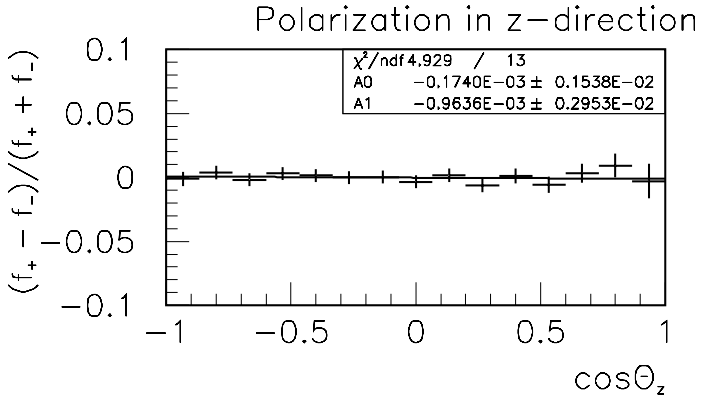






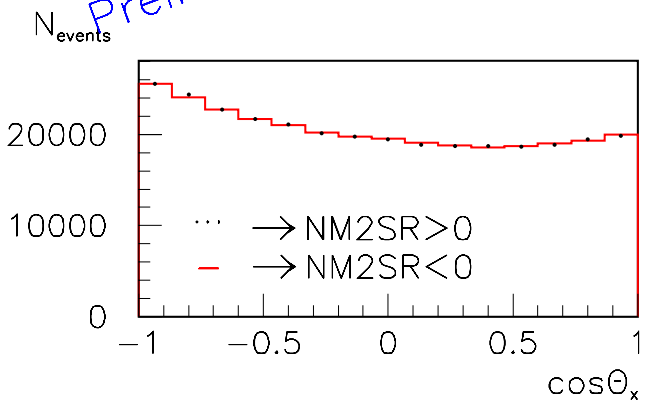


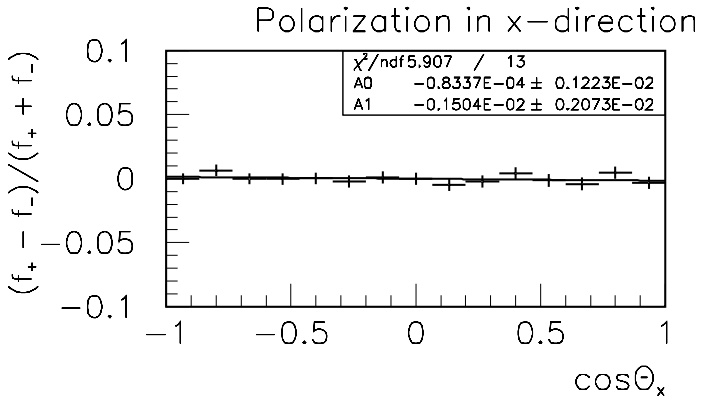


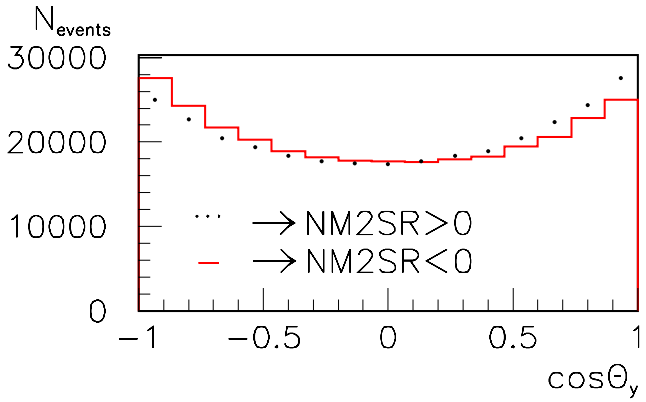


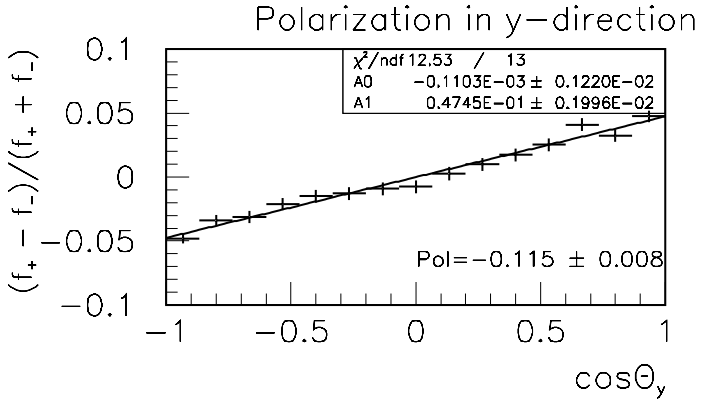
Analysis Magnet NM4AN<0

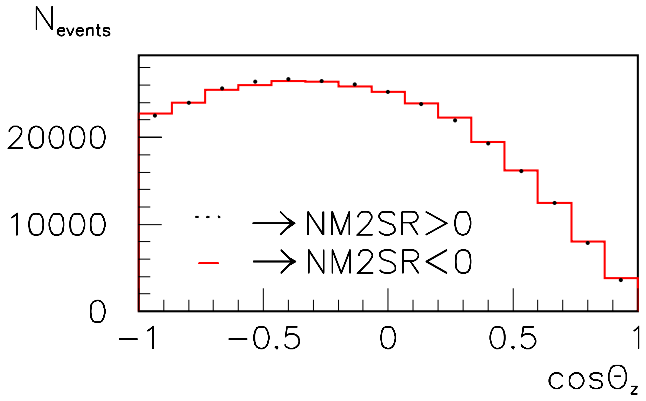
Preliminary

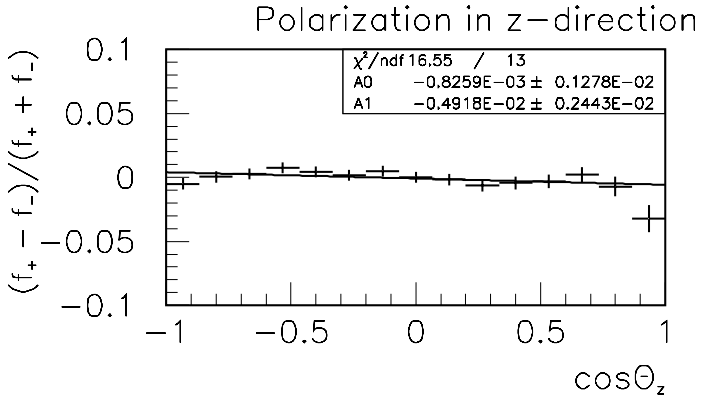






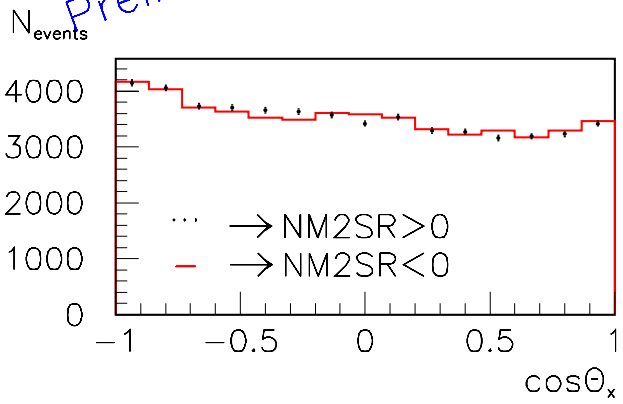


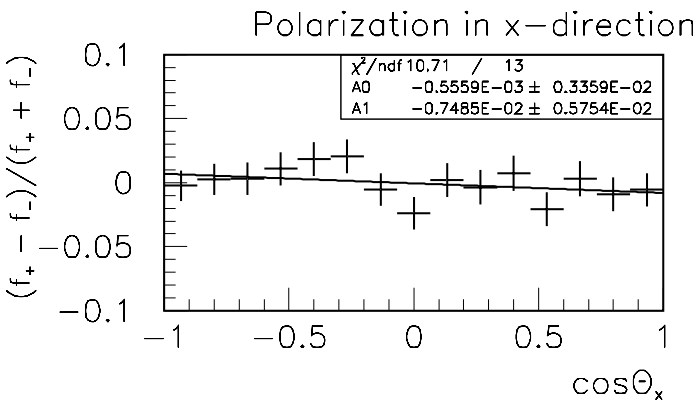


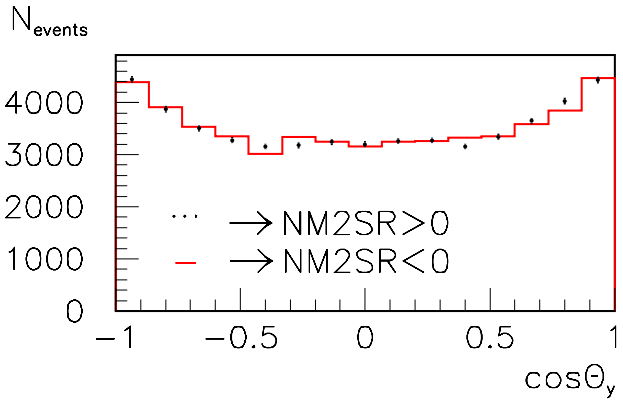


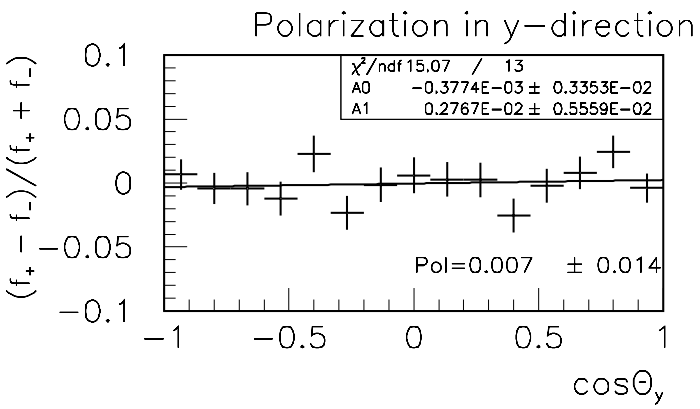
Analysis Magnet NM4AN>0

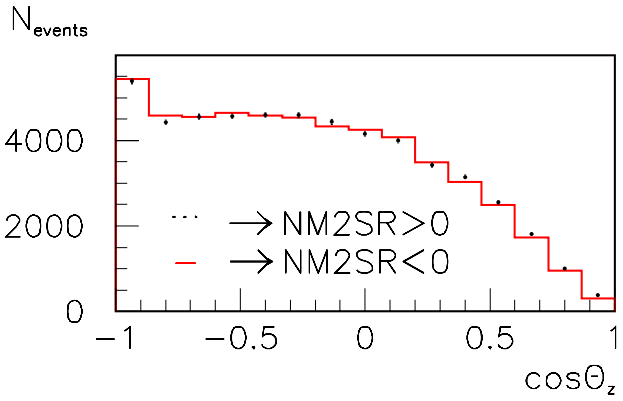
Preliminary

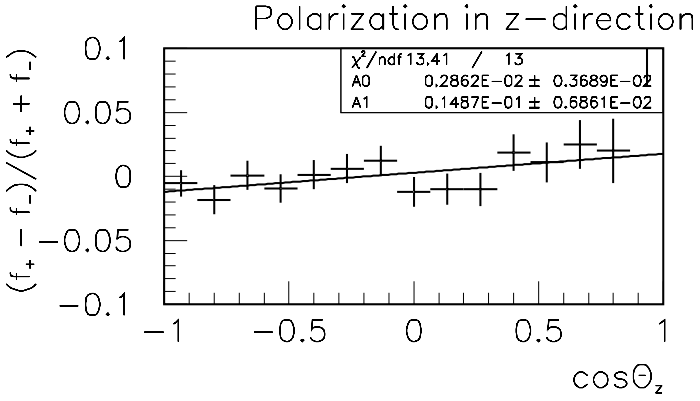






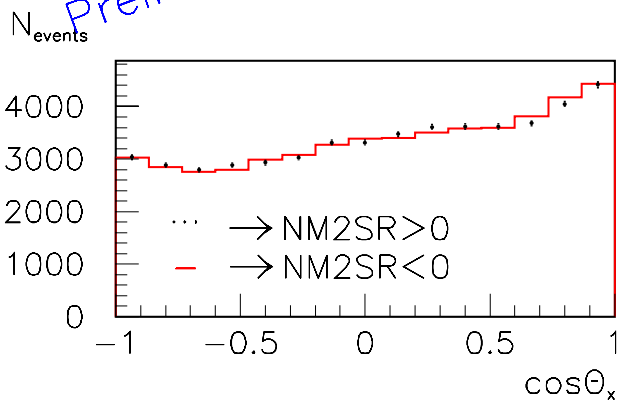


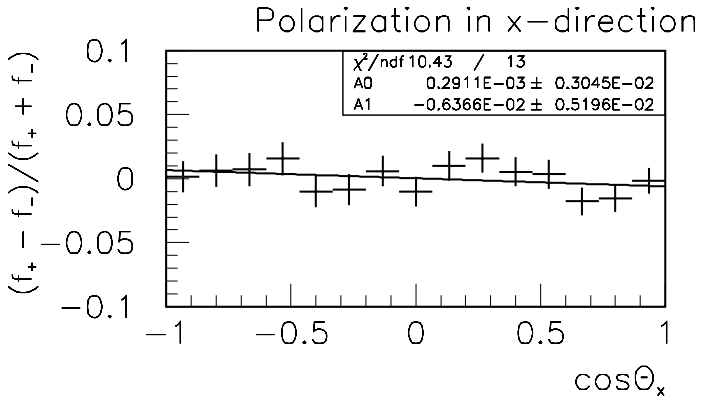


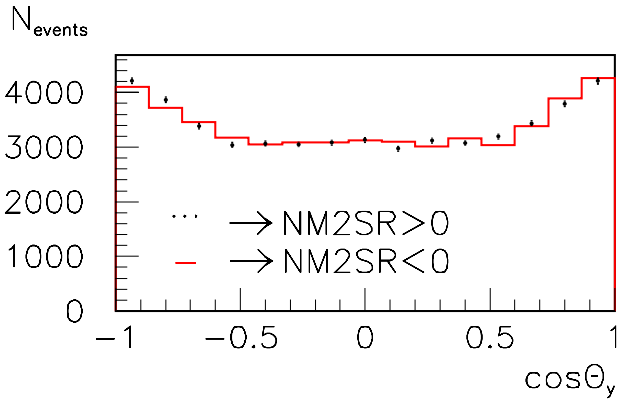


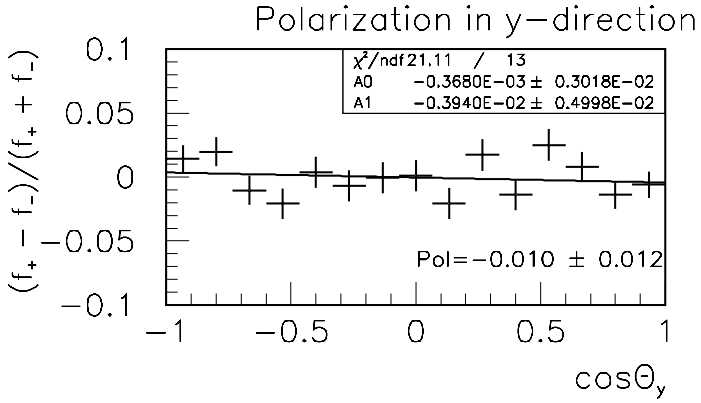
Analysis Magnet NM4AN<0

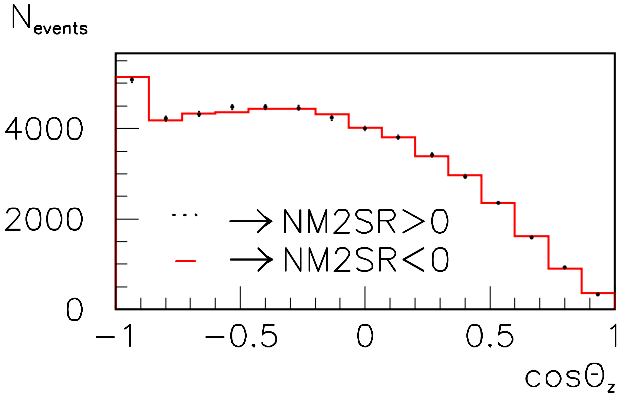
Preliminary

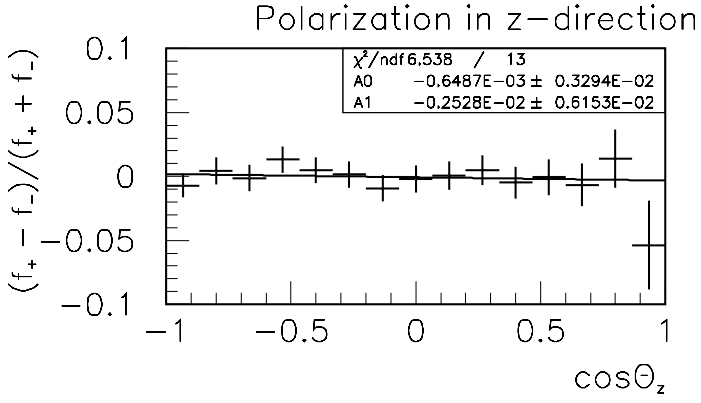


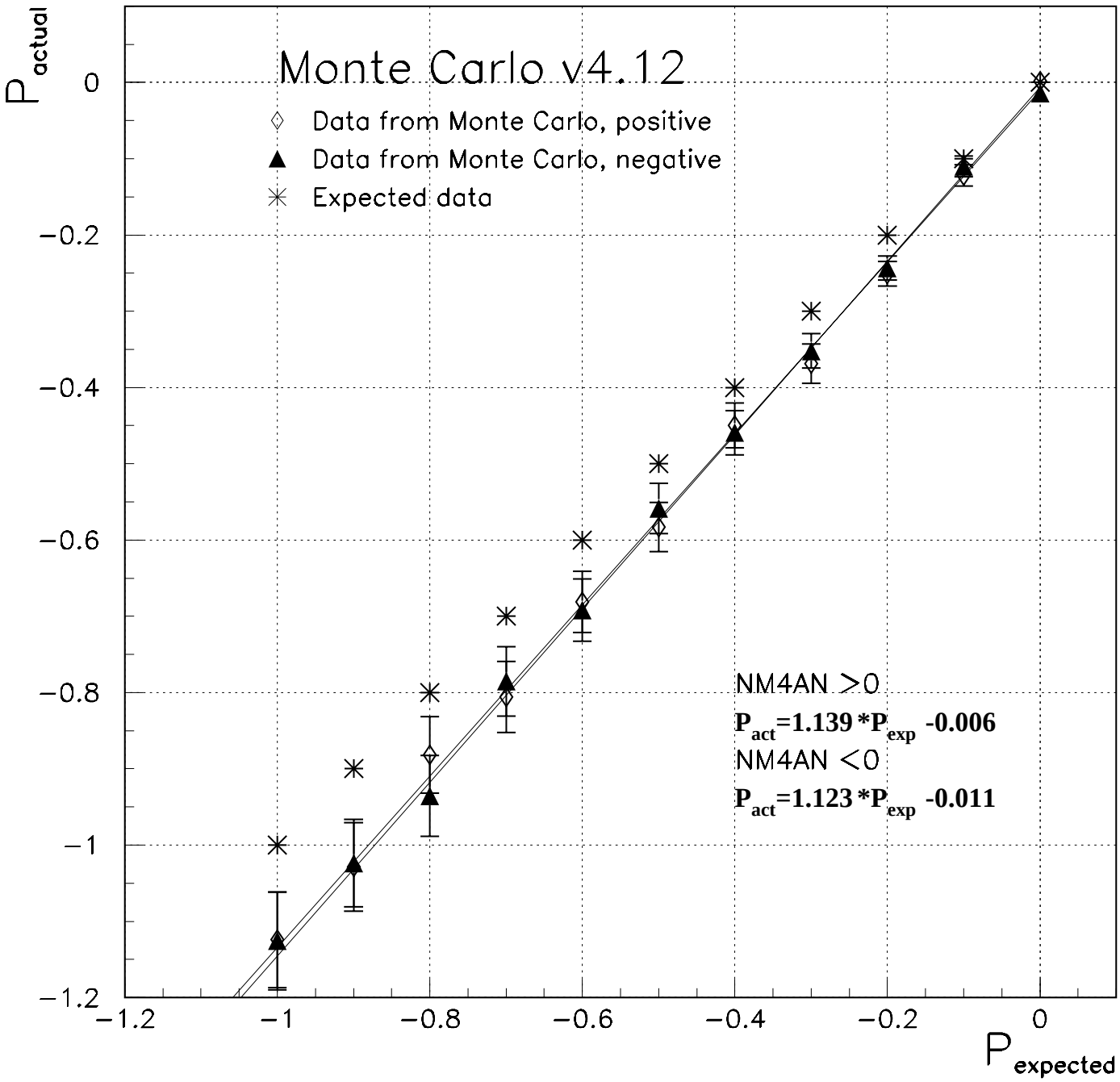


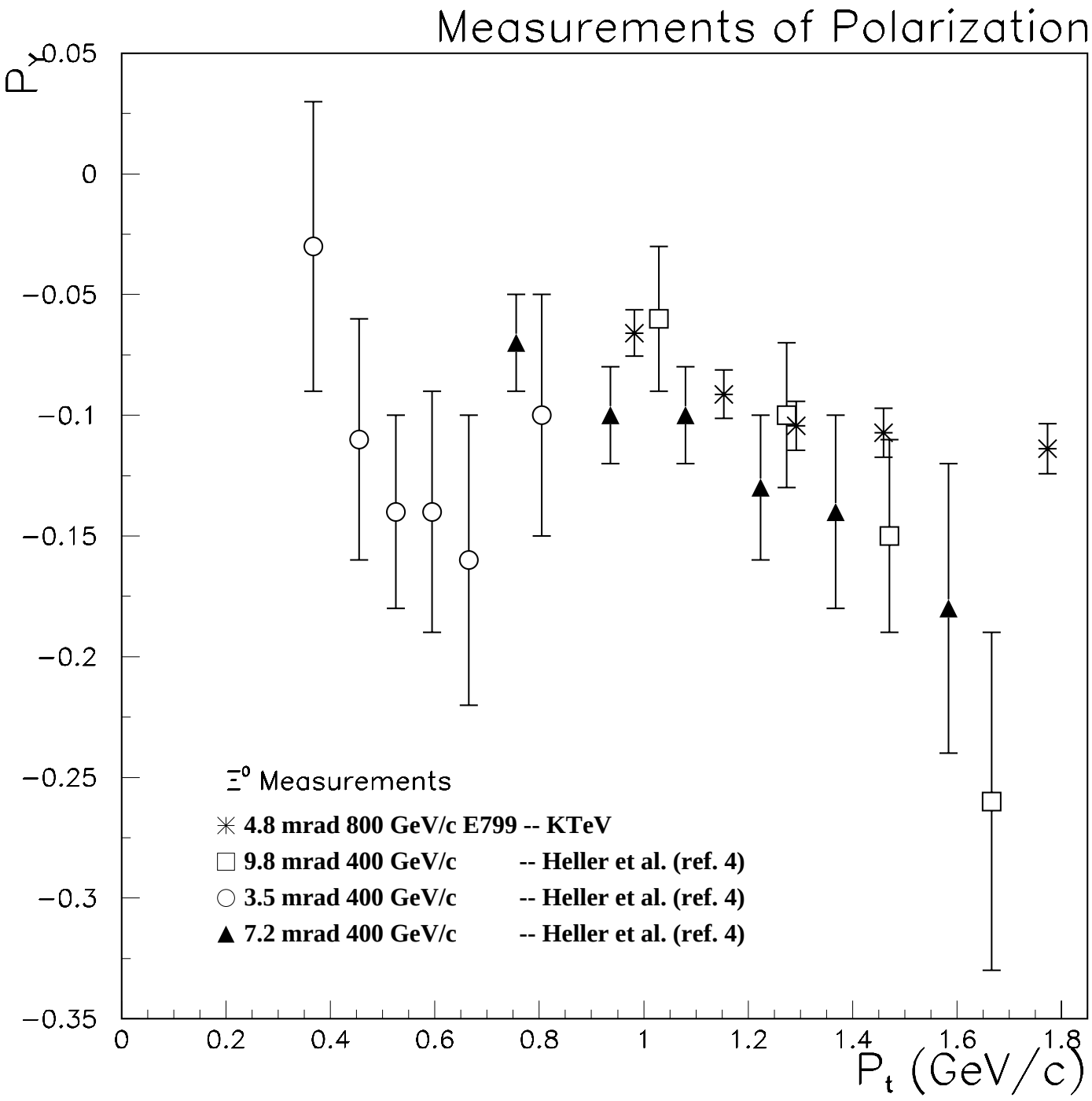


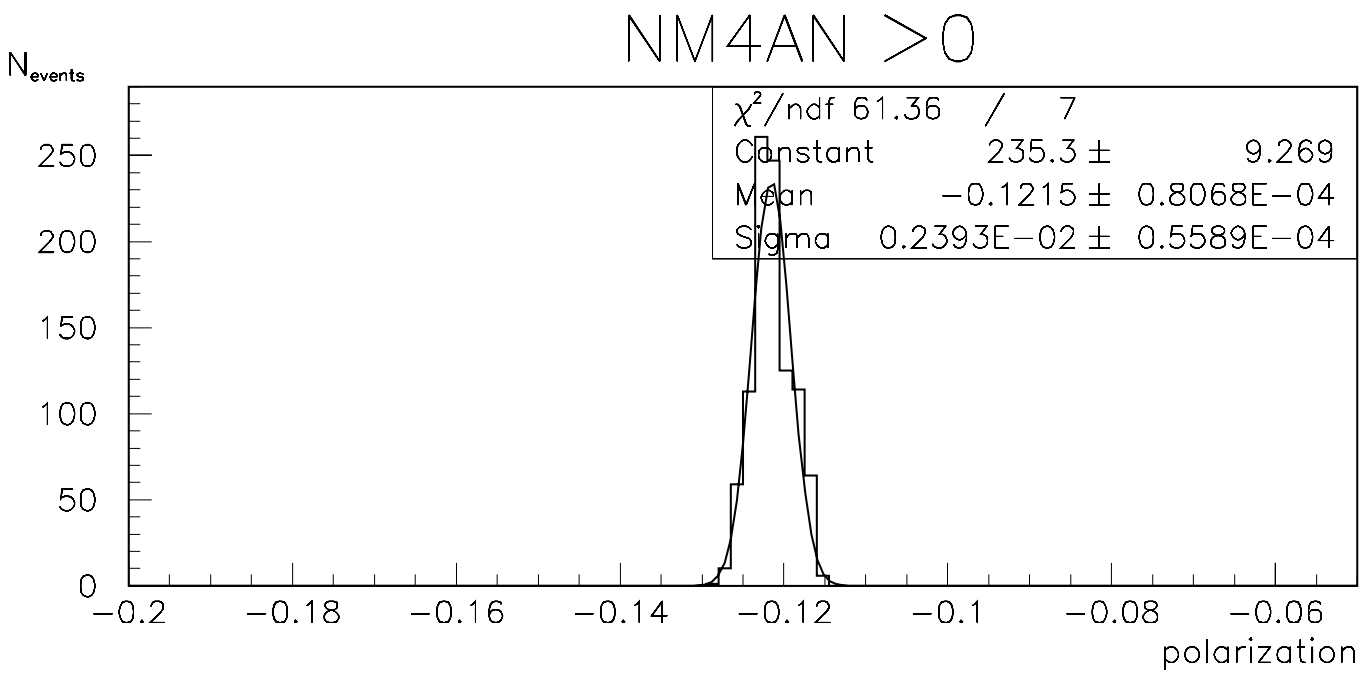


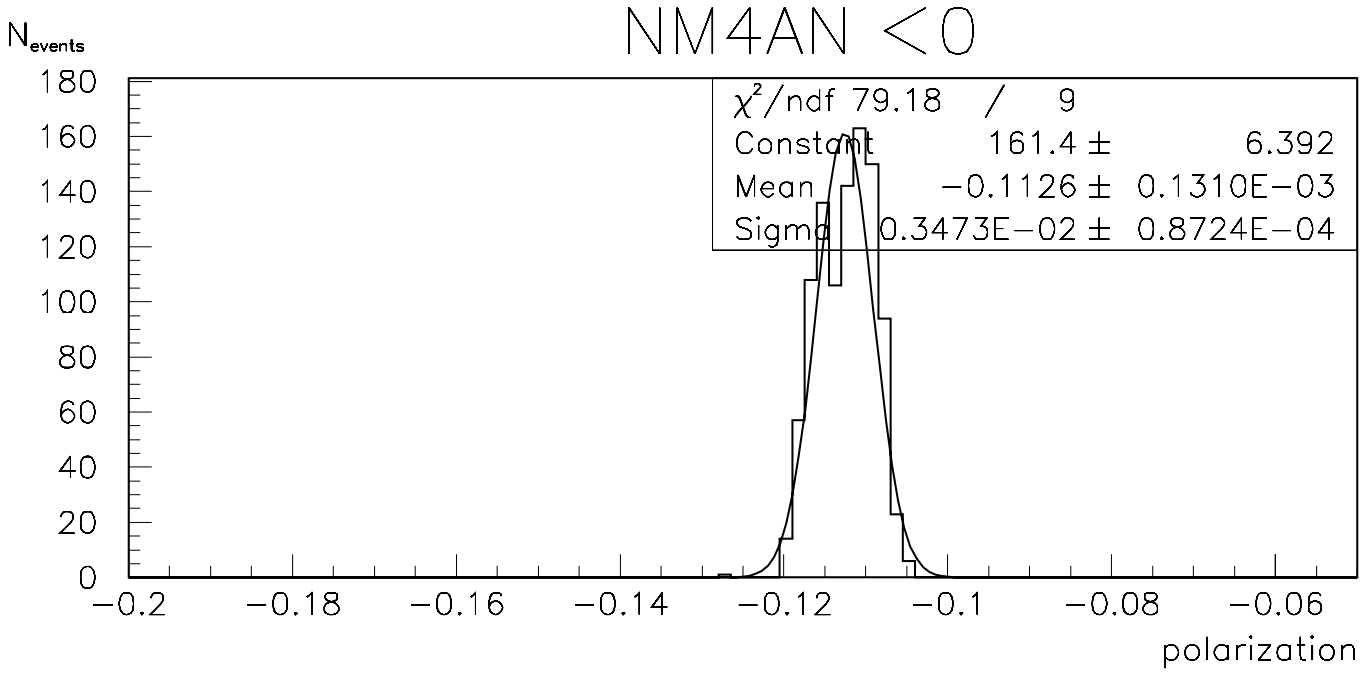


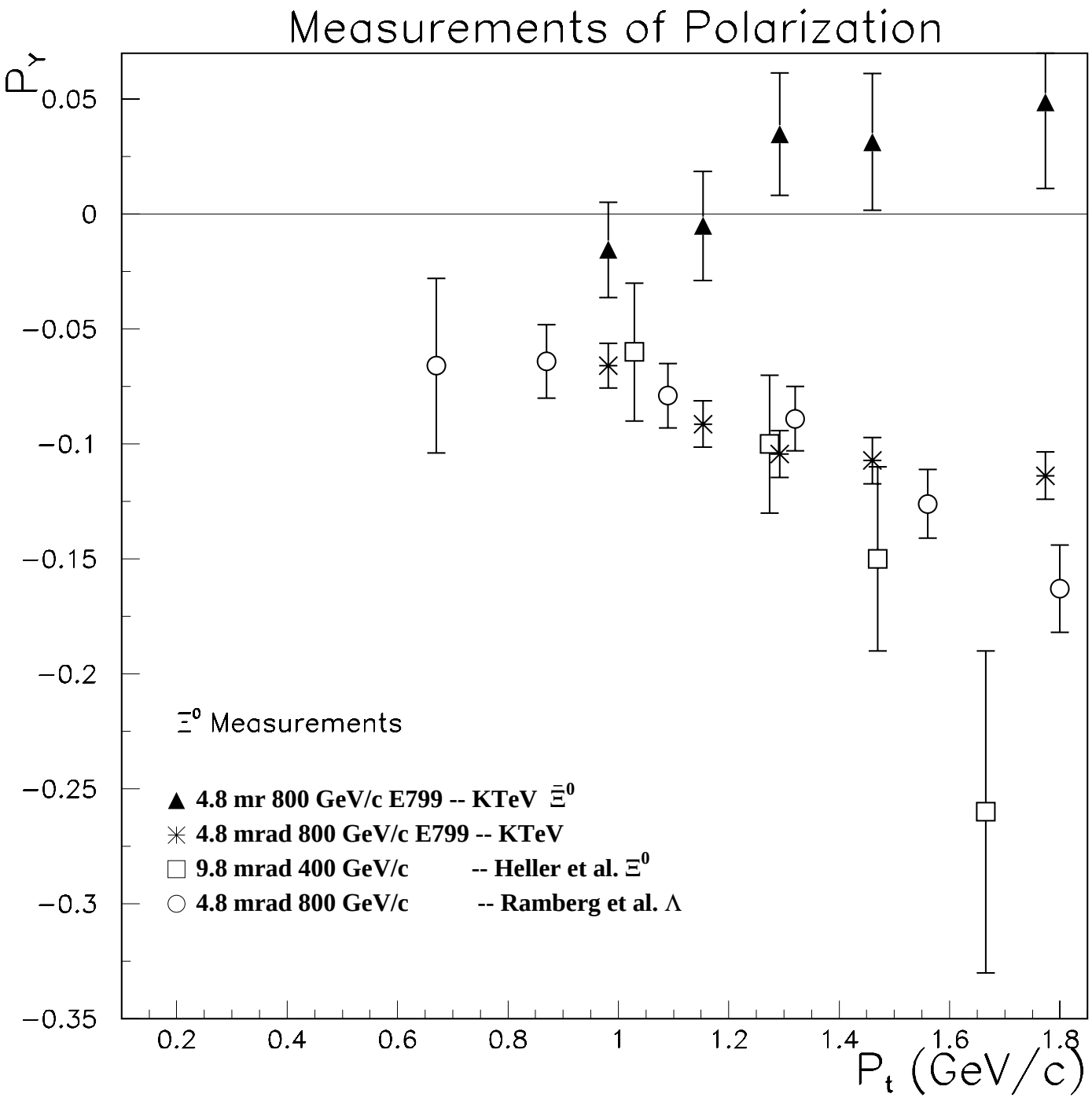



Monte Carlo v4.12
Data from Monte Carlo, positive
Data from Monte Carlo, negative
Expected data
NM4AN >0
P_act=1.139 *P_exp -0.006
NM4AN <0
P_act=1.123 *P_exp -0.011
P_actual
P_expected
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−1.2
−1
−0.8
−0.6
−0.4
−0.2
0


Measurements of Polarization
P_y
0.05
0
−0.05
−0.1
−0.15
−0.2
−0.25
−0.3
−0.35
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
P_t (GeV/c)
Ξ⁰ Measurements
4.8 mrad 800 GeV/c E799 -- KTeV
9.8 mrad 400 GeV/c -- Heller et al. (ref. 4)
3.5 mrad 400 GeV/c -- Heller et al. (ref. 4)
7.2 mrad 400 GeV/c -- Heller et al. (ref. 4)


NM4AN >0
N events
χ²/ndf 61.36 / 7
Constant 235.3 ± 9.269
Mean −0.1215 ± 0.8068E−04
Sigma 0.2393E−02 ± 0.5589E−04
250
200
150
100
50
0
−0.2
−0.18
−0.16
−0.14
−0.12
−0.1
−0.08
−0.06
polarization


NM4AN <0
N events
χ²/ndf 79.18 / 9
Constant 161.4 ± 6.392
Mean −0.1126 ± 0.1310E−03
Sigma 0.3473E−02 ± 0.8724E−04
180
160
140
120
100
80
60
40
20
0
−0.2
−0.18
−0.16
−0.14
−0.12
−0.1
−0.08
−0.06
polarization


Measurements of Polarization
P_y
0.05
0
−0.05
−0.1
−0.15
−0.2
−0.25
−0.3
−0.35
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
P_t (GeV/c)
Ξ^0 Measurements
▲ 4.8 mr 800 GeV/c E799 -- KTeV Ξ^0
✳ 4.8 mrad 800 GeV/c E799 -- KTeV
□ 9.8 mrad 400 GeV/c -- Heller et al. Ξ^0
○ 4.8 mrad 800 GeV/c -- Ramberg et al. Λ