Measurement of the Induced Polarization of Electroproduced Λ(1116) with CLAS

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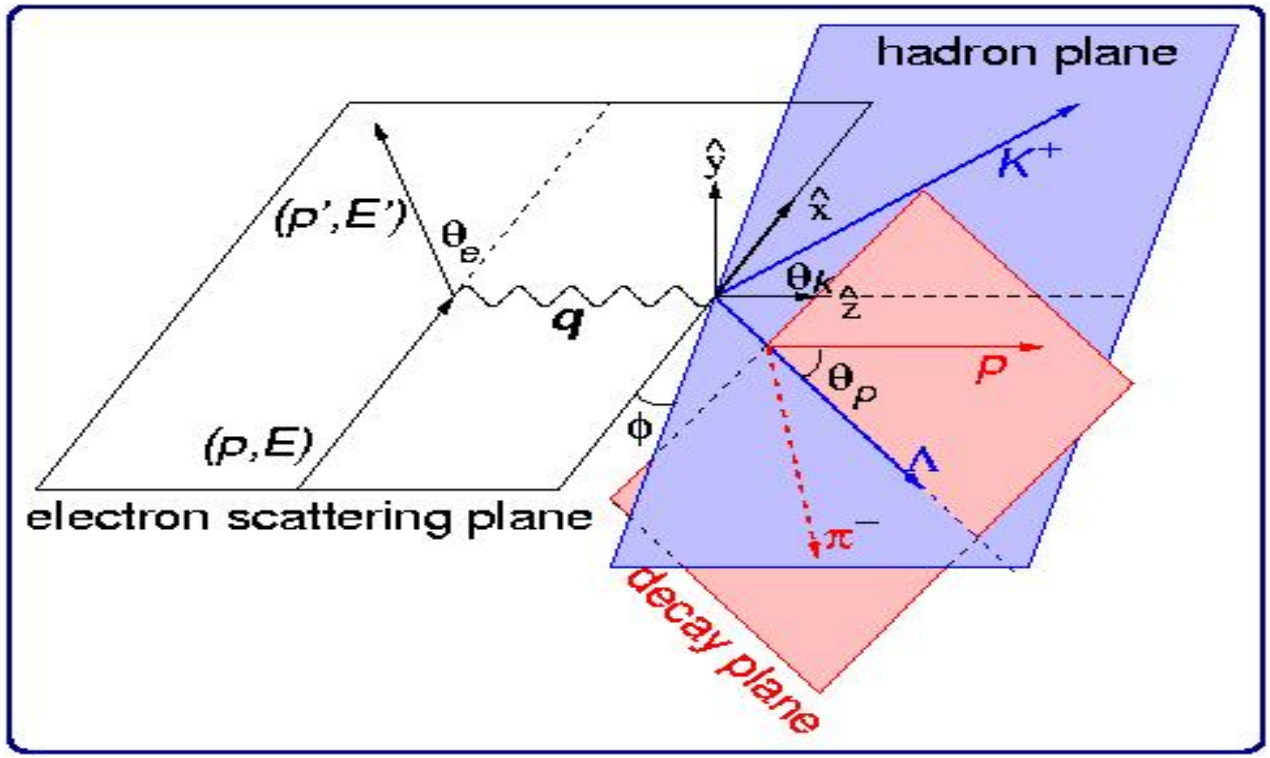
- Analysis Update (**E1F** dataset).
- Current status and future work.
- These results will be presented at the upcoming DNP conference.

Kinematics Definitions

$$e + p \rightarrow e' + K^{+} + (\Lambda \rightarrow \pi^{-} + p)$$



$\nu = E - E'$……Energy transferred by virtual photon.

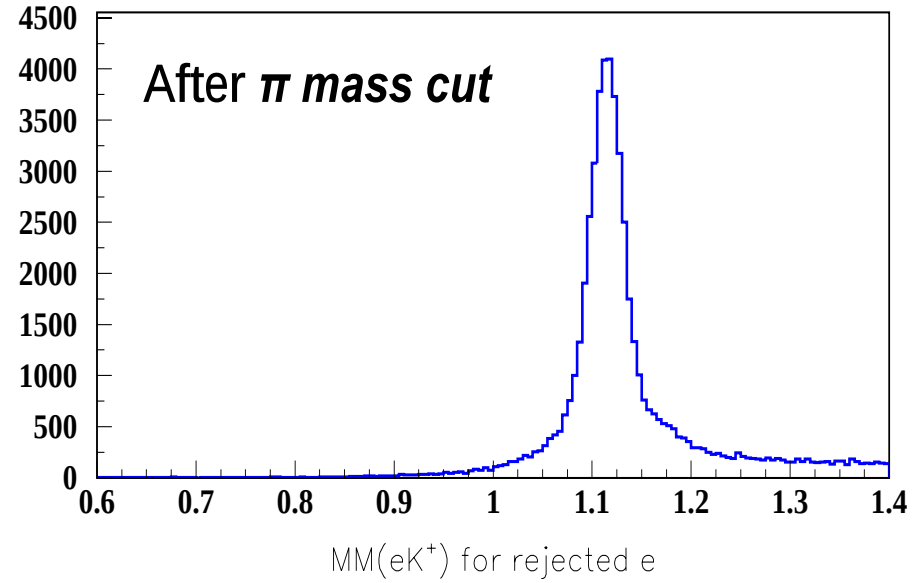
$Q^2 = -q^2 = 4EE'\sin^2(\theta_e/2)$……...Momentum of virtual photon.

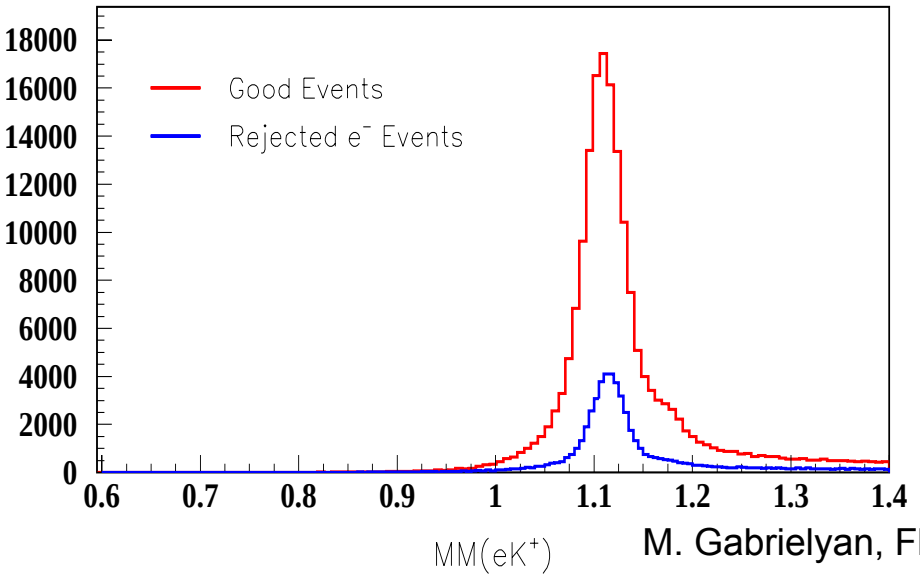
$W^2 = M_p^2 + 2M_p\nu - Q^2$……C.M. mass of intermediate state.

Analysis Method Summary

- Electron identification
  - Good EC fiducial cut
  - Good traceback to target
  - Fiducial cuts (flat acceptance region)
  - Momentum corrections
- Hadron (*K*,*p*) identification
  - Timing cut
  - Fiducial cuts
  - Momentum corrections
- Hyperon (Λ, Σ^0) identification
  - Reconstructed missing mass for $e+p \rightarrow e'K^+(Y)$
  - For recoil polarization observables $e+p \rightarrow e'K^+p(\pi^-)$ include π^- missing-mass cut

Study of Electron Cuts





Starting e^- sample ~296000.

All standard e cuts:

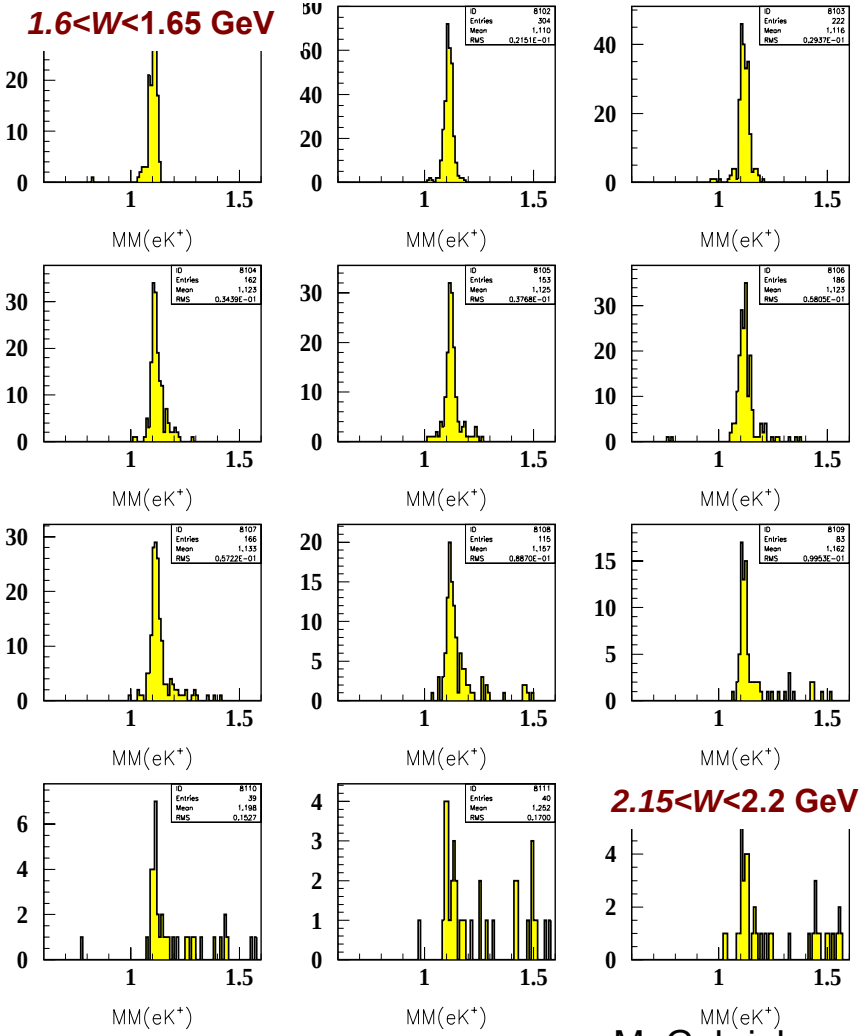
1. CC cut (nphe > 25). (~56,000 events)
2. EC inner cut. (~5,000 events)
3. Trigger threshold. (~3,000 events)
4. Reef cut. (~49,000 events)
5. Sampling Fraction. (~5,000 events)
6. EC Fiducial cut. ☑
7. Z-Vertex. ☑

Number of Events with ALL standard cuts was ~193,000.

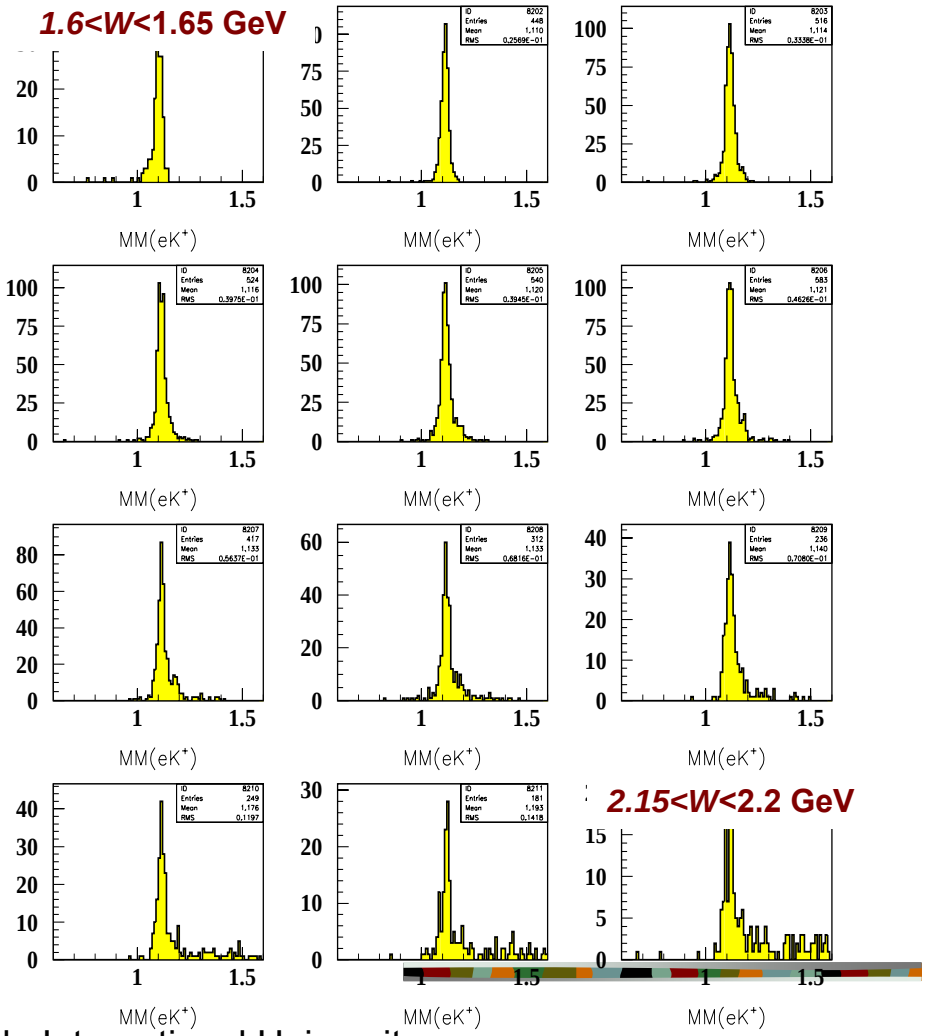
TOTAL Events Recovered ~89,000.

Study of Electron Cuts

Rejected e^-. $-1<\cos(\theta_K^{CM})<-0.5$



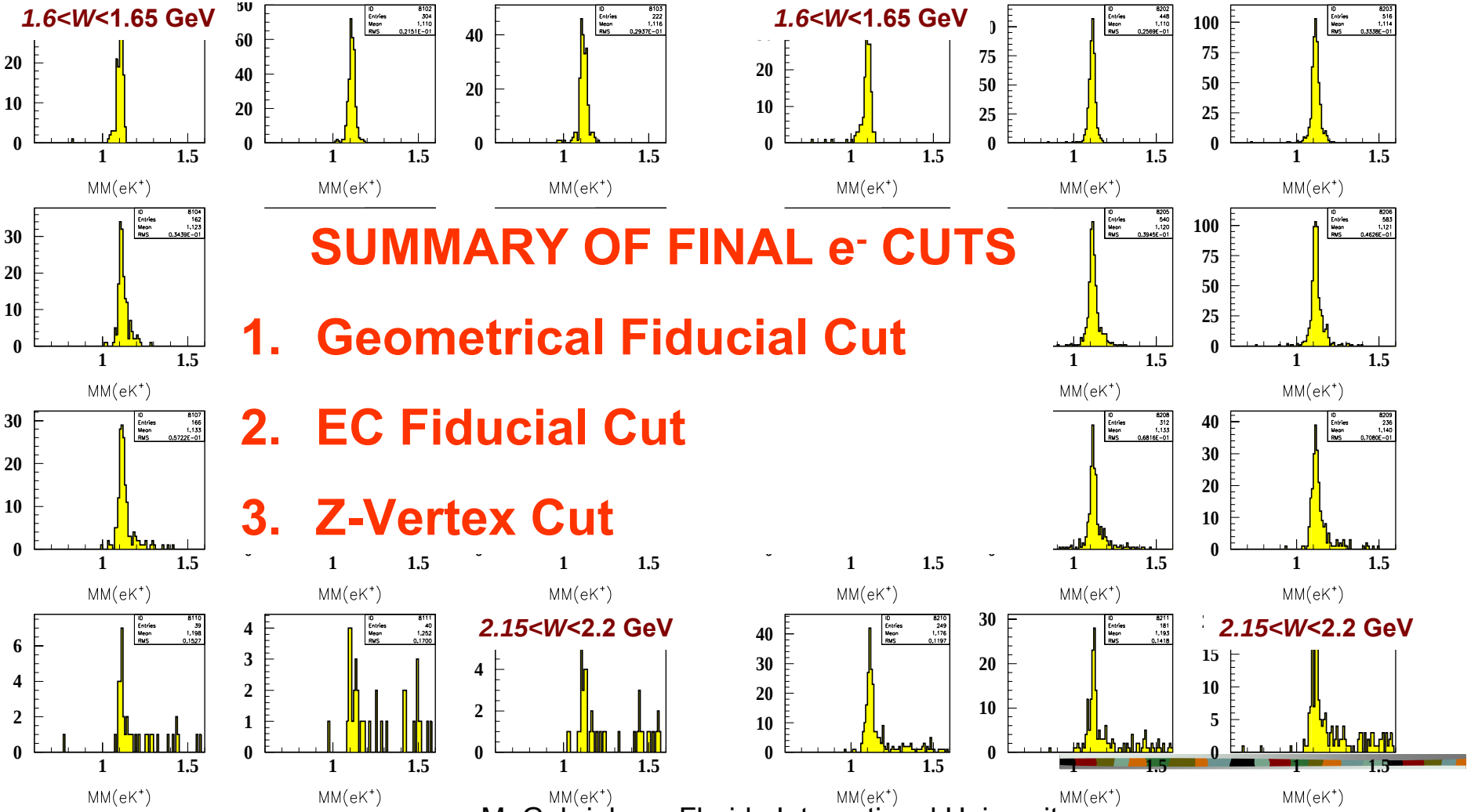
Rejected e^-. $-0.5<\cos(\theta_K^{CM})<0.$



Study of Electron Cuts

Rejected e^-. $-1<\cos(\theta_K^{CM})<-0.5$

Rejected e^-. $-0.5<\cos(\theta_K^{CM})<0.$



SUMMARY OF FINAL e^- CUTS

1. Geometrical Fiducial Cut
2. EC Fiducial Cut
3. Z-Vertex Cut

Hadron Identification

Timing cut to minimize $\Delta t = t_1 - t_2$

Δt - Difference between the time t_1 it takes for hadron with momentum p to travel from vertex to SC and the time t_2 it takes for assumed particle with the same momentum to travel the same distance.

$$t_1 = \frac{d}{\beta_1 c}, \quad m_1 = \frac{p}{\beta_1 \gamma c},$$

$$t_2 = \frac{d}{\beta_2 c}, \quad \beta_2 = \frac{p}{\sqrt{(m_2 c)^2 + p^2}}.$$

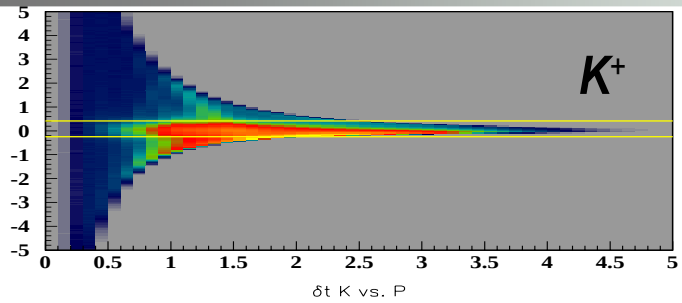
d - distance from vertex to SC system

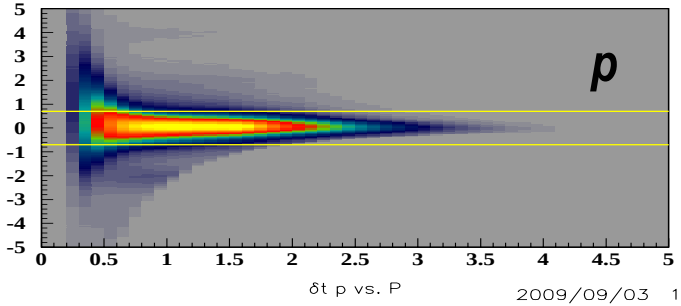
m_2 - is the *assumed* particle mass.

$$\Delta t = t_1 \left(1 - \sqrt{\frac{p^2 + (m_2 c)^2}{p^2 + (m_1 c)^2}} \right)$$

Minimum Δt identifies the hadron.

Hadron Identification





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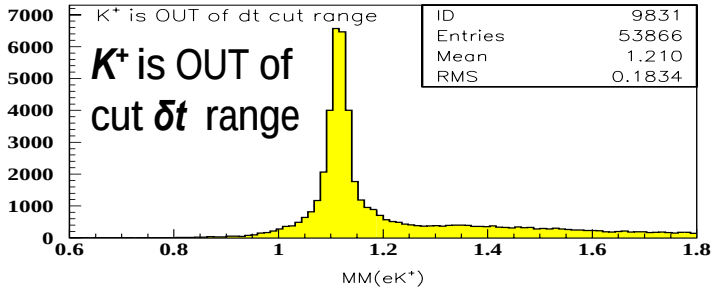
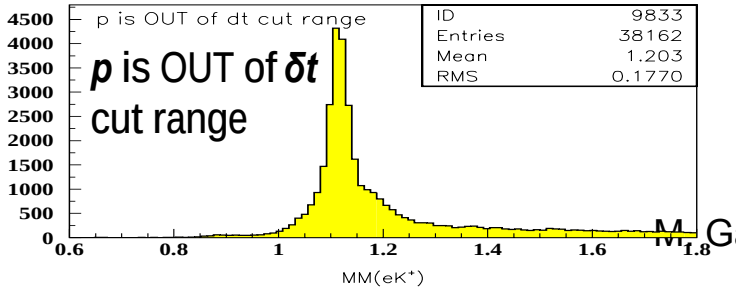
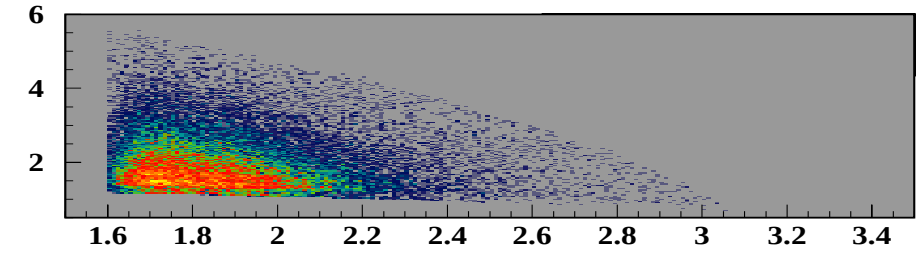
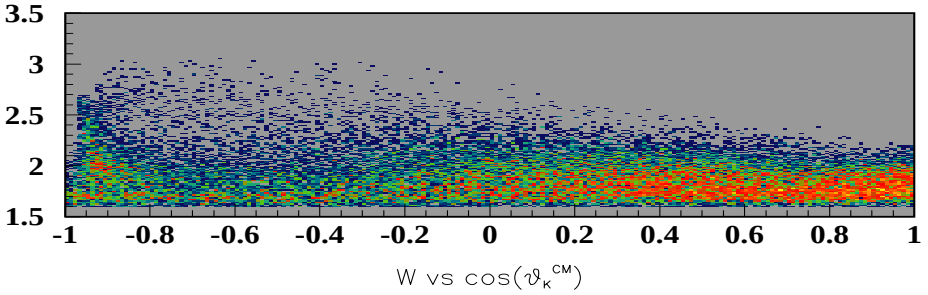
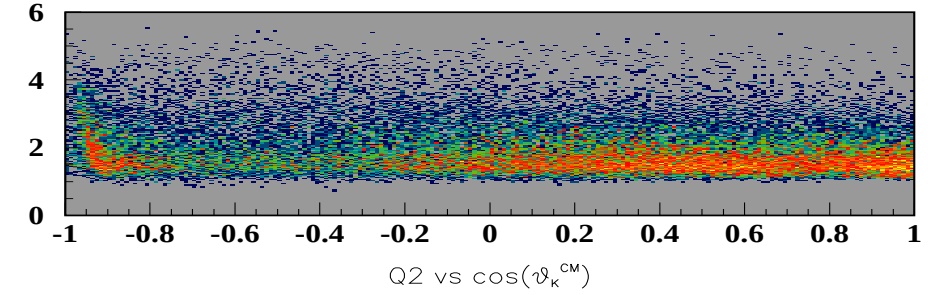




K^+ is OUT of δt cut range





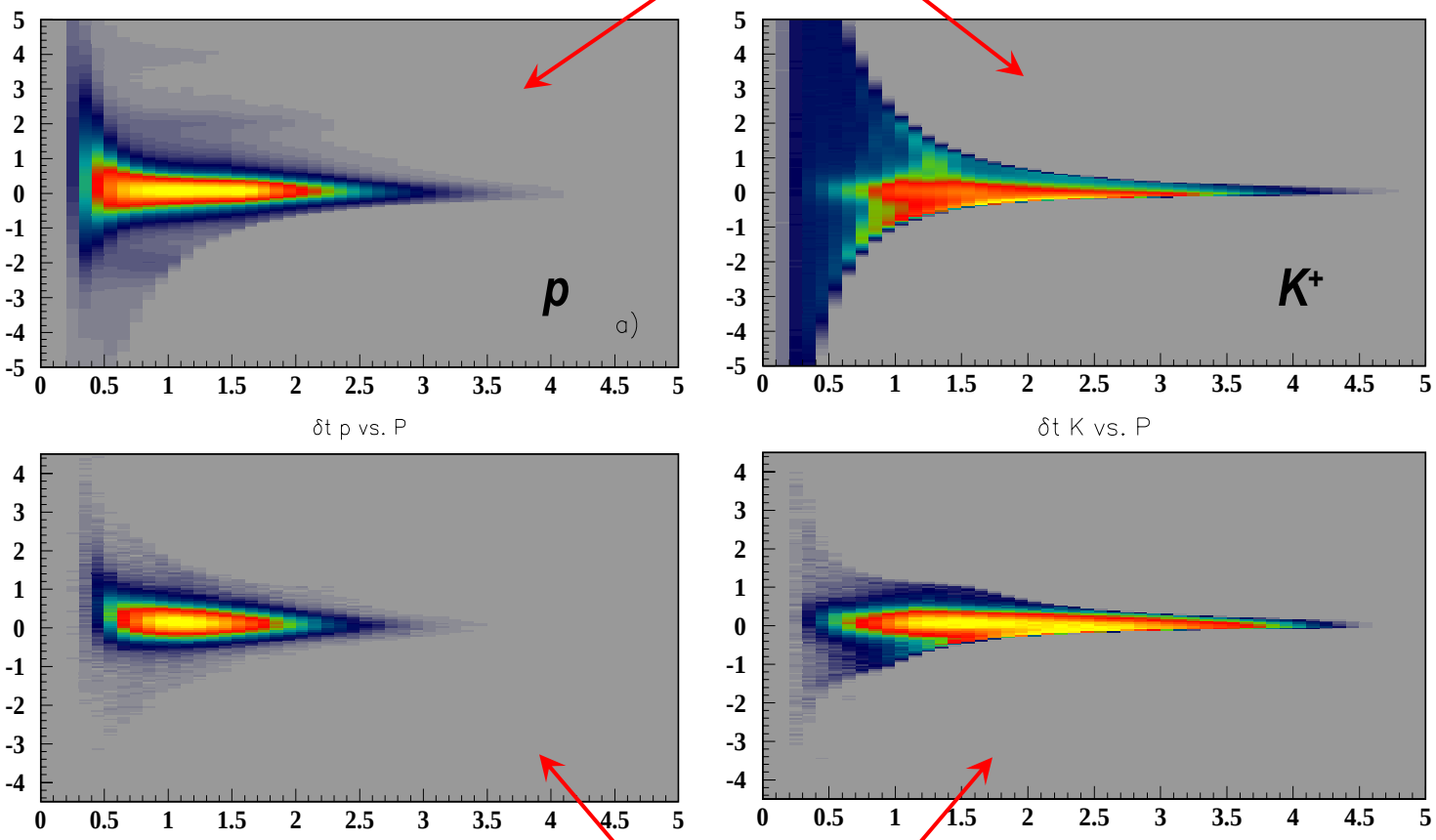


Removing δt cuts recovers ~85,000 events

Hadron Identification

Minimum Δt identifies the hadron.

ALL *p* and *K* (NO Λ or π missing mass cuts)



δt vs p

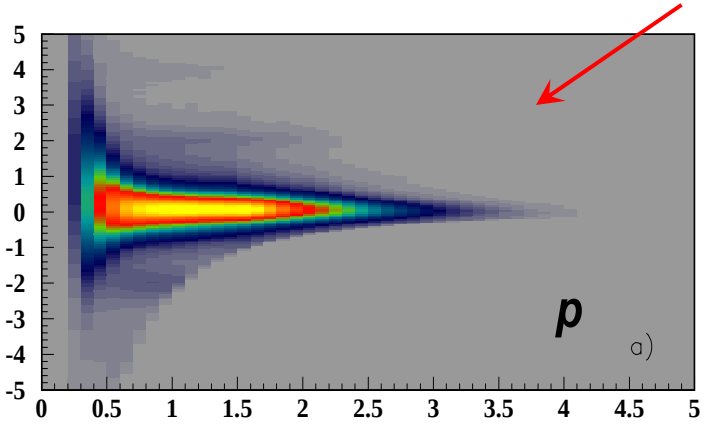
δt vs p

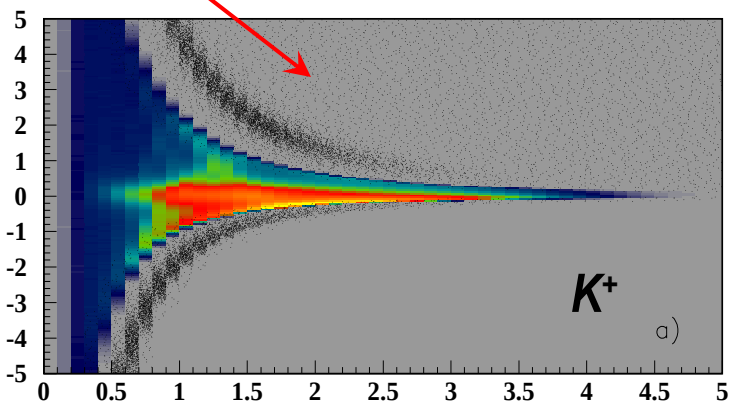
After Λ and π missing mass cuts

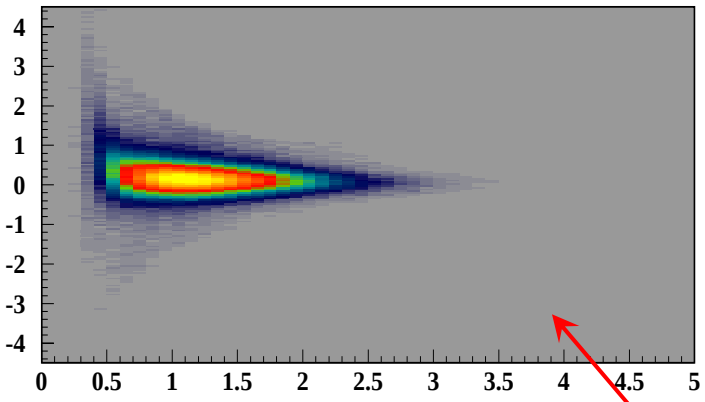
Hadron Identification

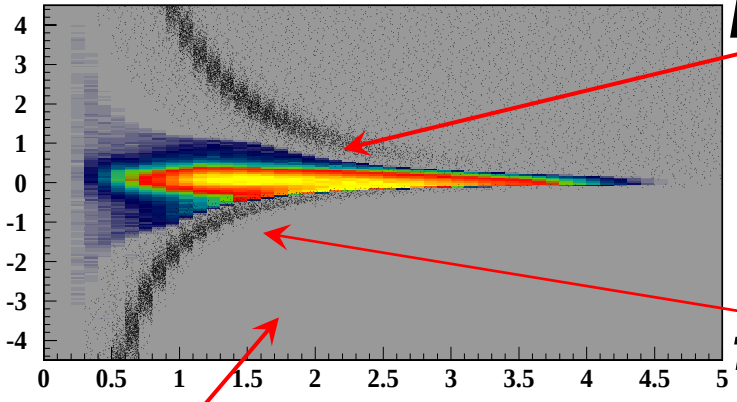
Minimum Δt identifies the hadron.

ALL *p* and *K* (NO Λ or π missing mass cuts)









p given K mass

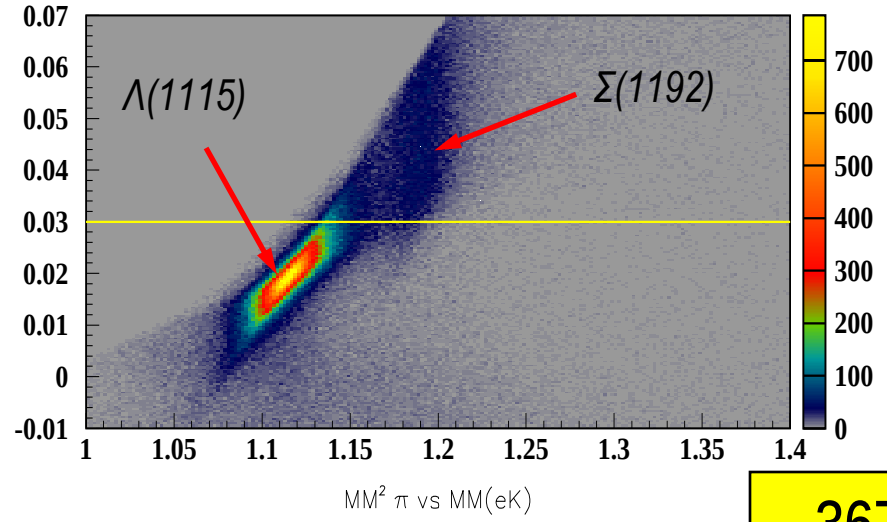
π given K mass

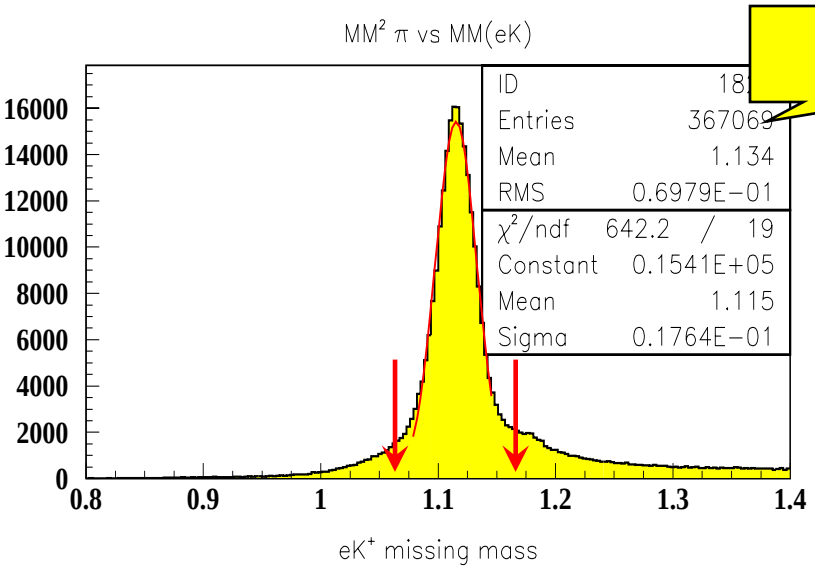
δt vs p

δt vs p

After Λ and π missing mass cuts

Hyperon Identification



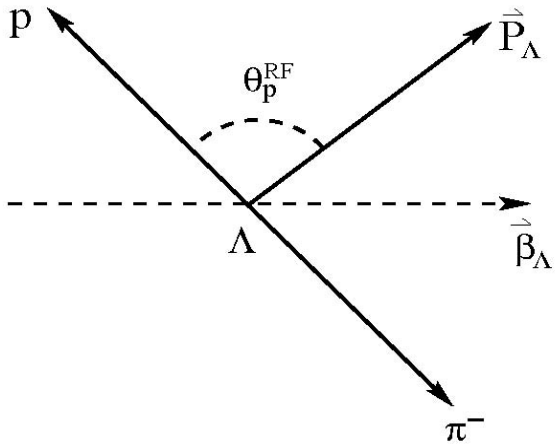


367,069

Total number of events with ALL standard e^- cuts was **~193,000**. Total number of events recovered after removing dt cuts and some of the e^- cuts is **~174,000**, bringing the total number of GOOD events to **~367,000.**

Background in the Λ missing mass spectrum is due to MOSTLY misidentified π's, some misidentified p's and Σ's.

Λ Polarization Extraction



Parity non-conservation in weak decay allows to extract recoil polarization from *p* angular distribution.

$$\frac{dN}{d\cos\theta_p^{RF}} = N(1+\alpha P_\Lambda \cos\theta_p^{RF}),$$

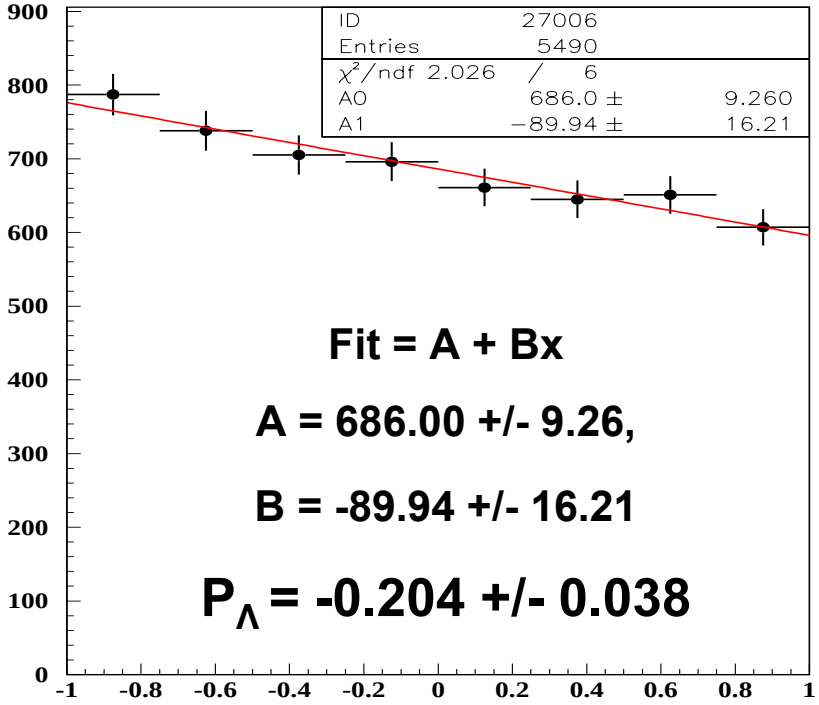
where: α= *0.642 ± 0.013* (PDG)

Two ways to extract polarization:

1. **Calculating $P_\Lambda \sim (N_F-N_B) / (N_F+N_B)$**

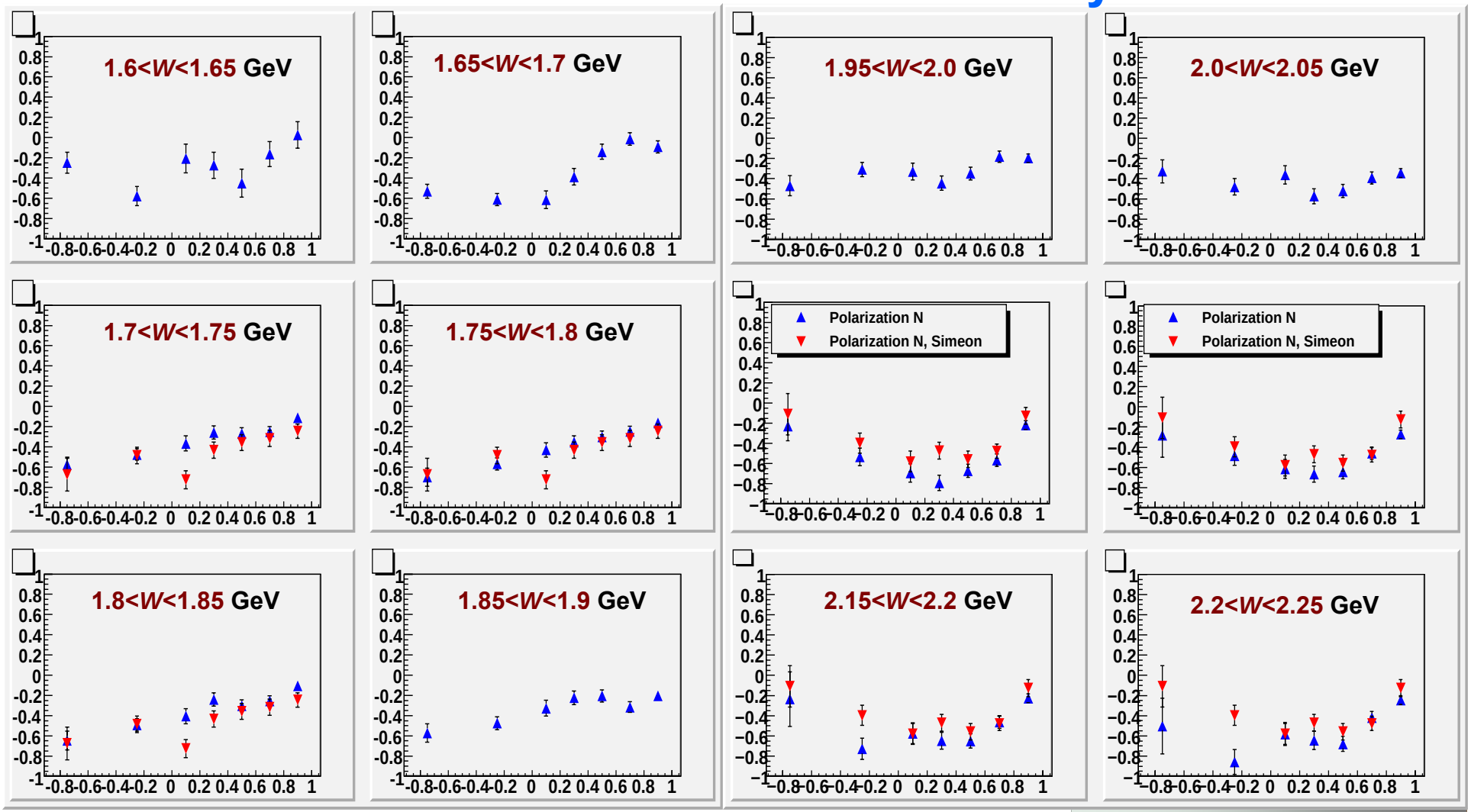
2. Fitting a line to angular distribution.

The presented polarization results are CALCULATED via forward-backward asymmetry.



Induced Polarization vs $\cos(\theta_K^{CM})$

Preliminary Results

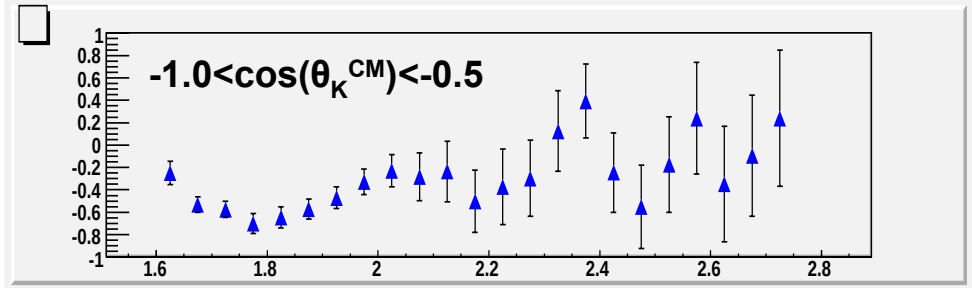


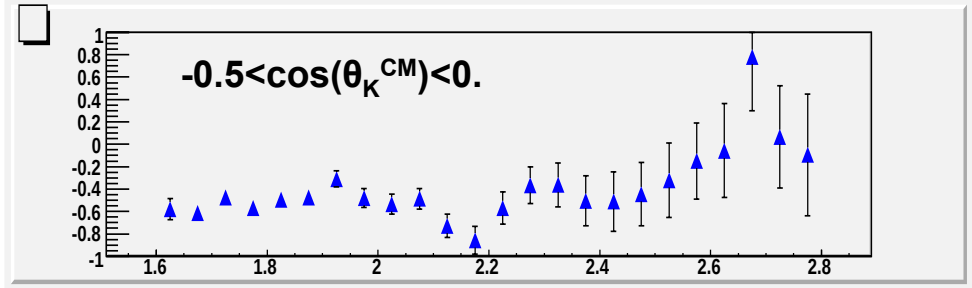
1.71<W<1.87 (GeV)
SUM over Q^2, Φ

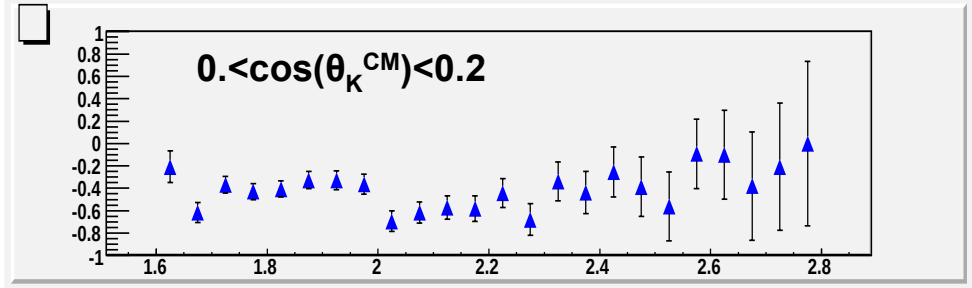
W: 1.6-2.2 (GeV), 50 MeV bins
SUM over Q^2, Φ

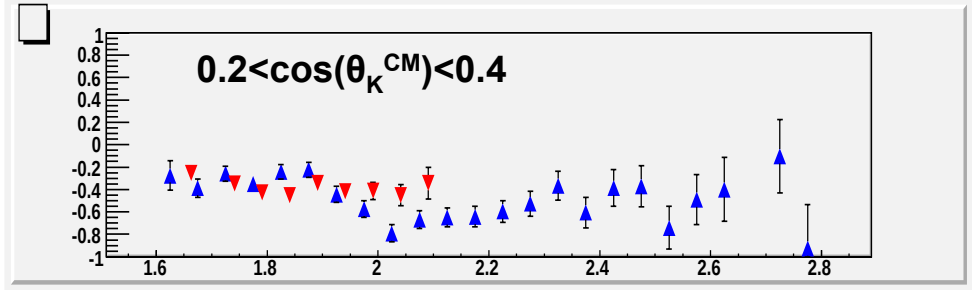
1.873<W<2.152 (GeV)
SUM over Q^2, Φ

Induced Polarization vs *W*





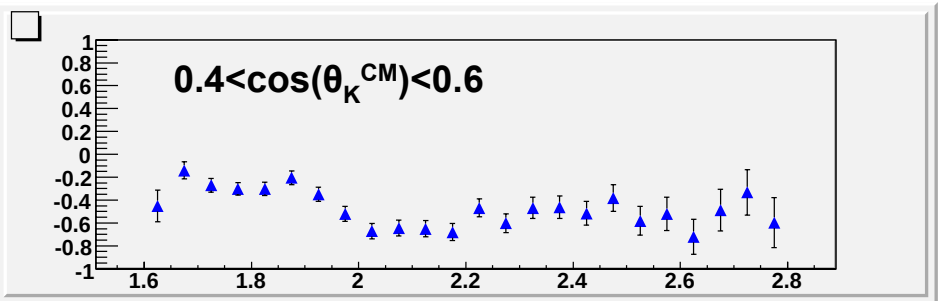


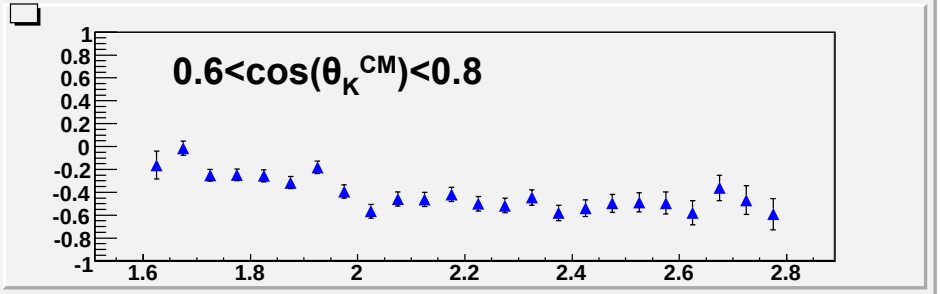


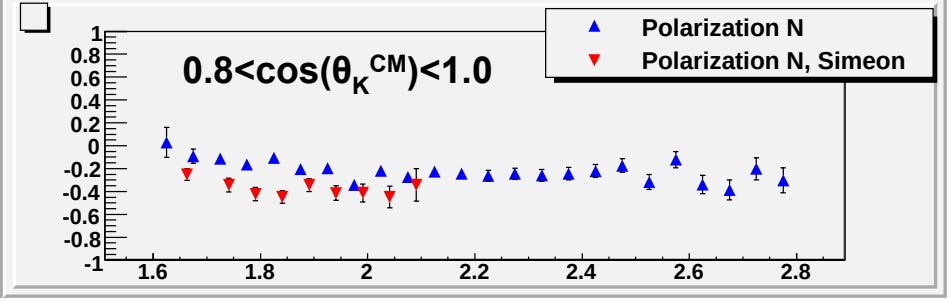
Preliminary Results

SUM over Q^2, Φ

Simeon's results are also summed over $\cos(\theta_K^{CM})$







Induced Polarization vs *W (photoproduction)*

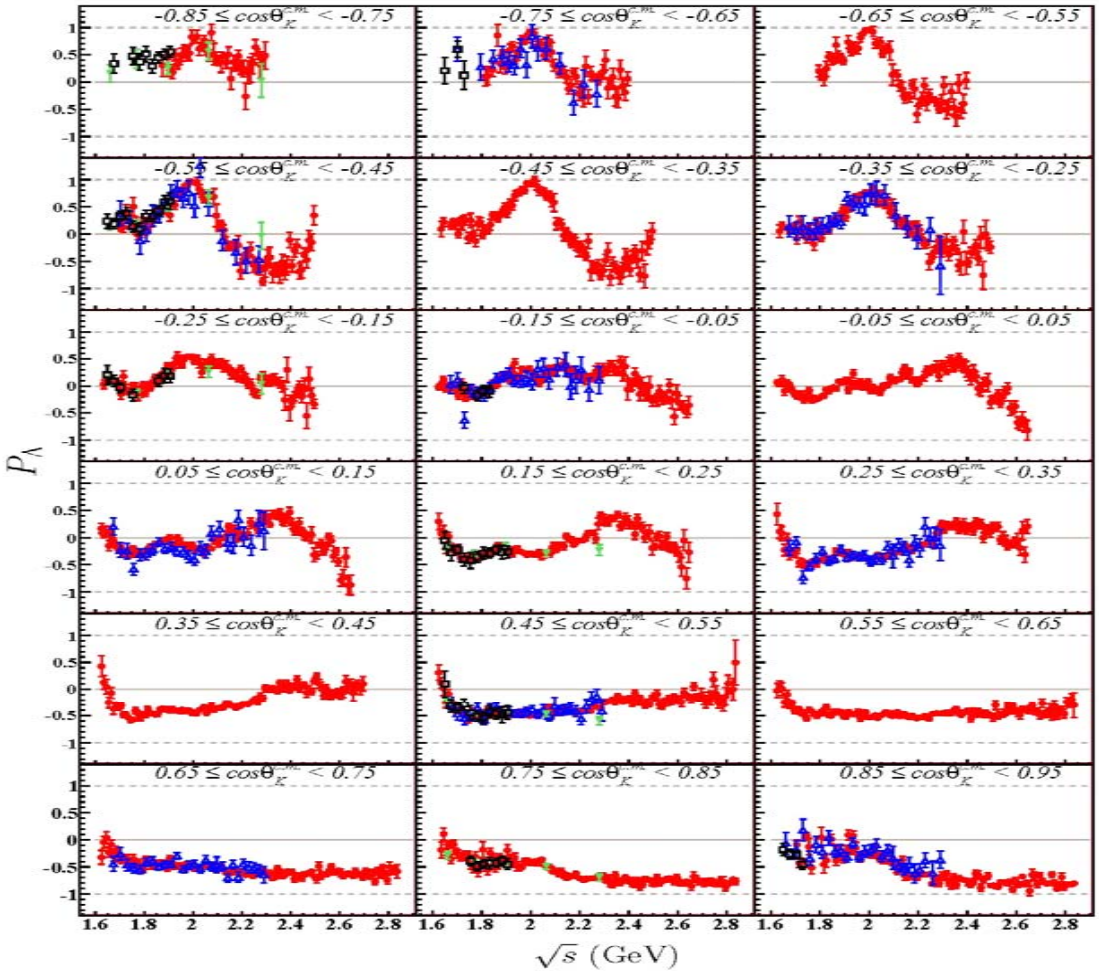
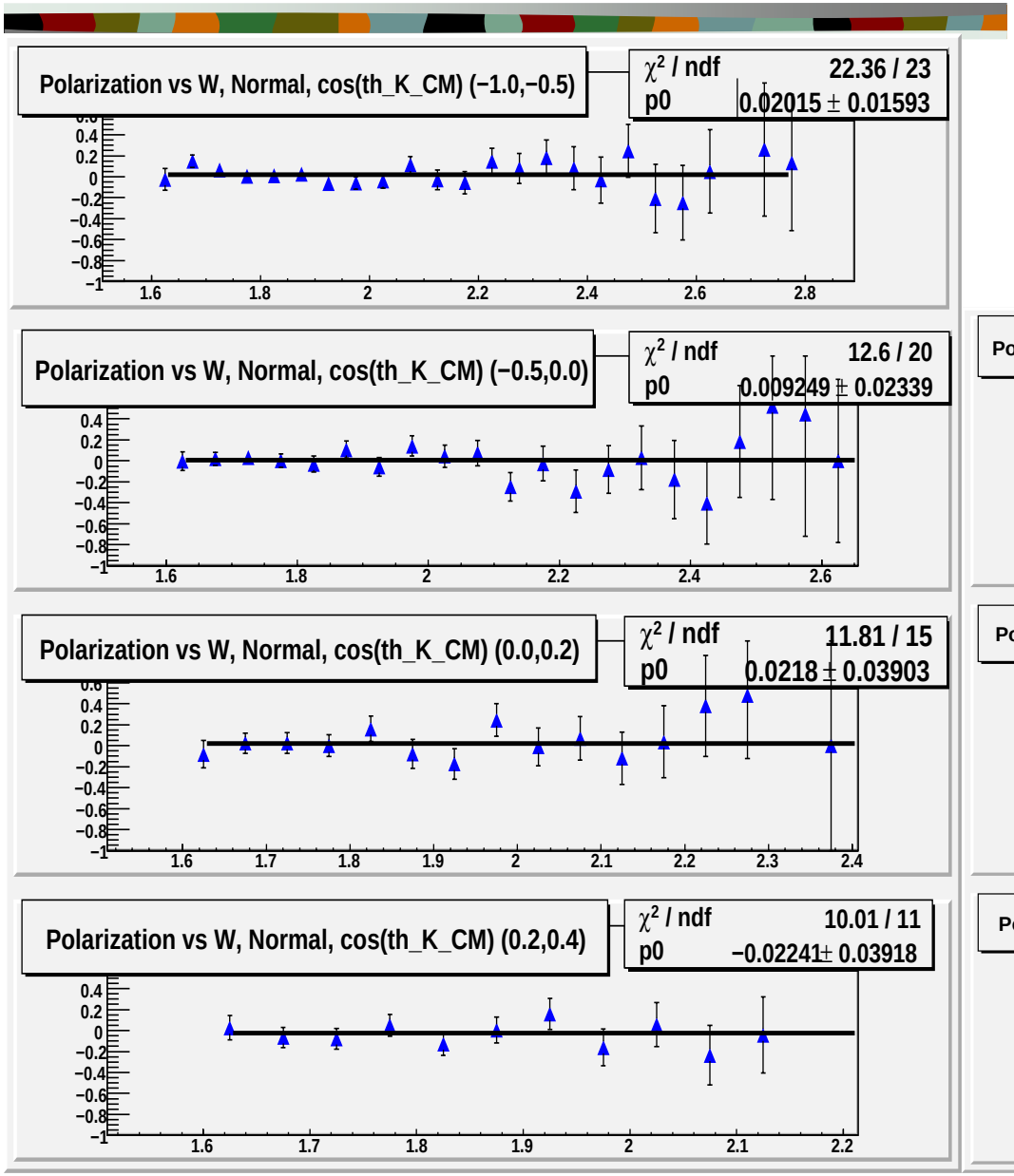


FIG. 12: (Color On-line) P_Λ *vs* $\sqrt{s}$ (GeV) in bins of $\cos\theta_K^{c.m.}$. Results of this analysis are represented by red circles, previous CLAS (McNabb, *et al.* [19]) results by blue triangles, SAPHIR 2004 (Glander, *et al.* [3]) by green triangles, and GRAAL 2007 (Lleres, *et al.* [20]) by black squares. Physical limits on P_Λ are indicated by dashed horizontal lines.

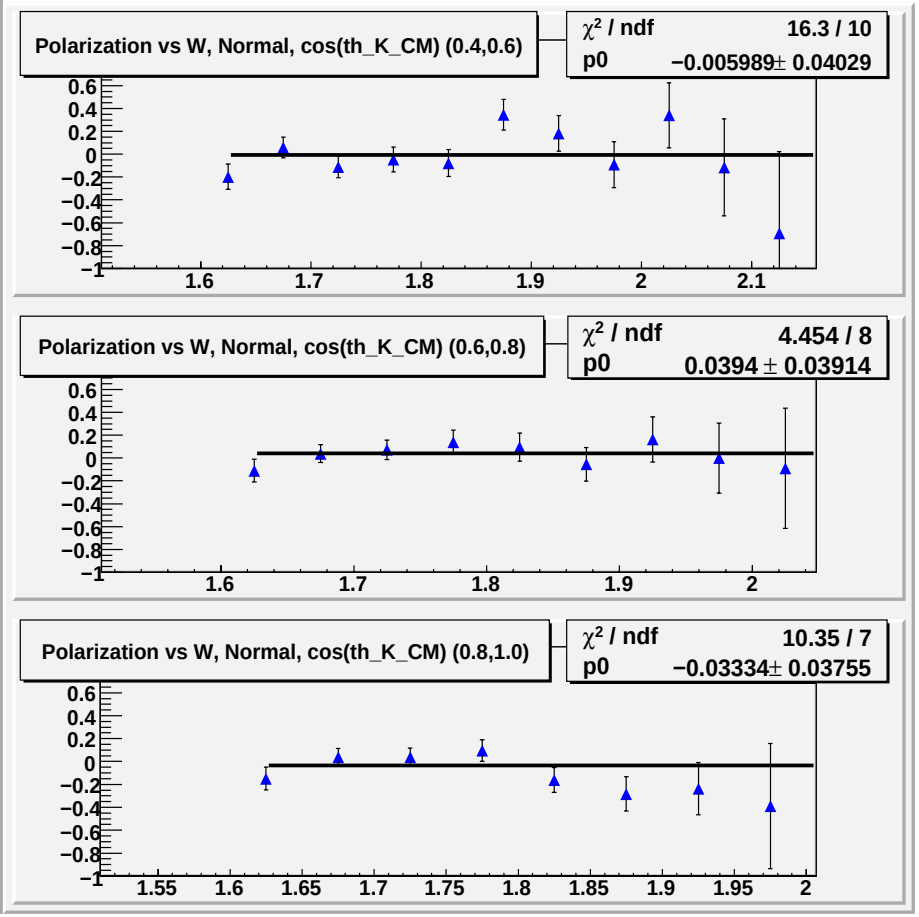
Figure from M. McCracken Dissertation

π Background Polarization vs W



Preliminary Results

SUM over Q^2, Φ



Current Status

- Geometrical fiducial cuts are finalized.
- e^- and hadron cuts are finalized.
- Final state identification cuts are finalized.
- Currently working on background subtraction using MC templates for fitting.

Polarized Σ contribution must be accounted for. Although the π and p backgrounds are unpolarized, they still have some dilution effect on polarization results.

Future Work

It is necessary to repeat induced polarization measurement by Simeon McAleer (FSU). Previous measurement combines data from 4 different data sets with different energies and torus currents.

E_{beam}(GeV)	W(GeV)	Q^2(GeV^2)	N_Λ	N_Σ
2.567	1.6-2.1	0.3-1.3	42000	8000
4.261	1.6-2.5	0.7-3.0	34000	6500
5.754	1.6-3.0	1.5-4.5	82000	16000
5.499	1.6-3.0	0.8-3.5	367000	?

NEXT…

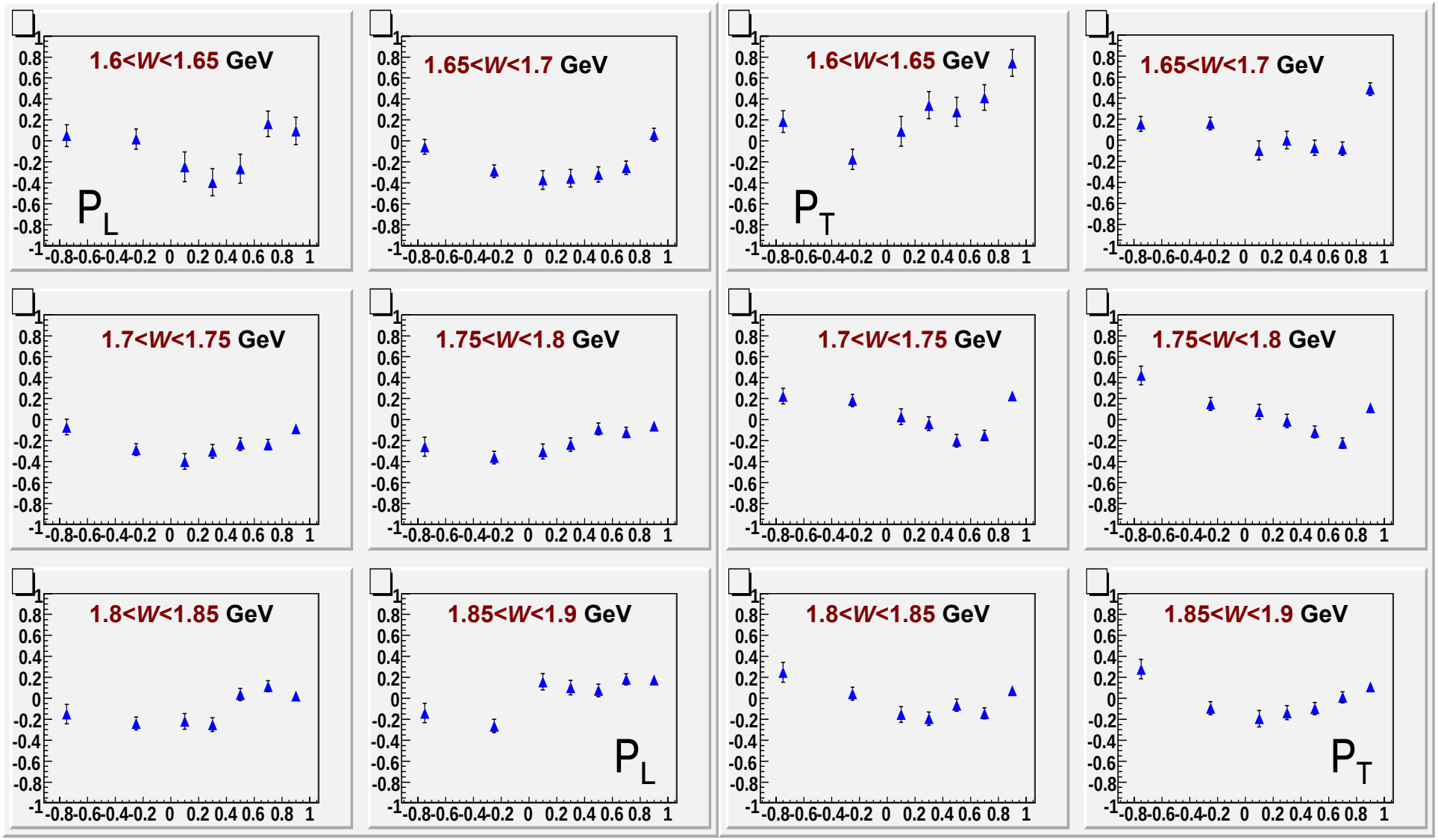
- Determine acceptance corrections.
- Acceptance corrected polarization extraction.

Strong systematic check of our results is to show that the P_L and P_T components are consistent with 0.

- Systematic error analysis.
- Comparison to theory.

P_L and P_T vs $\cos(\theta_K^{CM})$

No acceptance corrections. No background subtraction.



Fit Parameters for Background Polarization

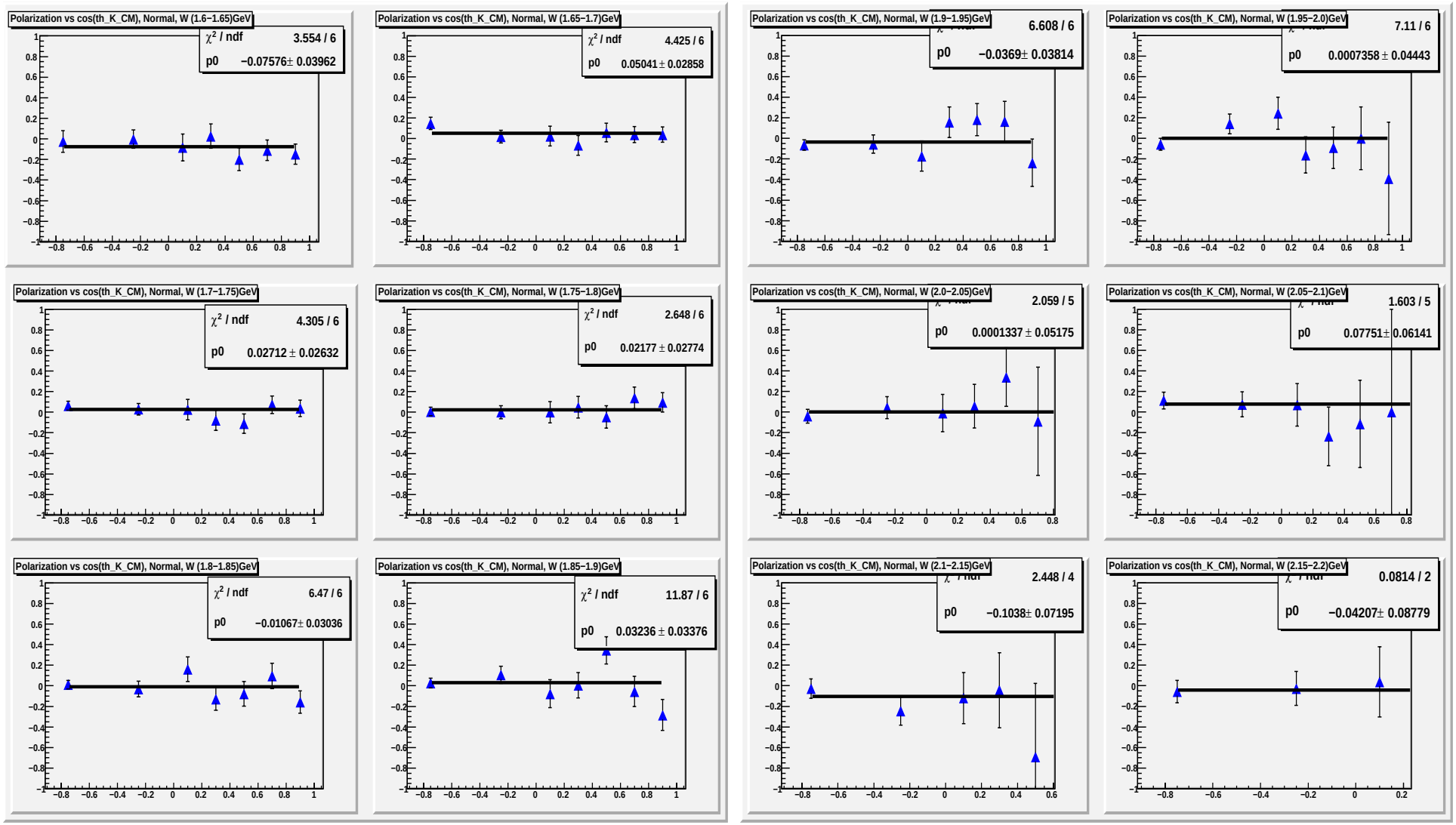
π Polarization vs $\cos(\theta_K^{CM})$

P0	X^2
-0.07576 ± 0.03962	3.554/6
0.05041 ± 0.02858	4.425/6
0.02712 ± 0.02632	4.305/6
0.02177 ± 0.02774	2.648/6
-0.01067 ± 0.03036	6.47/6
0.03236 ± 0.03376	11.87/6
0.03690 ± 0.03814	6.608/6
0.0007358 ± 0.04443	7.11/6
0.0001337 ± 0.05175	2.059/5
0.07751 ± 0.06141	1.603/5
-0.1038 ± 0.07195	2.448/4
-0.04207 ± 0.08779	0.0814/2

π Polarization vs W

P0	X^2
0.02015 ± 0.01593	22.36/23
0.009249 ± 0.02339	12.6/20
0.0218 ± 0.03903	11.81/15
-0.02241 ± 0.03918	10.01/11
-0.005989 ± 0.04029	16.3/10
0.03934 ± 0.03914	4.454/8
-0.03334 ± 0.037755	10.35/7

π Background Polarization vs cos(θ_K^{CM})



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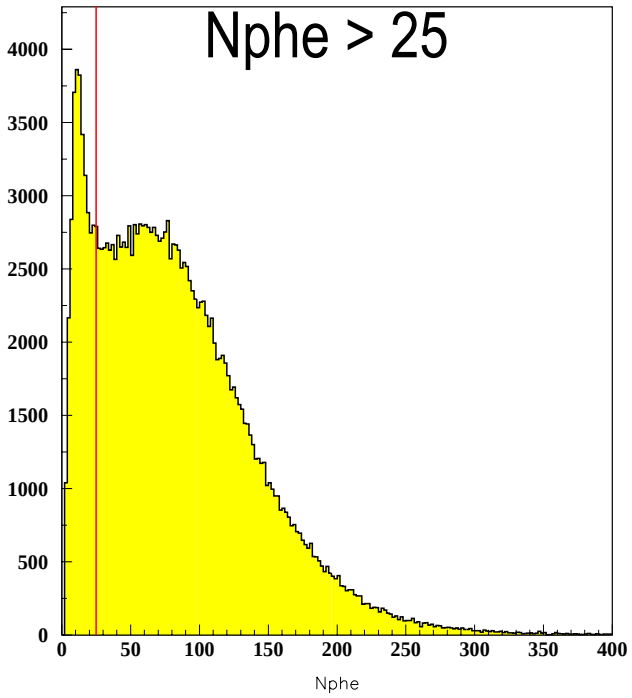
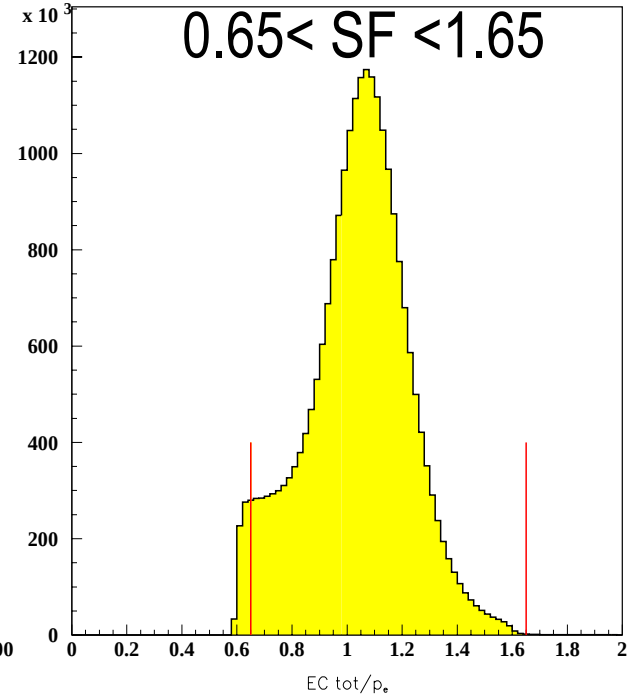
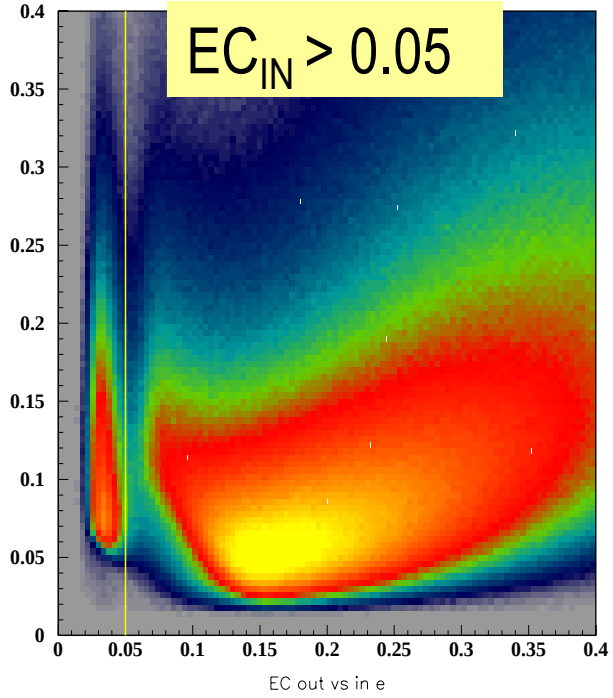
Electron Cuts



N_{phe}



EC_{total} / p_e



EC Out vs In

Applied e^- cuts are shown on the plots.