Measurement of the Induced Λ(1116) Polarization in K^+ Electroproduction at CLAS

M. Gabrielyan[1], B. Raue[1], D.S. Carman[2], K. Park[2]

1. Florida International University
2. Jefferson Lab

NSTAR 2011

5/19/2011

- Motivation. Why study ground state hyperon electroproduction?
- CLAS detector and analysis.
- Analysis results.
- Current status and future work.

Motivation

This study is *part* of a larger program that has a goal of measuring as many observables as possible for *KY* electroproduction.

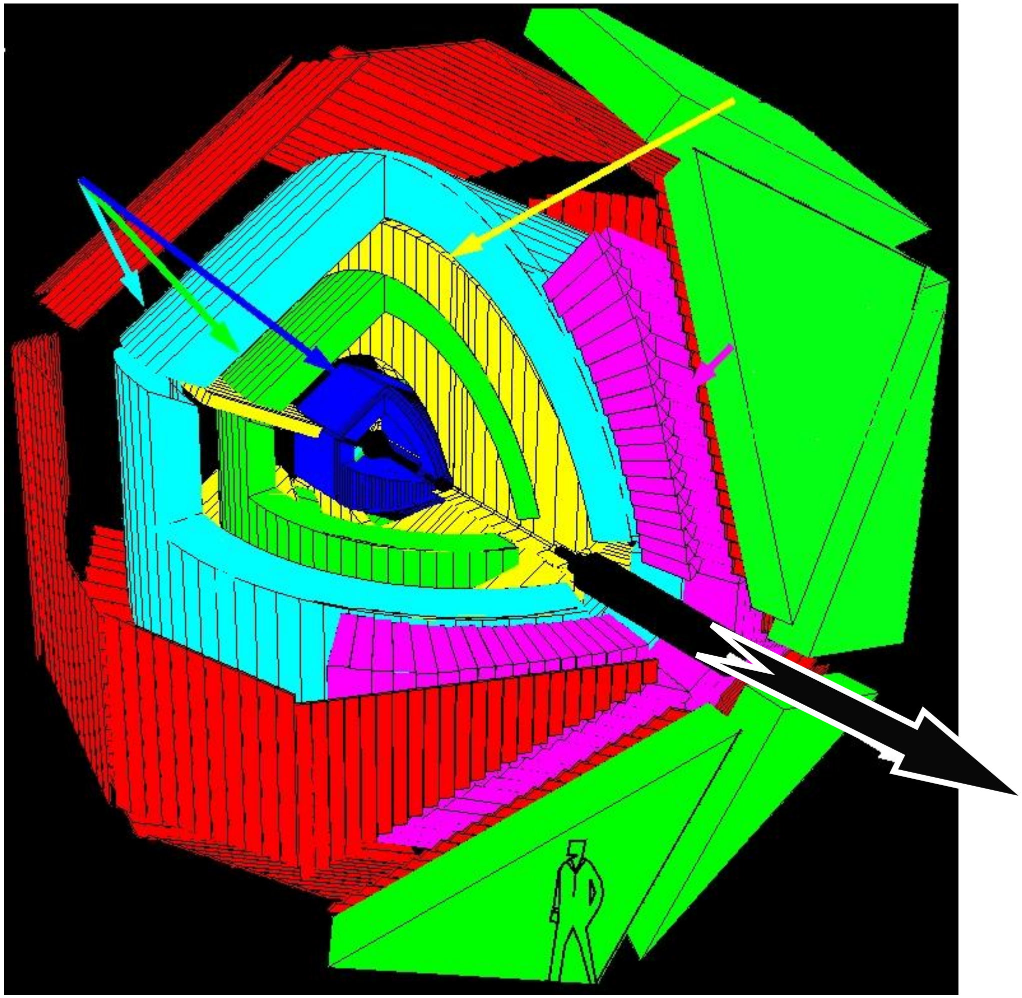
- Understand which *N*'s* couple to *KY* final states.

- These data are needed in a coupled-channel analysis to identify previously unobserved *N** resonances.

- Get a better understanding of the strange-quark production process by mapping out the kinematic dependencies for these observables.

- The results will tell us which (if any) of the currently available models best describe the data.

CEBAF Large Acceptance Spectrometer



•Toroidal magnetic field in region 2

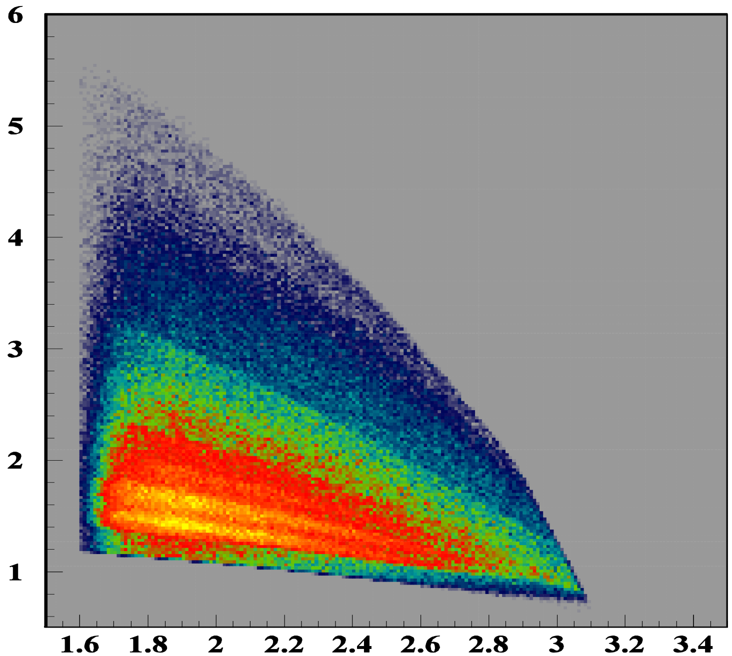
•3 regions of drift chambers located spherically around target provide charged particle tracking for angle and momentum reconstruction

•Cherenkov detectors provide e/π separation

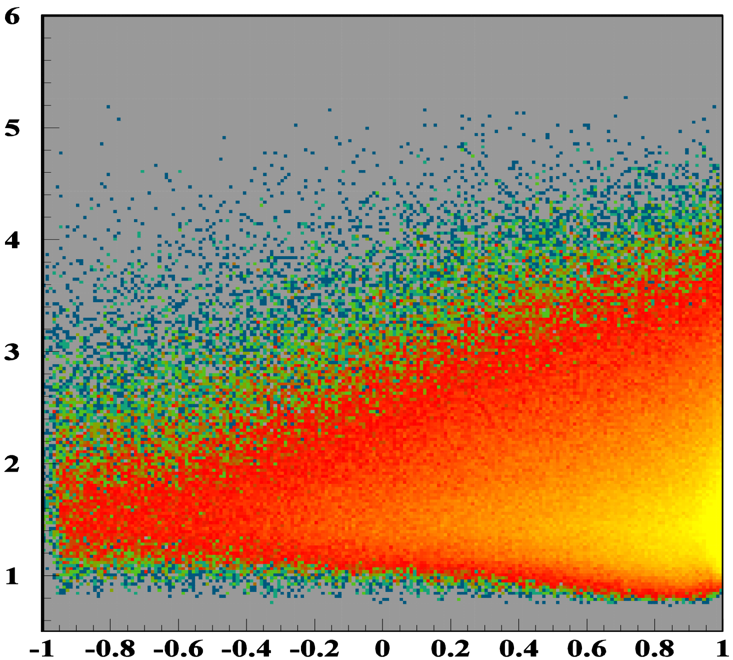
•Electromagnetic calorimeters give total energy measurement for electrons and neutrals and also e/π separation

•Time of flight scintillators for particle ID

Kinematics and E1F Dataset



Q^2 vs W



Q^2 vs $\cos(\theta_K^{CM})$

- Beam energy = 5.5 GeV
- Unpolarized Target
- Torus current = 2250 A
- 5B triggers, 213000 Λ's

- $0.8 < Q^2 < 3.5$ GeV^2
- $1.6 < W < 2.8$ GeV
- $-1.0 < \cos(\theta_K^{CM}) < 1.0$

Particle Identification

Electrons:

- Coincidence between CC and EC in the same sector.
- Negatively charged track in DC that matches in time with TOF.
- Momentum corrections applied to correct for DC misalignments and inaccuracies in the magnetic field map.

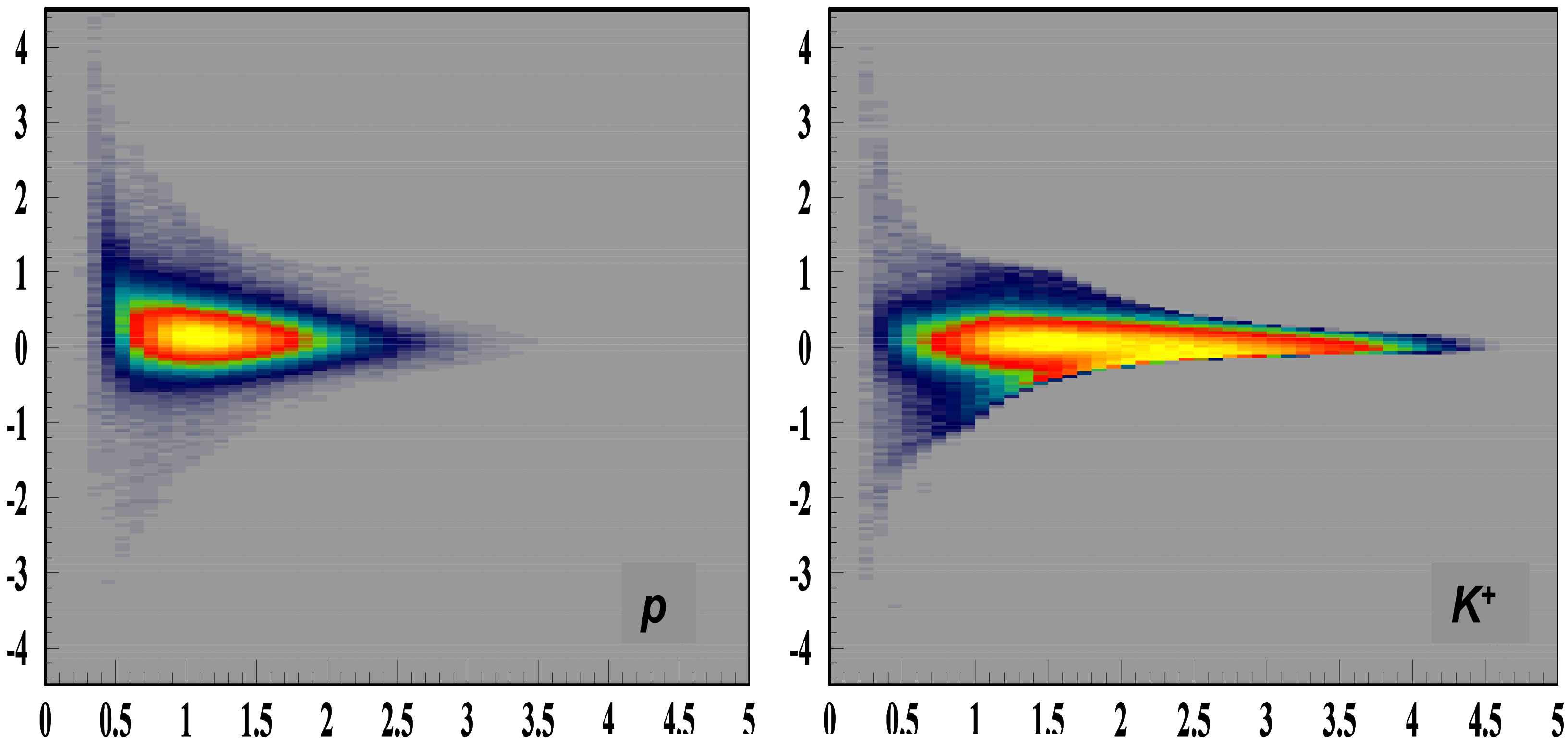
Hadrons: Time difference (Δt) between the measured time and the computed time for a given hadron species (π^+, K^+, p).

Minimum *Δt identifies the hadron.*

Hadron Identification

Minimum *Δt* identifies the hadron.

After Λ and π missing mass cuts

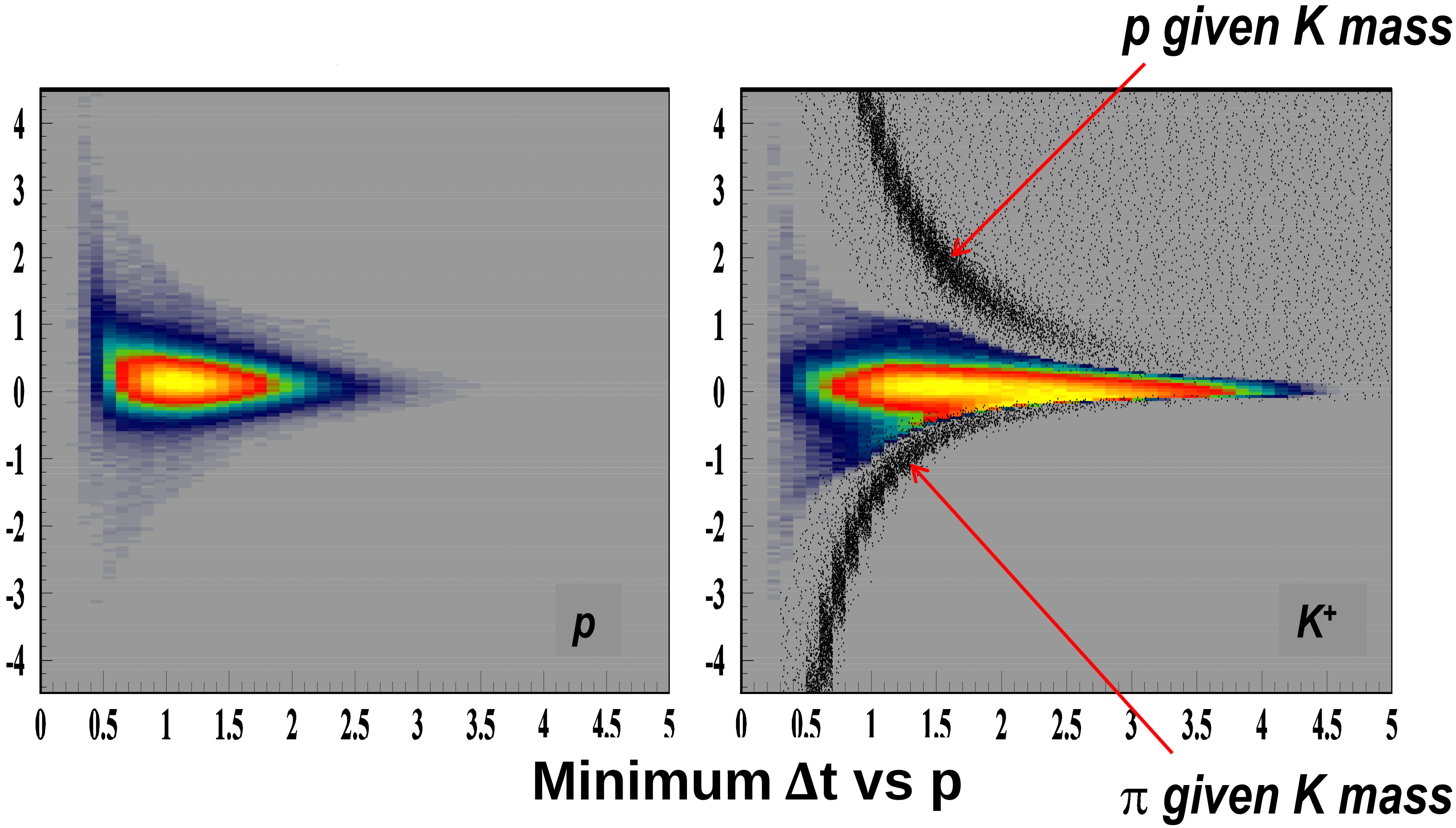


Minimum Δt vs p

Hadron Identification

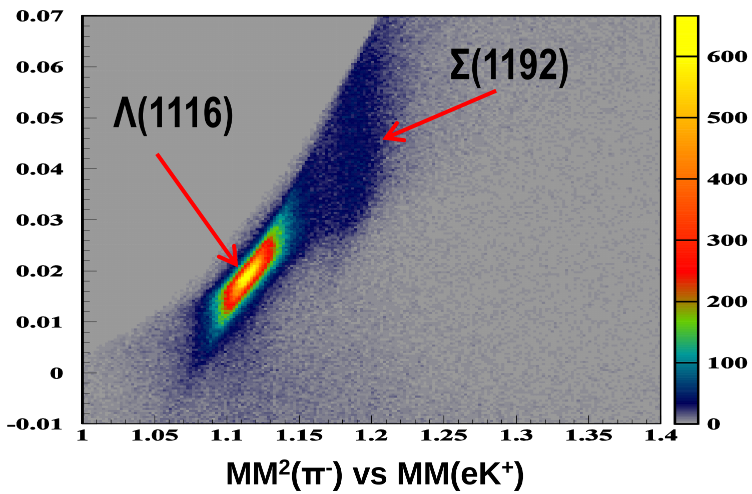
Minimum *Δt* identifies the hadron.

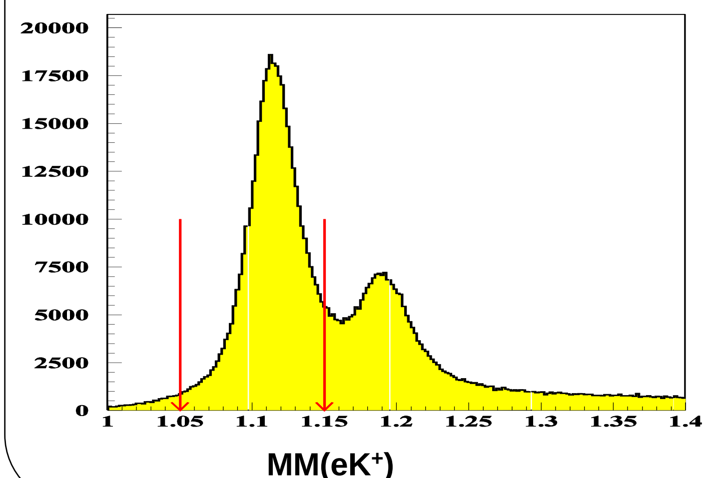
After Λ and π missing mass cuts

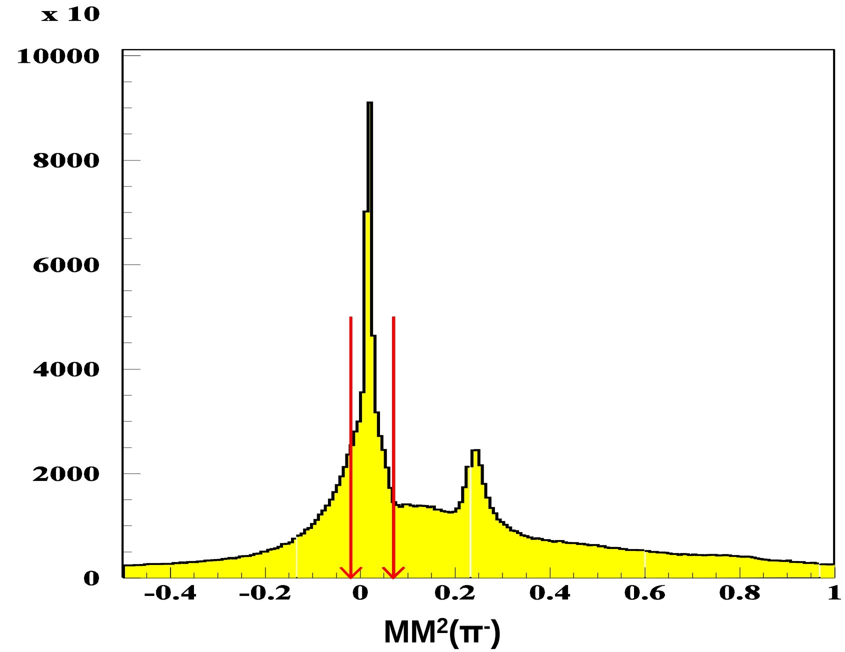


Λ Identification

- 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







Background in the hyperon missing mass spectrum is dominated by π's misidentified as K^{+}.

Cross Section for Electroproduction

$$\boxed{\frac{d^5\sigma}{dE'\,d\Omega_e\,d\Omega_K^*} = \Gamma\,\frac{d^2\sigma_v}{d\Omega_K^*}}$$

Polarized beam & recoil Λ, unpolarized target.

$$\frac{d\sigma_v}{d\Omega_K^*} = \sigma_0(1 + hA_{LT'} + P_{x'}\hat{x}'\cdot\hat{S}' + P_{y'}\hat{y}'\cdot\hat{S}' + P_{z'}\hat{z}'\cdot\hat{S}')$$

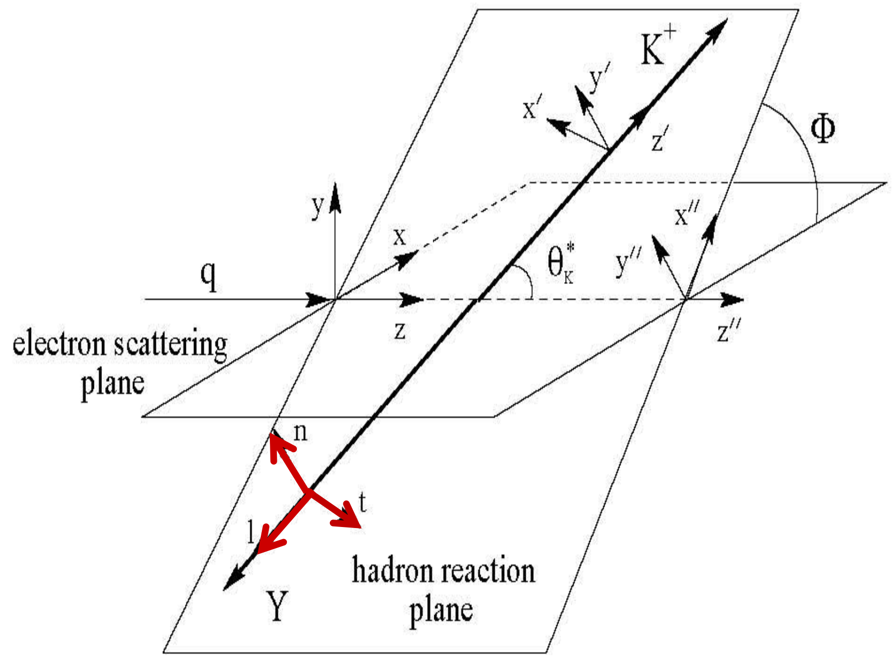
Where:

$$A_{LT'} = \frac{K_f}{\sigma_0}\sqrt{2\epsilon_L(1-\epsilon)}\,R^{00}_{LT'}\sin\Phi$$

$$P_{i'} = P^0_{i'} + hP'_{i'}$$

Transferred polarization

Induced polarization



Λ Polarization Extraction

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

$$\frac{dN}{d\cos\theta_p^{RF}} = N_0(1+\alpha P_\Lambda \cos\theta_p^{RF}),$$

where: α=*0.642   0.013* (PDG)

$$P_\Lambda = \frac{2}{\alpha}\cdot\frac{N_F - N_B}{N_F + N_B}$$

Here N_F and N_B are the acceptance corrected yields.

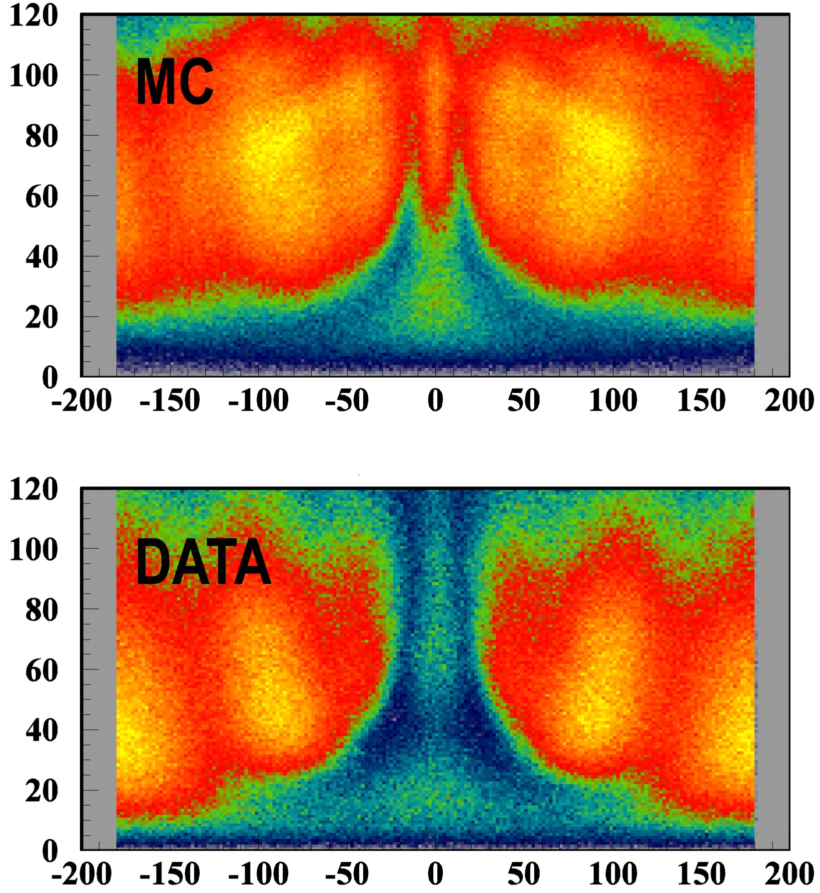
After *Φ* integration only P_N component survives for induced polarization (P_L, P_T = 0).

Carman et al., PRC 79 065205 (2009)

Acceptance Corrections

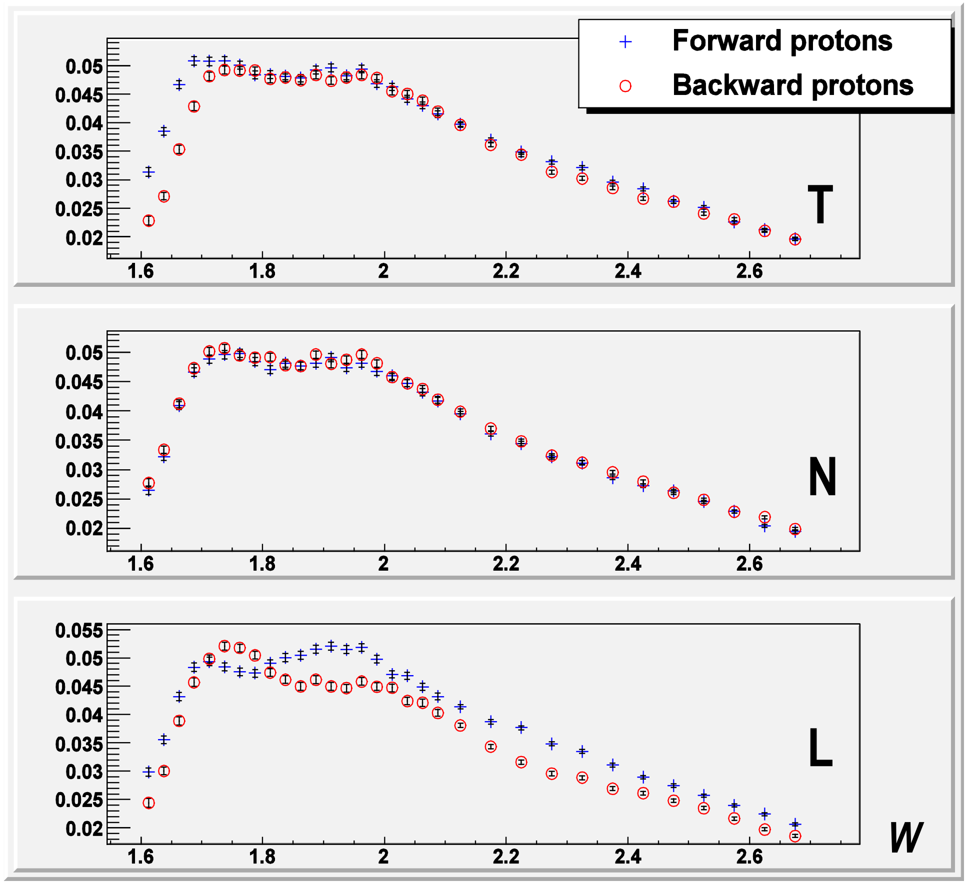
FSGen: Phase space generator with modified t-slope :
t-slope = 0.3 GeV^{-2}

Acceptance corrections are applied to background subtracted yields.



Θ_K vs φ_K CM

0.8<Cos(θ_K^{CM})< 1.0

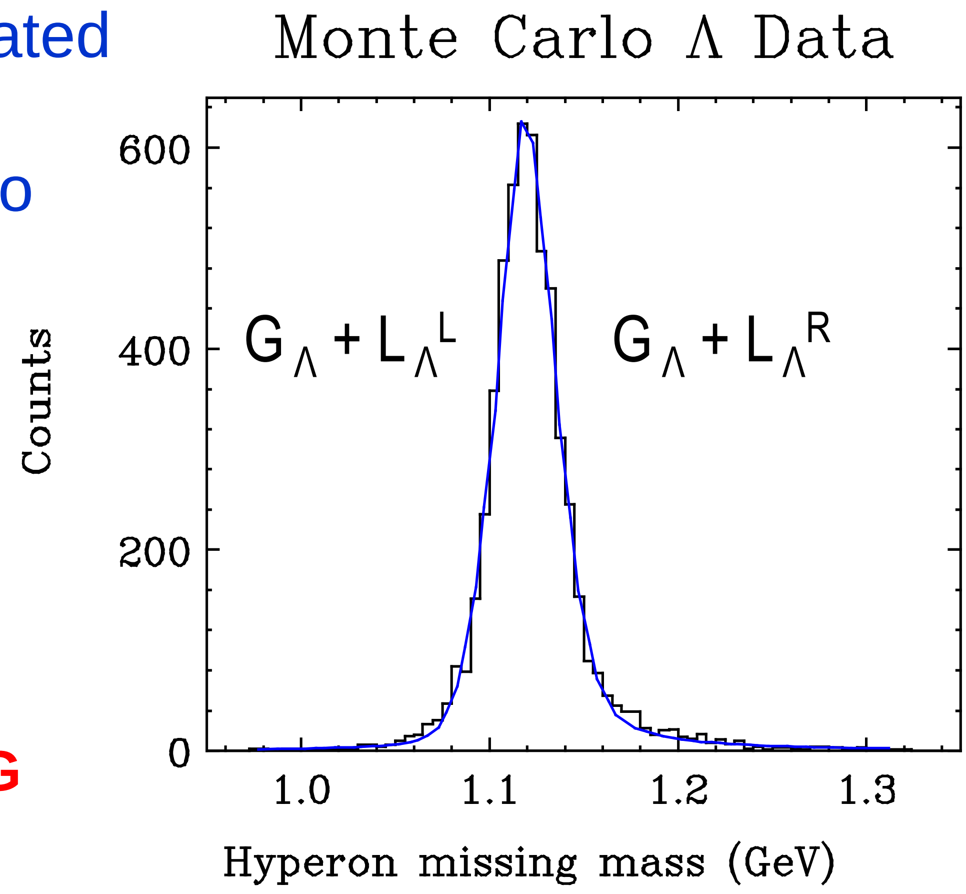


Acceptance factors vs W

Background Subtraction

The fit function form is motivated by the Λ and Σ Monte Carlo templates that are matched to data.

- $f_\Lambda = G_\Lambda + L_\Lambda^L + L_\Lambda^R$
- $f_\Sigma = G_\Sigma + L_\Sigma^L + L_\Sigma^R$
- $f_{BKG} = A^*(bkg\_temp)$
- $\mathbf{f_{TOTAL} = f_\Lambda + f_\Sigma + f_{BKG}}$

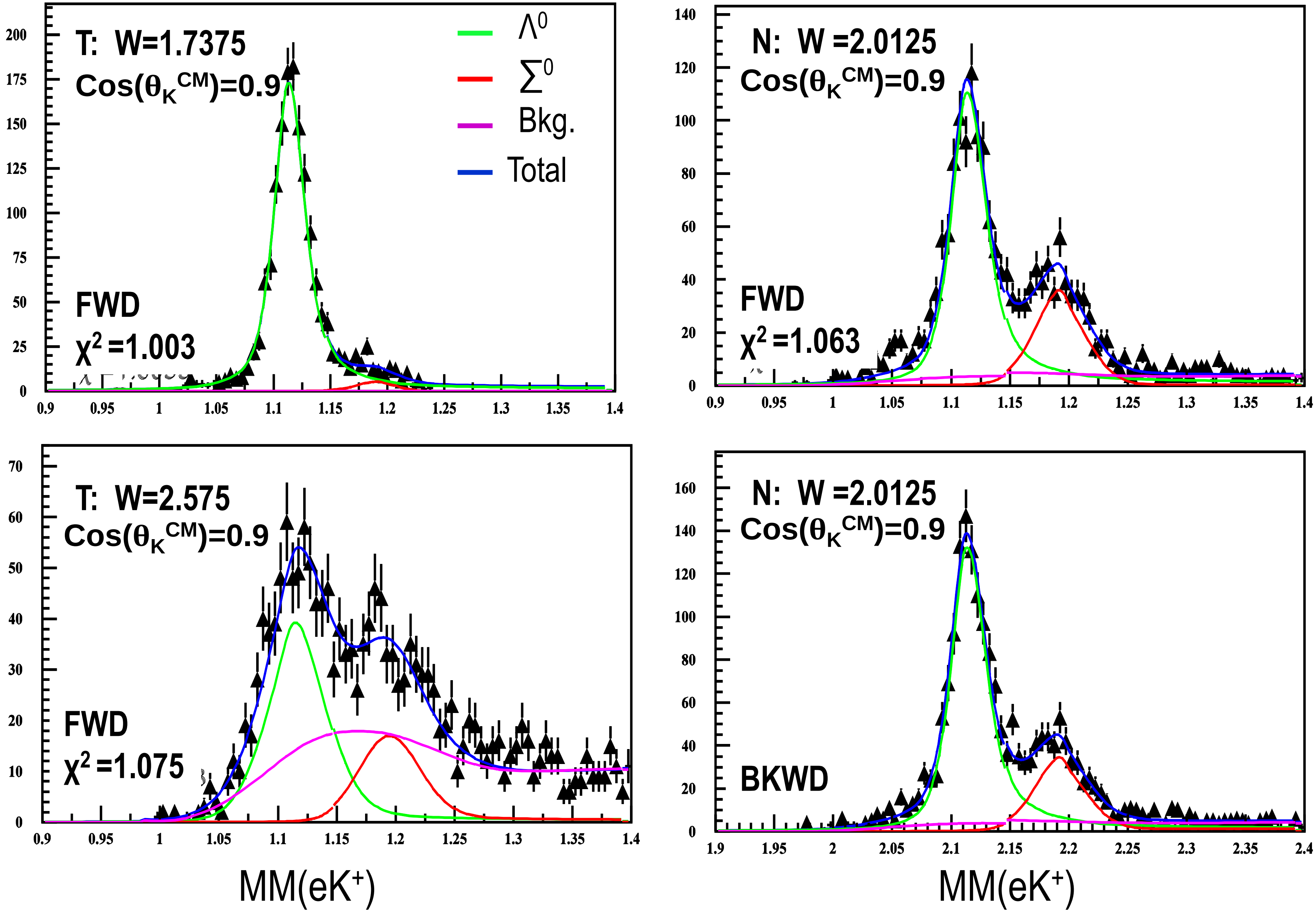


G_Λ = Gaussian,
L_Λ^L = Left Lorentzian,
L_Λ^R = Right Lorentzian,
A = Amplitude.

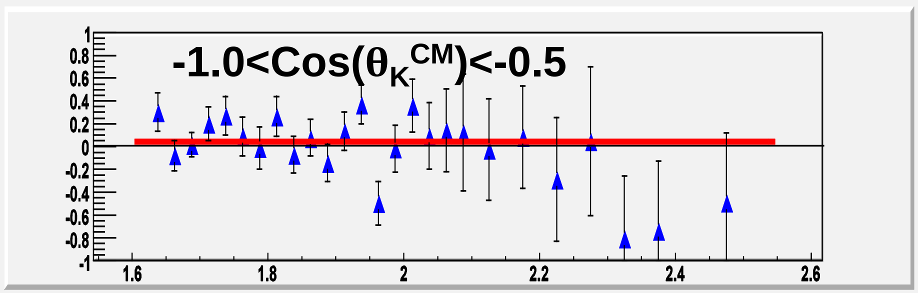
The background templates are generated from data by intentionally misidentifying pions as kaons.

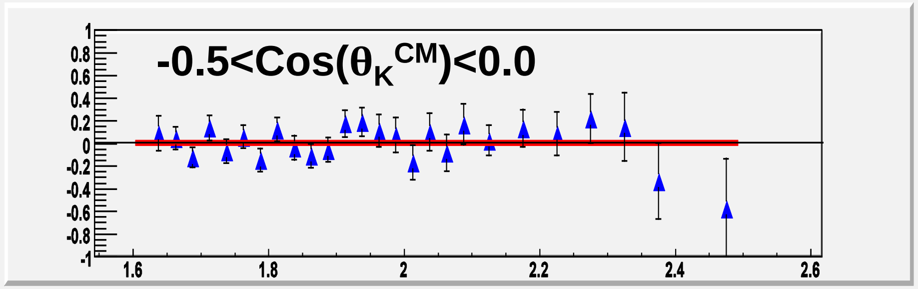
Background Subtraction

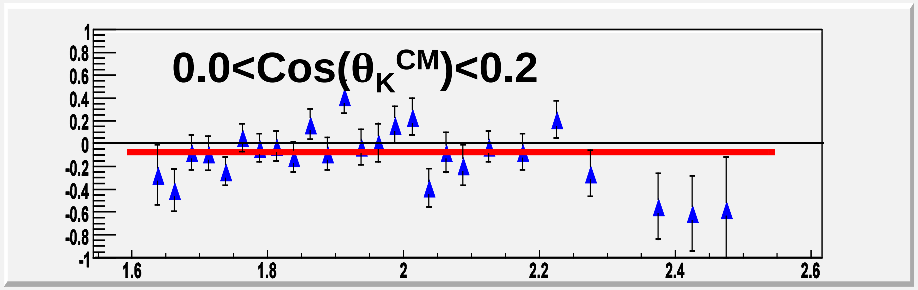
1.05 < MM(eK$^+$) < 1.15 GeV

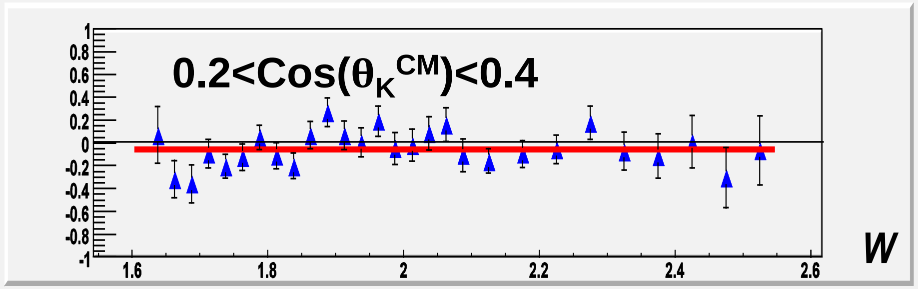


Systematics Check: P_L vs W





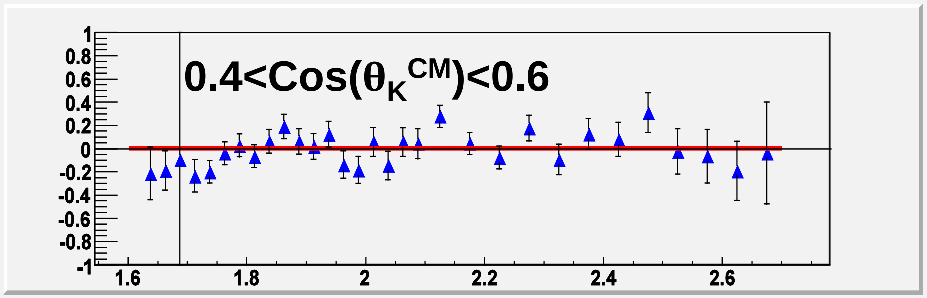


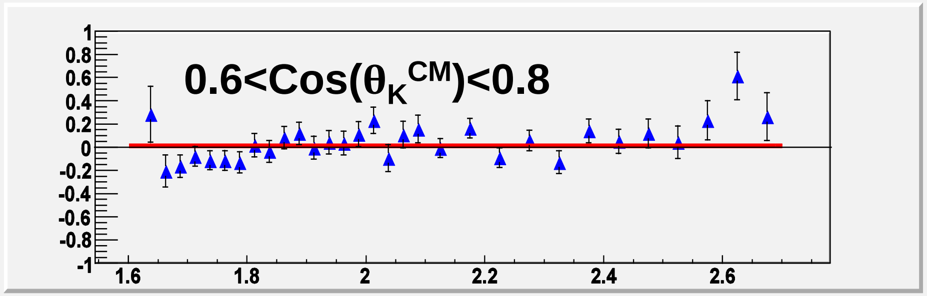


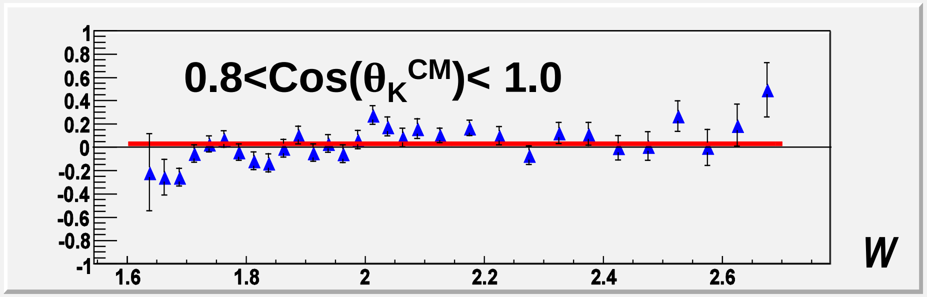
Preliminary Results

SUM over Q^2, Φ

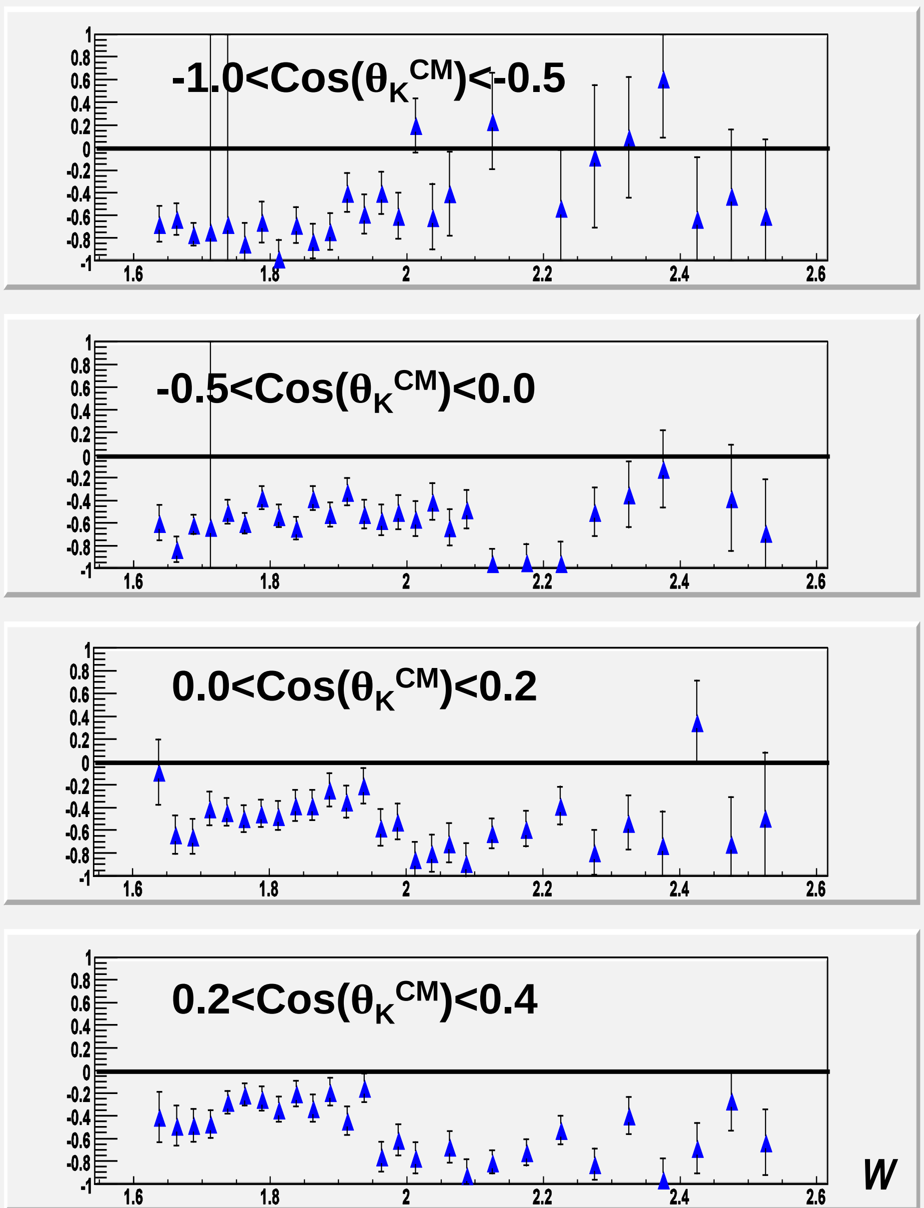
$$\overline{P}_L \leq 0.06$$







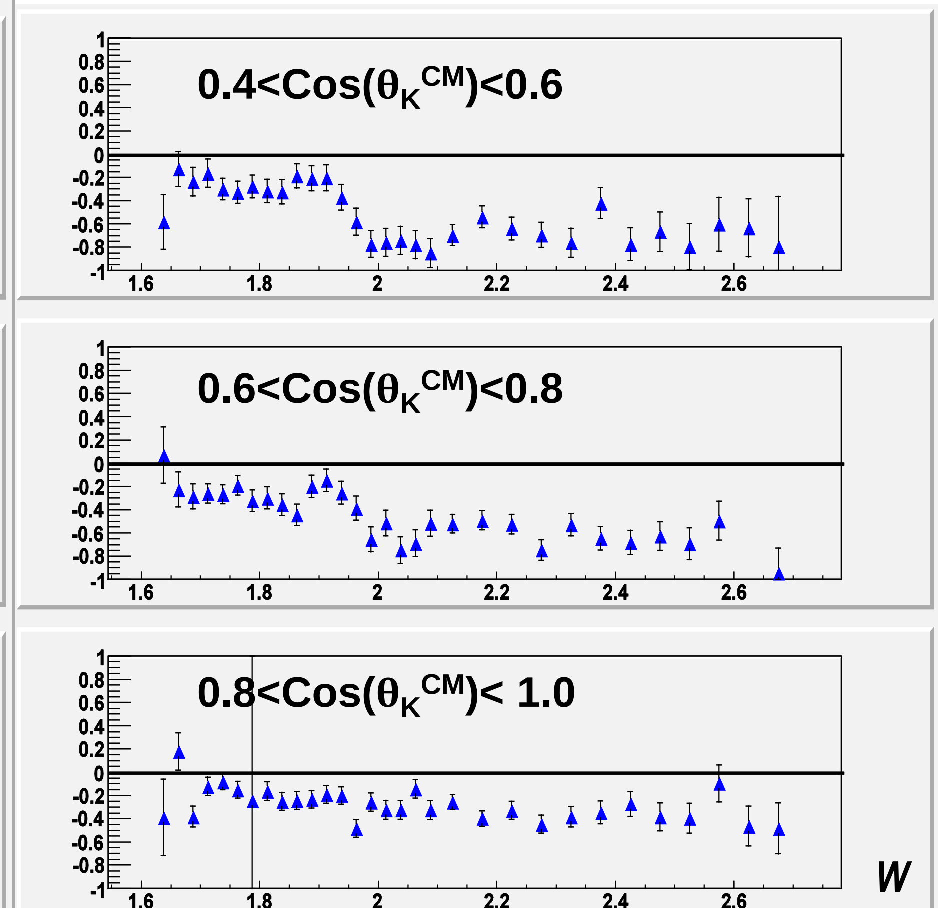
Induced Polarization P_N vs W



Preliminary Results

SUM over Q^2, Φ

$\langle$Systematics$\rangle \leq 0.06$



RPR Model

- Non-resonant background contributions treated as exchanges of kaonic Regge trajectories in the *t*-channel:

  K(494) and K^*(892) dominant trajectories. Both have a rotating Regge phase.

  This approach reduces the number of parameters.

- Included *established* *s*-channel nucleon resonances:

  S11(1650), P11(1710), P13(1720), P13(1900)

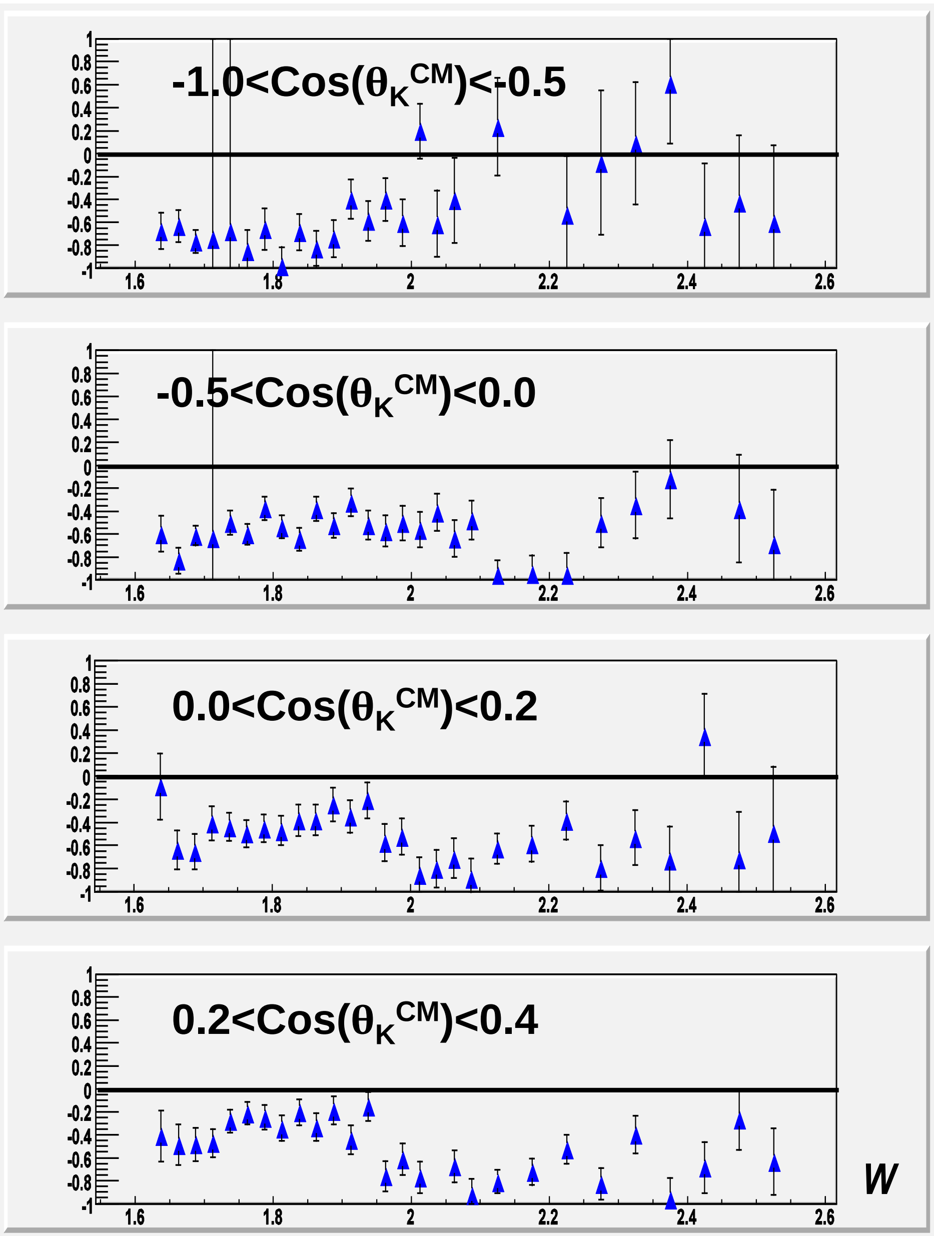
- Included *missing* resonance:

  D13(1900).

- Model was fit to forward angle ($\cos\theta_K^{CM} > 0$) photoproduction data (CLAS, LEPS, GRAAL) to constrain the parameters.

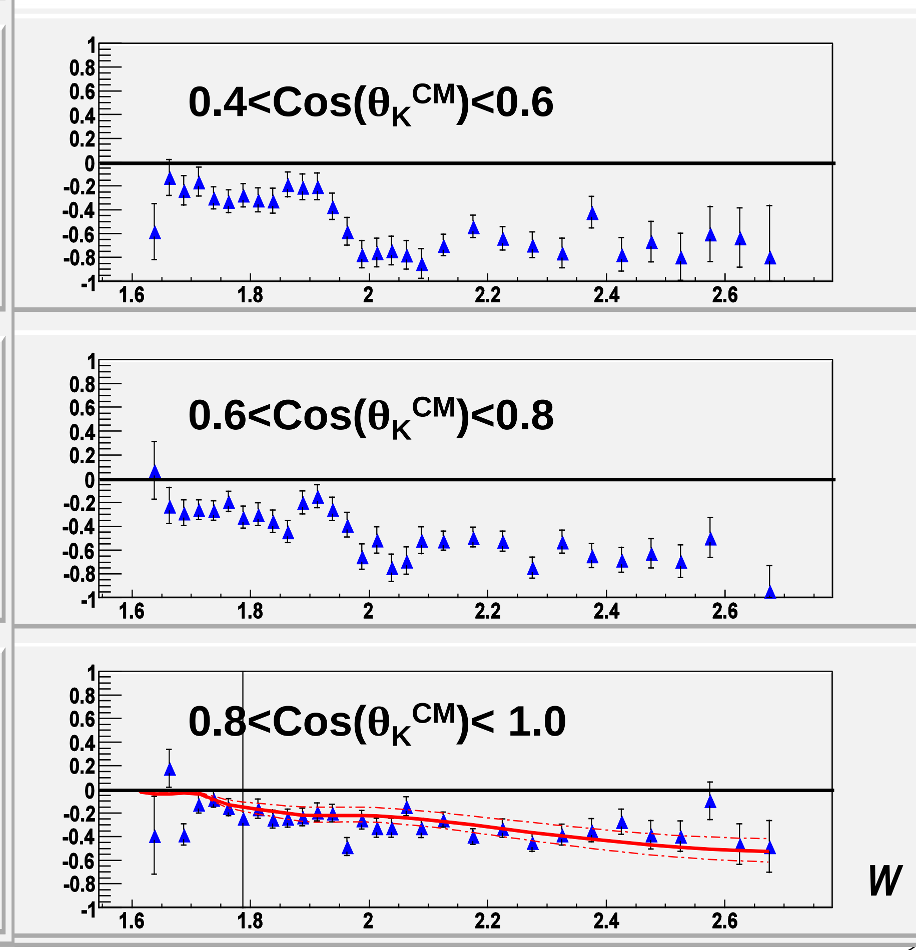
Corthals et al., Phys. Lett. B 656 (2007)

Induced Polarization P_N vs W

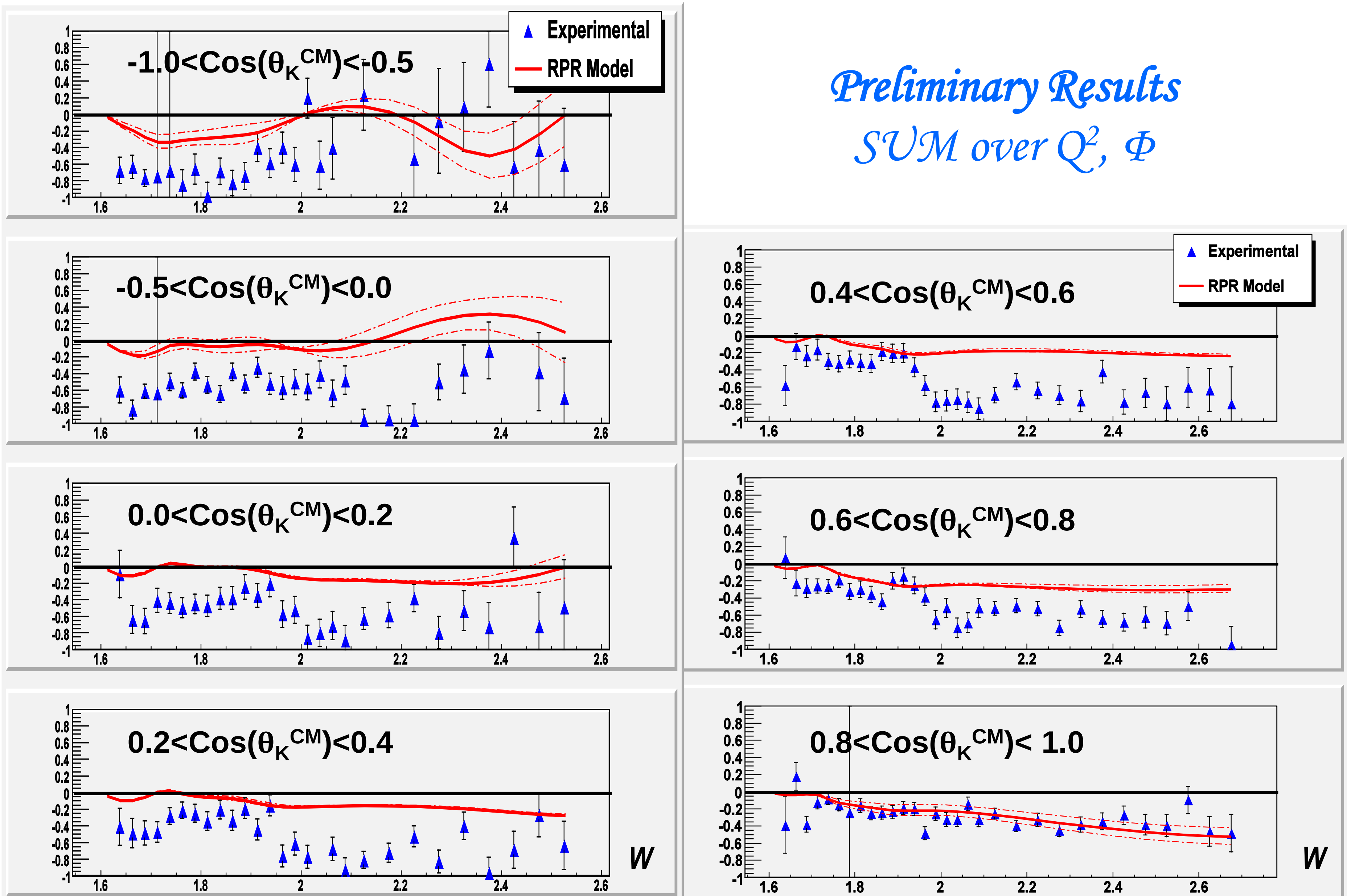


Preliminary Results

SUM over Q^2, Φ



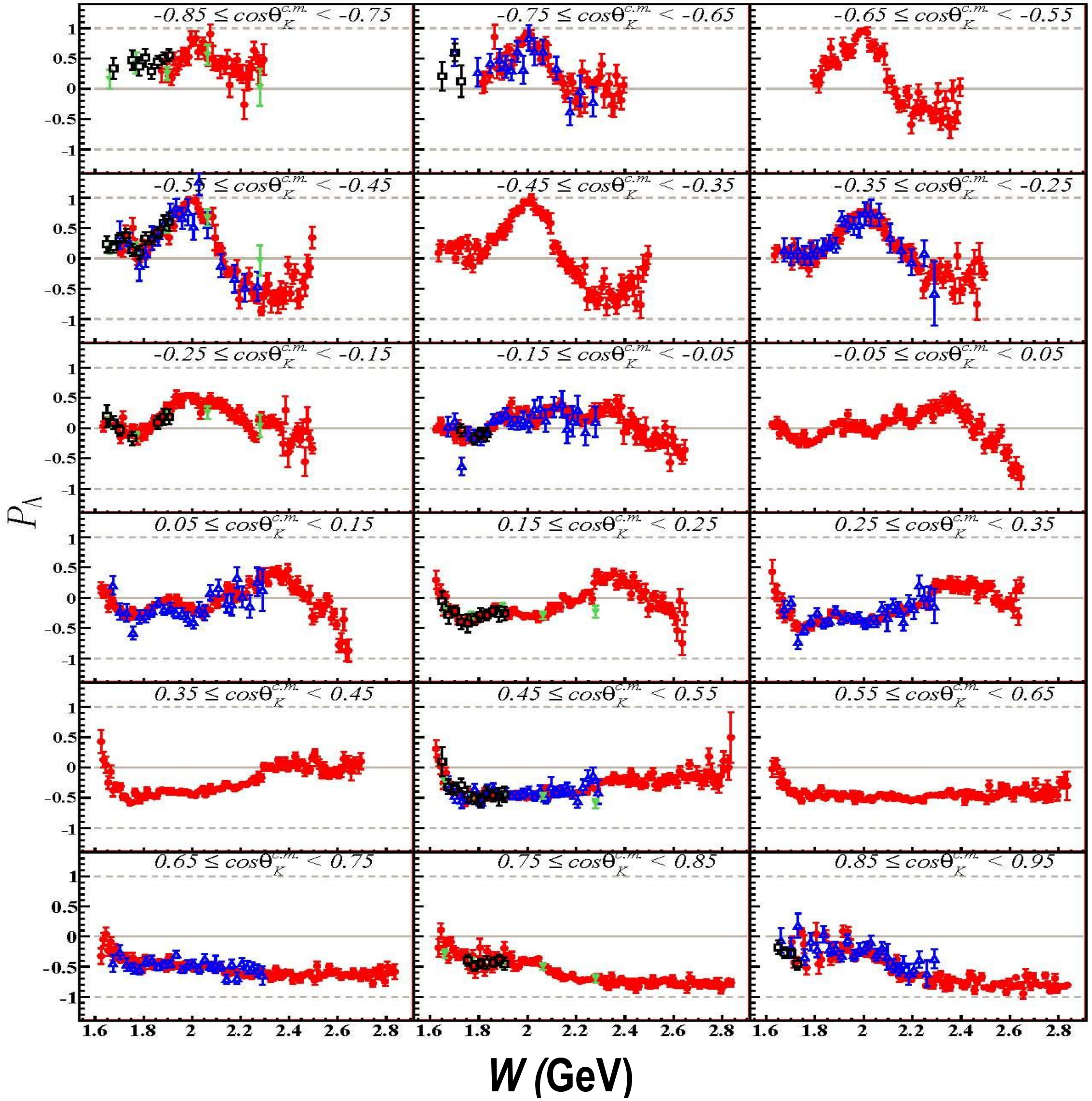
Induced Polarization P_N vs W



Preliminary Results

SUM over Q^2, Φ

Induced Polarization vs *W (photoproduction)*

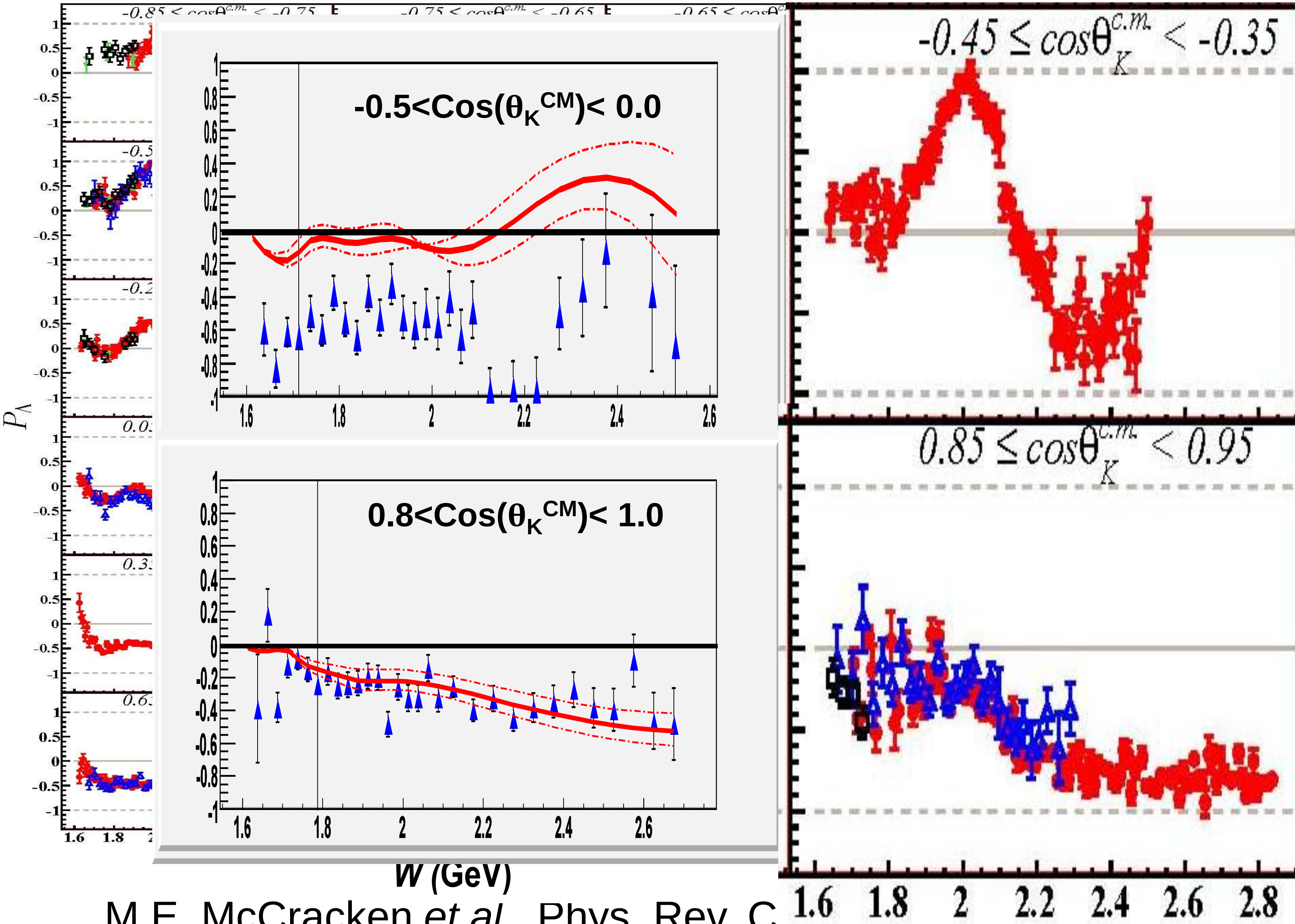


Red: McCracken, CLAS 2010
Blue: McNabb, CLAS 2004
Green: Glander, SAPHIR 2004
Black: Lleres, GRAAL 2007

Dashed lines indicate the physical limits of polarization.

M.E. McCracken *et al.*, Phys. Rev. C **81**, 025201 (2010).

Induced Polarization vs *W (photoproduction)*



2010
004
R 2004
2007
e
ation.

M.E. McCracken *et al.*, Phys. Rev. C

SUMMARY

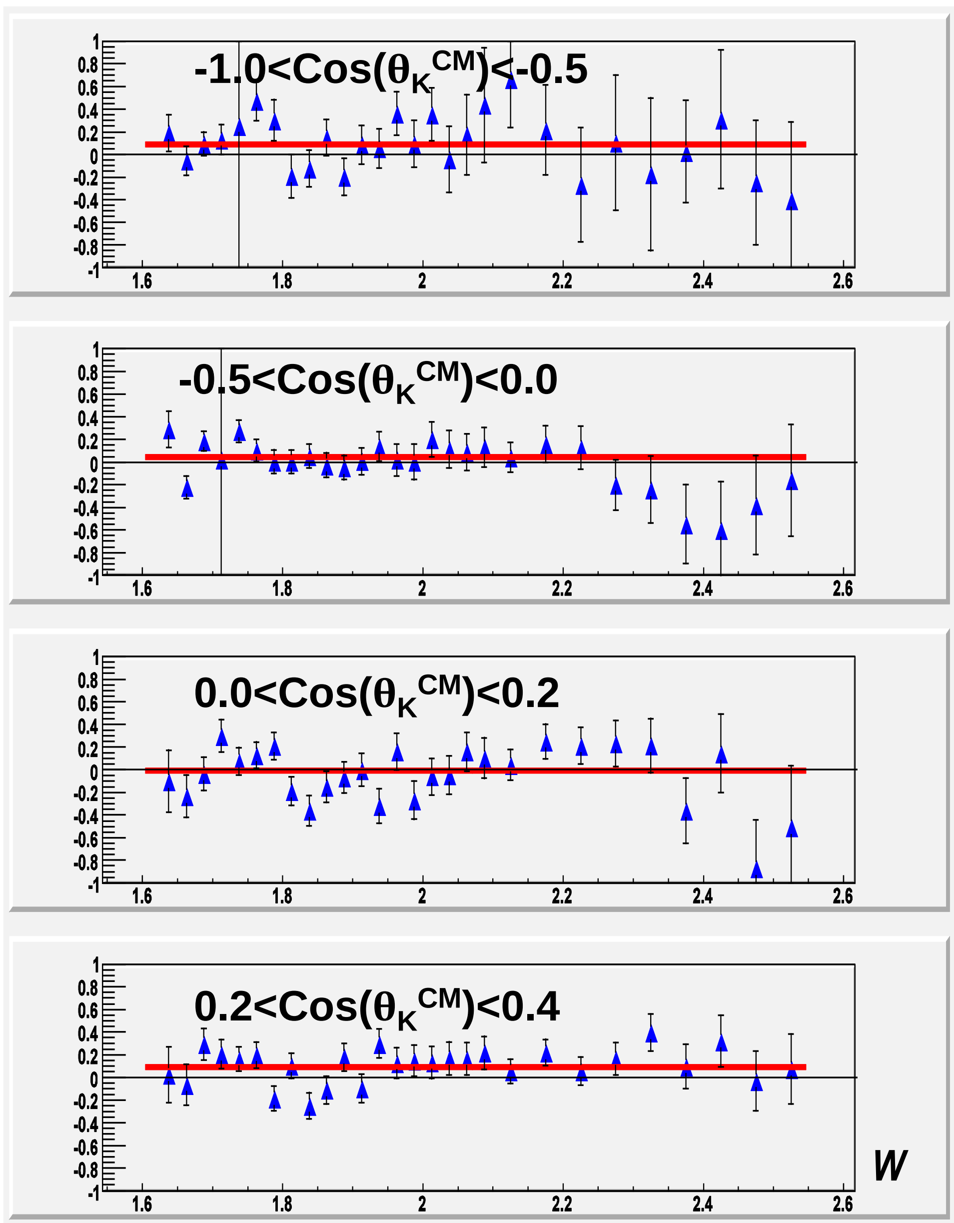
- ➢ Background subtraction and acceptance corrections are complete.
- ➢ RPR theoretical model calculations are in good agreement with experimental data at very forward kaon angles but they fail to reproduce the data at all other kaon angle bins.
  - RPR gives a reasonable description of photoproduction data (cos $\theta_K^{CM} > 0$).
- ➢ Experimental data are similar for both electro- and photoproduction at forward kaon angles, but are very different for backward kaon angles.

NEXT…

- Complete the systematic error analysis.
- Comparison to different theoretical models.

Funded in part by: The U.S. Dept. of Energy, FIU Graduate School

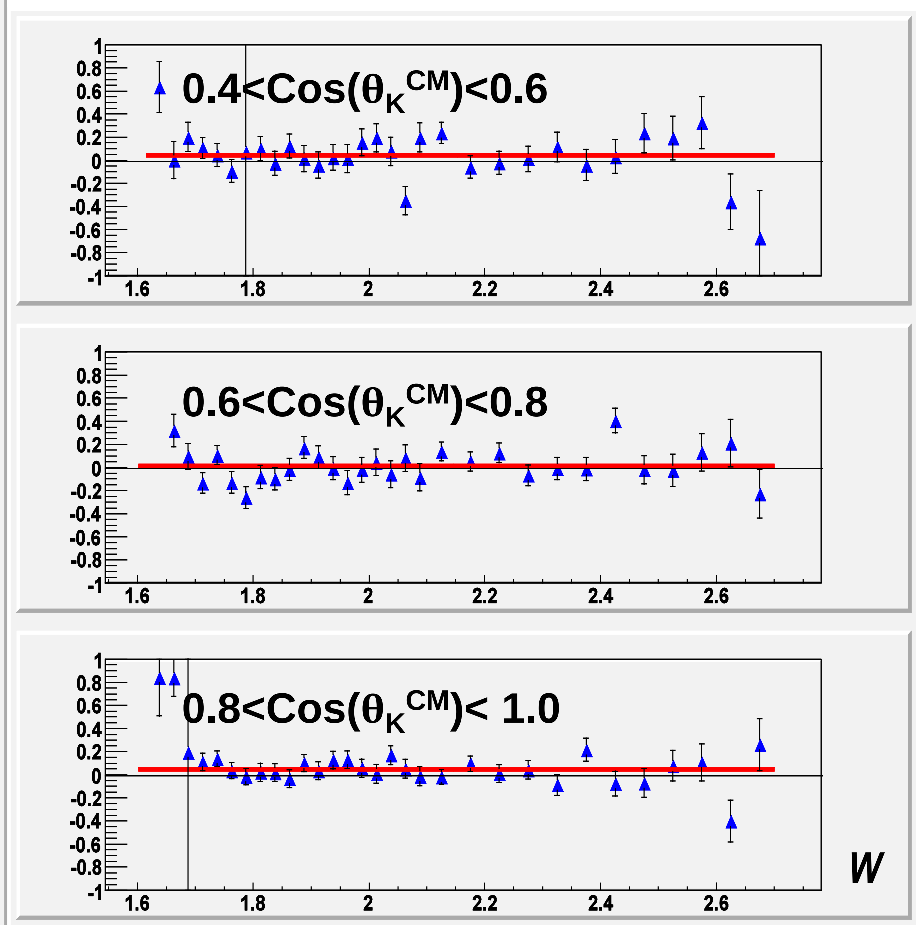
Systematics Check: P_T vs W



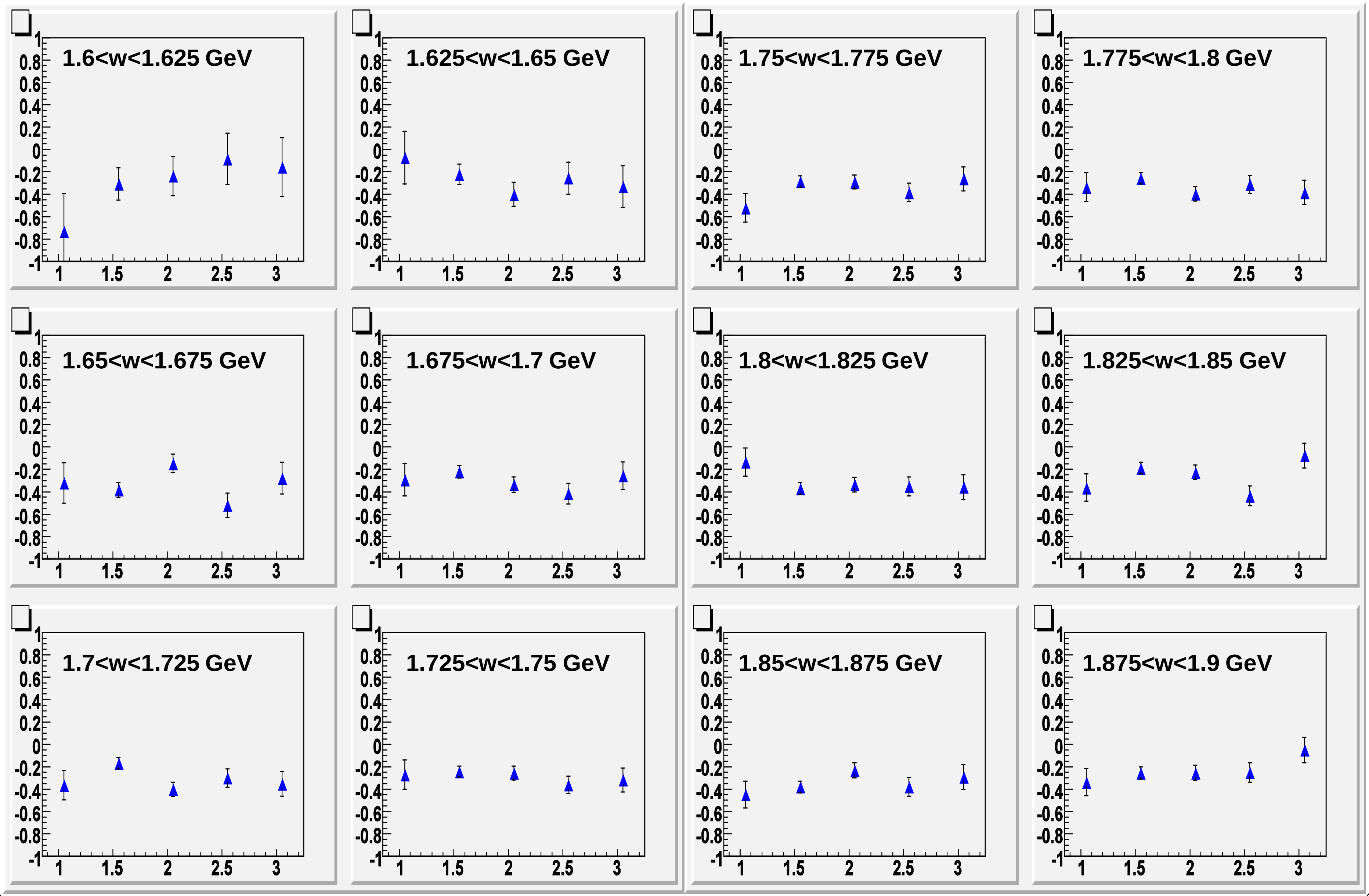
Preliminary Results

SUM over Q^2, Φ

$$\overline{P}_T \leq 0.11$$

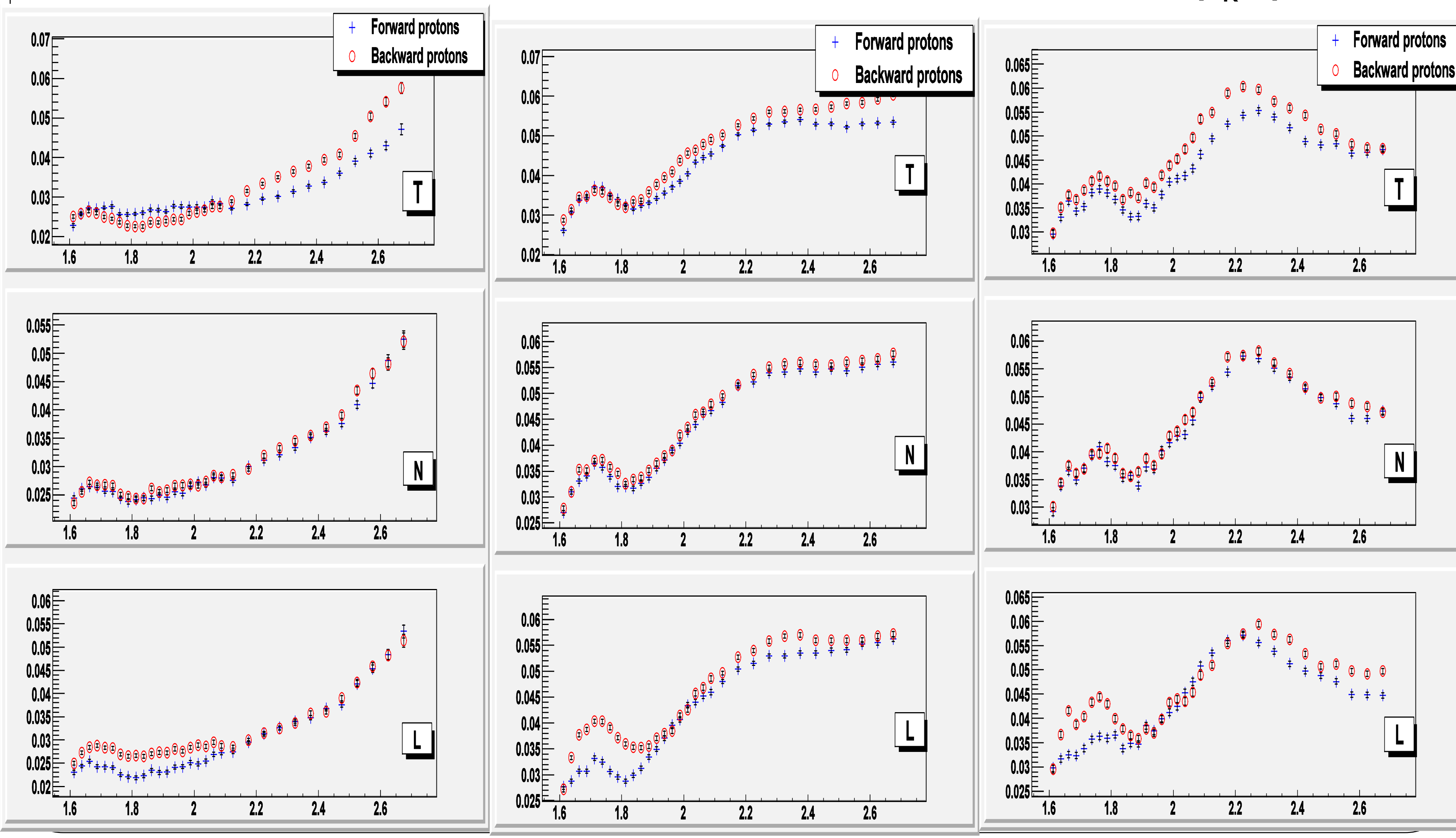


Polarization vs Q^2, Sum over $\cos(\theta_K^{CM})$, Φ



Acceptance Factors vs *W*

$-1.0<\cos(\theta_K^{CM})<-0.5$ **$-0.5<\cos(\theta_K^{CM})<0.0$** **$0.0<\cos(\theta_K^{CM})<0.2$**



Acceptance Factors vs *W*

0.2<Cos(θ_K^{CM})<0.4 **0.4<Cos(θ_K^{CM})<0.6** **0.6<Cos(θ_K^{CM})<0.8**