RG-K KY TRANSFERRED POLARIZATION

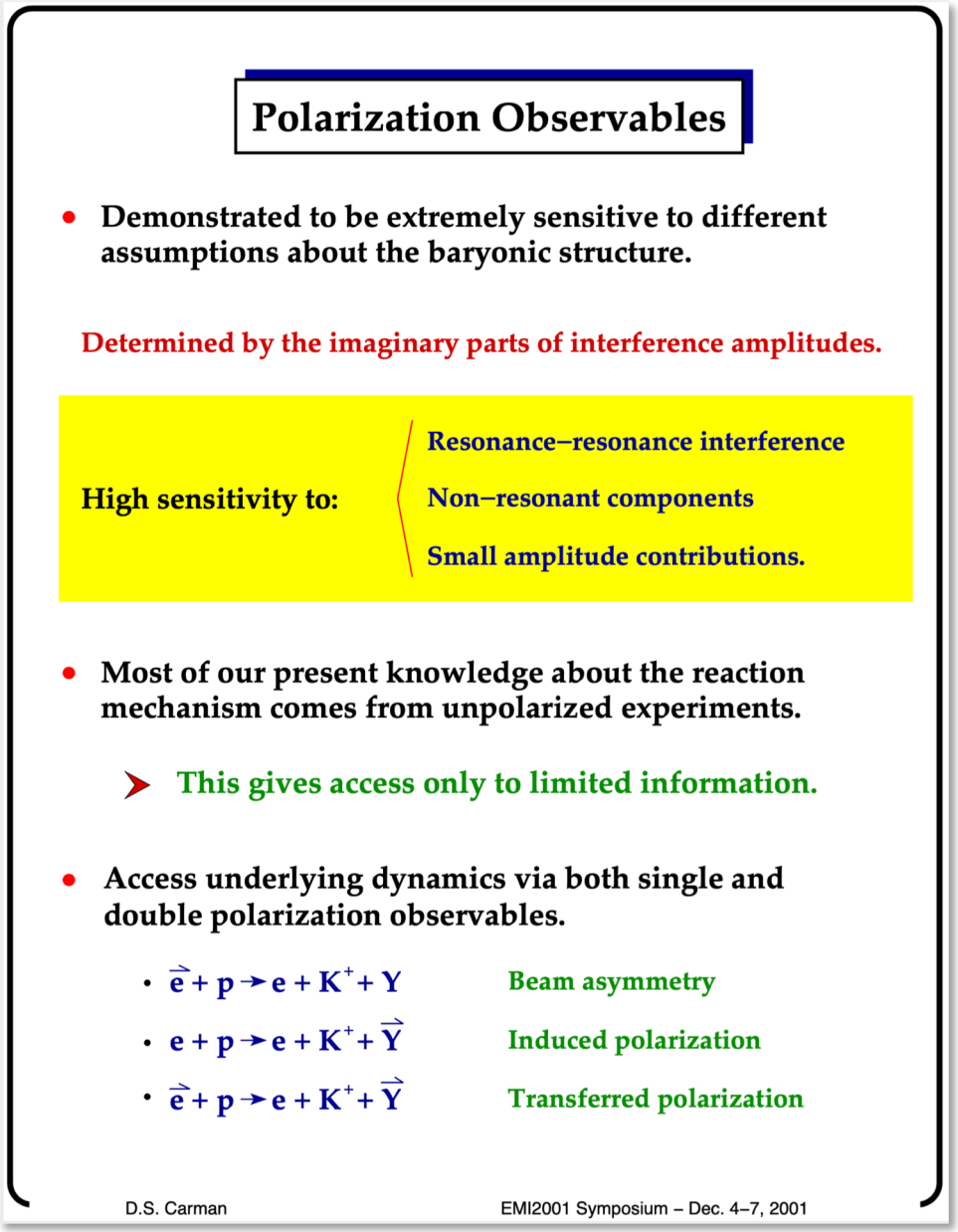
RG-K OVERVIEW:

- Acquired Nov. 29- Dec. 20, 2018
- 7.5 GeV with FT-ON:
  - run 5681-5870
  - 10.77 mC, P_b=85%
- 6.5 GeV with FT-OFF:
  - run 5874-6000
  - 18.23 mC, P_b=85%

ANALYSIS PLANS:

- Analyze pass-1 data to extract transferred polarization for $K^+\Lambda$ and $K^+\Sigma^0$ final states
- Compare to published CLAS data from e1c, e1-6
- Complete analysis review in 2021 to submit paper (PRC) by the end of the year

Motivation



Induced polarization:

- M. Gabrielyan et al. (CLAS), PRC 90, 035202 (2014)

Transferred polarization:

- D.S. Carman et al. (CLAS), PRC 065205 (2009)
- D.S. Carman et al. (CLAS), PRL 90, 0131804 (2003)

Fifth structure function:

- R. Nasseripour et al. (CLAS), PRC 77, 065208 (2008)

σ_L/σ_T from transferred polarization:

- B.A. Raue and D.S. Carman, PRC 71, 065209 (2005)

General:

- D.S. Carman et al., CERN Courier Sep. 2007
- D.S. Carman and M.D. Mestayer, CERN Courier Jun. 2003

Particle Identification

electrons

- Track status: $2000 \leq$ abs(STATUS) < 4000
- Event Builder PID $= 11$
- $1.0 < p_e < p_{beam}$ GeV
- $21 < TOF_e < 26$ ns
- $-10 \leq v_z^e \leq 2$ cm
- $W^2 > 0$ GeV
- 3.5σ S.F. cut
- 5 cm ECAL U, V, W fiducial cut
- π^- contamination removal:
  $E_{ECin}/p_e < -0.84 * E_{PCAL}/p_e + 0.17$
- $N_e = 1$

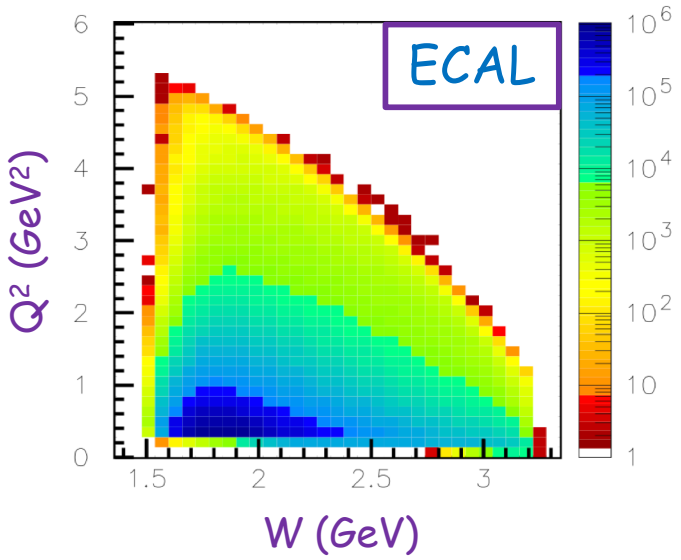
hadrons

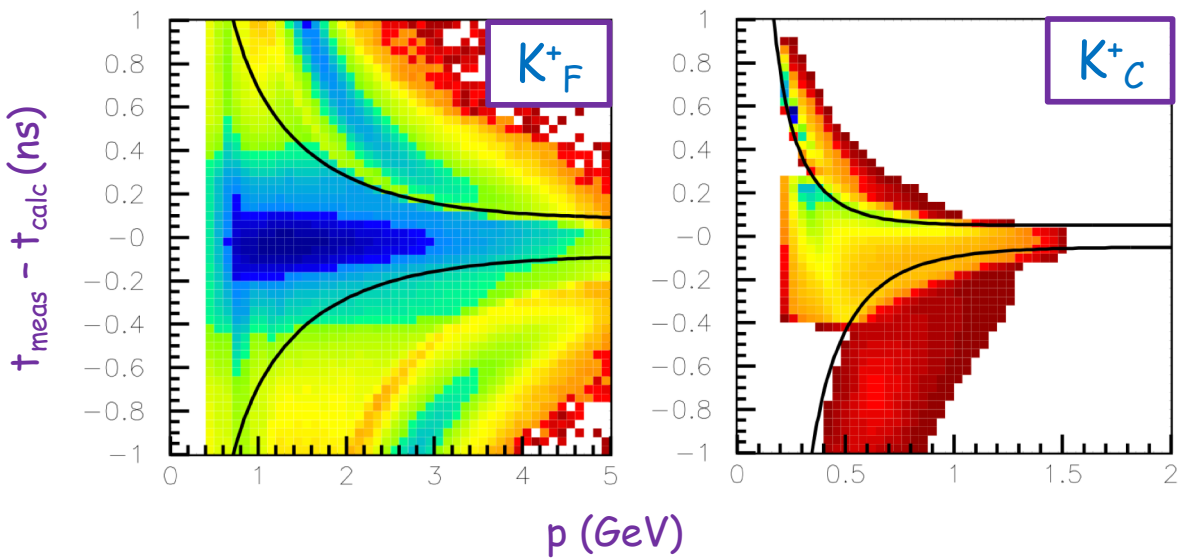
Forward Detector

- Track status: $2000 \leq$ abs(STATUS) < 4000
- π^+ misidentification cut: $MM(e'"K^{+\prime\prime}) < 1.075$ GeV
- $q \neq 0$
- $0.4 < p_h < p_{beam}$ GeV
- $0.4 < \beta_h < 1.1$
- Event Builder PID $= \pm 211, \pm 321$, or ± 2212
- $20 < TOF_h < 55$ ns ($q > 0$), $20 < TOF_h < 35$ ns ($q < 0$)
- $|\Delta t_{meas-calc}|$ cuts - see plots
- $-10 \leq v_z \leq 2$ cm (K^+ candidates)
- $|chi2pid_h| < 5$
- Forward Detector fiducial cuts

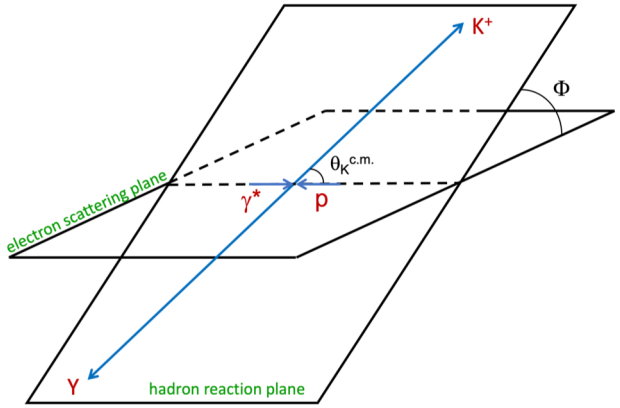
Central Detector

- Track status: abs(STATUS) ≥ 4000
- π^+ misidentification cut: $MM(e'"\pi^{+\prime\prime}) < 1.075$ GeV
- $q \neq 0$
- $0.2 < p_h < 3.0$ GeV
- $0.2 < \beta_h < 1.1$
- Event Builder PID $= \pm 211, \pm 321$, or ± 2212
- $0.5 < TOF_h < 4.0$ ns
- $|\Delta t_{meas-calc}|$ cuts - see plots
- $-10 \leq v_z \leq 2$ cm (K^+ candidates)
- $|chi2pid_h| < 5$
- CVT $NDF > 2$
- Account for tracks already reconstructed in Forward Detector





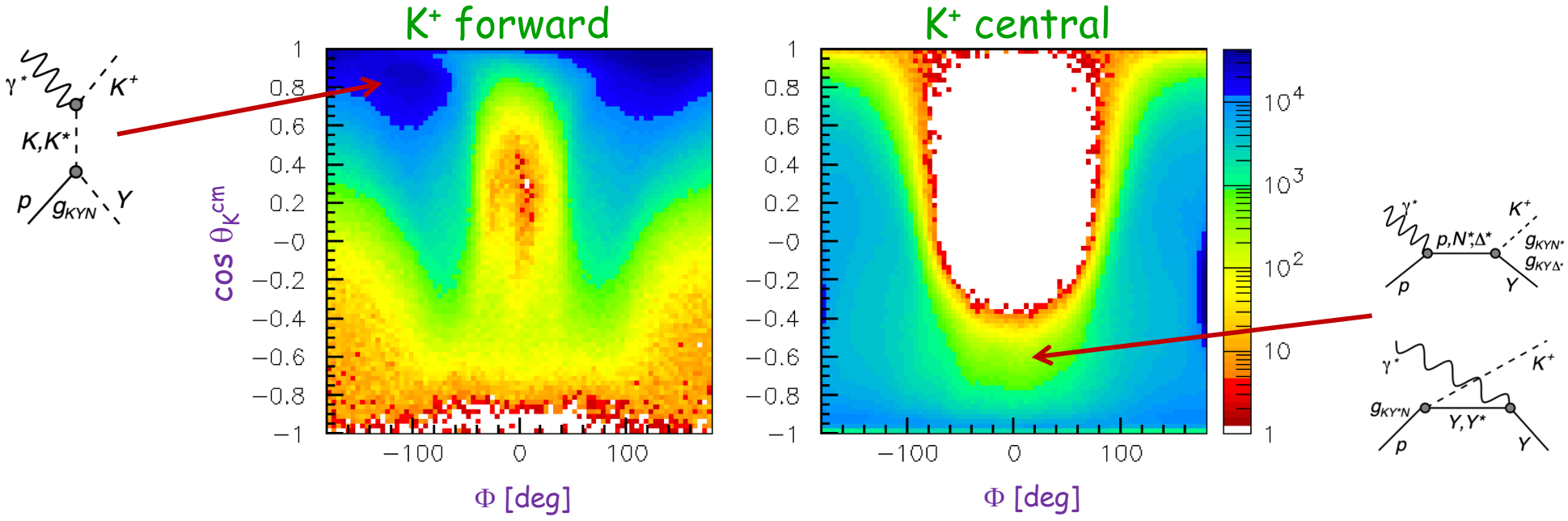
KY Event Reconstruction



$$p(\vec{e}, e' K^+) Y \qquad Y = \Lambda, \Sigma^0$$

$$\Lambda \to N\pi \qquad \Sigma^0 \to \Lambda\gamma \to N\pi\gamma$$

Final state detected: e', K+, p

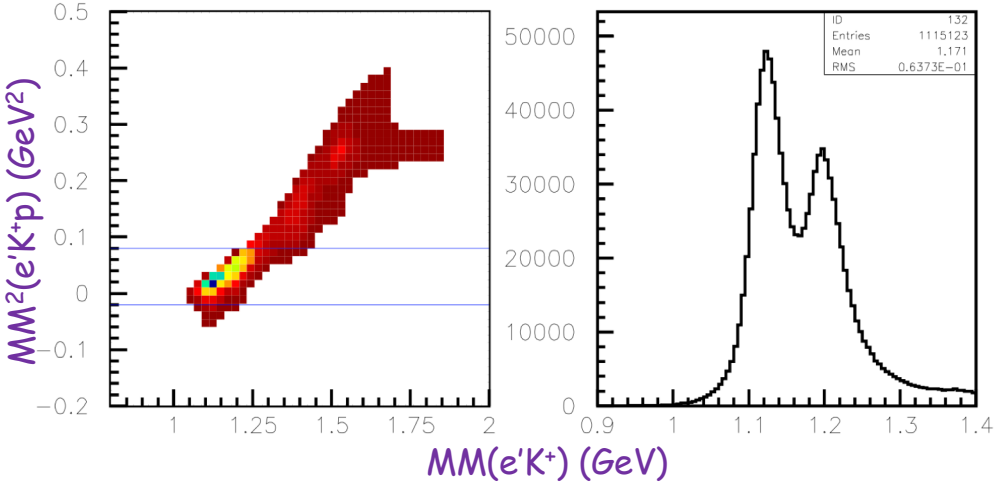


Acceptance of CLAS12 Central Detector crucial for accessing this polarization observable and to access effectively s-channel production

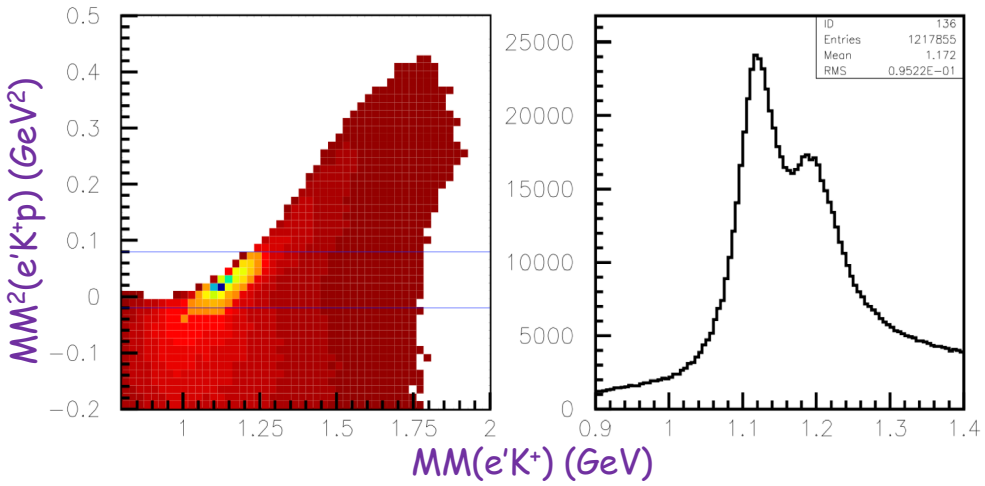
e'K⁺p Topologies

Favored Topologies

K⁺ forward, p forward

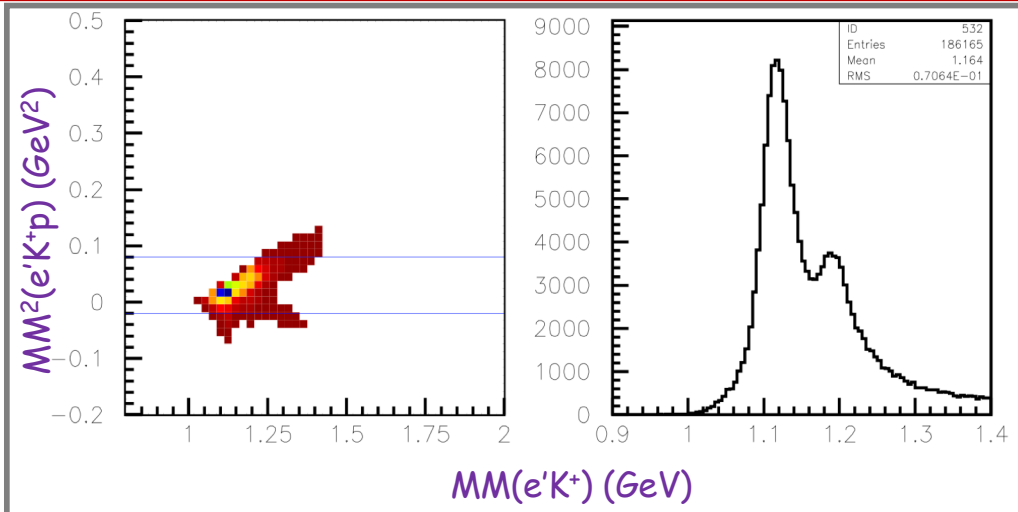


K⁺ central, p forward

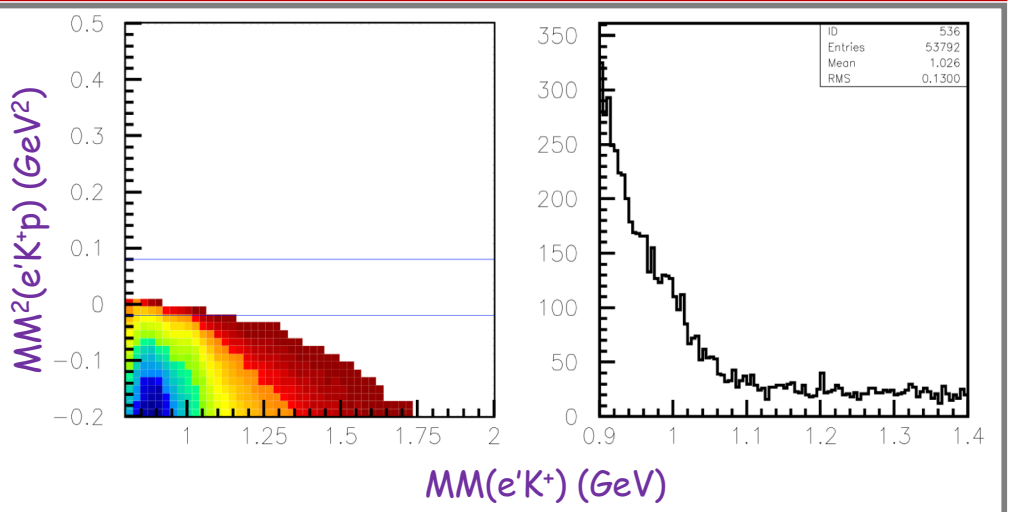


Unfavored Topologies

K⁺ forward, p central



K⁺ central, p central



Beam-Recoil Hyperon Polarization Analysis

$$A_{meas} = \frac{(N_\Lambda^+ + N_\Sigma^+ + N_B^+) - (N_\Lambda^- + N_\Sigma^- + N_B^-)}{N_\Lambda + N_\Sigma + N_B} = \alpha P_b P'_{meas} \cos\theta_P^{RF}$$

Λ Mass Region

$$A_{meas} = \frac{\alpha P_b P'_\Lambda \cos\theta_P^{RF} + \nu_\Sigma \alpha P_b P'_\Sigma \cos\theta_P^{RF} \cdot F_\Sigma}{1 + F_\Sigma + F_B}$$

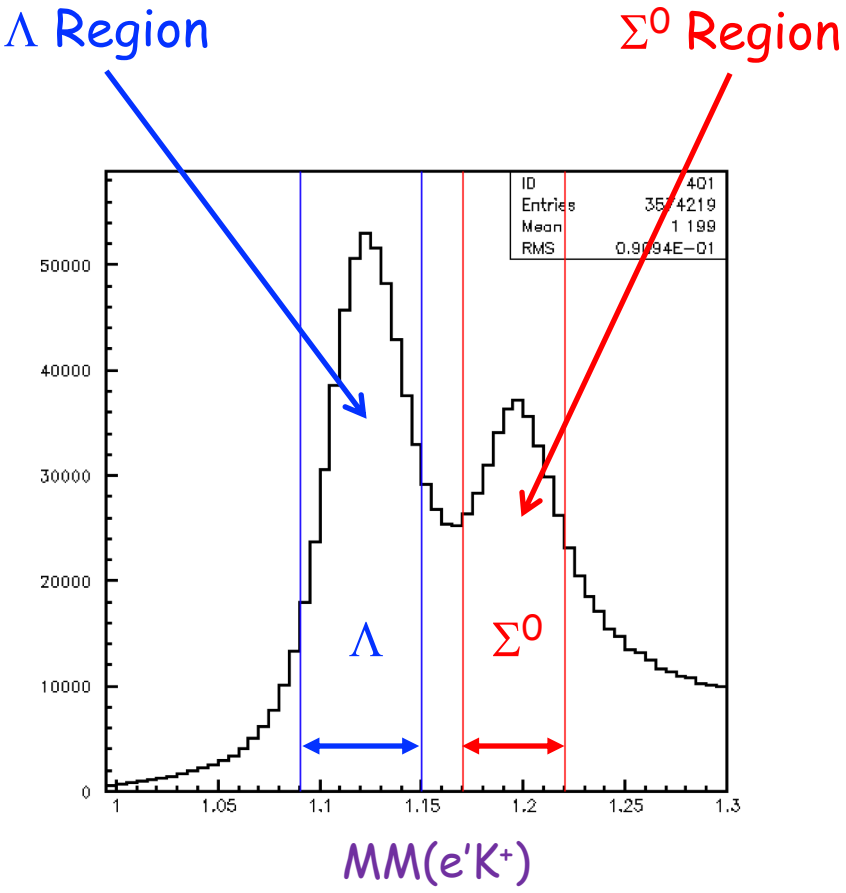
$$= \alpha P_b \left[\frac{P'_\Lambda + \nu_\Sigma P'_\Sigma F_\Sigma}{1 + F_\Sigma + F_B}\right] \cos\theta_p^{RF},$$

Assume $A_B = 0$

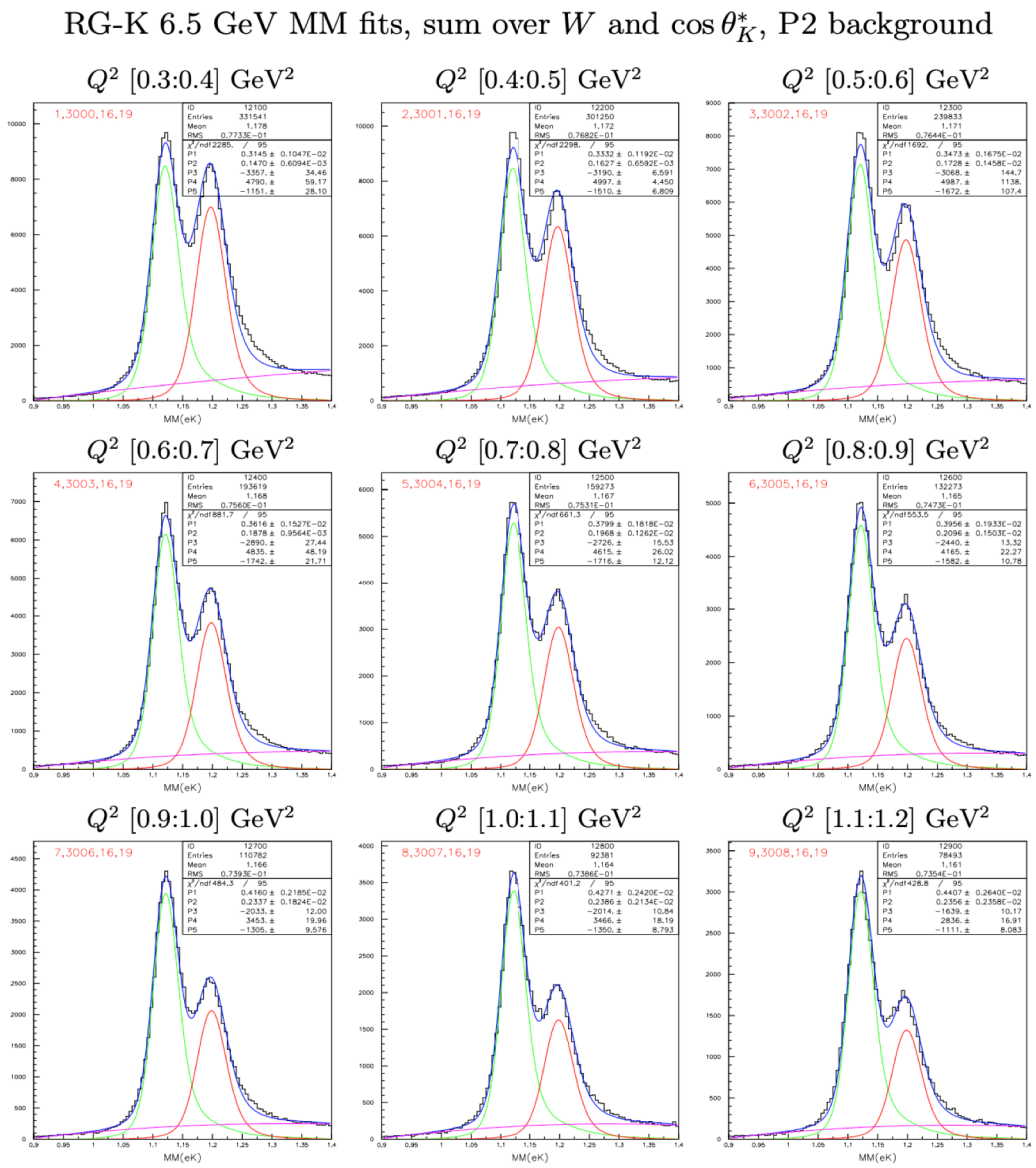
$$P'_{meas} = \frac{P'_\Lambda + \nu_\Sigma P'_\Sigma F_\Sigma}{1 + F_\Sigma + F_B}$$

$$P'_\Lambda = P'_{meas}(1 + F_\Sigma + F_B) - \nu_\Sigma P'_\Sigma F_\Sigma$$

Similar formalism in Σ^0 region



MM Spectrum Fits



Example fits use P2 background

Yield fitting approach:

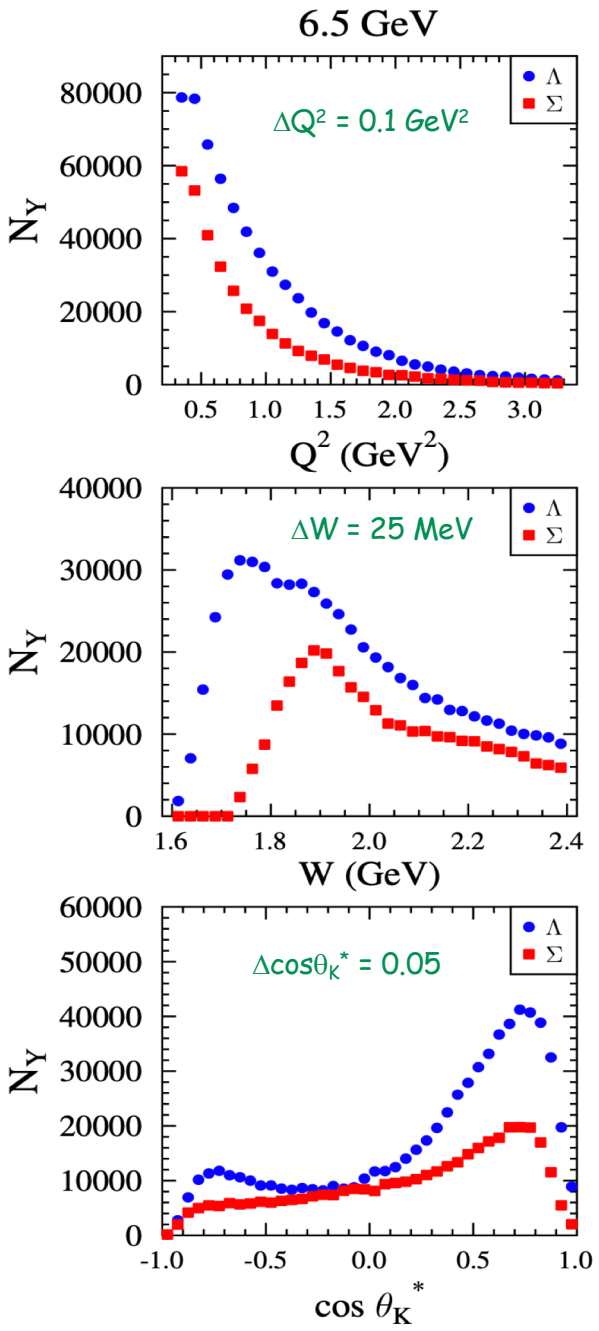
- Generate Monte Carlo $K^+\Lambda$ and $K^+\Sigma^0$ samples to use as fitting templates in bins matched to the data:
  - genKYandOnePion with background merging
- The background can be modeled with a polynomial or with the background channel
  - $e'\pi^+\pi^-p$ - with π^+ misidentified as a K^+
- Fit function:
  - GEMC resolution is better than data, so fit uses a Gaussian convolution of the templates to minimize χ^2

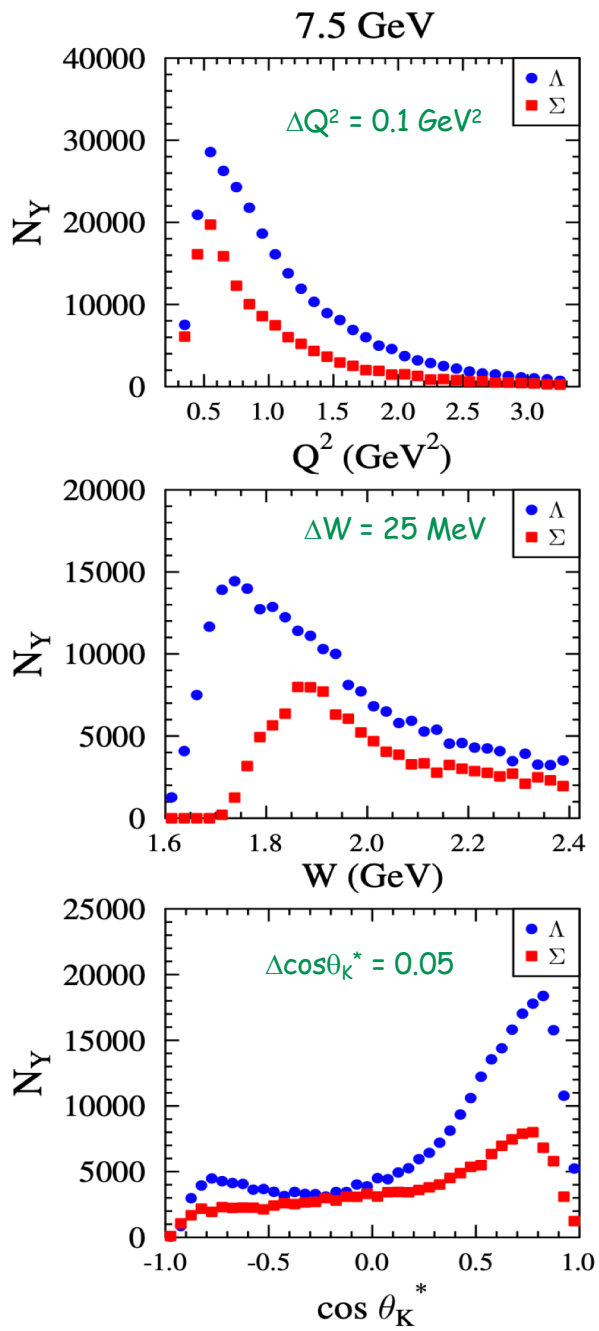
$$MM = A*[\text{TEMPLATE}_\Lambda] + B*[\text{TEMPLATE}_\Sigma] + C*[bck]$$

RG-K Hyperon Yields

N_Λ=620k

N_Σ=333k



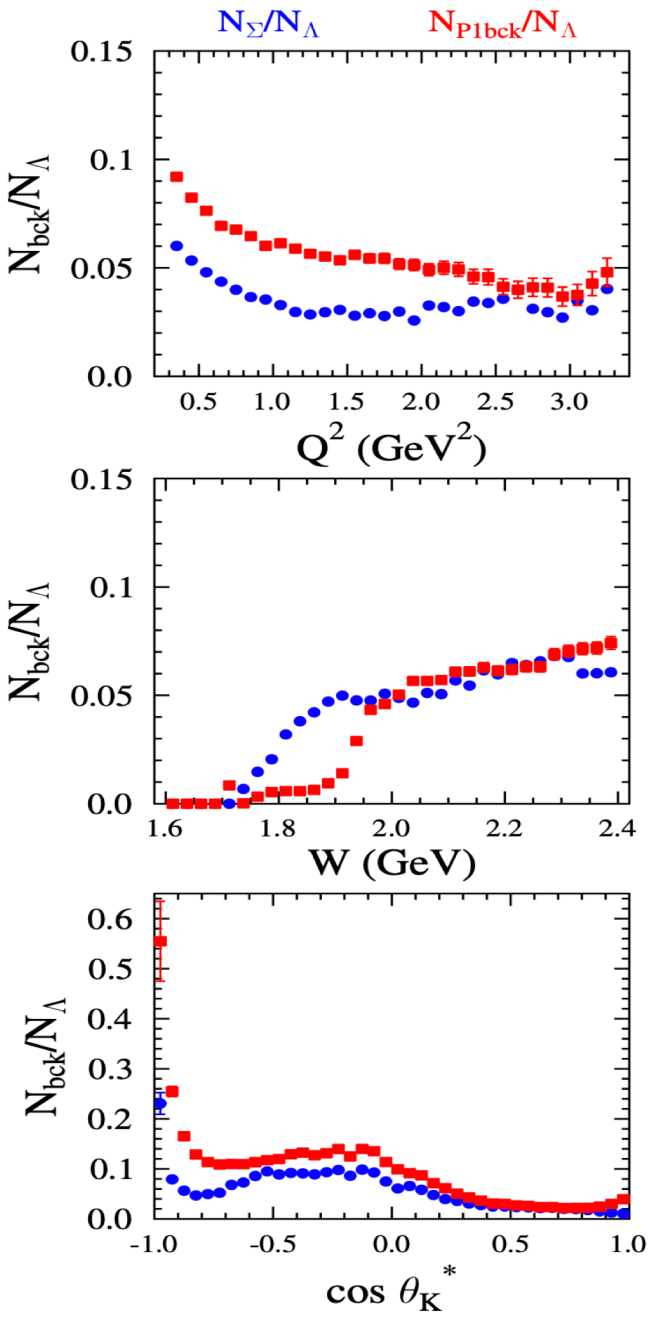


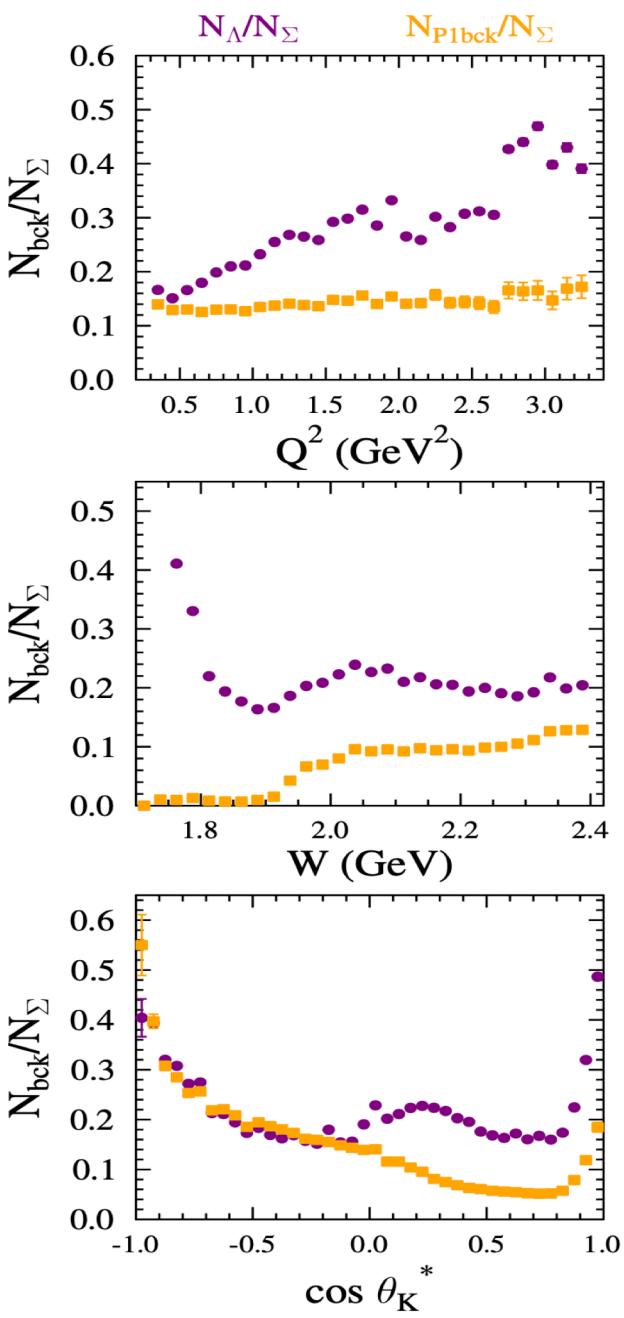
N_Λ=264k

N_Σ=135k

Background Ratios

Λ Mass Region





Σ^0 Mass Region

RG-K KY Coordinate System

6.1 Response Functions

Table 21 shows which response functions survive for various polarization conditions of the incident electron, target proton, and recoiling hyperon. In total, of the possible 144 terms in the full expansion of eq.(5), only 36 independent, non-vanishing response functions are necessary to describe the electroproduction of pseudoscalar mesons. The remaining terms vanish due to CPT symmetry considerations, or are related to other response functions that do not vanish.

Pol.		Response Functions								
β	α	T	L	^{c}LT	^{s}LT	^{c}TT	^{s}TT	^{c}LT$'$	^{s}LT$'$	TT$'$
0	0	R_T^{00}	R_L^{00}	R_{LT}^{00}	0	R_{TT}^{00}	0	0	$R_{LT'}^{00}$	0
x$'$	0	0	0	0	$R_{LT}^{x'0}$	0	$R_{TT}^{x'0}$	$R_{LT'}^{x'0}$	0	$R_{TT'}^{x'0}$
y$'$	0	$R_T^{y'0}$	‡	‡	0	‡	0	0	‡	0
z$'$	0	0	0	0	$R_{LT}^{z'0}$	0	$R_{TT}^{z'0}$	$R_{LT'}^{z'0}$	0	$R_{TT'}^{z'0}$
0	x	0	0	0	R_{LT}^{0x}	0	R_{TT}^{0x}	$R_{LT'}^{0x}$	0	$R_{TT'}^{0x}$
0	y	R_T^{0y}	R_L^{0y}	R_{LT}^{0y}	0	‡	0	0	$R_{LT'}^{0y}$	0
0	z	0	0	0	R_{LT}^{0z}	0	R_{TT}^{0z}	$R_{LT'}^{0z}$	0	$R_{TT'}^{0z}$
x$'$	x	$R_T^{x'x}$	$R_L^{x'x}$	$R_{LT}^{x'x}$	0	‡	0	0	$R_{LT'}^{x'x}$	0
x$'$	y	0	0	0	‡	0	‡	‡	0	‡
x$'$	z	$R_T^{x'z}$	$R_L^{x'z}$	‡	0	‡	0	0	‡	0
y$'$	x	0	0	0	‡	0	‡	‡	0	‡
y$'$	y	‡	‡	‡	0	‡	0	0	‡	0
y$'$	z	0	0	0	‡	0	‡	‡	0	‡
z$'$	x	$R_T^{z'x}$	‡	$R_{LT}^{z'x}$	0	‡	0	0	$R_{LT'}^{z'x}$	0
z$'$	y	0	0	0	‡	0	‡	‡	0	‡
z$'$	z	$R_T^{z'z}$	‡	‡	0	‡	0	0	‡	0

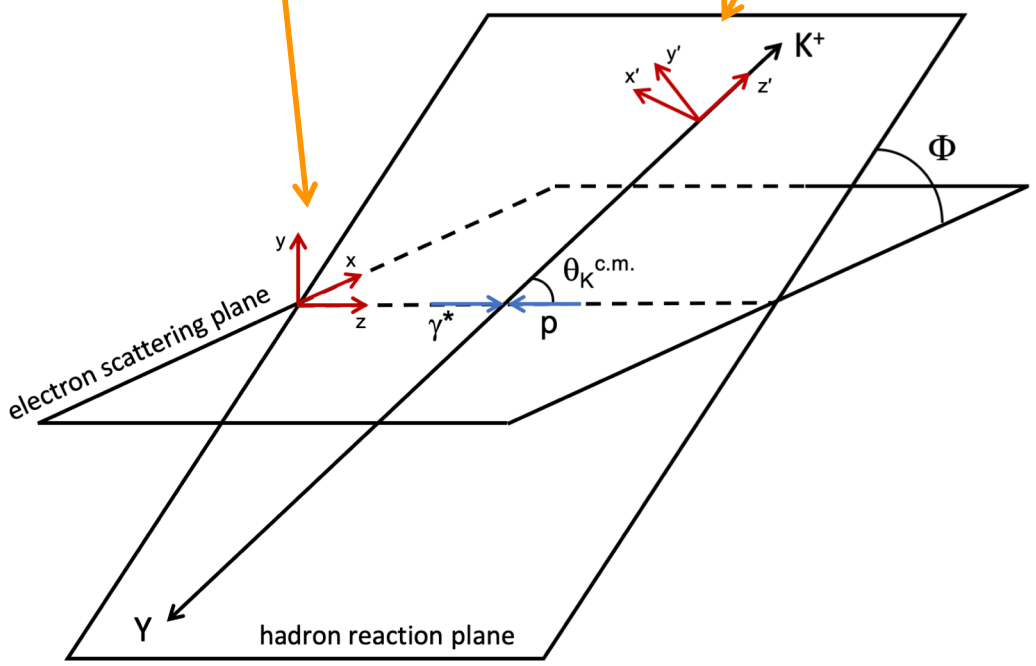
Table 21: Response functions for pseudoscalar meson production [7]. The target (recoil) polarization direction is indicated by α (β). The last three columns are for when the electron is polarized. ‡ indicates a response function which does not vanish but is related to other response functions.

$R^{\beta\alpha}(Q^2, W, \cos\theta_K^*)$

P_x^0	0
P_y^0	$\frac{1}{2}\sqrt{\epsilon(1+\epsilon)}K_I(R_{TL}^{x'0}\cos\theta_K^* + R_{TL}^{y'0} + R_{TL}^{z'0}\sin\theta_K^*)$
P_z^0	0
P_x'	$\frac{1}{2}\sqrt{\epsilon(1-\epsilon)}K_I(R_{TL'}^{x'0}\cos\theta_K^* - R_{TL'}^{y'0} + R_{TL'}^{z'0}\sin\theta_K^*)$
P_y'	0
P_z'	$\sqrt{1-\epsilon^2}K_I(-R_{TT'}^{x'0}\sin\theta_K^* + R_{TT'}^{z'0}\cos\theta_K^*)$

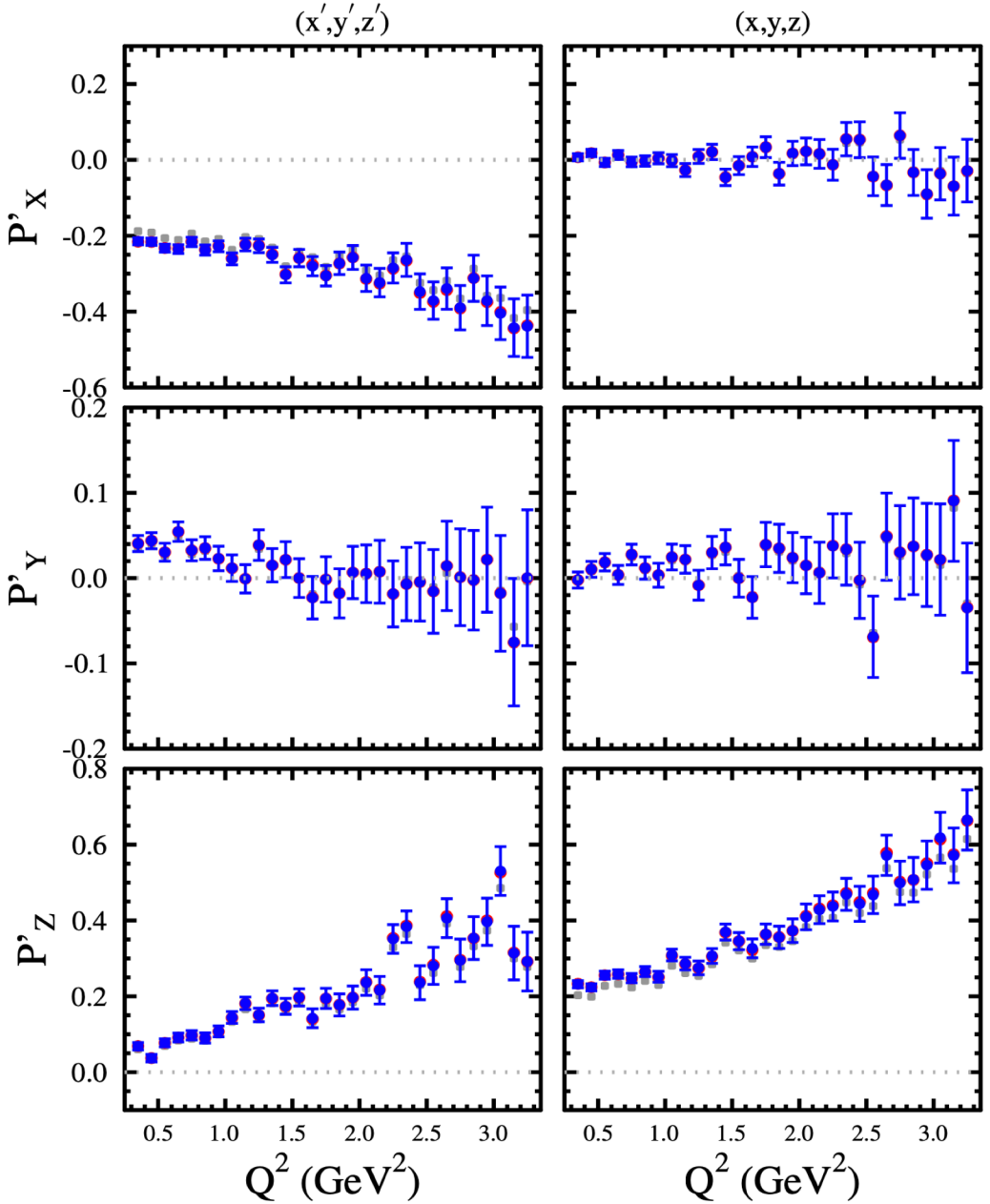
$\mathcal{P}_{x'}^0$	0
$\mathcal{P}_{y'}^0$	$K_I(R_T^{y'0} + \epsilon R_L^{y'0})$
$\mathcal{P}_{z'}^0$	0
$\mathcal{P}_{x'}'$	$K_I\sqrt{1-\epsilon^2}R_{TT'}^{x'0}$
$\mathcal{P}_{y'}'$	0
$\mathcal{P}_{z'}'$	$K_I\sqrt{1-\epsilon^2}R_{TT'}^{z'0}$

Φ-integrated components



Beam-Recoil Λ Transferred Polarization

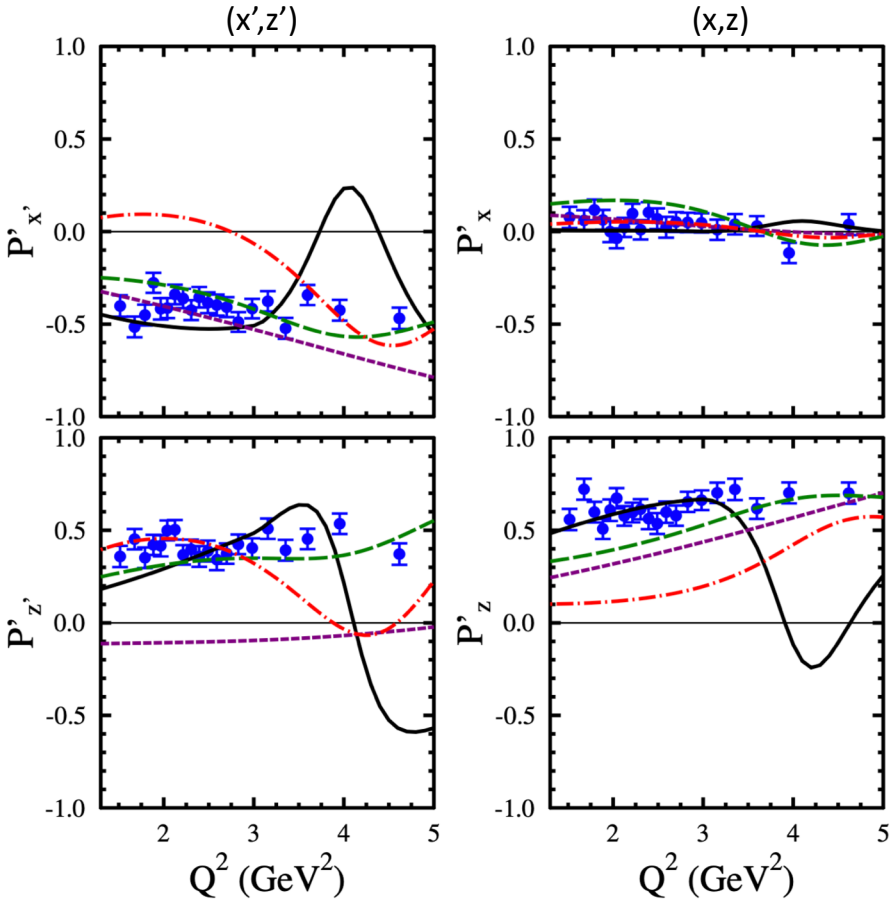
CLAS12 RG-K @ 6.535 GeV



ΔQ² = 0.1 GeV²

asmq sort: raw P1 bck P2 bck

CLAS e1-6 @ 5.754 GeV

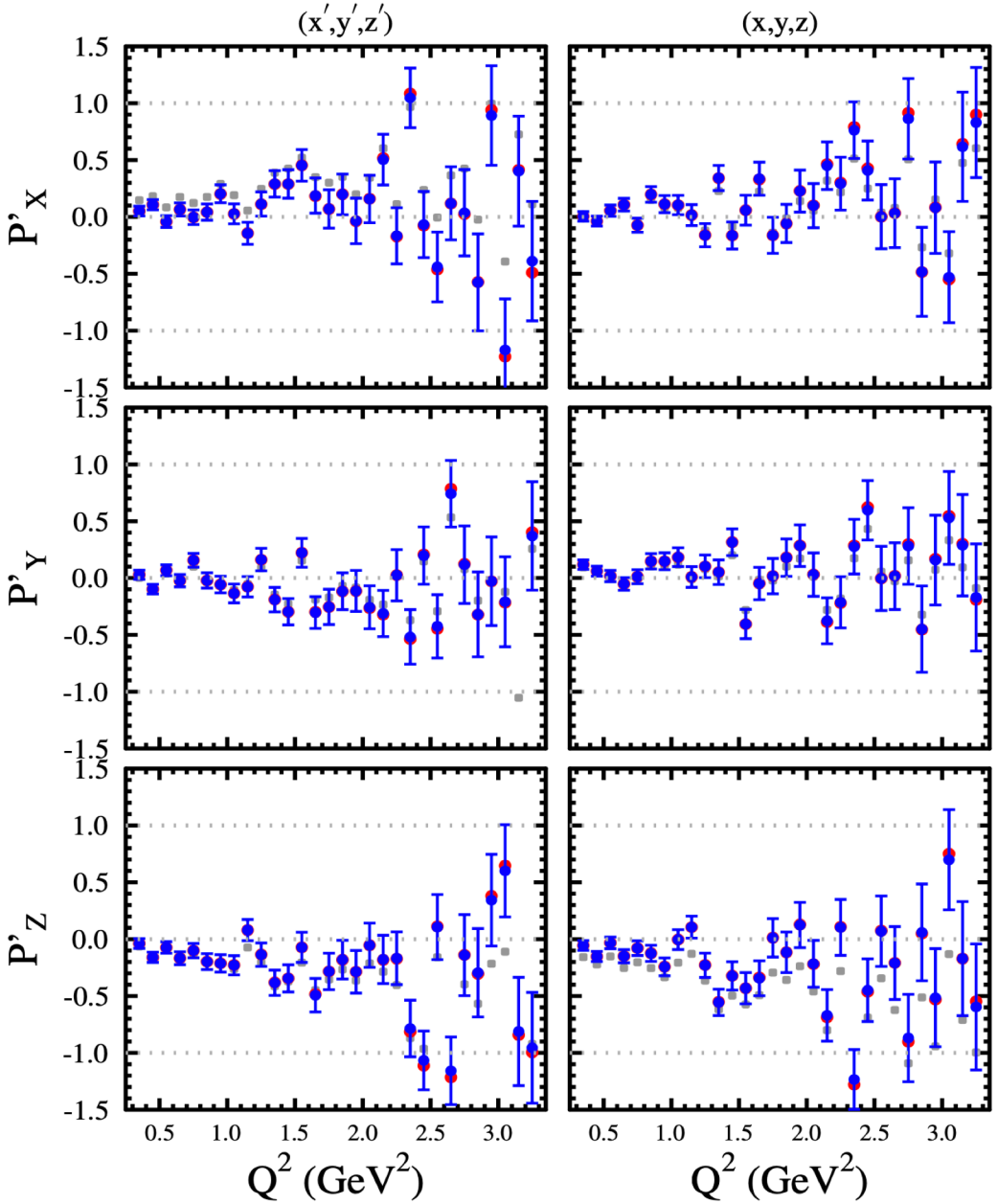


D.S. Carman et al., PRC79, 065205 (2009)

Mart/Bennhold RPR-2
RPR-1 Regge

Beam-Recoil Σ^0 Transferred Polarization

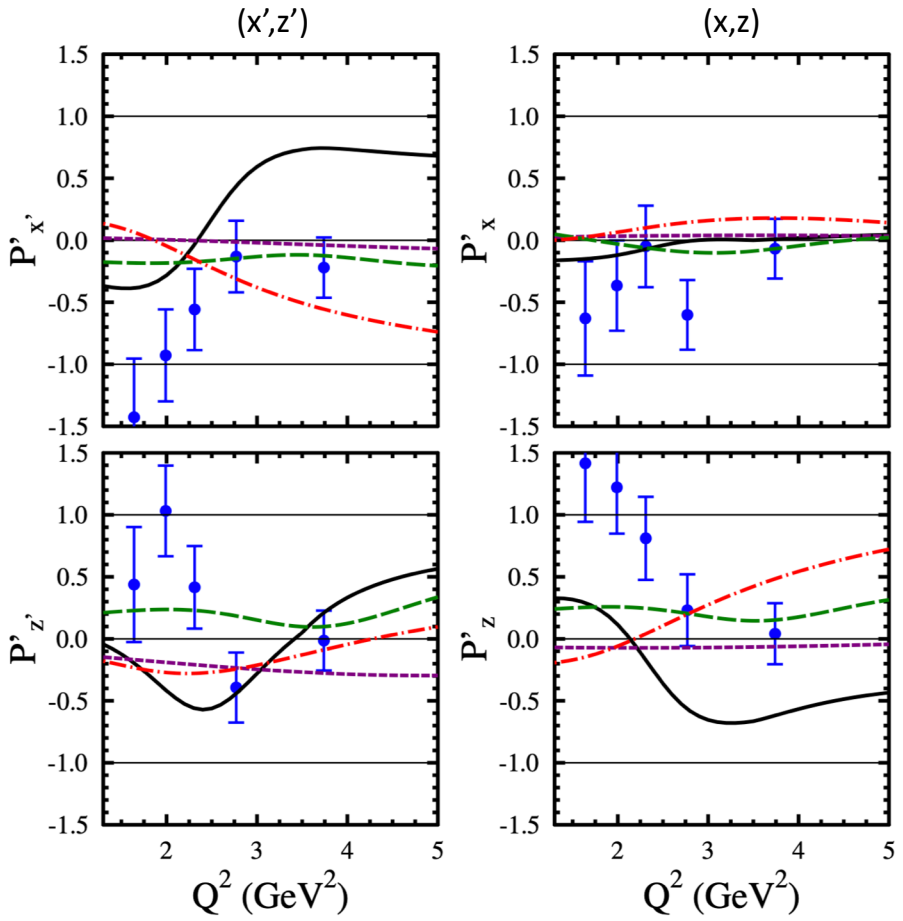
CLAS12 RG-K @ 6.535 GeV



ΔQ² = 0.1 GeV²

asmq sort: raw P1 bck P2 bck

CLAS e1-6 @ 5.754 GeV



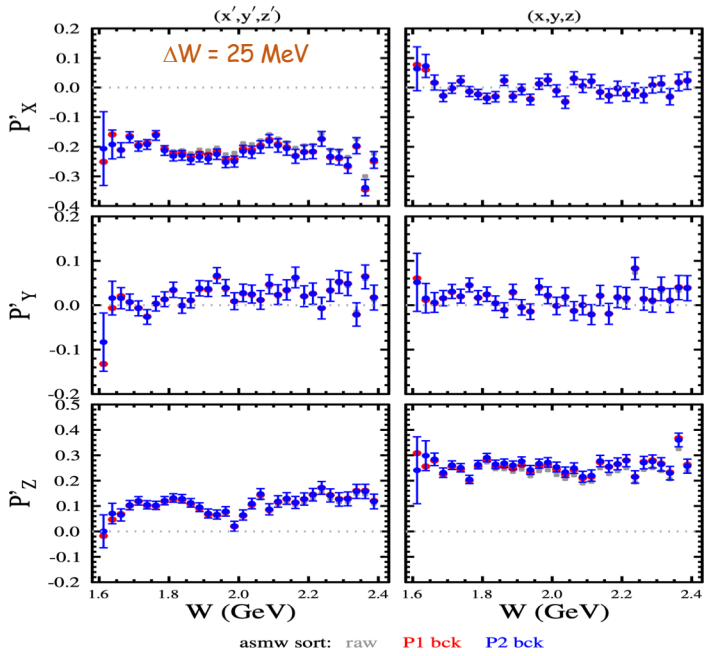
D.S. Carman et al., PRC79, 065205 (2009)

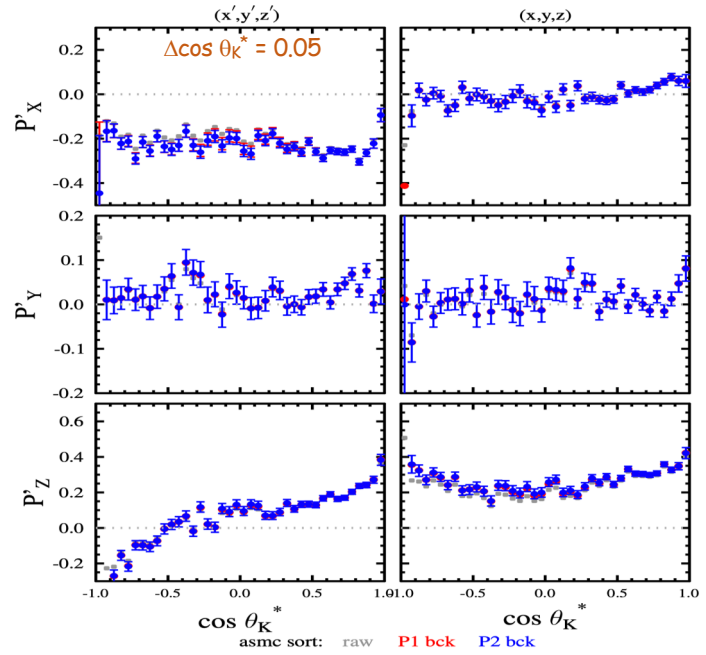
Mart/Bennhold RPR-2
RPR-1 Regge

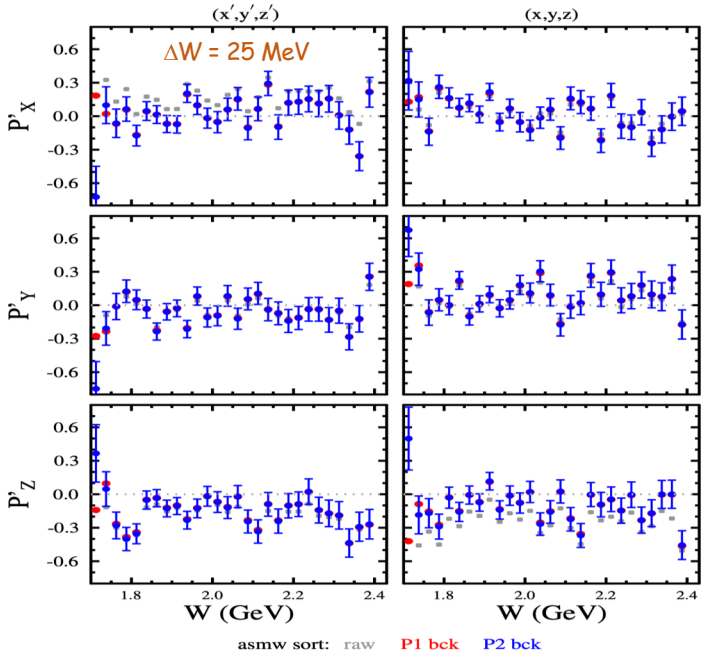
Hyperon Beam-Recoil Transferred Polarization

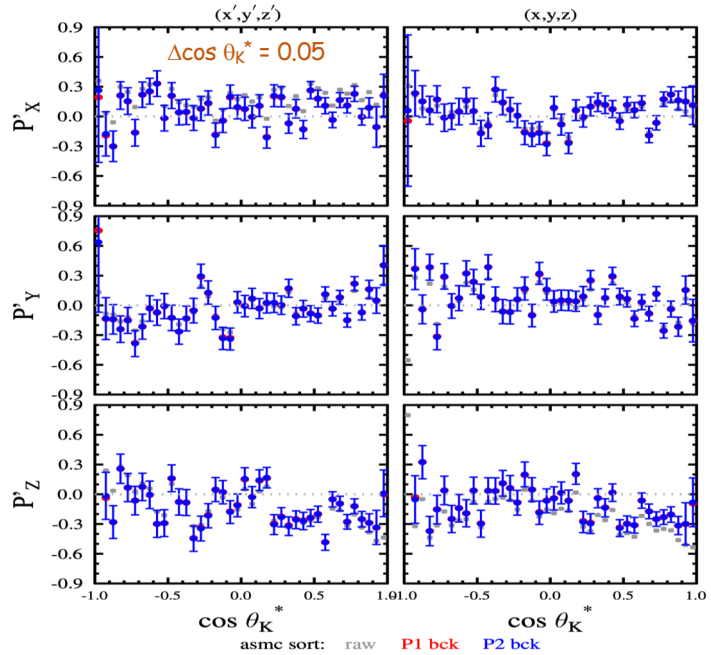
CLAS12 RG-K @ 6.535 GeV

Λ Final State









Σ⁰ Final State

RG-K KY Next Steps

1. Finalize single-dimensional analysis (Q^2, W, cos θ_K^*)
2. Work to advance multi-dimensional analysis
3. Quantify systematic uncertainties
4. Continue to develop complete analysis notes for review
5. Work with theorists for model curves
6. Prepare draft of paper – Phys. Rev. C target
7. GOAL: Aim for review by end of summer 2021

Much more detail on RG-K KY page at:

https://clasweb.jlab.org/wiki/index.php/Run_Group_K#tab=KY_Analysis_Work