Measurement of the Photon Beam Asymmetry Σ for $\gamma + p \to K^+\Sigma^0$ at $E_\gamma = 8.5$ GeV in GlueX

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On behalf of the GlueX Collaboration

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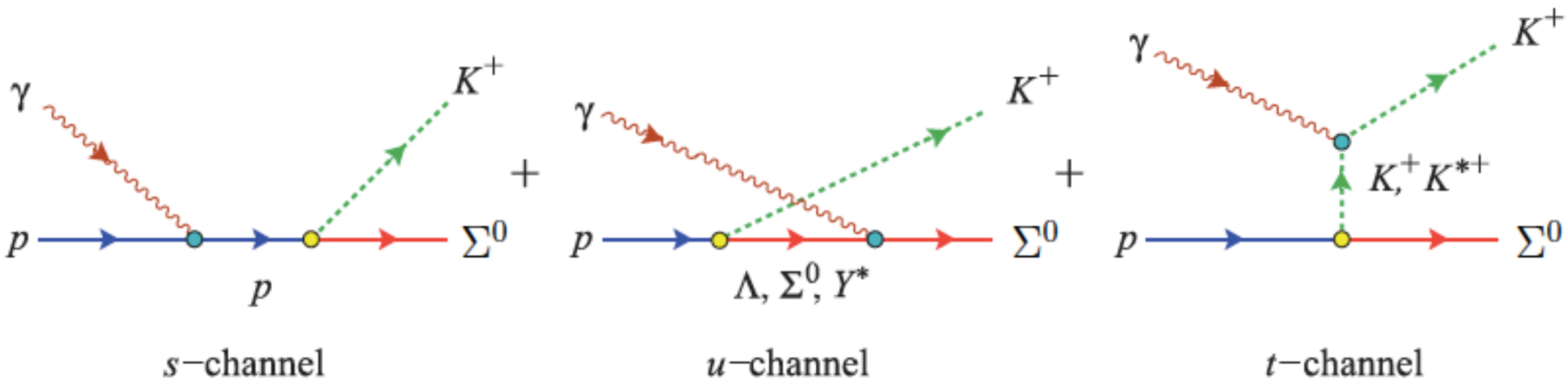
Introduction

- Important channels in kaon photoproduction

$$\gamma p \to KY(Y = \Lambda\,, \Sigma)$$

- Useful to study pair creation of strange and anti-strange quarks

- Different channels can contribute



- RPR-2007 model ➡ T. Corthals, T. Van Cauteren, J. Ryckebusch, and D. G. Ireland, Phys. Rev. C 75, 045204 (2007)

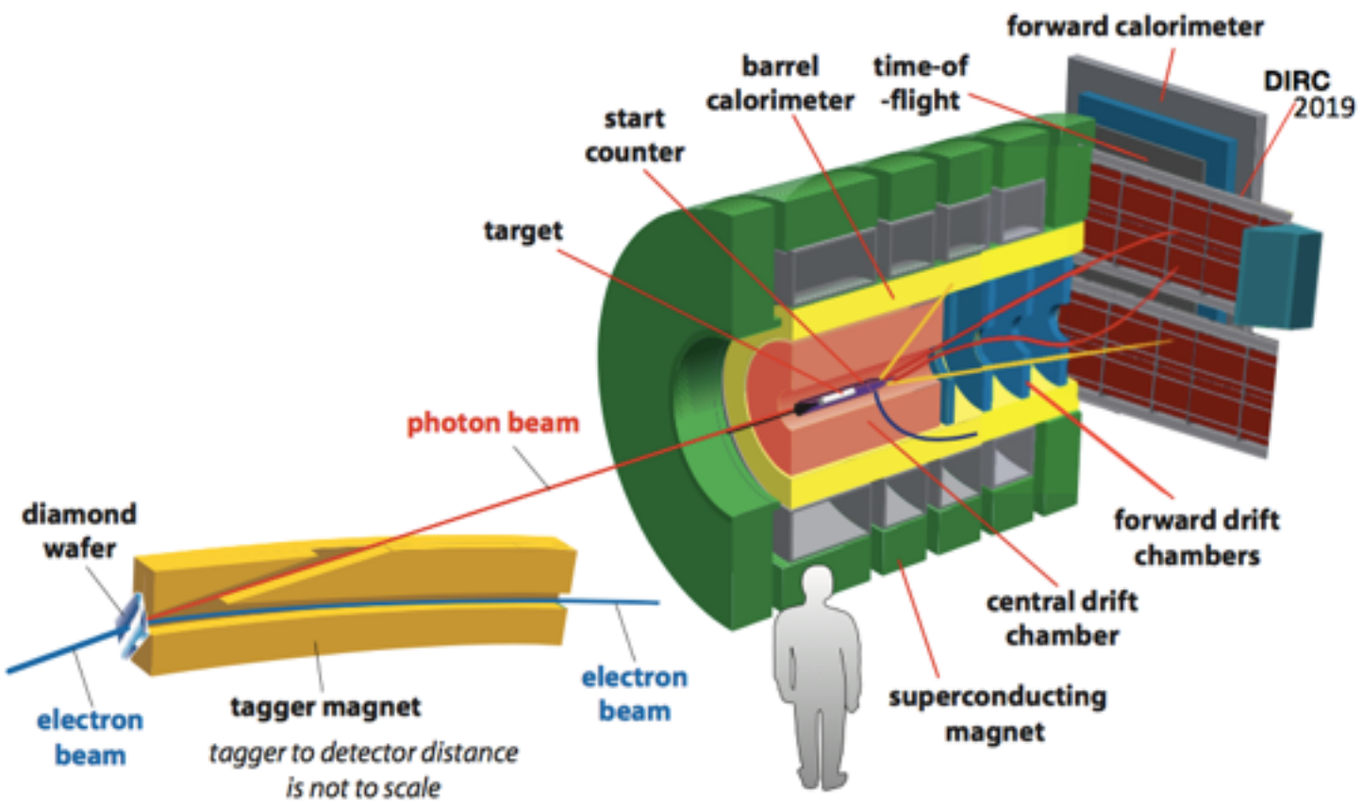
Physics Motivation

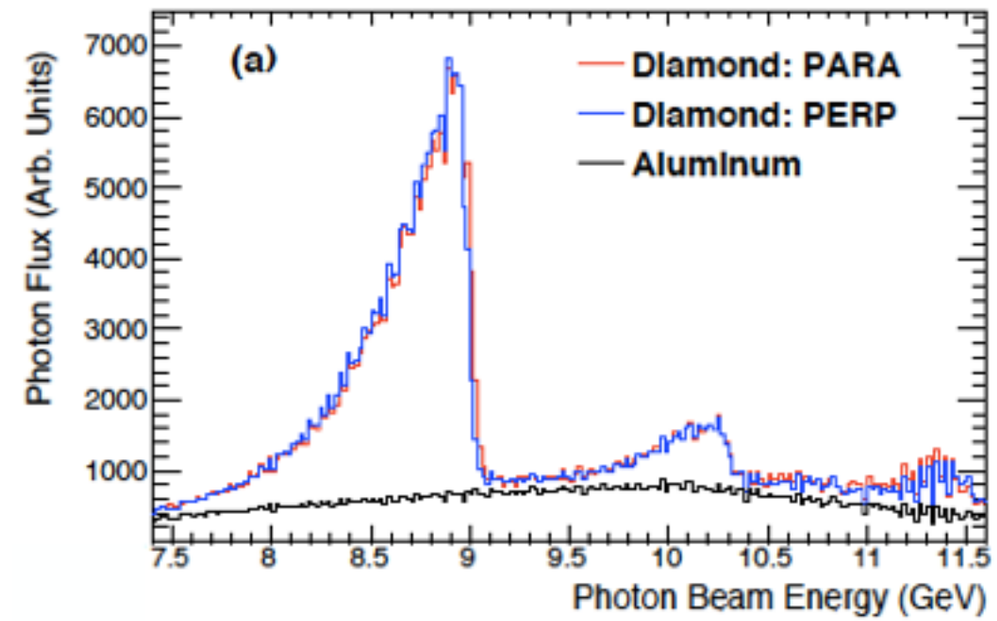
- Linearly polarized photon beam to study exchange of parity
- natural-parity ➡ $P = (-1)^J$
- unnatural-parity ➡ $P = (-1)^{J+1}$
- "Stichel's theorem" (Z. Phys. 180, 170 (1964))
  - to the leading power in *s*, cross section for photon polarized $\perp$ to production plane dominated by natural-parity exchange
  - for photon polarized $\parallel$ to production plane dominated by unnatural-parity exchange

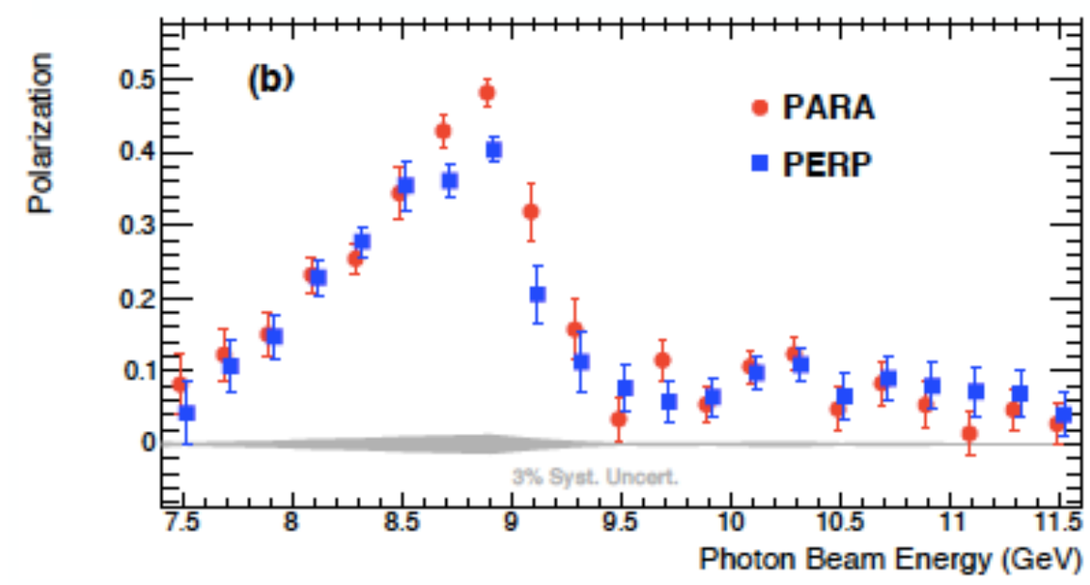
Beam Asymmetry $$\Sigma = \frac{(d\sigma_\perp/dt) - (d\sigma_\parallel/dt)}{(d\sigma_\perp/dt) + (d\sigma_\parallel/dt)}$$

GlueX Detector

- Jefferson Lab, Newport News, VA, USA
- Hall D
- CEBAF ➡ 12 GeV electron beam







- Photons are linearly polarized relative to crystal axes in the diamond
- Coherent bremsstrahlung
- Two polarization modes: PARA ➡ $\vec{E} \parallel$

  PERP ➡ $\vec{E} \perp$

Event Selection

$$\gamma + p \rightarrow K^+ + \Sigma^0(1193) \;\; \Rightarrow \; \Sigma^0 \rightarrow \Lambda\gamma$$

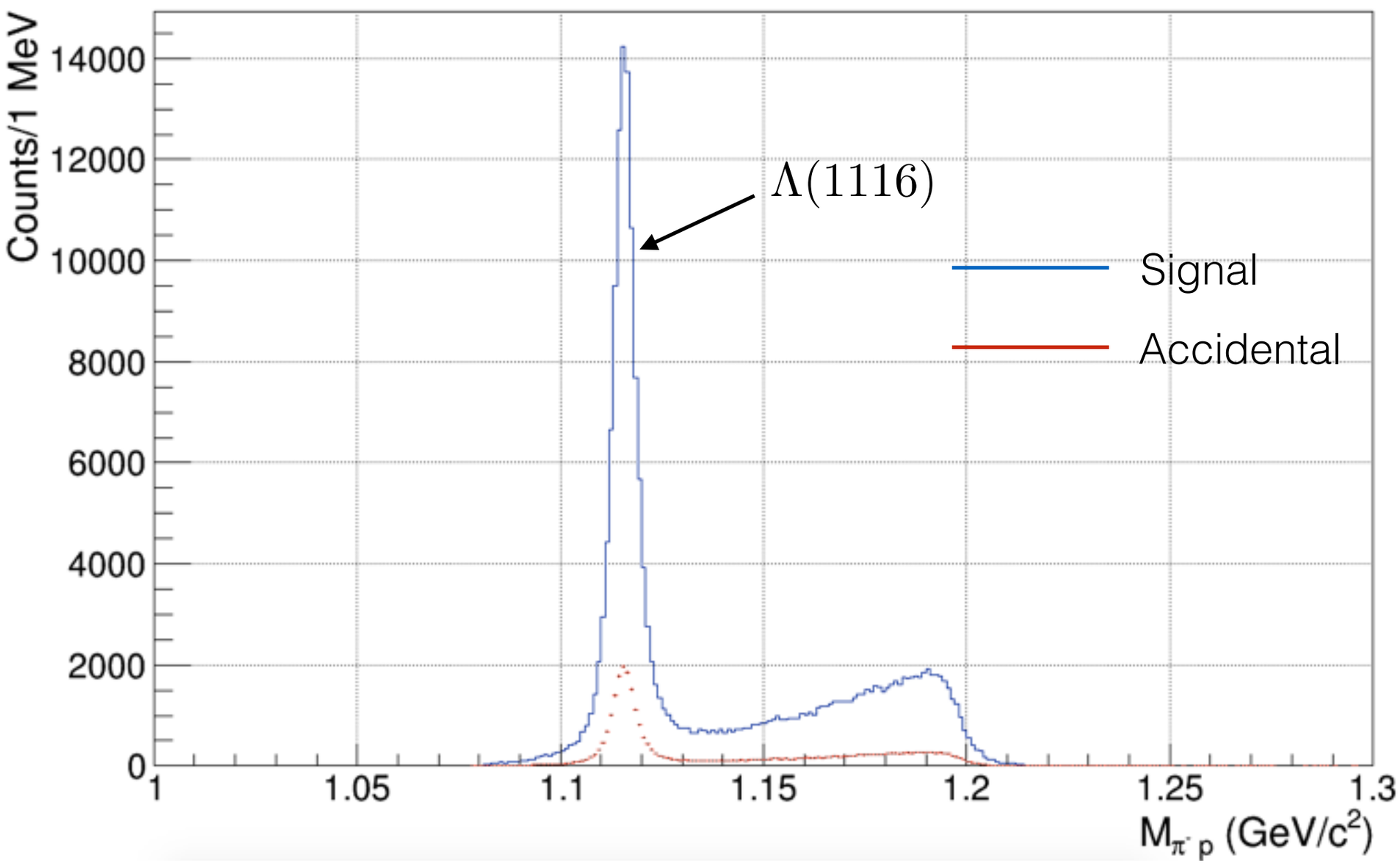
- Select combinations of particles matching the topology of

$$\gamma p \rightarrow K^+ \Lambda \gamma \;\; (\Lambda \rightarrow \pi^- p)$$

- Two positive tracks, one negative track and one neutral shower in final state
- -0.08 $GeV^2 <$ M_X^2 < 0.08 GeV^2
- Kinematic fit satisfying the conservation of energy and momentum (confidence level > 0.0001)
- PID for charged tracks was done with TOF and for photons with EM calorimeters

Invariant Mass of $\pi^- p$

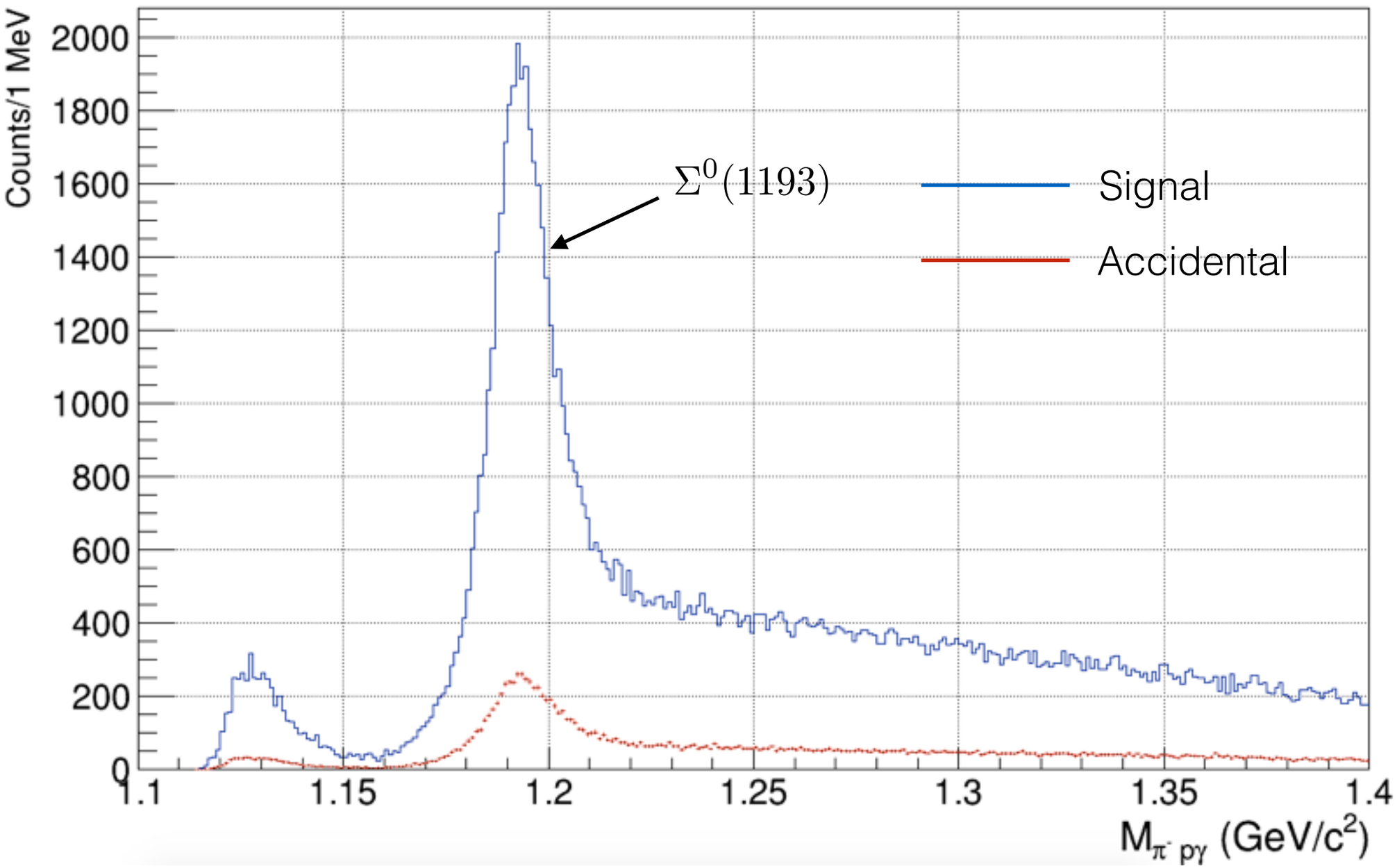
- Coherent peak ➡ $8.2 < E_{beam} < 8.8\,\mathrm{GeV}$



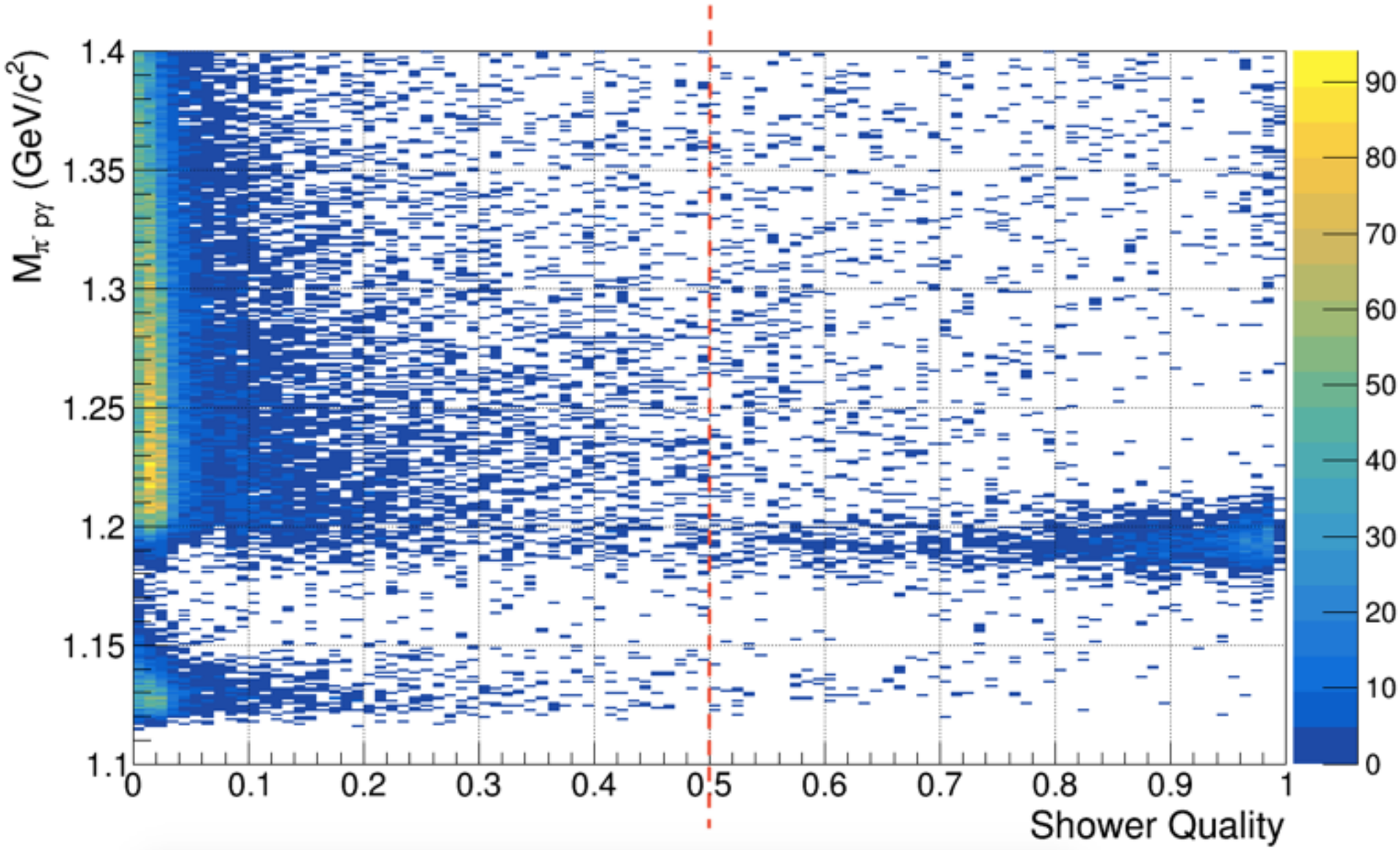
- Accidentals are scaled by the time window

Invariant Mass of $\pi^- p\gamma$

- Events within 1.107 < $M_{\pi^- p}$ < 1.125 GeV/c^2

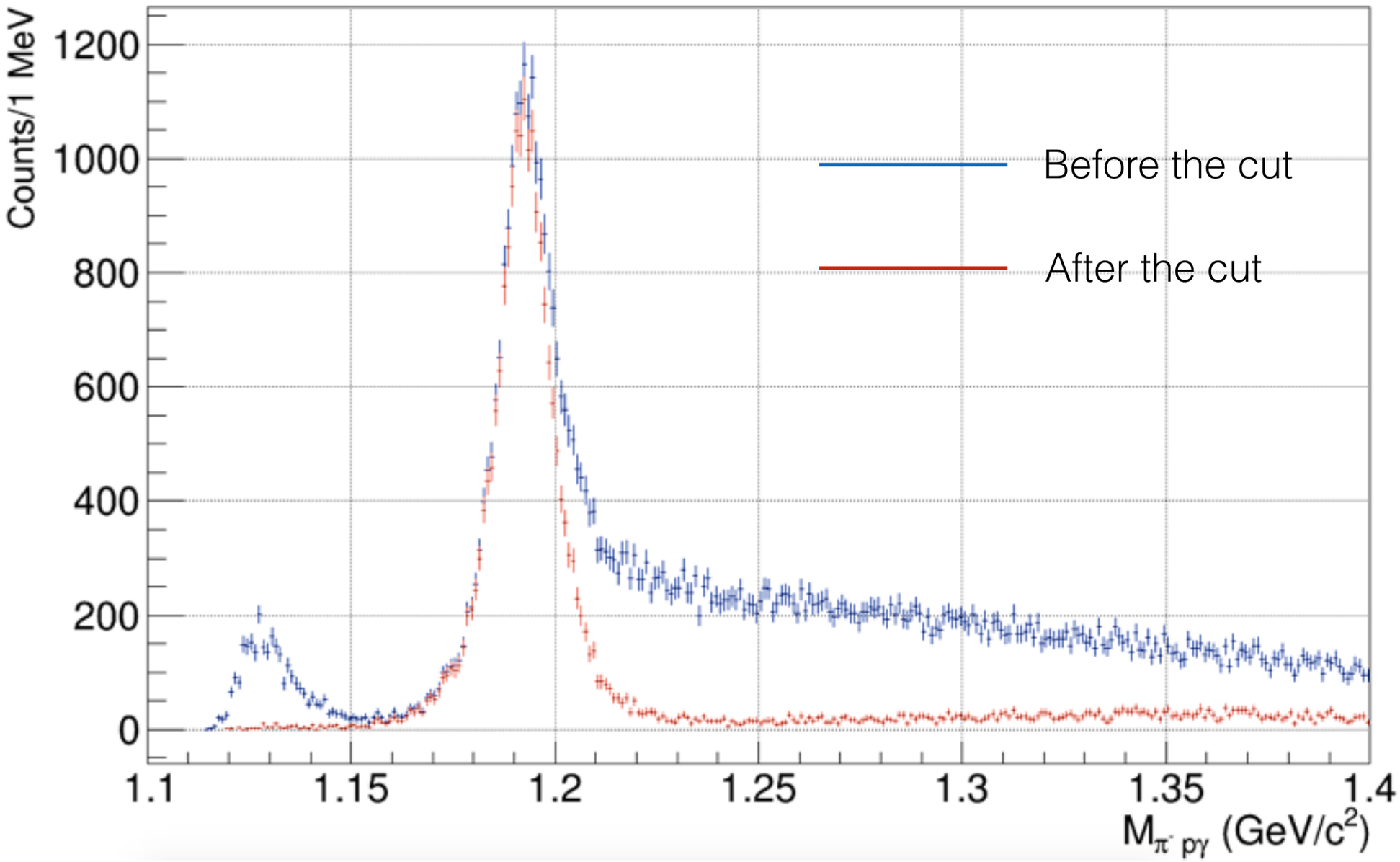


$M_{\pi^- p\gamma}$ vs FCAL shower quality



- Cut to remove extra showers from hadrons misidentified as photons in forward calorimeter (FCAL)
- Shower quality variable ➡ developed using neural net technology

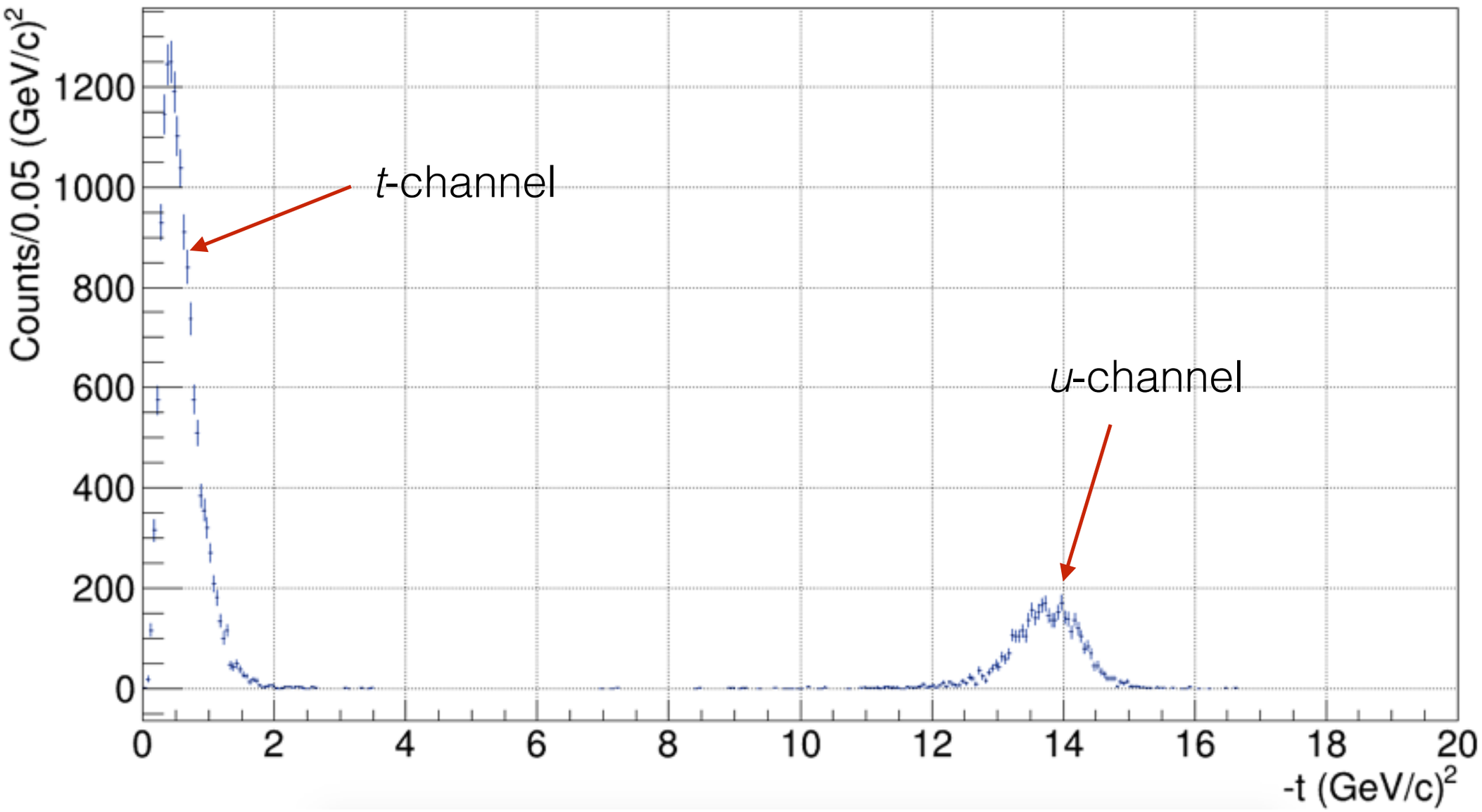
Cut on shower quality



- Shower quality > 0.5 ➡ clean Σ^0 peak
- Background of uncorrelated photons eliminated

-t distribution

- Events within $1.169 < M_{\pi^- p\gamma} < 1.217\ GeV/c^2$



$$-t = -[(p_{beam} - p_{K^+})^2]$$

- Both t- and u-channel contributions

Photon Beam Asymmetry

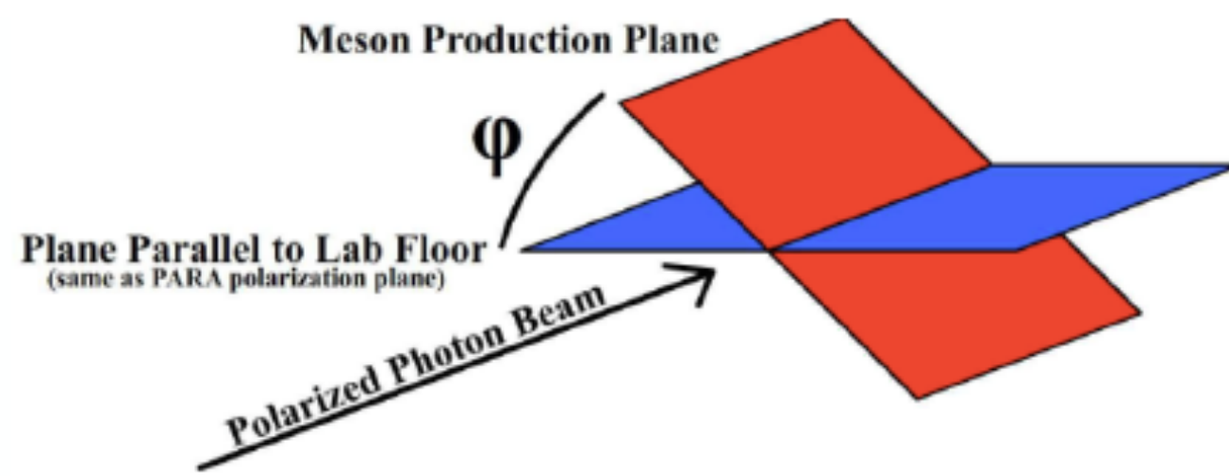
$$\sigma = \sigma_0[1 - P_\gamma \Sigma \cos 2(\phi_{K^+} - \phi_\gamma^{lin})]$$

<u>In terms of PARA and PERP yields and polarizations</u>

Yield Asymmetry

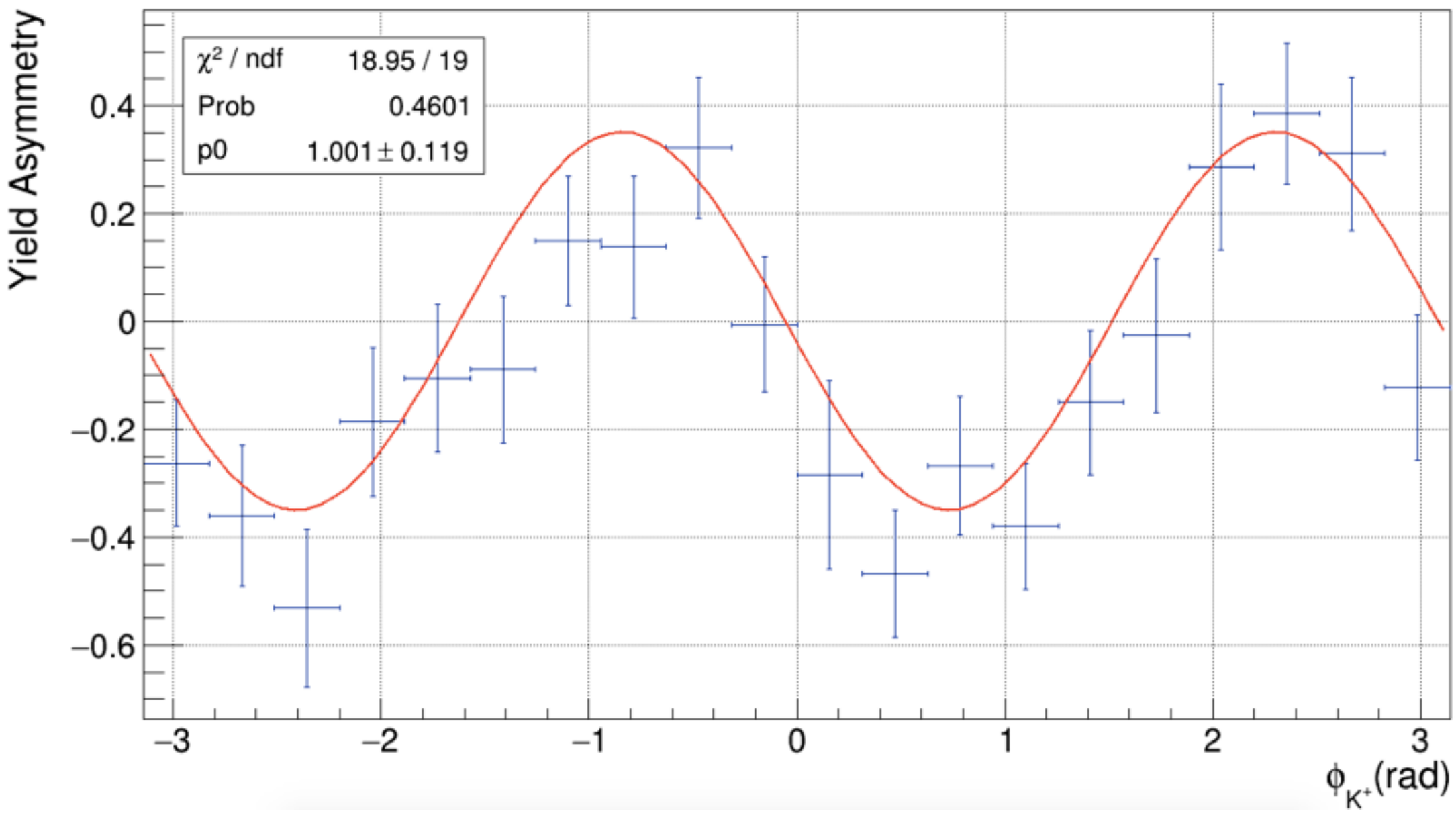
$$\frac{Y_\perp - F_R Y_\parallel}{Y_\perp + F_R Y_\parallel} = \frac{(P_\perp + P_\parallel)\Sigma \cos 2(\phi_{K^+} - \phi_0)}{2 + (P_\perp - P_\parallel)\Sigma \cos 2(\phi_{K^+} - \phi_0)}$$

- Σ - Beam asymmetry
- P_γ - Degree of photon polarization
- ϕ_{K^+} - Azimuthal angle of production plane
- ϕ_γ^{lin} - Azimuthal angle of photon beam linear polarization plane



Yield Asymmetry

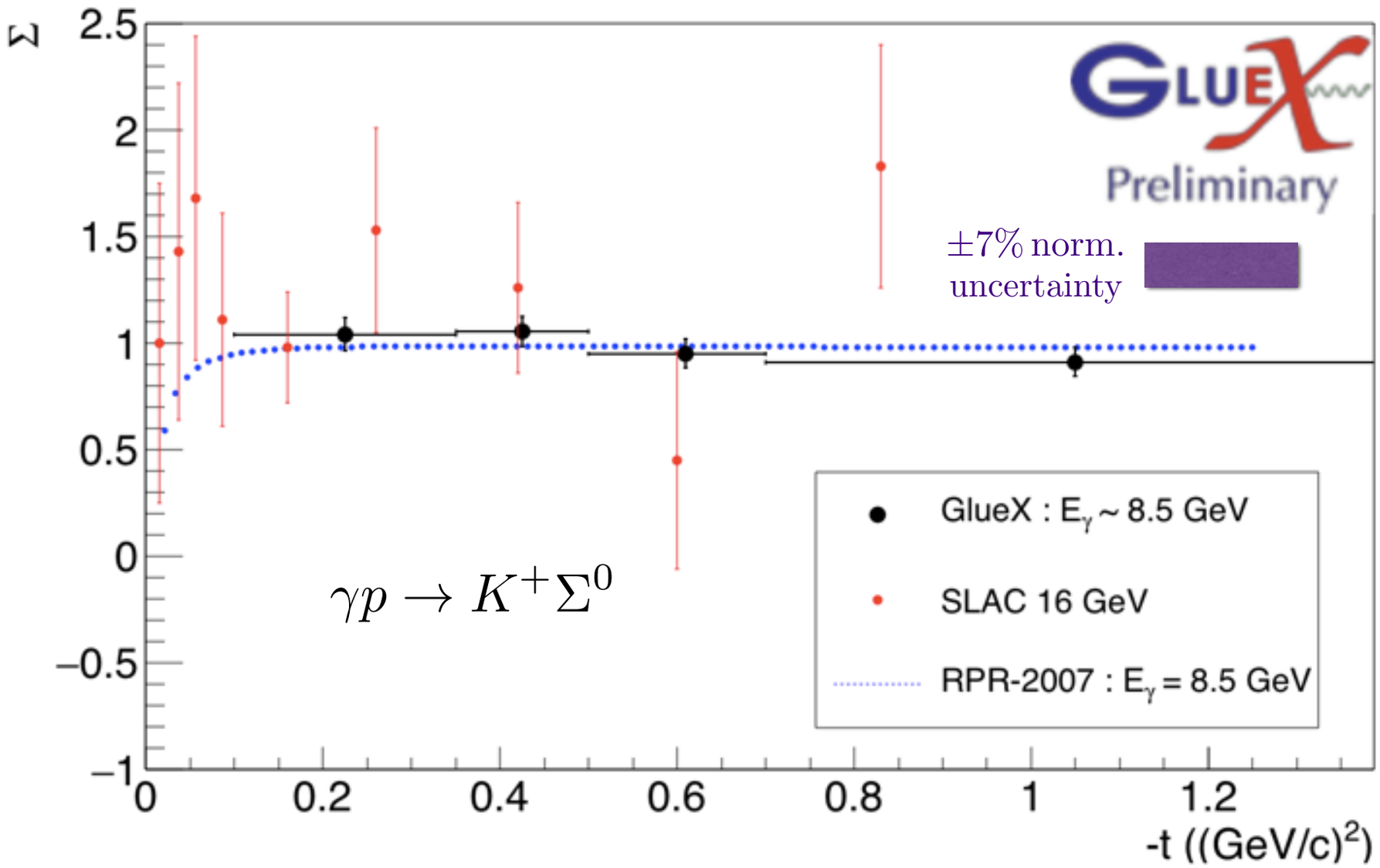
<u>-t=0.1-0.35 bin for 45/135</u>



$p_0 = \Sigma$ ➡ Beam asymmetry

Beam Asymmetry of $\gamma p \to K^+\Sigma^0$

- Combined result from two orientation sets (errors are statistical only)



Σ ~ 1

Natural parity exchange (K*(892))

RPR-2007 model: Phys. Rev. C 75, 045204 (2007)

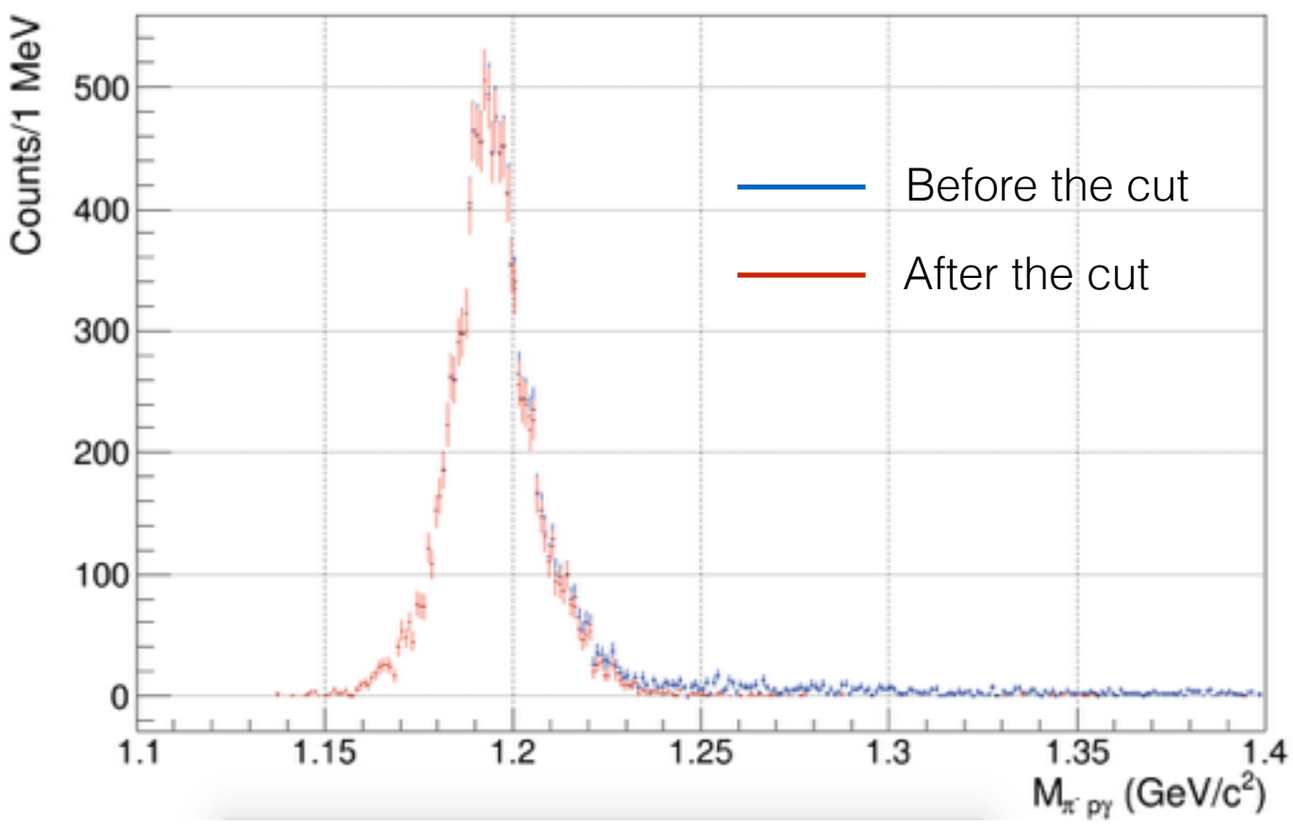
SLAC data: Phys. Rev. D 20 1553 (1979)

Outlook

- Work on the systematics
- Finalize the asymmetry measurement for *u*-channel (first time measurement)
- Work on the draft paper

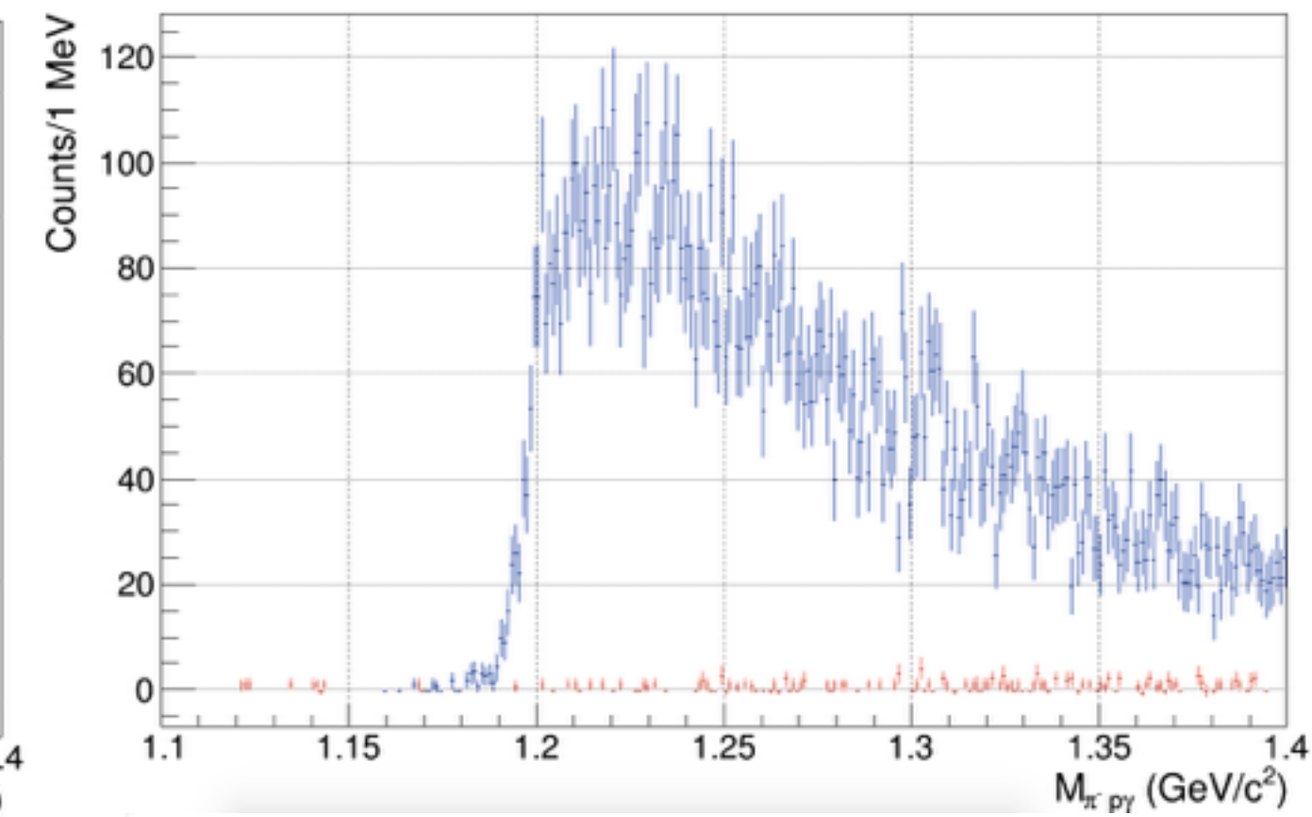
Backup - Effect of the cut on MC

$K^+\Sigma^0$ *t*-channel



$M_{\pi^- p\gamma}$

$K^+\Lambda$ *t*-channel

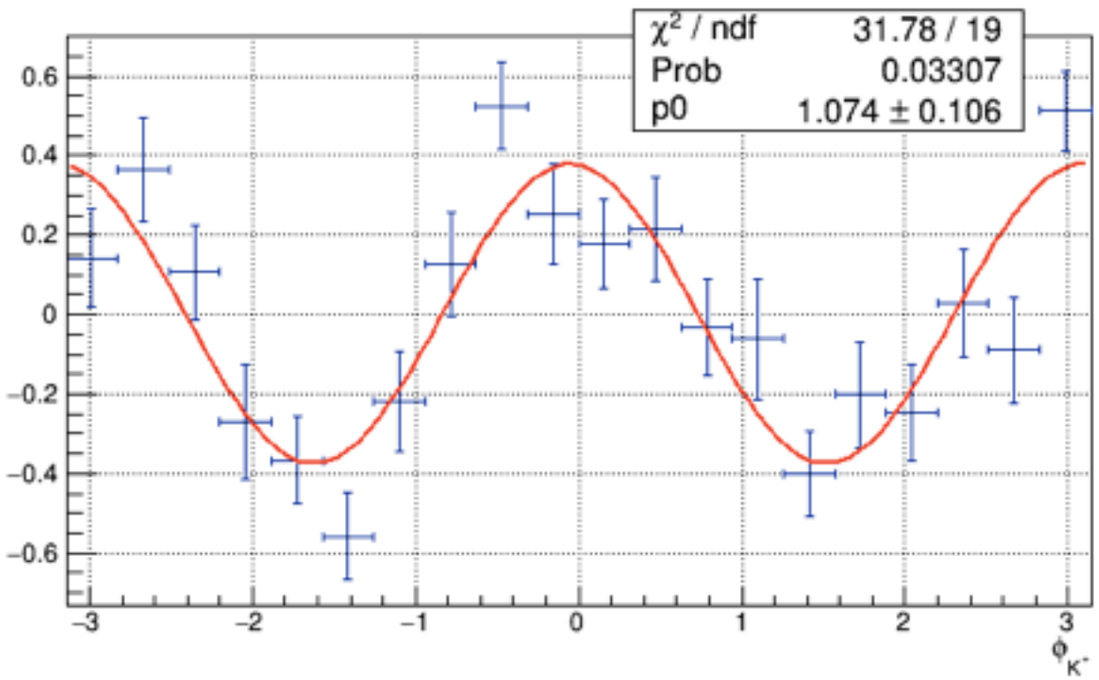


$M_{\pi^- p\gamma}$

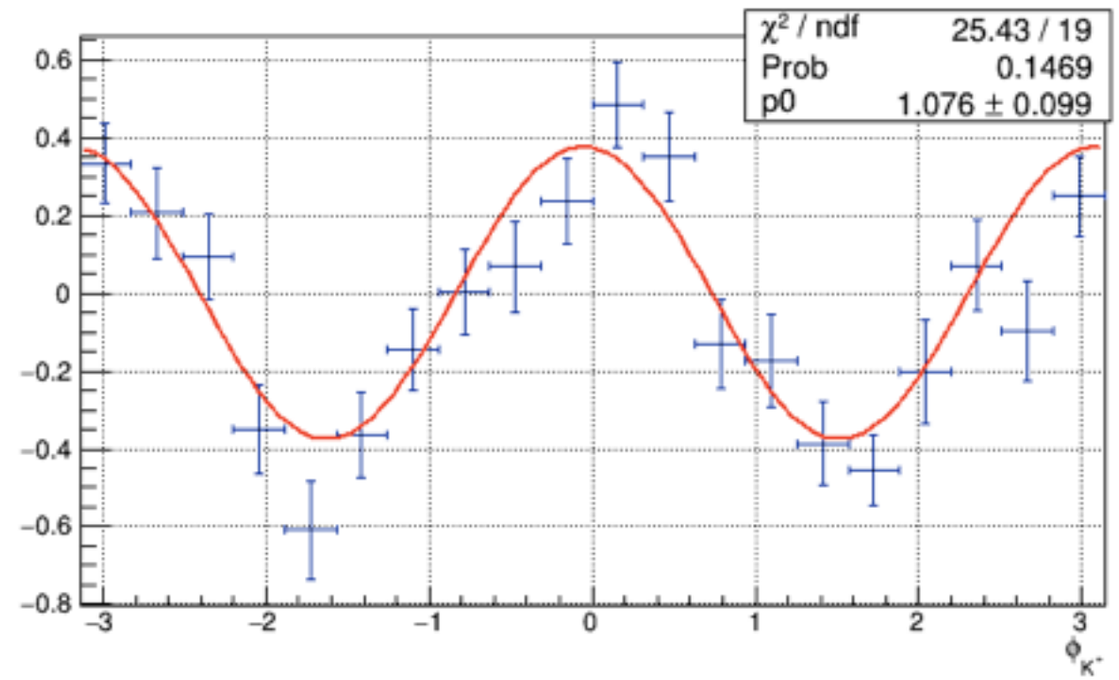
- FCAL shower quality > 0.5 cut eliminates the background coming from $K^+\Lambda$ *t*-channel
- No loss of signal events due to the cut

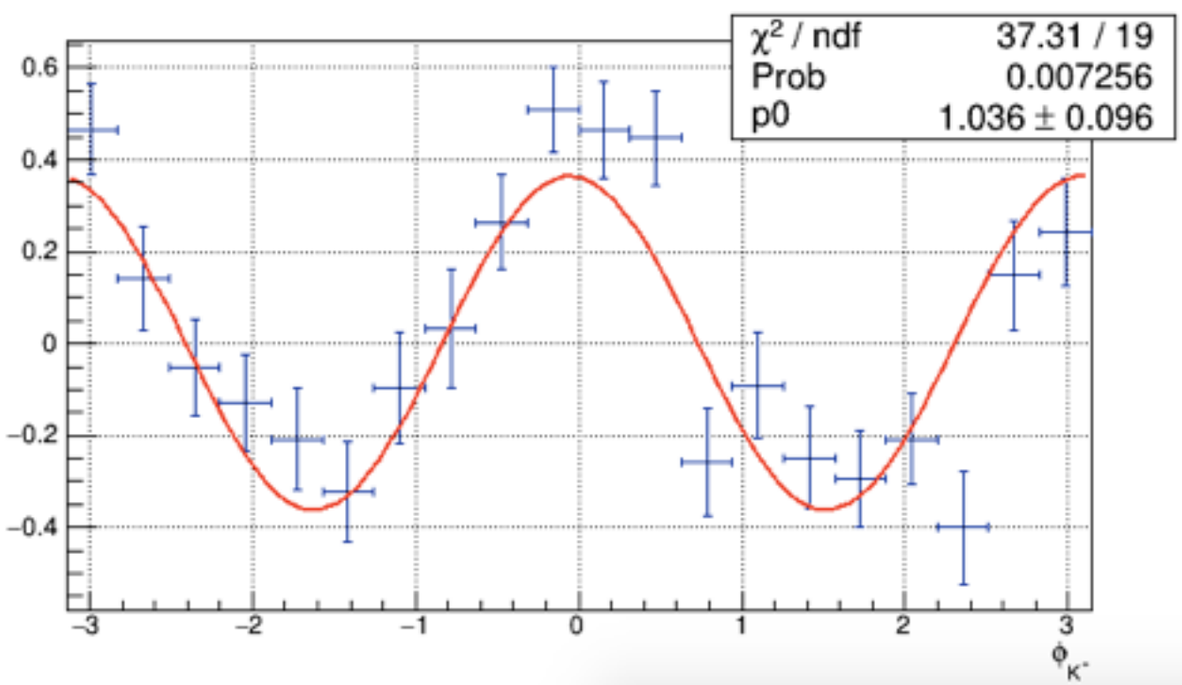
Backup-Yield Asymmetry (0/90) for *t* bins

-*t*=0.1-0.35

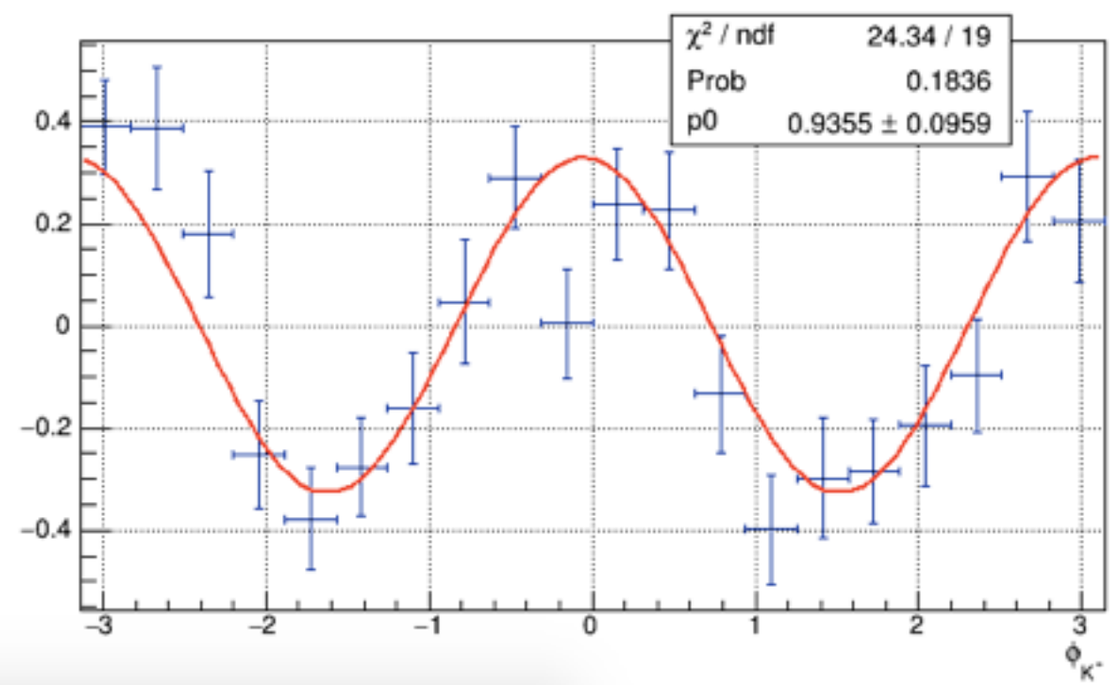


-*t*=0.35-0.50





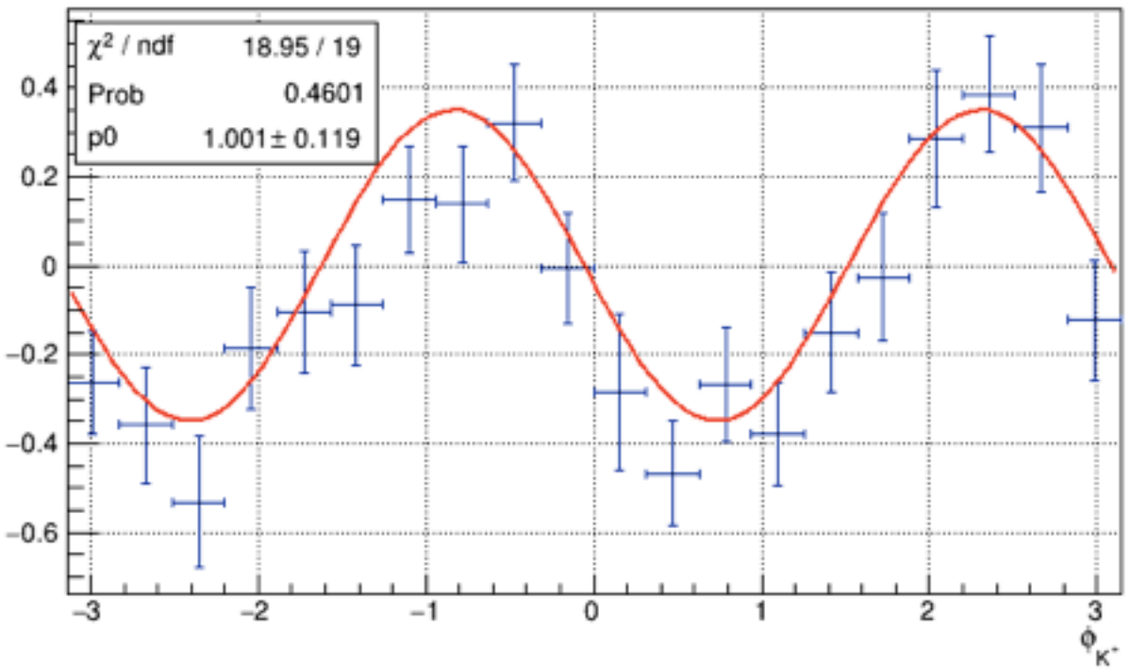
-*t*=0.50-0.70



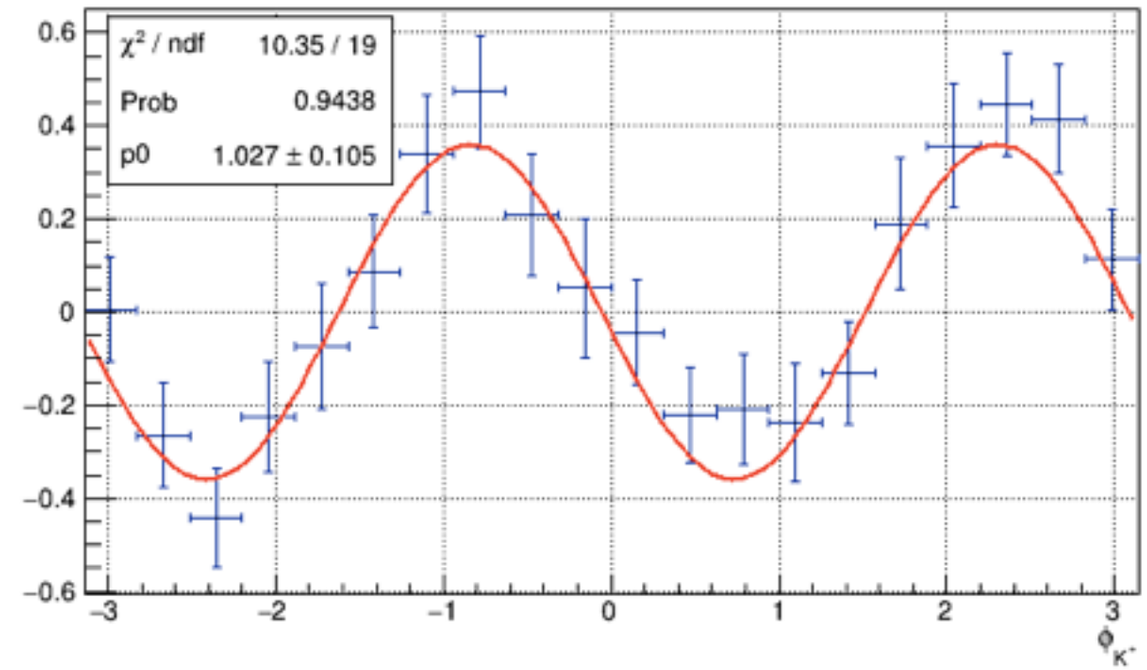
-*t*=0.70-1.40

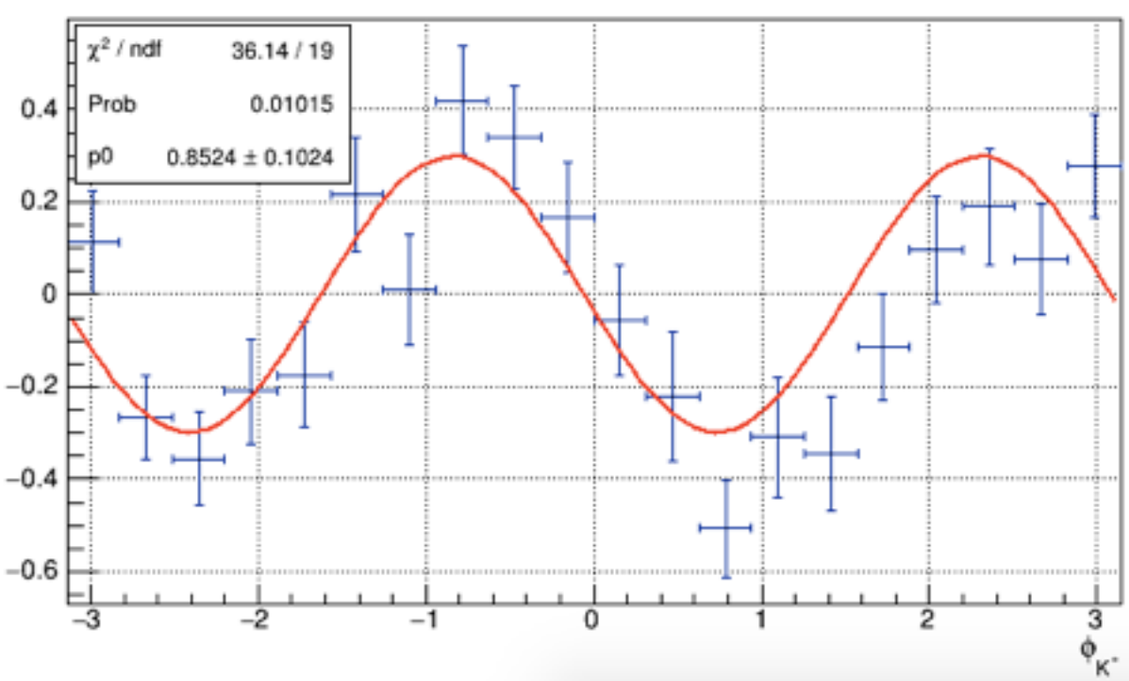
Backup-Yield Asymmetry (45/135) for *t* bins

-*t*=0.1-0.35

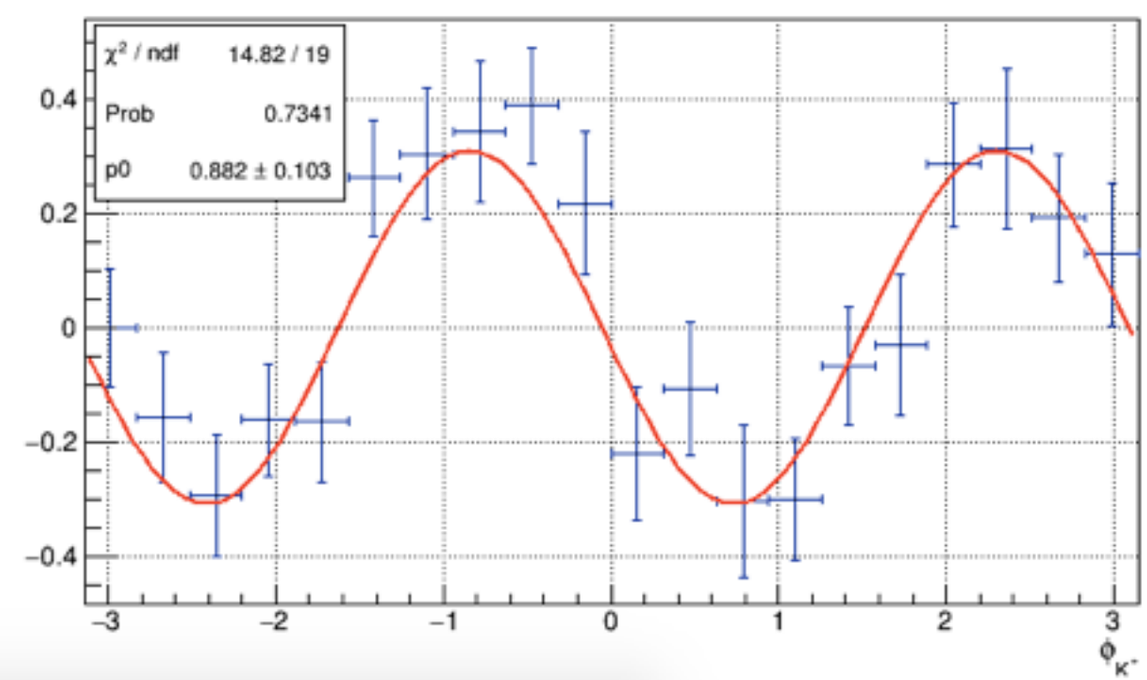


-*t*=0.35-0.50





-*t*=0.50-0.70



-*t*=0.70-1.40