Polarization of the Ξ^- in Photoproduction Using CLAS

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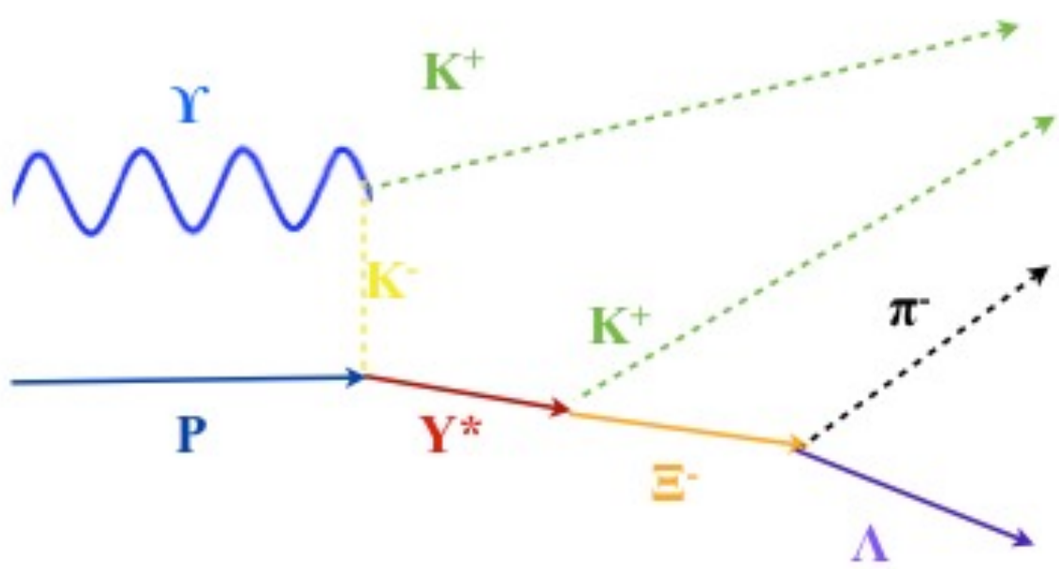
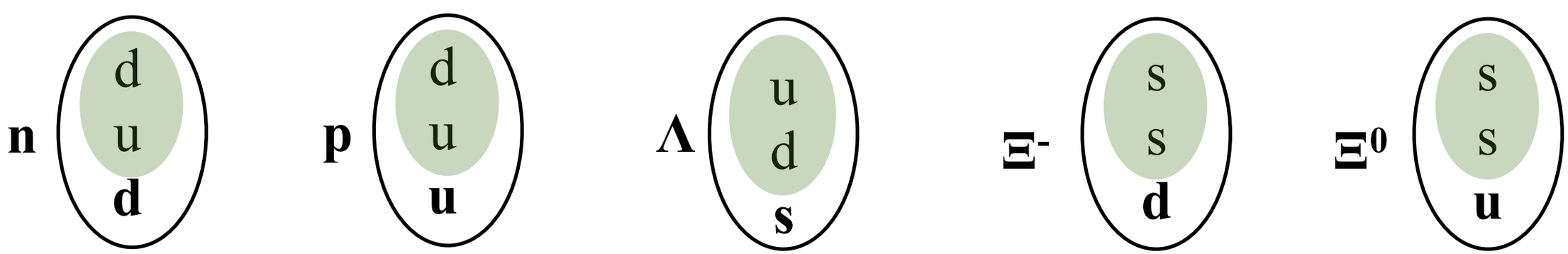
Introduction

- Ξ still largely unexplored.
- CLAS was used to obtain the worlds largest data set ("g12") for meson photoproduction.
- g12 provides a unique opportunity to study cross section and polarization observables for the photo-produced Ξ^- through the $\gamma\ p \rightarrow K^+ K^+ (\Xi^-) \rightarrow K^+ K^+ \pi^- (\Lambda)$ channel.
- The double polarization observables Cx and Cz along with the observable P are of particular interest.

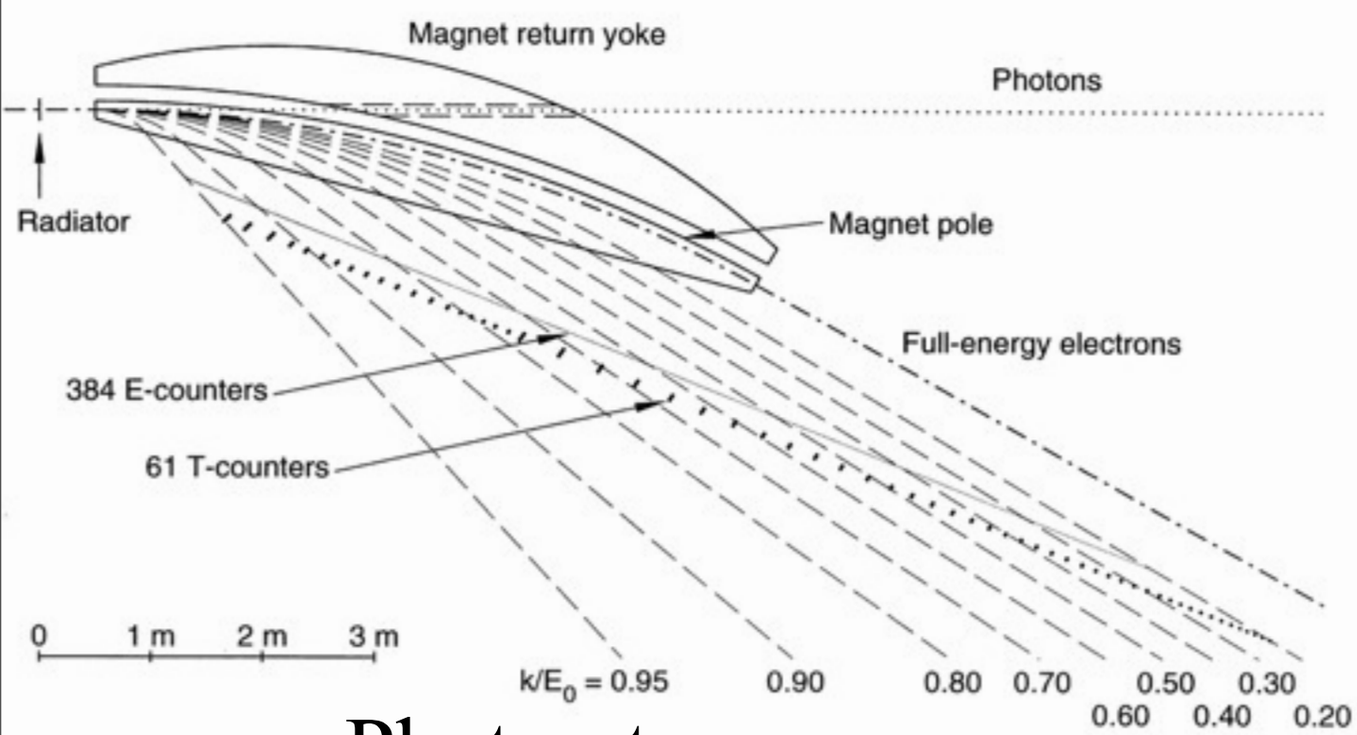


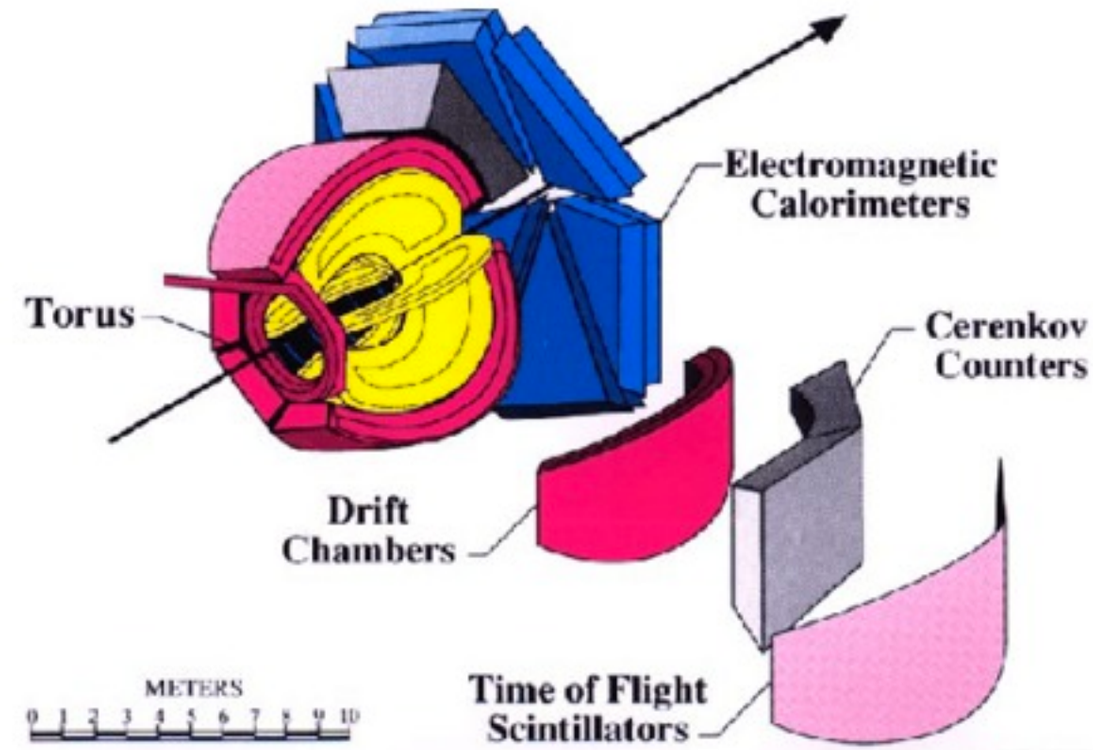
Motivation: why study Ξ polarization ?

- Polarization measurements could shed light on the polarization and production mechanism which are both presently unknown.
- Competing production models predict differing polarization results.
- Similar recent measurements for Λ polarization by CLAS provided insight into production.
- When combined with future experiments with target polarization, the results could provide a new means of extracting independent u and d contributions to nucleon polarization.



The CLAS detector:





Photon tagger:

measures energy and timing of electrons which emitted a photon. This way the energy of each photon is measured as well as the time the photon was at the center of the target.

CLAS spectrometer:

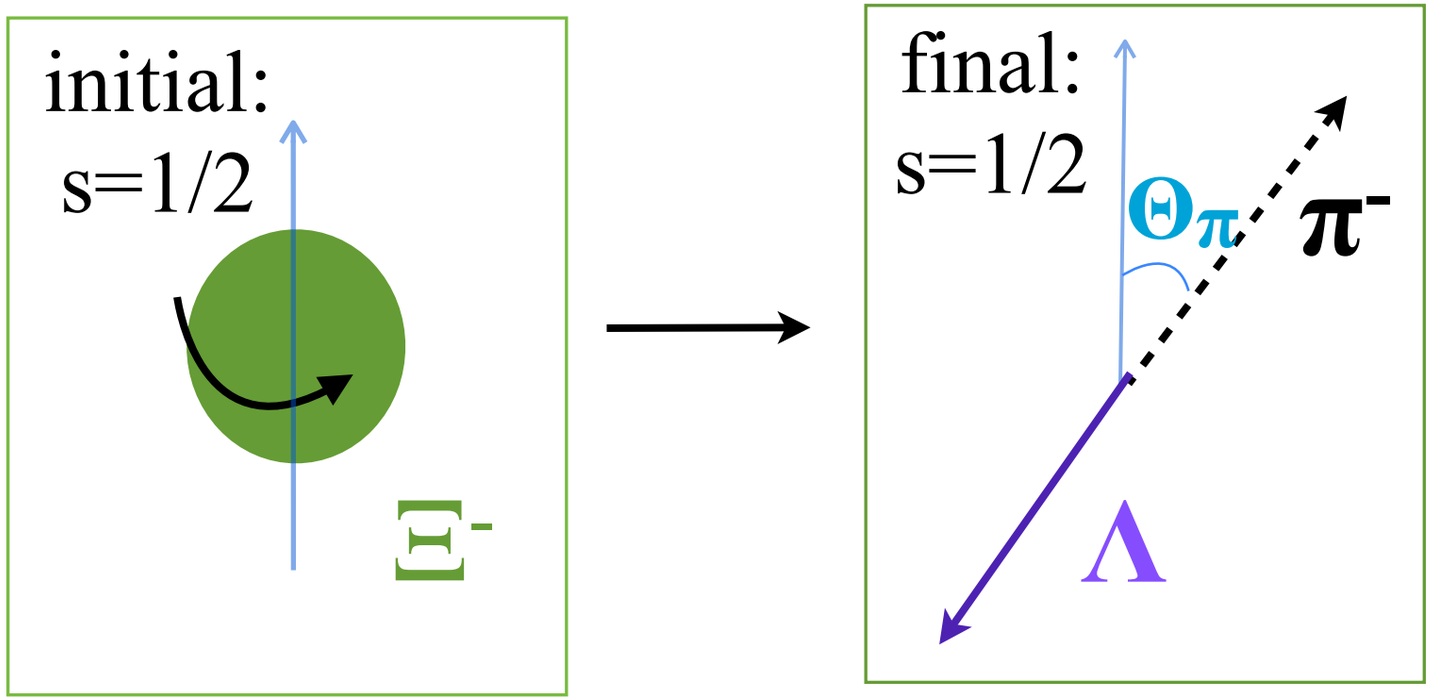
through timing and tracking CLAS reconstructs particle id and momentum of individual tracks as well as vertex information for each event.

A physics event requires coincident timing between the tagger and CLAS.

Extracting Polarization

Two body decay for a single event

$$\Xi^- \longrightarrow \Lambda\, \pi^-$$



In this case only s and p waves possible in final state.

$$|\Psi(\theta_\pi)|^2 = \frac{1}{2\pi}(1 - \alpha \cos\theta_\pi)$$

C is normalization factor,

α known:

α = -0.458 ± 0.012 [pdg]

Extracting Polarization (cont)

$$|\Psi(\theta_\pi)|^2 = \frac{1}{2\pi}(1 - \alpha\cos\theta_\pi)$$

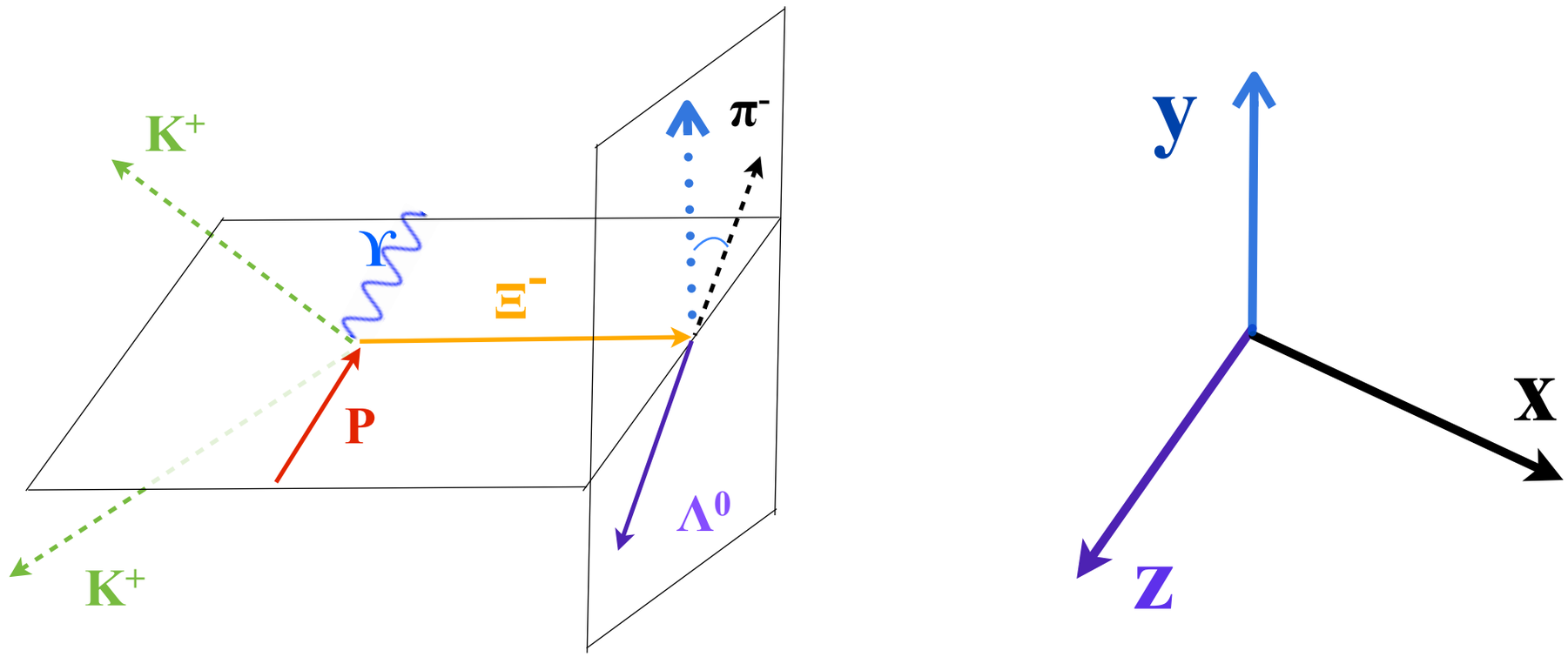
$$n(\theta_\pi) = \frac{N}{2\pi}(1 - \alpha P\cos\theta_\pi)$$

$$A = \frac{N^+ - N^-}{N^+ + N^-}$$

$$\boxed{P = \frac{-2A}{\alpha}}$$

A measurement the acceptance corrected forward/backward asymmetry (A) is sufficient to determine the polarization about any chosen axis.

Choosing polarization axes



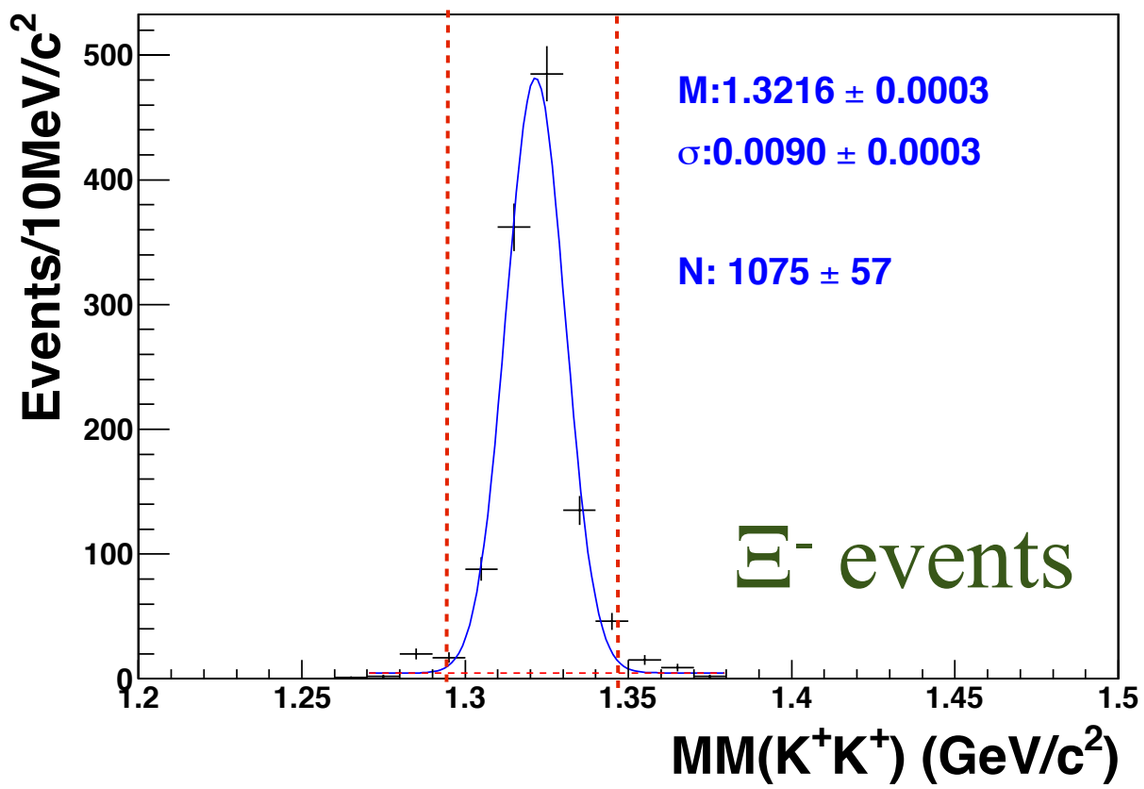
- Coordinate system defended in Ξ^- rest frame and chosen to separate recoil and transferred polarization
- y ⇒ P: normal to production plane and z. (out of plane: induced polarization)
- z ⇒ Cz: axis along beam direction. (in plane: transferred polarization)
- x ⇒ Cx: normal to y and z. (in plane: transferred polarization)
- Polarization in (x, y, z) direction called (C_x, P, C_z) respectively.

Results:
g11 & g12

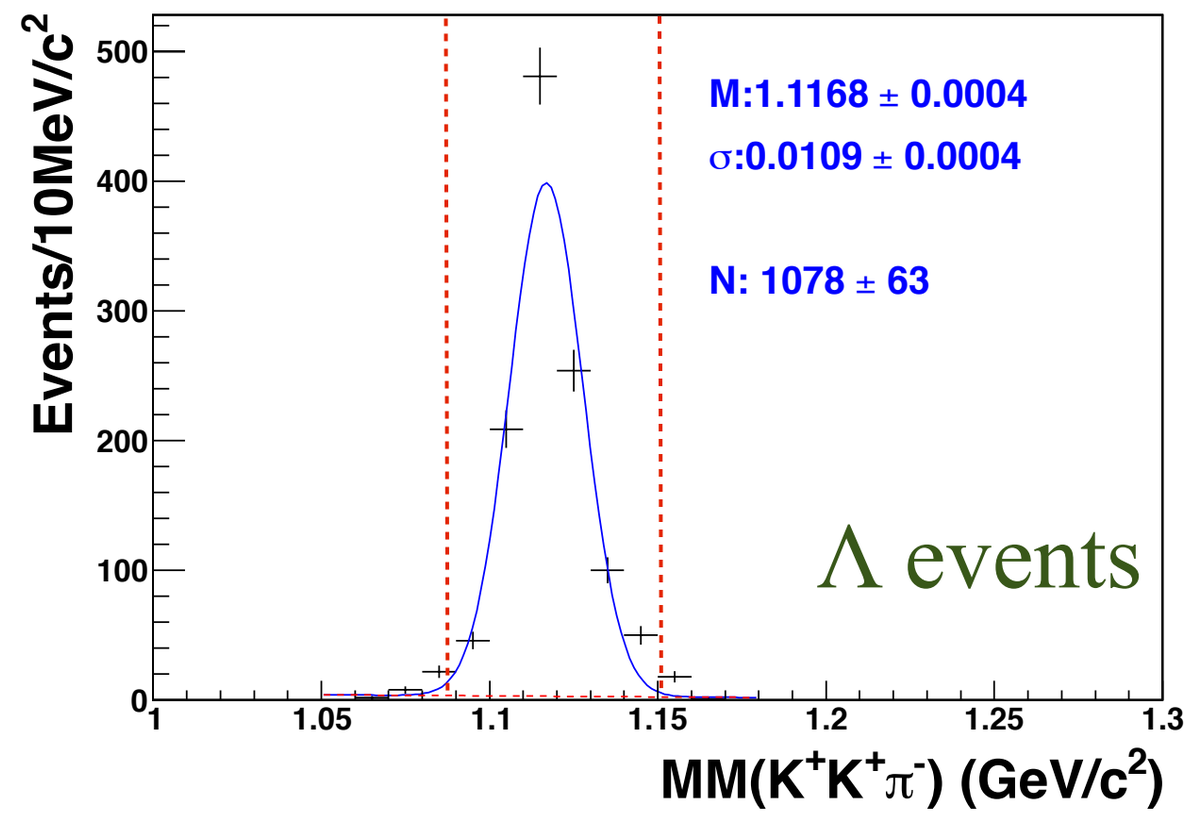
G11 statistics:

unpolarized beam E_Υ(2.8-3.8GeV)

M_{Ξ^-} = 1.321 GeV



M_Λ = 1.116 GeV



Number of $\Xi^- \rightarrow \Lambda\, \pi^-$

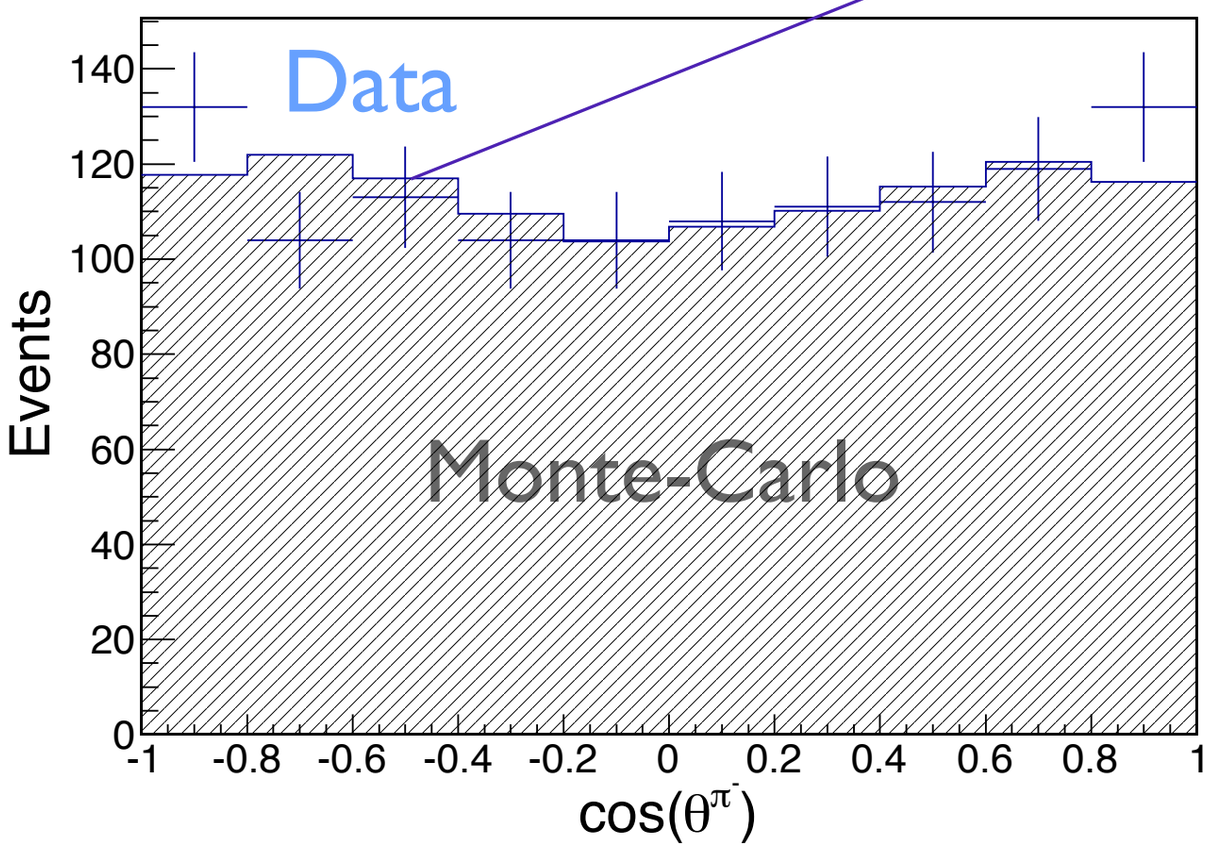
events ≈ 1070

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

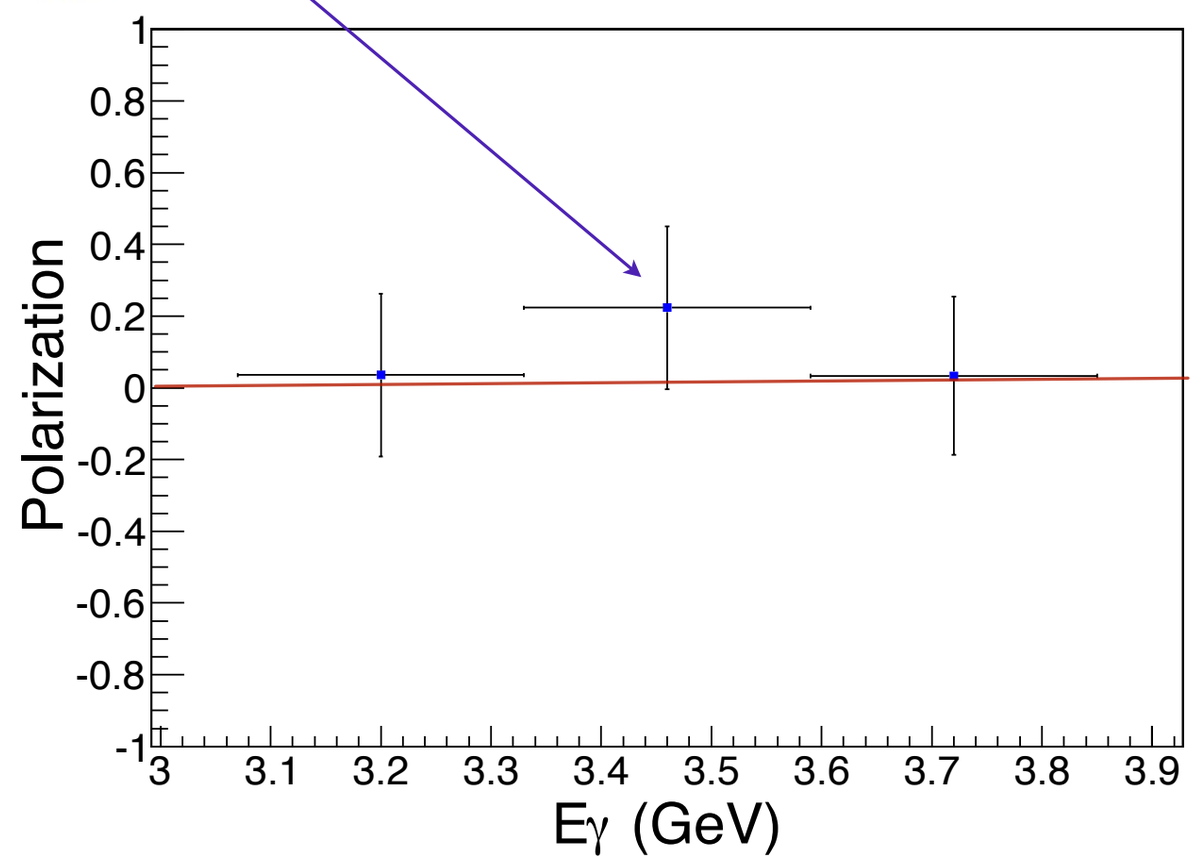
G11 Preliminary Results:

unpolarized beam E_Υ(2.8-3.8GeV)

$$P = \frac{-2A}{\alpha}$$



Projection of pion onto y axis (normal to the production plane).



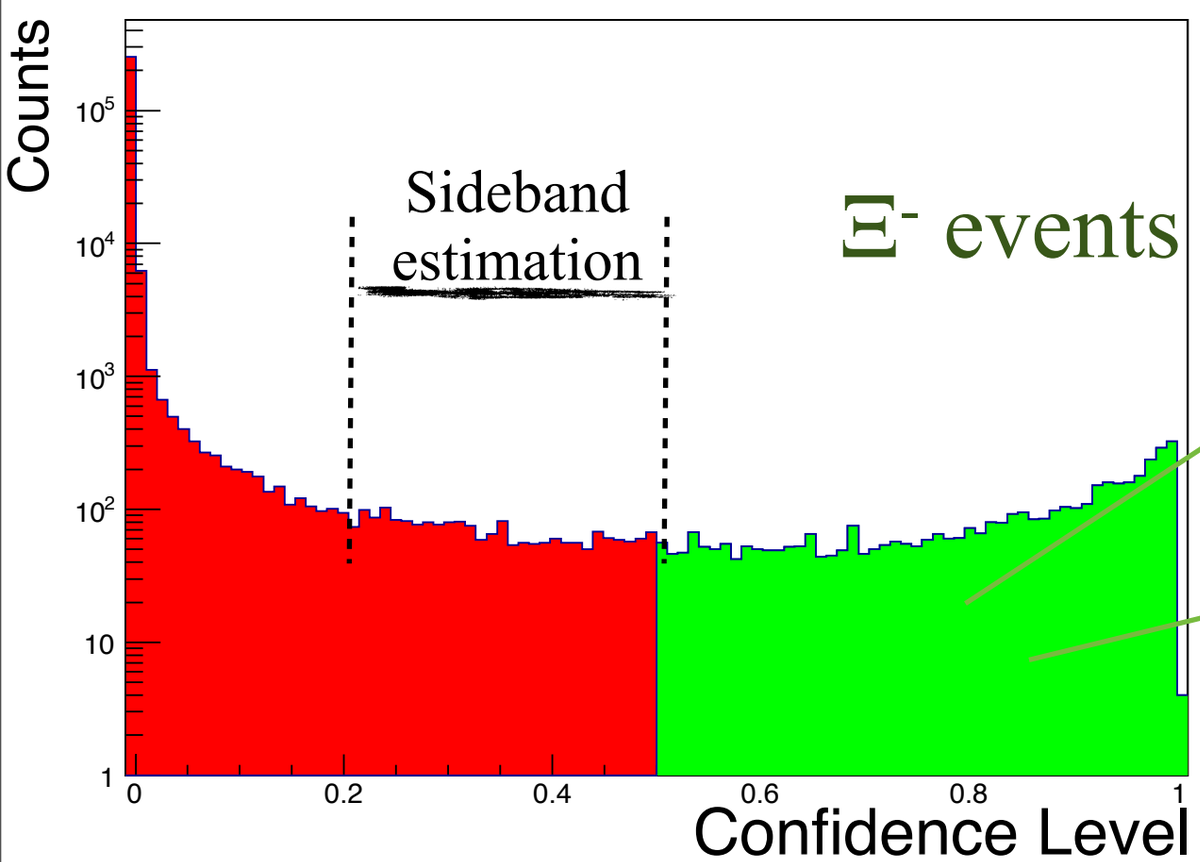
Binning polarization in beam energy buckets.

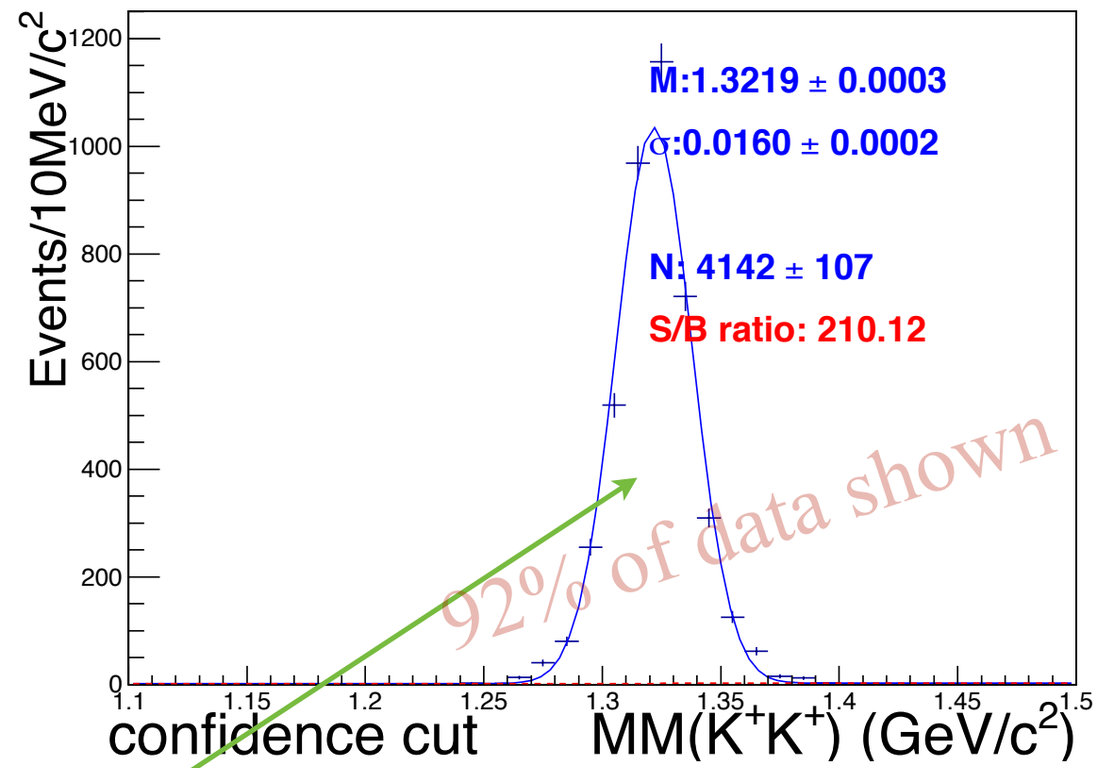
All bins showing polarization consistent with zero.

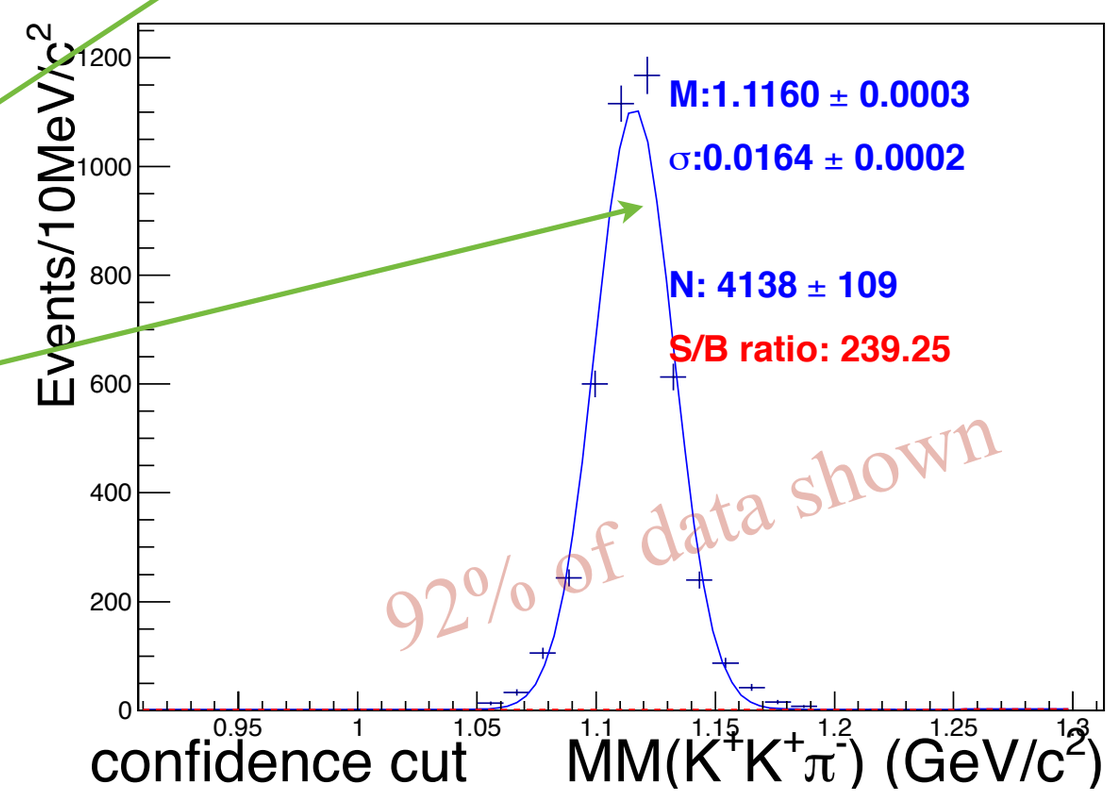
G12 statistics:

Polarized Beam, E_Υ(3.6-5.4GeV)

Number of $\Xi^- \rightarrow \Lambda\, \pi^-$ events ≈ 4100

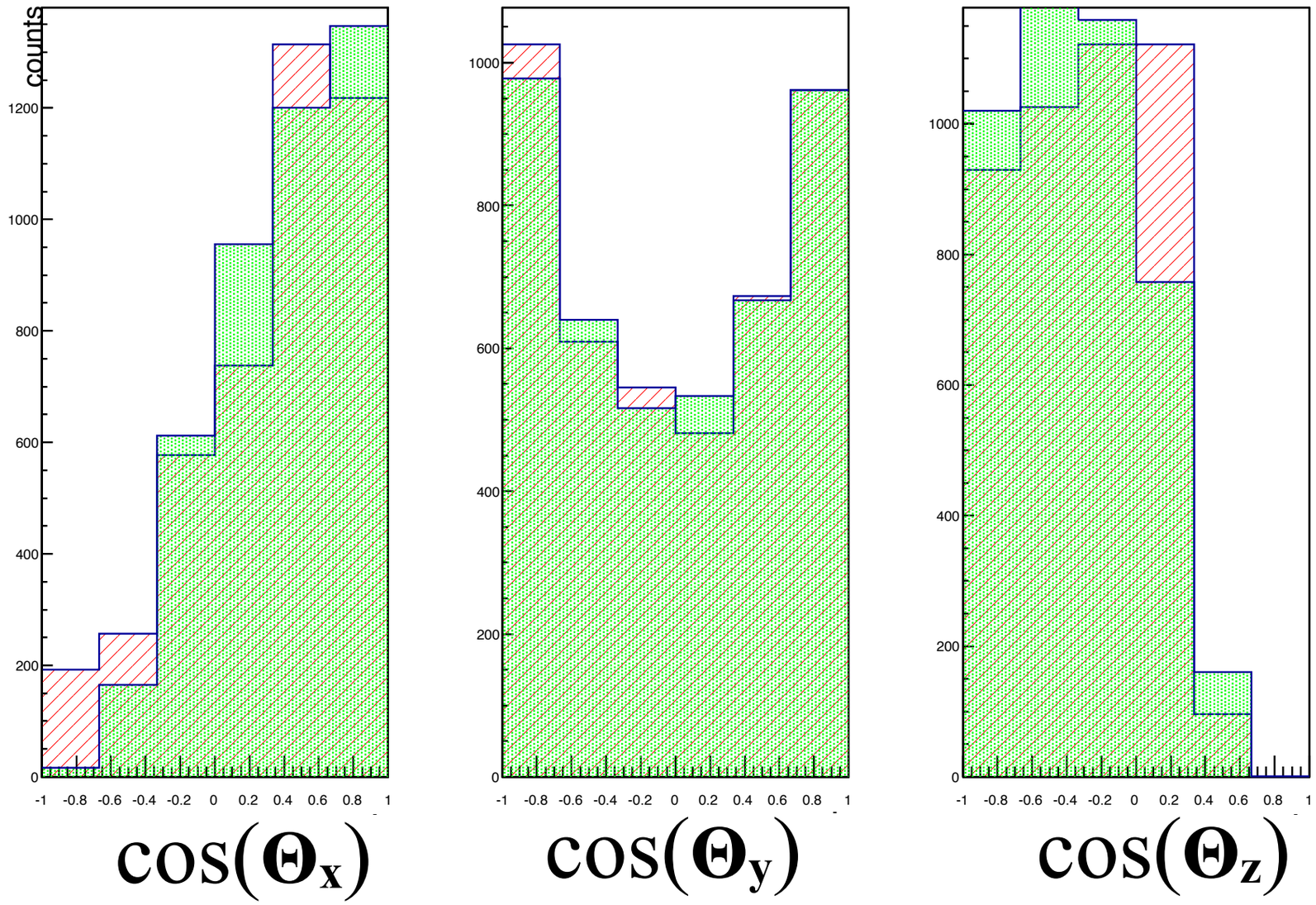






$\gamma\ p \rightarrow K^+ K^+ (\Xi^-) \rightarrow K^+ K^+ \pi^- (\Lambda)$

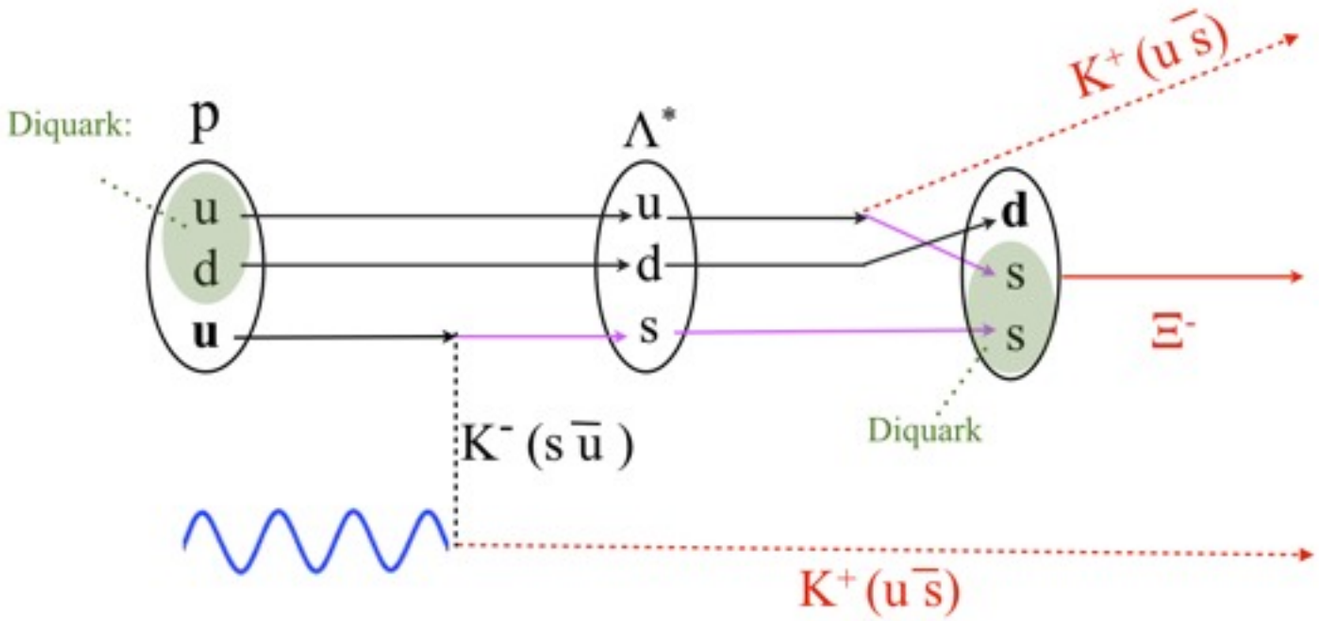
G12 preliminary Results:
Polarized Beam, E_Υ(3.6-5.4GeV)



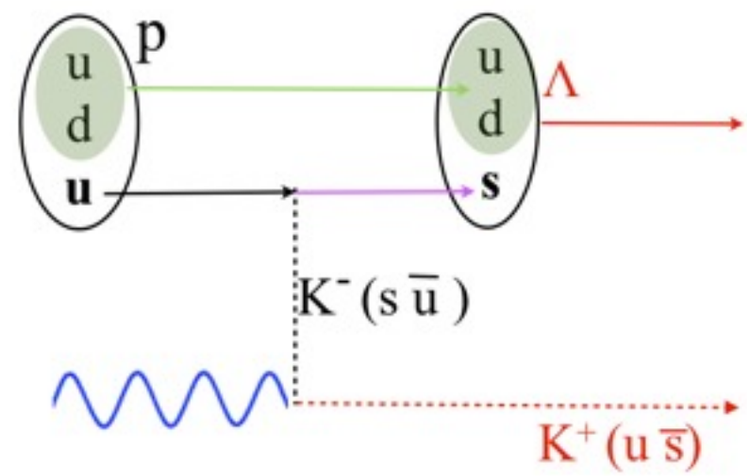
MC: red
Data: green

- Above shows an overlay of the data with MC events.
- Further work needed for simulation: i.e. match beam energy and t-slope spectra to the data.

zero polarization:
The diquark model



t-channel Ξ^- production model:



t-channel Λ production model:
From CLAS data Bradford et al found
$(P^2+C_x^2+C_y^2)^{1/2} = 1$

In this model only the d quark should contribute to the Ξ^- polarization. As a result one might expect small polarization if the target proton is unpolarized.

Summary

- Data from CLAS presents an opportunity to make a first time measurement of the polarization observables in Ξ photoproduction.
- The results will help shed light on Ξ^- production mechanism.
- Preliminary results show zero induced polarization.
- In order to extract a reliable measurement of the transferred polarization (g12), MC events need work.

Thank you!

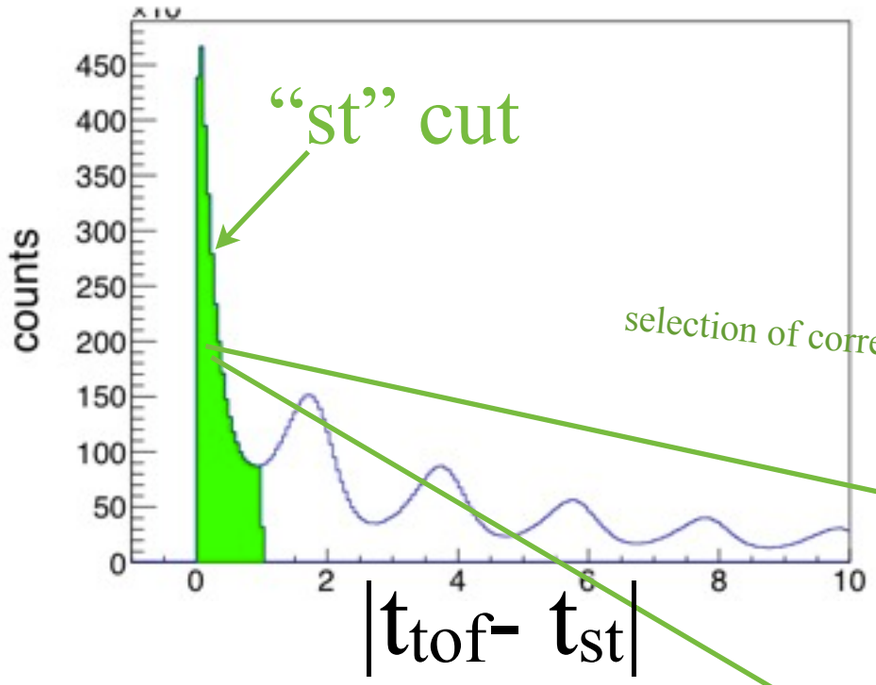
EXTRA

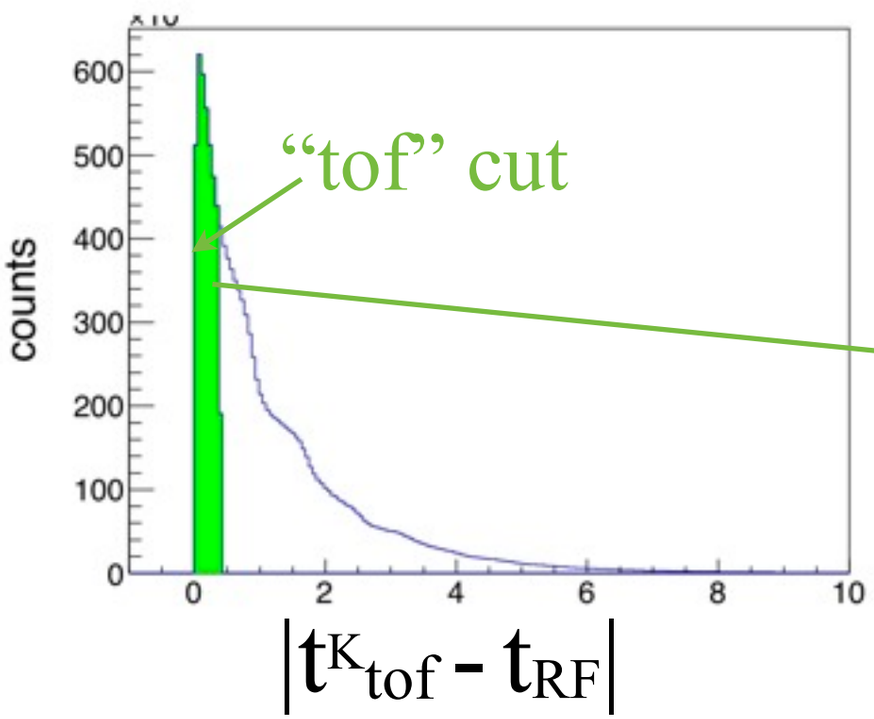
somthing about clas

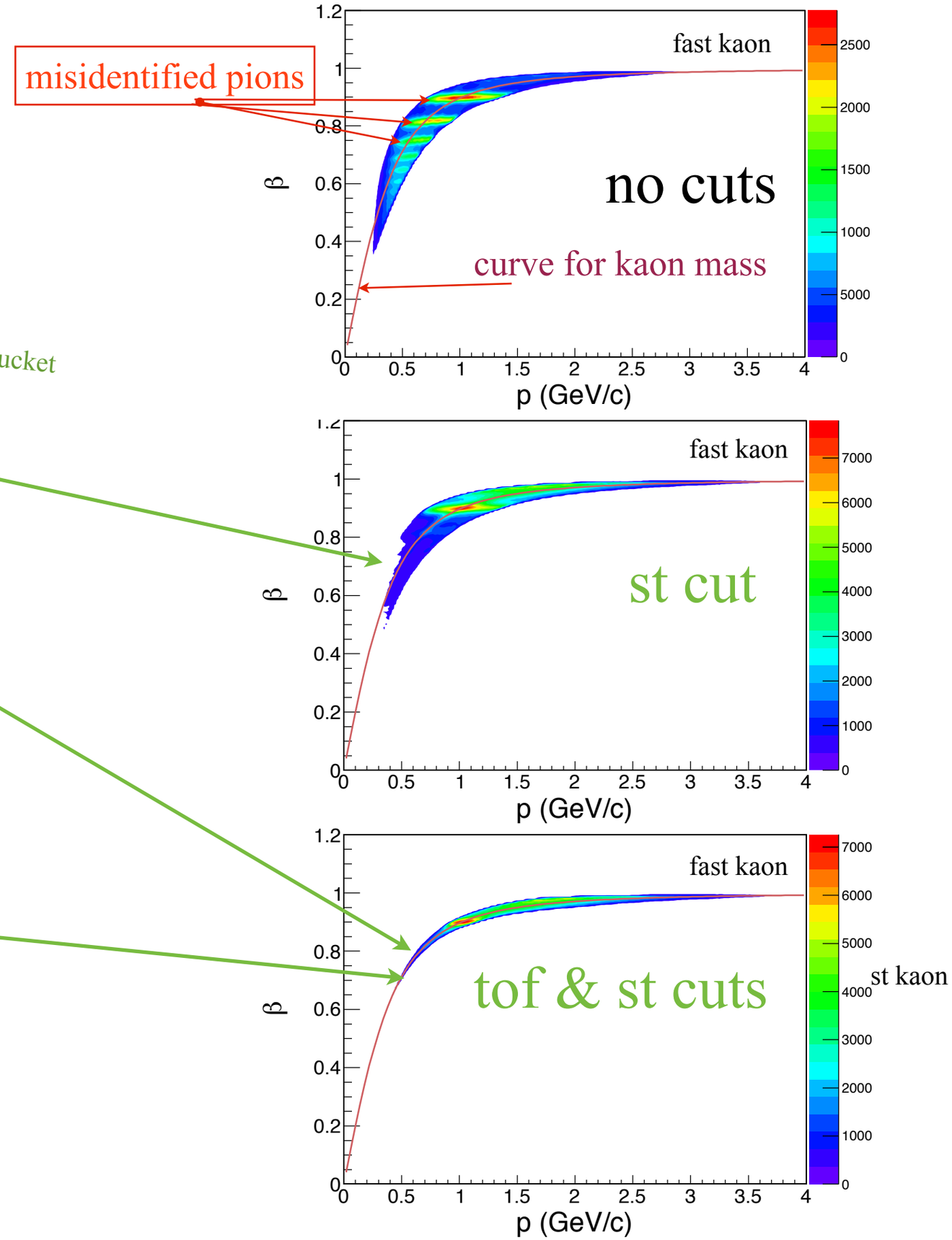
g12 production:

- 44 days of beam time
- photon energy [2.8 - 5.4]GeV
- DAQ rate ~ 8 kHz
- 26 billion triggers

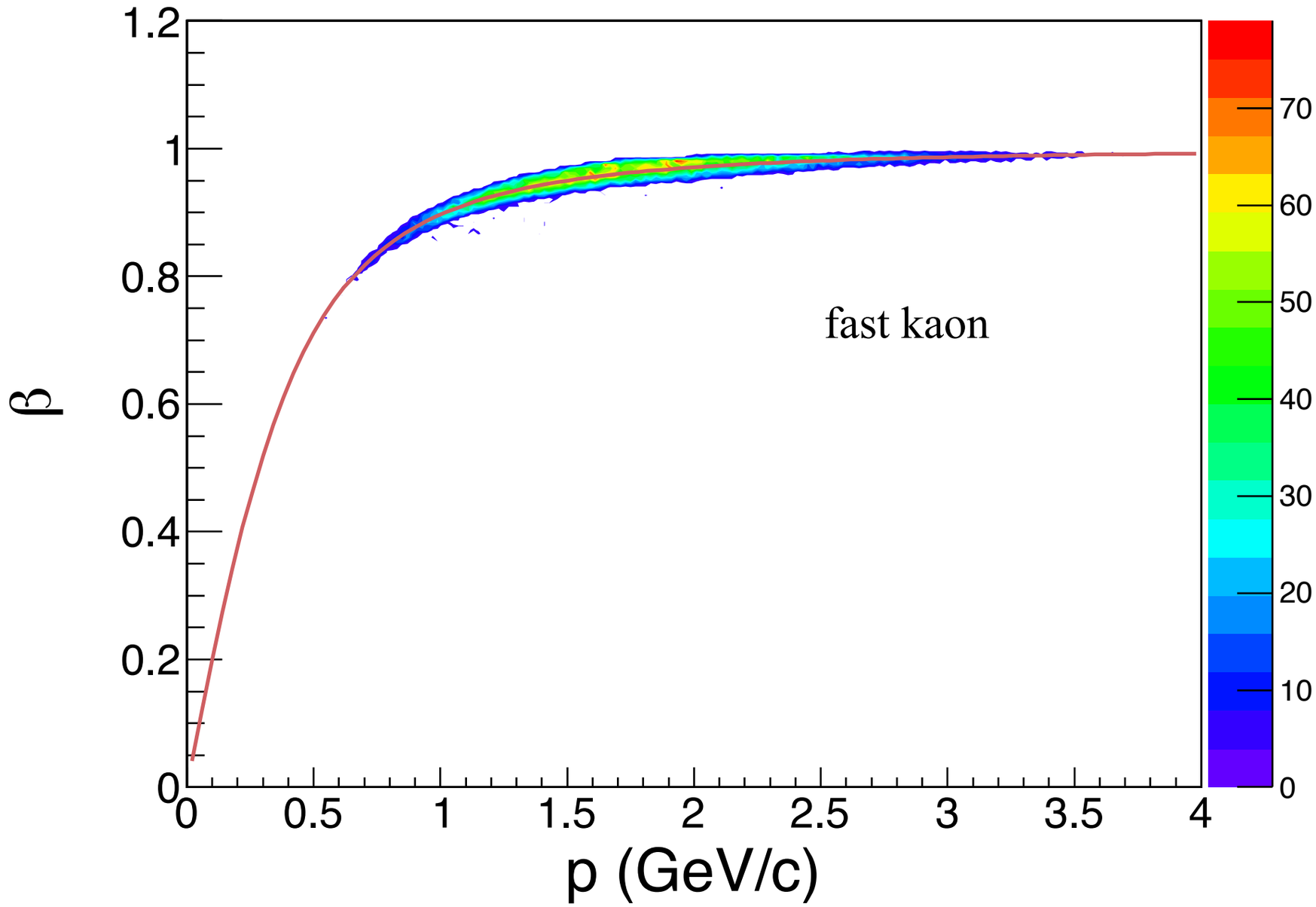
Event selection







Timing and mass cuts



By requiring the additional missing mass cuts the pion contamination is reduced

Systematic uncertainty

Source of uncertainty	P	C_x C_z
Uncertainty in photon beam polarization	NA	1.5%
Uncertainty in acceptance corrections	TBD	TBD
Uncertainty in α	± 0.026%	± 0.026%
Detector Resolution	TBD	TBD

- The error due to acceptance can be estimated through the simulation.
- Can vary the t-slope, mass and width of resonance independently in simulation and measure effect on polarization variables. In g12, fiducial cuts effect will also be investigated.
- Kinematic fitting will be used to address detector resolution.