2021 Fall Meeting of the APS Division of Nuclear Physics

Search for Excited Ξ^{*-} Hyperons in the Reaction $ep \rightarrow e'K^+K^+K^-(\Lambda/\Sigma)$ using CLAS12

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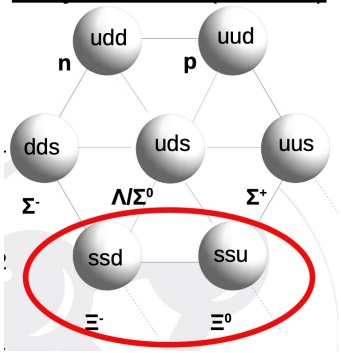
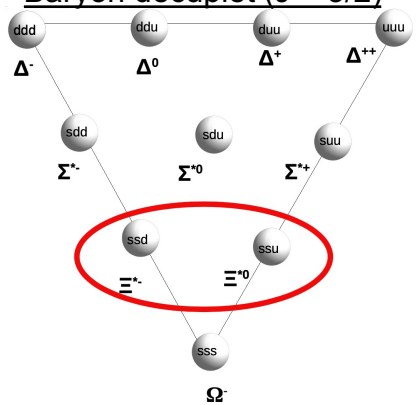
clas

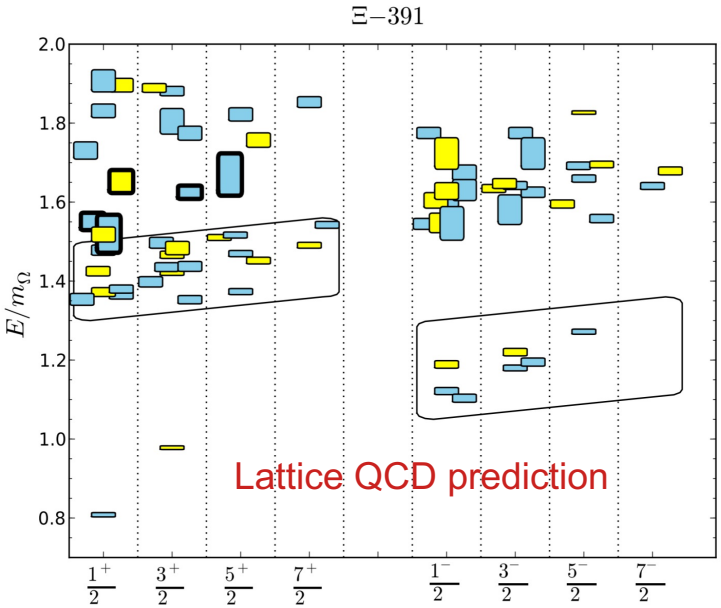
Motivation

Baryon Octet (J = 1/2)



Baryon decuplet (J = 3/2)



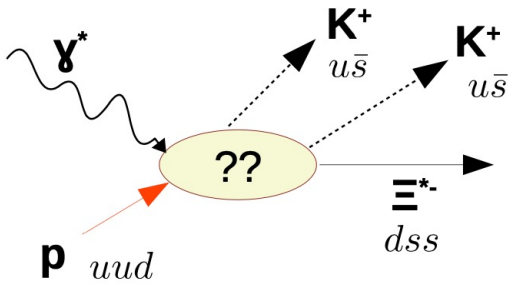


Robert G. Edwards et al. Phys. Rev. D 87 (2013) 054506

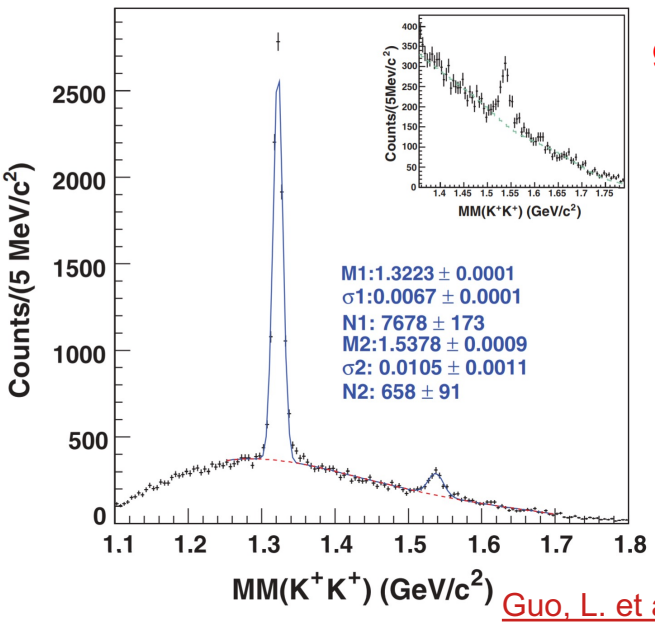
Particle	J^P	Overall status
$\Xi(1320)$	$\frac{1}{2}^+$	****
$\Xi(1530)$	$\frac{3}{2}^+$	****
$\Xi(1620)$		*
$\Xi(1690)$		***
$\Xi(1820)$	$\frac{3}{2}^-$	***
$\Xi(1950)$		***
$\Xi(2030)$	$\frac{5}{2}^?$	***
$\Xi(2120)$		*
$\Xi(2250)$		**
$\Xi(2370)$		**
$\Xi(2500)$		*

2021 PDG update

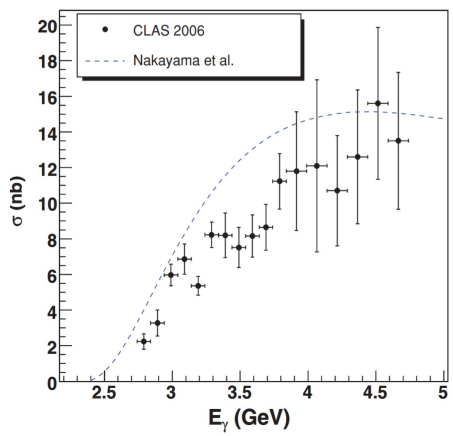
- Experimentally underexplored
- Small production cross section
- Production mechanism very interesting to explore
- Address "missing baryon" problem



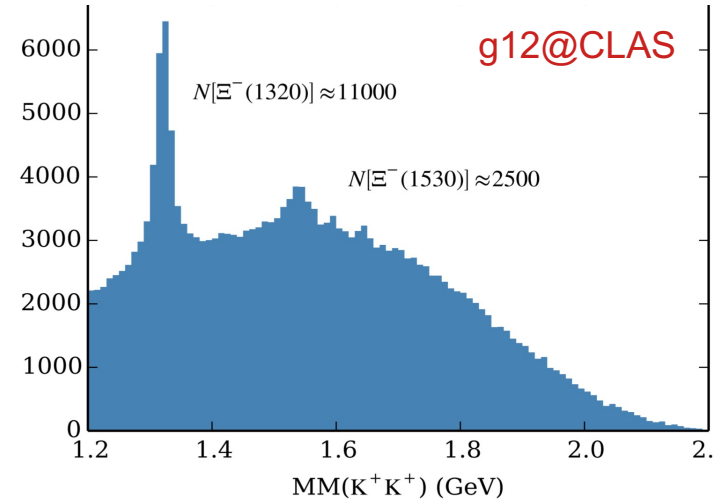
Existing CLAS photoproduction results

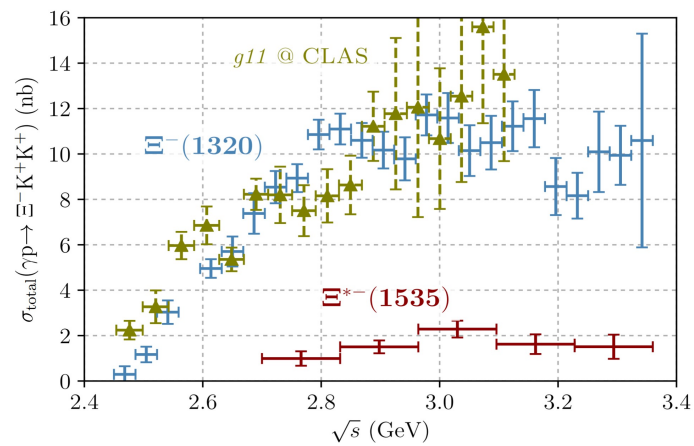


g11@CLAS



Guo, L. et al. Phys. Rev. C76, 025208 (2007)





J. T. Goetz et al. Phys. Rev. C 98, 062201 (2018)

- Data collected with low beam energy and no vertex detector
- Higher mass Ξ^* states are not visible in MM spectra
- Total cross section of $\Xi(1320)$ for E_γ up to 5.4 GeV
- Upper limit cross section calculated for $\Xi^*(1690)$, $\Xi^*(1820)$ and $\Xi^*(1950)$

CLAS12 spectrometer

Forward Detector:

$(5^o \leq \theta \leq 35^o)$

- *TORUS magnet*
- *HT Cherenkov Counter*
- *Drift chamber system*
- *LT Cherenkov Counter*
- *Forward ToF System*
- *Preshower calorimeter*
- *E.M. calorimeter (EC)*

Central Detector:

$(35^o \leq \theta \leq 125^o)$

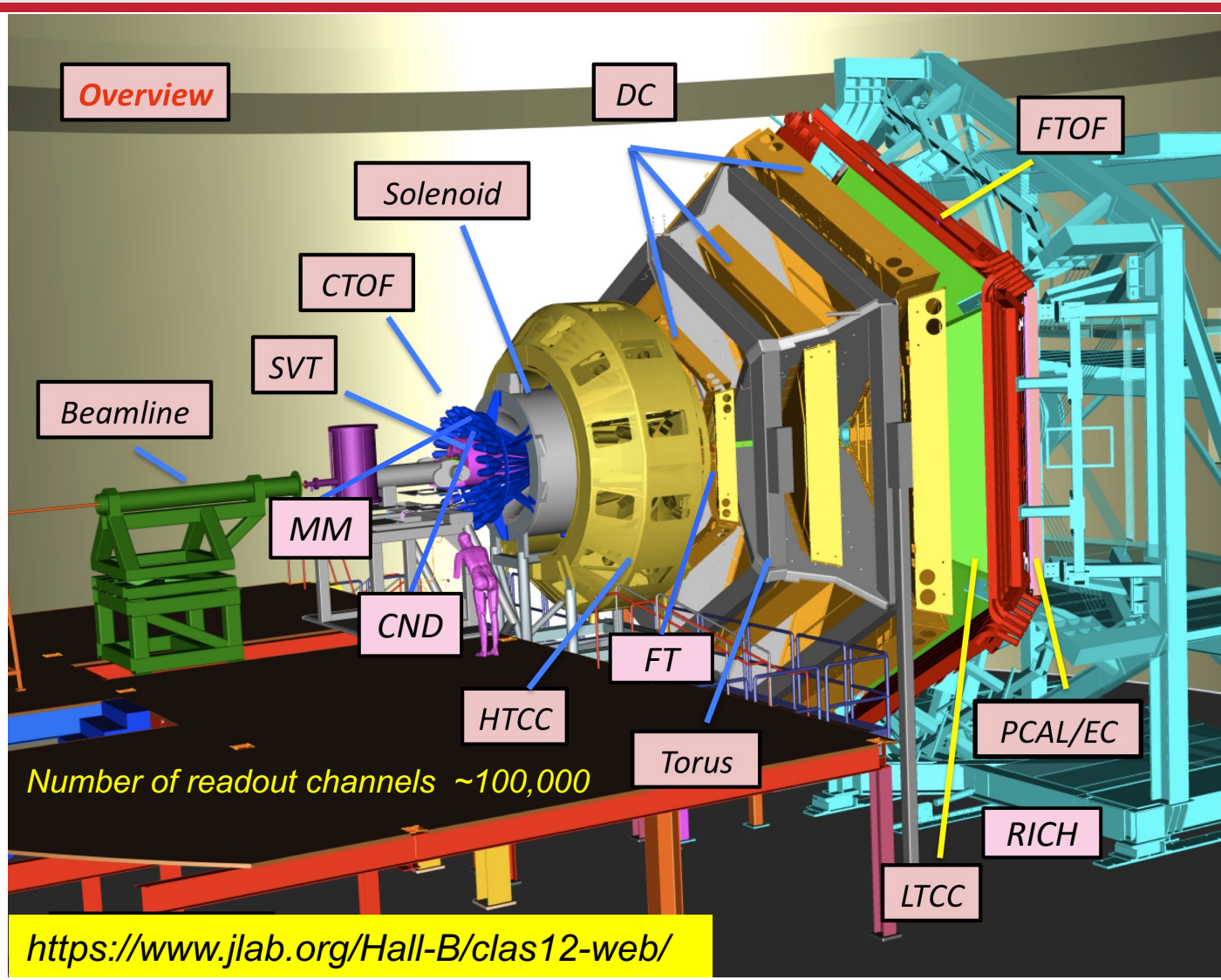
- *SOLENOID magnet*
- *Barrel Silicon Tracker*
- *Central Time-of-Flight*

Upgrades:

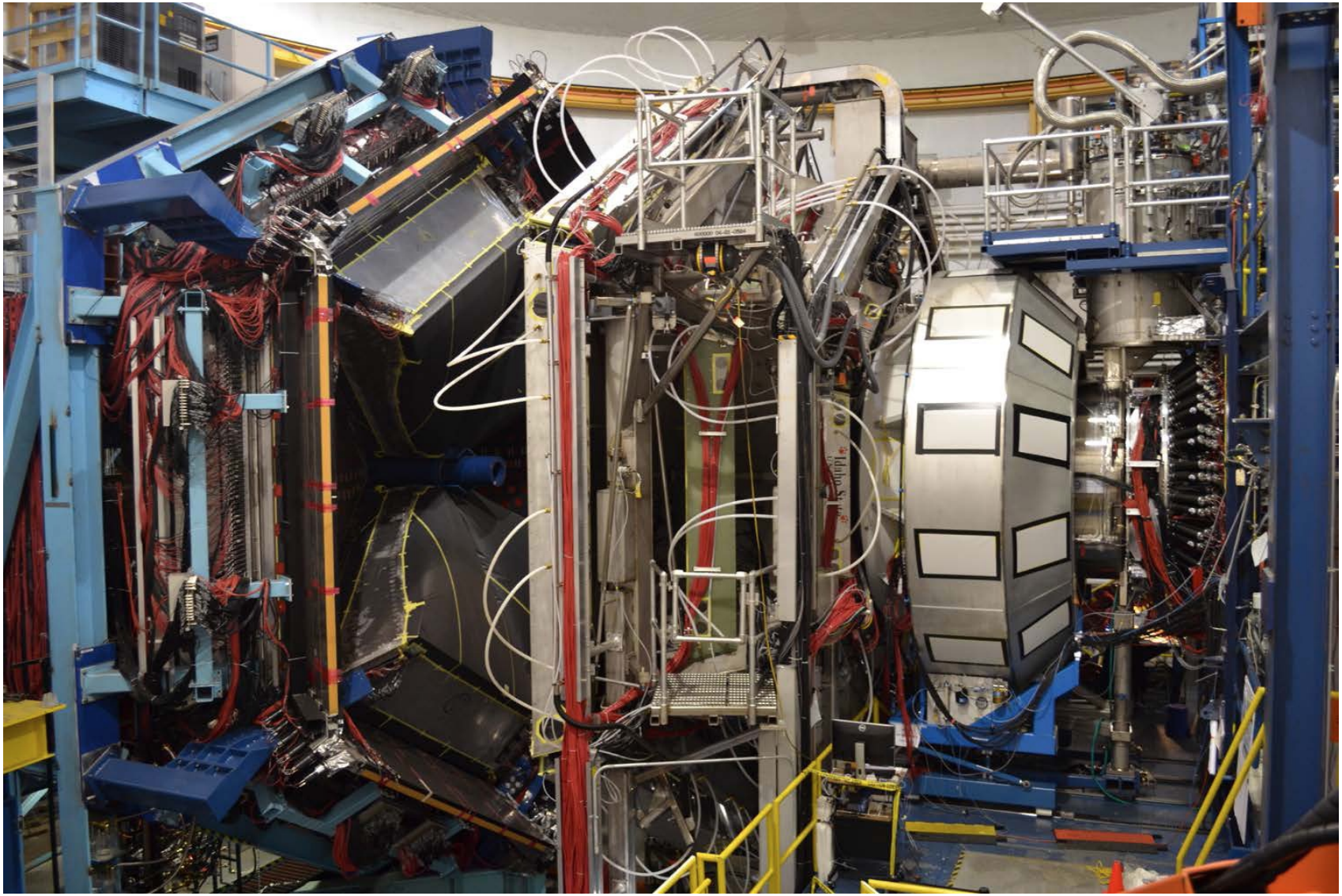
- *Micromegas (CD)*
- *Neutron detector (CD)*
- *RICH detector (FD)*

- ***Forward Tagger (FT)***

$(2^o < \theta < 5^o)$



CLAS12 installation in Hall B



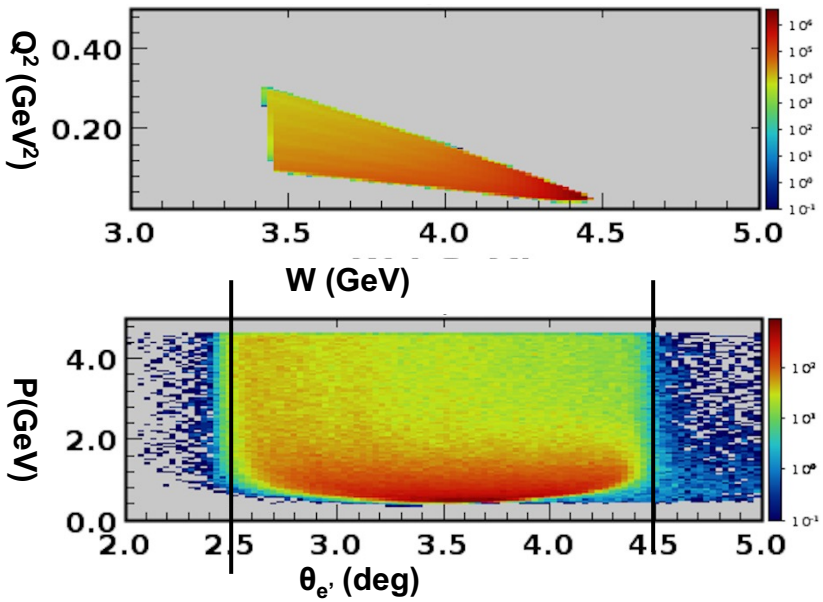
Exclusive Channel and event selection

$$\boldsymbol{ep} \rightarrow \boldsymbol{e'K^+K^+\Xi^{*-}}$$

$$\boldsymbol{\Xi^{*-}} \rightarrow \boldsymbol{K^-(\Lambda/\Sigma)}$$

- 10.6 GeV electrons on Liquid-Hydrogen target
- Scattered electron $\boldsymbol{e'}$ detected in two different regions
  - low Q^2 region to study quasi-real photoproduction - $\boldsymbol{e'}$ detected in the FT system which covers a very forward polar angle range of 2° to 5°
  - high Q^2 region to study electroproduction - $\boldsymbol{e'}$ detected in the FD system which covers a forward polar angle range of 5° to 35°
- Charged kaons detected in the CLAS12 (FD) detector in coincidence with the scattered electron
- Only 35% of the acquired data is analyzed

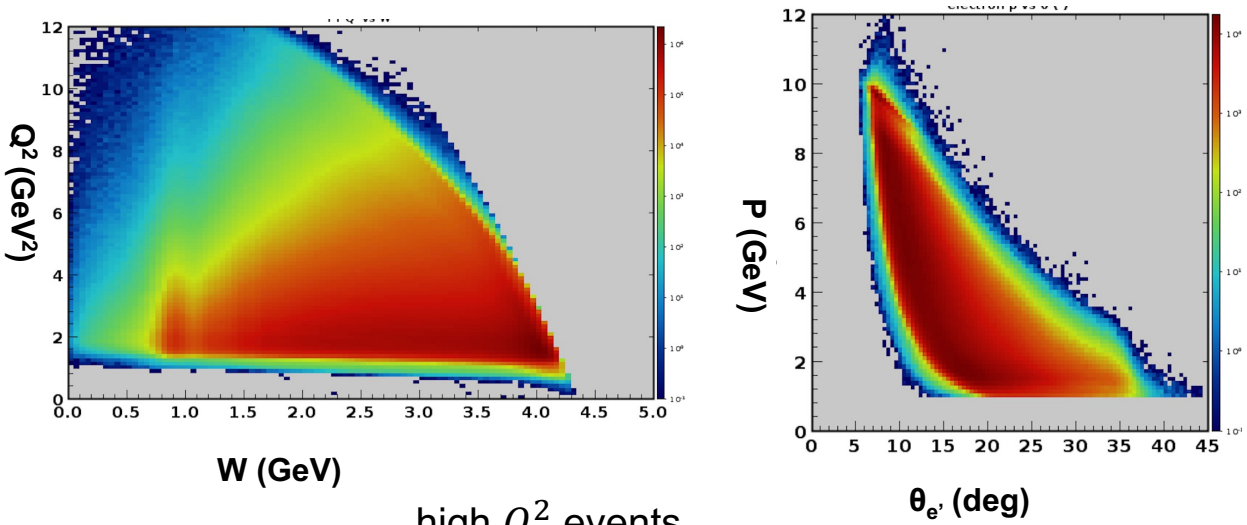
Electron selection



FT e' selection

- $0.1 < P_{e'}$(GeV) < 4.5
- $2.5^o < \theta_{e'} < 4.5^o$
- Forward Tagger energy correction
- N_e = 1

low-Q^2 (< 0.05 GeV^2) events

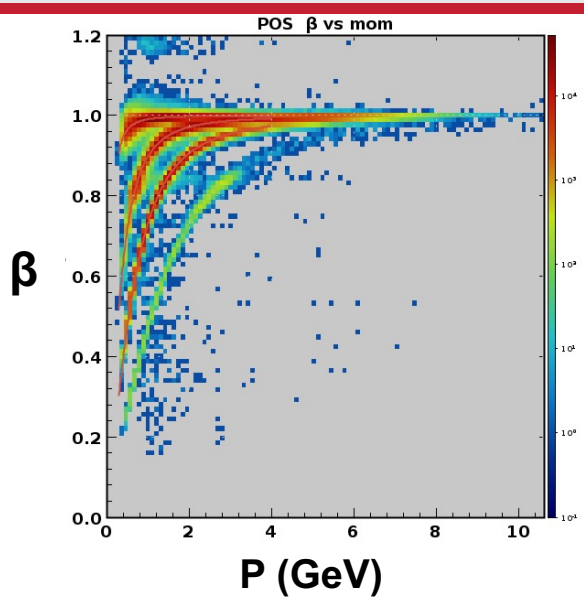


high Q^2 events

FD e' selection

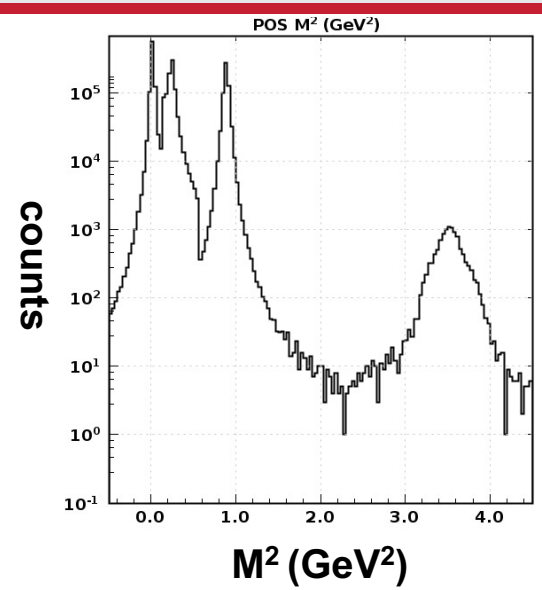
- $1 < P_{e'}$(GeV) < 10.6
- $5^o < \theta_{e'} < 35^o$
- $-10 < v^z_{e'}\ cm < 2$
- N_e = 1

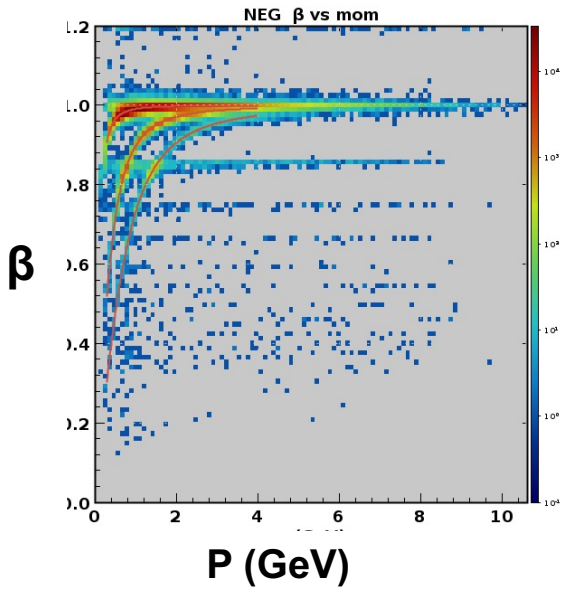
ToF Particle Identification Forward Detector



Positive Charged particles

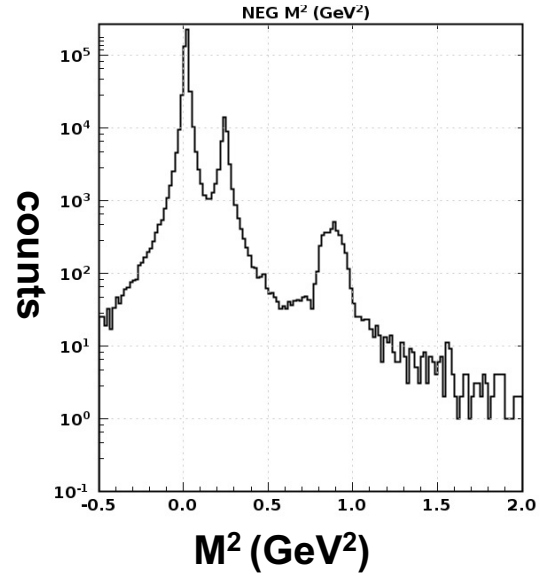
(π^+ / k^+ / p / d)



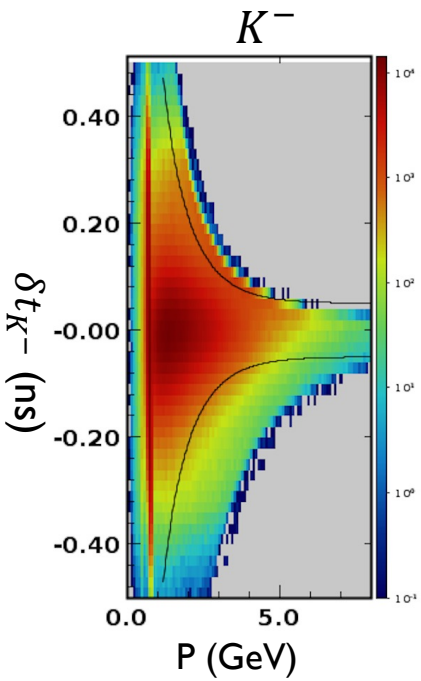


Negative Charged particles

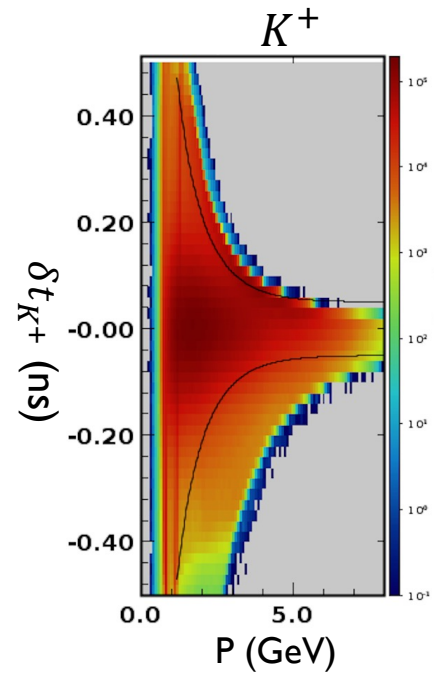
(π^- / k^- / $\bar{p}$)



Charged kaon selection



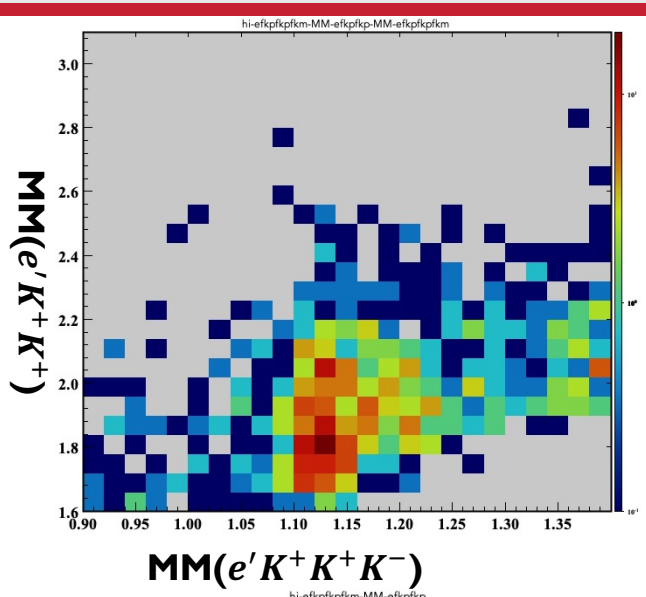
- Kaons detected in FD ($5^o < \theta_{K^\pm} < 35^o$)
- $0.4 < P_{K^\pm} < 10.604$ GeV
- $0.4 < \beta_{K^\pm} < 1.05$
- $-10 < v^z_{K^\pm} < 2$ cm
- Momentum dependent vertex time cut $\delta t_{meas-calc\ (K^\pm)}$ applied (see plots)

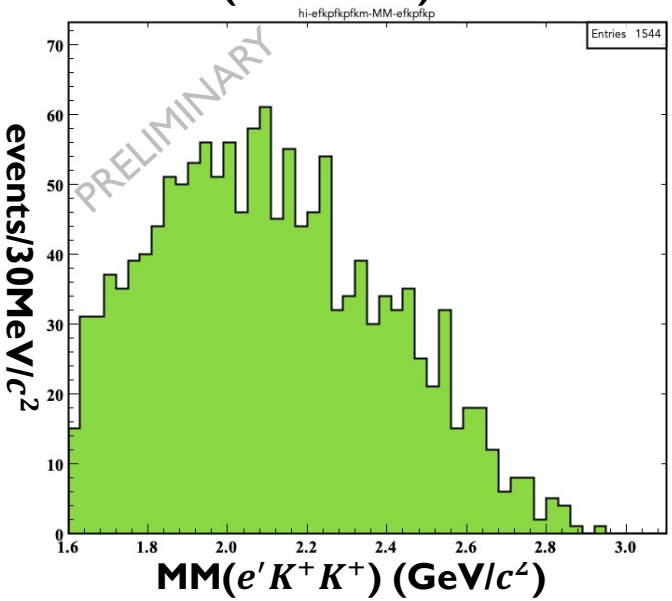


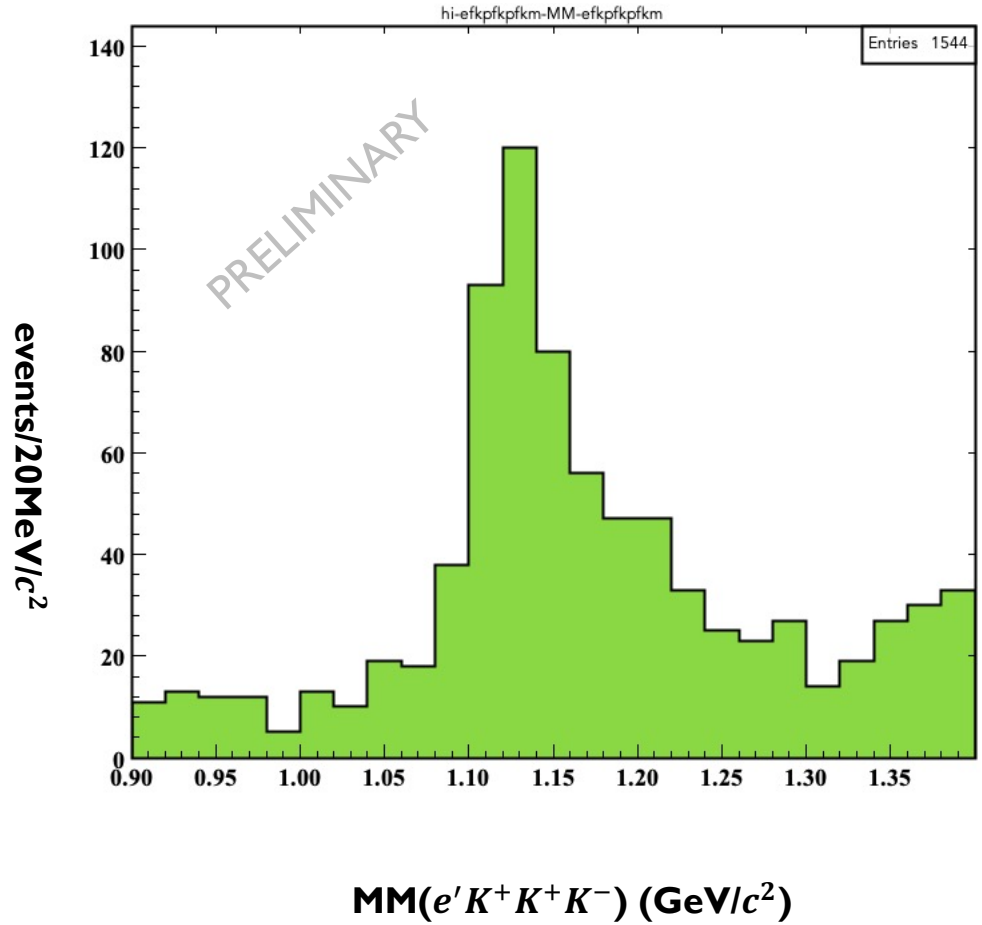
$$\delta t_{K^\pm} = \mathrm{ToF} * \left(1 - \sqrt{\frac{P^2_{K^\pm} + M^2_{calc}}{P^2_{K^\pm} + M^2_{K^\pm}}}\right)$$

$$M_{calc} = P^2_{K^\pm} * \left(\frac{1-\beta^2}{\beta^2}\right)$$

Preliminary MM spectra (electron in FD)

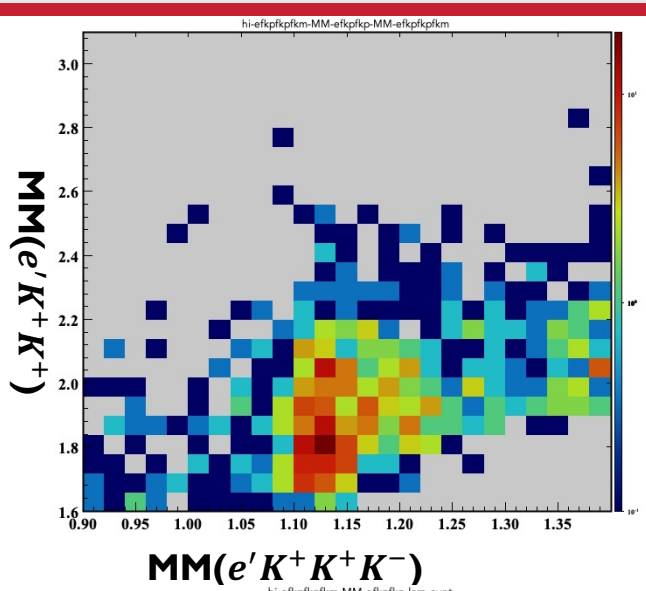


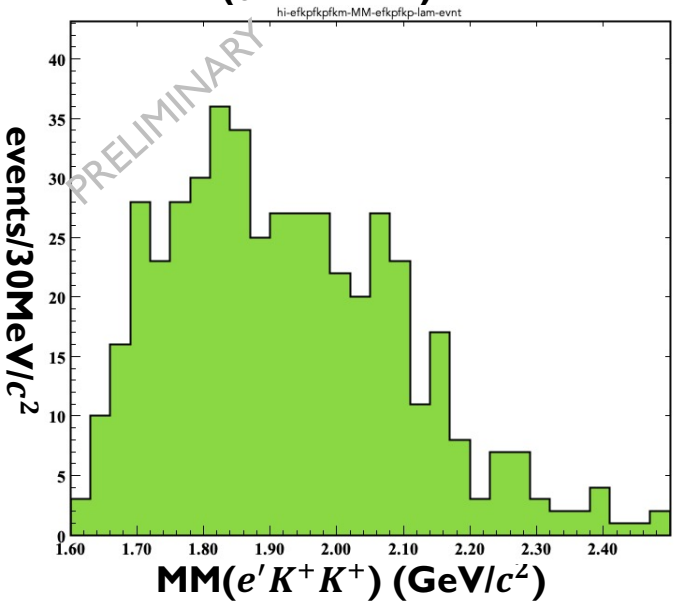


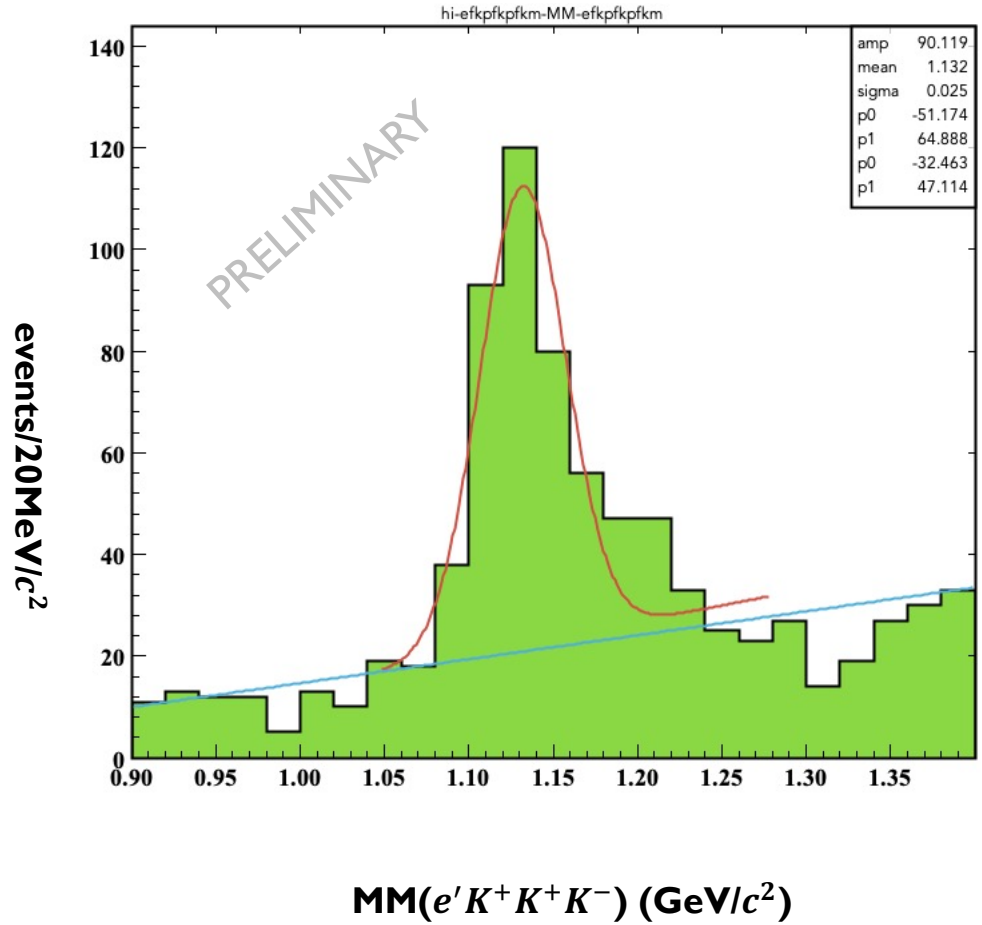


- High Q^2 Electroproduction

Preliminary MM spectra (electron in FD)

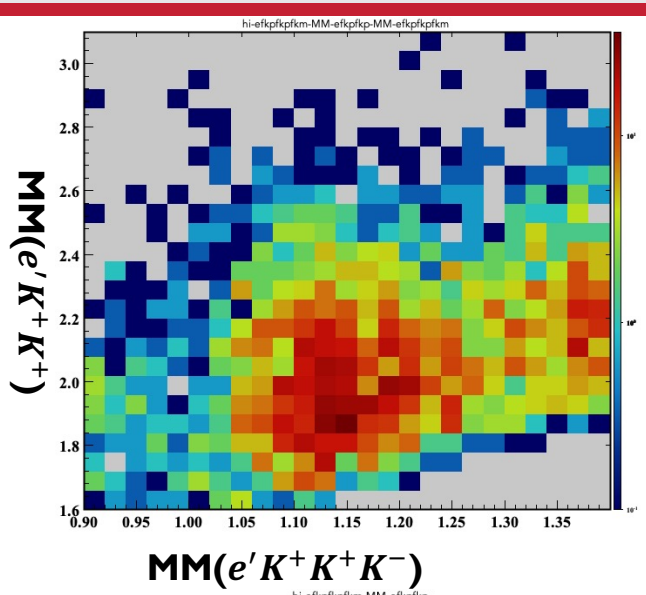


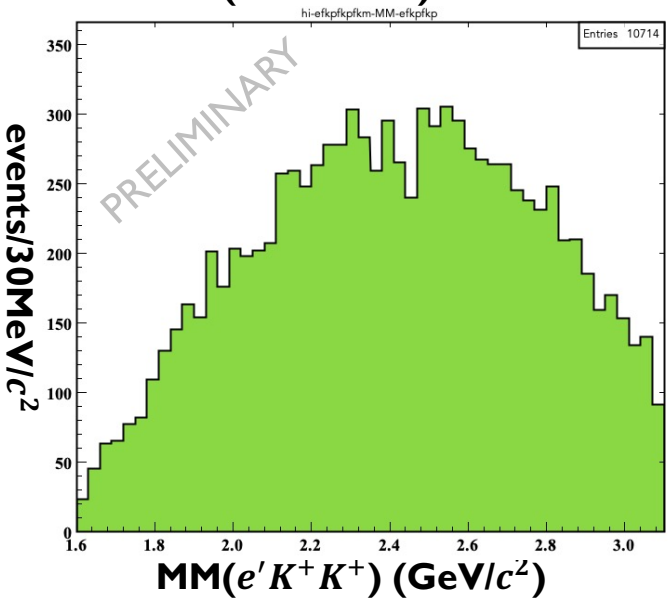


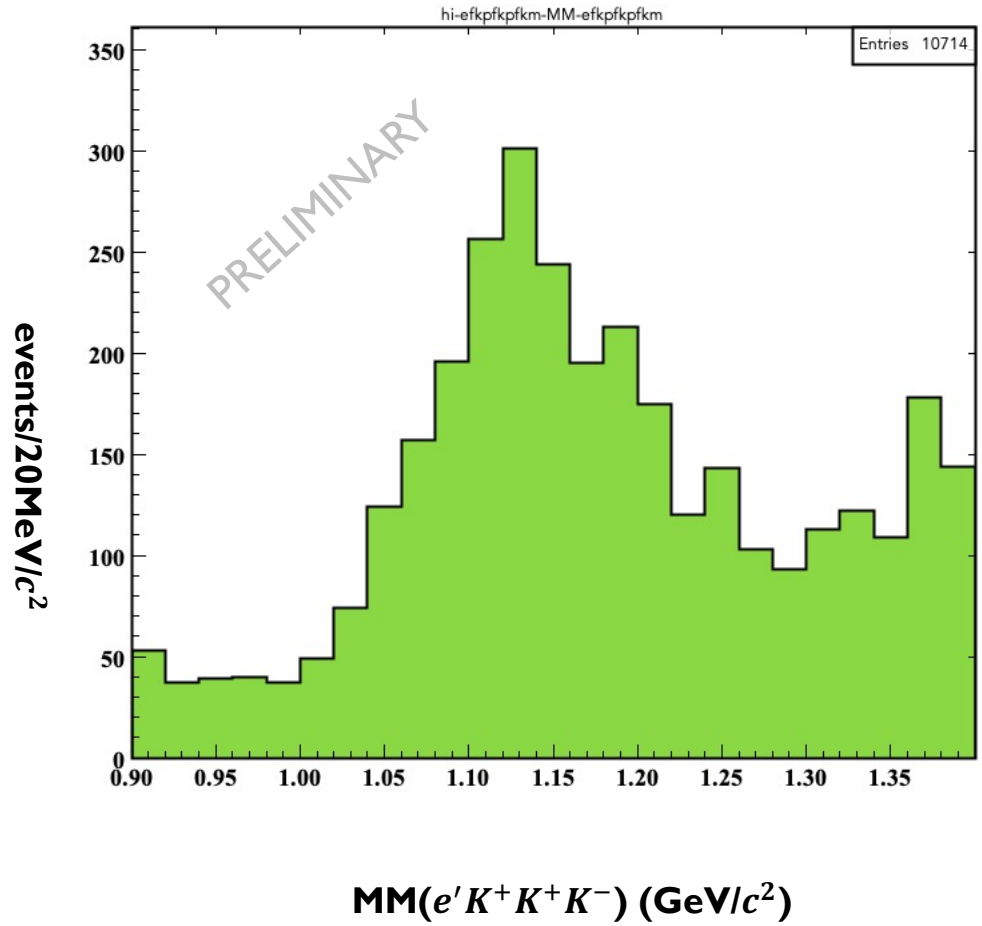


- High Q^2 Electroproduction

Preliminary MM spectra (electron in FT)

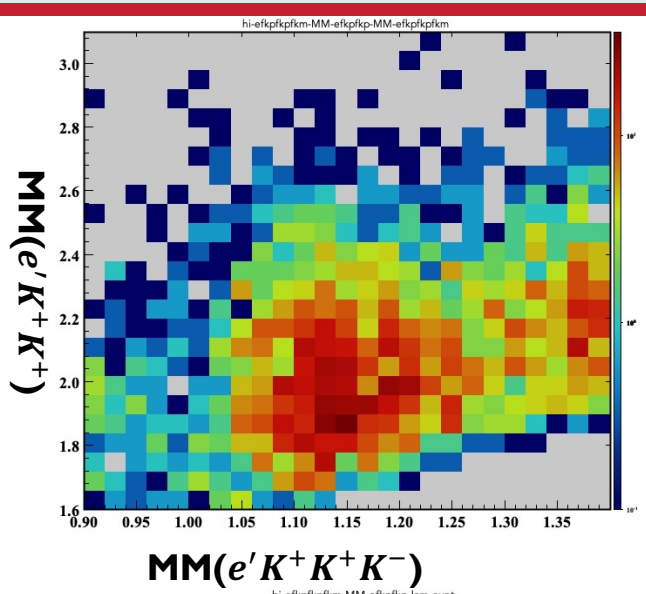


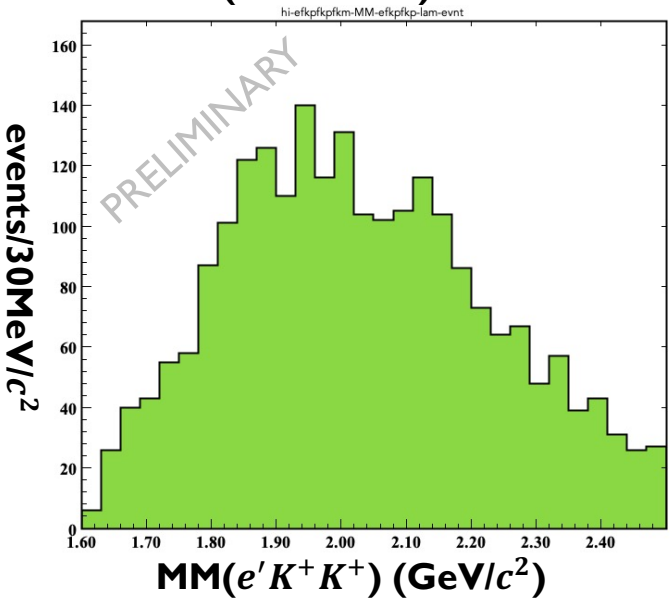


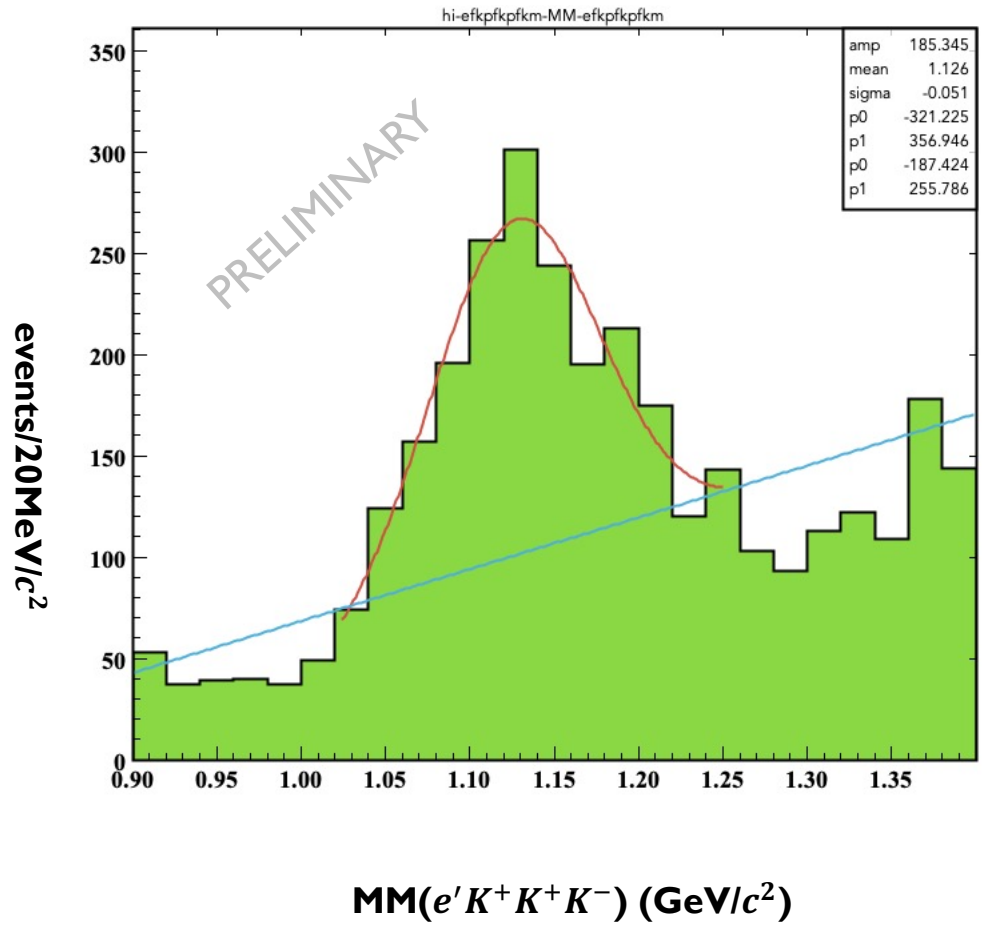


- Low Q^2 Electroproduction → Quasi-real photo production

Preliminary MM spectra (electron in FT)







- Low Q^2 Electroproduction → Quasi-real photo production

Summary

- Promising Ξ^{*-} resonances seen in the missing mass spectra from electroproduction as well as quasi-real photoproduction process using CLAS12 data

- This is still work in progress
  - Demands more statistics to further explore the cascade physics
  - Extend kinematic phase space by allowing kaons to detect in CD (~3 times more statistics expected while detecting particles in CD)
  - Work with full data set which will further increase the statistics by ~2 times more

Thank You !!!!

BackUP