Search for $\Phi(1860)$ in CLAS

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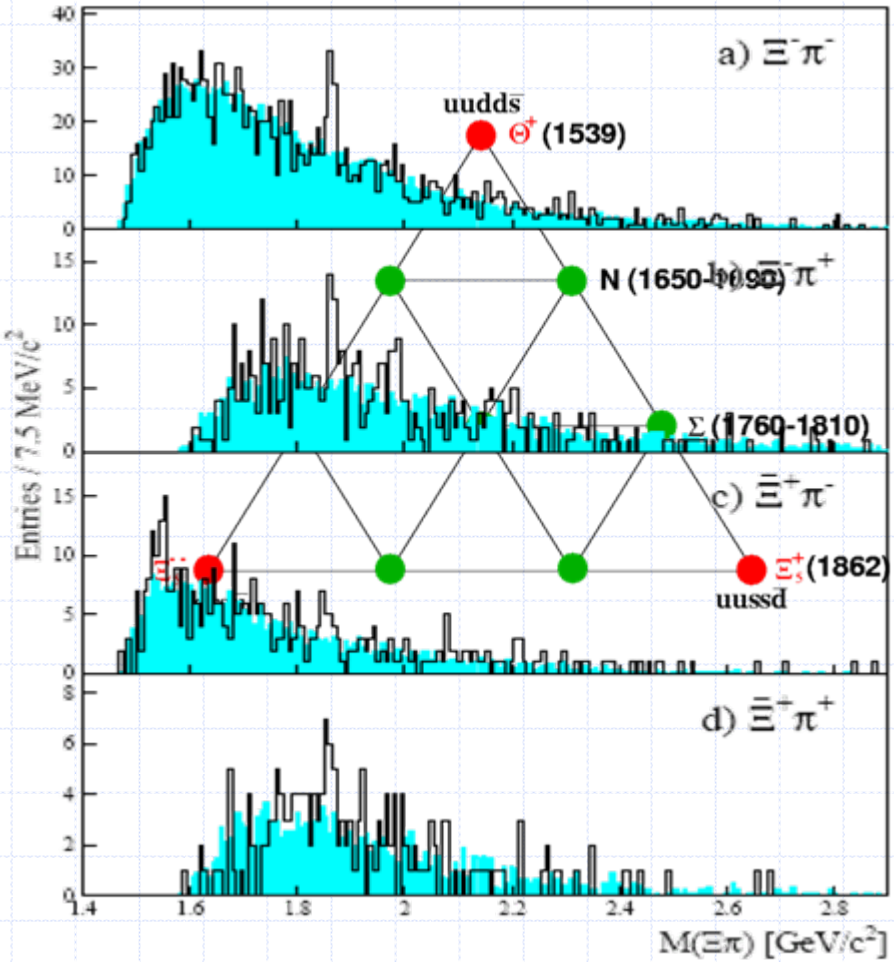
Outline of the Talk

- Physics Overview
- Objective of this experiment
- CLAS Data
- Summary

Introduction

- A number of experimental results suggest existence of $\Theta^+(1540)$ pentaquark state.
- Models predicted such a state as a part of pentaquark antidecuplet.
- 3 predicted states have predicted exotic quantum numbers.
- NA49 collaboration reported an observation of $\Xi_5(1860)$ ($\Phi(1860)$) states which they identified with two I=3/2 states of antidecuplet.
- Other experiments failed to confirm NA49 result.

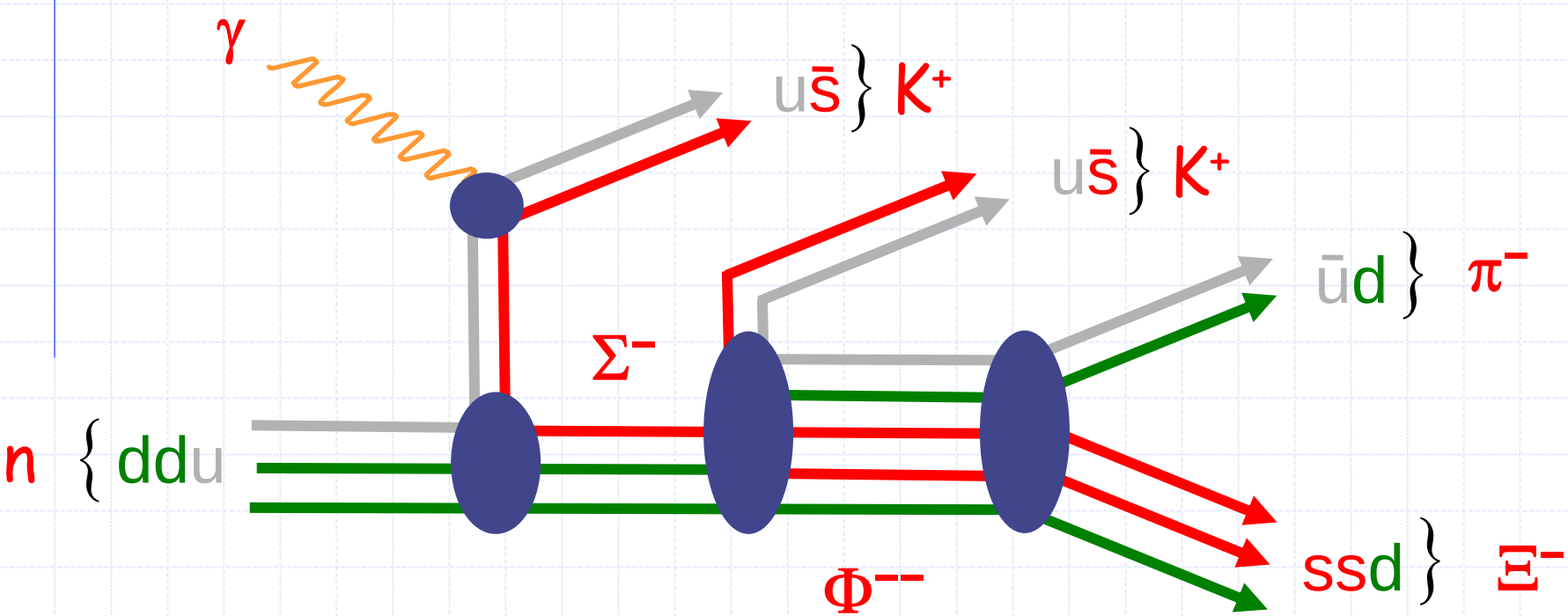


Status of $\Phi(1860)$ Search

Experiment	Initial state	Ξ^-	$\Xi(1530)$	$\Phi(1860)^{--}$
NA49	pp	1640	150	36
ALEPH	e^+e^-	3450	322	< 24
BaBar	e^+e^-	250000	24000	< 133
CDF	pp	35722	2182	< 63
COMPASS	μ^+ A	18000	1700	< 79
E690	pp	512850	70000	< 200
FOCUS	γp	800000	59391	< 170
HERA-B	pA	12000	1400	< 56
HERMES	e^-D	450	35	< 5
WA89	Σ^- A	676000	60000	< 760
ZEUS	ep	1561	192	< 56

Ageev et al, Eur. Phys. J C41 (2005)

Photo-Production Diagram



Φ^{--} is composed of (ssdd$\bar{u}$) quarks

Φ(1860) Decays

Exotic States

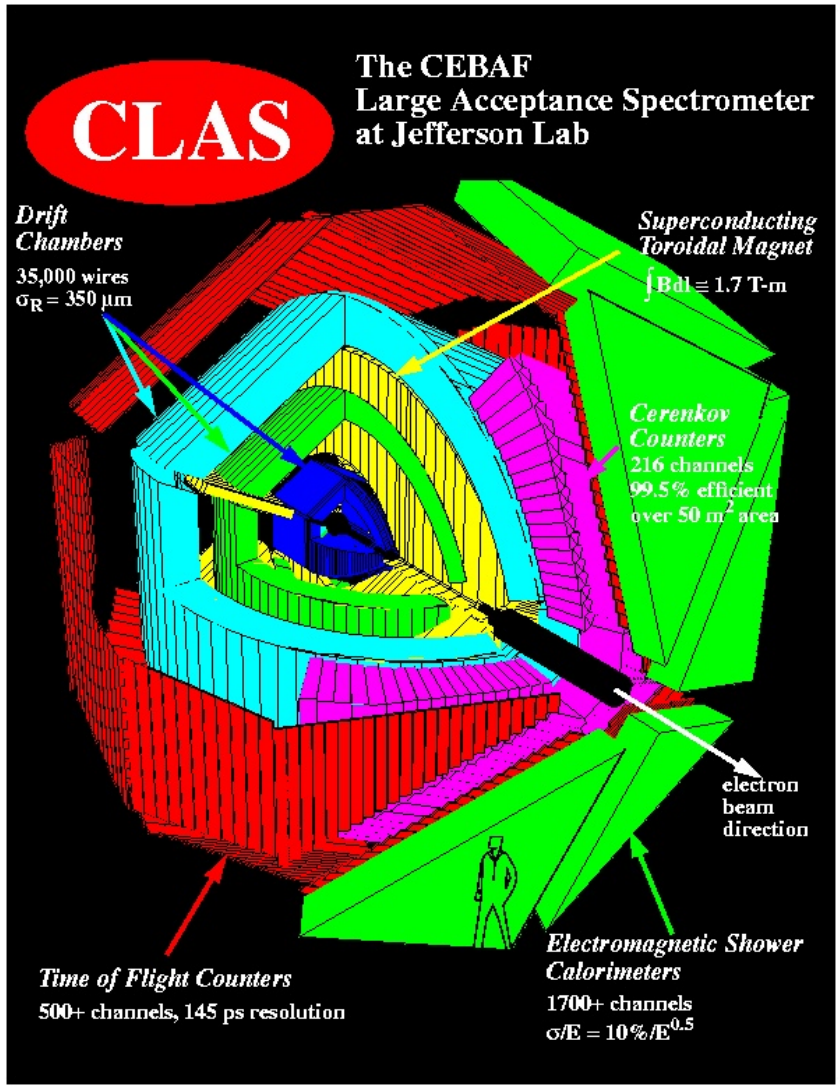
Primary decay	Secondary decay	Tertiary decay	Mass Constr.	Q=0	Br.
$\Phi^{--} \to \pi^-\Xi^-$ (0.5)	$\to \pi^-(\pi^-\Lambda)$	$\to \pi^-\pi^-(\pi^- p)$	Ξ^-, Λ		0.32
$\Phi^{--} \to K^-\Sigma^-$ (0.5)	$\to K^-(\pi^- n)$		Σ^-	n	0.5
$\Phi^- \to \pi^0\Xi^-$ (0.33)	$\to \pi^0(\pi^-\Lambda)$	$\to \pi^0\pi^-(\pi^- p)$	Ξ^-, Λ	π^0	0.21
$\Phi^- \to \pi^-\Xi^0$ (0.17)	$\to \pi^-(\pi^0\Lambda)$	$\to \pi^-\pi^0(\pi^- p)$	Ξ^0, Λ	π^0	0.11
$\Phi^- \to \overline{K}^0\Sigma^-$ (0.17)	$\to (\pi^-\pi^+)(\pi^- n)$		K_s, Σ^-	n	0.06
$\Phi^- \to K^-\Sigma^0$ (0.33)	$\to K^-(\gamma\Lambda)$	$\to K^-\gamma(\pi^- p)$	Σ^0, Λ	γ	0.21
$\Phi^0 \to \pi^0\Xi^0$ (0.33)	$\to \pi^0(\pi^0\Lambda)$	$\to \pi^0\pi^0(\pi^- p)$	Ξ^0, Λ	2 π^0	0.21
$\Phi^0 \to \pi^+\Xi^-$ (0.17)	$\to \pi^+(\pi^-\Lambda)$	$\to \pi^+\pi^-(\pi^- p)$	Ξ^0, Λ		0.11
$\Phi^0 \to K^-\Sigma^+$ (0.17)	$\to K^-(\pi^+ n)$		Σ^+	n	0.09
$\Phi^0 \to \overline{K}^0\Sigma^0$ (0.33)	$\to (\pi^+\pi^-)(\gamma\Lambda)$	$\to \pi^+\pi^-\gamma(\pi^- p)$	K_s, Σ^0, Λ	γ	0.07
$\Phi^+ \to \pi^+\Xi^0$ (0.5)	$\to \pi^+(\pi^0\Lambda)$	$\to \pi^+\pi^0(\pi^- p)$	Ξ^0,Λ	π^0	0.32
$\Phi^+ \to \pi^+\pi^+\Xi^-$ (?)	$\to \pi^+\pi^+(\pi^-\Lambda)$	$\to \pi^+\pi^+\pi^-(\pi^- p)$	Ξ^0,Λ		?
$\Phi^+ \to \overline{K}^0\Sigma^+$ (0.5)	$\to (\pi^+\pi^-)(\pi^+ n)$		K_s, Σ^+	n	0.09

Role of CLAS

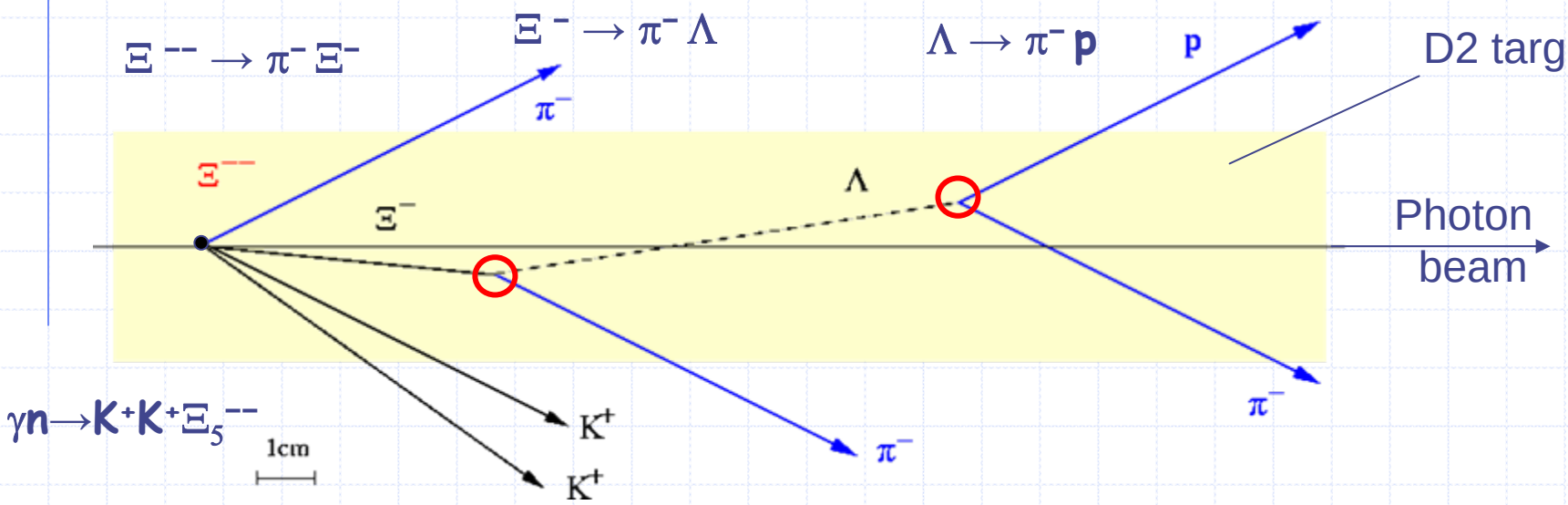
- Look for $\Phi(1860)$ in photo- and electro-production on neutron.
- CLAS allows simultaneous detection of multiple particles in the final state. In particular, channel

$$\begin{aligned}\gamma d \rightarrow (\ K^+K^+p_s\ )\ \Phi^{--} \rightarrow \\ (\ K^+K^+p_s\ )\ \pi^-\Xi^- \rightarrow \\ (\ K^+K^+p_s\ )\ \pi^-\pi^-\Lambda \rightarrow \\ (\ K^+K^+p_s\ )\ \pi^-\pi^-\pi^-p\end{aligned}$$

  can be studied wit CLAS.
- Directly reconstruct the Φ^{--} as a $p\pi^-\pi^-\pi^-$ system instead of using missing mass technique.
- Expected ~45 Φ^{--} events/nb in 40 days run.



Schematic of the Reaction



Reconstruction of detached vertices can be very helpful

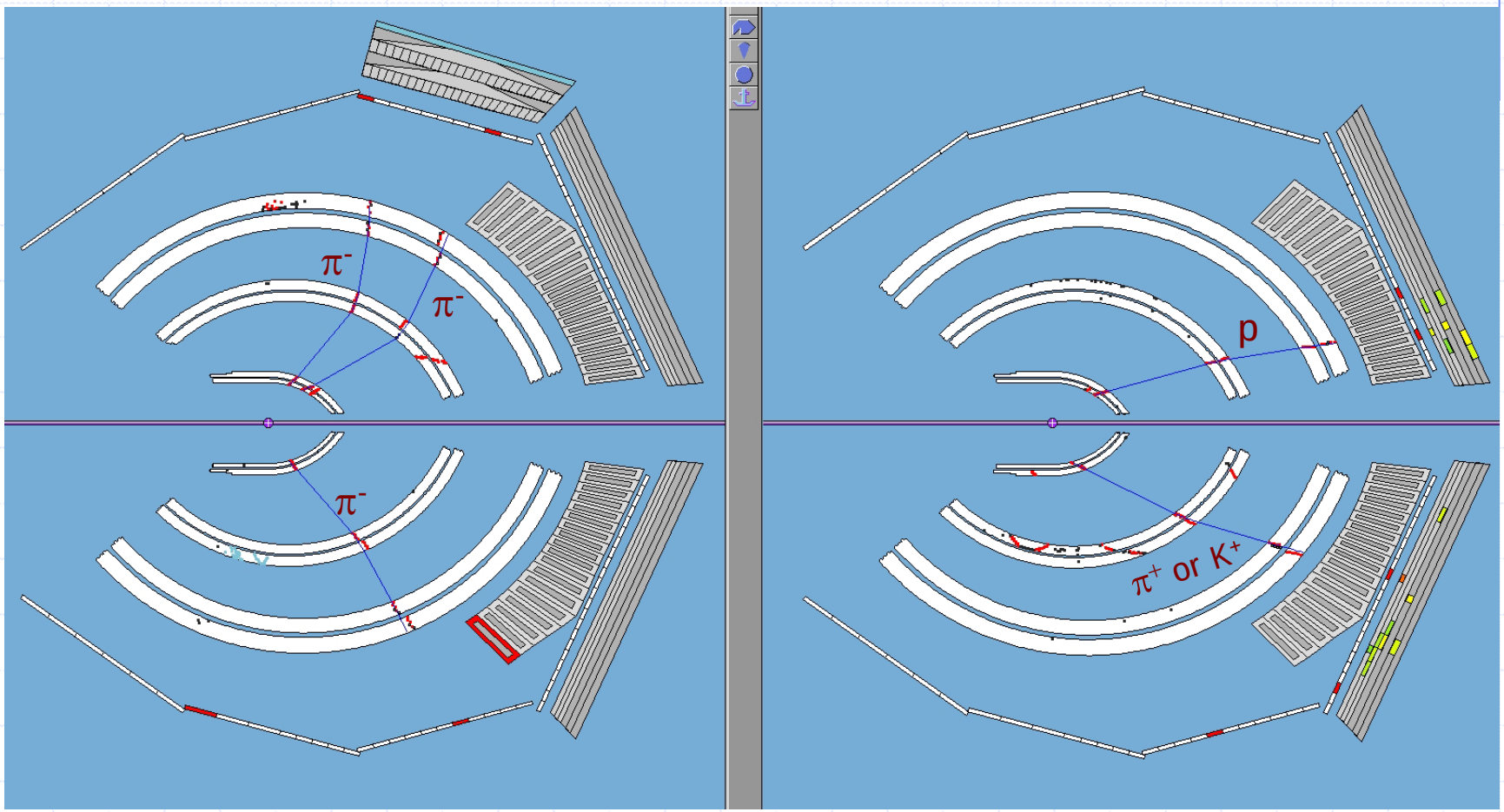
Production vertex and two decay vertices.

Ξ^- $c\tau$ = 4.9 cm
Λ $c\tau$ = 7.9 cm

EG3 Run Conditions

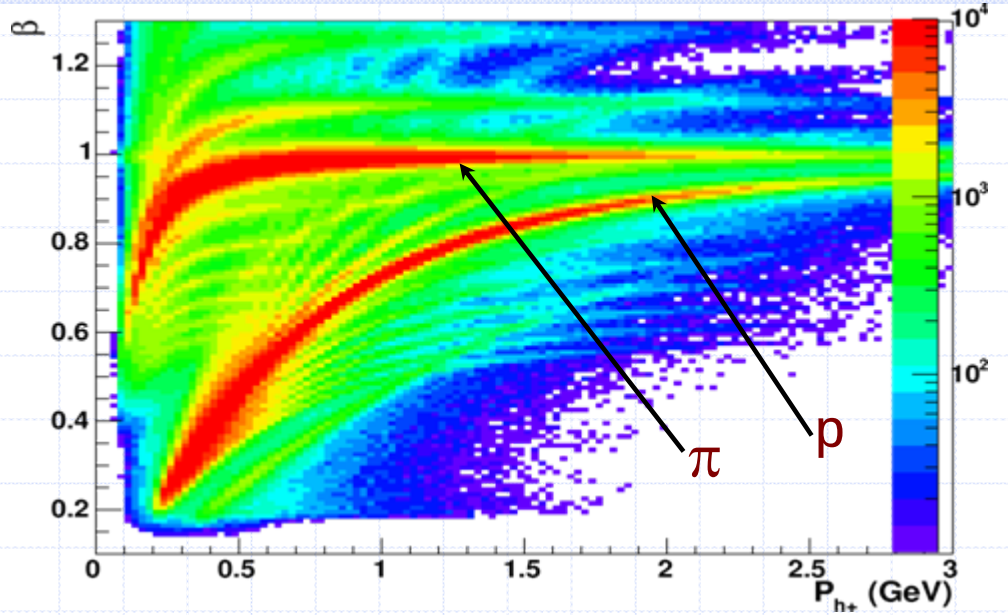
- Use CEBAF 5.7 GeV initial electron beam.
- Secondary tagged photon beam within a tagging range from 4.5-5.5 GeV at ~$2 \times 10^{7} sec^{-1}$ tagged γ-rate.
- 40-cm long deuterium target achieving integrated luminosity of ~100 pb^{-1} for active tagging range.
- Reversed magnetic field polarity to improve the acceptance for the negative tracks .
- Use 3-tracks trigger as the main trigger. Prescaled 2-track trigger.
- Collected total of 4 billion triggers (2 track + 3 track) in 40 calendar days.

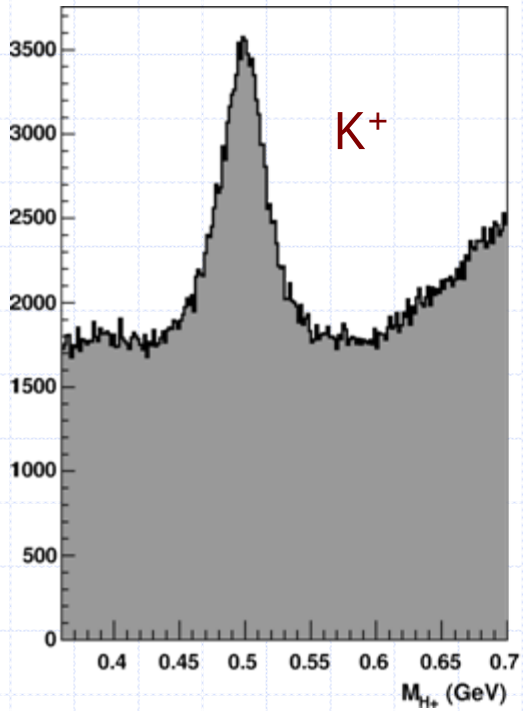
Sample Event in CLAS

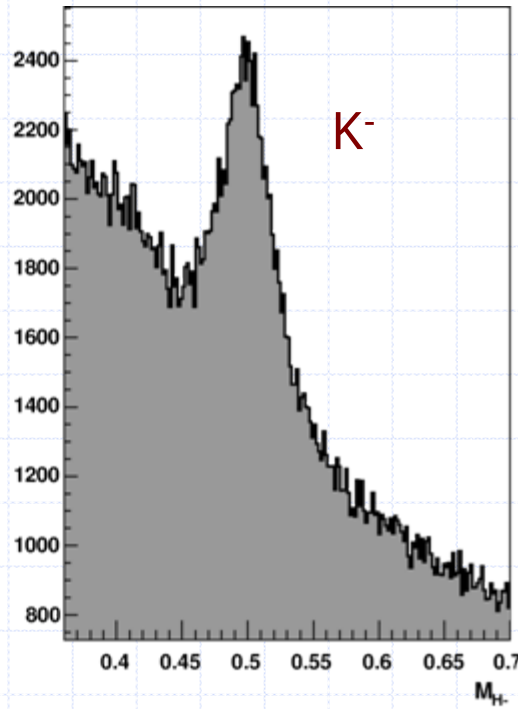


PID in CLAS

- Momentum determined from tracking in drift chambers.
- Timing determined from TOF system.
- Proton-pion separation is easy for P<2.5 GeV
- K^+ and K^- identification for P<1.5 GeV.

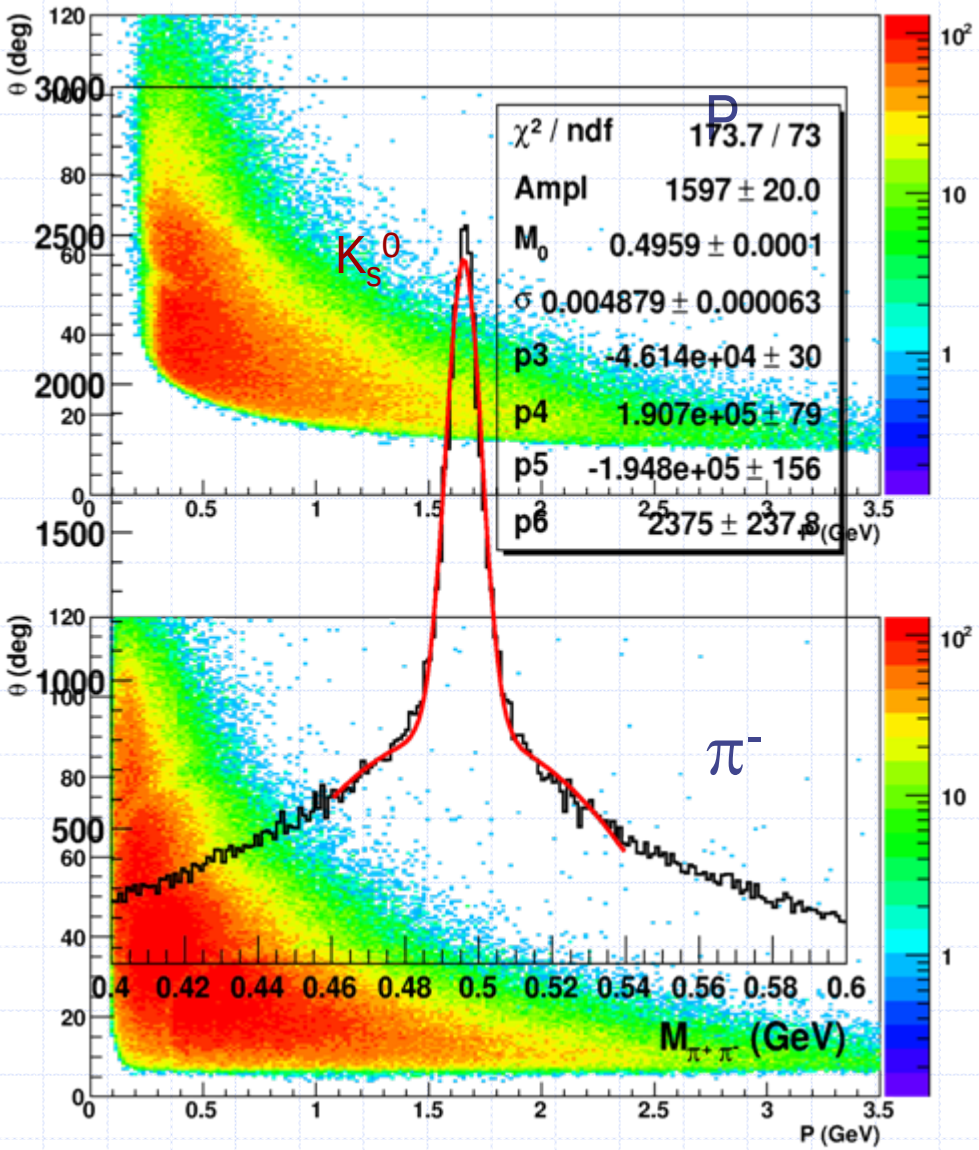




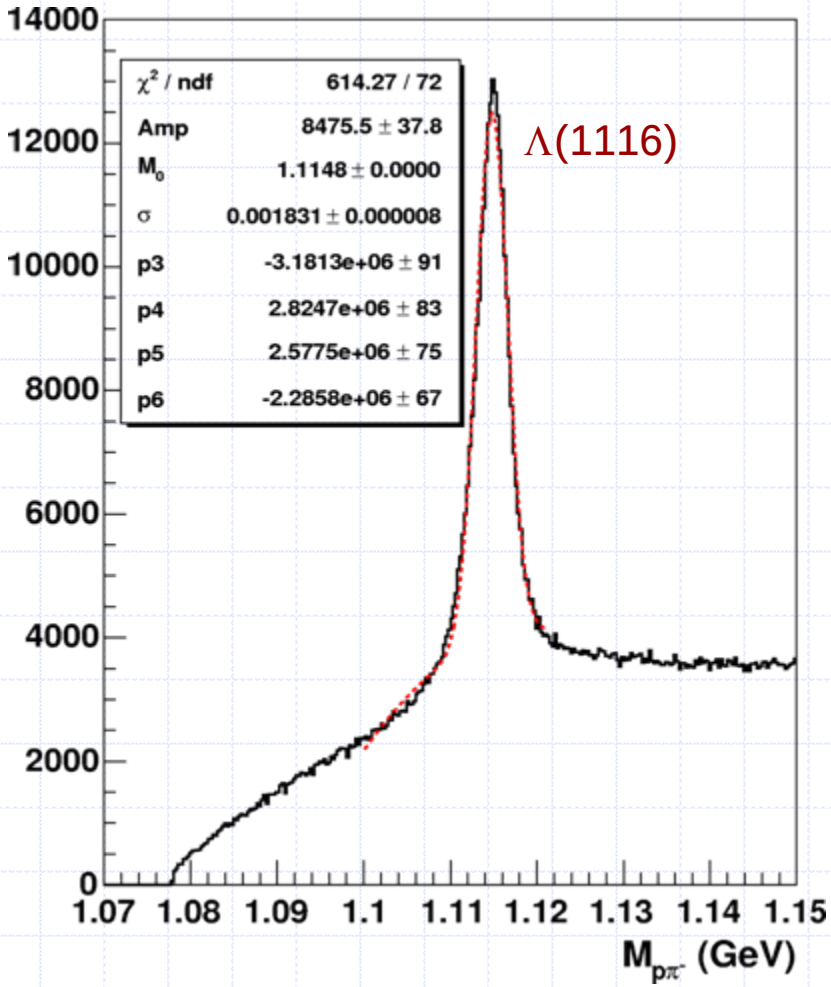


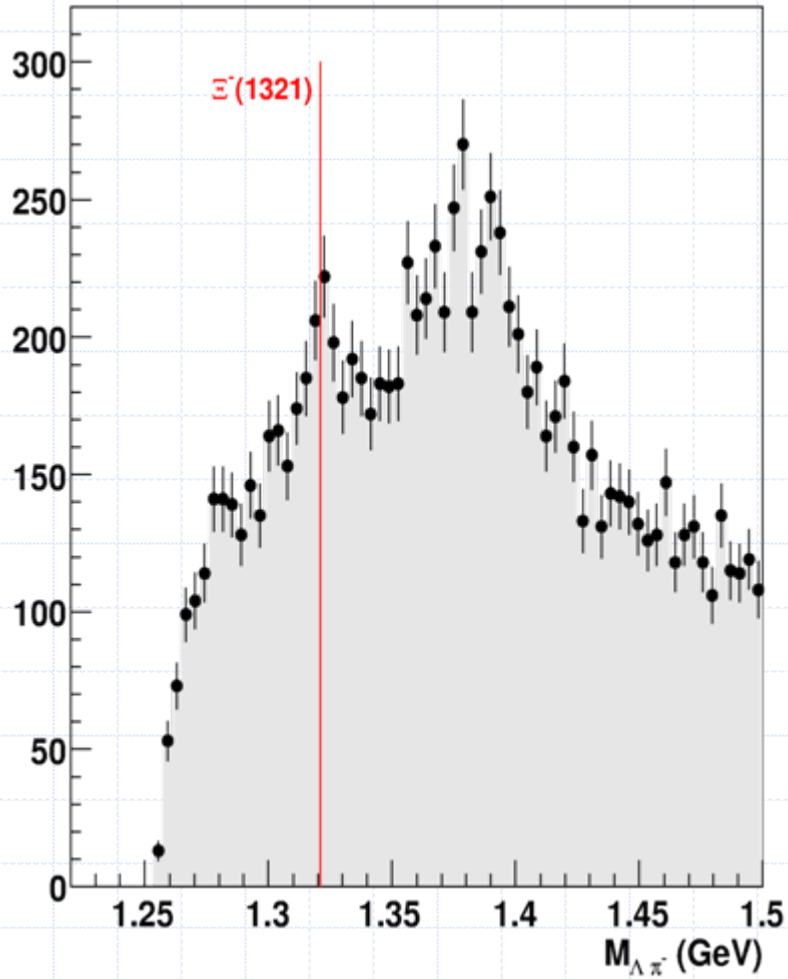
Kinematical Coverage

- Acceptance for π- is very good, from 8^o to 130^o due to reversed magnetic field.
- Forward-going protons are bent inward into the CLAS beam pipe.
- Forward kinematical coverage for K^- will allow for $\Theta^+(1540)$ search in $\gamma d \rightarrow K^- p \Theta^+$ channel in both $\Theta^+ \rightarrow K^+ n$ and $K^0 p$ decay channels.



Reconstruction of Particles





Summary

- EG3 run's primary goal is to search for $\Phi(1860)$ pentaquark seen in NA49.
- Used tagged photon beam on deuterium target.
- The data taking was completed in Feb 2005, collected 4 billion triggers.
- Calibrations are nearly complete, data processing will start very soon.
- Need to developed a procedure for detached vertex reconstruction to identify $\Xi^{-}(1321)$ and $\Phi^{--}(1860)$.
- The data can be used for $\Theta^{+}(1540)$ search as well.
- Stay tuned for the results.

The End

Kinematical Coverage

- The coverage for K^- is better than for K^+ .
- Cannot afford to tag strangeness with two K^+s.
- Still, can require one K^+ detection to clean up the data sample by losing 70% in statistics.