



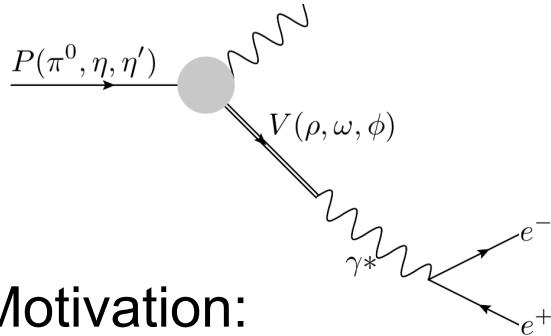
AN UPDATE ON THE ELECTROMAGNETIC TRANSITION FORM FACTOR OF THE η^{\prime} MESON WITH G12 AND CLAS12

Michael C. Kunkel | IKP-1

Transition Form Factors

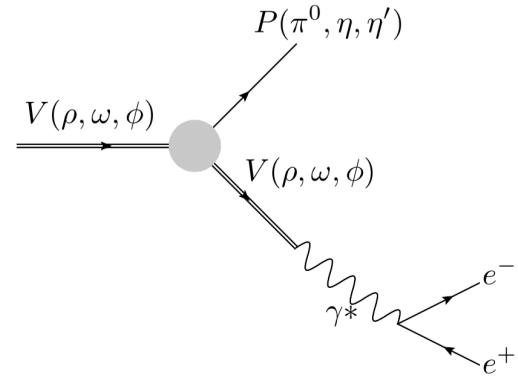
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Motivation:

- In the VMD model the transition form factors provides insight into the meson charge radius, $\langle r \rangle$.
- For pseudoscalar mesons η and η' , ratio of form factors provides information on mixing angle.
- For vector meson ω there currently exist discrepancy in the measurement of the form factor with VMD model.
- The knowledge of the η form factor is also needed for the interpretation of the g-2 experiment.
- g12 experiment collected data samples of the $p e^+ e^- X$ reaction using Cherenkov Counters and an Electromagnetic Calorimeter

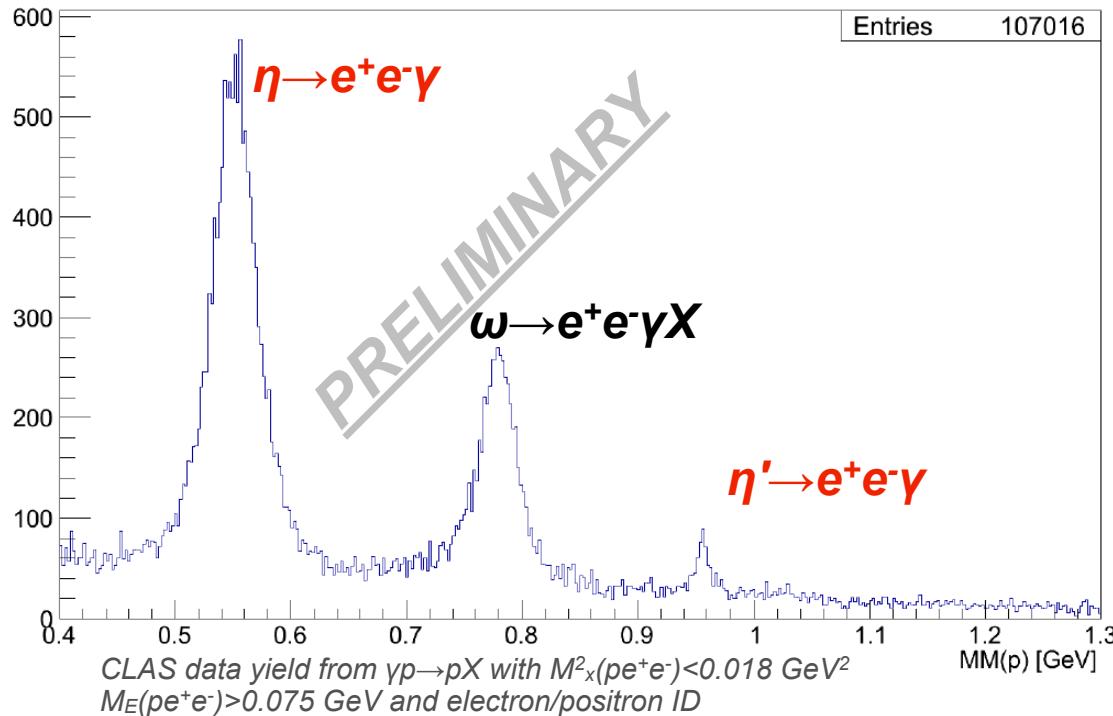


Transition Form Factors

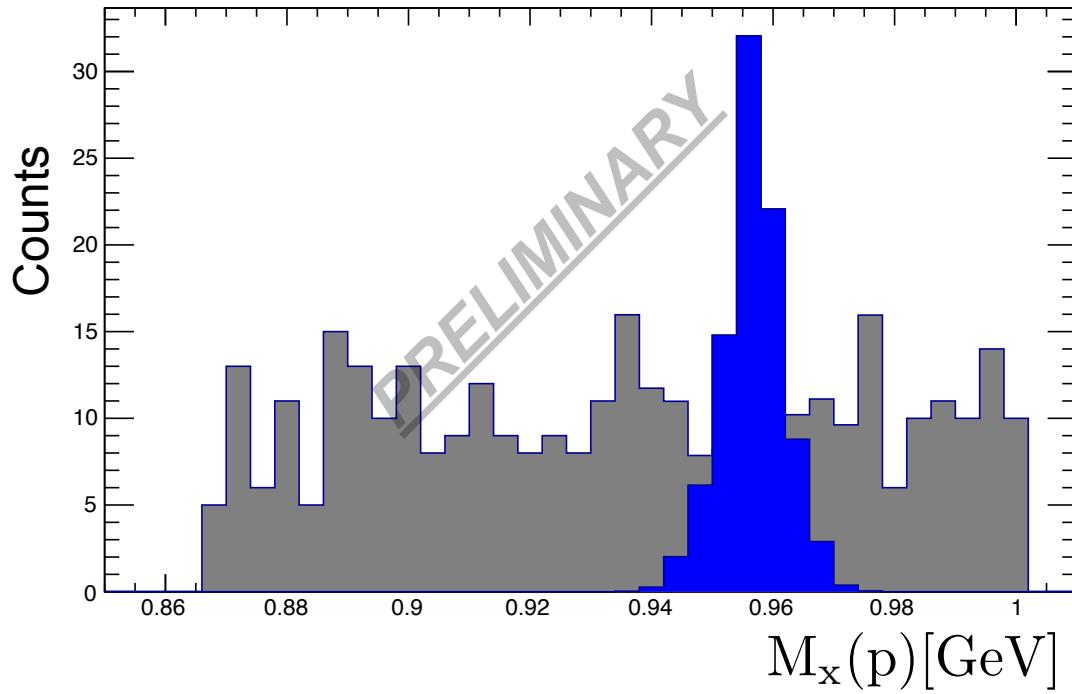
$$\frac{d\Gamma_{P \rightarrow l^+ l^- \gamma}}{dq^2 d\Gamma_{P \rightarrow \gamma\gamma}} = \frac{2\alpha}{3\pi q^2} \left(1 - \frac{q^2}{m_P^2}\right)^3 \left(1 - \frac{4m_l^2}{q^2}\right)^{1/2} \left(1 + \frac{2m_l^2}{q^2}\right) |_{\text{Q.E.D}}$$

$$\langle r \rangle = \frac{dF}{dq^2} \Big|_{q^2=0}$$

$$\frac{d\Gamma_{P \rightarrow l^+ l^- \gamma}}{dq^2 d\Gamma_{P \rightarrow \gamma\gamma}} |_{\text{measured}} = \frac{d\Gamma_{P \rightarrow l^+ l^- \gamma}}{dq^2 \Gamma_{P \rightarrow \gamma\gamma}} |_{\text{Q.E.D}} |F(q^2)|^2$$



$\eta' \rightarrow \gamma e^+ e^-$ Branching Ratio



BESIII $\Gamma(\eta' \rightarrow \gamma e^+ e^-)/\Gamma(\eta' \rightarrow \gamma\gamma) (2.13 \pm 0.09(\text{stat.}) \pm 0.07(\text{sys.})) \times 10^{-2}$ from 864 events [1]

CLAS preliminary BR consistent with BESIII from 89 events

Current status of η' charge radius



Current BESIII and CLAS data sets do not have enough statistics to determine which theoretical model fits the $\eta' \rightarrow$ charge radius

	$\langle r \rangle$	Number of events
BESIII ($\eta' \rightarrow \gamma e^+ e^-$)	$1.60 \pm 0.17(\text{stat}) \pm 0.08(\text{sys}) \text{ GeV}^{-2}$ [1]	894
CELLO ($\eta' \rightarrow \gamma \mu^+ \mu^-$)	$1.7 \pm 0.4 \text{ GeV}^{-2}$ [2]	75
CLAS ($\eta' \rightarrow \gamma e^+ e^-$)	TBD	89

Dispersion	$1.53^{+0.15}_{-0.08} \text{ GeV}^{-2}$	
ChPT	1.6 GeV^{-2}	
VMD	1.45 GeV^{-2}	

[1]BESIII, M. Ablikim et al., Phys. Rev. D92 (2015) 012001

[2]R. I. Dzhelyadi et al., Phys. Lett. B 88, 379 (1979)

Future CLAS e+e- pair physics

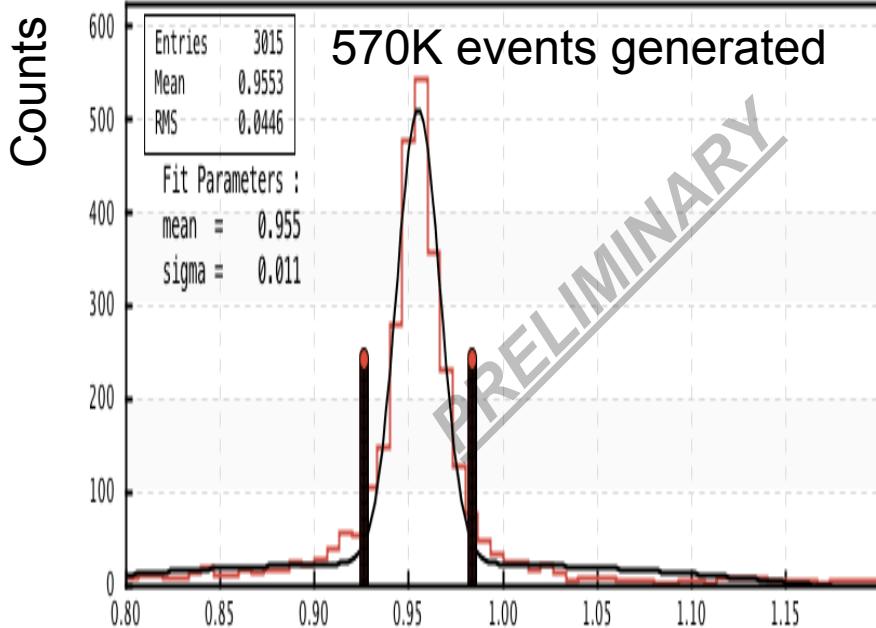
Electromagnetic structure of mesons and baryons. Currently we are benchmarking the $\eta' \rightarrow \gamma e^+ e^-$ decay. Here is a list of initial physics to be studied

Meson	Baryon
$\eta' \rightarrow \gamma e^+ e^-$	$(\Delta \rightarrow N e^+ e^-)$
$\omega \rightarrow \pi^0 e^+ e^-$	$\Lambda \rightarrow n e^+ e^-$ $\Lambda(1520) \rightarrow \Lambda e^+ e^-$
$\Phi \rightarrow \eta e^+ e^-$	
$J/\psi \rightarrow \pi^0 e^+ e^-$	$\Sigma^0 \rightarrow \Lambda e^+ e^-$ $\Sigma^+ \rightarrow p e^+ e^-$

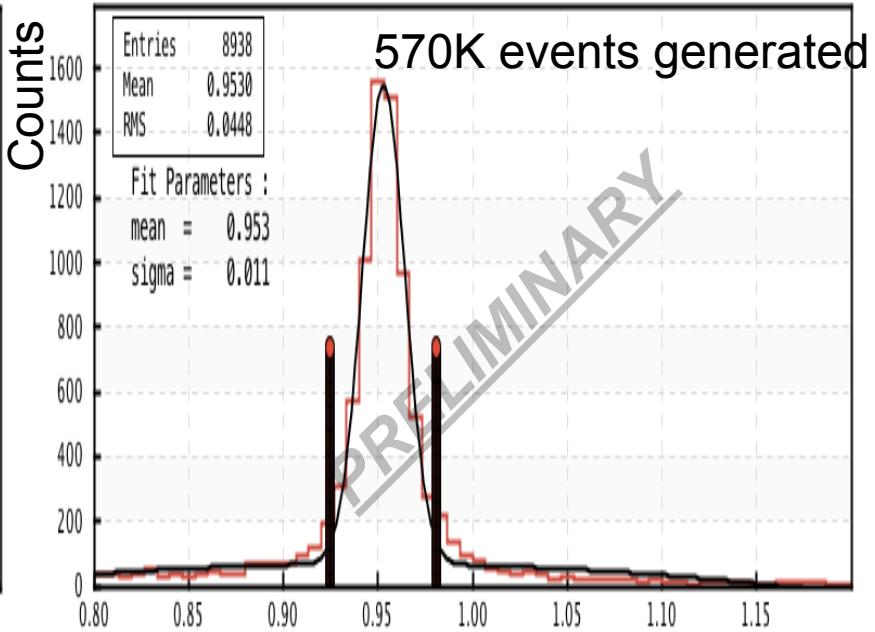
CLAS $\xi(e^+ e^-)/\xi(\pi^+ \pi^-)$ can be range $10^5 - 10^{11}$

CLAS $e^+ e^-$ efficiency (ε) range $1 - 10^{-2}$

Future CLAS η' Measurement



$M(e^+e^-\gamma)[GeV]$



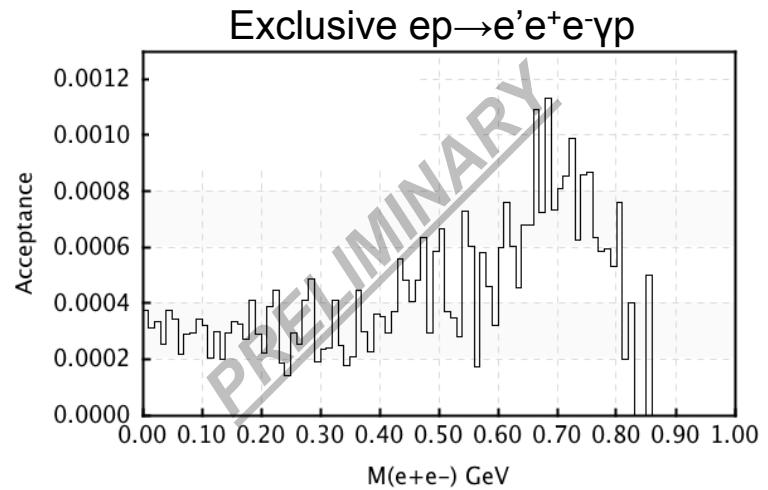
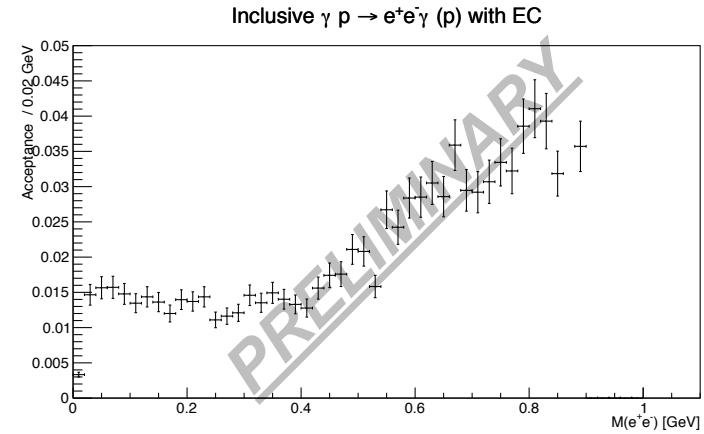
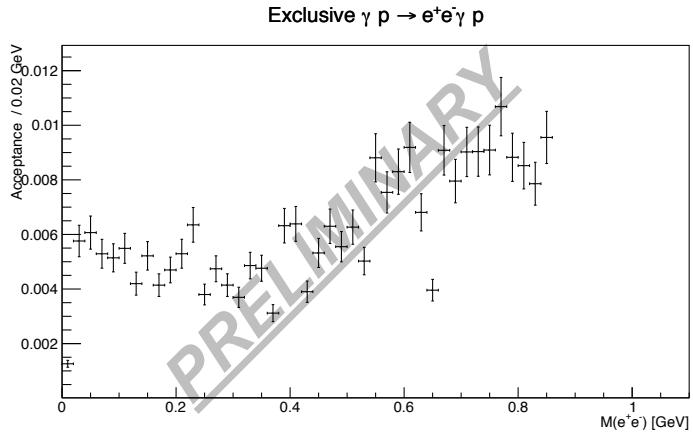
$M(e^+e^-\gamma)[GeV]$

Fully Exclusive
 $\gamma p \rightarrow \eta' p \rightarrow \gamma e^+ e^- p$

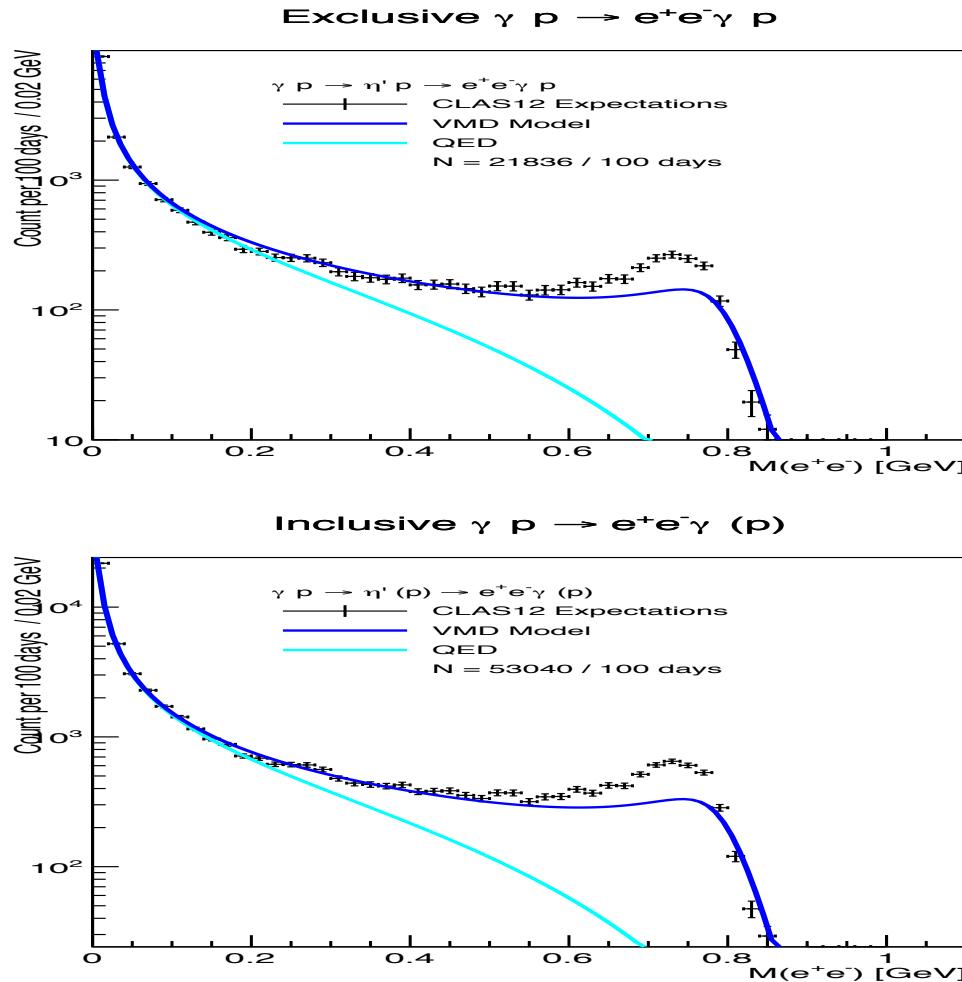
Inclusive
 $\gamma p \rightarrow \eta'(p) \rightarrow \gamma e^+ e^-(p)$

Future CLAS η' Acceptance

e⁺e⁻ Acceptance

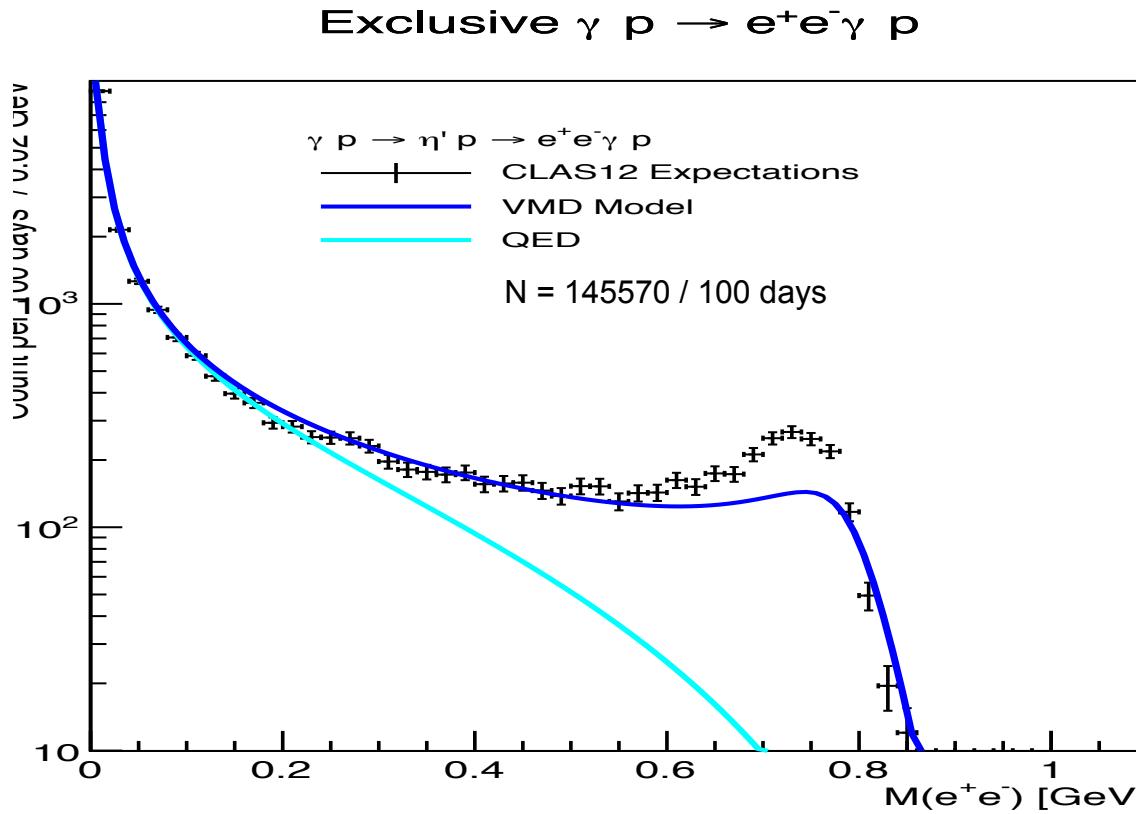


CLAS η' Rates at low Q^2



Within 100 days of beam-time CLAS can measure the η' transition form factor with a statistical uncertainty $\sim 1\%$

CLAS η' Rates with electroproduction



Within 100 days of beam-time CLAS can measure the η' transition form factor with a statistical uncertainty $\sim 1\%$

To Do

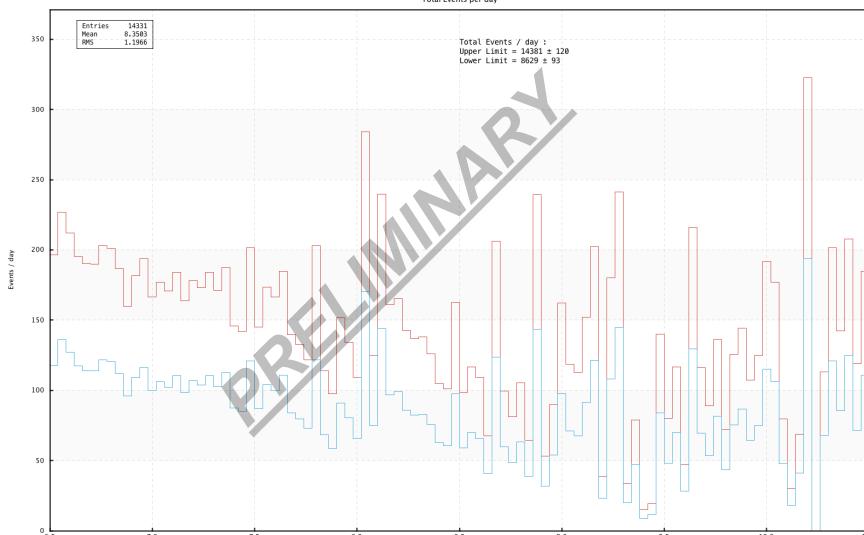
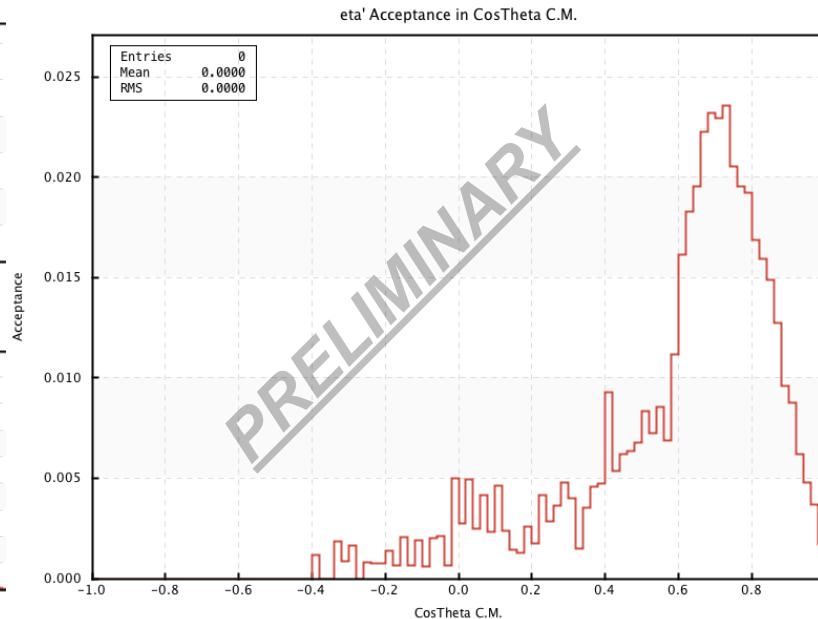
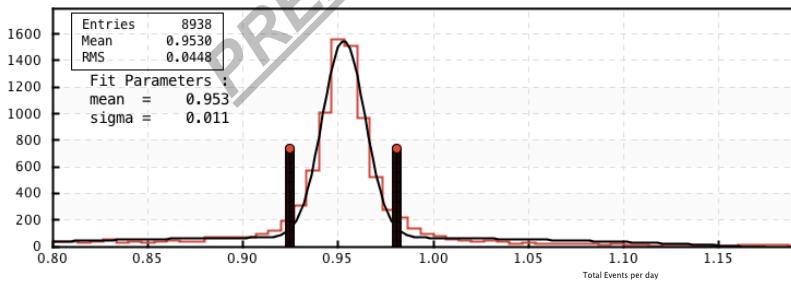
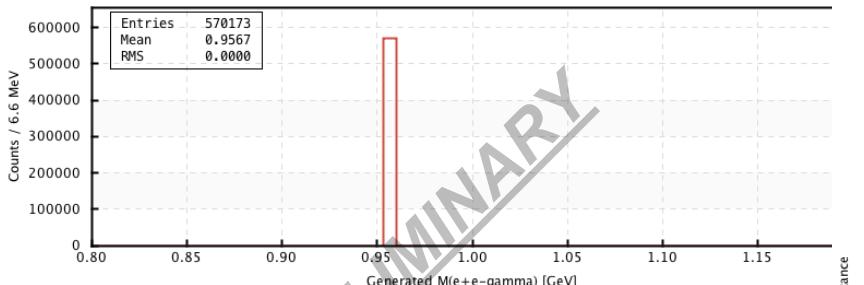
- Use GEMC reconstruction with coatjava with electroproduction
 - HTCC + EC
- Trigger studies
- Finish Φ , Δ , Σ^0 simulations
- Write proposal

Summary

- Transition form factors of pseudoscalar and vector mesons can be measured with CLAS
- Future CLAS data will provide data sets with statistics to accurately measure transition form factors and also branching ratio of e^+e^- decays.
 - Precision of transition form factor measurement in CLAS will determine validity of theoretical models.

BACKUP START HERE

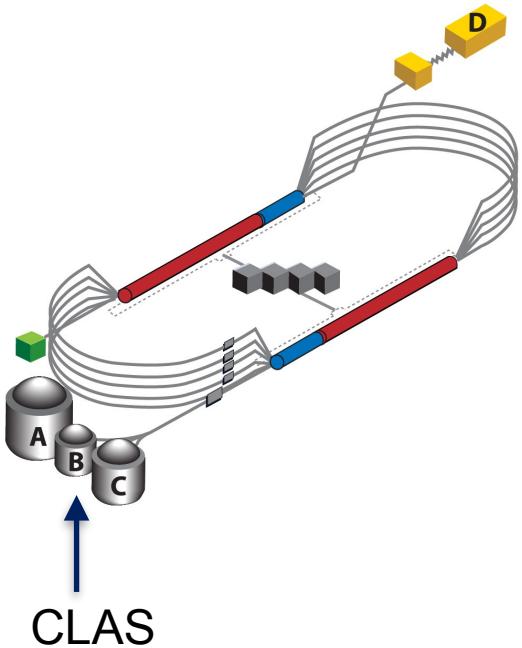
FUTURE CLAS η' MEASUREMENT



Inclusive $\gamma p \rightarrow \eta'(p) \rightarrow \gamma e^+ e^- (p)$
 Upper limit 14381 ± 120 events/day
 Lower limit 8629 ± 93 events/day

Exclusive $\gamma p \rightarrow \eta' p \rightarrow \gamma e^+ e^- p$
 Upper limit 1381 ± 12 events/day
 Lower limit 829 ± 9 events/day

Thomas Jefferson National Laboratory

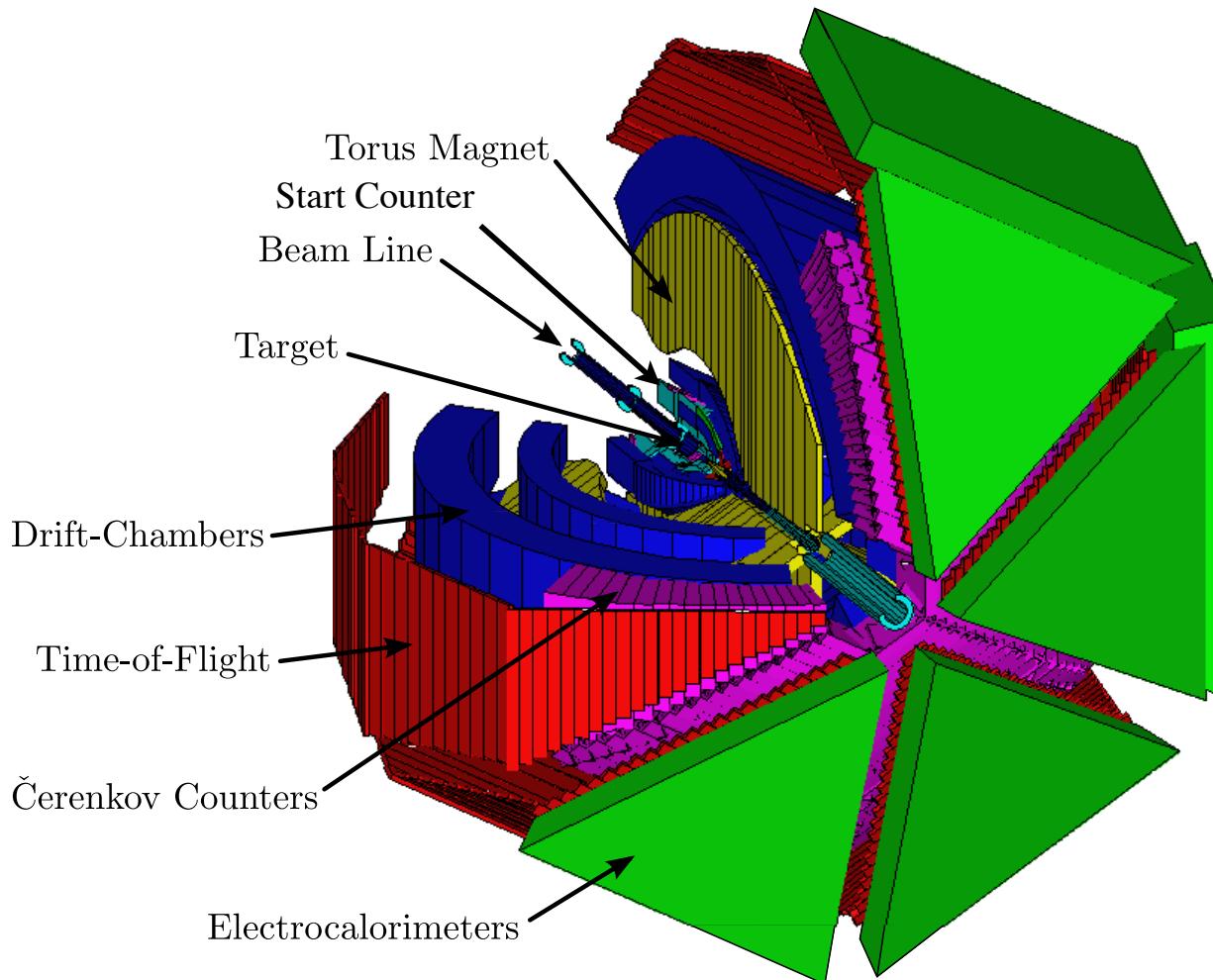


Continuous Electron Beam Accelerator Facility (CEBAF) at 12 GeV



Aerial View

CEBAF Large Acceptance Spectrometer (CLAS)



CLAS