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Light Meson Decays In CLAS and CLAS12

Michael C. Kunkel | DPG 2016 | IKP-1

Transition Form Factors

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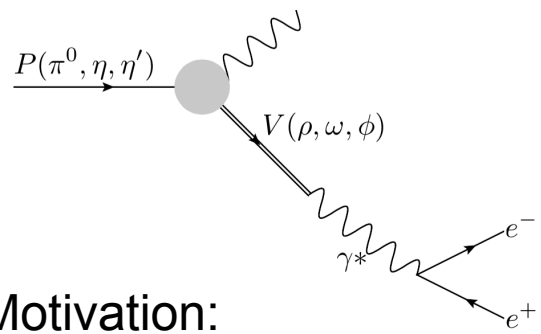

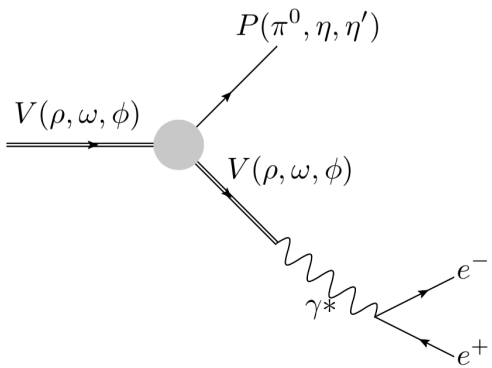

Motivation:

- 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 pe^+e^-X reaction using Cherenkov Counters and an Electromagnetic Calorimeter
- CLAS12 can provide excellent e^+/e^- identification up to a rejection $e^+e^-/\pi^+\pi^- \sim 10^{12}$

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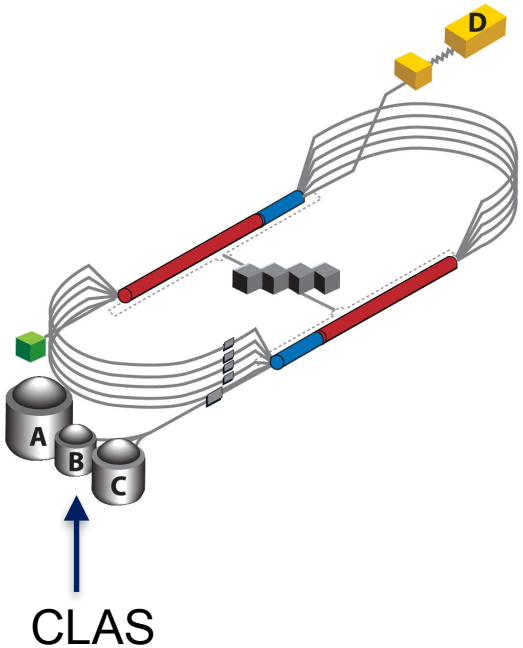
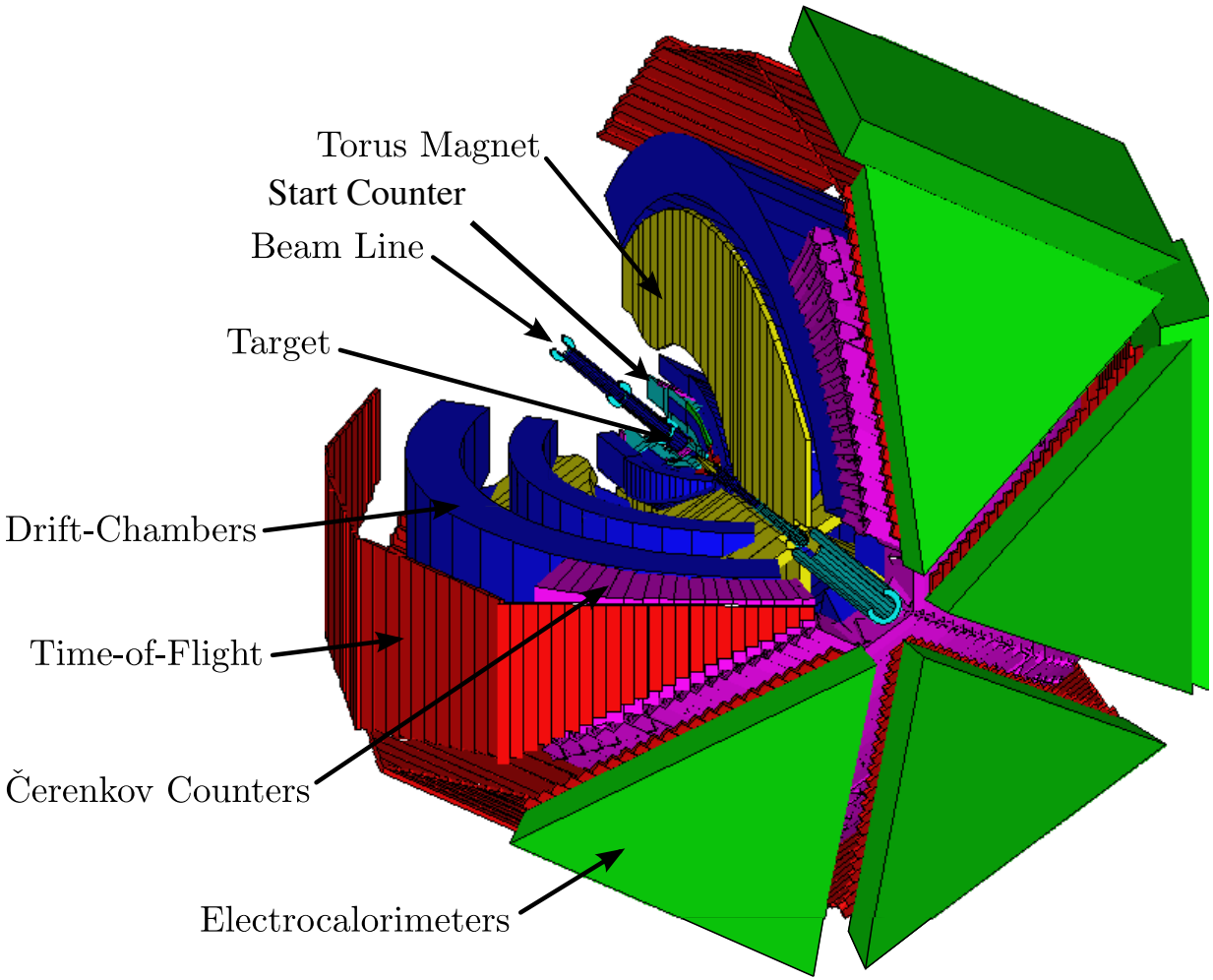


Continous Electron Beam Accelerator Facility (CEBAF) at 12 GeV

Aerial View

CEBAF Large Acceptance Spectrometer (CLAS)

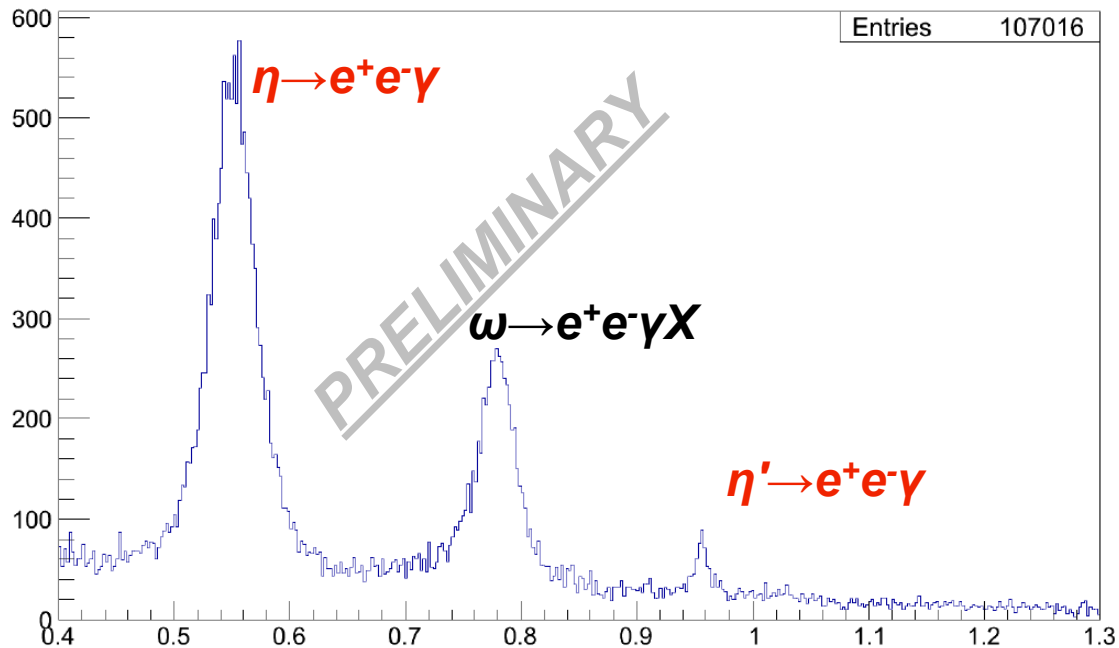


Transition Form Factors

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

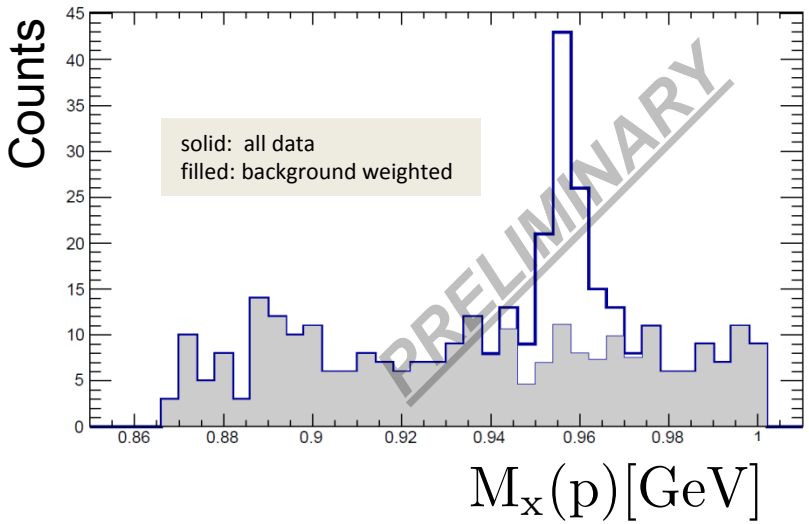
$$\langle \mathrm{r}\rangle = \frac{dF}{dq^2}\bigg|_{q^2=0}$$

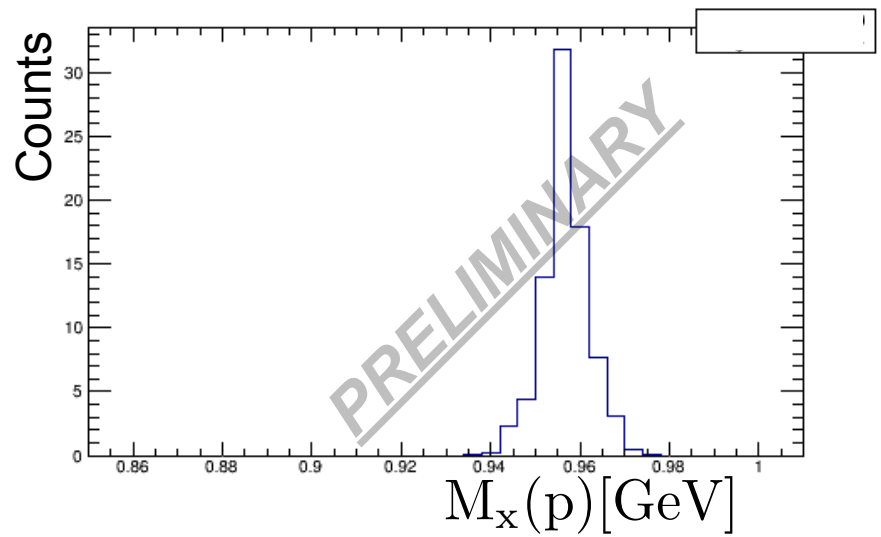
$$\frac{d\Gamma_{P_{P\to l^+l^-\gamma}}}{dq^2 d\Gamma_{P_{P\to\gamma\gamma}}}|_{\mathrm{measured}} = \frac{d\Gamma_{P_{P\to l^+l^-\gamma}}}{dq^2\Gamma_{P\to\gamma\gamma}}|_{\mathrm{Q.E.D}}\left|F(q^2)\right|^2$$



CLAS data yield from γp→pX with $M^2_x(pe^+e^-)<0.018$ GeV^2
$M_E(pe^+e^-)>0.075$ GeV and electron/positron ID

η′→γe+e− Branching Ratio





BESIII Γ(η′→γe+e−)/Γ(η′→γγ) (2.13±0.09(stat.)±0.07(sys.))×10^{-2} from 864 events [1]
CLAS preliminary BR consistent with BESIII from 89 events

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

Current status of η' charge radius

Current BESIII and CLAS data sets do not have enough statistics to determine which theoretical model fits the η′→ charge radius		
	$\langle r \rangle$	Number of events
BESIII (η′→γe+e−)	1.60 ± 0.17(stat) ± 0.08(sys) GeV^{-2} [1]	894
CELLO (η′→γμ+μ−)	1.7 ± 0.4 GeV^{-2} [2]	75
CLAS (η′→γe+e−)	TBD	89

Dispersion	$1.53^{+0.15}_{-0.08}$ 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)

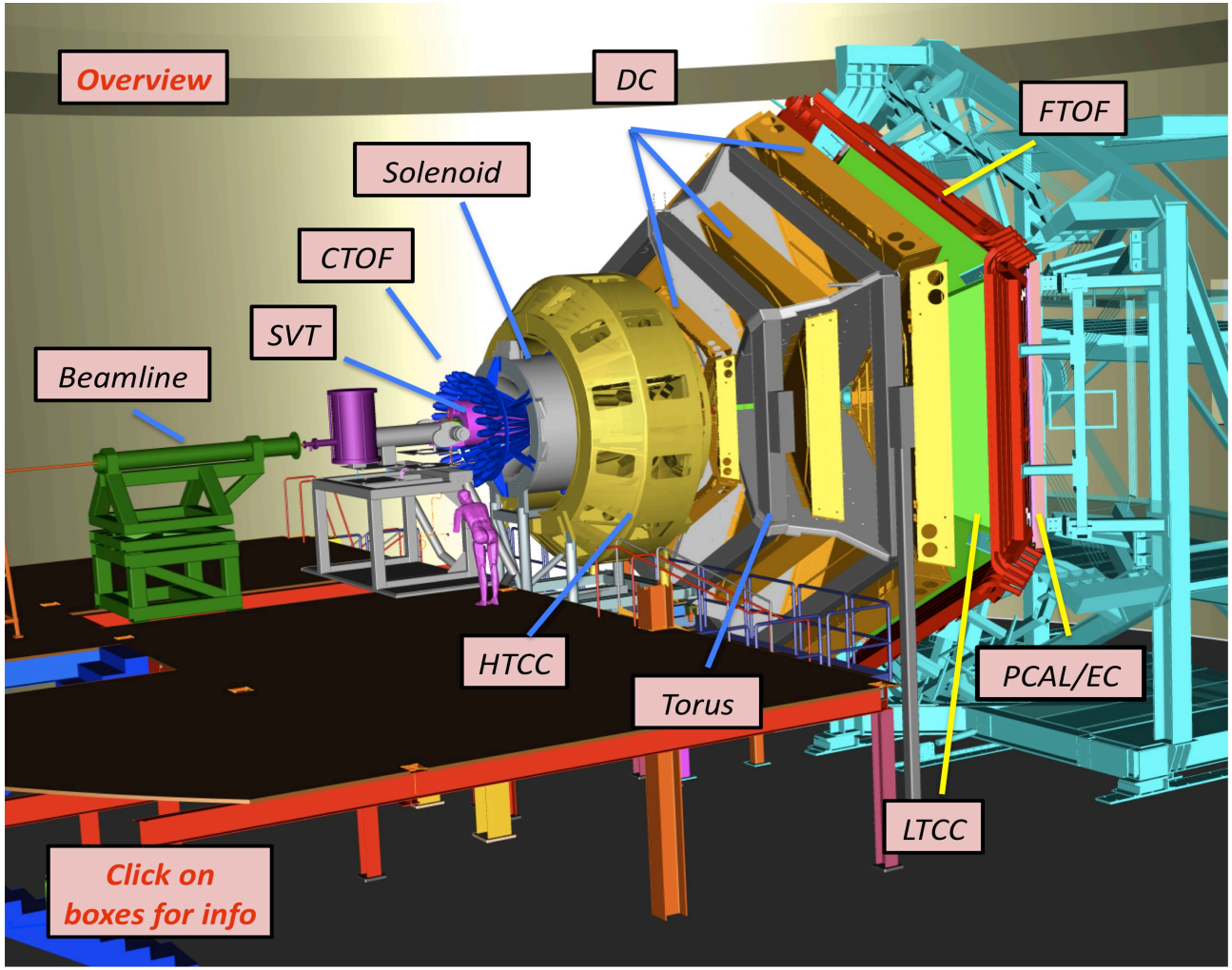
Future CLAS e+e- pair physics

Electromagnetic structure of mesons and baryons. Currently we are benchmarking the $\eta' \to \gamma e^+e^-$ decay. Here is a list of initial physics to be studied	
Meson	Baryon
$\eta' \to \gamma e^+e^-$	$(\Delta \to N e^+e^-)$
$\omega \to \pi^0 e^+e^-$	$\Lambda \to n e^+e^-$ $\Lambda(1520) \to \Lambda e^+e^-$
$\Phi \to \eta e^+e^-$	
$J/\psi \to \pi^0 e^+e^-$	$\Sigma^0 \to \Lambda e^+e^-$ $\Sigma^+ \to p e^+e^-$

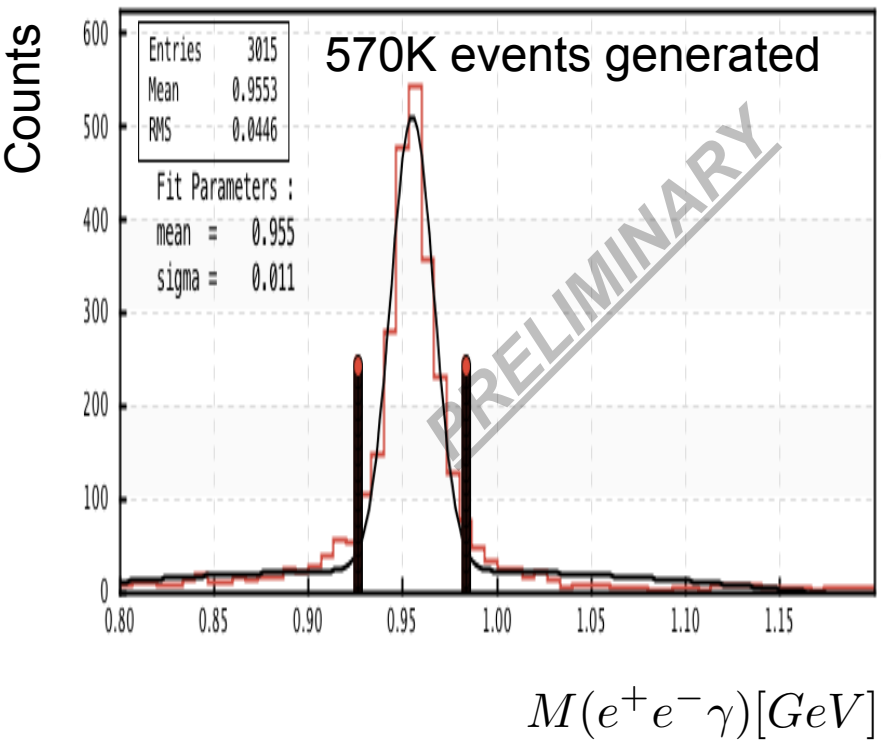
CLAS $\xi(e^+e^-)/\xi(\pi^+\pi^-)$ can be range 10^5 - 10^{12}

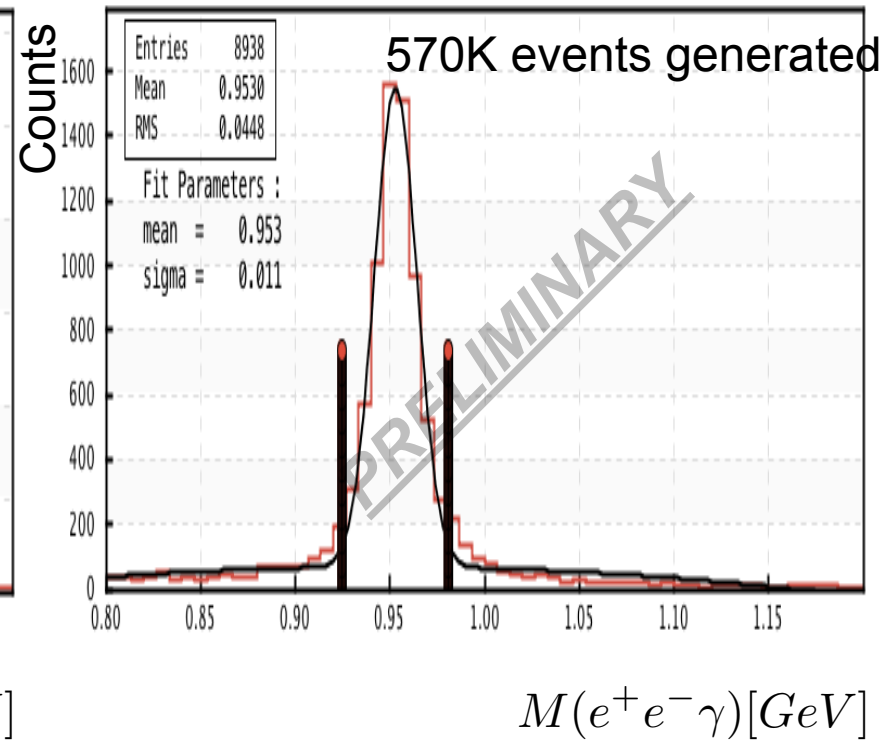
CLAS e^+e^- efficiency (ε) range 1 - 10^{-2}

CEBAF Large Acceptance Spectrometer (CLAS)



Future CLAS η' Measurement

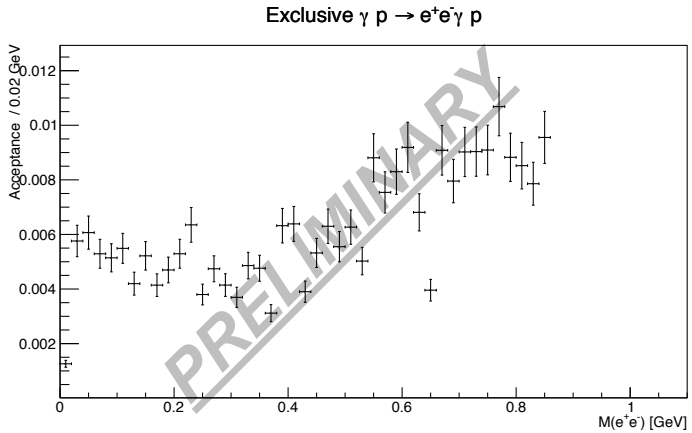


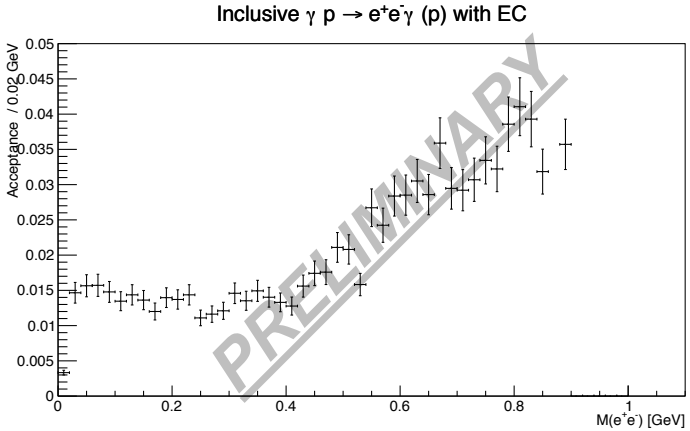


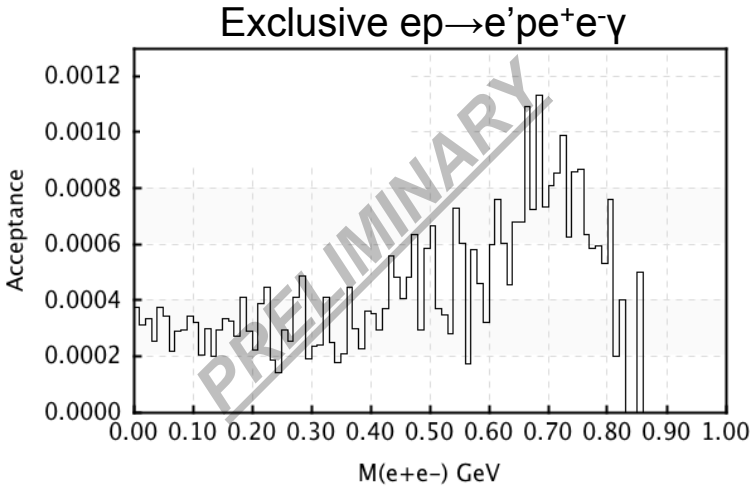
Fully Exclusive γp→η'p→ γe+e−p	Inclusive γp→η'(p)→ γe+e−(p)

Future CLAS η' Acceptance

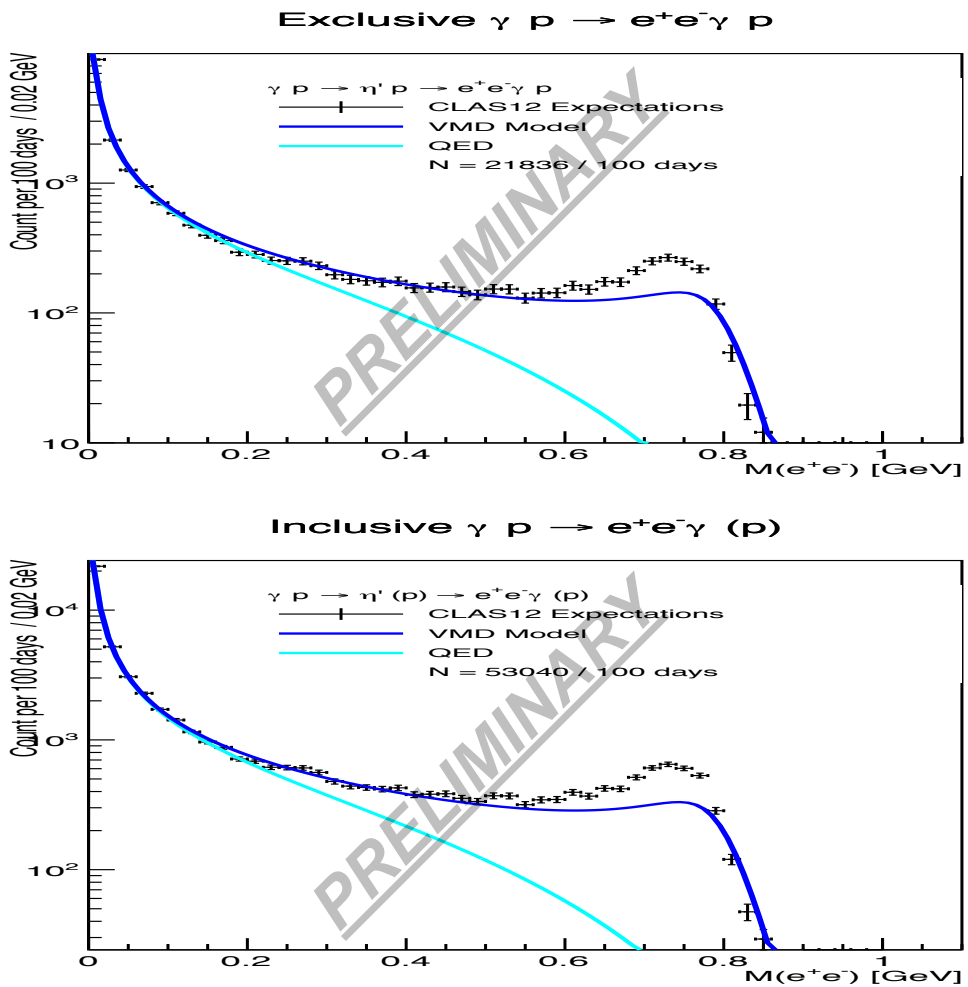
e^+e^- Acceptance





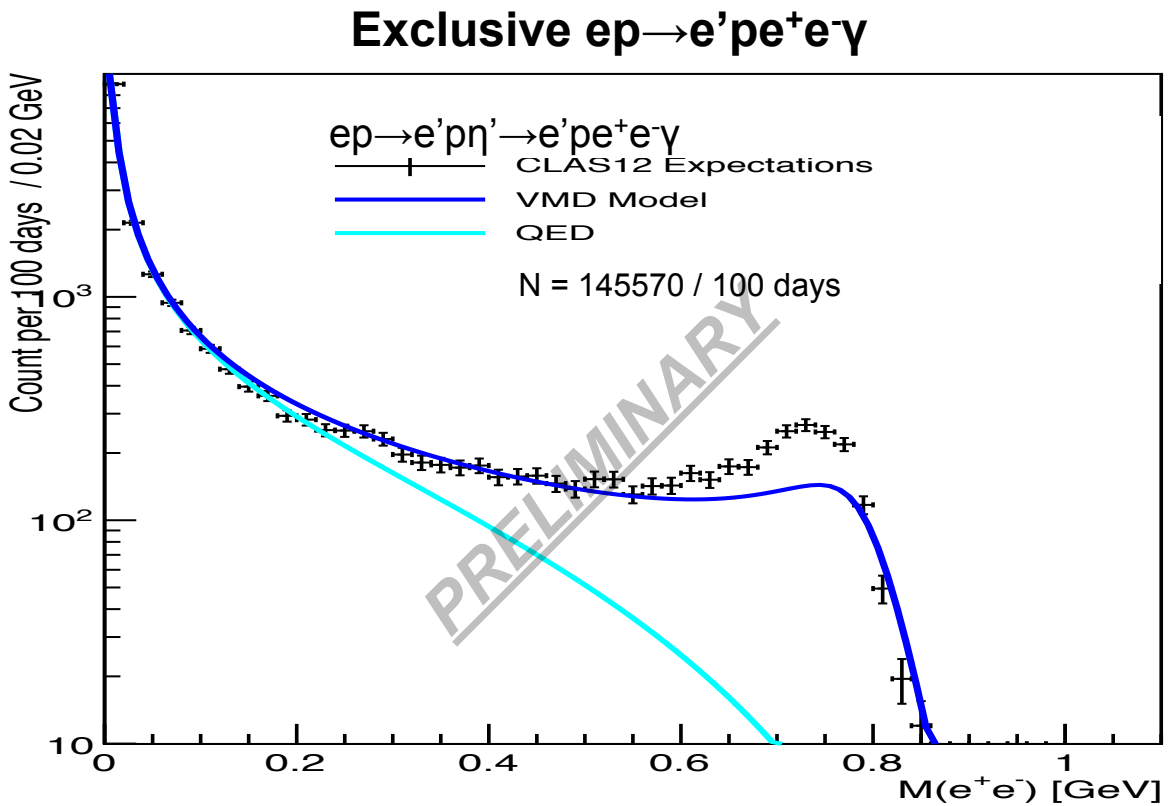


CLAS η' Rates at low Q^2



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

CLAS η' Rates with electroproduction



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

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.