Exclusive J/psi photoproduction with CLAS12

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Exclusive Meson Production and Short-Range Hadron Structure

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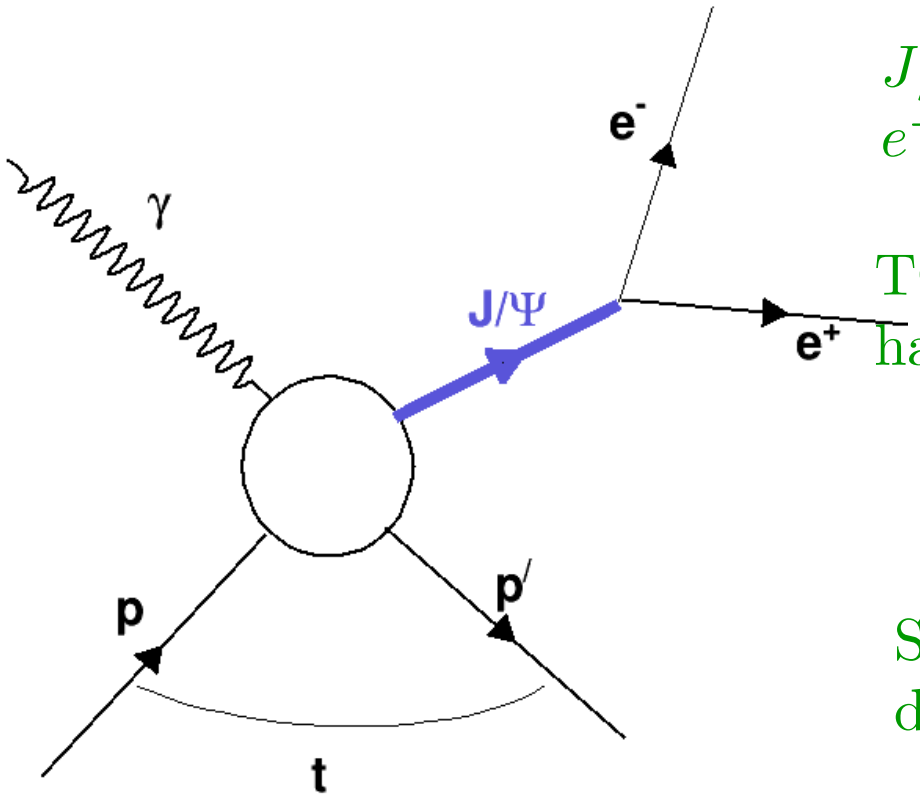
Thomas Jefferson National Accelerator Facility

The experiment E12-12-001

Timelike Compton Scattering and J/Ψ production on proton

Electron beam energy: 11 GeV
Luminosity:$> 10^{35} cm^{-2} s^{-1}$



J/Ψ will be identified through it's e^-e^+ decay mode.

TCS and elastic $J/\Psi(\rightarrow e^-e^+)$ production have identical final states: e^-e^+ and p

All three final state particles will be detected in CLAS12

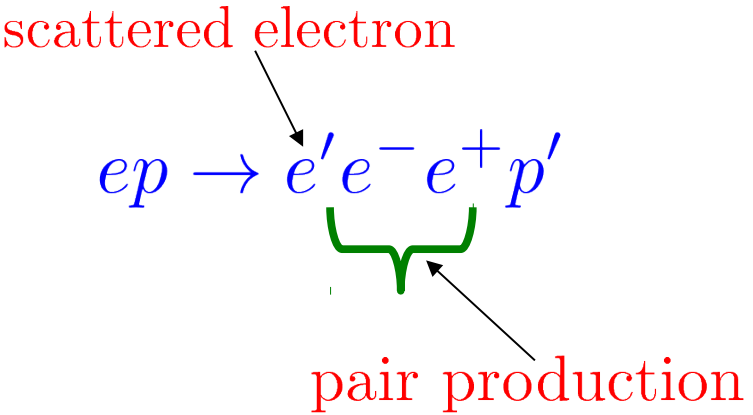
Scattered electron kinematics will be deduced from missing momentum analysis

photoproduction events will be selected by keping $P_\perp \sim 0$ and $Q^2 \sim 0$

Selection of Quasi-real photoproduction events from CLAS electroproduction data

Quasi-real photoproduction events, when incoming electron scatters at ~ 0 degree, ($P_\perp \sim 0$ and $Q^2 \sim 0$) have been selected from high energy electroproduction data on hydrogen

In the production of e^-e^+ pair there are two electrons in the final state



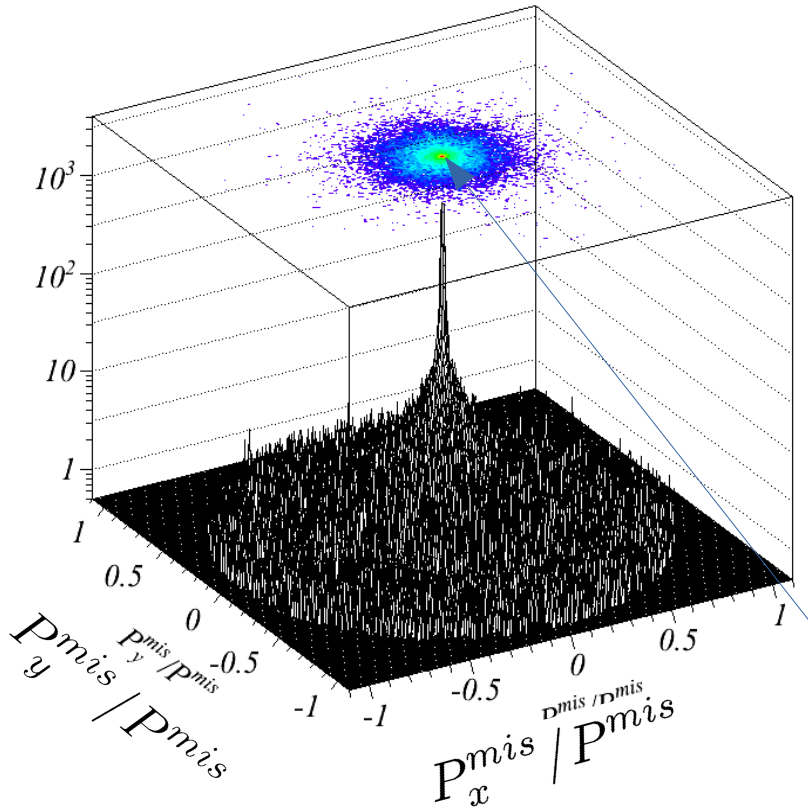
Final state to be analyzed

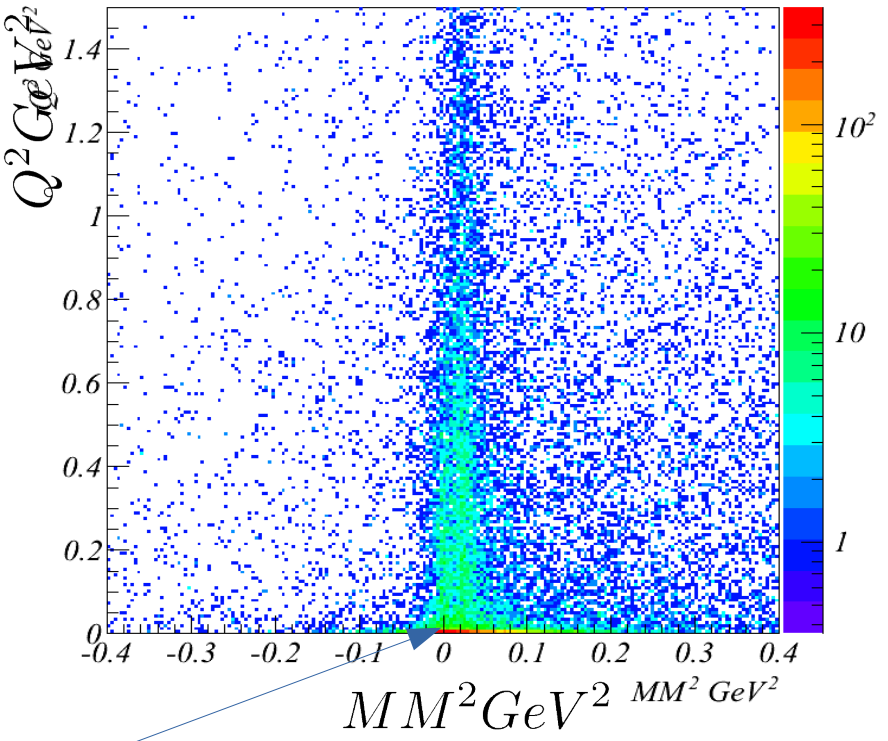
$$ep \rightarrow e^-e^+pX$$

The scattered electron momentum is deduced from the missing momentum analysis

Quasi-real photo-production of e^-e^+ pair with CLAS

The final state to be analyzed $ep \rightarrow e^- e^+ pX$



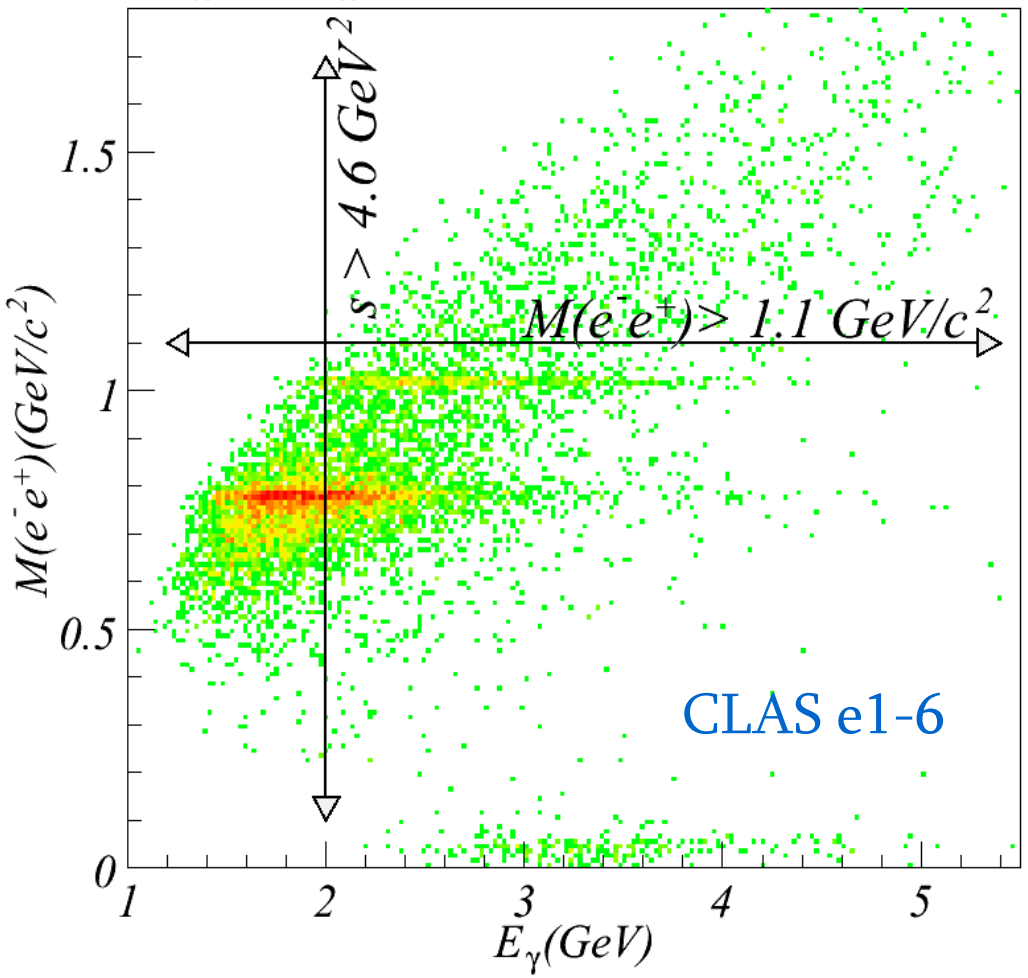


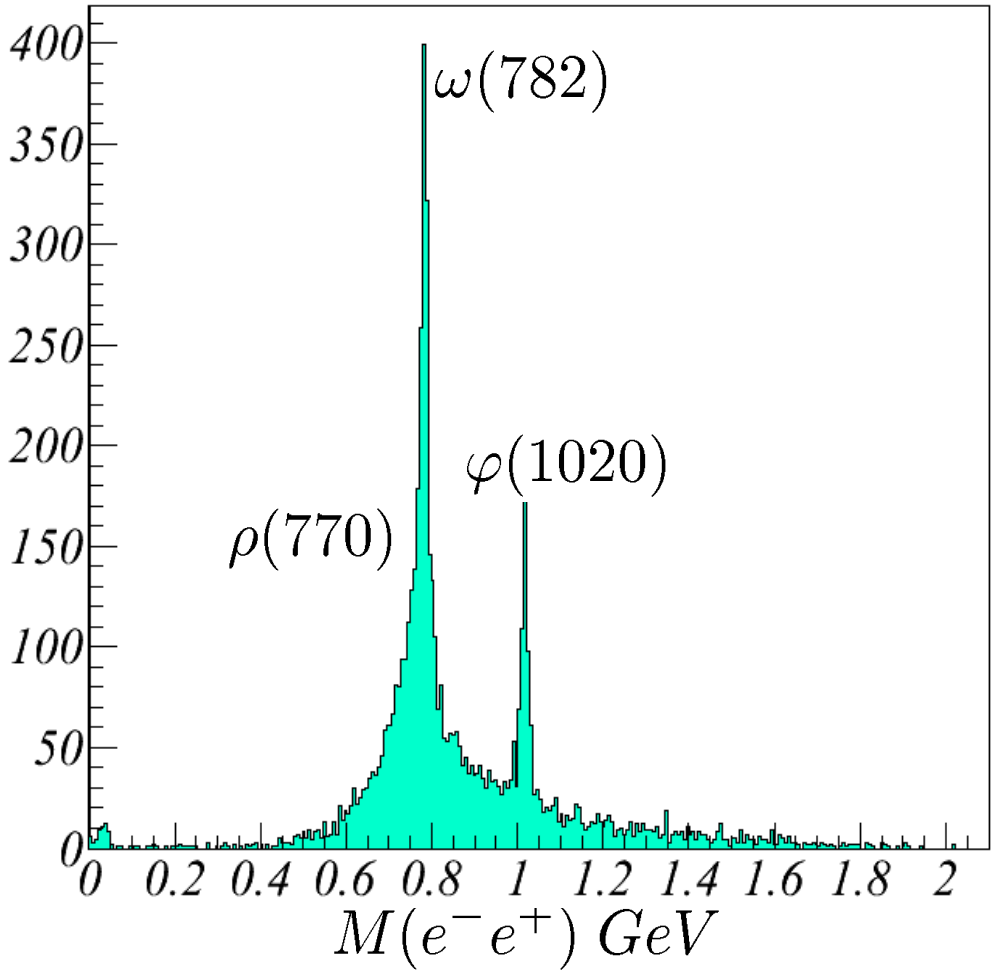
X is identified as a beam electron scattered at 0 degree

$Q^2 < 0.01 GeV^2$ $|M_x|^2 < 0.1 GeV^2$ $P_\perp \sim 0$

M(e-e+) distribution from 6 GeV data

Placing kinematic cuts on Q^2 and M_X^2 allow to select quasi-real photoproduction events





Similar picture is expected for CLAS12 with 11 GeV electron beam

Event generation

Elastic J/Ψ photo-production: $\gamma p \rightarrow J/\Psi(\rightarrow e^- e^+)p$

2 steps: $\gamma p \rightarrow J/\Psi p$ then $J/\Psi \rightarrow e^- e^+$

photon energy: $(Threshold - 11\ GeV)$

-t was generated in a $(t_{min} - 3.5)\ GeV^2$

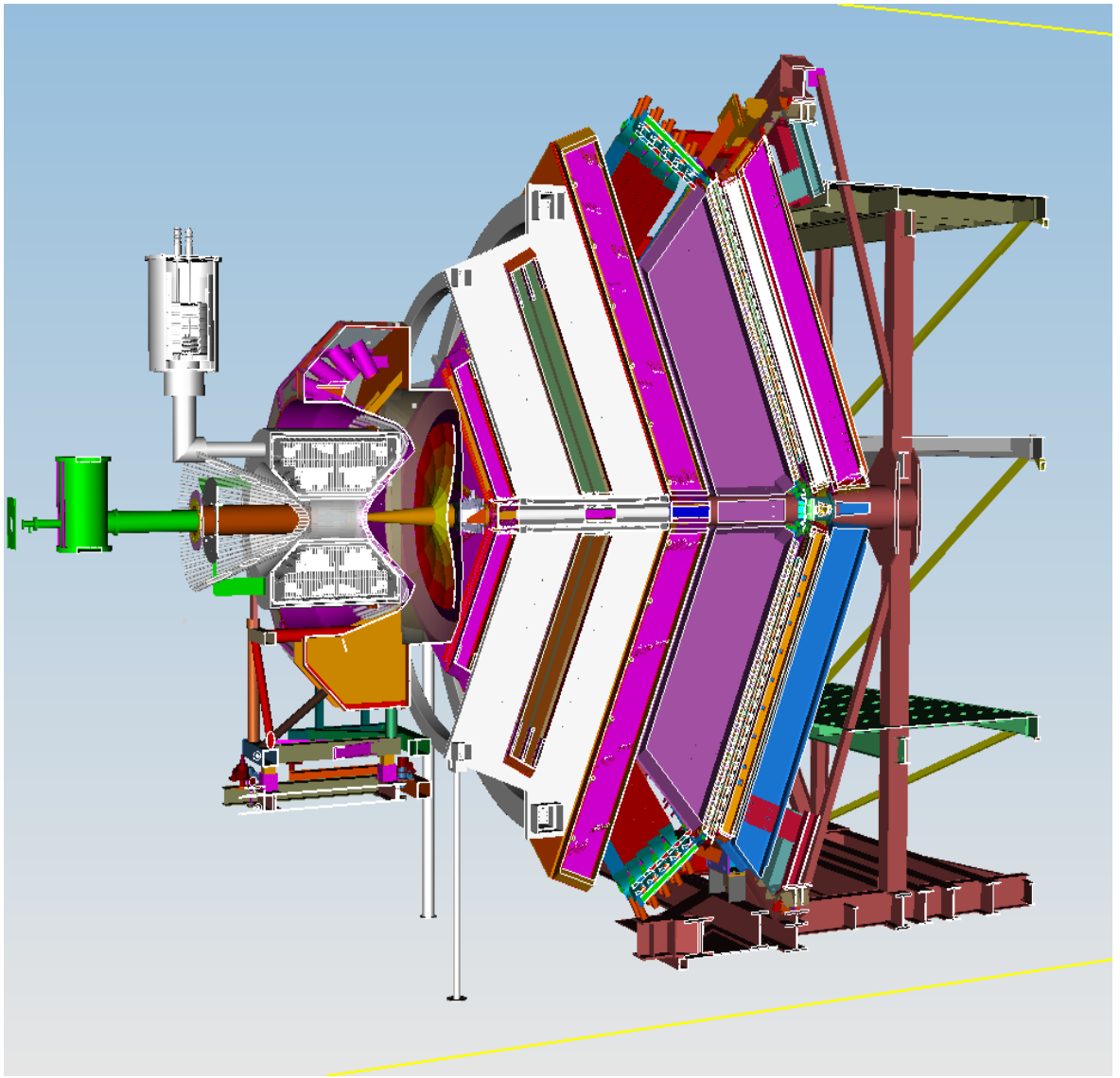
Then all generated events were passed through “fastmc” simulation package

Fastmc: accepts and smears tracks according to CLAS12 nominal acceptance and momentum and angular resolution

Torus current: maximal designed CLAS12 current

CLAS12

Forward Detector



Only forward part of CLAS12 will be used for J/ψ detection.

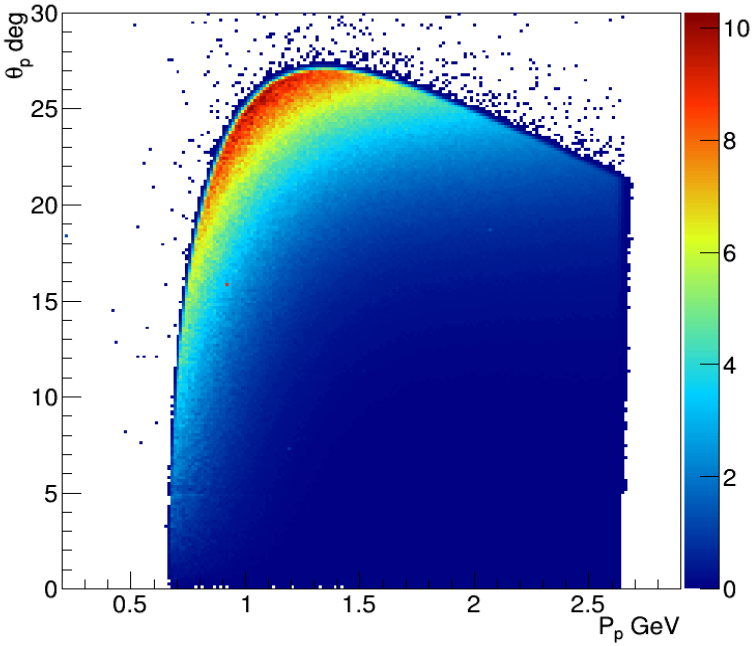
e- and e+ can be only detected in forward region and protons kinematically limited in small angles (Θ< 30 deg)

Protons (P < 2.7 GeV)
Only Forward region
5 deg < θ < 35 deg
p/K, p/π separation
> 10 σ

e^- and e^+	e/π suppression
Forward EC	≈100
HTCC	≈1000 (P < 4.9 GeV)

Protons

Generated



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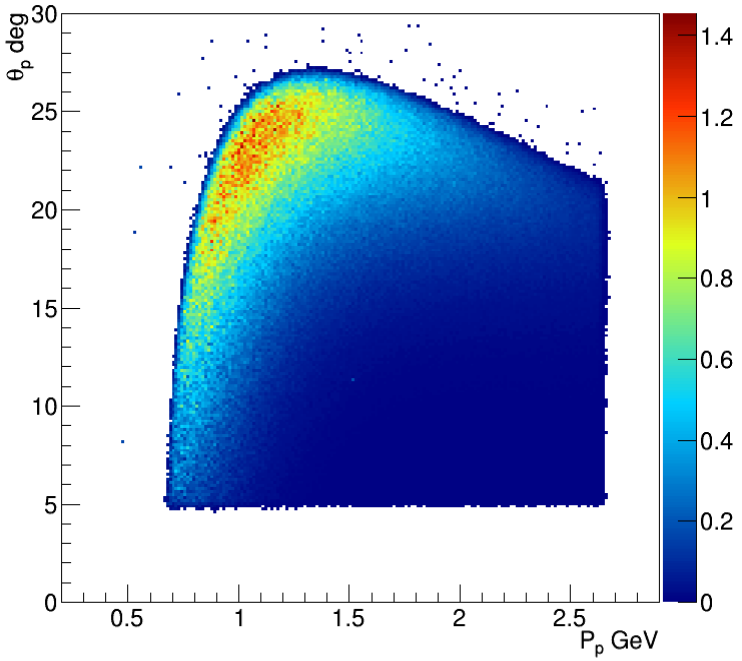
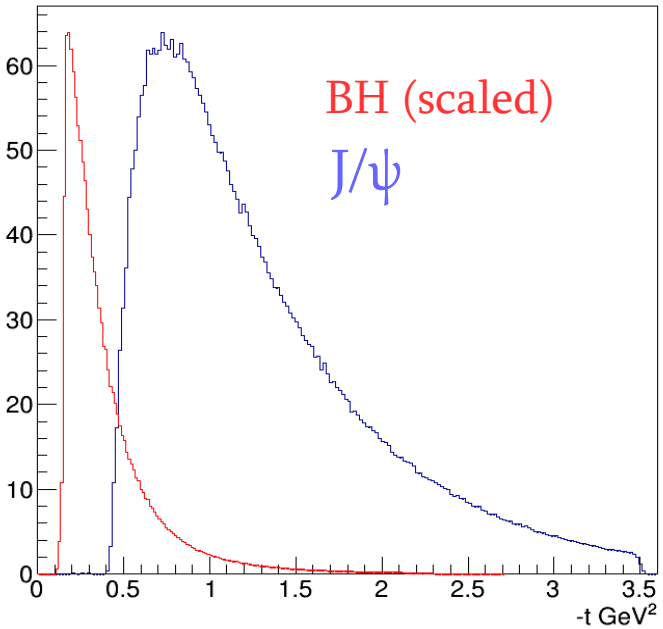
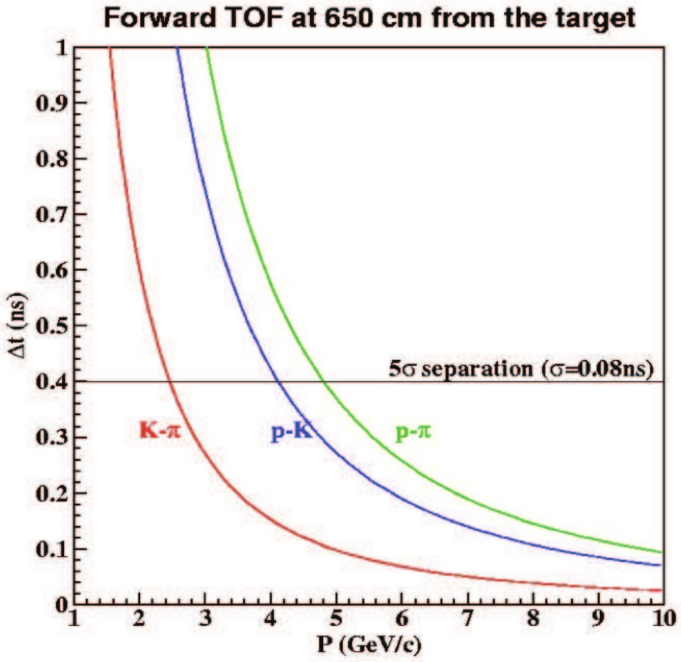




Because of the high t_min and high mass of J/Ψ, protons (unlike TCS/BH) will have higher momenta and smaller polar angle
Θ < 30 deg



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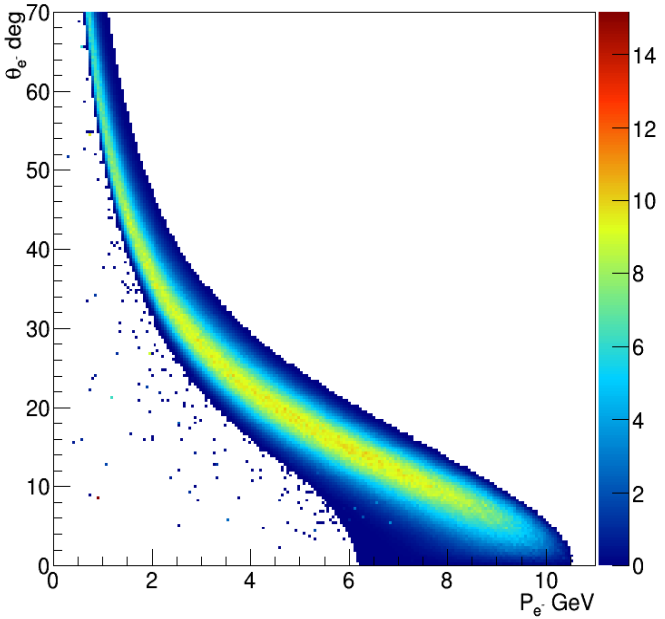
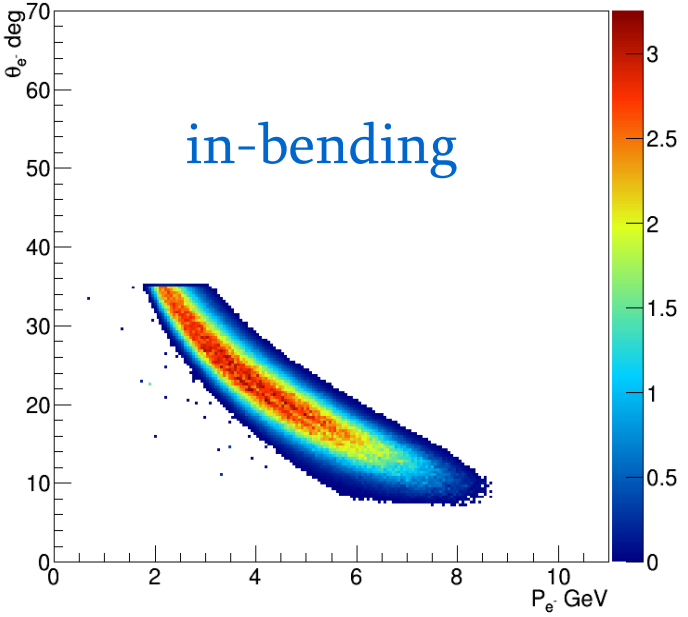
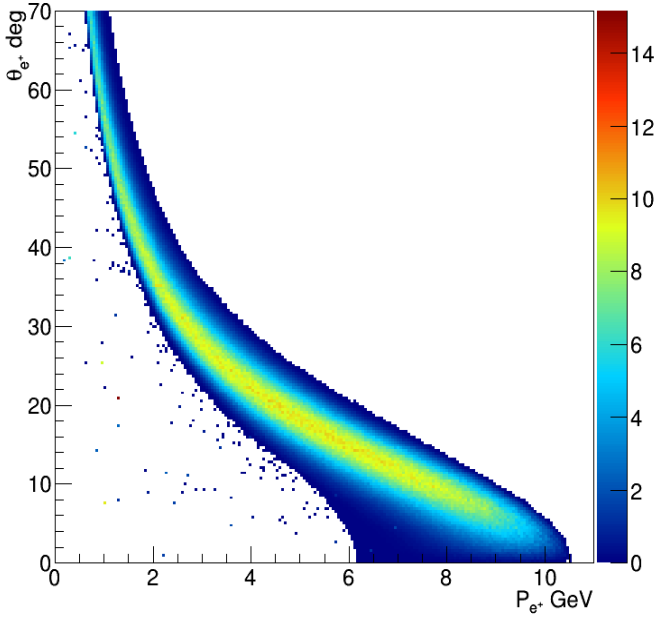
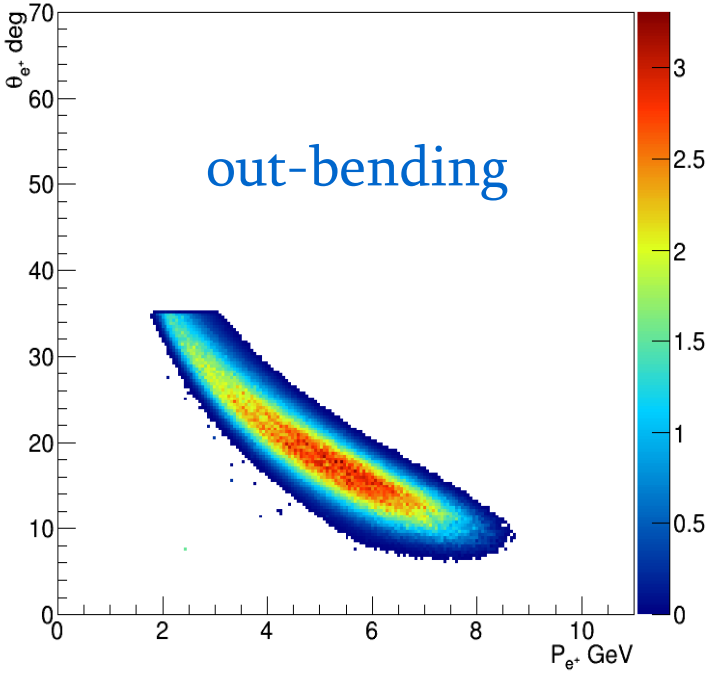


Electrons

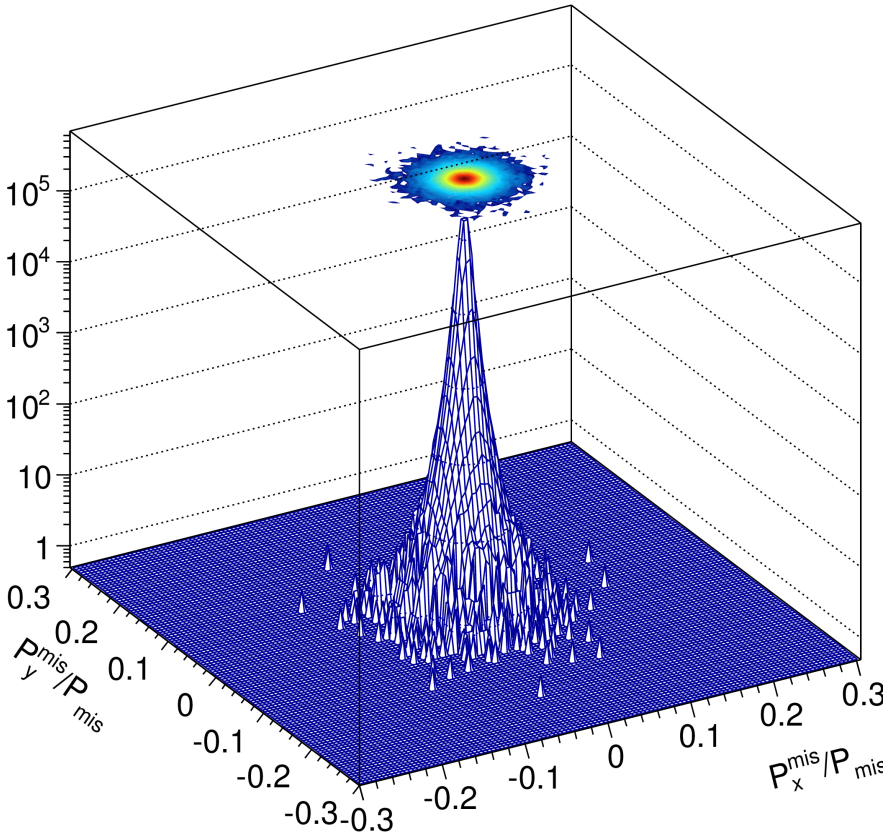


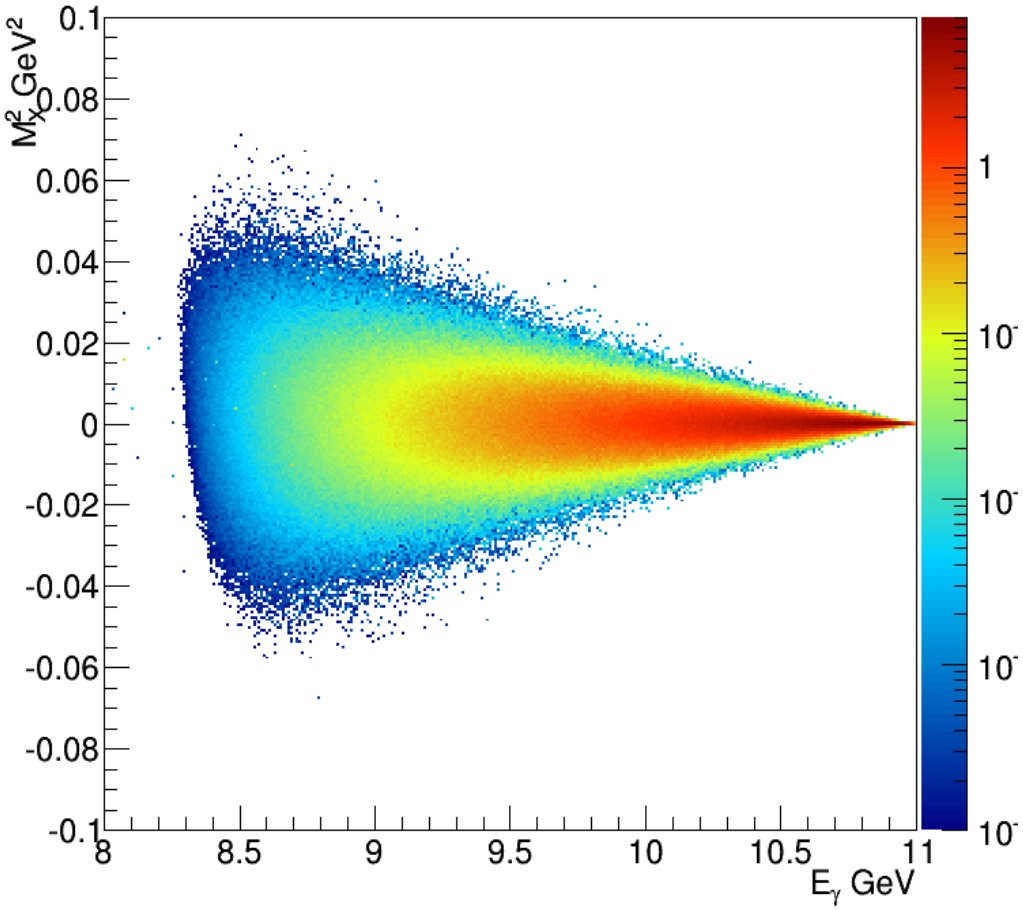


Positrons



Exclusivity distributions/cuts





Angular and momentum resolution of CLAS12 will allow to select quasi-real photo-production events

Contamination from π-π+ pairs

Both leptons have $P < 4.9GeV$

Suppression $\sim 10^{-10}$

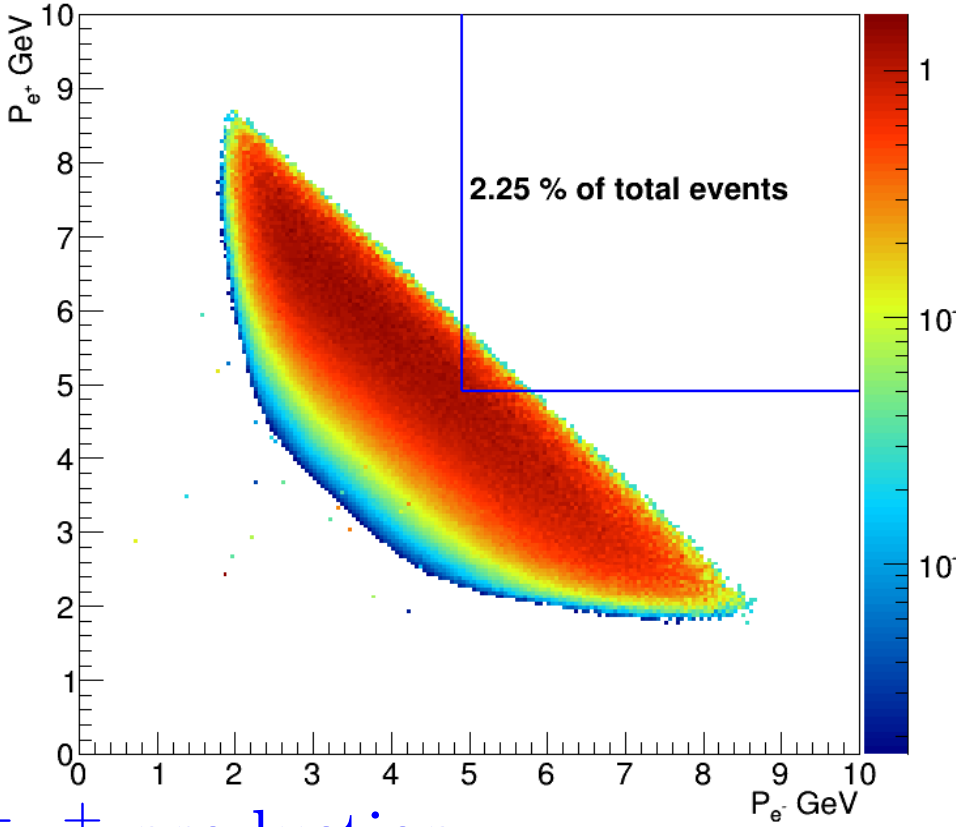
One of leptons have $P > 4.9GeV$

Suppression $\sim 10^{-7}$

Both leptons have $P > 4.9GeV$

Suppression $\sim 10^{-4}$

2.5% of Events



At energies of the experiment $\pi^-\pi^+$ production cross section $\approx$ 0.1 mb

J/Ψ cross section is about $\approx$ 0.3 nb

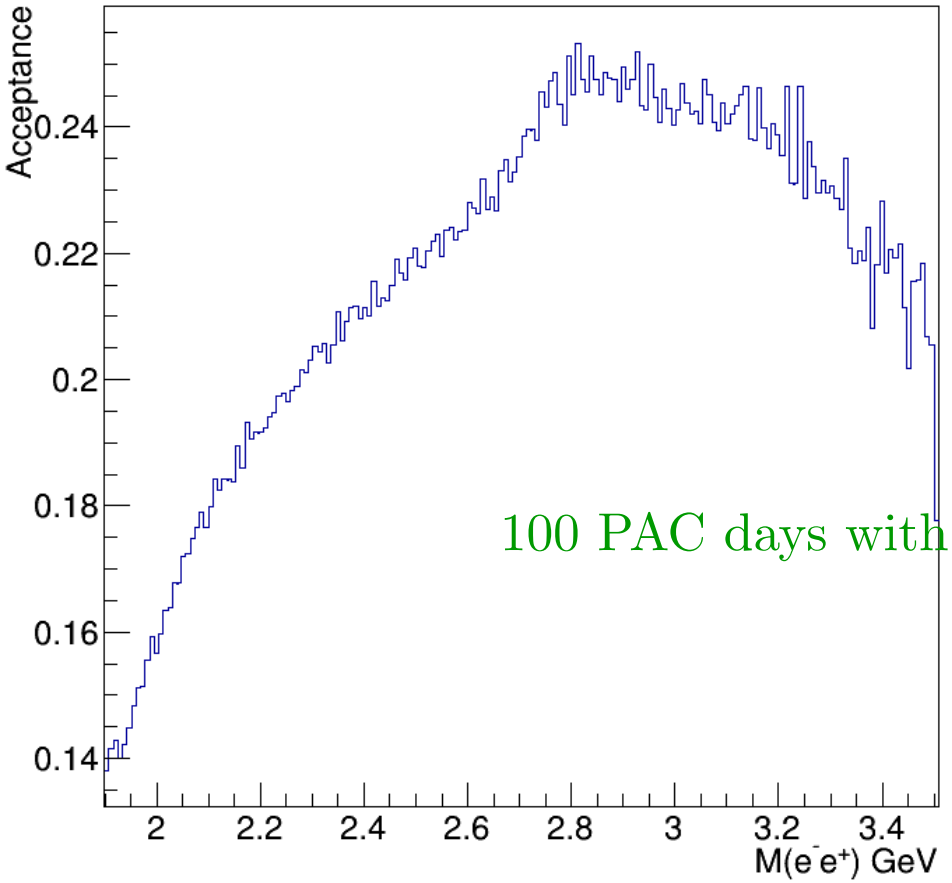
About 2.5% of evens (e- and e+ have momentum above HTCC threshold) can be eliminated from analysis without affecting statistical precision

Acceptance and count rates

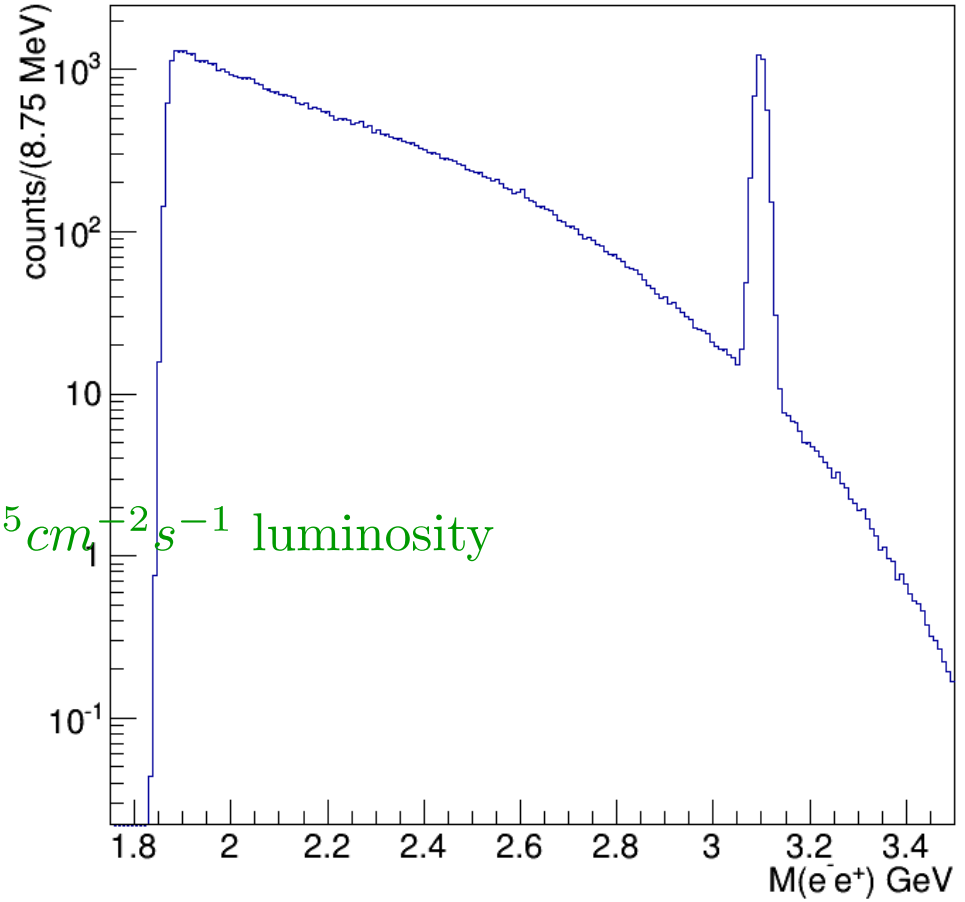
Acceptance is larger for higher masses

About 4K J/Ψ events are expected (2 gluon exchange assumption)

Signal to background ratio is about 100



100 PAC days with $10^{35} cm^{-2} s^{-1}$ luminosity



Rates for the cross section

$$\frac{d\sigma}{dt} = N_{2g} v \frac{(1-x)^2}{R^2 M^2} F_{2g}^2(t)(s-m_p^2)^2$$

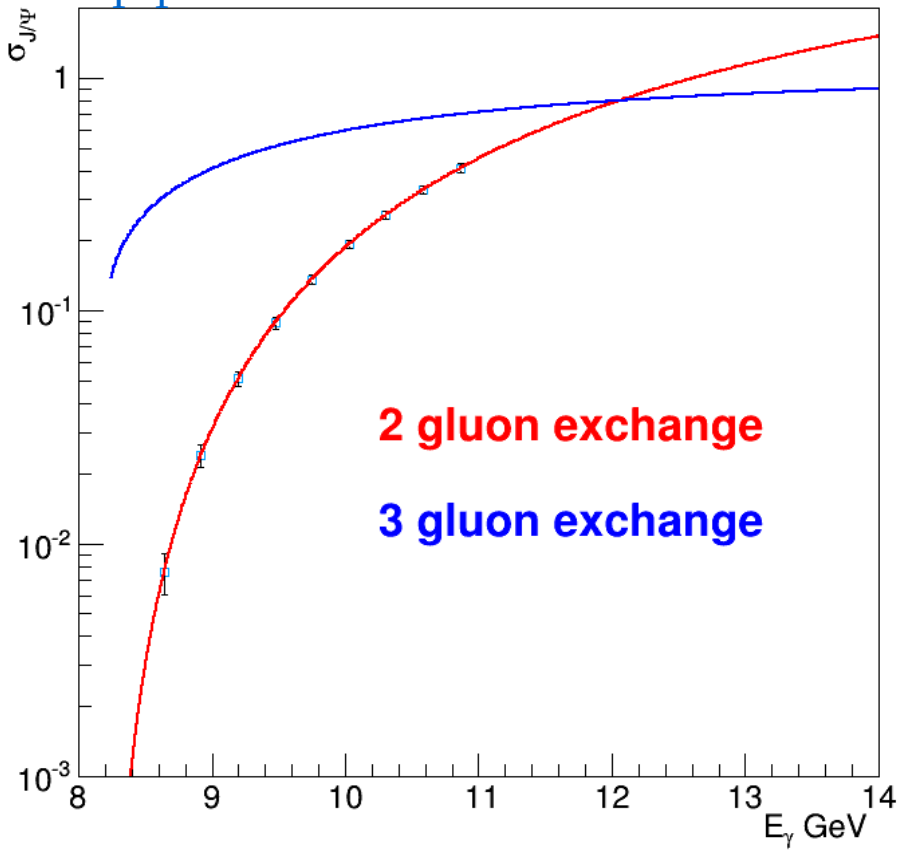
$$\frac{d\sigma}{dt} = N_{3g} v \frac{(1-x)^0}{R^4 M^4} F_{3g}^2(t)(s-m_p^2)^2$$

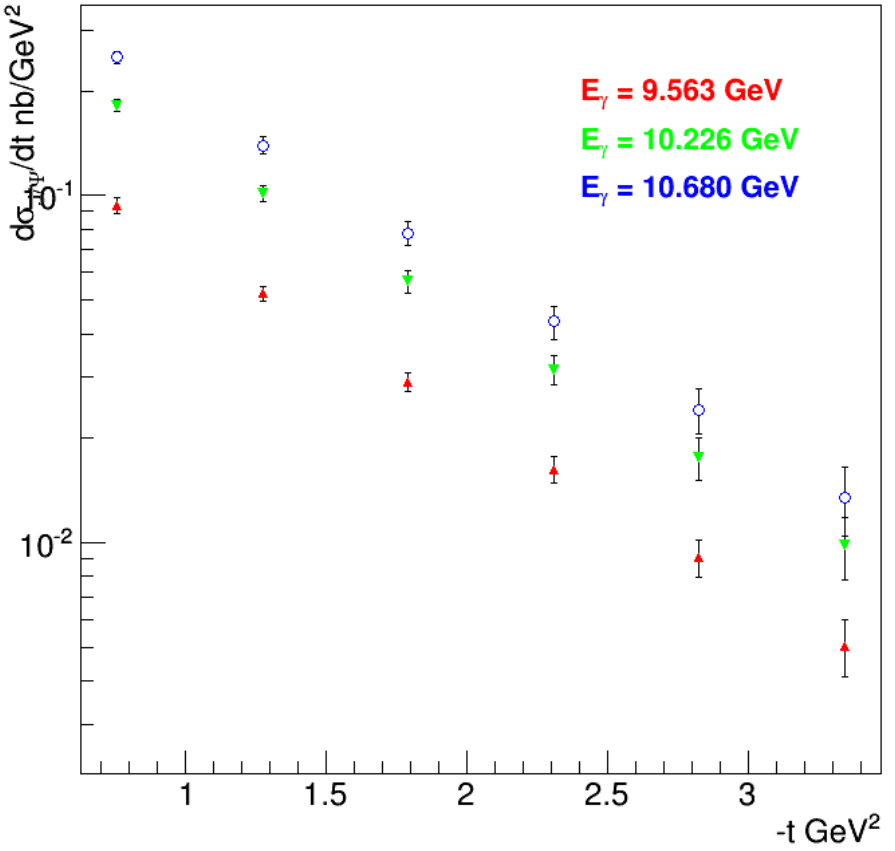
Phys. Lett., B498:23–28, 2001
hep-ph/0010343

Parametrization of proton for factor

$$F^2(t) = exp(1.13t)$$

With the 2 gluon Exchange assumption and 100 PAC days with $10^{35} cm^{-2} s^{-1}$ luminosity





Summary

12 GeV upgrade of CEBAF machine will allow J/Ψ to be produced in Jlab experimental halls

Quasi-real photo-production events can be selected using the technique that was used to select TCS events from CLAS 6GeV data.

Large acceptance of CLAS12 will allow to measure J/Ψ cross section near threshold with an accuracy that will allow to distinguish between 2 gluon exchange and 3 gluon exchange contributions.

1st step to start studies of gluonic structure of proton