J/ψ Photoproduction Near Threshold With CLAS12

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CLAS Collaboration

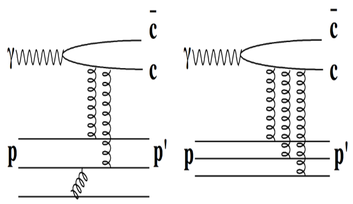
The Importance *of* J/ψ

- J/ψ is a charm-anti-charm meson
- Discovered simultaneously by experimentalists at BNL and SLAC
- Significant because it confirmed the Glashow-Iliopoulos-Maiani (GIM) mechanism, which explained the suppression of flavor transitions
- Over the years, J/ψ production has been used as a mechanism for studying QCD
- There is great interest in J/ψ production with e+e- colliders

[1] A. Khare Curr. Sc.**77**, 1210 (1999)

J/ψ Facts	
Mass	3095 MeV
Charge	0e
Spin	1
Width Γ	93 KeV

Physics Motivation



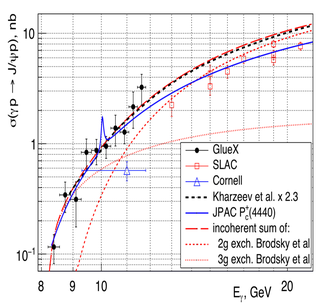
$$\frac{d\sigma}{dt} = N_{2g}\frac{(1-x)^2}{R^2M^2}F_{2g}^2(t)(s-m_p^2)^2$$

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

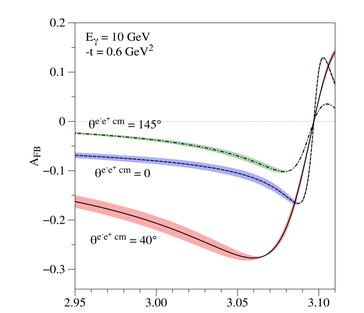
[2] S.J. Brodsky, E. Chudakov, P. Hoyer, and J.M. Laget. Phys. Rev. Lett. (2008)

Physics Goals

- Probe the distribution of color charge in the nucleon
  - Measure the t-dependence of the differential cross section of J/ψ photoproduction
- Study the production mechanism of J/ψ near threshold
  - Measure the total cross section as a function of photon energy
- Study the forward-backward asymmetry to access the real part of the Compton scattering amplitude

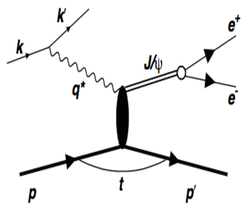


[3] A. Ali (GlueX Collaboration). Phys. Rev. Lett. (2019)

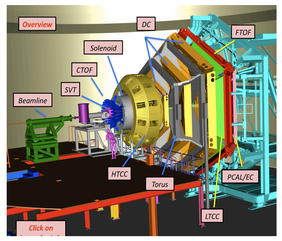


[4] O. Gryniuk, M. Vanderhaeghen. Phys. Rev. Lett. (2016)

J/ψ Detection With CLAS12



- The CLAS12 forward detector has shown to have optimal performance for detecting electrons and positrons. In addition, hadrons can be effectively distinguished up to an energy of 5 GeV.
- The un-detected scattered electron provides kinematics for possible quasi-real photon exchange events through missing mass analysis.



Fall 2018 Run Conditions	
Magnetic Fields	Maximum current settings of the Torus and Solenoid magnets
Beam Energy	10.6 GeV
Target	Liquid Hydrogen
Beam Current	50 nA
Time Period	August 20, 2018 to November 15, 2018

Particle Identification & Event Selection

For e^+e^- detection (p < 5 GeV)…

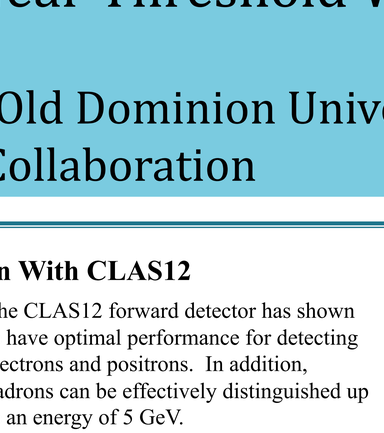
- Compare measured ECAL sampling fraction to the expected
- HTCC photoelectrons cut & PCAL minimum energy cut

For proton detection…

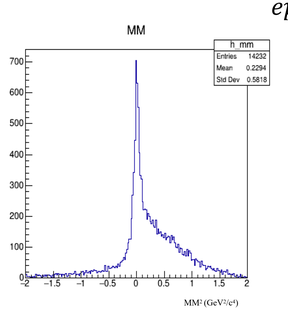
- Restrict to the FTOF detector for comparison between measured & expected vertex time

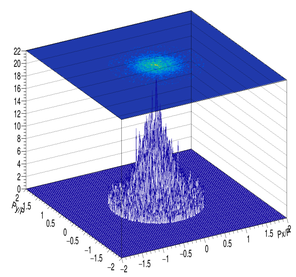
For e+e- detection (p > 5 GeV) …

- Utilize additional cuts related to pion rejection, including the addition of machine learning. This was based on the ROOT Multi-Variate Analysis package. The Boosted Decision Tree (BDT) was selected as a viable algorithm.



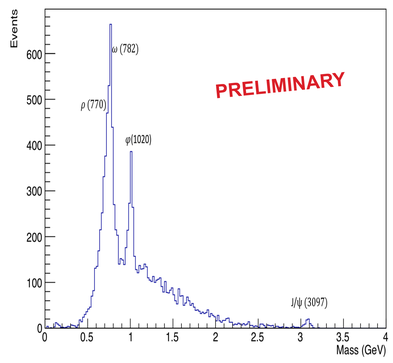
$$ep \rightarrow e^+e^-p'(e')$$

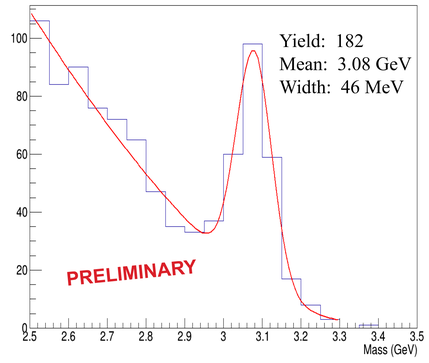




- Events are selected by measuring physical quantities related to the un-detected scattered electron
- Low values of the square of the missing mass and transverse momentum components show evidence of quasi-real photoproduction

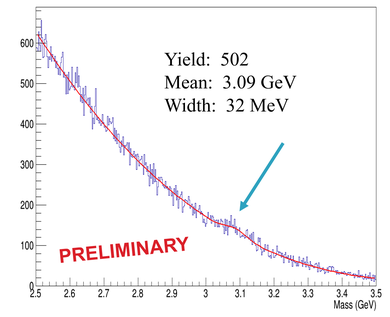
Exclusive J/ψ 's With Fall 2018 Data

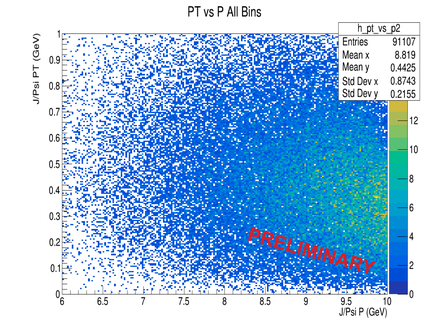




- Exclusivity cuts on the square of the missing mass and transverse momentum were applied.
- The invariant mass spectrum shows the successful reconstruction of vector mesons.
- The invariant mass at higher masses displays the J/ψ signal above the Bethe-Heitler background. Both in-bending and out-bending datasets were used from the Fall 2018 run.

Inclusive J/ψ 's With Fall 2018 Data





- Inclusive J/ψ detection does not require the proton, which can increase acceptance.
- To calculate photon energy and momentum transfer, the momentum and transverse momentum of the e+e- pair are calculated and are correlated with Eγ and –t.

Summary

- Analysis framework with particle identification and event selection nearly complete
- Pass1 data processing of Fall 2018 is complete
- Pass1 data processing for Spring 2018 & Spring 2019 will commence later this year
- Acceptances and normalization using Bethe-Heitler MC simulations will be completed with the addition of background merging
- Kinematic fitting & momentum corrections to be developed for this reaction.

References

[1] A. Khare Curr. Sc.**77**, 1210 (1999)
[2] S.J. Brodsky, E. Chudakov, P. Hoyer, and J.M. Laget. Phys. Rev. Lett. (2008)
[3] A. Ali (GlueX Collaboration). Phys. Rev. Lett. (2019)
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Acknowledgements

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