Tagged analysis of J/ψ photoproduction near threshold in CLAS12

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Motivation

•The production process of the J/ψ is sensitive to Gravitational Form Factors (GFF) which provide information about the mechanical properties of the nucleon. We can relate the gluon GFF to the J/ψ photoproduction differential cross section.

•With the determination of the GFF is possible to give information about the mass radius of the proton such that

$$< r_m^2 > = \frac{6}{m_p}\frac{dG}{dt}\Big|_{t=0}$$

•On the other hand, it is expected that the pentaquark resonances reported by the LHCb collaboration to be produced in the process $\gamma + p \rightarrow P_c \rightarrow J/\psi + p$

Low Q^2 electroproduction of J/ψ

The reaction to study is $ep \rightarrow e' J/\psi\ p' \rightarrow e' e^+ e^- X$ where X corresponds to the recoil proton.

- In the missing momentum analysis, the missing four-momenta is defined as:

$$p_X = p_e + p_p - p_{e^-} - p_{e^+} - p_{e'}$$

- Such that the missing mass is:

$$M_X^2 = p_X^2$$

- The J/ψ events should be seen in the invariant mass distribution of the electron-positron pair as:

$$M^2(e^-e^+) = (p_{e^-} + p_{e^+})^2$$

- The hadronic mass W, a mass variable where pentaquarks can be searched, is calculated as:

$$W = \sqrt{m_p^2 + 2m_p E_\gamma - Q^2}$$

Where $Q^2 = 2E_{beam}E_{e'}(1 - \cos(\theta_{e'}))$ and $E_\gamma = E_{beam} - E_{e'}$

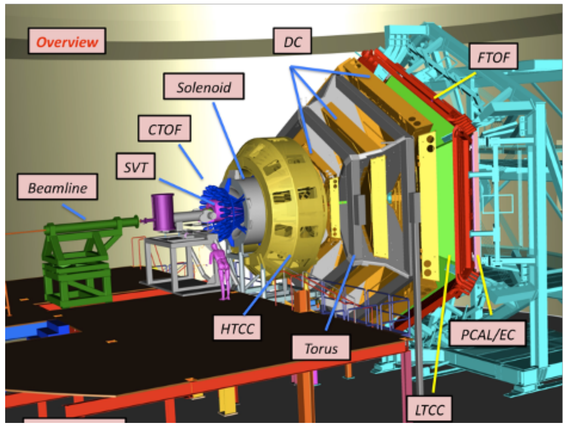
- There is an ongoing untagged photoproduction analysis that study the reaction:

$$ep \rightarrow Xe^+e^-p'$$

Experiment at CLAS12

Target: Liquid Hydrogen

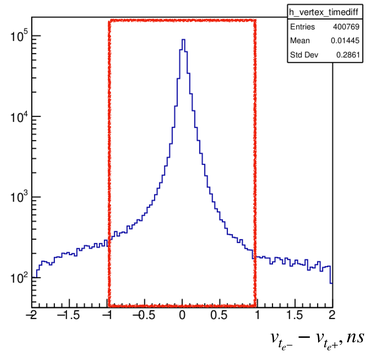
Data Sets
- Fall 2018
  - 10.6 GeV
  - Inbending and Outbending
- Spring 2019
  - 10.2 GeV
  - Inbending



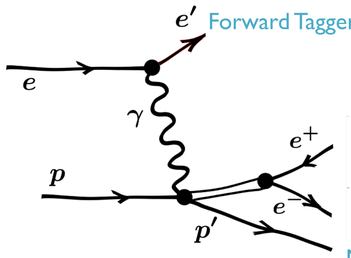
The CLAS12 in Hall-B provides the energy range, E>8.2 GeV, and particle detection capabilities for studies of near threshold production of J/ψ meson via its decay to lepton pairs.

Event Selection

- Events that have one e^- and one e^+ in the FD are selected.
- The e^-e^+ pair is identified using the PID in the Event Builder.
- A cut in the SF of the e^+ is added to prevent pion contamination.
- Fiducial cuts in momentum, energy and vertex time are applied to remove background.
- Radiative energy loss correction is applied to the lepton pair.

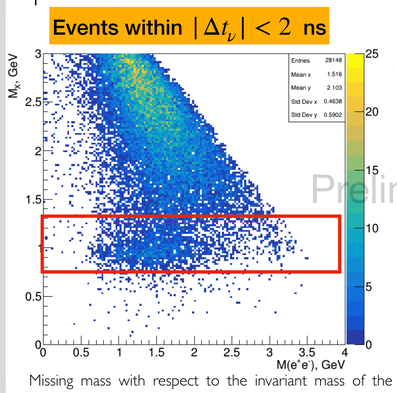


Vertex time difference between the electron and the positron pair. Events that have a difference of less than 1 ns are selected into the next step.

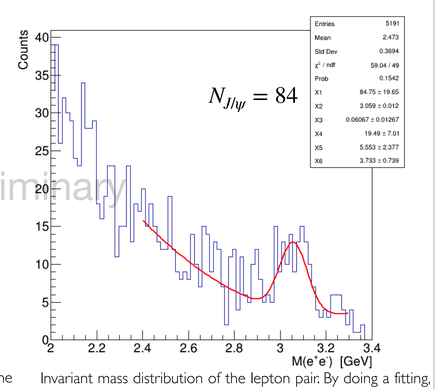


Results

- Events that have one e^- in the FT AND have $|\Delta t_\nu| < 2$ ns.
- Select the events that correspond to the missing mass of the proton.



Missing mass with respect to the invariant mass of the lepton pair. Events that have a missing mass between 0.7 GeV and 1.3 GeV are select in the final step.



Invariant mass distribution of the lepton pair. By doing a fitting, we can find that the number of J/ψ mesons is around $N_{J/\psi} = 84$.

Next Steps…

Extraction of the cross-section

The cross-section depends on W, Q^2 and t :

$$\frac{d\sigma}{dWdQ^2dt} = \frac{N_{J/\psi}(W, Q^2, t)}{L \cdot Br \cdot \eta}\frac{1}{\Delta W \Delta Q^2 \Delta t},$$

Where $L = N_e \cdot N_p$, $Br = 0.06$ and η is the detector efficiency, obtained via Montecarlo simulations. By integrating over Q^2 and t, we can study the W dependence as

$$\frac{d\sigma_i}{dW} = \frac{Y_i}{L \cdot Br}\frac{1}{\Delta W} \qquad Y_i = \sum_{j=1}^{N_{J/\psi}^i}\frac{1}{\eta_j}$$

Explore other topologies and final states

$ep \rightarrow e'e^-p'X$ or $ep \rightarrow e'e^+p'X$

$J/\psi \rightarrow \mu^-\mu^+$ that has $\sim 6\,\%$ branching ratio

Exploring this other topologies and final state will boost the statistics.

References

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