Measurement of the Beam and Target Asymmetry in $\gamma p \rightarrow p\pi^+\pi^-$ with the CLAS Spectrometer at JLab

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on the behalf of CLAS Collaboration

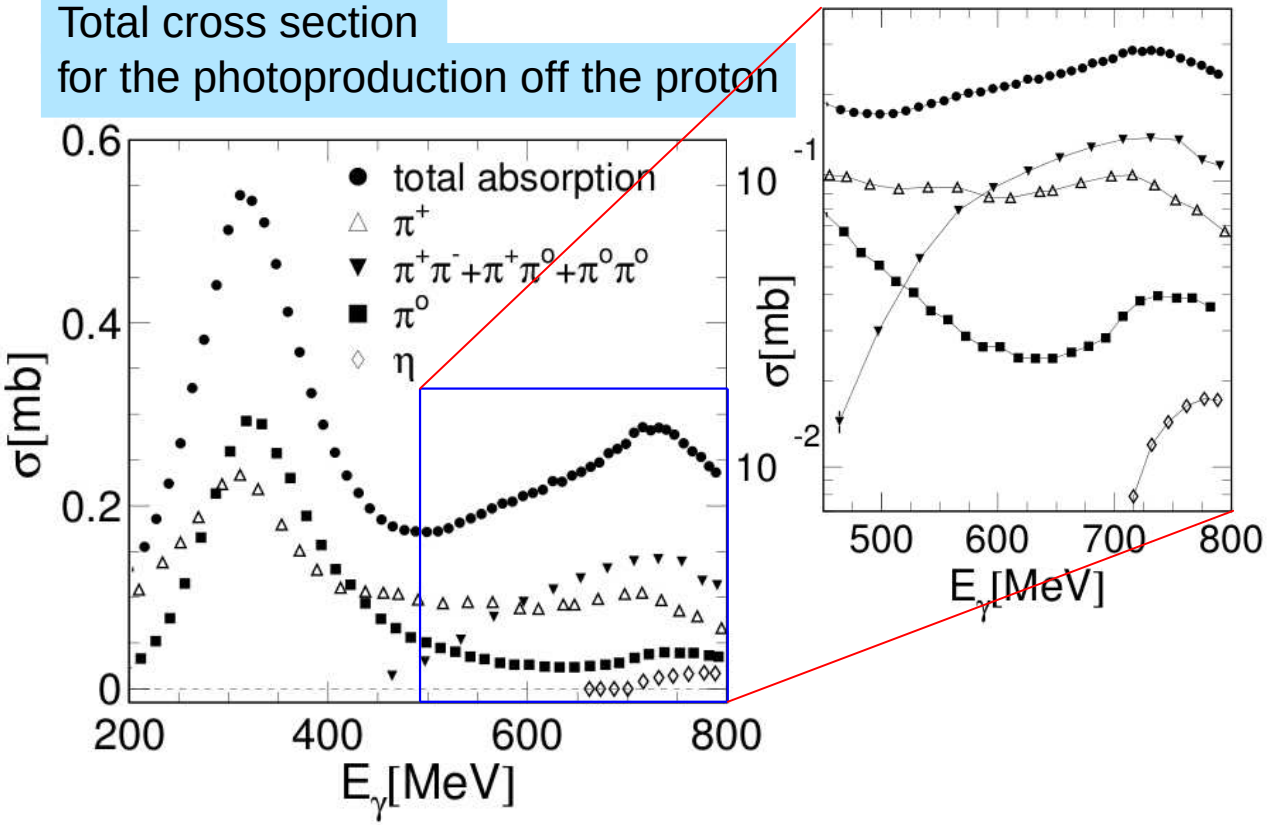
Florida State University

April 2, 2012

Outline

Why is $\pi^+\pi^-$ photoproduction needed

Total cross section
for the photoproduction off the proton



Total cross section
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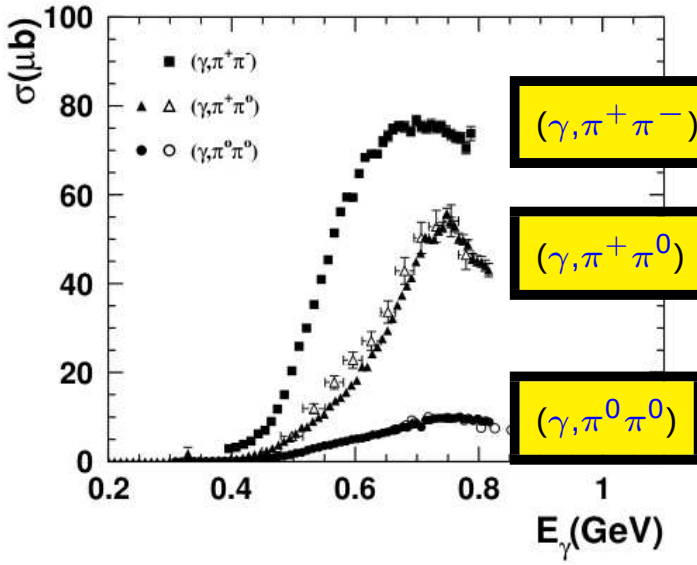
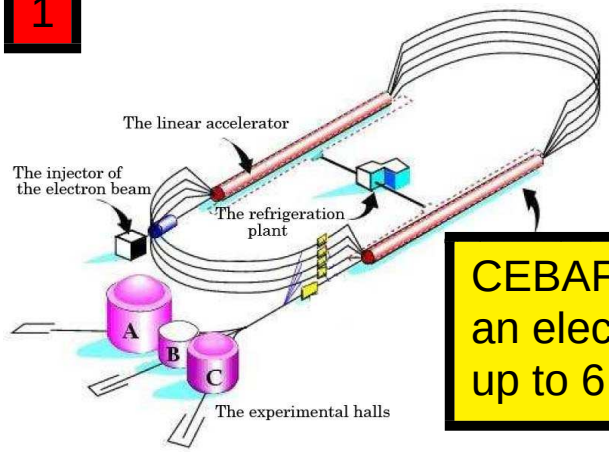


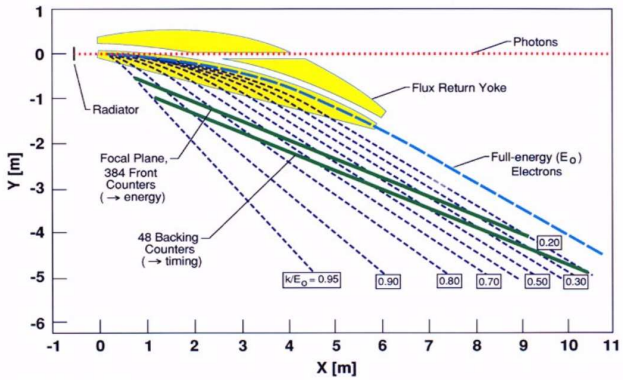
- Search for new baryon states that are predicted by quark models and Lattice QCD.
- The most intense cross section contribution is from double pion production, especially (γ, π^+ π^-), in the second resonance region
- Polarization observables are important in the resonance extraction from data.

FROST Experiment at Jefferson Laboratory

1



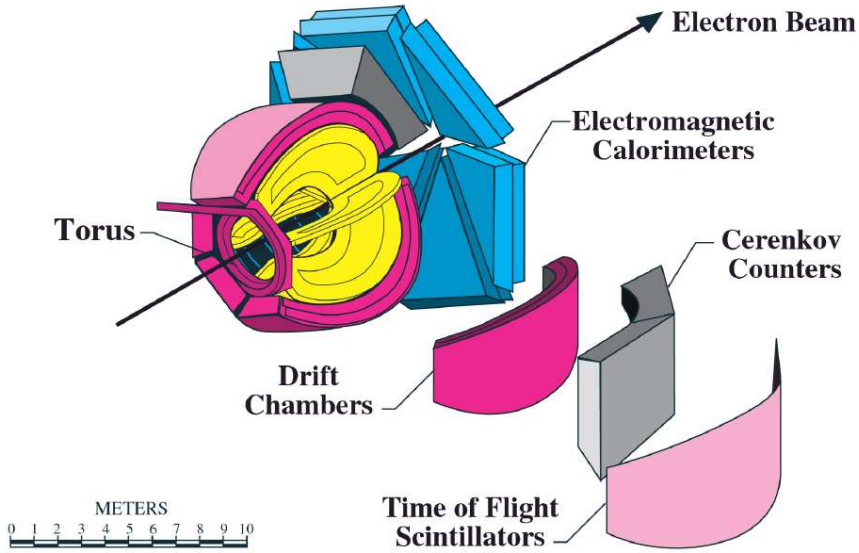
CEBAF can deliver an electron beam up to 6 GeV.



2 JLAB Hall B bremsstrahlung photon tagger

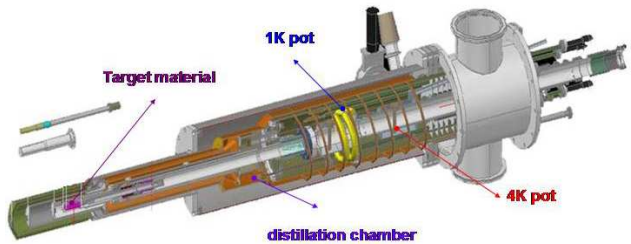
- E_γ = 20-95 % of E_0
- Circularly-polarized photon beam

3 CEBAF Large Acceptance Spectrometer (CLAS)



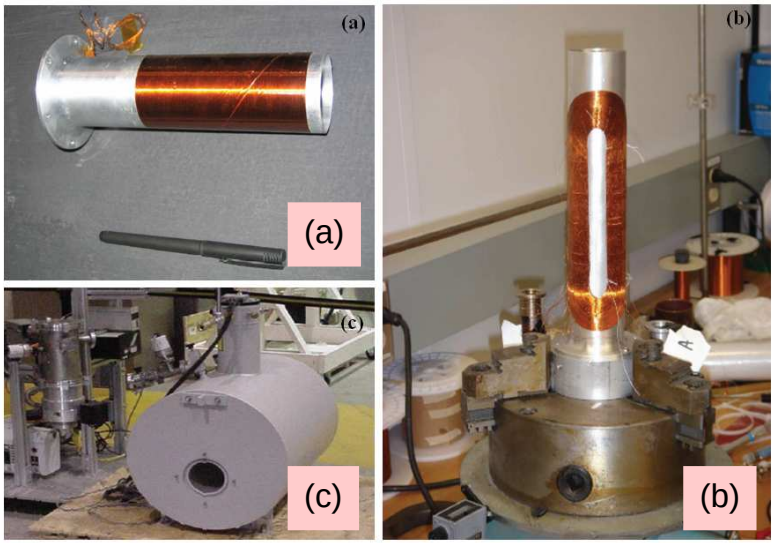
4 The FROzen-Spin Target (FROST)

- Longitudinally-polarized target



The FRozen-Spin Target (FROST)

1 High magnetic field (5 T)



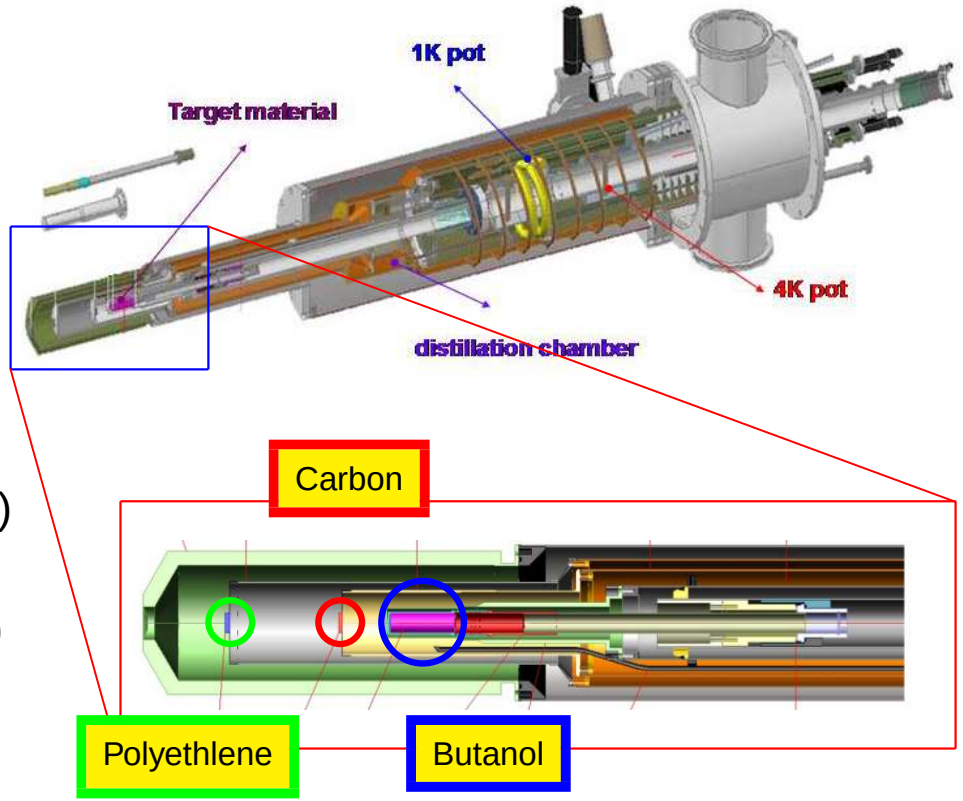
(a) The longitudinal holding magnet. (0.56 T) (Nov. 2007 - Feb. 2008)

(b) The transversal holding magnet. (0.50 T) (March 2010 - August 2010)

(c) The polarizing magnet. (5 T)

2 Low temperature

28 mK (w/o beam) and 30mK (w/ beam)



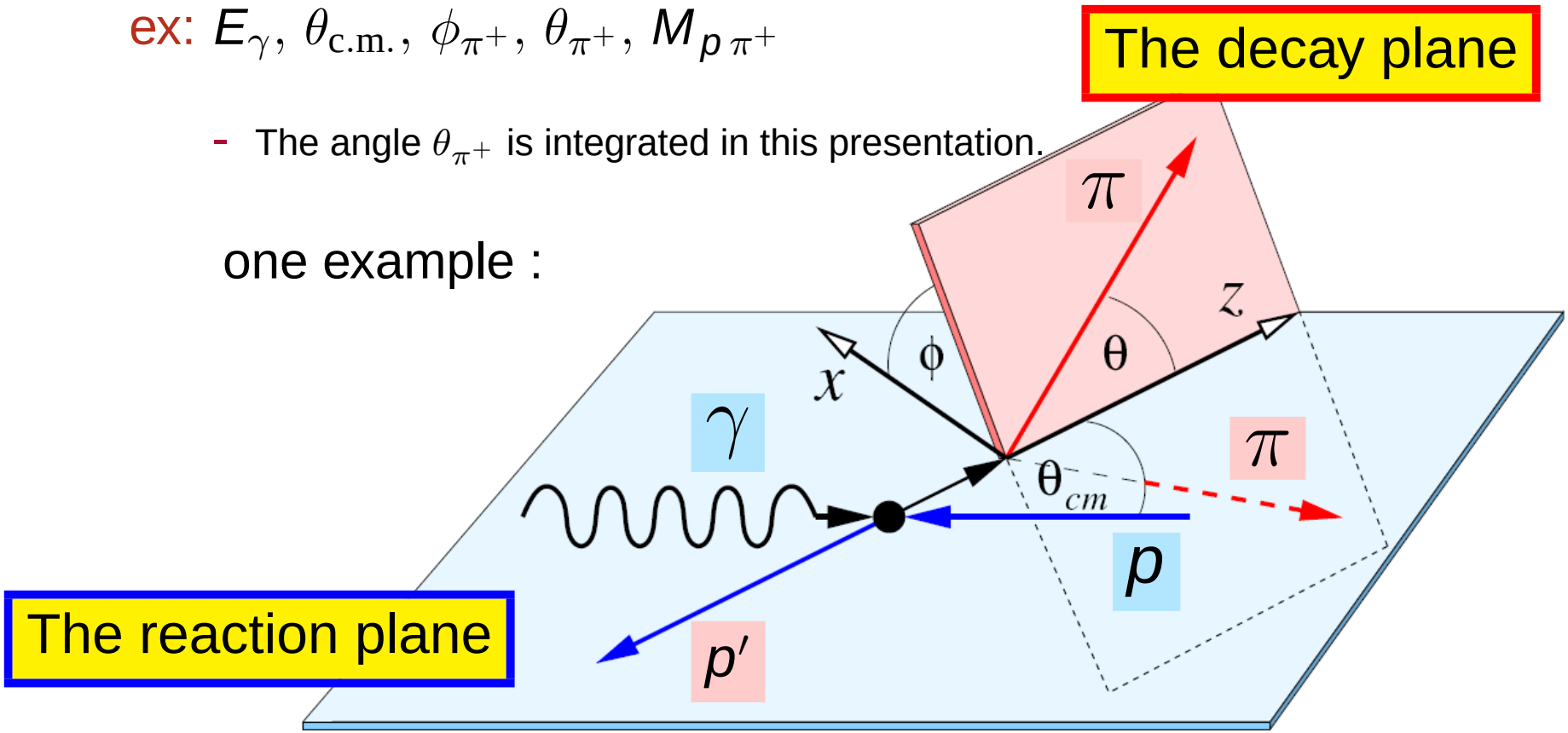
Photoproduction of $\pi^+\pi^-$ off the proton: Kinematics

- The π^+ π^- photoproduction require 5 independent variables.

  ex: E_γ, $\theta_{\text{c.m.}}$, ϕ_{π^+}, θ_{π^+}, $M_{p\,\pi^+}$

  - The angle θ_{π^+} is integrated in this presentation.

one example :



Polarization observables

The data used for this research :

1. circularly-polarized beam
2. longitudinally-polarized target

$$\frac{\mathrm{d}\,\sigma}{\mathrm{d}\,\mathrm{x_i}} = \sigma_0 \{ (1 + \Lambda_z \cdot \mathbf{P_z}) + \delta_\odot (\mathbf{I}^\odot + \Lambda_z \cdot \mathbf{P}_z^\odot) \}$$

- $\delta_\odot$ and $\vec{\Lambda}_z$: The degree of beam and target polarizaton
- $\mathbf{P}_z^\odot$, $\mathbf{P_z}$, and $\mathbf{I}^\odot$: The polarization observables

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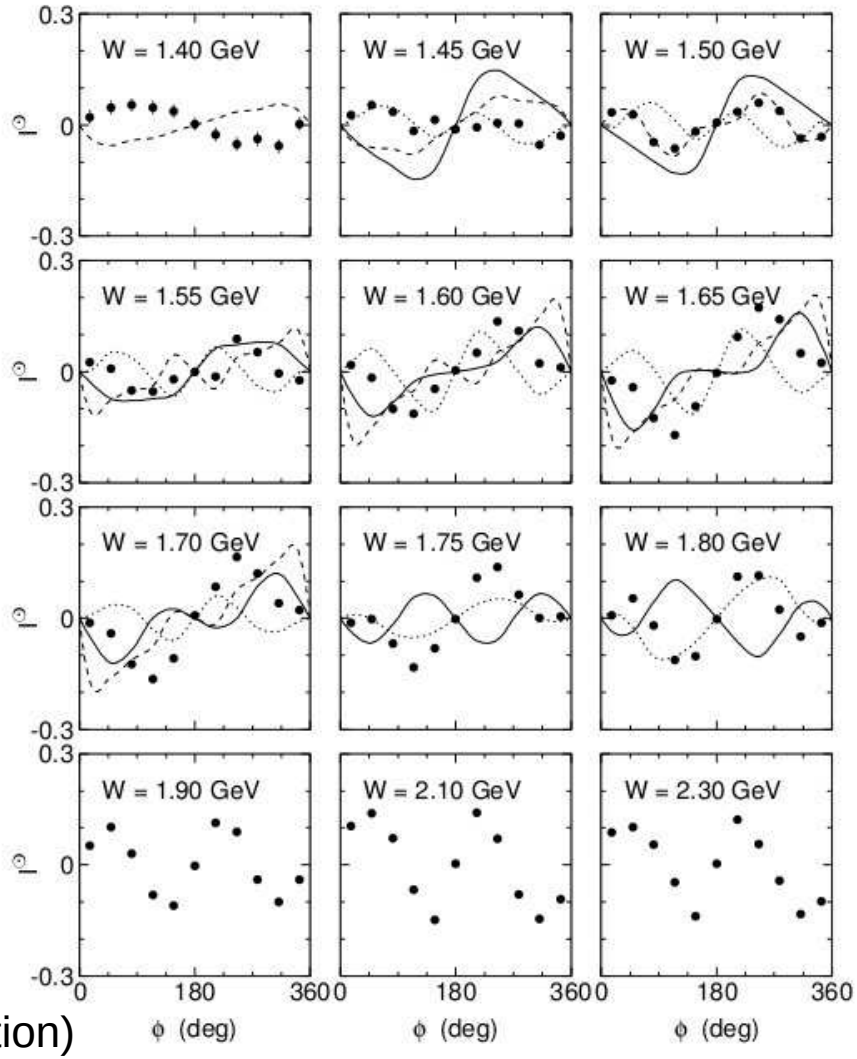


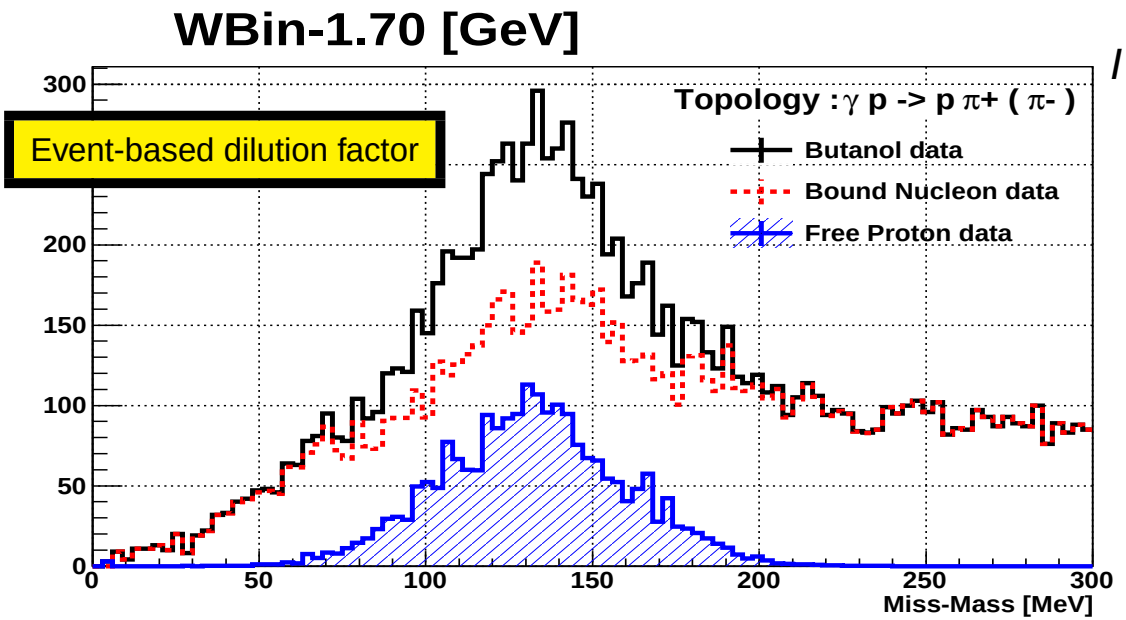
$\mathbf{I}^\odot$ only is published

- Phys.Rev.Lett. 95, 162003 (2005, CLAS Collaboration)

Polarization observable $I^{\odot}$

$$I^{\odot}(W, \theta^*, \phi^*) = \frac{1}{\bar{\delta}_{\odot}(E_\gamma)} \frac{\left\{ N(\rightarrow)_{beam} - N(\leftarrow)_{beam} \right\}}{\left\{ N(\rightarrow)_{beam} + N(\leftarrow)_{beam} \right\}}$$

- $\bar{\delta}_{\odot}(E_\gamma)$: The average of the degree of the photon beam polarizations
- $\rightarrow$ ($\leftarrow$) : the direction of the beam polarization is parallel (anti-parallel) to the beam.

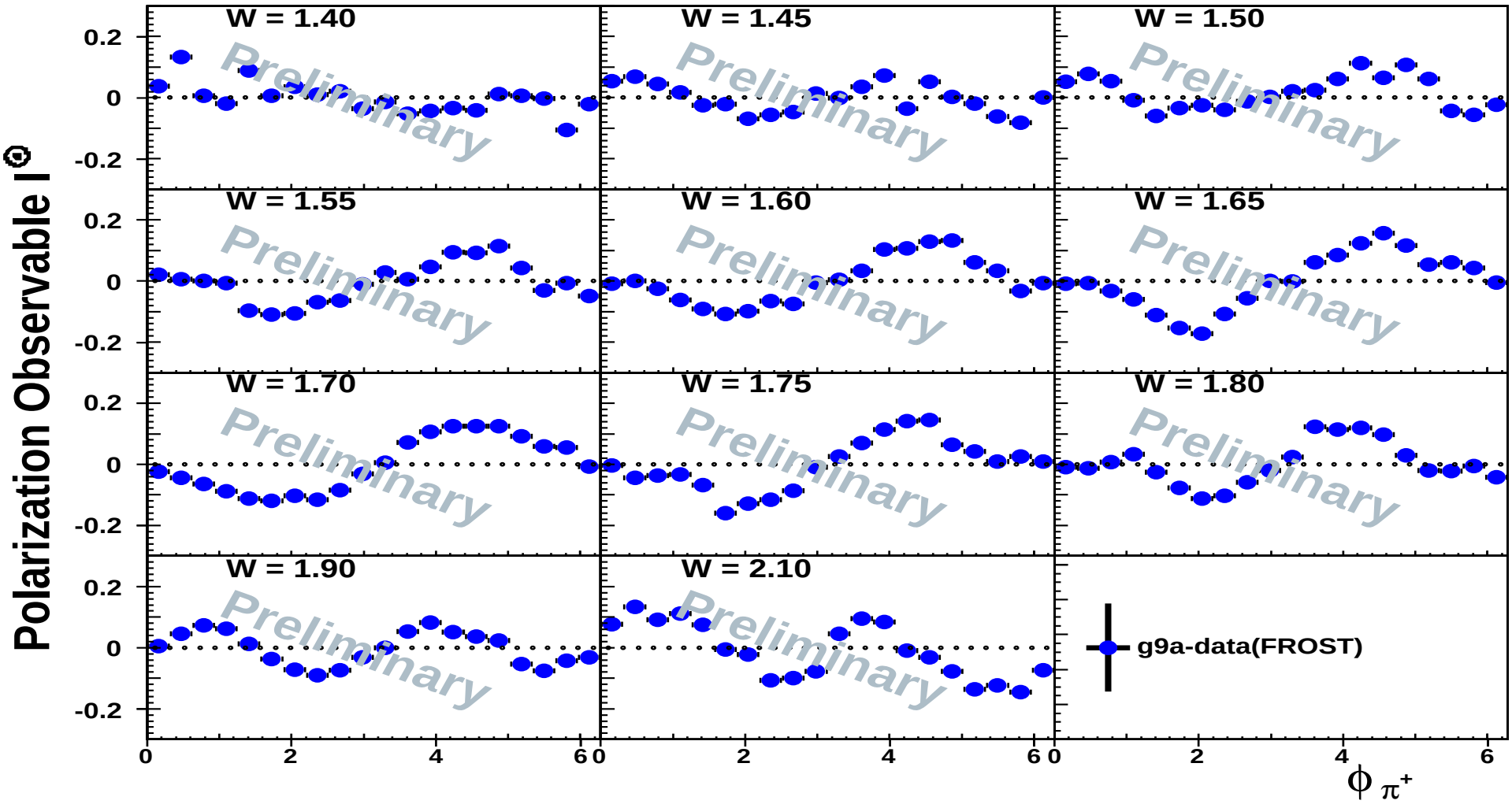


$$I^{\odot}(Butanol) = \frac{f_B}{f_F + f_B} \cdot I^{\odot}(Bound\ Nucleon) + \frac{f_F}{f_F + f_B} \cdot I^{\odot}(Free\ Proton)$$

(Dilution Factor)

- f_F : the ratio of free proton to butanol
- f_B : the ratio of bound nucleon to butanol

Beam asymmetry $I^{\odot}$ from proton data



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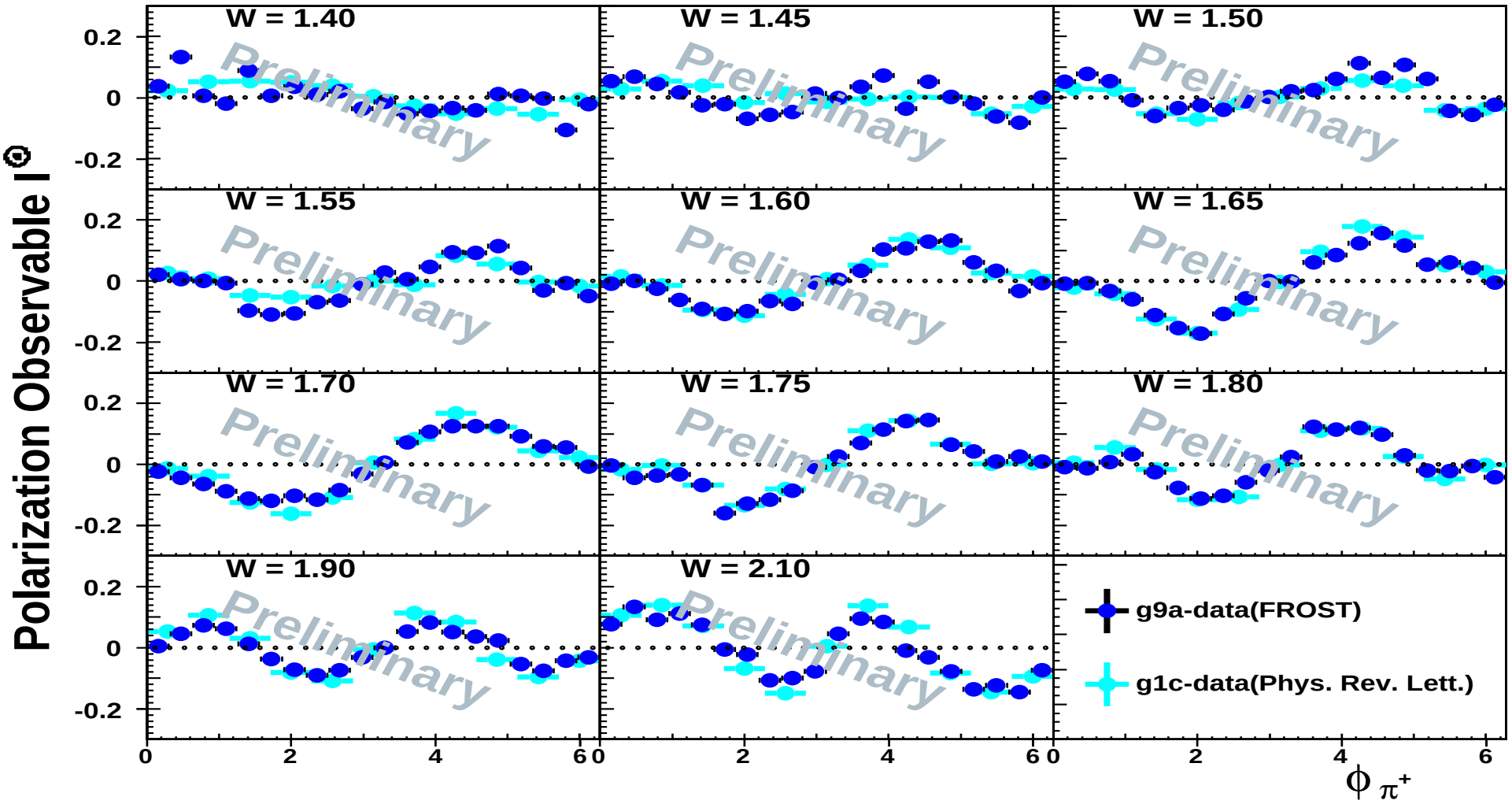
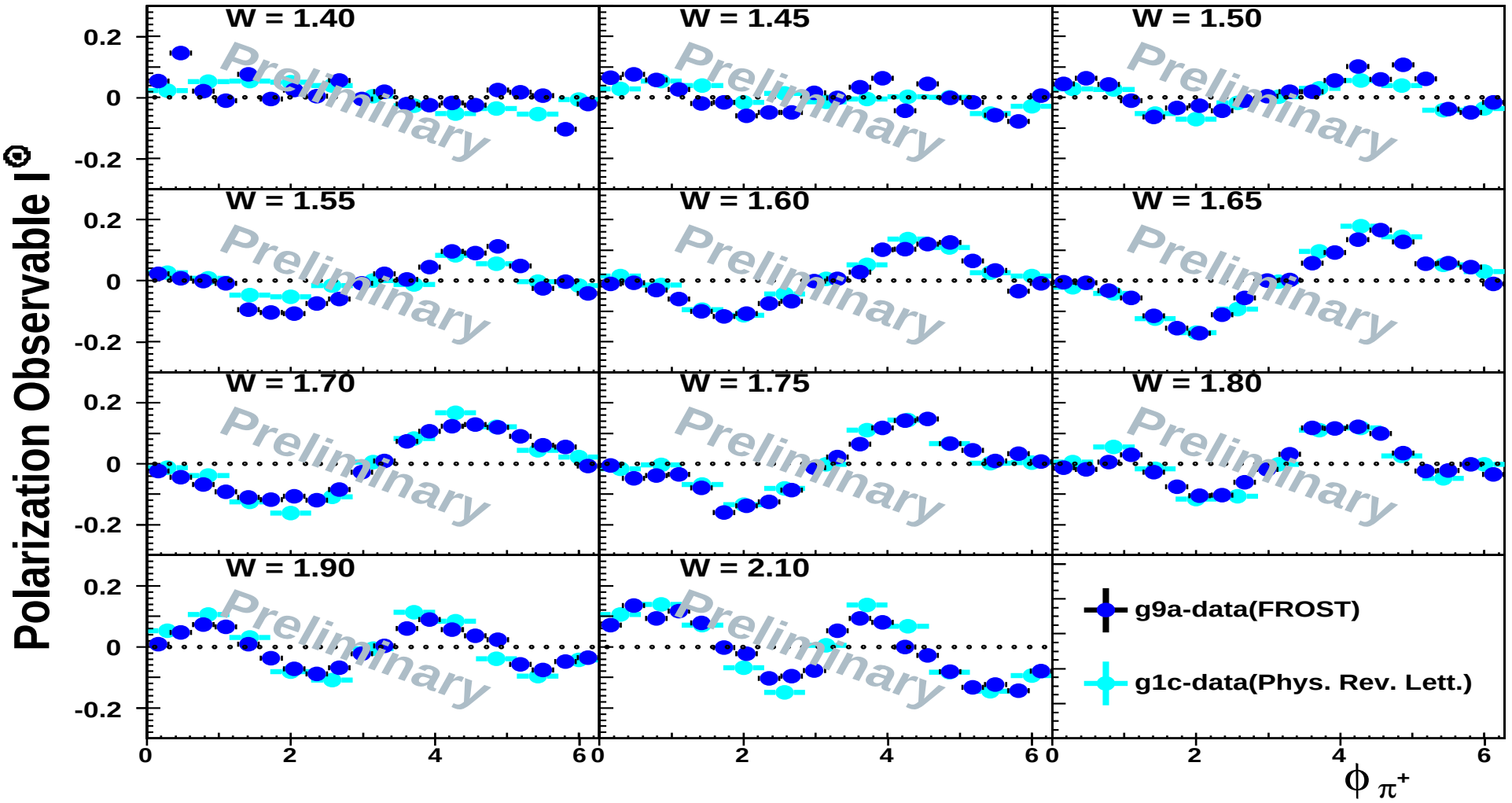
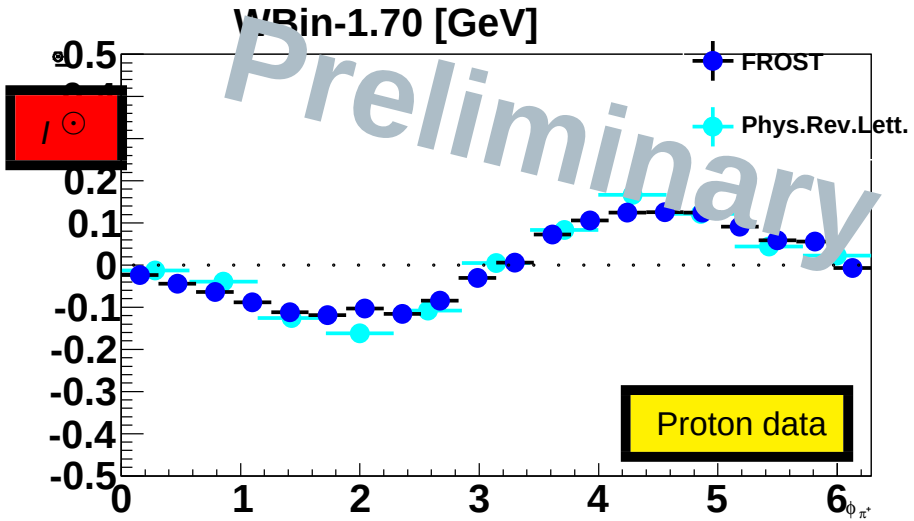
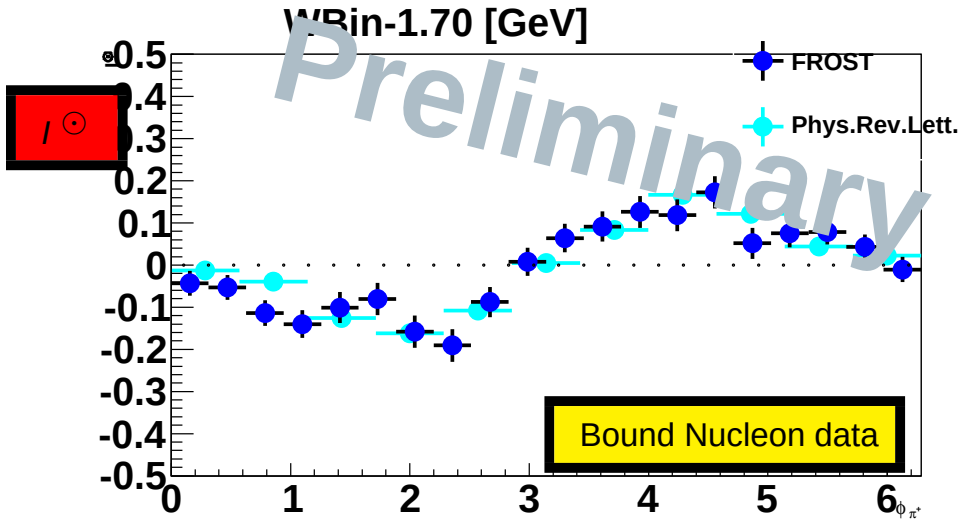


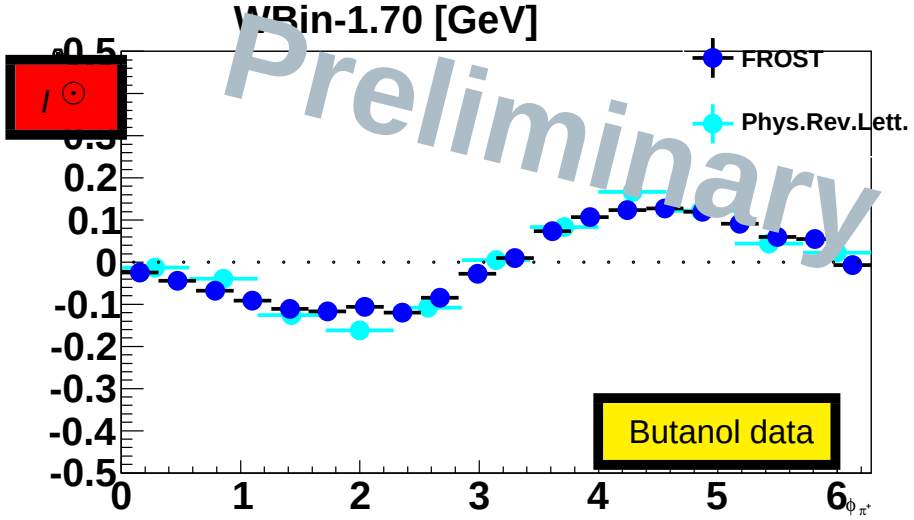
Beam asymmetry $I^{\odot}$ from butanol data



Observable $I^{\odot}$ from different target nucleons





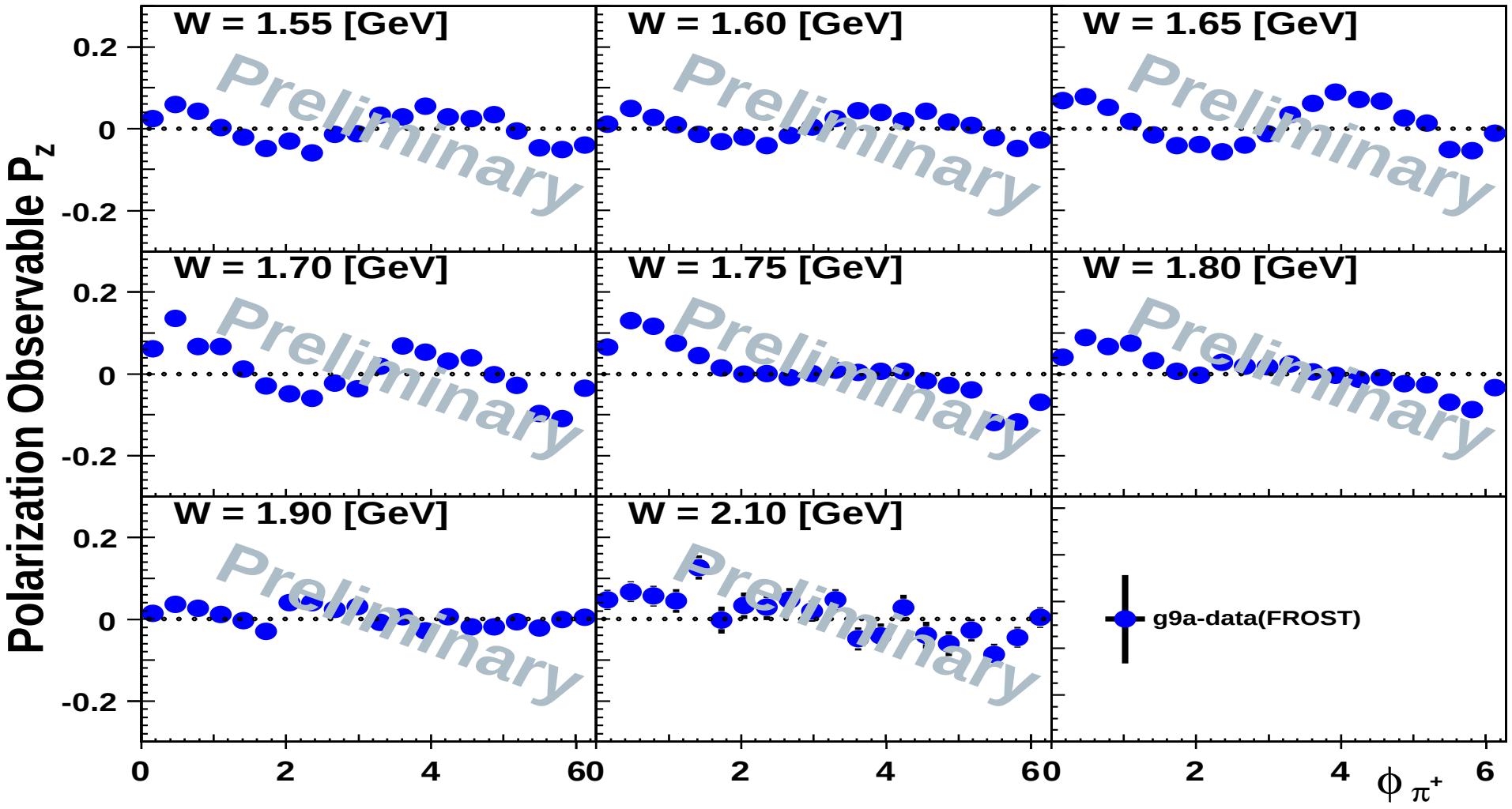


If $I^{\odot}(\textit{Bound Nucleon}) \simeq I^{\odot}(\textit{Proton})$

- that is, if fermi motion effect is small

$I^{\odot}(\textit{Butanol}) \simeq I^{\odot}(\textit{Proton})$

Target Asymmetry P_z from proton data



Summary

- The event-based dilution factor can separate the background from the butanol data efficiently.
- Polarization Observable $I^{\odot}$ using the FROST data has a good agreement with the previous published CLAS data.
- The preliminary result for the target asymmetry is shown.