# Preliminary Results on Polarization Observables for Double-Pion Photoproduction from CLAS

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on behalf of the CLAS collaboration

Florida State University, Tallahassee, Florida

DNP Fall Meeting

10/26/2013

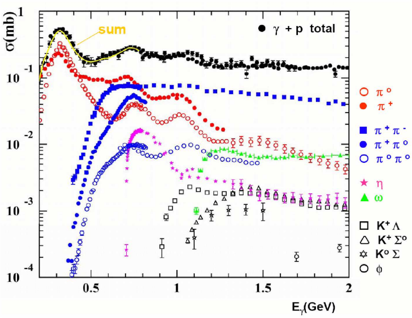
# Outline

1. Motivation
2. CLAS experiments
3. Results
4. Outlook

# Motivation

**Understanding excited baryons -**

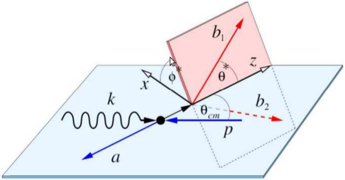
- **Photoproduction** - effective degrees of freedom in strong QCD
- **Electroproduction** - structure of excited baryons and nature of confining forces



**Spin observables** necessary to isolate resonant contributions for extraction of N* parameters.

**Focus of the talk -** Spin observables for $p\pi^+\pi^-$ photoproduction. This reaction is the biggest contributor to the total photoabsorption cross section above 1.7 GeV c.m. energies.

# Spin observables for $\vec{\gamma}\,\vec{p} \to p\pi\pi$



5 independent kinematic variables needed -
E$_\gamma$, $\phi^*_{\pi^+}$, $\cos(\theta^*_{\pi^+})$, $\cos(\theta^{c.m.}_p)$, $m_{\pi^+\pi^-}$

For $p\pi\pi$ state, w/o measuring polarization of recoiling p, reaction rate I-

$$I = I_0\{(1 + \bar{\Lambda}_i \cdot \bar{P})$$

W. Roberts *et al.*, Phys. Rev. C **71**, 055201 (2005)

$$+\delta_\odot(I^\odot + \bar{\Lambda}_i \cdot \bar{P}^\odot)$$
$$+\delta_l[\sin 2\beta(I^s + \bar{\Lambda}_i \cdot \bar{P}^s) + \cos 2\beta(I^c + \bar{\Lambda}_i \cdot \bar{P}^c)]\}$$

| | Longitudinally polarized target | Transversely polarized target |
|---|---|---|
| Circular γ beam | 🟨 $P_z$, $P_z^\odot$, $I^\odot$ | 🟦 $P^\odot_{x,y}$, $P_{x,y}$, $I^\odot$ |
| Linear γ beam | 🟦 $P^{s,c}_z$, $P_z$, $I^{s,c}$ | 🟨 $P^{s,c}_{x,y}$, $P_{x,y}$, $I^{s,c}$ |

🟨 **FSU**

🟦 USC

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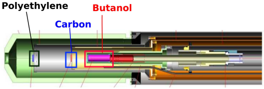
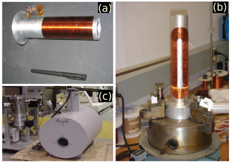
# CLAS experiments

The g8b run -
Linearly polarized photons,
unpolarized $H_2$ target

CLAS detector- charged particles detection,almost $4\pi$ coverage





The FROzen Spin Target (FROST) experiment -
Linearly/circularly polarized photons,
Longitudinally/ transversely polarized protons in butanol target

# The FROST experiment analysis

Topologies -

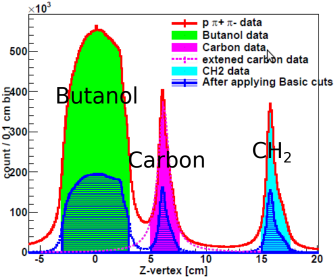
$\vec{\gamma}\,\vec{p} \to p\pi^+$ (missing $\pi^-$)

$\vec{\gamma}\,\vec{p} \to p\pi^-$ (missing $\pi^+$)

$\vec{\gamma}\,\vec{p} \to p\pi^+\pi^-$

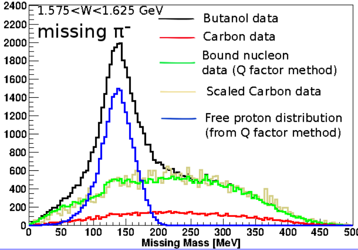
5% confidence level cut

C, $CH_2$ to tackle bound nucleon data.



S. Park, Ph.D. thesis, FSU

Event-based Qfactor method-to remove background due to bound nucleons.



Event-based Qfactor method advantages -

- plotting asymmetries in different dimensions w/o finding an overall dilution factor each time
- Event-based Partial Wave Analysis possible.

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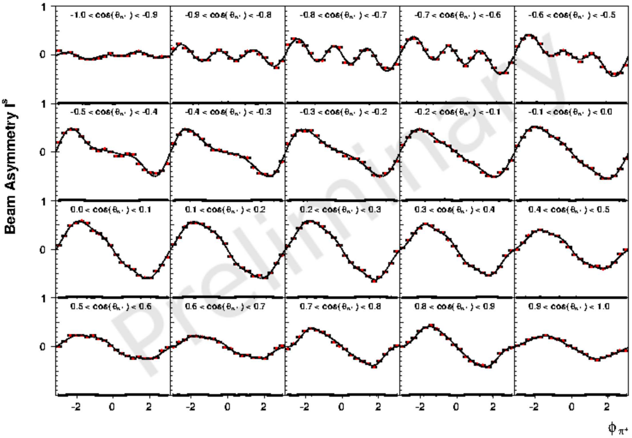
# $I^s$ in $\vec{\gamma} p \to p\pi^+\pi^-$, $1.45 < E_\gamma < 1.5$ GeV (g8b run group)



3-dim. phase space
(E$_\gamma$, $\phi^*_{\pi^+}$, cos($\theta^*_{\pi^+}$))
**Excellent statistics !**

C. Hanretty, CLAS
g8b run group, FSU

Photon beam: linear, Target: unpolarized $H_2$.

$$I = I_0\{\delta_l[\mathbf{I^s} sin(2\beta) + I^c cos(2\beta)]\}$$

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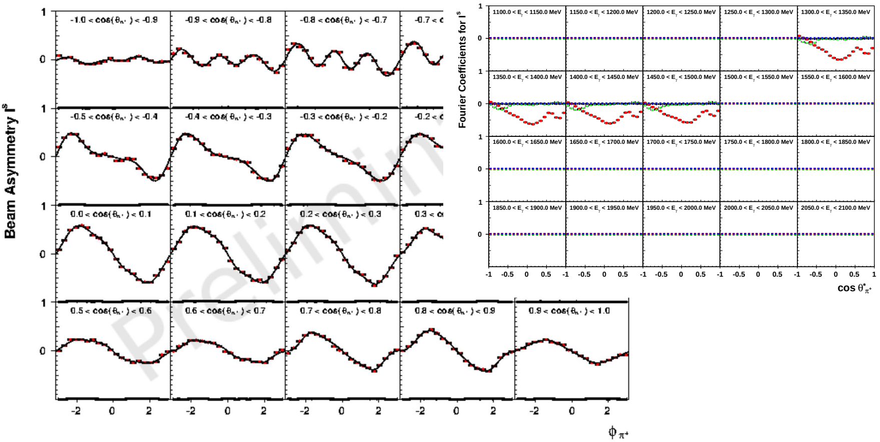

C. Hanretty, CLAS g8b run group, FSU

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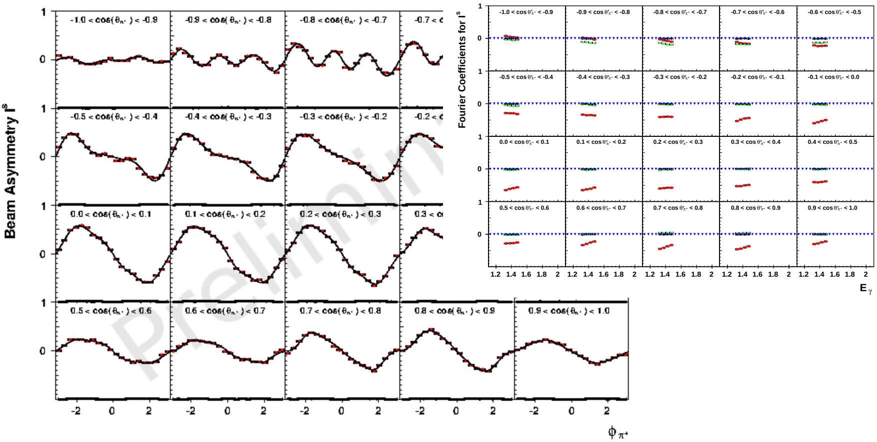

**C. Hanretty, CLAS g8b run group, FSU**

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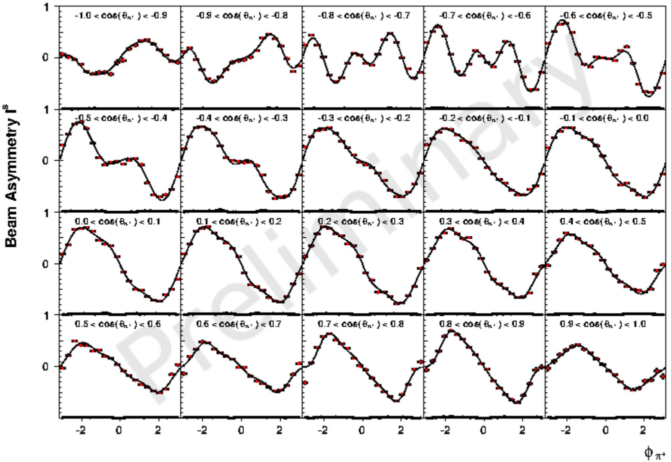
$$I = I_0\{\delta_l[\mathbf{I}^s sin(2\beta) + I^c cos(2\beta)]\}$$

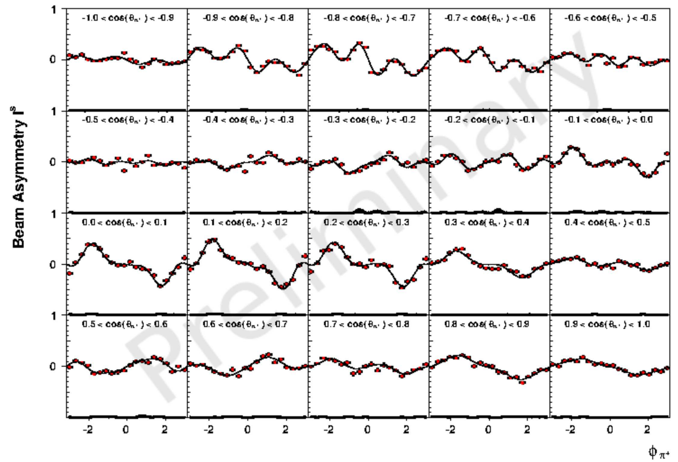
# $I^s$ (1.45< $E_\gamma$ < 1.5 GeV, -1.0< cos($\theta_p^{c.m.}$) <-0.5)



C. Hanretty, CLAS
g8b run group, FSU

4-dim. phase space (E$_\gamma$, $\phi^*_{\pi^+}$, cos($\theta^*_{\pi^+}$), cos($\theta_p^{c.m.}$))

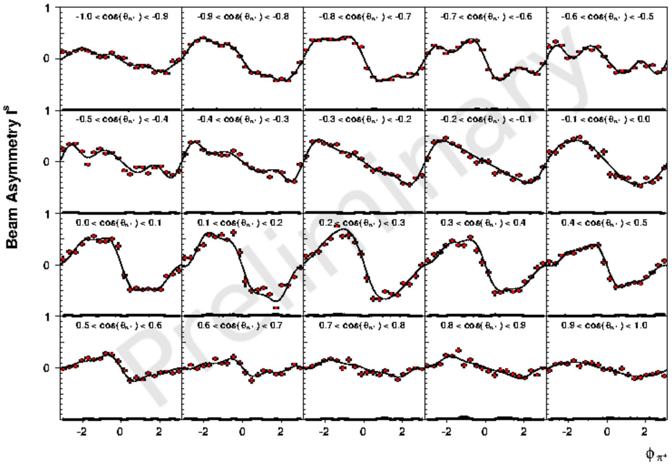
# $I^s$ (1.45< $E_\gamma$ <1.5 GeV, -0.5< $\cos(\theta_p^{c.m.})$ <0.0)



C. Hanretty, CLAS
g8b run group, FSU

4-dim. phase space ($E_\gamma$, $\phi^*_{\pi^+}$, $\cos(\theta^*_{\pi^+})$, $\cos(\theta_p^{c.m.})$)

# $I^s$ (1.45< $E_\gamma$ <1.5 GeV, 0.0< cos($\theta_p^{c.m.}$) <0.5)



C. Hanretty, CLAS
g8b run group, FSU

4-dim. phase space (E$_\gamma$, $\phi^*_{\pi+}$, cos($\theta^*_{\pi+}$), cos($\theta_p^{c.m.}$))

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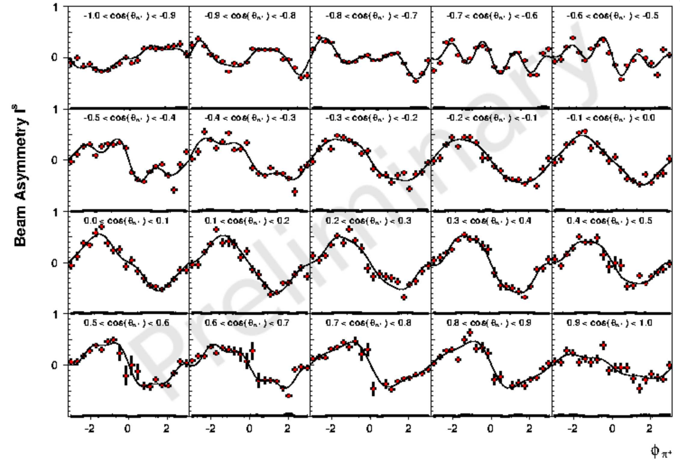
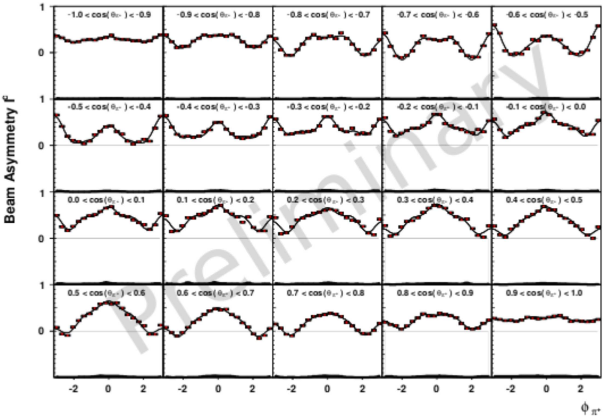


C. Hanretty, CLAS
g8b run group, FSU

4-dim. phase space (E$_\gamma$, $\phi^*_{\pi^+}$, $\cos(\theta^*_{\pi^+})$, $\cos(\theta_p^{c.m.})$)

# $I^c$ in $\vec{\gamma} p \rightarrow p\pi^+\pi^-$, 1.45< $E_\gamma$ <1.5 GeV (g8b run group)



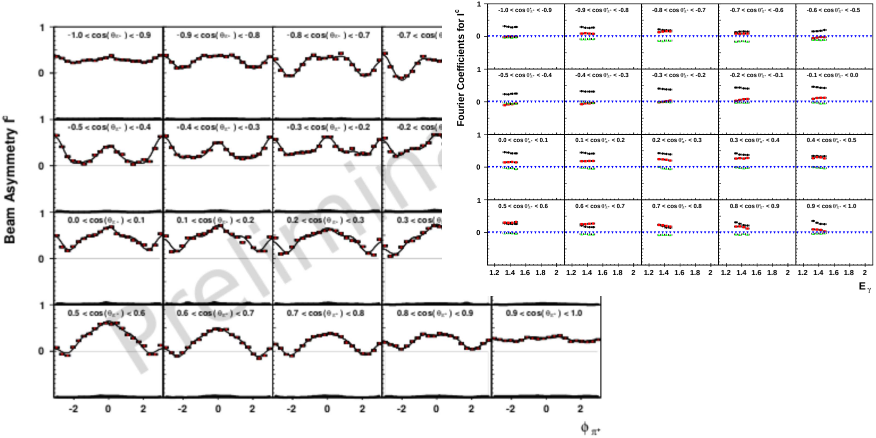
3- dim. phase space
(W, $\phi^*_{\pi^+}$, cos($\theta^*_{\pi^+}$))

C. Hanretty, CLAS g8b run group, FSU

Photon beam: linear, Target: unpolarized $H_2$.

$$I = I_0\{\delta_l[I^s sin(2\beta) + \mathbf{I^c} cos(2\beta)]\}$$

# $I^c$ in $\vec{\gamma} p \to p\pi^+\pi^-$, 1.45< $E_\gamma$ <1.5 GeV (g8b run group)



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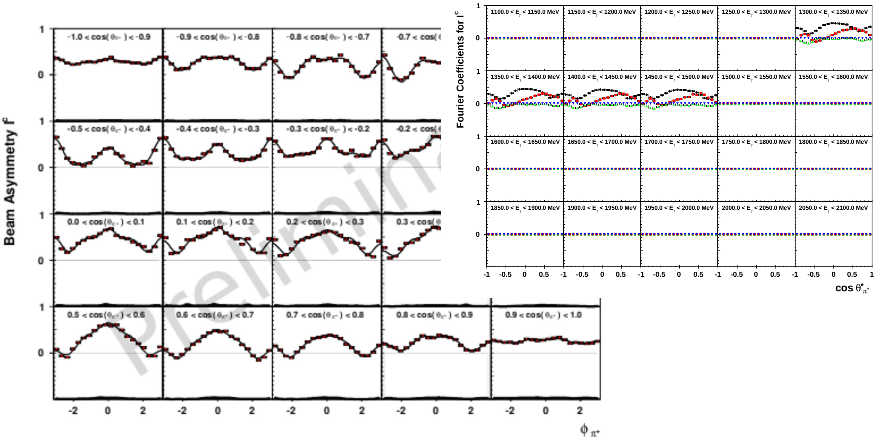

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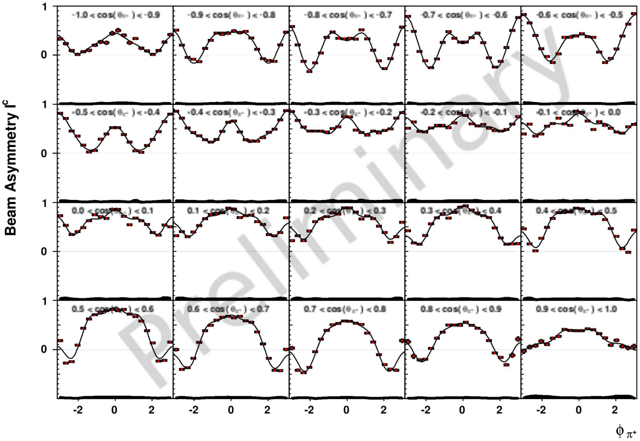
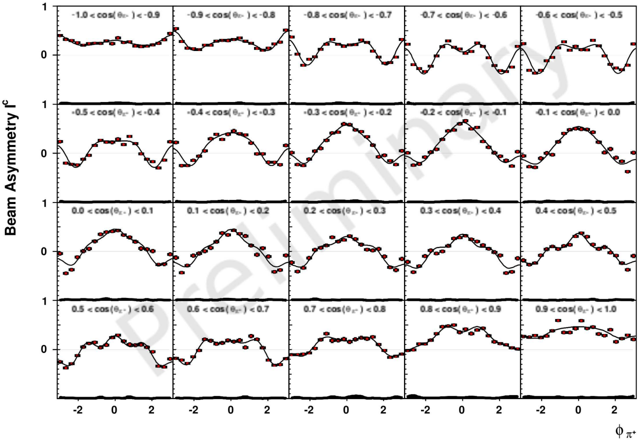


C. Hanretty, CLAS
g8b run group, FSU

4-dim. phase space (E$_\gamma$, $\phi^*_{\pi^+}$, $\cos(\theta^*_{\pi^+})$, $\cos(\theta_p^{c.m.})$)

# $I^c$ (1.45< $E_\gamma$ < 1.5 GeV, -0.5< cos($\theta_p^{c.m.}$) <0.0)



C. Hanretty, CLAS
g8b run group, FSU

4-dim. phase space (E$_\gamma$, $\phi^*_{\pi^+}$, cos($\theta^*_{\pi^+}$), cos($\theta_p^{c.m.}$))

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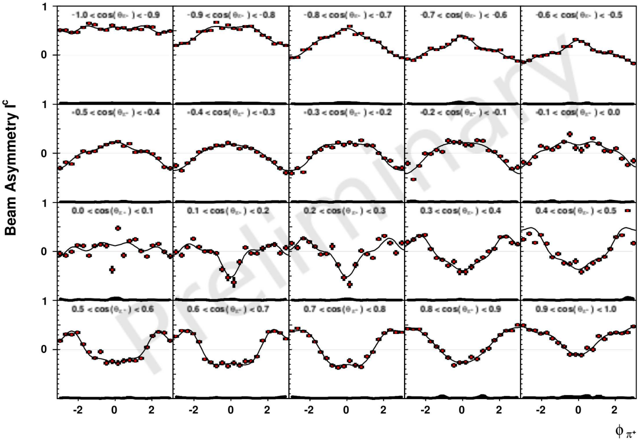

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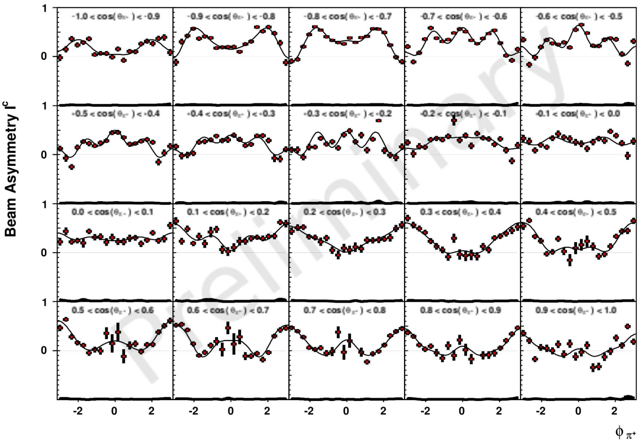
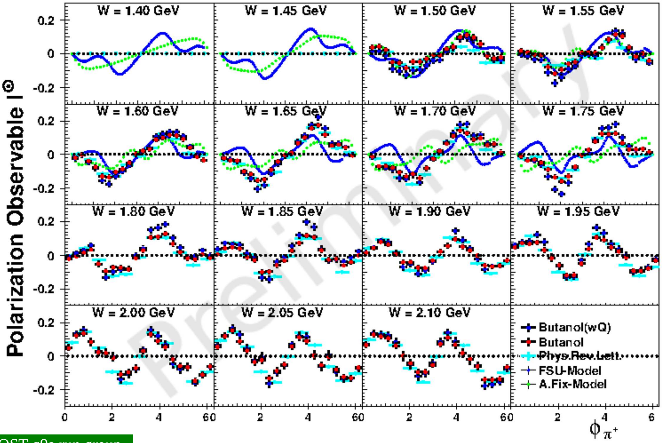


C. Hanretty, CLAS
g8b run group, FSU

4-dim. phase space (E$_\gamma$, $\phi^*_{\pi^+}$, cos($\theta^*_{\pi^+}$), cos($\theta_p^{c.m.}$))

# $I^\odot$ in $\vec{\gamma}\vec{p} \to p\pi^+\pi^-$ (FROST g9a run group)



2-dim phase space (W, $\phi^*_{\pi^+}$)

S. Park, FROST g9a run group, FSU

S. Strauch *et al.*, PRL 95, 162003 (2005)

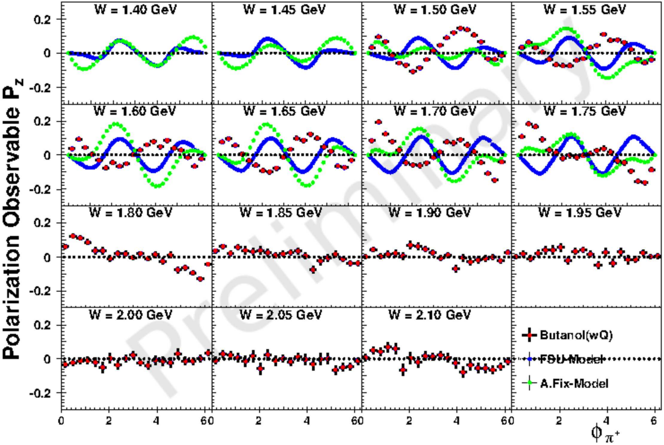
**FSU model** by Winston Roberts.

**A. Fix model** (Eur. Phys. J. A25, 115-135, 2005)

Beam: Circular, Target: Longitudinal FROzen Spin.

$$I = I_0\{(1 + \Lambda_z P_z) + \delta_\odot(\mathbf{I}^\odot + \Lambda_z P_z^\odot)\}$$

# $P_z$ in $\vec{\gamma}\,\vec{p} \to p\pi^+\pi^-$ (FROST, g9a run group)



2- dim. phase space (W, $\phi^*_{\pi^+}$)

S. Park, FROST g9a run group, FSU

Beam: Circular, Target: Longitudinal FROzen Spin.

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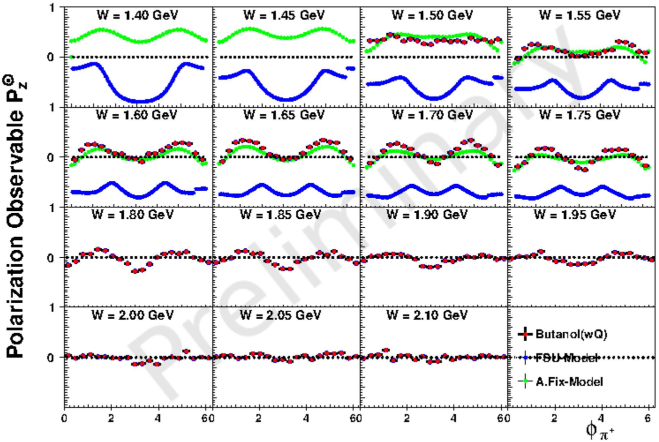
# $P_z^{\odot}$ in $\vec{\gamma}\,\vec{p} \rightarrow p\pi^+\pi^-$ (FROST g9a run group)



2-dim. phase space (W, $\phi^*_{\pi^+}$)

S. Park, FROST g9a run group, FSU

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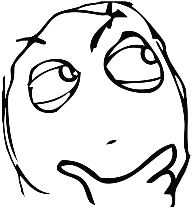
- Ongoing analysis to extract $P^{s,c}_{x,y}$,$P_{x,y}$ at FSU (g9b run group data, FROST experiment)
- Very close to completing the set of spin observables (for beam and target polarizations) for 2 pion final state.
- Next step - extracting resonances from the obervables -
- ◇ Improve the models shown for the spin observables
- ◇ Partial Wave Analysis to extact helicity amplitudes

# Thank You !



**Any questions ? ..**