G14 Polarization Observables for Double Pion Photo-production

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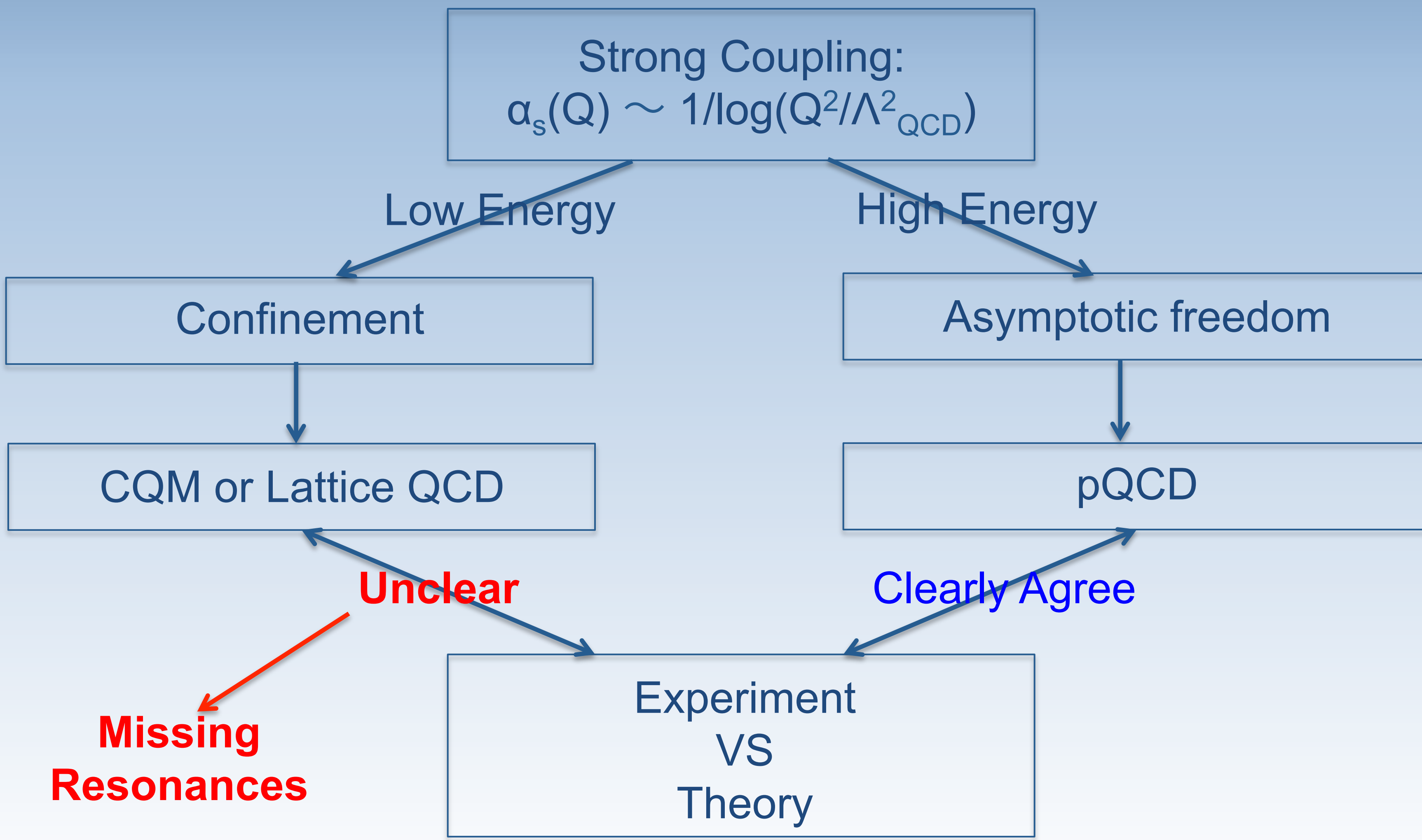
For the JLab CLAS Collaboration

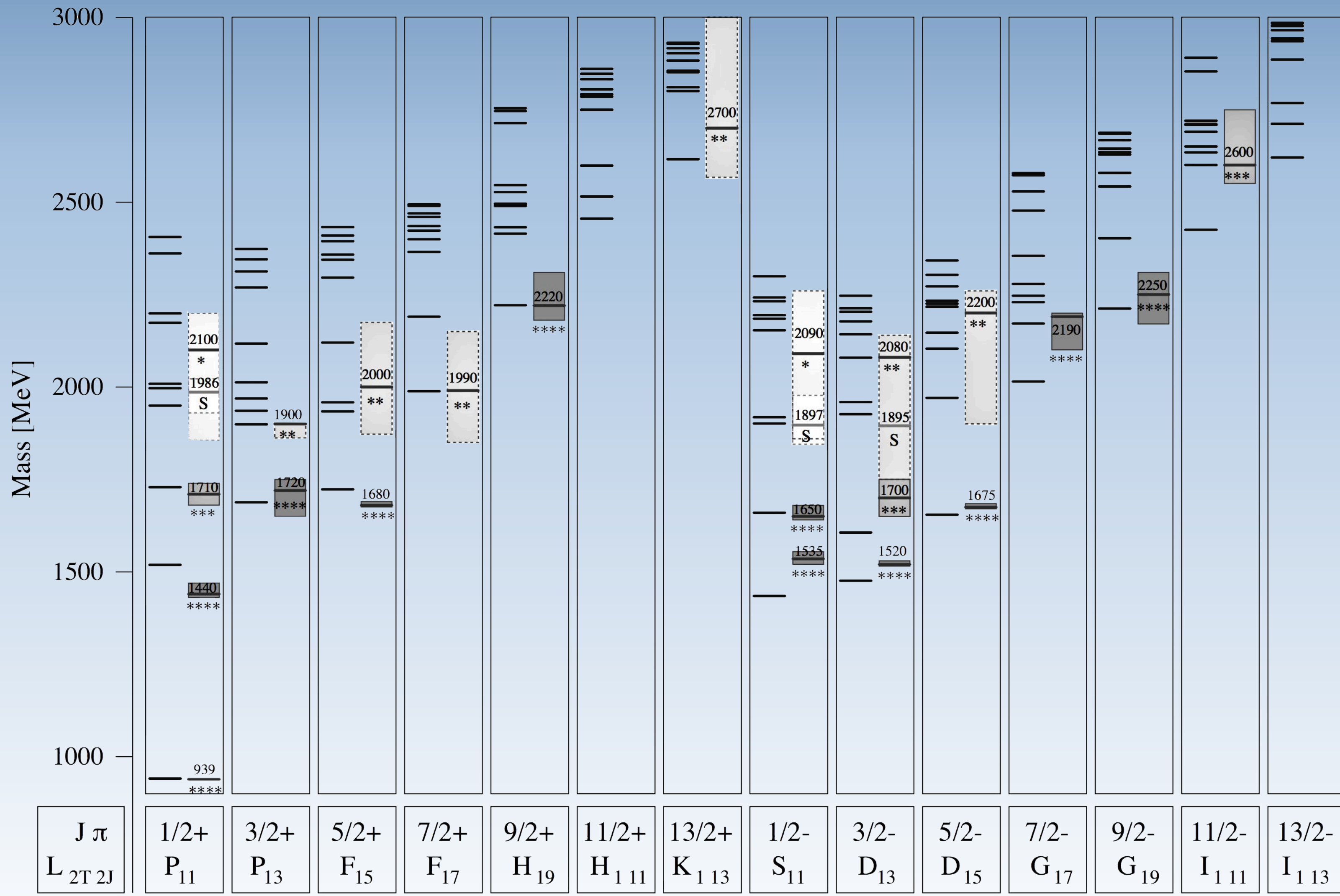
Outline

- Motivation
- Experiment Setup
- Kinematics
- Preliminary Results
- Summary and Future Work

Motivation: Confinement



Motivation: Missing Resonances



2012 PDG new(3) or changed(6) resonances		
N(1685)	??	*
N(1860)	$5/2^+$	**
N(1895)	$3/2^-$	S
N(1875)	$3/2^-$	***
N(1986)	$1/2^+$	S
N(1880)	$1/2^+$	**
N(2090)	$1/2^-$	*
N(1895)	$1/2^-$	**
N(1900)	$3/2^+$	**
N(1900)	$3/2^+$	***
N(2040)	$3/2^+$	*
N(2200)	$5/2^-$	**
N(2060)	$5/2^-$	**
N(2080)	$3/2^-$	**
N(2150)	$3/2^-$	**

Figure 1. The calculated N-resonance spectrum. The states labeled by “S” belong to SAPHIR results. [U. Loring *et al*., Eur. Phys. J. A 10(2001) 395]

Motivation: Missing Resonances

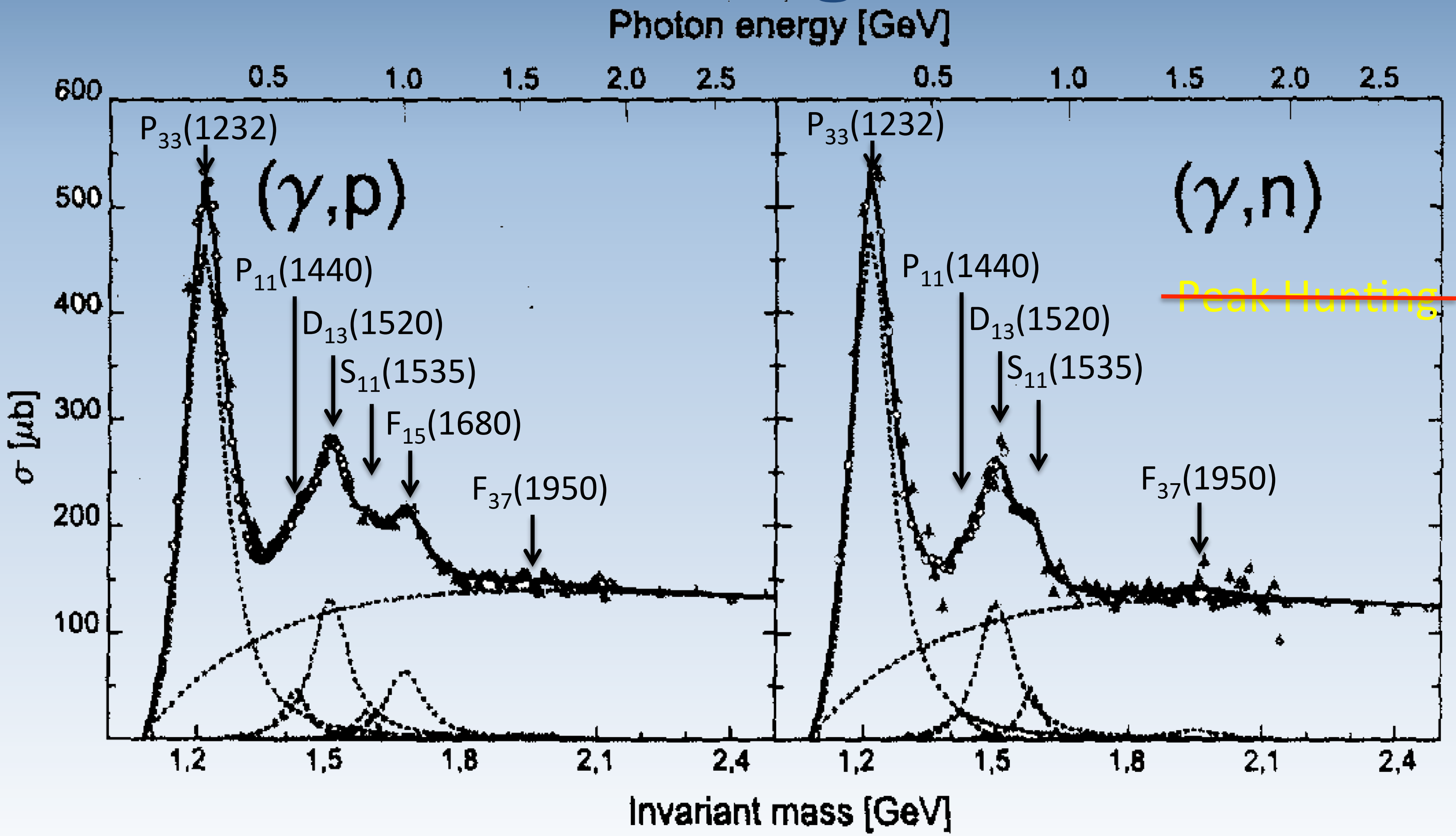
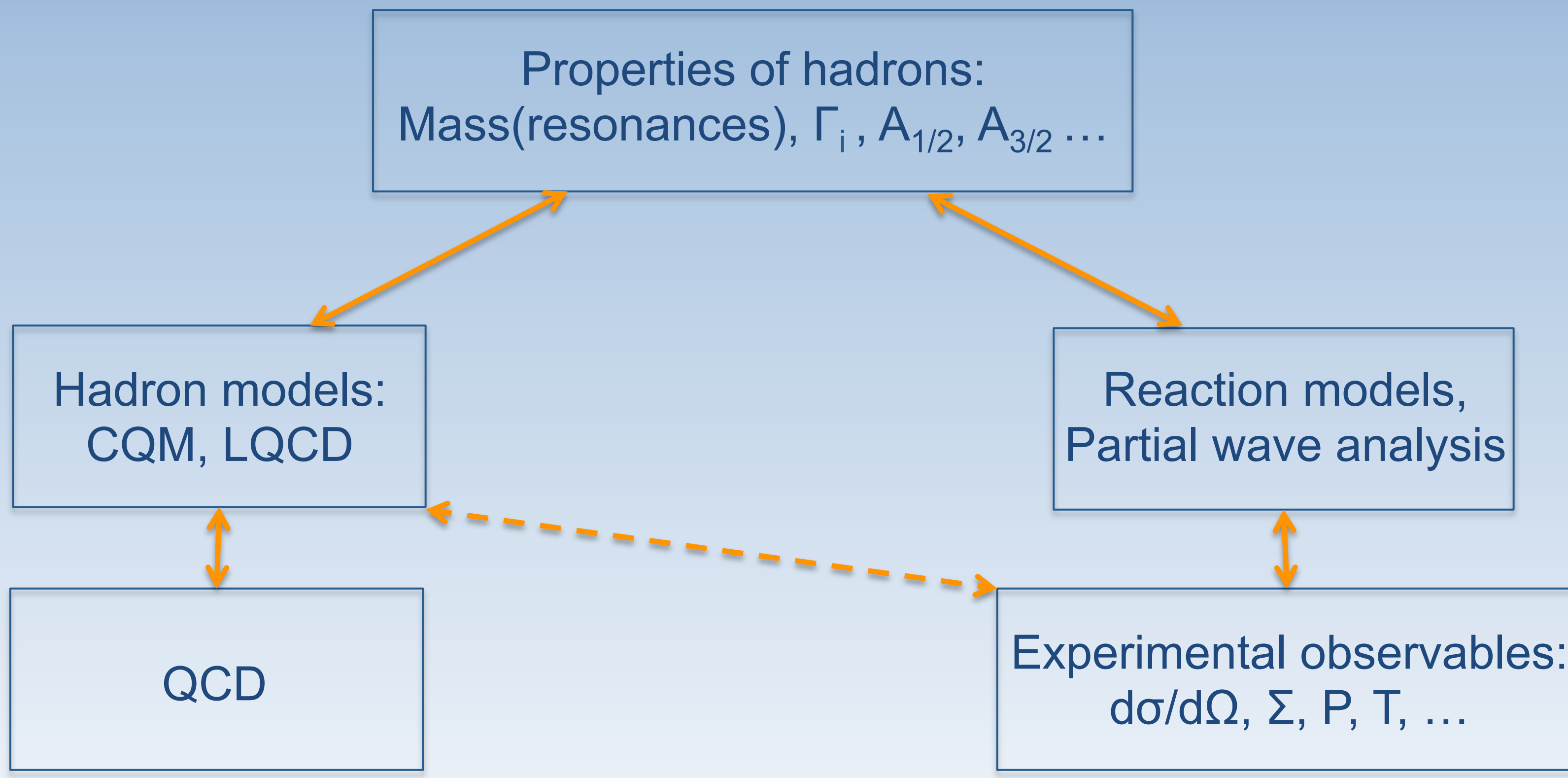
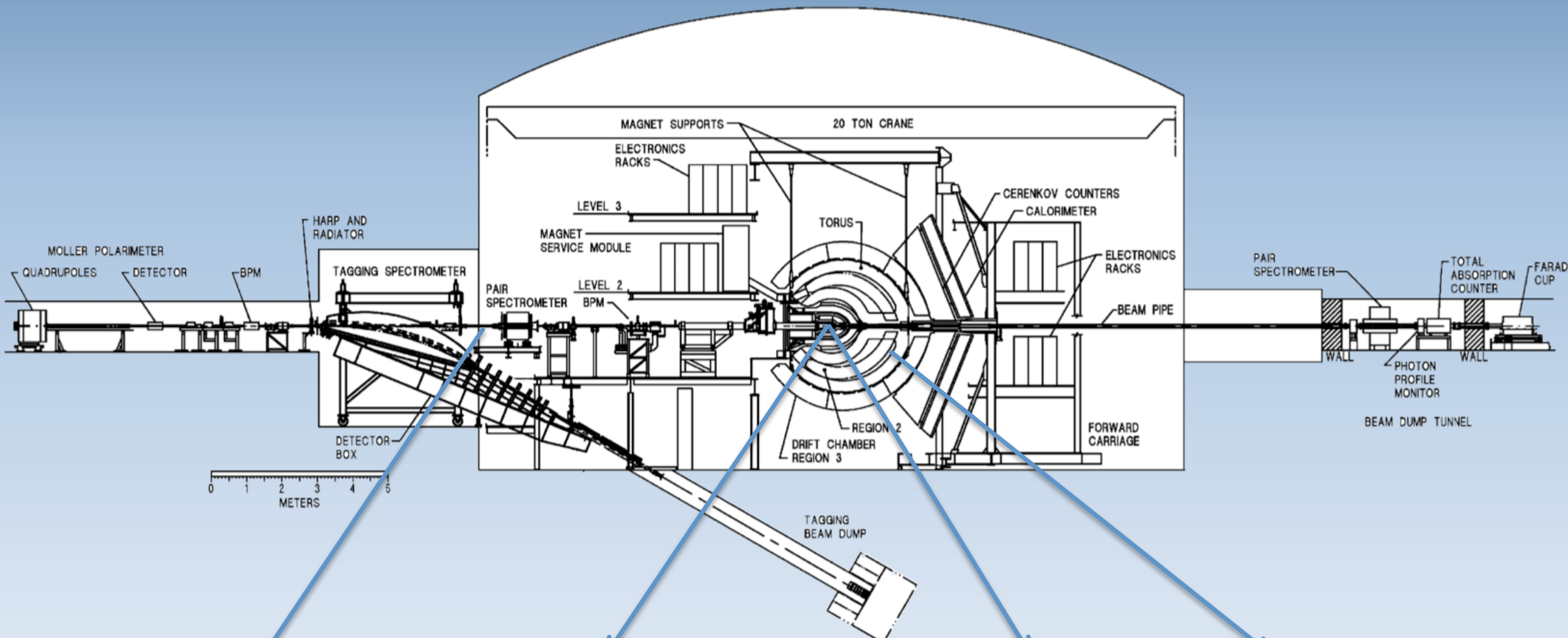


Figure 2. Cross section for total photo-production. [N. Bianchi et al., PRC 54(1996)1688]

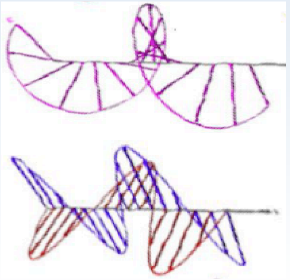
Motivation: Missing Resonances



G14 Experiment Setup: JLab Hall B



Polarized photon beam



CLAS detector (CEBAF Large Acceptance Spectrometer)

HD-Ice target

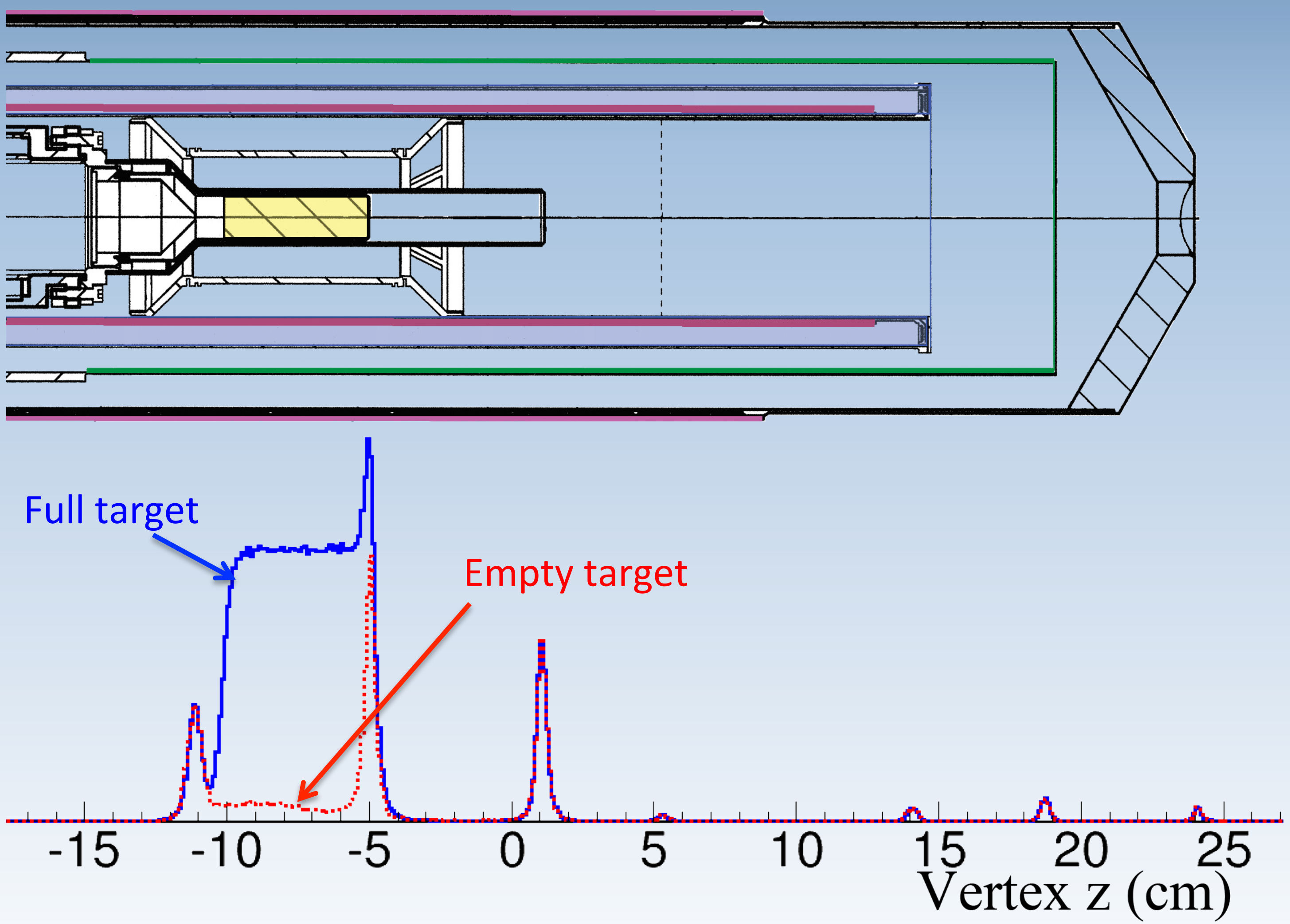


Figure 3. top: HD-Ice IBC layout; bottom: z vertex for recoiled protons.

HD-Ice target

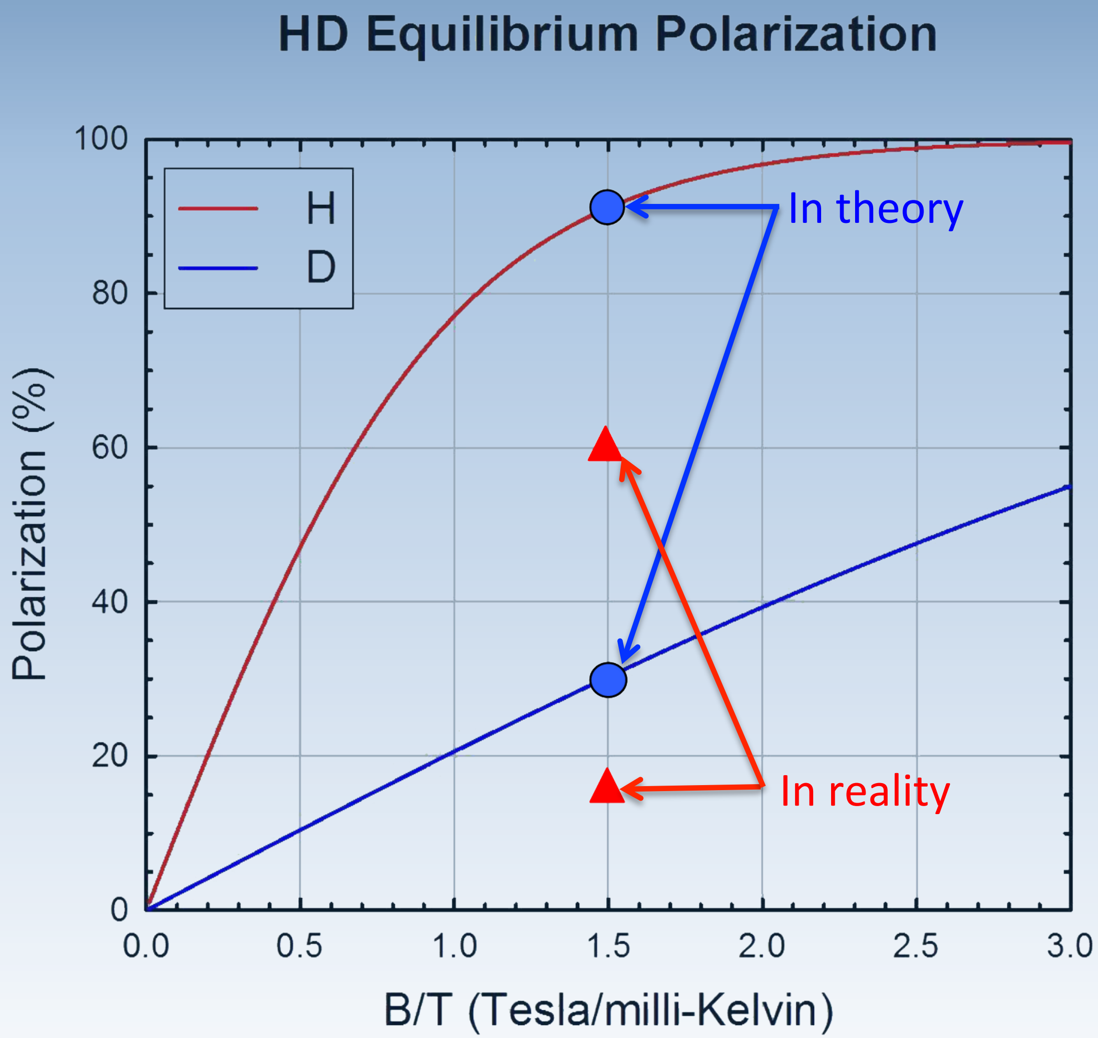


Figure 4. Brillouin function for HD Equilibrium Polarization.
Xiangdong Wei's talk in PTSP 2013

Transfer polarization from H to D using SFP (Saturated Forbidden Passage):

H: ~50% → ~28%
D: ~16% → ~27%

Double pion photo-production: Kinematics

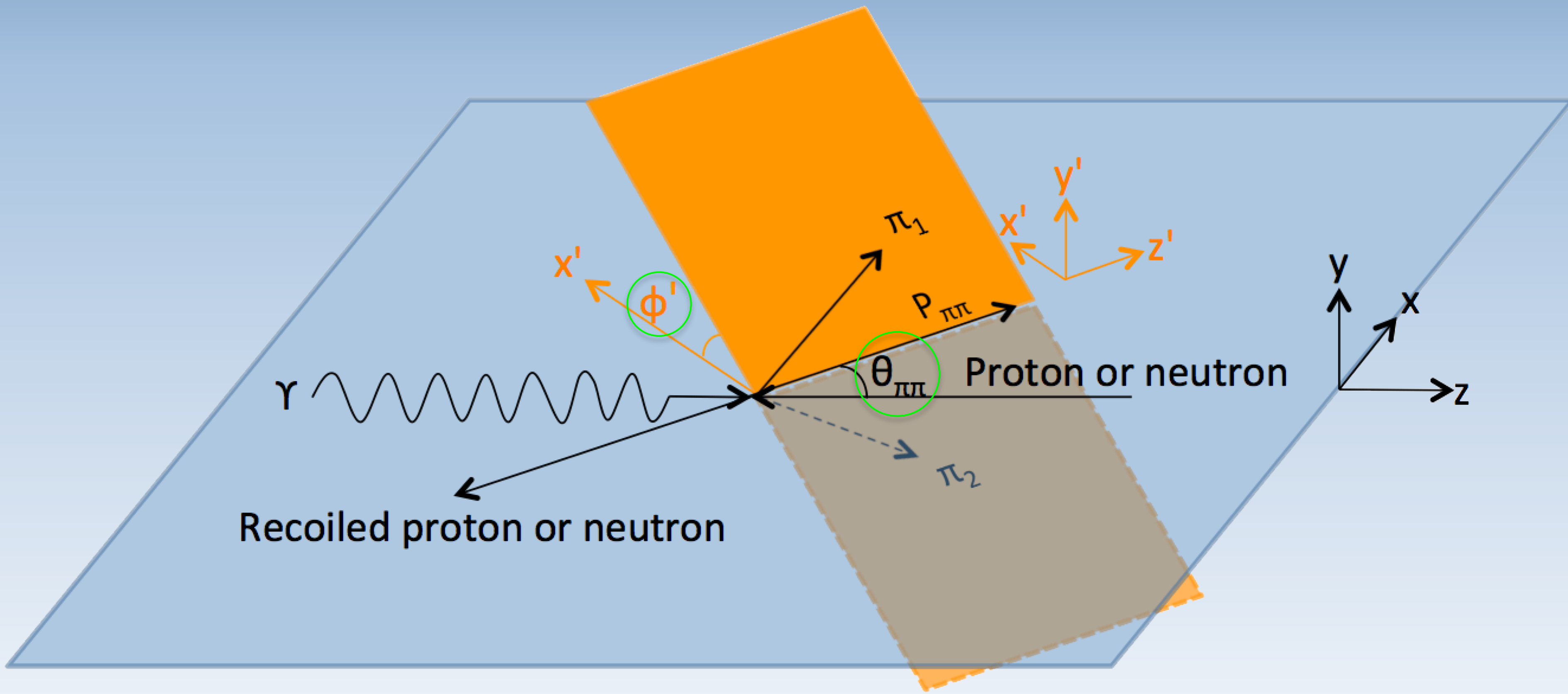


Figure 5. Kinematics for double pion photo-production.

Double pion photo-production: Observables

$d\sigma/d\Omega = \sigma_0\{(1+\Lambda\bullet P) + \delta_{\odot}(I^{\odot}+\Lambda\bullet P^{\odot}) + \delta_l[\sin2\beta(I^S+\Lambda\bullet P^S) + \cos2\beta(I^C+\Lambda\bullet P^C)]\}$

σ_0: un-polarized cross section

$\delta_{\odot}$, δ_l: degree of polarization of photon beam

Λ: degree of polarization of target

P, $P^{\odot}$, P^S, P^C, $I^{\odot}$, I^S, I^C: 15 polarization observables

Circularly polarized beam, and longitudinal polarized target, $\delta_l=0$, $\Lambda=\Lambda_z$,

$d\sigma/d\Omega = \sigma_0\{(1+\Lambda_z P_z) + \delta_{\odot}(I^{\odot}+\Lambda_z P_z^{\odot})\}$

P_z, $I^{\odot}$, $P_z^{\odot}$ can be plotted in terms of $\theta_{\pi\pi}$ and ϕ' to compare with predictions

Double pion photo-production: Observables

Parity Conservation

P_z, $I^{\odot}$ are odd function of ϕ'

$P_z^{\odot}$ is even function of ϕ'

$$P_z(\theta_{\pi\pi}) = \int P_z(\theta_{\pi\pi}, \phi')d\phi' = 0$$

$$I^{\odot}(\theta_{\pi\pi}) = \int I^{\odot}(\theta_{\pi\pi}, \phi')d\phi' = 0$$

$$P_z^{\odot}(\theta_{\pi\pi}) = \int P_z^{\odot}(\theta_{\pi\pi}, \phi')d\phi' \neq 0$$

With data of Λ_z positive, define $E^* = (I^{\odot}+\Lambda_z P_z^{\odot})/(1+\Lambda_z P_z)$

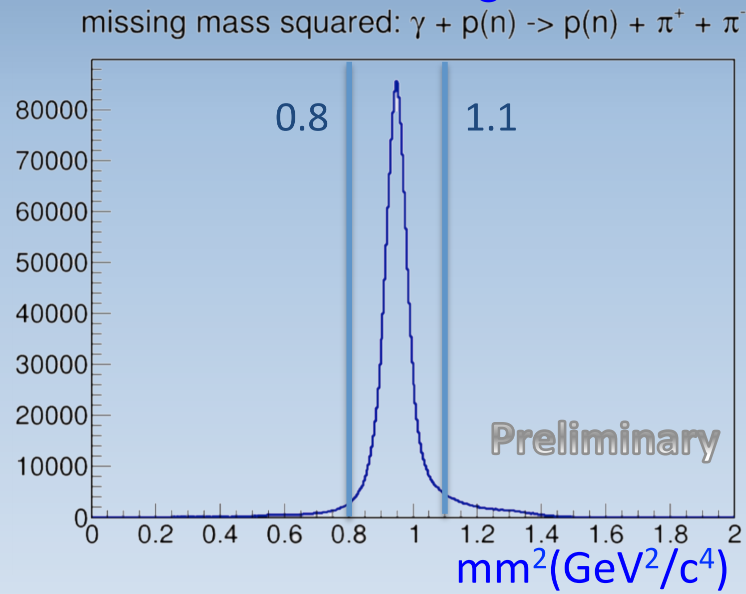
Since $\Lambda_z = 0.27$

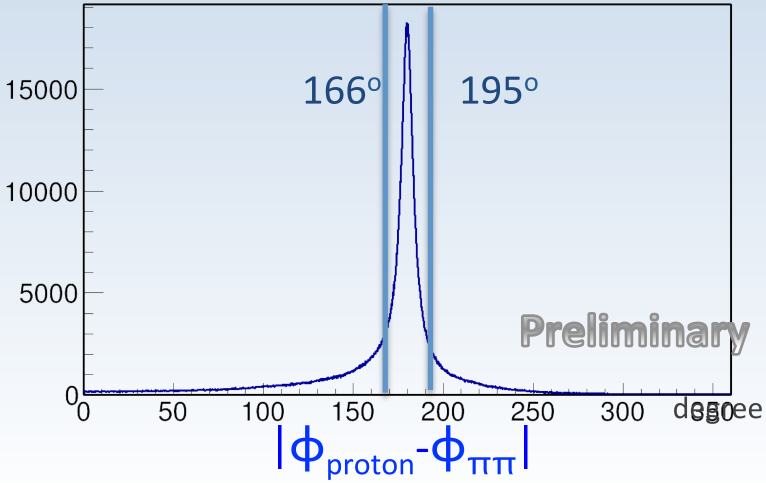
$$E^*(\phi') = \int E^*(\theta_{\pi\pi}, \phi')d\theta_{\pi\pi} \approx I^{\odot}(\phi')$$

$$E^*(\theta_{\pi\pi}) = \frac{\int \left(I^{\odot} + \Lambda_z P_z^{\odot}\right) d\phi'}{\int (1 + \Lambda_z P_z)\, d\phi'} = \Lambda_z P_z^{\odot}(\theta_{\pi\pi})$$

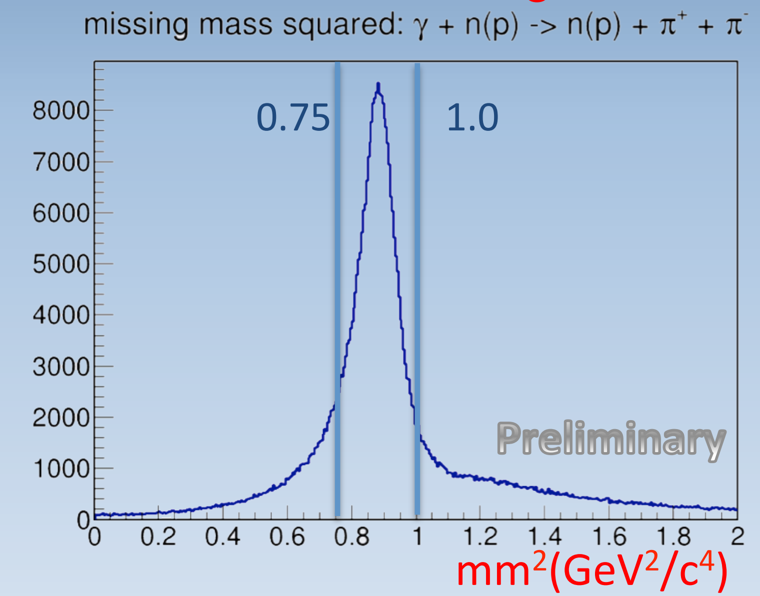
Data Analysis

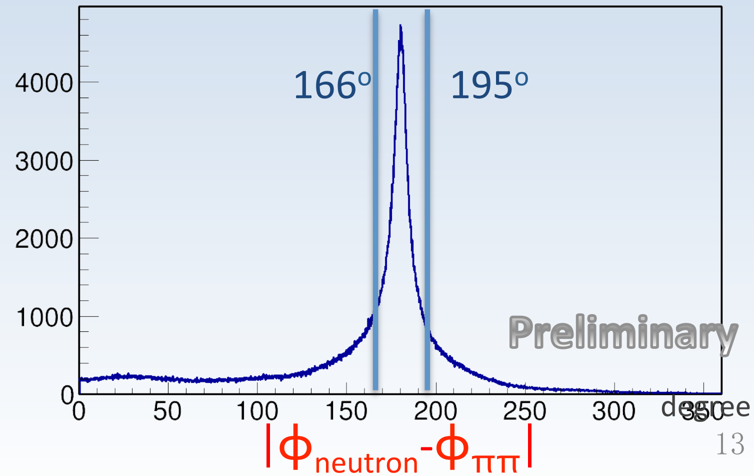
Proton target





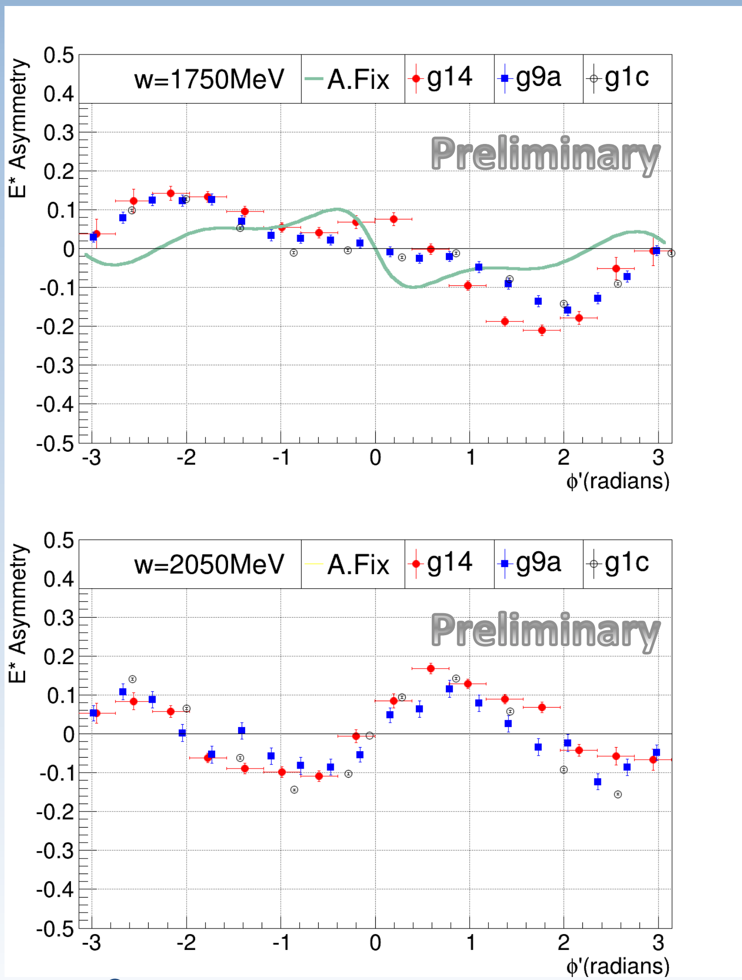
Neutron target



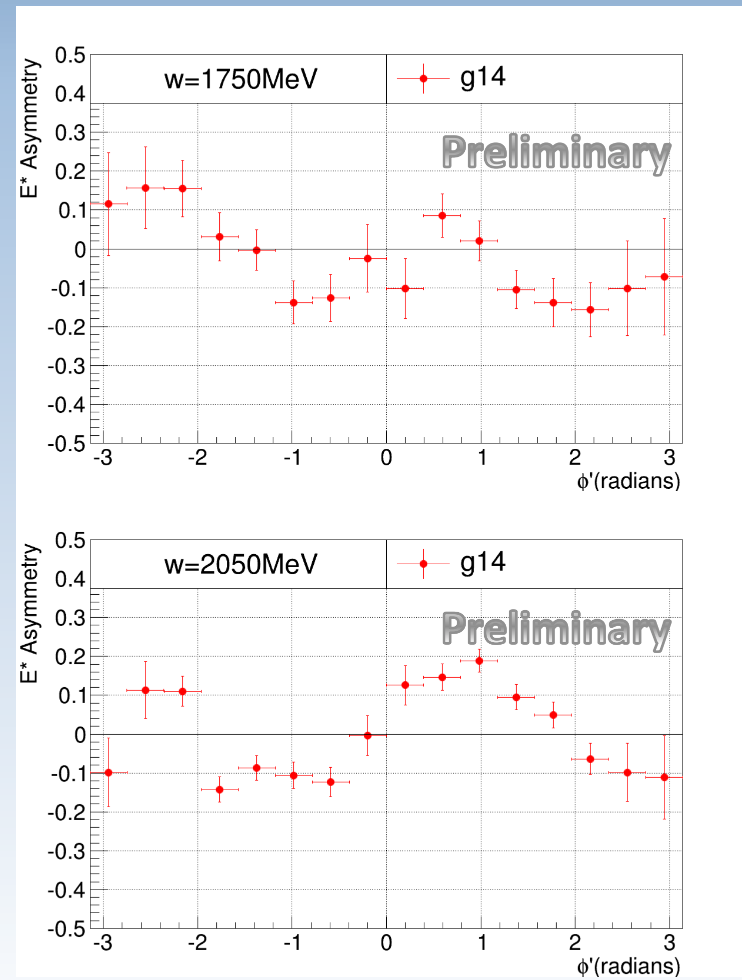


$I^{\odot}(\phi')$: E* vs. ϕ'

Proton target



Neutron target

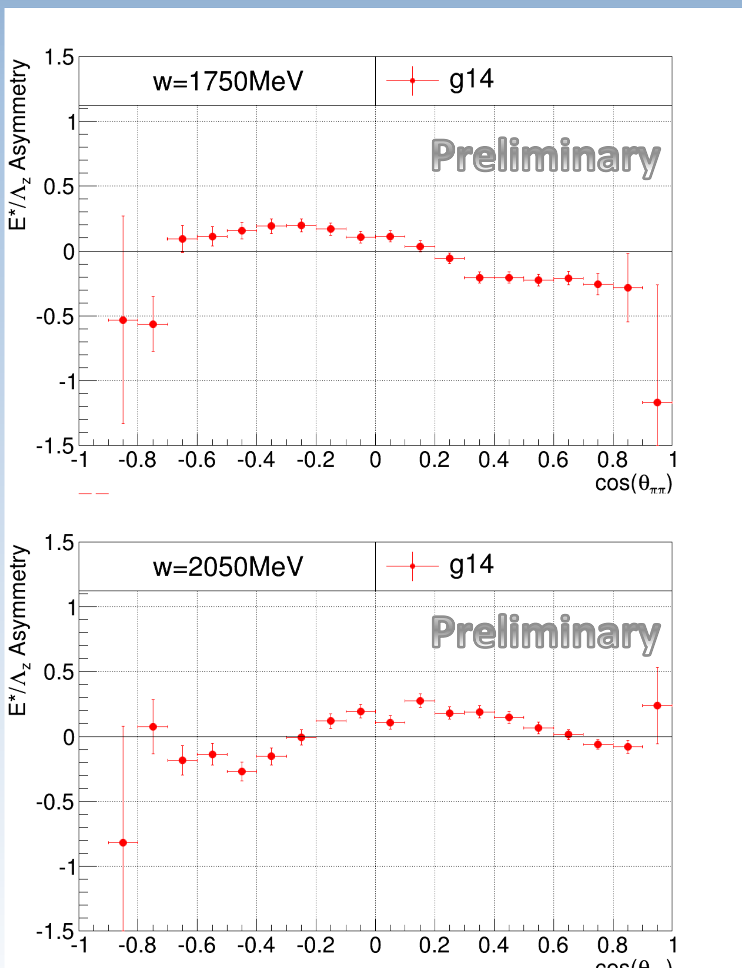


: $I^{\odot}$ [A. Fix *et al.*, Eur. Phys. J. A 25(2005) 115.] : E* [g14 analysis.]

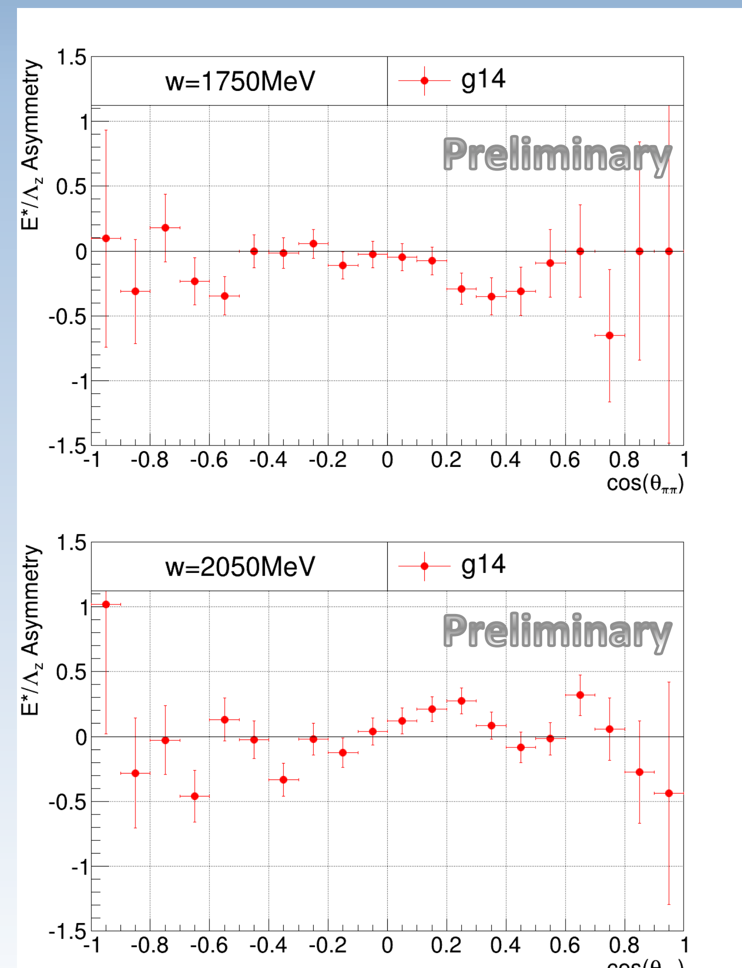
: $I^{\odot}$ [S. Park's g9a analysis.] : $I^{\odot}$ [S. Strauch *et al.*, Phys. Rev. Lett. 95(2005) 162003.]

$P_z^{\odot}(\theta_{\pi\pi})$: E^*/Λ_z vs. $\cos(\theta_{\pi\pi})$

Proton target



Neutron target



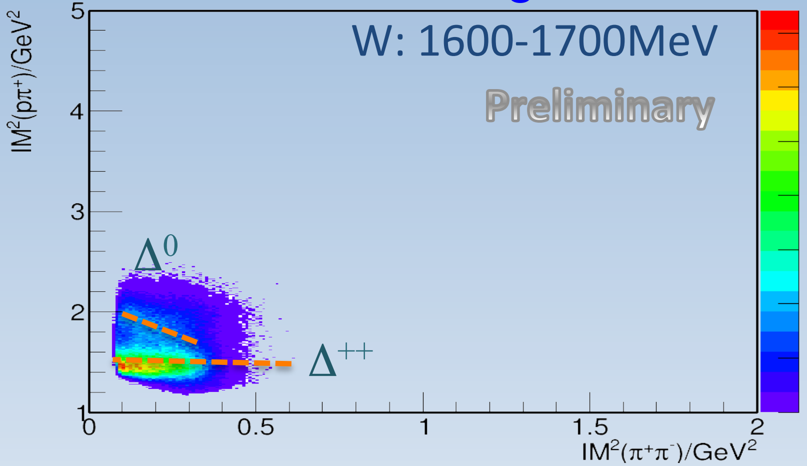
Dalitz Plots

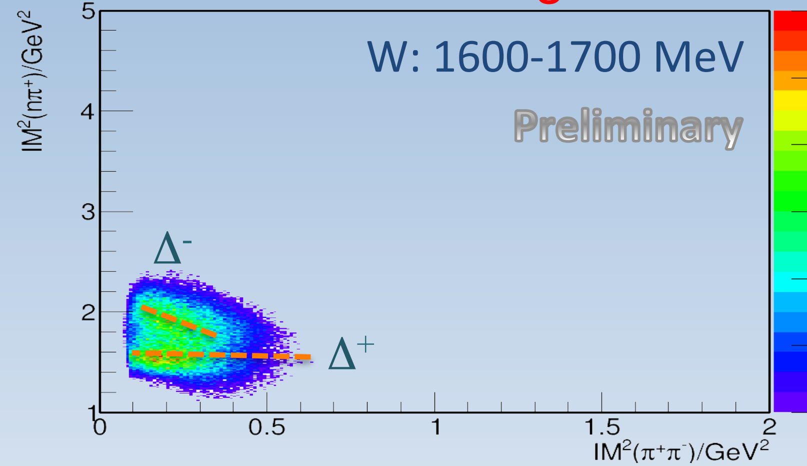
$\gamma p \rightarrow N^{*}$ or $\Delta^{*} \rightarrow \pi^{-}\Delta^{++}$, $\pi^{+}\Delta^{0}$ or $\rho^{0}p \rightarrow p\pi^{+}\pi^{-}$

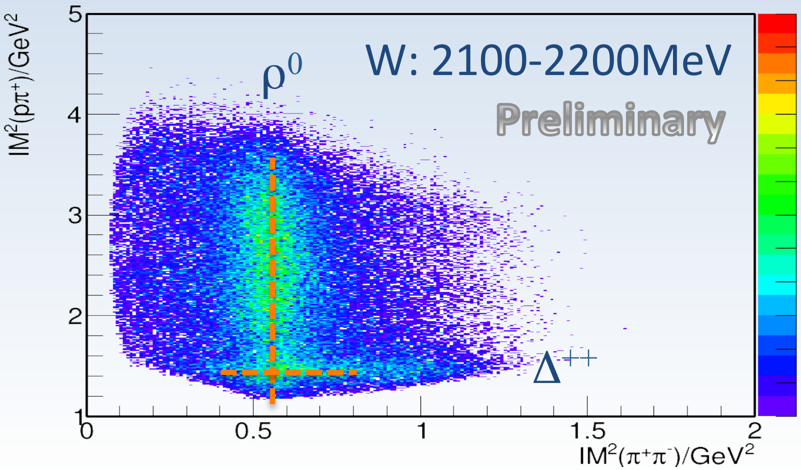
$\gamma n \rightarrow N^{*}$ or $\Delta^{*} \rightarrow \pi^{-}\Delta^{+}$, $\pi^{+}\Delta^{-}$ or $\rho^{0}n \rightarrow n\pi^{+}\pi^{-}$

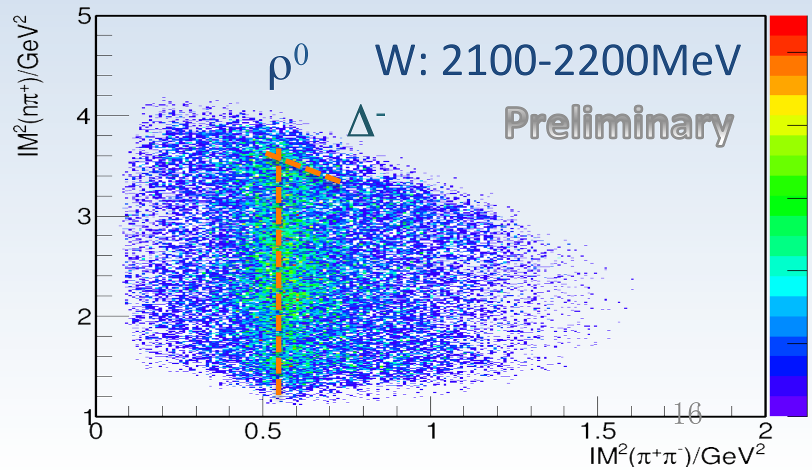
Proton target

Neutron target









Summary and Future Work

- Introduced G14 experiment
- Showed preliminary result for two charged pion channel: Asymmetry and dalitz plots

- Use full data to separate P_z, $I^{\odot}$, $P_z^{\odot}$
- Use dalitz plots to study intermediate channels

GRAZIE!

DISCUSSIONE?

Backup slides

For circularly polarized beam, and longitudinal polarized target, $\delta_l=0$, $\Lambda=\Lambda_z$,

$d\sigma/d\Omega = \sigma_0\{(1+\Lambda_z P_z) + \delta_\odot(I^\odot+\Lambda_z P_z^\odot)\}$

$$P_z = \frac{1}{\Lambda_z}\frac{[N(\rightarrow\Rightarrow)+N(\leftarrow\Rightarrow)]-[N(\rightarrow\Leftarrow)+N(\leftarrow\Leftarrow)]}{[N(\rightarrow\Rightarrow)+N(\leftarrow\Rightarrow)]+[N(\rightarrow\Leftarrow)+N(\leftarrow\Leftarrow)]}$$

$$I^\odot = \frac{1}{\delta_\odot}\frac{[N(\rightarrow\Rightarrow)+N(\rightarrow\Leftarrow)]-[N(\leftarrow\Rightarrow)+N(\leftarrow\Leftarrow)]}{[N(\rightarrow\Rightarrow)+N(\rightarrow\Leftarrow)]+[N(\leftarrow\Rightarrow)+N(\leftarrow\Leftarrow)]}$$

$$P_z^\odot = \frac{1}{\Lambda_z\delta_\odot}\frac{[N(\rightarrow\Rightarrow)+N(\leftarrow\Leftarrow)]-[N(\rightarrow\Leftarrow)+N(\leftarrow\Rightarrow)]}{[N(\rightarrow\Rightarrow)+N(\leftarrow\Leftarrow)]+[N(\rightarrow\Leftarrow)+N(\leftarrow\Rightarrow)]}$$

$\rightarrow$ denotes the direction of polarization for the photon beam;

$\Rightarrow$ denotes the direction of polarization for the target.

$$E^* = \frac{1}{\delta_\odot}\frac{N(\rightarrow\Rightarrow)-N(\leftarrow\Rightarrow)}{N(\rightarrow\Rightarrow)+N(\leftarrow\Rightarrow)} = (I^\odot+\Lambda_z P_z^\odot)\frac{1}{1+\Lambda_z P_z} \approx I^\odot$$

Backup slides

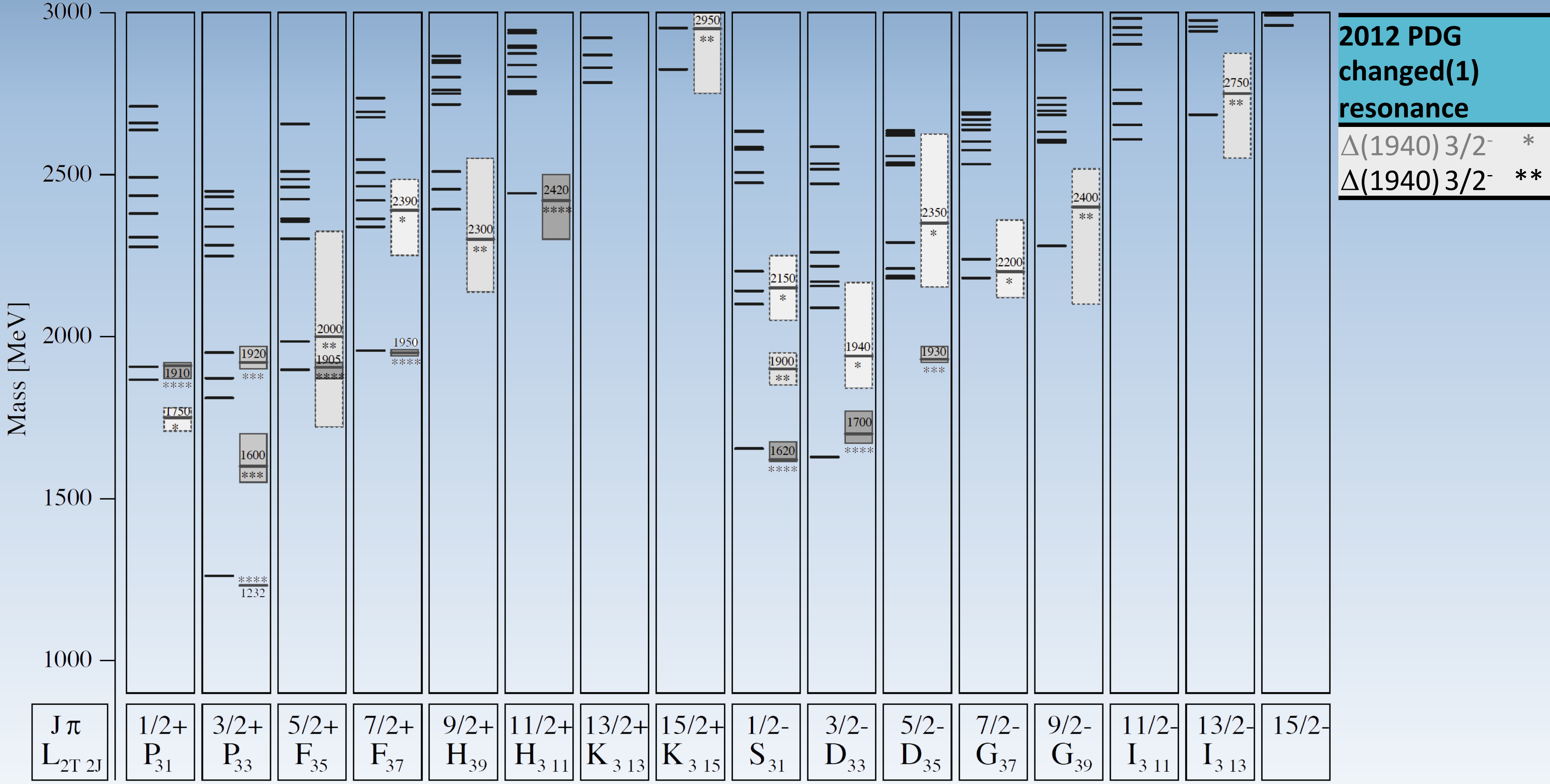
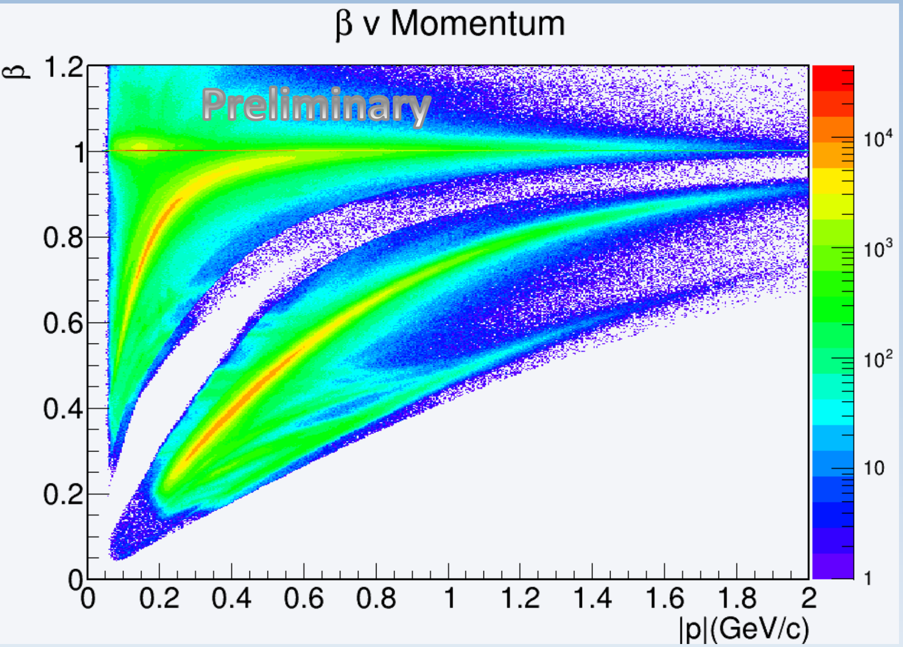


Figure 2. The calculated Δ-resonance spectrum. [U. Loring *et al*., Eur. Phys. J. A 10(2001) 395]

Backup slides



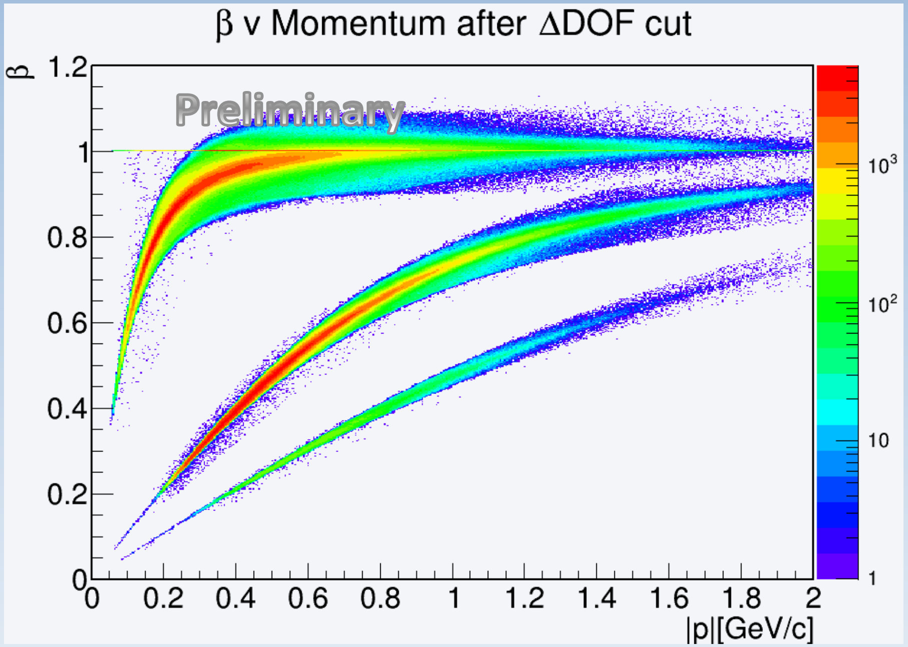


Figure. PID from GPID bank: β vs. |p| for $\pi^{\pm}$, proton, deuteron before and after ΔTOF cut.

Backup slides

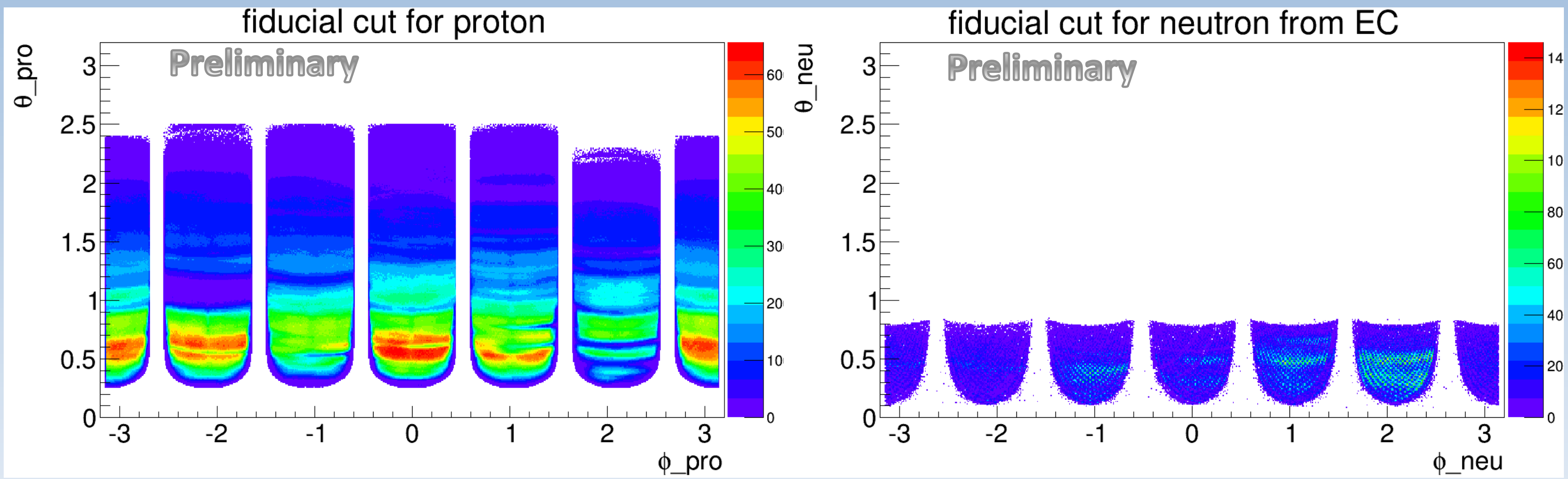
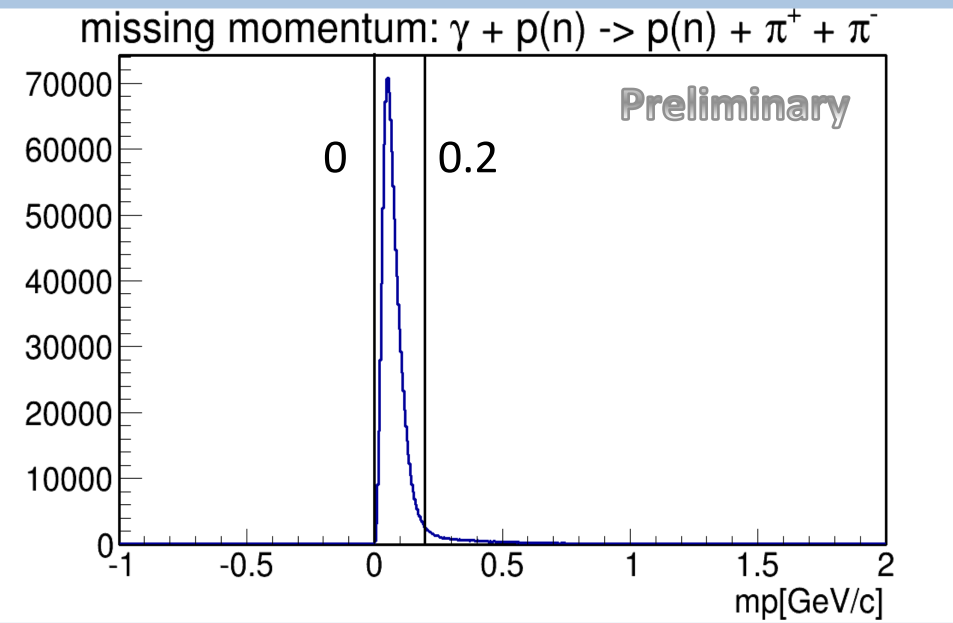


Figure. Fiducial cut for proton and neutron.

Backup slides

Proton target



Neutron target

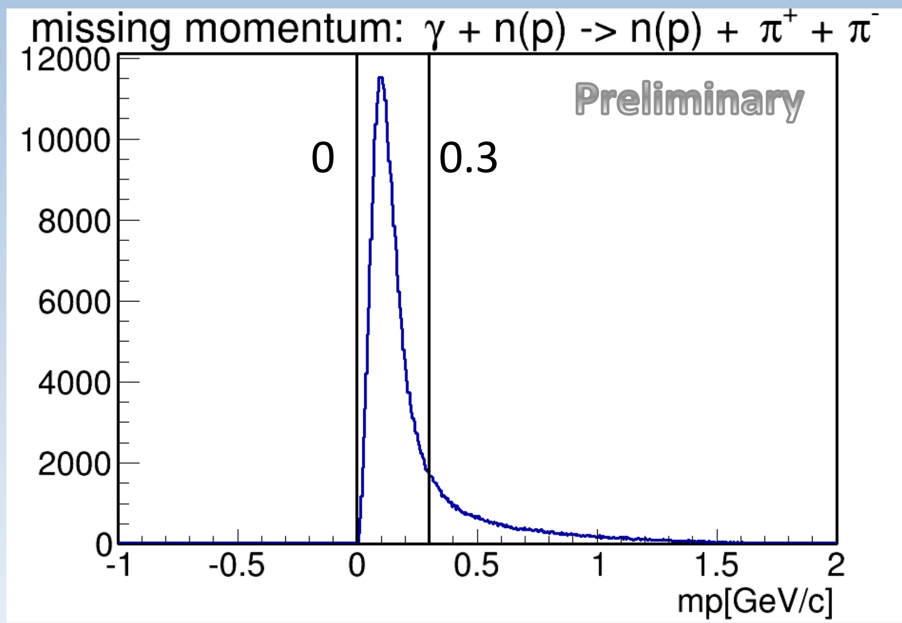


Figure. Missing momentum cut.

Backup slides

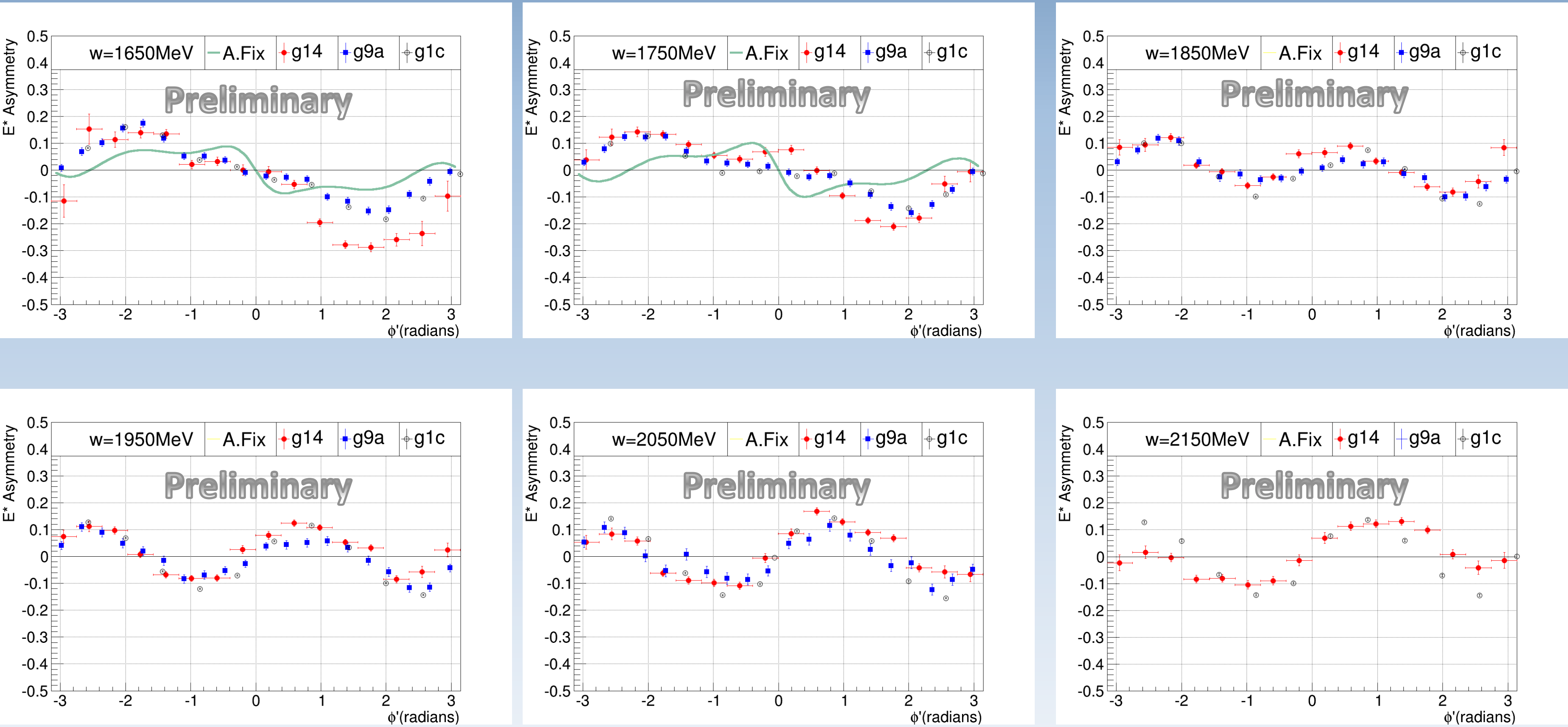


Figure. E* asymmetry vs. ϕ' for proton target.

Backup slides

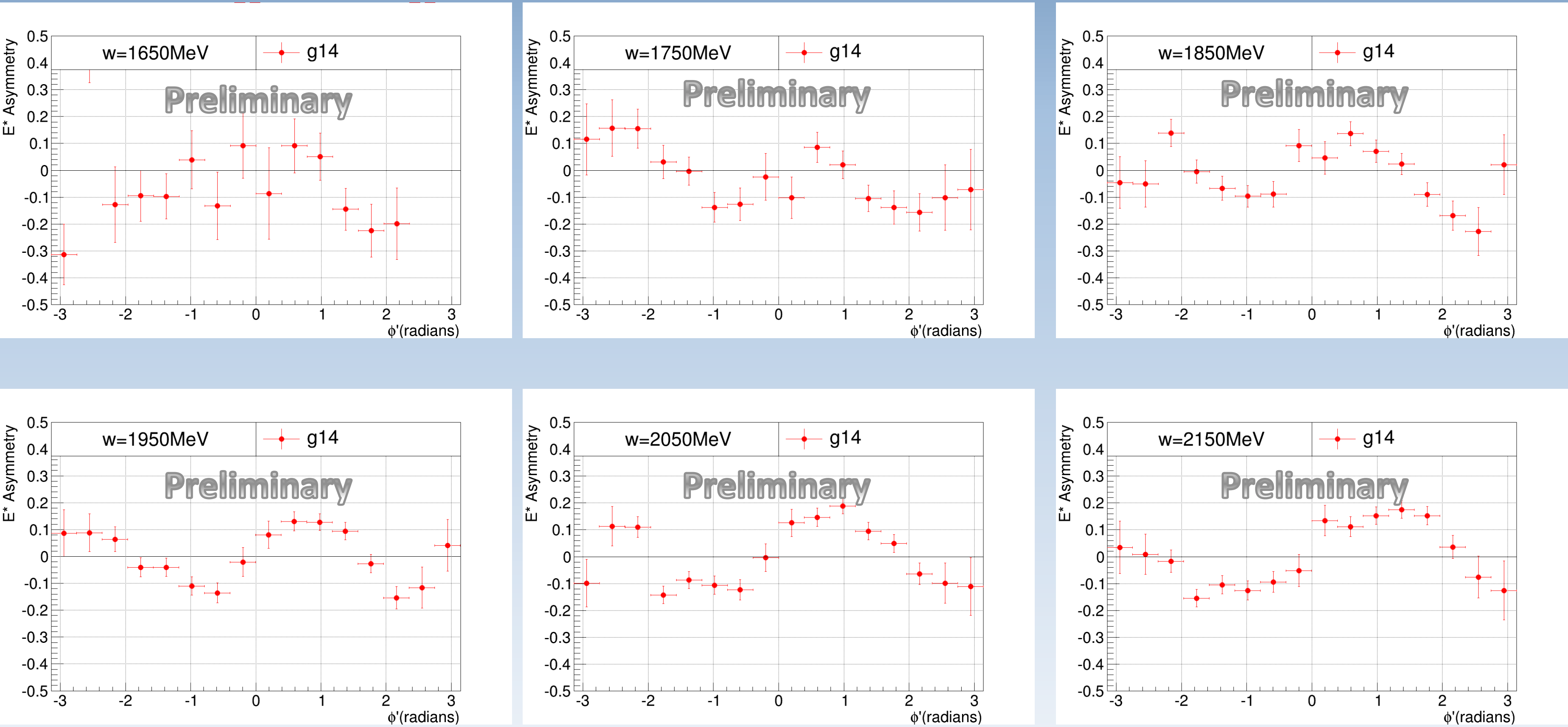


Figure. E* asymmetry vs. ϕ’ for quasi free neutron target.

Backup slides

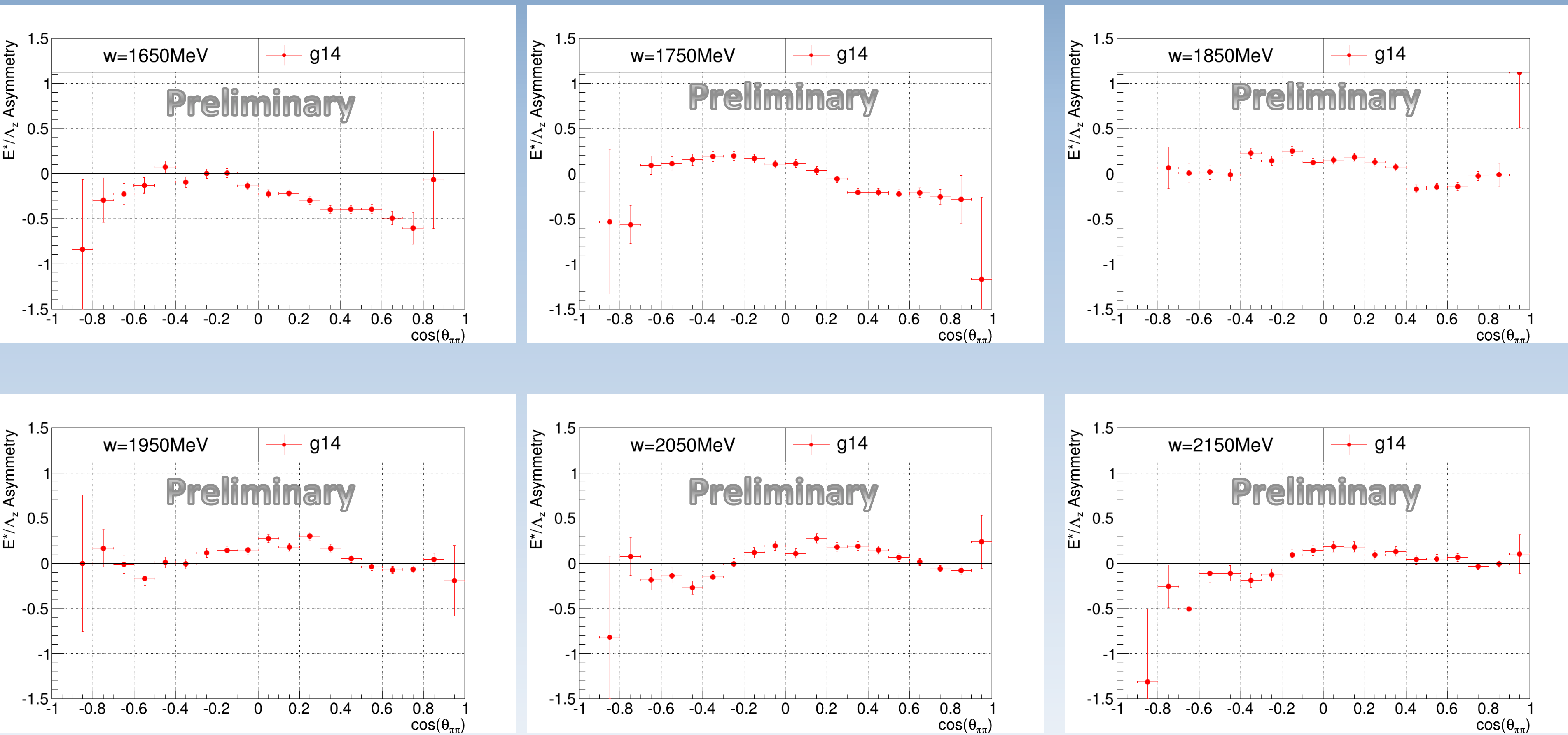


Figure. E^*/Λ_z asymmetry vs. $\cos(\theta_{\pi\pi})$ for proton target.

Backup slides

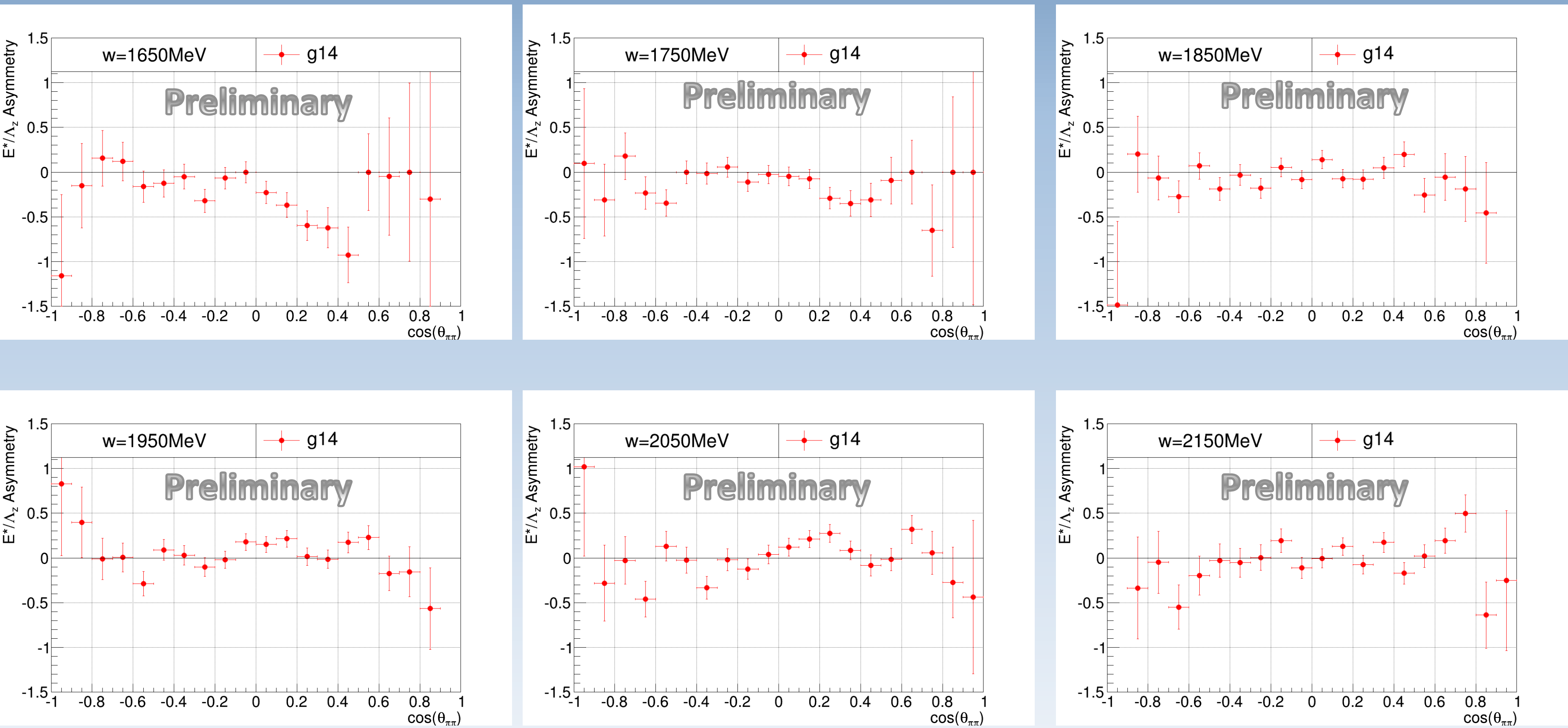


Figure. E^*/Λ_z asymmetry vs. $\cos(\theta_{\pi\pi})$ for quasi free neutron target.