Meson photoproduction with CLAS

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Jefferson Lab

For the CLAS Collaboration

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KRAKÓW, POLAND
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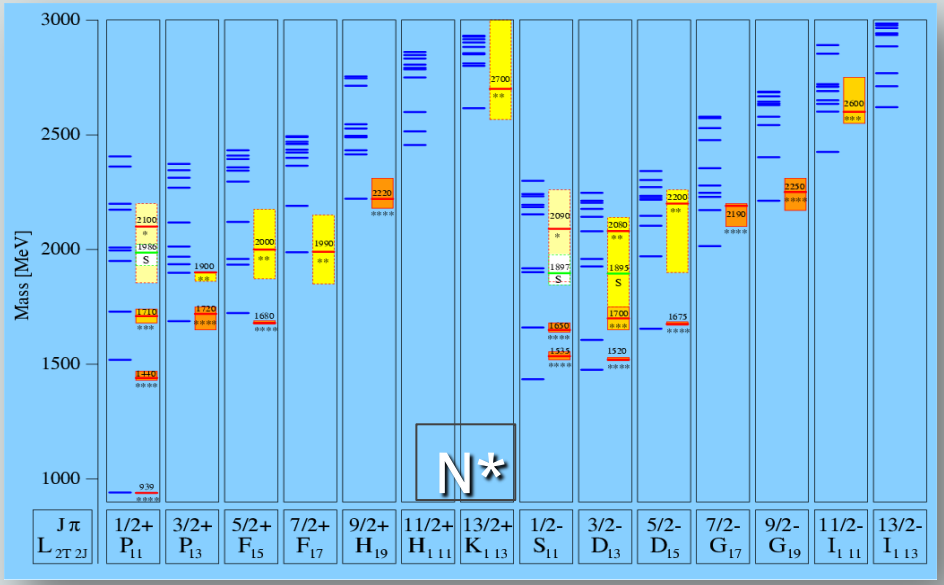
JSA Jefferson Lab
Thomas Jefferson National Accelerator Facility

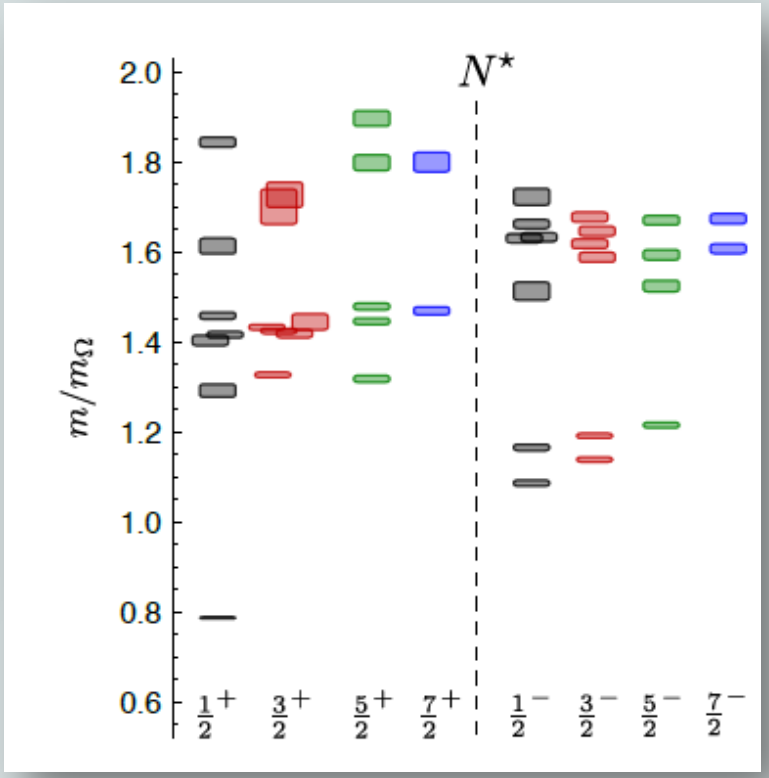
MESON 2012

Outline

- Introduction
- Experimental details
- Selected results: single pion photoproduction
- Summary

Baryon Resonance Spectrum





- Masses, widths, and coupling constants not well known for many resonances
- Most models predict more resonance states than observed

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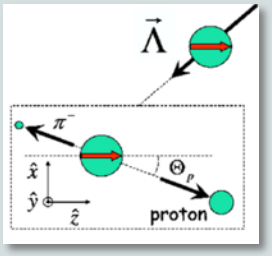

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$\Sigma d\sigma/dt$	$\|b_1\|^2+\|b_2\|^2-\|b_3\|^2-\|b_4\|^2$	$\{L(\frac{1}{2}\pi,0);-;-\}$	
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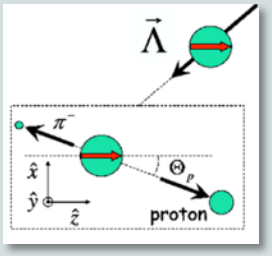

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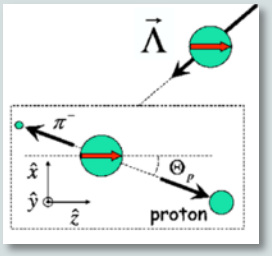

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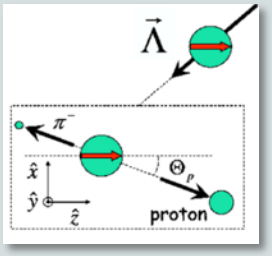

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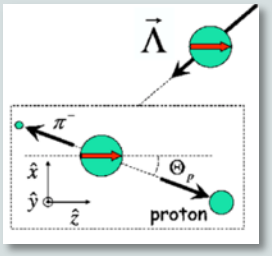

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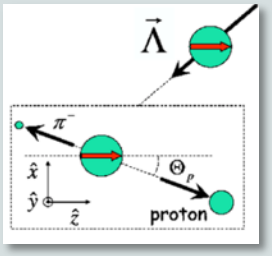

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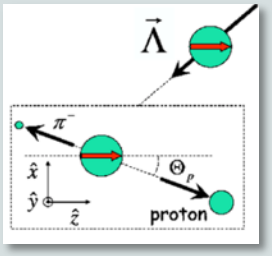

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Complete, and over-determined

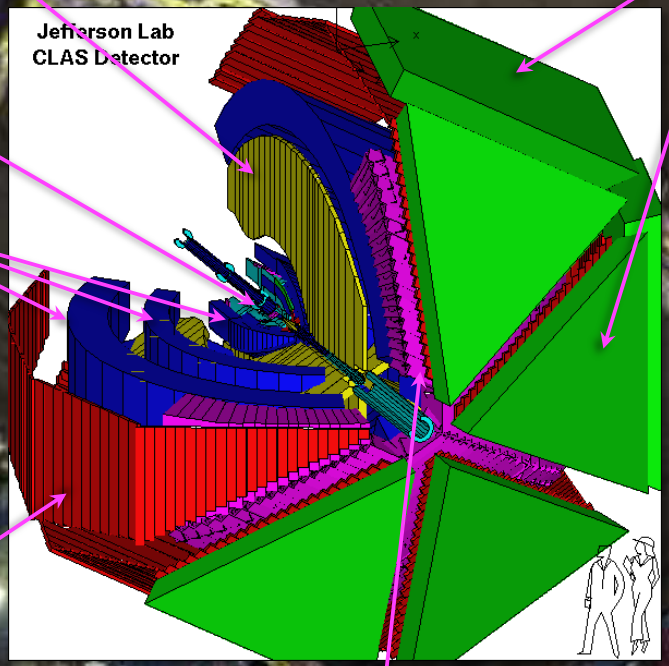
CEBAF Large Acceptance Spectrometer 1997-2012

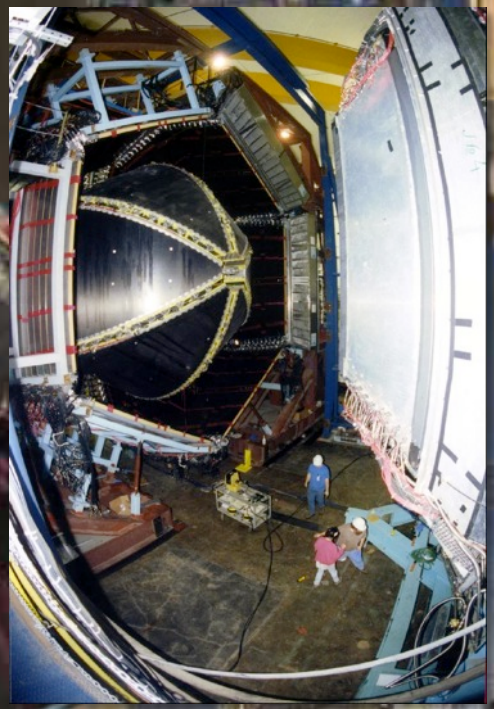
Torus magnet
6 superconducting coils

Electromagnetic calorimeters
Lead/scintillator, 1296 photomultipliers

target, start counter

Drift chambers
35,000 cells

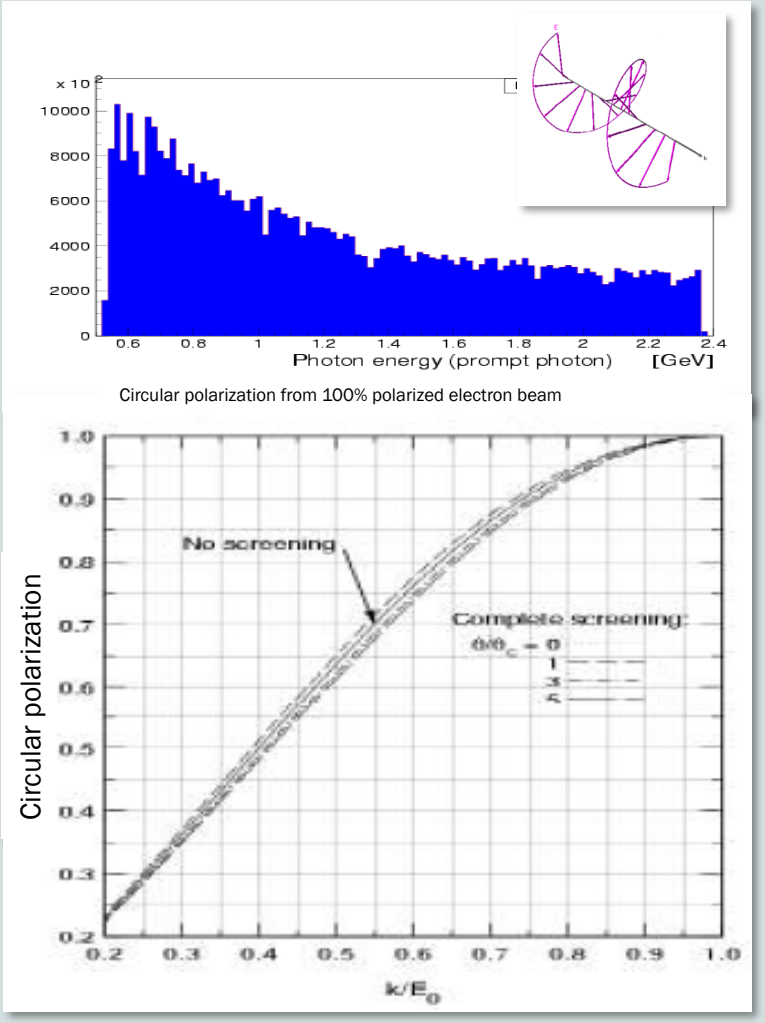




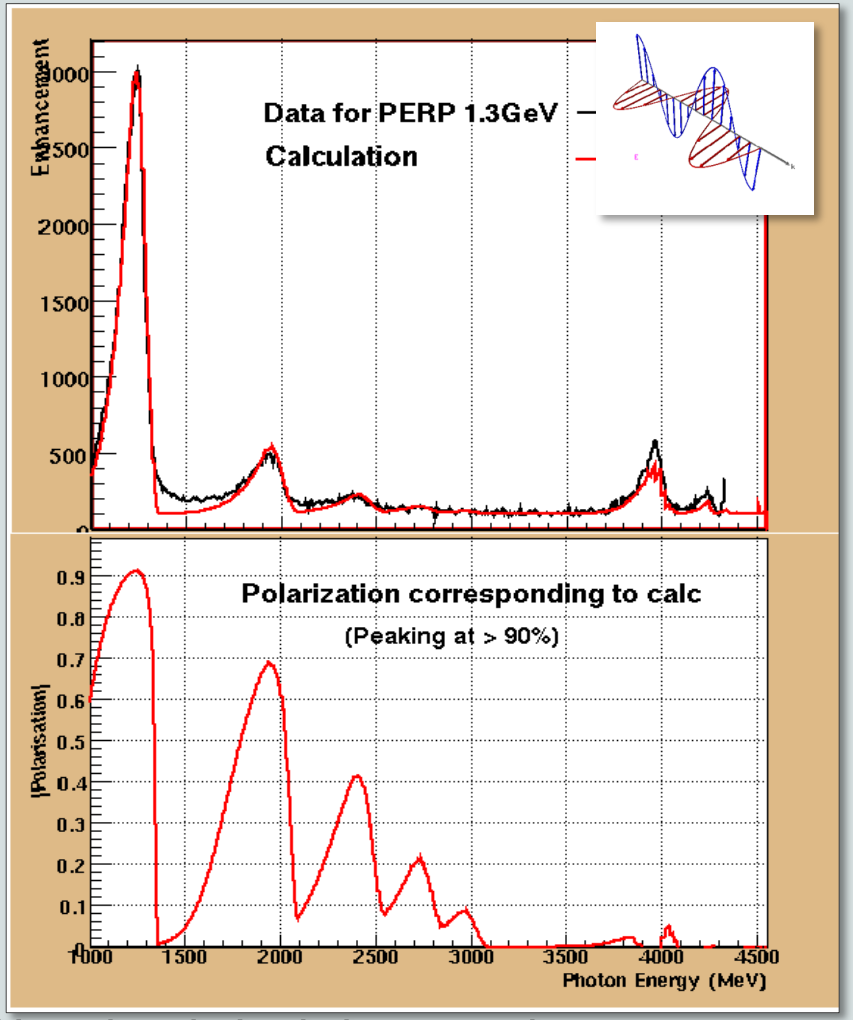
Time-of-flight counters
plastic scintillators, 684 photomultipliers

Gas Cherenkov counters
e/π separation, 256 PMTs

Polarized pohoton beam

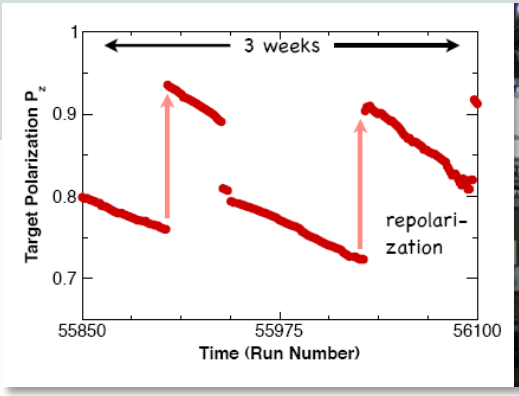


Circularly polarized beam produced by longitudinally polarized electrons



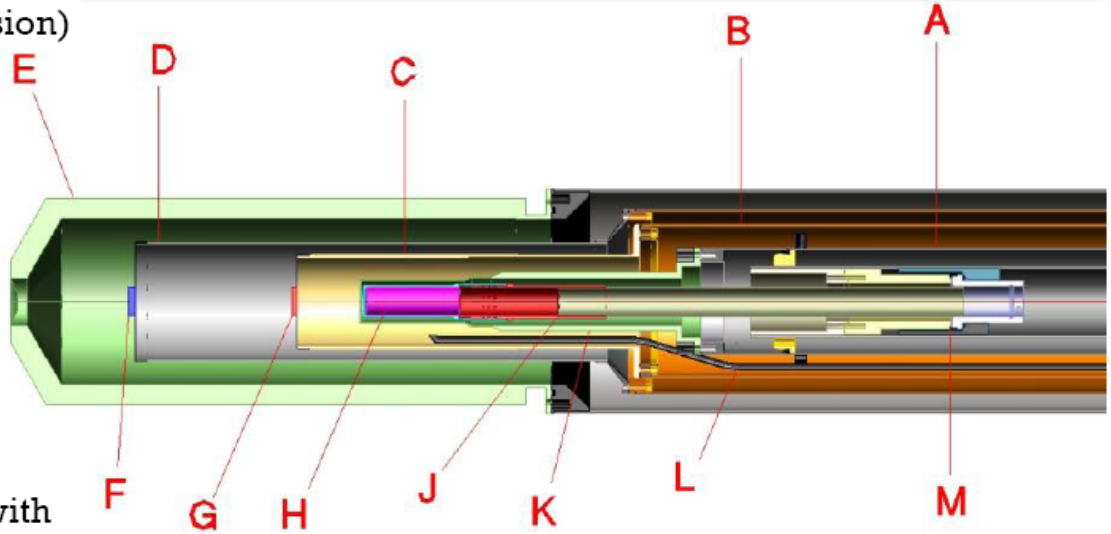
Linearly polarized photons: coherent bremsstrahlung on oriented diamond crystal

FROST



The FroST target and its components:

A: Primary heat exchanger
B: 1 K heat shield
C: Holding coil
D: 20 K heat shield
E: Outer vacuum can (Rohacell extension)
F: CH2 target
G: Carbon target
H: Butanol target
J: Target insert
K: Mixing chamber
L: Microwave waveguide
M: Kapton coldseal



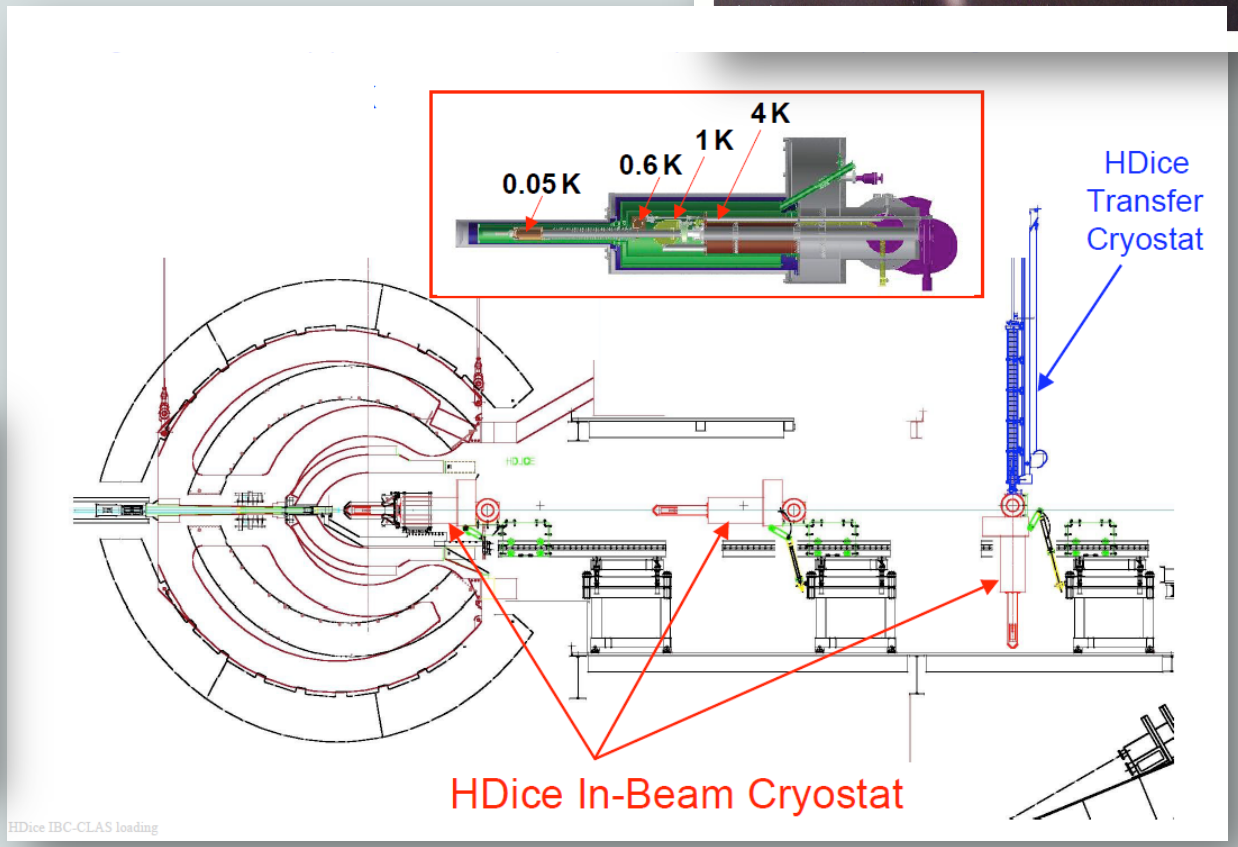
Performance Specs:

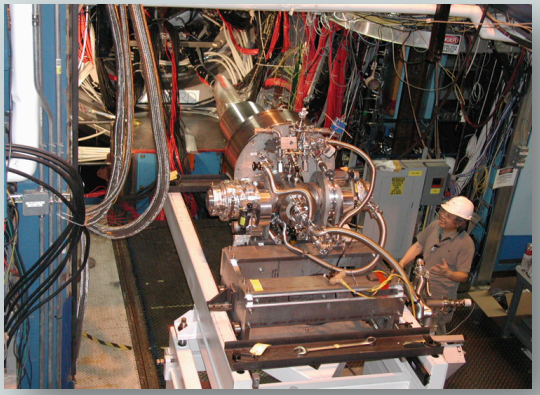
Base Temp: 28 mK w/o beam, 30 mK with
Cooling Power: 800 μW @ 50 mK, 10 mW @ 100 mK, and 60 mW @ 300 mK
Polarization: +82%, -90%
1/e Relaxation Time: 2800 hours (+Pol), 1600 hours (-Pol)
Roughly 1% polarization loss per day.

HDIce polarized target

HDIce Solid Deuterium-Hydride (HD) – a new class of polarized target

- Polarized at very high magnetic field and very low temperatuer
- Transferred to in beam cryostat
- Spin can be moved between H and D with RF transitions
- All material can be polarized with almost no background





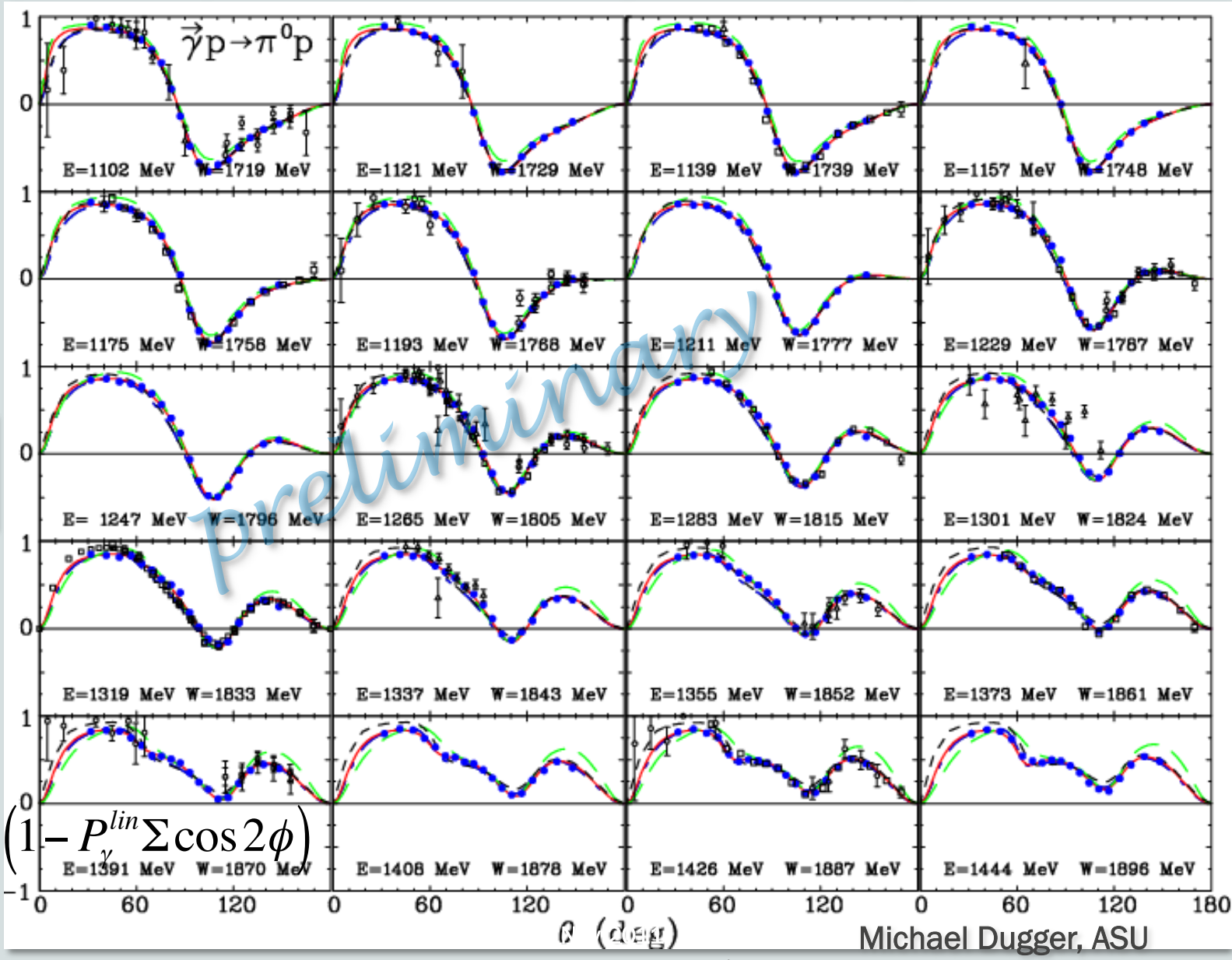
What we measure with CLAS

- $\gamma p \rightarrow \pi^0 p$, $\pi^+ n$
- $\gamma p \rightarrow \eta p$
- $\gamma p \rightarrow \eta' p$
- $\gamma p \rightarrow KY$ ($K^+\Lambda$, $K^+\Sigma^0$, $K^0\Sigma^+$)
- $\gamma p \rightarrow \pi^+\pi^- p$ ωp, ρp, ϕp

- $\gamma n \rightarrow \pi^- p$
- $\gamma n \rightarrow \pi^+\pi^- n$
- $\gamma n \rightarrow \Sigma^- K^+$, ΛK^0
- $\gamma n \rightarrow \omega n$

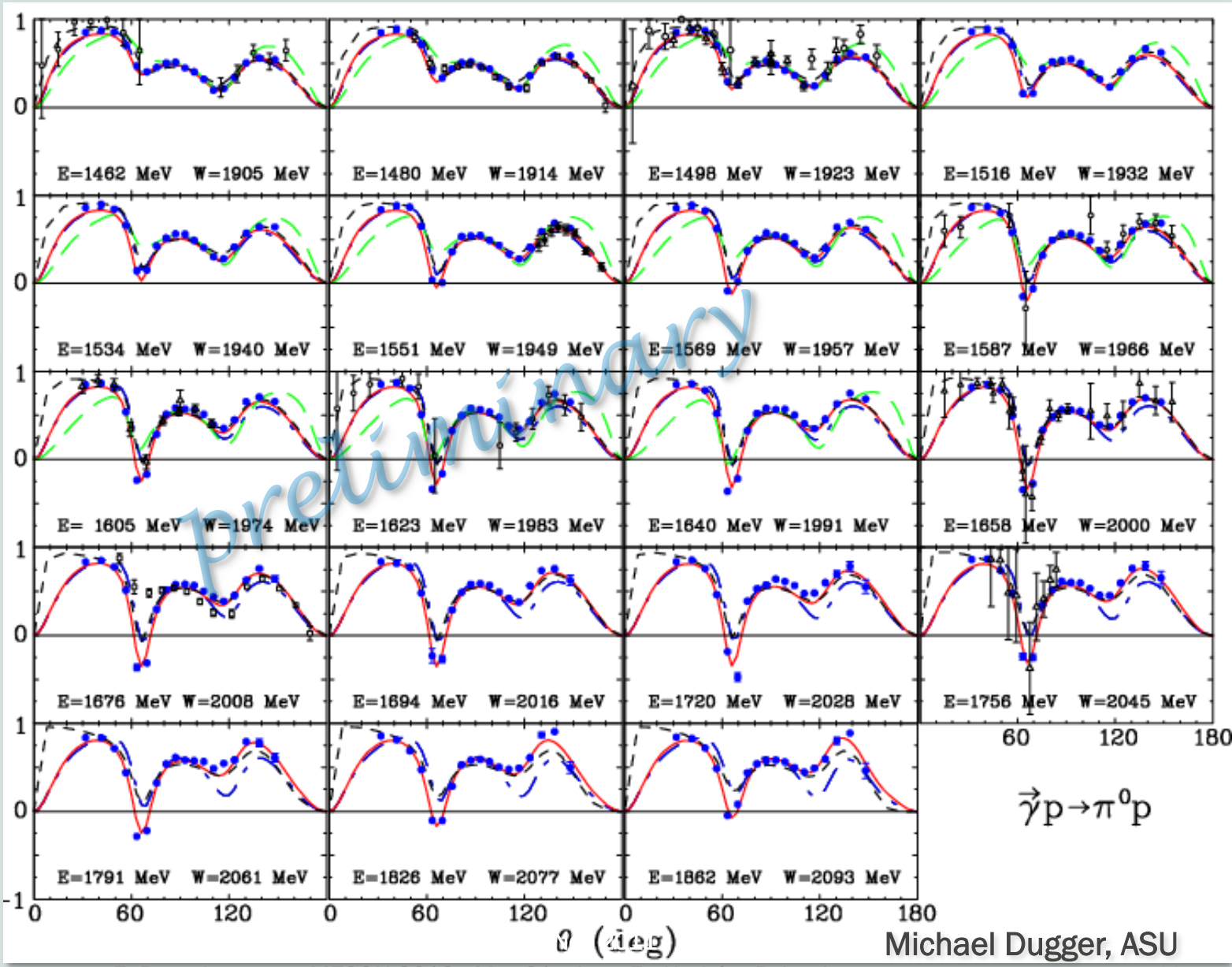
Polarization in Single pion photoproduction

γp→π⁰p Photon asymmetry Σ

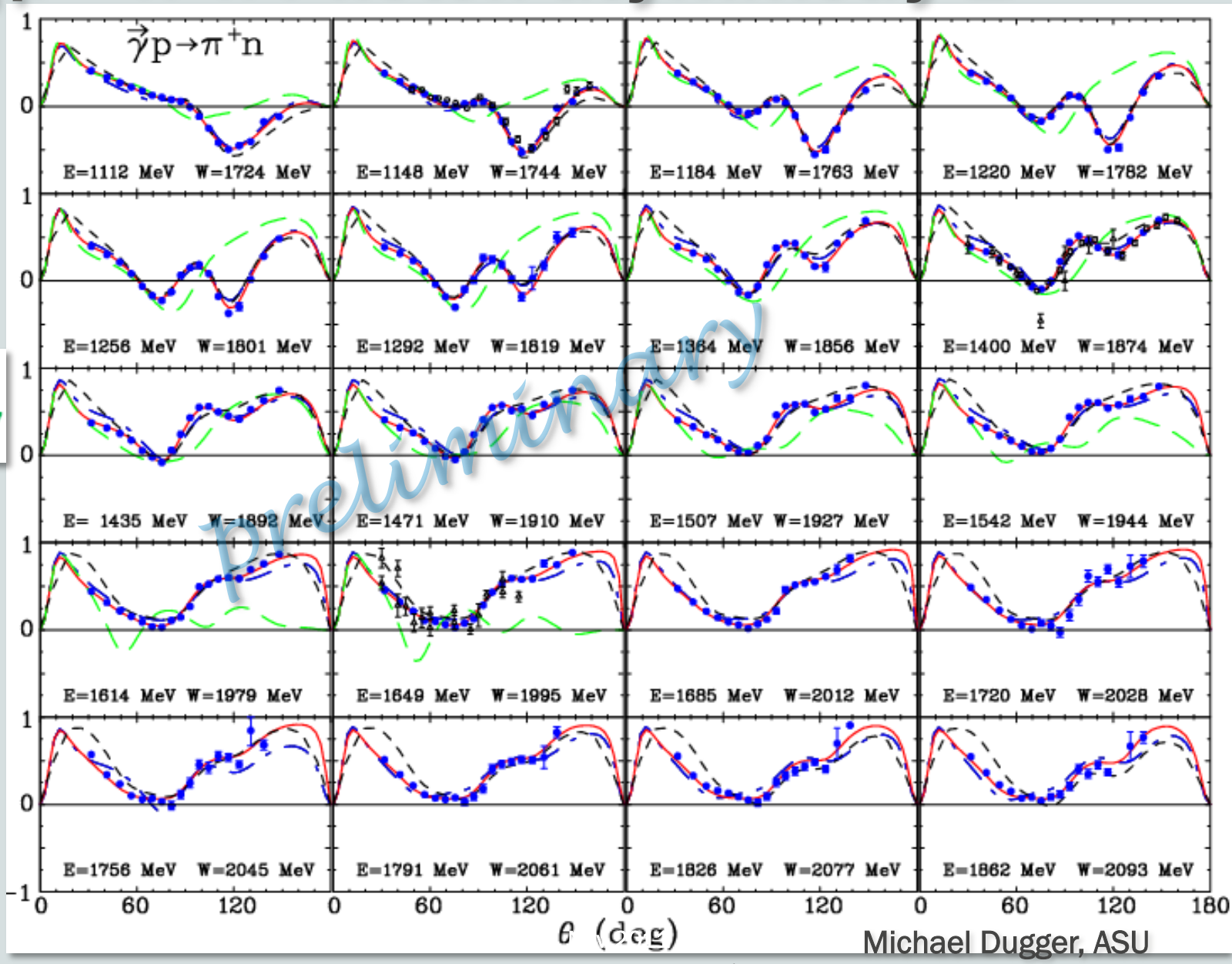


$$\frac{d\sigma}{d\Omega}=\left(\frac{d\sigma}{d\Omega}\right)_0\left(1-P_\gamma^{lin}\Sigma\cos 2\phi\right)$$

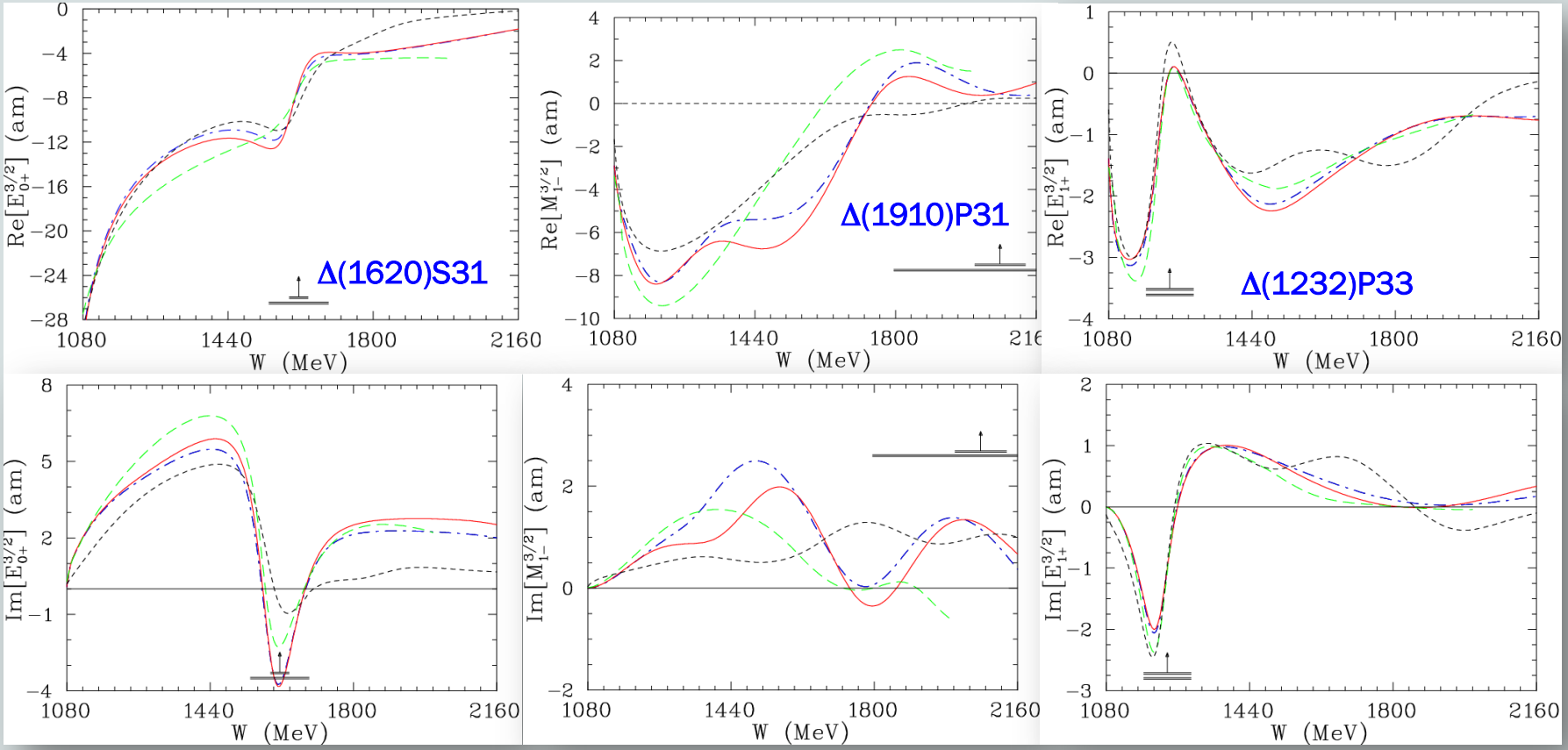
$\gamma p \rightarrow \pi^0 p$ Photon asymmetry Σ



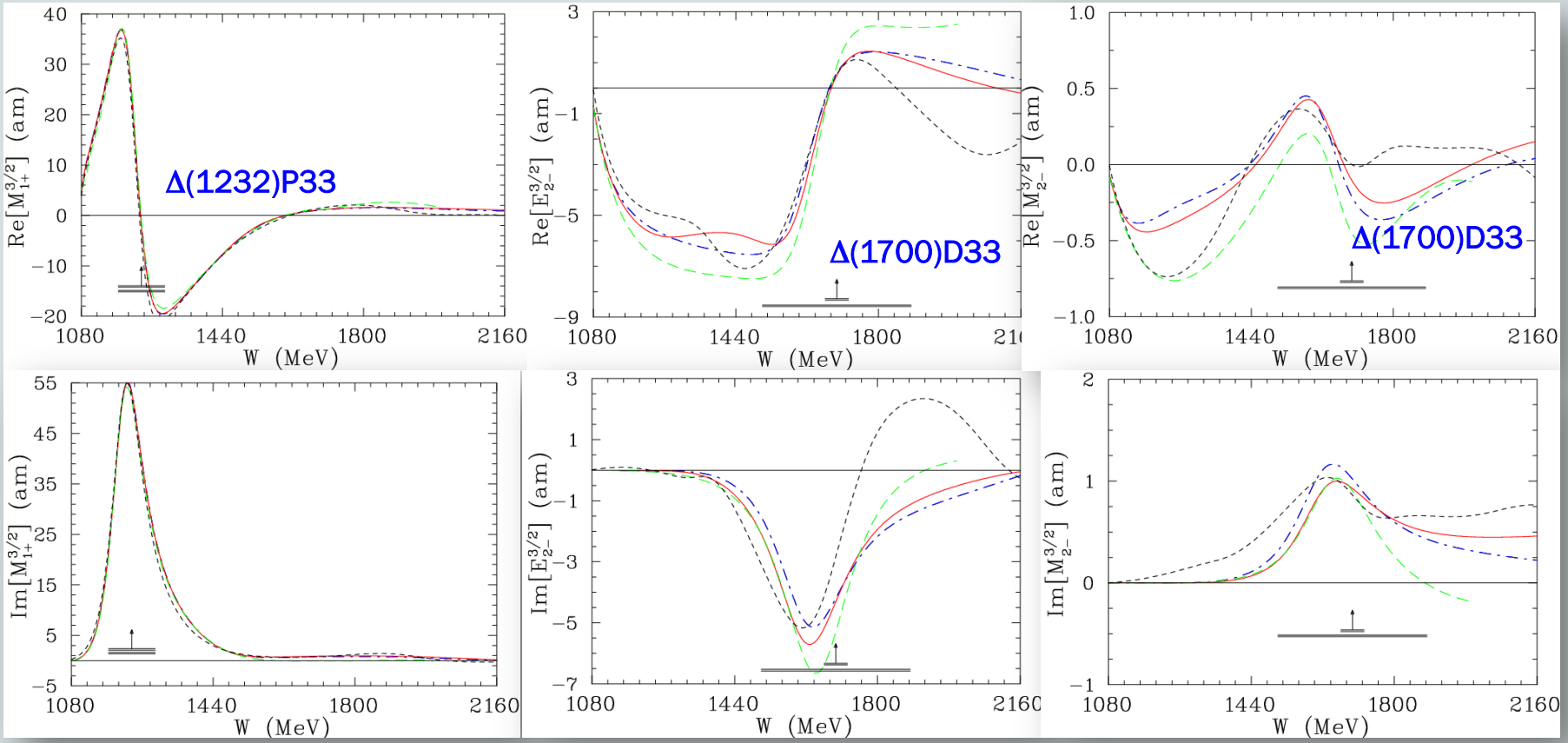
$\gamma p \rightarrow \pi^+ n$ Photon asymmetry Σ



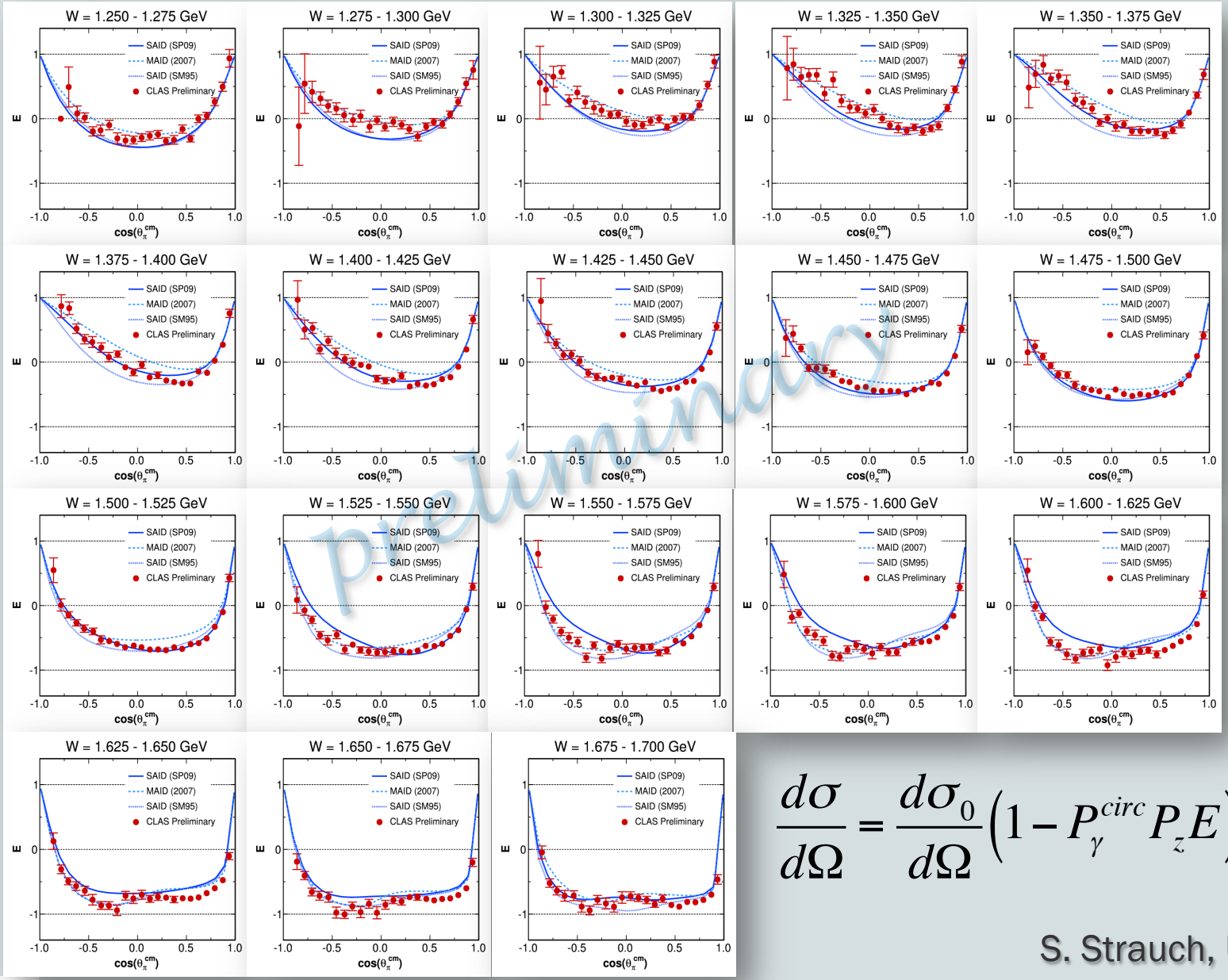
I=3/2 multipoles



I=3/2 multipoles



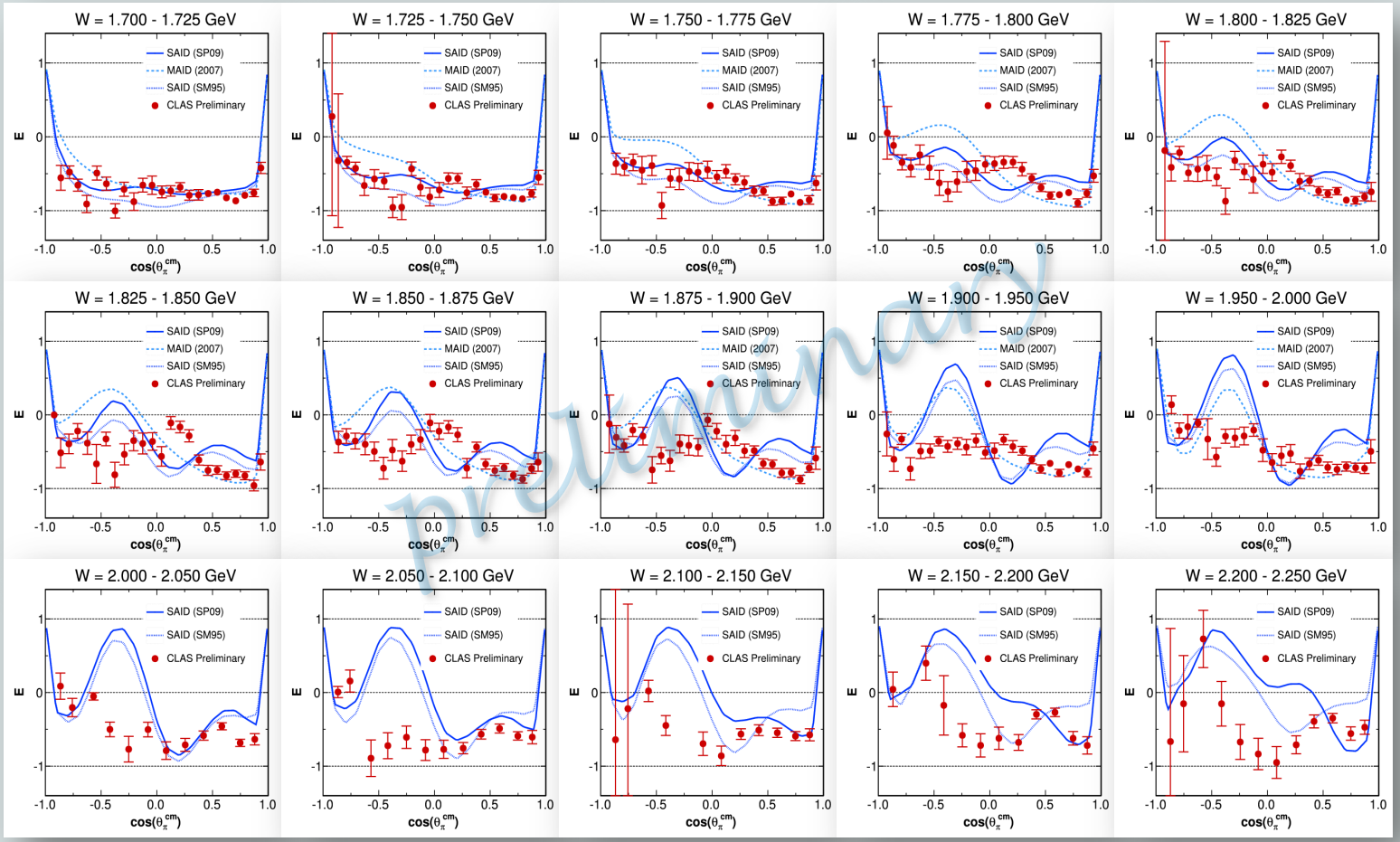
$\gamma p \rightarrow \pi^+ n$ Helicity asymmetry E



$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega}\left(1 - P_\gamma^{circ} P_z E\right)$$

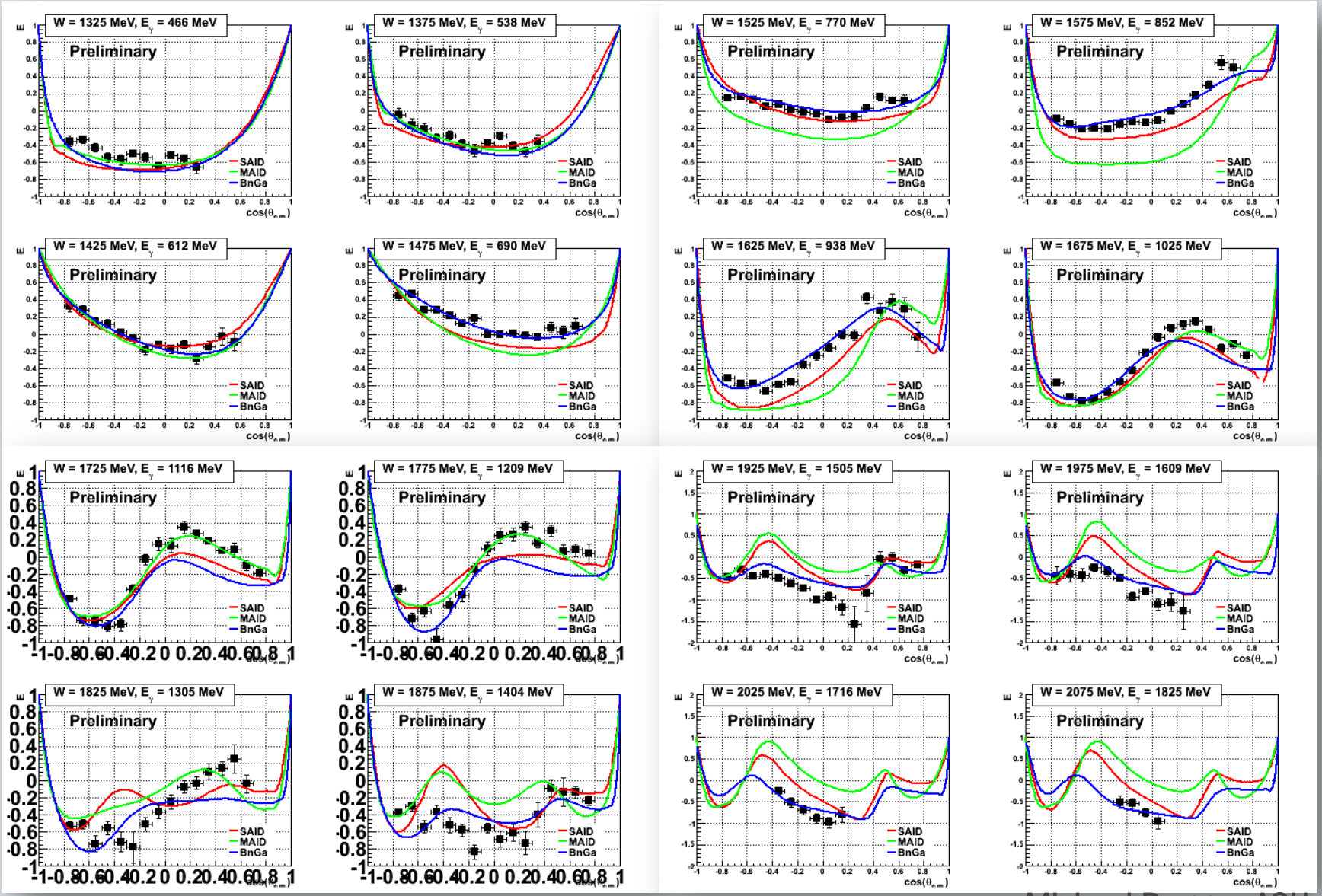
S. Strauch, USC

$\gamma p \rightarrow \pi^+ n$ Helicity asymmetry E



For W< 1.75 GeV all of the models represent the data fairly well.
For W> 1.75 GeV none of the models represents the data well.

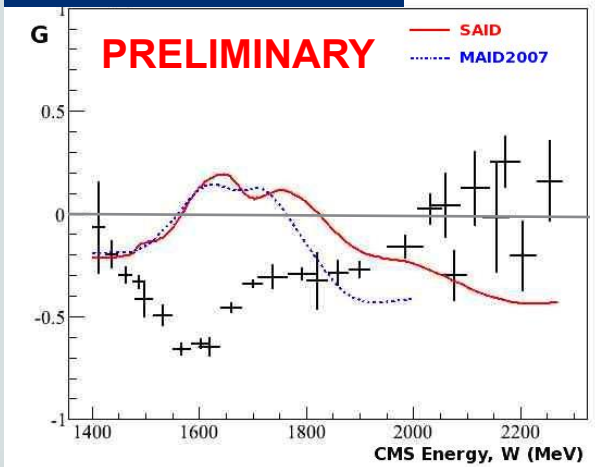
$\gamma p \rightarrow \pi^0 p$ Helicity asymmetry E



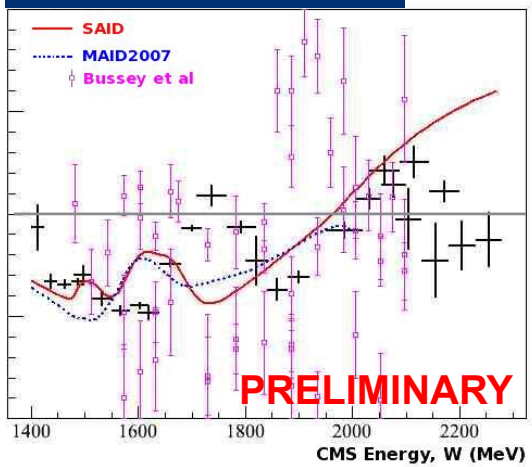
Michael Dugger, ASU

$\gamma p \rightarrow \pi^+ n$ Helicity asymmetry G

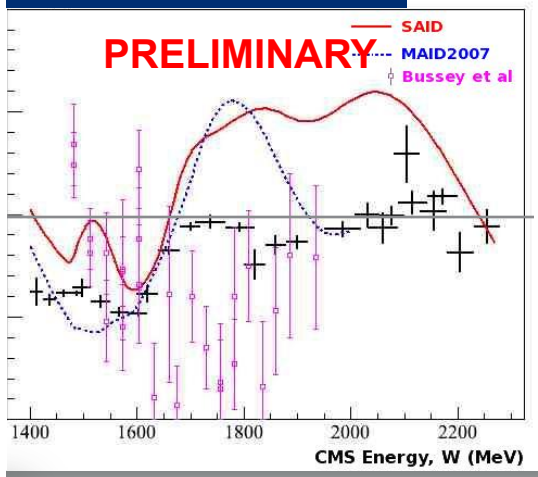
$\cos(\theta_\pi)$=-1 to -0.6



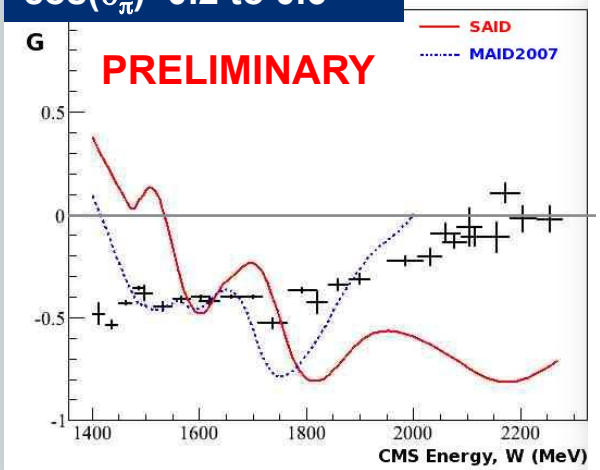
$\cos(\theta_\pi)$=-0.6 to -0.2



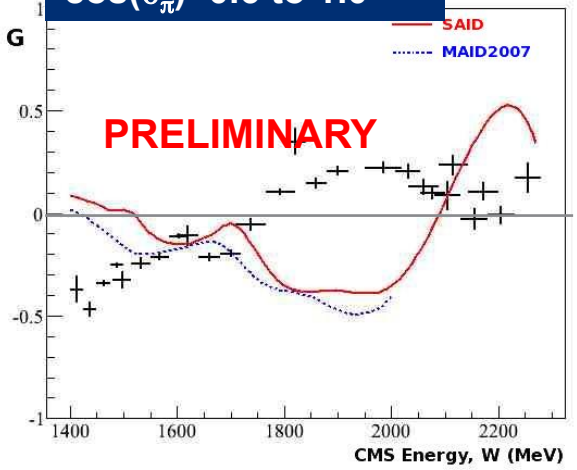
$\cos(\theta_\pi)$=-0.2 to 0.2



$\cos(\theta_\pi)$=0.2 to 0.6



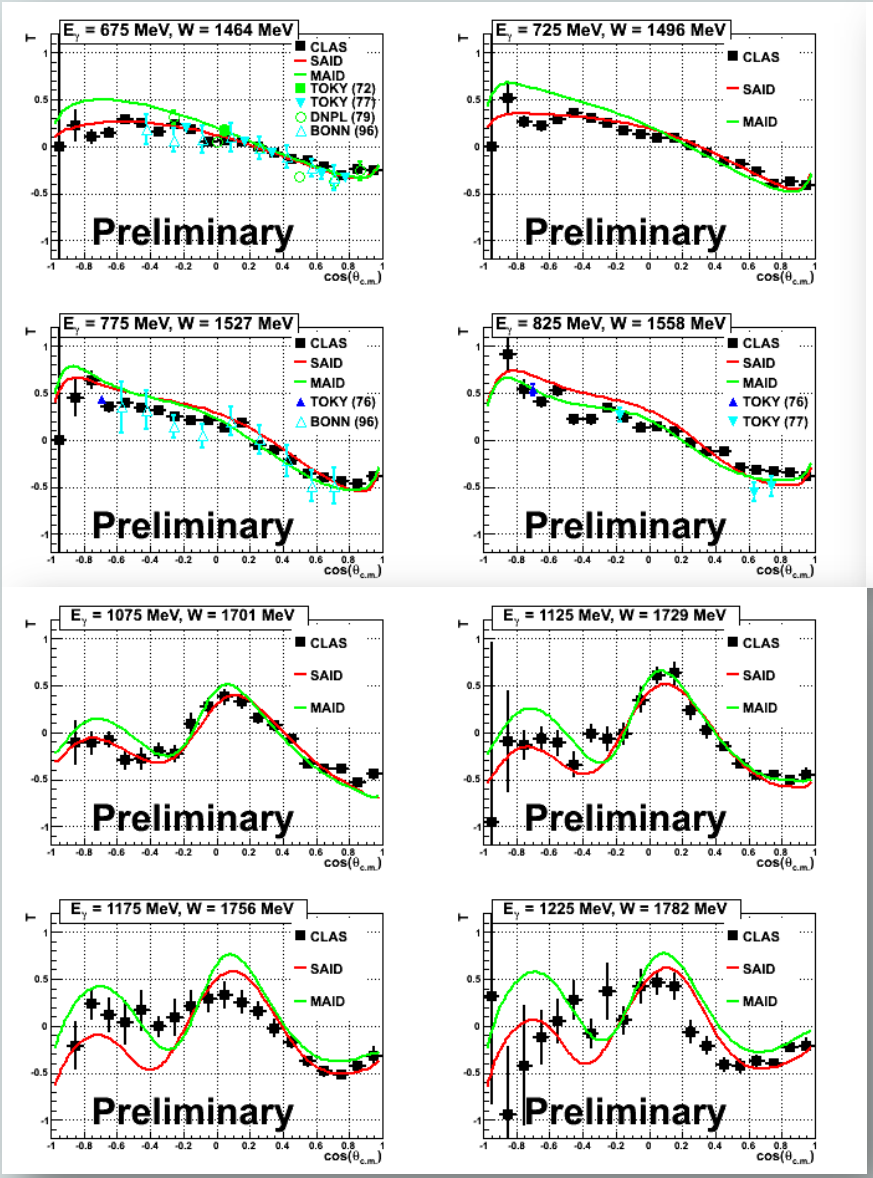
$\cos(\theta_\pi)$=0.6 to 1.0



$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega}\left(1 - P_T \Sigma \cos(2\varphi) + P_T P_z G \sin(2\varphi)\right)$$

Jo McAndrew

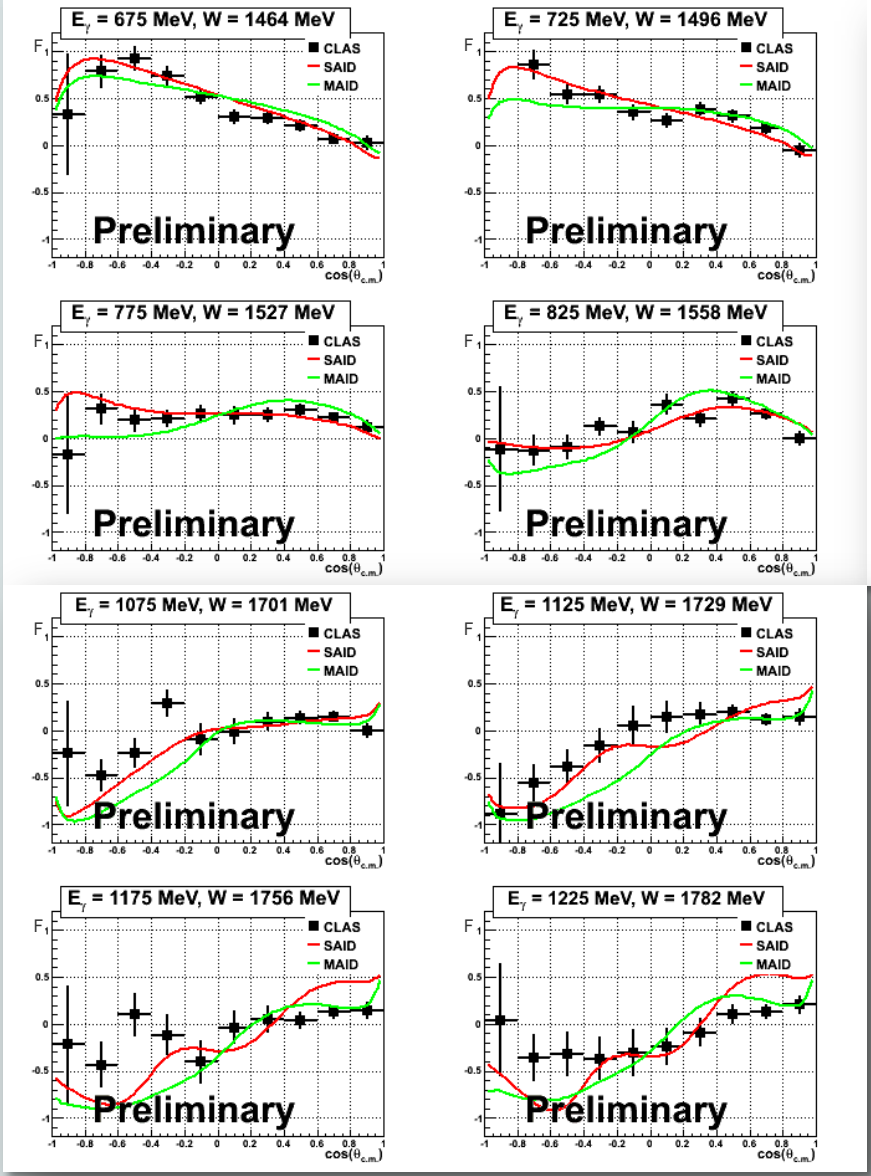
$\gamma p \rightarrow \pi^+ n$ Target asymmetry T

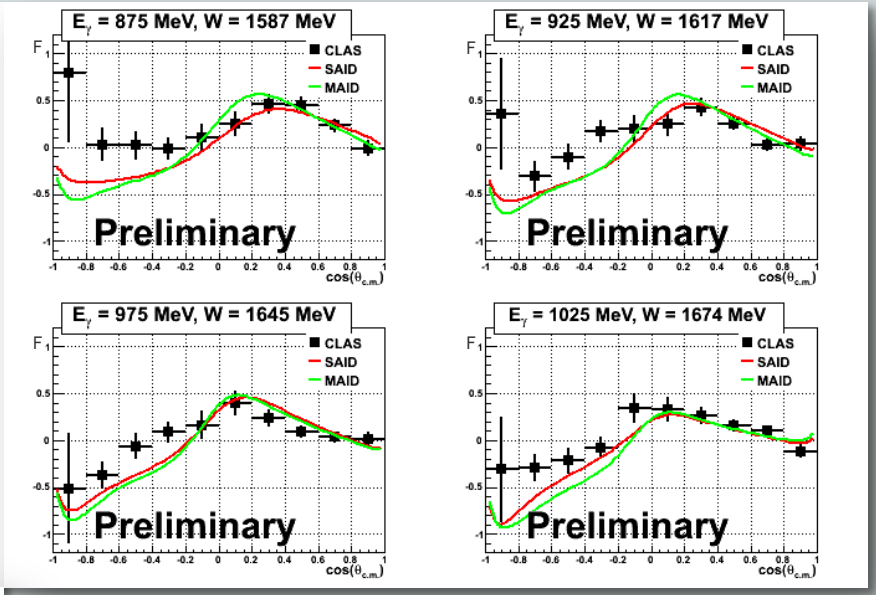


$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega}\left(1 + P_y T\right)$$

Michael Dugger, ASU

$\gamma p \rightarrow \pi^+ n$ asymmetry F





$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega}\left(1 + P_x P_\gamma^{circ} F + P_y T\right)$$

Michael Dugger, ASU

Status of meson photoproduction

	σ	Σ	T	P	E	F	G	H	T_x	T_z	L_x	L_z	O_x	O_z	C_x	C_z
Proton target																
$p\pi^0$	✔	✓	✓	✓	✓	✓	✓	✓								
$n\pi^+$	✔	✓	✓	✓	✓	✓	✓	✓								
$p\eta$	✔	✓	✓	✓	✓	✓	✓	✓								
$p\eta'$	✔	✓	✓	✓	✓	✓	✓	✓								
$p\omega$	✔	✓	✓		✓	✓	✓	✓								
$K^+\Lambda$	✔	✓	✓	✔	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✔	✔
$K^+\Sigma^0$	✔	✓	✓	✔	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✔	✔
$K^{0*}\Sigma^+$	✔	✓	✓	✓	✓	✓	✓	✓								
"Neutron" target																
$p\pi^-$	✔	✓	✓		✓	✓	✓	✓								
$p\rho^-$	✓	✓	✓		✓	✓	✓	✓								
$K^+\Sigma^-$	✓	✓	✓		✓	✓	✓	✓								
$K^0\Lambda$	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
$K^0\Sigma^0$	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
$K^{0*}\Sigma^0$	✓	✓														

✔ - published ✔ - acquired

Summary

- "*compete measurement*" in pseudoscalar meson photoproduction is reality
- Data collection with proton and deuteron targets is complete
- Data are being analyzed