Studies of η photoproduction in the baryon resonance excitation region with CLAS

APS DNP 2013 Fall Meeting: Mini Symposium on Meson Photoproduction and Nucleon Resonance Spectroscopy

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CLAS Collaboration

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Introduction

Mapping the Baryon Spectrum:

Straightforward approach: meson production experiment

i.e. measuring cross section (σ) vs. c.o.m. energy (W)

(meson as emission upon baryon de-excitation)

Complications:

1. superposition $N^*(I = \frac{1}{2})$ and $\Delta(I = \frac{3}{2})$
2. baryon resonances are broad compared to their spacing - difficult to disentangle

Solutions:

1. **resonance filtering:** $\eta(I = 0) + N(I = \frac{1}{2}) \rightarrow N^*(I = \frac{1}{2})$ resonances
2. measure **polarization observables** in addition to cross section

Study photoproduction amplitudes by measuring η production spectra in different permutations of beam and target polarizations

Summary of Observables and Results/Analysis Status in CLAS

Work in CLAS:

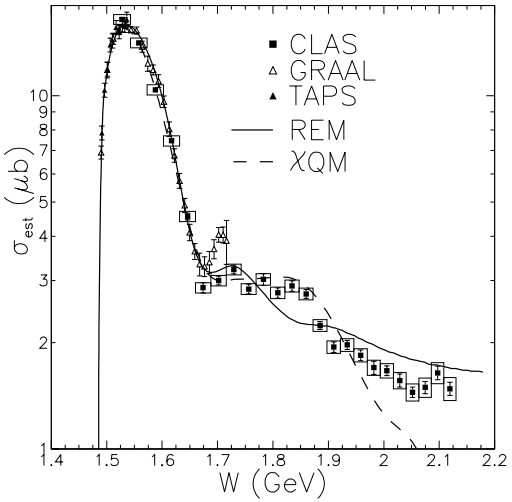
- Jefferson Lab facilities reached >80% beam and target polarizations!
  $\Rightarrow$ high analyzing power
- CLAS detector used toroidal B field
  $\Rightarrow$ ideal for arbitrarily polarized targets

Possible beam/target polarization observables and measurement status:

beam: \ target:	unpolarized	transverse	longitudinal
unpolarized	σ_0	T	-
linear	Σ	H, P	G
circular	-	F	E

- published
- in analysis review
- significant progress
- early stage
- not yet analyzed

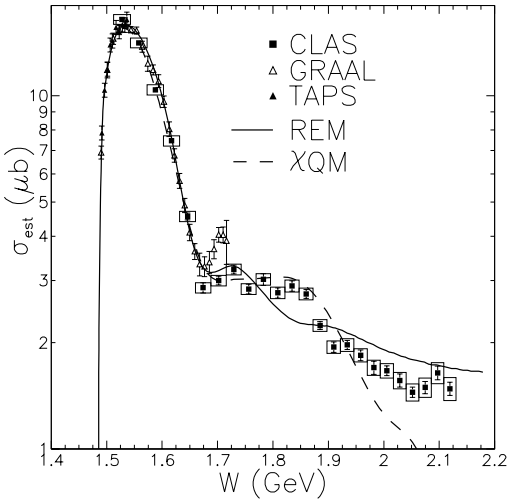
Differential Cross Section

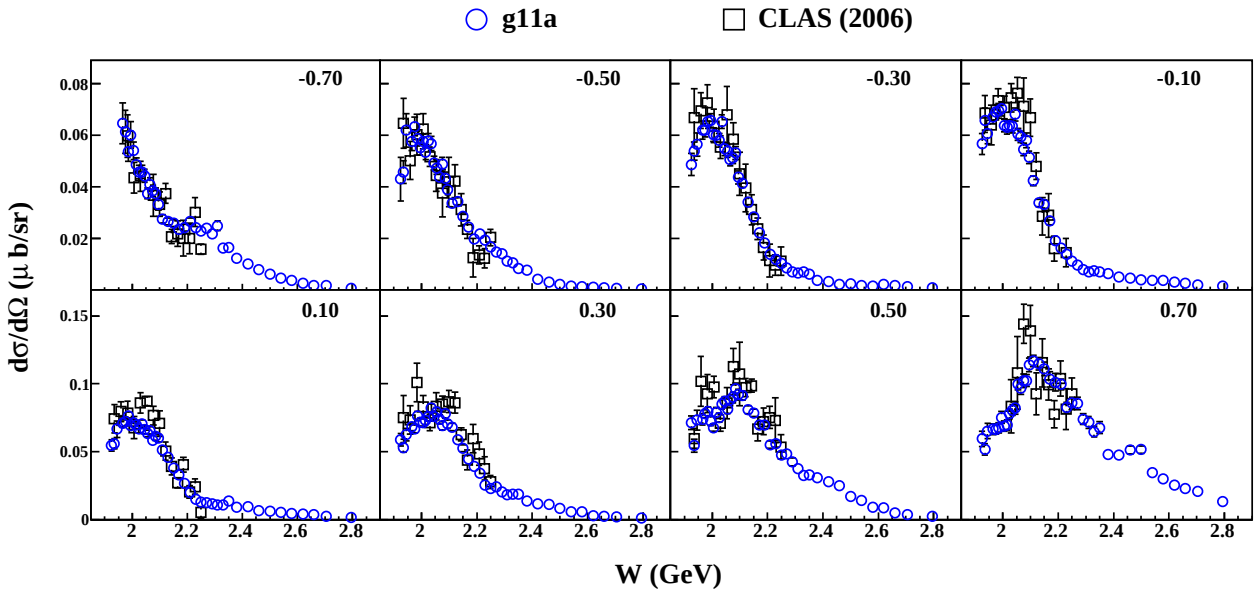


Estimated σ_{tot}

Dugger et. al., PRL 89 (2002)

Differential Cross Section





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Expanded reach in energy over the years

Williams et. al., PRC 80 (2009)

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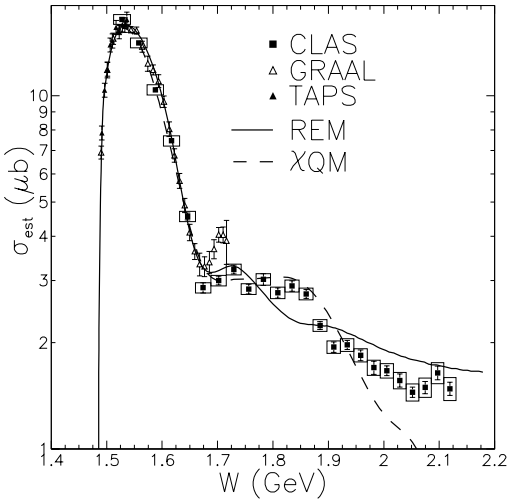

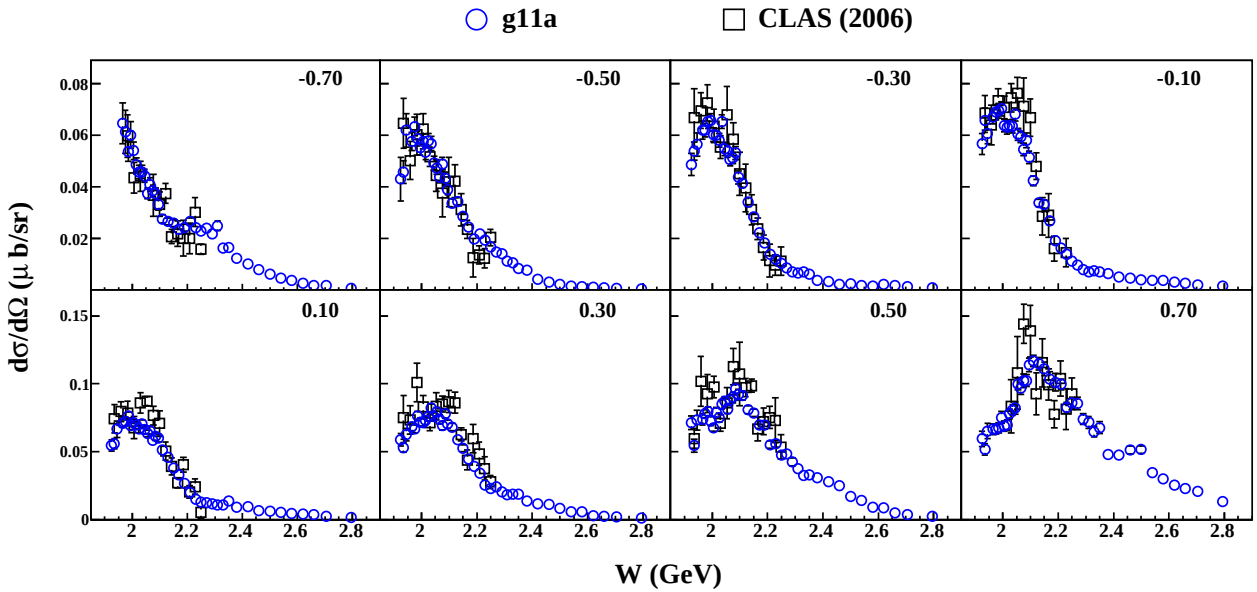

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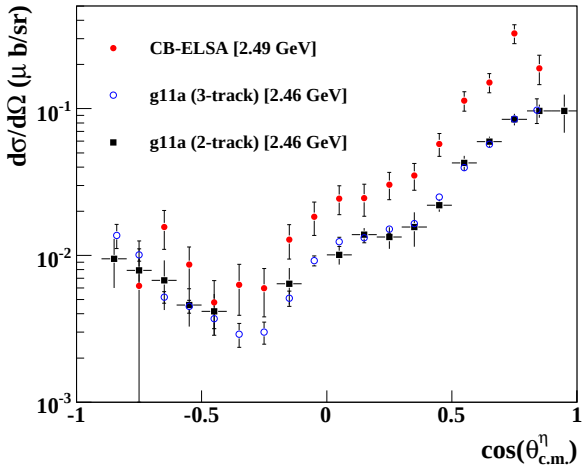
A challenge to reconcile with CB-ELSA

Two topologies from CLAS data are shown, with different acceptance and background.

Flux or trigger normalization discrepancies?

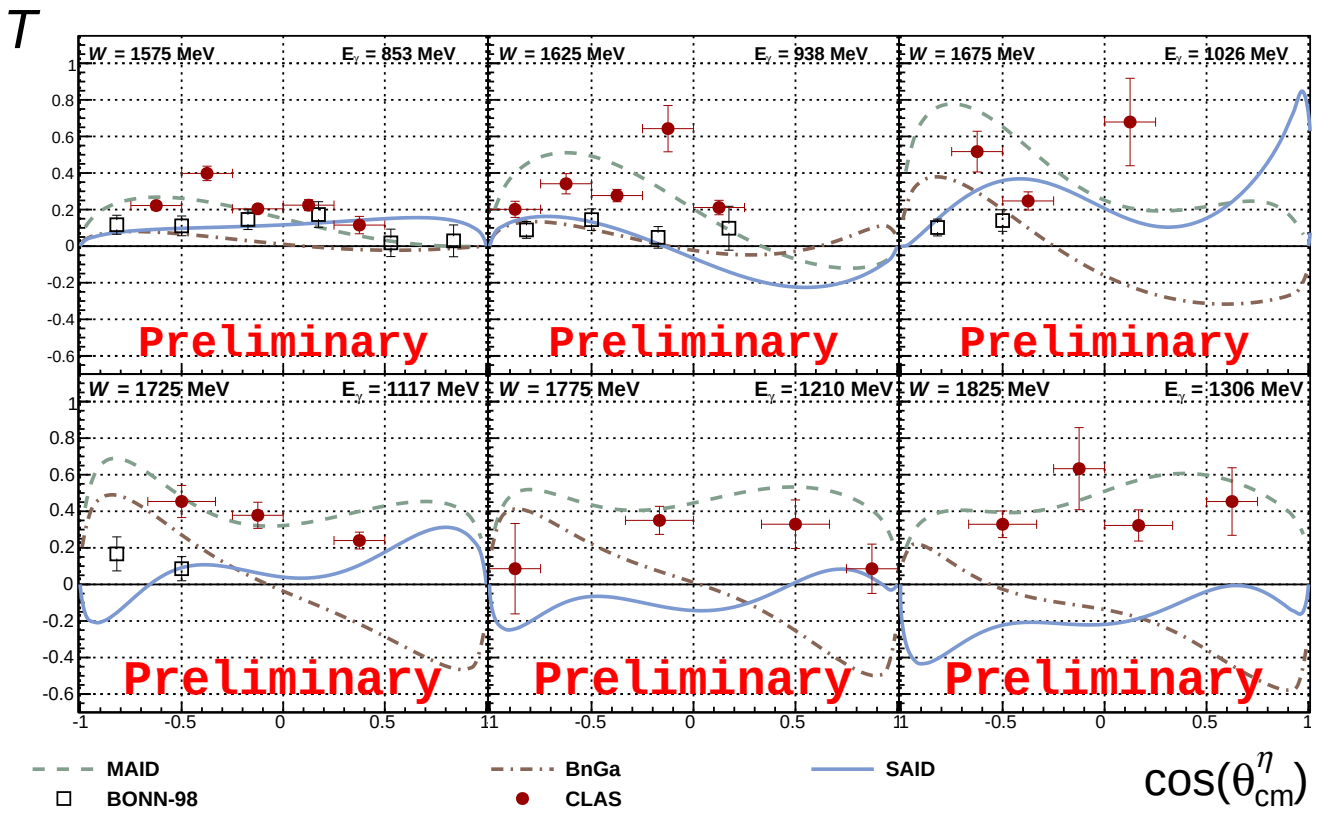


Target Asymmetry: T

Polarization: Beam, Target: circular, transverse

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma}{d\Omega_0}\left(1 + P_{xy}^{T} P_{C}^{\gamma} F \cos(\beta - \phi) + P_{xy}^{T} T \sin(\beta - \phi)\right)$$

T for $\gamma\, p \rightarrow p\, \eta$



Ross Tucker, Arizona State University

Double-polarization: F

Polarization: Beam, Target: circular, transverse

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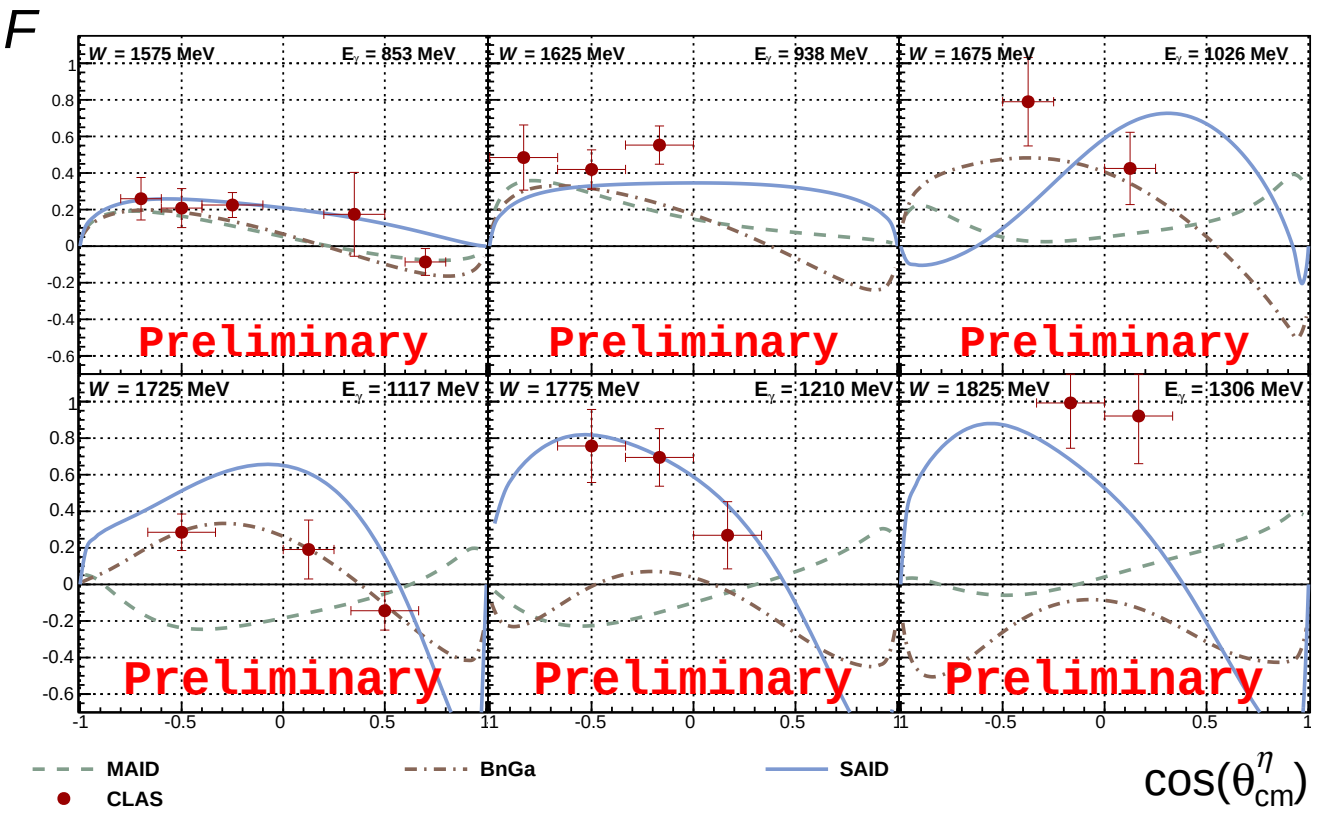
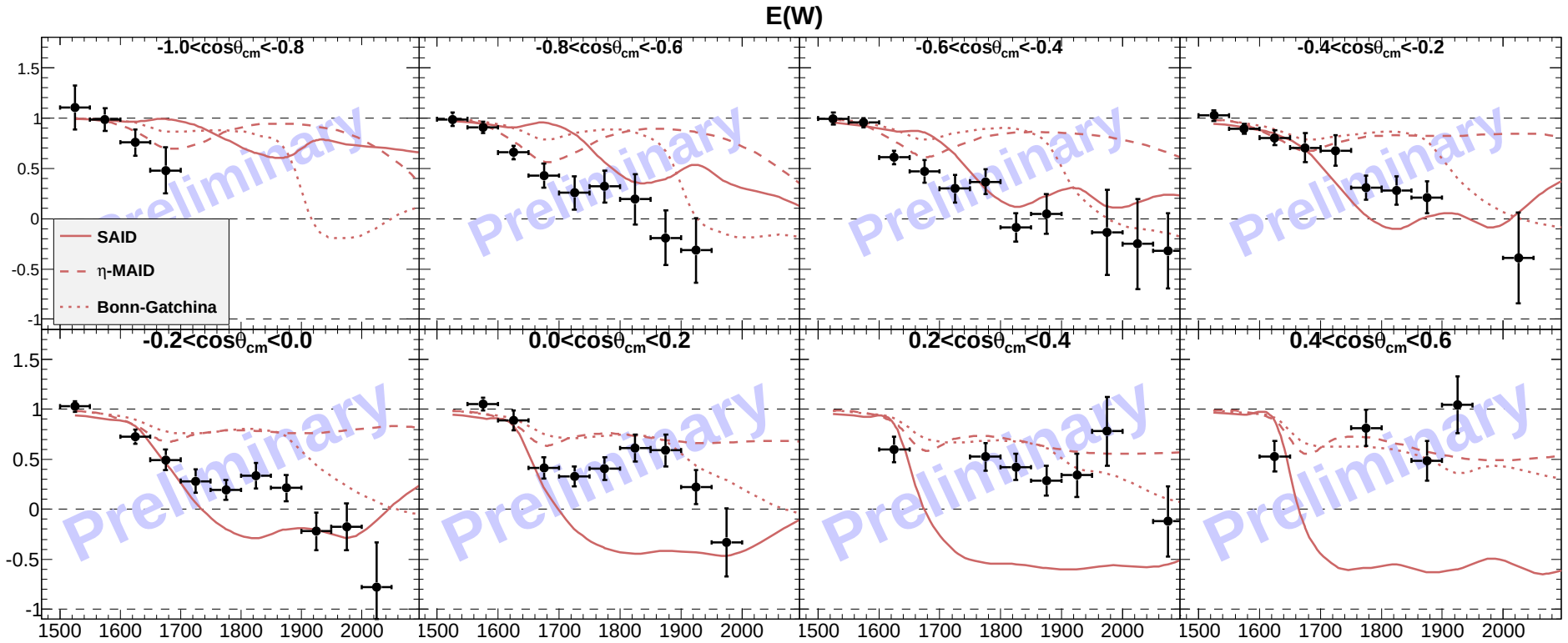


Helicity Asymmetry: E

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma}{d\Omega}_0 \left(1 - P_z^T P_C^\gamma E\right)$$



Helicity asymmetry E as a function of center of mass energy W(MeV)

See: Igor Senderovich, Session PE 002 (Sat. 10:42)

Beam Asymmetry: Σ

Polarization:

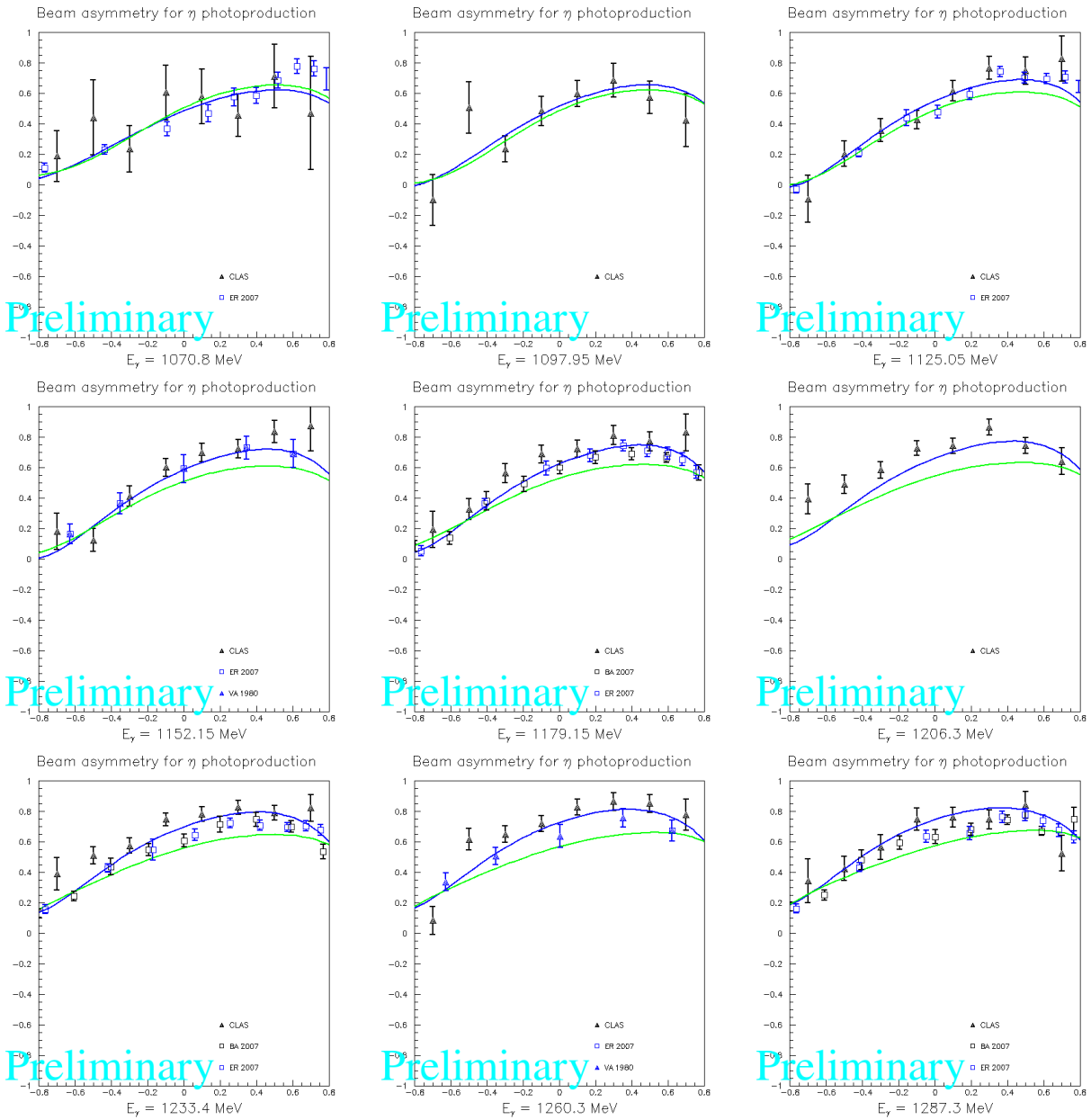
Beam: linear

Target: -

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

CE*	energy bins (MeV)
1.3	1071-1287
1.5	1260-1476
1.7	1476-1689
1.9	1689-1876

*Coherent Edge position (GeV) of linearly-polarized beam



Patrick Collins,
Catholic University

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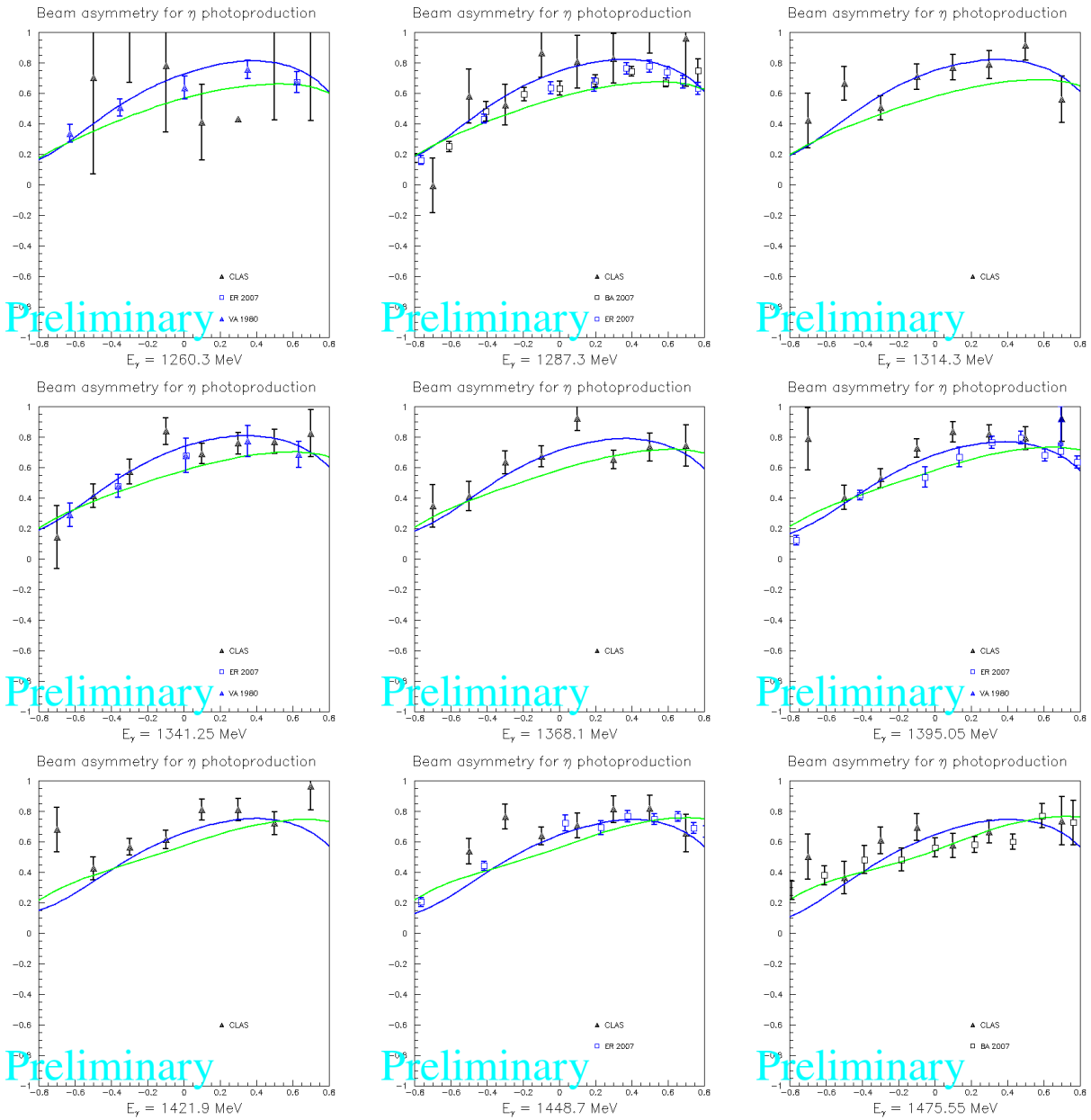

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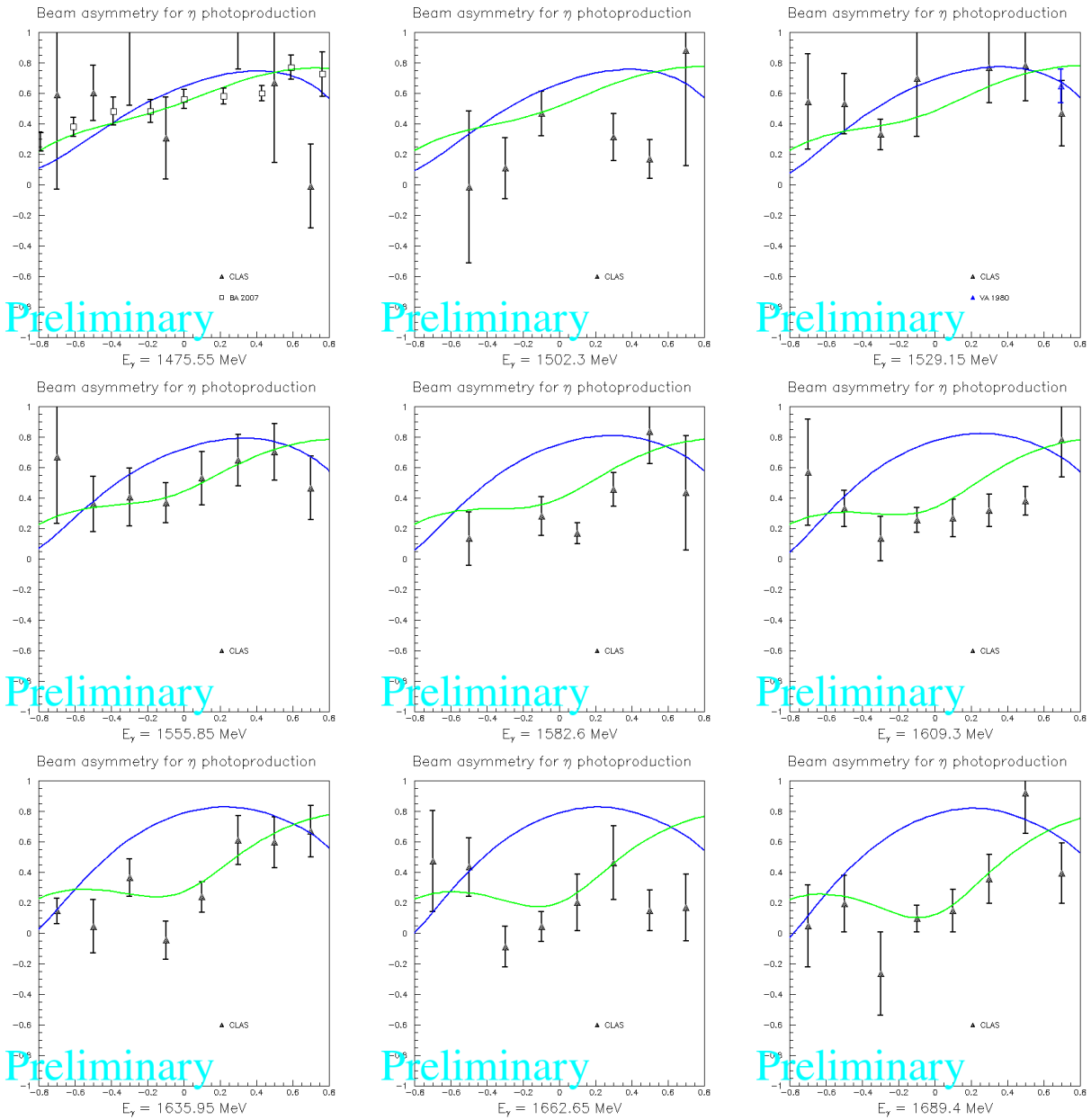

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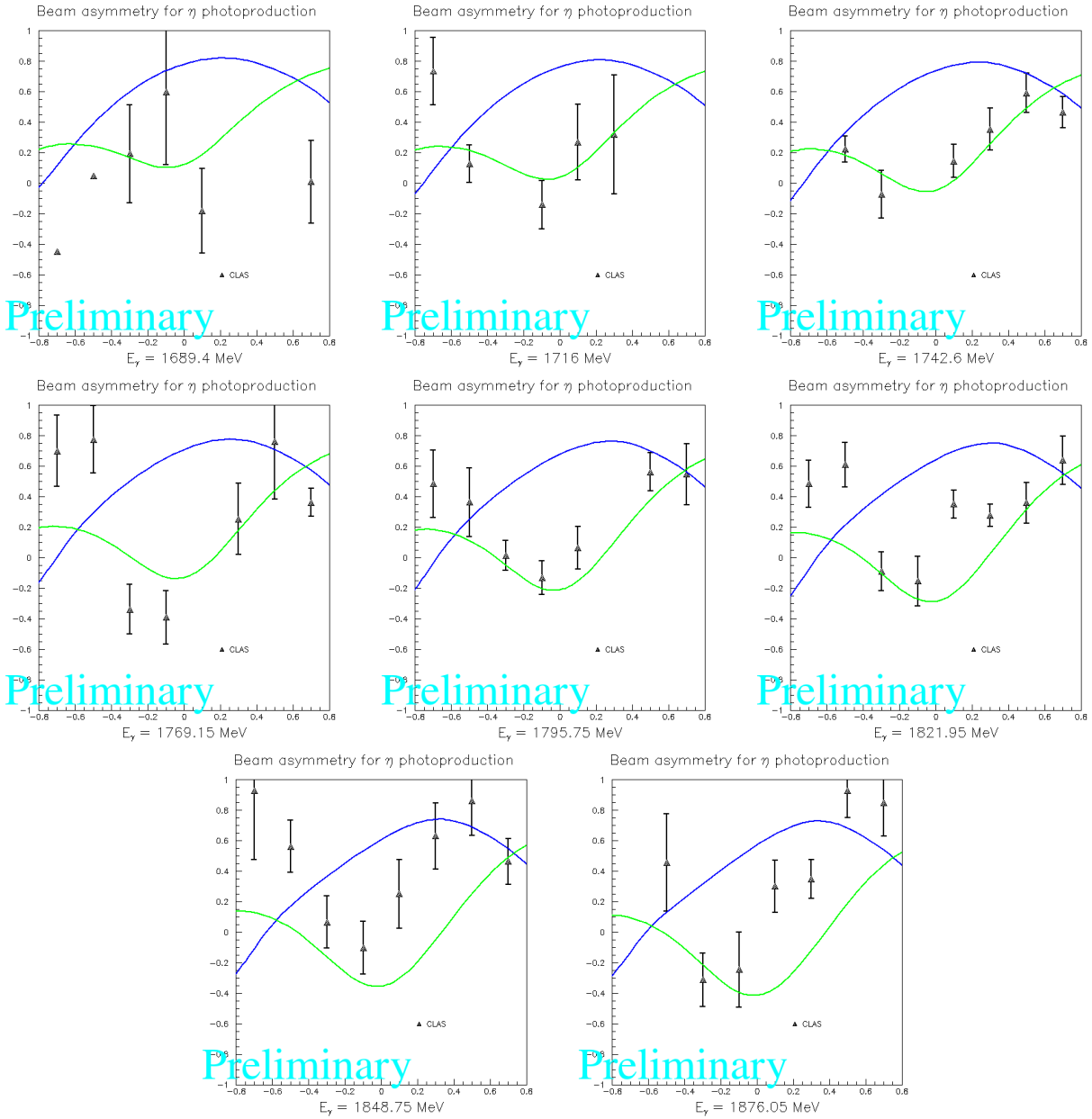

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Double-polarization: G

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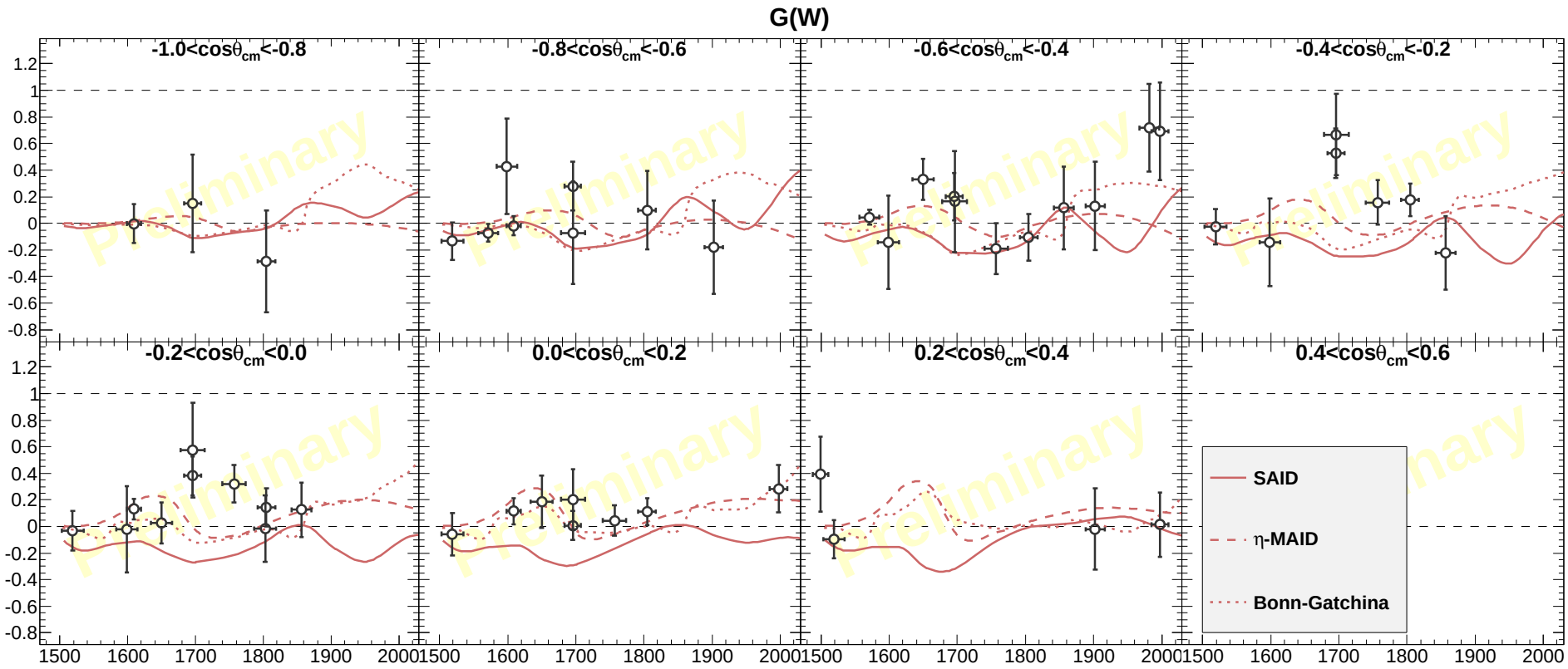

Beam/target polarization asymmetry G as a function of center of mass energy W(MeV)

See: Igor Senderovich, Session PE 002 (Sat. 10:42)

Summary and Outlook

CLAS analysis status for η photoproduction

- Differential cross section results published ✓
- Mature analyses for Σ, E, T, F ↻
- Progress on G ↻
- To do: H or P ↻