Exclusive π^o and η electro-production at high Q^2 in the resonance region

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NSTAR 2011
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Baryon form factors

- Knowledge of $N^\star$ form factors complements nucleon FF

❑P_{33}(1232) I = 3/2 J = 3/2 Decays to πN with 99% BR
  - Can be excited by M1, E2 and S1 multipoles
  - M1 dominates

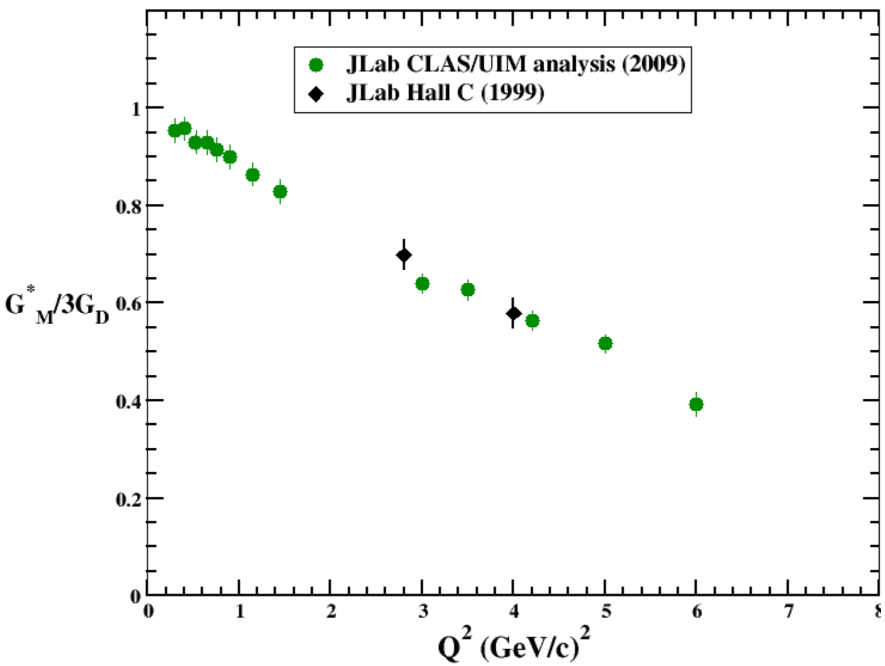
❑S_{11}(1535) Negative parity partner I = 1/2 J =1/2 Decays to ηN with 55% BR
  - $A_{1/2}$ helicity amplitude dominates over $S_{1/2}$

- Measure Q^2 dependence of baryon form factor data

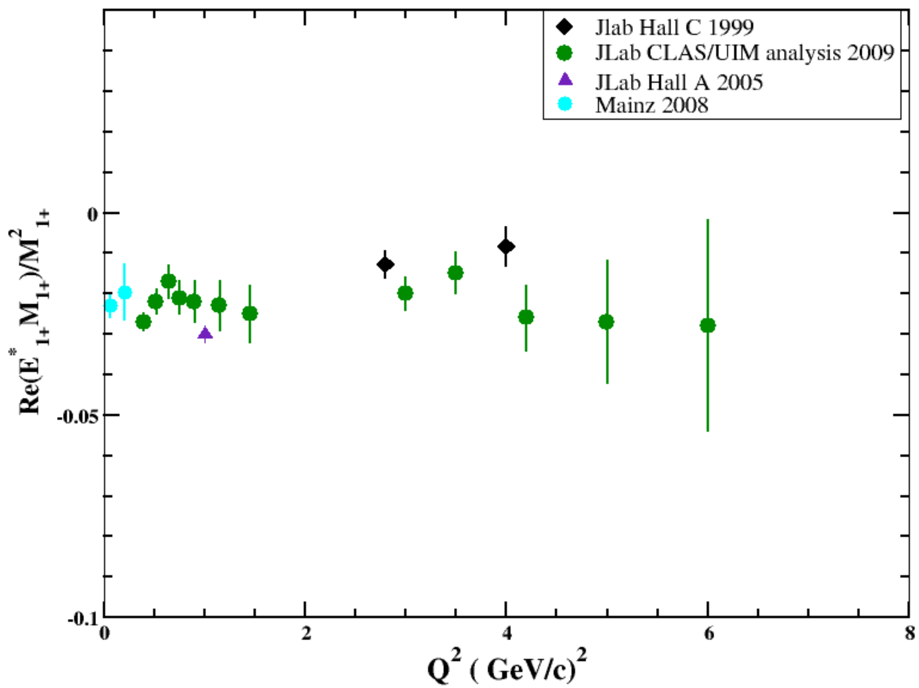
❑Map out the spatial densities of the nucleon
❑Address the role of meson cloud
❑Study the transition from meson/baryon degrees of freedom to the asymptotic regime

Previous $p(e,e'p)\pi^\circ$ Experiments

Magnetic FF, G^*_M, for $P_{33}(1232)$



E2/M1 for $P_{33}(1232)$



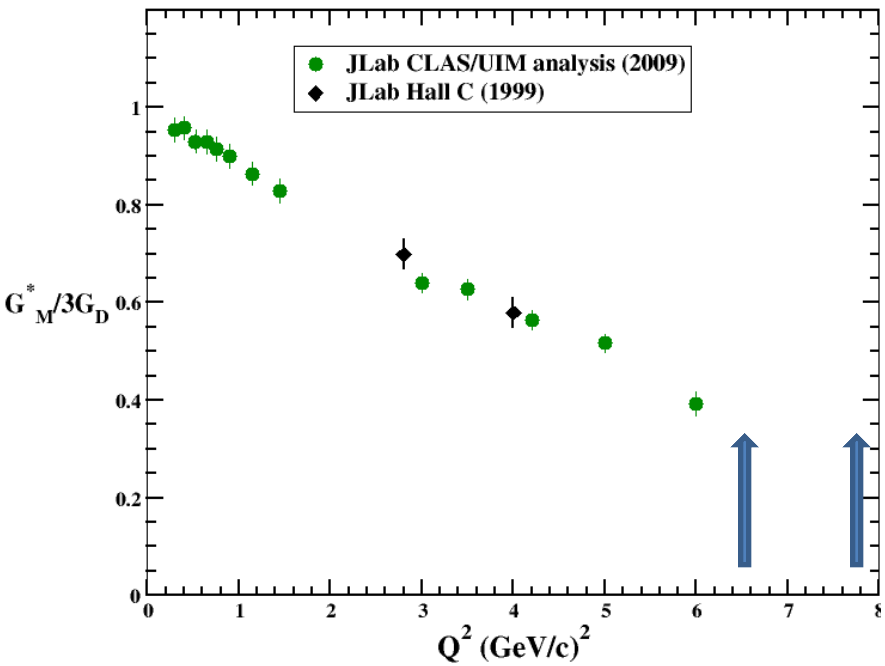
Two frameworks used to extract multipoles from experimental data

- Fixed-t dispersion relations
- Unitary Isobar Model (UIM)

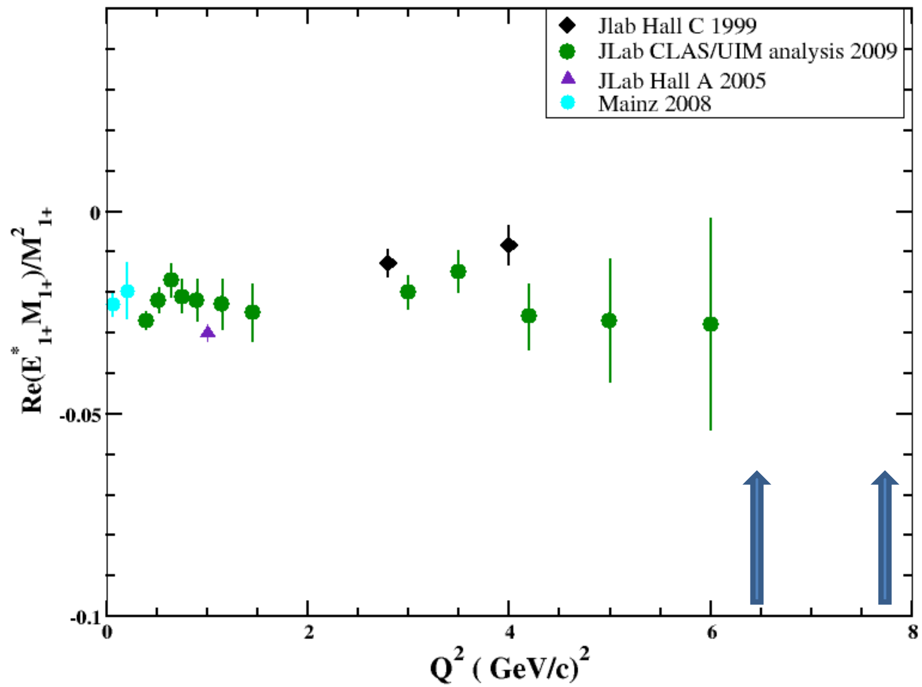
I. G. Aznauryan, V. D. Burkert, the CLAS Collaboration Phys.Rev.C80:055203,2009

Previous $p(e,e'p)\pi^{\circ}$ Experiments

Magnetic FF, G^*_M, for $P_{33}(1232)$



E2/M1 for $P_{33}(1232)$

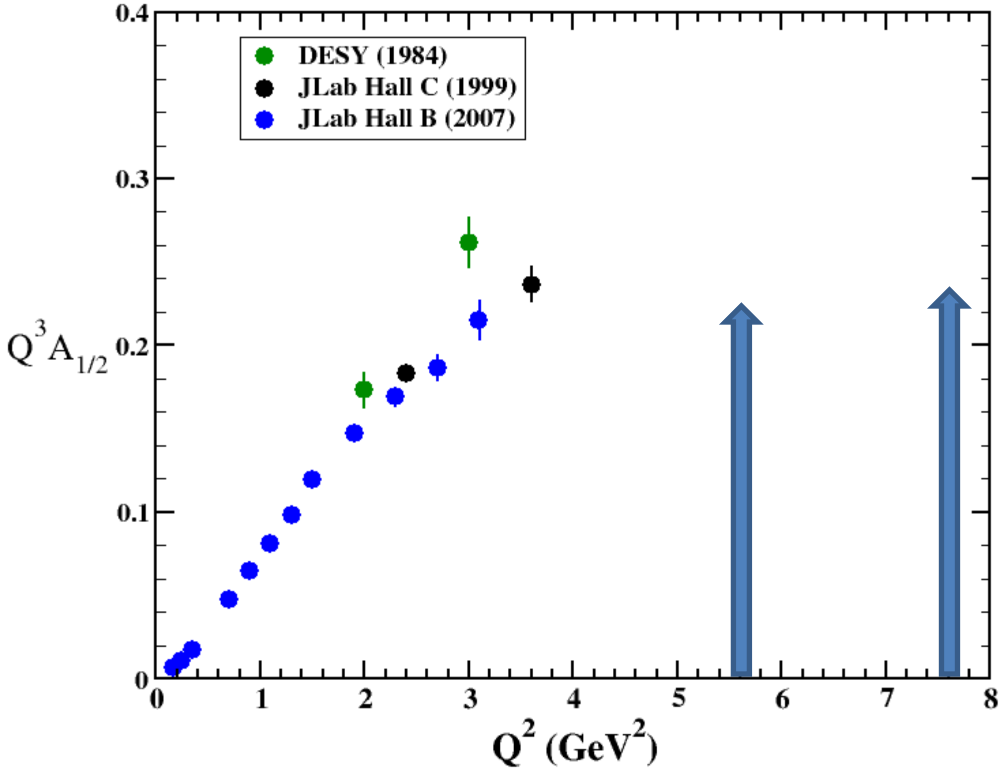


New Hall C data

- cross sections for W = 1.08 to 1.4 GeV
- Full θ^* and ϕ^* at $Q^2 = 6.4\ GeV^2$, partial at $Q^2 = 7.7\ GeV^2$

Previous $p(e, e'p)\eta$ Experiments

Helicity Amplitude $A_{1/2}$ for $S_{11}(1535)$



At very large Q^2 expect $Q^3 A_{1/2}$ to be a constant.

New Hall C data

- cross sections for W = 1.50 to 1.59 GeV
- Full θ^* and ϕ^* at Q^2 = 5.7 GeV^2,
- partial coverage at Q^2 = 7.0 GeV^2

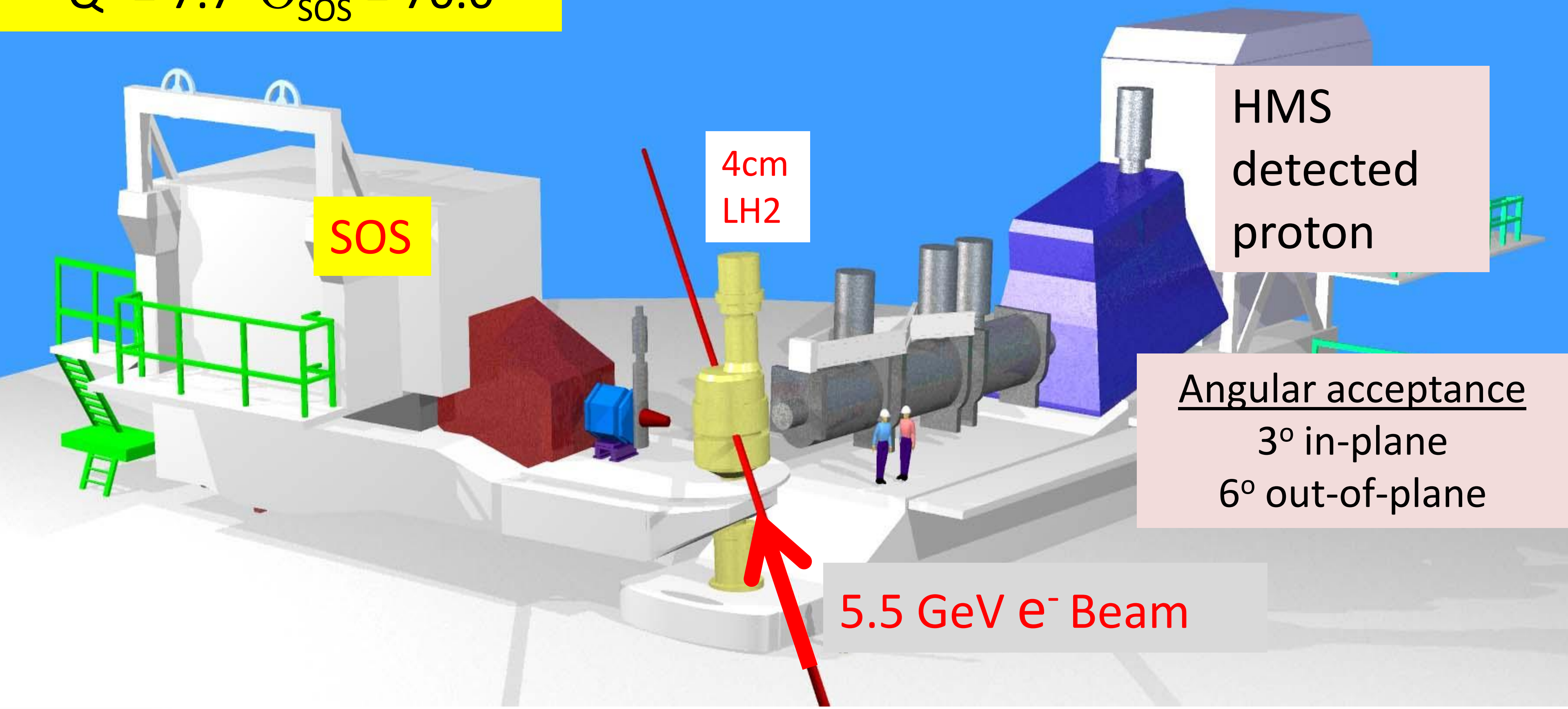
Hall C Experiment 00-102

SOS detected electrons

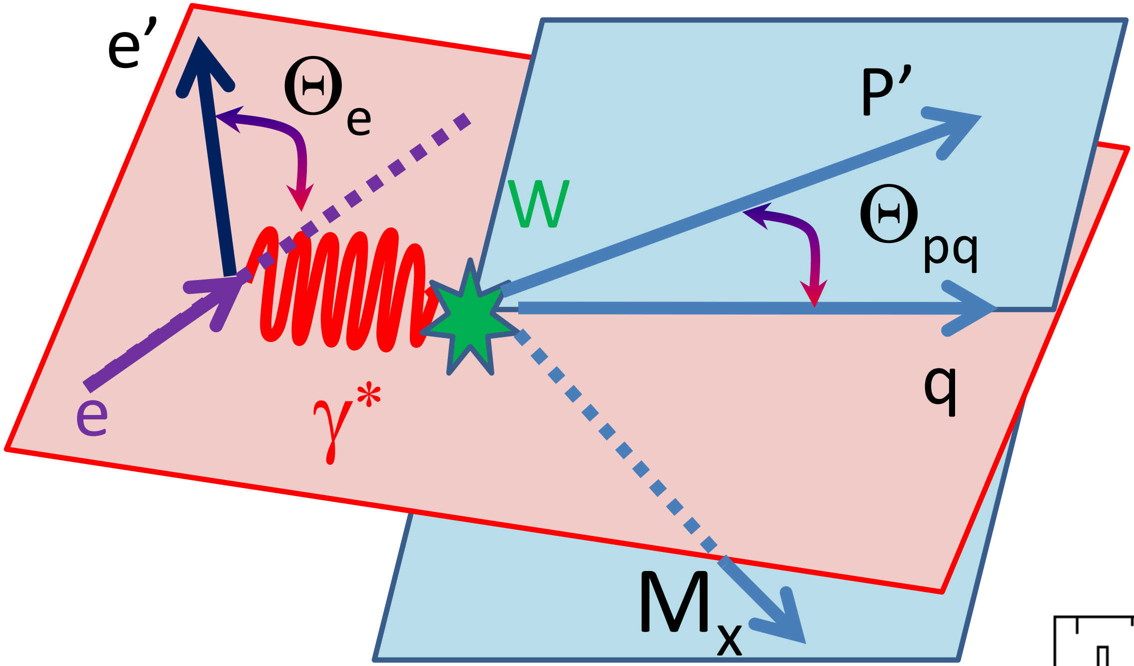
$Q^2 = 6.4$ $\Theta_{SOS} = 47.5$

$Q^2 = 7.7$ $\Theta_{SOS} = 70.0$

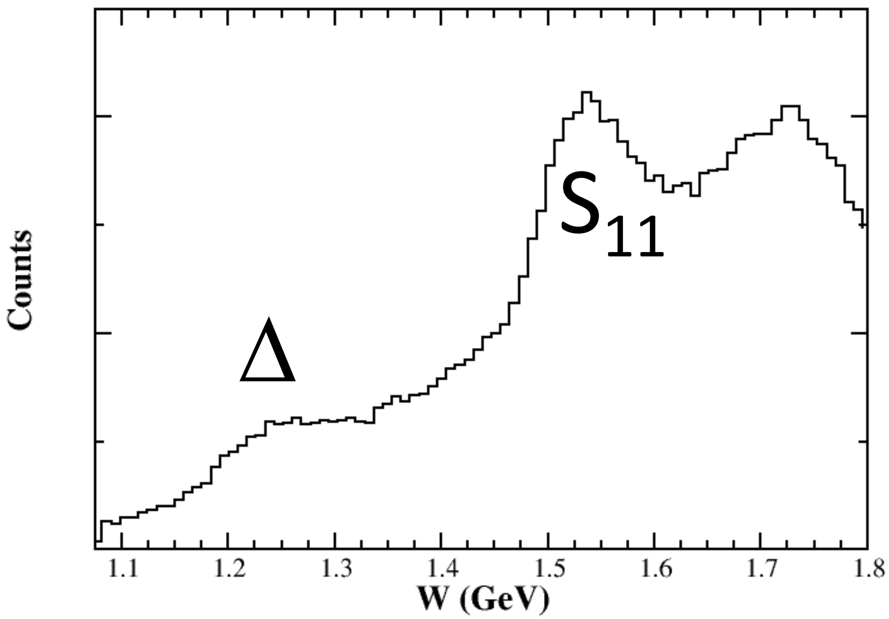
Q2	Θ_{HMS}	P_{HMS}
6.4	11.2 to 24	2.3 to 4.7
7.7	11.2 to 14	3.2 to 4.7

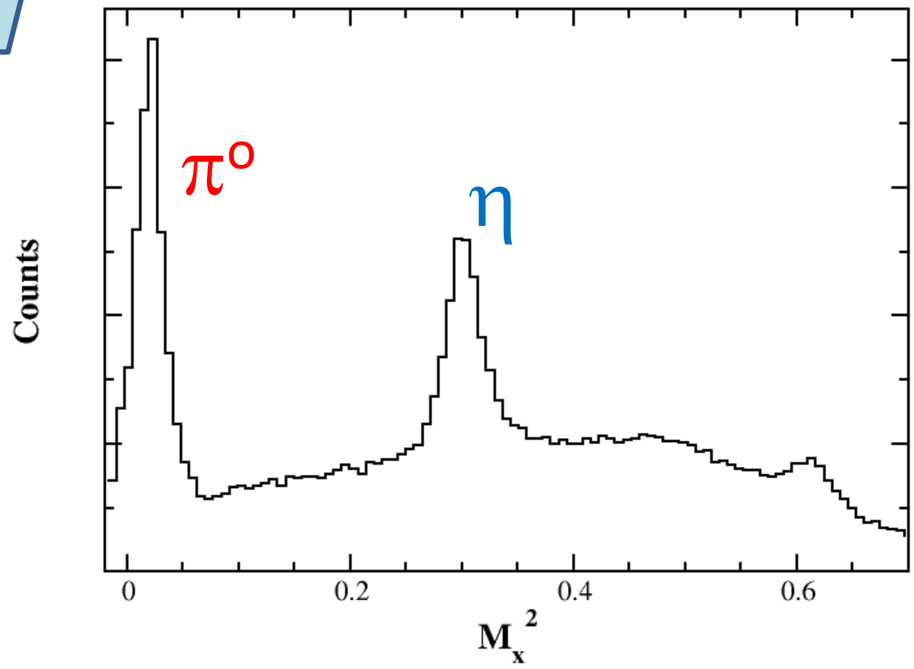


Identifying exclusive channels

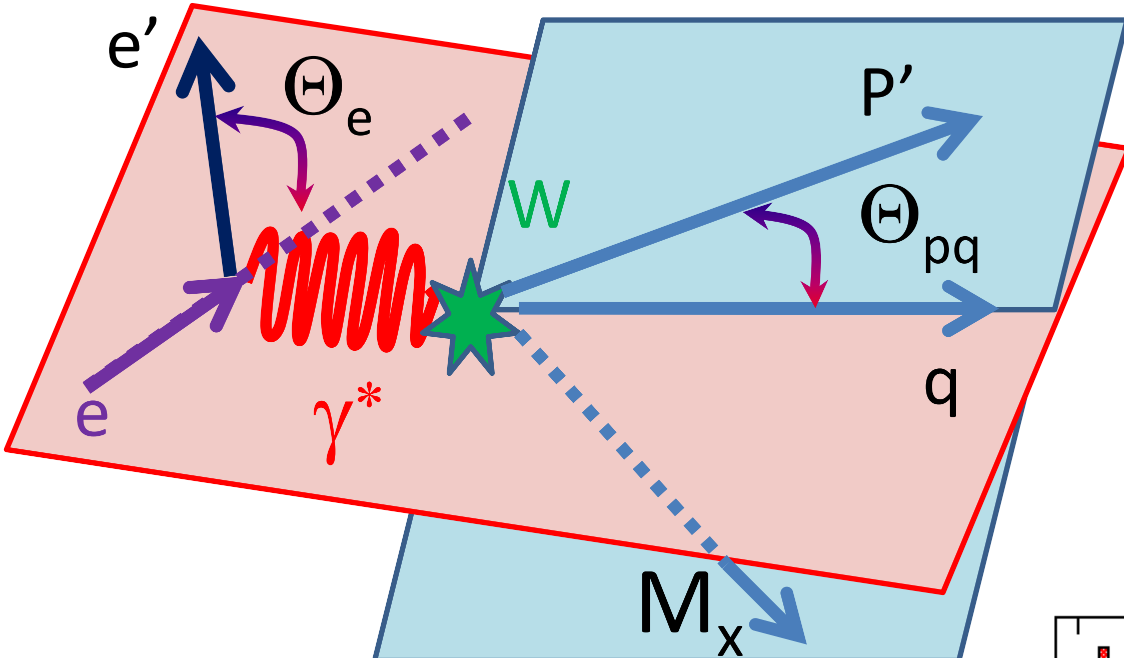


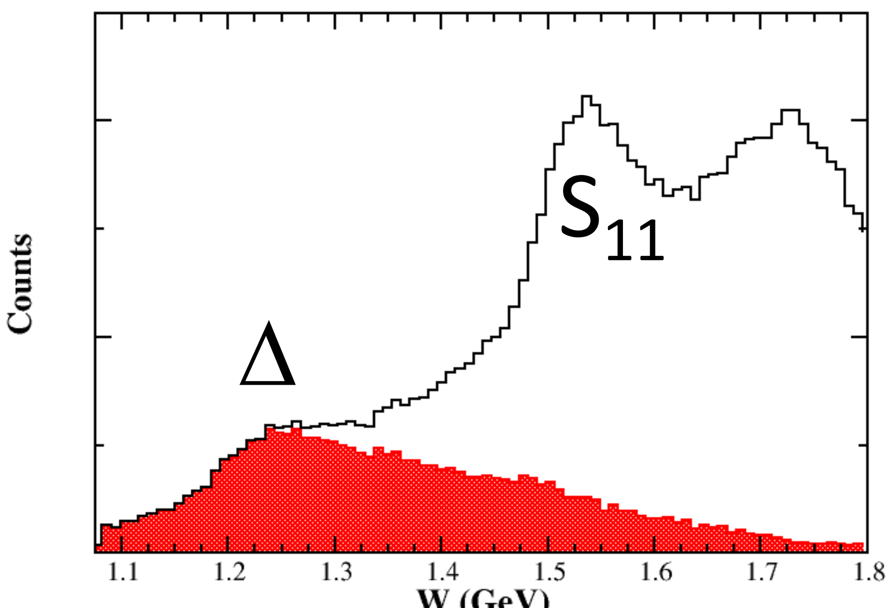
Eliminate radiated elastic events with cut on ϕ_{cm} =180

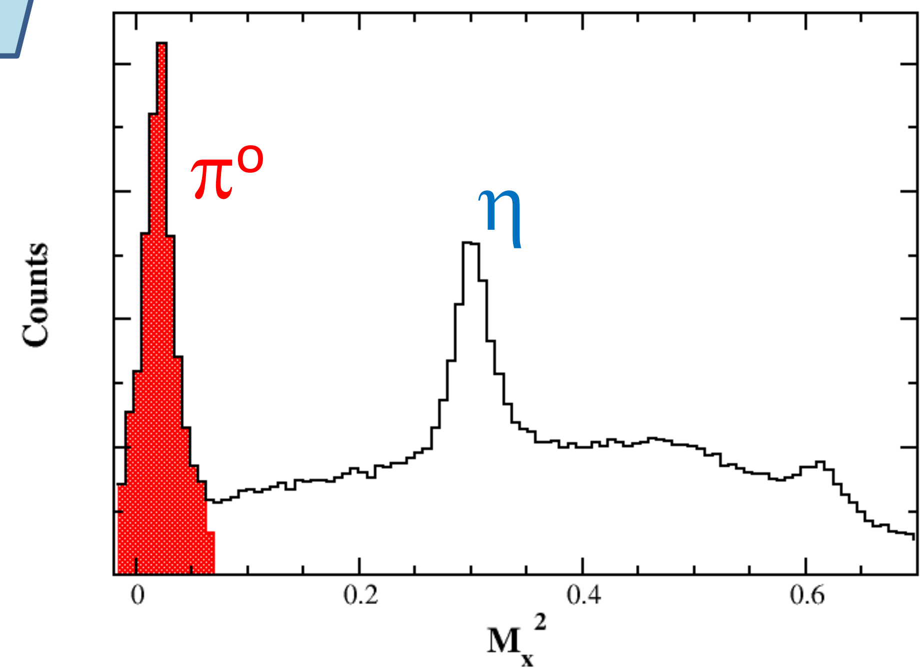




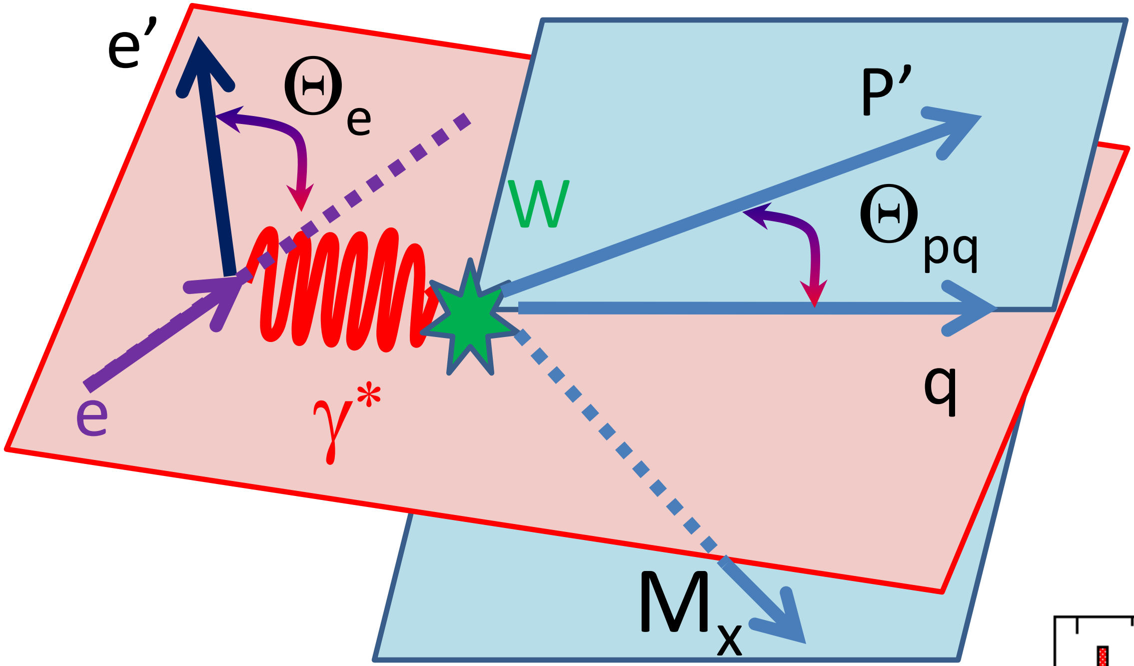
Identifying exclusive channels

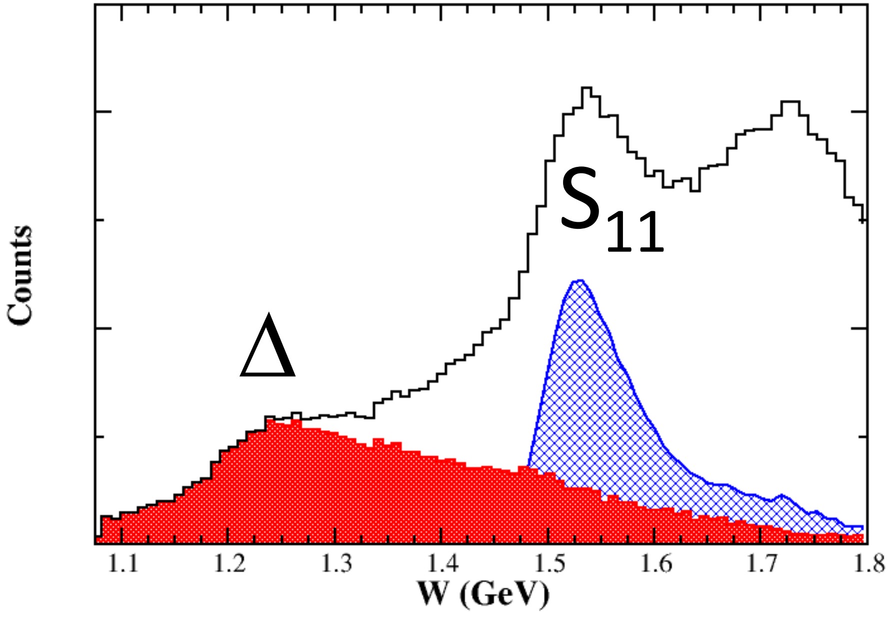


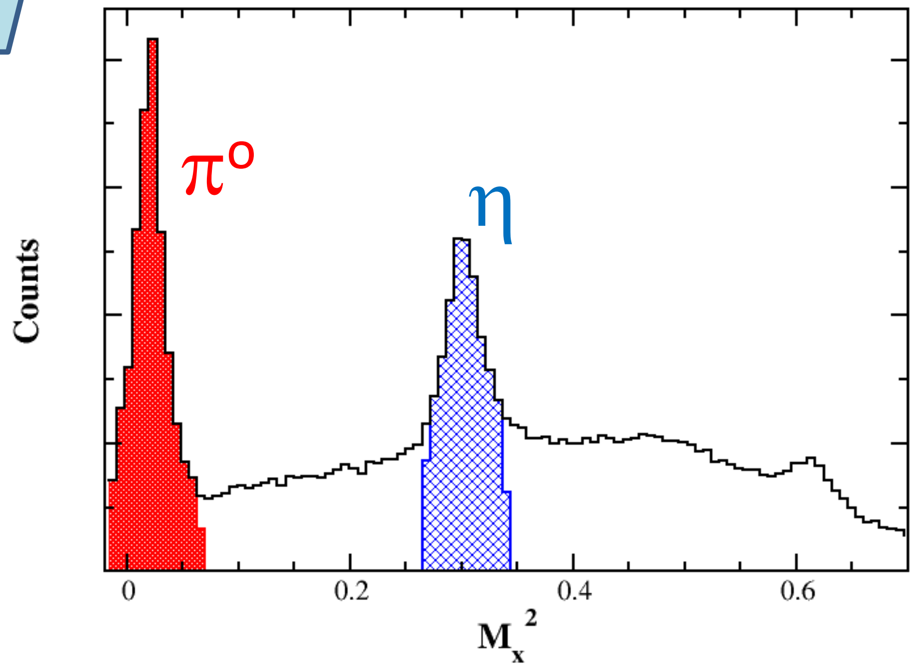




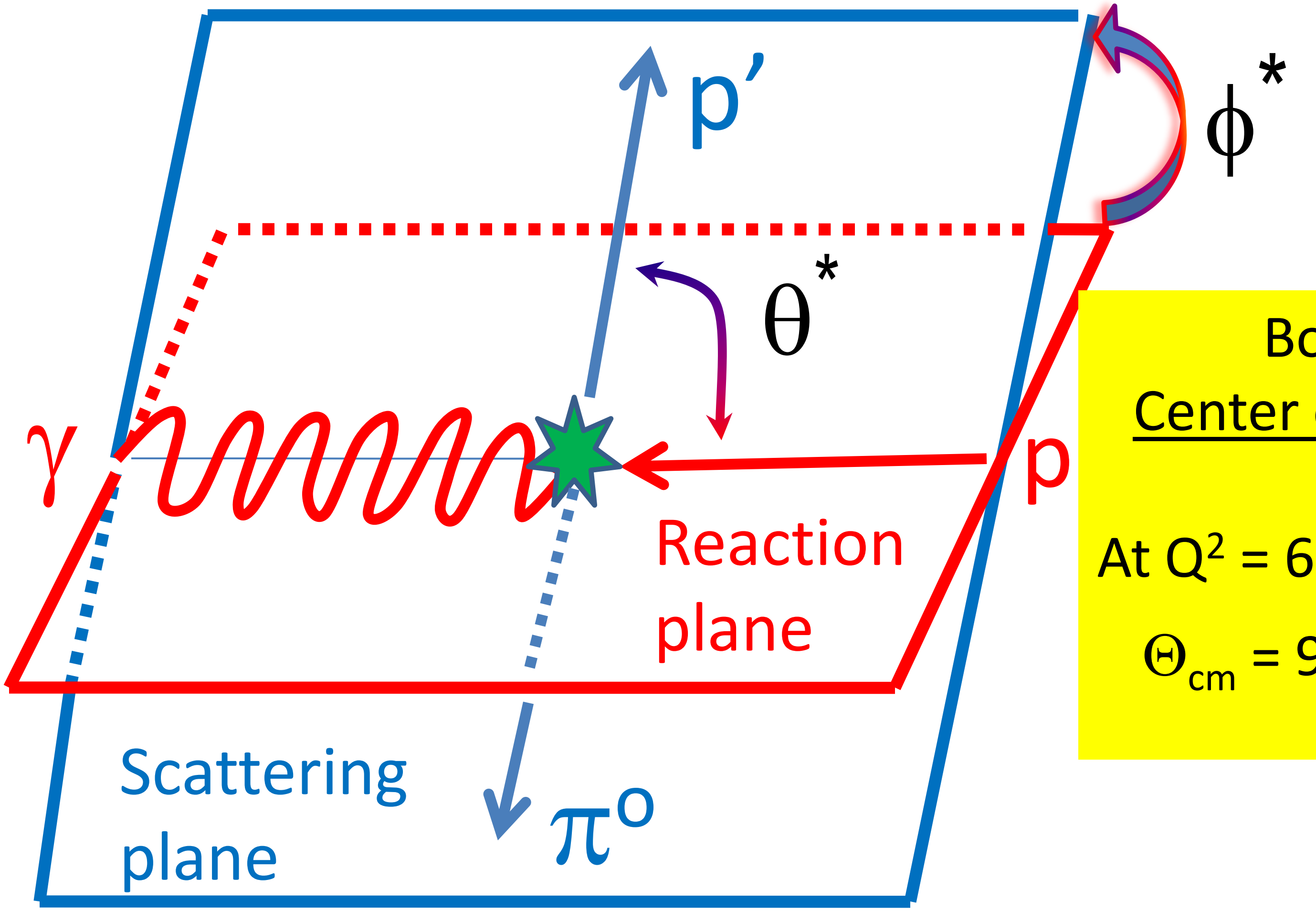
Identifying exclusive channels







Meson Production in γp center of mass



Boost from

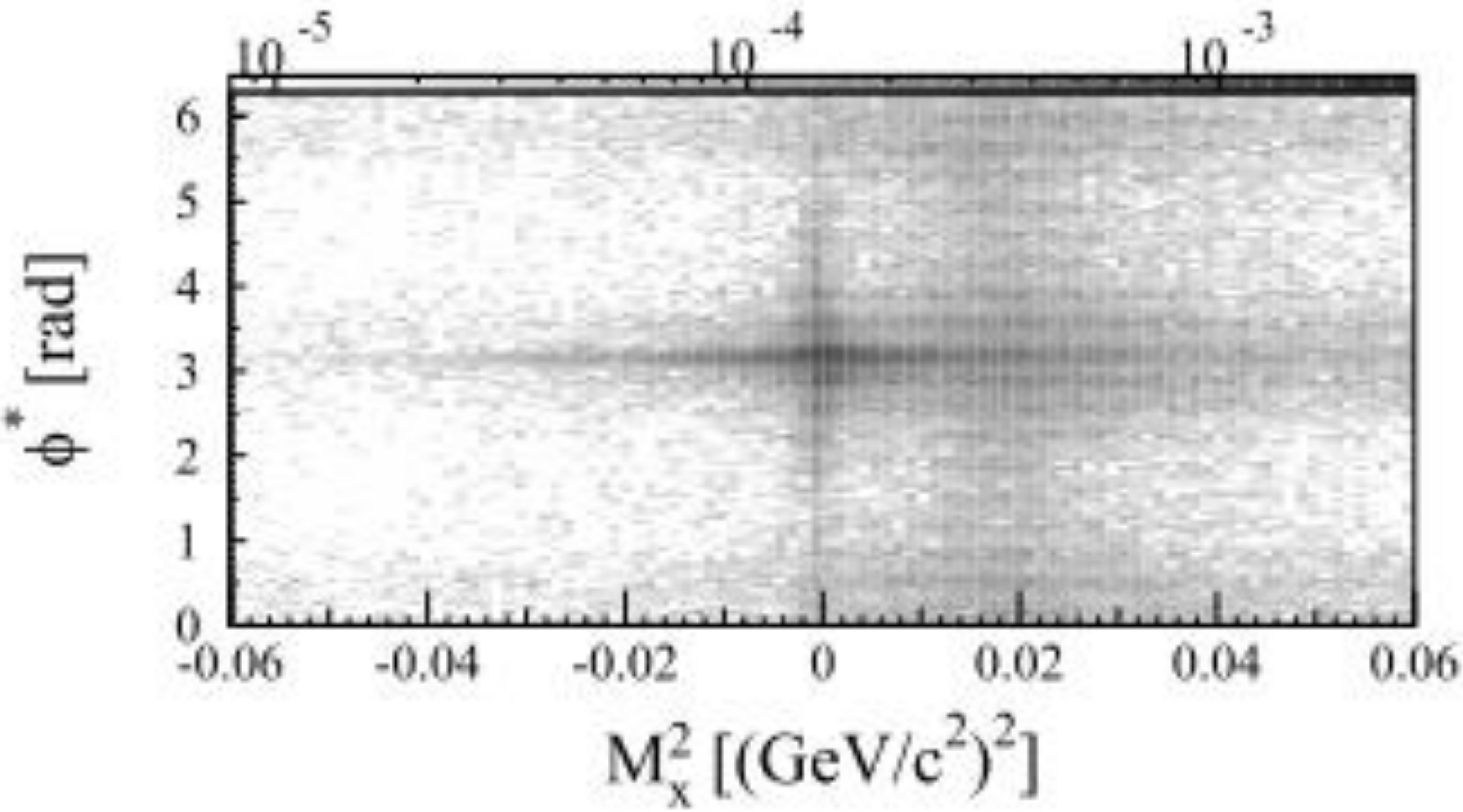
<u>Center of Mass to LAB</u>

At $Q^2 = 6.4$ GeV^2

$\Theta_{cm} = 90^o$ $\Theta_{pq} = 3.7^o$

$$\frac{d\sigma}{d\Omega^\star} = \sigma_T + \epsilon\sigma_L + \epsilon\sigma_{TT}\cos 2\phi^\star + \sqrt{2\epsilon(1+\epsilon)}\sigma_{LT}\cos\phi^\star$$

Elimination of elastic radiated process

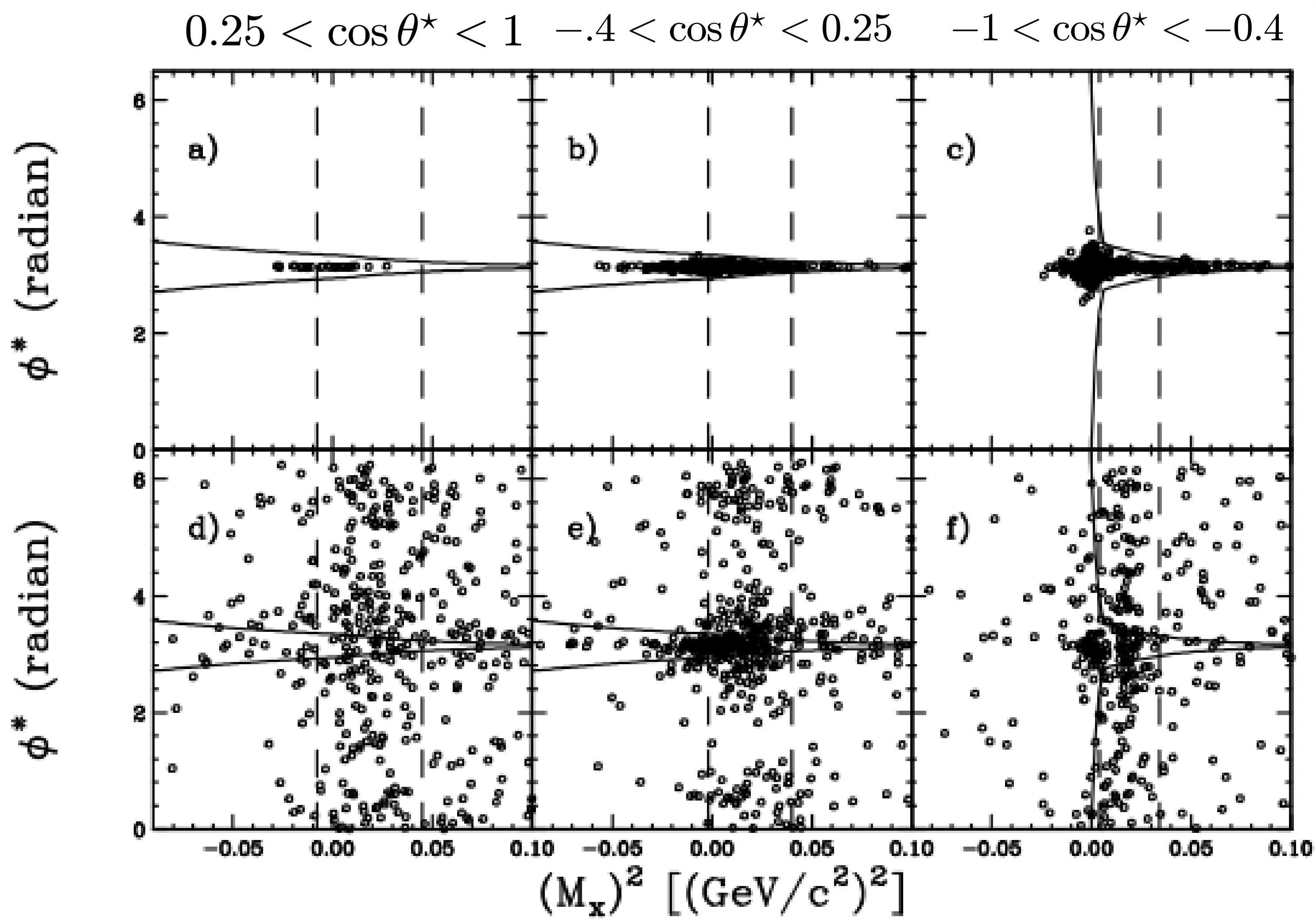


$Q^2 = 6.4\ GeV^2$

Elimination of elastic radiated process

Simulation of elastic radiated events

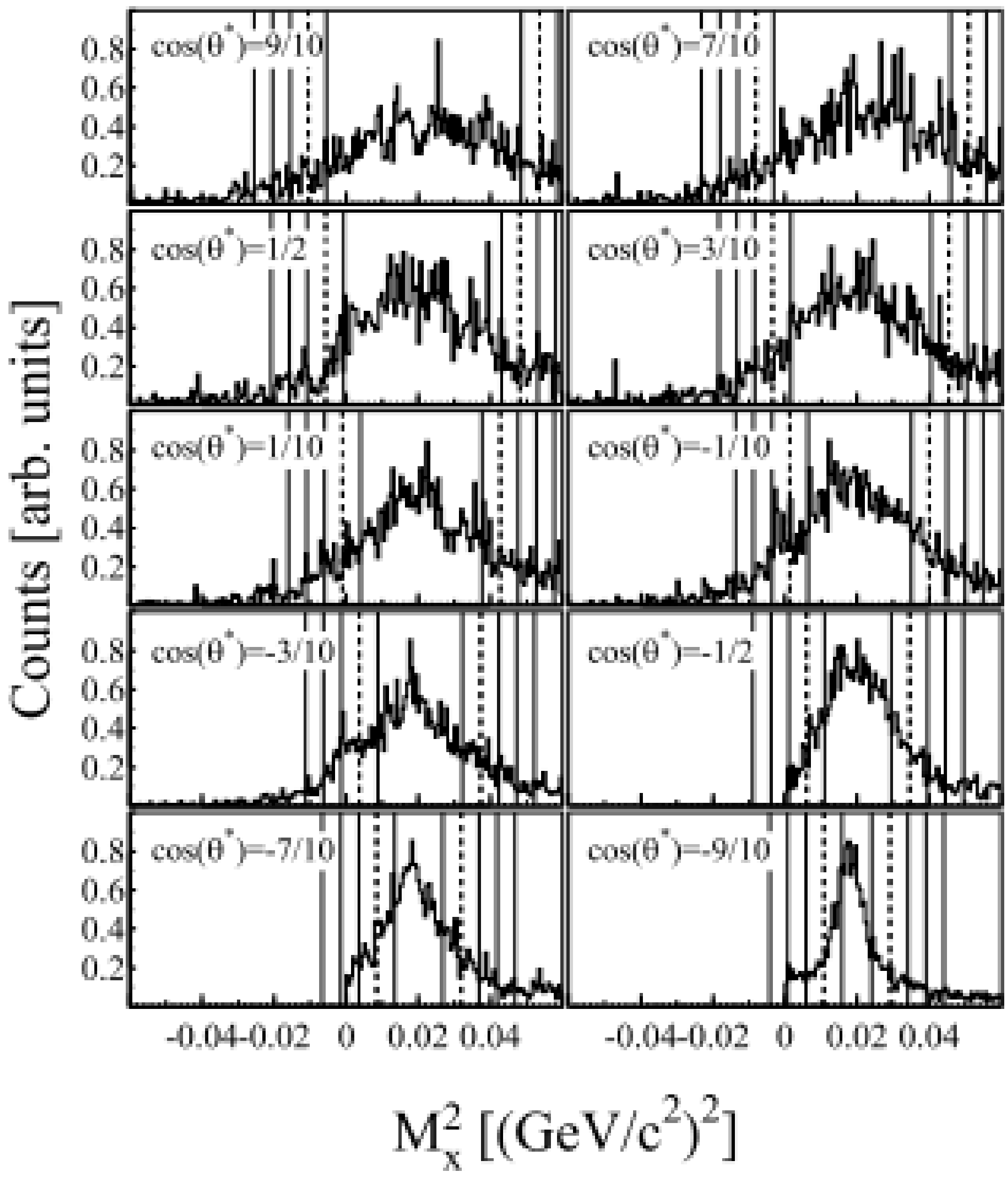
Data



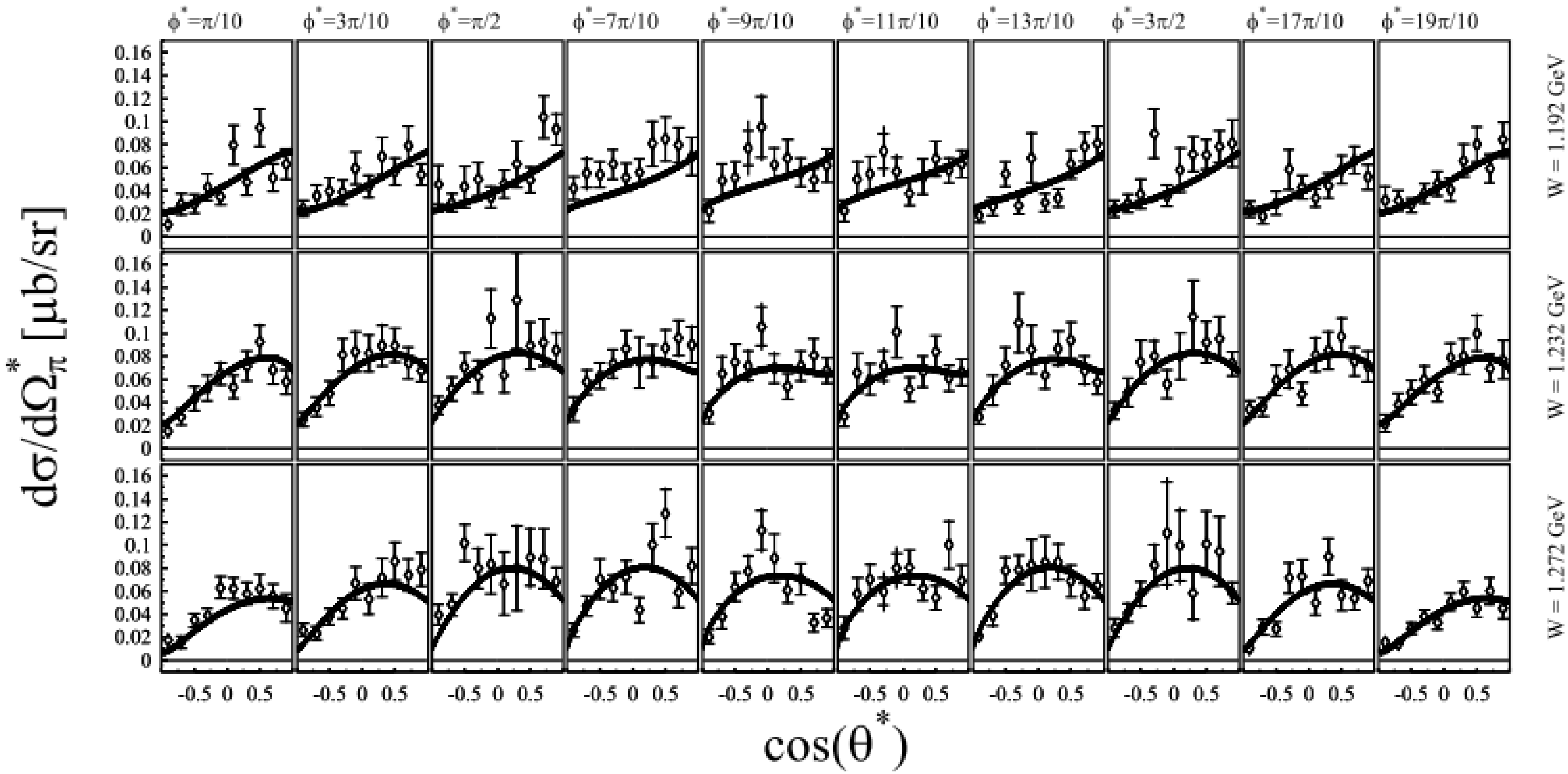
Q^2 = 6.4 GeV^2

Elimination of elastic radiated process

Q^2 = 6.4 GeV^2



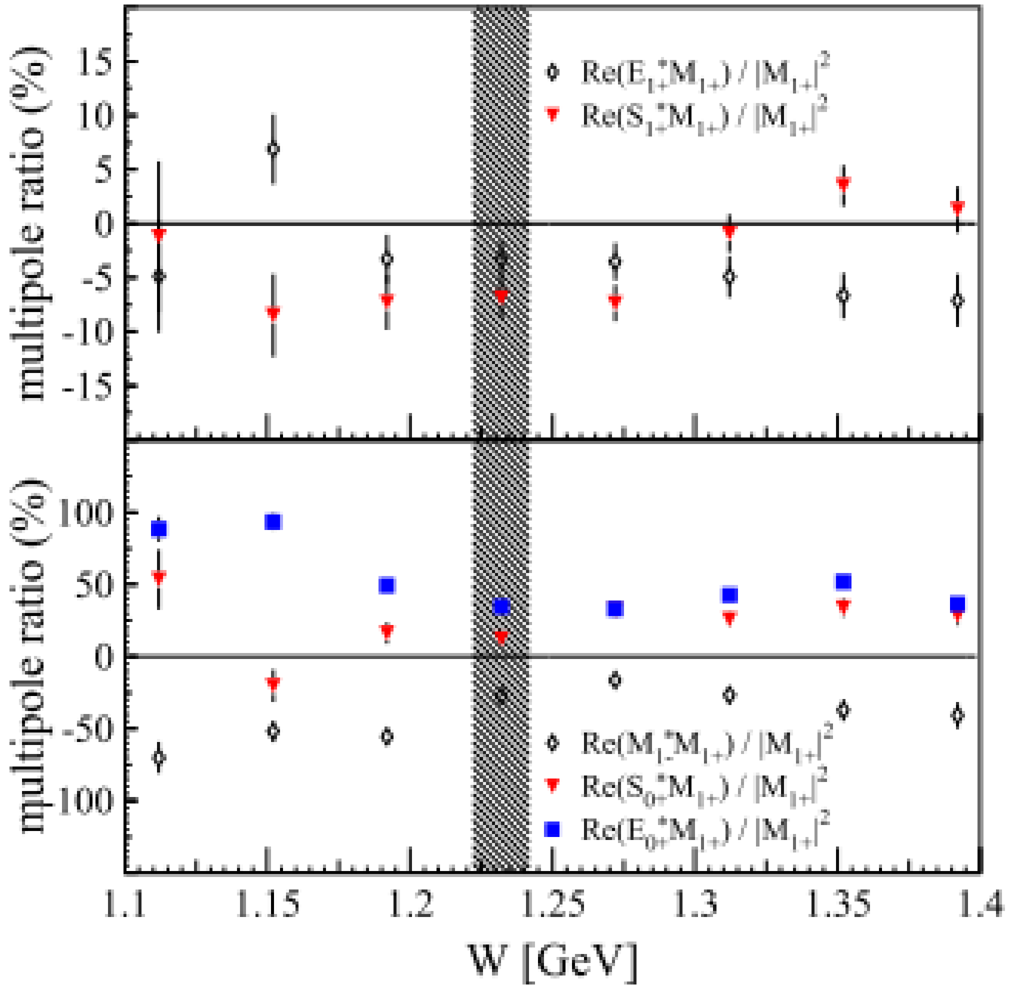
π^o production c.m. cross section



$$\frac{d\sigma}{d\ \ ^\star} = A_o + A_1\cos\theta^\star + A_2\cos^2\theta^\star + \epsilon B_o \cos 2\phi^\star \sin^2\theta^\star$$
$$+ \sqrt{2\epsilon(1+\epsilon)}\cos\phi^\star (C_o + C_1\cos\theta^\star)\sin\theta^\star$$

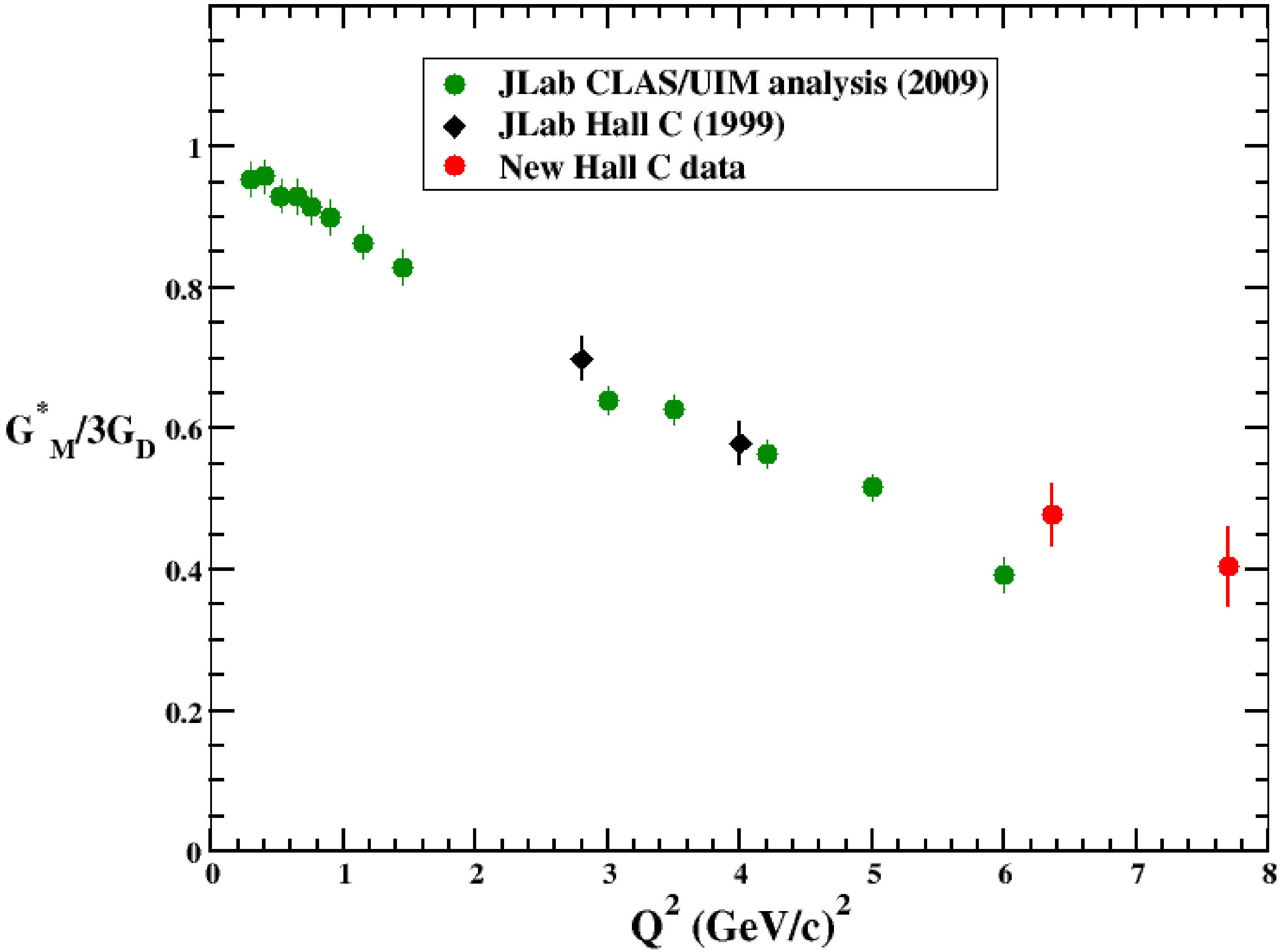
Truncated Multipole Analysis

$Q^2 = 6.4\ GeV^2$



•Large M1- and E0+ so *M1 dominance is not viable*
• Need to use cross section data in global analysis framework like UIM to reliably extract multipoles

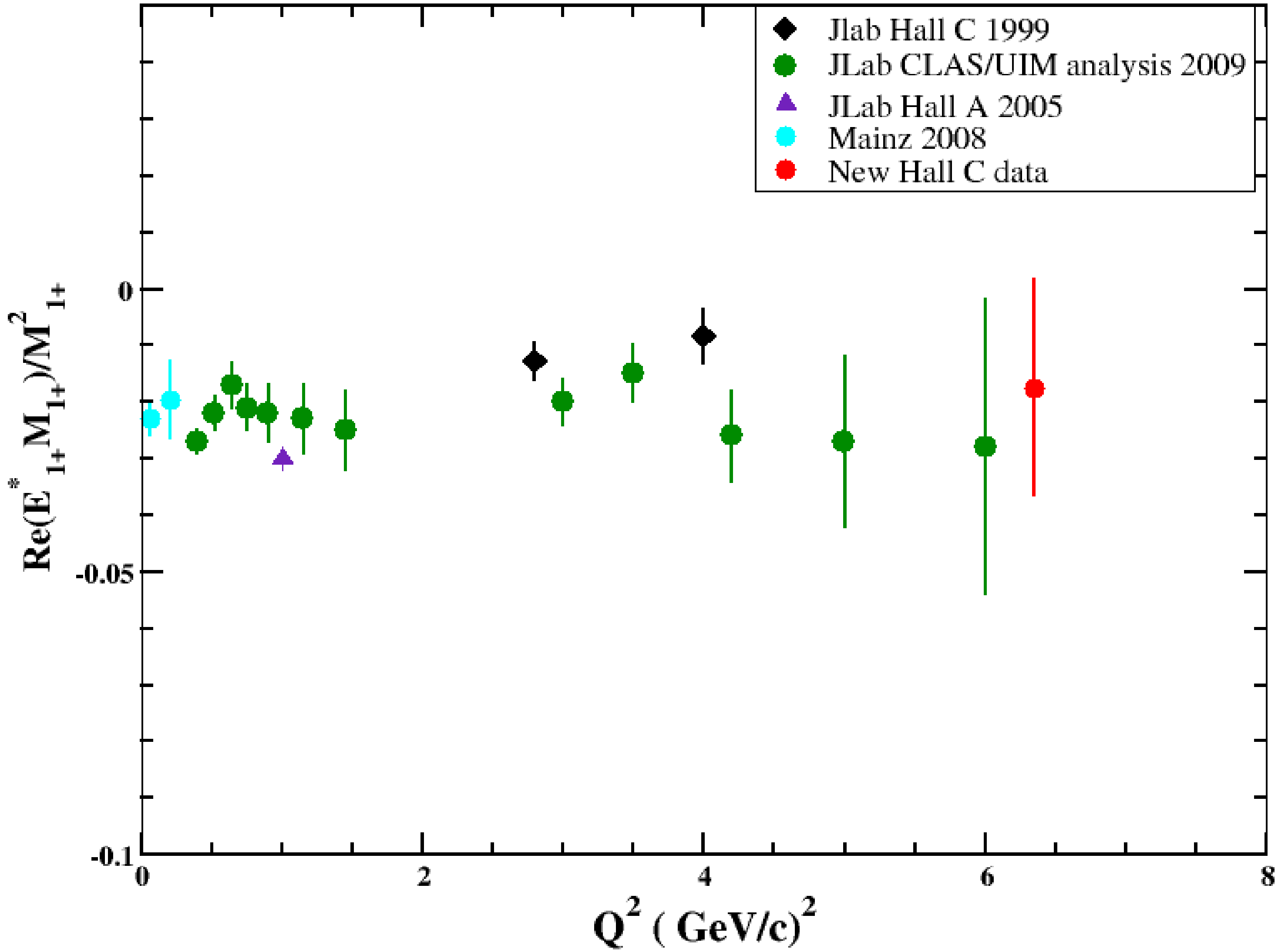
Δ Magnetic Form factor



A. N. Villano et al   Phys.Rev.C80:035203

ArXiv:0906.2839v2 has UIM analysis results

P33 E2/M1



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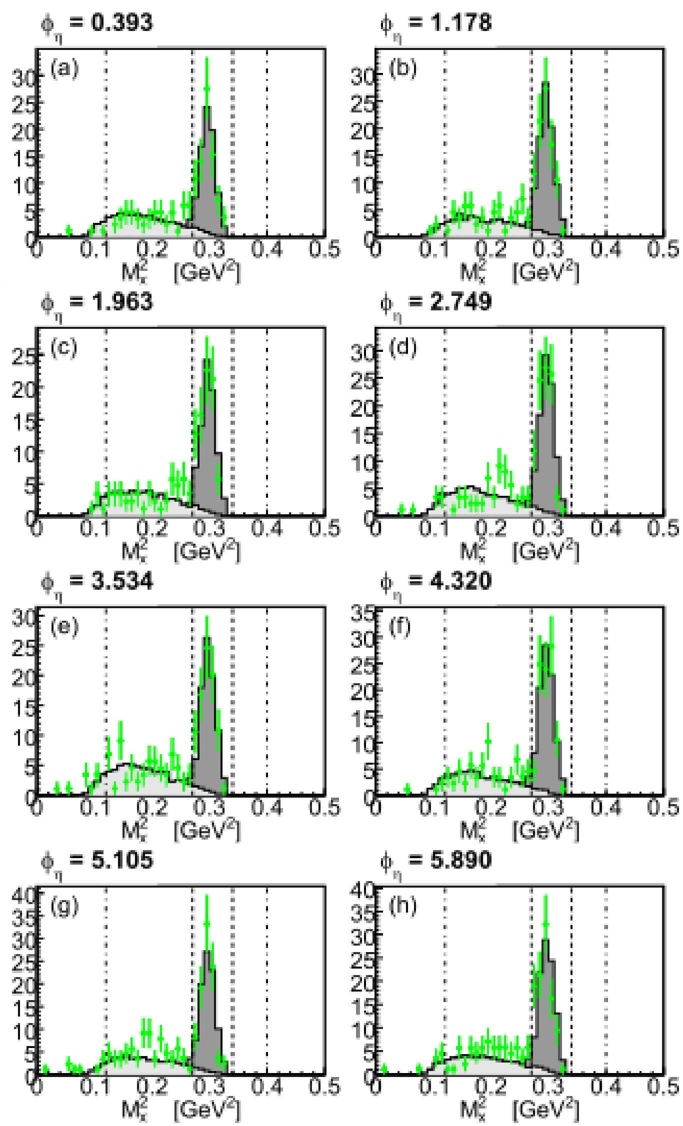
ArXiv:0906.2839v2 has UIM analysis results

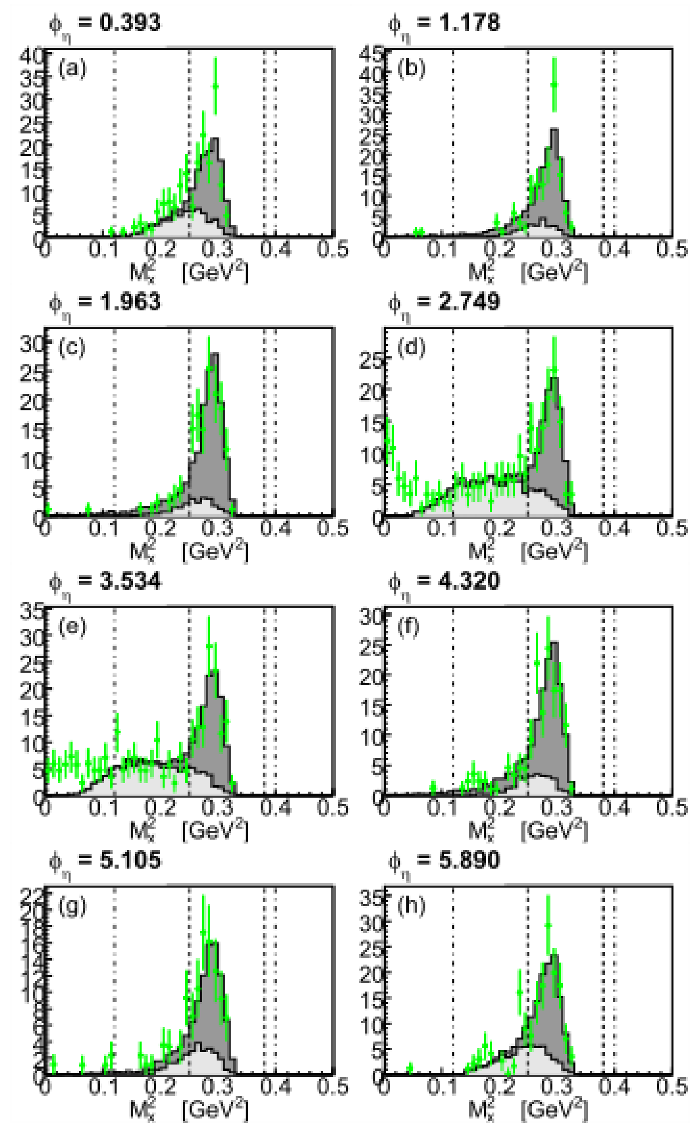
Multipion subtraction in η production

W = 1.5 GeV

$\cos\theta^\star_\eta = -0.92$

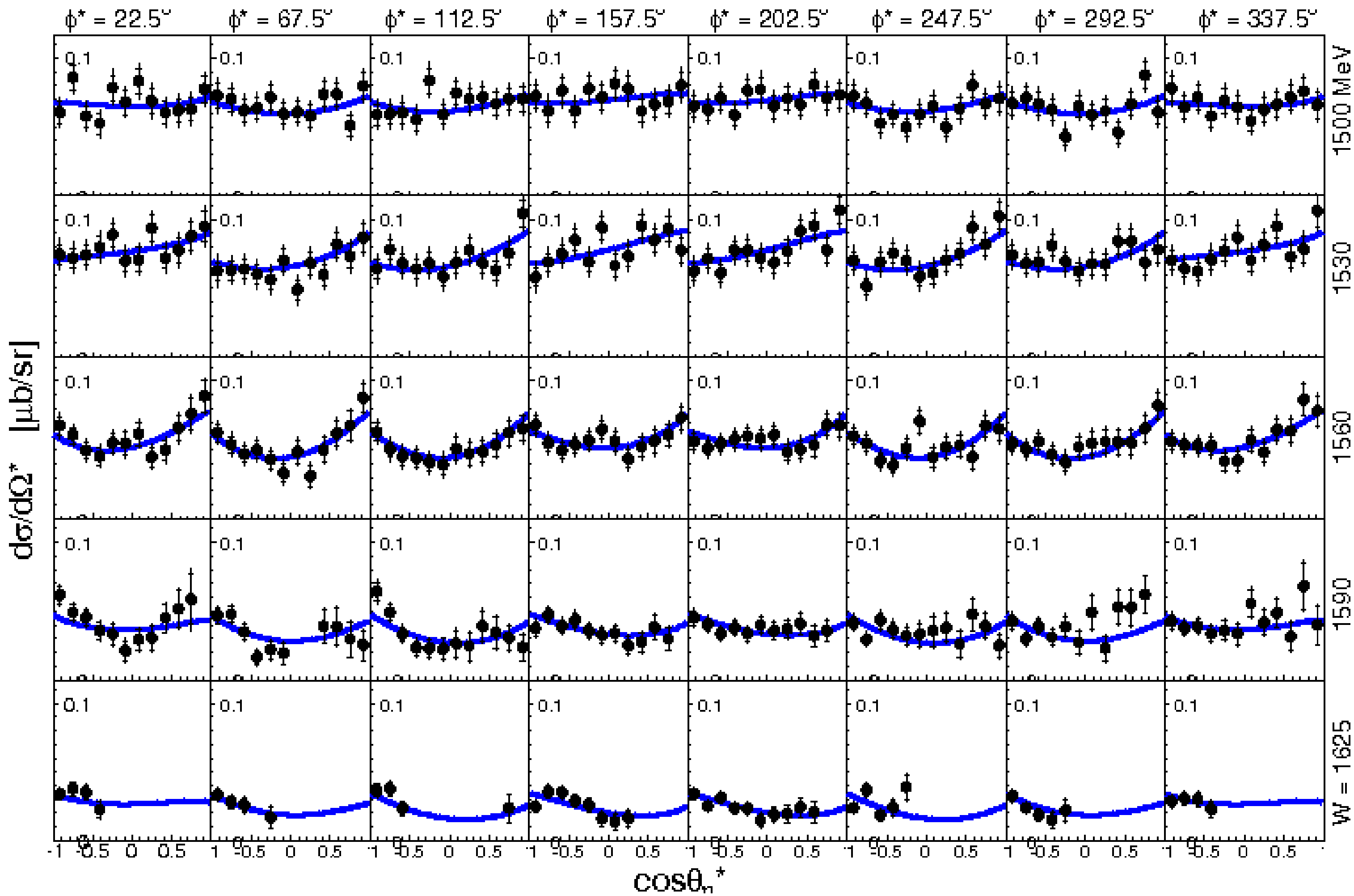


$\cos\theta^\star_\eta = 0.42$



η production cross section

$Q^2 = 5.7$
data

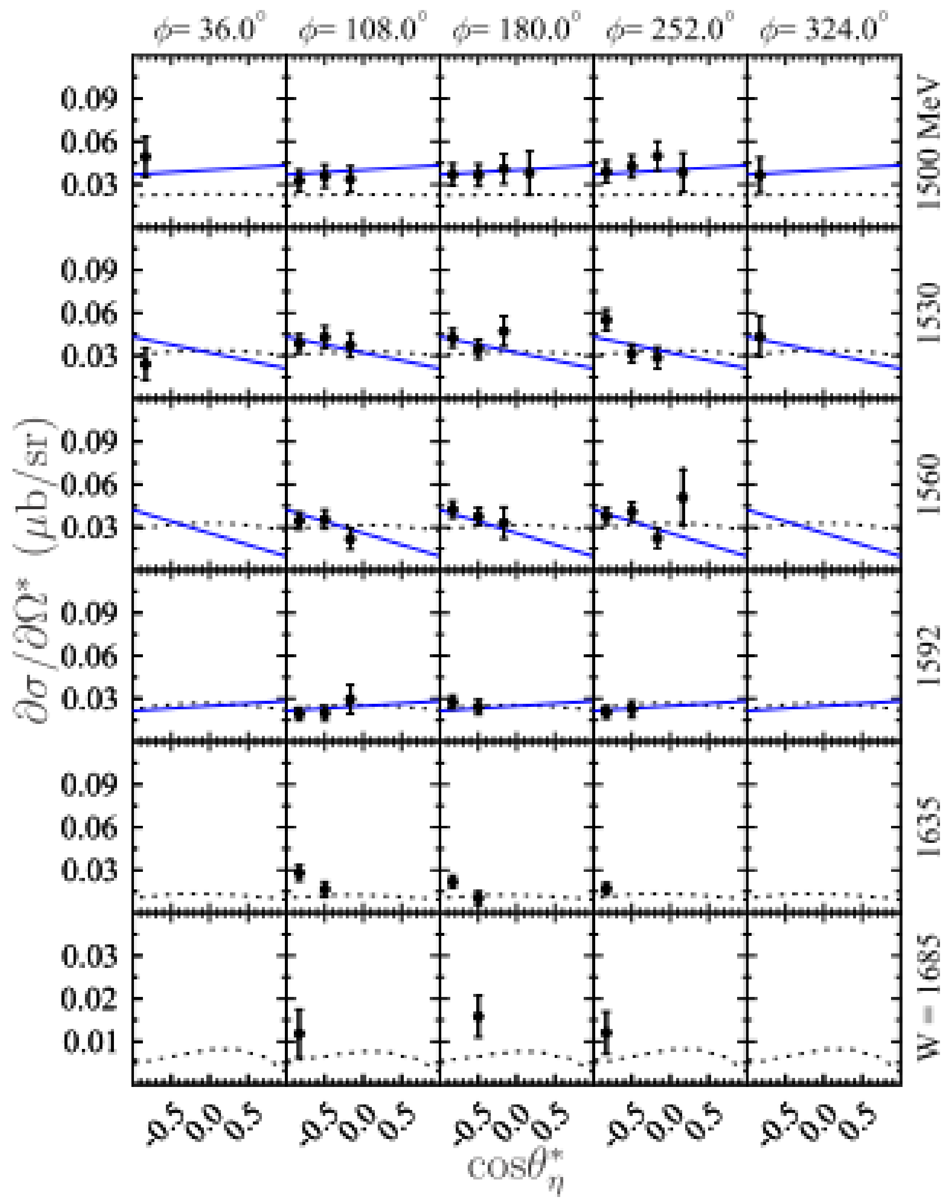


$$\frac{d\sigma}{d\Omega^*} = A + B\,\cos\theta^* + C\,\cos^2\theta^* + D\,\sin\theta^*\cos\phi^* + E\,\cos\theta^*\sin\theta^*\cos\phi^* + F\,\sin^2\theta^*\cos2\phi^*$$

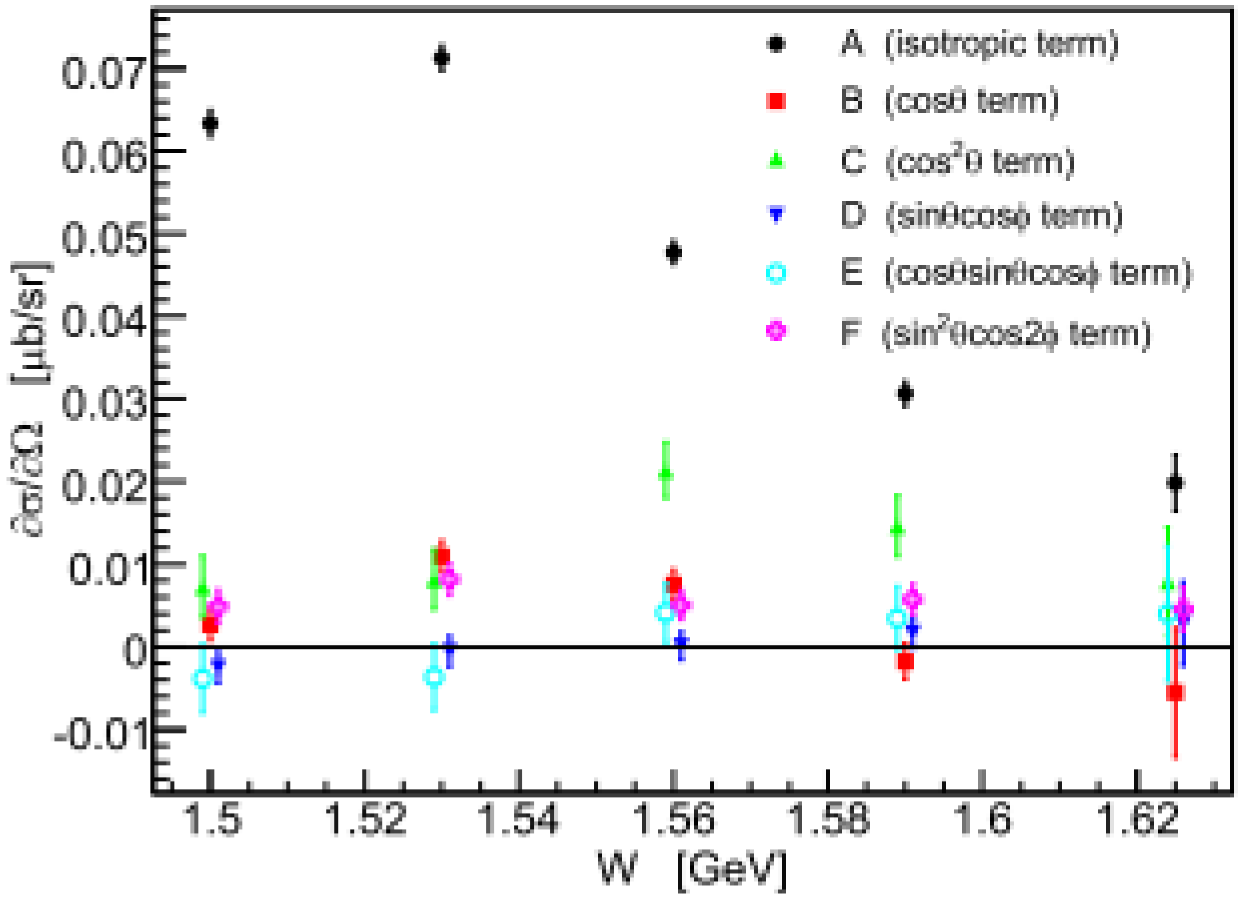
η production cross section

Q^2 = 7.0 data
Fit with

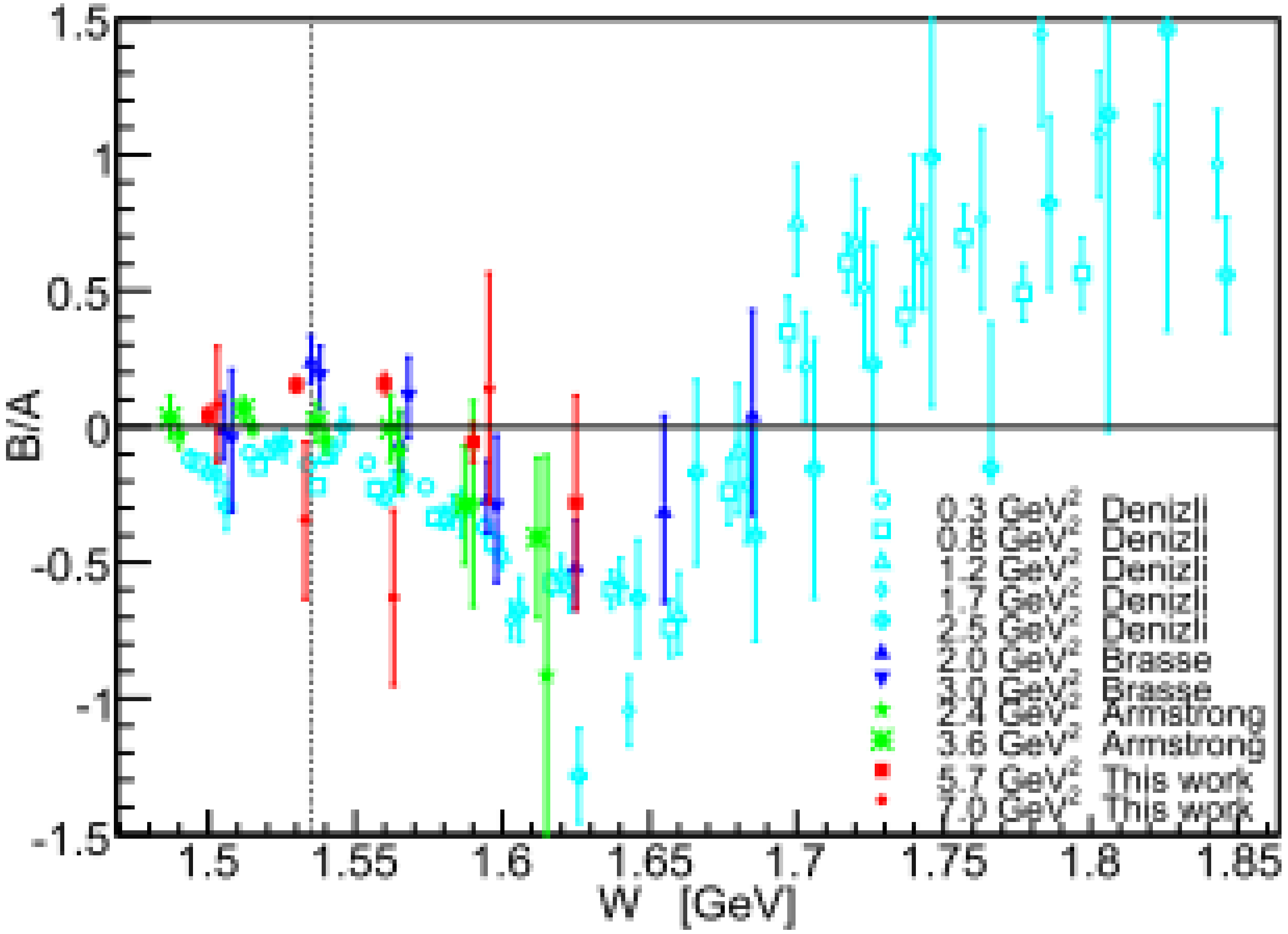
$$\frac{d\sigma}{d\Box^{\star}} = A_o + A_1 \cos\theta^{\star}$$



Fit Coefficients

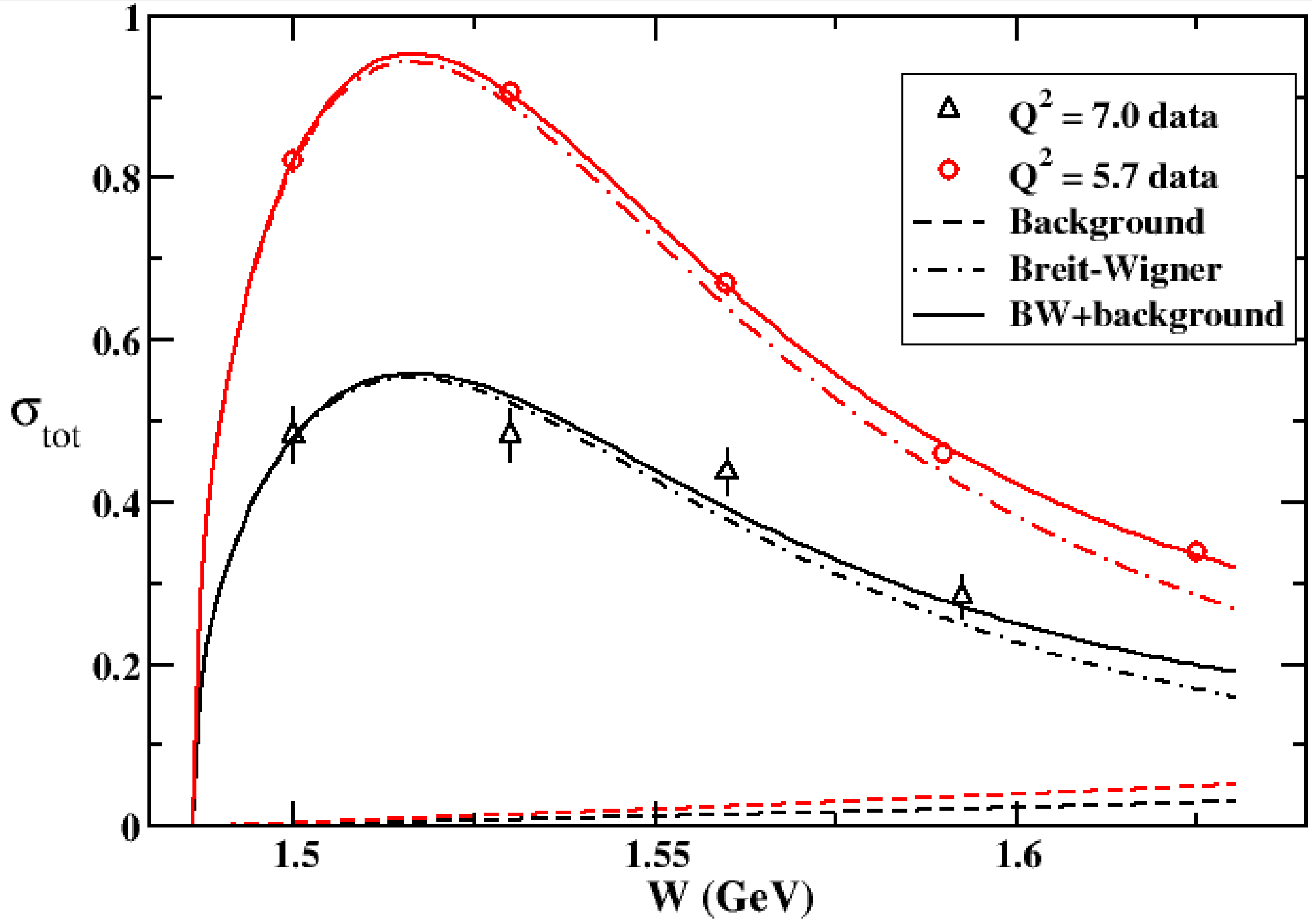


Fit Coefficients



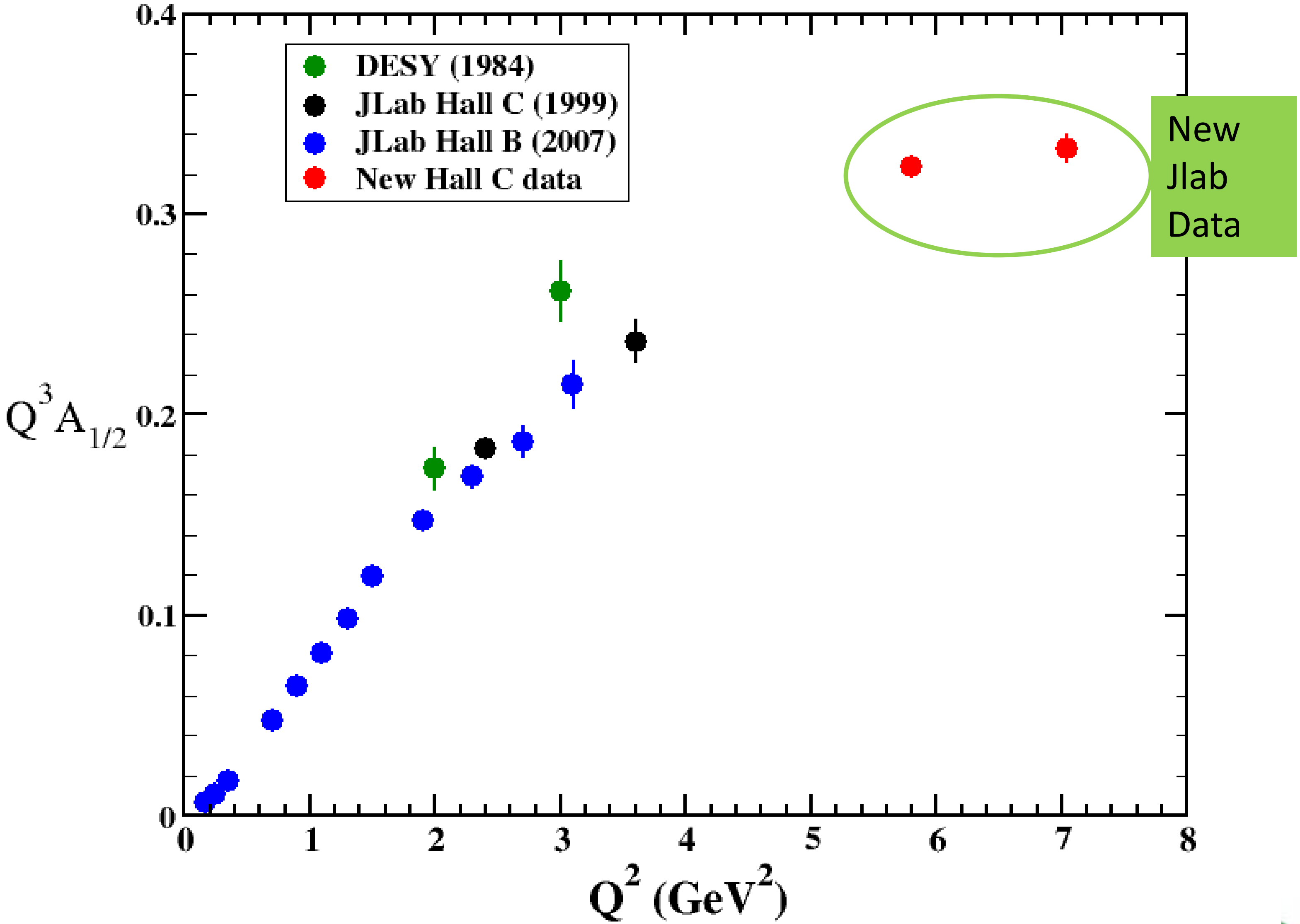
$$\frac{d\sigma}{d\Omega^*} = A + B\ \cos\theta^* + C\ \cos^2\theta^* + D\ \sin\theta^*\cos\phi^* + E\ \cos\theta^*\sin\theta^*\cos\phi^* + F\ \sin^2\theta^*\cos2\phi^*$$

η total cross section



Simultaneous fit both data sets with relativistic Breit-Wigner.

Q^2 dependence of $A_{1/2}$ for S_{11}



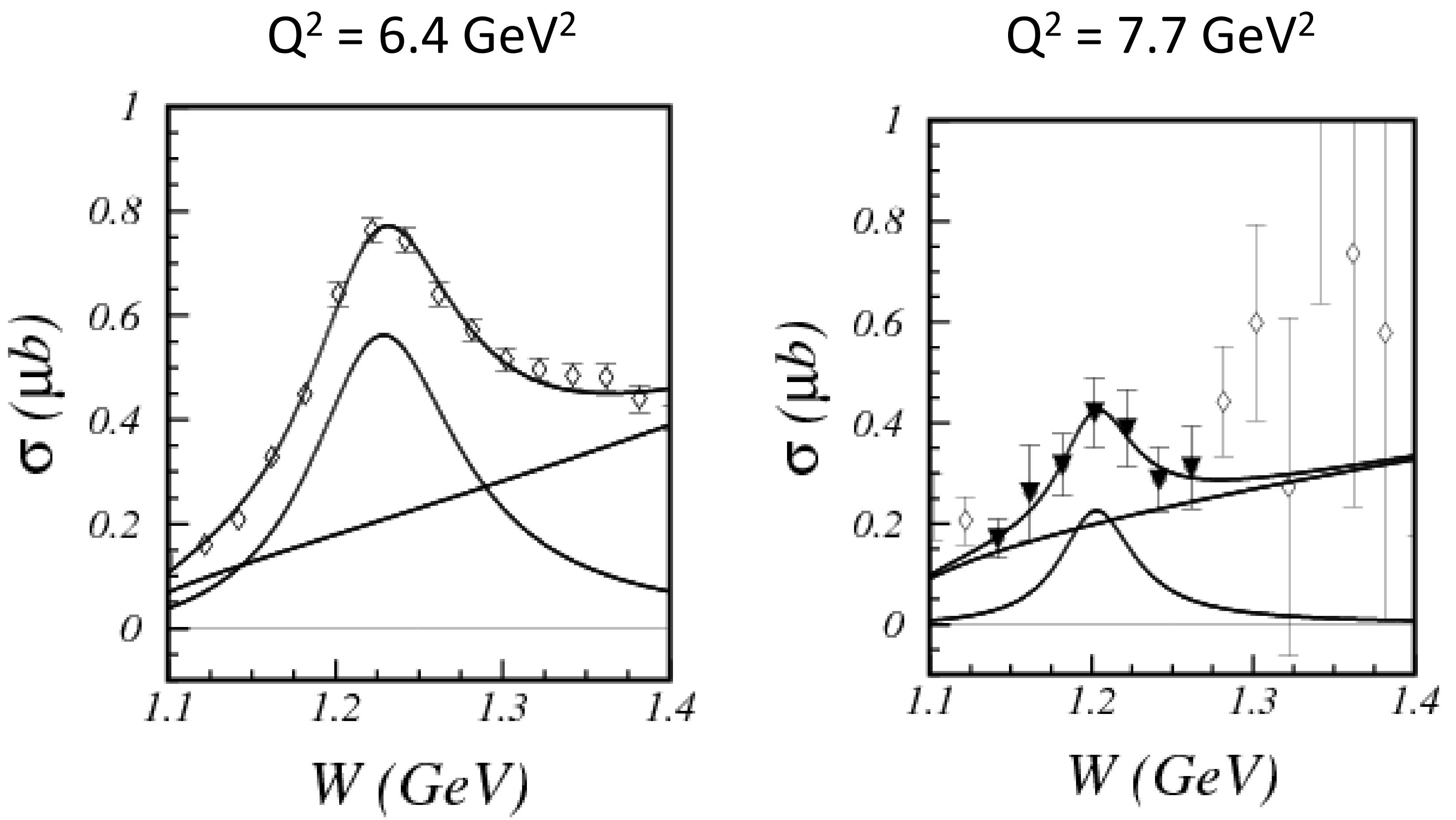
Summary

- Measured $p(e,e'p)\pi^\circ$
  - Full Θ_{cm} and ϕ_{cm} for W = 1.08 to 1.4 GeV at Q^2 = 6.4 GeV^2
  - Partial Θ_{cm} and ϕ_{cm} for W = 1.08 to 1.4 GeV Q^2 = 7.7 GeV^2
  - Determine G^*_M, E2/M1 in global UIM analysis
  - A. N. Villano et al, Phys.Rev.C80:035203,2009
    ArXiv:0906.2839v2 has UIM analysis results

- Measured $p(e,e'p)\eta$
  - Full Θ_{cm} and ϕ_{cm} for W = 1.50 to 1.59 GeV at Q^2 = 5.7 GeV^2
  - Partial Θ_{cm} and ϕ_{cm} for W = 1.50 to 1.59 GeV at Q^2 = 7.0 GeV^2
  - Determine $A_{1/2}$ for S_{11}
  - M. Dalton et al, Phys.Rev.C80:015205,2009

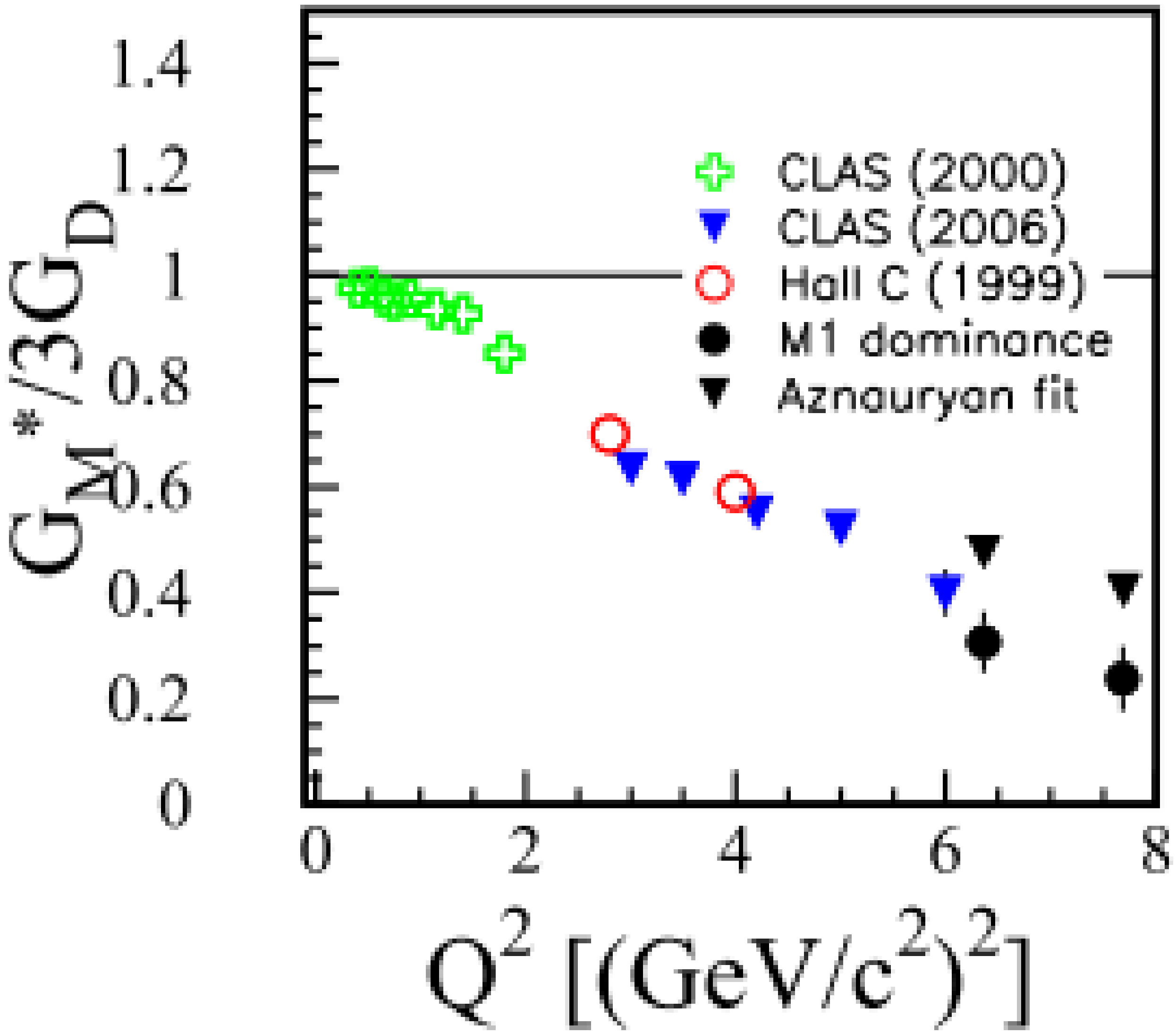
Backup slides

Total cross section

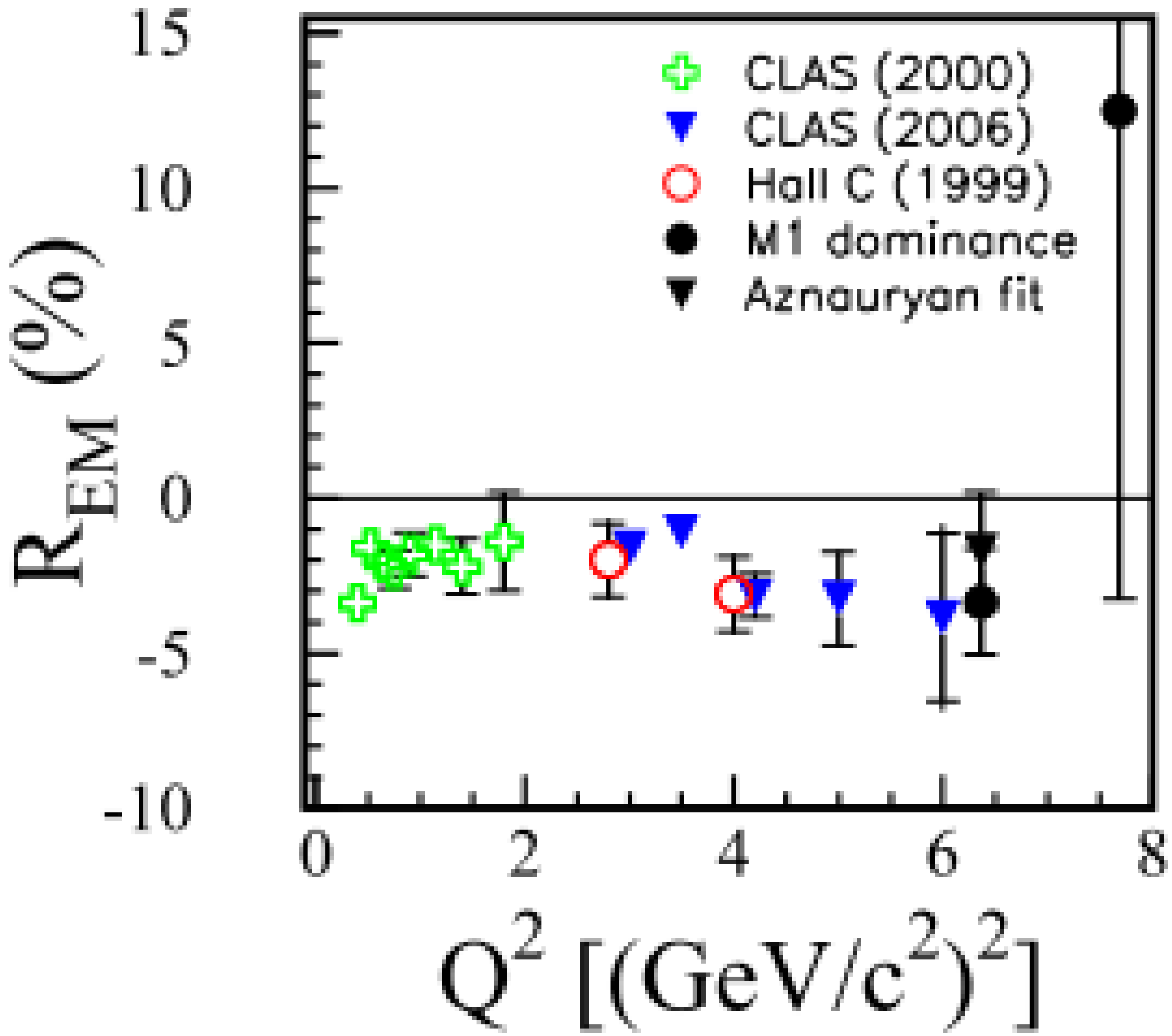


Fit total cross section with Breit-Wigner + background
Assume M1 dominance and extract G_M

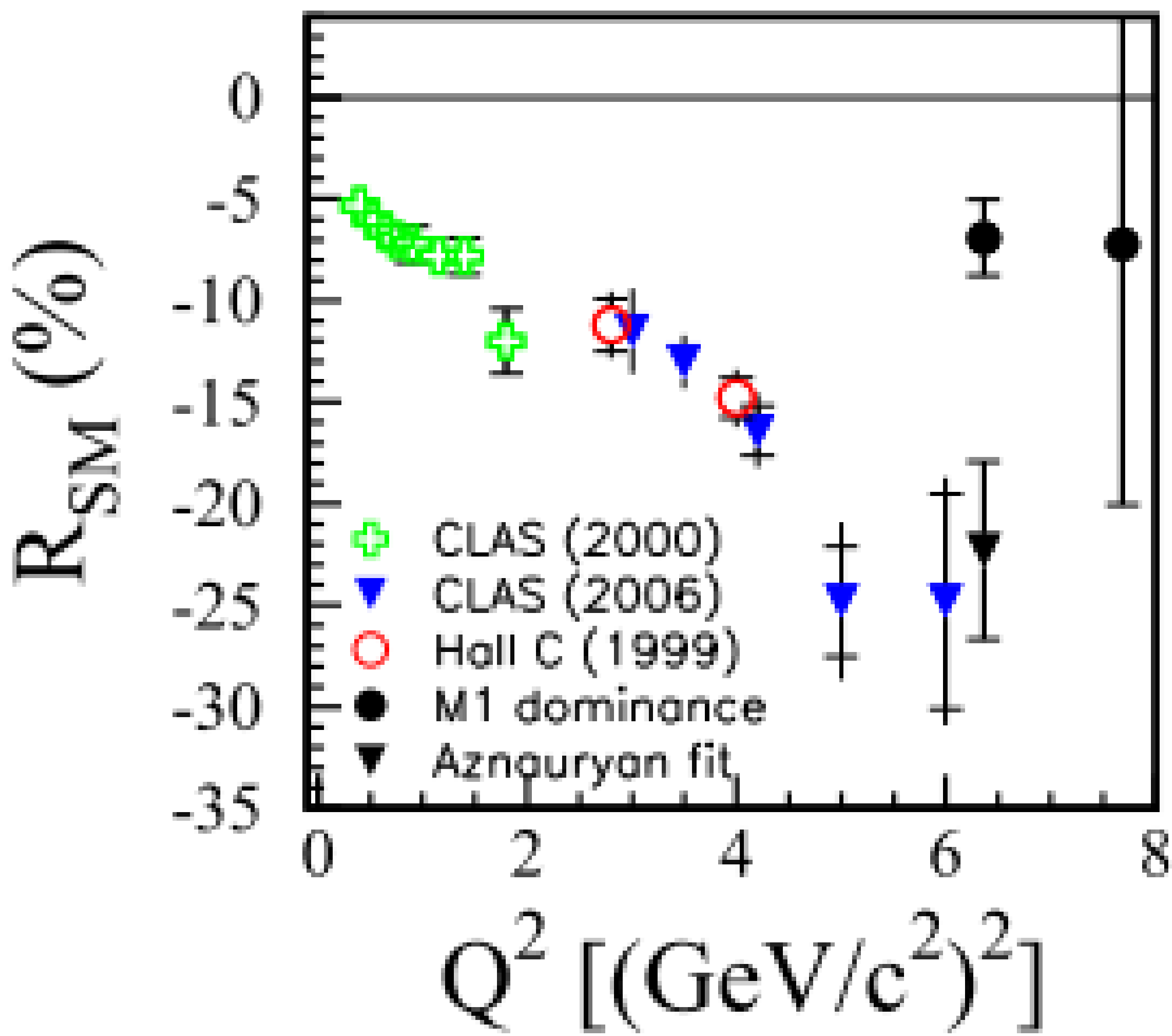
Comparison to UIM extraction



Comparison to UIM extraction



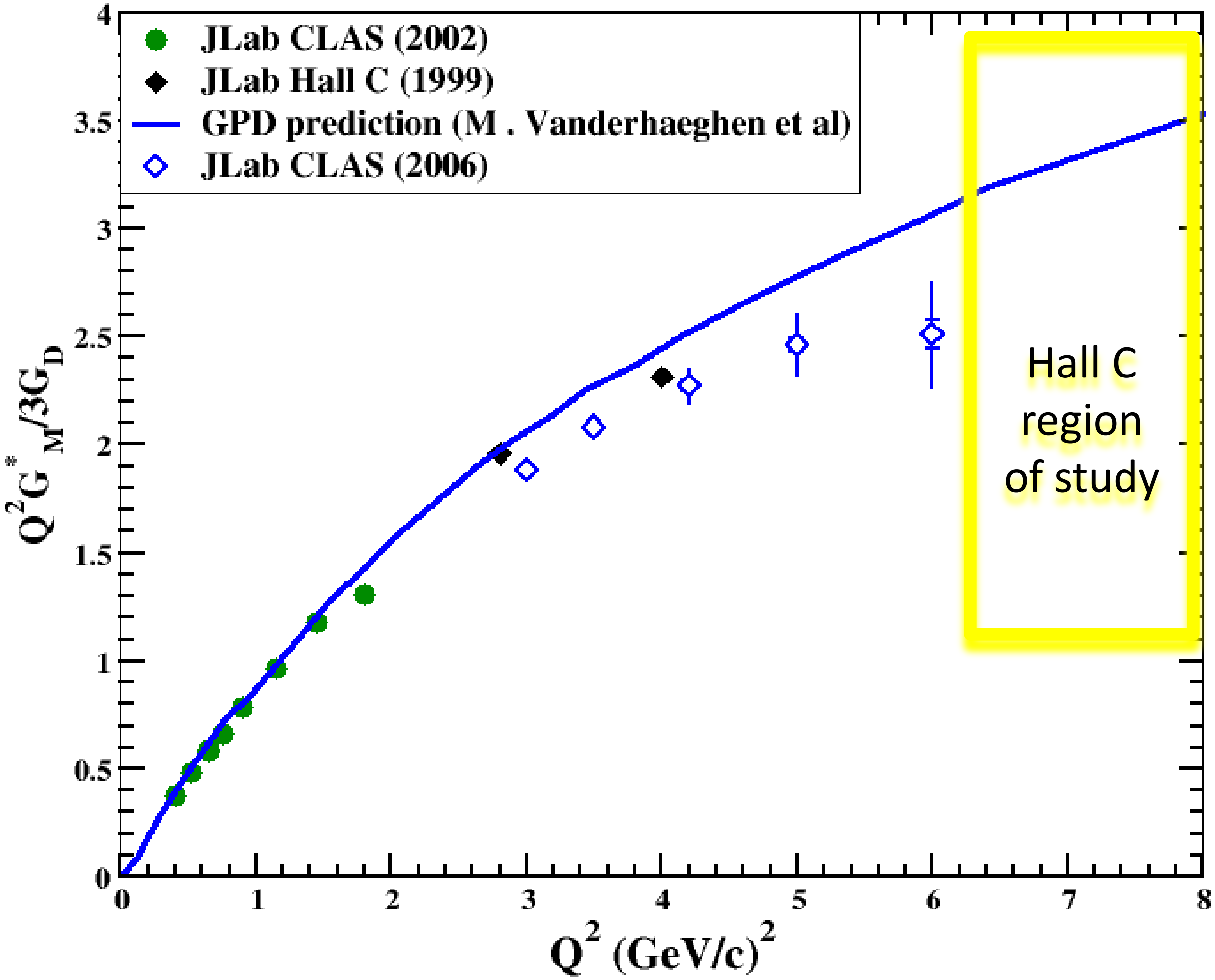
Comparison to UIM extraction

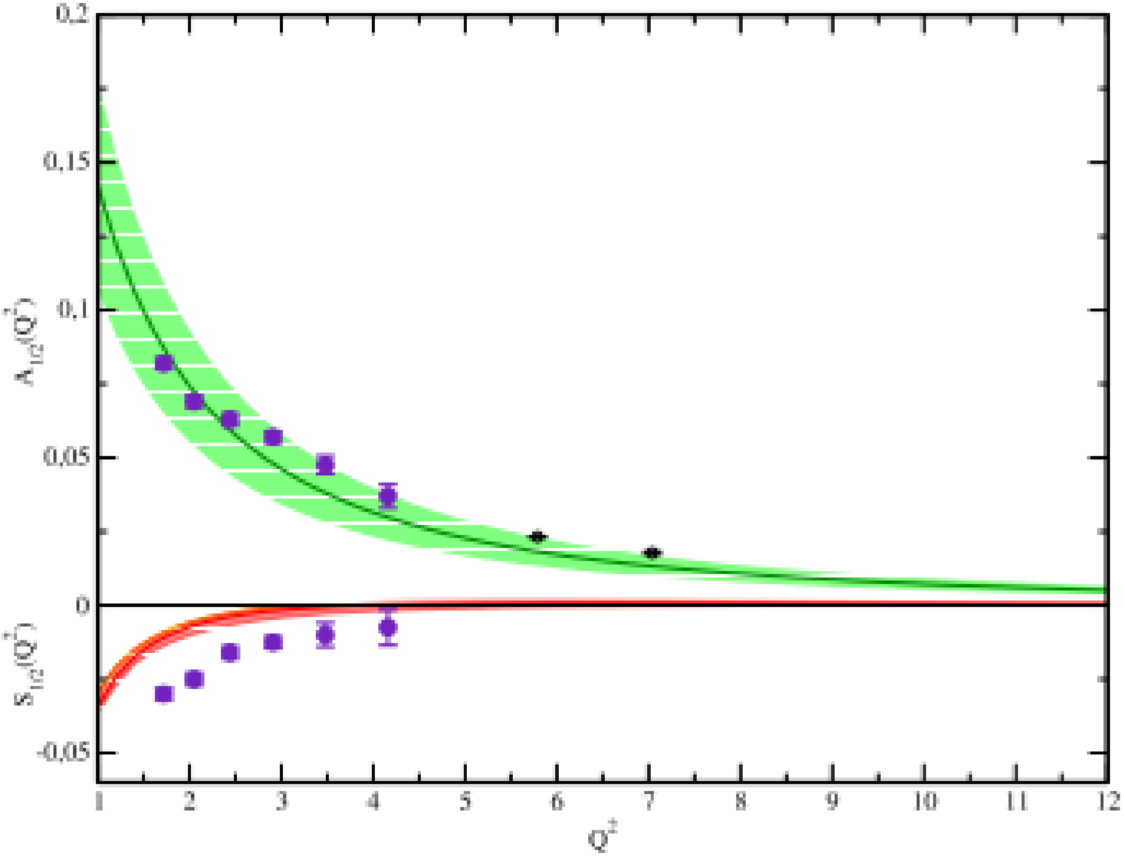


Magnetic FF, G^*_M, for $P_{33}(1232)$

In Large N_c limit with GPDs E^u and E^d from fits to proton and neutron data

$$G^*_M(t) = \frac{G^*_M(0)}{\kappa_V} \int_{-1}^{+1} dx \left\{ E^u(x,\xi,t) - E^d(x,\xi,t) \right\} = \frac{G^*_M(0)}{\kappa_V} \left\{ F_2^p(t) - F_2^n(t) \right\}$$




0,2
0,15
0,1
0,05
0
-0,05
$A_{1/2}(Q^2)$
$S_{1/2}(Q^2)$
1
2
3
4
5
6
7
8
9
10
11
12
Q^2