SPIN ASYMMETRIES IN ELECTROPRODUCTION AT JLAB-CLAS

- Interest in resonance region to clarify role of known resonances: possibly find new ones using longitudinally polarized electrons scattering on polarized protons and deuterons
- Spin degrees of freedom good at selecting particular resonances
- Inclusive results have high statistics: some resonances very prominent.
- Exclusive reactions have additional selectivity: will show results for $\pi^+\pi^-$, ρ, and η final states. Analysis of single pion and kaon final states in progress.
- Above resonance region, reaction mechanism of interest. Case of diffractive ρ electroproduction will be presented.
- Many other interesting aspects (GDH Sum Rule, Bjorken Sum Rule, $\delta u/u$ at high x) not presented here for lack of time.

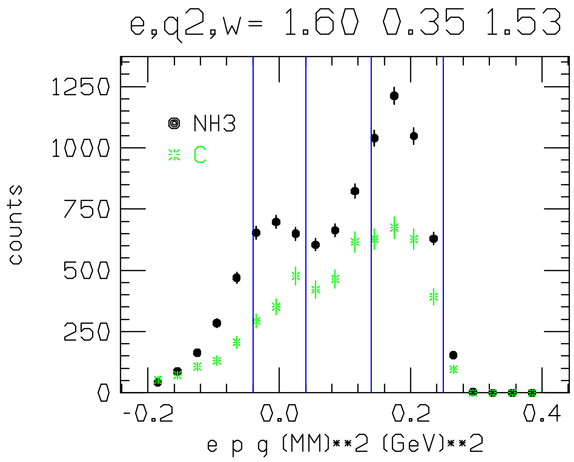
EXCLUSIVE η ELECTROPRODUCTION

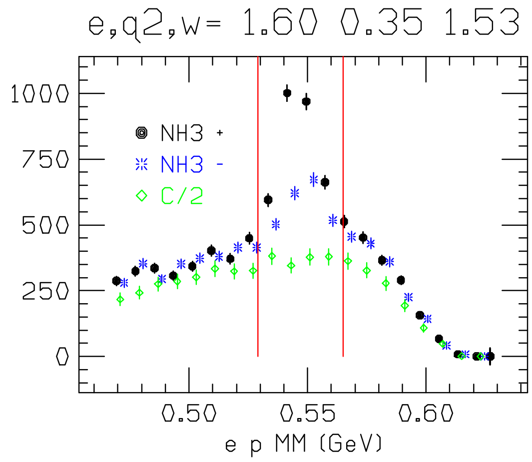
- **Mainly couples to $S_{11}(1535)$, higher mass S_{11} resonances ($I = 0$ pseudoscaler)**
- **Spin-averaged cross section strongly peaked near 1.53 GeV, secondary peak visible near 1.7 GeV**
- **For spin-1/2 resonances, A_1=1.**
- **$A_1 < 1$ indicates coupling to spin-3/2 resonances**
- **Single-spin asymmetries non-zero if interference diagrams important.**

Will put cross section plot here

$ep \rightarrow ep\eta$ EVENT SELECTION

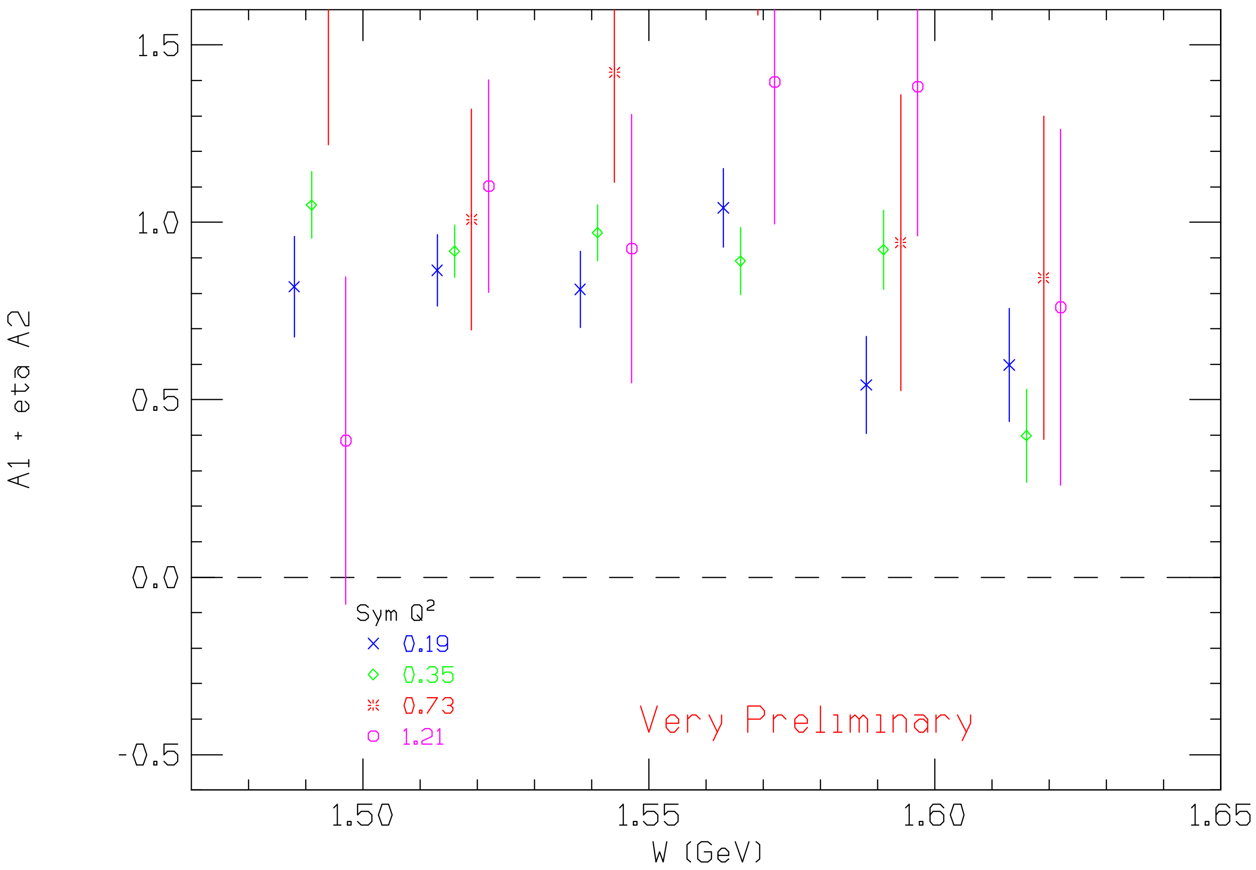
- Scattered electron, recoil proton, and 1 photon detected in CLAS, and no pions detected.
- (Missing mass)^2 must be near 0 ($\eta \rightarrow \gamma\gamma$) or 0.2 GeV^2 ($\eta \rightarrow 3\pi^0$) (left figure)
- Cut on *ep* missing mass near *eta* mass
- Subtract ^{15}N, He background using C spectrum (green points).
- remaining background from $ep \rightarrow ep2\pi^0$. For now, assume same asymmetry as $ep \rightarrow ep\eta$ (to be improved in future).
- Large double spin asymmetry visible in raw data.





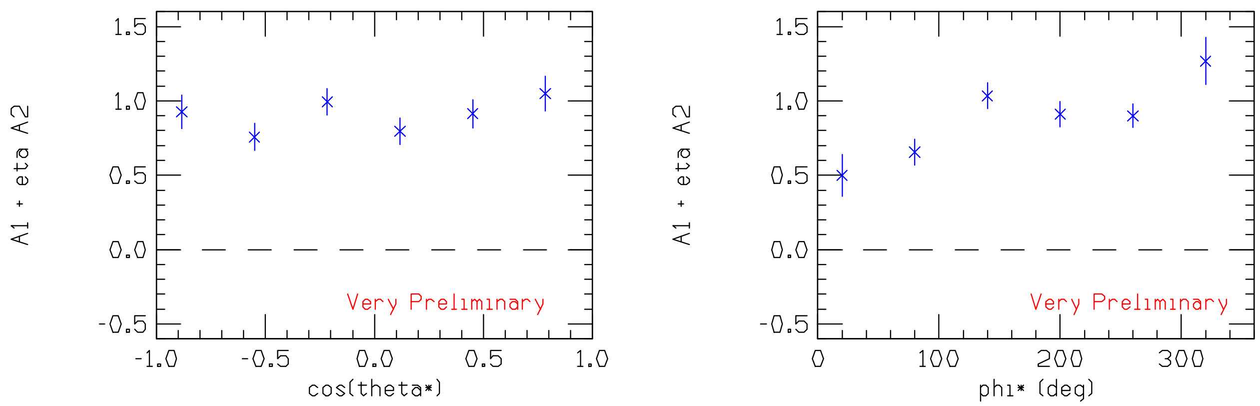
$ep \to ep\eta \;\; A_1 + \eta A_2$

- $A_1 + \eta A_2$ determined as for inclusive scattering, except for D use fixed $R = \sigma_L/\sigma_T = 0.2$, based on limited existing data.
- Typical values of η are 0.2, and $A_2 < \sqrt{R}$, so $\eta A_2 < 0.1$.
- Averaged over $\cos(\theta^*)$ and ϕ^*, $A_1 + \eta A_2$ is close to 1 at $S_{11}(1535)$, except at $W > 1.6$ GeV (where $S_{11}(1535)$ no longer dominates cross section).



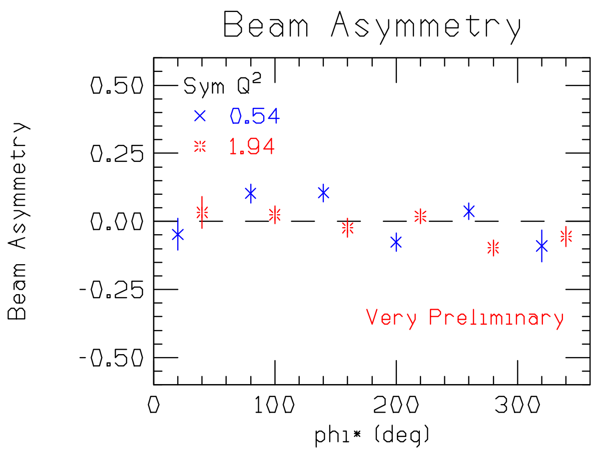
$$ep \to ep\eta \quad A_1 + \eta A_2$$

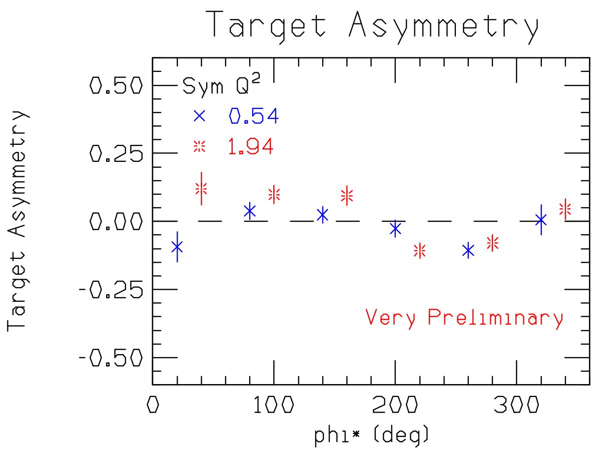
- Plots show $A_1 + \eta A_2$ averaged over Q^2 and W (for $W < 1.6$).
- Left plot is average $A_1 + \eta A_2$ versus $\cos(\theta^*)$, averaged over ϕ^*. Appears constant.
- Right plot is average $A_1 + \eta A_2$ versus ϕ^* averaged over $\cos(\theta^*)$. Slight trend possibly indicated by data.



$ep \to ep\eta$ SINGLE SPIN ASYMMETRIES

- Plots show target and beam single-spin asymmetries averaged over W and $\cos(\theta^*)$ for two Q^2 regions.
- Beam SSA small but possible non-zero. Can only depend on $\sin(\phi^*)$.
- Target SSA is small but seems to be non-zero and follow a $\sin(\phi^*)$ dependence.





OUTLOOK FOR $ep \to ep\eta$

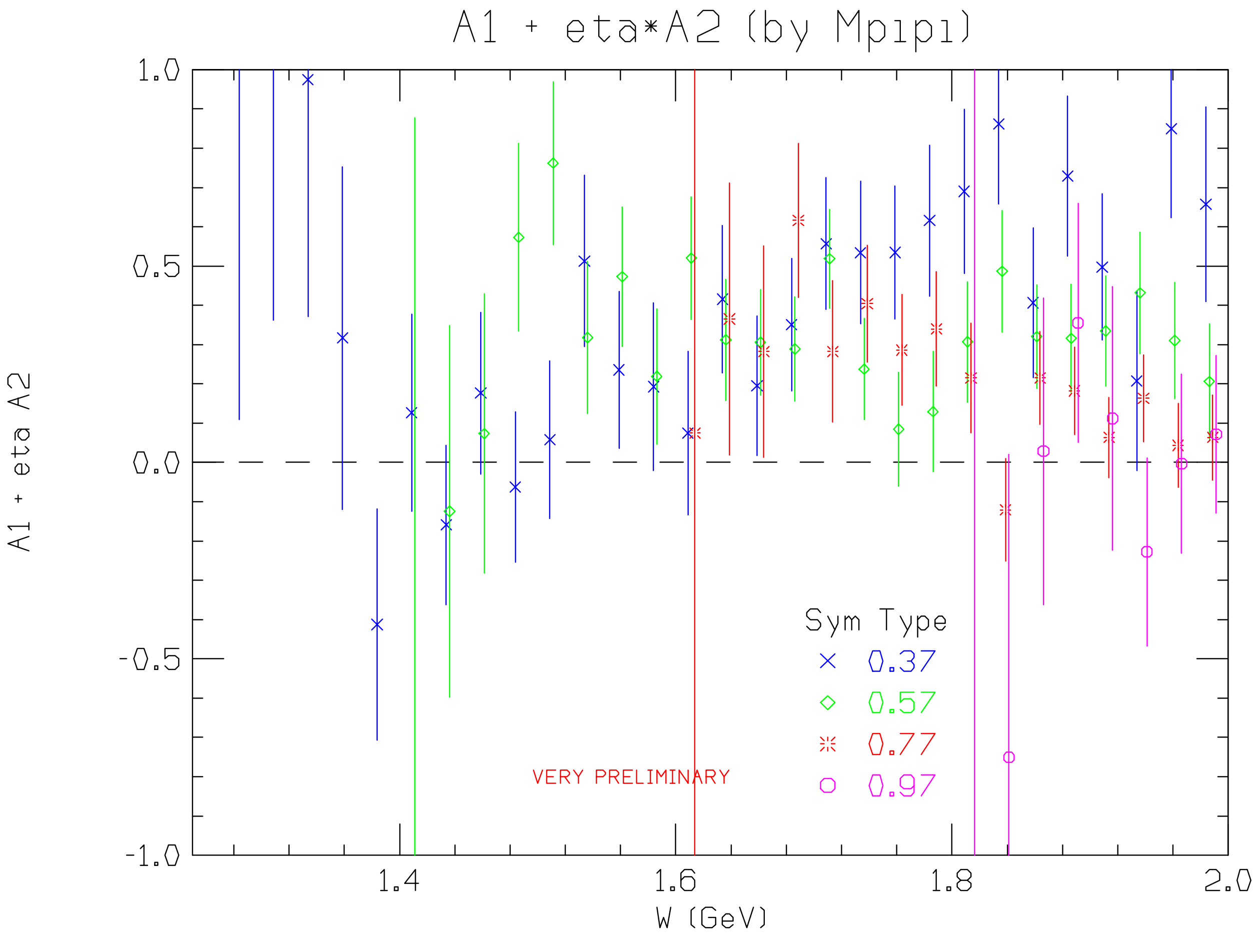
- Correction for dilution and asymmetry of $ep \to ep2\pi^0$ needed(small for $W < 1.6$ GeV).
- Comparison to models such as η-MAID needed to interpret data.
- Much more data will soon be available with $E = 2.4$ GeV and $E = 4.2$ GeV. The acceptance and resolution of CLAS is better suited to these energies than the $E = 1.7$ GeV and $E = 5.7$ GeV analyzed so far. This will allow better examination of the interesting region $W > 1.6$ GeV.

$ep \to ep\pi^+\pi-$ REACTION

- Interesting because only couples strongly to selected resonances (for example, decay of $S_{11}(1535)$ to $\pi\pi$ is $< 10\%$.
- Possible new narrow resonance seen in spin-averaged cross section at CLAS: any evidence in double-spin asymmetry? Models predict varying degrees of sensitivity, depending on quantum numbers of resonance.

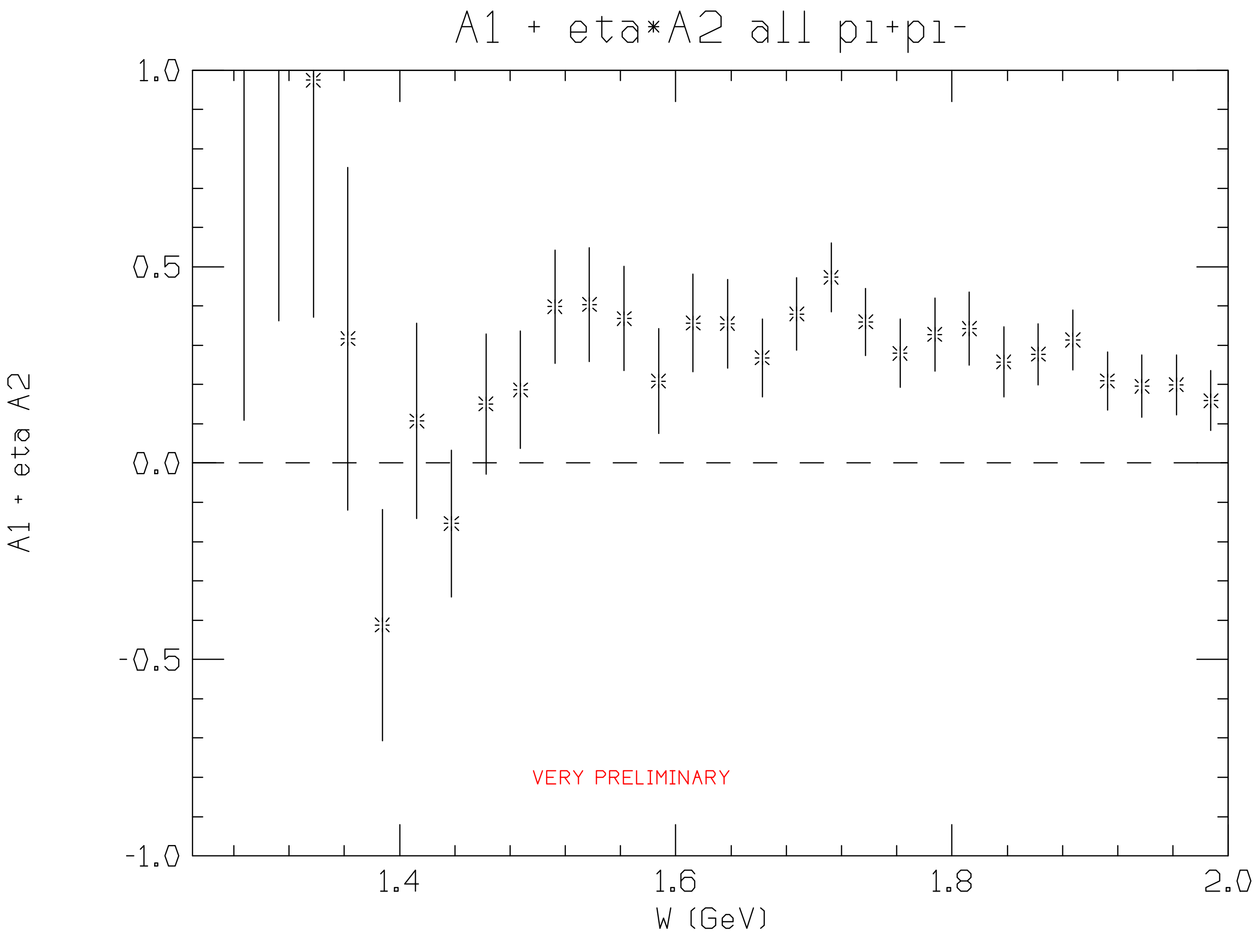
$ep \to ep\pi^+\pi-$ ($E = 5.7$ GeV)

- Plot show $A_1 + \eta A_2$ for all $E = 5.7$ data sets, averaged over event topology, for four regions in $M_{\pi\pi}$. Do dependence of event type was observed.
- A_1 is largest for low $M_{\pi\pi}$, smallest for high $M_{\pi\pi}$.
- Only clear structure is dip near 1.45 GeV.



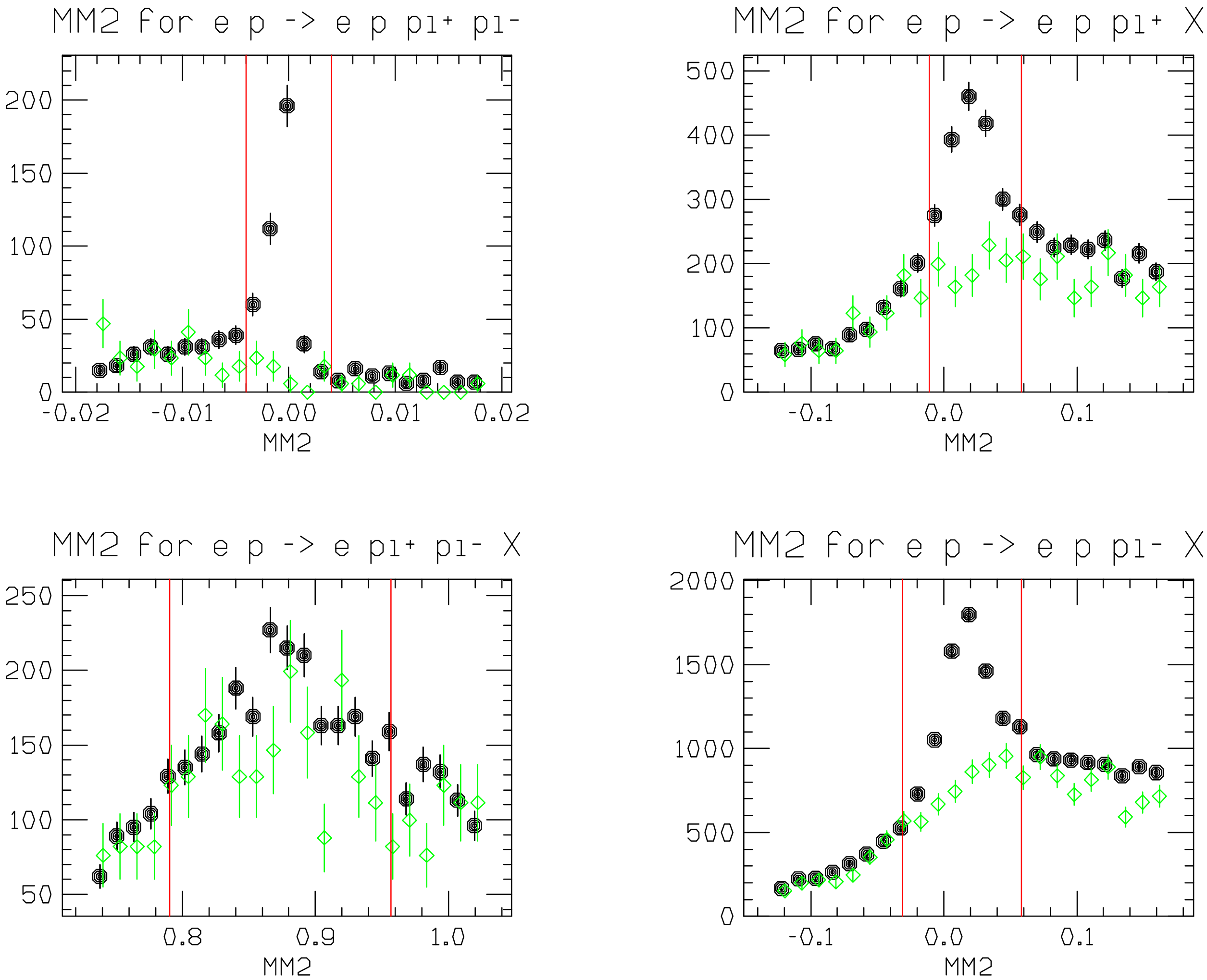
$ep \longrightarrow ep\pi^+\pi-$ ($E = 5.7$ GeV)

- Plot show $A_1 + \eta A_2$ for all $E = 5.7$ data sets, averaged over event topology and $M_{\pi\pi}$.
- Dip near 1.45 GeV still evident. No clear structure seen near 1.72 GeV (hint of a bump).



$ep \rightarrow ep\pi^+\pi-$ EVENT SELECTION

- Selected events where all final state particles detected, or one particle missing.
- Cuts on missing mass reduce N background (green), especially when all particles detected.
- Plots are for one typical bin in W, Q^2, and $-t'$, and torus polarity.

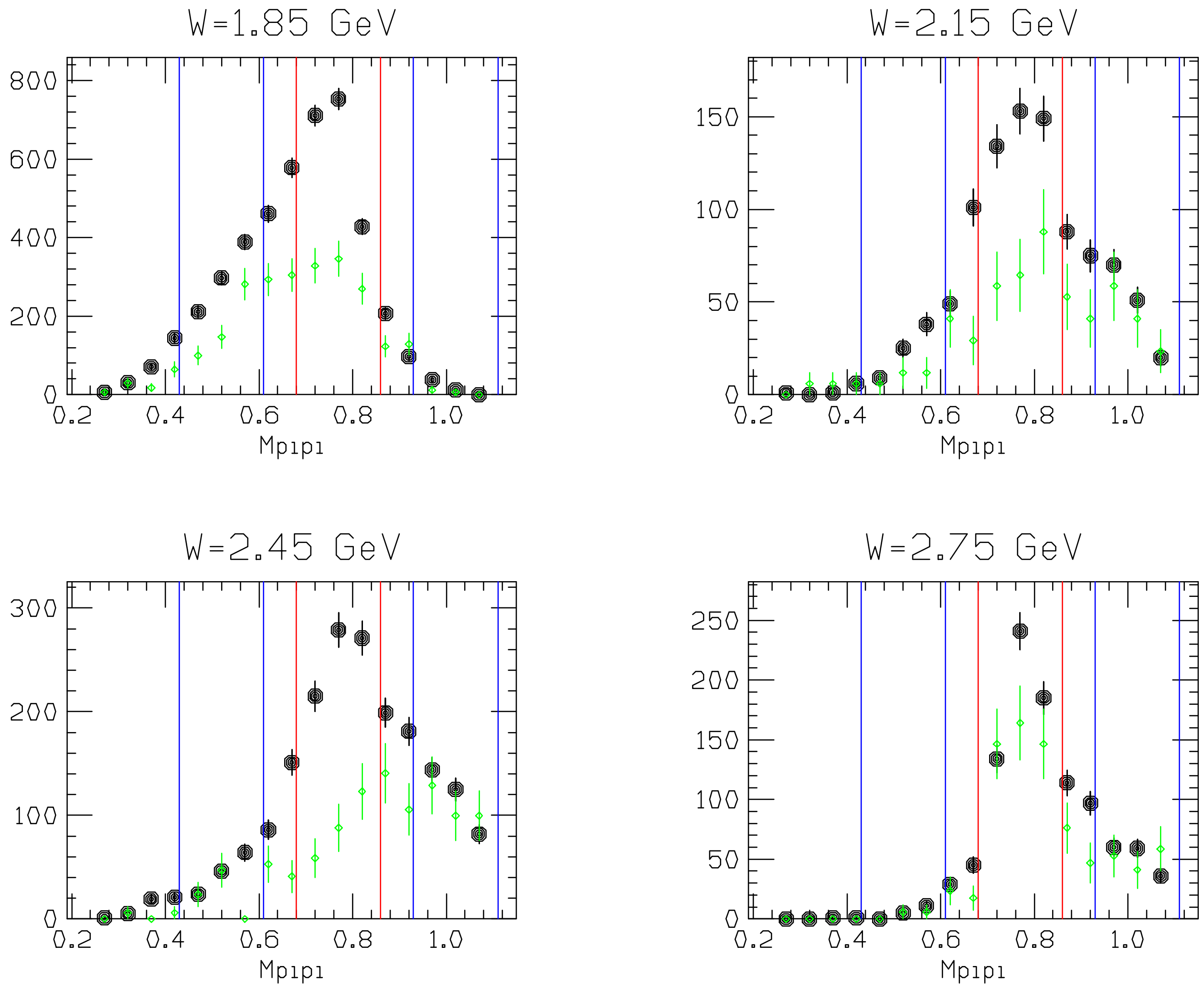


EXCLUSIVE ρ^0 ELECTROPRODUCTION

- Process is large part of total cross section at high W, low $-t'$, low Q^2.
- Can be described in terms of Reggeon exchange at lower W, (model of Kochelev et al.) possibly changing to Pomeron exchange at higher W (model of Ivanov et al.)
- GVMD prediction of Fraas is $A_1(\rho) \approx 2A_1^i/(1+(A_1^i)^2)$, where A_1^i is for inclusive electron scattering (valid at high Q^2).
- Double spin asymmetry interesting to distinguish (Pomeron exchange gives $A_1 = 0$, Reggeon gives $A_1 > 0$.
- HERMES found $A_1 = 0.23 \pm 0.14$ at $< W >= 4.9$ GeV, $< Q^2 >= 1.8$ GeV^2, and $< -t' >= 0.15$ GeV^2 for proton target.
- CLAS kinematics probe lower W region. Used $Q^2 > 0.5$ GeV^2, $1.75 < W < 3$ GeV, $-t' < 0.4$ GeV^2 (beam energy fixed at 5.7 GeV). Non-diffractive production will be important.

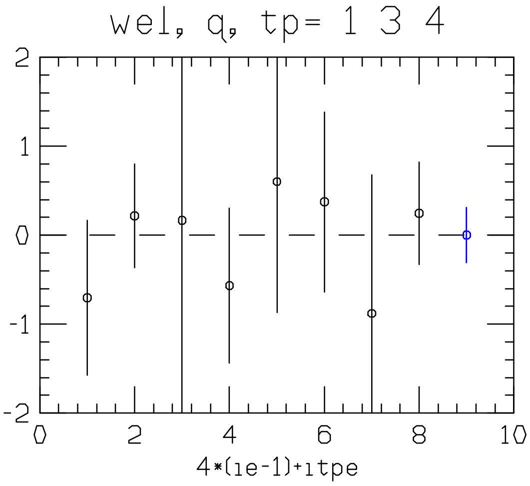
$ep \rightarrow ep\rho$ EVENT SELECTION

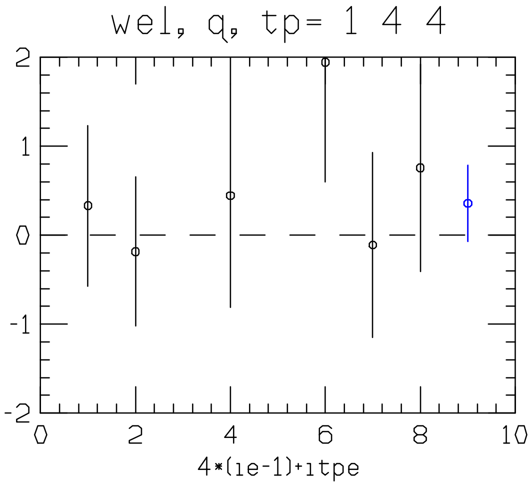
- Selected $\pi^+\pi^-$ final state for four event topologies as described before, then ρ events selected with cuts shown by red lines for representative ep missing mass spectra for four W bins.
- Dilution and asymmetry from non-ρ events made using events within green lines (net correction to A_1 close to zero on average).



$ep \rightarrow ep\rho$ DOUBLE SPIN ASYMMETRY

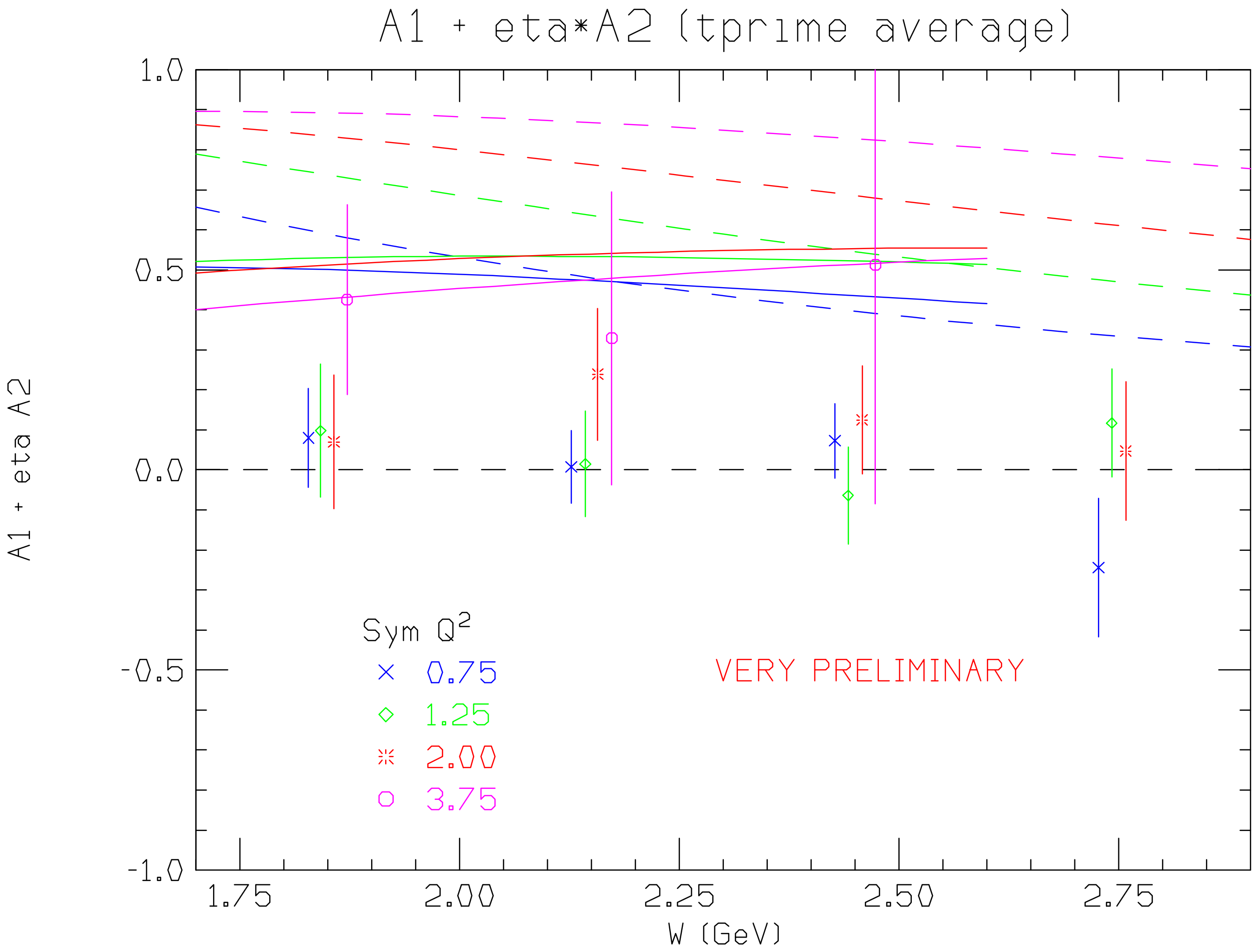
- Double spin asymmetry formed in each kinematic bin for each event topology and torus polarity.
- Converted to $A_1 + \eta A_2$ using HERMES parameterization $R = \sigma_L/\sigma_T = 0.35(Q^2/0.59)^{0.62}$
- $A_1 + \eta A_2$ then averaged over event topology and torus polarity.





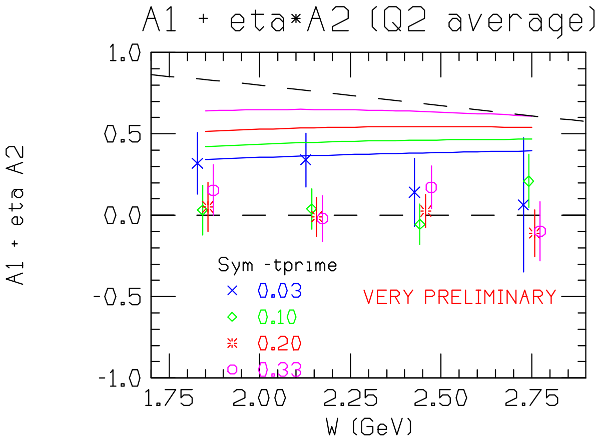
$ep \to ep\rho\ A_1 + \eta A_2$

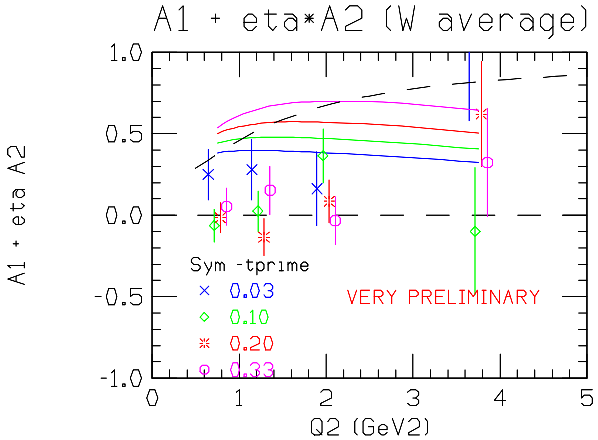
- **Plot shows $A_1 + \eta A_2$ averaged over $0 < -t' < 0.4$ GeV^2. Values are close to zero (slightly positive on average).**
- **Possible trend for increase with Q^2, towards better agreement with Fraas prediction (dashed curves) and Regge model of Kochelev et al. (solid curves).**



$ep \to ep\rho \; A_1 + \eta A_2$

- Also examined (W,$-t'$) dependence averaged over Q^2 (left) and (Q^2,$-t'$) dependence averaged over W. Possible trend for larger $A_1 + \eta A_2$ at larger Q^2.





OUTLOOK FOR $ep \rightarrow ep\rho$

- Need to study how holes in acceptance could bias results.
- Hope to obtain Regge model predictions at these kinematics.
- Can extend study to ρ^+
- Study in resonance region ($W < 2$) may reveal information on N^* states.
- Study can also be extended away from ρ mass peak.
- Study of ϕ^* dependence may reveal interesting information.
- Study of SSA interesting: see talk of H. Avakian.