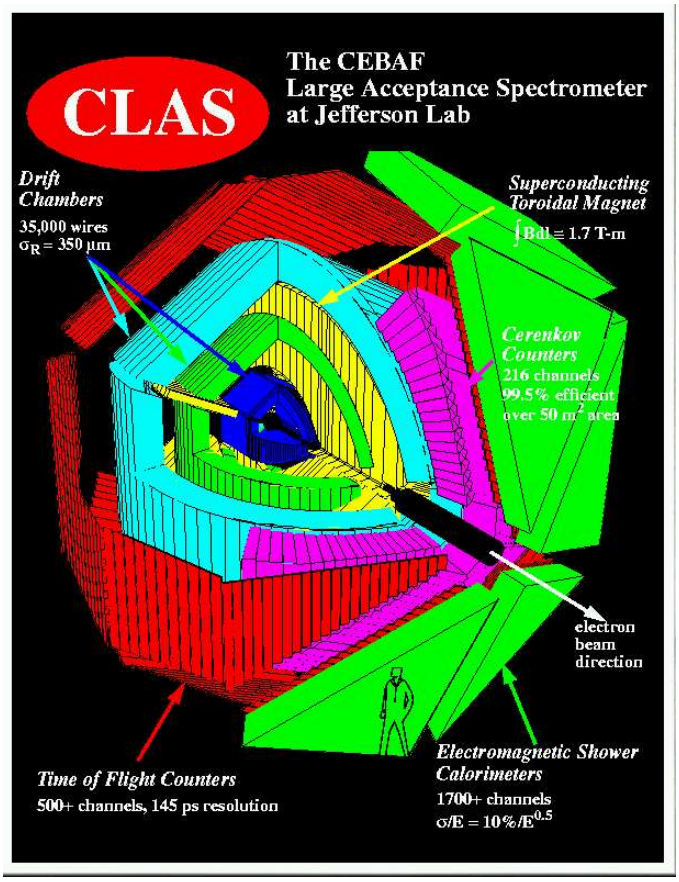
SPIN ASYMMETRIES IN EXCLUSIVE AND SEMI-INCLUSIVE ELECTROPRODUCTION AT JLAB-CLAS

- 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 ηp final state ($S_{11}(1535)$ dominated).
- Above resonance region, reaction mechanism of interest. Case of diffractive ρ electroproduction will be presented.
- Semi-inclusive DIS of interest for flavor decomposition of spin-dependent PDF's: very preliminary results for π^+, π^0, and $\pi-$ for proton and deuteron targets.

EXPERIMENT



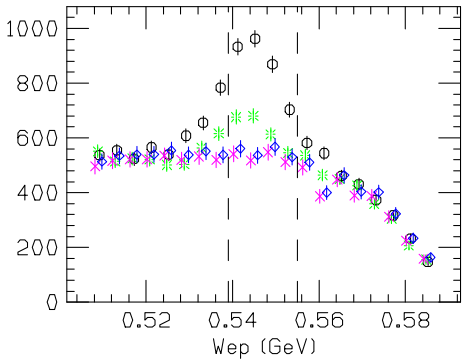
- 1.6 to 5.7 GeV longitudinally polarized electrons ($P_b = 70\%$)
- Longitudinally polarized protons ($P_t = 70\%$) and deuteron ($P_t = 30\%$) using NH_3, ND_3 at 1 K and 5 T
- Electrons, hadrons detected in CLAS
- EG1 experiment in 1998, 2000. 2×10^{10} electron triggers.
- Preliminary results from 1.6 and 5.7 GeV (2.4 and 4.2 GeV data still being processed).

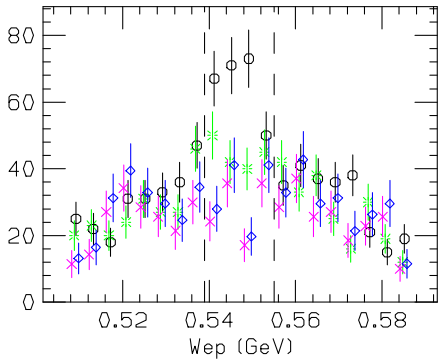
EXCLUSIVE η ELECTROPRODUCTION

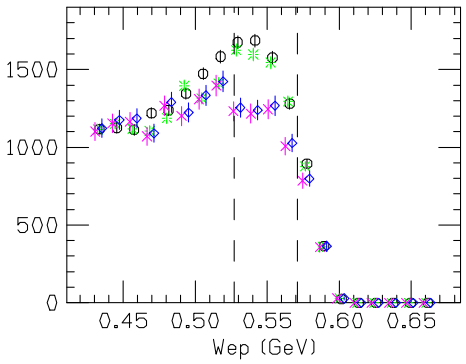
- Mainly couples to $S_{11}(1535)$, higher mass S_{11} resonances ($I = 0$ pseudoscaler)
- Spin-averaged cross section strongly peaked near 1.53 GeV, secondary peak visible near 1.7 GeV
- For spin-1/2 resonances, $A_1 = \frac{\sigma_{1/2} - \sigma_{3/2}}{\sigma_{1/2} + \sigma_{2/2}} = 1$.
- $A_1 < 1$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

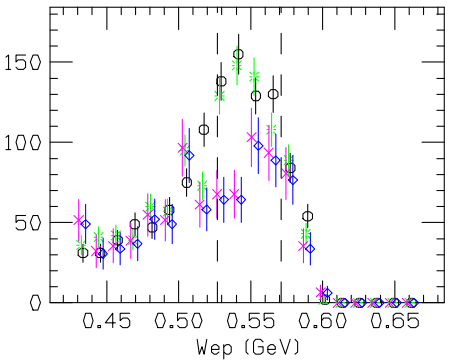
$ep \rightarrow ep\eta$ EVENT SELECTION

- Scattered electron, recoil proton.
- Missing mass W_{ep} must be near M_η.
- Large helicity dependence visible in raw 1.6 GeV spectra (black/green points have target and beam polarizations parallel or anti-parallel).
- Subtract ^{15}N, He background using C spectrum (blue/purple points).



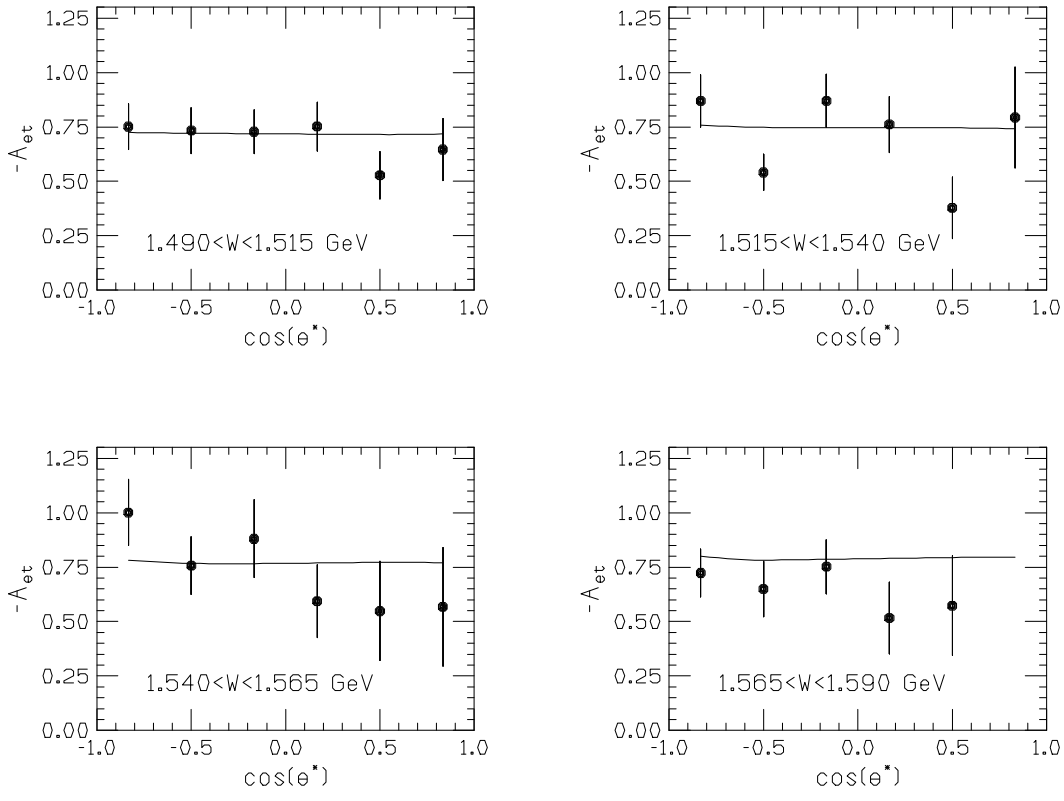






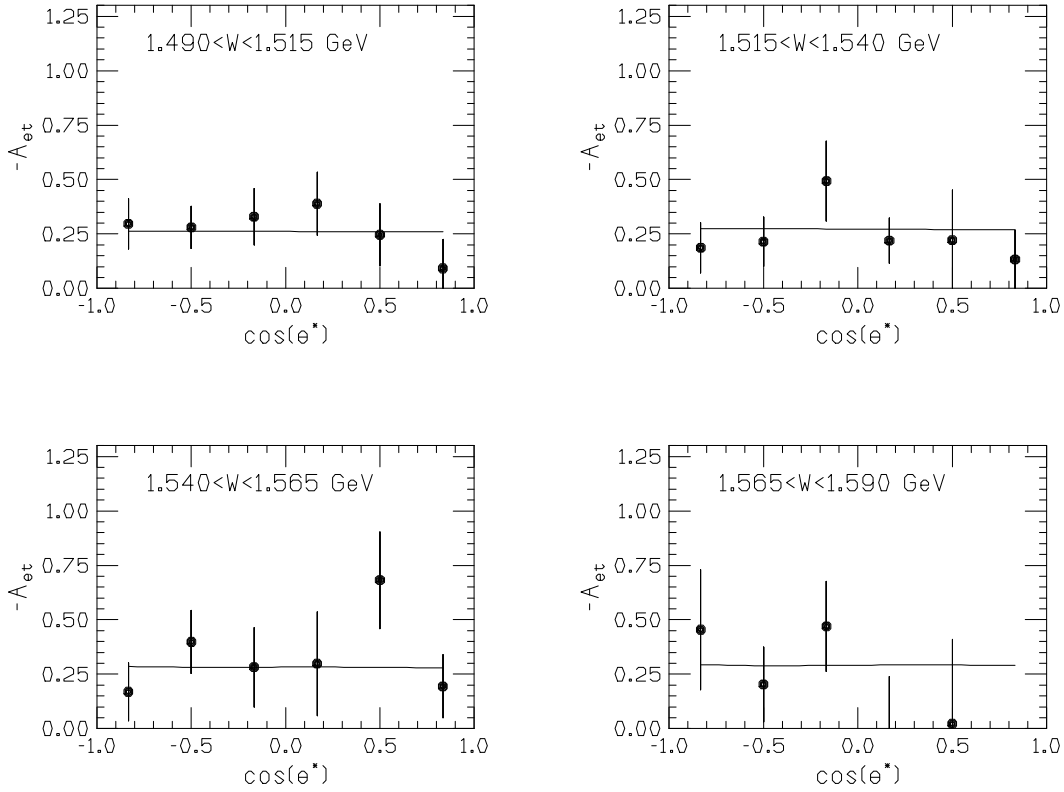
$ep \rightarrow ep\eta$ A_{et} $E = 1.6$ GeV

- Extracted double spin asymmetry $A_{et} = A_{LL}$ near $S_{11}(1535)$ peak versus $\cos(\theta^*)$
- Average $Q^2 = 0.4$ GeV^2.
- Results consistent with $A_{et}/D = A_1 = 1$ since $D \approx 0.75$ for 1.6 GeV data set.
- Good agreement with ETA-MAID (curves).



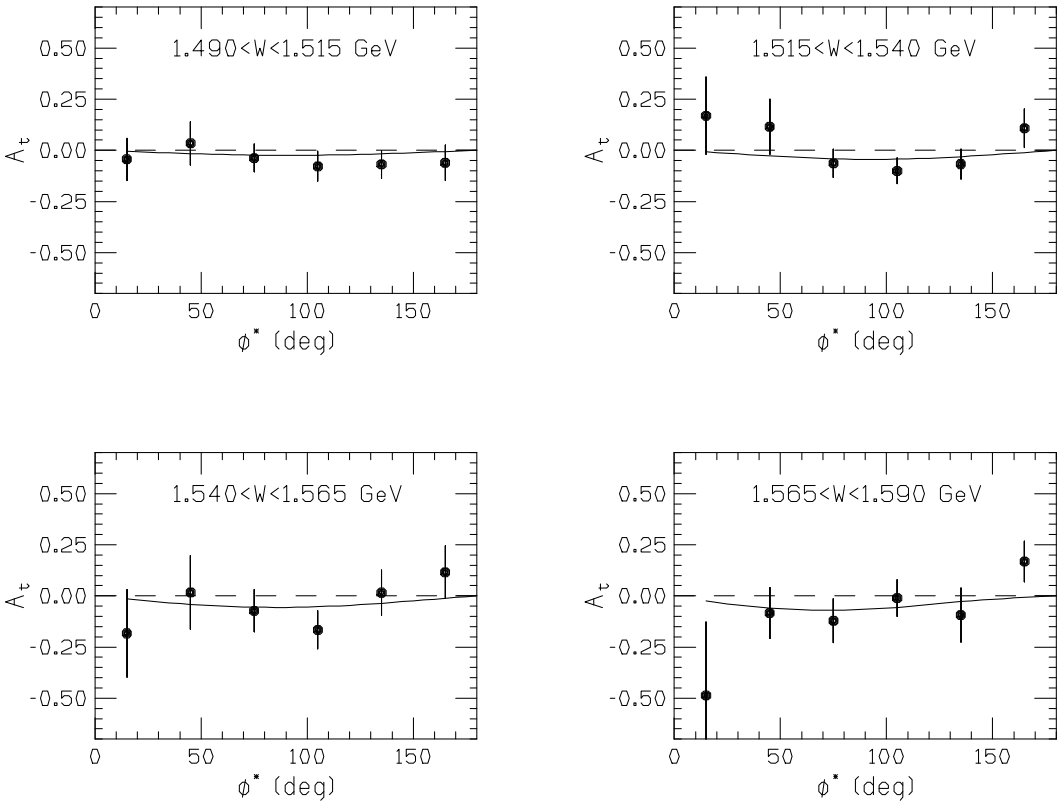
$ep \rightarrow ep\eta$ A_{et} $E = 5.7$ GeV

- Results consistent with $A_{et}/D = A_1 = 1$ since $D \approx 0.25$ for 5.7 GeV data set.
- Average $Q^2 = 1.0$ GeV^2.
- Again, good agreement with ETA-MAID (curves).
- No observed dependence on $\cos(\theta^*)$



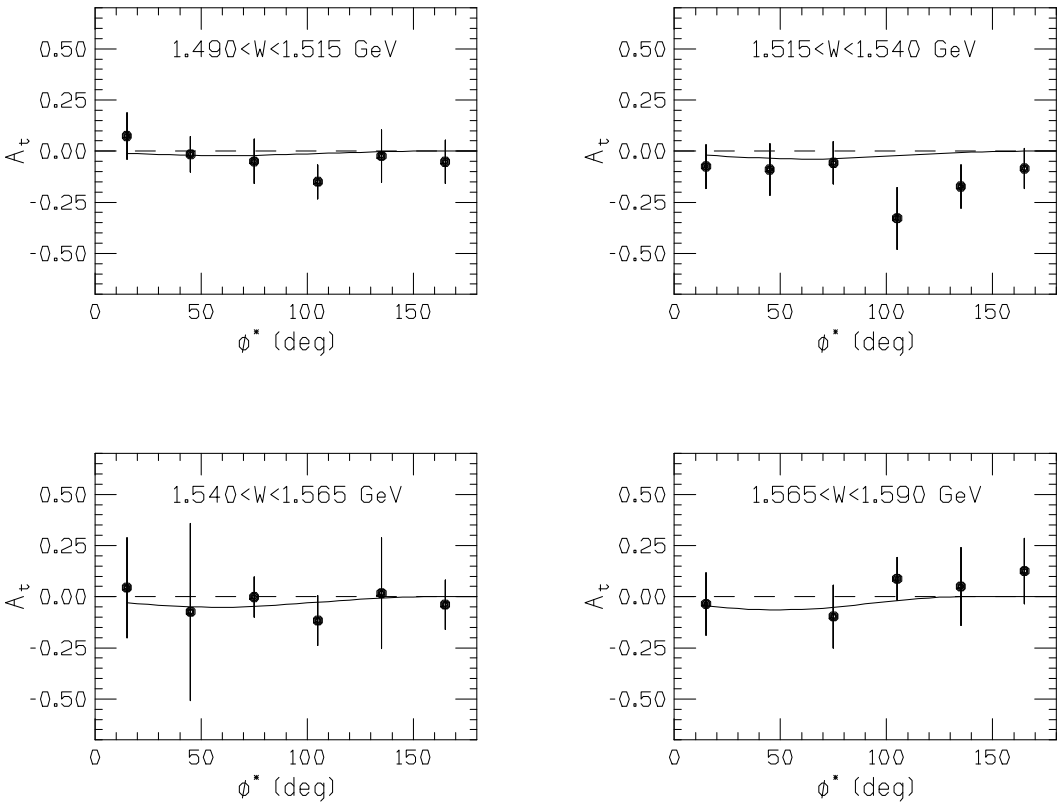
$ep \rightarrow ep\eta$ A_t $E = 1.6$ GeV

- Extracted target single-spin asymmetry $A_t = A_{UL}$ also. Odd function of ϕ^*.
- Results consistent with zero and ETA-MAID (curves).
- Very different from A_t for exclusive pion production (large values, sensitive to interference).



$ep \rightarrow ep\eta$ A_t $E = 5.7$ GeV

- Again, results consistent with zero and ETA-MAID (curves).
- Conclude that for $1.5 < W < 1.6$ GeV, transition to $S_{11}(1535)$ very dominant: little evidence of other resonances or non-resonant background.
- Poor signal-to-noise prevents looking at higher W.

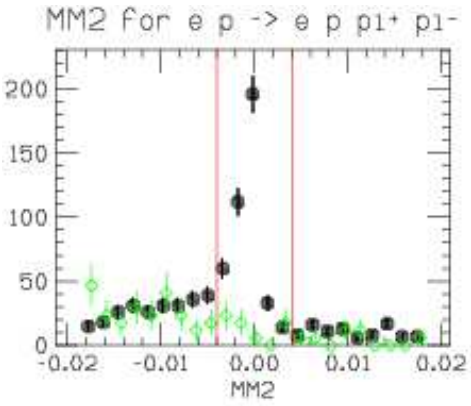


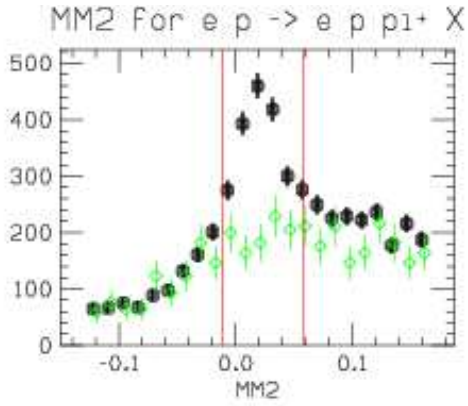
EXCLUSIVE ρ^0 ELECTROPRODUCTION

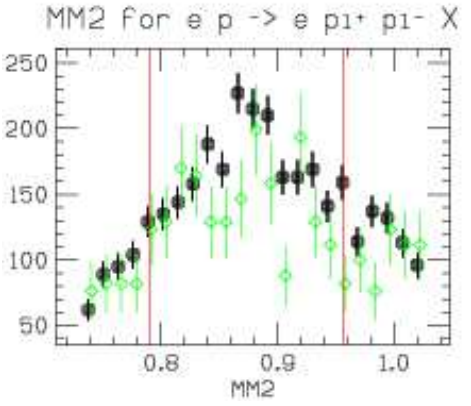
- Process is large part of total cross section at high W, low $-t'$, low Q^2.
- Can be described in terms of Reggeon exchange at lower W, (model of Kochelev et al.) possibly changing to Pomeron exchange at higher W (model of Ivanov et al.)
- GVMD prediction of Fraas is $A_1(\rho) \approx 2A_1^i/(1+(A_1^i)^2)$, where $A_1^i \approx g_1/F_1$ is for inclusive electron scattering (valid at high Q^2).
- Double spin asymmetry interesting to distinguish Pomeron exchange (gives $A_1 = 0$), and Reggeon exchange (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.

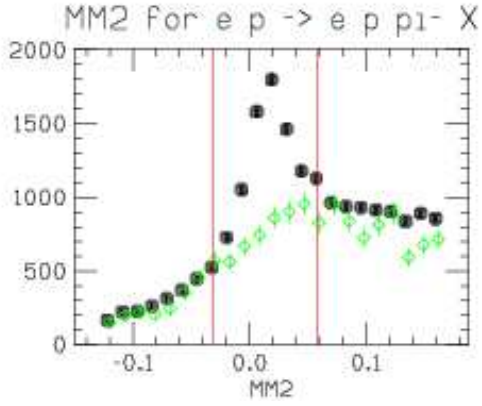
$ep \rightarrow ep\pi^+\pi-$ EVENT SELECTION

- 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.



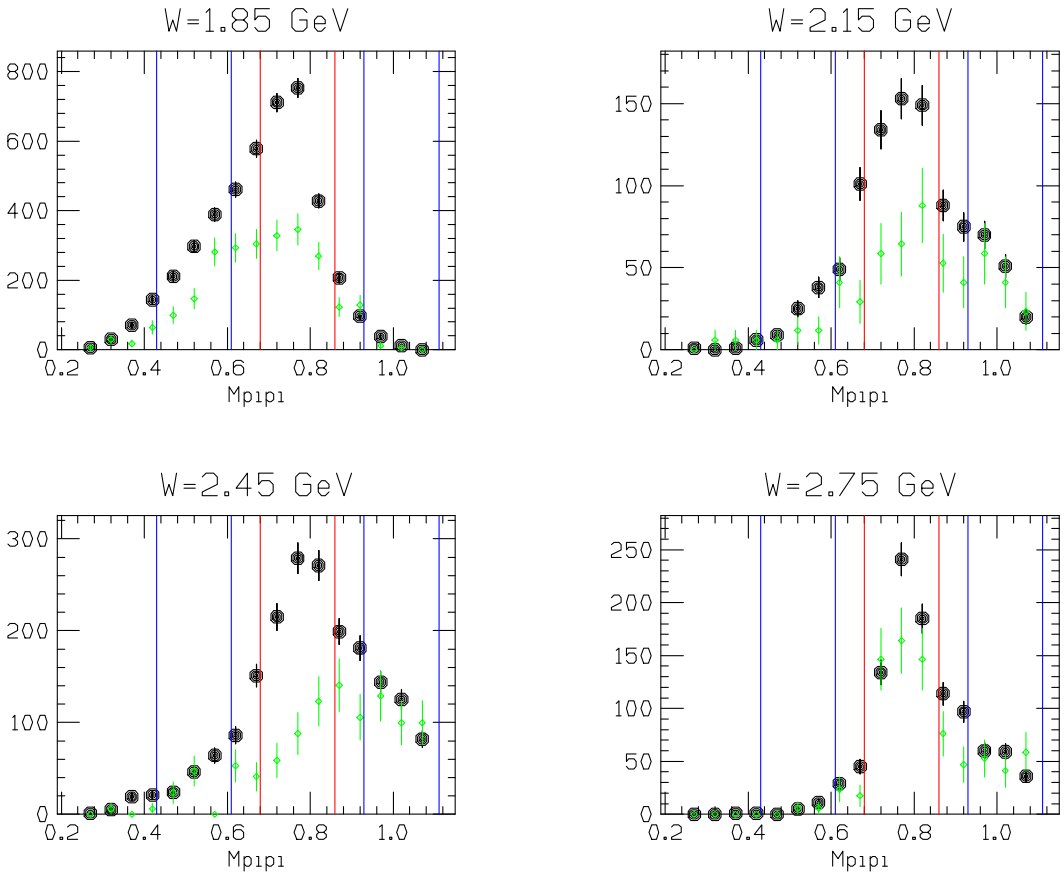






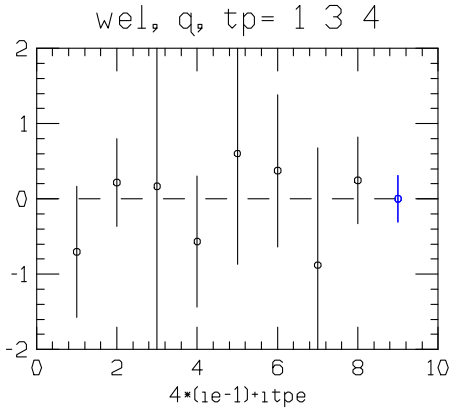
$ep \rightarrow ep\rho$ EVENT SELECTION

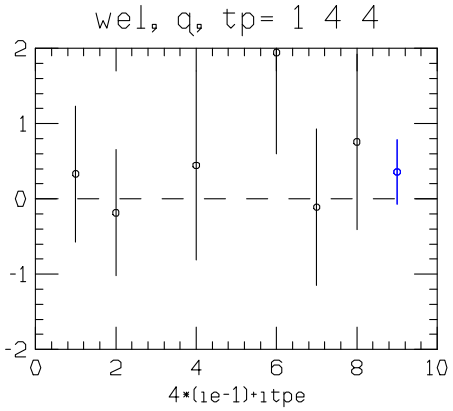
- Given the $\pi^+\pi^-$ sample, ρ events selected with cuts shown by red lines for representative ep missing mass spectra for four W bins.
- Dilution and asymmetry from non-ρ events made using events within blue lines (net correction to A_1 close to zero on average).



$ep \rightarrow ep\rho$ DOUBLE SPIN ASYMMETRY

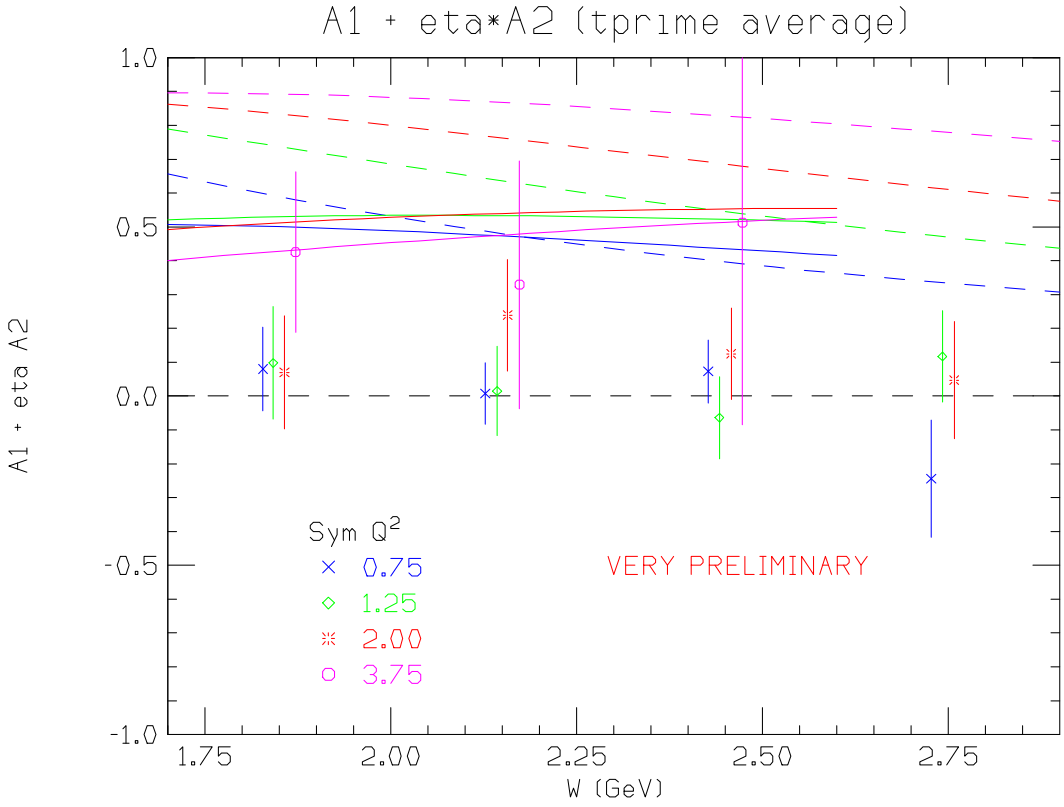
- Double spin asymmetry formed in each kinematic bin for each event topology and torus polarity.
- Converted to $A_1 + \eta A_2$ using HERMES parameterization $R = \sigma_L/\sigma_T = 0.35(Q^2/0.59)^{0.62}$ to calculate virtual photon depolarization D.
- $A_1 + \eta A_2$ then averaged over event topology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





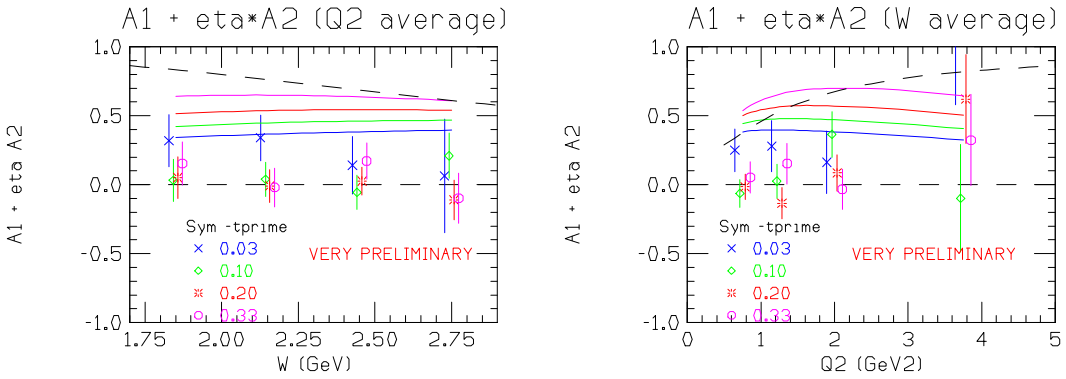
$ep \to ep\rho\ A_1 + \eta A_2$

- 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, toward better agreement with Fraas prediction (dashed curves) and Regge model of Kochelev et al. (solid curves).



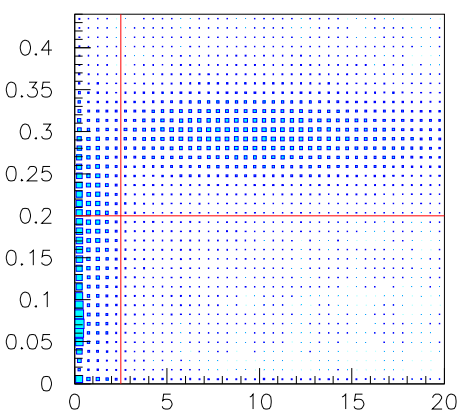
$ep \rightarrow ep\rho\ A_1 + \eta A_2$

- **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.**

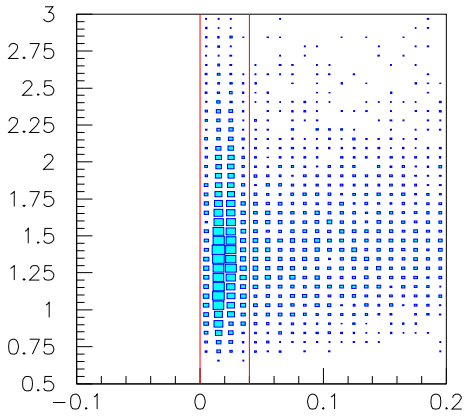


SIDIS Event Selection

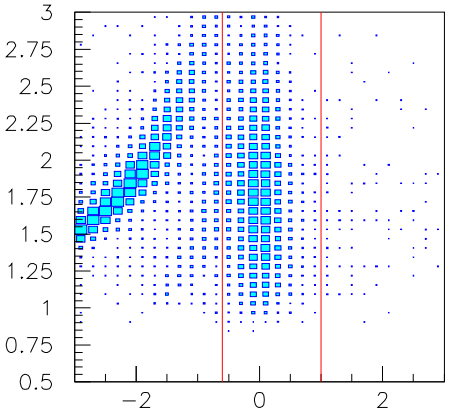
- Studied Semi-Inclusive DIS using electron-pion coincidences.
- Goals include study of fragmentation and flavor decomposition of polarized parton distribution functions (PDF's).
- Plots show clean particle ID for electrons, pions.



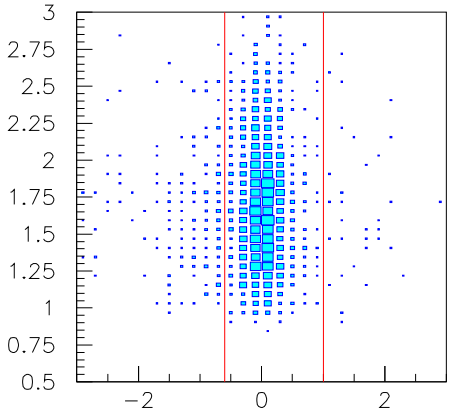
Cherenkov Signal (p.e.) vrs Ecal/P



Mass**2 (GeV**2) vrs E for gamma−gamma



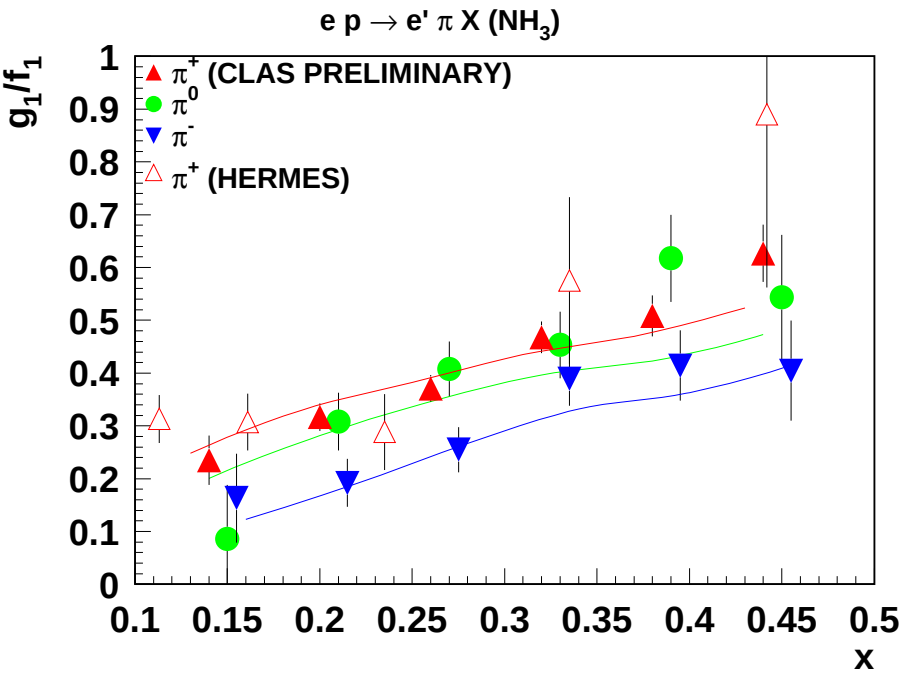
Delta Time (nsec) vrs P (GeV) for pi+



Delta Time (nsec) vrs P (GeV) for pi−

SIDIS A_1 for proton

- Used SIDIS cuts: $Q^2 > 1.3$ GeV^2, $0.4 < z = E_\pi/\nu < 0.7$, $W > 2$ GeV, $M_x > 1.1$ GeV.
- $g_1/F_1 \approx A_1$ in good agreement PEPSI LO Monte Carlo using GRV PDF's for proton target.
- Clearly see g_1/F_1 for π^- smaller than π^+ and π^0 as expected from larger (negative) δd contributions.



SIDIS (cont)

- Deuteron also studied: errors somewhat larger.
- Good statistic precision for $x > 0.2$ compared to previous World data on proton and deuteron
- Ongoing: additional data at 4.2 GeV, dependence on z, p_t, Q^2, M_x cuts, flavor decomposition of polarized PDF's.

Summary

- Rich body of inclusive semi-inclusive, and exclusive data from CLAS with polarized beam and target.
- Combined, allow detailed study of resonance region, deep-inelastic region and PDF's, and the transition between them.