Exclusive Production of Baryon Resonances Using $^1H(e,e'p)X$ at High Q^2

Experiment 01-002 at Jefferson Lab in Hall C

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For the Hall C Baryon Collaboration

Institutions (Full Listing)

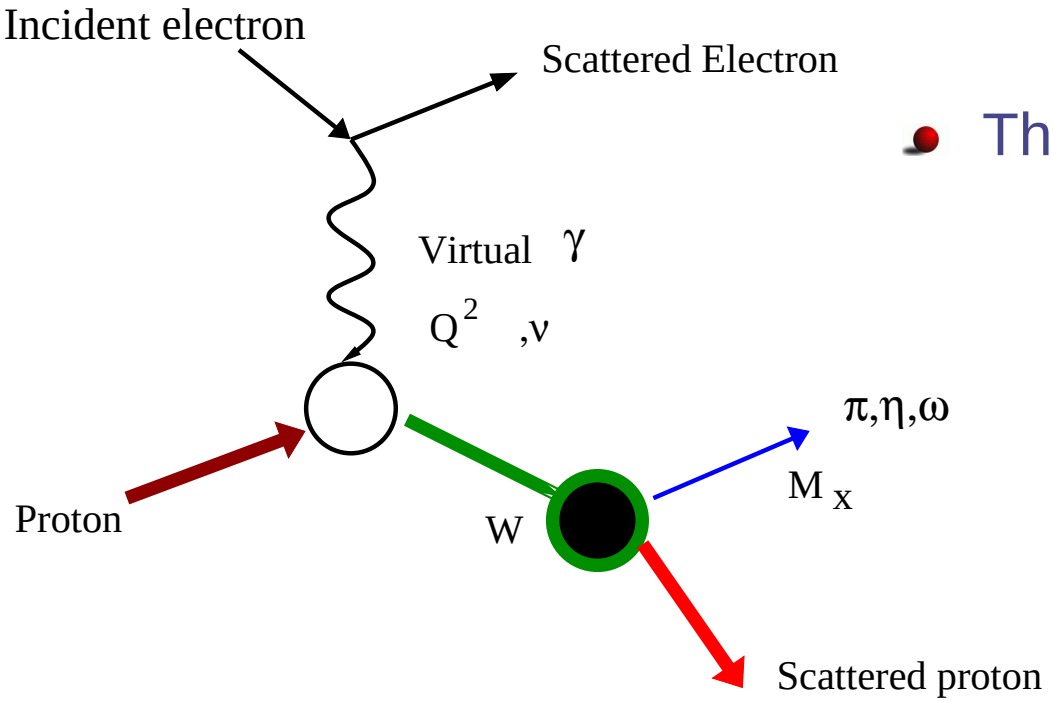
Spring 03 Collaboration

Argonne Nat. Lab., Bucharest, Univ. of Colorado, Duke Univ., Florida Int. Univ., George Washington Univ., Hampton Univ., Jefferson Lab, Mississippi State Univ., Univ. North Carolina A & T, NIKHEF, Rensselaer Polytechnic Institute, Univ. of Regina, Univ. of Massachusetts, Univ. North Carolina at Wilmington, Univ. of Virginia, Yerevan Physics Institute, Ohio Univ., Univ. of the Witwatersrand, Univ. of Houston, Univ. of Connecticut

Goals of the Experiment

- Baryon resonances $\Delta(1232)$ and S_{11} studied to extract transition amplitudes for exclusive π^0, η, ω production
- Differential cross sections extracted and used to determine multipole transition amplitides at larger value of Q^2 than previously achieved
- Transition to pQCD will be studied through the Q^2 dependence of the quantity $E2/M1$ on the Δ (should approach unity in pQCD)
- W range of the experiment is expanded since the last installment in 1997 (experiment 97-101)
- Transition form factors extracted for $\Delta(1232)$ and S_{11} at the highest Q^2 thus far

Electro-production Process



- The reactions for this analysis are:

$$\gamma^\star + p \rightarrow (N^\star, \Delta) \rightarrow p + \pi^0$$

$$p + \eta$$

$$p + \omega$$

Virtual Photo-production

- The differential cross section can be written:

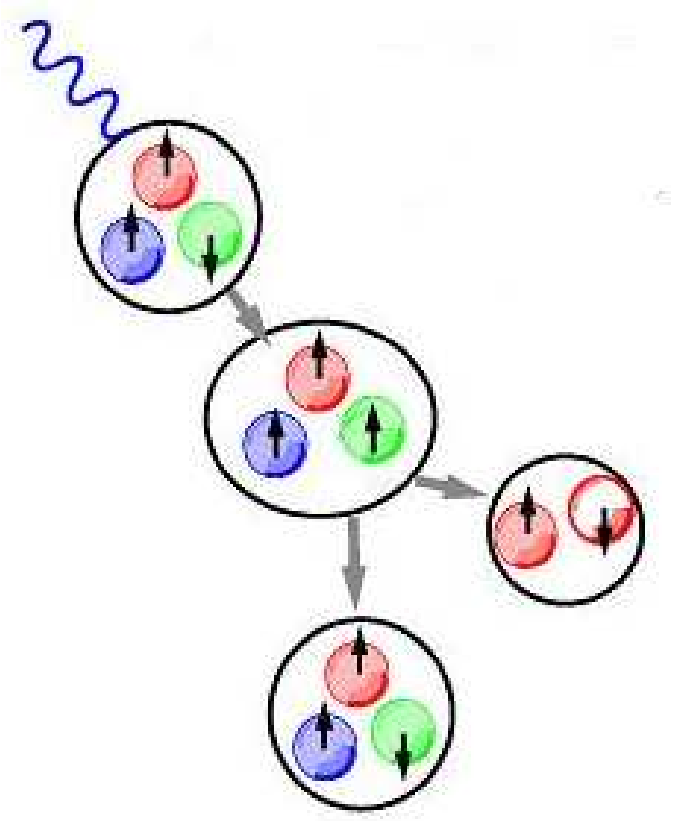
$$\frac{d\sigma}{dE' d\Omega_e d\Omega_\pi} = \Gamma \frac{d\sigma}{d\Omega_\pi^\star}$$

$$\Gamma \equiv \frac{\alpha}{2\pi^2} \frac{E}{E'} \frac{W^2 - M^2}{2MQ^2} \frac{1}{1-\epsilon}$$

- Expand in terms of angles:

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

CQM Predictions



- Process described by a single quark spin flip
- Predicts M1 dominance as is seen at low energy

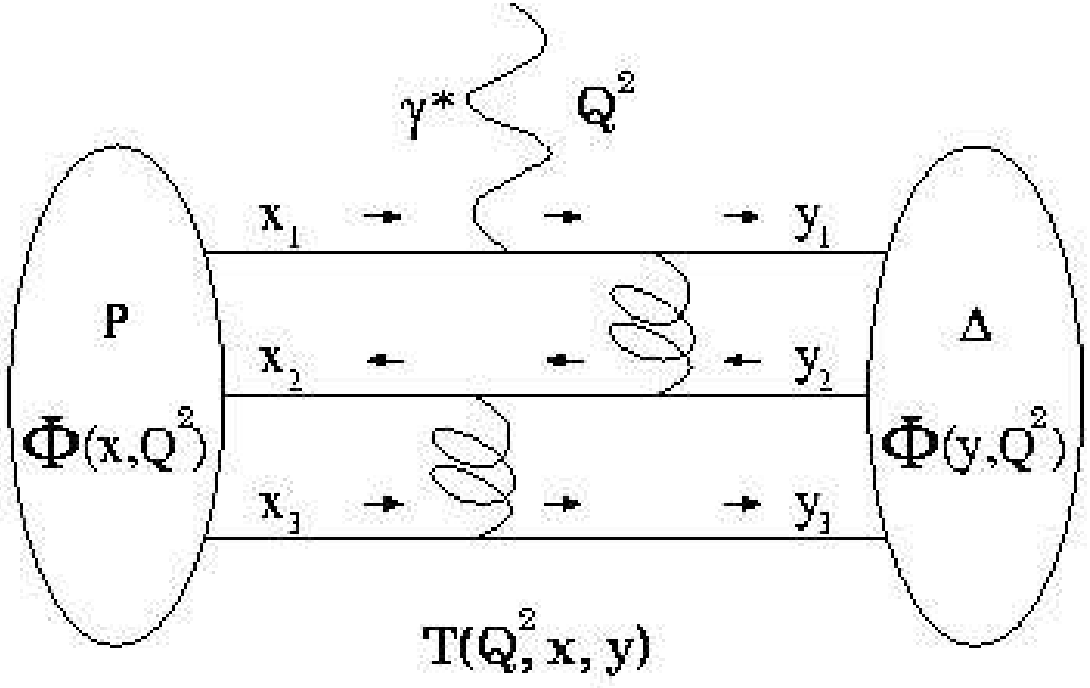
pQCD Limit

- QCD Factorization Theorem

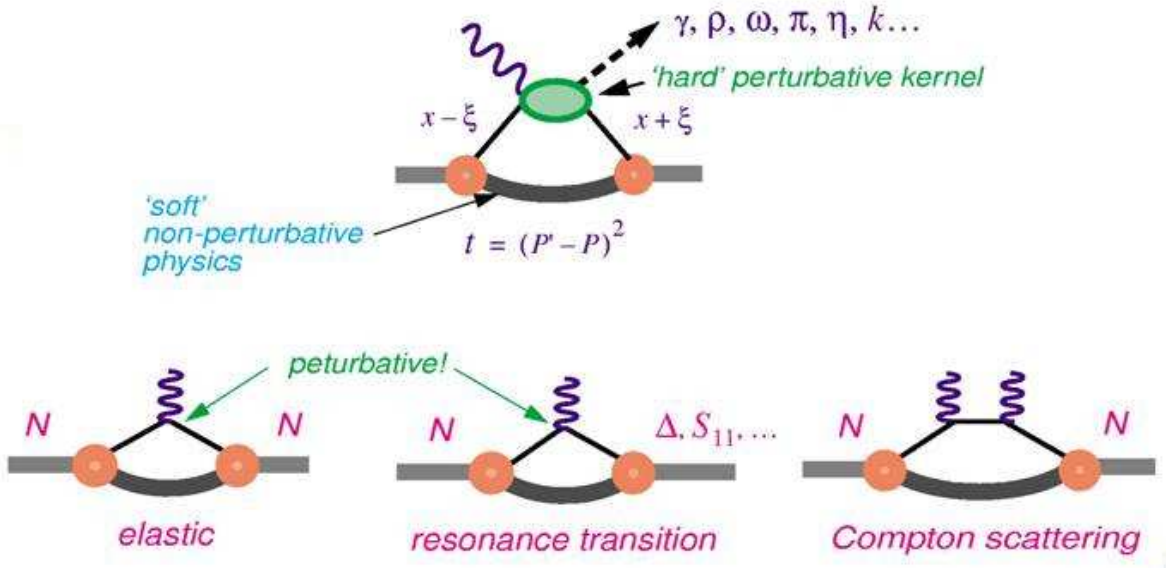
  $\mathcal{A}(Q^2) =$

  $\int dxdy\Phi_p(Q^2,x)T(Q^2,x,y)\Phi_\Delta(Q^2,y)$

- Indications of pQCD
  - $G_M^\star \sim \frac{1}{Q^4}$
  - $A_{\frac{1}{2}} \sim \frac{1}{Q^3}$
  - $\frac{A_{\frac{3}{2}}}{A_{\frac{1}{2}}} \to 0$
  - $(\frac{E2}{M1})_\Delta \to 1$

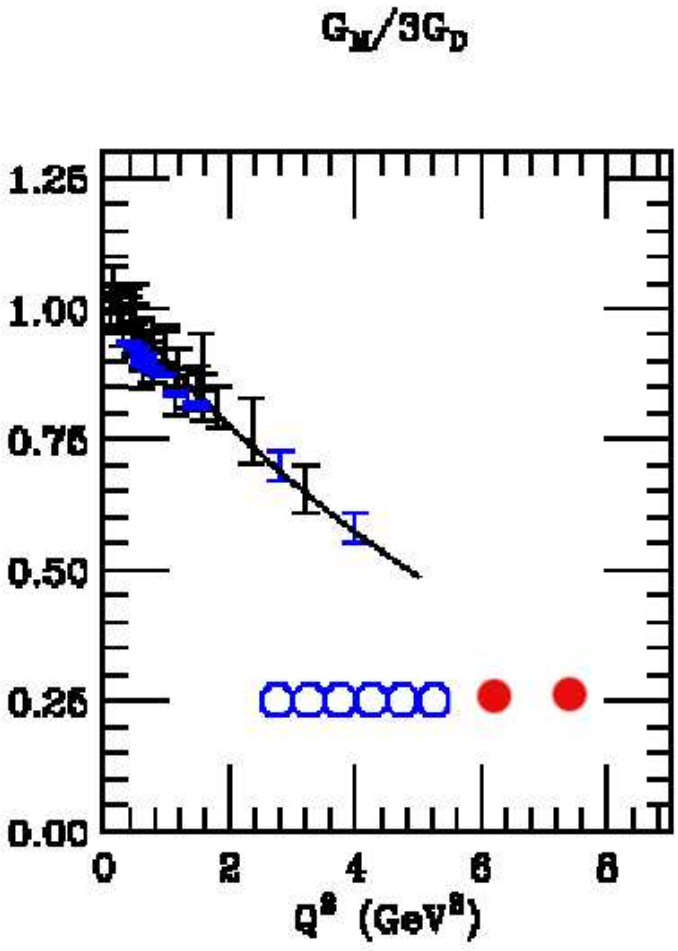


GPD Description



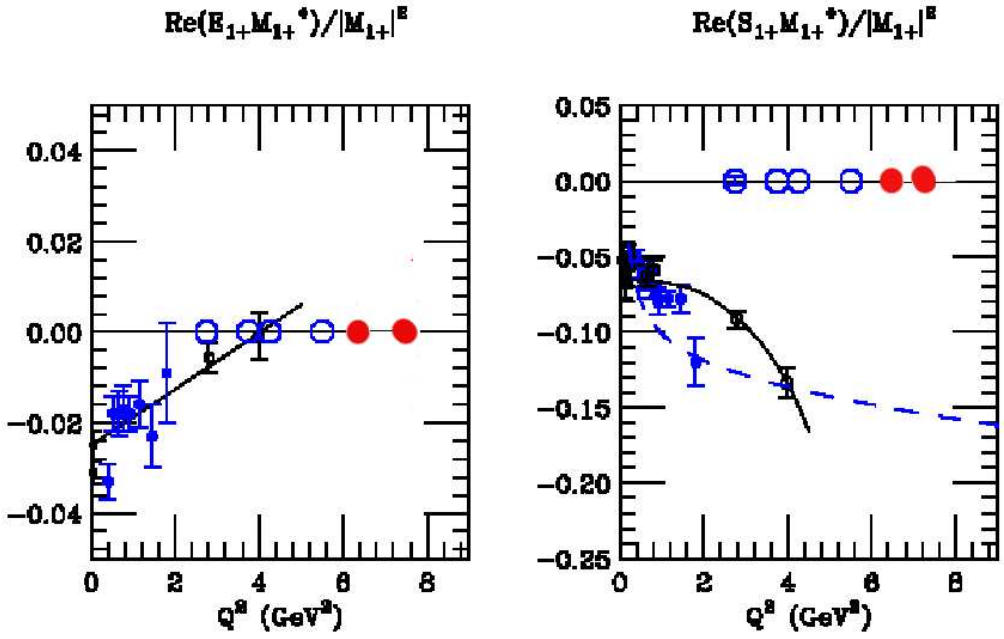
- Parameterize soft non-perturbative physics into a Generalized Partron Distribution
- Full specification of GPD's relates several interactions

Form Factor Data



- Form factor is falling faster than dipole
  - $G_D = \frac{1}{(1+\frac{Q^2}{.71})^2}$
  - Recall pQCD predicts $\frac{1}{Q^4}$ dependence
- Expected Hall B points shown in blue
- GPD descriptions imply that G_M is directly related to G_{Ep} in the large N_c limit

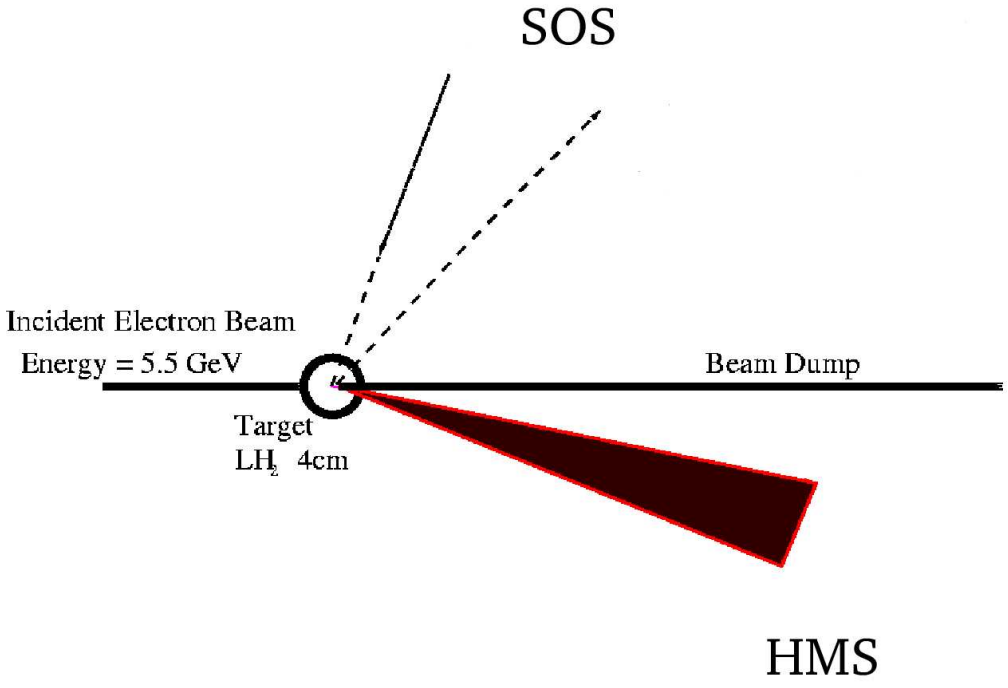
Multipole Amplitudes



- pQCD limits are not realized in previous measurements
  - $\frac{E_{1+}}{M_{1+}} \neq 1$
  - $\frac{S_{1+}}{M_{1+}}$ not constant

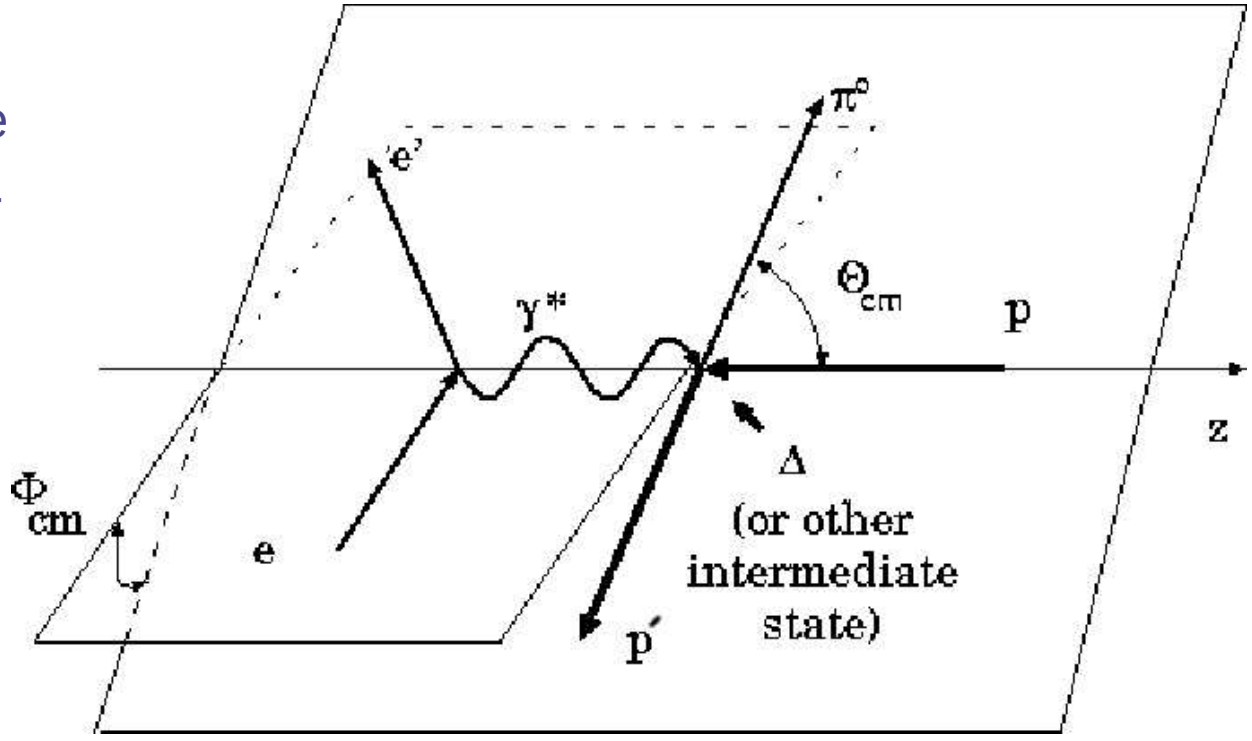
Hall C E01-002 Settings

- $Q^2 = 6.3$ GeV^2 setting
  - 2.13 GeV $\leq P_p \leq$ 4.7 GeV
  - $11.22^o \leq \Theta_p \leq 24.0^o$
- $Q^2 = 7.7$ GeV^2 setting
  - 3.24 GeV $\leq P_p \leq$ 4.7 GeV
  - $\Theta_p = 11.22^o, 14.2^o$



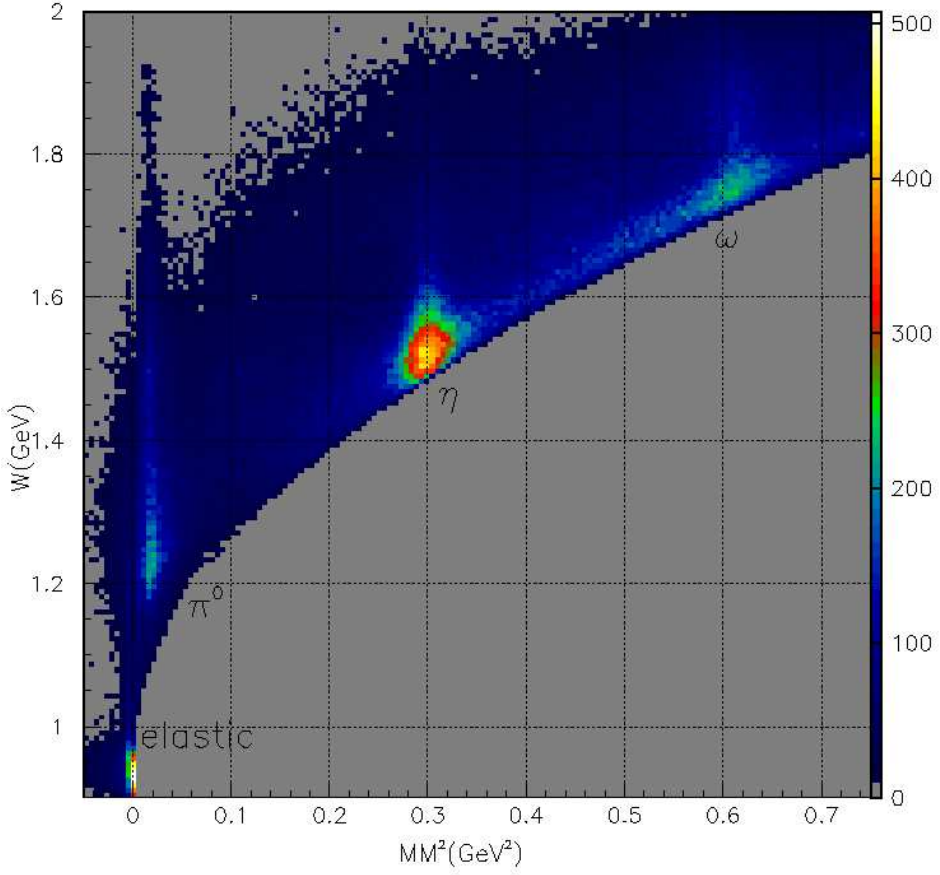
The Reaction Planes

- The center of mass frame is shown where γ^* and p are colinear with equal and opposite momentum

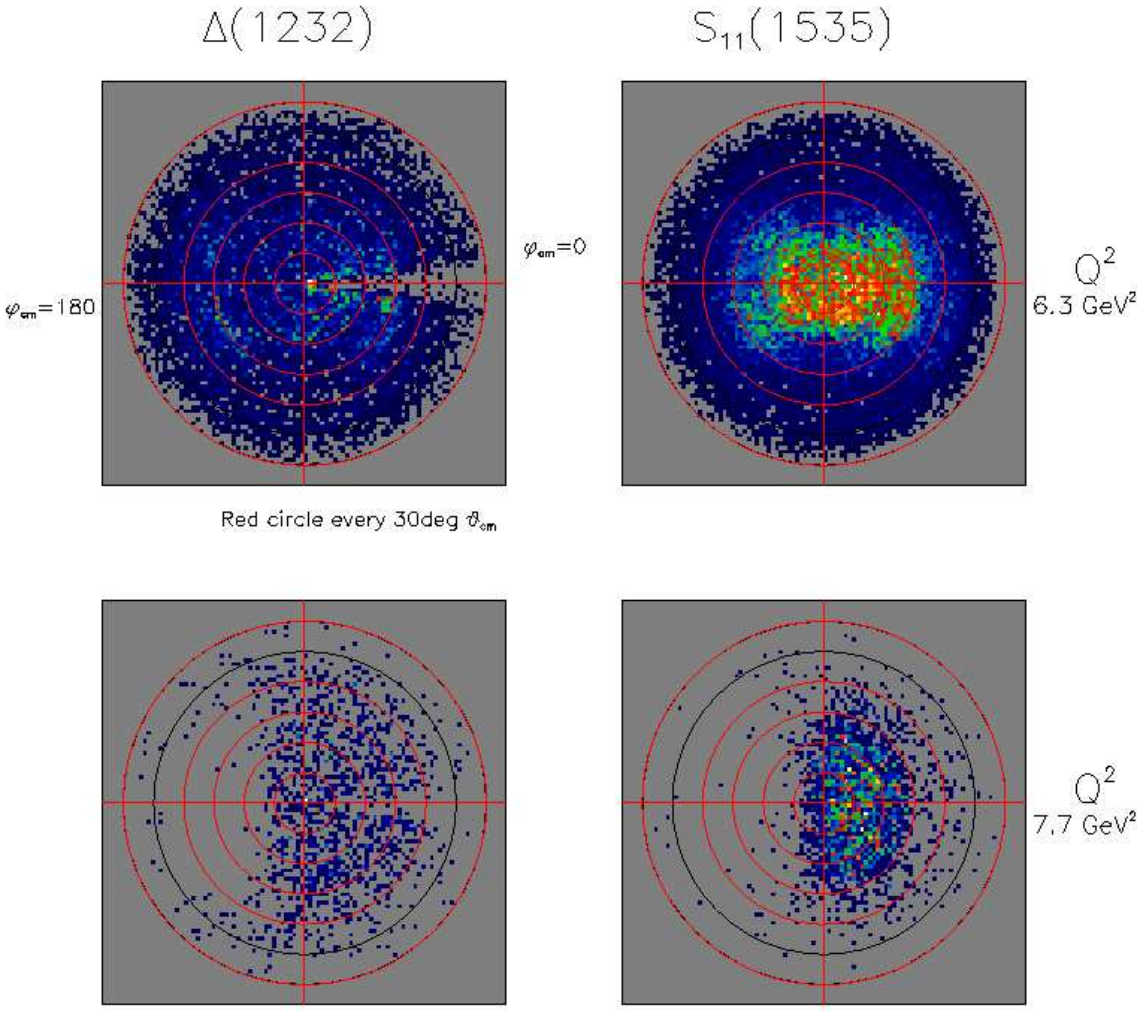


Baryon Resonances

- The $\Delta(1232)$ and S_{11} resonances are clearly correlated with the π^0 and η M_x^2 peaks
- The elastic events clearly come from lower W with some overlap into a higher W region due to pre or post radiation
- The ω meson comes from the largest W region for the experiment

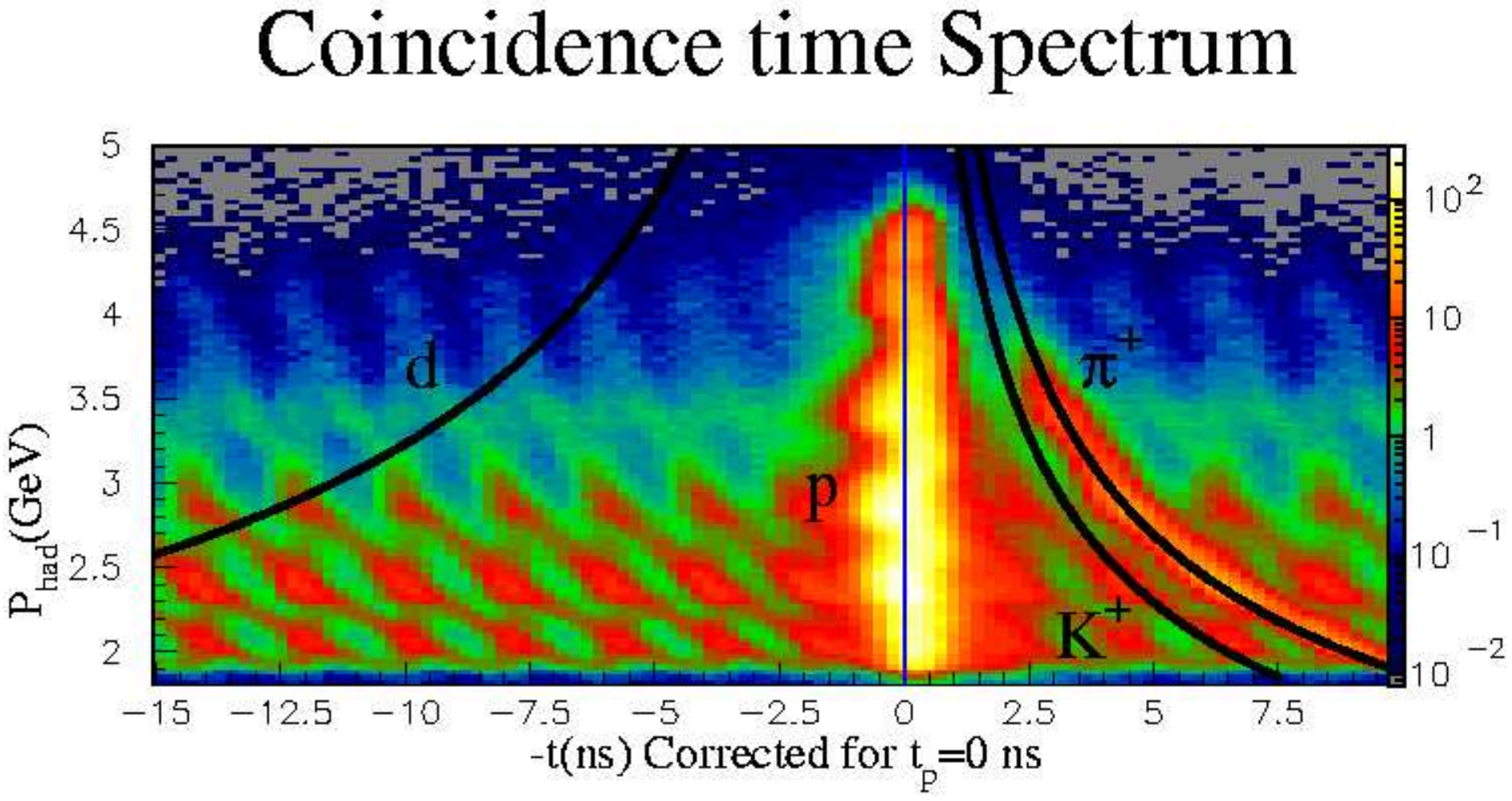


Angular Coverage in CM



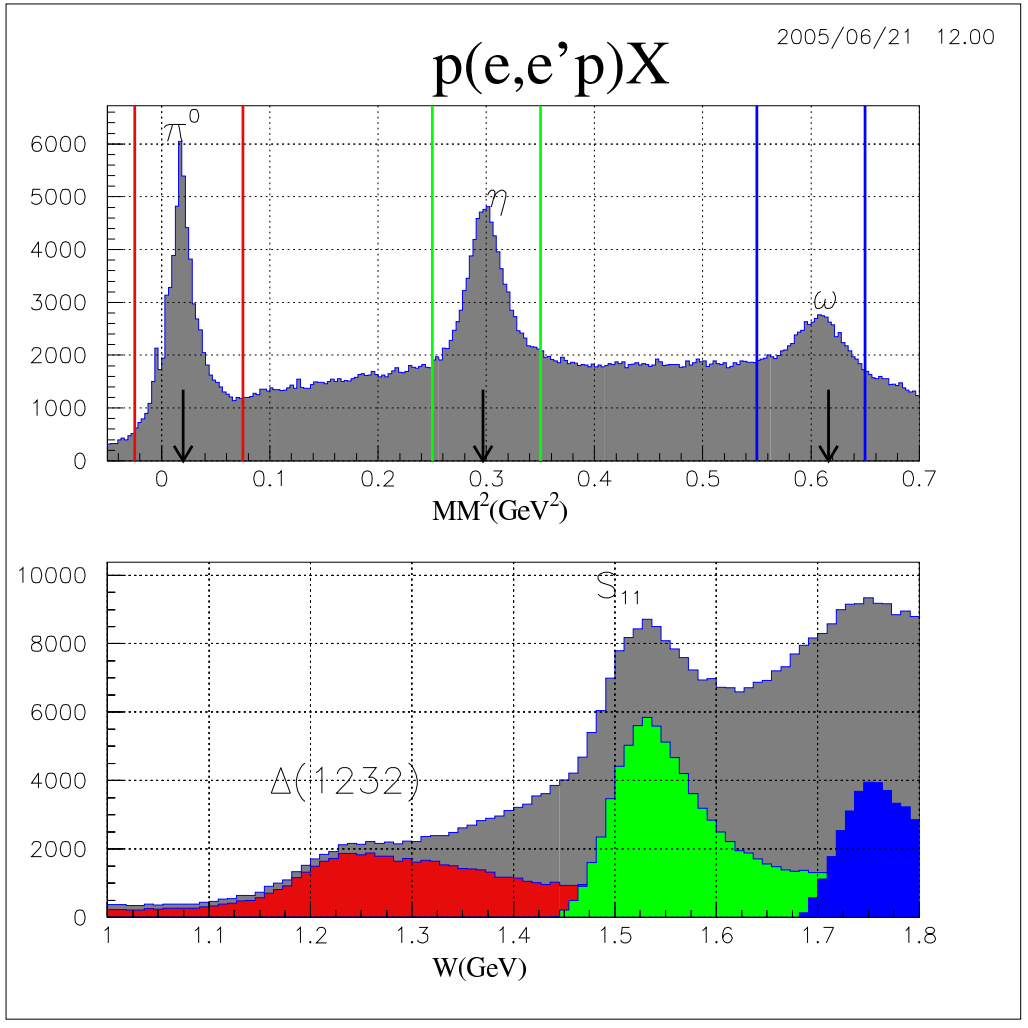
- Events on plot are mapped by:
  - $x = \theta_{cm} cos(\phi_{cm})$
  - $y = \theta_{cm} sin(\phi_{cm})$
- Each concentric circle represents 30 degrees in θ_{cm}
- Shows good coverage of center of mass variables

Accidental Corrections

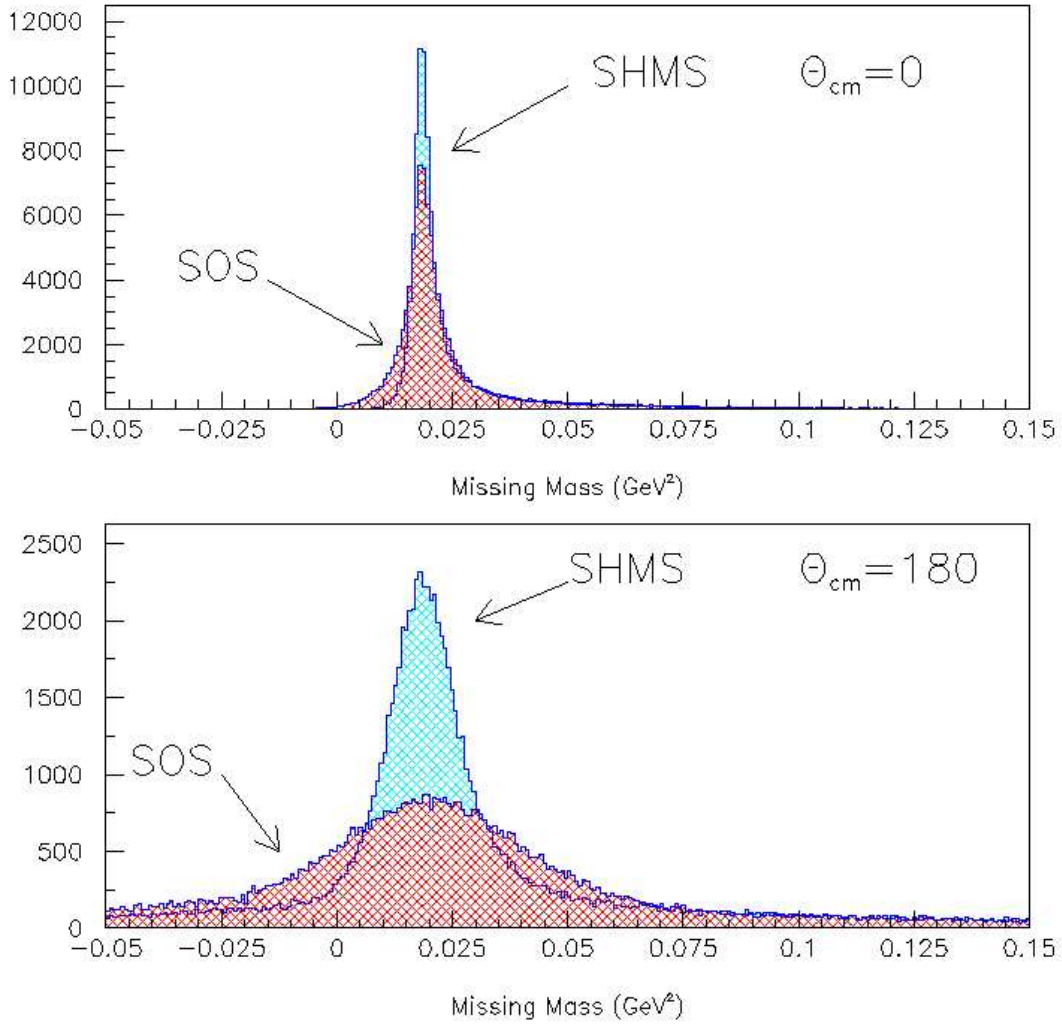


Exclusive Studies

- The M_x^2 peaks can be used to constrain the reaction and/or baryon resonance
- The M_x^2 resolution for the π^0 allows detailed study of the reaction ${}^1H(e,e'p)\pi^0$
- Exclusive cross sections and amplitudes will be compared to models and previous data

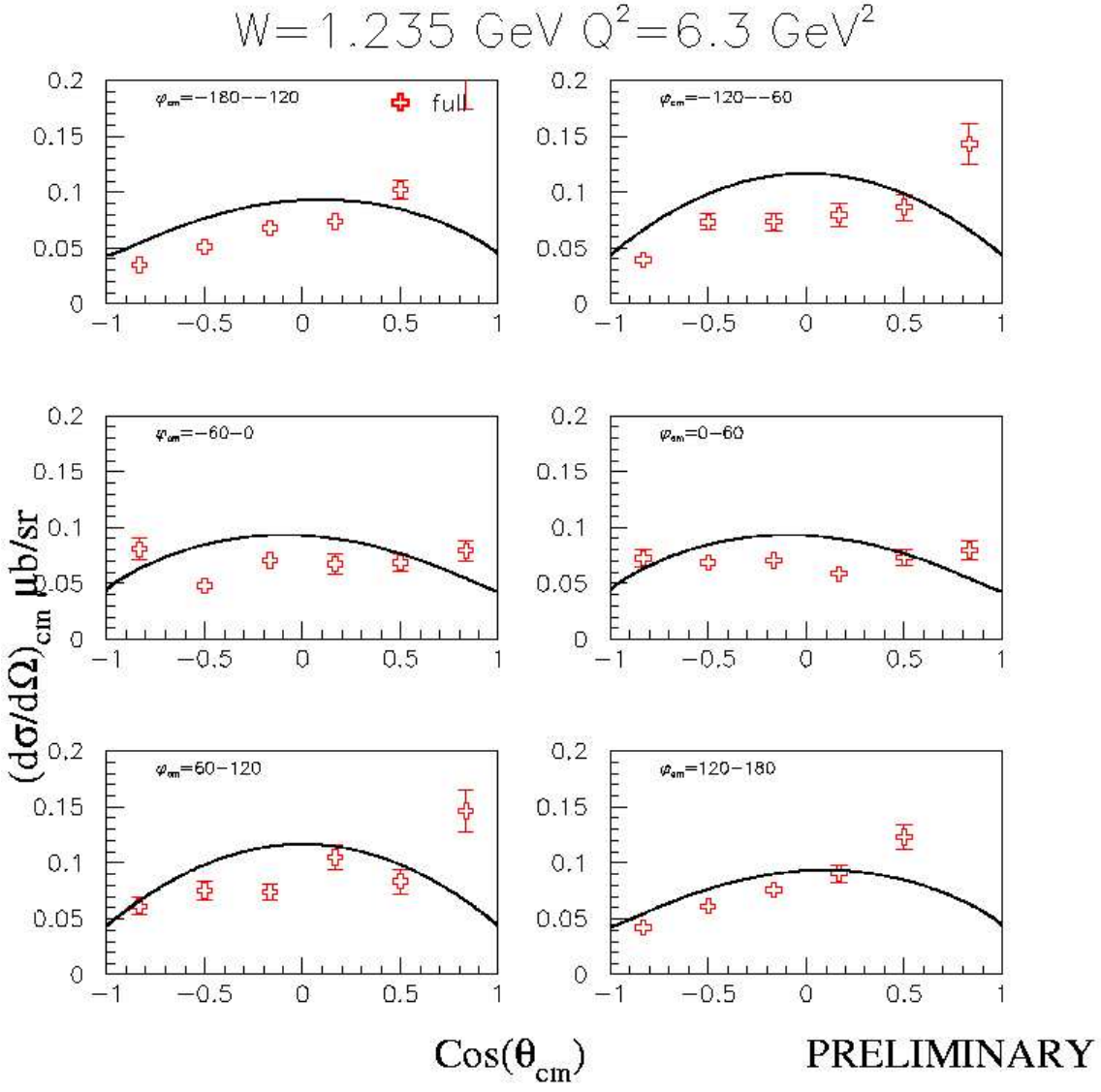


SHMS Resolution



- Resolution decreases as one goes to higher θ_{cm}
- SHMS spectrometer will help mitigate this resolution loss

$\Delta(1232)$ Differential Cross Section



- Radiative cut utilized, not a full correction
- Seem to see some flattening and forward enhancement this may change as analysis progresses
- 30 MeV W bin on top of the $\Delta(1232)$

Tasks

- Completed tasks
  - Accidental corrections
  - Various efficiency corrections
- In progress & to do
  - Full radiative corrections
  - Model Iteration
  - Multipole extraction

Summary

- Beam energy of $5.5GeV$ with two Q^2 settings
  - Measure the cross sections for ${}^1H(e,e'p)X$, $X = \{\pi^0, \eta, \omega\}$
  - X identified by missing mass, M_x
  - Q^2 of 6.3 and $7.7GeV$ for Δ resonance
  - Varied proton arm angle and momentum to cover wide range of θ_{cm} and ϕ_{cm} bins for W up to $2GeV$
- Physics to extract
  - Plan to extract the $G_M^\star$, E_{1+}/M_{1+}, S_{1+}/M_{1+} for the Δ
  - Plan to extract $Q^3 A_{\frac{1}{2}}$ for the S_{11}
  - Study the transition from *soft* to *hard* physics as a function of Q^2
  - Constrain the t and x dependence of the GPD with elastic and transition form factors and wide angle Compton form factors