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INCLUSIVE CROSS SECTION RESULTS WITH CLAS12

VALERII KLIMENKO
Postdoctoral Appointee

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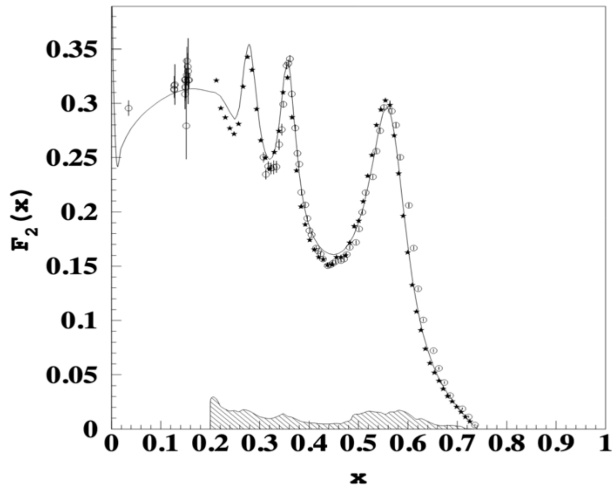
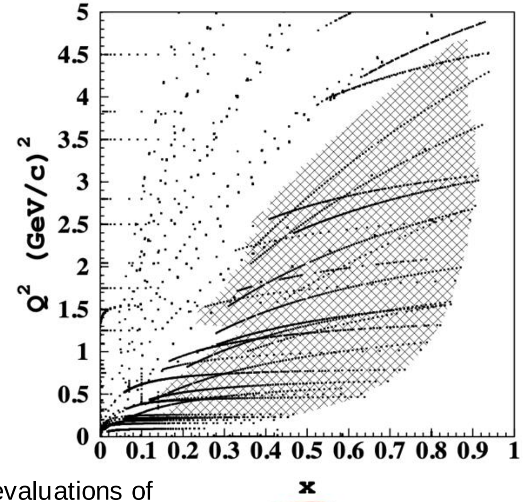
CLAS RESULTS

- CLAS measured the inclusive cross section up to x = 0.9 and Q^2 from 0.25 to 4.5 GeV^2
- Owing to large acceptance of CLAS, the information on inclusive structure function F_2 can be obtained within a wide range of W from pion threshold to maximal kinematically allowed W-values in any given bin of Q^2 covered in the measurements



Stars: M. Osipenko et al., *Phys. Rev. D 67* (2003), 092001, [hep-ph 0301204]
Other points: world data, see above paper



M. Osipenko et al., *Phys. Rev. D 67* (2003), 092001, [hep-ph 0301204]

World data used for moment evaluations of F_2. Shaded area corresponds to CLAS.

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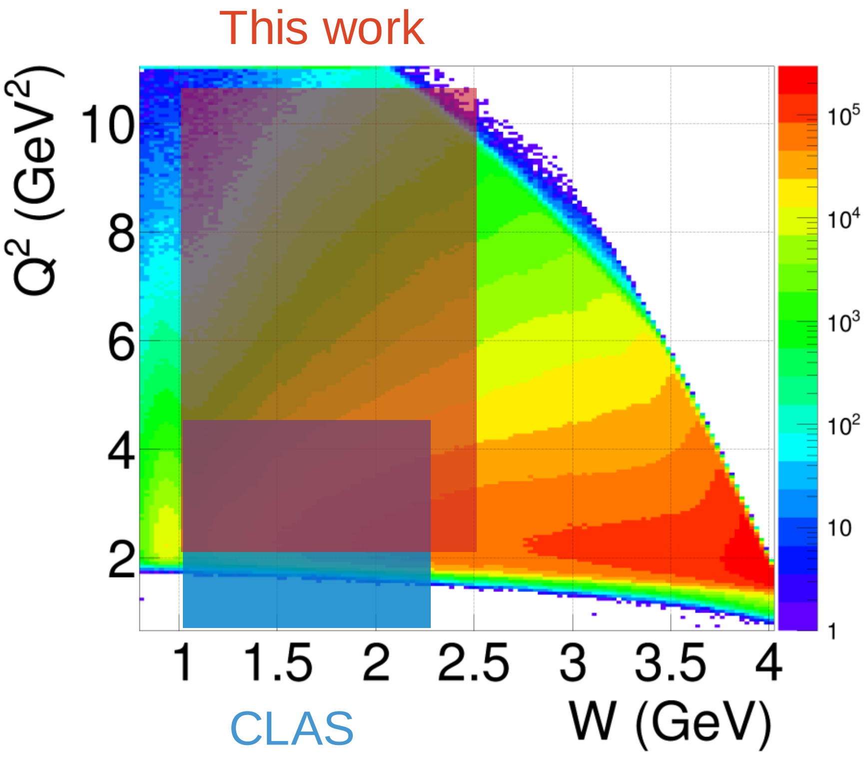
CROSS SECTION EXTRACTION

$$\frac{d\sigma}{dQ^2 dW} = \frac{1}{\Delta Q^2 \Delta W} \cdot \frac{N}{\eta \cdot R \cdot B \cdot N_0} \cdot \frac{1}{N_A \rho t / A_\omega}$$

- Q^2 - four-momentum transfer squared
- W - invariant mass of the final hadron system
- R - radiative correction factor
- B - bin size correction
- N - bin event yield
- η - is the product of geometrical acceptance and electron detection efficiency
- N_A - Avogadro’s number
- ρ - target density
- t - target length
- A_ω - atomic weight of the target
- N_0 - live-time corrected incident electron flux summed over all data runs

ELECTRON PID

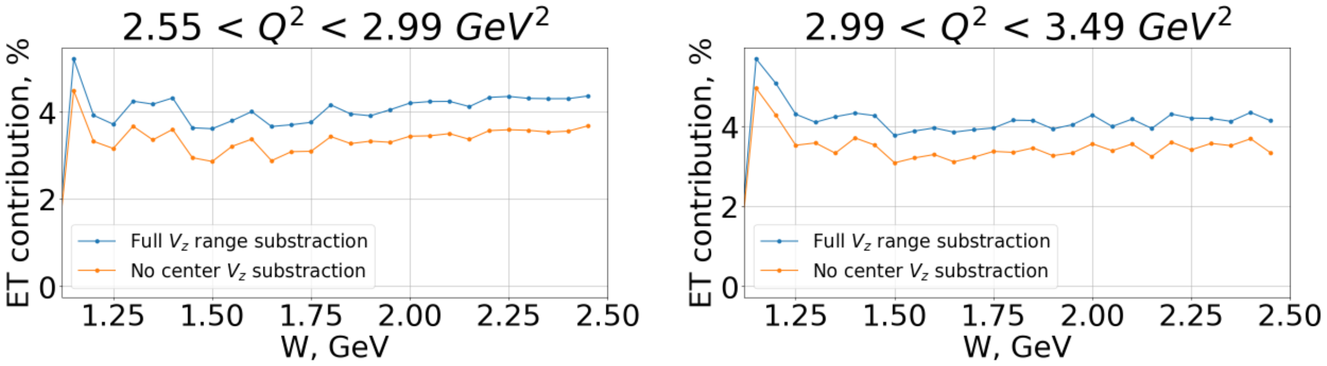
- Limited to Forward Detector (5 - 35° coverage in polar angle)
- Event Builder ID
- DC and PCAL Fiducial cuts
- -8 < Vertex Z < 2 cm
- 3.5-σ cuts on a parameterized momentum-dependent sampling fraction.
- Electron/pion separation (triangular cut)

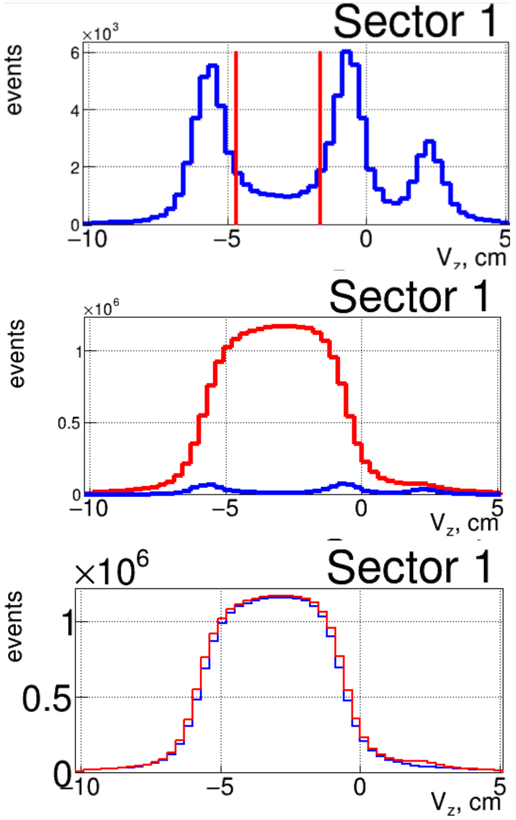


EMPTY TARGET CONTRIBUTION

$$yield_{hydrogen} = yield_{Full\ Target} - yield_{empty} * \frac{Q_{Full\ Target}}{Q_{Empty}}$$

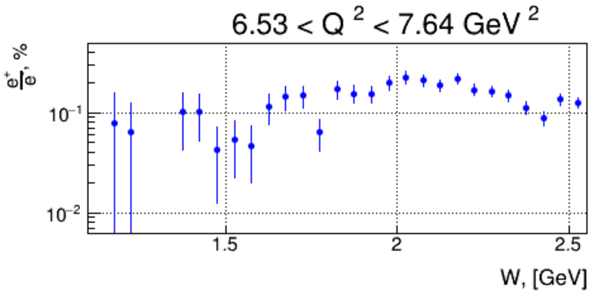
Empty target contribution for a few Q^2 bins

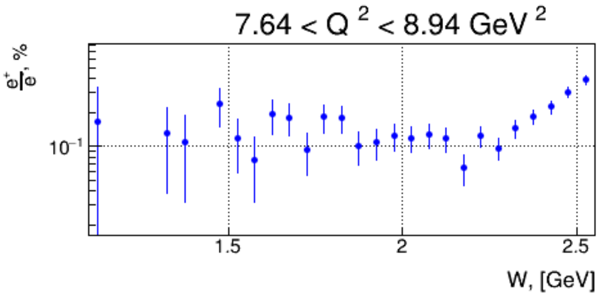


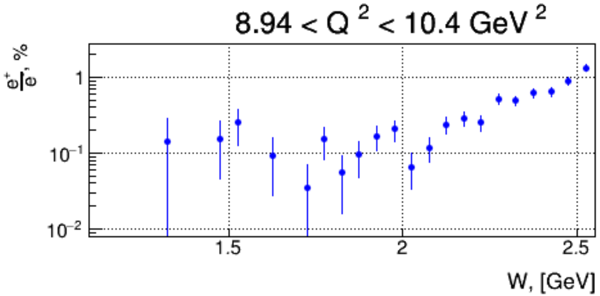


CHARGE SYMMETRIC BACKGROUND

- The positrons in outbending data should behave like the charge symmetric background electrons in inbending data
- We looked at e^+X and e^-X signals in outbending and inbending data using similar ID as we have in inbending data
- The ratio is below 0.5%







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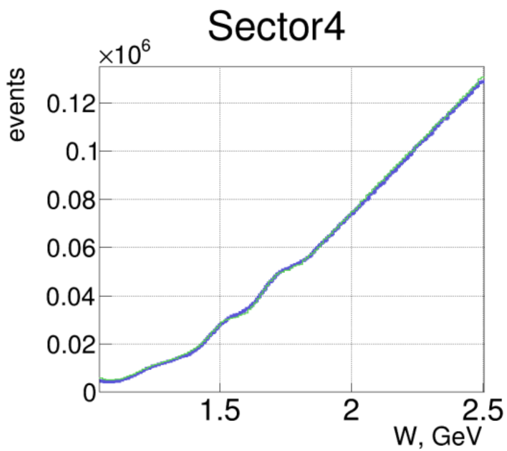
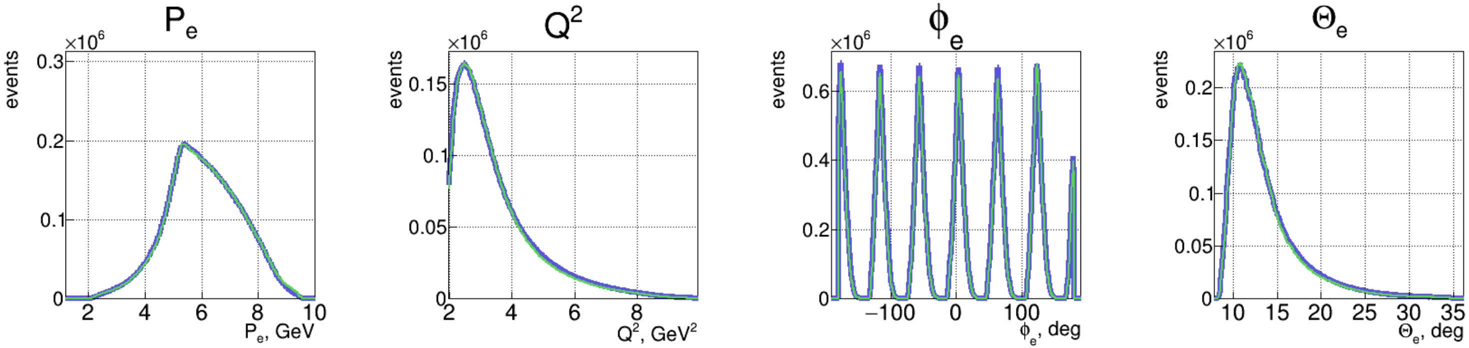
SIMULATION

- Inclusive EG: M. Sargsyan, CLAS-NOTE 90-007 (1990).
- Elastic rad + Elastic tail + Inelastic rad.
- Kinematic range:
  - Theta range 5 - 36°
  - Scattered electron momentum 1.4 – 10 GeV
  - Full Q^2 coverage.
  - Additional kinematic smearing to match the resolution of reconstructed data.



Green – Data
Blue – SIM reconstructed



ACCEPTANCE CORRECTIONS

- Measurement is distorted and transformed by various effects such as finite resolution, limited acceptance of the detector, and detection efficiency so a correction is required

- Basic method for acceptance correction is **bin-by-bin** method

$$Acceptance = \frac{\#\,Events\,Reconstructed}{\#\,Events\,Generated}$$

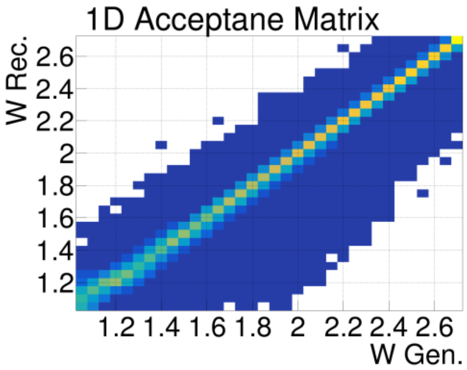
- However, it does not take into account the connection between generated and reconstructed events, so it has a potentially large bias by relying on truth MC.

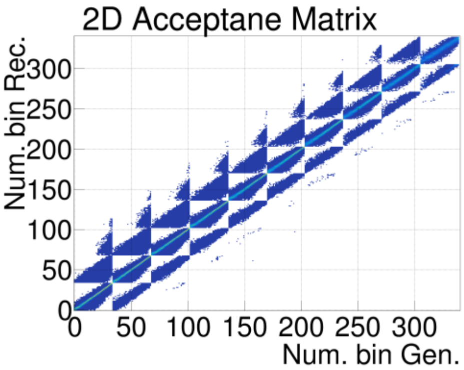
MATRIX DECONVOLUTION

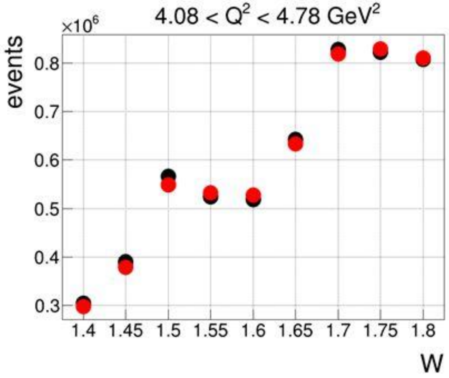
- Acceptance Matrix: $A_{(i,j)}$ describes both acceptance (geometrical acceptance and detector efficiency) and bin migration:

$$A_{(i,j)} = \frac{\#\ Events\ Generated\ in\ bin\ j\ but\ Reconstructed\ in\ bin\ i}{Total\ number\ of\ Events\ Generated\ in\ the\ jth\ bin}$$

- Acceptance unfolding: $Y_i = A_{(i,j)}X_j \Rightarrow X_j = A^{-1}_{(i,j)}Y_i$ where Y_i number of measured events in i-th bin, X_j is number of acceptance corrected events in j-th bin







CERN RooUnfold package was used: https://gitlab.cern.ch/RooUnfold/RooUnfold

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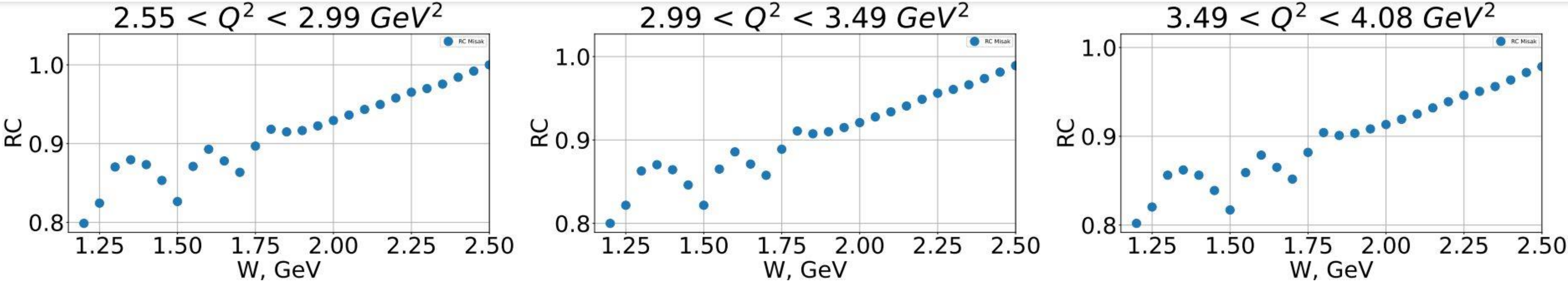
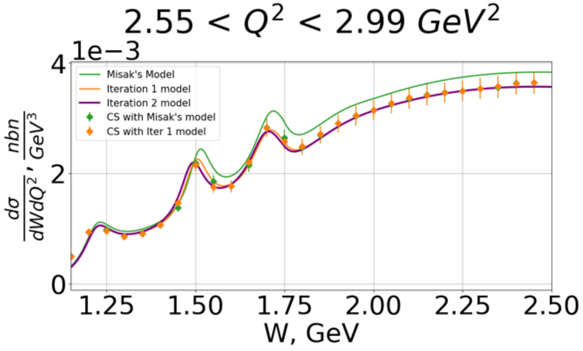
RADIATIVE CORRECTIONS

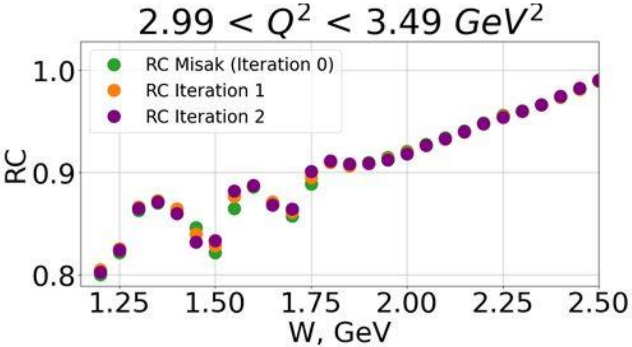
- Each (Q^2,W) bin was divided into 21x11 sub bins
- Cross Sections with rad. effects on and off were calculated in every sub bin
- Radiative Correction factor: $\frac{Mean\ Cross\ Section\ (Rad)}{Mean\ Cross\ Section\ (No\ Rad)}$

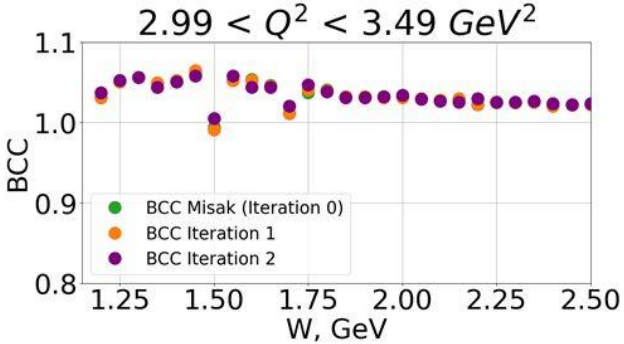


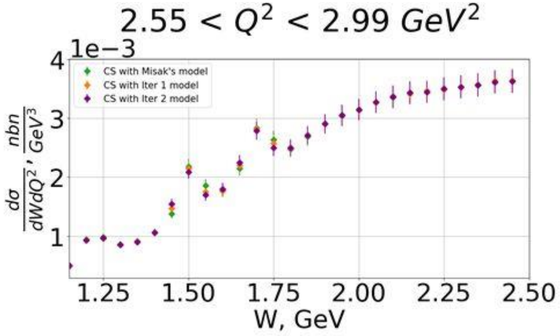
INCLUSIVE CROSS SECTIONS VIA CONVERGED ITERATIONS

- The preliminary inclusive cross section can be used as a base for new event generator and as a new model for RC and BC estimation.







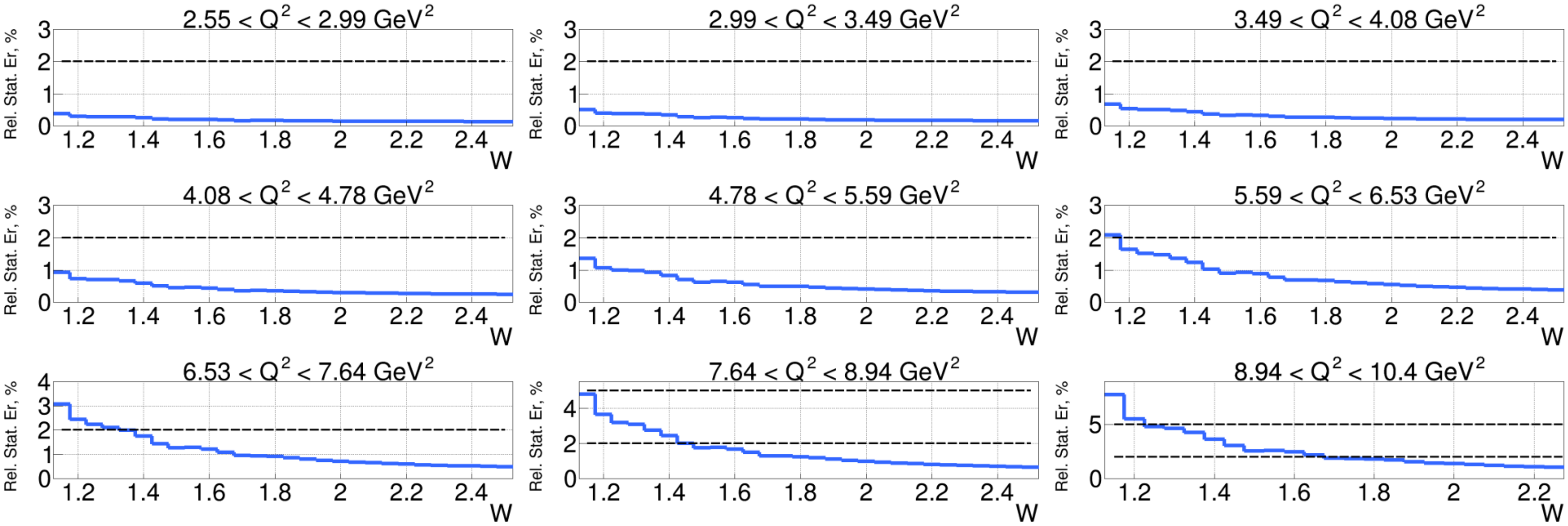


Cross Section with three models:
Green – Cross Sections with initial model
Orange - Cross Sections with iteration 1 model
Purple - Cross Sections with iteration 2 model

There is small peak shift. Peaks become narrower with iterations number.

STATISTICAL UNCERTAINTY

- 1% on average



SYSTEMATIC UNCERTAINTIES

- 7% on average

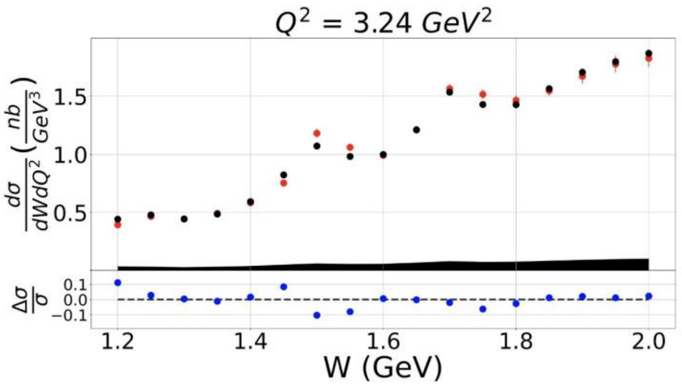
Average Systematic Uncertainty

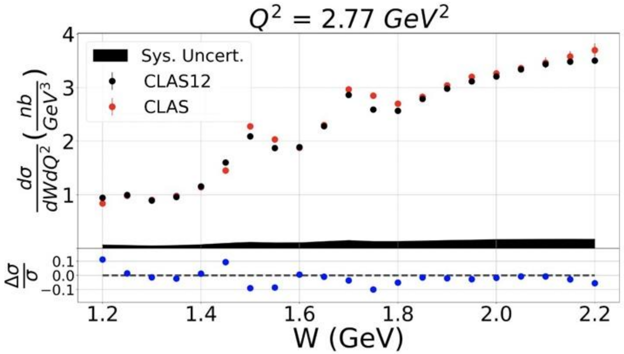
Bin-by-Bin Sources	Uncertainty [%]
Sampling fraction cut	0.02
Pion contamination	0.1
PCAL fiducial cut	0.12
Momentum smearing	0.28
Bin-centering corrections	0.32
Empty target subtraction	0.33
Radiative corrections	0.36
Momentum corrections	0.46
Charge symmetric background	0.5
Deconvolution method	0.55
Vertex-z cut	0.57
DC fiducial cut	0.72
Electron pion separation cut	0.79
Torus field map	3.0
Sector dependence	4.41
Total Bin-by-Bin	5.8

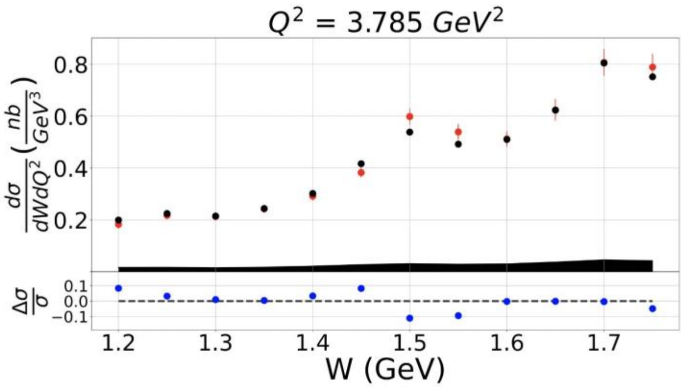
Scale Type Sources	Uncertainty [%]
Beam charge uncertainty	1.2
Target thickness uncertainty	1.8
Background merging	3.0
Total Scale	3.7
Total Bin-by-Bin and Scale	6.9

CLAS12 VS CLAS

- CLAS12 measurements
- CLAS data (after interpolation into the grid of our experiment), Phys. Rev. D67, 092001 (2003)
- The bottom plots associated with each Q^2 plot show the relative cross section difference, (CLAS12-CLAS)/CLAS12, between the two measurements. The dashed horizontal line on each plot is at zero relative difference.

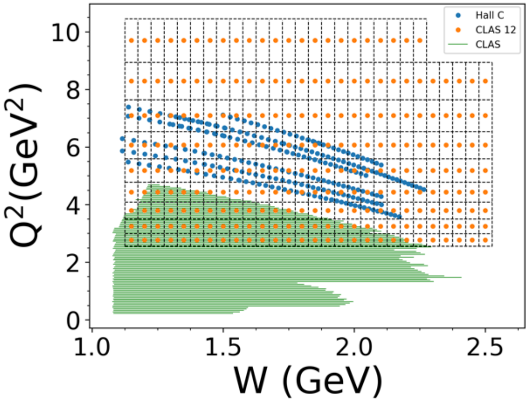


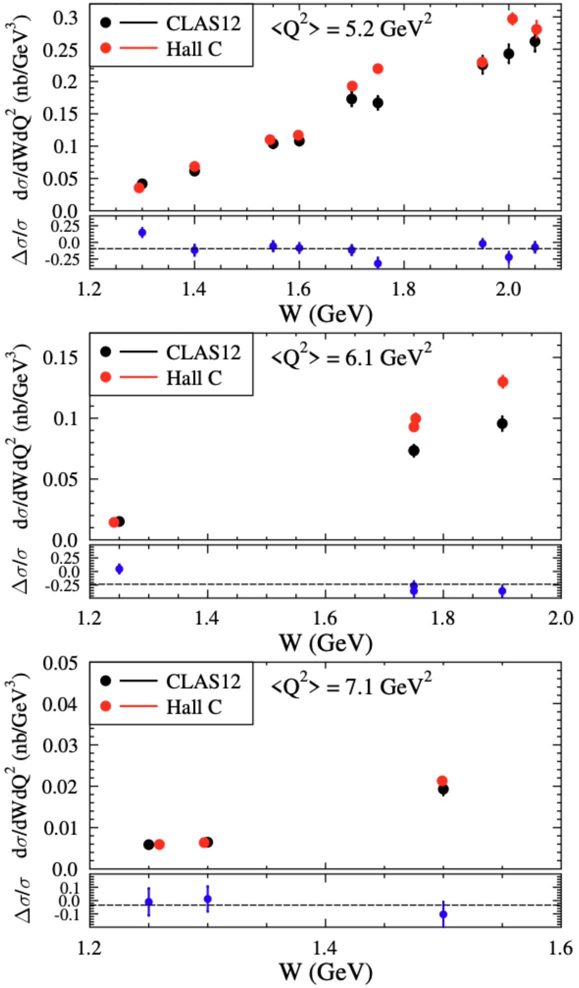




CLAS12 VS HALL C

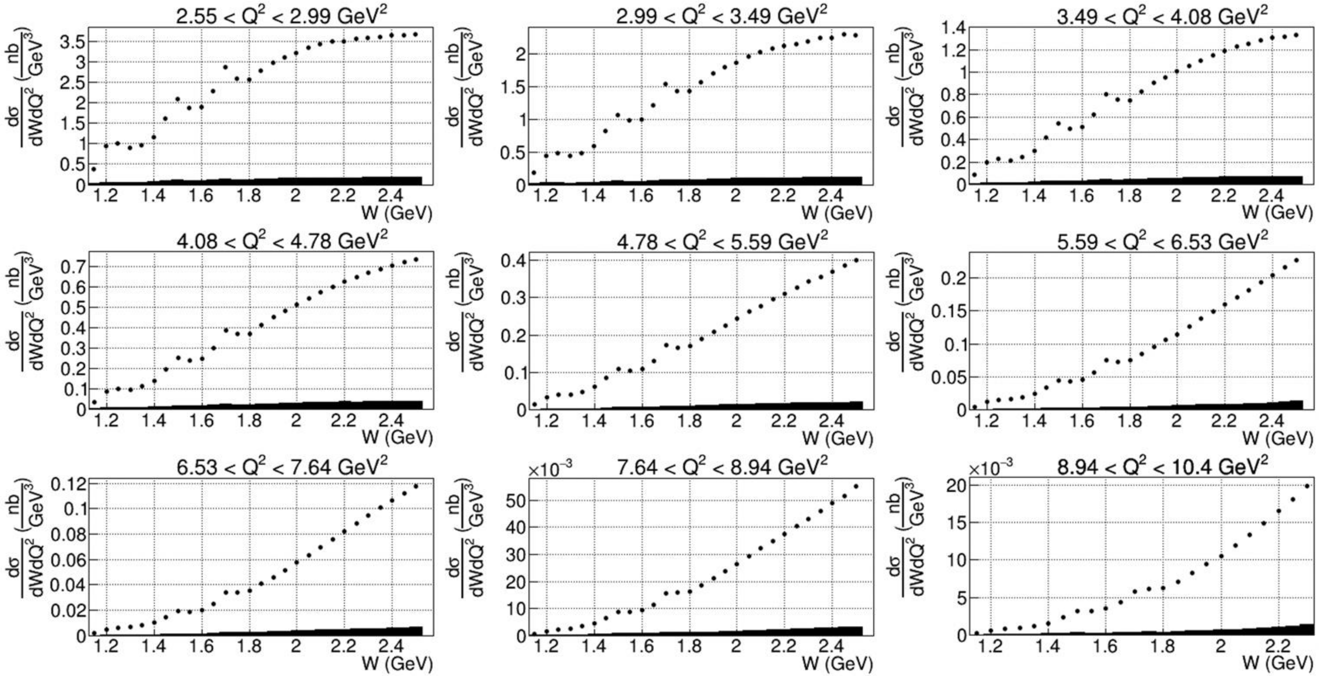
- Because of the small acceptance of the Hall C spectrometer, inclusive cross sections are only available within bins for highly correlated values of W and Q^2
- In total there are 16 data points for which a direct comparison between the two datasets can be made.
- The average relative difference in the CLAS12 and Hall C datasets is about 10 %





RESULTS

- The systematic uncertainty is shown by the filled area at the bottom of each plot



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CONCLUSIONS

- The first results on inclusive electron scattering cross sections from CLAS12 are available from CLAS12 in the kinematic range of $1.15 < W < 2.5$ GeV and $2.55 < Q^2 < 10.4$ GeV^2. Our new measurements show reasonable agreements with world data in overlapping Q^2 regions.

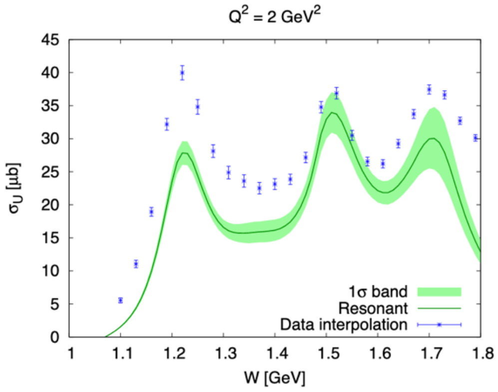
- Evaluation of the resonant contributions from exclusive meson electroproduction data will pave the way to extend knowledge on the nucleon PDF at large x in the resonance region.

- The (e,e'X) data from CLAS12 offer an opportunity to explore the evolution of the inclusive structure function F_2 within the range of distances where the transition from strongly coupled to pQCD regimes is anticipated.

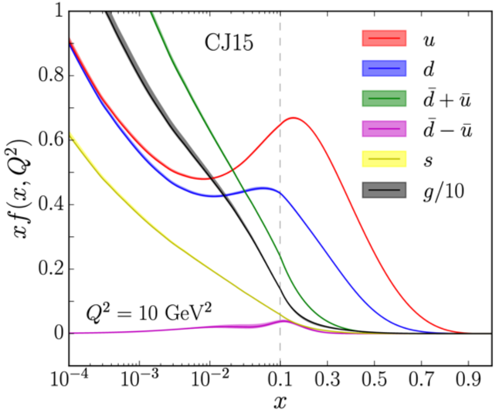
BACK UP

EXTENDING KNOWLEDGE OF THE NUCLEON PDF IN THE RESONANCE REGION

- Global QCD analyses have provided detailed information on the nucleon PDFs in a wide range of parton fractional longitudinal momentum, x, from 10^{-4} to 0.9
- At large x, in the nucleon resonance region W < 2.5 GeV, the PDFs are significantly less explored.
- Extractions in this region require accounting for higher twist effects, target-mass corrections and evaluation from the nucleon resonance electroexcitations



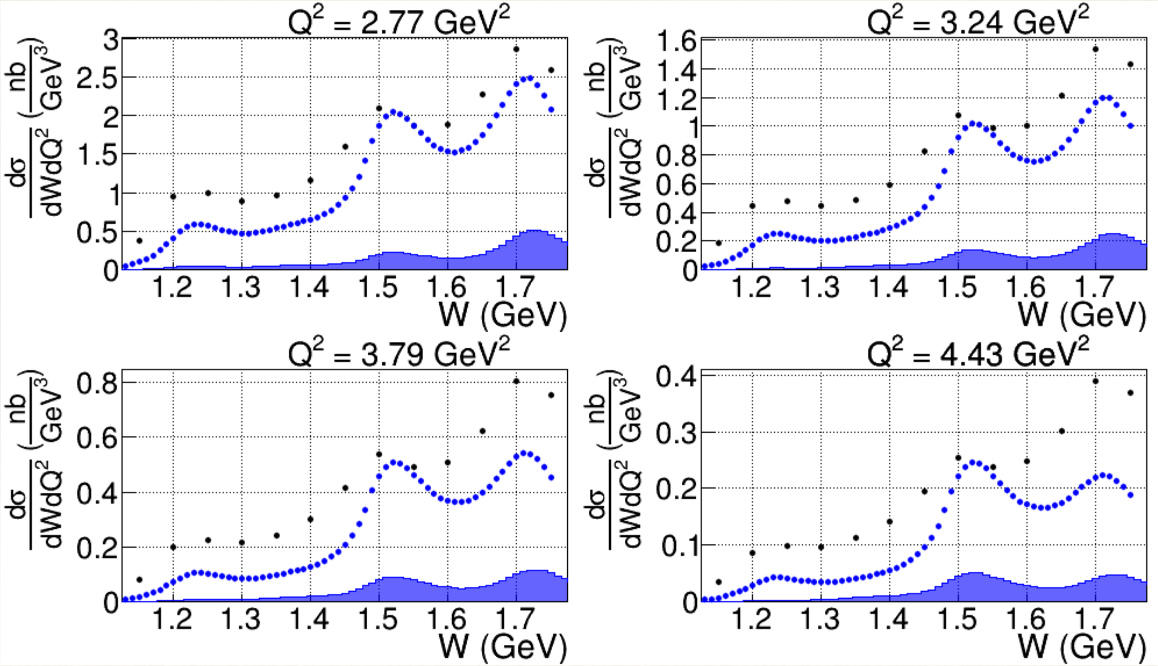
A. N. Hiller Blin et al., *Phys. Rev.* C 100 (2019) 3, 035201, [hep-ph 1904.08016]



A. Accardi et al., *Phys. Rev. D.* 11, 114017 (2016), [hep-ph 1602.03154]

Resonant Contributions

- The blue points represent the computed resonant contributions from the experimental results on the resonance electrocouplings from the studies of πN, ηN, $\pi^+\pi^-$p electroproduction off protons with CLAS. The shadow areas at the bottom of each plot show the systematic uncertainties for the evaluation of the resonant contributions
- The resonant amplitudes were computed within the Breit-Wigner ansatz with the γ_vpN electrocouplings available from the studies of meson electroproduction data in the resonance region.

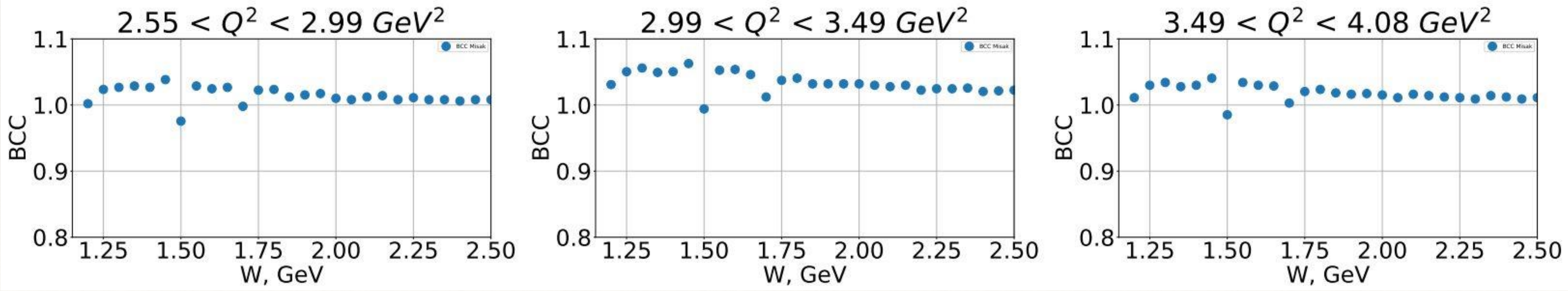


Bin Size Corrections

$$\frac{d\sigma}{dQ^2dW} = \frac{1}{\Delta Q^2 \Delta W} \cdot \frac{N}{\eta \cdot R \cdot B \cdot N_0} \cdot \frac{1}{N_A \rho t / A_\omega}$$

Each (Q^2,W) bin was divided into (the same) 21x11 sub bins.

$$\mathrm{B} = \frac{Cross\ Section\ (No\ Rad)\ in\ the\ central\ point}{Mean\ Cross\ Section\ (No\ Rad)}$$



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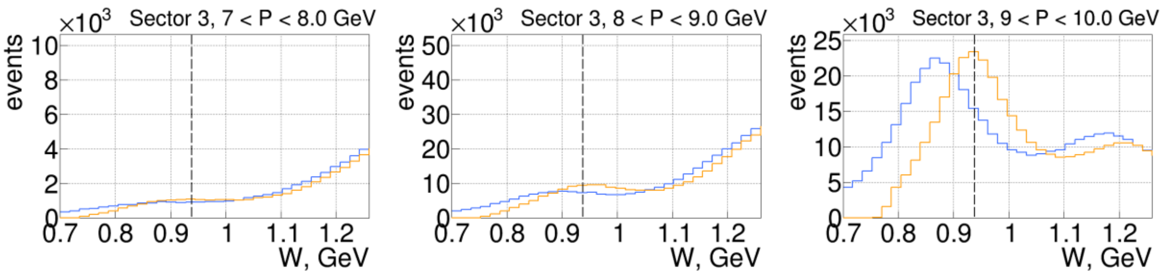
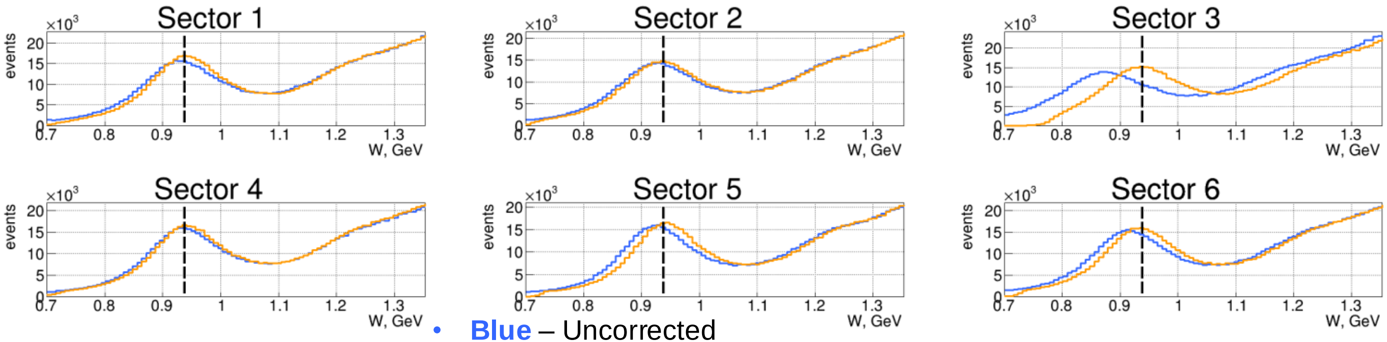
Momentum Corrections

- Momentum correction obtained from Momentum Correction Task Force
- Elastic peak is only clearly visible in the highest momentum bin (lowest Q^2)

W spectrum in momentum before and after corrections

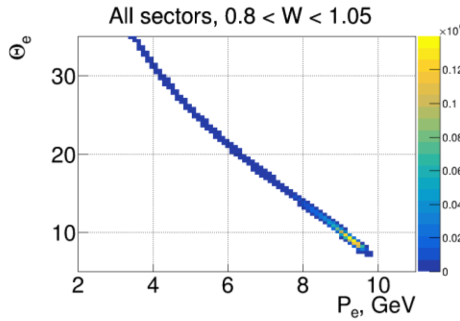


W spectrum before and after corrections



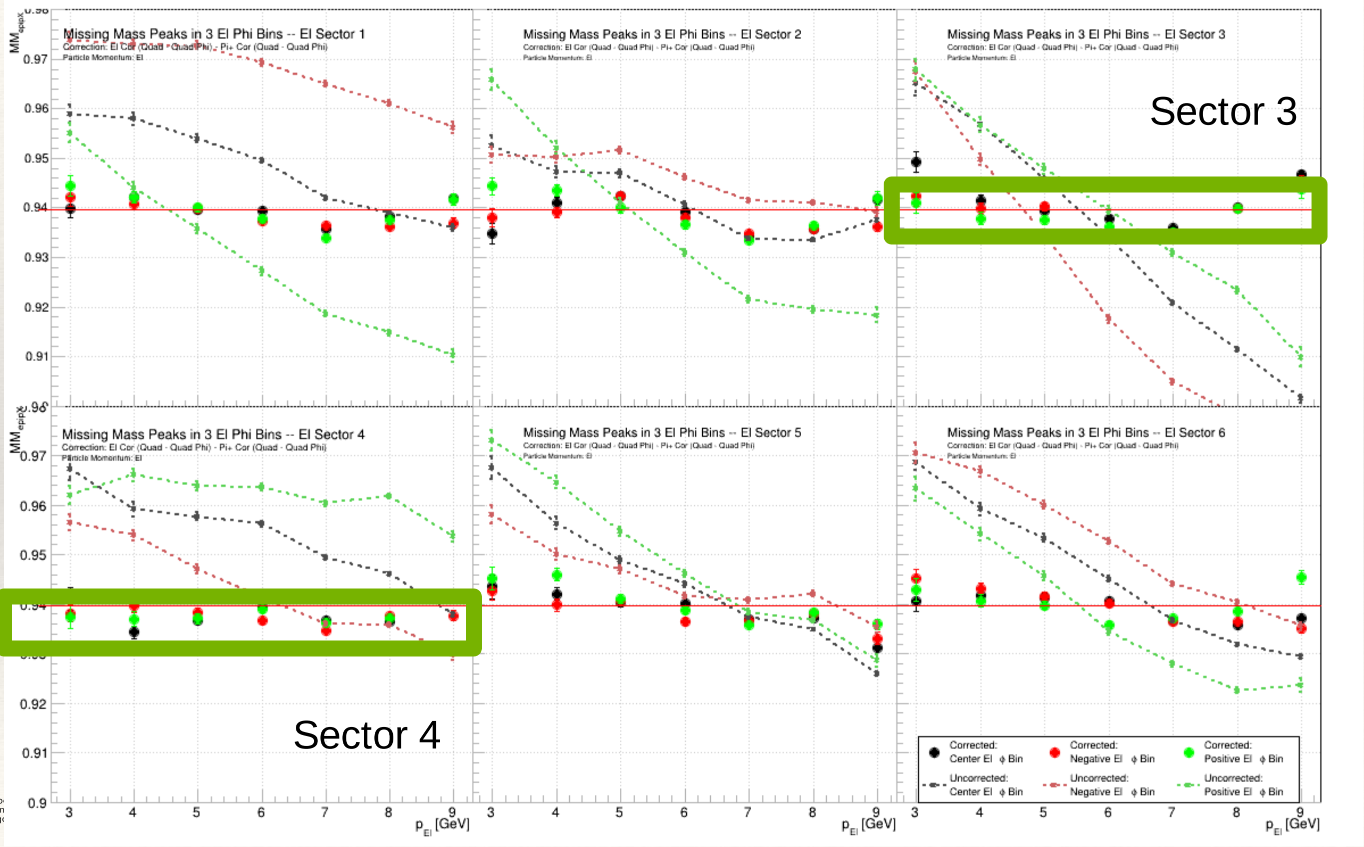
- **Blue** – Uncorrected
- **Orange** – Corrected

Kinematic coverage



Momentum Corrections

MM($e\pi^+X$) neutron peak position as a function of P_e for all sectors



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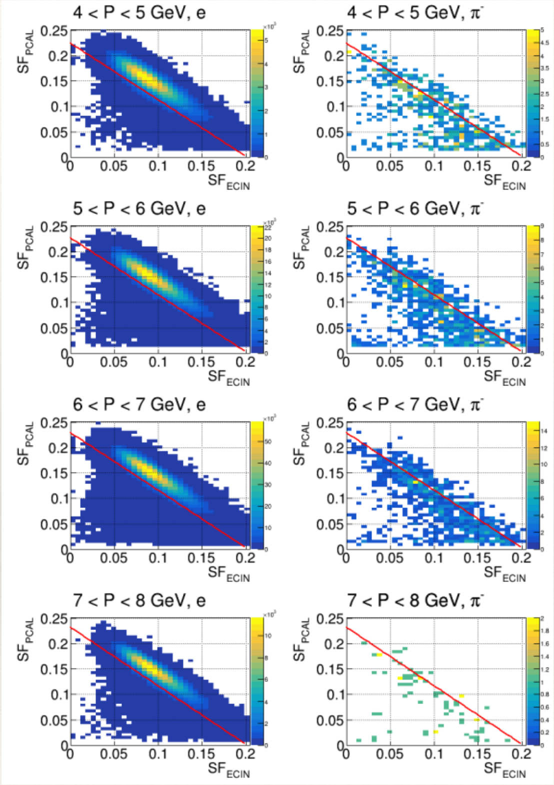
Pion Contamination



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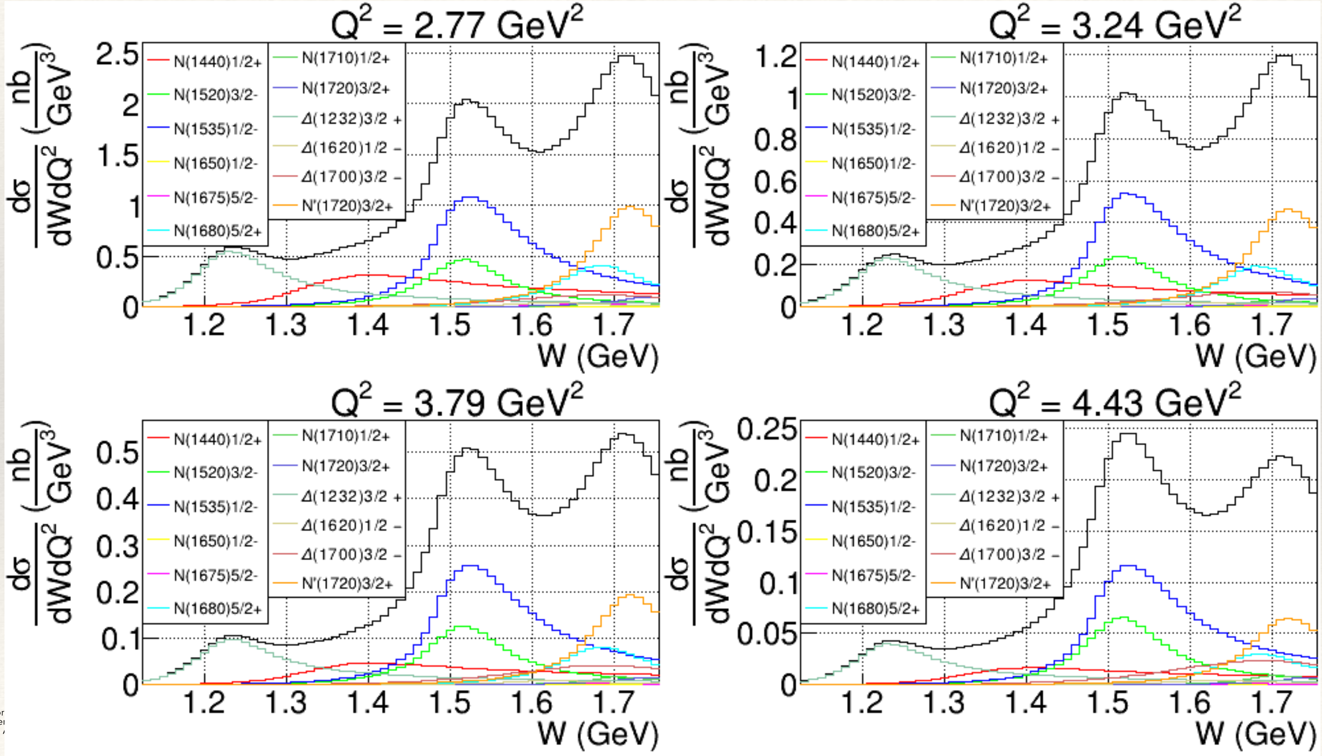
Decomposition of the Resonant Contributions

- Each of the three resonance region maxima seen in our data arise from several excited states of the nucleon

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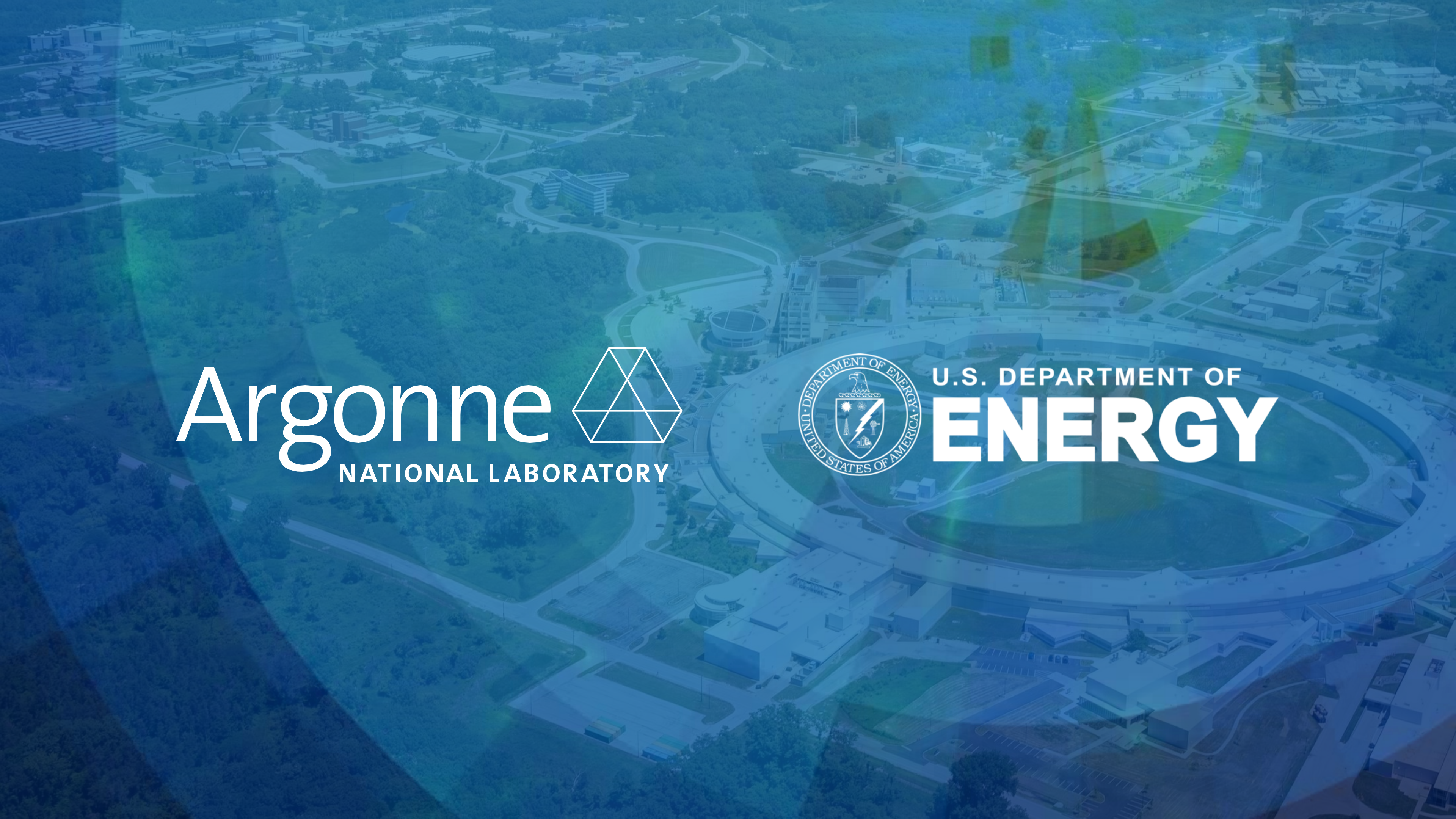
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