Inclusive Electron Scattering off Protons with CLAS12

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for the CLAS collaboration

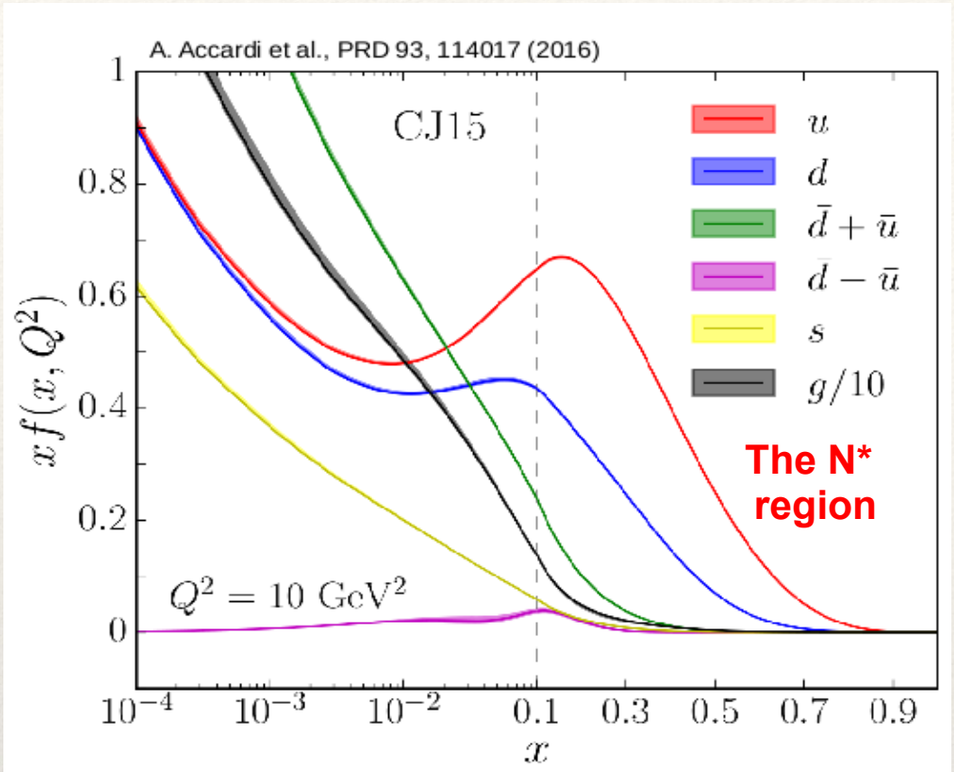
CEBAF Large Acceptance Spectrometer

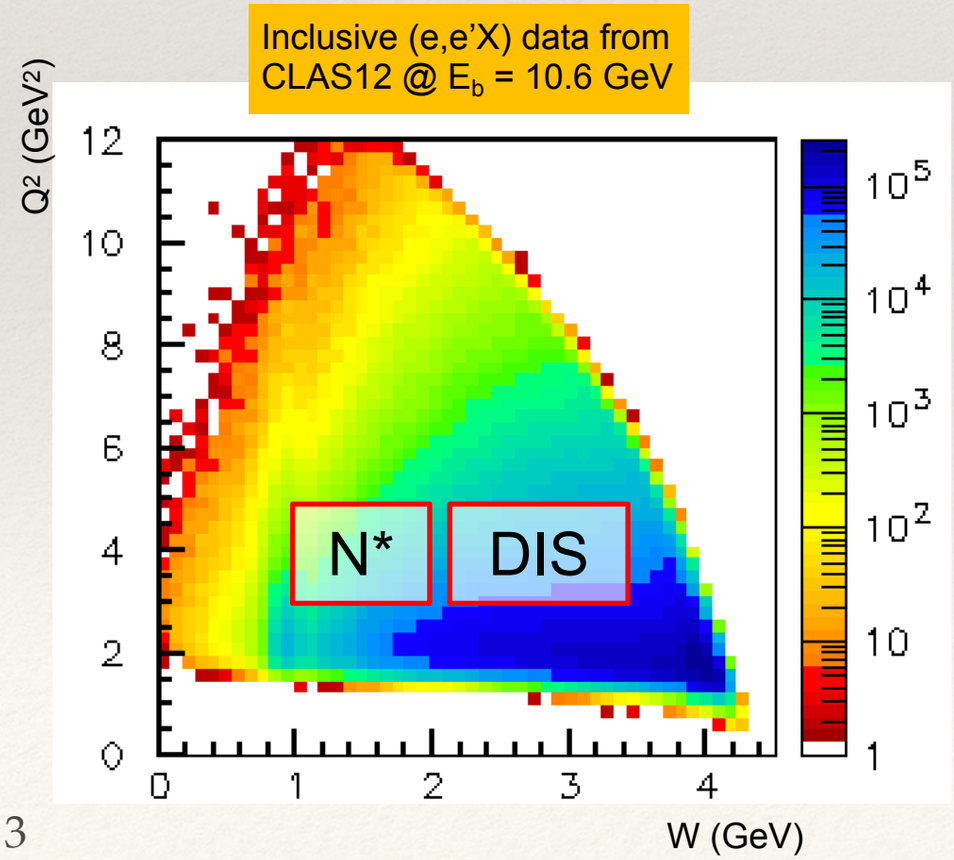
Jefferson Lab

Introduction and Motivation

- Provide the fist data from CLAS12 on inclusive p(e,e')X cross sections at 1.1 GeV<W<3.0 GeV and Q^2<9.0 GeV^2 of interest for the N* and DIS studies as well as for validation of the results from semi-inclusive and exclusive electroproduction channels.
- Extension of the results on inclusive structure function towards $Q^2 > 4.0$ GeV^2 available within a broad W-range from the Nπ threshold to maximal allowed W within any given Q^2-bin.
- New opportunities for gaining insight into the ground nucleon PDF in the resonance region and into quark-hadron duality from the analysis of the inclusive structure functions both in the resonance and DIS regions.
- Detailed information on the scattered electron measurements with CLAS12 that are indispensable for all future analyses of semi-inclusive and exclusive cross sections.

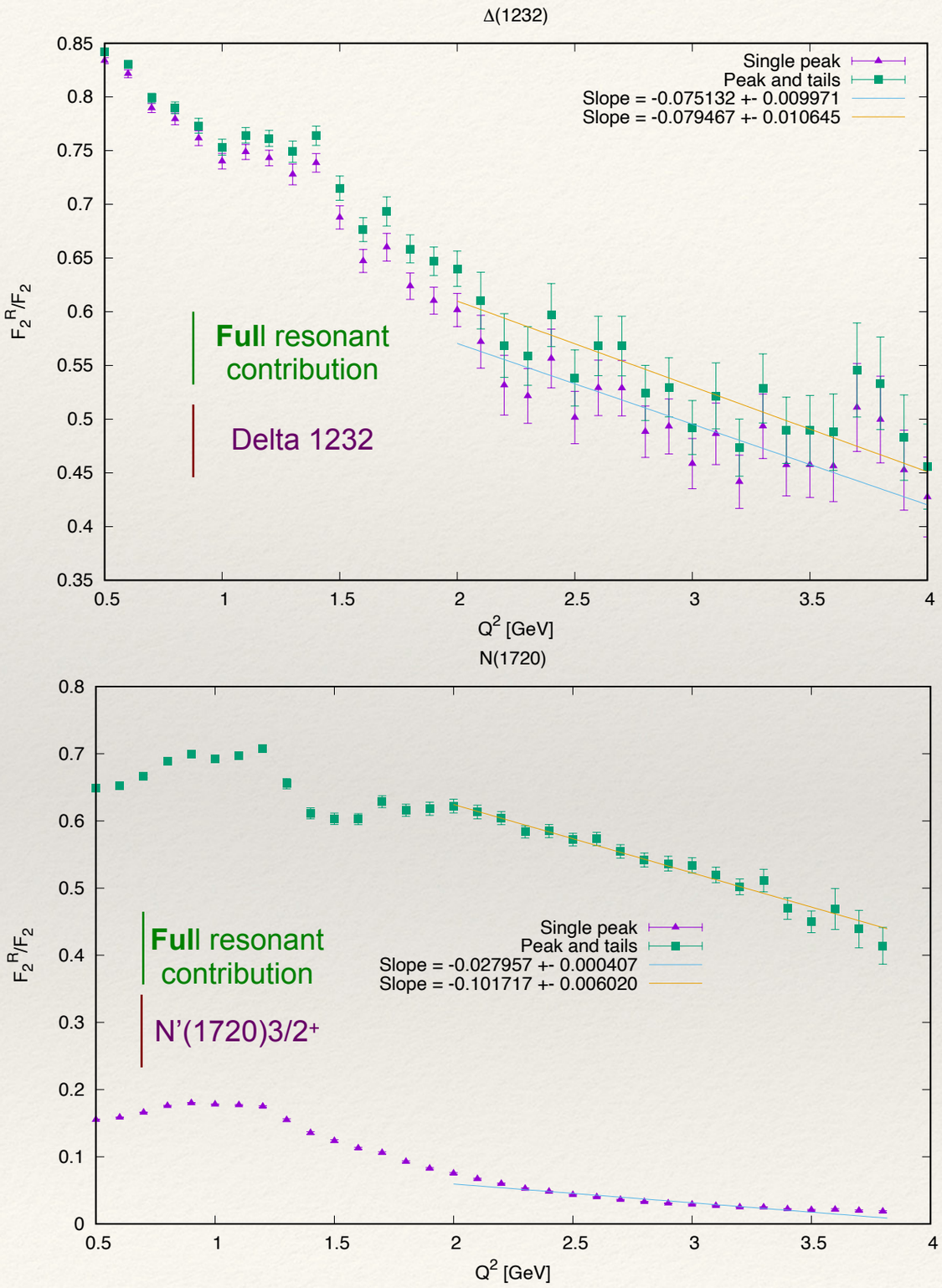
Extending Knowledge of the Nucleon PDF in the Resonance Region





- Study of ground state nucleon PDF from inclusive electron scattering offers an effective tool for nucleon structure exploration
- Global QCD-driven analyses have provided detailed information on the quark and gluon PDFs in a wide range of x_B from 10^{-4} to above 0.9 and at Q^2 from 1 - 10^4 GeV^2
- PDF studies in the resonance region at W < 2.0 GeV require accounting for resonance contributions
- Hall A/C provided accurate p(e,e')X data in the resonance region; due to limited acceptance, data are available on correlated (W,Q^2) grid and offer limited W-coverage at a given Q^2 – a few 100 MeV at Q^2>4.0 GeV^2
- (e,e'X) data from CLAS12 with almost 4π-acceptance cover the W-range from pion threshold to 4.0 GeV in all Q^2-bins
- Advances in the developments of the quasi-/pseudo-PDF concepts allow to evaluate the ground nucleon PDF starting from the QCD Lagrangian.

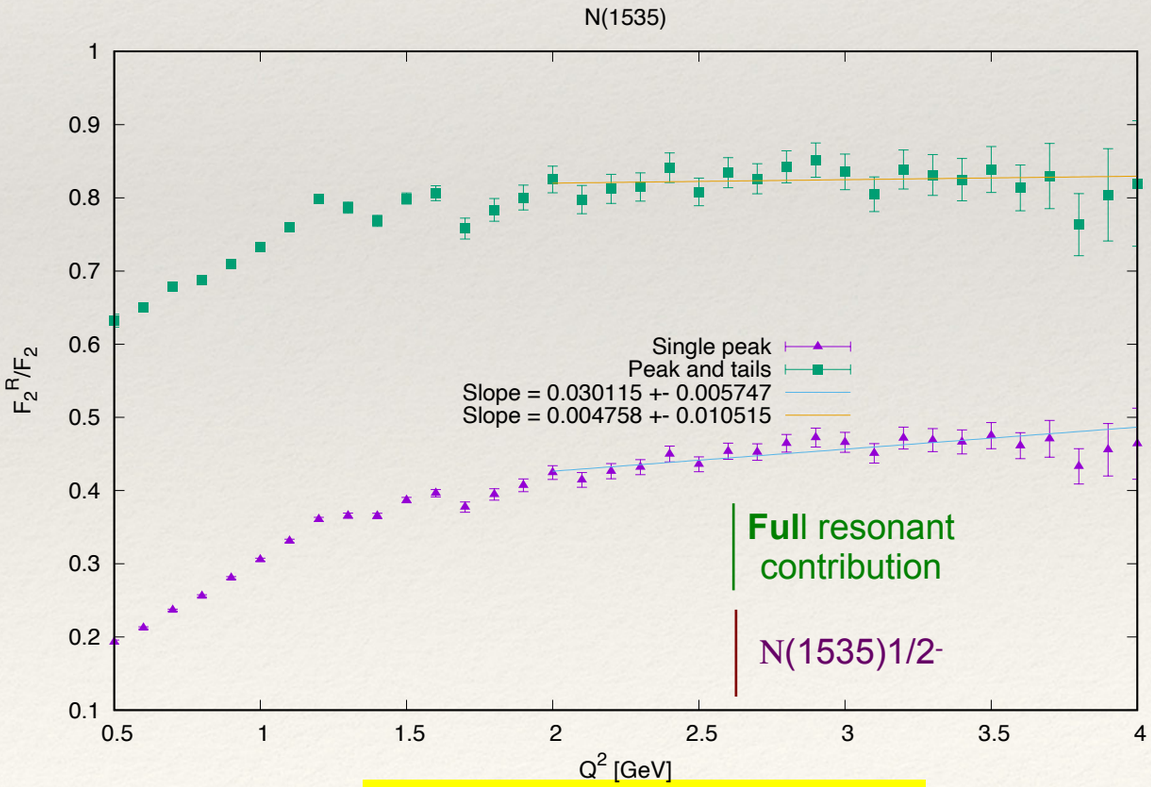
Resonant Contributions into Inclusive Electron Scattering from the JLab Data



New N' (1720)3/2+ state has been recently observed:
V.I.Mokeev et al, Phys.Lett B 805,13457 (2020).

Resonance contribution into F2 structure function

- Significant (>40%) resonant contributions at $Q^2<4.0$ GeV^2 in the region of W<1.8 GeV.

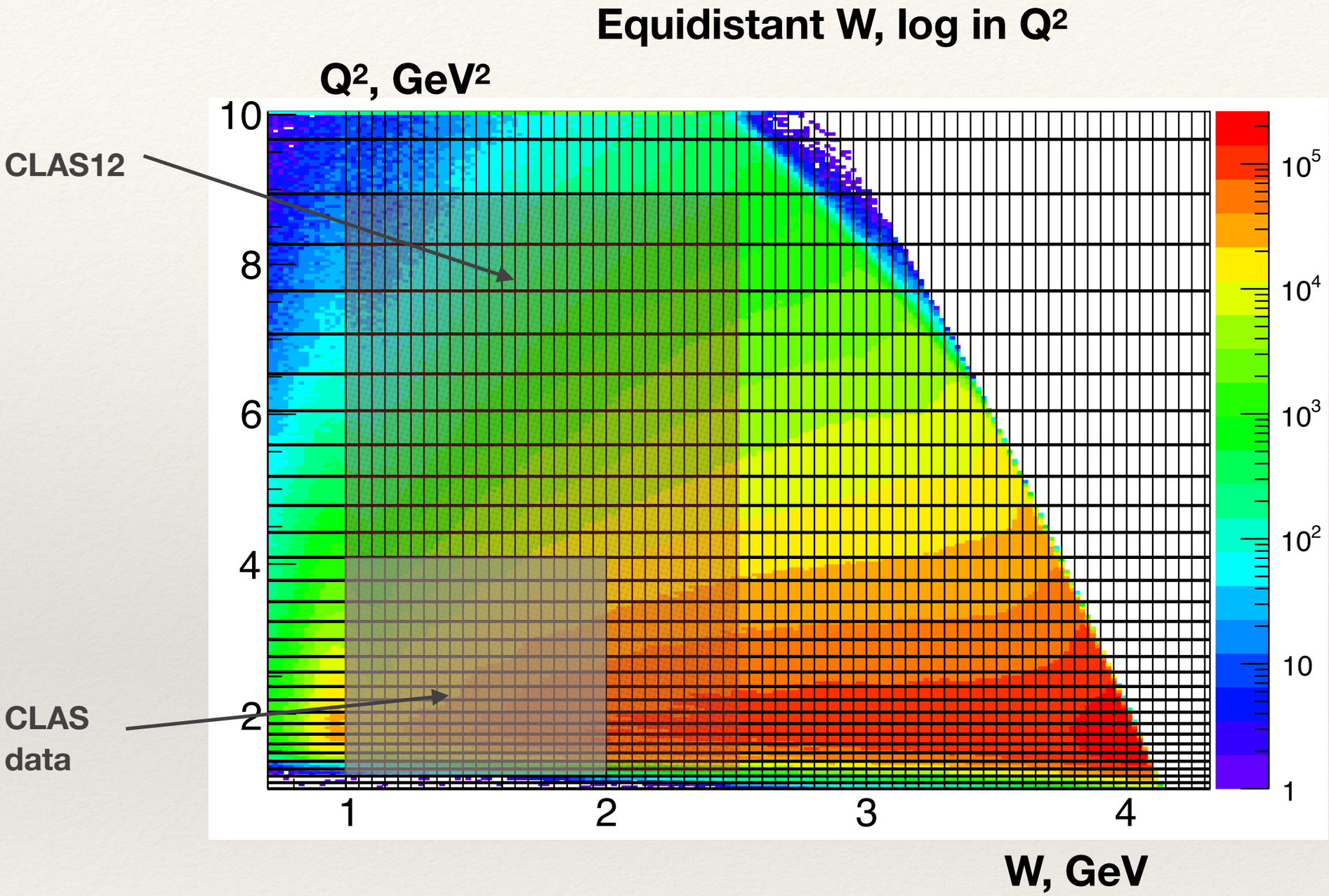


A.N. Hiller Blin, et al
JPAC,Theory and Physics Div.

Analysis Schematics

- Electron ID and event selection;
- Simulation, acceptance and radiative corrections;
- Luminosity correction;
- Dataset selection;
- Results.

Kinematic Coverage and Binning

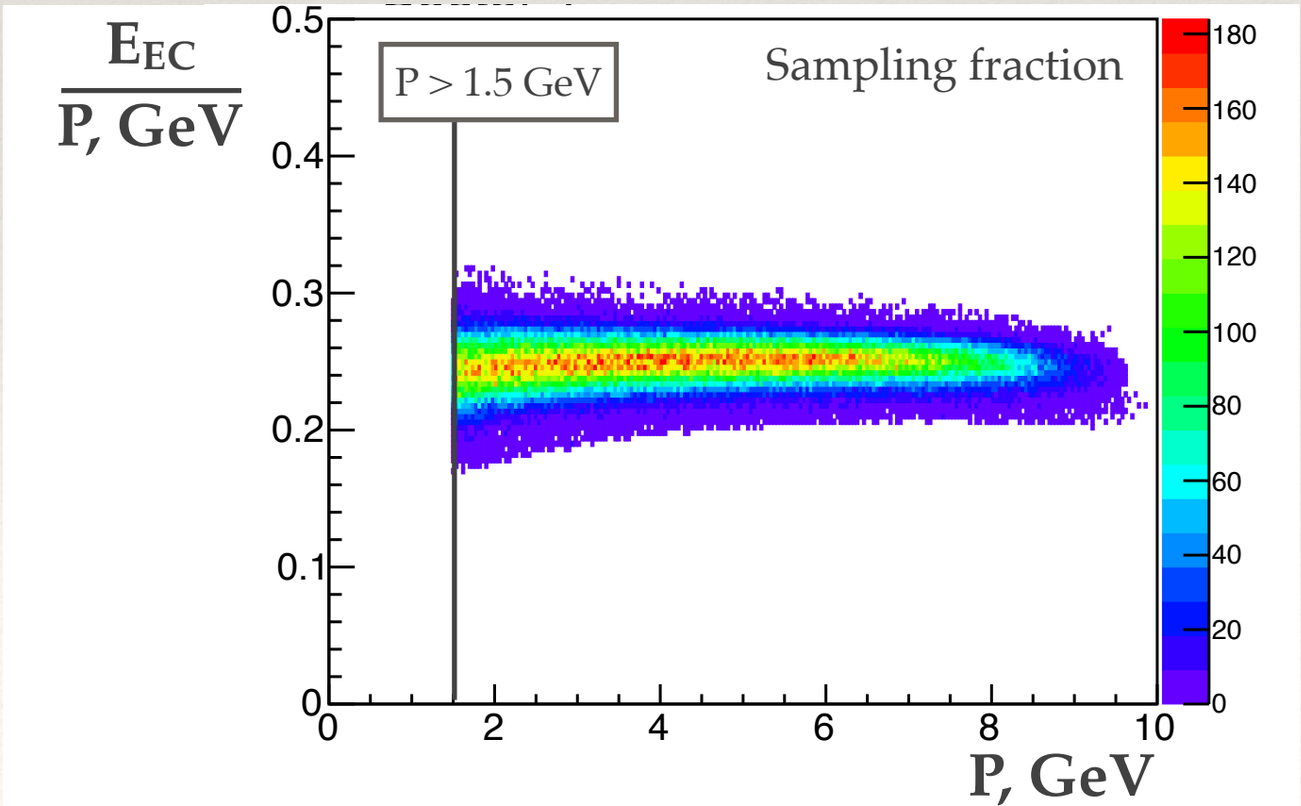


Reasonable and comparable statistics in all Q^2 bins;
Good coverage and fine binning over W;
Compatible with DIS studies.

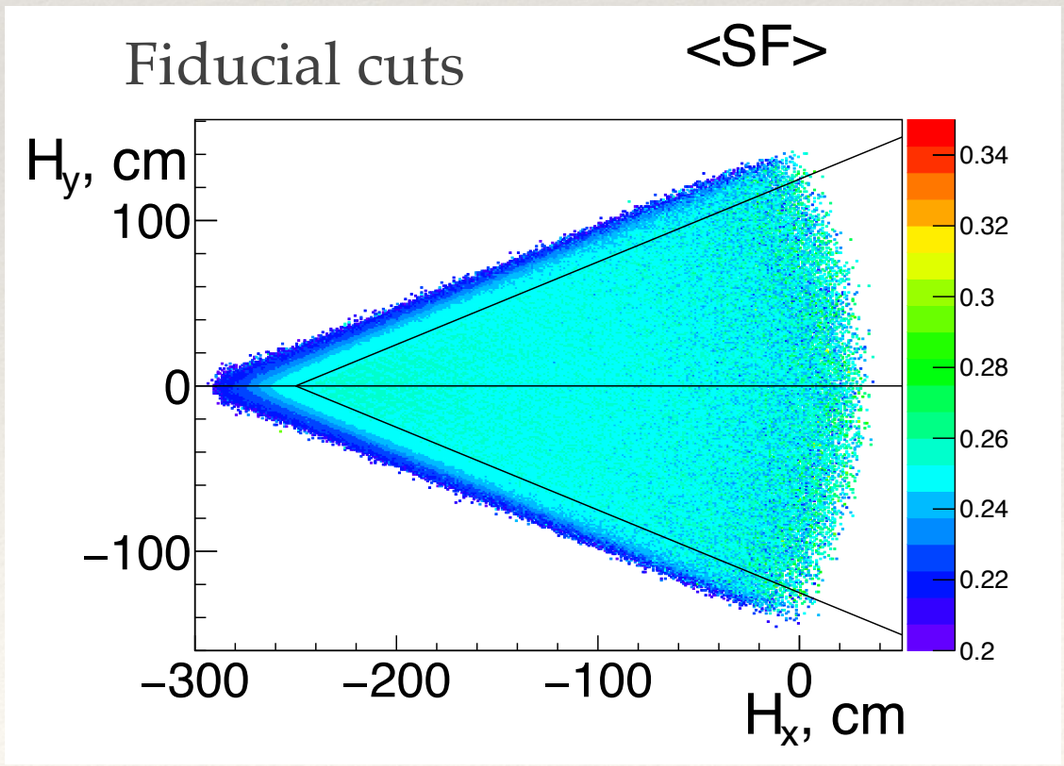
Electron ID

- Limited to Forward Detector (5 -35 degrees coverage in polar angle)
- Electrons are selected by the CLAS12 Event Builder
  - Negative track in **DC** with a hit in **TOF**, **ECAL** and **HTCC**;
  - 2.0 photoelectrons in HTCC;
  - 60 MeV in PCAL;
- Additional cuts:
  - 3σ cuts on a parameterized momentum-dependent sampling fraction;
  - Vertex cut;
  - P > 1.5 GeV;
  - PCAL fiducial cut in coordinates from system.

MC

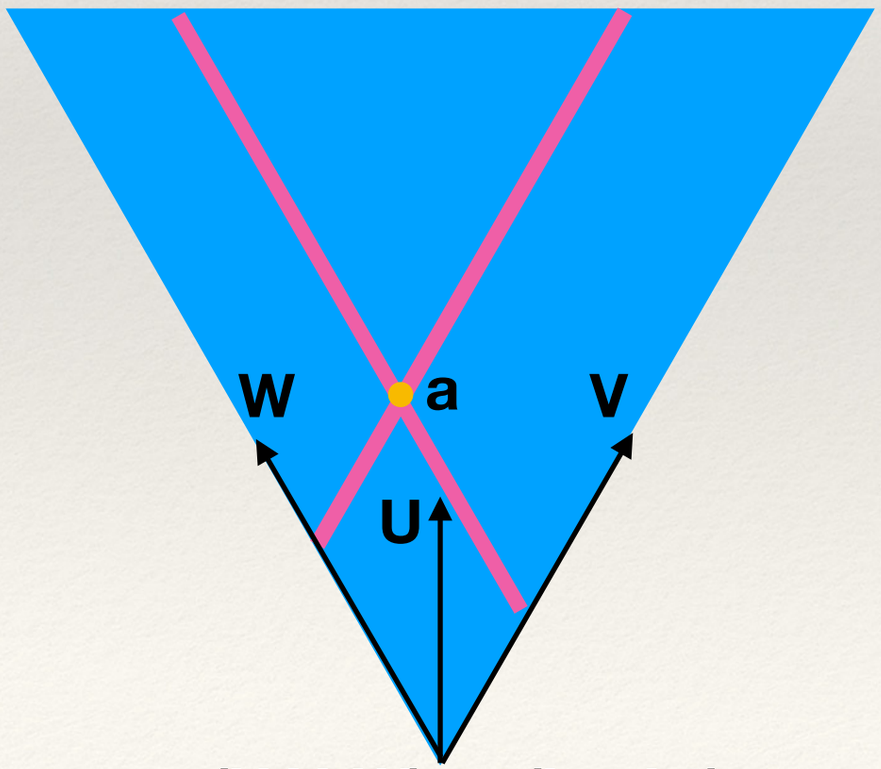


MC



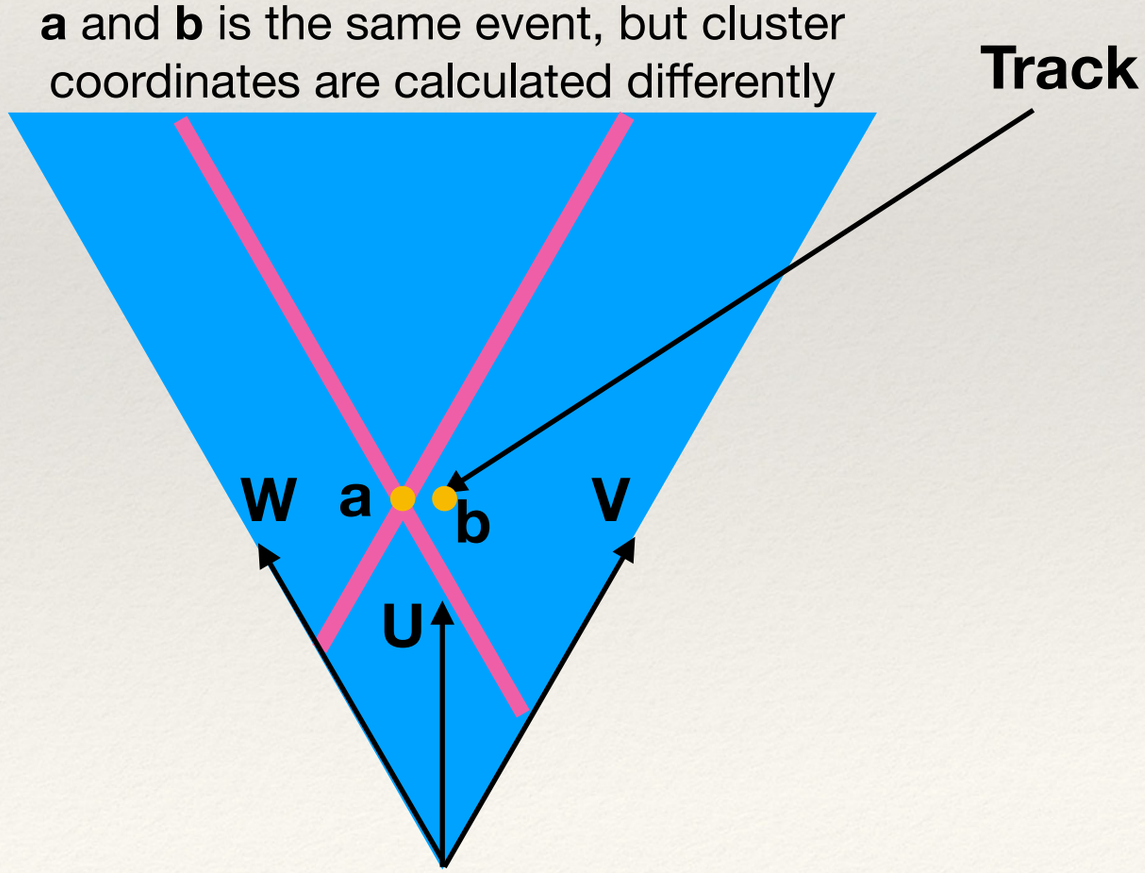
PCAL Fiducial Cut

- Different ways to calculate position of PCAL cluster
- Before we used U, V and W (internal to PCAL) and/or Lx, Ly (CLAS system) which is calculated from U, V and W
  - Sensitive to PCAL alignment
  - Resolution is limited by the strip width
- Lets go for coordinates from tracking: intersection of track with PCAL plane (Hx, Hy)
  - Not sensitive to PCAL alignment (sensitive to DC but it seem to be under control)
  - Very good resolution



a(U,V, W)->a(Lx, Ly)

a and **b** is the same event, but cluster coordinates are calculated differently



b(Hx, Hy)

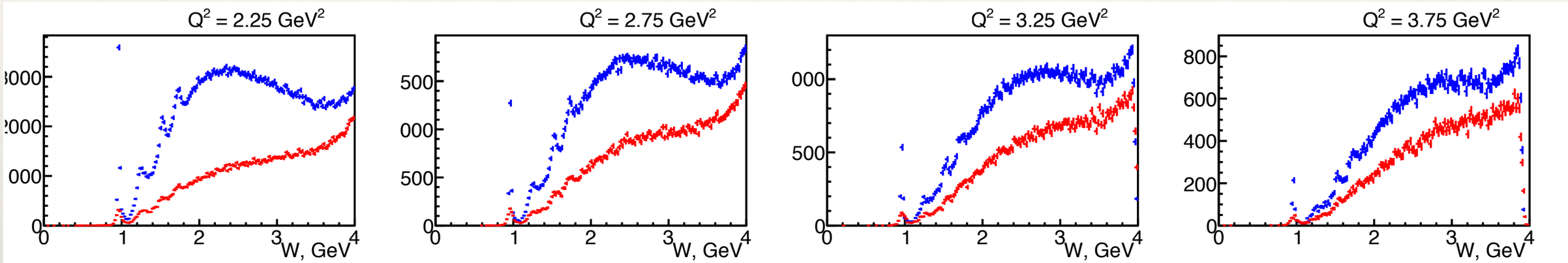
Acceptance and Luminosity Corrections

Generated events

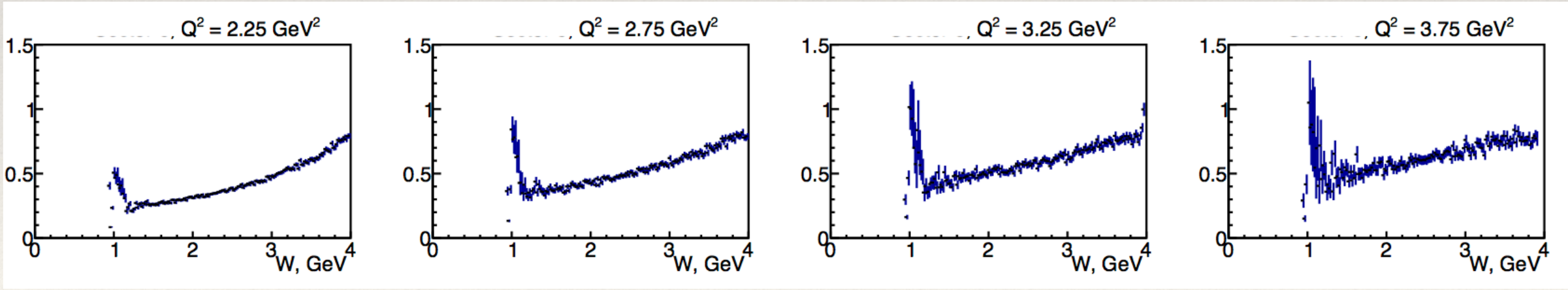
Reconstructed simulation events

Inclusive event generator: M. Sargsyan, CLAS-NOTE 90-007 (1990).
Includes elastic and radiative effects

Same reconstruction algorithm is used between data and simulation.
Both generated and reconstructed event display the main features of inclusive electron cross section, namely elastic peak, resonance region with "bumps" and smooth DIS region.
Background efficiency merging is implemented into the simulation.



Acceptance Correction



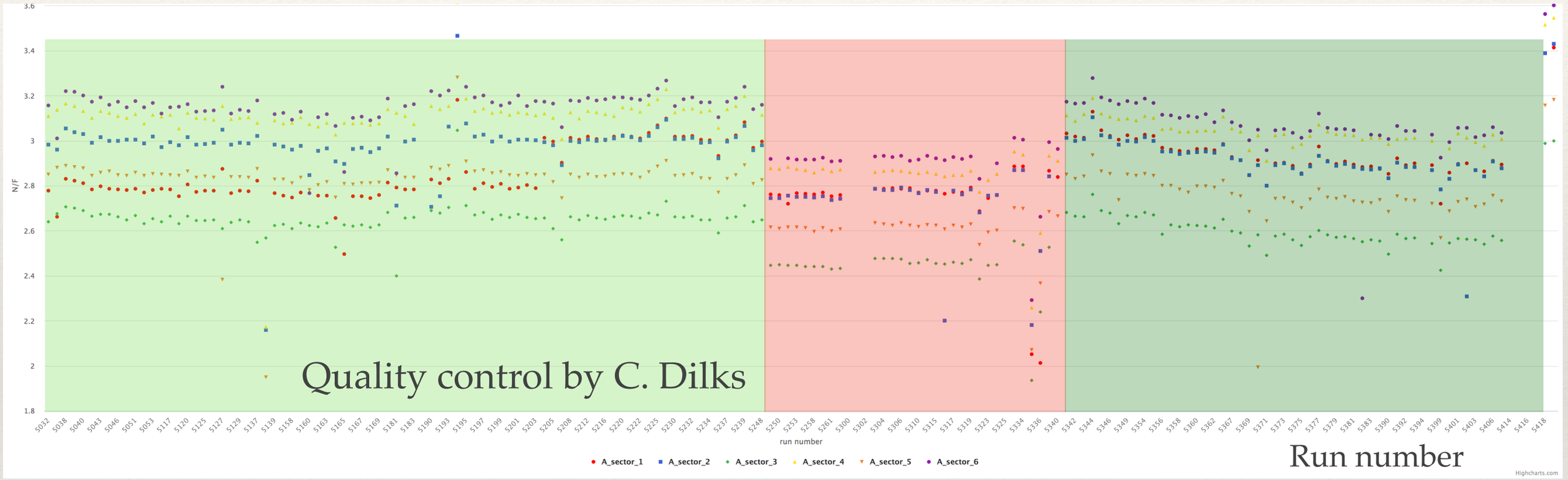
Sample of the acceptance correction for a few Q^2 bins

Luminosity Correction

Luminosity correction is based on the geometry and properties of the target (5 cm length liquid hydrogen) and integrated beam charge collected on the Faraday cup and accounts for the for the data acquisition system live time.

Dataset selection

Number of electron triggers / fCup charge

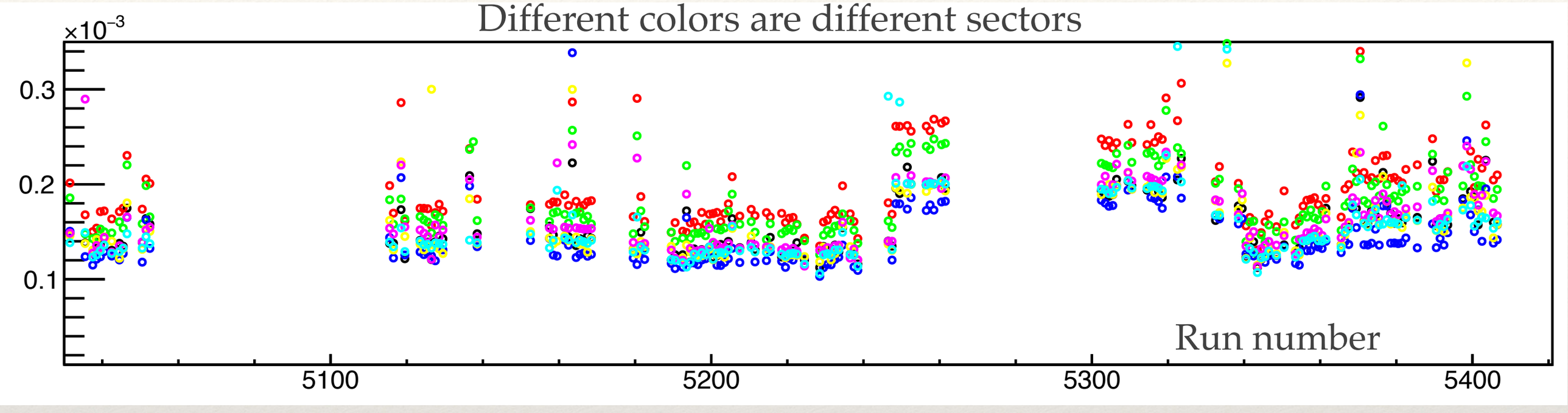


- Sector by sector dependance goes away with fiducial cuts
- Clearly different regions with different and consistent yields
- Need to have a clear understanding of the reason (detector calibrations, trigger conditions, beam conditions, etc)
- Will it stay with proper particle ID / fiducial cuts?
- Lets go to the cross section and compare it to the model

Dataset selection

Chi2

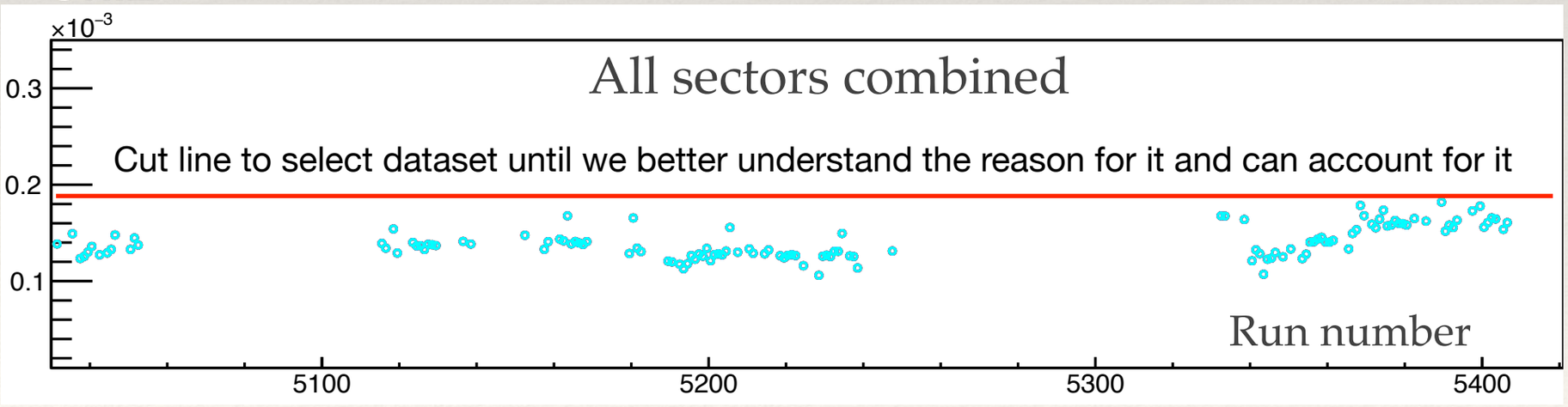
chi^2 = (Model - data)*(Model - data), summed over all Q^2 and W bin

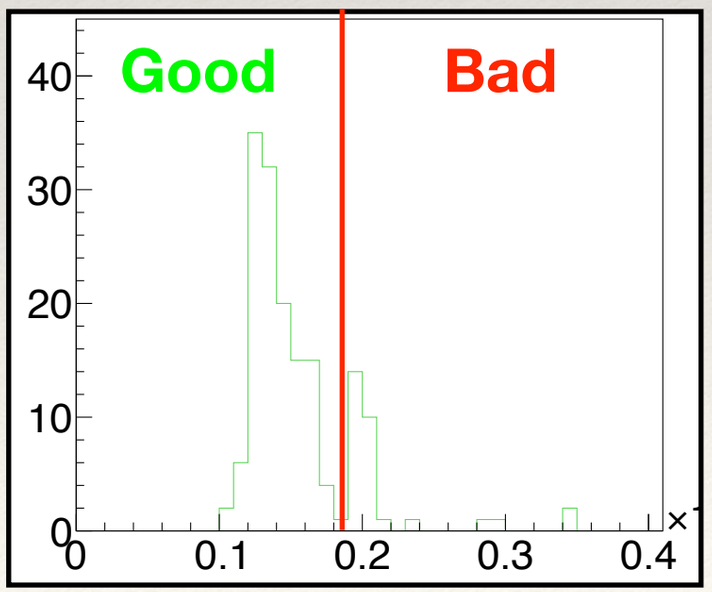


Clearly see the same structure as for the electron yield

Chi2, all sectors combined

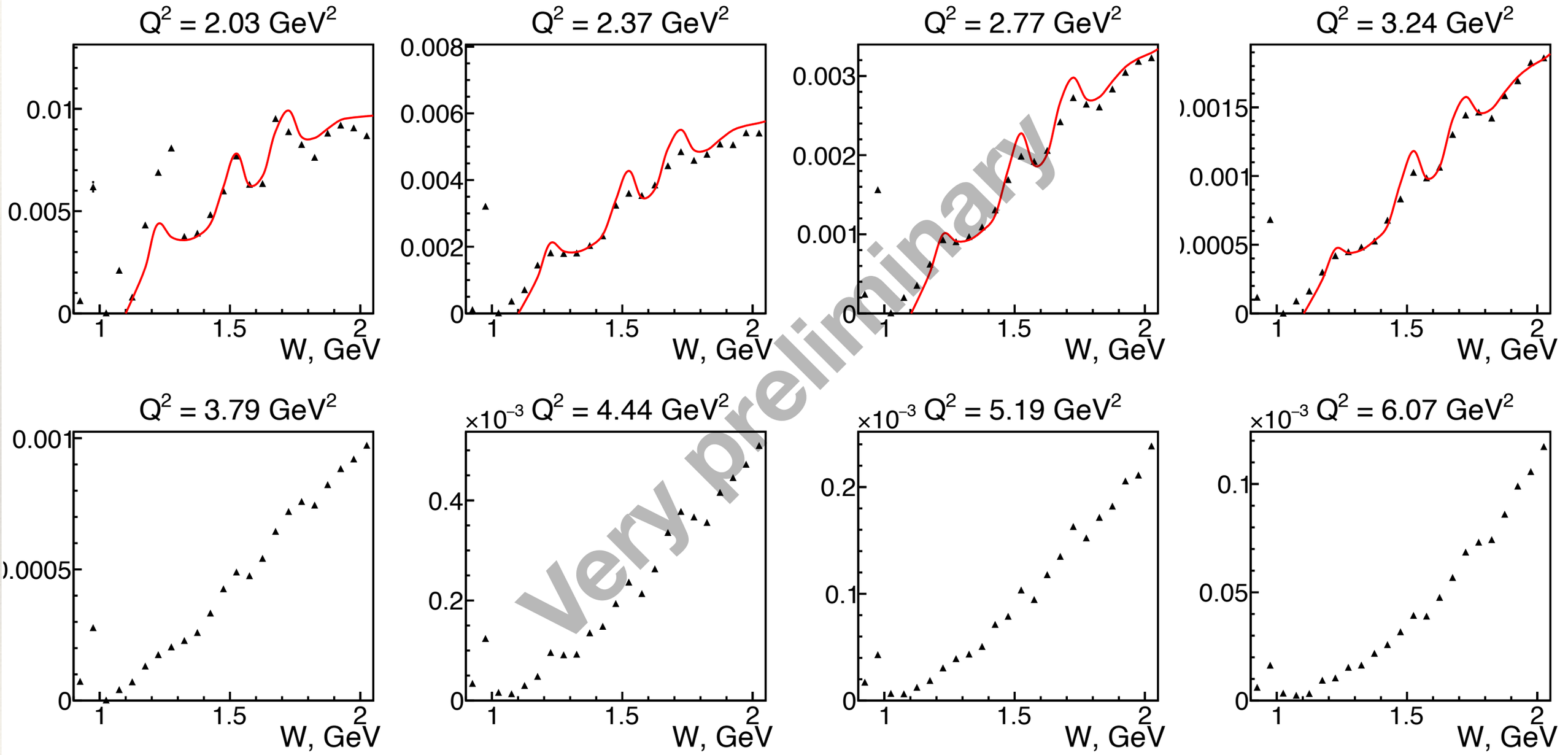
Chi2





Results

"Good runs" (130 runs, 75% of RGA Inbending by FCup charge)

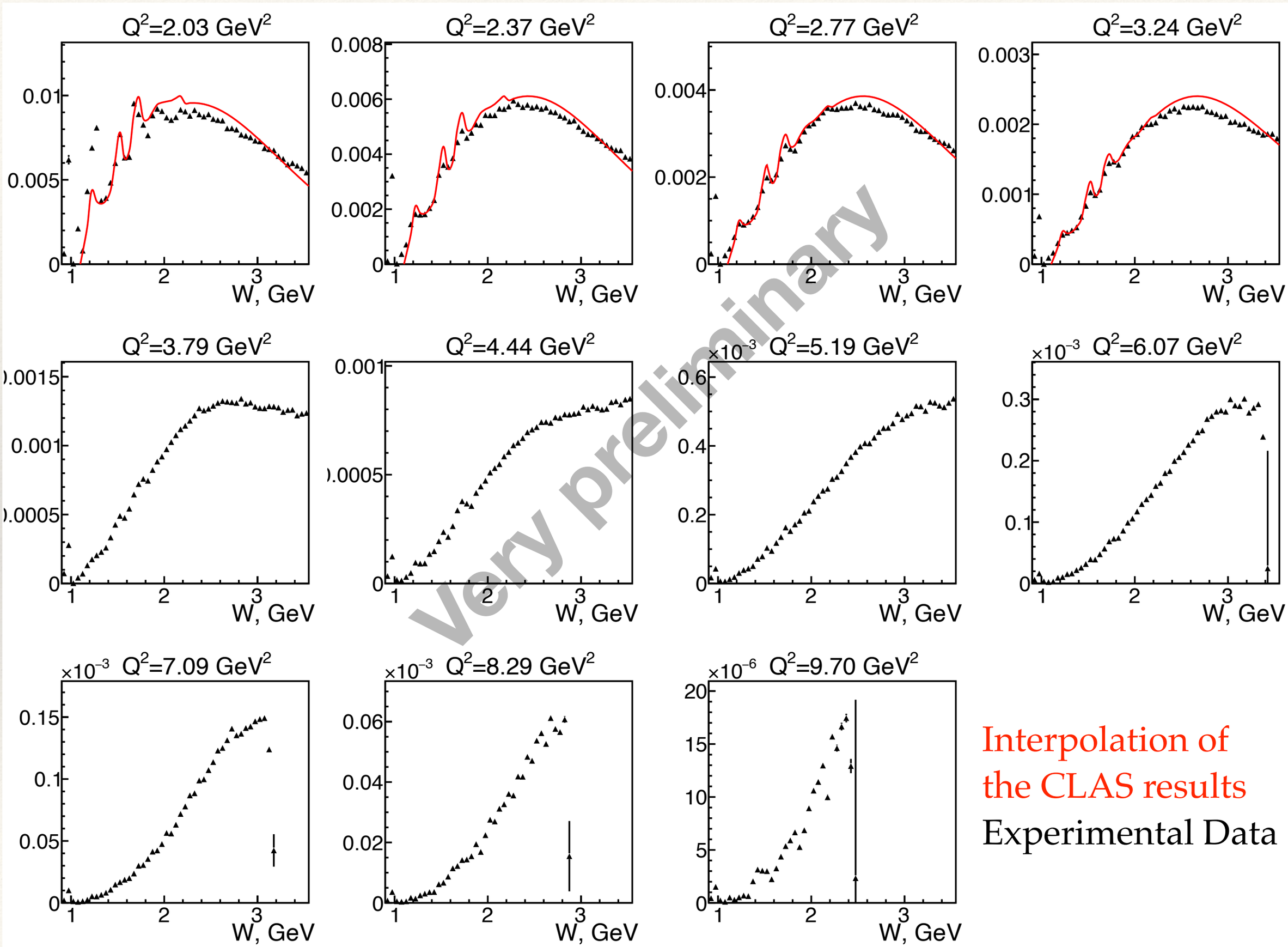


Luminosity and acceptance corrected yield with radiative corrections (selected data).

Interpolation of the CLAS results

Experimental Data

“Good runs” (130 runs, 75% of RGA Inbending by FCup charge)



Future Plans

- Improvements of electron ID procedure;
- Bin centering and momentum corrections;
- Dataset selection and understanding of electron yields;
- Better evaluation of the efficiency for the electron detection;
- Improved matching of detector response and acceptance between Monte Carlo and data;
- Extensive studies of the systematic uncertainties.

Summary

- Preliminary results on the acceptance corrected and luminosity normalized yields of inclusive electron scattering events have become available from CLAS12 in the range of 1.1 GeV <W<2.5 GeV and beyond in any given bin at Q^2 at 2.0 GeV^2 <Q^2<9.0 GeV^2;
- The shapes of the W-dependencies of the event yields are in a reasonable agreement with the those obtained from the interpolation of the CLAS/world data on inclusive electron scattering;
- At Q^2 < 3.5 GeV^2 our preliminary results are consistent with the available data within~10%
- The near term efforts are focused on the extraction of the inclusive electron scattering cross section with detailed studies of normalization and electron detection efficiency of particular importance for the semi-inclusive and fully exclusive cross section measurements with the CLAS12;
- The developed approach for evaluation of the resonant contributions into inclusive electron scattering from the CLAS results on the γ_vpN* electrocouplings opens up new opportunities for gaining insight into the ground state nucleon PDF at large x_B and for the studies of quark-hadron duality.

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