Inclusive electroproduction with CLAS12

N. Markov, Jefferson Lab
for the CLAS collaboration

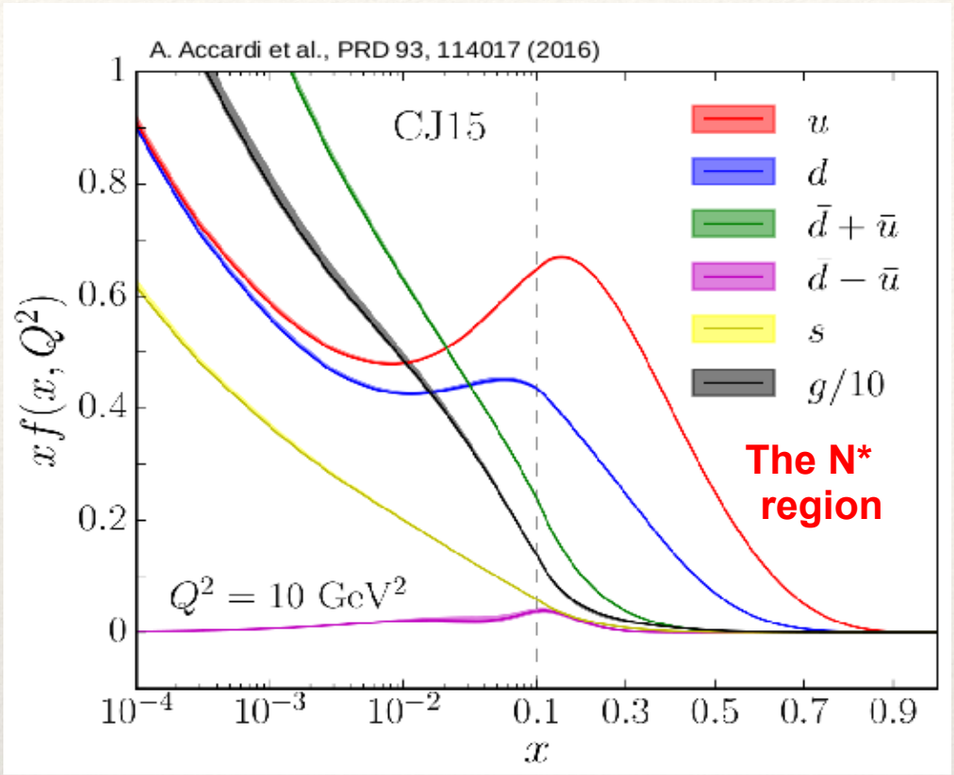
CEBAF Large Acceptance Spectrometer

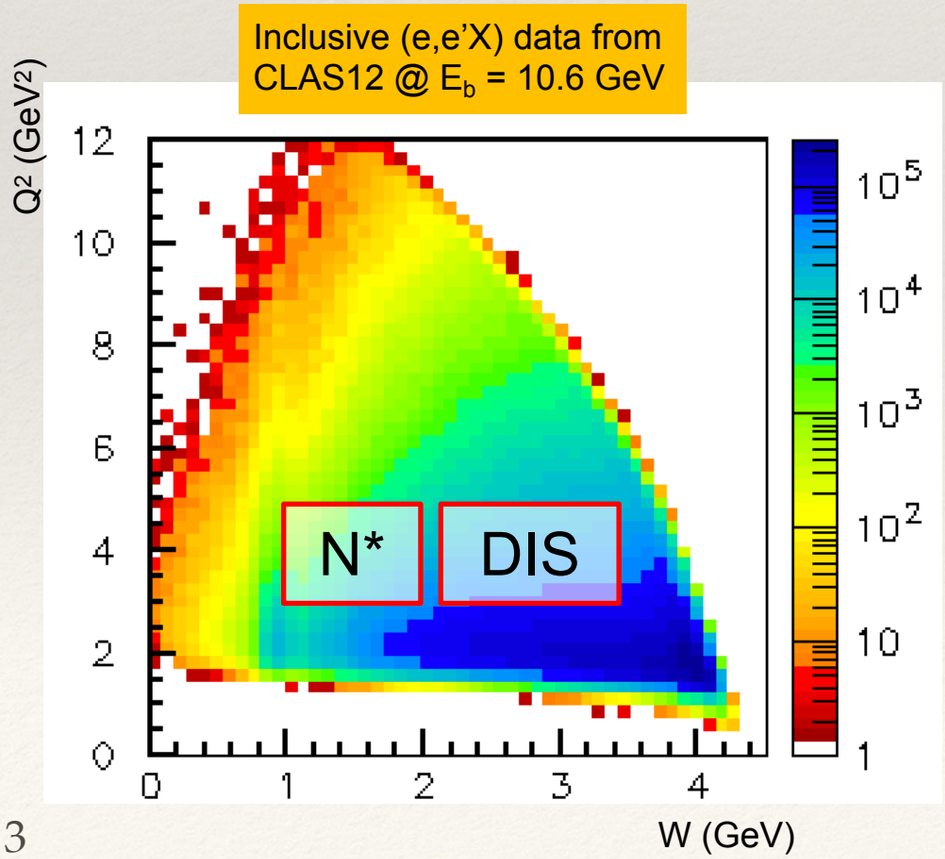
Jefferson Lab

Overview

- Introduction and motivation
- Electron Identification and data analysis
- Next steps and outlook
- Summary

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
- The 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 (e,e'X) data in 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
- CLAS12 data offer opportunities to explore evolution of the ground state nucleon PDF at distances where the transition from the strong-QCD to pQCD regimes is expected

Data analysis

Dataset

- RGA Fall 2018
- 10.6 GeV electron beam
- Torus -100%
- Solenoid -100%
- 5 cm liquid hydrogen target
- Pass1 dataset, runs 5032 - 5419

Data analysis

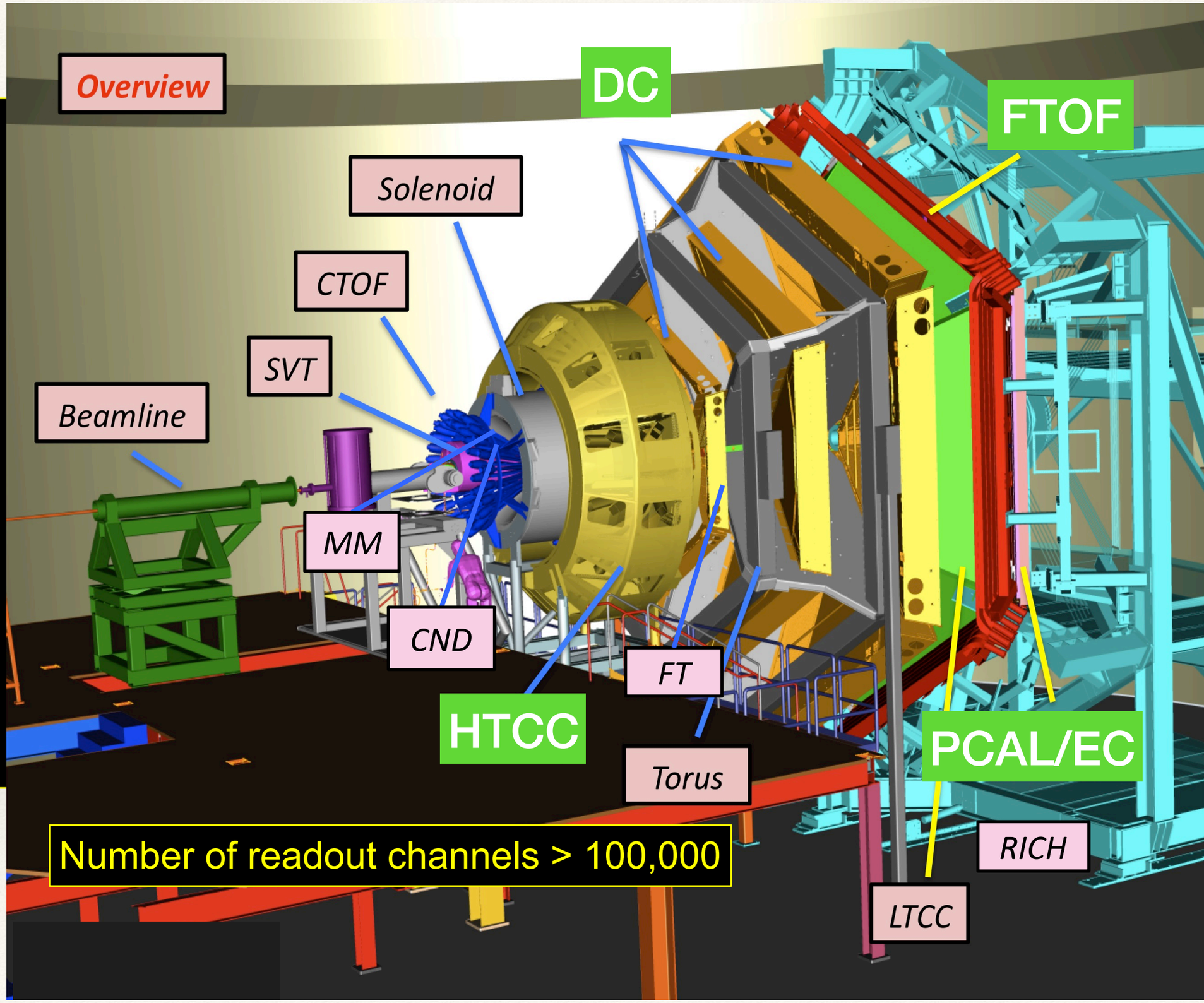
Electron ID

Forward Detector (FD)

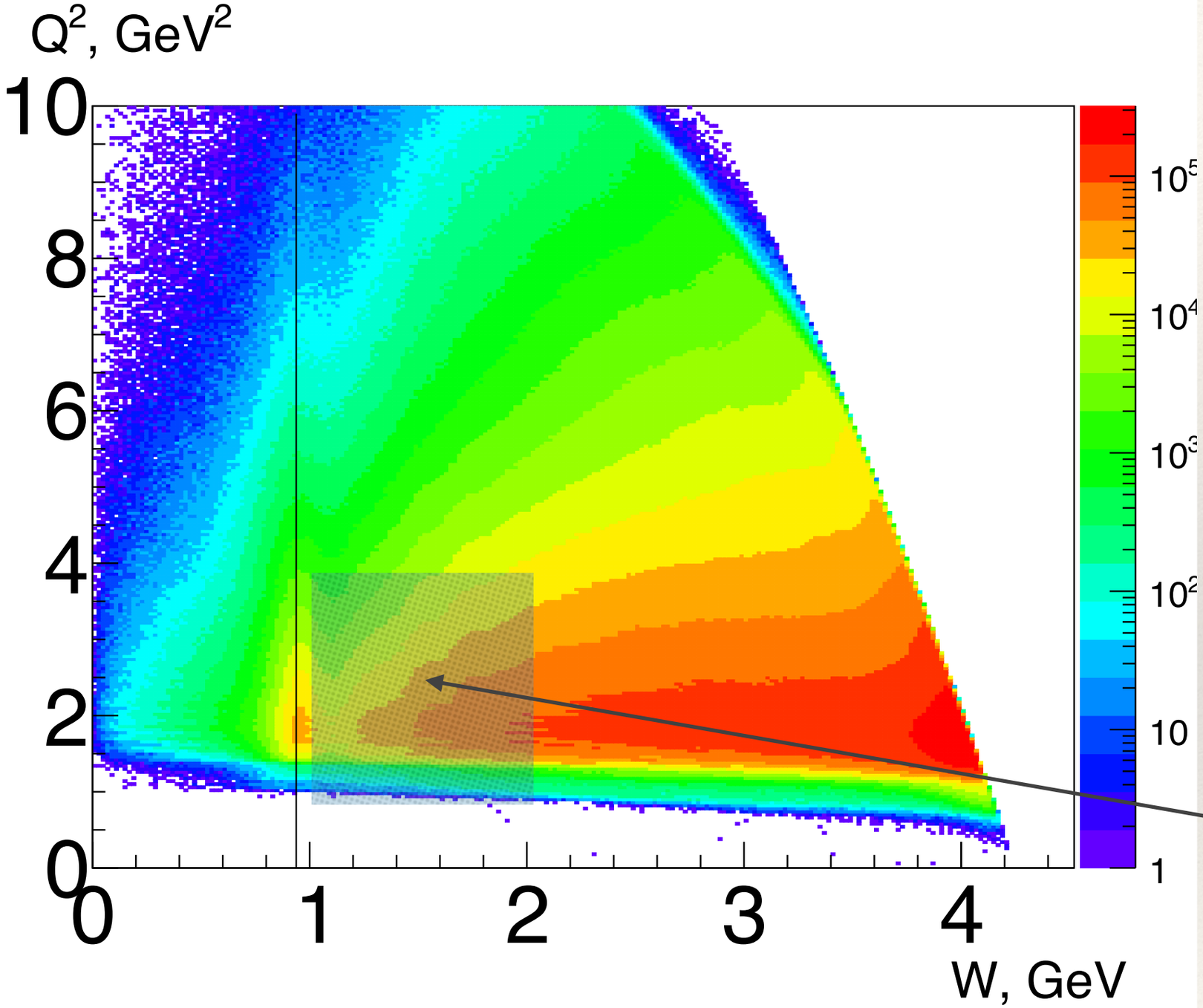
- TORUS magnet
- HT Cherenkov Counter
- Drift chamber system
- LT Cherenkov Counter
- Forward ToF System
- Pre-shower calorimeter
- E.M. calorimeter
- Forward Tagger
- RICH detector

Central Detector (CD)

- Solenoid magnet
- Silicon Vertex Tracker
- Central Time-of-Flight
- Central Neutron Detector
- MicroMegas



Kinematic Coverage



We will report data in the Q^2 region up to ~ 10 GeV^2.

Data analysis

From the CLAS12 Analysis Note Template

RGA Analysis Overview and Procedures

April 28, 2020

The CLAS Collaboration and RGA has put a lot of efforts into the crucial common parts of the data analysis:

- Electron ID
- Fiducial cuts
- Background merging and efficiency
- Momentum correction

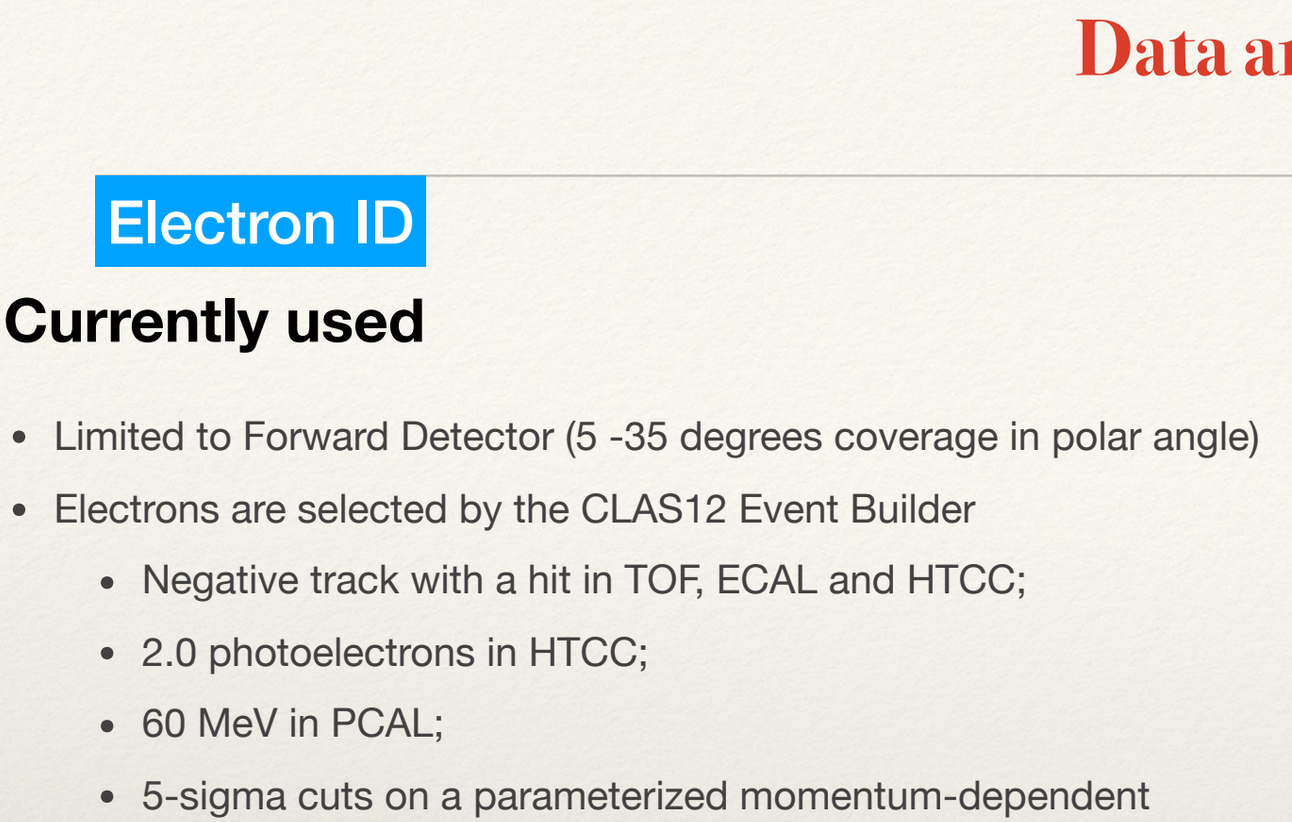
Hadron Structure Group is actively involved in all of these activities and is working toward a common goal.

Data analysis

Electron ID

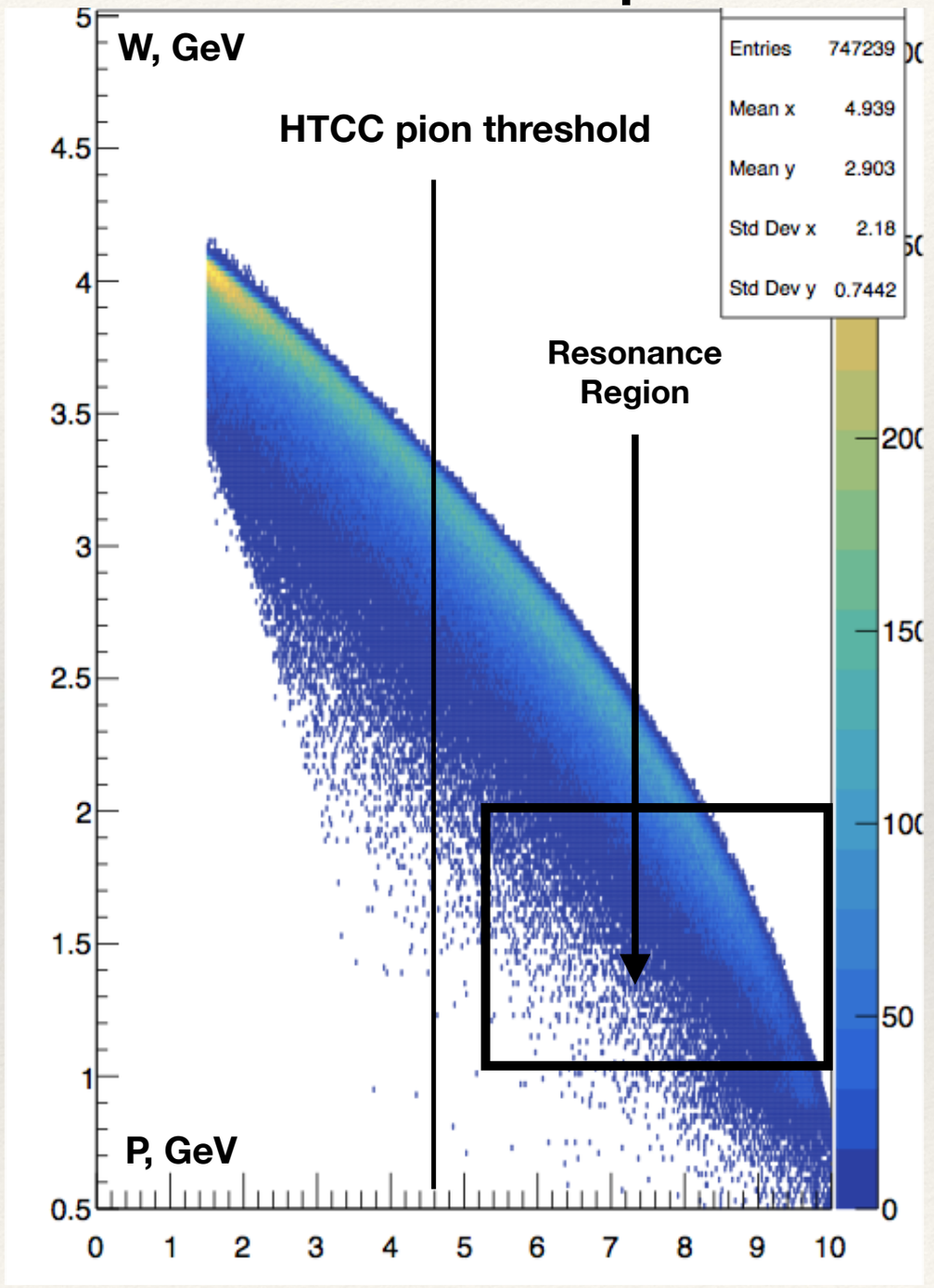
Currently used

- Limited to Forward Detector (5 -35 degrees coverage in polar angle)
- Electrons are selected by the CLAS12 Event Builder
  - Negative track with a hit in TOF, ECAL and HTCC;
  - 2.0 photoelectrons in HTCC;
  - 60 MeV in PCAL;
  - 5-sigma cuts on a parameterized momentum-dependent sampling fraction.



Forward Calorimeter
sampling fraction for electrons

Issues and plans

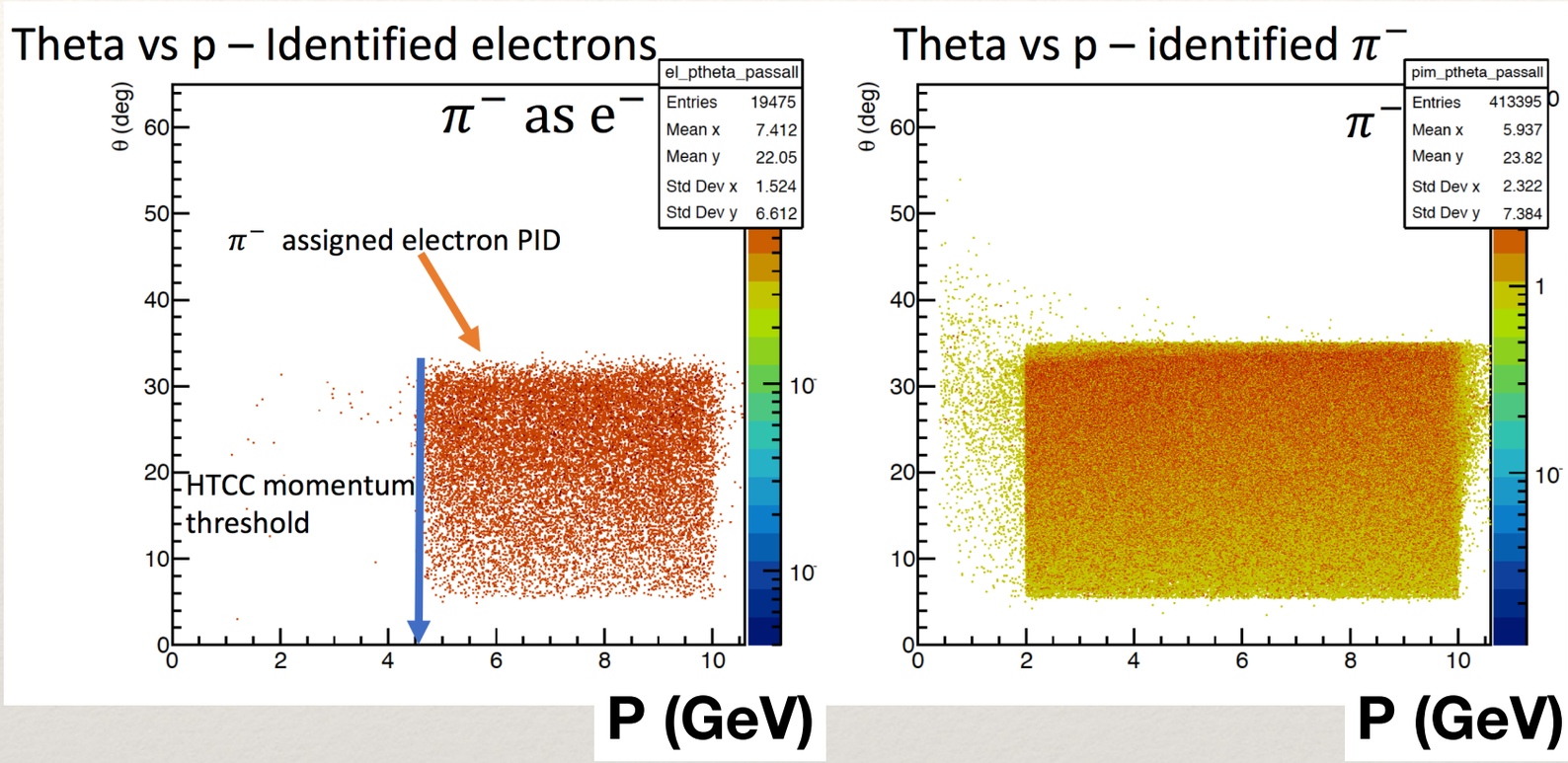


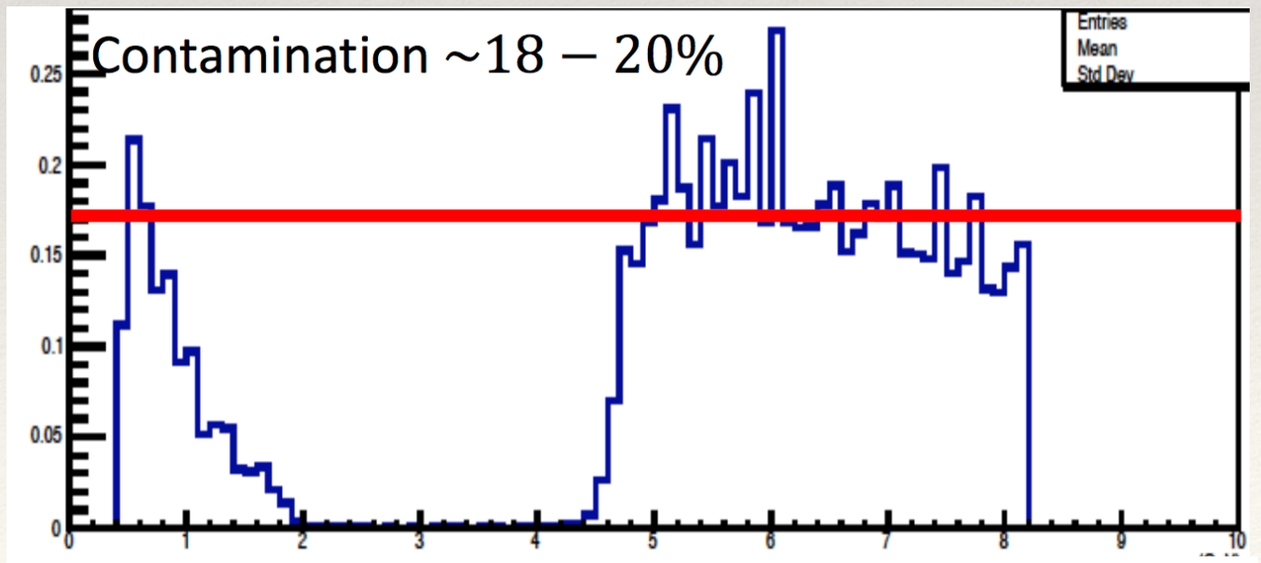
Possible problems of electron/ pion misidentification

Data analysis

Electron ID

Electrons and pions were simulated independently over full phase space;
Misidentified electrons and pion were analyzed using standard electron ID + fiducial cuts;
Pythia was used to estimate realistic ratio of pions to electrons to better estimate contamination;
Contamination from pions, identified as electrons was estimated.



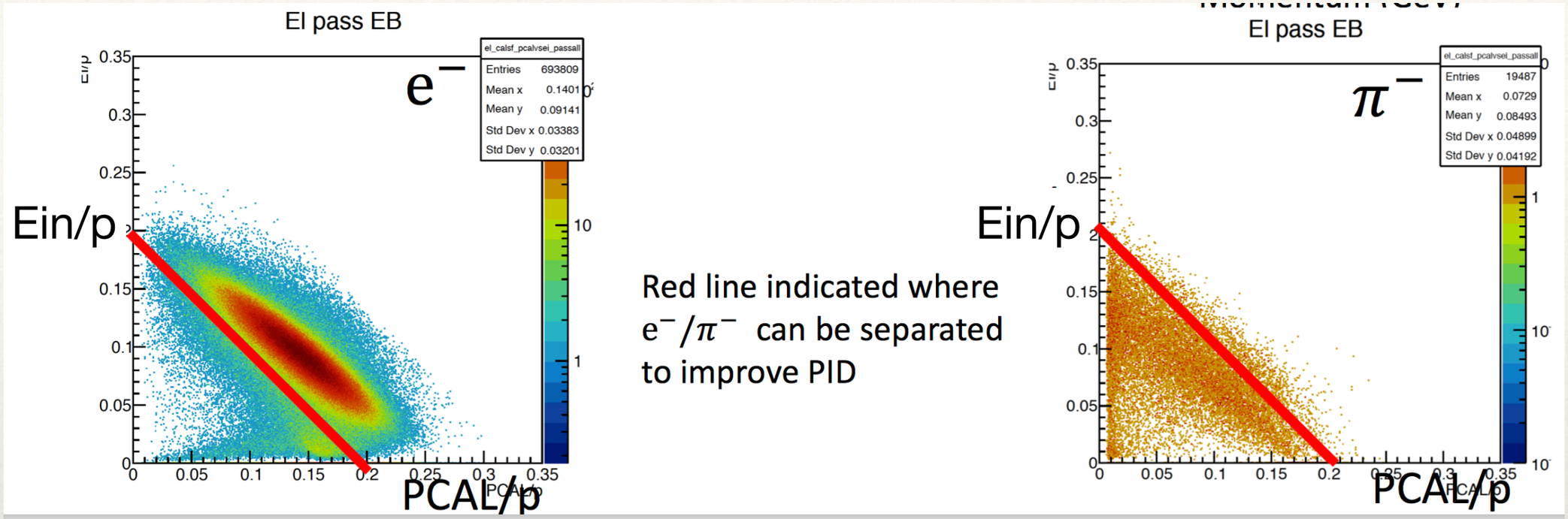


Need (W, $Q^{2)}$ kinematics dependent contamination factor

B. Clary (UCONN)

Data analysis

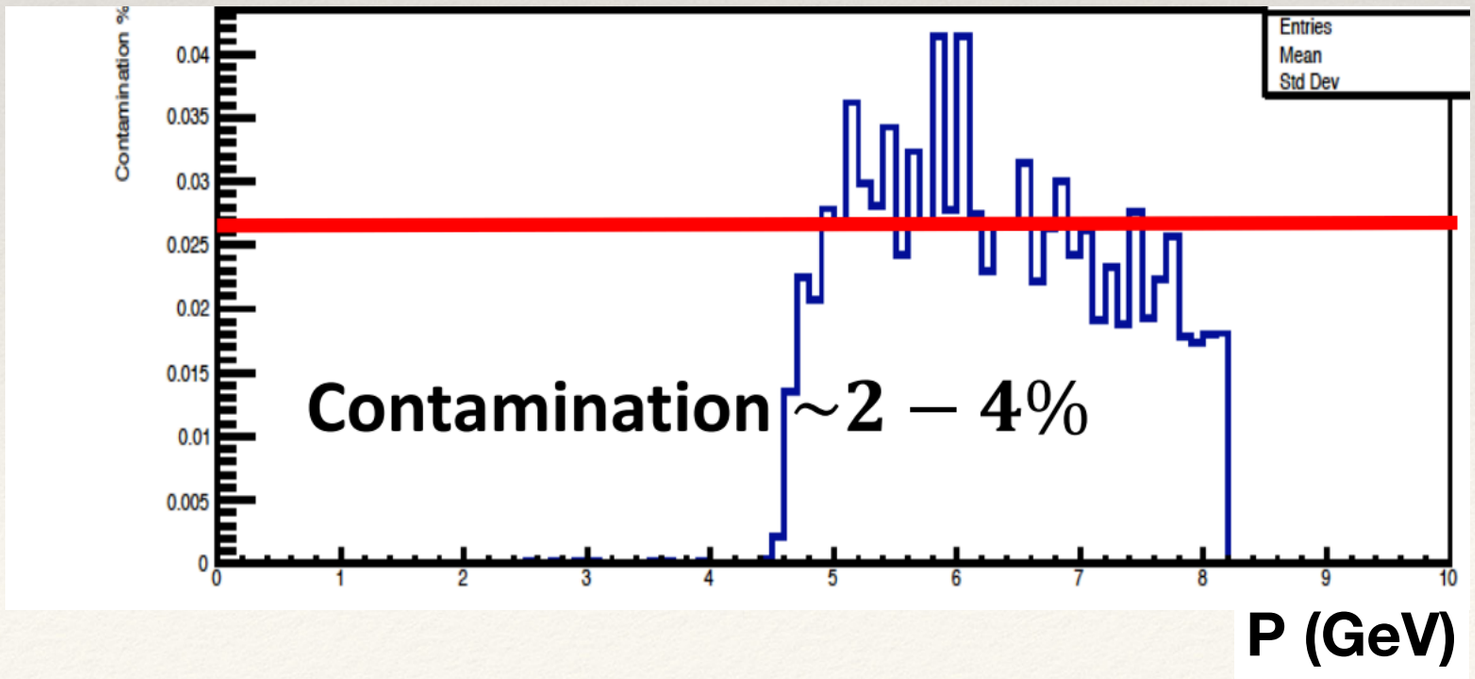
Electron ID



There are other efforts to improve electron ID based on the shower profile moments in the ECAL (Pierre).

Need (W, $Q^{2)}$ kinematics dependent contamination factor

B. Clary (UCONN)



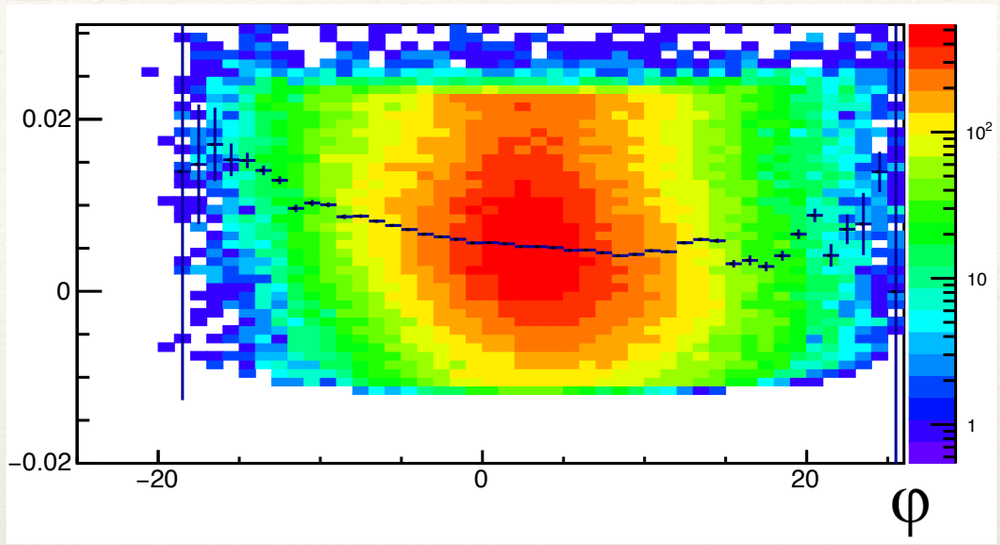
Data analysis

Momentum correction

Procedure

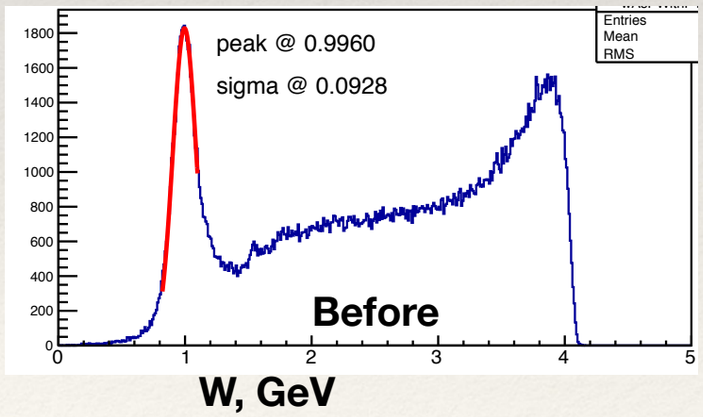
Assuming
elastic kinematics
beam energy
and by trusting
electron theta angle
we can reconstruct electron momentum.

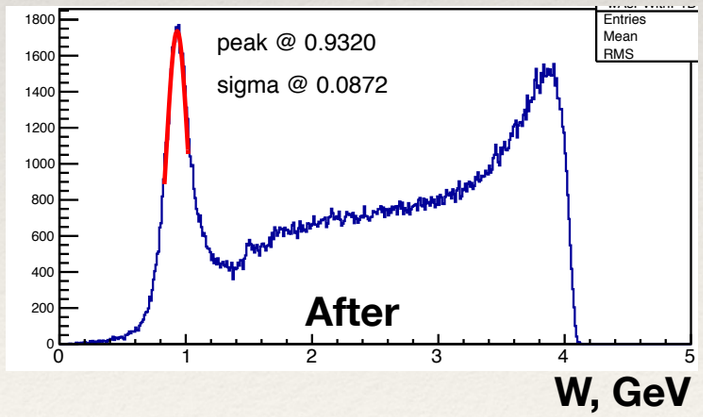
ΔP/P



Results

ep->ep





Shown for the “DNP” cook

Future steps

- **Working with kinematical correction task force.**

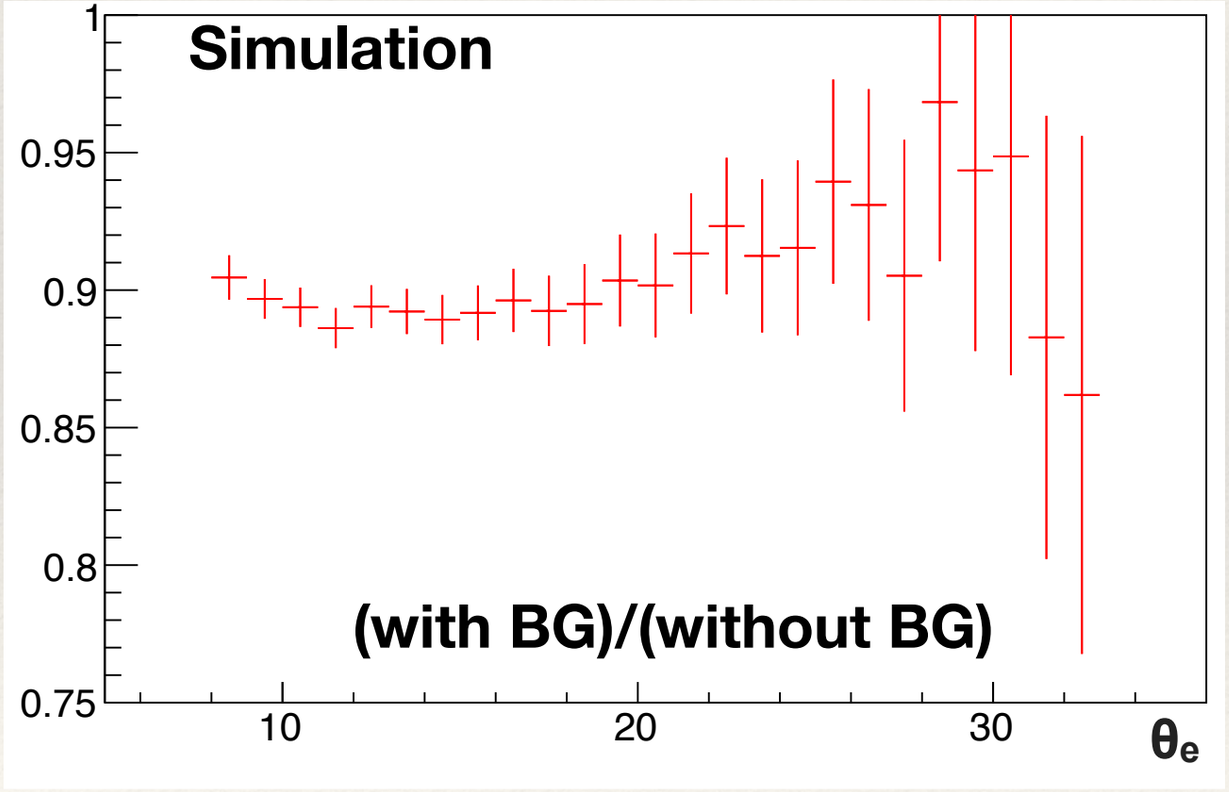
Data analysis

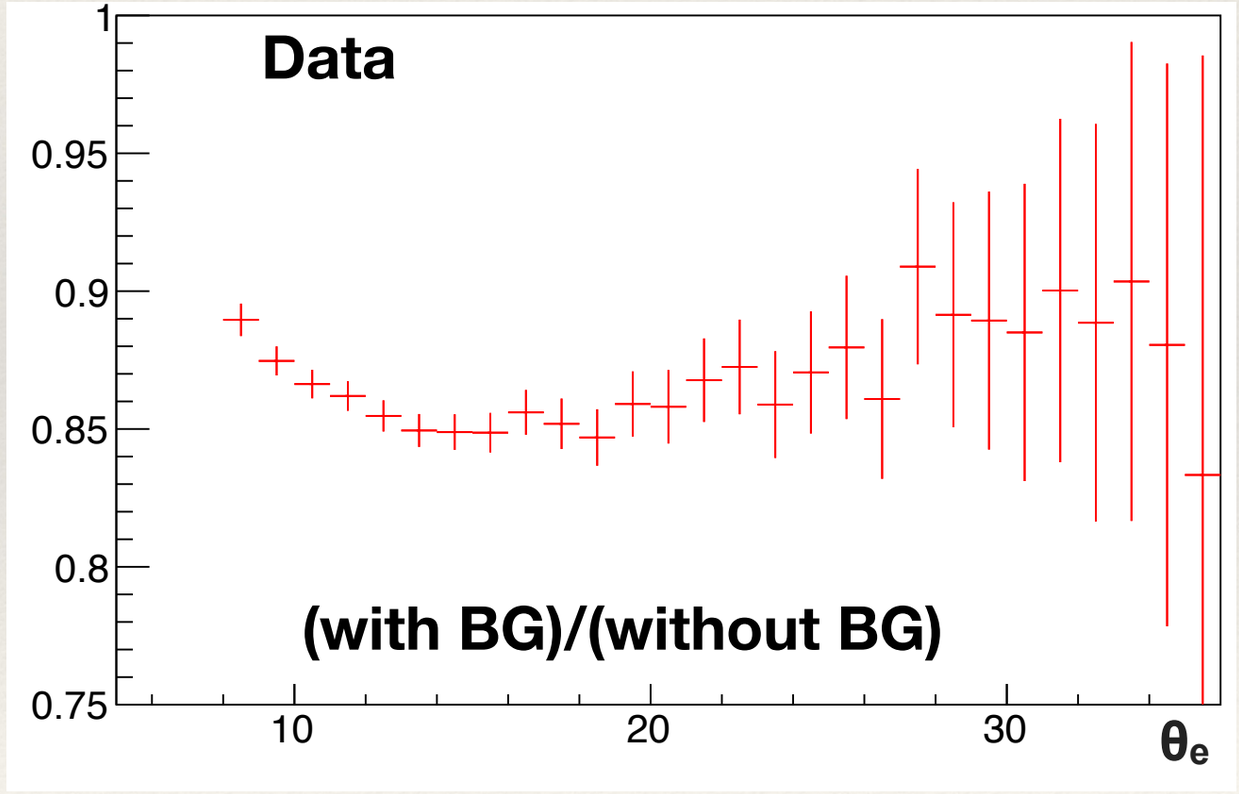
Efficiency and background merging

There is a difference in the normalized by Faraday cup event yield between runs with different beam current. We are dealing with electrons, so will concentrate on their behavior.

Procedure:
random trigger hits are extracted from the 45 nA data files;
timing of hits is aligned between data and simulation;
This hits are added to
- 5 nA (low current) data
- Inclusive electron simulation

Reconstruction is run on events with additional background hits (both data and low lumi simulation).





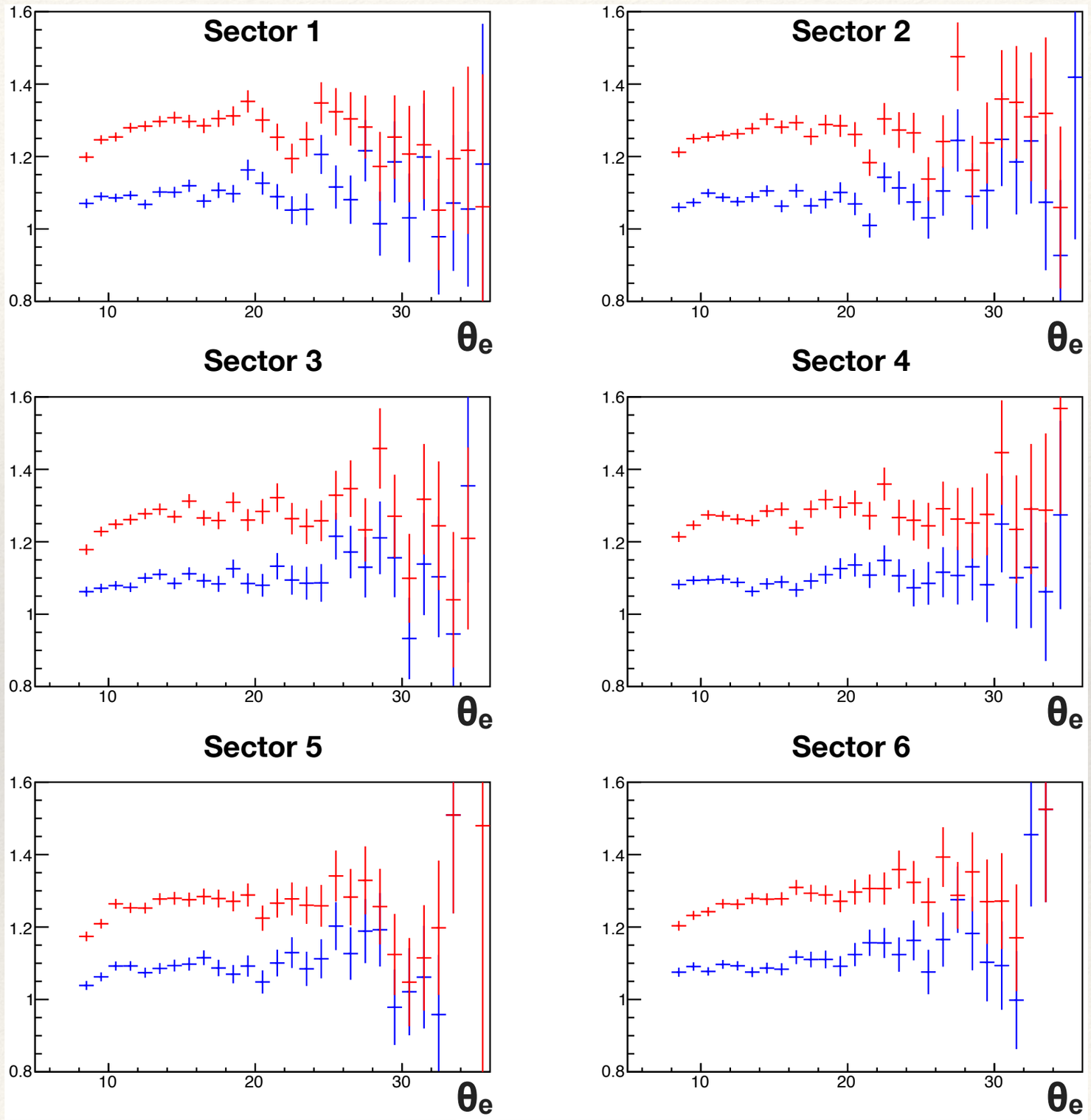
Very similar behavior

Need a cross check with a regular luminosity data

Data analysis

Efficiency and background merging

Same background is added to 5 nA data runs and normalized yield is compared to the 45 nA run.
Significant improvement when background is added to 5 nA run.
*possible correction due to Faraday cup fix.

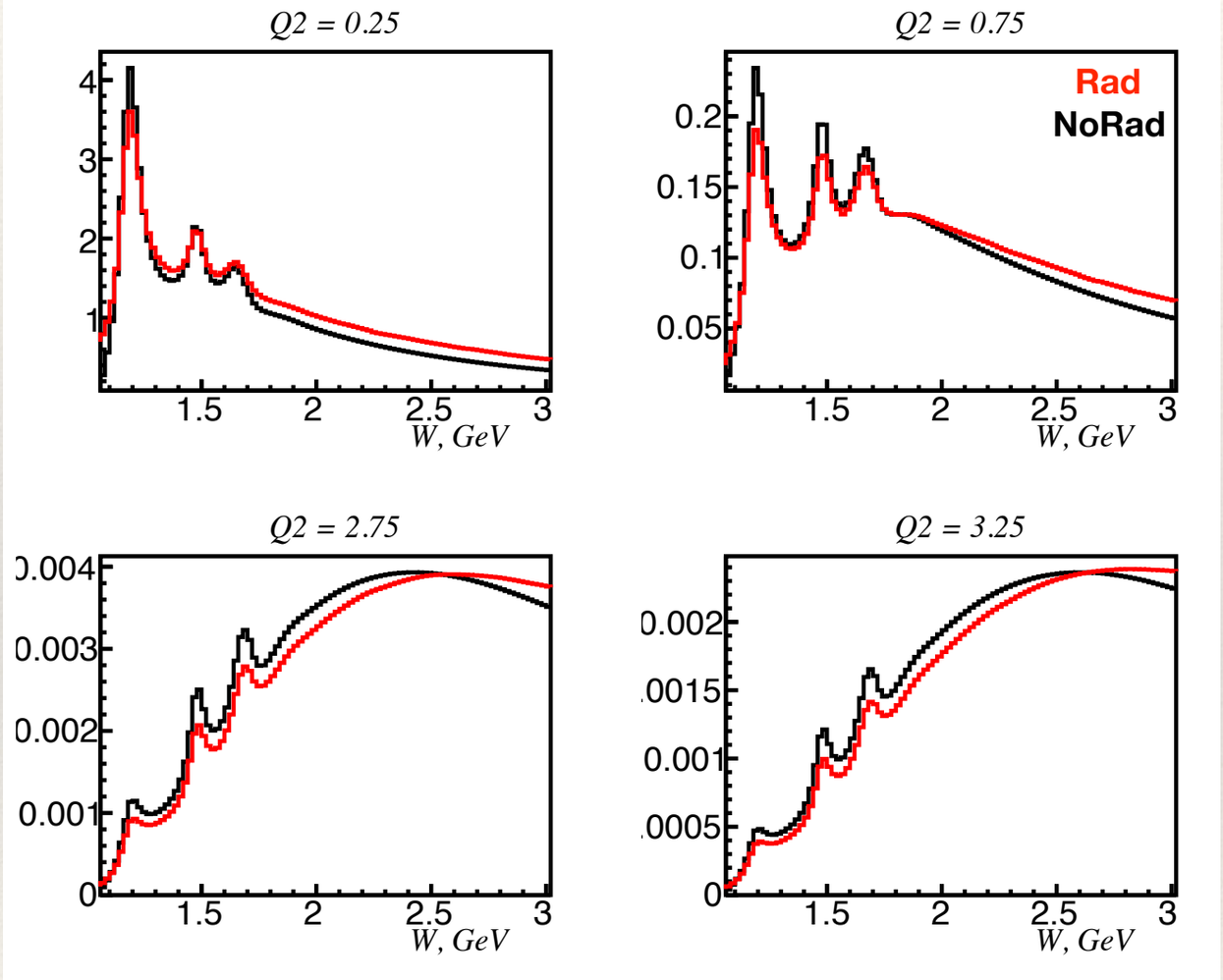


Data analysis

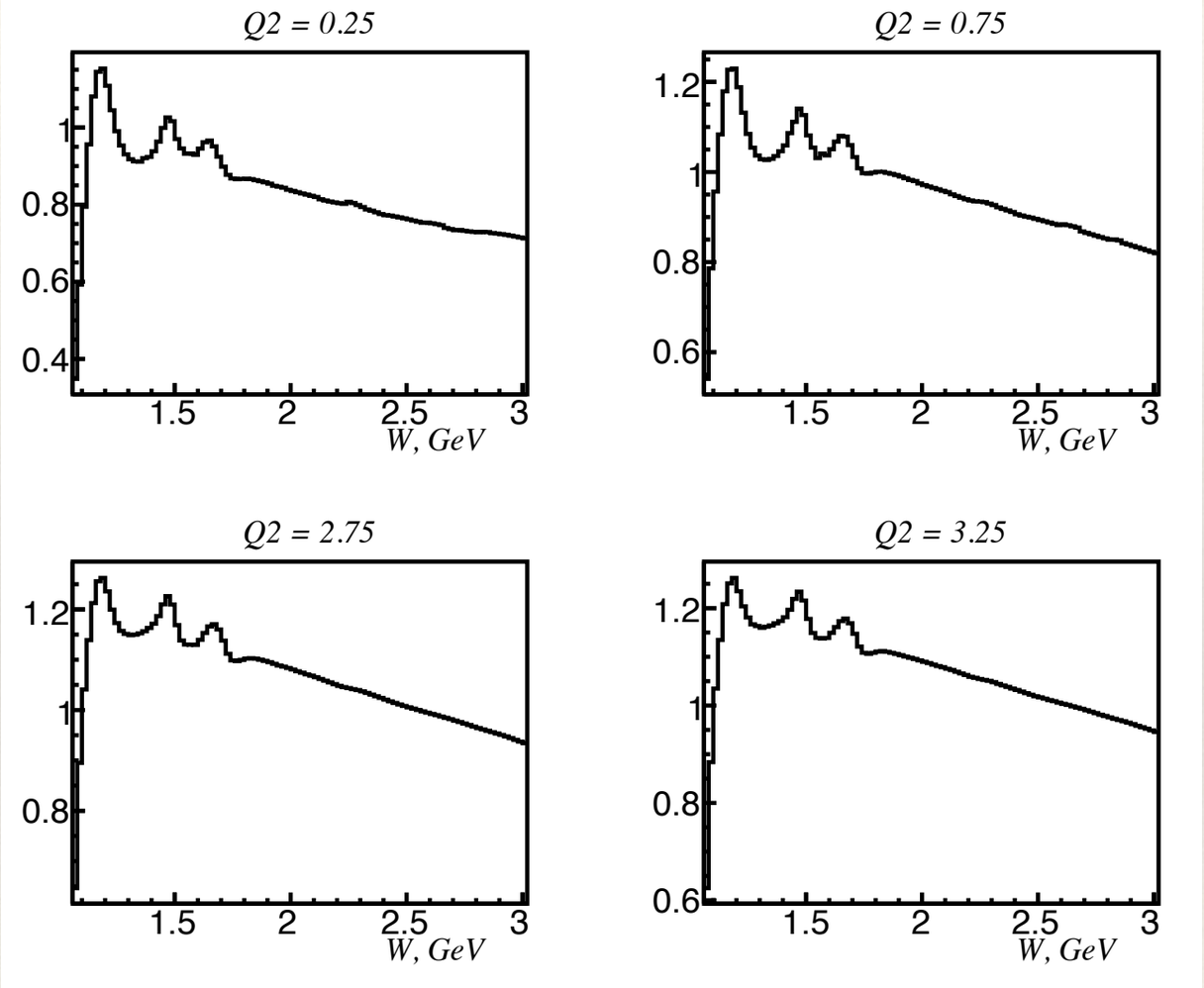
Radiation correction

Based on the inclusive event generator developed using the Mo and Tsai formalism for the radiative effects

Cross section



Radiative correction



- Sample for several Q^2 bins;
- Radiative correction is obtained as a ratio of radiated to nonradiated cross sections in the W and Q^2 bins of interest;

Acceptance and Luminosity Corrections

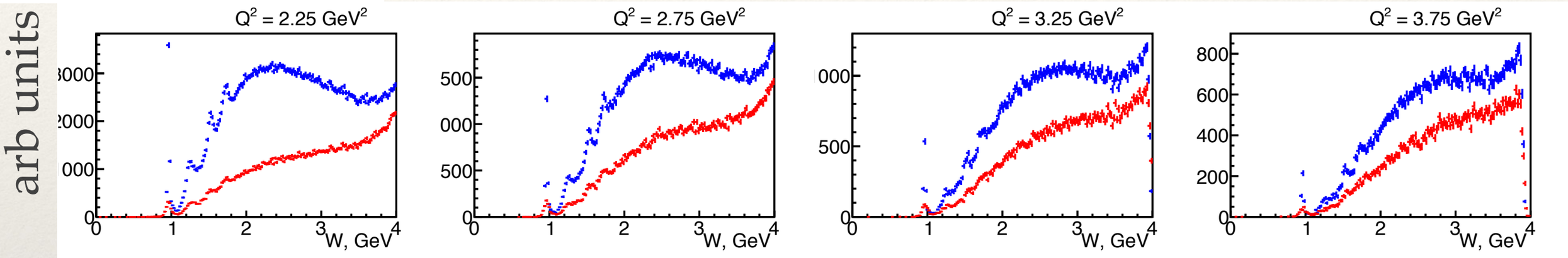
Generated events

Reconstructed simulation events

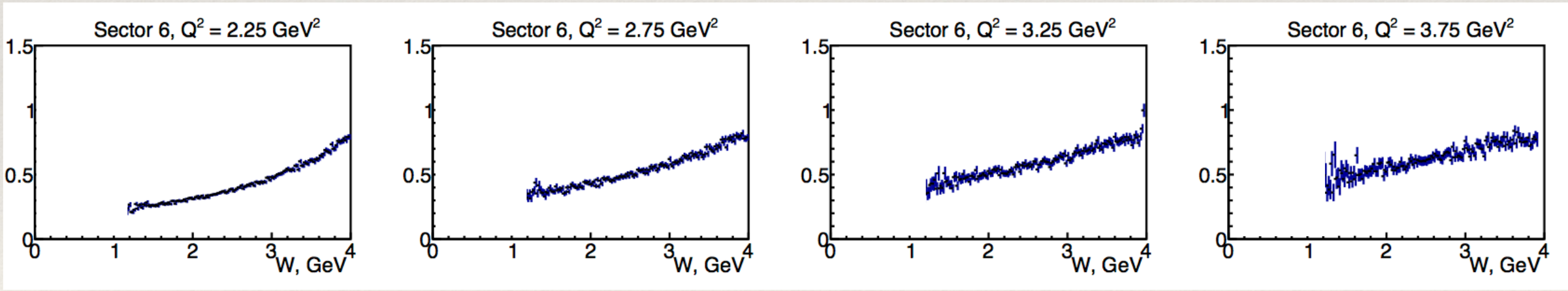
Inclusive event generator: M. Sargsyan, CLAS-NOTE 90-007 (1990).

Includes elastic and radiative effects

Same reconstruction algorithms are used between data and simulation.
Both generated and reconstructed events display main features of inclusive electron cross section, namely elastic peak, resonance region with “bumps” and smooth DIS region.



Acceptance Correction



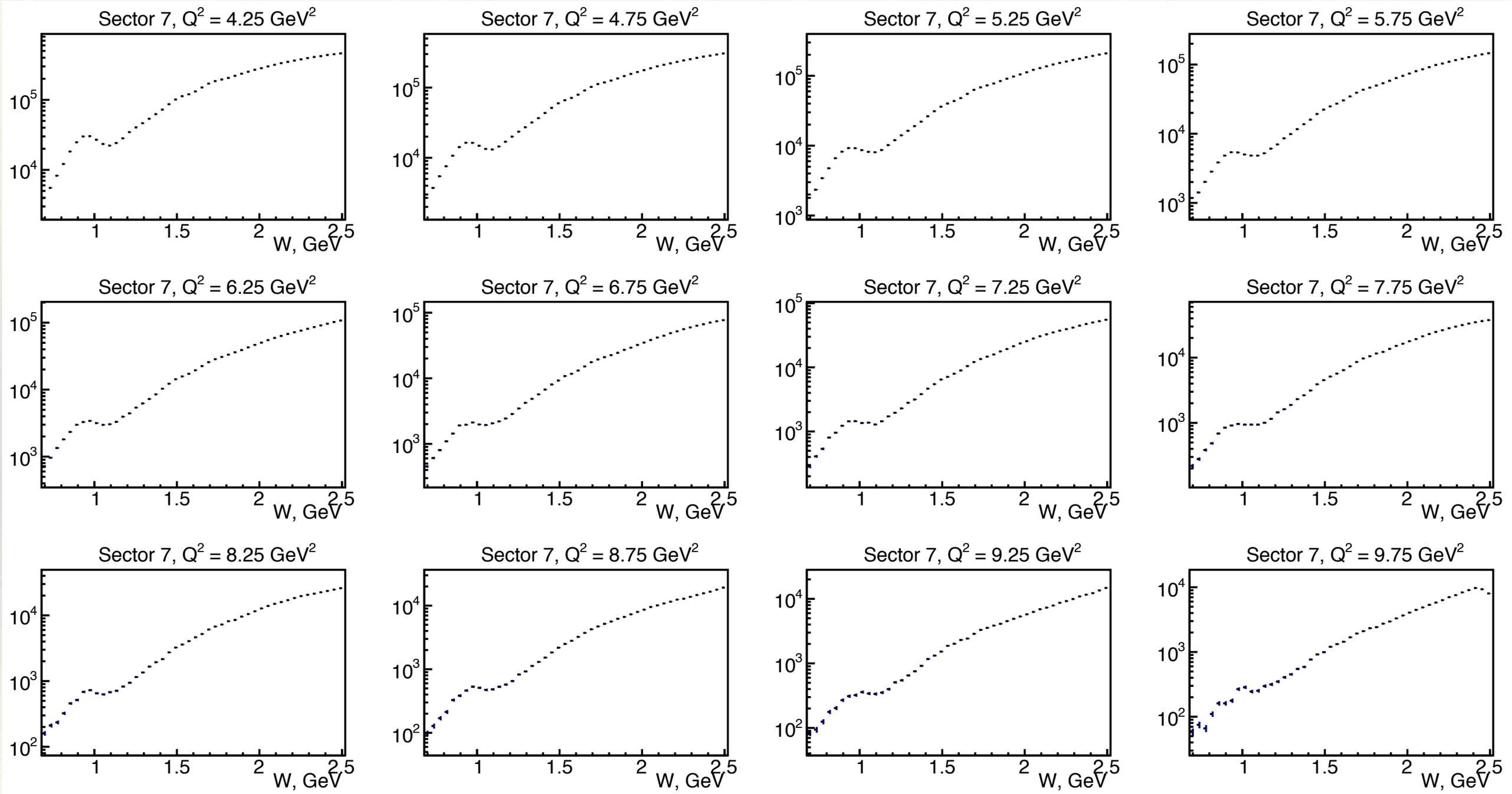
Sample of the acceptance correction for a few Q^2 bins

Luminosity Correction

Luminosity correction is based on the geometry and properties of the target (5 cm long liquid hydrogen) and integrated beam charge on the Faraday Cup. Need a correction (available, will be implemented in the next iteration of trains)

Data analysis

Statistics



ΔW = 50 MeV
ΔQ² = 0.5 GeV²

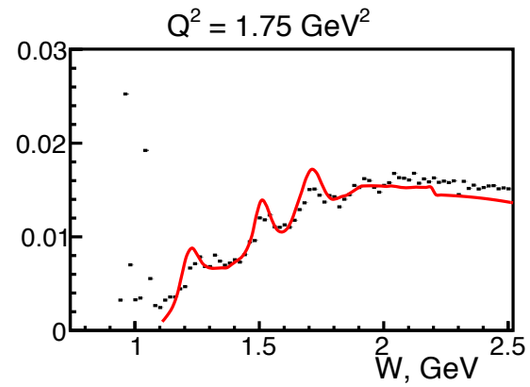
Considering Different binning schemes

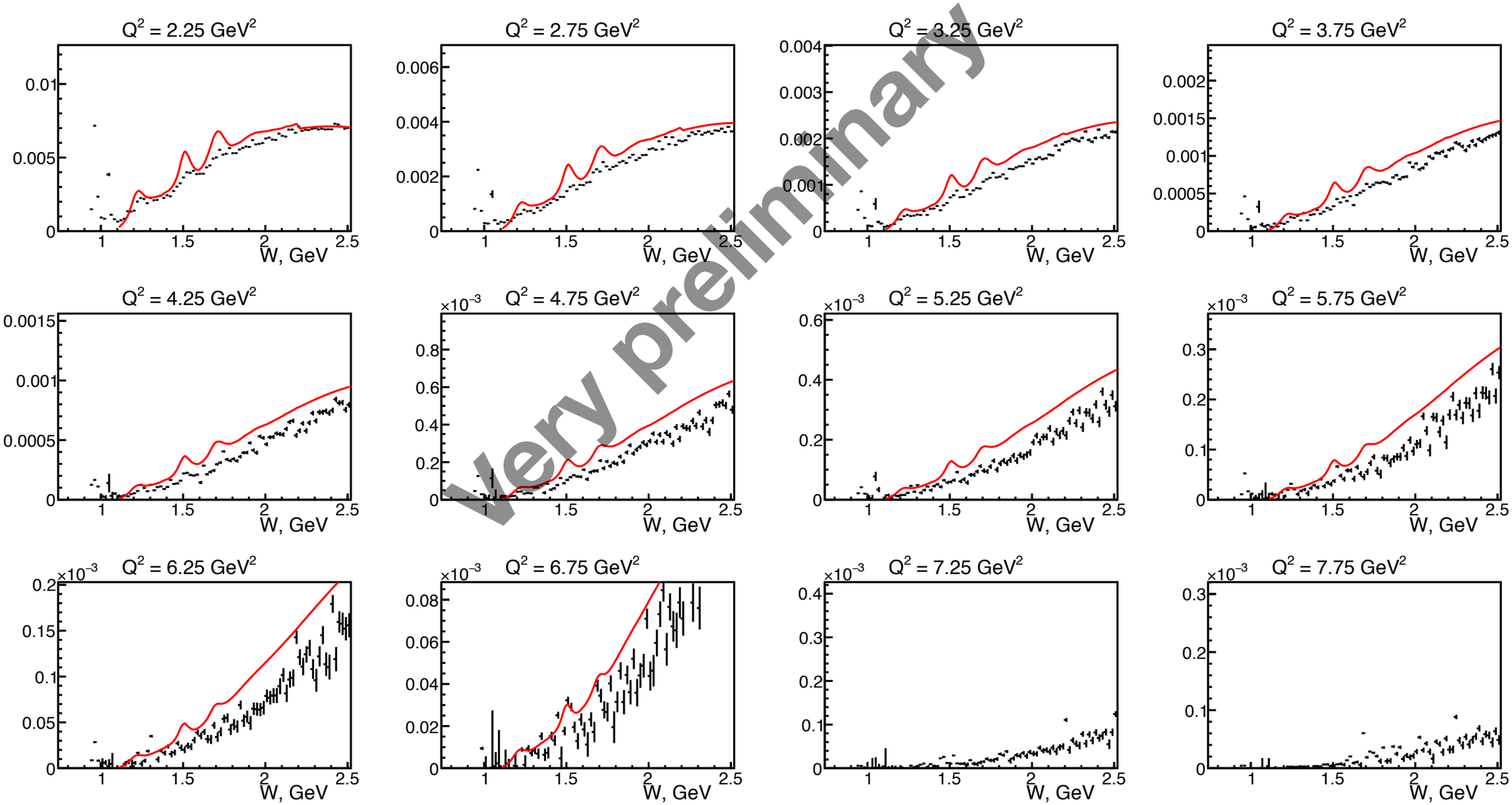
Data analysis

Results

All sectors combined
Simplistic Electron ID
No momentum corrections
Simplistic tracking efficiency
Not corrected Faraday cup charge

CLAS12 preliminary results
World data





Future plans

- Improvement of electron ID procedure;
- Introduction of fiducial cuts;
- Better understanding of detector/tracking efficiency, both from the low lumi data analysis and background merging procedure with simulation;
- Improved momentum corrections;
- Better understanding of the CLAS12 resolution;
- Understanding of the systematic uncertainties;
- Finalize simulation.

Summary

- Preliminary results on the inclusive electron scattering cross section are available from the CLAS12 in the kinematic area of W from 2.0 GeV to 4.0 GeV in any given Q^2 bin within Q^2 range from 4.0 GeV^2 to 10 GeV^2;

- Working closely with the fiducial cut task force, tracking efficiency task force and momentum correction task force to finalize electron ID and yield determination;

- Knowledge of the resonance contribution paves the way to study the parton distribution of the ground state nucleon in the resonance region;

- These experimental results (based only on electron detection in the Forward Detector) and the developed physics analysis tools make this work an excellent candidate for a first publication from CLAS12.

CEBAF Large Acceptance Spectrometer

Jefferson Lab

Paper draft

Inclusive Electron Scattering in the Resonance Region from a Hydrogen Target with CLAS12

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(Dated: March 19, 2020)

Inclusive electron scattering cross sections from a hydrogen target at a beam energy of 10.6 GeV have been measured with data collected from the CLAS12 spectrometer at Jefferson Laboratory. These high-precision data cover a wide kinematic area in invariant energy W up to 4 GeV and four-momentum transfer Q^2 from 1 to 10 GeV^2. Using a framework developed based on the resonant contributions determined with data from the CLAS spectrometer spanning W up to 2 GeV and Q^2 up to 4.5 GeV^2 that has been extrapolated into the kinematic regime of the CLAS12 measurements, estimates for the resonant contributions to inclusive electron scattering have been determined with small systematic uncertainties. Together these data from CLAS and CLAS12 provide important information regarding the nucleon parton distributions through the nucleon resonance region in the regime of large Bjorken scaling variable x_B, as well as detailed insight for studies of quark-hadron duality.

A complete draft of the paper intended for the publication in Phys. Rev. Lett. is prepared and was circulated in the Hadron Spectroscopy Working Group.
It will be more widely circulated within the First Experiment Group in the coming weeks for feedback.