Inclusive Electron Scattering off Protons with CLAS12

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for the CLAS collaboration

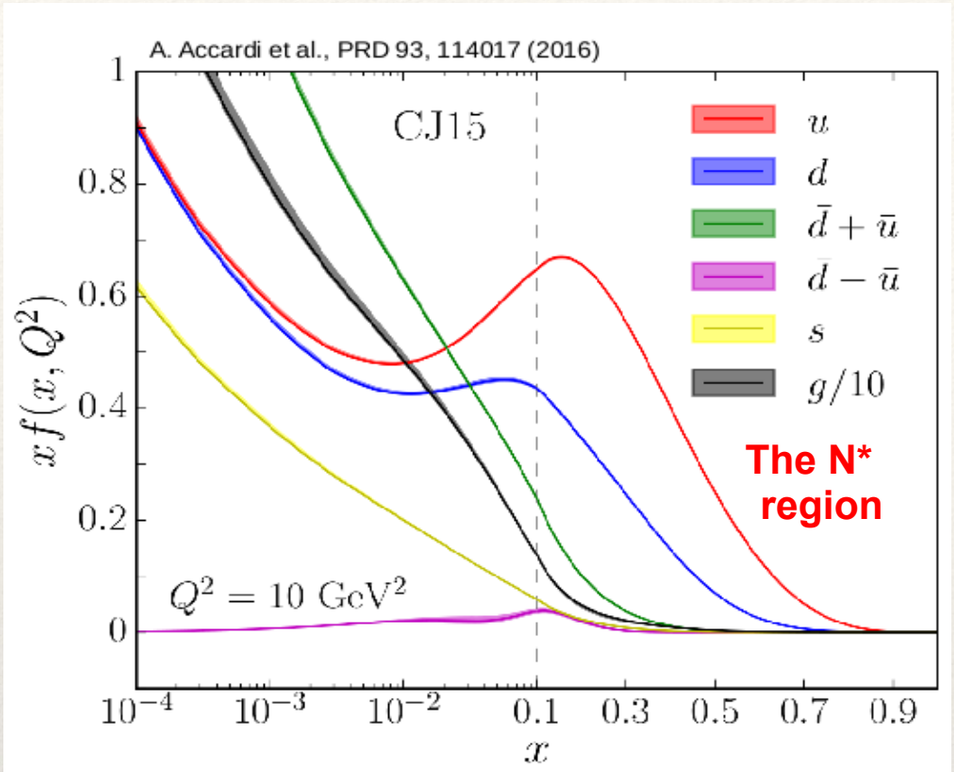
CEBAF Large Acceptance Spectrometer

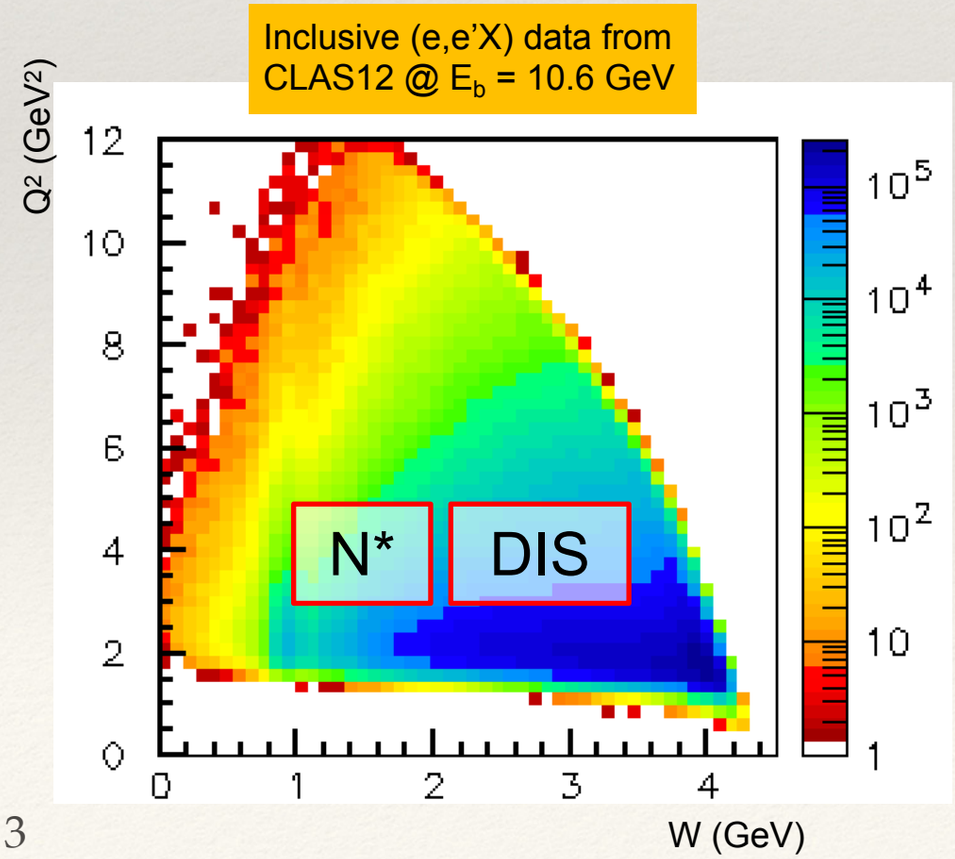
Jefferson Lab

Introduction and motivation

- Provide the fist data from CLAS12 on inclusive (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 the scattered electron measurements with the CLAS12 indispensable for all future analyses of semi-inclusive and exclusive cross sections.

Extending Knowledge of the Nucleon PDF in the Resonance Region

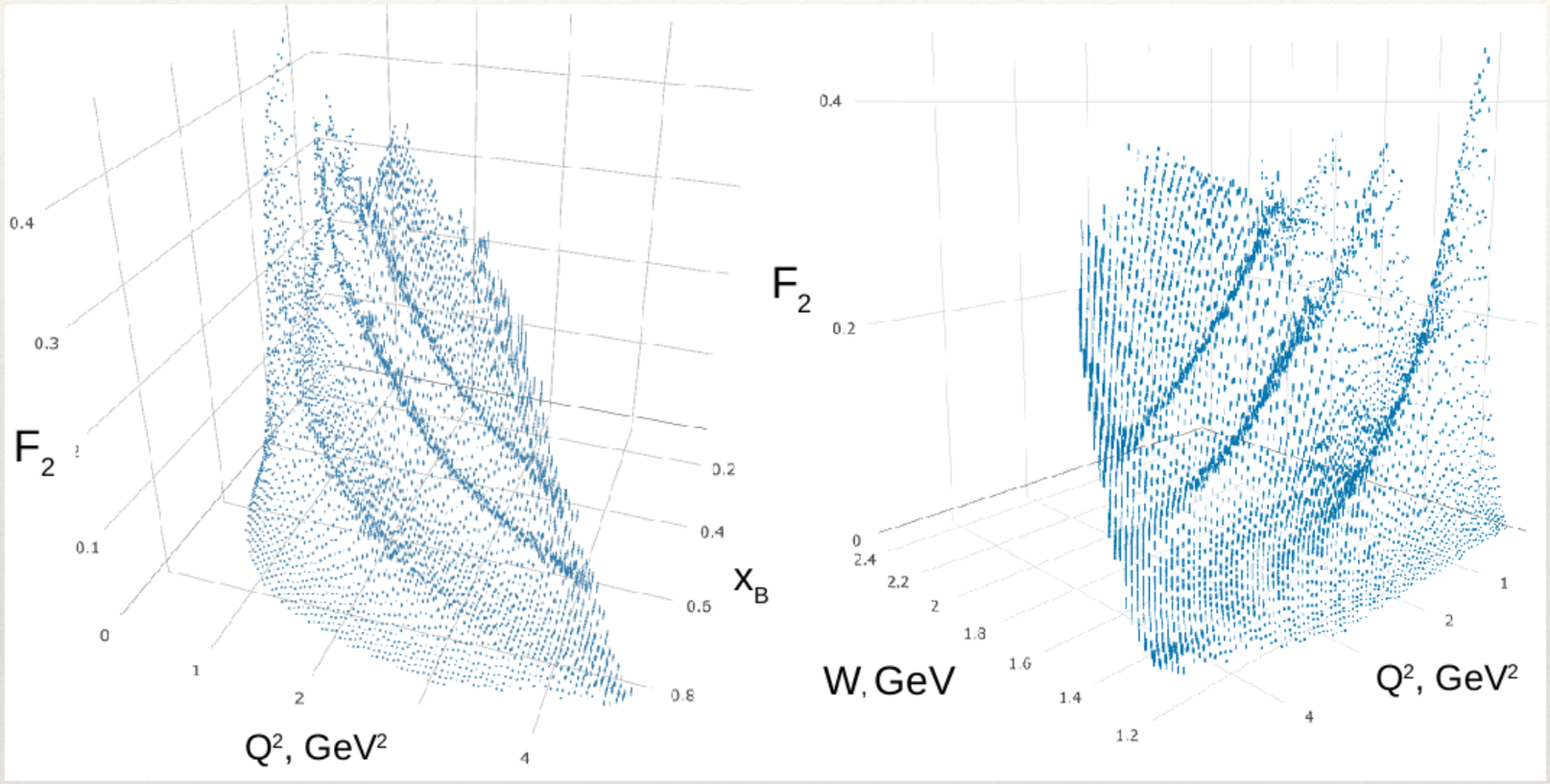




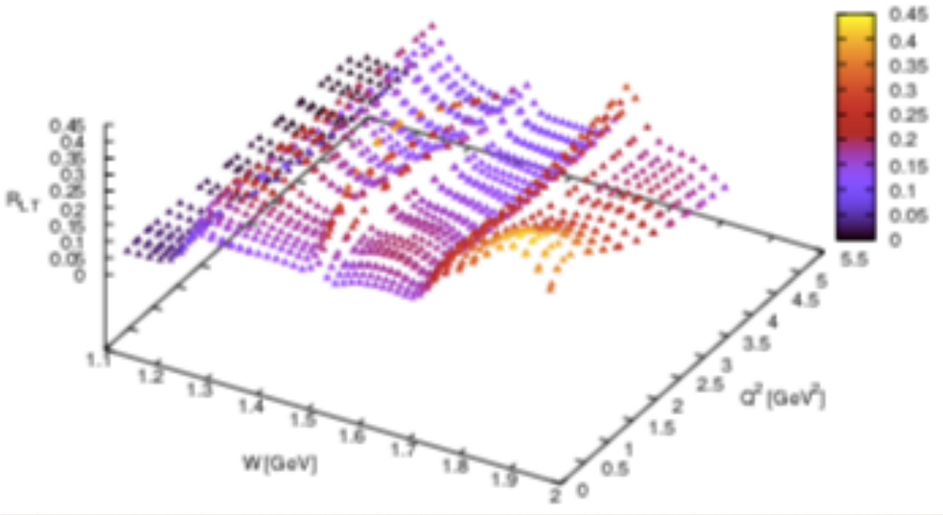
- Study of ground state nucleon PDF from inclusive electron scattering offers an effective tool for nucleon structure exploration
- The global QCD-driven analyses have provided detailed information on the quark and gluon PDFs in a wide range of x_B from 10^{-4} to above 0.9 and at Q^2 from 1 - 10^4 GeV^2
- 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
- Advances in the developments of the quasi-/pseudo-PDF concepts allow to evaluate the ground nucleon PDF starting from the QCD Lagrangian.

Inclusive Structure Function F_2 from CLAS Data

The F_2 structure function was measured with CLAS in the N* region with large coverage over x_B/W as a function of Q^2



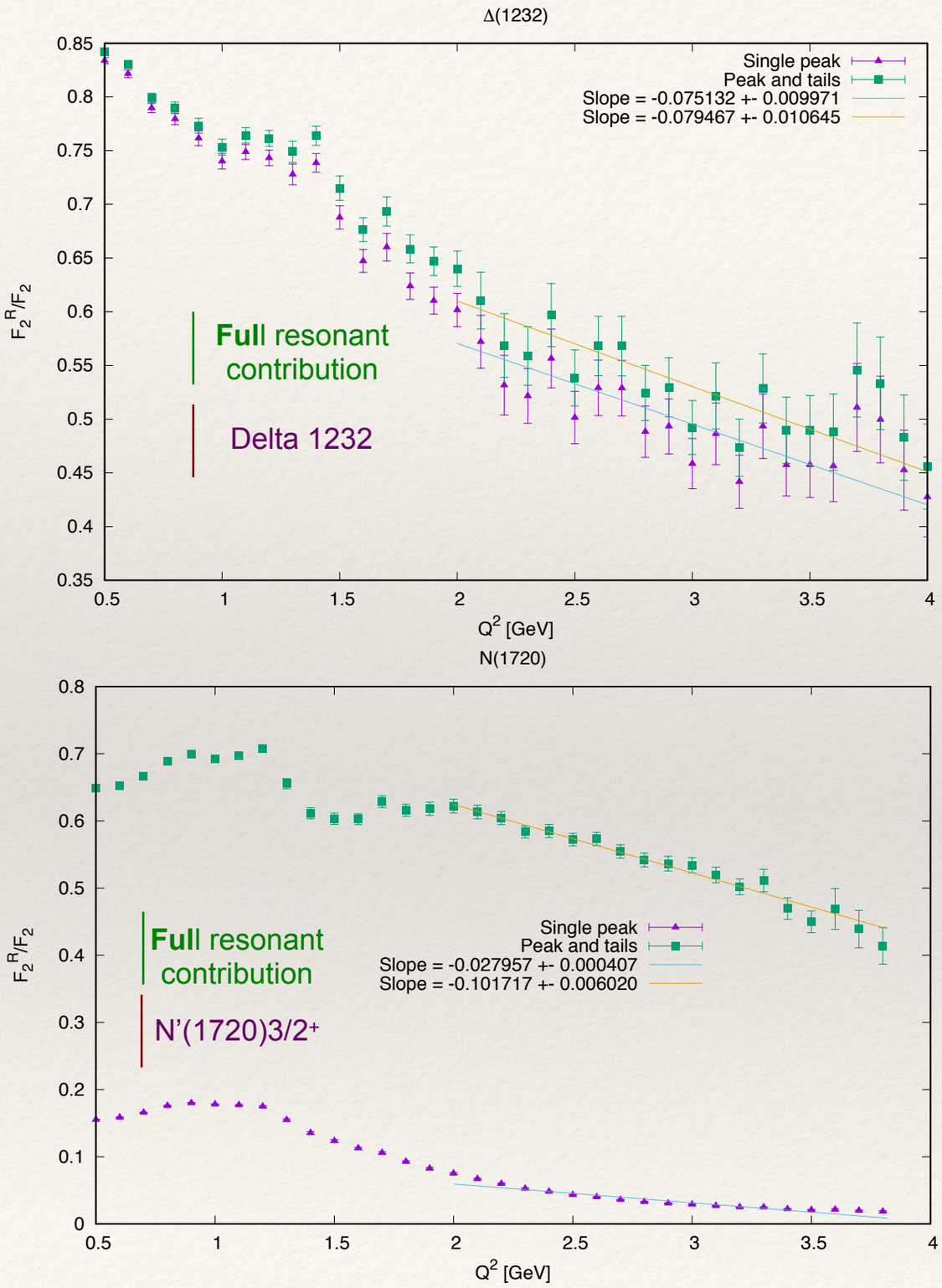
Ratio $R_{LT}=\sigma_L/\sigma_T$ from Hall A/C data



Y. Liang, PhD thesis, The American University (2003)

The preliminary results on longitudinal (σ_L) and transverse (σ_T) inclusive cross sections in the resonance region have become available from the JLab experimental data for the first time (A.N. Hiller Blin et al., paper in preparation)

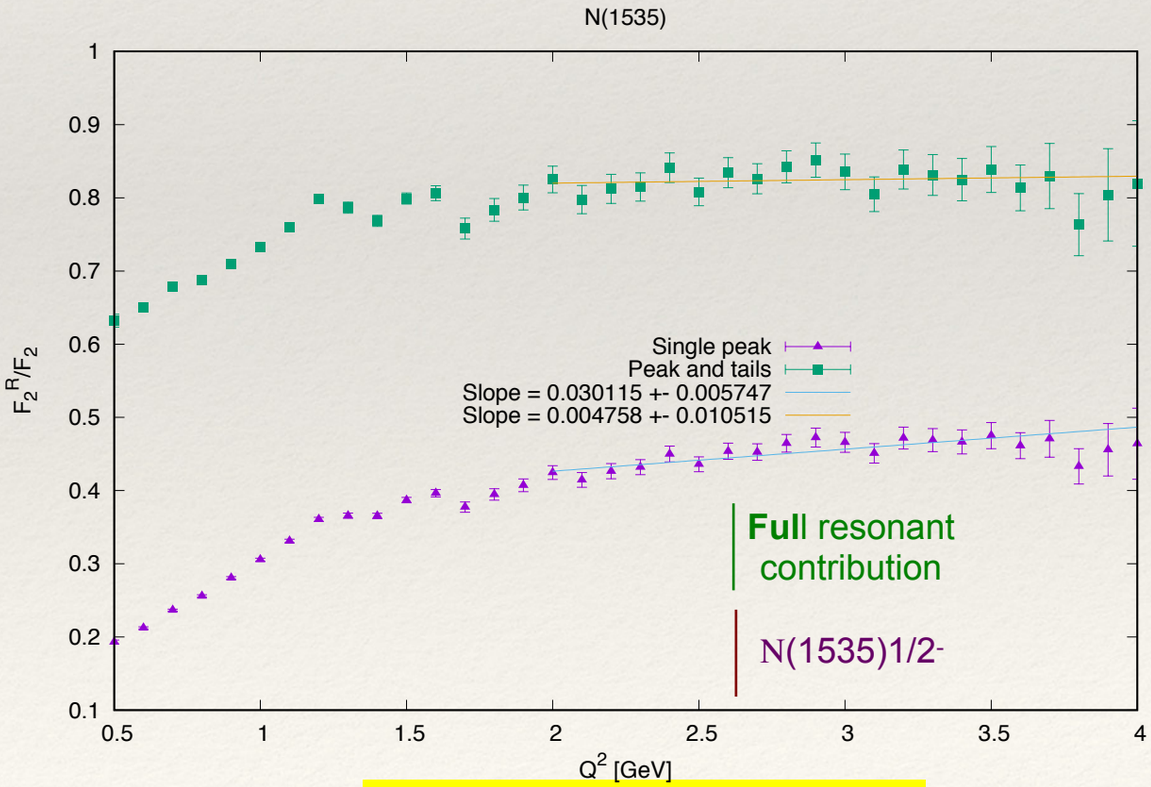
Resonant Contributions into Inclusive Electron Scattering from the JLab Data



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.

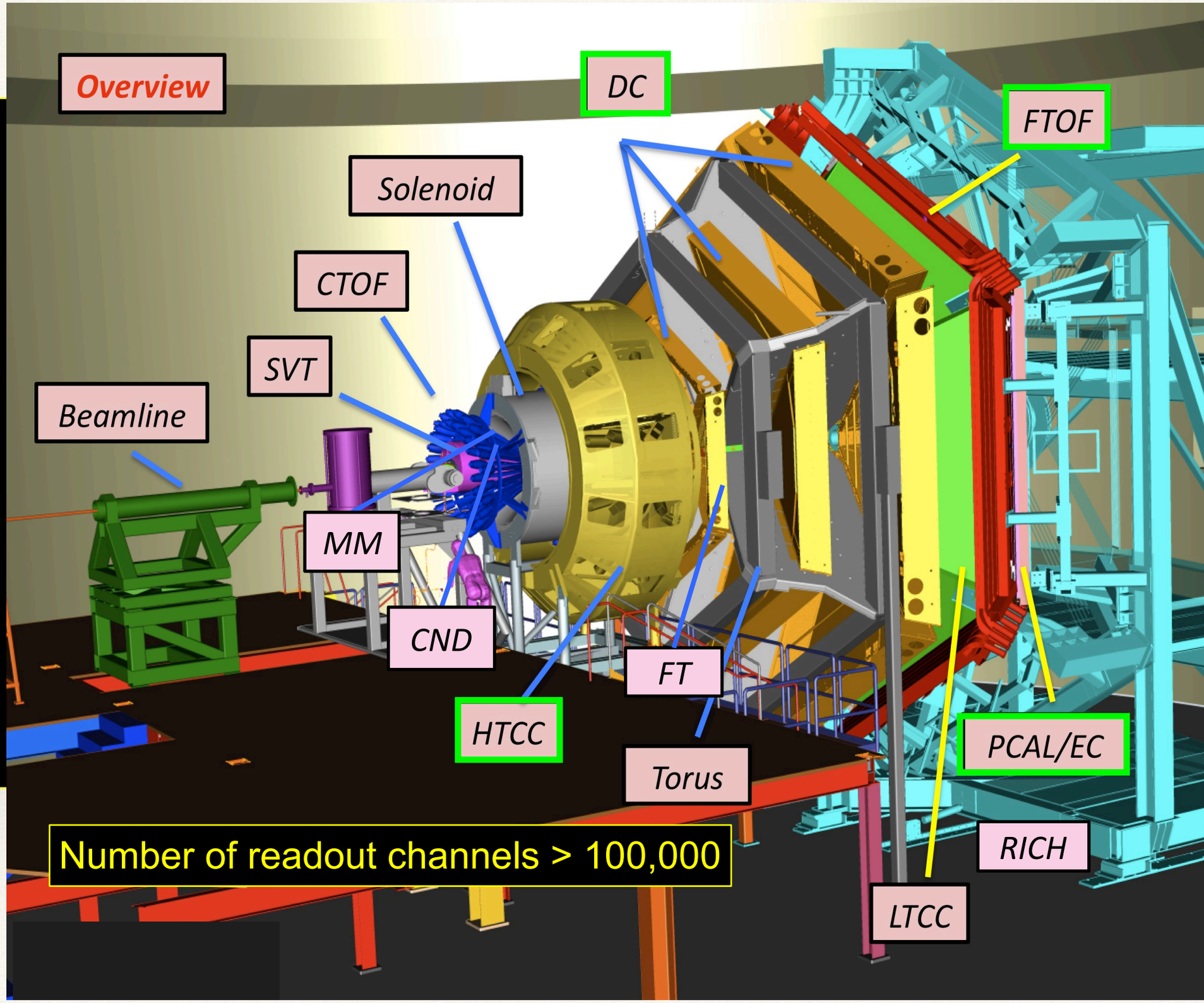
CLAS12 Detector

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

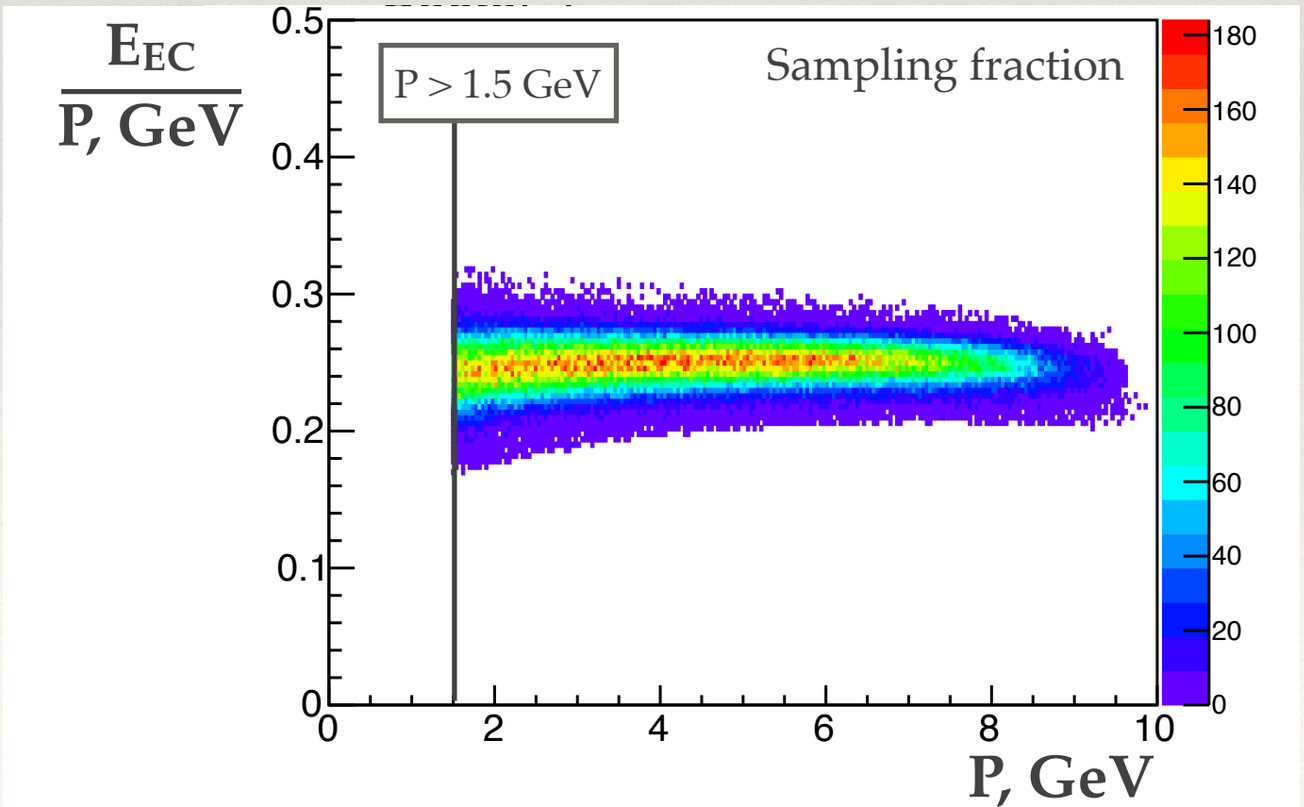


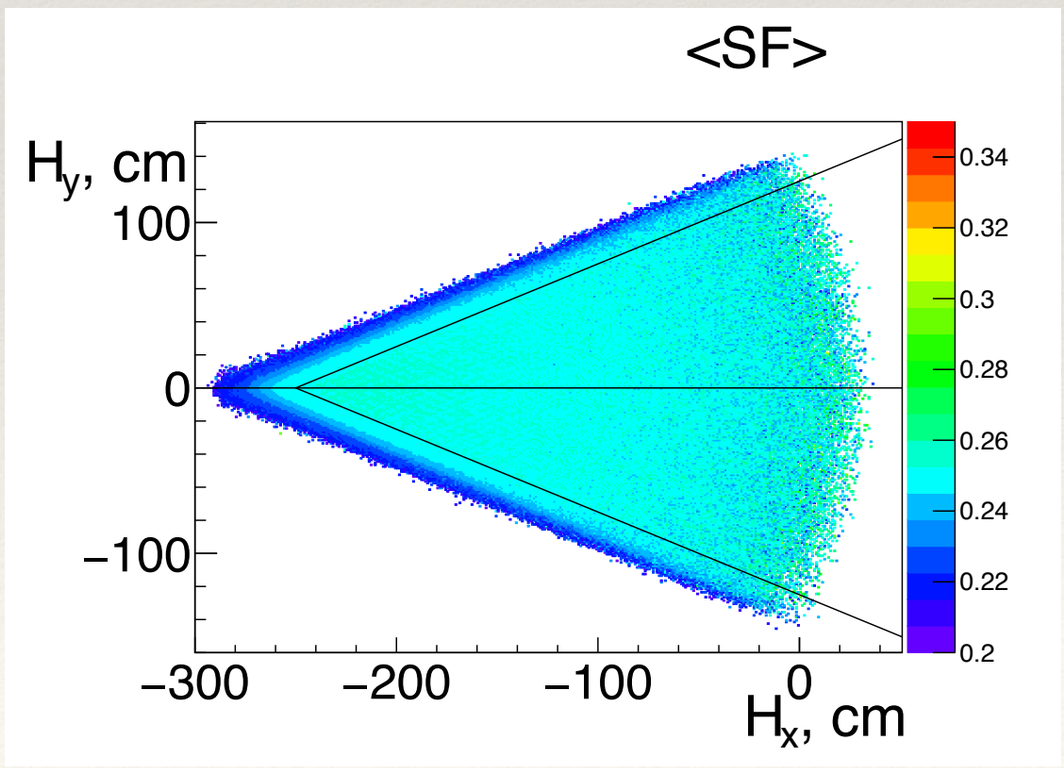
Analysis schematics

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

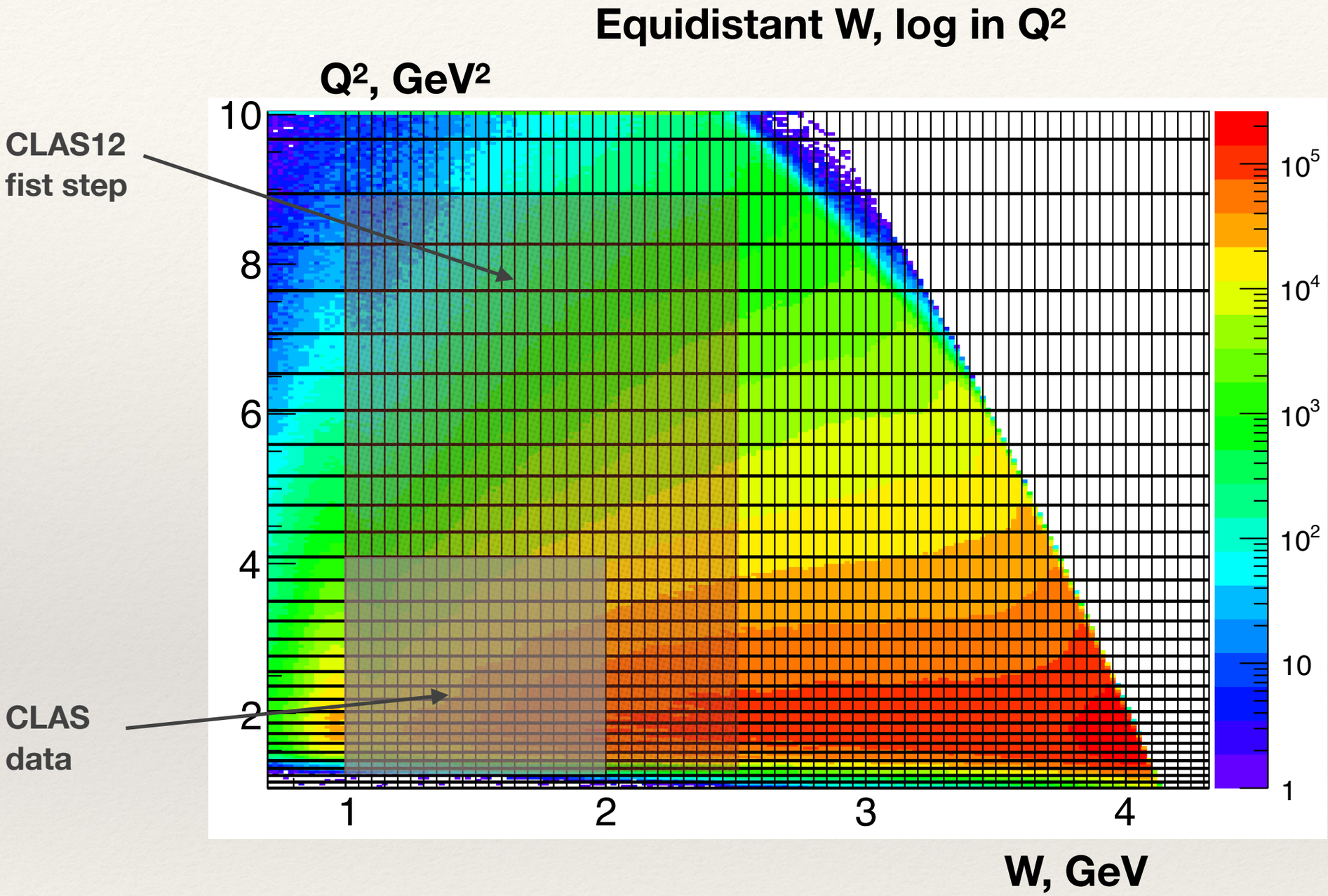
Electron ID

- 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** and a highest momentum;
  - 2.0 photoelectrons in HTCC;
  - 60 MeV in PCAL;
- Additional cuts:
  - 3-σ cuts on a parameterized momentum-dependent sampling fraction;
  - Vertex cut;
  - P > 1.5 GeV
  - PCAL fiducial cut.





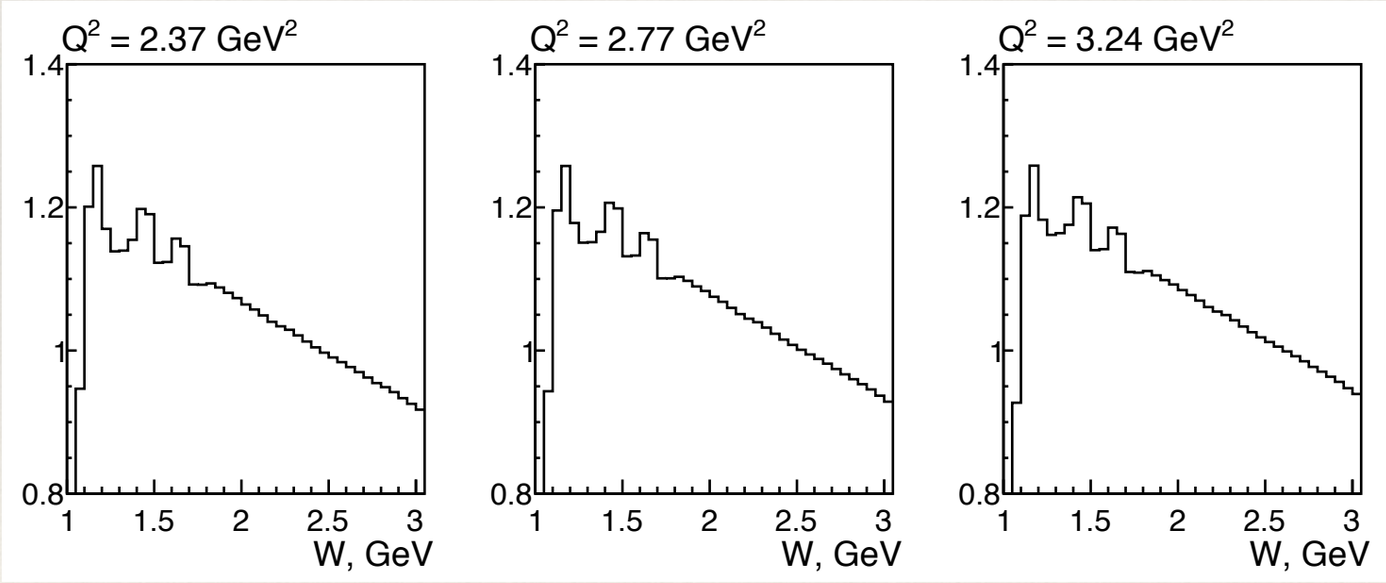
Kinematic Coverage and Binning



Reasonable and comparable statistics in all Q2 bins;
Good coverage and details over W;
Compatible with DIS studies.

Corrections

- **Radiative corrections**
  - Based on the event generator capable to output cross section with and without Mo and Tsai radiate correction as well as elastic radiative tail;
  - Calculated in each (W, Q^2) bin.



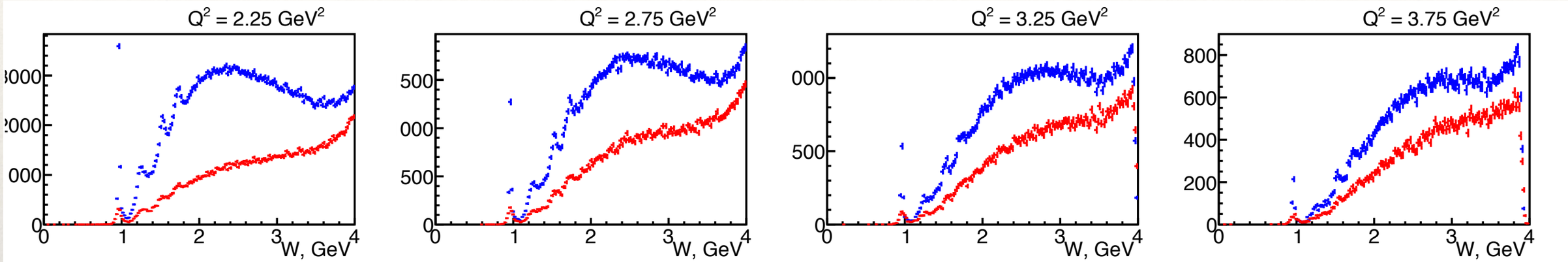
Acceptance and Luminosity Corrections

Generated events

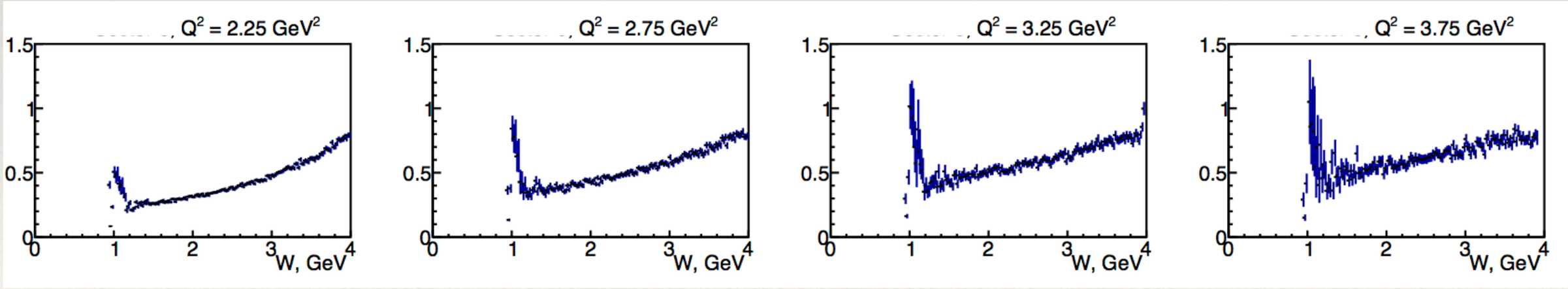
Reconstructed simulation events

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 event display main features of inclusive electron cross section, namely elastic peak, resonance region with "bumps" and smooth DIS region.
The scaling of the tracking efficiency with the beam current is implemented.



Acceptance Correction

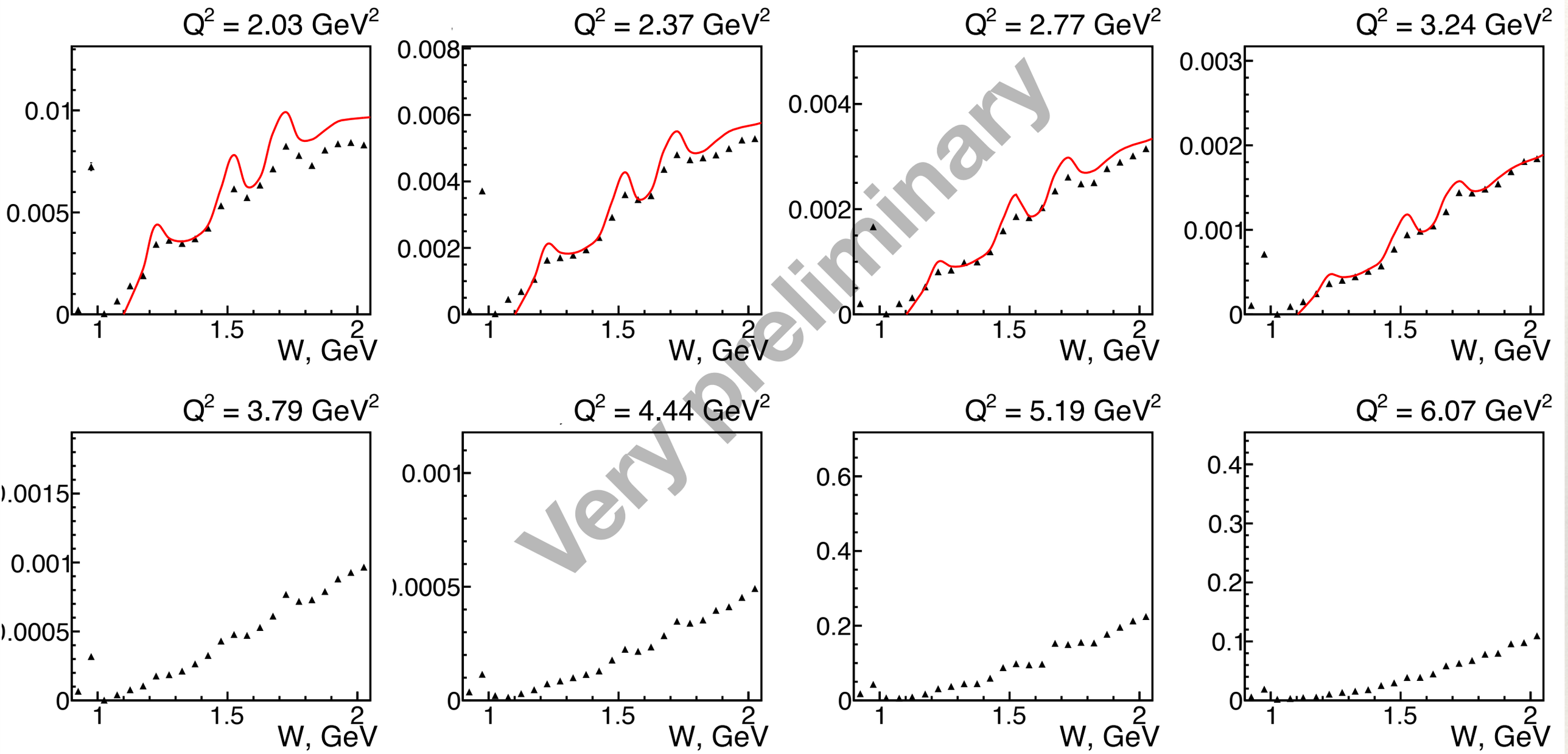


Sample of the acceptance correction for a few Q^2 bins

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. It is accounted for the Live Time of the Data Acquisition system.

Results



Luminosity and acceptance corrected yield with radiative corrections.

Interpolation of the CLAS results

Experimental Data

Future plans

- Improvements of electron ID procedure;
- Bin centering and momentum correction;
- Better evaluation of the efficiency for the electron detection.
- 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 the CLAS12 in the range of 1.1 GeV <W<2.5 GeV in any given bin of 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 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~15%
- The near term efforts are focused on the extraction of the inclusive electron scattering cross section in the mentioned above kinematics area of W and Q^2 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 gvpN* electrocouplings opens up new opportunities for gaining insight into PDF at large x_B and for the studies of quark-hadron duality.

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