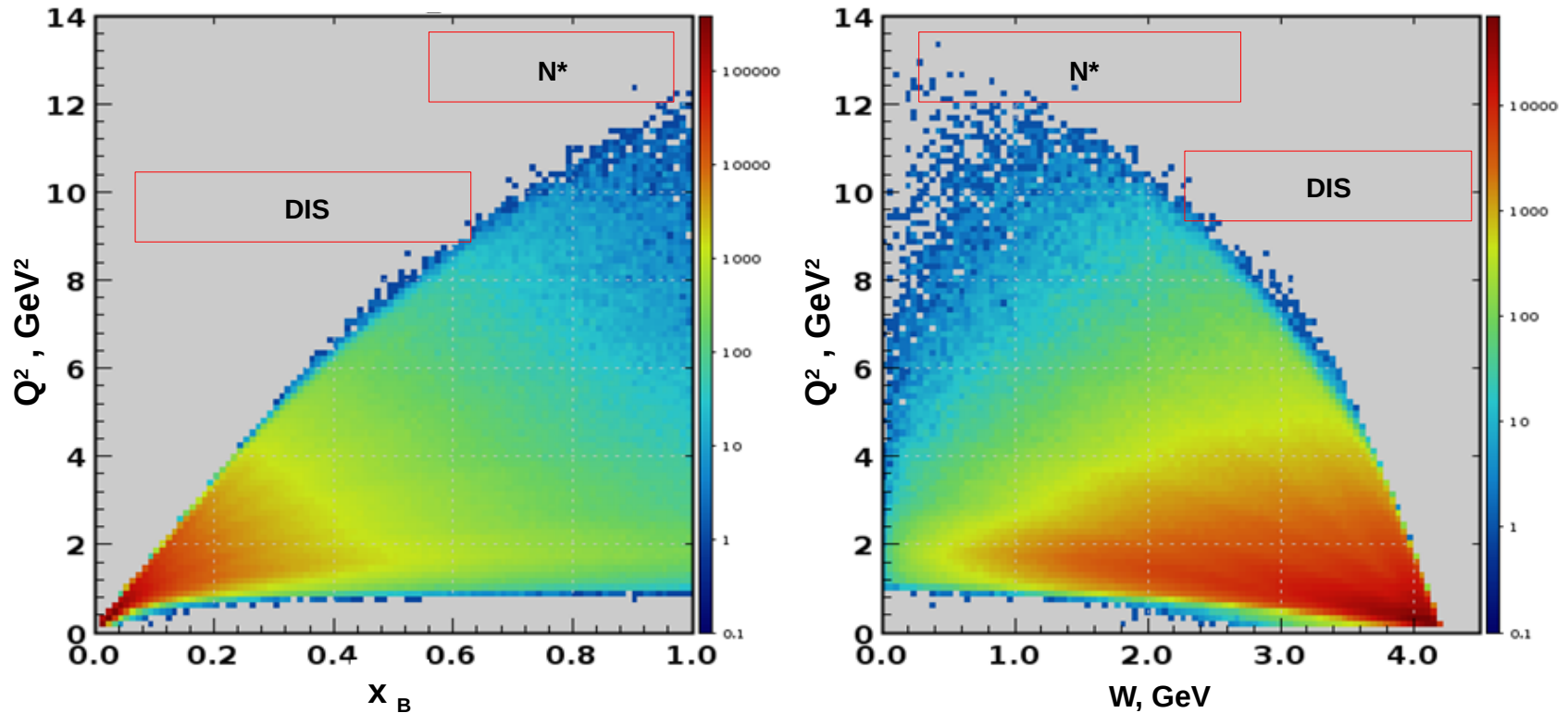


# Evaluation of the inclusive structure functions for the experiments with CLAS12

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# First measurements with CLAS12



Accessible kinematic coverage with CLAS12. Inclusive electron scattering events from the RGA run

# N\* studies at $0.05 \text{ GeV}^2 < Q^2 < 7.0 \text{ GeV}^2$ with CLAS12

|                                                      |                                                                                                                                                                                                                                    |
|------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Hybrid Baryons</b><br>E12-16-010                  | Search for hybrid baryons (qqqq) focusing on $0.05 \text{ GeV}^2 < Q^2 < 2.0 \text{ GeV}^2$ in mass range from 1.8 to 3 GeV in $K\Lambda$ , $N\pi\pi$ , $N\pi$ (A. D'Angelo, et al.)                                               |
| <b>KY</b><br><b>Electroproduction</b><br>E12-16-010A | Study N* structure for states that couple to KY through measurements of cross sections and polarization observables that will yield $Q^2$ evolution of electrocoupling amplitudes at $Q^2 < 7.0 \text{ GeV}^2$ (D. Carman, et al.) |

**Approved by PAC44**

Run Group conditions:

$E_b = 6.6 \text{ GeV}$ , 50 days

$E_b = 8.8 \text{ GeV}$ , 50 days

- Polarized electrons, unpolarized  $\text{LH}_2$  target
- $L = 1 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$

# CLAS12 $N^*$ Program at High $Q^2$

E12-09-003

Nucleon Resonance Studies with CLAS12

*Gothe, Mokeev, Burkert, Cole, Joo, Stoler*

E12-06-108A

KY Electroproduction with CLAS12

*Carman, Gothe, Mokeev*

- Measure exclusive electroproduction cross sections from an unpolarized proton target with polarized electron beam for  $N\pi$ ,  $N\eta$ ,  $N\pi\pi$ , KY:

*$E_b = 11. \text{ GeV}$ ,  $Q^2 = 3 \rightarrow 12 \text{ GeV}^2$ ,  $W \rightarrow 3.0 \text{ GeV}$  with nearly complete coverage of the final state phase space*

- Key Motivation

*Study the structure of all prominent  $N^*$  states in the mass range up to 2.0 GeV vs.  $Q^2$  up to 12  $\text{GeV}^2$ .*

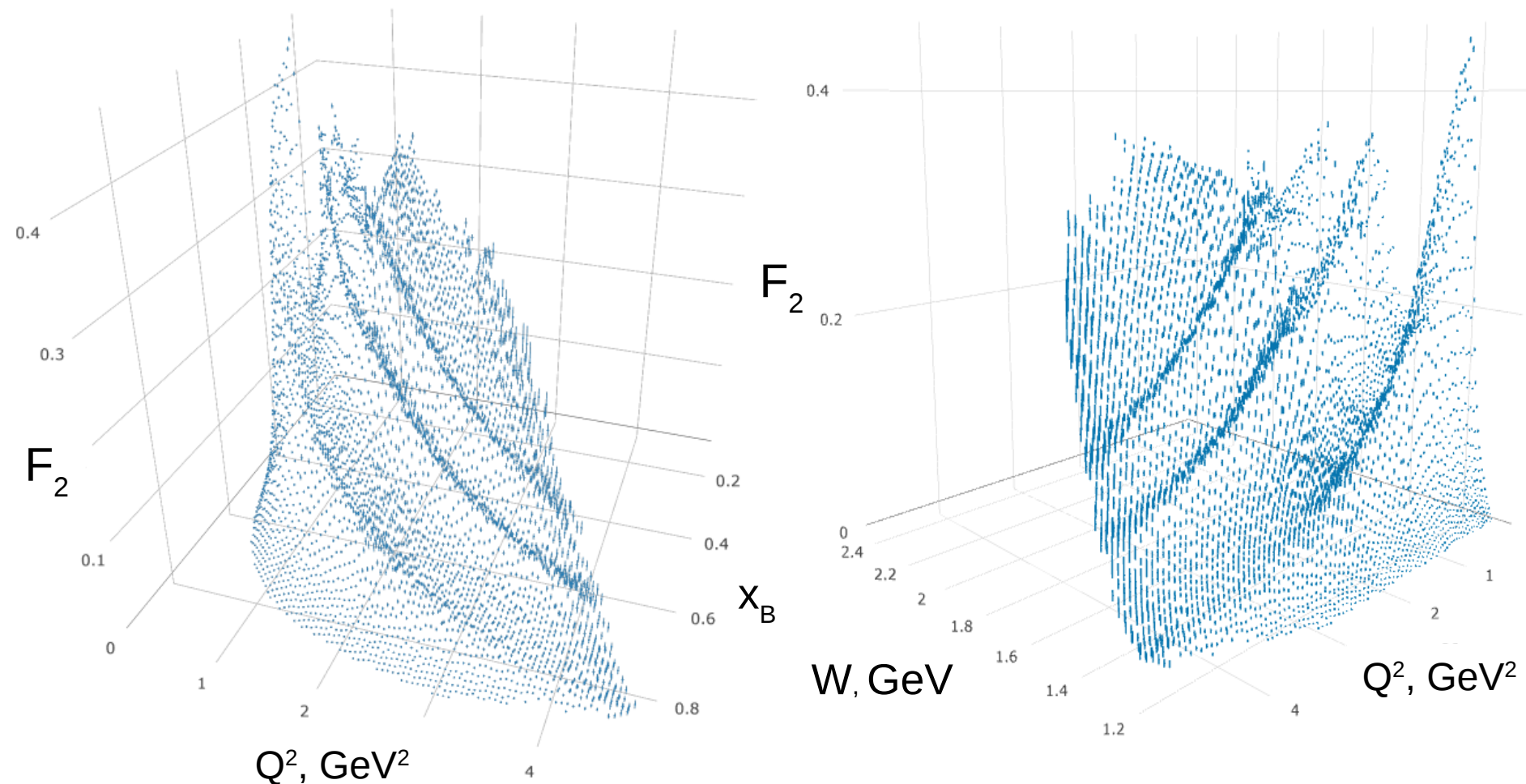
*CLAS12 is the only facility to map-out the  $N^*$  quark with minimal meson-baryon cloud contributions.*

# The role of inclusive electron scattering

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- Benchmark for the CLAS12 performance
- Check for normalization of exclusive/inclusive reaction cross-section
- Validation for the electron detection efficiency
- The tool for evaluation of inclusive electron scattering cross-section  $\gamma_v + p \rightarrow p + X$  from the CLAS/world data was developed

# CLAS results on inclusive structure function $F_2$



Osipenko et al. (CLAS Collaboration), Phys. Rev. D 67, 092001, 2003

Outside of kinematic coverage of the CLAS data P.Bosted parametrization, M.E. Christy and P.E. Bosted, arXiv:0711.0159

# Evaluation of the structure functions and inclusive cross sections

- CLAS data were used for the **interpolation** of inclusive cross-sections in the kinematic range covered by CLAS
- For the **extrapolation** of the data we used P. Bosted fit
- Combination of these **interpolation/extrapolation** were fitted by this dependence in spirit of operator product expansion

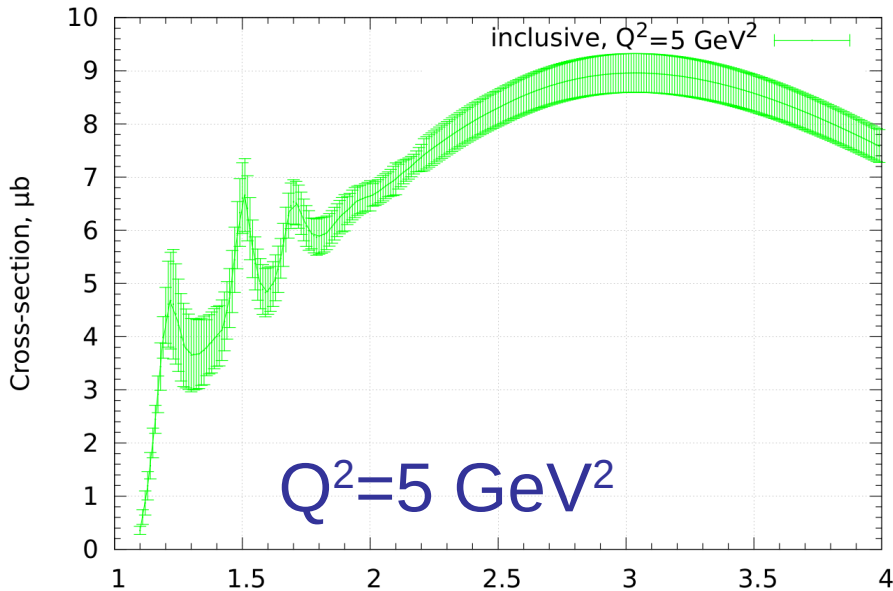
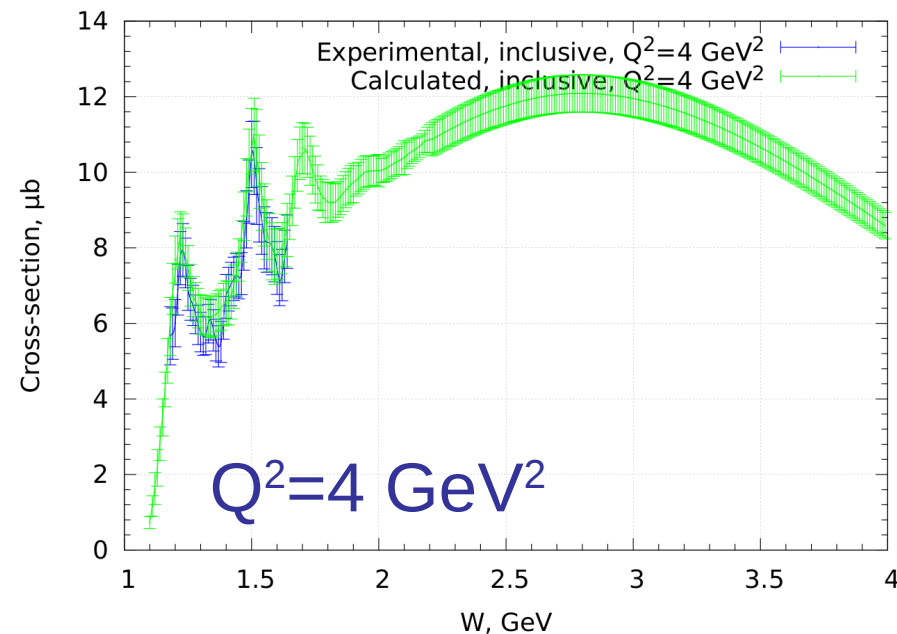
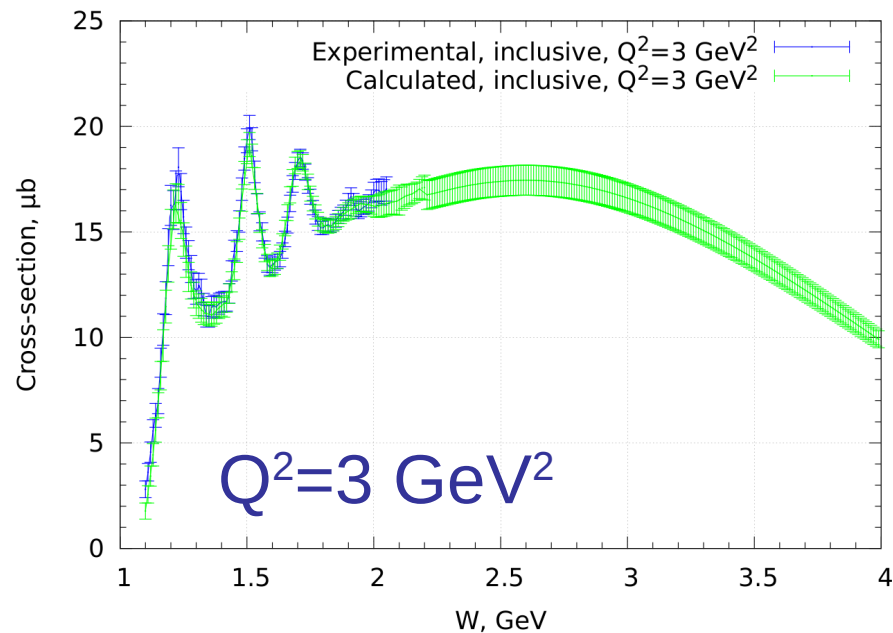
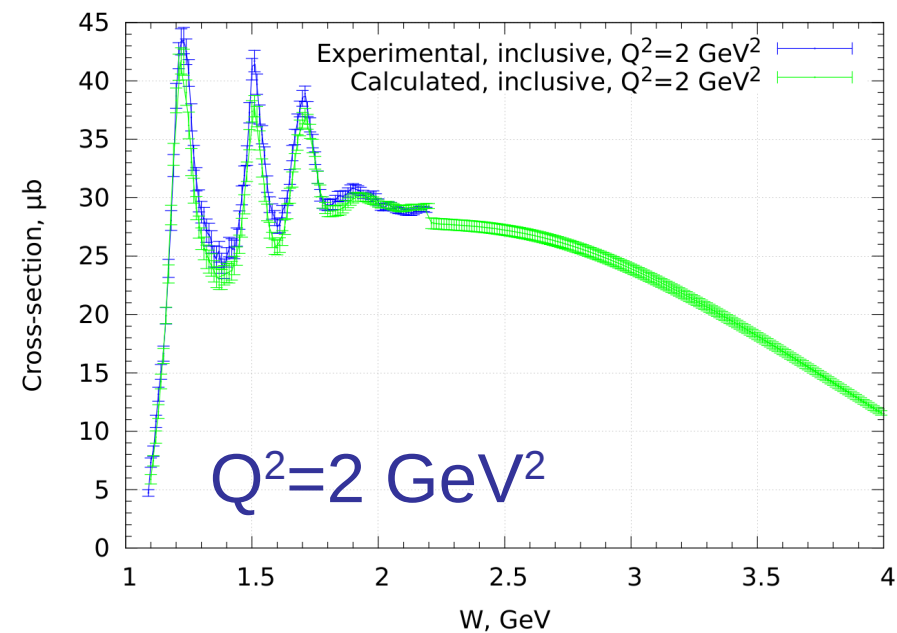
$$F_{1,2}(W, Q^2) = C_0^{1,2}(W) + \frac{C_1^{1,2}}{Q^2} + \frac{C_2^{1,2}}{Q^4} + \dots$$

Relations between inclusive structure functions and cross sections:

$$\begin{aligned} \sigma(W, Q^2) &= \sigma_T(W, Q^2) + \epsilon \sigma_L(W, Q^2) & W_2 &= (\sigma_T(W, Q^2) + \sigma_L(W, Q^2)) \frac{K}{4\pi^2\alpha} \frac{1}{1 + \frac{\nu^2}{Q^2}} \\ W_1 &= \frac{K}{4\pi^2\alpha} \sigma_T(W, Q^2), & K &= \frac{W^2 - M_N^2}{2W} & F_1(W, Q^2) &= M_N W_1(W, Q^2) \\ \alpha &= 1/137 & & & F_2(W, Q^2) &= \nu W_2(W, Q^2) \end{aligned}$$



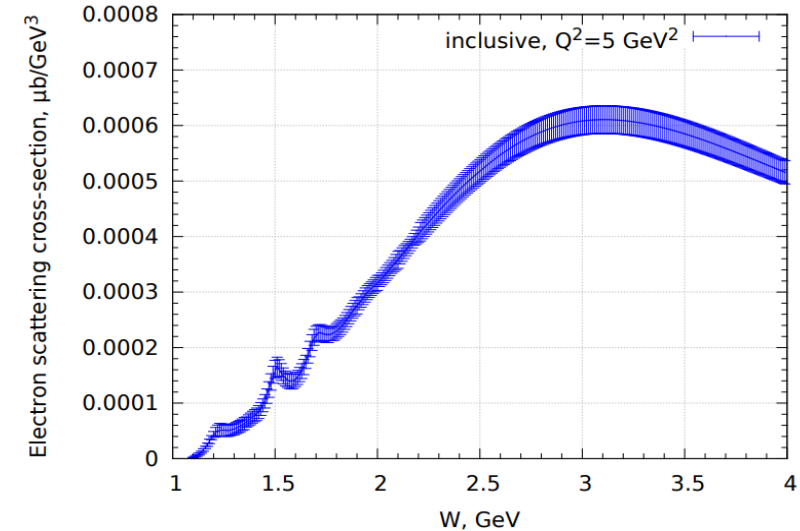
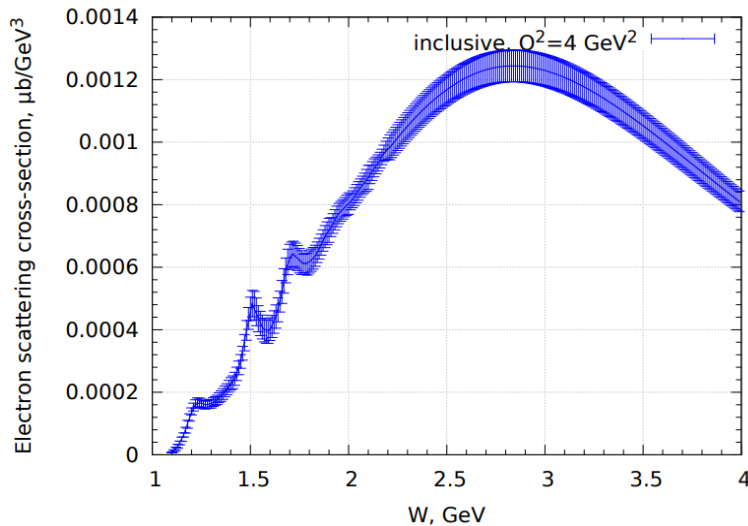
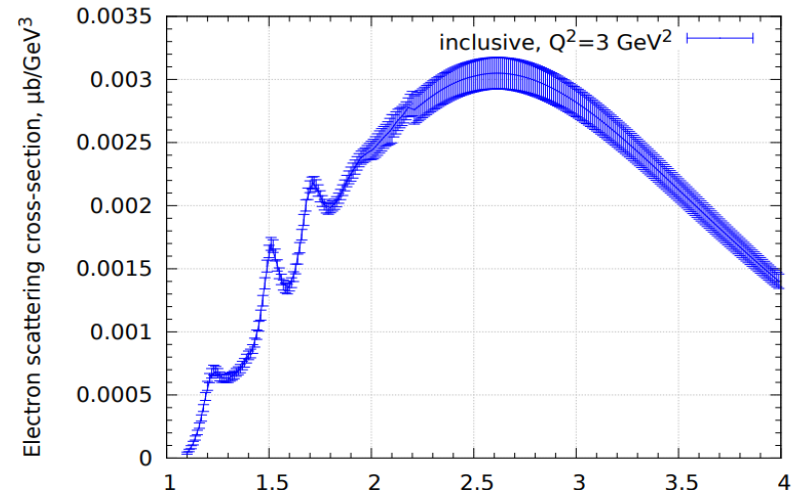
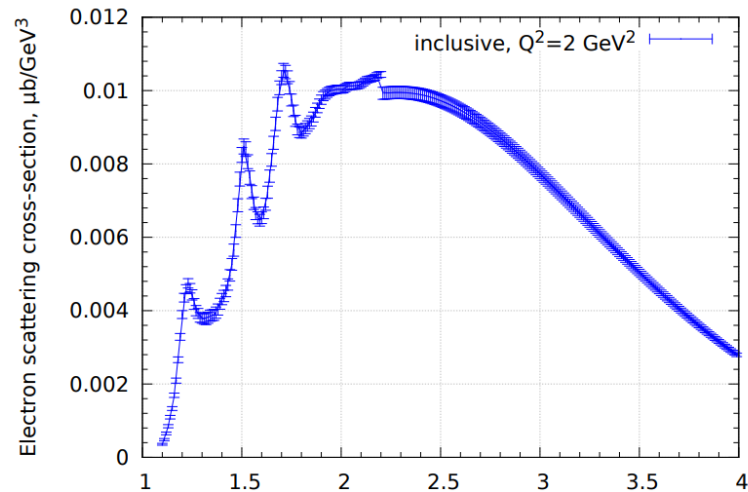
# Inclusive virtual photon cross sections from the CLAS/world data



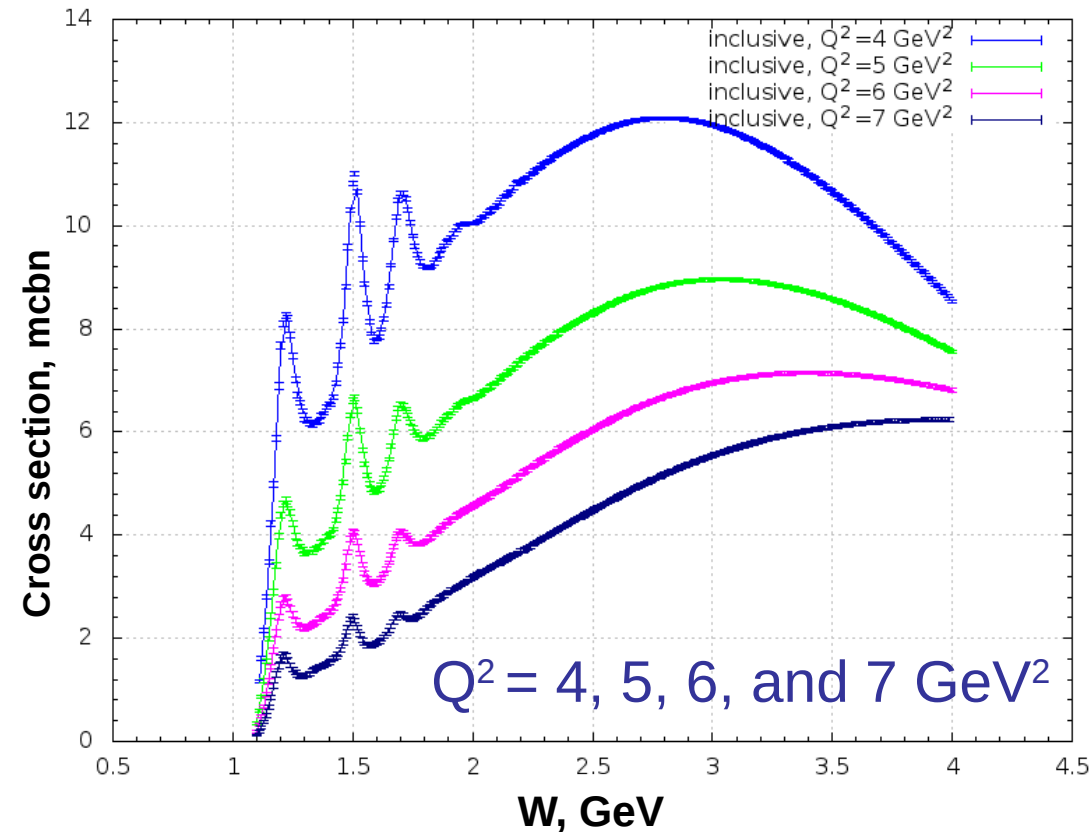


# Inclusive electron scattering cross sections

$$\frac{d^2\sigma_{ep\rightarrow X}}{dWdQ^2} = \Gamma_\nu \sigma_{\text{incl}}$$



# Inclusive electron scattering cross sections



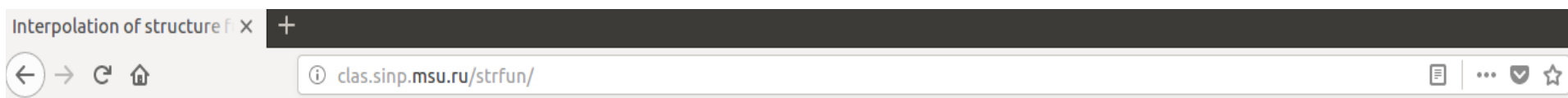
## Projected CLAS12 results

- Electron beam energy: 10.6 GeV
- Integrated luminosity:  
 $12.8 \times 10^{10} \text{ mb}^{-1}$
- Bin sizes:  
 $W = 0.01 \text{ GeV}$  and  $Q^2 = 0.1 \text{ GeV}^2$
- Expected statistical accuracy  
is in the range from 0.2% to 2.0%

- First precise measurements of inclusive cross section evolution with  $W$  and  $Q^2$  in the resonance region (smallest bin sizes over  $W$ ,  $Q^2$  ever achieved) at  $Q^2 > 5 \text{ GeV}^2$ , yield valuable insight into quark hadron duality

Data are available on the web page

<http://clas.sinp.msu.ru/strfun/>



## Structure functions and cross-sections

**Observable:** F2 ☐ Show  $W$  grid instead of  $x$

**Channels:** ☒ inclusive ☐  $\pi^+n$  ☐  $\pi^0p$  ☐  $\pi^+\pi^-p$  ☐  $2\pi^0p + \pi^+\pi^0n$  ☐  $\pi^+n + \pi^0p + \pi^+\pi^-p$  ☐  $K^+\Lambda$  ☐  $K^+\Sigma^0$  ☐  $\eta p$

**Abscissa** **First** **Step** **Last**

**$Q^2, \text{GeV}^2$ :** ☐ 0.45 0.01 0.45

**$x$ :** ☒ 0.1 0.01 0.9

**Data set:** ☒ Experimental ☐ Calculated ☐ Resonant contributions

**Results view:** ☐ HTML ☐ Plot ☒ Plot-SVG ☐ Text ☐ Gnuplot ☐ PDF

**Plot type:** ☒ csplines ☐ lines ☐ points

Calculate

# Summary

- Evaluation of inclusive structure functions, virtual photon, and electron scattering cross sections were carried out in the kinematic range of  $W < 4$  GeV and  $Q^2 < 7$  GeV<sup>2</sup> corresponding to the kinematic coverage of the CLAS12 detector.
- These results will allow us to check the CLAS12 performance, absolute normalization, and electron detection efficiency for most reactions, which will be studied with CLAS12
- User interface for evaluation of the aforementioned observables is available on <http://clas.sinp.msu.ru/strfun/>