Exploring inclusive structure functions in the resonance region

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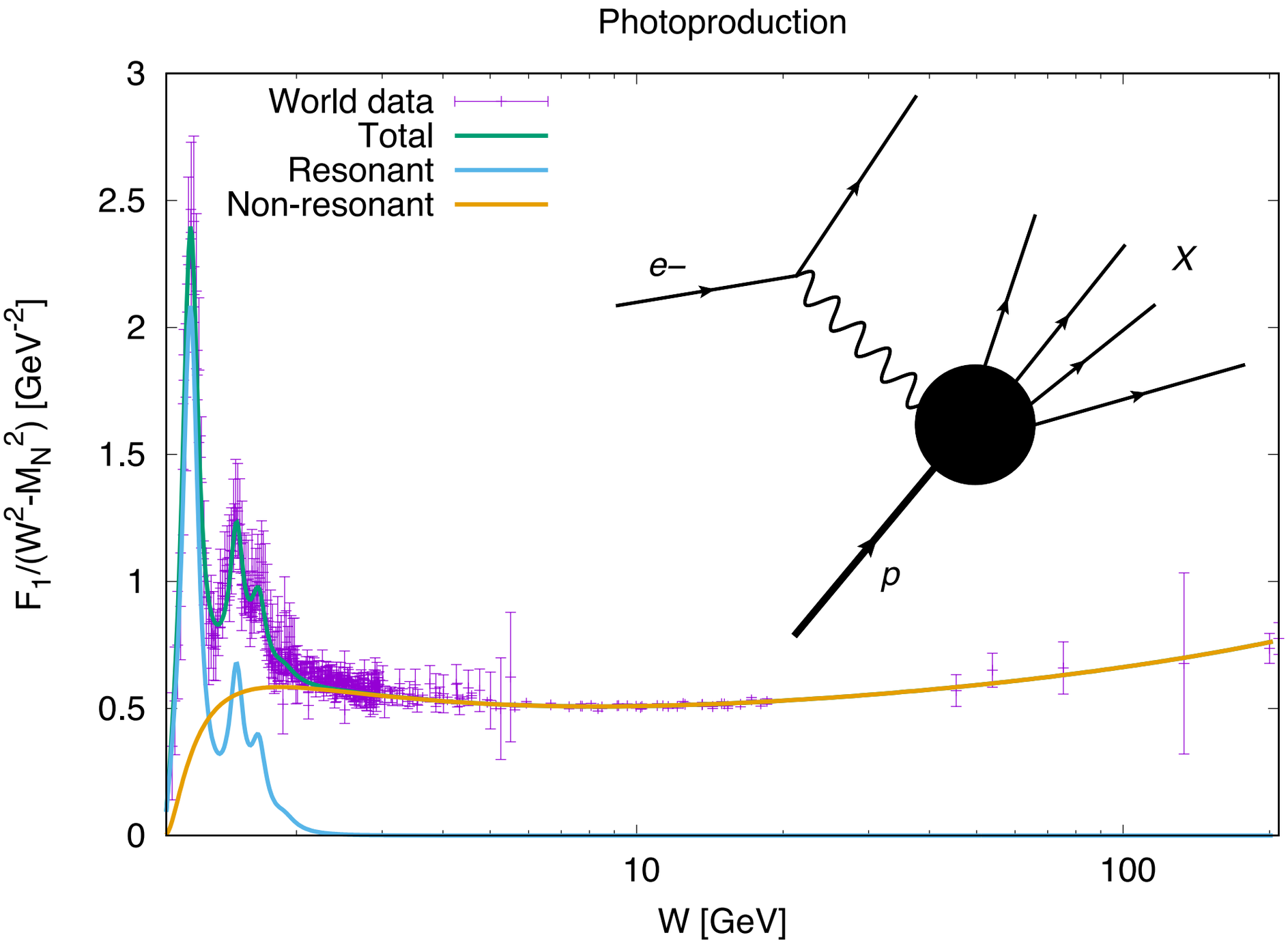
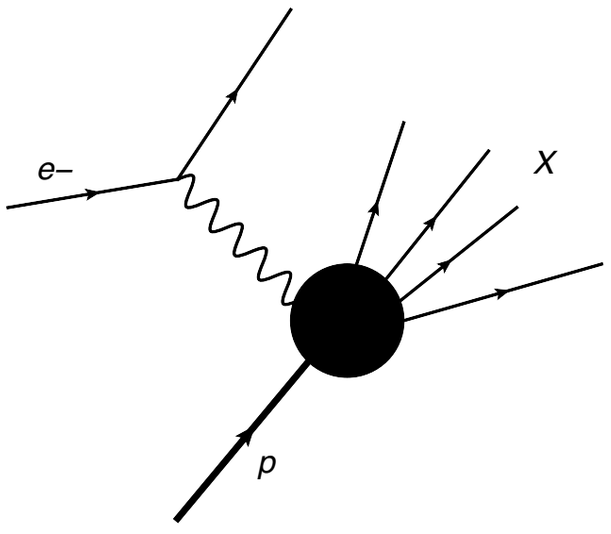
Nucleon excitation structure



Inclusive electron scattering



$$F_1 \propto \sigma_T(W, Q^2)$$

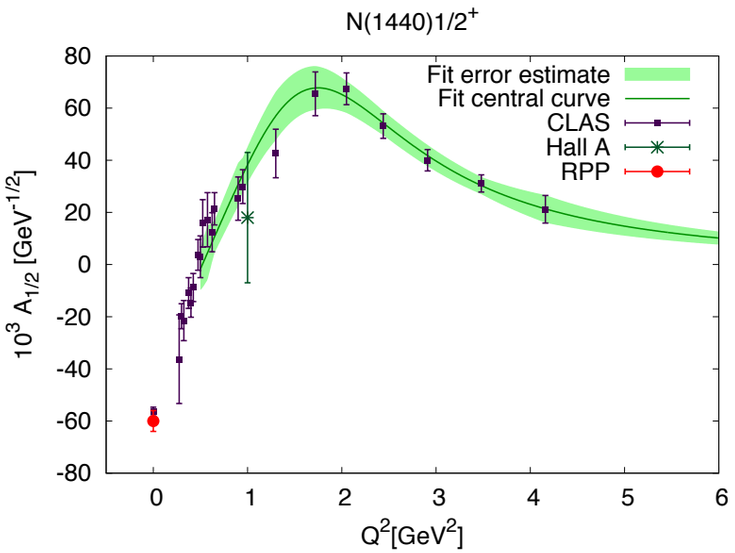
$$F_2 \propto \sigma_T(W, Q^2) + \sigma_L(W, Q^2)$$

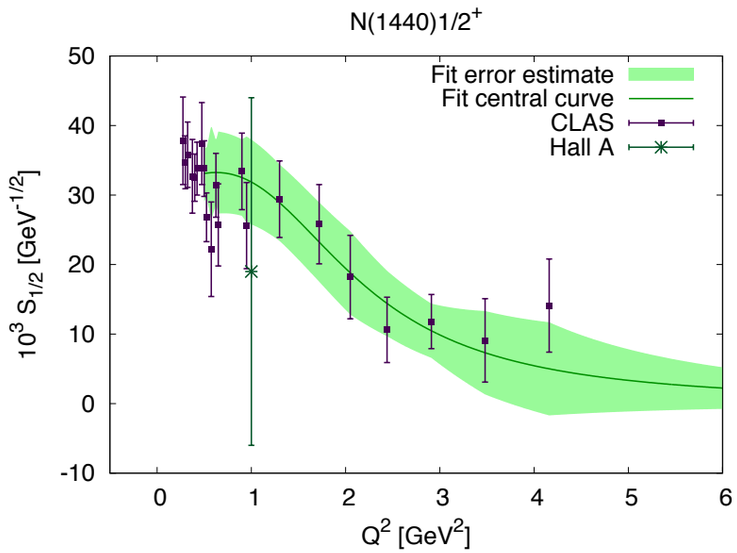
$$F_L \propto \sigma_L(W, Q^2)$$

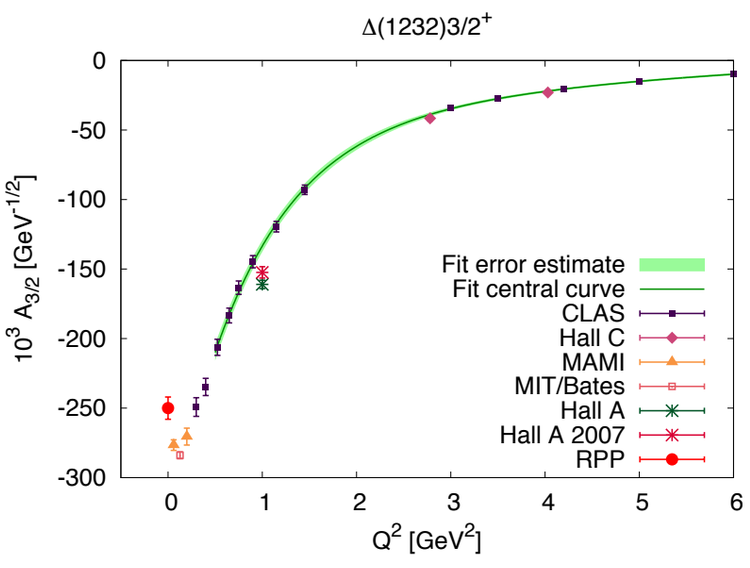
$$\sigma_U(W, Q^2) = \sigma_T(W, Q^2) + \epsilon_T \sigma_L(W, Q^2)$$

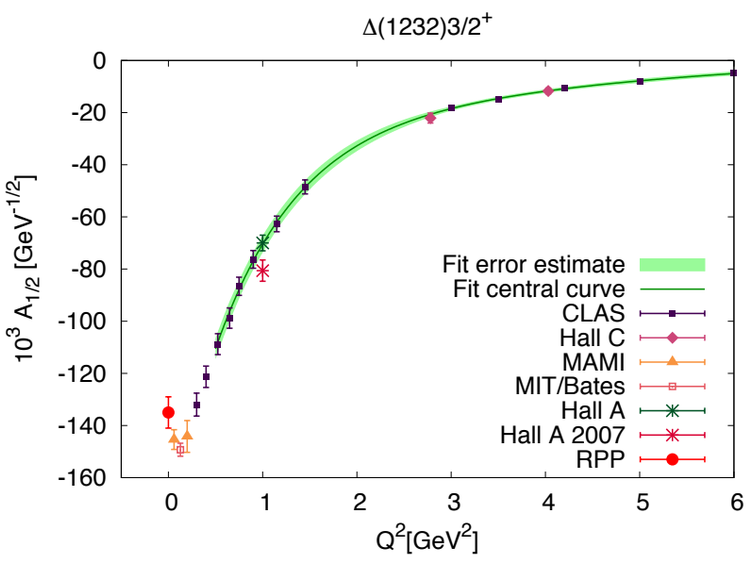
- Gives access to structure functions
- Resonance region displays highly non-trivial behaviour with W and Q^2
- **Precise CLAS data** up to 3rd resonance regime
- CLAS12 is to reach 0.05 $GeV^2 < Q^2 < 12\ GeV^2$, W up to 4 GeV
- Access to PDFs at large x and tests on quark-hadron duality

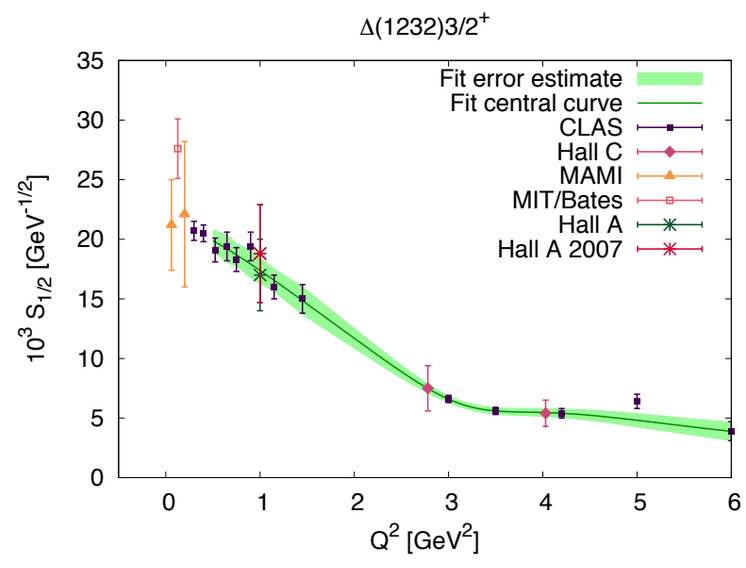
Exclusive electron scattering







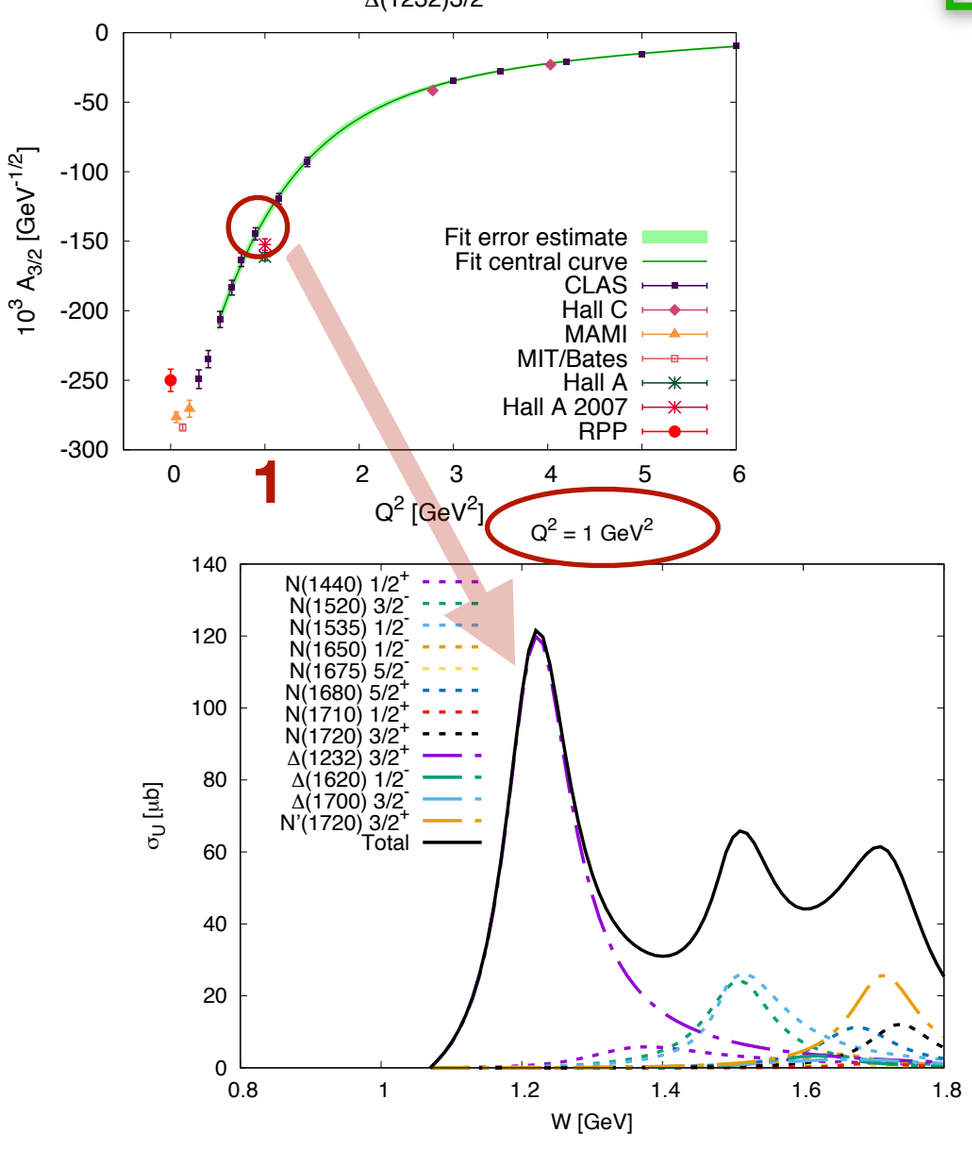




- World and CLAS data on longitudinal and transverse electrocouplings
  https://userweb.jlab.org/~mokeev/resonance_electrocouplings/ *https://userweb.jlab.org/~isupov/couplings/*
- Allow us to determine **each of the resonant contributions separately**

From exclusive to inclusive electron scattering

$$\sigma_{T,L}(W,Q^2) = \sigma^{R}_{T,L}(W,Q^2) + \sigma^{NR}_{T,L}(W,Q^2)$$



Breit-Wigner resonance model

Mokeev et al., PRC 86 (2012) 035203

Resonances with $M_r < 1.75$ GeV included:

$$\sigma^{R}_{T,L}(W,Q^2) = \frac{\pi}{q^2_\gamma} \sum_{N^*,\Delta^*} (2J_r+1) \frac{M_r^2 \Gamma_{\rm tot}(W) \Gamma^{T,L}_\gamma(M_r,Q^2)}{(M_r^2 - W^2)^2 + M_r^2 \Gamma^2_{\rm tot}(W)}$$

$$\Gamma^{T}_\gamma(M_r,Q^2) \sim \left|A_{1/2}(Q^2)\right|^2 + \left|A_{3/2}(Q^2)\right|^2$$

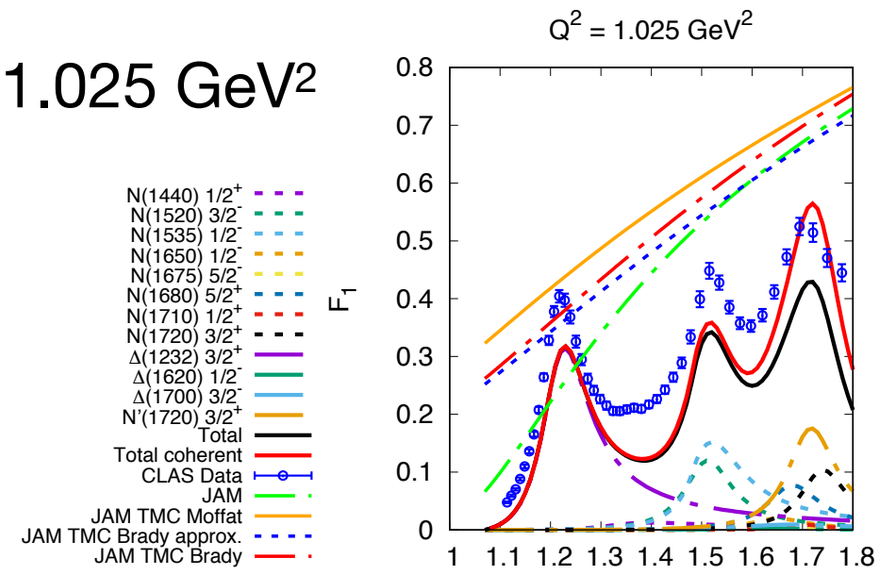
$$\Gamma^{L}_\gamma(M_r,Q^2) \sim \left|S_{1/2}(Q^2)\right|^2$$

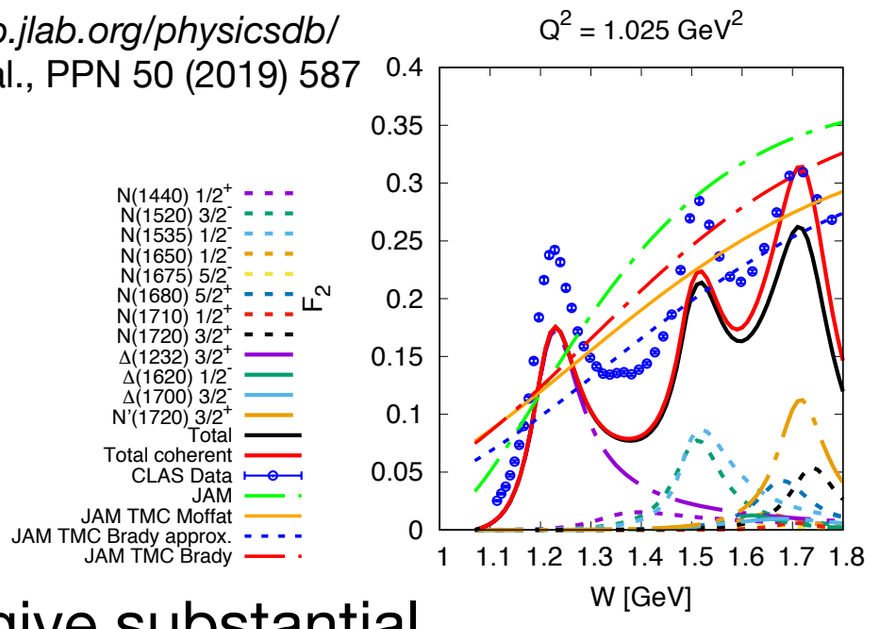
Updated previous work with coherent sum

Resonant contributions at different Q^2

https://clas.sinp.msu.ru/strfun-dev
https://clasweb.jlab.org/physicsdb/
Golubenko et al., PPN 50 (2019) 587

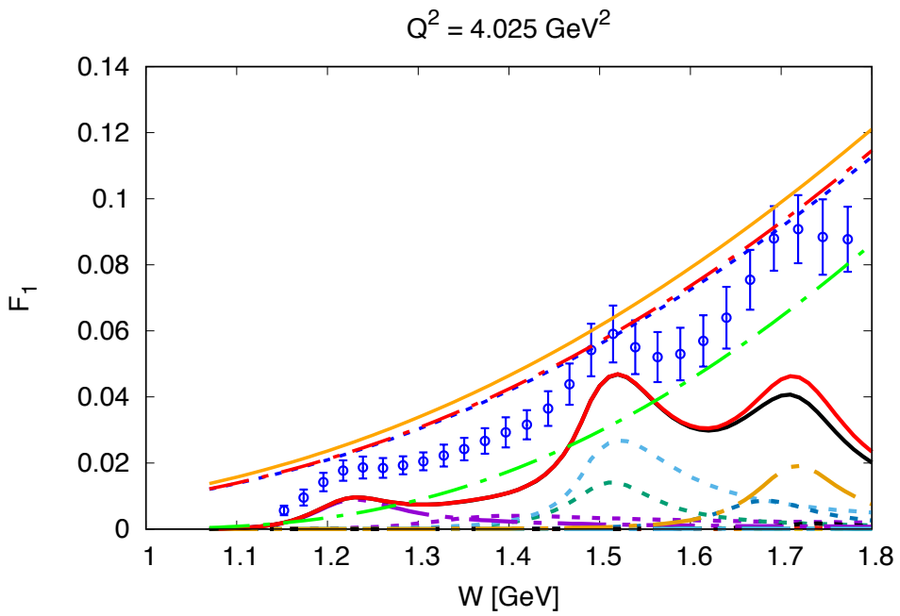
Q^2 = 1.025 GeV^2

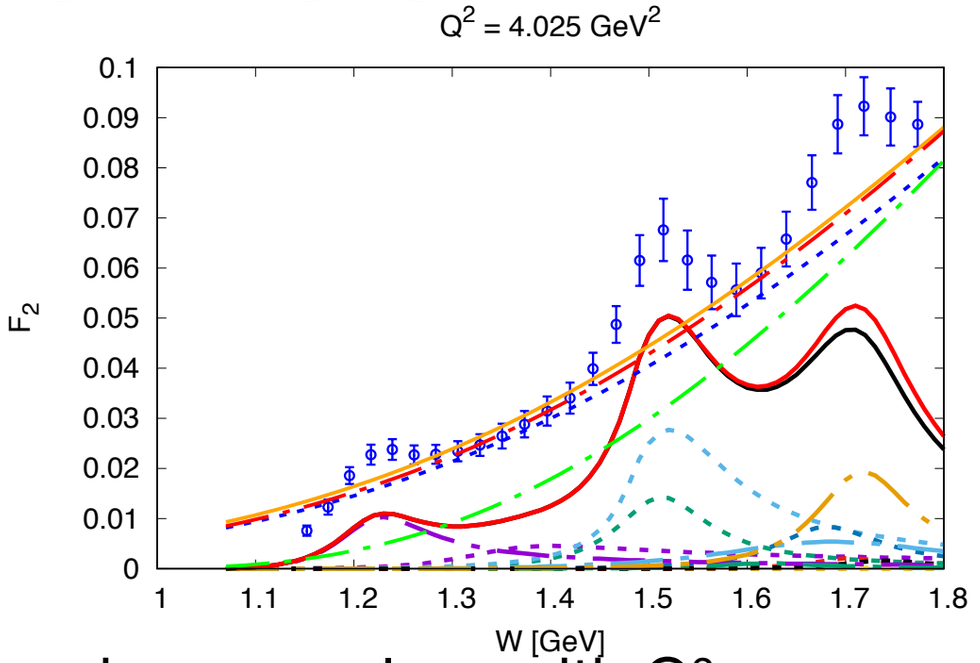




Tails of resonances give substantial contributions to neighbouring regions!

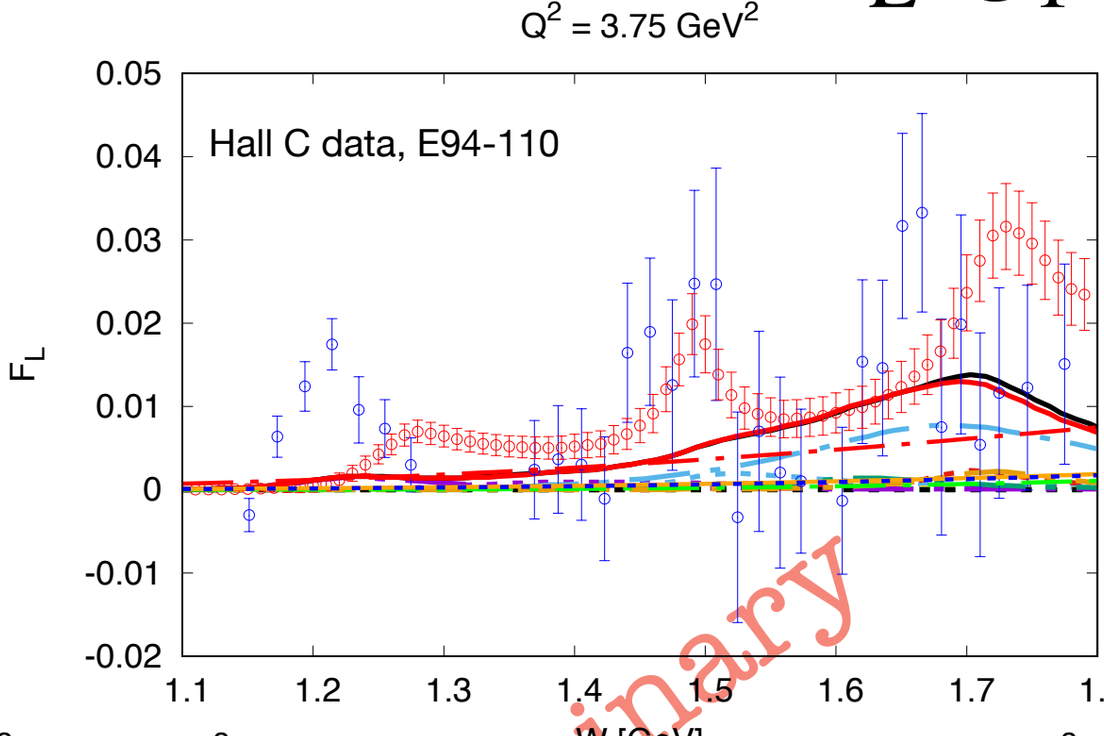
Q^2 = 4.025 GeV^2

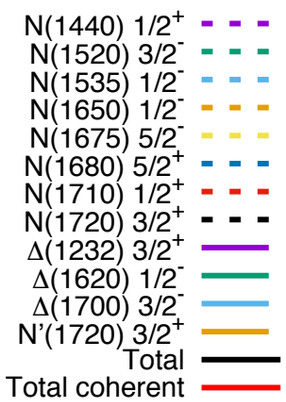


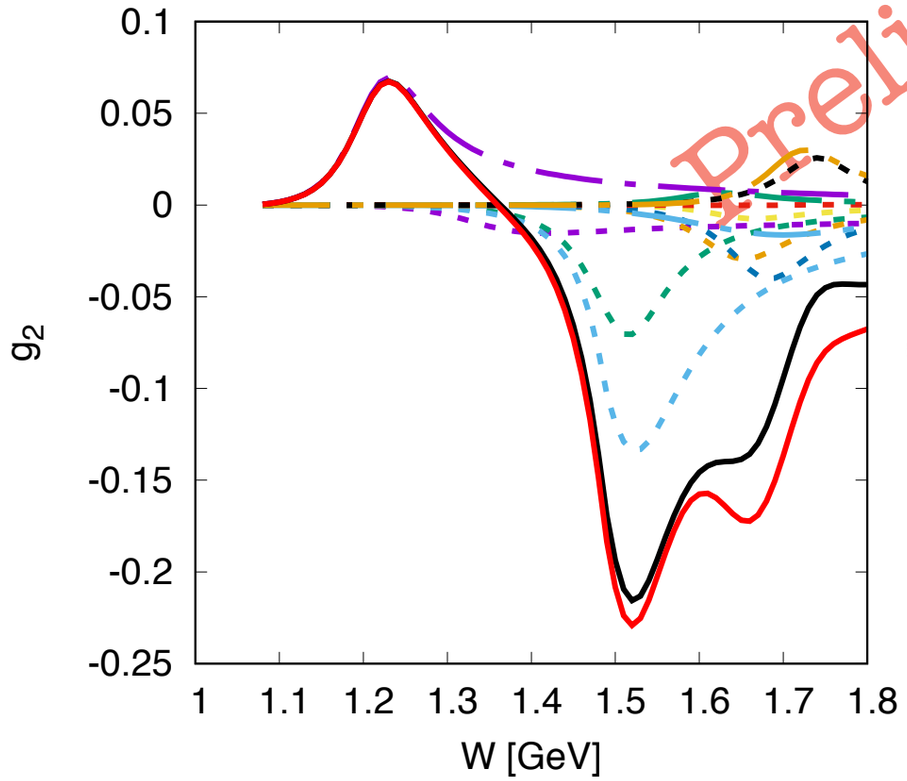


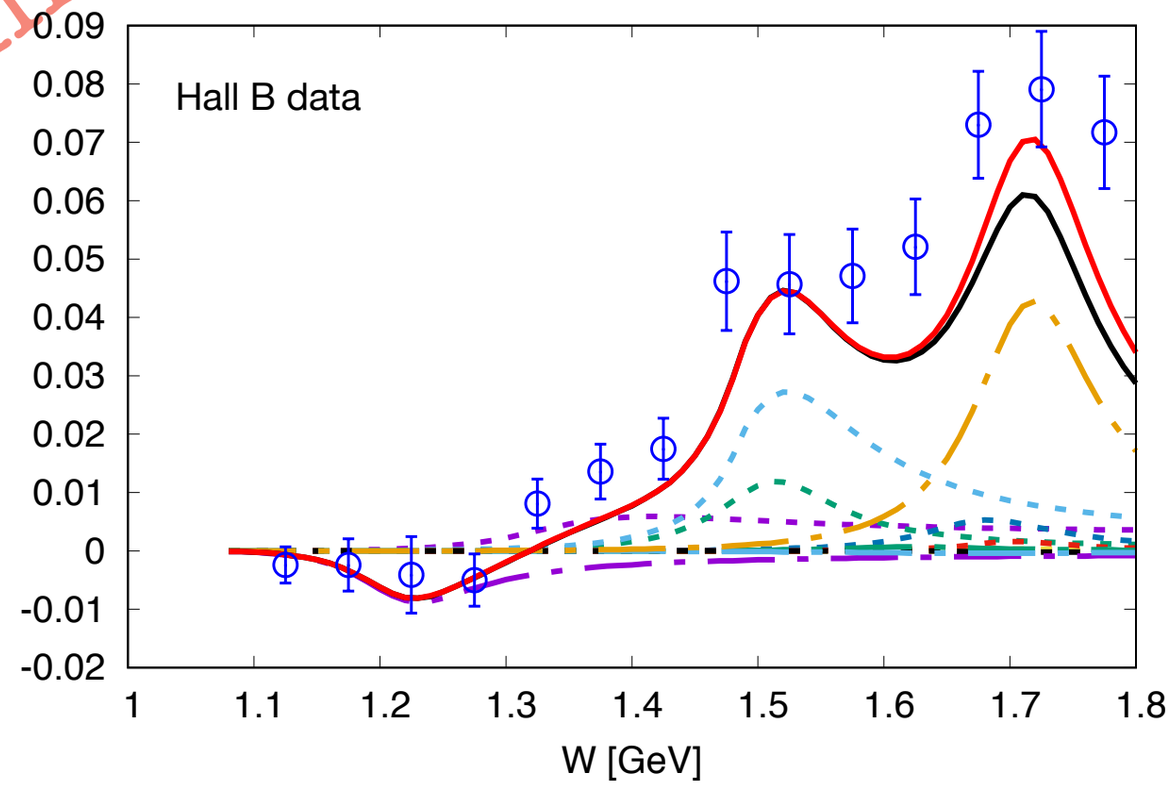
Second resonance region decreases less with Q^2: intricate differences in Q^2 evolution of electrocouplings.

Same exercise for F_L, g_1, g_2

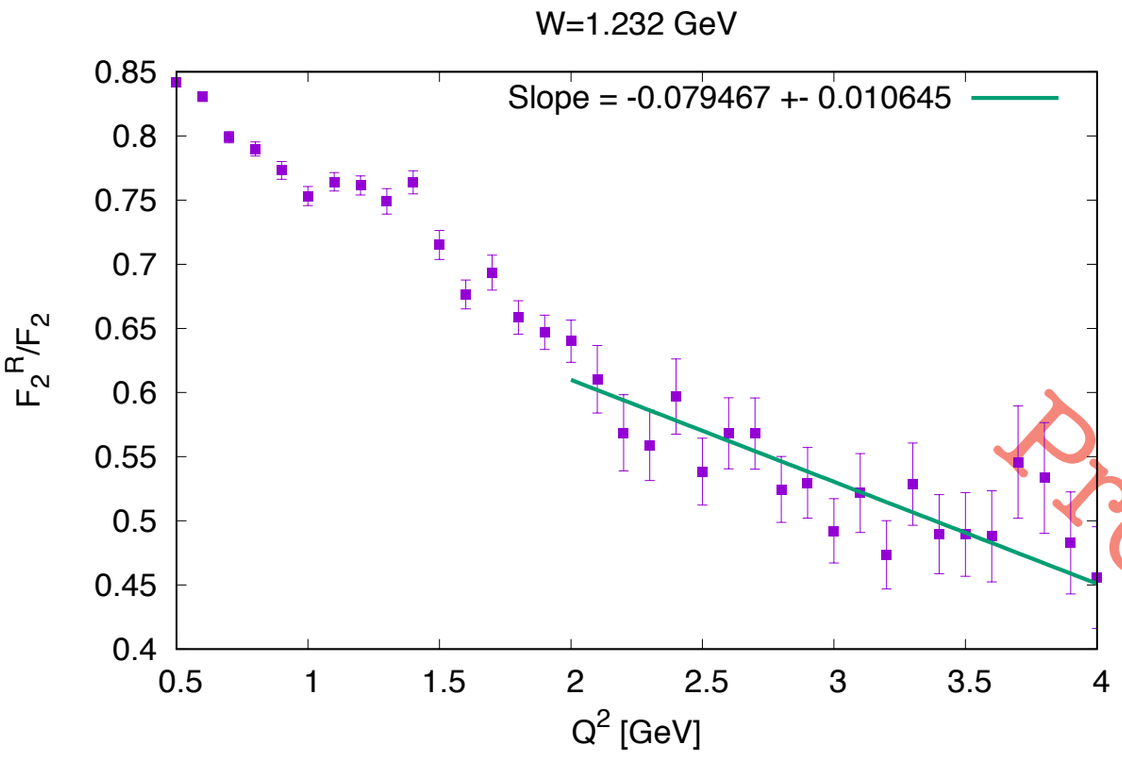


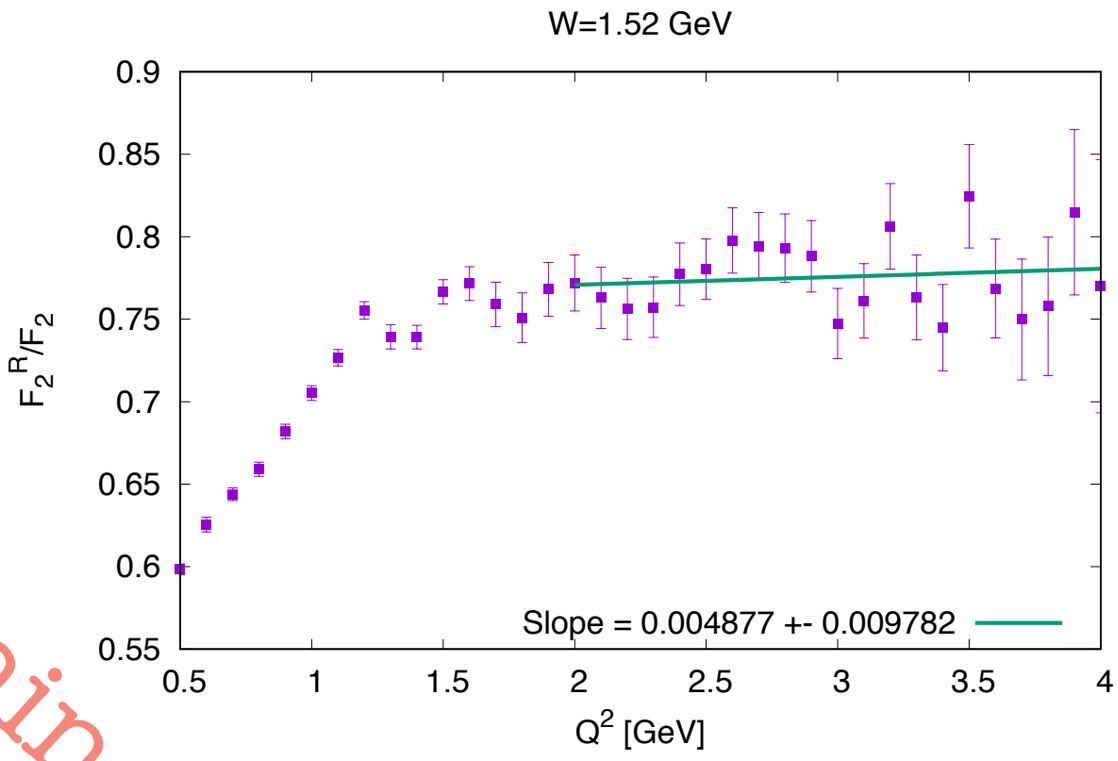




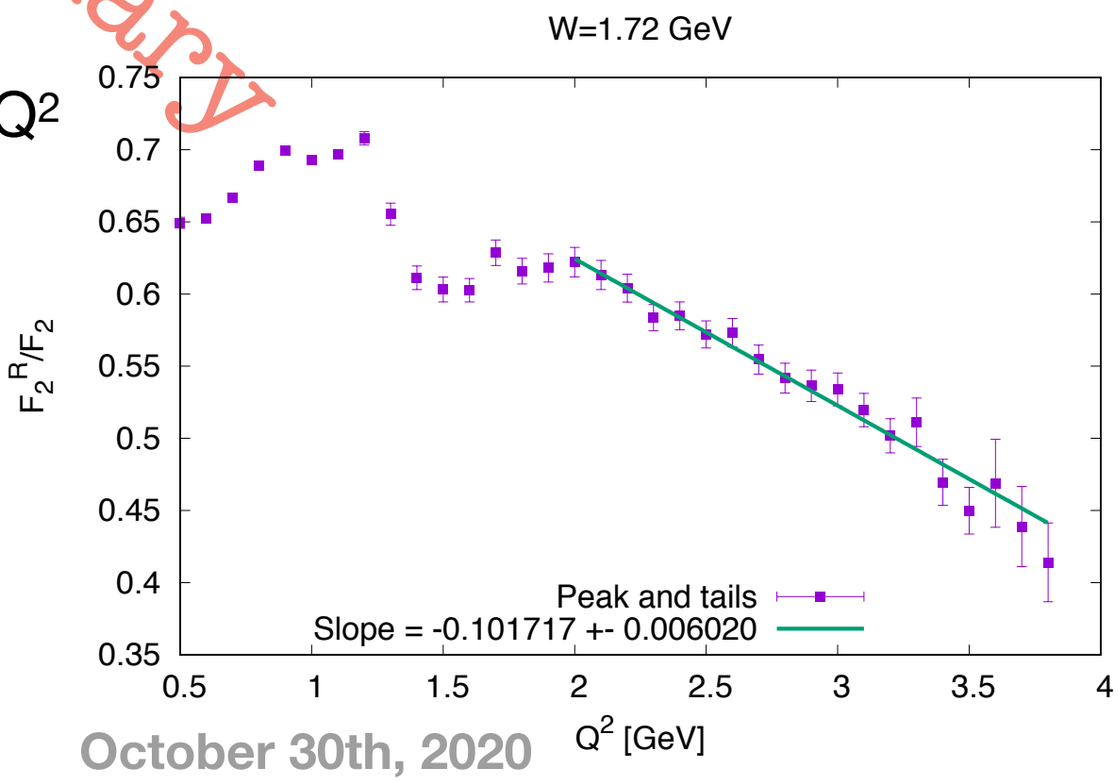


Q^2 evolution





- The resonance contributions decrease with Q^2
- But so do the total contributions
- $\Delta(1232)$: even at 4 GeV^2, 50% significance
- 2nd resonance region: nearly flat ratio
- Points to non-vanishing resonances!



Summary and outlook

- Well-covered **electrocouplings** from **exclusive** CLAS data:
  allows access to the non-trivial behaviour in W and Q^2 of the
  inclusive electron scattering in the **resonance region** for the first time!

- Information about electrocouplings of all prominent excited states:
  essential for credible evaluation of the resonant contributions to inclusive reaction.

- Currently studying the Q^2 evolution of (also polarized) structure functions

- Will allow for insight into PDFs at large x:
  truncated moments to give insight into resonance versus DIS regions