Event generator for exclusive $p\pi^0$, $n\pi^+$, $K^+\Lambda$, $K^+\Sigma^0$ electroproduction at Q^2 up to 12 GeV^2

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- Nπ and KY channels play an important role in the N* studies
- They offer insight into partonic structure functions from the DIS data

CLAS12 N* Program at High Q^2

E12-09-003	E12-06-108A
Nucleon Resonance Studies with CLAS12	KY Electroproduction with CLAS12
Gothe, Mokeev, Burkert, Cole, Joo, Stoler	*Carman, Gothe, Mokeev*

- Measurements of the 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 GeV, Q^2 = 3 → 12 GeV^2, W → 3.0 GeV with the almost 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 GeV^2.*

N* studies at 0.05 GeV^2 < Q^2 < 7.0 GeV^2 with CLAS12

Approved by PAC44

Hybrid Baryons E12-16-010	Search for hybrid baryons (qqqg) focusing on 0.05 GeV^2 < Q^2 < 2.0 GeV^2 in mass range from 1.8 to 3 GeV in KΛ, Nππ, Nπ *(A. D'Angelo, et al.)*
KY Electroproduction 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 GeV^2 *(D. Carman, et al.)*

Basic for the event generator development

CLAS provided detailed cross section information for the exclusive channels: $p\pi^0$, $n\pi^+$, $K^+\Lambda$, $K^+\Sigma^0$ at Q^2<5-6 GeV^2 and W<3.0 GeV

Data can be found in the CLAS physics DB http://clas.sinp.msu.ru/jlab/

The new CLAS12 detector extends the kinematic coverage W < 4.5 GeV and $5 < Q^2 < 12$ GeV^2. This region remains almost unexplored in exclusive electroproduction. Evaluation of the CLAS12 efficiency and experiment modeling require the realistic event generators at this kinematics.

Developed EGs are based on interpolation ($Q^2 < 5$ GeV^2) of the CLAS data on exclusive differential cross sections and extrapolation ($Q^2 > 5$ GeV^2) of fully integrated cross sections.

Extrapolation of the fully integrated cross sections

Exclusive channel contributions to inclusive structure functions F_1 and F_2 were evaluated from the integrated cross section:

$$\sigma_{ch} = \sigma_{T,ch} + \varepsilon\sigma_{L,ch} \quad \sigma_{L,ch} \approx 0.2\sigma_{T,ch}$$

$$W_{1,ch} = \frac{K}{4\pi^2\alpha}\sigma_{T,ch}$$

$$W_{2,ch} = \frac{\sigma_{T,ch} + \sigma_{L,ch}}{4\pi^2\alpha}\frac{(2\nu M_p - Q^2)Q^2}{2M_p(Q^2+\nu^2)}$$

$$F_{1,ch} = M_p W_{1,ch} \qquad F_{2,ch} = \nu W_{2,ch}$$

In spirit of the operator product expansion:

$$F_{1,2}(W,Q^2) = C_0 + \sum_{\tau} C_\tau \left(\frac{\Lambda^2_{QCD}}{Q^2}\right)^{\tau/2}$$

Q^2 – dependence of $F_{1,ch}$ and $F_{2,ch}$ were fit in each W bin independently at $Q^2 < 5$ GeV^2

$$F_{1,2,ch}(W,Q^2) = \sum_{n=0,1,2} C_n \frac{1}{(Q^2)^n}$$

this parametrization was used for extrapolation at $Q^2 > 5$ GeV^2

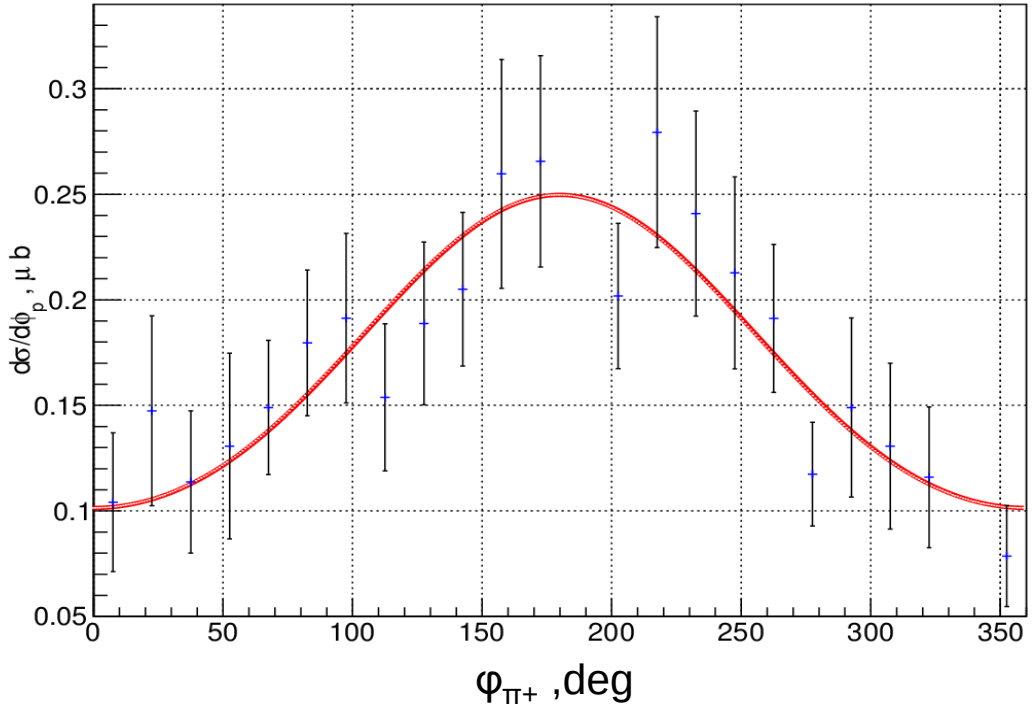
Extraction of the integrated cross sections from the CLAS data

At each W and Q^2 the phi-distributions of the measured cross sections were fit by

$$\frac{d\sigma_{ch}(\theta,\varphi)}{d\cos\theta d\varphi} = A_{ch}(\theta) + B_{ch}(\theta)\cos\varphi + C_{ch}(\theta)\cos 2\varphi$$

$$\sigma_{ch,\mathrm{int}}(W,Q^2) = \int_0^{\pi} A_{ch}(W,Q^2,\theta)\sin\theta d\theta$$

Example: $n\pi^+$, $Q^2 = 4.16$ GeV^2, W = 1.27 GeV, $\cos(\Theta_{\pi+}) = 0.3$



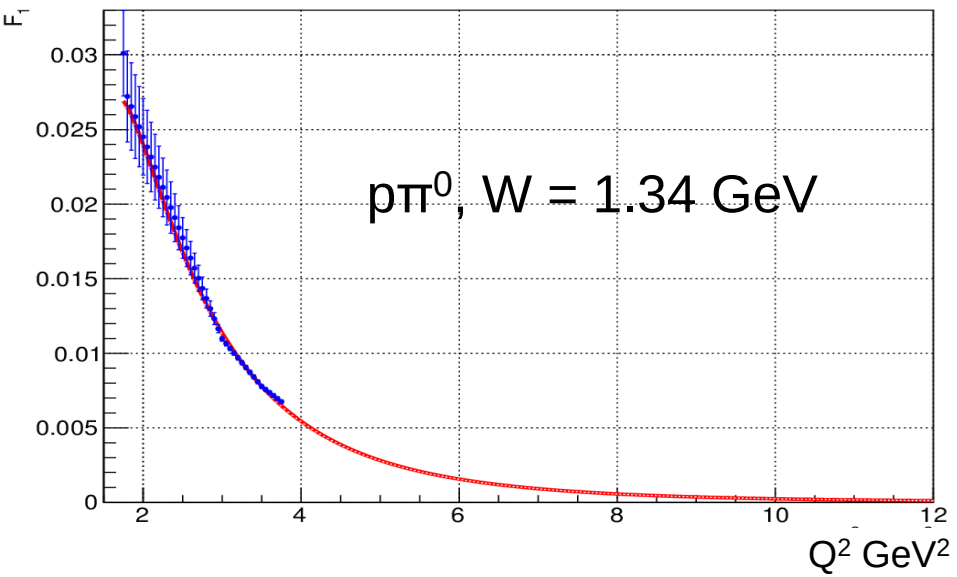
Extrapolation of the fully integrated cross sections

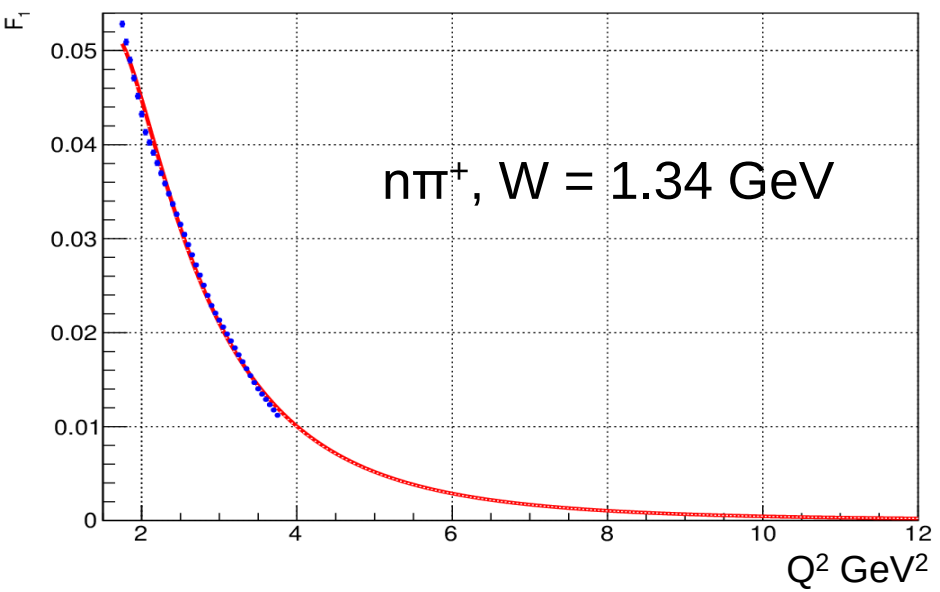
Constraints from the results on inclusive structure functions $F_{1,inc}$ and $F_{2,inc}$ [*M.E.Christy. P.E.Bosted arXiv:0712.3731*] were used in the exclusive contribution extrapolation in the range of $Q^2>5.0$ GeV^2

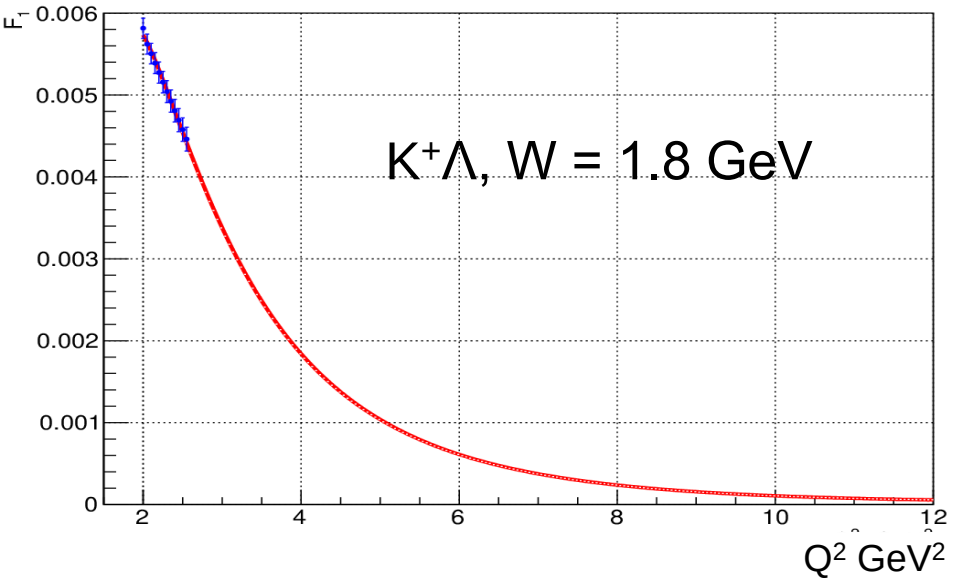
$$0 < (R_{1,2} = F_{1,2,ch} / F_{1,2,inc}) < 1$$

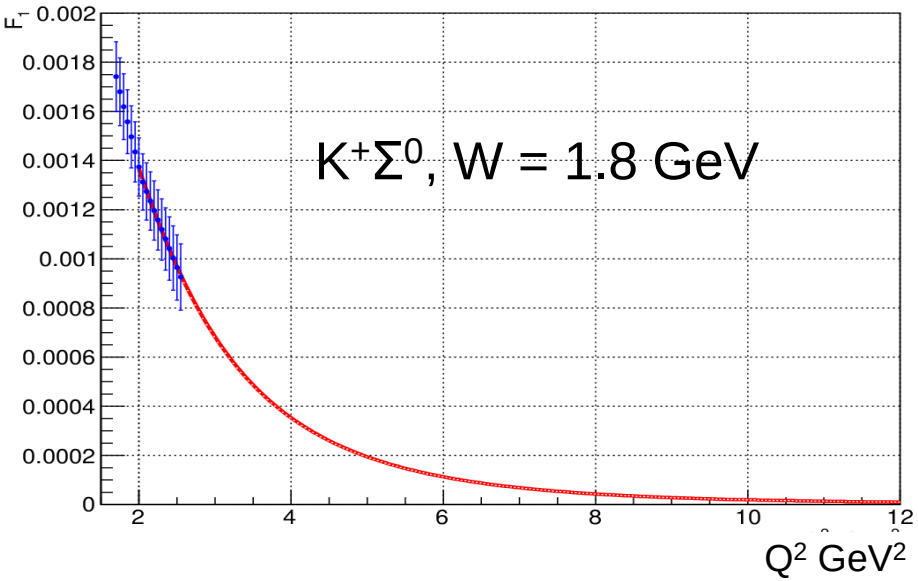
The shapes of the 2-fold differential cross sections were assumed to be the same as in the experimental data at maximal Q^2 where the measured cross sections are available

Fit of the exclusive contributions $F_{1,ch}$ into inclusive $F_{1,\,inc}$ structure function and their extrapolation at 5 GeV^2< Q^2 < 12 GeV^2

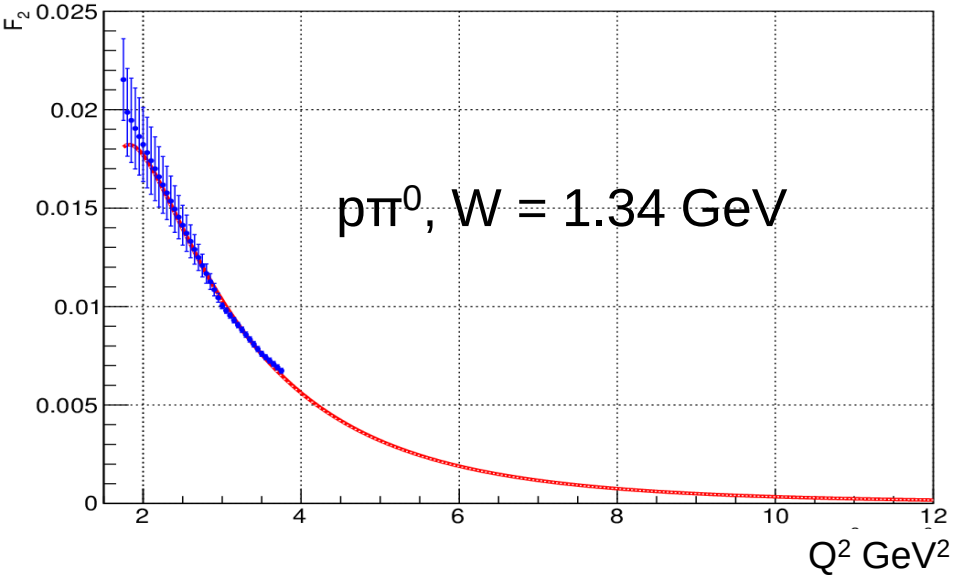


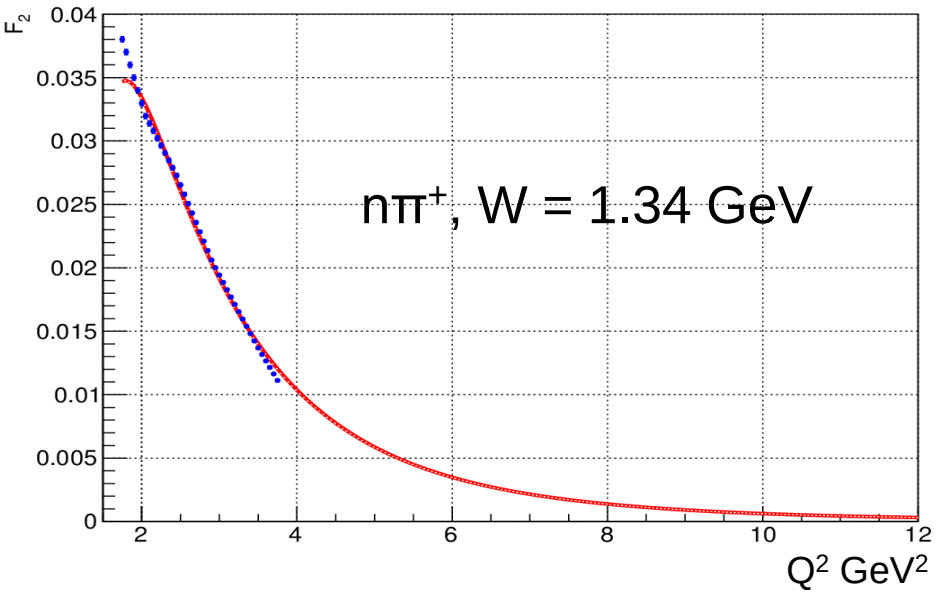


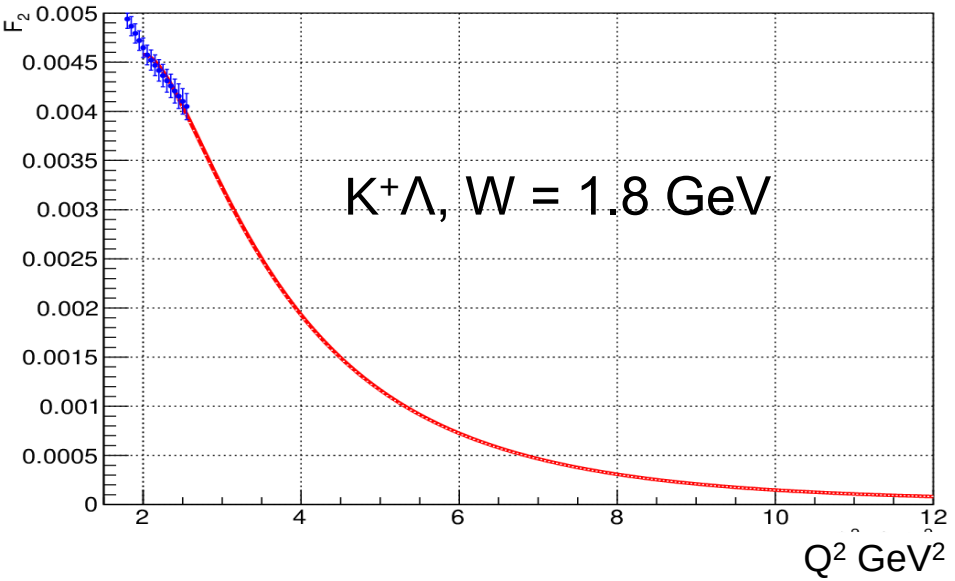


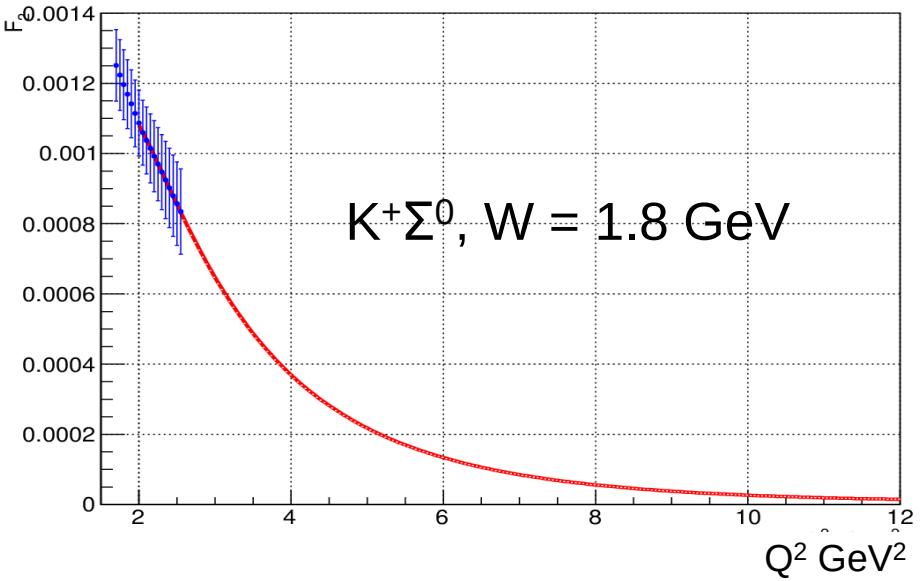


Fit of the exclusive contributions $F_{2,ch}$ into inclusive $F_{2,\,inc}$ structure function and their extrapolation at 5 GeV^2< Q^2 < 12 GeV^2





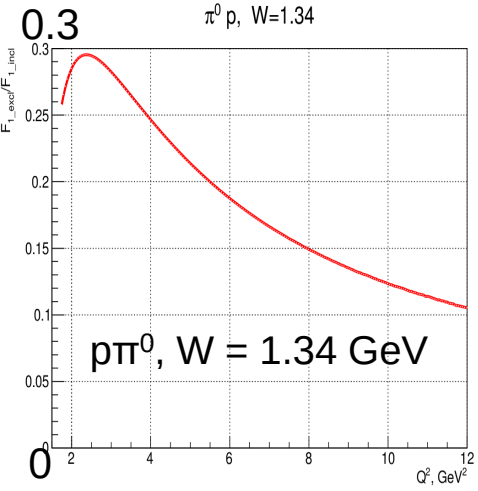


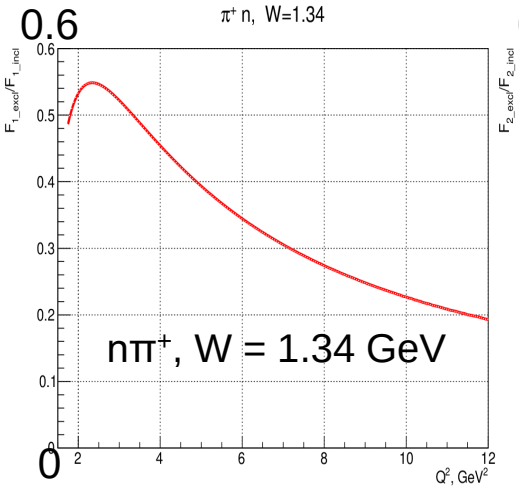


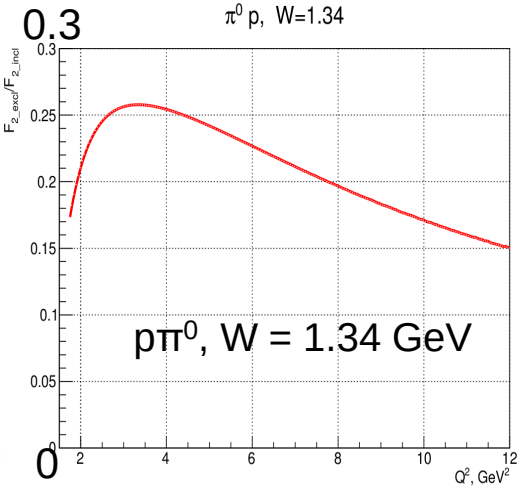
Constraints from inclusive structure functions

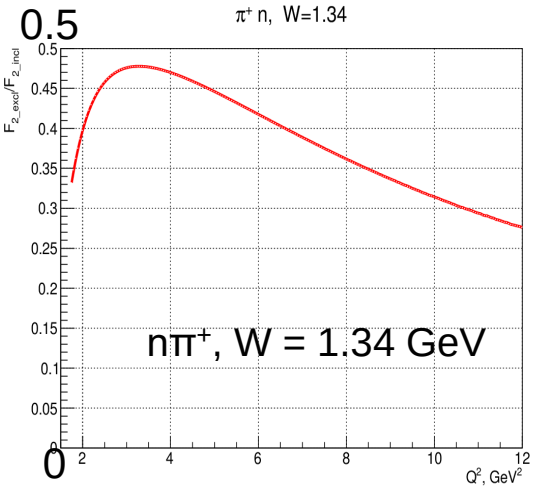
F /F 1,ch 1,inc

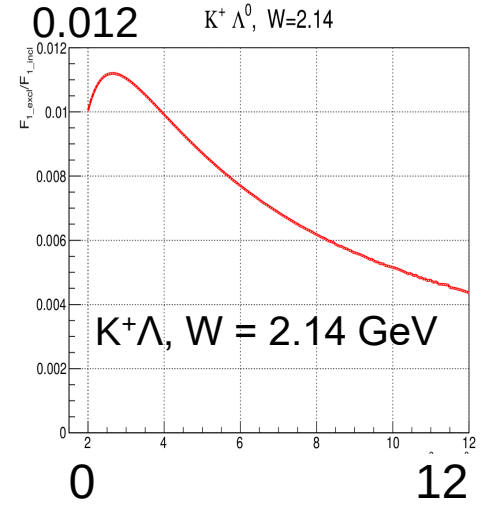
F /F 2,ch 2,inc

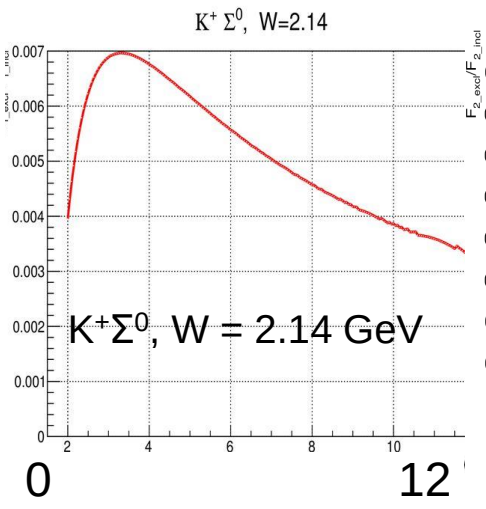


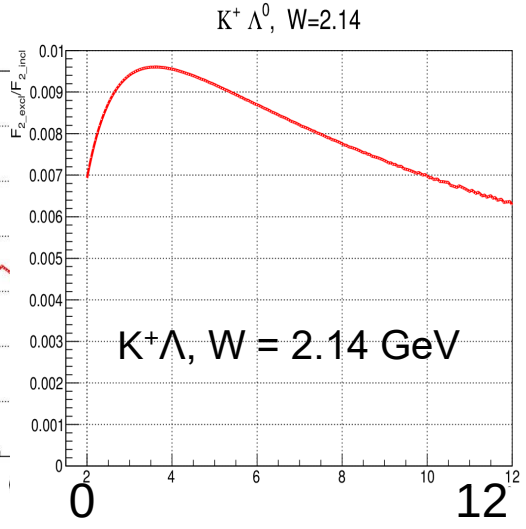


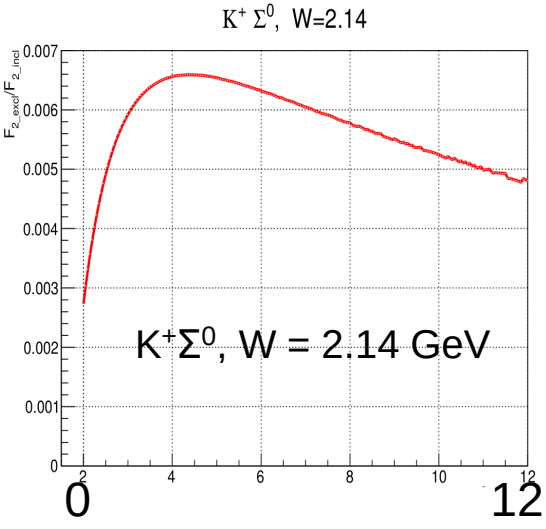




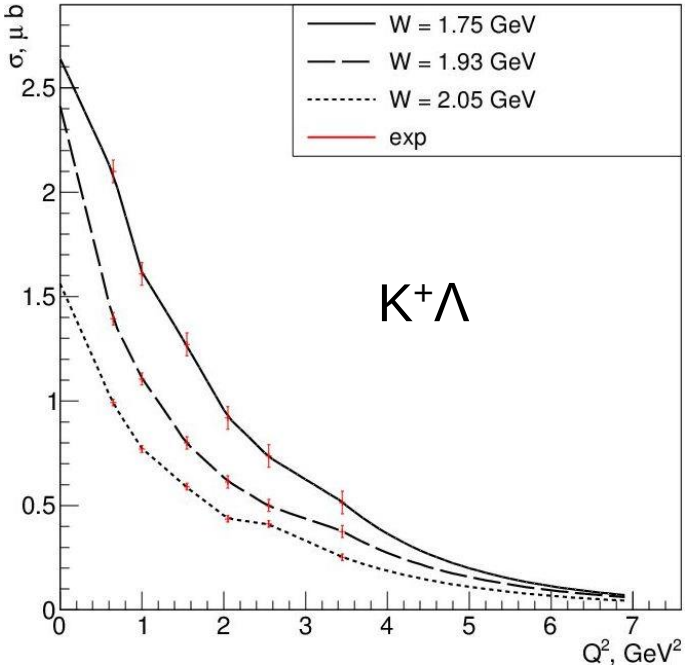


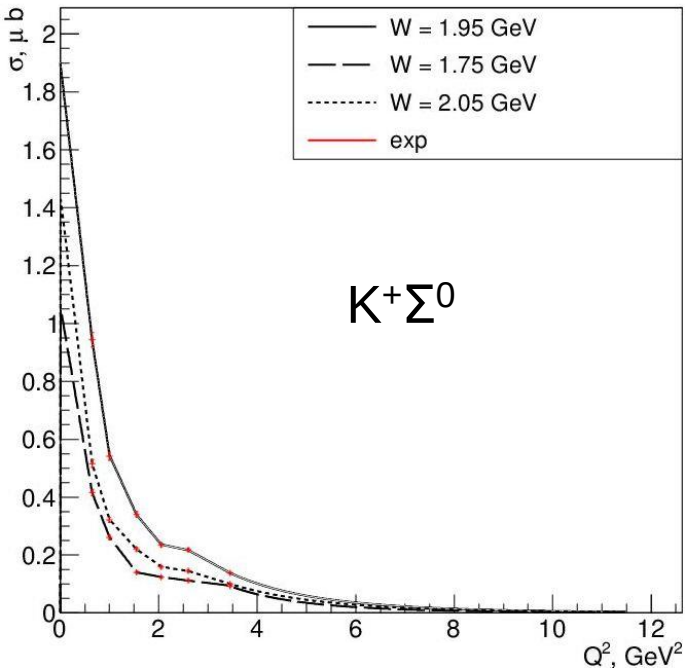


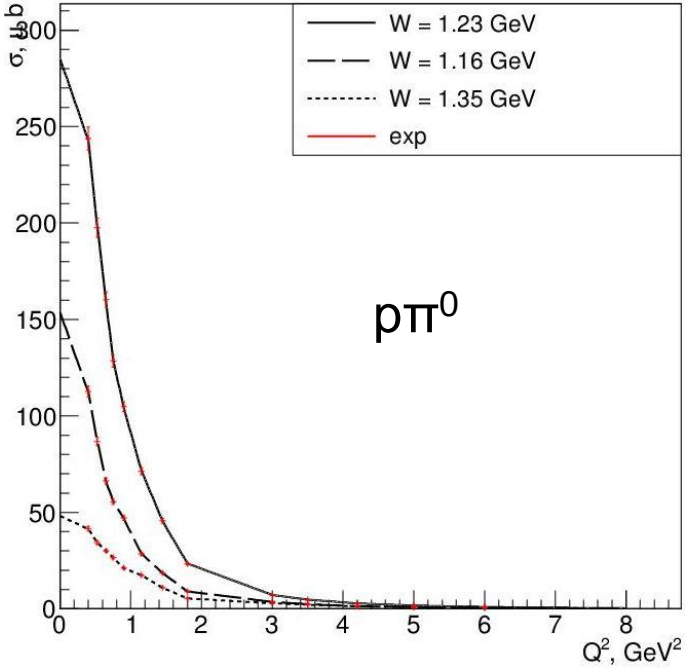


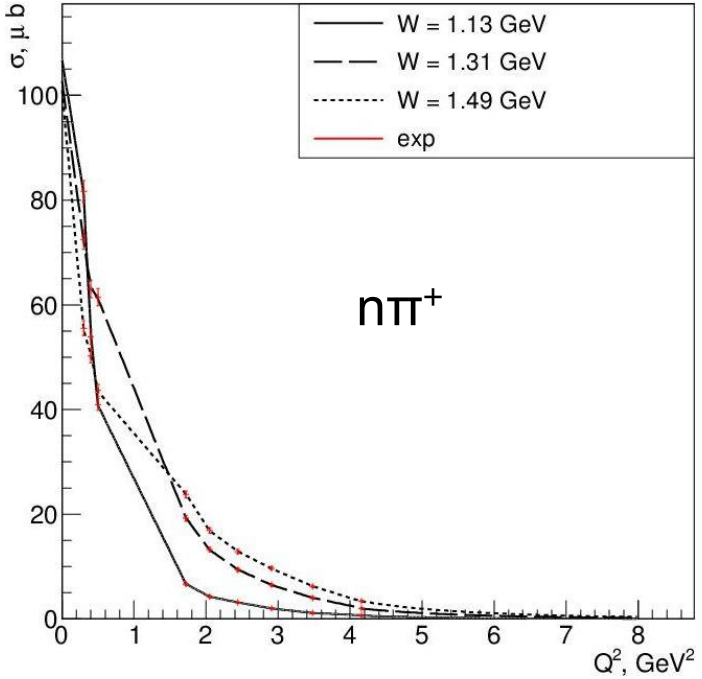


Q^2-evolution of interpolated/extrapolated fully integrated cross sections at different W, Ebeam = 12 GeV





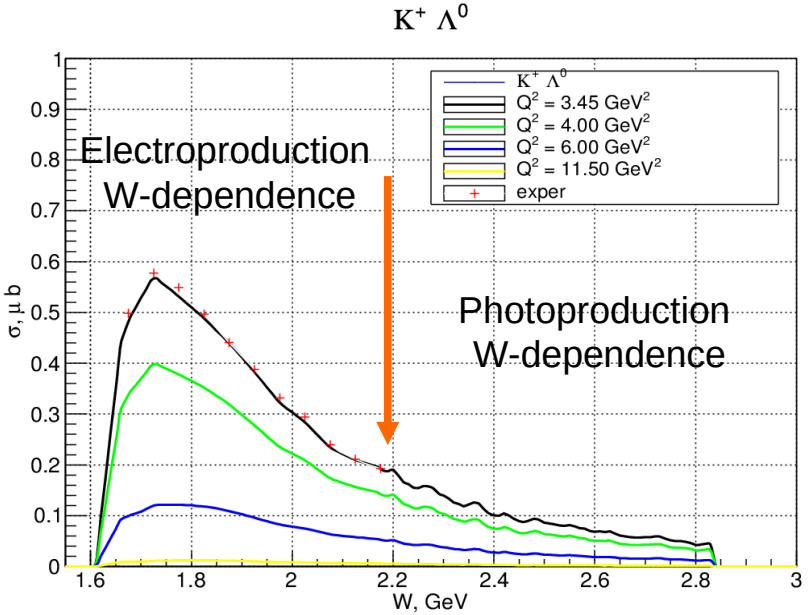


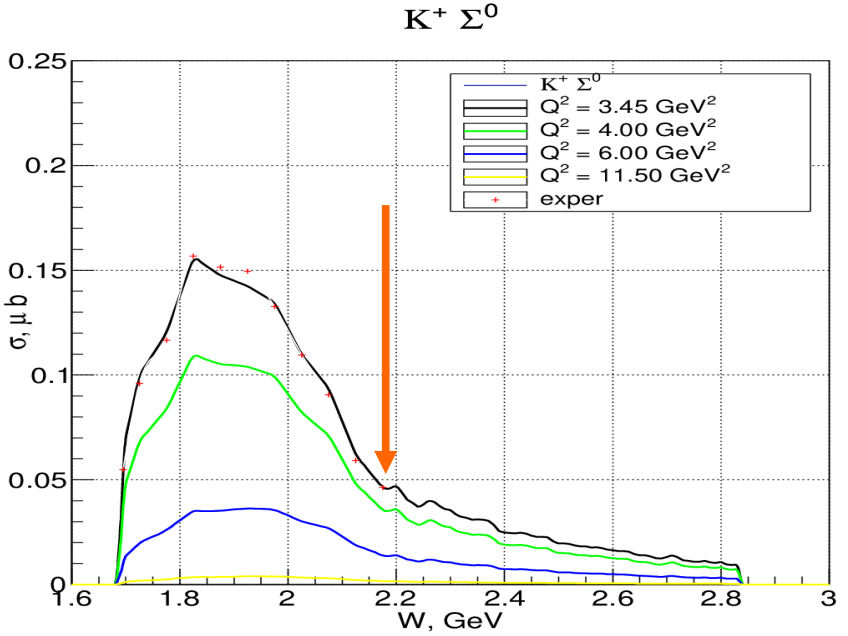


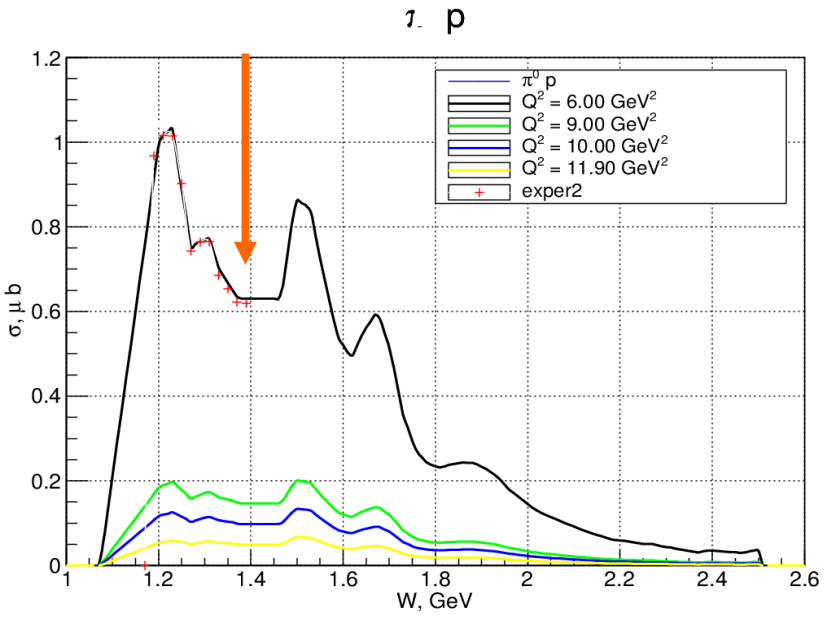
Extrapolation of the exclusive electroproduction cross sections into the W regions where the data are not available

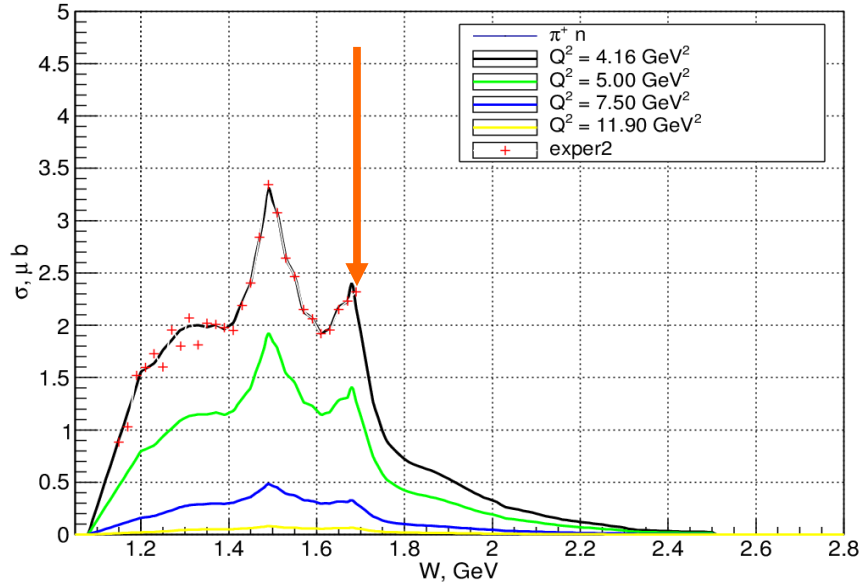
$$\sigma_{ch}(W,Q^2)=\sigma_{ch}(W_{\max},Q^2)\frac{\sigma_{ch,ph}(W,Q^2=0)}{\sigma_{ch,ph}(W_{\max},Q^2=0)}$$

Extrapolation is based on W-dependence of the photoproduction data



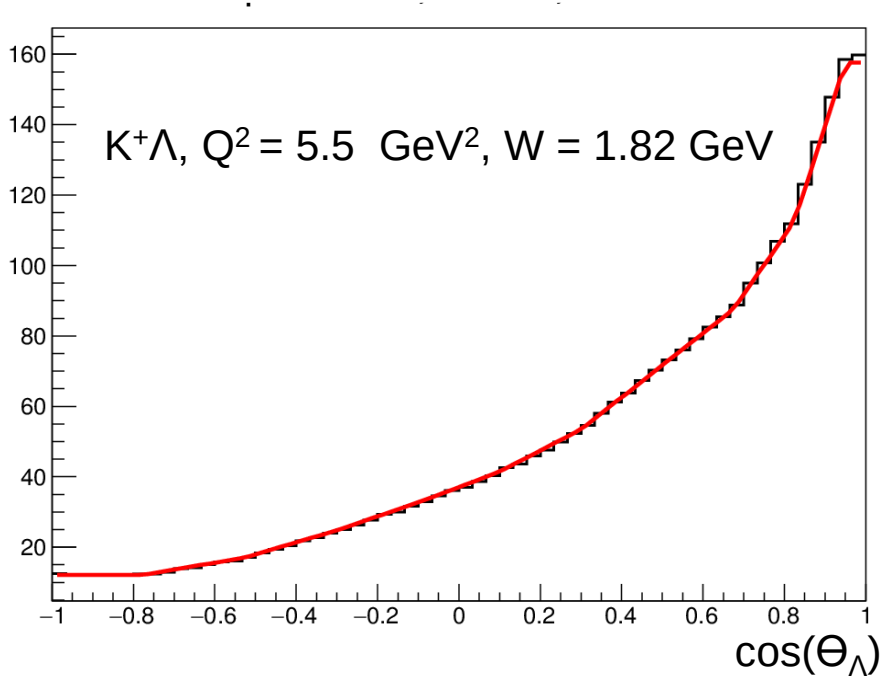


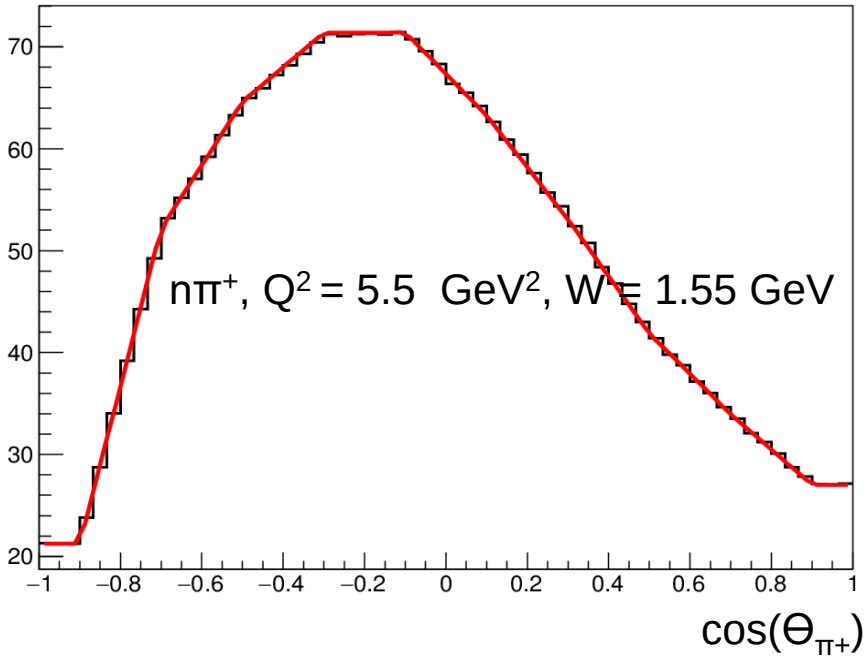


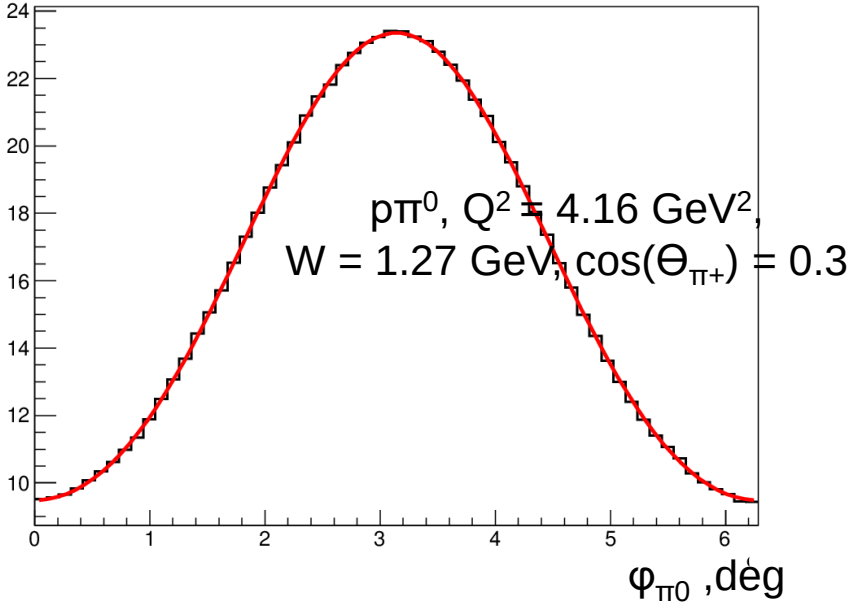


Computed event distributions from EGs normalized to the fully integrated cross section values

Examples:







Summary

The method for extrapolation of $p\pi^0$, $n\pi^+$, $K^+\Lambda$, $K^+\Sigma^0$ exclusive electroproduction cross sections from the CLAS data towards high photon virtualities $5 < Q^2 < 12$ GeV^2 covered with the CLAS12 has been developed.

Event generators for modeling $p\pi^0$, $n\pi^+$, $K^+\Lambda$, $K^+\Sigma^0$ are available in *https://userweb.jlab.org/~golovach/ev_gen/www_eg/* *and can be* used for analyses of the experimental data from the CLAS and CLAS12

Possible contributions to the common tools?