SoLID Event Generator Update

Ye Tian

Syracuse University

June 10-11 2021 SoLID collaboration meeting

SoLID Inclusive Event Generators

Electron Generators:

evgen_inclusive_e https://github.com/JeffersonLab/evgen_inclusive_e.git

1. **Fit F1F209**

The W<3 GeV Peter Bosted fit (2009)

The W>3 GeV world PDF sets

2. **Fit F1F221**

The W^2<20 GeV^2 and all Q^2<30 GeV^2---Christy's fit (2021)

- ✓ Significantly improved the fits to proton (W^2>7), deuteron, 4He, 12C, 27Al, and 56Fe (covering the full 12 GeV kinematics).
- ○ For 3He, all the physics components in the fit scale very well with A but the Fermi momentum parameters has not been set to a reasonable value (plan to update the fit soon).

SoLID Inclusive Event Generator

3. Radiative effects----- David Flay

- Refine the code---user friendly
- Add a scaling function on Born cross section

$$f(E_s) = 0.906 - 0.00699E_s$$

Jlab data: E94-010, E01-012 and F1F209 (Fortran code to calculate F1 and F2 ---P. Bosted and V. Mamyan)

4. Add energy loss calculation routines---Jixie

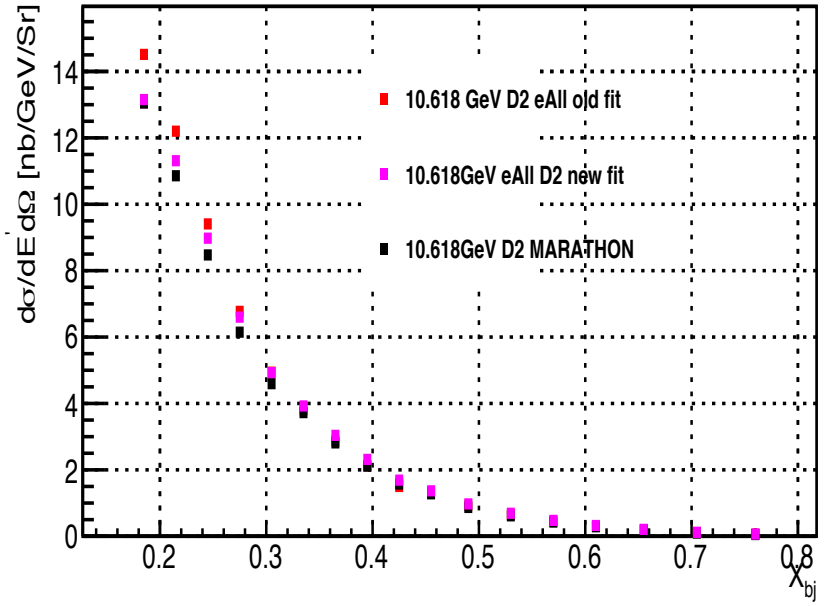
- After Eloss Kinematics Ei, Wi, Q2i, Xi, and yi

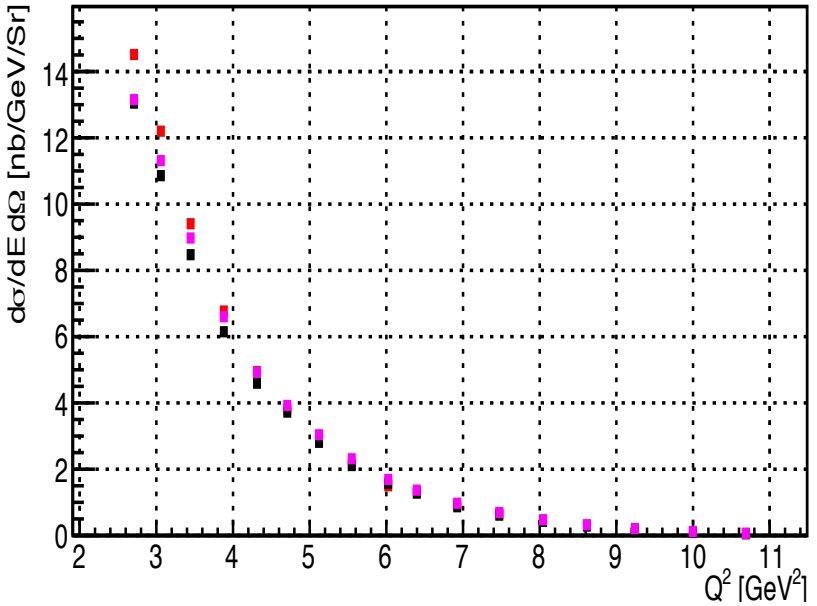
➢ **eicRate (eDIS)** /group/solid/solid_svn/evgen/eicRate_20101102/

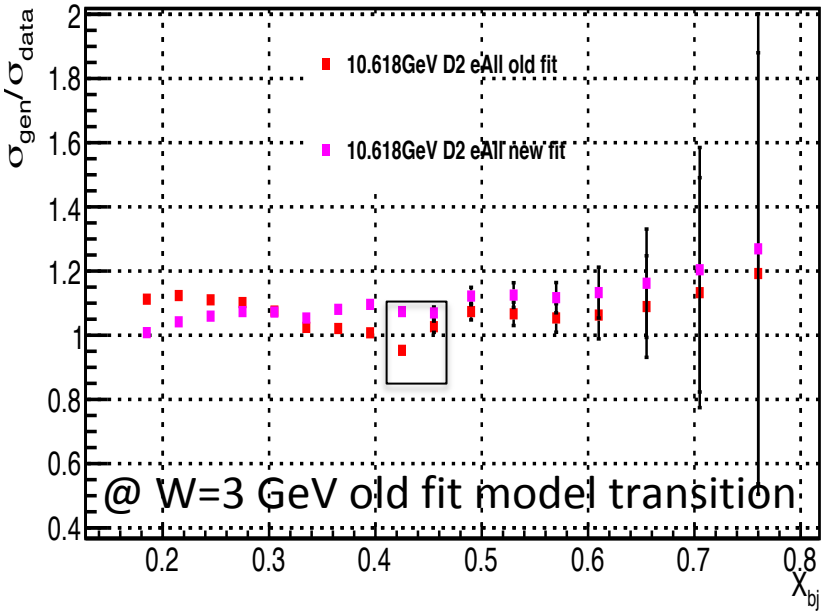
✓ **Compare the outputs from the updated "inclusive_e" generator to the available data.**

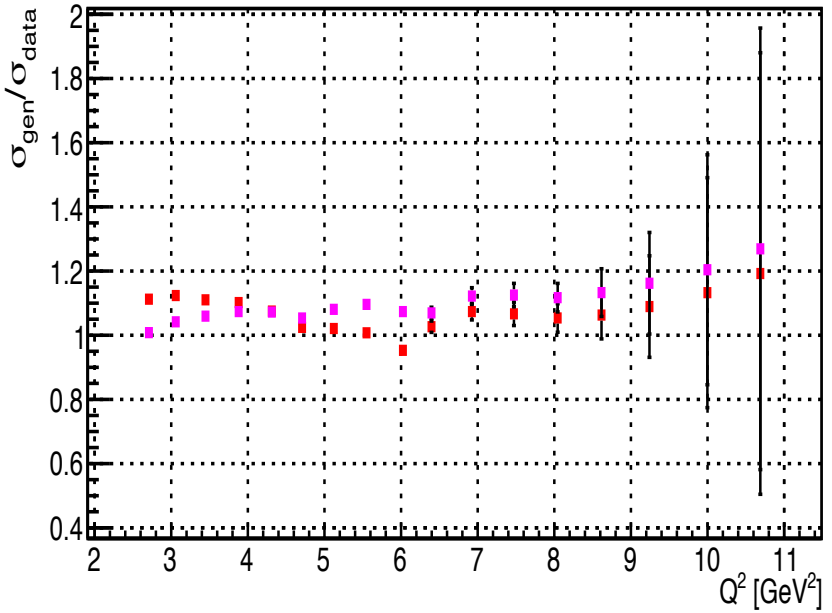
- **6 GeV d2n data**------David's thesis He3 target
- **10.6GeV MARATHON data**---------Jason Earl Bane' thesis D2, 3He, H3------**W>2.5 GeV**

D2 target

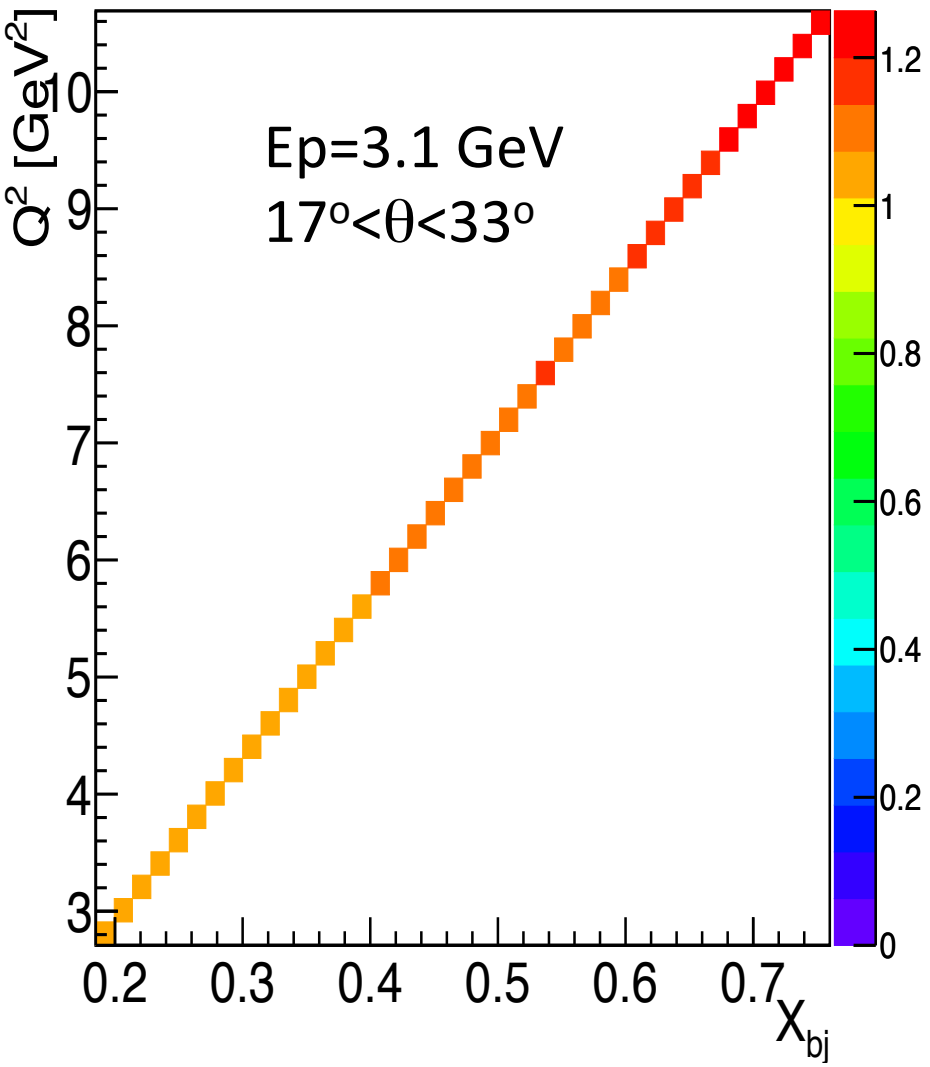

dσ/dE'dΩ [nb/GeV/Sr]
10.618 GeV D2 eAll old fit
10.618GeV eAll D2 new fit
10.618GeV D2 MARATHON
X_bj

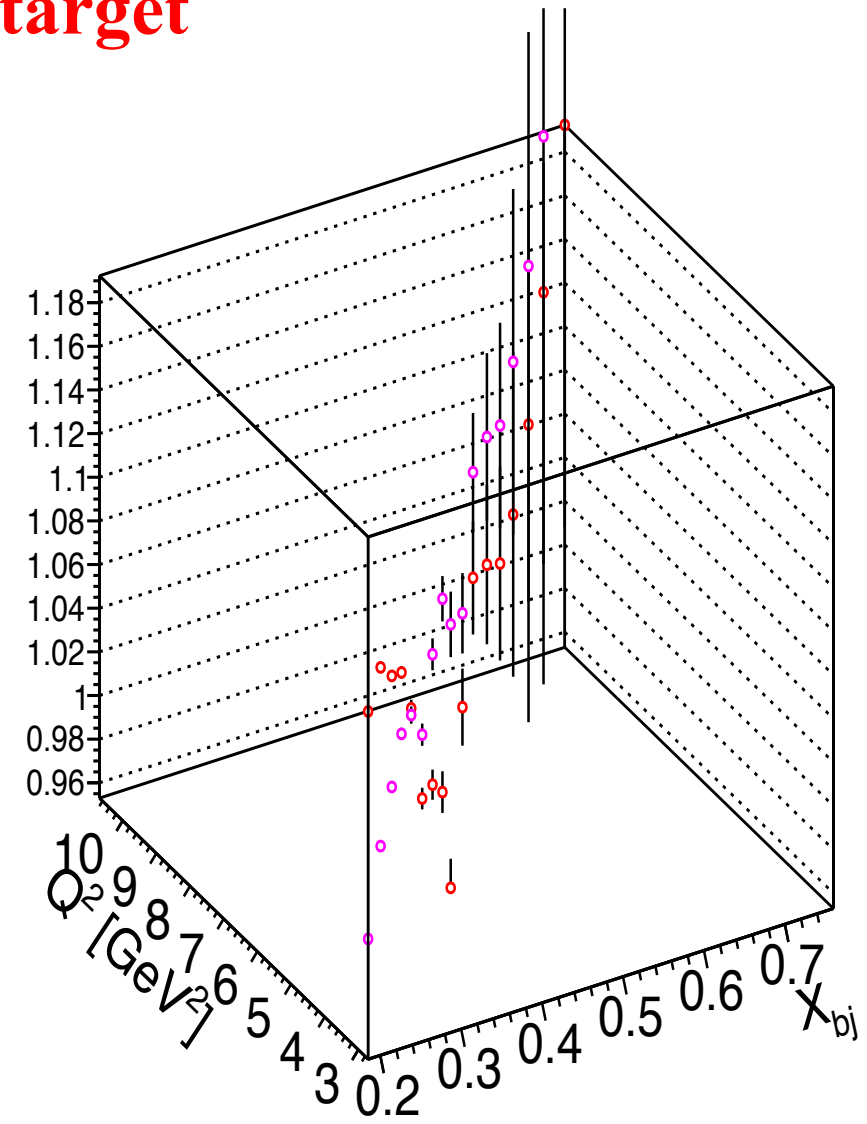

dσ/dE'dΩ [nb/GeV/Sr]
Q² [GeV²]


σ_gen/σ_data
10.618GeV D2 eAll old fit
10.618GeV D2 eAll new fit
@ W=3 GeV old fit model transition
X_bj

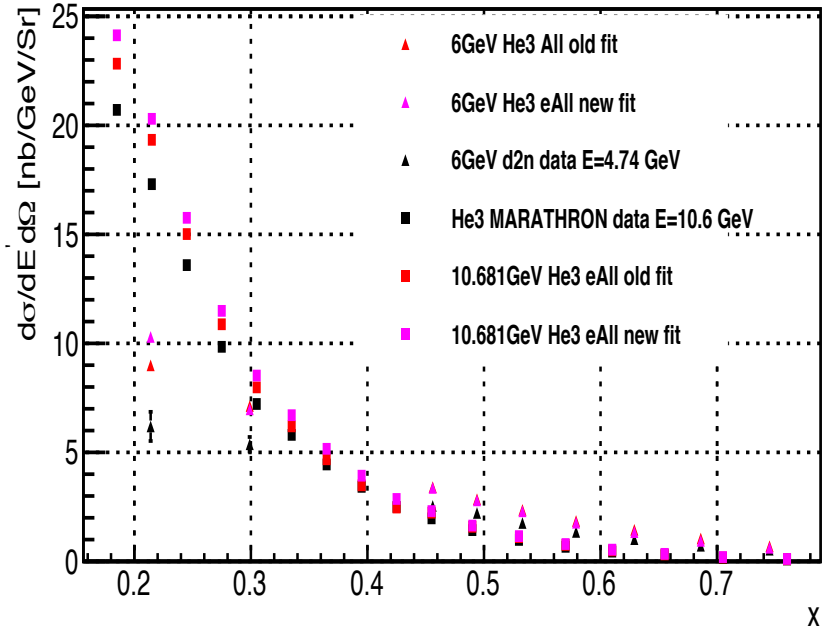

σ_gen/σ_data
Q² [GeV²]

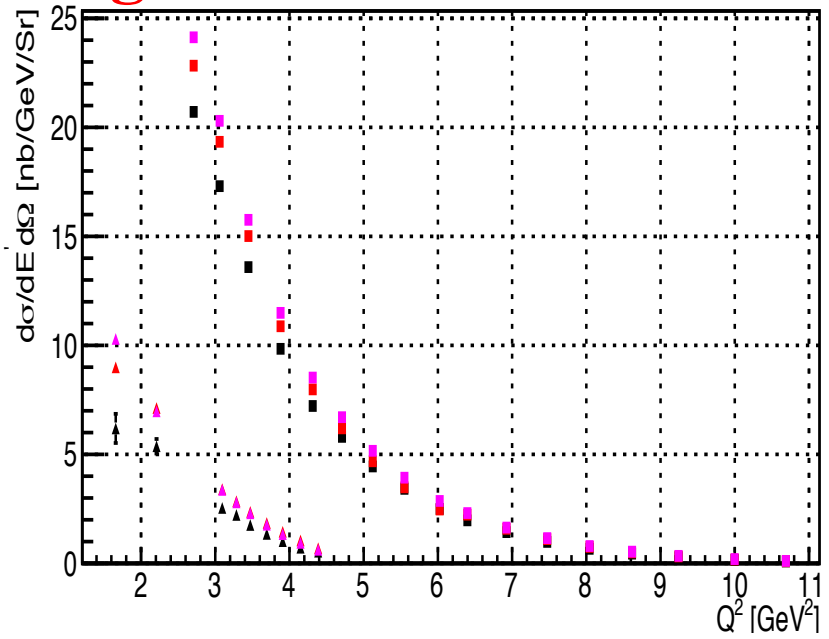
D2 target

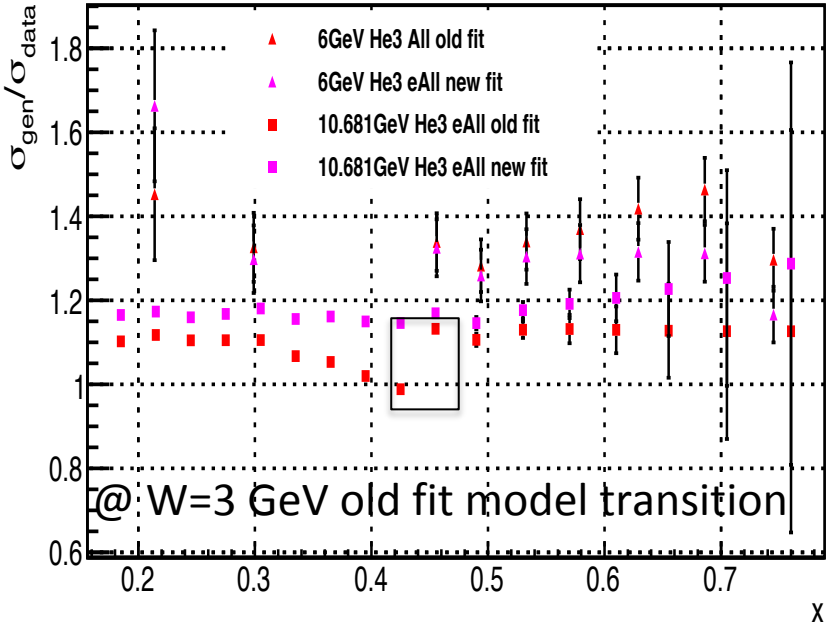


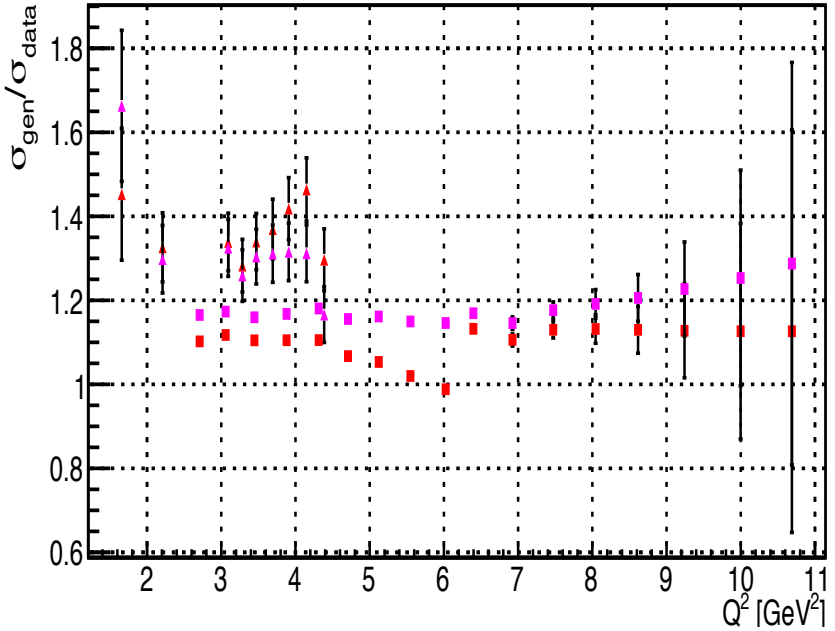


He3 target


6GeV He3 All old fit
6GeV He3 eAll new fit
6GeV d2n data E=4.74 GeV
He3 MARATHRON data E=10.6 GeV
10.681GeV He3 eAll old fit
10.681GeV He3 eAll new fit
dσ/dE'dΩ [nb/GeV/Sr]
x


dσ/dE'dΩ [nb/GeV/Sr]
Q² [GeV²]


6GeV He3 All old fit
6GeV He3 eAll new fit
10.681GeV He3 eAll old fit
10.681GeV He3 eAll new fit
σgen/σdata
x
@ W=3 GeV old fit model transition


σgen/σdata
Q² [GeV²]

Hadron Generators

- **evgen_bggen:** https://github.com/JeffersonLabevgen_bggen.git

➢ E>3 GeV: PYTHIA is used
➢ 0.15<E<3 GeV: a mixture of 10 dominating π exclusive processes ($\gamma + p$) is used. For the single pion production differential cross sections, the SAID code is used.

1. Z dependence (loop Z and E_γ)
2. Improve the simulation efficiency----user friendly
3. Investigate π^- "double-peak" momentum distribution

- **eicRate (hadron): Wiser fit** /group/solid/solid_svn/evgen/eicRate_20101102/

❖ The estimated charged pion rate from "bggen" generator has <30 % uncertainties by quantifying with the MARATHON data, and π^0 estimated rate has 20-30% uncertainty compared with DVCS data.

Ongoing----Compare to Geant4

- Compare eAll to geant4 simulation
- Compare bggen to geant4 simulation

} Need more statistics

1mm and 40 cm LH, LD, He_3 targets+sphere, vacuum

Physics: QGSP_BERT_HP+STD+Optical

- STD: EM standard.
- QGSP_BERT_HP

✓ The physics list most recommended for HEP

✓ Used by ATLAS

✓ Contains standard EM processs

✓ Uses Bertini cascade for hadrons of energy below~10GeV

✓ Uses QGC model for high energies (>20GeV)

✓ Used for neutrons below 20MeV (with high precision neutron model)

✓ Can be used for radiation protection and shielding applications.

❖ Goal: fast and complete simulation tools

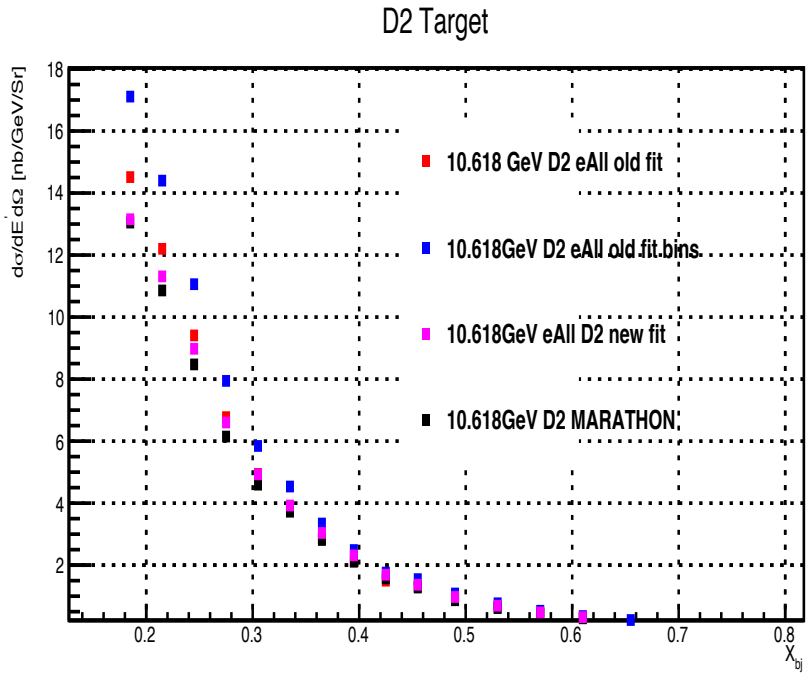
Summary and Outlook

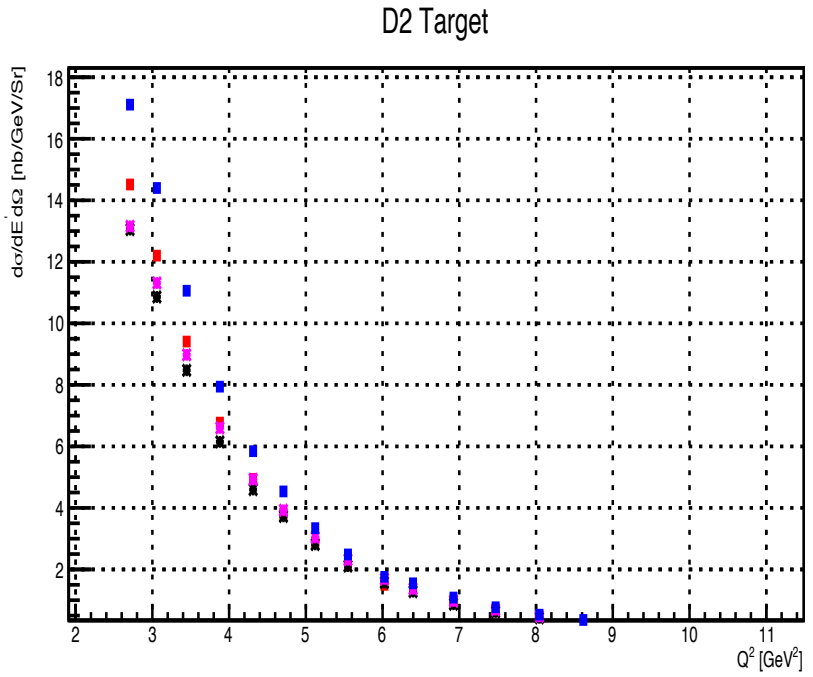
- The new F1F221 fit has been adapted in the evgen_inclusive_e generator, and it covers the full 12GeV kinematics.

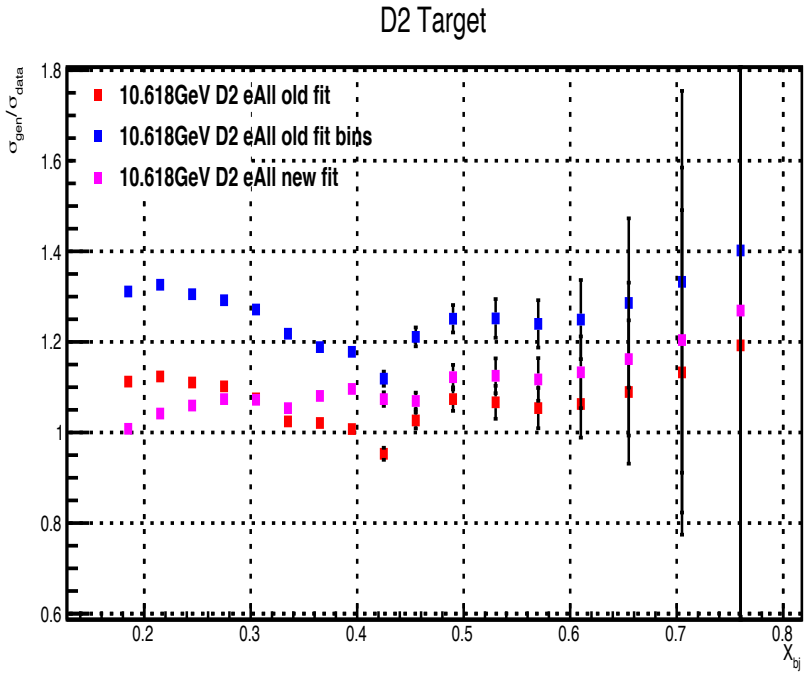
- Inclusive electron cross sections calculated from the evgen_inclusive_e generator with F1F221 fit are <20% higher than MARATHON data for LD2 target, and <30 % higher than MARATHON and d2n data for He3 target.

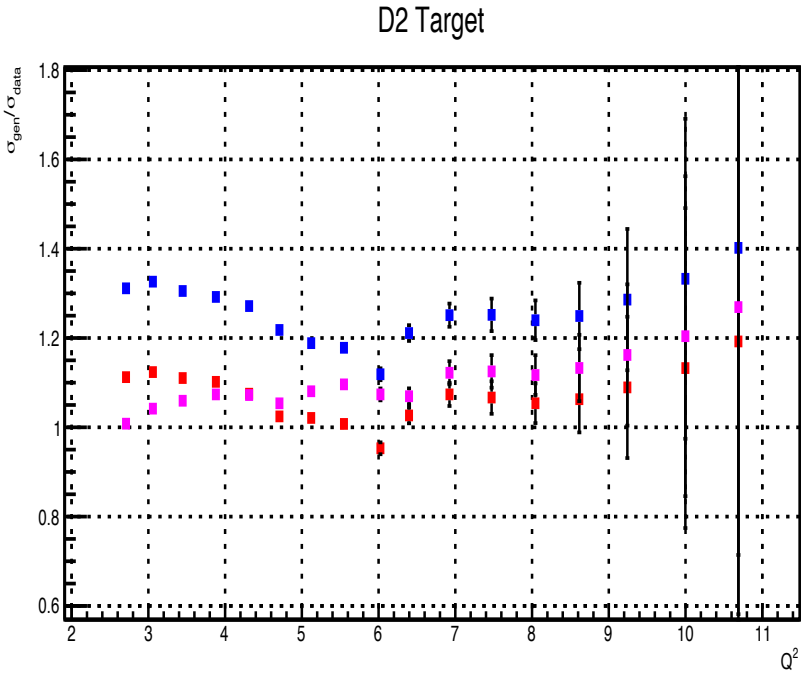
- The comparisons between geant4 electron simulation and evgen_inclusive_e generator, geant4 hadron simulation and bggen are ongoing.

Back Up

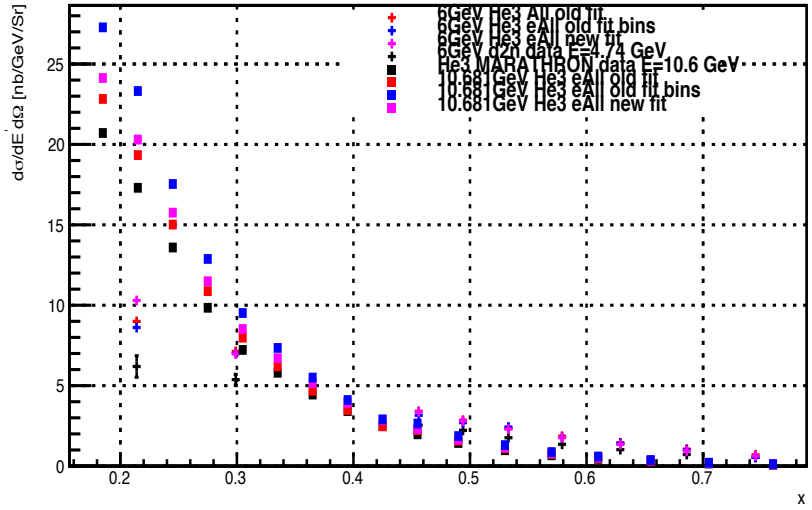

D2 Target
dσ/dE'dΩ [nb/GeV/Sr]
10.618 GeV D2 eAll old fit
10.618GeV D2 eAll old fit bins
10.618GeV eAll D2 new fit
10.618GeV D2 MARATHON
X_bj

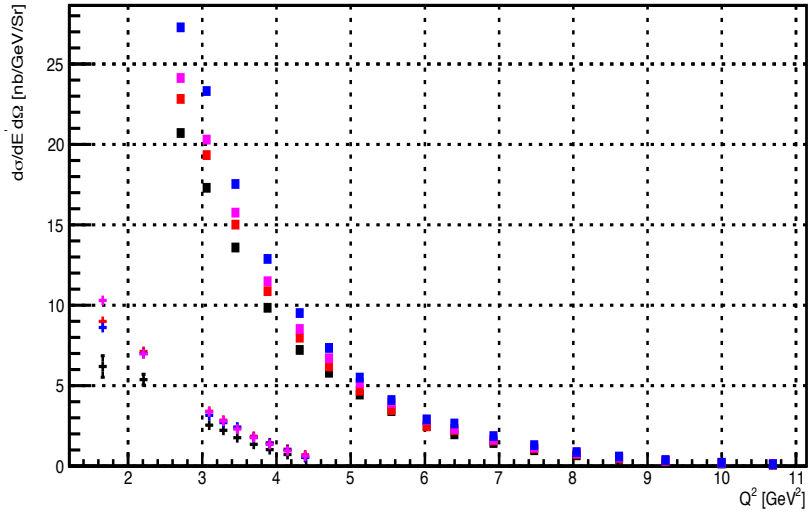

D2 Target
dσ/dE'dΩ [nb/GeV/Sr]
Q² [GeV²]

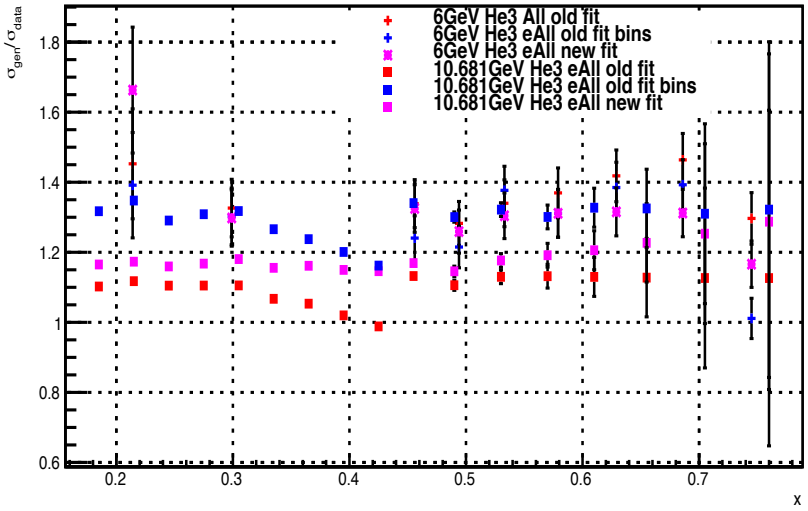

D2 Target
σ_gen/σ_data
10.618GeV D2 eAll old fit
10.618GeV D2 eAll old fit bins
10.618GeV D2 eAll new fit
X_bj

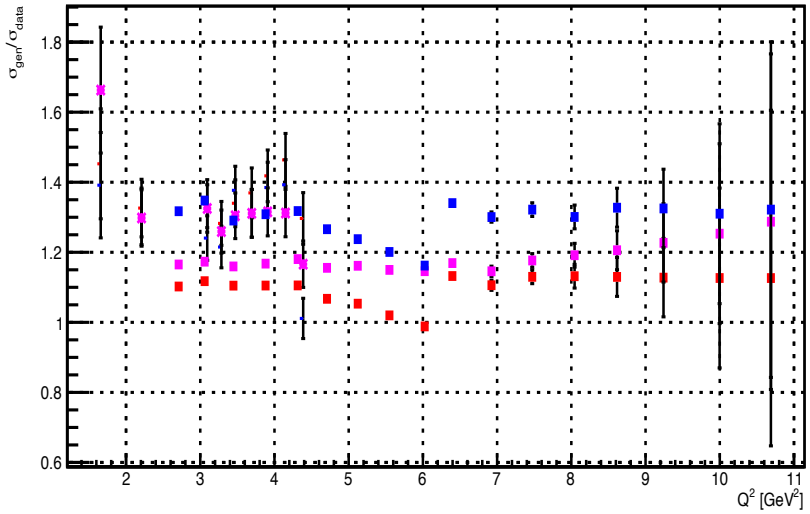

D2 Target
σ_gen/σ_data
Q²

He3 target









@ W=3 GeV old fit model transition

Assumption

- Rate calculation for A>1:

$\sigma_{\pi-}(D)= \sigma_{\pi-}(n)+\sigma_{\pi-}(p)=\sigma_{\pi+}(p)+\sigma_{\pi-}(p)$

$\sigma_{\pi+}(D)= \sigma_{\pi+}(n)+\sigma_{\pi+}(p)=\sigma_{\pi-}(p)+\sigma_{\pi+}(p)$

$\sigma_{\pi-}(He_3)= \sigma_{\pi-}(n)+2\sigma_{\pi-}(p)=\sigma_{\pi+}(p)+2\sigma_{\pi-}(p)$

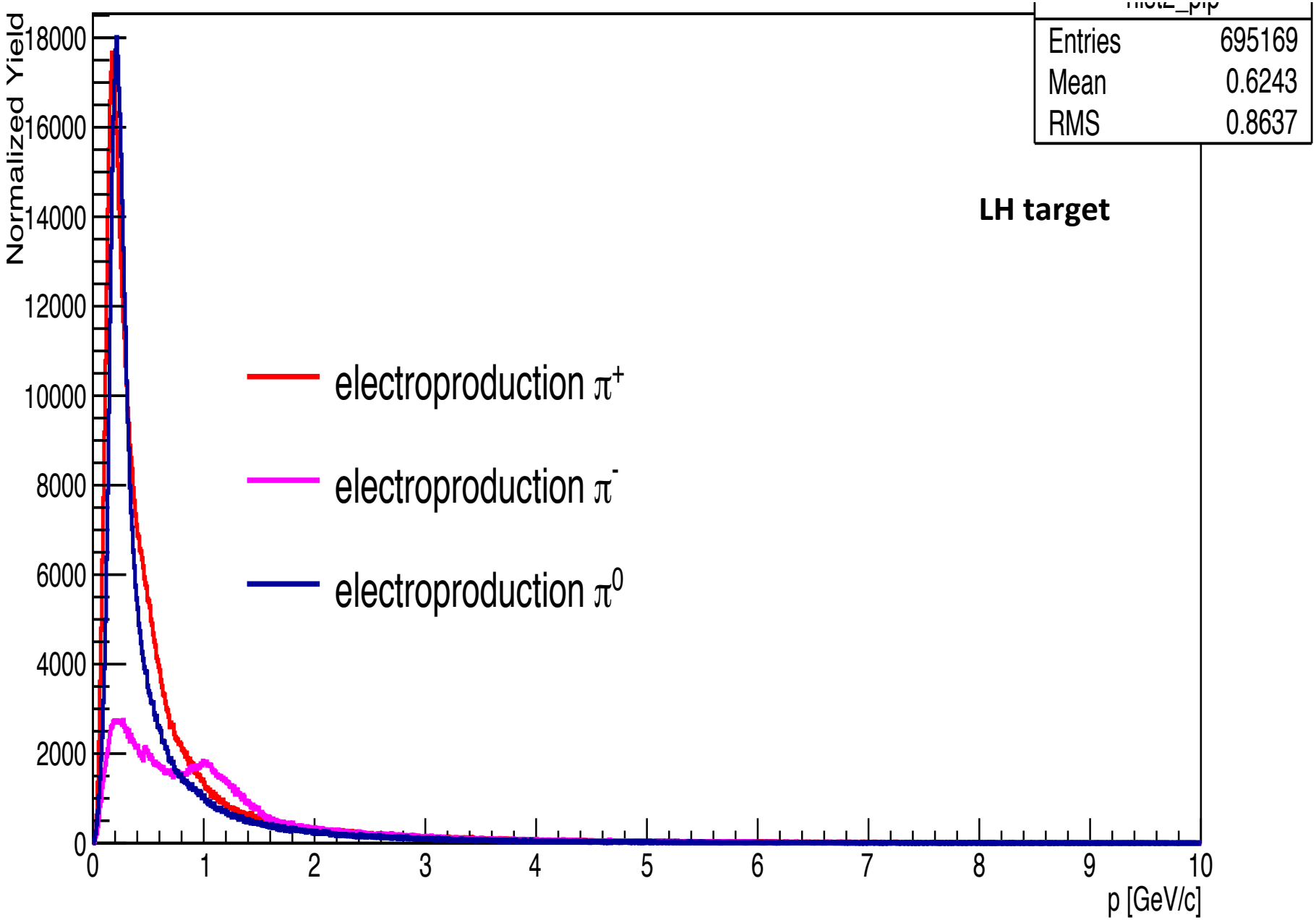
$\sigma_{\pi+}(He_3)= \sigma_{\pi+}(n)+2\sigma_{\pi+}(p)=\sigma_{\pi-}(p)+2\sigma_{\pi+}(p)$

Check the above assumption with MARATHON data:

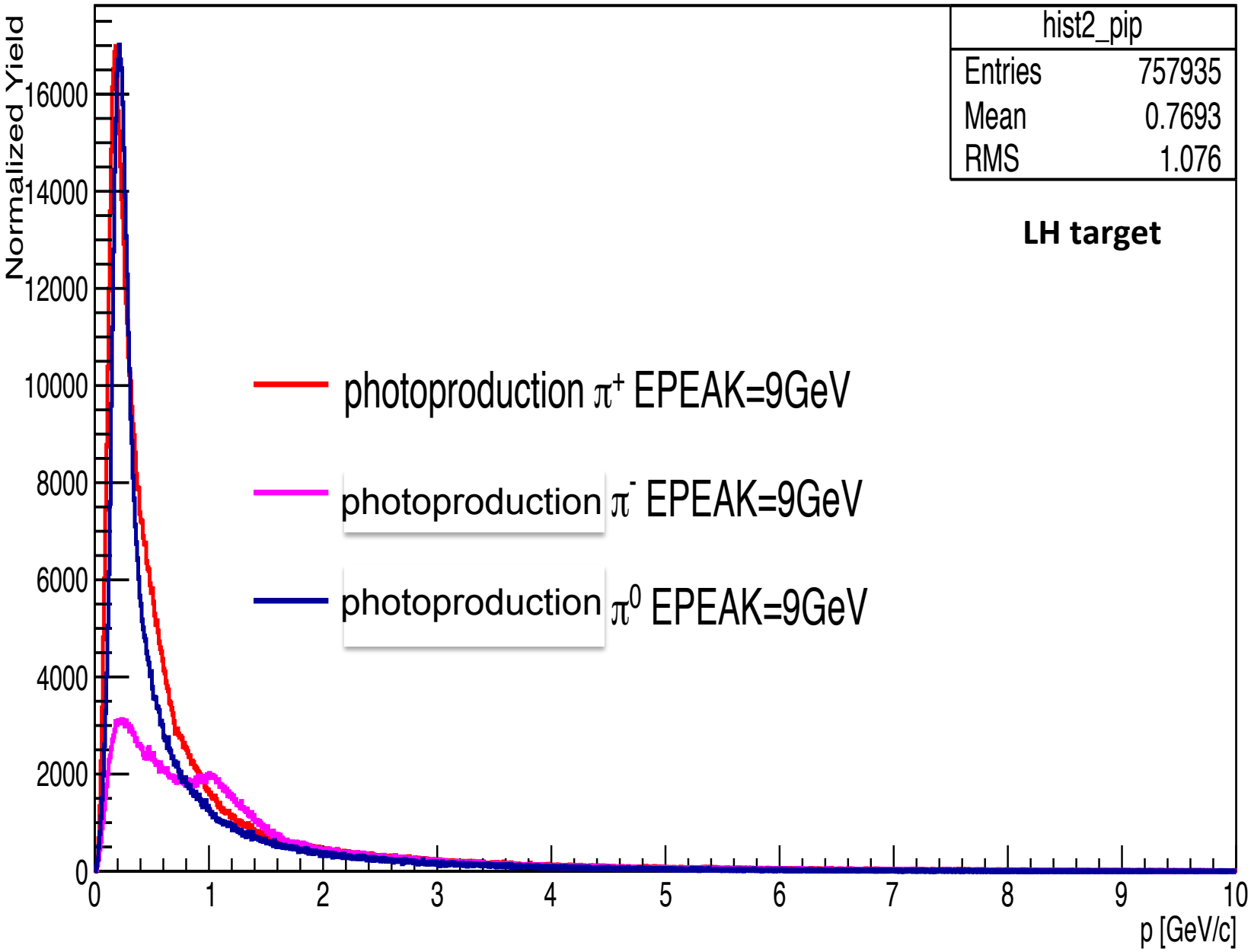
$\sigma_{\pi-}(n)=\sigma_{\pi+}(p)=1/3*[2\sigma_{\pi-}(H3)-\sigma_{\pi-}(He3)]$

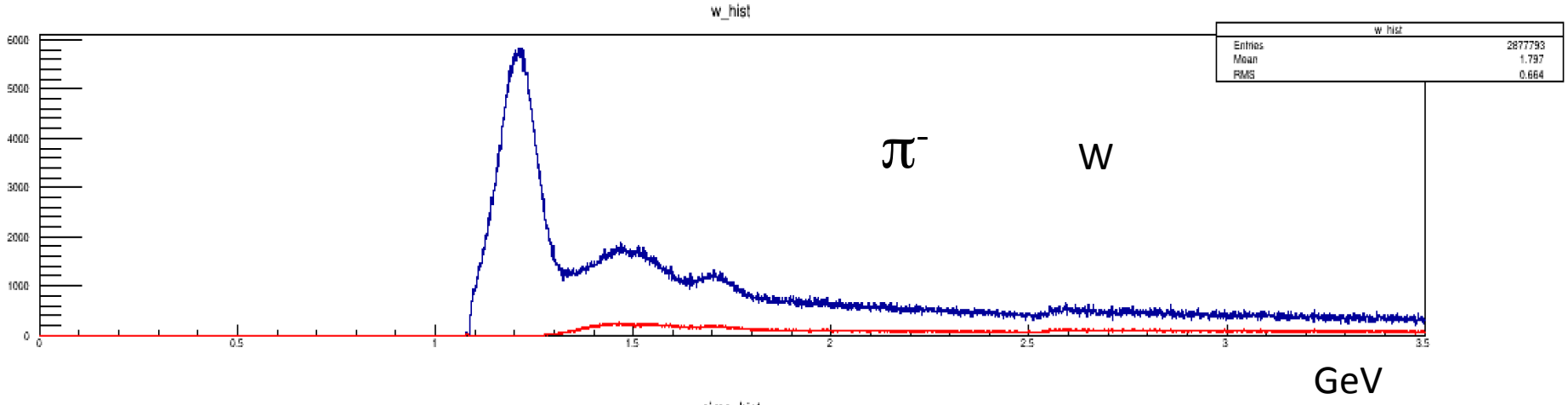
$\sigma_{\pi-}(p)=\sigma_{\pi+}(n)=1/3*[2\sigma_{\pi-}(He3)-\sigma_{\pi-}(H3)]$

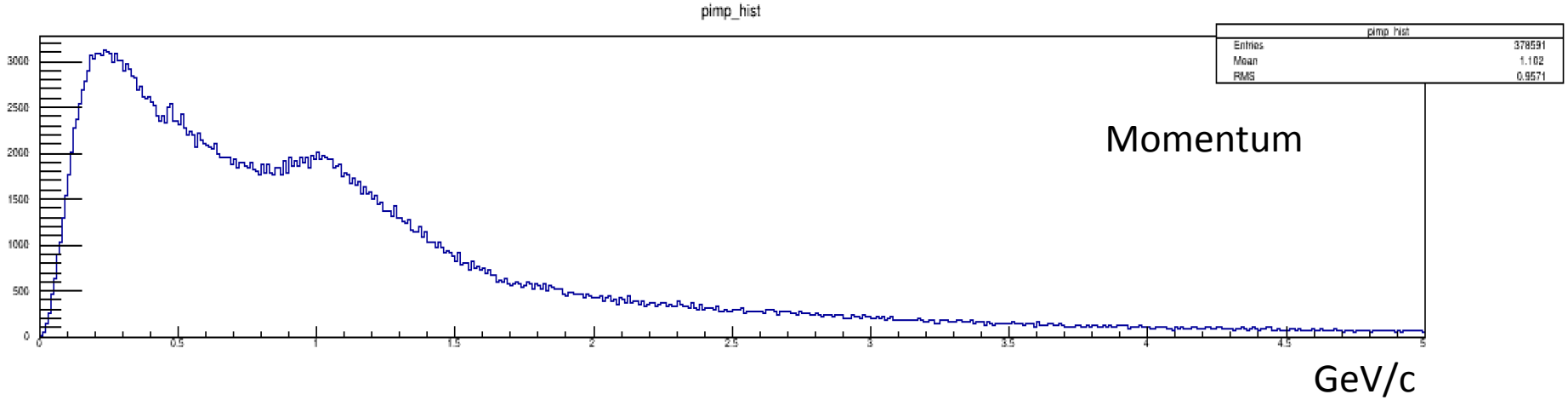
Bggen Electroproduction

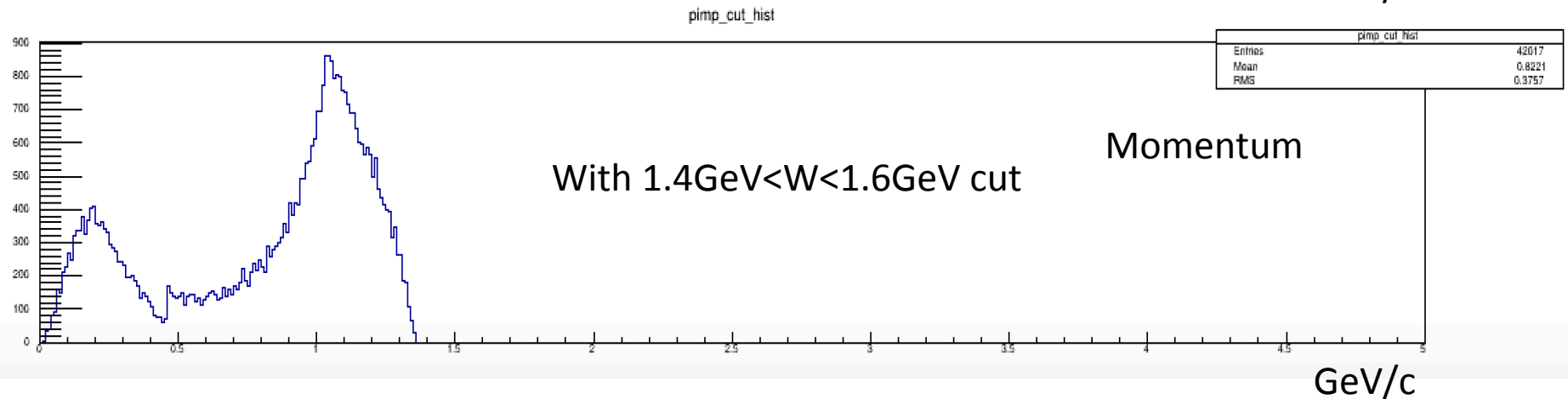


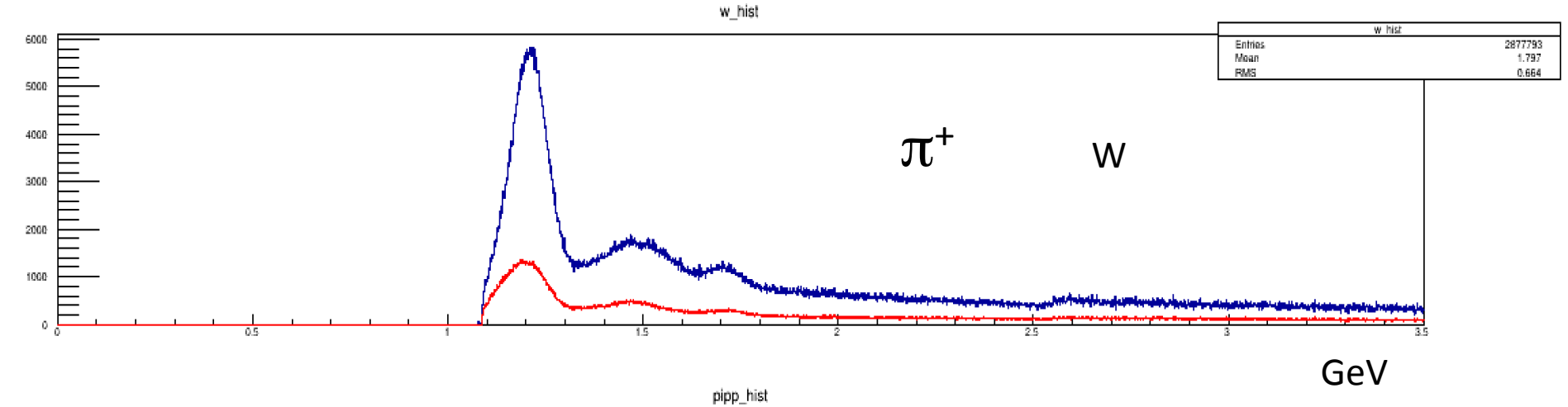
Bggen Photoproduction

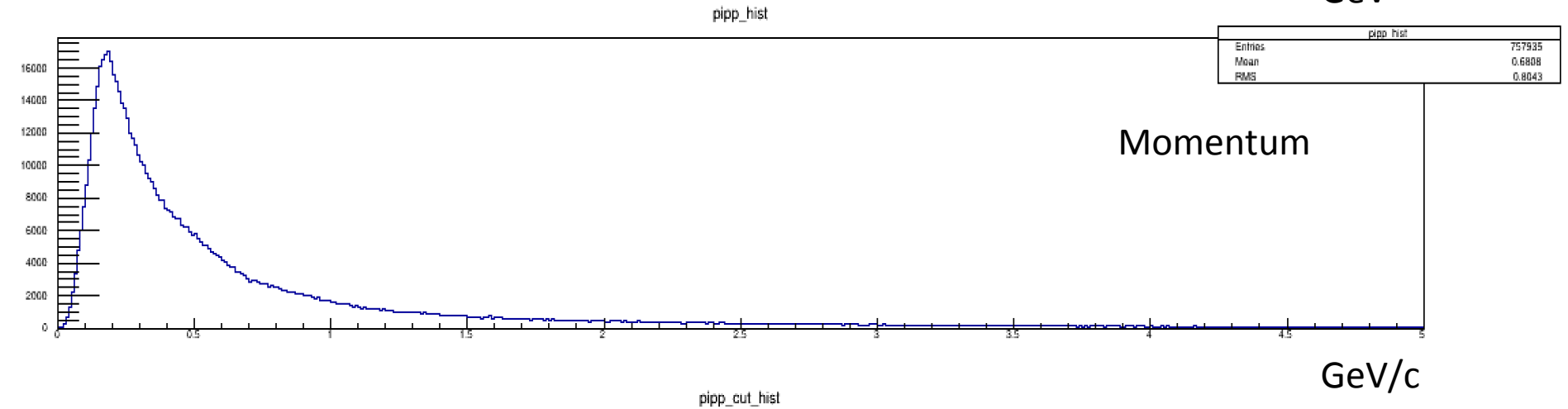


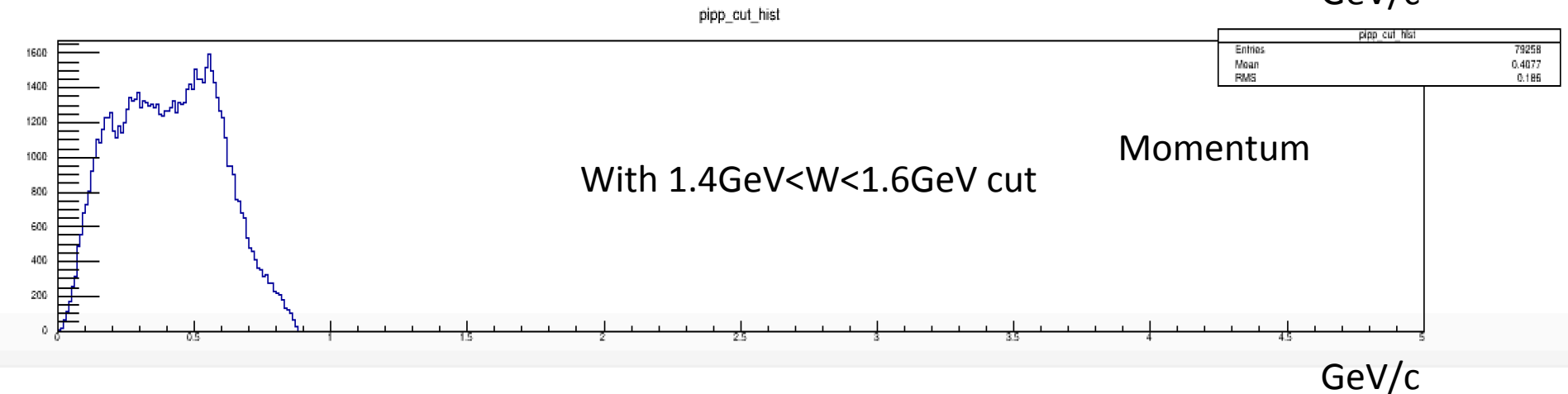

w_hist
w_hist
Entries 2877793
Mean 1.797
RMS 0.664
π^-
W
GeV


pimp_hist
pimp_hist
Entries 378591
Mean 1.102
RMS 0.9571
Momentum
GeV/c


pimp_cut_hist
pimp_cut_hist
Entries 42017
Mean 0.8221
RMS 0.3757
With 1.4GeV<W<1.6GeV cut
Momentum
GeV/c


w_hist
w_hist
Entries 2877793
Mean 1.797
RMS 0.664
π^+
W
GeV


pipp_hist
pipp_hist
Entries 757935
Mean 0.6808
RMS 0.8043
Momentum
GeV/c


pipp_cut_hist
pipp_cut_hist
Entries 79258
Mean 0.4077
RMS 0.186
Momentum
With 1.4GeV<W<1.6GeV cut
GeV/c