SoLID Event Generator Update

Ye Tian

Jan. 2021 collaboration meeting

SoLID Inclusive Event Generator

Electron:

- **evgen_inclusive_e**

The W<3 GeV Peter Bosted fit ($Q^2<11$ $(GeV/C)^2$)

The W>3 GeV world PDF sets

- **eicRate (eDIS)**

Hadron:

- **Evgen_bggen**

➢ 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.

- **eicRate (hadron): by Wiser fit**

Electron

❖ **Inclusive_e generator+ radiative effects------ David Flay**

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

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

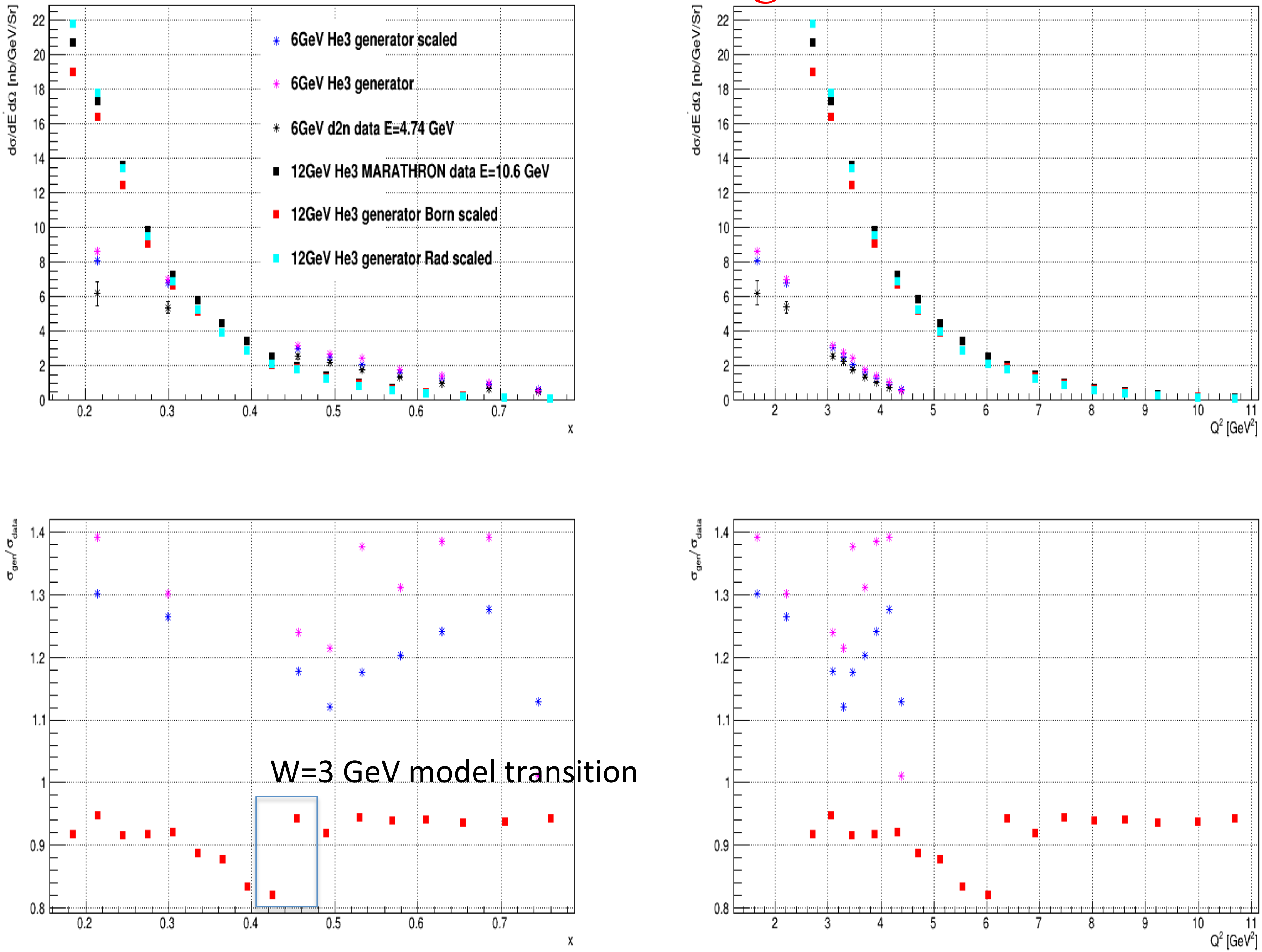
$$f\left(E_s\right) = 0.906 - 0.00699 E_s$$

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

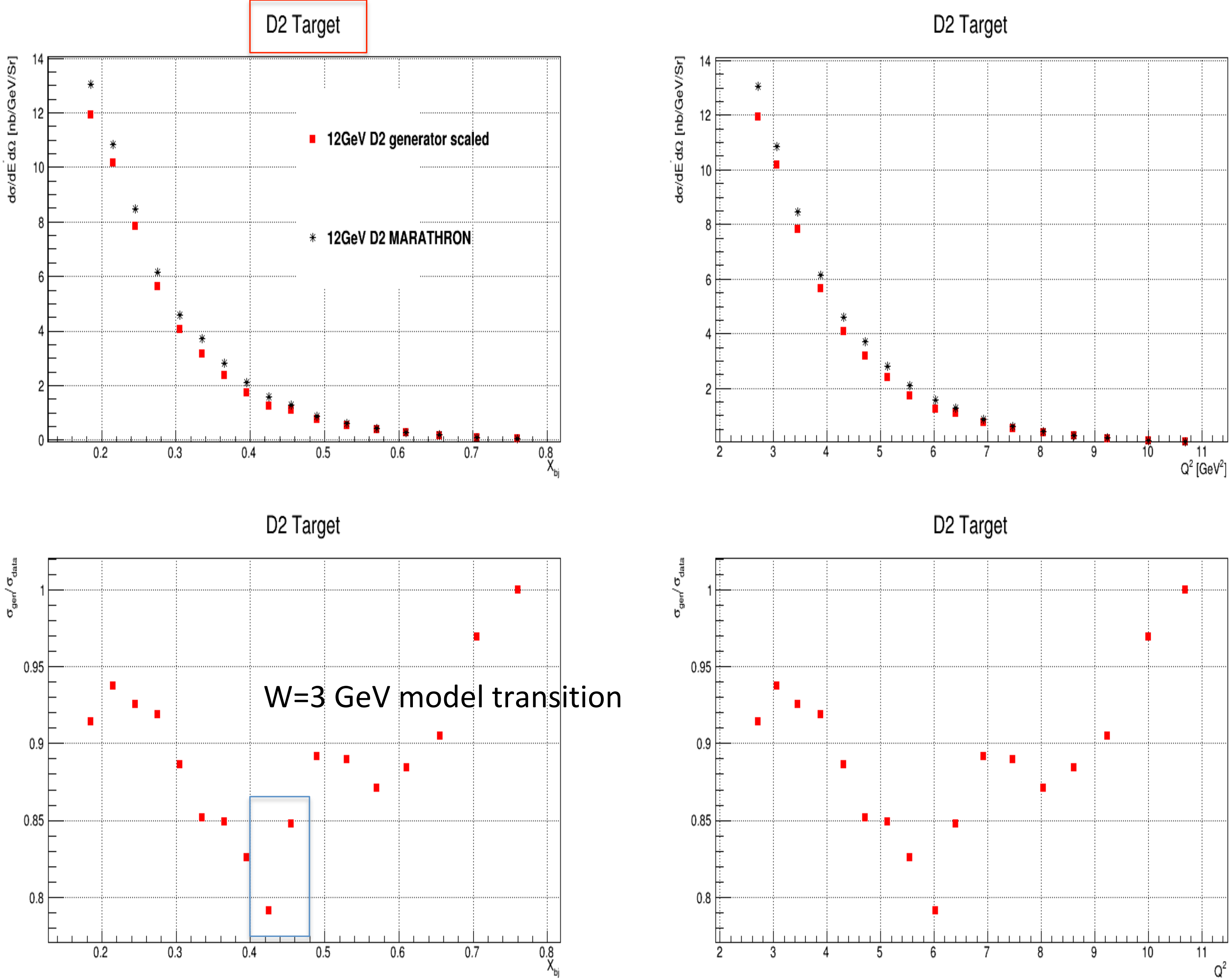
❖ **Compare the outputs from the updated "inclusive_e" generator to the available data.**

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

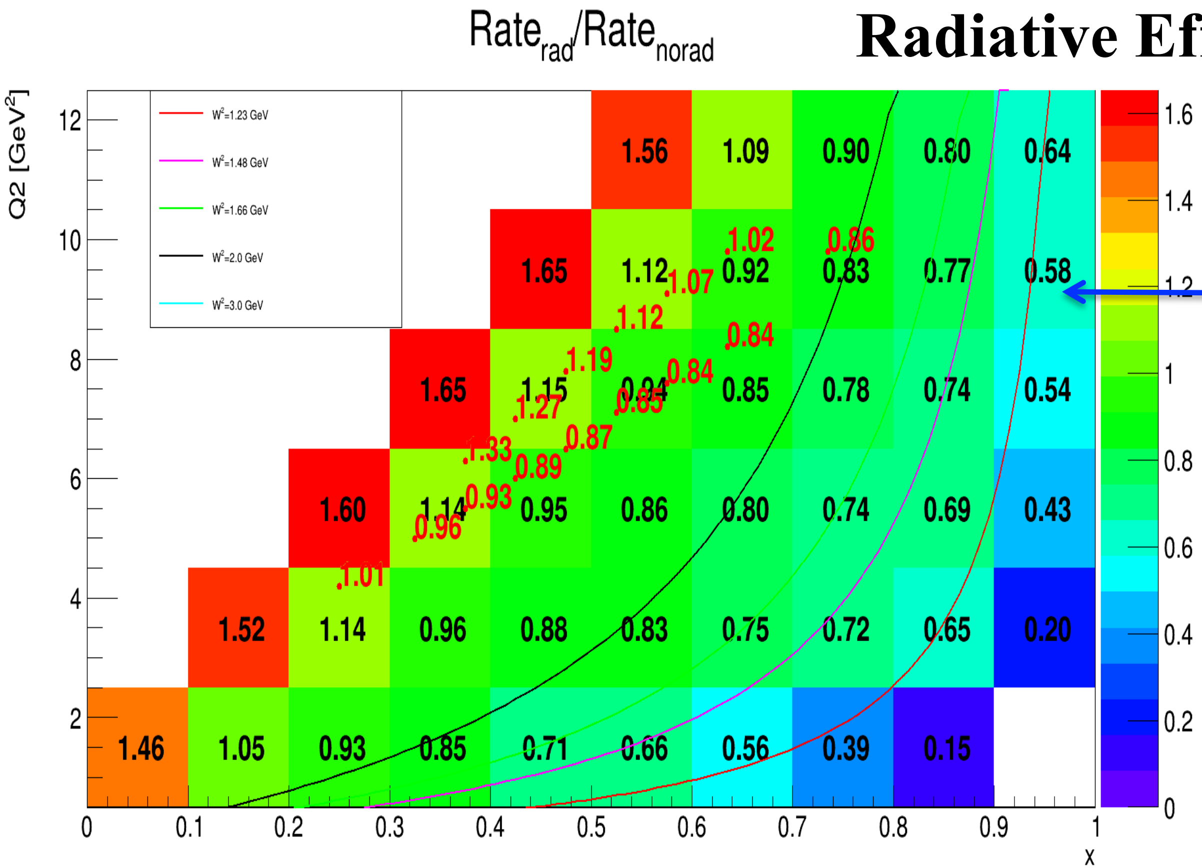
He3 target



6GeV He3 generator scaled
6GeV He3 generator
6GeV d2n data E=4.74 GeV
12GeV He3 MARATHRON data E=10.6 GeV
12GeV He3 generator Born scaled
12GeV He3 generator Rad scaled
$d\sigma/dE' d\Omega$ [nb/GeV/Sr]
x
Q^2 [GeV^2]
$\sigma_{gen}/\sigma_{data}$
W=3 GeV model transition

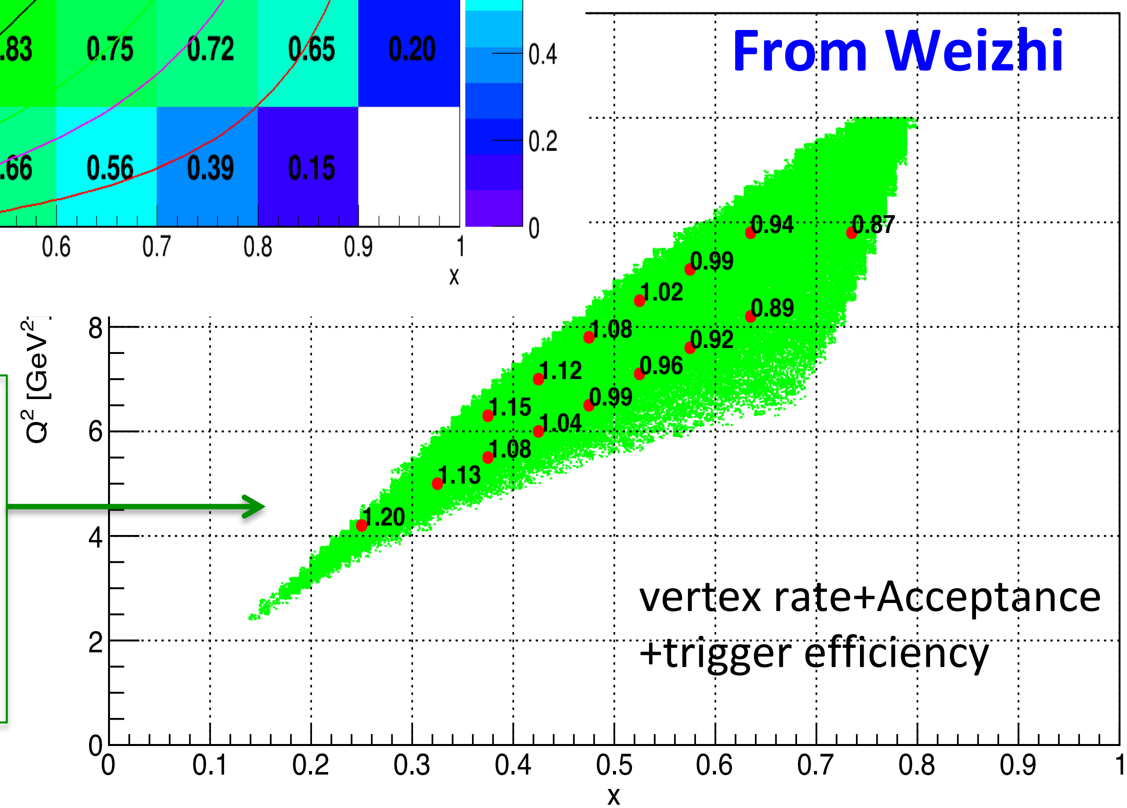

D2 Target
12GeV D2 generator scaled
12GeV D2 MARATHRON
dσ/dE' dΩ [nb/GeV/Sr]
X_bj
D2 Target
dσ/dE' dΩ [nb/GeV/Sr]
Q^2 [GeV^2]
D2 Target
σ_gen/σ_data
X_bj
W=3 GeV model transition
D2 Target
σ_gen/σ_data
Q^2

Radiative Effect for PVDIS LD2

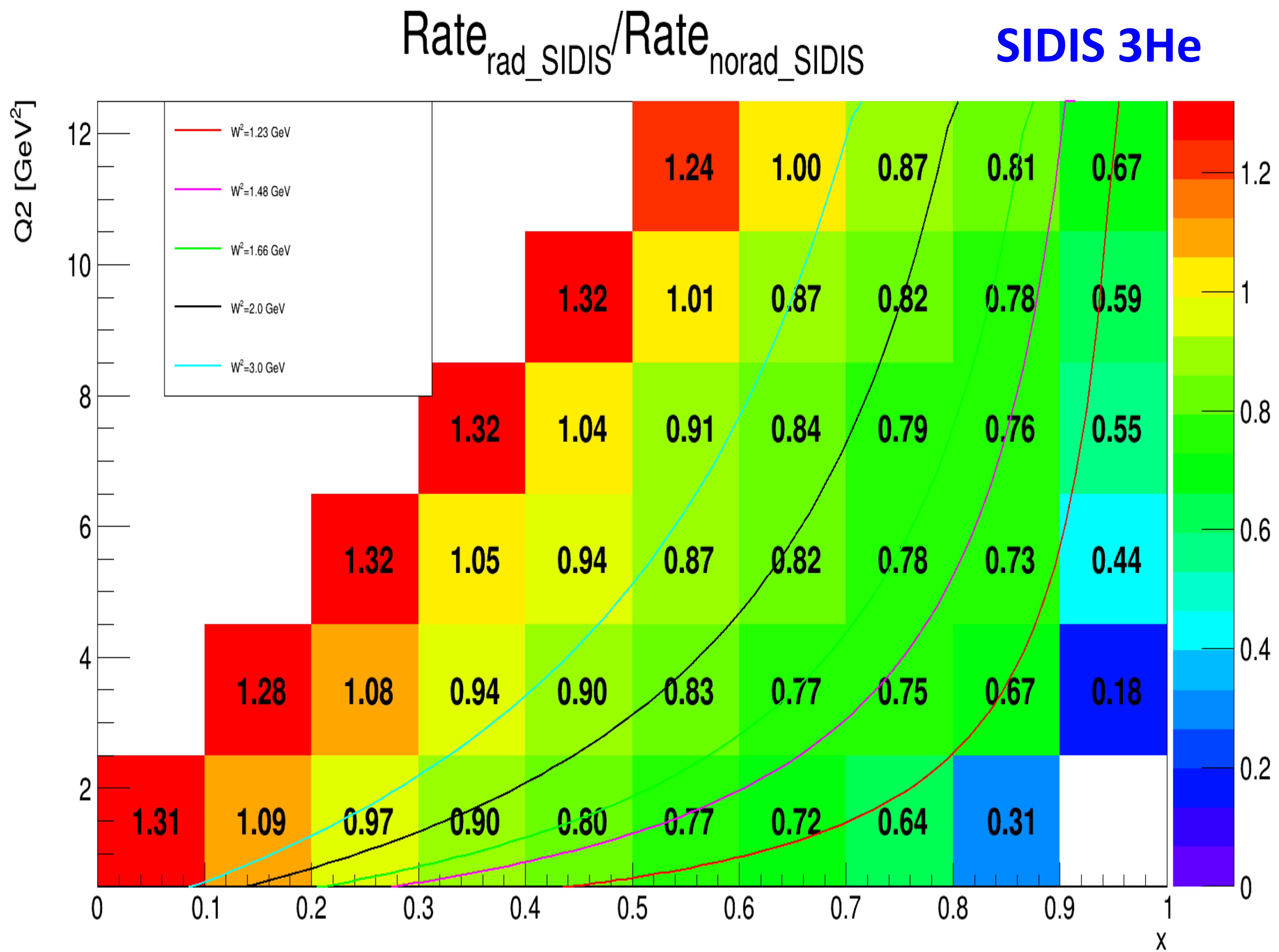


- RLb= Al window+$1/2X_0^{target}$
- RL = $1/2X_0^{target}$
- RLa= side wall(400um)+ chamber window(200um) +air to GEM(100cm)

/ $eAll_{norad}$



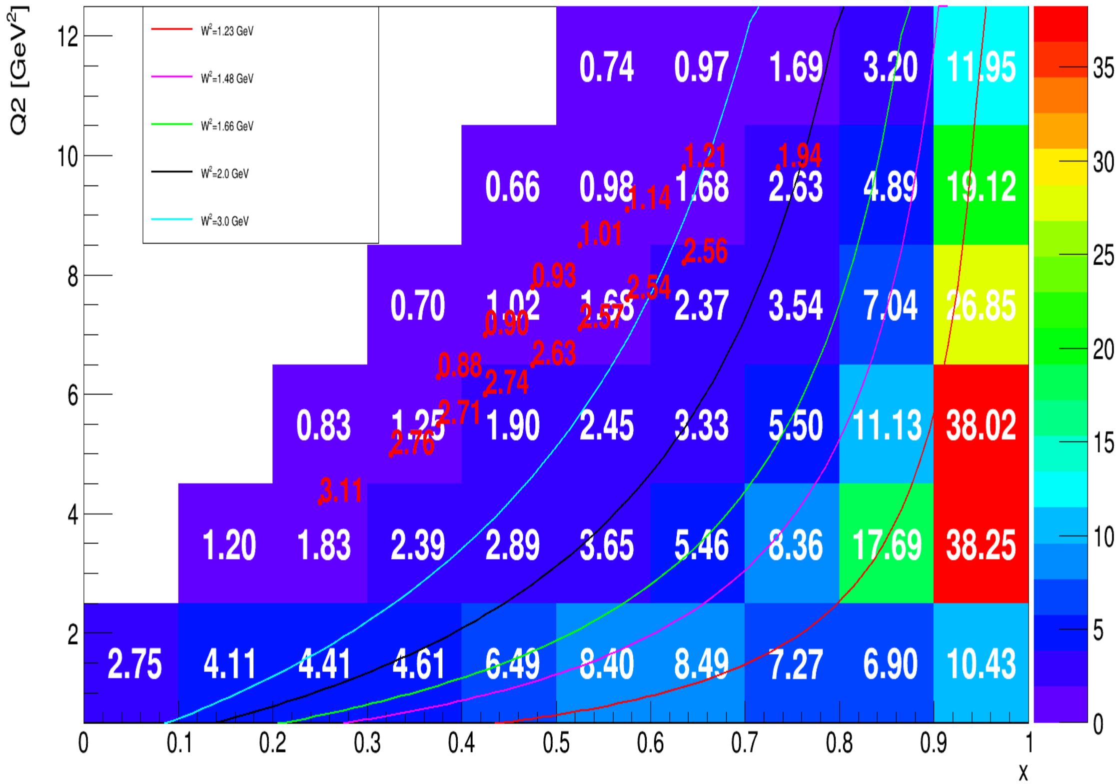
- RLb= Al window+$1/2X_0^{target}$
- RL = $1/2X_0^{target}$
- RLa= GEMC

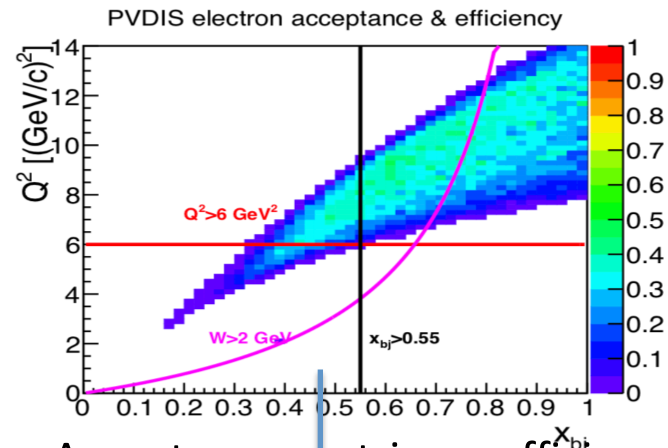


$Rate_{rad\_SIDIS}/Rate_{norad\_SIDIS}$
SIDIS 3He
Q2 [GeV^2]
x
W^2=1.23 GeV
W^2=1.48 GeV
W^2=1.66 GeV
W^2=2.0 GeV
W^2=3.0 GeV
1.24 1.00 0.87 0.81 0.67
1.32 1.01 0.87 0.82 0.78 0.59
1.32 1.04 0.91 0.84 0.79 0.76 0.55
1.32 1.05 0.94 0.87 0.82 0.78 0.73 0.44
1.28 1.08 0.94 0.90 0.83 0.77 0.75 0.67 0.18
1.31 1.09 0.97 0.90 0.80 0.77 0.72 0.64 0.31

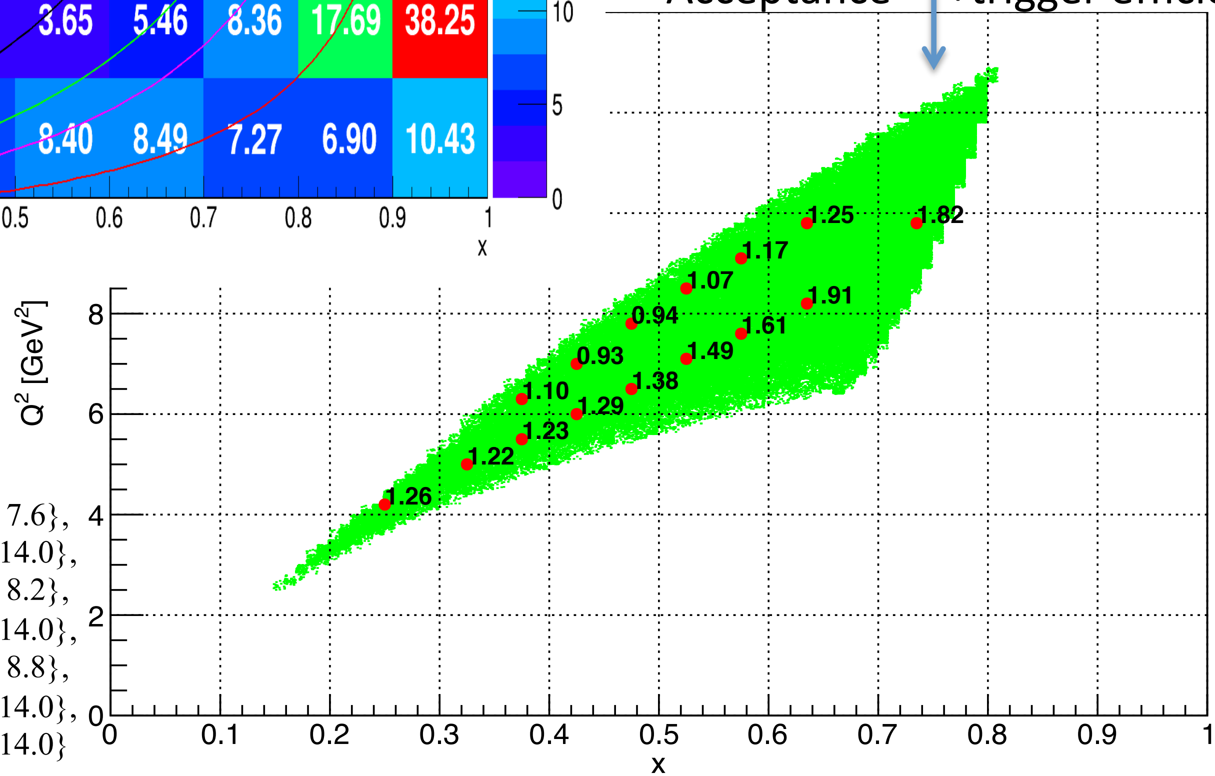
Rate$_{eAll}$/Rate$_{eDIS}$ No Radiative effects

PVDIS LD2





Acceptance +trigger efficiency




```
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{0.20,0.30,    0.0,14.0},
{0.30,0.35,    0.0,14.0},
{0.35,0.40,    0.0, 5.8},
{0.35,0.40,    5.8,14.0},
{0.40,0.45,    0.0, 6.4},
{0.40,0.45,    6.4,14.0},
{0.45,0.50,    0.0, 7.0},
{0.45,0.50,    7.0,14.0},
{0.50,0.55,    0.0, 7.6},
{0.50,0.55,    7.6,14.0},
{0.55,0.60,    0.0, 8.2},
{0.55,0.60,    8.2,14.0},
{0.60,0.67,    0.0, 8.8},
{0.60,0.67,    8.8,14.0},
{0.67,0.80,    0.0,14.0}
};
```
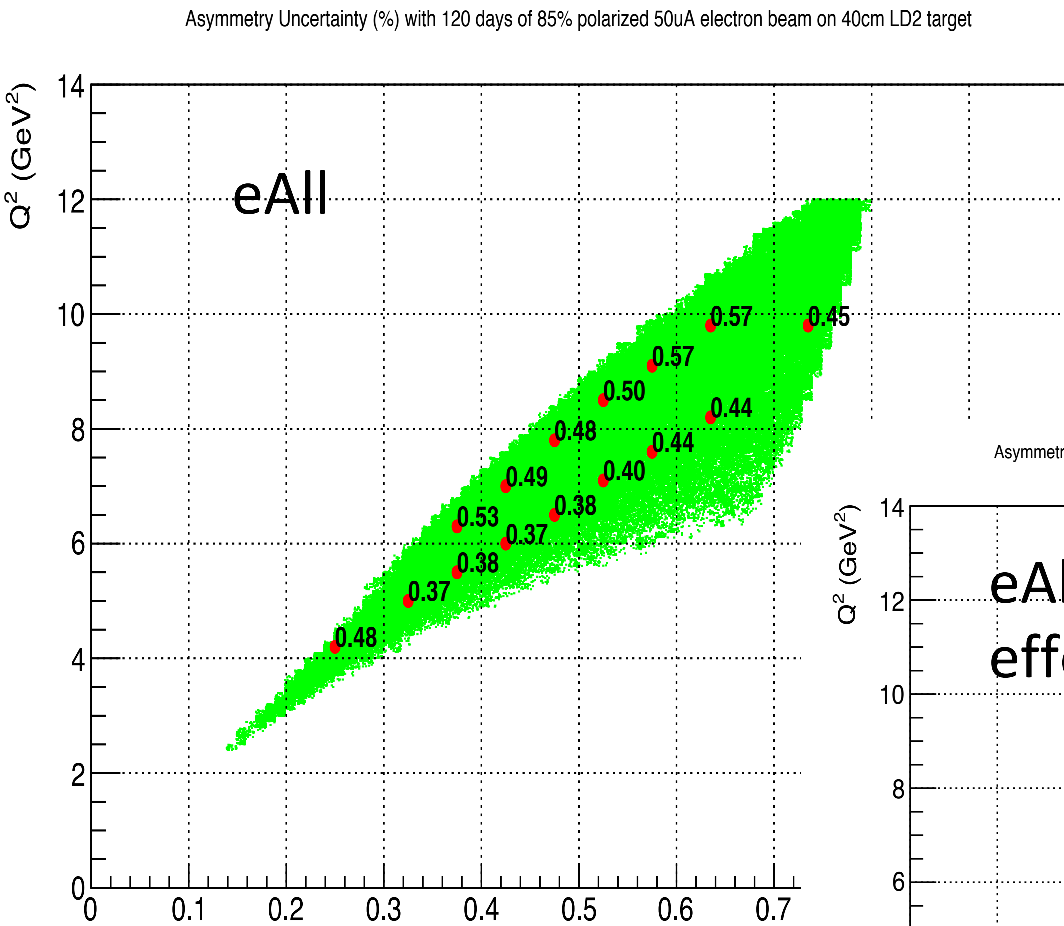
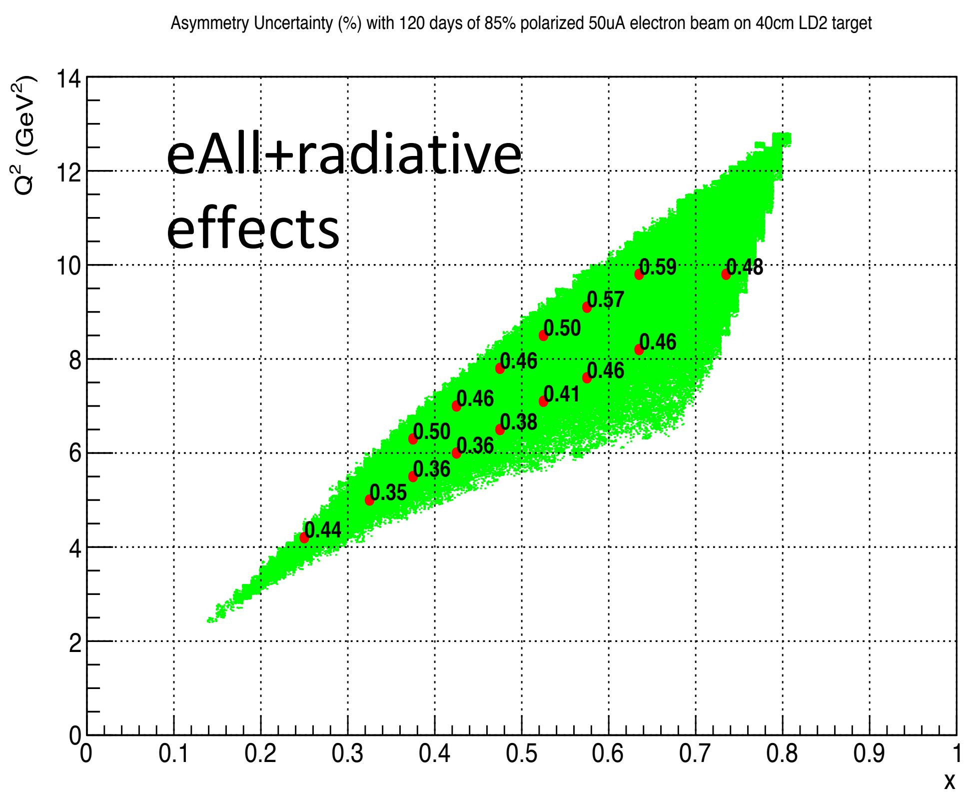

PVDIS Asymmetry Uncertainty (%)

From Weizhi





Evgen_inclusiv_e generator

Current inclusive electron generator (eAll)

- **W<3 GeV**

M.E. Christy and P.E. Bosted-----2009

Empirical fit

3He fit?

- **W>3 GeV :** PDF sets

New improved fit from M.E. Christy is going to be released.

Current inclusive electron generator (eAll)

- **W up to 12GeV-----**
- HallC data on F2 at W>3 GeV

better 3He fit !

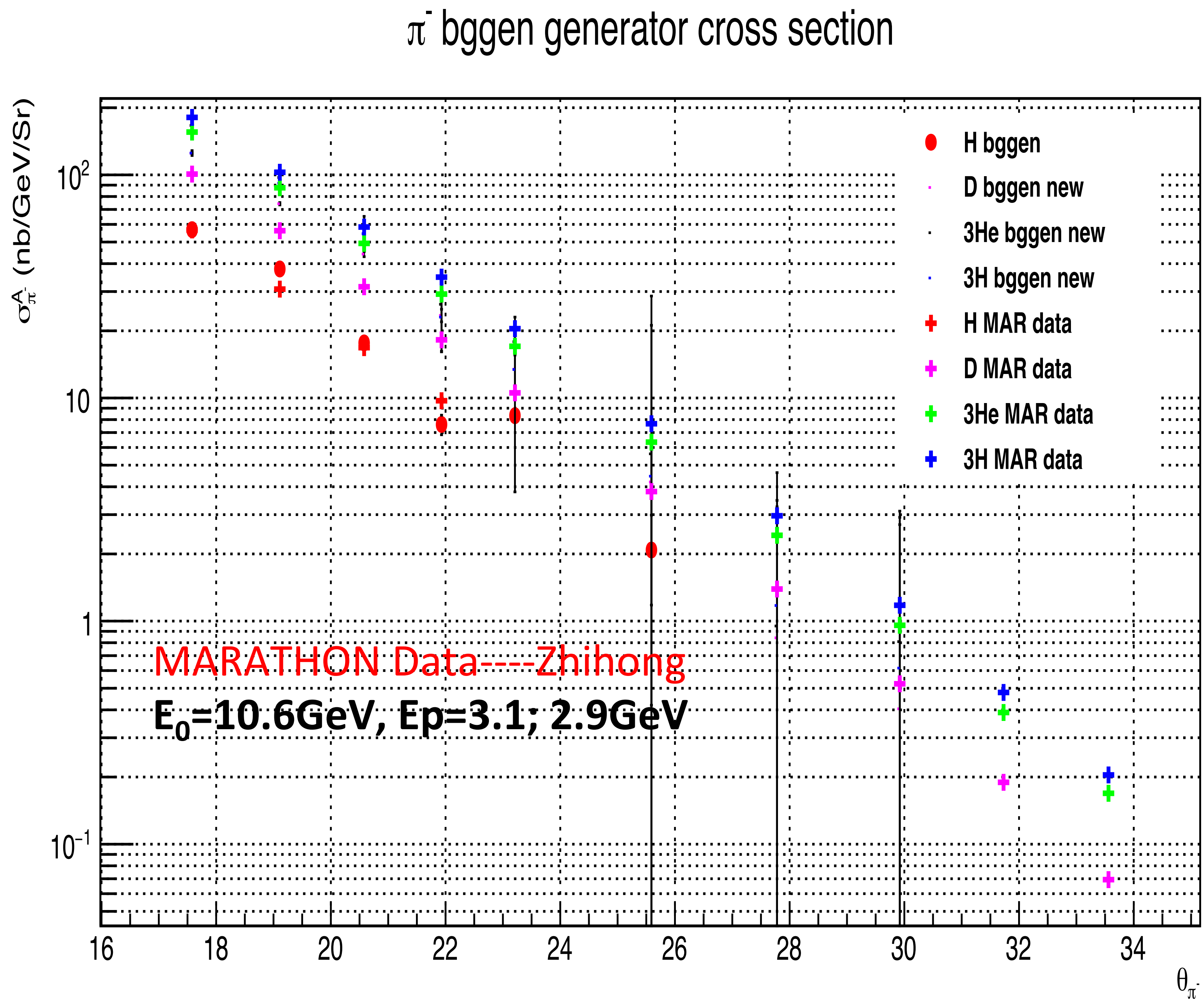
Hadron Generator

- Hadron Generator (Bggen_Version_1.3) modified by Jixie Zhang :

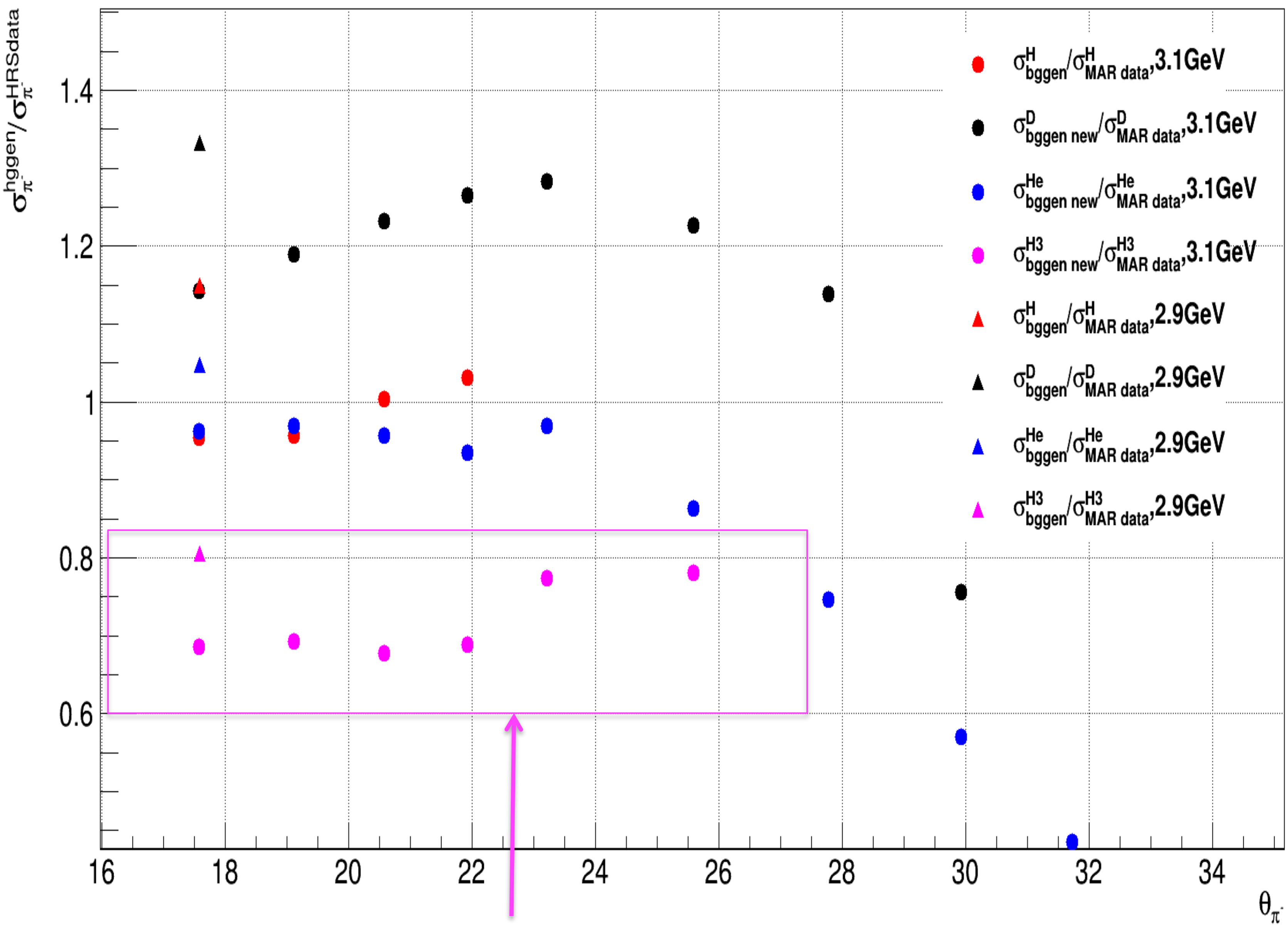
➢ E>3 GeV: PYTHIA is used

➢ 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.

➢ Adding Z dependence (loop Z and E_γ).


π⁻ bggen generator cross section
$\sigma^{A}_{\pi^-}$ (nb/GeV/Sr)
θ_{π^-}
H bggen
D bggen new
3He bggen new
3H bggen new
H MAR data
D MAR data
3He MAR data
3H MAR data
MARATHON Data----Zhihong
E_0=10.6GeV, Ep=3.1; 2.9GeV
10^2
10
1
10^{-1}
16
18
20
22
24
26
28
30
32
34

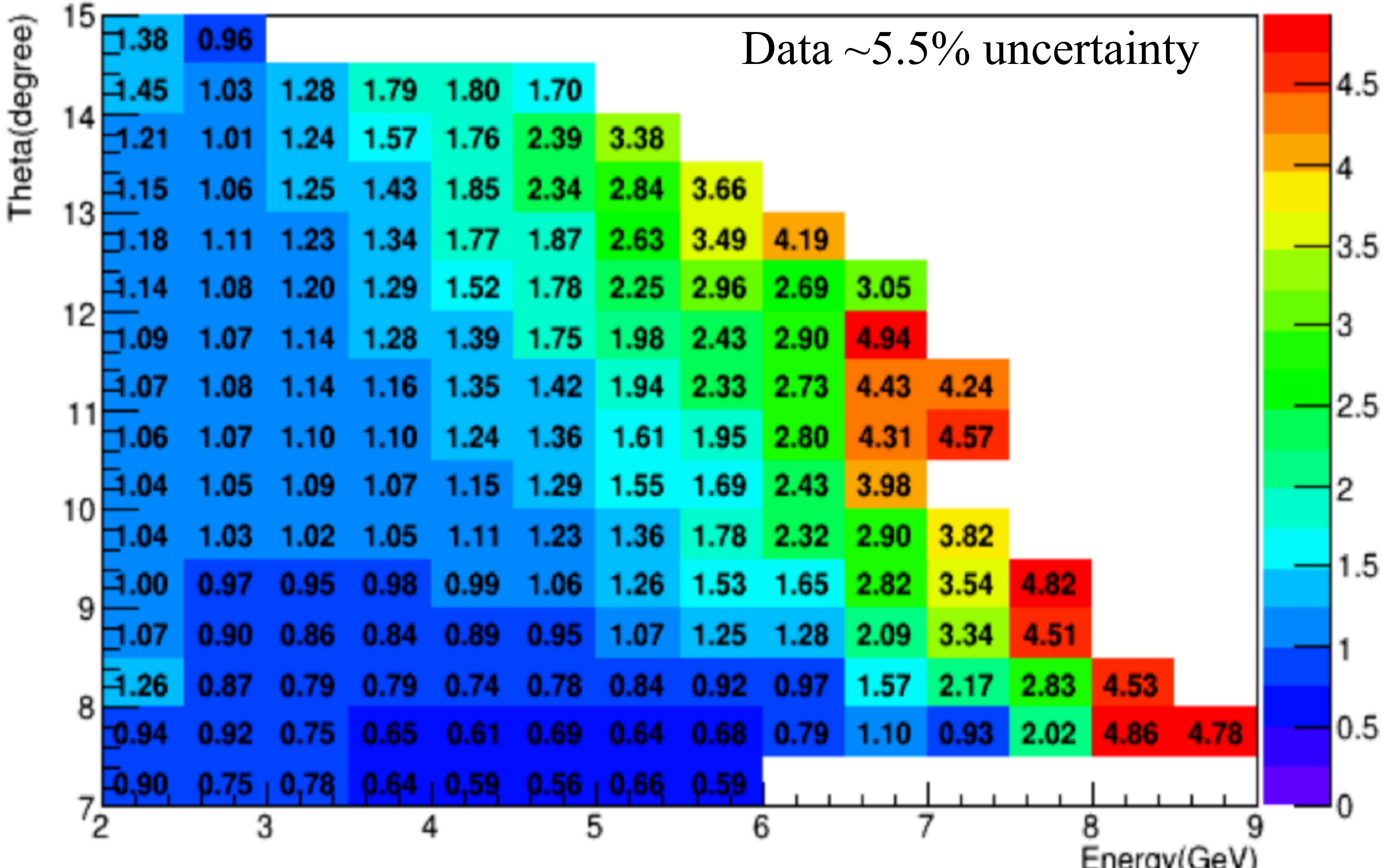
π⁻ cross section ratio



Original target density reported for the tritium target is ~10 % different than what was reported.

From Ye Tian (SDU PhD thesis)

π^0 DVCS_yield /bggen_yield



Summary and Outlook

- The radiative effects estimated with the evgen_inclusive_e generator are <30% at high x region for PVDIS and SIDIS setups.

- 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.

- Check SIDIS trigger rate with evgen_inclusive_e.

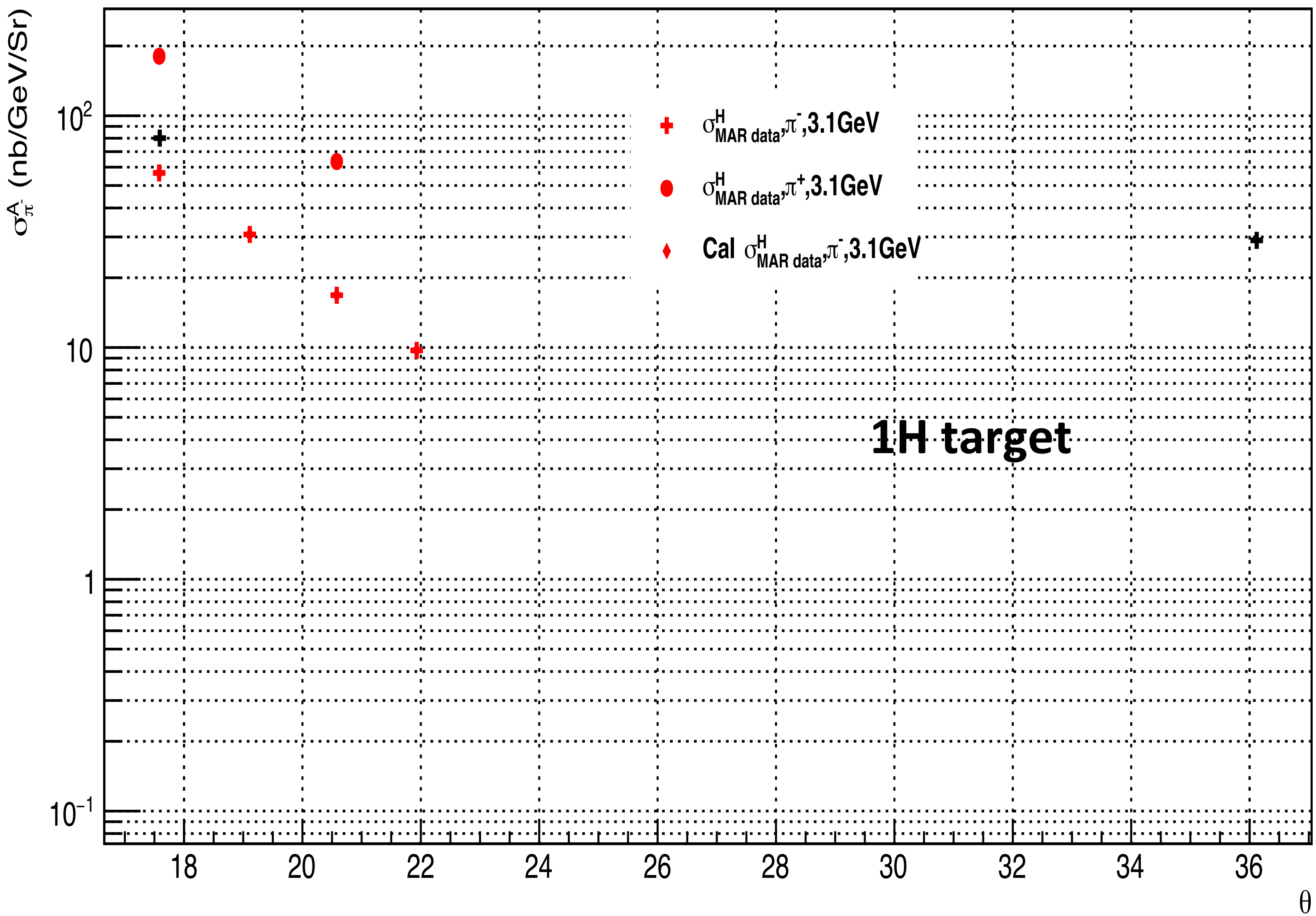
- Keep developing the evgen_inclusive_e generator.

- Adding neutron data, MARATHON data (H2, D2, 3He, H3), to the bggen generator for a longer term plan.

Back Up

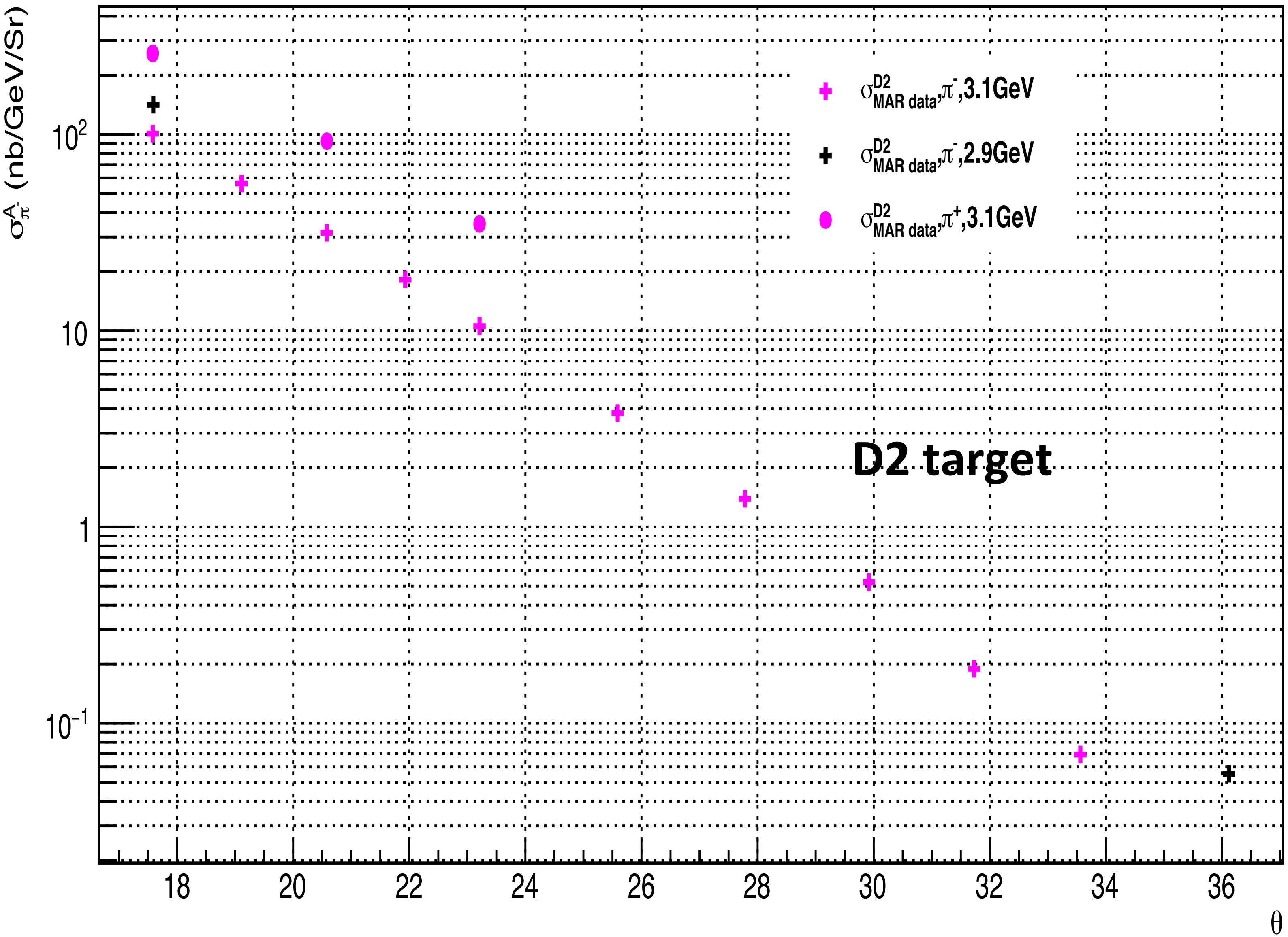
MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV



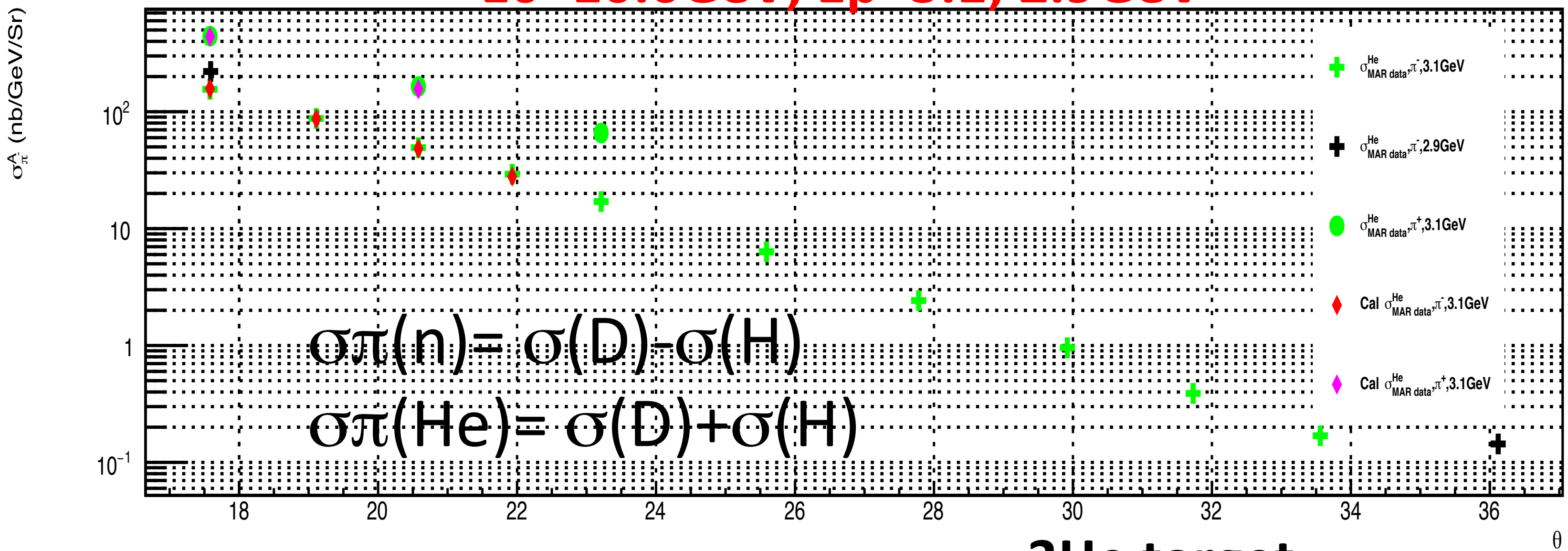
MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV



MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV

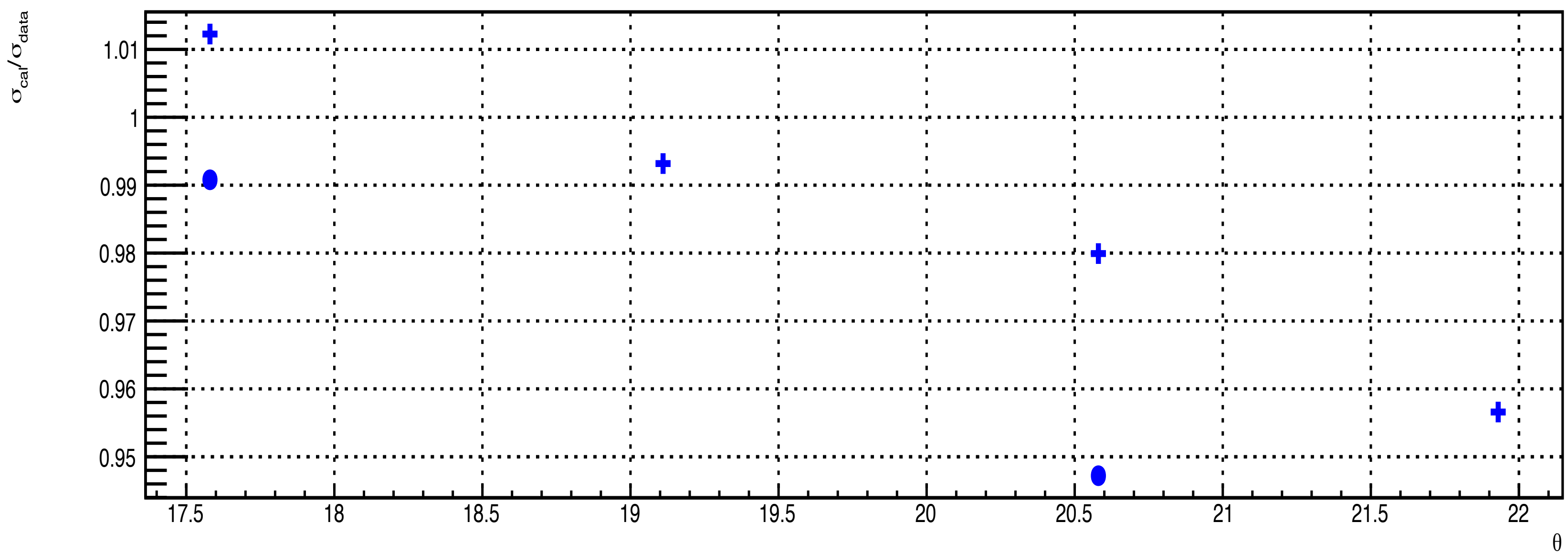


$\sigma\pi(n) = \sigma(D) - \sigma(H)$

$\sigma\pi(He) = \sigma(D) + \sigma(H)$

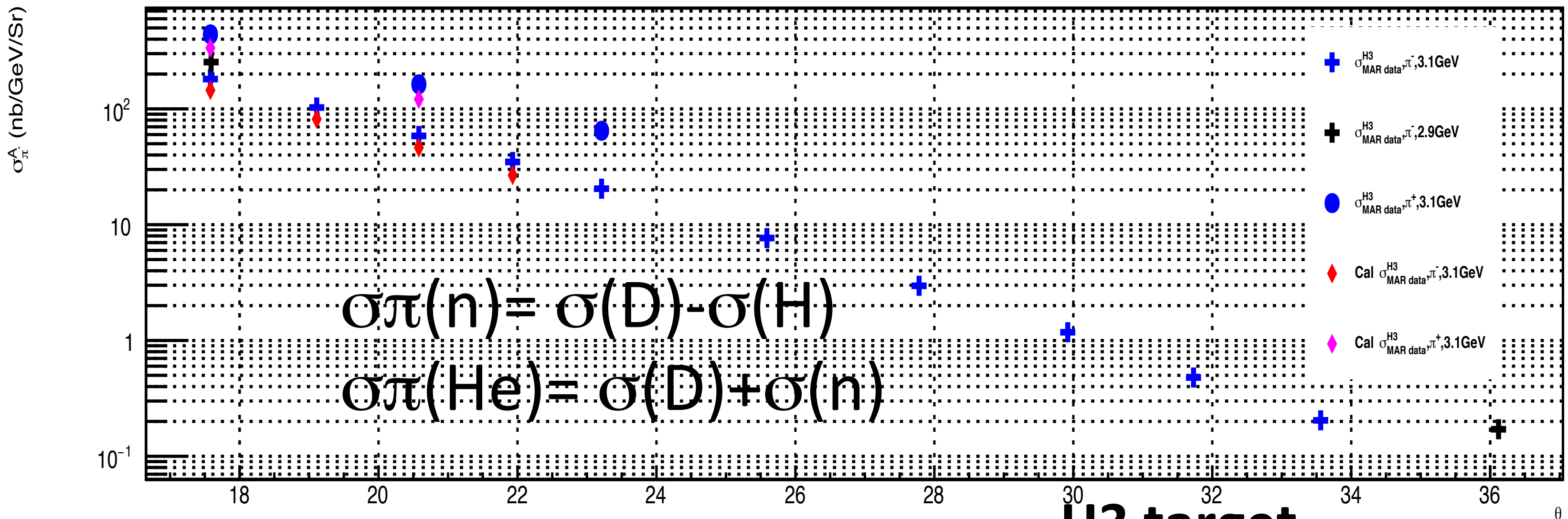
3He target

Ignore unclear effects



MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV

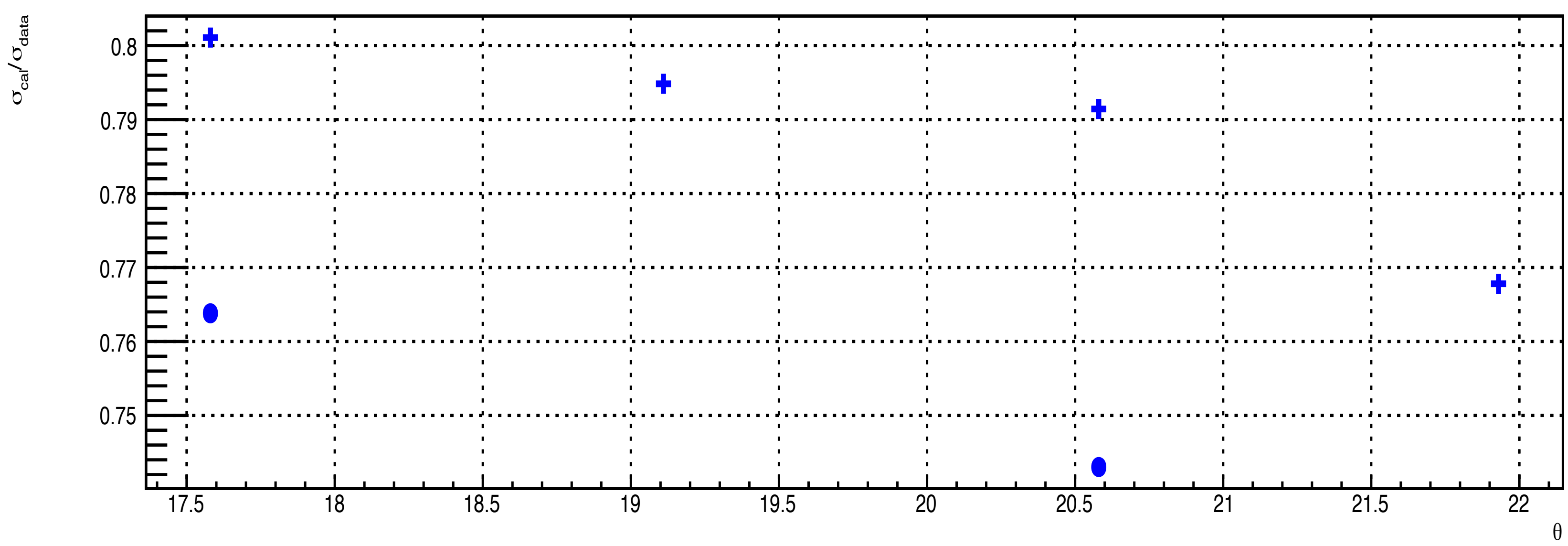


$\sigma\pi(n)= \sigma(D)-\sigma(H)$

$\sigma\pi(He)= \sigma(D)+\sigma(n)$

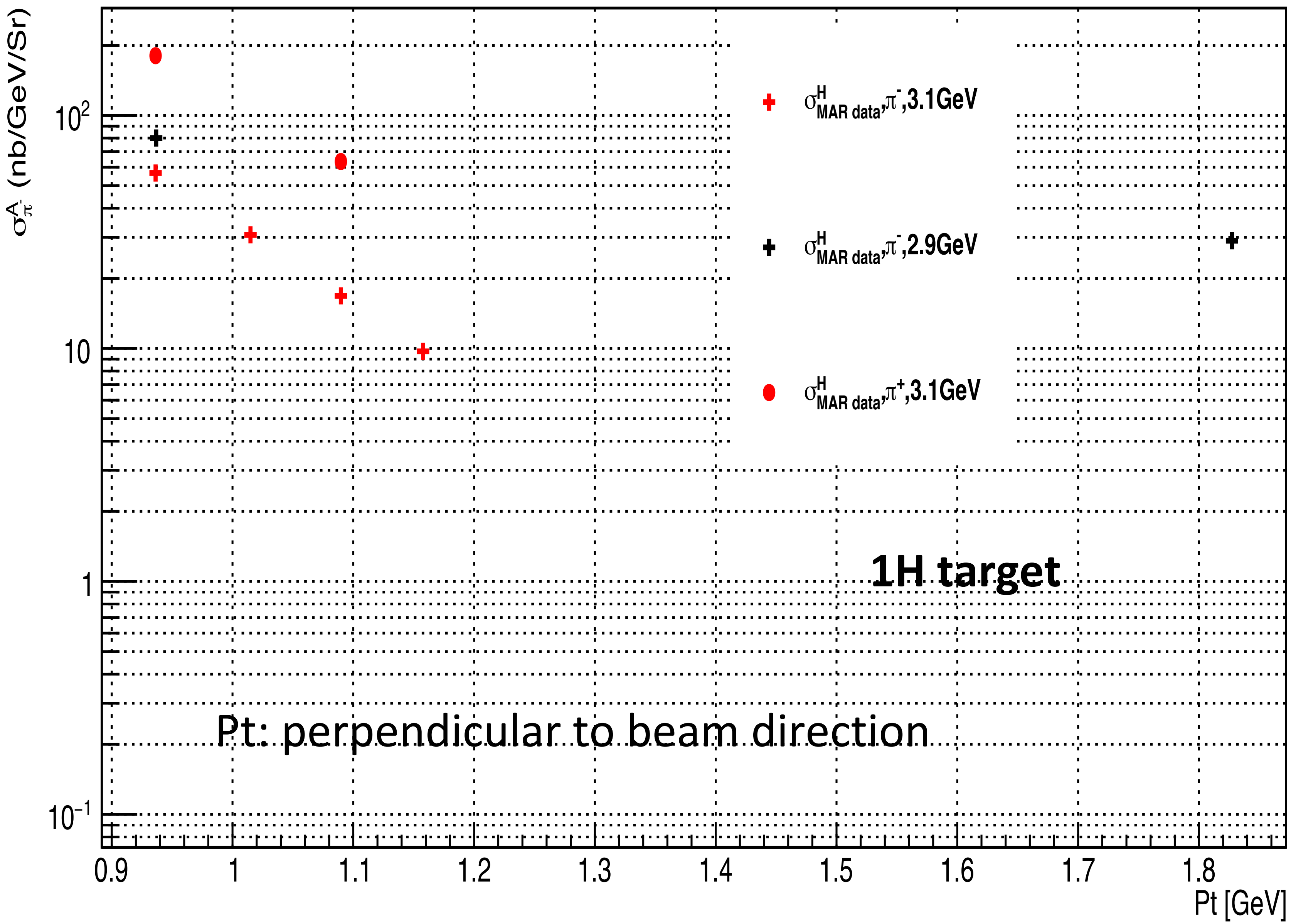
H3 target

Ignore unclear effects



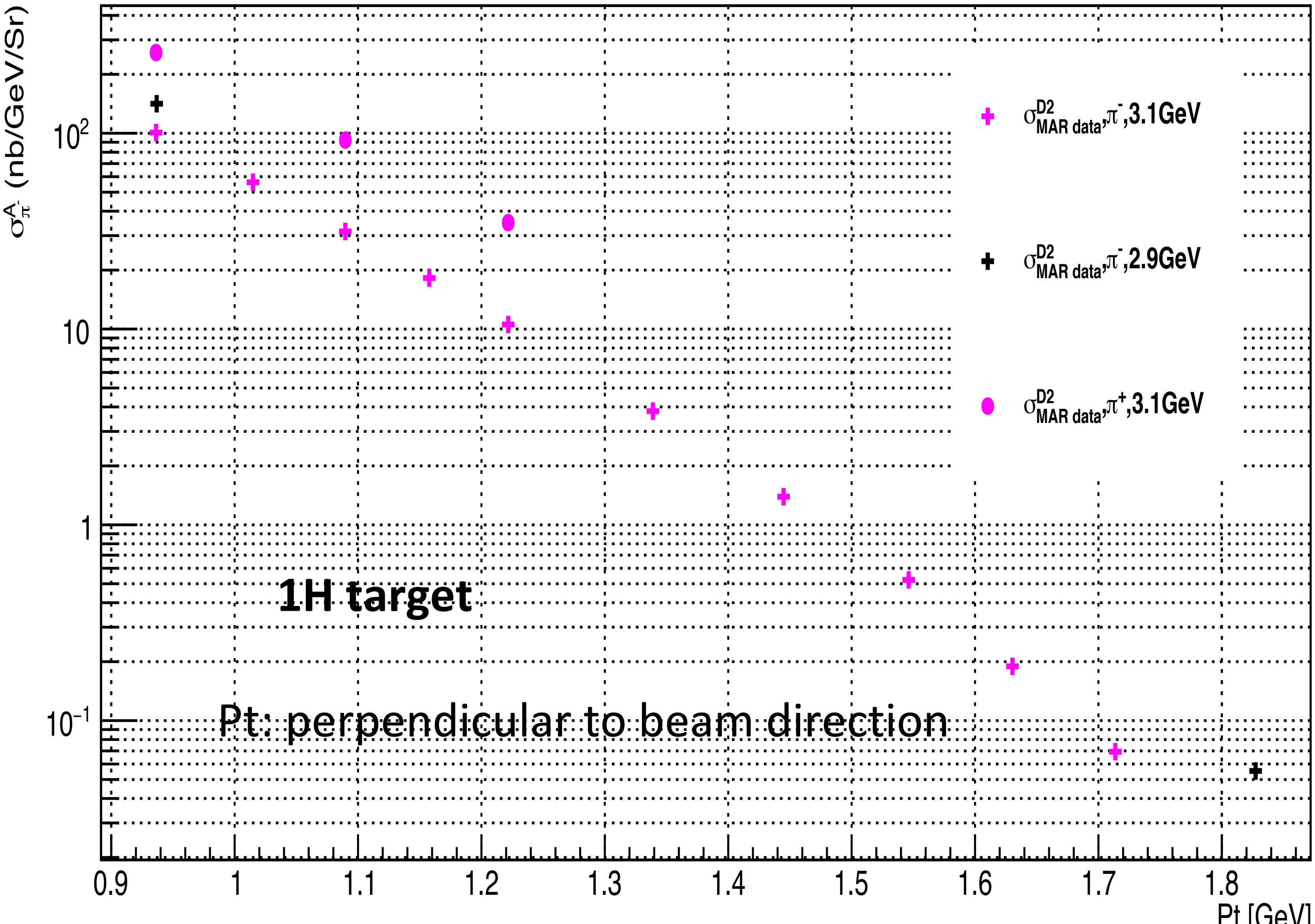
MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV



MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV



Hard pion electroproduction at medium energies-----paper

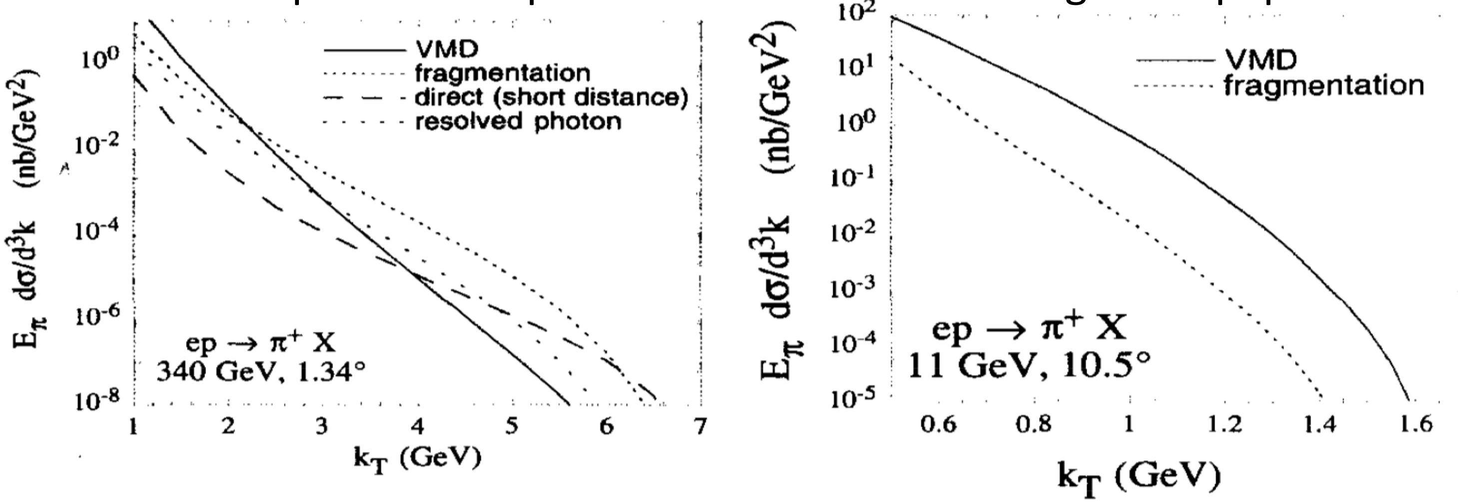


Figure 2. Soft and fragmentation contributions induced by real photons.

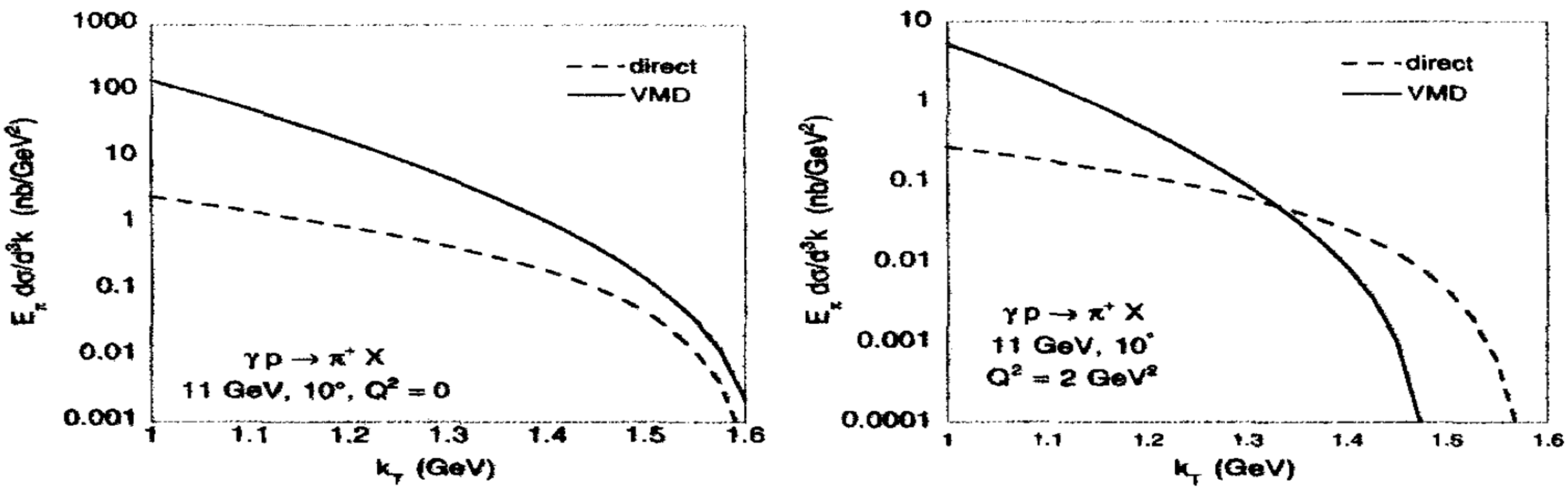


Figure 4. On and off shell transversely polarized photon processes.

eDIS

The cross sections for neutral- and charged-current deep inelastic scattering on unpolarized nucleons can be written in terms of the structure functions in the generic form

$$\frac{d^2\sigma^i}{dxdy} = \frac{4\pi\alpha^2}{xyQ^2}\,\eta^i \left\{ \left(1 - y - \frac{x^2y^2M^2}{Q^2}\right) F_2^i + y^2xF_1^i \boxed{\mp \left(y - \frac{y^2}{2}\right) xF_3^i} \right\}, \tag{18.8}$$

where i = NC, CC corresponds to neutral-current ($eN \to eX$) or charged-current ($eN \to \nu X$ or $\nu N \to eX$) processes, respectively. For incoming neutrinos, $L^W_{\mu\nu}$ of Eq. (18.3) is still true, but with e, λ corresponding to the outgoing charged lepton. In the last term of Eq. (18.8), the $-$ sign is taken for an incoming e^+ or $\overline{\nu}$ and the $+$ sign for an incoming e^- or ν. The factor $\eta^{\mathrm{NC}} = 1$ for unpolarized $e^\pm$ beams, whereas*

$$y = \frac{E}{\left(\mathrm{M}*\frac{\mathrm{x}}{2.0}+\mathrm{E}\right)} = \frac{E}{M*\frac{Q^2}{2M\nu}*\frac{1}{2}+E} = \frac{E}{\frac{4EE'sin^2\frac{\theta}{2}}{4\nu}+E} = \frac{\nu}{E'sin^2\frac{\theta}{2}+\nu} = \frac{\nu}{E'sin^2\frac{\theta}{2}+E-E'} = \frac{\upsilon}{E-E'\left(1-sin^2\frac{\theta}{2}\right)} \neq \frac{\upsilon}{E}$$

$$x \in (0,1), y \in \left(0, \frac{E}{\left(\mathrm{M}*\frac{\mathrm{x}}{2.0}+\mathrm{E}\right)}\right)$$

$$\boxed{\frac{d^2\sigma}{dxdE'} = \frac{1}{E}\frac{d^2\sigma}{dxdy}}$$

$$\dot{N} = \sigma * \mathcal{L} = \frac{d^2\sigma}{dxdy\mathrm{d}\varphi} 2\pi * x * y * \mathcal{L}$$

Solid inclusive e

F1=Z*F1p+(A–Z)*F1n;
F2=Z*F2p+(A–Z)*F2n;

The W<3 GeV Peter Bosted fit ($Q^2<11\ (GeV/C)^2$)
The W>3 GeV world PDF sets

$$\frac{d^2\sigma}{dE'd\Omega} = \sigma_{Mott}\left[\frac{1}{\nu}F_2(x,Q^2) + \frac{2}{M}F_1(x,Q^2)tan^2\frac{\theta}{2}\right]$$

$$\sigma_{Mott} = \frac{4a^2E'^2}{Q^4}cos^2\frac{\theta}{2}$$

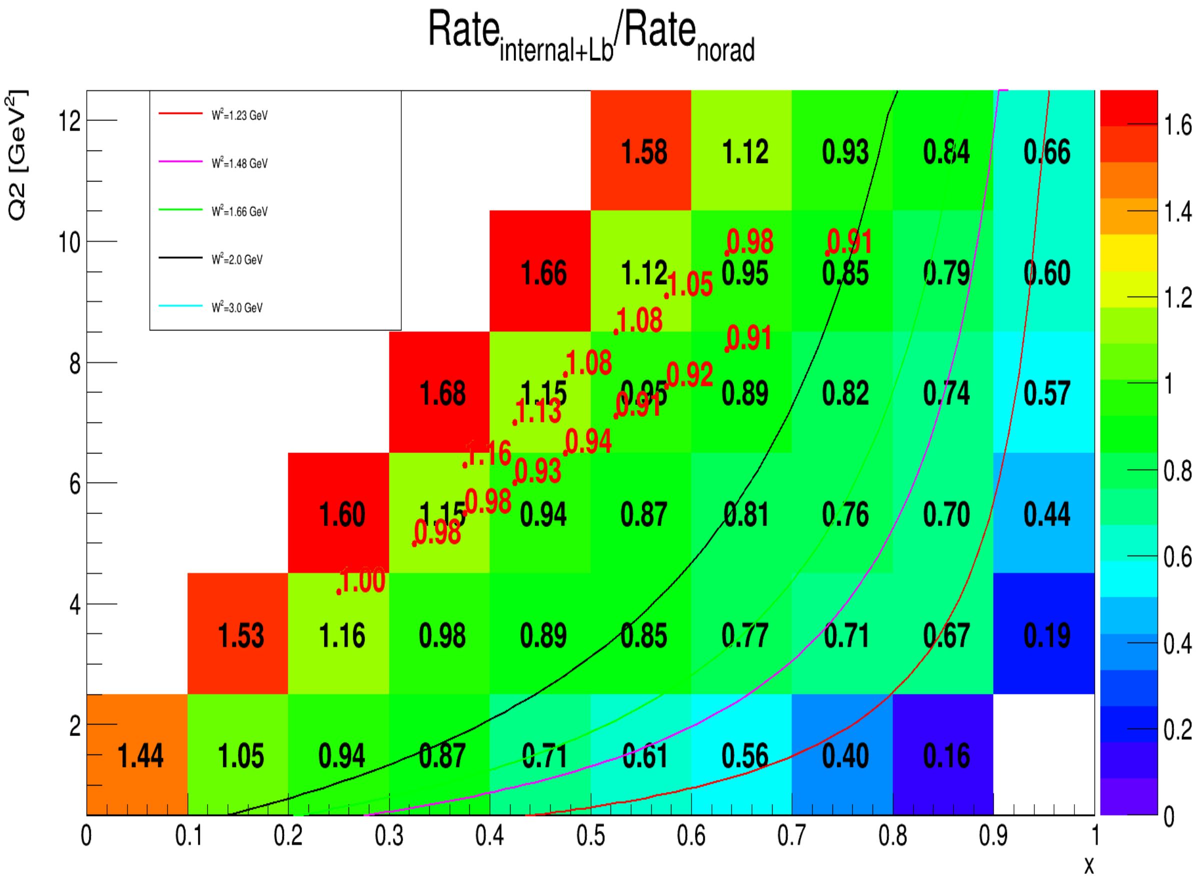
$$F_{1g} = F_{2g}\frac{(1+\gamma^2)}{2x(1+R)}$$

F2g from parton model

$$\boxed{F_{1g} = F_{2g}\frac{1}{2x}}$$

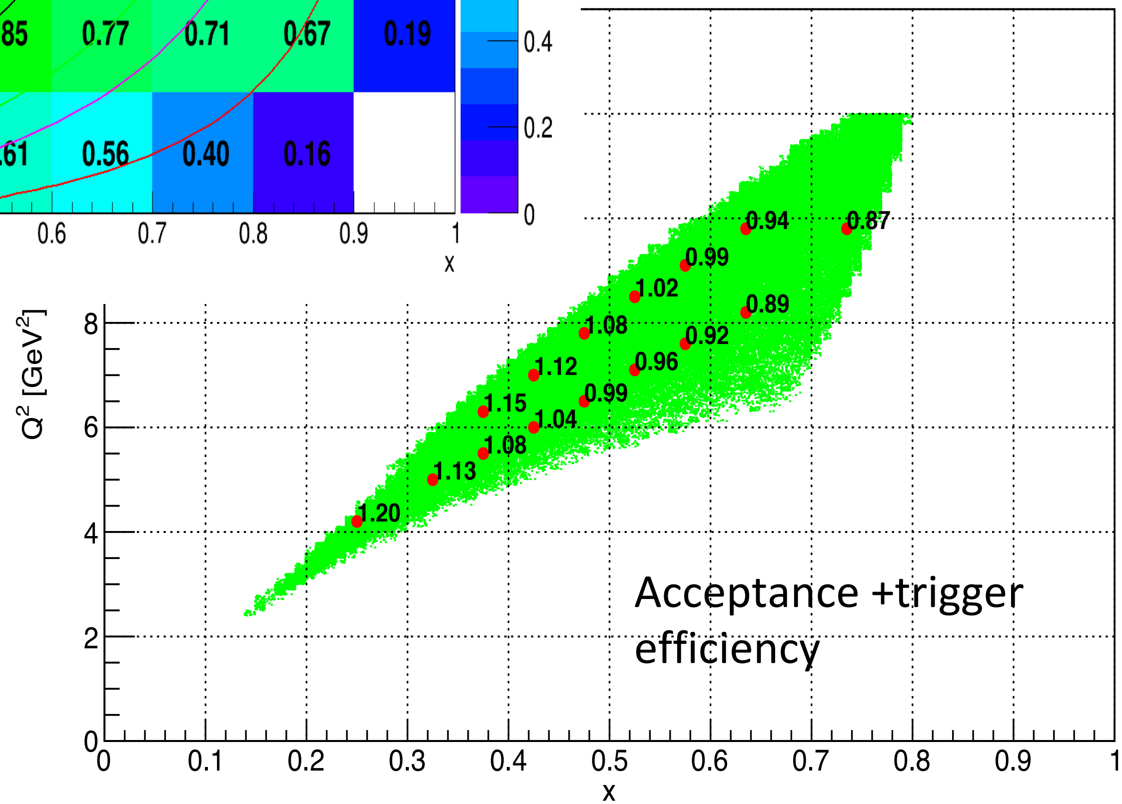
$$\dot{N} = \sigma * \mathcal{L} = \frac{d^2\sigma}{dE'd\Omega}dE' * d\Omega * \mathcal{L}$$

PVDIS LD2



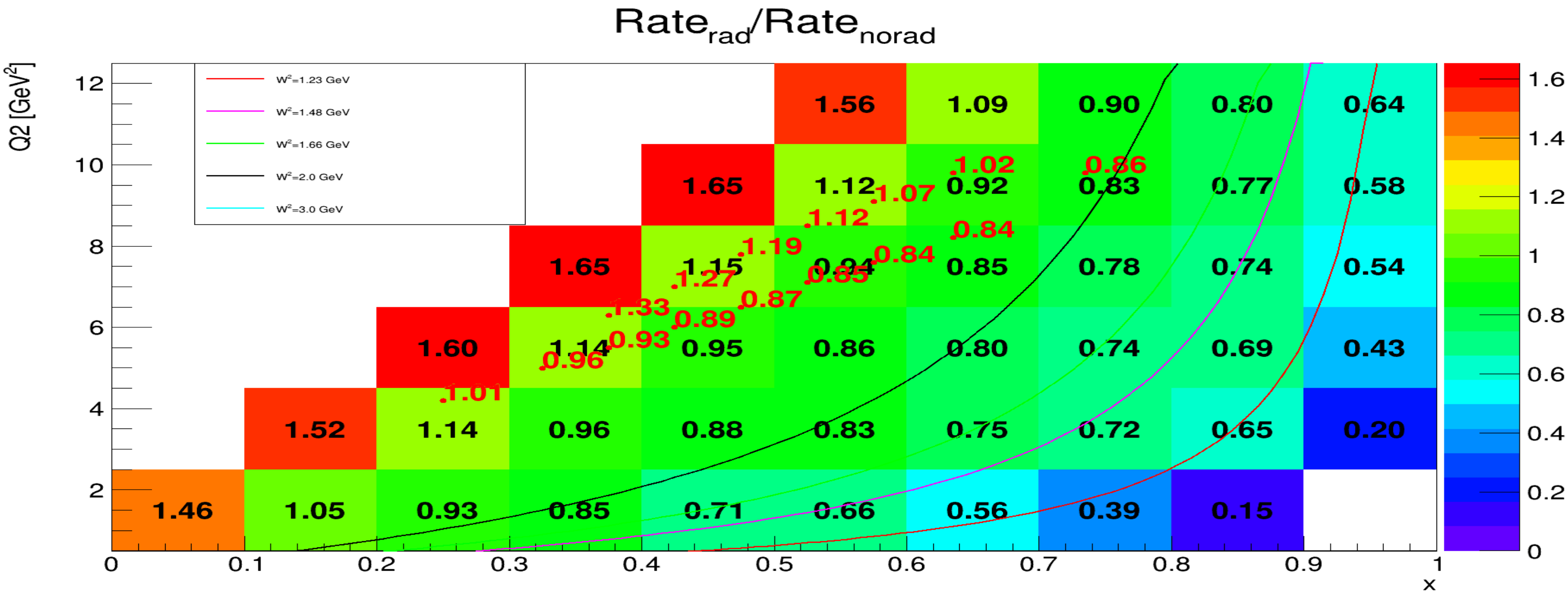
- Rla=0
- RL = $1/2X_0^{target}$
- RLb= side wall(400um)+ chamber window(200um) +air to GEM(100cm)

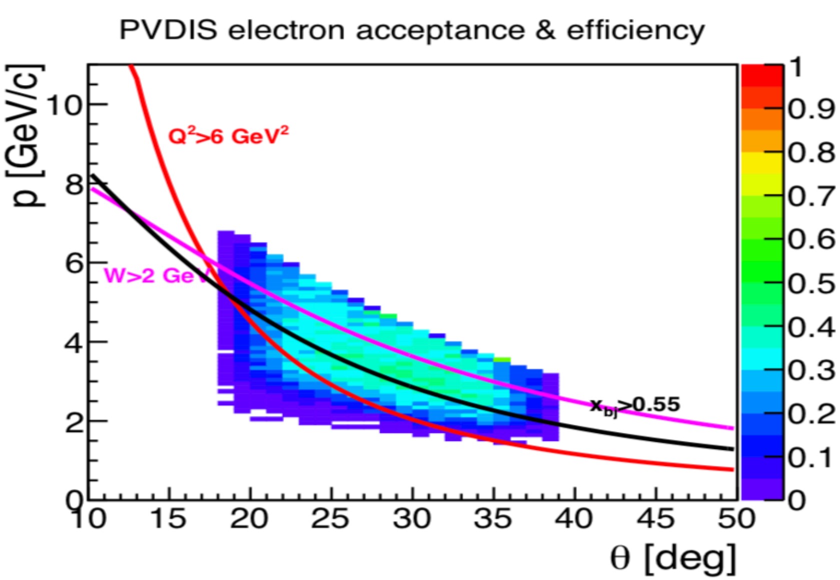
/ $eAll_{norad}$

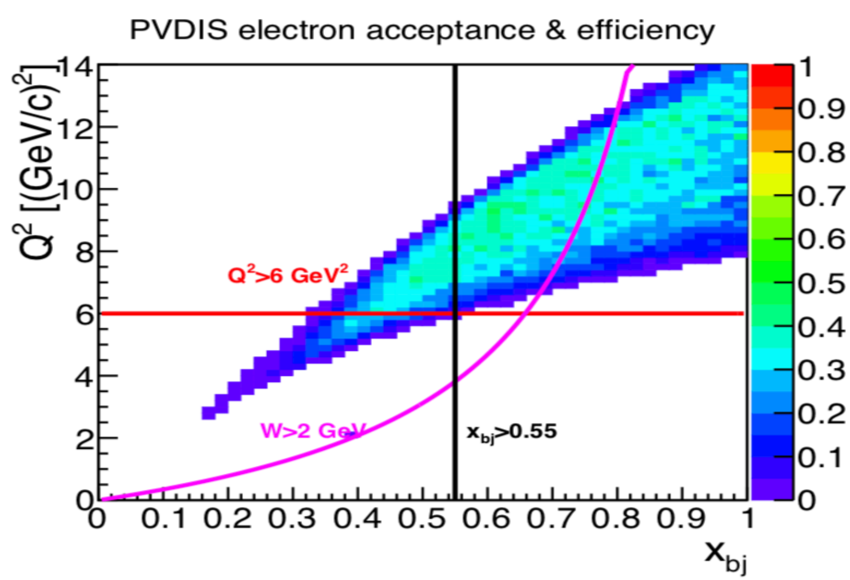


- RLa= Al window+$1/2X_0^{target}$
- RL = $1/2X_0^{target}$
- RLb= GEMC

Radiative Effect for PVDIS LD2







Assumption

- Rate calculation for A>1:

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

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

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

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

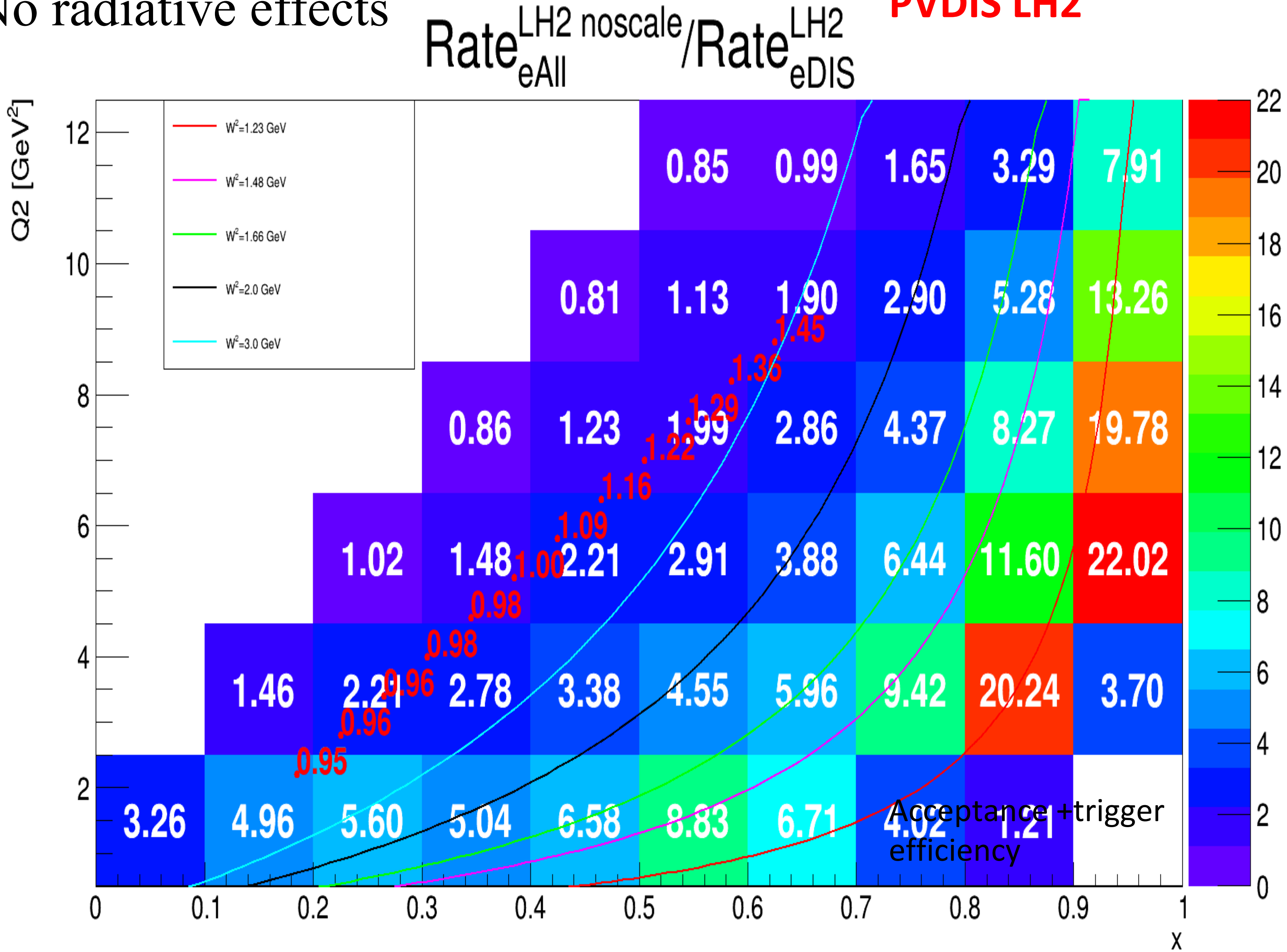
Check the above assumption with MARATHON data:

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

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

No radiative effects

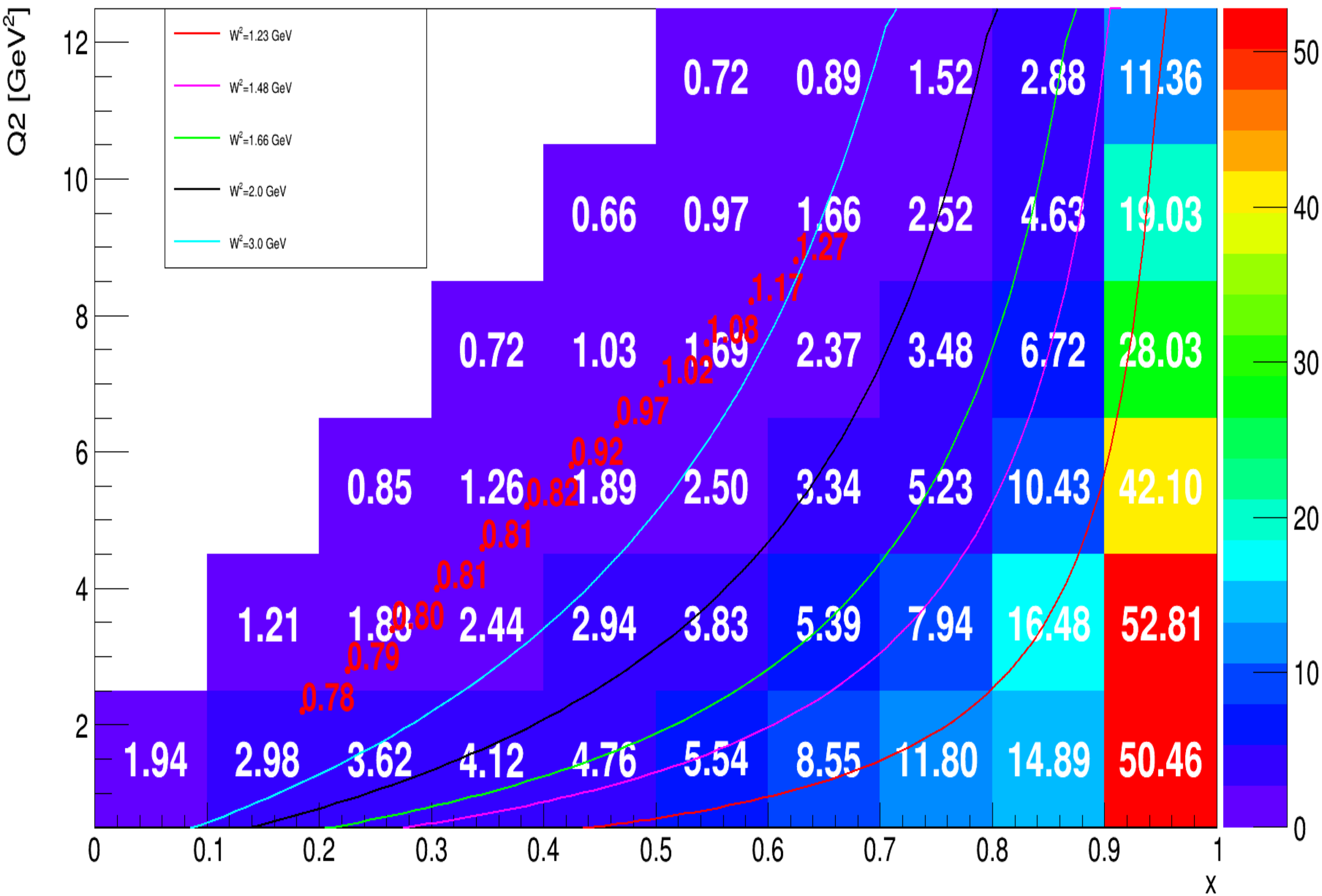
PVDIS LH2



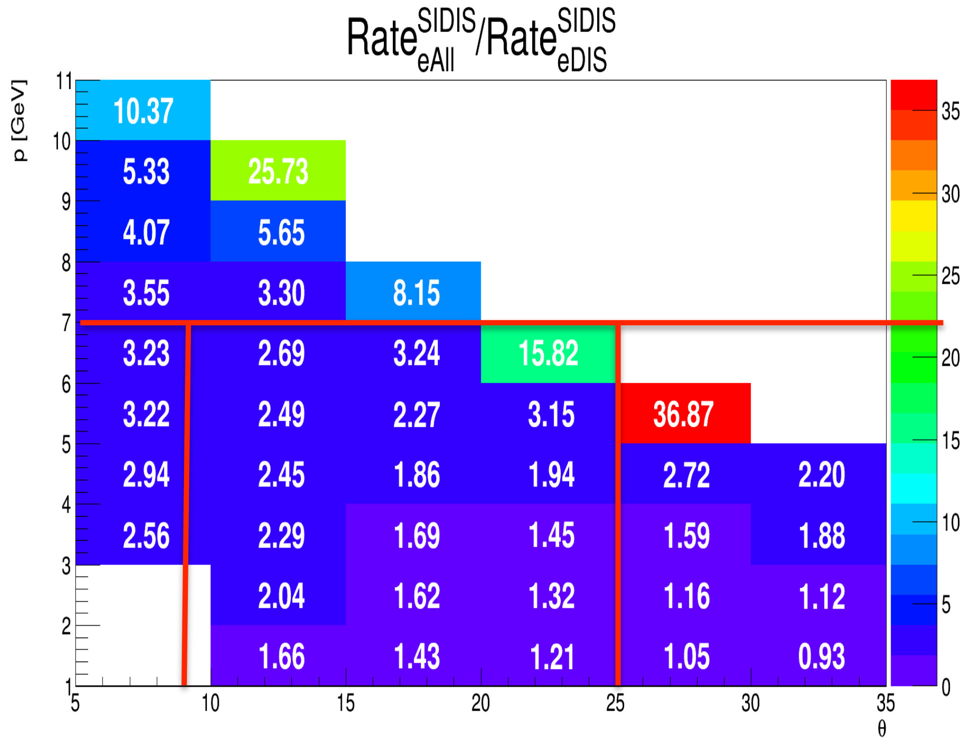
No radiative effects

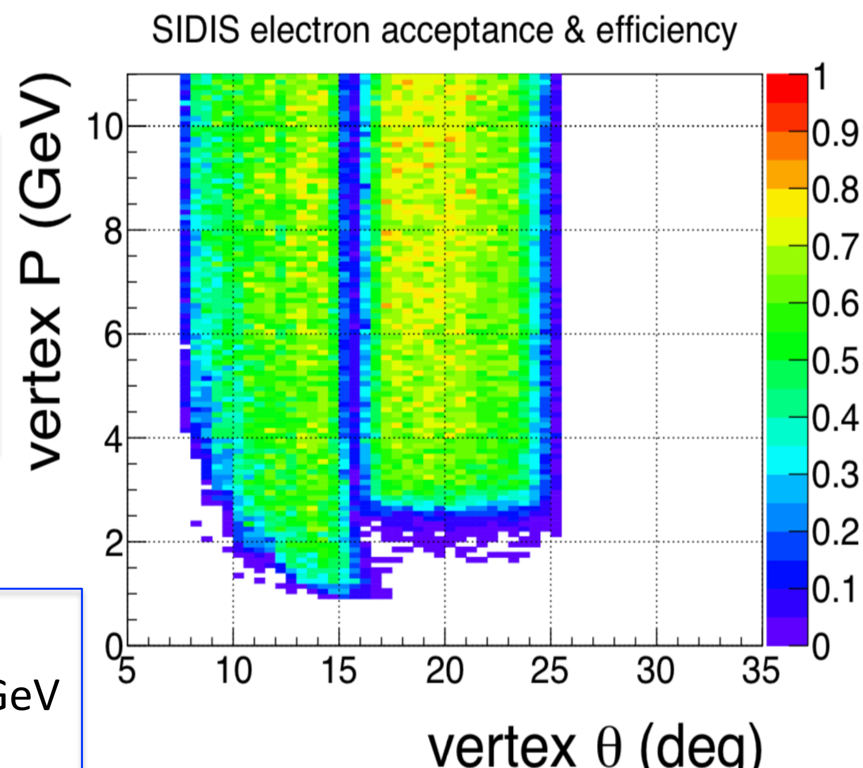
SIDIS 3He

$Rate^{SIDIS}_{eAll}/Rate^{SIDIS}_{eDIS}$



SIDIS He3





Current inclusive electron generator (eAll)

- **W<3 GeV**

M.E. Christy and P.E. Bosted-----2009 Empirical fit

3He fit?

- **W>3 GeV :** PDF sets

New improved fit from M.E. Christy is going to be released.

Current inclusive electron generator (eAll)

- **W up to 12GeV-----** HallC data on F2 at W>3 GeV better 3He fit !