

SoLID Event Generator Update

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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

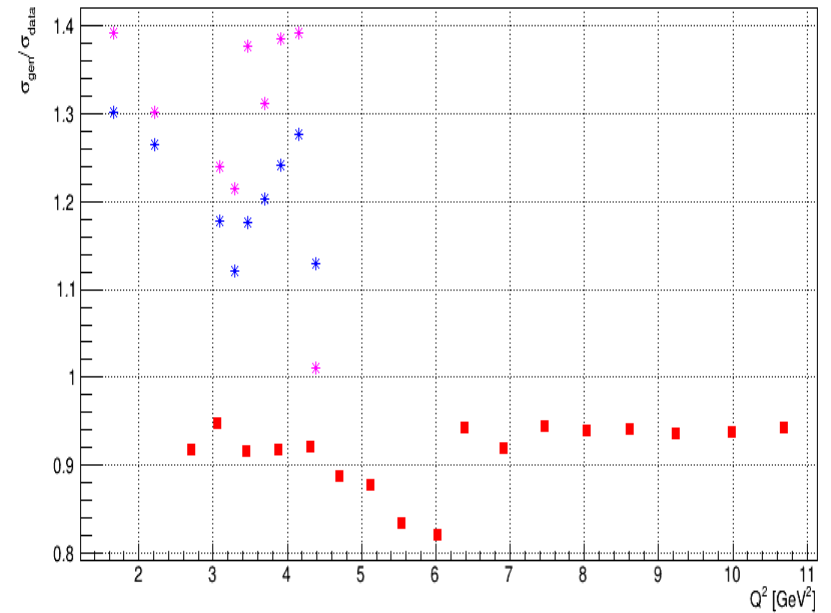
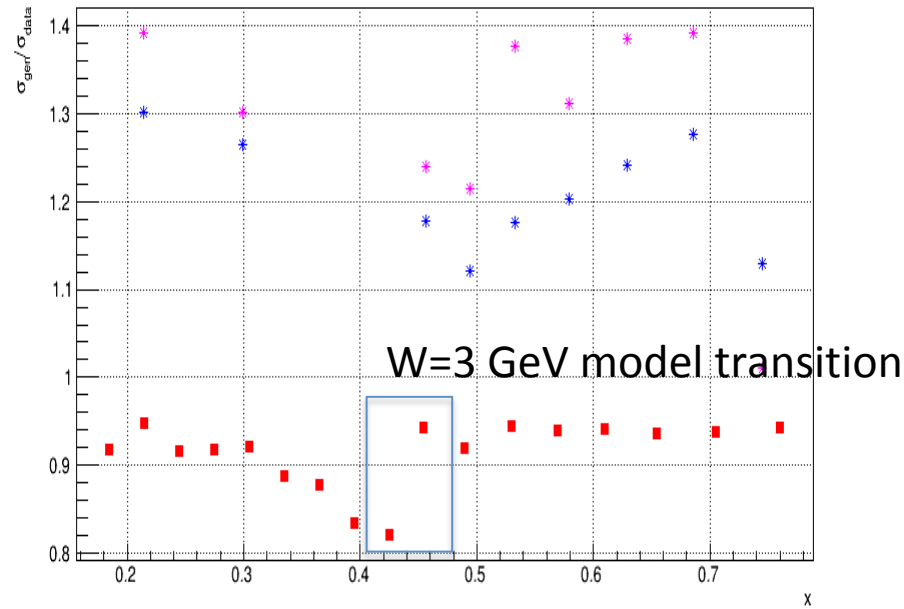
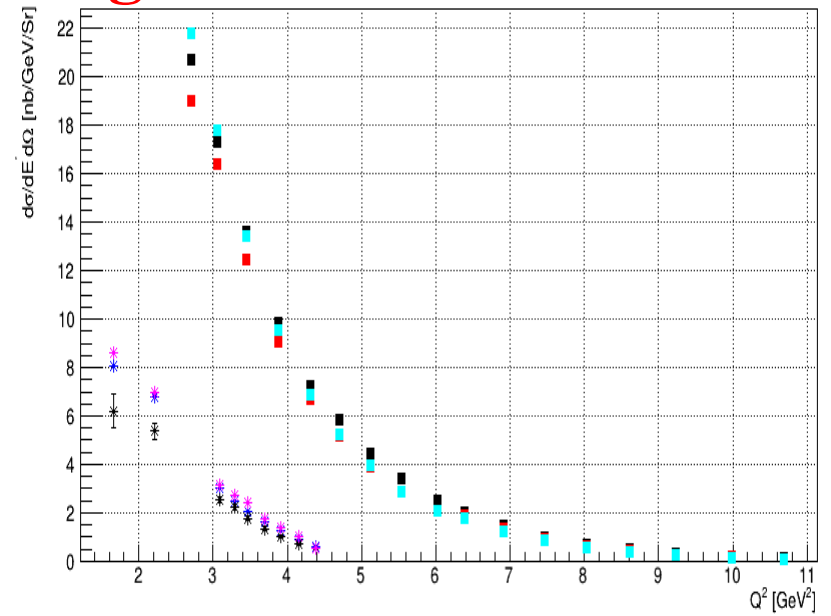
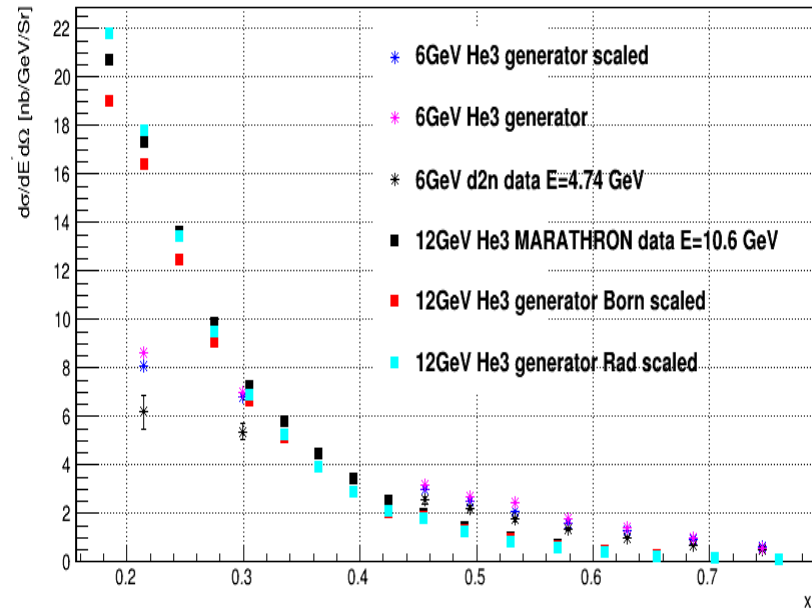
$$f(E_s) = 0.906 - 0.00699E_s$$

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

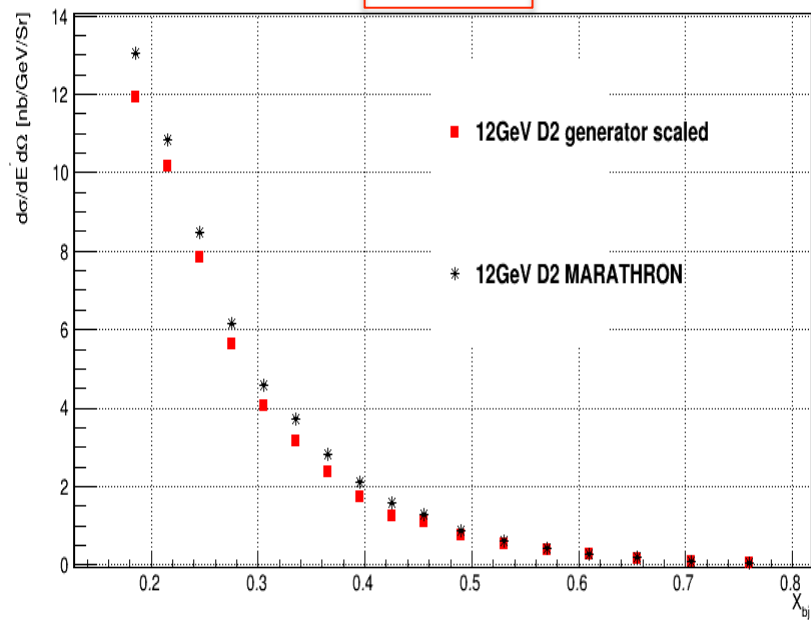
❖ **Compare the outputs from the updated “inclusive_e” generator to the available data.**

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

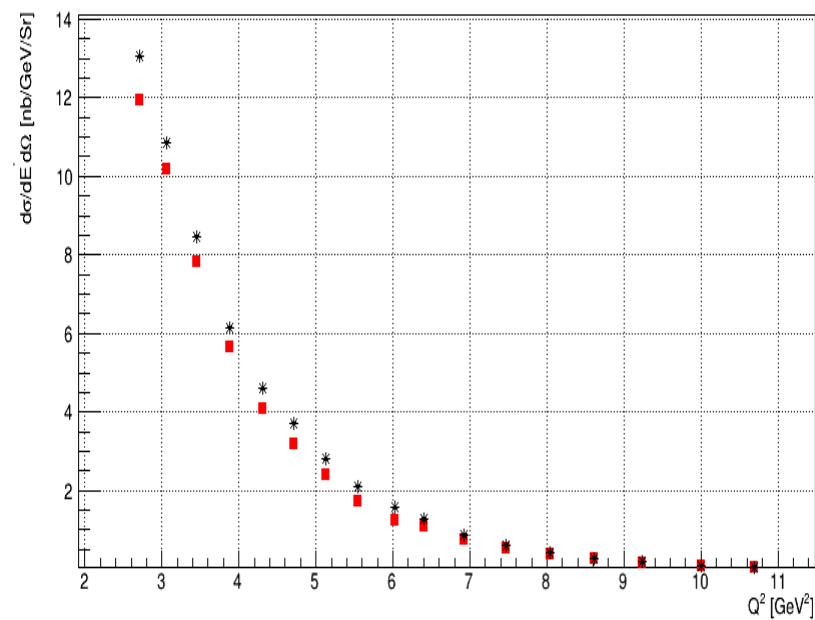
He3 target



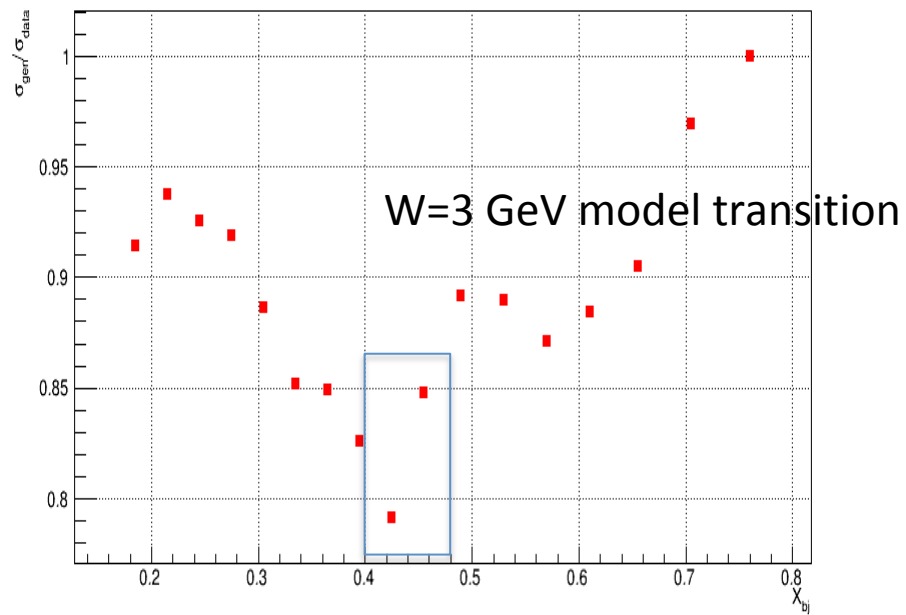
D2 Target



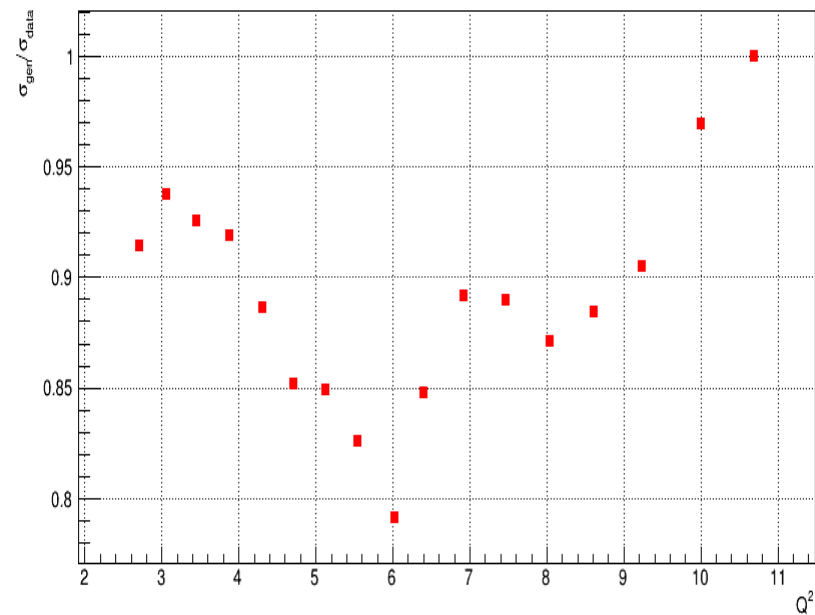
D2 Target



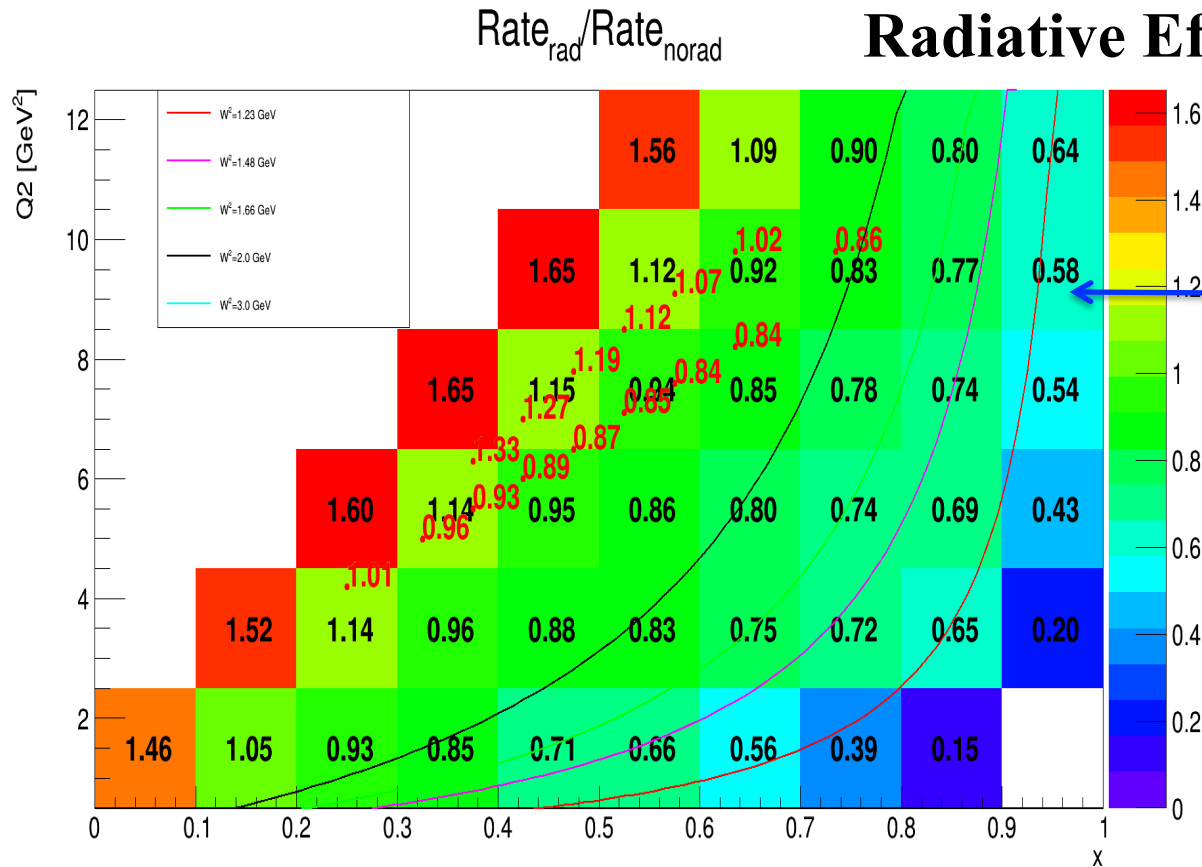
D2 Target



D2 Target



Radiative Effect for PVDIS LD2

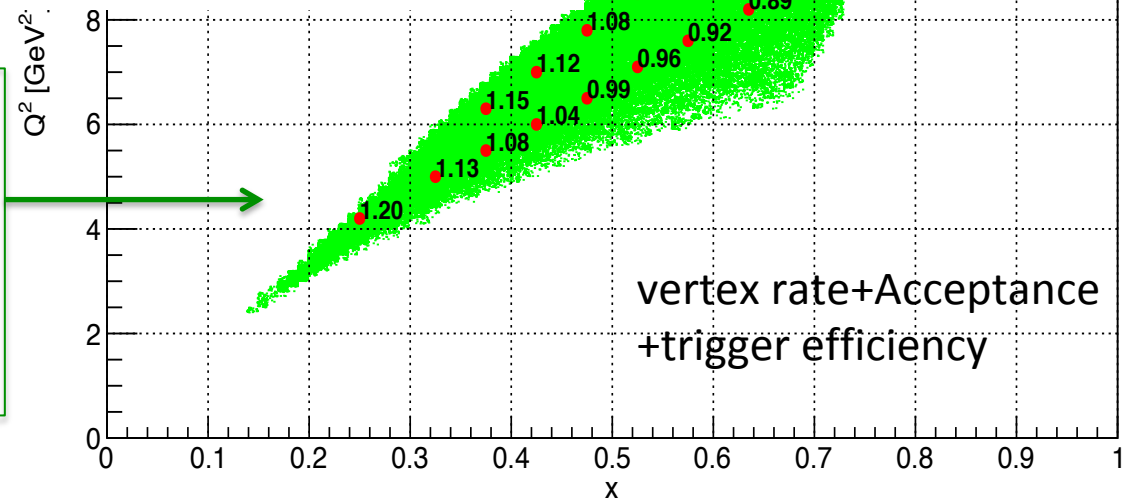


- RLa= Al window+1/2X₀^{target}
- RL = 1/2X₀^{target}
- RLb= side wall(400um)+
chamber window(200um)
+air to GEM(100cm)

/ eAll_{norad}

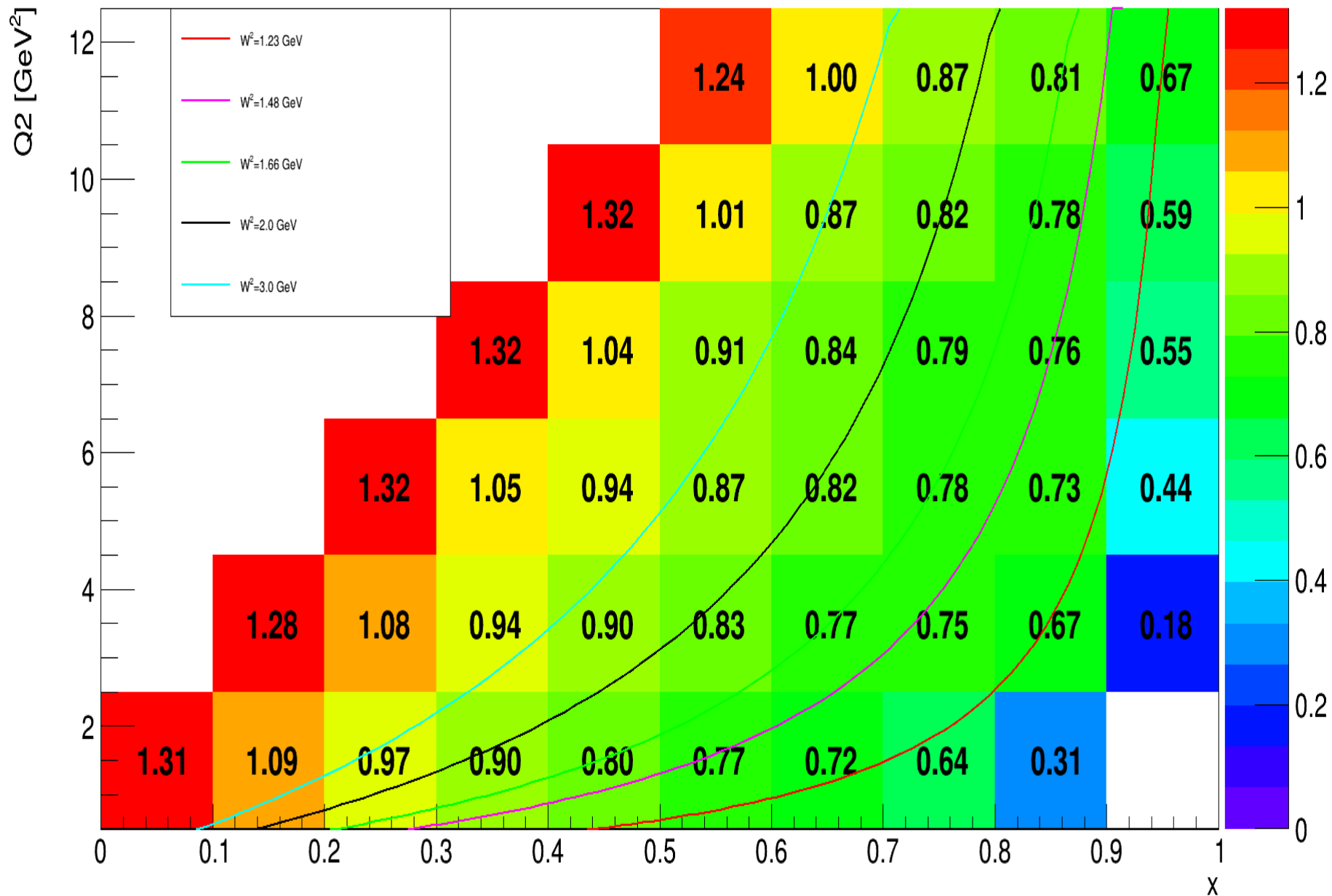
From Weizhi

- RLa= Al window+1/2X₀^{target}
- RL = 1/2X₀^{target}
- RLb= GEMC



Rate_{rad_SIDIS}/Rate_{norad_SIDIS}

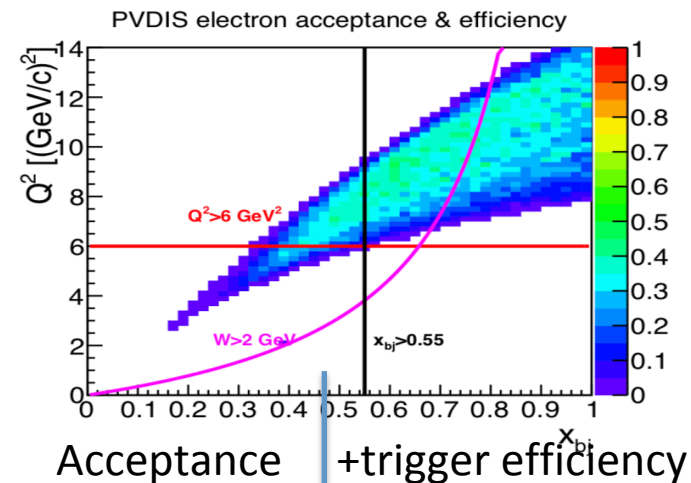
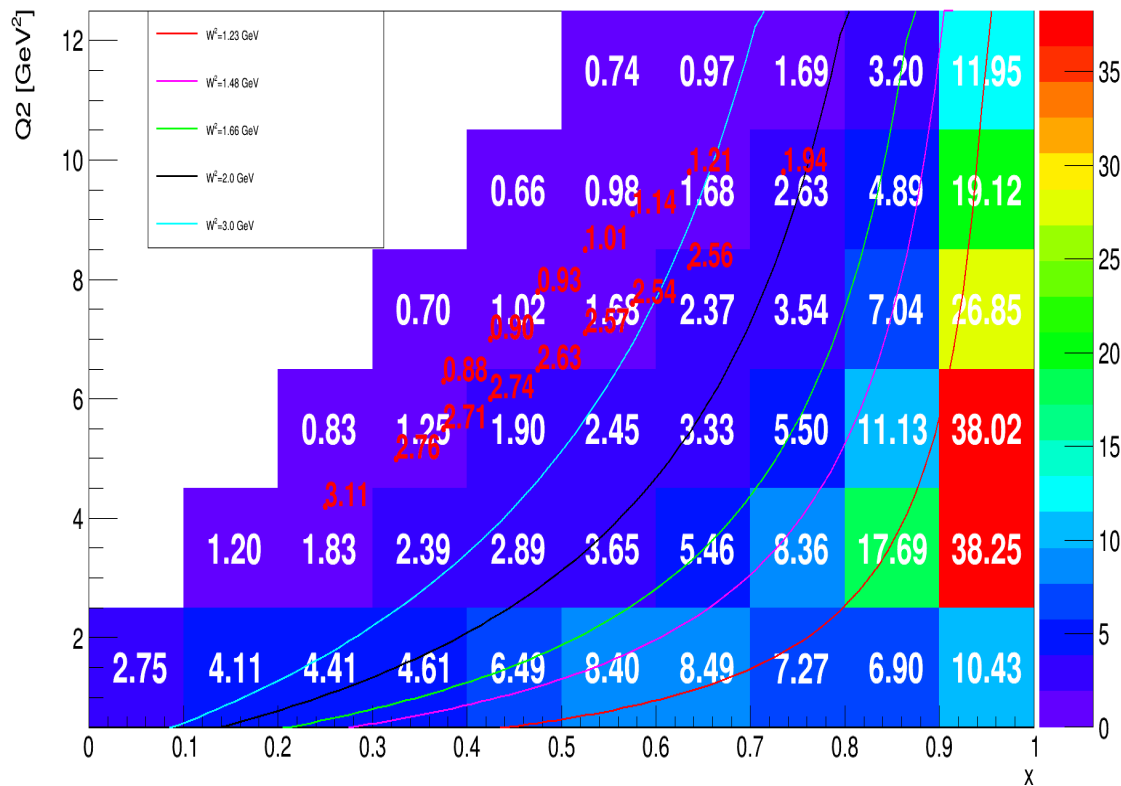
SIDIS 3He



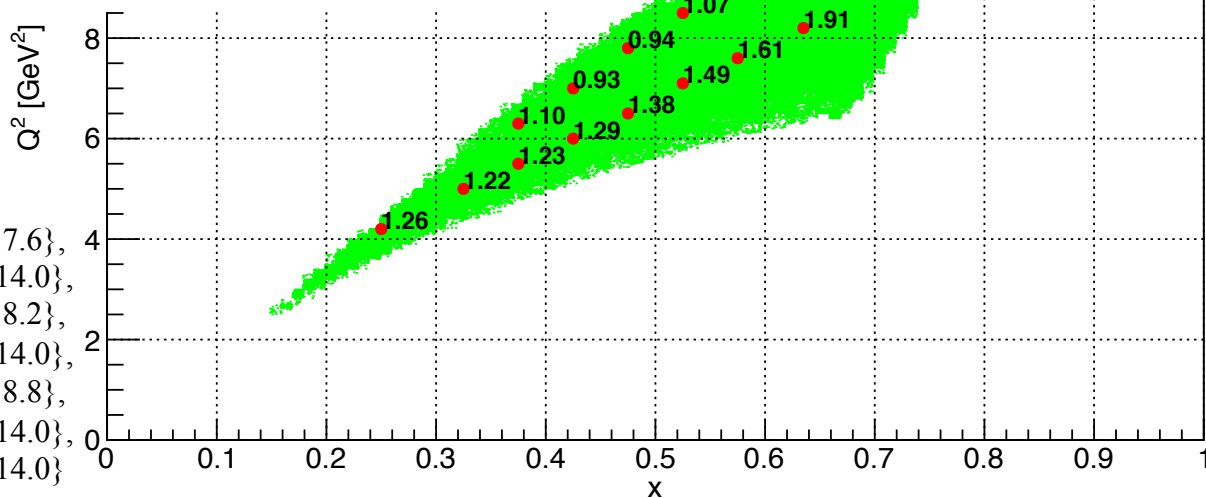
Rate_{eAll}/Rate_{eDIS}

No Radiative effects

PVDIS LD2



Acceptance + trigger efficiency

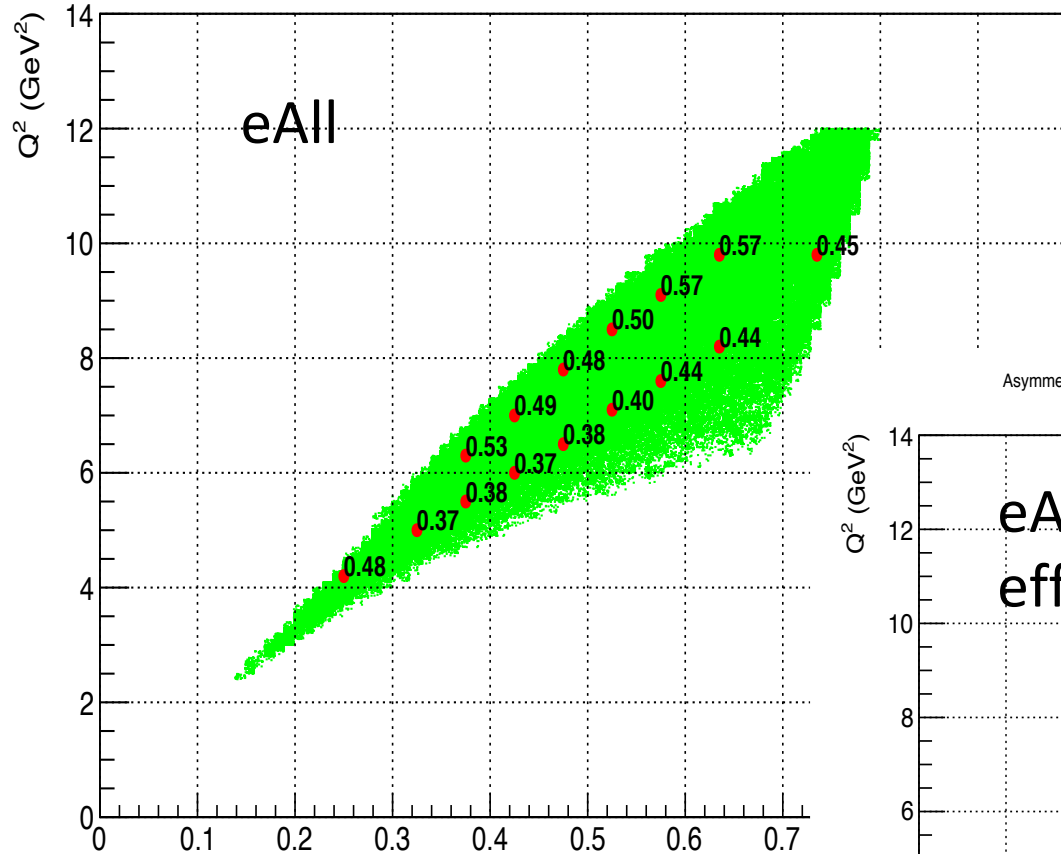


```
double bin[Nbin][4]={
{0.20,0.30, 0.0,14.0},
{0.30,0.35, 0.0,14.0},
{0.35,0.40, 0.0, 5.8},
{0.35,0.40, 5.8,14.0},
{0.40,0.45, 0.0, 6.4},
{0.40,0.45, 6.4,14.0}, {0.50,0.55, 0.0, 7.6},
{0.45,0.50, 0.0, 7.0}, {0.50,0.55, 7.6,14.0},
{0.45,0.50, 7.0,14.0}, {0.55,0.60, 0.0, 8.2},
};
{0.55,0.60, 8.2,14.0},
{0.60,0.67, 0.0, 8.8},
{0.60,0.67, 8.8,14.0},
{0.67,0.80, 0.0,14.0}
```

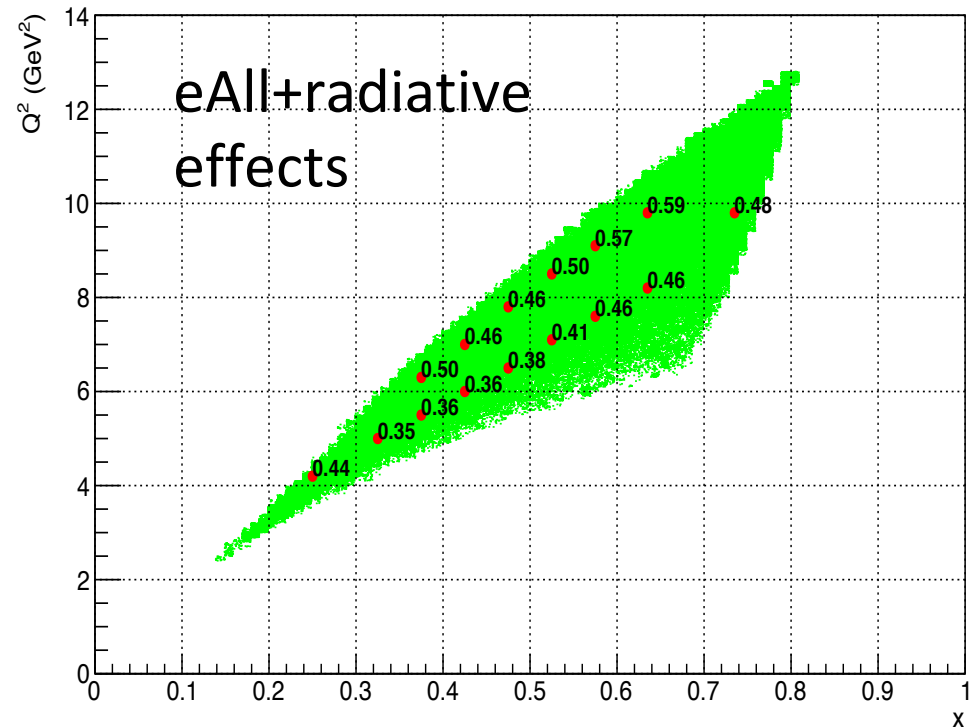
PVDIS Asymmetry Uncertainty (%)

Asymmetry Uncertainty (%) with 120 days of 85% polarized 50uA electron beam on 40cm LD2 target

From Weizhi



Asymmetry Uncertainty (%) with 120 days of 85% polarized 50uA electron beam on 40cm LD2 target



Evgen_inclusiv_e generator

Current inclusive electron generator (eAll)

- **$W < 3 \text{ GeV}$**

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

Empirical fit

3He fit?

- **$W > 3 \text{ GeV}$: PDF sets**

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



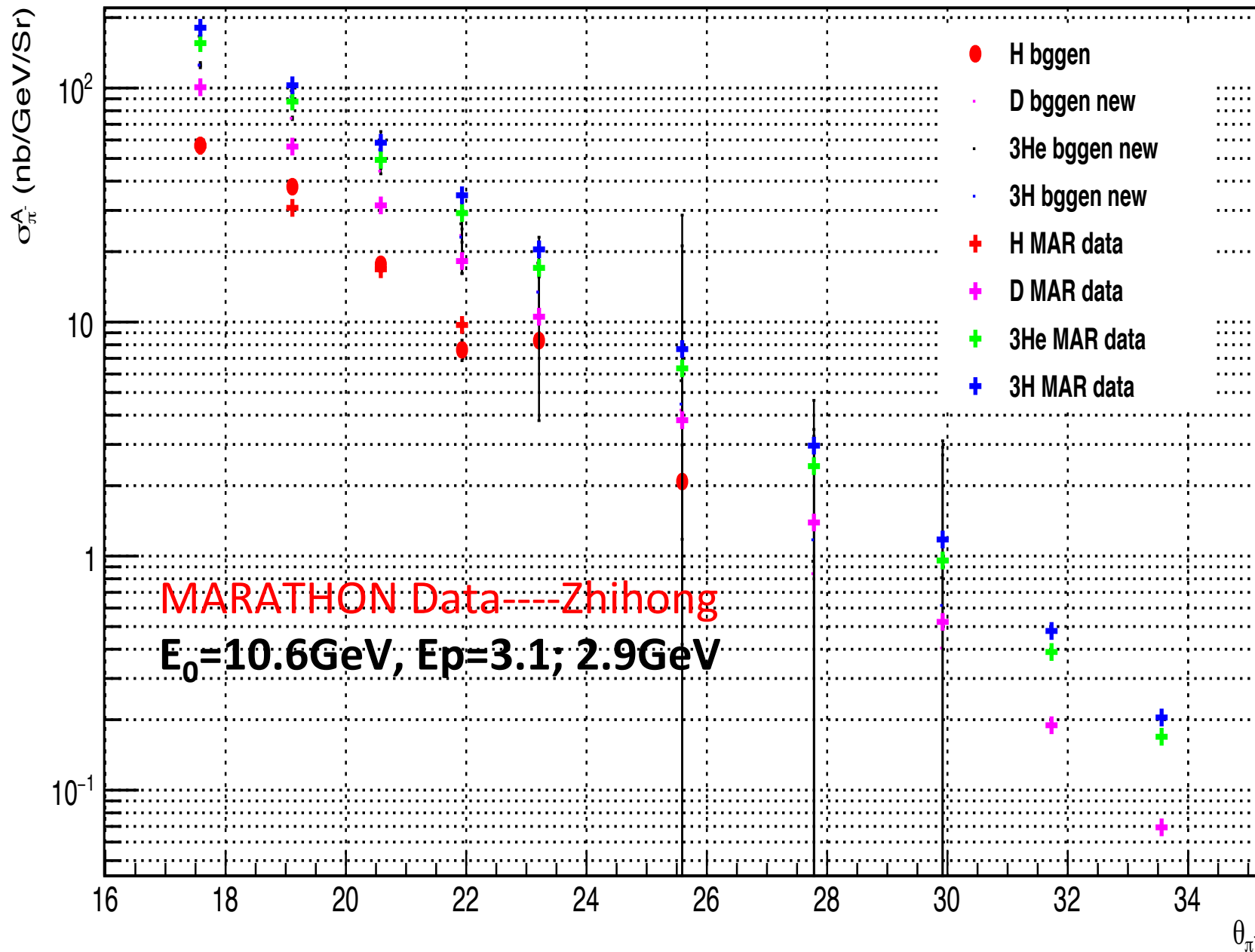
Current inclusive electron generator (eAll)

- **W up to 12 GeV -----**
- HallC data on F2 at $W > 3 \text{ GeV}$
better 3He fit !

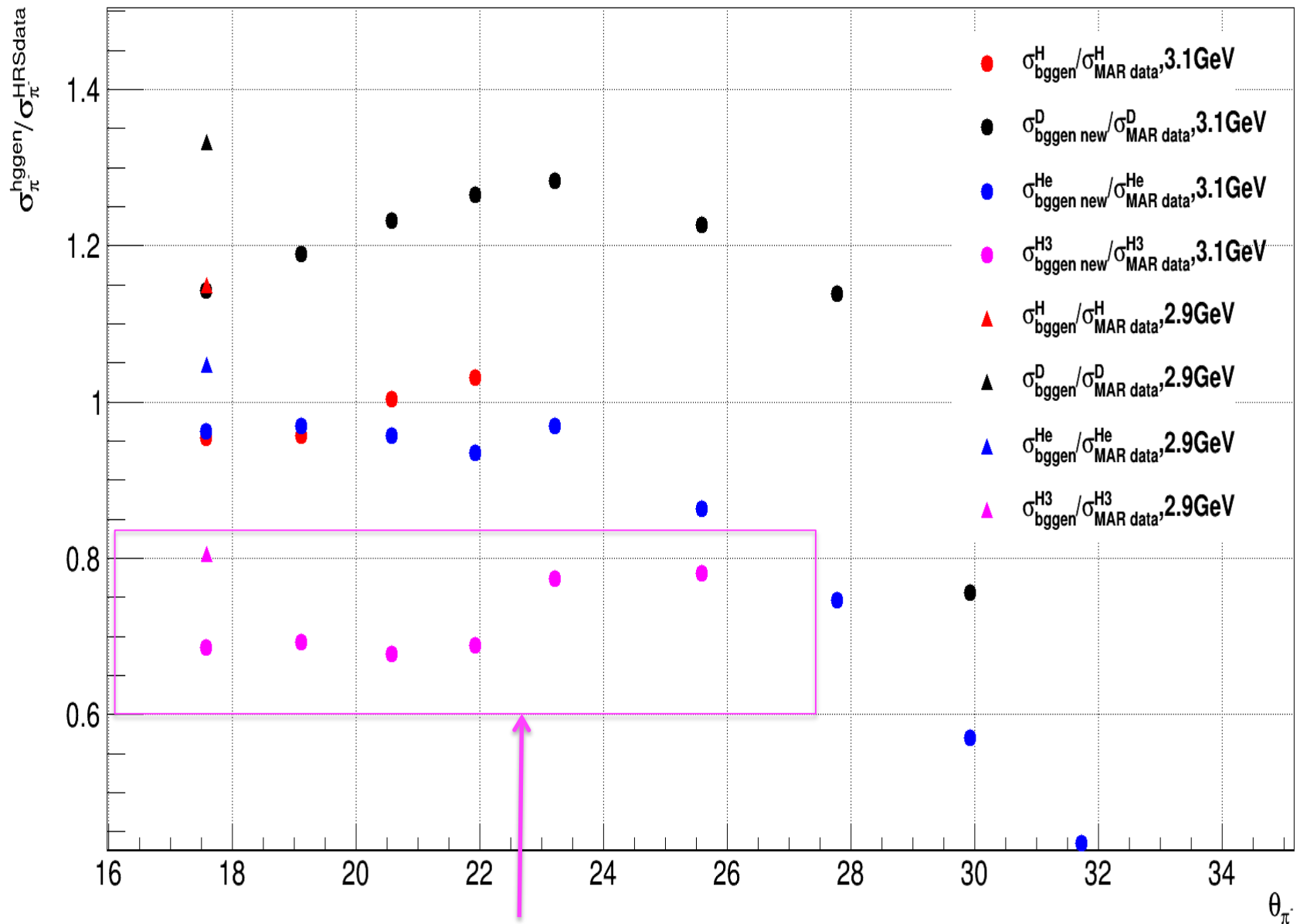
Hadron Generator

- 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 \(loop Z and \$E_\gamma\$ \)](#).

π^- bggen generator cross section

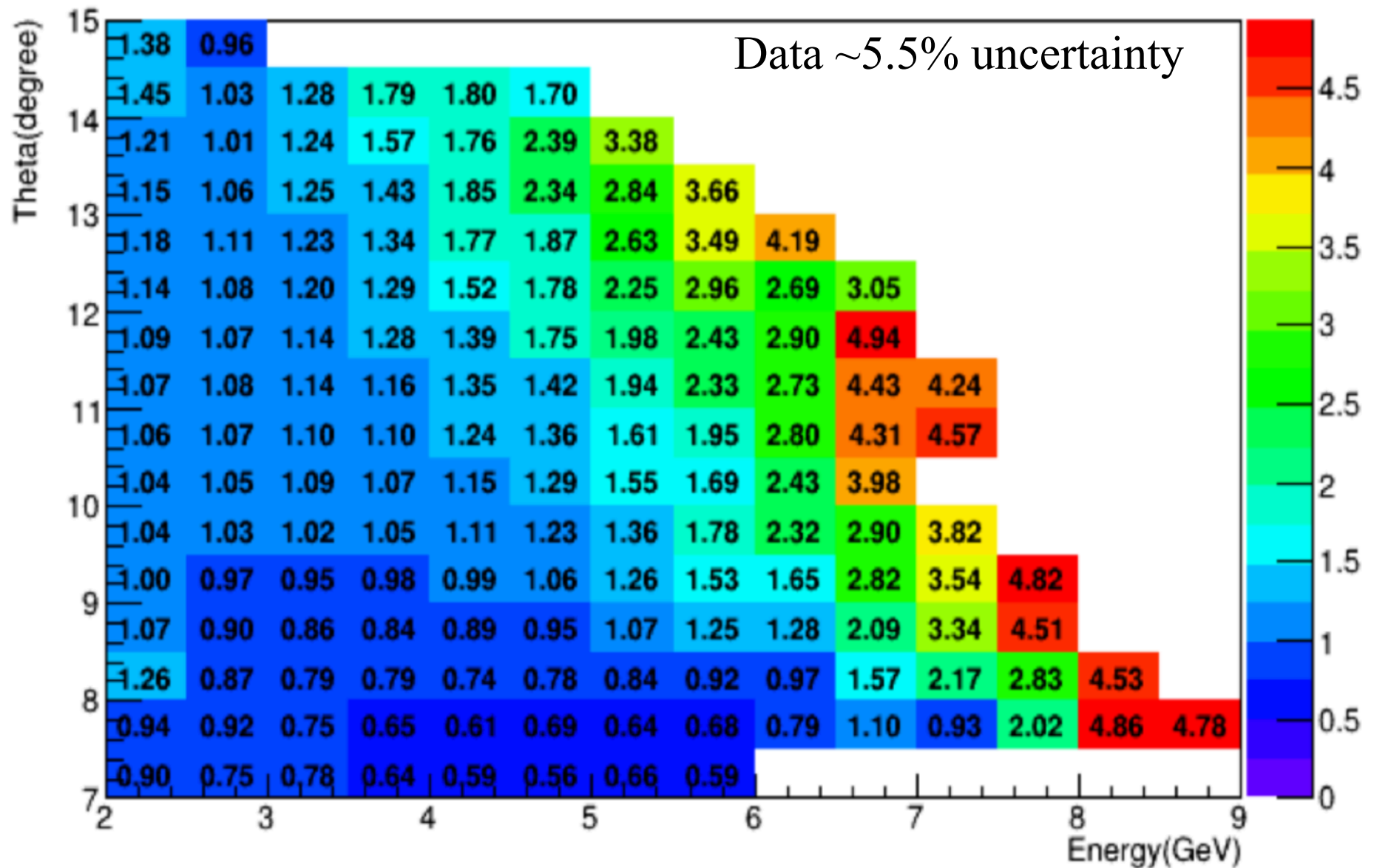


π^- cross section ratio



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

π^0 DVCS_yield /bggen_yield



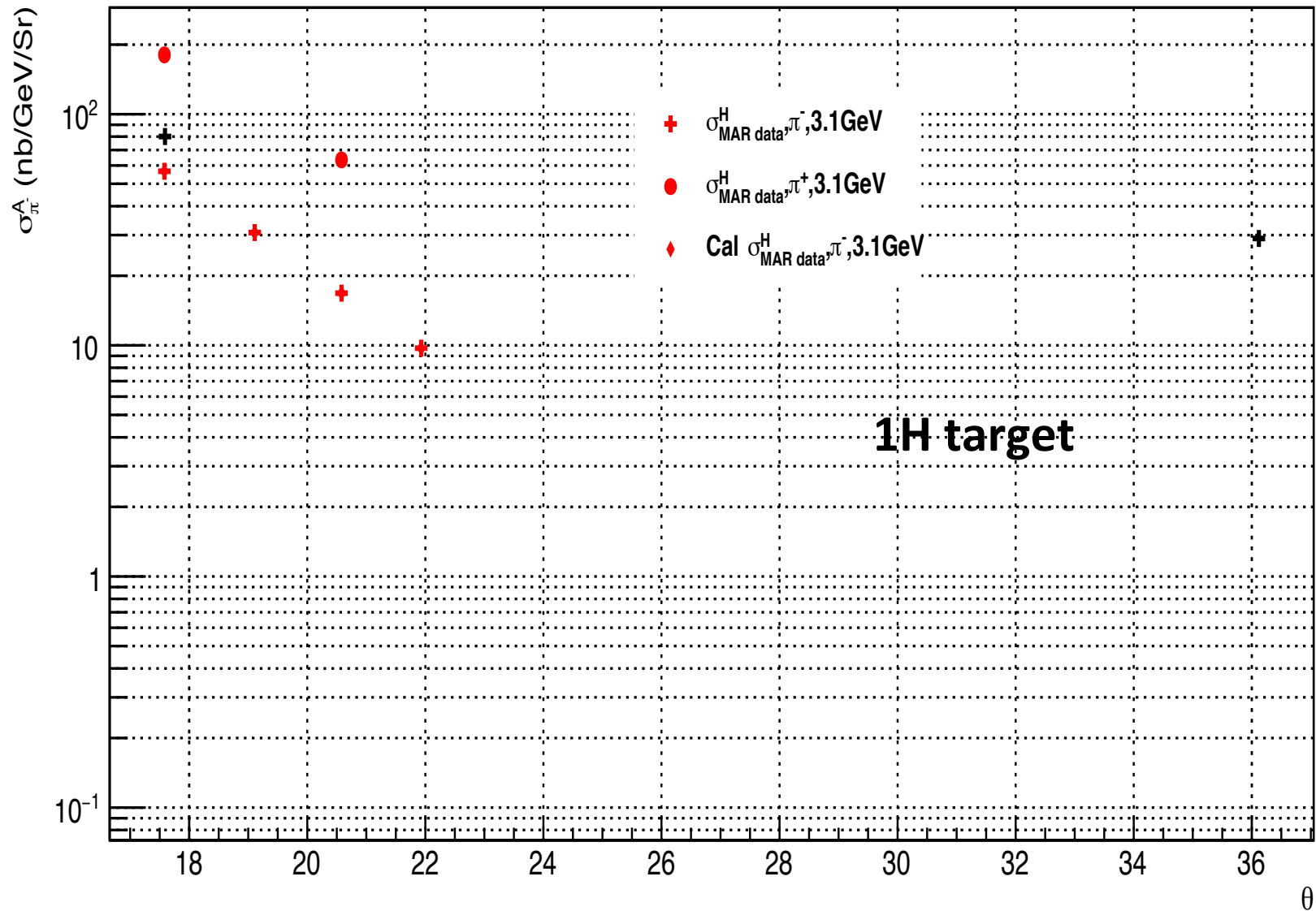
Summary and Outlook

- 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

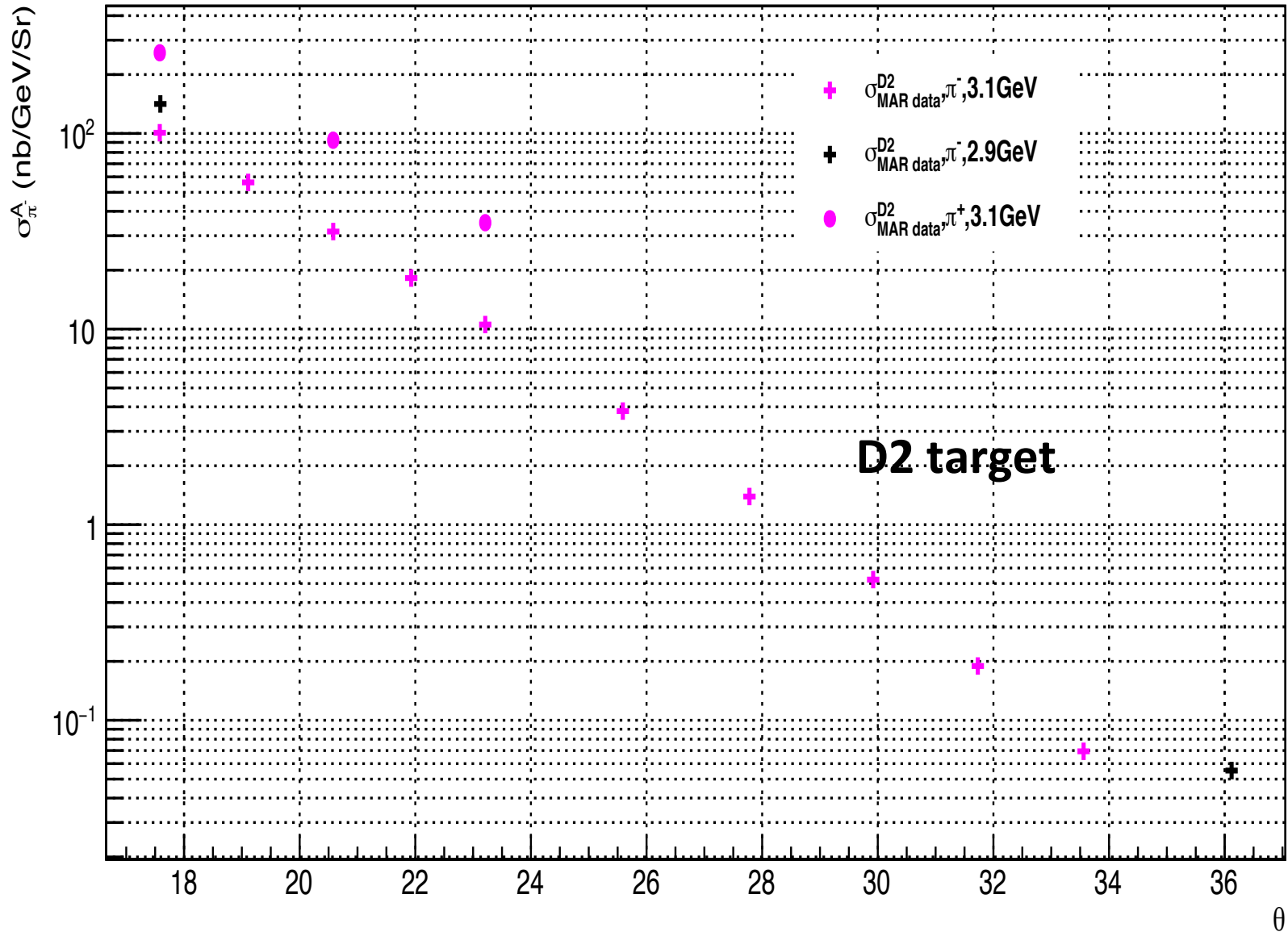
MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV



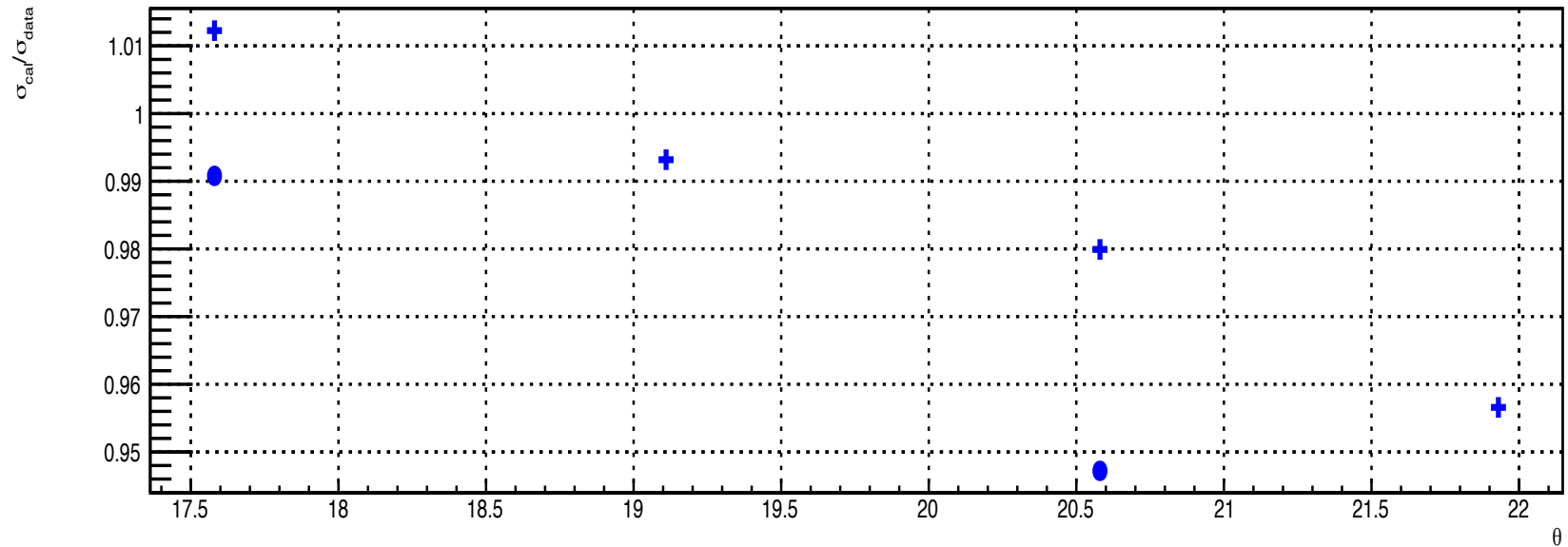
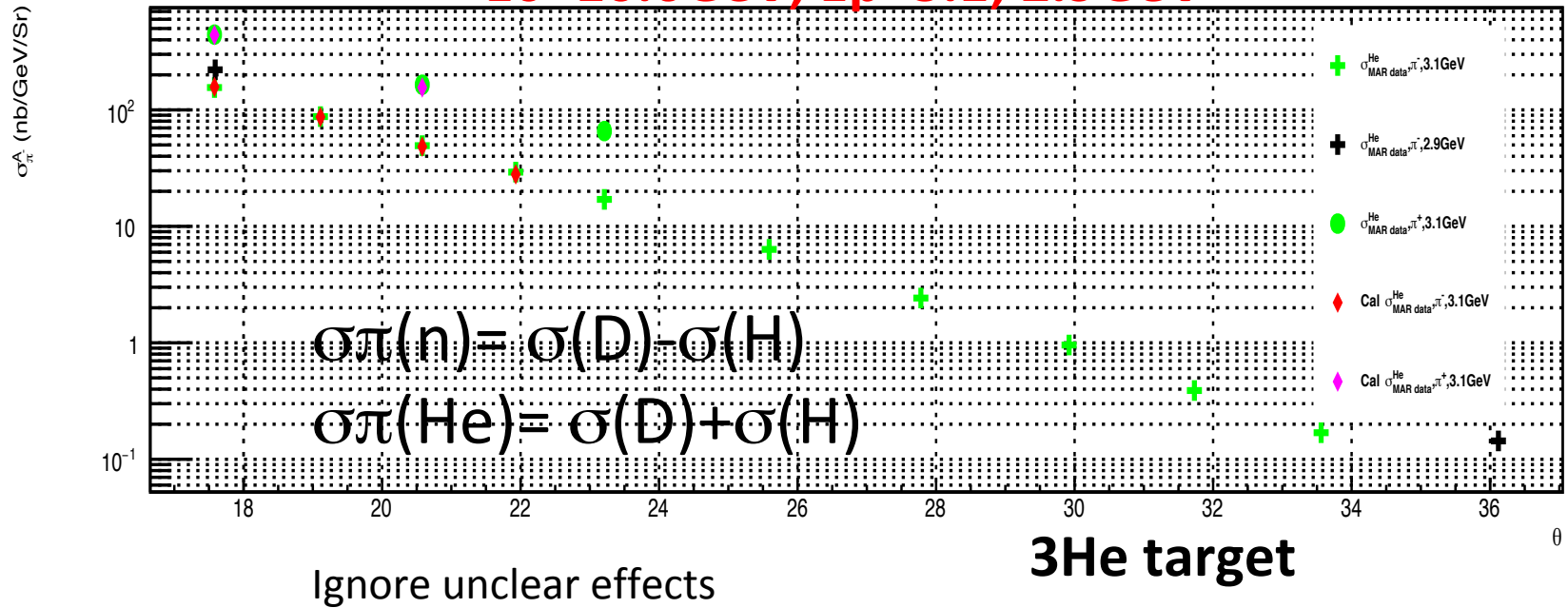
MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV



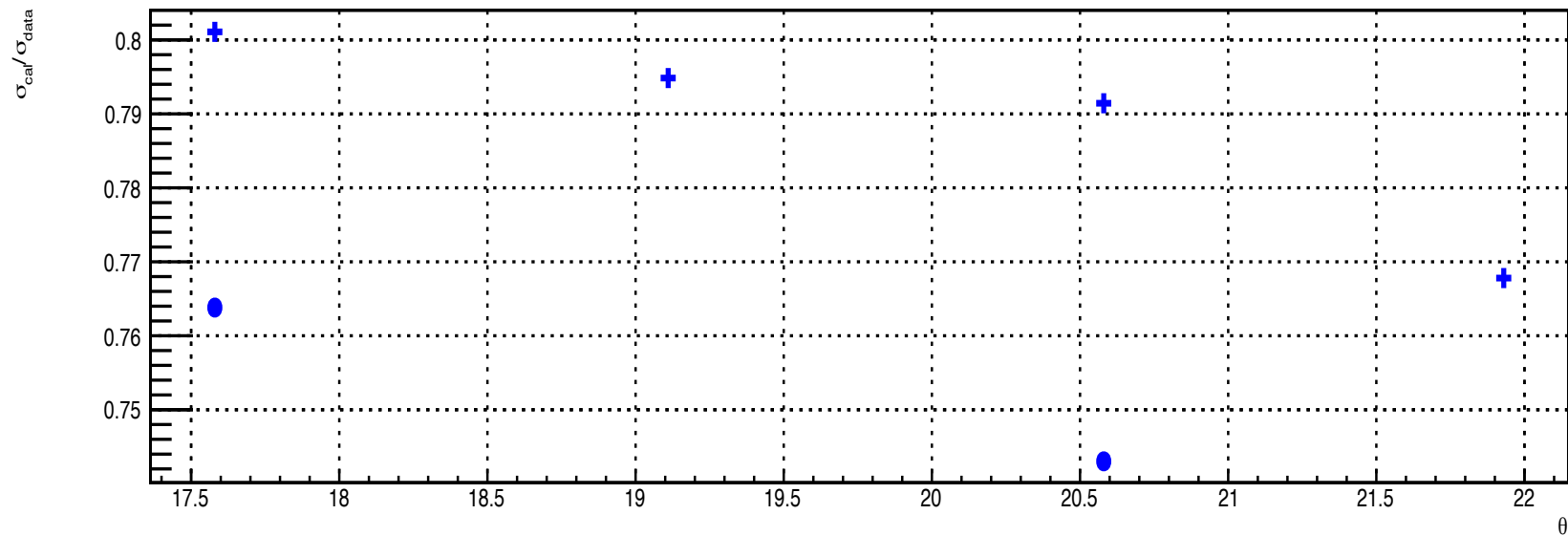
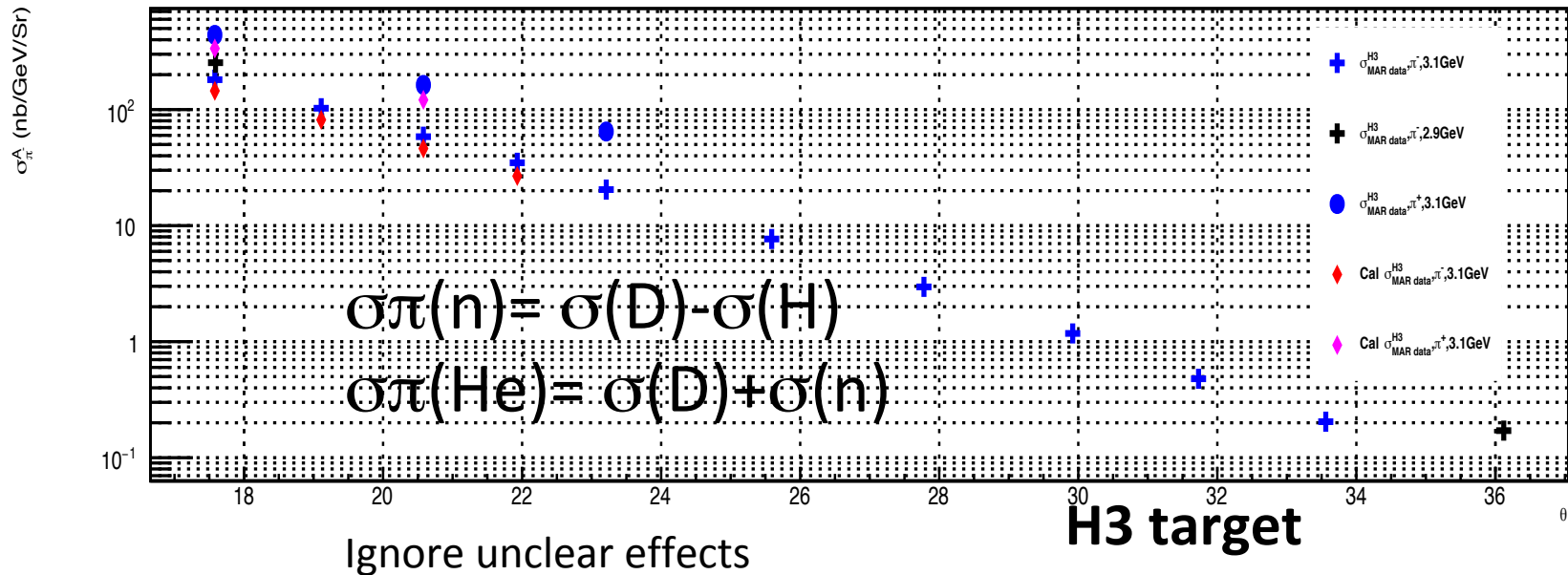
MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV



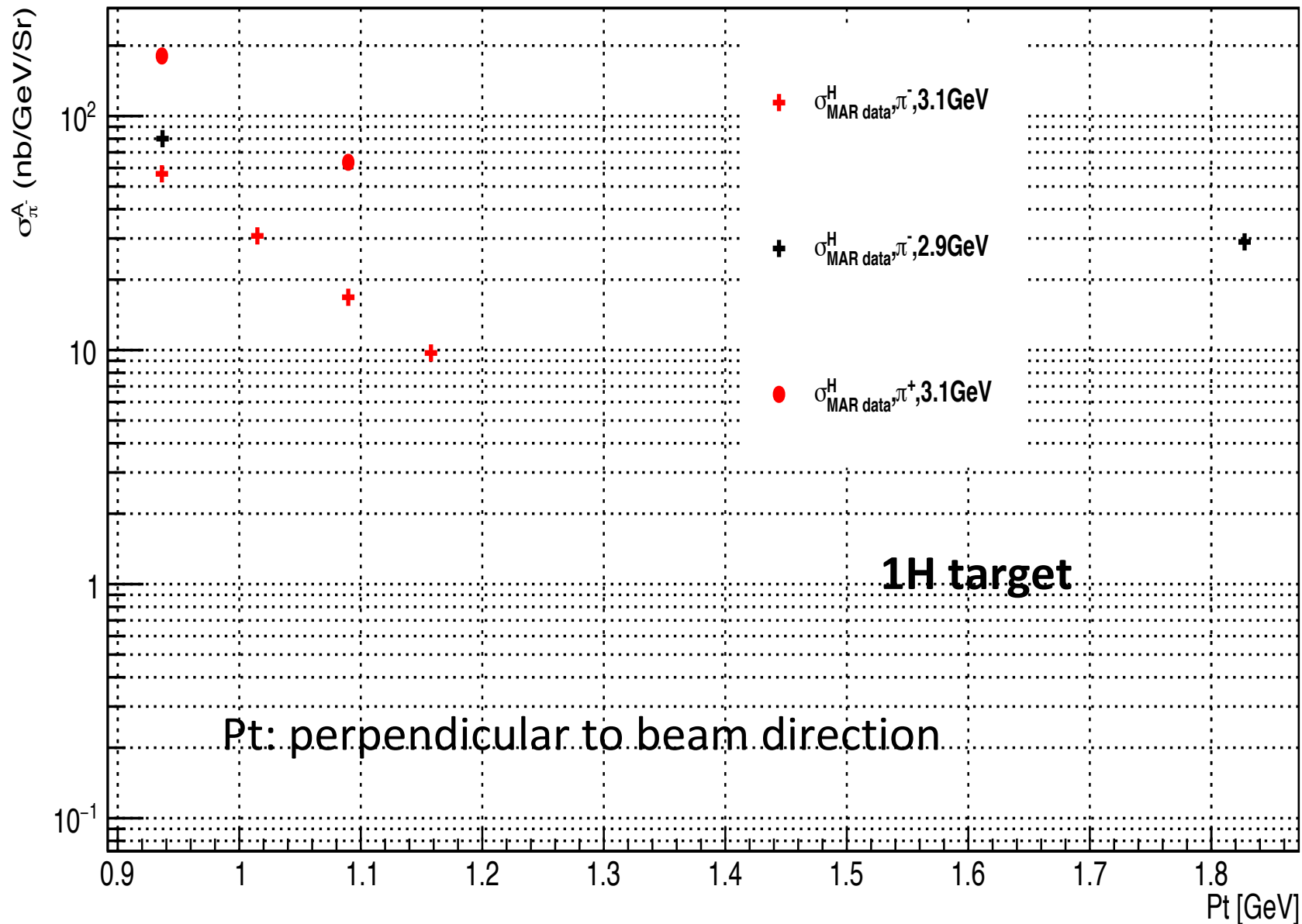
MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV



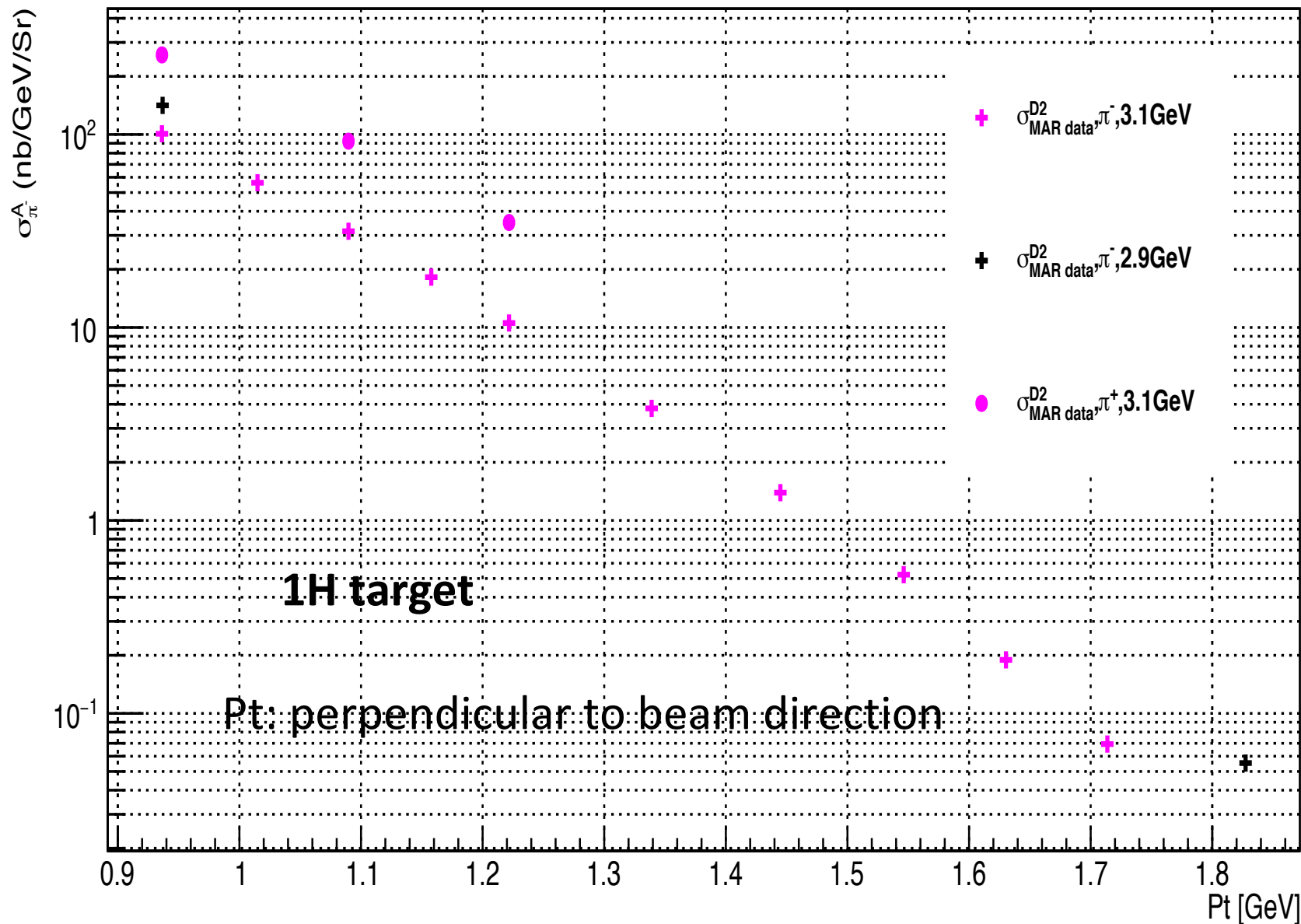
MARATHON Data

E0=10.6GeV, E_p=3.1; 2.9GeV



MARATHON Data

E0=10.6GeV, Ep=3.1; 2.9GeV



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

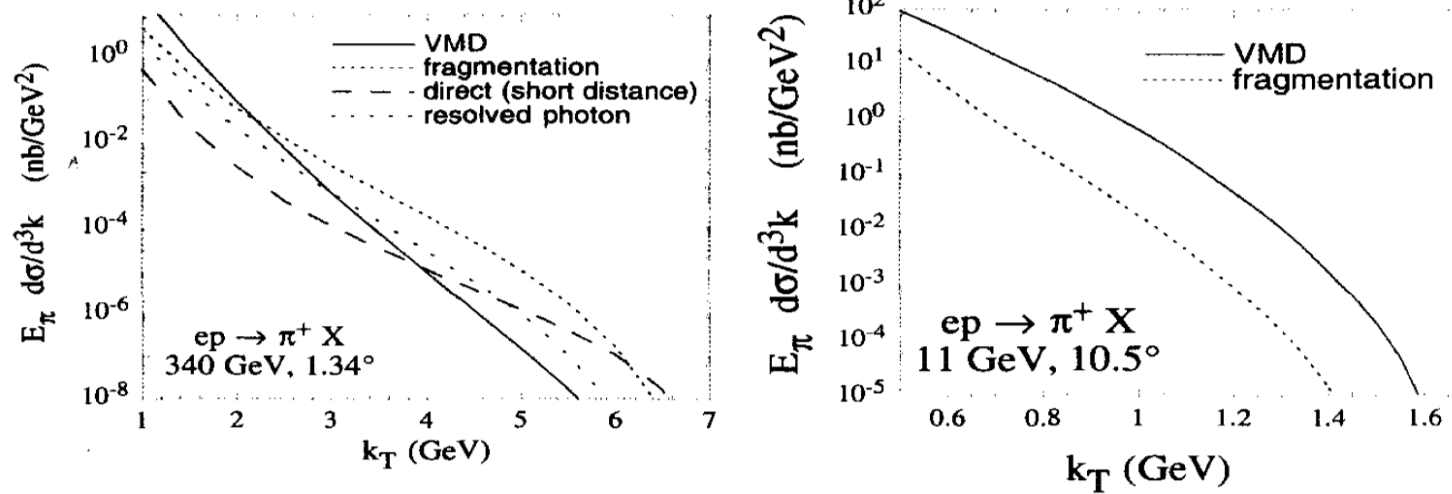


Figure 2. Soft and fragmentation contributions induced by real photons.

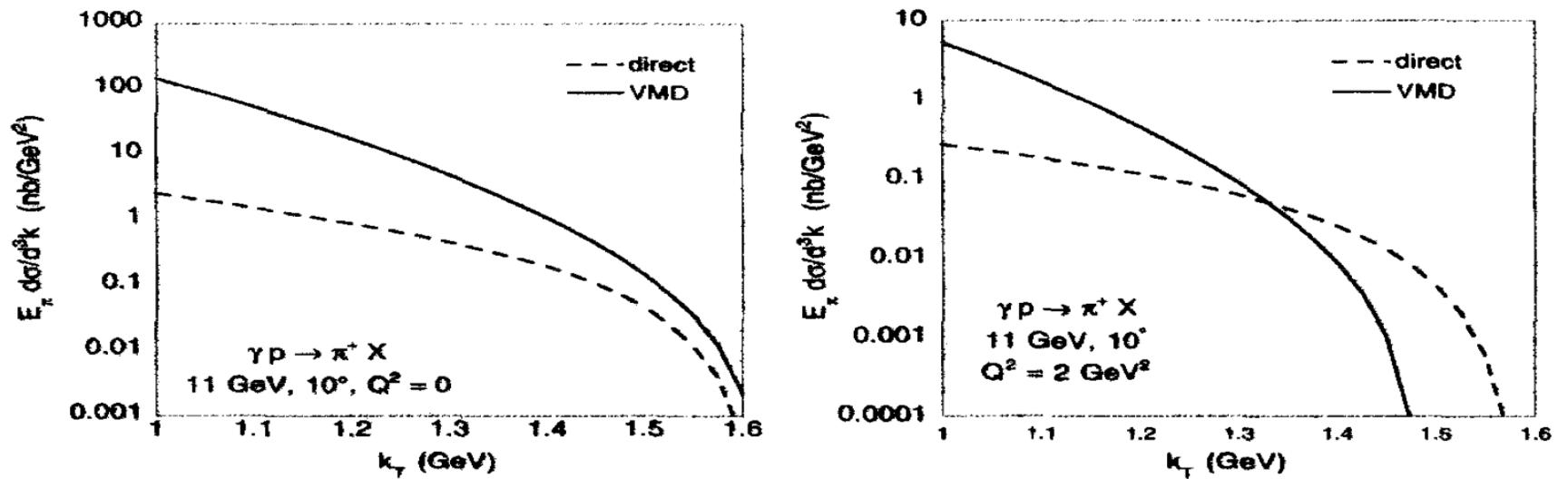


Figure 4. On and off shell transversely polarized photon processes.

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

$$\frac{d^2\sigma^i}{dxdy} = \frac{4\pi\alpha^2}{xyQ^2} \eta^i \left\{ \left(1 - y - \frac{x^2y^2M^2}{Q^2}\right) F_2^i + y^2 x F_1^i \mp \left(y - \frac{y^2}{2}\right) x F_3^i \right\}, \tag{18.8}$$

where $i = \text{NC, CC}$ corresponds to neutral-current ($eN \rightarrow eX$) or charged-current ($eN \rightarrow \nu X$ or $\nu N \rightarrow eX$) processes, respectively. For incoming neutrinos, $L_{\mu\nu}^W$ 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 $\bar{\nu}$ and the $+$ sign for an incoming e^- or ν . The factor $\eta^{\text{NC}} = 1$ for unpolarized $e^\pm$ beams, whereas*

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

$$\frac{\nu}{E' \sin^2 \frac{\theta}{2} + \nu} = \frac{\nu}{E' \sin^2 \frac{\theta}{2} + E - E'} = \frac{\nu}{E - E' \left(1 - \sin^2 \frac{\theta}{2}\right)} \neq \frac{\nu}{E}$$

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

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

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

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

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

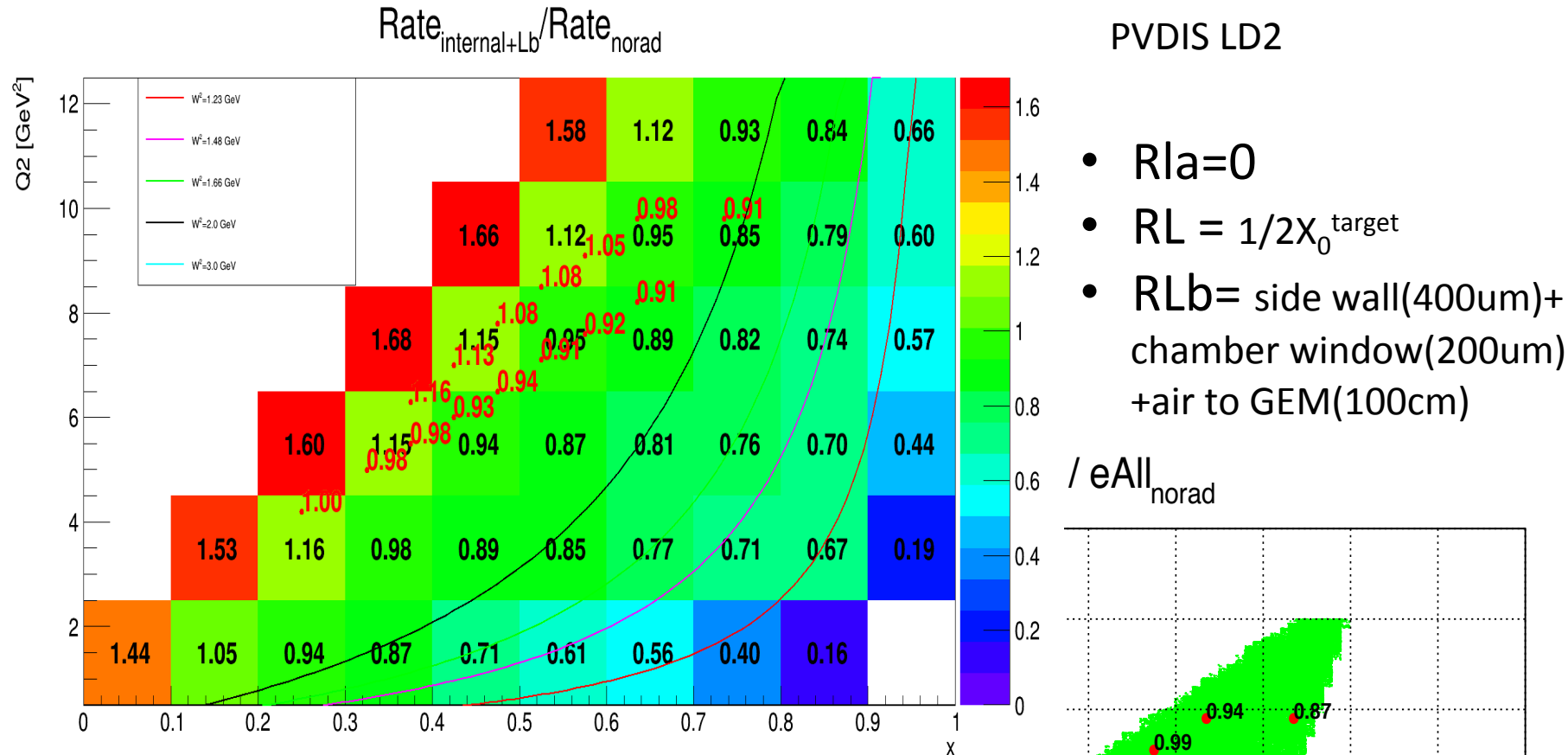
$$\sigma_{Mott} = \frac{4a^2 E'^2}{Q^4} \cos^2 \frac{\theta}{2}$$

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

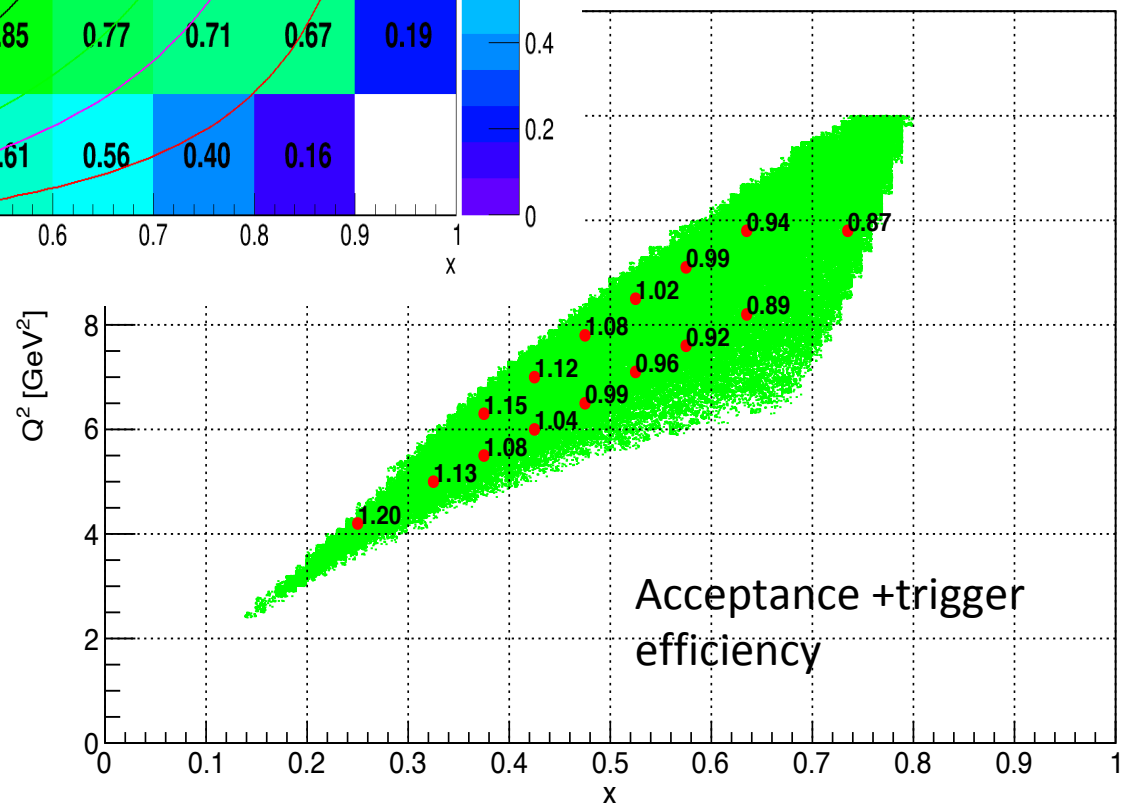
F2g from parton model

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

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

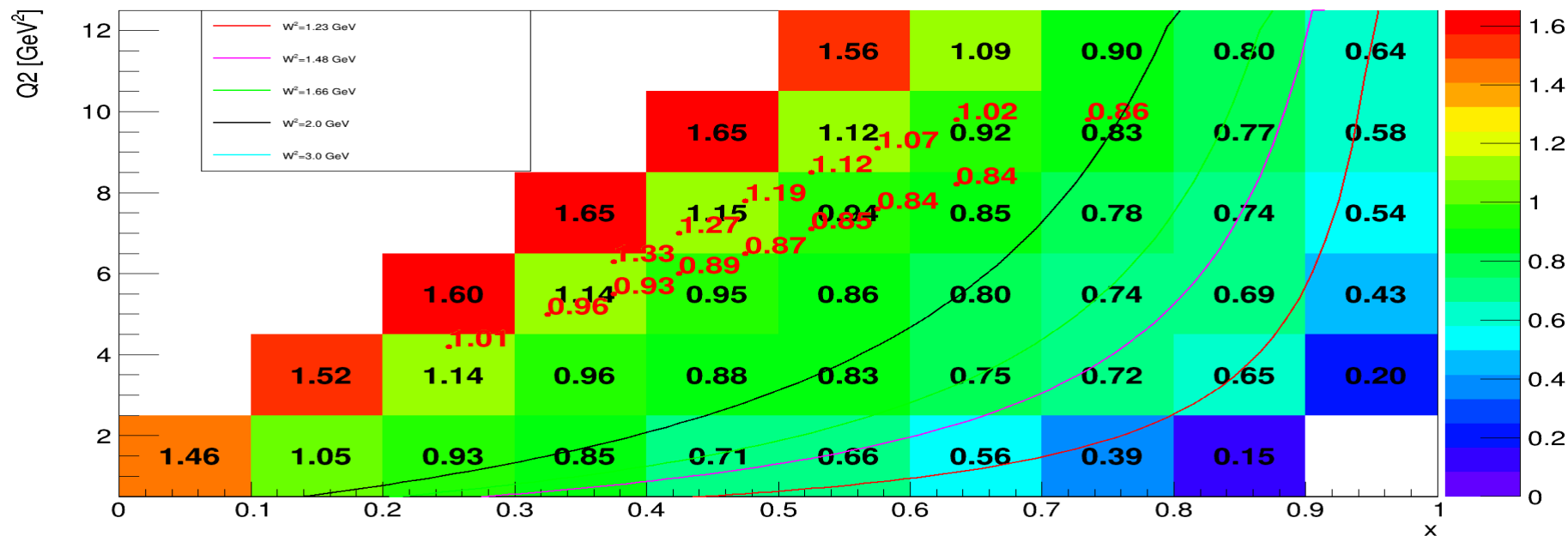


- RLa= Al window+ $1/2X_0^{\text{target}}$
- $RL = 1/2X_0^{\text{target}}$
- RLb= GEMC

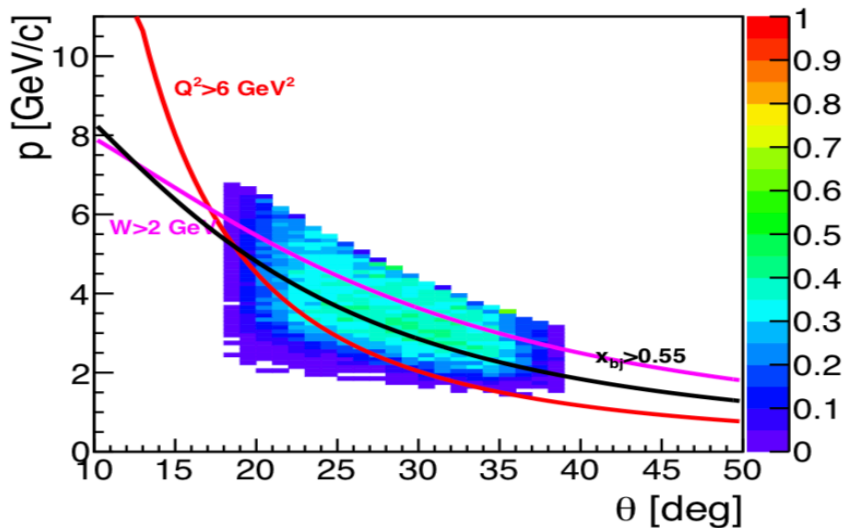


Radiative Effect for PVDIS LD2

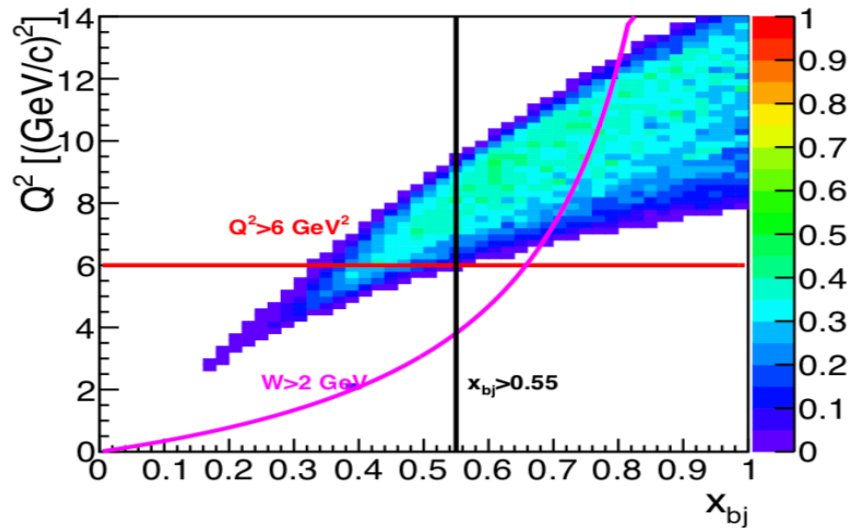
$\text{Rate}_{\text{rad}}/\text{Rate}_{\text{norad}}$



PVDIS electron acceptance & efficiency



PVDIS electron acceptance & efficiency



Assumption

- Rate calculation for $A > 1$:

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

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

$$\sigma_{\pi^-}(\text{He}_3) = \sigma_{\pi^-}(n) + 2\sigma_{\pi^-}(p) = \sigma_{\pi^+}(p) + 2\sigma_{\pi^-}(p)$$

$$\sigma_{\pi^+}(\text{He}_3) = \sigma_{\pi^+}(n) + 2\sigma_{\pi^+}(p) = \sigma_{\pi^-}(p) + 2\sigma_{\pi^+}(p)$$

Check the above assumption with MARATHON data:

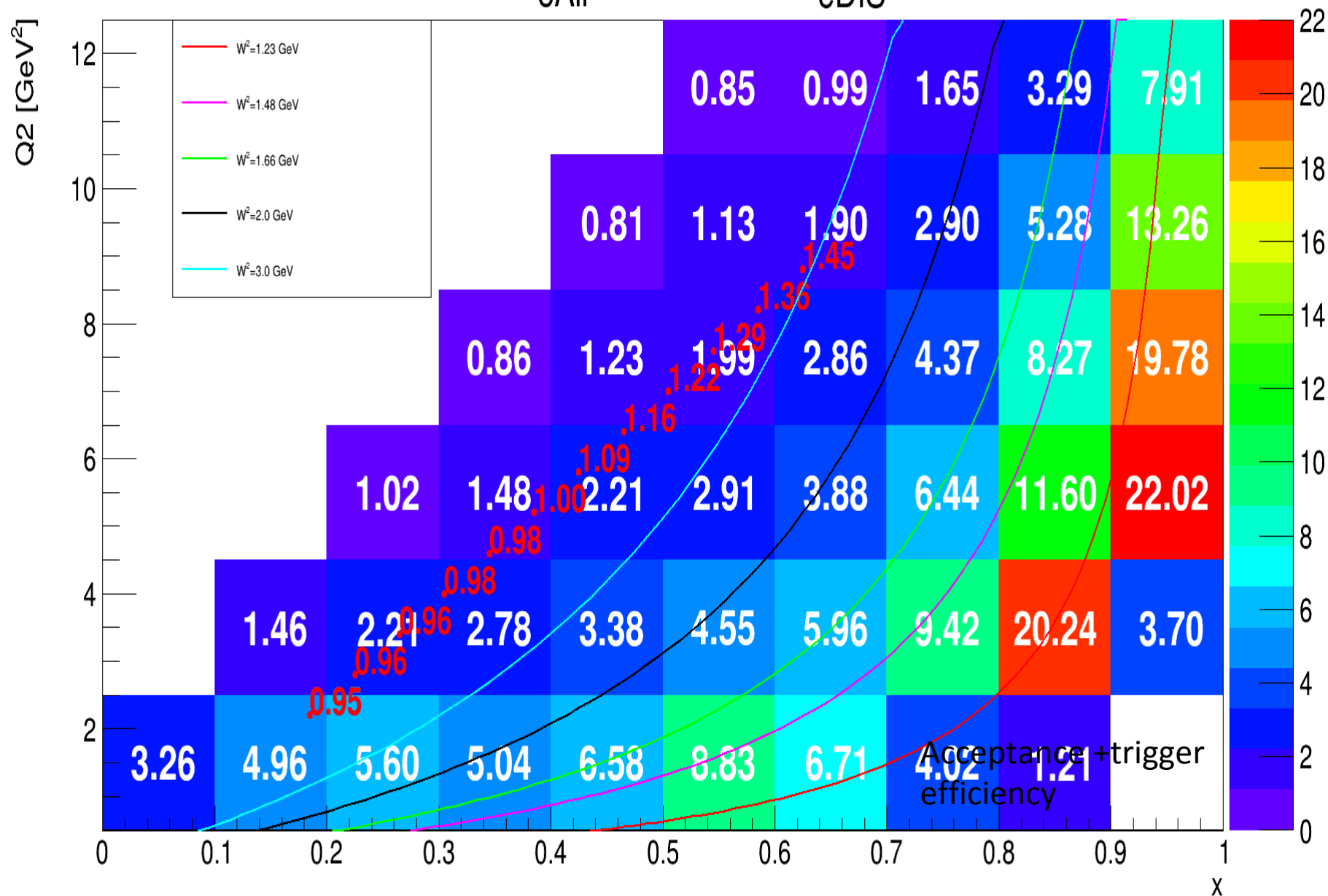
$$\sigma_{\pi^-}(n) = \sigma_{\pi^+}(p) = 1/3 * [2\sigma_{\pi^-}(\text{H3}) - \sigma_{\pi^-}(\text{He3})]$$

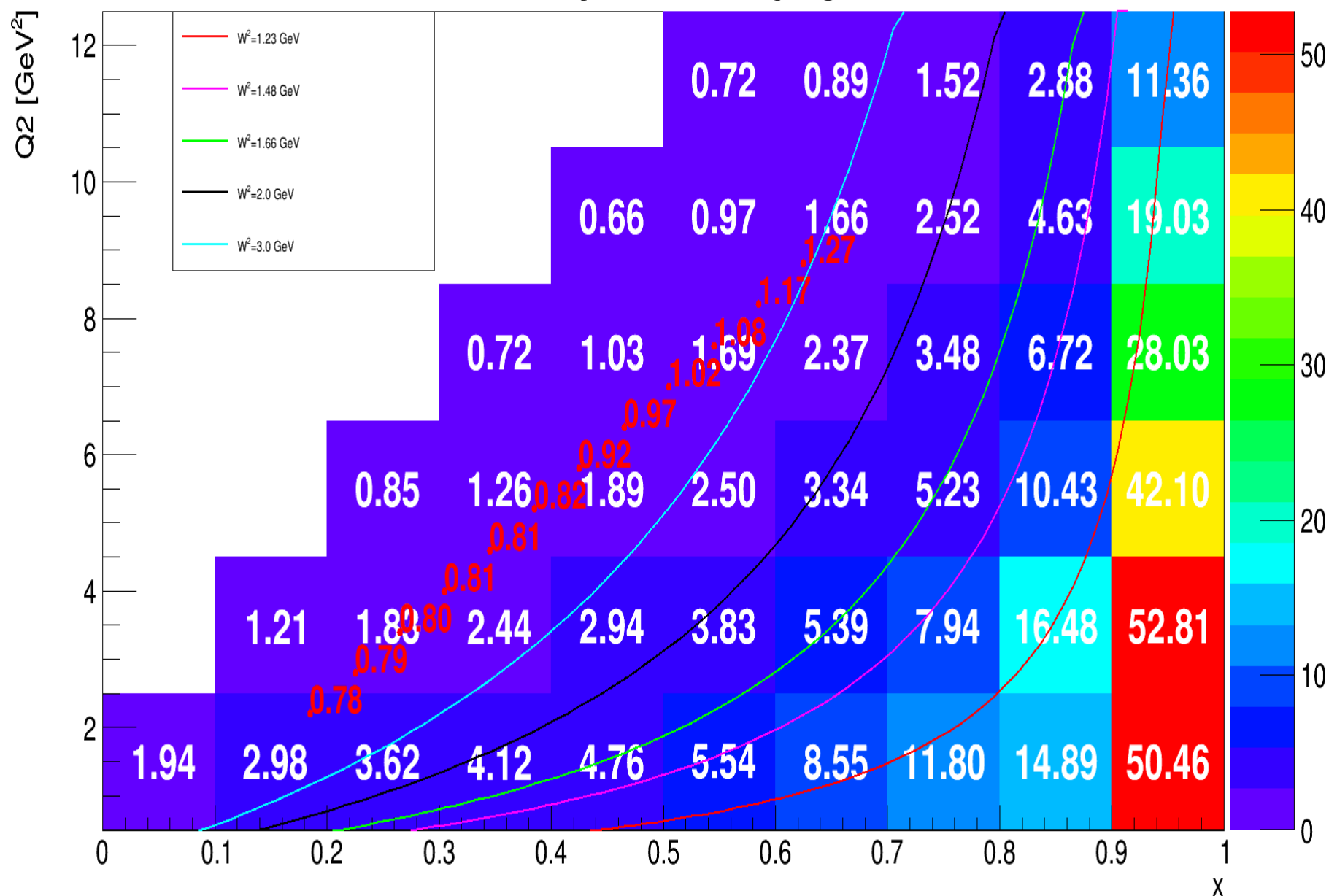
$$\sigma_{\pi^-}(p) = \sigma_{\pi^+}(n) = 1/3 * [2\sigma_{\pi^-}(\text{He3}) - \sigma_{\pi^-}(\text{H3})]$$

No radiative effects

Rate^{LH2 noscale}_{eAll} / Rate^{LH2}_{eDIS}

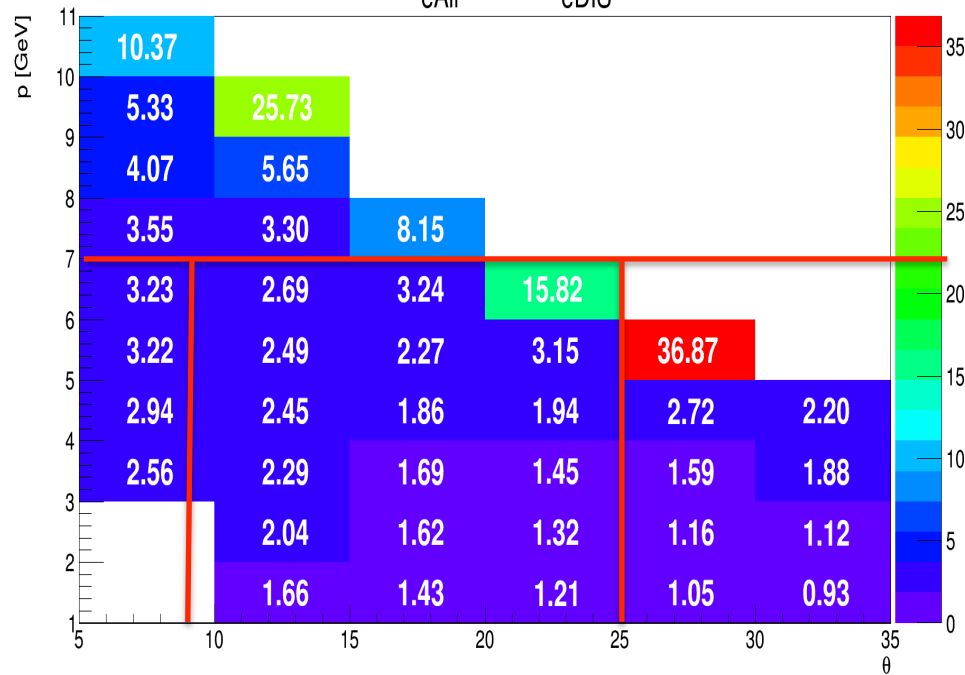
PVDIS LH2



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


SIDIS He3

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



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- **W<3 GeV**

M.E. Christy and P.E. Bosted-----2009 Empirical fit
3He fit?

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

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Current inclusive electron generator (eAll)

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

