Photo-Production Model Comparison : HallD, PDG, Wiser

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Outline

Photo-Production Models

- Photo-production cross sections generated by hall D low energy generator
- Total Photo-production cross sections from PDG [1]
- Wiser Photo-production cross section summed for all the processes [2]

Hall D Low Energy Photo-Production Generator

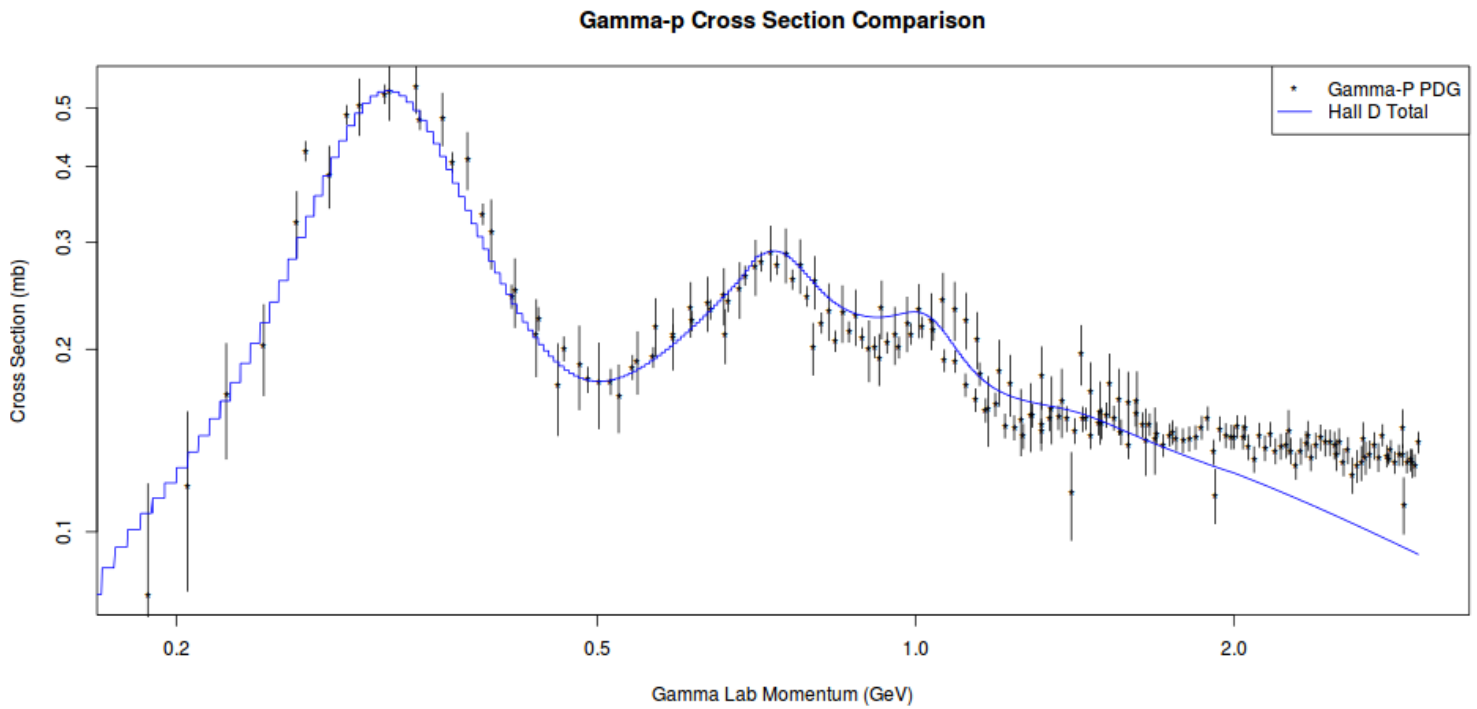
- Hall D generator uses various experimental data to generate photo-production cross sections for photon energies below $3\ \mathrm{GeV}$
- It uses modified version of PYTHIA to generate photo-production cross sections for photon energies above $3\ \mathrm{GeV}$

Following $\gamma + p^+$ reactions are considered for photon energies below $3\ \mathrm{GeV}$

1. $p^+ + \pi^0$
2. $n + \pi^+$
3. $p^+ + \pi^+ + \pi^-(non - res.)$
4. $p^+ + \rho^0$
5. $\Delta^{++} + \pi^-$
6. $p^+ + \pi^0 + \pi^0$
7. $n + \pi^+ + \pi^0$
8. $p^+ + \eta^0$
9. $p^+ + \pi^+ + \pi^- + \pi^0$
10. $n + \pi^+ + \pi^+ + \pi^-$

Compare Hall D vs. PDG

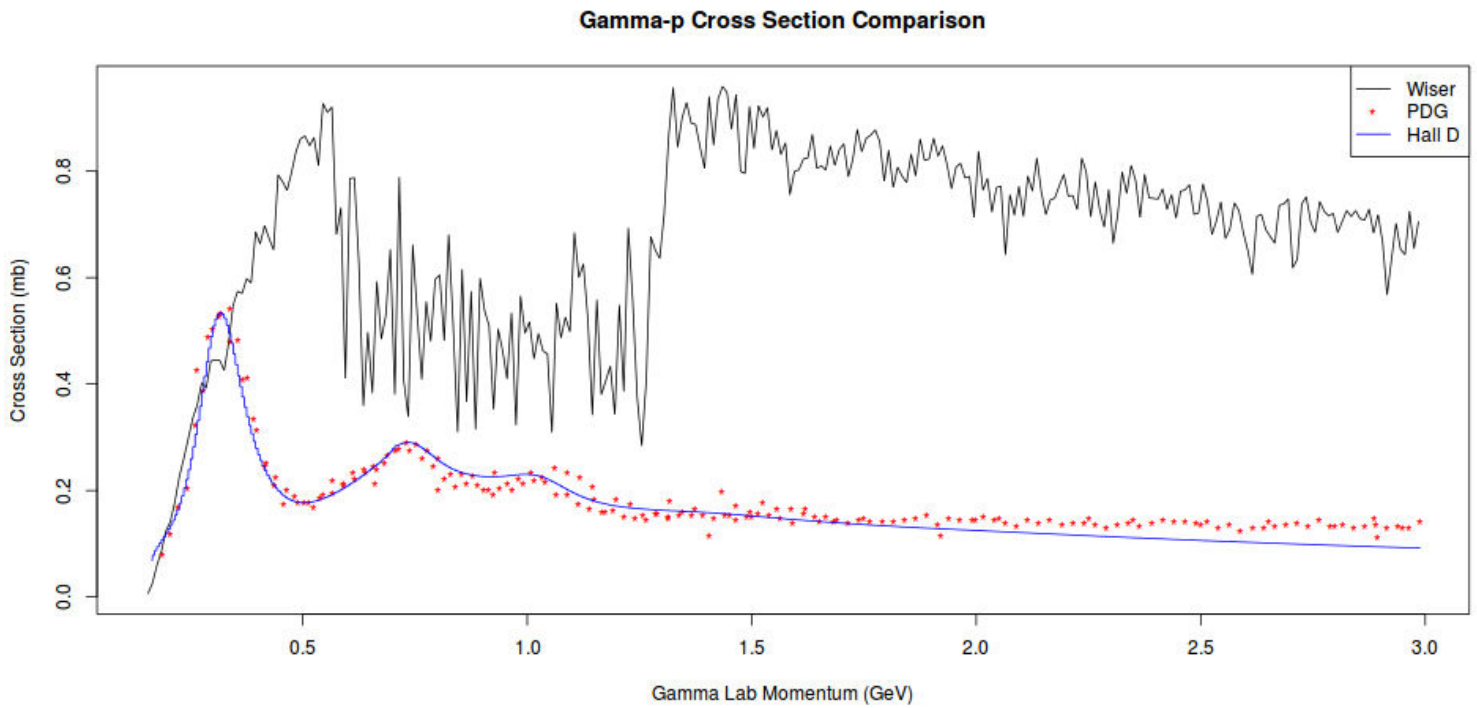
Compared total cross sections from Hall D low energy event generator and PDG photo-production cross sections on proton for γ momentum less than $3\ \mathrm{GeV}$



Wiser Photo-Production Cross Section

- Wiser cross section,$\sigma_{\mathrm{i}}(\mathrm{E}_{\gamma})$ is computed for all the processes : $\pi^{\pm}$, $K^{\pm}$,P^{+} and $\bar{P}^{-}$
- The cross section for π^{0} is the average of $\pi^{\pm}$ cross sections
- Then all the cross sections are summed to compute the total wiser cross section
- See slide 14 for steps

Wiser Photo-Production Cross Section



Wiser Photo-Production Cross Section

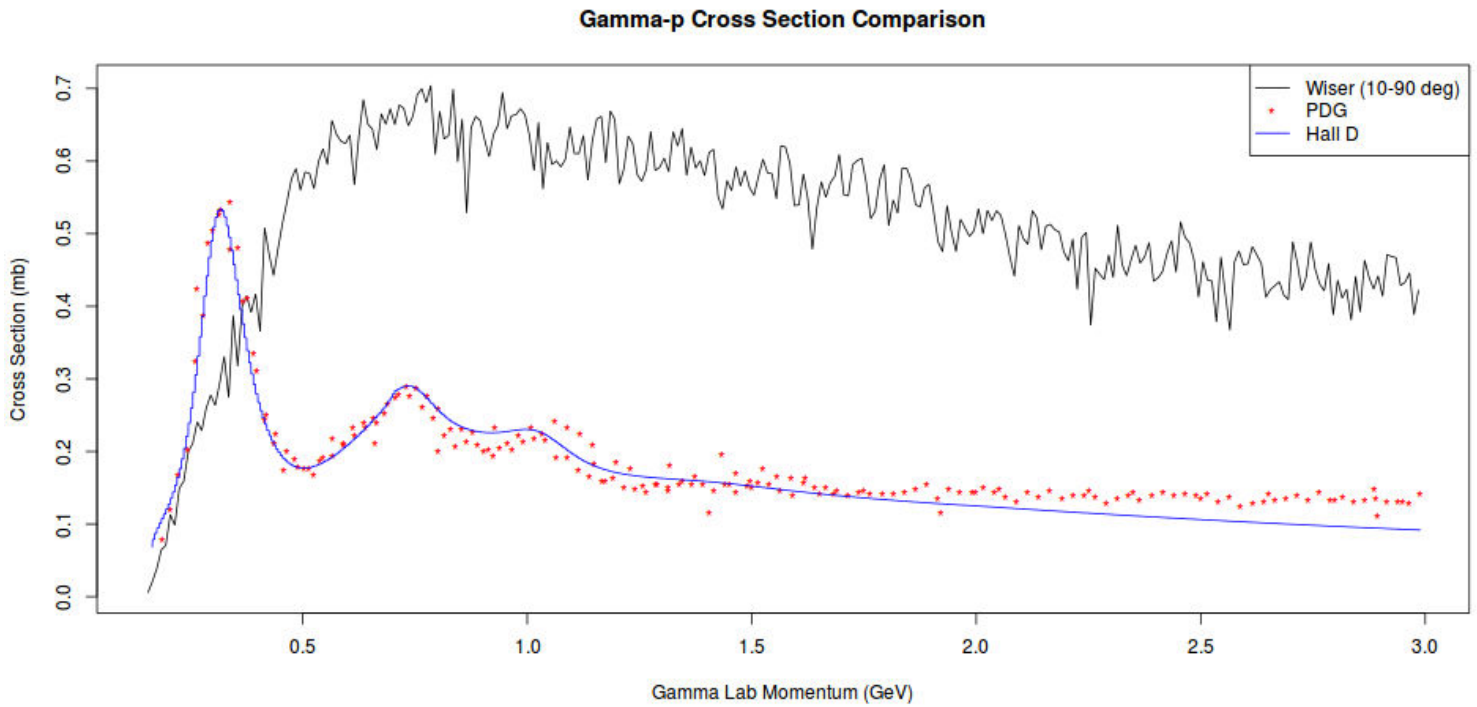


Figure: Wiser cross section only for 10 deg. to 90 deg.

From Photo-Production to Electro-Production

- Assume material before vertex as a radiator to make real photons and then use photo-production
- Wiser generator used during preCDR simulations used wiser photo-production + The Equivalent Photon Radiator approximation to generate pion background $\rightarrow$ std. wiser generator
- Use Taitor-Wright/Forward Peaking Approximation (FPA) with wiser photo-production to generate pion background : Wiser-FPA generator (see Michael Paolone's May 2015 collaboration meeting talk)
- Skip Photo-Production to Electro-Production step and use EPC code by O'Connell and Lightbody to generate electro-pion background (see Michael Paolone's May 2015 collaboration meeting talk)

Pion Background from Different Methods

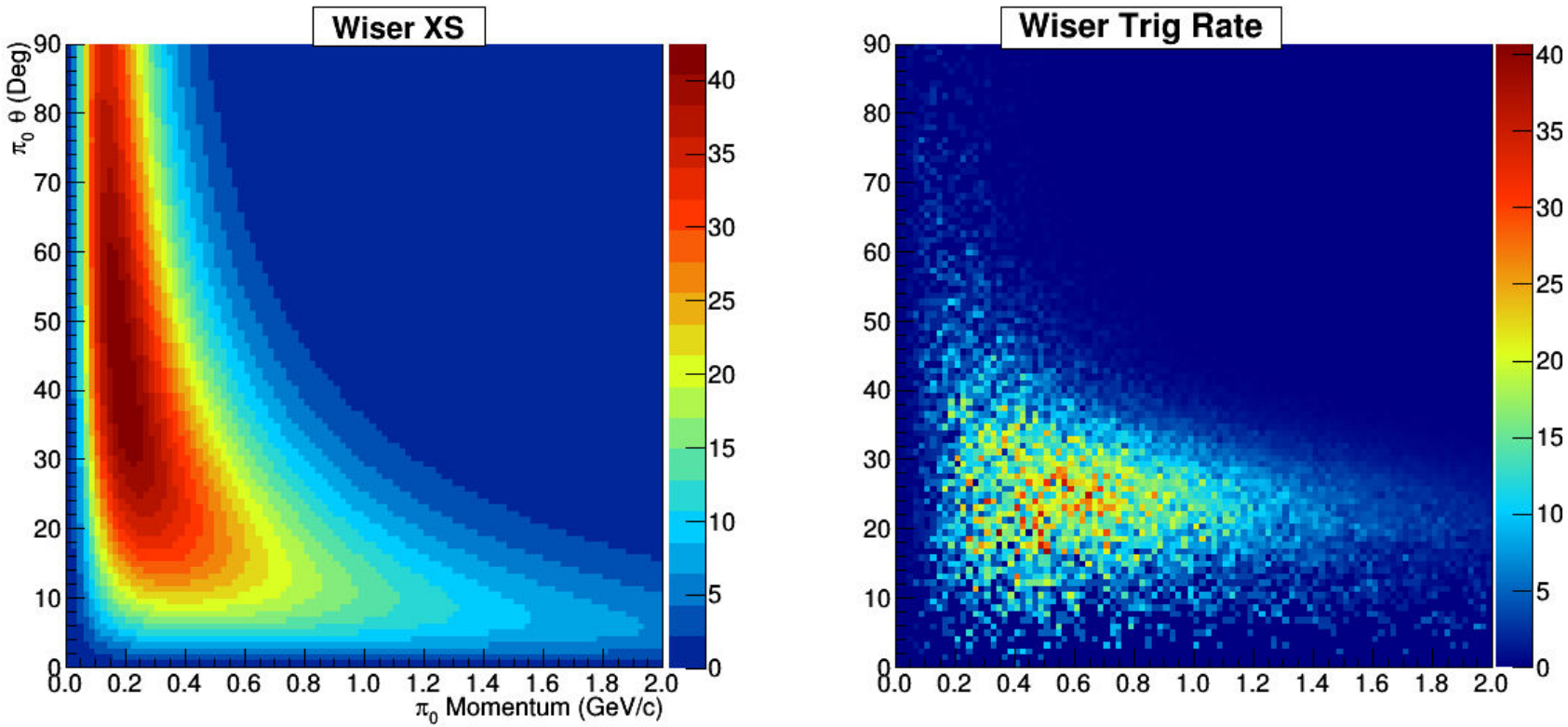


Figure: Using Std. Wiser Generator (see Michael Paolone's May 2015 collaboration meeting talk). Total cross section is $\sim 80\mu$b

Pion Background from Different Methods

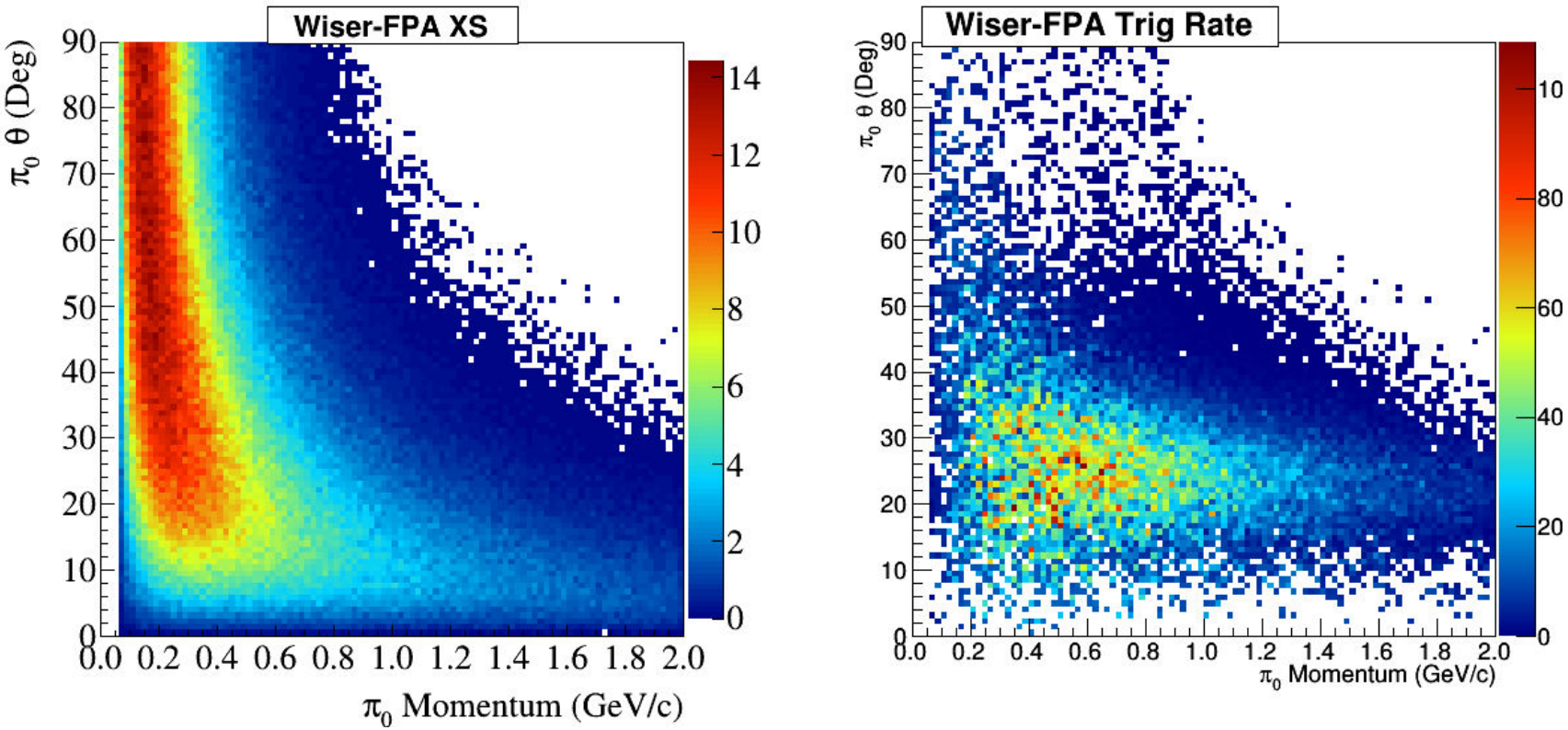


Figure: Using Wiser-FPA (see Michael Paolone's May 2015 collaboration meeting talk). Total cross section is $\sim 23.1\mu\mathrm{b}$

Pion Background from Different Methods

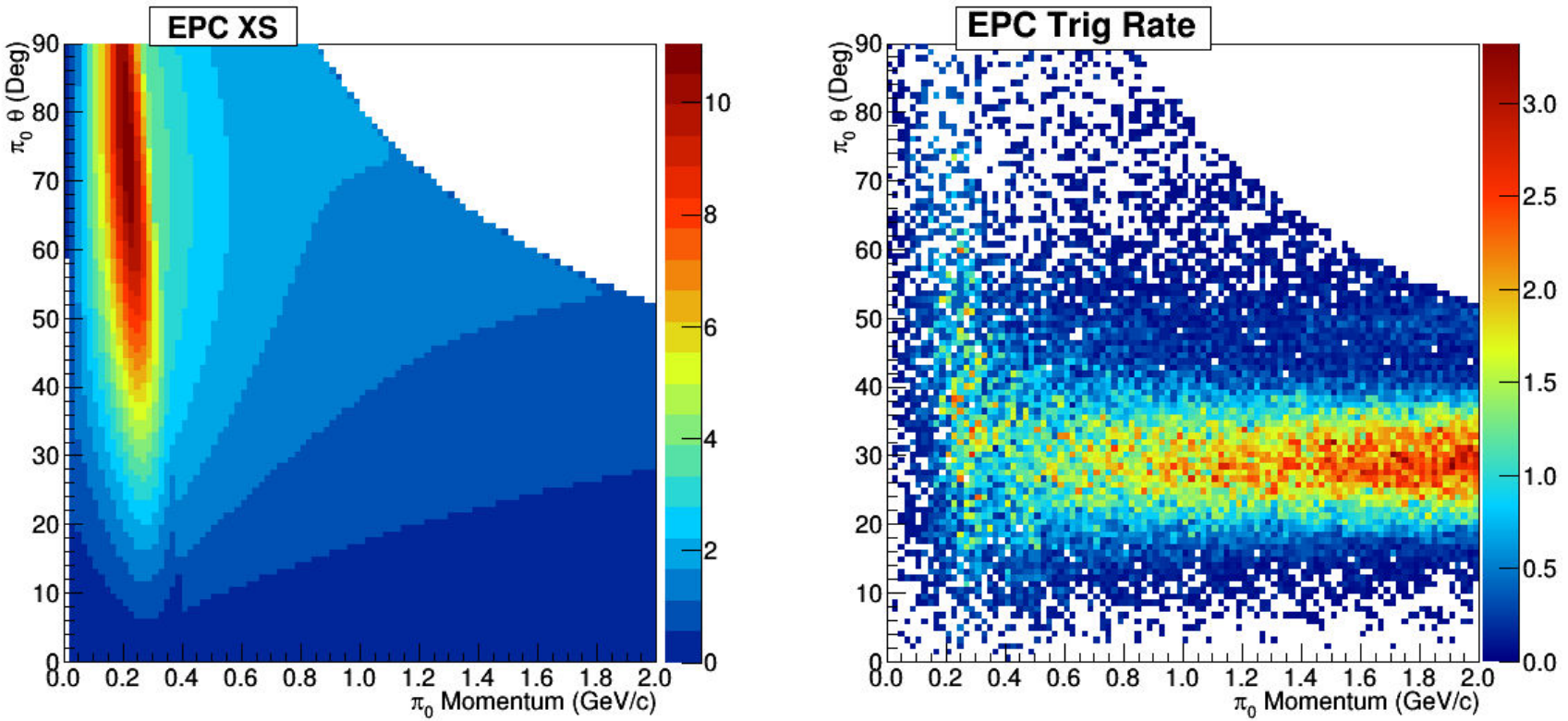


Figure: Using EPC code (see Michael Paolone's May 2015 collaboration meeting talk). Total cross section is $\sim 13\mu$b

Summary

- Wiser photo-production does not agree well with PDG in the energies we are interested in and therefore we need a correct hadronic generator
- Different methods used to go from Photo-Production to Electro-Production do not agree as shown by Michael Paolone
- If we use a photo-production generator like hall-D which approximation best suited for SoLID ?
- Other options include EPC code which is probably valid in the range 0.5 to $5\ \mathrm{GeV}$

Wiser Code Steps

- The main FORTRAN routine returns the differential cross section per monochromatic photon beam : $\mathrm{E}' \frac{\mathrm{d}^3\sigma}{\mathrm{dp}'^3} / \mathrm{E}_\gamma$
- Where $(\mathrm{E}', \mathrm{p}')$ is the hadron momentum and E_γ is the incident photon energy
- The total cross section for a monochromatic photon beam for i^{th} type interaction,

$$\sigma_\mathrm{i}(\mathrm{E}_\gamma) = \int_{\mathrm{phase-space}} \frac{\mathrm{d}\sigma_\mathrm{i}(\mathrm{E}_\gamma)}{\mathrm{dp}'\mathrm{d}\Omega} \mathrm{dp}'\mathrm{d}\Omega$$

- Where $\frac{\mathrm{d}\sigma_\mathrm{i}(\mathrm{E}_\gamma)}{\mathrm{dp}'\mathrm{d}\Omega} = \frac{\mathrm{p}'^2}{\mathrm{E}'} \cdot \left(\mathrm{E}' \frac{\mathrm{d}^3\sigma}{\mathrm{dp}'^3} / \mathrm{E}_\gamma \right) \cdot \mathrm{E}_\gamma$
- And subscript i is,

1. $\mathrm{i} = 0, 1 : \pi^\pm$
2. $\mathrm{i} = 2, 3 : K^\pm$
3. $\mathrm{i} = 4, 5 : P^+$ and $\bar{P}^-$

π^0 cross section is the average of $\pi^\pm$ cross sections

K.A. Olive et al.
Review of Particle Physics.
Chin.Phys., C38:090001, 2014.

S. Riodan, X. Zheng, Z. Zhao, and N. Ton.
Comparison between Wiser π^- rates calculation and data from transversity and PVDIS experiments.
Internal document, 2014.