Electro-Production Hall D Generator Update 1

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Overview

- Electro-Production is implemented using the hall D event generator
  - See previous updates on this
- Geant4 (QGSP_BERT) and hall D generators are compared for proton & deuterium targets
- Using Wiser and Hall D generators, pions are generated for scattering angle < 90 deg for 11 GeV electron beam on proton & deuterium 40 cm targets
- Using Geant4 (QGSP_BERT), 11 GeV electron beam incident on proton & deuterium 40 cm targets
- See last talk for initial results

Hadrons from Secondary Target Interactions

- Initially primary vertices generated by hall D electro-prod. generator were placed on an empty target
- Now they are placed in the actual 40 cm proton & deuterium targets
- Only about 0.6 % additional hadron vertices are created in the target

Technical : Handling Geant4 Detector Hits

- The target itself is a sensitive detector and hits are recorded
  - Used these hits to compute rates (cross sections) there were compared between G4 and Hall D
- The way Geant4 sensitive det. record hits, there will be multiple hits recorded for a single hadron track: For example see a sample event,

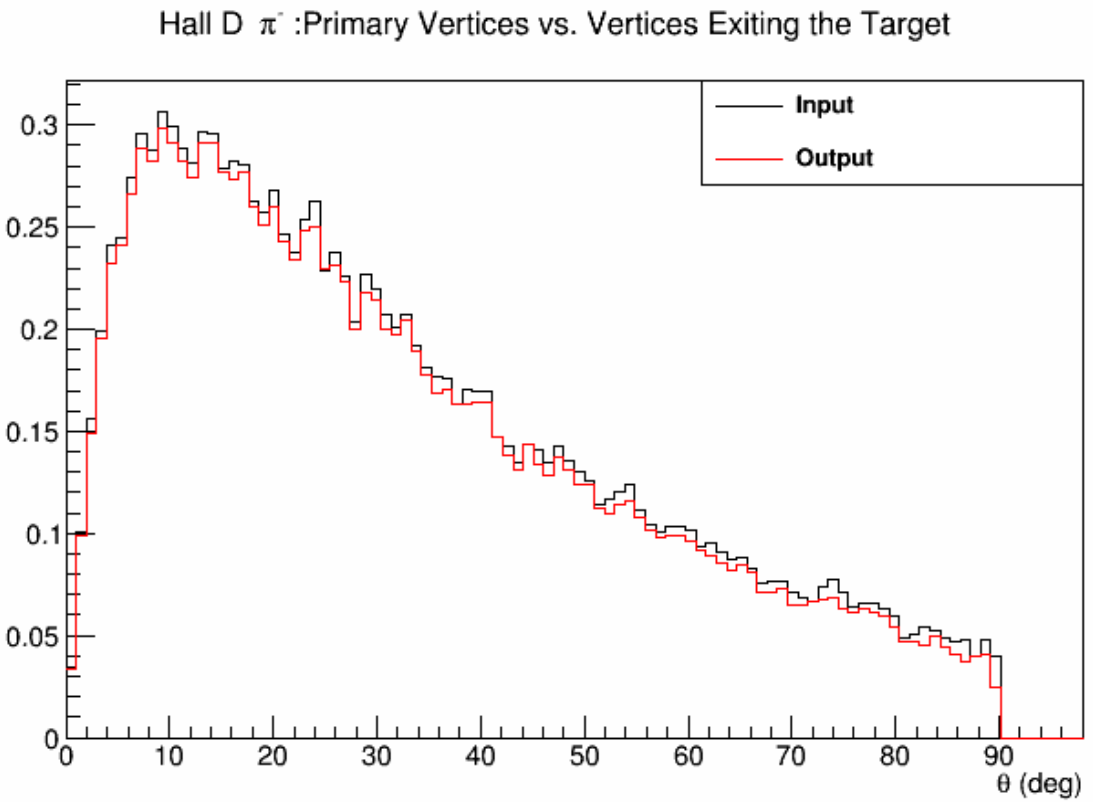
Row	Instance	ev.evnum	hit.p	hit.pid	hit.det	hit.t	hit.trid
1	0	2	1.4443016	-211	666	0	1
1	1	2	1.4300100	-211	666	0.1204307	1
1	2	2	1.4298311	-211	666	0.1966750	1
1	3	2	0.1550178	2212	666	0.1966750	3

Technical : Handling Geant4 Detector Hits

- The target itself is a sensitive detector and hits are recorded
  - Used these hits to compute rates (cross sections) there were compared between G4 and Hall D
- In this case the primary pion is recorded by hits inside the target
- Therefore target sensitive detector overestimates hadron rates (or xs)
- A detector outside of the target (a sphere around the 40 cm hydrogen target) to detect hadrons coming out of the target
- Use these hadrons to estimate the rates (and xs).
- Then results are compared between Hall D generator and G4

Effect of Target on Hadron Rates : An Observation

- There is a difference between hadrons created inside the hydrogen target and hadrons coming out of the hydrogen target.
- Suppression of hadrons coming outside the target
  - About 4% less hadron tracks come out of the target



Bremsstrahlung photon Contribution

- The electro-production cross section due to Bremsstrahlung photons,

$$d\sigma = \sigma_\gamma(\omega) \cdot N_{BREMS}(\omega) \frac{d\omega}{\omega}$$

$$N_{BREMS}(\omega) = \frac{d}{X_0}\left(\frac{4}{3} - \frac{4\omega}{3E} + \frac{4\omega^2}{3E^2}\right)$$

- Where X_0 is the radiation length and d = ρ.t where ρ is target density and t is target thickness
- For now t = 40 cm was used but that is not the average t for electrons incident on the target
  - Now t = 20 cm (average thickness)

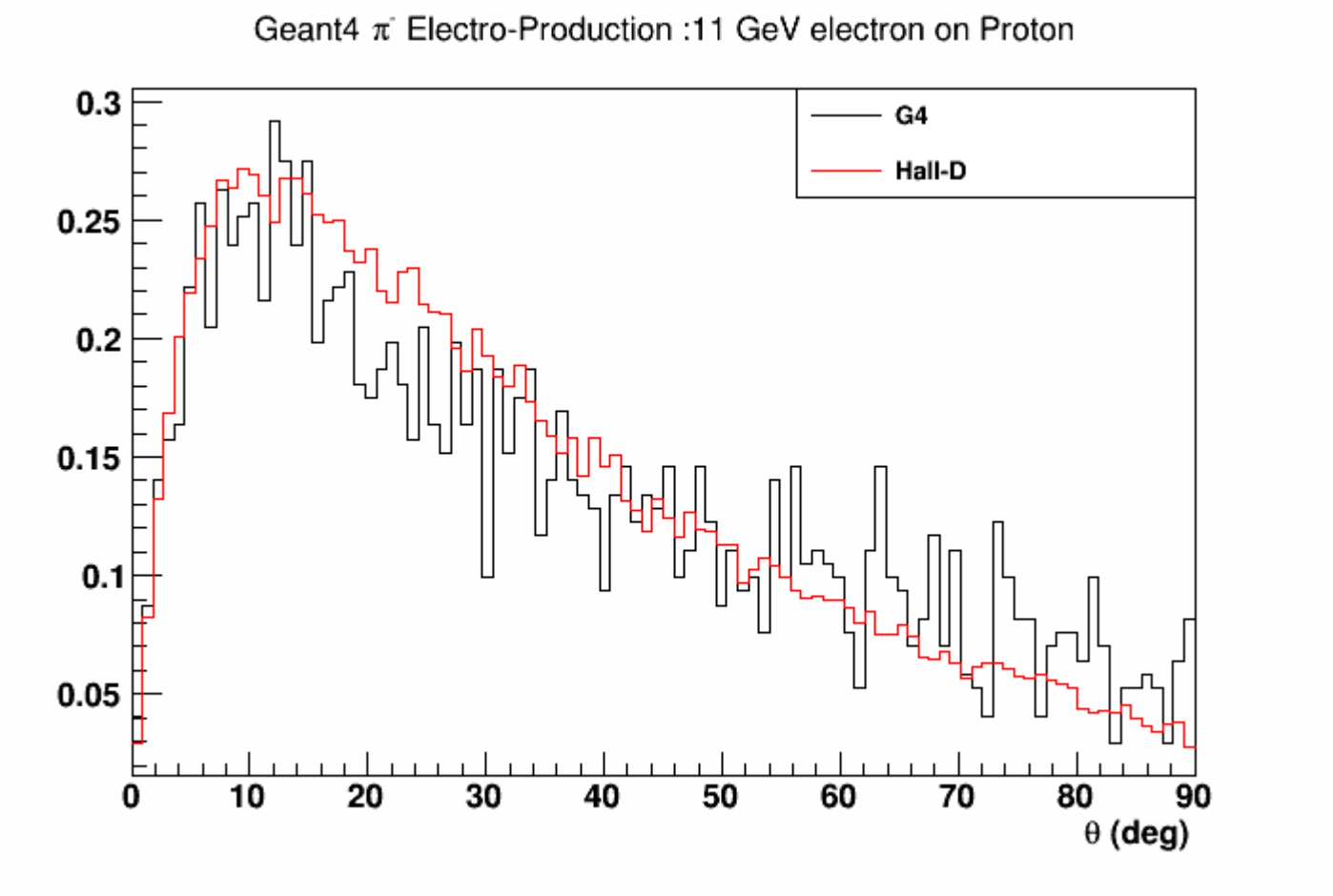
Hall D vs. Geant4 : Proton Target

- Using hall D gen, 1 million hadron events were generated
- Using Geant4, 100 million electrons incident on 40 cm proton target

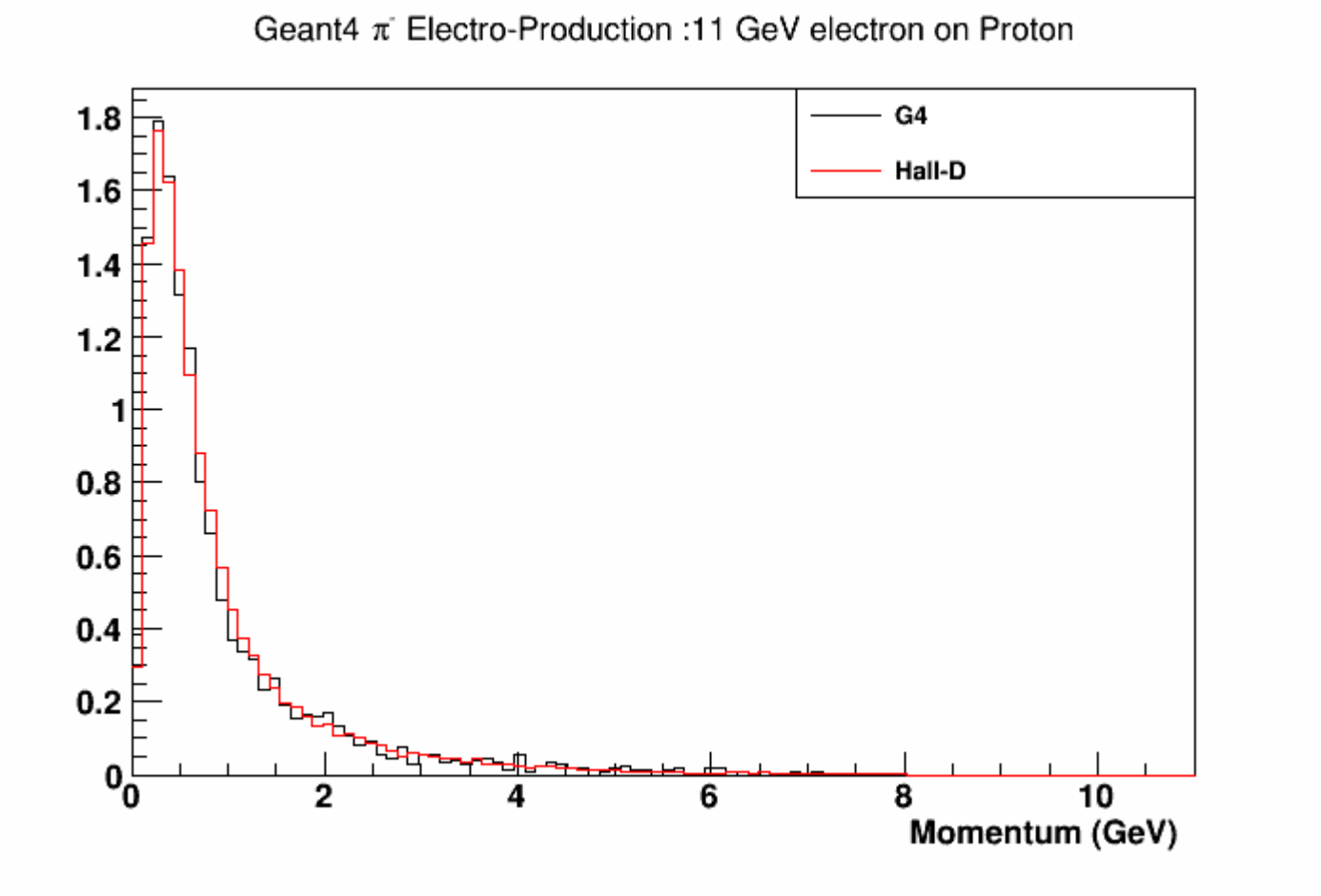
Pion Type	Total Proton xs for theta < 90 deg			Hall D vs. G4 agreement
	Wiser xs	Hall D xs	Geant4 xs	
	(mb)	(mb)	(mb)	(%)
pi0*	88.5	21.5	26.5	-19
pi-	54.6	13.6	13.4	2
pi+	123.7	29.6	29.3	1

* It is not trivial to check pi0 cross section directly using outside detector. Therefore cross section is computed from hits inside the target

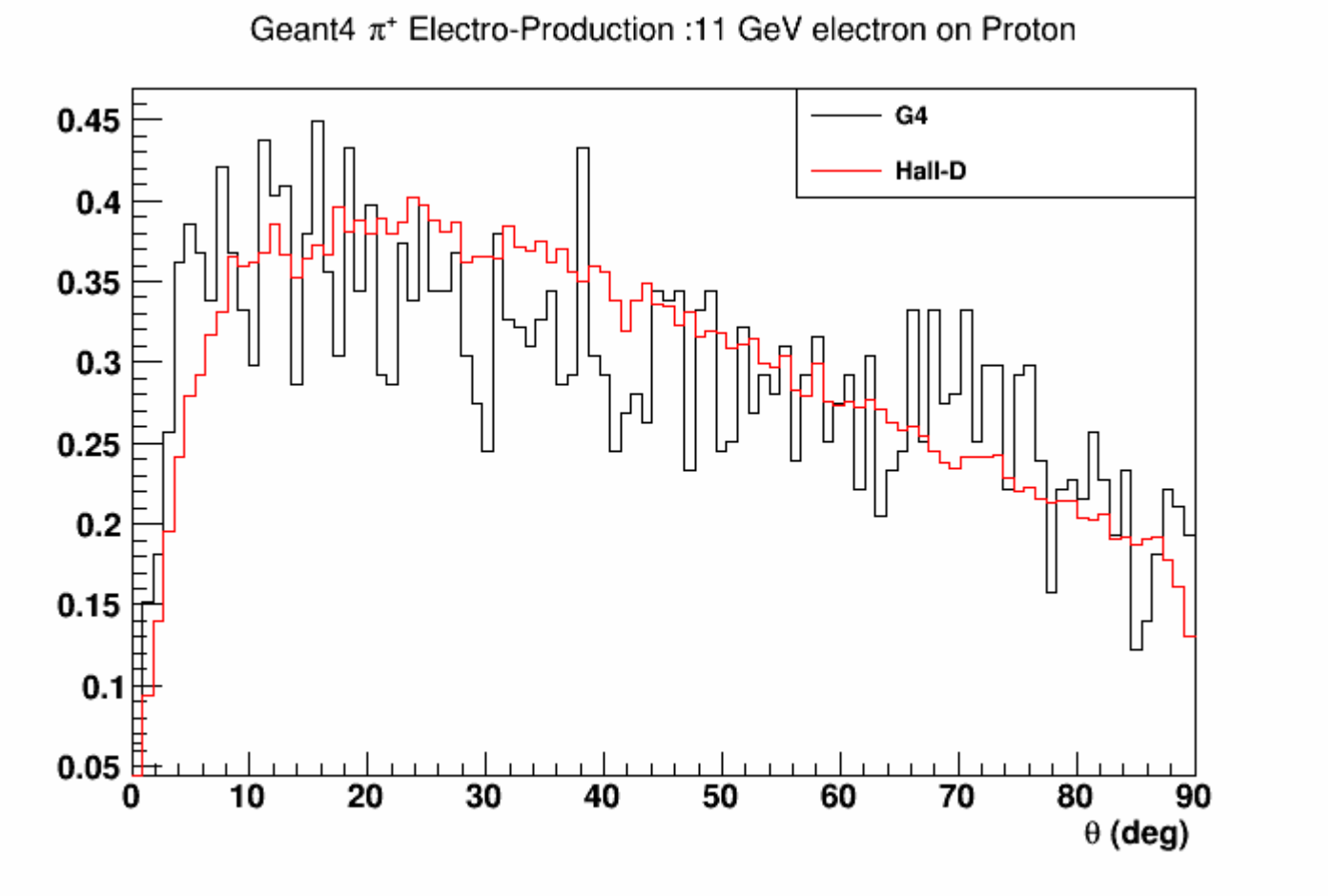
Hall D vs. Geant4 : Proton Target



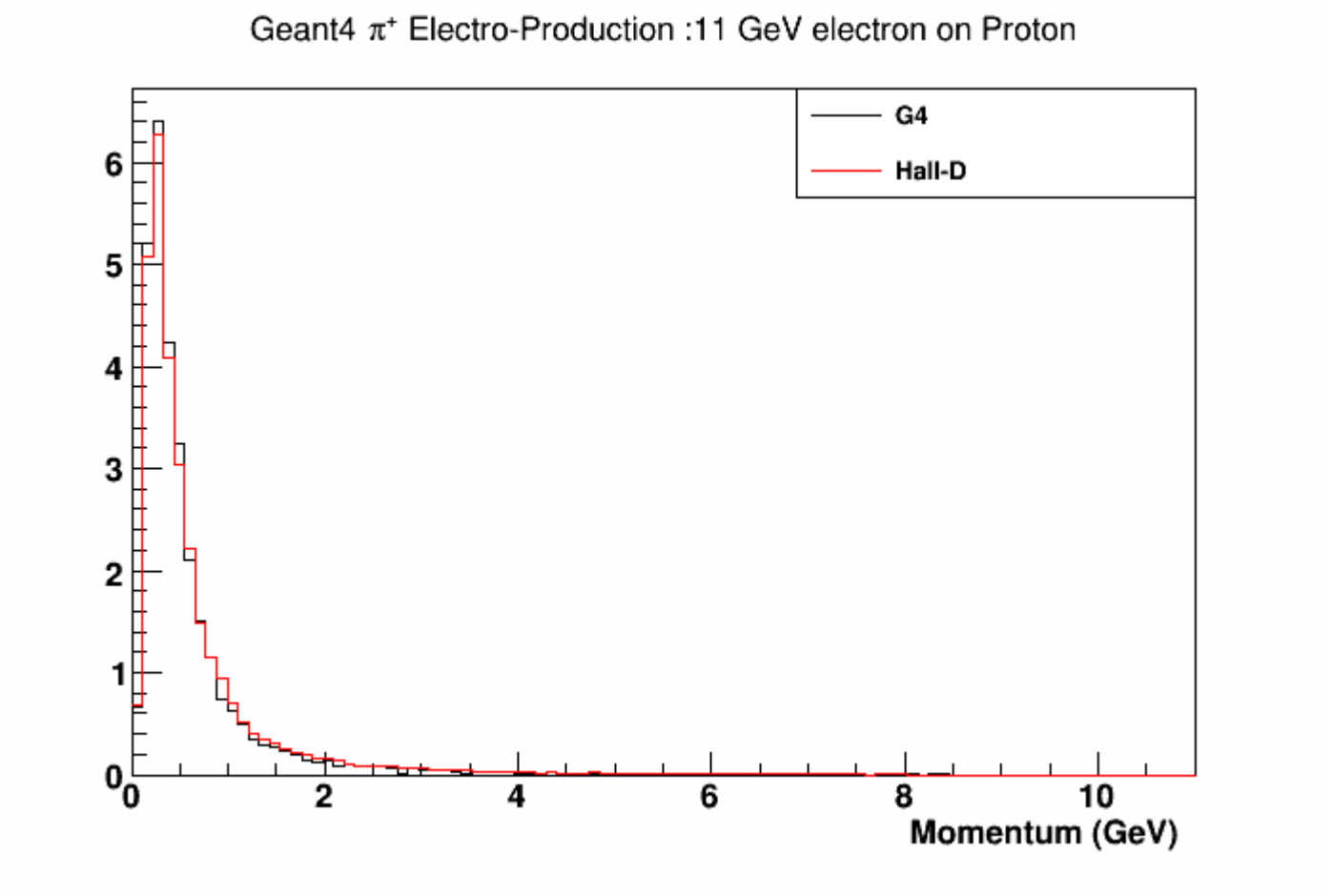
Hall D vs. Geant4 : Proton Target



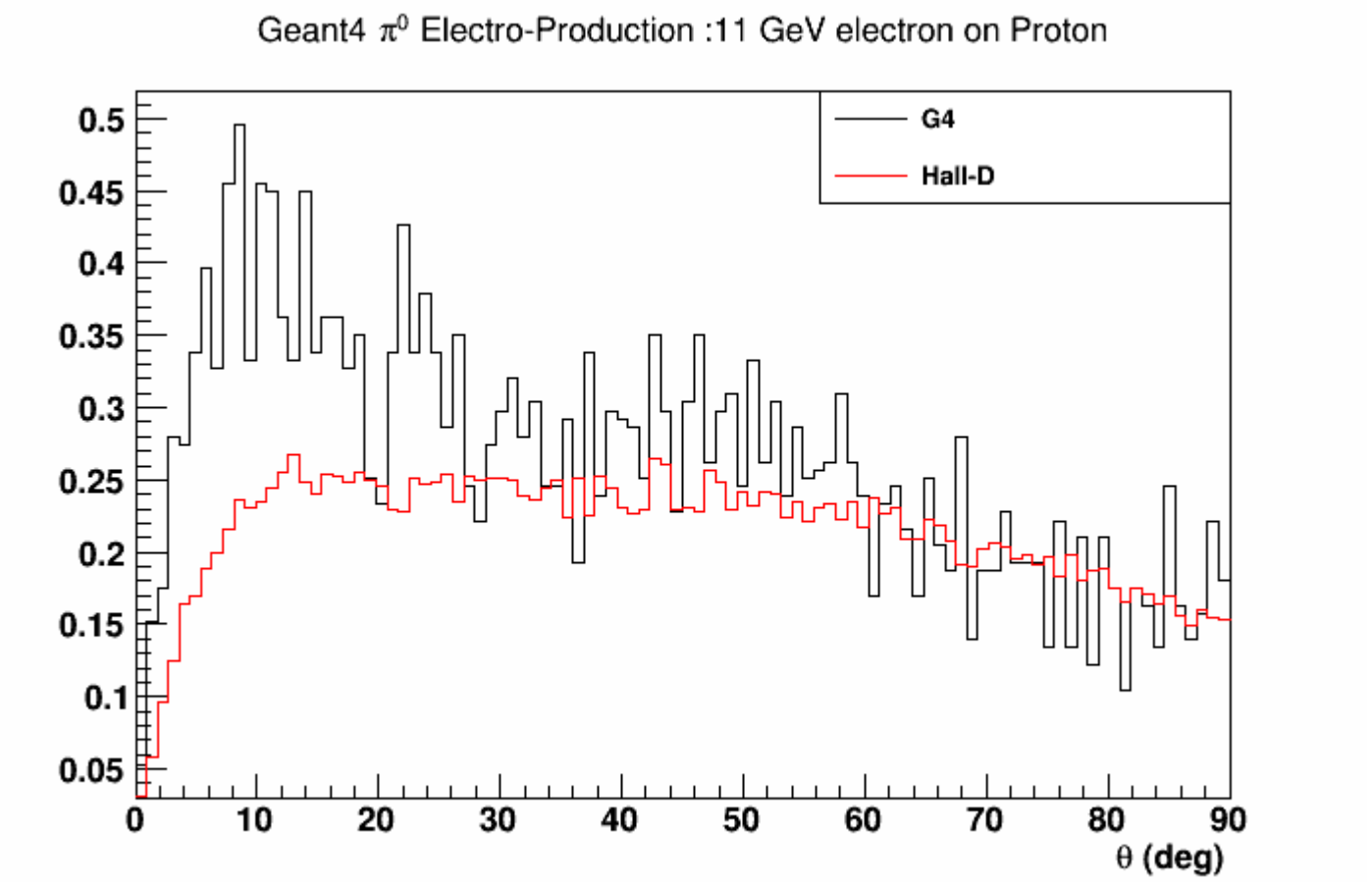
Hall D vs. Geant4 : Proton Target



Hall D vs. Geant4 : Proton Target

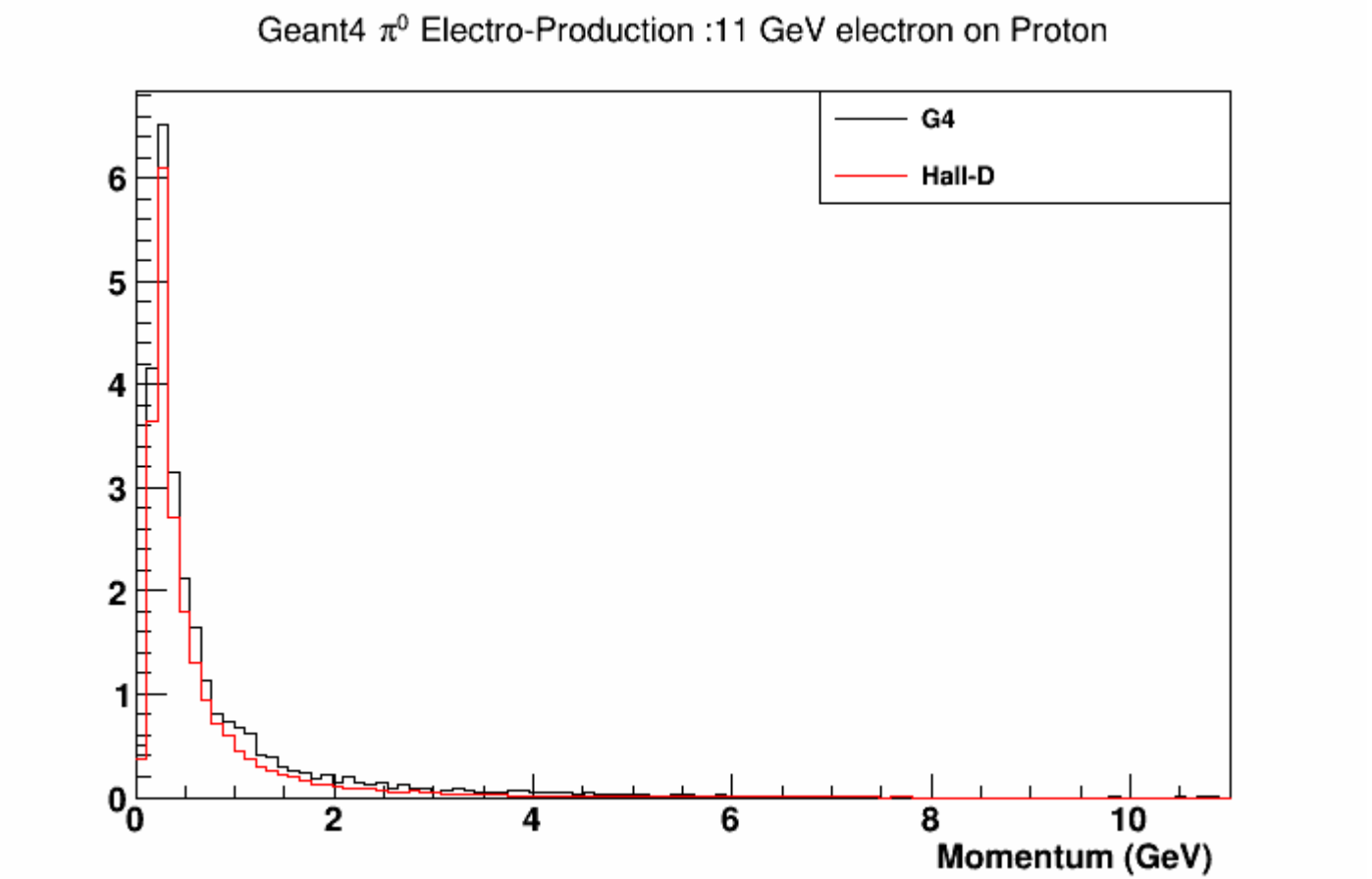


Hall D vs. Geant4 : Proton Target



* It is not trivial to check pi0 tracks directly using outside detector. Therefore tracks plotted from hits inside the target

Hall D vs. Geant4 : Proton Target



* It is not trivial to check pi0 tracks directly using outside detector. Therefore tracks plotted from hits inside the target

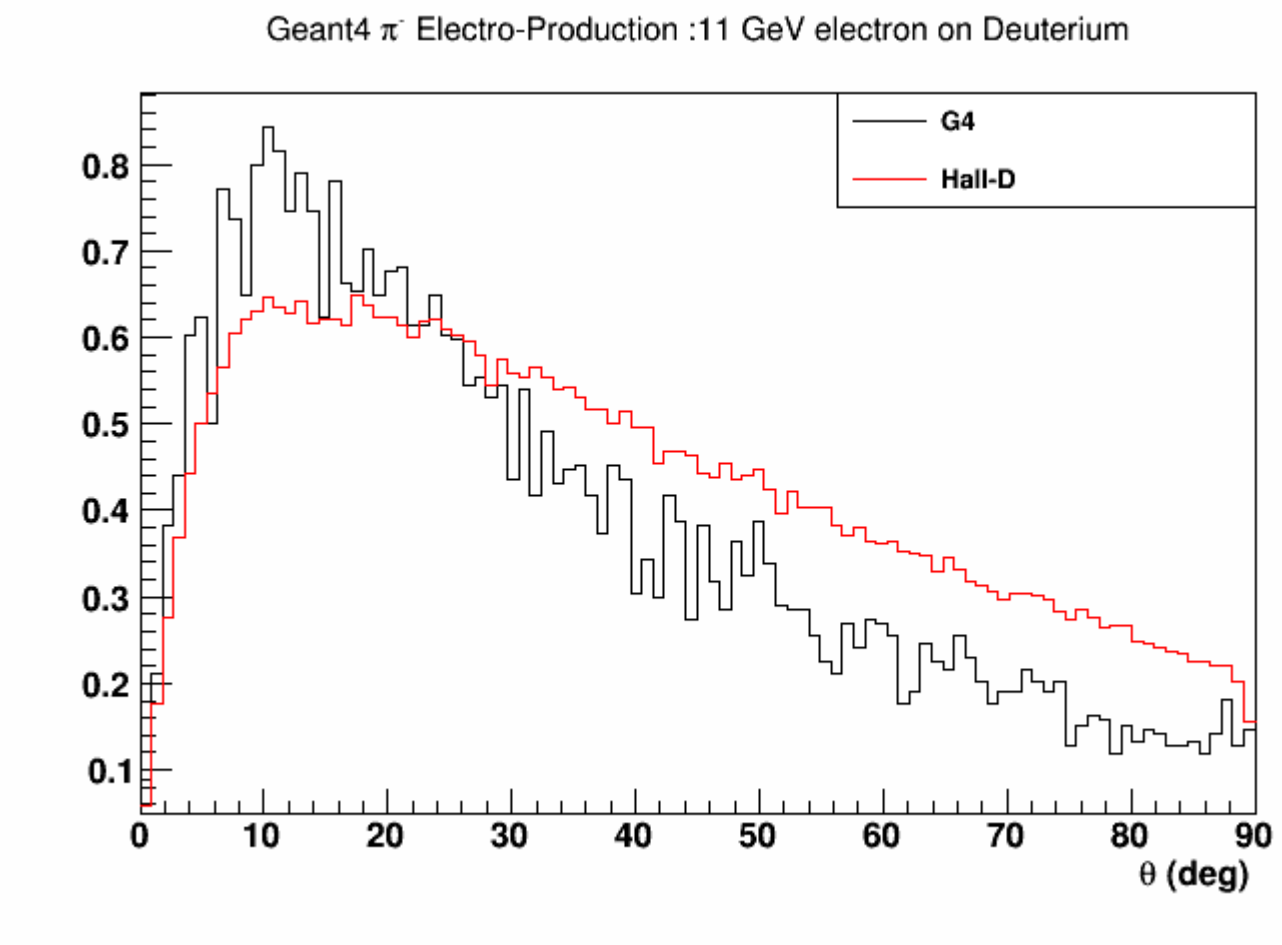
Hall D vs. Geant4 : Deuterium Target

- Using hall D gen, 1 million hadron events were generated
- Using Geant4, 100 million electrons incident on 40 cm deuterium target

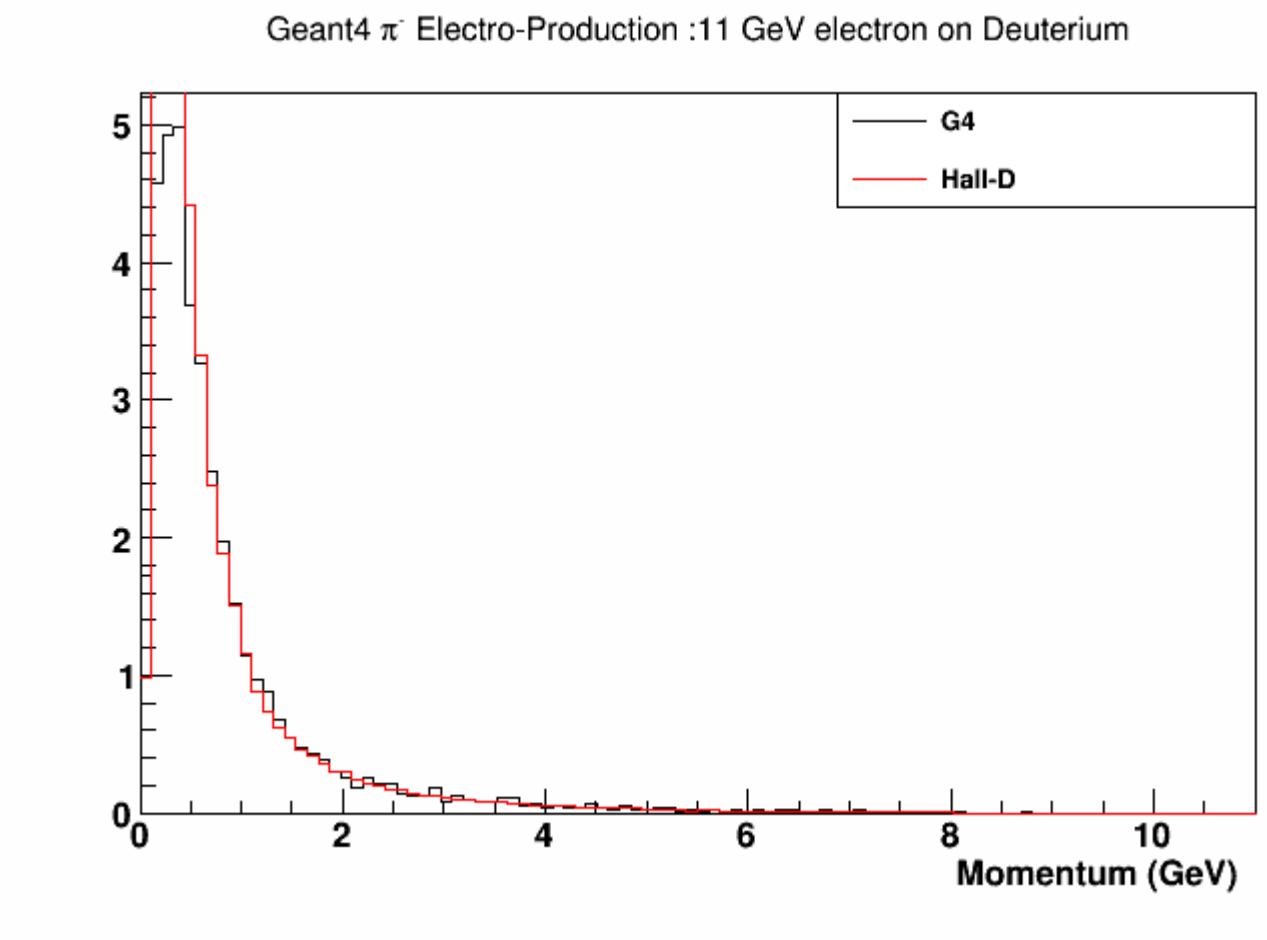
Pion Type	Total Deuterium xs for theta < 90 deg			Hall D vs. G4 agreement
	Wiser xs	Hall D xs	Geant4 xs	
	(mb)	(mb)	(mb)	(%)
pi0*	189.7	43.0	84.8	-49
pi-	191.6	43.2	38.1	13
pi+	192.7	43.2	37.6	15

* It is not trivial to check pi0 cross section directly using outside detector. Therefore cross section is computed from hits inside the target

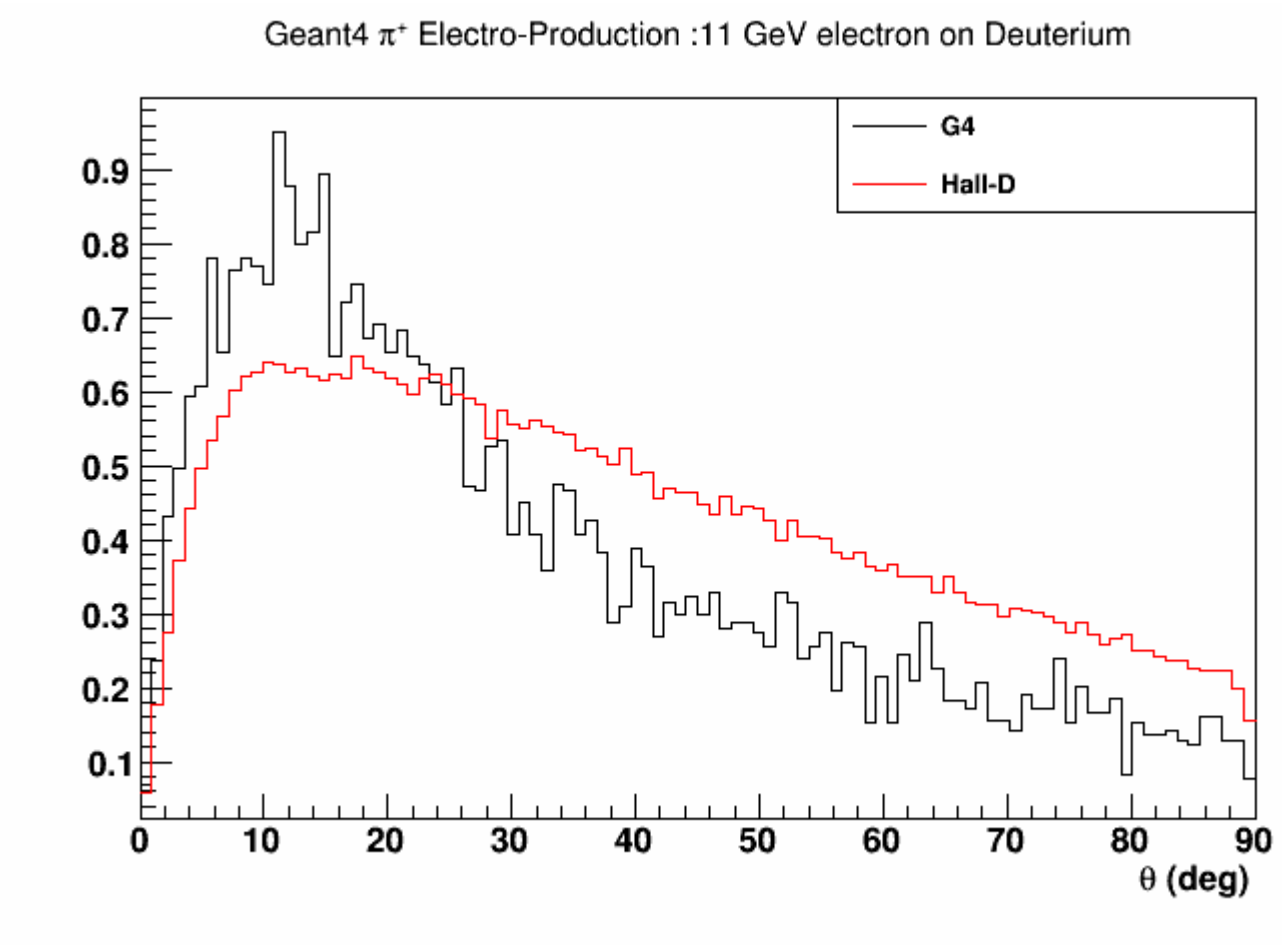
Hall D vs. Geant4 : Deuterium Target



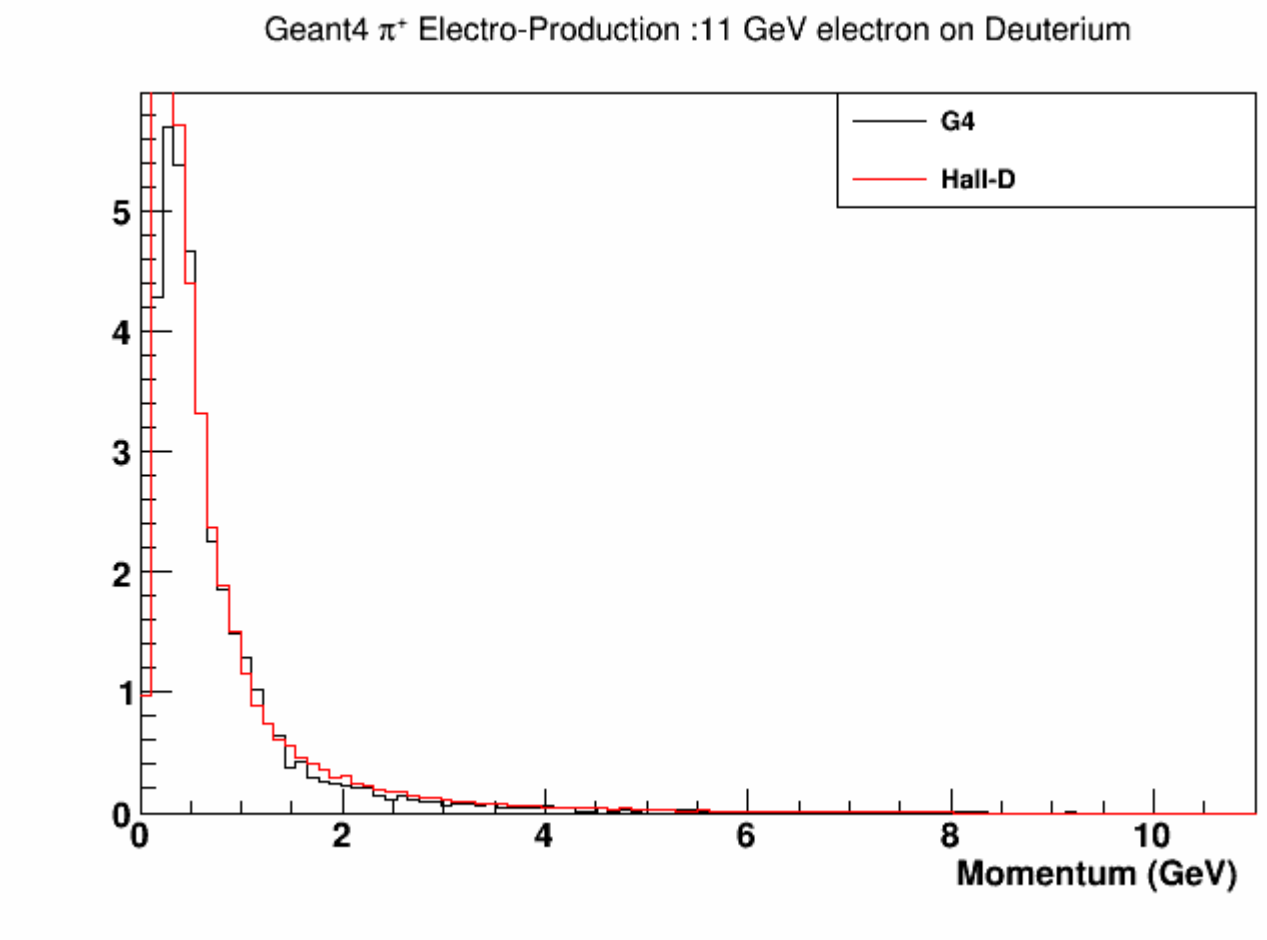
Hall D vs. Geant4 : Deuterium Target



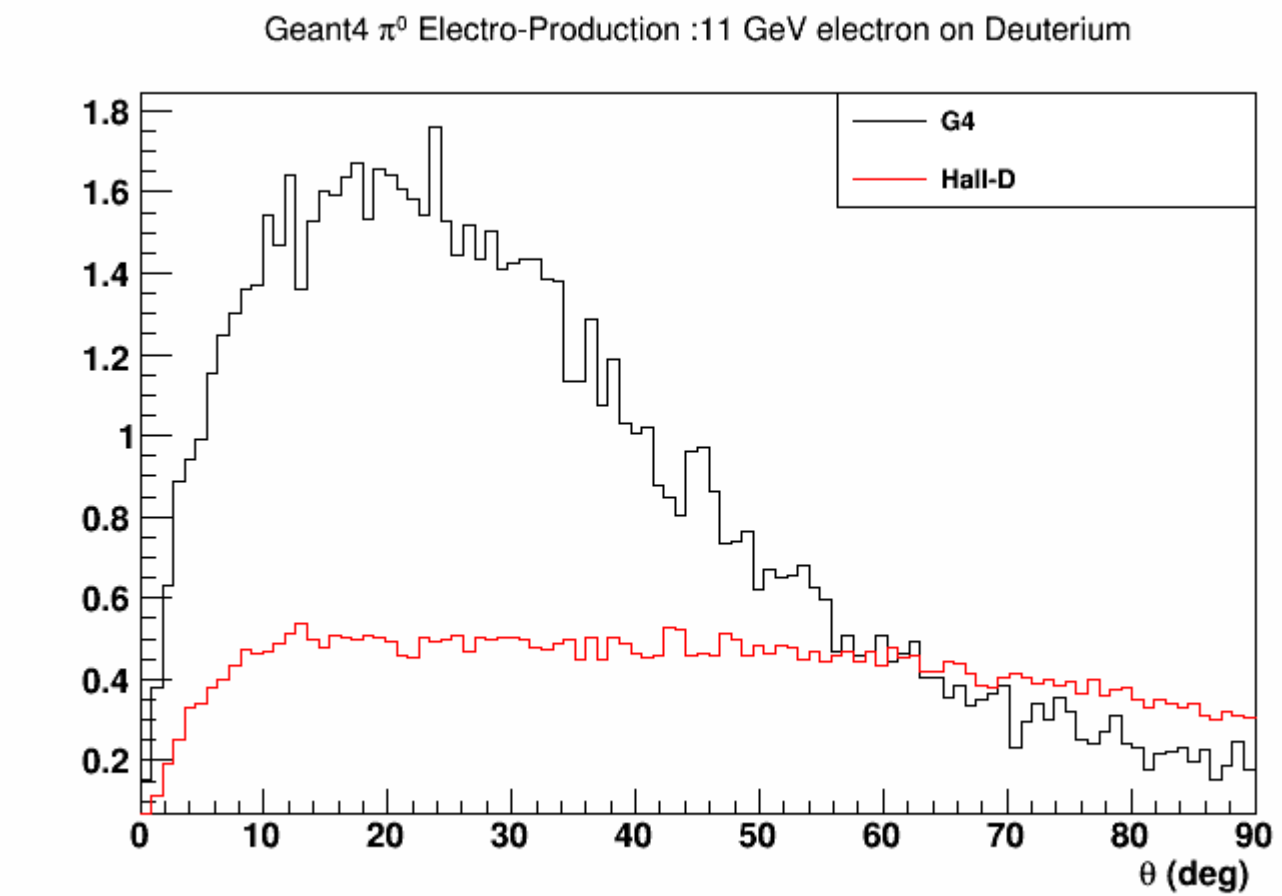
Hall D vs. Geant4 : Deuterium Target



Hall D vs. Geant4 : Deuterium Target

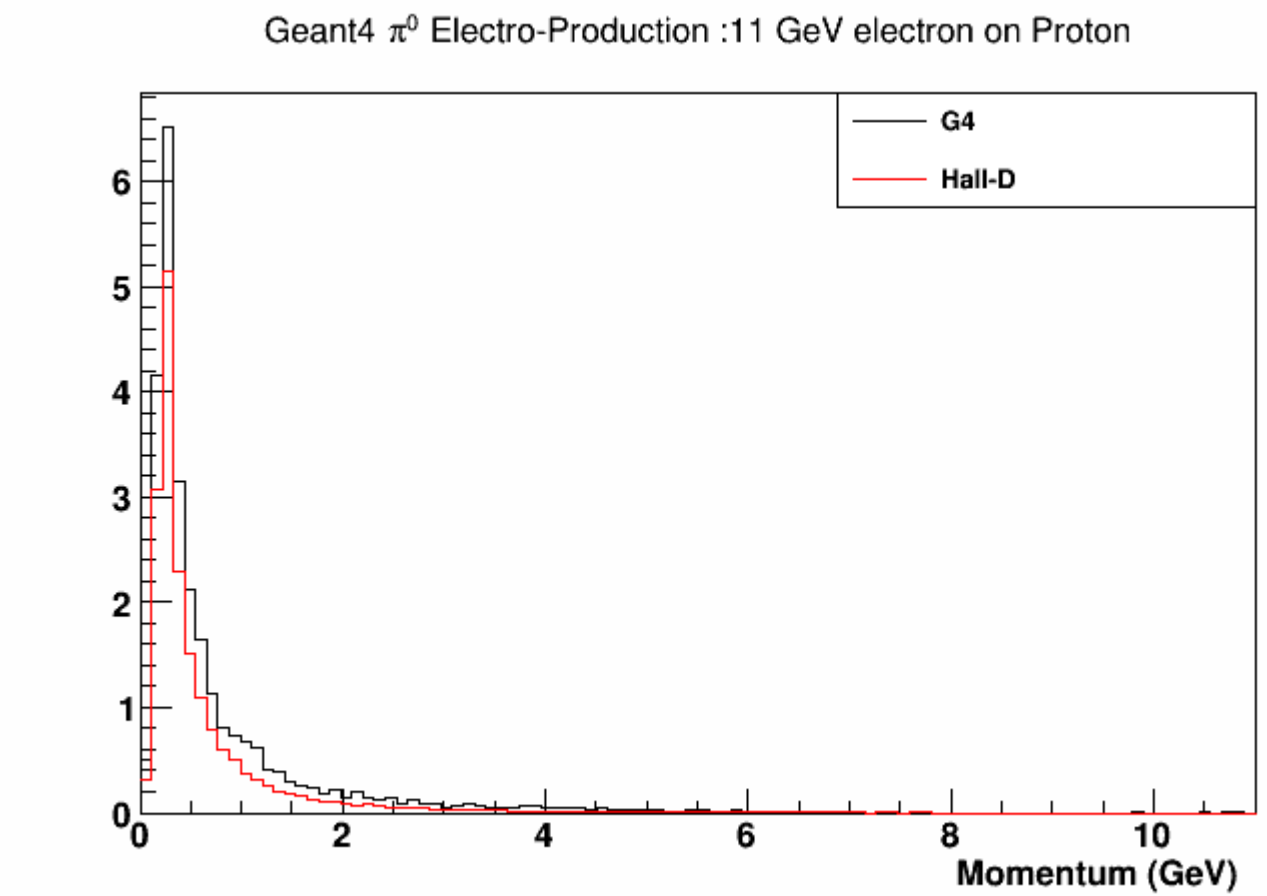


Hall D vs. Geant4 : Deuterium Target



* It is not trivial to check pi0 tracks directly using outside detector. Therefore tracks plotted from hits inside the target

Hall D vs. Geant4 : Deuterium Target



* It is not trivial to check pi0 tracks directly using outside detector. Therefore tracks plotted from hits inside the target

Next Steps

- Now agreement between G4 and Hall D is much better
  - I will move forward with following list (from last talk!)
- Implement lund format to generate inputs for GEMC
  - Very soon
- Provide trigger rates
  - Currently I can only do ECAL
  - Need Micheal's assistant for Cerenkov
- Repeat some ECAL studies I have done for understand and optimize ECAL trigger
- Generate ECAL + Cerenkov integrated output
  - To do final trigger rates and other trigger optimizations
  - To do level-3 farm analysis (Alex)

Backups

Hall D vs. Geant4 : Proton Target

- Using hall D gen, 1 million hadron events were generated
- Using Geant4, 100 million electrons incident on 40 cm proton target

Pion Type	Total Proton xs for theta < 90 deg			Hall D vs. G4 agreement
	Wiser xs	Hall D xs	Geant4 xs	
	(mb)	(mb)	(mb)	(%)
pi0	88.5	31.3	26.8	17
pi-	54.6	20.7	23.5	-12
pi+	123.7	44.4	50.7	-12

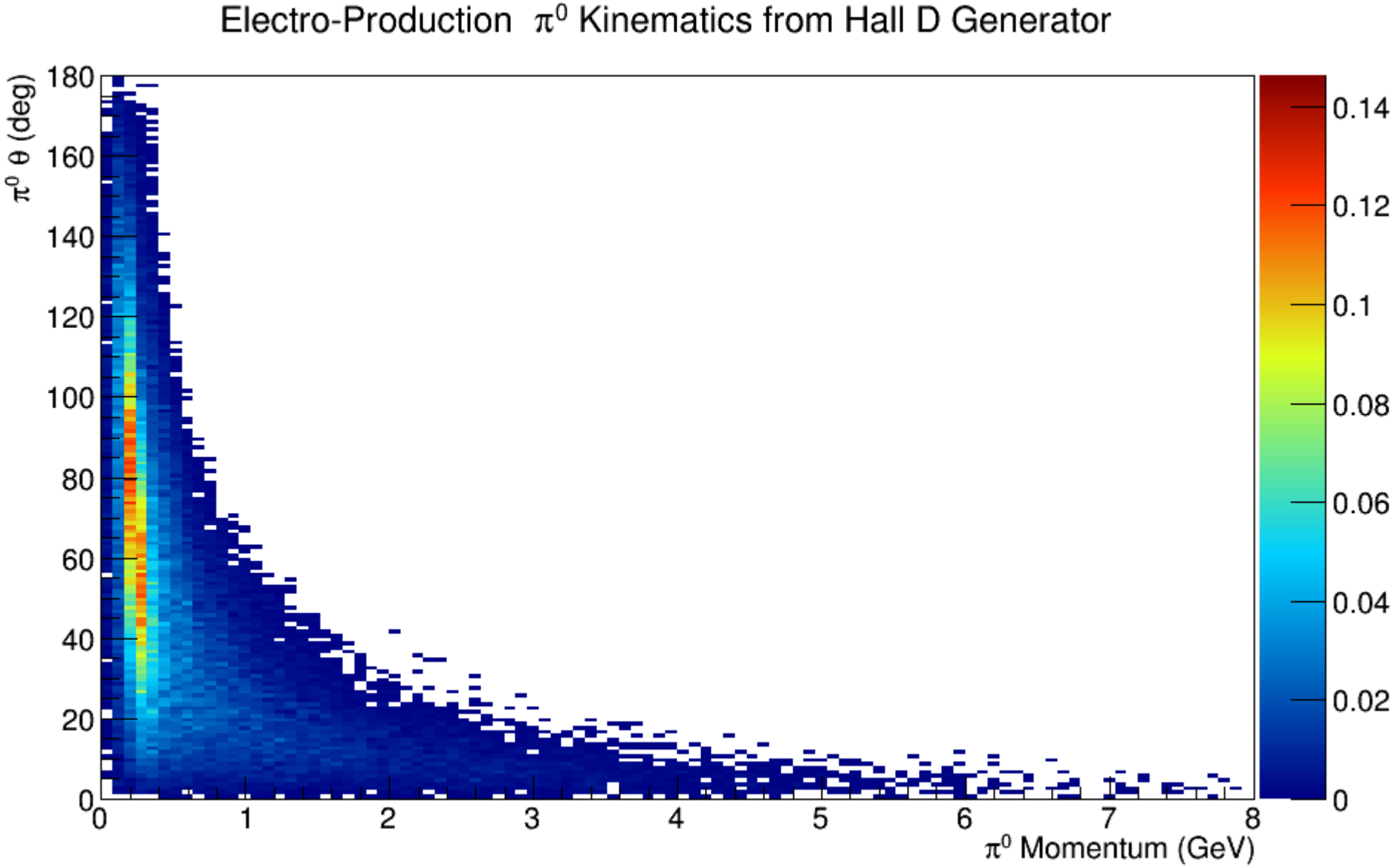
Hall D vs. Geant4 : Deuterium Target

- Using hall D gen, 1 million hadron events were generated
- Using Geant4, 100 million electrons incident on 40 cm deuterium target

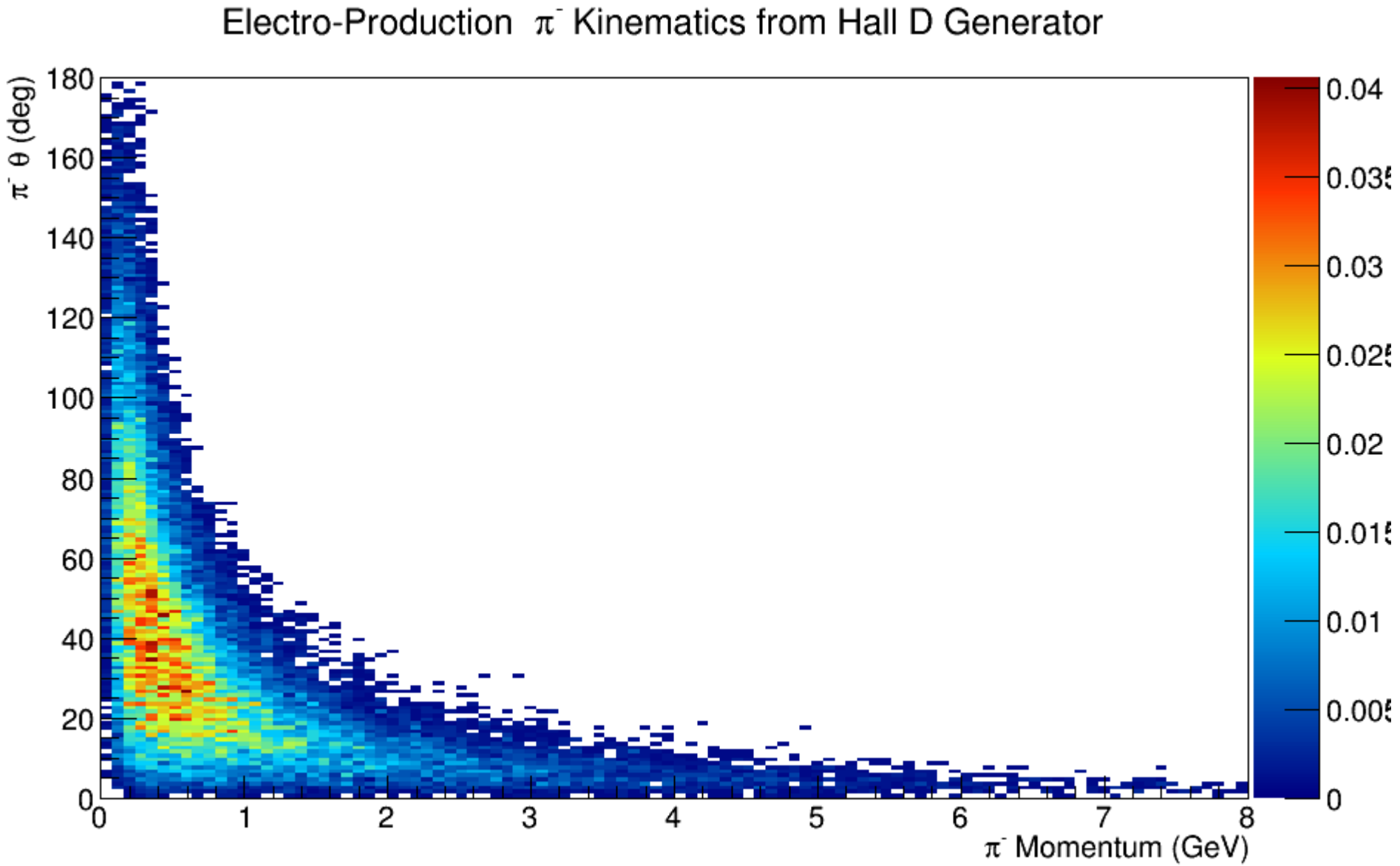
Pion Type	Total Deuterium xs for theta < 90 deg			Hall D vs. G4 agreement
	Wiser xs	Hall D xs	Geant4 xs	
	(mb)	(mb)	(mb)	(%)
pi0	189.7	62.5	84.6	-26
pi-	191.6	65.1	73.2	-11
pi+	192.7	65.1	71.3	-9

* It is not trivial to check pi0 cross section directly using outside detector. Therefore cross section is computed from hits inside the target

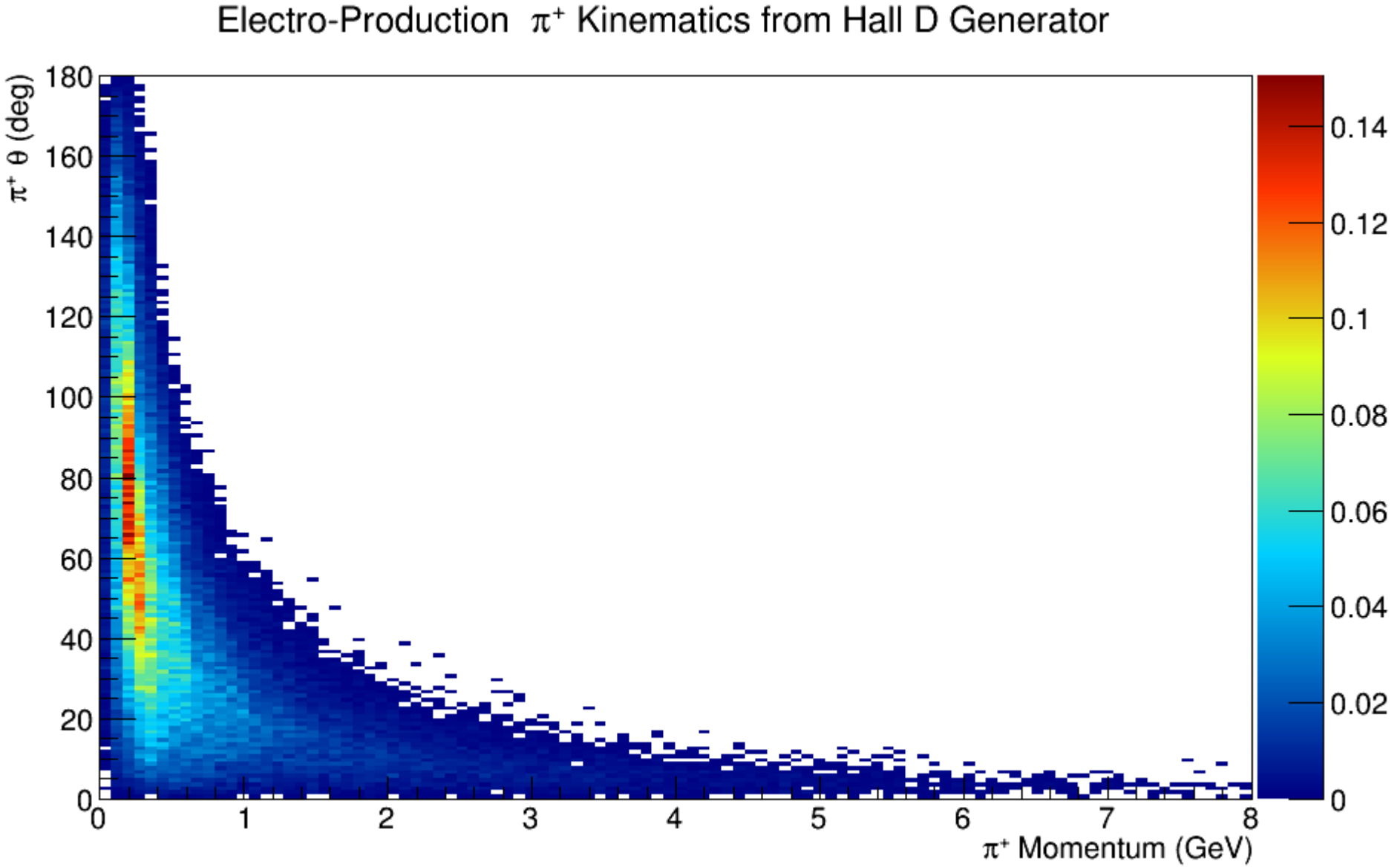
Hall D Generator : Proton Target



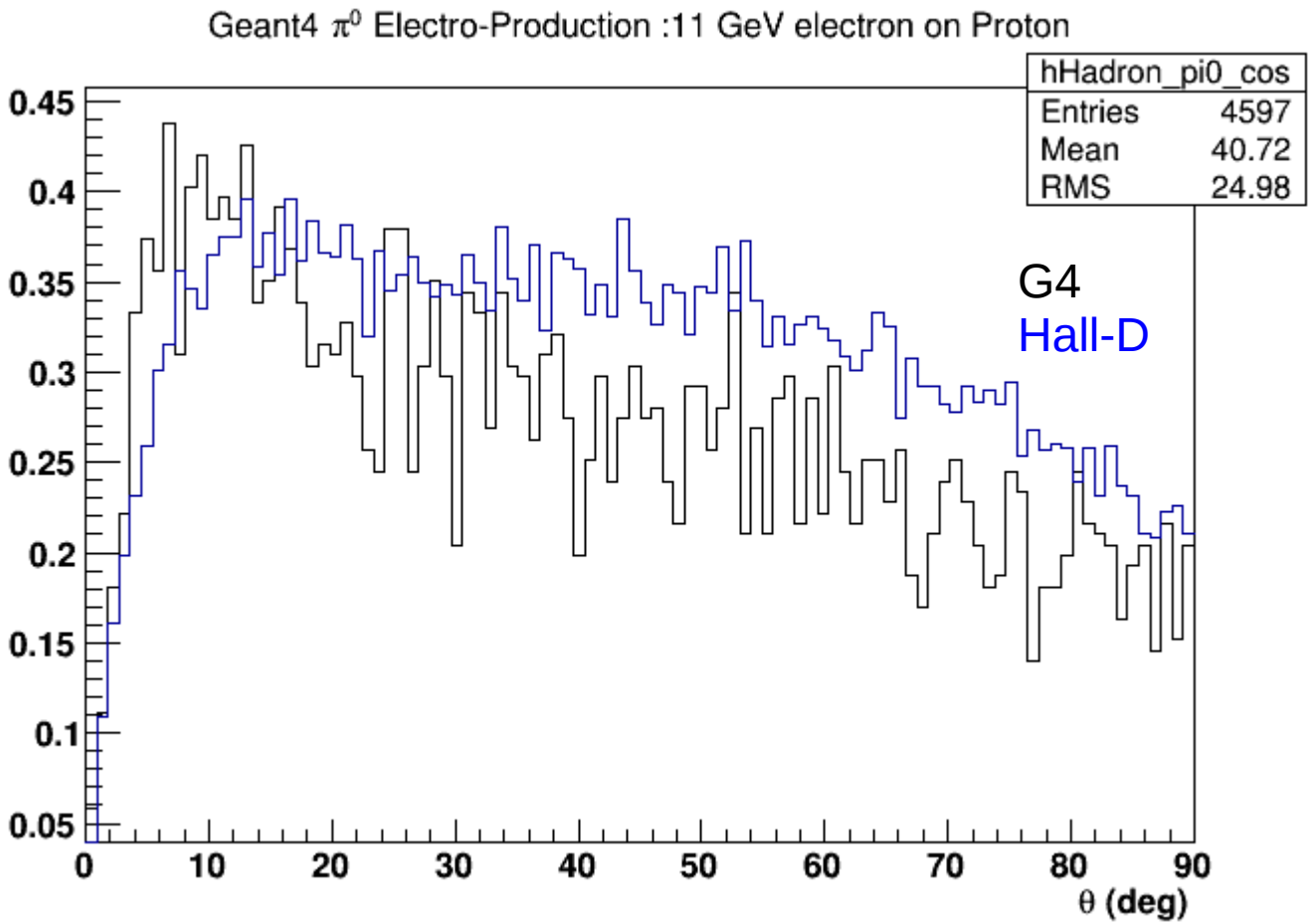
Hall D Generator : Proton Target



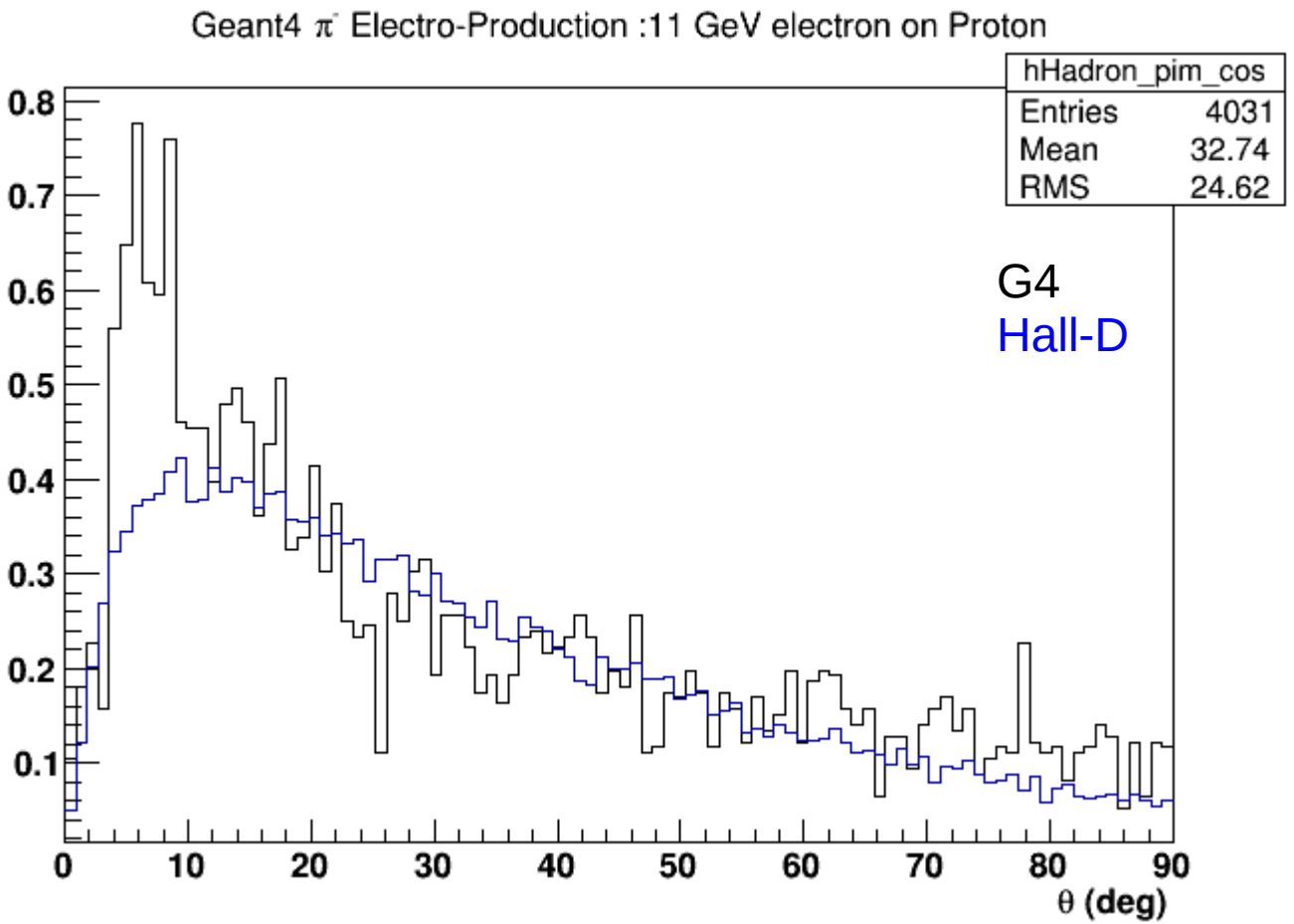
Hall D Generator : Proton Target



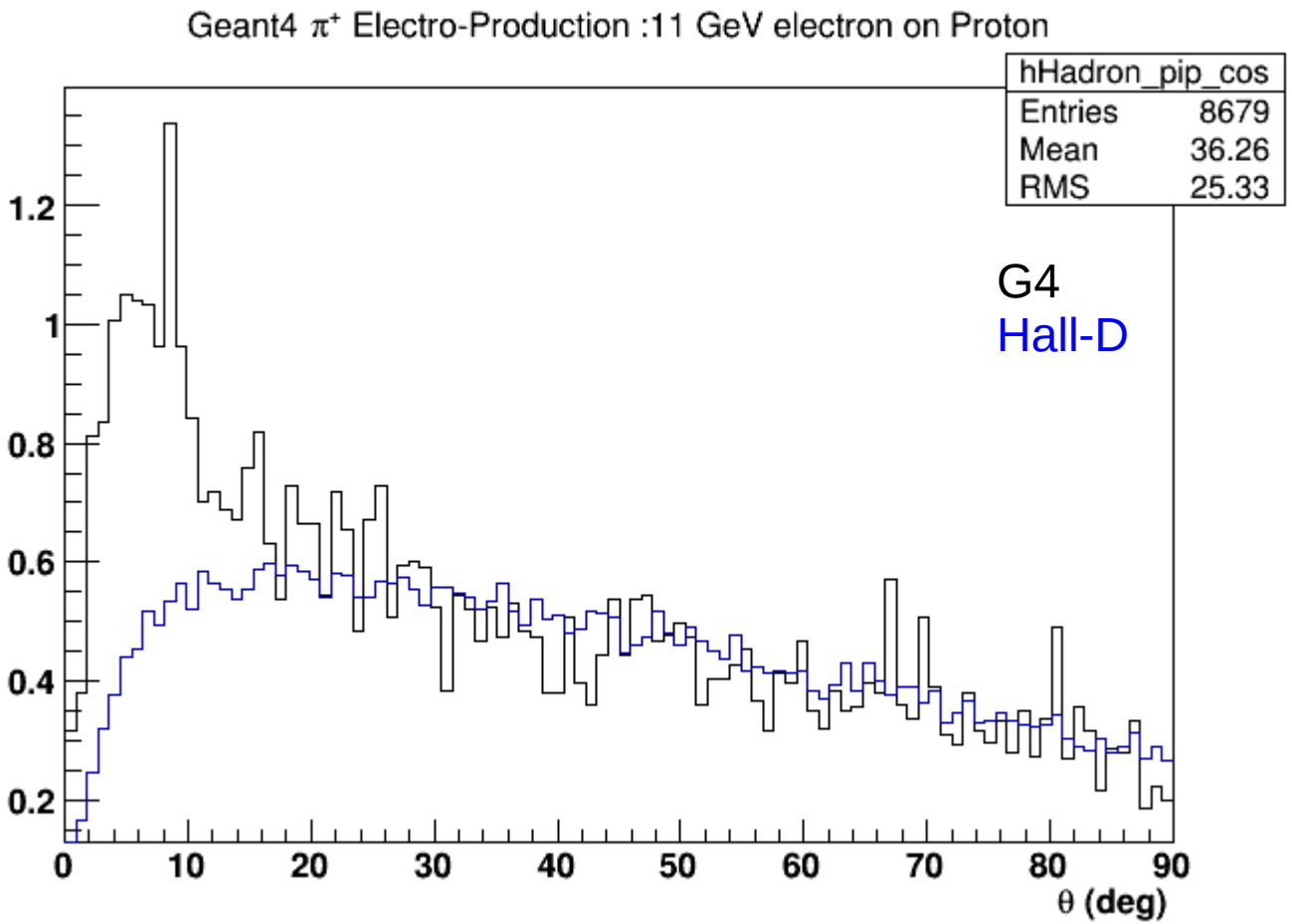
Hall D vs. Geant4 : Proton Target



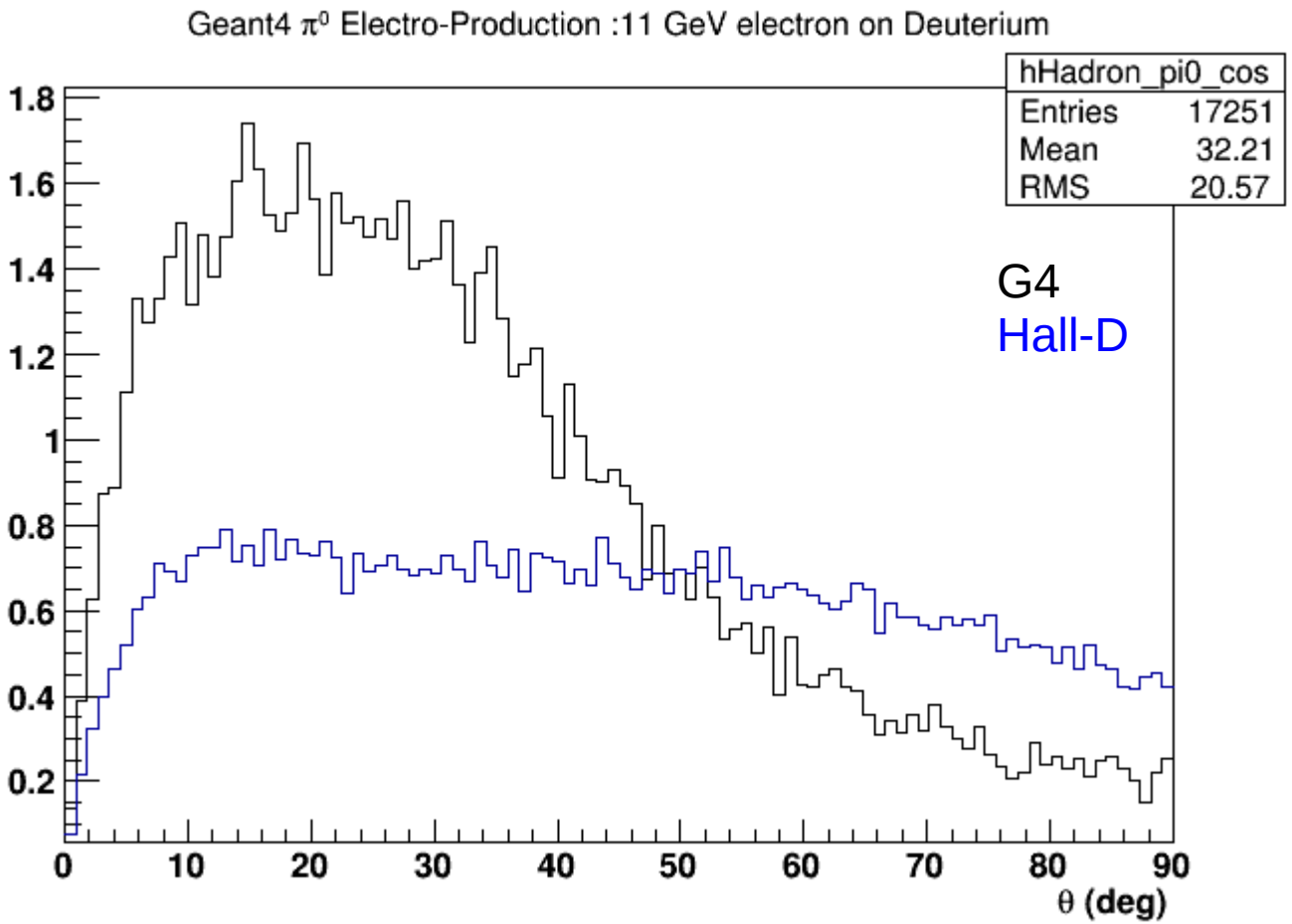
Hall D vs. Geant4 : Proton Target



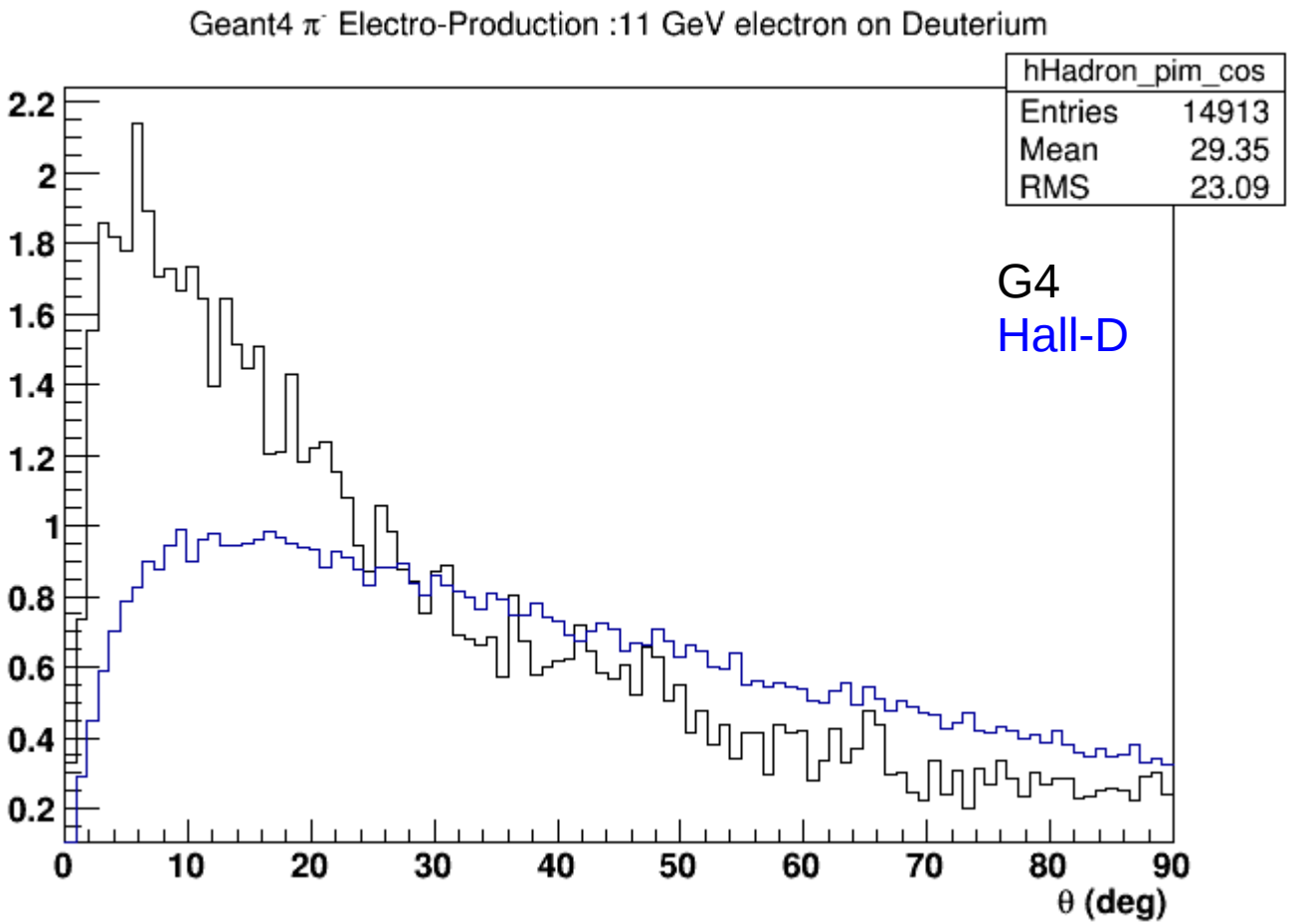
Hall D vs. Geant4 : Proton Target



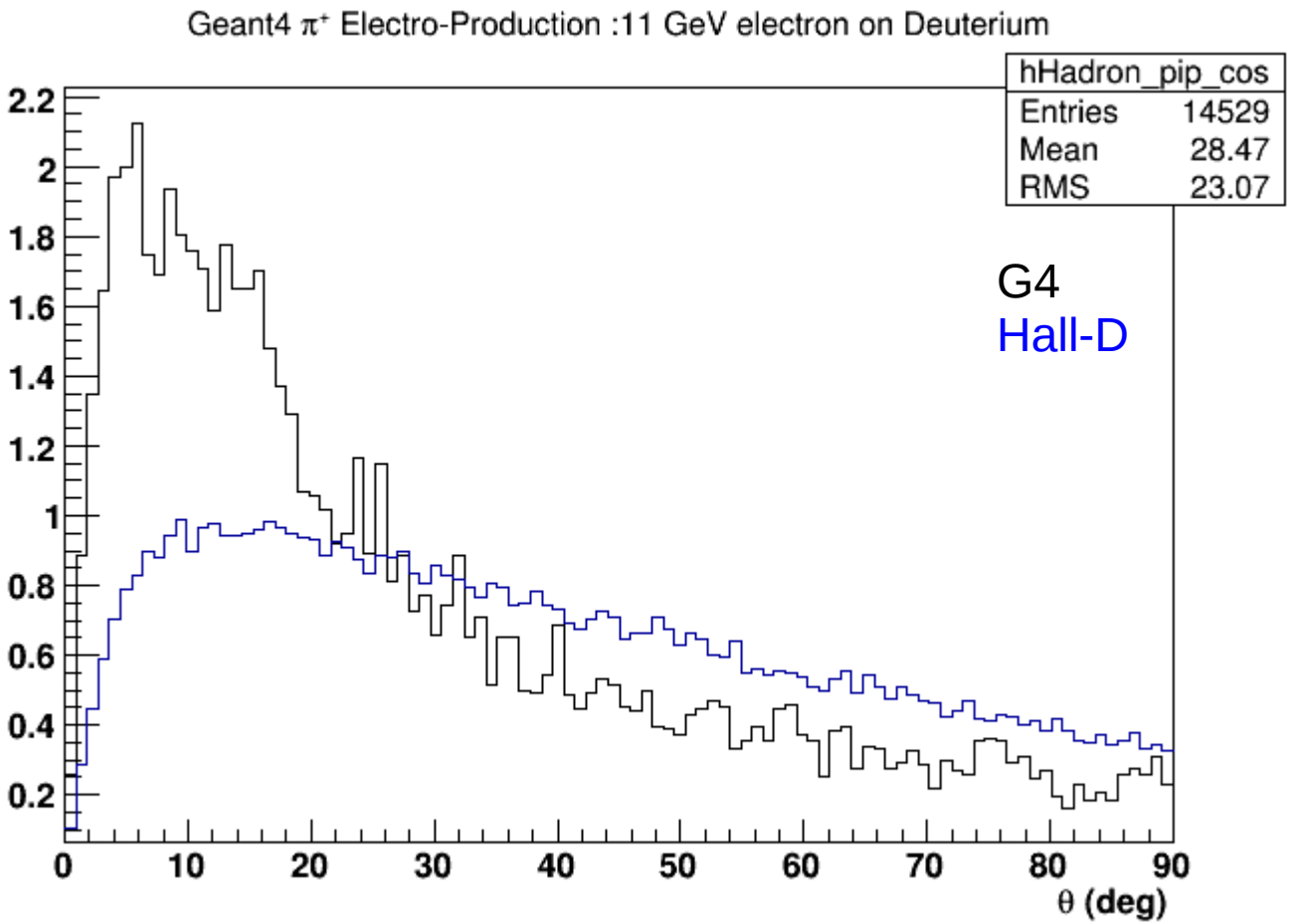
Hall D vs. Geant4 : Deuterium Target



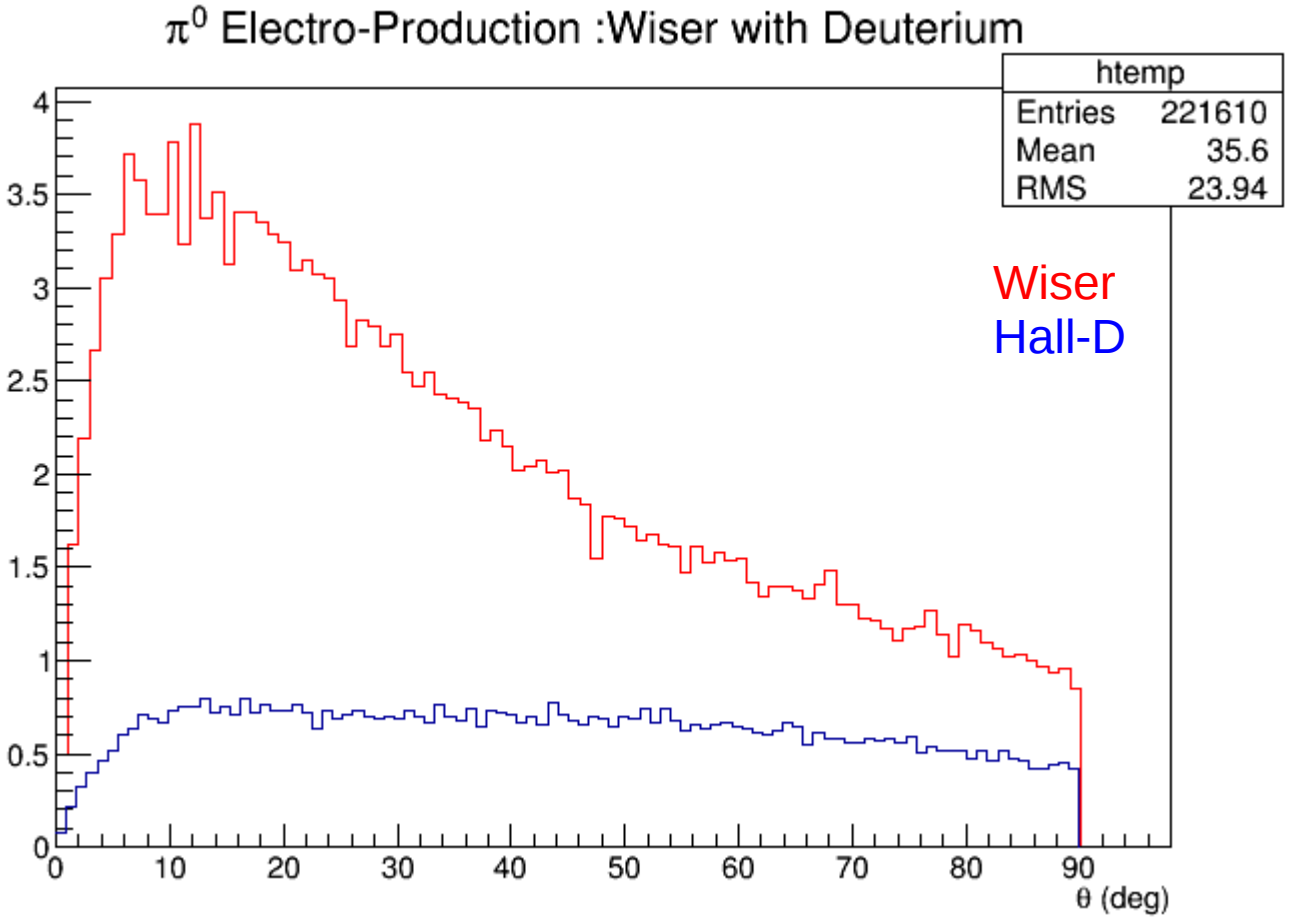
Hall D vs. Geant4 : Deuterium Target



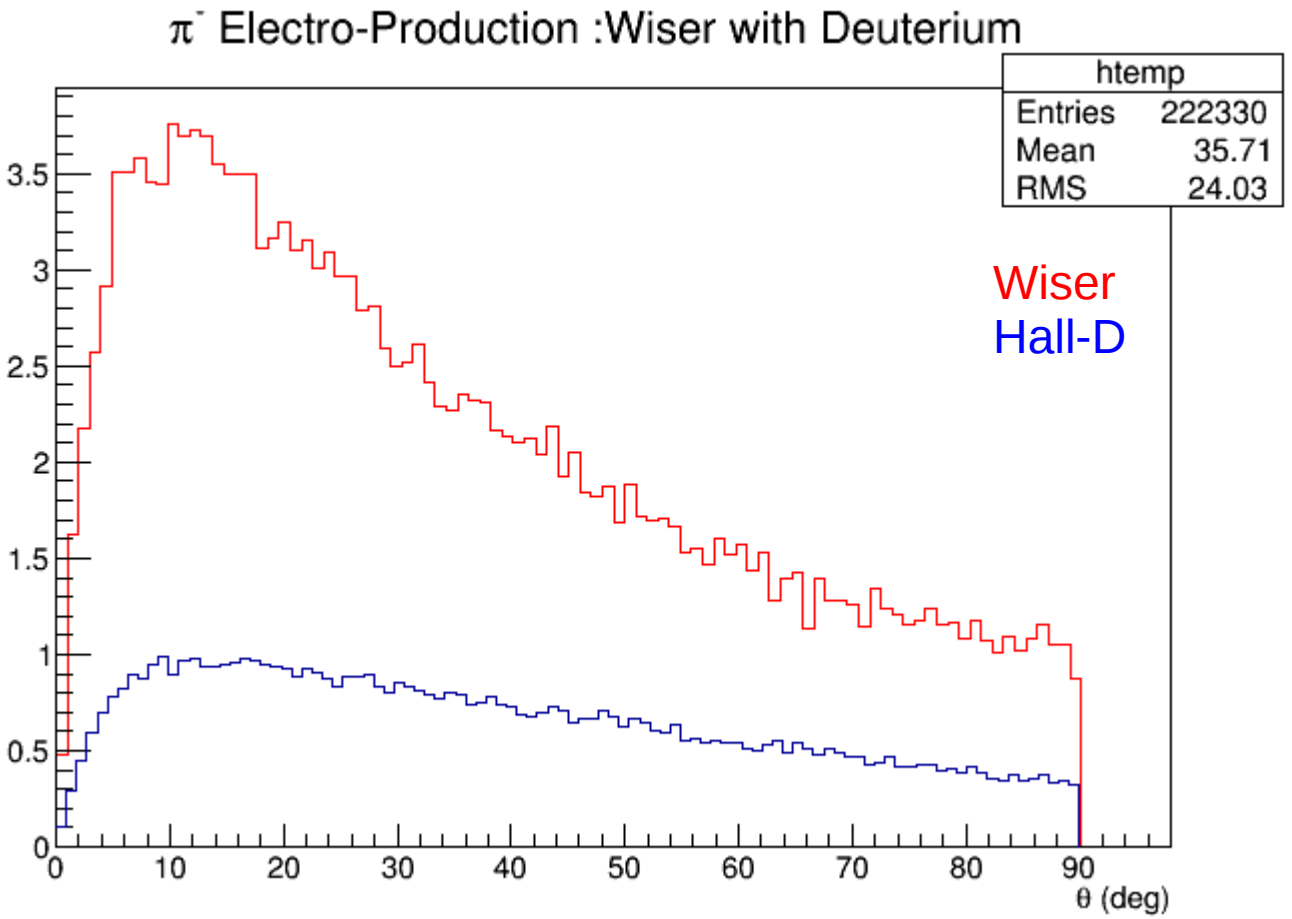
Hall D vs. Geant4 : Deuterium Target



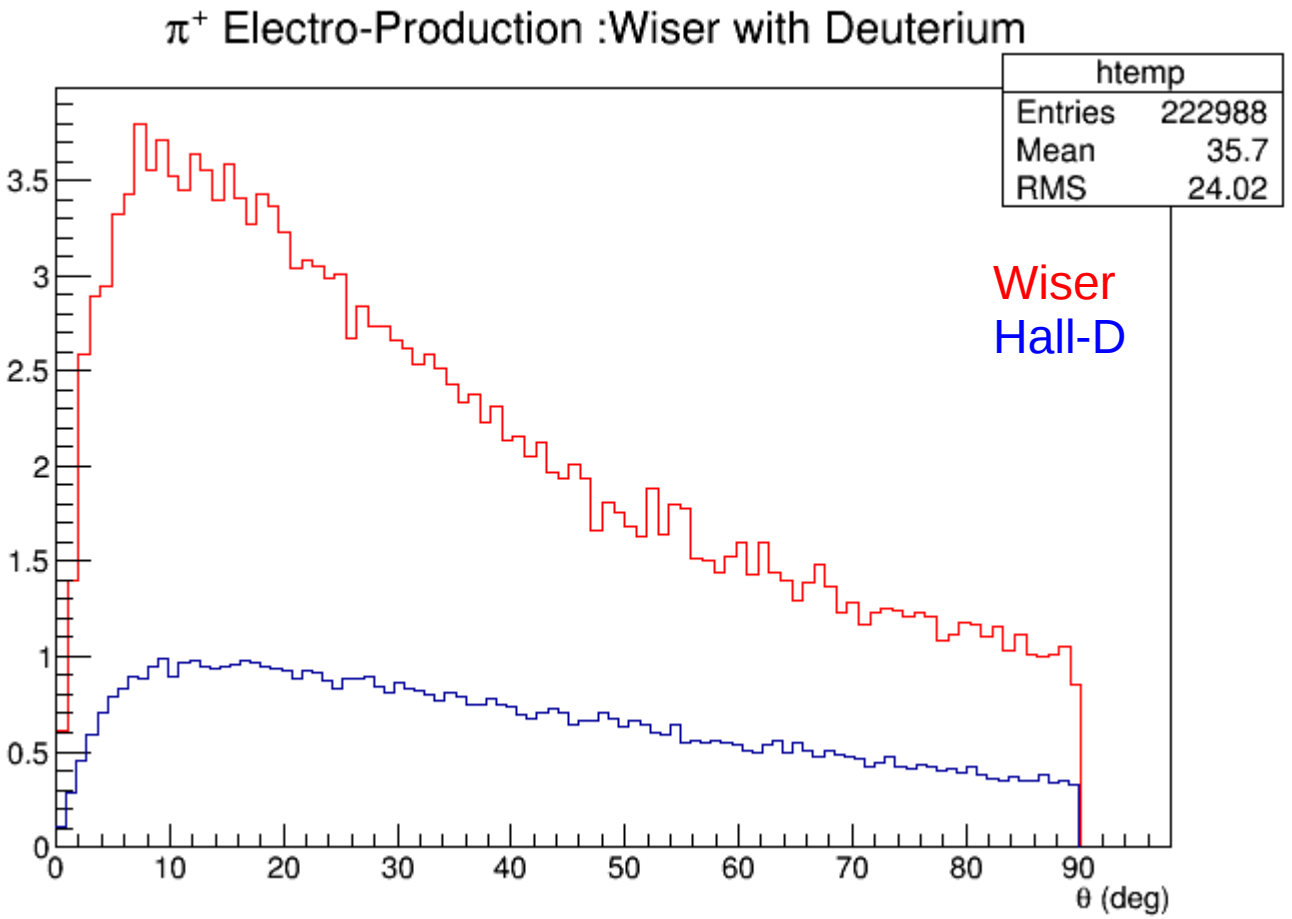
Hall D vs. Wiser : Deuterium Target



Hall D vs. Wiser : Deuterium Target



Hall D vs. Wiser : Deuterium Target



Generator Output Summary

- Geant4 and Hall generators agrees within 10% - 20%
  - I do not distinguish primary and secondary vertex produced pions in G4 while hall D only produce primary vetices → Could explain higher pion xs in G4
- Wiser overestimates pions

Pion Type	Total Proton xs for theta < 90 deg			Hall D vs. G4 agreement
	Wiser xs	Hall D xs	Geant4 xs	
	(mb)	(mb)	(mb)	(%)
pi0	n/a	31.3	26.8	17
pi-	n/a	20.7	23.5	-12
pi+	n/a	44.4	50.7	-12

Pion Type	Total Deuterium xs for theta < 90 deg			Hall D vs. G4 agreement
	Wiser xs	Hall D xs	Geant4 xs	
	(mb)	(mb)	(mb)	(%)
pi0	189.7	62.5	84.6	-26
pi-	191.6	65.1	73.2	-11
pi+	192.7	65.1	71.3	-9

Total Deuterium Rates for theta < 90 deg				Hall D vs. G4 agreement
Pion Type	Wiser Total	Hall D Total	Geant4 Tota	
	(MHz)	(MHz)	(MHz)	(%)
pi0	123166.2	40627.8	53831.7	-25
pi-	126437.2	42695.7	46536.0	-8
pi+	125068.8	42695.7	45337.7	-6