Electro-Production Hall D Generator Update 2

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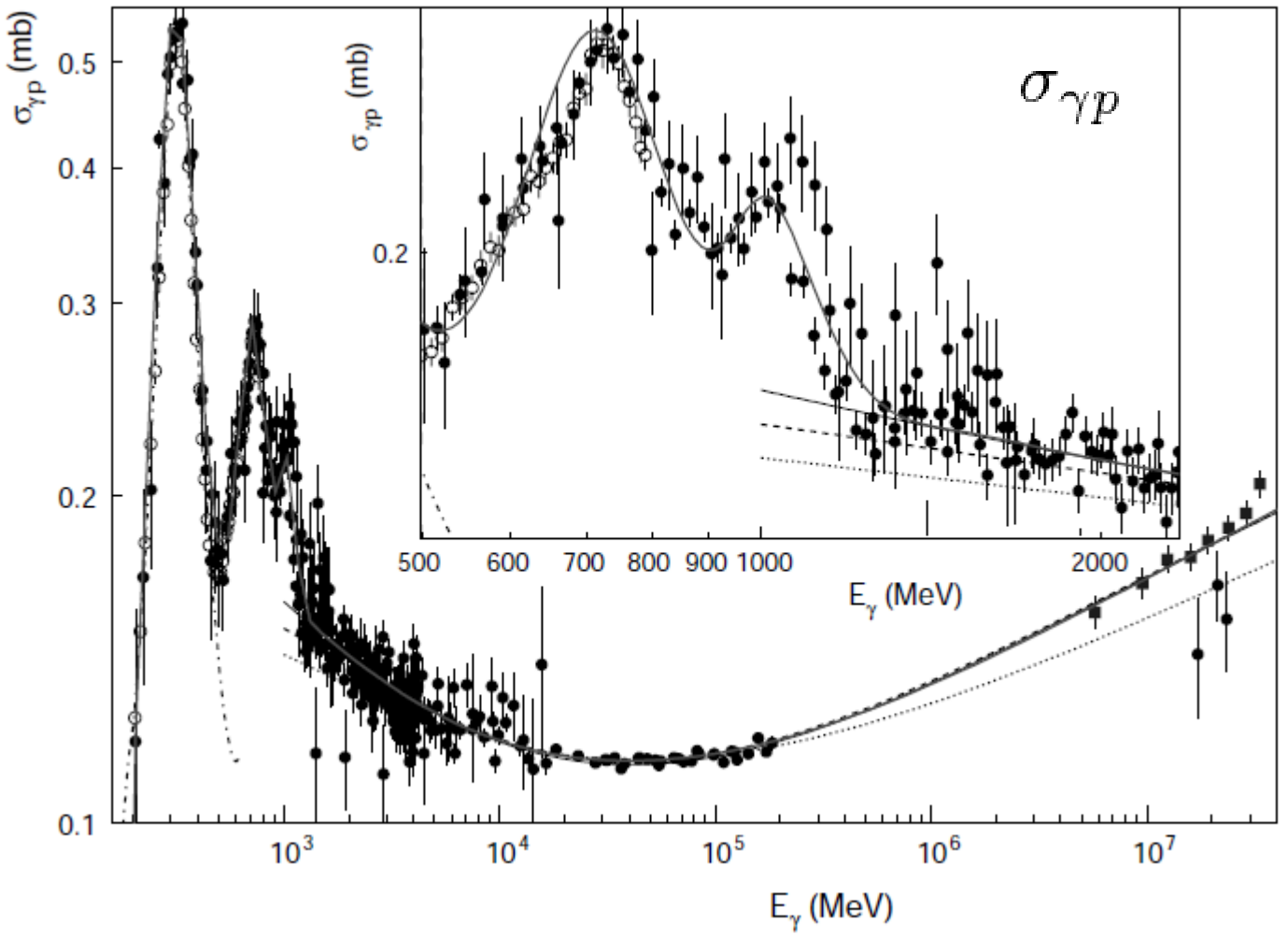
Overview

- Hadron Production implementation in GEANT4
- Geant4 (QGSP_BERT) and hall D generators are compared for proton & deuterium targets
- Geant4 QGSP_BERT and FTFP_BERT physics lists are compared for deuterium target
- For the analysis the scattering angle is limited to < 90 deg

Hadron Production implementation in GEANT4

- The hadron interactions (say for photo or electro production) in Geant4 are implemented in a two fold method
- Geant4 determines the photonuclear or electronuclear interaction going to take place based on the total cross section
  - For photoproduction cross section, it uses a fit based on models and data.
  - For electroproduction Geant4 uses EPA approximation
- The next step is to simulate the fragmentation of the excited hadronic system in nuclear matter into set of final hadrons
- In earlier versions they used the CHIPS (Chiral Invariant Phase Space) model
- Now it's either Quark Gluon String model + Bertini cascade model (QGSP_BERT) or FTF model which uses a different string model with Bertini cascade model (FTFP_BERT)

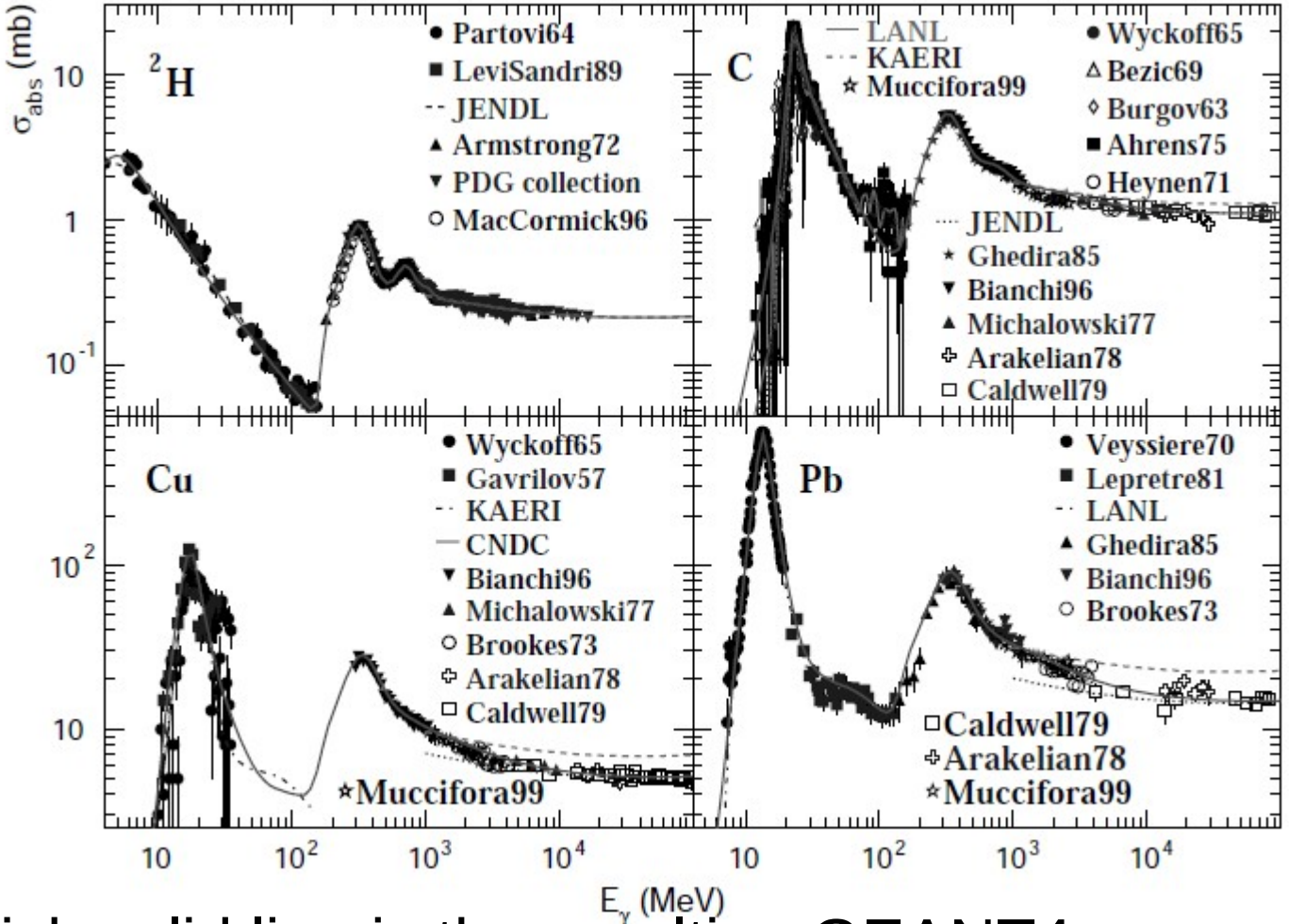
Hadron Production implementation in GEANT4



The thick solid line is the resulting GEANT4 approximation

Reference : M. V. Kossov, Eur. Phys. J. A 14, 377 (2002)

Hadron Production implementation in GEANT4



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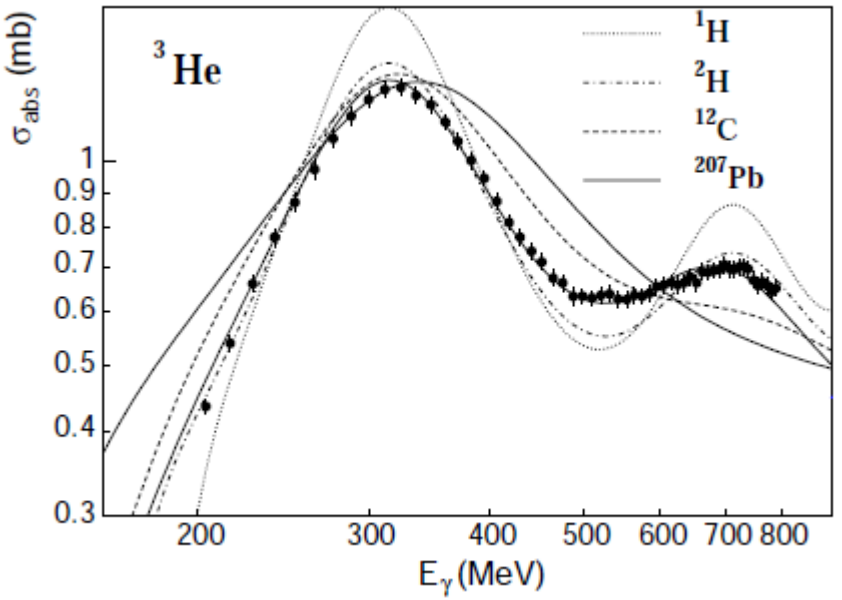
Hadron Production implementation in GEANT4



Thick line the thick solid line is the GEANT4 approximation for 3He. For comparison the approximation curves for 1H (dotted line), 2H (dash-dotted line), C (dashed line), and Pb (thin solid line) are also shown

Reference : M. V. Kossov, Eur. Phys. J. A 14, 377 (2002)

Hall D vs. Geant4 Cross Sections from Proton Target for Scattering Angle less than 90 deg.

Hall D Gen.

	Pi0		Pi-		Pi+	
Mom. Range	xs	Rate	xs	Rate	xs	Rate
(GeV)	(mb)	(MHz)	(mb)	(MHz)	(mb)	(MHz)
0 - 1	18.28	9771.24	10.23	5465.82	26.13	13965.47
1 - 2	2.18	1164.50	2.36	1258.96	3.10	1654.65
2 - 3	0.64	341.37	0.81	432.42	0.87	466.53
3 - 4	0.24	127.00	0.36	192.33	0.35	186.56
4 - 5	0.10	54.58	0.17	90.26	0.17	92.10
5 - 10	0.07	37.26	0.15	81.08	0.15	80.82
Total	21.51	11495.92	14.07	7520.84	30.77	16446.40

Geant4

	Pi0		Pi-		Pi+	
Mom. Range	xs	Rate	xs	Rate	xs	Rate
(GeV)	(mb)	(MHz)	(mb)	(MHz)	(mb)	(MHz)
0 - 1	20.88	11158.91	10.06	5376.62	26.11	13954.87
1 - 2	3.25	1735.00	2.22	1185.79	2.70	1441.67
2 - 3	1.13	602.26	0.79	421.27	0.71	380.70
3 - 4	0.53	280.84	0.36	190.35	0.30	159.15
4 - 5	0.34	180.99	0.16	87.37	0.12	65.53
5 - 10	0.32	171.63	0.14	74.89	0.12	62.41
Total	26.46	14142.11	13.73	7336.29	30.06	16064.35

Hall D vs. Geant4 Cross Sections from Proton Target for Scattering Angle less than 90 deg.

	Hall D Pi0		Geant4 Pi0	
Mom. Range	xs	Rate	xs	Rate
(GeV)	(mb)	(MHz)	(mb)	(MHz)
0.0 - 0.1	0.28	147.99	0.40	215.31
0.1 - 0.2	2.56	1369.69	3.02	1613.30
0.2 - 0.3	6.07	3242.93	6.41	3426.31
0.3 - 0.4	3.14	1675.90	3.63	1937.83
0.4 - 0.5	1.88	1004.96	2.16	1154.59
0.5 - 0.6	1.40	748.60	1.69	901.82
0.6 - 0.7	1.00	534.23	1.29	689.63
0.7 - 0.8	0.81	434.26	0.89	477.44
0.8 - 0.9	0.61	324.84	0.74	396.30
0.9 - 1.0	0.54	287.84	0.65	346.38

Hall D vs. Geant4 Cross Sections from Deuterium Target for Scattering Angle less than 90 deg.

Hall D Gen.

	Pi0		Pi-		Pi+	
Mom. Range	xs	Rate	xs	Rate	xs	Rate
(GeV)	(mb)	(MHz)	(mb)	(MHz)	(mb)	(MHz)
0 - 1	36.57	23258.31	36.36	23127.00	36.36	23127.00
1 - 2	4.36	2771.83	5.45	3467.62	5.45	3467.62
2 - 3	1.28	812.56	1.68	1069.88	1.68	1069.88
3 - 4	0.48	302.29	0.71	450.94	0.71	450.94
4 - 5	0.20	129.91	0.34	217.04	0.34	217.04
5 - 10	0.14	88.69	0.30	192.68	0.30	192.68
Total	43.02	27363.54	44.85	28525.58	44.85	28525.58

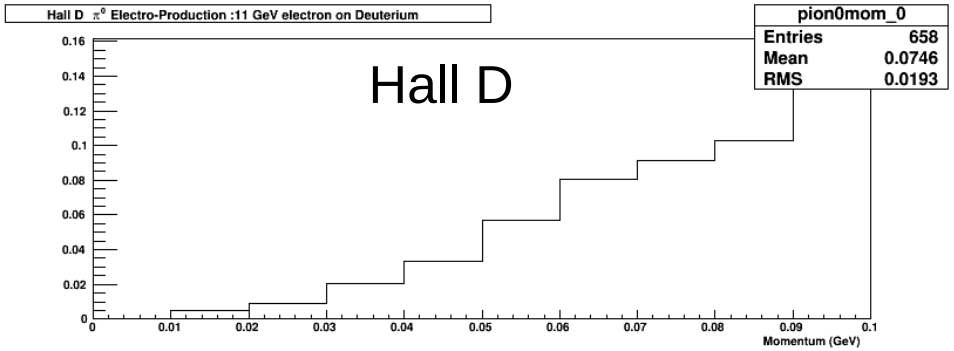
Geant4

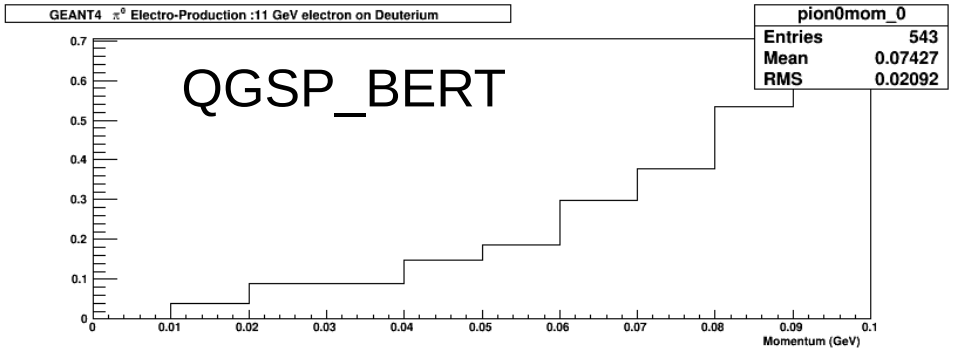
	Pi0		Pi-		Pi+	
Mom. Range	xs	Rate	xs	Rate	xs	Rate
(GeV)	(mb)	(MHz)	(mb)	(MHz)	(mb)	(MHz)
0 - 1	72.79	46297.94	30.52	19415.73	31.12	19793.28
1 - 2	6.87	4371.82	5.81	3694.67	5.20	3304.61
2 - 3	2.25	1429.19	1.67	1064.09	1.31	833.17
3 - 4	1.21	770.76	0.77	489.92	0.53	333.89
4 - 5	0.65	411.91	0.34	218.44	0.28	174.75
5 - 10	0.97	614.74	0.34	215.31	0.25	159.15
Total	84.76	53911.94	39.46	25098.12	38.67	24598.81

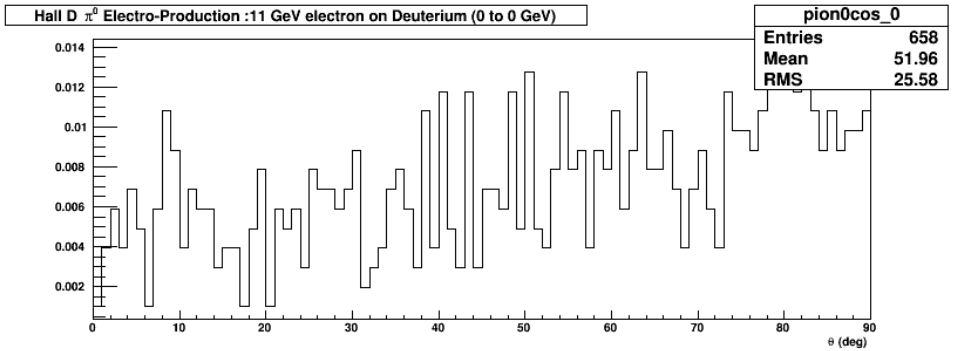
Hall D vs. Geant4 Cross Sections from Deuterium Target for Scattering Angle less than 90 deg.

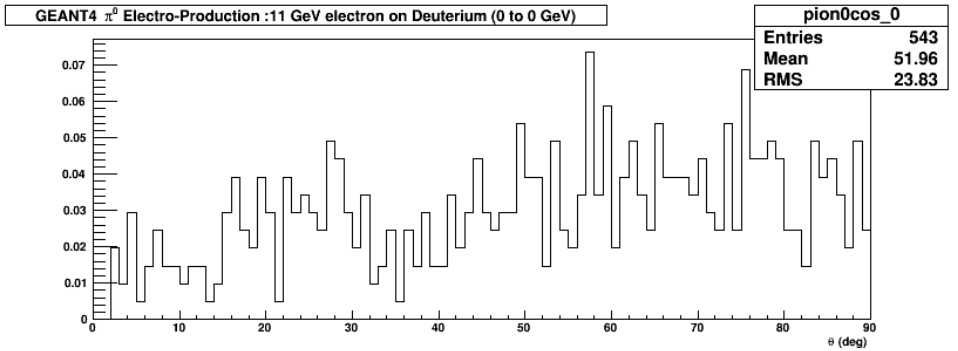
	Hall D Pi0		Geant4 Pi0	
Mom. Range	xs	Rate	xs	Rate
(GeV)	(mb)	(MHz)	(mb)	(MHz)
0.0 - 0.1	0.55	352.26	2.43	1547.77
0.1 - 0.2	5.13	3260.24	13.03	8288.02
0.2 - 0.3	12.14	7719.09	23.20	14756.80
0.3 - 0.4	6.27	3989.11	13.57	8628.16
0.4 - 0.5	3.76	2392.08	7.18	4565.29
0.5 - 0.6	2.80	1781.89	4.37	2780.37
0.6 - 0.7	2.00	1271.62	3.08	1959.67
0.7 - 0.8	1.63	1033.66	2.47	1572.73
0.8 - 0.9	1.22	773.22	1.91	1213.87
0.9 - 1.0	1.08	685.15	1.55	986.08

Hall D vs. Geant4 π^0 Cross Sections



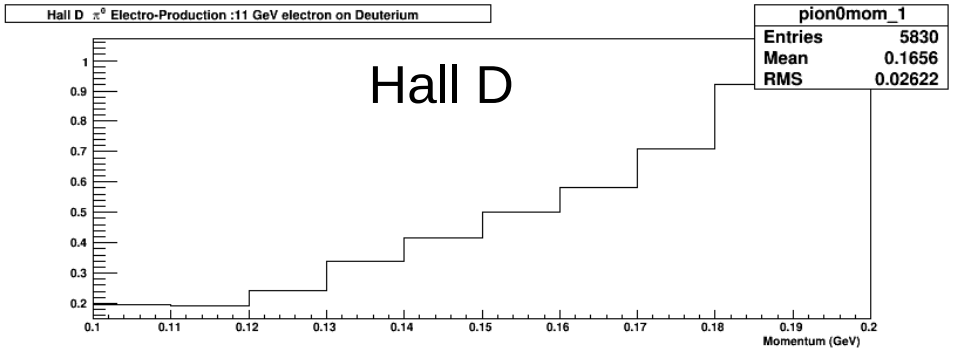


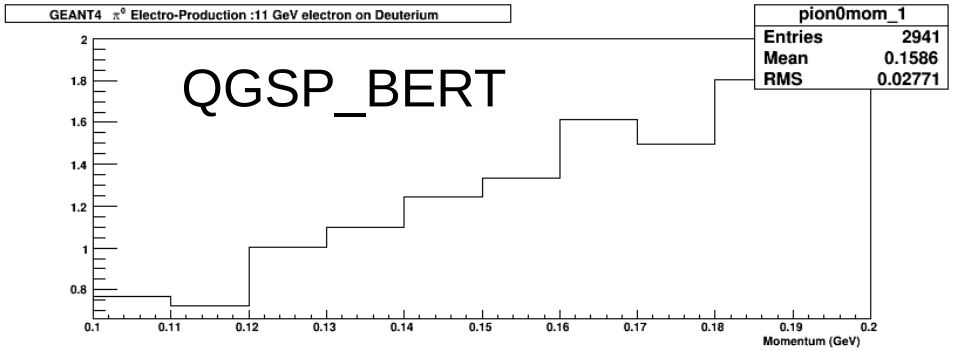


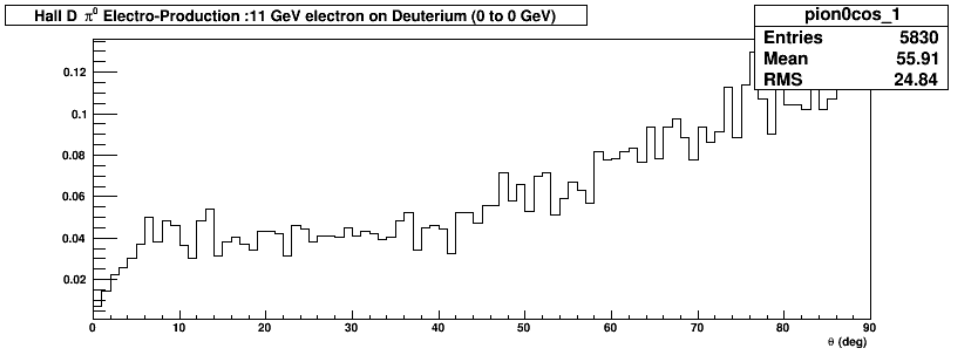


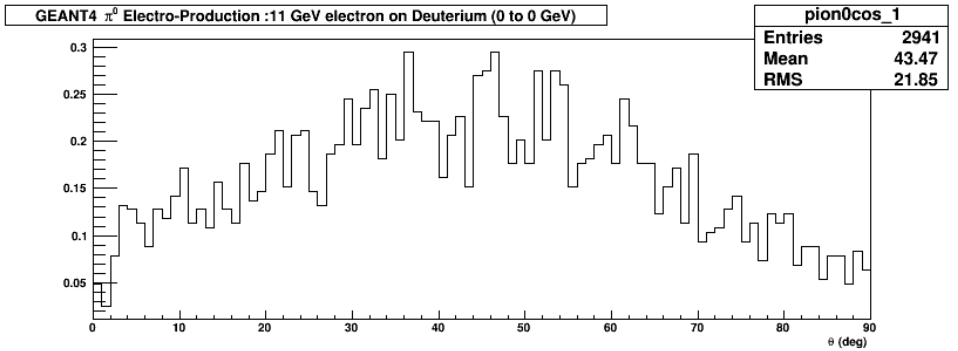
π^0 Momentum range : 0 – 100 MeV

Hall D vs. Geant4 π^0 Cross Sections



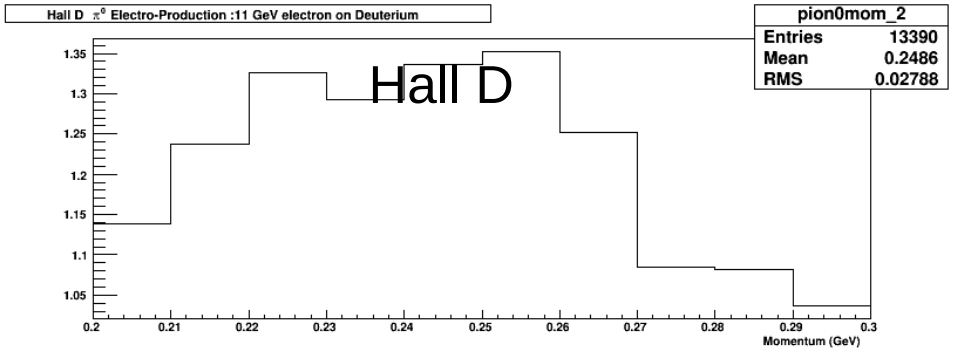


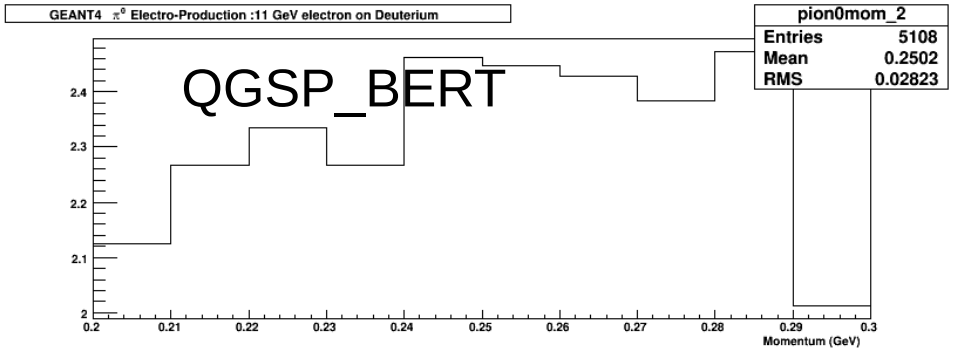


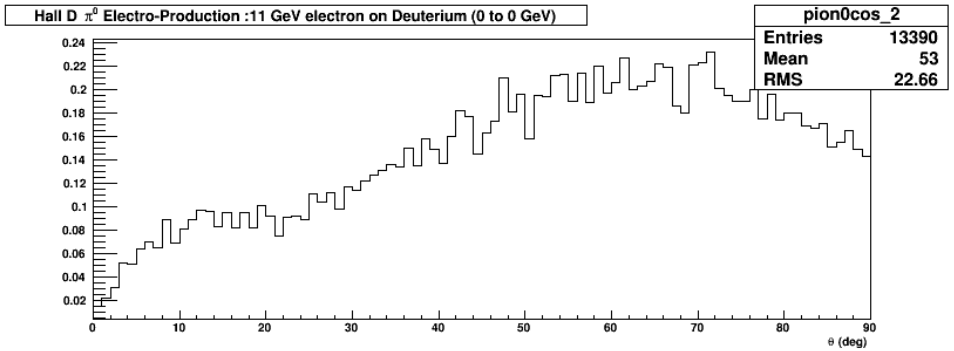


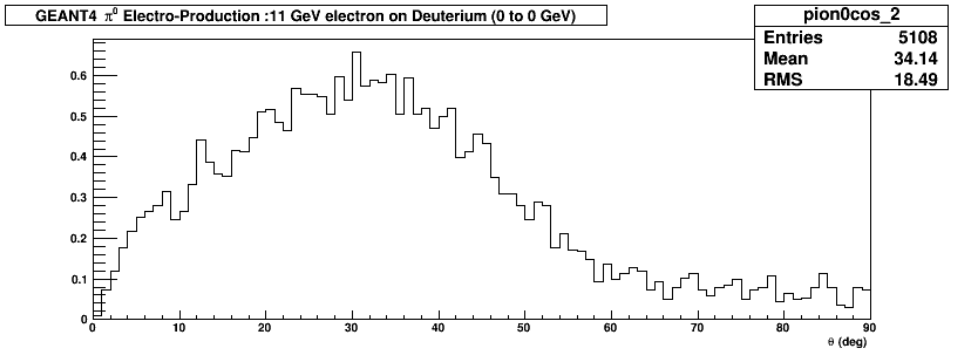
π^0 Momentum range : 100 – 200 MeV

Hall D vs. Geant4 π^0 Cross Sections



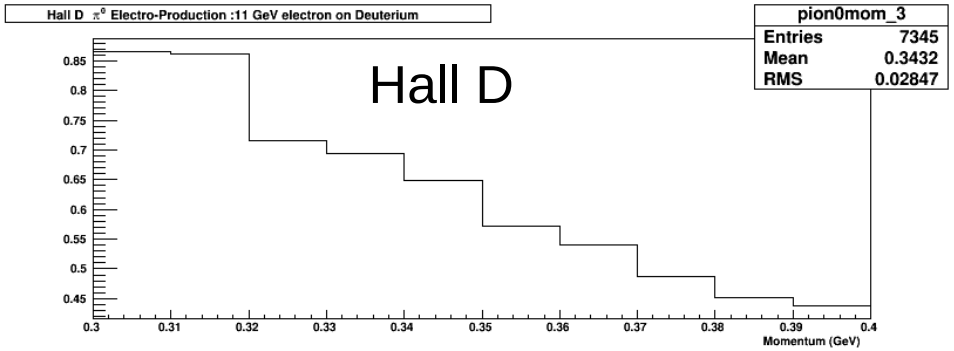


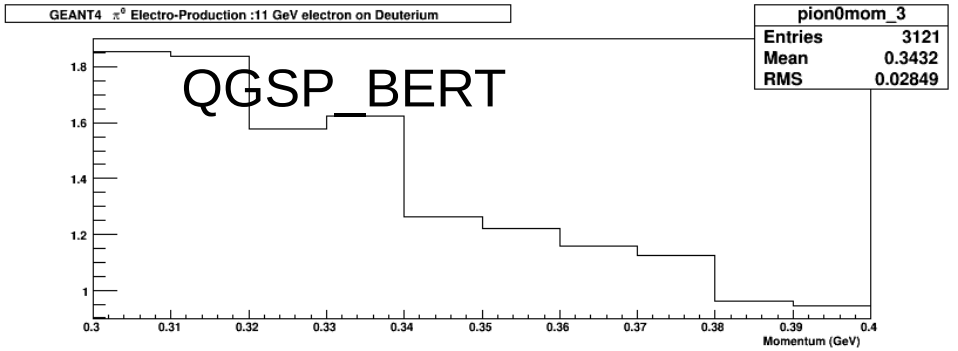


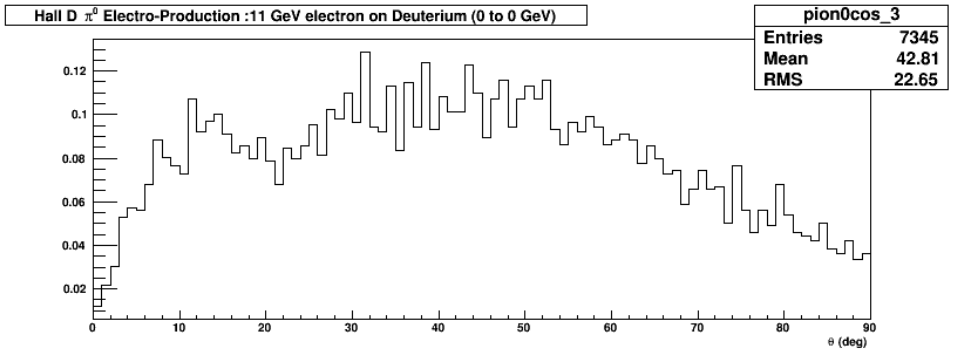


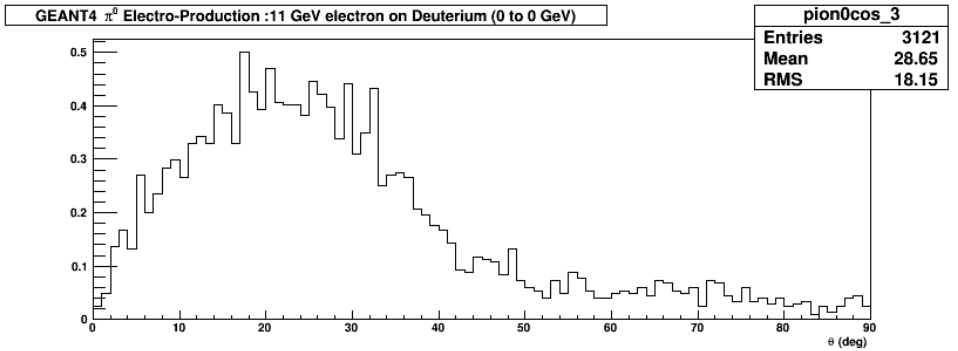
π^0 Momentum range : 200 – 300 MeV

Hall D vs. Geant4 π^0 Cross Sections



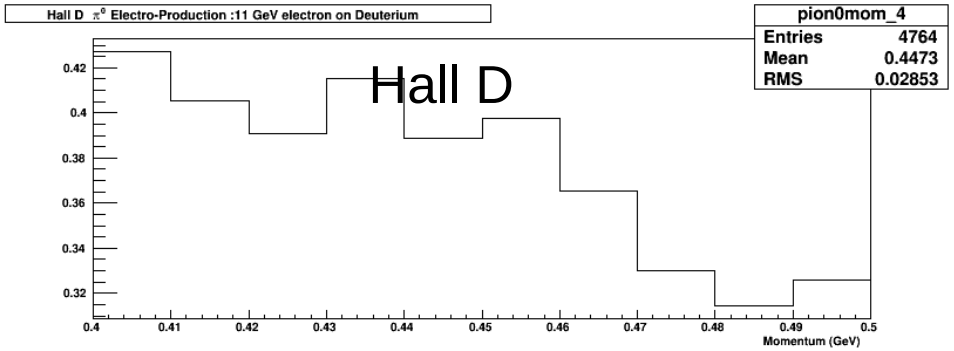


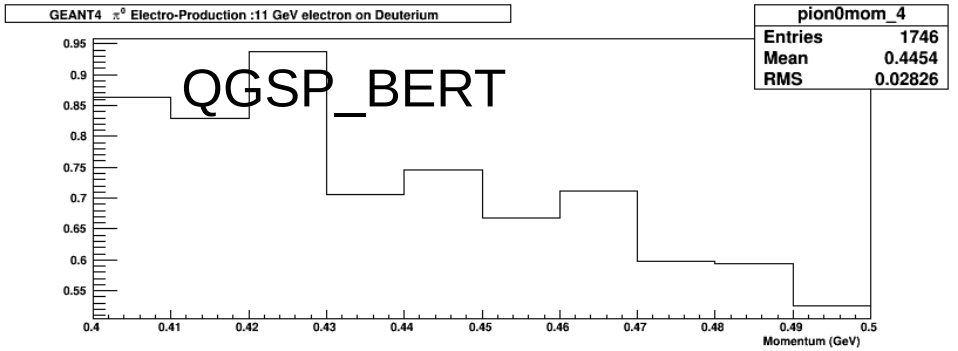


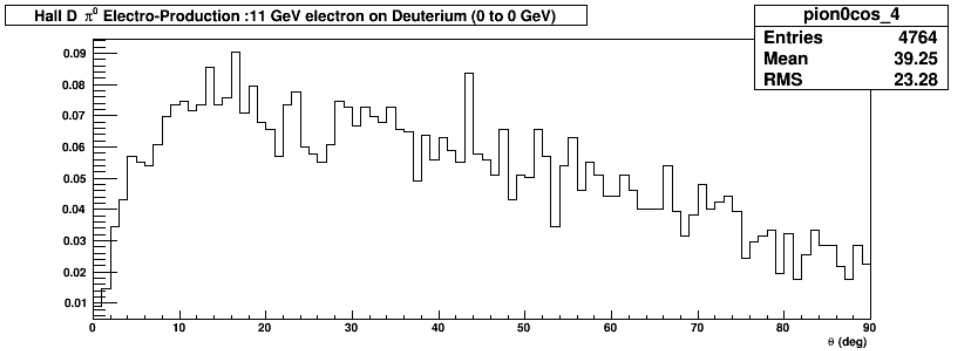


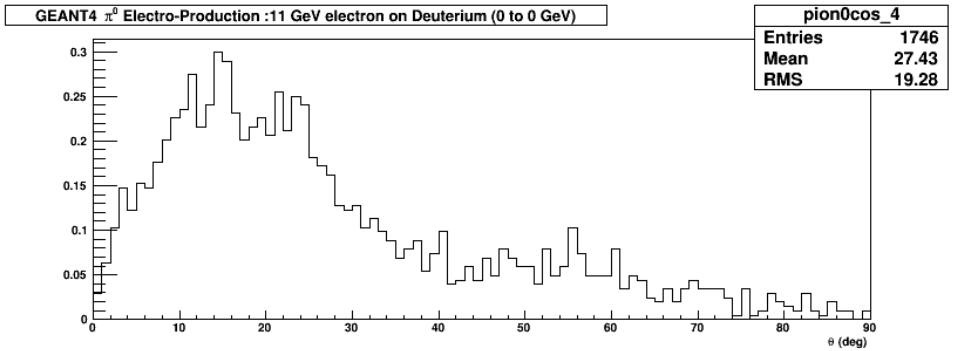
π^0 Momentum range : 300 – 400 MeV

Hall D vs. Geant4 π^0 Cross Sections



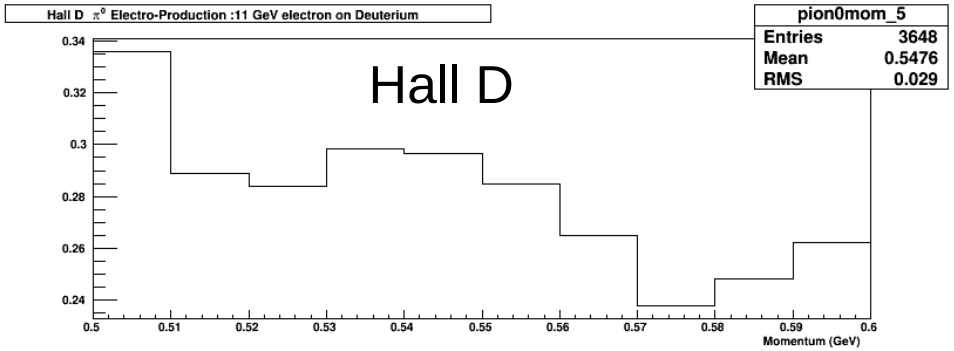


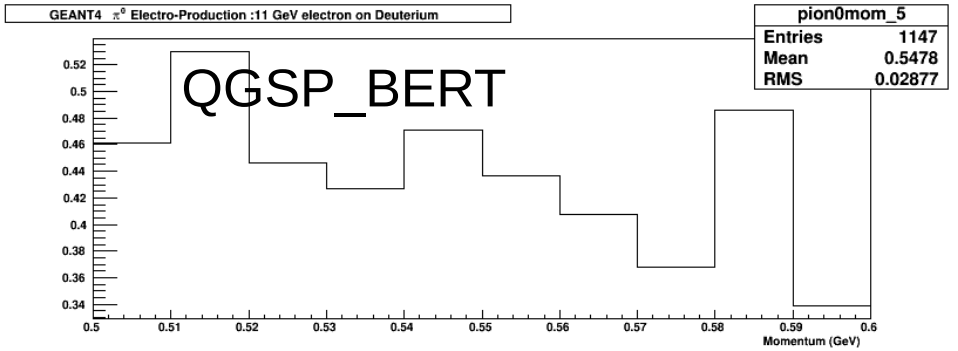


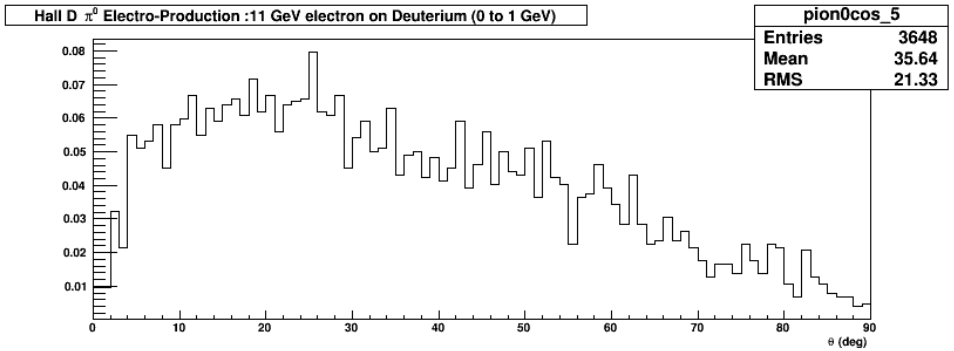


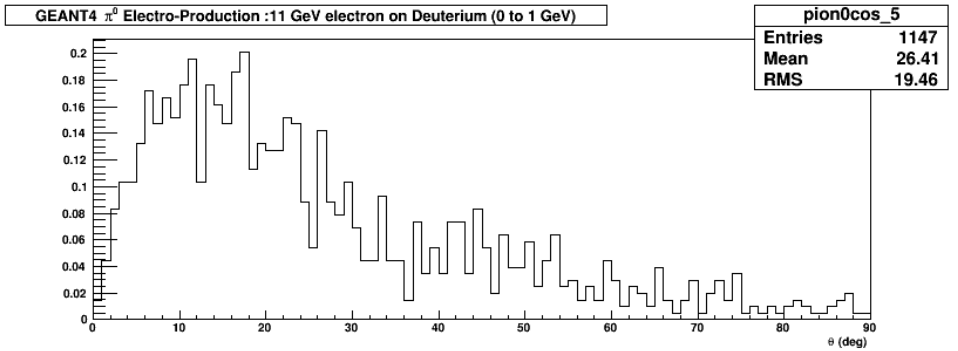
π^0 Momentum range : 400 – 500 MeV

Hall D vs. Geant4 π^0 Cross Sections



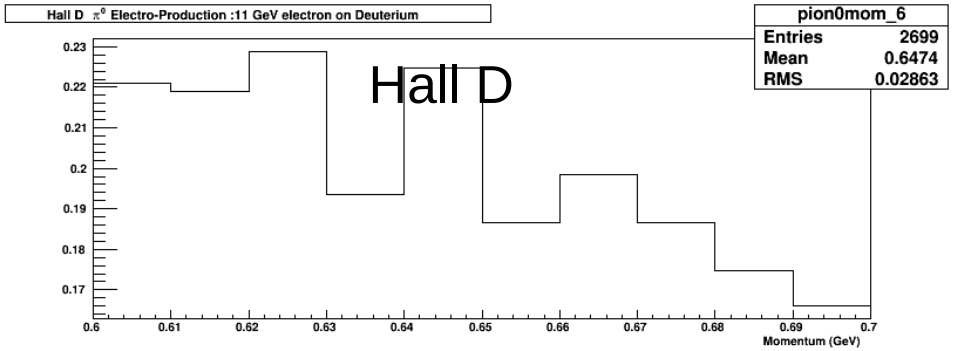


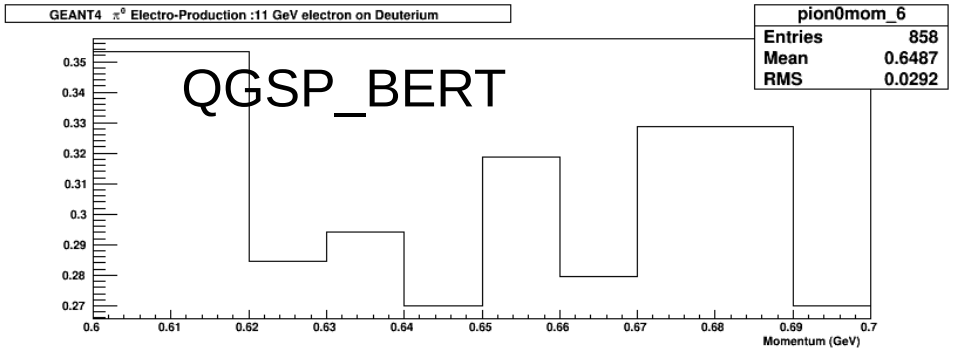


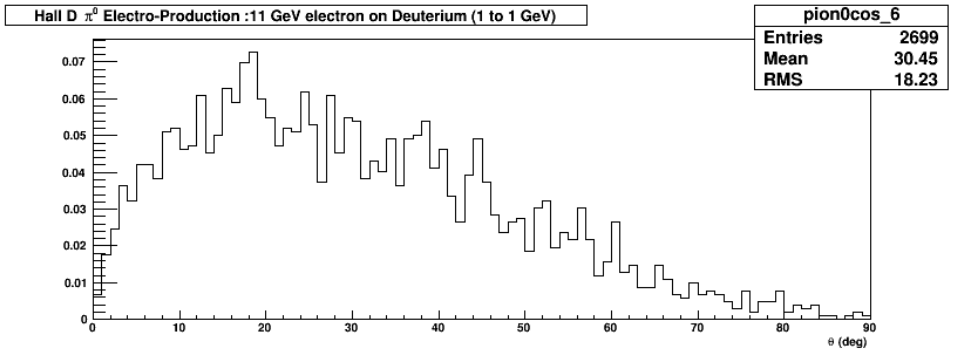


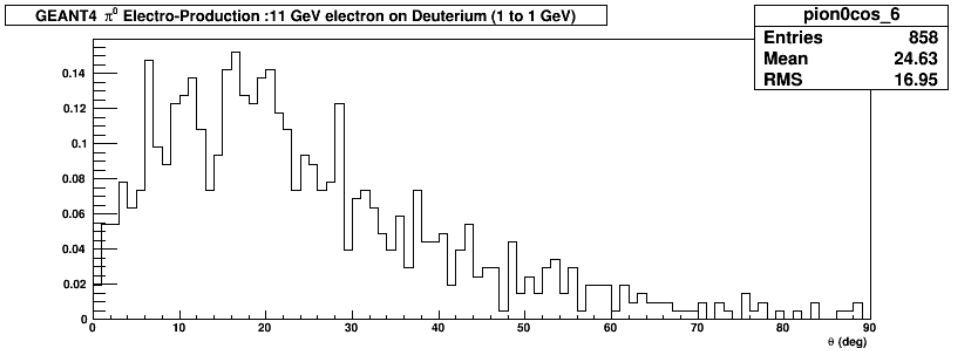
π^0 Momentum range : 500 – 600 MeV

Hall D vs. Geant4 π^0 Cross Sections



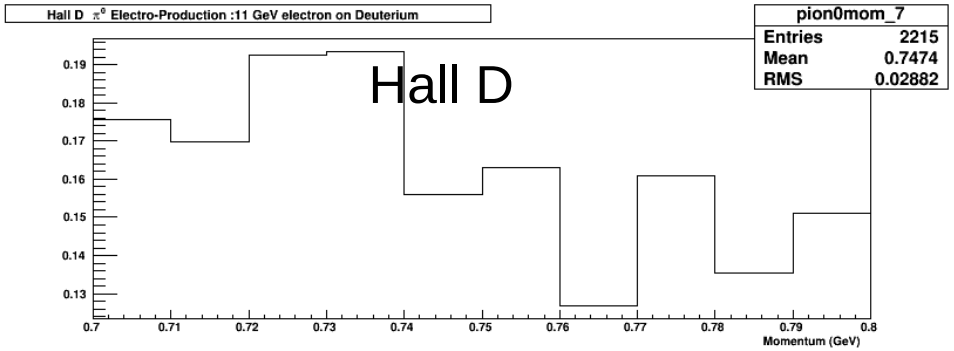


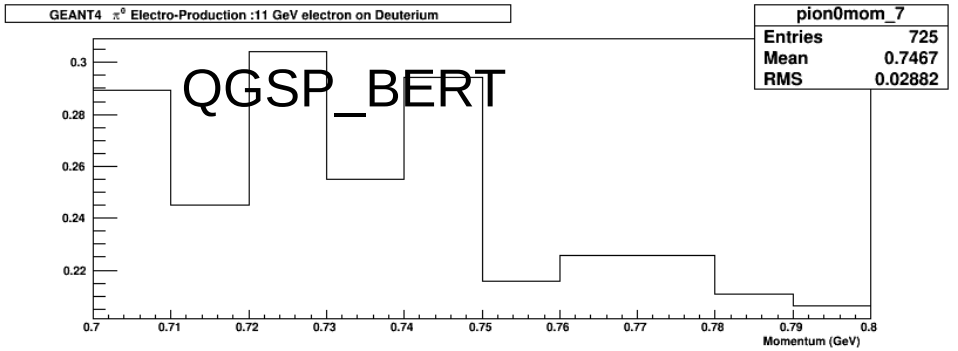


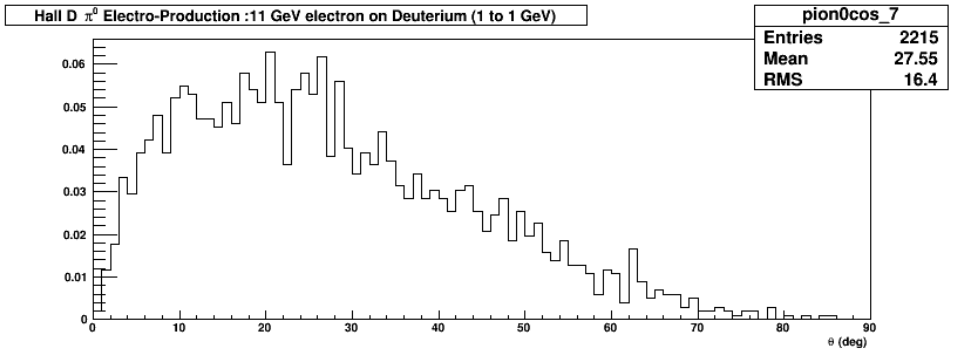


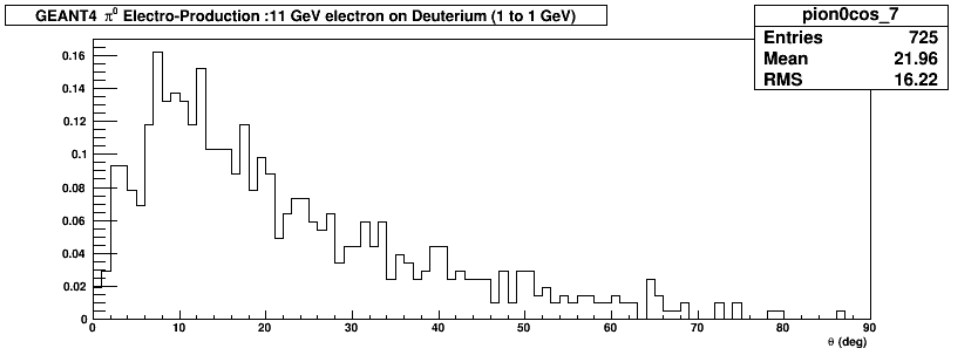
π^0 Momentum range : 600 – 700 MeV

Hall D vs. Geant4 π^0 Cross Sections



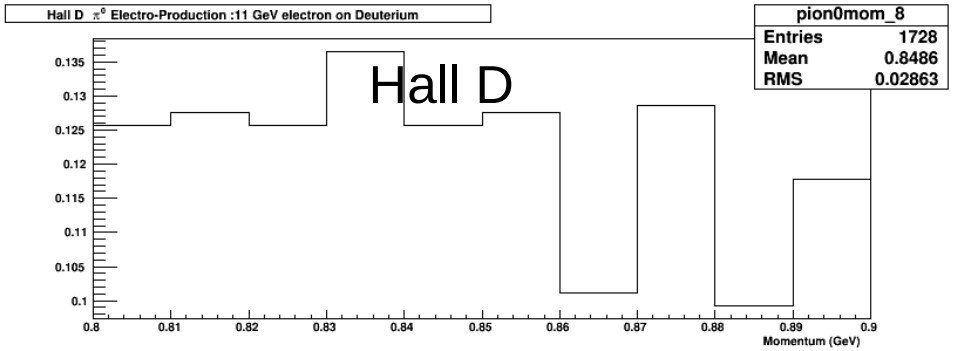


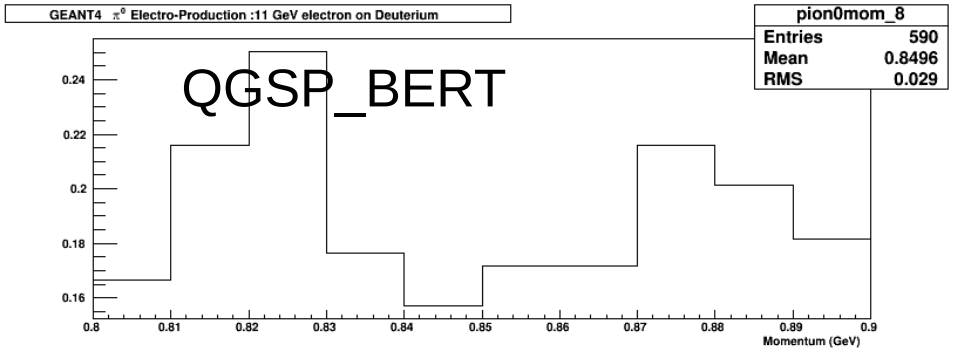


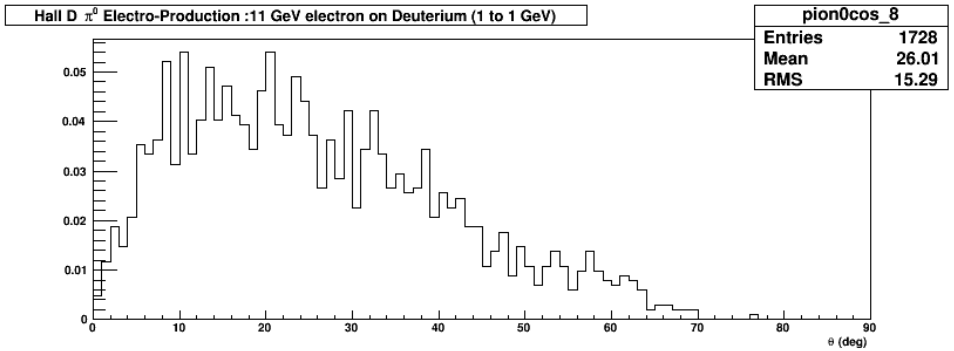


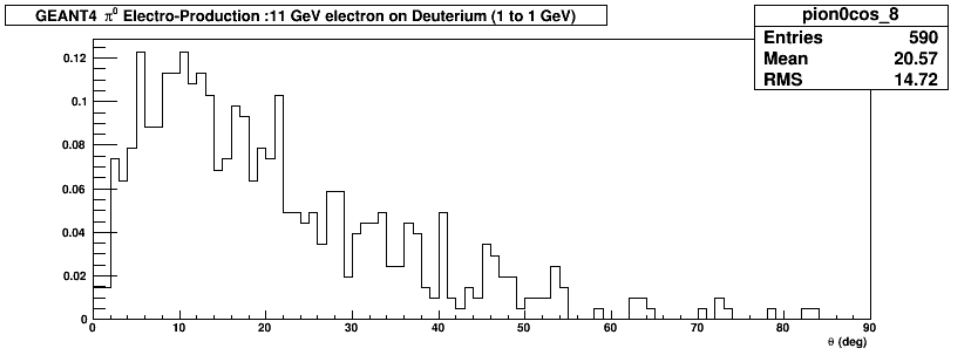
π^0 Momentum range : 700 – 800 MeV

Hall D vs. Geant4 π^0 Cross Sections



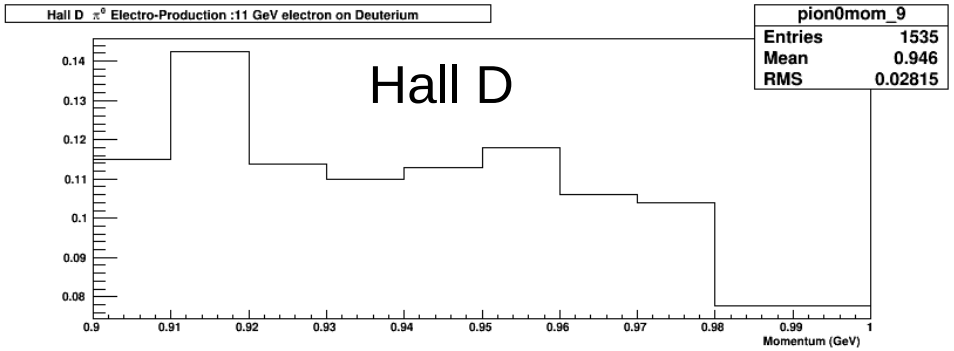


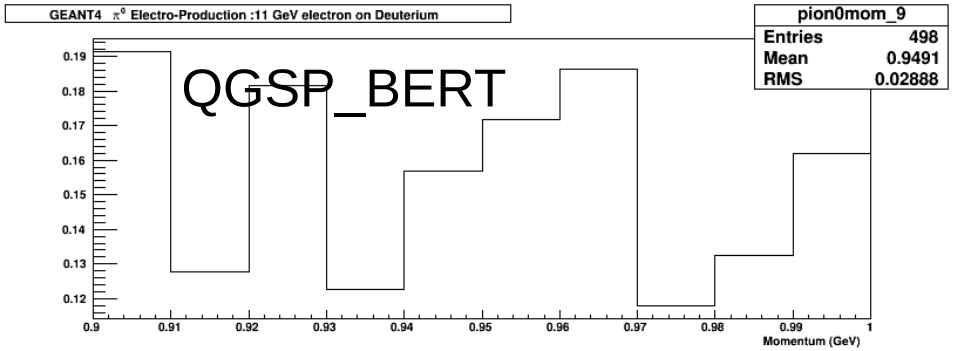


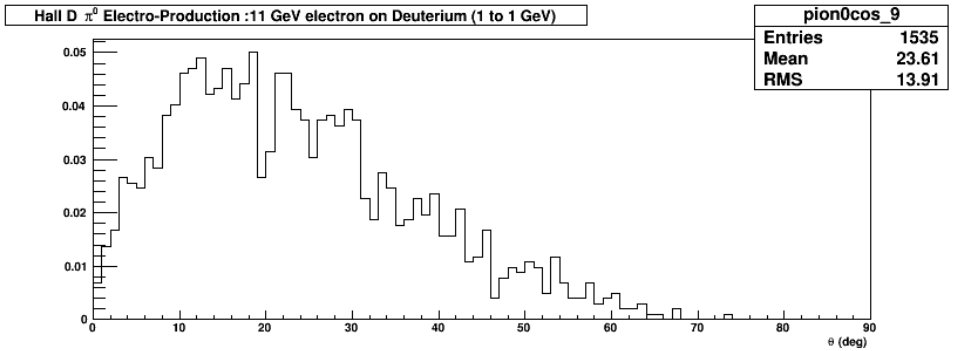


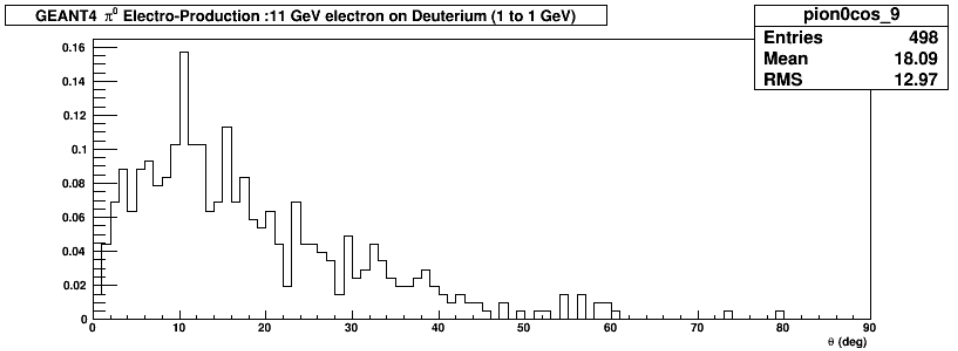
π^0 Momentum range : 800 – 900 MeV

Hall D vs. Geant4 π^0 Cross Sections









π^0 Momentum range : 900 – 1000 MeV

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections

	FTFP_BERT Pi0		QGSP_BERT Pi0	
Mom. Range	xs	Rate	xs	Rate
(GeV)	(mb)	(MHz)	(mb)	(MHz)
0.0 - 0.1	2.24	1426.07	2.43	1547.77
0.1 - 0.2	13.35	8493.98	13.03	8288.02
0.2 - 0.3	22.55	14344.89	23.20	14756.80
0.3 - 0.4	14.02	8915.24	13.57	8628.16
0.4 - 0.5	6.97	4434.23	7.18	4565.29
0.5 - 0.6	4.59	2920.79	4.37	2780.37
0.6 - 0.7	3.10	1972.16	3.08	1959.67
0.7 - 0.8	2.22	1410.47	2.47	1572.73
0.8 - 0.9	1.77	1123.38	1.91	1213.87
0.9 - 1.0	1.47	933.03	1.55	986.08

More References

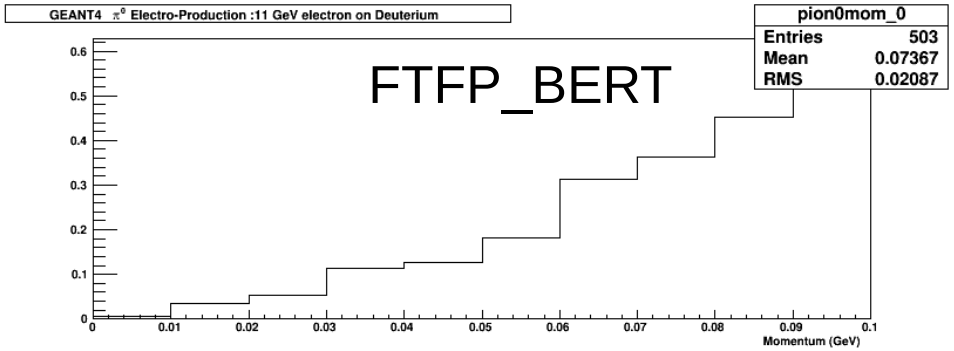
- References for the old CHIPS model
  - P.V. Degtyarenko, M.V. Kossov, H.P. Wellisch, Eur. Phys. J. A 8, 217 (2000)
  - P.V. Degtyarenko, M.V. Kossov, H.P. Wellisch, Eur. Phys. J. A 9, 411 (2001)
  - P.V. Degtyarenko, M.V. Kossov, H.P. Wellisch, Eur. Phys. J. A 9, 421 (2001)
- Reference for Geant4 photo and electro production cross sections
  - M. V. Kossov, Eur. Phys. J. A 14, 377 (2002)

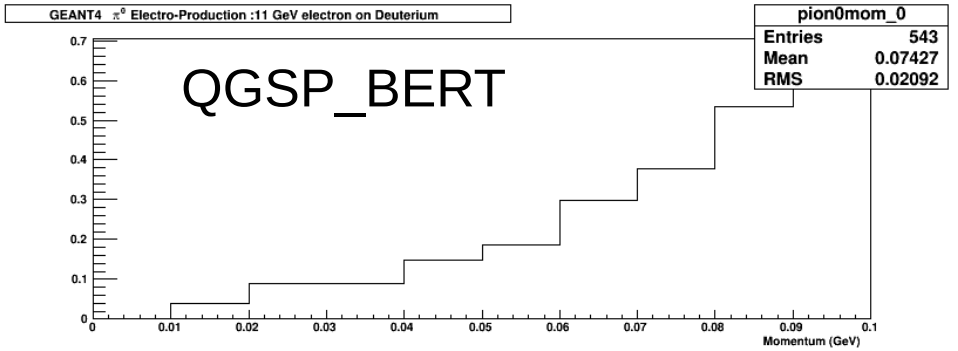
Excess π^0 photo-production on Deuterium in SAMPLE experiment

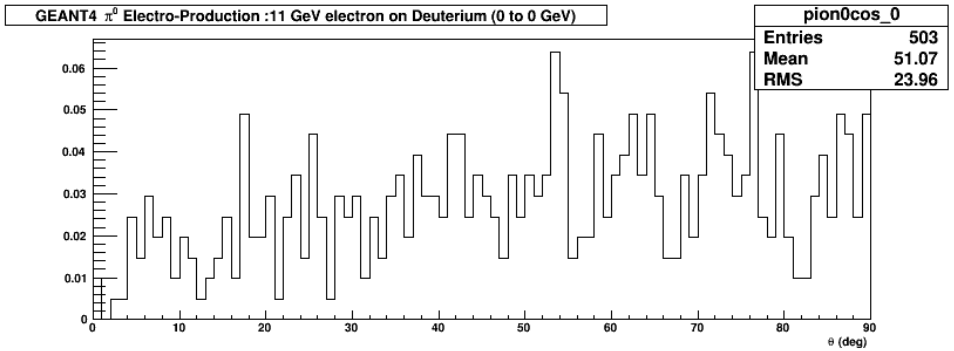
- Coherent pi0 production ($^2H(\gamma,\pi^0)^2H$) in deuterium around the pion threshold
  - Directly from a single nucleon (direct process)
  - From a two-step mechanism where first a charged pion is produced on a one nucleon and then charge exchanges to a pi0 on a second nucleon → rescattering mechanism
- Around the pion threshold rescattering mechanism increases the π^0 cross section significantly and dominates.
  - Then as the energy of the incident photon increases the rescattering terms are still important.
- Discussed in the J.C Bergstrom, et. al. paper and they refer to the paper J. H Koch and R. M. Woloshyn, Phys. Rev. C 16, 1968

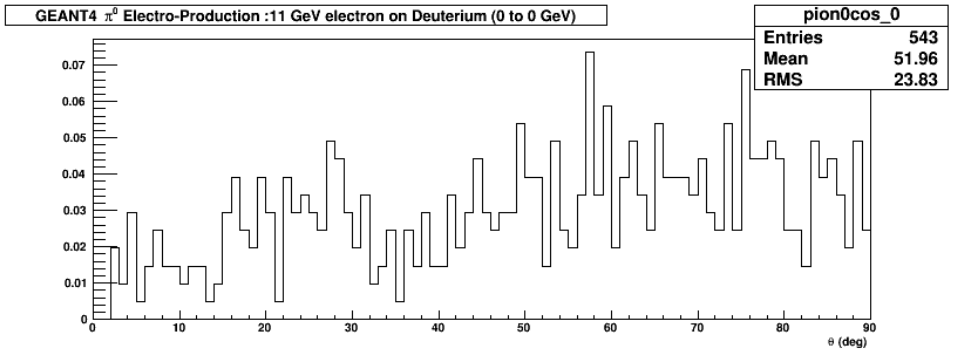
Backups

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections



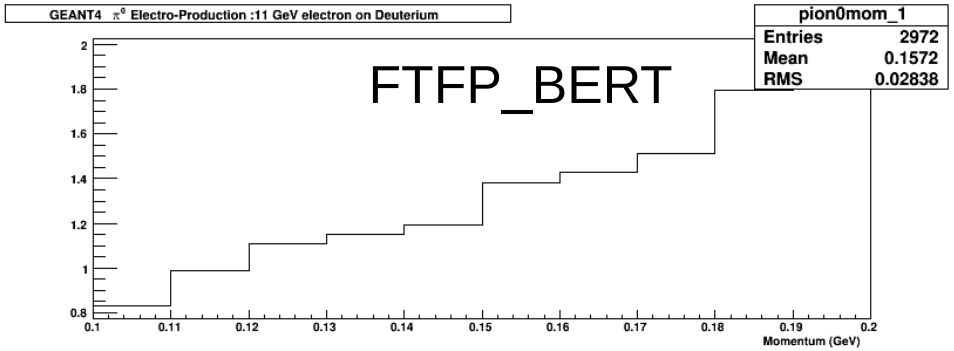


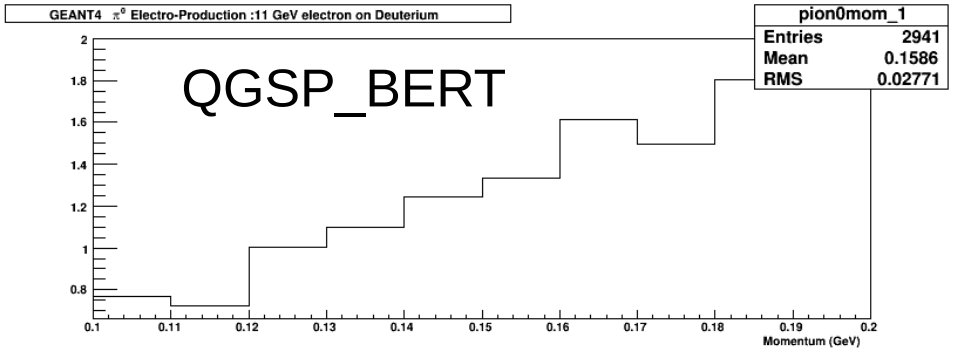


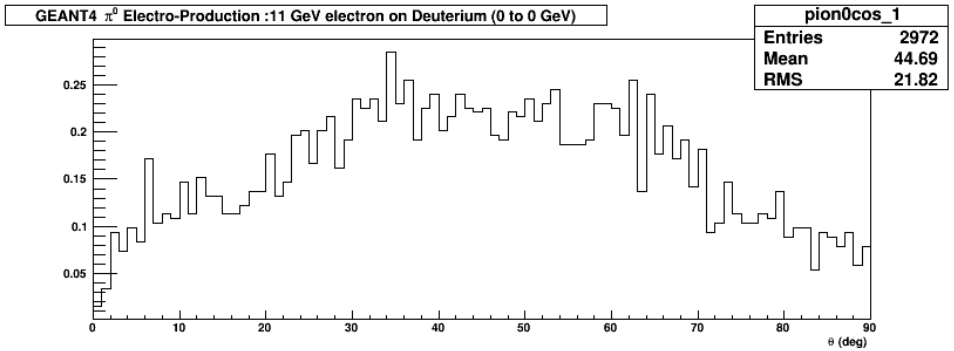


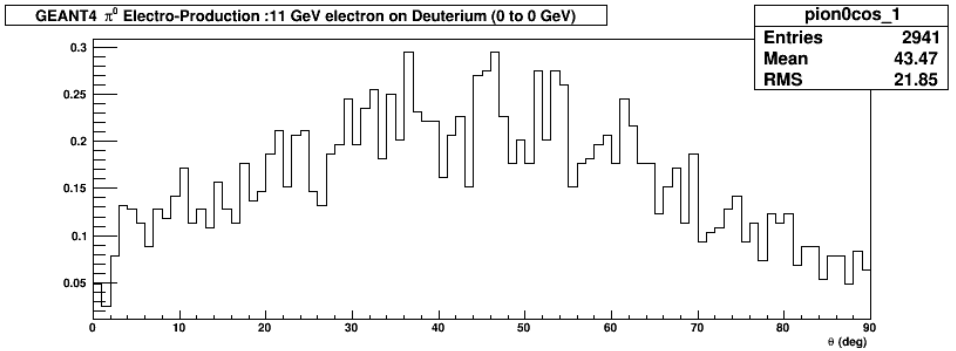
π^0 Momentum range : 0 – 100 MeV

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections



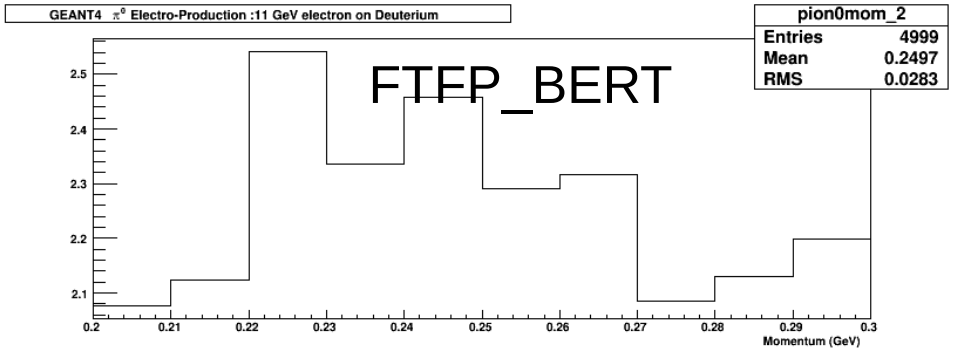


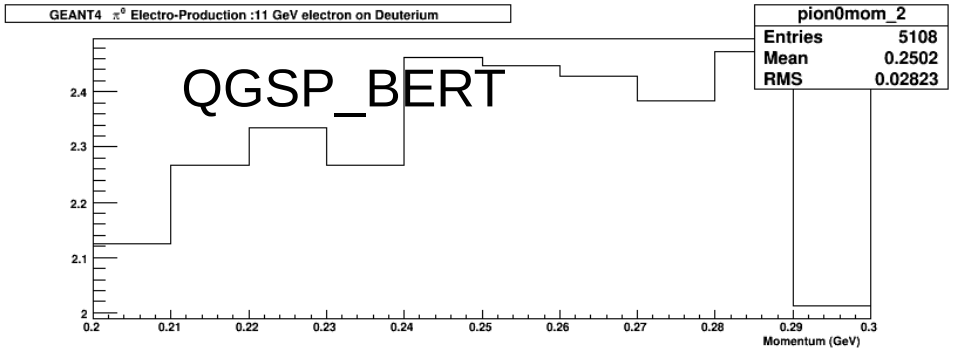


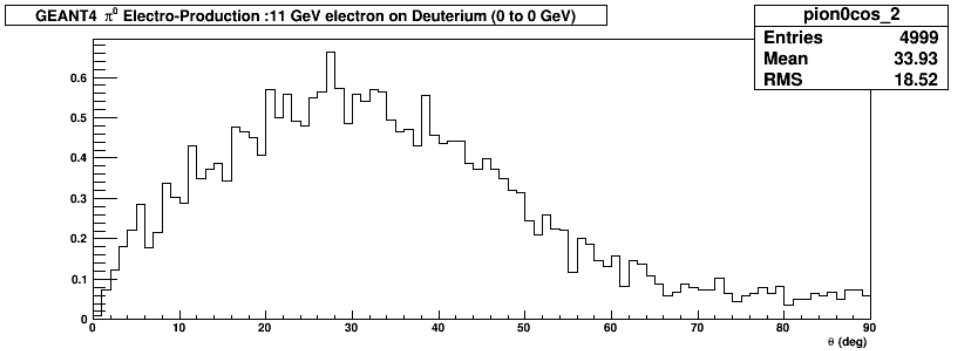


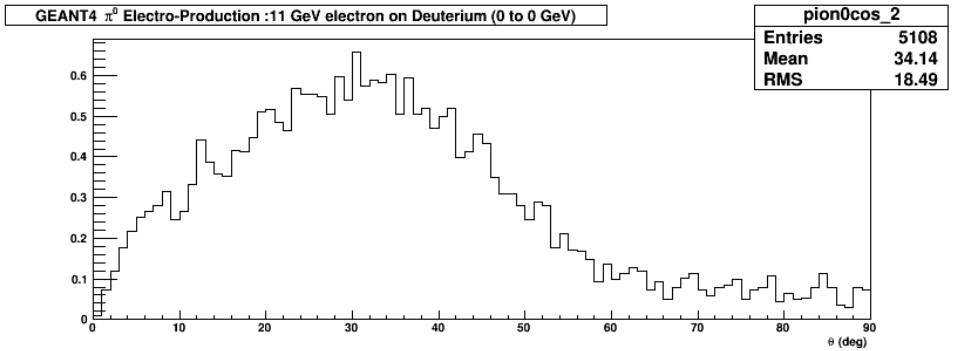
π^0 Momentum range : 100 – 200 MeV

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections



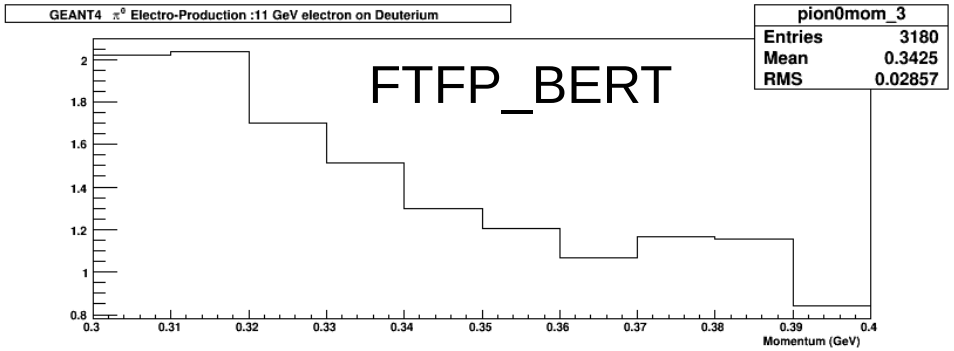


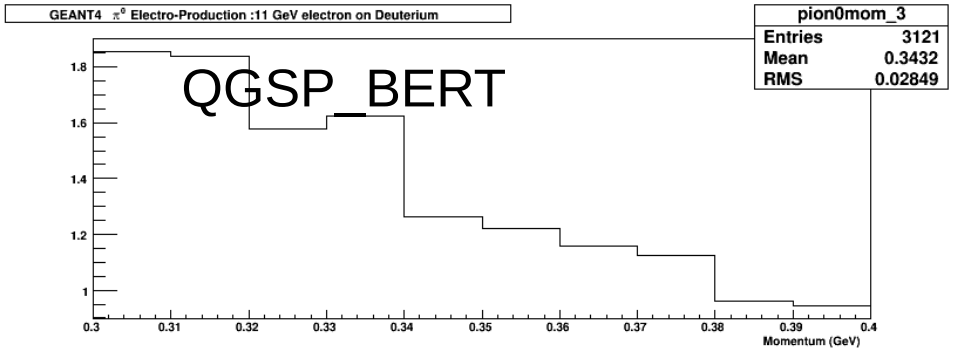


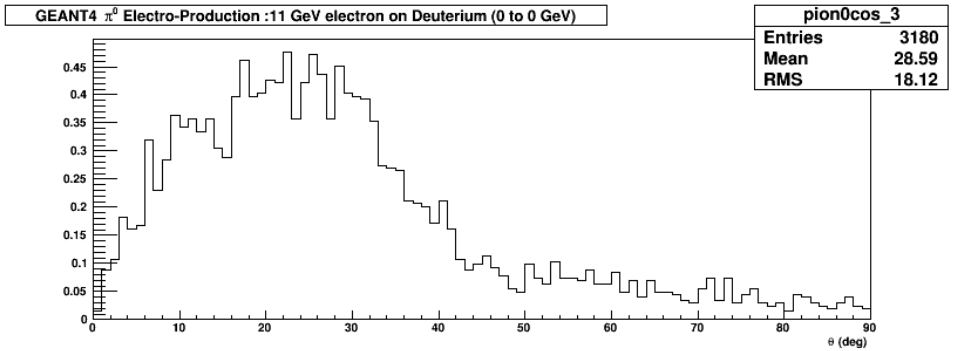


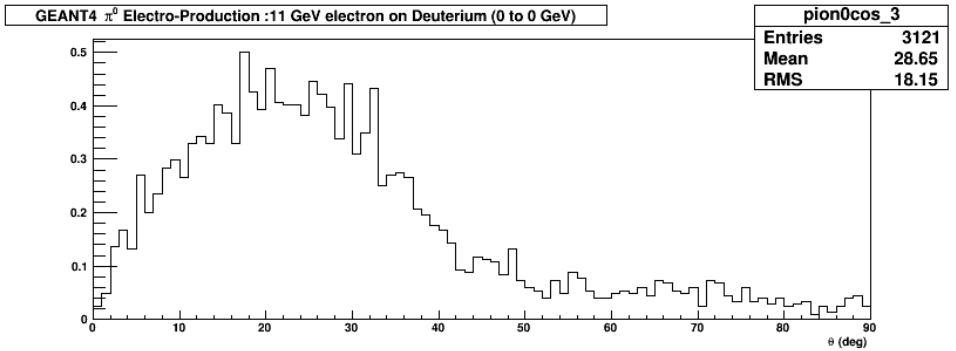
π^0 Momentum range : 200 – 300 MeV

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections



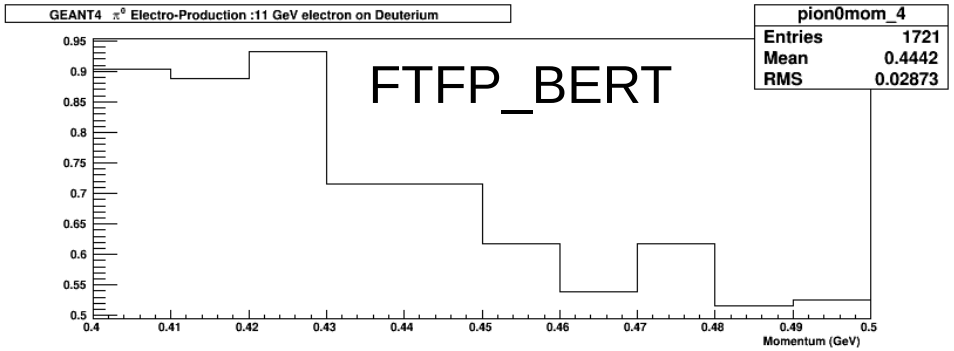


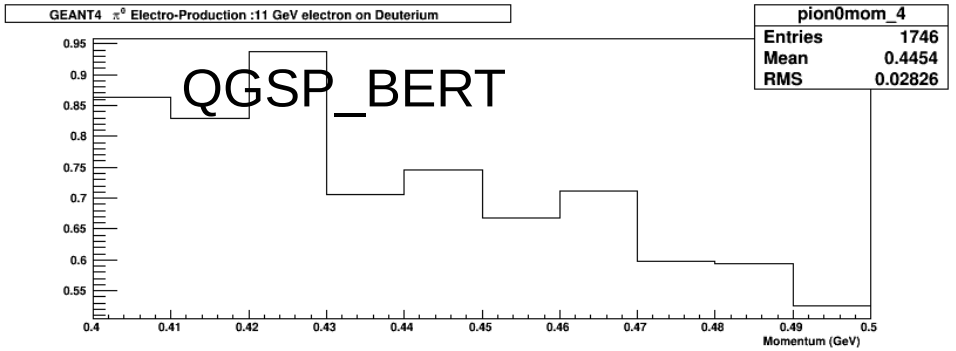


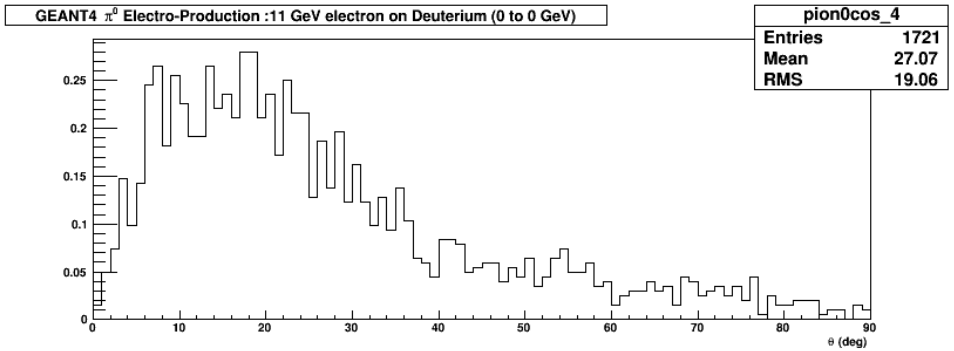


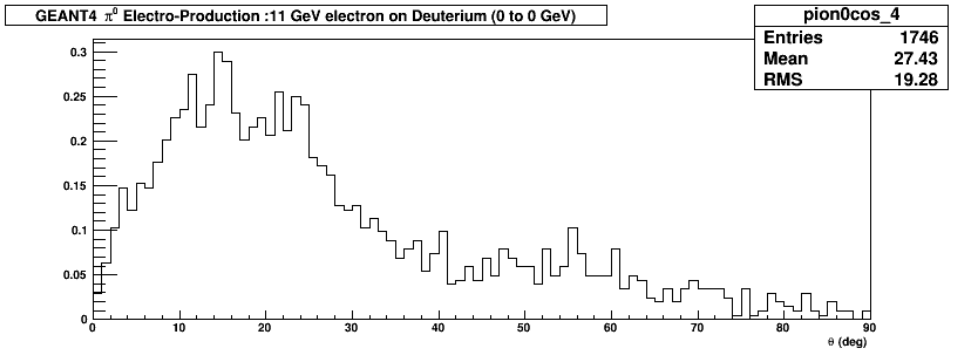
π^0 Momentum range : 300 – 400 MeV

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections



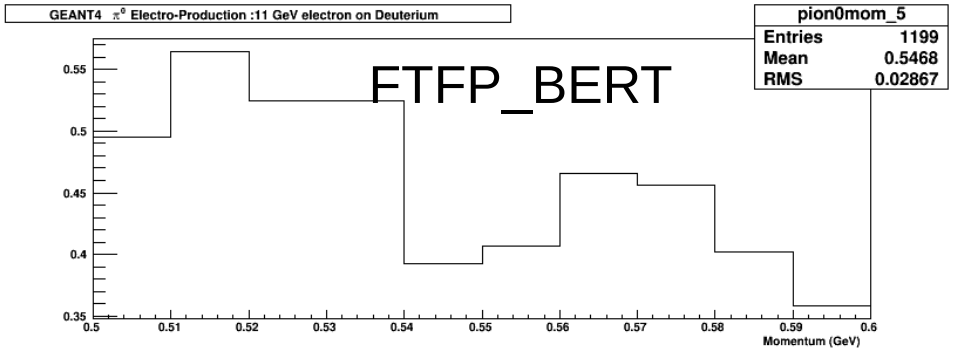


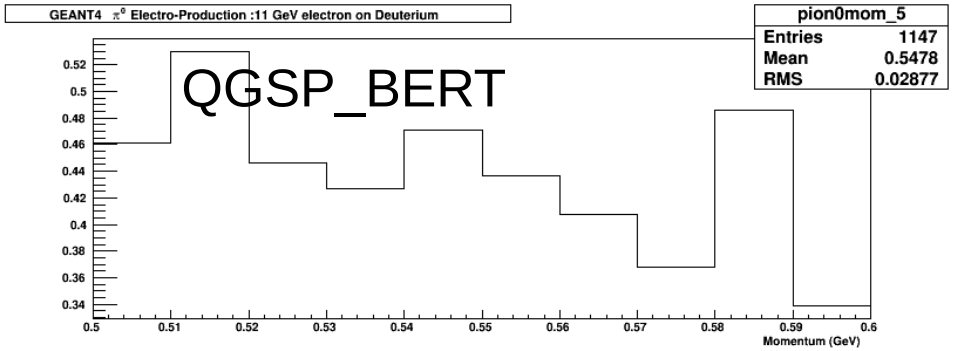


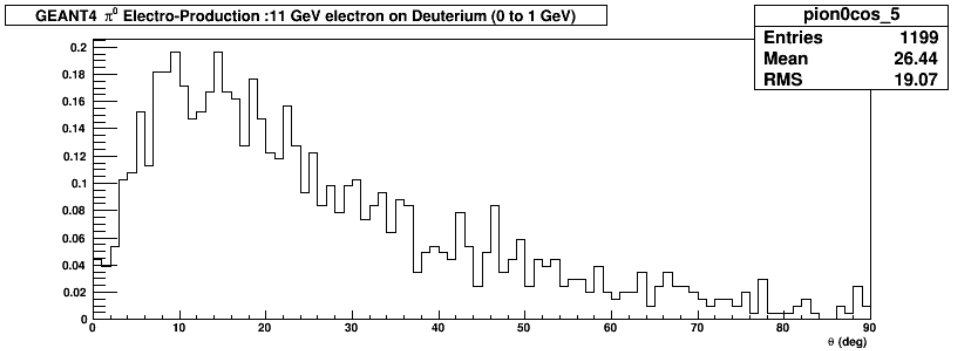


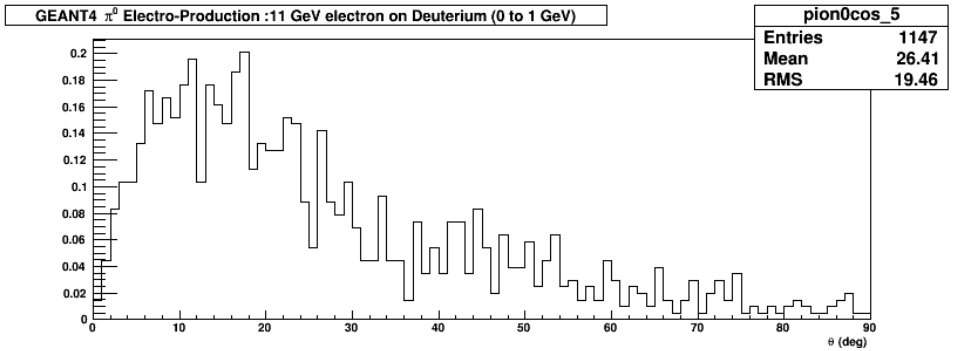
π^0 Momentum range : 400 – 500 MeV

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections



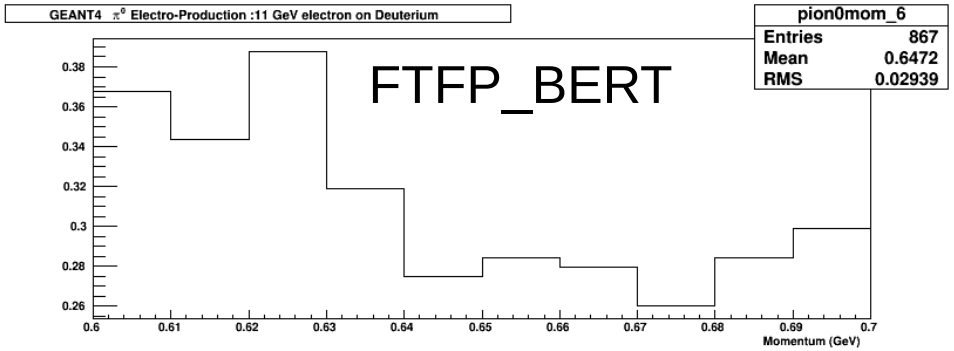


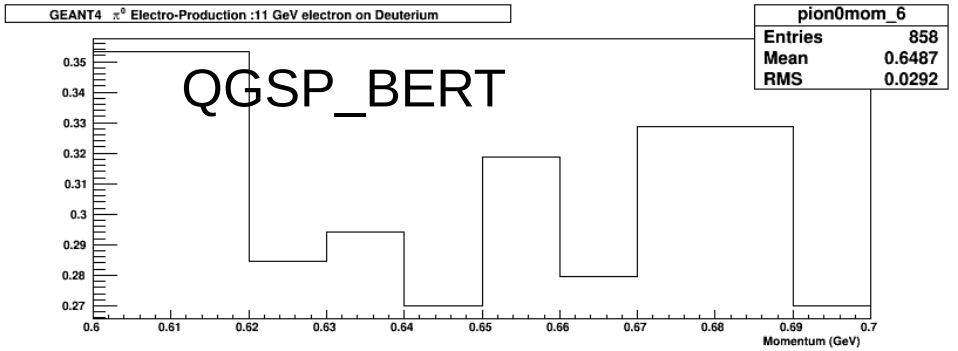


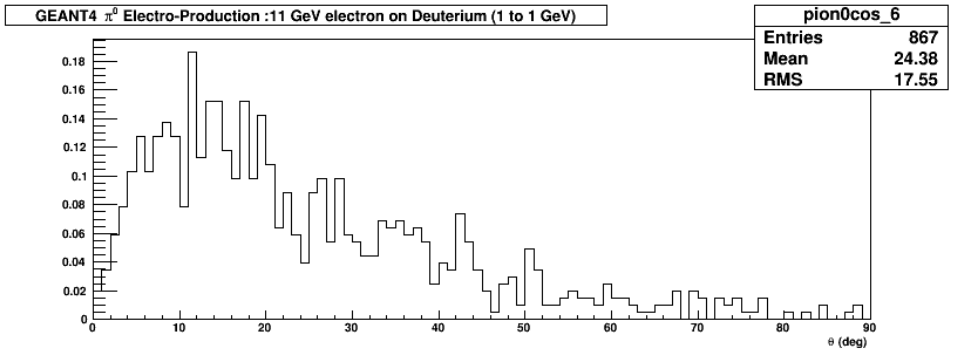


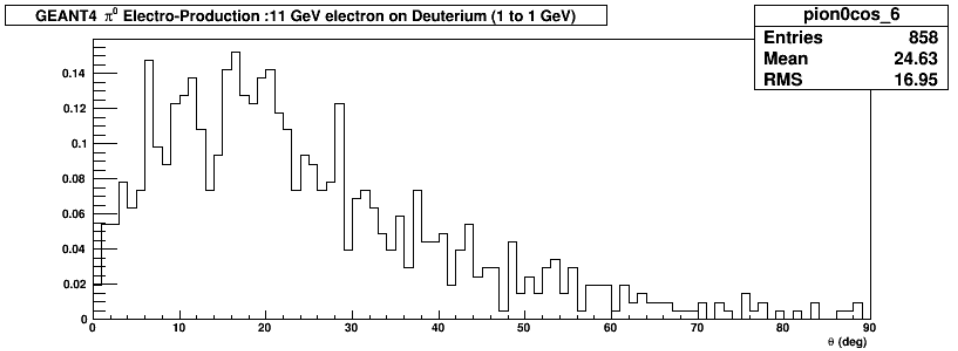
π^0 Momentum range : 500 – 600 MeV

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections



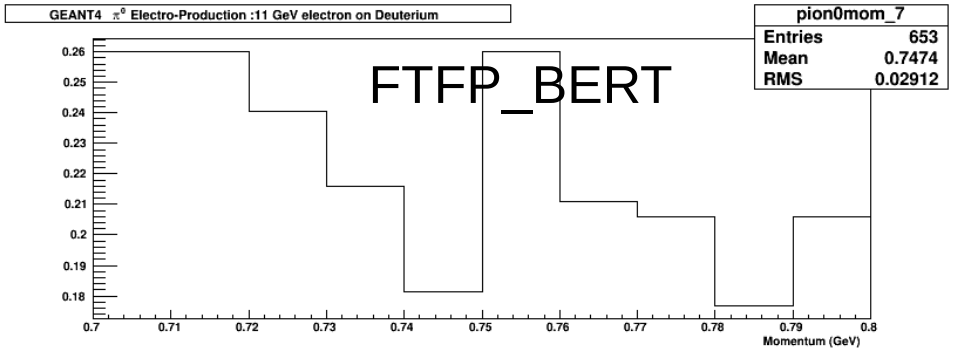


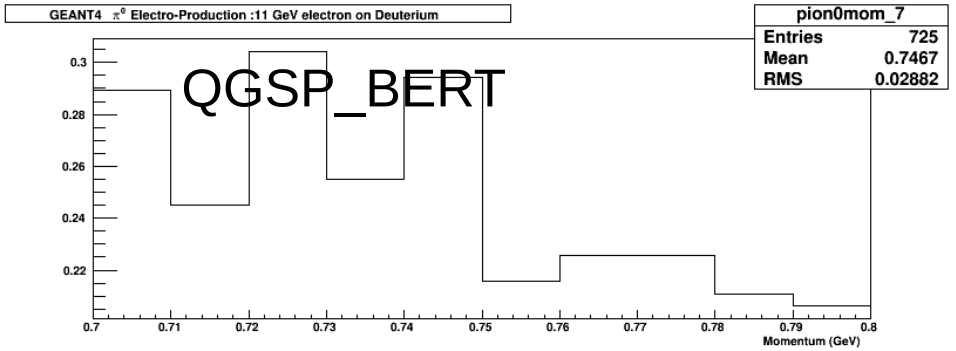


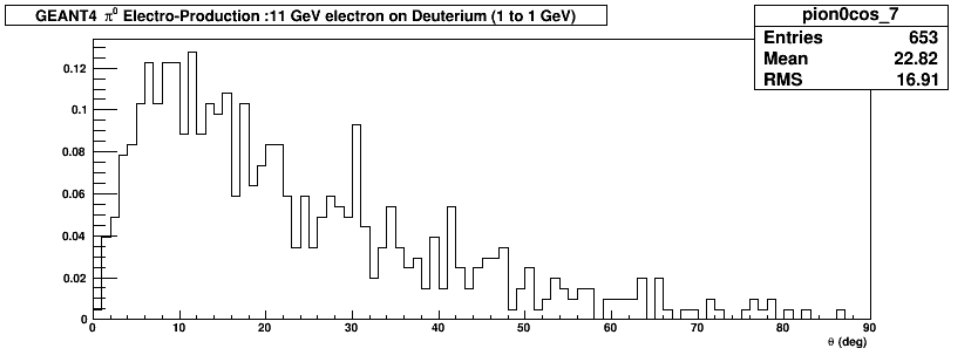


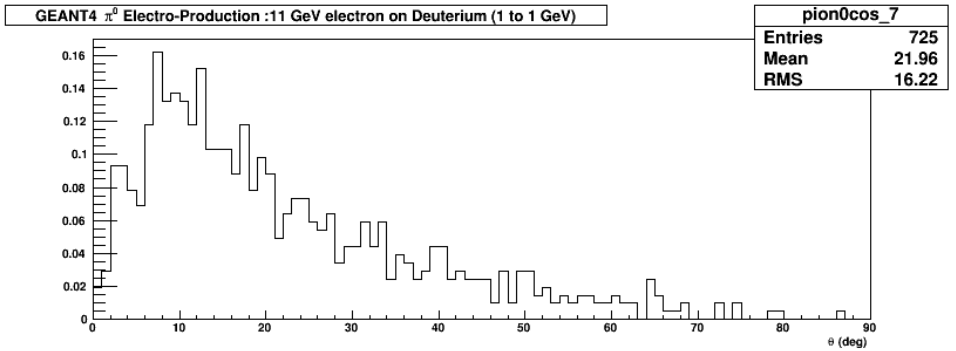
π^0 Momentum range : 600 – 700 MeV

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections



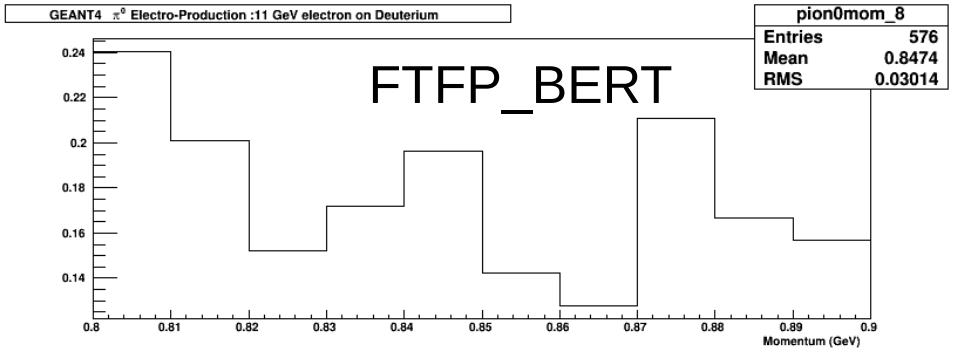


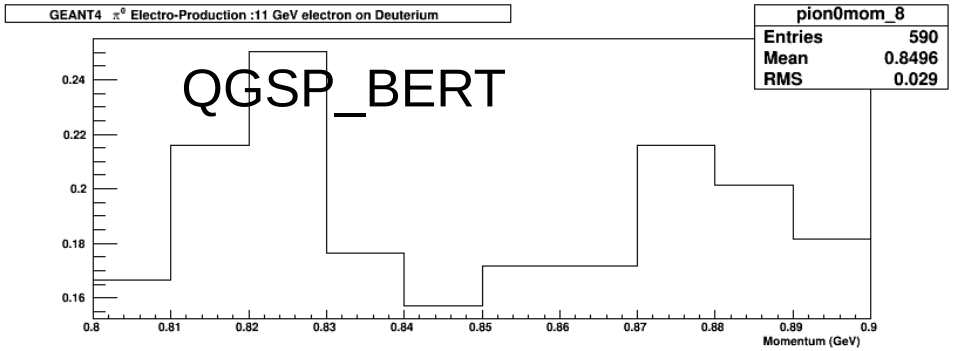


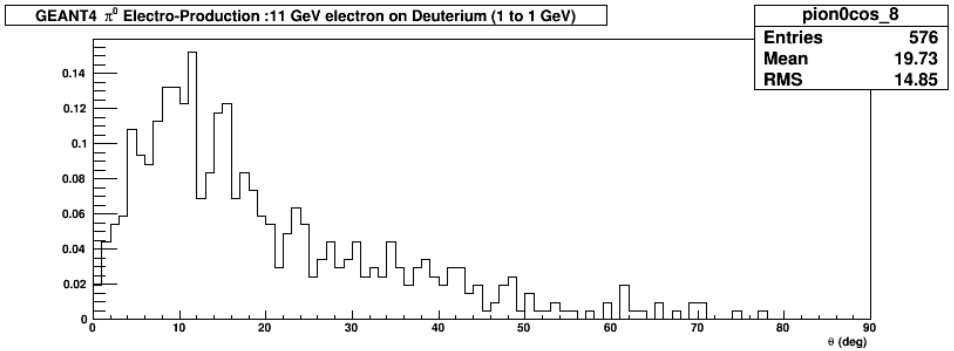


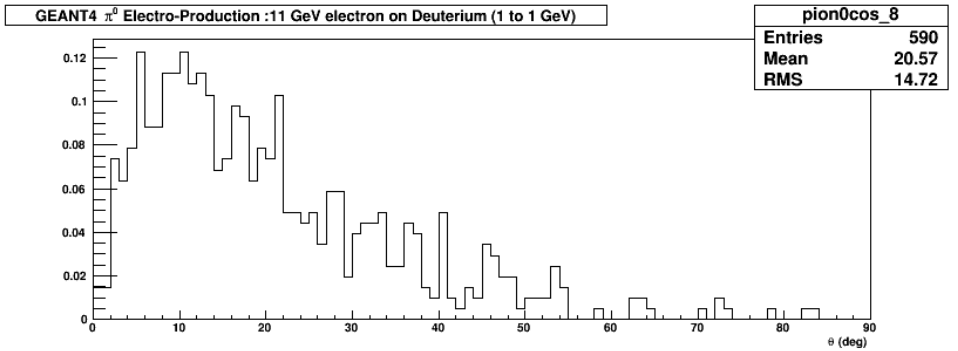
π^0 Momentum range : 700 – 800 MeV

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections



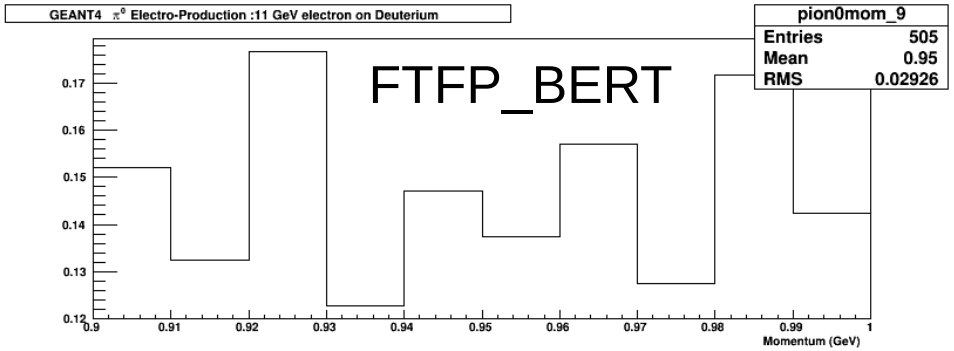


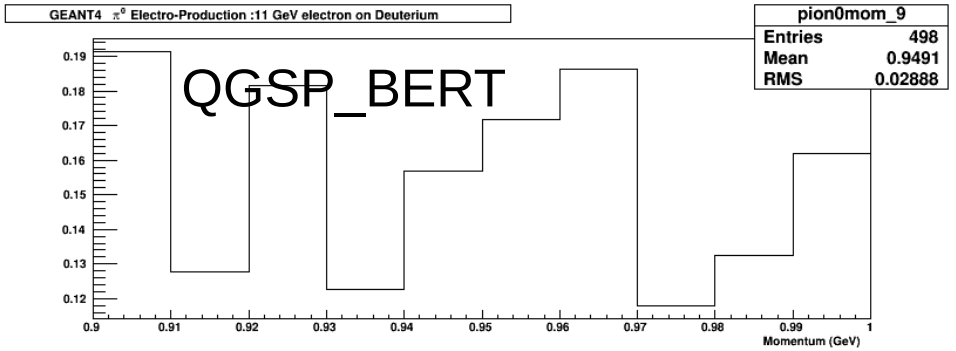


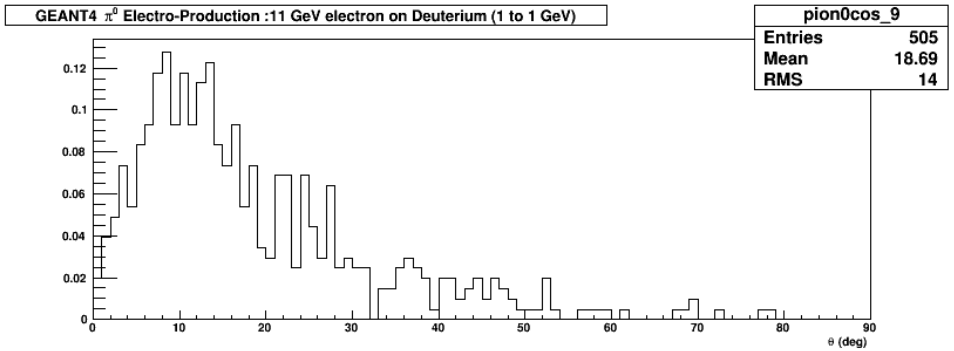


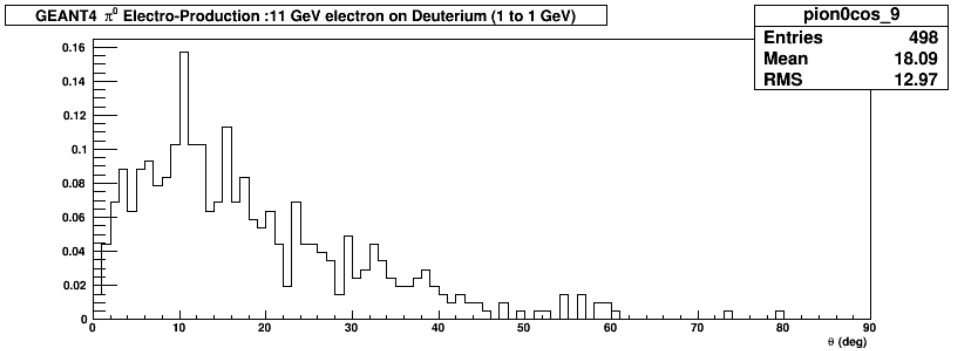
π^0 Momentum range : 800 – 900 MeV

Geant4 QGSP_BERT vs. FTFP_BERT π^0 Cross Sections









π^0 Momentum range : 900 – 1000 MeV