



Geant4.10.00-ref08 : Summary of Validation Results from test19, 47, 48, and 75

Julia Yarba, Fermilab Geant4 Hadronic Group Meeting October 29, 2014

General Information

- Included:
 - AtRest processes test48
 - Gamma-N interactions test75
 - Bertini, Binary, FTF in the 1.4-7.5GeV range test47("ITEP")
 - FTFP, QGSP(+G4LundStringFragm.) at 31GeV/c or 158GeV/c test19
- Releases:
 - Geant4.9.6.p03
 - Geant4.10.00.p02
 - Geant4-10-00-ref-07
 - Geant4-10-00-ref-08 most recent
- Signature plots shown if non-negligible changes
- Selected results from statistical testing of FTF shown as tables
- Otherwise, a verbal overview
- All results/plots have been uploaded to G4 Validation Repository: http://g4validation.fnal.gov:8080/G4ValidationWebApp/G4ValHAD.jsp

At Rest Processes (test48)

- No changes in pi-, K-, Sigma-, pbar capture/annihilation throughout 4.10 development cycles (although non-negligible changes vs 9.6.p03 – reported at previous meetings)
- It's my understanding that negative effects in modeling pi- capture are being worked on
- Still serious concerns about G4MuonMinusCapture as jobs occasionally get "stuck" – not only if "chained" configurations but also on a single target
 - The problem occurs in batch and can be reproduced interactively
 - The problem can go away with a change of startup random seed
 - Memory footprint has been checked no major concerns
 - The problem appears specific to 4.10 cycle, but not in 9.6.p03

Gamma-N Interactions (test75)

- No changes throughout 4.10 development cycle up to ref08
- Changes from 9.6.p03 have been reported at previous meetings
- Where we have data, the changes are "neutral" (statistically)

Proton or Pion Interactions in the Intermediate Energy Range (test47)

- Only the "ITEP" part included
 - 1.4 or 7.5 GeV/c proton on C, U
 - 1.4 or 5 GeV/c pi+/- on C, U
 - Proton or neutron production
- No significant changes in Bertini or FTF in ref08
- No significant changes in Bertini throughout 4.10 cycle, but certain changes as compared vs 9.6.p03:
 - Somewhat better for all projectiles at lower momentum (1.4GeV/c)
 - Somewhat worse for all projectiles at higher momentum (5 or 7.5GeV/c)
 - Exception: pi- on U significantly worse in 4.10 cycle (see next slide)
 - Should have pointed it out earlier...

1.4 GeV/c pi- on U -> p + X (test47)

piminus+U to p at 1.40 GeV (bertini) (0 = 59.10)



piminus+U to p at 1.40 GeV (bertini) (0 = 119.00)



bertini vs (ITEP) Data χ^2 /NDF = 1.89259 for geant4-09-06-p03 χ^2 /NDF = 23.3003 for geant4-10-00-p02 χ^2 /NDF = 21.3446 for geant4-10-00-ref-07 χ^2 /NDF = 21.348 for geant4-10-00-ref-08

bertini vs (ITEP) Data

Insufficient dataset

J.Yarba - Geant4.10.00-ref08: Summary of Validation Results

on neutron production

Insufficient

data

5GeV/c pi- on U -> p/n +X



J.Yarba - Geant4.10.00-ref08: Summary of Validation Results

Proton or Pion Interactions in the Intermediate Energy Range – Additional Info

- In general, pion production in proton/pion interactions in the intermediate energy range is part of test35
- However, as part of working on the NuBeam physics list (for FNAL Nu beamline), I have a "byproduct" – statistical comparison of Bertini or FTF results vs HARP data on C or Be in 3-12GeV/c range:
 - Bertini is stable (or slightly better) from 9.6.p03 and through 4.10 cycle in modeling pion production by a proton or pion beam on light targets
 - FTF in somewhat patchy situation, as it is from stable to negatively affected for pion production by a pion beam on light targets (tables later)
 - FTF is substantially (negatively) affected when modeling pion production by a proton beam on light targets (tables later in this talk)
- NOTE: I understand that testing Bertini at 12GeV is on the "verge" of its current tuning

High Energy Models (test19)

• FTF

 Results for 31GeV/c p+C improved in ref08 – secondary proton spectra were negatively affected in earlier cycles but they're moving back towards the data (see following slides)

NOTE: results for pion production in 31GeV/c p+C have been closer to the data in 4.10 cycle than in 9.6

However, K+/pi+ spectra remain negatively affected (see following slide)

- Results for 158GeV/c p+C are still substantially worse than in 9.6
- G4LundStringFragmentation negatively affected in recent developments; results for QGSP+G4LundStringFragmentation remain worse than in 9.6 or 4.10.p02 (reported at the previous G4 HAD group meeting)
- QGS stable
 - NOTE: QGS (even with the old string fragm. model) is still better that FTF at high energies

31GeV/c p+C -> p + X FTF - regression test (I)



J.Yarba - Geant4.10.00-ref08: Summary of

Validation Results

31GeV/c p+C -> p + X FTF - regression test (II)





MC vs NA61 Data; χ^2 /NDF calculated over ALL theta bins χ^2 /NDF = 20.6122 for geant4-09-06-p03 vs NA61 Data χ^2 /NDF = 36.8967 for geant4-10-00-p02 vs NA61 Data χ^2 /NDF = 36.2969 for geant4-10-00-ref-07 vs NA61 Data χ^2 /NDF = 24.4708 for geant4-10-00-ref-08 vs NA61 Data



31GeV/c p+C – K+/pi+ ratio vs momentum FTF - regression test (II)



J.Yarba - Geant4.10.00-ref08: Summary of Validation Results

158GeV/c p+C -> pi+ + X FTF - regression test (I)



158GeV/c p+C -> pi- + X FTF - regression test (II)



158GeV/c p+C -> p + X FTF - regression test (III)



158GeV/c p+C -> pbar + X FTF - regression test (IV)



158GeV/c p+C -> n + X FTF - regression test (V)



J.Yarba - Geant4.10.00-ref08: Summary of Validation Results

Results from Statistical Tests (chi2) of FTF in the 3-158GeV/c Range of Beam Momenta

- In the next several slides there are table that show results of FTF regression testing from the statistical point of view, i.e. χ²/NDF calculated over FTF predictions vs exp. spectra
- Results are shown only for light targets (C or Be)
- The χ^2 /NDF values are integral, i.e. calculated over groups of distributions:
 - Momentum spectra in all θ –bins at 3-31GeV/c
 - Double diff. pt-spectra at 158GeV/c
 - Note-1: χ^2 /NDF can be calculated for each individual distribution
 - Note-2: plots for double diff. pt-spectra are not yet included in standard validation output
- Similar numbers exist for other models; just not included here

FTF(P): χ^2 /NDF for p + C $\longrightarrow \pi^+$ + X

	3 GeV/c	5 GeV/c	8 GeV/c	12 GeV/c	31 GeV/c	158 GeV/c
9.6.p03	4.27	6.82	7.97	9.71	18.06	43.33
10.00.p02	6.04	9.93	8.89	11.65	4.84	51.67
10.00-ref07	6.02	10.01	8.80	10.31	5.96	47.49
10.00-ref08	15.53	18.52	13.10	14.42	5.85	54.88

FTF(P): χ^2 /NDF for p + C $\longrightarrow \pi^-$ + X

	3 GeV/c	5 GeV/c	8 GeV/c	12 GeV/c	31 GeV/c	158 GeV/c
9.6.p03	3.36	4.20	5.42	5.64	12.83	40.23
10.00.p02	6.57	19.10	28.29	29.16	3.37	48.63
10.00-ref07	6.88	19.33	27.89	25.23	2.14	39.26
10.00-ref08	6.48	14.58	19.24	17.69	3.11	40.65

For 3-31GeV/c range, χ^2 is calculated over momentum spectra in all θ -bins At 158GeV/c, χ^2 is calculated over double diff. pt-spectra in all xF-bins

FTF(P): χ^2 /NDF for $\pi^+ + C \rightarrow \pi^+ + X$

	3 GeV/c	5 GeV/c	8 GeV/c	12 GeV/c
9.6.p03	17.28	15.53	18.09	3.71
10.00.p02	21.59	16.63	21.40	4.50
10.00-ref07	22.70	19.33	24.90	5.77
10.00-ref08	18.55	15.87	22.20	4.94

FTF(P): χ^2 /NDF for π^+ + C $\rightarrow \pi^-$ + X

	3 GeV/c	5 GeV/c	8 GeV/c	12 GeV/c
9.6.p03	11.62	15.81	9.91	2.66
10.00.p02	17.51	18.32	10.72	2.80
10.00-ref07	19.08	19.64	11.50	3.25
10.00-ref08	21.10	21.35	12.86	3.77

χ^2 is calculated over momentum spectra in all θ -bins

FTF(P): χ^2 /NDF for π^- + C $\rightarrow \pi^+$ + X

	3 GeV/c	5 GeV/c	8 GeV/c	12 GeV/c
9.6.p03	28.57	14.87	16.28	18.70
10.00.p02	38.45	18.92	19.40	22.63
10.00-ref07	42.19	23.02	25.60	30.19
10.00-ref08	29.64	16.47	19.71	25.29

FTF(P): χ^2 /NDF for $\pi^- + C \rightarrow \pi^- + X$

	3 GeV/c	5 GeV/c	8 GeV/c	12 GeV/c
9.6.p03	25.11	22.12	22.53	15.45
10.00.p02	28.59	21.32	21.51	15.42
10.00-ref07	30.40	23.47	23.69	18.00
10.00-ref08	30.61	24.32	24.53	19.42

 χ^2 is calculated over momentum spectra in all θ -bins

FTF(P): χ^2 /NDF for p + Be $\rightarrow \pi^+$ + X

	3 GeV/c	5 GeV/c	8 GeV/c	8.9GeV/c	12 GeV/c
9.6.p03	3.80	5.93	8.76	13.09	9.93
10.00.p02	6.49	8.14	12.02		14.67
10.00-ref07	6.48	8.19	10.79	16.59	12.58
10.00-ref08	14.04	13.72	16.04	23.89	18.44

FTF(P): χ^2 /NDF for p + Be $\rightarrow \pi^-$ + X

	3 GeV/c	5 GeV/c	8 GeV/c	8.9 GeV/c	12 GeV/c
9.6.p03	5.07	7.82	10.19	17.08	13.74
10.00.p02	13.11	33.20	51.20		58.36
10.00-ref07	13.06	32.65	45.99	67.79	45.79
10.00-ref08	12.83	25.77	35.39	51.89	33.68

χ^2 is calculated over momentum spectra in all θ -bins

FTF(P): χ^2 /NDF for π^+ + Be $\rightarrow \pi^+$ + X

	3 GeV/c	5 GeV/c	8 GeV/c	12 GeV/c
9.6.p03	18.42	12.10	8.55	3.68
10.00.p02	22.30	12.58	8.62	4.10
10.00-ref07	23.51	14.88	10.15	5.14
10.00-ref08	19.63	12.45	9.00	4.64

FTF(P): χ^2 /NDF for π^+ + Be $\rightarrow \pi^-$ + X

	3 GeV/c	5 GeV/c	8 GeV/c	12 GeV/c
9.6.p03	11.79	13.15	10.74	3.16
10.00.p02	17.42	15.01	9.50	3.13
10.00-ref07	17.61	13.34	8.05	3.25
10.00-ref08	19.07	13.93	8.33	3.50

χ^2 is calculated over momentum spectra in all θ -bins

J.Yarba - Geant4.10.00-ref08: Summary of Validation Results

FTF(P): χ^2 /NDF for π^- + Be $\rightarrow \pi^+$ + X

	3 GeV/c	5 GeV/c	8 GeV/c	12 GeV/c
9.6.p03	25.74	14.06	14.55	10.68
10.00.p02	33.78	16.81	17.42	13.53
10.00-ref07	40.02	20.35	22.73	17.62
10.00-ref08	28.53	15.61	18.58	14.97

FTF(P): χ^2 /NDF for π^- + Be $\rightarrow \pi^-$ + X

	3 GeV/c	5 GeV/c	8 GeV/c	12 GeV/c
9.6.p03	31.27	24.19	23.14	19.90
10.00.p02	37.25	22.60	20.37	18.26
10.00-ref07	38.57	24.43	21.89	20.41
10.00-ref08	39.42	25.27	22.20	20.73

χ^2 is calculated over momentum spectra in all $\theta\text{-bins}$

J.Yarba - Geant4.10.00-ref08: Summary of Validation Results

Summary of Geant4.10.00-ref08 Validation

- Changes of concern remain in several area
- Capture processes
 - pi- (repairs in progress)
 - mu- (needs further investigation)
- Intermediate and high energies
 - Issues in Bertini for pi- beam (overlooked in earlier tests)
 - FTF is probably most widely affected
 - Some trend for improvements (31GeV/c p+C)
 - Intermediate (<10GeV) and high energy ranges remain of concern