Geant 4

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Geant4 Hadronic Models - Validation Results from G4.10.00.ref07

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Geant4 Hadronic Group Meeting

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General Information (I)

- Included:
  - AtRest processes (capture, annihilation) – test48
  - Gamma-N interactions – test75
  - Bertini, Binary, FTF in the 1.4-7.5GeV range – test47 (“ITEP”)
  - FTFP, QGSP(+G4LundStringFragm.) at 31GeV or 158GeV – test19
- Releases:
  - Geant4.9.6.p03 (for regression)
  - Geant4.10.00.p02 (for regression)
  - Geant4-10-00-ref-07 – most recent
- Plots will be shown only if non-negligible changes
- Otherwise, a verbal overview will be given

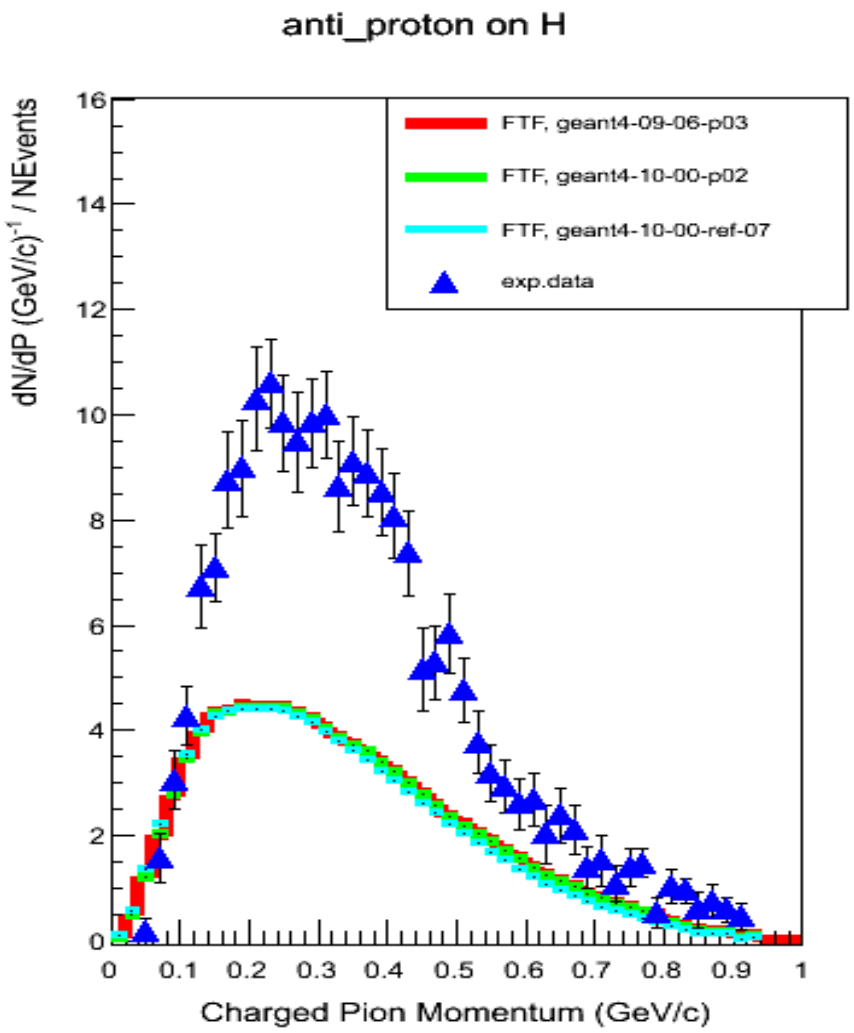
General Information (II)

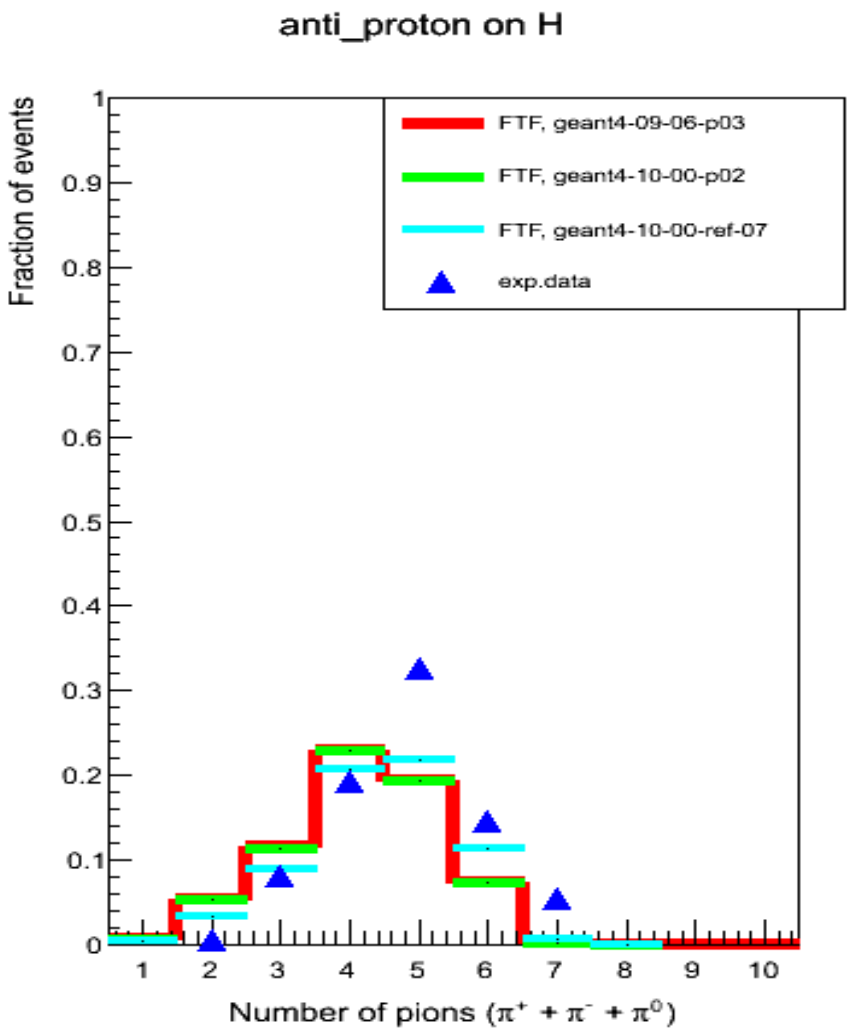
- Revisited errors in the exp.datasets (where available) – statistical, systematic, total…
  - if both stat. & sys. errors are available, total errors are calculated and used (quadratic sum)
- Started adding chi2 tests (in addition to MC/Data metrics)

AtRest Processes – test48

- No changes in K- or Σ capture processes as modeled by Bertini (no other models are currently used)
- Not-exactly-good changes in π- capture, as modeled by Bertini (only model used), between 4.9.6(.p03) and 4.10-series; no changes between 4.10.00.p02 and 4-10-00-ref-07
- Some changes in multiplicity of secondary pions from pbar+H as modeled by FTF (only model), but no changes in the charged pion momenta
- μ- capture ("old" and "new"):
  - G4MuonMinusCapture ("new") – changes in 4-10-00 cycle vs 4.9.6(.p03) BUT !!!... Can't tell if they're good or not because…
  - Job μ- on Ag gets STUCK (both in p02 and ref07)– results **postponed**
  - NOTE: no problematic jobs in 4.9.6(.p03)

Pion production pbar+H annihilation

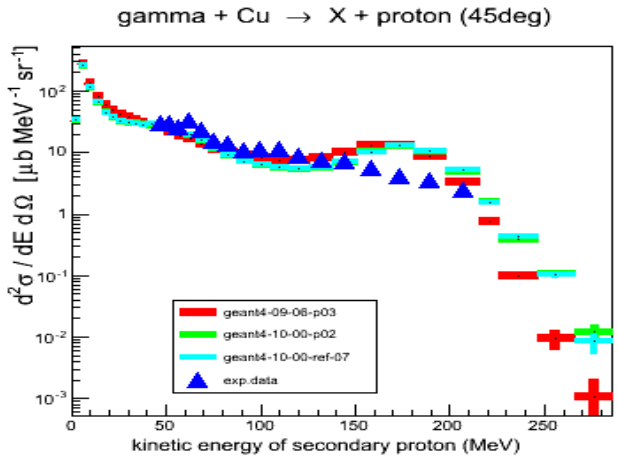


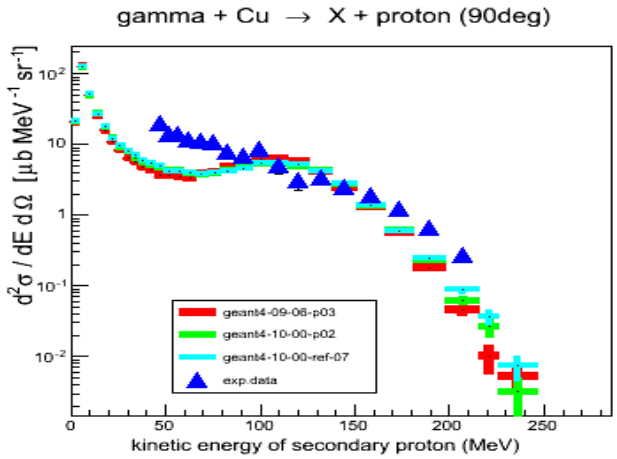


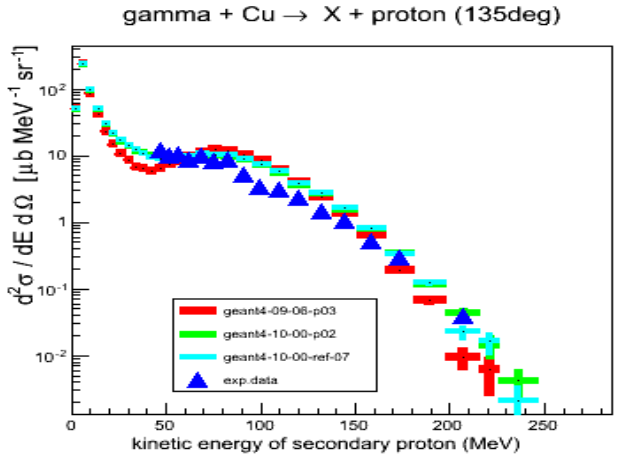
Gamma-N interactions – test75 (I)

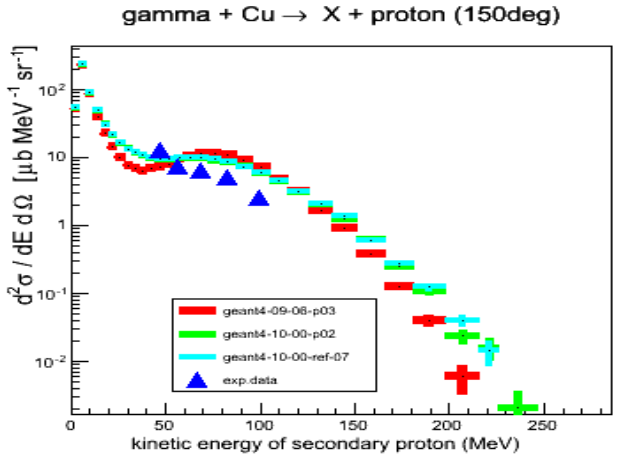
- Some variations have been observed between 4.9.6.(.p03) and 4.10-series
  - Reported in previous meeting, following questions from CMS
  - Nothing statistically significant where we have data
- No significant changes in 4-10-00-ref-07
- Plots included in the following slides

Proton production in 300 MeV gamma on Cu (kinetic energy of sec.proton in diff.angular bins)



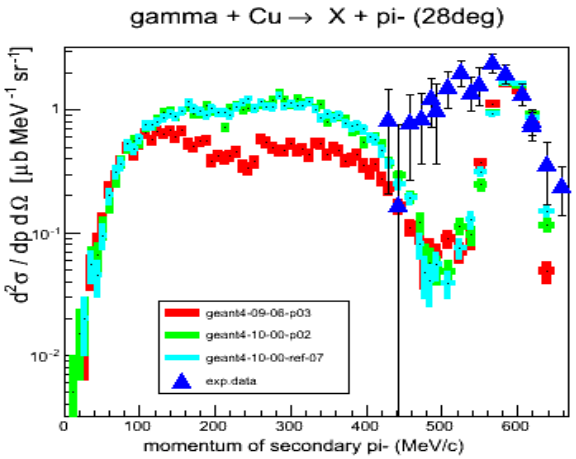


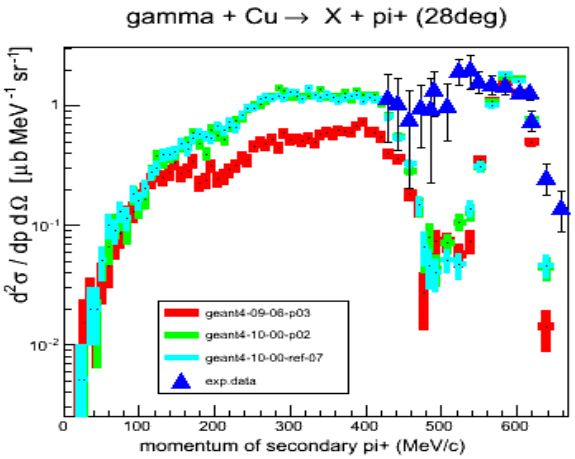


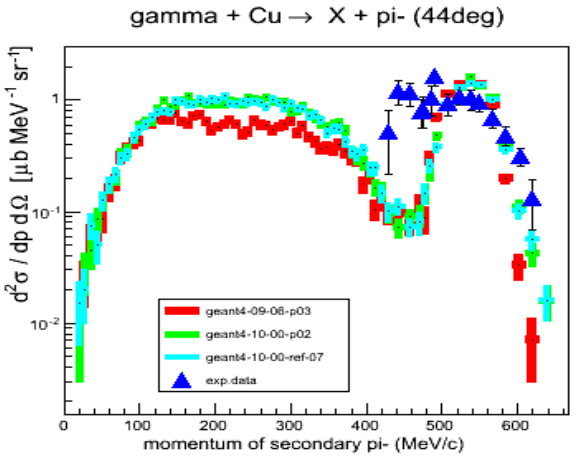


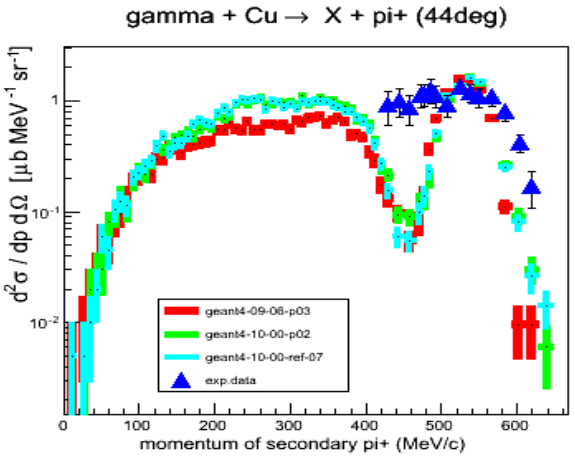
Bertini vs Data (R. Schumacher et al., Phys. Rev. C 25, 2269 (1982))
χ^2/NDF = 40.255 for geant4-09-06-p03
χ^2/NDF = 33.3162 for geant4-10-00-p02
χ^2/NDF = 33.6209 for geant4-10-00-ref-07

Pion production in 668 MeV gamma on Cu (momentum of sec.pion in diff.angular bins)









Bertini vs Data (K. Baba et al., Nucl. Phys. A322, 349 (1979))
χ^2/NDF = 6.06188 for geant4-09-06-p03
χ^2/NDF = 5.75549 for geant4-10-00-p02
χ^2/NDF = 5.74008 for geant4-10-00-ref-07

Bertini vs Data (K. Baba et al., Nucl. Phys. A322, 349 (1979))
χ^2/NDF = 6.06188 for geant4-09-06-p03
χ^2/NDF = 5.75549 for geant4-10-00-p02
χ^2/NDF = 5.74008 for geant4-10-00-ref-07

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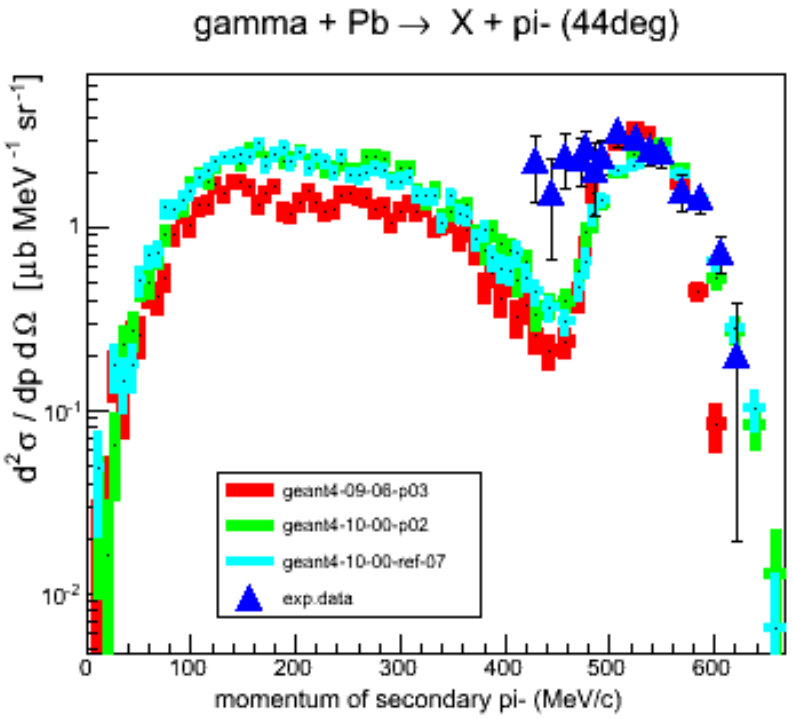
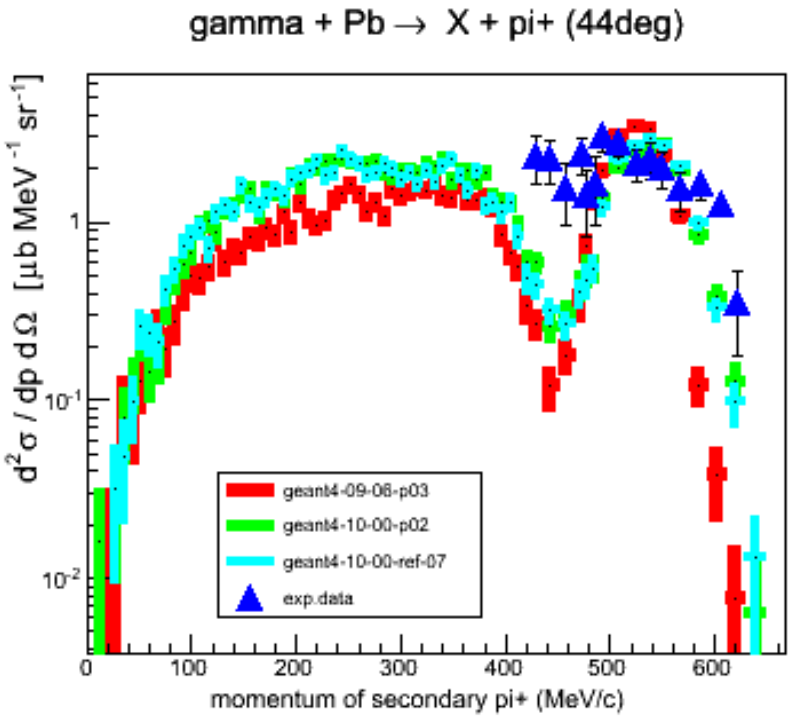
Pion production in 668 MeV gamma on Pb (momentum of sec.pi+ in diff. angular bins)



Bertini vs Data (K. Baba et al., Nucl. Phys. A322, 349 (1979))
χ^2/NDF = 7.85246 for geant4-09-06-p03
χ^2/NDF = 7.09168 for geant4-10-00-p02
χ^2/NDF = 7.04987 for geant4-10-00-ref-07



Bertini vs Data (K. Baba et al., Nucl. Phys. A322, 349 (1979))
χ^2/NDF = 9.20132 for geant4-09-06-p03
χ^2/NDF = 7.73243 for geant4-10-00-p02
χ^2/NDF = 8.0871 for geant4-10-00-ref-07

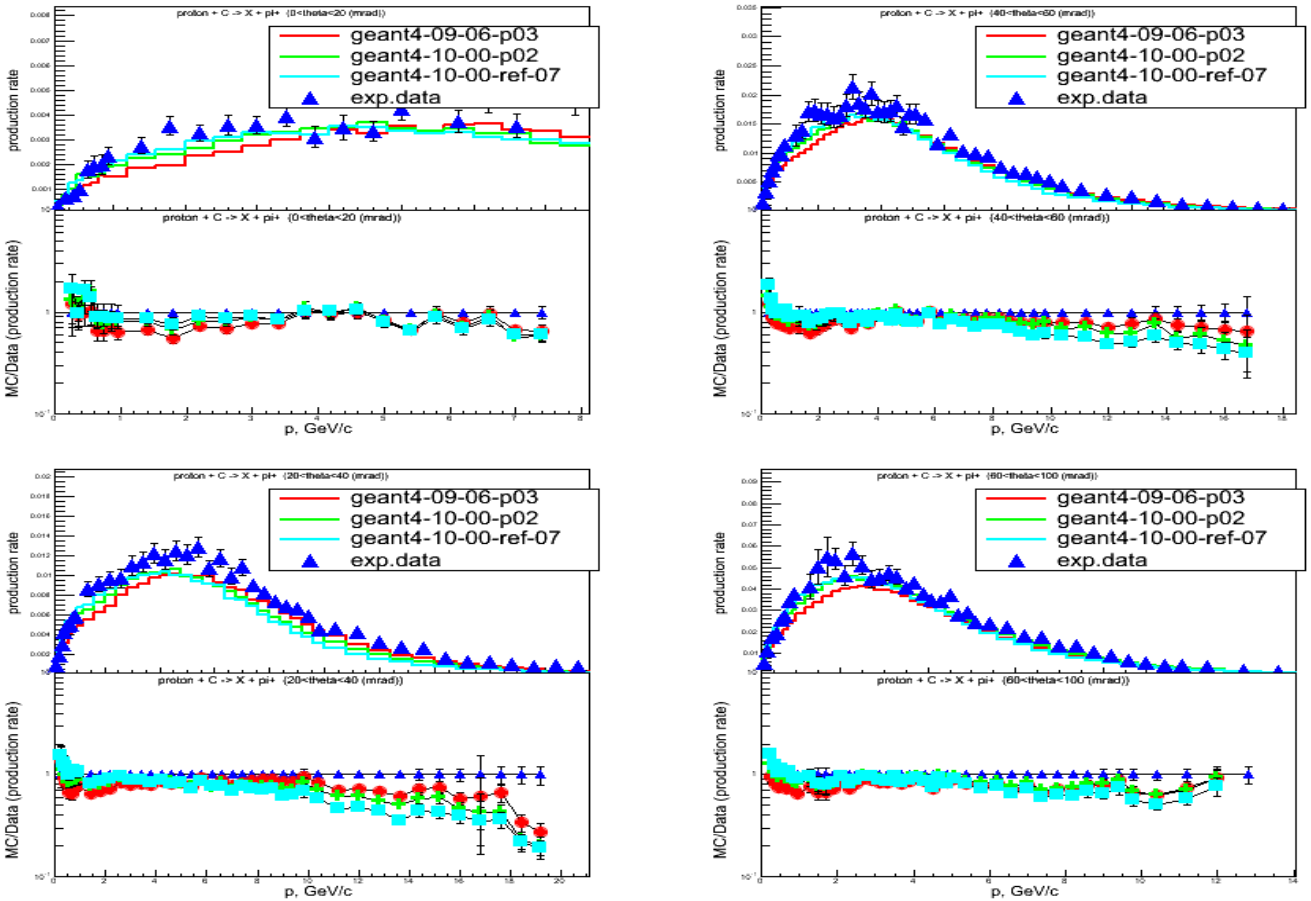
Hadronic Interactions at Intermediate Energies – test47

- Only the "ITEP" part included – p on C or U at 1.4GeV/c or 7.5GeV/c, π(+/-) on C or U at 1.4GeV/c or 5GeV/c
- Looked at proton or neutron production
- No significant variations observed for Bertini, Binary, or FTF from 4.9.6(.p03) and up to 4-10-00-ref-07
- However, there's a "semi-official" observation:
  - While working on NuBeam physics list, used data from HARP for p or π beam on C or Be target in the 3-12GeV range (formally, this is part of test35) and observed non-negligible variations in modeling pion production by FTF in the 4-10-series
  - Did we have any detailed reports on this already ???

Hadronic Interactions at High Energies – test19 (I)

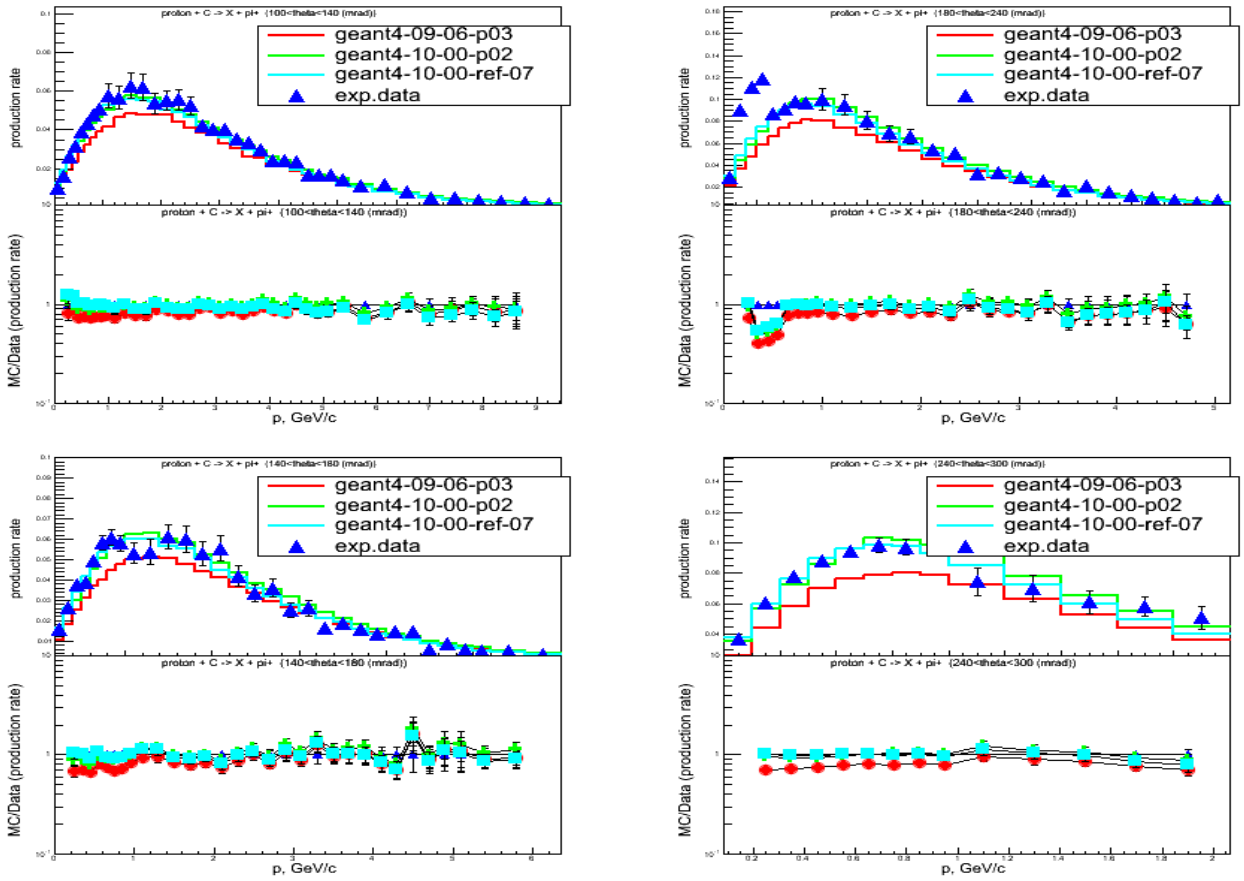
- QGSP and FTFP vs NA61 (31GeV) or NA49 (150GeV) data
- G4LundStringFragmentation tested with FTFP or QGSP
- No changes in QGSP from 4.9.6(.p03) onward
- Significant changes in FTFP as compared vs 4.9.6(.p03)
- Changes in G4LundStringFragmentation in 4-10-00-ref-07, especially visible for pion production in p+C at 158GeV
- NOTE: statistical analysis (chi2) has been added to the tests

Geant4/FTFP vs NA61 data (I)
p+C at 31GeV/c, mom. of sec. π+ in diff. theta bins



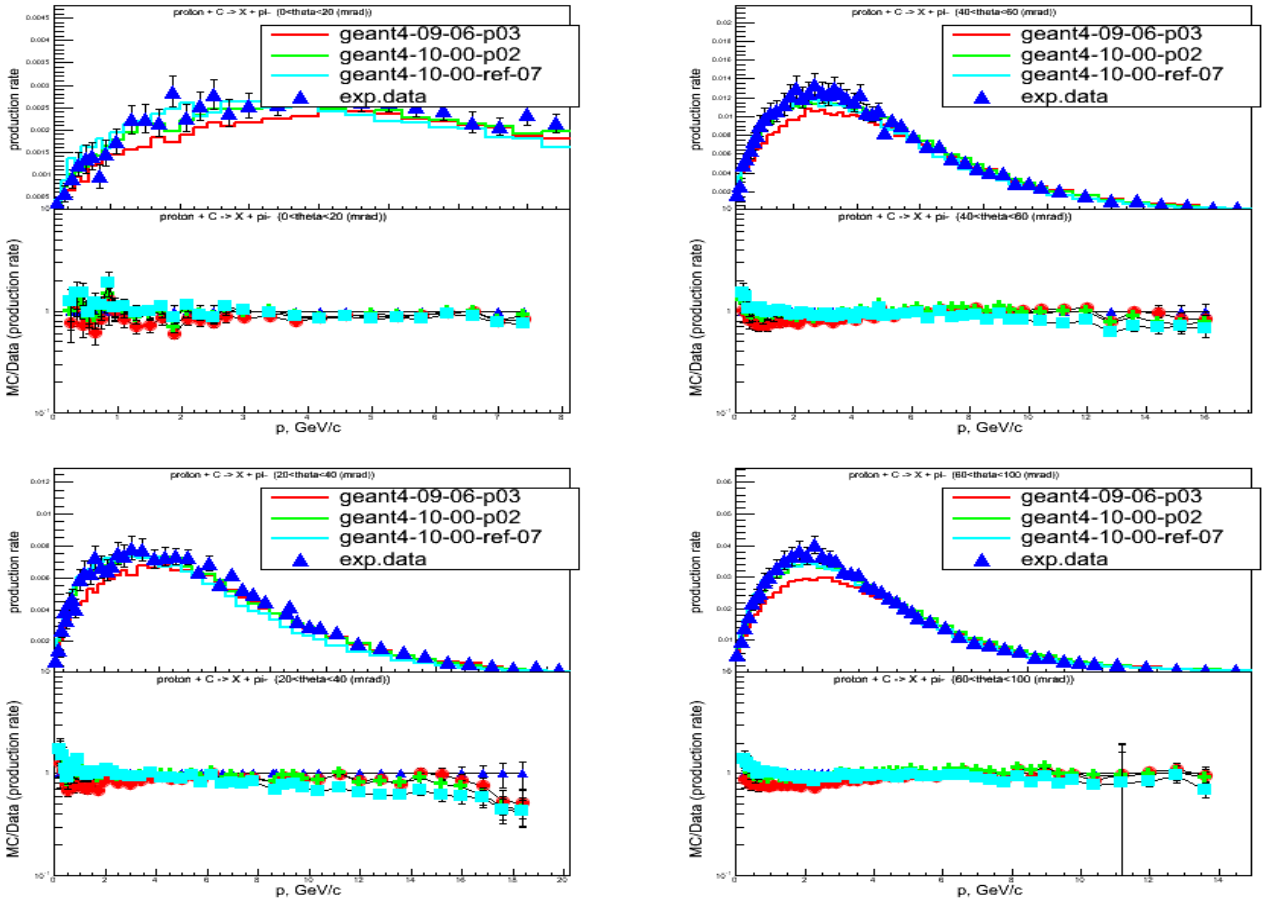
MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
χ^2/NDF = 7.77691 for geant4-09-06-p03 vs NA61 Data
χ^2/NDF = 4.95804 for geant4-10-00-p02 vs NA61 Data
χ^2/NDF = 5.9599 for geant4-10-00-ref-07 vs NA61 Data

Geant4/FTFP vs NA61 data (II)
p+C at 31GeV/c, mom. of sec. π+ in diff. theta bins



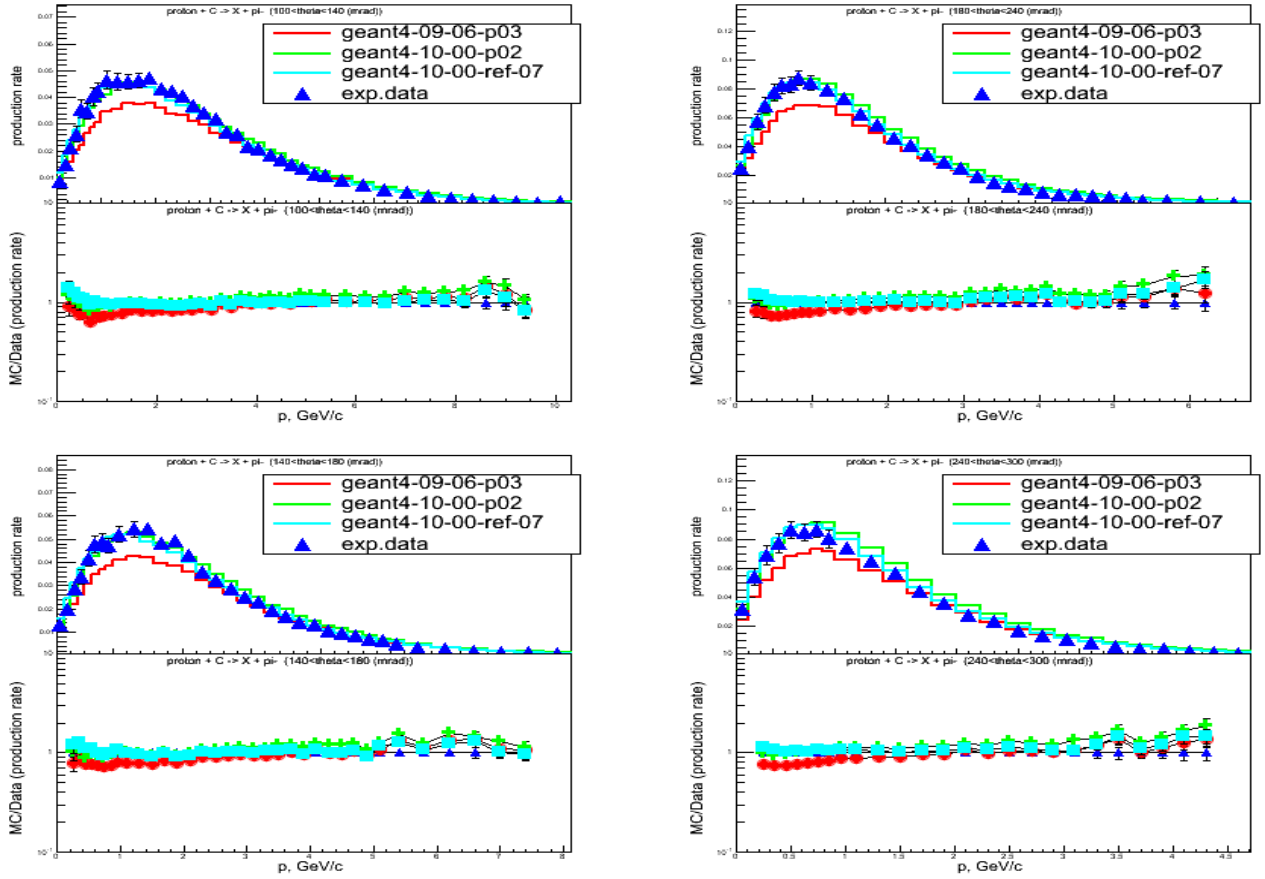
MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
χ^2/NDF = 7.77691 for geant4-09-06-p03 vs NA61 Data
χ^2/NDF = 4.95804 for geant4-10-00-p02 vs NA61 Data
χ^2/NDF = 5.9599 for geant4-10-00-ref-07 vs NA61 Data

Geant4/FTFP vs NA61 data (III)
p+C at 31GeV/c, mom. of sec. π- in diff. theta bins



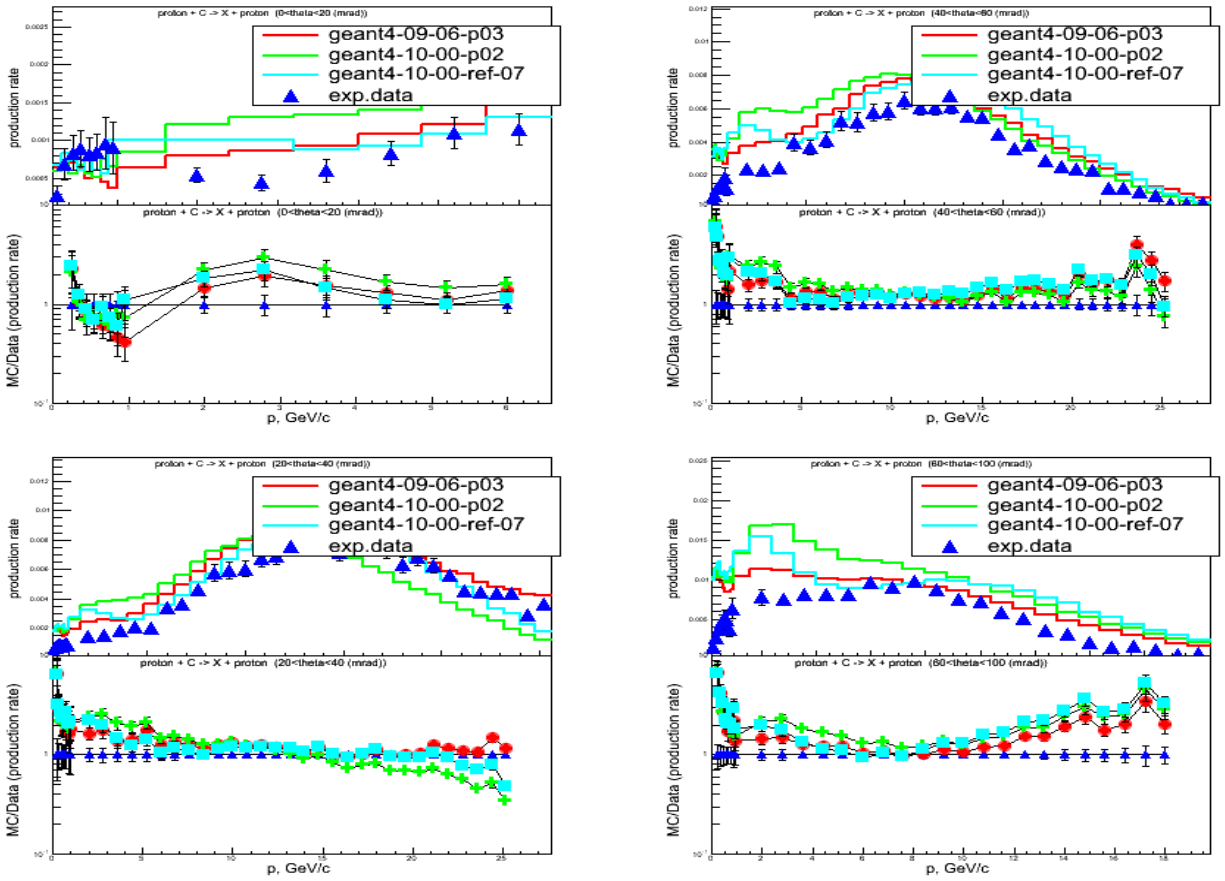
MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
χ^2/NDF = 3.47181 for geant4-09-06-p03 vs NA61 Data
χ^2/NDF = 2.86862 for geant4-10-00-p02 vs NA61 Data
χ^2/NDF = 2.13766 for geant4-10-00-ref-07 vs NA61 Data

Geant4/FTFP vs NA61 data (IV)
p+C at 31GeV, mom. of sec. π- in diff. theta bins



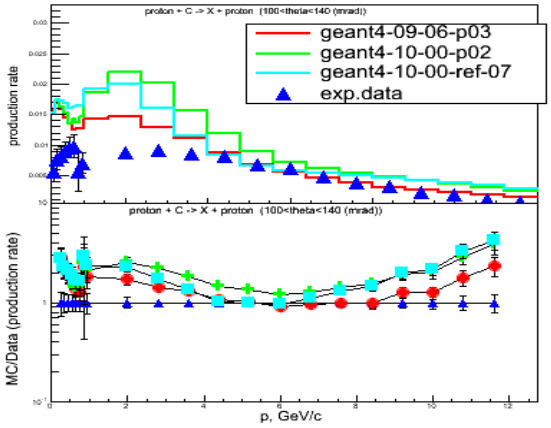
MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
χ^2/NDF = 3.47181 for geant4-09-06-p03 vs NA61 Data
χ^2/NDF = 2.86862 for geant4-10-00-p02 vs NA61 Data
χ^2/NDF = 2.13766 for geant4-10-00-ref-07 vs NA61 Data

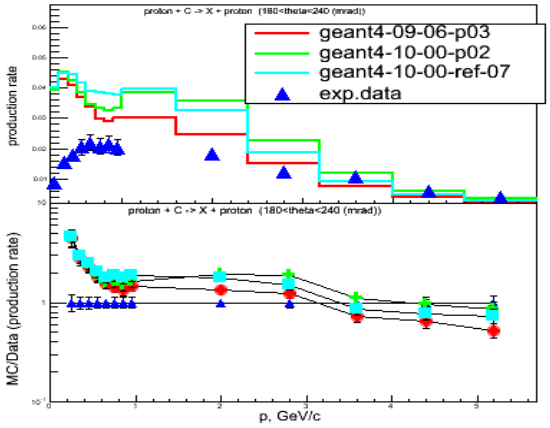
Geant4/FTFP vs NA61 data (V)
p+C at 31GeV/c, mom. of sec. proton in diff. theta bins

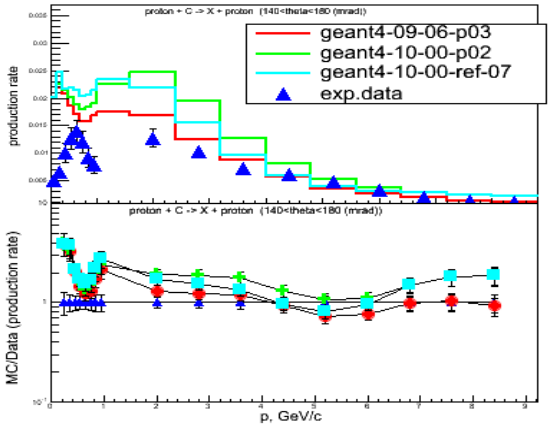


MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
χ^2/NDF = 20.6122 for geant4-09-06-p03 vs NA61 Data
χ^2/NDF = 36.8967 for geant4-10-00-p02 vs NA61 Data
χ^2/NDF = 36.2969 for geant4-10-00-ref-07 vs NA61 Data

Geant4/FTFP vs NA61 data (VI)
p+C at 31GeV/c, mom. of sec. proton in diff. theta bins

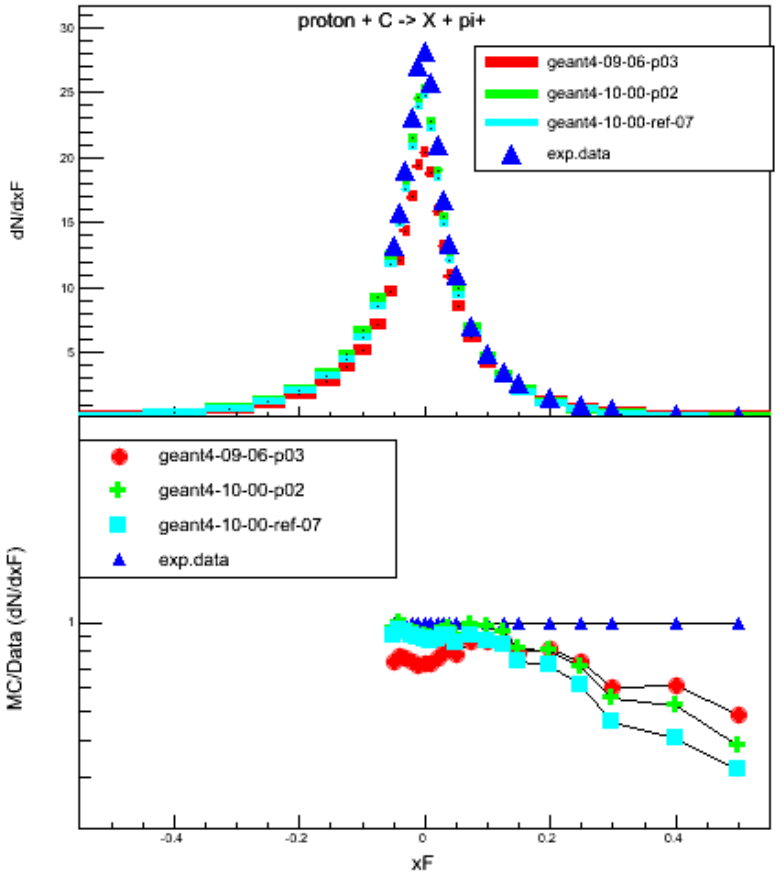




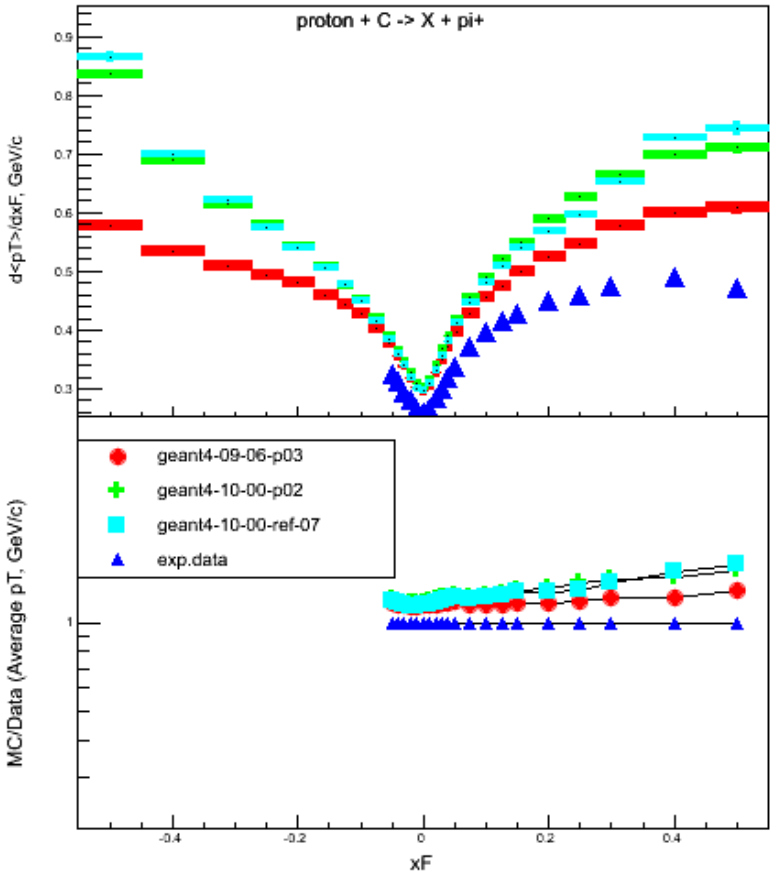


MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
χ^2/NDF = 20.6122 for geant4-09-06-p03 vs NA61 Data
χ^2/NDF = 36.8967 for geant4-10-00-p02 vs NA61 Data
χ^2/NDF = 36.2969 for geant4-10-00-ref-07 vs NA61 Data

Geant4/FTFP vs NA49 data (I)
p+C at 158GeV/c, av.mult or <pT> vs xF for sec. π+

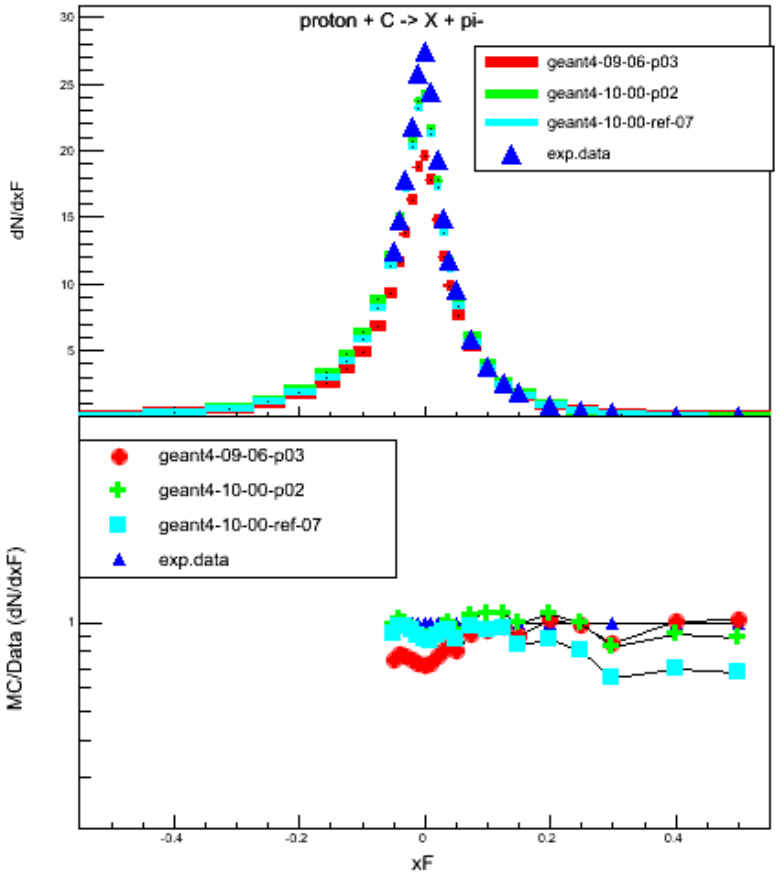


χ^2/NDF = 101.638 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 67.1446 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 105.788 for geant4-10-00-ref-07 vs NA49 Data

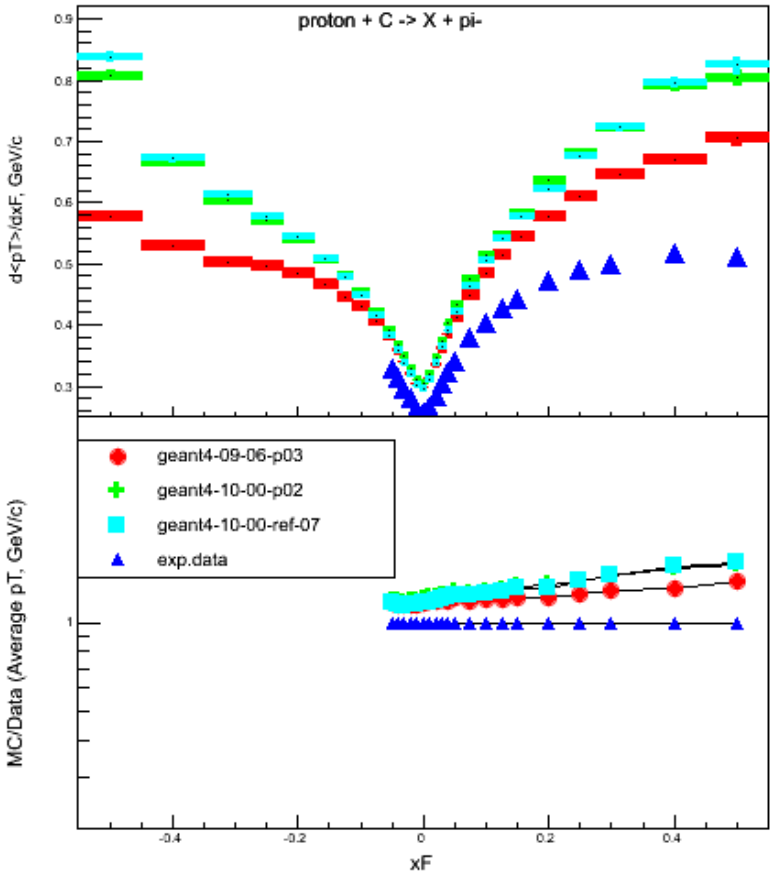


χ^2/NDF = 44.0521 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 104.664 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 89.7958 for geant4-10-00-ref-07 vs NA49 Data

Geant4/FTFP vs NA49 data (I)
p+C at 158GeV/c, av.mult or <pT> vs xF for sec. π-

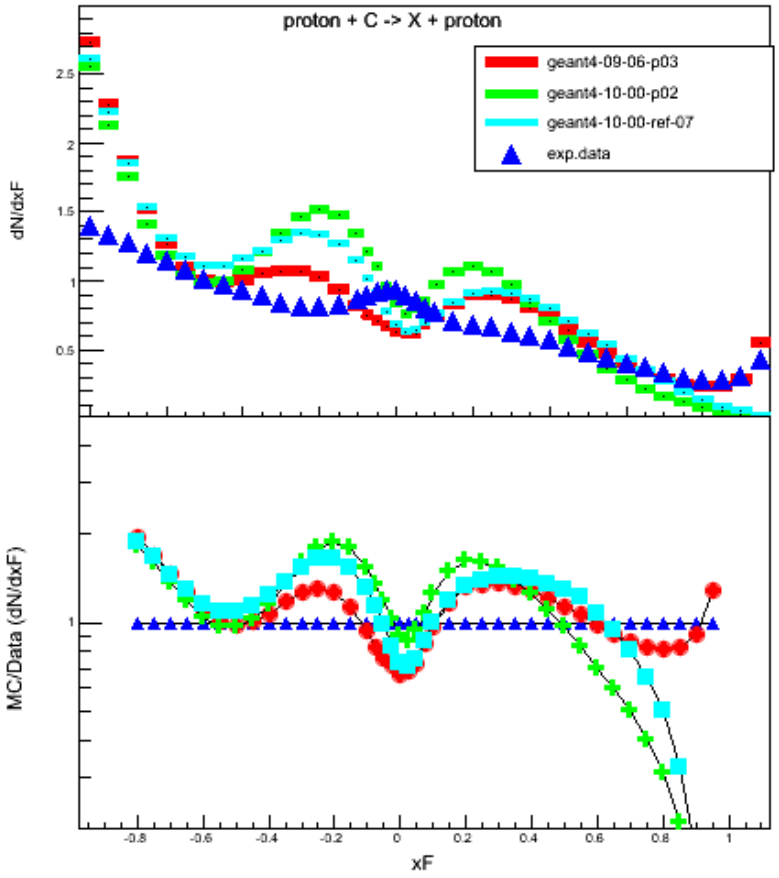


χ^2/NDF = 49.9851 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 7.61099 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 30.1753 for geant4-10-00-ref-07 vs NA49 Data

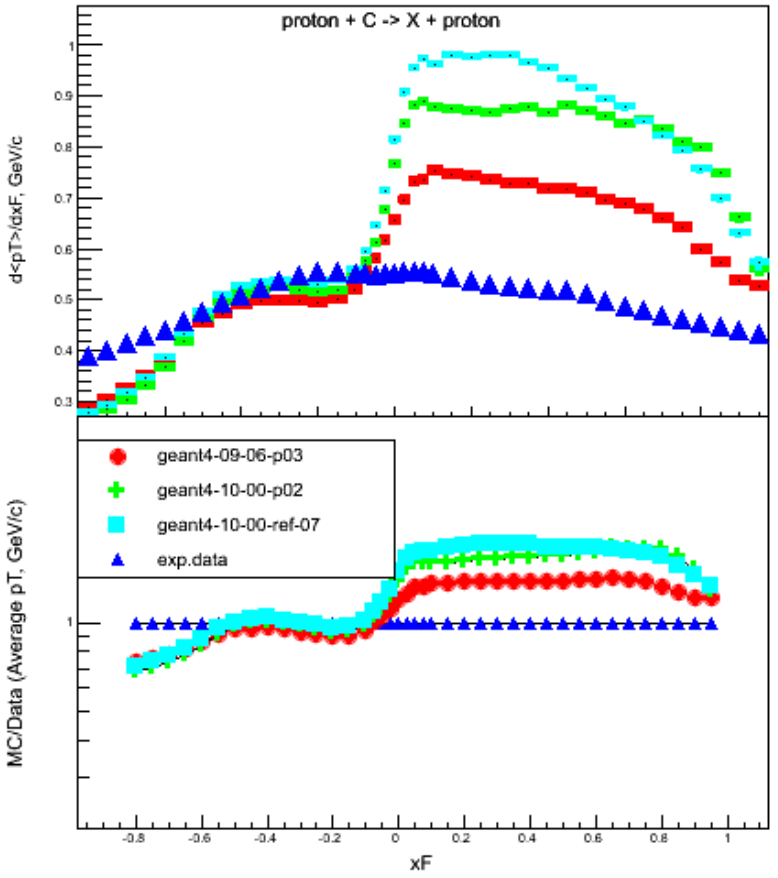


χ^2/NDF = 64.9376 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 126.062 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 108.891 for geant4-10-00-ref-07 vs NA49 Data

Geant4/FTFP vs NA49 data (I)
p+C at158 GeV/c, av.mult or <pT. vs xF for sec. proton

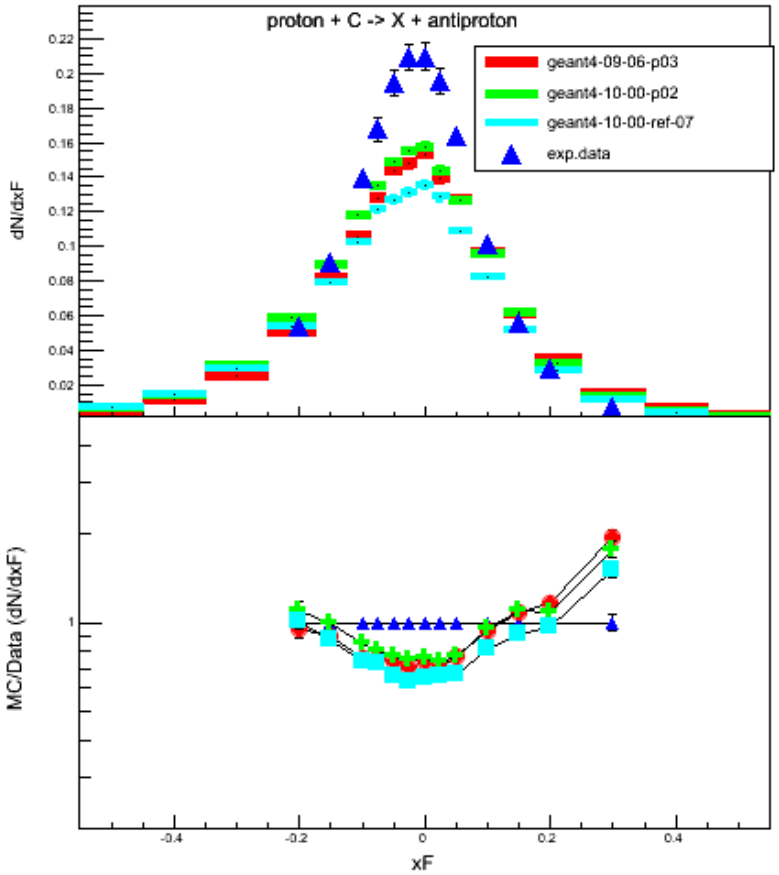


χ^2/NDF = 61.4103 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 191.987 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 134.469 for geant4-10-00-ref-07 vs NA49 Data

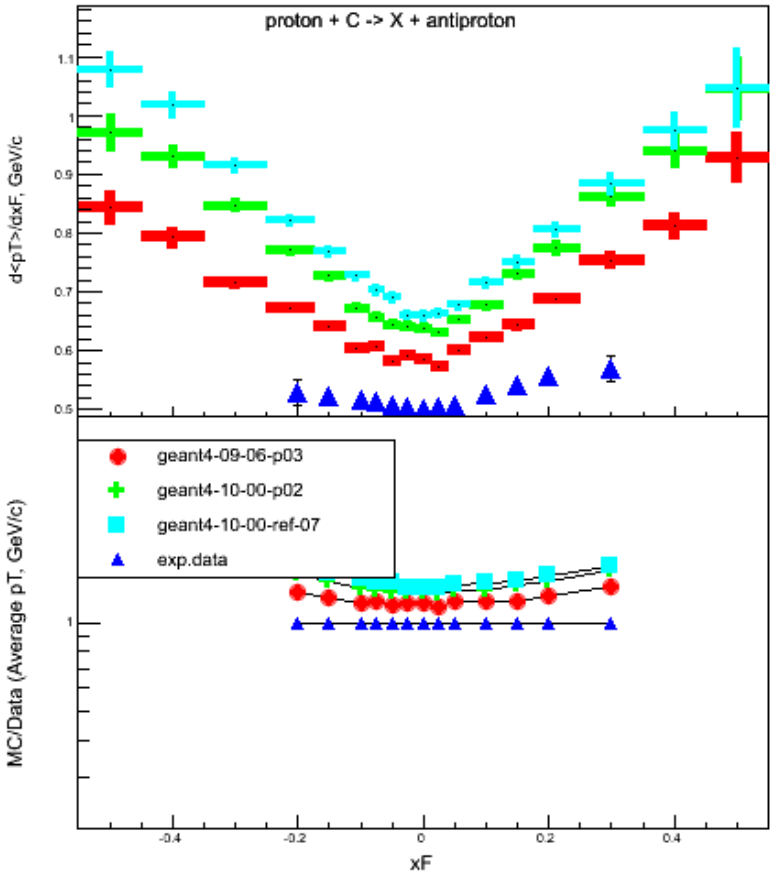


χ^2/NDF = 100.03 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 297.034 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 392.288 for geant4-10-00-ref-07 vs NA49 Data

Geant4/FTFP vs NA49 data (I)
p+C at158 GeV/c, av.mult or <pT> vs xF for sec. pbar

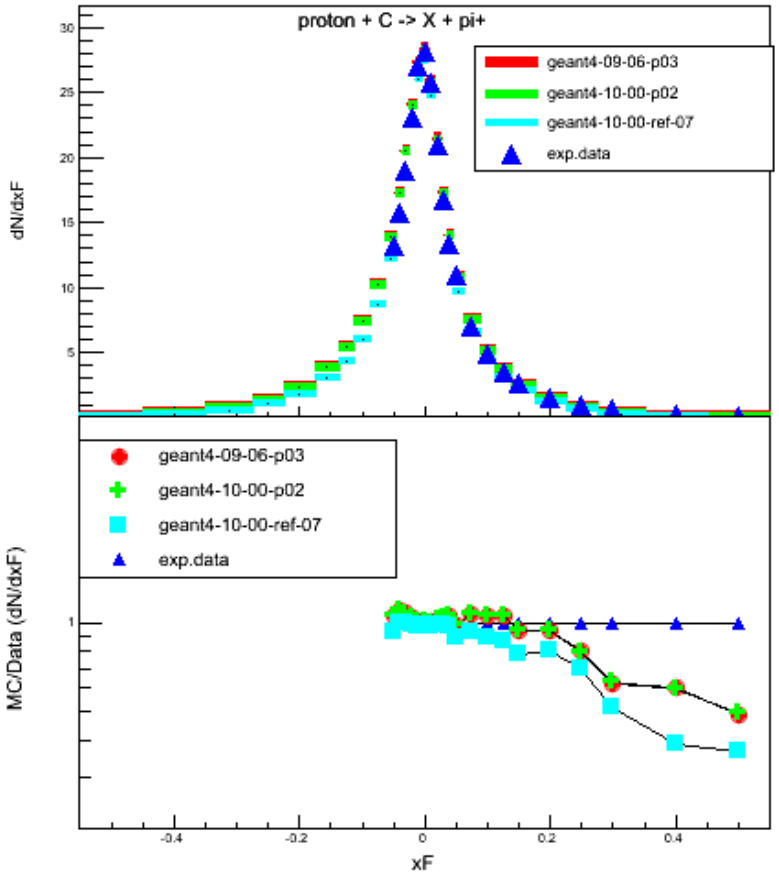


χ^2/NDF = 35.3746 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 26.3837 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 44.71 for geant4-10-00-ref-07 vs NA49 Data

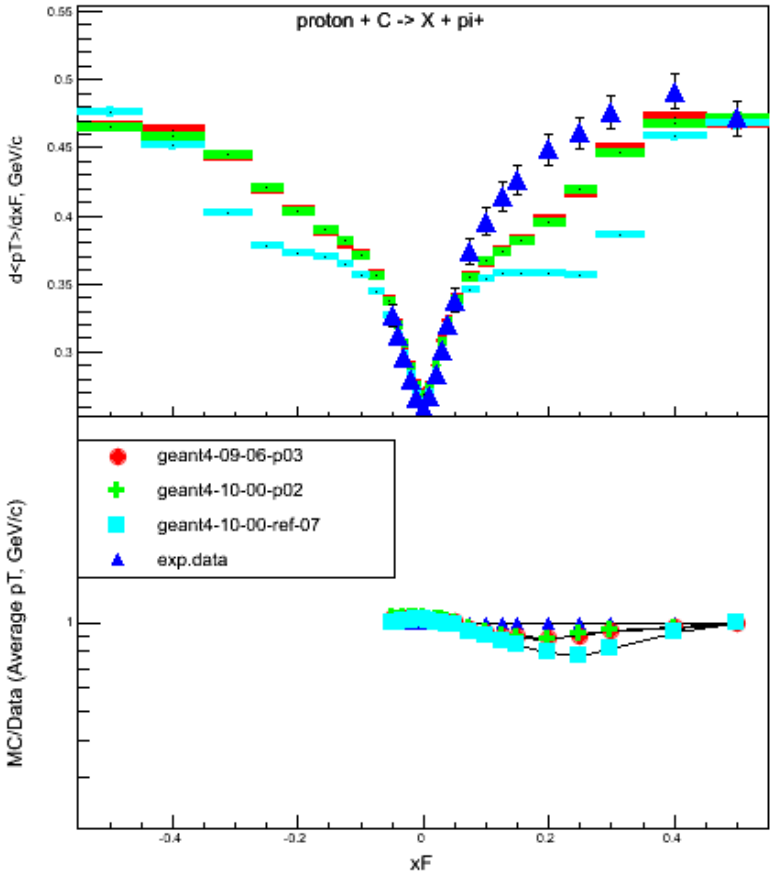


χ^2/NDF = 33.4866 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 88.2401 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 117.838 for geant4-10-00-ref-07 vs NA49 Data

Geant4/QGSP+G4LundStringFragm vs NA49 data (I)
p+C at 158GeV/c, av.mult or <pT> vs xF for sec. π+

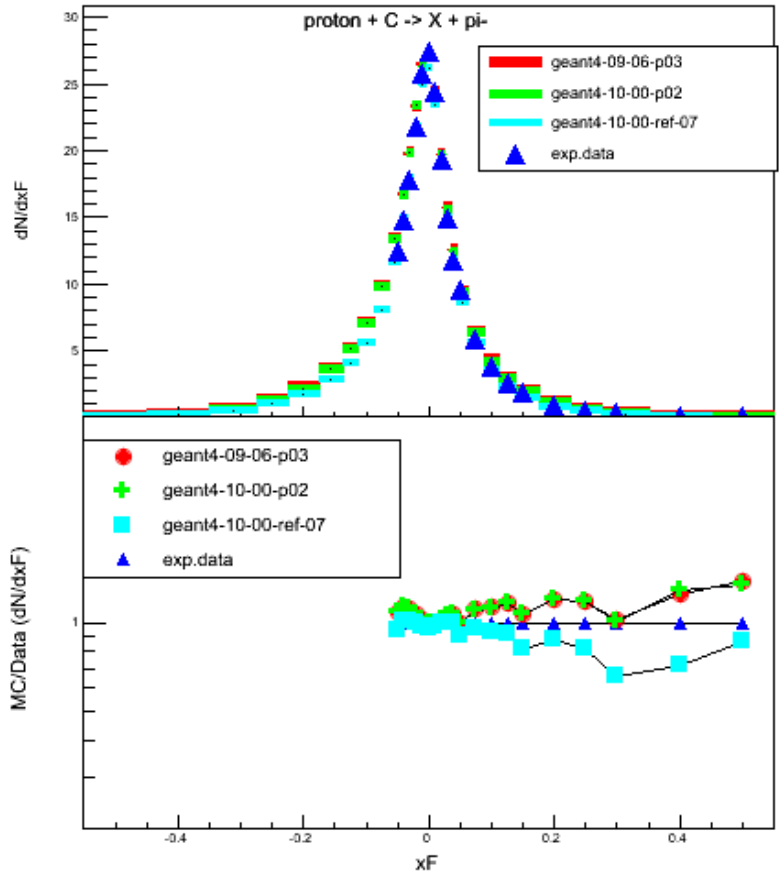


χ^2/NDF = 40.7387 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 40.3322 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 80.854 for geant4-10-00-ref-07 vs NA49 Data

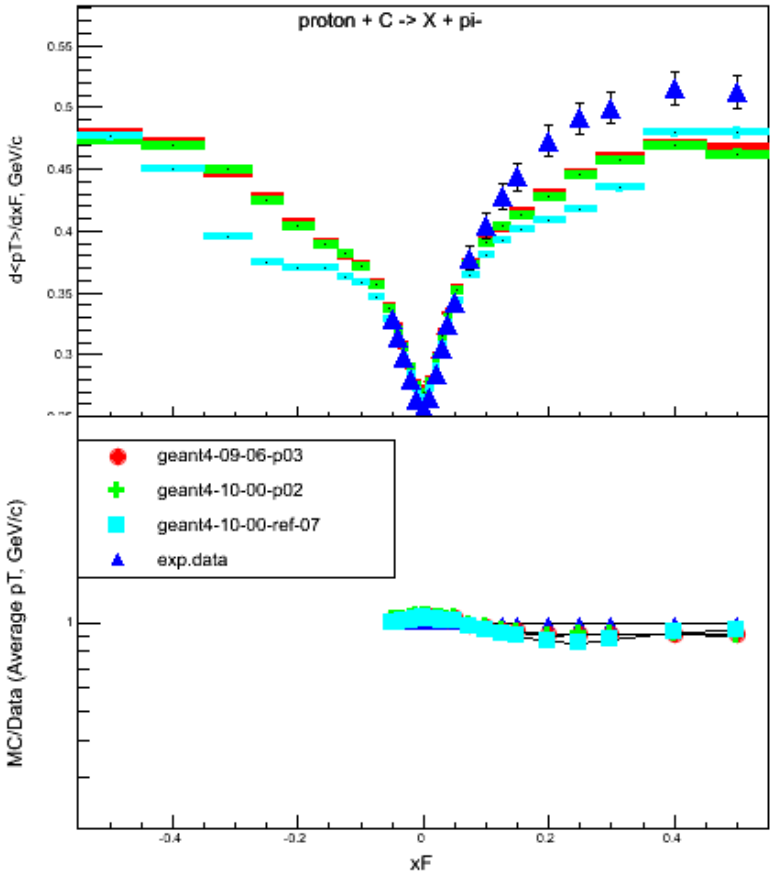


χ^2/NDF = 5.08895 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 5.10719 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 15.1271 for geant4-10-00-ref-07 vs NA49 Data

Geant4/QGSP+G4LundStringFragm vs NA49 data (I)
p+C at 158GeV/c, av.mult or <pT> vs xF for sec. π-



χ^2/NDF = 22.0648 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 21.2807 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 21.3836 for geant4-10-00-ref-07 vs NA49 Data



χ^2/NDF = 5.00217 for geant4-09-06-p03 vs NA49 Data
χ^2/NDF = 5.05301 for geant4-10-00-p02 vs NA49 Data
χ^2/NDF = 6.86847 for geant4-10-00-ref-07 vs NA49 Data

Summary (I)

- AtRest processes:
  - Bertini continues showing effect of changes introduced early in 4.10 development cycle for pi- capture
  - There're also changes in modeling mu- capture, and a concern about a stuck job for certain target
  - K- and Σ capture modeling is stable
  - Some changes in FTF for pbar annih., but they're OK
- Gamma-N: some changes in 4.10 (same in 4-10-00-ref-07), but they don't seem large where we have data
- Intermediate energy: no significant changes in Bertini, Binary of FTF for modeling proton or neutron production in proton, π on C or U; however, there maybe effects in FTF for π production (revisit HARP data, test35 ?)

Summary (II)

- High energy: non-negligible-to-significant changes in FTF
- Pion production is mainly affected negatively at higher energy
- Proton production is negatively affected at 31 or 158GeV
- Antiproton production is also affected
- Changes in G4LundStringFragmentation in 4-10-00-ref-07 are also non-negligible when combined with QGSP; visible negative effect for modeling pion production