



Geant 4

Validation of Geant4.10.1.p02 and Geant4.10.2.b01
Brief Summary
from test19, 47, 48, and 75

Julia Yarba, Fermilab
Geant4 Hadronic Group Meeting
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General Information

- Included:
 - AtRest processes – test48
 - Gamma-N interactions – test75
 - Baryon production by Bertini, Binary, FTF at intermediate energies – test47
 - FTFP, QGSP(+G4LundStringFragm.) at 31GeV/c or 158GeV/c – test19
- Releases:
 - Geant4.10.1.p02
 - **Geant4.10.2.b01**
- NOTE-1: NO difference between 10.1.p01 and 10.1.p02 found based on these tests
- NOTE-2: Identical results from 10.2.b01 and 10.1.ref06
- Only signature plots shown (interesting/non-negligible changes)
- Otherwise, a verbal overview
- All results/plots uploaded to G4 Validation Repository:

<http://g4devel.fnal.gov:8080/G4WebAppNG>

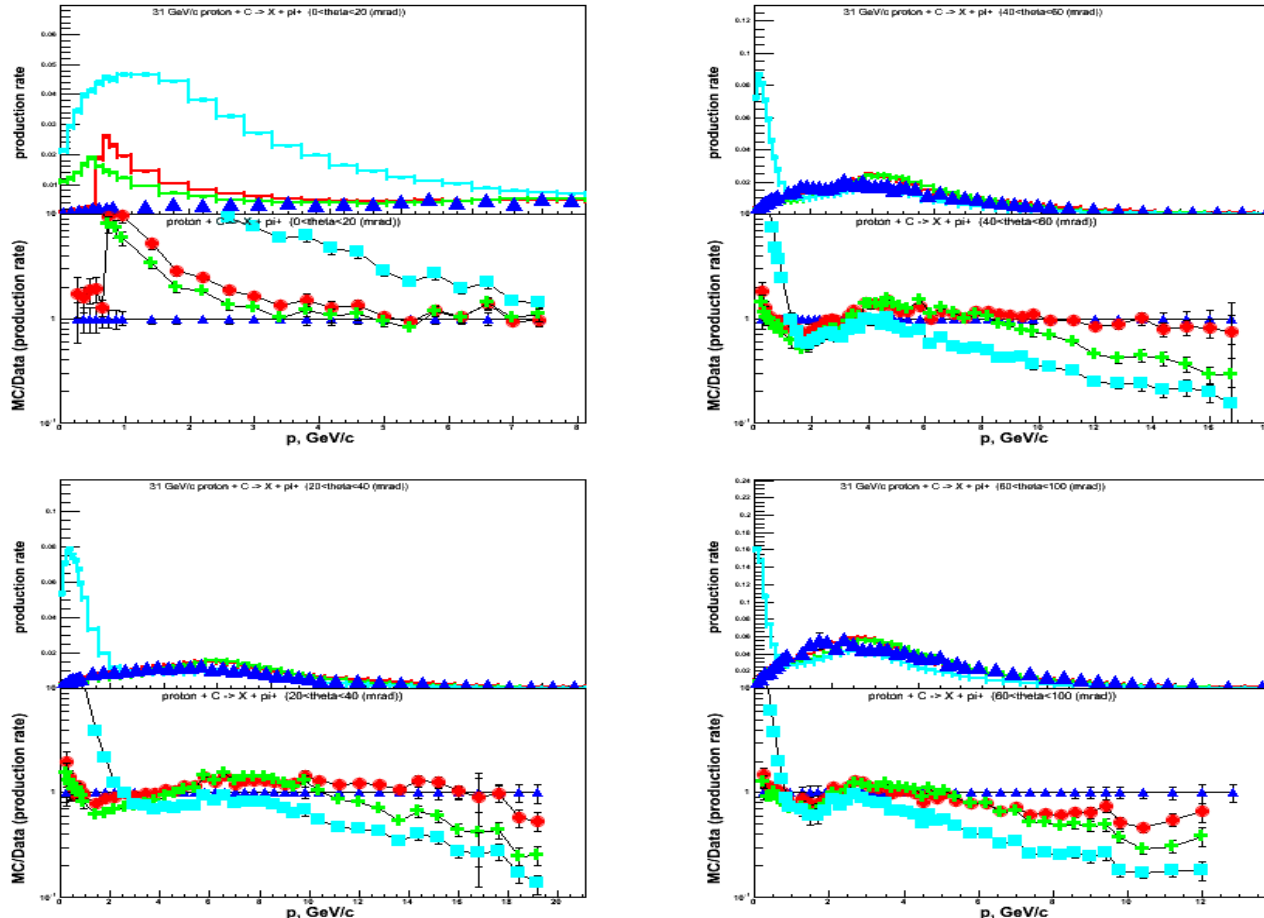
G4.10.1.p02 & G4.10.2.b01 Summary

- NO changes found in Bertini, Binary, INCLXX
- Changes in FTF(P) observed in G4.10.2.b01
 - Already discussed at previous meeting (6/17/15, 5/20/15)
 - Same in G4.10.1.ref05 and G4.10.2.b01
 - NOTE-1: FTF appeared to be “best” in G4.10.1.ref04
 - NOTE-2: Results from the most current revision of FTF are mainly improving (as compared e.g. vs 9.6-series) but some aspects are of concern
- **Multiple changes observed in OSG as of G4.10.2.b01 (or ref06)**
 - Discussions at previous meetings
 - Expected to be an improvement but...
 - Current results further deviate from thin target data (NA61, NA49)
 - Apparently, multiple changes in the core code but tuning of parameters is not complete yet
 - Plots in the following slides

- RESULTS IN THE FOLLOWING SIDES ARE BY A TRADITIONAL COMBINATION OF QGS(P)+G4QGSMFragmentation

QGSP: 31 GeV/c p+C -> π^+ +X (I)

NA61 Data: N.Abgrall et al., Phys.Rev. C84, 034604 (2011)

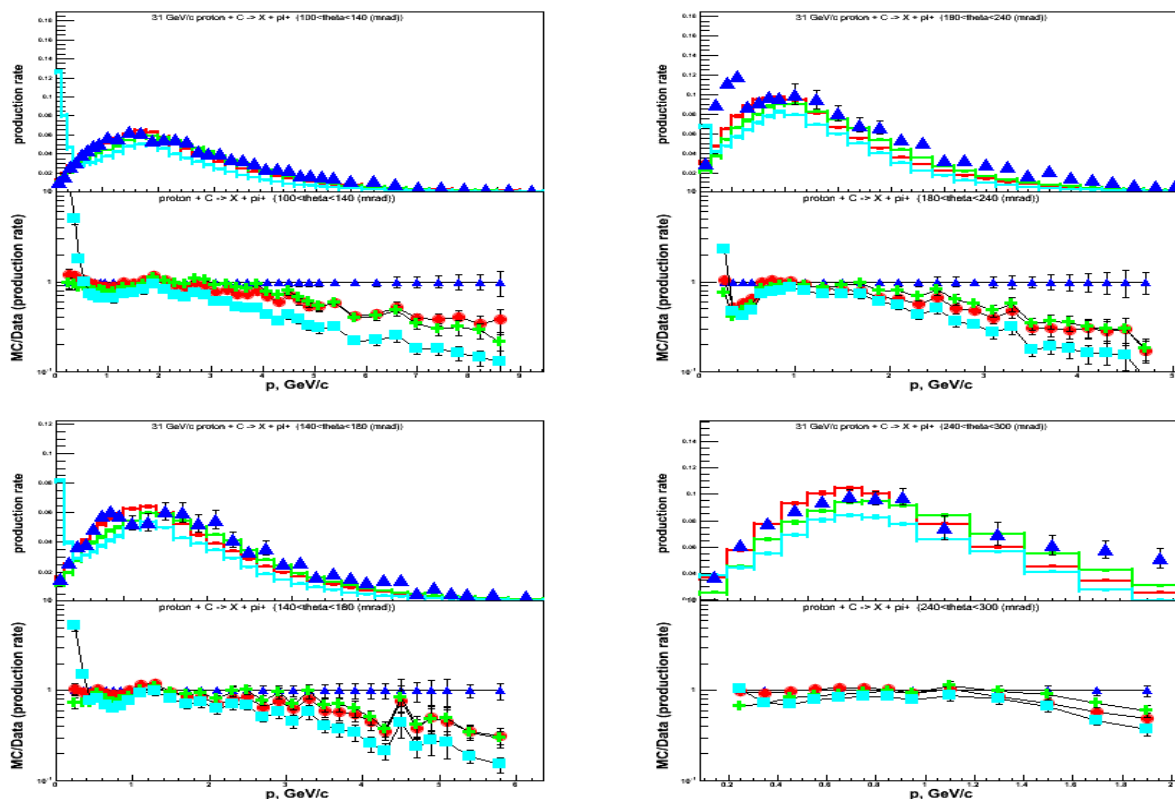


MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
 $\chi^2/\text{NDF} = 25.2436$ for geant4-09-06-patch-04 vs NA61 Data
 $\chi^2/\text{NDF} = 35.1526$ for geant4-10-01-patch-02 vs NA61 Data
 $\chi^2/\text{NDF} = 559.977$ for geant4-10-02-beta-01 vs NA61 Data



QGSP: 31GeV/c p+C -> π^+ +X (II)

NA61 Data: N.Abgrall et al., Phys.Rev. C84, 034604 (2011)

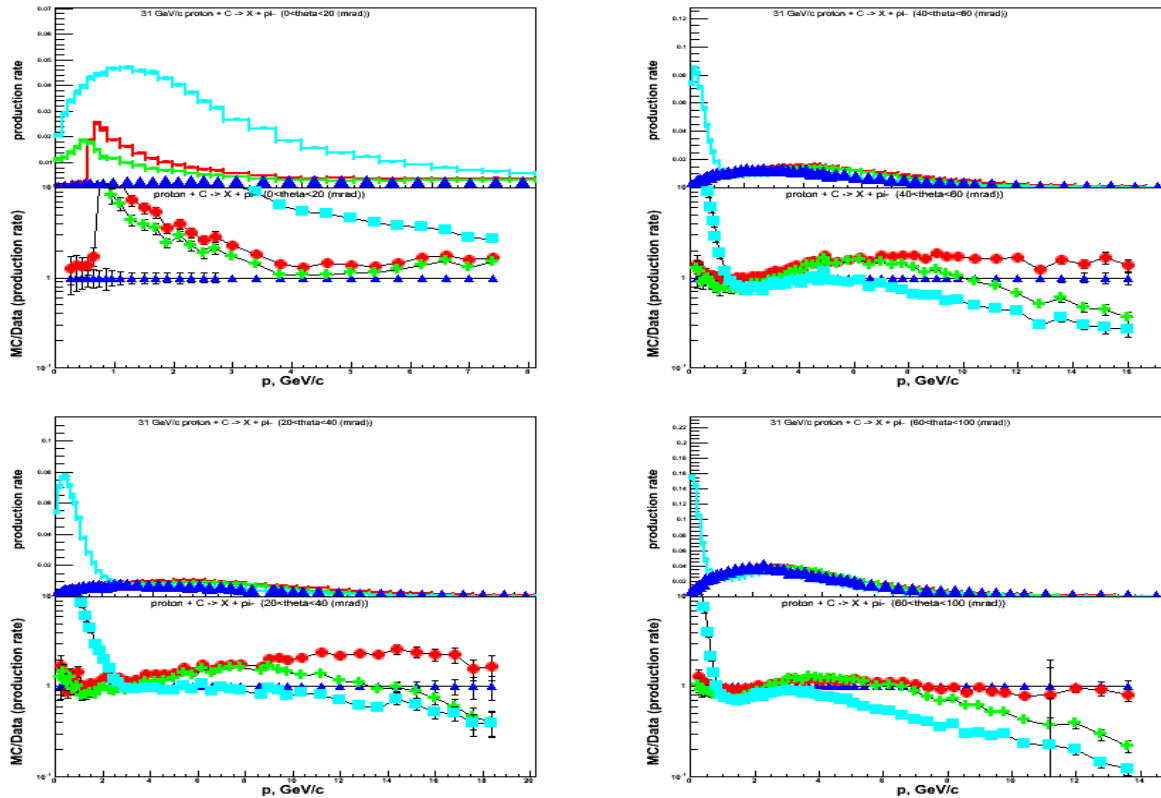


MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
 $\chi^2/\text{NDF} = 25.2436$ for geant4-09-06-patch-04 vs NA61 Data
 $\chi^2/\text{NDF} = 35.1526$ for geant4-10-01-patch-02 vs NA61 Data
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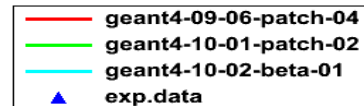
— geant4-09-06-patch-04
 — geant4-10-01-patch-02
 — geant4-10-02-beta-01
 ▲ exp.data

QGSP: 31GeV/c p+C -> π^- +X (I)

NA61 Data: N.Abgrall et al., Phys.Rev. C84, 034604 (2011)

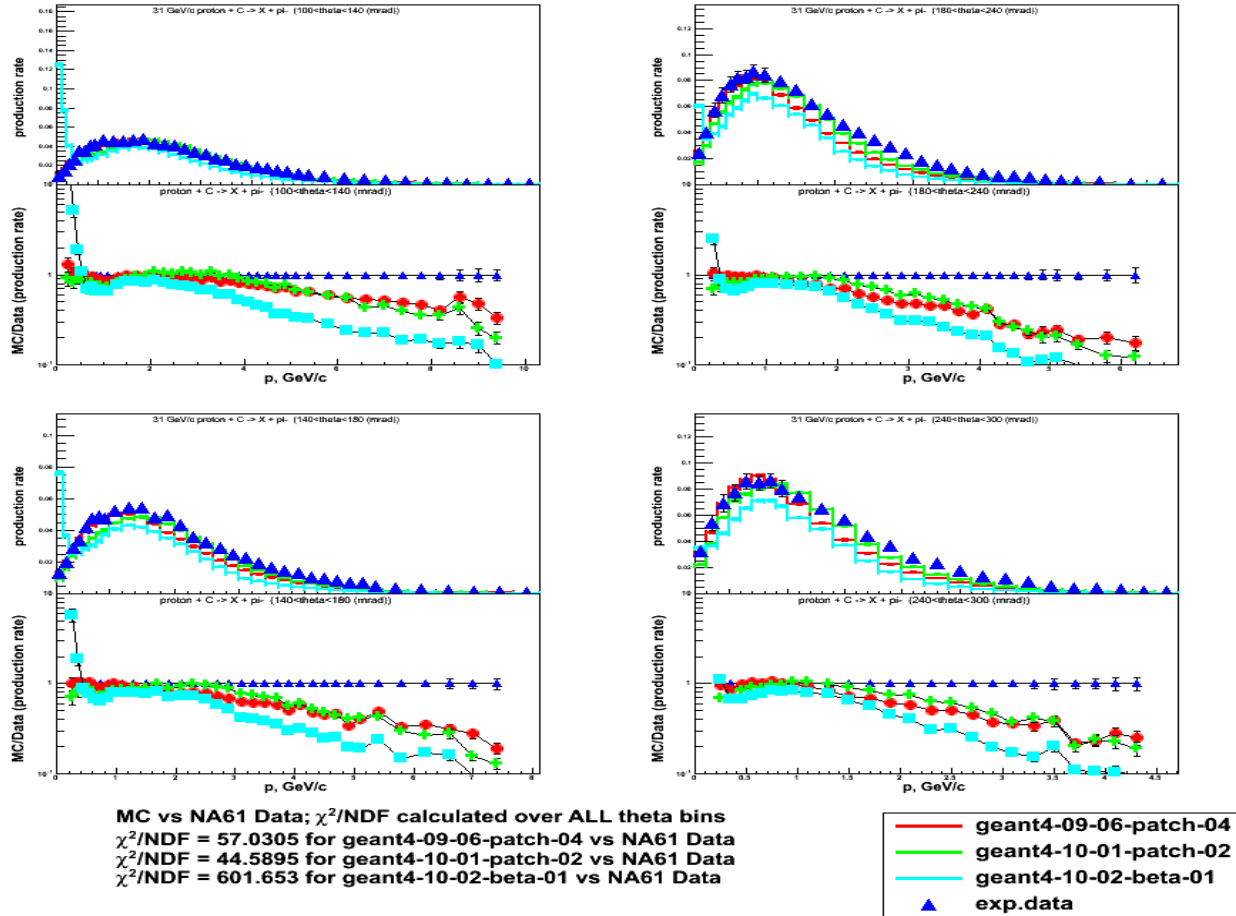


MC vs NA61 Data; χ^2 /NDF calculated over ALL theta bins
 χ^2 /NDF = 57.0305 for geant4-09-06-patch-04 vs NA61 Data
 χ^2 /NDF = 44.5895 for geant4-10-01-patch-02 vs NA61 Data
 χ^2 /NDF = 601.653 for geant4-10-02-beta-01 vs NA61 Data



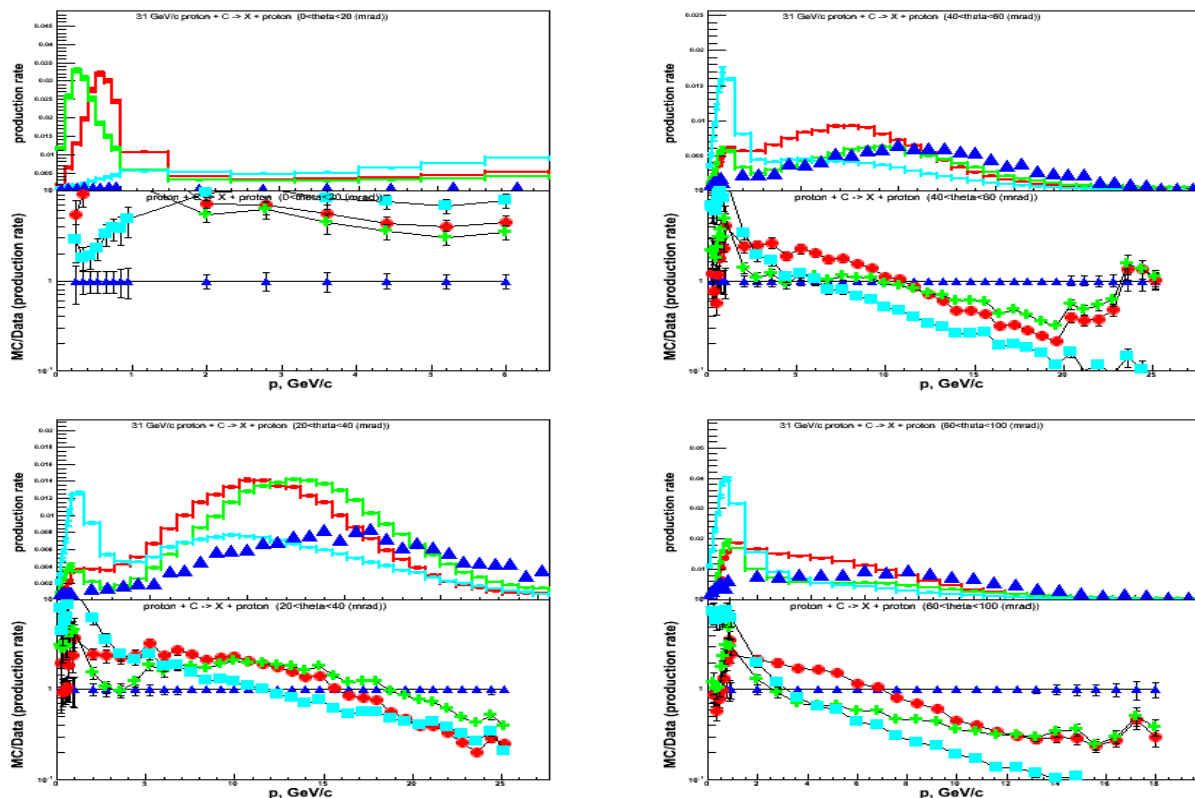
QGSP: 31GeV/c $p+C \rightarrow \pi^-+X$ (II)

NA61 Data: N.Abgrall et al., Phys.Rev. C84, 034604 (2011)



QGSP: 31GeV/c p+C -> p+X (I)

NA61 Data: N.Abgrall et al., Phys.Rev. C84, 034604 (2011)

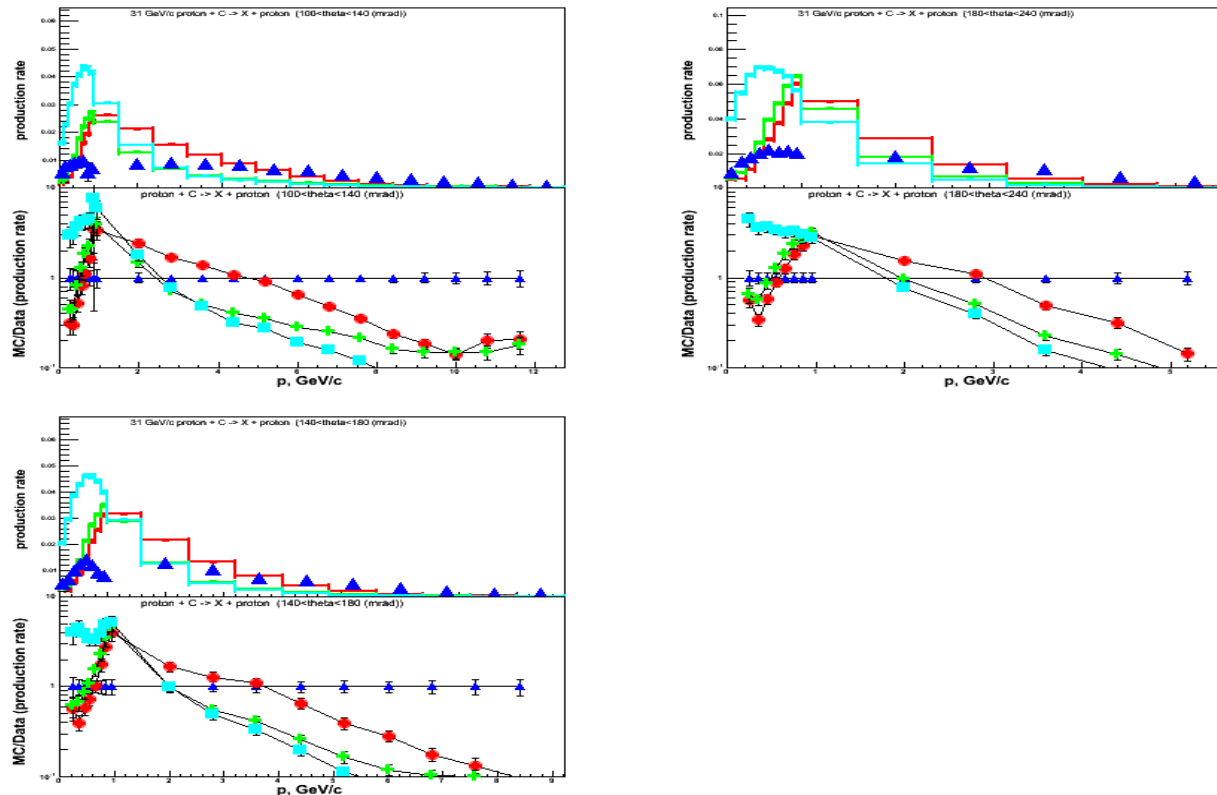


MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
 $\chi^2/\text{NDF} = 116.326$ for geant4-09-06-patch-04 vs NA61 Data
 $\chi^2/\text{NDF} = 116.84$ for geant4-10-01-patch-02 vs NA61 Data
 $\chi^2/\text{NDF} = 164.634$ for geant4-10-02-beta-01 vs NA61 Data



QGSP: 31GeV/c p+C -> p+X (II)

NA61 Data: N.Abgrall et al., Phys.Rev. C84, 034604 (2011)

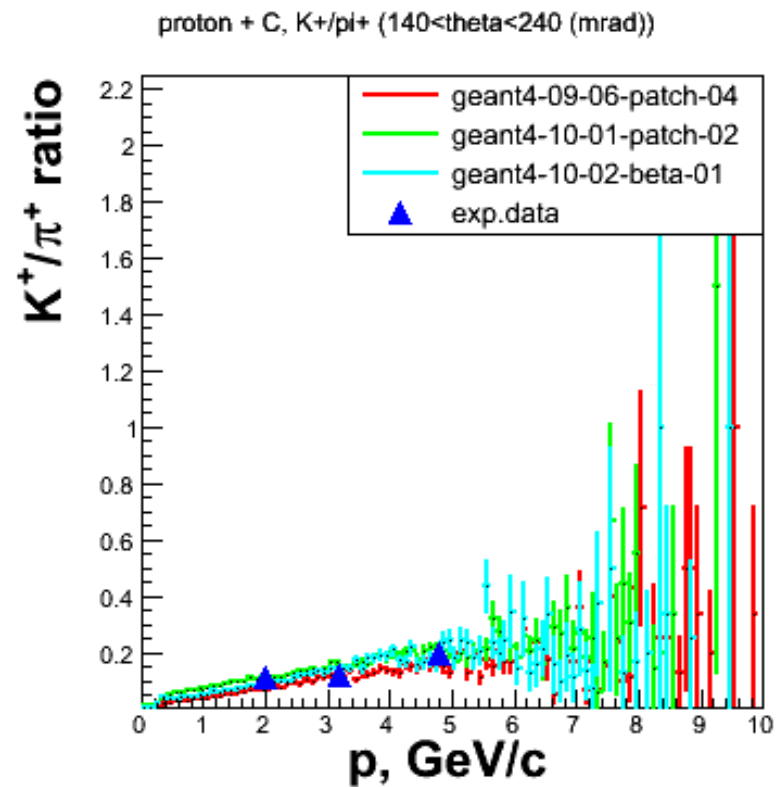
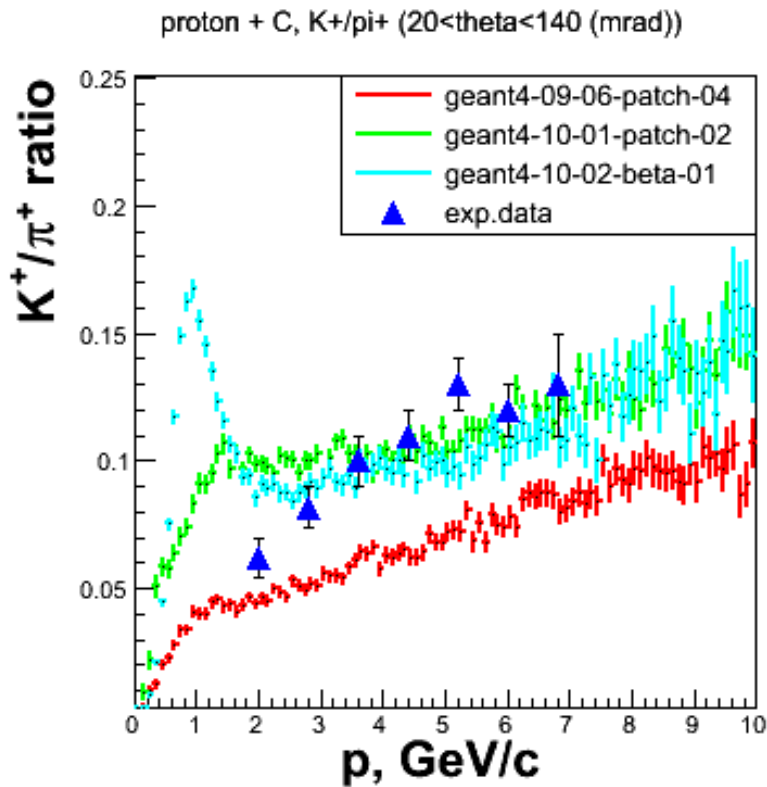


MC vs NA61 Data; χ^2/NDF calculated over ALL theta bins
 $\chi^2/\text{NDF} = 116.326$ for geant4-09-06-patch-04 vs NA61 Data
 $\chi^2/\text{NDF} = 116.84$ for geant4-10-01-patch-02 vs NA61 Data
 $\chi^2/\text{NDF} = 164.634$ for geant4-10-02-beta-01 vs NA61 Data



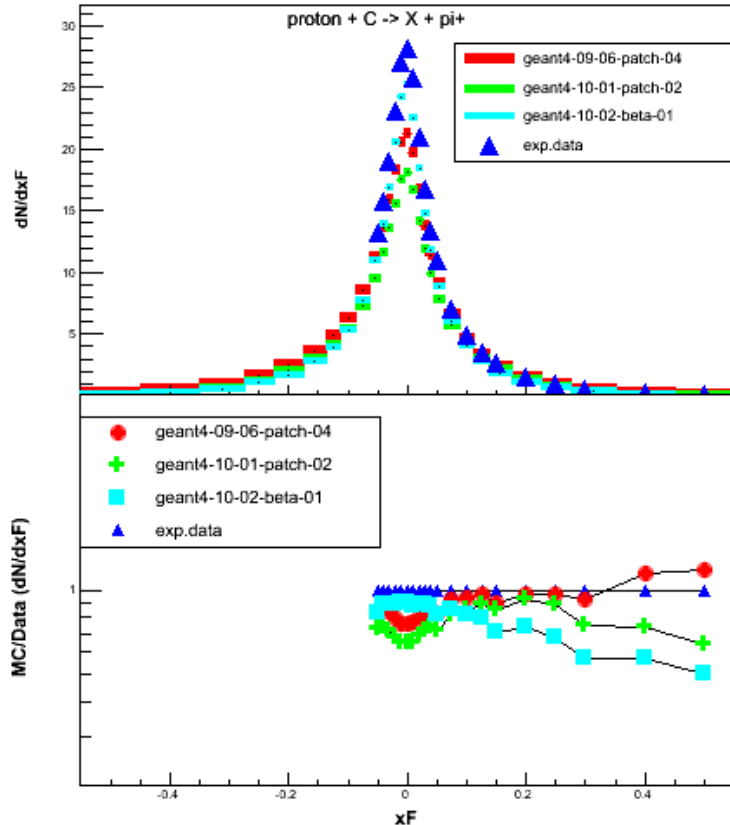
QGSP: K^+/π^+ in 31GeV/c p+C

NA61 Data: N.Abgrall et al., Phys.Rev. C84, 034604 (2011)

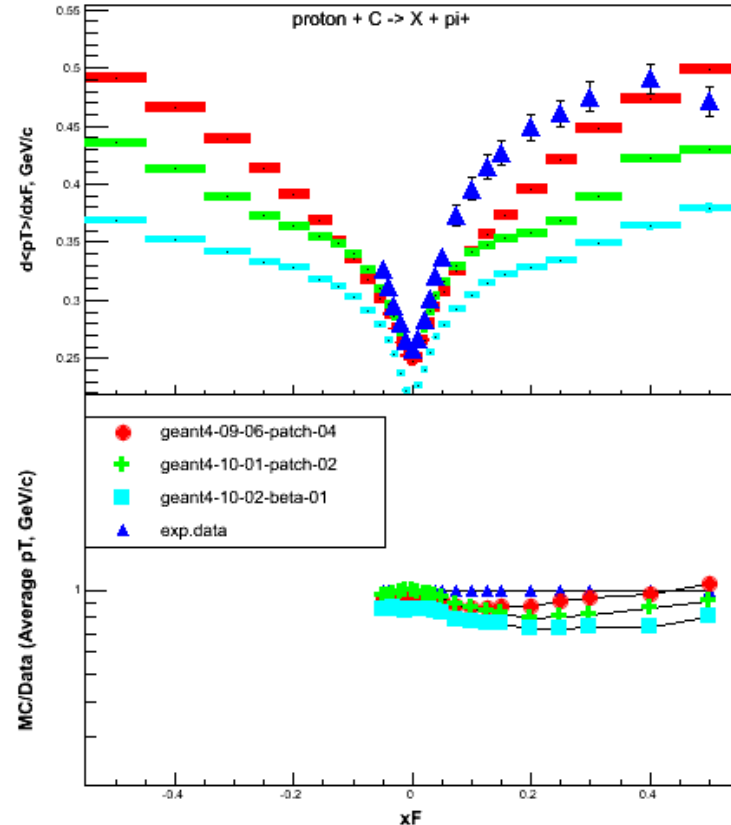


QGSP: 158GeV/c p+C $\rightarrow \pi^+ + X$

NA49 Data: <http://spshadrons.web.cern.ch/spshadrons>



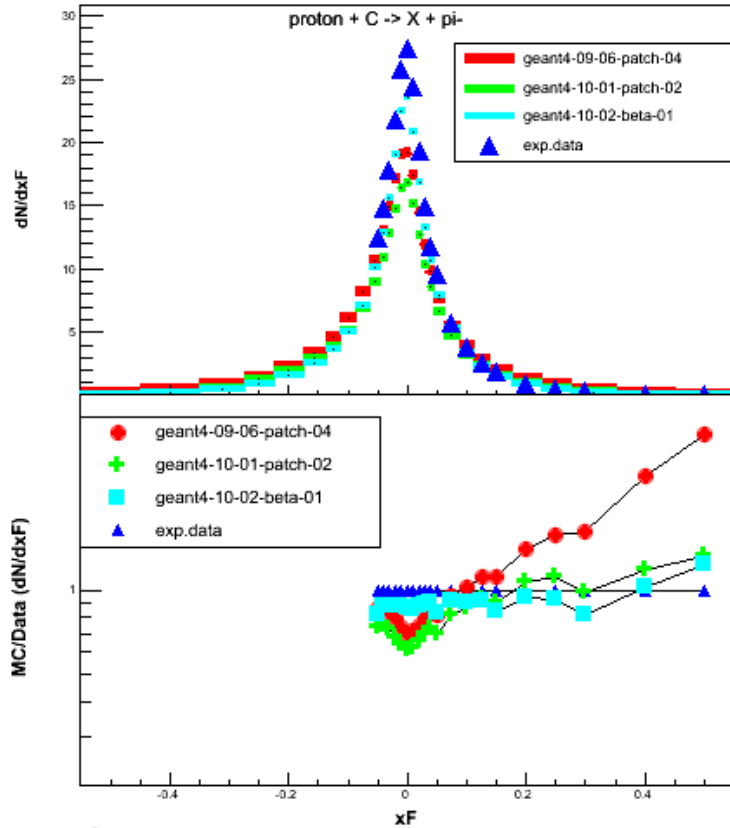
$\chi^2/NDF = 36.3626$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/NDF = 104.566$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/NDF = 80.1344$ for geant4-10-02-beta-01 vs NA49 Data



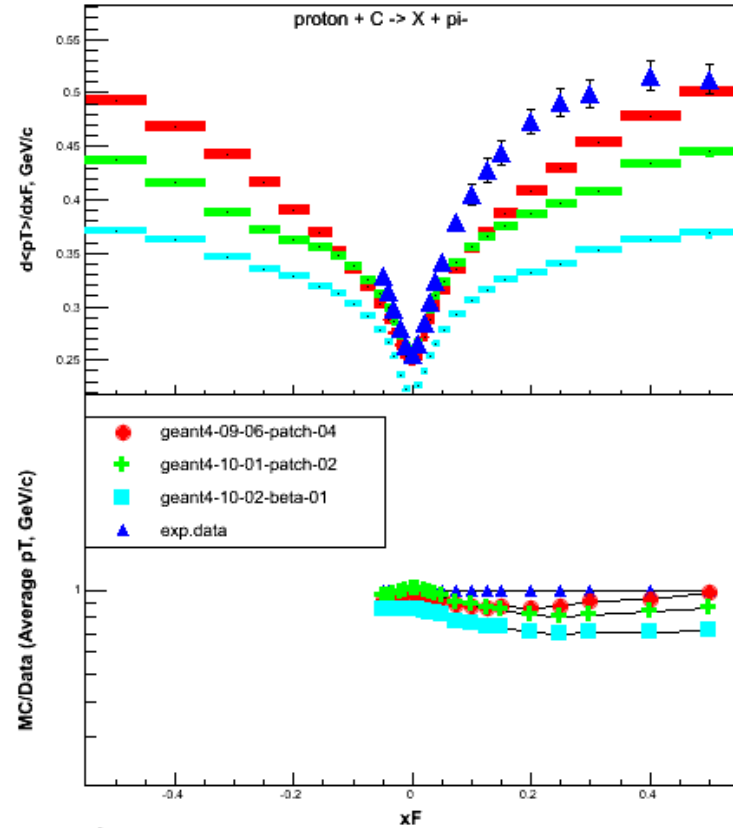
$\chi^2/NDF = 11.7152$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/NDF = 18.7212$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/NDF = 62.2574$ for geant4-10-02-beta-01 vs NA49 Data

QGSP: 158GeV/c p+C -> $\pi^- + X$

NA49 Data: <http://spshadrons.web.cern.ch/spshadrons>



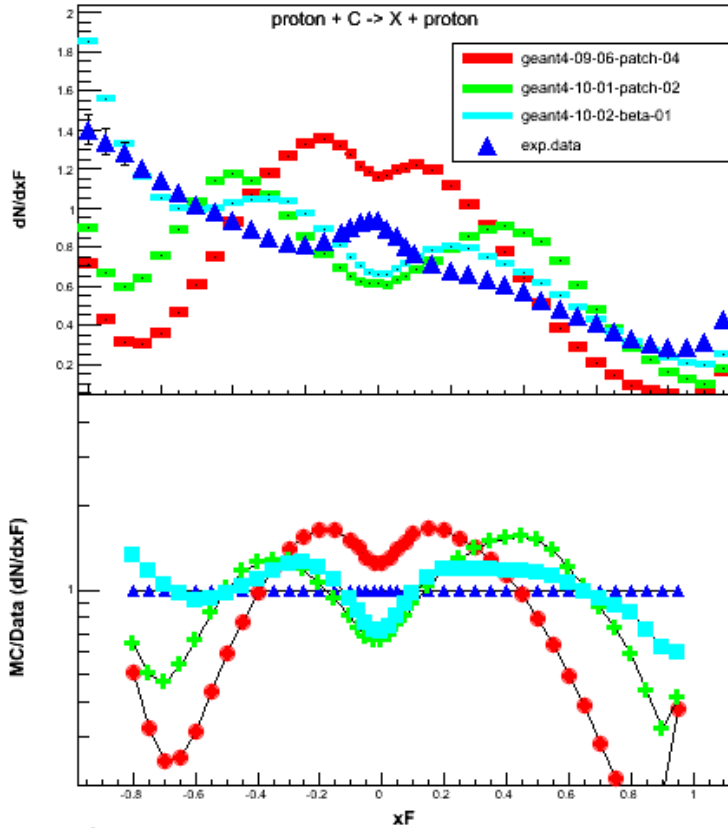
$\chi^2/NDF = 354.8$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/NDF = 97.9746$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/NDF = 24.1156$ for geant4-10-02-beta-01 vs NA49 Data



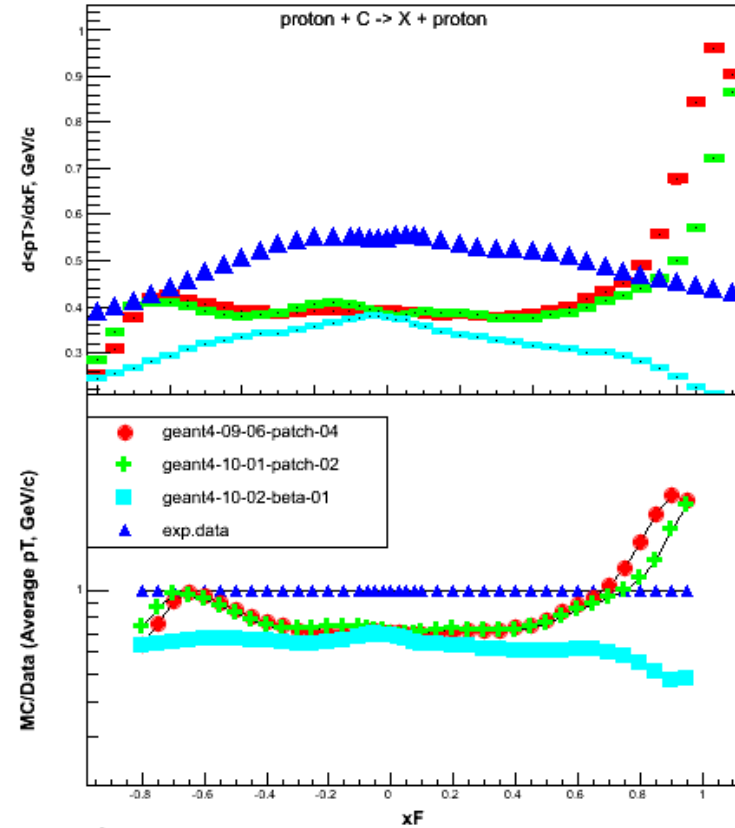
$\chi^2/NDF = 11.9402$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/NDF = 17.128$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/NDF = 73.4602$ for geant4-10-02-beta-01 vs NA49 Data

QGSP: 158GeV/c p+C -> p+X

NA49 Data: <http://spshadrons.web.cern.ch/spshadrons>



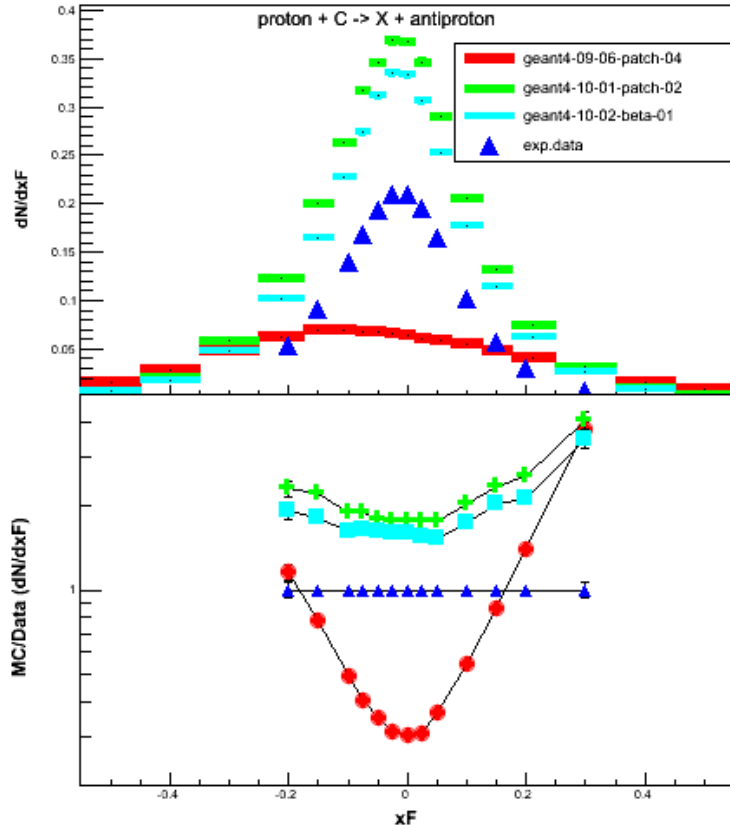
$\chi^2/\text{NDF} = 231.3$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/\text{NDF} = 103.019$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/\text{NDF} = 30.8385$ for geant4-10-02-beta-01 vs NA49 Data



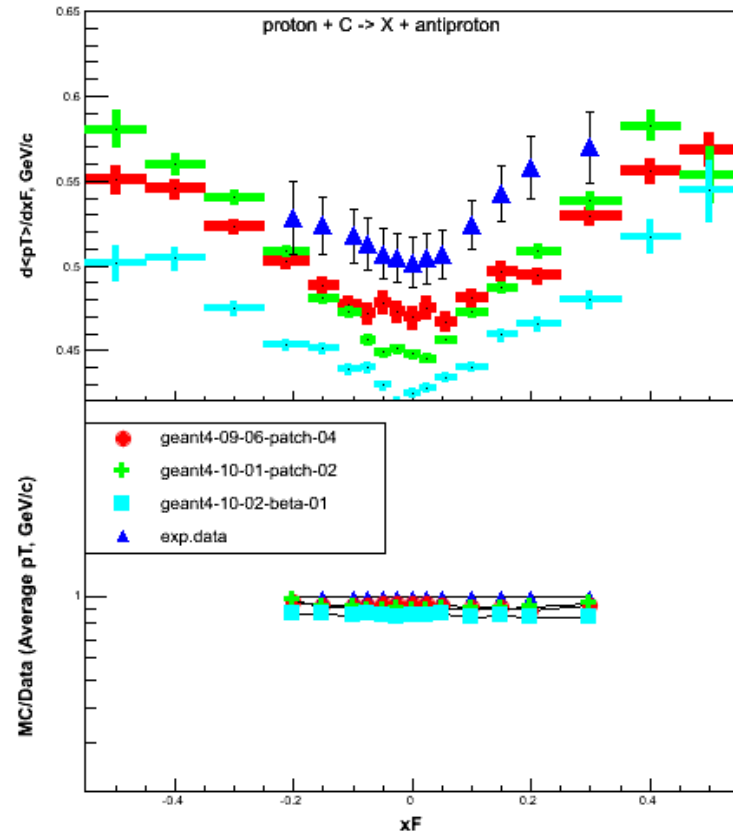
$\chi^2/\text{NDF} = 171.15$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/\text{NDF} = 121.335$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/\text{NDF} = 195.116$ for geant4-10-02-beta-01 vs NA49 Data

QGSP: 158GeV/c p+C -> pbar+X

NA49 Data: <http://spshadrons.web.cern.ch/spshadrons>



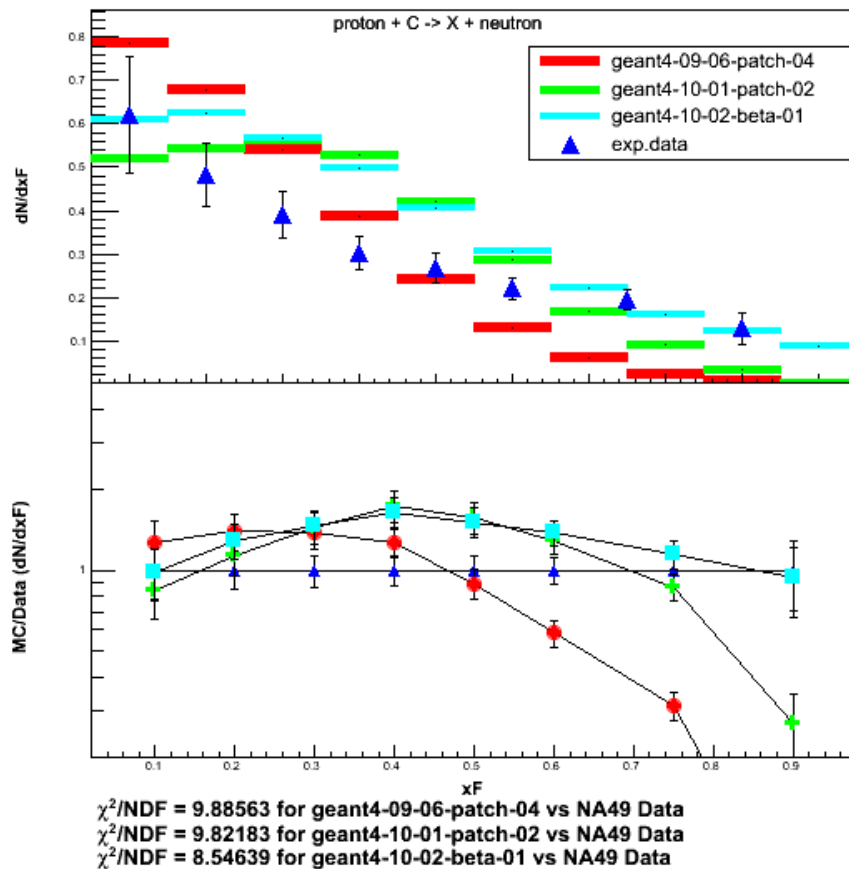
$\chi^2/\text{NDF} = 234.989$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/\text{NDF} = 510.46$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/\text{NDF} = 293.146$ for geant4-10-02-beta-01 vs NA49 Data



$\chi^2/\text{NDF} = 5.27085$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/\text{NDF} = 9.90636$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/\text{NDF} = 23.8635$ for geant4-10-02-beta-01 vs NA49 Data

QGSP: 158GeV/c p+C -> n+X

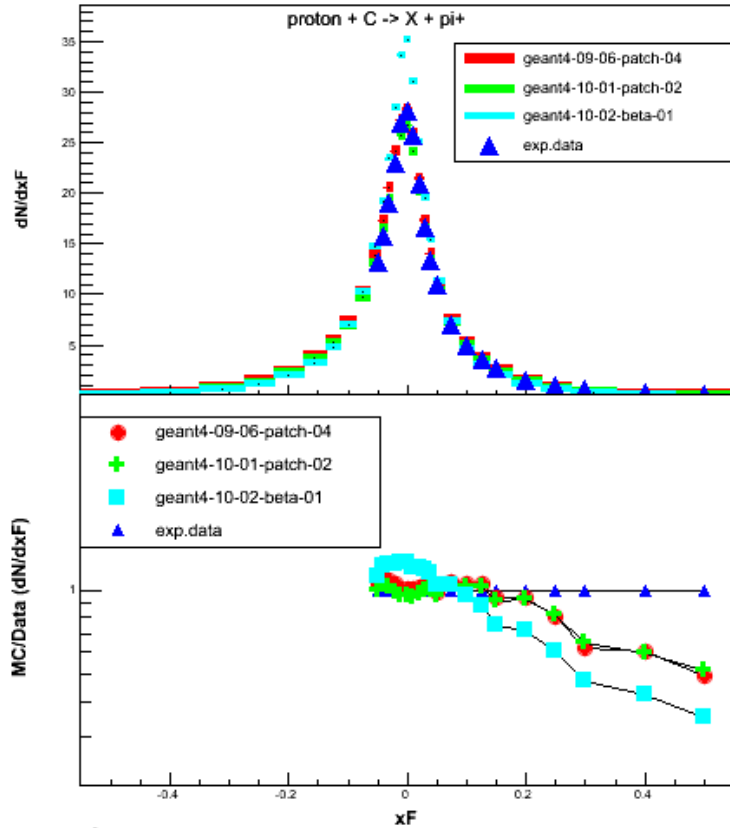
NA49 Data: <http://spshadrons.web.cern.ch/spshadrons>



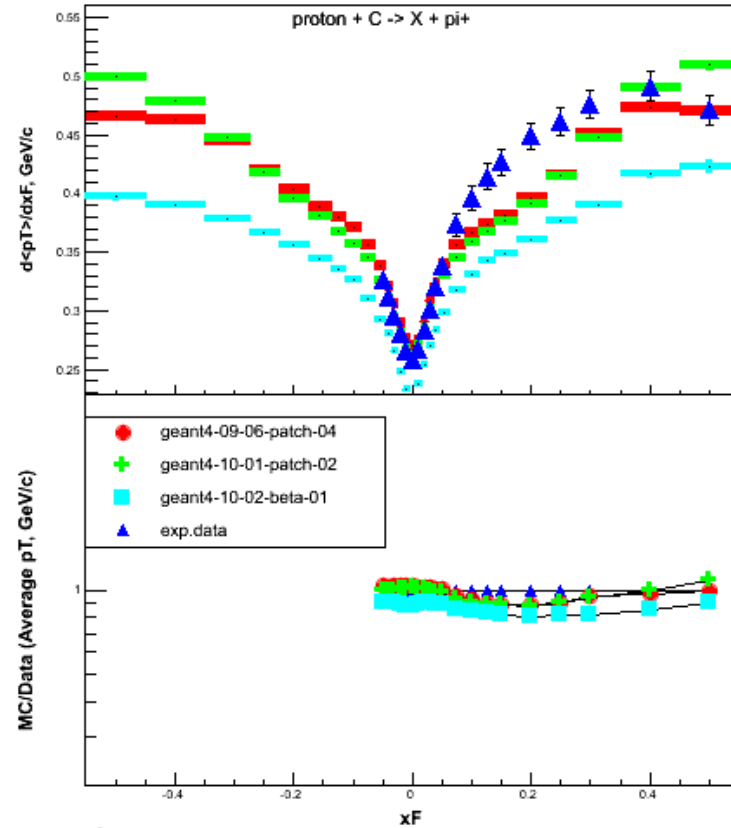
- RESULTS IN THE FOLLOWING SIDES ARE BY A COMBINATION OF **QGS(P)+G4LundStringFragmentation**
- Back in the 9.6 series it appeared that this combination delivers results that closest to the data at higher energies, e.g. 158GeV, while at 31GeV use of G4LundStringFragmentation did not seem to improve the agreement with the data
- In the 10.0/10.1 series, changes have been made to G4LundStringFragmentation (in connection to FTF development)
- Only results for 158 GeV/c p+C are included in this report
- Results for 31 GeV/c p+C are as discouraging as those shown in earlier slides (for traditional QGS(P)+G4QGSMFragmentation)

QGSP+G4Lund: 158GeV/c p+C -> π^+ +X

NA49 Data: <http://spshadrons.web.cern.ch/spshadrons>



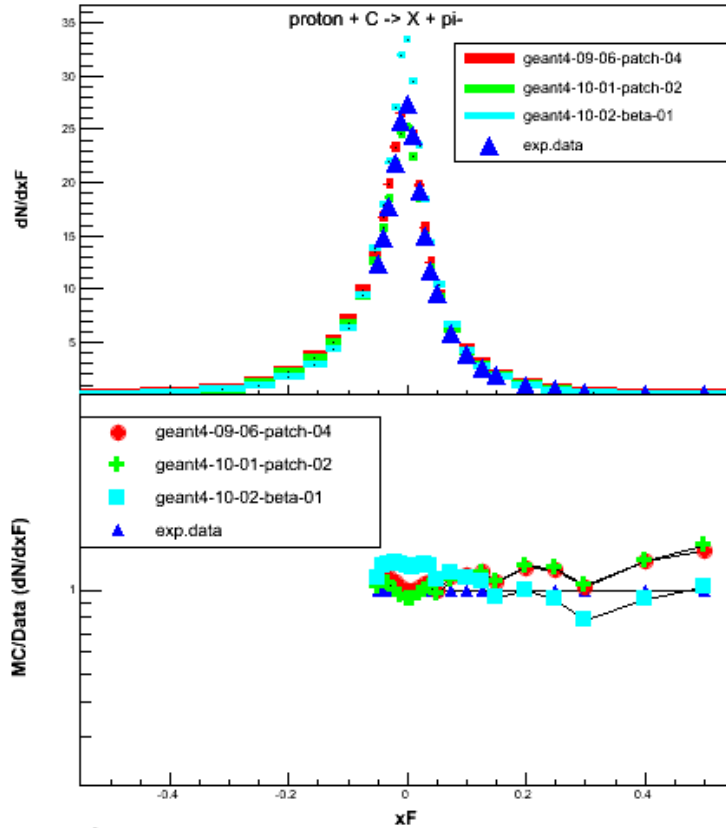
$\chi^2/NDF = 40.569$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/NDF = 36.8519$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/NDF = 121.499$ for geant4-10-02-beta-01 vs NA49 Data



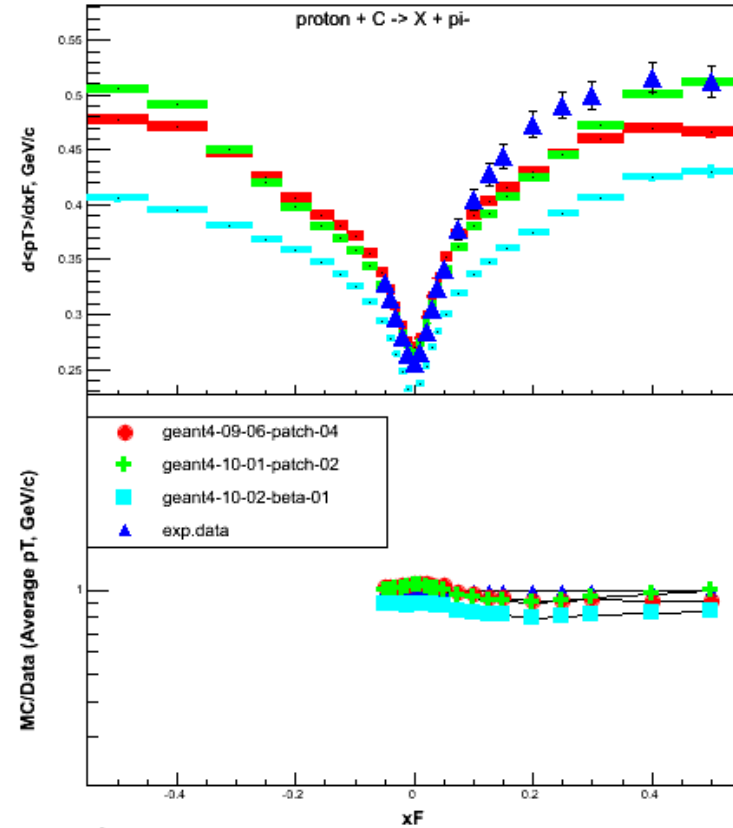
$\chi^2/NDF = 5.13675$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/NDF = 5.96156$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/NDF = 29.9472$ for geant4-10-02-beta-01 vs NA49 Data

QGSP+G4Lund: 158GeV/c p+C -> π^- +X

NA49 Data: <http://spshadrons.web.cern.ch/spshadrons>



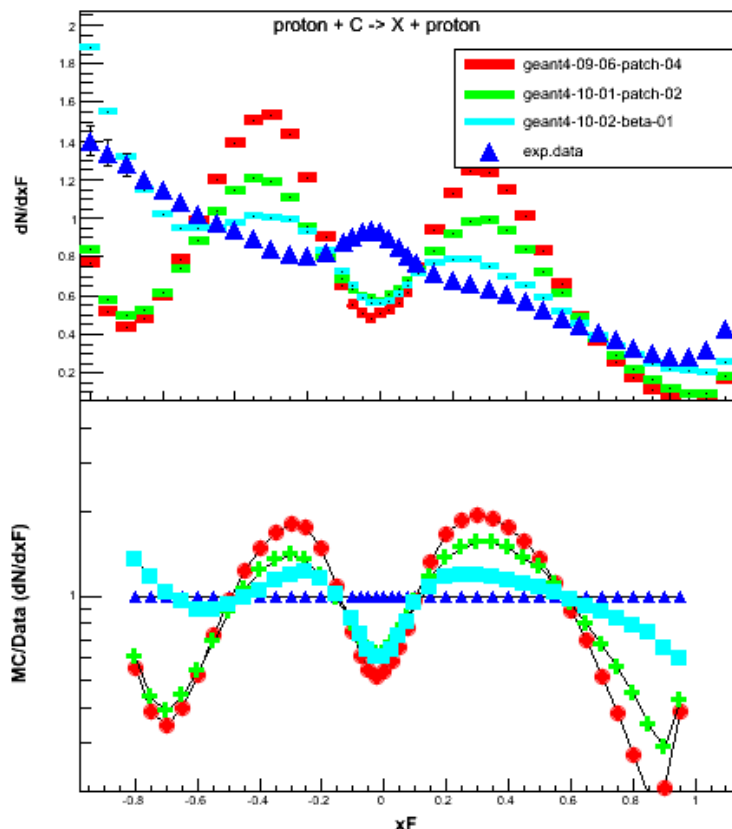
$\chi^2/NDF = 22.4302$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/NDF = 21.3832$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/NDF = 43.5655$ for geant4-10-02-beta-01 vs NA49 Data



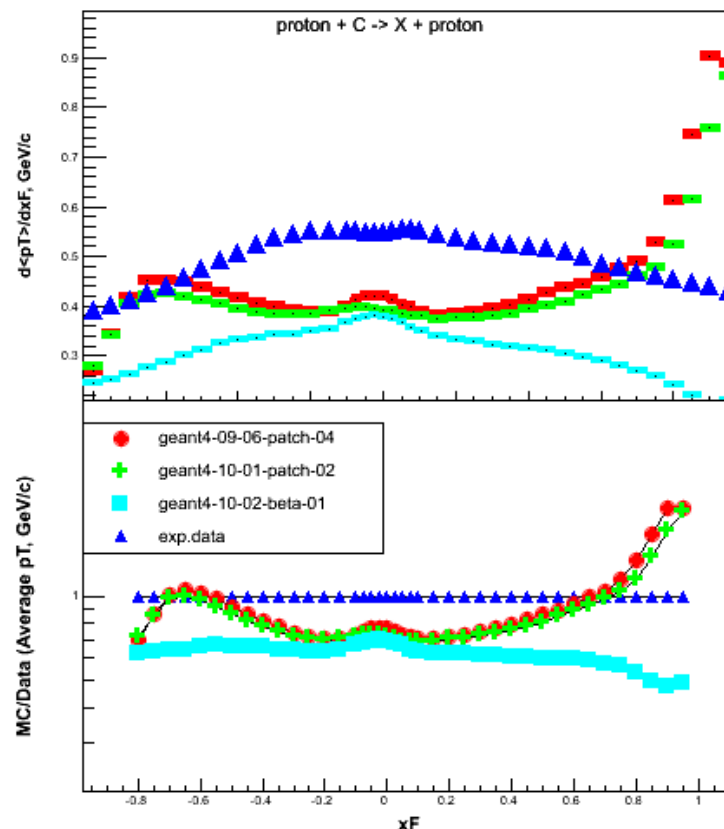
$\chi^2/NDF = 4.91784$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/NDF = 3.57276$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/NDF = 33.6931$ for geant4-10-02-beta-01 vs NA49 Data

QGSP+G4Lund: 158GeV/c p+C -> p+X

NA49 Data: <http://spshadrons.web.cern.ch/spshadrons>



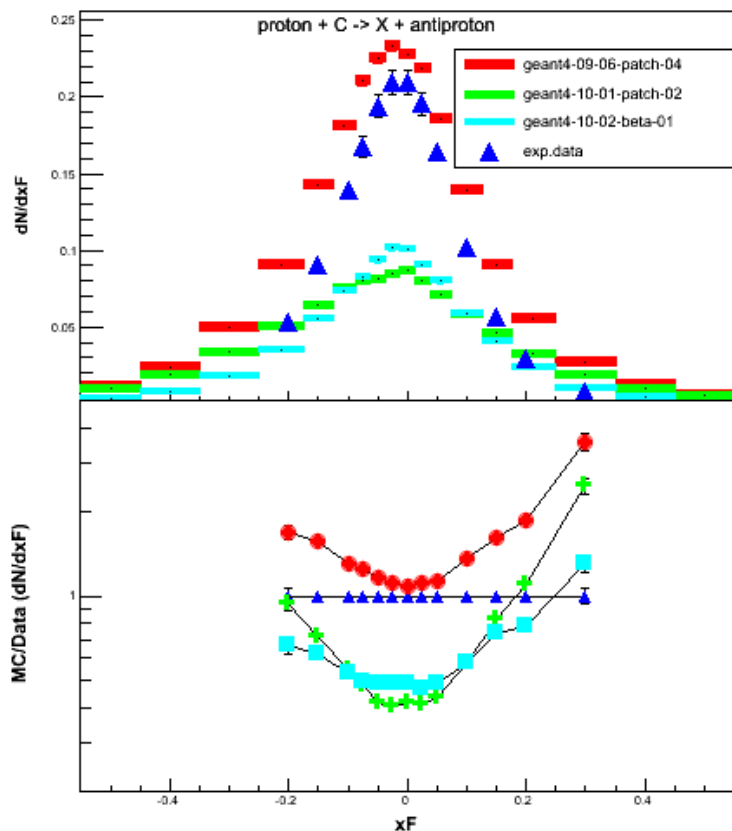
$\chi^2/\text{NDF} = 282.133$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/\text{NDF} = 125.701$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/\text{NDF} = 40.4869$ for geant4-10-02-beta-01 vs NA49 Data



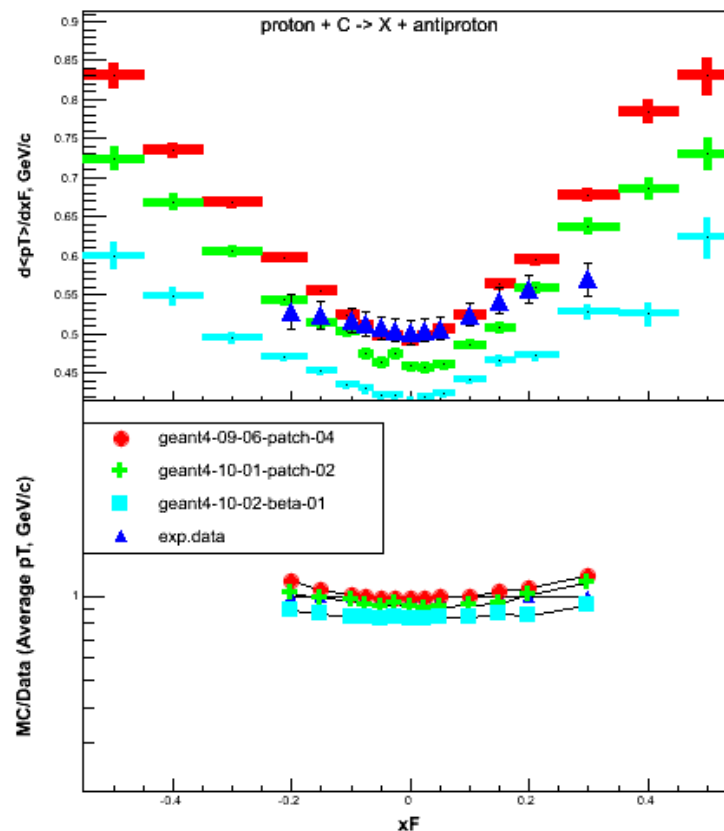
$\chi^2/\text{NDF} = 136.048$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/\text{NDF} = 122.603$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/\text{NDF} = 203.277$ for geant4-10-02-beta-01 vs NA49 Data

QGSP+G4Lund: 158GeV/c p+C -> pbar+X

NA49 Data: <http://spshadrons.web.cern.ch/spshadrons>



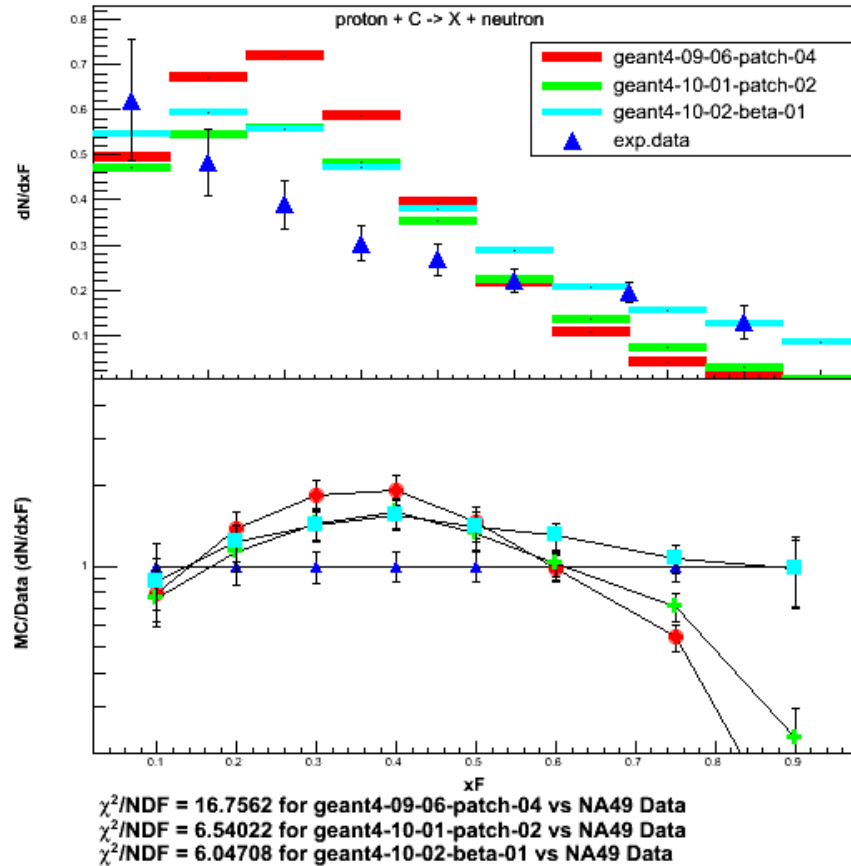
$\chi^2/\text{NDF} = 126.273$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/\text{NDF} = 151.297$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/\text{NDF} = 117.101$ for geant4-10-02-beta-01 vs NA49 Data



$\chi^2/\text{NDF} = 3.25397$ for geant4-09-06-patch-04 vs NA49 Data
 $\chi^2/\text{NDF} = 4.71739$ for geant4-10-01-patch-02 vs NA49 Data
 $\chi^2/\text{NDF} = 23.2734$ for geant4-10-02-beta-01 vs NA49 Data

QGSP+G4Lund: 158GeV/c p+C -> nbar+X

NA49 Data: <http://spshadrons.web.cern.ch/spshadrons>



Summary of Geant4.10.1.p02 and Geant4.10.2.b01 Validation

- No major changes in Bertini, Binary, or INCLXX
- Changes in FTF discussed in earlier meetings (ref05 summary, etc.)
- Multiple changes in QGS as of 10.2.b01
 - Apparently multiple changes in the core code
 - Tuning is still in progress (?)
 - Results substantially degrade (deviate from thin target data)

- All results are publicly available:

<http://g4devel.fnal.gov:8080/G4WebAppNG>