Validation of Geant4 Hadronic Models at High Energies

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Simulation Validation meeting

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  - NA49: p + p/C → $\pi^{\pm}$ + X, 158 GeV/c
  - NA22: π/K + Al/Au → x^{+} + X, 250 GeV/c
  - Omega: $\pi^{+/-}$ + p → π^{0} + X, 140 GeV/c
  - E592: p + Ta → π^{+} +X, 400 GeV/c
- Several more are planned

- Geant4 version 9.2 beta01

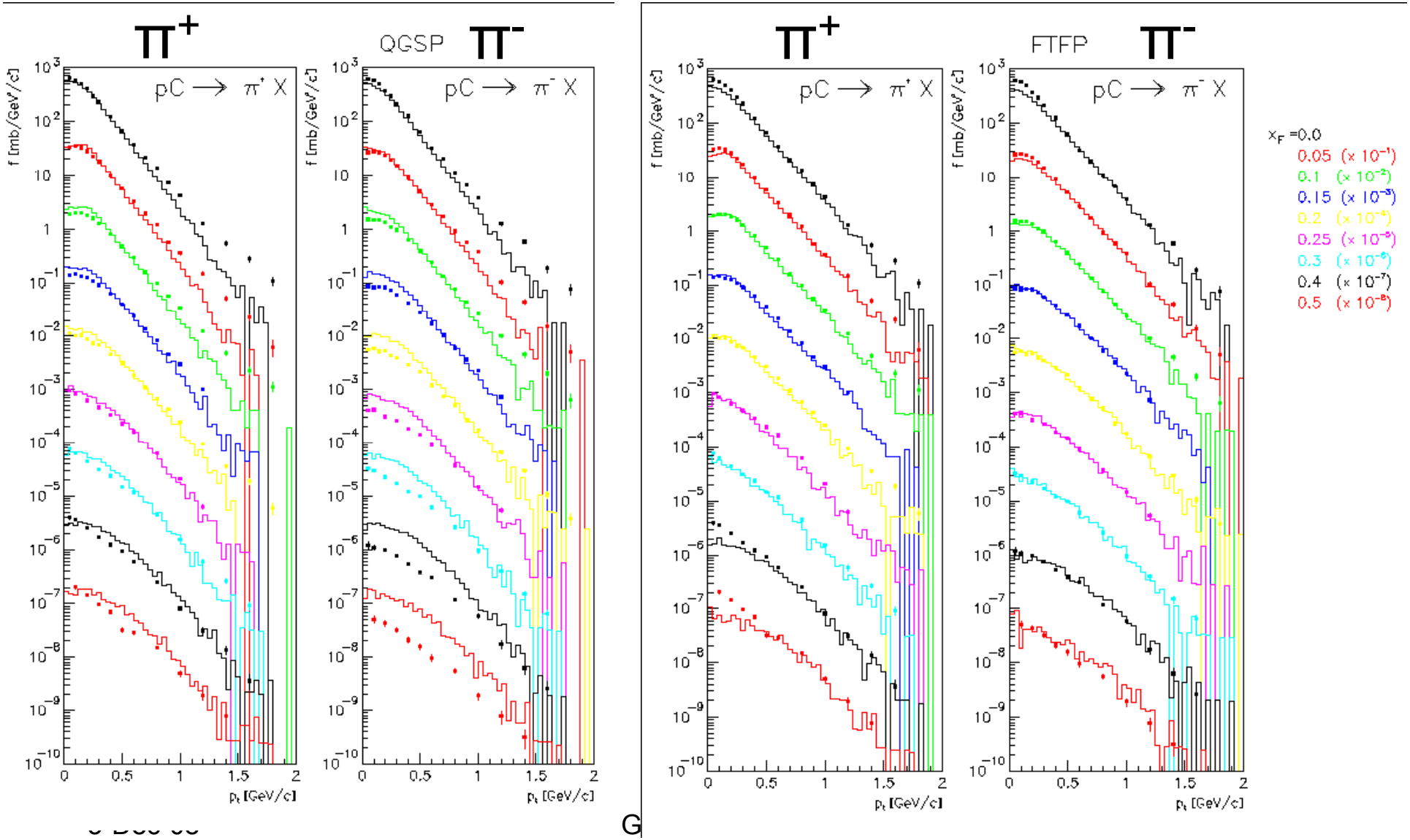
Motivation

- Geant4 offers several models for inelastic interaction at high energies (> 10-20 GeV)
  - Two theory inspired models, QGS and FTF
  - Parameterized model
- Validation of these models against experimental data is important
  - Thin target data allow to directly compare to model prediction
- Many experimental data are available
  - Selected a subset covering a range of observables and particles

Data(1)

- Data from NA49 on p + C → $\pi^{\pm}$ + X, at 158GeV/c beam momentum
  - Eur. Phys. J. C49, 897-917 (2007)
  - A large dataset of high precision data
  - Double differential cross section as function of x_F and p_T
  - Production cross section for pions vs p_T for a set of x_F

Na49 compared to QGS and new FTF



Data(2)

- EHS-NA22: pi+ / K+ scattering off Al or Au at 250 GeV/c
  - Z.Phys. C50, p361-371 (1991)
- Rapidity distribution for positive particles, starting at momenta ~190 MeV/c
  - part of (grey) protons (190-1200 MeV/c) from nuclear de-excitation included in selected distributions
    - Allows to validate nuclear de-excitation model
      - Cascade vs Precompound model

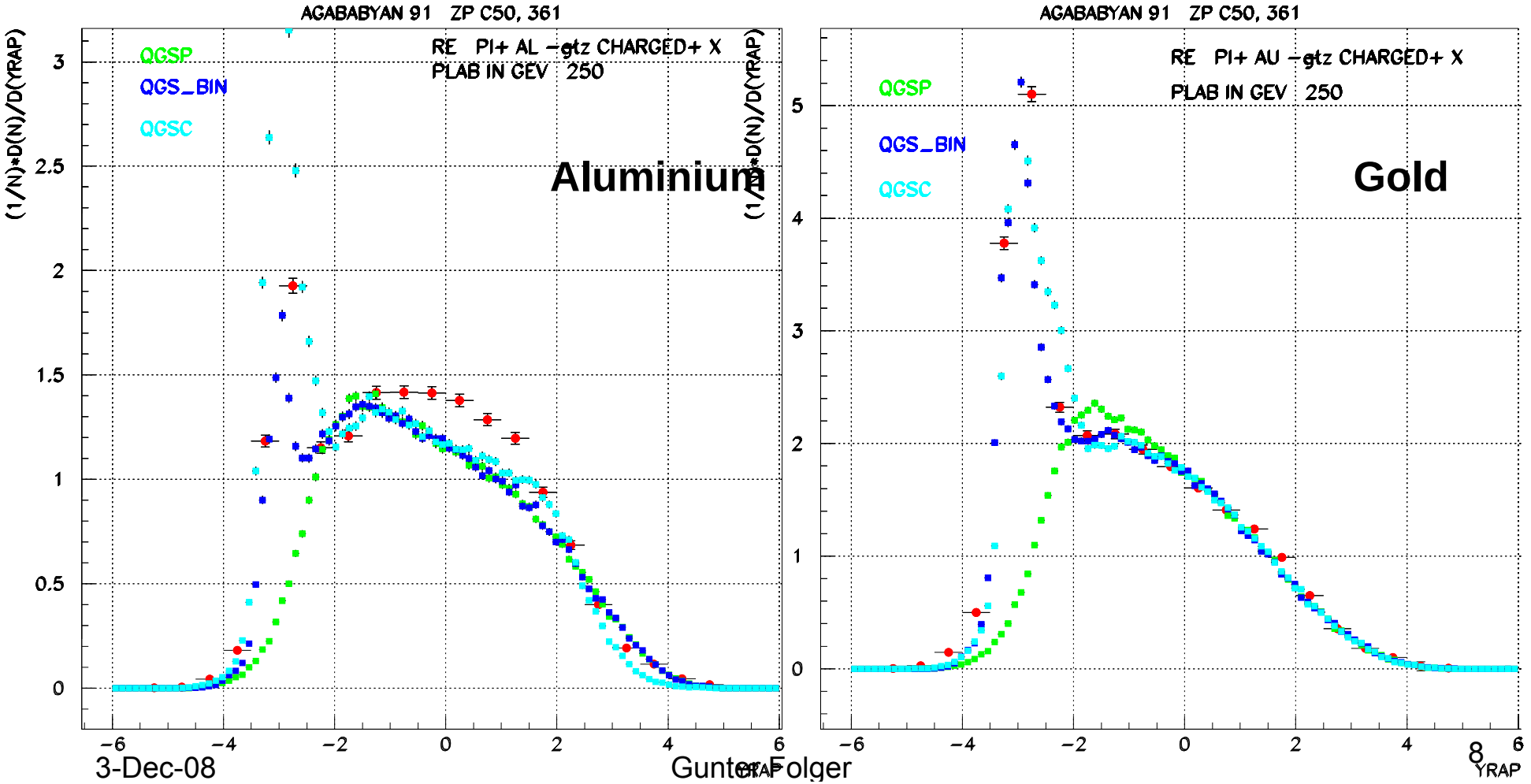
Where differ
QGSP, QGSC, QGS_BIN

- QGSP
  - QGS string model
  - Followed by nuclear deexciation using precomcpound
    - ~20 MeV excitation energy per wounded nucleon
- QGSC
  - QGS string model
  - Followed by Chips model to simulate “low energy” part of interacion
    - Re-absorbe some part of particles produced in QGS to get energy in nucleus (~1 GeV / fermi, as funtcion of impact parameter)
- QGS_BIN
  - QGS string model
  - Followed by Binary cascade for nuclear de-excitation
    - Uses formation time and coordinates of QGS
    - Particles formed within the wounded nucleus can re-scatter, increasing multiplicity of emitted nucleons.

- Equivalent for FTFP and FTF_BIN.

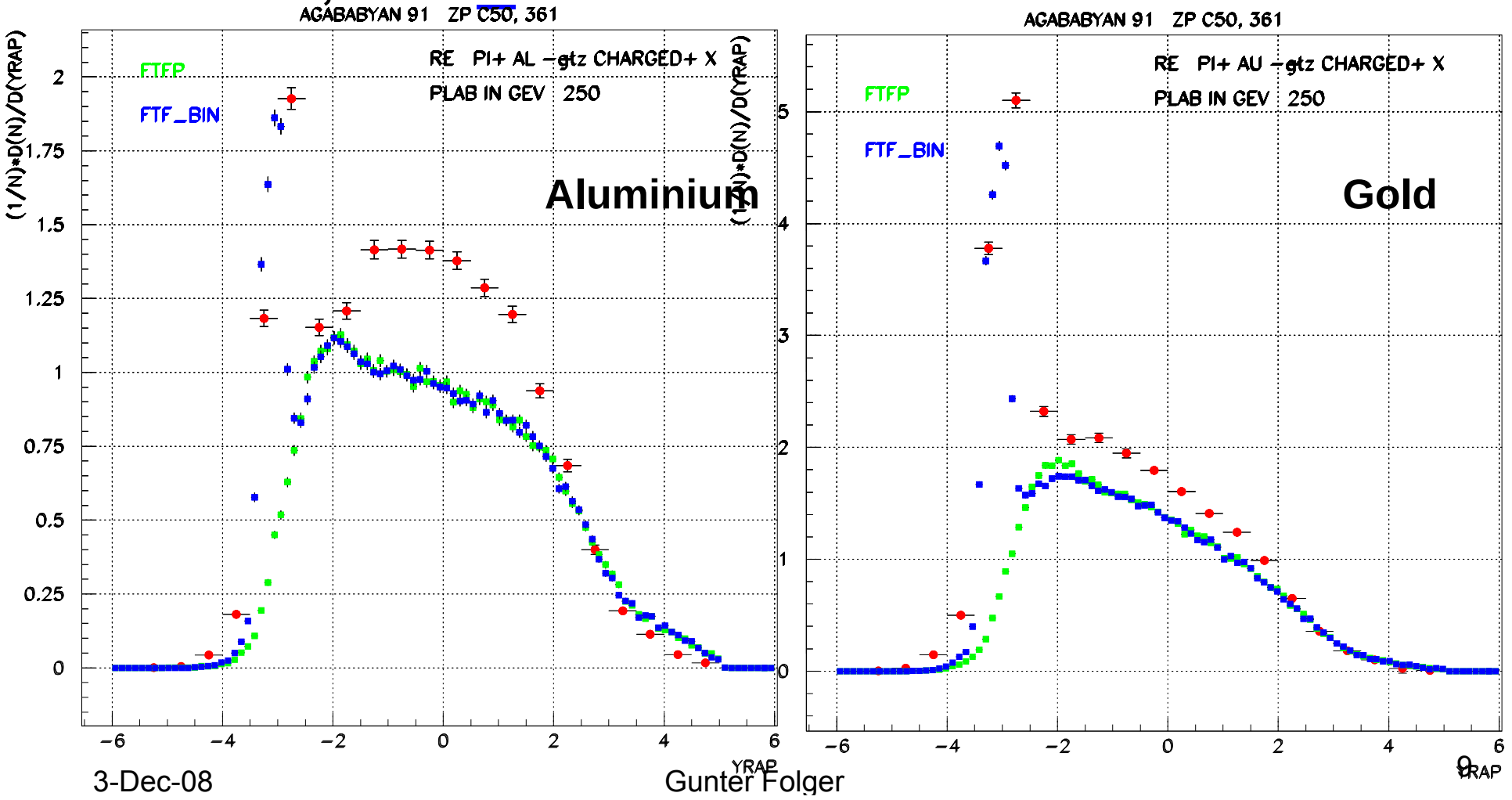
Na22 compared to QGS

- QGSP, QGSC, and QGS_BIN



NA22 compared to FTF model

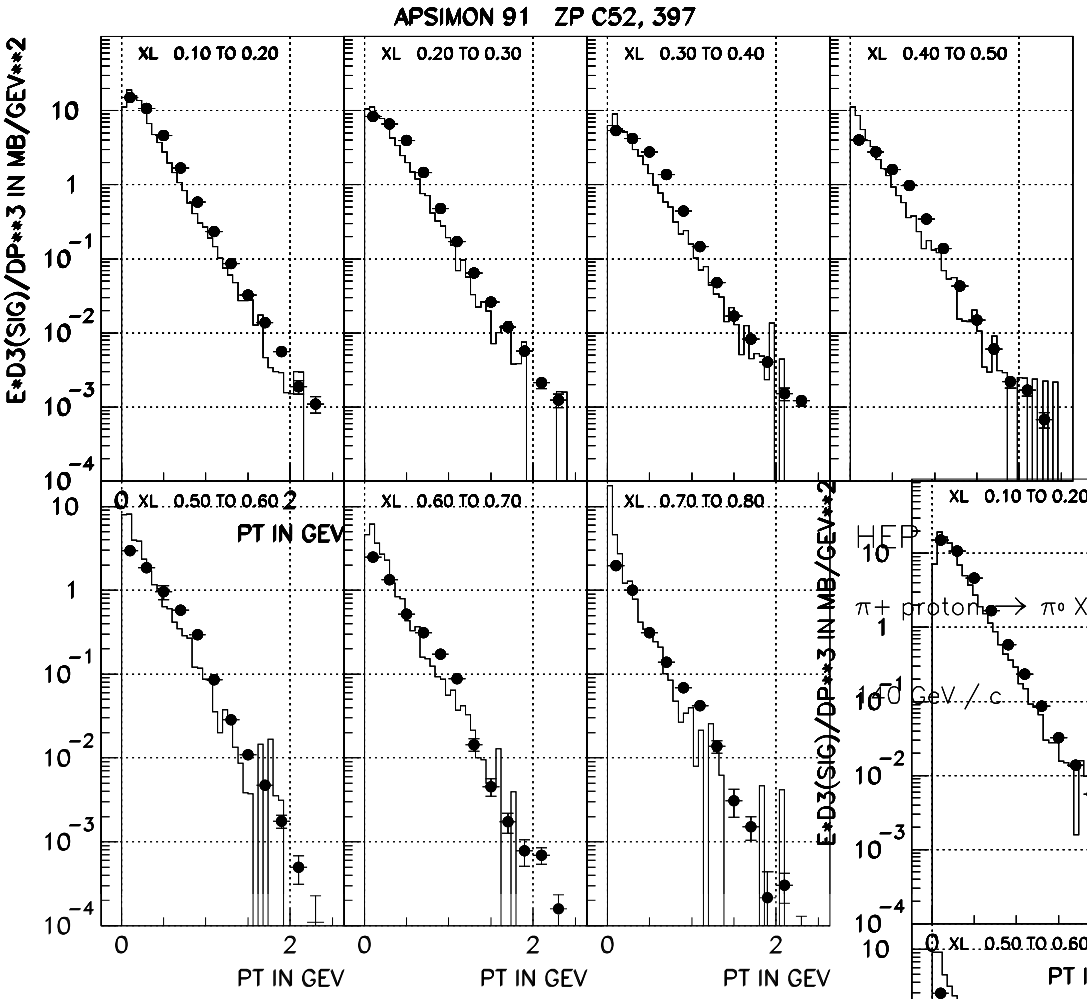
- FTFP, FTF_BIC



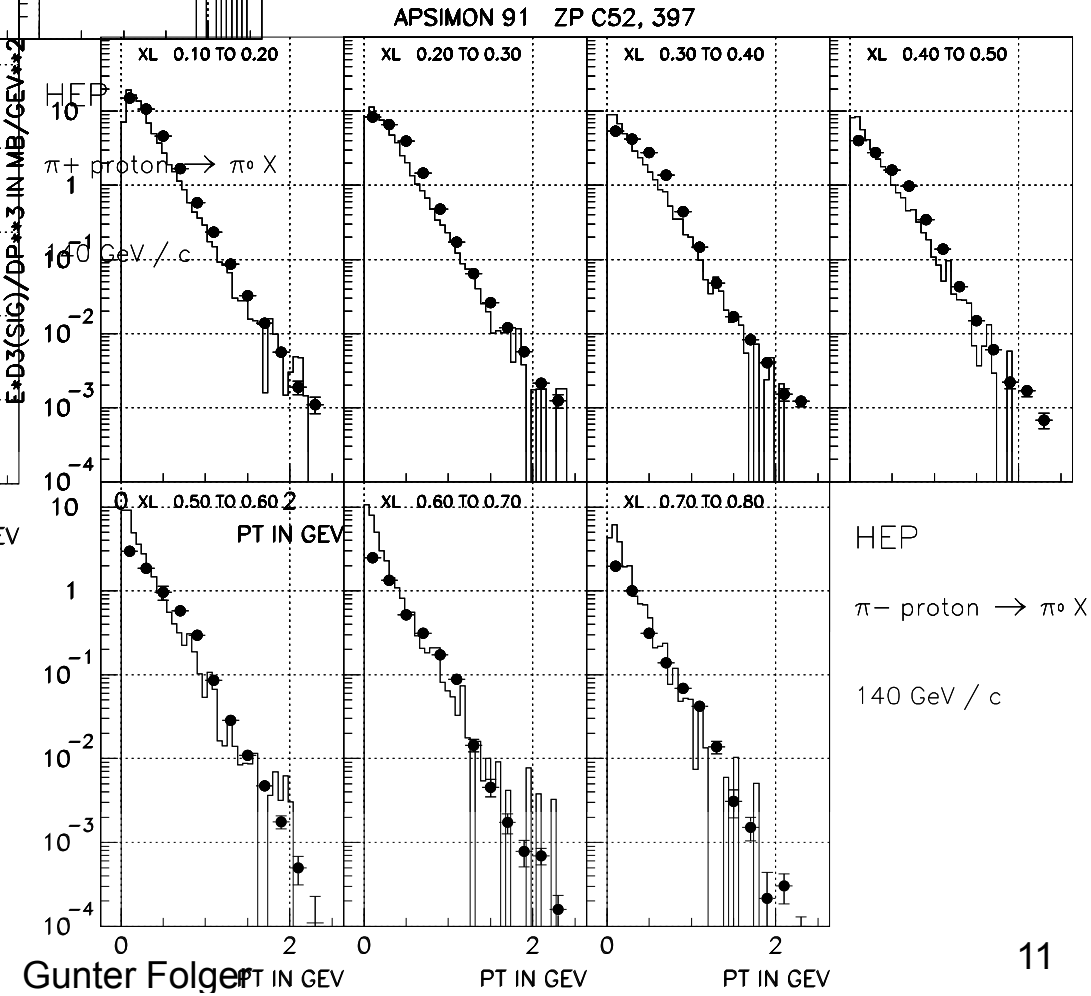
Omega

- Omega Photon Collaboration:
- π^0 production cross section for $\pi^{+/-}$ scattering off Hydrogen at 140 GeV/c
  - Z. Phys. C 52, 397-405 (1991)
  - Data is summed for π^+ and π^-
    - "no difference seen"
- Hadronic shower simulation is sensitive to π^0 production (response, shape)

Parameterized model (HEP)

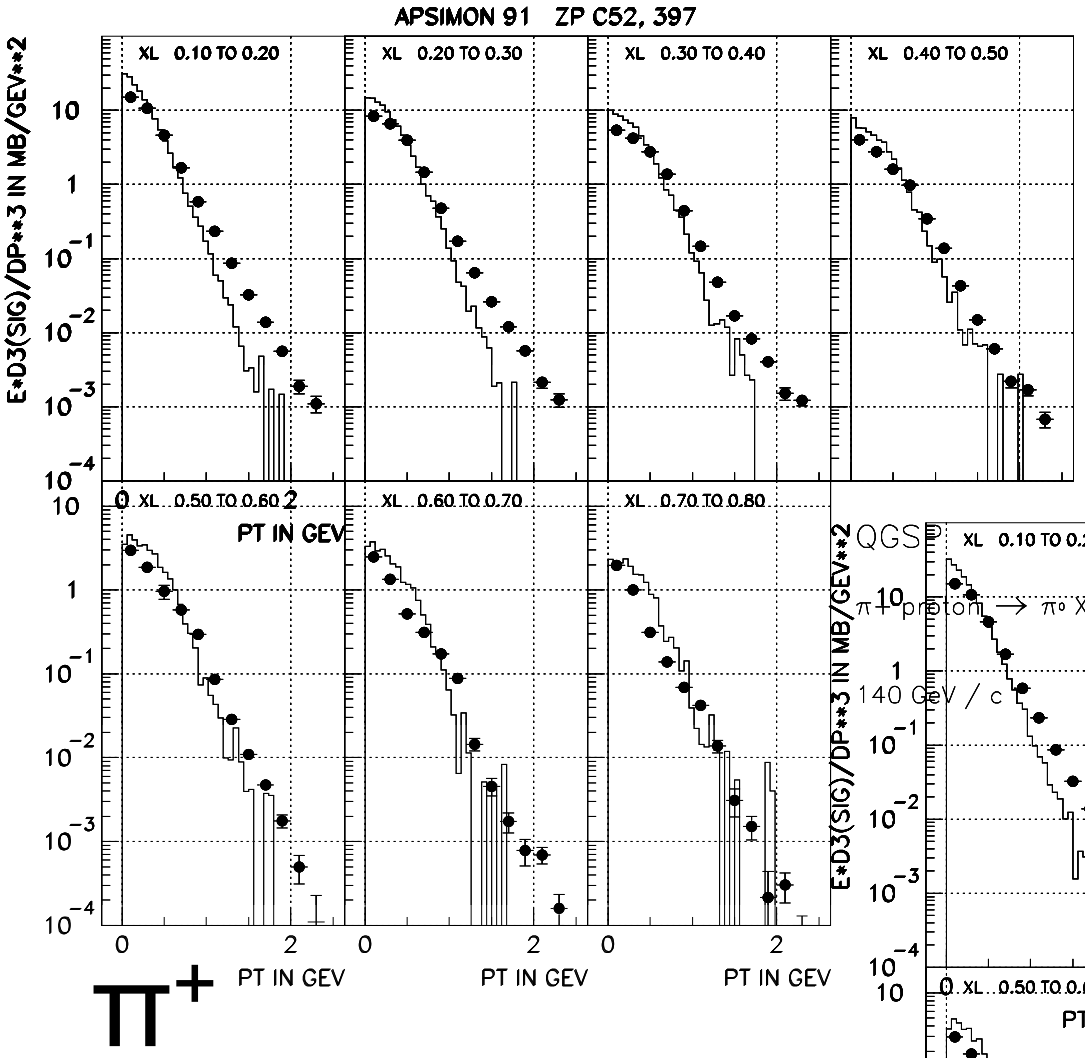


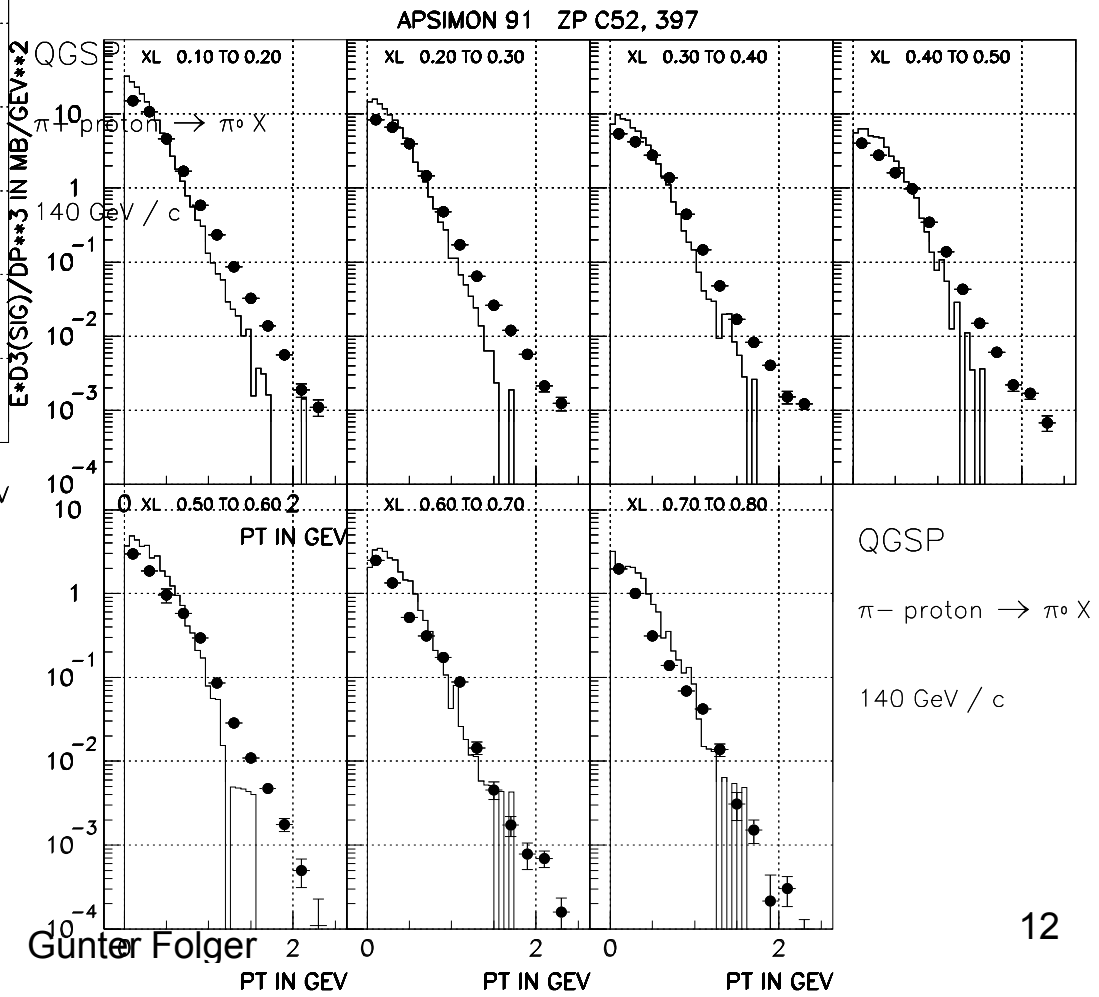
π^+



π^-

QGS model


APSIMON 91 ZP C52, 397
XL 0.10 TO 0.20
XL 0.20 TO 0.30
XL 0.30 TO 0.40
XL 0.40 TO 0.50
XL 0.50 TO 0.60
XL 0.60 TO 0.70
XL 0.70 TO 0.80
E*D3(SIG)/DP**3 IN MB/GEV**2
PT IN GEV
π+


APSIMON 91 ZP C52, 397
QGSP
π+ proton → π0 X
140 GeV / c
XL 0.10 TO 0.20
XL 0.20 TO 0.30
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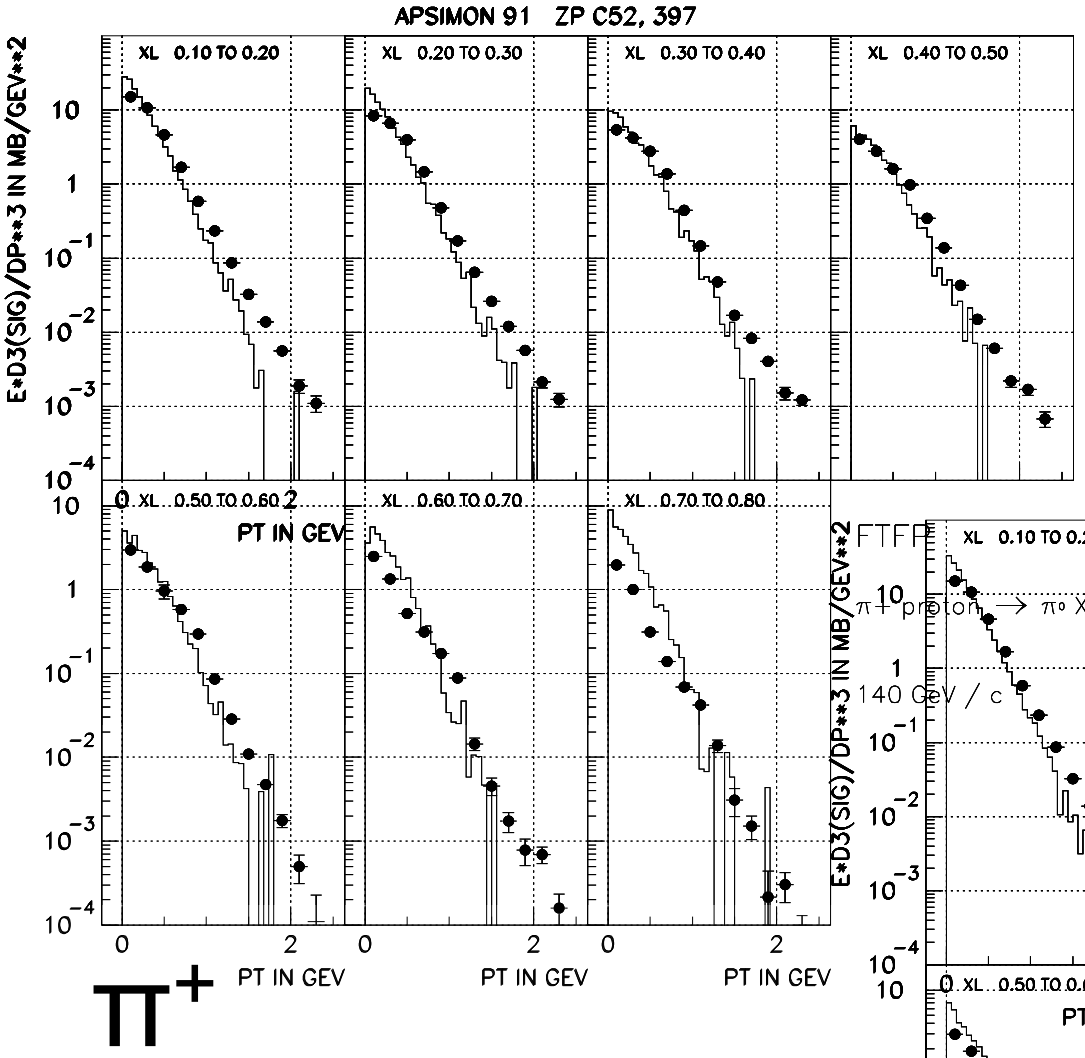
XL 0.70 TO 0.80
E*D3(SIG)/DP**3 IN MB/GEV**2
PT IN GEV
QGSP
π− proton → π0 X
140 GeV / c
π−

FTF model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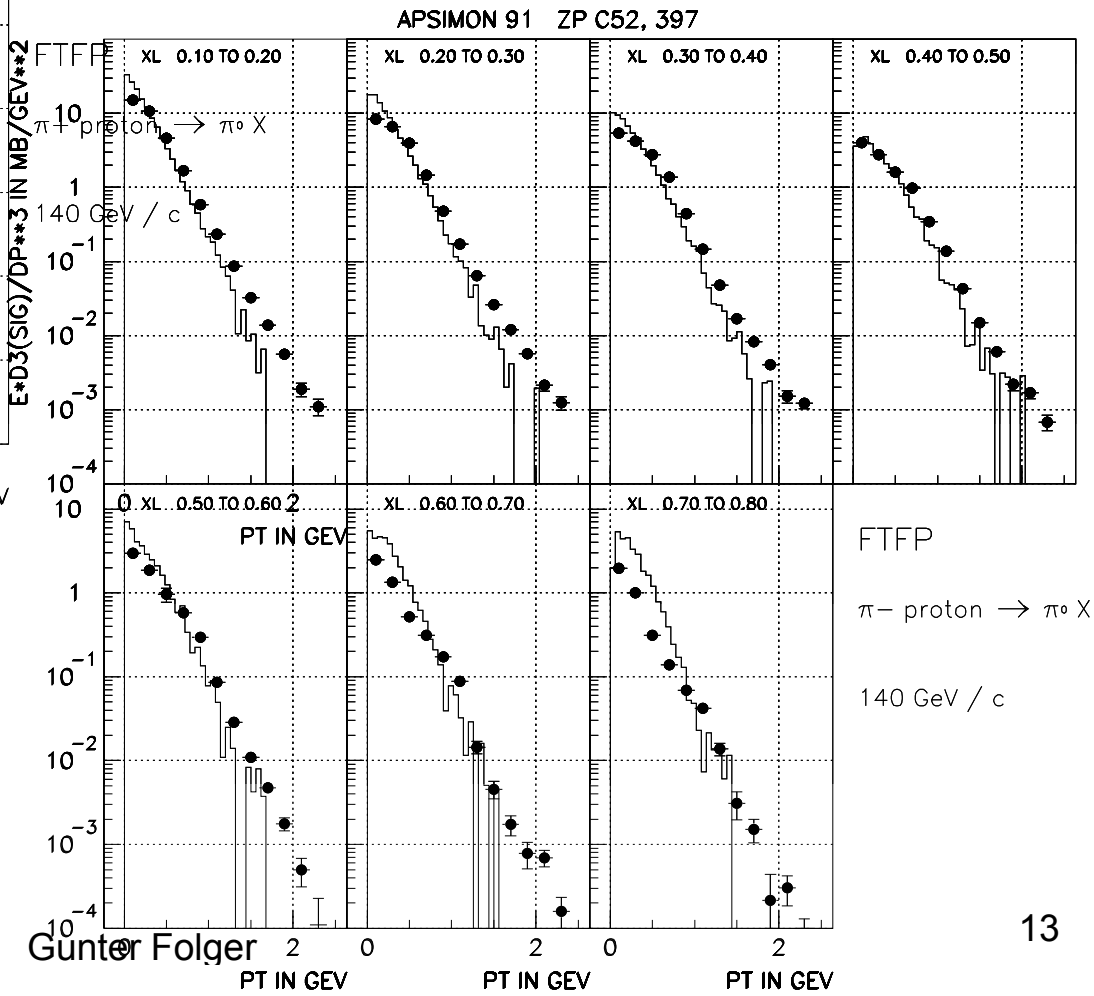
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140 GeV / c
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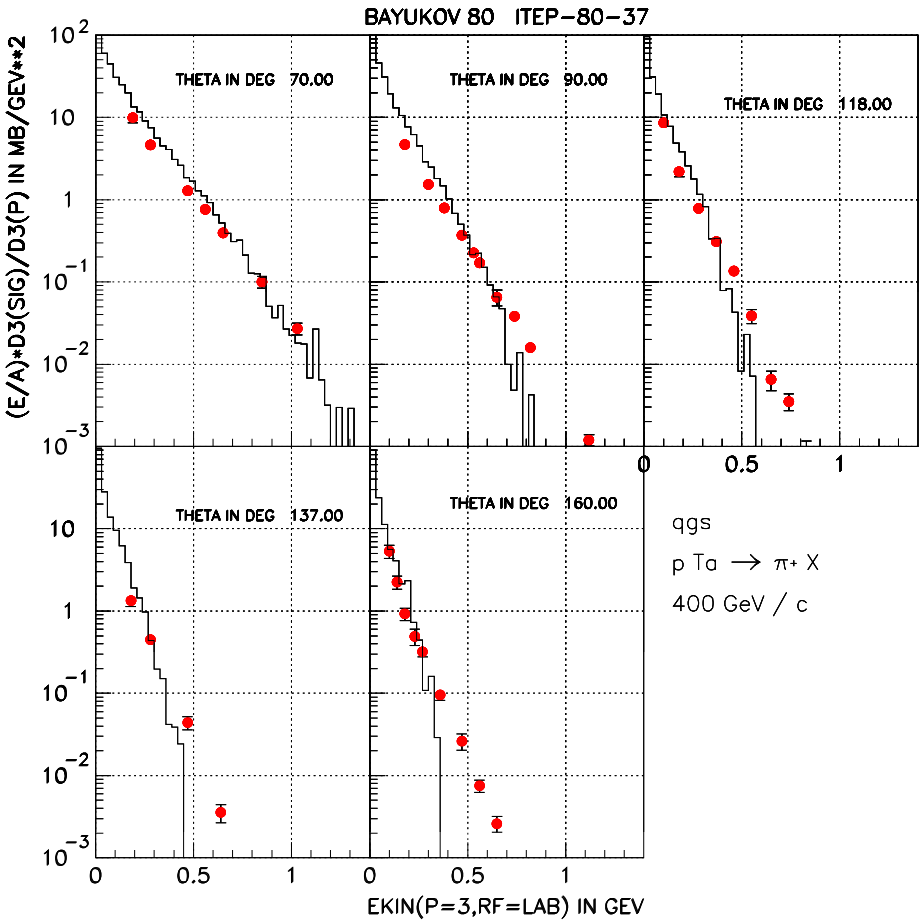
E*D3(SIG)/DP**3 IN MB/GEV**2
PT IN GEV
FTFP
π− proton → π0 X
140 GeV / c
π−

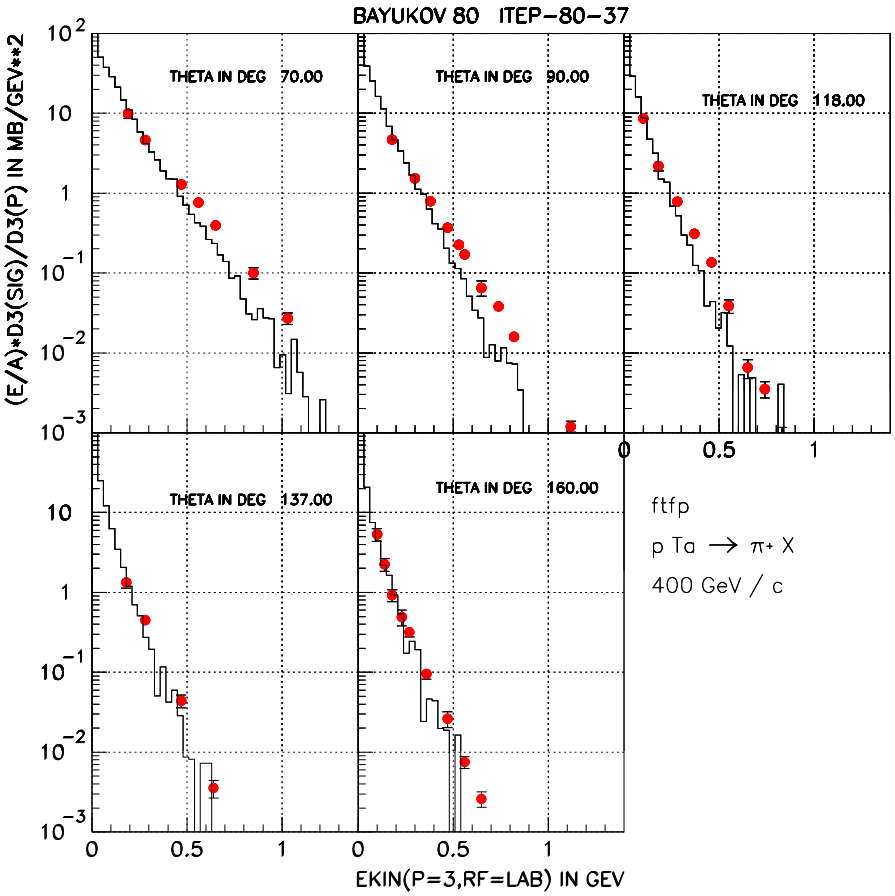
Data(4)

- E592 collaboration
- p + Ta → $\pi^{+/-}$ + X, 400 GeV/c
  - ITEP-80-37, Phys.Rev. C22, 700-710, (1980)
  - Cross section as function of kinetic energy for secondary pions under scattering angles between 70° and 160°



QGS model

FTF model



Summary

- Validation of Geant4 models (QGS, FTF) against thin target experiments has been done
  - Various combinations of primary and secondary particle are studied
  - For light and heavy nuclei
  - A range of observables has been analyzed
- Both models give satisfactory agreement with experimental data
- Revised FTF gives better overall description of data