Preliminary Results from Benchmarking FTF Simulation vs FNAL SAS M6E Data
- Work in Progress -

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Geant4 Hadronic Group Meeting

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General Information (I)

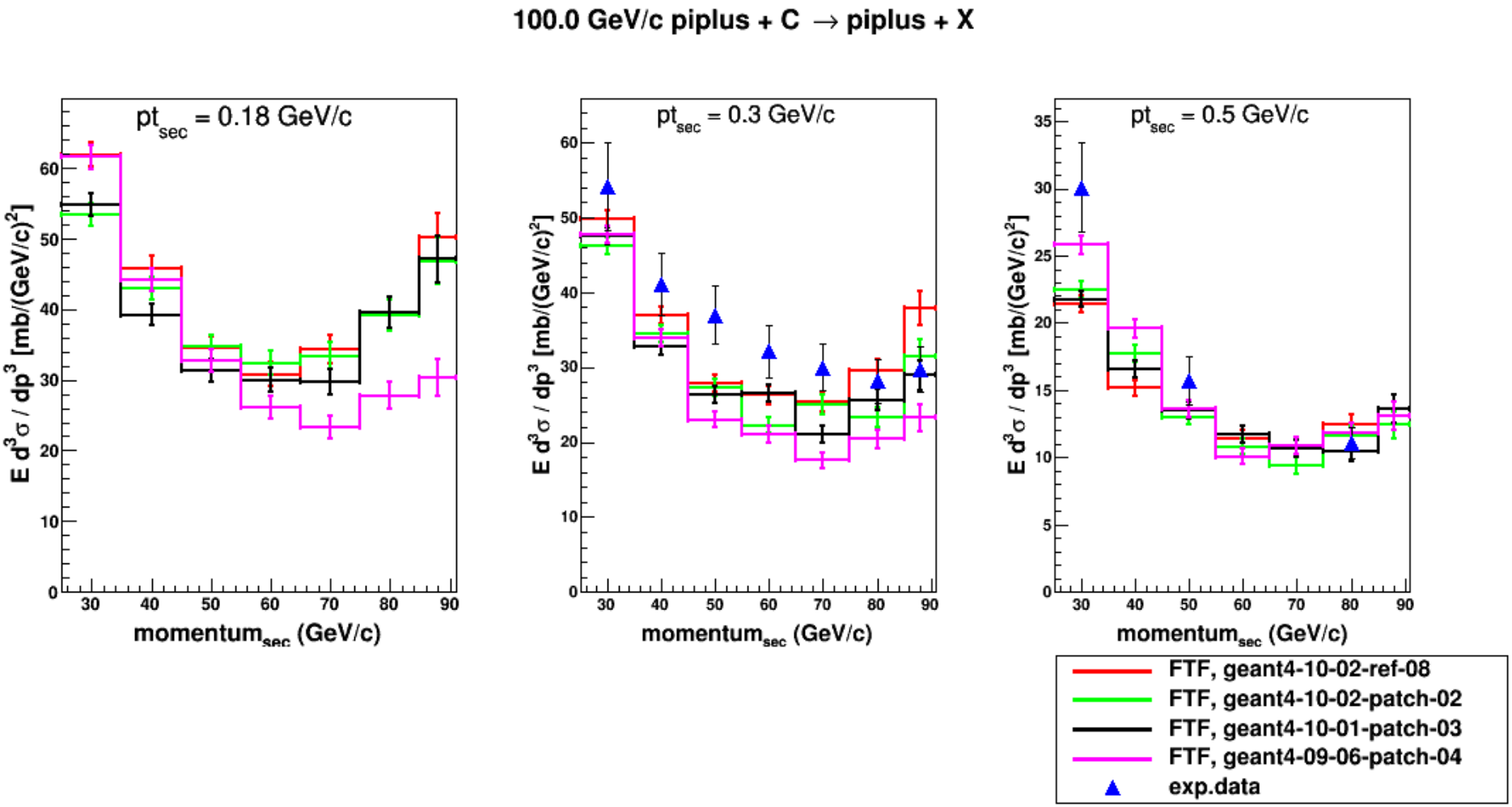
- Expand validation of high energy HAD models (FTF, QGS) by including hadron+A data for heavier targets:
  - Single Arm Spectrometer (SAS) at M6E beamline at FNAL
    - Phys.Rev. D27 (1983) 2580; https://inspirehep.net/record/12592
  - Data for 100GeV/c proton, π^+, K^+ on C, Al, Cu, Ag, Pb target
    - Currently selected subset for C, Cu, Pb since the datasets are fullest
    - Currently using data for π^+ or proton beam
  - Production of $\pi^\pm$, $K^\pm$, proton, antiproton
  - Data are published a momentum spectra of secondary particles, at different values of p_t of the secondary
- NOTE-1: There seem to be data on production of neutral particles by high energy beam, but could not yet find data on π^0 production
- NOTE-2: Data from J.J. Whitmore et al., Z. Phys. C 62, 199-227 (1994), are included in test22 – do we run such validation regularly ?

General Information (II)

- Results are for release 10.2.ref08
- Retroactive validation rounds include 9.6.p04, 10.1.p03, 10.2.p02
- Only FTF is tested in this "reduced" round
  - Obviously, QGS will be included in later rounds
- MC statistics is 100K events per case – relatively large stat.errors
  - Normally, 1M events per case – will be done in the future rounds
  - At present, χ^2 calculations are not included (due to low MC stat.)
- Data are included where available
  - Statistical and systematic (10%) errors are included on the data

100GeV/c π^+ on C,Cu,Pb -> π^+ + X

- Mainly, relatively modest changes in FTF results among 10.x series
- Some appreciable changes as compared to 9.6.p04 but not huge
- Visual agreement between FTF results and the data is OK for all 3 types of targets (C, Cu, or Pb), roughly speaking for all releases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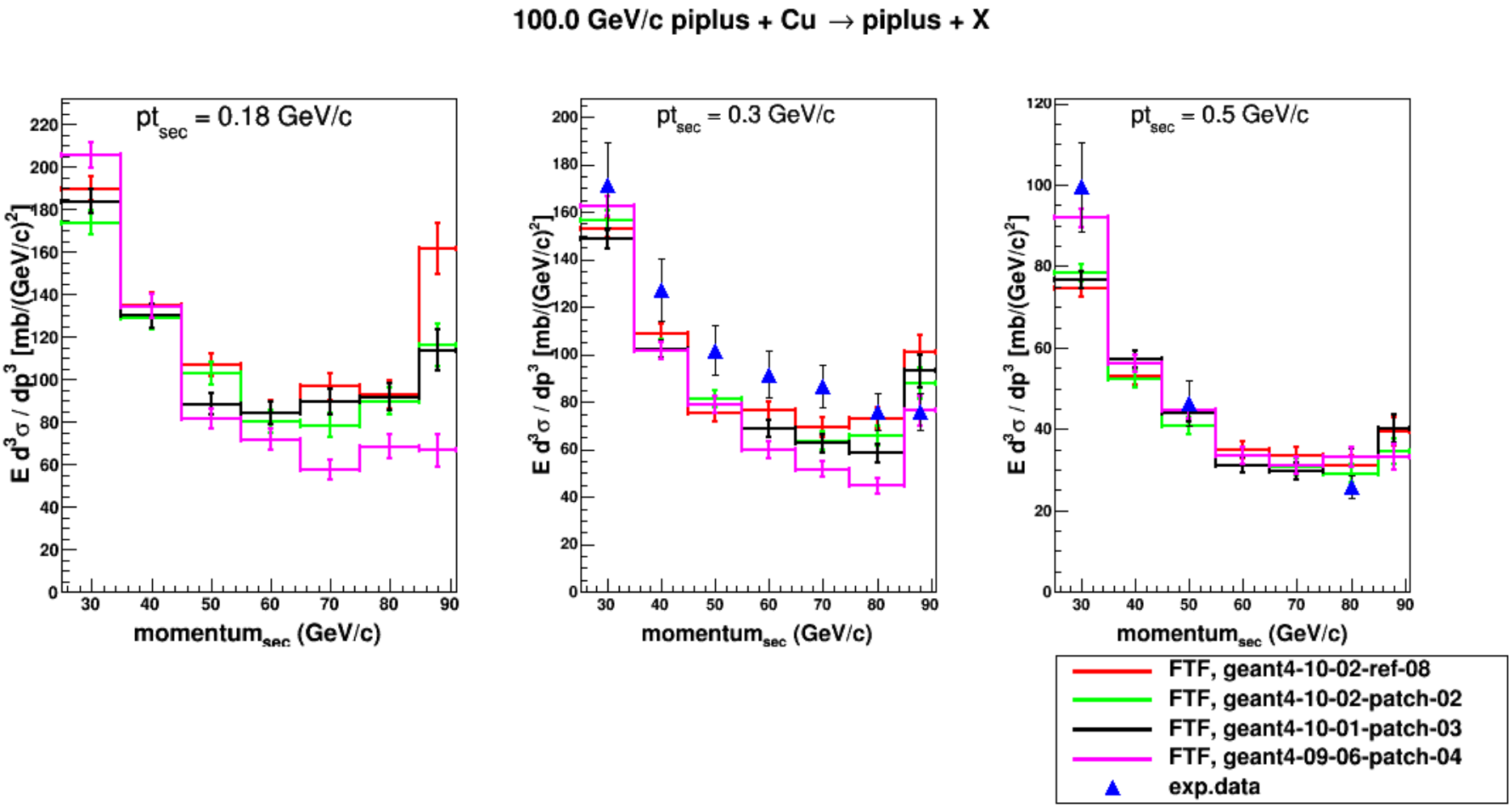
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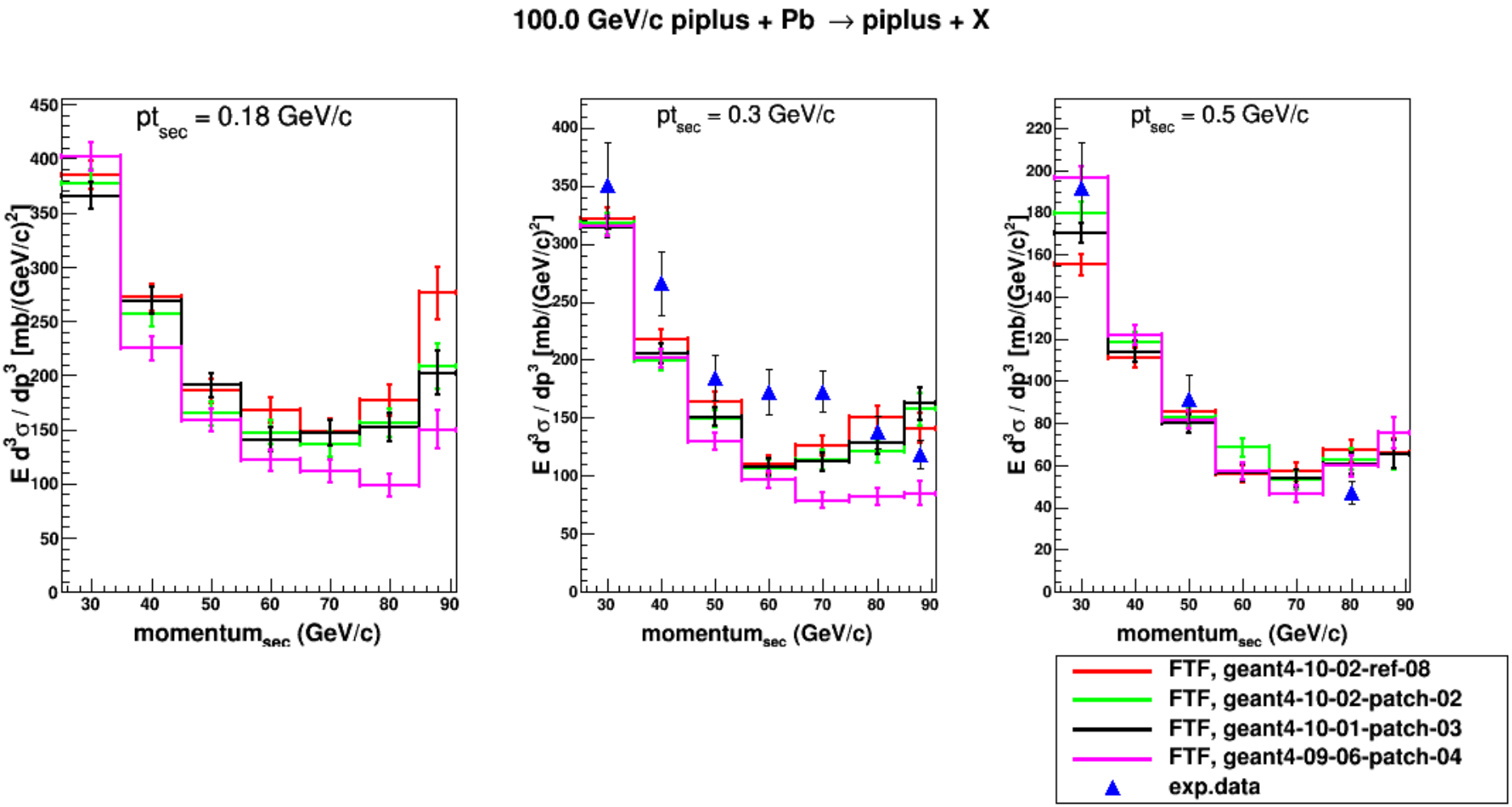
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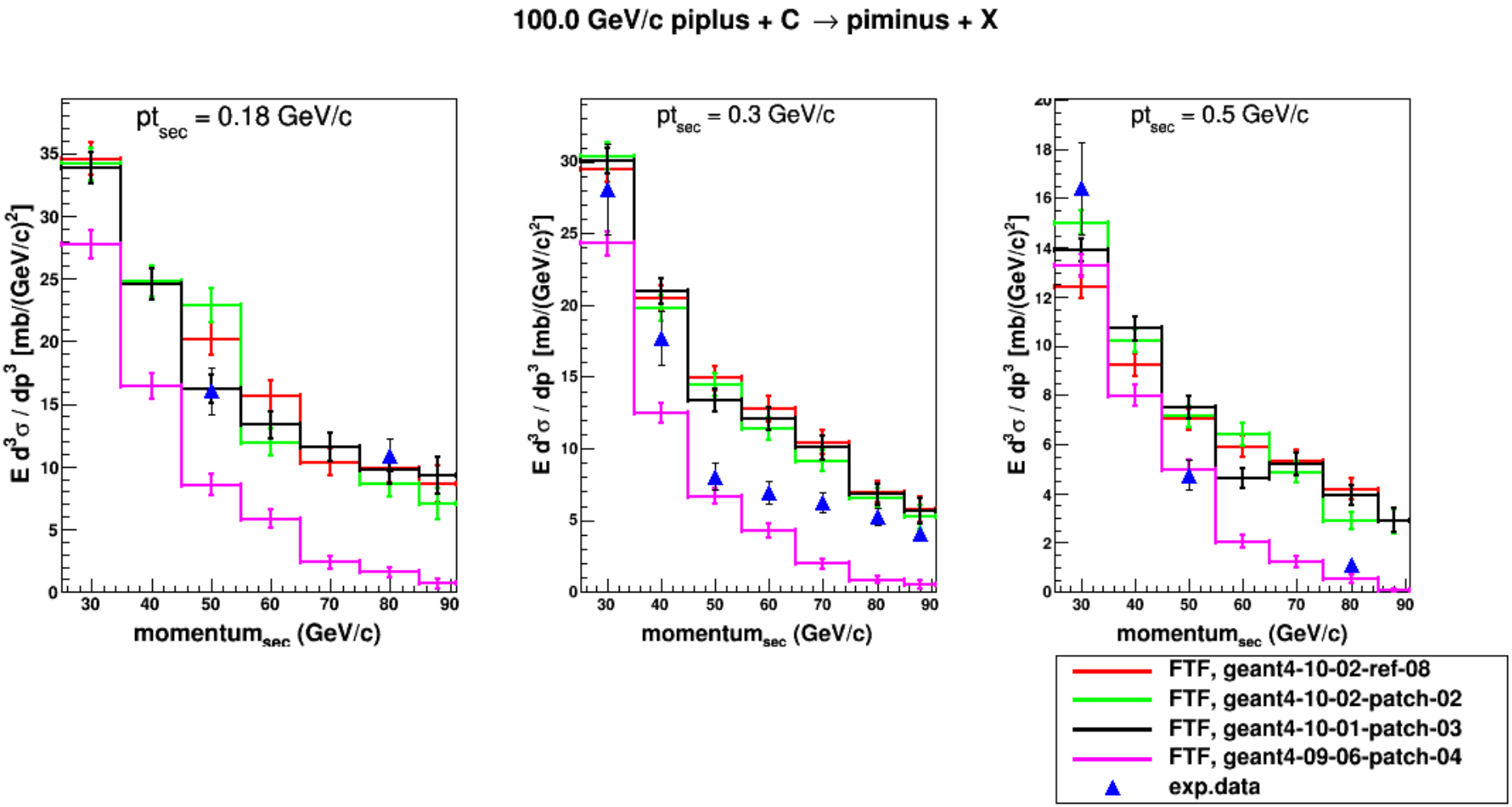
100GeV/c π^+ on C,Cu,Pb -> π^- + X

- Relatively modest changes in FTF results among 10.x series
- Substantial changes as compared to 9.6.p04
- Agreement with the data is "questionable" as the data often end up "in-between 9.6 and 10.x"
  - Overall MC trend in 10.x is towards overproducing π^-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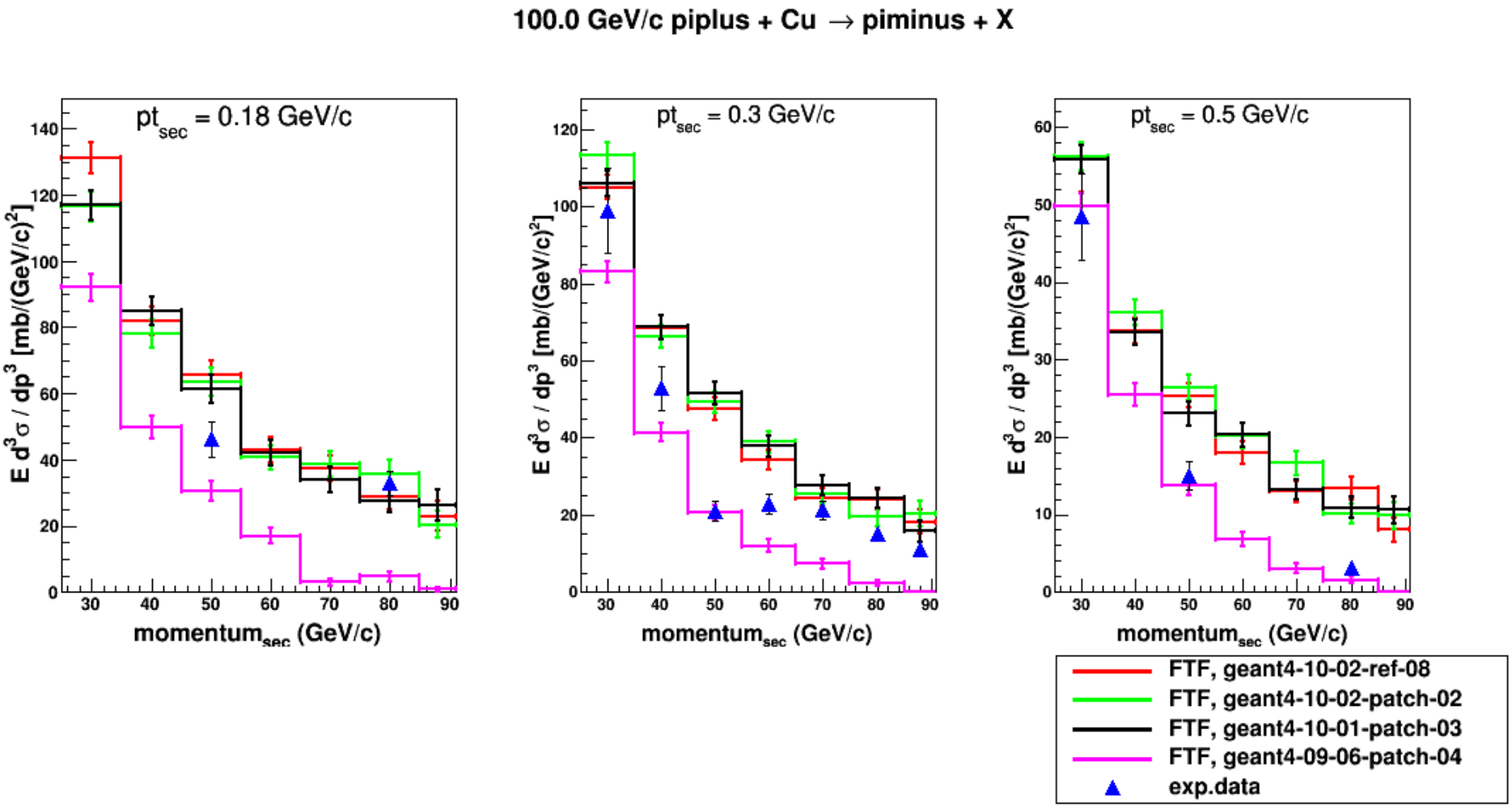
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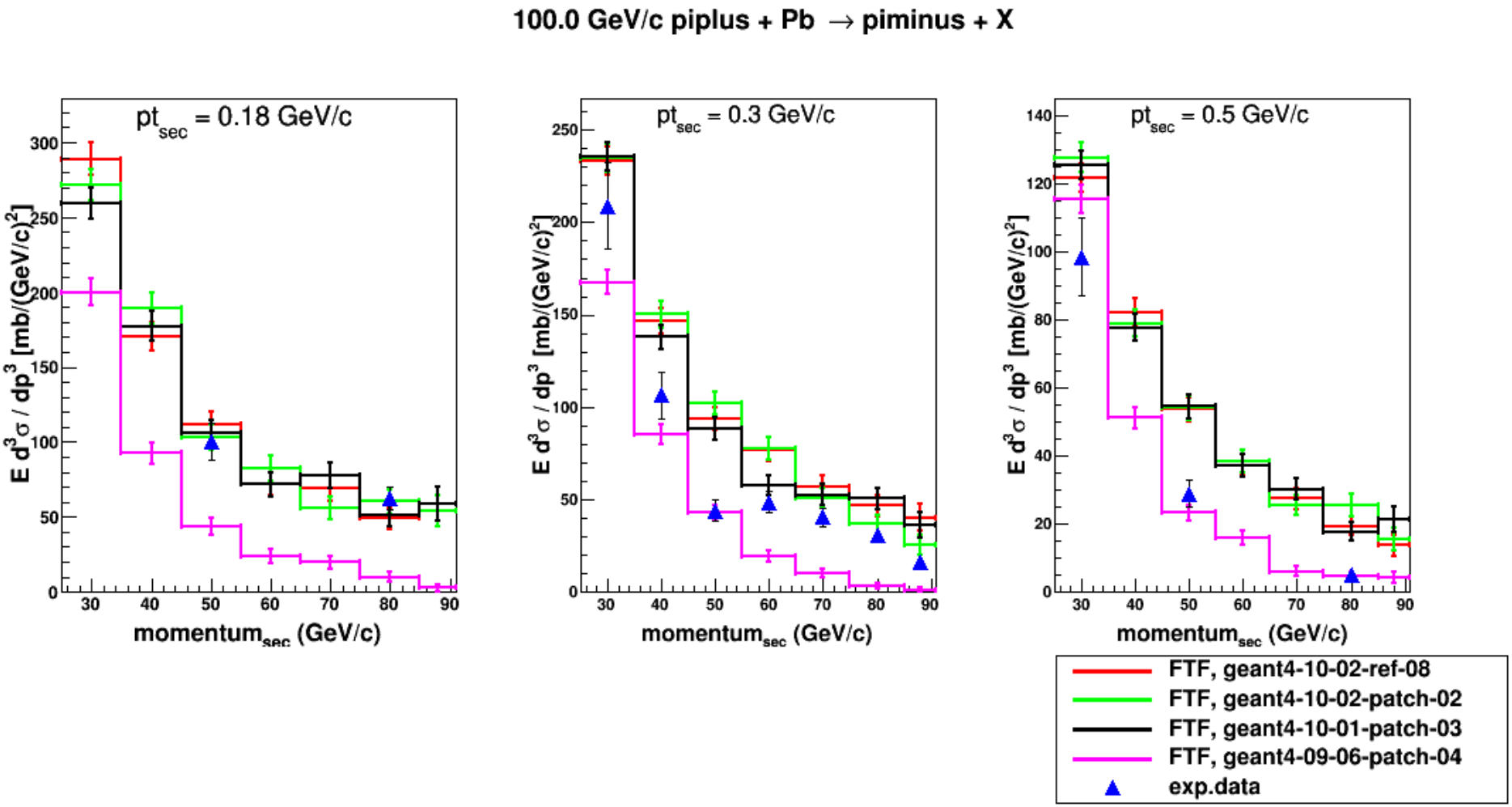
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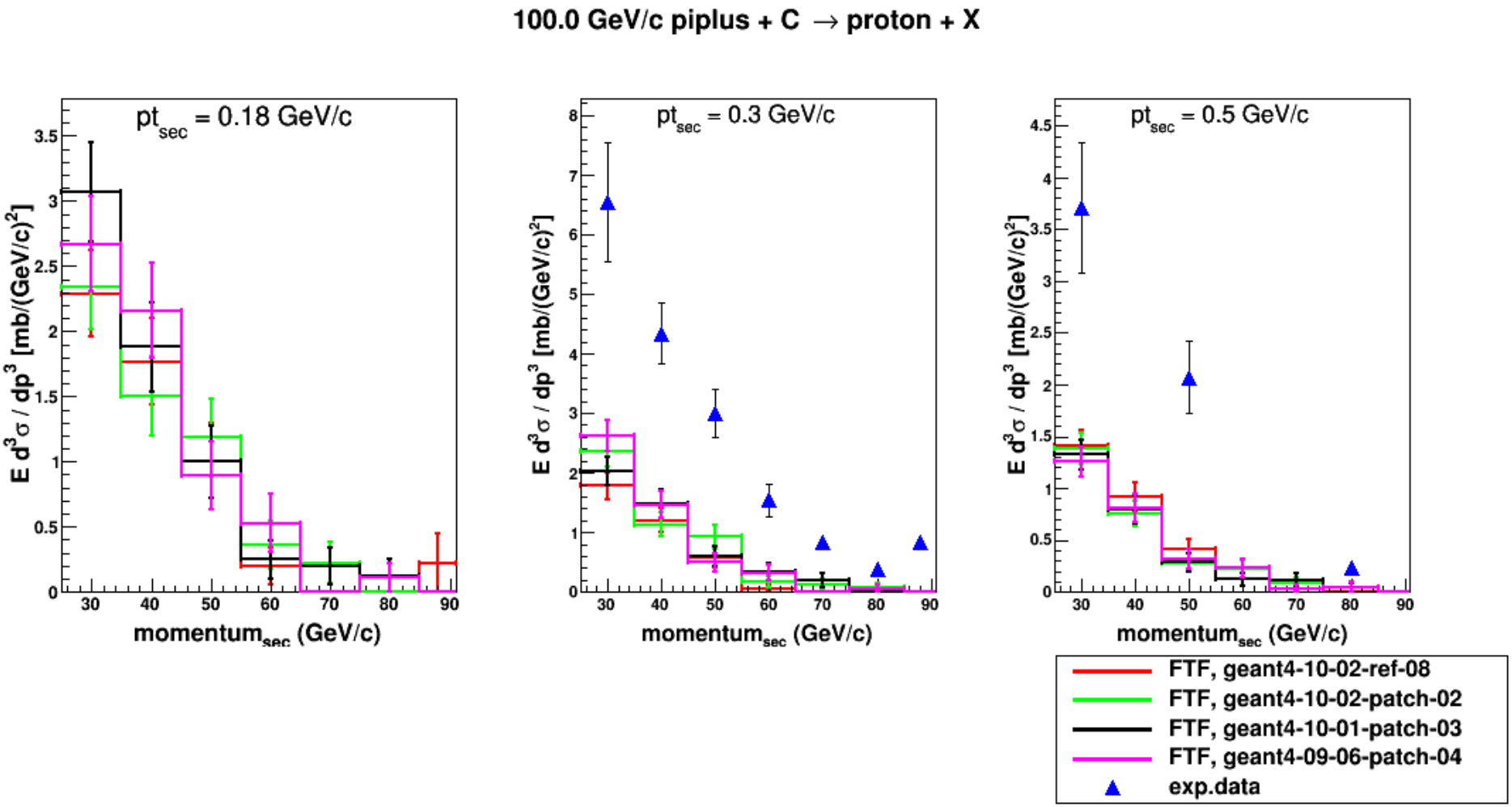
100GeV/c π^+ on C,Cu,Pb -> proton + X

- Relatively modest changes in FTF results among all releases
  - More statistics is needed to make further statements
- Overall trend towards underproducing secondary proton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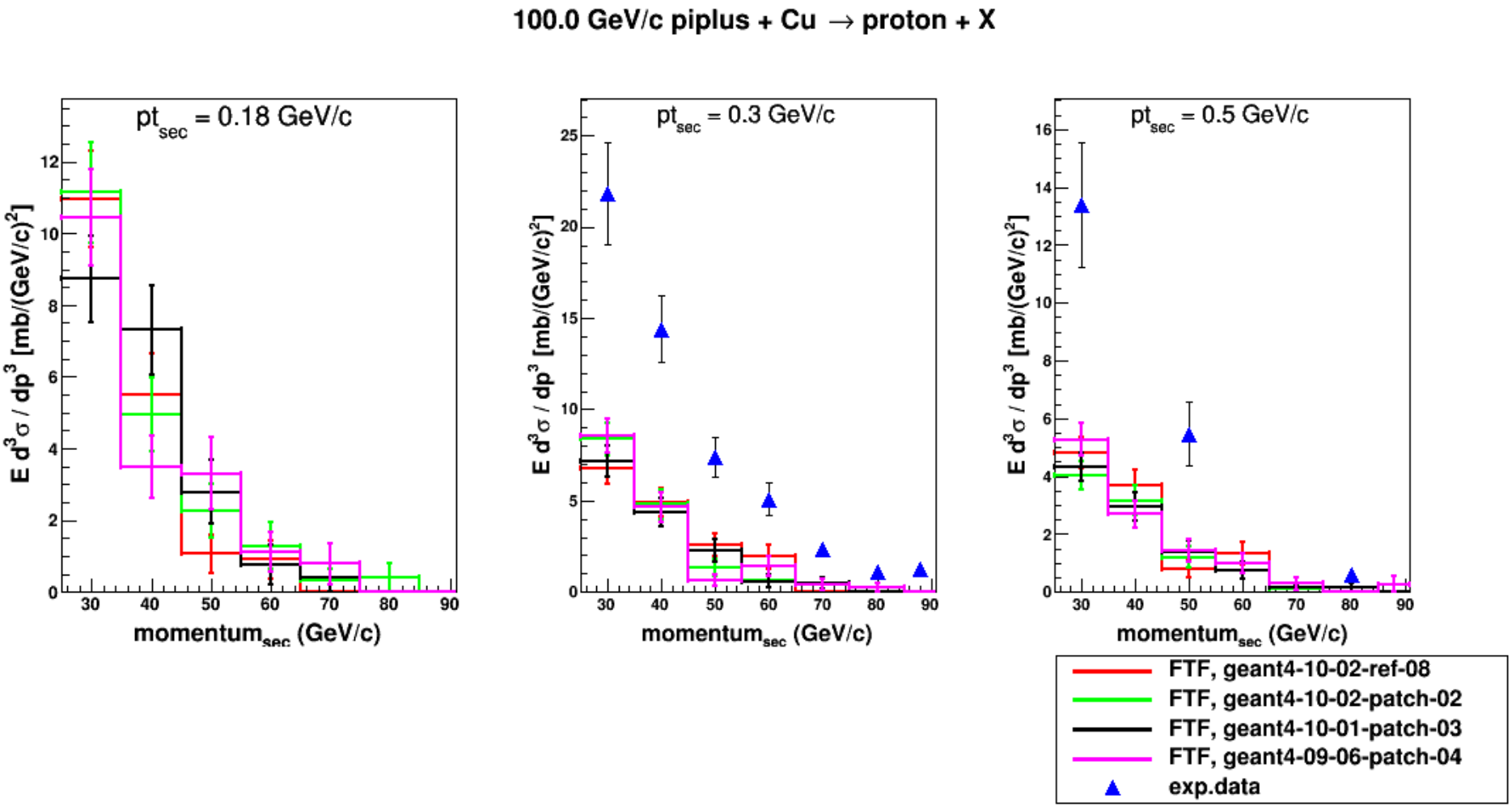
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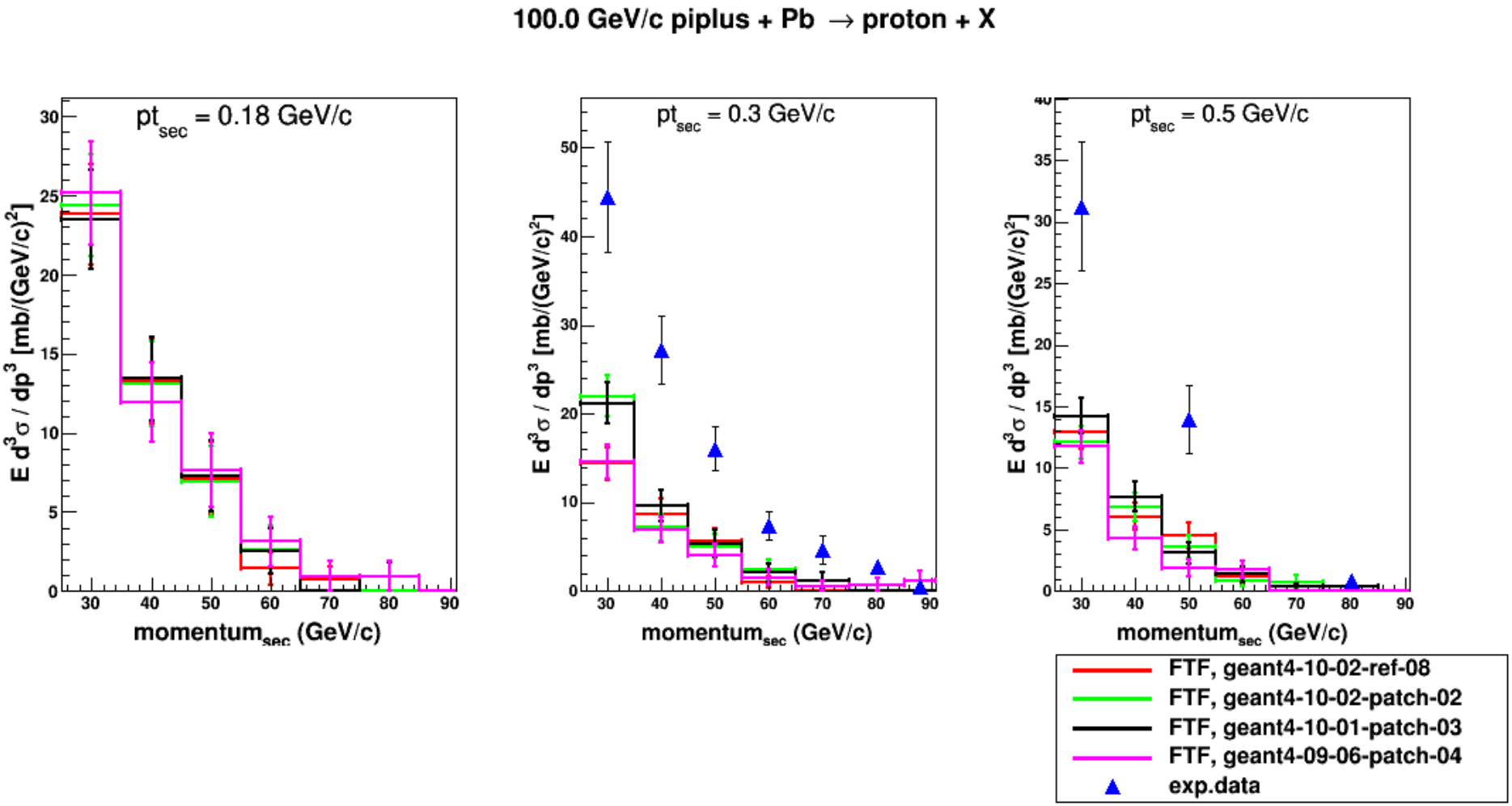
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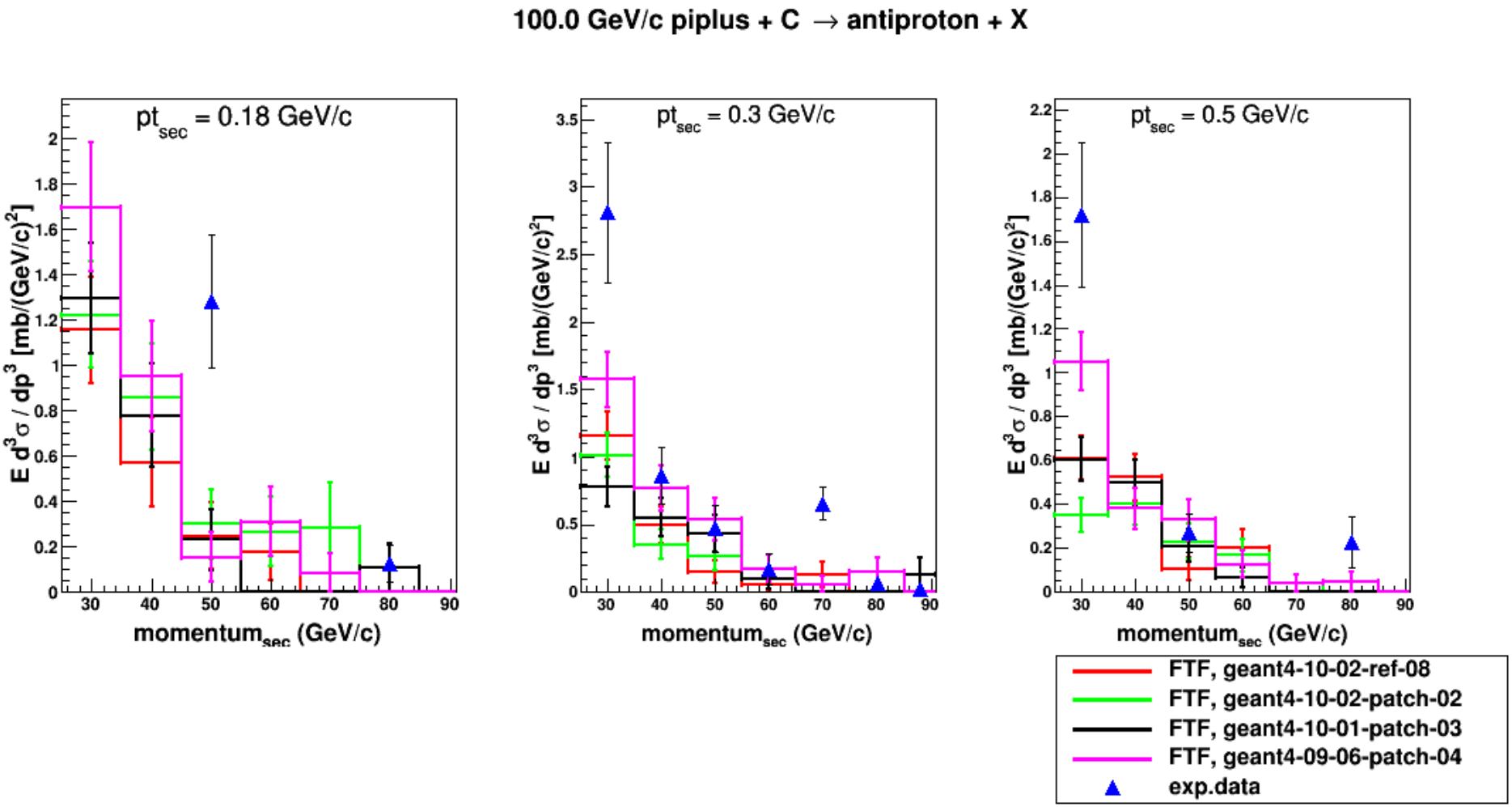
100GeV/c π^+ on C,Cu,Pb -> pbar + X

- Certain variations appear to be there but more statistics is needed in order to state whether the changes are appreciable or modest
- From a rough, visual inspections the agreement with the data appears to be OK for all 3 targets (C, Cu, Pb)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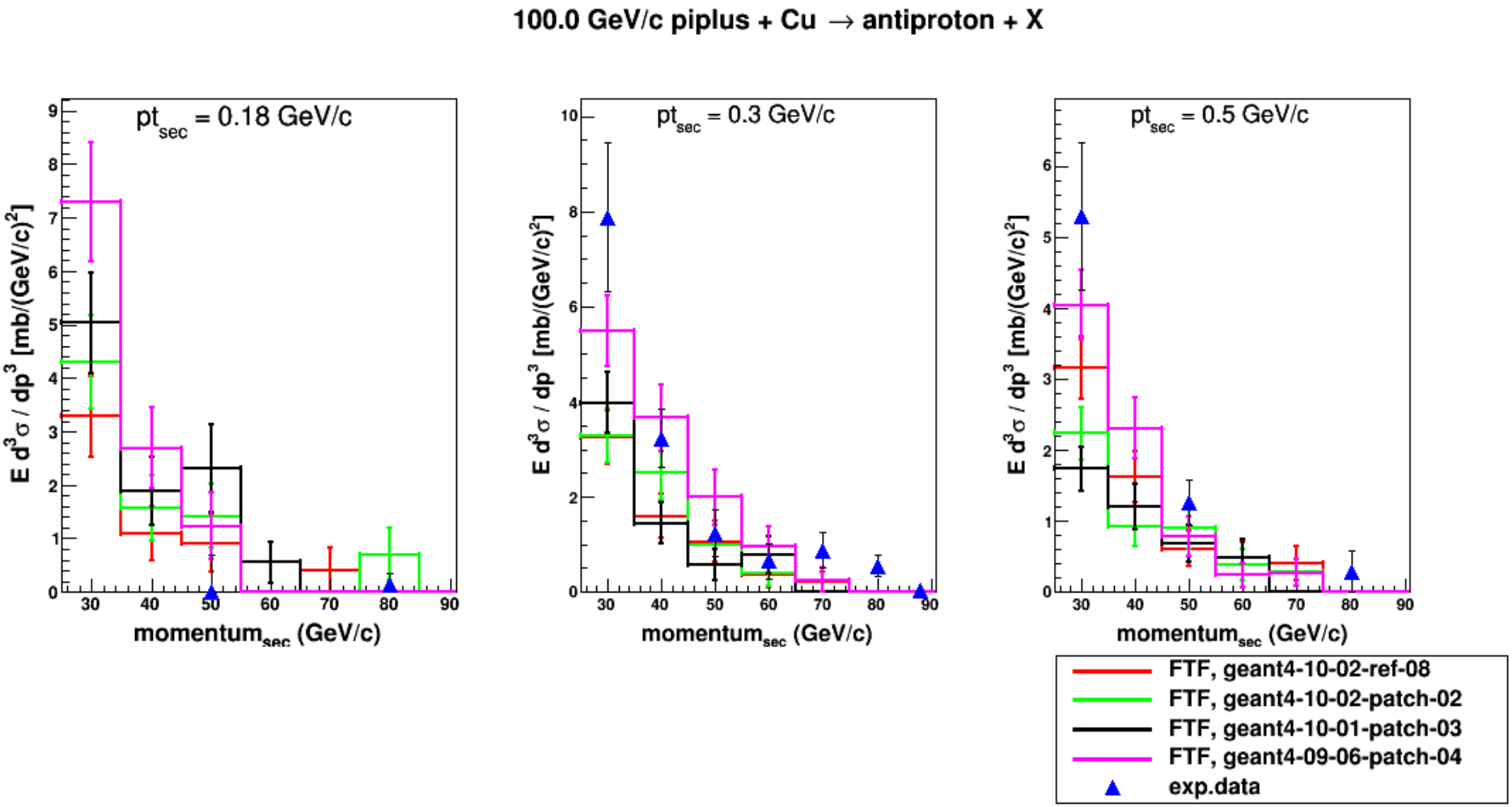
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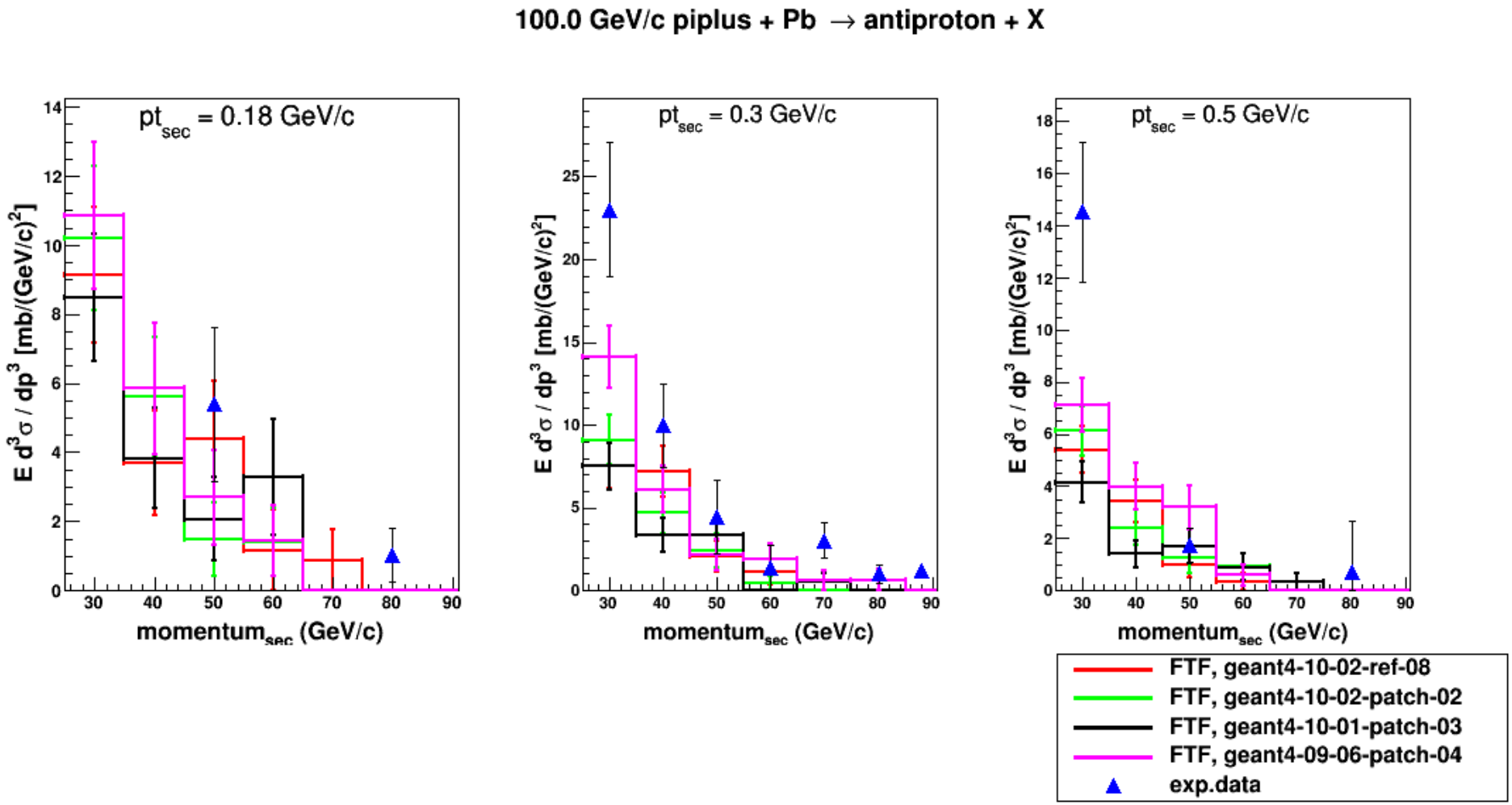
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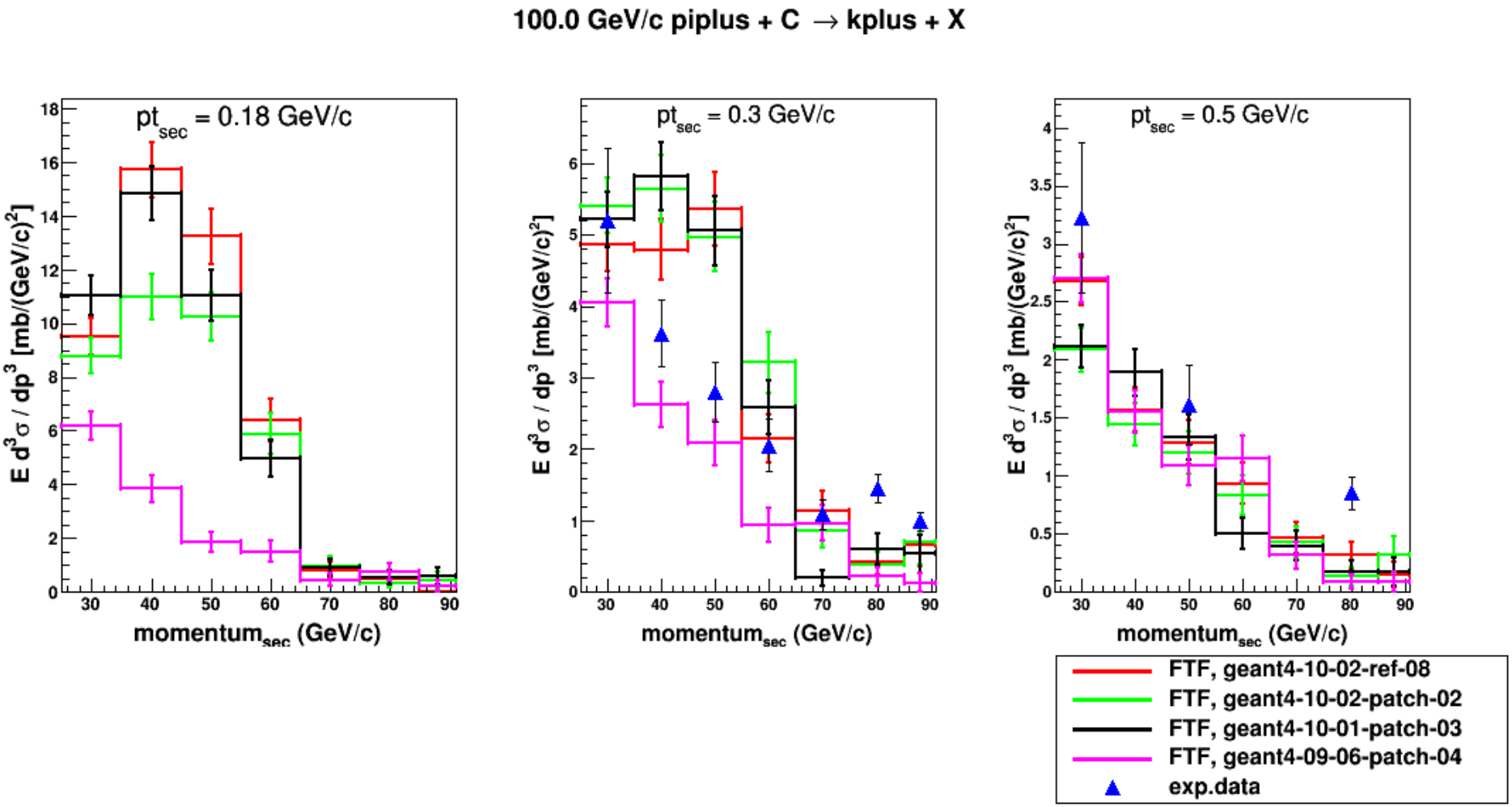
100GeV/c π^+ on C,Cu,Pb -> K^+ + X

- Modest to substantial changes from 9.6.p04 and throughout 10.x
  - Although more statistics is needed for further assessment
- Agreement with the data is questionable
  - Wasn't it better in 9.6.p04 ?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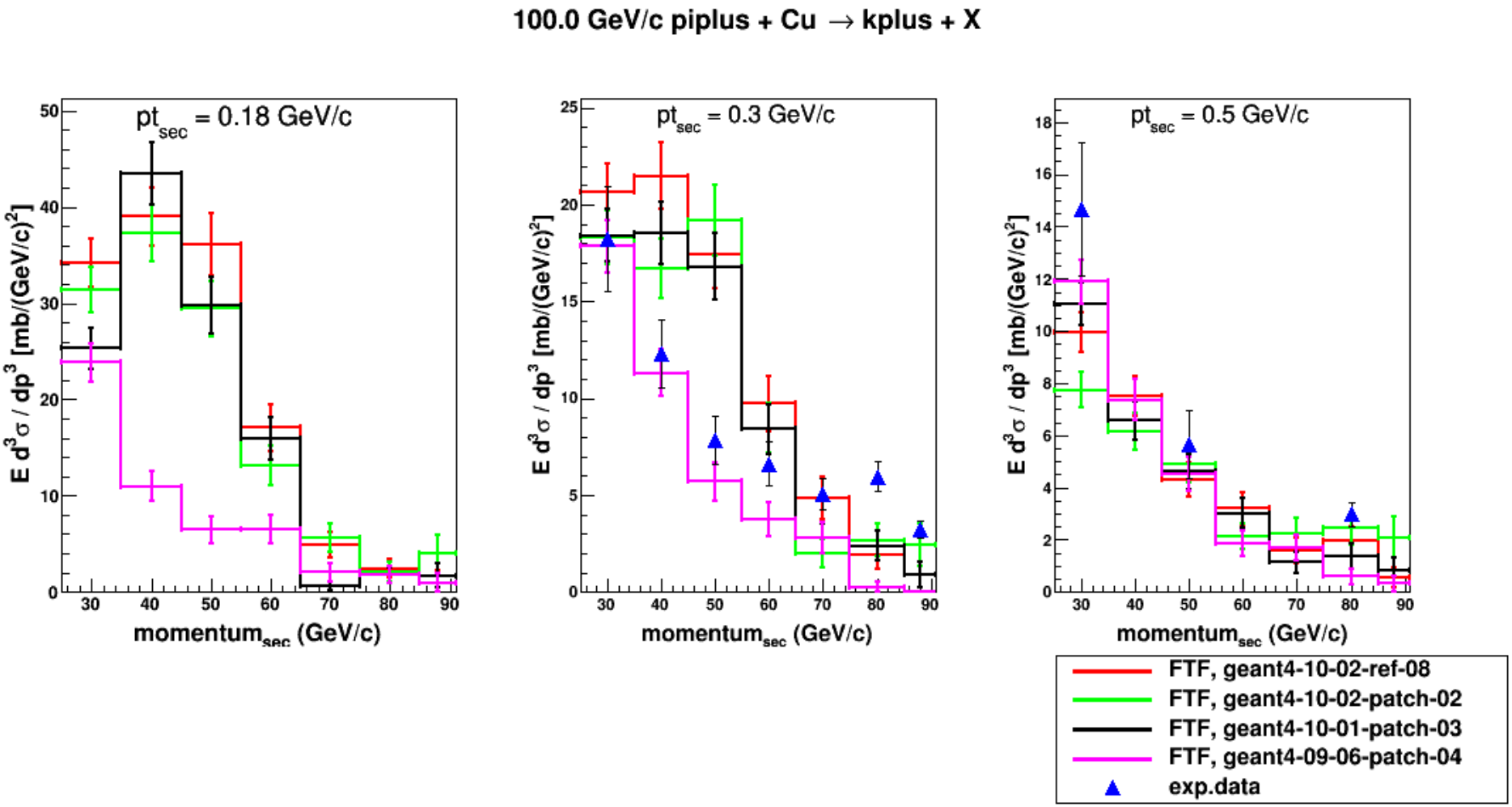
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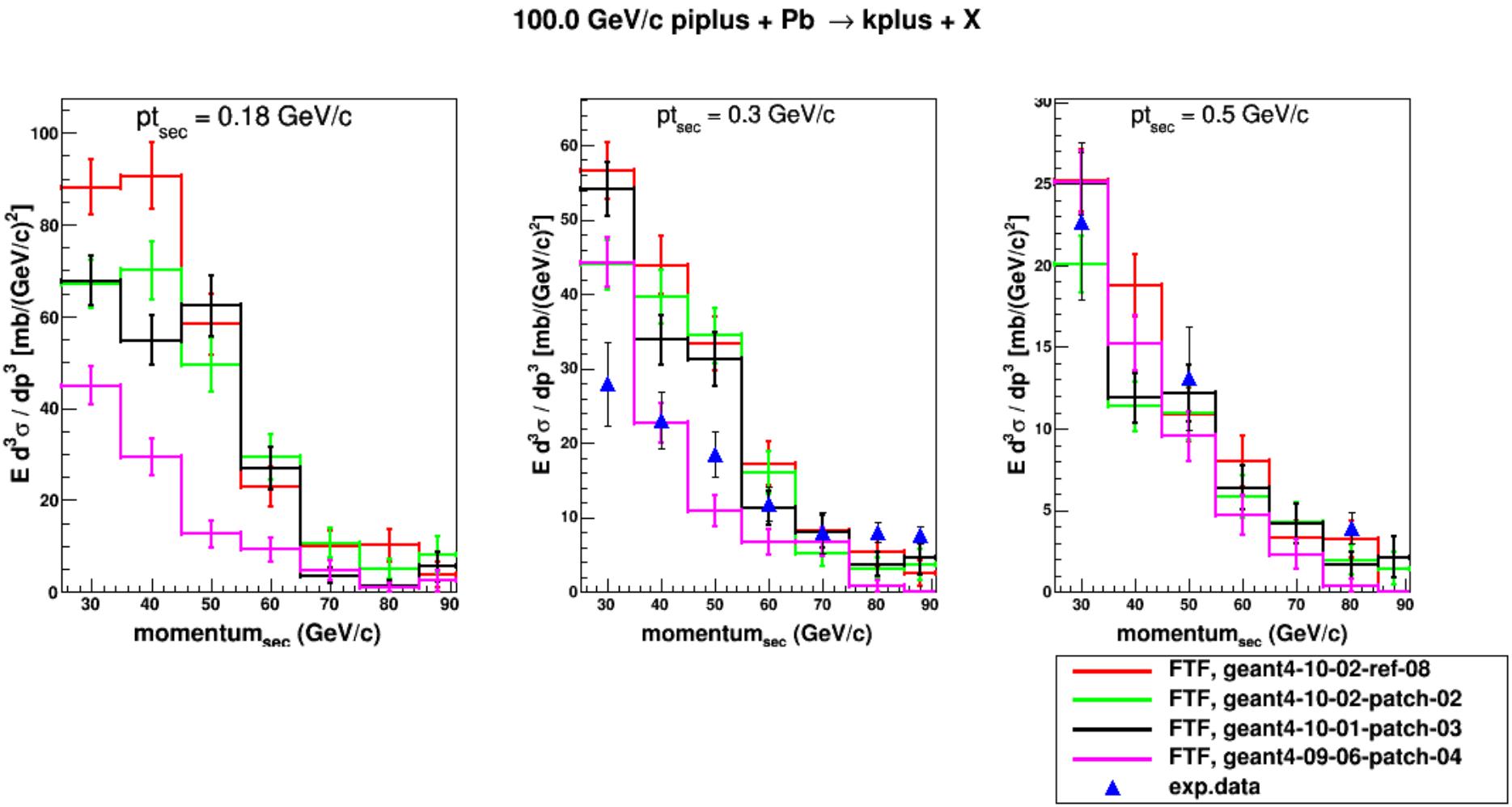
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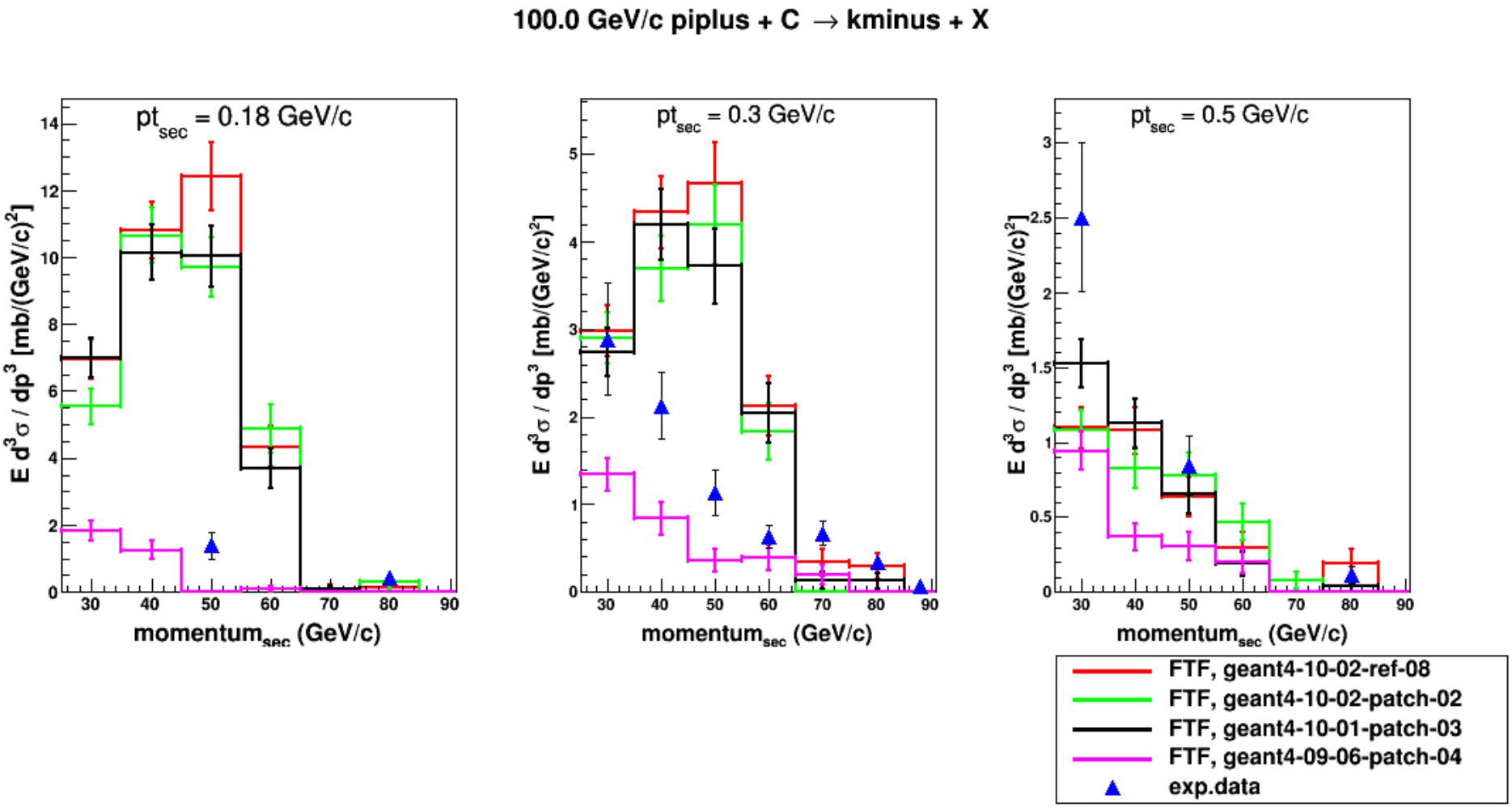
100GeV/c π^+ on C,Cu,Pb -> K^- + X

- Modest to substantial changes from 9.6.p04 and throughout 10.x
  - More statistics is needed for further assessment
- Data seem to end up “in-between 9.6.p04 and the 10.x series”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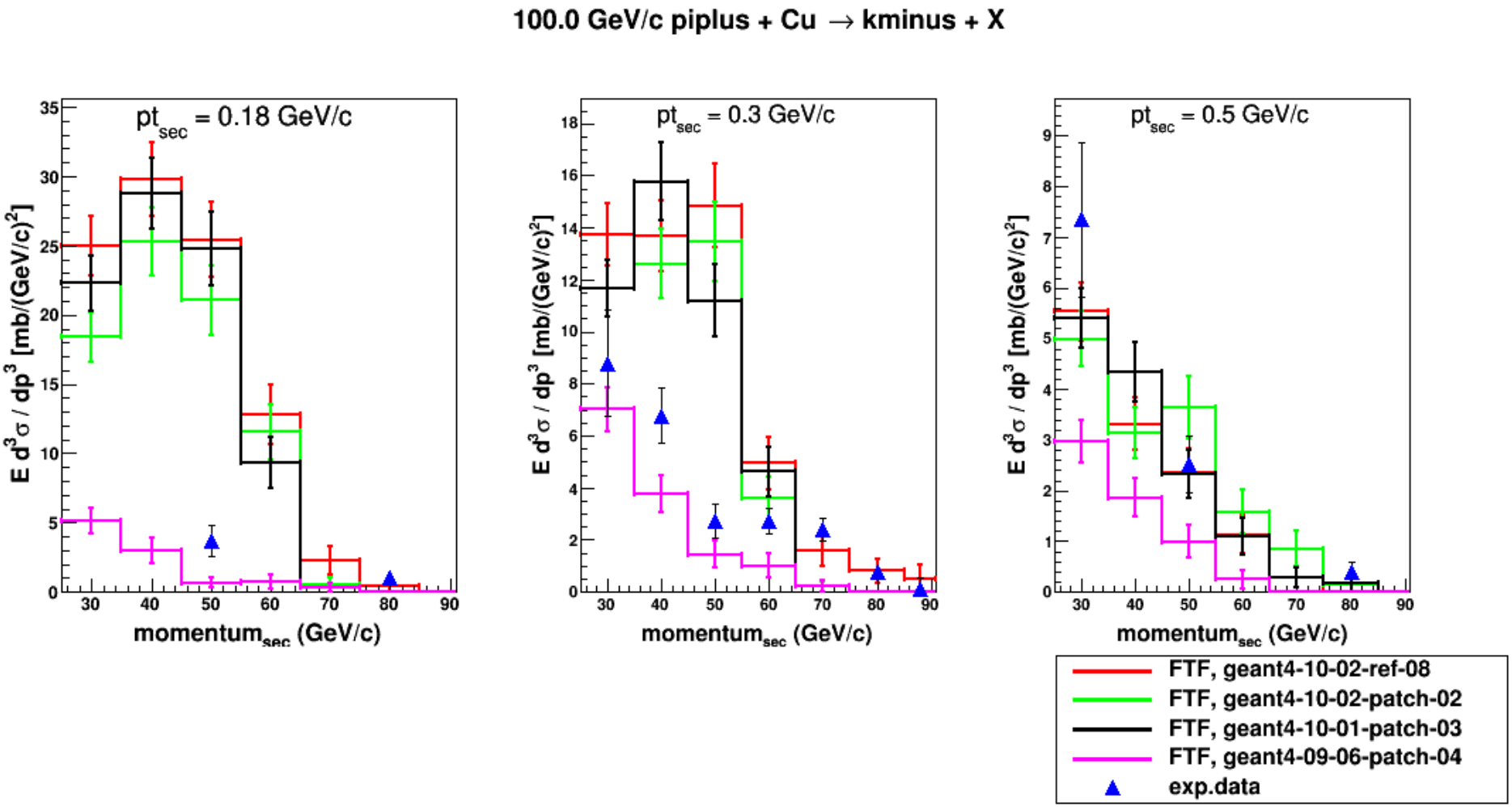
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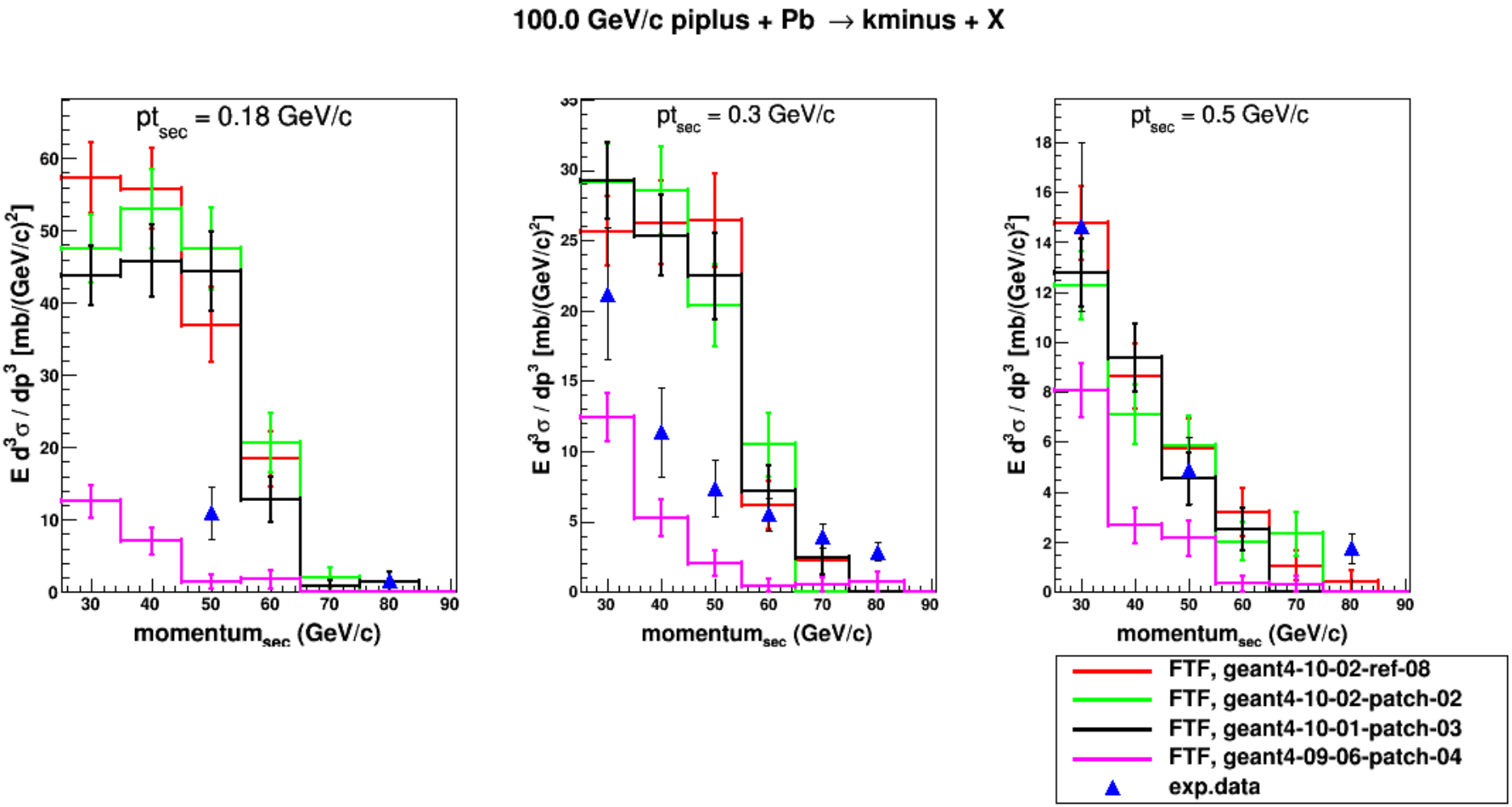
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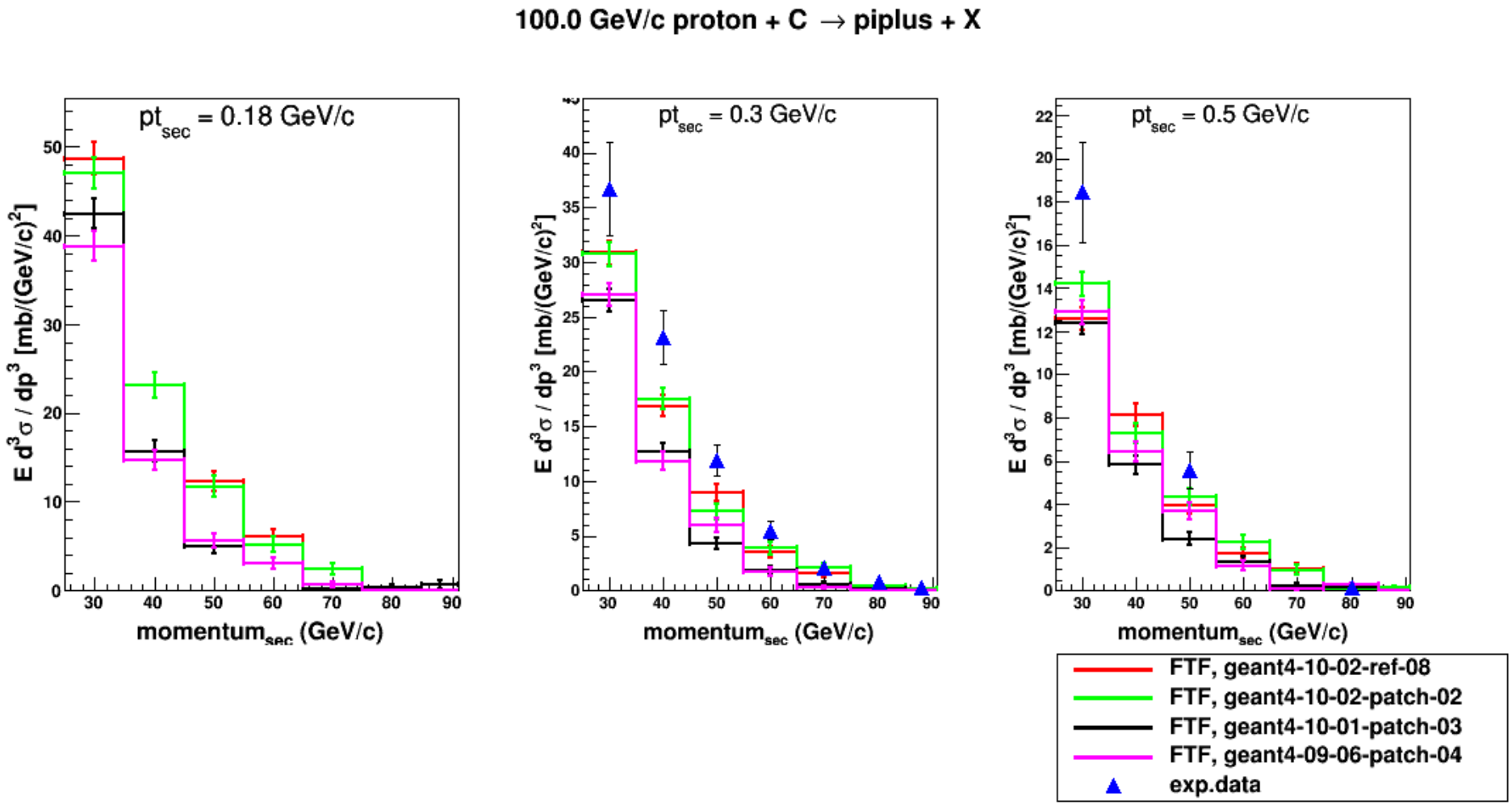
100GeV/c proton on C,Cu,Pb -> π^+ + X

- Relatively modest changes throughout releases
- Overall (visual) trend towards somewhat improving the agreement with the data
- Agreement with the data for C target is OK (we already know this from comparison vs NA61, NA49 data)
- Trend towards underproduction for heavier targets (Cu, Pb)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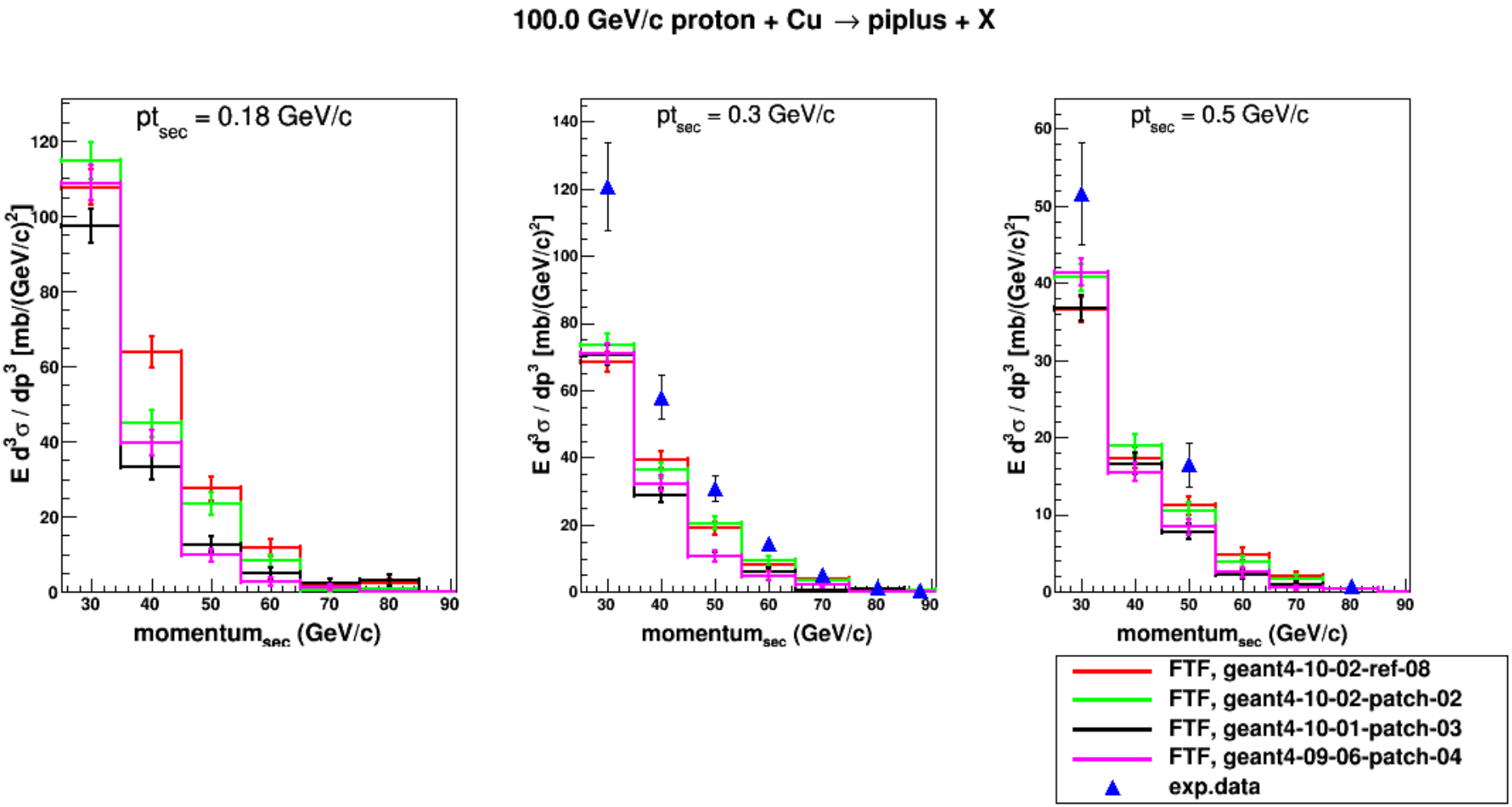
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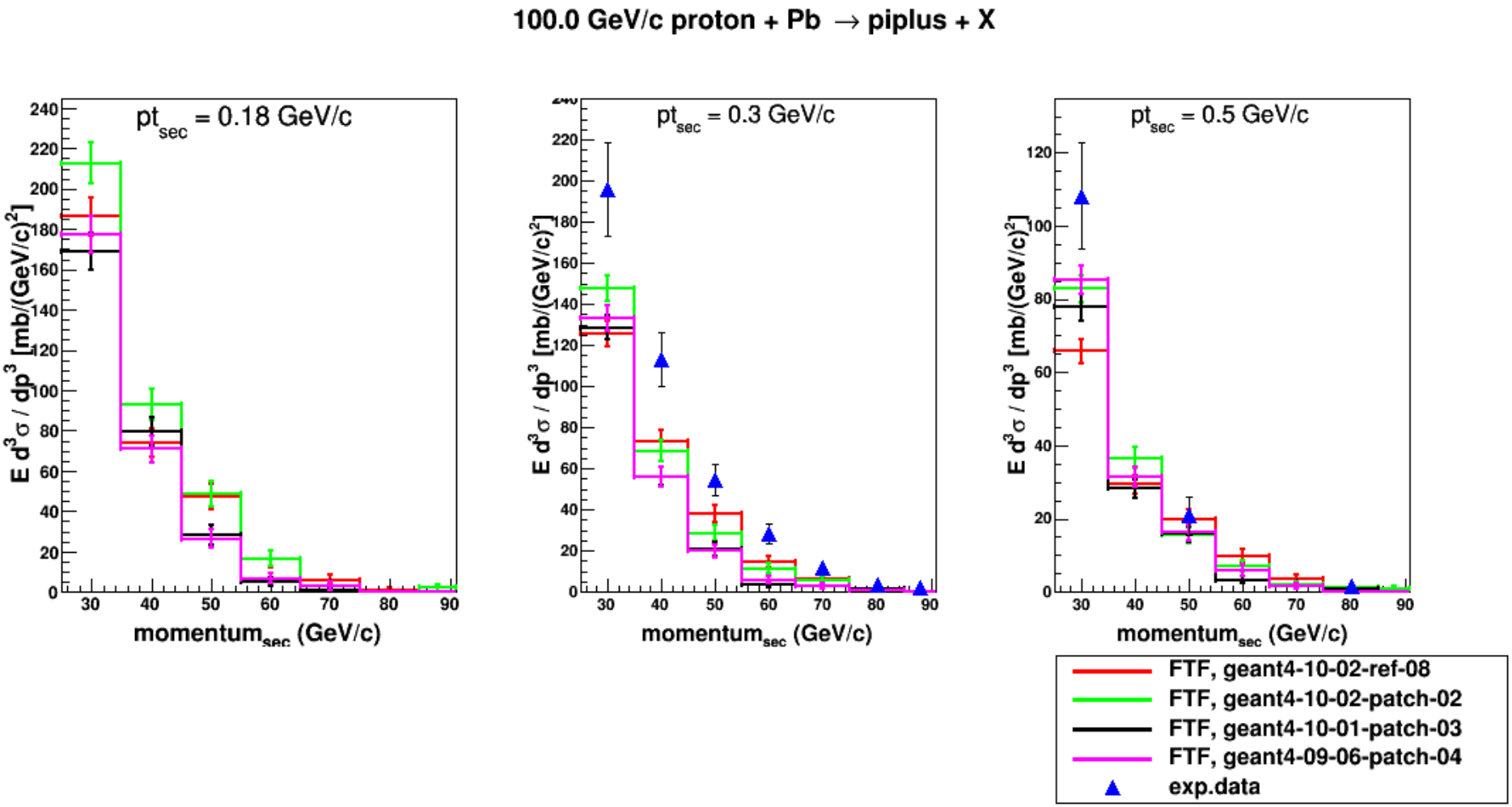
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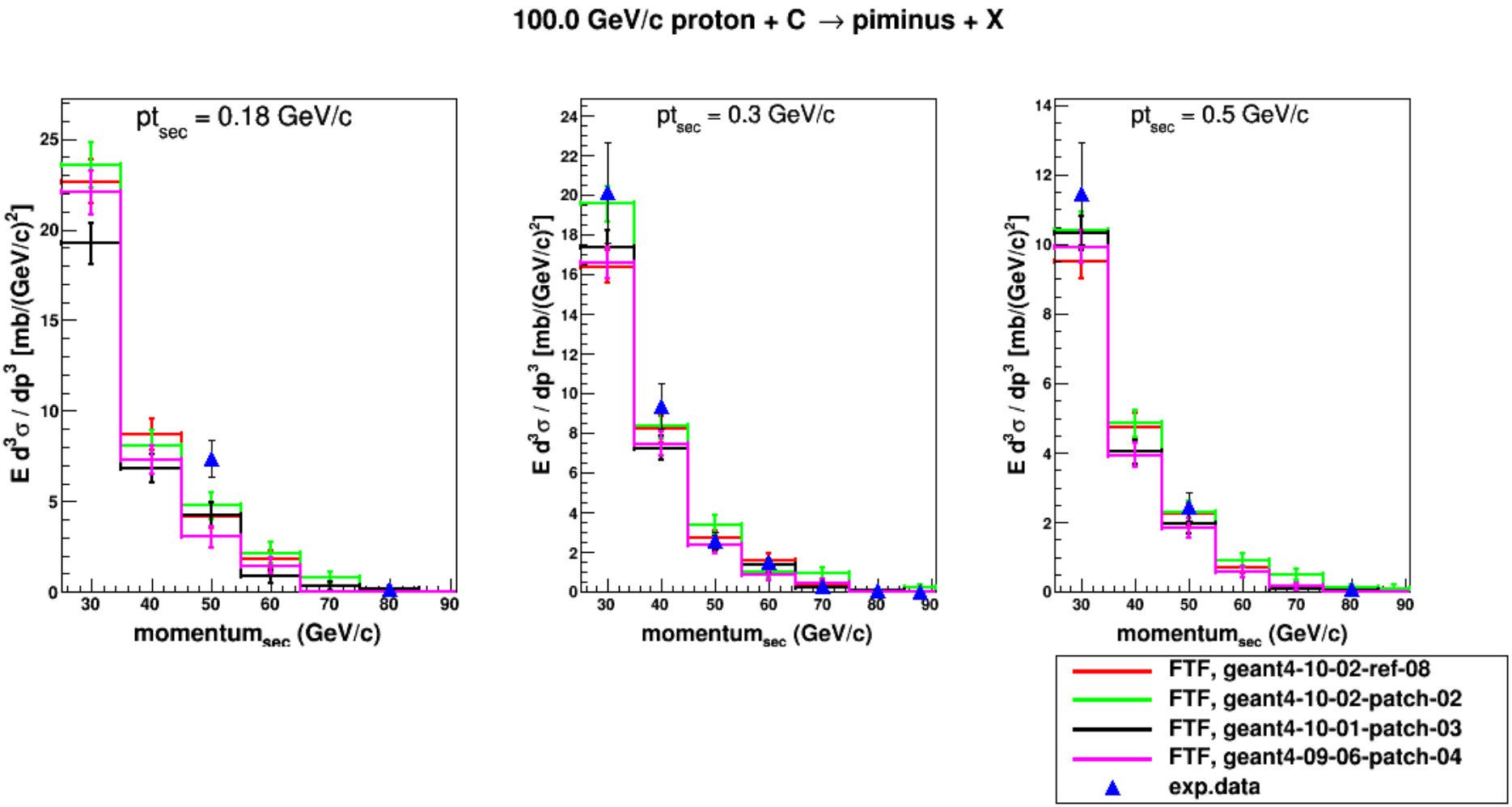
100GeV/c proton on C,Cu,Pb -> π^- + X

- Relatively modest changes throughout releases
- Visual agreement with the data is OK for all 3 targets (C, Cu, Pb)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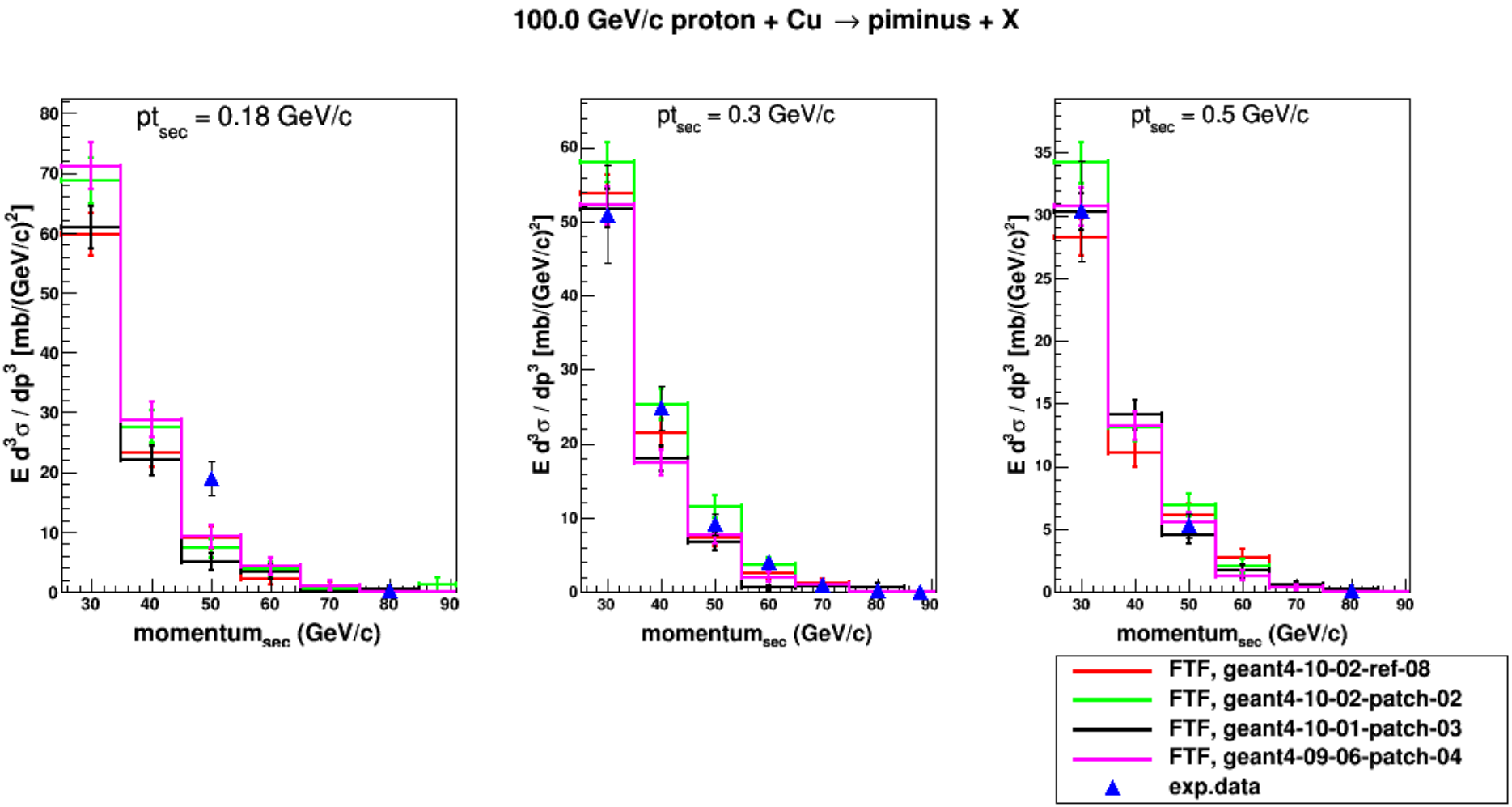
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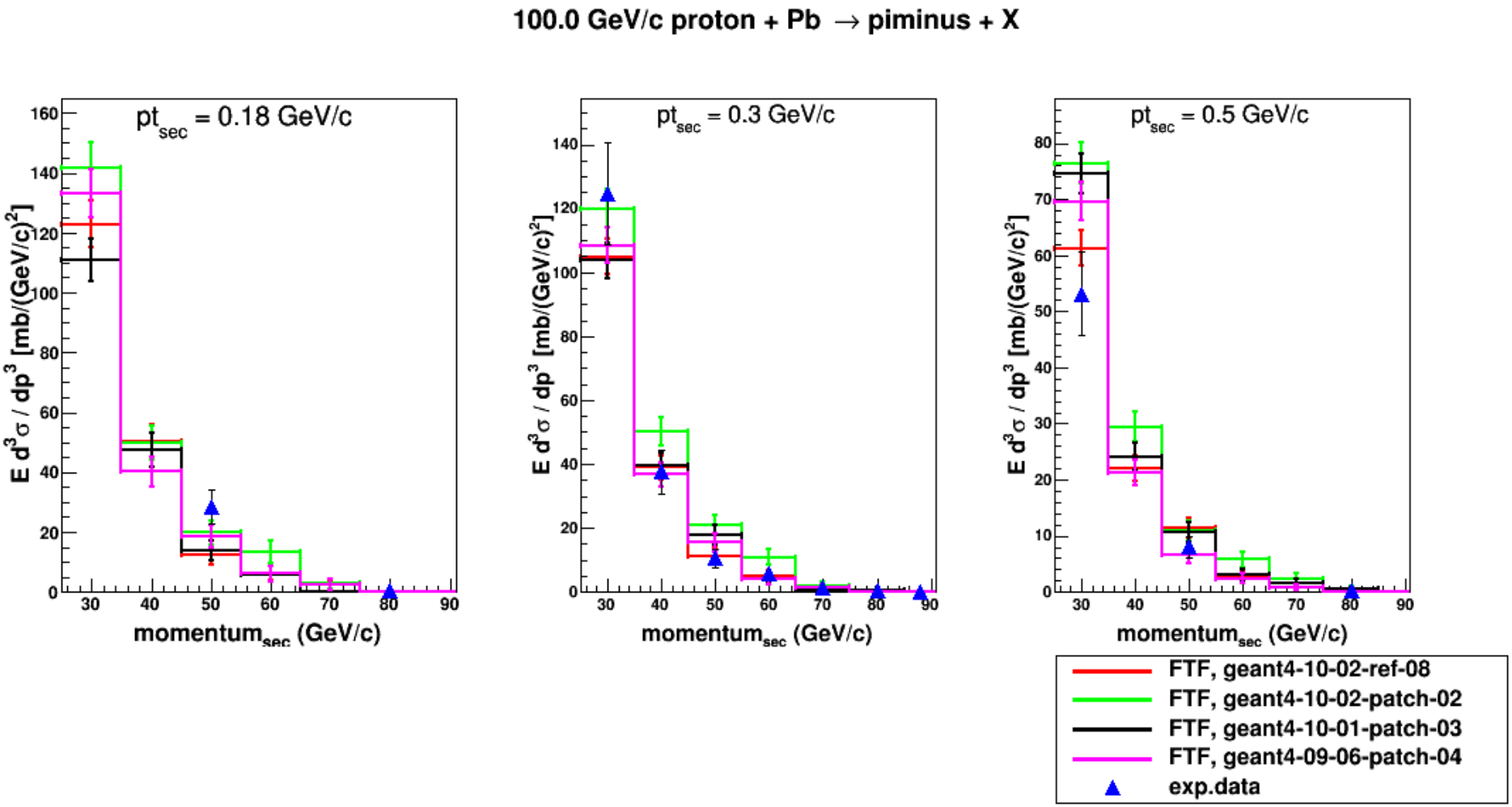
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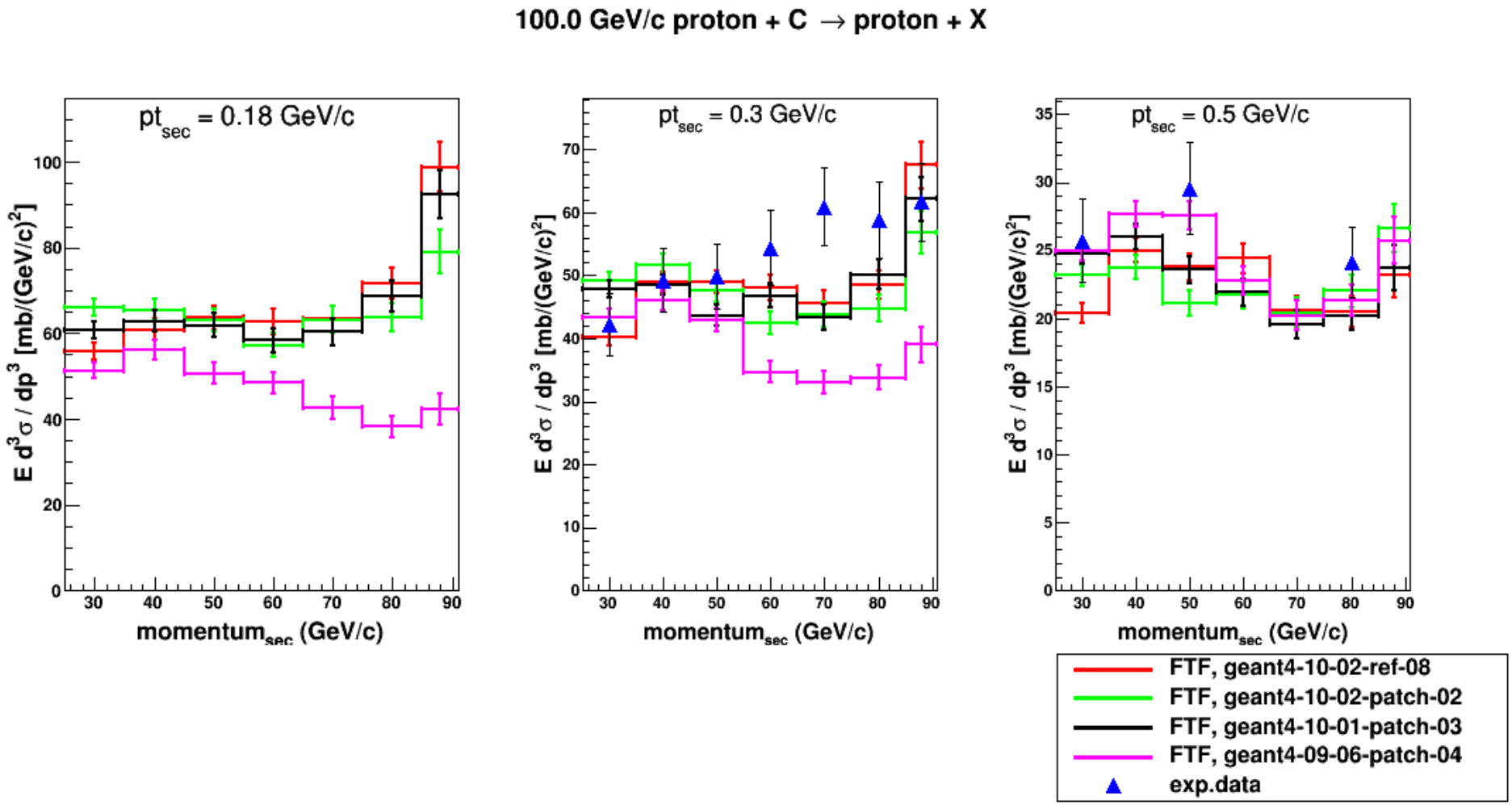
100GeV/c proton on C,Cu,Pb -> proton + X

- Modest changes through 10.x series
- Modest to appreciable changes as compared vs 9.6.p04
- Overall trend seems to be towards improving agreement with the data in the 10.x series as compared to 9.6.p04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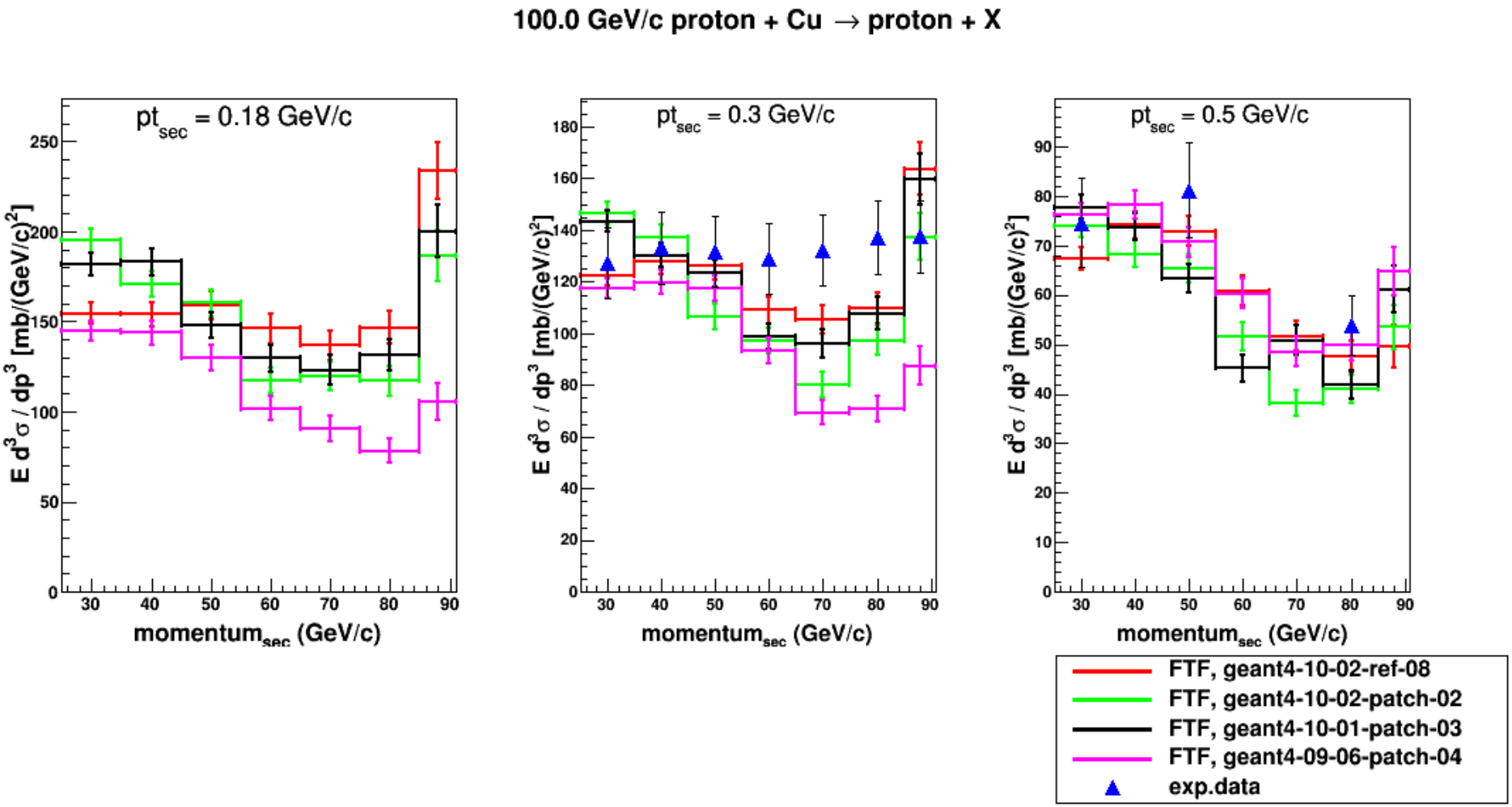
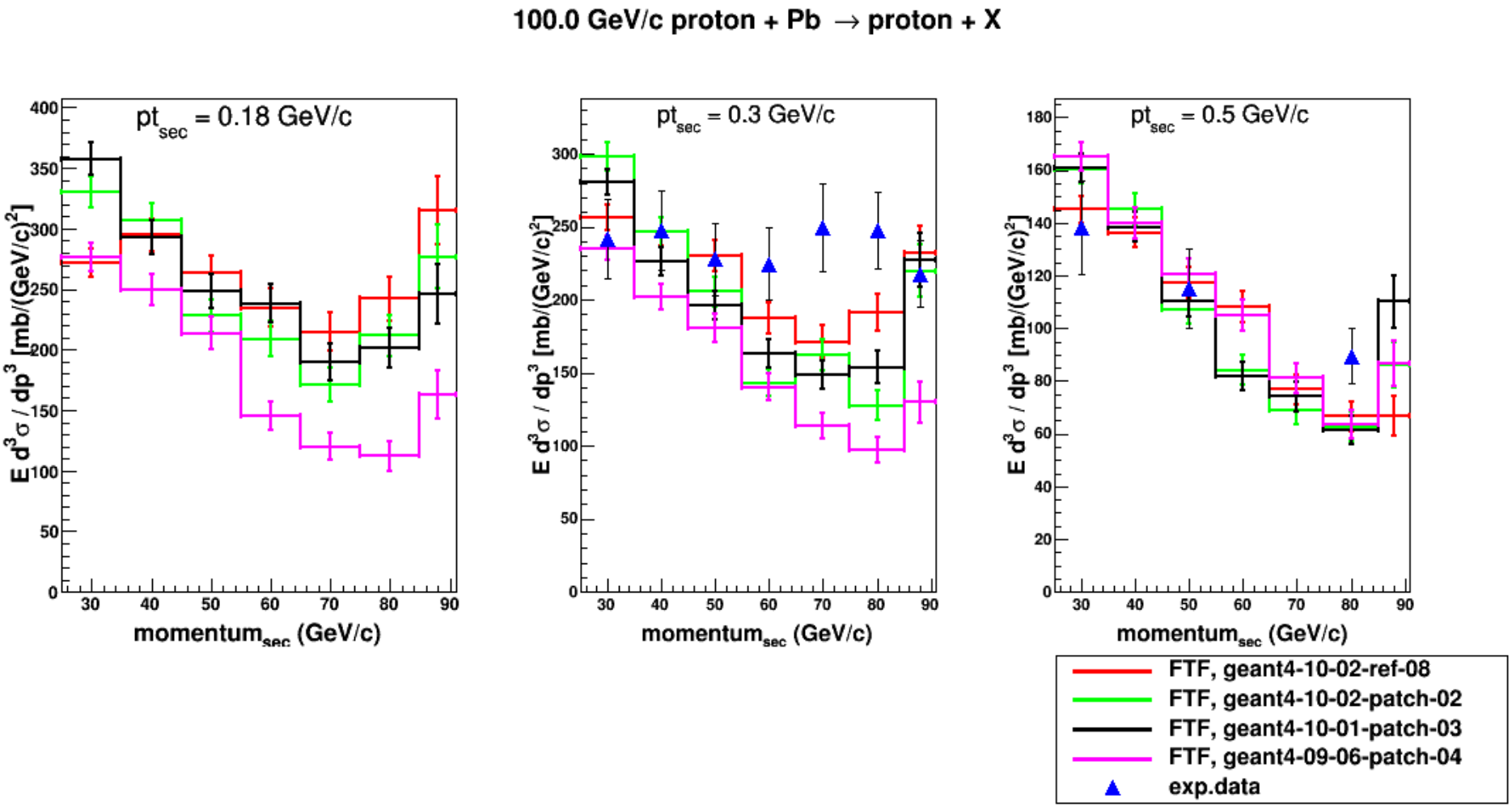
FTF, geant4-09-06-patch-04
exp.data


100.0 GeV/c proton + Cu → proton + X
pt_sec = 0.18 GeV/c
pt_sec = 0.3 GeV/c
pt_sec = 0.5 GeV/c
E d³σ / dp³ [mb/(GeV/c)²]
momentum_sec (GeV/c)
FTF, geant4-10-02-ref-08
FTF, geant4-10-02-patch-02
FTF, geant4-10-01-patch-03
FTF, geant4-09-06-patch-04
exp.data


100.0 GeV/c proton + Pb → proton + X
pt_sec = 0.18 GeV/c
pt_sec = 0.3 GeV/c
pt_sec = 0.5 GeV/c
E d³σ / dp³ [mb/(GeV/c)²]
momentum_sec (GeV/c)
FTF, geant4-10-02-ref-08
FTF, geant4-10-02-patch-02
FTF, geant4-10-01-patch-03
FTF, geant4-09-06-patch-04
exp.data

100GeV/c proton on C,Cu,Pb -> $K^{\pm}$, antiproton + X

- Larger statistics is needed to discuss $K^{\pm}$ and/or antriproton production by a proton beam – will be done shortly
- At a glance, nothing "terrible" has been detected

Summary

- For the past several release cycles we tended to judge quality of high energy models (FTF, QGS) based on agreement with data obtained with a proton beam incident on light (H, C) target
- Now we are adding benchmarking vs data on heavier targets (Cu, Pb), including data obtained with a high energy pion beam
- This is preliminary study based on a very limited statistics but…
- … it indicates so far that the (dis)agreement with the data looks reasonably consistent across all target nuclei in question
  - The only "outlier" is π^+ production by a proton beam
- We definitely need to benchmark collectively vs available data such as NA61, NA49, FNAL SAS M6E, Z. Phys. C 62 (1994), etc.
- We are still largely judging the quality of high energy (string) models based on simulation of charged hadron production
  - Maybe we should try to look also into production of neutrals