ADDING DATA TO PPFX

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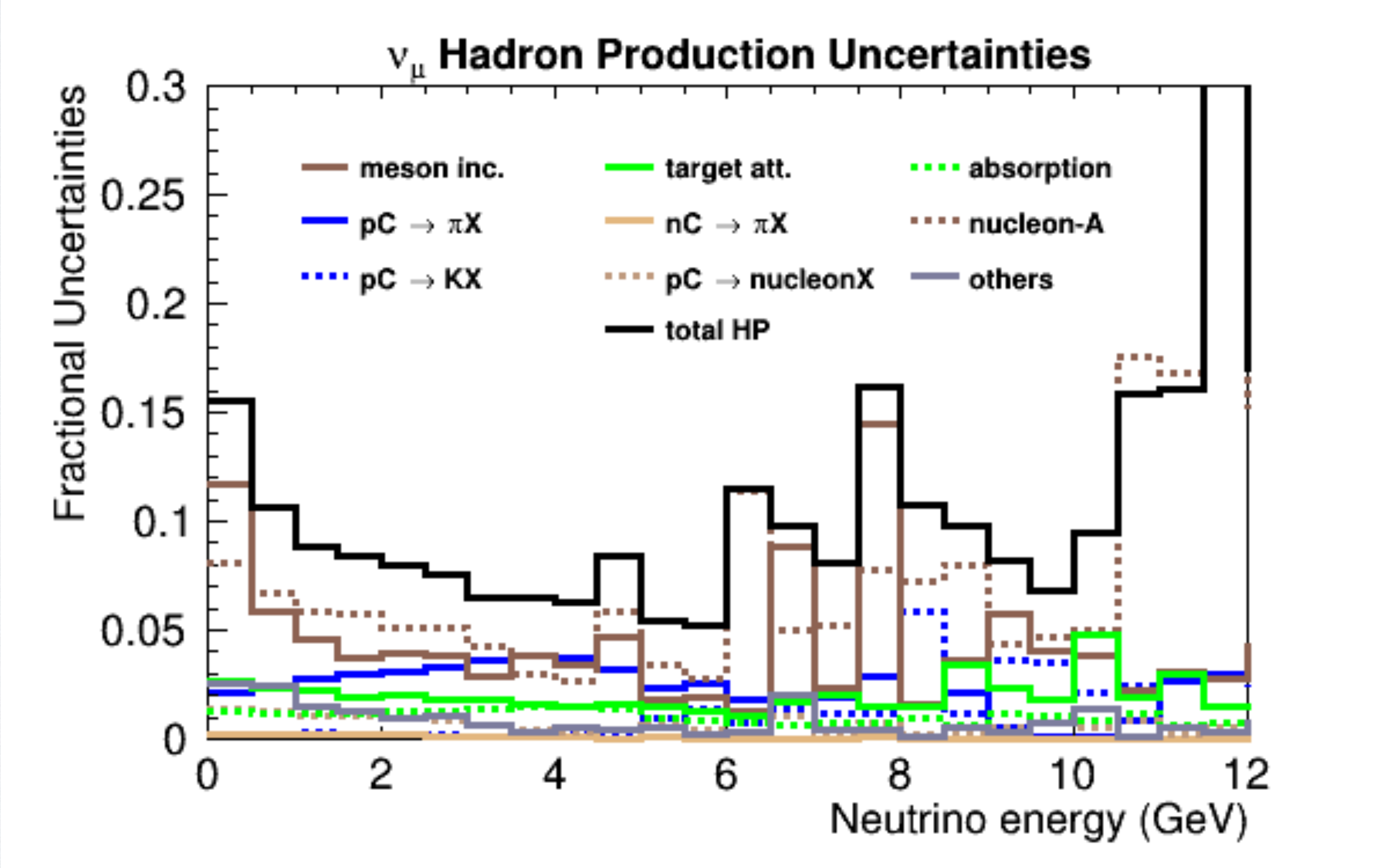
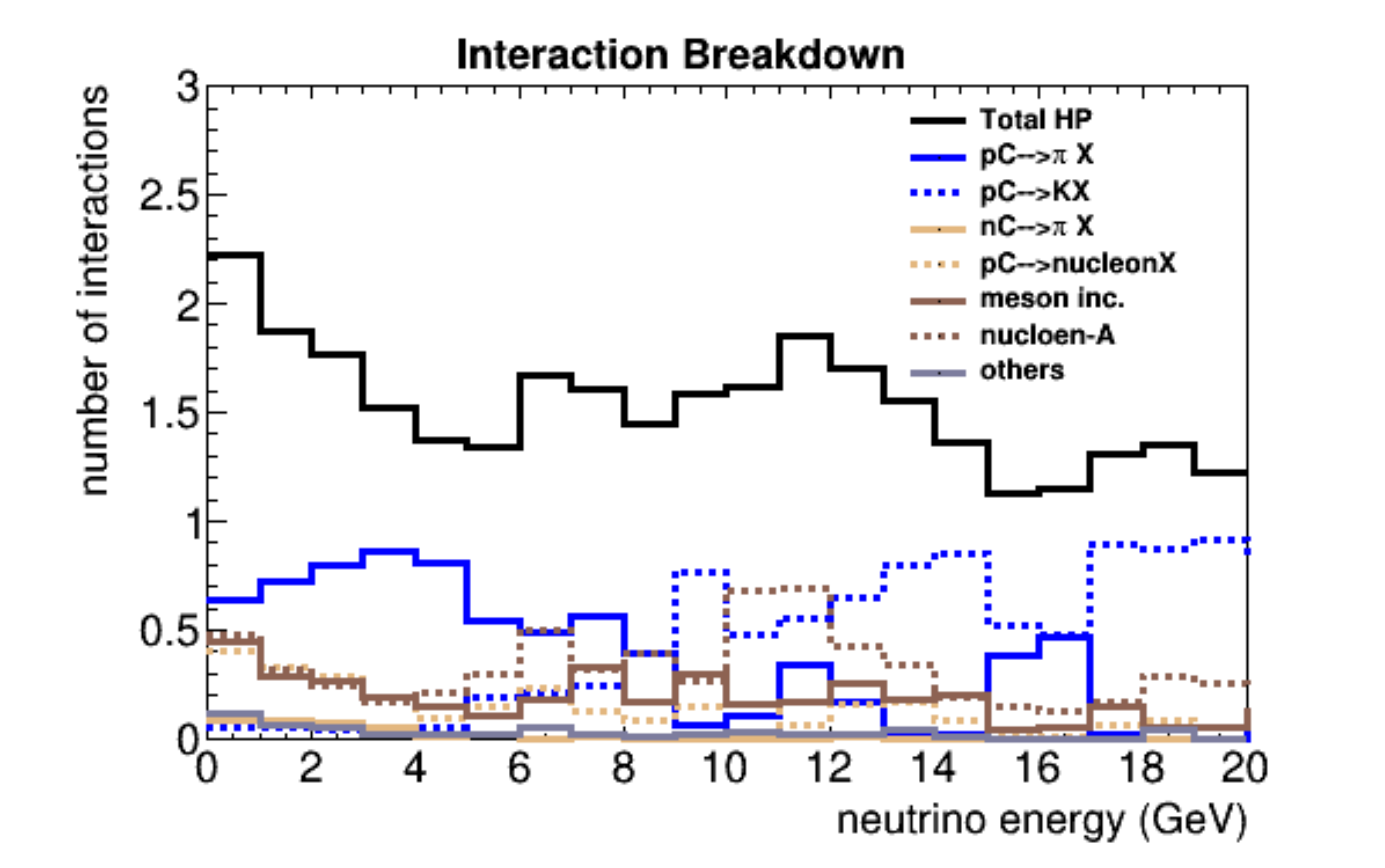
INTRODUCTION

- Many people have attempted to put new data into PPFX
  - Have never quite finished
  - A recurrent problem: Do a bunch of stuff, get an answer that doesn't make sense
  - Not clear where in the bunch of stuff things went wrong
  - So, I'm going to try to do this in small steps, where I know what to expect at each step
    - Start with NA61 60 GeV pion incident data

FIRST: BASELINE PLOTS (DUNE FD)

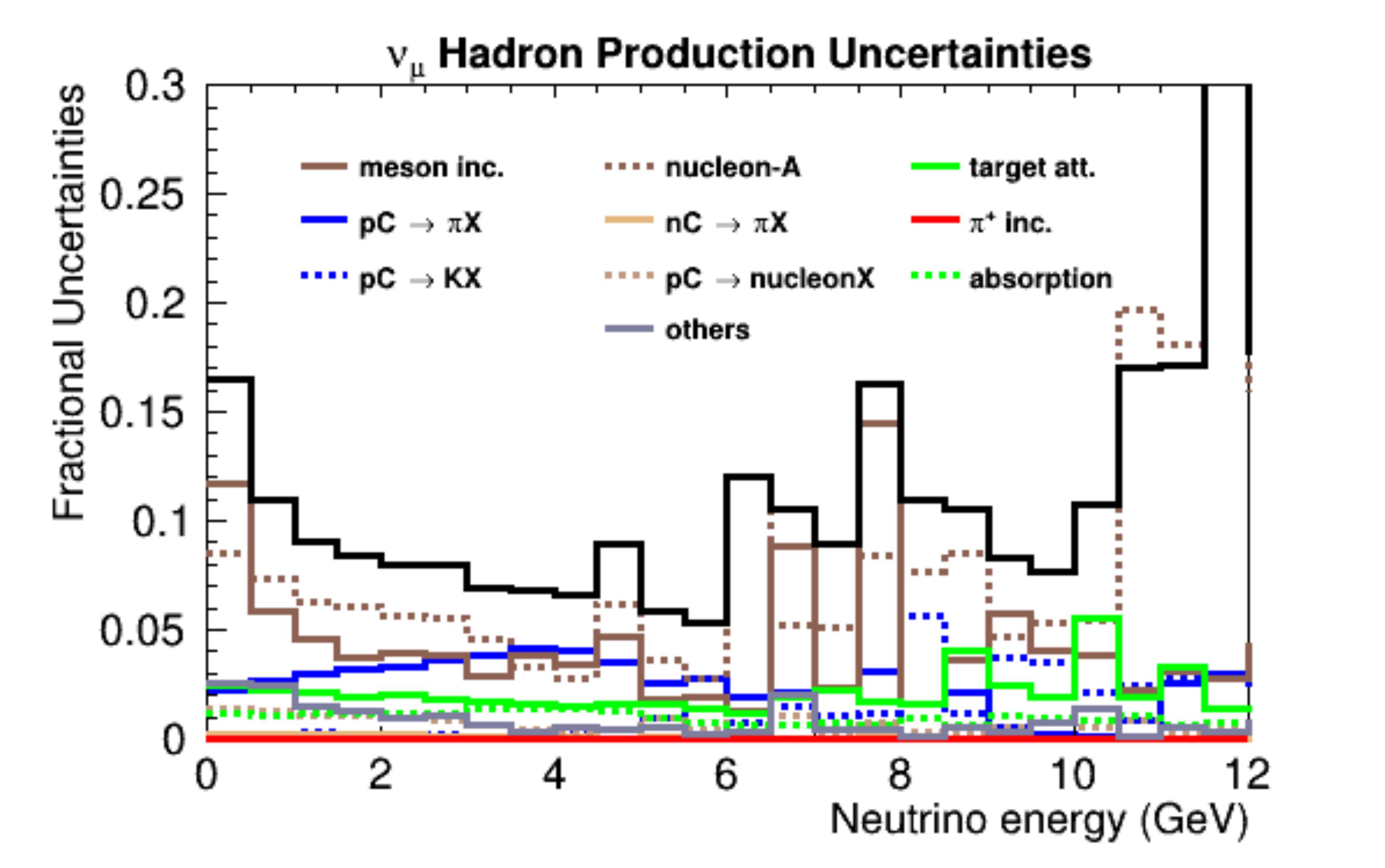


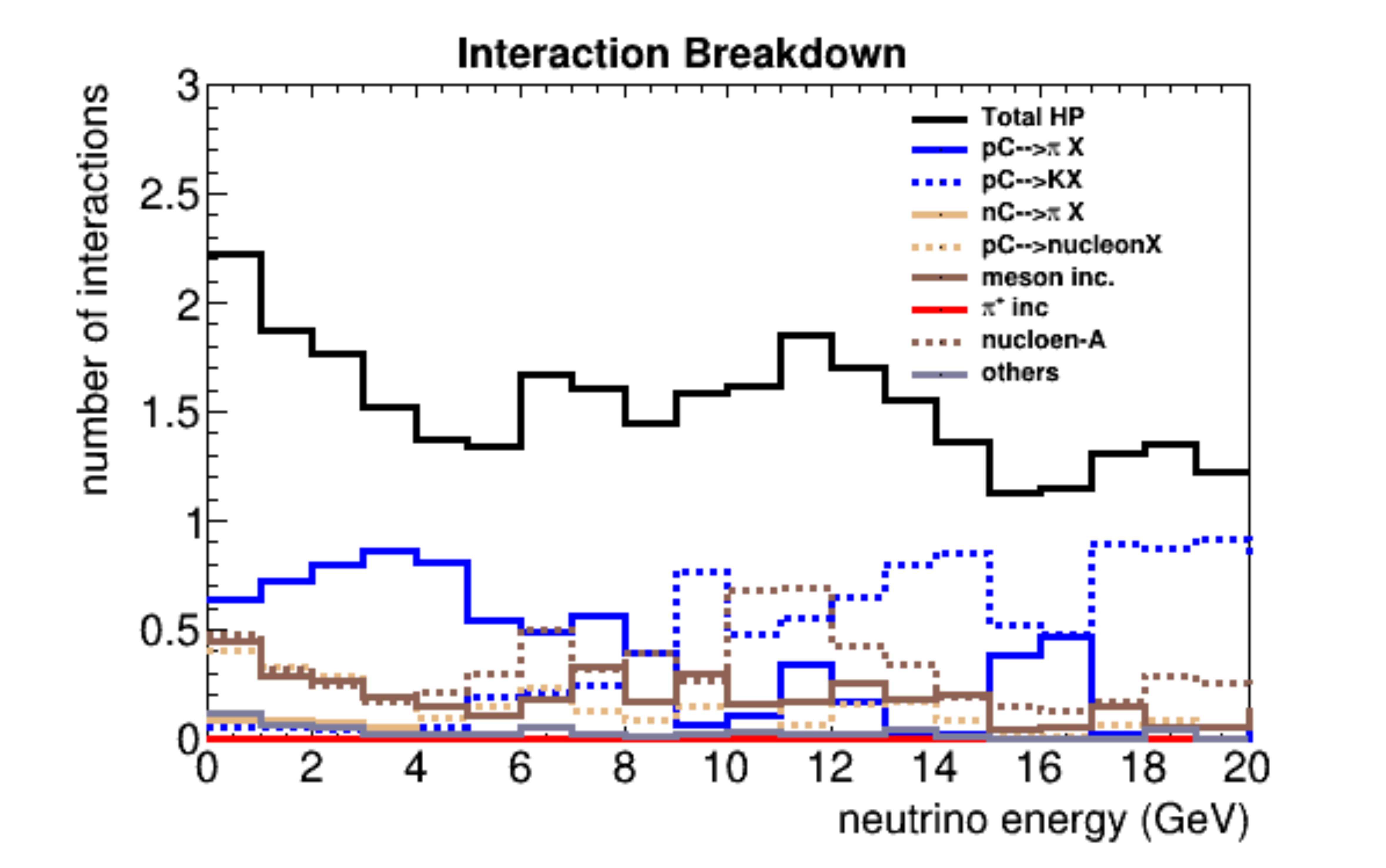
This was made with doReweight_ppfx_dune
And hp_uncer.C in the ppfx repository
Modified for cosmetics



This was made with CreateIMapHists.cpp in the ppfx repository
And draw uncertainty in the g4lbnf repository
Modified for cosmetics

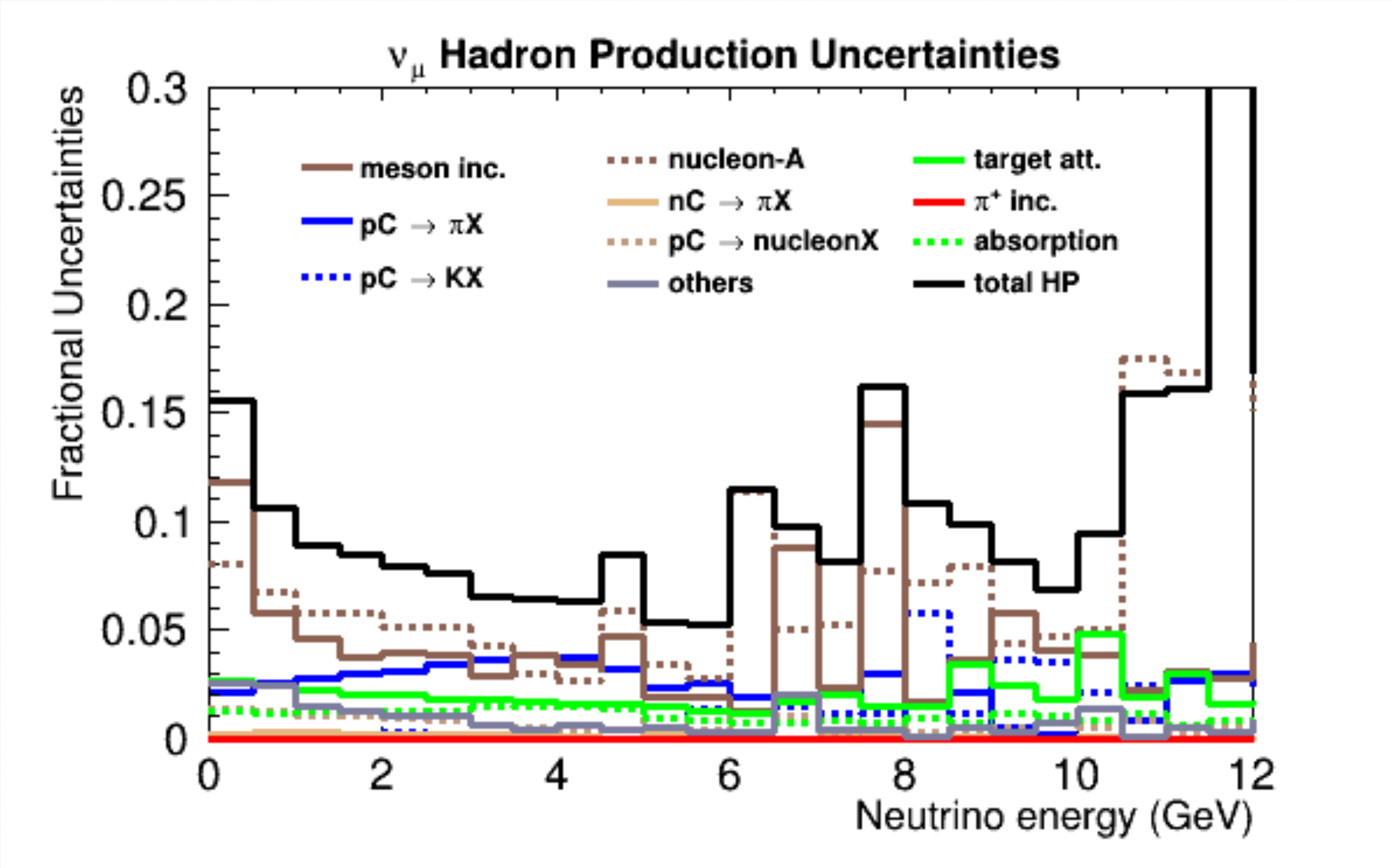
AFTER MAKING A DUMMY REWEIGHTER

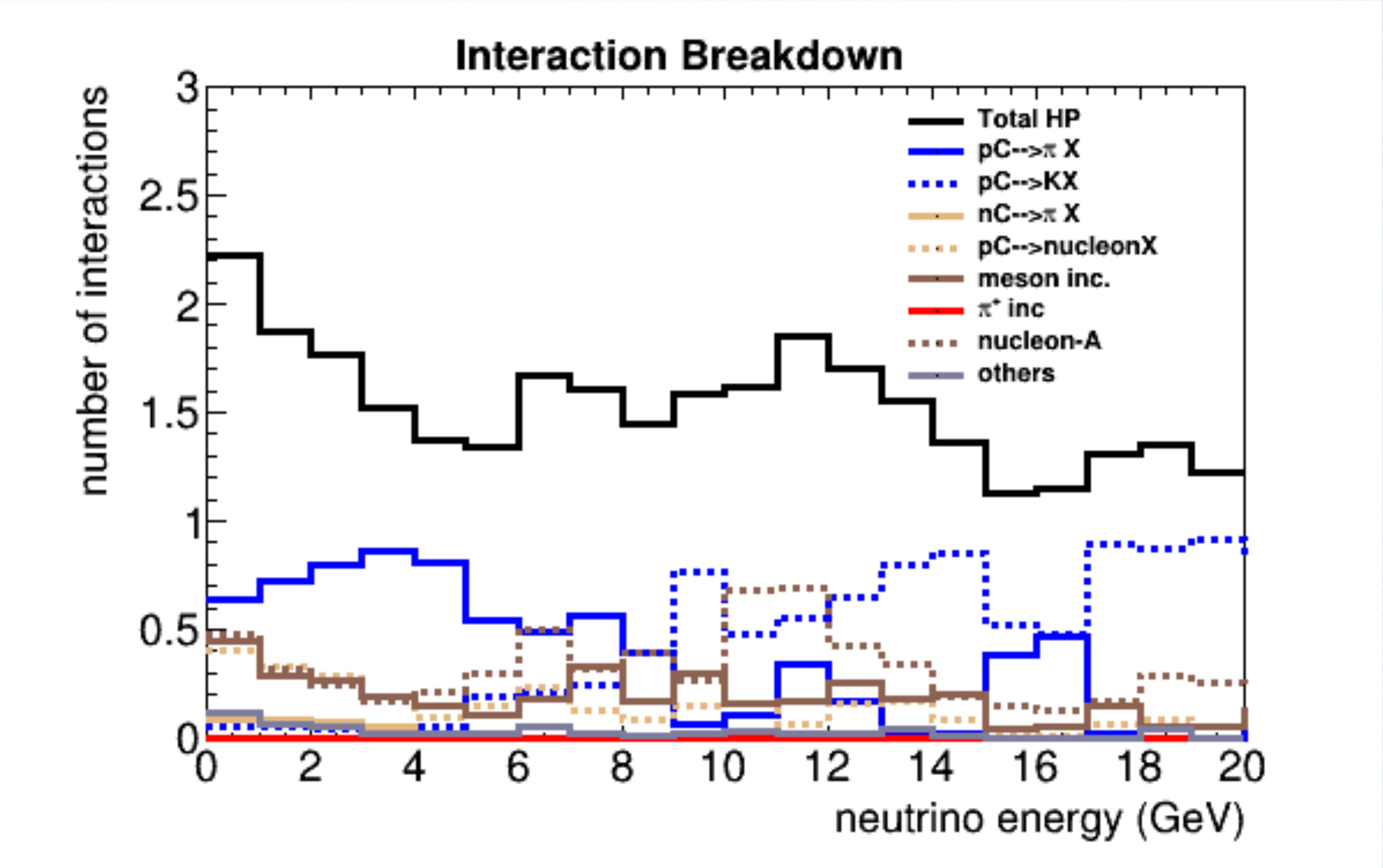




Some small differences due to my adding some parameters for the new reweighter to Parameters_default.xml
This changes the random numbers used by other reweighers. For the moment, I forced this new reweighter to use parameters from the old MesonInc reweighter, to avoid this problem….

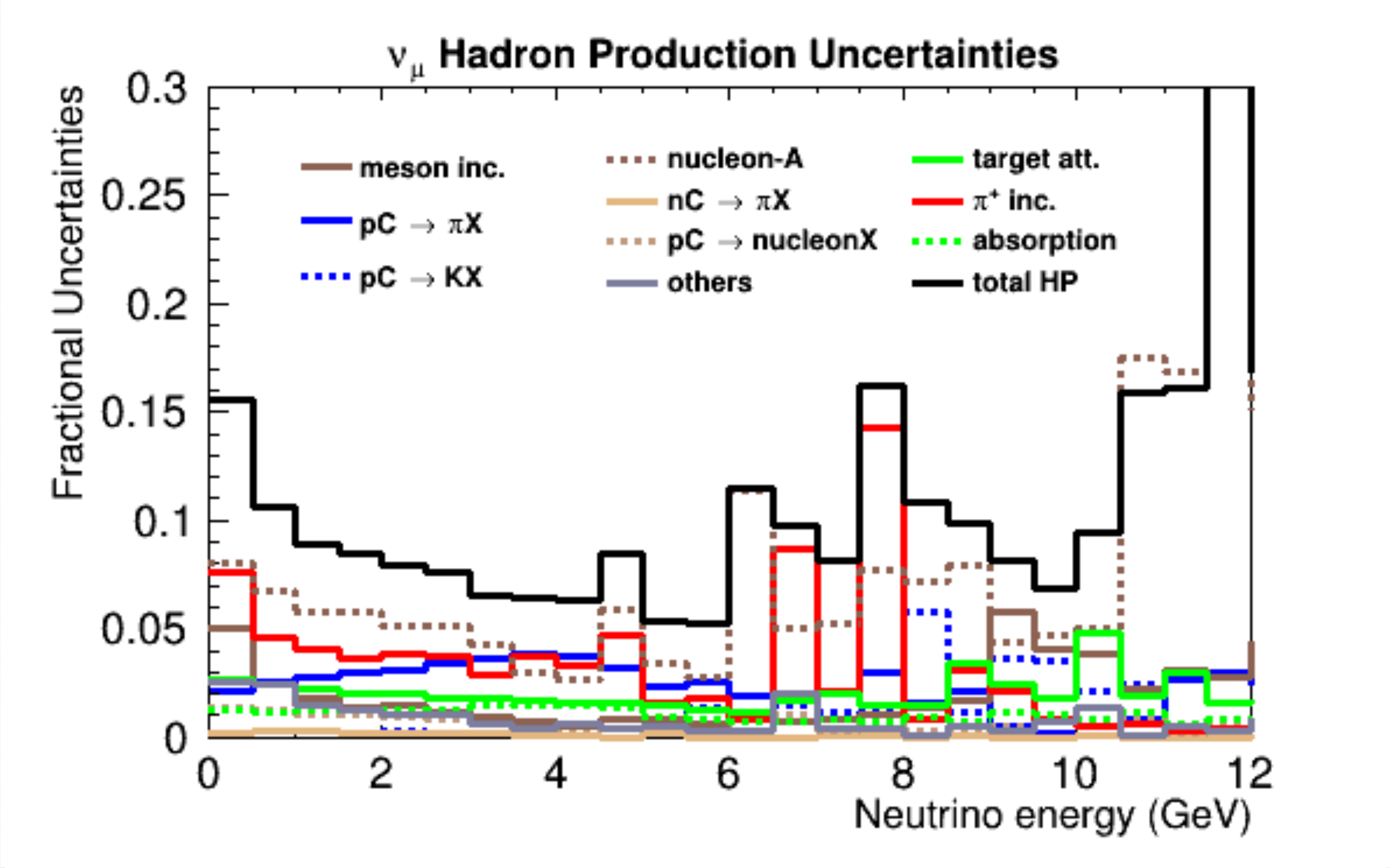
TURNING ON THE DUMMY REWEIGHTER

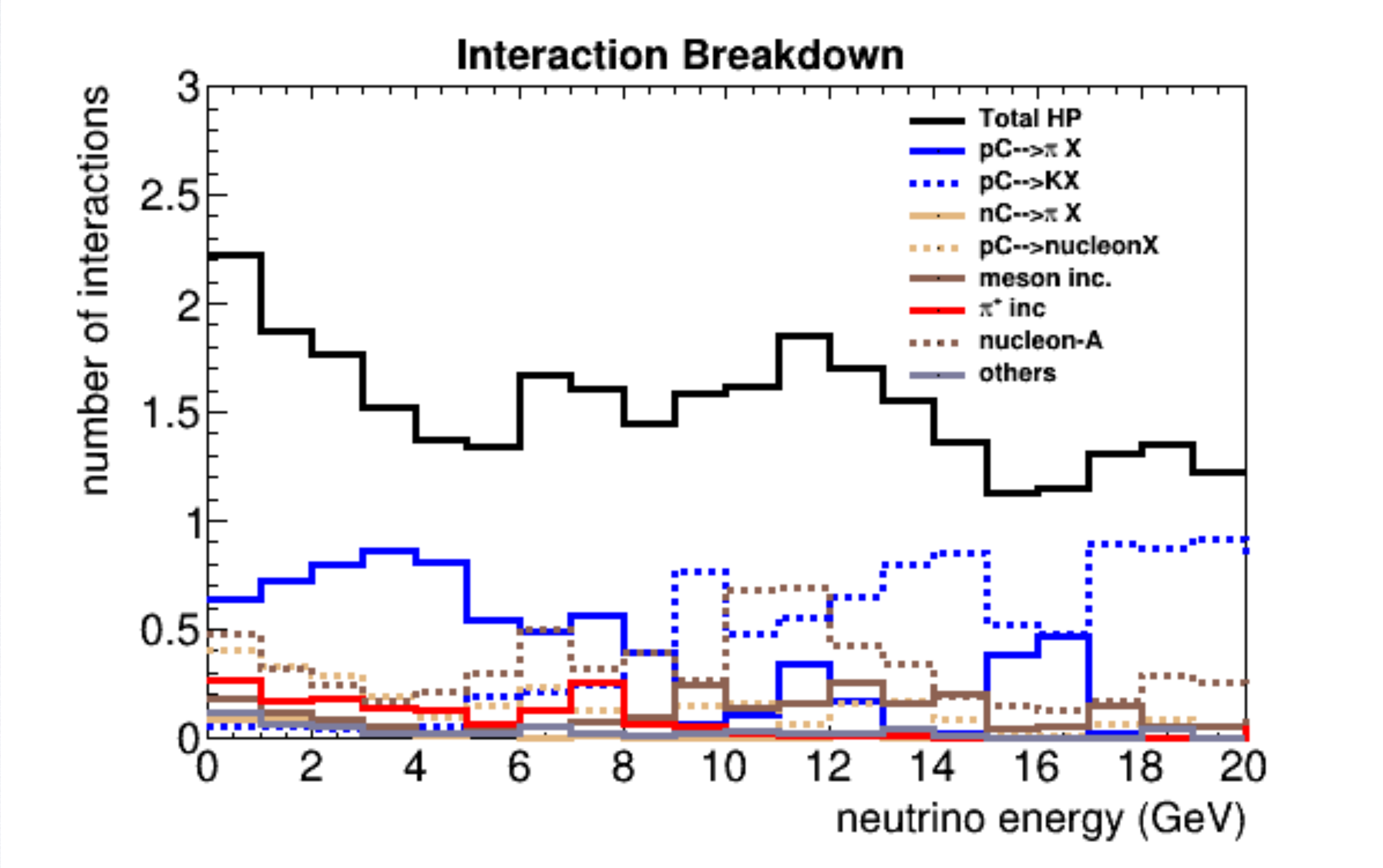




This is after reverting the changes to parameter. Exact agreement again.

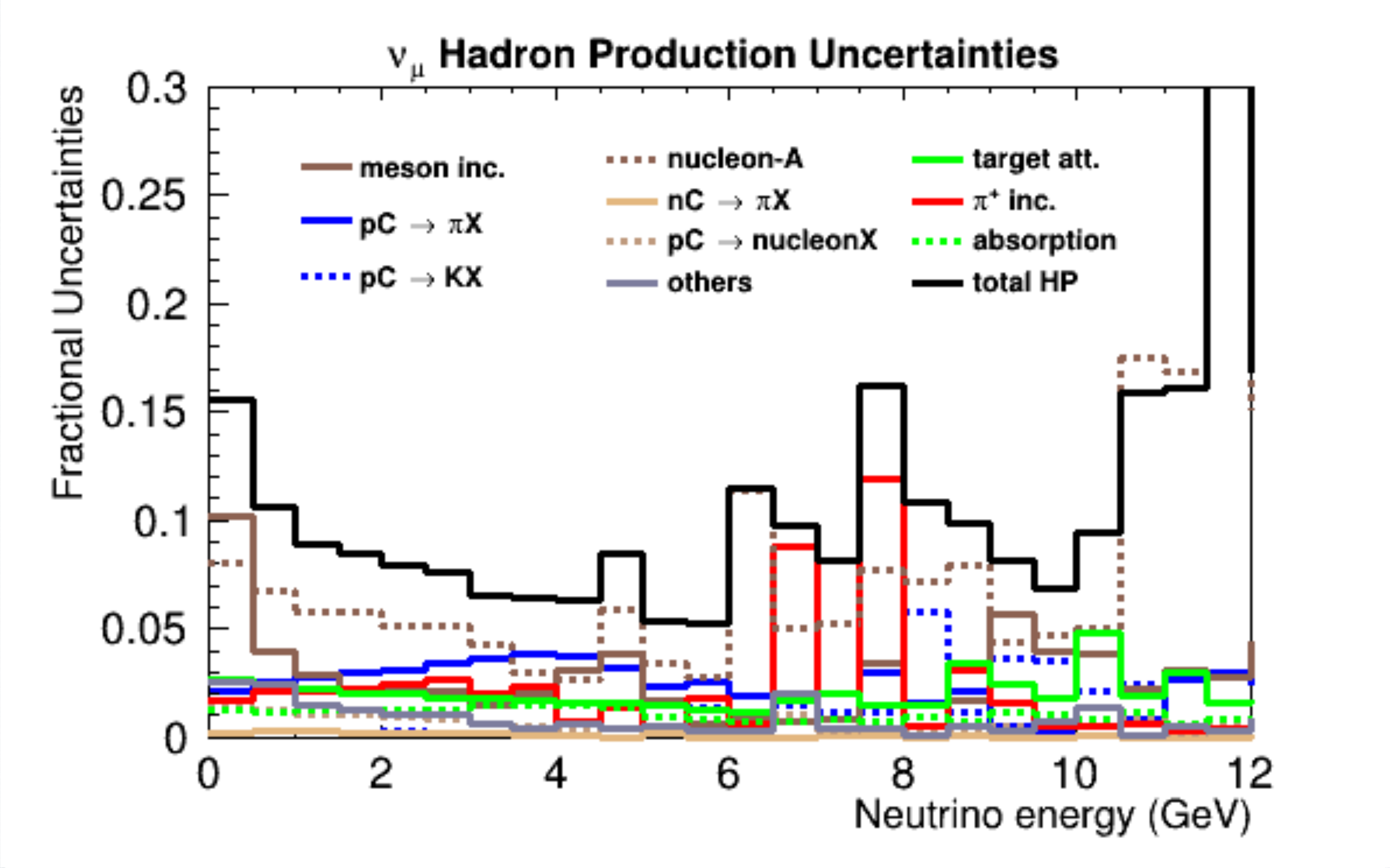
MAKING IT REWEIGHT PION INC

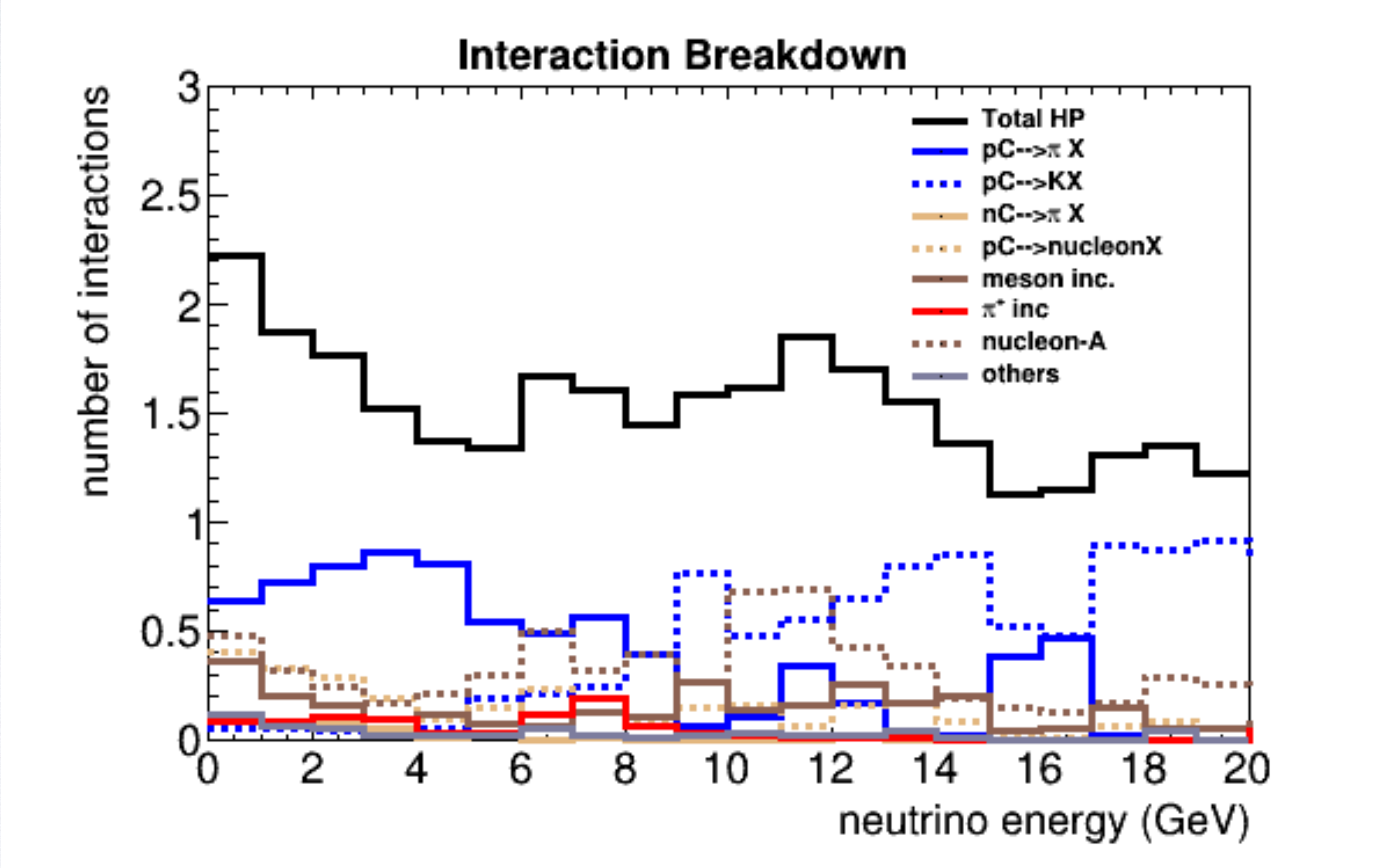




Here, the new reweighter covers all pi+ incident interactions and uses same uncertainties and random numbers as before. The only lines that change are the ones associated with the meson incident reweighter, as expected. And the total uncertainty and number of interactions per neutrino is unchanged, which is also good

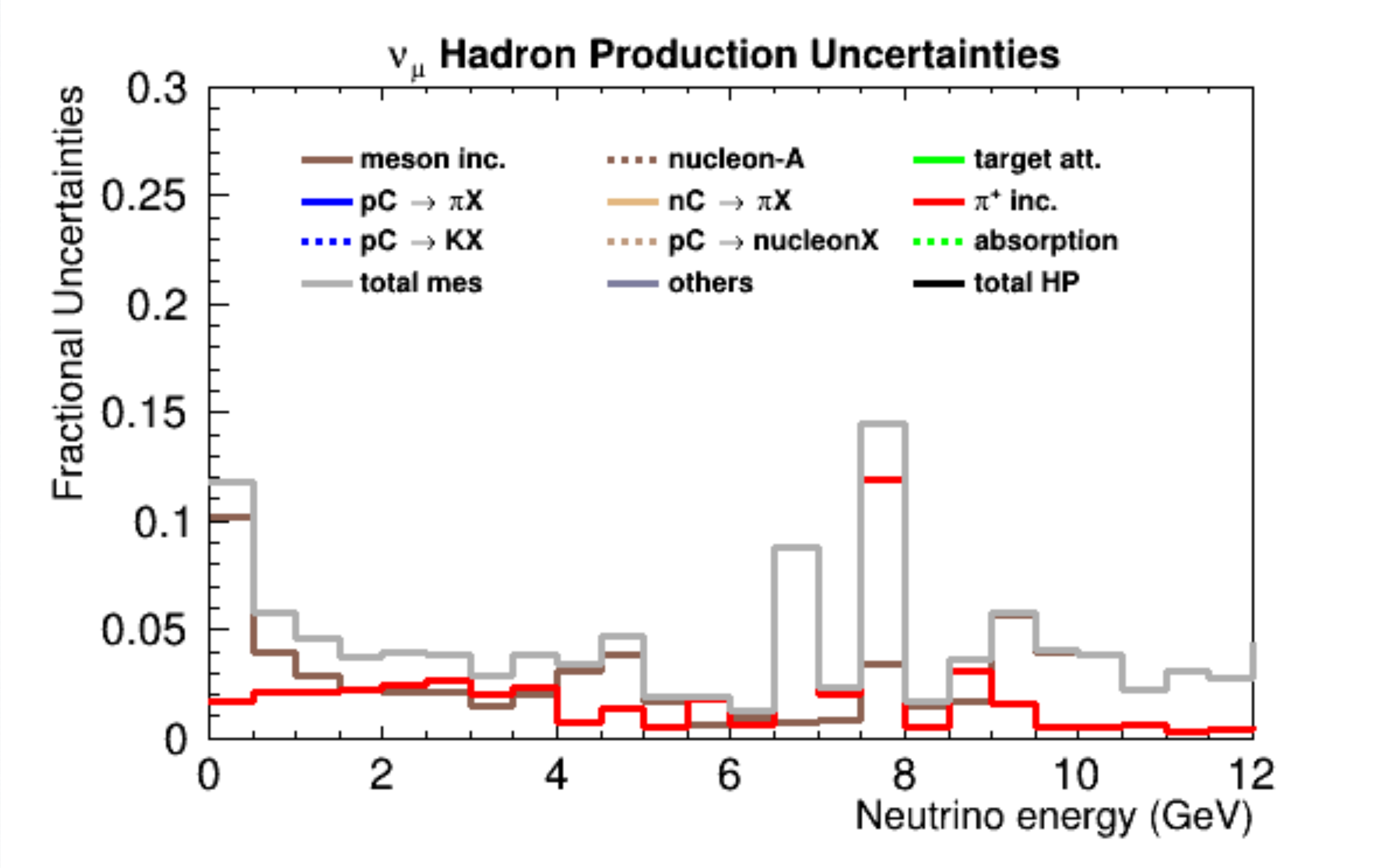
MAKING IT REWEIGH PION INC

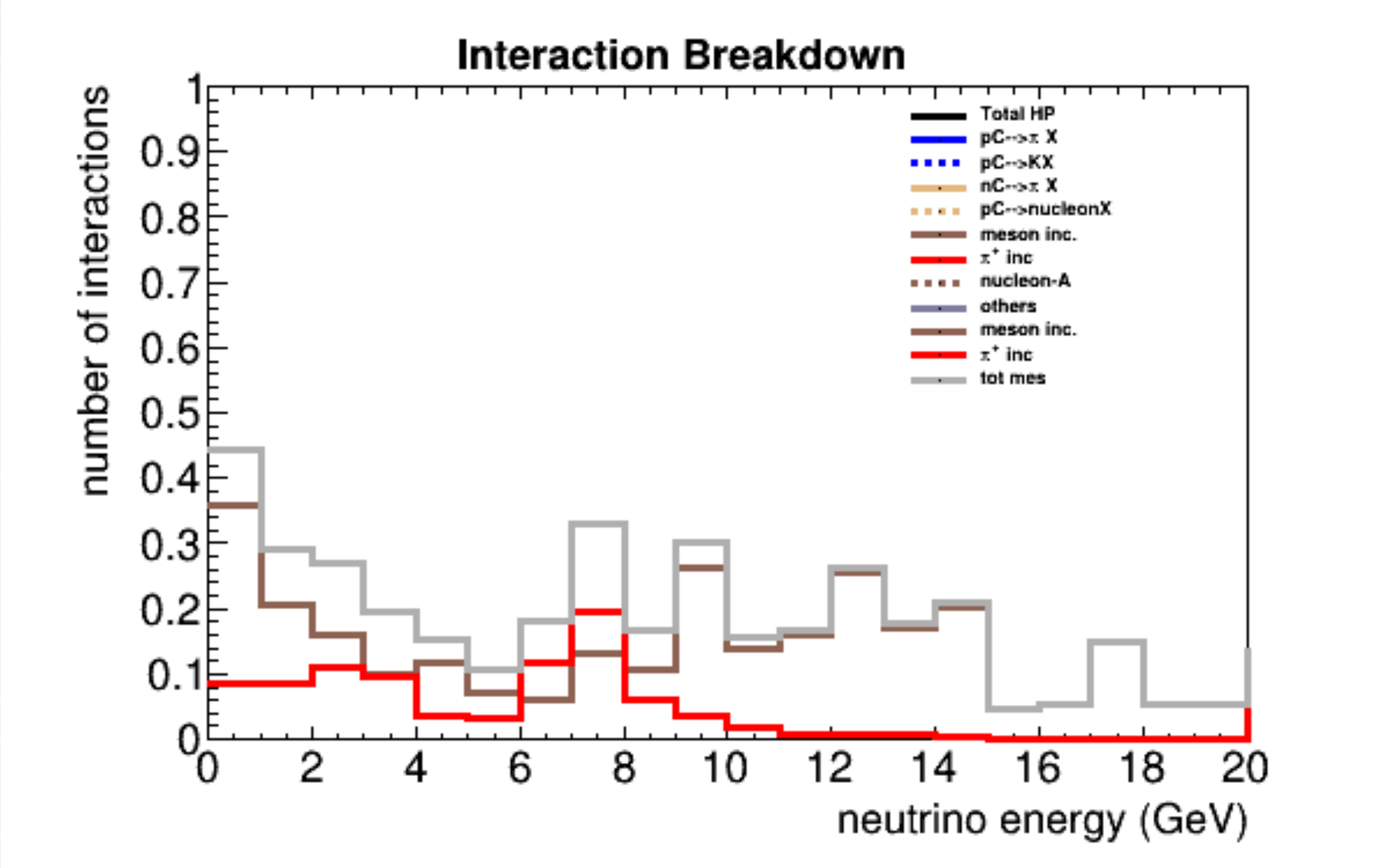




Now the new reweighter covers only interactions within the NA61 phase space
We may be able to extend it with isospin symmetry to pi- incident, but I'm going to proceed with this for now

MAKING IT REWEIGH PION INC



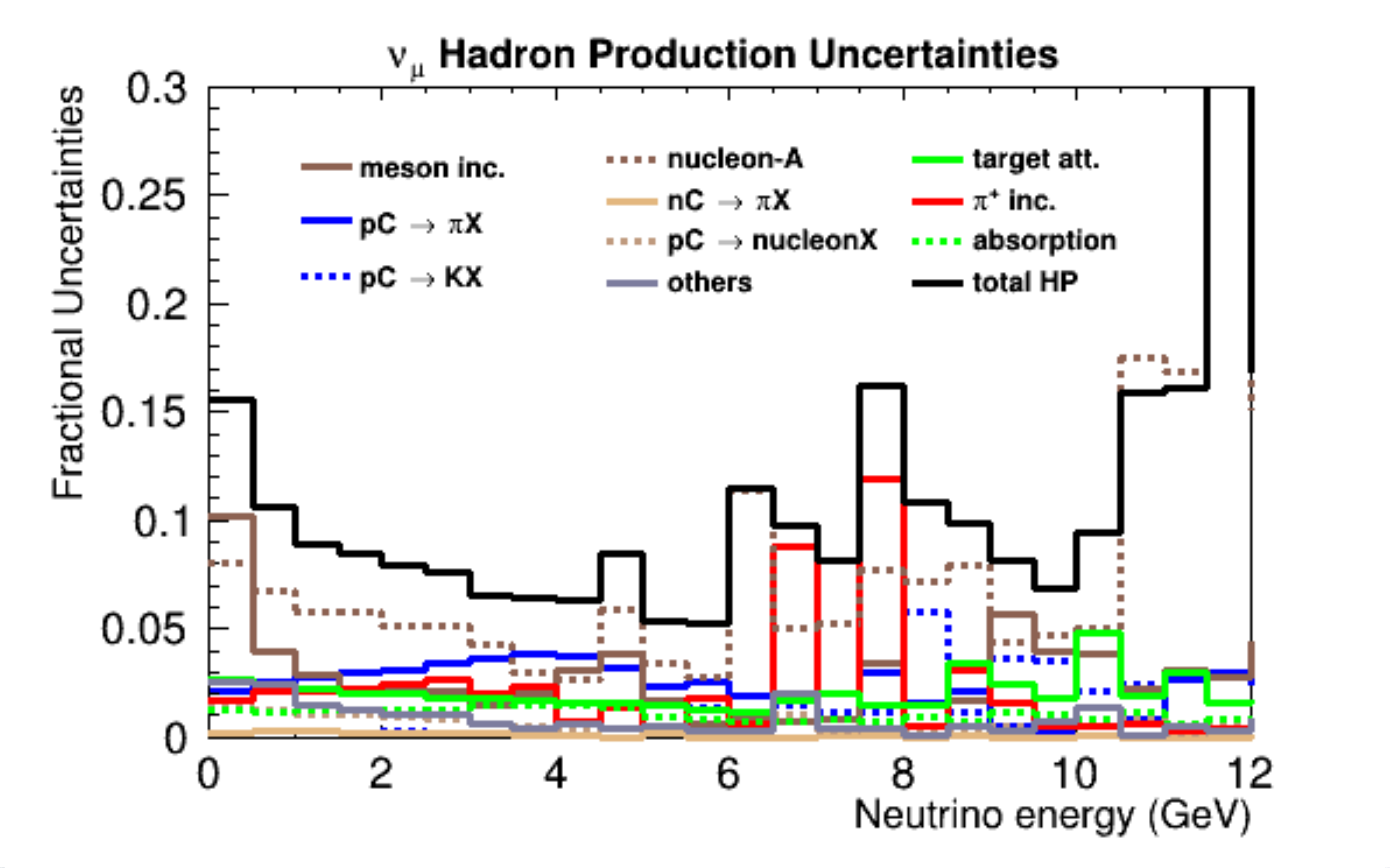


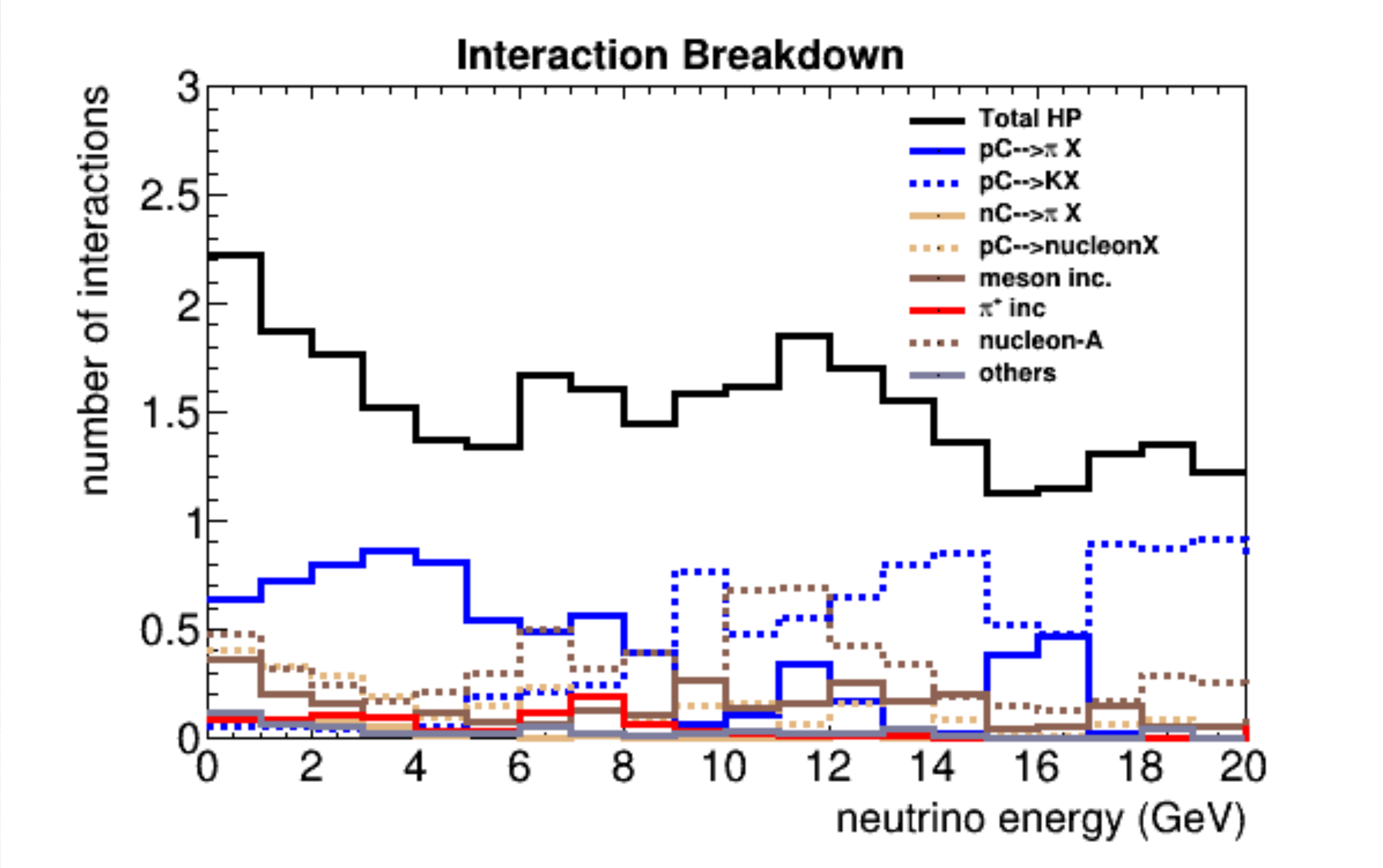
This is the same as the previous, but just showing meson incident, for easier viewing

MULTIPLICITY COMPARISONS

- The next logical steps involve modifying the new reweighter to use NA61 uncertainties
  - This will going to break the random numbers used previously
  - But I thought of way to avoid that
    - Random numbers come from a TRandom3 instance in CentralValuesAndUncertainties.cpp
    - I can leave that TRandom3 object alone and create a new one for the new reweighter
      - This will preserve the random numbers used for other reweighters

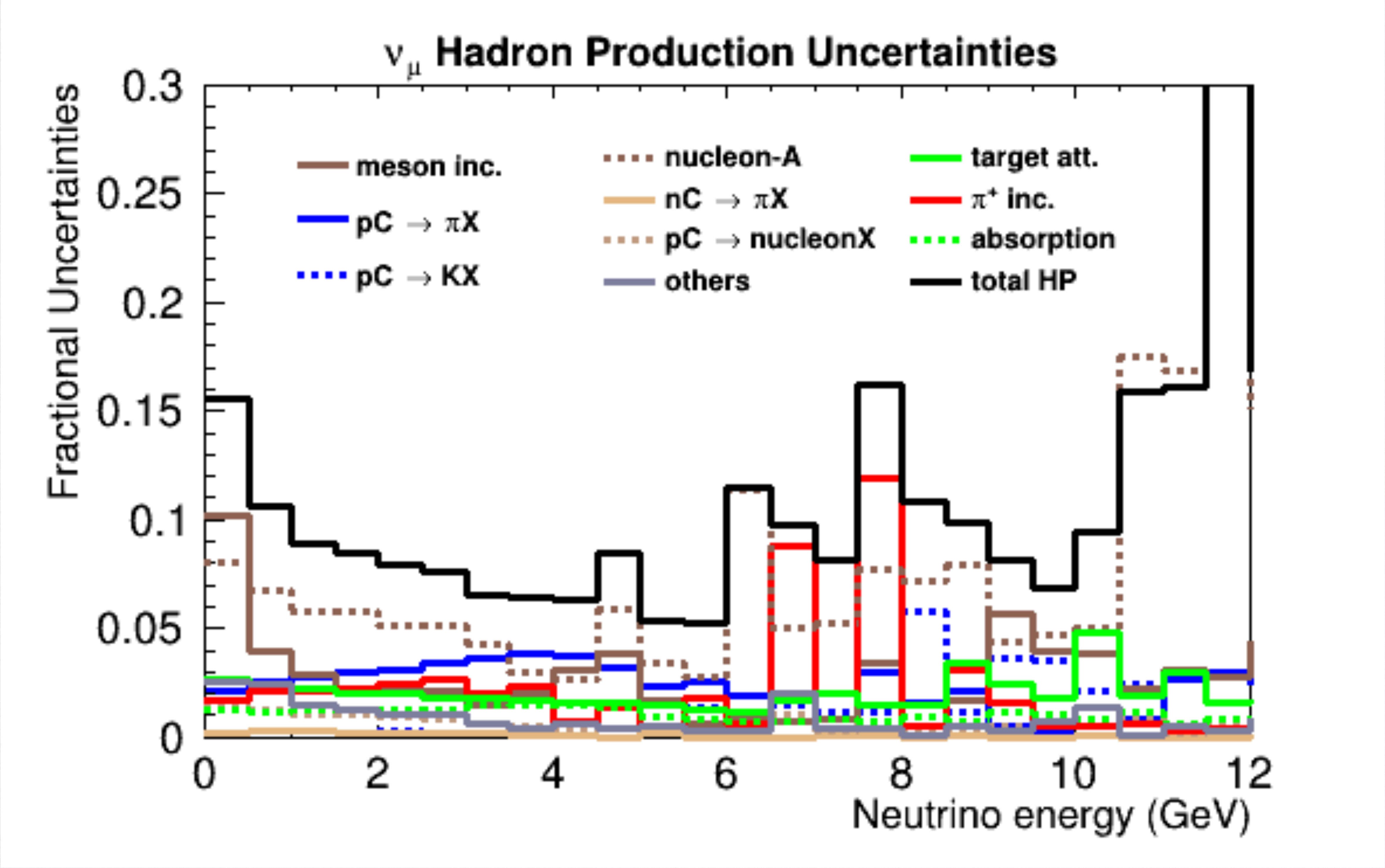
ADDING NEW PARAMETERS

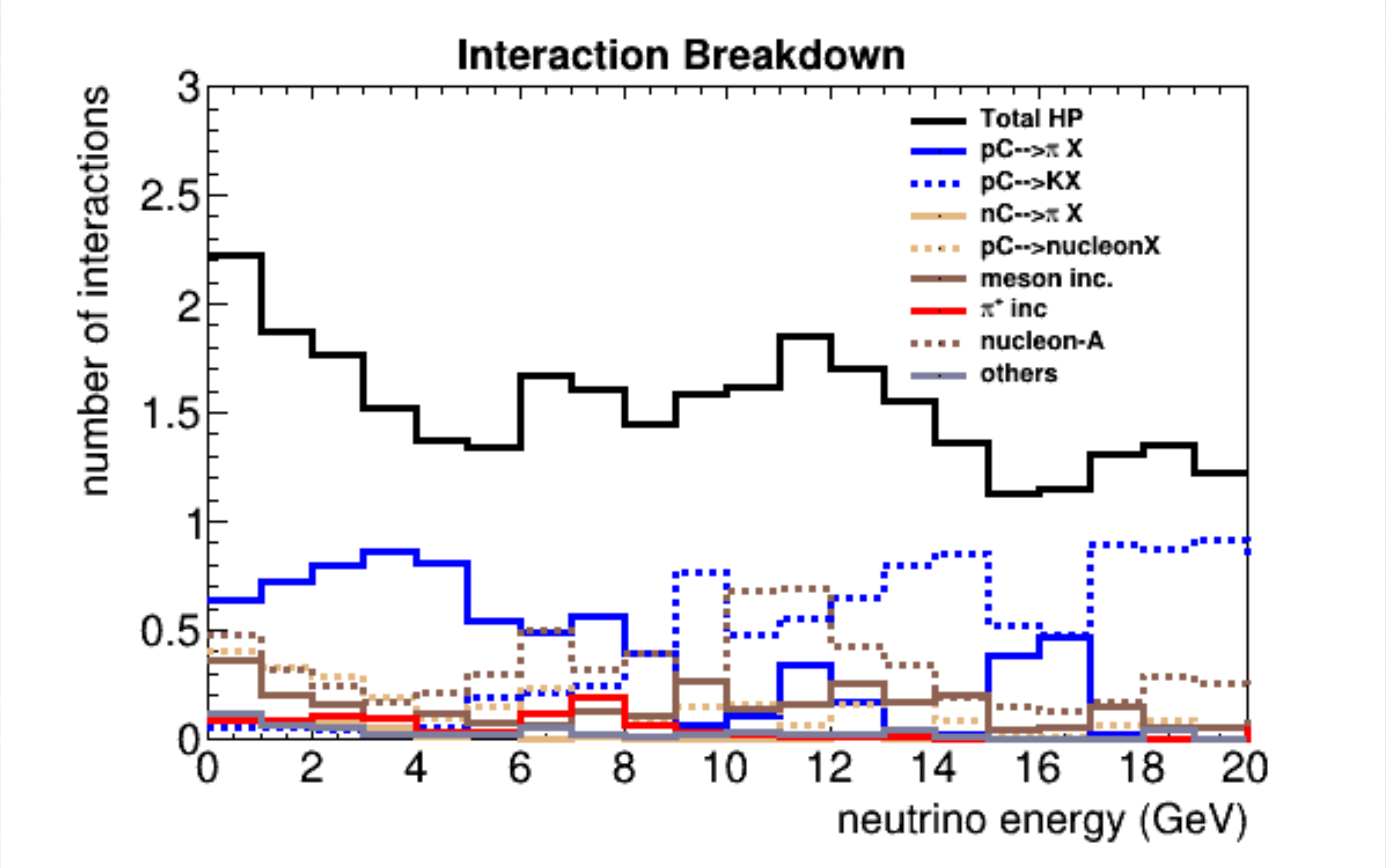




Before Adding New Parameters

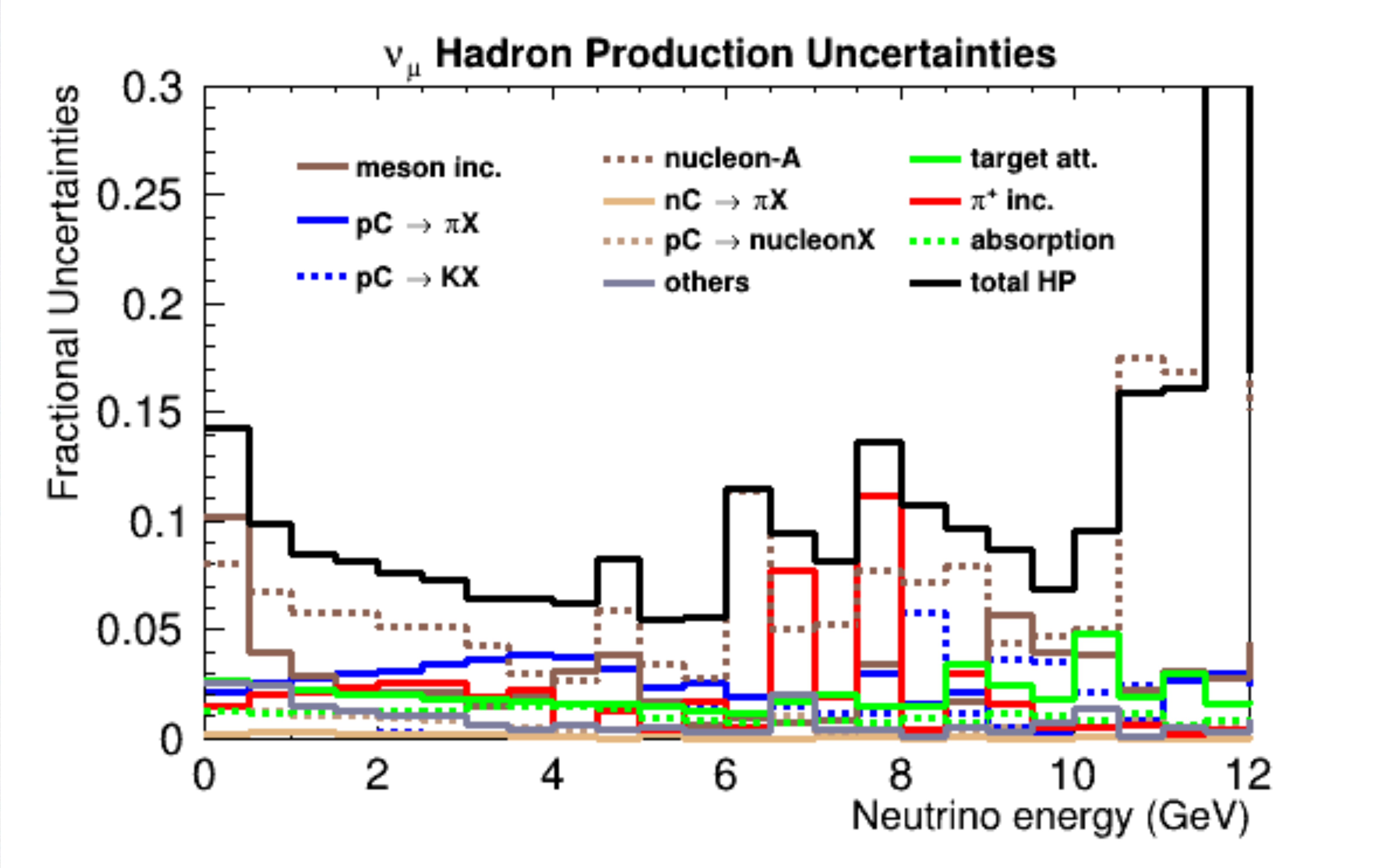
ADDING NEW PARAMETERS

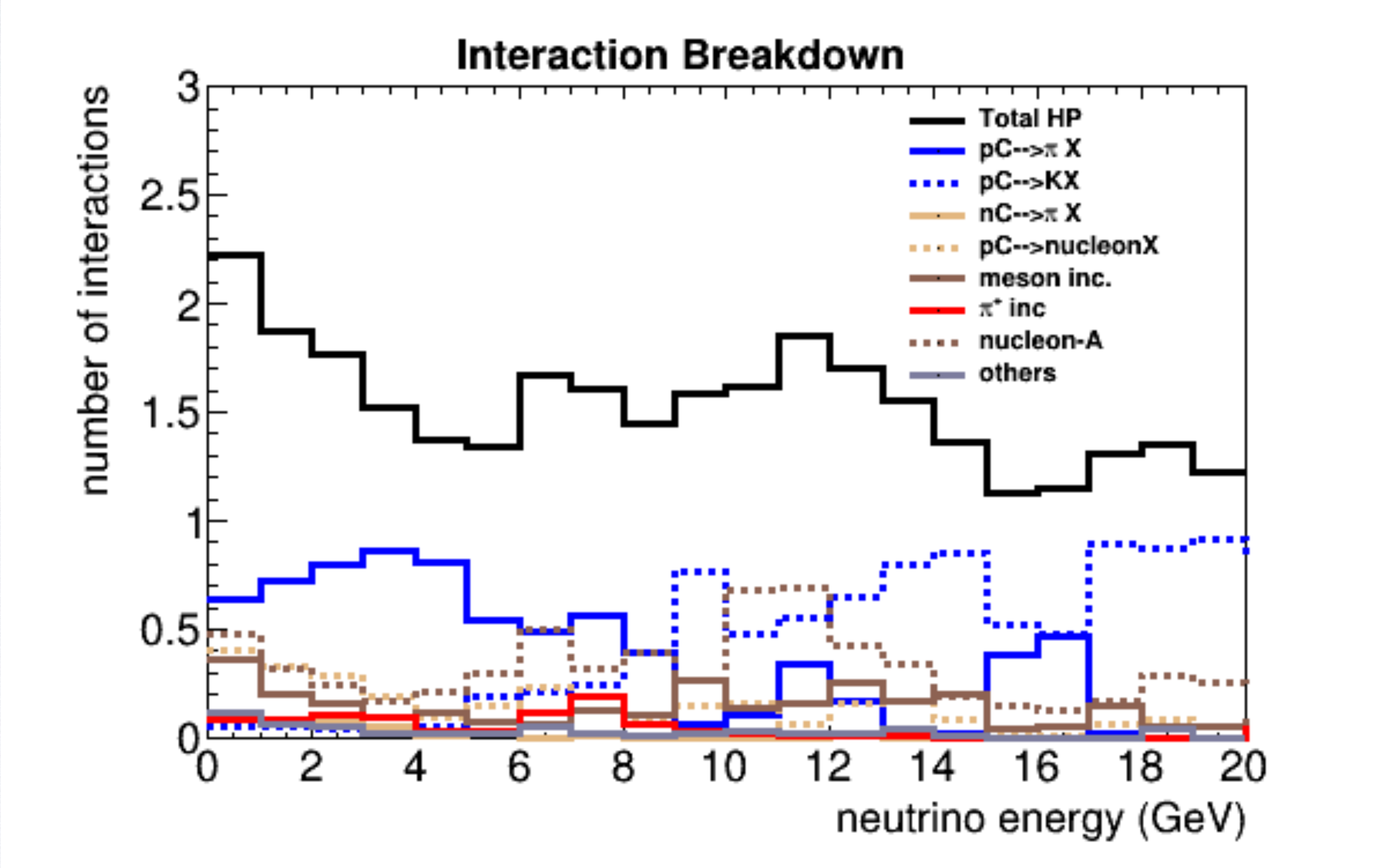




After Adding New Parameters (but not using them yet).
No changes, because I'm using a new TRandom3 object.

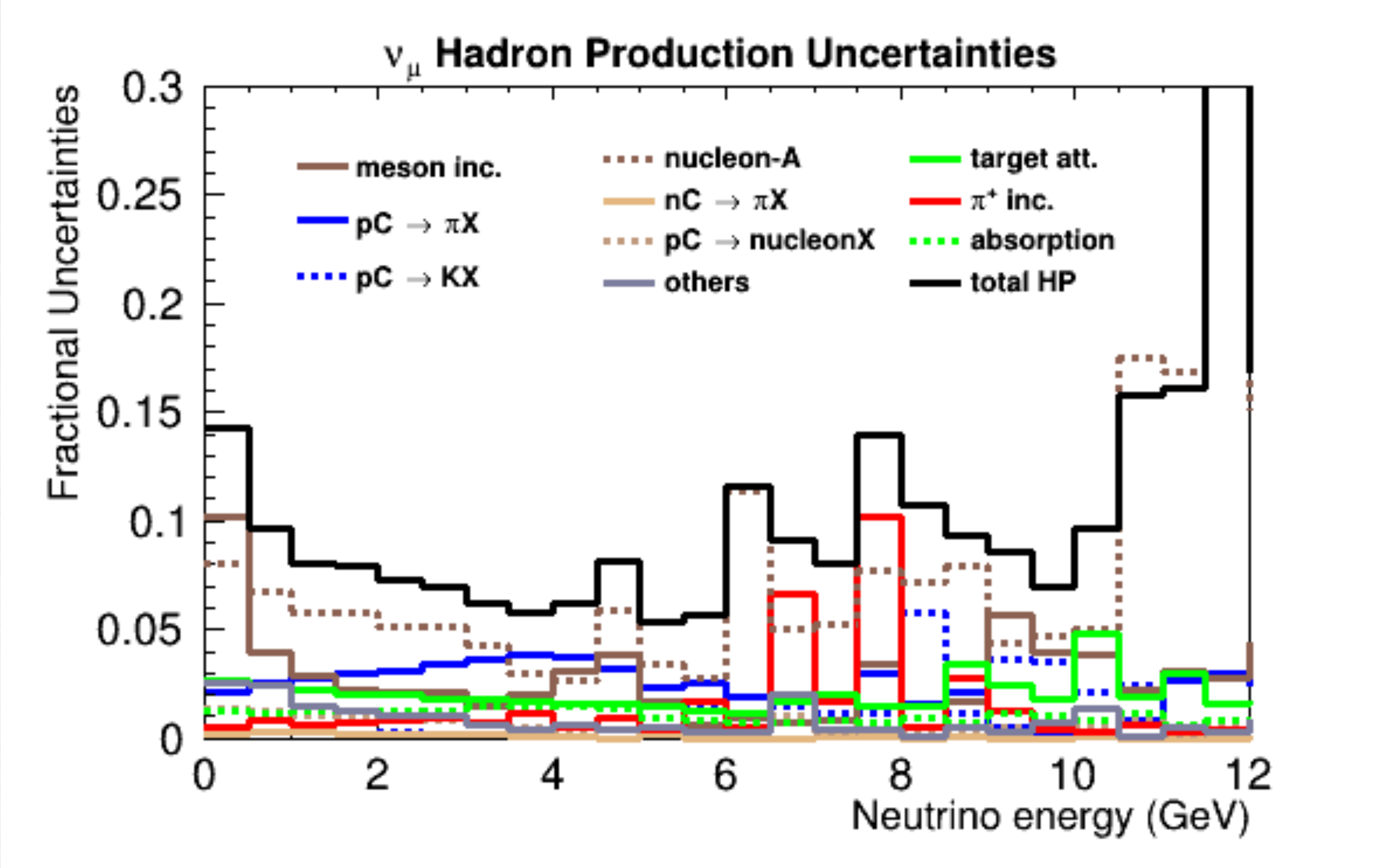
ADDING NEW PARAMETERS

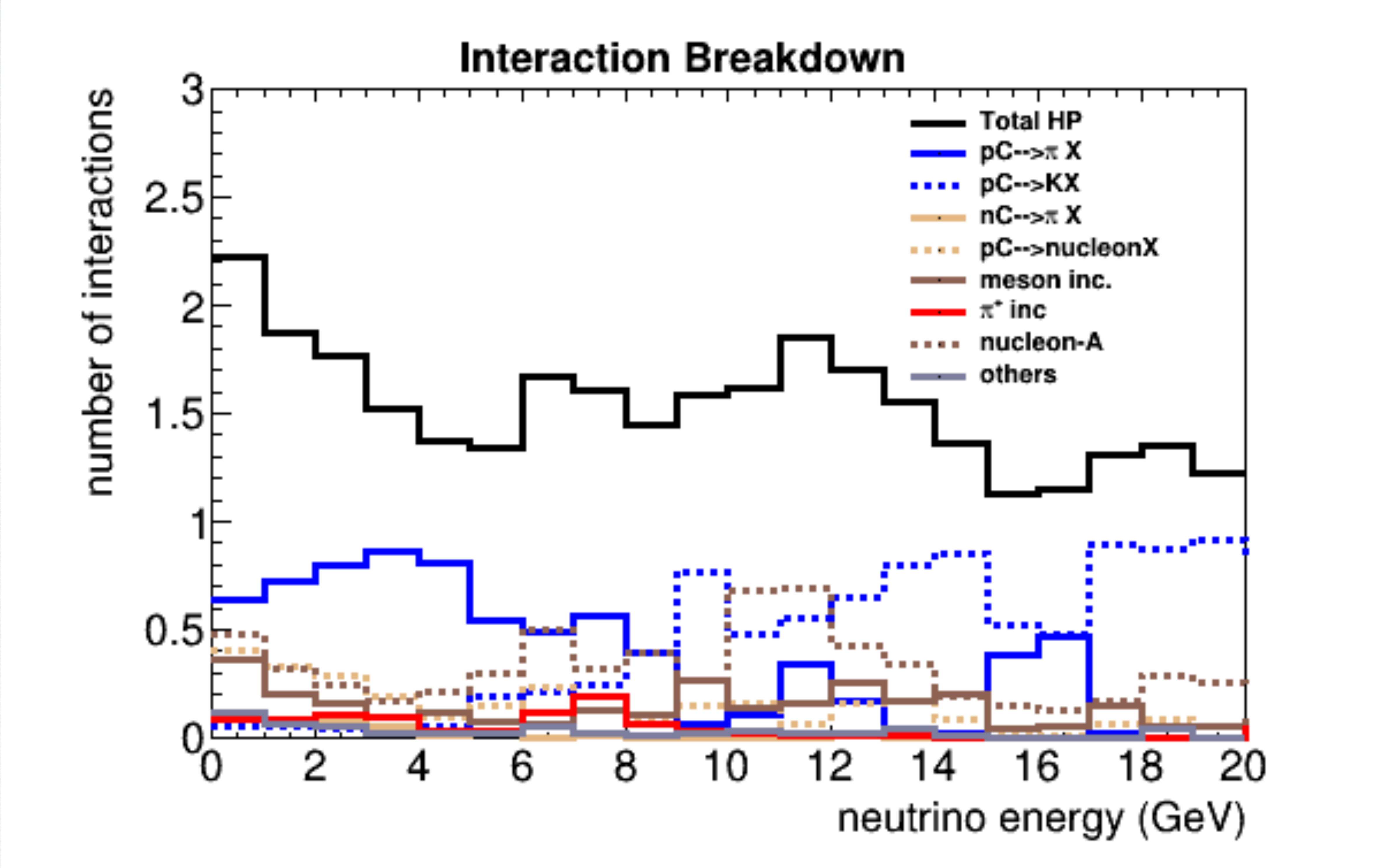




After Adding New Parameters (and using them for the new reweighter)
Here, the only line that changes is the new reweigher, which has small changes consistent with statistical fluctuations, as expected, since I changed the random numbers.

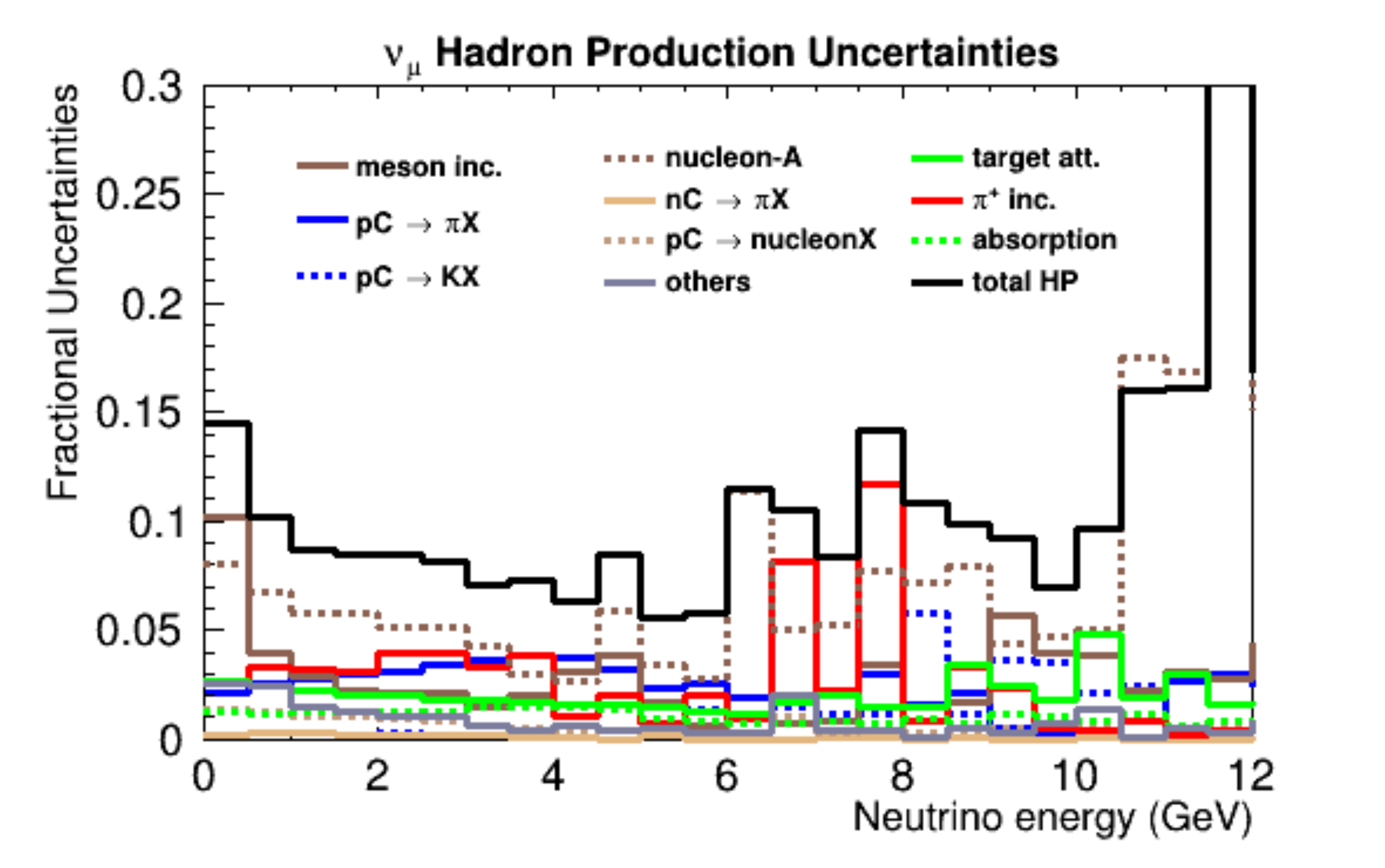
USING NA61 BINNING

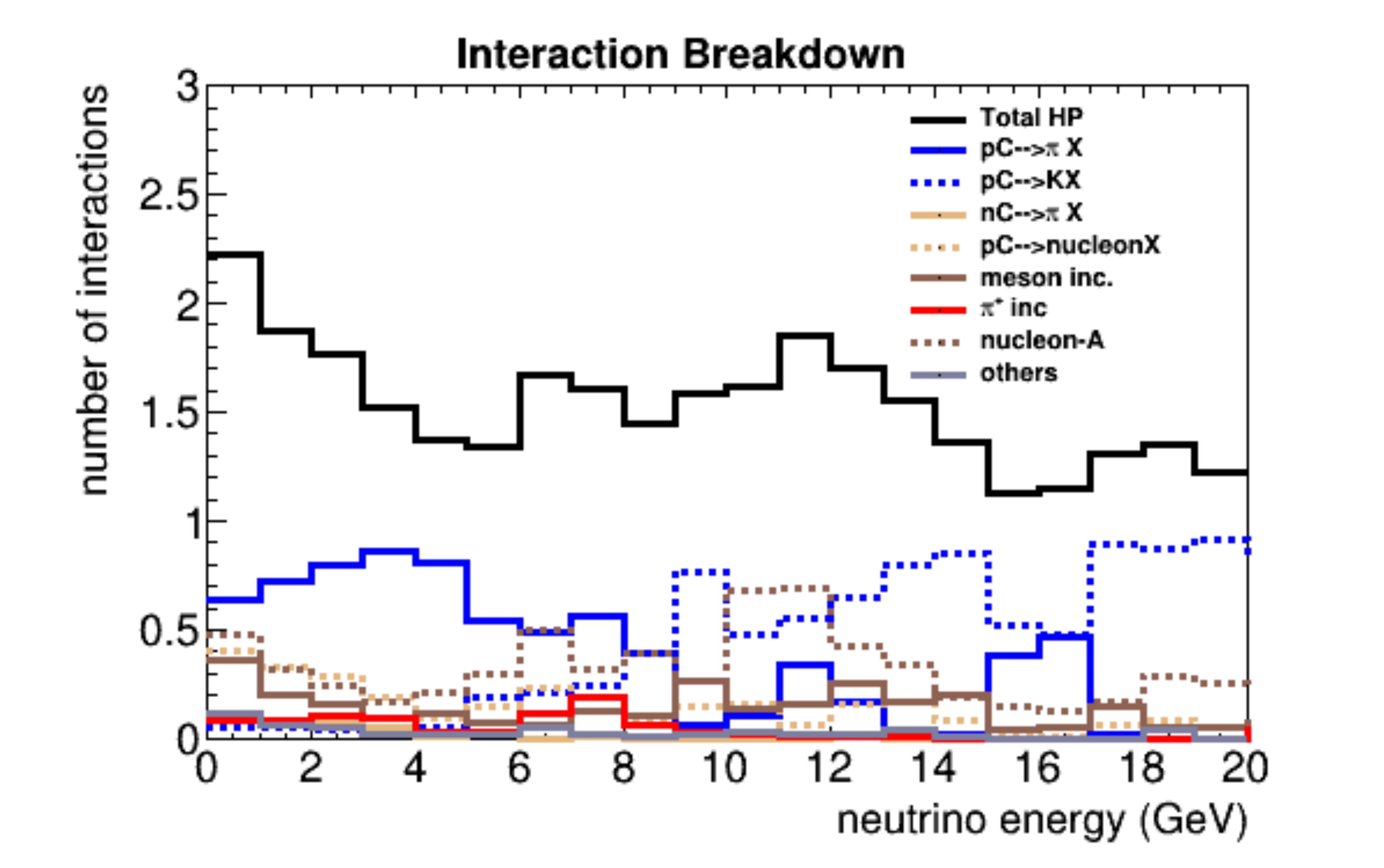




Now, instead of 4 bins for each produced species, I'm using NA61's binning (but still 40% uncertainty in each bin, uncorrelated). The uncertainties go down because we are now averaging over many more bins than before.

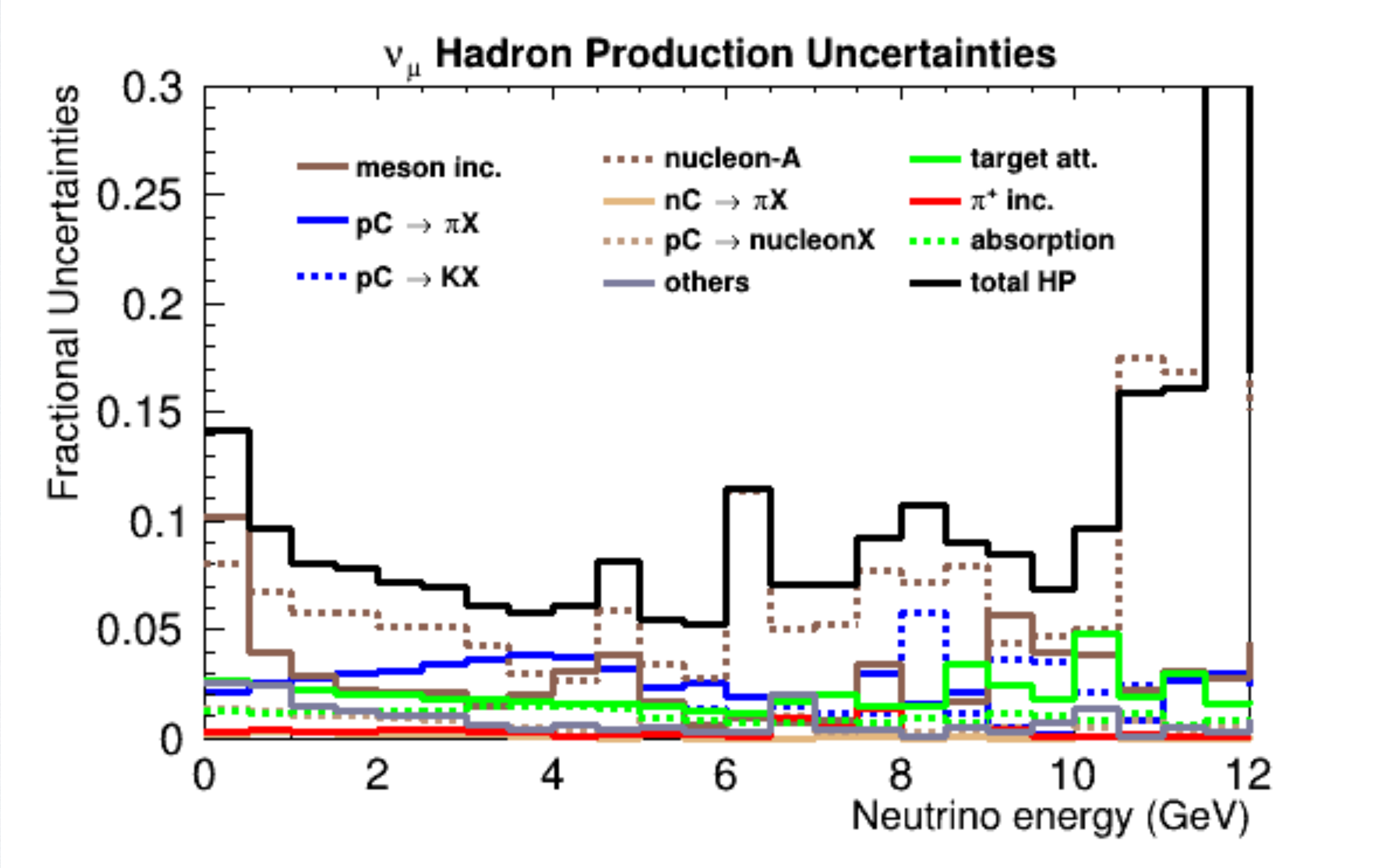
USING NA61 BINNING

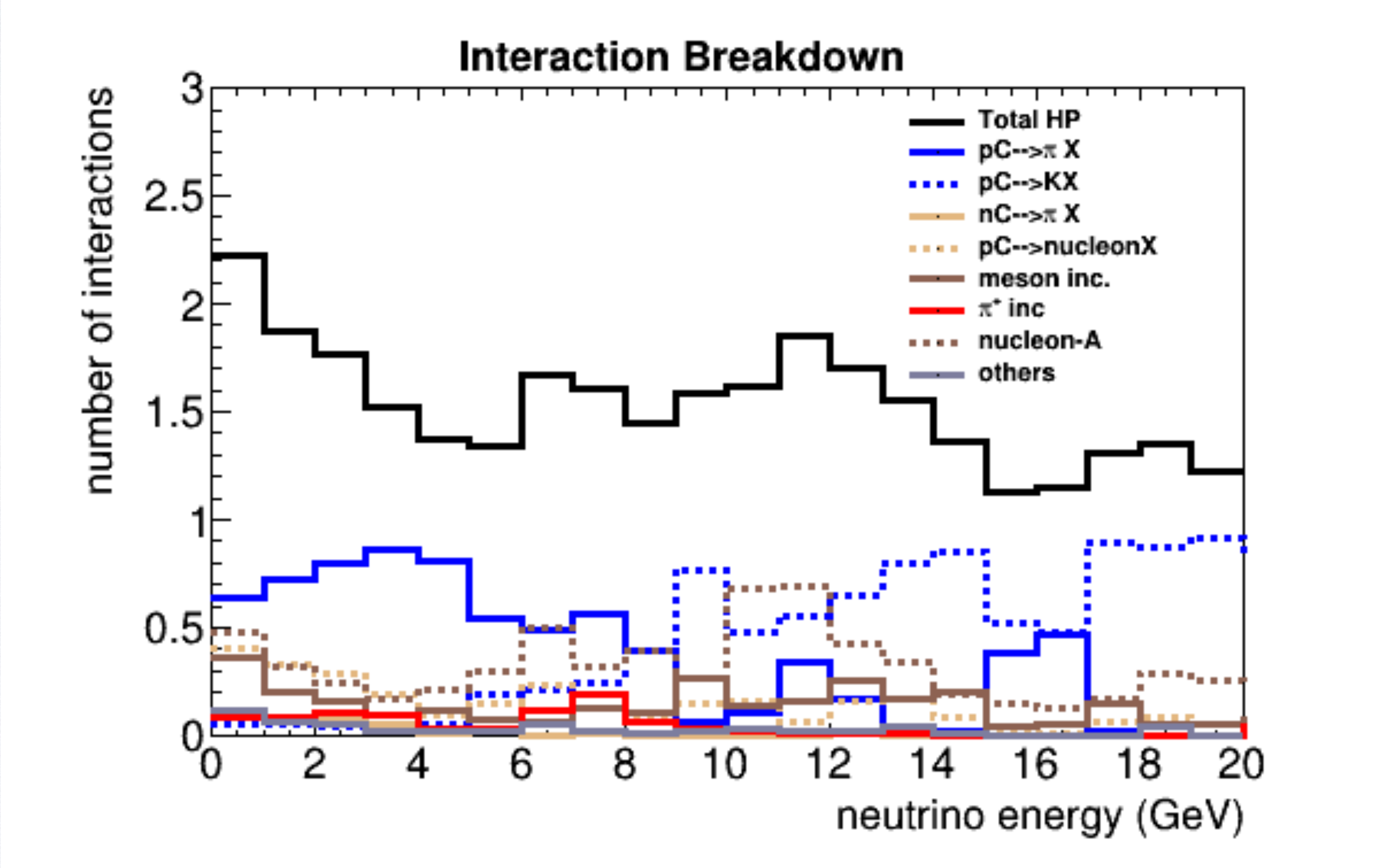




Same as previous slide, butnow uncertainties are fully correlated.
This causes them to go up quite a bit, as expected.

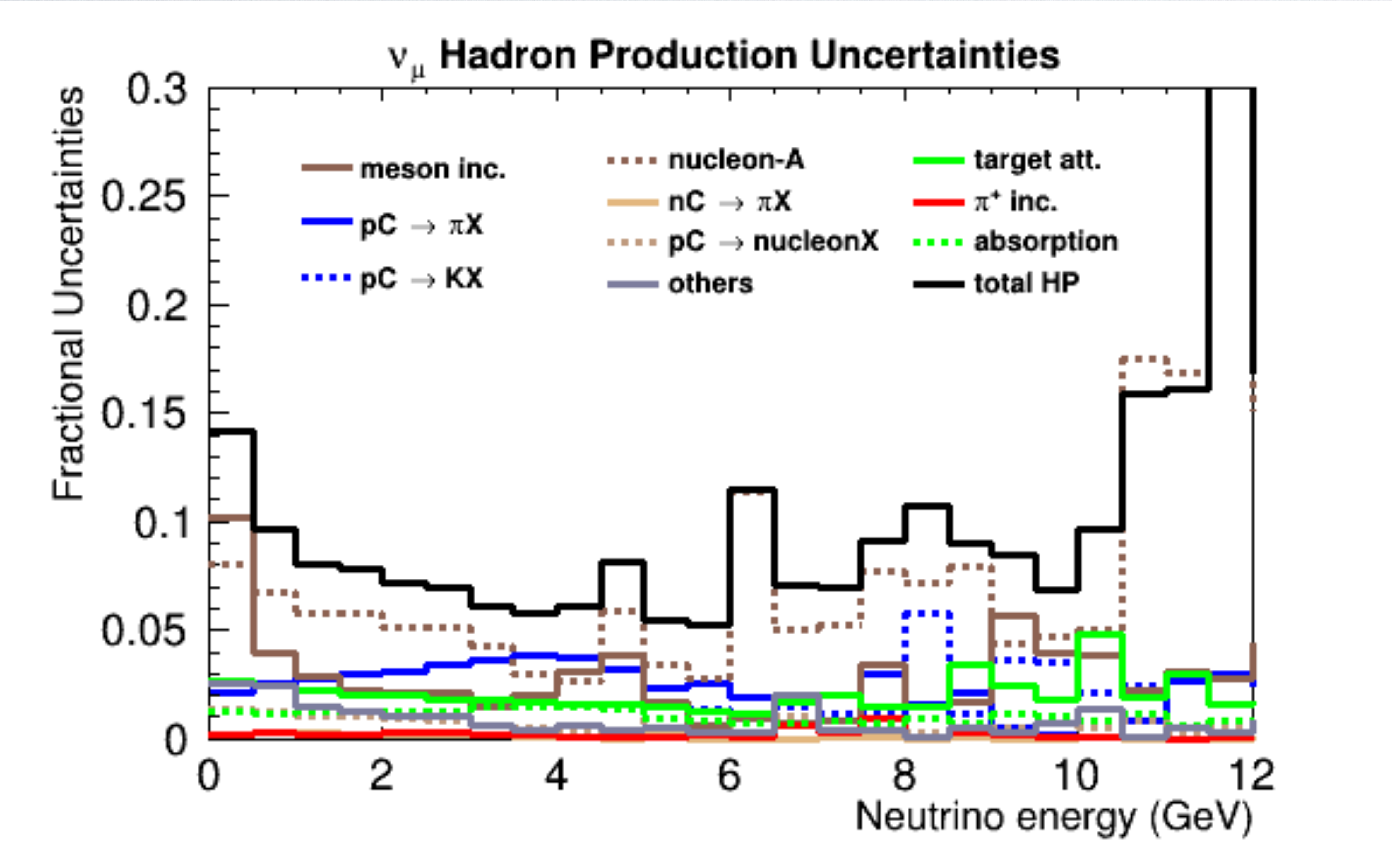
USING NA61 BINNING

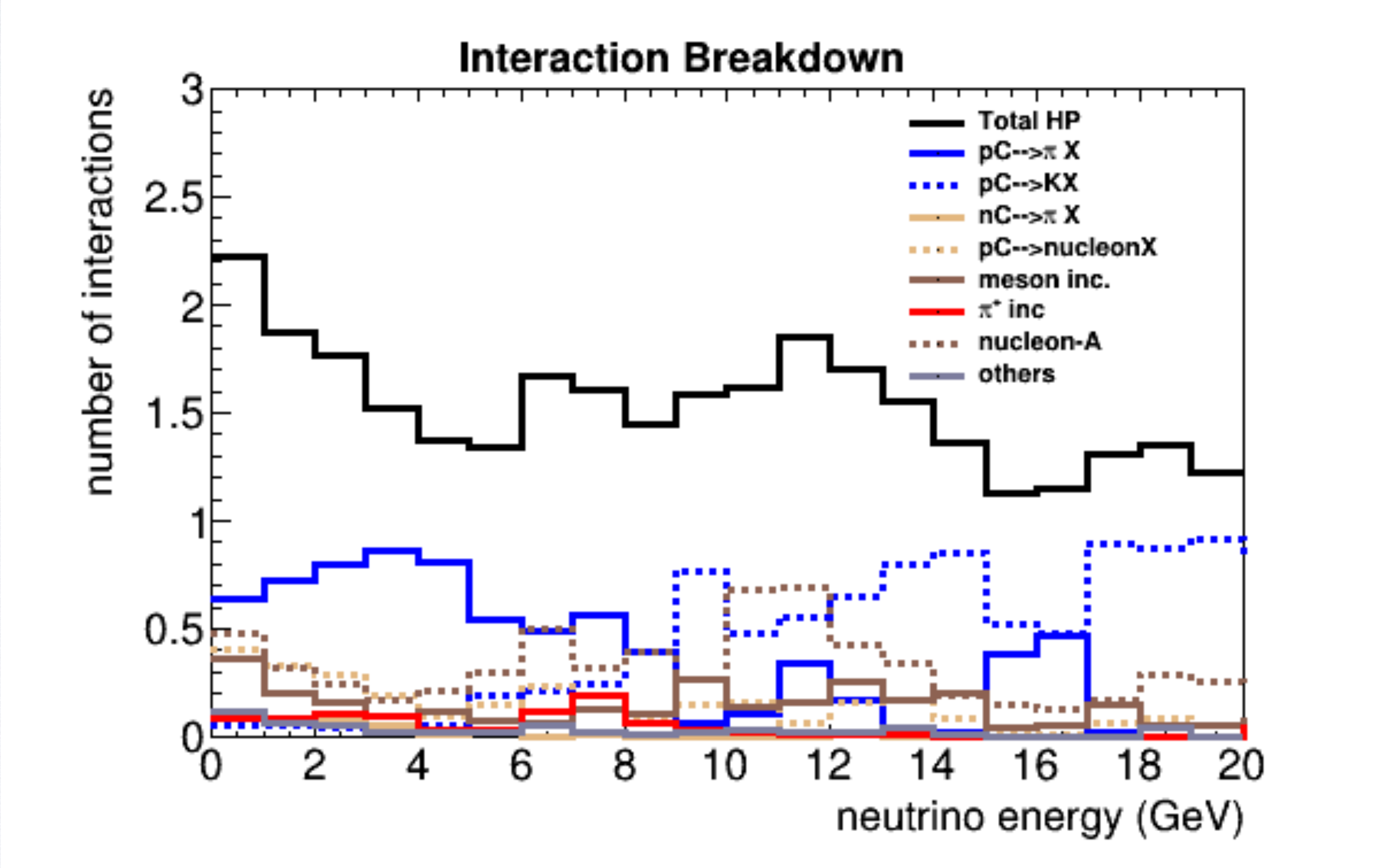




Now using NA61 uncertainties, all fully correlated

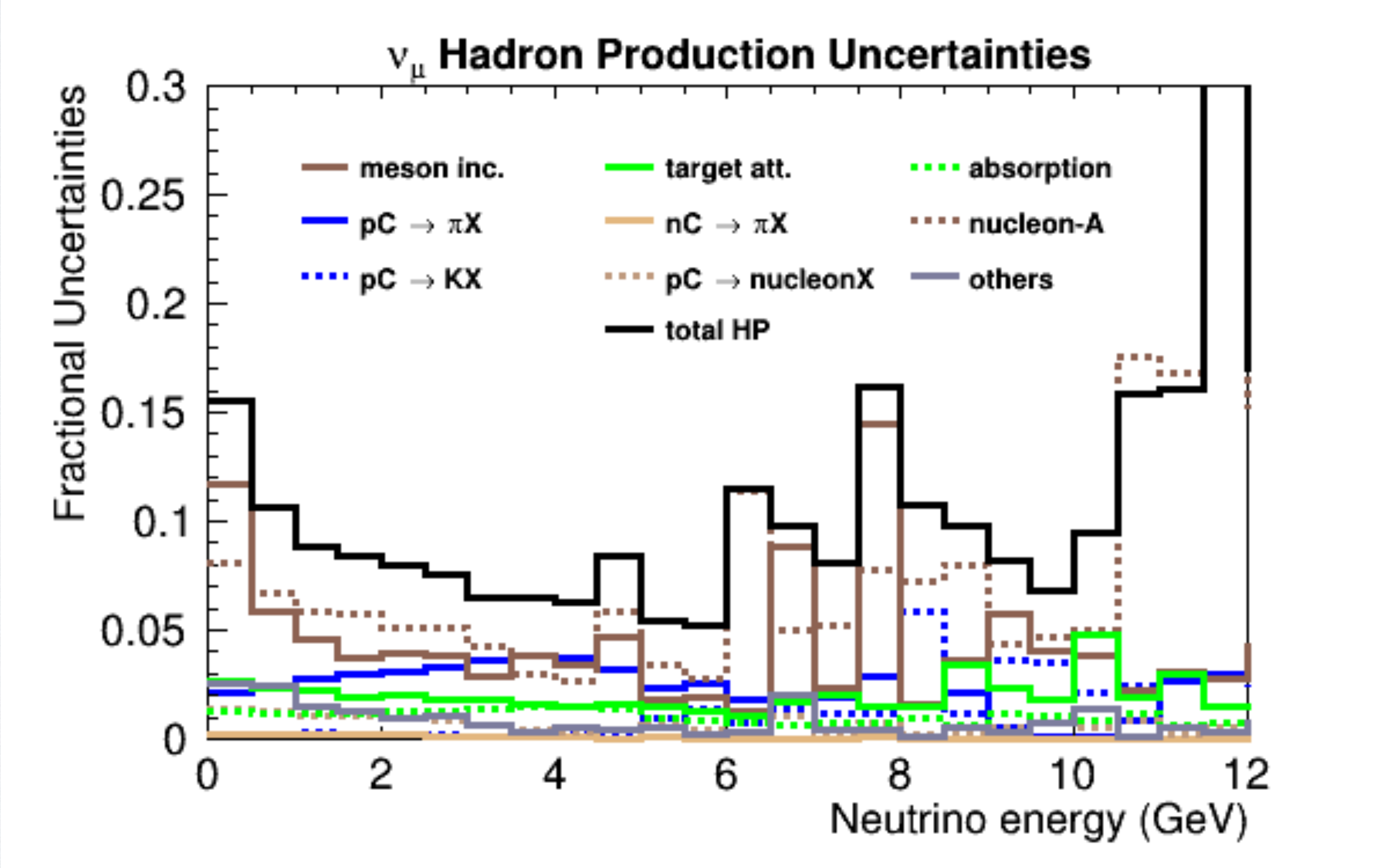
USING NA61 BINNING

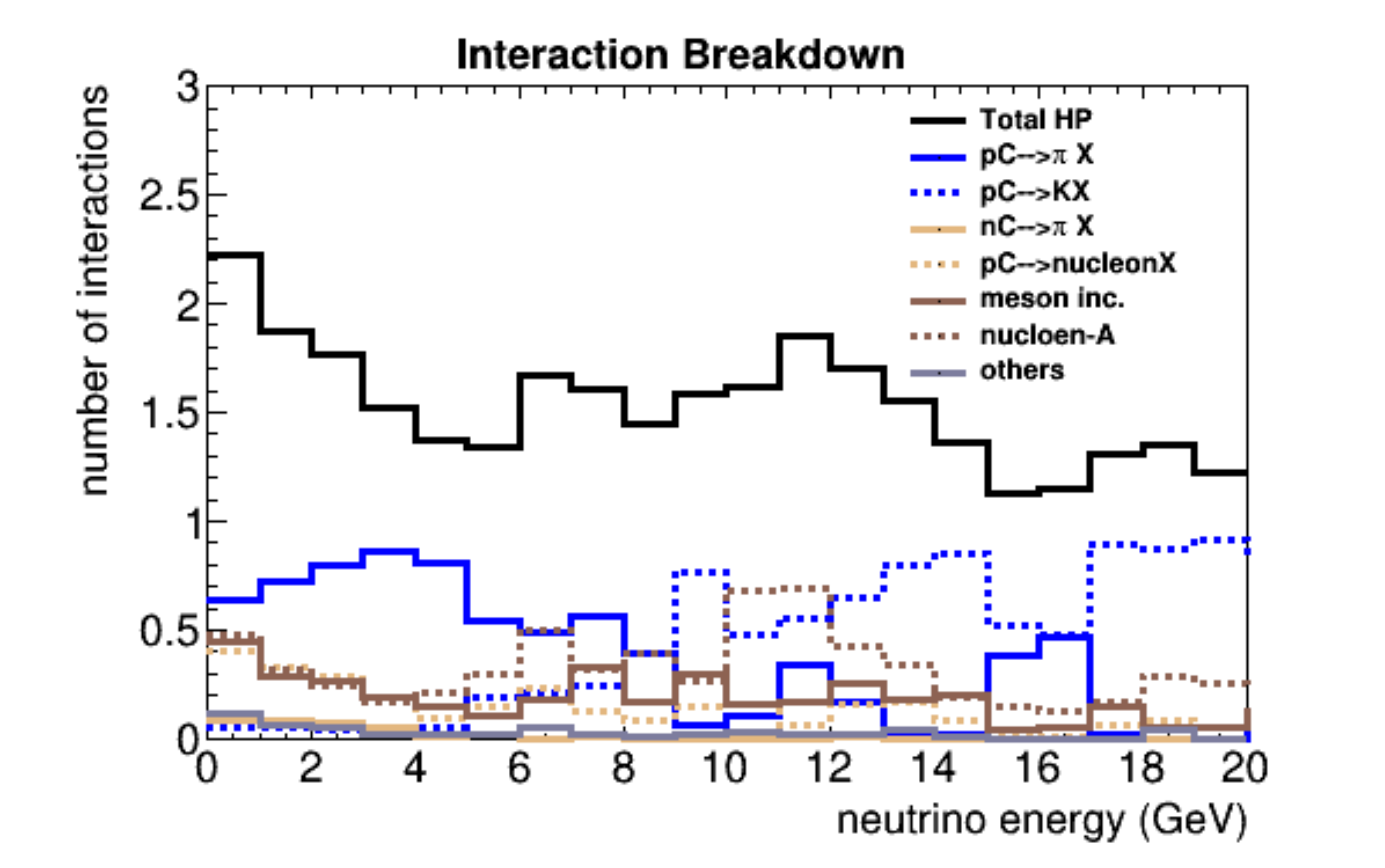




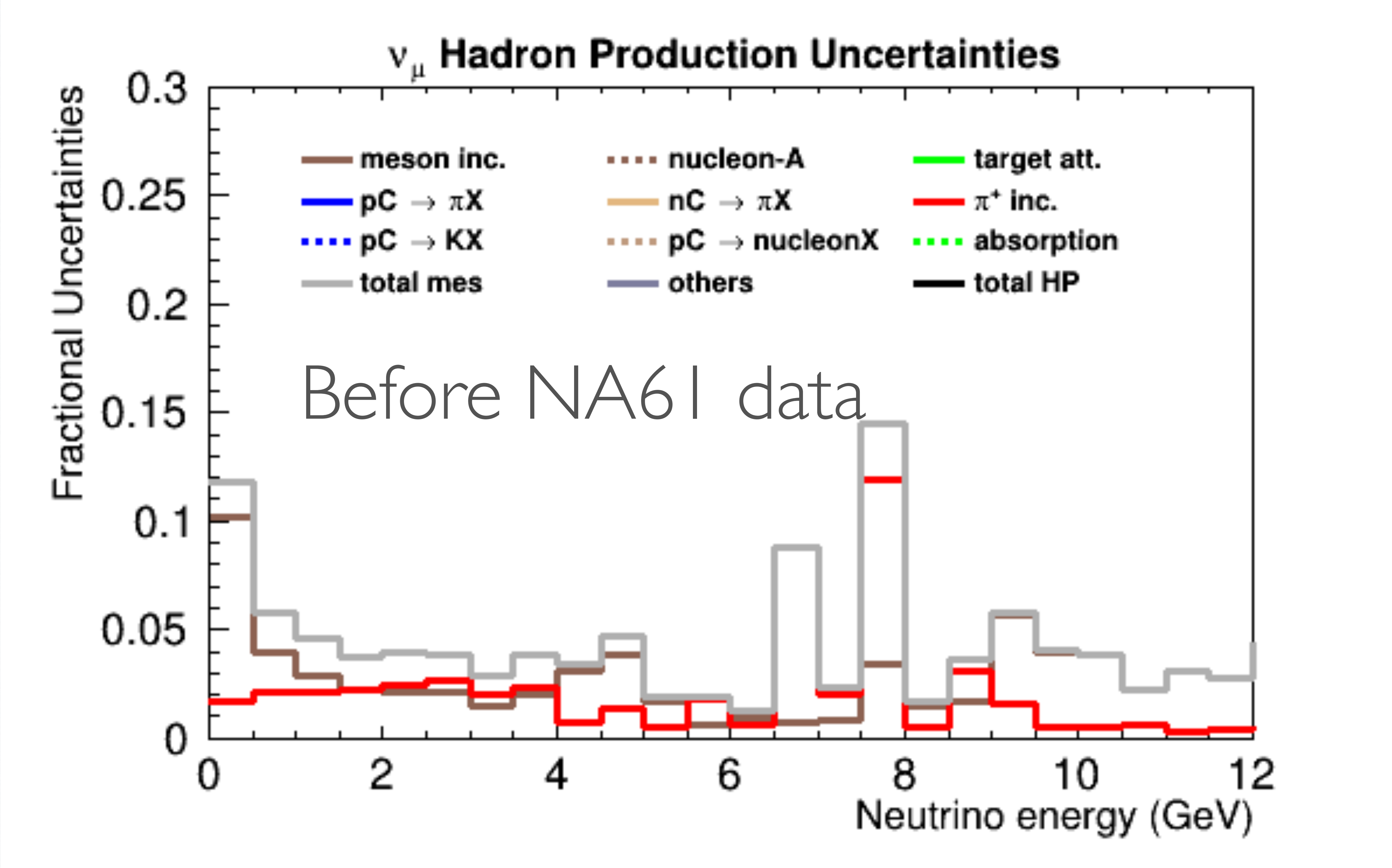
Now using NA61 uncertainties, partially correlated

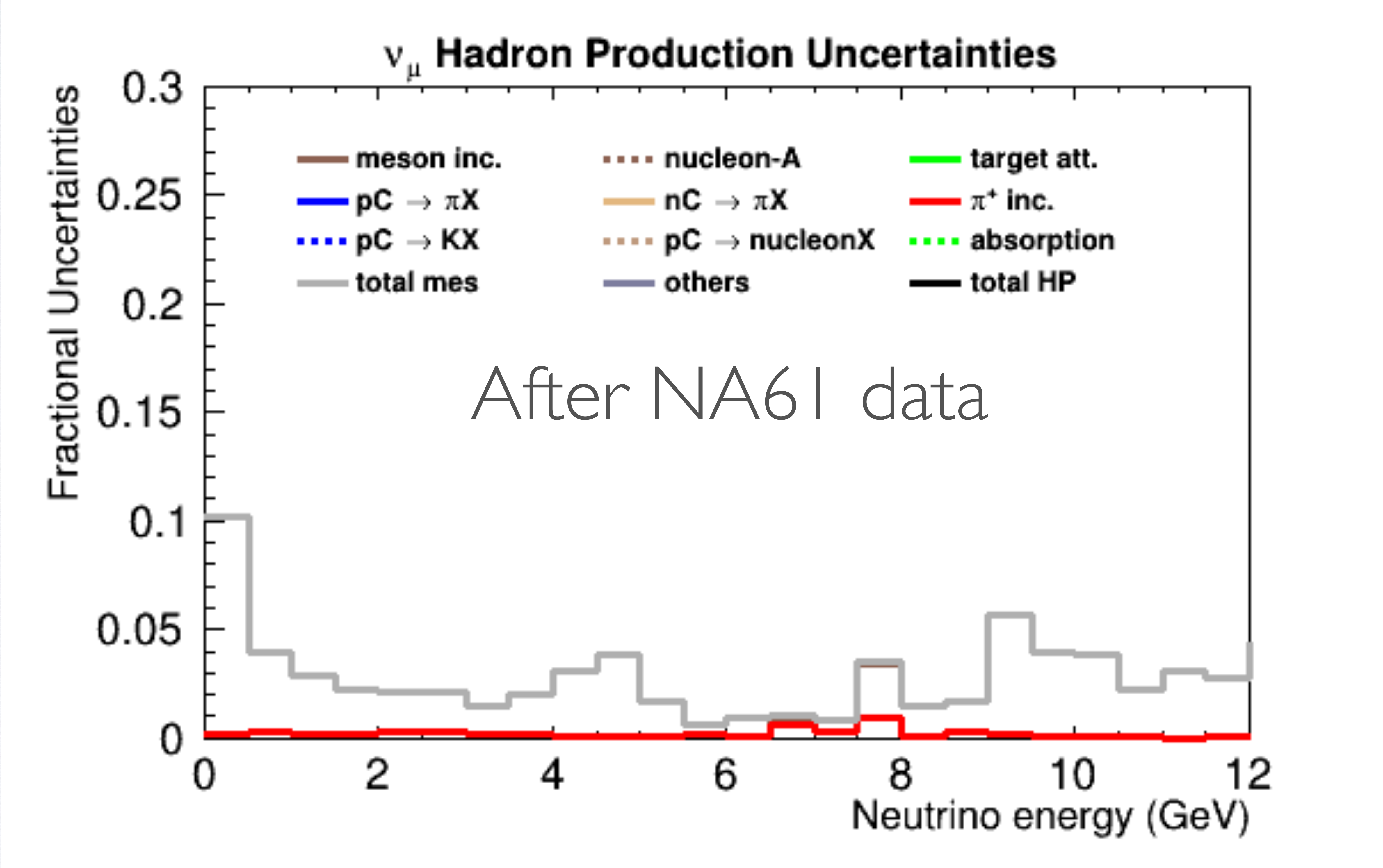
BASELINE PLOTS FOR COMPARISON





BEFORE/AFTER COMP



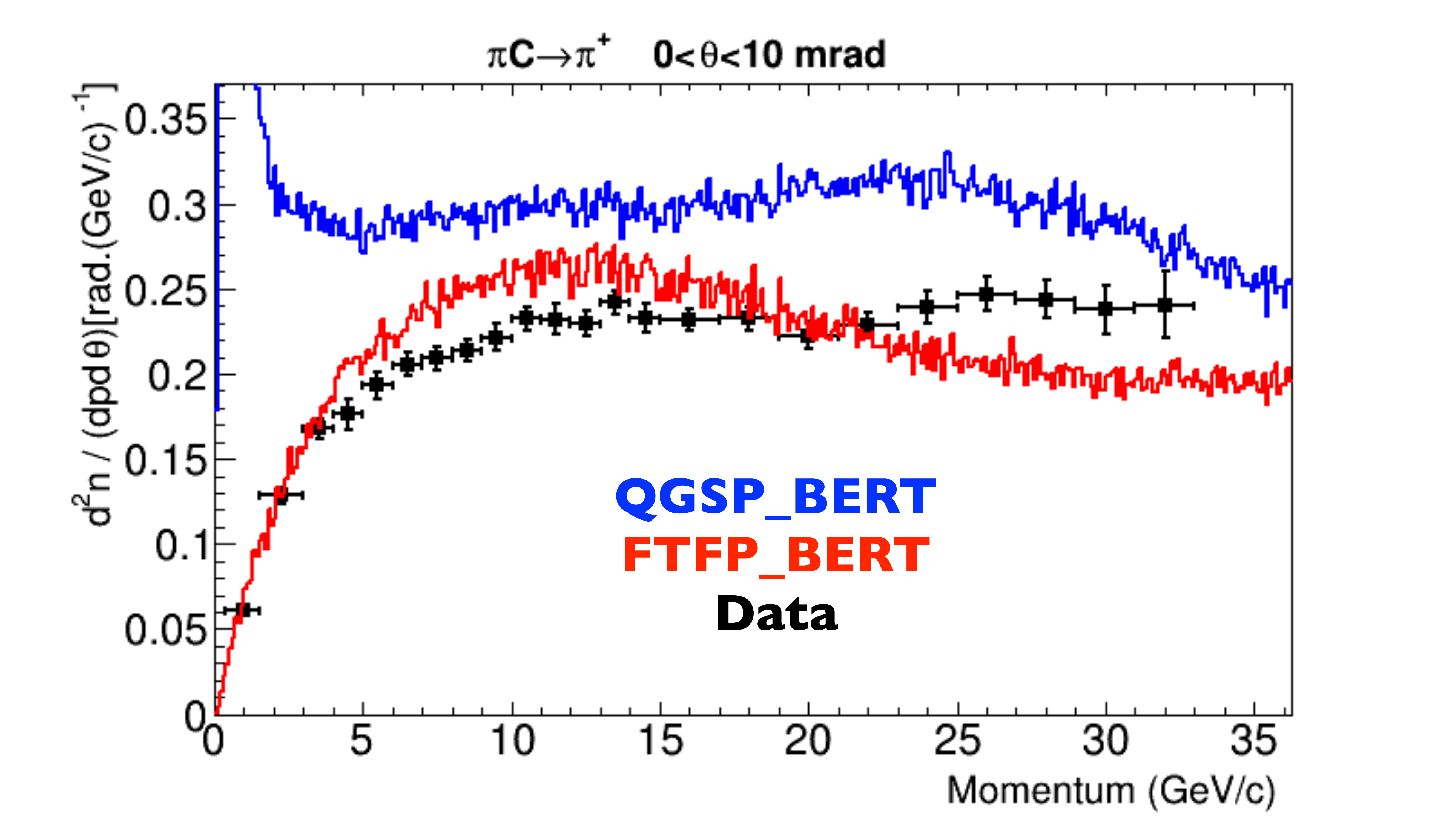


DISCUSSION

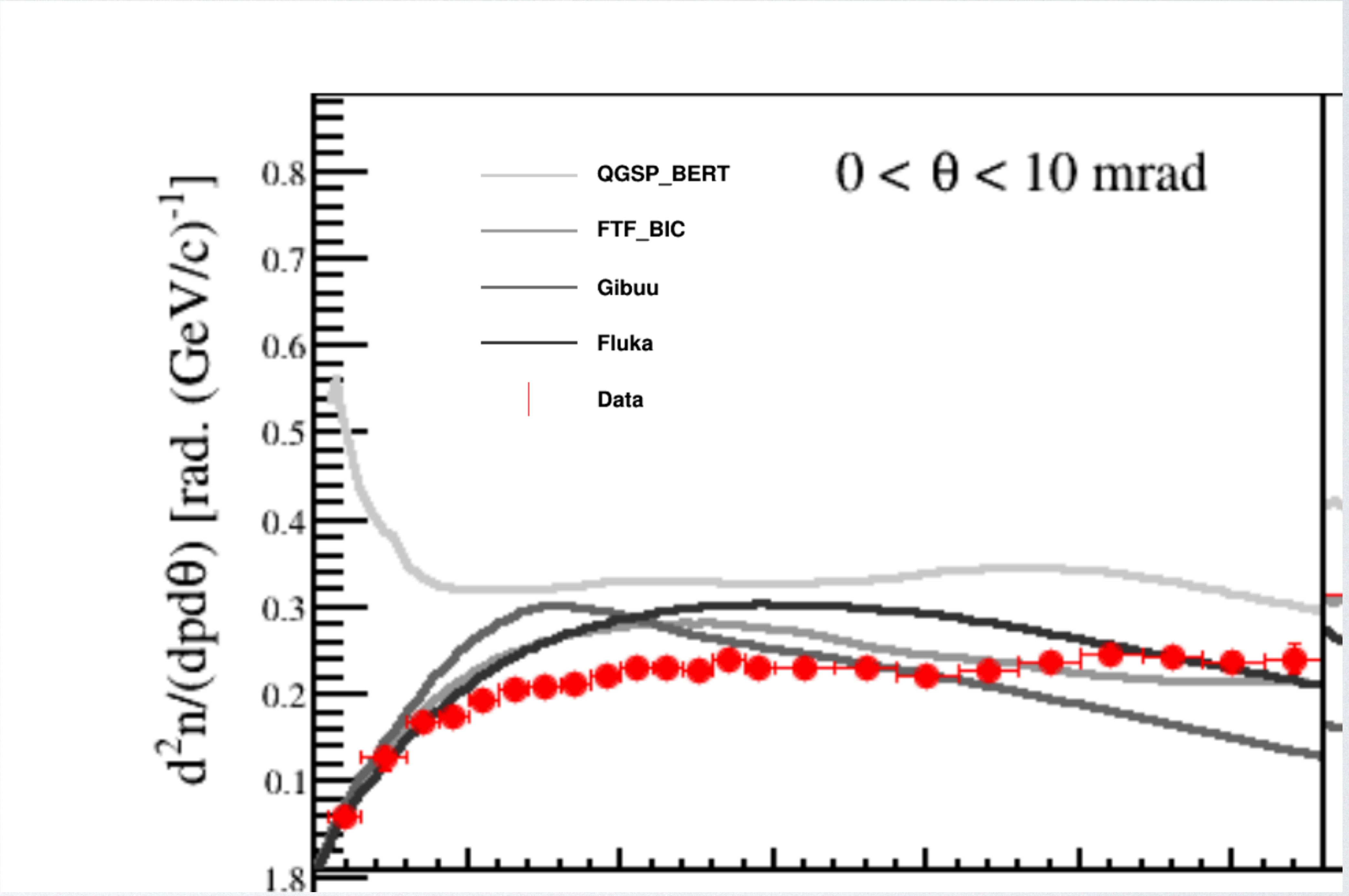
- So that's what the uncertainty would be if we constrained the pi+ incident events with this data
- Now let's actually that
- First step: look at data vs MC

MULTIPLICITY COMPARISONS

G4HP (G4 v10.3.p03b)



NA61 Paper (G4 v10.4)



These use a modified version of CreateMult.C in g4hp

MULTIPLICITY COMPARISONS

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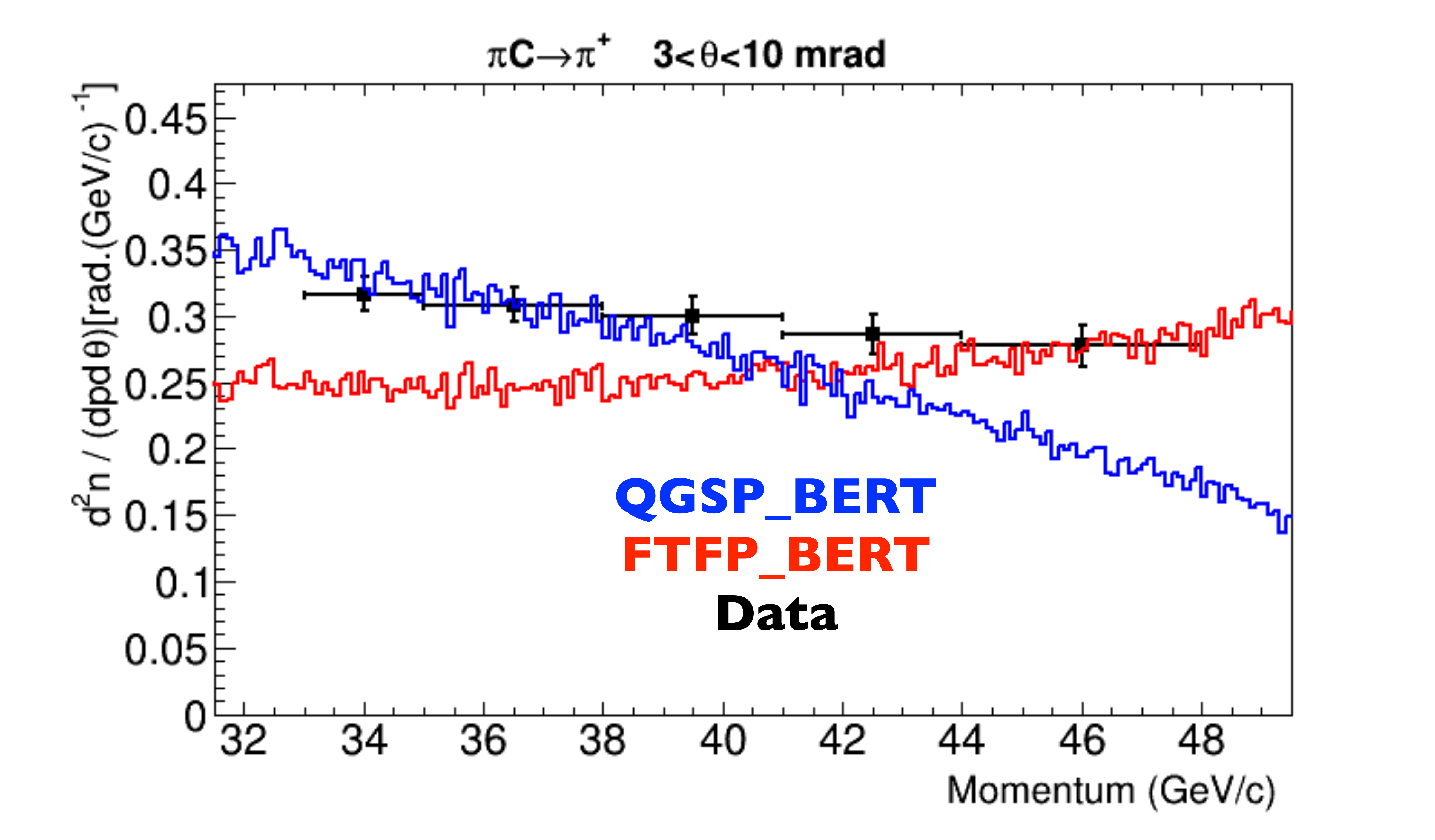

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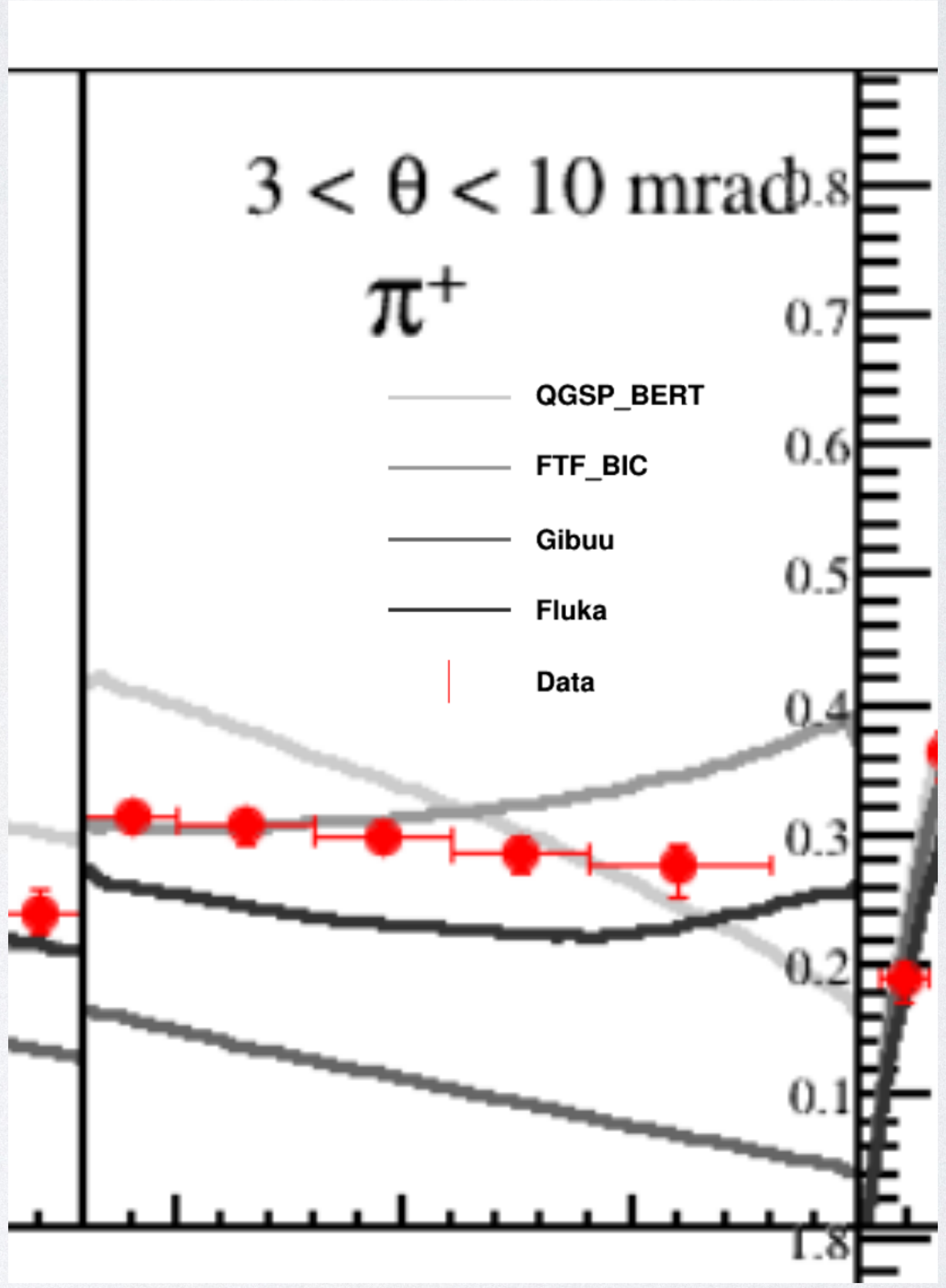

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MULTIPLICITY COMPARISONS

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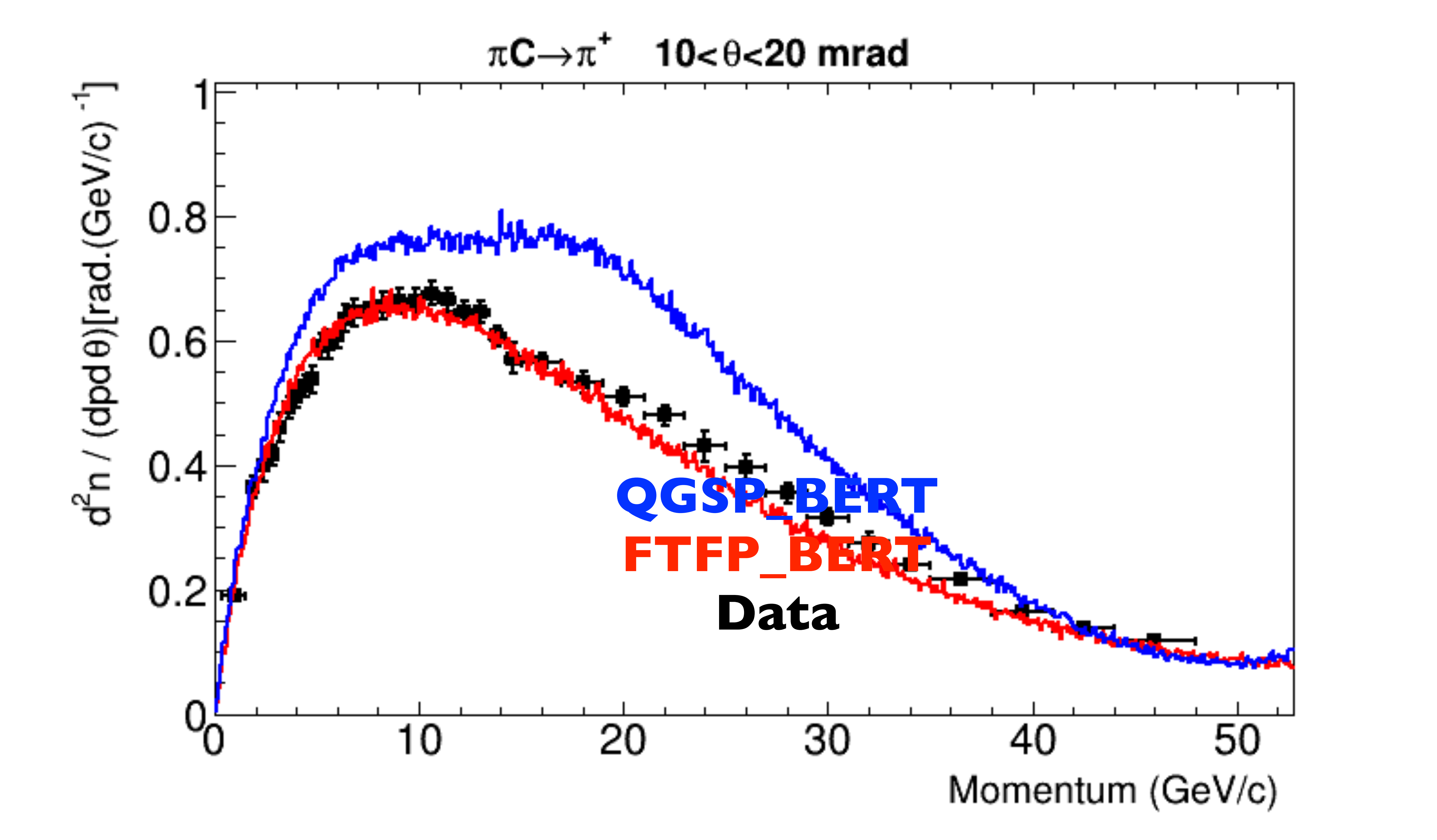

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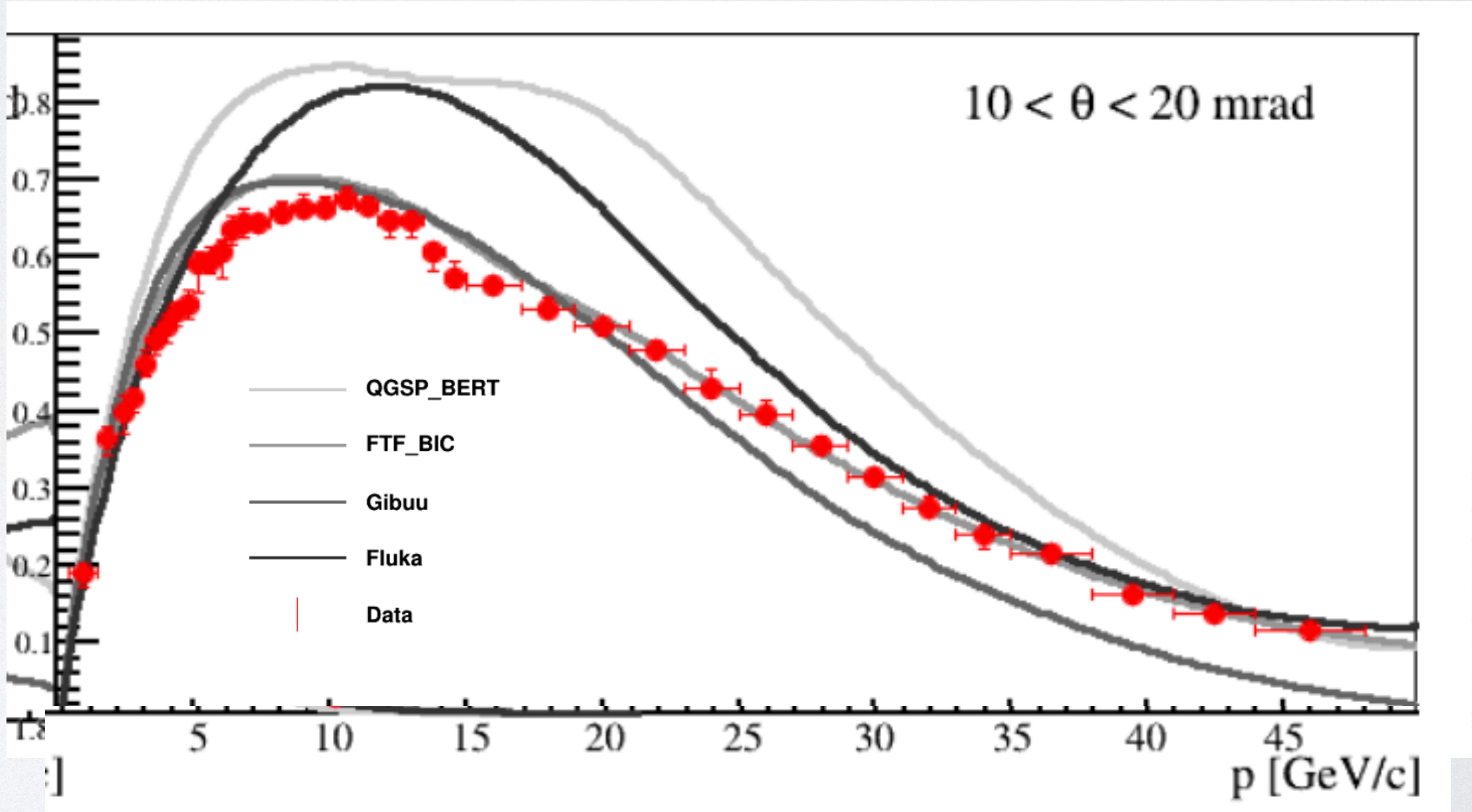

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MULTIPLICITY COMPARISONS

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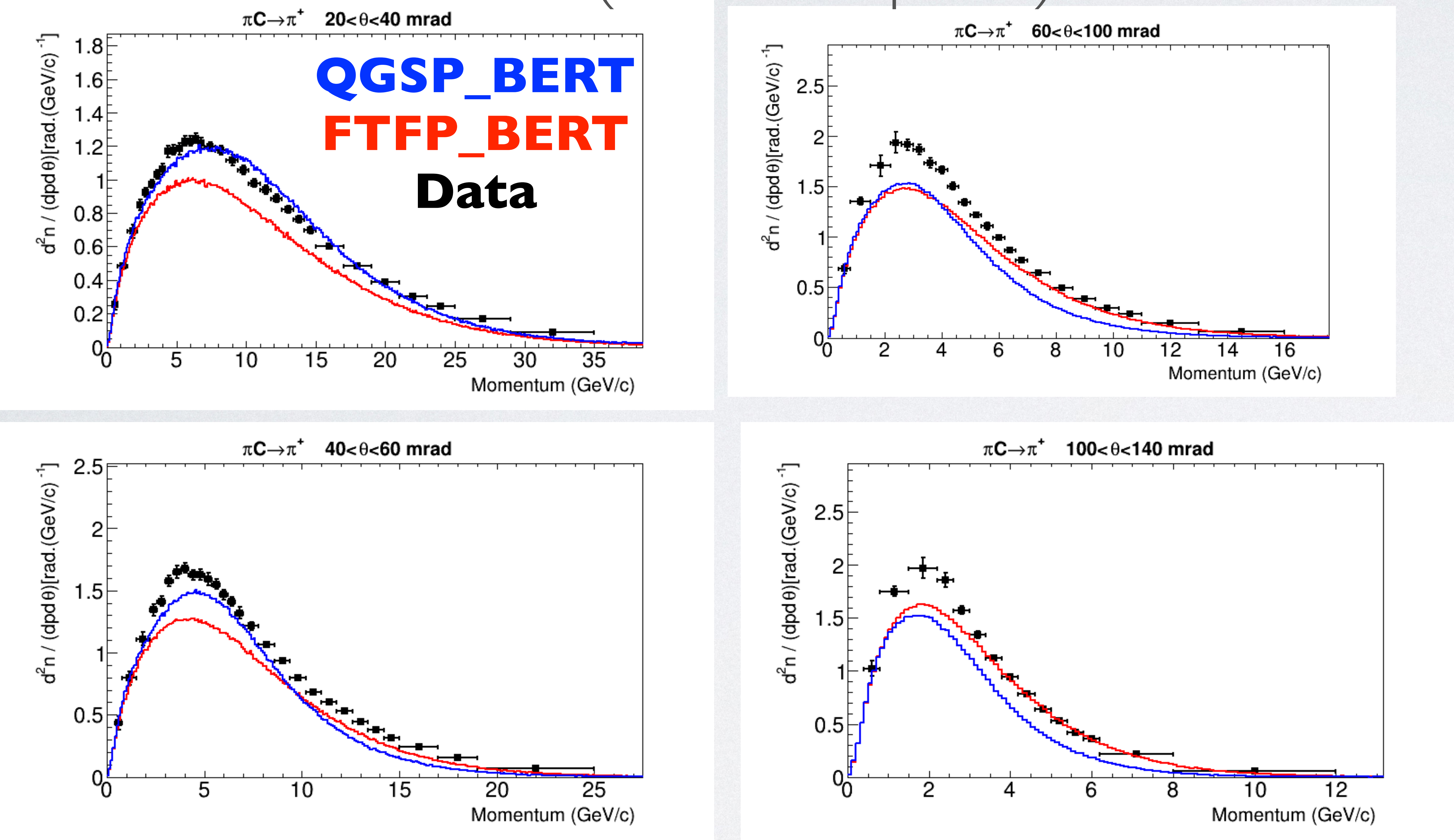

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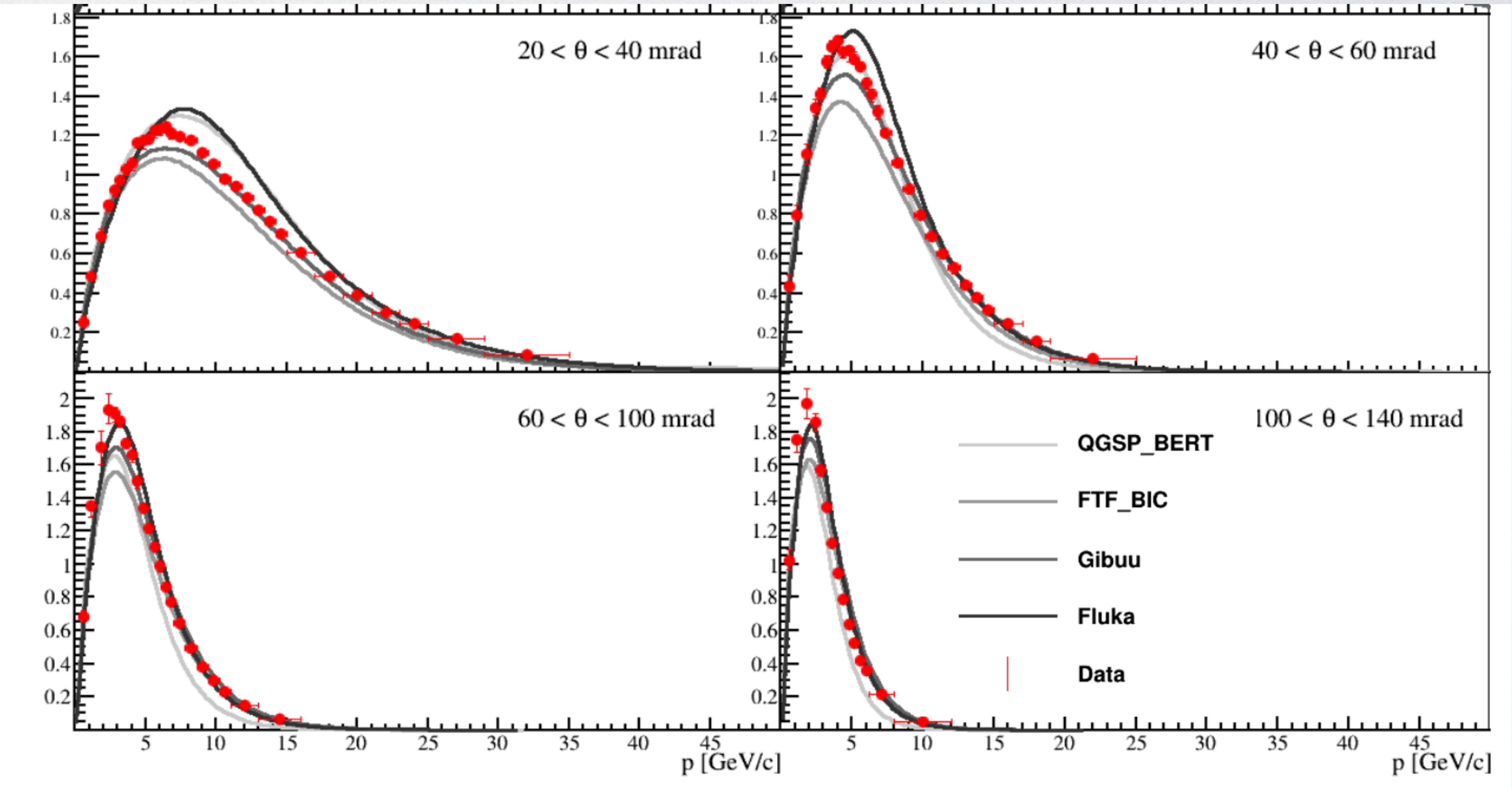


These use a modified version of CreateMult.C in g4hp

MULTIPLICITY COMPARISONS

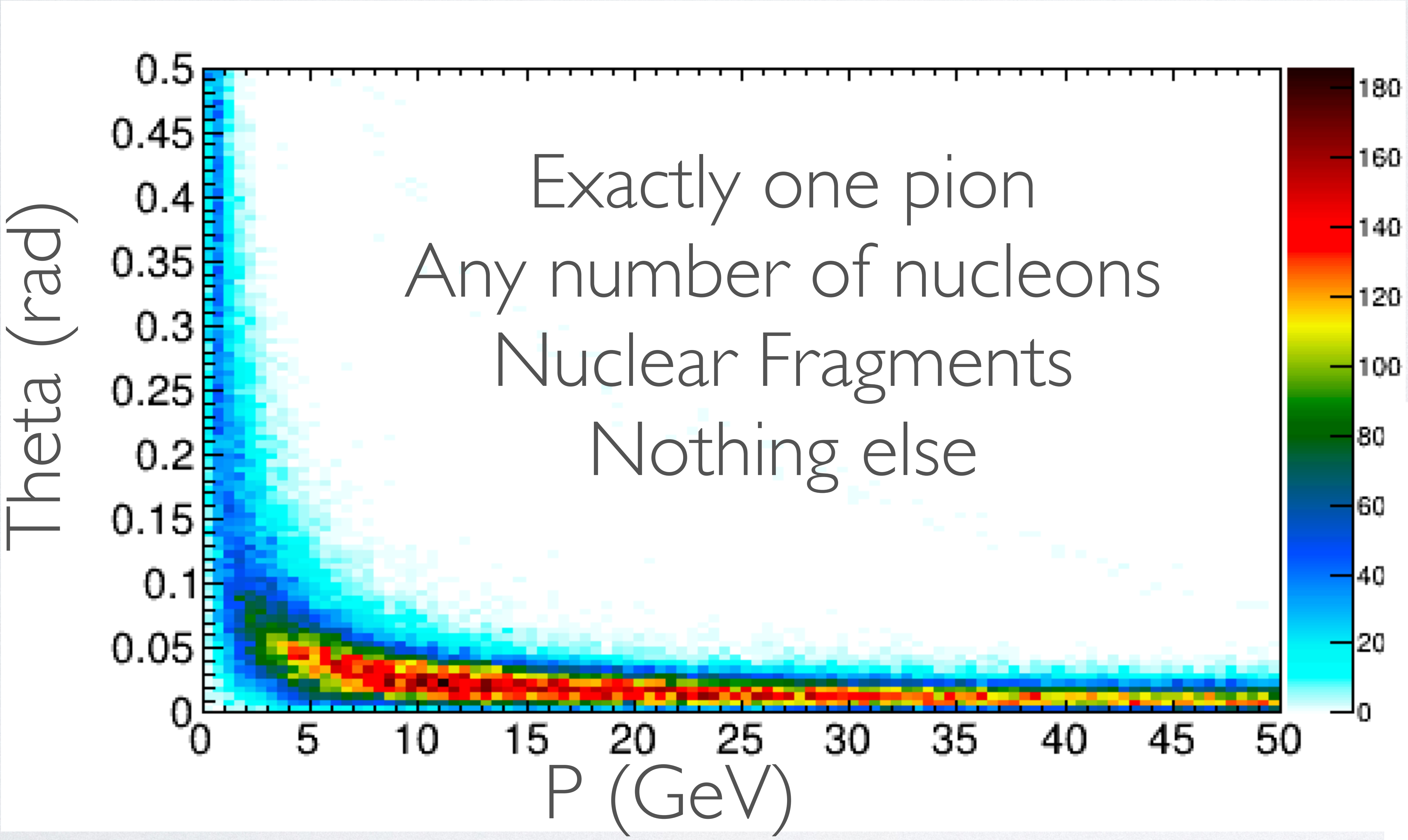
- Discussion
  - Although these look plausible, I'm still not sure the signal definition is correct
  - G4HP plots include
    - All e.g. pions produced in a particular energy/angle bin, normalized by all 'production' event
    - Production events: anything with a pi or k in final state
  - Emailed Scott, the analyzer of the NA61 data:

> What I remember is that I had to separate the G4 events by what the outgoing particles were. In elastic events, there should be exactly one pi+ particle and no other outgoing particles. For QE events, there should be exactly one pi+ particle, but there may be neutrons, protons (and possibly nuclear fragments). All other combinations of outgoing particles should correspond to production events. I also remember making distributions of the outgoing pi+ (angular and forward momentum?) to make sure that these distributions were what you'd expect for elastic and quasi-elastic interactions.

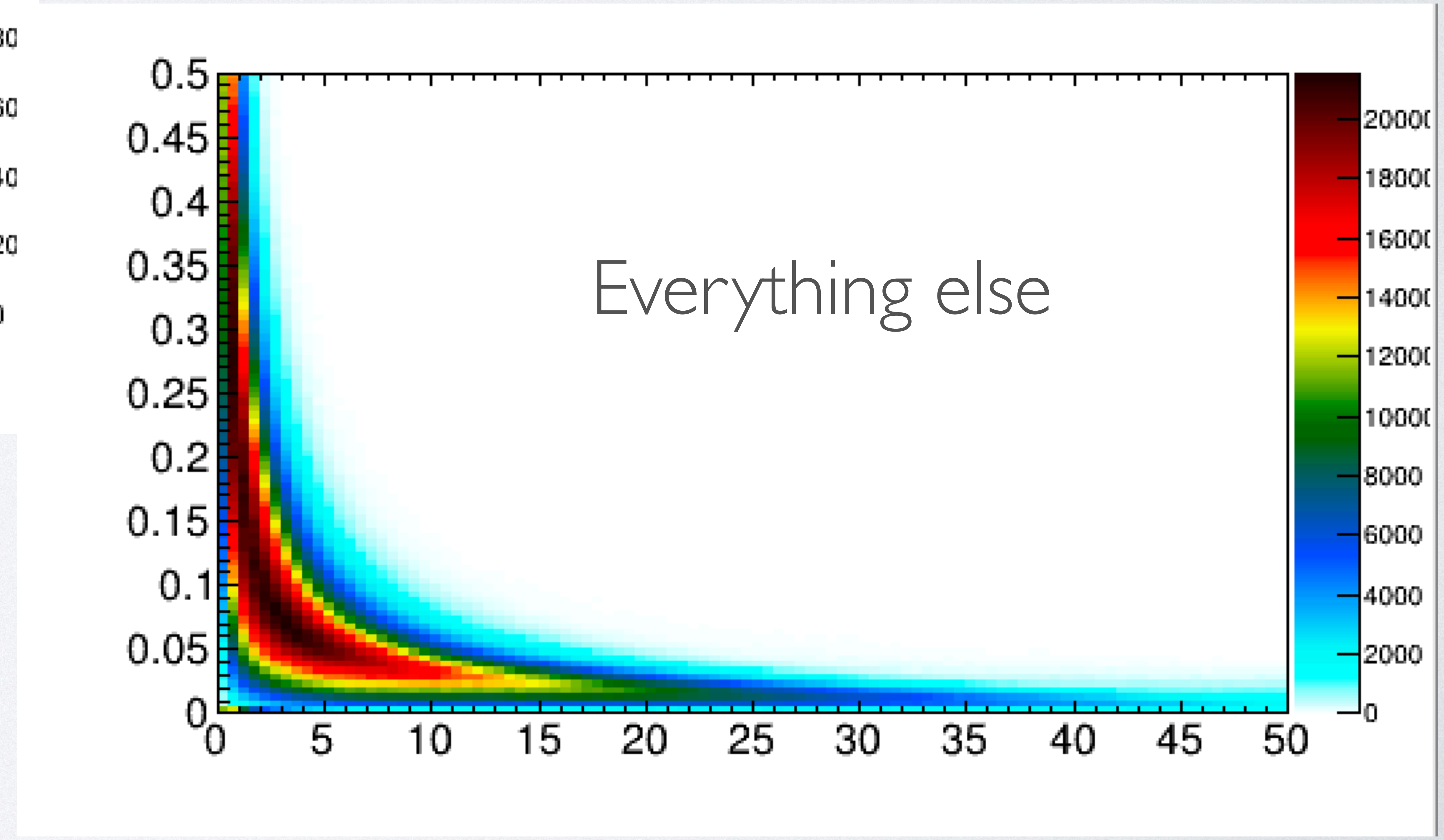
MULTIPLICITY COMPARISONS

- So I have a plan for doing data/MC comparisons and forming weights, but
  - I don't think the flux record stores enough information to determine whether an interaction was quasi elastic
  - So I don't know how to exclude those from this reweighter
  - Also, I don't know whether Feynman scaling is valid for just the production component of the cross section

MULTIPLICITY COMPARISONS



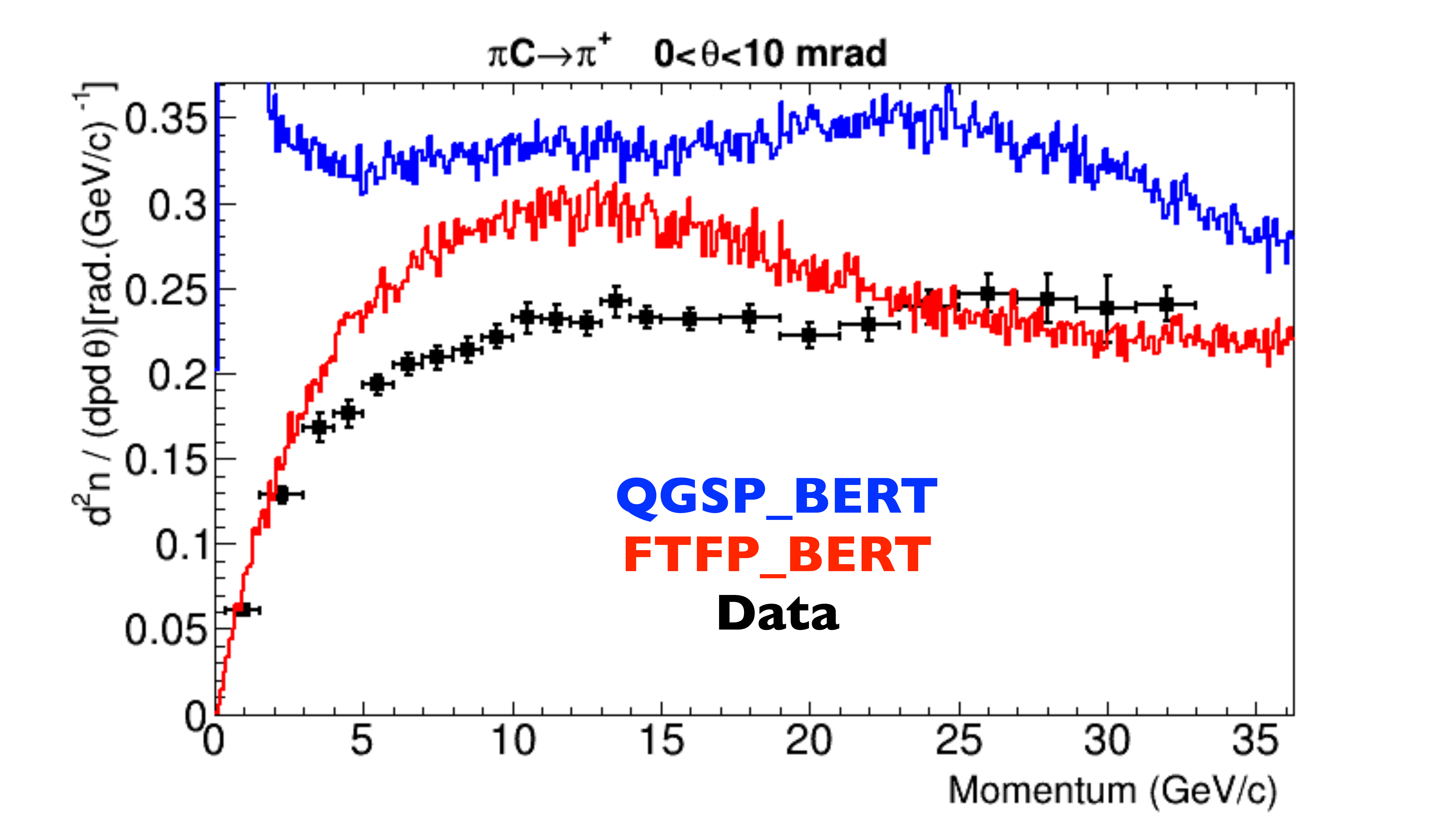
And these "production"



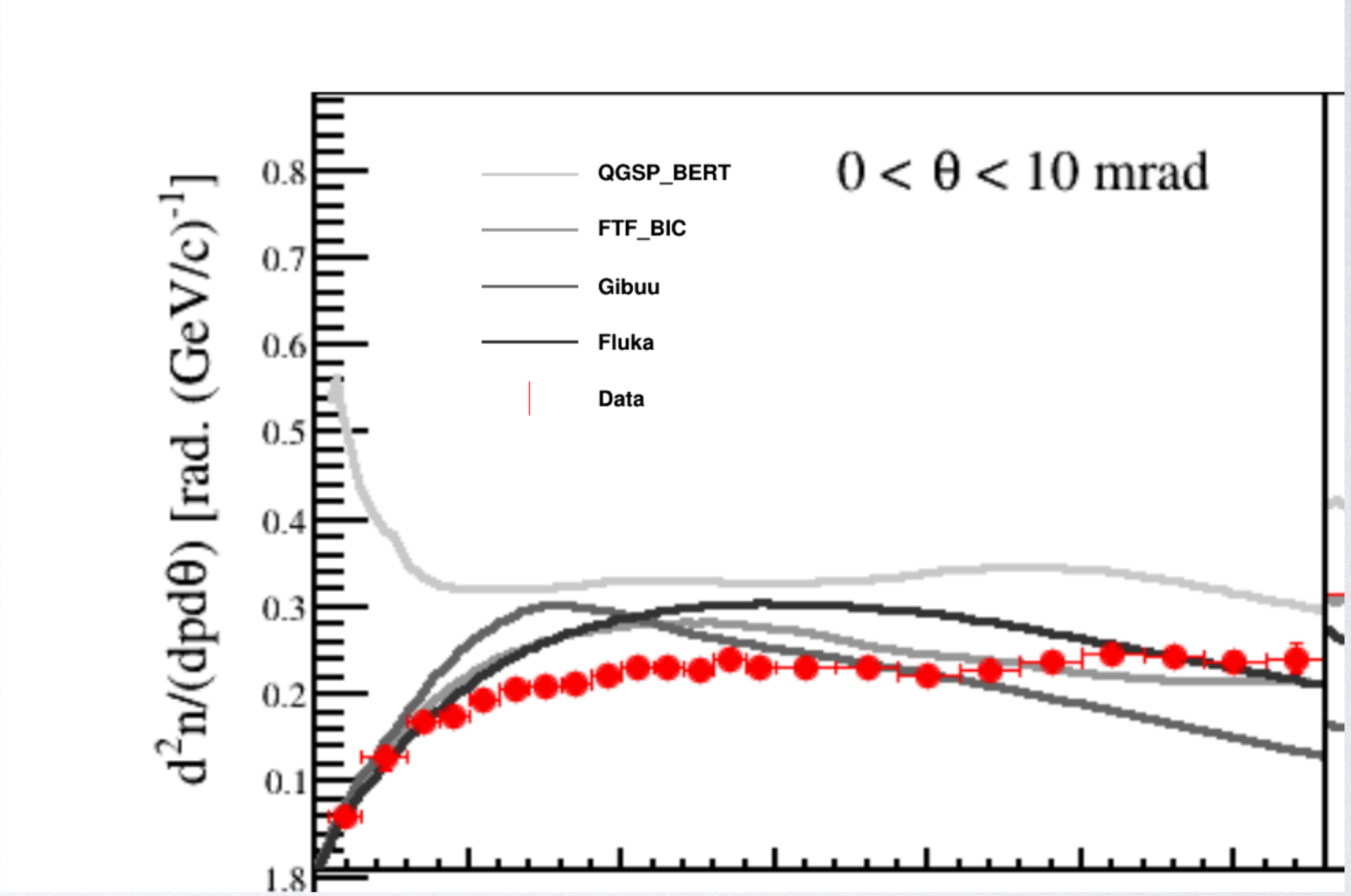
Going to call these "quasielastic"

MULTIPLICITY COMPARISONS (NEW PROD DEFINITION)

G4HP (G4 v10.3.p03b)



NA61 Paper (G4 v10.4)



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MULTIPLICITY COMPARISONS

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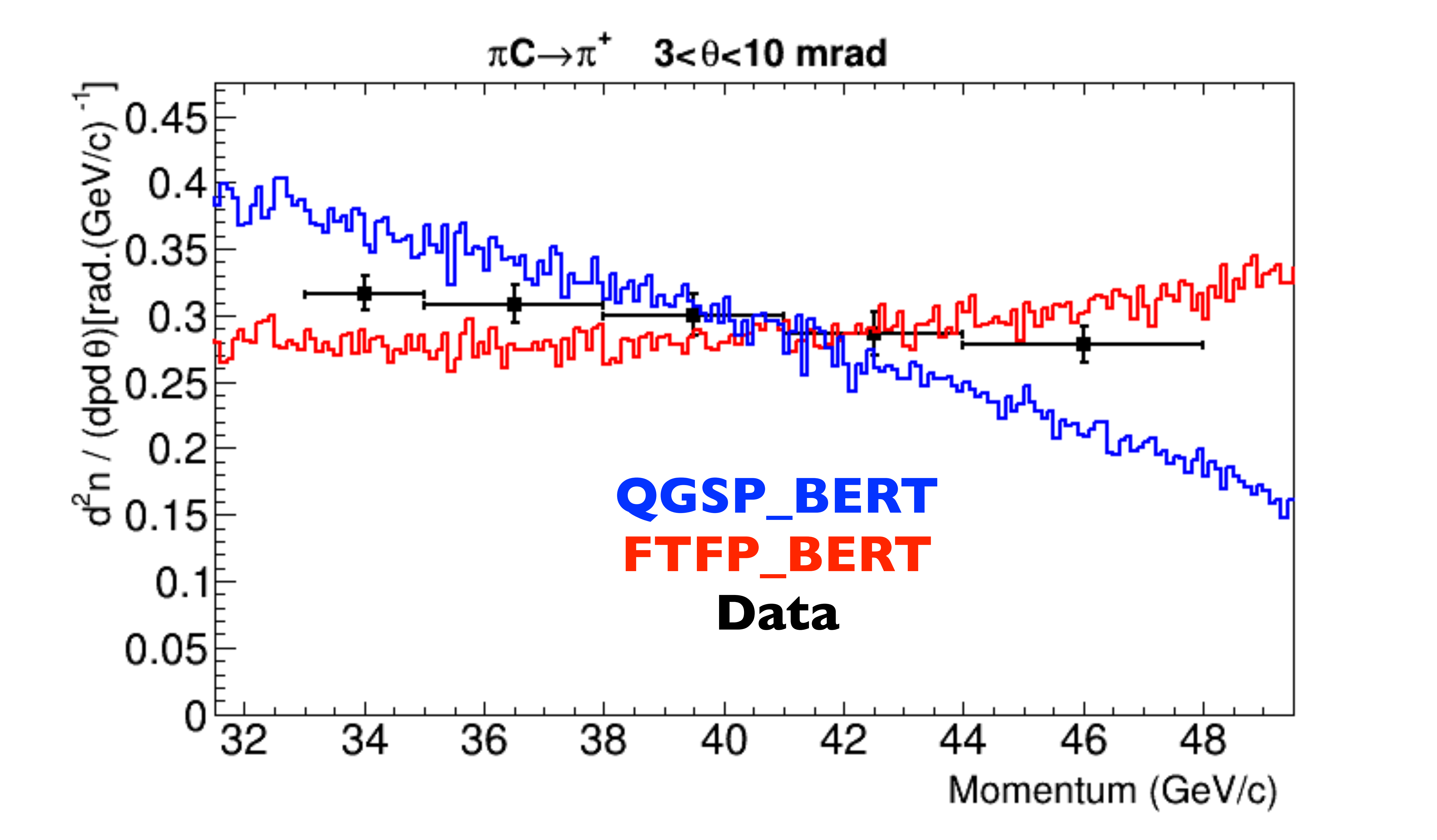

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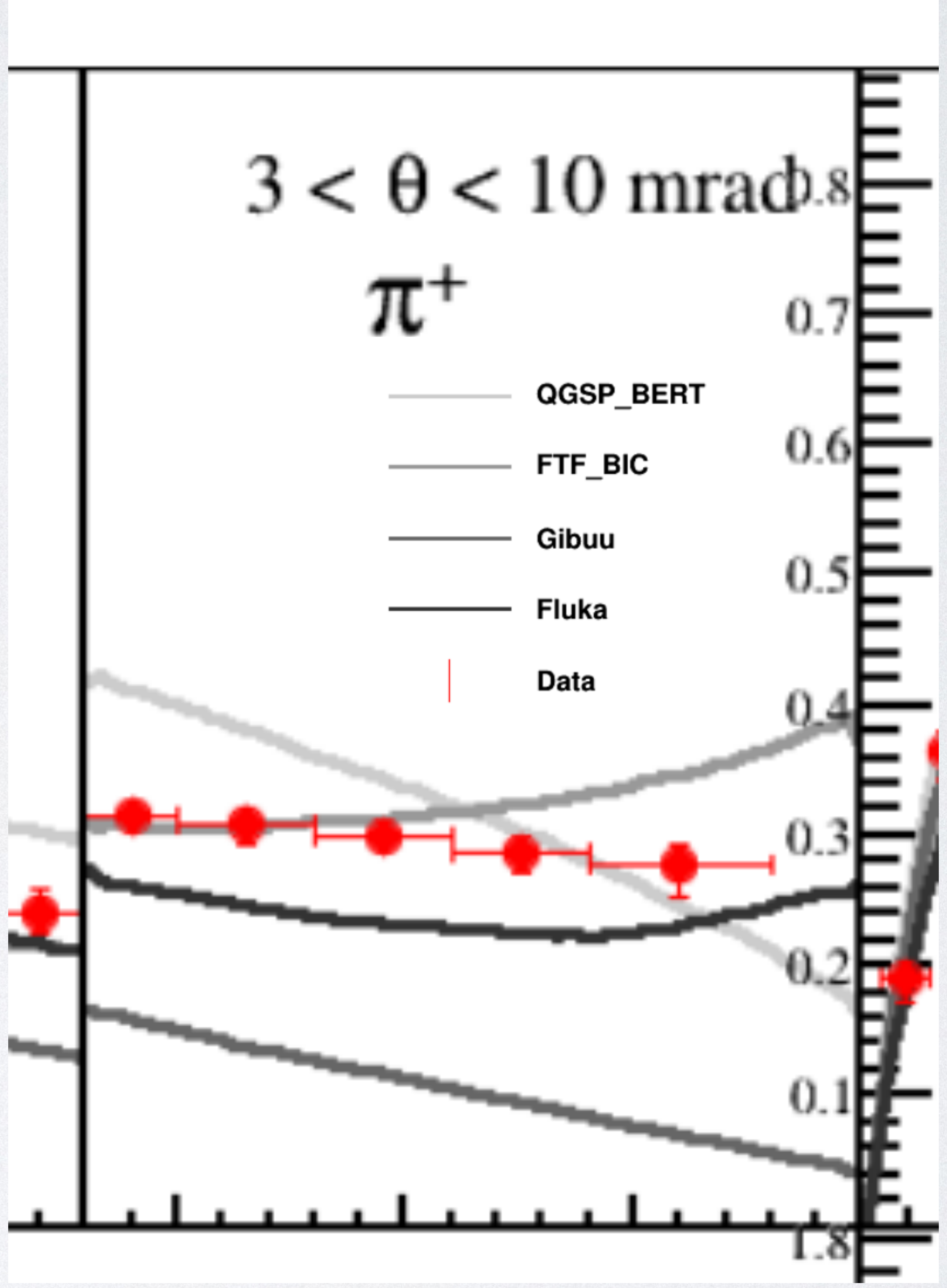

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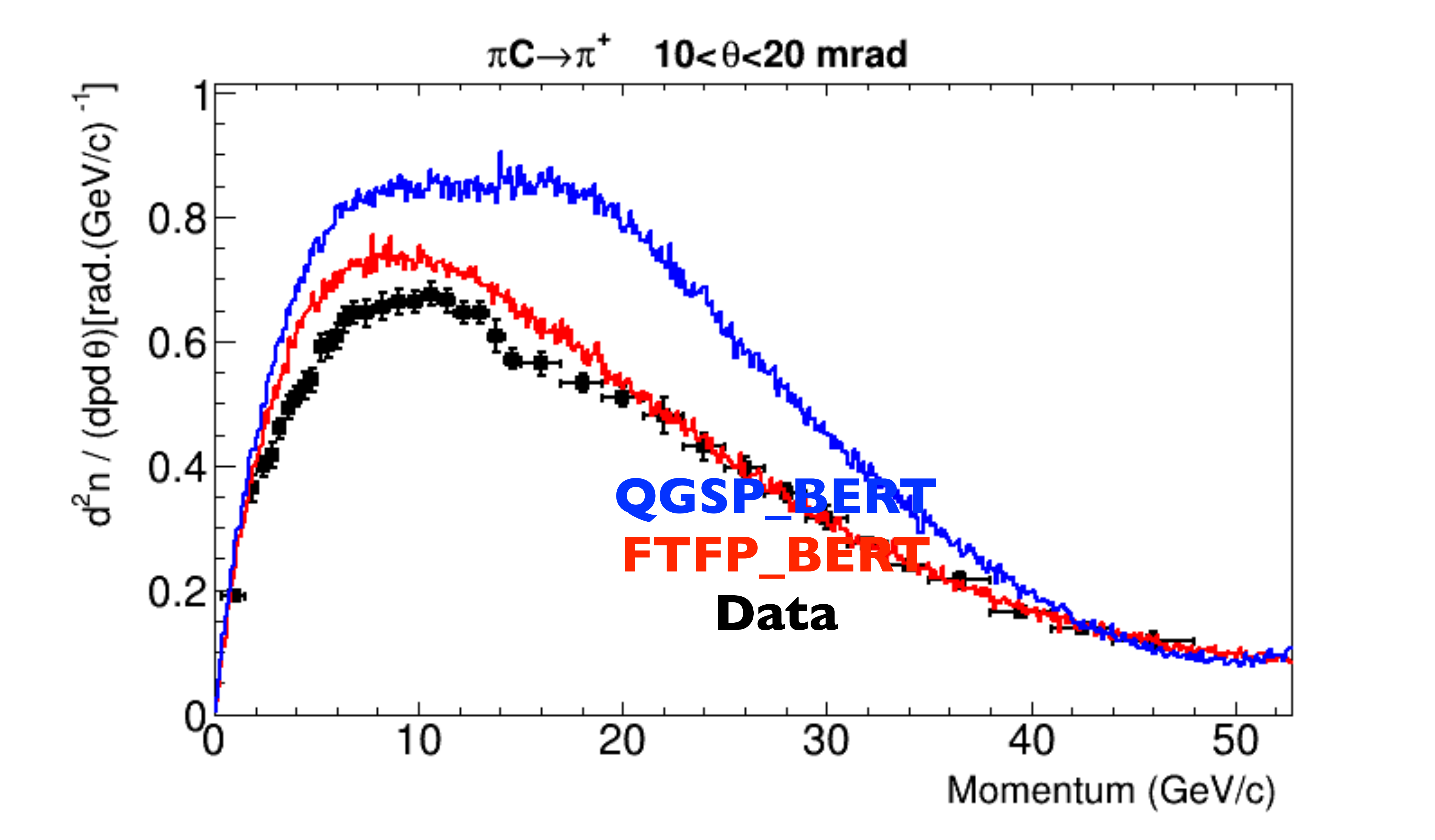
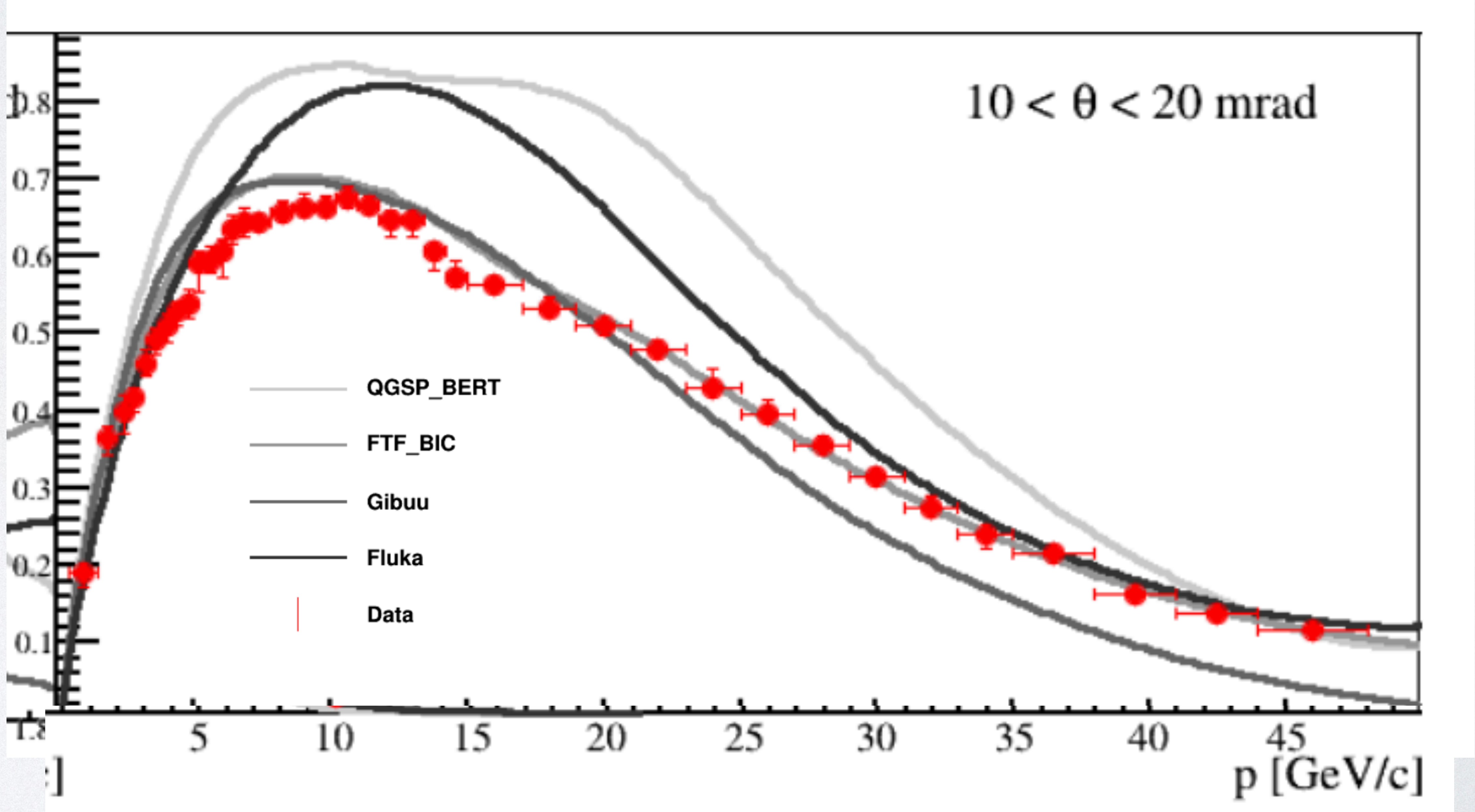
MULTIPLICITY COMPARISONS (NEW PROD DEFINITION)

G4HP



NA61 Paper



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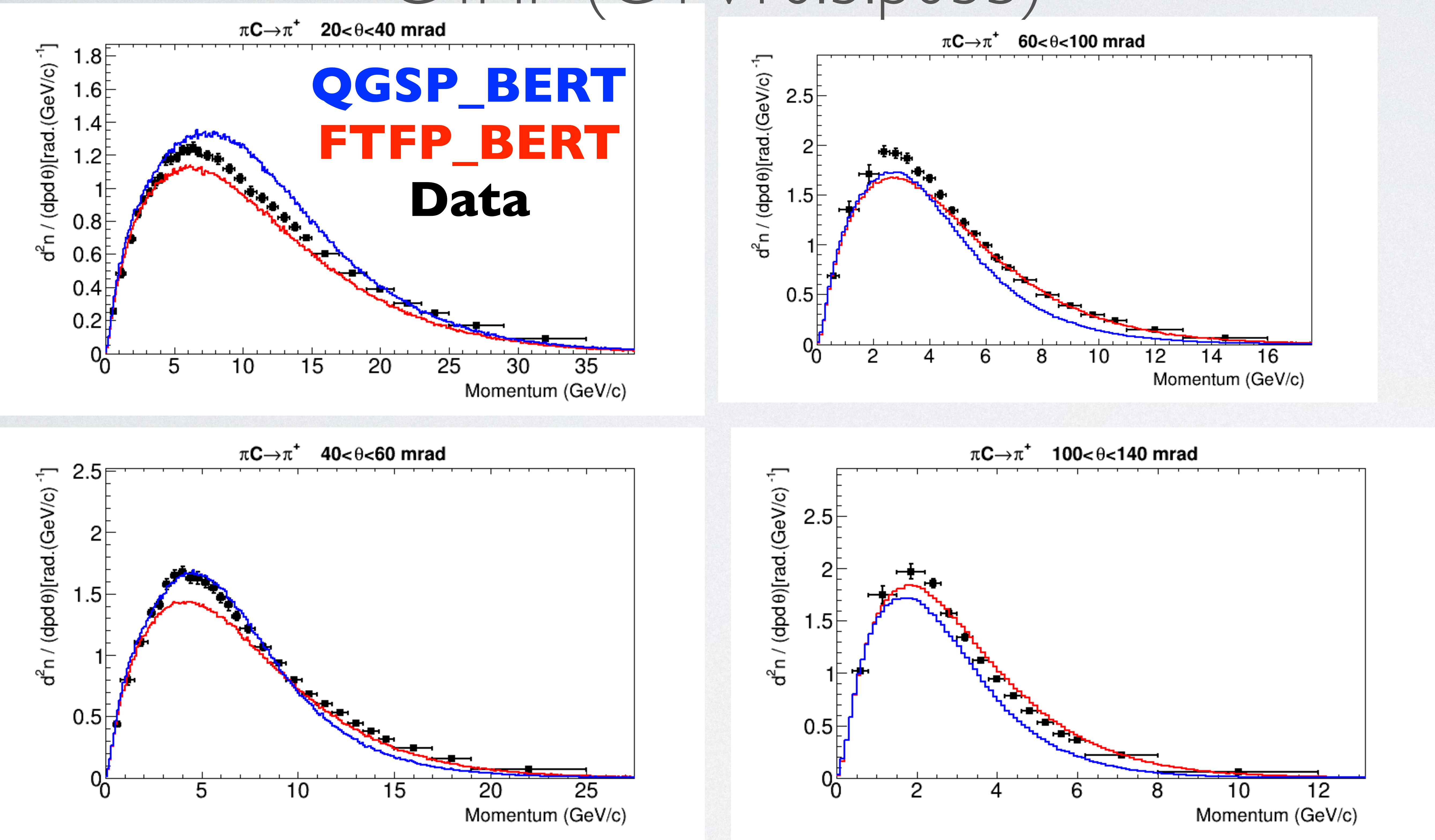
MULTIPLICITY COMPARISONS

G4HP (G4 v10.3.p03b)



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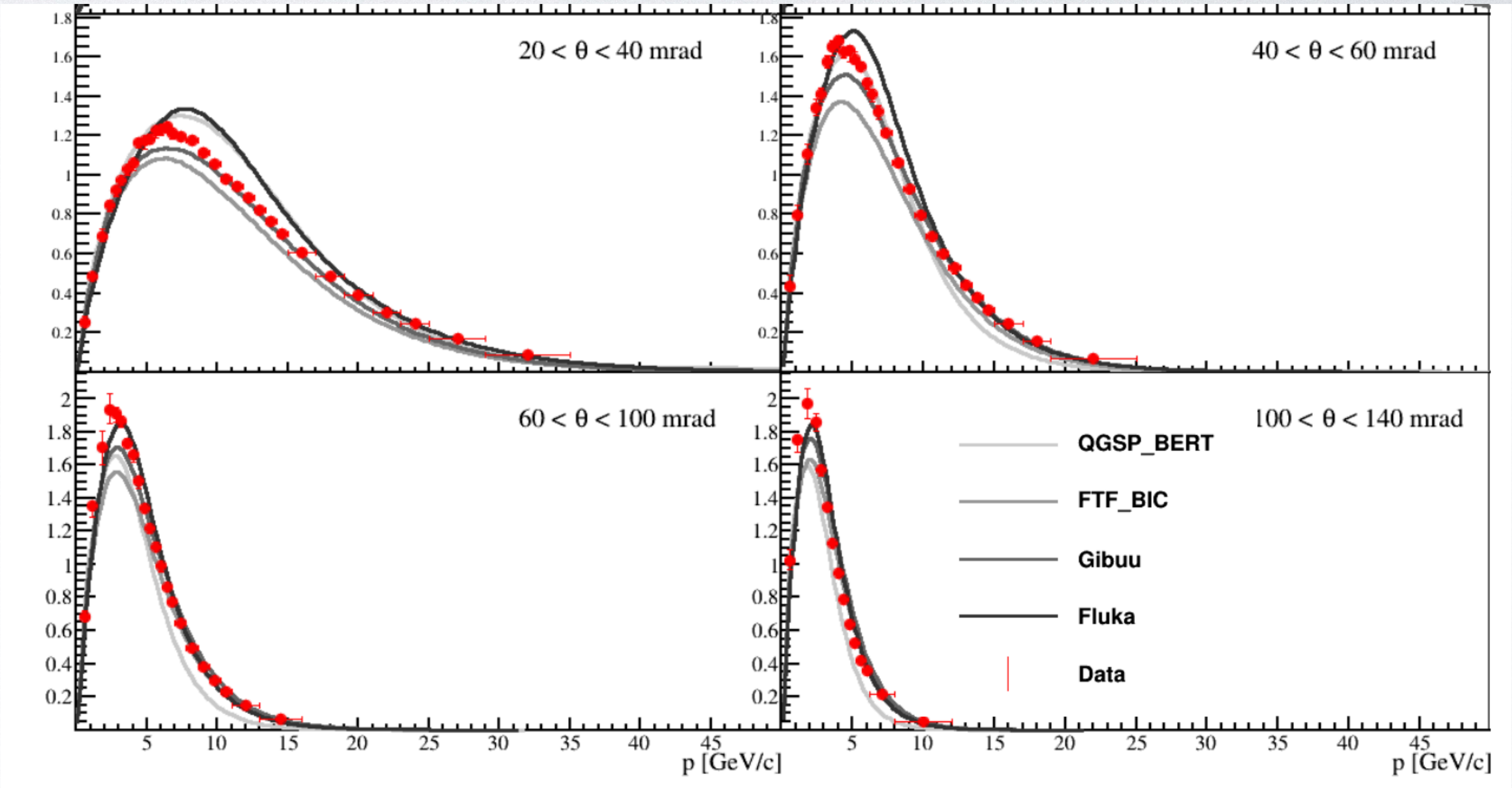


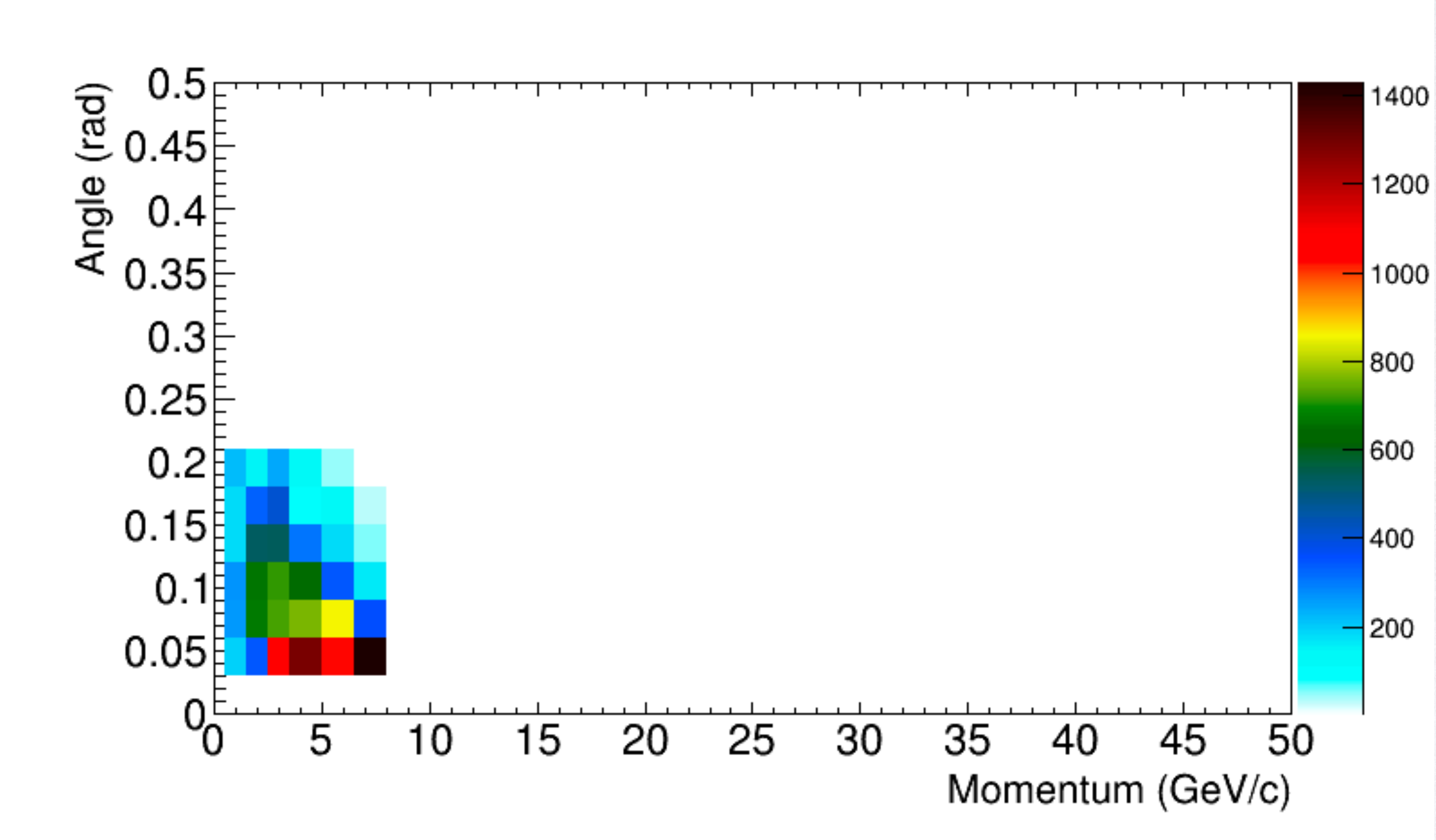
These use a modified version of CreateMult.C in g4hp

DISCUSSION

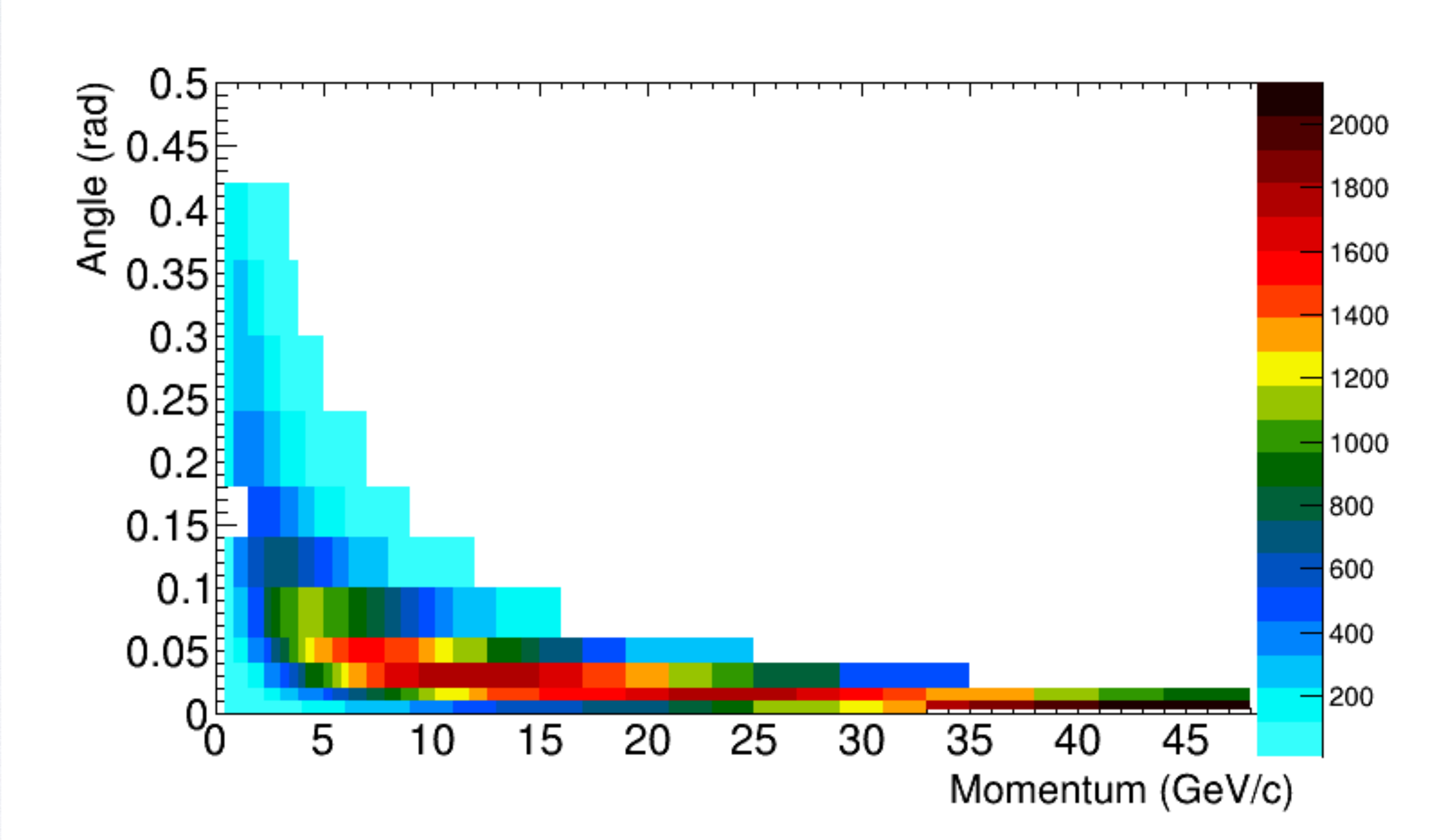
- Next up: need to deal with energy scaling
- Will need to scale data from 60 GeV to whatever incident energy an interaction in a flux ancestor record is at
- Use Feynman scaling
- Scale to 12 GeV and compare with HARP data

ENERGY SCALING

HARP @ 12 GeV



NA61 @ 60 GeV

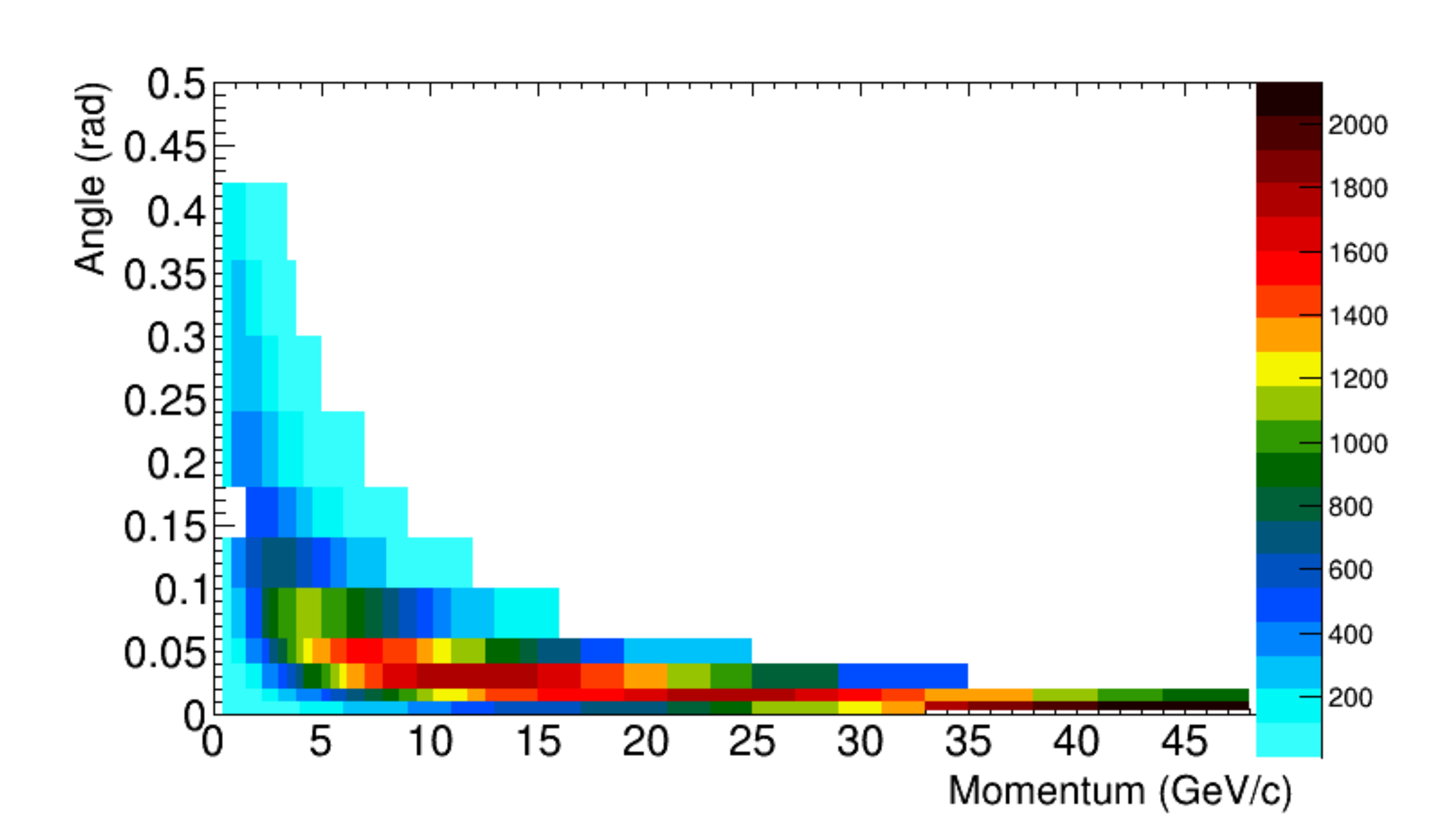


Invariant differential cross sections

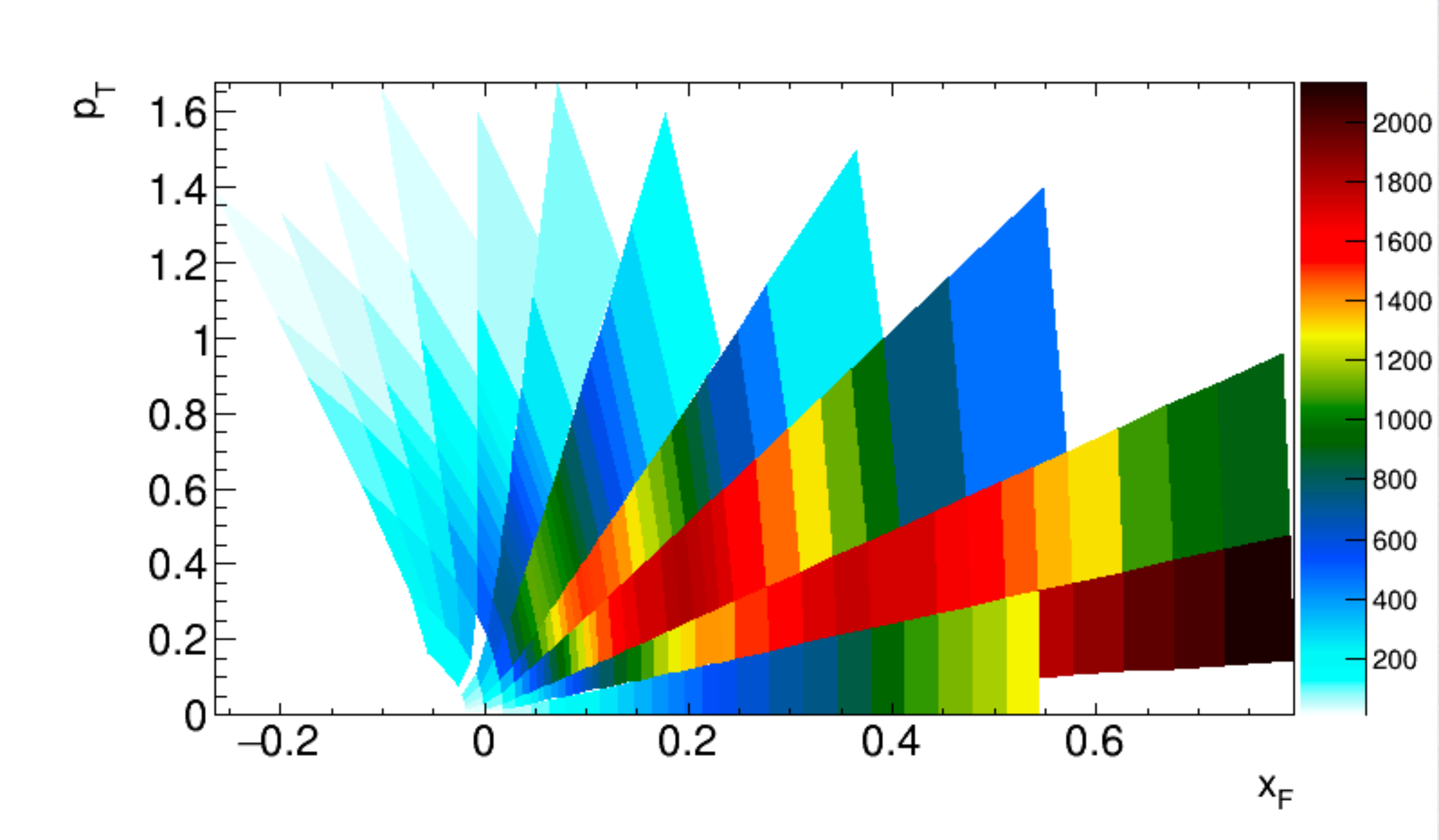
Note: we don't expect these to be the same, since the cross section is not invariant in p/theta

ENERGY SCALING

NA61 @ 60 GeV, p-theta



NA61 @ 60 GeV, xf-pt

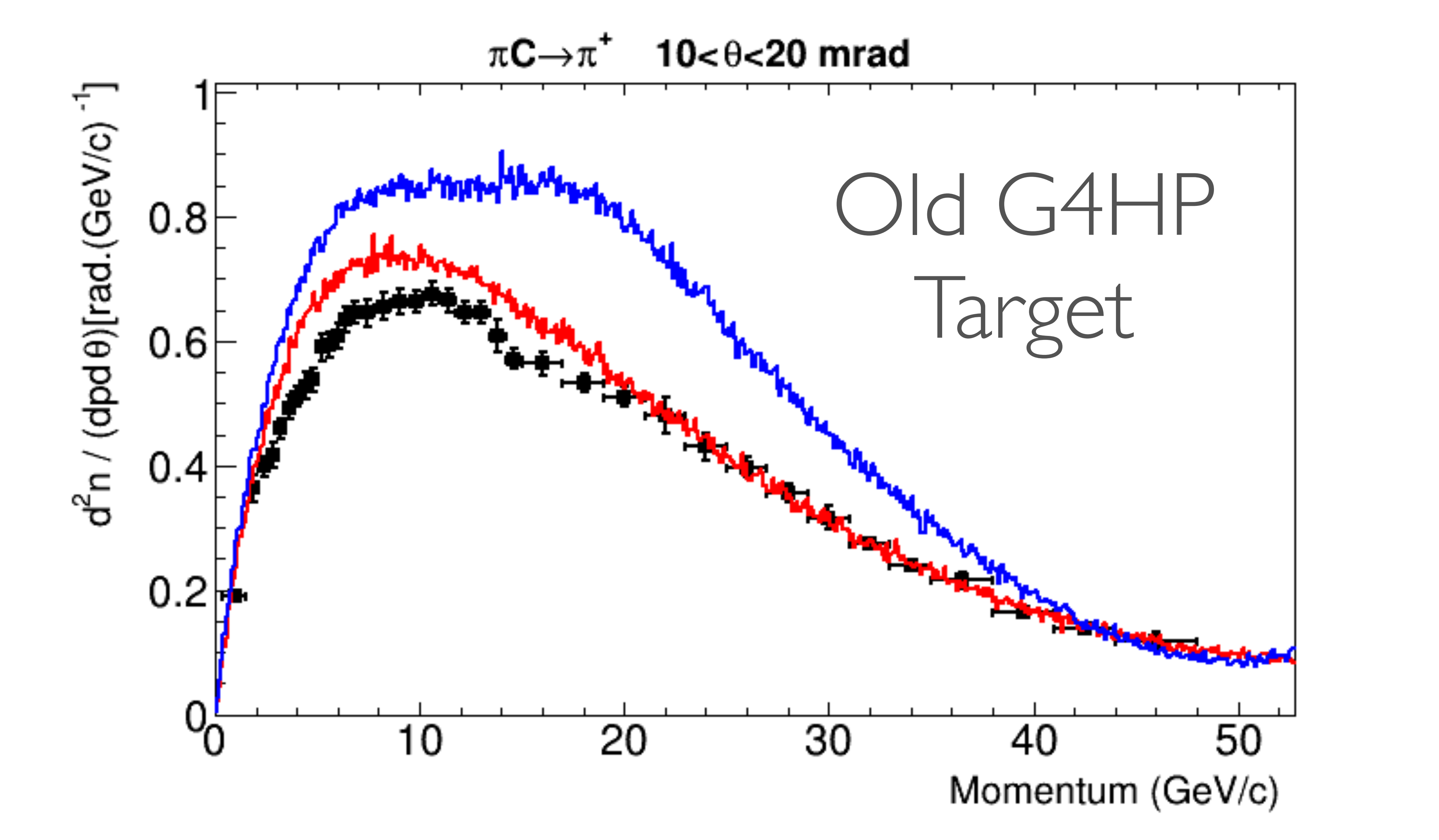


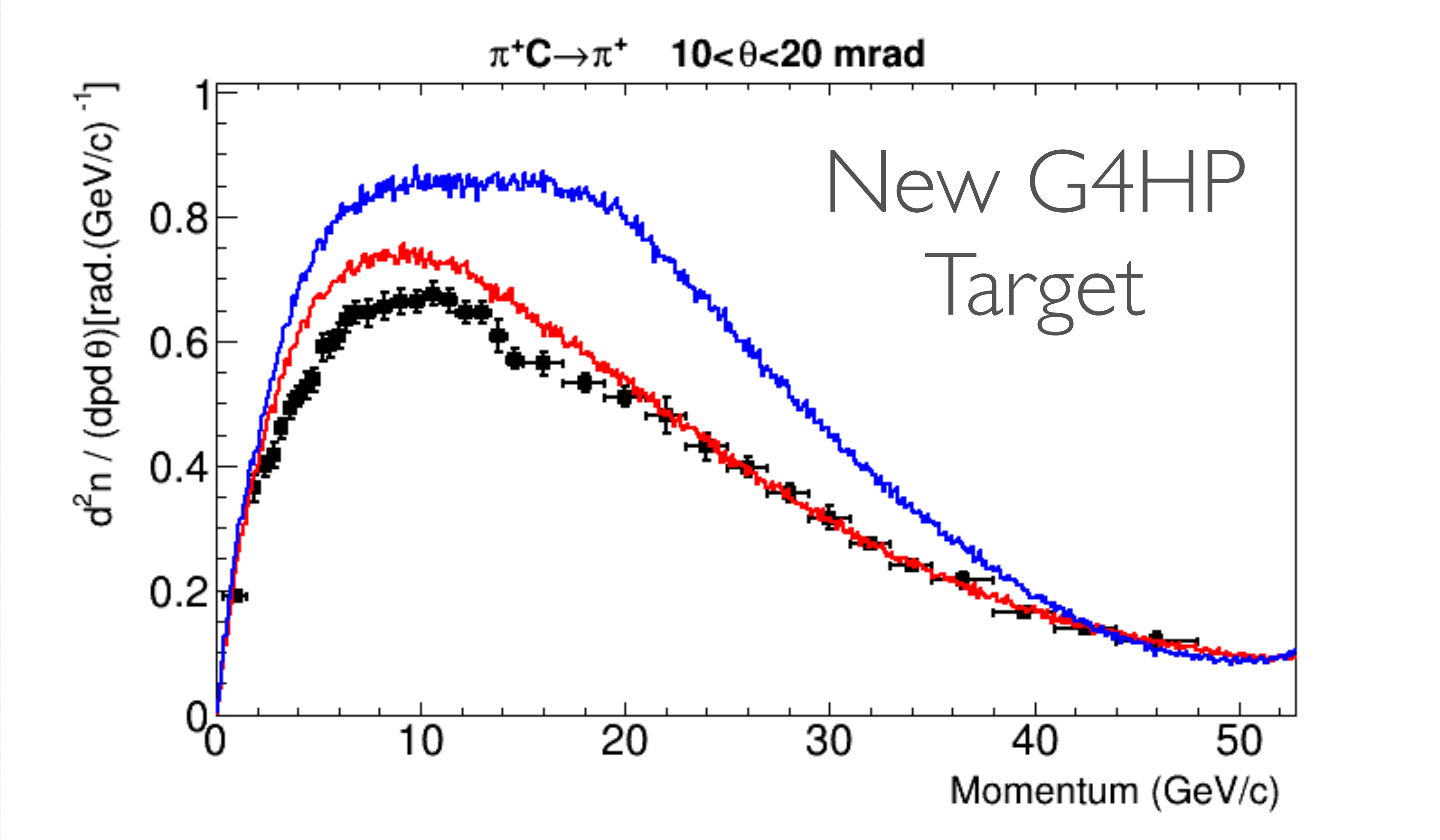
Invariant differential cross sections

DISCUSSION

- Now need to run simulations to get invariant cross section at 12 and 60 GeV (and ratio)
- At this point, I became concerned that the target in NA61 is different than the target in G4HP
- So I updated the target:
  - Changed target thickness from 7 mm to 14.8 mm
  - Changed density from 1.78 g/cm3 to 1.8 g/cm3 as in Scotts paper
  - Changed beam start point to -15 mm to make sure beam didn't start in the middle of the target (was previously -6.5 mm) (target is surrounded by air; I'm not sure why)
- The only thing that changed was stats:

DIFFERENT G4HP TARGETS

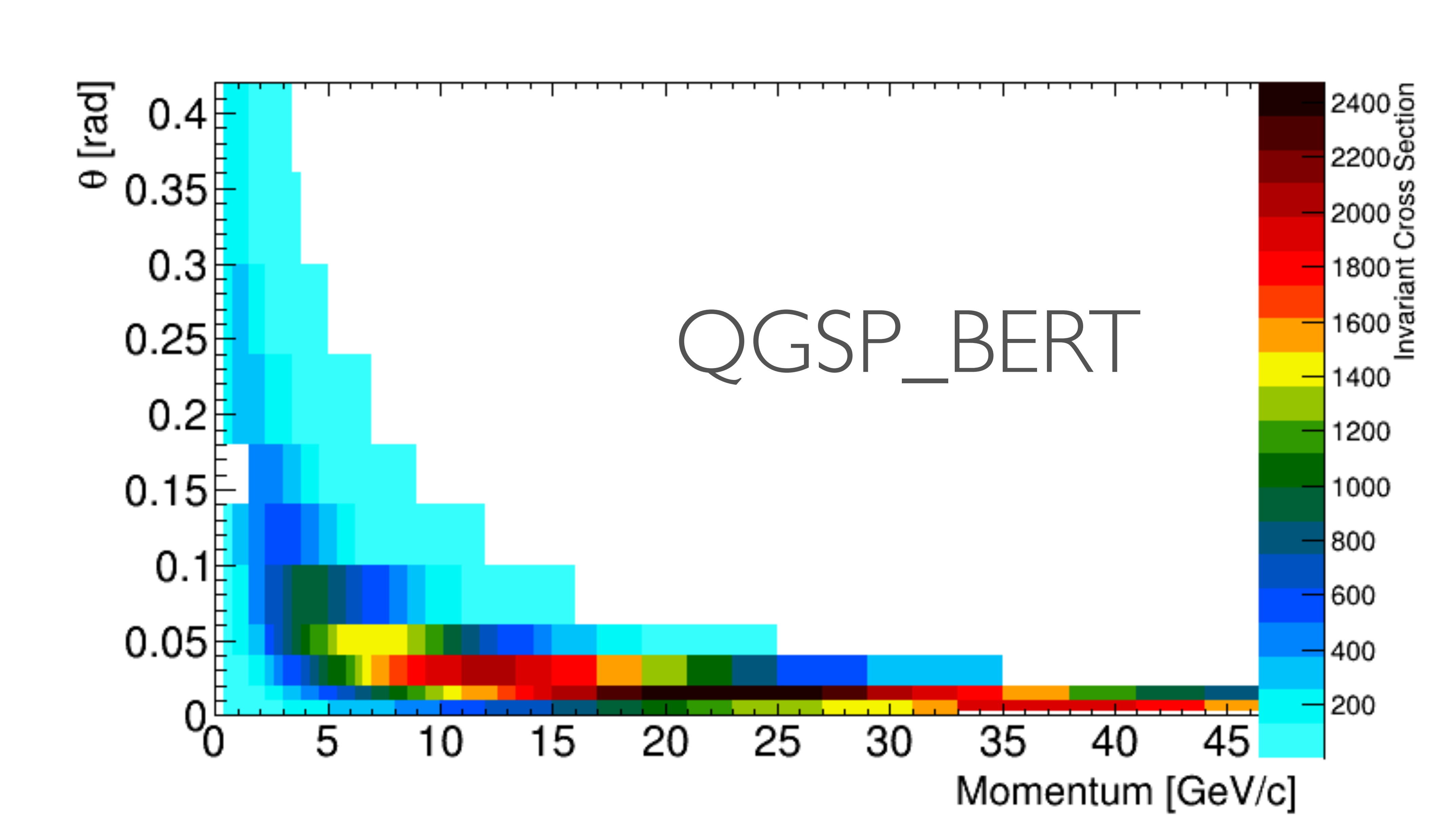


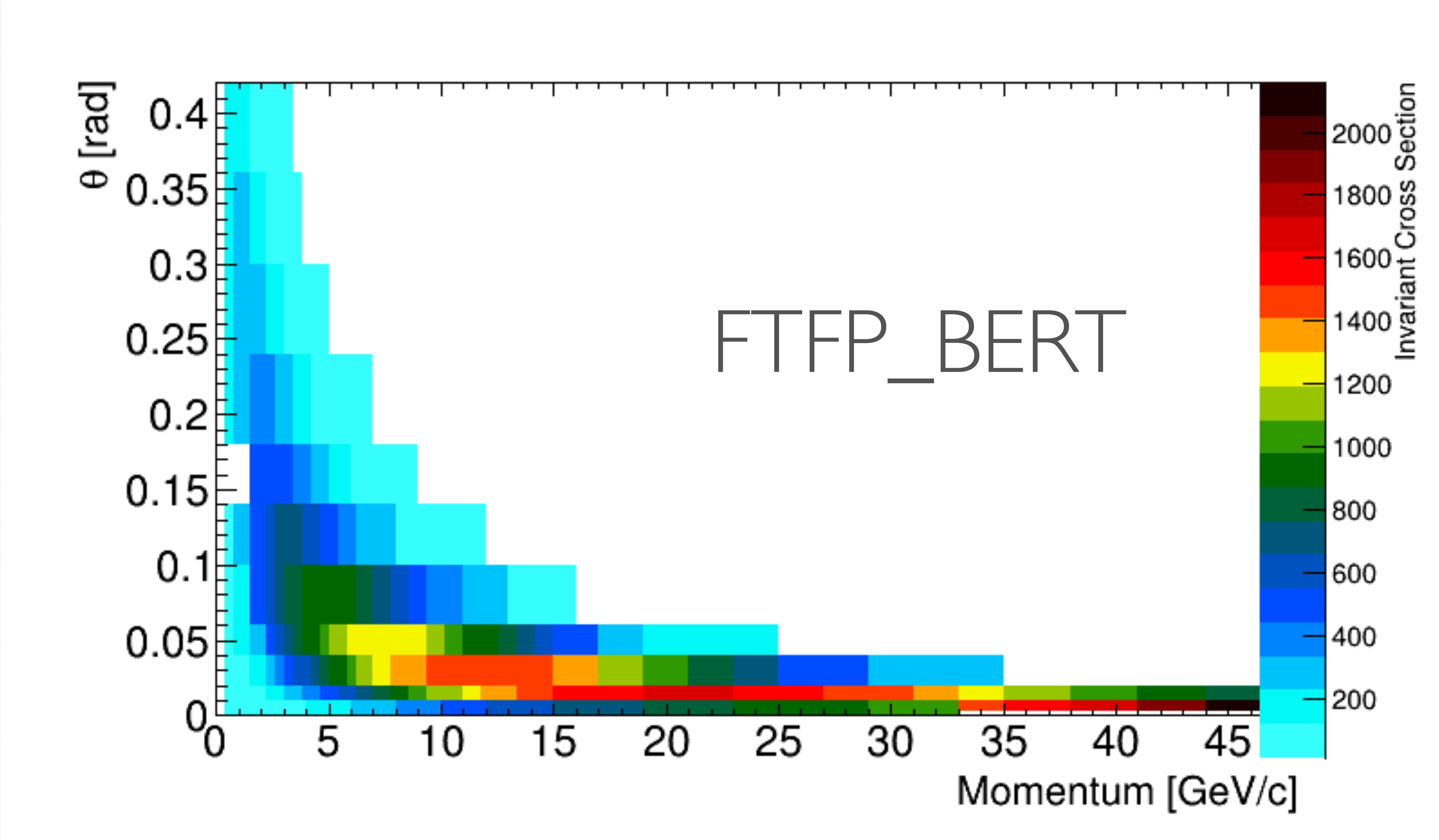


DISCUSSION

- Next up: need invariant cross sections in MC at 12 and 60
  - Modified CreateYields.C and CreateInvXS.C in ppfx/ana to do this

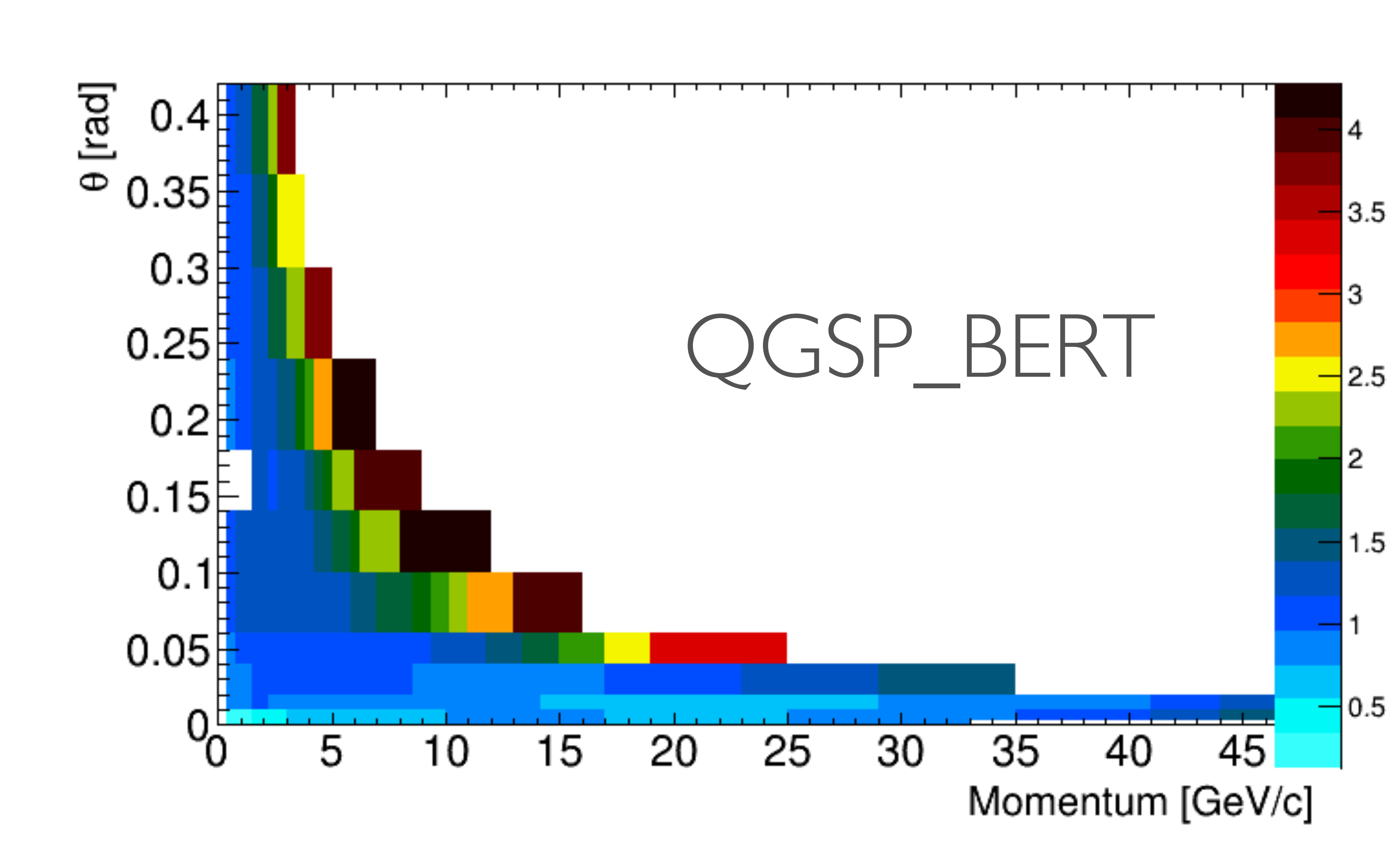
INVARIANT CROSS SECTIONS (MC)

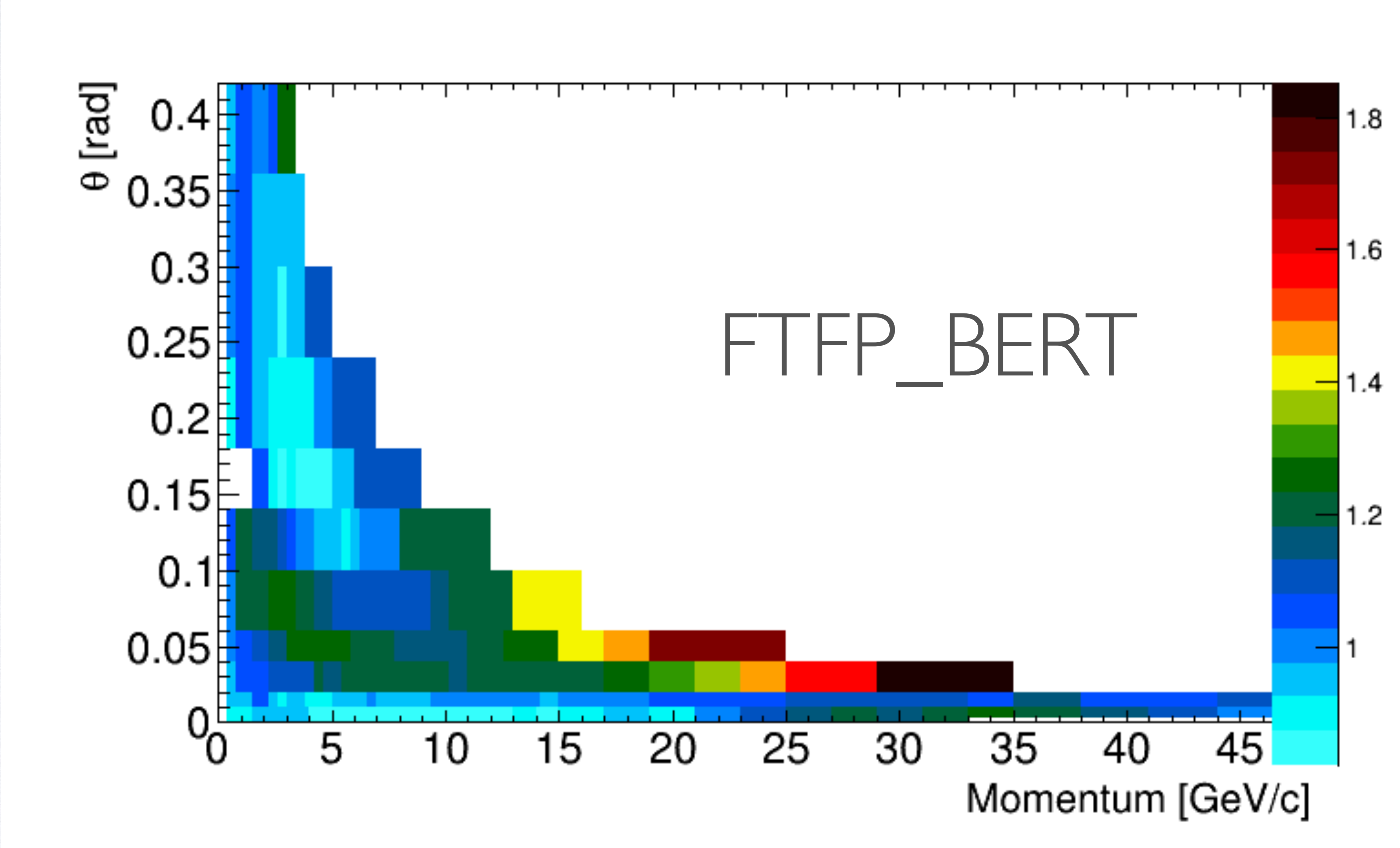




Invariant differential cross sections 60 GeV pi+C->pi+X

INVARIANT CROSS SECTIONS (MC)





Invariant differential cross sections 60 GeV pi+C->pi+X

Ratios to data

CONCLUSION

Thank You for Listening!