Comparison between the NA61 π^+ + C @ 60 GeV and MC (Status)
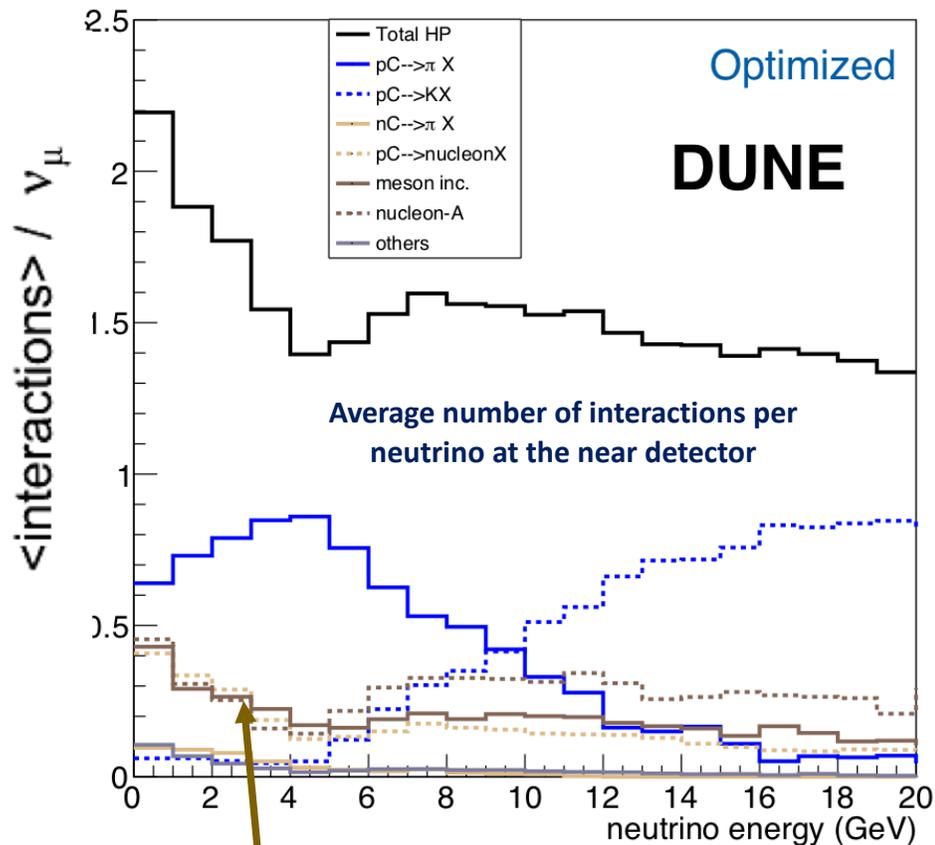
Nilay Bostan (UIowa)

For PPFX group meeting

Oct 23/20

Why is the meson incident data important for DUNE?

**What kinds of interactions are happening in the beamline?**

Hadron Production Uncertainties for DUNE Optimized beam

L. Fields (NA61 Workshop 2017)

L. Fields (NA61 Workshop 2017)

Optimized

DUNE

Average number of interactions per neutrino at the near detector

Optimized

DUNE

To constrain the interactions of meson incidents is very important to reduce the uncertainties in the low energy region.

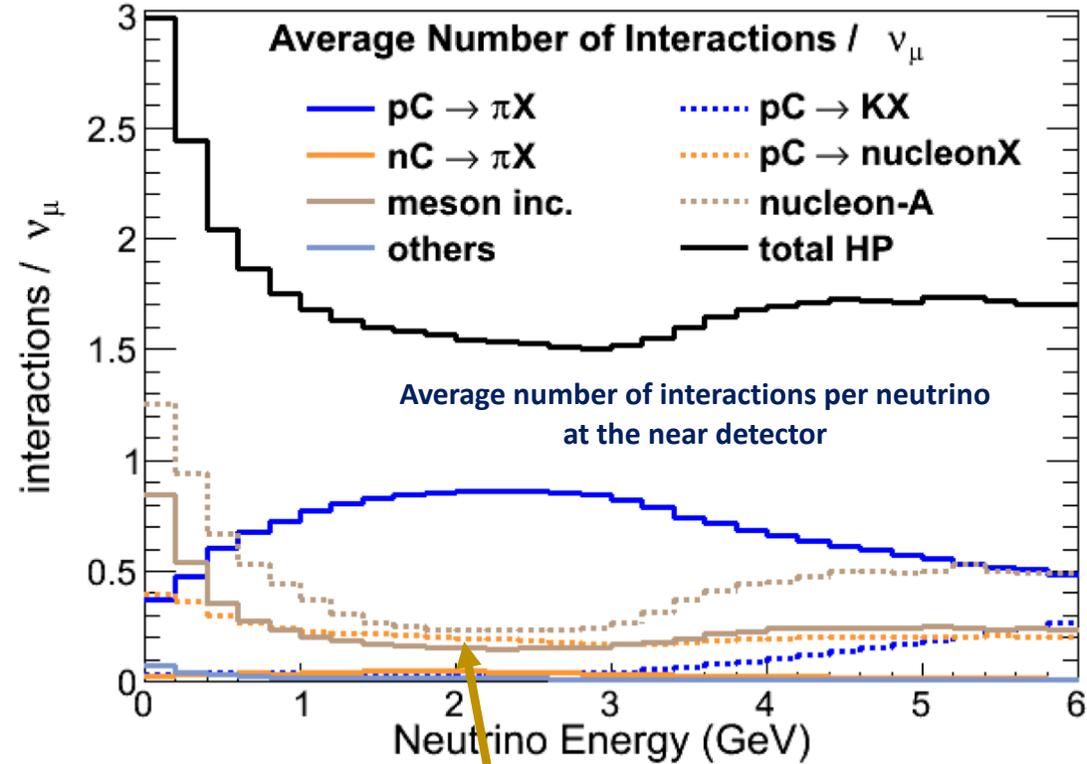*No data applied to meson incidents: Assuming large uncertainty* for meson incident
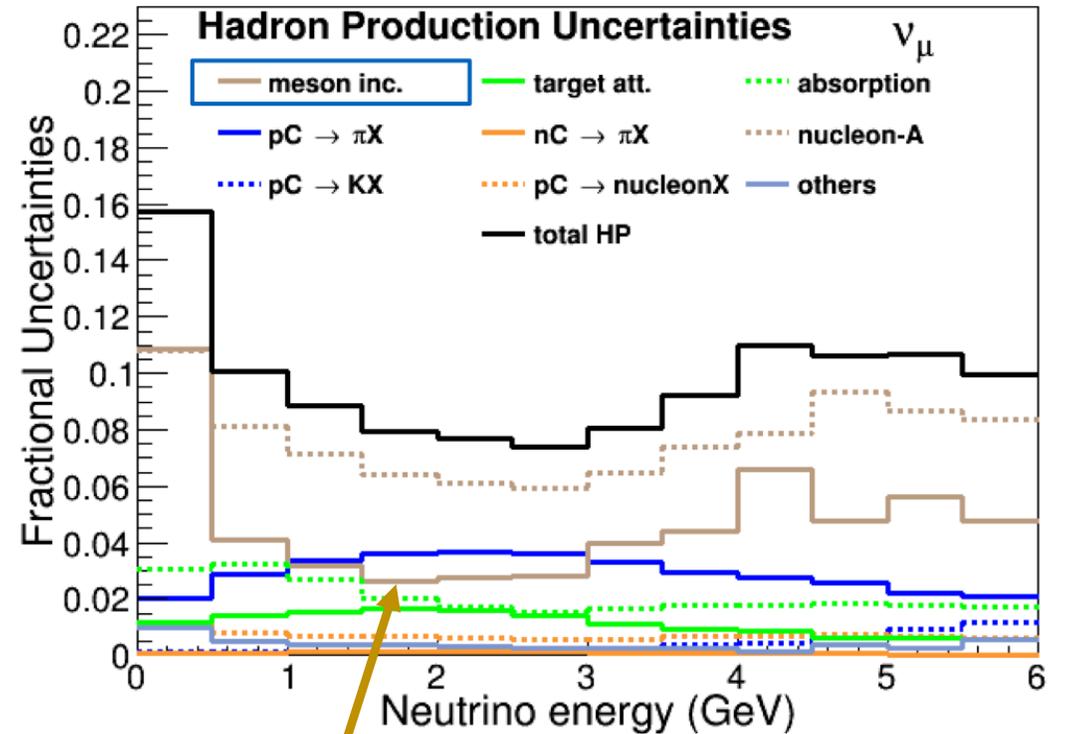
1
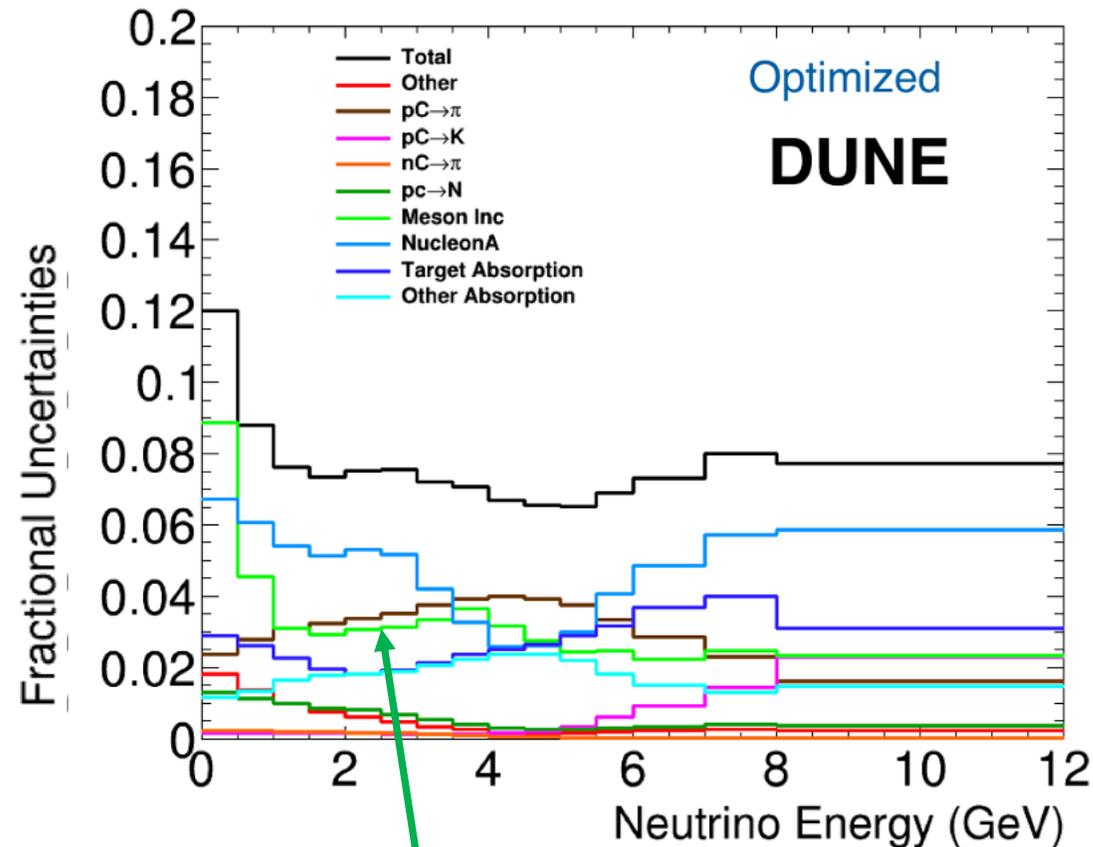
Why is the meson incident data important for NOvA?

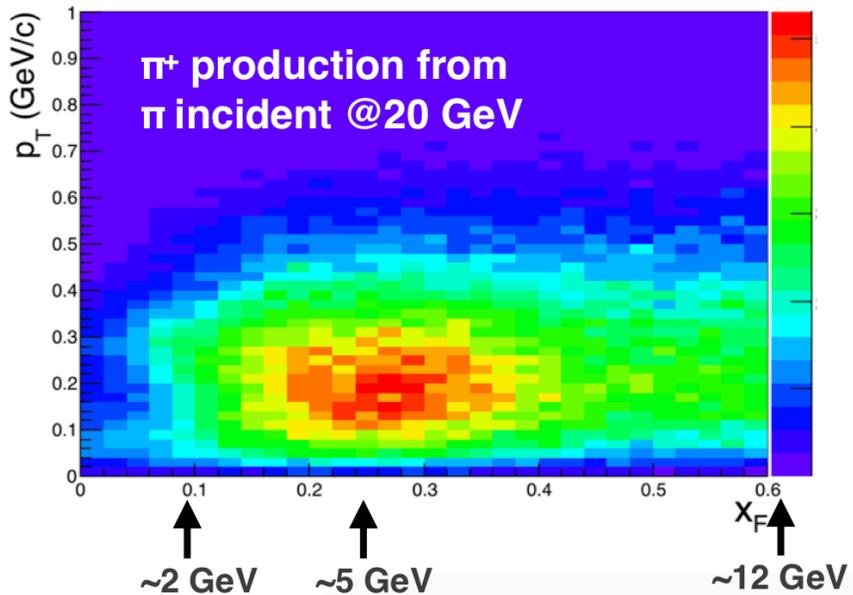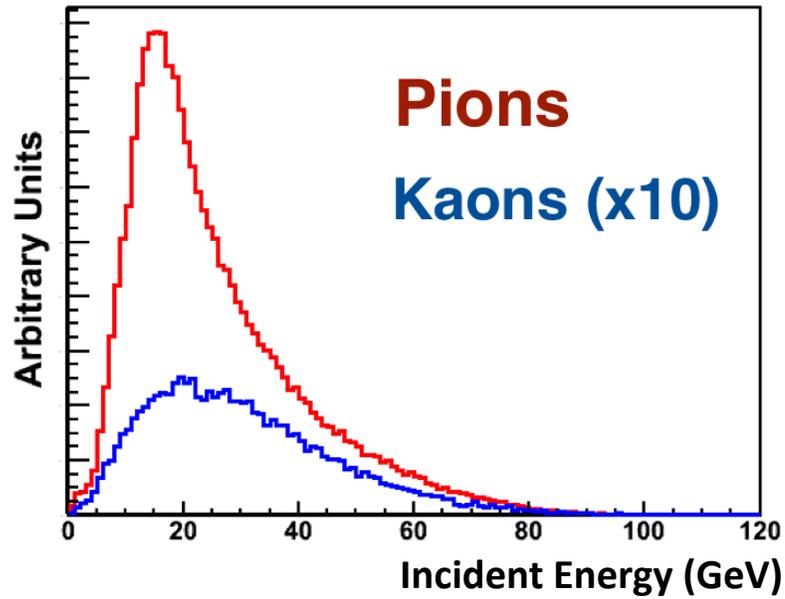*π, K* and ***nucleons*** *productions from **pC** based on data (mainly NA49), Leo Aliaga.*

To constrain the interactions of meson incidents is very important to reduce the uncertainties in the low energy region.

No data applied to meson incidents: Assuming large uncertainty for meson incident

Incident Momentum

Pions

Kaons (x10)

π+ production from π incident @20 GeV

~2 GeV   ~5 GeV   ~12 GeV

NOvA ND, ν_μ

~80% neutrinos have form of incident mesons and ~70% low energy neutrinos come from pion producing pions. It tells us to constrain the interactions of meson incidents is very important to reduce the uncertainties in the low energy region.
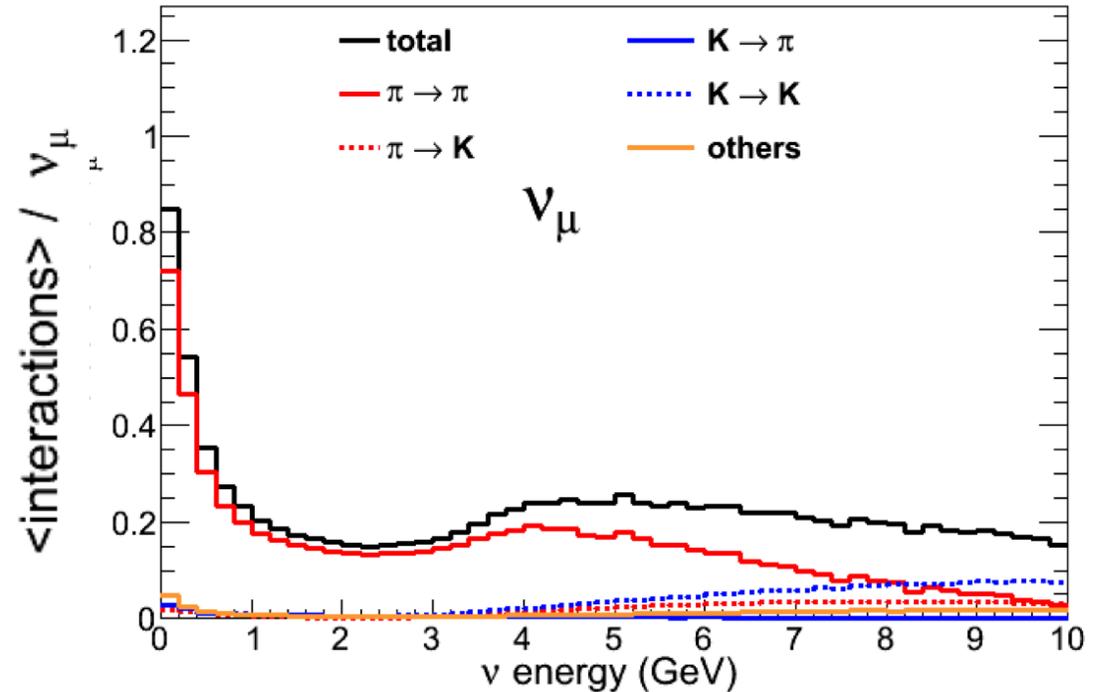
3

Introduction

- My work is to constrain the pion interactions in the beamline using external HP data particularly the recently published NA61 data.

- Another challenge for this analysis is to scale to the different materials than C (ex: Al). (This work will be done by Antoni)

- In this talk, I will show my first comparisons of the NA61 data to QGSP_BERT and FTFP_BERT models for GEANT 4 (v4_10_3_p03b, LBNF current version) by using G4HP.

- This work includes characterizing the pion interaction in NuMI and DUNE beamlines, and about how to do energy scale the data to energy relevance for the beamlines.

  - I will show the comparisons for [0, 10] mrad and [40, 60] mrad.

NA61/SHINE

Phys. Rev. D 100, 112004

EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

S∙∙INE

CERN-EP-2019-198
January 20, 2020

Measurements of hadron production in $\pi^+ + C$ and $\pi^+ + Be$ interactions at $60\,GeV/c$

The NA61/SHINE Collaboration

[hep-ex] 17 Jan 2020

- This paper includes NA61 pion and kaon production from pion incident on C and Be at 60 GeV (published data).

- The integrated production, inelastic cross sections and differential cross sections were measured for produced π+, π−, K+, K−, protons, KS0, Λ and Λ.

- The inelastic cross sections measurements are the first to be made at a beam momentum of 60 GeV/c. The production cross section of interactions of π+ + Be at 60 GeV/c was measured for the first time as well.

- NA61 measures multiplicities in a different momentums [0-50] GeV/c and angle beam [0-420] mrad.

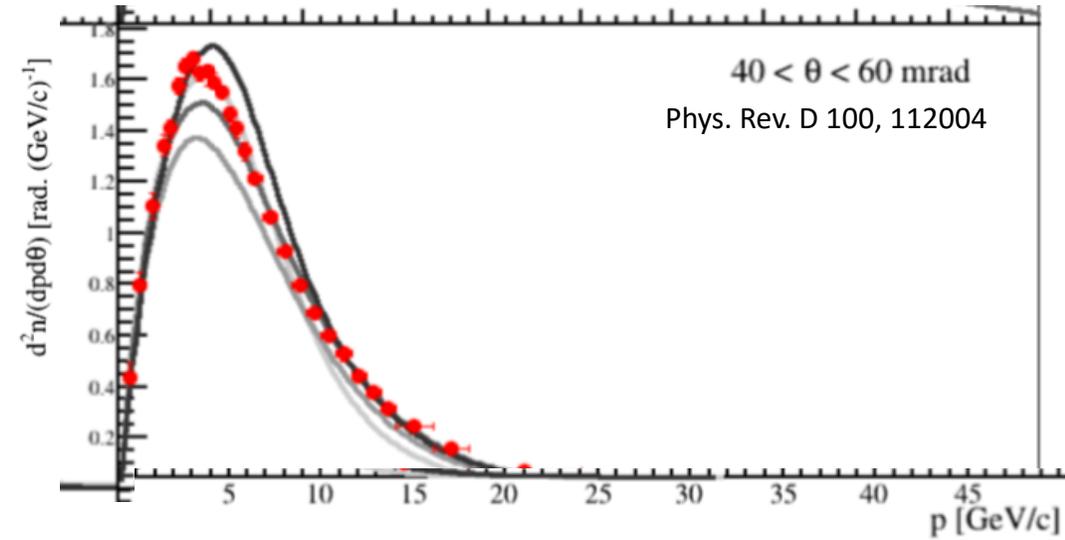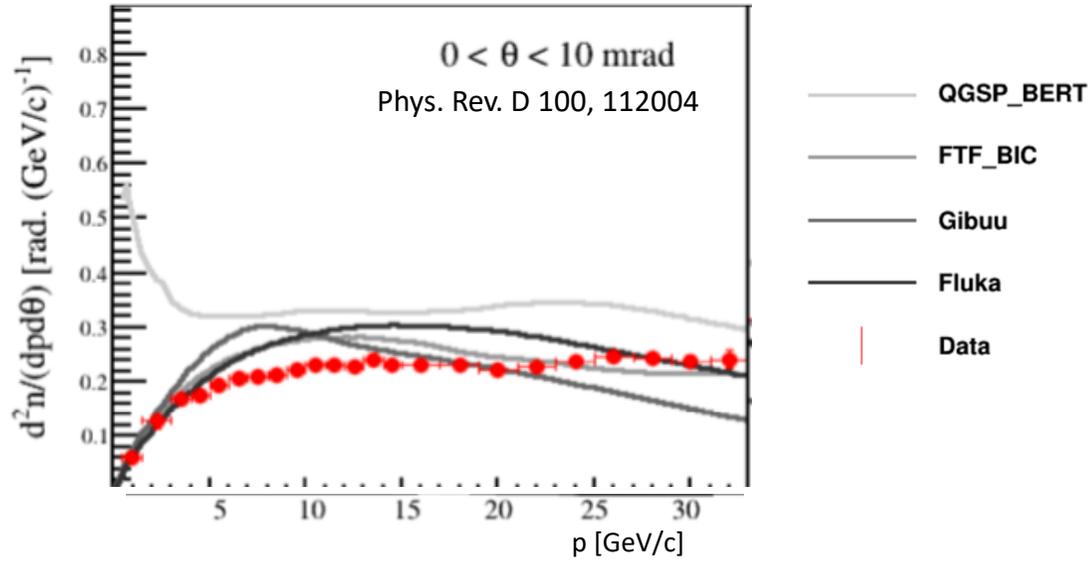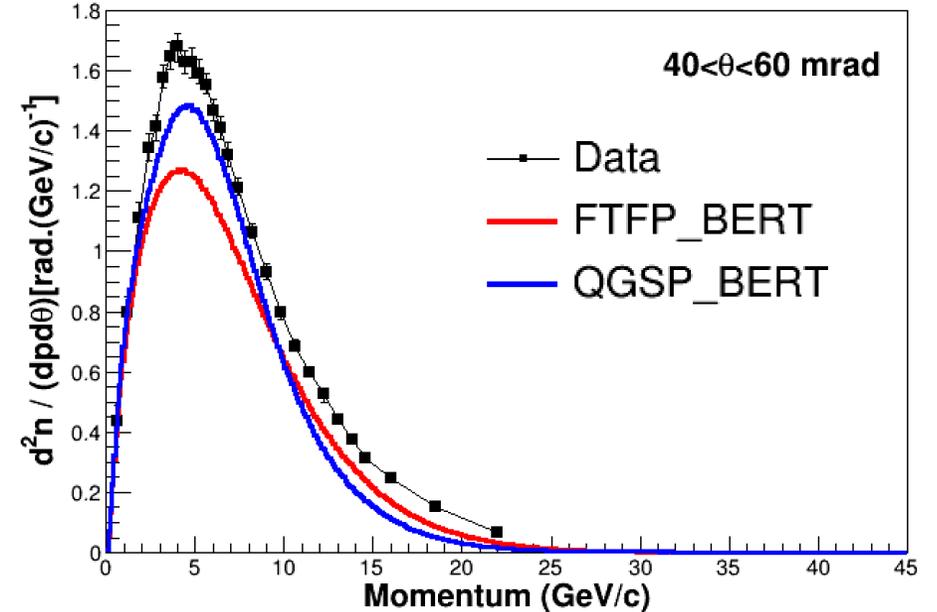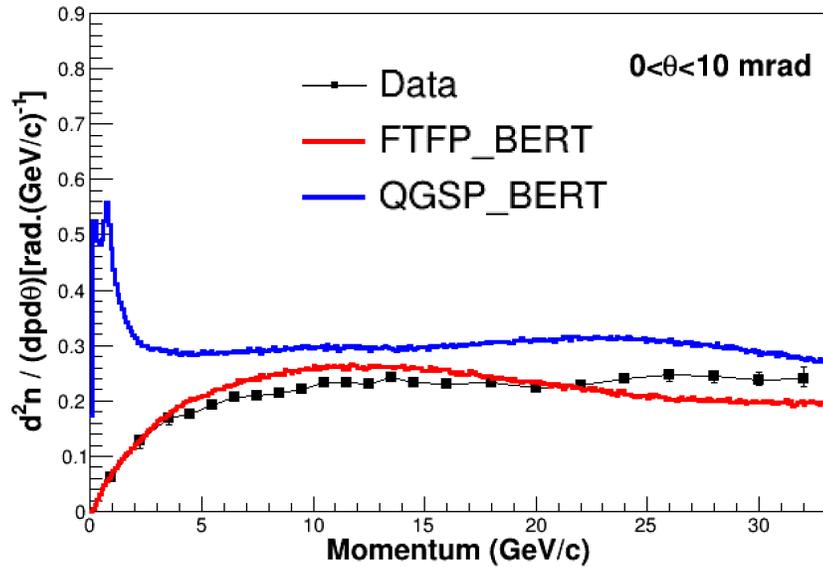$d^2n / (dpd\theta)[rad.(GeV/c)^{-1}]$

https://edms.cern.ch/document/2215444
presents the numerical values of the multiplicity measurements of charged pions, charged kaons and protons along with statistical, systematic and total uncertainties for each kinematic bin analyzed.

For $\pi^+ + C \to \pi^+ + X$ @ 60 GeV
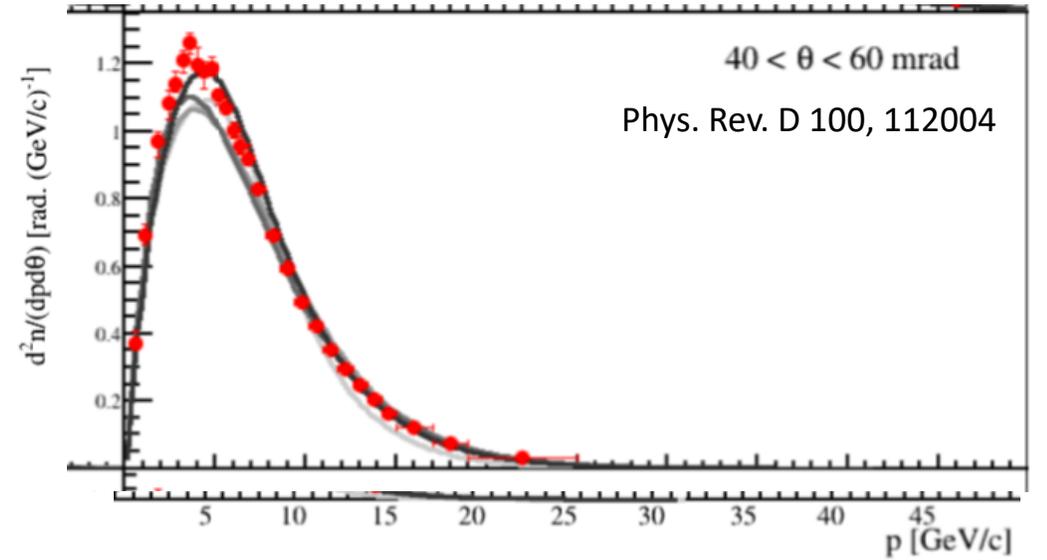
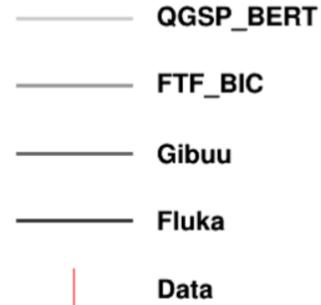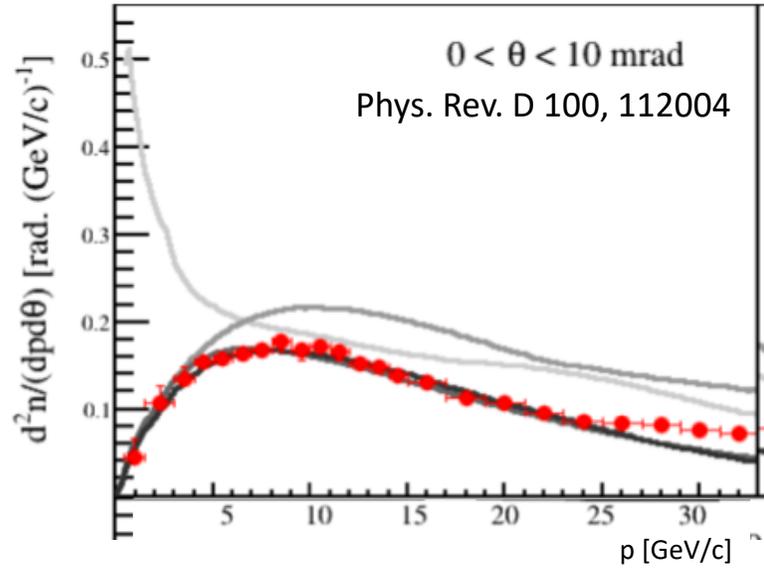Top plots are taken from NA61, 2020 paper

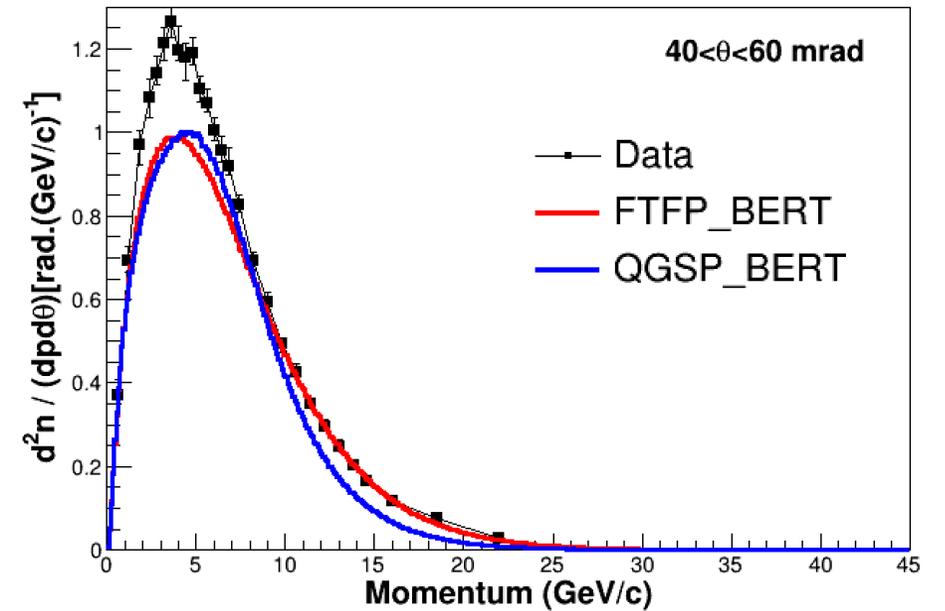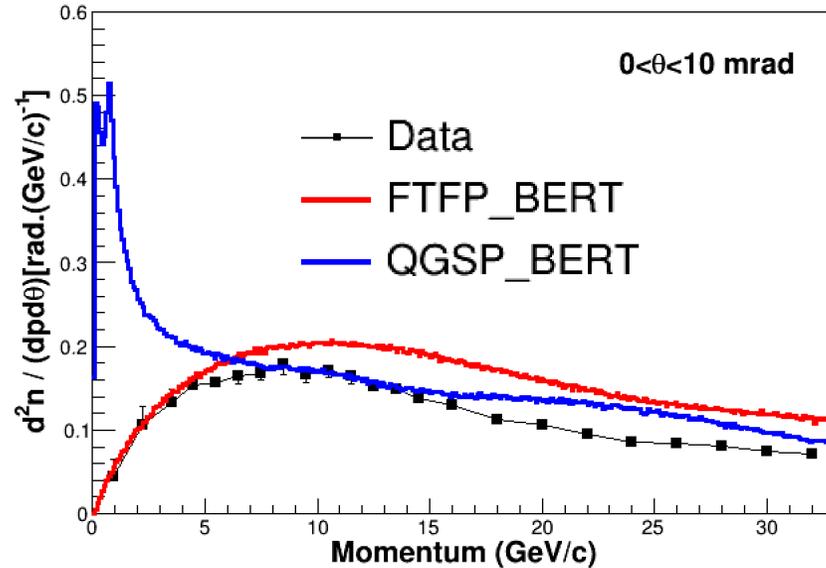Bottom plots are from my calculation by using G4HP

The error bars represent total uncertainties except for the normalization uncertainty.

For $\pi^+ + C \rightarrow \pi^- + X$ @ 60 GeV

Top plots are taken from NA61, 2020 paper

Phys. Rev. D 100, 112004

$0 < \theta < 10$ mrad

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$40 < \theta < 60$ mrad

QGSP_BERT
FTF_BIC
Gibuu
Fluka
Data

Bottom plots are from my calculation by using G4HP

$0<\theta<10$ mrad

Data
FTFP_BERT
QGSP_BERT

$40<\theta<60$ mrad

Data
FTFP_BERT
QGSP_BERT

The error bars represent total uncertainties except for the normalization uncertainty.

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Conclusion

- I made a first comparison of NA61 data with QGSP_BERT and FTFP_BERT by using G4HP.

- I am currently working to do the comparison with all angle ranges and produced particle multiplicities.

- I am working also to do characterization of pion incident for DUNE and NuMI.

- I will work on comparing the NA61 data to data at other energies (HARP, Barton) for the energy scaling.

BACKUP

For $\pi^+ + C \rightarrow \pi^+ + X$ @ 60 GeV
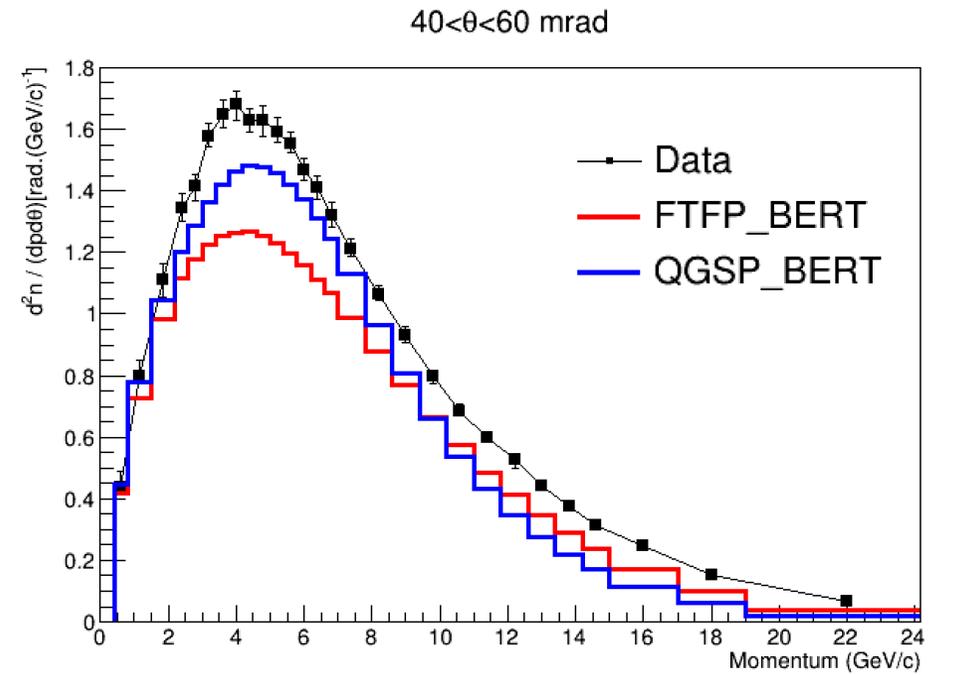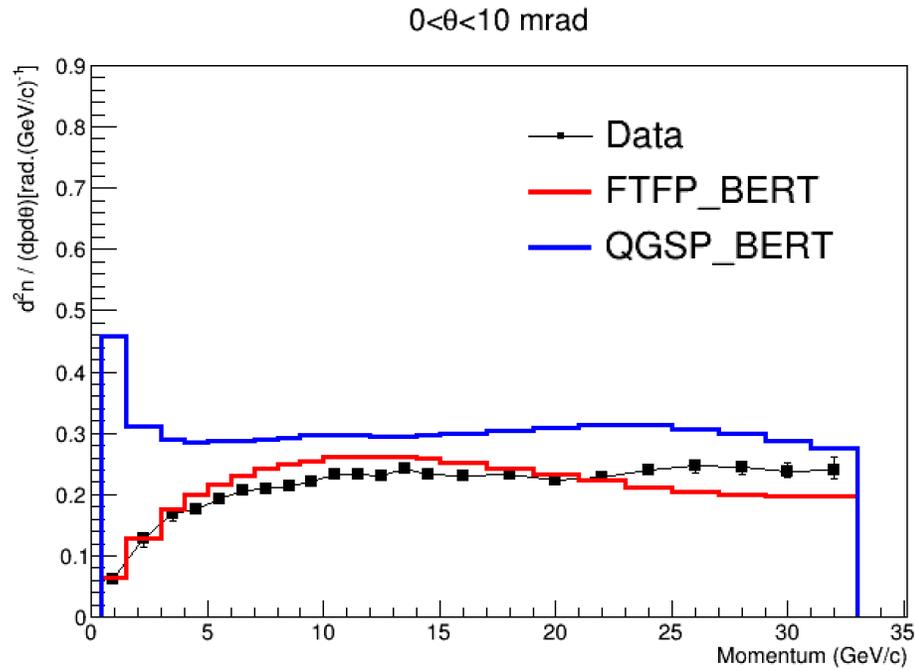
For $\pi^+ + C \rightarrow \pi^- + X$ @ 60 GeV
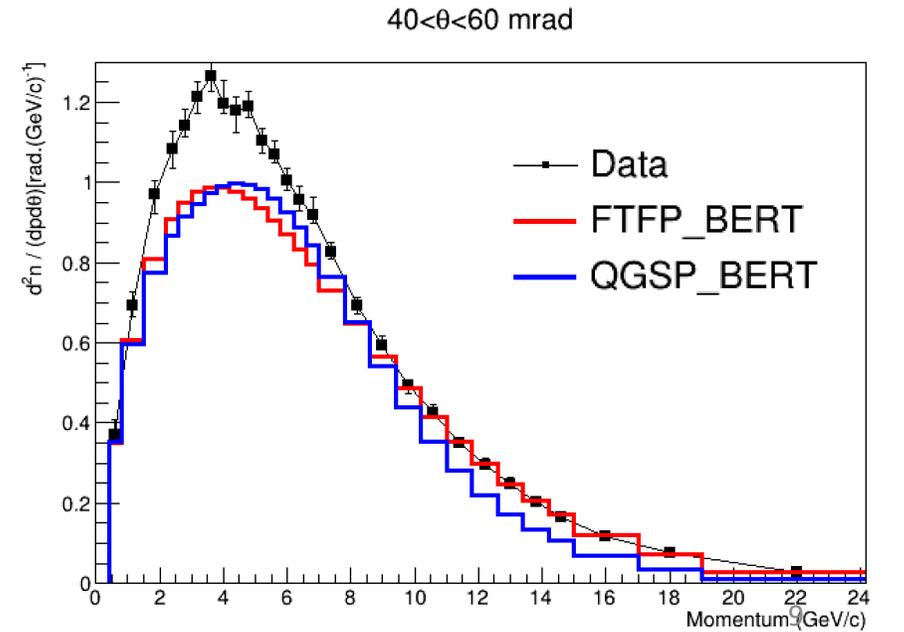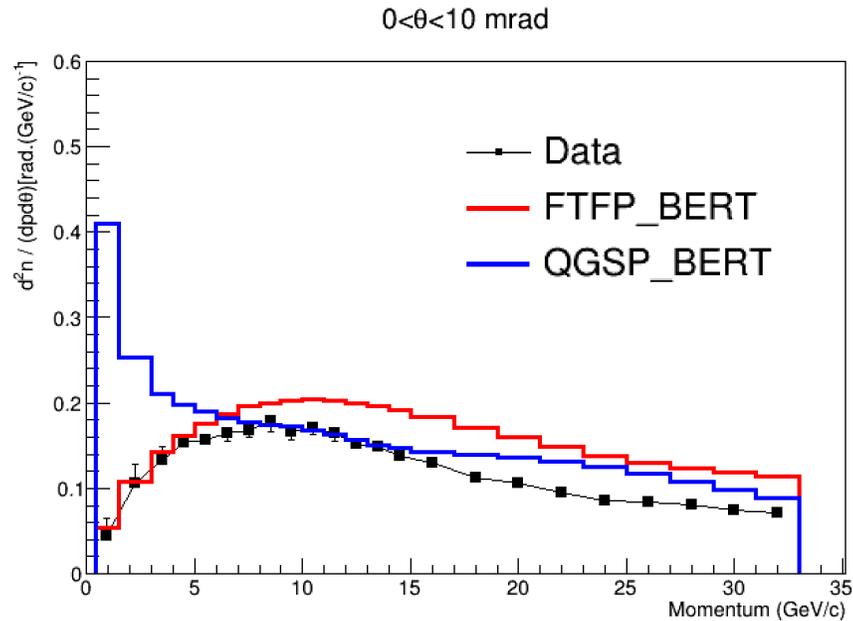
Cluster	37701781@jobsub01.fnal.gov
Number of Jobs	500
Submitted	2020-10-21 04:32:33 +0000 UTC
Owner/Group	nbostan / dune (nbostan@FNAL.GOV)
Command	g4hp_job.sh
Requested Memory	1200 MiB
Requested Disk	35.0 GiB
Expected Wall Time	23h40m0s

[View this cluster on Fifemon](#)

Average time waiting in queue: 4m8s

Success rate (% jobs with exit code 0): 100.0%

Used	Min	Max	Avg
Memory	395.5 MiB	480.3 MiB	460.0 MiB
Disk	0.0 GiB	0.0 GiB	0.0 GiB
Wall Time	3m35s	31m13s	6m17s
CPU Time	2m45s	12m38s	4m52s

Efficiency	Min	Max	Avg
Memory	33.8%	41.0%	39.3%
Disk	0.0%	0.0%	0.0%
CPU	14.0%	97.3%	77.4%
Time	0.3%	2.2%	0.4%

Exit Code	# Jobs
0	500