Adding NA61 Data to PPFX

Lu Ren
Dec. 5th, 2023
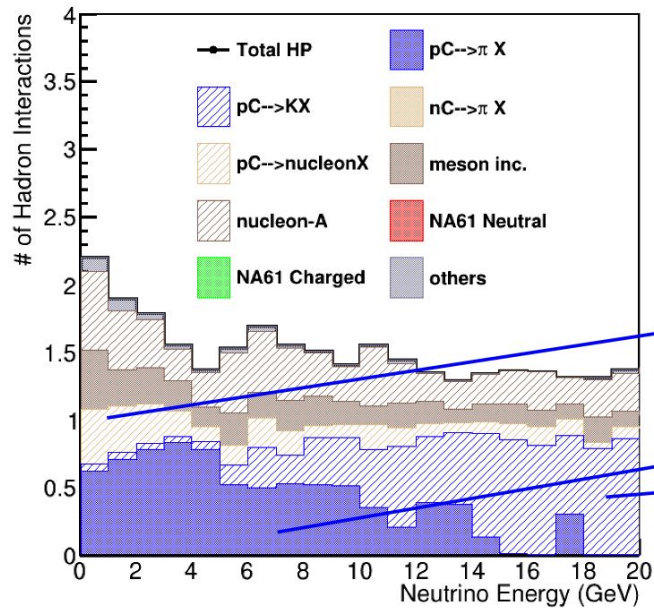
University of Colorado **Boulder**

Last Update at the DUNE collaboration meeting in May
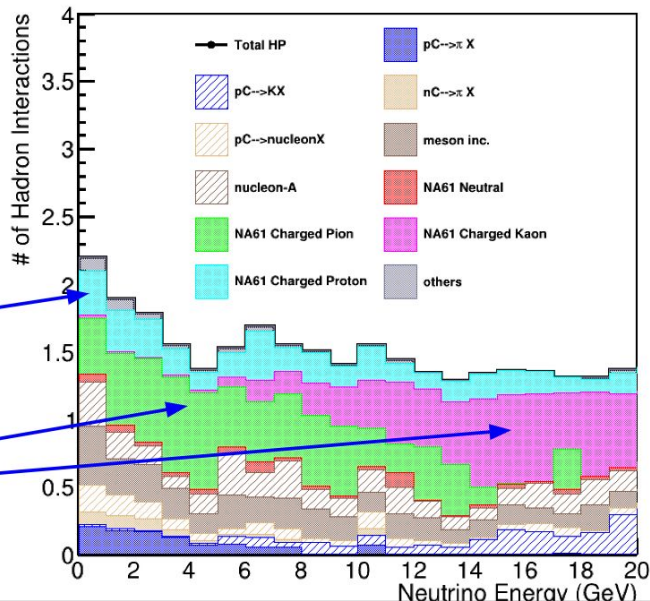

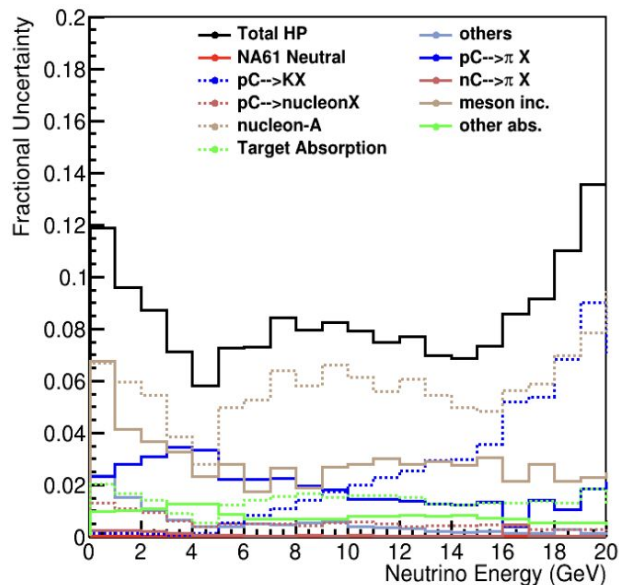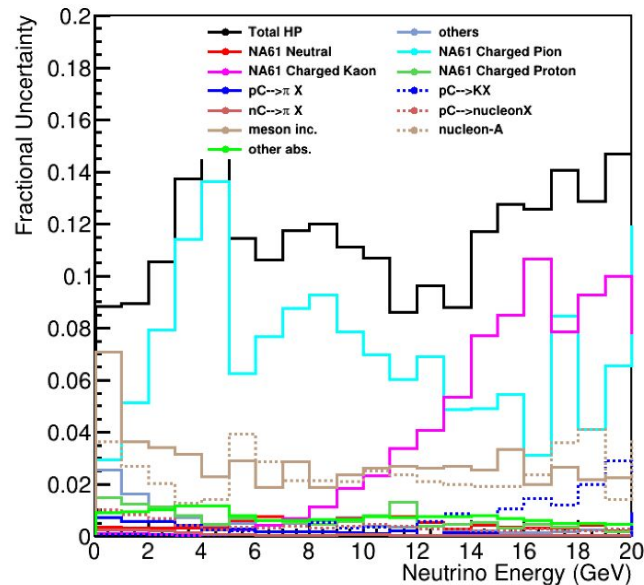Effect on Breakdown of Hadron Interactions

ν_μ

NA61 OFF

NA61 ON

Last Update at the DUNE collaboration meeting

Effect on DUNE ND Flux Uncertainty ν_μ

OFF

ON

Since then

- NA61 pC@120GeV/c charged paper published
  https://journals.aps.org/prd/pdf/10.1103/PhysRevD.108.072013

Measurements of π^+, π^-, p, $\bar{p}$, K^+ and K^- production in $120 \ \mathrm{GeV}/c \ \mathrm{p} + \mathrm{C}$ interactions

H. Adhikary *et al.* (NA61/SHINE Collaboration)
Phys. Rev. D **108**, 072013 – Published 26 October 2023

- Complete data release https://edms.cern.ch/document/2771737/1

📄	README.txt	2.7 KB	2022-12-02 16:40:14
	combinedMultiplicities_K0S.root	190.6 KB	2023-03-02 10:00:44
	combinedMultiplicities_Lam.root	202.7 KB	2023-03-02 10:00:44
	combinedMultiplicities_ALam.root	70.3 KB	2023-03-02 10:00:44
	combinedMultiplicities_K.root	778.8 KB	2023-10-16 15:12:30
	combinedMultiplicities_P.root	2.6 MB	2023-10-16 15:12:30
	combinedMultiplicities_Pi.root	6.8 MB	2023-10-16 15:12:30

Added in PPFX xml files

- Updated all xml files in PPFX with the new data release
- Added components of uncertainty for debugging purpose
- Detector response uncertainty is not available
  - Waiting for author's reply…

ROOT Files
- combinedMultiplicities_Pi.root
  - Uncertainties;1
    - Uncorrelated;1
    - Total;1
    - DetectorResponse;1
    - FeedDown;1
    - Model;1
    - ProductionCrossSection;1
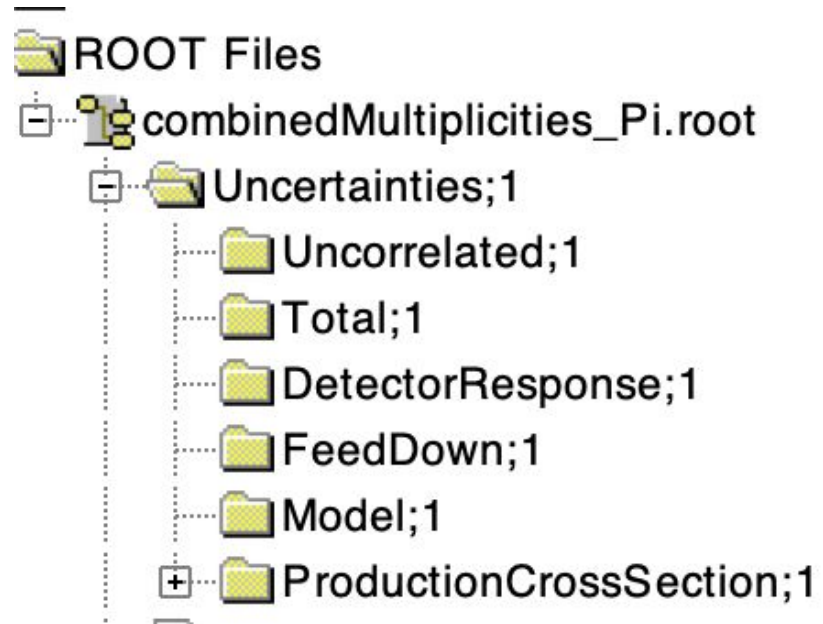
Why is NA61 pC→ pi uncertainty so large?

- Quick summary: still unknown, most likely a bug…
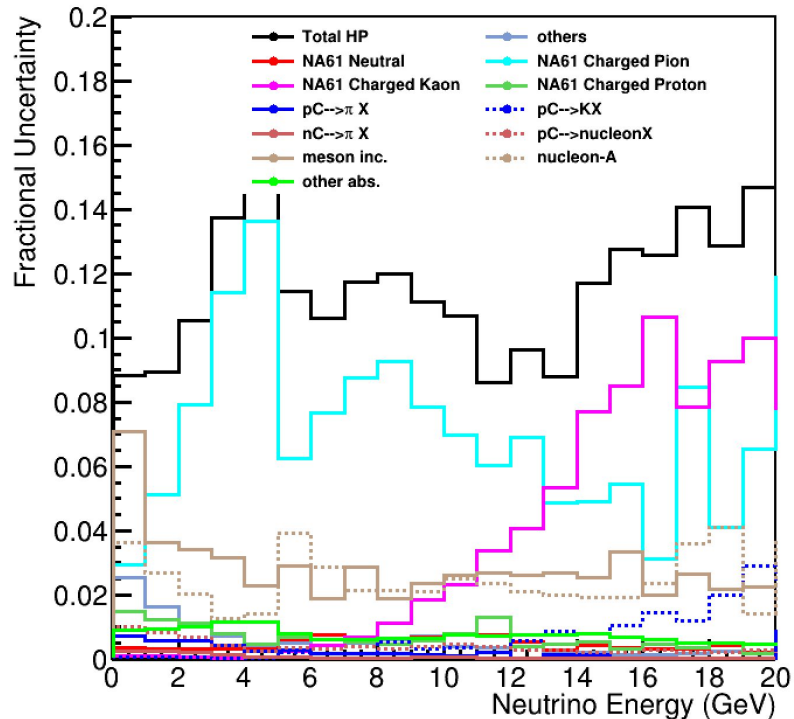
What I did

- Turned off all reweighters except for **NA61pC120ChargedPionReweighter.cpp**

```
../scripts/inputs_default.xml
../scripts/inputs_imap.xml
../scripts/inputs_mipp_numi.xml
../scripts/inputs_NA61_2022.xml
../scripts/inputs_NA61_later_2023.xml
../scripts/inputs_NA61_pCPi_only.xml
```

What I did

- Turned off all reweighters except for **NA61pC120ChargedPionReweighter.cpp**

- Produced the flux uncertainty plot as is
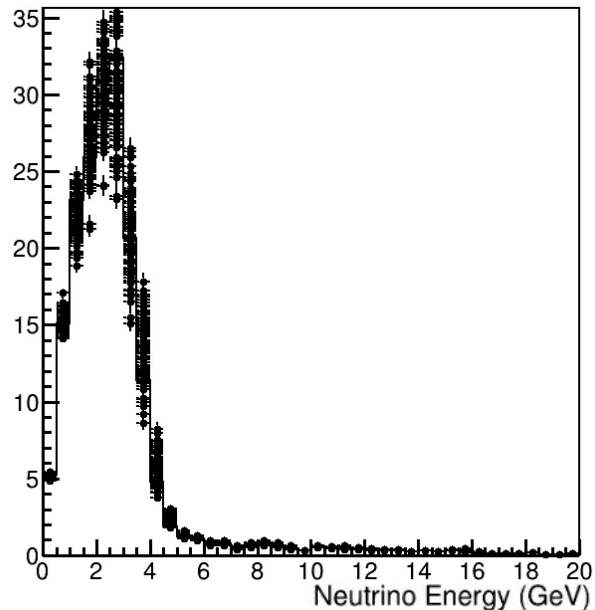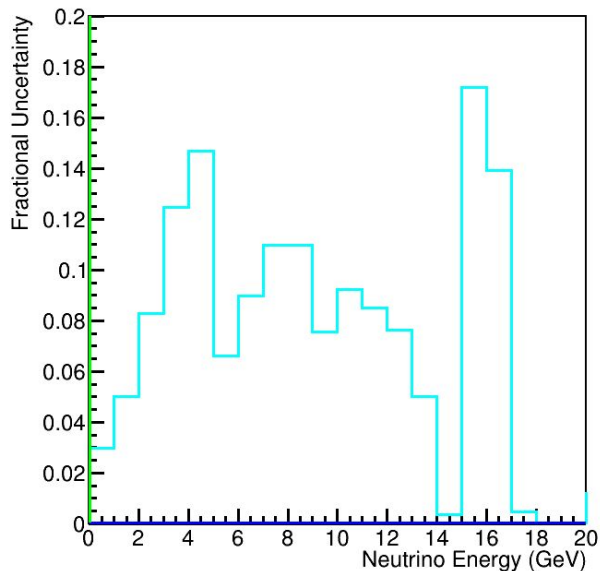
What I did

- Turned off all reweighters except for **NA61pC120ChargedPionReweighter.cpp**

- Produced the flux uncertainty plot as is

- For pi$^+$, replaced the NA61 total uncertainty with different components (uncorrelated uncertainty, model uncertainty, production uncertainty, respectively), but saw no change at all

- Replaced the NA61 total uncertainty with a constant of 4% for all bins, still saw no change…
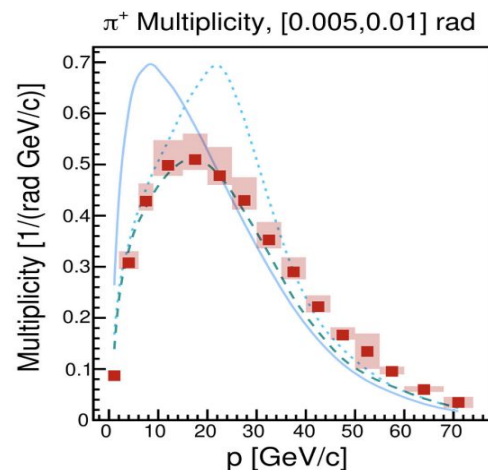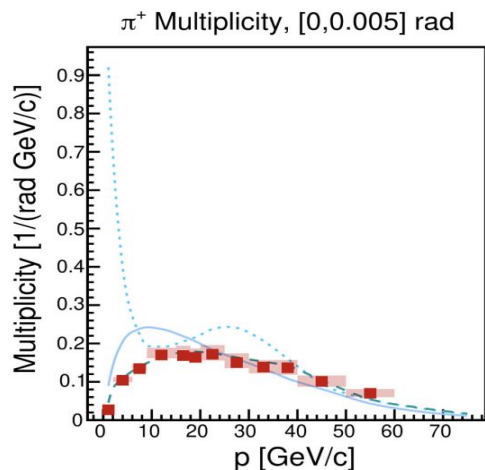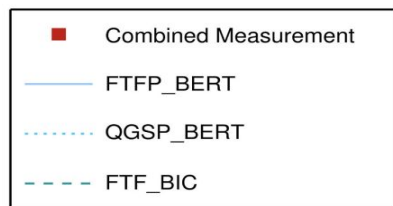
What I have examined / will exam

- No obvious bugs found

  - NA61pC120ChargedPionReweighter.cpp

  - MakeReweight.cpp

  - ReweightDriver.cpp

  - doReweight_dk2nu_dune.C

- CentralValuesAndUncertainties.cpp

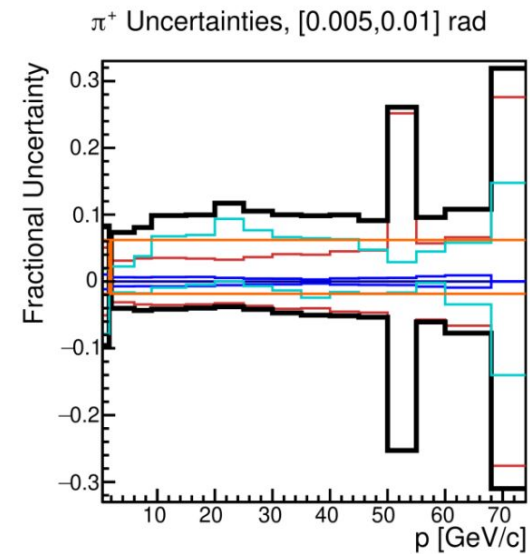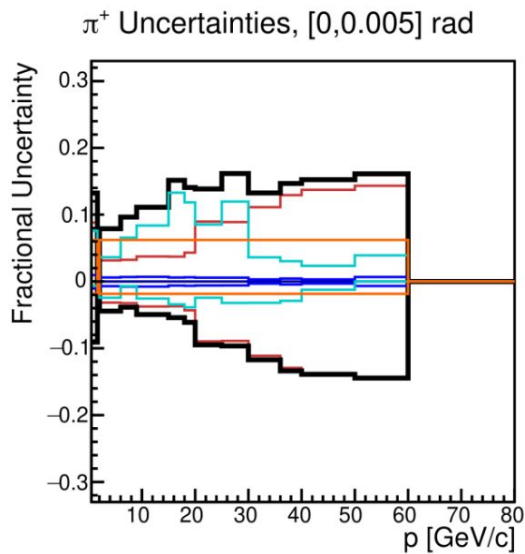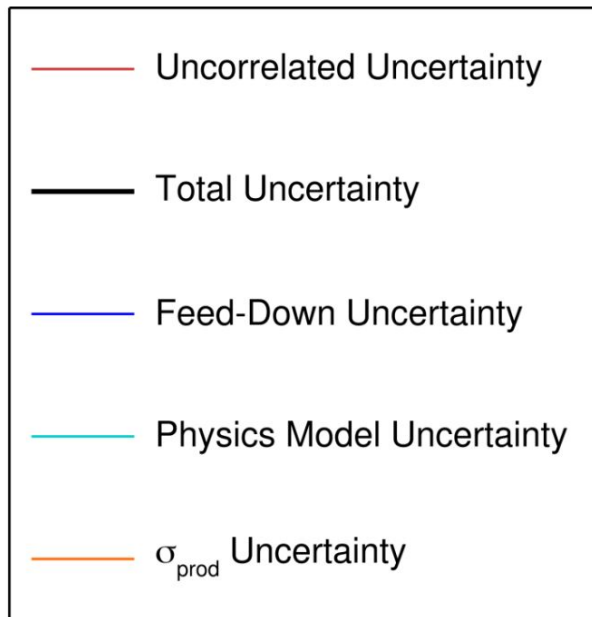 - Trying to print out parameter tables in different universes

```
sprintf(namepar,"NA61_pC_120_%s_stats_%d","PIPLUS",ii);
double data_cv  = cvPars.getParameterValue(std::string(namepar));
double data_sys = univPars.getParameterValue(std::string(namepar));
```

Another concern

- In NA61/SHINE, the central values for the Monte Carlo corrections were determined using the FTFP_BERT physics list
- "The QGSP_BERT physics model was not used for this uncertainty calculation due to large differences between the model predictions and these measurements"
- Still using CV data as MC at the momentum

Backup

Uncorrelated Uncertainty

Total Uncertainty

Feed-Down Uncertainty

Physics Model Uncertainty

σ_{prod} Uncertainty

π^+ Uncertainties, [0,0.005] rad

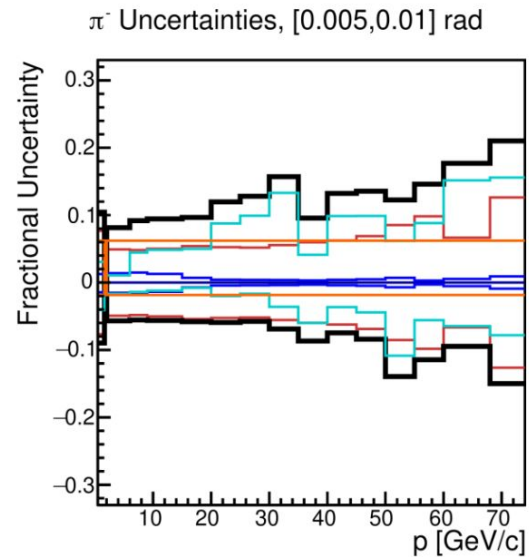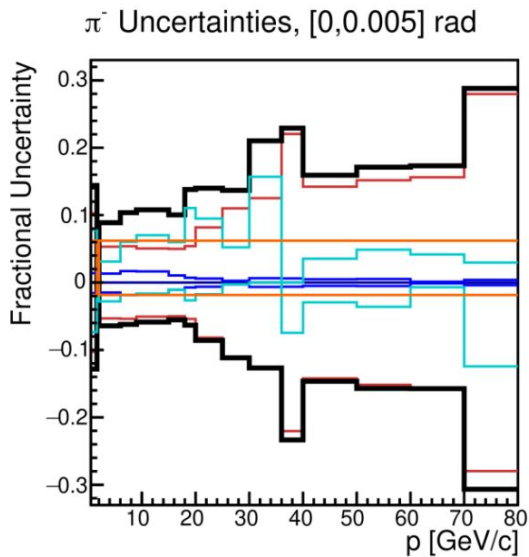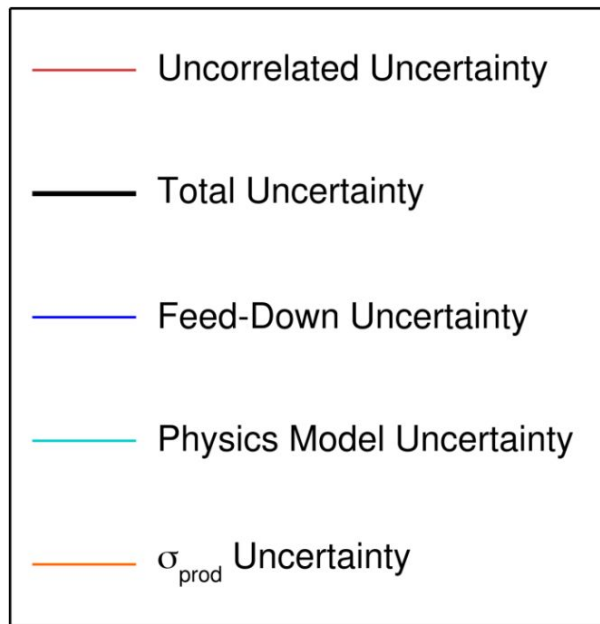π^+ Uncertainties, [0.005,0.01] rad

FIG. 24: Systematic uncertainty breakdown for the combined π^- analysis. Two representative angular bins are shown.