An Update:
NA61 incident pion data interpolation

pi + C → pi + X

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For PPFX group meeting

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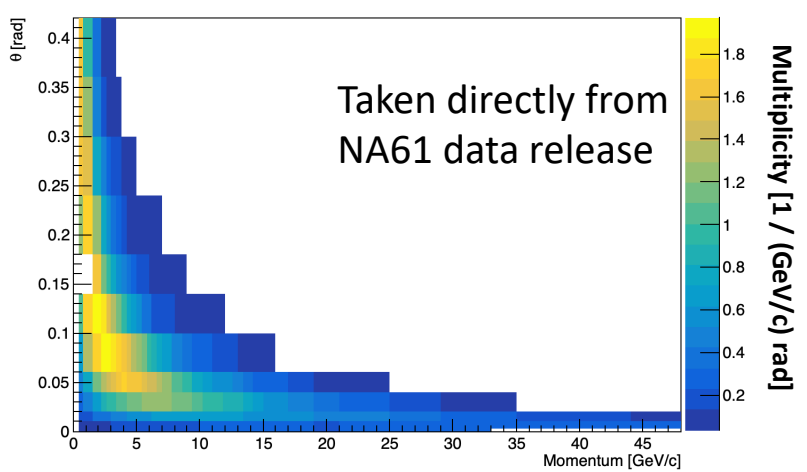
Introduction

- We are exploring different ways to treat the NA61 π^+C-> π^+X @ 60 GeV data and using as a correction into the PPFX code.
- In this presentation, I show an interpolation of the NA61 data in each shift created by using the multi-universe technique.
- The first purpose is to explain this update presenting the procedure.
- We are treated the NA61 statistical and systematic uncertainties independently. Some assumptions were made for the systematics that we can improve:
  - We use the systematic “Up” as gaussian distributed around the central value.
  - We assume 50% bin-to-bin correlation.

Reminder

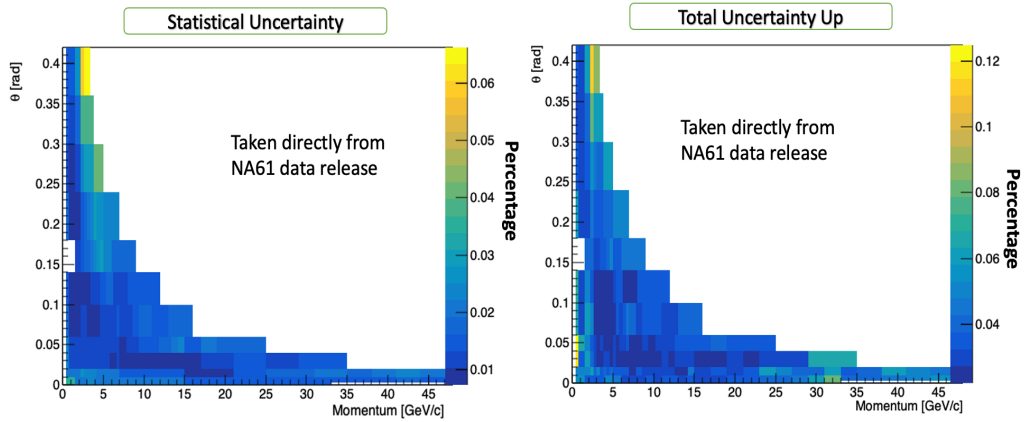
Data central value

- The central value comes in TH2Poly bins of (θ, P). For instance for the same momentum bin we can have different θ ranges:

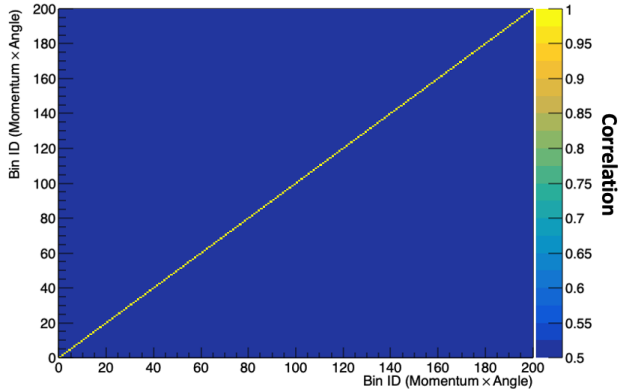


- For statistical uncertainties, random shifts in uncorrelated bins, Gaussian distributed and using the statistical uncertainty, are generated creating new data in 5000 universes in total. We interpolate in each universe.

Data uncertainties: Statistical uncertainty (left), Total uncertainty "Up" (Systematics Up and statistical added in quadrature)



- For systematic uncertainties, the bin-to-bin correlation is not published by NA61. The data release split in systematics coming from different sources and we use **+50% correlation** across all bins as a first attempt.



Procedure

- We consider the data values (central value or the shift generated inside the uncertainties) as (θ, P) data points (we use TGraph2D).

- We interpolate (we use a TGraph2D):
  - By using a variable **momentum bins** to make the bin center of the data to be in the center of the interpolation binning.
  - Momentum: in [0, 50] GeV/c and Angle bins: 2 mrad in [0, 420] mrad.

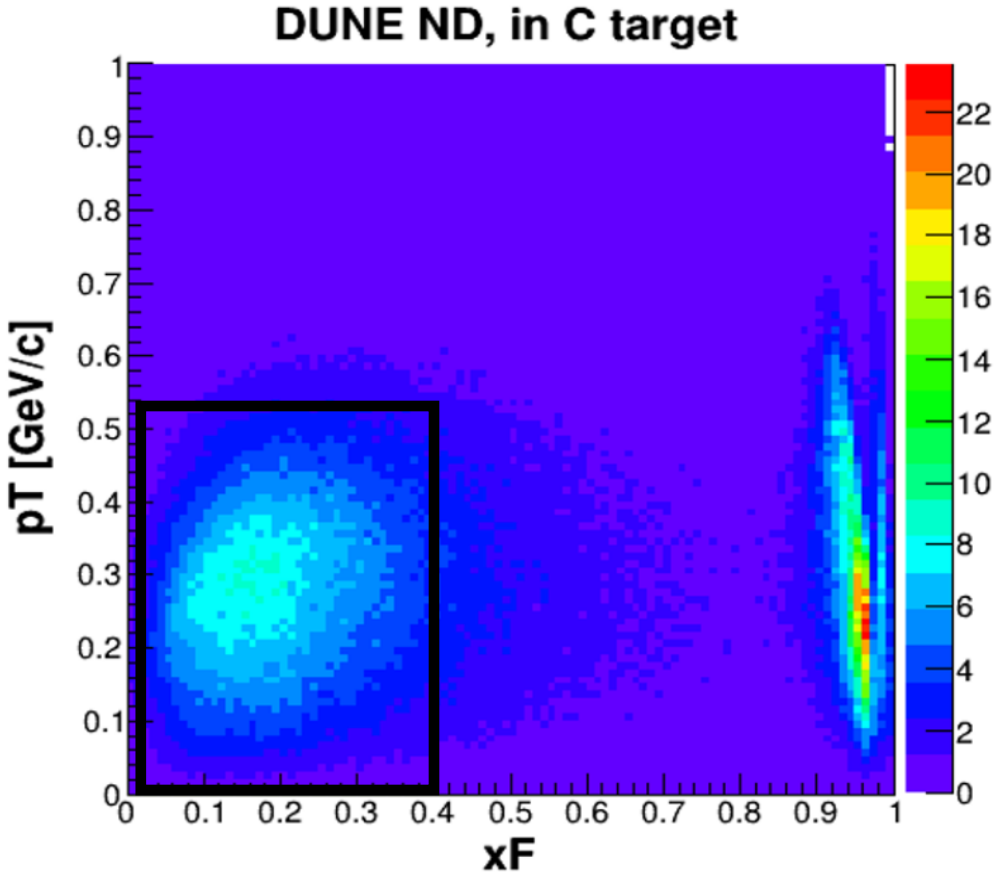
- For **Systematic uncertainties:**

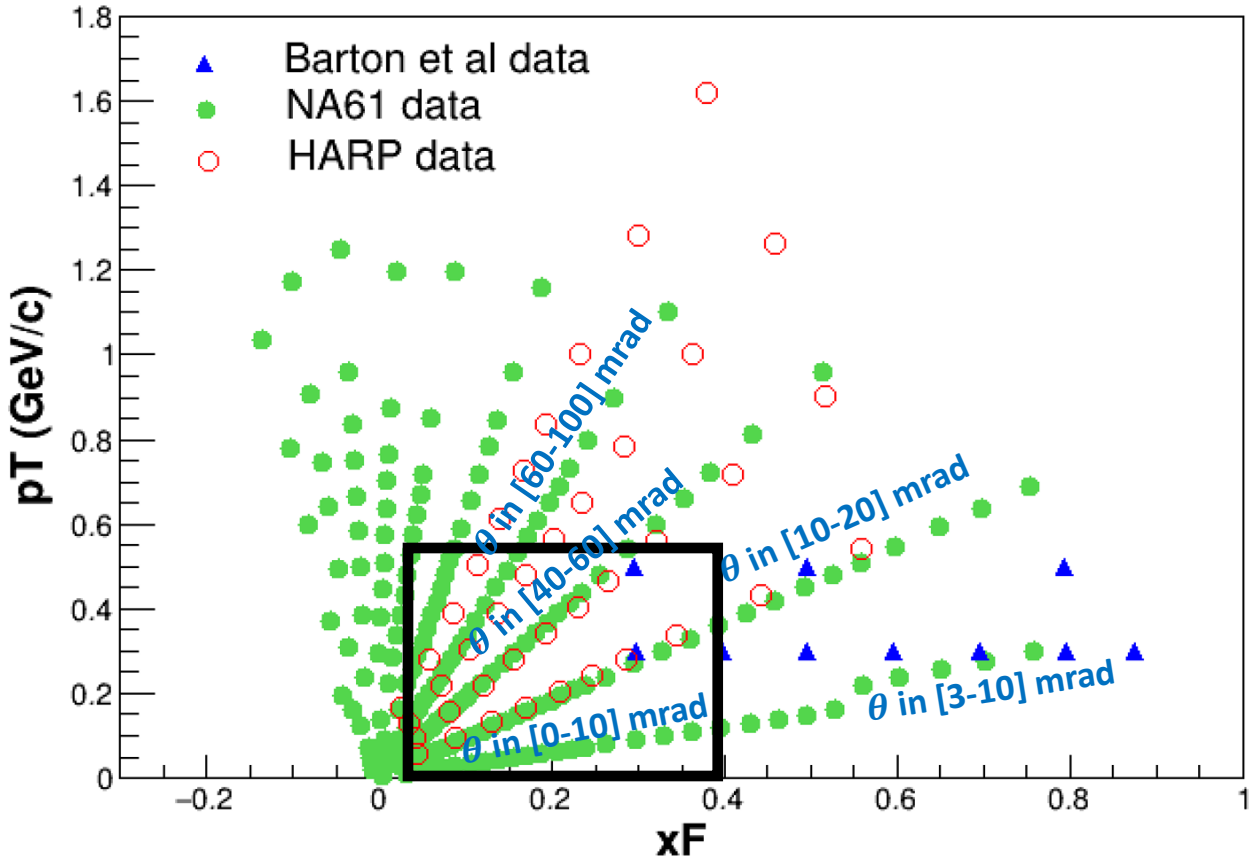
  → We apply the **Cholesky decomposition** (we use TDecompChol) to get the lower matrix triangle and multiply by the vector of shifts. We calculate 5000 universes.

- As a check, we also use **Spline interpolation** technique just for comparison (we use TSpline3).

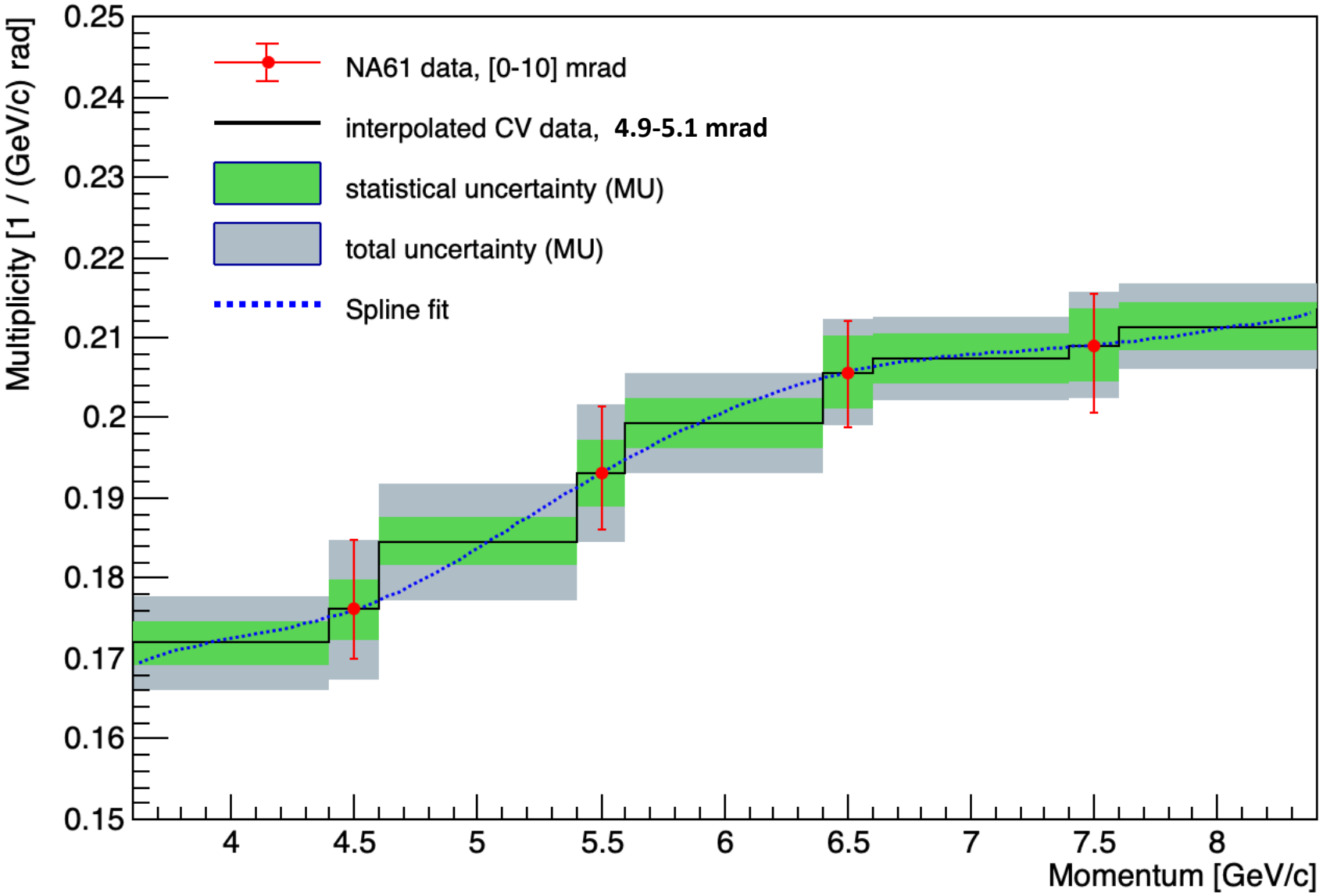
- **In the next slides, I will show the results by using this procedure for each angle range in the NA61 data.**

I presented at the last meeting, the relevant xF-pT ranges which we interest:

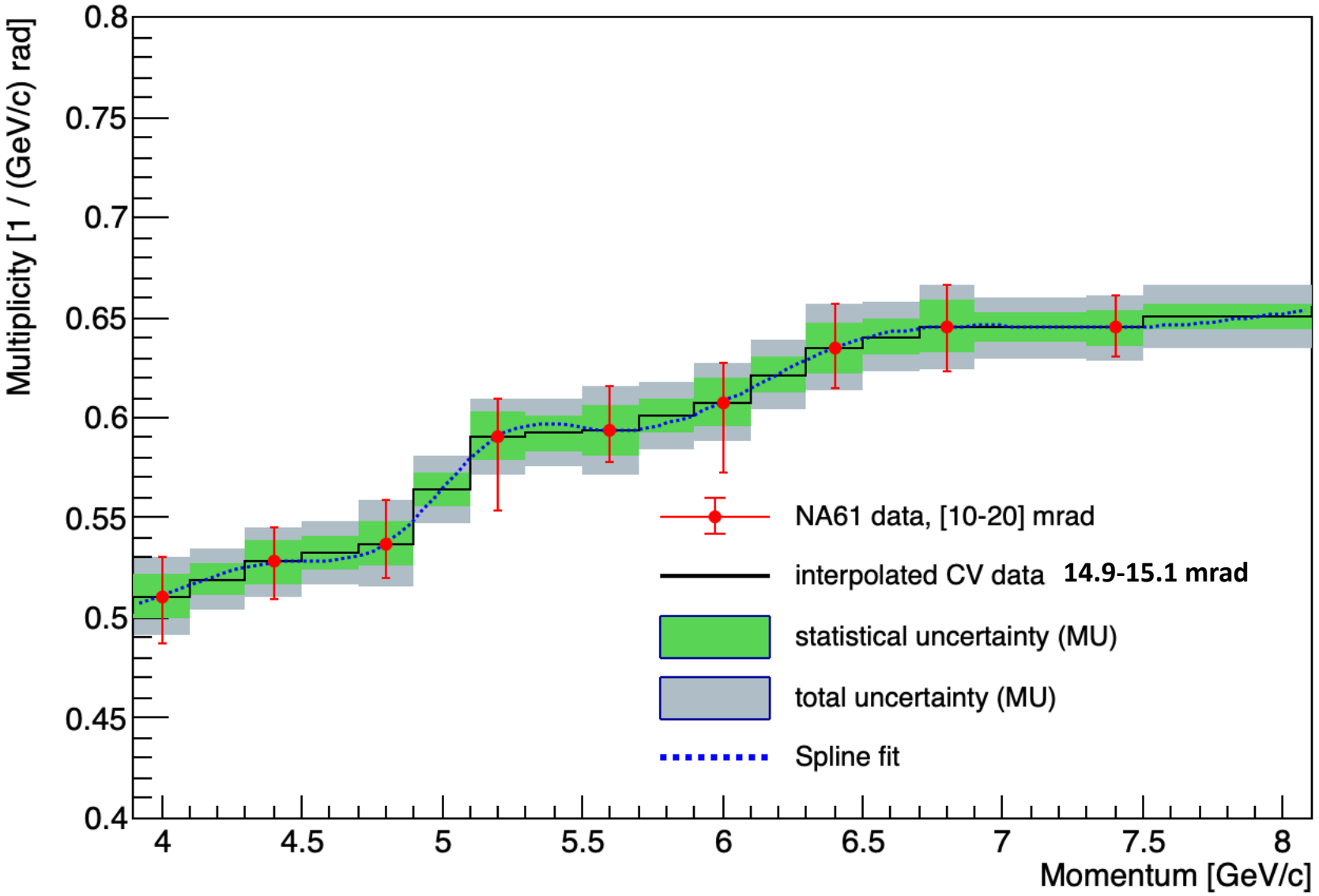




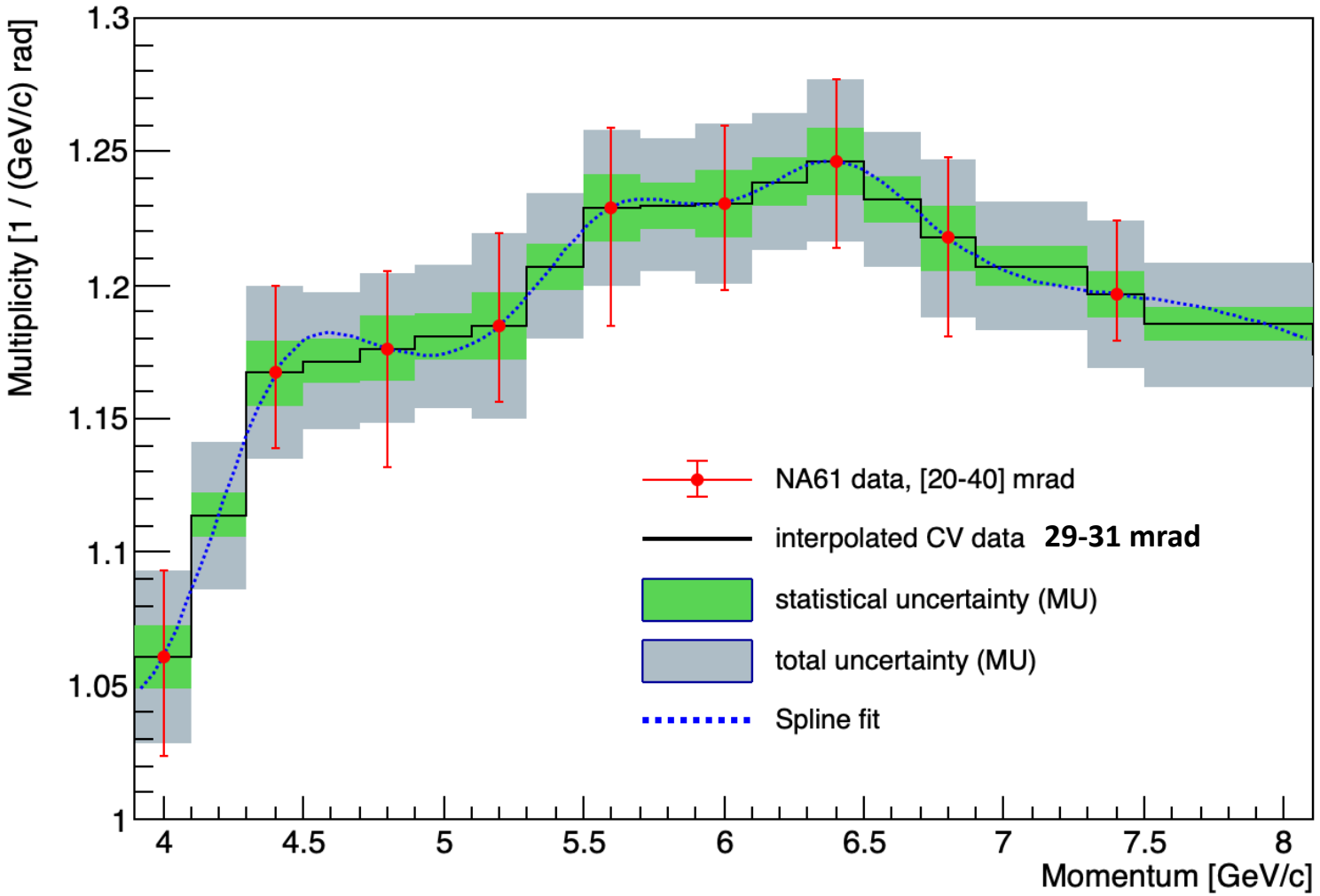
0-10 mrad:


NA61 data, [0-10] mrad
interpolated CV data, 4.9-5.1 mrad
statistical uncertainty (MU)
total uncertainty (MU)
Spline fit
Multiplicity [1 / (GeV/c) rad]
Momentum [GeV/c]
0.25
0.24
0.23
0.22
0.21
0.2
0.19
0.18
0.17
0.16
0.15
4
4.5
5
5.5
6
6.5
7
7.5
8

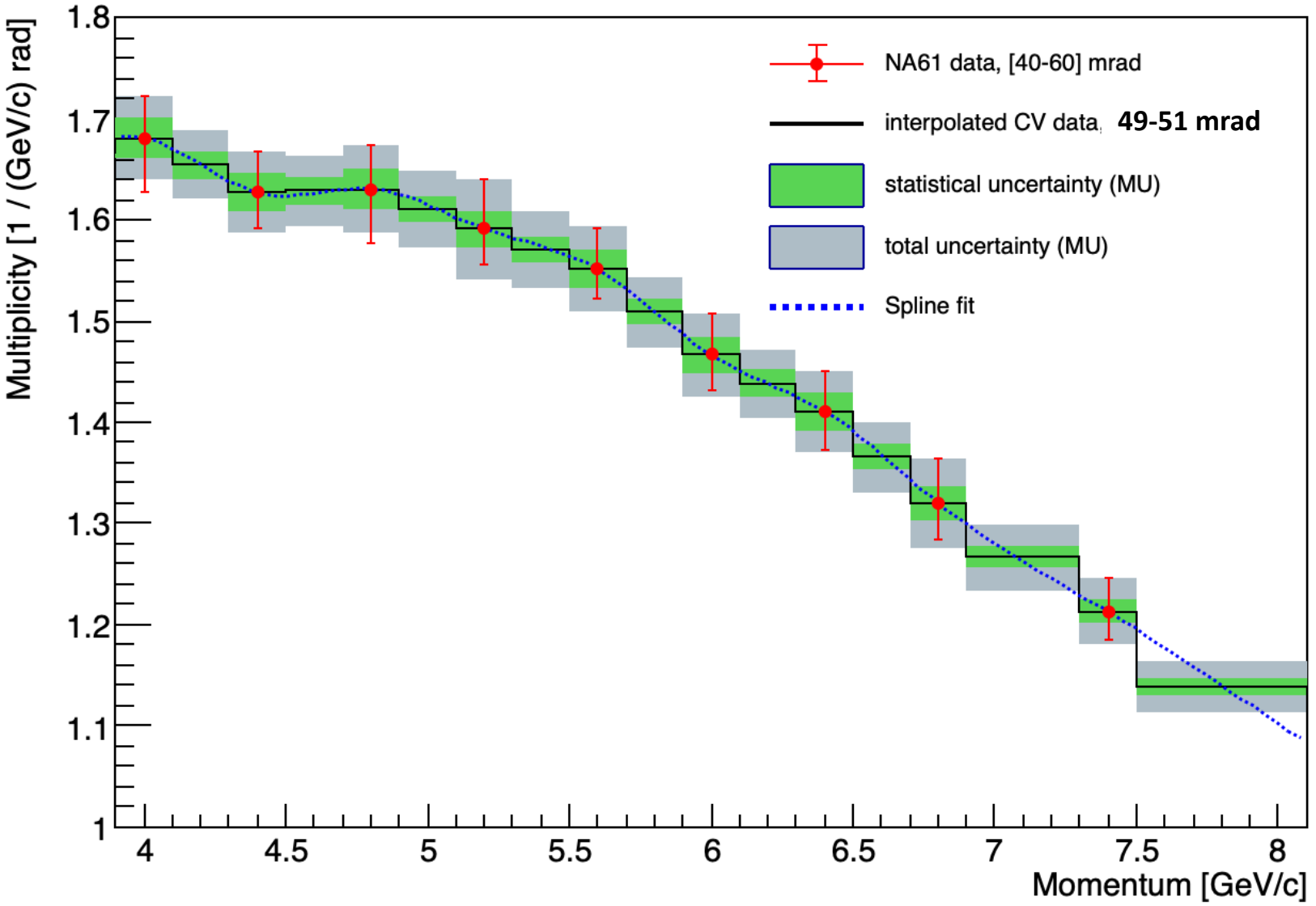
10-20 mrad:


Multiplicity [1 / (GeV/c) rad]
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
4
4.5
5
5.5
6
6.5
7
7.5
8
Momentum [GeV/c]
NA61 data, [10-20] mrad
interpolated CV data 14.9-15.1 mrad
statistical uncertainty (MU)
total uncertainty (MU)
Spline fit

20-40 mrad:


Multiplicity [1 / (GeV/c) rad]
1.3
1.25
1.2
1.15
1.1
1.05
1
4
4.5
5
5.5
6
6.5
7
7.5
8
Momentum [GeV/c]
NA61 data, [20-40] mrad
interpolated CV data 29-31 mrad
statistical uncertainty (MU)
total uncertainty (MU)
Spline fit

40-60 mrad:


Multiplicity [1 / (GeV/c) rad]
Momentum [GeV/c]
NA61 data, [40-60] mrad
interpolated CV data, 49-51 mrad
statistical uncertainty (MU)
total uncertainty (MU)
Spline fit

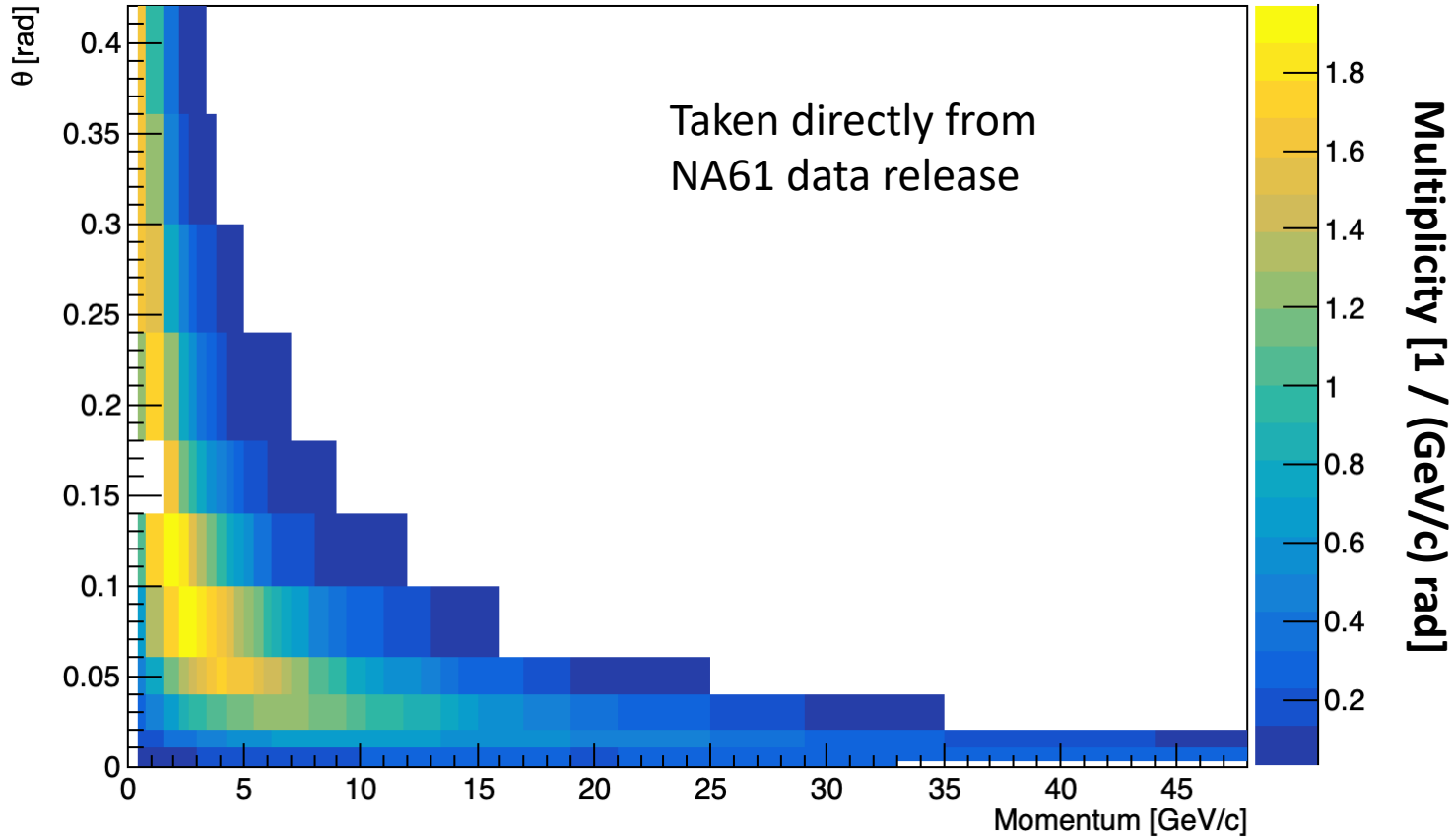
Conclusions

- This is my first study to interpolate NA61 data.
- We show the results by using the procedure which was explained in slide-3 for each angle range in the NA61 data.
- I am going to understand some details about how the interpolation works and to understand the multi-universe technique.
- I am presenting today these preliminary results to contribute a discussion about the procedure to use NA61 data.

Backup

Data central value

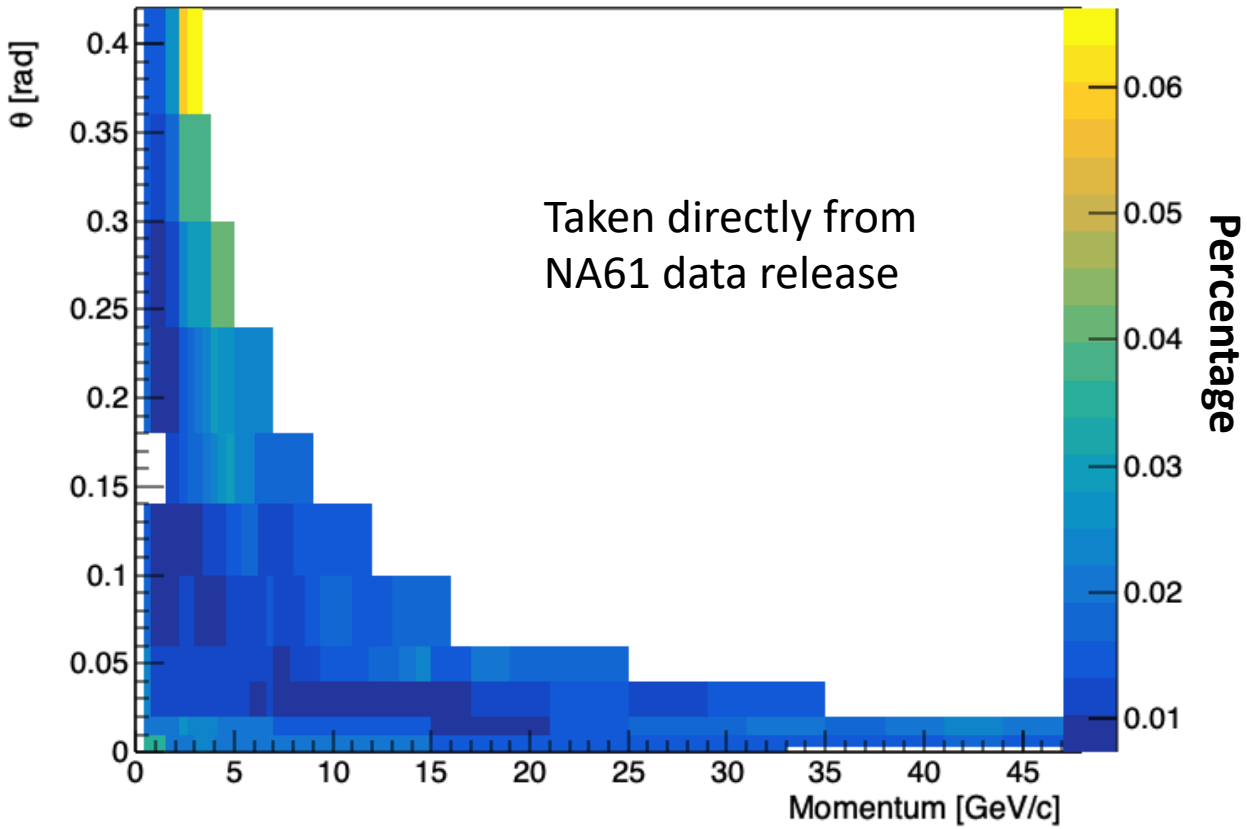
- The central value comes in TH2Poly bins of (θ,P). For instance, for the same momentum bin we can have different θ ranges:



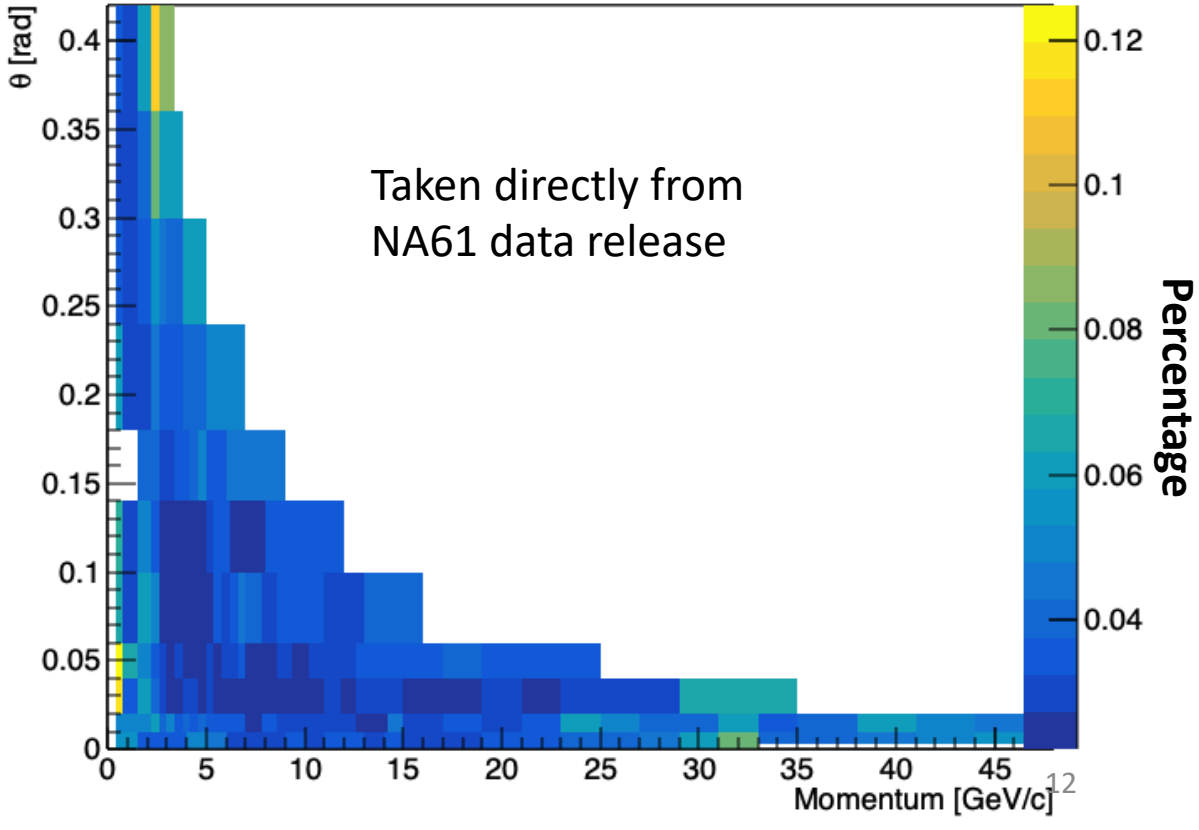
Data uncertainties

- Uncertainties are shown below:
  - Statistical uncertainty (left)
  - Total uncertainty “Up” (Systematics Up and statistical added in quadrature)

Statistical Uncertainty



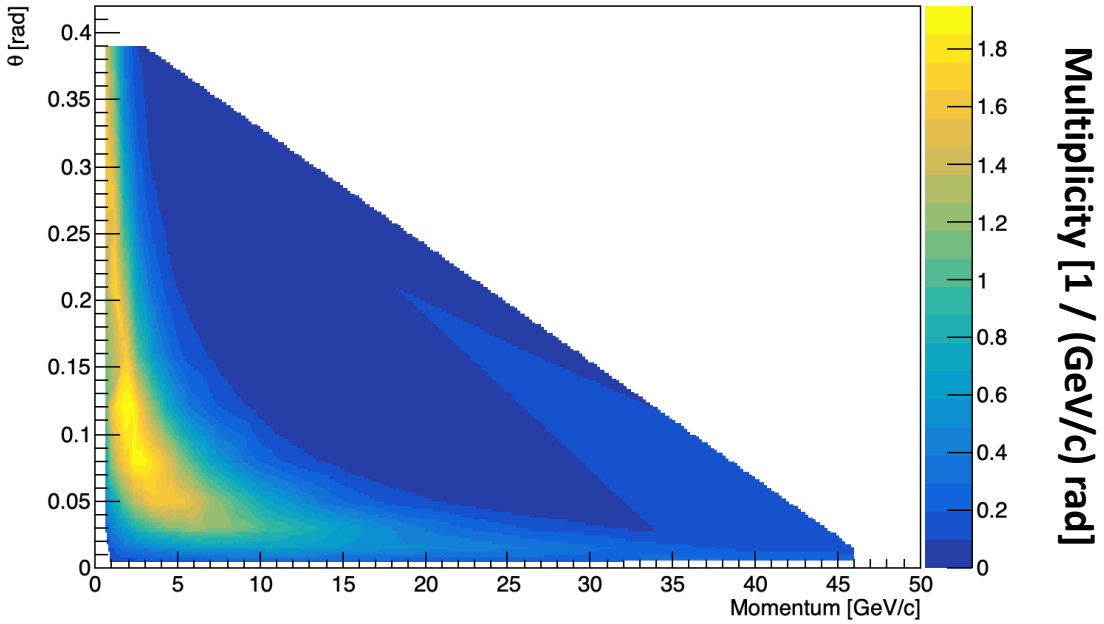
Total Uncertainty Up



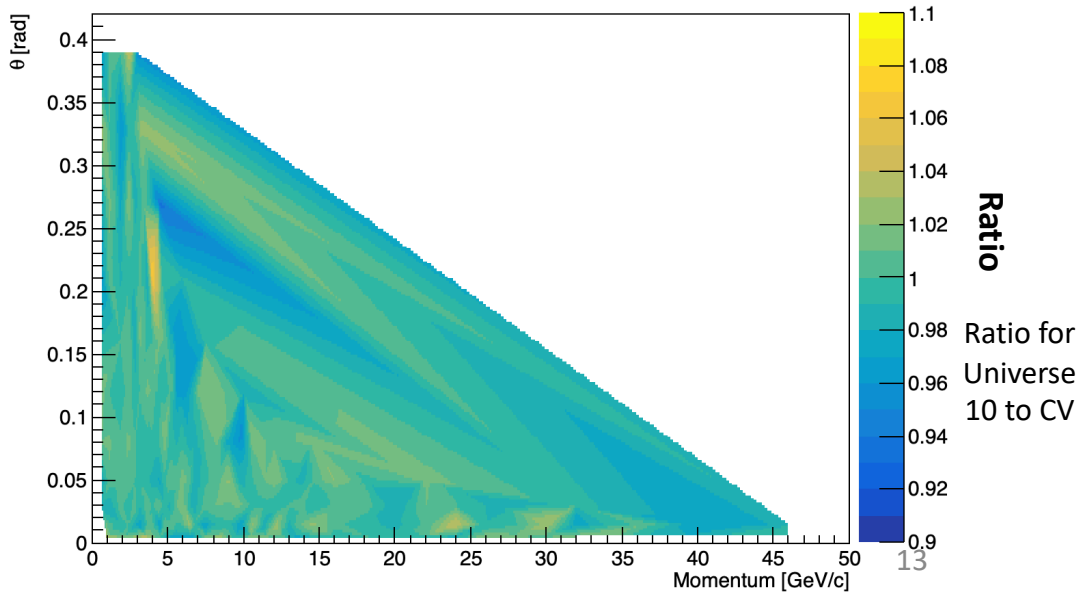
Statistical uncertainties

- We are treated the NA61 statistical and systematic uncertainties independently.
- Random shifts in uncorrelated bins, gaussian distributed and using the statistical uncertainty, are generated creating new data in 5000 universes in total. We interpolate in each universe.
- For instance, for the new data in universe 10:

New CV in universe 10



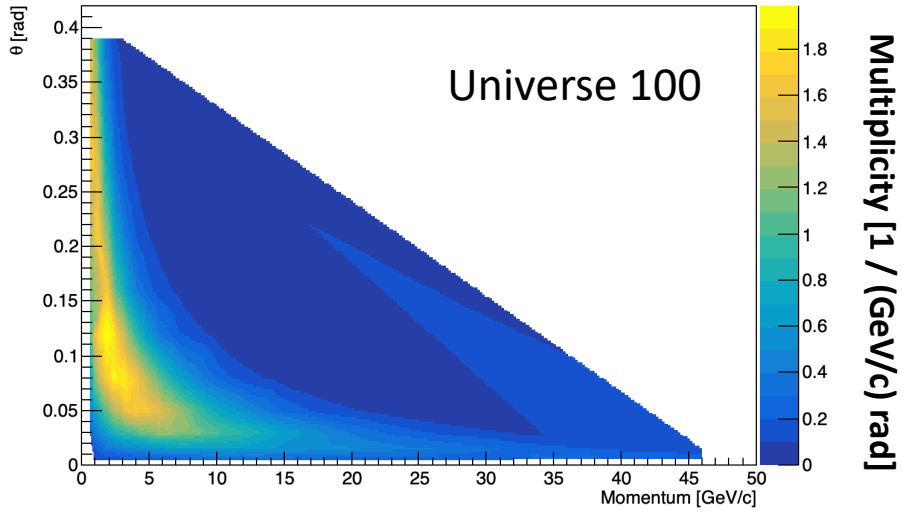
Ratio of the new CV over the nominal

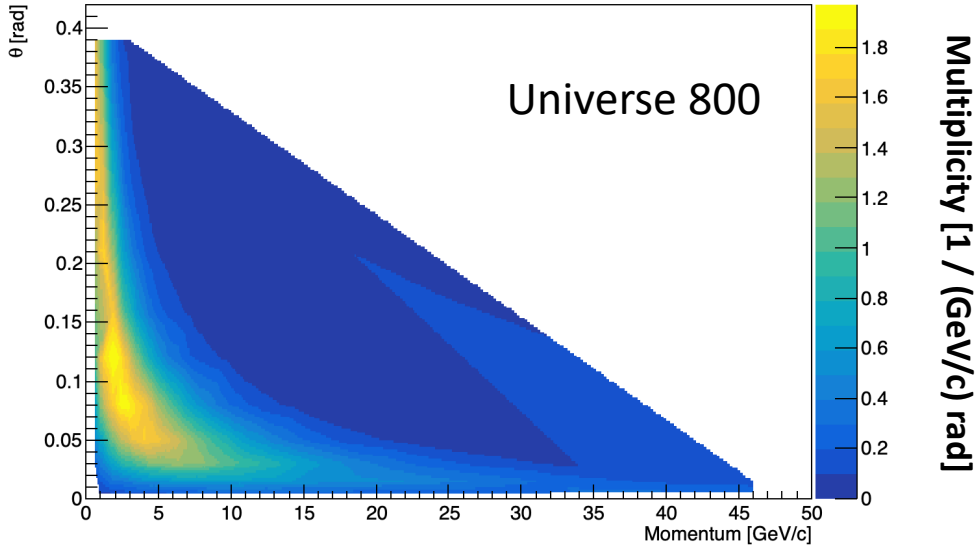


Statistical uncertainties

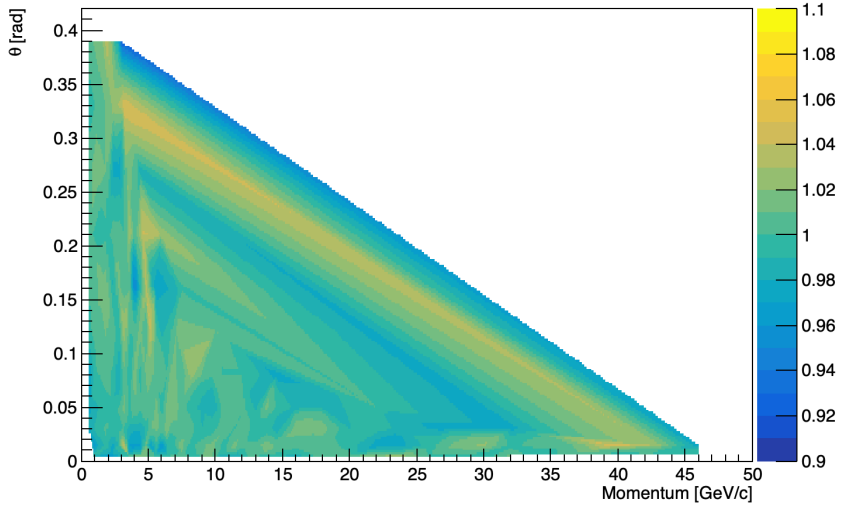
- Other examples:

New CV

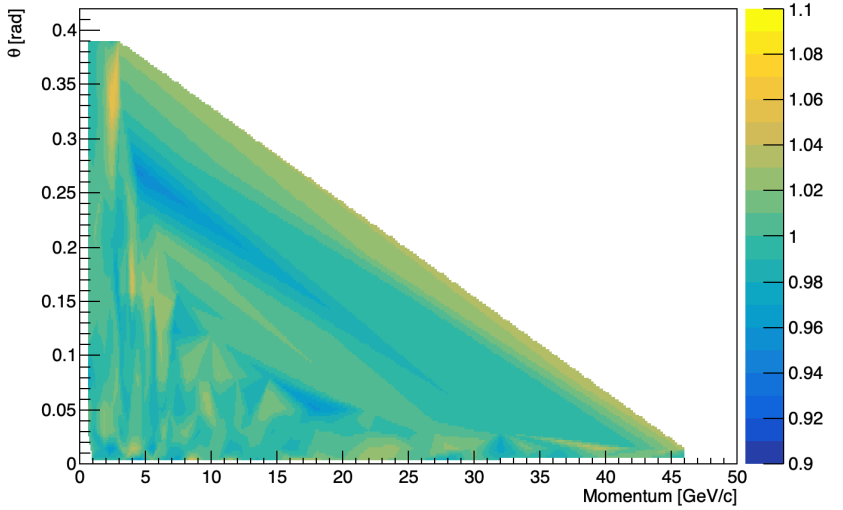




Ratio of the new CV over the nominal



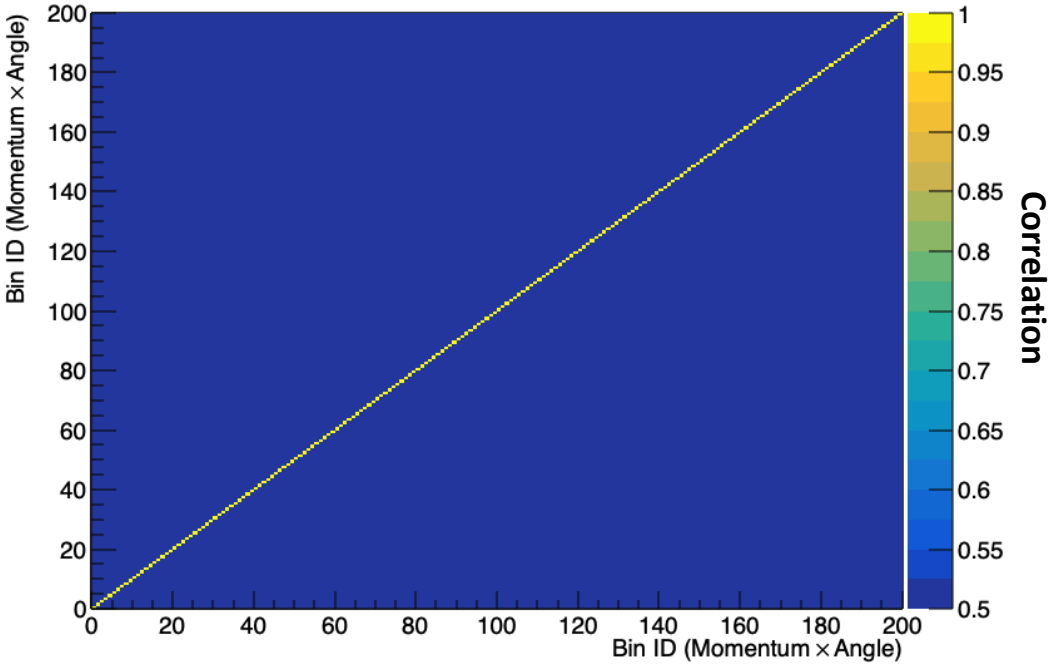
Ratio for Universe 100 to CV

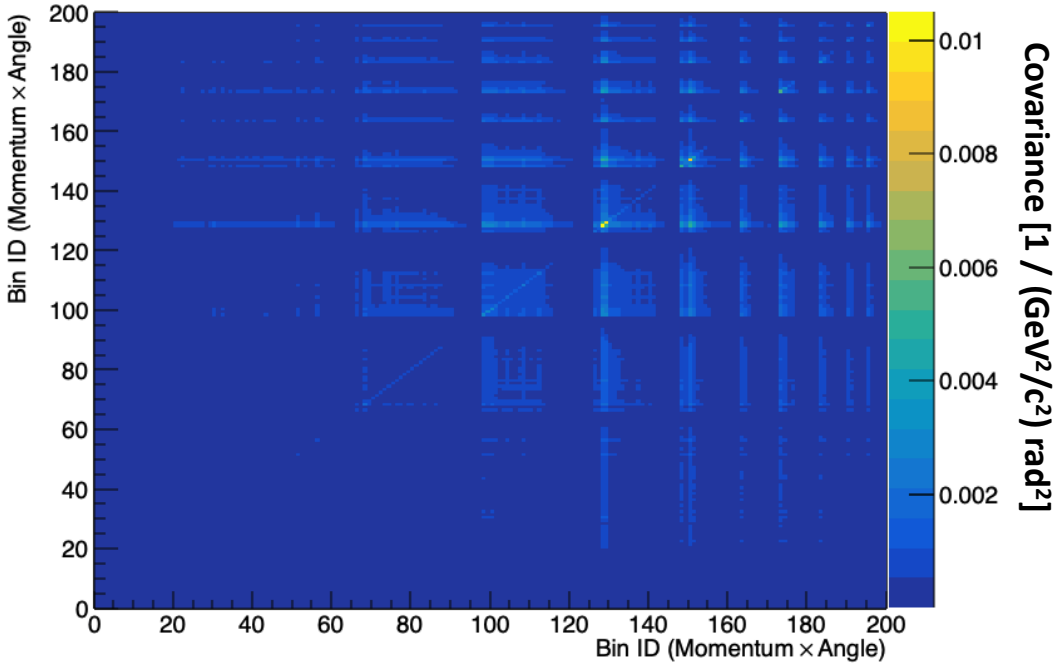


Ratio for Universe 800 to CV

Systematic uncertainties

- The bin-to-bin correlation is not published by NA61. The data release split in systematics coming from different sources.
- We use +50% correlation across all bins as a first attempt (we want to have the infrastructure when we have better values).

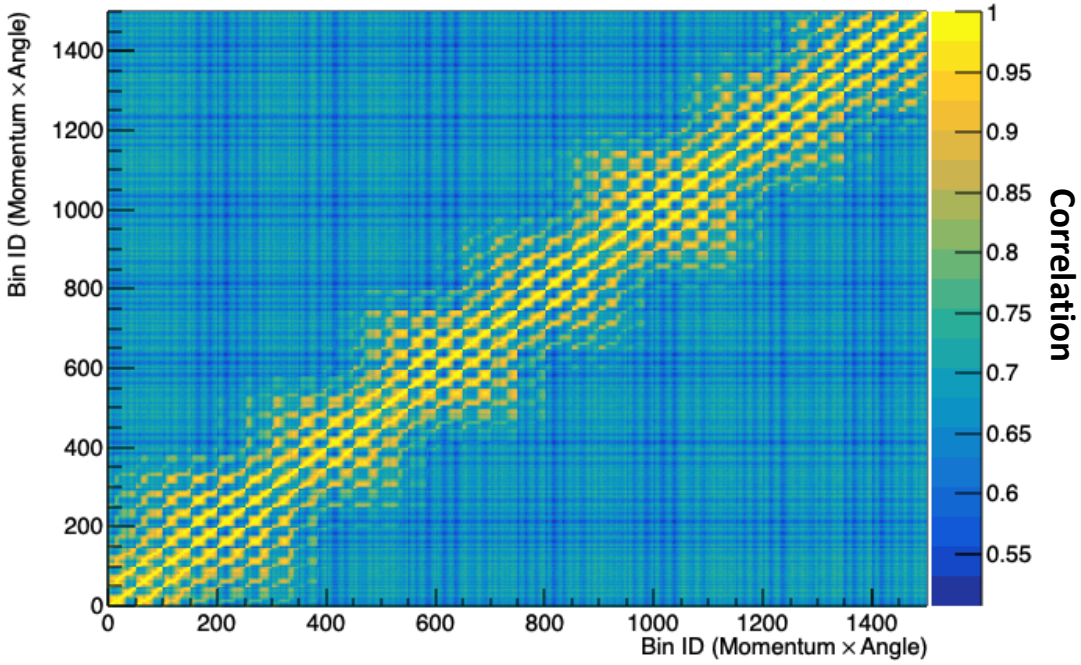


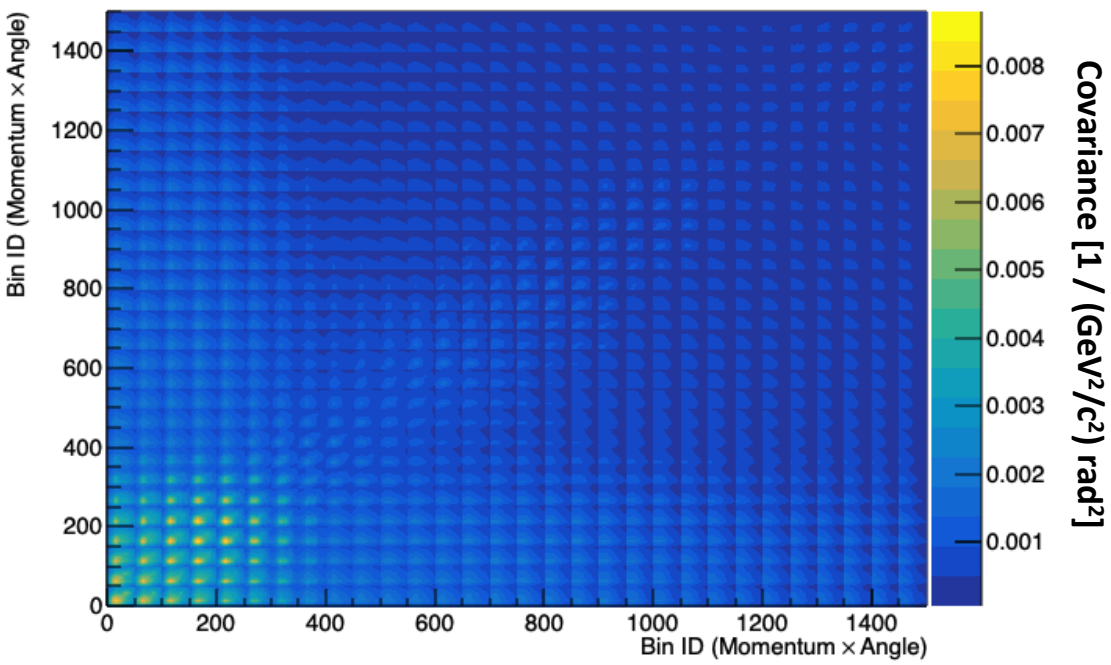


- 200 data we have for NA61 in total

Systematic uncertainties

- We apply the Cholesky decomposition to get the lower matrix triangle and multiply by the vector of shifts. We calculate 5000 universes.
- As a check I show the correlation and covariance matrix for a sub-area of the (θ,P) for the interpolated 5000 universes after interpolation:



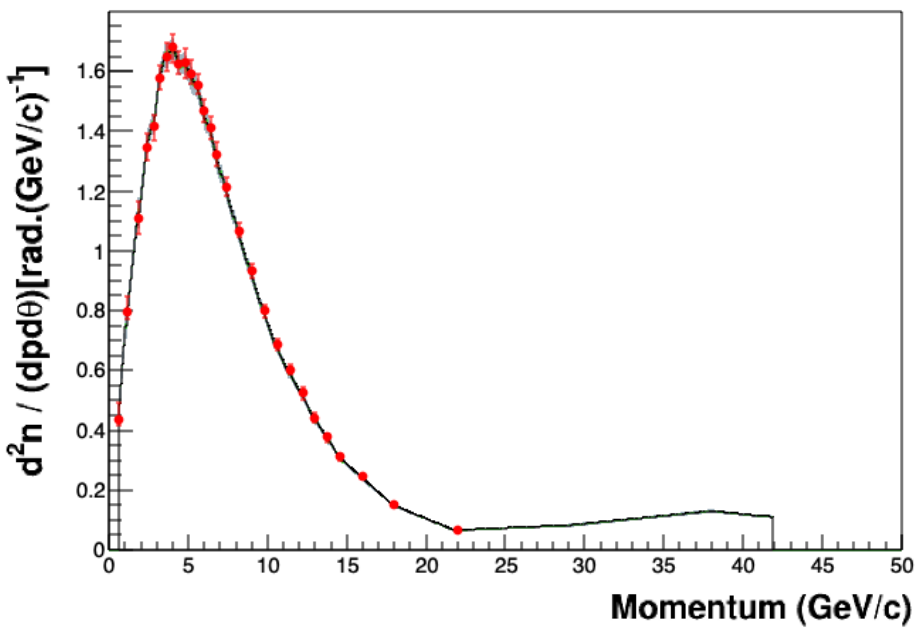


- 1500 interpolated bins: P in [2,5] GeV/c and θ in [50,150] mrad

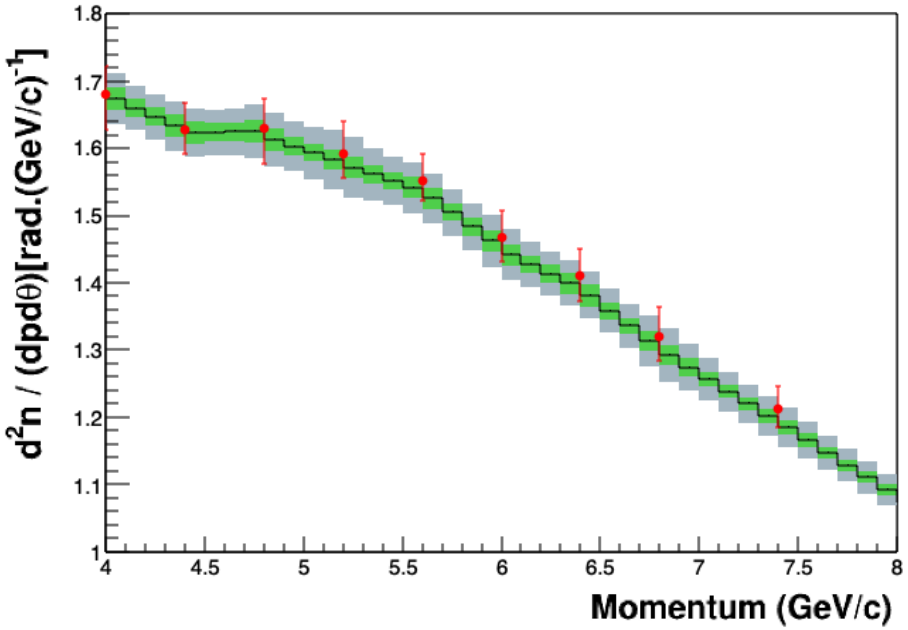
Data vs Interpolated data using only statistical uncertainties

NA61 (red) in [40,60] mrad. Error bars are total uncertainties.

Interpolated NA61: central value (black) in [50,52] mrad. Green bar statistical and gray bar the total (statistical and systematics added in quadrature)



Zooming in:



Center of the bin

- This **is just an exercise** to see of the center of bin may scale well with the angle range (**I am not using it in the interpolation**):