

Comparing NA49/NA61 data to FLUKA

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Goal

Use a standalone FLUKA installation with simplified geometry and compare outputs to external hadron production data (NA49 and NA61).

Outline

- FLUKA setup and NA49 experiment.
- Qualitative comparison between FLUKA and NA49 for π^\pm and K^\pm production.
- π^\pm production in NA61 simulated by FLUKA.

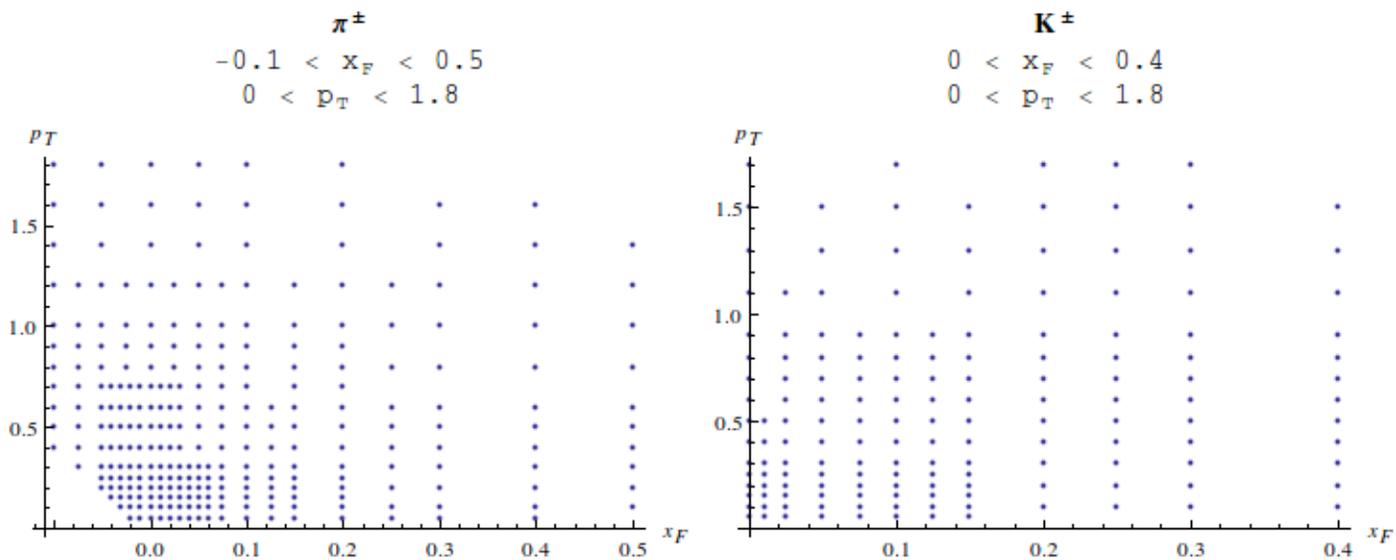
NA49 data

- Downloadable in ASCII format from the CERN NA49 website.
- Throwing protons with momentum 158 GeV at a thin (7 mm) carbon target.
- Measuring invariant cross sections in p+C reaction, binned in Feynman X and transverse momentum in the nucleon-nucleon center of mass system (CMS). We will *always* measure p_T in GeV and cross sections in mb / GeV².

$$F(x_F, p_T) = E(x_F, p_T) \cdot \frac{d^3 \sigma(x_F, p_T)}{dp^3}$$

NA49 data

- Phase space coverage



FLUKA settings

Version

Standalone installation of FLUKA version **2011.2b.4**. Also used FLUKA tool USY-SUW to read binaries.

Geometry

Simplified geometry of thin (1mm) carbon cylinder in vacuum, approximately 0.2% of interaction length.

Physics

All FLUKA defaults. For more information take a look [here](#).

Detectors

Using the USRYIELD function in FLUKA. It has options to request invariant cross sections for any particle and binned in (x_F, p_T) . Measured with respect to beam direction and in nucleon-nucleon cms.

FLUKA settings

Binning

Bins are 0.05 wide in x_F and p_T , small enough to avoid finite bin size corrections (following NA49 correction instructions). Chosen one by one to be in the same position as NA49.

- Example of USRYIELD input.

```
USRYIELD      809.0    PION+   -30.0    regTAR    regVAC     1.0 pipl
USRYIELD      2.025    0.025   40.0    -0.0725   -0.0775   602.0 &
```

To compare with NA61 data we will use the same USRYIELD function with different parameters (more on this later).

Scaling factor

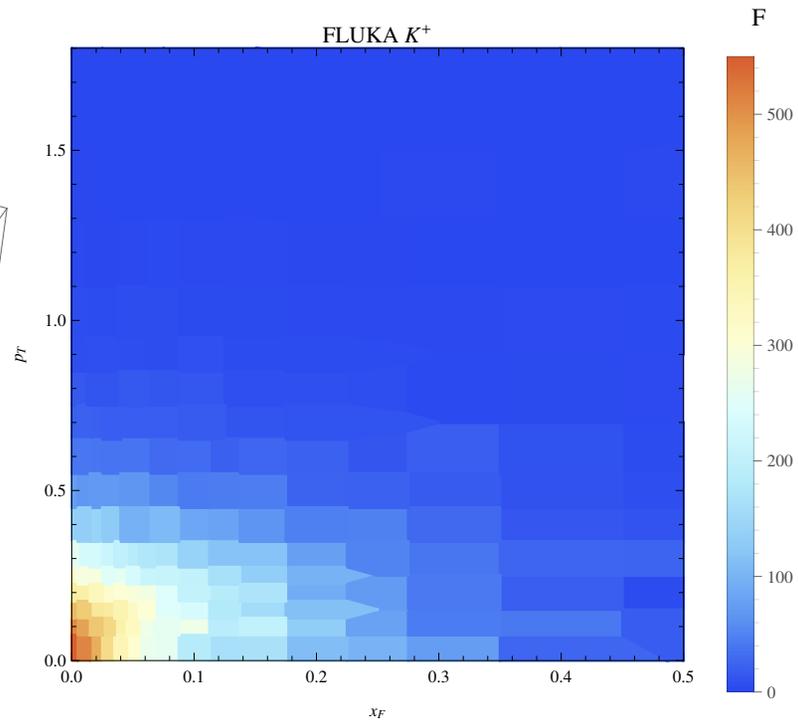
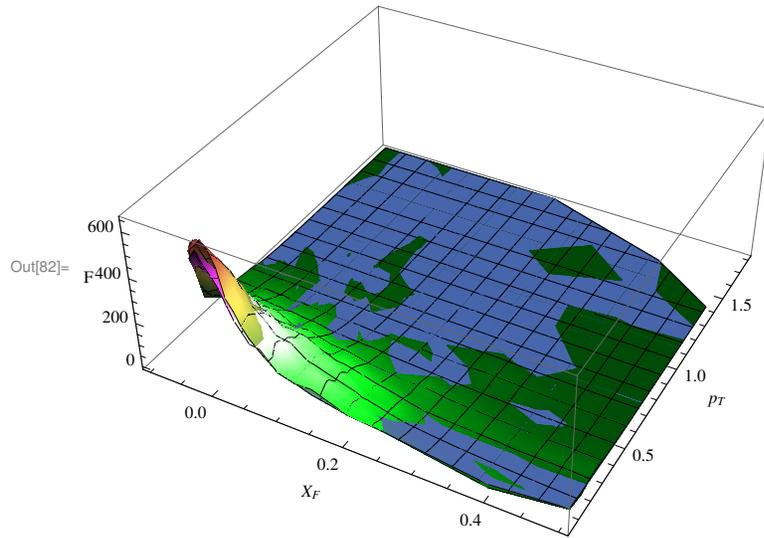
FLUKA by default normalizes cross section results by the interaction probability. To compare to actual data, this must be reverted by scaling the output.

$$L_{\text{int}} = \frac{A}{\sigma_{\text{prod}} \rho N_A} \sim 41.5 \text{ cm}$$

$$\rho_{\text{int}} = 1 - e^{-L/L_{\text{int}}} \sim 0.0025$$

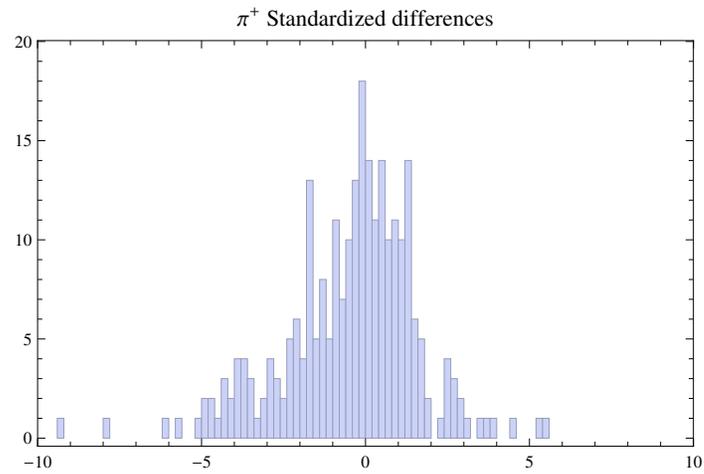
NA49 π^+ data

FLUKA results



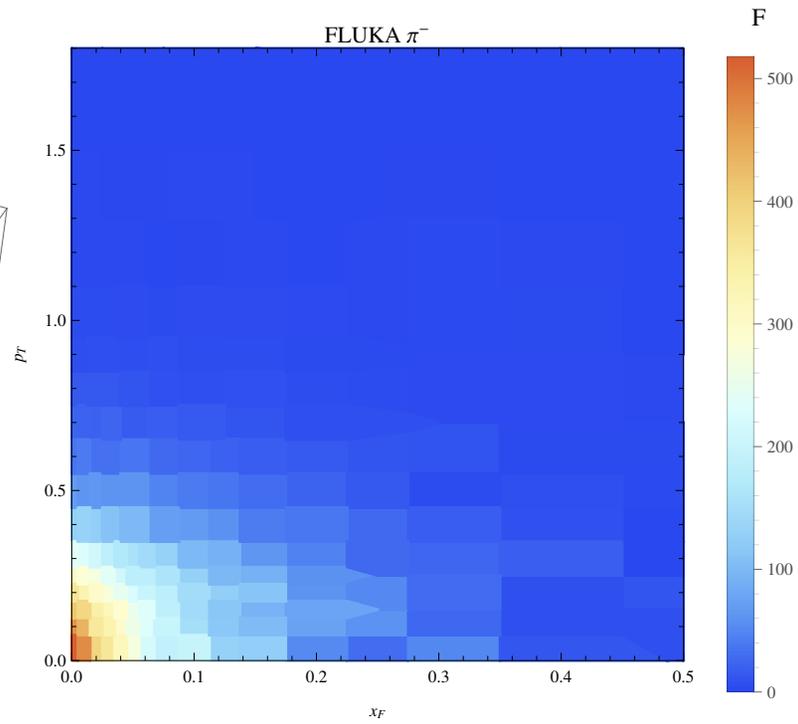
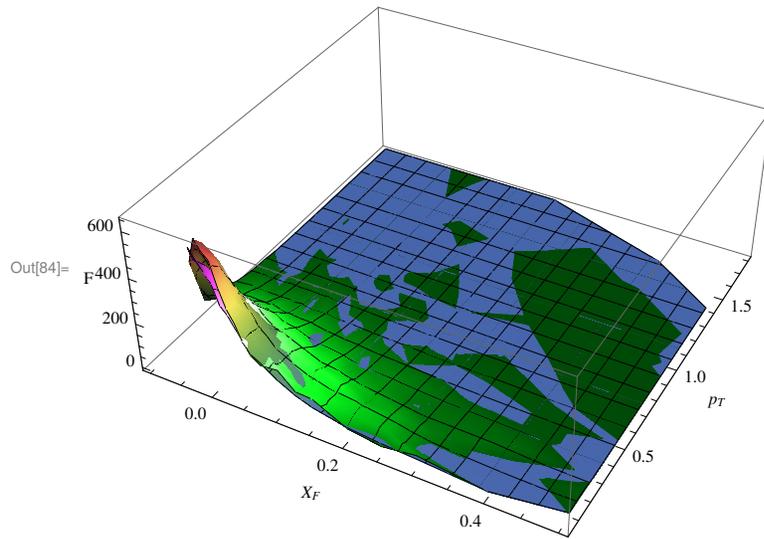
Some statistics

- Measuring standardized differences: $\zeta = \frac{F_{\text{fluka}} - F_{\text{NA49}}}{\sqrt{(\sigma^2)_{\text{fluka}} + (\sigma^2)_{\text{NA49}}}}$
- Caution: big outliers.



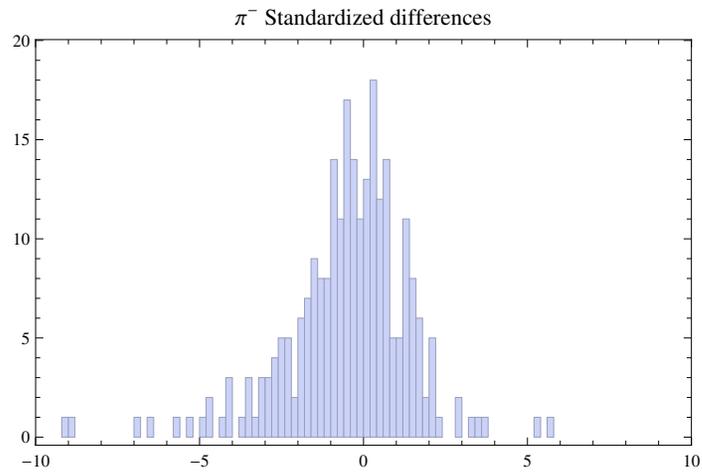
NA49 π^- data

FLUKA results



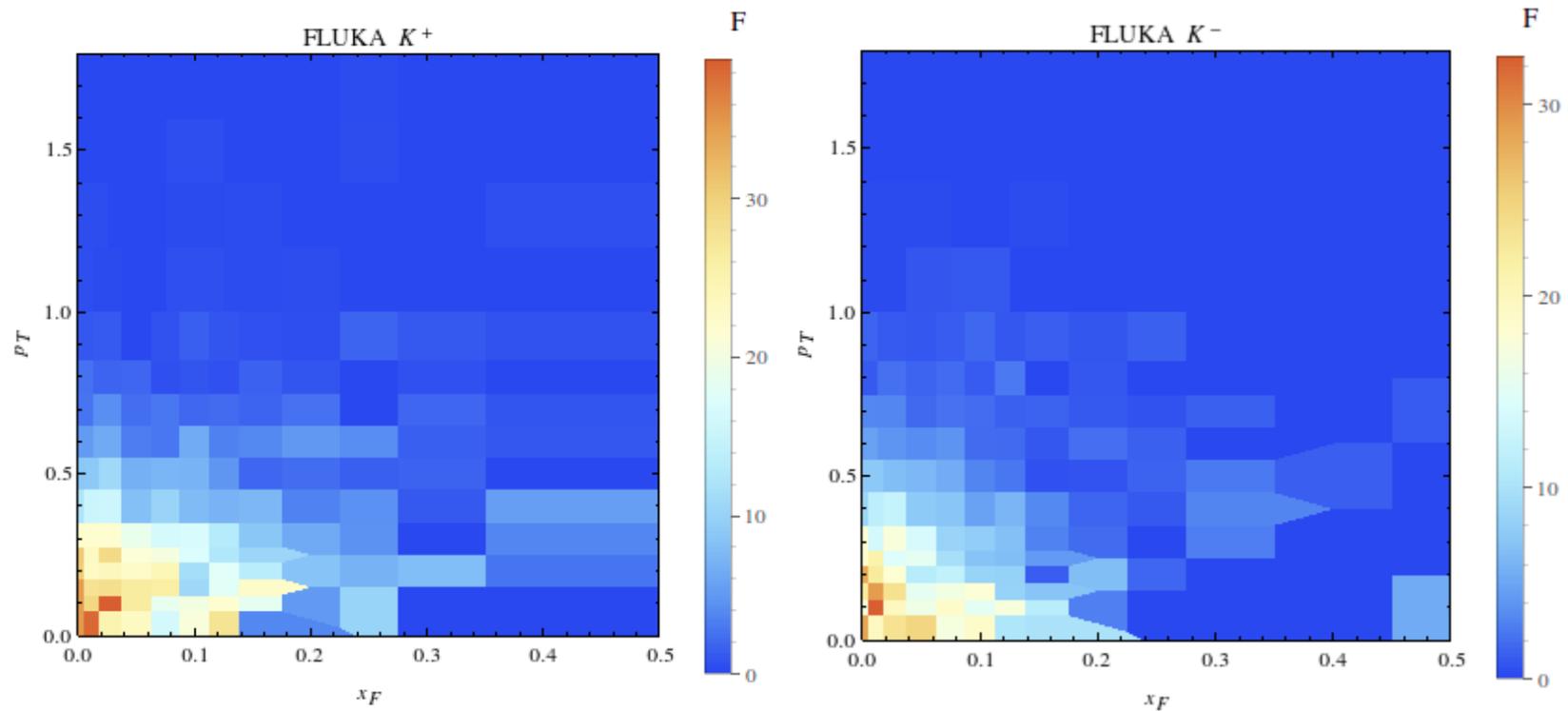
Some statistics

- Measuring standardized differences: $\zeta = \frac{F_{\text{fluka}} - F_{\text{NA49}}}{\sqrt{(\sigma^2)_{\text{fluka}} + (\sigma^2)_{\text{NA49}}}}$
- Caution: big outliers.



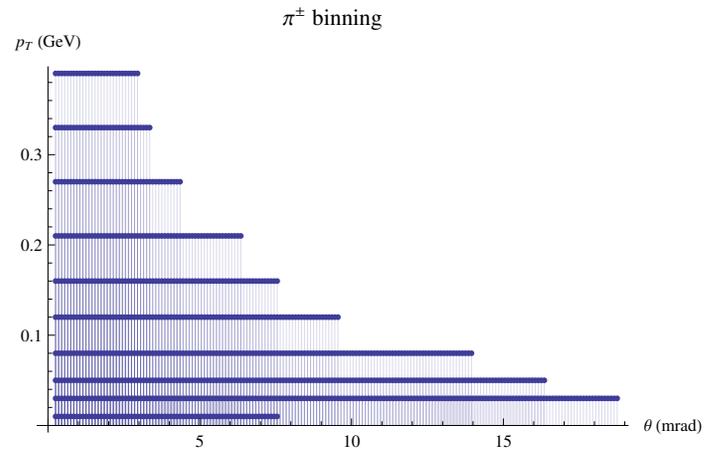
FLUKA simulating NA49 K^\pm

Simulations run, but comparisons are terrible. Factors of ~ 15 between NA49 and FLUKA.



NA61 data

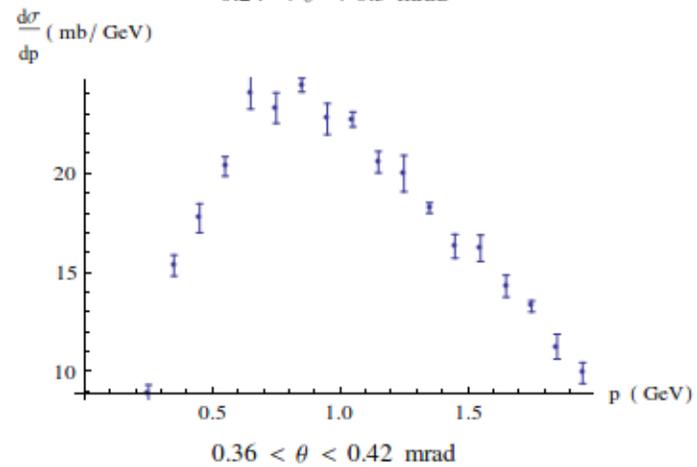
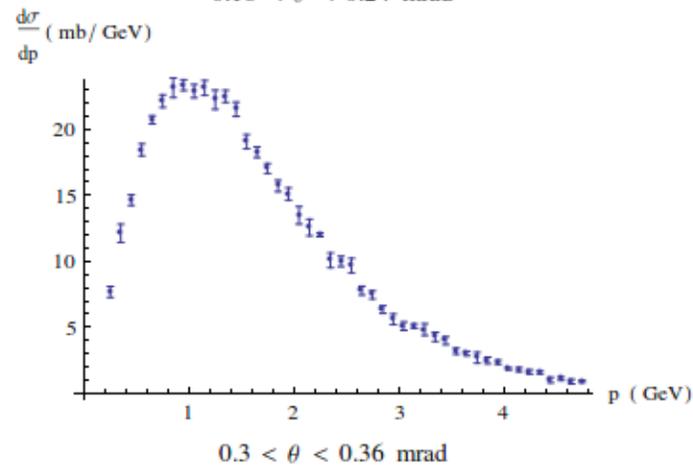
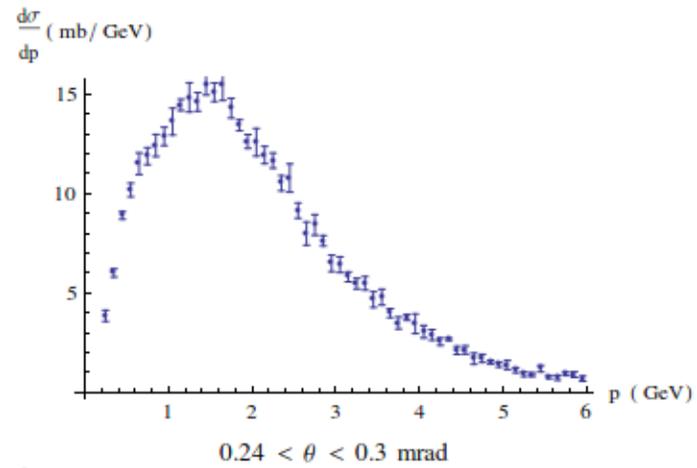
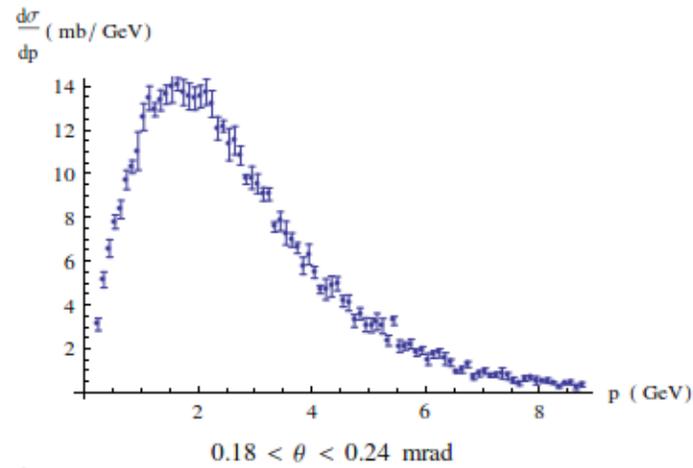
- Haven't found them online. Have requested to the authors.
- Measuring π^\pm differential cross sections $\frac{d\sigma}{dp}$ with p measured in GeV in the lab frame and binned in polar angle in the lab frame.
- Phase space coverage of charged pions, approximately:



- Study of kaon production and K/π ratio (not shown today).

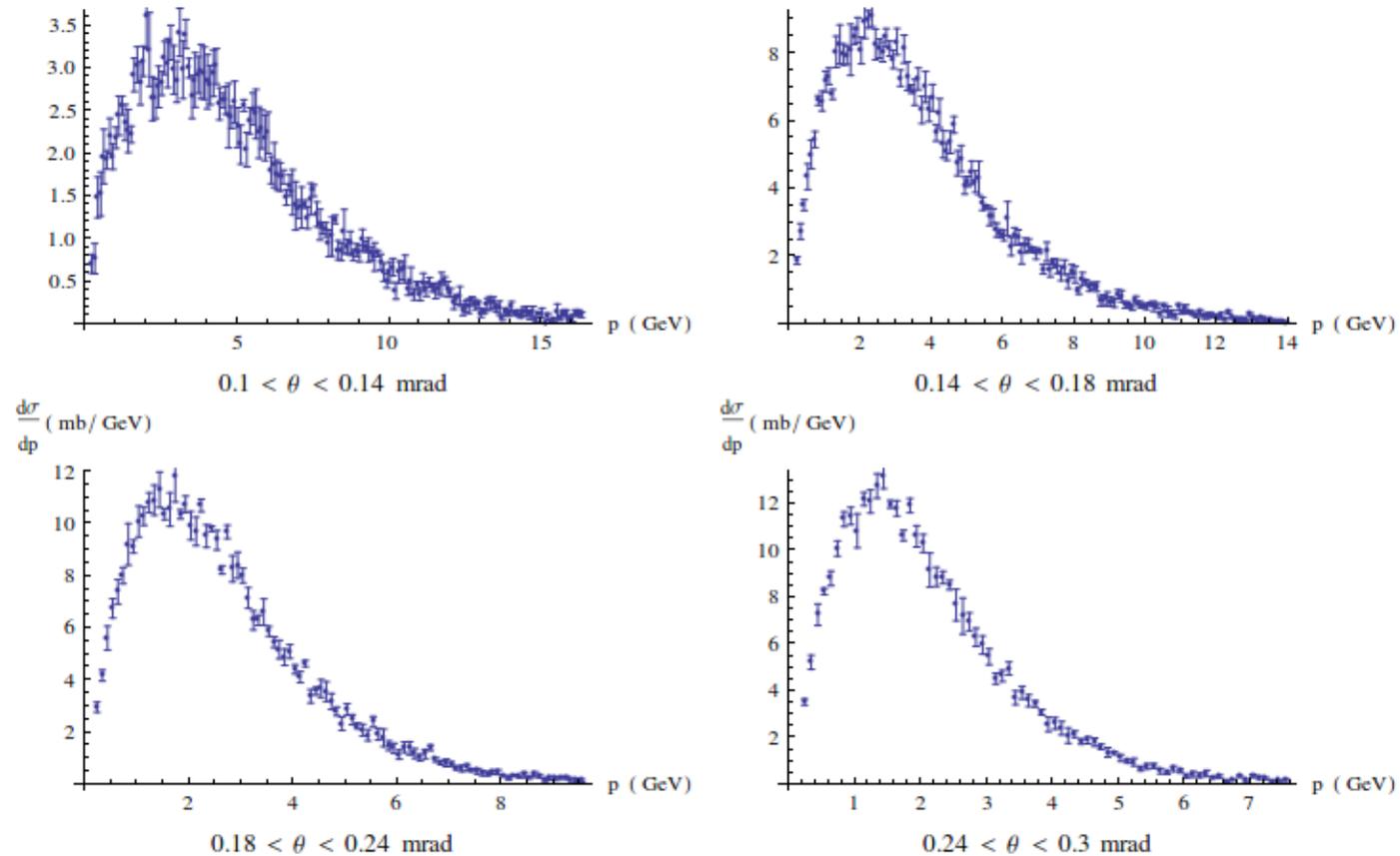
FLUKA simulating NA61 π^+

Nice shape, but big errors. No statistical comparison with NA61 available.



FLUKA simulating NA61 π^-

Nice shape, but big errors. No statistical comparison with NA61 available.



NA49 summary

- Pions fit well, except for some outliers in the low (x_F , p_T) region.
- Kaons do not fit well at all. Further investigation is required. Factors of ~15 between NA49 and FLUKA.

NA61 summary

- Again, pions seem to fit well. However, no quantitative measure has been done (no accessible data *yet* from NA61).
- Kaons and K^+ / π^+ need further exploration.

What's next

- K^\pm in NA61, and K/π ratio.
- **More statistics**: we have the machinery working, now we have to get data and do significant tests.
- **Consistency check**: using other functions in FLUKA to obtain cross sections and compare again. Perhaps USRBDX function, USRYIELD with more sophisticated options.
- Write documentation.
- Make code accessible and data files available as ROOT NTuples.