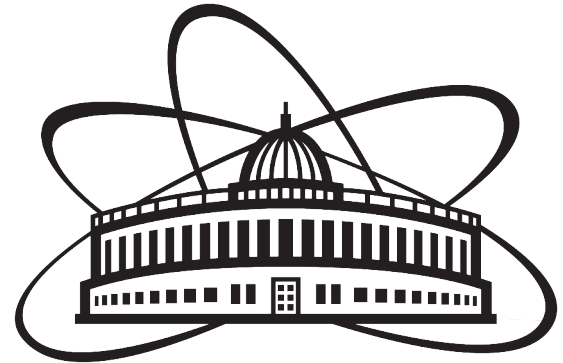


Validation of Pythia8 for prompt photon and π^0 production



SAMARA
UNIVERSITY

Samara National
Research University



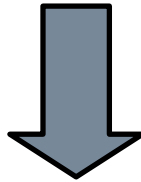
Ospennikov N.Y.,

supervisor Shipilova A.V., START supervisor Denisenko I.I.

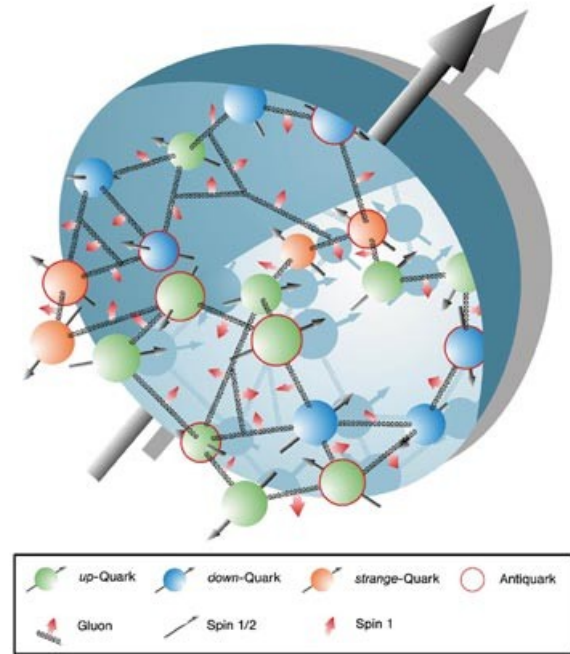
SPD Physics Weekly Meeting, JINR, Dubna
22 November 2023

Motivation

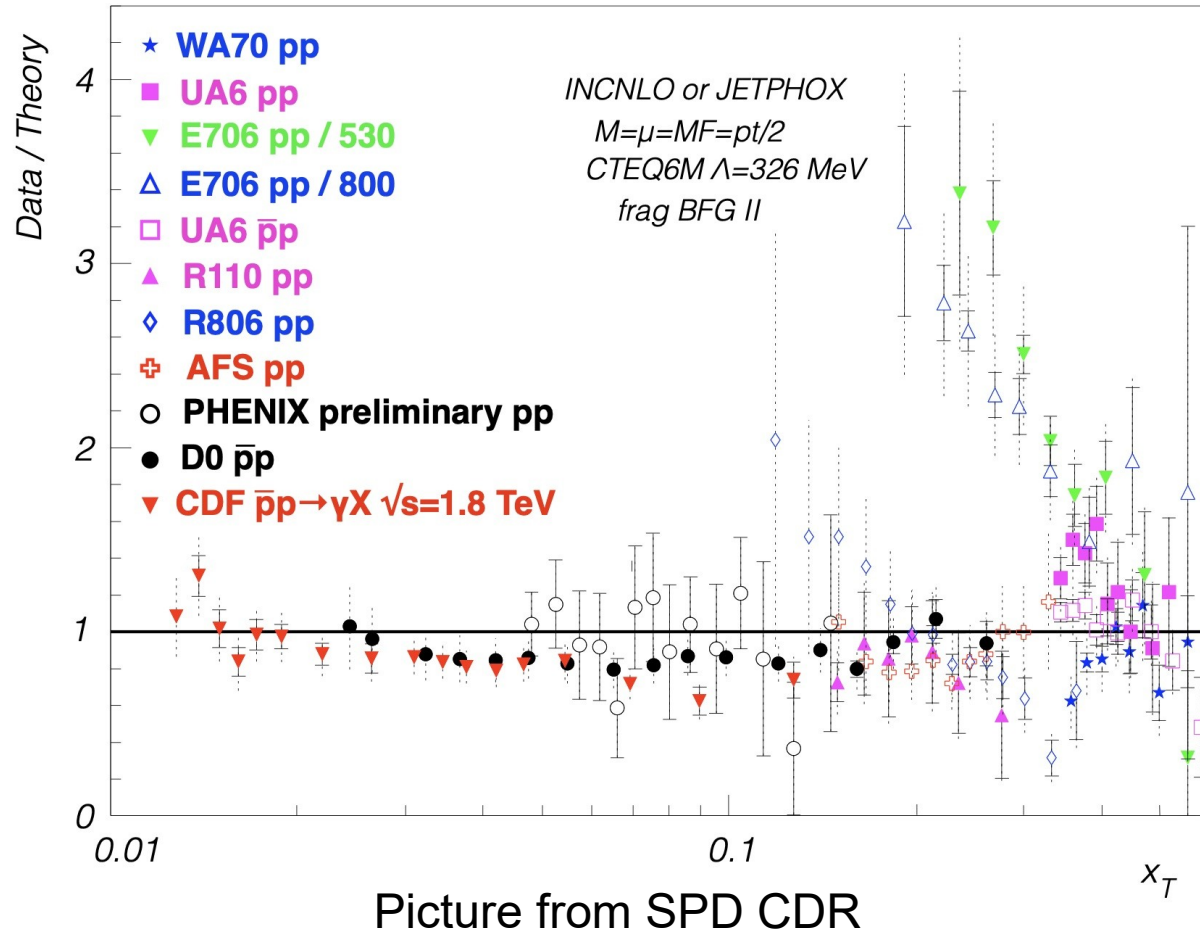
- ➔ The direct photon production in proton-proton collisions, both inclusive and heavy-meson-associated, is an important source of information on gluon distribution function inside the proton.
- ➔ The studies of transverse single-spin and double longitudinal asymmetries in polarized-beam collisions → the information of the spin gluon content.
- ➔ The study of direct photon production is one of the important tasks of the physical program at Spin Physics Detector (SPD) at NICA Collider.



Recognize the direct photons from the background



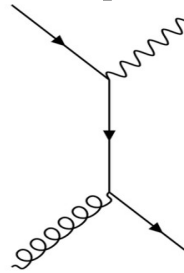
Experiment to theory relation



Direct photon production

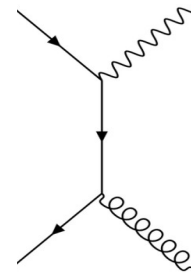
Compton scattering

$$g + q \rightarrow \gamma + q$$



Annihilation

$$q + \bar{q} \rightarrow \gamma + g$$



Pythia configuration

Processes:

```
pythia.readString("PromptPhoton:qg2qgamma = on");
pythia.readString("PromptPhoton:qqbar2ggamma = on");
```

→ *Switch off primordial kT:*

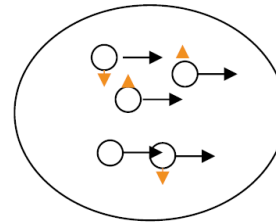
```
pythia.readString("BeamRemnants:primordialKT = off");
```

→ *Switch off kT, ISR, FSR:*

```
pythia.readString("BeamRemnants:primordialKT = off");
pythia.readString("PartonLevel:ISR = off");
pythia.readString("PartonLevel:FSR = off");
```

→ *Recommended:*

```
pythia.readString("BeamRemnants:primordialKThard = 1.2");
pythia.readString("PhaseSpace:mHatMin = 0.05");
pythia.readString("PhaseSpace:pTHatMin = 1.0");
```



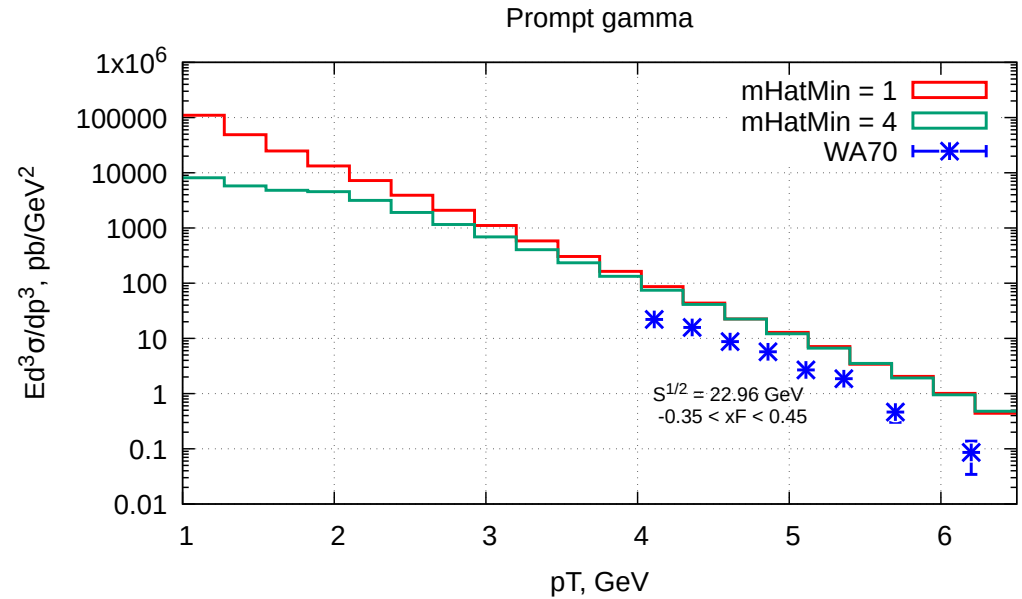
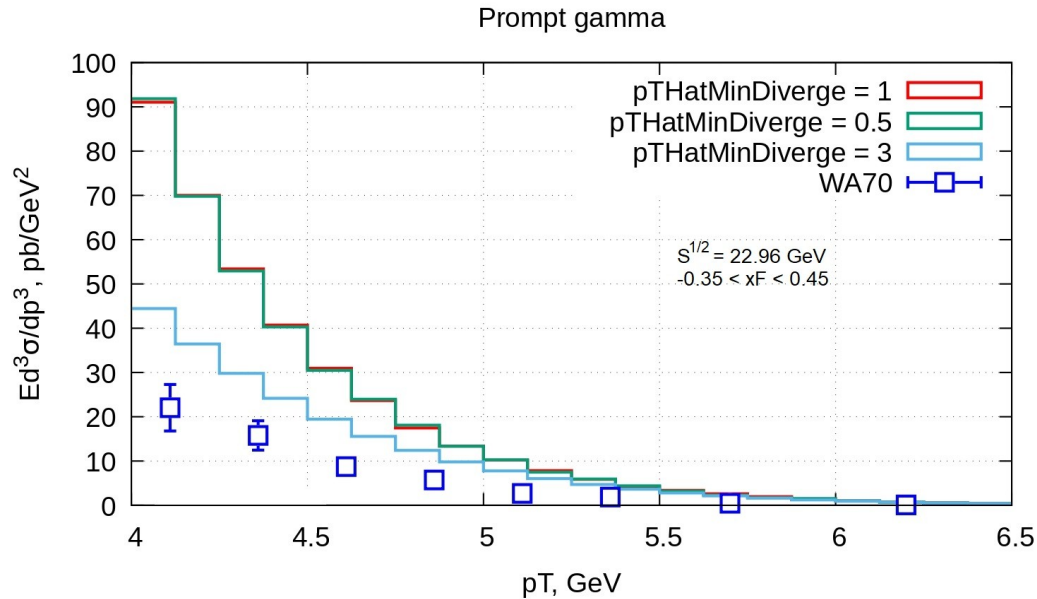
p

Phase space cuts

PhaseSpace:mHatMin (default = 4.; minimum = 0.)

PhaseSpace:pTHatMinDiverge (default = 1.; minimum = 0.5)

PhaseSpace:pTHatMin (default = 0.; minimum = 0.)



Examples of distributions for different values of the above parameters

Invariant cross section extraction

Formula for experimental data:

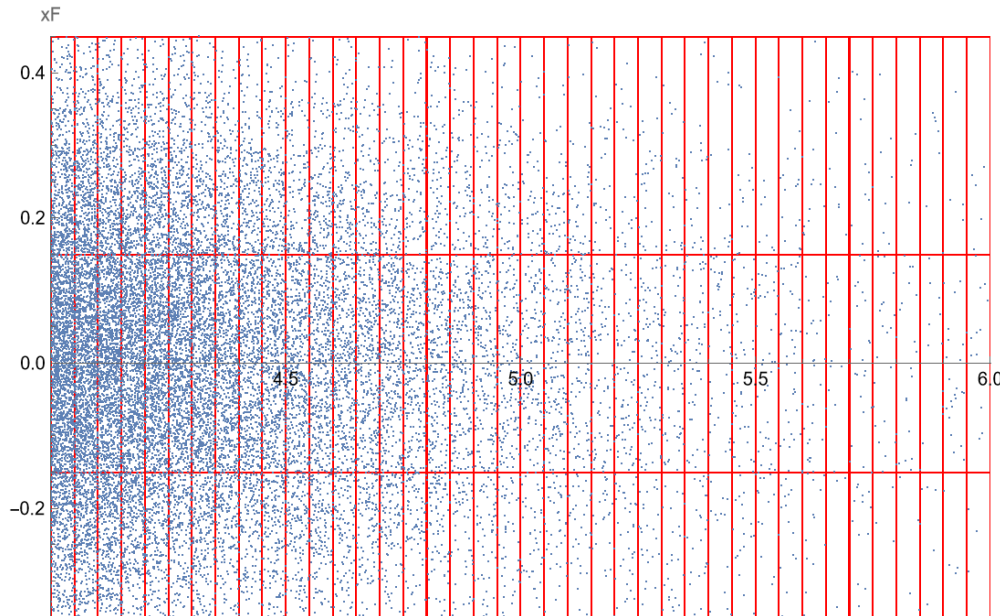
$$\langle D\sigma \rangle = \frac{1}{p_T^+ - p_T^-} \int_{p_T^-}^{p_T^+} dp_T \frac{1}{y^+ - y^-} \int_{y^-}^{y^+} dy D\sigma$$

Formula for generated data:

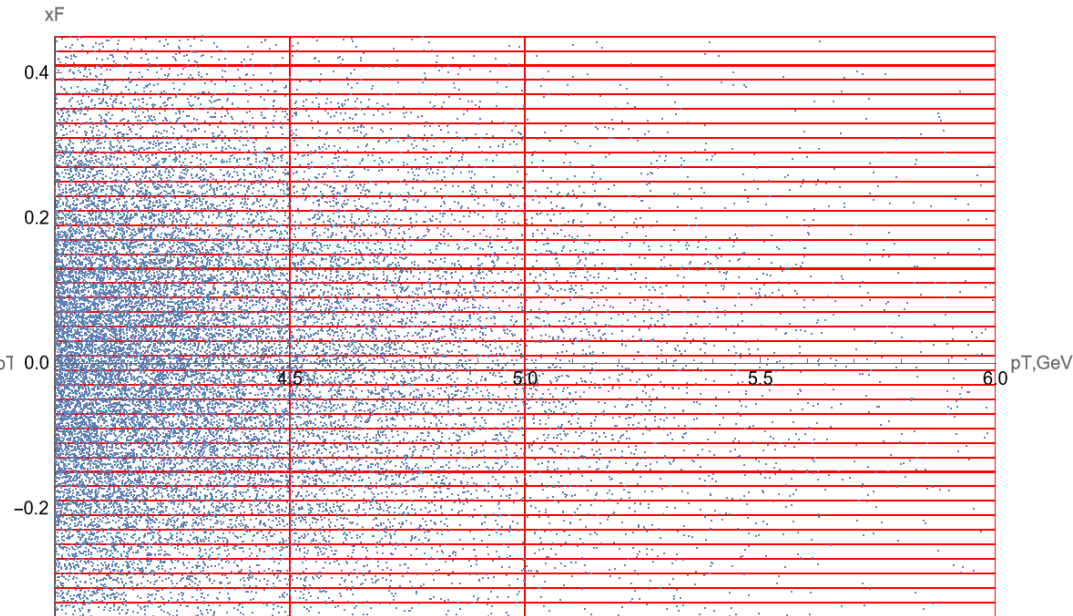
$$E \frac{d^3\sigma}{dp^3} = \frac{\sigma_{total}}{N_{events}} \frac{1}{\pi \sqrt{S} \Delta x_F \Delta p_T} \sum_{i=1}^{N_0} \frac{E_i}{p_{T,i}}$$

Bin widths for histograms

p_T distributions



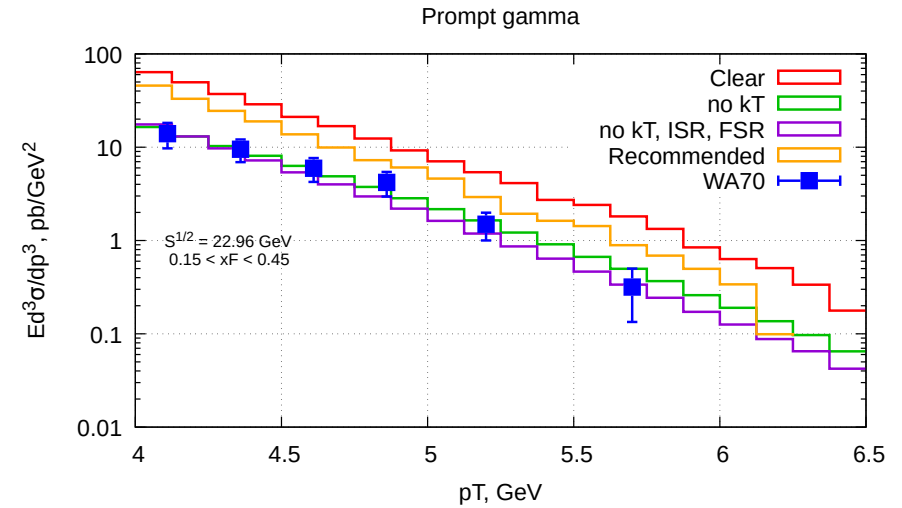
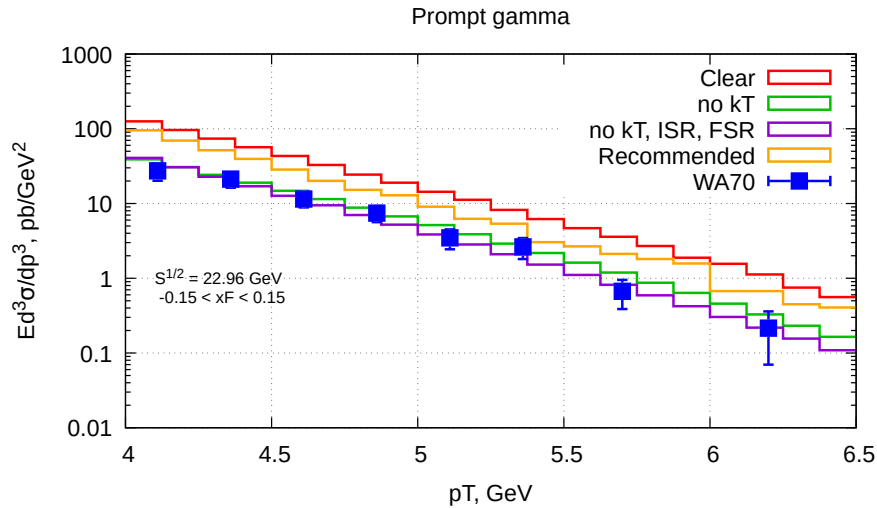
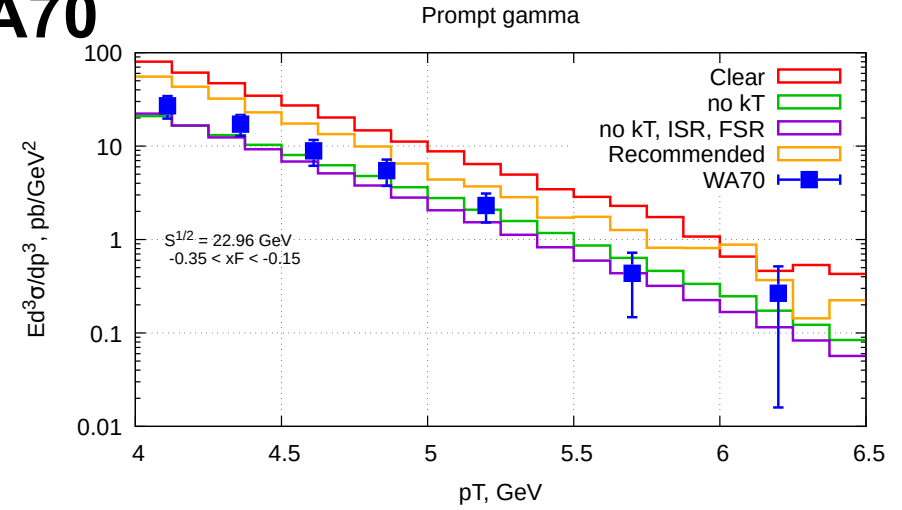
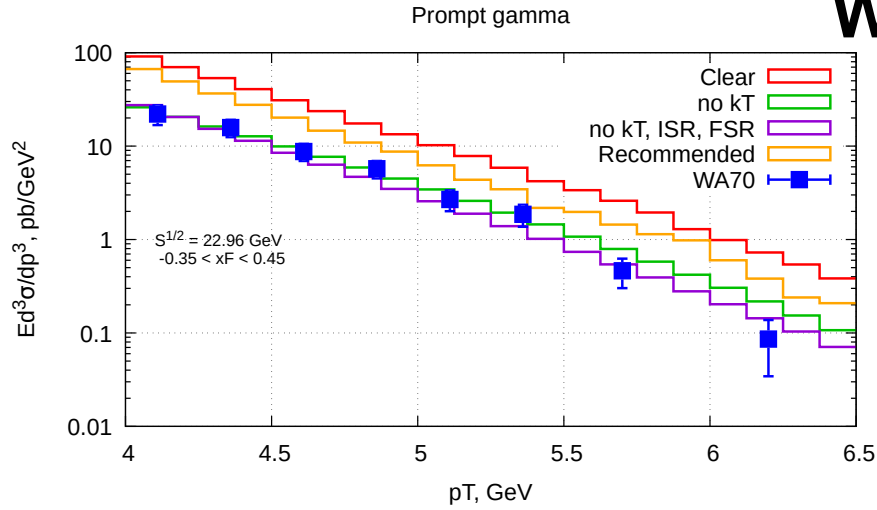
x_F distributions



List of experiments

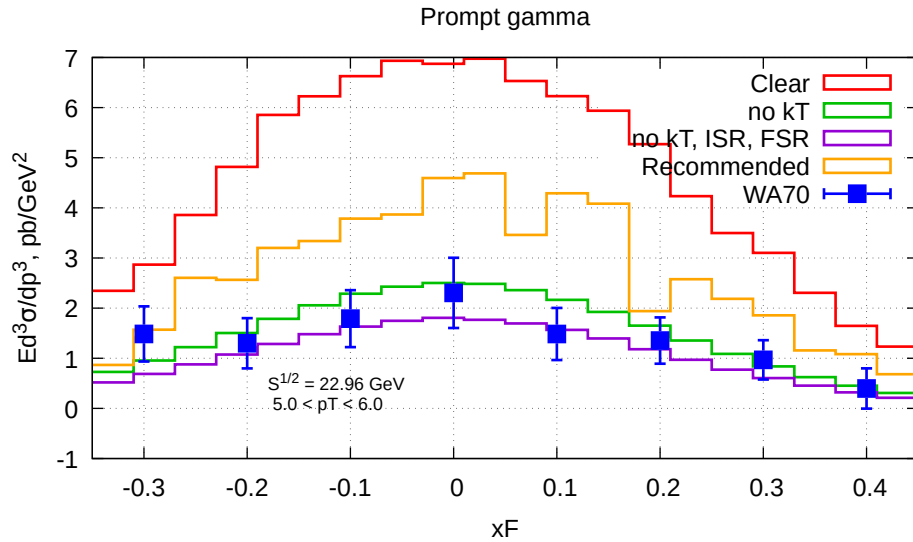
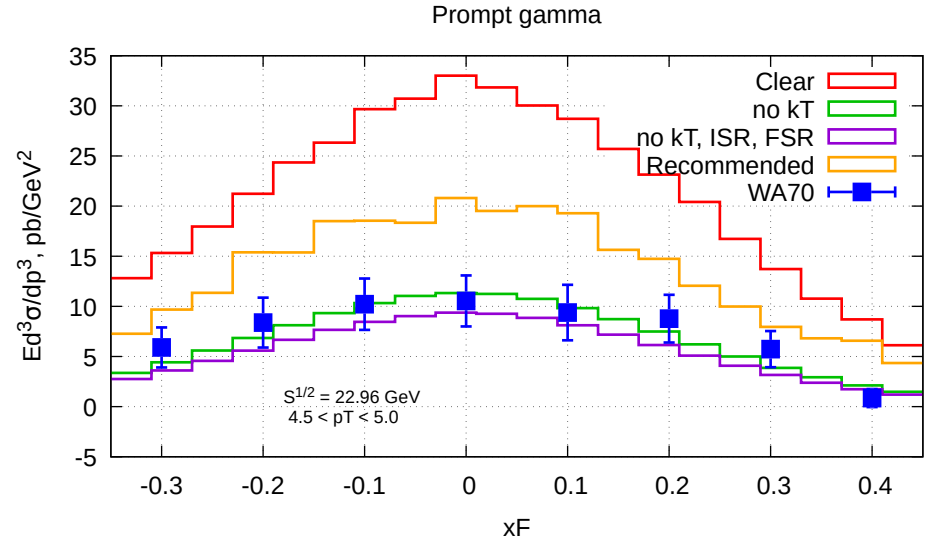
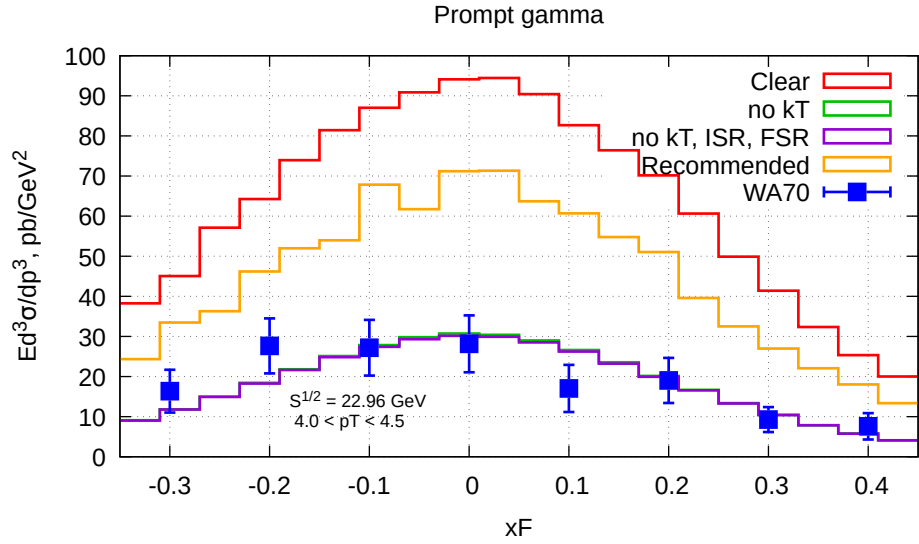
Name	\sqrt{S}
E704	19.4 GeV
WA70	22.96 GeV
UA6	24.3 GeV
R806	63.0 GeV
R110	63.0 GeV

WA70



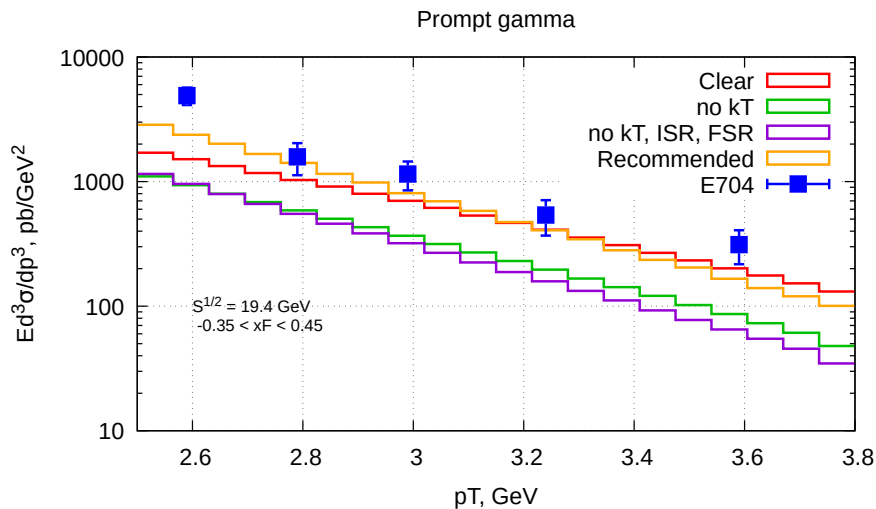
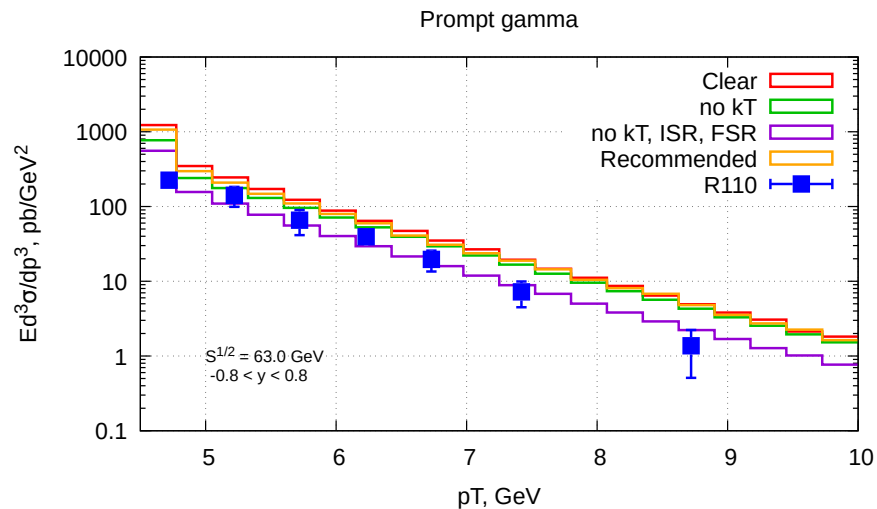
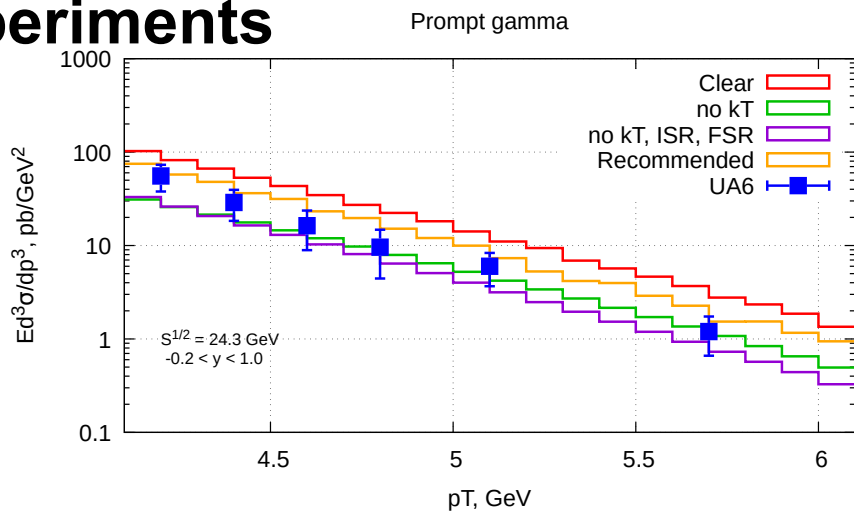
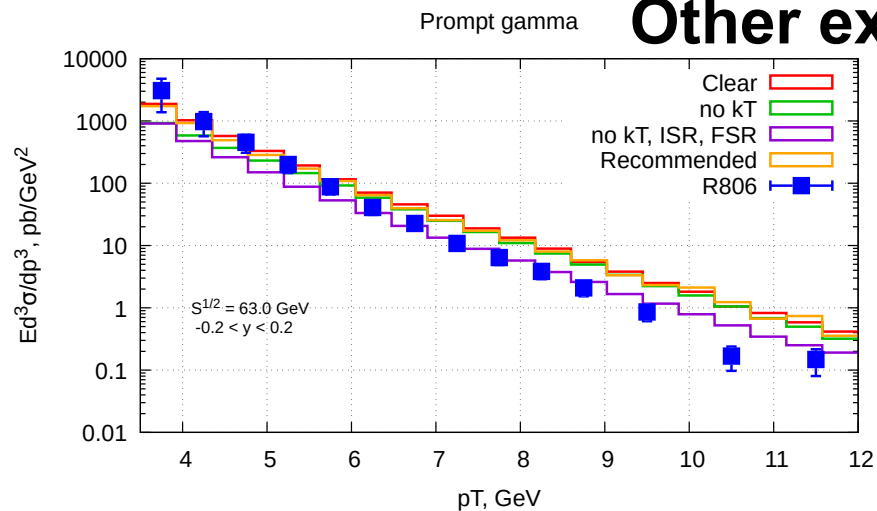
Distribution of photons by p_T in different x_F intervals

WA70



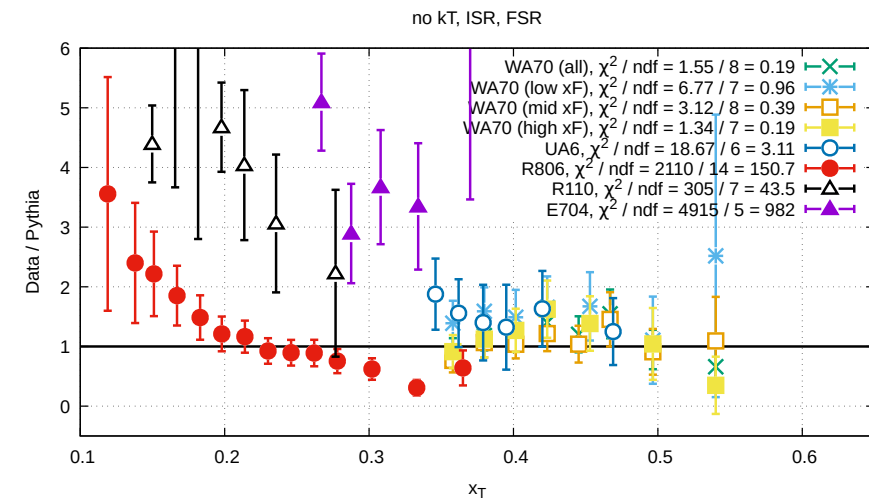
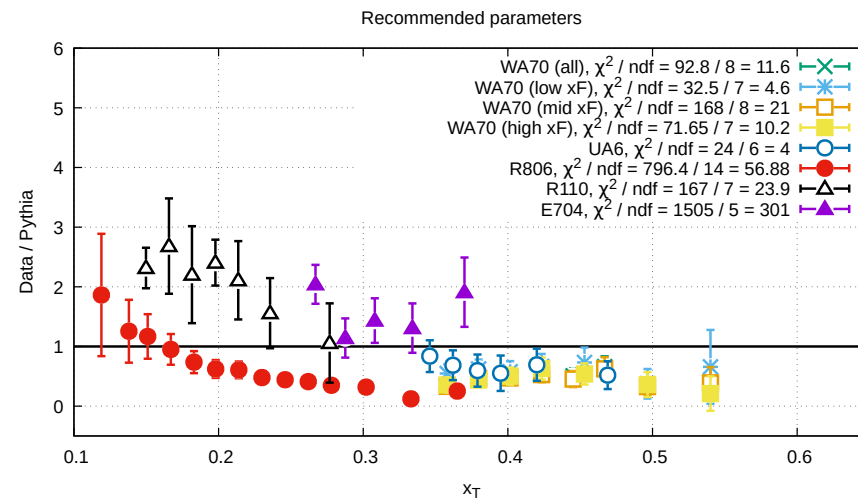
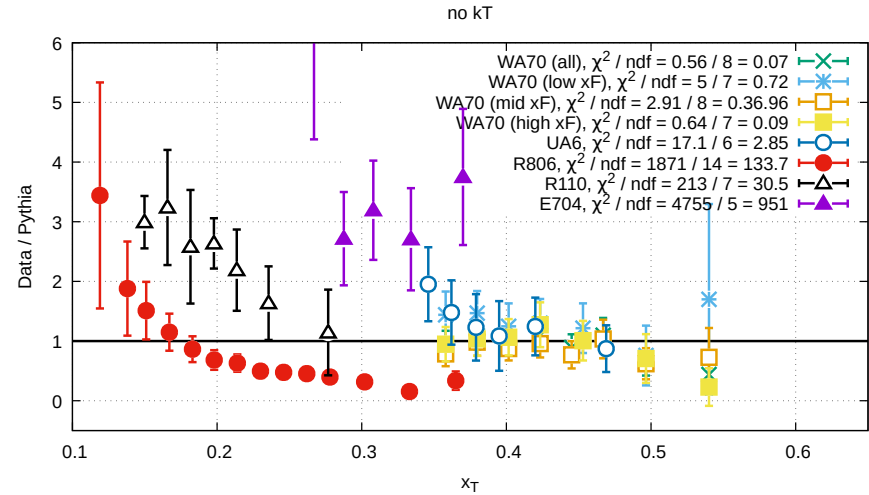
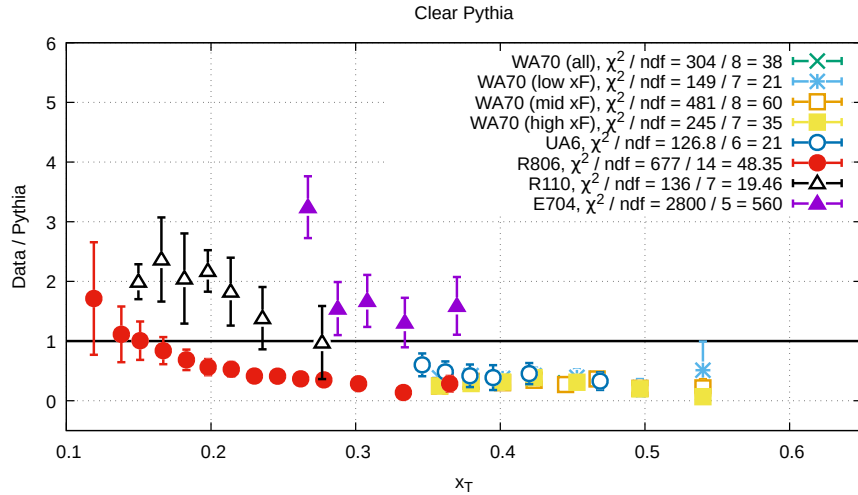
Distribution of photons by x_F in different p_T intervals

Other experiments

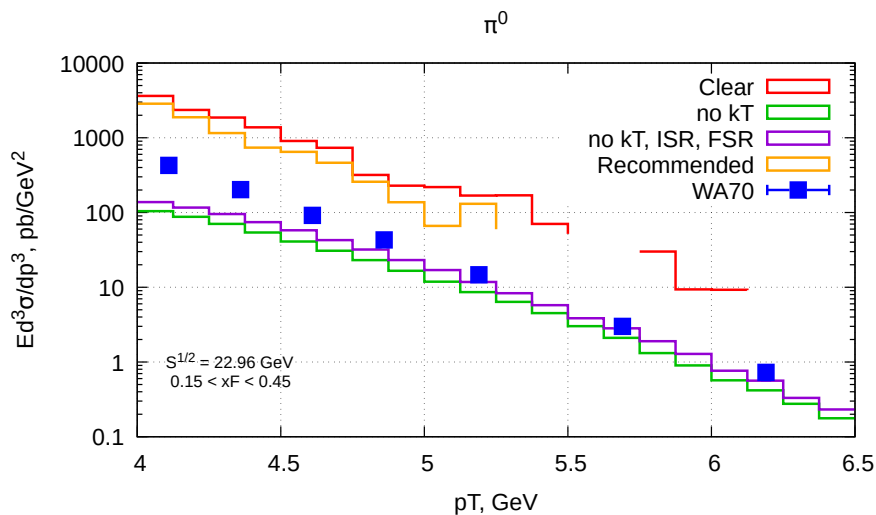
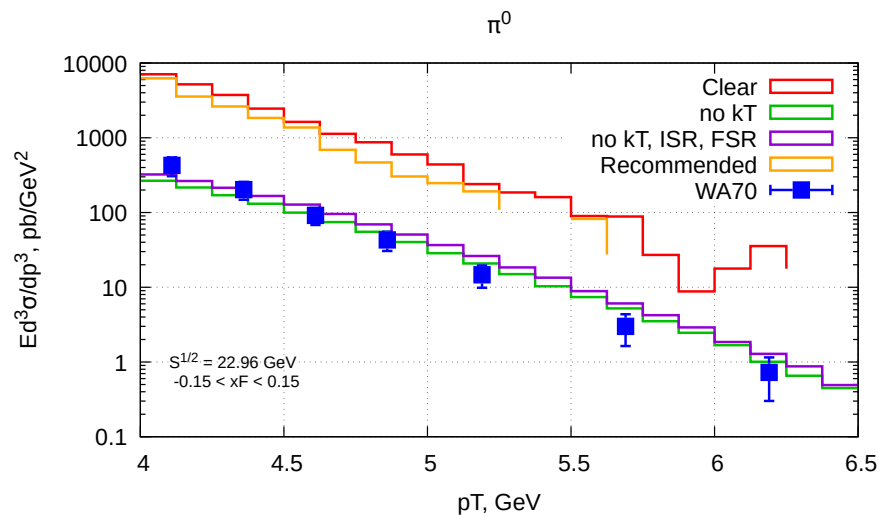
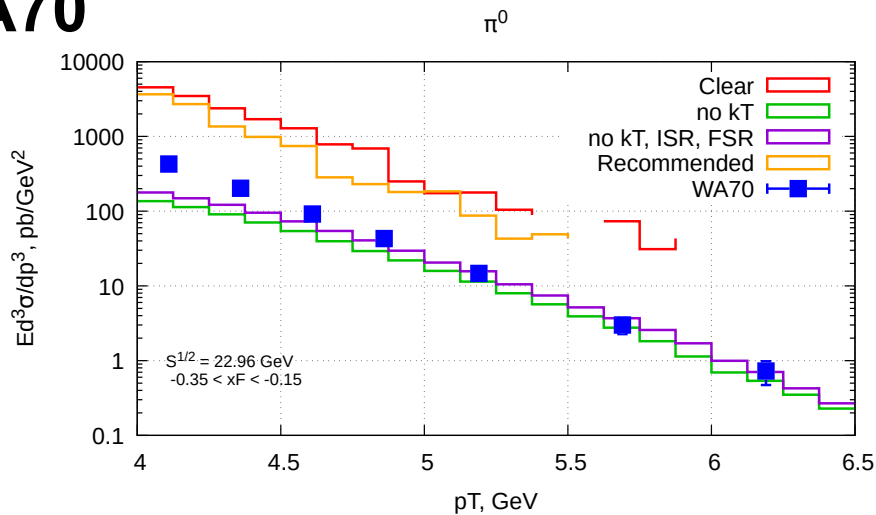
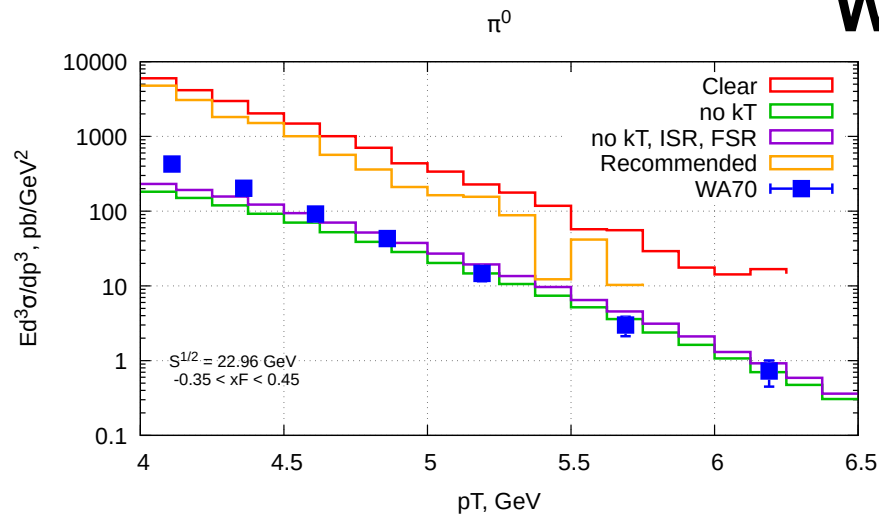


Distribution of photons by p_T

Experiment to Pythia relation

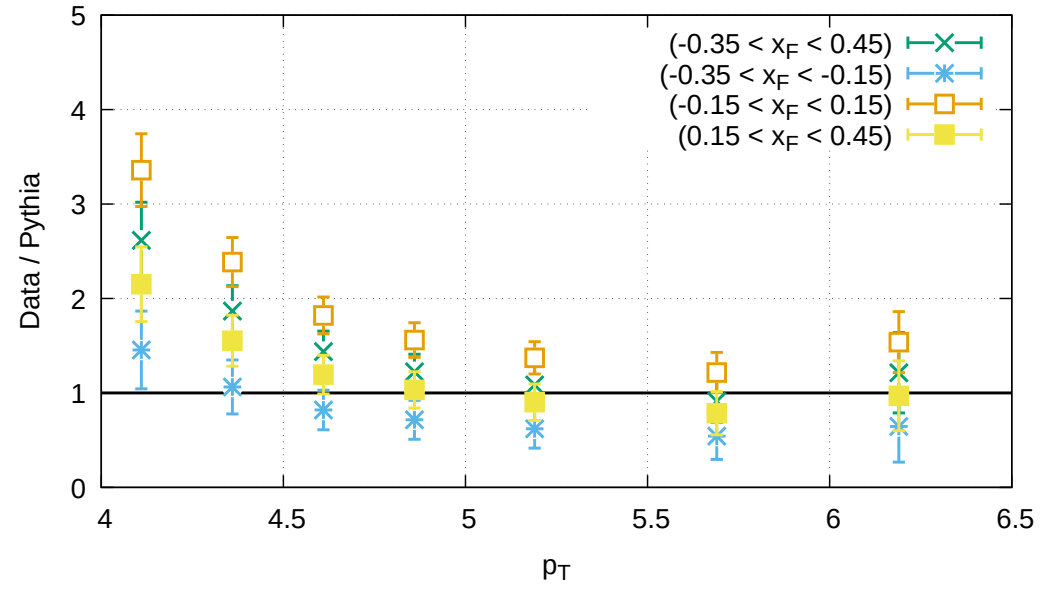
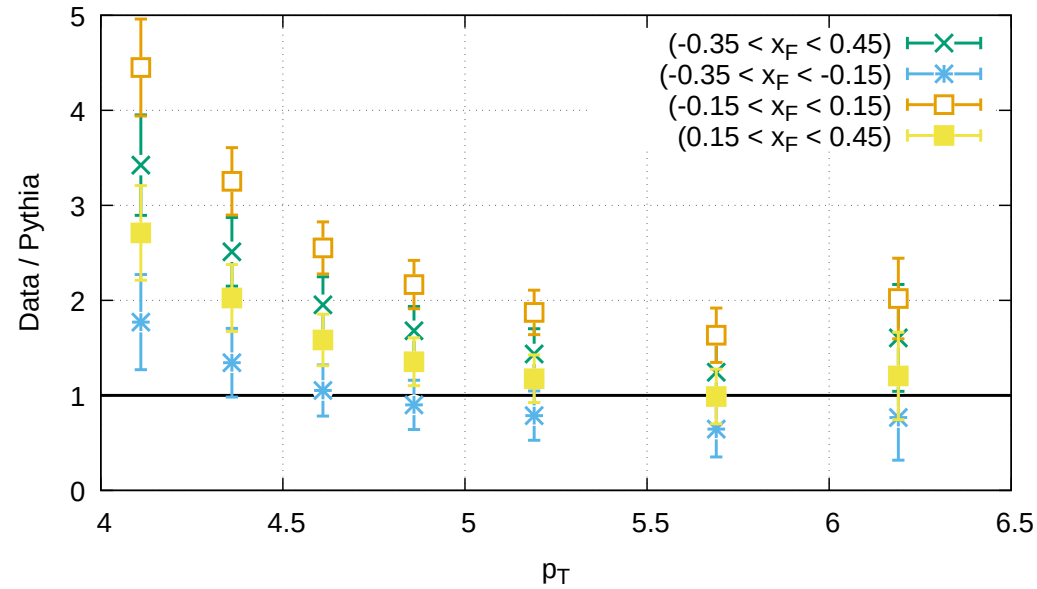


WA70



Distribution of π^0 by p_T

WA70



The ratio of the experimental values of the cross section to the values from the Pythia at the settings: no kT (left) and no kT, ISR, FSR (right)

Conclusion and plans

- ➔ We studied direct photon production: signal processes and the main source of background photons.
- ➔ We tested 4 Pythia configurations: by default; disabled primordial kT; disabled primordial kT, ISR and FSR; recommended from SPD wiki.
- ➔ We simulated the photon spectra which are in a satisfactory agreement with existing experimental data with the set of c.m. energies close to NICA ones.
- ➔ For these experiments, we plotted a ratio of experimental data to generated data, similar to the graph from the SPD CDR.
- ➔ We simulated the π^0 spectra which are in a satisfactory agreement with existing experimental data, but for higher values of p_T we need more statistics.
- ➔ Next step is to check whether disabling primordial kT affects the shape of the spectra for different variables.

Thank you for your attention