Jet production and the inelastic pp cross section at the LHC

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Motivation

Integrated cross section for hard $2 \to 2$ process above some $p_{T,min}$:

$$\sigma_{int}(p_{T,min}) = \int_{p_{T,min}} dp_T \frac{d\sigma}{dp_T}$$

- divergency: $d\sigma \propto \frac{dp_T^2}{p_T^4}$

  $\sigma_{int}(p_{T,min}) \propto \frac{1}{p_{Tmin}^2}$ for $p_{T,min} \to 0$
- $\sigma_{int} > \sigma_{inel}$

Proposal for a measurement:

- Visible leading minijet (charged particle) cross section integrated over transverse momentum
- Event cross section (rather than inclusive jet cross section)
- Comparison with inelastic σ(pp) within acceptance - no extrapolation needed

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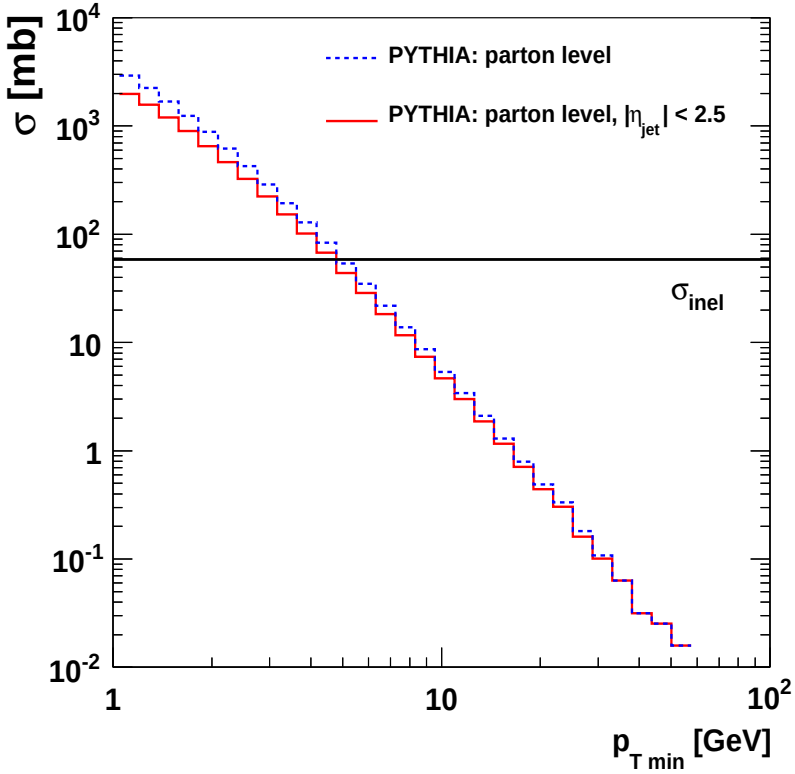
Integrated leading minijet cross section:



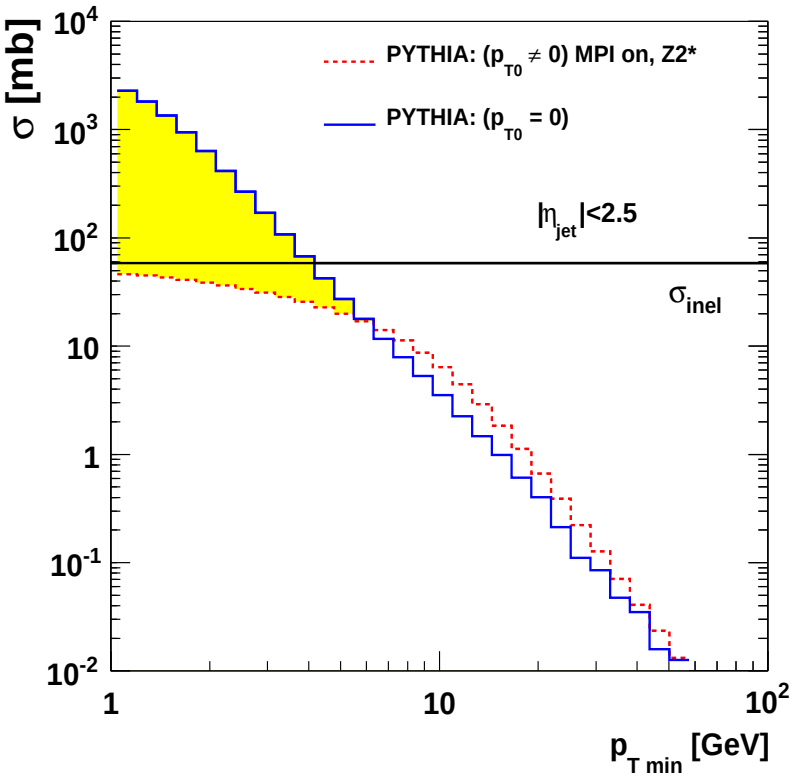
$\sigma_{jet} > \sigma_{inel}$ in η range accessible by experiments

Regulator p_{T0}

In PYTHIA the rise of σ_{int} is tamed by:

$$\sigma \longrightarrow \sigma \times \frac{\alpha_s^2(p_{T0}^2+p_T^2)}{\alpha_s^2(p_T^2)} \frac{p_T^4}{(p_{T0}^2+p_T^2)^2}$$

energy-dependent p_{T0} is determined by tuning to data (PARP(82) $\sim$ few GeV)

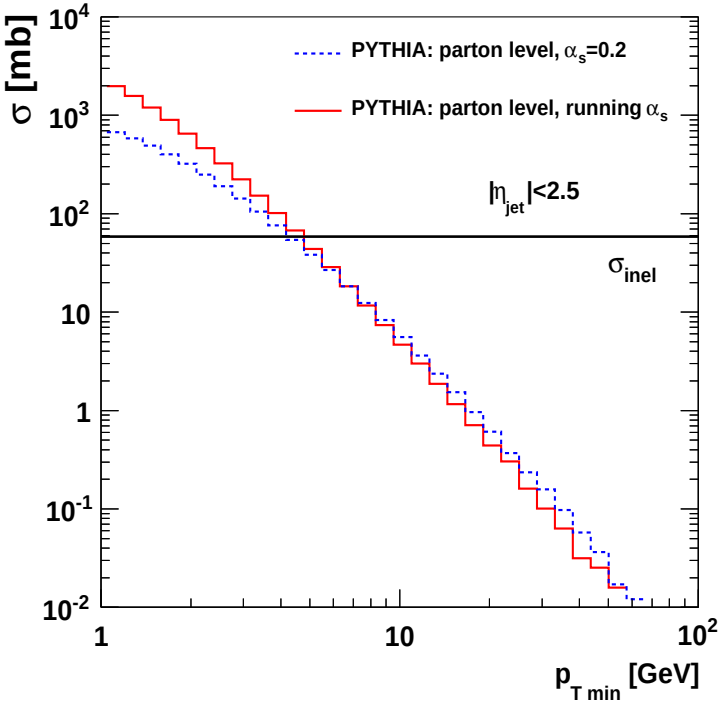


PYTHIA with $p_{T0} = 0$

PYTHIA with $p_{T0} \neq 0$

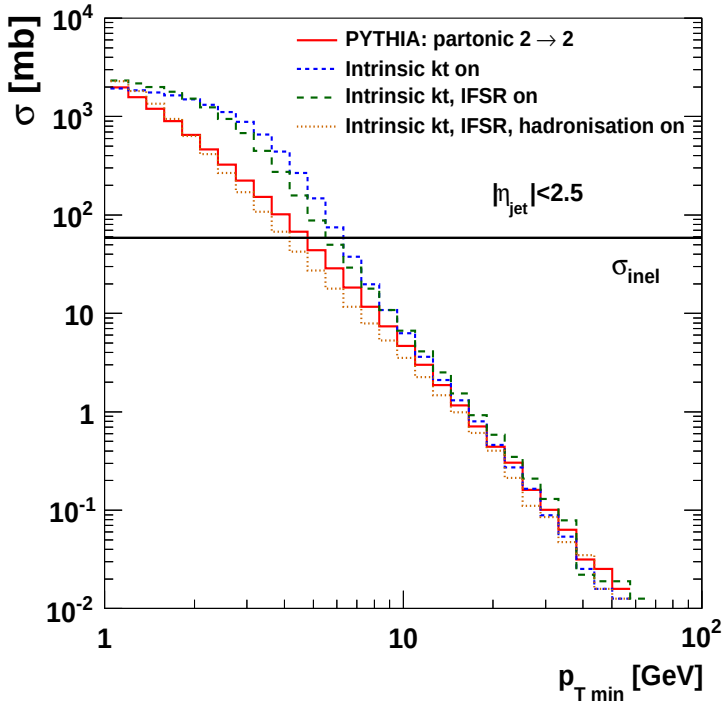
Parton → hadron-level cross section

Partonic cross section using a fixed ($\alpha_s = 0.2$) and running α_s:



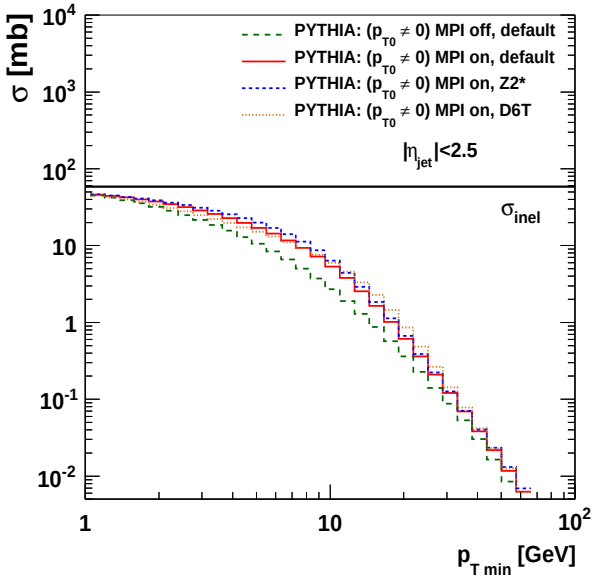
- No large effect from infrared behavior of the QCD coupling

Cross section from purely partonic $2 \to 2$ process, including intrinsic k_T-effects, initial and final state parton showers (IFSR), hadronisation



- Jet cross section exceeds σ_{inel} for $p_T \sim 3$ GeV

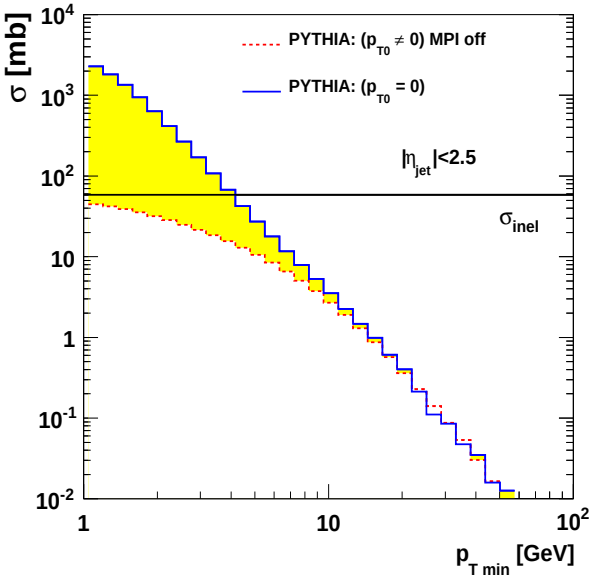
Effect on MPI



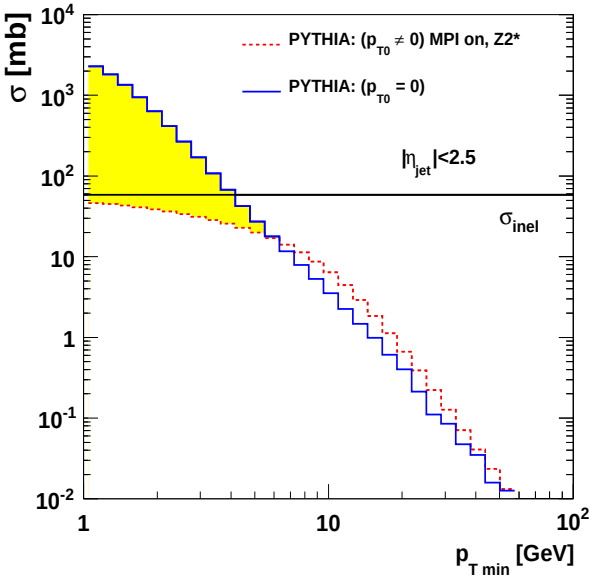
← PYTHIA with $p_{T0} \neq 0$ and MPI with different UE tunes

- Taming does not totally depend on MPI

PYTHIA ($p_{T0} \neq 0$), MPI off



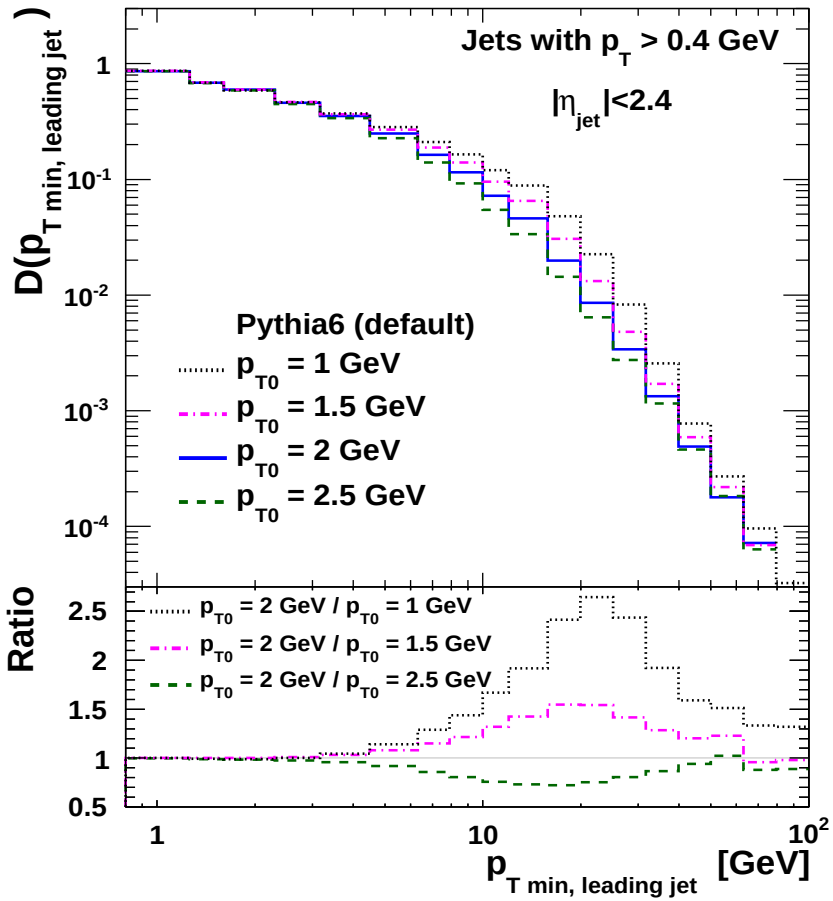
PYTHIA ($p_{T0} \neq 0$), MPI on



Sensitivity to p_{T0}

- p_{T0} was varied by $\Delta p_{T0} = 0.5$ GeV
- PYTHIA default value: $p_{T0} = 2$ GeV

$$\sigma \rightarrow \sigma \times \frac{\alpha_s^2(p_{T0}^2+p_T^2)}{\alpha_s^2(p_T^2)} \frac{p_T^4}{(p_{T0}^2+p_T^2)^2}$$



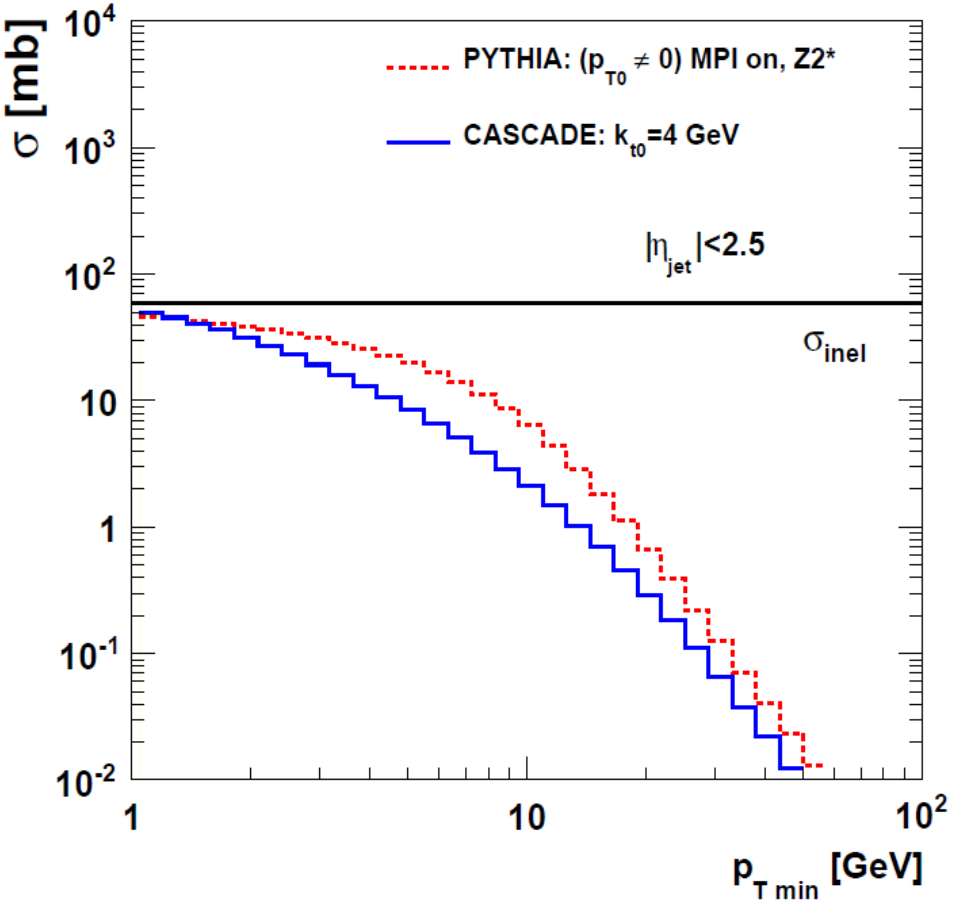
→ Sensitivity to p_{T0}

Normalised distribution:

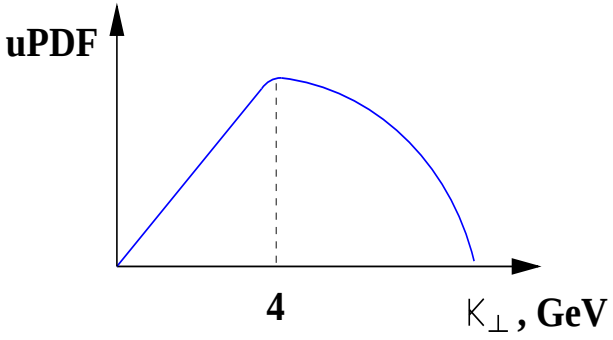
$$D(p_{T,min\ leading}) = \frac{1}{N} \int_{p_{T,min\ leading}} dp_{T,leading} \left(\frac{dn}{dp_{T,leading}} \right)$$

Collinear vs k_T factorised framework

- k_T factorized: low-p_T behavior results from
  - ME dependence (standard low-p_T rise for $k_T \ll p_T$, slower rise for $k_T \simeq p_T$)
  - unintegrated PDF (suppression of the low-k_T region)



Modification of unintegrated PDF such that it goes to zero for $k_T \longrightarrow 0$:

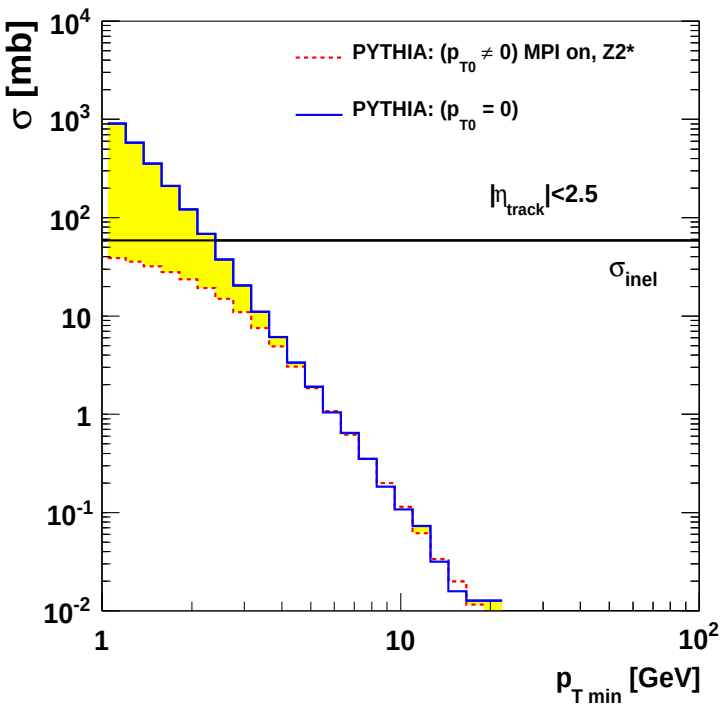


$\longrightarrow$ CASCADE with modified uPDF tamed the cross section

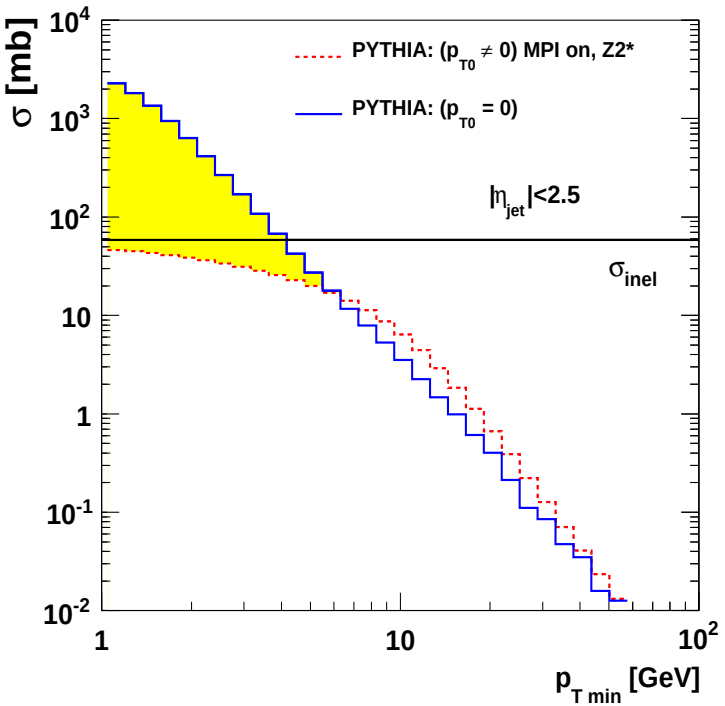
Leading charged particle

Similar to minijet the integrated leading charged particle distribution can be studied

Leading charged particle



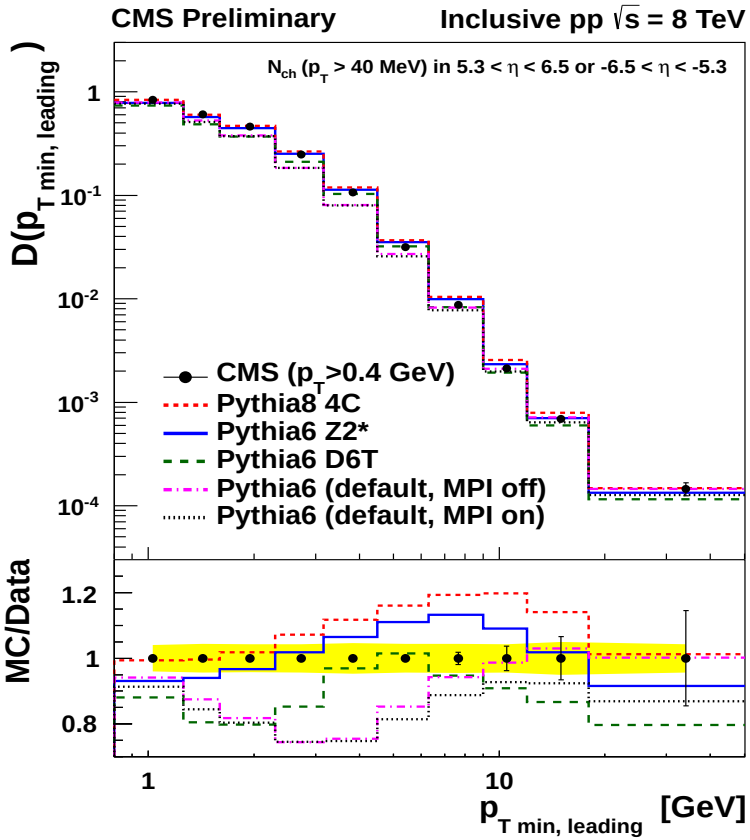
Leading minijet

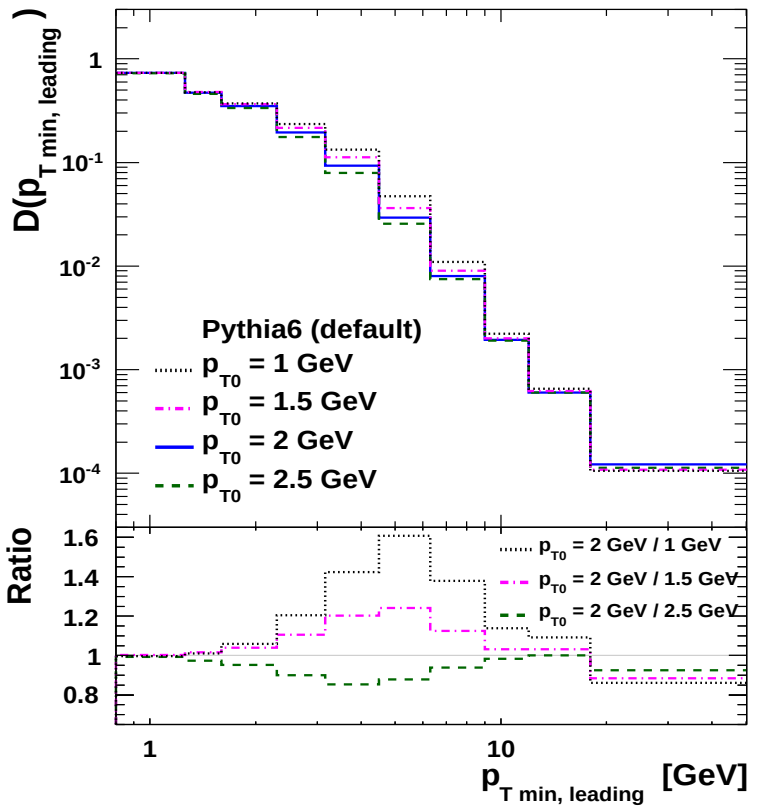


- First measurement of the integrated leading charged particle distribution (see Panagiotis Katsas talk)

Normalised distribution: $D(p_{T,min\ leading}) = \frac{1}{N} \int_{p_{T,min\ leading}} dp_{T,leading} \left(\frac{dn}{dp_{T,leading}} \right)$

Measurement of the integrated leading charged particle together with PYTHIA predictions:





- Shape of the data not well described
- Deviations between different PYTHIA tunes

- Sensitivity to p_{T0}

Summary

- Suggest a "new" observable cross section
  - leading minijet or leading charged particle cross section - "event cross section" integrated over transverse momentum
  - sensitivity to the unitarity bound set by the total inelastic proton-proton cross section
- pQCD extended to small transverse momentum predicts violation of unitarity at about few GeV, visible in $|\eta| < 2.5$
  - proposal for measurement of leading charged particle and minijet cross sections
  - probe transition from perturbative to non-perturbative region
  - first CMS measurements show very interesting behaviour