Multiple **P**arton **I**nteractions in **P**hoto**P**roduction

Contents:

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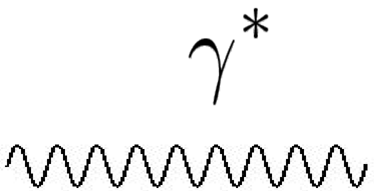
Deep **I**nelastic **S**cattering. Madrid, 29th of April, 2009.

Introduction & Motivation

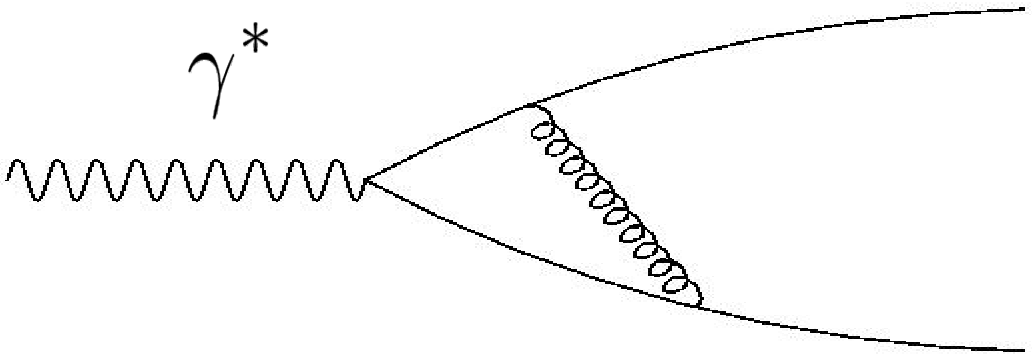
Introduction & motivation

✗ At high virtualities, Q^2, the photon is a point-like particle



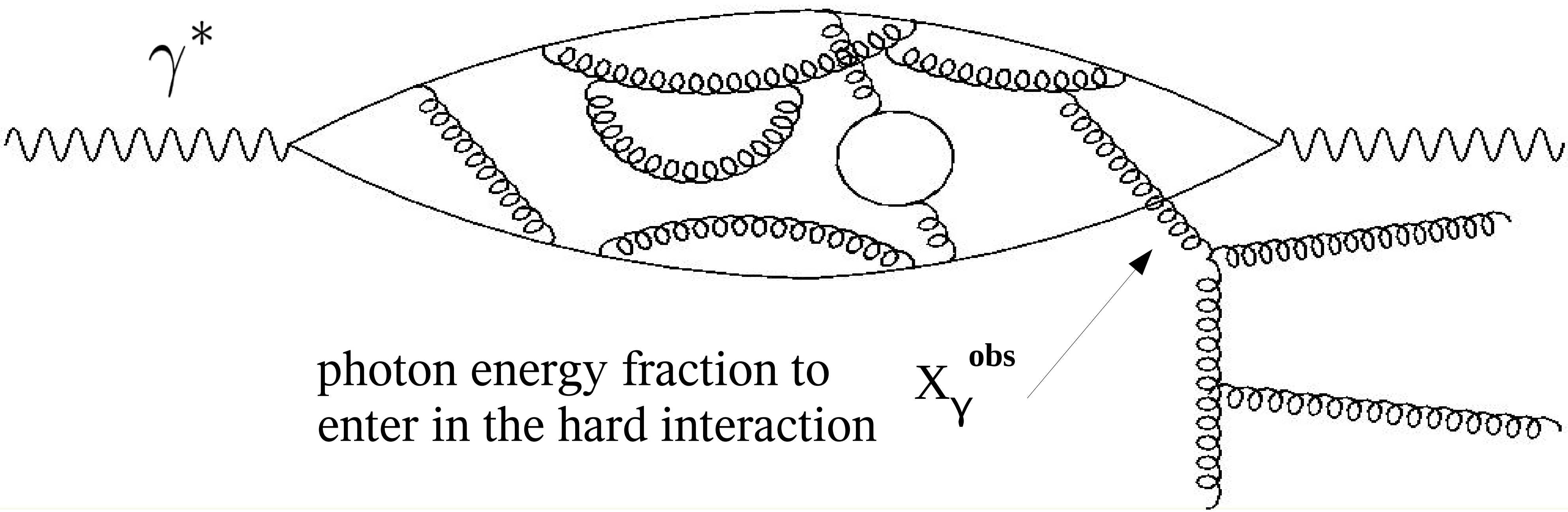
Introduction & motivation

✗ while going to lower virtualities the photon lives longer and may fluctuate into a quark-anti quark pair



Introduction & motivation

✗ in photoproduction the photon lives enough to develop a complicated hadronic structure.

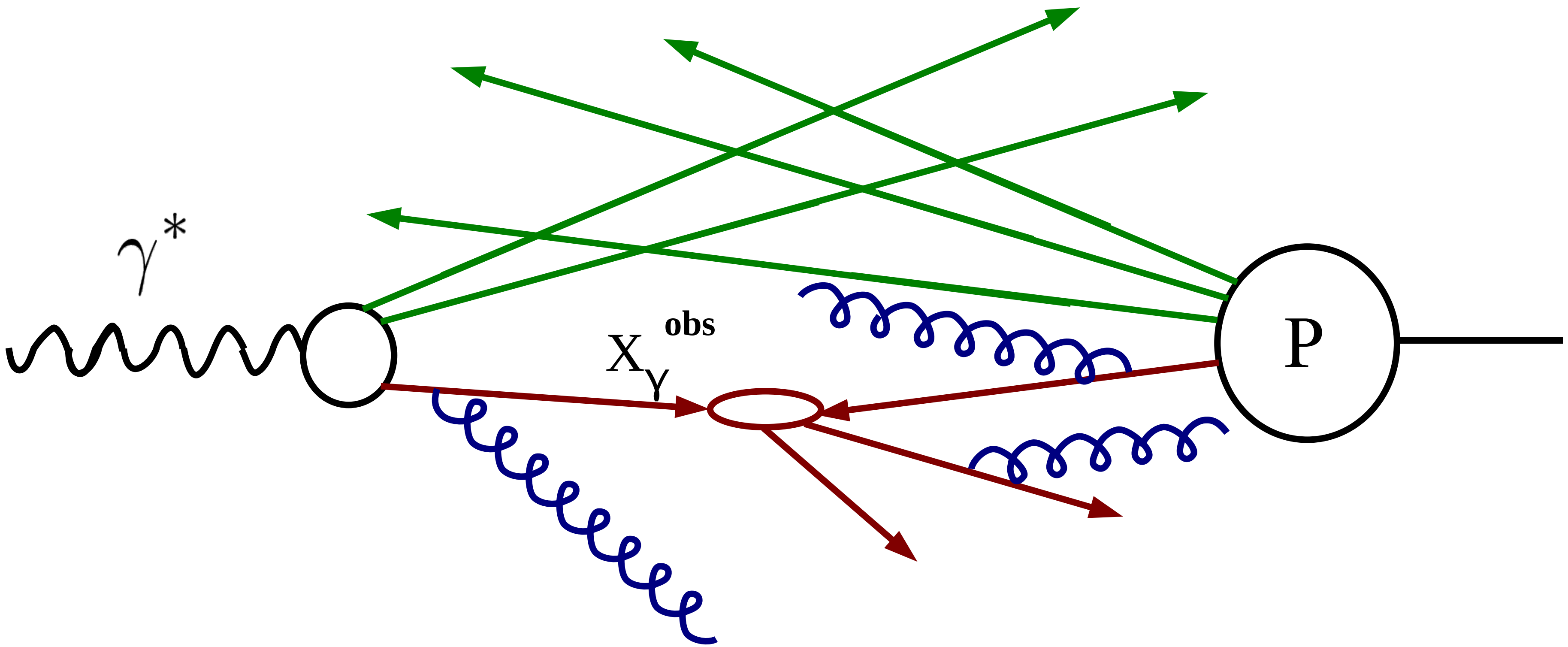


photon energy fraction to enter in the hard interaction x_γ^{obs}

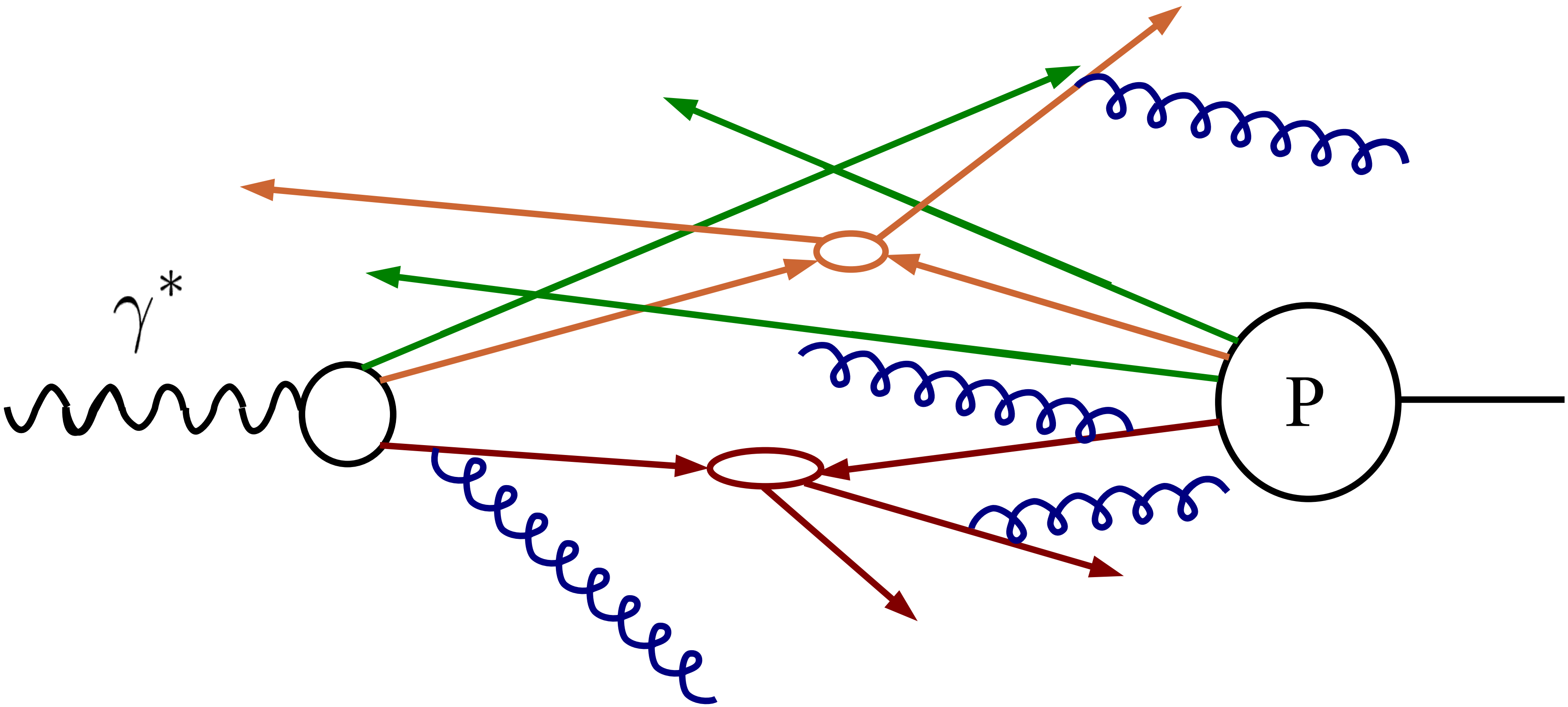
- high values correspond to point-like photons
- low values correspond to hadron-like photons

Introduction & motivation

In ep at low X_γ we can have a similar situation to the hadron-hadron collisions

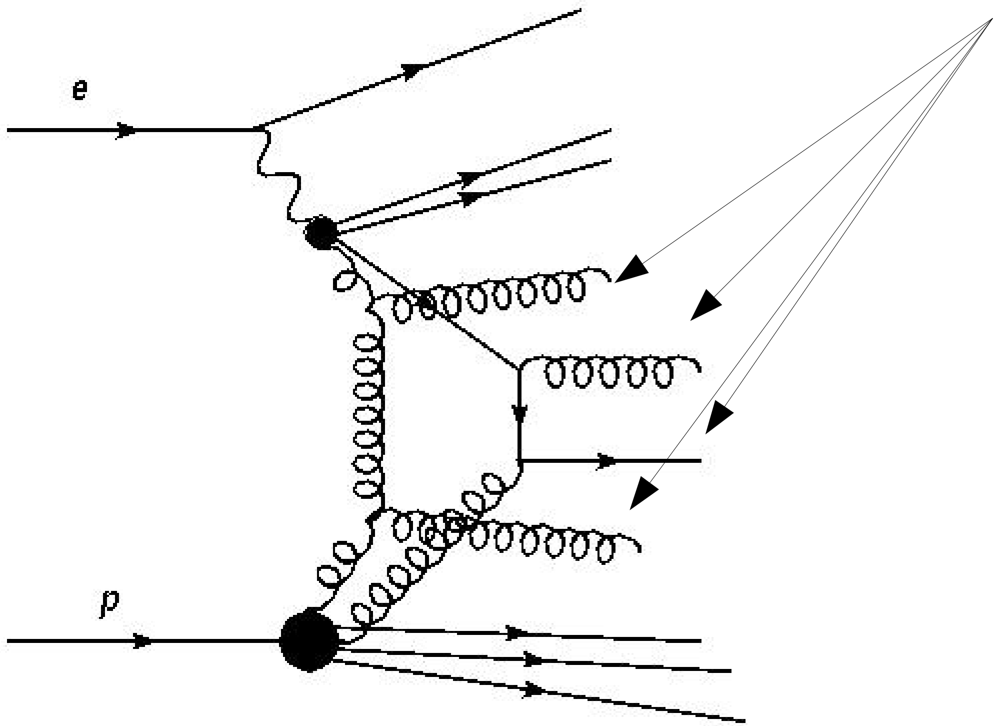


there are remnants from the photon and the proton side and partons from the remnants can interact



Multiple parton interactions

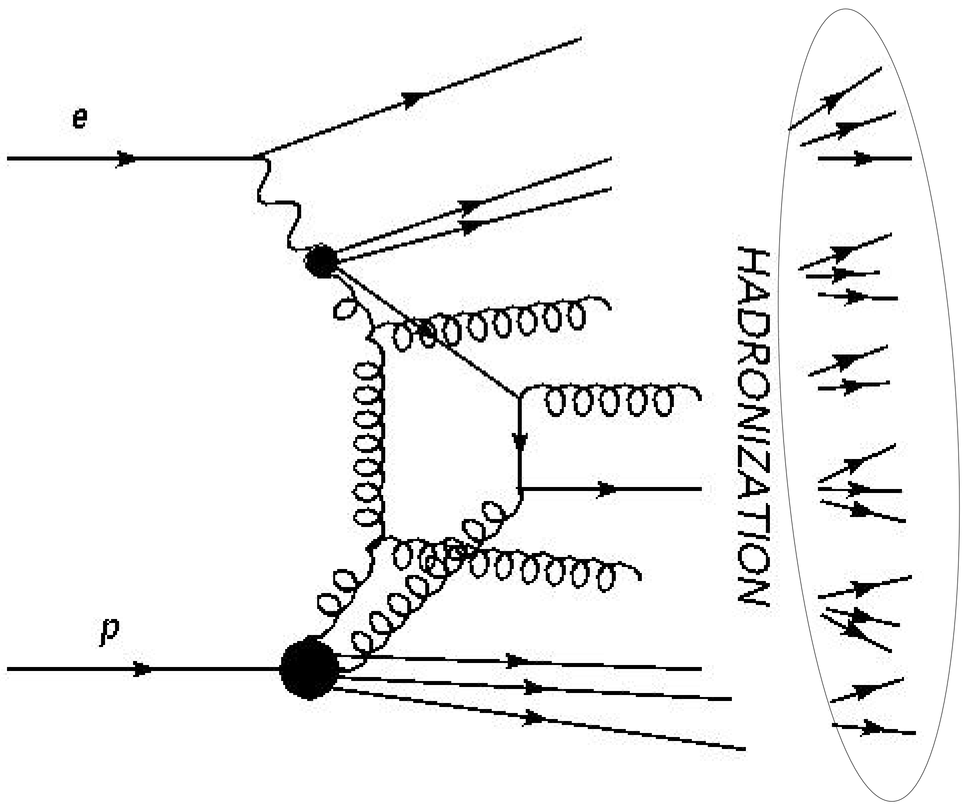
Observables:



- Hard MPI in multi jet events: several jets with high P_T

Multiple parton interactions

Observables:



- Hard MPI: in multi jet events with high P_T^{jets}

- Semi-soft MPI: multi jet event with low P_T^{jets}

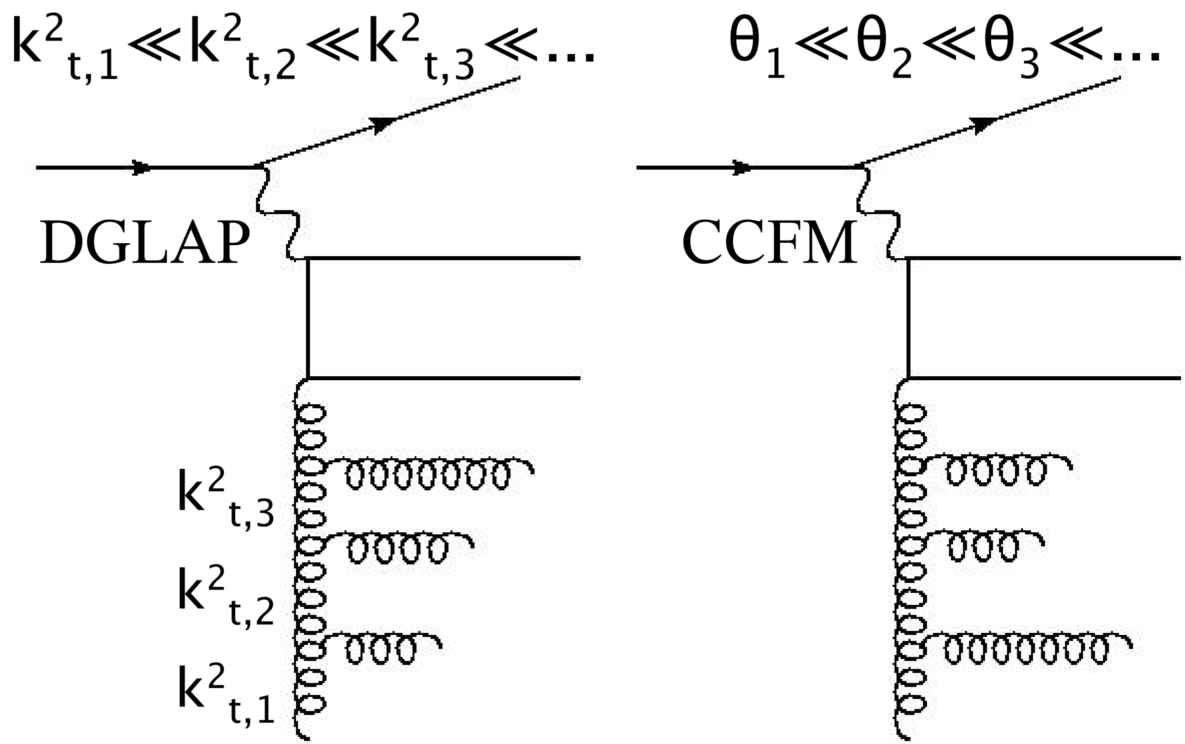
- Soft MPI: charged particles

Monte Carlo

- ✔ PYTHIA: LO ME + DGLAP PS (+ MPI model)

  (semi-)hard MPI + different string scenarios for hadronization

- ✔ CASCADE: off shell LO ME + CCFM PS (no resolved photon, no MPI model implemented)



Previous measurements

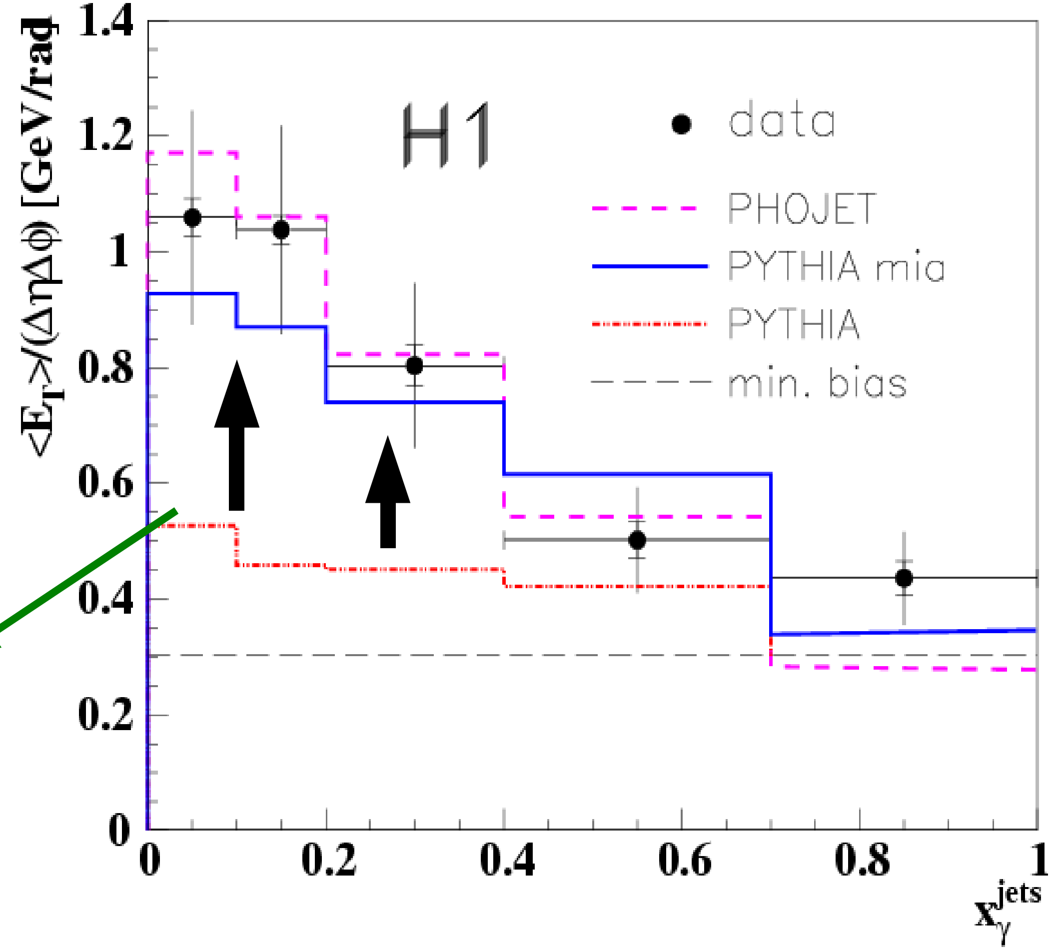
Energy flow outside jets at H1

Photoproduction $Q^2 < 0.01\ GeV^2$

At least two jets ($E_T^{jet} > 5$ GeV

$-1 < \eta^{jet} < 2.5$)

The transverse energy density outside the jets can be described when MPI are simulated.



"Jets and Energy Flow in Photon-Proton Collisions at HERA" Z.Phys.C70:17-30,1996

Previous measurements

Transverse energy correlations at H1

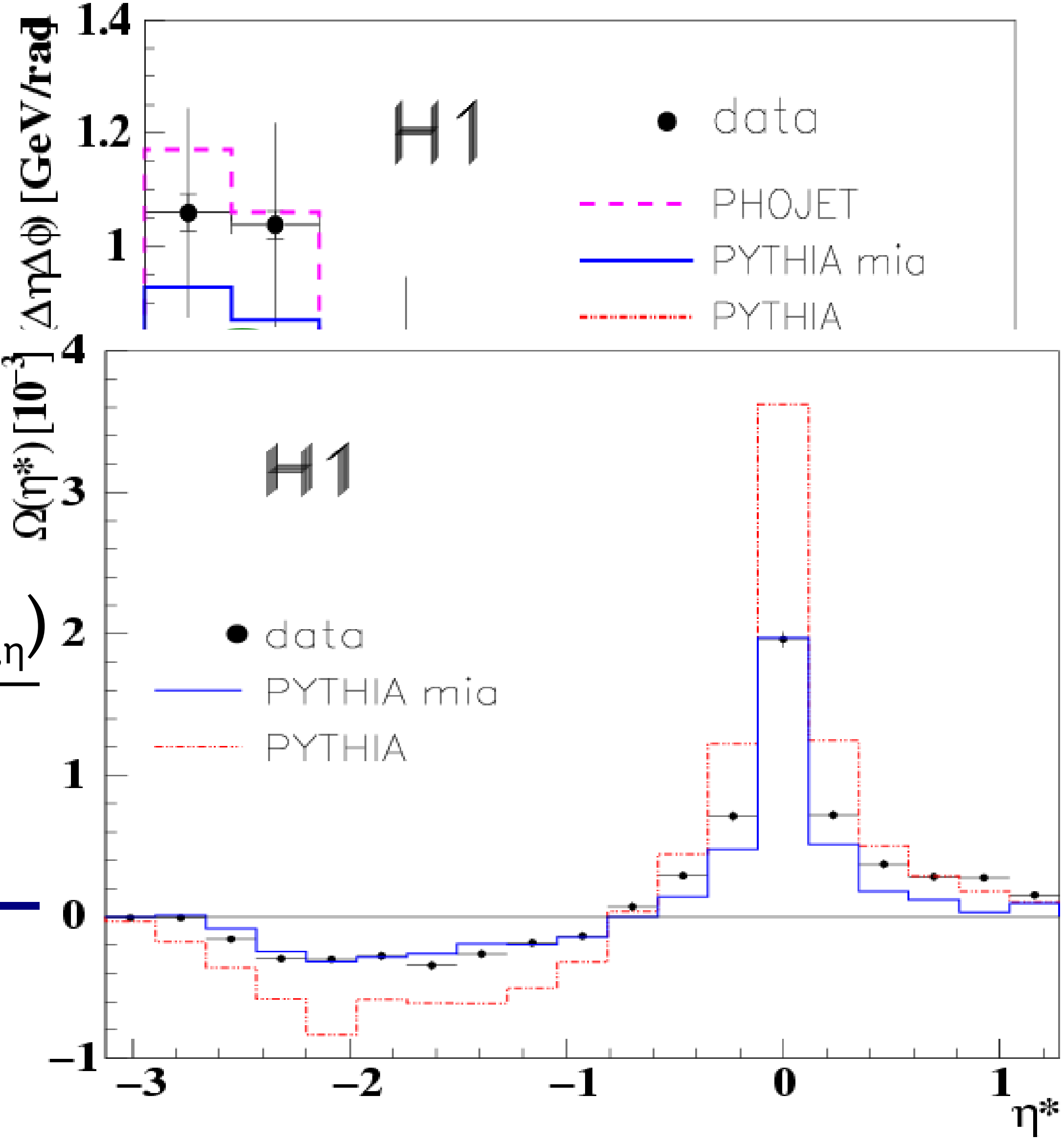
Photoproduction $Q^2 < 0.01\ \mathrm{GeV}^2$

High E_T sample ($E_T > 20$ GeV

$-0.8 < \eta < 3.3$)

$$\Omega = \frac{1}{N_{ev}} \sum_{i=1}^{N_{ev}} \frac{(\langle E_{T,\eta=0}\rangle - E^{i}_{T,\eta=0})(\langle E_{T,\eta}\rangle - E^{i}_{T,\eta})}{(E_T^{\,2})_i}$$

Including MPI the Ω rapidity correlations can be described



"Jets and Energy Flow in Photon-Proton Collisions at HERA" Z.Phys.C70:17-30,1996

Preliminary analysis: charged particles

Charged particle multiplicity

$Q^2 < 0.01\ GeV^2$

$0.3 < y < 0.65$

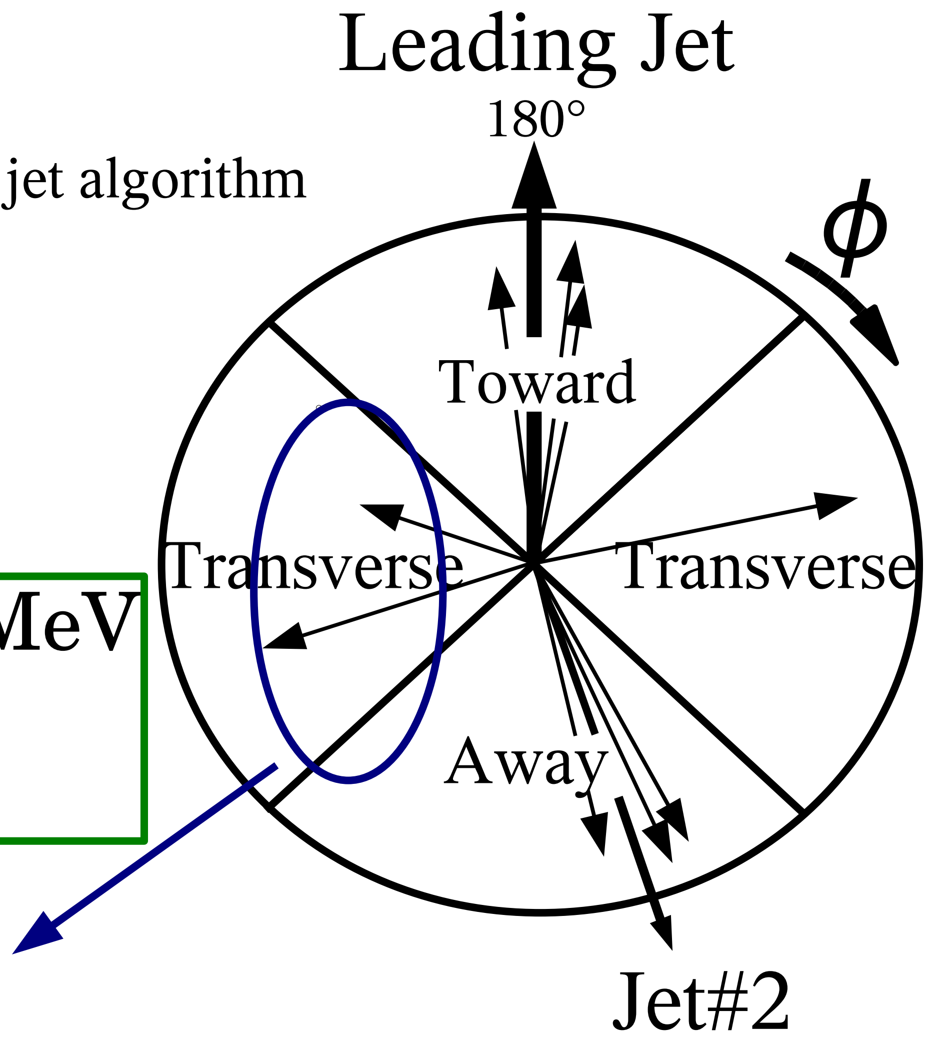
inclusive k_T jet algorithm

Dijet events: $P_T^{jets} > 5\ GeV$

$|\eta^{jets}| < 1.5$

Charged particles: $P_T > 150\ MeV$

$|\eta| < 1.5$



The high activity region is the transverse region hemisphere with higher $P_T^{sum} = \sum_i^{tracks} p_T^i$

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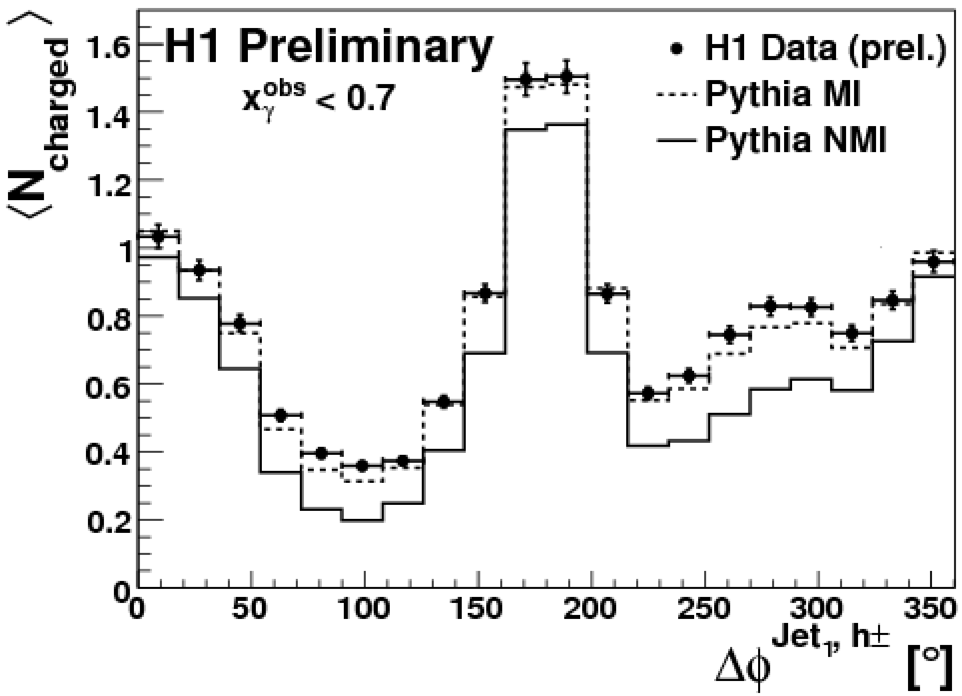
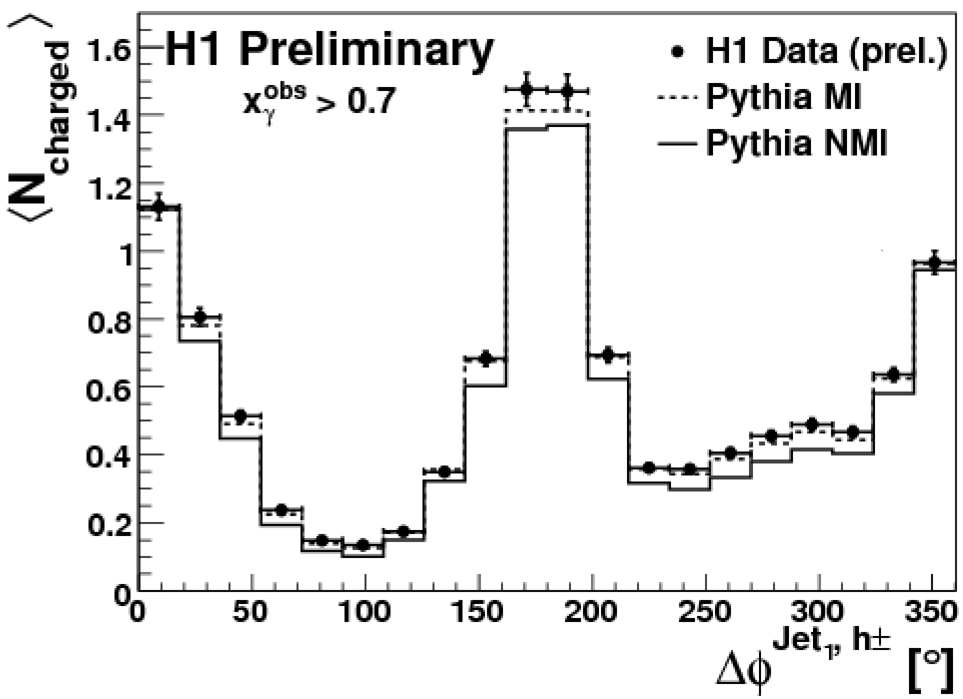
Charged particle multiplicity

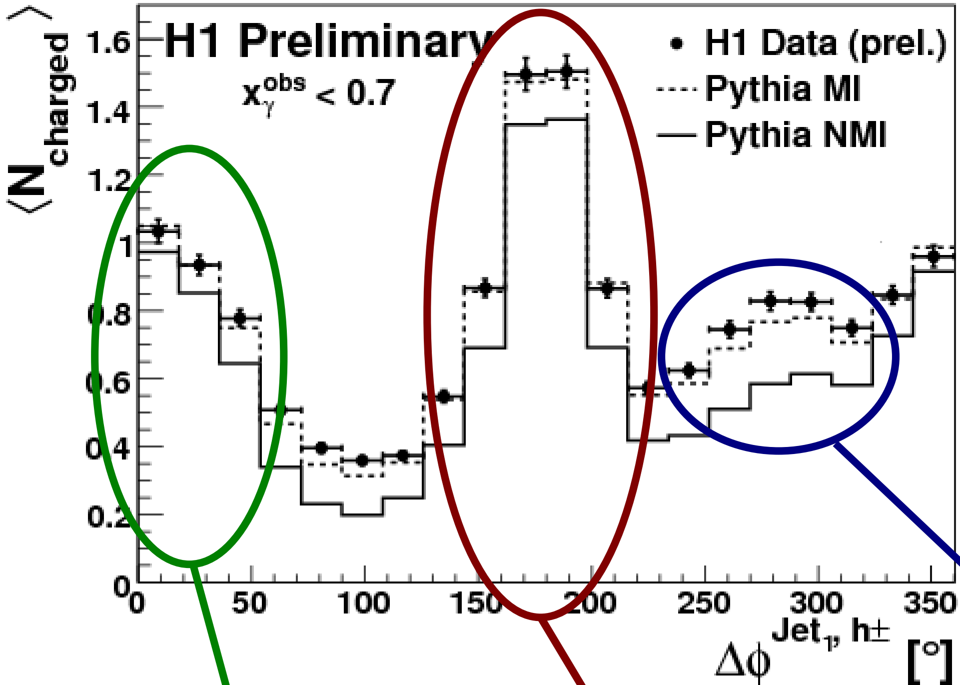
✗ Charge particle multiplicity as a function of the Δϕ between the leading jet and the charged particles

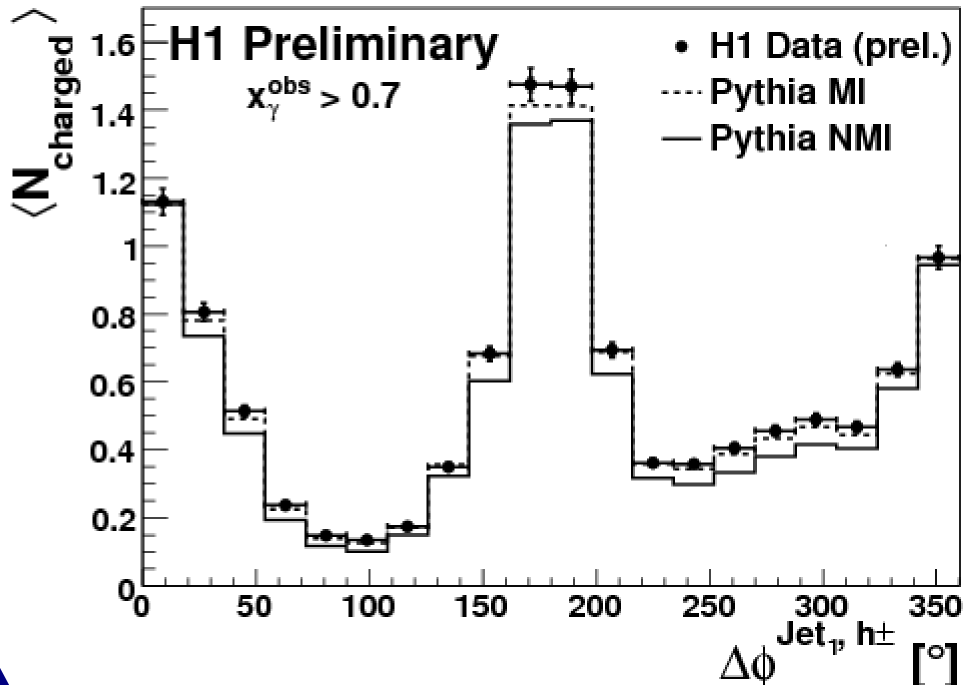




Charged particle multiplicity

✗ Charge particle multiplicity as a function of the $\Delta\phi$ between the leading jet and the charged particles





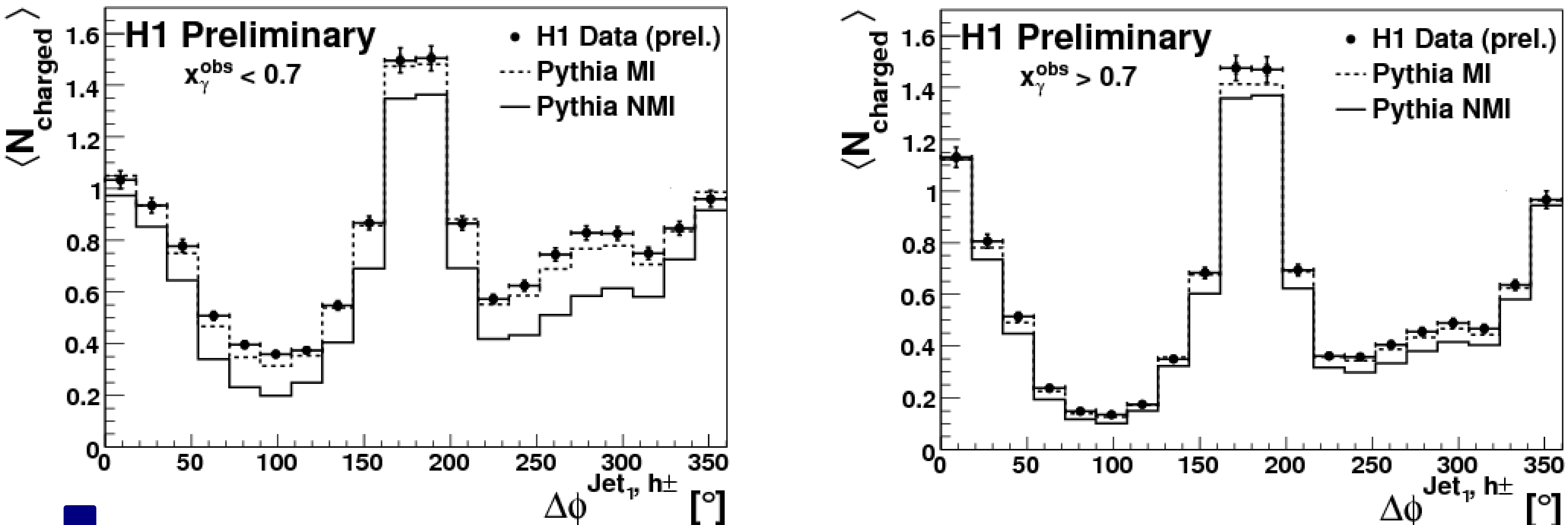
High activity transverse region

Leading jet: toward region

Second jet (usually)

Charged particle multiplicity

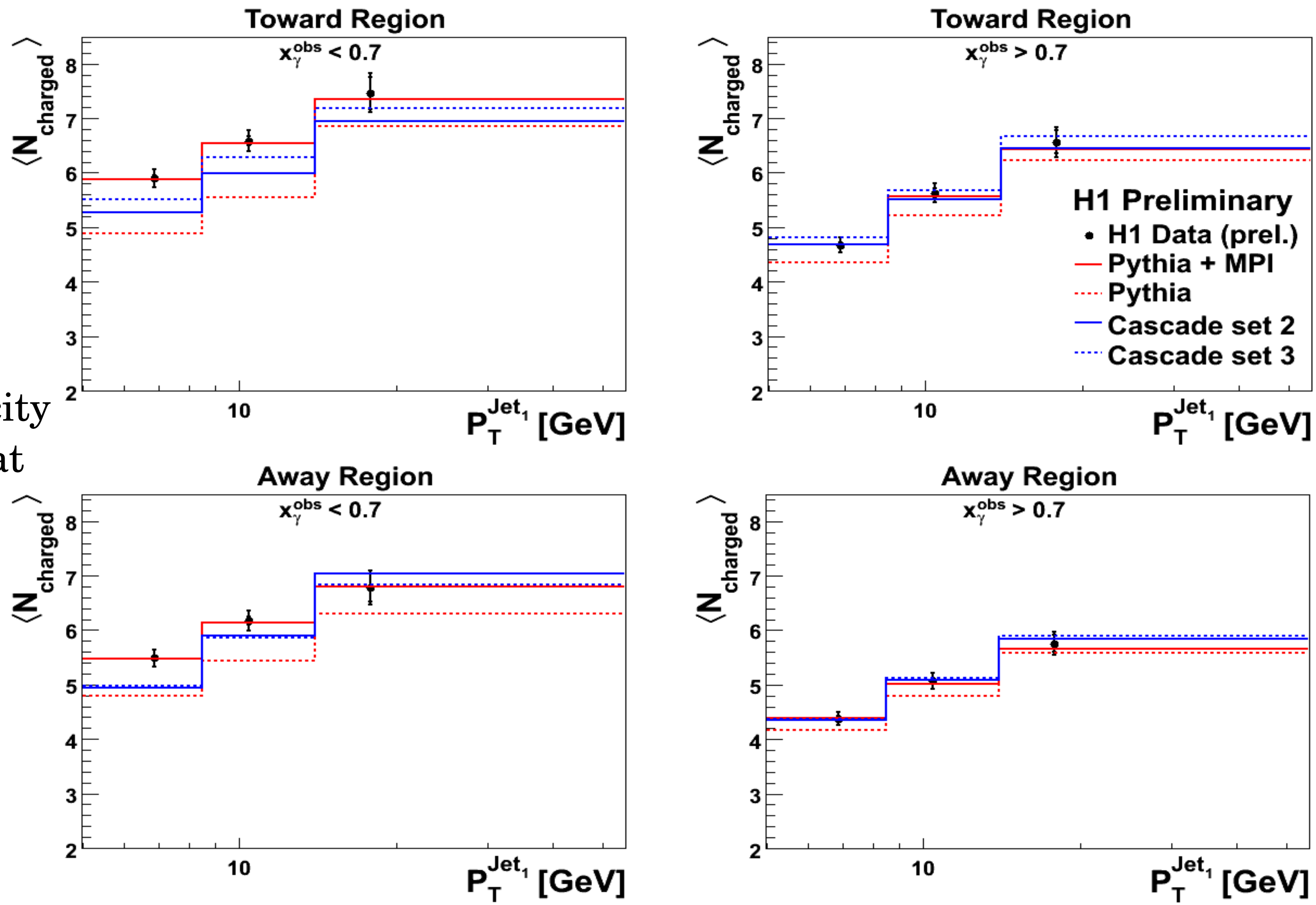
✗ Charge particle multiplicity as a function of the $\Delta\phi$ between the leading jet and the charged particles



Pythia describes data only when including MPI effects

It looks as a pedestal over the $\Delta\phi^{Jet1,h\pm}$ but…it is not so simple…

Charged particle multiplicity

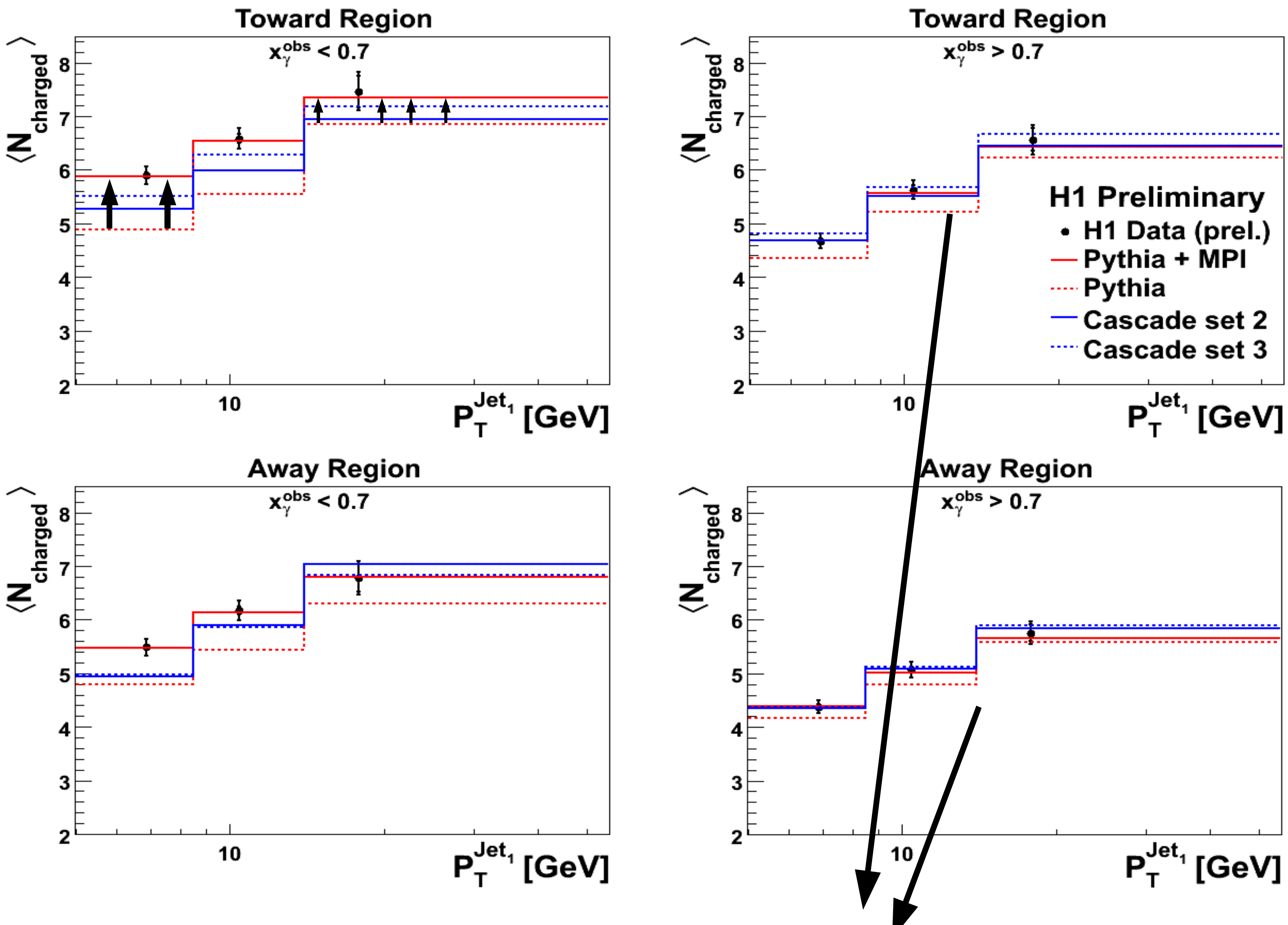


Higher multiplicity at $X_\gamma < 0.7$ than at higher values

Multiplicity increases with P_T^{Jet1}

Charged particle multiplicity

MPI contributes more at low P_T^{Jet1} as seen by Pythia



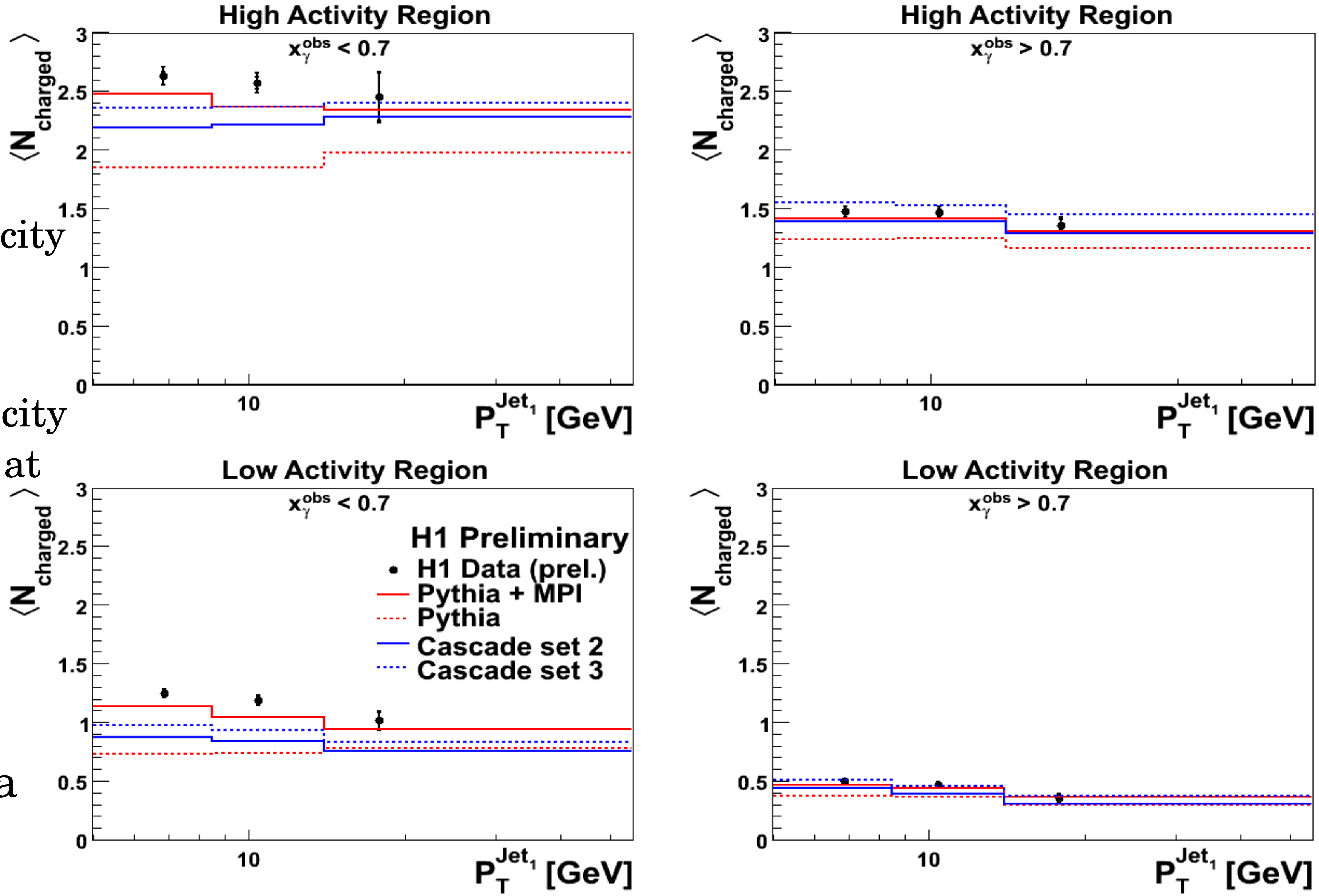
The models do not differ very much among each other at $X_\gamma > 0.7$

Charged particle multiplicity

At Xγ<0.7 the largest multiplicity is predicted by Pythia MPI

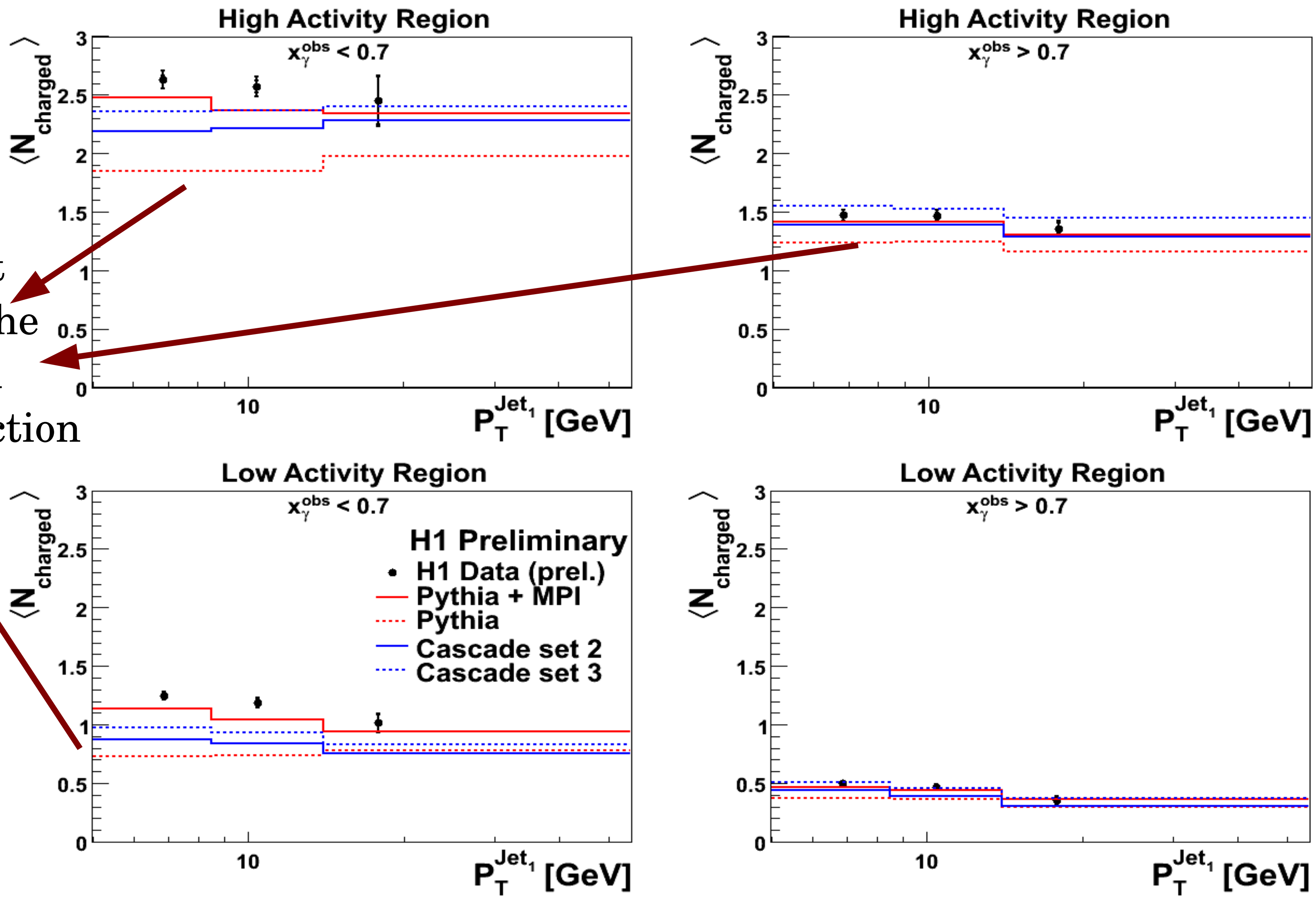
Higher multiplicity at Xγ<0.7 than at higher values

Pythia + MPI describes data best

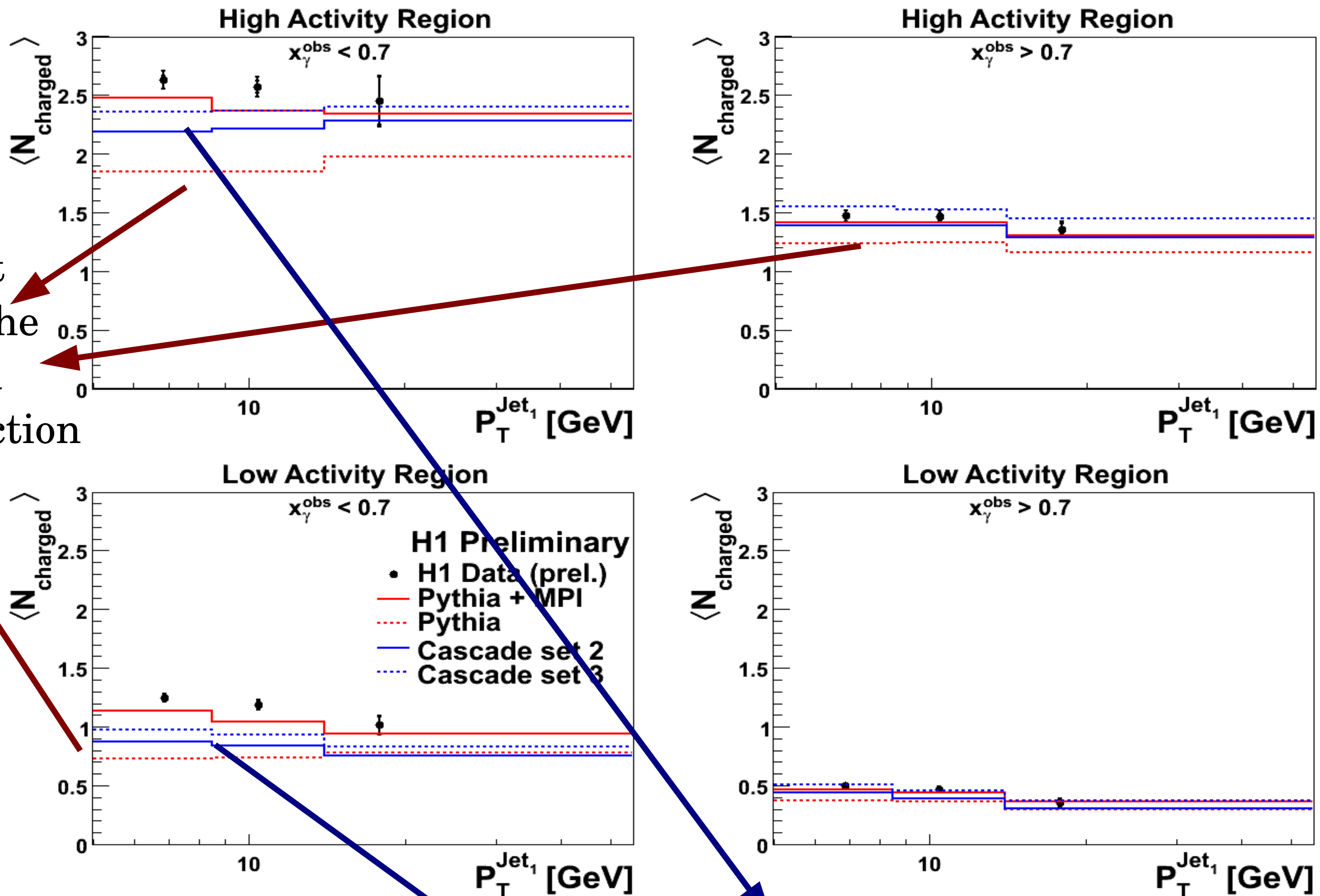


Charged particle multiplicity

Pythia without MPI predicts the lowest charged particle production in all regions



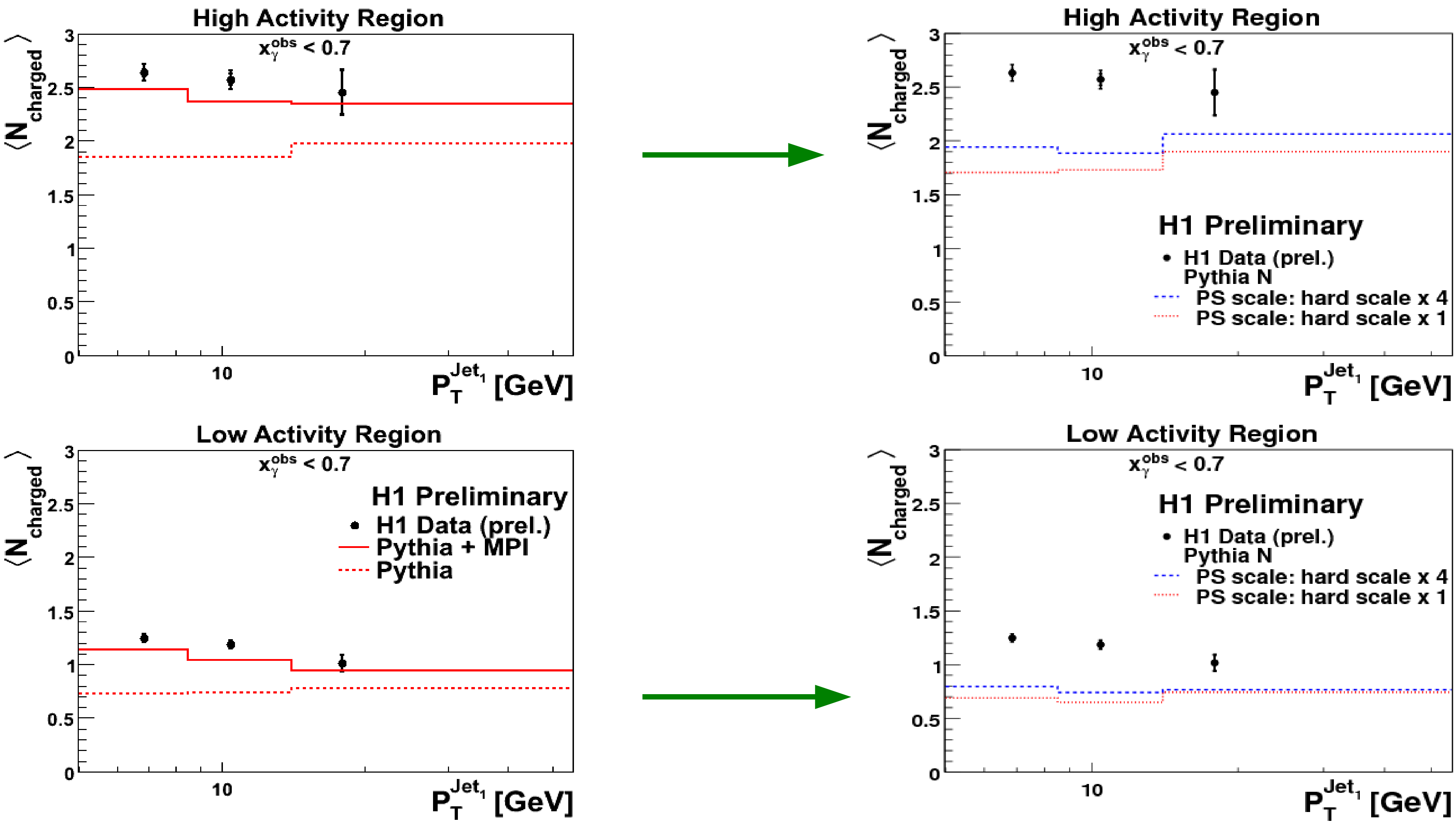
Charged particle multiplicity



Pythia without MPI predicts the lowest charged particle production in all regions

Cascade predicts a charged particle multiplicity lower than data at $X\gamma < 0.7$

Charged particle multiplicity

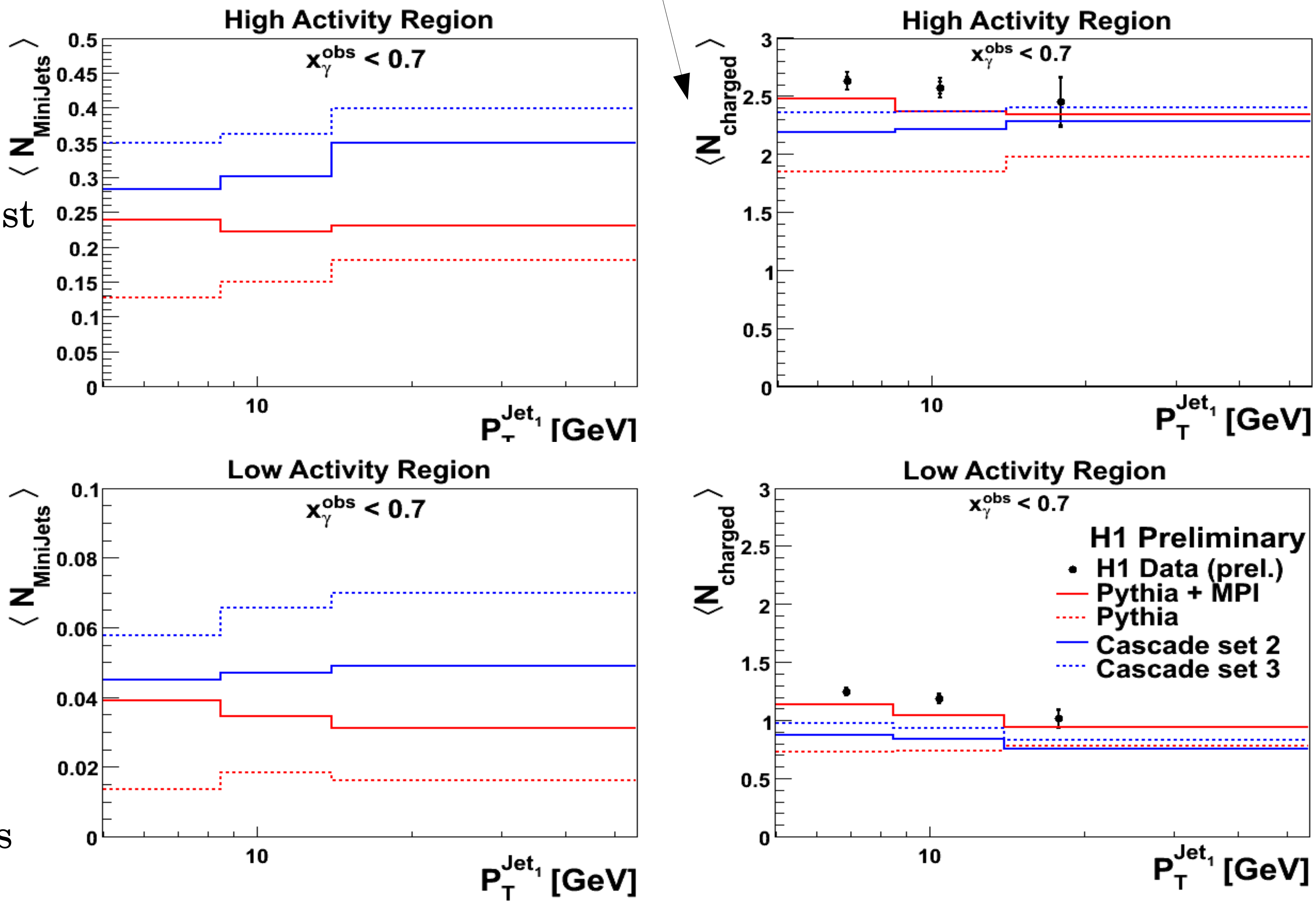


DGLAP is not able to really produce more activity without MPI

minijet multiplicity

minijet defined as P_T^{jets} >3.5 GeV

charged particles



Here, the largest multiplicity is predicted by Cascade

Very large differences among all predictions for minijet analysis

→minijets is a good observable to be analyzed.

Summary

✔ Soft MPI:

✔ Charged particle multiplicity in photoproduction

Charged particle multiplicity outside the hard interaction not described without MPI (although CASCADE…)

✔ Semi-soft:

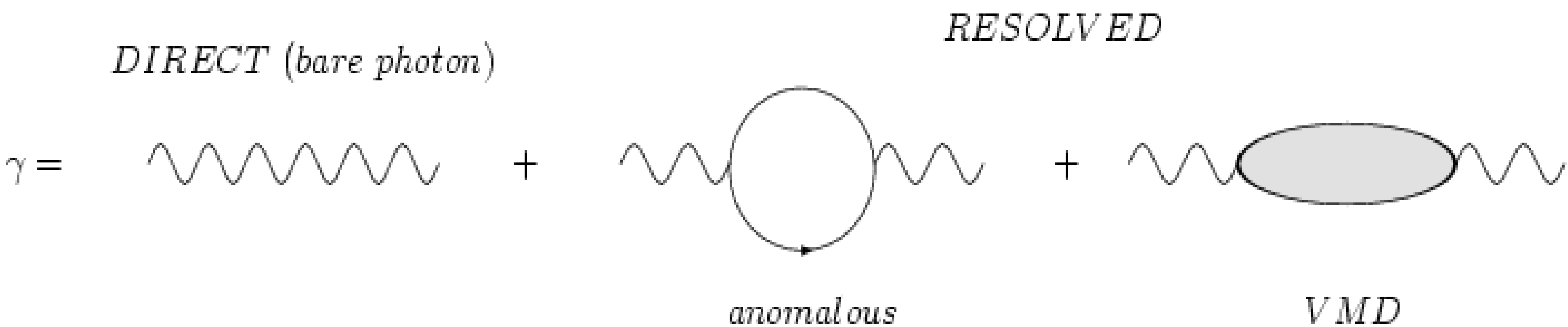
✔ Low P_T jets

Very promising observable to study the MPI and the UE. Minijets in photoproduction can provide supplementary information

Need to improve MC: improve PS (CASCADE) and MPI?

Thanks for your attention

✗ in photoproduction the photon lives enough to develop a complicated hadronic structure.

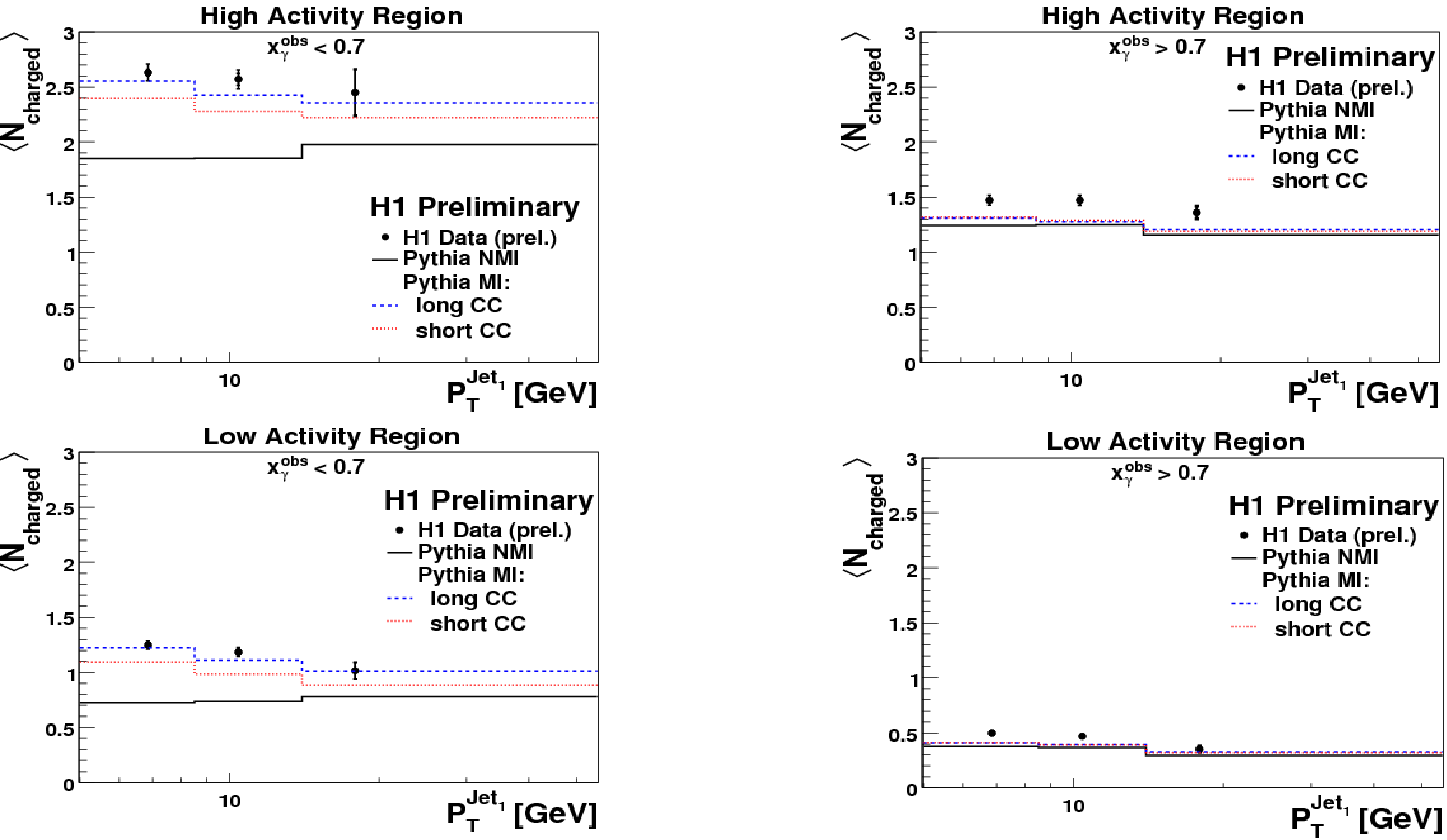


photon energy fraction to enter in the hard interaction

$$x_\gamma^{obs} = \frac{\sum_{i=1}^{N_{jets}} E_T^{jet_i} e^{-\eta^{jet_i}}}{2 E_\gamma}$$

- high values correspond to point-like photons
- low values correspond to hadron-like photons

HERA present: Charged particle multiplicity



- ✗ MPI contributes more at low P_T^{Jet1} BUT not as just a pedestal since it decreases with increasing P_T^{Jet1}