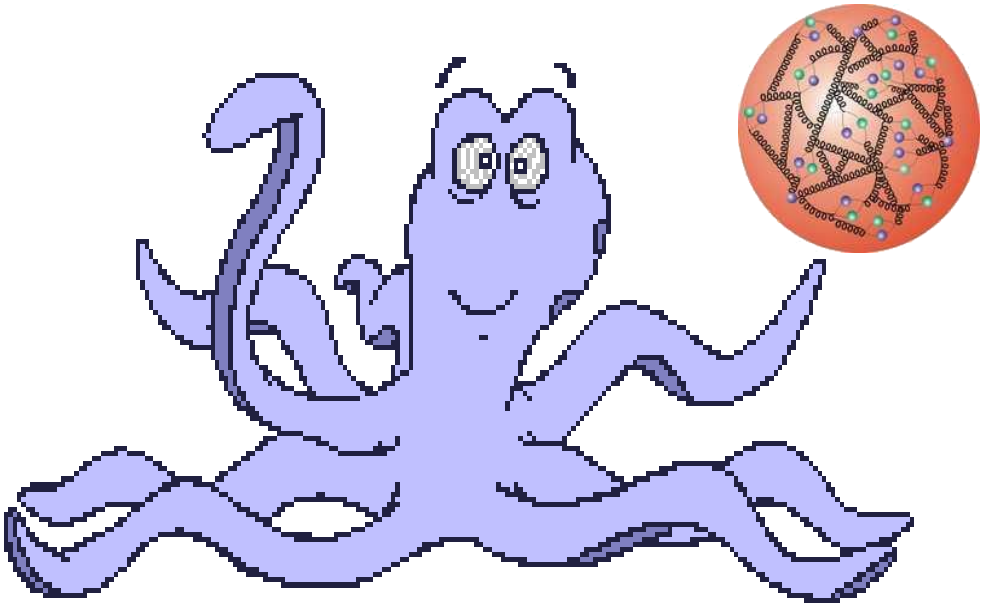
Multiple Parton Interactions in Photoproduction at H1 at HERA.



Lluís Martí Magro (DESY)

DPG, Heidelberg. 7th of March, 2007.

Multiple Parton Interactions (MI)

Contents:

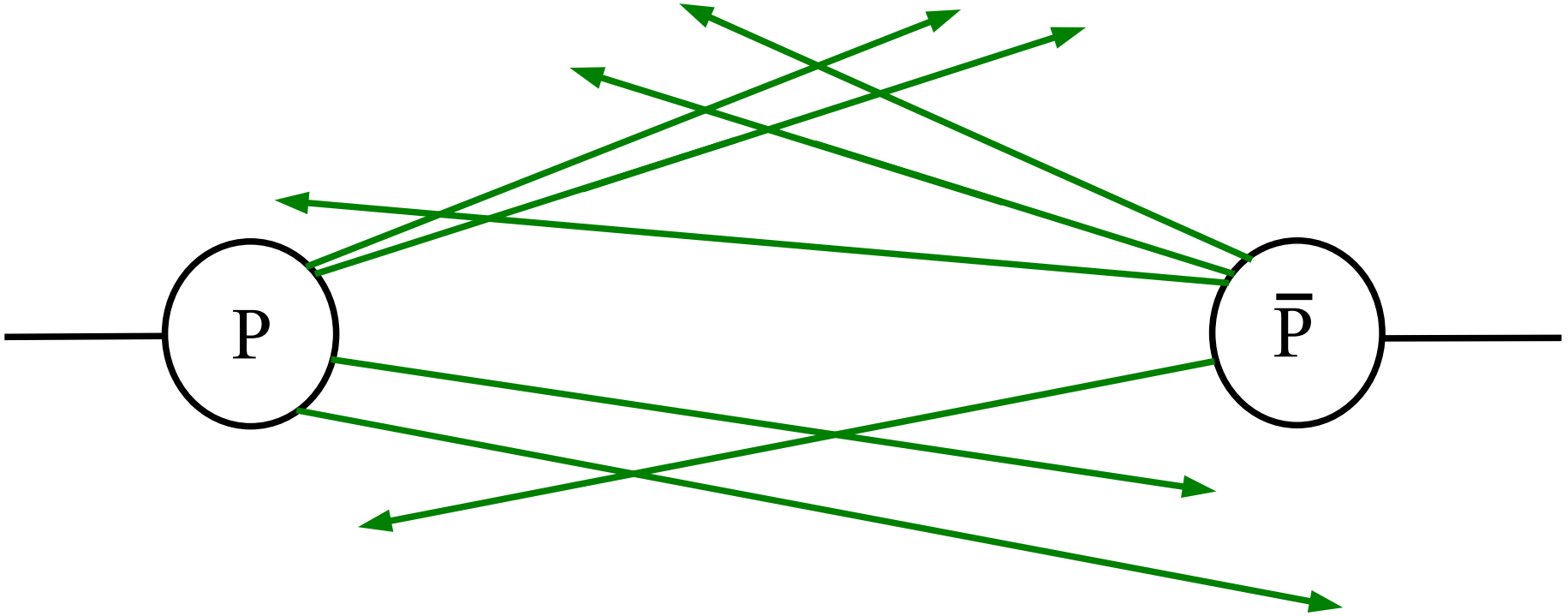
I. Introduction & motivation to MI (very short).

II. Sample definition: all inclusive flavour and charm in PhP.

III. New measurement at HERA, i.e. observable: multiplicity as a function of φ.

Introduction: hadron-hadron collision

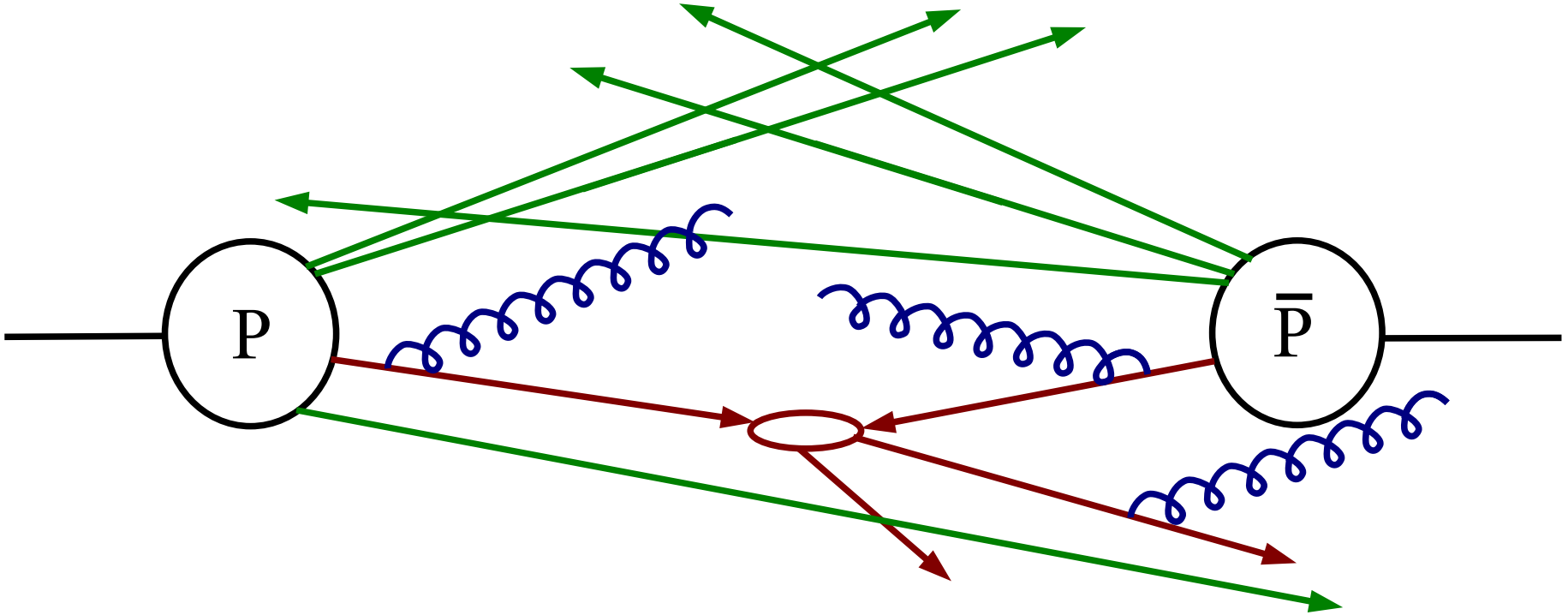
- "Minimum- Bias" event: only soft particles are produced.



No hard interaction ⟶ we cannot apply pQCD.

Introduction: hadron-hadron collision

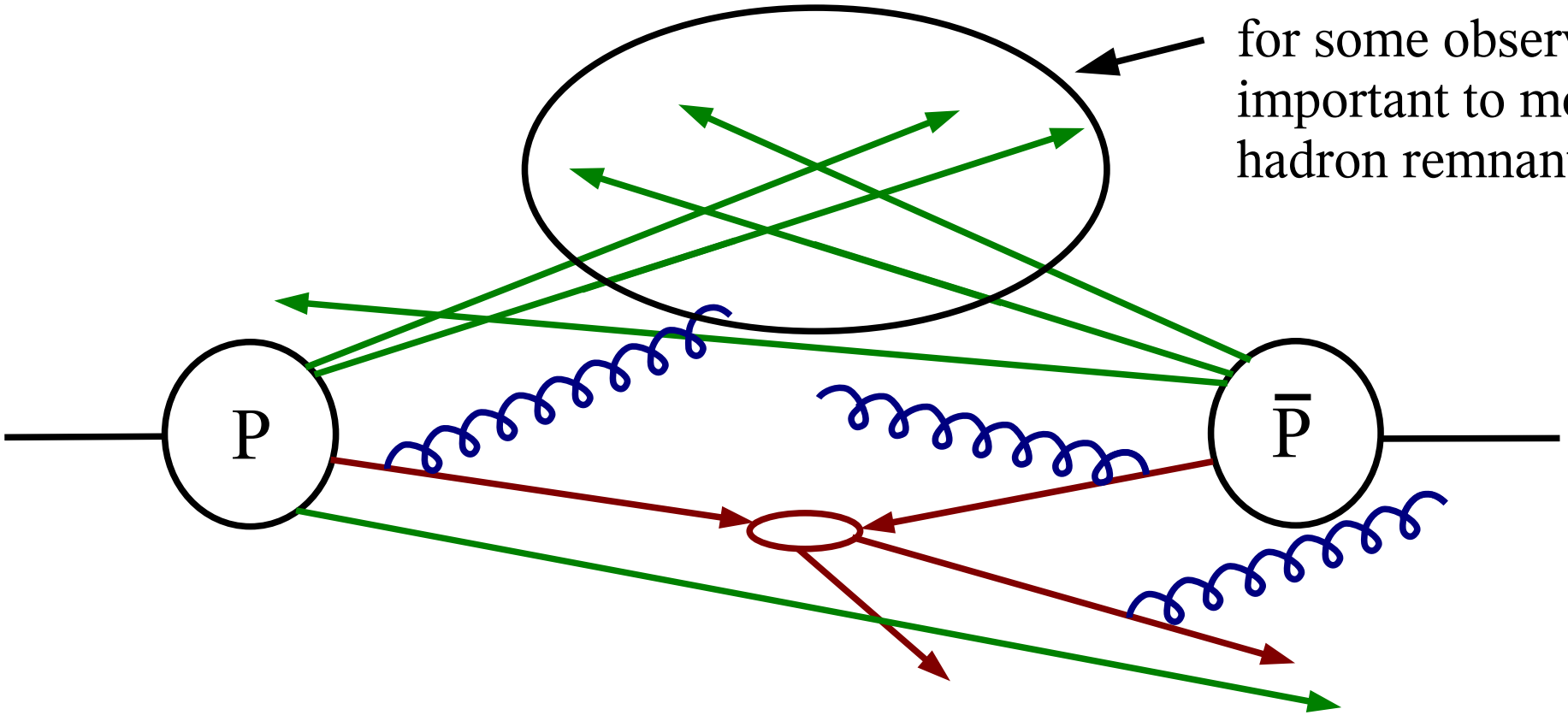
- Hard collision: apply pQCD



but there is also a soft (or maybe not so soft) component

Introduction: hadron-hadron collision

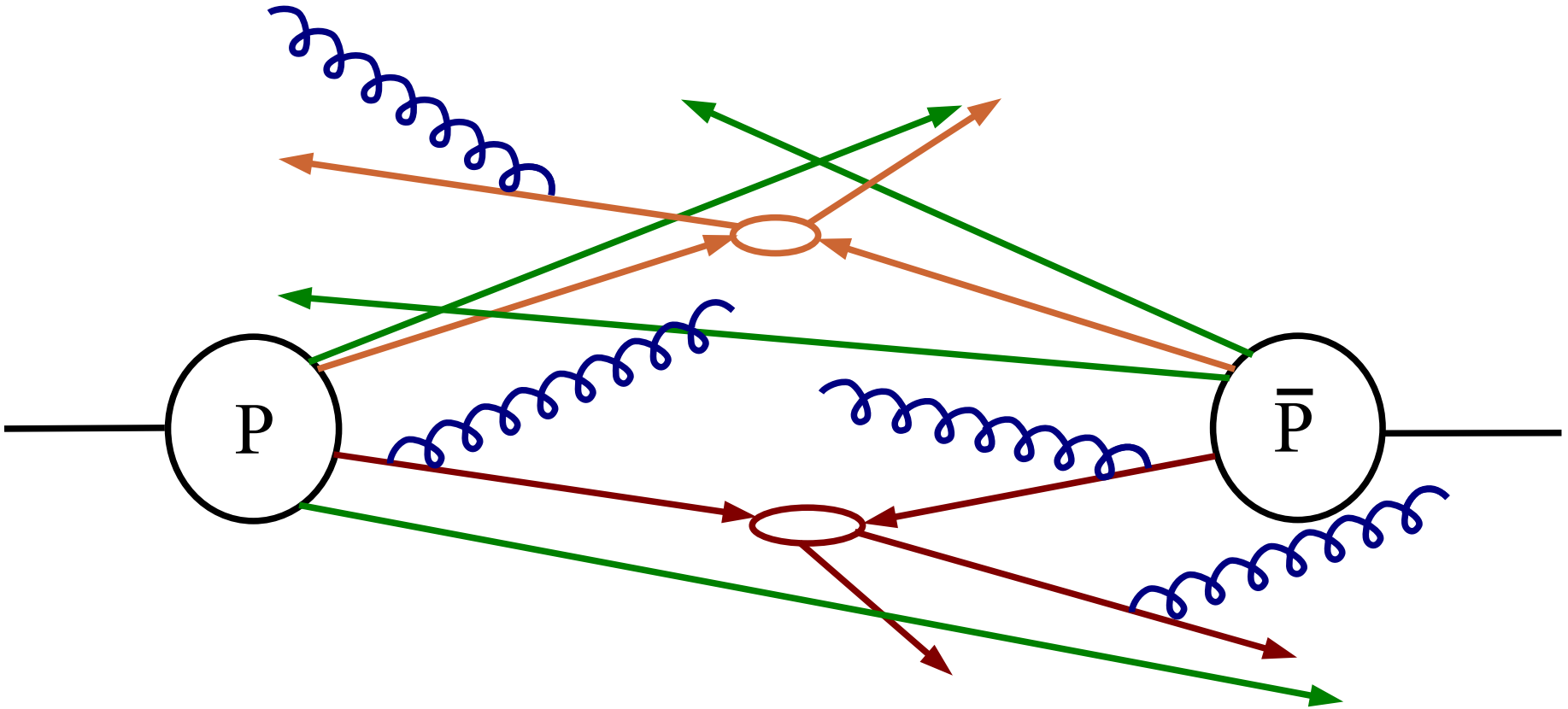
- Hard collision: apply pQCD



but there is also a soft (or maybe not so soft) component

Introduction: hadron-hadron collision

- MI: go down to low transverse momenta (as far as possible) and model the remnants.



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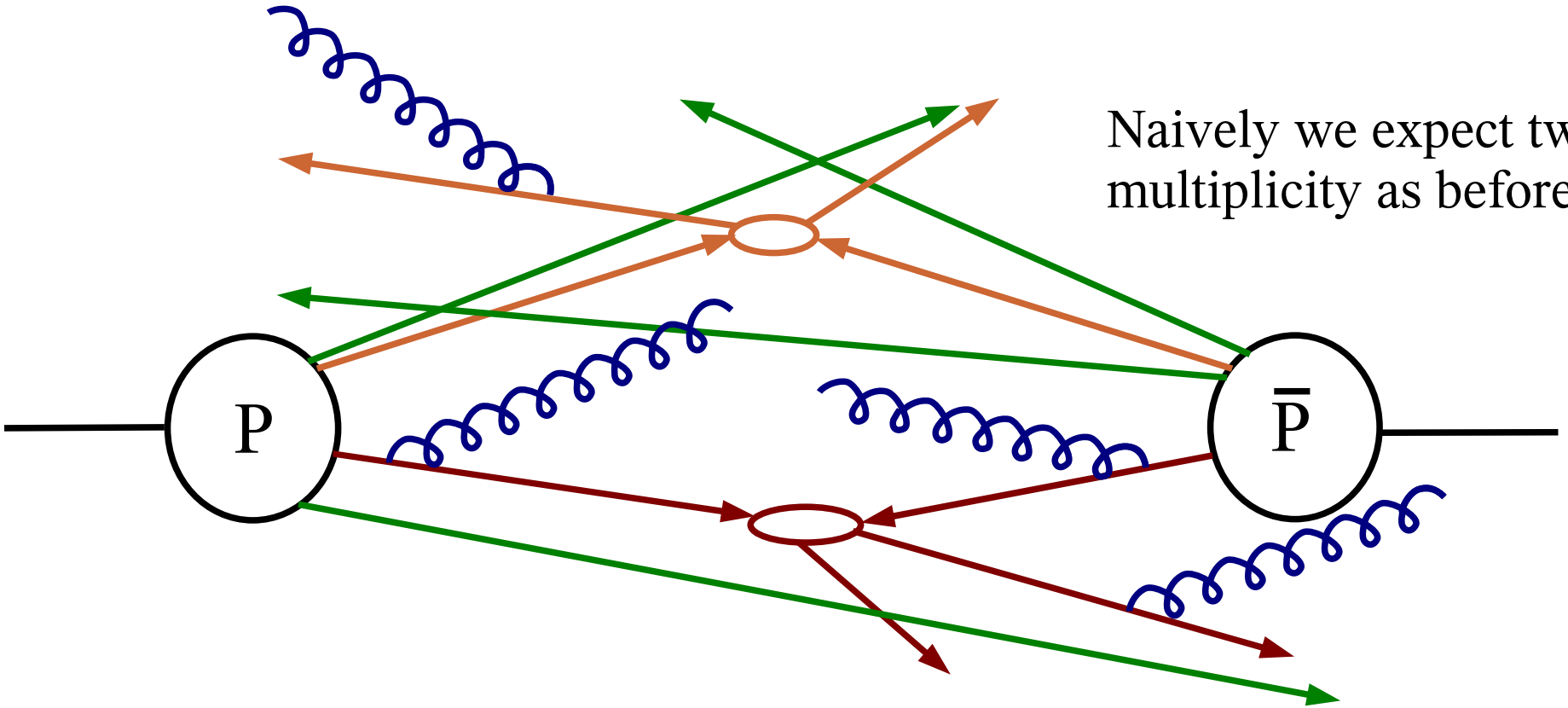
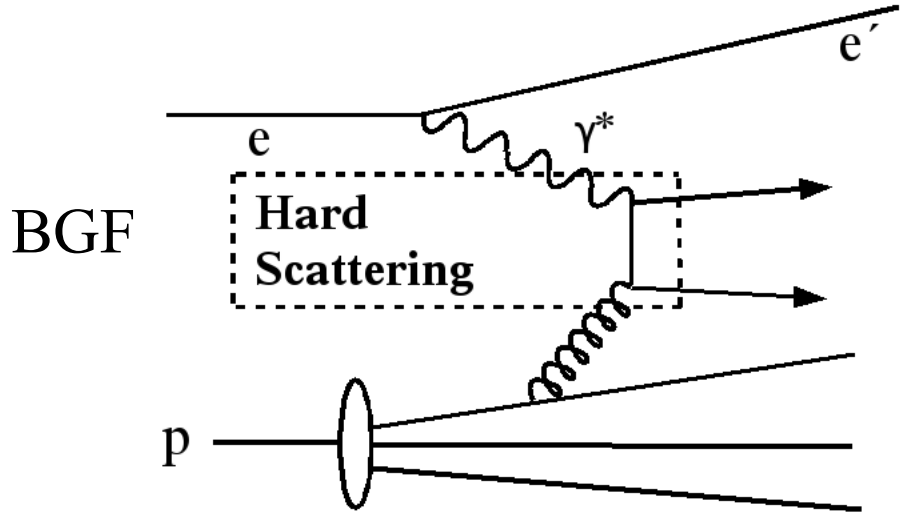
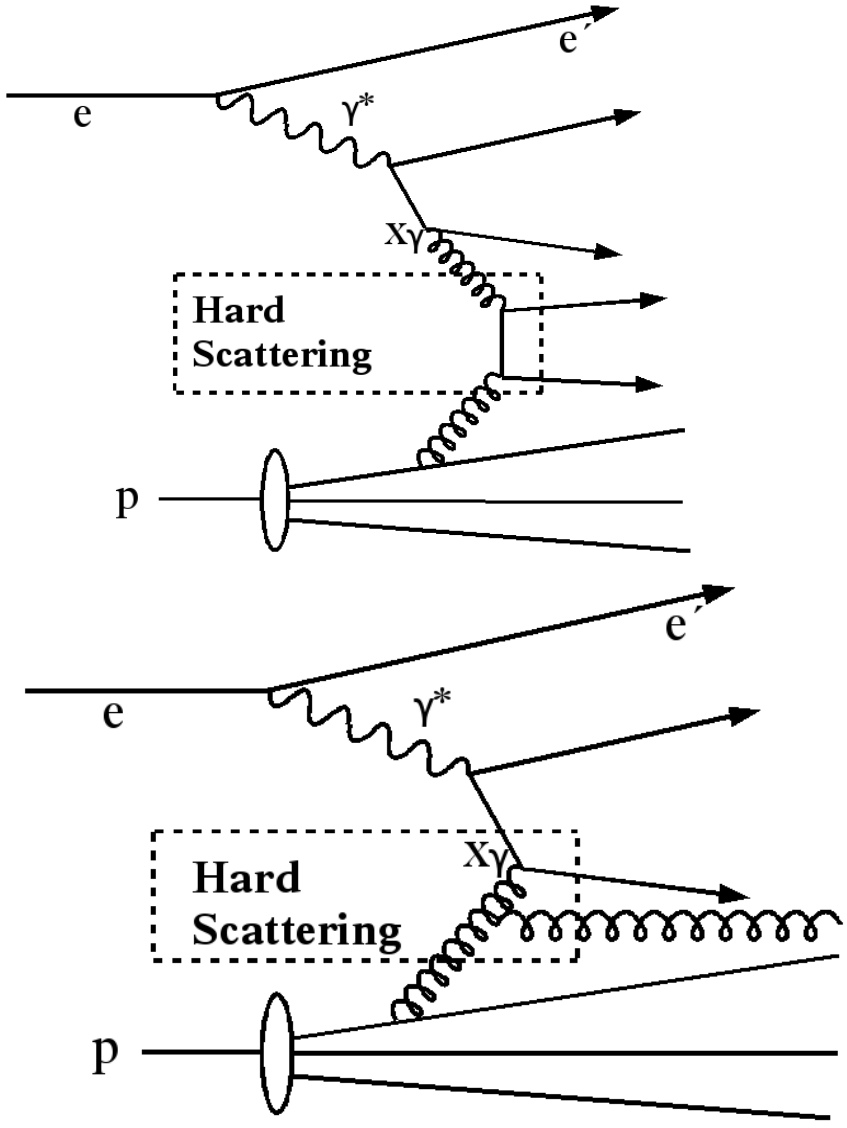


the question is how to do it....

Introduction: Pythia

Three types of events are generated: BGF (direct), resolved and excitation events.





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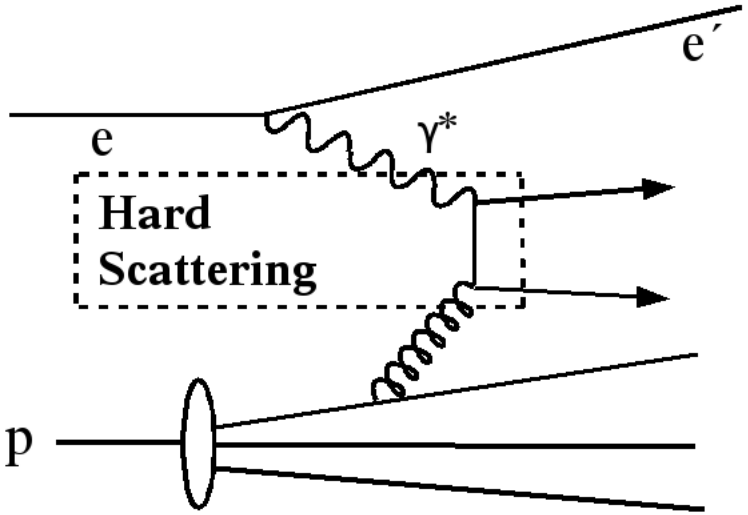
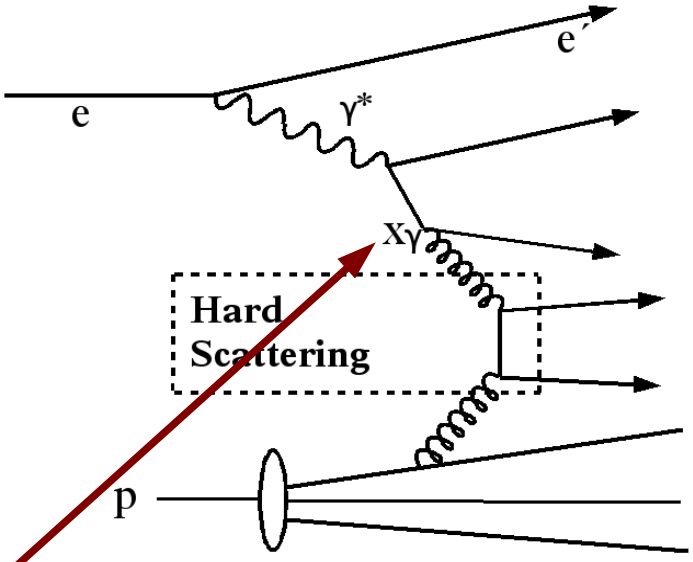
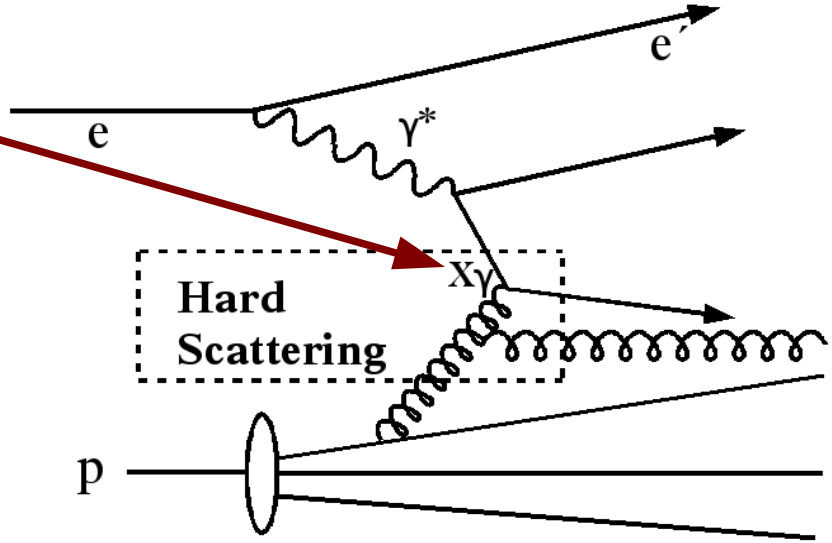
BGF







$$x_\gamma^{obs} = \frac{\sum_{h\in Jet1}(E-p_z)+\sum_{h\in Jet2}(E-p_z)}{\sum_h (E-p_z)}$$

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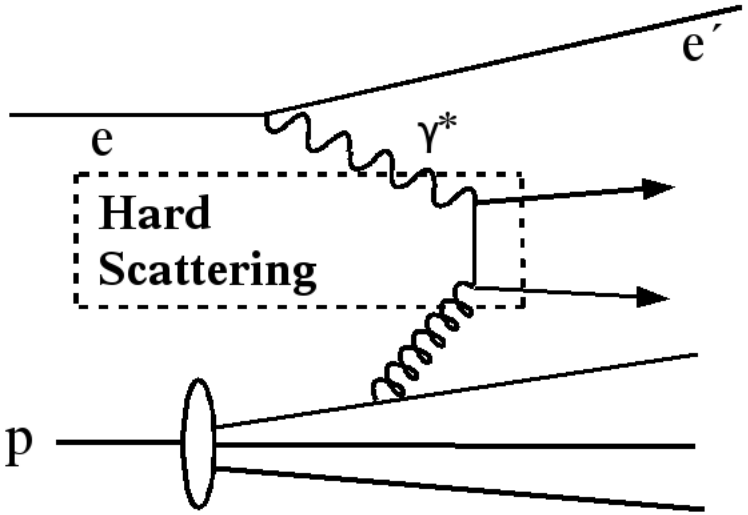
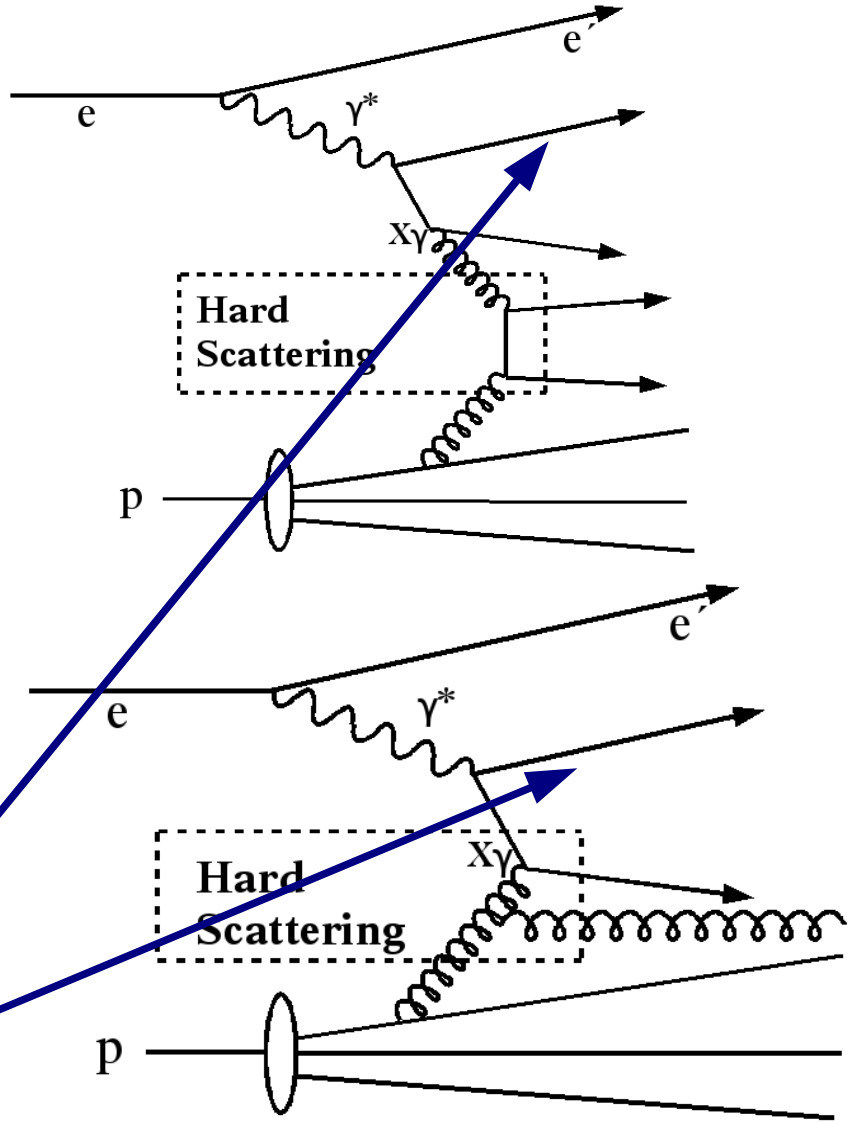
BGF



$$x_\gamma^{obs} = \frac{\sum_{h\in Jet1}(E-p_z)+\sum_{h\in Jet2}(E-p_z)}{\sum_h (E-p_z)}$$

Photon remnants like in hadron-hadron collisions



Sample selections

Event Selection:

- Common selection: photoproduction
- DiJet sample with: $P_t > 7(6)$ GeV, $|\eta| < 1.5$ — Kt clustering algorithm (pt weighted recom. scheme)
- Charm sample:

  Muon $P_t > 2.5$ GeV, $|\eta| < 1.5$

The highest P_t Jet is the "Leading Jet"

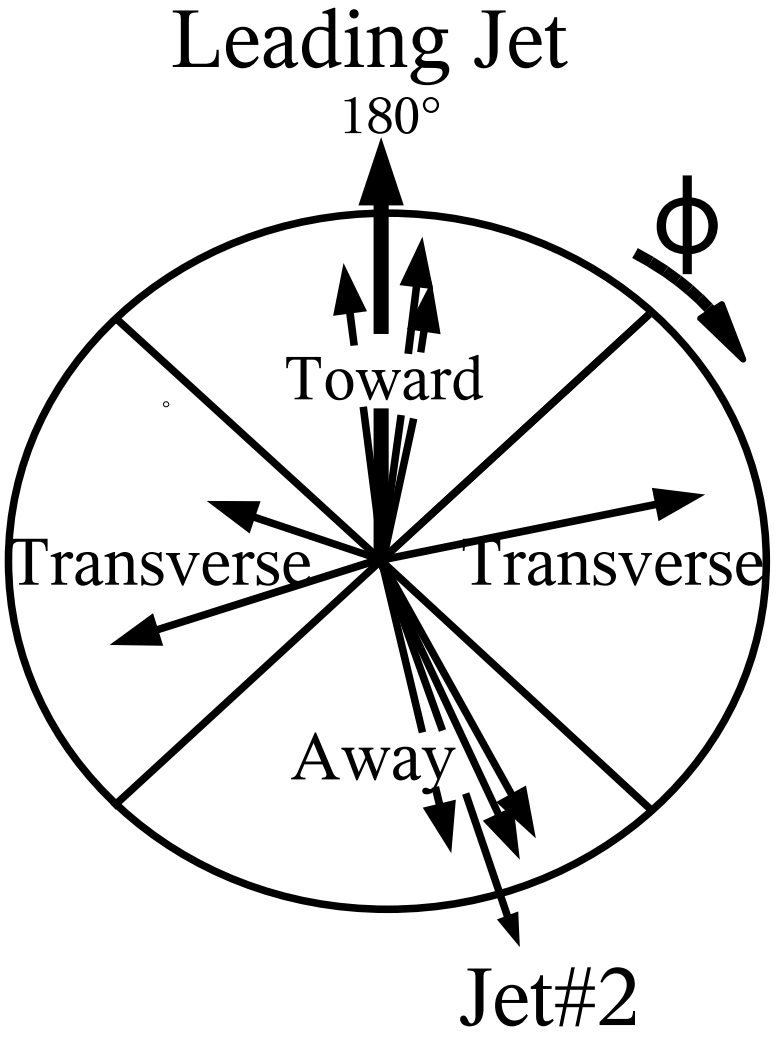
Observables

Particle Multiplicity: average number of measured particles per event as a function of φ.

- Charged particles:
  - with $P_t > 150$MeV and $|\eta| < 1.5$

We define three regions:

- Toward: $120° < |\varphi|$
- Transverse: $60° < |\varphi| < 120°$
- Away: $|\varphi| < 60°$



Multiplicity

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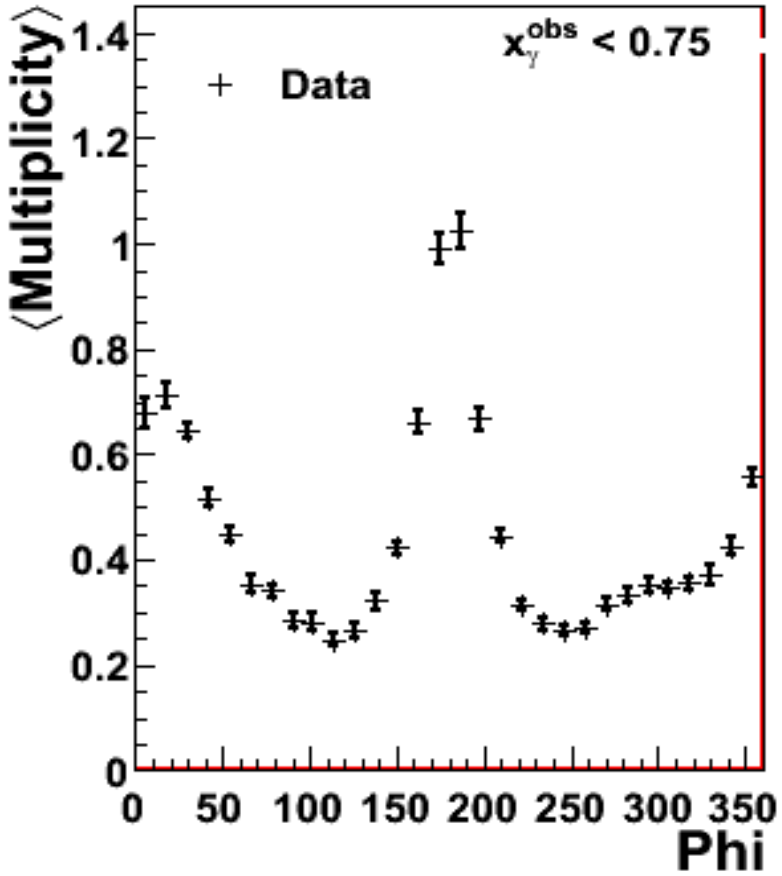

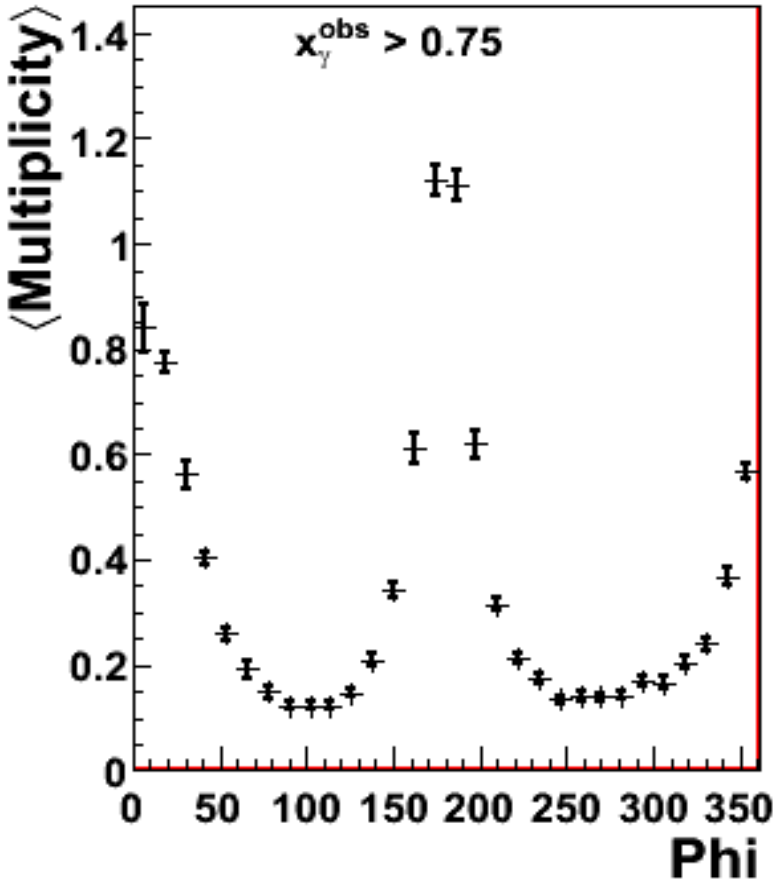

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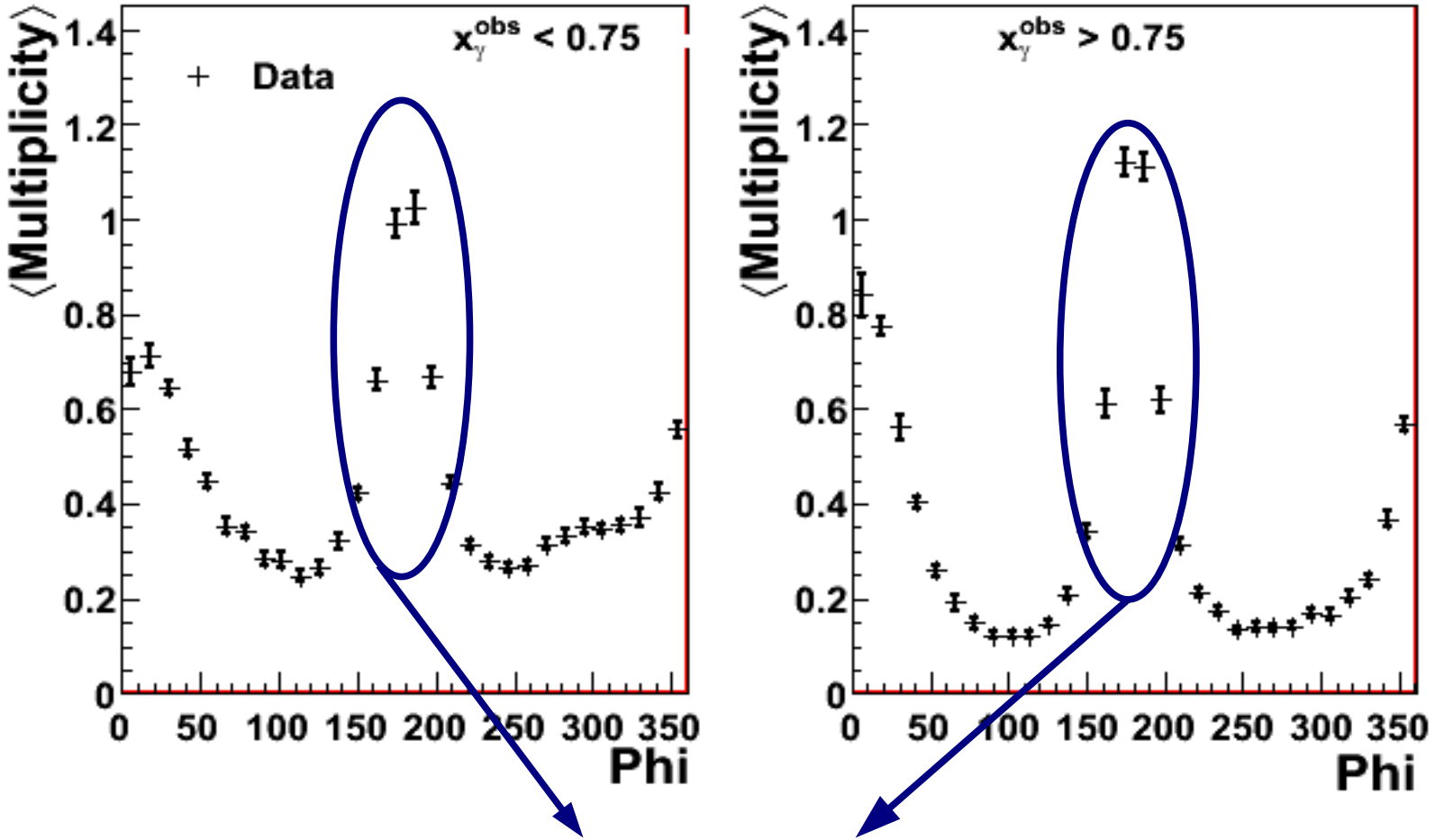

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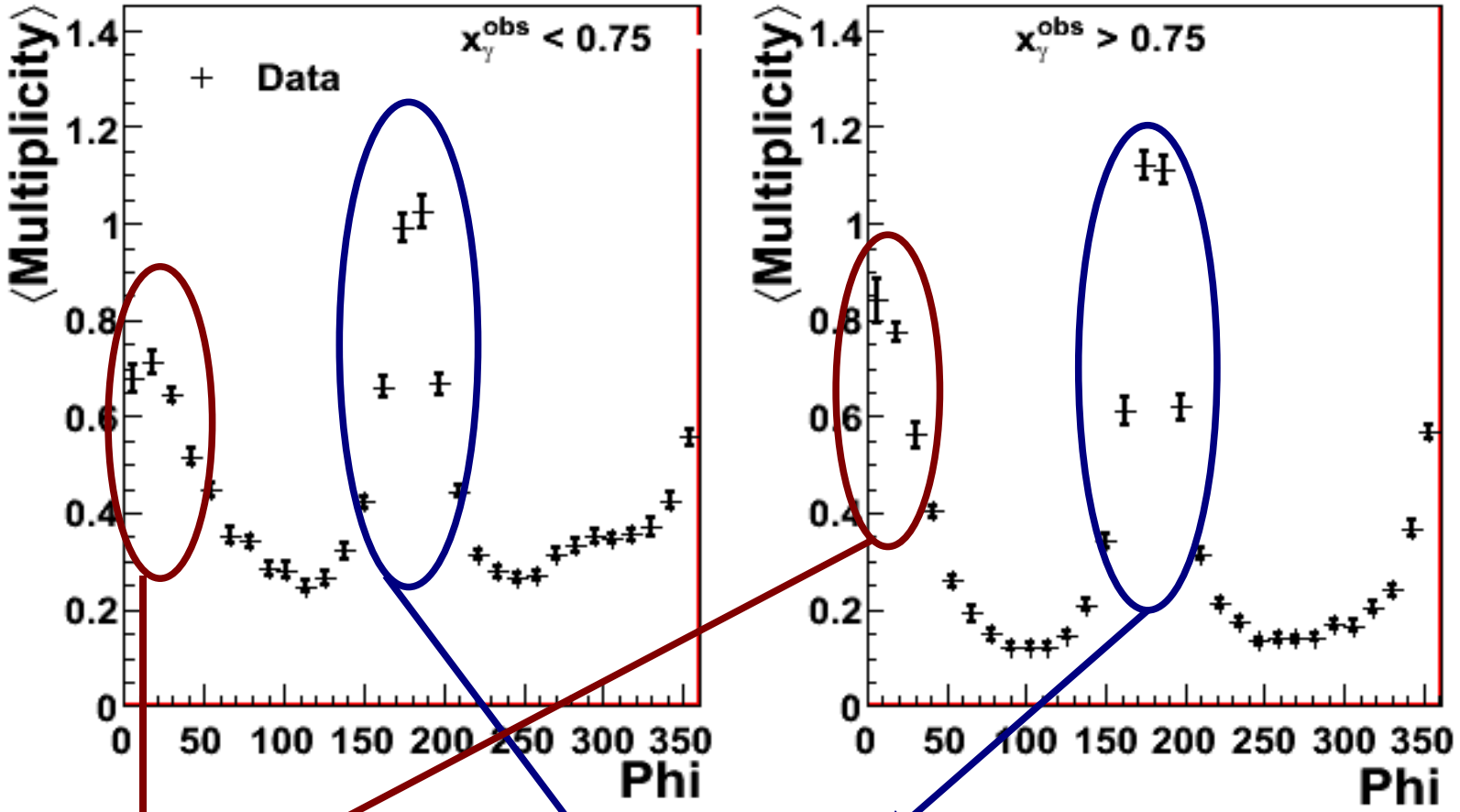

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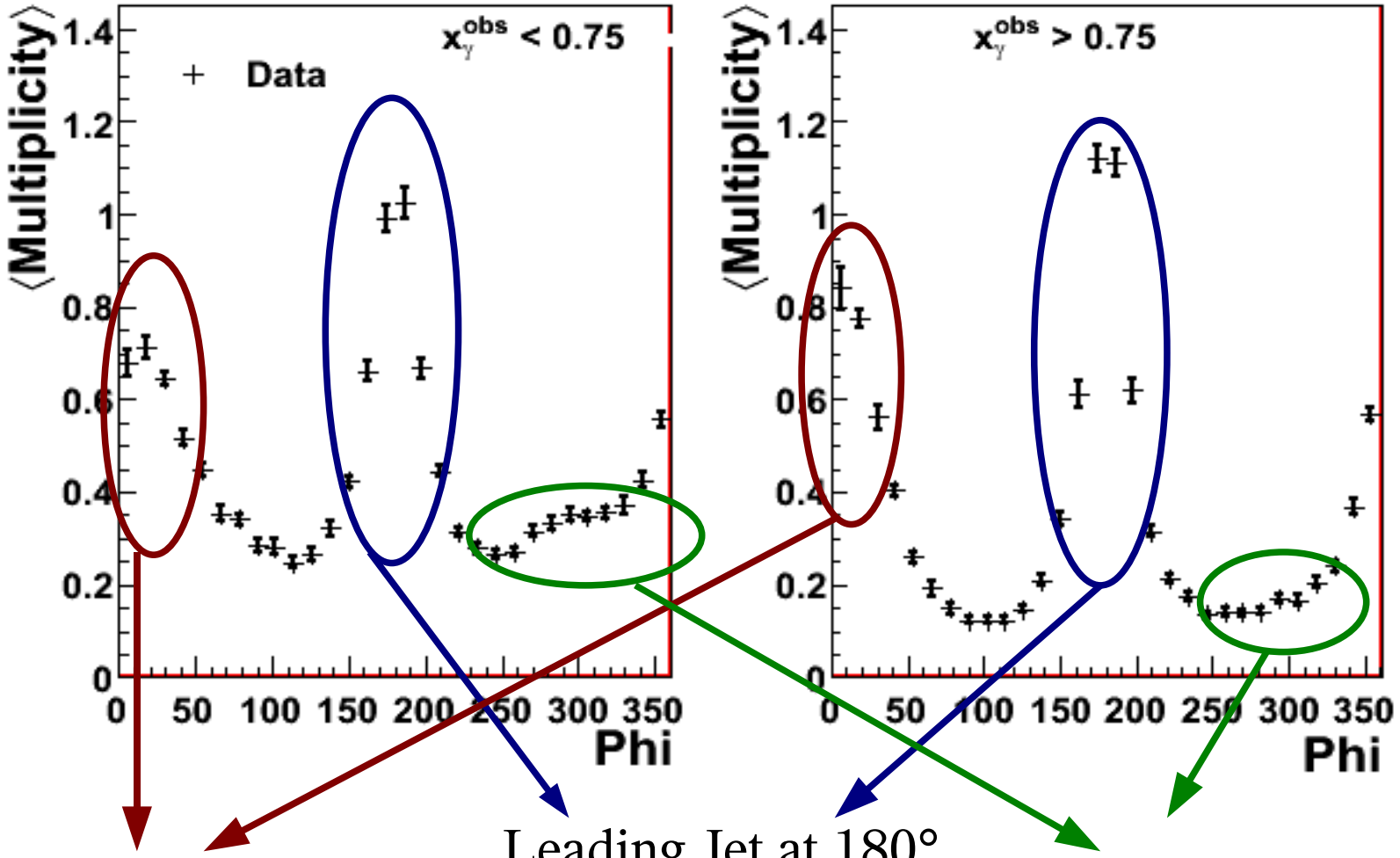


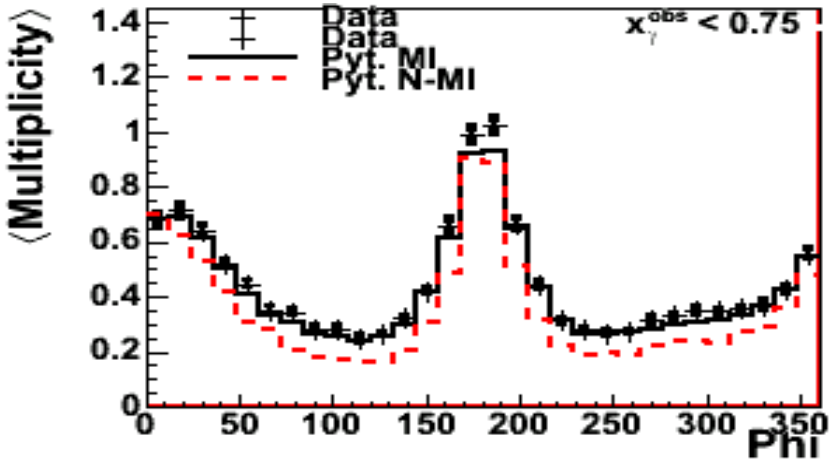
Second Jet axis

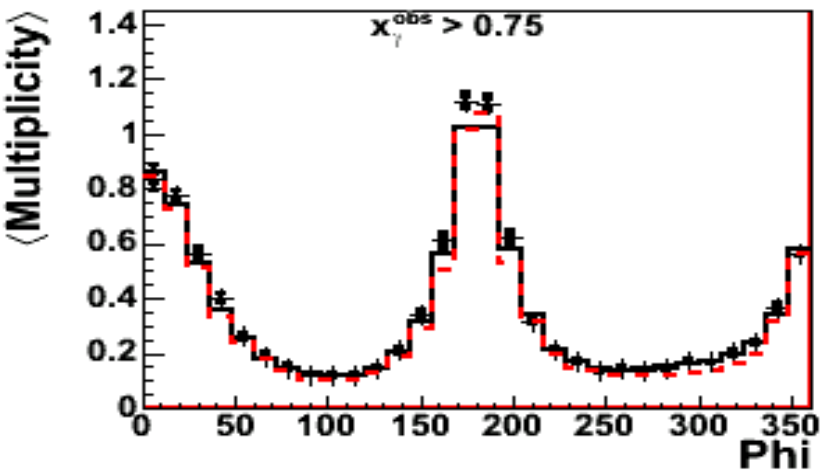
Leading Jet at 180°

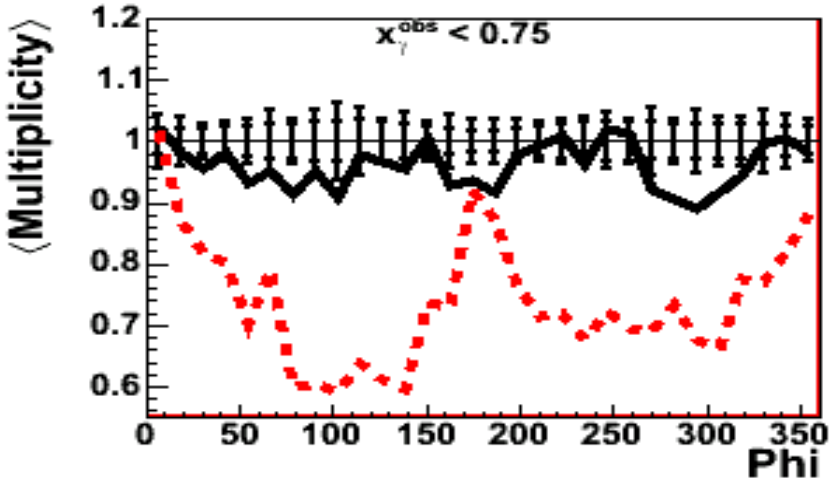
shoulder from 3th jets and hard radiation.

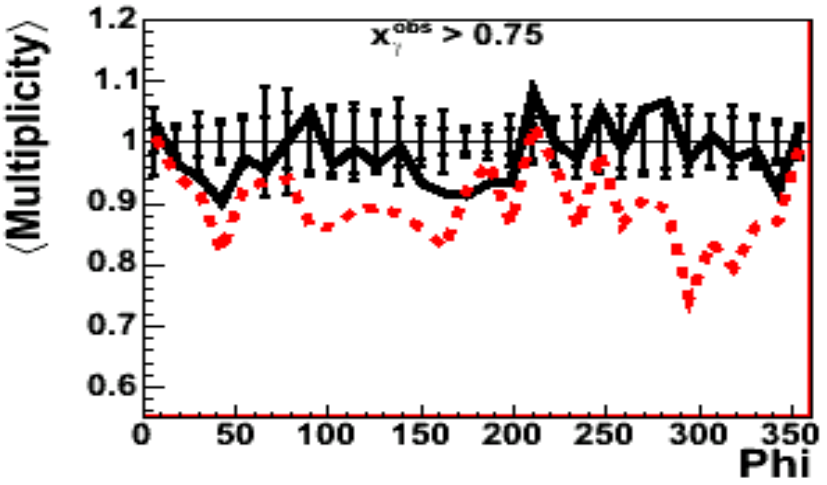
Dijet sample track multiplicity

Particle multiplicity: Average number of measured particles per event.









Dijet sample track multiplicity

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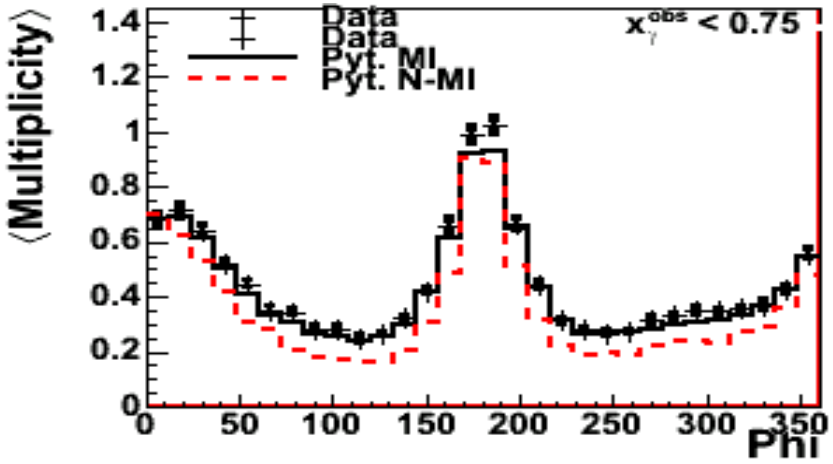
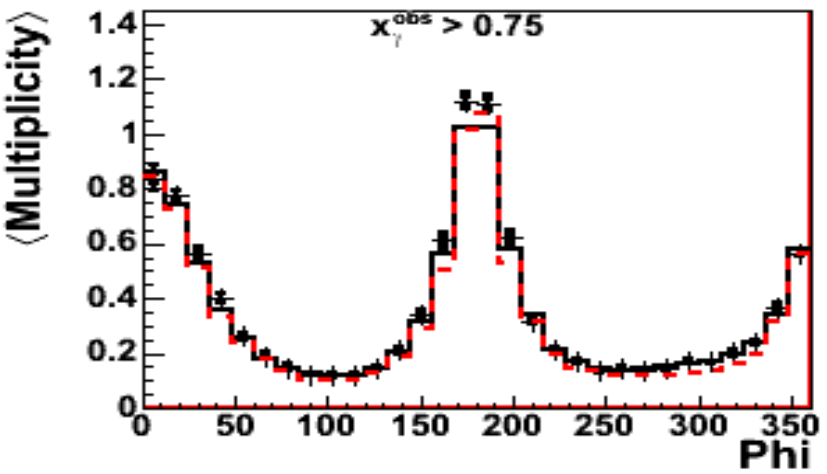
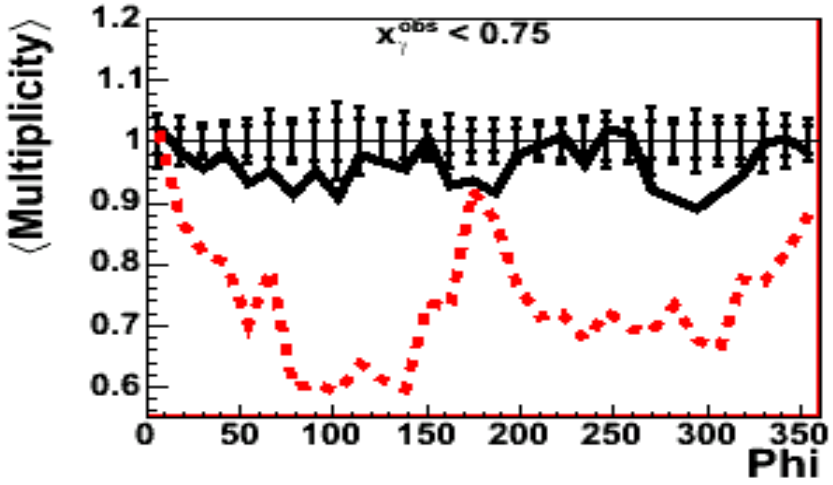
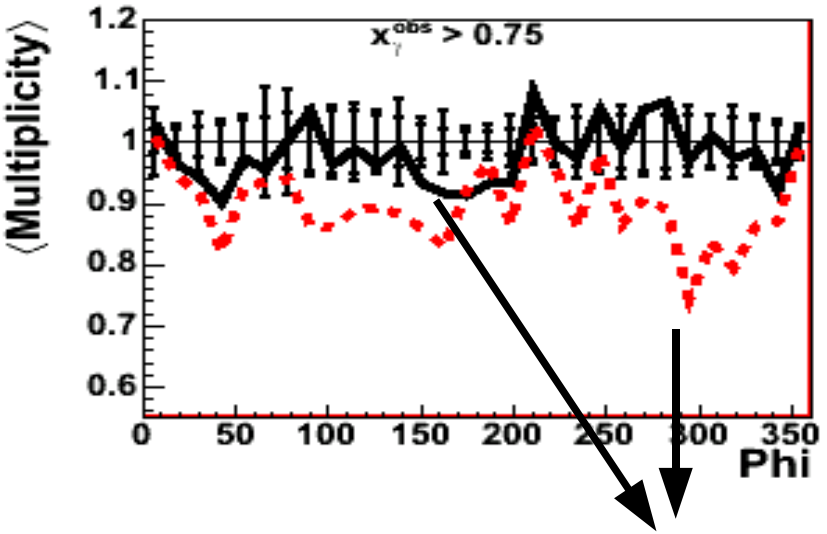




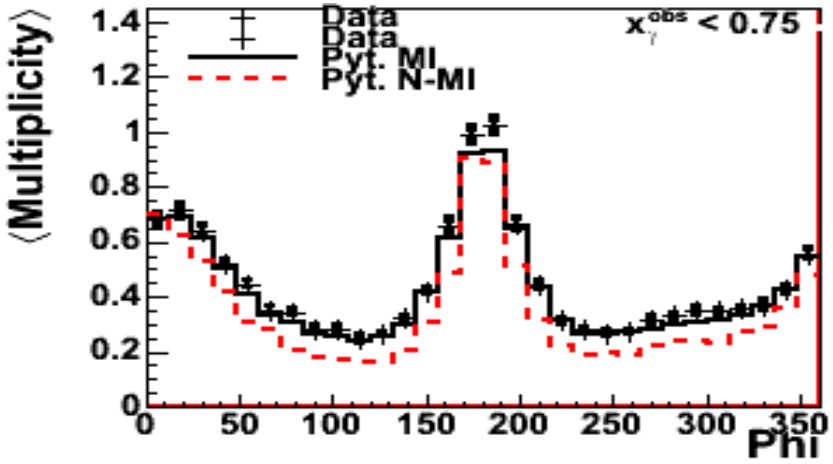


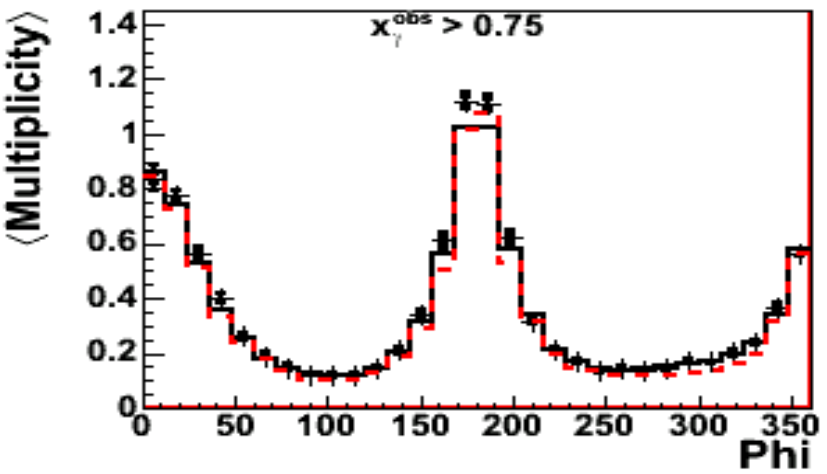


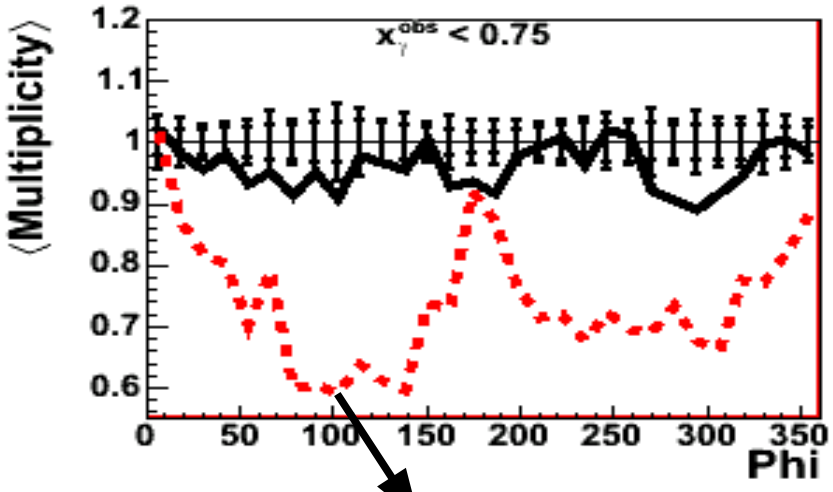
Ratio Data/MC

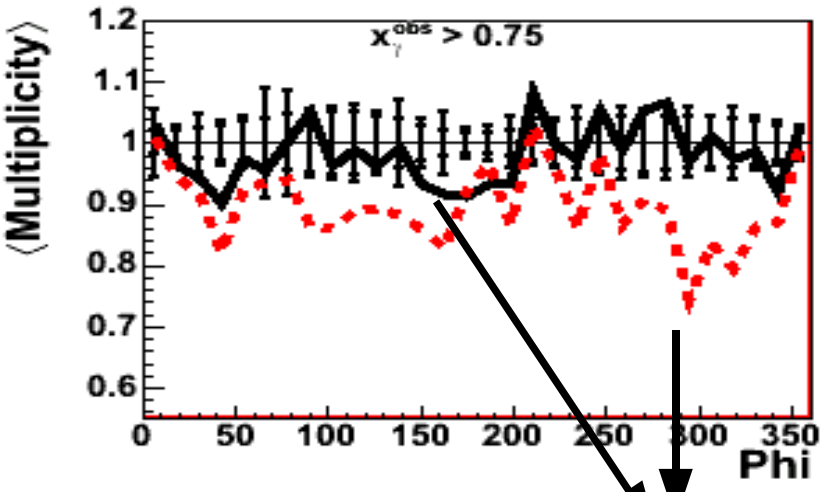
Dijet sample track multiplicity

Particle multiplicity: Average number of measured particles per event.









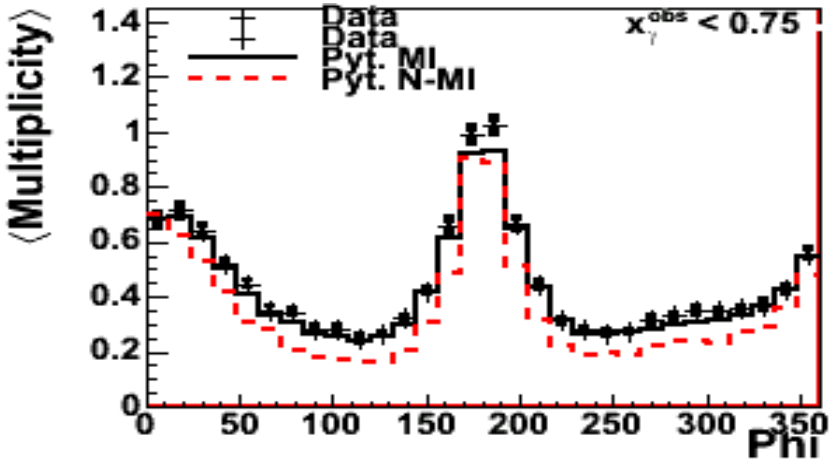
~6σ between data and Pythia w/o MI

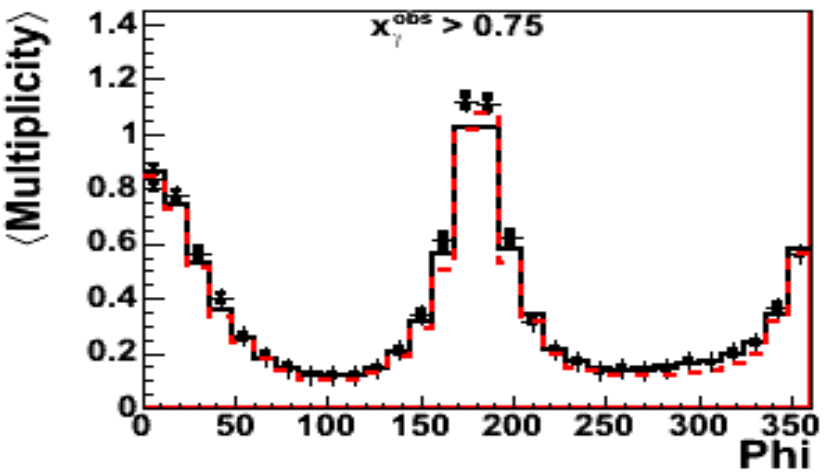
Total uncertainty is less than 10%

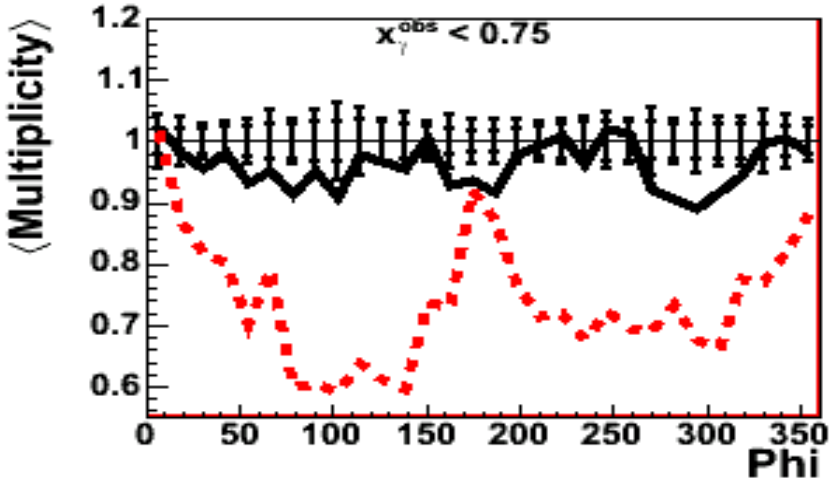
Ratio Data/MC

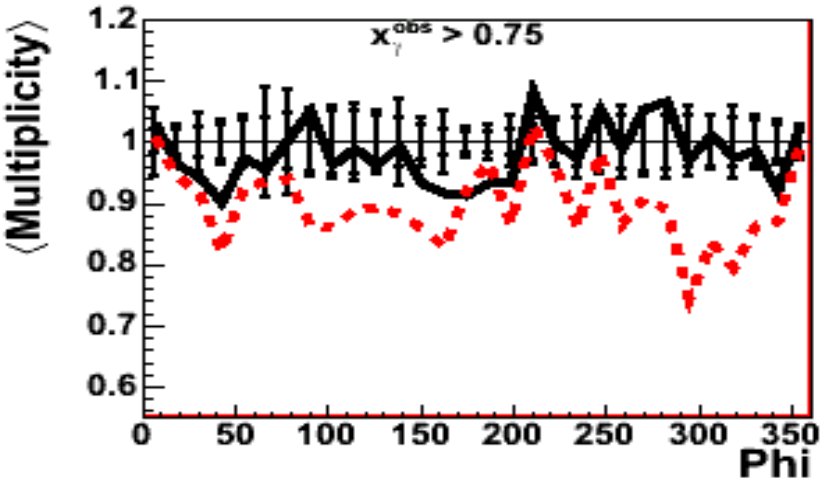
Dijet sample track multiplicity

Particle multiplicity: Average number of measured particles per event.





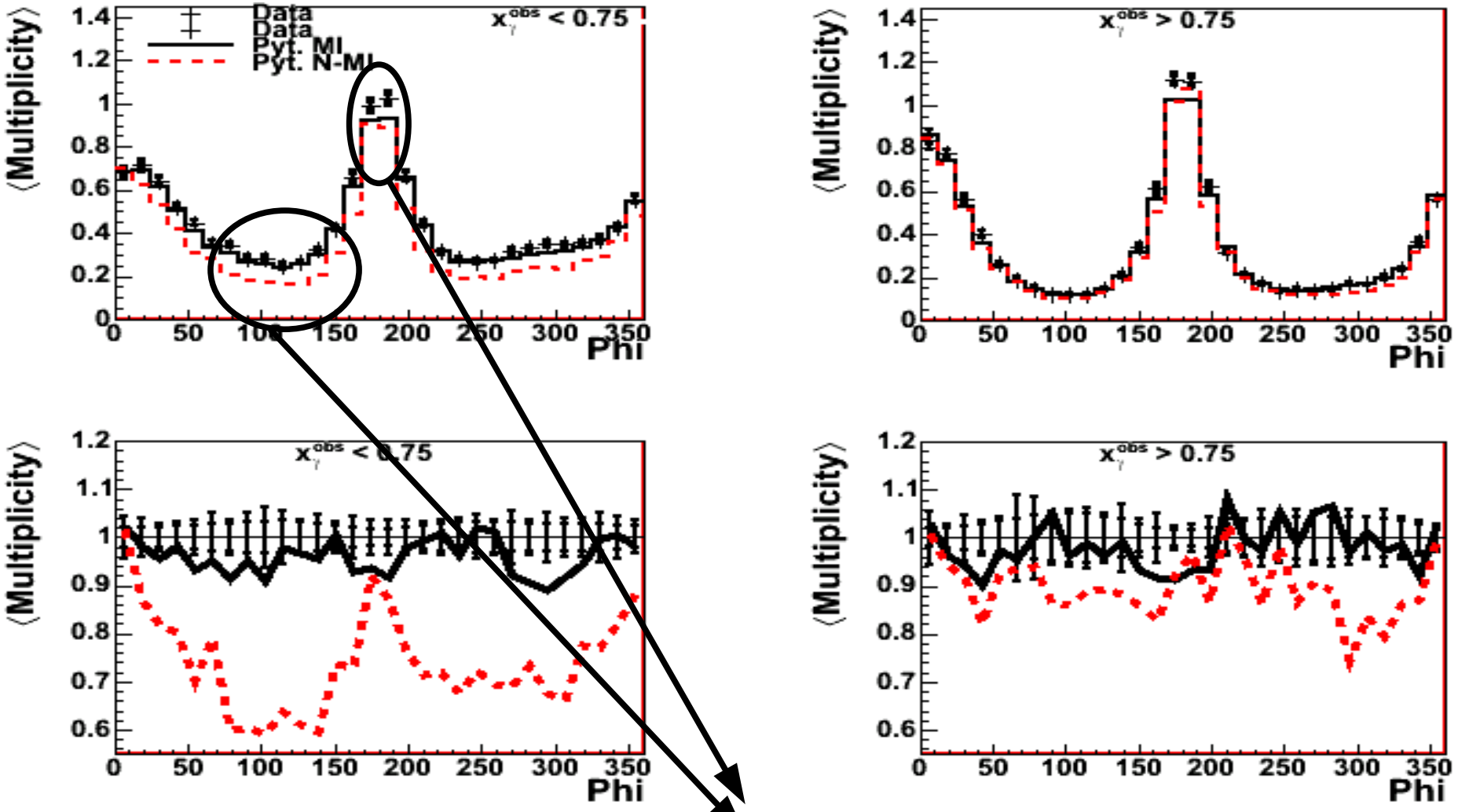




Pythia MI describes all regions!

Dijet sample track multiplicity

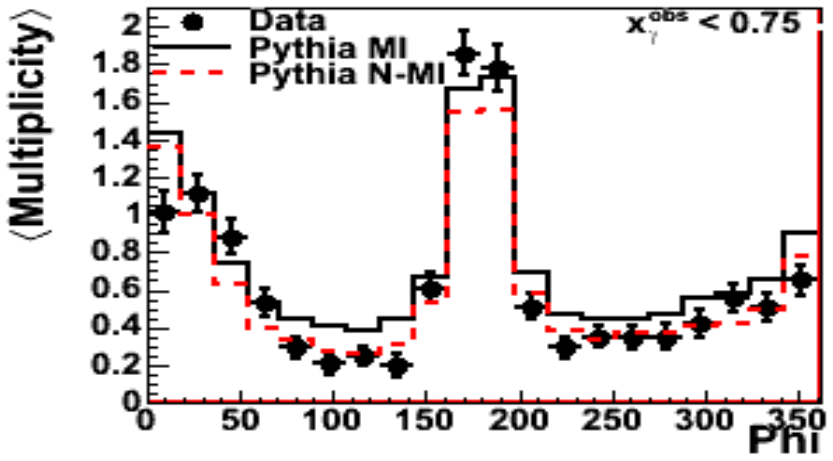
Particle multiplicity: Average number of measured particles per event.

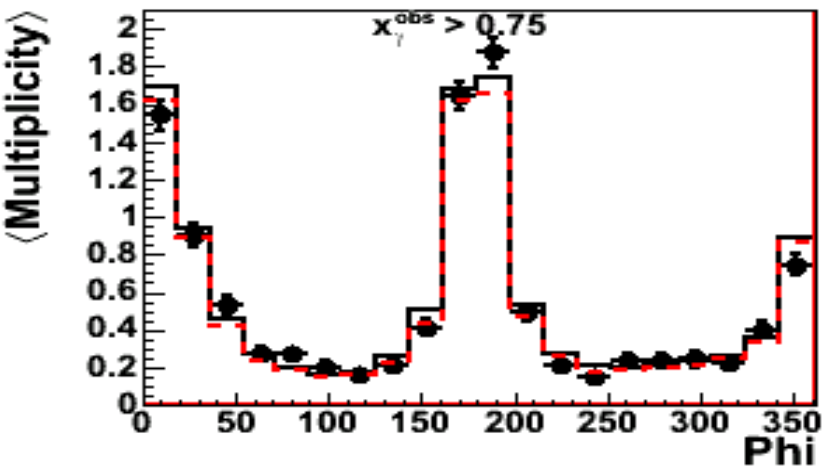


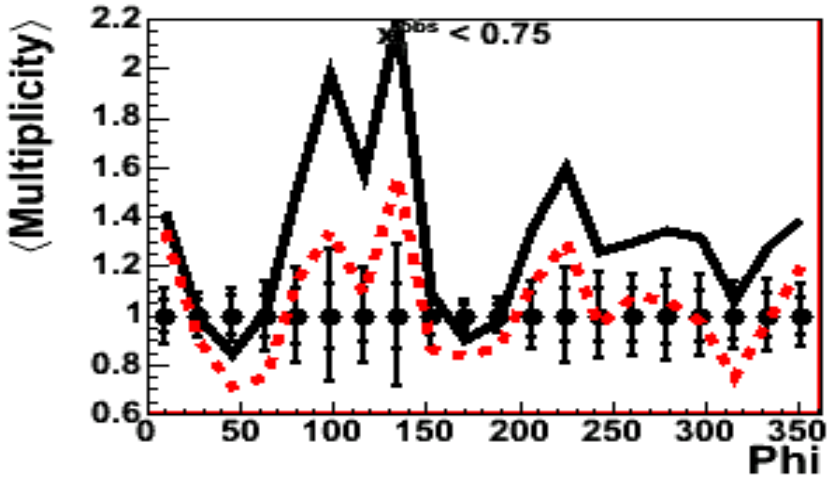
Our naïve expectation is not fulfilled.
It is not just counting pears and apples!

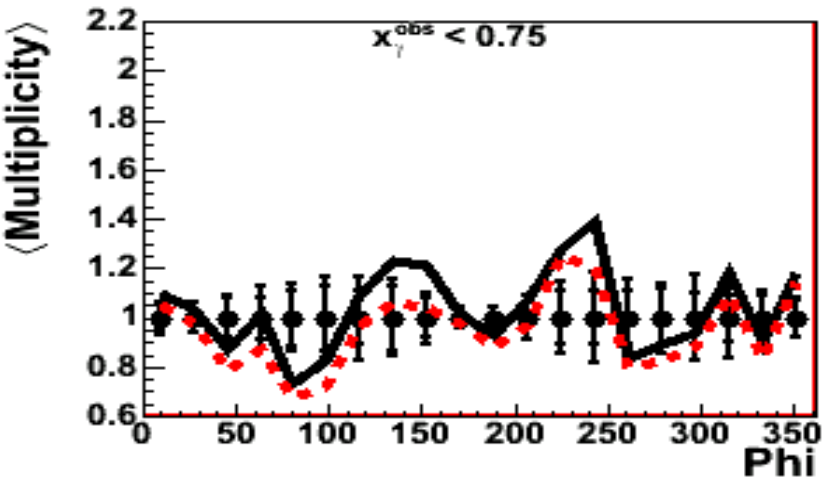
Charm with dijets track multiplicity

Particle multiplicity: Average number of measured particles per event.





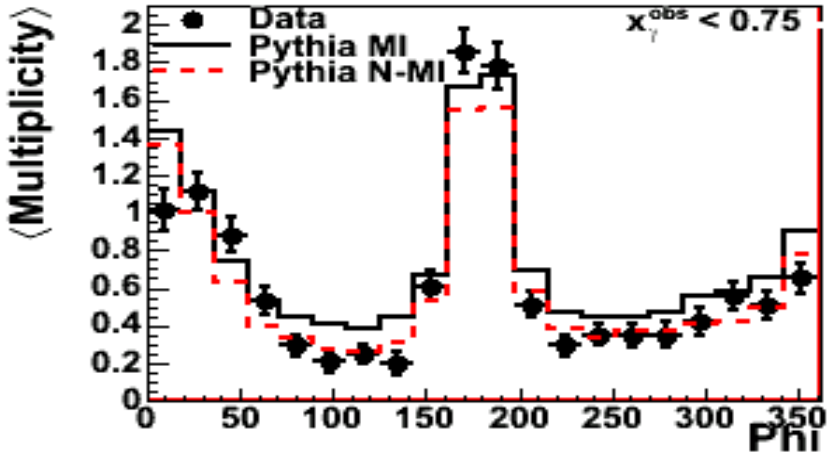


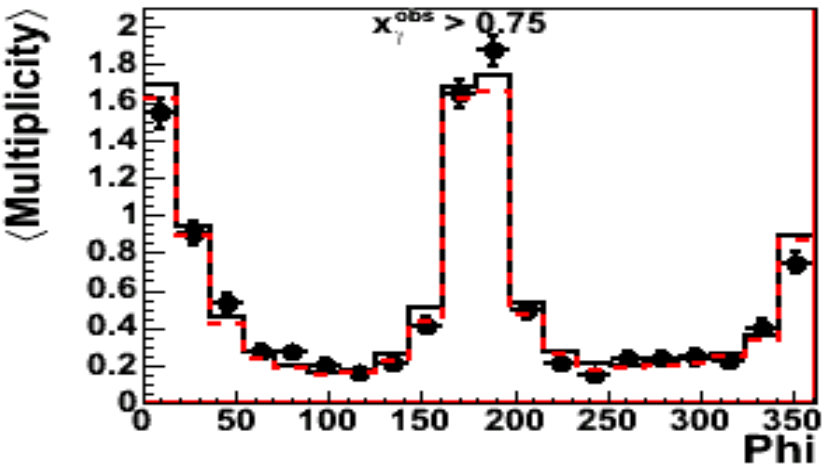


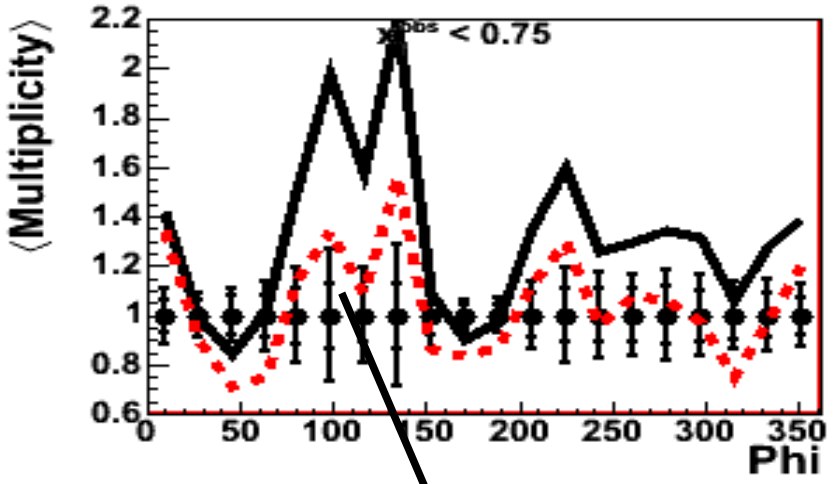
Now Pythia MI does not describe data in the low X_γ bin!

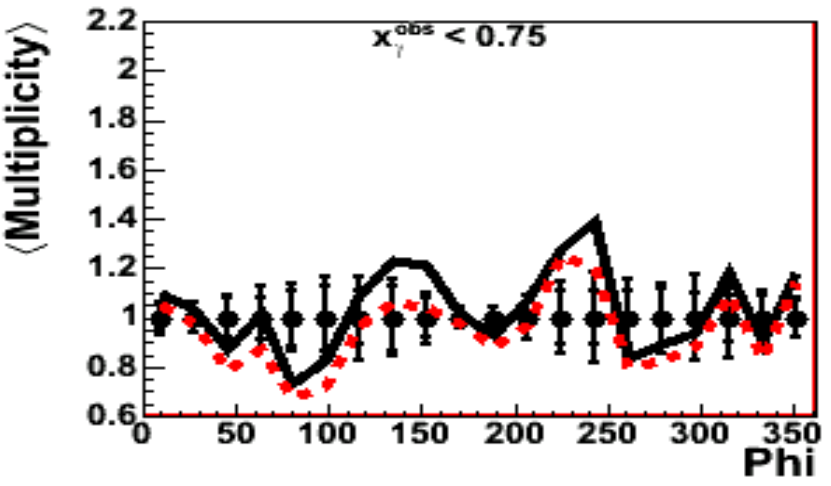
Charm with dijets track multiplicity

Particle multiplicity: Average number of measured particles per event.









Statistical uncertainties are larger than before! (~15% in transverse region)

Summary and outlook

Summary:

Dijet sample:

- ✔ PYTHIA MI describes multiplicity in both X_γ bins and all regions (especially the transverse).
- ✔ The difference in multiplicity between PYTHIA w/o MI and Data is ~6σ in the transverse region.

Charm with dijet:

- ✔ Only the high X_γ region is well described.
- ✔ In the low X_γ the best description is done with Pythia w/o MI.

It is clear we still have a lot to understand about MI!

Backup

Pythia MI Model.

Parameter values used in Pythia:

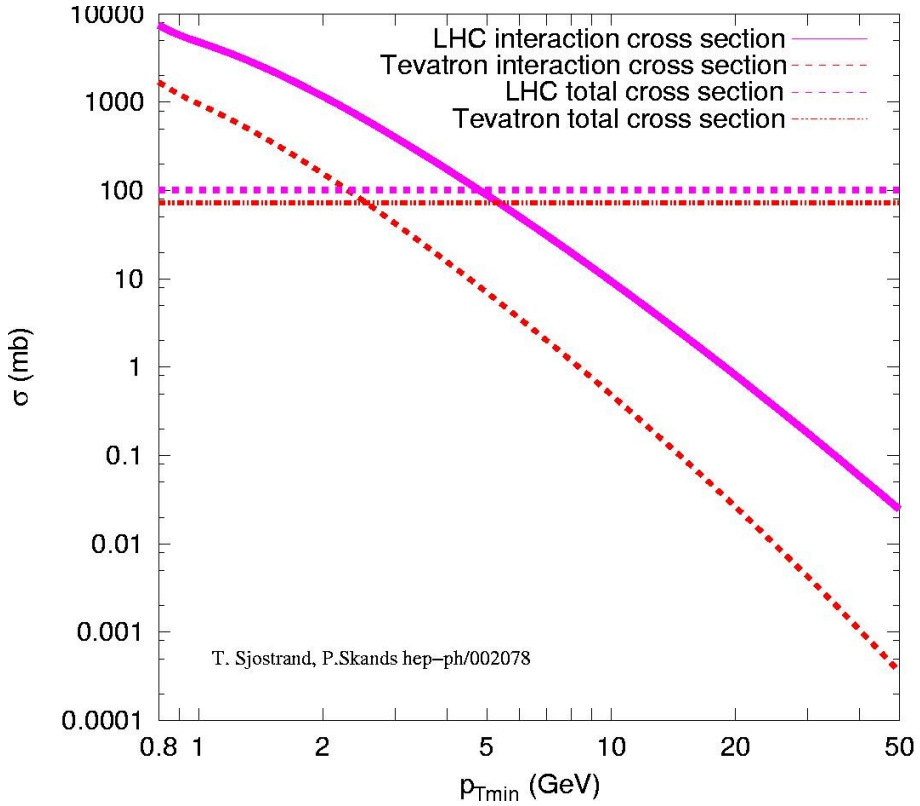
- PARP 67: set to 4 (default 1). Scale factor that governs the amount of initial-state radiation
- MSTP 82: set to 1. Same MI probability in all events. Abrupt Ptmin cut-off.
- PARP 82: set to 1.20GeV (default 1.55GeV). Regularization scale. Cut-off for MI.
- MSTP 93: set to 5 (default 1). Primordial K_t distribution in photon $dK^2_t/(K^2_{t0} + K^2_t)$
- PARP 99: set to 0.6GeV (default 0.4GeV). K^2_{t0} value in MSTP93
- PARP 100: set to 5GeV (default 2GeV). Upper cut-off for primordial K_t distribution.

Pythia MI Model.

Some observations and hypothesis....

Fact: The $\sigma_{int}(p_t)$ diverges and is larger than the measured σ_{nd} for $p_\perp \to 0$.

A numerical illustration:



hep-ph/0402078

Pythia MI Model.

Some observations and hypothesis....

Fact: The $\sigma_{int}(p_t)$ diverges and is larger than the measured σ_{nd} for $p_\perp \to 0$.

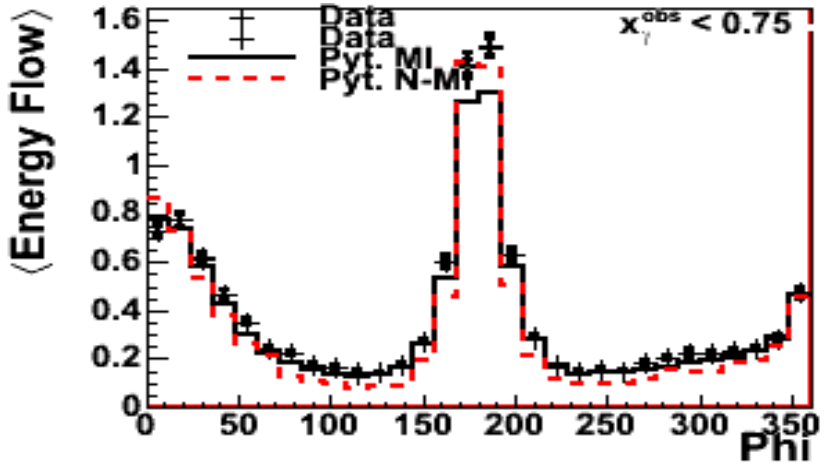
We interpret this as MPI: if we have two interactions this is counted twice in $\sigma_{int}(p_t)$ but only once in σ_{nd}.

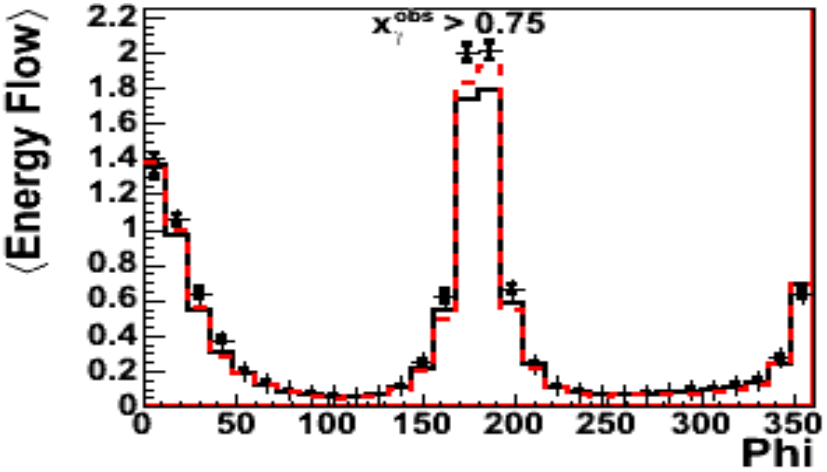
Thus:

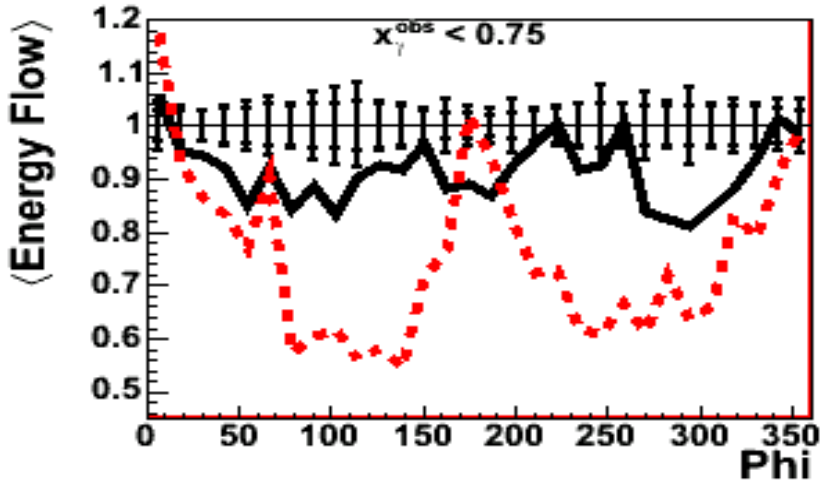
$$\langle n \rangle_{p_{\perp min}} = \frac{\sigma_{int}(p_{\perp min})}{\sigma_{nd}}$$

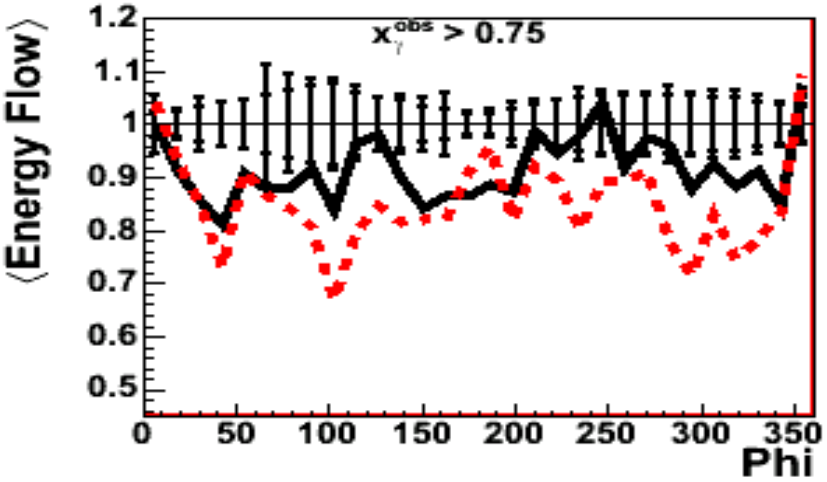
Dijet sample energy flow

Energy flow: average scalar Pt sum per event as a function of φ.



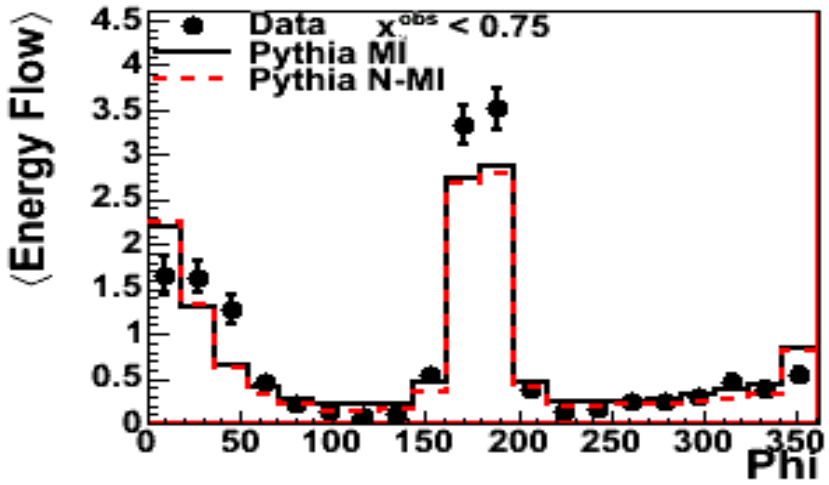


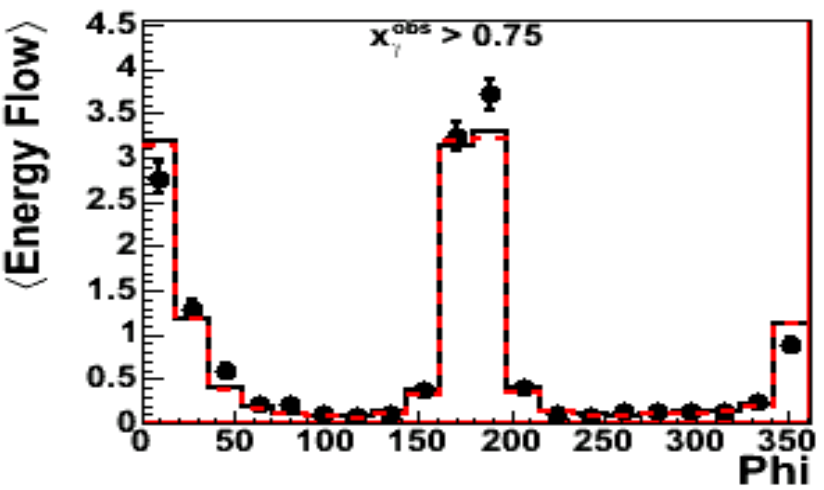


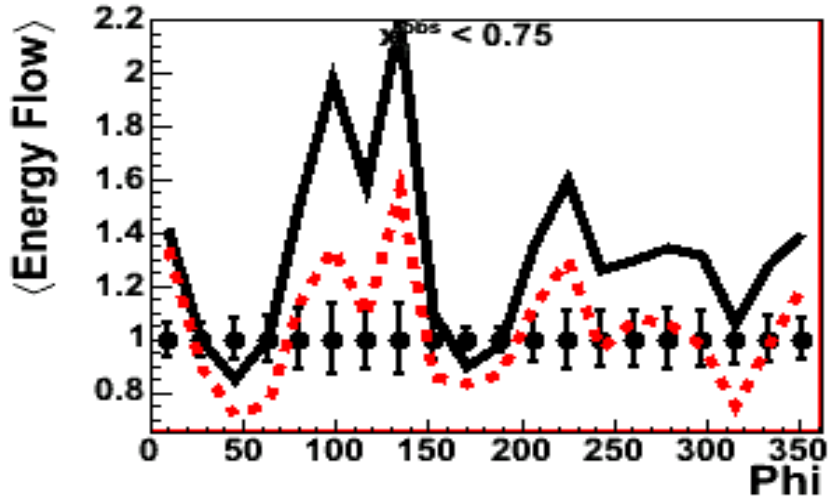


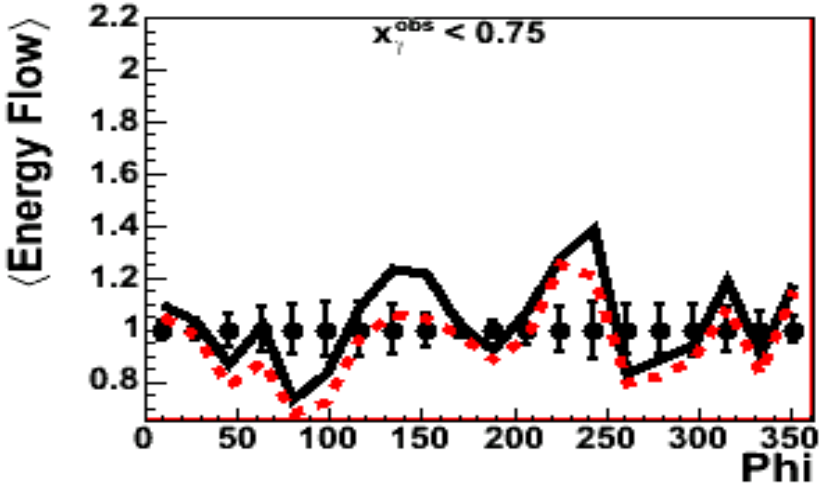
Charm with dijet energy flow

Energy flow: average scalar Pt sum per event as a function of φ.

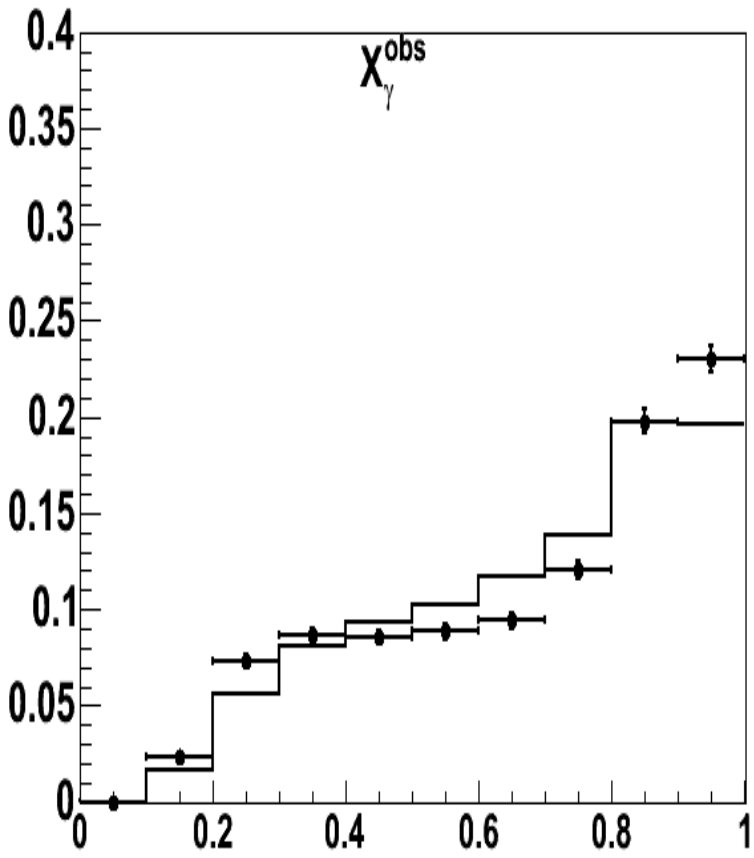


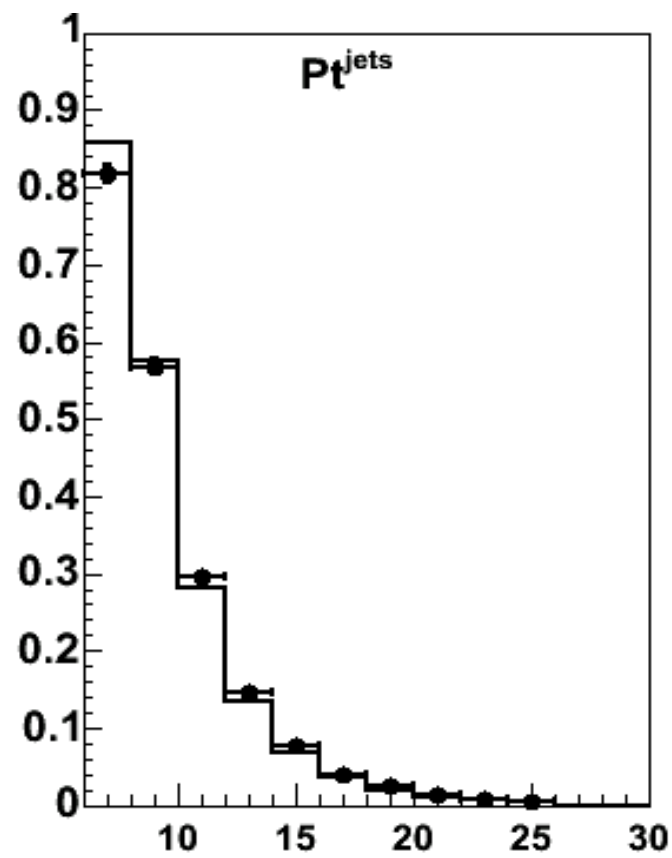


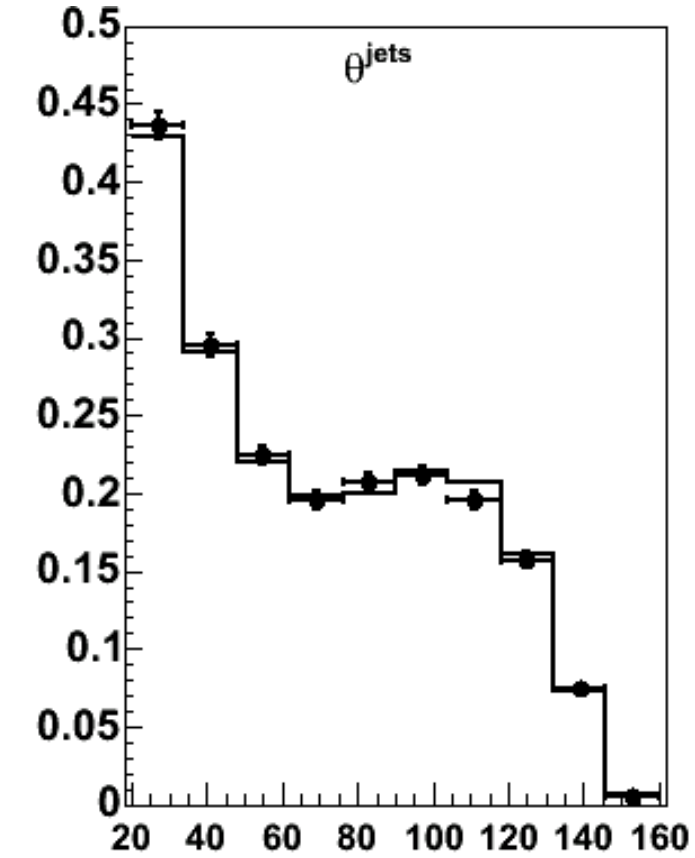




Dijet sample: some control plots





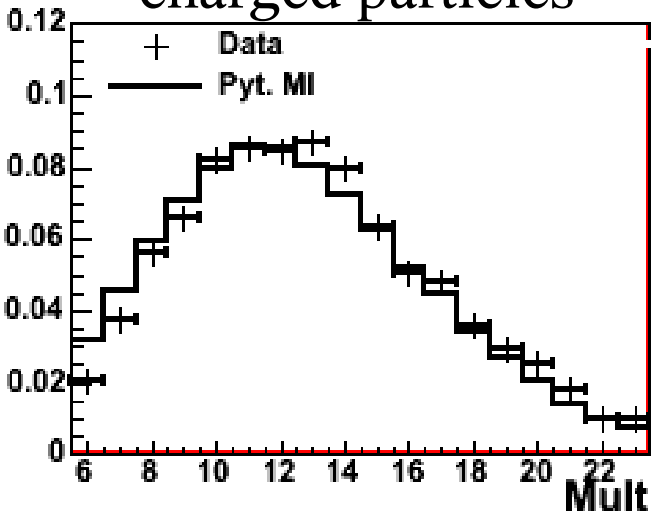


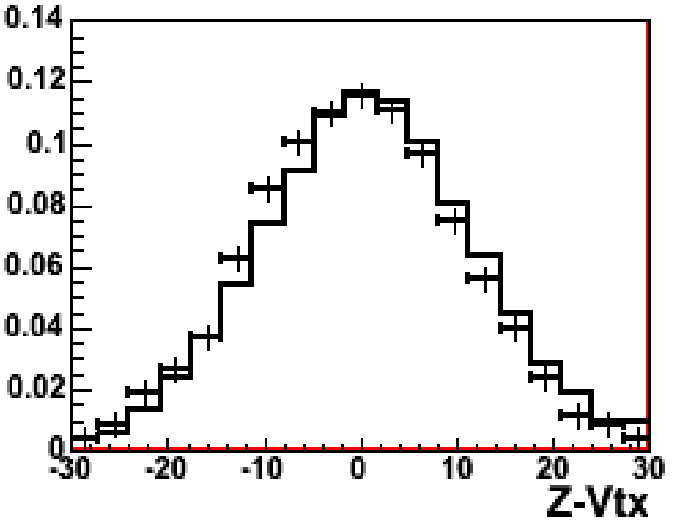
(shape normalized)

PYTHIA MI (def.) describes data reasonably well.

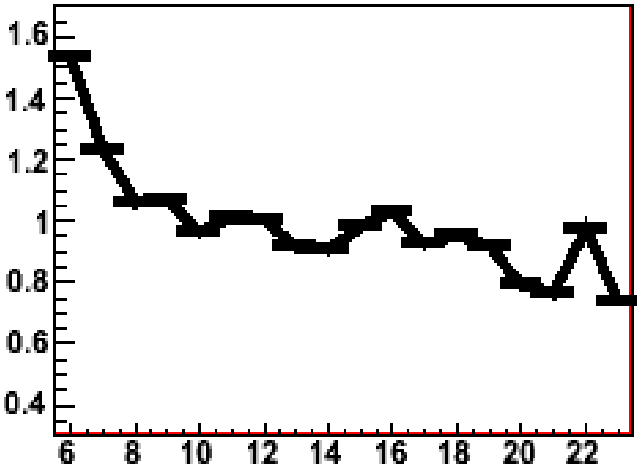
Dijet sample: some control plots

charged particles

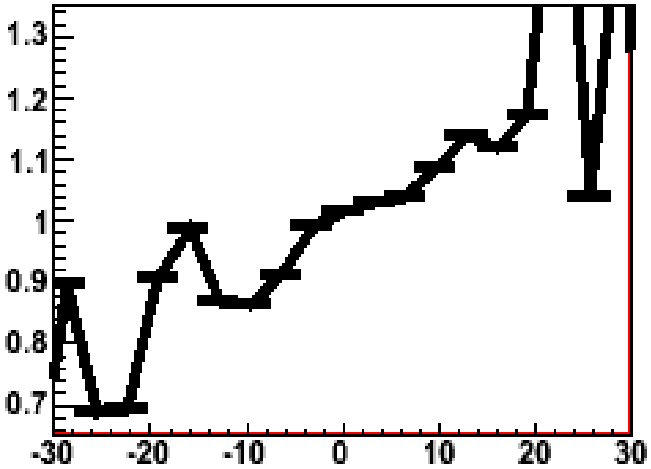




Data/Pythia MI



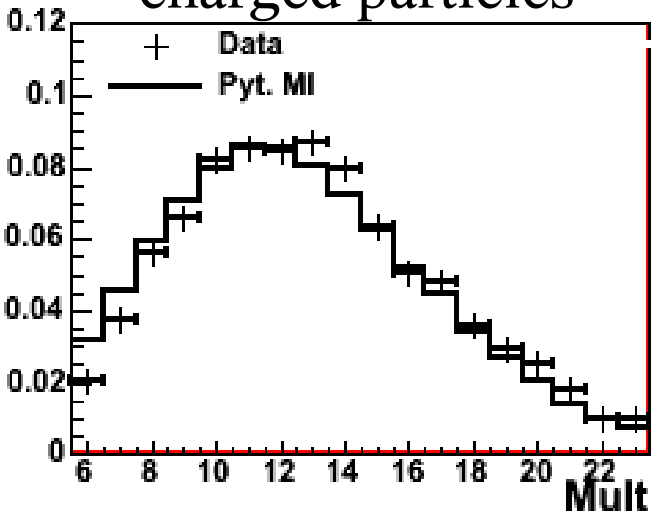
Data/Pythia MI

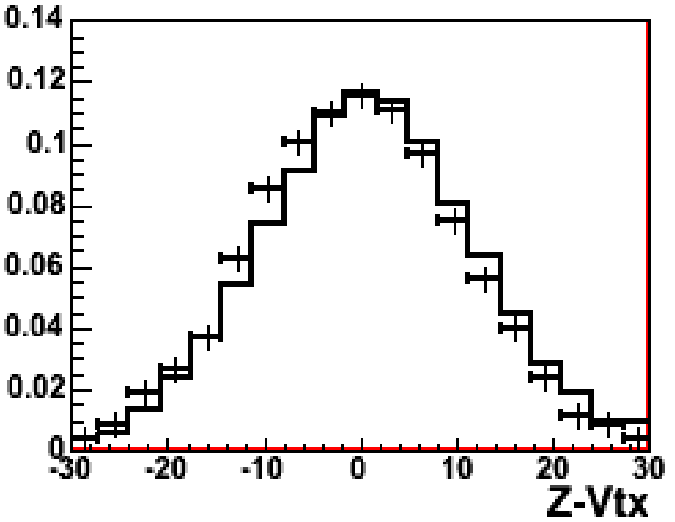


(shape normalized)

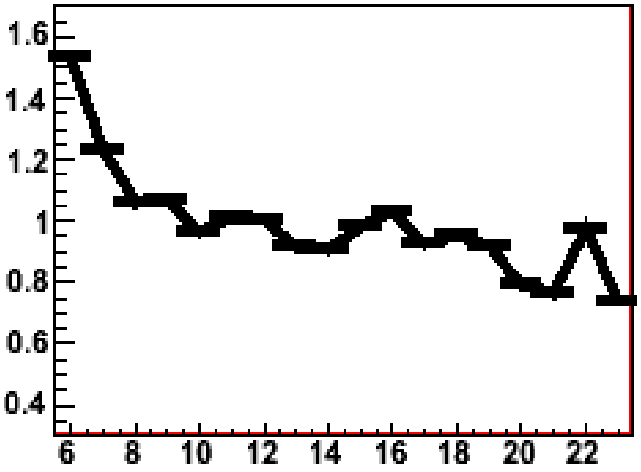
Dijet sample: some control plots

charged particles

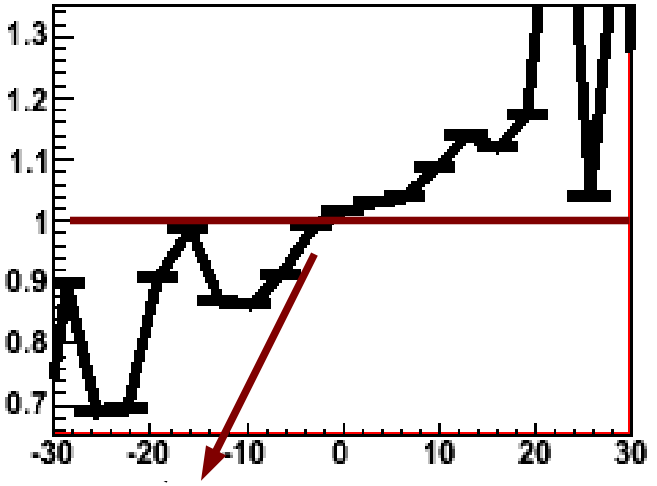




Data/Pythia MI



Data/Pythia MI



weight the events

Systematics: calculation and plots

- We vary the nominal values to get the different contributions as follows:

$$\frac{Data}{MC^{sim/rec}} MC^{Gen} - \frac{Data_{p_t^{\pm},\ldots}}{MC^{sim/rec}_{p_t^{\pm},\ldots}} MC^{Gen}$$

Systematics: calculation and plots

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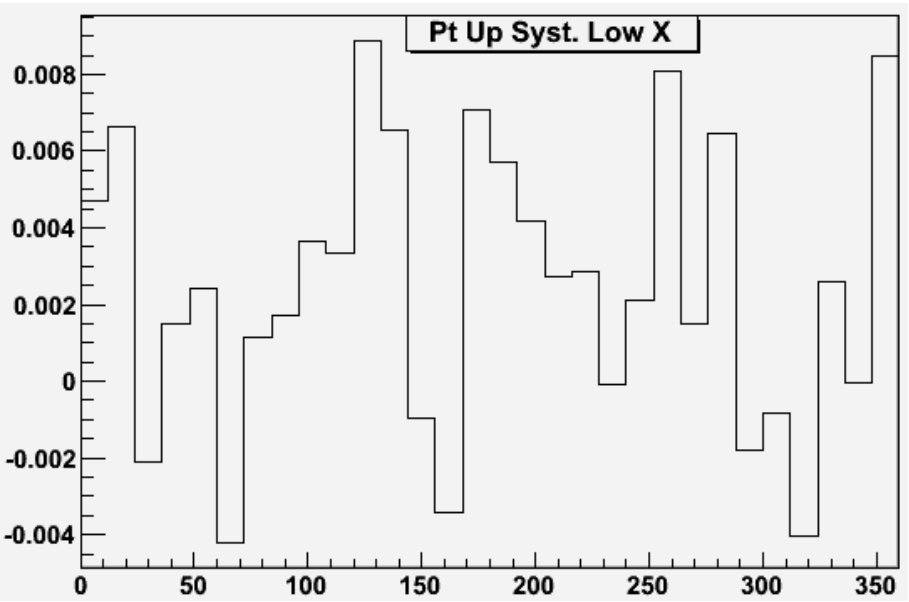

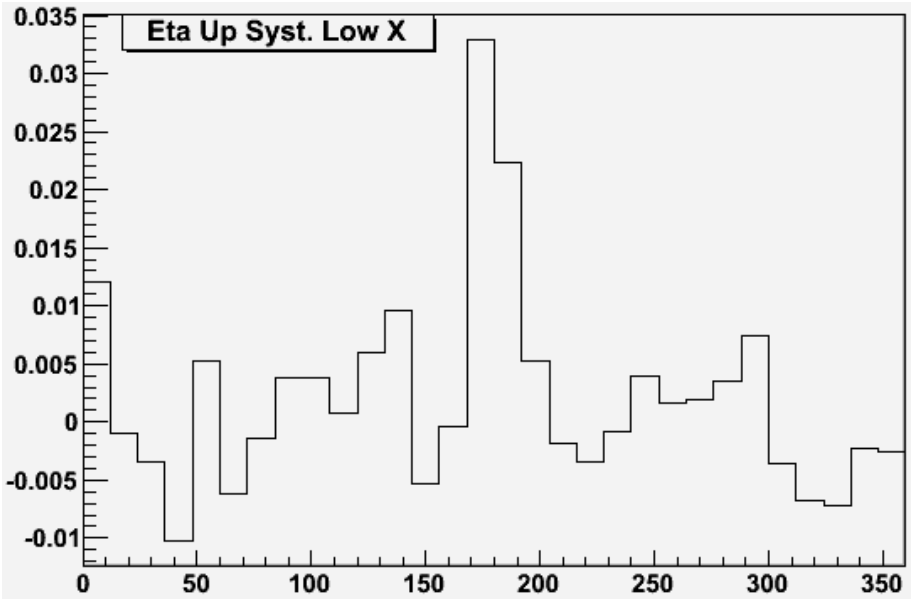

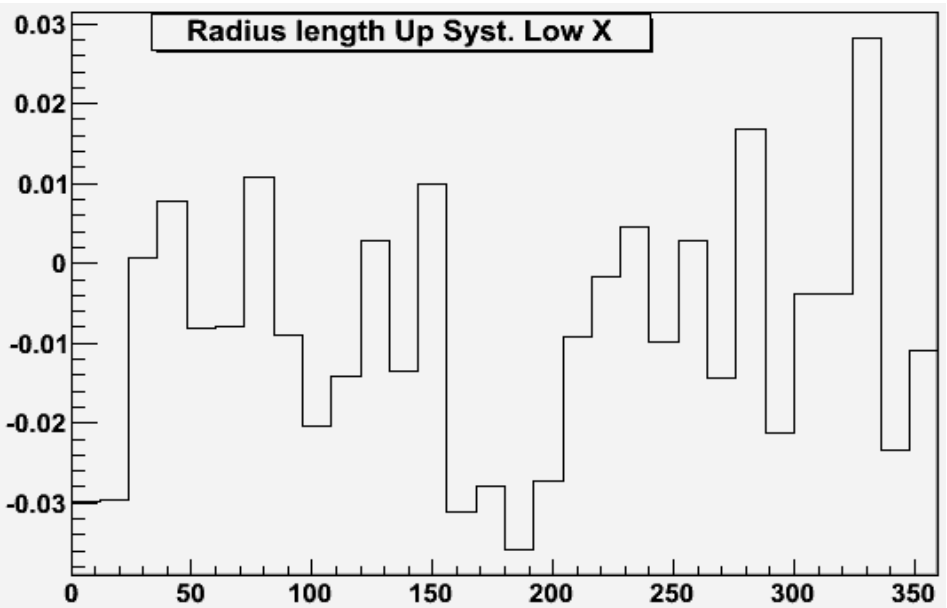

End of Backup