Forward jets in the CASTOR calorimeter at the CMS detector

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Outline

- **CASTOR**
- **Parton Dynamics Introduction**
- **Jets in CASTOR region**
- **Energy Deposit – Jet Energy Correlation**
- **Summary**

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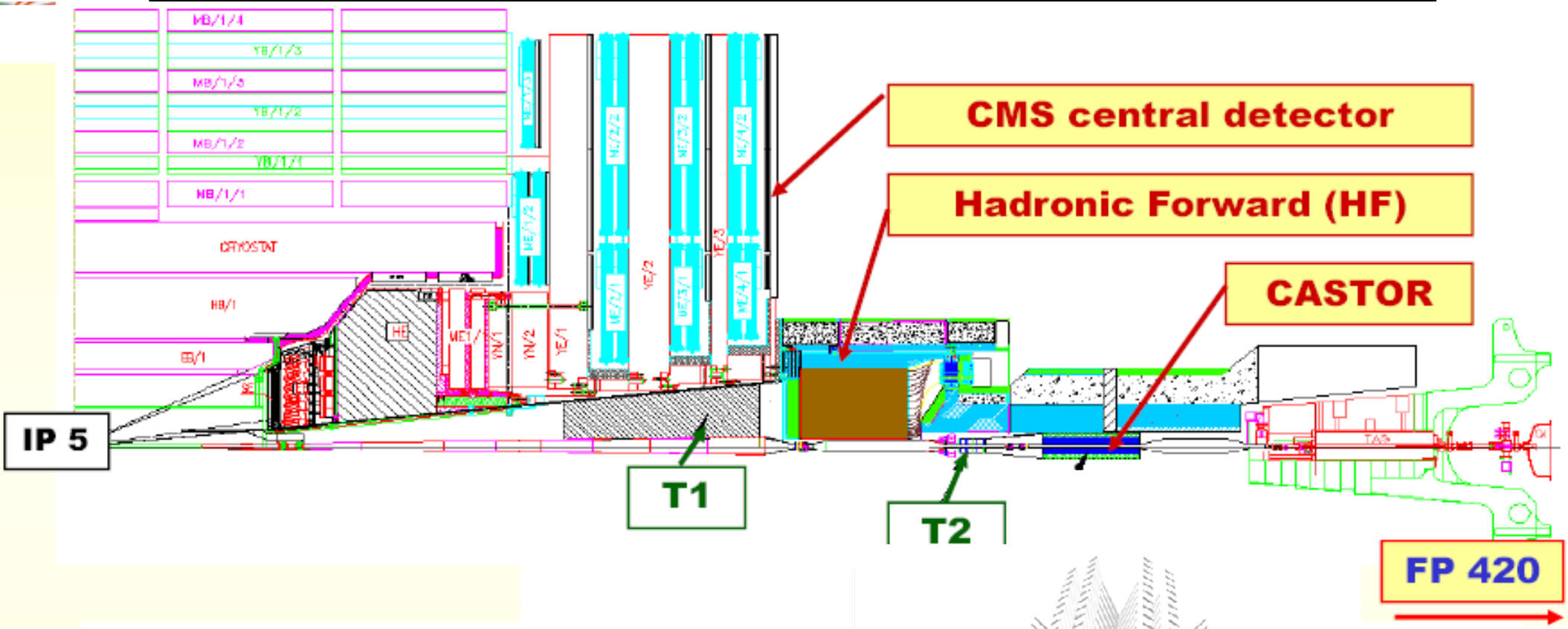
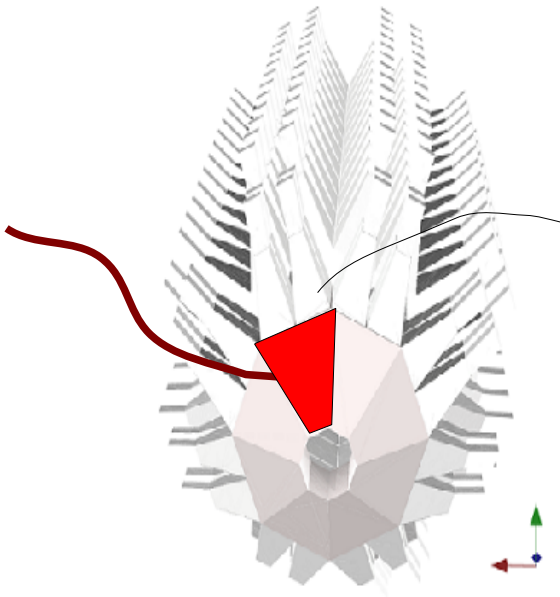
CASTOR calorimeter



Cherenkov radiation calorimeter.
Tungsten absorbers + Quartz plates.
224=16 x (2 EM + 12 HAD) channels.

$$5.2 < \eta < 6.6$$



Parton Dynamics

Matrix element QCD calculations exist only for up to Next-to-Leading-Order O(α_s^3).

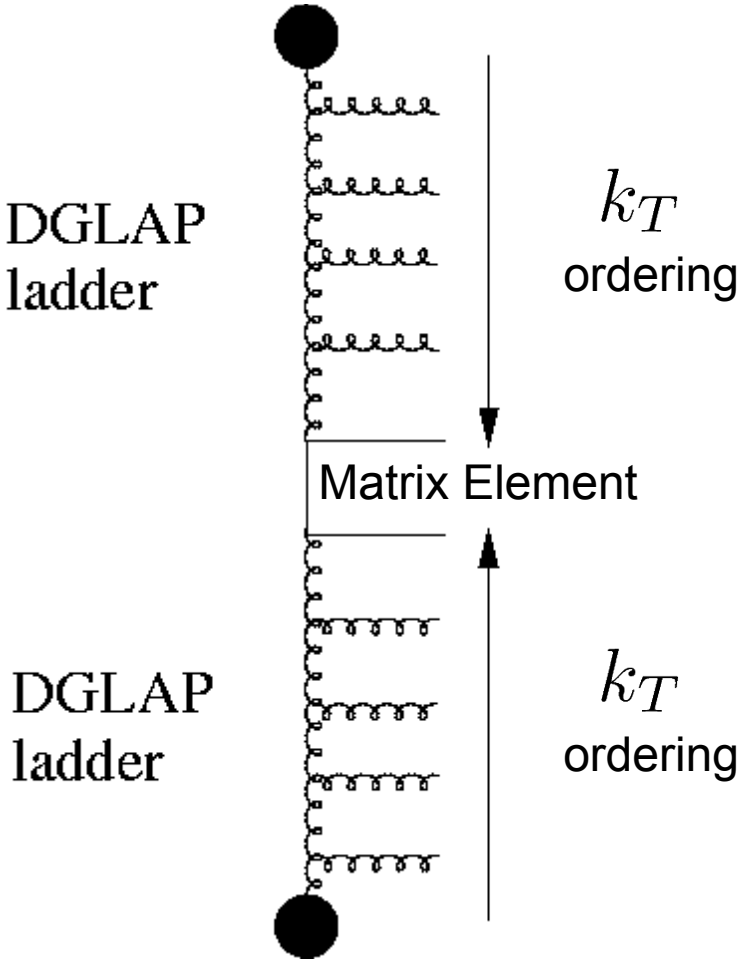
Higher order reactions estimated by using approximate calculations,
so called evolution equations.
Different evolution equations resum different terms
in the pertubative expansion.

DGLAP

(*Dokschitzer-Gribov-Lipatov-Altarelli-Parisi*)

Resums terms depending on parton
virtuality, resulting in ordering
of virtuality of propagators ~ kt of emitted partons.

Implemented in e.g. the Monte Carlo
generators **RAPGAP (ep) and PYTHIA (pp)**



Parton Dynamics

Non DGLAP calculations

→ ***Non ordering in k_t***

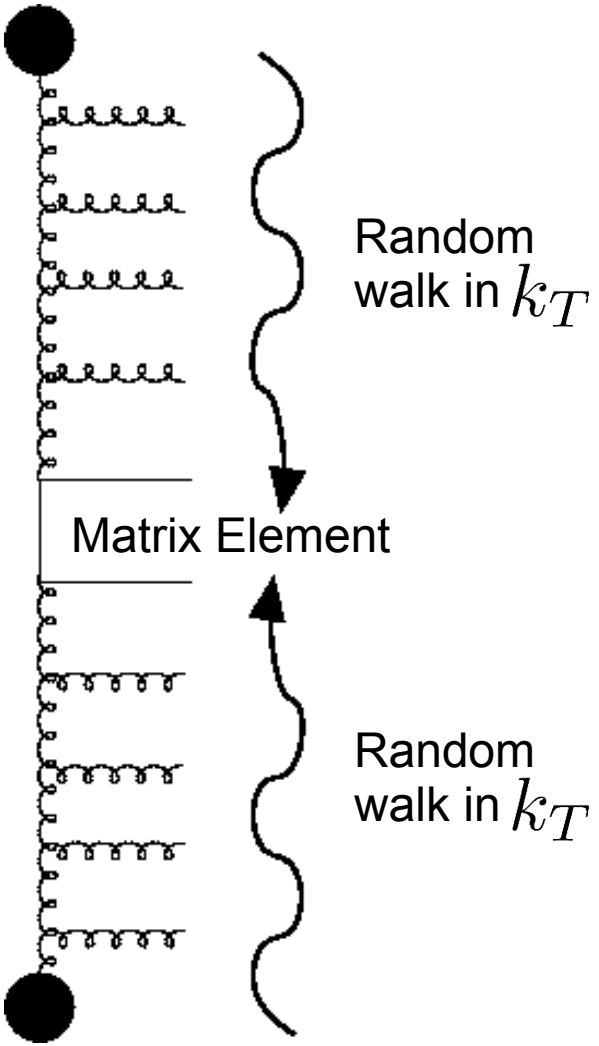
BFKL/CCFM

(Balitski-Fadin-Kripov-Lipatov)/(Ciafaloni,Catani,Fiorani,Marchesini)

Resums terms depending on parton propgator fractional momentum.

BFKL: Strong ordering of momentum fraction of propagators.

CCFM: Angular ordering of gluon emissions
Implemented in Monte Carlo generator ***CASCADE*** **(ep/pp)**

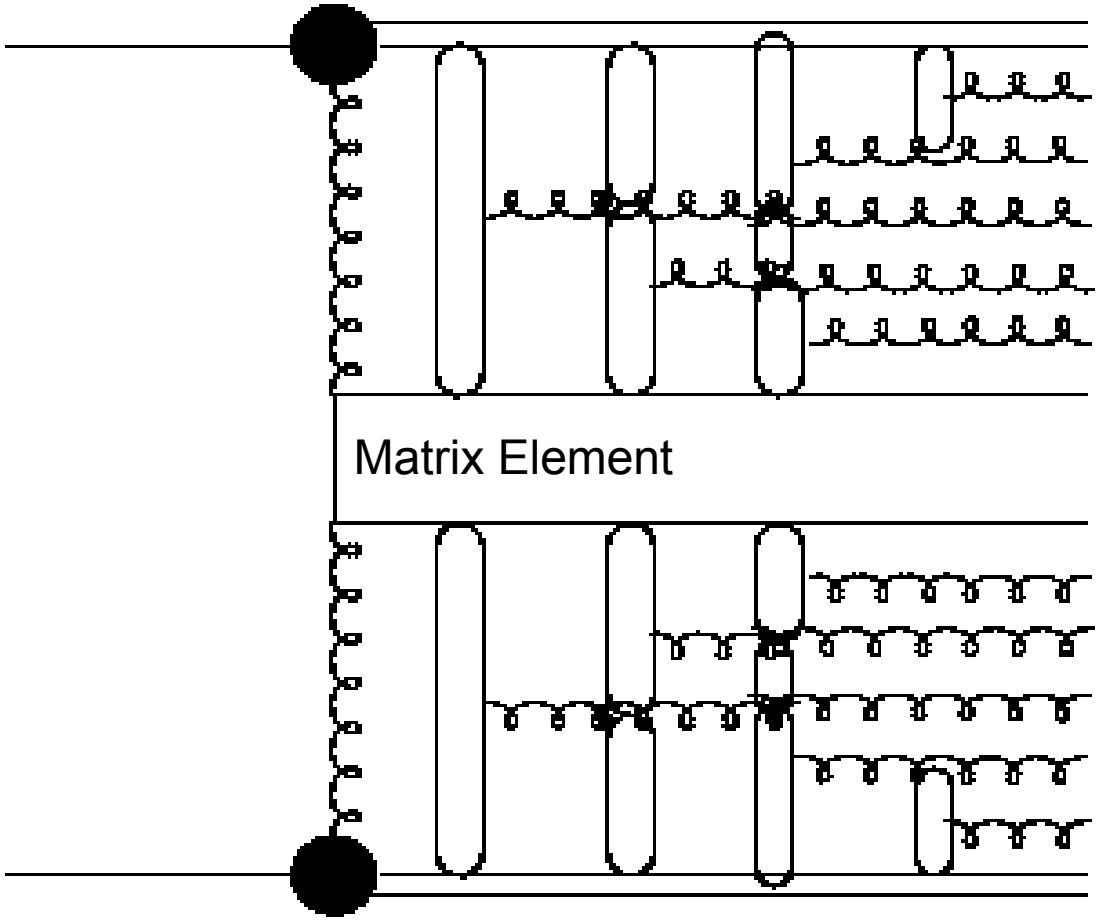


Parton Dynamics

Non DGLAP like dynamics can be estimated by using the

Color Dipole Model (CDM)

Colored objects span color dipoles in between.
Dipoles decays into gluons...
....which in turn spans new color dipoles, and so on...



Final state partons random walk in k_T

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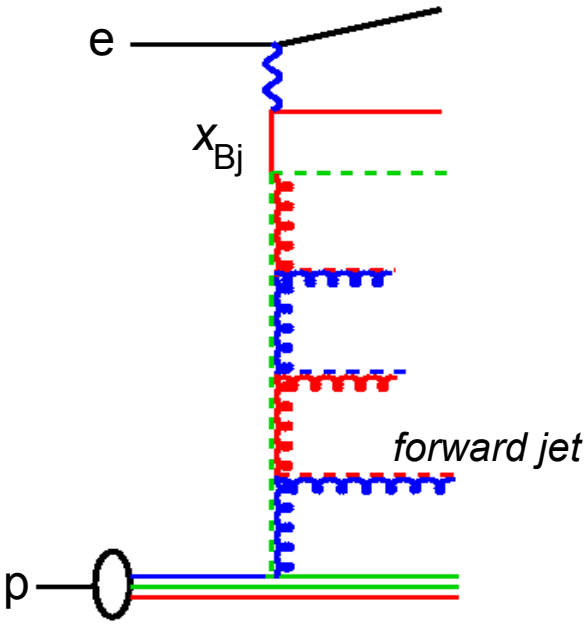
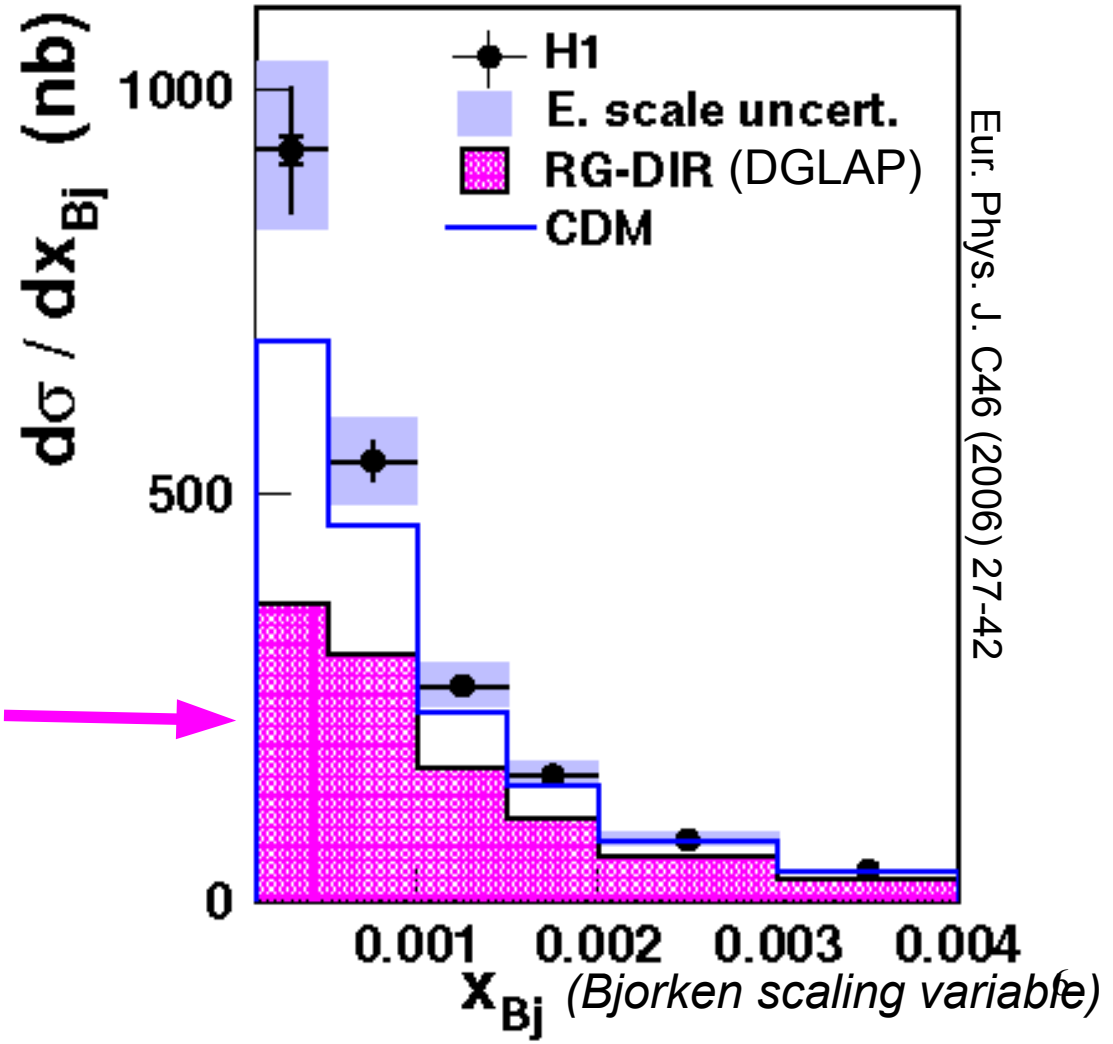
Parton Dynamics

In **ep physics at HERA DGLAP describes inclusive measurements** (e.g. F_2) **successfully**. but **fails for** more exclusive final states, for example **forward jet production:**



Ordering of kt of emissions (DGLAP) are not sufficient.

Need more hard emissions in forward region.



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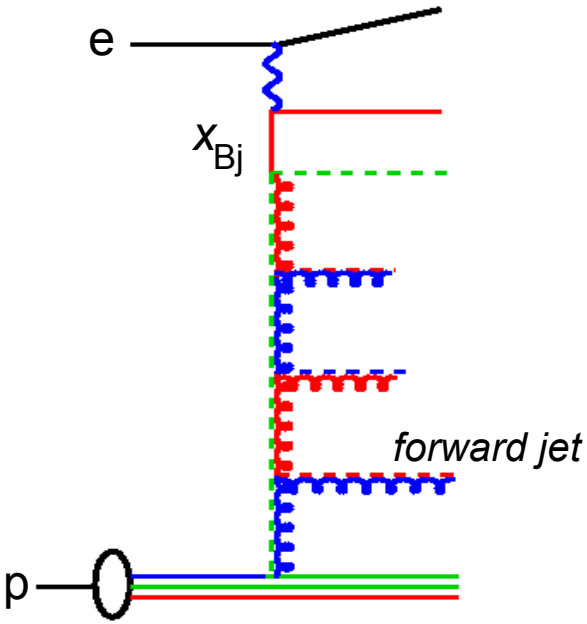
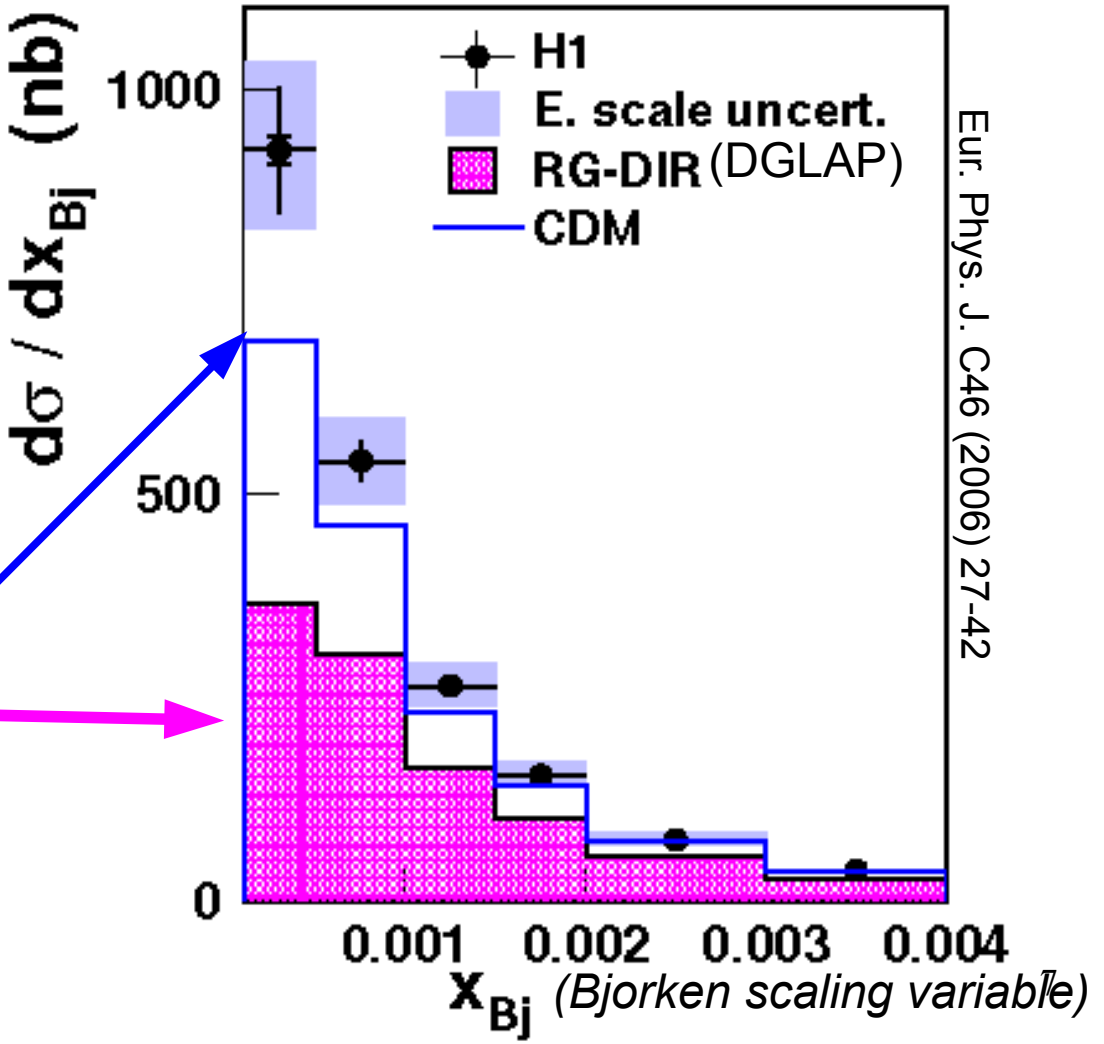


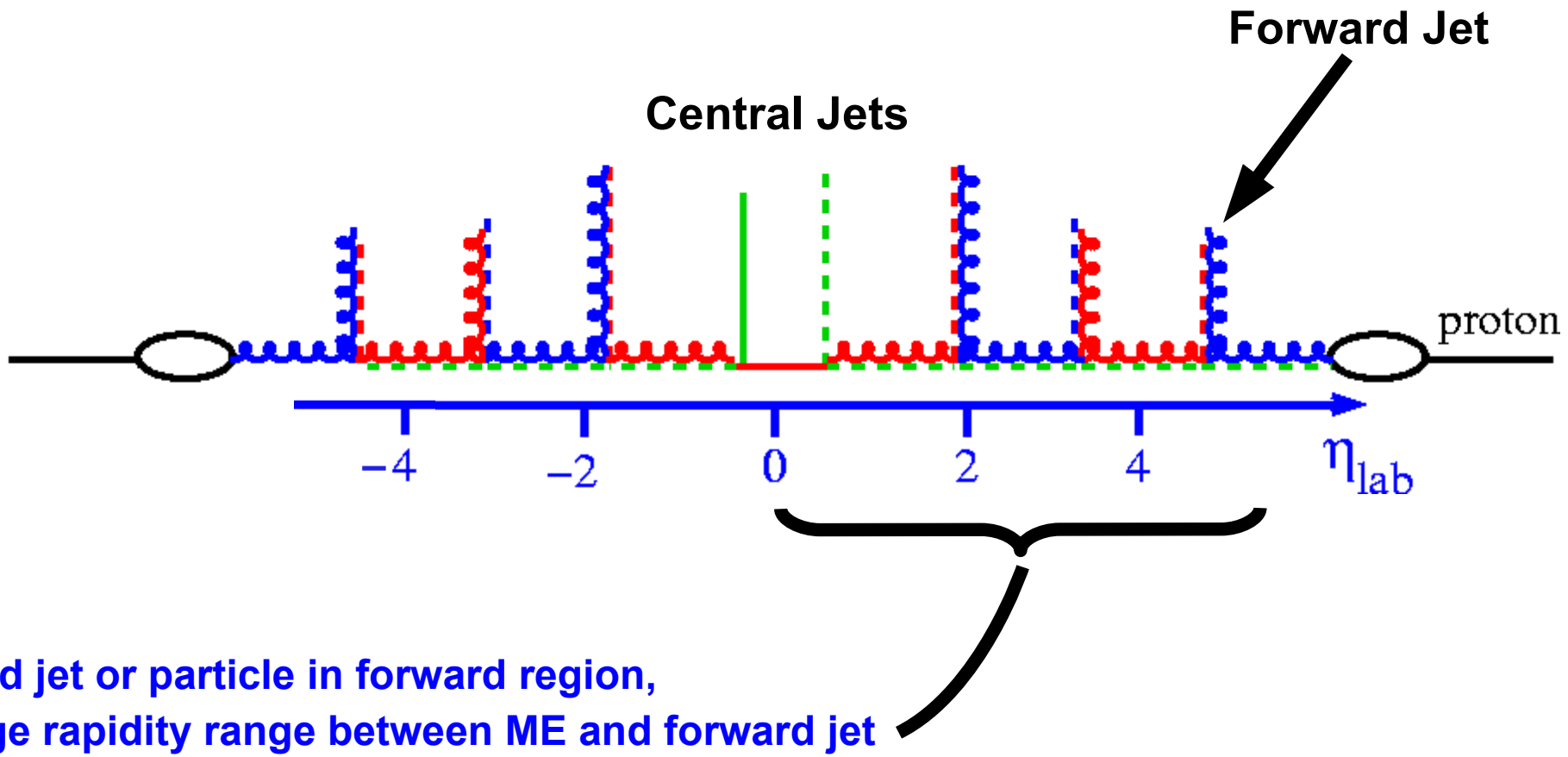


Ordering of kt of emissions (DGLAP) are not sufficient.

Need more hard emissions in forward region.

As for example in the Color Dipole Model (BFKL like scenario).

Forward Jets at LHC



Hard jet or particle in forward region,
large rapidity range between ME and forward jet

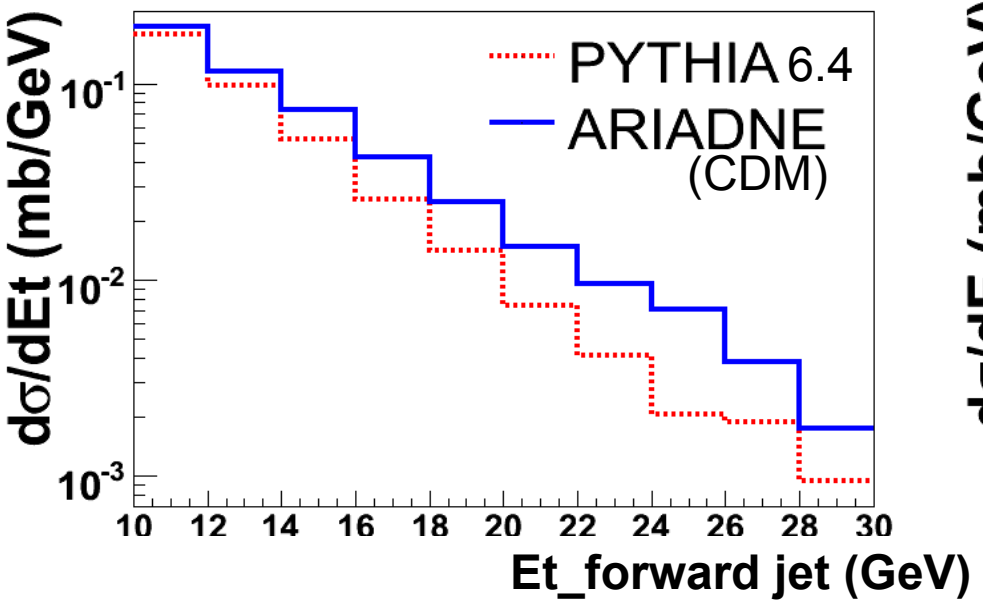
- **Opens up phase space for emissions, higher order reactions**
- **Small x physics**
- **Gain information of the full evolution**

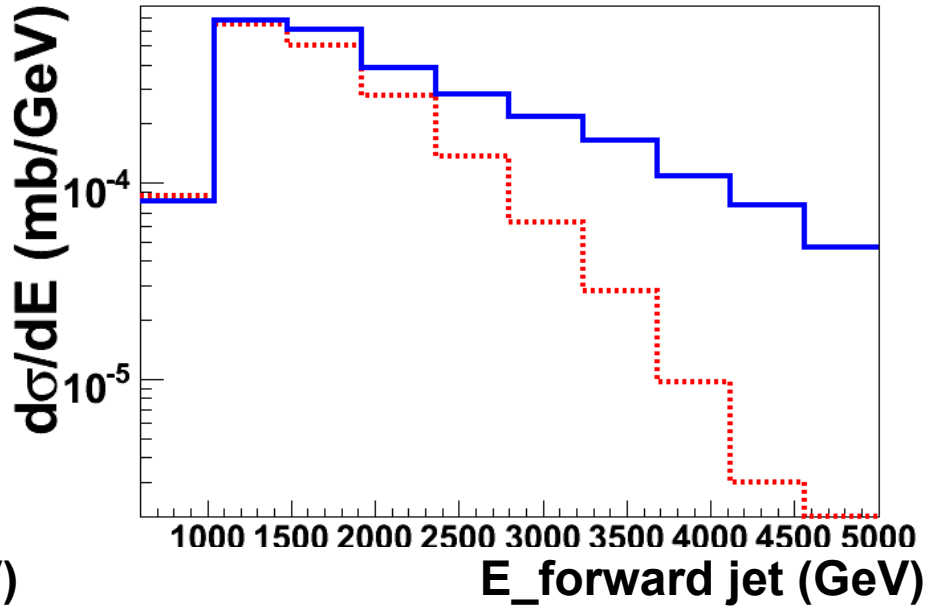
Tool to learn about higher order QCD reactions

Forward Jets in CASTOR

Selection: 2 central jets, 1 jet in CASTOR region $(5.2 < \eta < 6.6)$
with $E_t > 10$ GeV

Hadron level





ARIADNE with the Color Dipole Model – giving a more BFKL like final state – with partons unordered in kt (with respect to rapidity) – predicts more hard jets in the CASTOR region.

Both PYTHIA and ARIADNE are run together with Multipartoninteractions Tune A. (Tune A = One of the R. Field tunes to TEVATRON data.)

Effects from MI

Selection: 2 central jets, 1 jet in CASTOR region $(5.2 < \eta < 6.6)$
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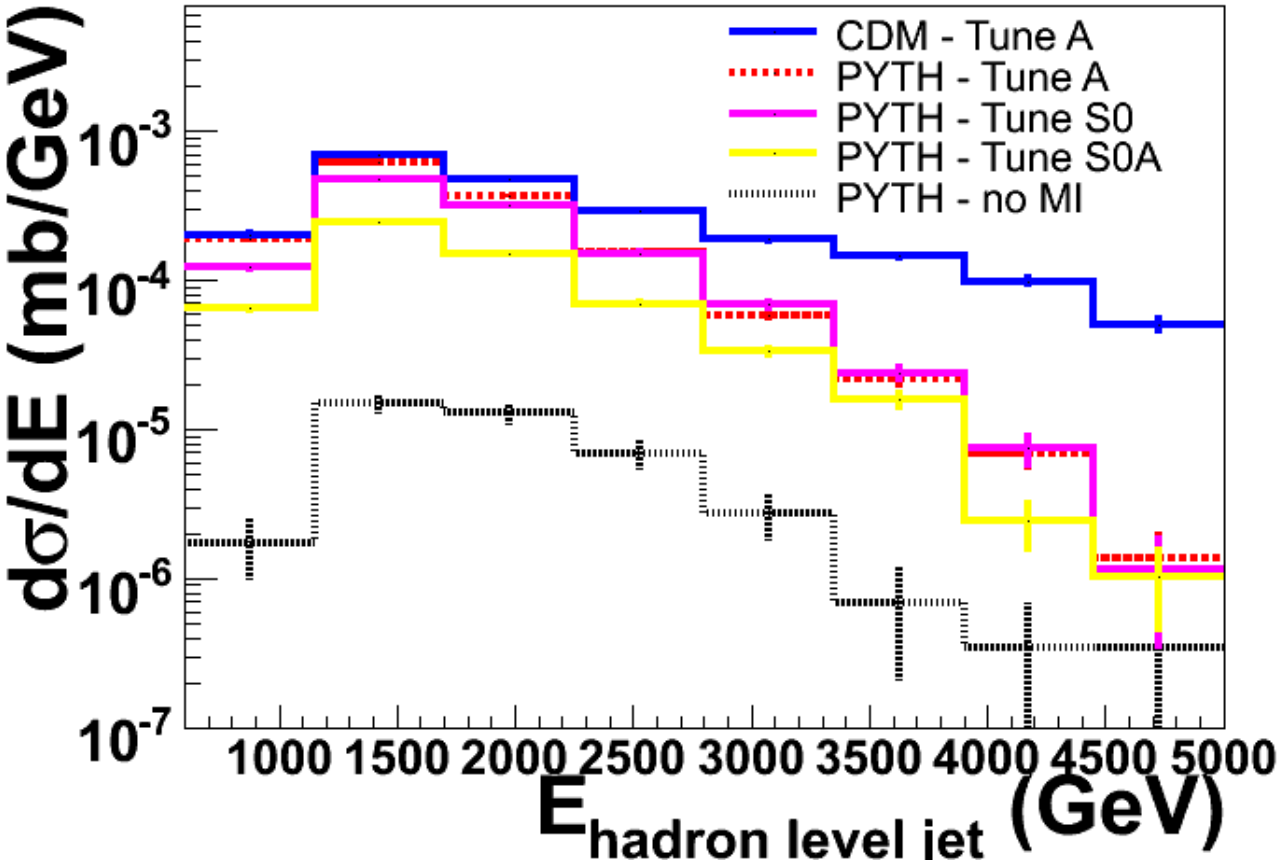


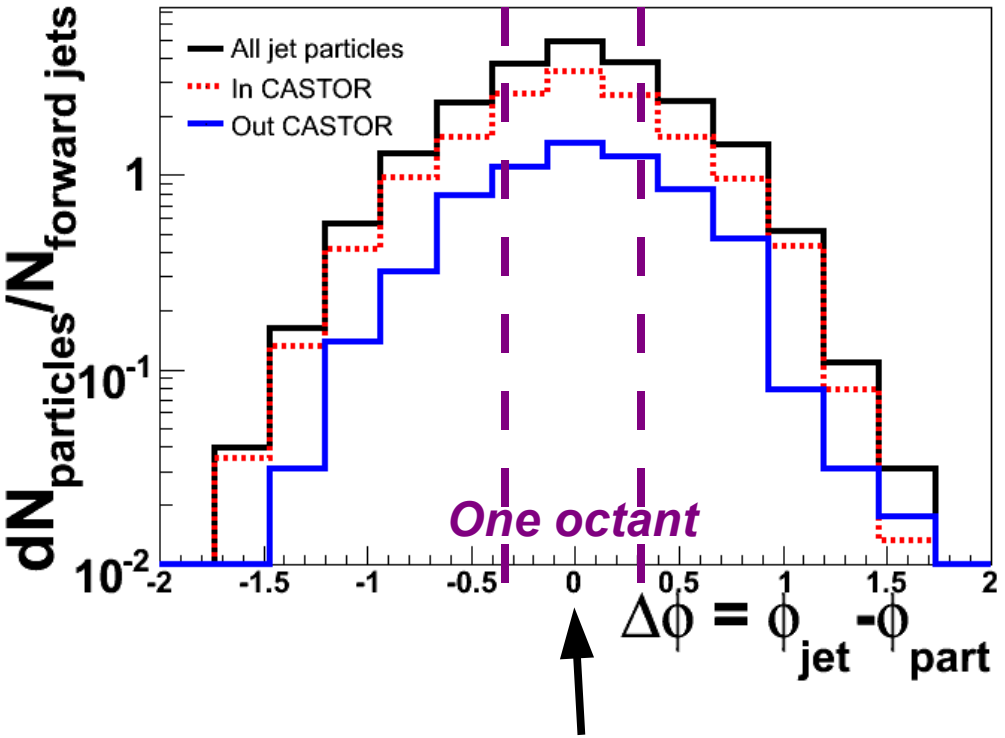
- **Large effect from switching MI off.**
- **At high E difference between CDM and PYTHIA larger than different MI tunes/models**

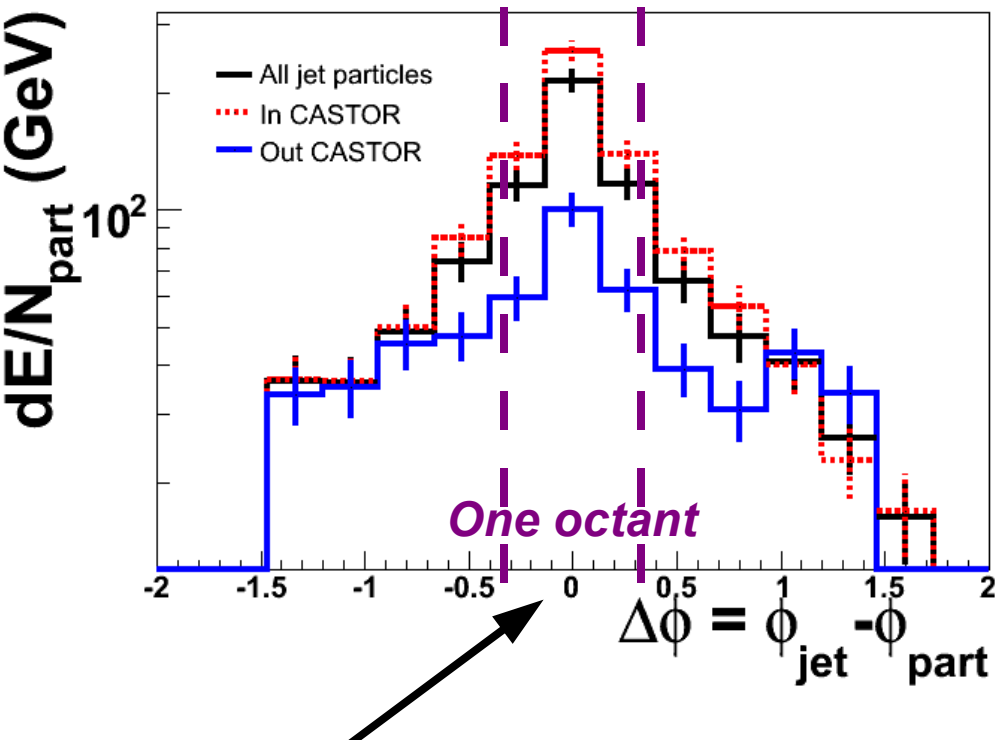
(Also see Z.Rurikovas talk on MI in CASTOR)

Forward Jets in CASTOR

Forward jet events: How much activity can we expect in CASTOR?

"JET PROFILES"





- On event average ~ 10 particles/most active octant
- On average 100 GeV/particle in octant around jet axis

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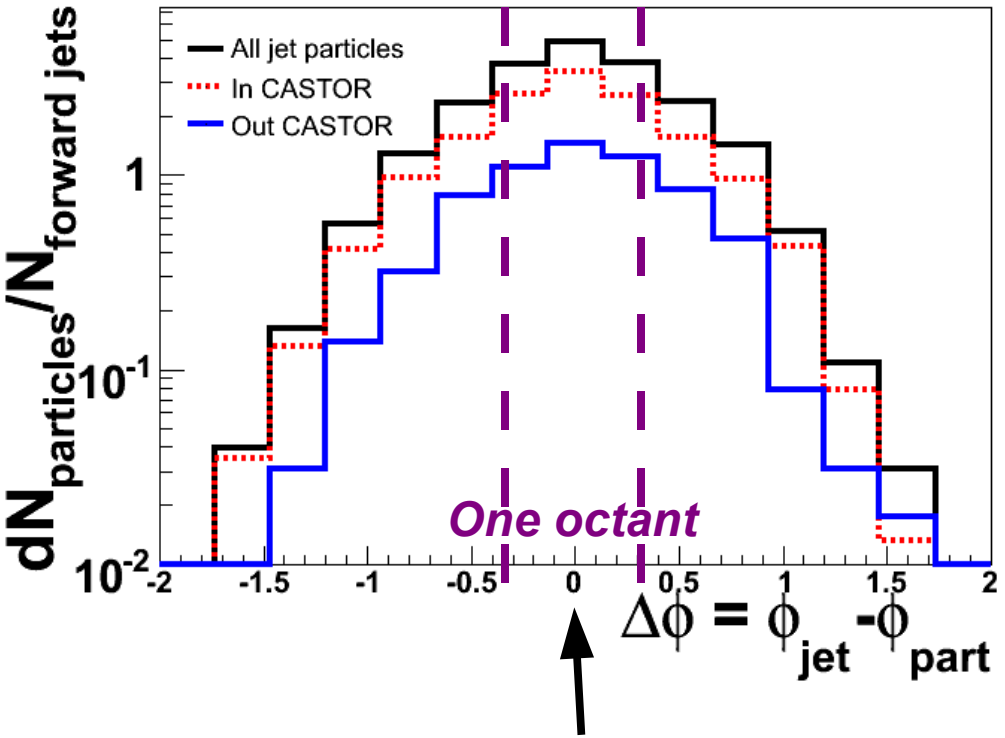

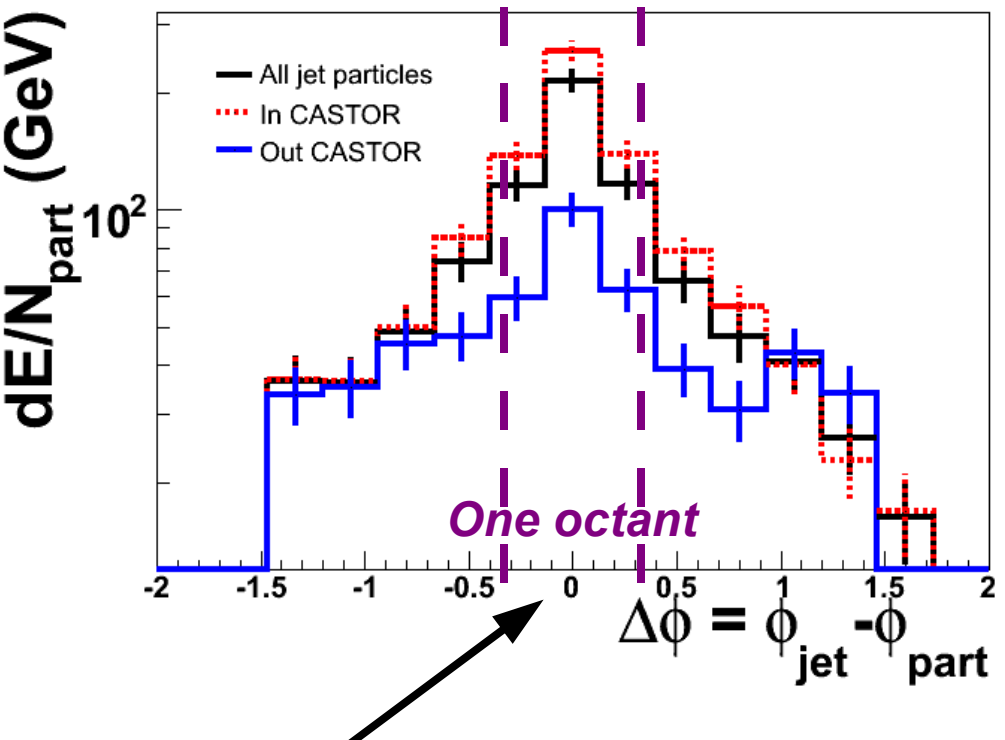

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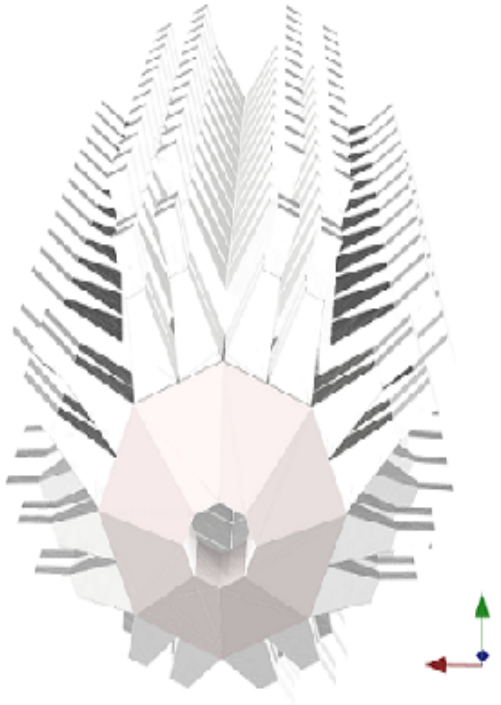
In addition *no rapidity separation* in CASTOR.

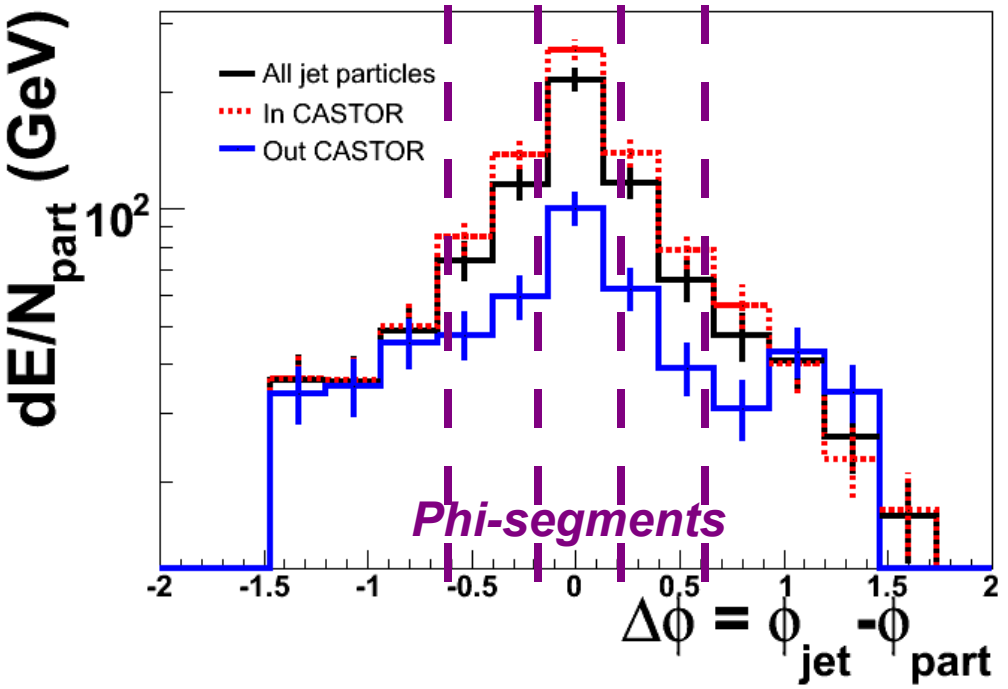
Too much activity to separate particles and run a conventional jet algorithm

Jet Energy – CASTOR energy correlation

Measure deposit energy in CASTOR.

- **Total energy deposit in CASTOR**
- **Energy in most active Phi-segment**
- **Energy in most active Phi-segment + Energy in two neighbouring Phi-segments**





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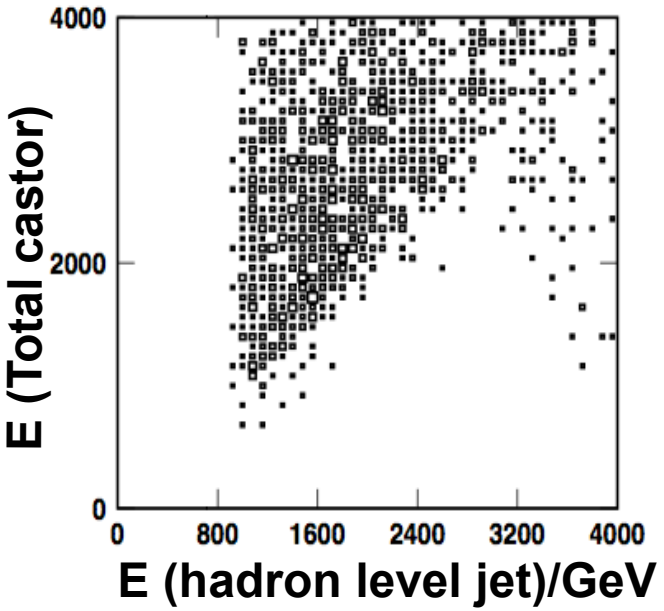
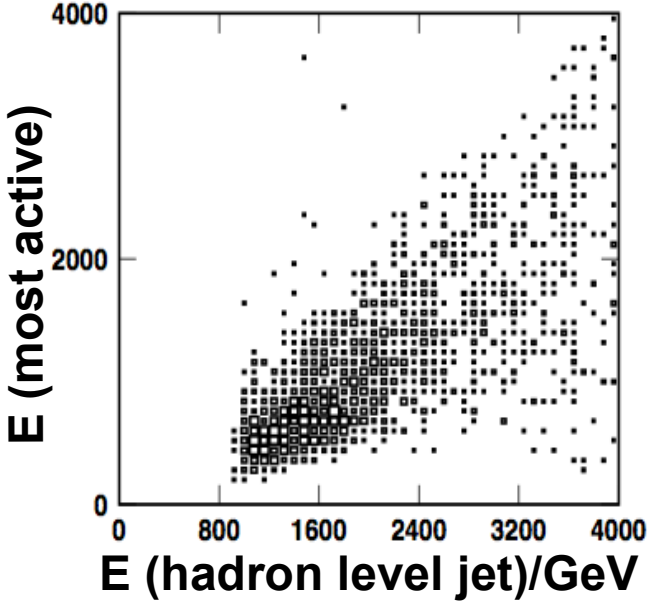
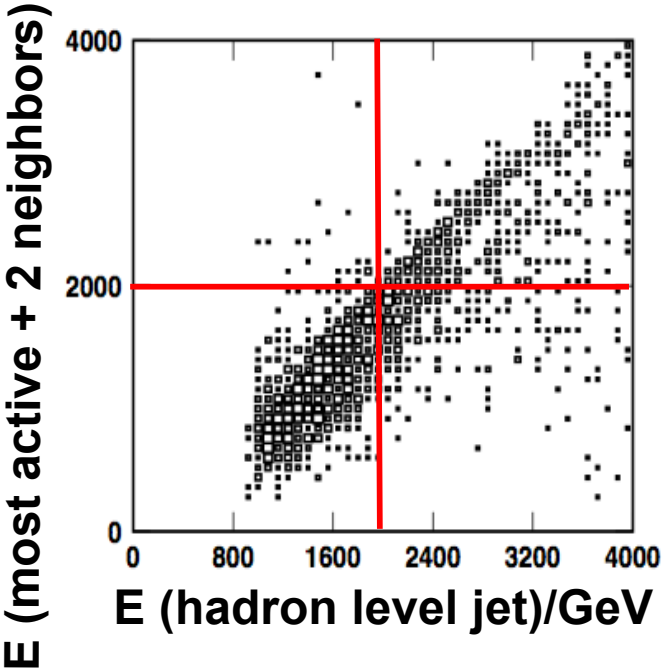
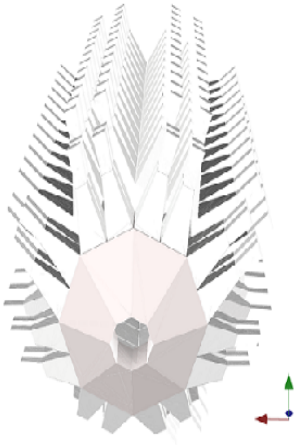






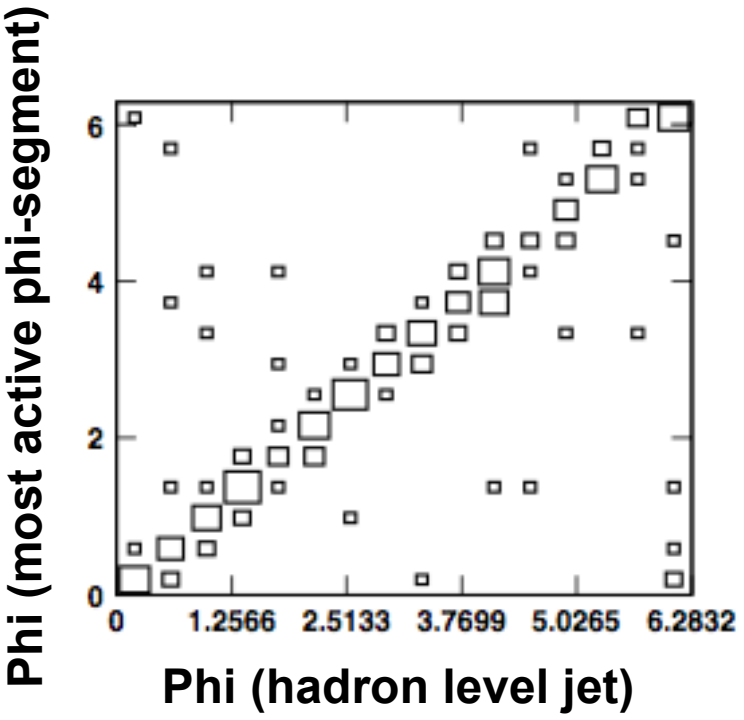
E (hadron level jet) > 10 GeV

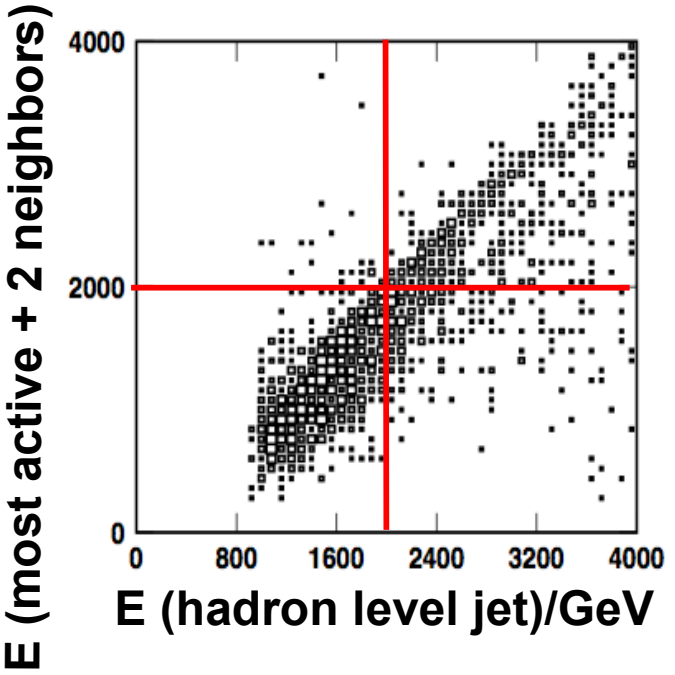
Jet Energy – CASTOR energy correlation



On hadron level in Monte Carlo:

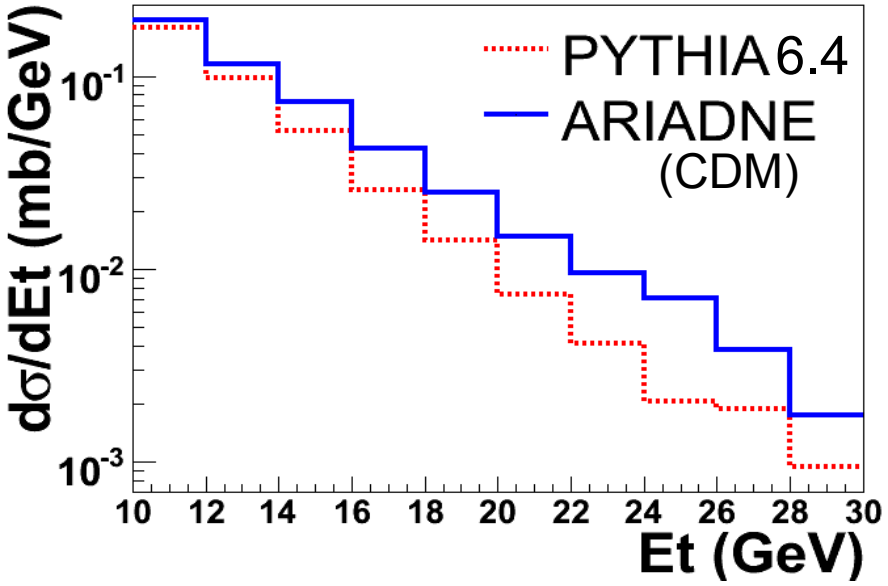
١.Divide forward region into 16 Phi-regions.
٢.For each region sum energy of all stable particles.
٣.Find region with highest energy.
٤.Add energy from 2 neighbouring cells.

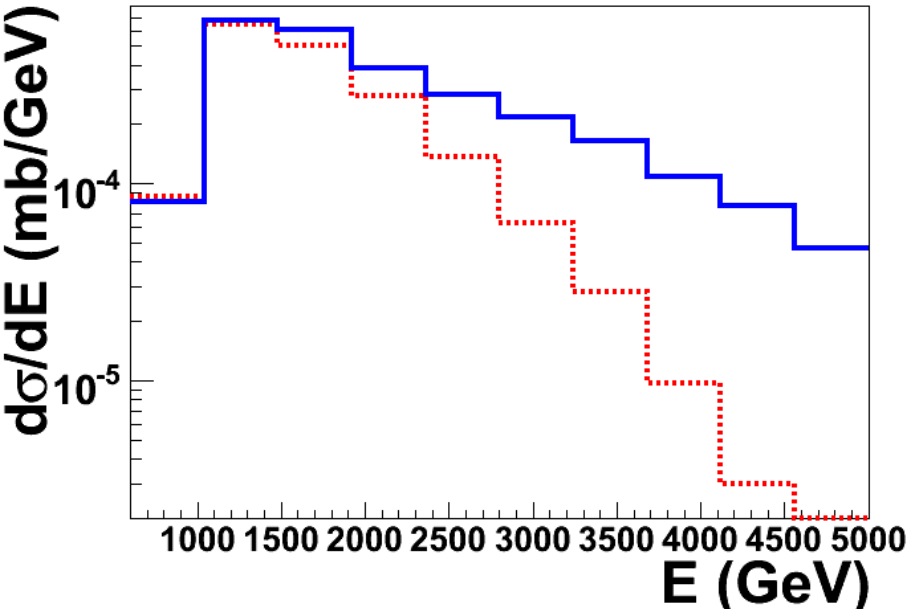




MC comparison

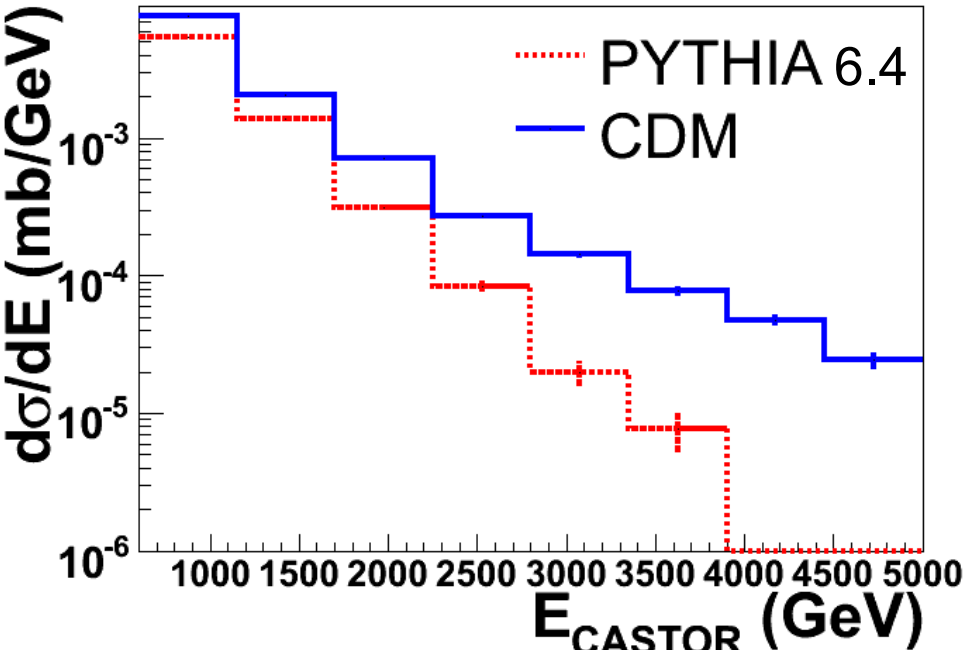
Before, forward jets hadron level:





Now, segments in CASTOR:

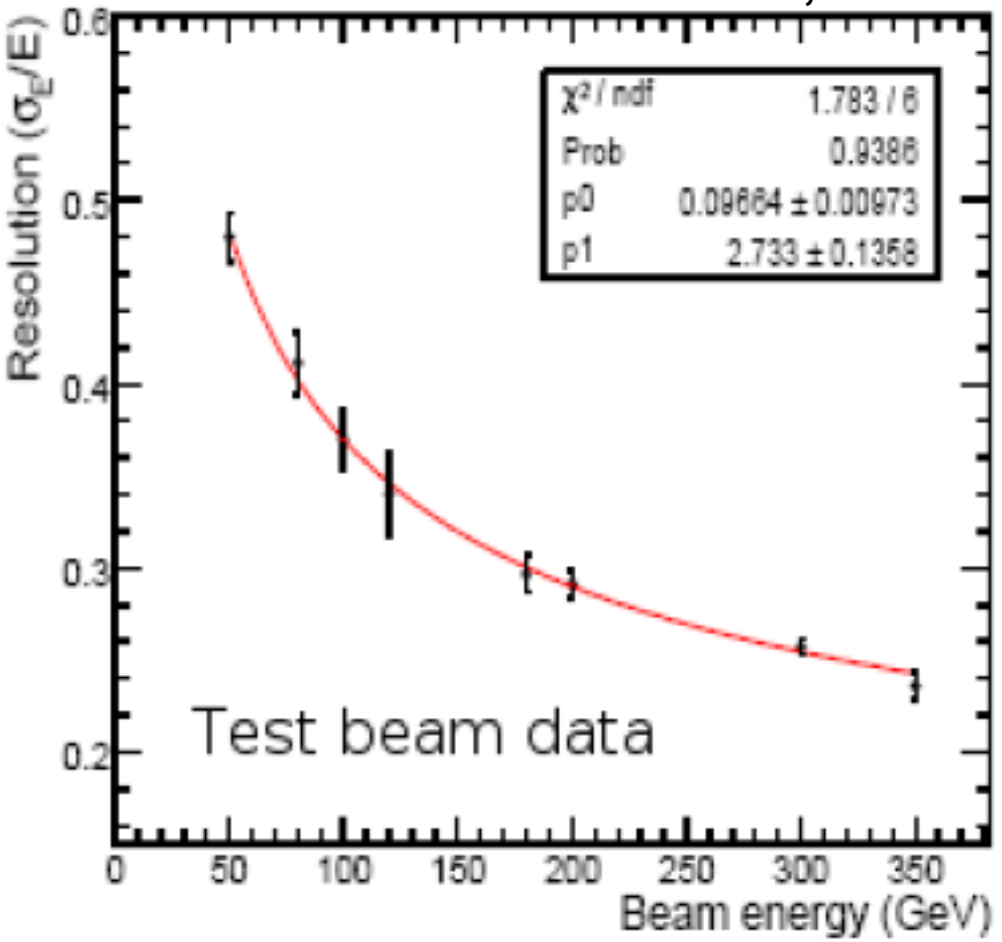
Still large difference between different QCD models.



Detector effects

Energy resolution

From CASTOR test beam data, 2007



Smear **all particles** accordning to:

$$\frac{\sigma}{E} = p_0 + \frac{p1}{\sqrt{E}}$$

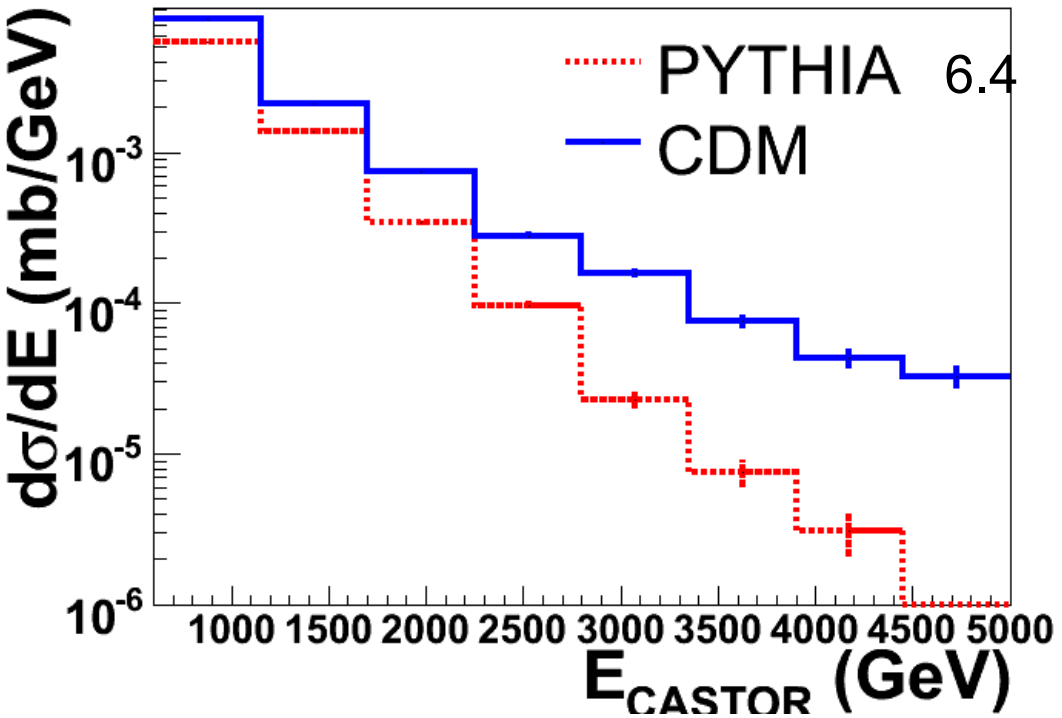
where

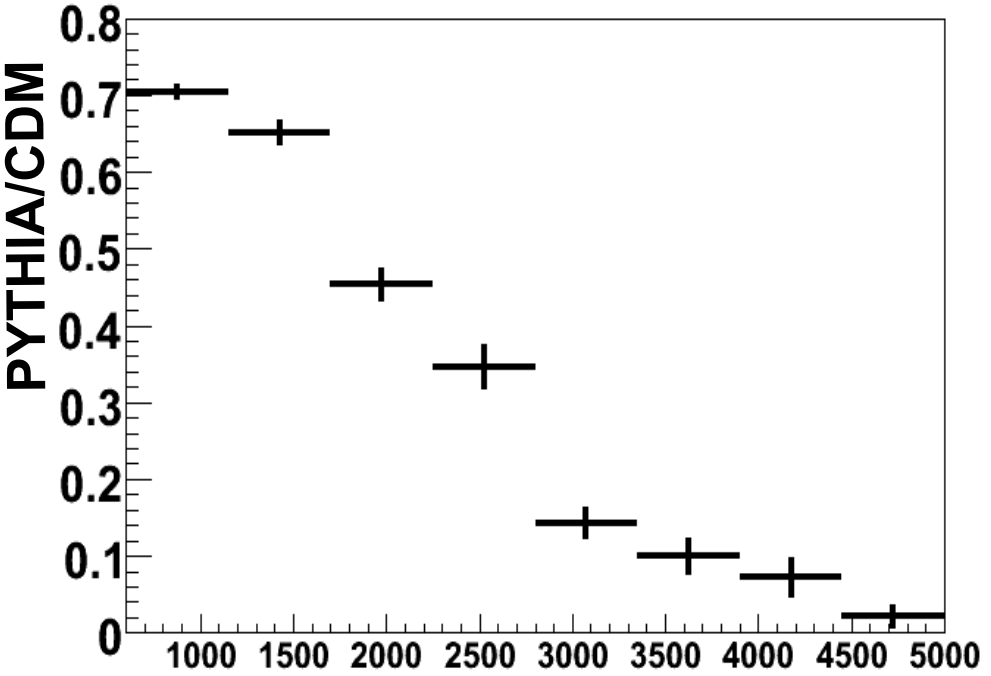
$$p_{0,hadrons} = 0.09664$$
$$p_{1,hadrons} = 2.733$$

$$p_{0.EM} = 0.063$$
$$p_{1,EM} = 0.886$$

Result

After: **-Energy smearing of particles**
-Noise cut of particles (E_particles > 10 GeV)
-Summing up energy in most active CASTOR segment+neighbours





→ **By using CASTOR we can make measurements that distinguish between the different QCD models (DGLAP/non-DGLAP).**

Summary

- 2+Forward Jet events: Sensitivity to parton dynamics beyond DGLAP
- Limitation: CASTOR is a calorimeter without rapidity separation and the particle multiplicity within a detector segment can be high.
- However, good correlation between energy deposit in CASTOR azimuthal segments and the jet energy.
- CASTOR will be of great use to study QCD dynamics.

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