The 2nd International Conference on Particle Physics and Astrophysics (ICPPA-2016)

Nuclear physics and particle physics

Azimuthal decorrelation of jets widely separated in rapidity in pp collisions at $\sqrt{s} = 7$ TeV

(10.1007/JHEP08(2016)139)

CMS collaboration

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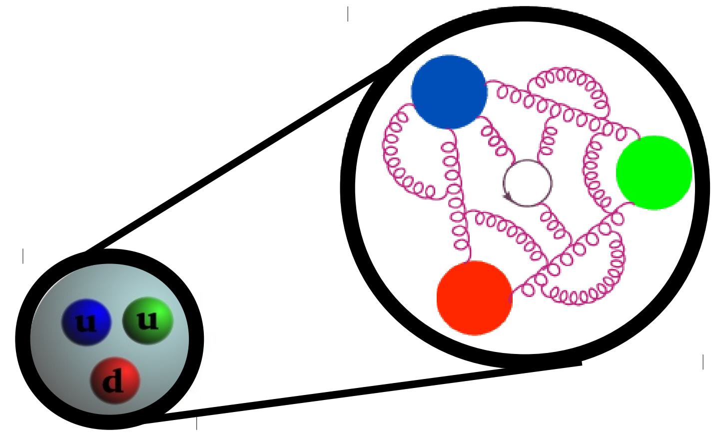
10 - 14 October 2016 | MEPhI, Moscow

Content:

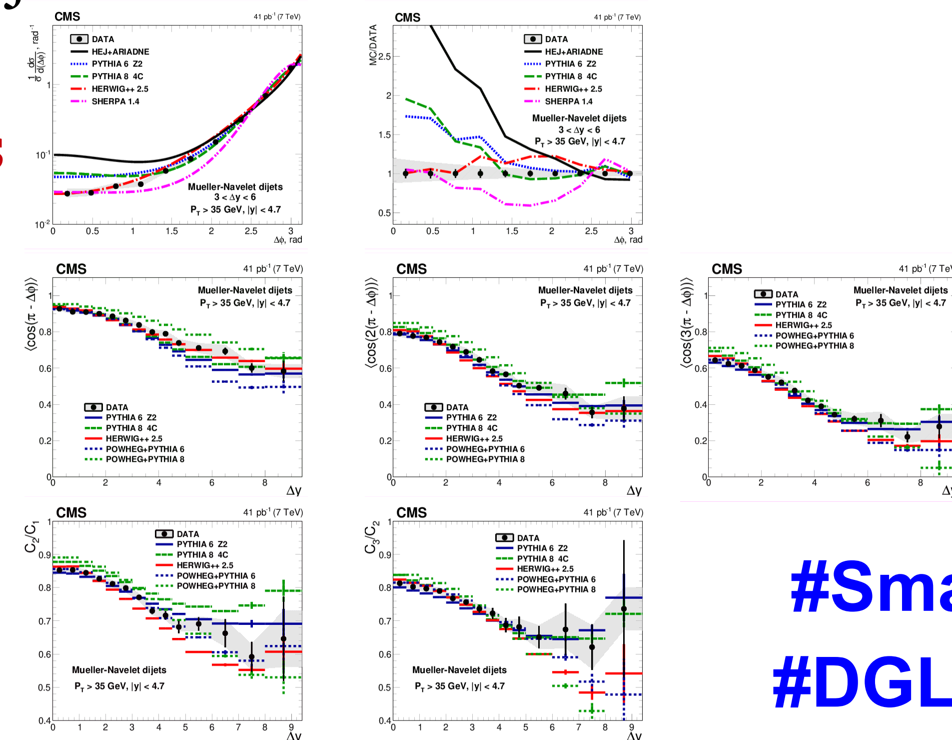


1. Introduction and Motivation
2. CMS Detector and collaboration
3. Observables for di-jet decorrelations:

Δφ distributions

Average cosines

Cosines ratios



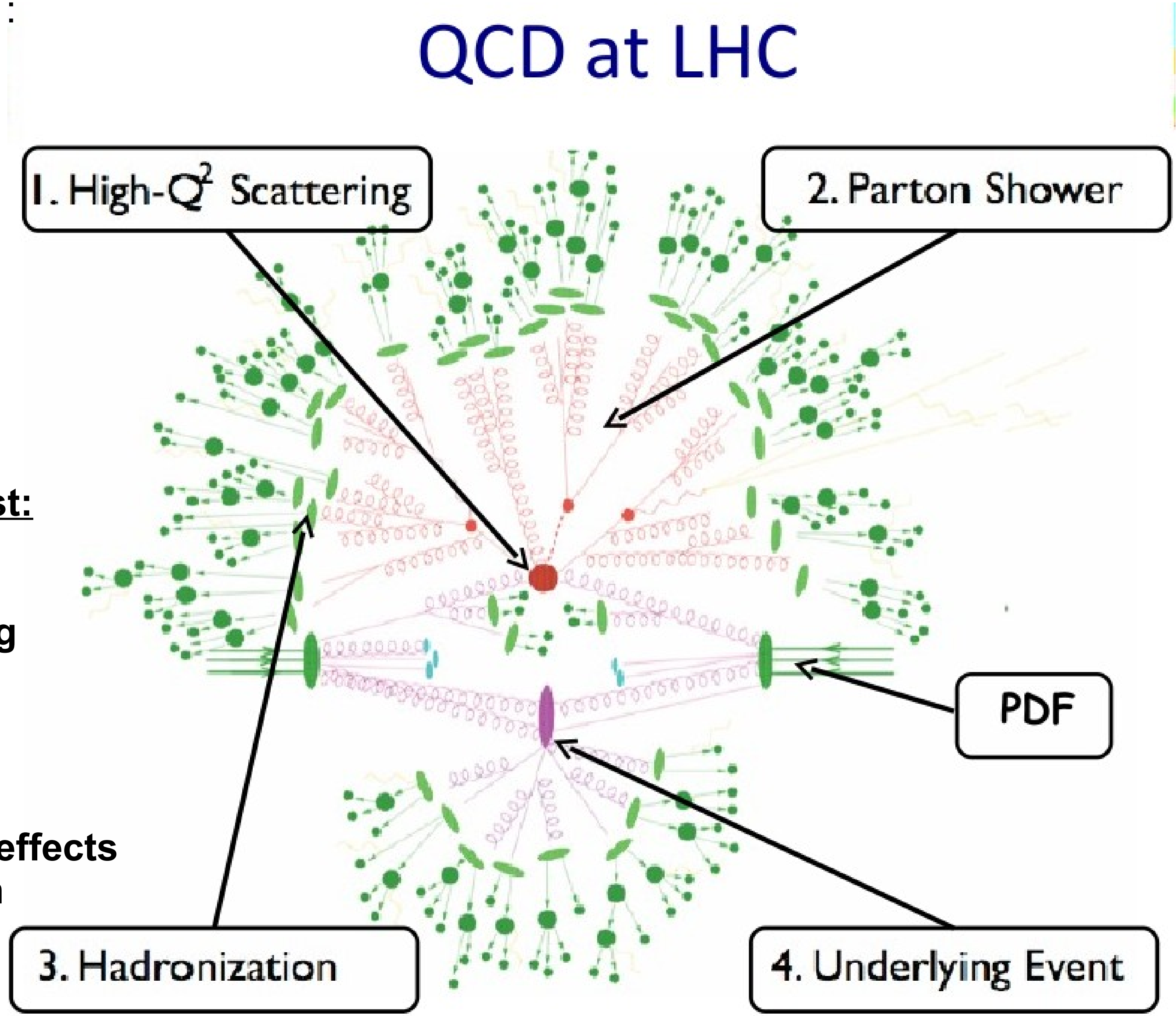
#pQCD

#Small-x physics

#DGLAP vs BFKL

4. Comparison with models and previous (D0, 1996) results
5. Summary and Conclusions

Introduction:



Typical Event:
1) p-p, 7 TeV
2) Inclusive jet
   p_T > 35 GeV
3) anti-k_T
   R = 0.5

Phenomena of Interest:
1) Parton Shower:
   ISR & FSR
2) High-Q^2 scattering
3) PDF

Search for
1) Higher Order QCD effects
2) BFKL resummation
3) MPI

Introduction:

Mueller-Navelet dijets: max Δy in the event (**y ≈ η**)

A.H.Mueller , H.Navelet, Nucl. Phys. B 282 (1987) 727

jet p_T > 35 GeV, |y| < 4.7

$$y=\frac{1}{2}\ln\left(\frac{E+p_z}{E-p_z}\right)\approx-\ln\left(\tan\left(\frac{\theta}{2}\right)\right)=\eta$$

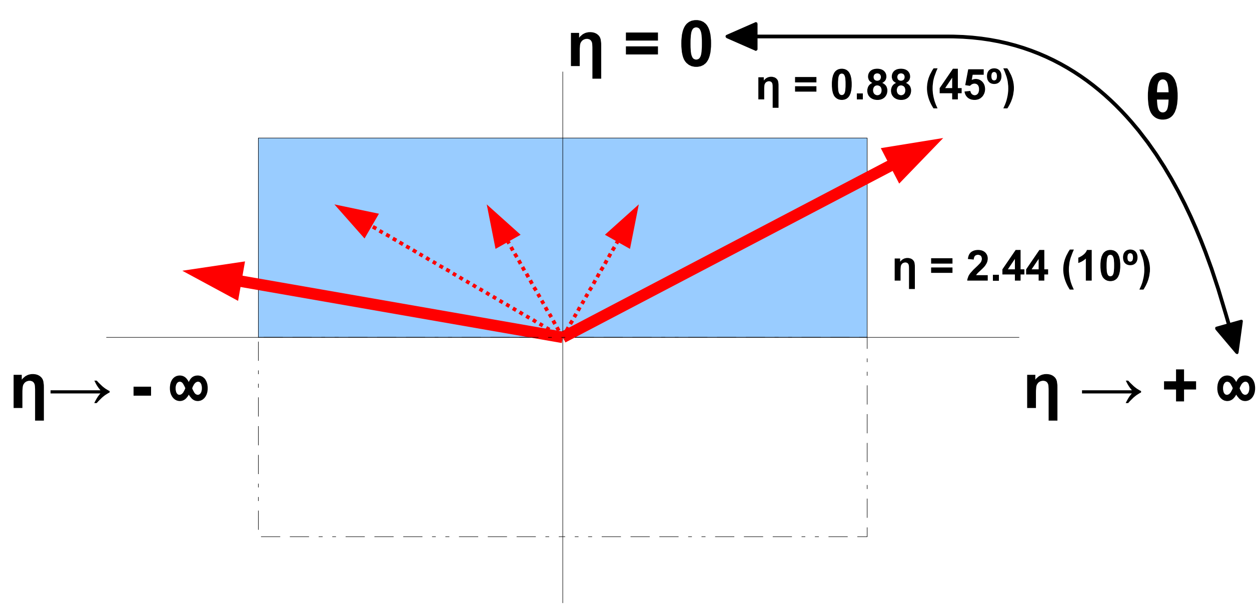
$$\Delta y=|y_1-y_2|$$

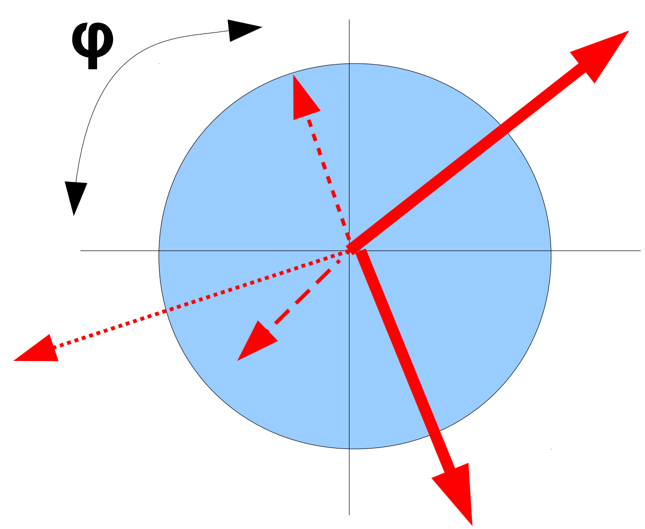
— invariant to collision-axis boost

Δφ — 0 < Δy < 3, 3 < Δy < 6, 6 < Δy < 9.4

C1 = <cos(π-Δφ)> C2 = <cos(2(π-Δφ))> C3 = <cos(3(π-Δφ))> C2/C1, C3/C2	vs Δy

✔ **Decorrelation in azimuthal plane**
reflects radiation activity between jet



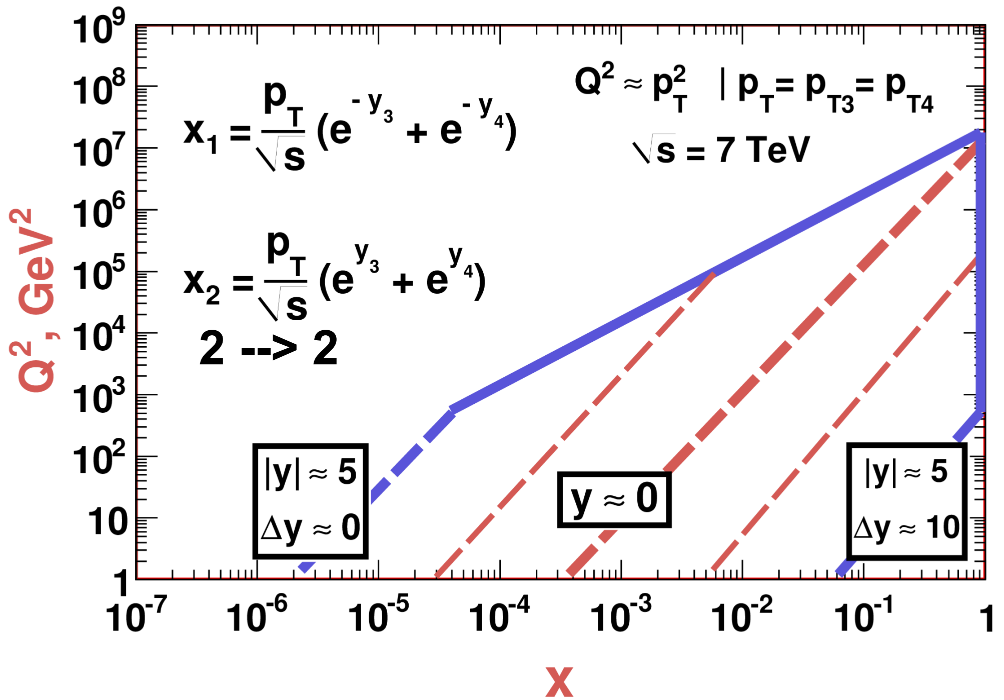


Motivation:

DGLAP log(Q ^ 2) $\frac{\sqrt{s}}{2} \gtrsim k_T$ vs $\frac{\sqrt{s}}{2} \gg k_T$ BFKL log(1/x)

- ✔ **BFKL kinematic region should be determined experimentally**
- ✔ **BFKL effects enhanced by** $(\alpha_s \Delta y)^n$

Large Hadron Collider for Small-x

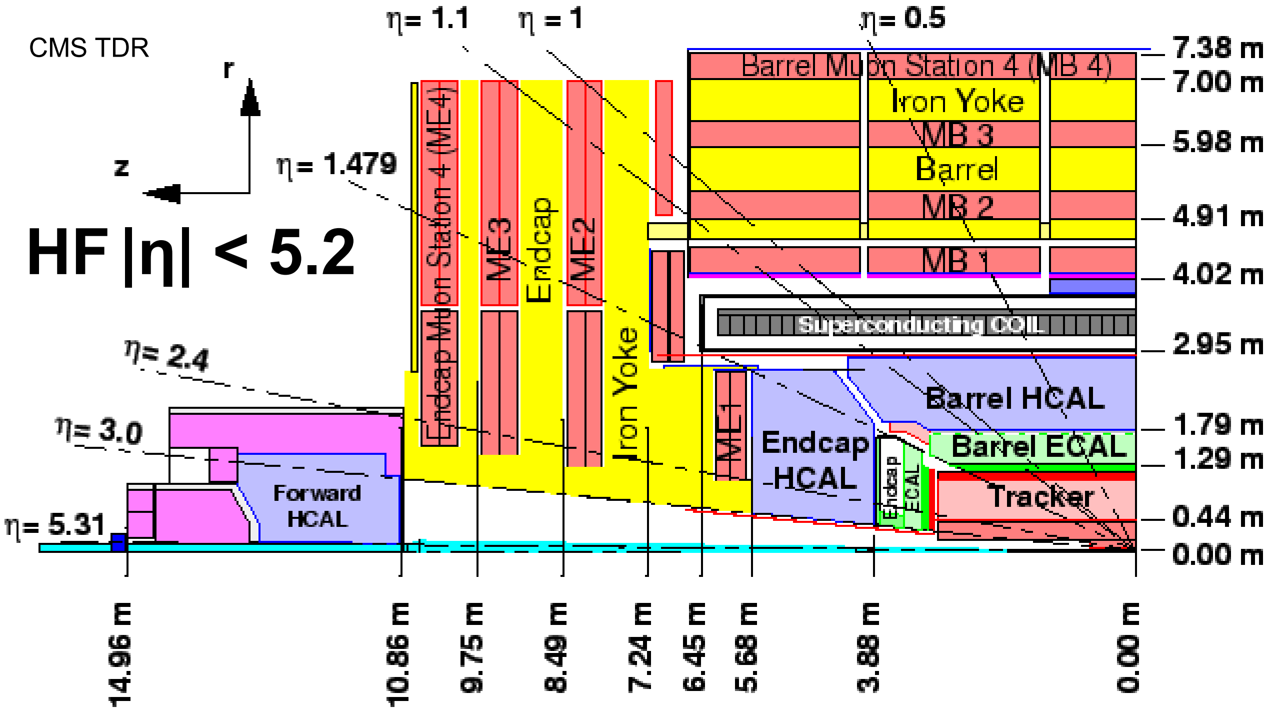


1. New region reached with CMS HF
2. Increased energy 7-8 TeV and low Pile-Up Runs
3. Forward-Backward Trigger

At low p_T: x ~ 10^-5

Forward-Backward Jets with low pT is an essential aspect of small-x physics

CMS Detector



HF |η| < 5.2

Tracker

σ/pT ~ 1.5·10-4 pT(GeV) ⊕0.005

EM Calorimeter

σE/E ≈ 2.9%/√E(GeV) ⊕ 0.5% ⊕ 0.13GeV/E

HAD Calorimeter

σE/E ≈ 120%/√E(GeV) ⊕ 6.9% (|η| < 3)

σE/E ≈ 198%/√E(GeV) ⊕ 9% (3 < |η| < 5)

Muon Spectrometer

σpT/pT ≈ 1% low-pT muons
σpT/pT ≈ 5% 1-TeV muons

From inside out:

- **Tracking**
  - Silicon pixel
  - Silicon strip
- **calorimeters**
  - PbWO4 crystals - EM
  - Scintillator based - HAD
- **3.8T solenoid**
- **return yoke instrumented with muon chambers**

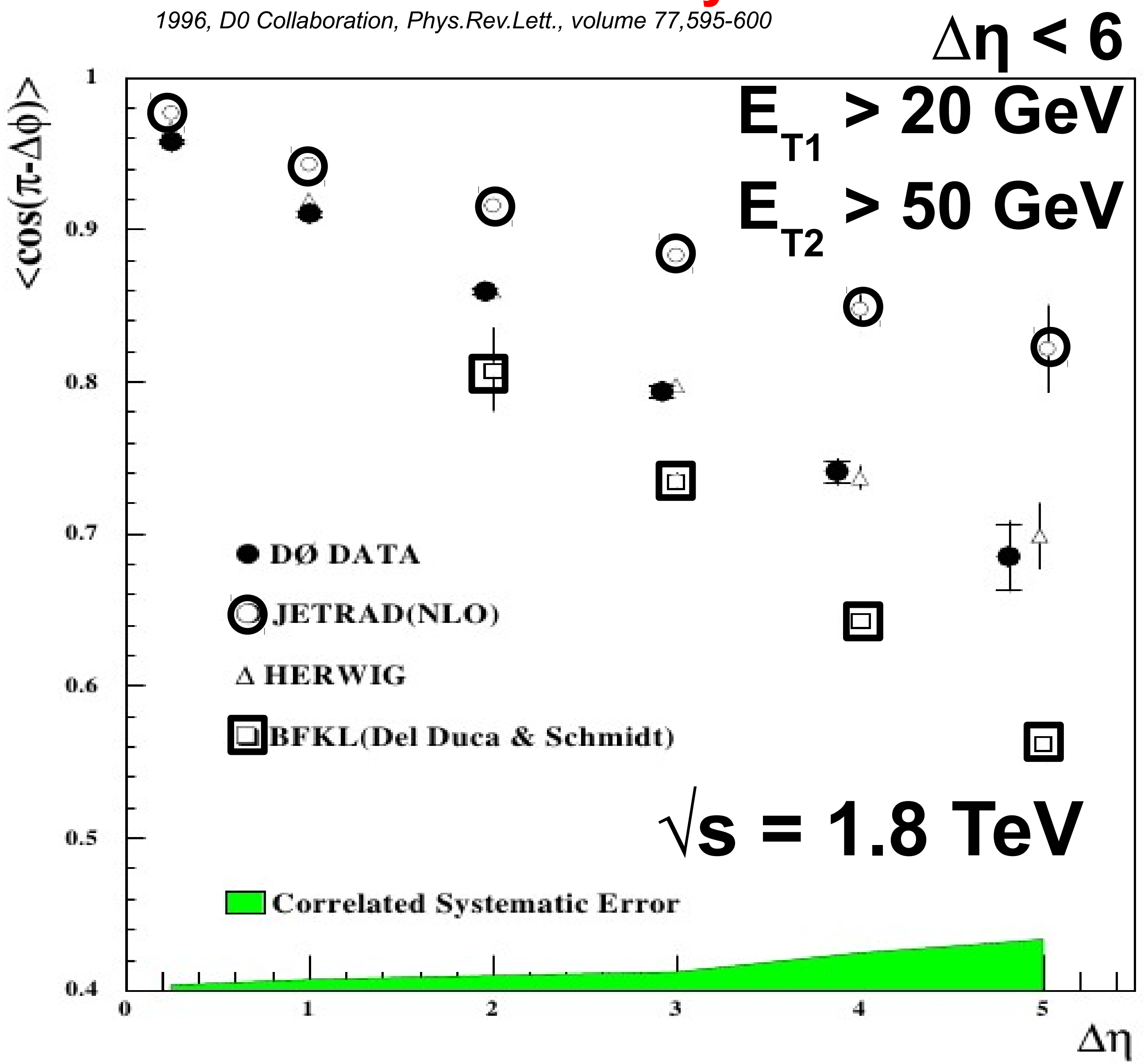
<u>**Low Pile-Up**</u> Runs:

2010 data
AntiKt R = 0.5 Jet Clustering

Previous results:

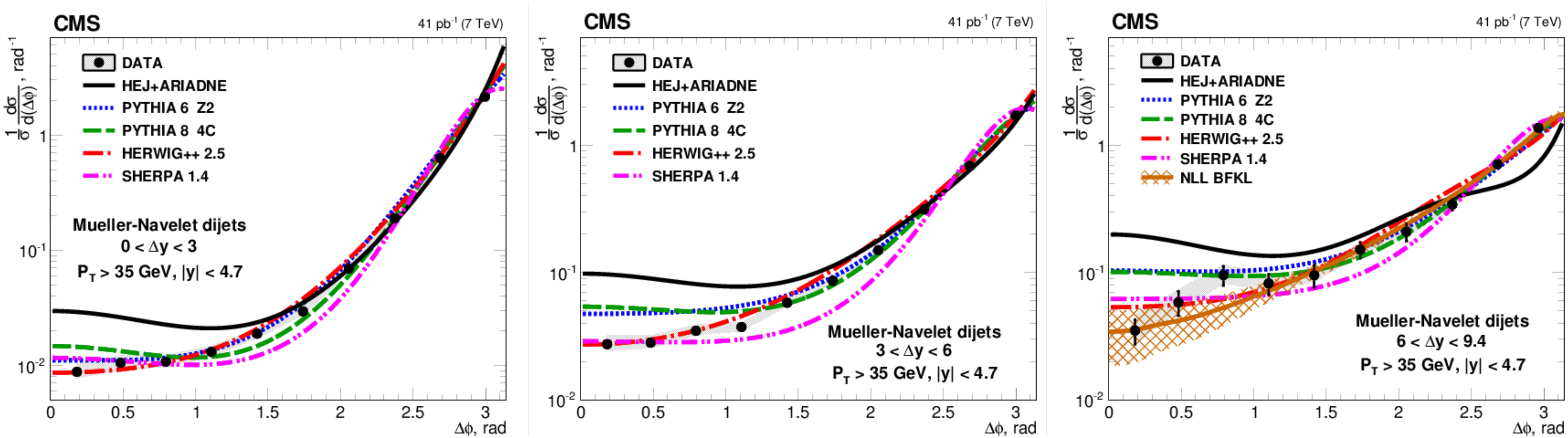
MN-decorrelations by D0:

1996, D0 Collaboration, Phys.Rev.Lett., volume 77,595-600



- ✔ Sensitivity to different models
- ✔ Expected more decorrelations with BFKL
- ✔ L0xPartonShowers Herwig 6 describes data, NLO JETRAD does not

Azimuthal Decorrelation at 7 TeV



Models for comparison

DGLAP approach at LL approximation:

PYTHIA 6 (version 6.422) Z2
HERWIG++ (version 2.5.1) UE-7000-EE-3
PYTHIA 8 (version 8.145) 4C

Fixed order NLO terms:

POWHEG + Pythia 6 Z2 / 8 4C

Tree level 2->2+n ME and LL parton showers:

SHERPA 1.4

LL BFKL elements:

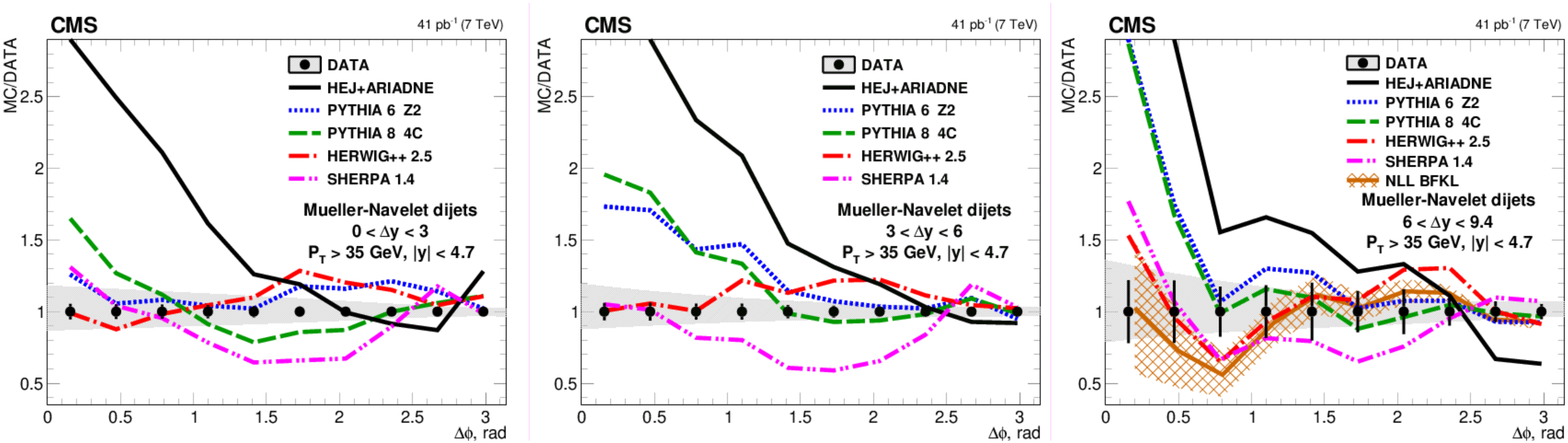
HEJ+ARIADNE 0.99b

NLL BFKL analytical calculations

Phys. Rev. Lett. 112 (2013) 082003

✔ High level of back-to-back correlation in the region $\Delta y < 3.0$ becomes less peaked at $\Delta\varphi \approx \pi$ when going to larger Δy

Azimuthal Decorrelation at 7 TeV



Δy < 3.0

- PYTHIA 6 and HERWIG ++ describe the data well, showing some deviation only at low Δφ
- PYTHIA 8 and SHERPA exhibit significant deviations from the data beyond the uncertainties at intermediate and large Δφ

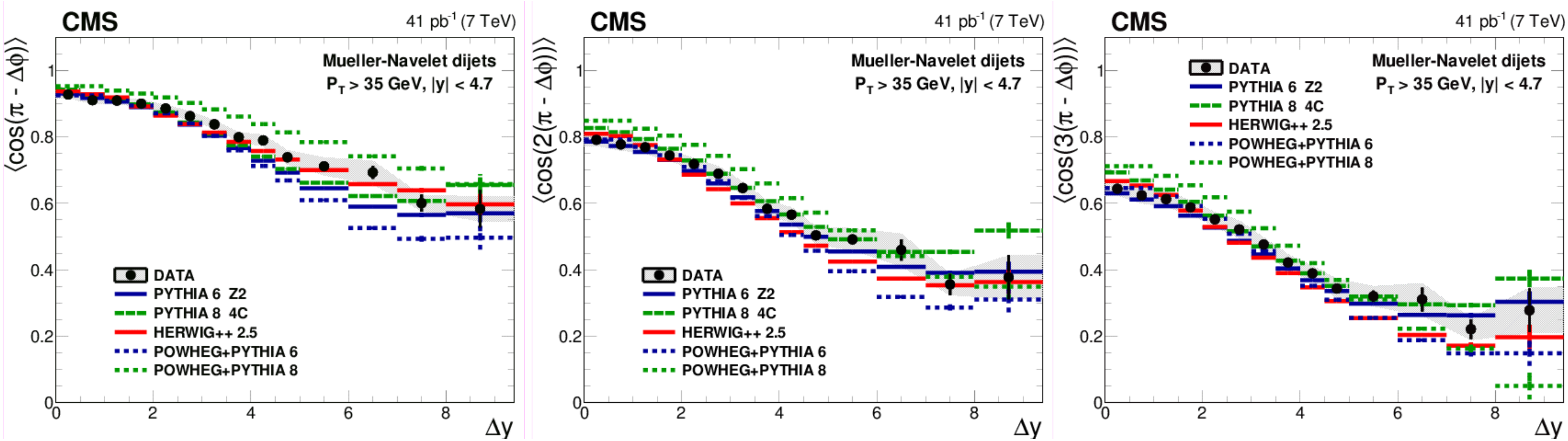
3.0 < Δy < 6.0 and 6.0 < Δy < 9.4

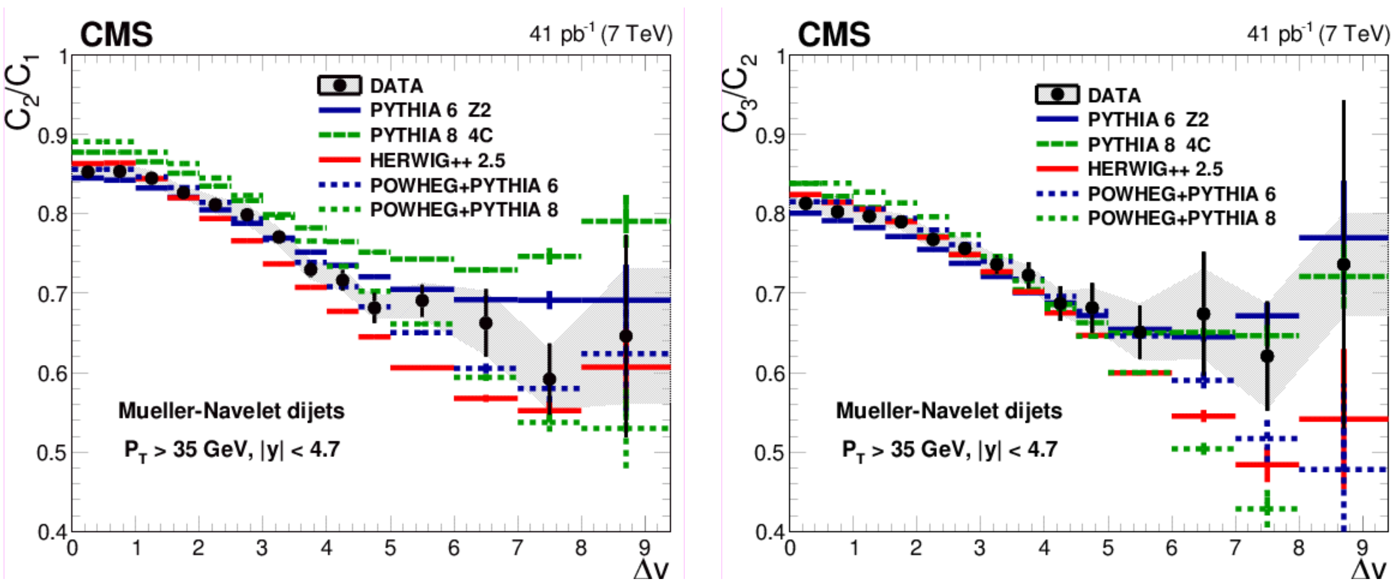
- PYTHIA 6 and 8 show a significant deviation at small Δφ
- HERWIG ++ and SHERPA show deviations to the measurements in the medium Δφ region, but are close to the data at very small Δφ

HEJ + ARIADNE package overestimates the azimuthal decorrelation at small Δφ at all Δy

NLL BFKL agree well with the data within the experimental and theoretical uncertainties

Azimuthal Decorrelation at 7 TeV



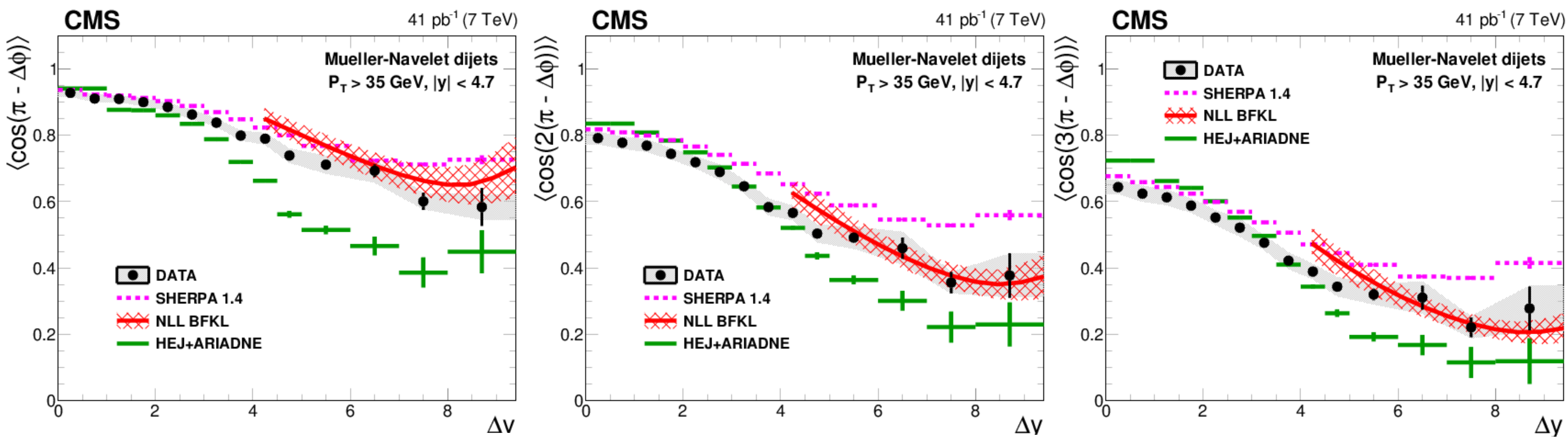


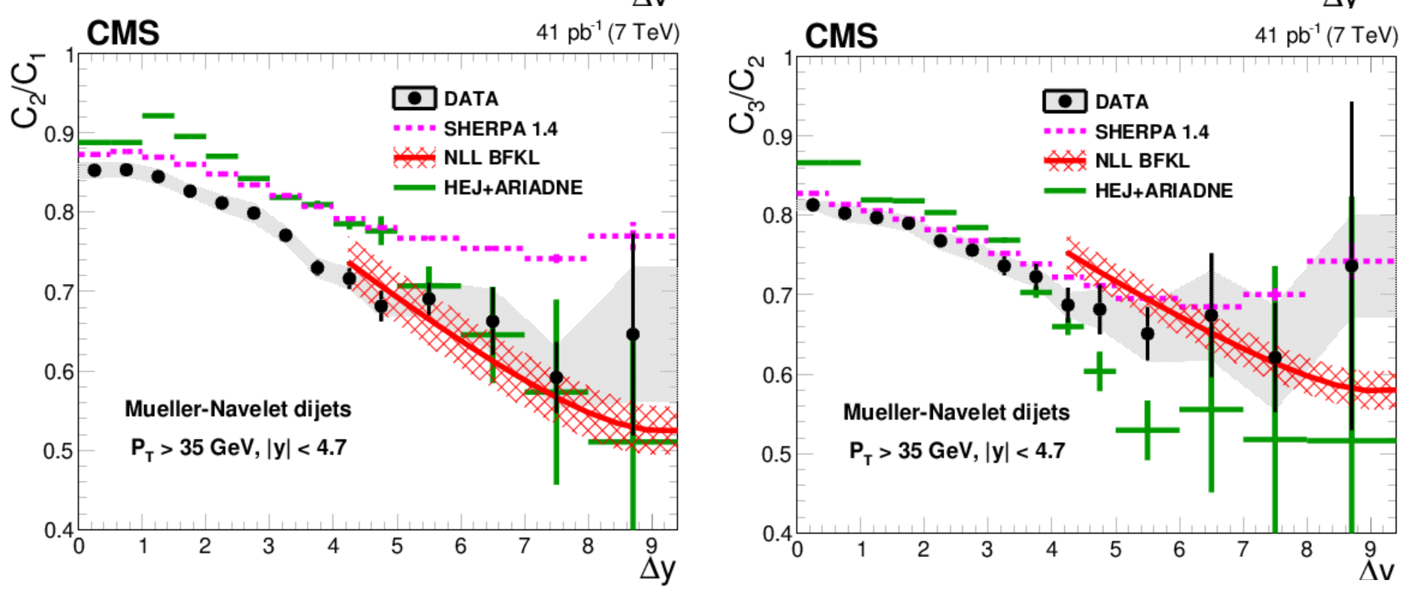
< 1 at Δy = 0, due to jets with pT < 35 GeV

decrease with increasing Δy

Colour-coherence effects (colour dipoles, polar-angle ordering, etc.) at small Δy (DGLAP domain), leads to an improvement of data description, while at large Δy they yield a worse description of the data

Azimuthal Decorrelation at 7 TeV

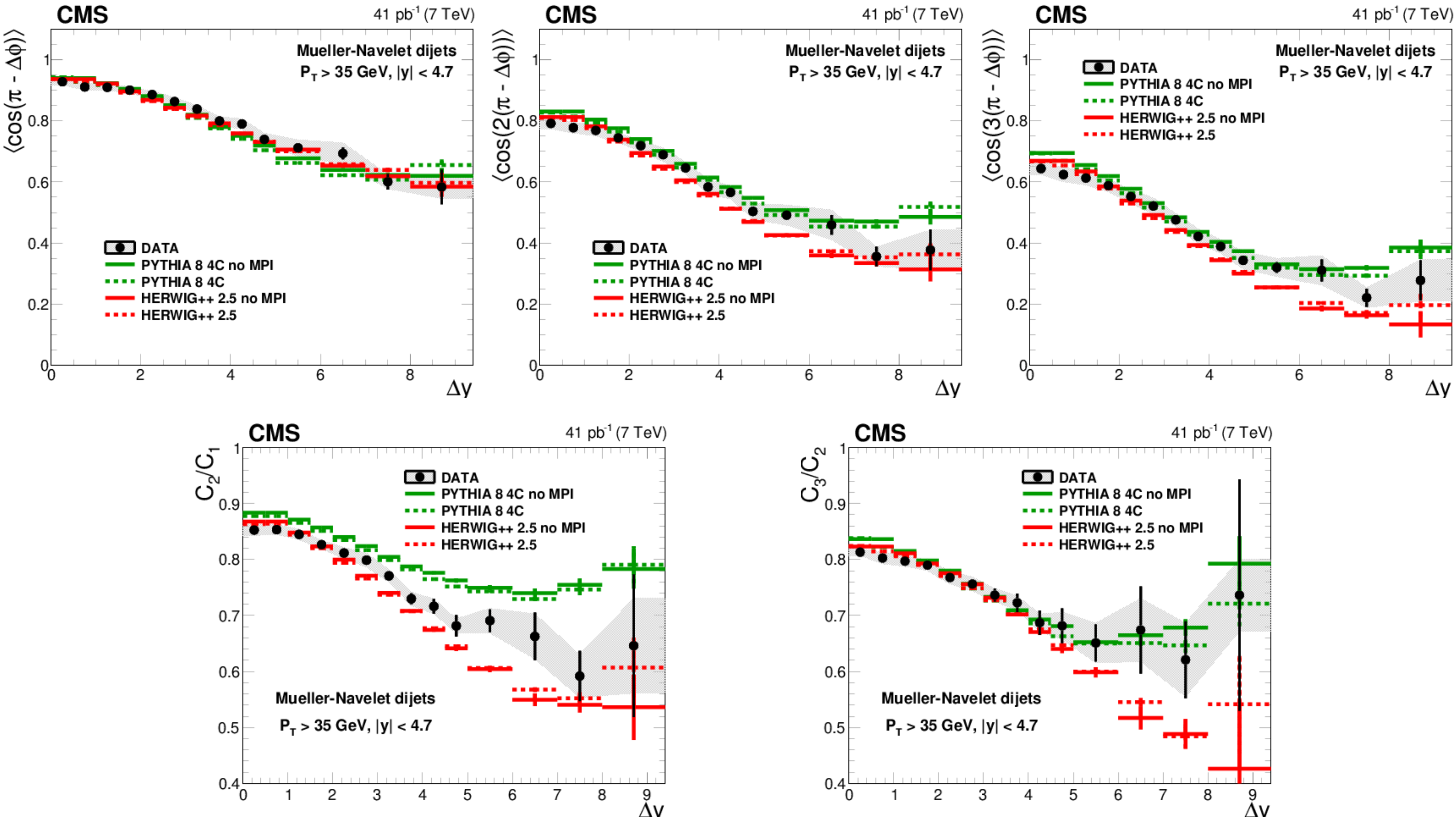




NLL BFKL agrees well with the data within the experimental and theoretical uncertainties

A better theoretical prediction might be obtained if colour-coherence contributions are replaced by the complete BFKL calculation at large Δy

Azimuthal Decorrelation at 7 TeV



MPI deviations are much smaller than systematic uncertainties

Summary & Conclusions

✔ **MN dijets measured for the first time up to Δy < 9.4 with pT > 35 GeV**
✔ **PYTHIA 6 Z2, PYTHIA 8 4C, HERWIG++ 2.5, SHERPA 1.4**
do not provide a good description of all measurements, but
Herwig++ gives overall best description
✔ **NLL BFKL** agrees well with the data for all measured observables
within the experimental and theoretical uncertainties at Δy > 4
✔ *MPI deviations are much smaller than systematic uncertainties*

The observed sensitivity to the implementation of the colour-coherence effects in the DGLAP MC generators and the reasonable data-theory agreement shown by the NLL BFKL analytical calculations at large Δy, may be considered as indications that the kinematical domain of the present study lies in between the regions described by the DGLAP and BFKL approaches

Tuning of QCD MC models is essential since they can not describe all data within experimental uncertainties

Thank you for your attention!

yours Azimuthal Decorrelations