QCD results from CMS

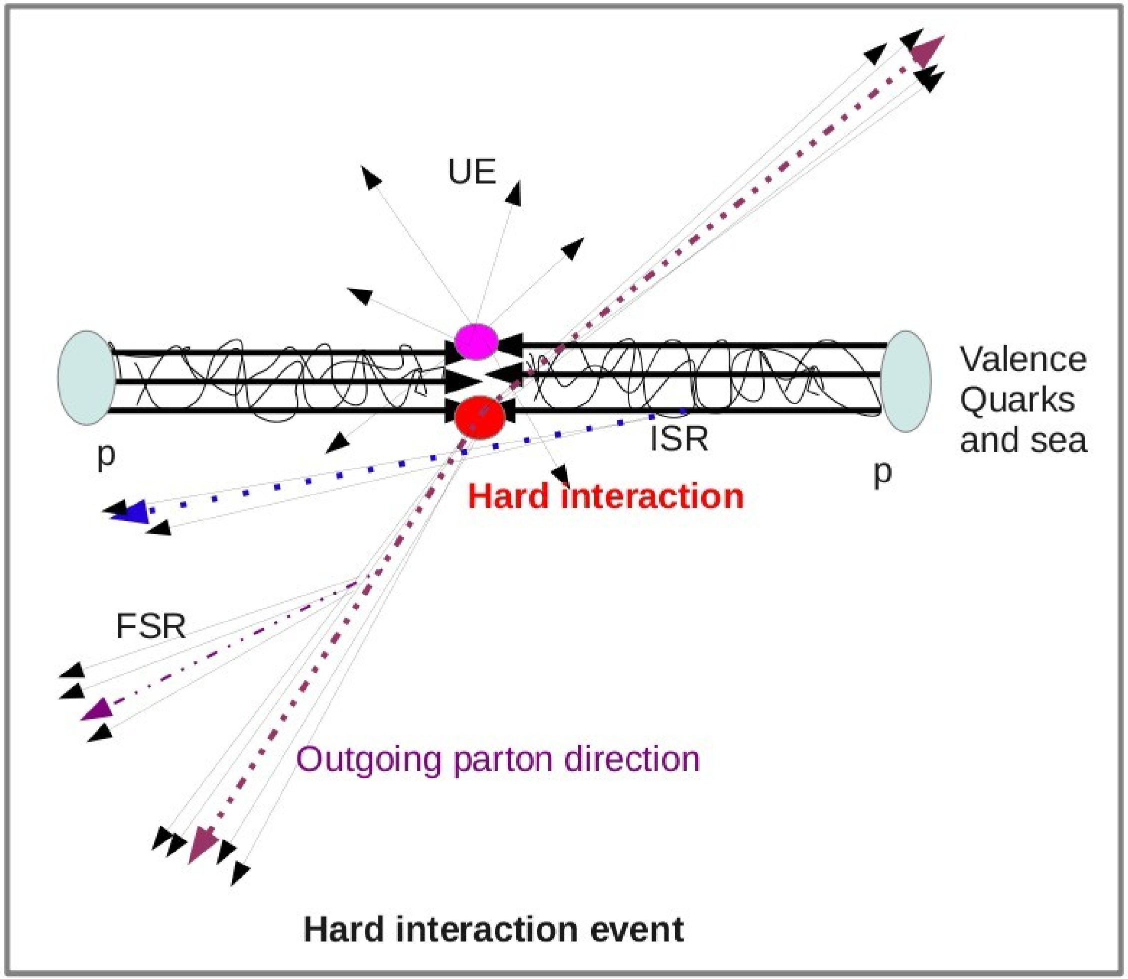
International Moscow Workshop on
the Phenomenology of Strong Interactions
In Tribute to Alexey Kaidalov

Vladimir Gavrilov (ITEP)
On behalf of the CMS Collaboration

Content

- Introduction
- CMS experiment and data taking in pp collisions
- Jet reconstruction and calibration
- Inclusive jet x-sections and PDF
- Di-jets at high mass region
- 3/2 jet ratio, 3-jet mass and α_s
- Color coherence
- Di-jets with large rapidity separations
- Conclusions

QCD at high energy pp collisions

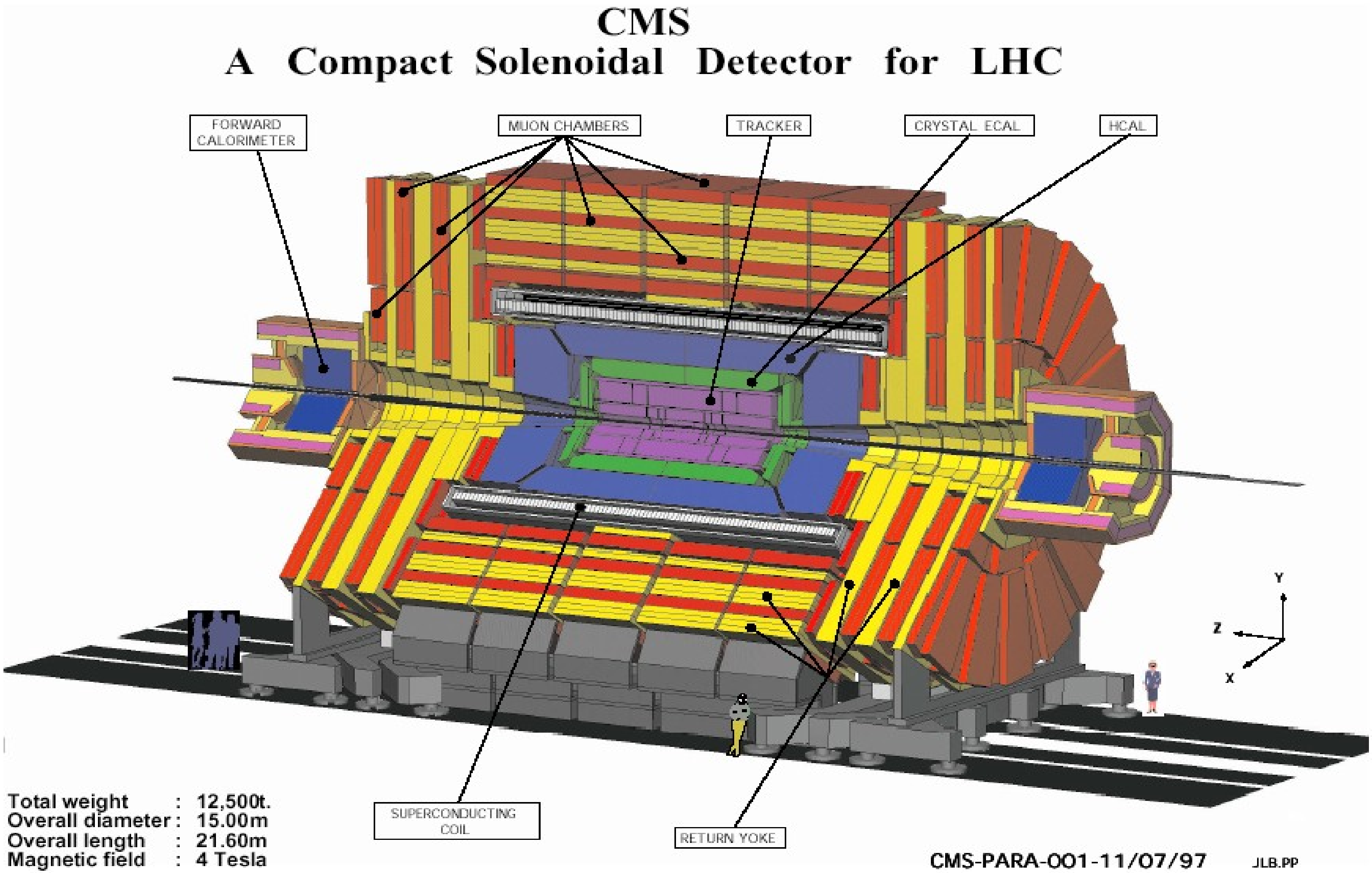


pQCD allows to calculate x-sections of hard processes with high Pt jets

Corrections for non-perturbative effects like MPI, hadronisation and underlying event are small

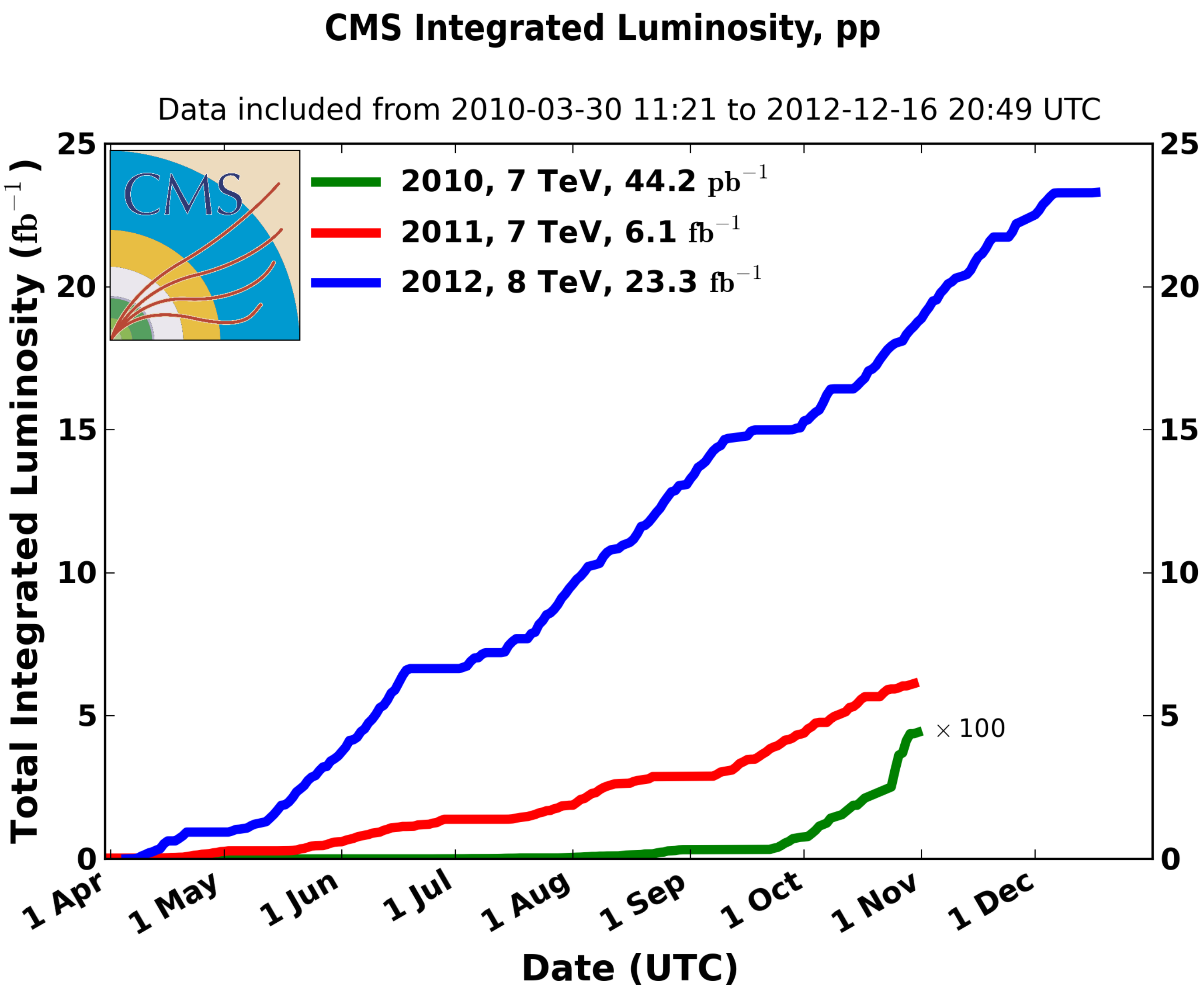
Di-jet production at high mass region allows to search for phenomena beyond SM

CMS detector



4

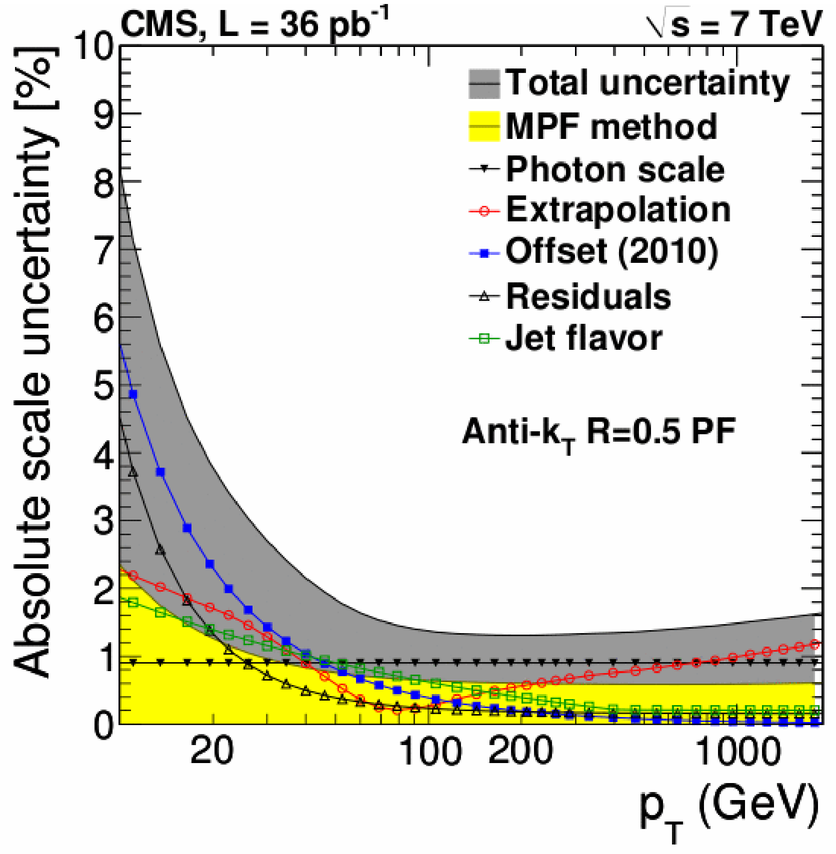
pp data taking

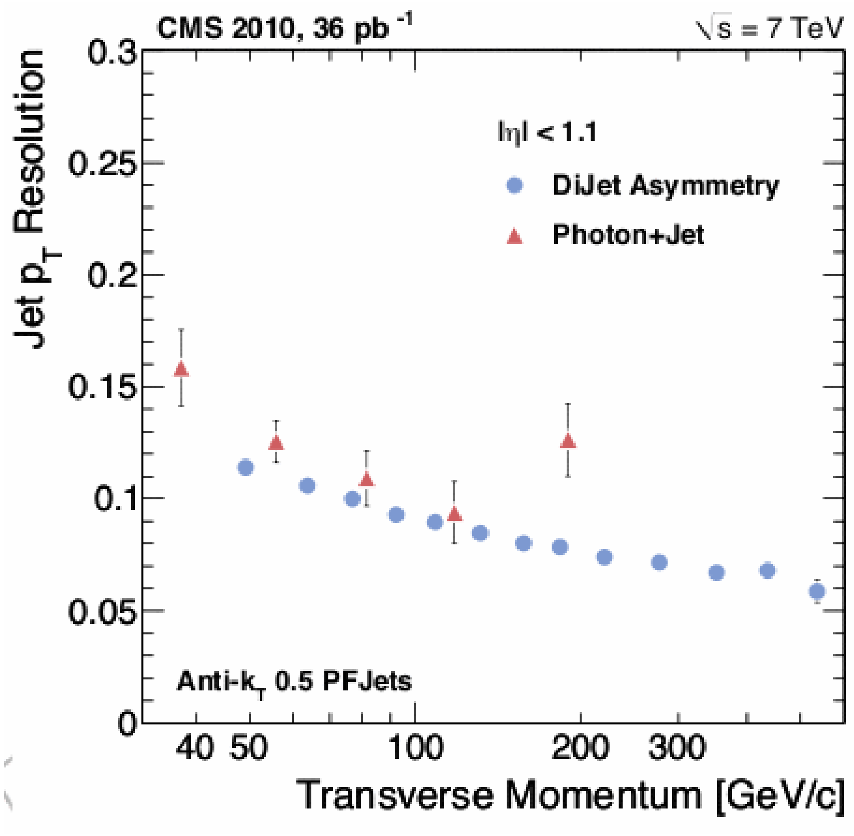


Jet reconstruction

- Jets at CMS are reconstructed using anti-kt clustering algorithm (d=0.5 and d=0.7)
- Information from Calorimeters, Tracker and Muon system is used for jet reconstruction
- Jet energy calibration is based on Pt balance for di-jet, photon-jet and Z-jet events
- Correction of jet Pt spectra for jet energy smearing is performed using unfolding technique

Jet performance



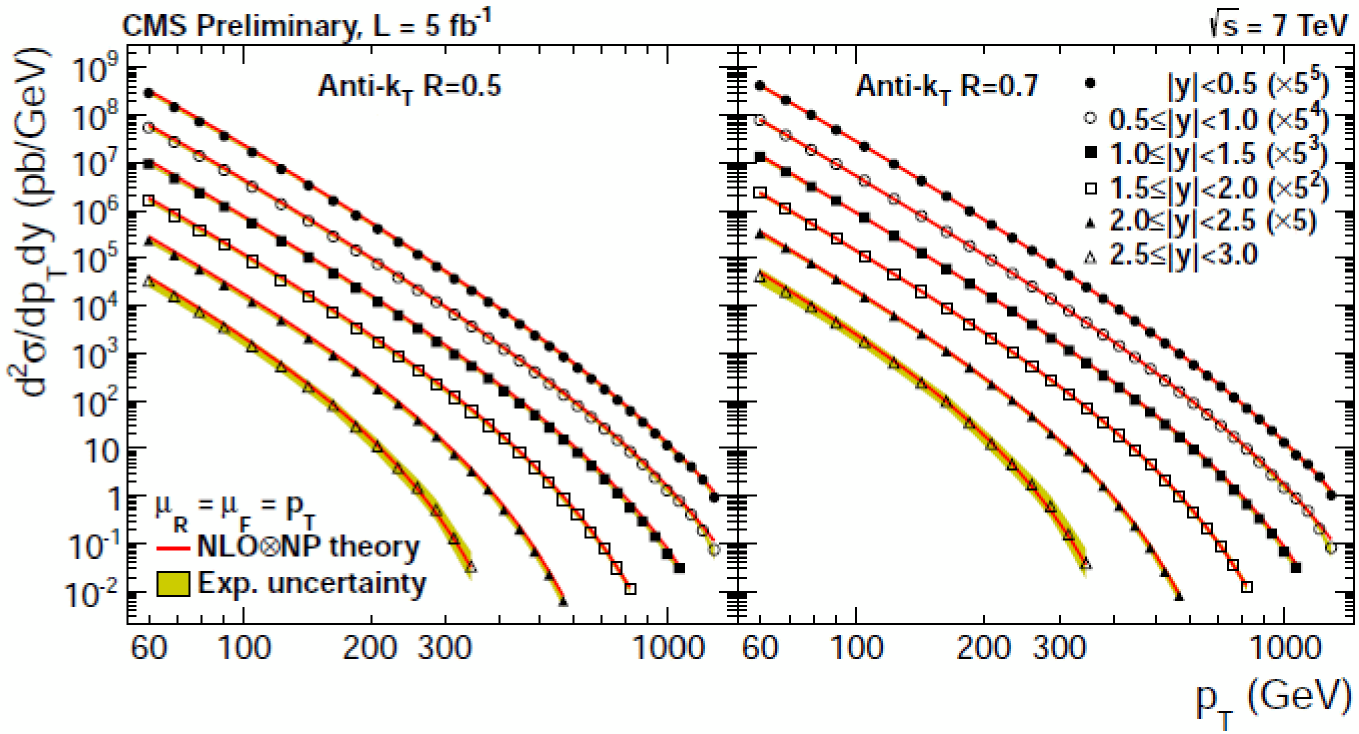


JINST, 6(2011)P11002

Comparison with QCD calculations

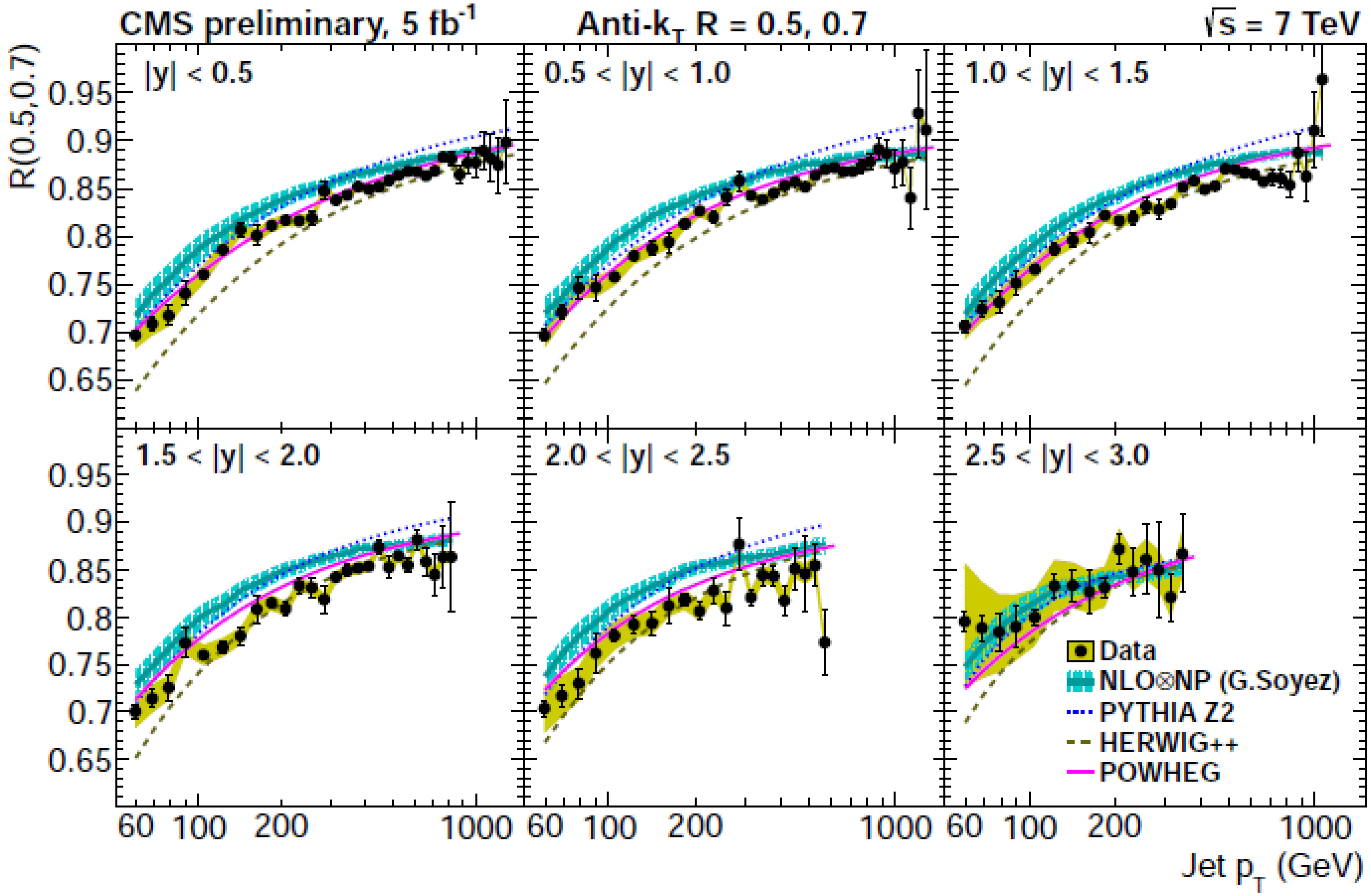
- QCD NLO calculations of inclusive jet x-sections are performed for different PDFs
- Corrections for non-perturbative effects (hadronisation, multi-parton interactions and underlying event) are calculated using MC generators
- The results are compared with data corrected to particle level jets

Inclusive jets at 7TeV



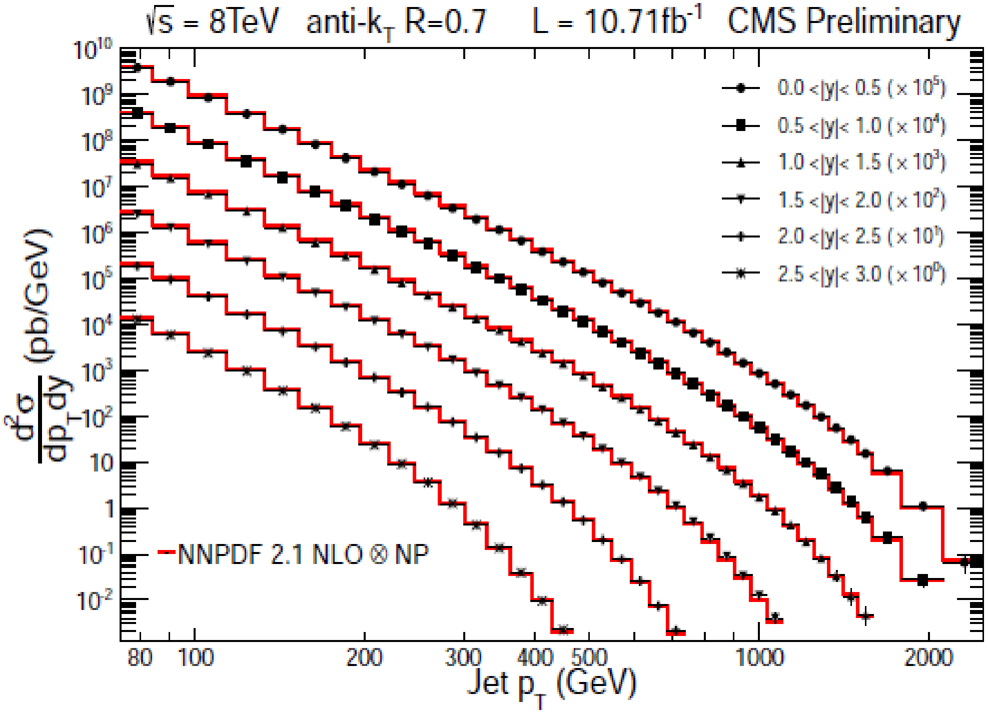
CMS PAS SMP 13-002
PR D87(2013)112002

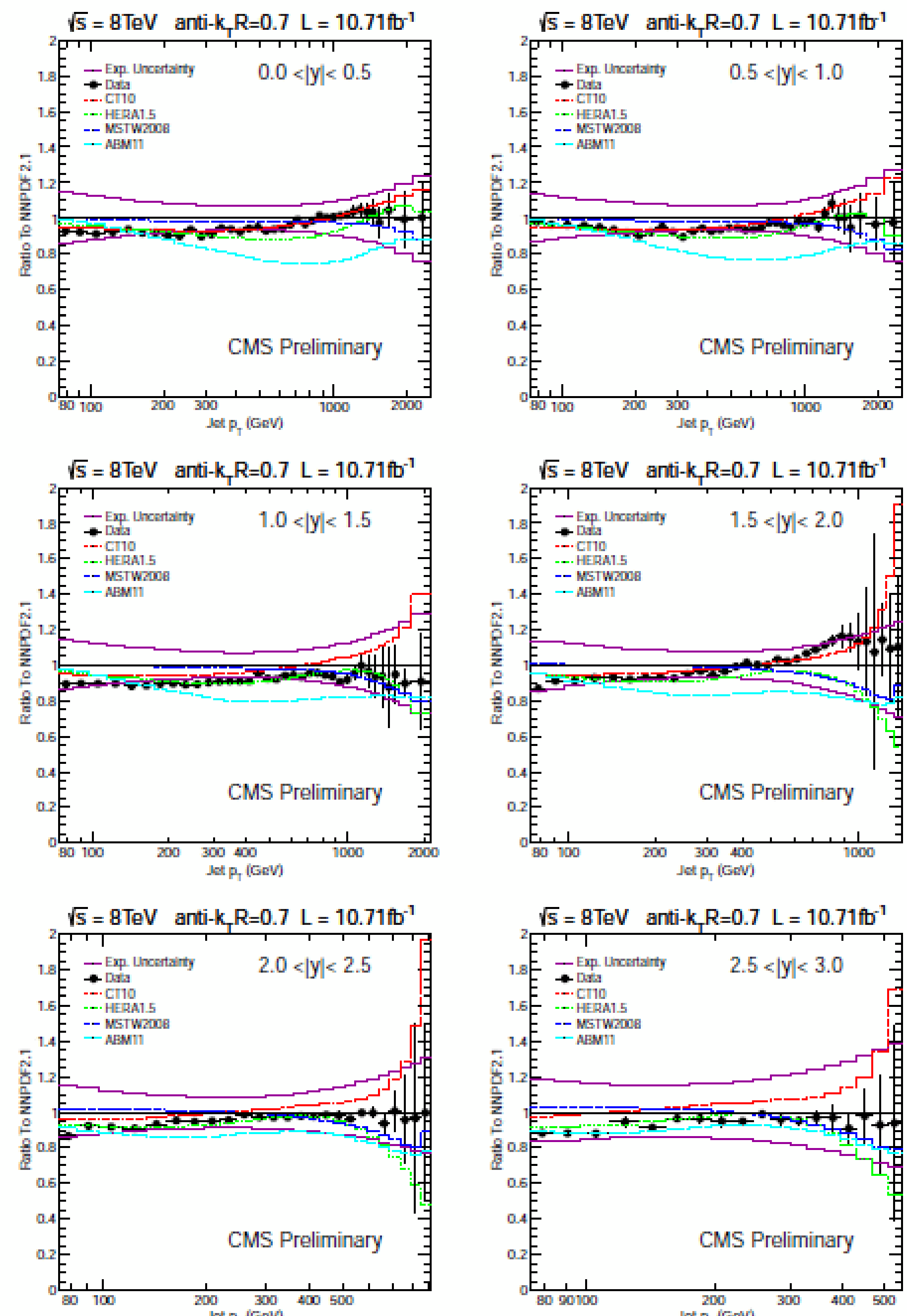
Ratio ak5/ak7



CMS PAS SMP 13-002

Inclusive jets at 8 TeV

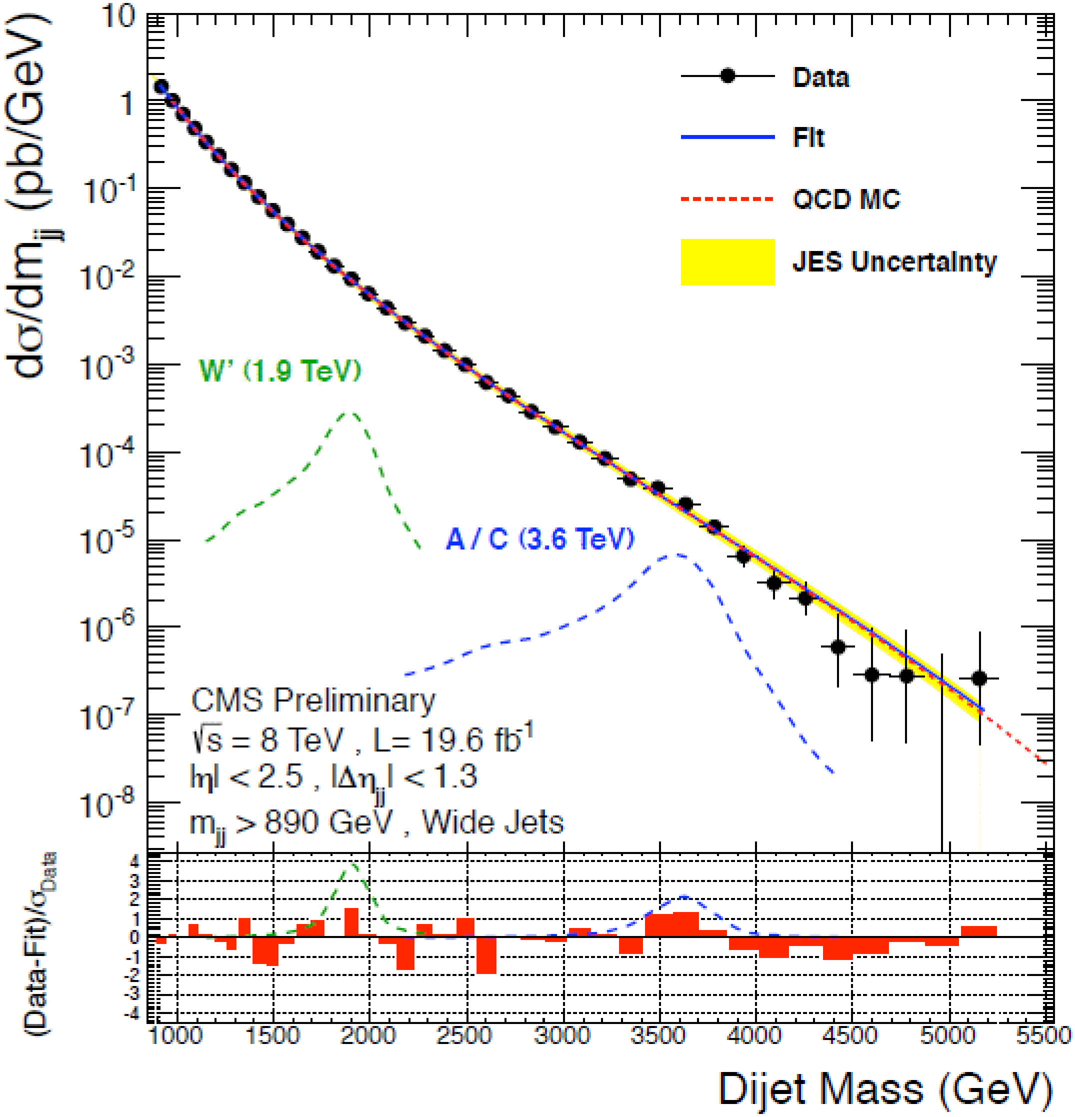




Results for 7 and 8 TeV
will be used for PDF tuning

CMS PAS SMP 12-012

Di-jet mass distribution

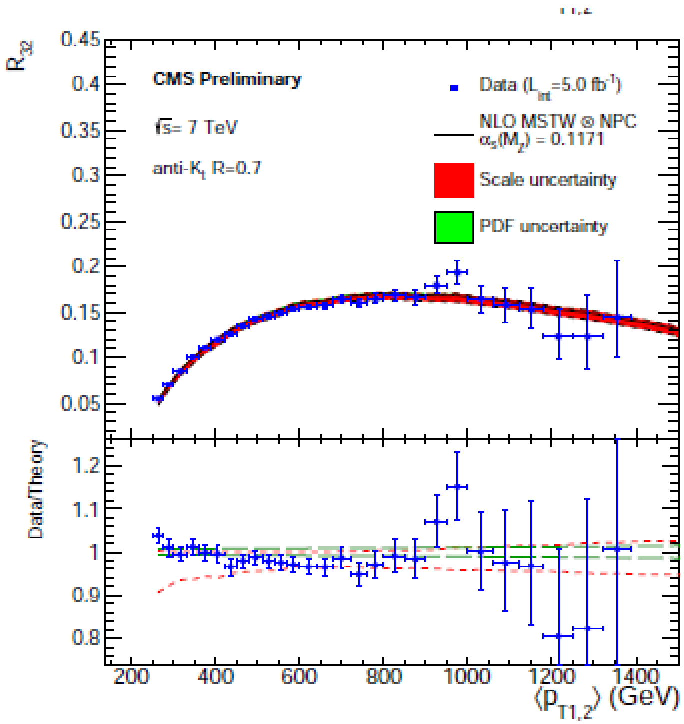


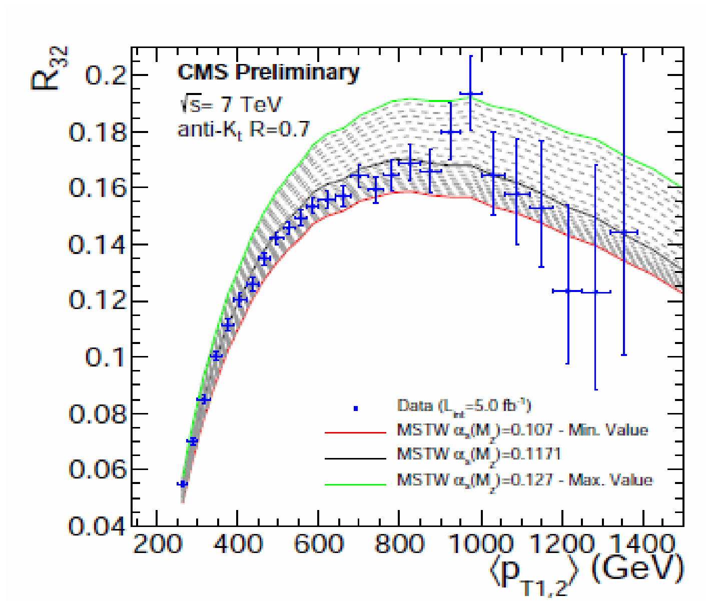
CMS PAS EXO-12-059

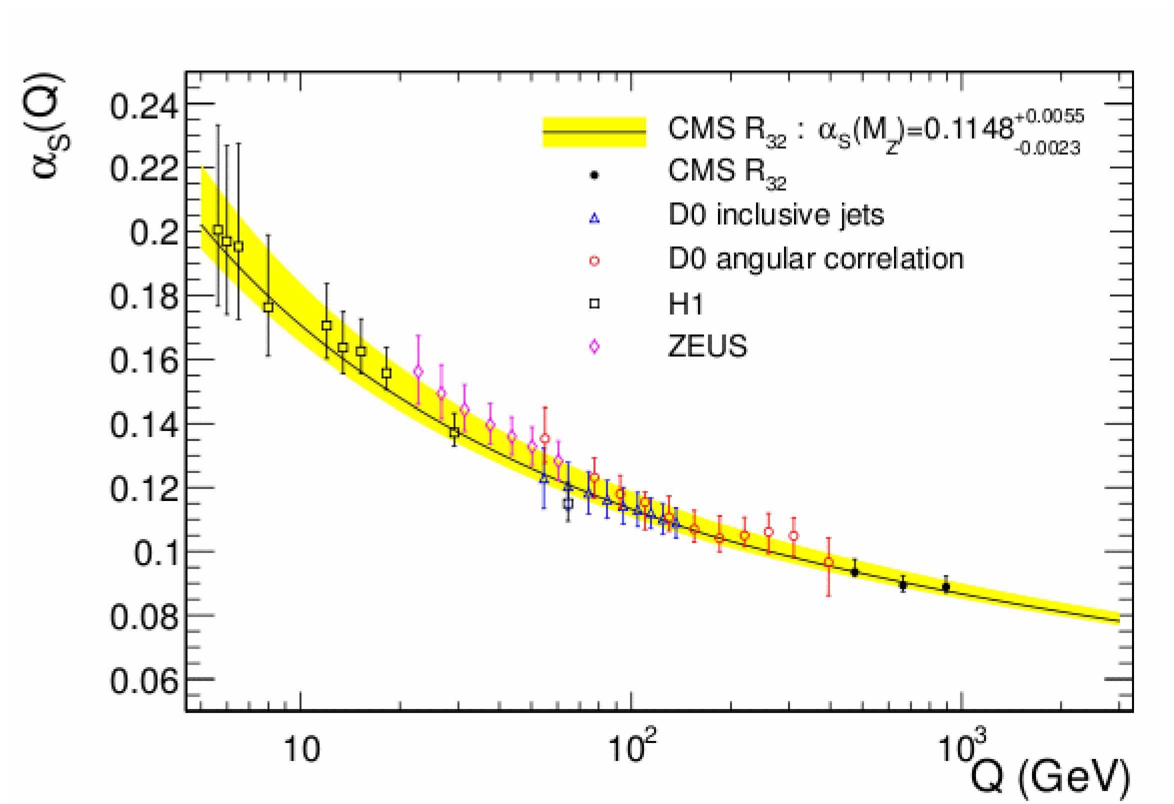
Good agreement between data and QCD for high mass di-jet distribution

No heavy objects beyond SM decaying into two jets were observed up to ~5TeV

R32 and alpha s



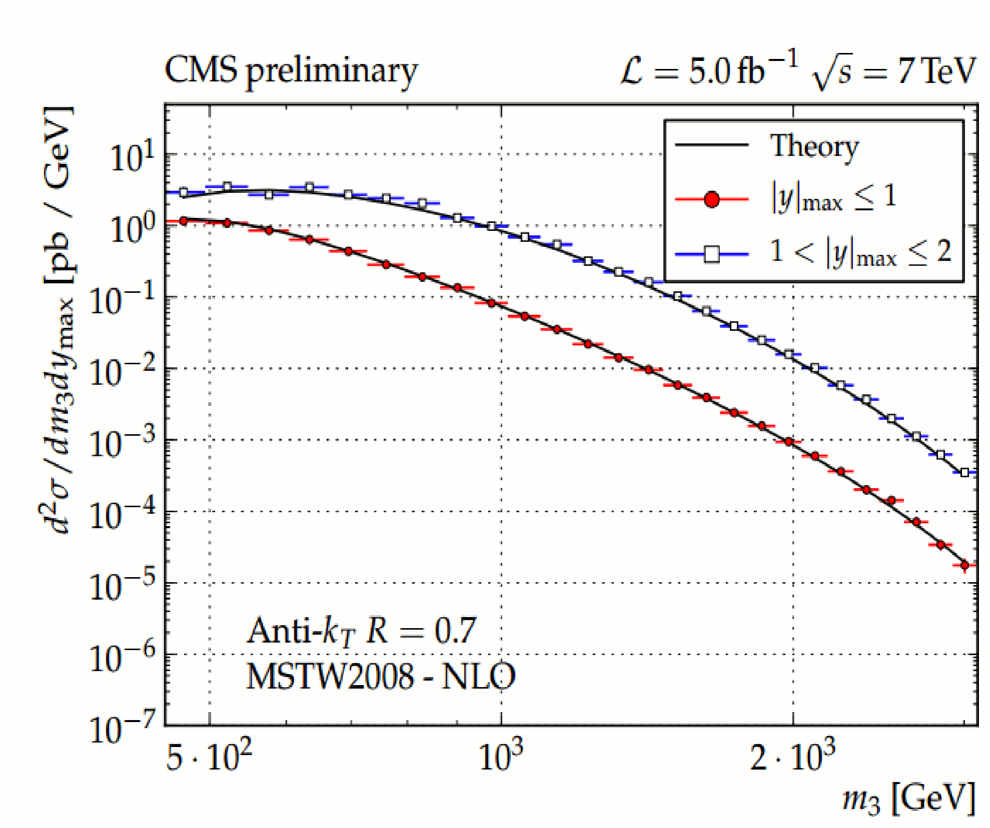


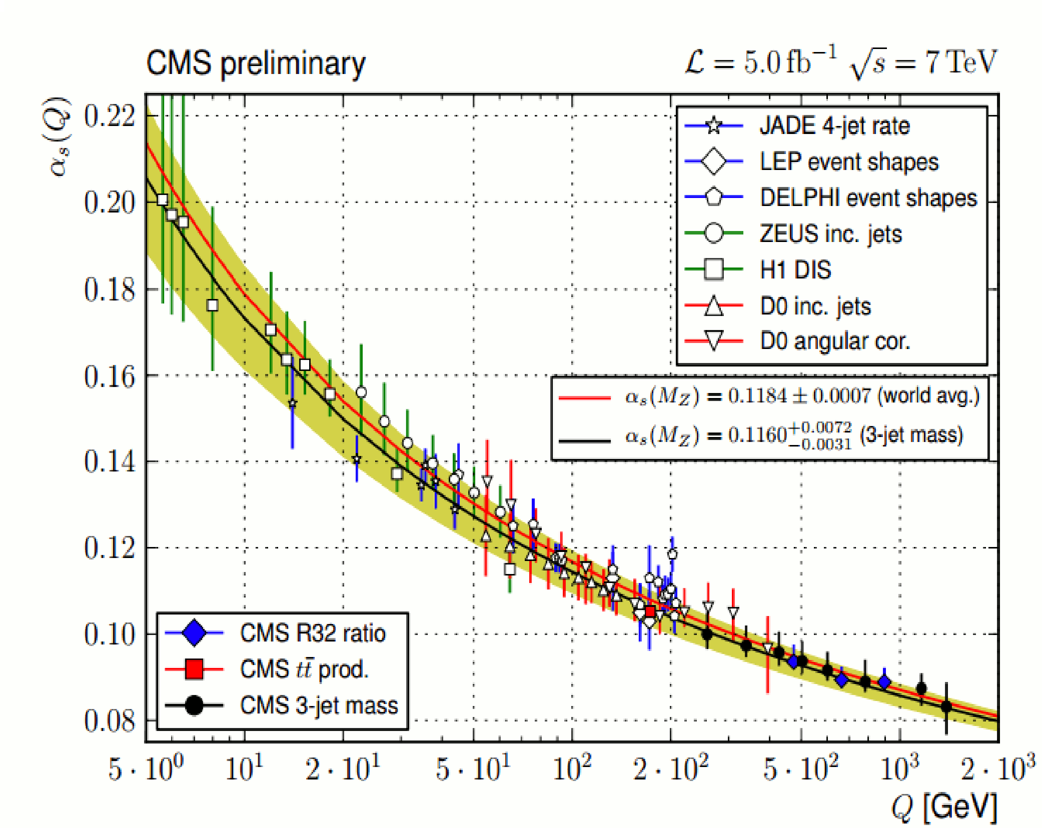


$$\alpha_S(M_Z) = 0.1148 \pm 0.0014\,(\text{exp.}) \pm 0.0018\,(\text{PDF})^{+0.0050}_{-0.0000}\,(\text{scale}),$$

CERN-PH-EP-2012-343
Submitted to EPJC

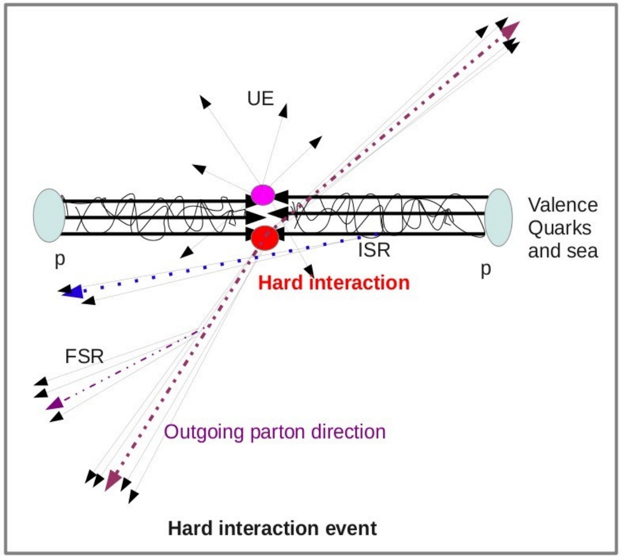
3-jet mass analysis

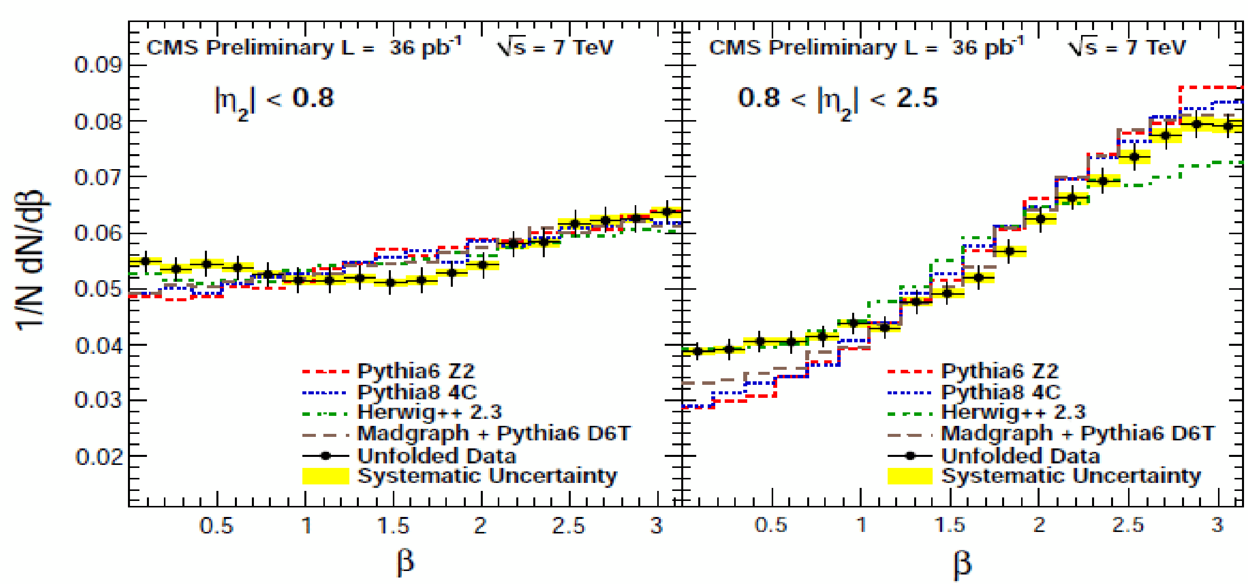




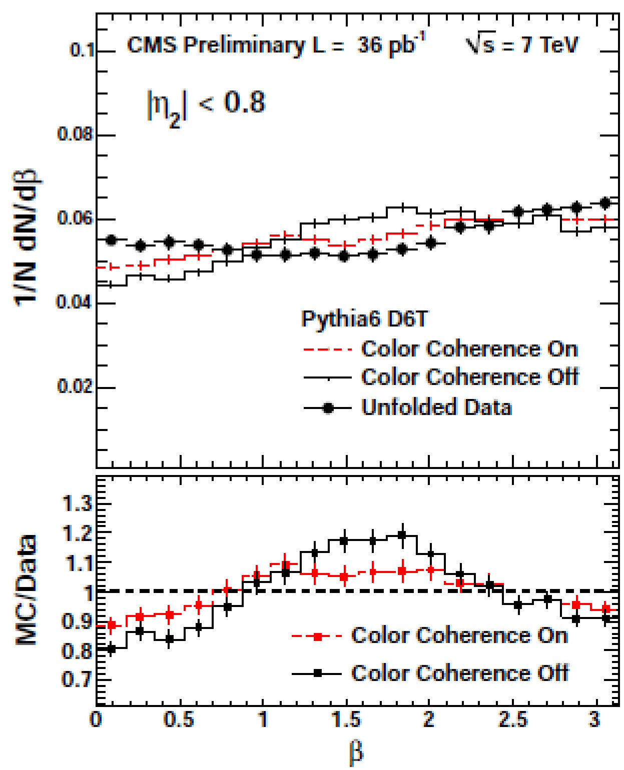
CMS-PAS_SMP-12-027

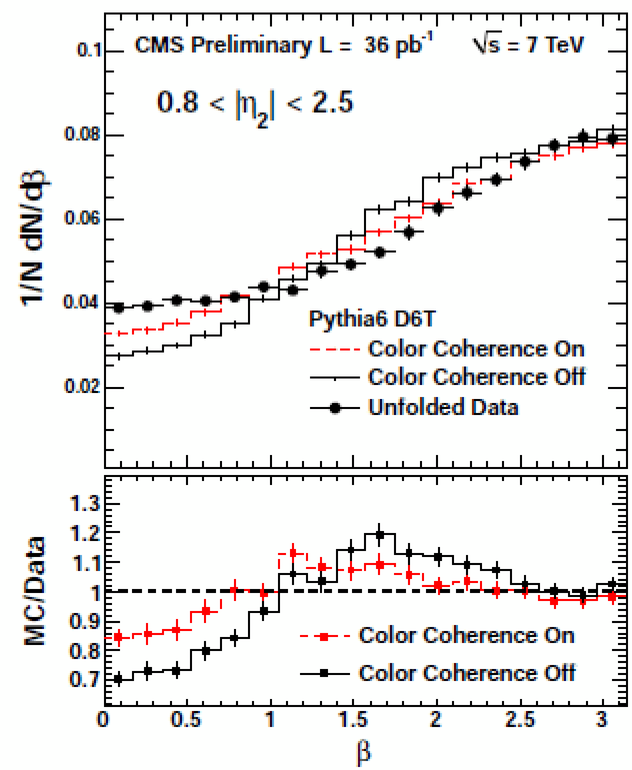
Color coherence





Selection criteria
$p_{T1} > p_{T2} > p_{T3} > 30$ GeV
$\lvert\eta_1\rvert, \lvert\eta_2\rvert < 2.5$
$M_{12} > 220$ GeV
$0.5 < \sqrt{(\Delta\eta_{23})^2 + (\Delta\phi_{23})^2} < 1.5$

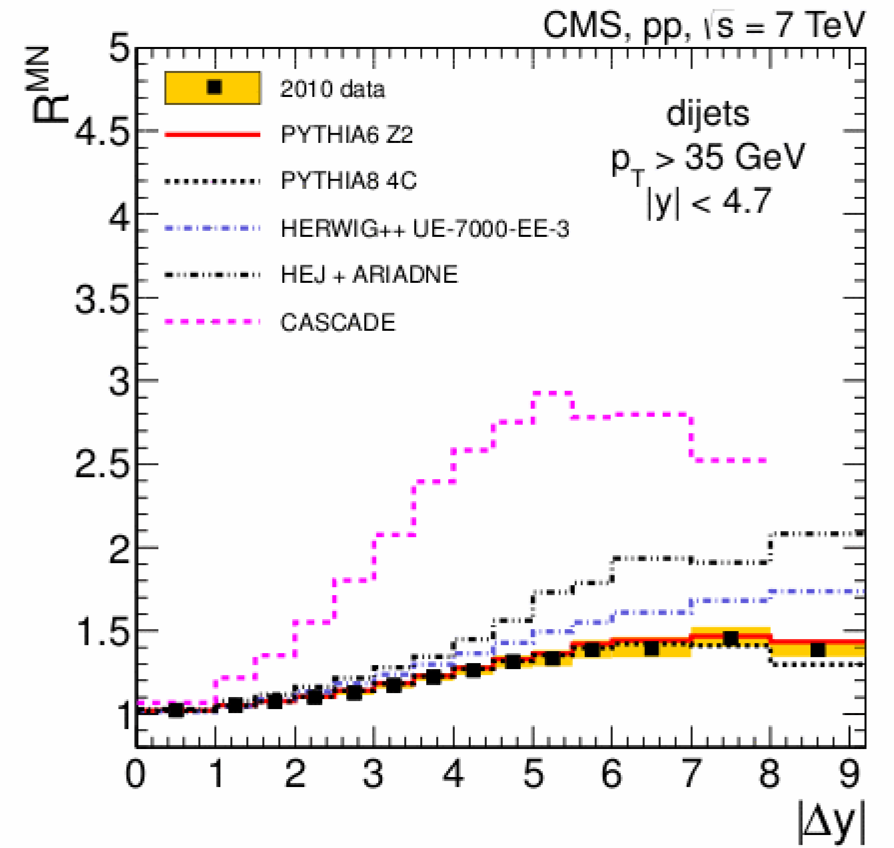




$$\beta = |\text{atan2}(\Delta\phi_{23}, \Delta\eta_{23})|$$

CMS PAS SMP-12-010

K-factor



EPJ C72(2012)2216

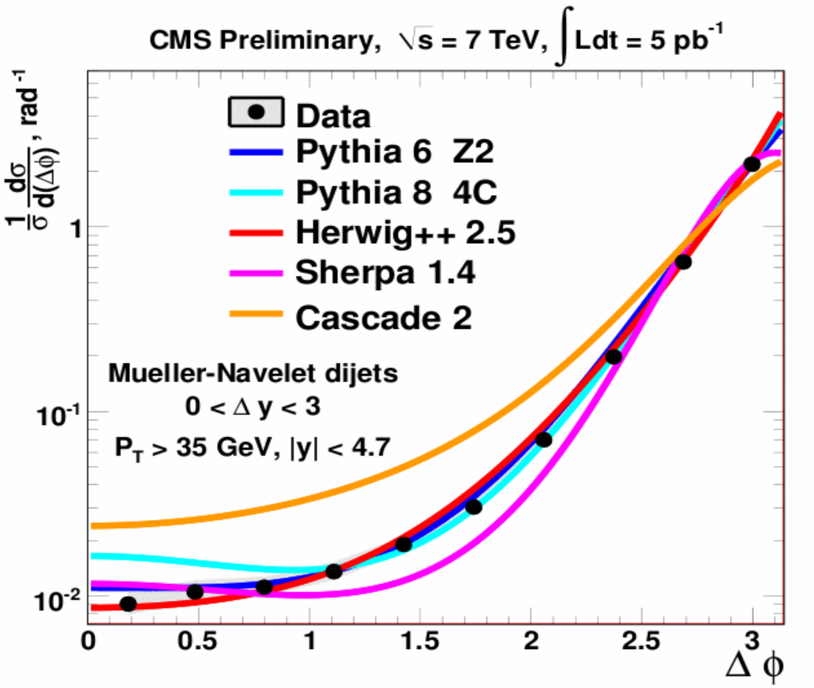
Mueller-Nevelet*) jet pair: the most forward and the most backward jets in the event

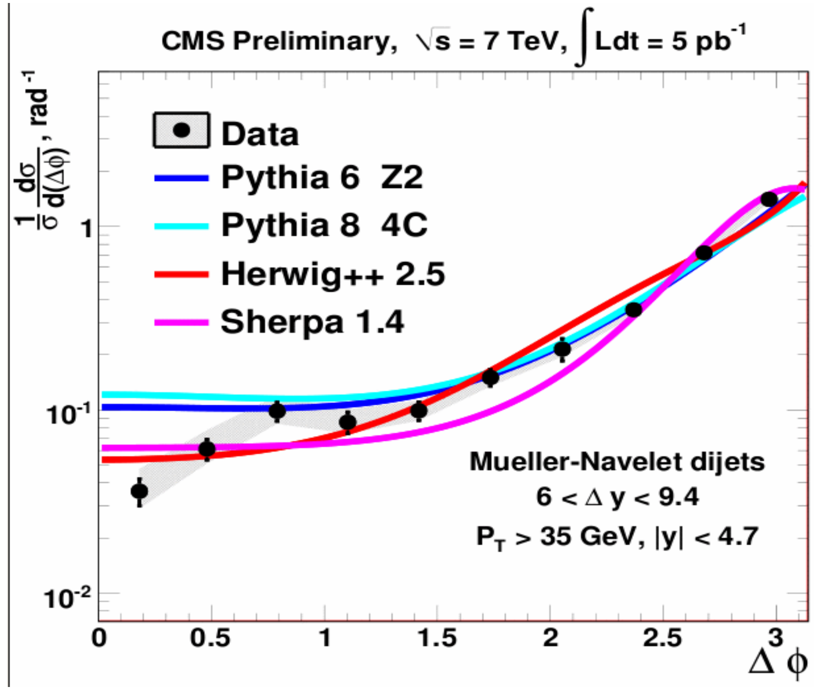
$R^{MN} = (d\sigma^{MN}/dy)/(d\sigma^{excl}/dy)$

Where σ^{excl} is the x-section of the process with production of only two jets (above the threshold)

*) NP B 282(1987)727

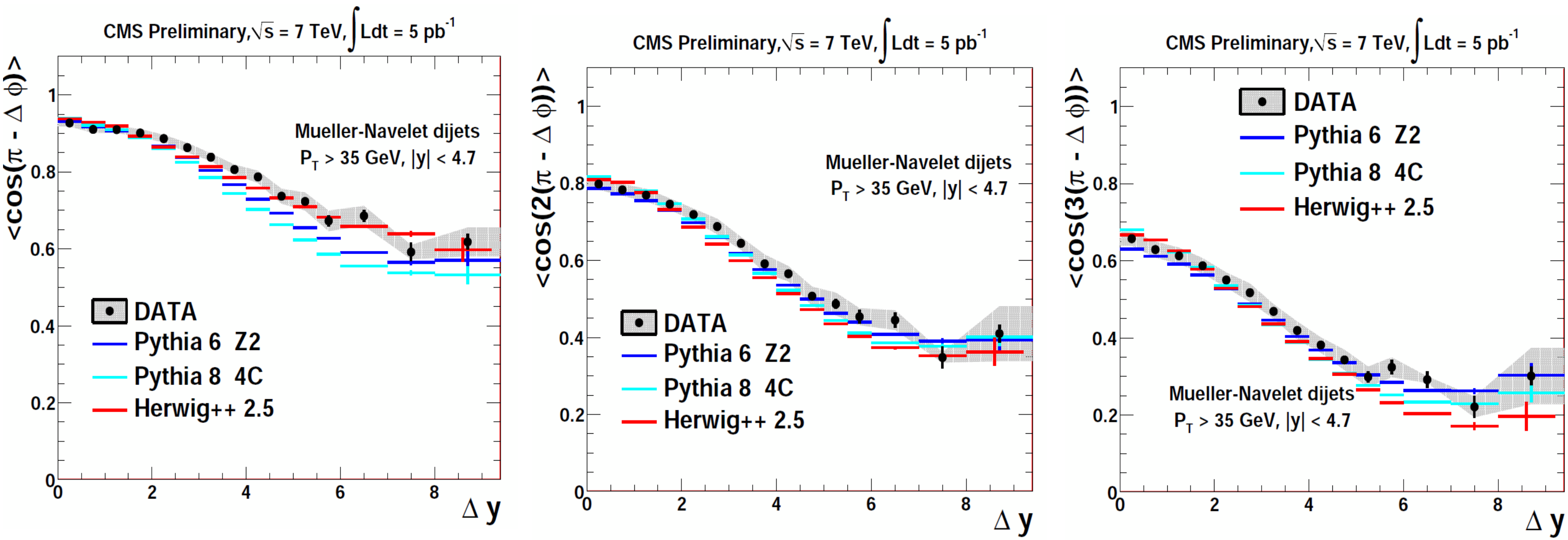
azimuthal de-correlation





CMS PAS FSQ-12-002

azimuthal de-correlation (2)

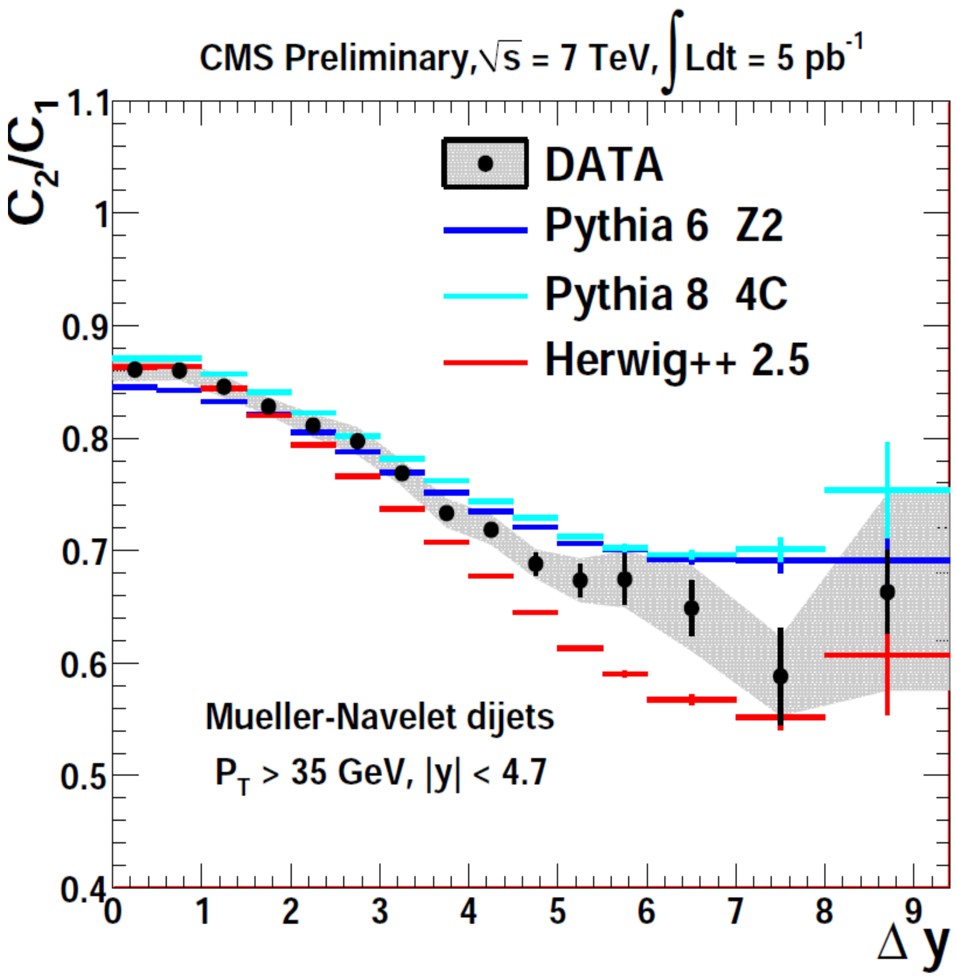


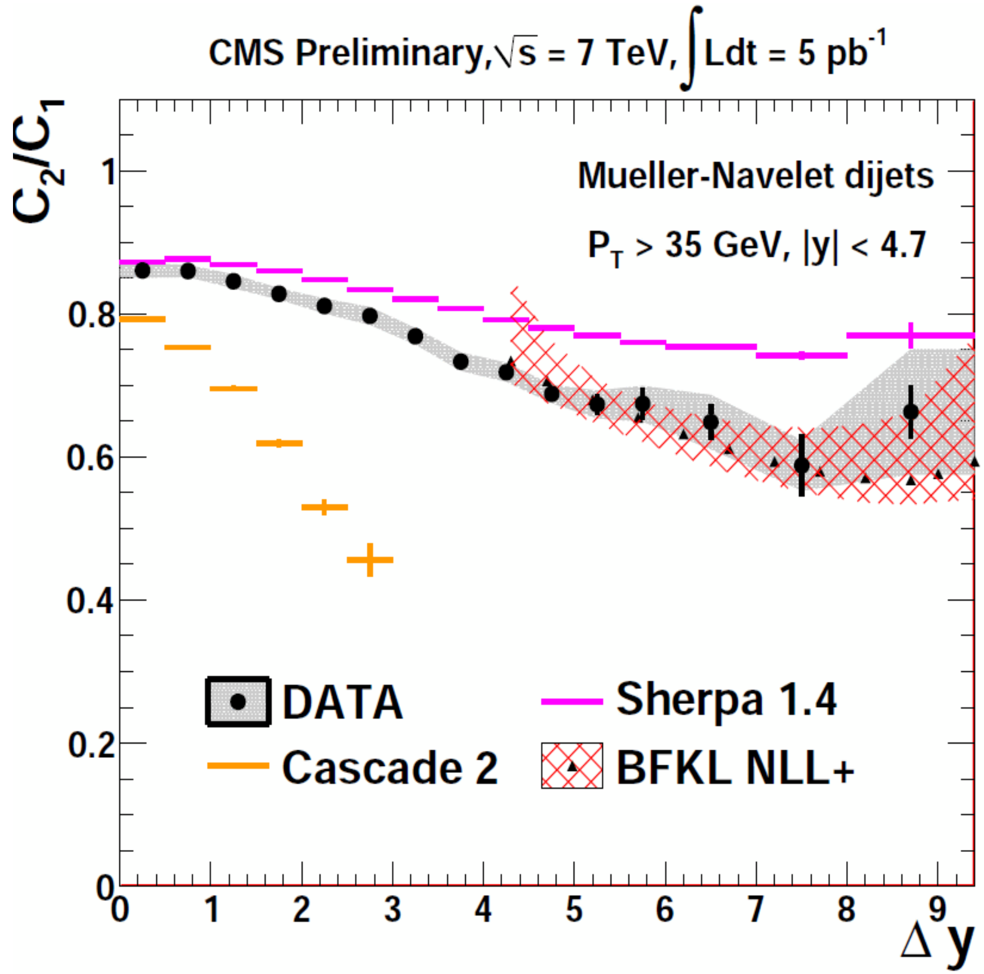
$$\frac{1}{\sigma}\frac{d\sigma}{d(\Delta\phi)}(\Delta y, p_{T\min}) = \frac{1}{2\pi}\left[1 + 2\sum_{n=1}^{\infty} C_n(\Delta y, p_{T\min}) \cdot cos(n(\pi - \Delta\phi))\right]$$

Herwig++ looks to do a better job than Pythia

CMS PAS FSQ-12-002

Cos ratios

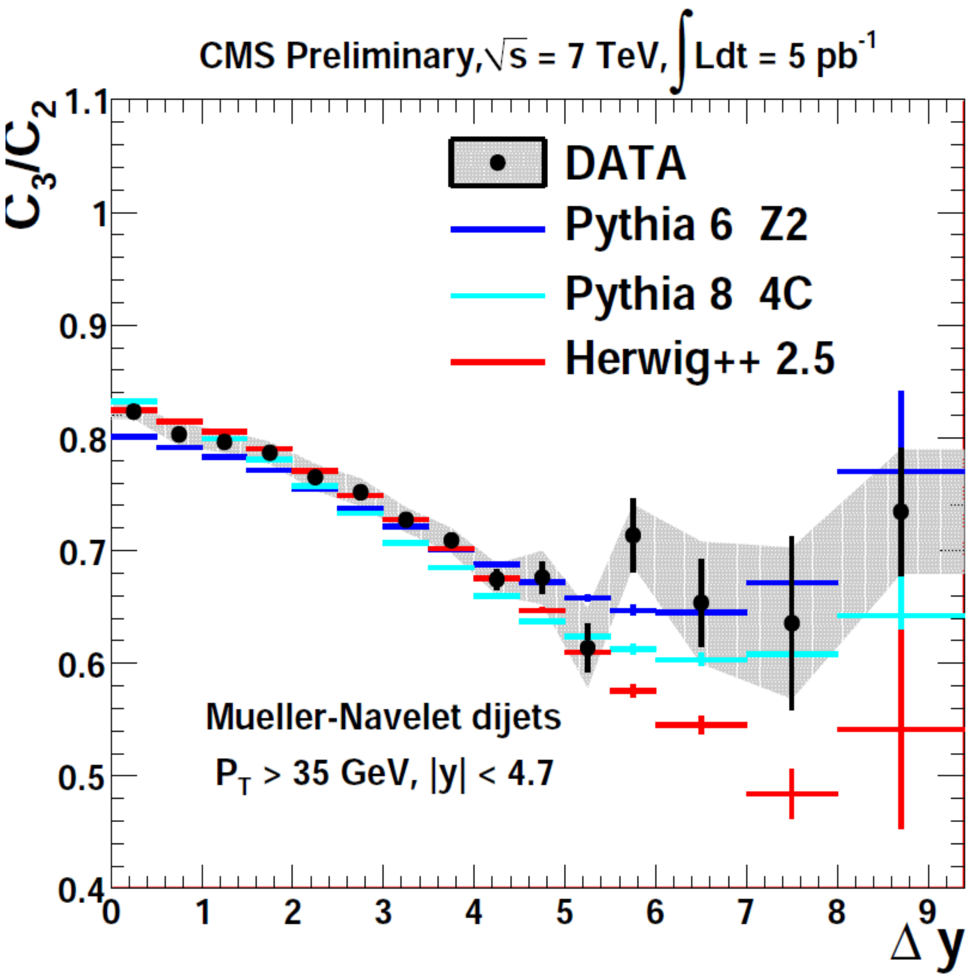




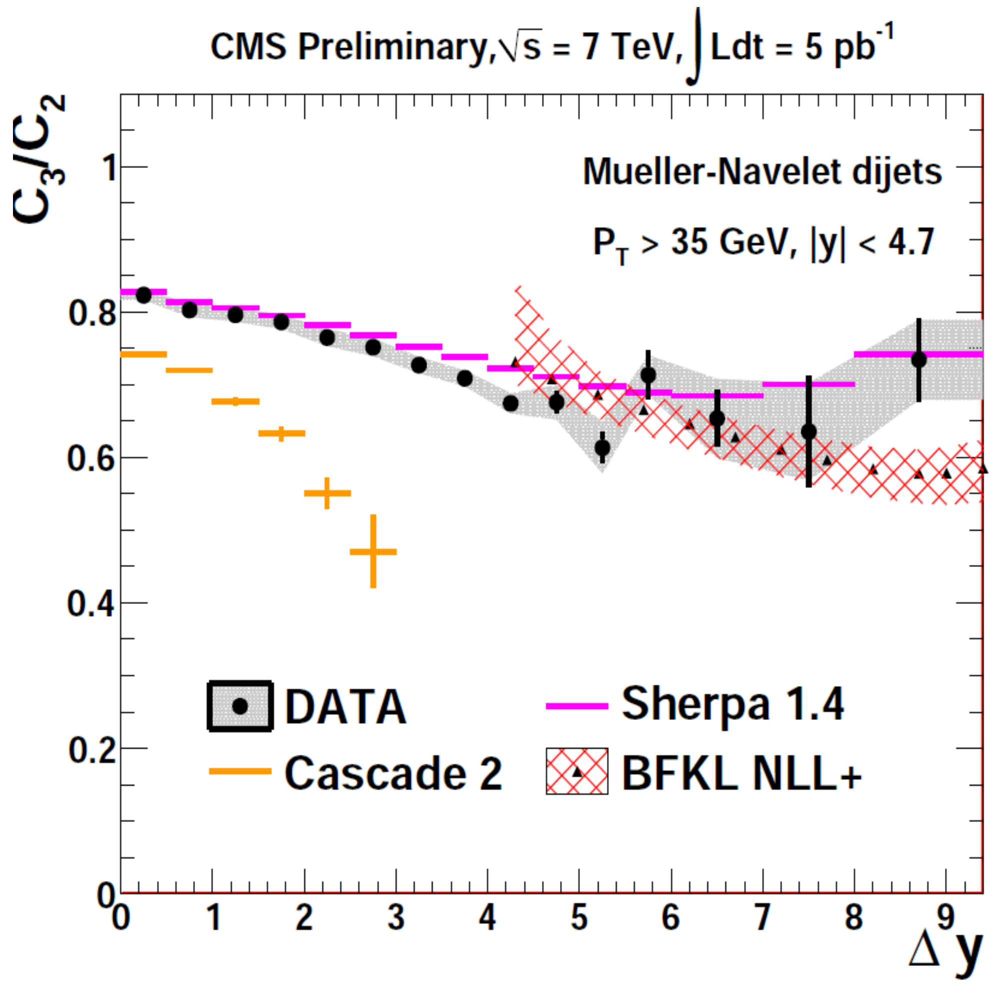
CMS PAS FSQ-12-002

BFKL NLL: B.Dicloue, L. Szymanowski, and S. Wallon , arXiv:hep-ph/1302.7012

Cos ratios

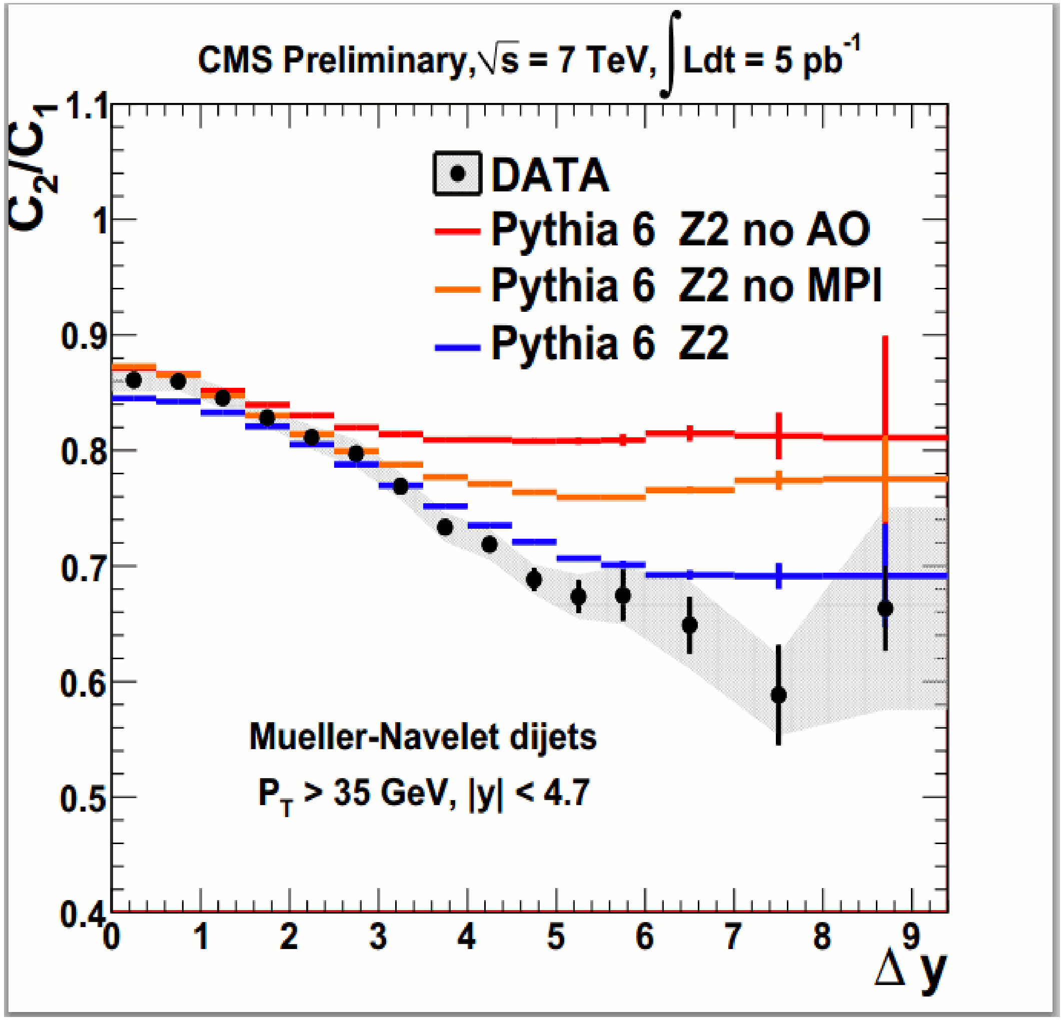


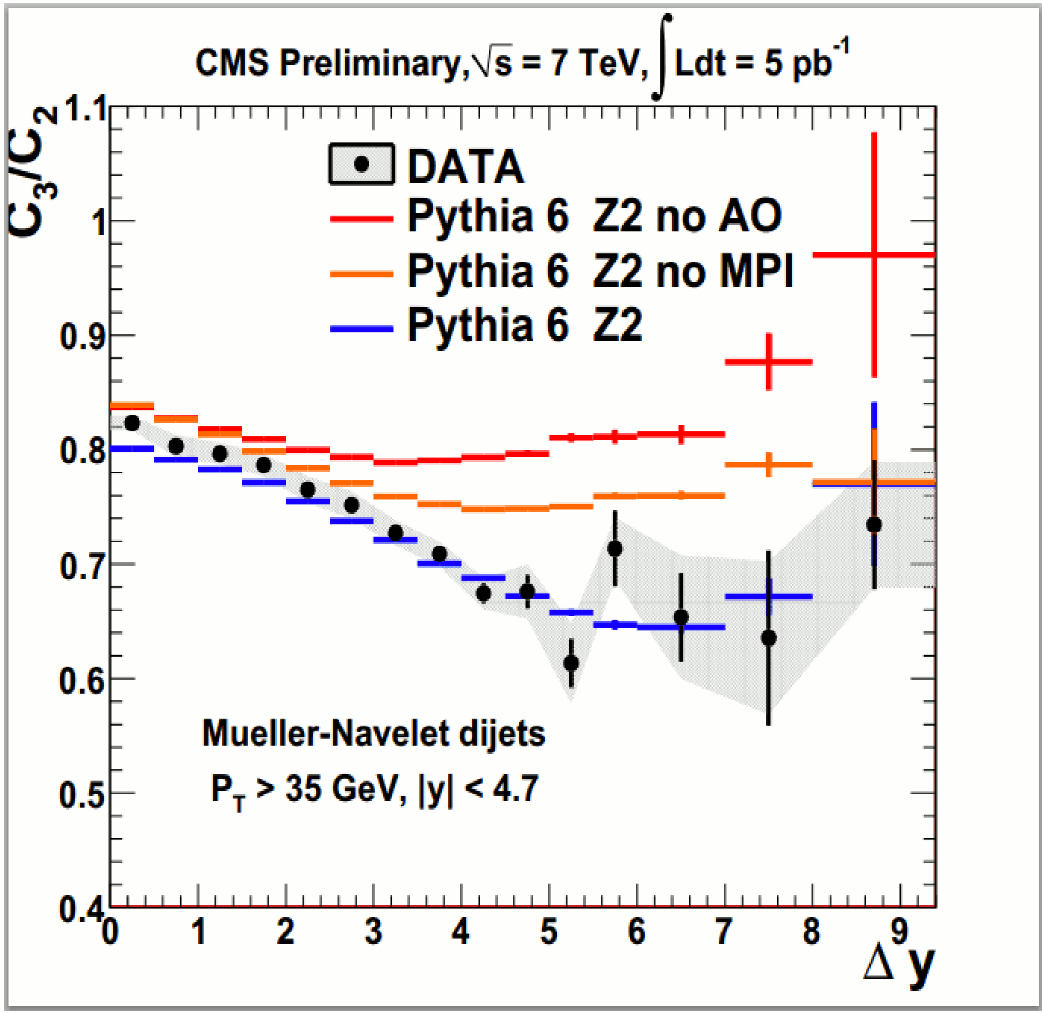
CMS Preliminary, √s = 7 TeV, ∫Ldt = 5 pb⁻¹
C3/C2
DATA
Pythia 6 Z2
Pythia 8 4C
Herwig++ 2.5
Mueller-Navelet dijets
PT > 35 GeV, |y| < 4.7
Δy



CMS Preliminary, √s = 7 TeV, ∫Ldt = 5 pb⁻¹
C3/C2
Mueller-Navelet dijets
PT > 35 GeV, |y| < 4.7
DATA
Sherpa 1.4
Cascade 2
BFKL NLL+
Δy

Cos ratios





MPI and Angular Ordering accounting are necessary for data description

Summary

- Production of hadron jets at high energy pp collisions was studied at CMS
- Results on inclusive jet x-section will allow to constrain proton PDF
- 2jet/3jet ratio and 3-jet mass distribution allow to measure α_s at highest Q^2
- Color coherence was studied for 3jet processes
- Di-jet azimuthal de-correlation was measured in wide rapidity range