

Dijet Azimuthal Decorrelations VS NLO pQCD, Herwig and Pythia

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Special thanks to:

Michael Begel, Pavel Demine, Alexander Kupčo,
Christophe Royon, Markus Wobisch

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- Summary and outlook

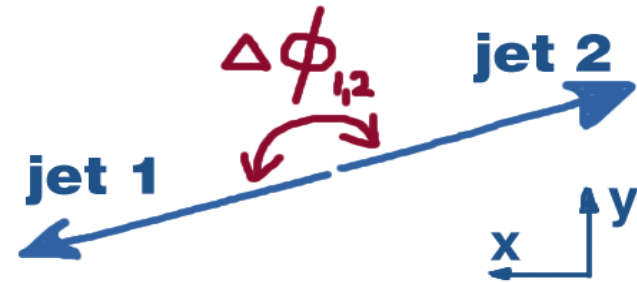
All results presented
here are **PRELIMINARY!**



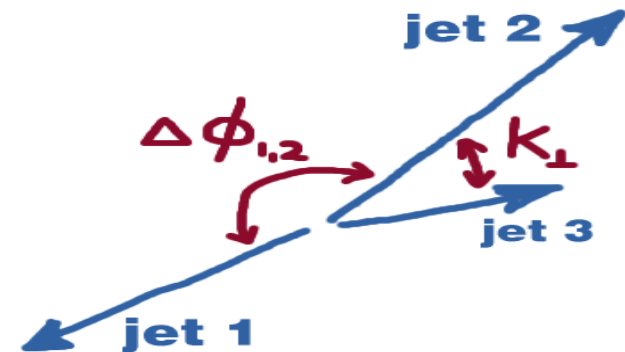
Theoretical Motivation

- In 2→2 scattering, partons emerge back-to-back → additional radiation introduces decorrelation in $\Delta\Phi$ between the two leading partons/jets
 - Soft radiation: $\Delta\Phi \sim \pi$
 - Hard radiation: $\Delta\Phi < \pi$
- $\Delta\Phi$ distribution is directly sensitive to higher-order QCD radiation
- Testing fixed-order pQCD and parton-shower models across $\Delta\Phi$:
 - $\Delta\Phi \sim \pi$:
 - ❖ FO calculations unstable
 - ❖ PS Monte Carlo's applicable
 - $2\pi/3 < \Delta\Phi < \pi$:
 - ❖ First non-trivial description by 2→3 tree-level ME
 - ❖ 2→3 NLO ME calculations became available recently (NLOJET++)
 - $\Delta\Phi < 2\pi/3$ (3-jet “Mercedes”)
 - ❖ 2→4 processes and higher

Dijet production in lowest-order pQCD



3-jet production in lowest-order pQCD



Experimental Motivation

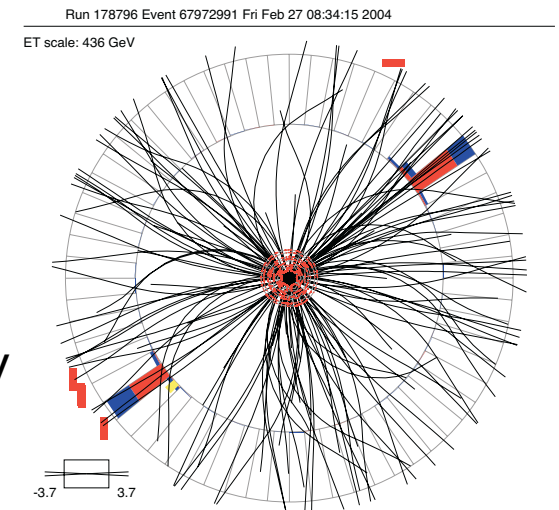
- Observable: $\Delta\Phi$ distribution between the two leading jets normalized by the integrated dijet cross section

$$\frac{1}{\sigma_{\text{dijet}}} \cdot \frac{d\sigma_{\text{dijet}}}{d\Delta\Phi}$$

- Advantages:

- $\Delta\Phi$ is a simple variable, uses only the two leading jets
- No need to reconstruct any other jets!
- Jet direction is well measured
- Reduced sensitivity to jet energy scale

$$M_{jj} = 1206 \text{ GeV}$$

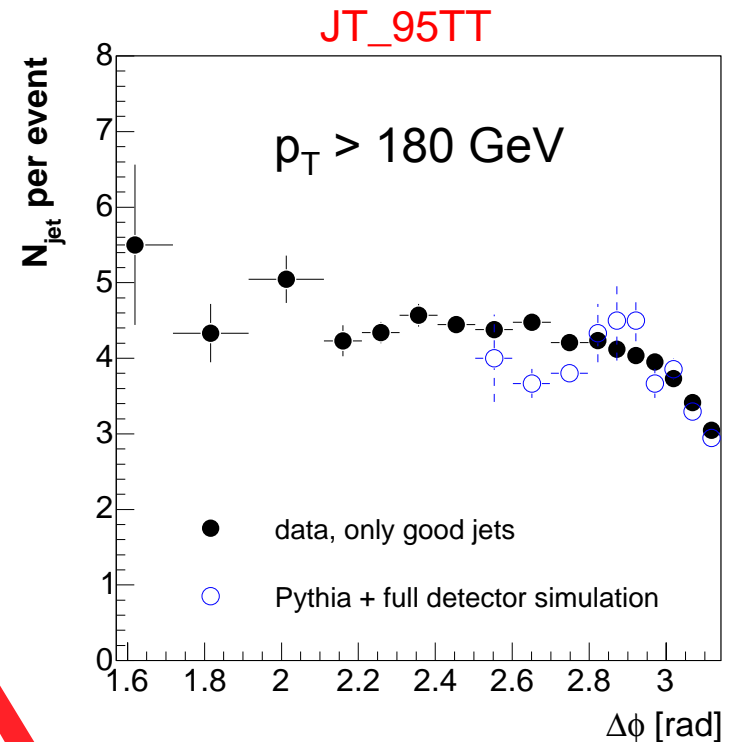
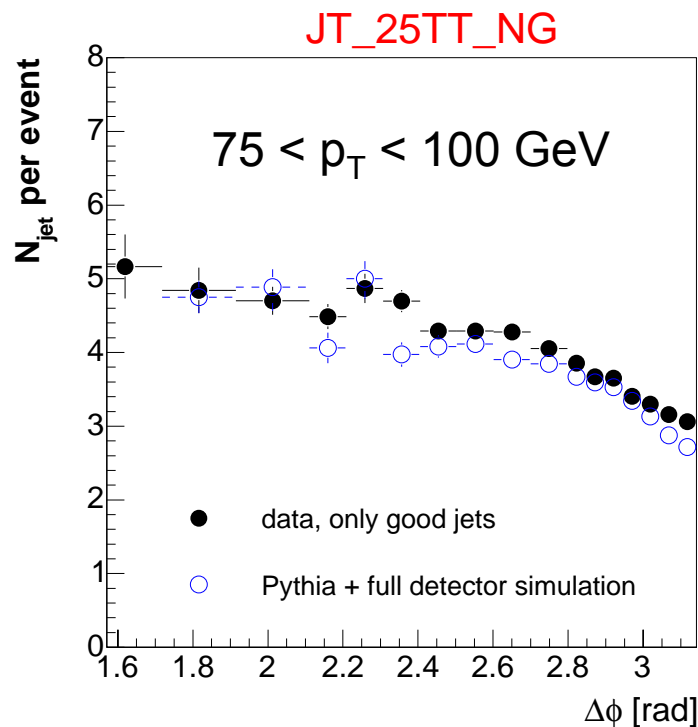


Analysis Overview

- Data sample:
 - ~150 pb⁻¹ used in analysis
 - At least two jets reconstructed with cone R=0.7
 - Require that two leading jets are central: $|y_{\text{jet}1,2}| < 0.5$
 - Jet p_T's in the region of full trigger efficiency
 - Running conditions, jets, vertex, missing E_T satisfy quality requirements
- Corrections for:
 - Cut efficiencies
 - Jet energy scale
 - Resolution smearing (unfolding)
- $\Delta\Phi$ distribution measured only for $\Delta\Phi > \pi/2$ to avoid jet overlaps

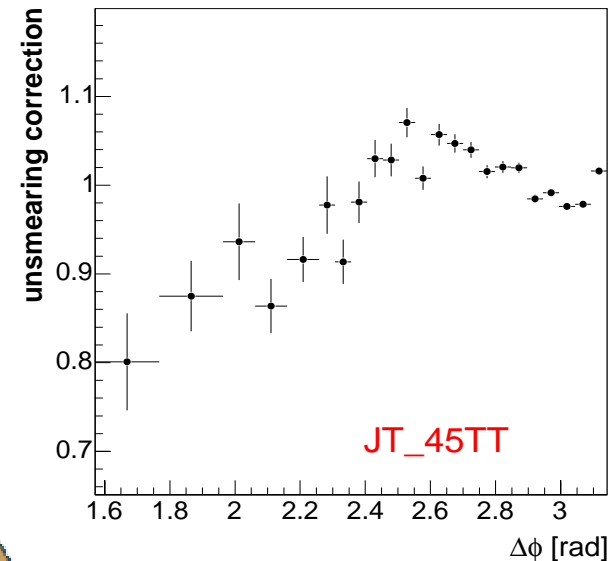
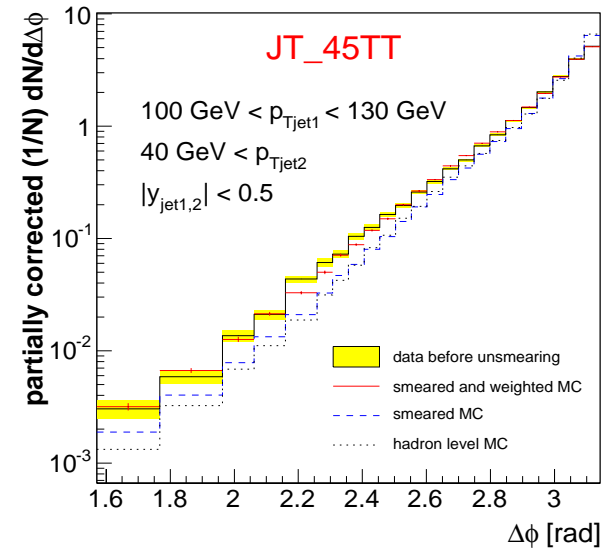
Jet Multiplicity vs $\Delta\Phi$

- Good agreement between data and MC with full detector simulation (MC slightly low)
- Average $\langle n_{\text{jet}} \rangle$ increases towards low $\Delta\Phi$, as expected



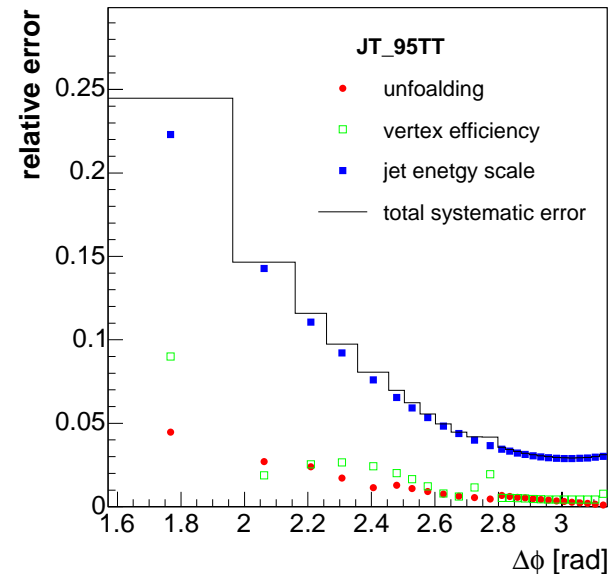
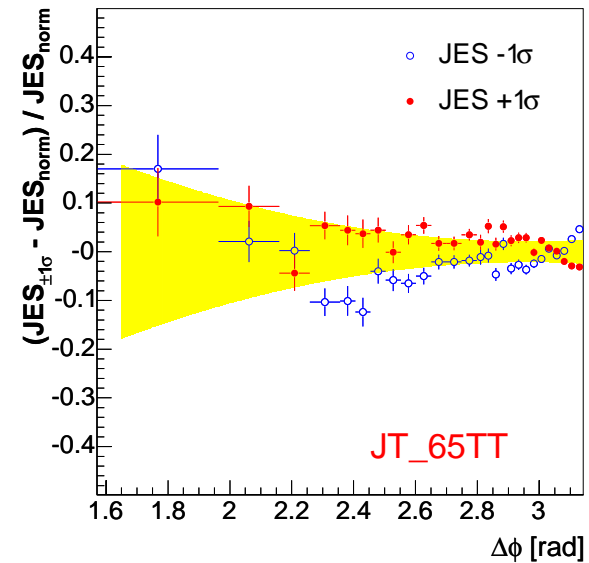
Resolution Unfolding

- Unfolding procedure:
 - ➔ Start with the $\Delta\Phi$ spectrum obtained for jets reconstructed at hadron level in events from Pythia
 - ➔ Smear this spectrum according to measured resolutions in $\Delta\Phi$ (from MC) and p_T (from data)
 - ➔ Reweight the resulting spectrum to fit the data
- Correction = unsmeared spectrum / smeared spectrum
(bin-by-bin, after reweighting)
 - ➔ Includes effects of jet reordering due to smearing in p_T
 - ➔ Shapes similar in all p_T ranges
 - ➔ Unfolding corrections not huge
 - ➔ Work in progress

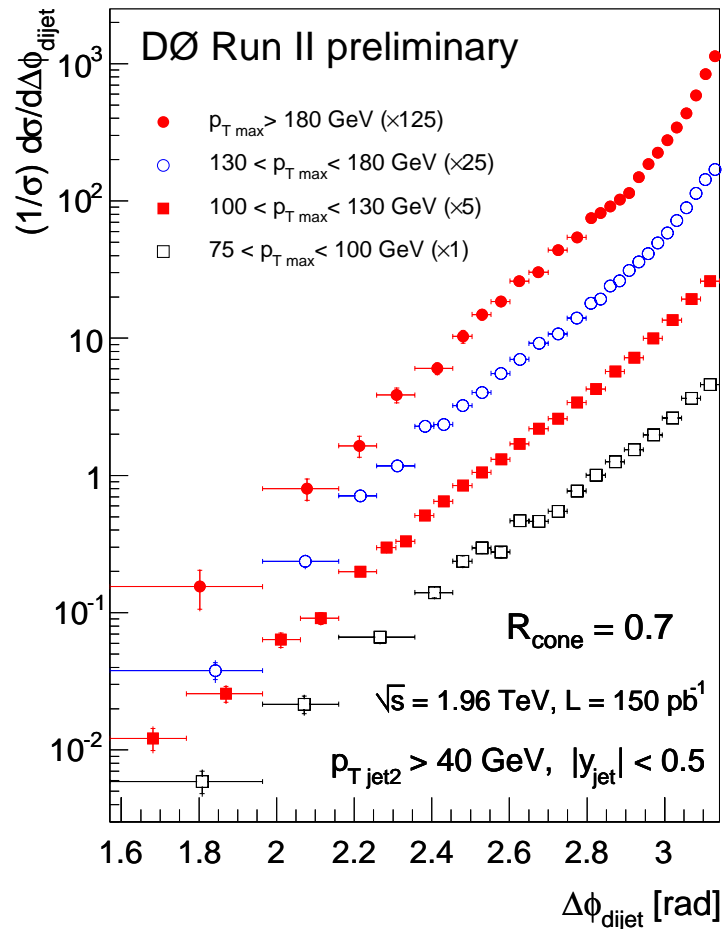


Systematics

- Jet energy scale still results in a substantial uncertainty
 - But, fractionally, much smaller than in the case of the absolute cross sections
 - A new jet energy scale determination, with significantly smaller uncertainties, is propagating through the analyses
- Other sources:
 - Vertex efficiency
 - Unfolding (under study)
- Estimated uncertainties:
~5% ($\Delta\Phi \sim \pi$) to ~25% ($\Delta\Phi \sim \pi/2$)

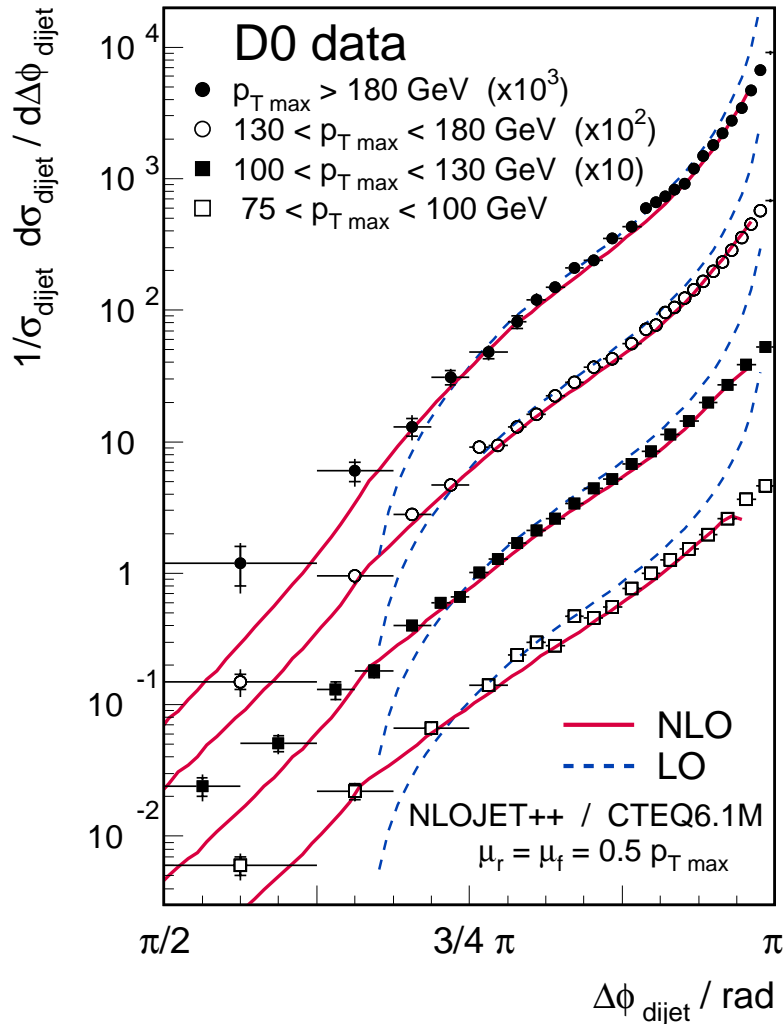


Results: Dijet Azimuthal Decorrelations



- Recap:
 - ➔ Central jets $|y| < 0.5$
 - ➔ Second-leading $p_T > 40 \text{ GeV}$
 - ➔ Leading jet p_T bin thresholds:
 - ◆ 75, 100, 130, 180 GeV
- Towards larger p_T , $\Delta\Phi$ spectra more strongly peaked at $\sim\pi$
 - ➔ Increased correlation in $\Delta\Phi$
- Distributions extend into the “4 final-state parton regime”, $\Delta\Phi < 2\pi/3$

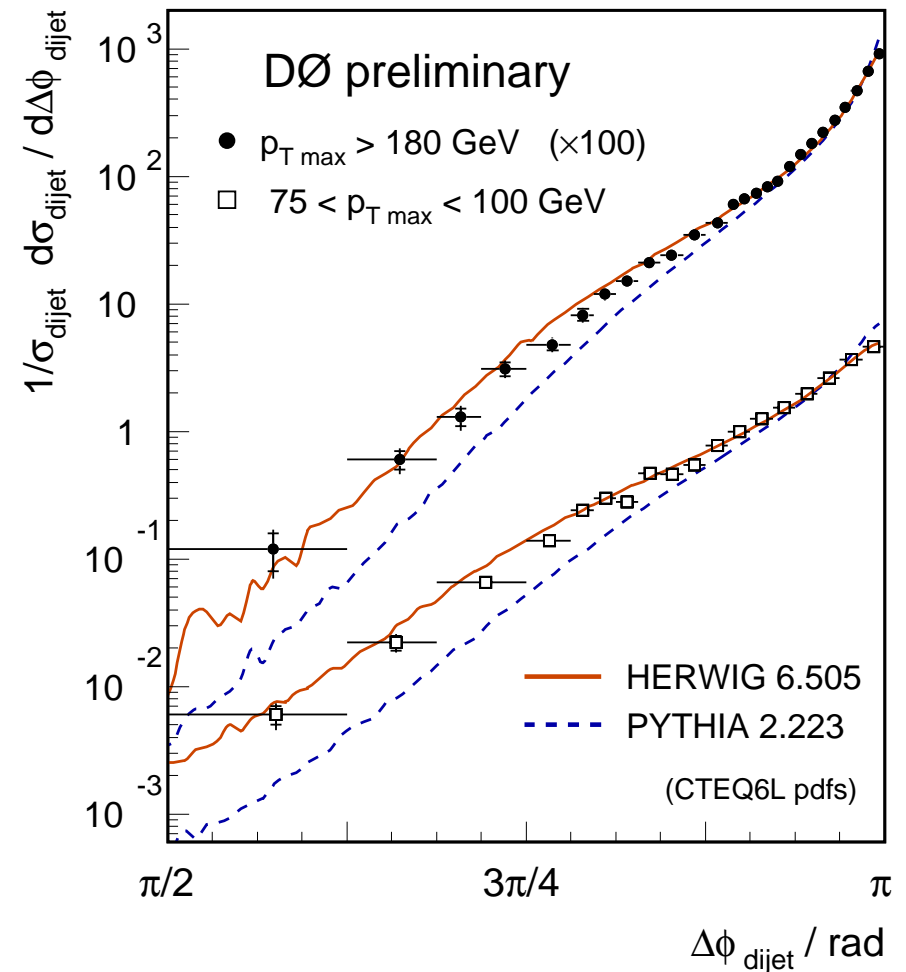
Comparison to Fixed-Order pQCD



- **Leading order (dashed blue curve)**
 - clear limitations
 - ➔ Divergence at $\Delta\Phi = \pi$ (need soft processes)
 - ➔ No phase-space at $\Delta\Phi < 2\pi/3$ (only three partons)
- **Next-to-leading order (red curve)**
 - ➔ Good description over the whole range, except in extreme $\Delta\Phi$ regions

Comparison to Parton-Shower Monte Carlo's

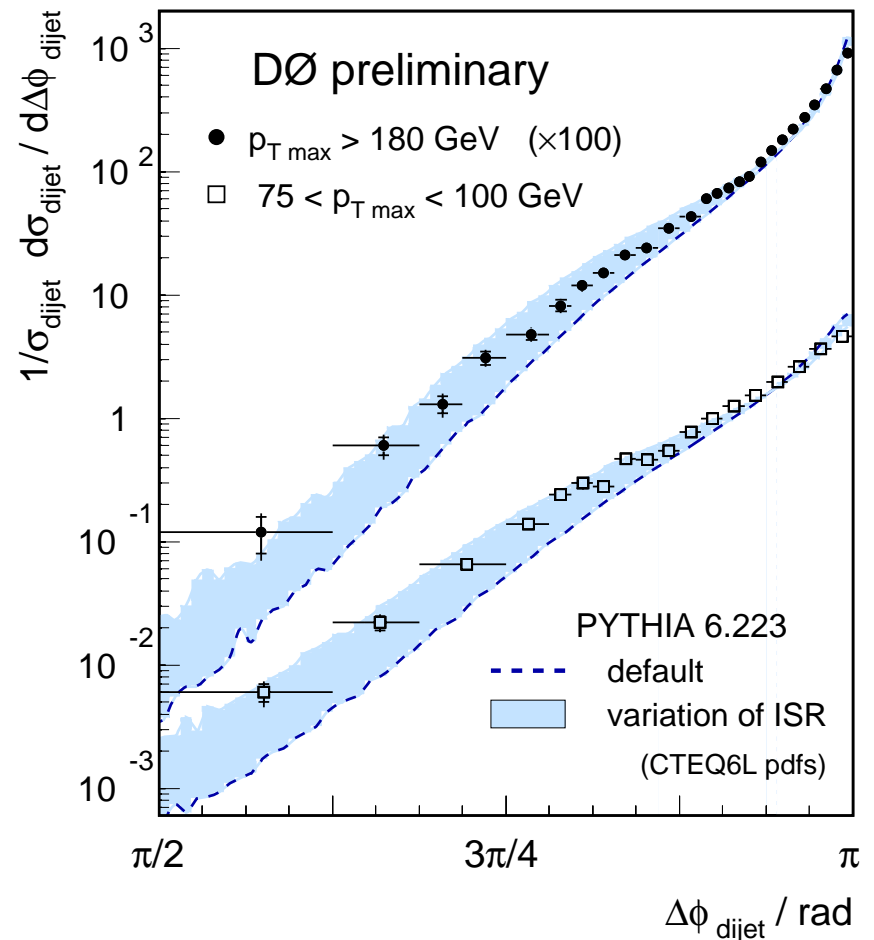
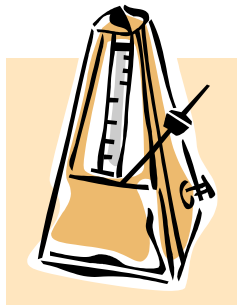
- Testing the radiation process:
 - 3rd and 4th jets generated by parton showers
 - ❖ Soft and collinear approx.
- HERWIG 6.505 (default)
 - Good overall description!
 - Slightly too high in mid-range
- PYTHIA 6.223 (default)
 - Very different shape
 - Too steep dependence
 - Underestimates low $\Delta\phi$



CTEQ6L

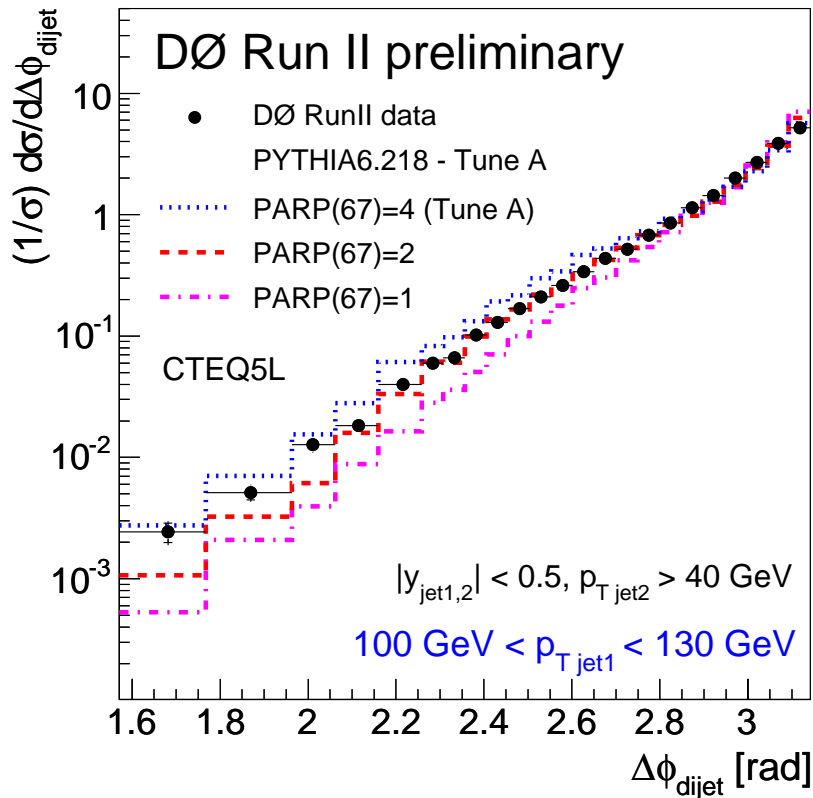
Impact of ISR in Pythia

- $\Delta\Phi$ distributions are sensitive to the amount of initial-state radiation
 - Plot shows variation of PARP(67) from 1.0 (current default) to 4.0 (previous default, Tune A)
 - ❖ PARP(67) controls the scale of parton showers
 - Intermediate value suggested
- More PYTHIA tuning possible!

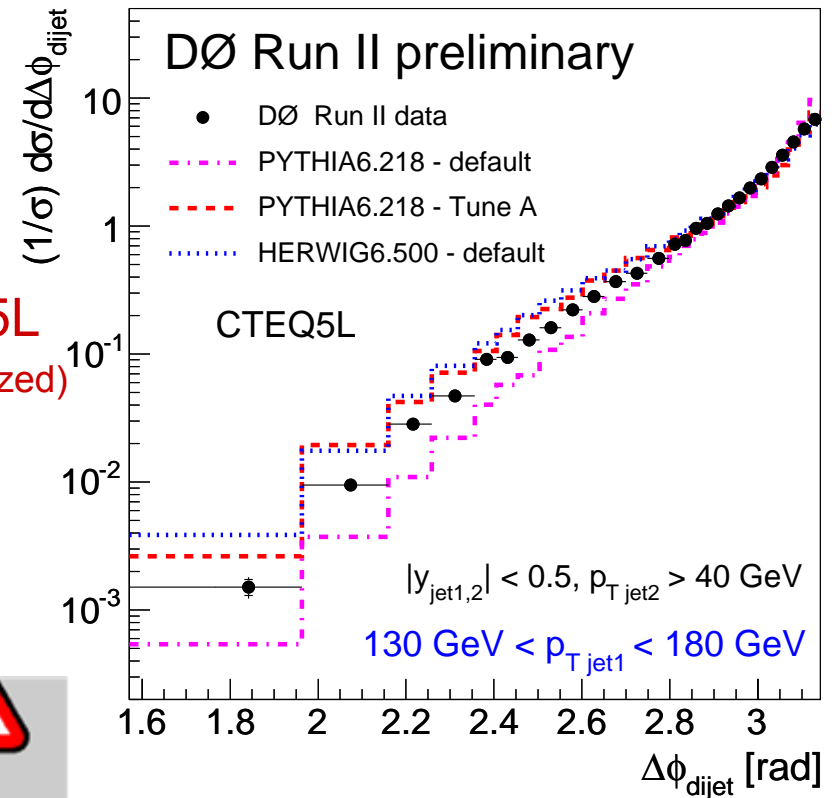


$\Delta\Phi$, Tune A, CTEQ5L and All That...

- Most of variation from PARP(67)
 - ➔ Sensitivity to soft underlying event small
- HERWIG prediction with CTEQ5L (parameterized) not as good as with CTEQ6L



CTEQ5L
(parameterized)



Summary and Outlook

- The $\Delta\Phi$ distribution has been measured for central jets in four p_T regions using 150 pb^{-1} of DØ Run II data
 - ➔ Sensitive to higher-order QCD processes
 - ➔ Test of 3-jet NLO pQCD at Tevatron
 - ❖ good agreement for most of $\Delta\Phi$ range
 - ➔ Prospects for tuning parton-shower Monte Carlo's
 - ❖ Herwig doing well, sensitivity to ISR in Pythia
- Plans, hopes, dreams:
 - ➔ Extend the measurement to lower p_T values
 - ❖ More sensitivity to initial-state gluons
 - ❖ A handle on quark vs gluon induced showers
 - ➔ Extend to forward rapidities for one of the jets
 - ❖ Probe even smaller values of $\Delta\Phi$
 - ❖ More sensitivity to initial-state gluons
 - ➔ Extend to b-tagged jets
 - ❖ Probe gluon \rightarrow bbar splitting
 - ❖ Interesting overlap with top, Higgs physics...

Frixione, Nason, Webber

