Inclusive Jet Cross Section Measurement (DØ)

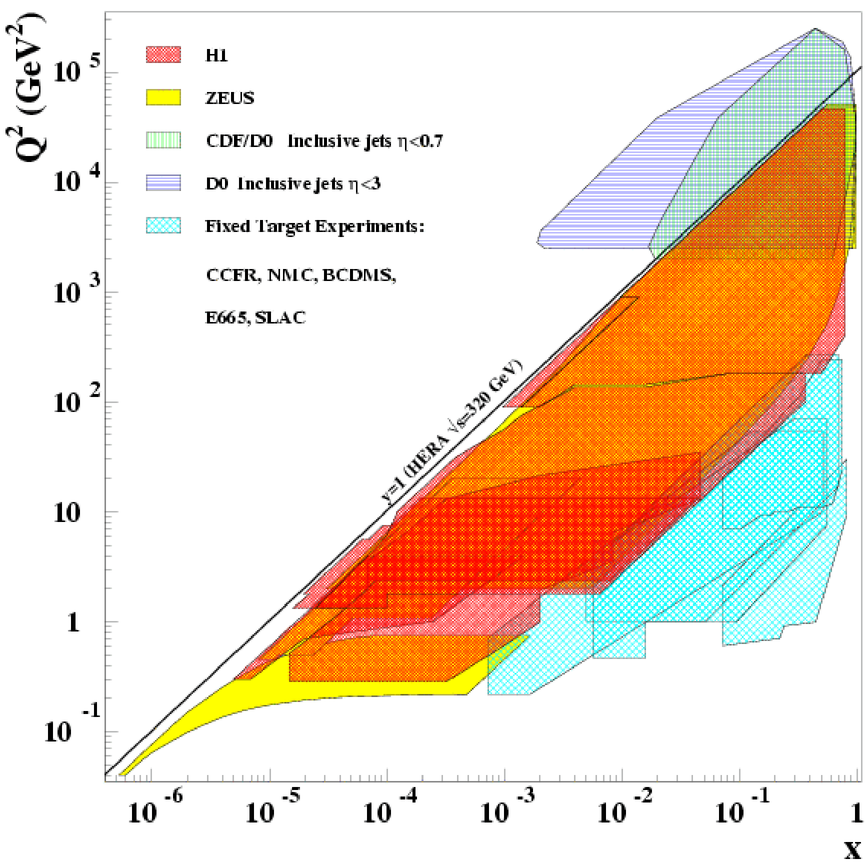
On behalf of DØ collaboration

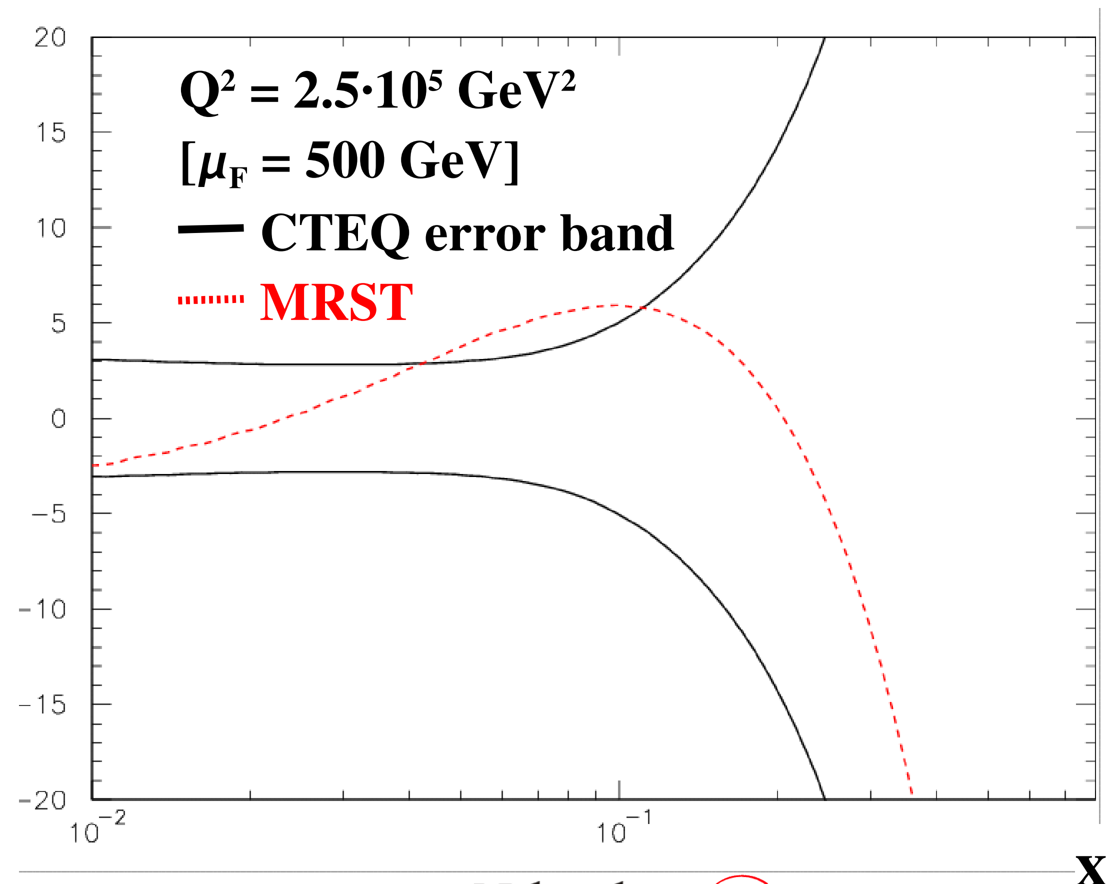
Mikko Voutilainen

University of Nebraska-Lincoln
Helsinki Institute of Physics

Motivation

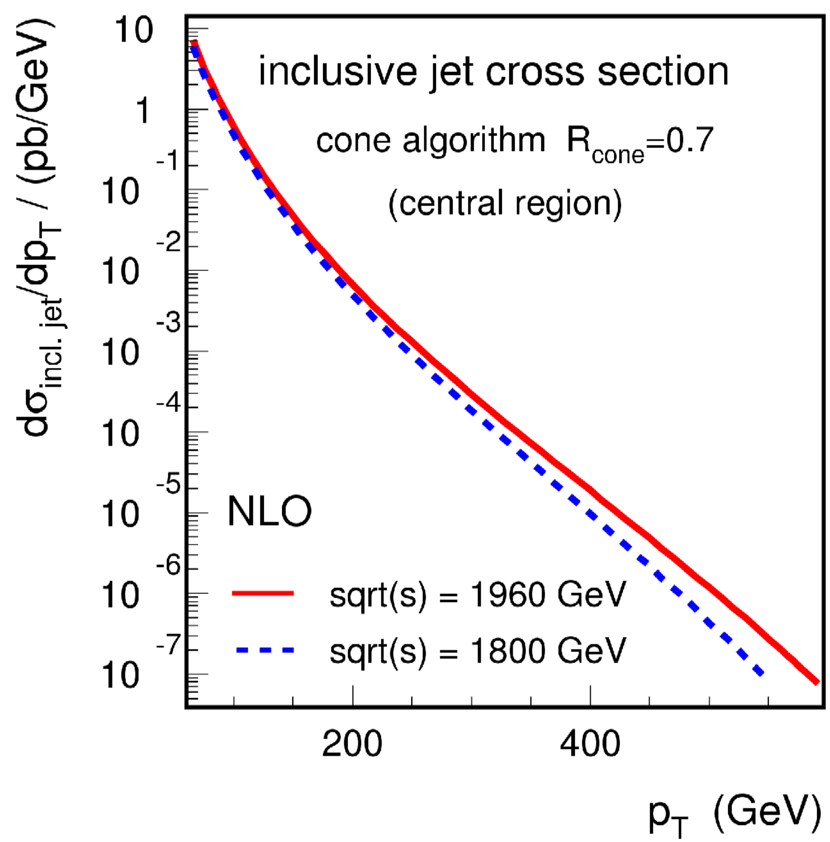
- We can chart PDFs in the high energy, high x domain
- Gluon parton distribution functions (PDFs) not yet so well constrained ⇒ we can constrain PDFs at high x



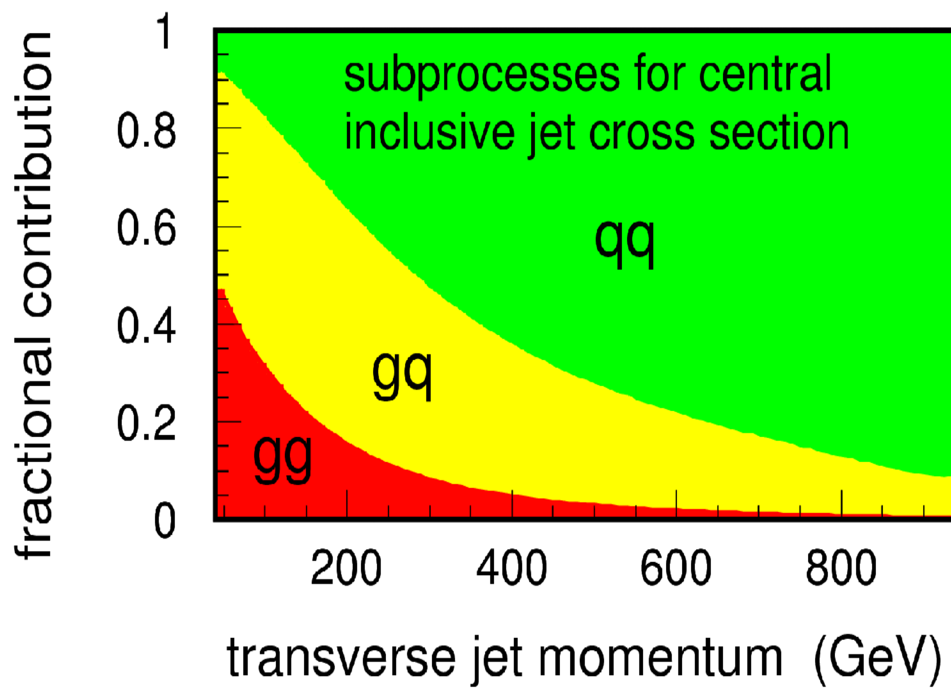


Dataset

- Data were acquired with the upgraded DØ detector between 2002 and 2005 in Run II of the Fermilab Tevatron
- Data selection was based on run quality, event properties, and jet quality criteria

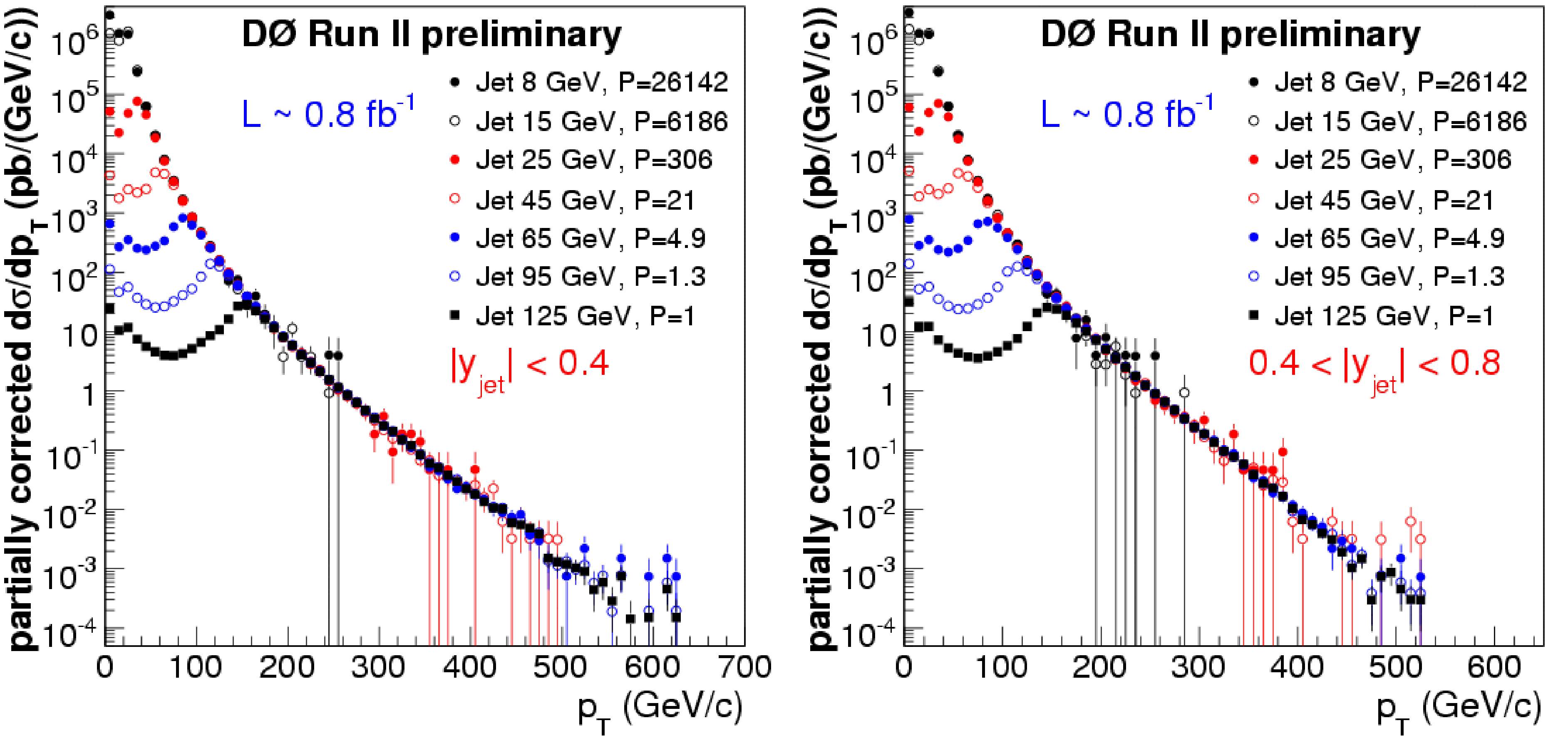


- Integrated luminosity ~0.8 fb^{-1}



Triggers

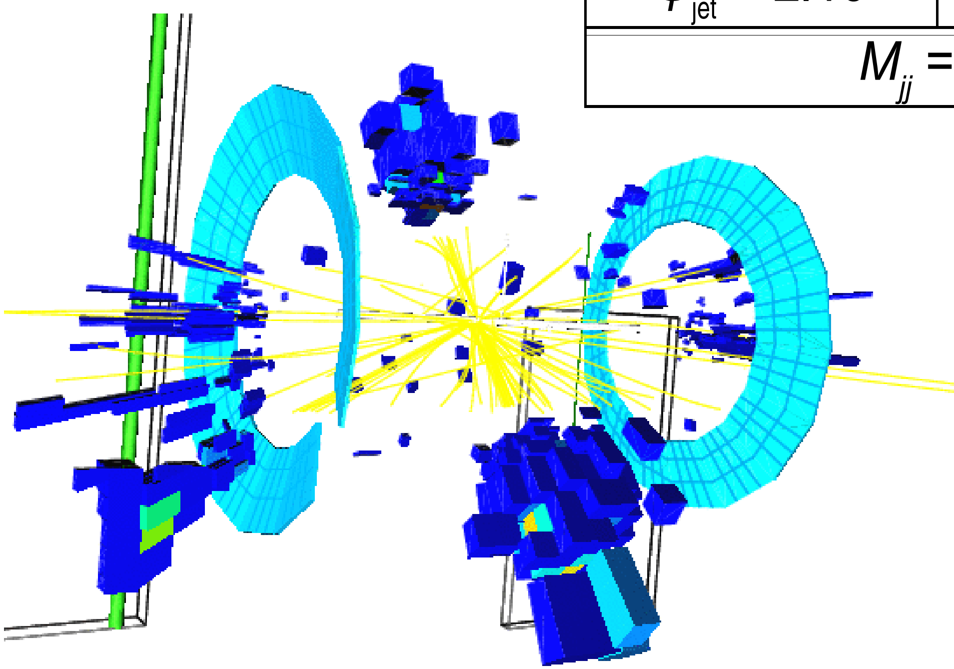
- Events used in this analysis were triggered by single jet triggers. These require a few energetic trigger towers at level 1 of the trigger, and then a cone jet at the third level of the trigger

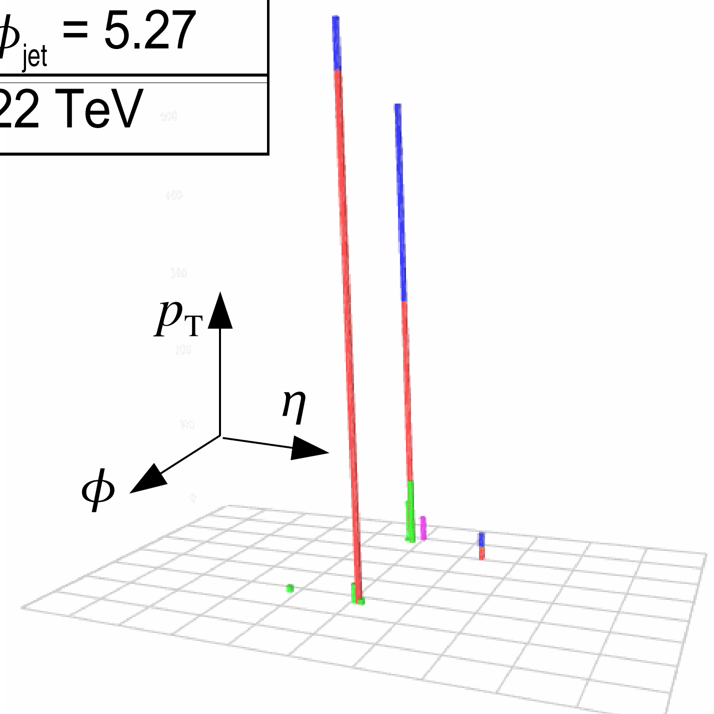


Highest pT event

- Different views of the event that contains the jet with highest transverse momentum in the sample
- Jets are reconstructed offline with an iterative cone algorithm

first jet	second jet
p_T = 624 GeV y_{jet} = 0.14 ϕ_{jet} = 2.10	p_T = 594 GeV y_{jet} = -0.17 ϕ_{jet} = 5.27
M_{jj} = 1.22 TeV	



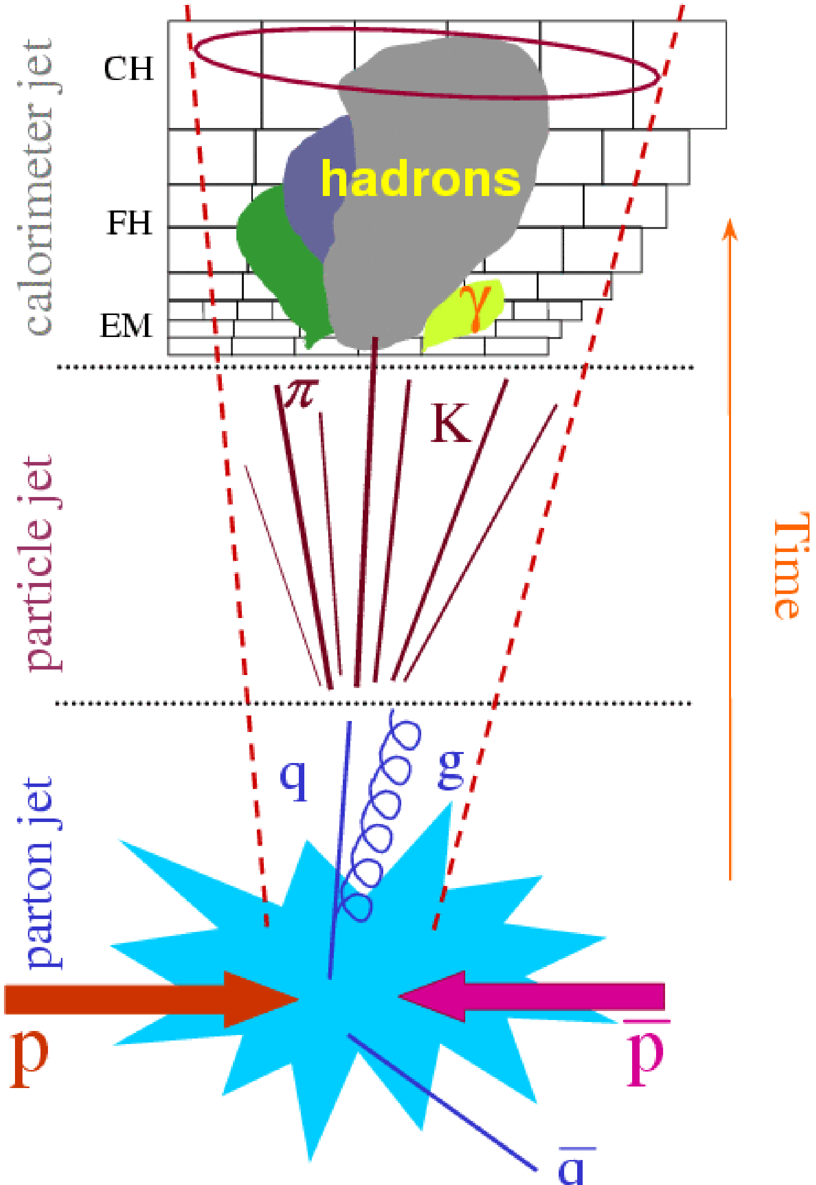


Jet Energy Scale

- Jet Energy Scale returns the measured calorimeter jet energy to the particle level

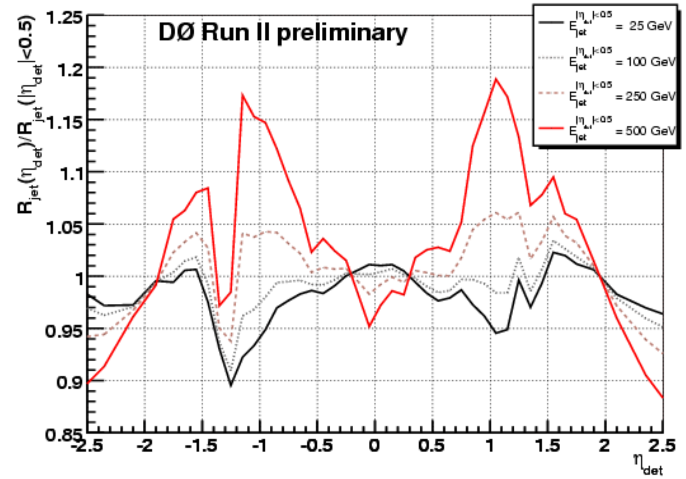
$$E_{ptcl} = \frac{E_{cal} - Offset}{R \cdot S}$$

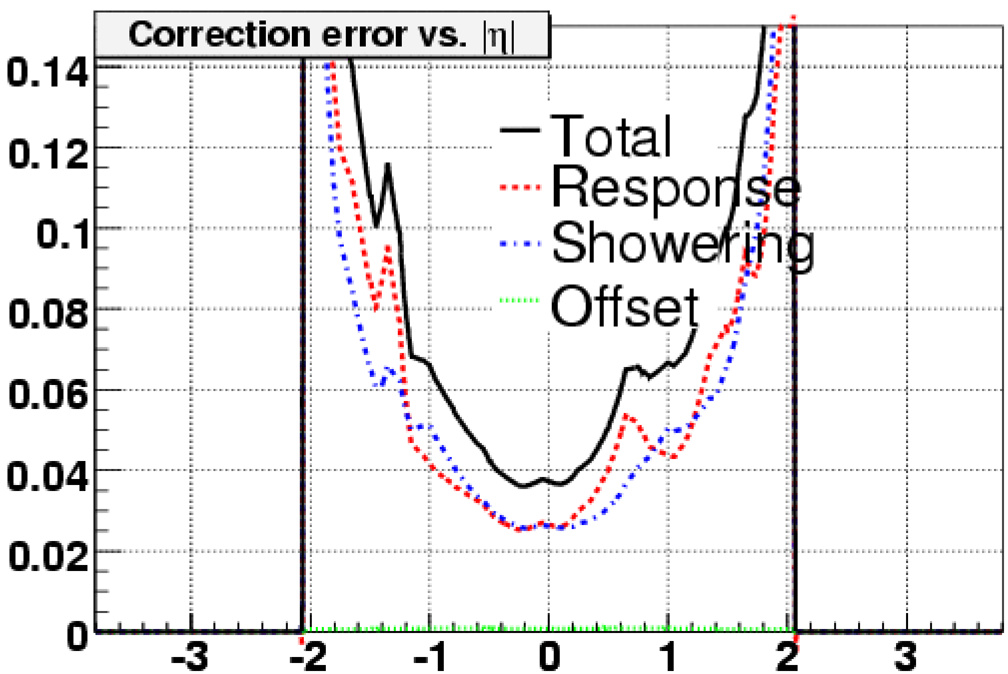
- Offset from energy density in zero bias and minimum bias events
- EM energy scale is calibrated using $Z \rightarrow e^+e^-$ events
- Jet energy scale is set using γ+jets events
- η-dependent corrections are derived combining γ+jets and dijet events to allow greater statistics and higher reach in energy
- Showering measured from energy density around jet, subtracting physics out-of-cone

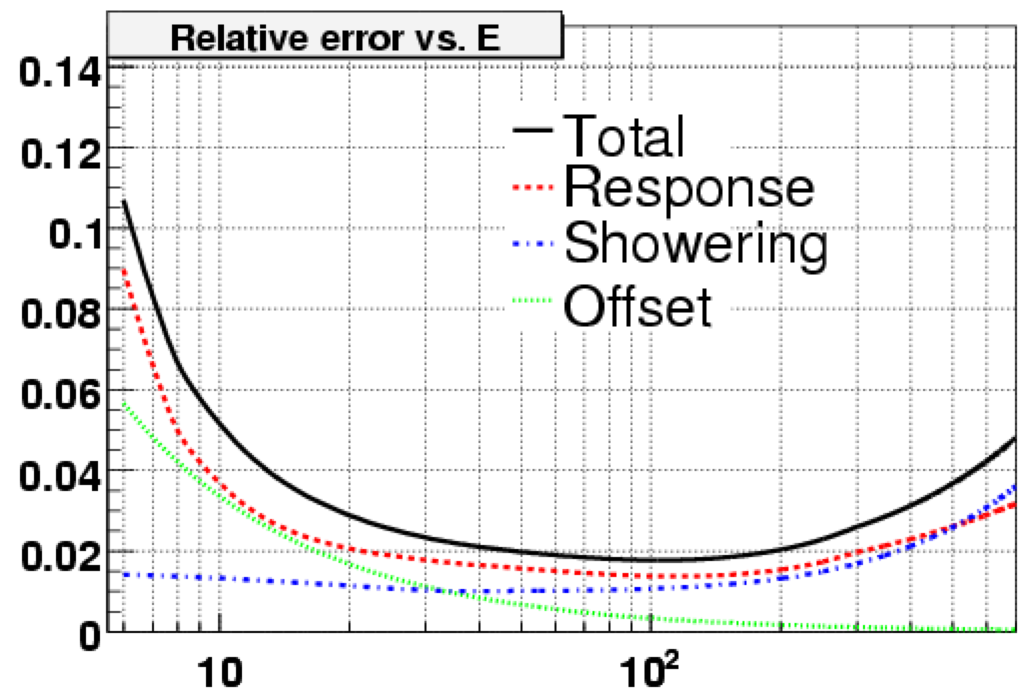


Jet Energy Scale

- Current Jet Energy Scale was derived for a subsample (~10%) of the full dataset
- Statistical error dominating at high p_T , but will improve with full statistics





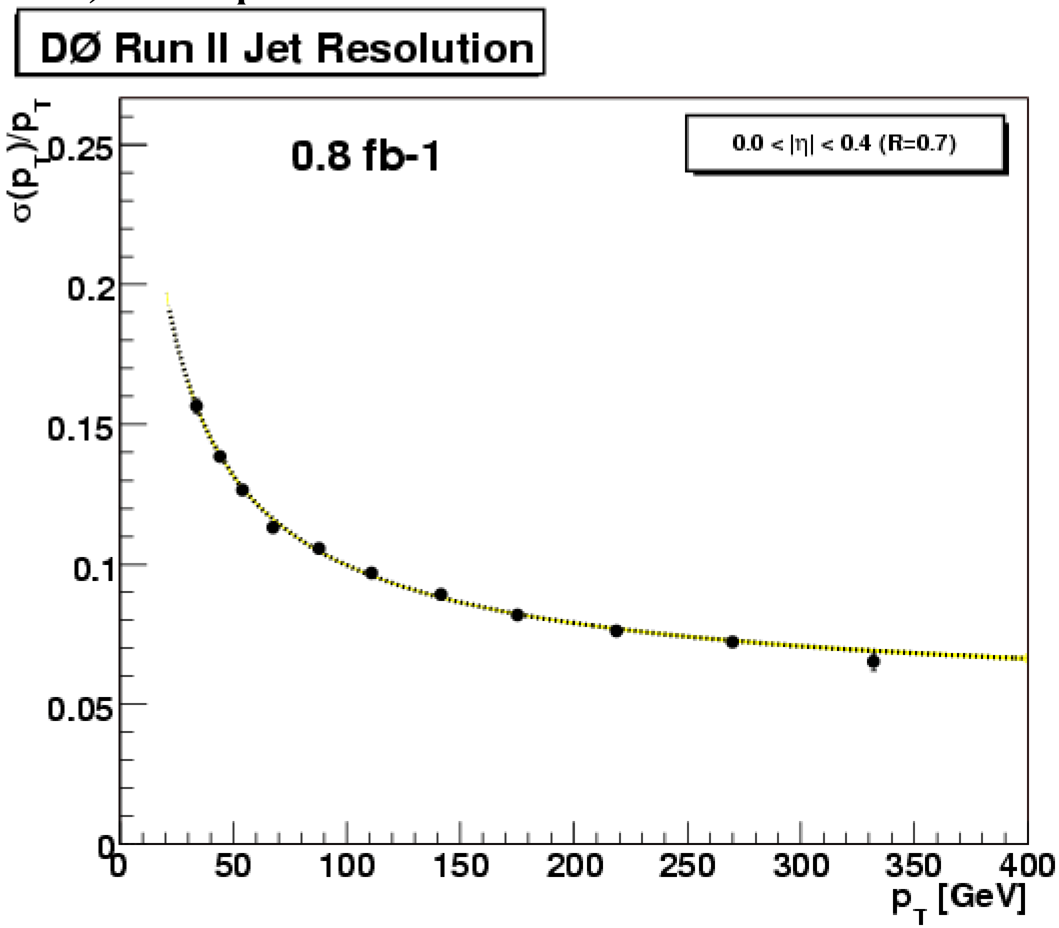


Jet pT resolution

- Jet p_T resolution was measured directly on data using dijets
- Basic variable dijet asymmetry A, which is corrected for soft radiation (third jet below reco threshold) and particle level imbalance
- Recent hadronic layer calibration improved resolution

$$A = \frac{|p_{T,1} - p_{T,2}|}{p_{T,1} + p_{T,2}},$$

$$\frac{\sigma_{p_T}}{p_T} = \sqrt{2}\,A$$

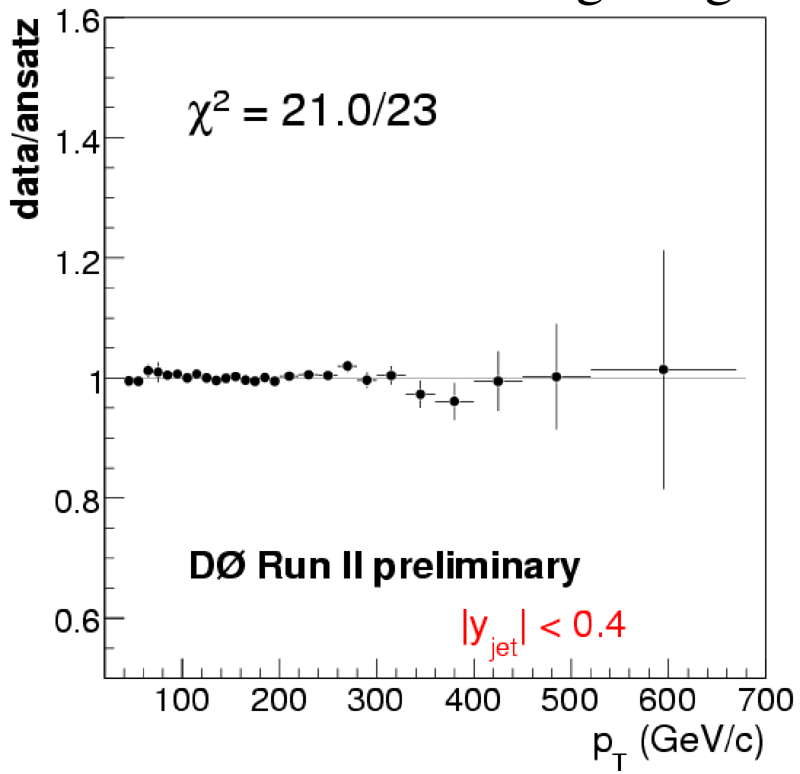


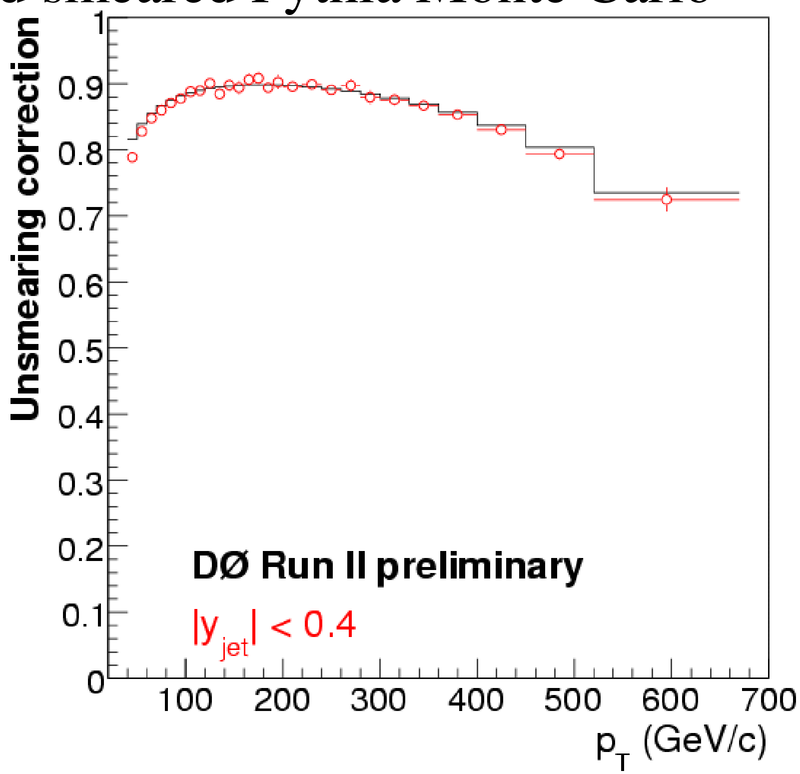
Unsmearing

- Cross section ansatz with four free parameters is smeared with Gaussian resolutions from data and the resulting smeared ansatz is fit to data

$$f(N,\alpha,\beta,\gamma)=N(pT/GeV)^{-\alpha}\left(1-\frac{2\cosh(y_{min}\,p_T)}{\sqrt{s}}\right)^{\beta}\exp(-\gamma\, p_T)$$

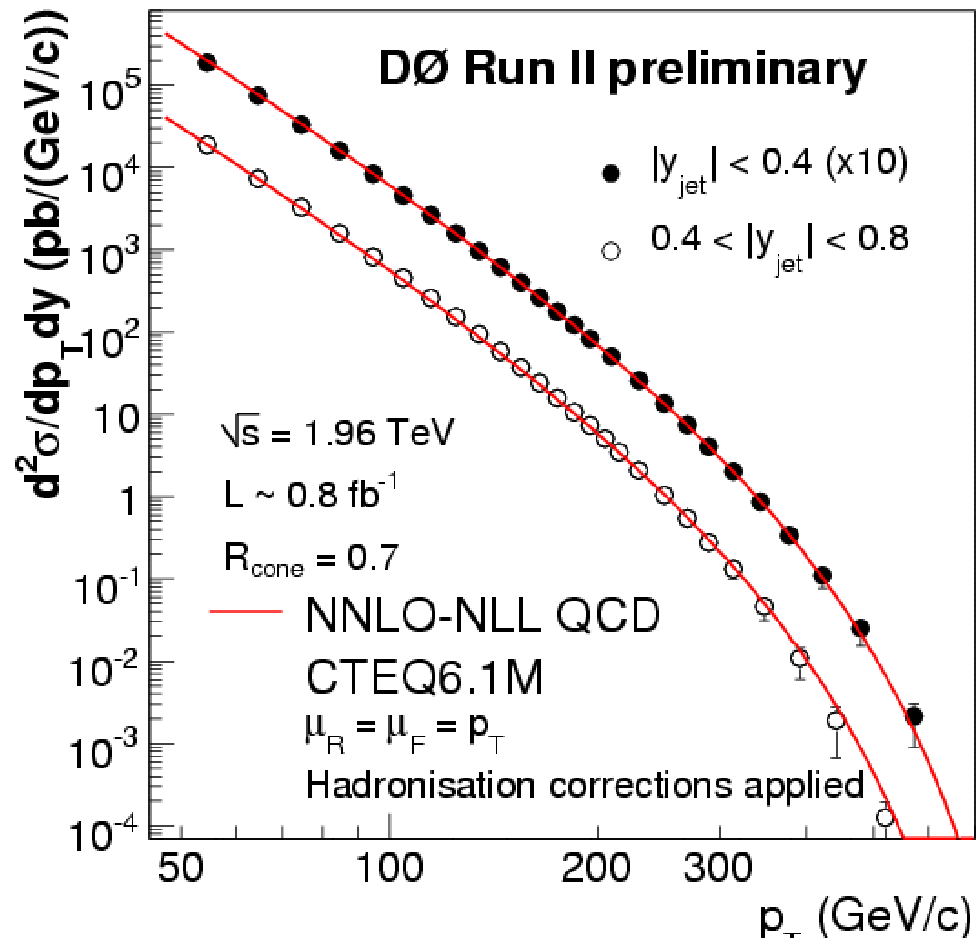
- Ratios of the original to the smeared ansatz functions are used to correct the data
- Result was checked using weighted and smeared Pythia Monte Carlo





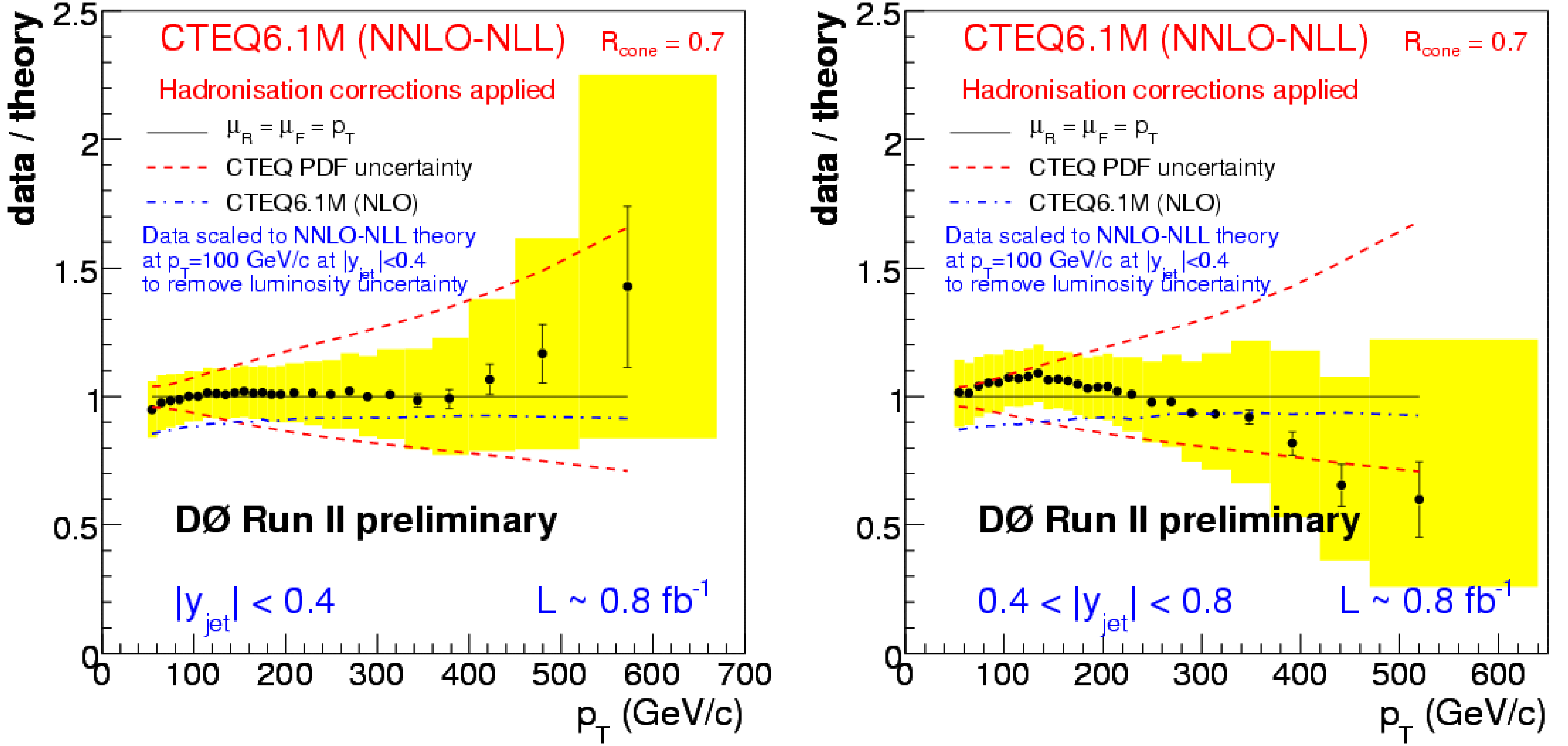
Results

- Data scaled to NNLO-NLL theory (CTEQ6.1M) at $p_T = 100$ GeV shows good agreement with theory over a wide p_T range
- NLO predictions computed using fastNLO based on NLOJet++ (*Z. Nagy, Phys. Rev. Lett. 88, 122003, 2002*) with the CTEQ6.1M parametrisation, and NNLO-NLL corrections computed using threshold resummation techniques (*Kidonakis et. al, Phys. Rev. D63, 054019, 2001*)



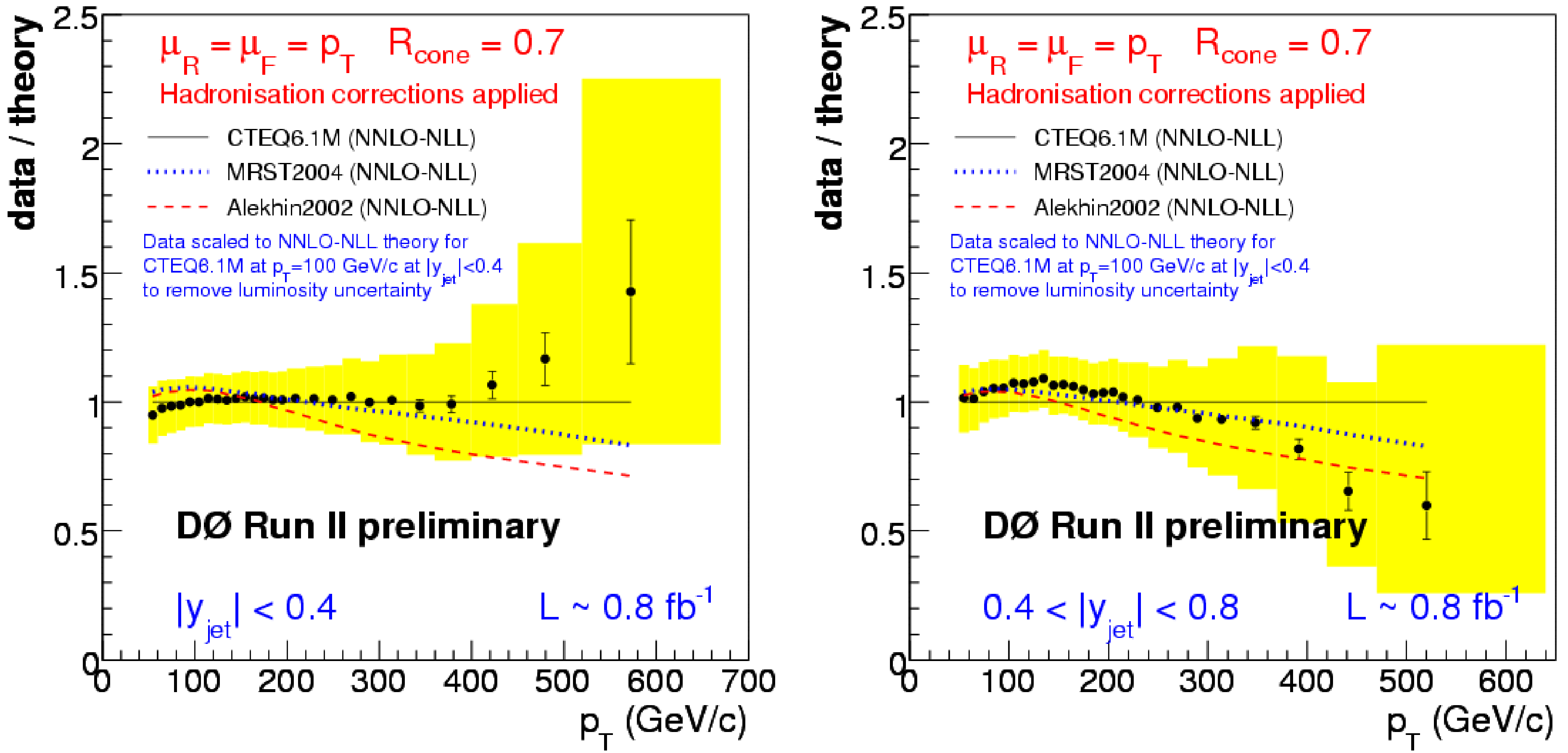
Results

- The sensitivity to constrain PDF's is there
- Caveat: JES uncorrelated between rapidity bins due to smaller sample, explaining the different trends in the bins. To be updated by summer



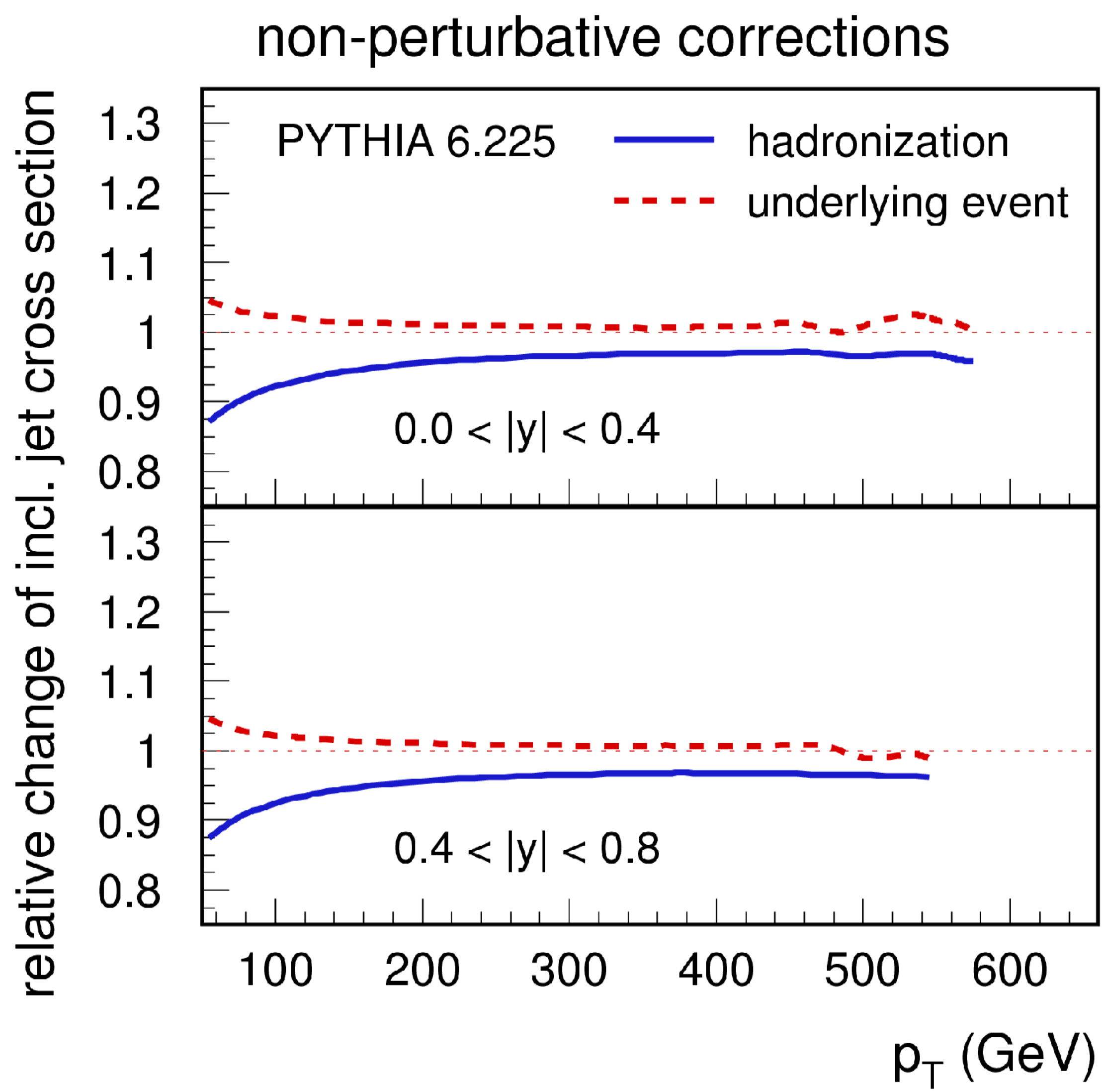
Results

- We are also sensitive to different PDF sets (CTEQ, MRST, Alekhin)
- The p_T and rapidity uncertainty correlations needed for this. We expect to have these correlations by summer



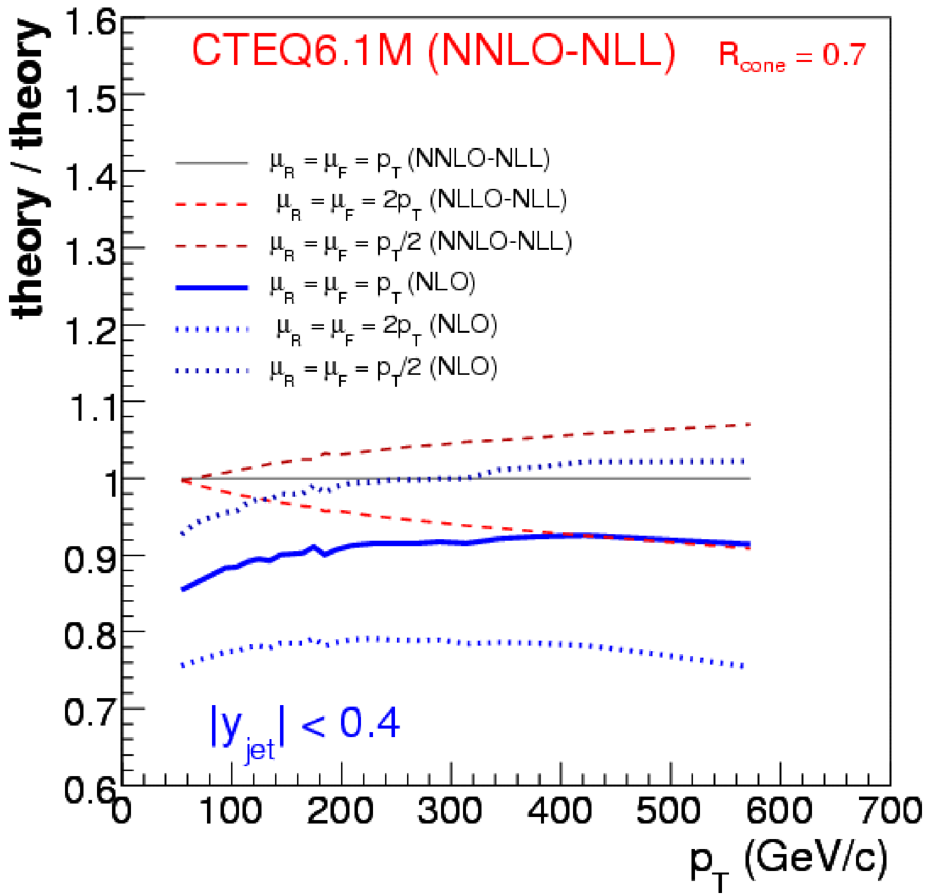
Non-perturbative corrections

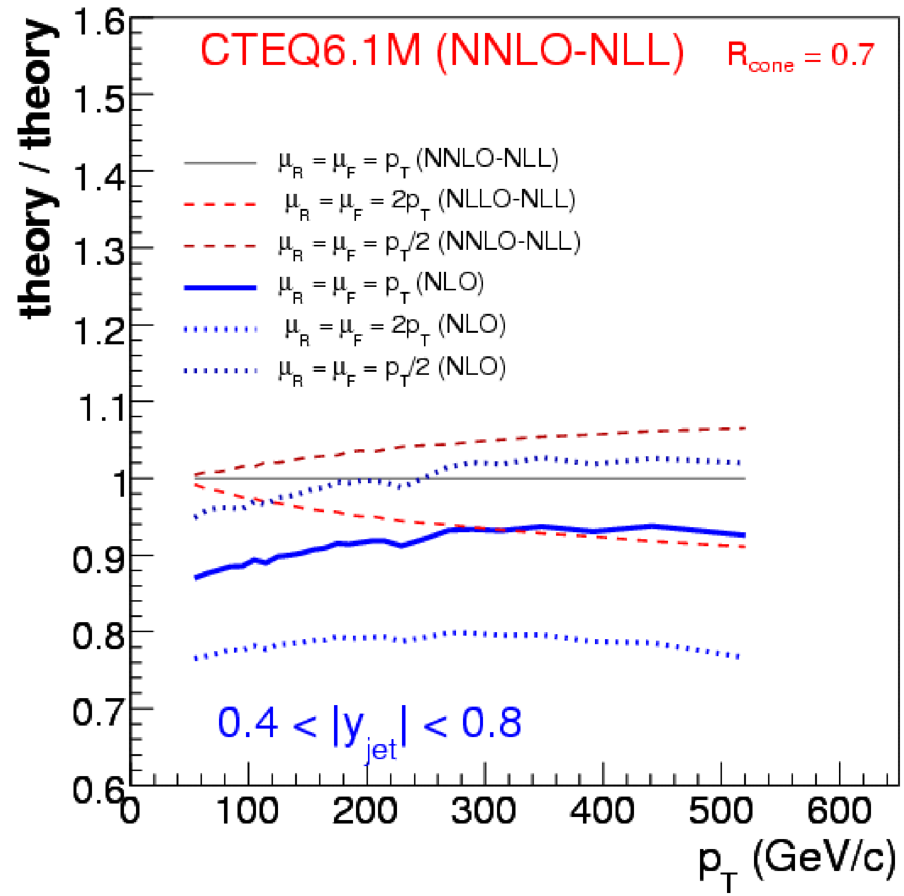
- The underlying event is already corrected by the Jet Energy Scale
- The NLO and NNLO-NLL predictions have been corrected for hadronization effects using Pythia



Theory updates

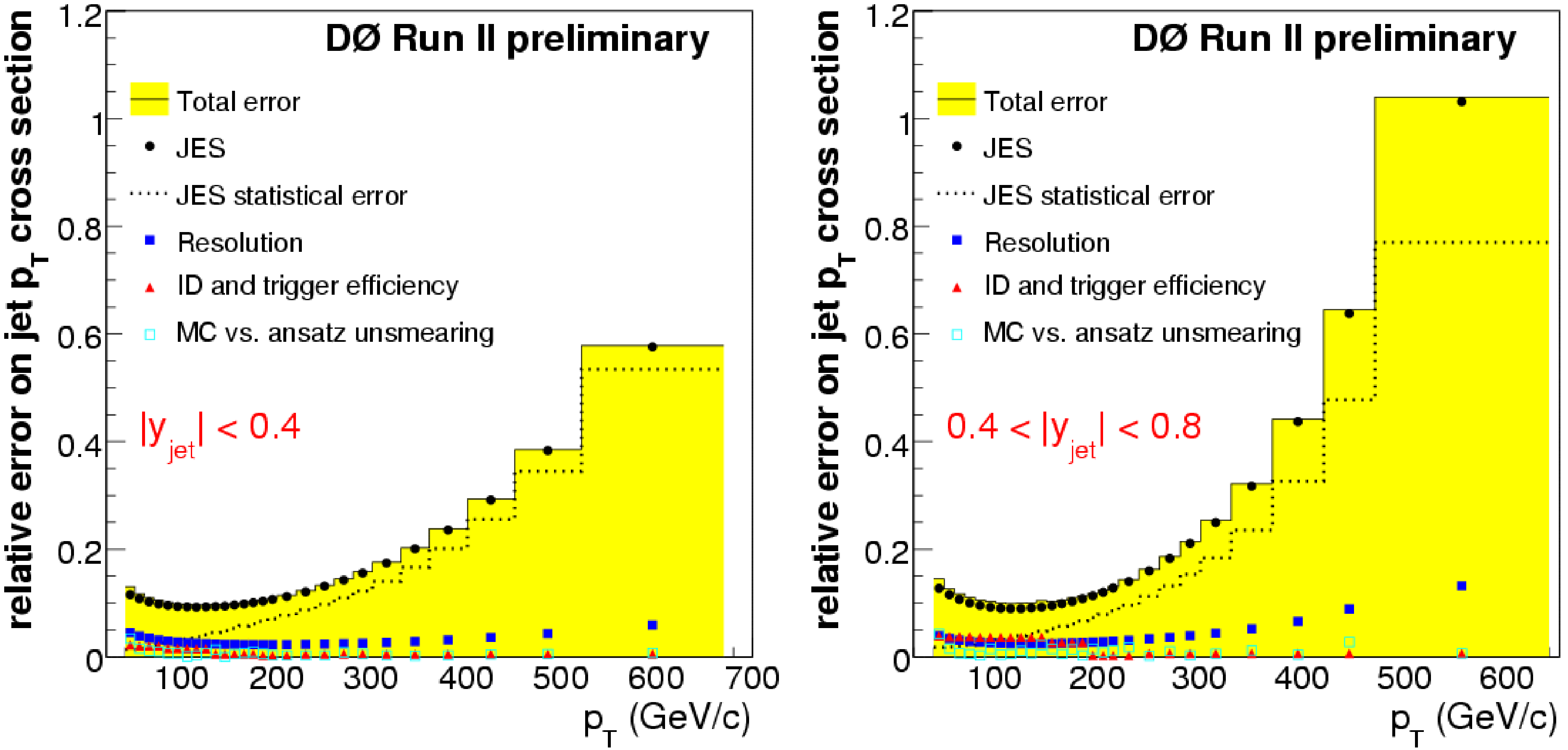
- Updated NNLO-NLL has 12% higher prediction than NLO at $p_T = 100$ GeV
- Scale uncertainty significantly smaller at low p_T





Total uncertainty

- Low pT uncertainty is close to Run I uncertainty: 8% (RunI) vs 10% (RunII) at 100 GeV in |y| < 0.5 / 0.4
- High p_T still leaves room for improvement: RunI last bin 30%, RunII last bin 60%
- JES statistical error dominant at high p_T, which will improve with full statistics



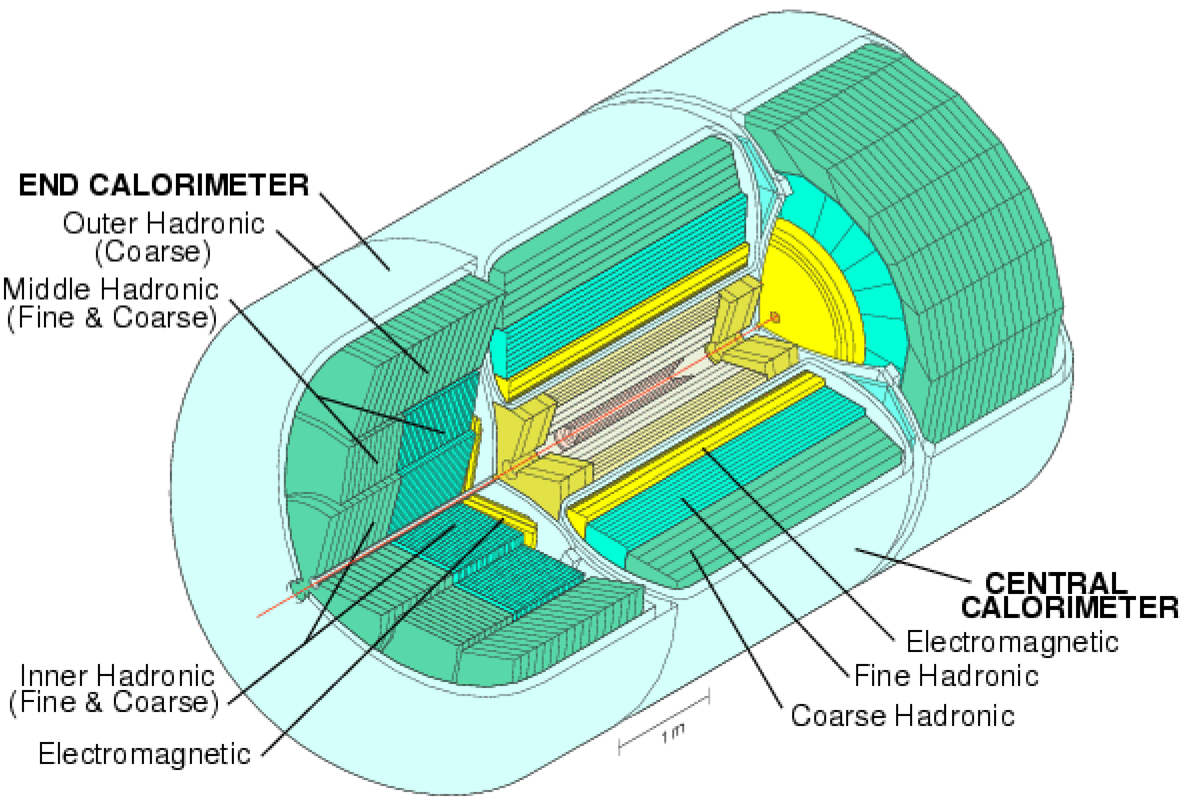
Conclusion

- New preliminary measurement of the inclusive jet cross section based on an integrated luminosity of about 0.8 fb^{-1}
- We have compared the results versus several PDFs and achieved sensitivity to them
- Plans:
  - Further improvements are expected with final JES by summer
  - By summer we will also have the full cross section

Back up slides

DZero

- Liquid argon calorimeter with good jet energy resolution

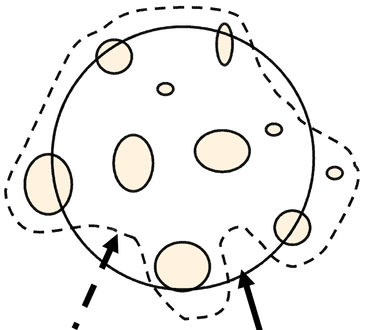


The "Run II cone algorithm"

"particle" = {experiment: calorimeter towers / MC: stable particles / pQCD: partons}

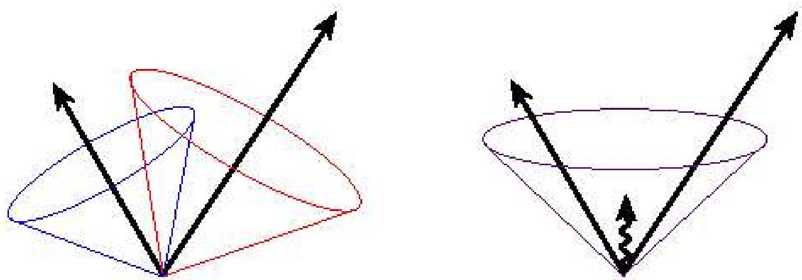
three parameters: $R_{\rm cone} = 0.7$, $p_{T\rm min} = 6$ GeV, overlap fraction $f = 50\%$

- Use all particles as **seeds**
  - make cone of radius $\Delta R = \sqrt{(\Delta y^2 + \Delta\phi^2)} < R_{cone}$ around seed direction
  - proto jet: add particles within cone in the "E-scheme" (adding four-vectors)
  - iterate until stable solution is found with: cone-axis = jet-axis
- Use all **midpoints** between pairs of jets as **additional seeds** ⇒ infrared safety!!!
  - (repeat procedure as described above)



- Take all solutions from the first two steps:
  - remove identical solutions
  - remove proto-jets with $p_{T\rm jet} < p_{T\rm min}$
- Look for jets with **overlapping cones**:
  - merge jets, if more than a fraction f of $p_{T\rm jet}$ is contained in the overlap region
  - otherwise split jets: assign the particles in the overlap region to the nearest jet (→ and recompute jet-axes)

Jet algorithms



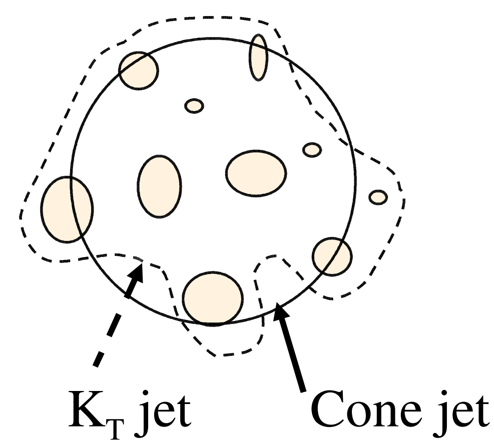
Run I Legacy Cone:

- Draw a cone of fixed size in $\eta-\phi$ space around a seed
- Compute jet axis from E_T-weighted mean and jet E_T from ΣE_T's
- Draw a new cone around the new jet axis and recalculate axis and new E_T
- Iterate until stable
- Algorithm is sensitive to soft radiation

Improved Run II Cone : "Joint Jet Working Group"

- Use 4-vectors instead of E_T
- Add additional midpoint seeds between pairs of close jets
- Split/merge after stable protojets found
- Improved infrared safety at NLO

(D0 Run II/CDF MIDPOINT)



V. O'Dell