Measurement of 3-jet differential cross section $d\sigma_{3jet}/dM_{3jet}$ in $p\bar{p}$ collisions at $\sqrt{s} = 1.96\,\mathrm{TeV}$

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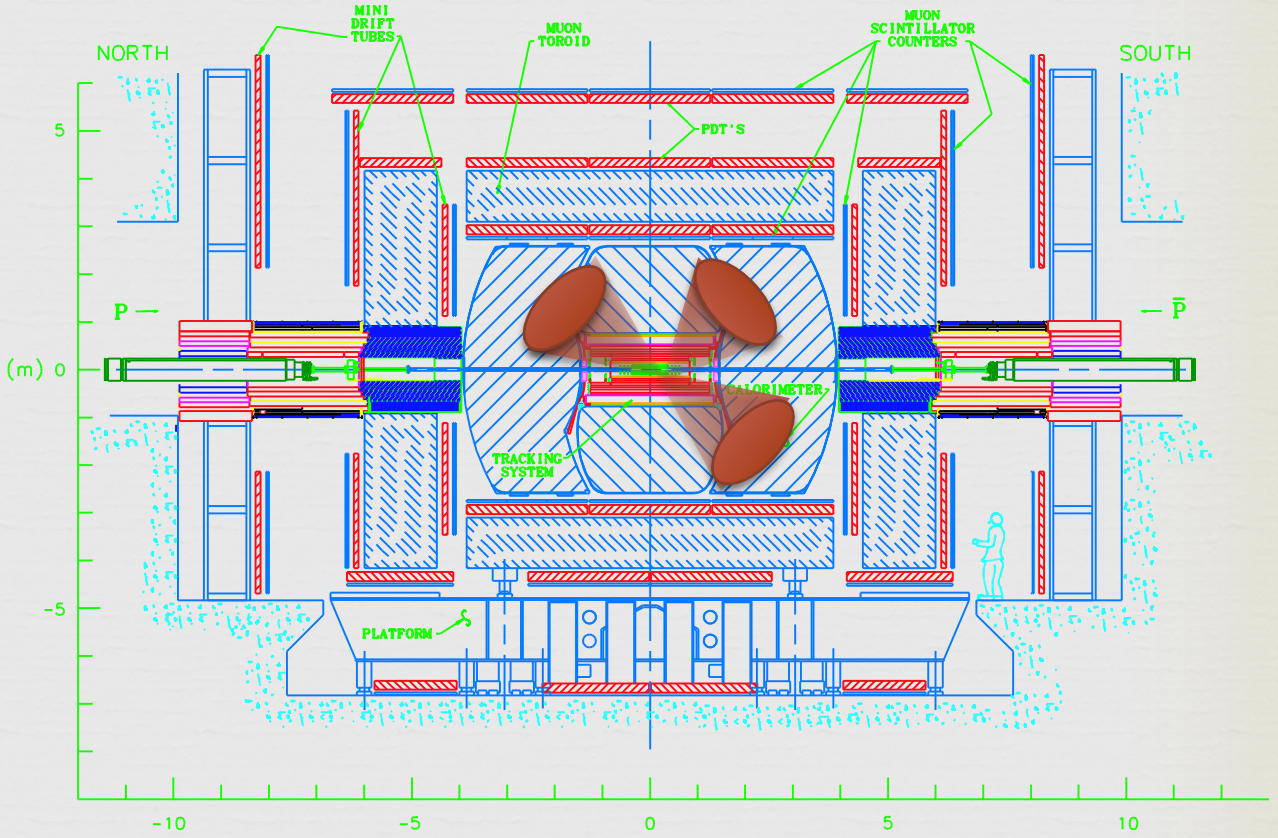
Motivation

- 3-jet events are directly sensitive to the pQCD matrix elements of $\mathcal{O}(\alpha_s^3)$
- Similar sensitivity to the PDFs as in 1-, 2-jet cross section measurements
- Precision phenomenology
  - Can be used for simultaneous determination of α_s and PDFs
- Search for physics beyond the SM

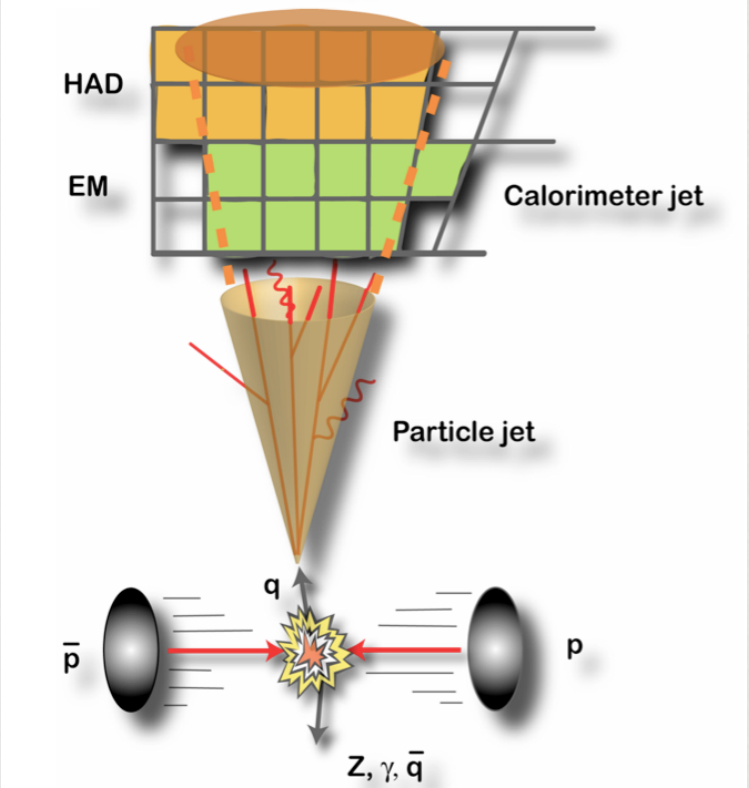
Detector & Event

- Liquid Ar/U Calorimeter
  - Jet triggering
  - Three R=0.7 cone jets
  - Jet midpoint cone algorithm
- Silicon & Scintillating fiber tracking
  - Vertexing
  - JES corrections
- Muon system
  - Trigger efficiency studies
- 3-Level trigger system



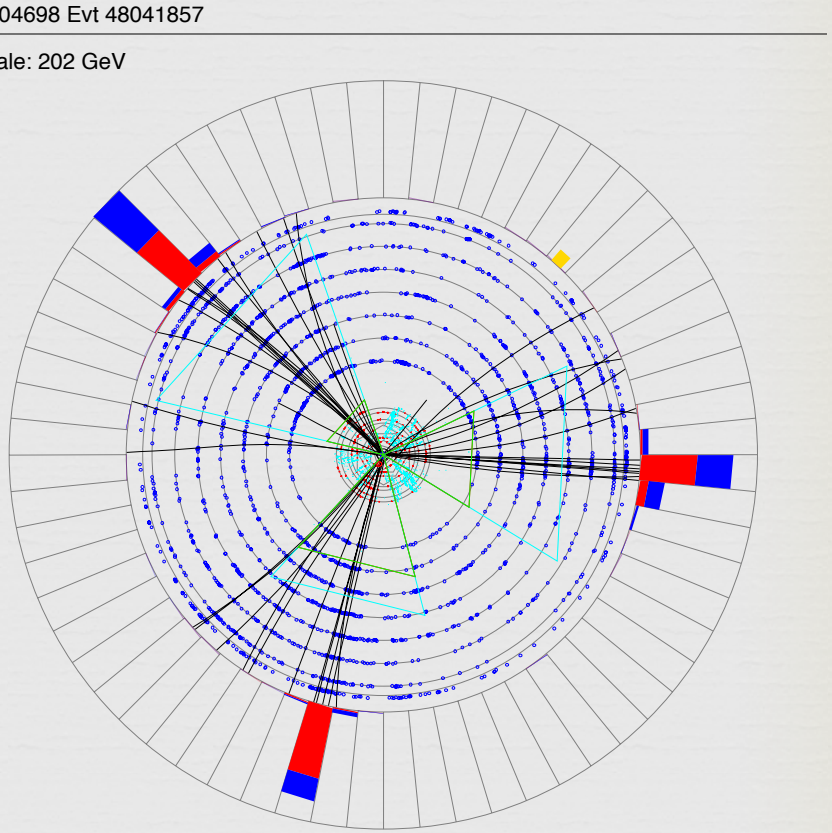
Data & Model

- 0.7 fb^{-1} of data between 2004-2005
  - Inclusive jet triggers with different p_T thresholds
  - In each M_{3jet} bin chosen trigger fully efficient
- Particle-level jets from MC with MSTW2008LO PDFs to correct data for detector resolution
  - Fast simulation parameterized from GEANT full detector simulation
    - Jet reconstruction efficiencies
    - Vertex misidentification
    - Resolution effects in jet p_T, angles



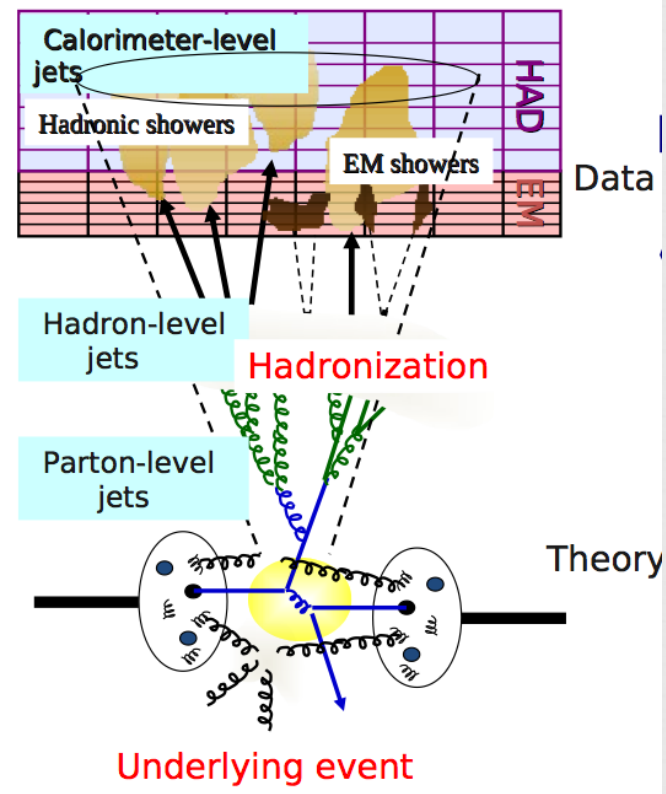
Data & Selection

- Events are triggered by the highest p_T jet
- Primary vertex within 50 cm of the center
  - Vertex is required to have 3 tracks pointing to it
- 3 reconstructed p_T ordered jets, p_T^1>150 GeV
  - 3 inclusive rapidity measurements:
    - $|y|<0.8$, $|y|<1.6$, $|y|<2.4$, p_T^3>40 GeV
  - 2 high p_T measurements:
    - p_T^3>70 GeV, p_T^3>100 GeV, $|y|<2.4$



JES Corrections

- Jet p_T are corrected for:
  - Calorimeter response
  - Energy flow through the jet cone
  - Additional interactions and pile-up
- Absolute energy calibration from data:
  - Z→ee events
  - p_T imbalance in γ + jet events in $|y|<0.4$
  - Di-jet events for higher $|y|$, p_T
- Total correction 50-20% for jet p_T 50-400 GeV
- Corrections due to different fractional contributions of gluon and quark jets (2-4%)
- M_{3jet} is calculated using the corrected jet p_T



Resolution Effects

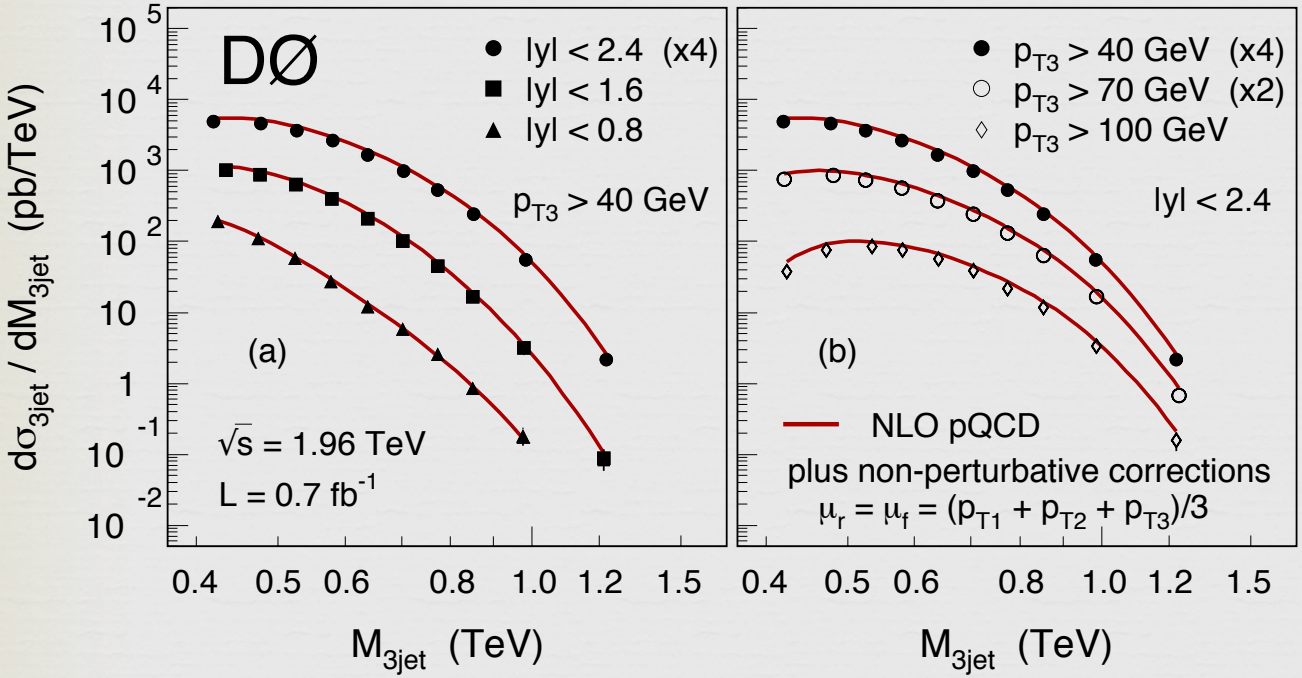
- Trigger efficiency for each bin 99%
- Vertex acceptance 91.4-92.9%
- JetID (shower shape, etc.) requirement efficiency 97.5%
  - Jet misID < 0.1%
- Detector resolution for jet p_T 15-10% for 40-400 GeV jets
- Generated events reweighted to match M_{3jet}, $|y|$, p_T
- M_{3jet} binning chosen as twice the resolution

Systematics

- 65 independent sources of systematic uncertainty

Source	Value	Source	Value
Jet energy calibration	±10-30%	Reweigting of gen. events	±2.5%
Luminosity	±6.1%	Trigger efficiency	±2%
Jet p_T resolution	±1-5%	Jet θ resolution	±1%
Systematic shifts in $\lvert y \rvert$	±3%	Other	<1%

Differential Cross Section



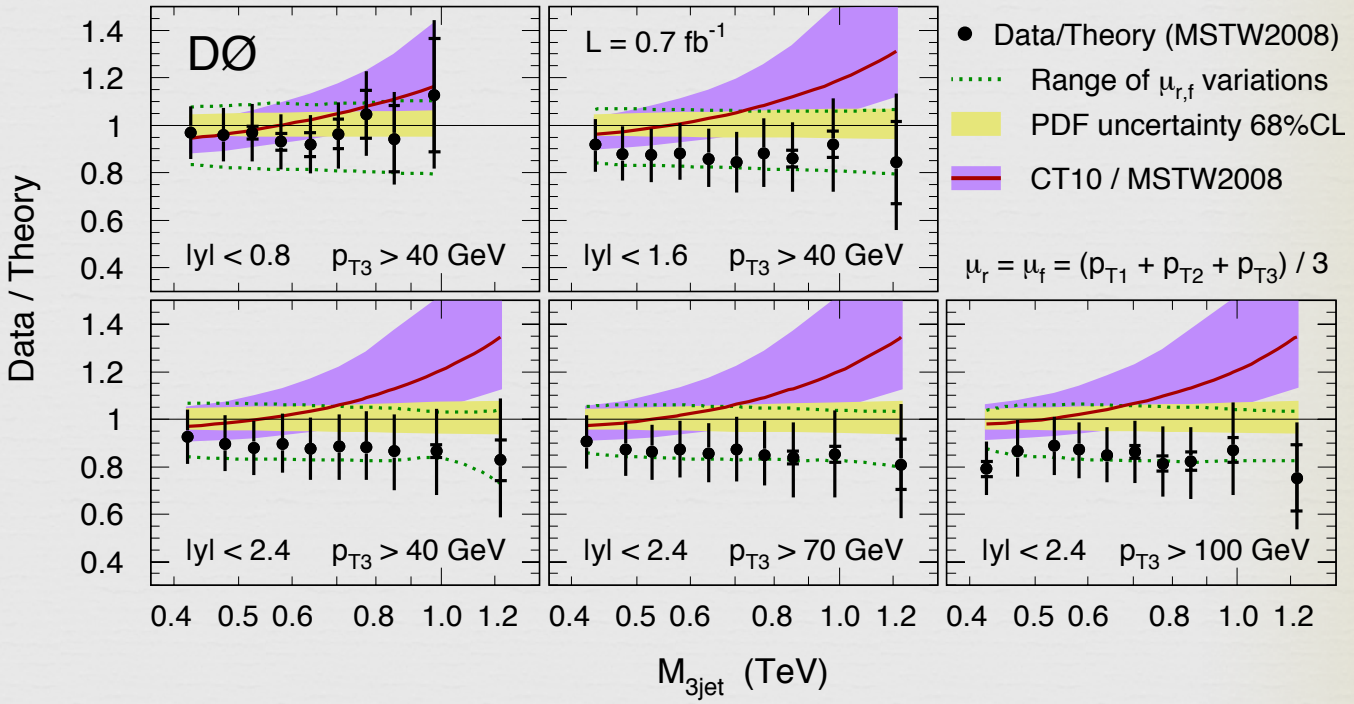
- pQCD from FASTNLO based of NLOJET++
- MSTW08NLO PDFs
- $\alpha_s(M_Z)$=0.1202
- Non-perturbative corrections from PYTHIA DW

Hadroniz	Underl.	Total
For |y|<2.4, p_T^3>100 GeV, M_{3jet}=0.4		
-13.8	5.3	-9.3
For |y|<2.4, p_T^3>40 GeV, M_{3jet}=1.1		
-10.1	13.7	2.2

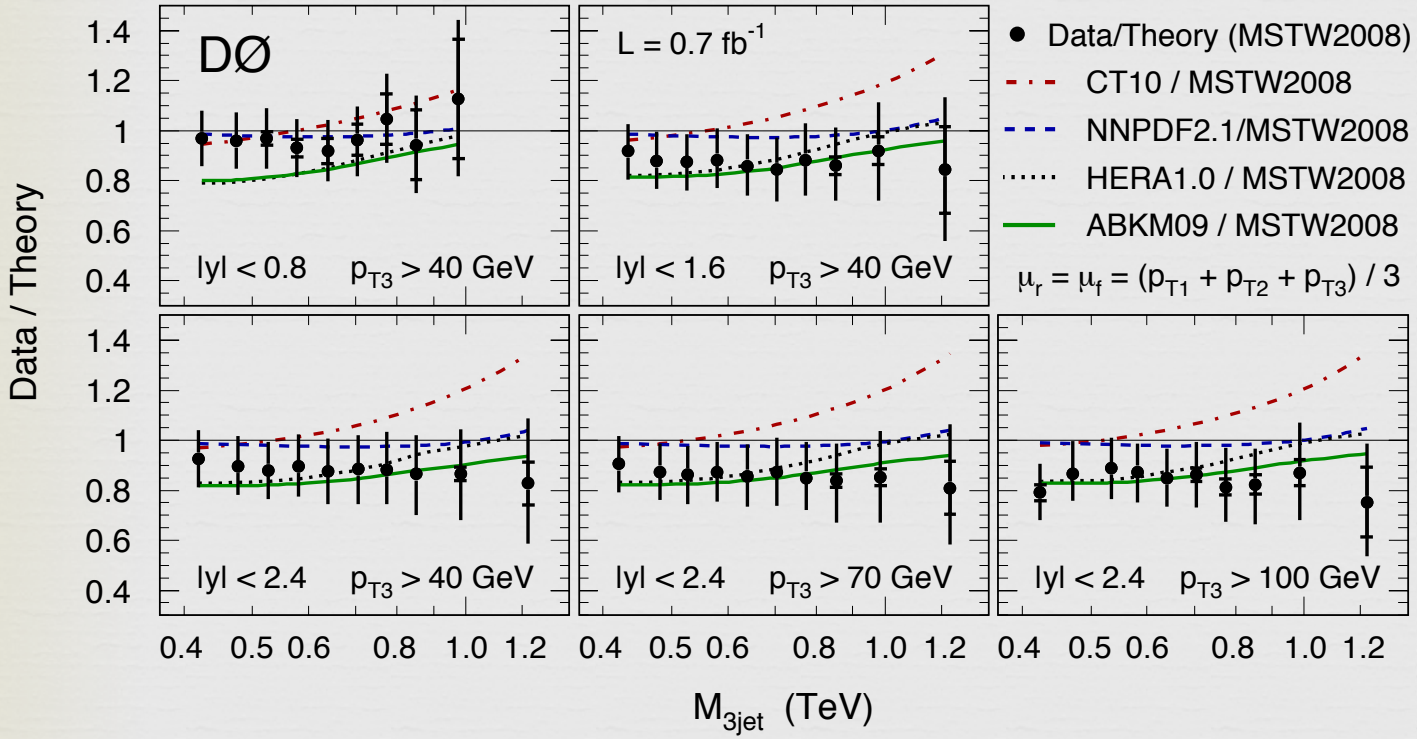
- Different PYTHIA tunes (A, BW, Z1, Perugia, Perugia hard tunes) affect the total corrections by less than 5%

Different PDFs with uncertainties

- Data below theory by 4-15% but within $\mu_{r,f}$ variations
- Scale variations affect prediction by +(5-10)% -(15-20)%
- CT10 ($\alpha_s(M_z)$=0.118)
- Published at 90% C.L, rescaled by 1/1.645 to 68% C.L.
- 30% higher at M_{3jet}=1.2 TeV



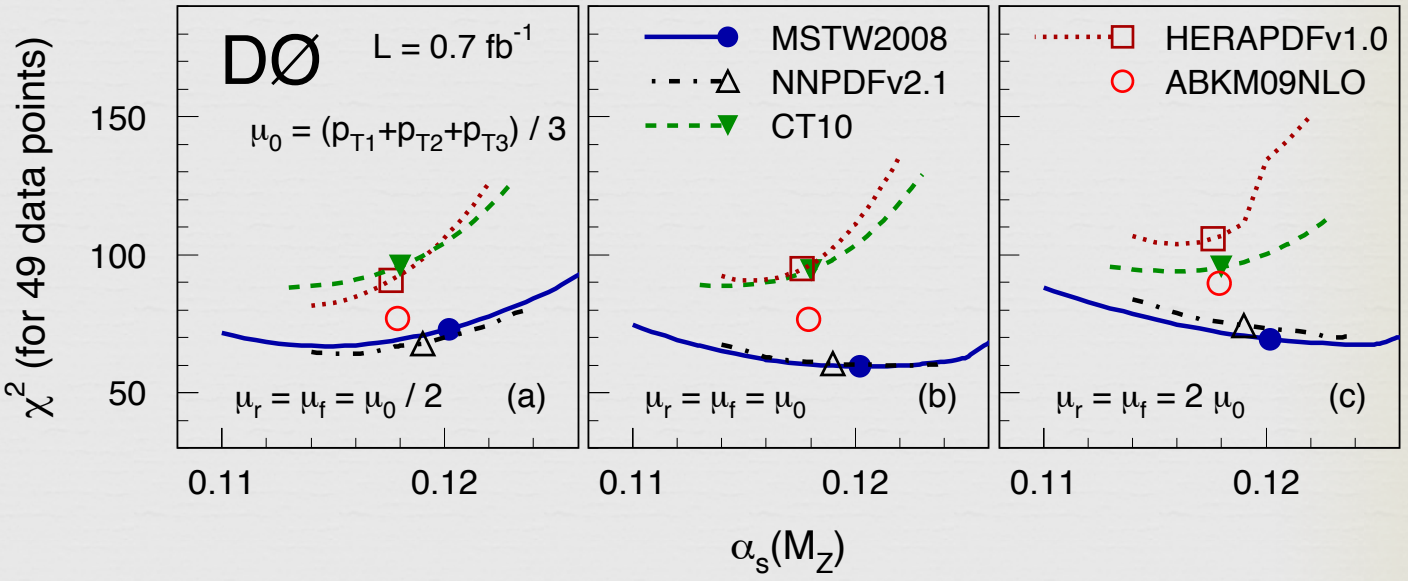
More PDFs



- NNPDF ($\alpha_s(M_Z)$=0.119) agrees with MSTW08NLO within 4%
- HERAPDFv1.0 ($\alpha_s(M_Z)$=0.1176) is 15-20% below CT10
- ABKM09NLO ($\alpha_s(M_Z)$=0.1179) predict smallest xsection at high M_{3jet}

X^2 test

- At world average ($\alpha_s(M_Z)$=0.1184) for all PDFs lowest X^2 is at $\mu_r = \mu_f = \mu_0$
- Best agreement MSTW08NLO $\alpha_s(M_Z)$=0.121 with X^2=59.5
- NNPDFv2.1 at $\alpha_s(M_Z)$=0.123 close
- ABKM09NLO $\alpha_s(M_Z)$=0.1179 only 1 value
- HERAPDFv1.0, CT10 large X^2
- PDF sensitivity of 3-jet cross section data



- Experimental uncertainties with correlations
- Underlying event and hadronization uncertainties
  - ½ the size of individual correction, independent
- PDF uncertainties, statistical uncertainties ignored

Conclusions

- First measurement of inclusive 3-jet differential cross section as a function of M_{3jet} in the
- 5 scenarios, 3 rapidity regions, 3 requirements on p_T of the 3rd jet
- Compared to pQCD in NLO in α_s and various PDF parametrizations
  - Computed χ^2 for different scale choices and different $\alpha_s(M_z)$ values
  - Best description of the data from MSTW2008NLO and NNPDFv2.1 PDF sets
    - Describe both the normalization and shape
  - ABKM09NLO reasonable description of the data, slightly different shape
  - HERAPDFv1.0 and CT10 predict different M_{3jet} shape, poorer agreement with the data