PDF Reweighting and Uncertainties on W+Jets

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Overview

- **Aim:**
  - Evaluate PDF uncertainties on W+jets events
  - Make a comparison with systematic experimental uncertainties
  - Final goal is to estimate effect of PDF uncertainties on the cross section as a function of cumulative jet multiplicity.
- SM sample not available yet. A SUSY sample was used with high filter cuts.
- In this talk:
  - Test of PDF Reweighting Techniques
  - Preliminary results on PDF uncertainties for Et and rapidity distributions of electrons and jets and for jet multiplicities.

Data Set

- SUSY Sample: **W(→ e nu)+ jets**
  csc11 data (AlpgenJimmyWenu) made with Alpgen/Herwig
- Simulation with Athena release 11.0.42, Reconstruction in 12.0.4
- PDF set: **CTEQ6LL**

Dataset	#Partons	Incl/excl	#events	σ (pb)
5223	2	exc	2090	504
5224	3	exc	5853	122
5225	4	exc	6249	28.4
5226	5	inc	5802	6.1

- **Generator Event Filter (EF):**
  - N Jets (Pt>40GeV) ≥ 4
  - MissEt > 80GeV
  - Leading Jet: Pt>80GeV

Info at: https://twiki.cern.ch/twiki/bin/view/Atlas/WplusJetsAlpgen

PDF Reweighting Technique

- Use PDF Reweighting to avoid many Monte Carlo generations
- Generate a MC sample with PDF set 1 and weight every event to PDF 2:

$$EW = \frac{f_{PDF_2}(x_1, flav_1, Q)}{f_{PDF_1}(x_1, flav_1, Q)} \cdot \frac{f_{PDF_2}(x_2, flav_2, Q)}{f_{PDF_1}(x_2, flav_2, Q)}$$

→ Reweight SUSY sample to 40 PDF error sets (CTEQ6M) to evaluate PDF Uncertainties.

First need to test Reweighting Technique

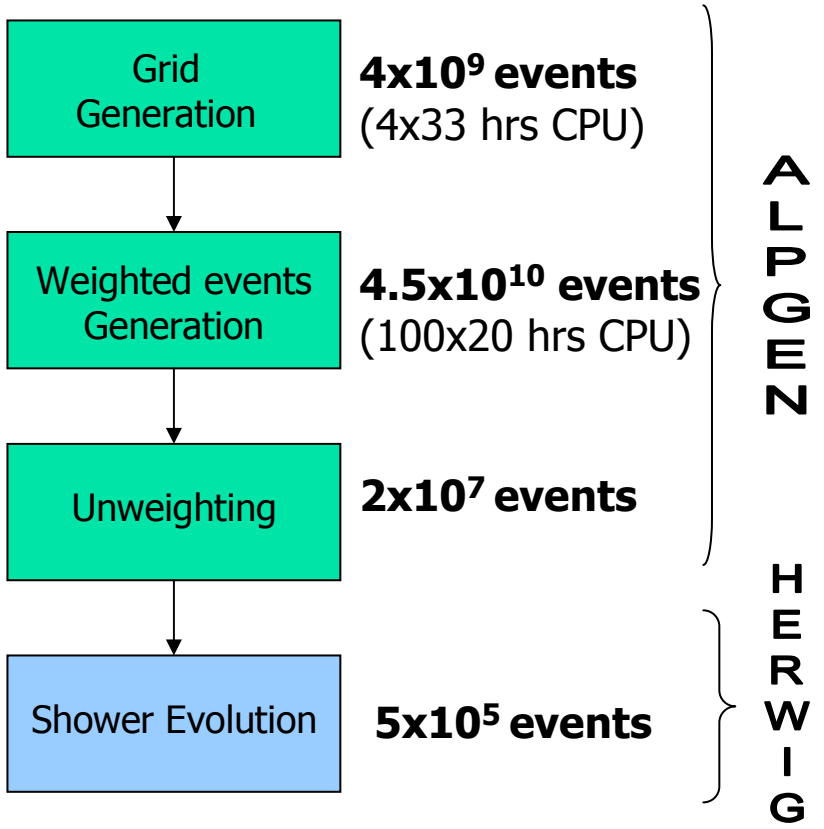
- To test we generated 3 samples of W+3partons with different PDFs (CTEQ6L, MRST2001lo, MRST2001nlo) and compared reweighted events with generated events.
  Requirements:
  - High statistics (~500,000 events per sample)
  - Generated samples consistent with SUSY sample (EF Cuts)

- Generation:
  - Hard Process with ALPGEN
  - Hadronization + Parton Shower (PS) with Herwig/Jimmy within Athena framework (release 11.0.42)
  - Simulation with AtlasFast (release 12.0.6)

ALPGEN Generation

- ALPGEN: exact matrix element calculation at LO for multiparton final states in hadronic collisions
- Problems:
  - Long warm-up for generation grid
  - Low efficiency: Unweighting
    Jet-Parton matching
    Tight EF Cuts (SUSY)

Npart	Unw Eff	MLM Eff	EF Eff
2	3.81×10^{-3}	0.54	0.0024
3	4.4×10^{-4}	0.43	0.0646
4	2.3×10^{-4}	0.35	0.0203
5	4.0×10^{-5}	0.49	0.290



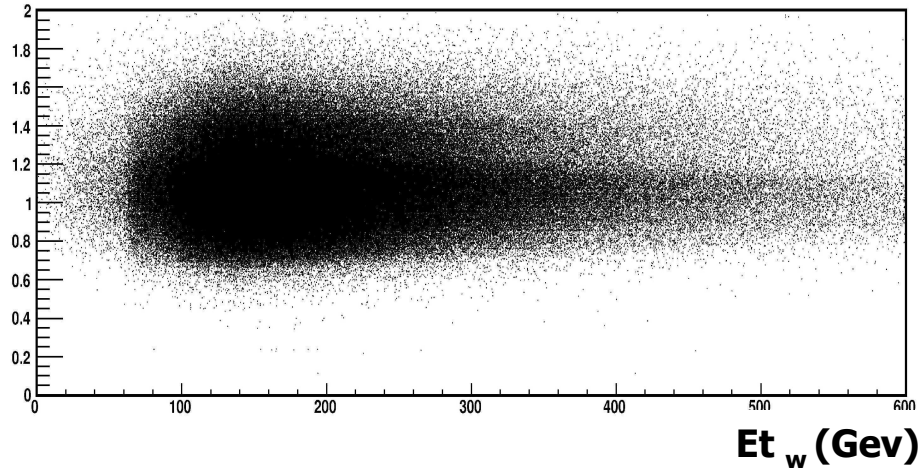
PDF Reweighting Results

- Compare
  MRST2001nlo generated
  with
  MRST2001nlo weighted (from CTE6L)
- Large weights (LO→NLO):

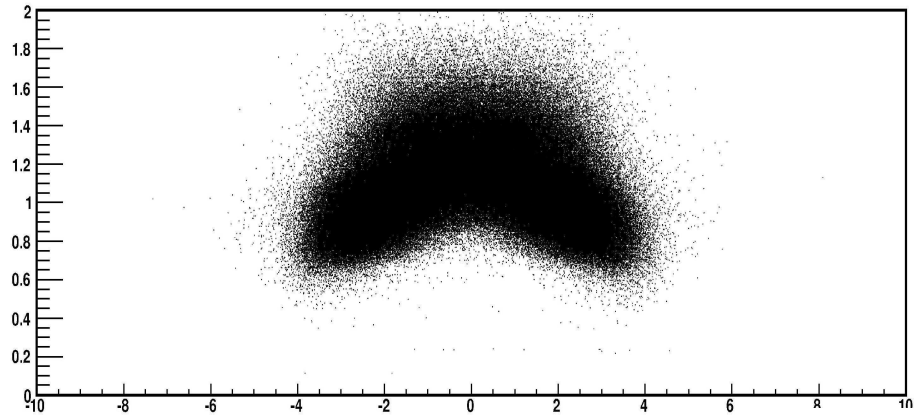
$$0.6 < \frac{MRST\,2001nlo}{CTEQ6L} < 1.8$$

- Reweighting accurate to few percent in measurable regions
- Affected by statistical effects at edges of kinematic regions
- Parton Shower does not have any significant effect

MRST2001nlo/CTEQ6L

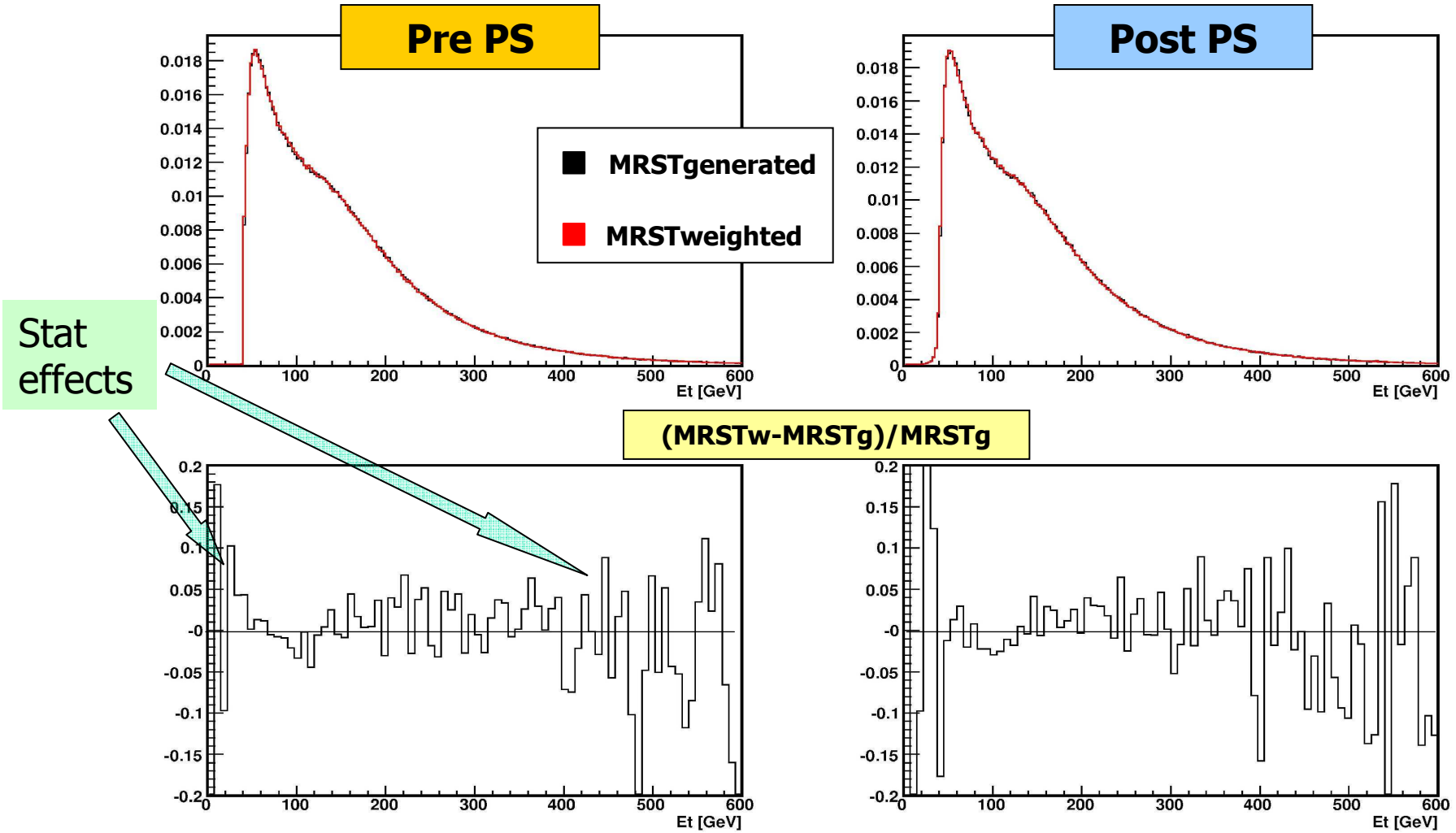


Et $_w$ (Gev)

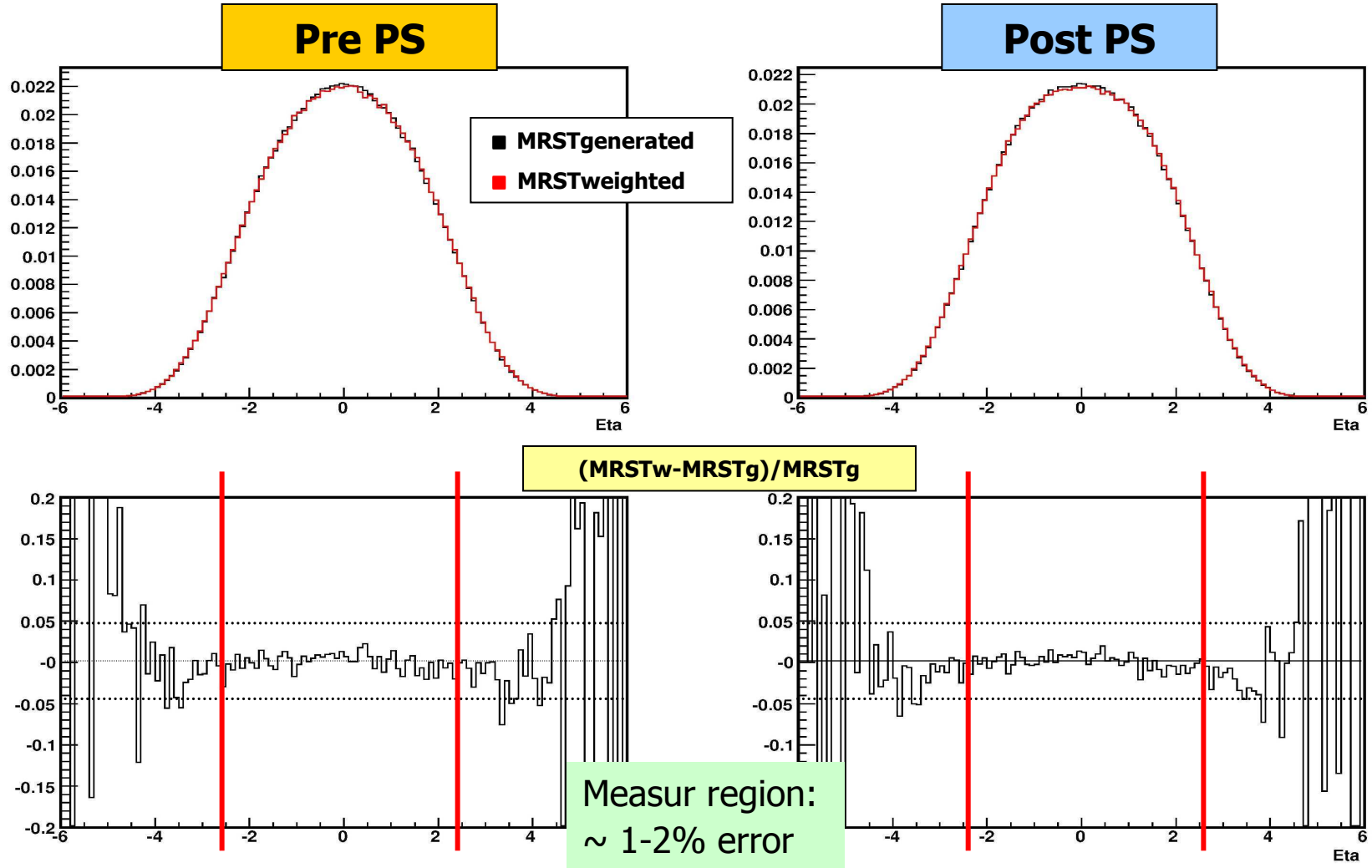


Eta $_w$

Partons: Et (Pre/Post PS)



Partons: Eta (Pre/Post PS)



PDF Reweighting: Results

Partons Before PS (No cuts)		
Variable	Mean(%)	var
Et	-0.44	0.85
Eta	1.61	0.95

Partons Before PS (Centr.Region)		
Variable	Mean(%)	var
Et	0.85	0.43
Eta	0.06	0.14

Partons After PS (No cuts)		
Variable	Mean(%)	var
Et	-0.32	0.99
Eta	2.41	1.55

Partons After PS (Centr.Region)		
Variable	Mean(%)	var
Et	0.60	0.46
Eta	0.10	0.14

- Relative difference between two samples:

$(MRST_{wgt} - MRST_{gen})/MRST_{gen}$

- No significant effect from PS
- Mean Accuracy: 1% in cent. regions:

$-2.5 < \eta < 2.5$

$50 < Et_{part,ele} < 400GeV$

$100 < Et_{W} < 400GeV$

W Bef PS (No cuts)		
Variable	Mean(%)	var
Et	0.43	0.54
y	-1.15	0.69

W Bef PS (Centr.Region)		
Variable	Mean(%)	var
Et	1.01	0.34
y	0.25	0.26

W After PS (No cuts)		
Variable	Mean(%)	var
Et	-0.19	0.60
y	1.53	0.84

W After PS (Centr. Regionl)		
Variable	Mean(%)	var
Et	0.80	0.37
y	0.26	0.26

Electrons (No cuts)		
Variable	Mean	var
Et	2.33	1.6
Eta	0.65	1.23

Electrons (Centr.Region)		
Variable	Mean	var
Et	5.5	0.82
Eta	-0.02	0.25

Electron Et ?

PDF Uncertainties

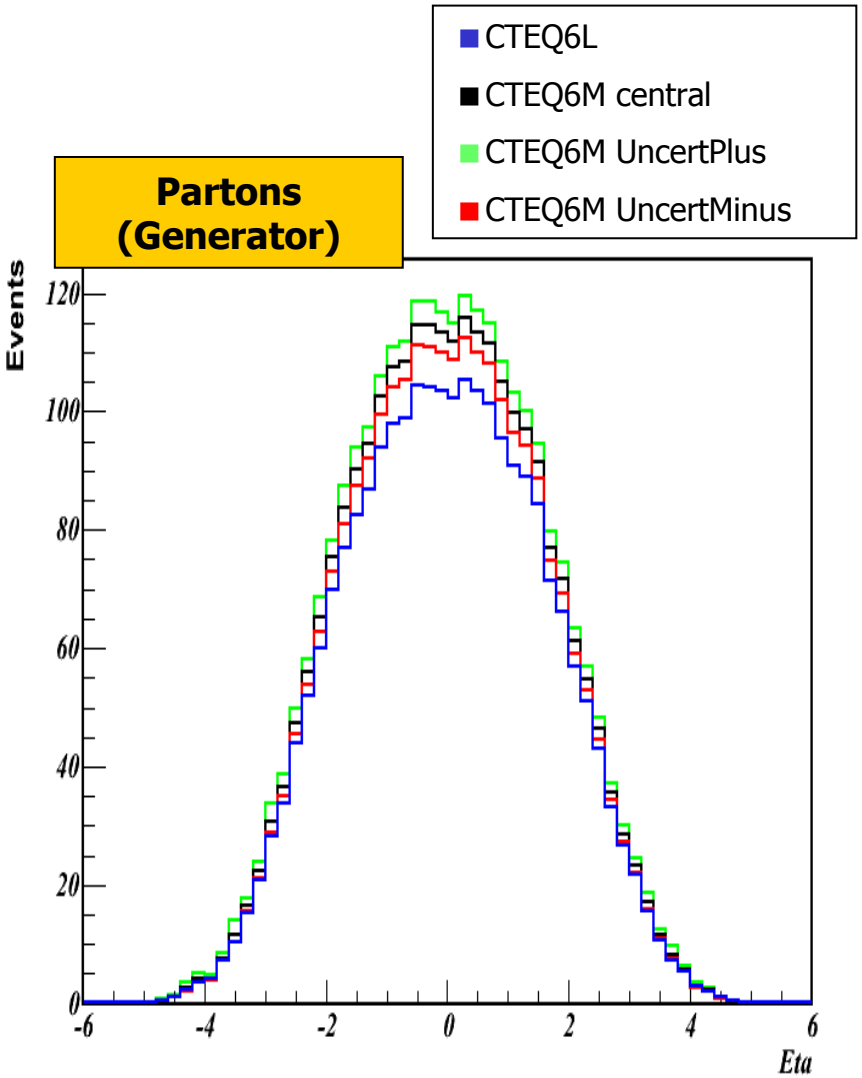
- SUSY sample produced with CTEQ6L(LO) but PDF error sets only for CTEQ4M (NLO)

Need to reweight:

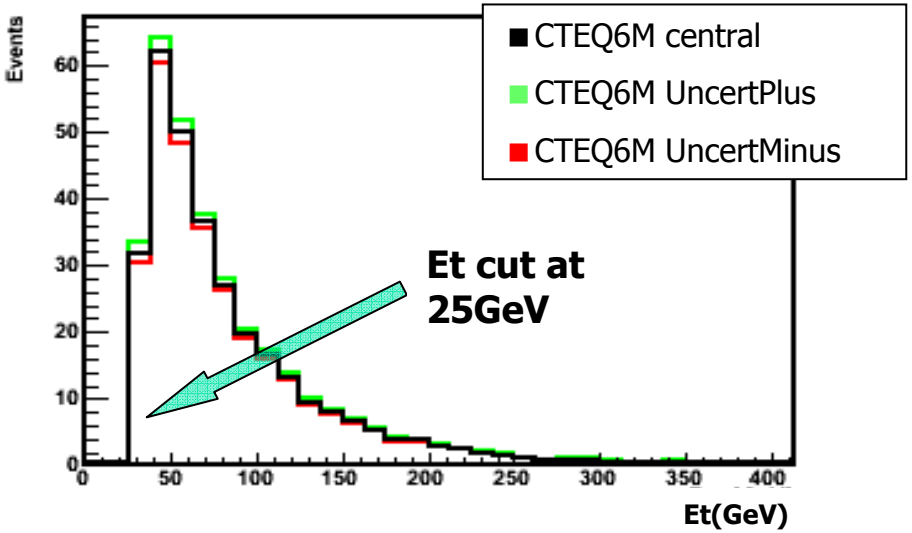
1. CTEQ6L→CTEQ6M central
2. CTEQ6L→40 CTEQ6M error sets

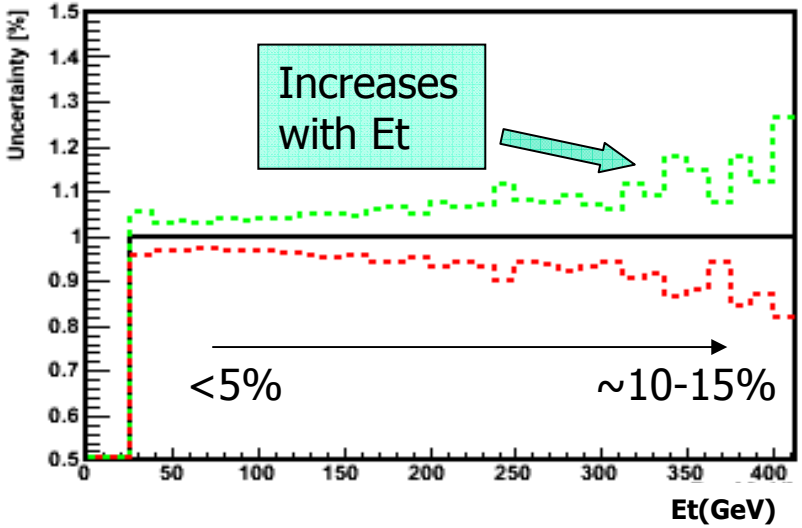
Significant Reweighting (average event weight~1.2)

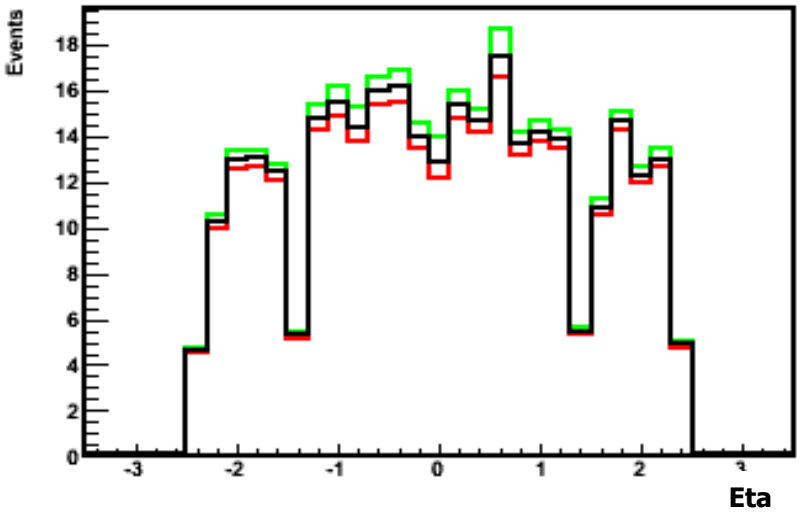
Look at distributions of electrons, partons, jets in Et and Eta

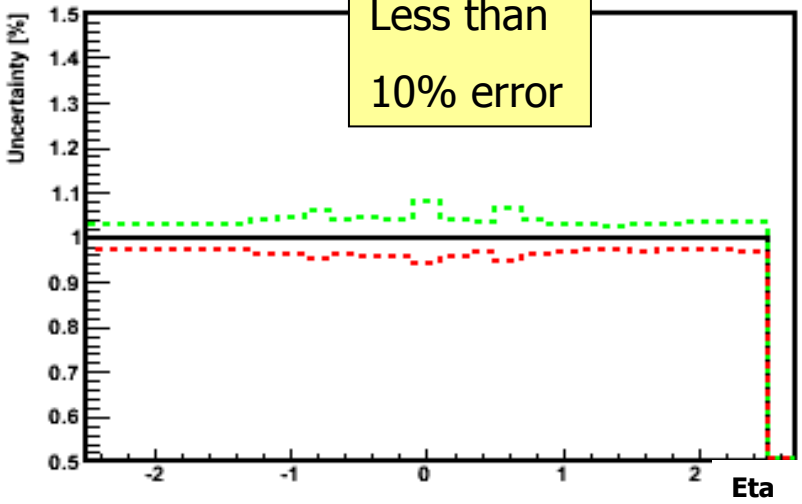


PDF Uncert: Electrons at Det.

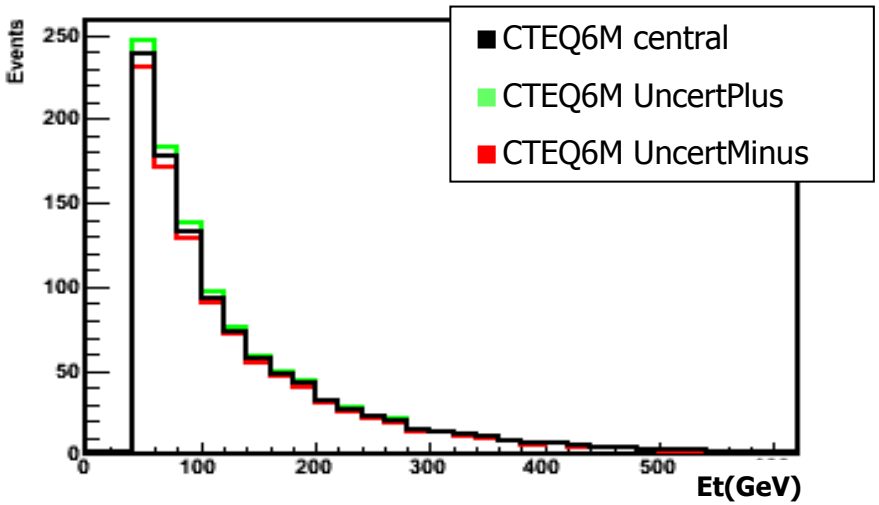


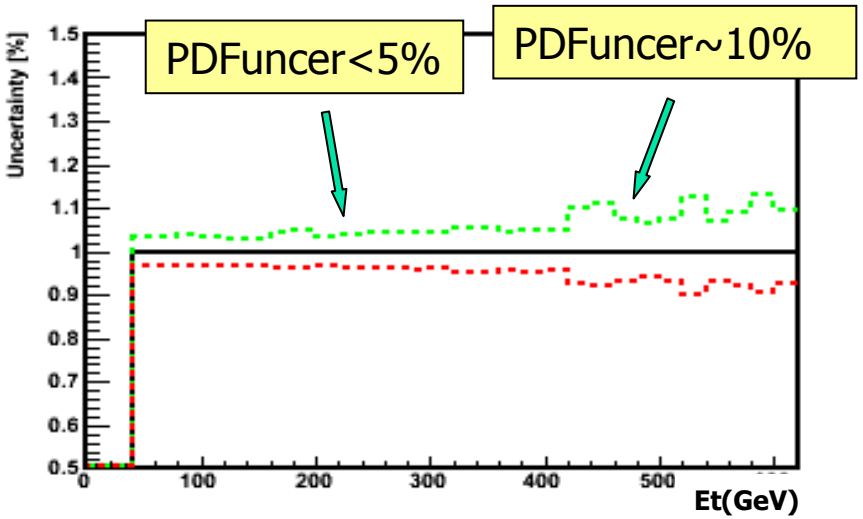


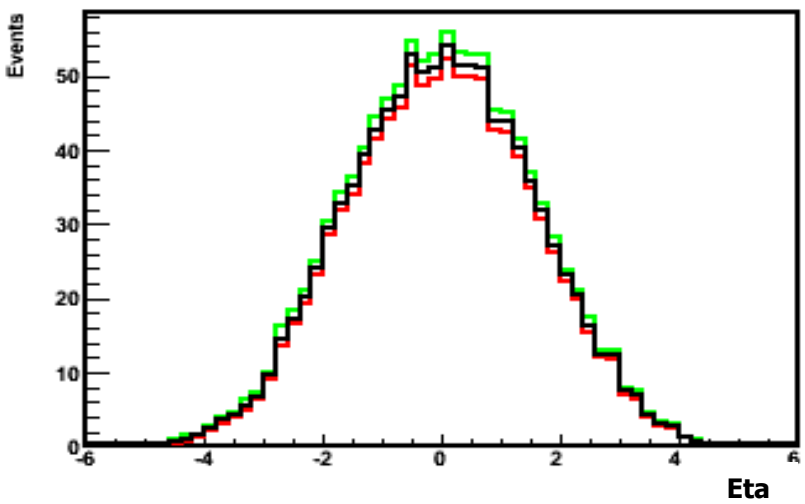


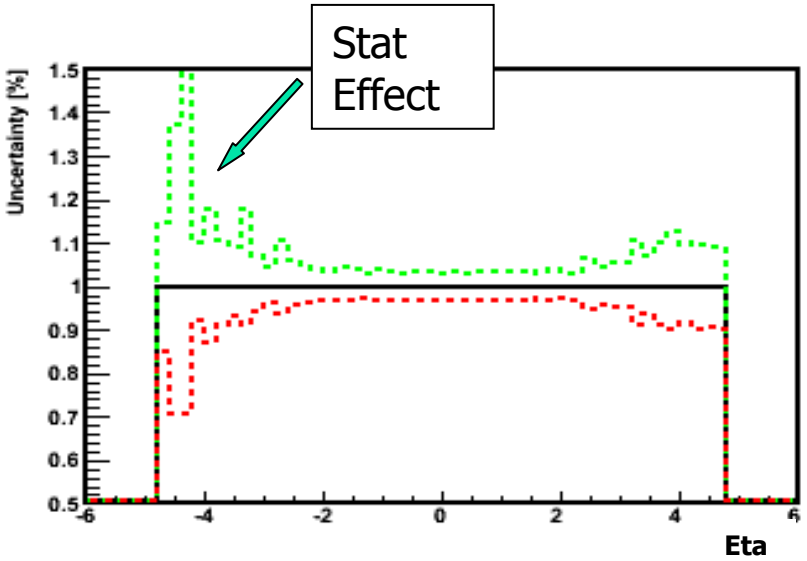


PDF Uncert: Jets at Det.

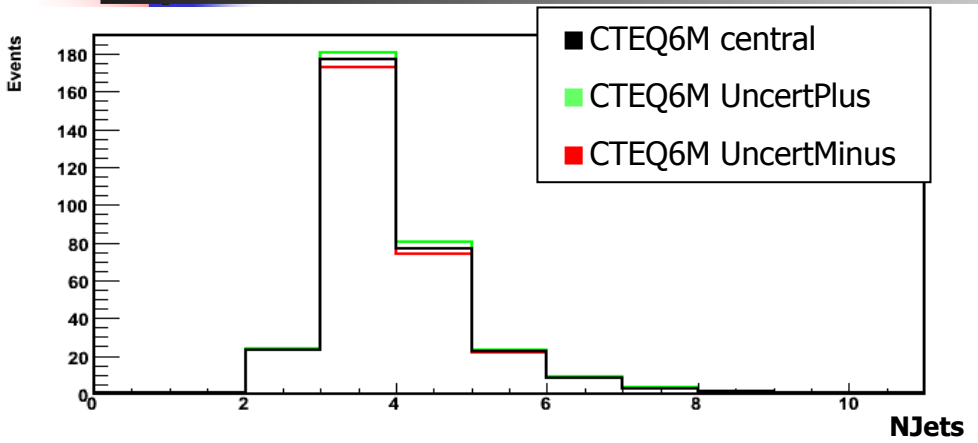


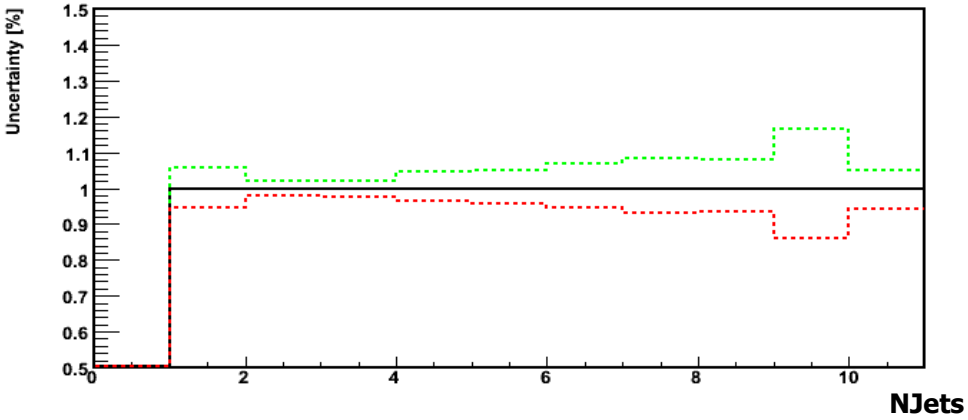






PDF Uncert. on Jet multiplicity





Njets	1	2	3	4	5	6	7	8	9	10
PDF Unc(%)	5-6	2	3	4-5	4-5	5-7	7-8	7-8	15-17	5-6

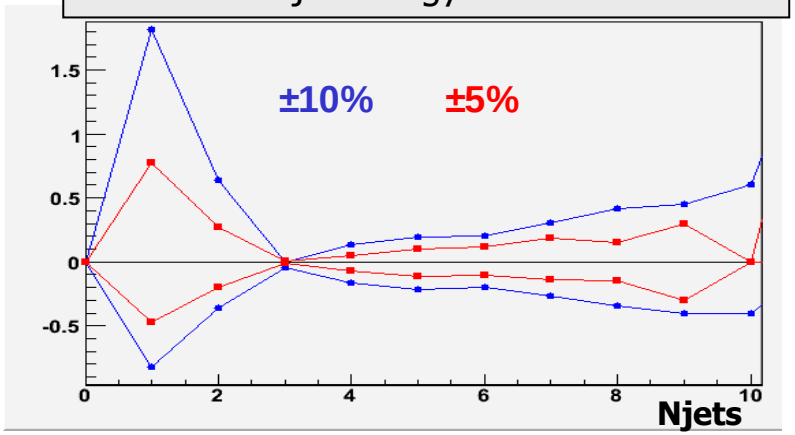
Uncertainty on cross section depends on jet multiplicity:

- PDF uncert below 10%, except for Njets=9 (15-17%)

Compare with Jet Energy Scale uncertainty (results from Alessandro Tricoli, ATLAS CSC Note W/Z + Jets, 14th February 2007)

- **can be much higher than 20%**

Cross Section Uncertainty
With 5-10% jet energy miscalibration



Conclusions

- Tested Reweighting technique on CTEQ6L and MRST2001nlo
  - accurate to 1% on average in central kinematic regions (except for electron Et)
  - affected by statistical effects at edge of kinematic regions
  - Effect of parton shower not significant

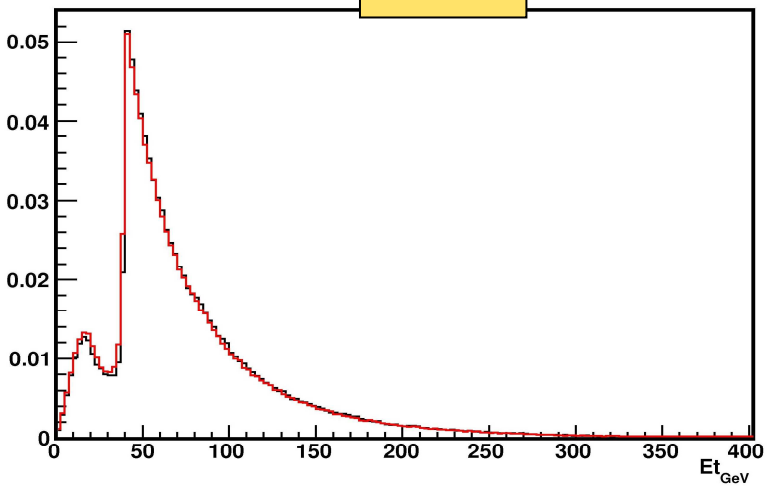
  Pretty good considering that we are reweighting from LO to NLO!

- Evaluated PDF Uncertainties on SUSY sample of W+jets (tight filter cuts)
  - Weighted CTEQ6L→CTEQ6M central + 40 error sets
  - PDF Uncertainties of the order of 5% at low Et and central η region
  - Increases above 10% at high Et and edges of η region
  - PDF Unc. on Jet multiplicity is less than 10% (except for Njets=9), lower than jet energy scale uncertainty

- Further Studies
  - Investigate uncertainties on Cumulative Jet Multiplicity
  - Compare PDF uncertainties with experimental systematic uncertainties
  - Same studies on SM sample of W+jets (should be available soon)

Extras: PDF Reweighting (Electrons)

Et



Eta