Frank Chlebana
Apr 29 2004

QCD Jet Results

- Dataset
- Using the MC to Correct the Data
- DiJet Mass Distribution (206 pb^{-1})

Rob Harris

- Inclusive Jet Cross Section (210 pb^{-1})

Gene Flanagan

- Inclusive b-jet production (150 pb^{-1}) CDFNOTE 6984

Monica D'Onofrio

- $b\bar{b}$ jet production (32 pb^{-1}) CDFNOTE 6985

Anant Gajjar, Ronan McNulty, Andrew Mehta, Tara Shears

Dataset

Vertex problem in data processed with 5.1.0 ("C" dataset) has a measurable effect on the E_T distribution.

This problem was fixed in the "D" dataset.

Runs 138815 (2002.02.09) *through* 168889 (2003.09.06) have been reprocessed

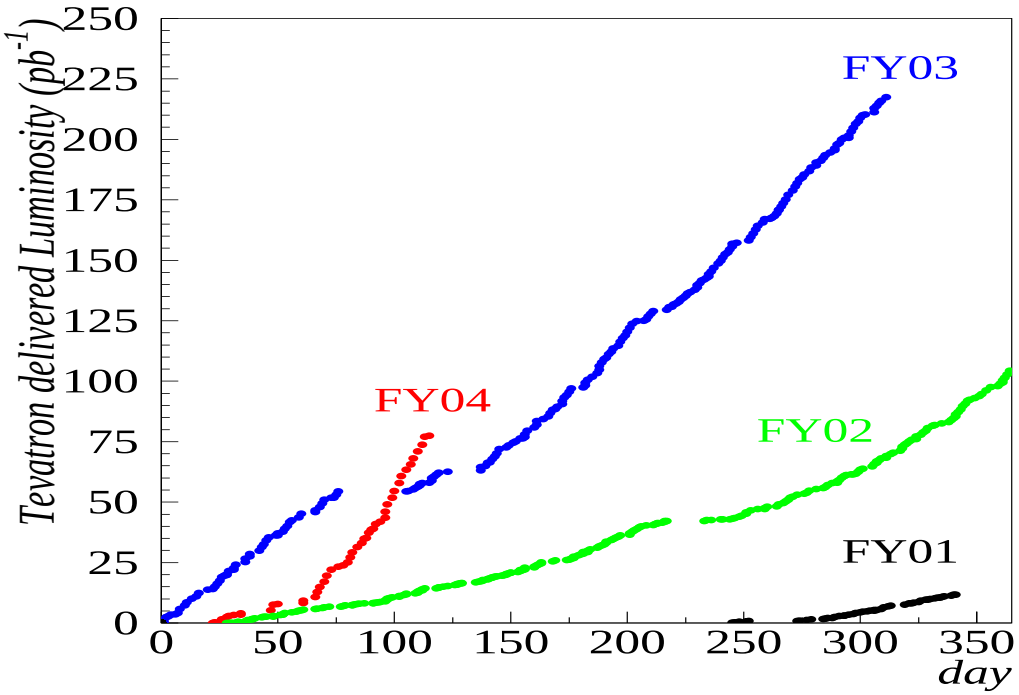
$\rightarrow$ gjt10d, gjt20d, gjt30d, gjt40d datasets processed with offline version 5.3.1.

48 pb^{-1} waiting to be reprocessed after shutdown and before COT studies

Runs 168889 (2003.09.06) *through* 179056 (2004.02.13)

Using the QCD good run list:
Lumi = 208.76 pb

$\sim$ 70 runs were removed because of event count mismatches between ntuple and database, after removing these runs we have:
Lumi = 192.67 pb

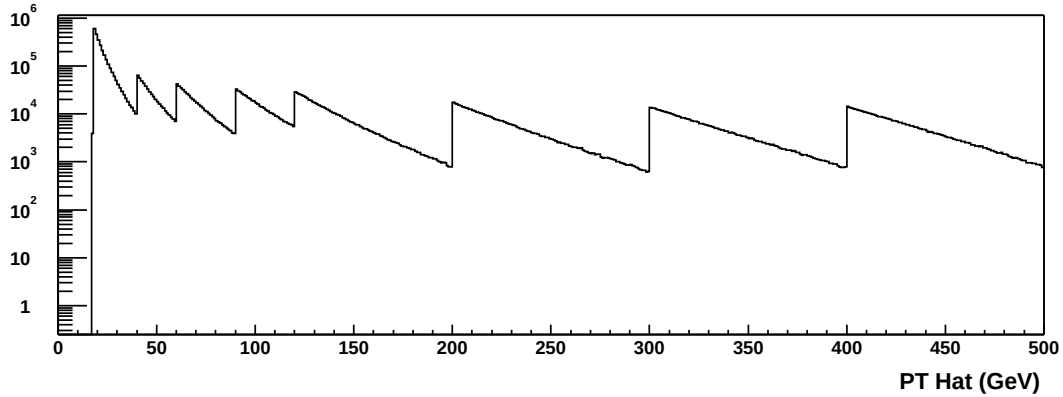


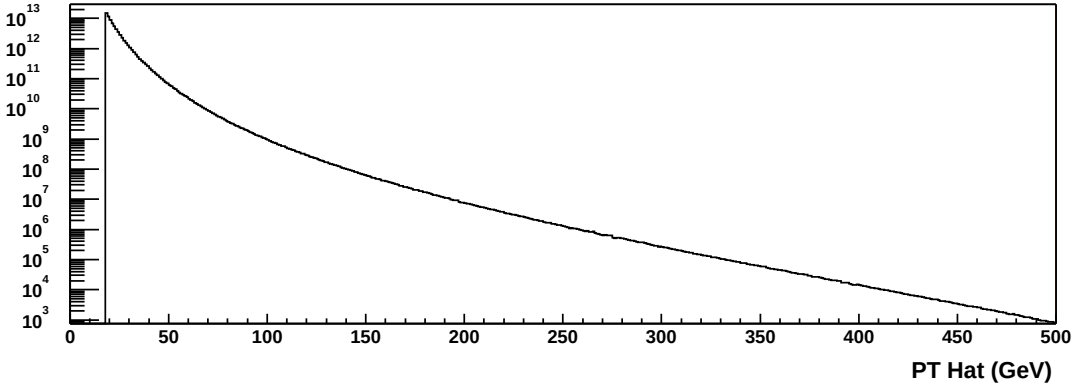
Tevatron can perform well

Collecting data with high efficiency (over 90%).

Already have about 250 pb^{-1} of data on tape
$\rightarrow$ Will use this for our first results. *More than 2$\times$ Run I sample*

MC generated with 4.9.1, Pythia DiJet CTEQ5L



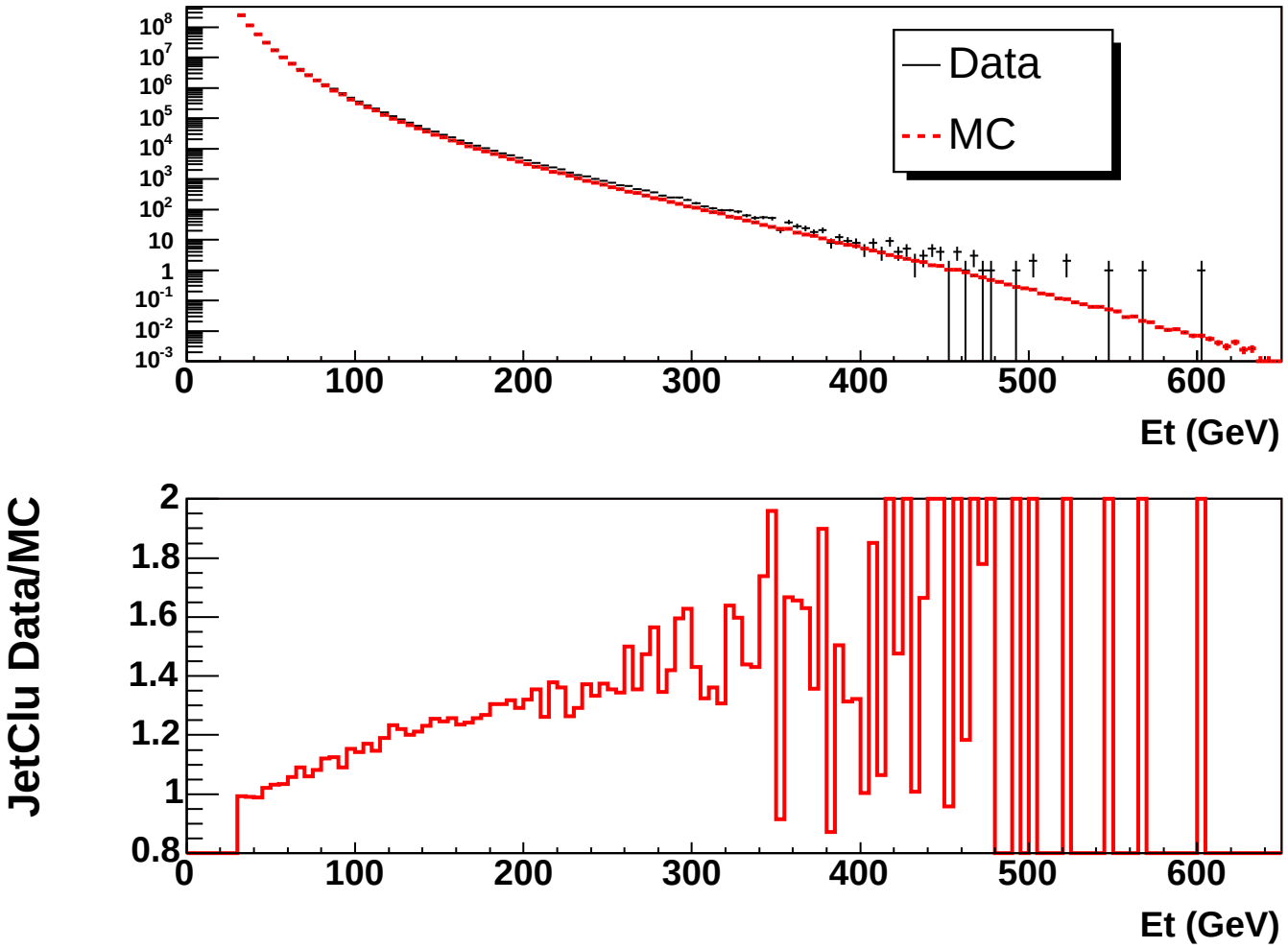


Pt Hat	Events
18	2794437
40	497497
60	462136
90	448709
120	581465
200	479477
300	447021
400	498348

MC samples combined by weighting the event based on the generated PTHat.

The result is a smooth distribution...

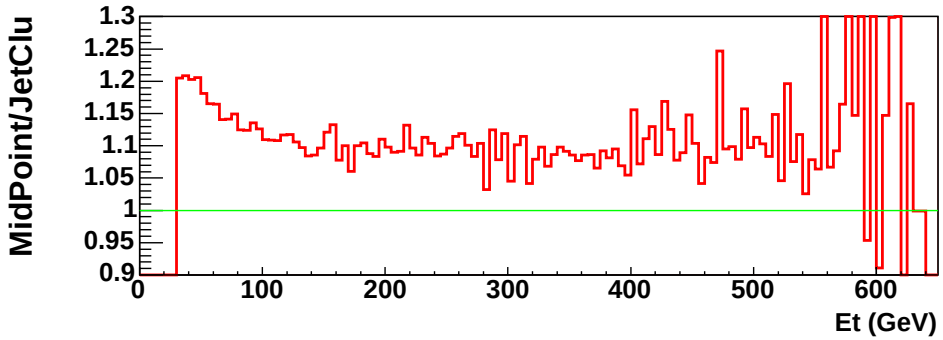
Measured Data Compared with "Measured" MC



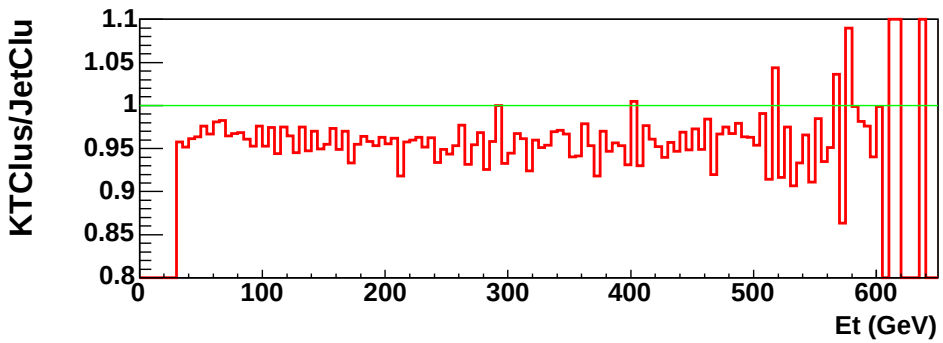
→ *Data rising with increasing* E_T

Results for JetClu

Ratio of the "measured" inclusive jet cross section for KtClus and MidPoint over JetClu.



MidPoint finds more jets at lower E_T.



JetClu, KtClus and MidPoint have the same shape at high E_T

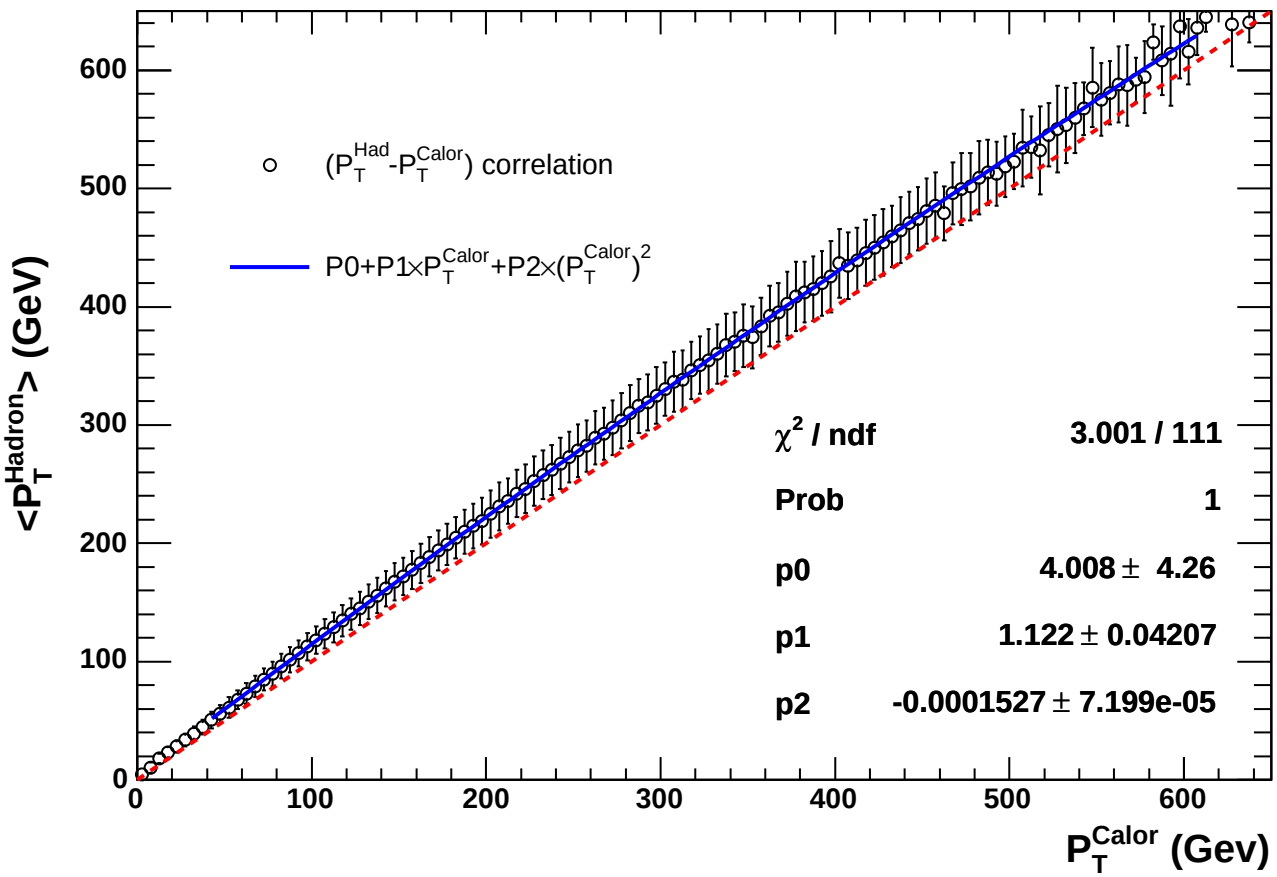
Using the MC to correct the data allows us more flexibility in exploring different jet algorithms and PDFs.

→ Don't need to derive specific corrections for different jet algorithms, cone sizes...

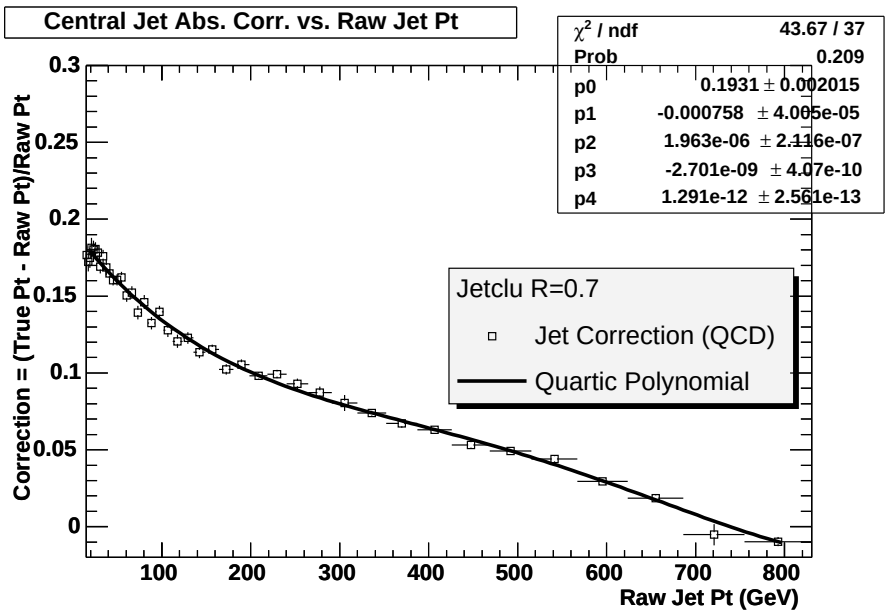
Using the MC to Correct the Data

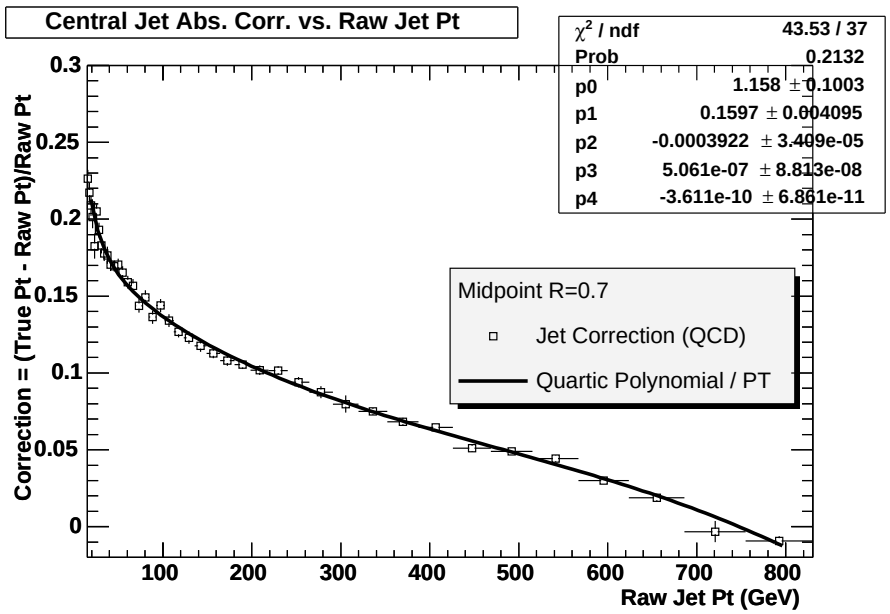
Correction in two steps:

Determine $P_T^{hardon} - P_T^{measured}$ vs $P_T^{measured}$ from the MC



The P_T correction depends on the jet algorithm and also on the MC used (PYTHIA, HERWIG).



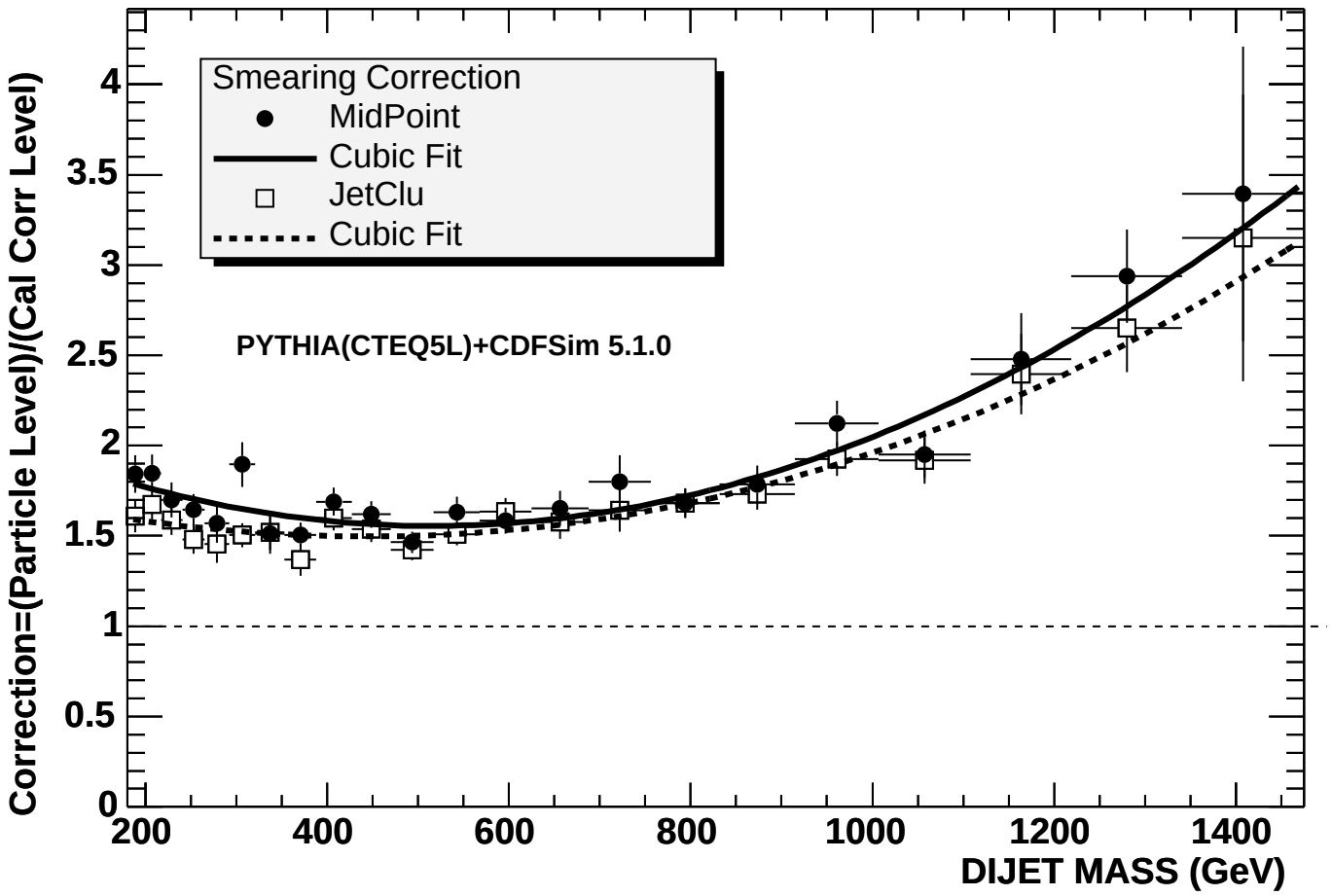


Rob...

After applying the P_T correction we still need to apply a smearing correction.

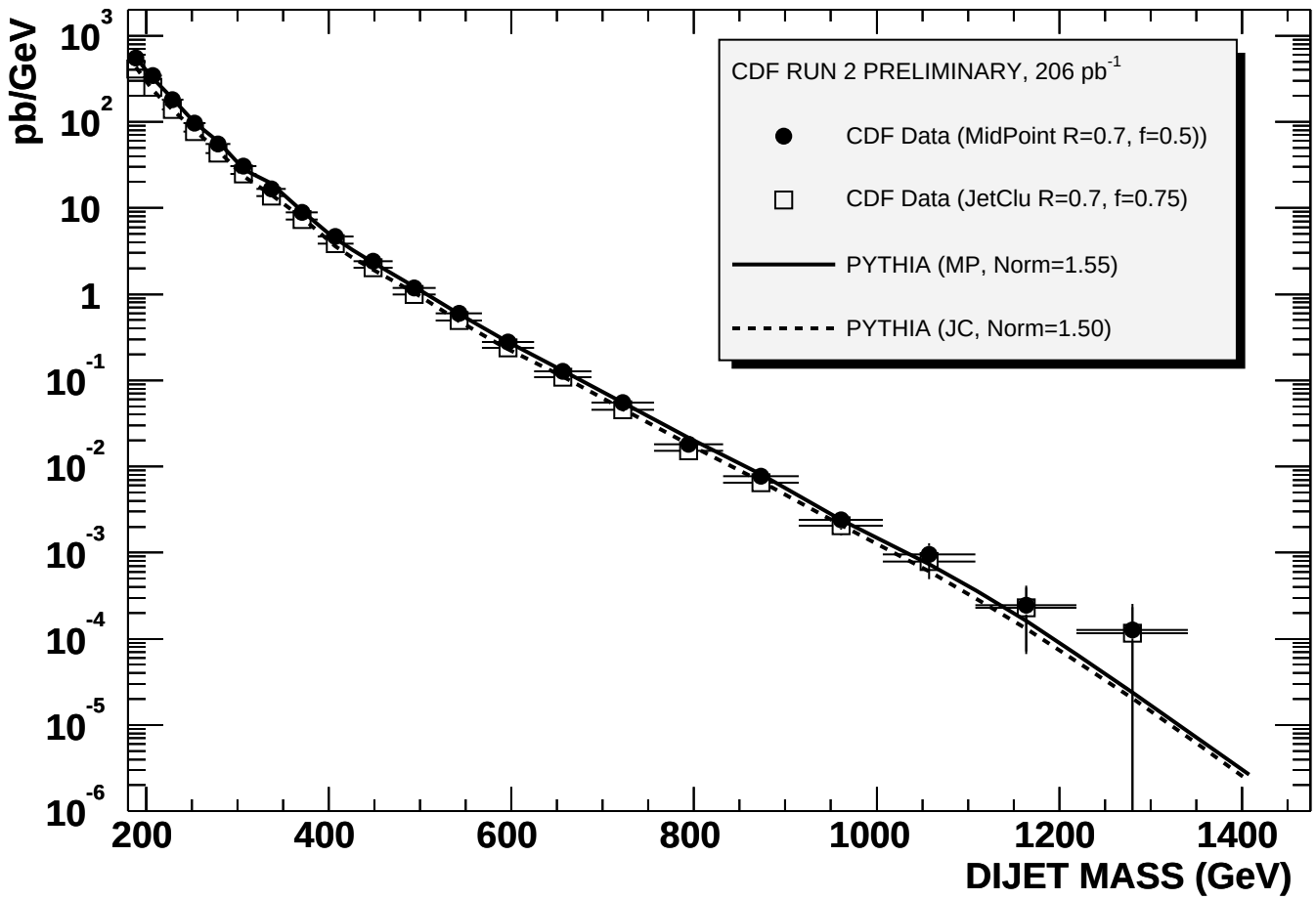
$$\text{Correction} = \frac{\text{Rate at particle level}}{\text{Rate at Corrected Detector Level}}$$

Smearing correction for the DiJet mass distribution determined for both JetClu and MidPoint



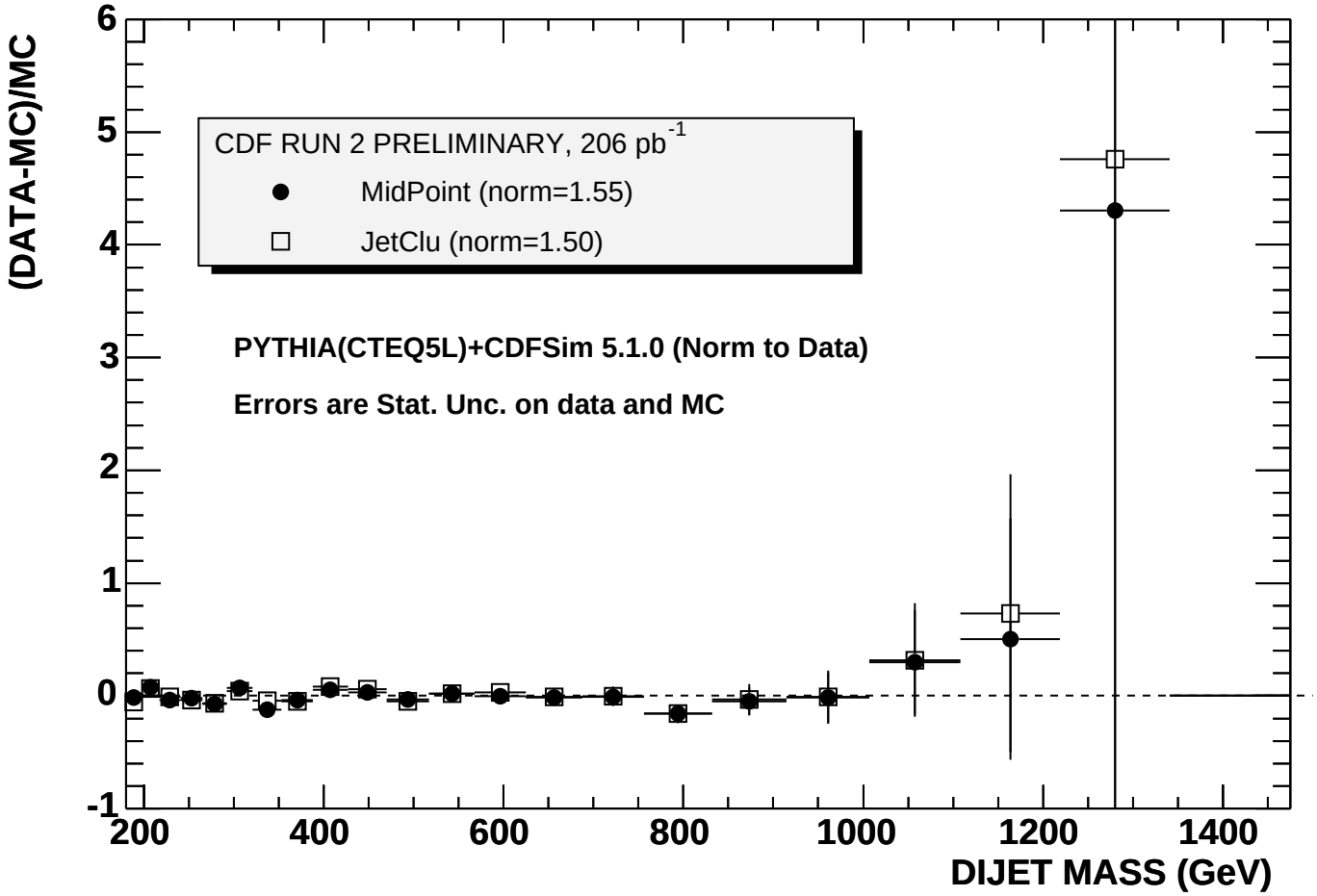
Can reweight the MC to get a better agreement on the "measured" quantities....

Fully Corrected Dijet Mass Distribution Compared with PYTHIA



JetClu and MidPoint results are in good agreement

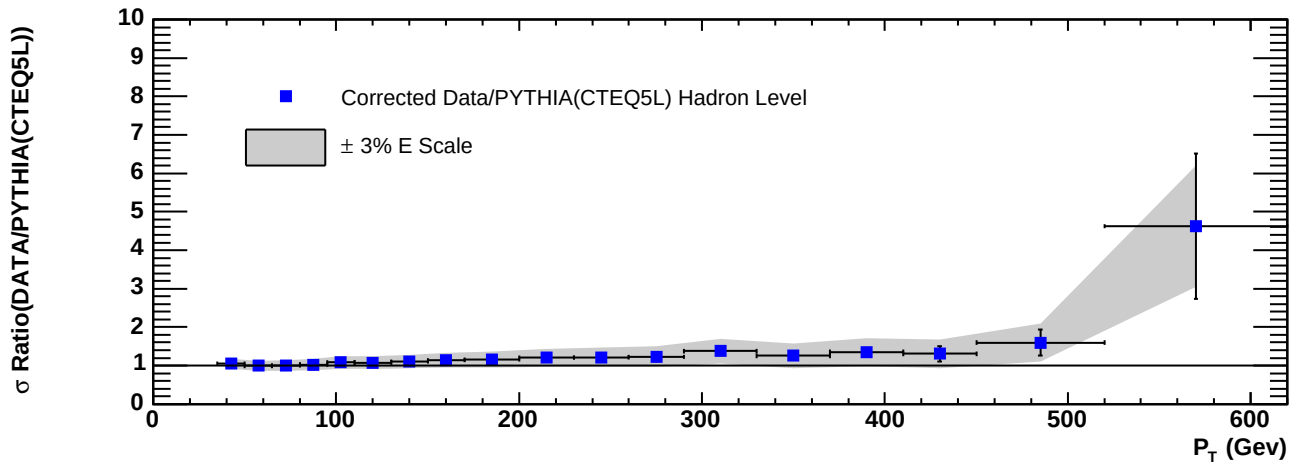
DiJet Mass Distribution is smooth and agrees with QCD

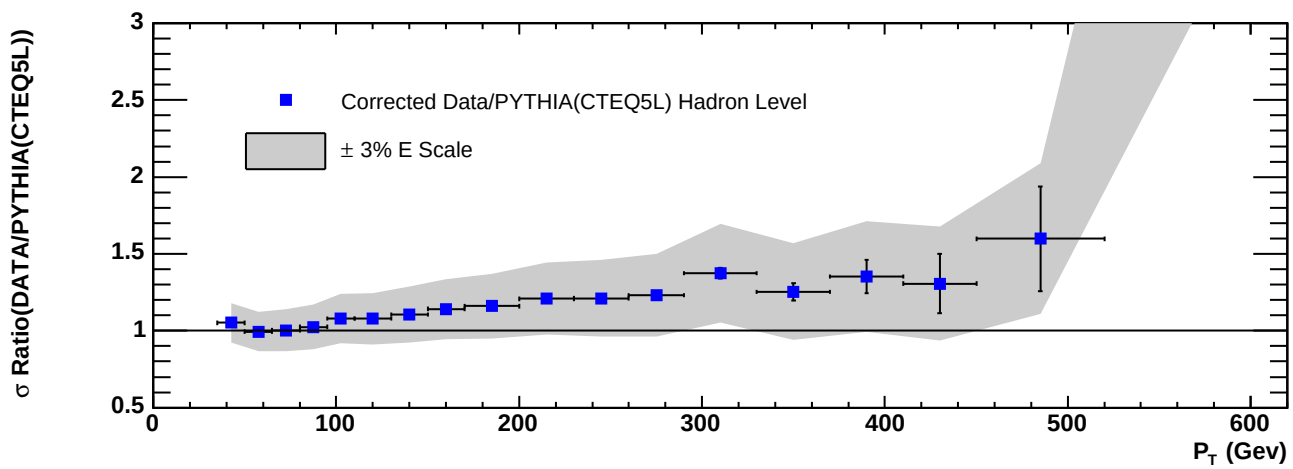


Previous results used a correction that was not smooth resulting in "bumps".

Inclusive Jet Cross Section (MidPoint)

Apply same technique to correct the data.

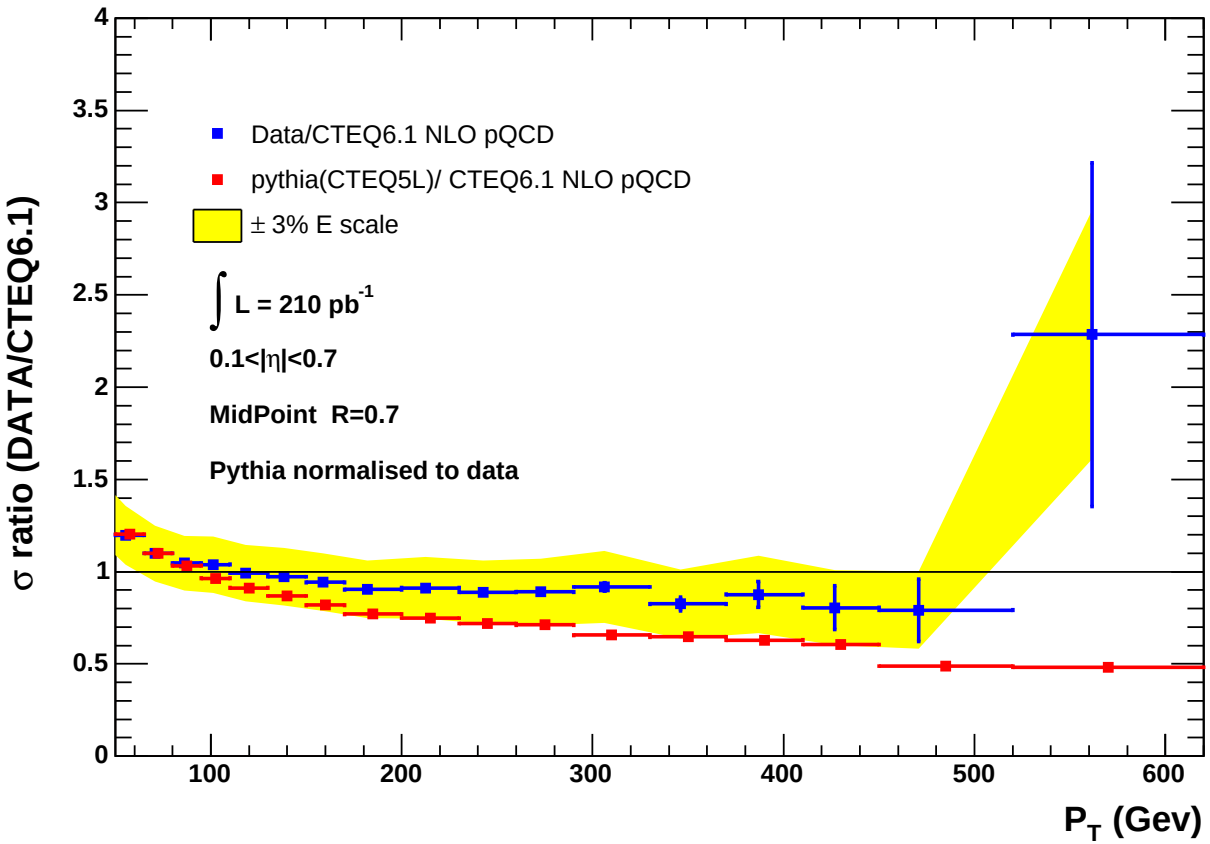




Gene...

Data compared to PYTHIA using the MidPoint jet algorithm

Data corrected to the hadron level compared to NLO calculation



Gene...

Rise at low E_T...

Want to present results that can be used outside of CDF, still need correction to go from the hadron $\rightarrow$ parton level.

See Regis' talk for more details

What is missing...

Easy comparisons to NLO calculations.

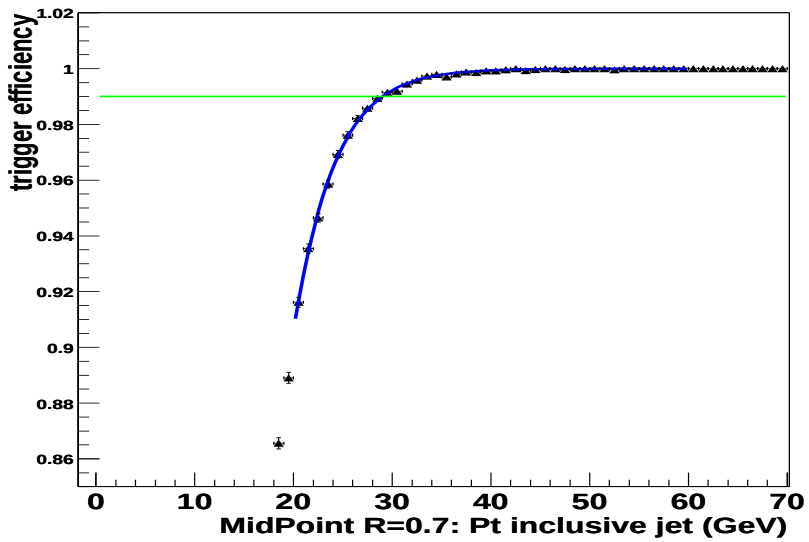
Ellis, Kunszt and Soper Jet Programs (EKS)
"We also provide some explanation, but we must admit that the programs are not designed to be user friendly."

Jetrad
Need to add different jet algorithms...

Would like to have a well defined interface that allows one to easily change PDFs, Jet algorithms, Jet settings such as RSep, D... scales...

Work is in progress at interfacing new PDFs and jet algorithms to jetrad.

Extending Measurements to Lower E_T



The Single Tower 5 (ST5) trigger will allow us to extend measurements to lower E_T.

Allows use to have high efficiency down to $E_T = 30$ GeV

Monica...

But why stop there?

Have the capability to explore the transition to perturbative QCD

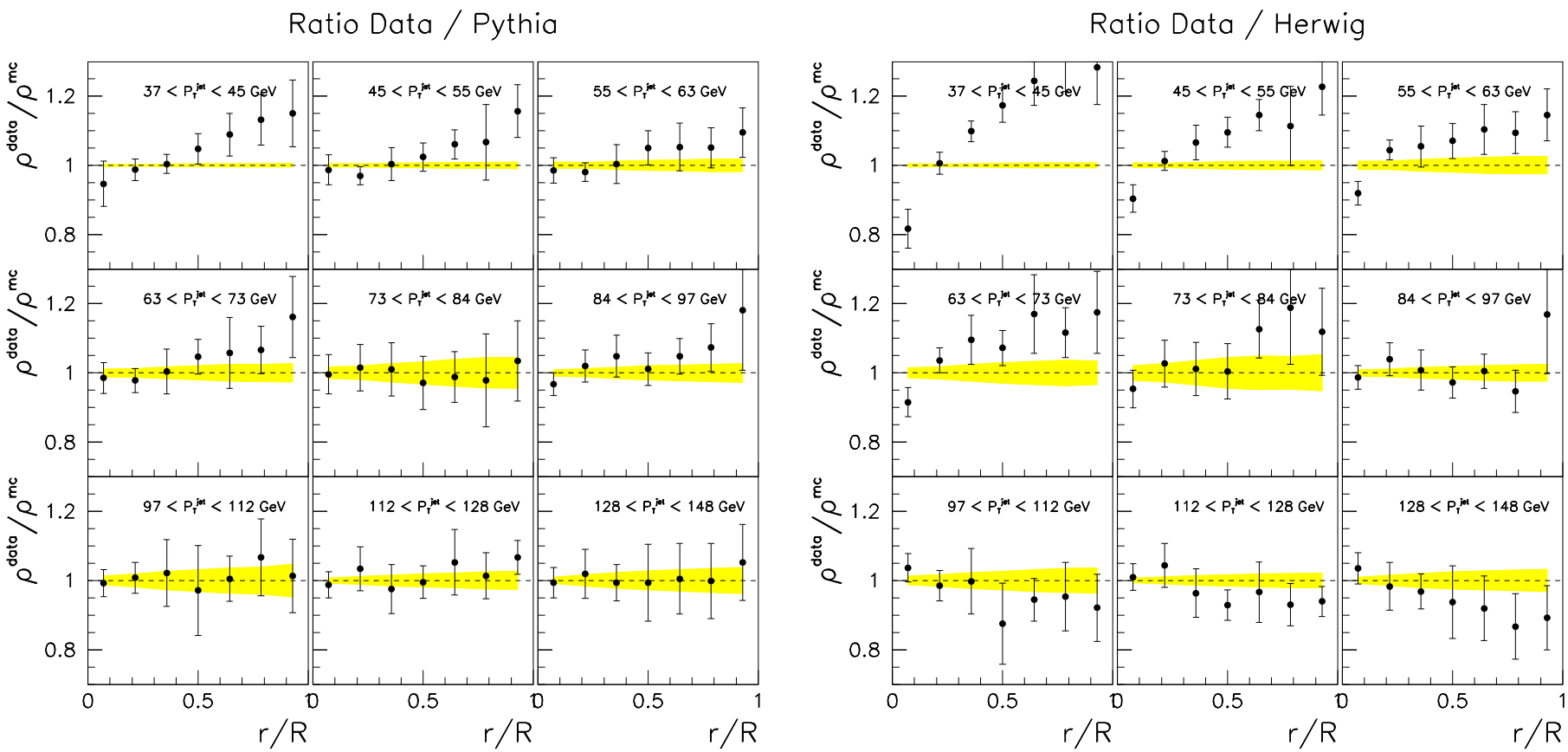
→*Special runs....*

→*New Triggers...*

→*Detailed understanding of the trigger efficiency*

ST5 trigger allows use to reach as low as 30 GeV

$\rightarrow$ Need to understand how good the simulation is at low E_T



Mario...

From jet shape studies it looks like jets in PYTHIA are well described for $p_T > 70 GeV$

Inclusive b-jet Cross Section

Positive tagged secondary vertex using 2D SecVtx

Using the MidPoint (cone = 0.7) jet clustering algorithm

Central jets $0.1 < |\eta| < 0.7$

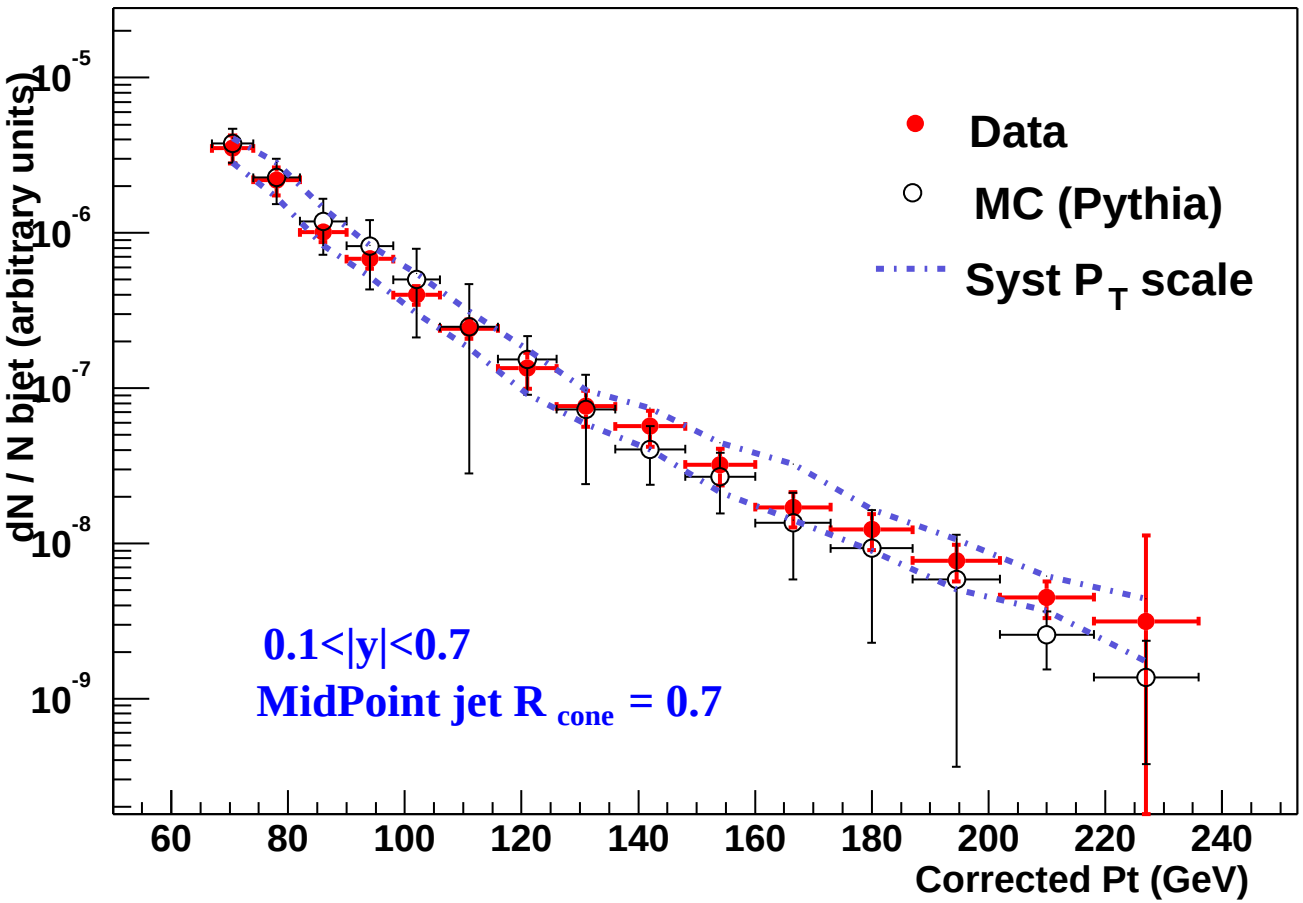
Require one good (VClass $\geq$ 12) primary vertex

$|z| < 60$ cm

ST5, J20, J50, J70, J100 ("C" dataset. Runs with vertex problem are removed)

Pythia Tune A used for jet corrections (same method as other analyses)

Corrected b-jet dN/N Distribution



Monica...

Result for APS

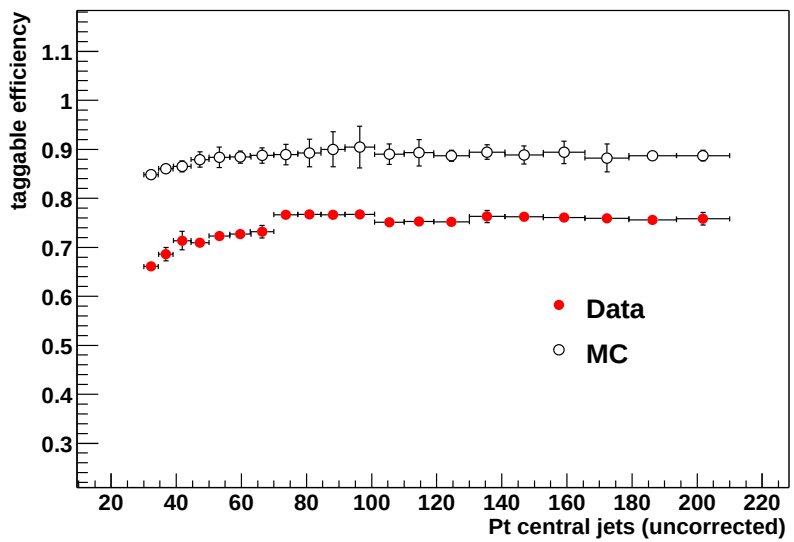
For now only show results for $p_T > 70$ GeV

Inclusive b-jet Cross Section

$$\sigma_i \text{bjet} = \frac{N_{tagged} \cdot f_b}{\epsilon_{btag} \cdot \epsilon_{taggable} \cdot \Delta\eta \cdot \Delta P_T^i \cdot \mathcal{L}}$$

N_{tagged}	Number of tagged jets using SecVtx
f_b	Fraction of b's among tagged jets
ϵ_{btag}	B tagging efficiency, probability that a b-jet is tagged ($N_{bjettagged}/N_{bjet}$)
$\epsilon_{taggable}$	Taggable efficiency, probability to find a jet with at least two good tracks
$\Delta\eta$	Rapidity range = 1.2
ΔP_T^i	Bin in transverse momentum
$\mathcal{L}$	Integrated luminosity

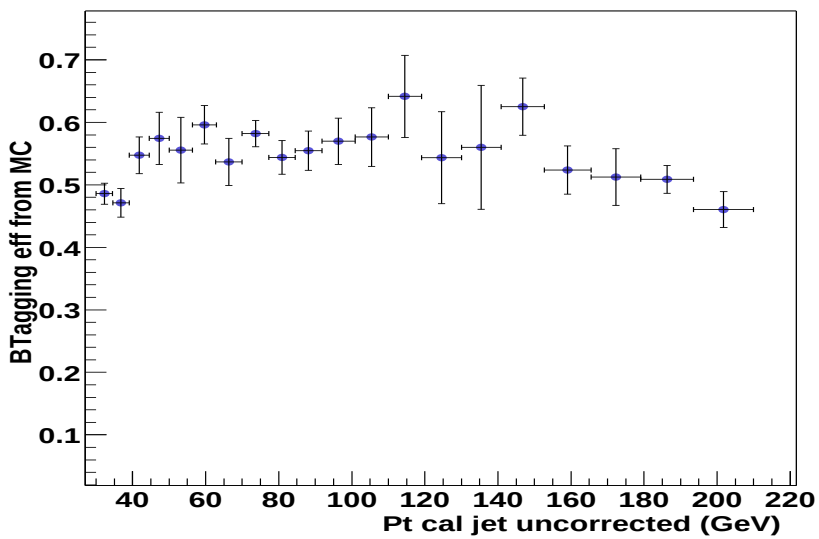
Tagging Efficiency



Taggable efficiency, $\epsilon_{taggable}$, Probability to find a jet with at least two good tracks

Data and MC have different efficiencies.

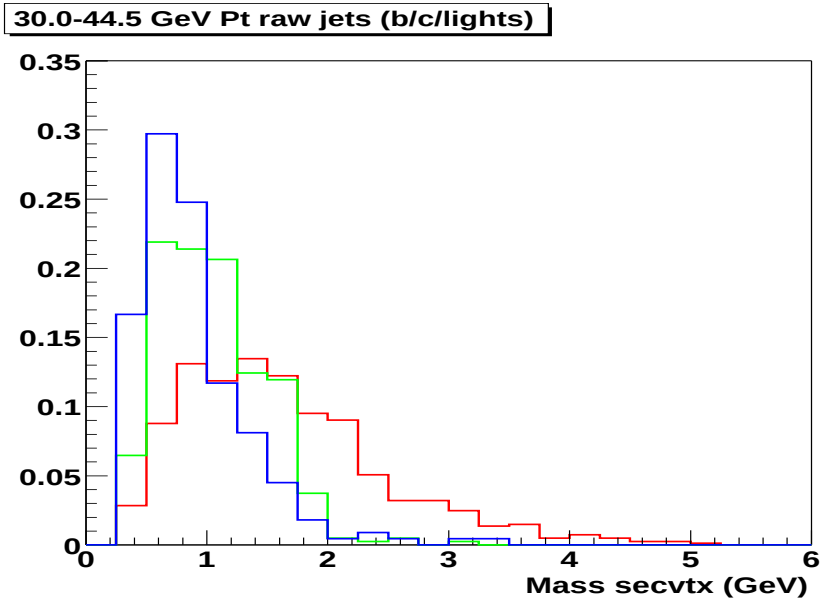
F(Data/MC) = 0.83 ± 0.03



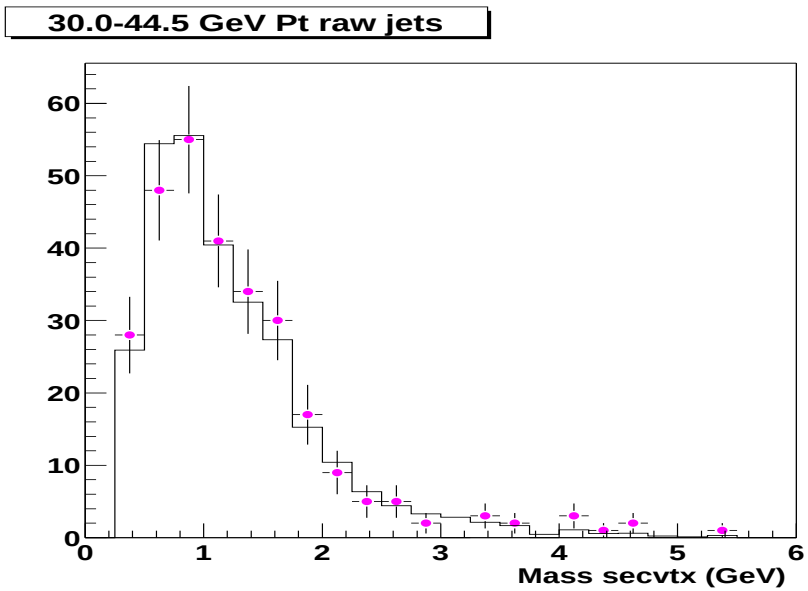
B Tagging efficiency, probability that a b-jet is tagged

$$\epsilon_{btag} = \frac{N_{\text{bjettagged}}}{N_{\text{bjet}}}$$

MC Templates used to determine the B fraction



B fraction determined from the MC using the secondary vertex mass as a discriminant.

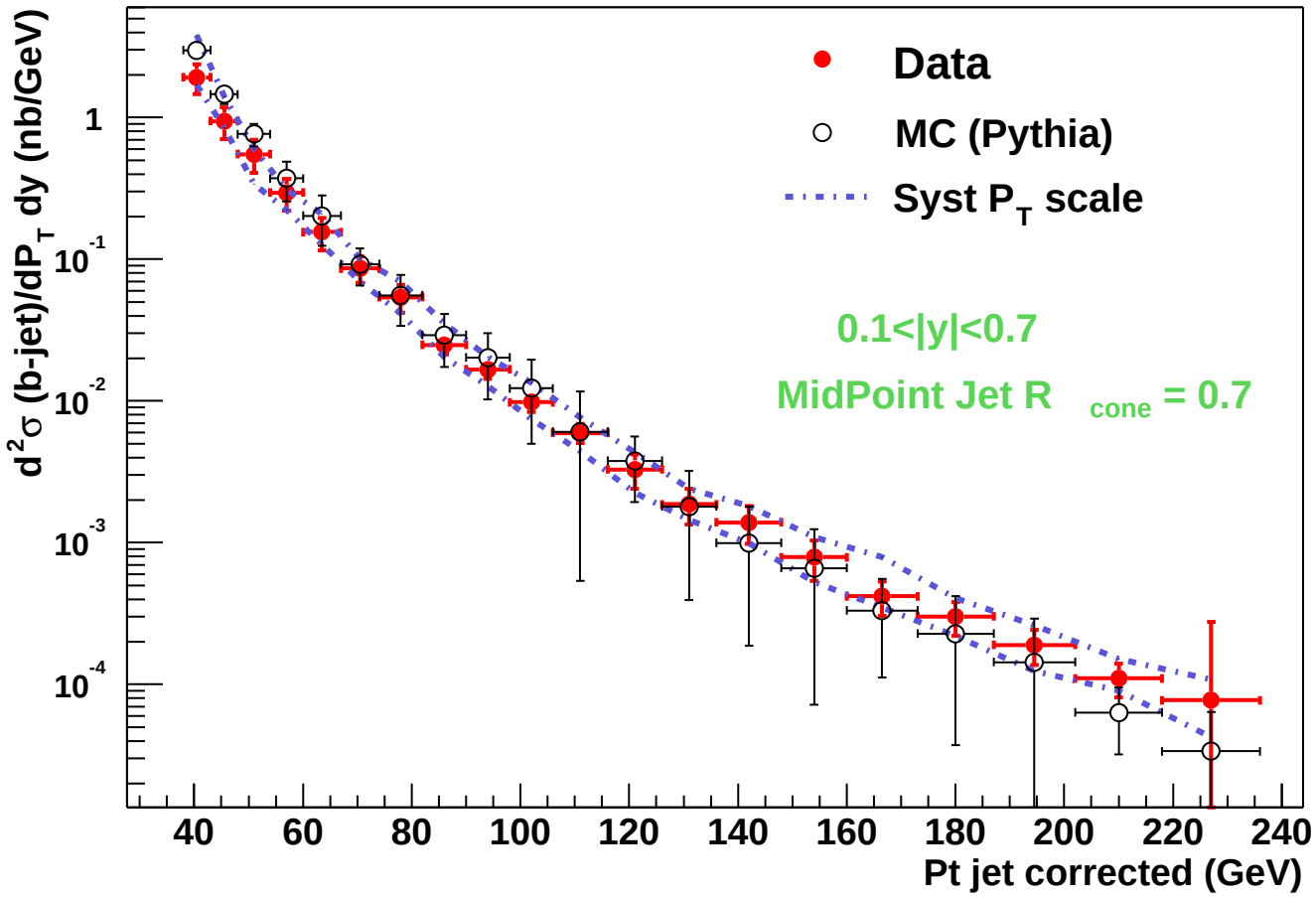


B Fraction Fits Result

Need to combine bins due to limited MC statistics

Effect of different tagging efficiencies in the Data and MC not included

Corrected b-jet Differential Cross-Section



Measured p_T range 30 - 210 GeV

$b\bar{b}$ Jet Production Cross Section

Event Selection

Two positively tagged 2D SecVtx jets within $|\eta| < 1.2$

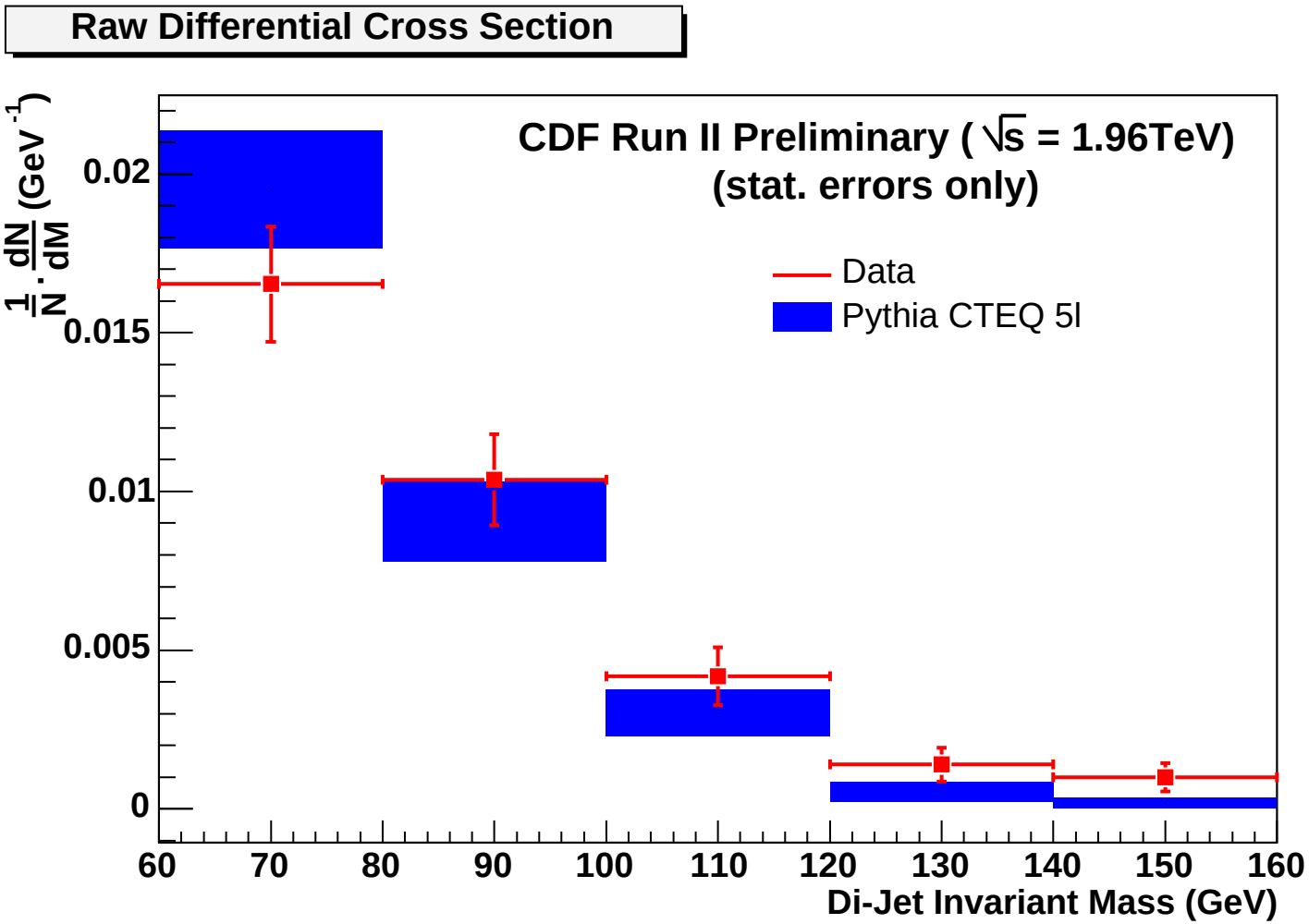
Lead jet with corrected $E_T > 30$ GeV

Second jet with raw $E_T > 10$ GeV

JetClu (cone = 0.7)

Corrections from JetUser V491_HPT1_26MAR03

$b\bar{b}$ Jet Rate



Anant...

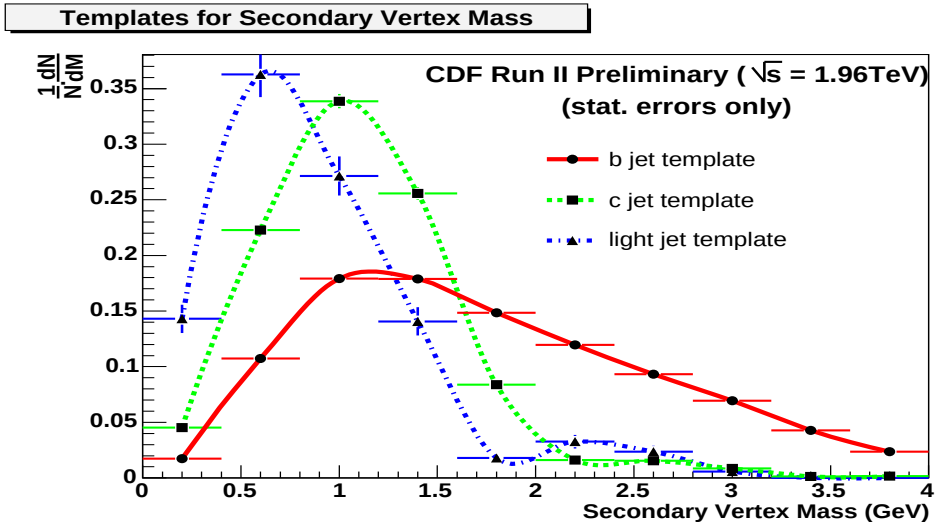
Result for APS

To go from Jet Rate to Cross Section:

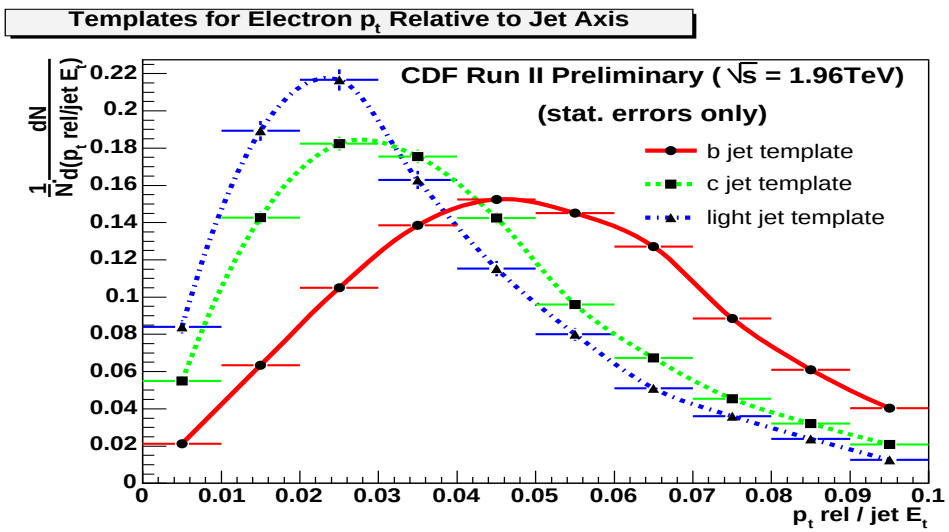
$$\sigma_{b\bar{b}} = \frac{N \cdot p}{\epsilon_b^2 \cdot \epsilon_{jet} \cdot \epsilon_{trig} \cdot \mathcal{L}}$$

N	Number of tagged events using 2D SecVtx
p	Purity
ϵ_b	B tagging efficiency (require two tagged jets)
ϵ_{jet}	Jet reconstruction efficiency determined from the MC
$\mathcal{L}$	Integrated Luminosity

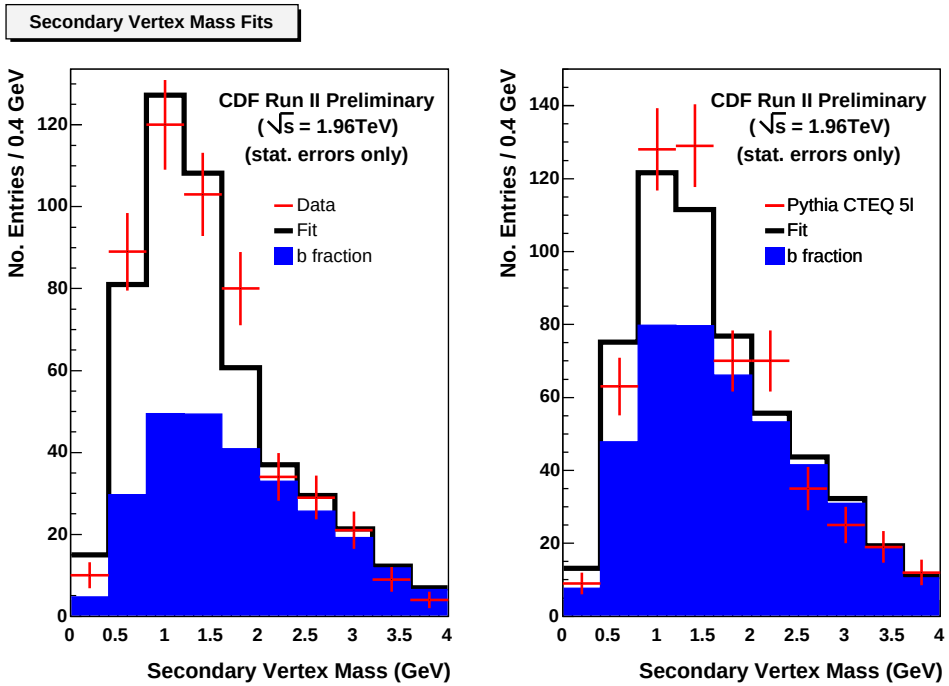
MC templates used to determine purity and B tagging efficiency



Invariant mass of tracks associated with the secondary vertex.



Transverse momentum of electron in a jet relative to the jet axis, p_T^{rel}



Purity determined from a fit to the mass spectrum from particles associated with the secondary vertex

Purity $= 0.55 \pm 0.06\%$

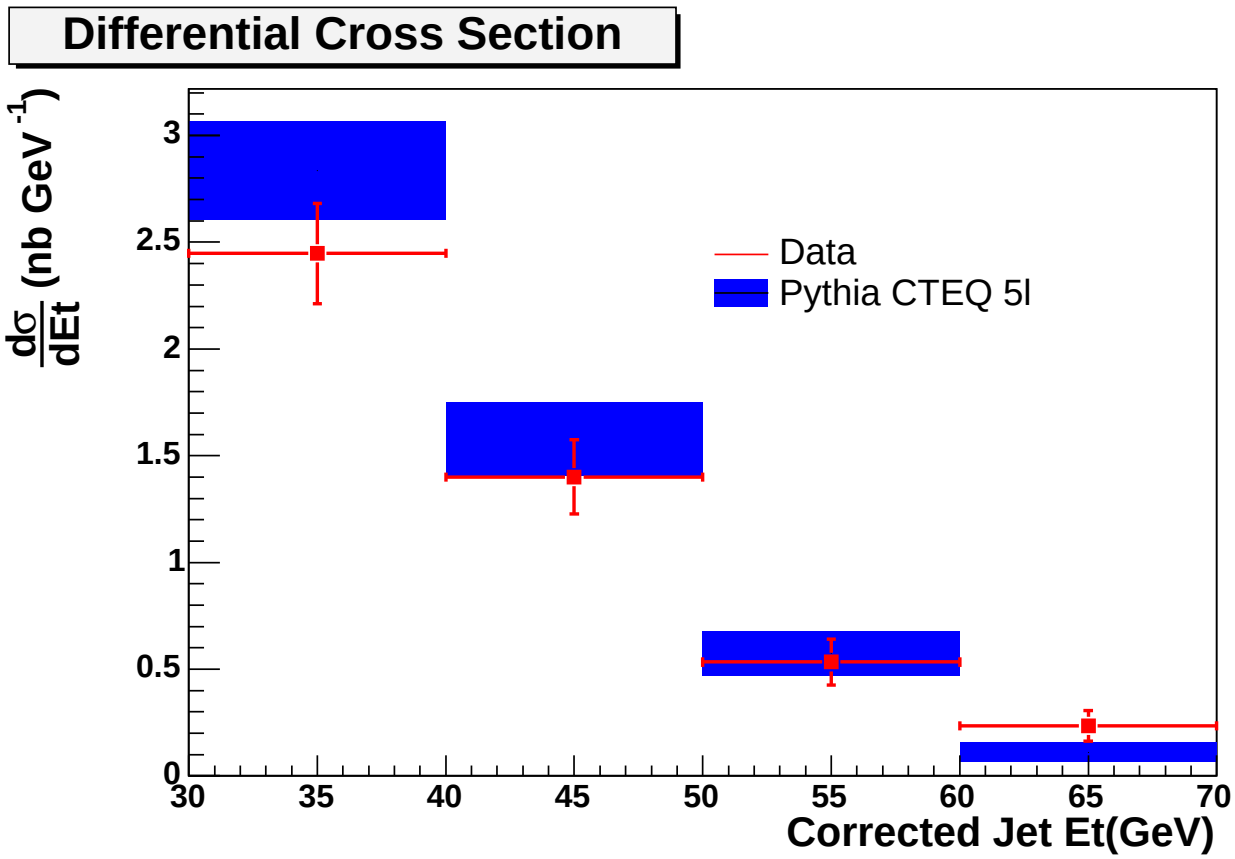
Vary combinations of b, c and light used in the template spectrum to estimate the systematic uncertainty on the SecVtx b tagging efficiency.

Systematic Uncertainty on $\epsilon_b = 13.5\%$

Total production cross section:

$$\sigma_{b\bar{b}} = 54.1 \pm 5.6 \; ^{+13.8}_{-15.2} \text{ nb}$$

Differential Inclusive $b\bar{b}$ Jet Production Cross Section



Conclusions

Several independent analyses are underway which helps keep the momentum and provides important cross checks

Results are mature and ready to show at APS. For now show raw distributions in regions that are well understood

Still some work to get to publishable results...

Using data collected up to the start of the COT studies (250 pb^{-1})
$\rightarrow$ Our dataset is *already* on tape...

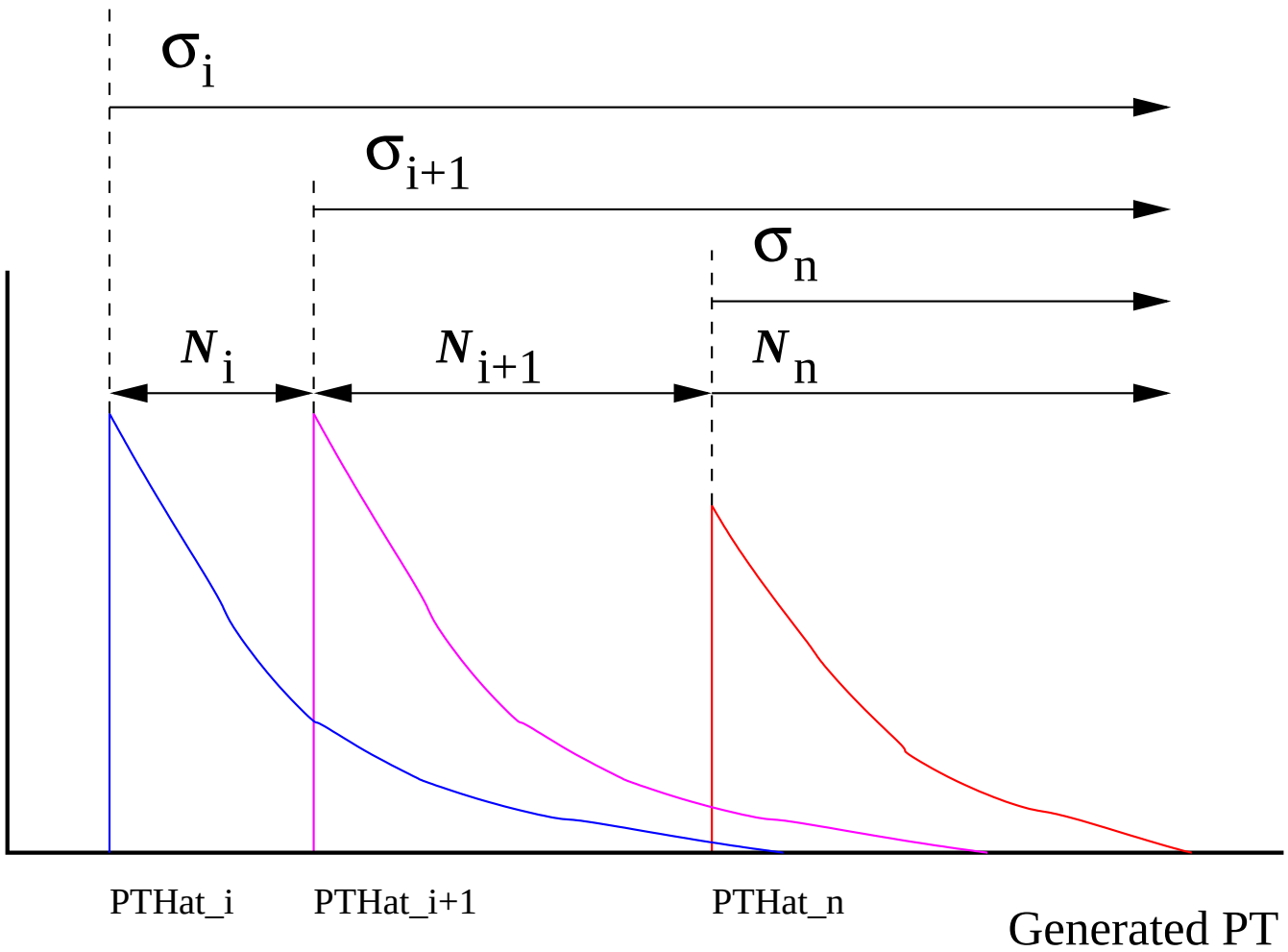
On track to have "final" results on the time scale of the end of the year

Using the MC to correct the data provides greater flexibility in comparing different jet algorithms, PDFs...

Now using Run II Jet algorithms (MidPoint, KtClus...

Additional Slides

Combining the MC samples...

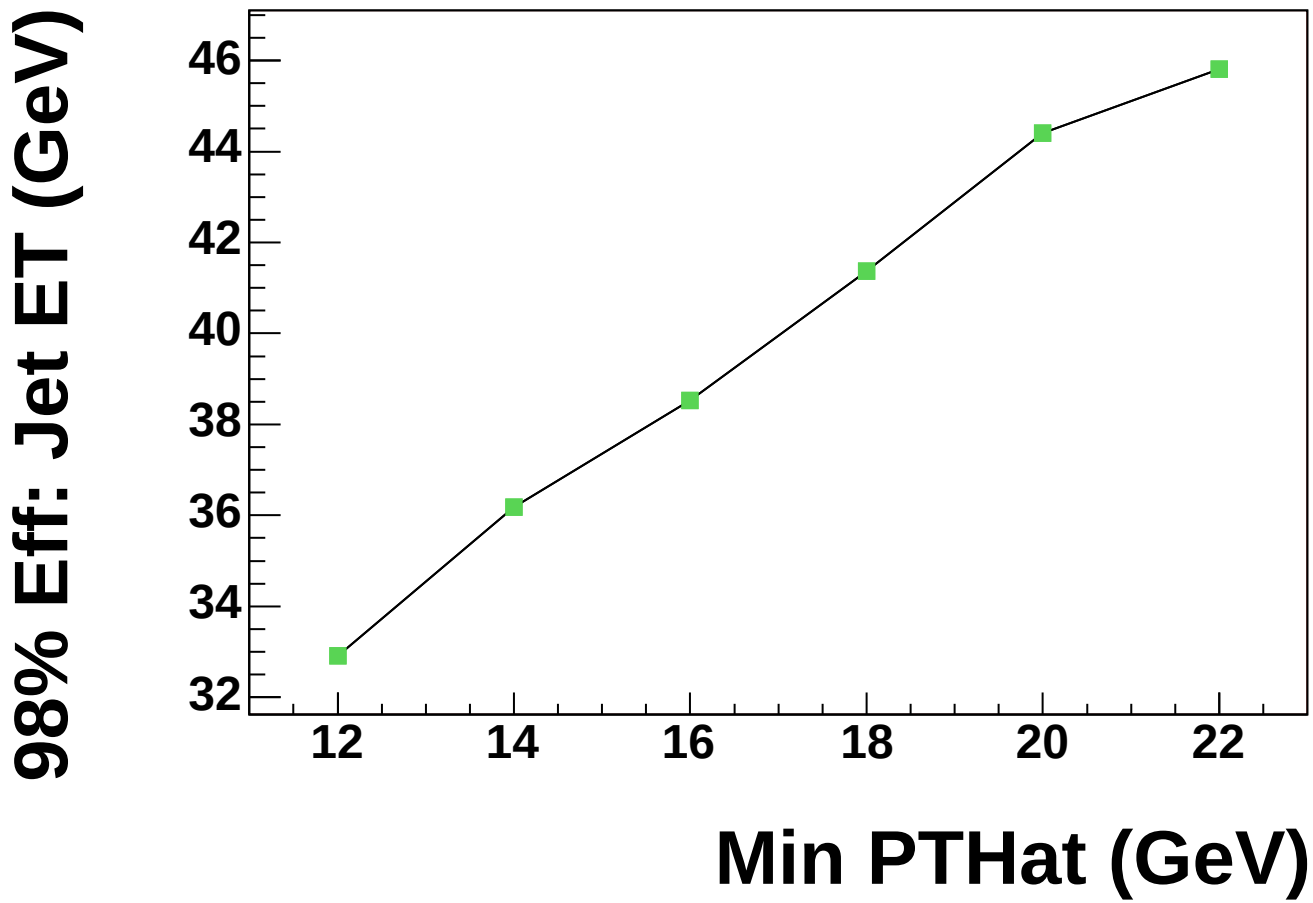


If $PTHat$ is between $PTHat_i$ and $PTHat_{i+1}$

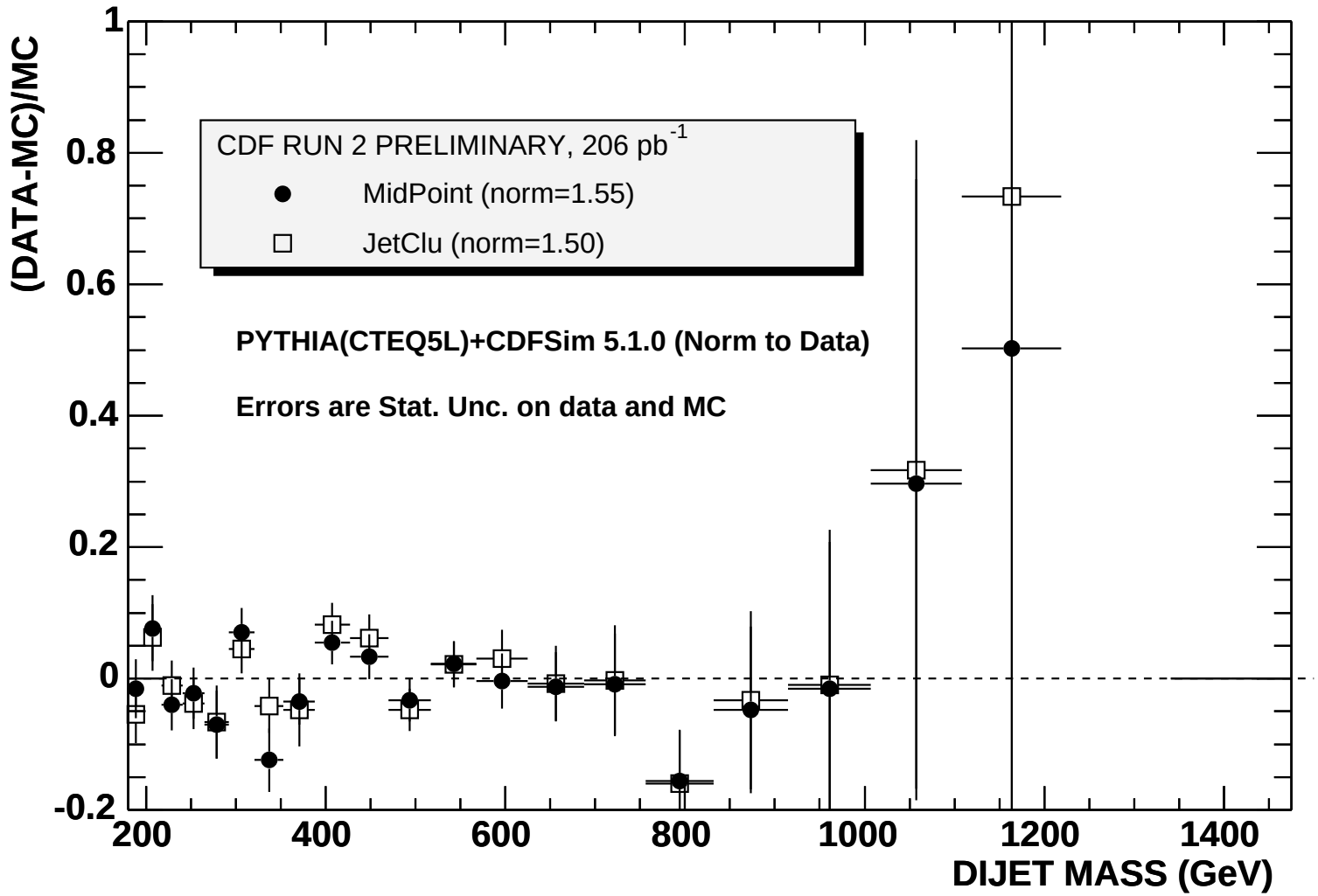
$wt_i = (N_n/\sigma_n) \times (\sigma_i - \sigma_{i+1})/N_i$

How low in PtHat do we have to generate events?

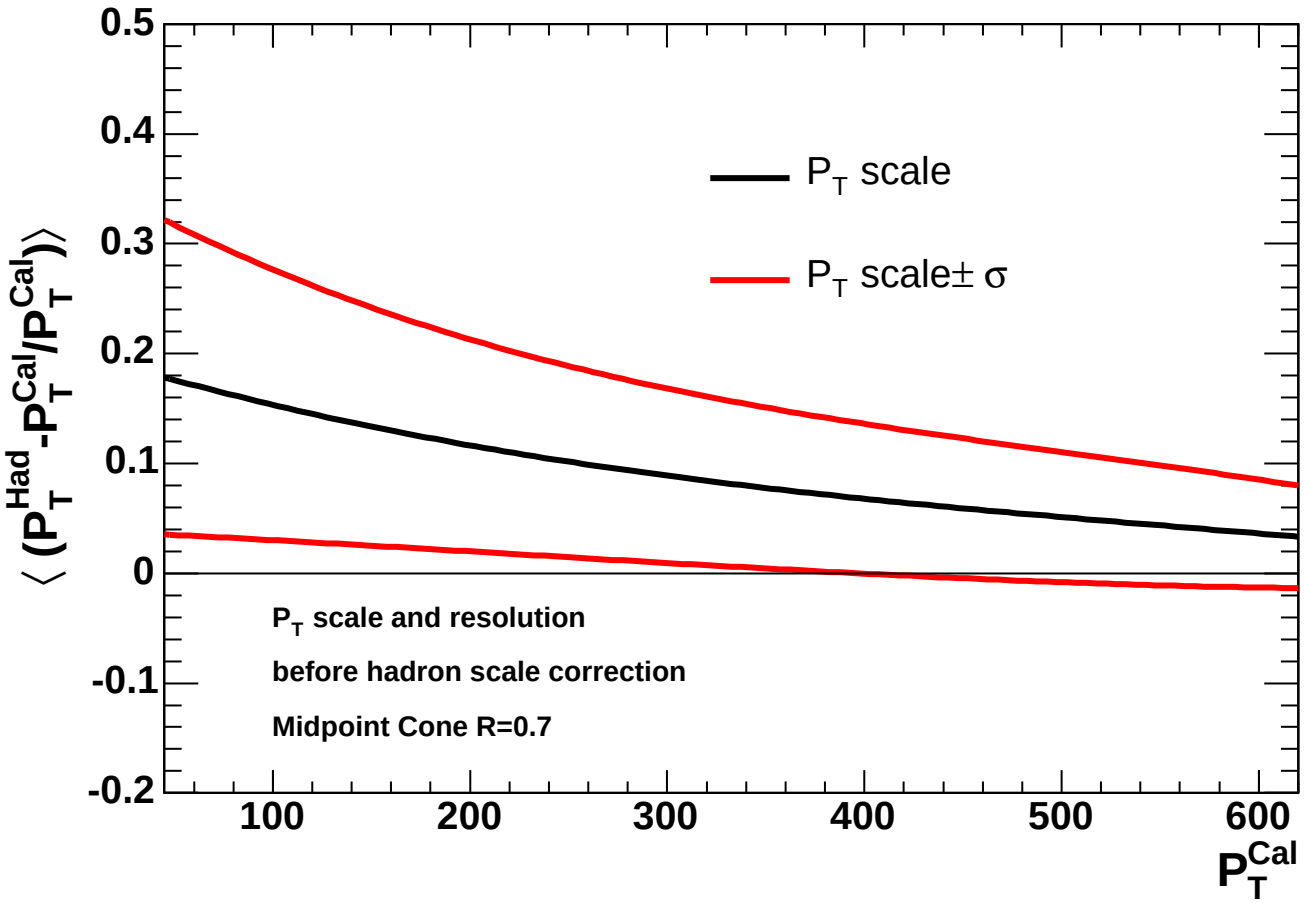
Plotted the Inclusive jet ET for 98% efficiency.



Require $E_T > 45$ GeV when using PTHat > 18 GeV


CDF RUN 2 PRELIMINARY, 206 pb^{-1}
MidPoint (norm=1.55)
JetClu (norm=1.50)
PYTHIA(CTEQ5L)+CDFSim 5.1.0 (Norm to Data)
Errors are Stat. Unc. on data and MC
(DATA-MC)/MC
DIJET MASS (GeV)
1
0.8
0.6
0.4
0.2
0
-0.2
200
400
600
800
1000
1200
1400

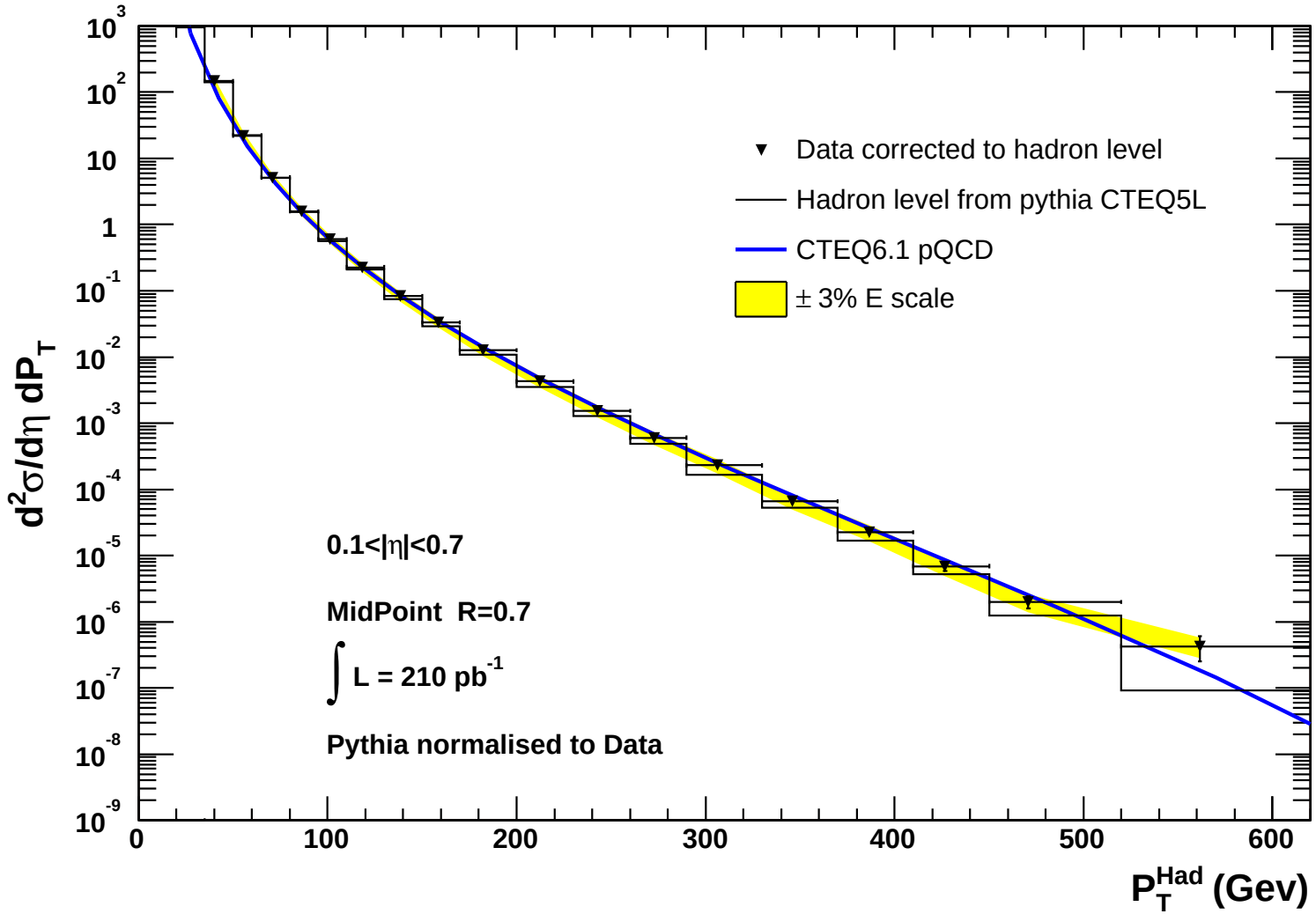
Jet Resolutions



Jet resolution varies from 10% at low E_T to 4% at high E_T.

Jet E_T is shifted by 14% at low E_T to about 3% at high E_T.

Bin sizes selected according to resolution.


Data corrected to hadron level
Hadron level from pythia CTEQ5L
CTEQ6.1 pQCD
± 3% E scale
0.1<|η|<0.7
MidPoint R=0.7
∫ L = 210 pb-1
Pythia normalised to Data
d2σ/dη dPT
PTHad (Gev)
10-9
10-8
10-7
10-6
10-5
10-4
10-3
10-2
10-1
1
10
102
103
0
100
200
300
400
500
600