# PYTHIA-vs-HERWIG for Top Mass

Are jets better measured by PYTHIA or HERWIG?

Jet Shapes from Mario's analysis

Jet correction studies:

- Use $\gamma$-jet balance to check corrections
- Relative correction
- Jet response
- Underlying event
- Out of cone corrections

Summary: can we tell which jets are better?

Is the mass analysis sensitive to t-tbar spin correlations?

# Jet Shapes studies (Mario's)

Most jets in top events are below 150 GeV
Midpoint algorithm used, R=0.7
Corrections made from PYTHIA tune A
Statistical and syst. uncertainties used.

Mario's jet shapes: CDF-7240
(published in PRD, 2005)

Results:

PYTHIA jets fit the data better

For $P_T$<65 GeV
HERWIG jets are narrower by 5% at $P_T$=50 GeV

For $P_T$>80 GeV
HERWIG jets are wider by 5% at $P_T$=125 GeV

Shows fraction of $P_T$ in annulus 0.3-0.7

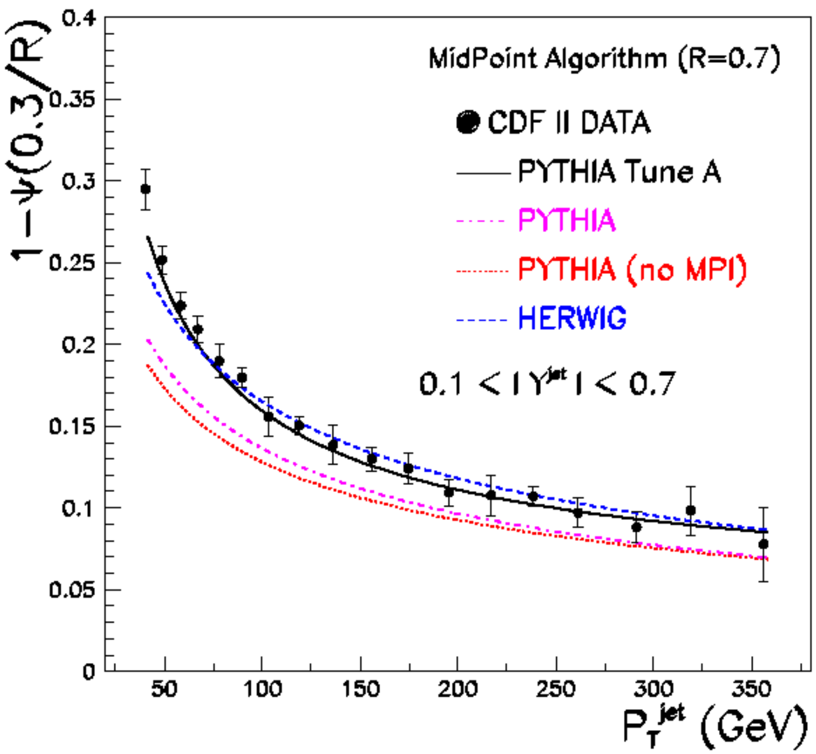



FIG. 5c The measured integrated jet shape, $1-\Psi(0.3/R)$, as a function of $P_T^{jet}$ for jets with $0.1 < |Y^{jet}| < 0.7$ and 37 GeV $< P_T^{jet} <$ 380 GeV. Error bars indicate the statistical and systematic uncertainties added in quadrature. The predictions of PYTHIA-Tune A (solid line), PYTHIA (dashed-dotted line), PYTHIA-(no MPI) (dotted line) and HERWIG (dashed line) are shown for comparison.

Comments:
PYTHIA used for the corrections.
Discrepancy only in R=0.3-0.7

# $\gamma$-jet balance: $\eta$(rel. corr. only) NIM

Relative corrections calculated from di-jet samples: separately for data and MC (using PYTHIA)
Systematics calculated by varying the selection cuts

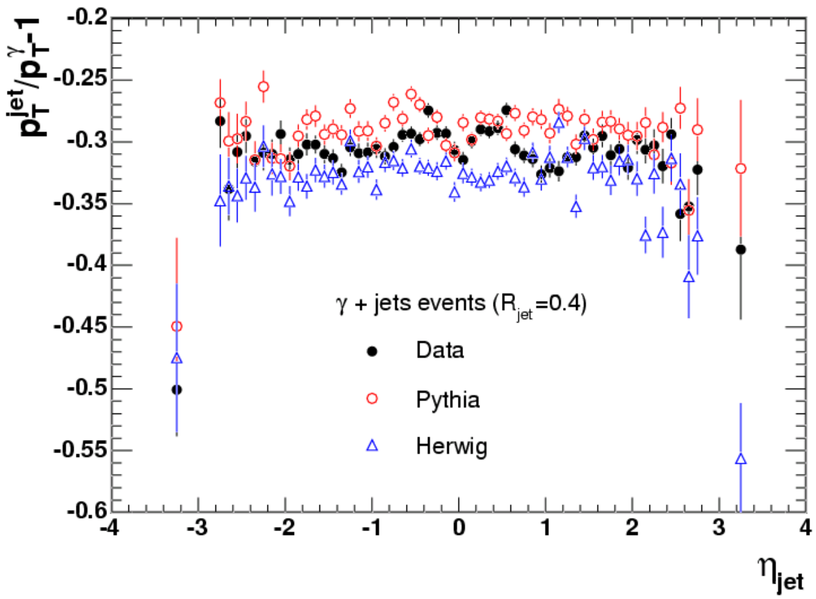
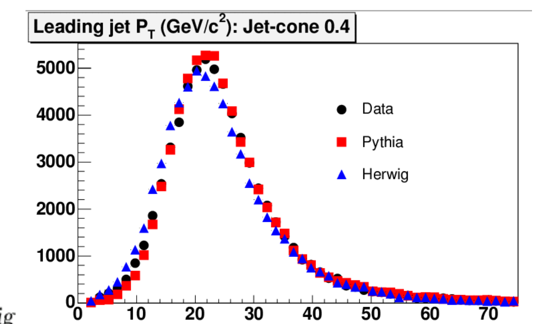



Figure 34: $p_T$ balance, $\frac{p_T^{jet}}{p_T^{\gamma}} - 1$, in data (full circles), Pythia (open circles) and Herwig (open triangles) as function of $\eta_{jet}$ for $R_{jet} = 0.4$

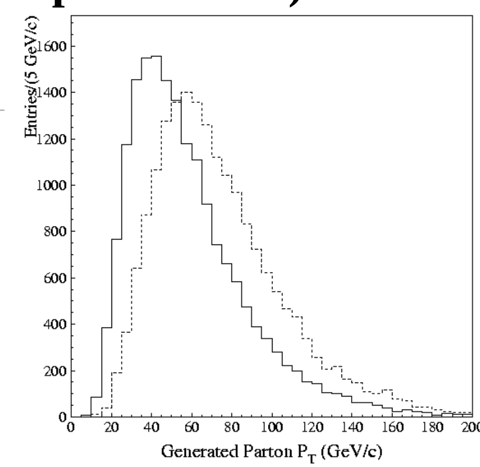
Plot shows test of corrections on $\gamma$-jet data and in MC samples.

**Jets in $\gamma$-jet events (uncorrected)**

**Mousumi Datta**




**Top jets:light and b quarks at parton level)**




Jets in $\gamma$-jets are softer than top jets

HERWIG has 2% less $P_T$ in cone of R=0.4
PYTHIA has 2% more $P_T$ in cone of R=0.4

# Jet response (NIM absolute corrections)

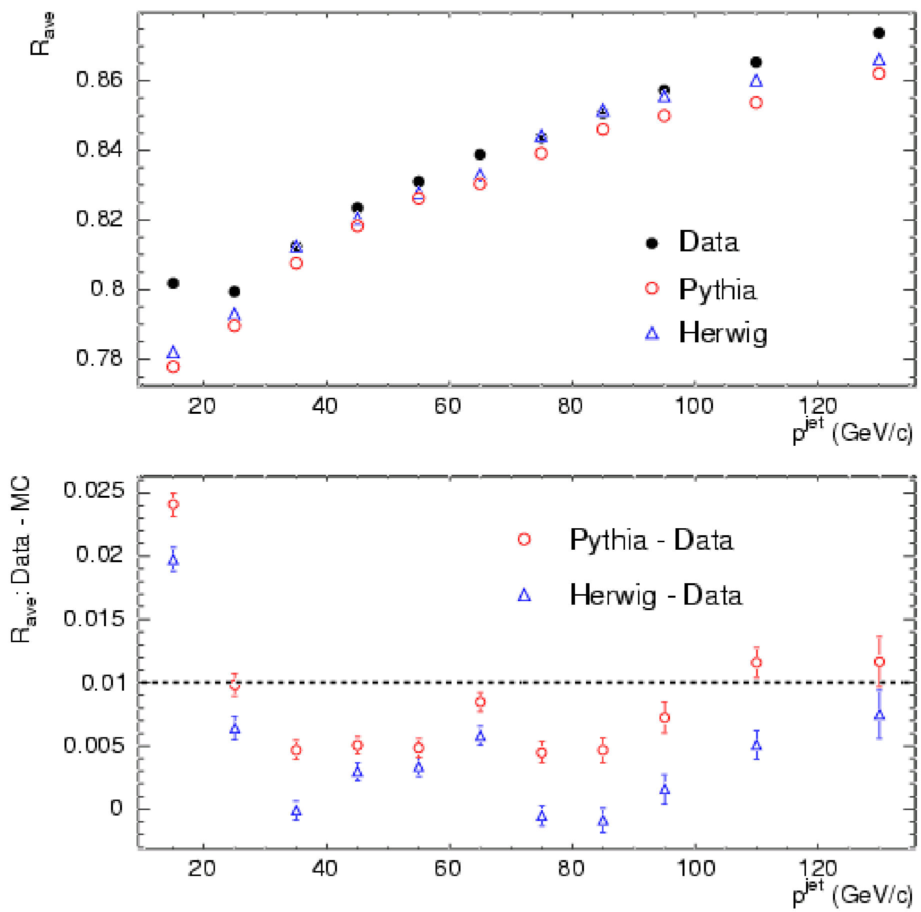



Figure 24: *Top: Jet response $R_{ave}$ for data (closed circles), Pythia (open circles) and Herwig (open triangles) for $R_{jet} = 0.4$ jets as function of $p_T^{jet}$. Bottom: Difference between data and Pythia (open circles) and data and Herwig (open triangles).*

HERWIG is better then PYTHIA on jet response

PYTHIA used to calculate the absolute corrections.

Systematics from many sources. The largest one from uncertainty of calorimeter response to charged particles.
GLASH used for calorimeter simulation.

See CDF-7450, Bhatti et al.

# $\gamma$-jet balance (partial corr.) NIM

## Check of relative and  and absolute corrections on $\gamma$-jet events

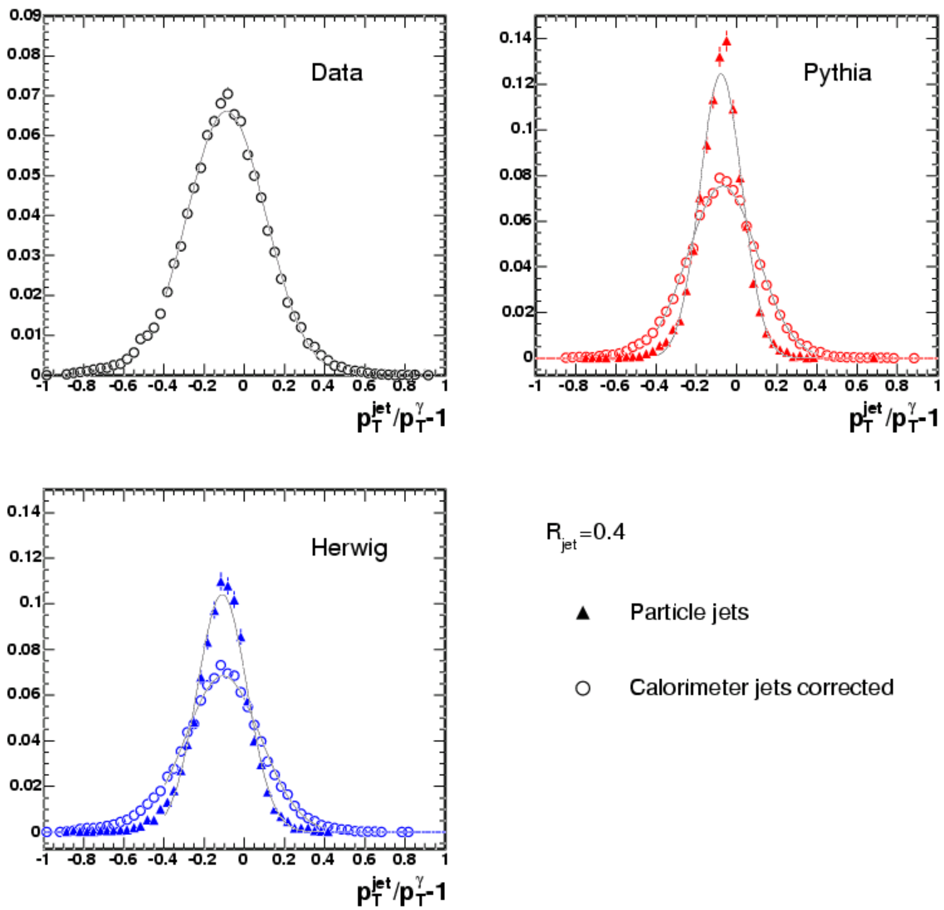



Figure 35: $\gamma$-jet balance in data, Pythia and Herwig for $R_{jet}$=0.4. Overlaid is the cor sponding $\gamma$-jet balance on generator level (triangles). The distributions are normalized

HERWIG-data ~ - 2.0%
PYTHIA -data ~ + 1.8%

No way to choose

Table 4: Mean value of $p_T^{jet}/p_T^{gamma} - 1$ after $\eta$-dependent and absolute energy correction for data, Pythia, and Herwig for $R_{jet}$=0.4, 0.7 and 1.0. For Pythia and Herwig, the values are given also for particle jets.

| Sample | $R_{jet}$=0.4 | $R_{jet}$=0.7 | $R_{jet}$=1.0 |
|---|---|---|---|
| Calorimeter jets | | | |
| Data | $-0.088 \pm 0.001$ | $-0.016 \pm 0.001$ | $0.022 \pm 0.001$ |
| Pythia | $-0.070 \pm 0.001$ | $-0.015 \pm 0.001$ | $-0.002 \pm 0.001$ |
| Herwig | $-0.108 \pm 0.001$ | $-0.043 \pm 0.001$ | $-0.024 \pm 0.001$ |
| Particle jets | | | |
| Pythia | $-0.078 \pm 0.001$ | $-0.037 \pm 0.001$ | $-0.009 \pm 0.001$ |
| Herwig | $-0.113 \pm 0.002$ | $-0.061 \pm 0.002$ | $-0.019 \pm 0.002$ |

For $\gamma$-jet balance studies see CDF-7452, Canelli et al.

# Underlying event (NIM)

Rick Field's studies show PYTHIA tune A fits data better

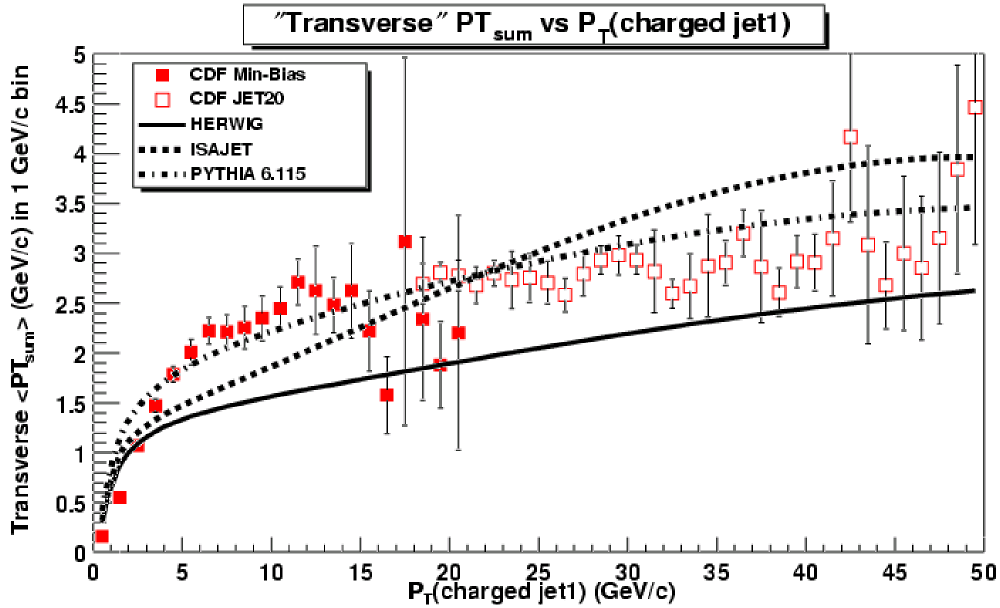



Figure 33: *The average transverse momentum of charged particles in the transverse region versus jet $p_T$ [33]. The data are shown as points and are compared to the predictions from Pythia (dashed-dotted line), Herwig (solid line) and Isajet (dashed line).*

For $P_T$> 10 GeV/c HERWIG is lower than the data by ~ .5 GeV/c. This is the Sum(PT) in the transverse region (A=4/3*π), for a radius of 0.4 we expect 0.5*3/4*.16=0.06 GeV discrepancy. This is ~0.1 GeV (20%) for the UE=0.4 GeV evaluated from calorimeter measurements (see next page)

# Out of cone (NIM)

γ-jet balance results ($P_T$ jets ≤ 100 GeV). Left plot shows $P_T$ in annulus 0.4-1.3: includes both UE and Out-of-Cone $P_T$

HERWIG (blue) is closer to the data than PYTHIA

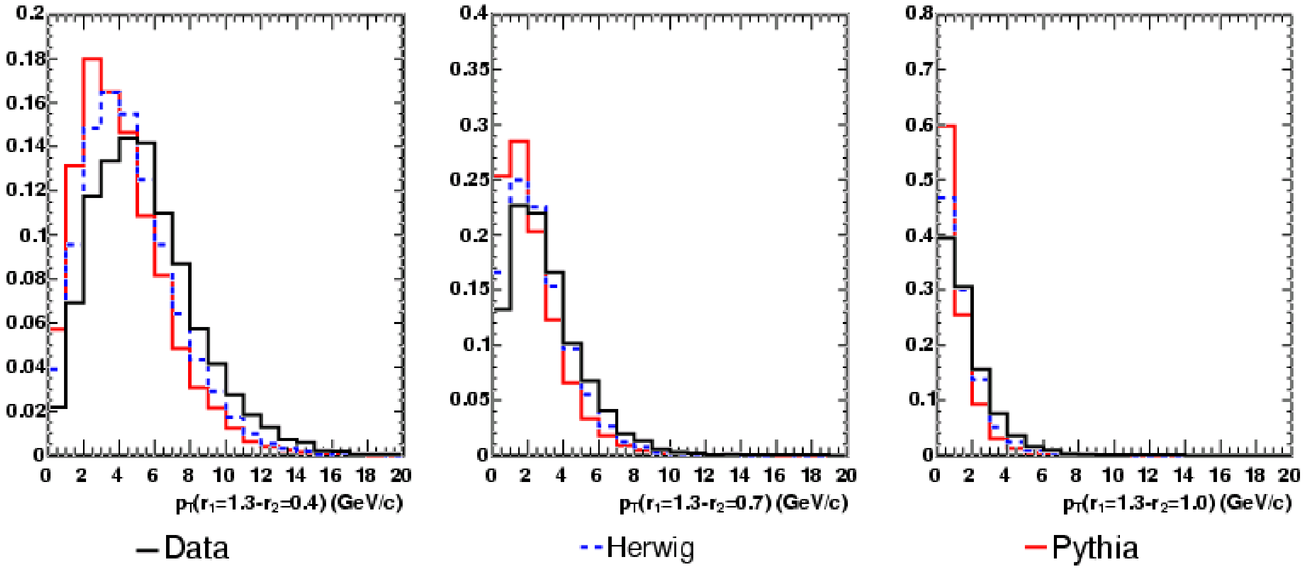



Figure 31: *Normalized distributions of the momentum in different annuli outside the jet cone for data, Pythia and Herwig γ+jets events.*

OOCC and UE (0.4 GeV for R=0.4) determined from PYTHIA dijet samples. Systematics include difference between PYTHIA and HERWIG.

# $\gamma$-jet balance: all corrections NIM

All corrections applied (UE and OOCC determined from PYTHIA)

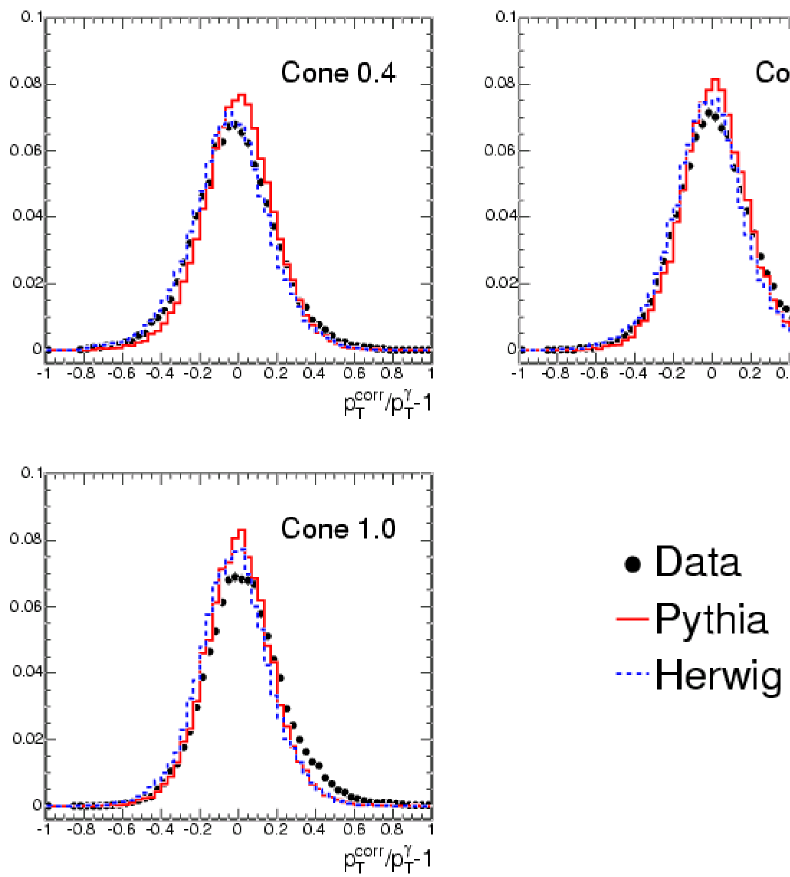



Figure 36: $\gamma$-jet balance in data, Pythia and Herwig using $R_{jet}$=0.4, 0.7 and 1.0 after $\eta$-dependent, absolute and OOC+UE corrections.

HERWIG-data ~ - 2.0%
PYTHIA-data ~ + 1.8%

No way to choose

Table 6: Mean value of $p_T^{jet}/p_T^{\gamma} - 1$ after all corrections, including the out-of-cone energy correction for data, Pythia, and Herwig for jet cones of $R_{jet}$ = 0.4, 0.7 and 1.0.

| Sample | $R_{jet}$=0.4 | $R_{jet}$=0.7 | $R_{jet}$=1.0 |
|---|---|---|---|
| Data | $-0.019 \pm 0.001$ | $0.010 \pm 0.001$ | $0.024 \pm 0.001$ |
| Pythia | $-0.001 \pm 0.001$ | $0.011 \pm 0.001$ | $0.000 \pm 0.001$ |
| Herwig | $-0.040 \pm 0.001$ | $-0.018 \pm 0.001$ | $-0.023 \pm 0.001$ |

# Summary

- Mario's plots show that PYTHIA is better than HERWIG between R= 0.3 and 0.7

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- Jet response show that HERWIG is slightly better than PYTHIA

- Out of cone plots show that HERWIG is better than PYTHIA between R= 0.4 and 1.3.

- $\gamma$-jet balance data show that HERWIG is below the data by ~2% PYTHIA is above the data by ~1.8% at every level of correction.

Both PYTHIA and HERWIG disagree with the data at the 2% level (note, however, that jets in $\gamma$-jet are softer that top jets)

PYTHIA does not have spin correlations in the Matrix Element.

Are the ME analyses sensitive to spin correlations?