Jet energy resolution using di-jet balance and kT techniques

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Jet – EtMiss phone conference
10 – 31 – 2007

Jet Energy Resolution

- Jet resolution is crucial in many physics analysis and searches, different ways to improve it are being investigated

- Obtain jet resolutions without using truth information (as if in data)

  - Dijet balance technique (used in "D0")

  - kT balance technique (used in "CDF")

- Jet energy resolution has three main contributions

$$\frac{\sigma(E_T)}{E_T} \approx \frac{a}{\sqrt{E_T}} \oplus \frac{b}{E_T} \oplus c$$

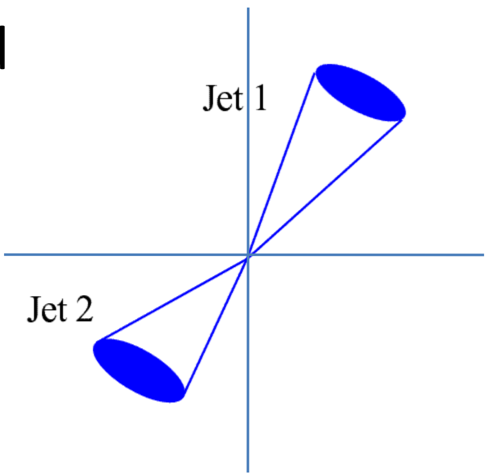
- ✓ Stochastic response
- ✓ Electronic noise term
- ✓ Constant term: Dead material, calorimeter non - compensation

Dijet Balance Technique

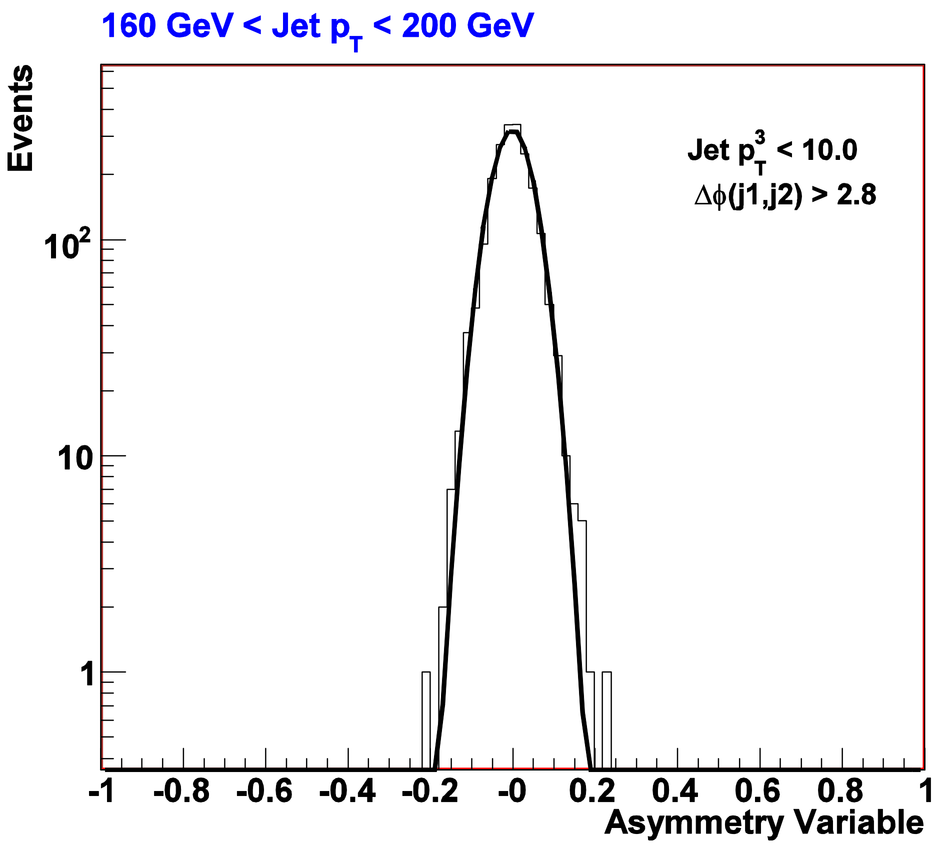
- Determination of the jet E_T resolution based on energy conservation in the transverse plane

  - ✓ 1 primary vertex
  - ✓ Two back-to-back leading jet (DeltaPhi > 2.8)
  - ✓ No other reconstructed jet with $E_T > 10$ GeV
  - ✓ Both jets in the same Eta region*
  - ✓ "True" MET = 0 required to remove b-jets and jets with muons

  - ✓ Data samples : 12.0.6 (trig1_misal1_csc11)
  - ✓ J0, J2 – J7 used
  - ✓ Cone R = 0.7 made from calo towers



Dijet balance: Asymmetry distribution

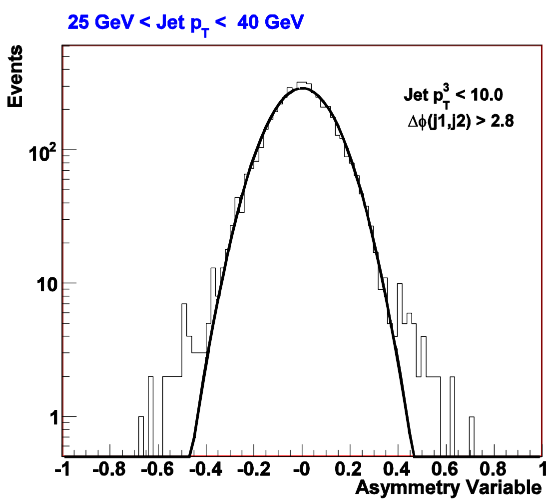


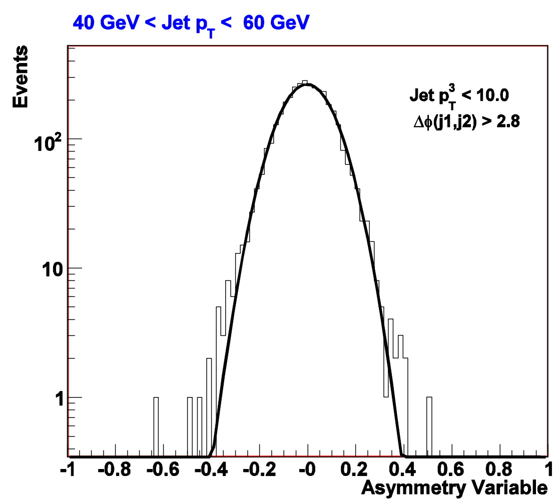
$$A = \frac{E_{T,1} - E_{T,2}}{E_{T,1} + E_{T,2}}$$

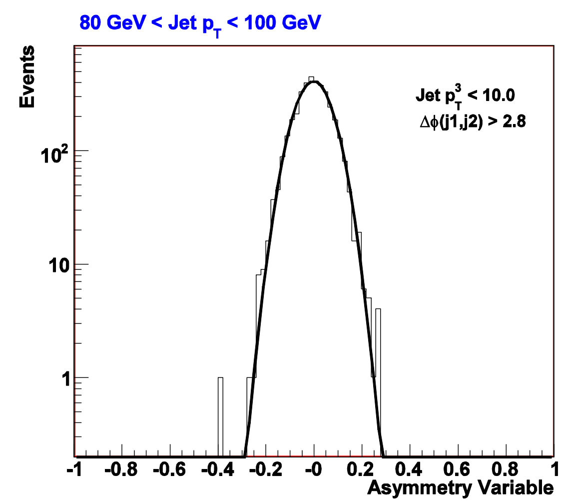
$$\left(\frac{\sigma_{E_T}}{E_T}\right) = \sqrt{2}\,\sigma_A$$

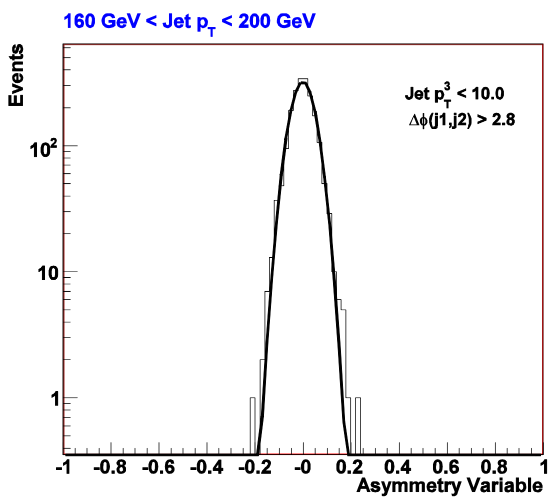
- ✓ Data sample is divided in 6 pT regions
- ✓ Asymmetry variables are fitted with single gaussians

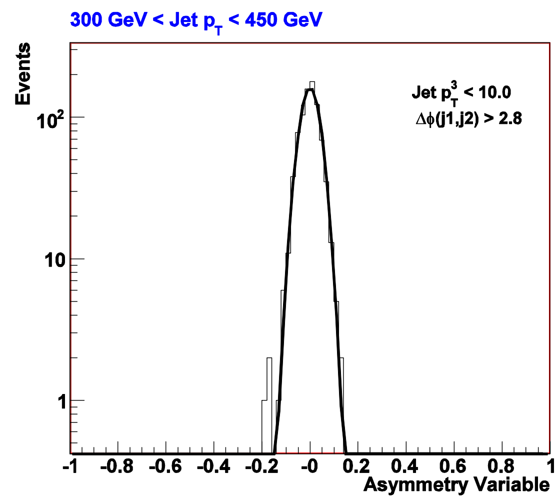
Asymmetry distribution (pT3 < 10 GeV)

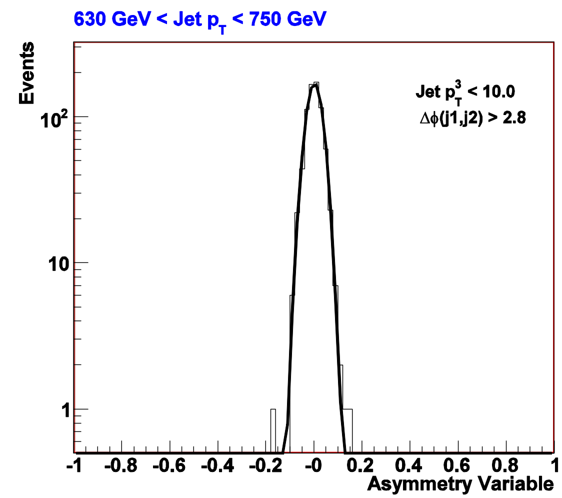




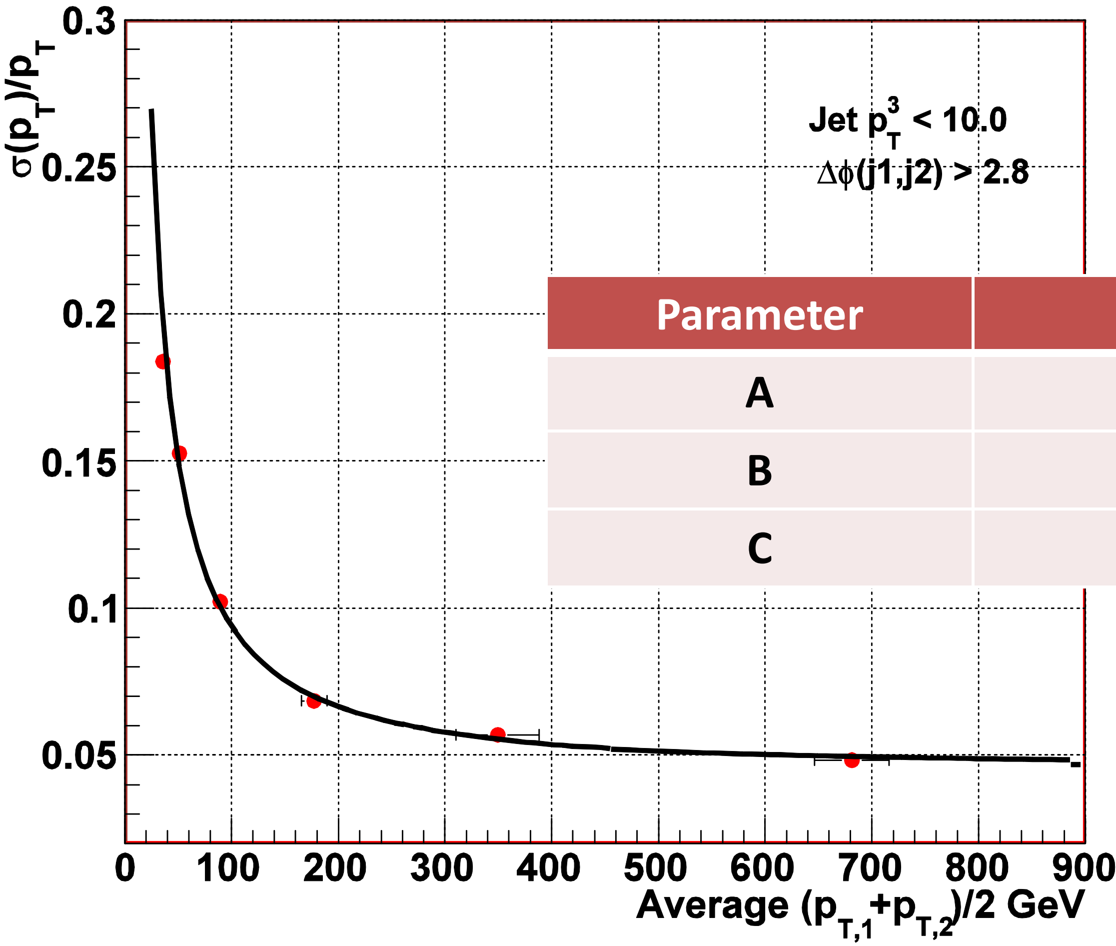








Resolution (pT3 < 10 GeV)



$$\frac{\sigma(E_T)}{E_T} \approx \frac{a}{\sqrt{E_T}} \oplus \frac{b}{E_T} \oplus c$$

Parameter	Value	Error
A	0.6	± 0.1
B	5.7	± 0.9
C	0.041	± 0.003

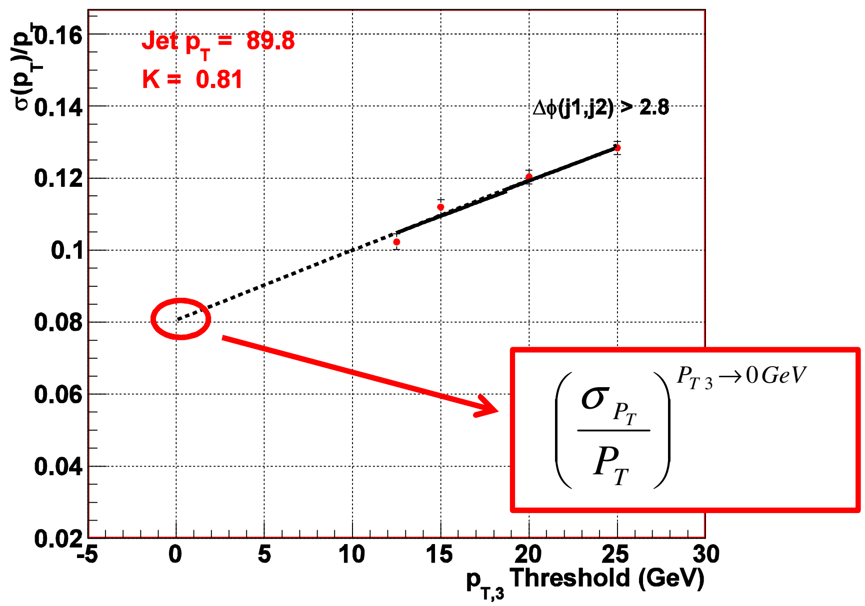
Soft radiation correction

- Events with soft radiation prevent the two leading jets from balancing in the transverse plane

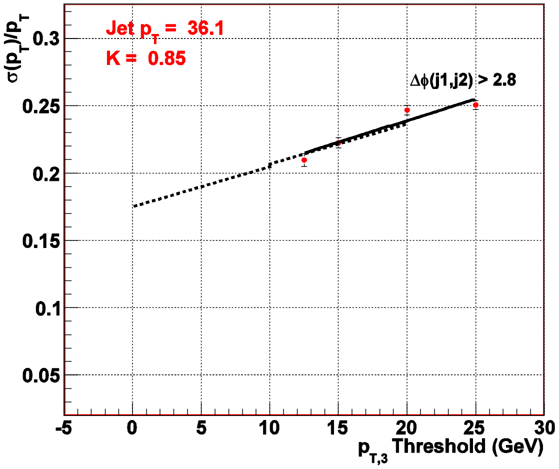
- Resolutions in samples are computed using different third jet thresholds

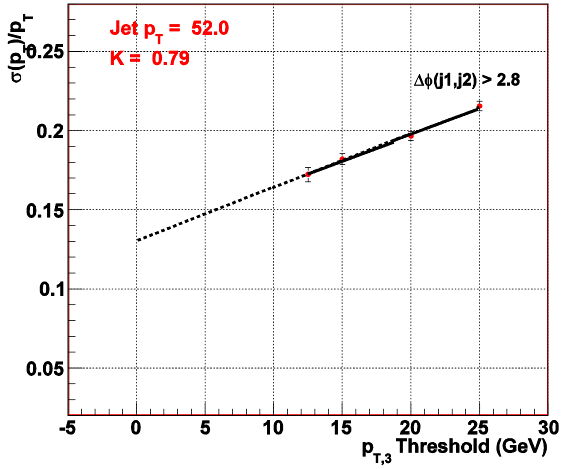
  - $p_{T3} < 12.5$ GeV
  - $p_{T3} < 15$ GeV
  - $p_{T3} < 20$ GeV
  - $p_{T3} < 25$ GeV

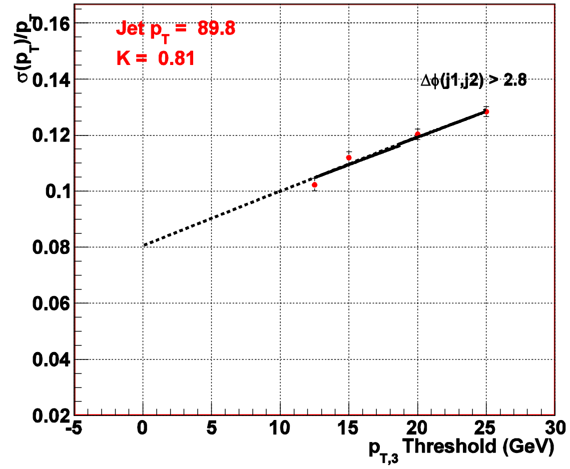
- Extrapolate to $pT_3 = 0$ (ideal Dijet sample)

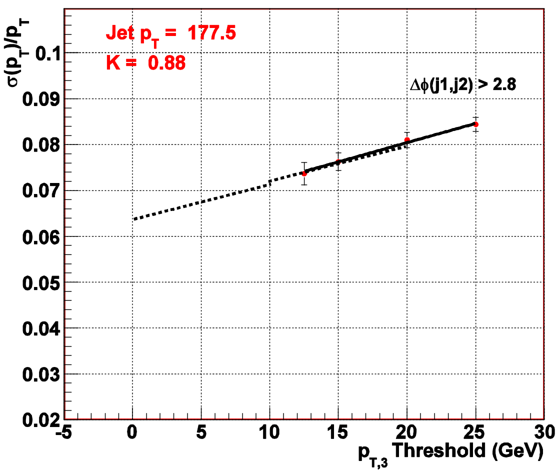


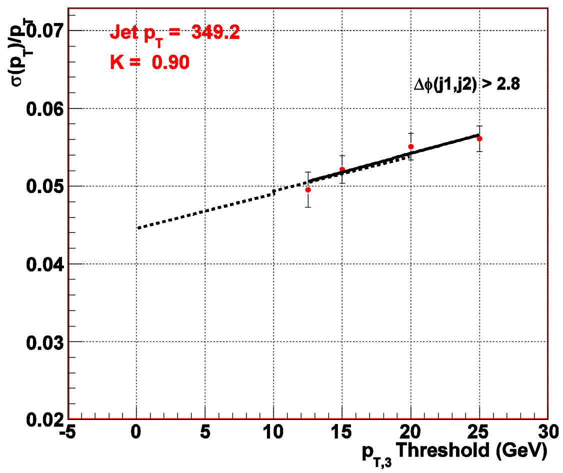
Soft radiation correction

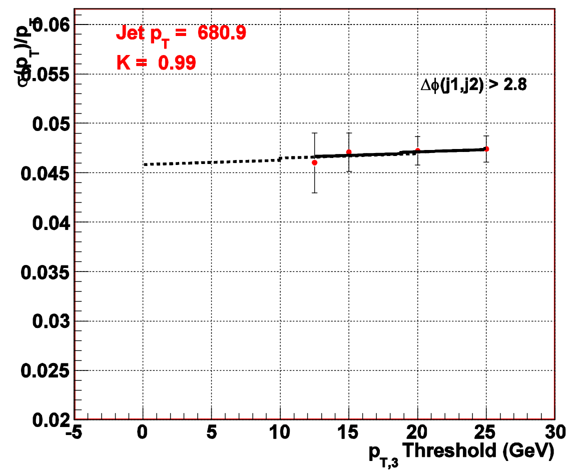




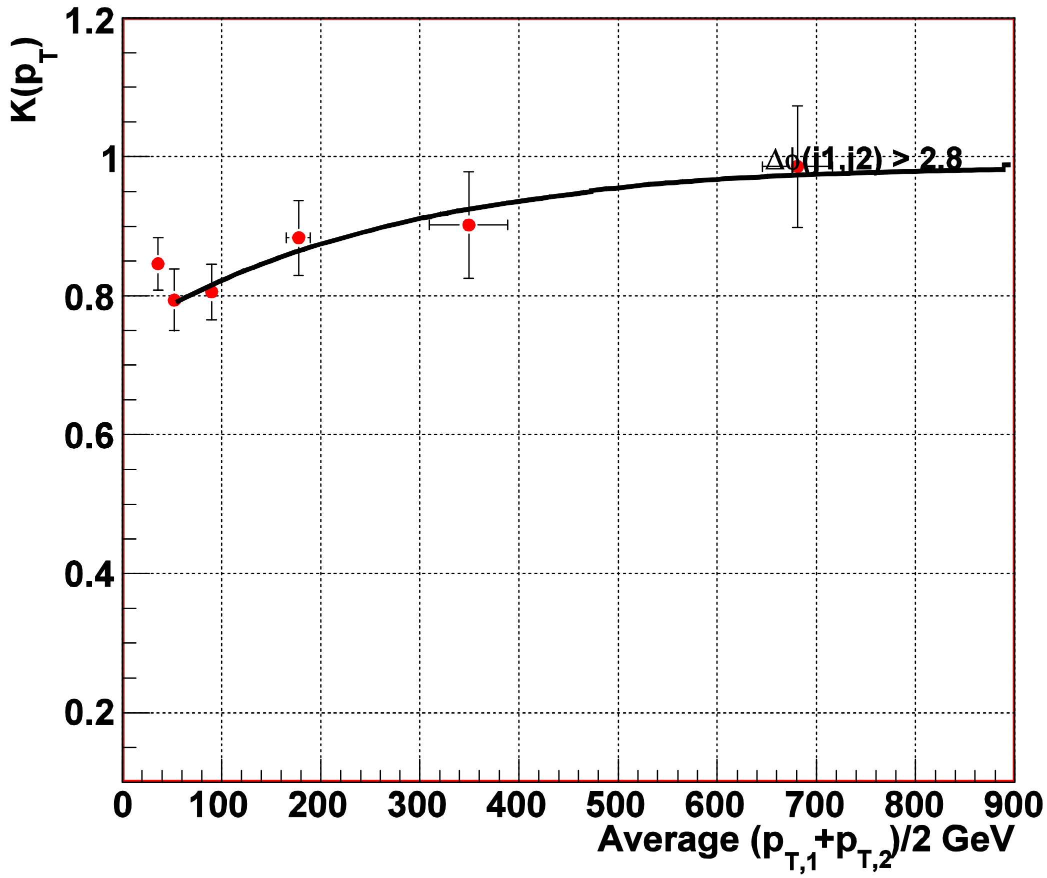








Soft radiation correction



Soft radiation bias should be larger at small transverse energies, and negligible at high pT:

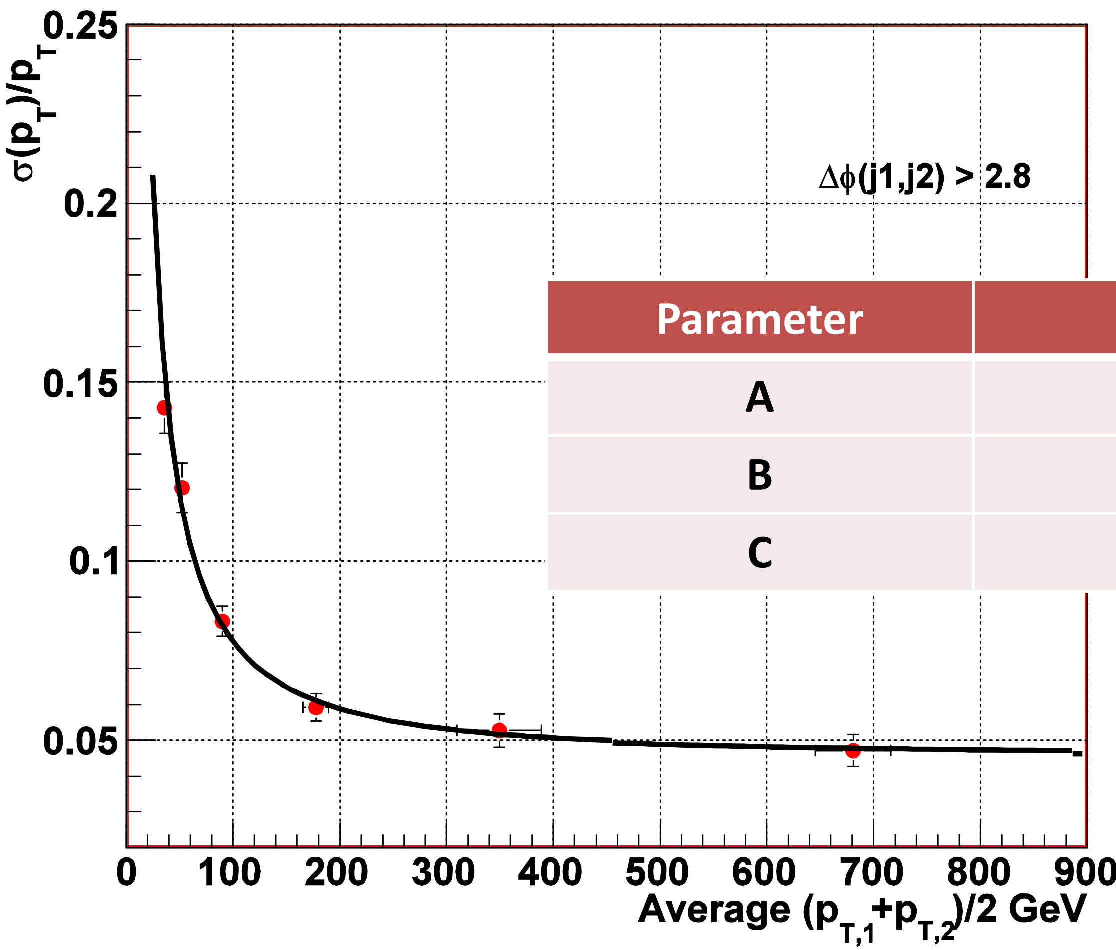
$$K(P_T) = \frac{\left(\frac{\sigma_{P_T}}{P_T}\right)^{P_{T3}\to 0GeV}}{\left(\frac{\sigma_{P_T}}{P_T}\right)^{P_{T3}<10GeV}}$$

$$K(P_T) = 1 - \exp^{a-bP_T}$$

Unbiased fractional energy resolution

$$\left(\frac{\sigma_{P_T}}{P_T}\right)_{Corrected} = K(P_T)\left(\frac{\sigma_{P_T}}{P_T}\right)_{Uncorrected}$$

Resolution (After SR correction)

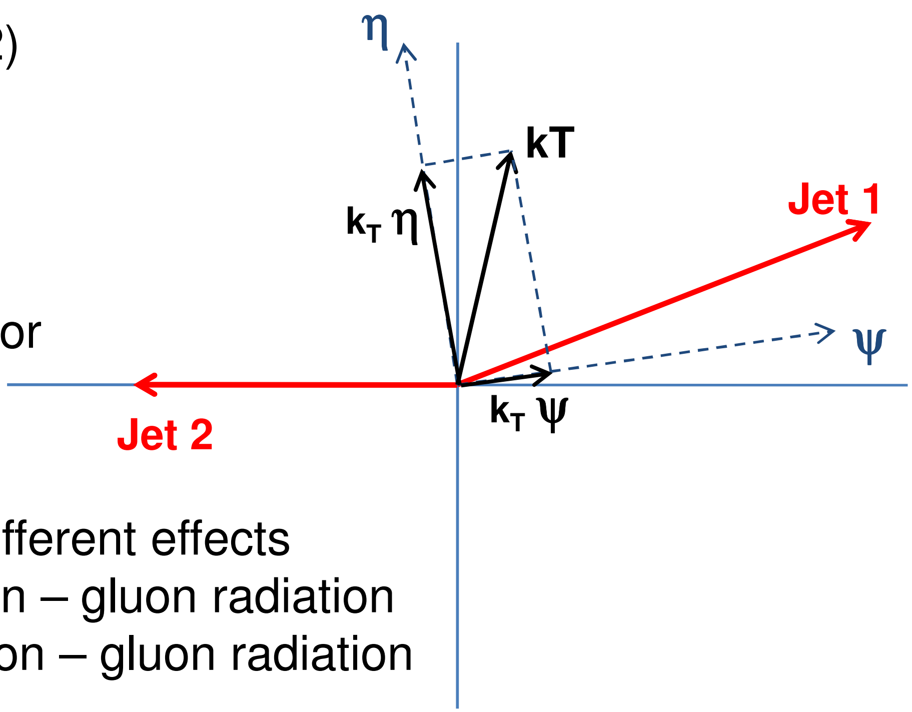


$$\frac{\sigma(E_T)}{E_T} \approx \frac{a}{\sqrt{E_T}} \oplus \frac{b}{E_T} \oplus c$$

Parameter	Value	Error
A	0.5	± 0.2
B	4.3	± 1.3
C	0.043	± 0.006

kT Balance Technique

- Method used in CDF (developed by UA2)
- Project Imbalance vector kT onto 2 components (psi,eta)
  - ✓ **Eta axis** = Azimuthal angular bisector of the dijet system
  - ✓ **Psi axis** = Orthogonal to Eta axis

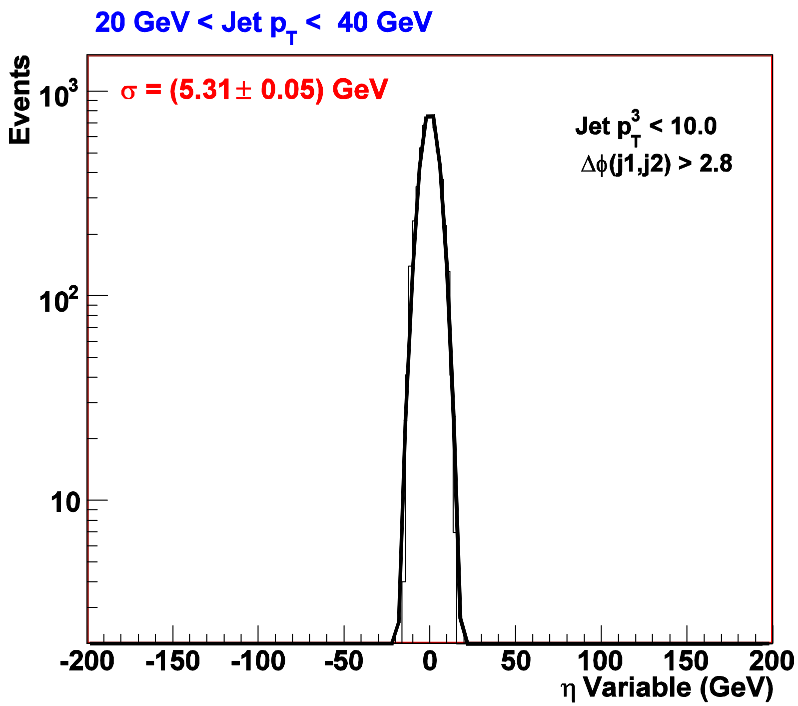


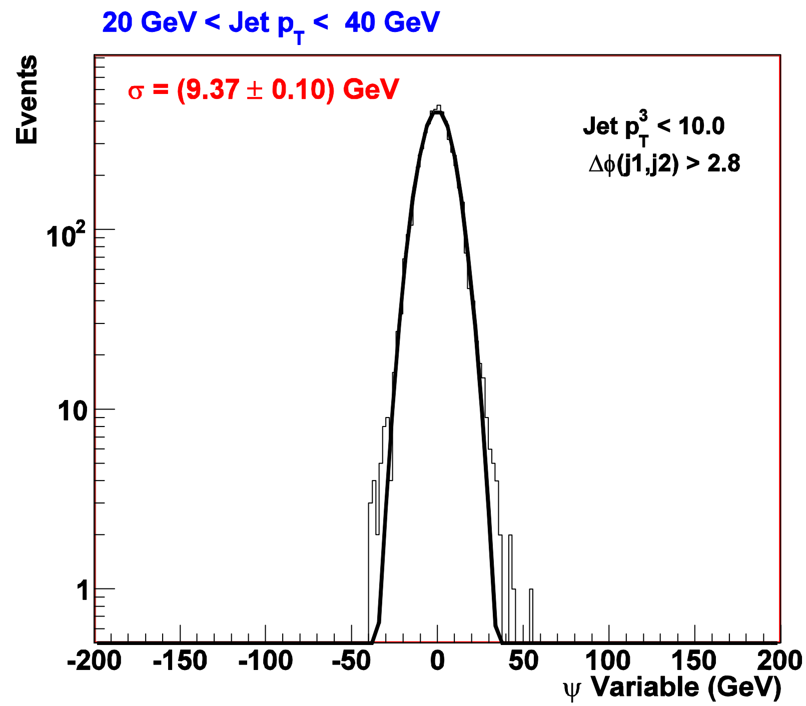
- Psi & Eta components are sensitive to different effects
  - ✓ Psi distribution: jet energy resolution – gluon radiation
  - ✓ Eta distribution: jet angular resolution – gluon radiation
- Soft radiation contibution is removed by subtracting in quadrature $\sigma(\eta)$ from $\sigma(\psi)$

$$\sigma_{eff} = \sqrt{\sigma_\psi^2 - \sigma_\eta^2}$$

- Hard gluon radiation effects are reduced by rejecting events with $pT_3 > 10$ GeV

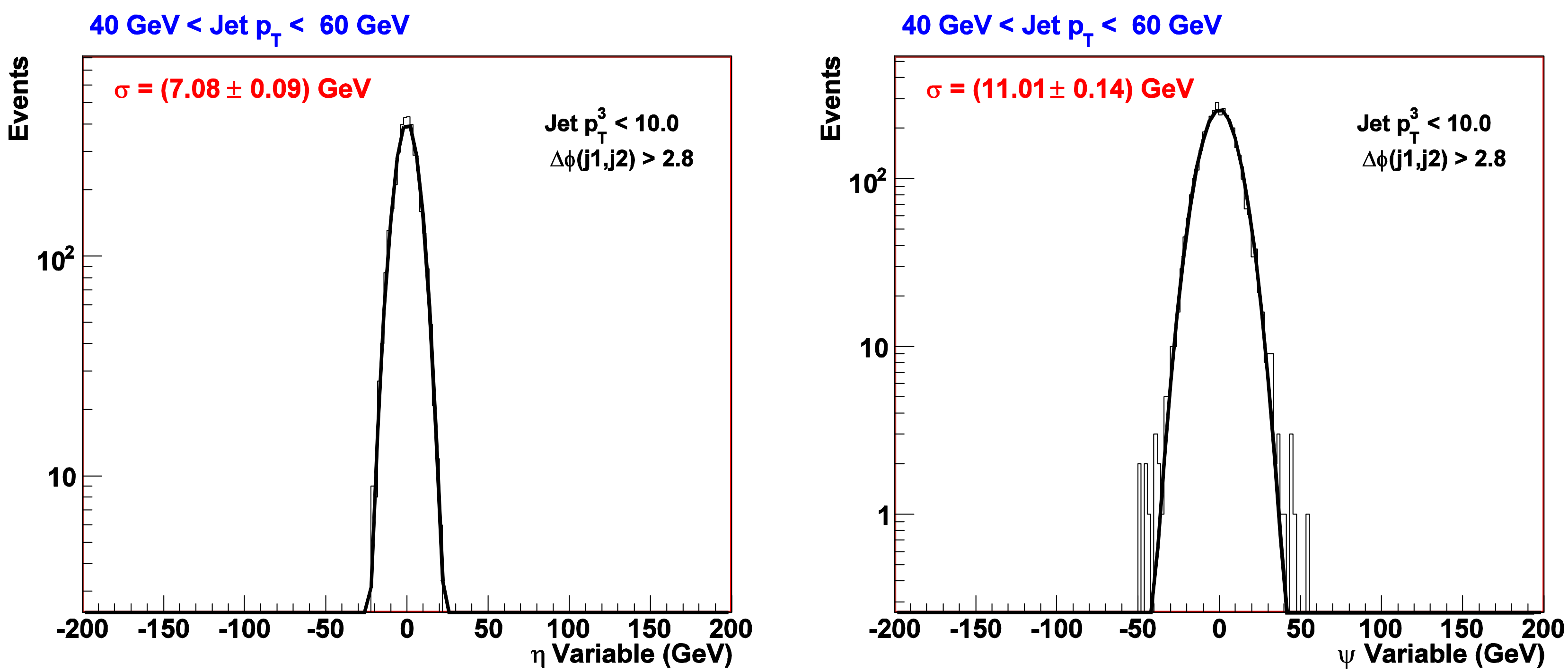
Distributions of the 2 kT components





- ✓ Data sample divided in 6 pT regions
- ✓ Eta and Psi variables were fitted with single gaussians

Distributions of the 2 kT components



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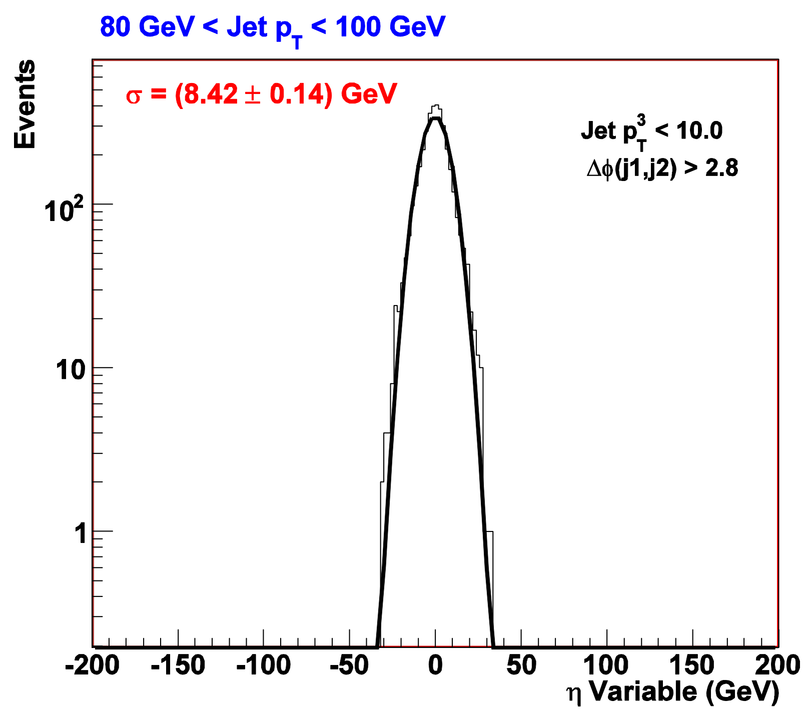

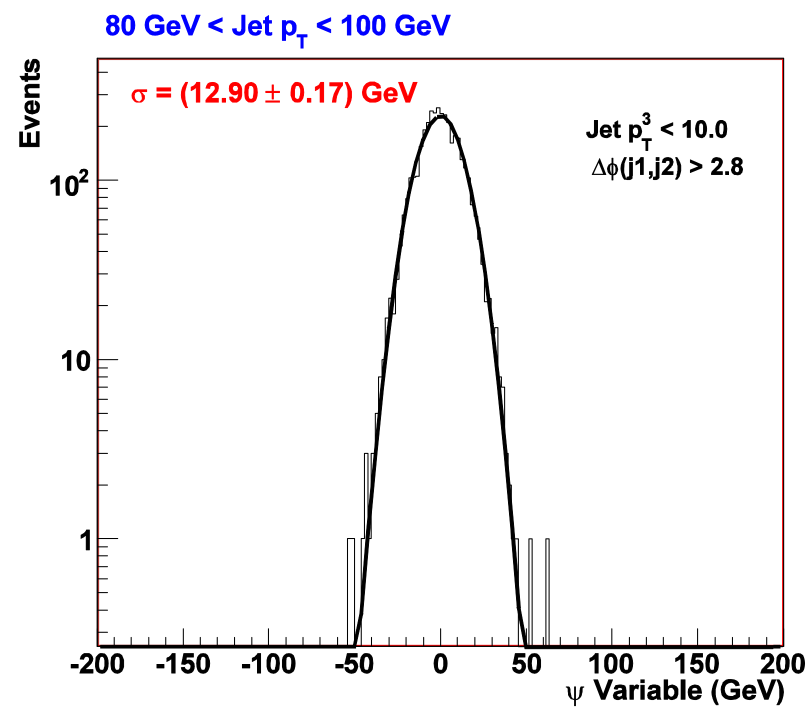

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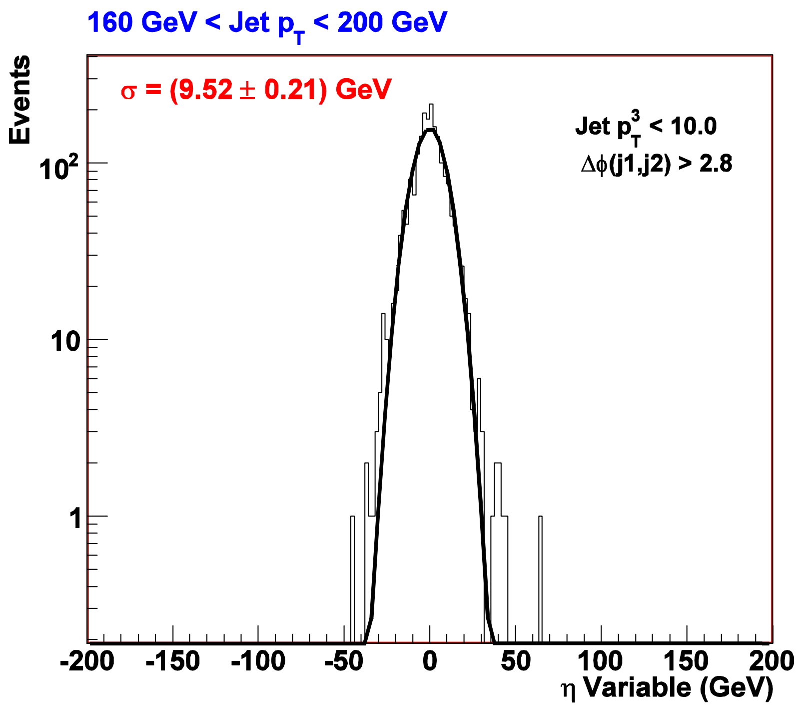
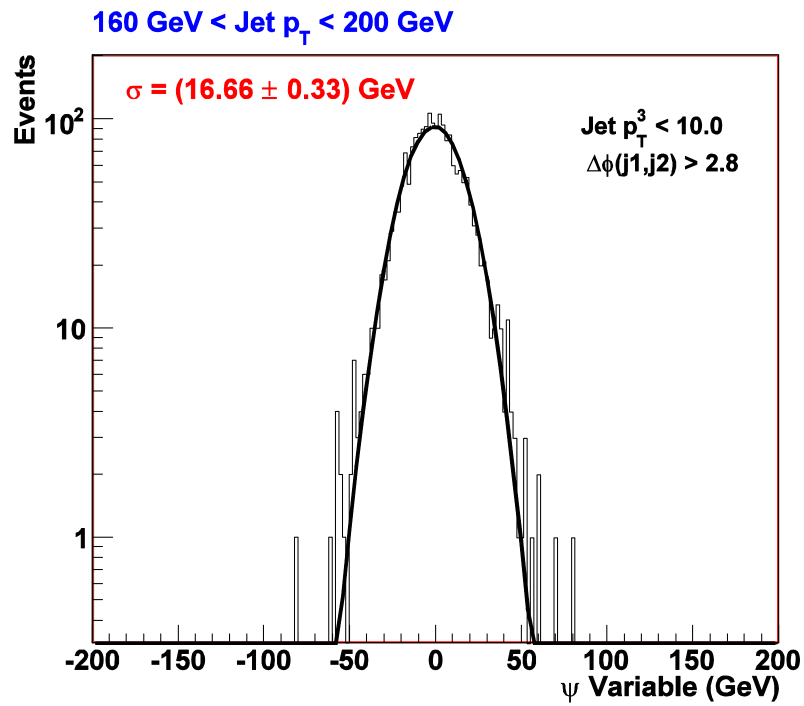
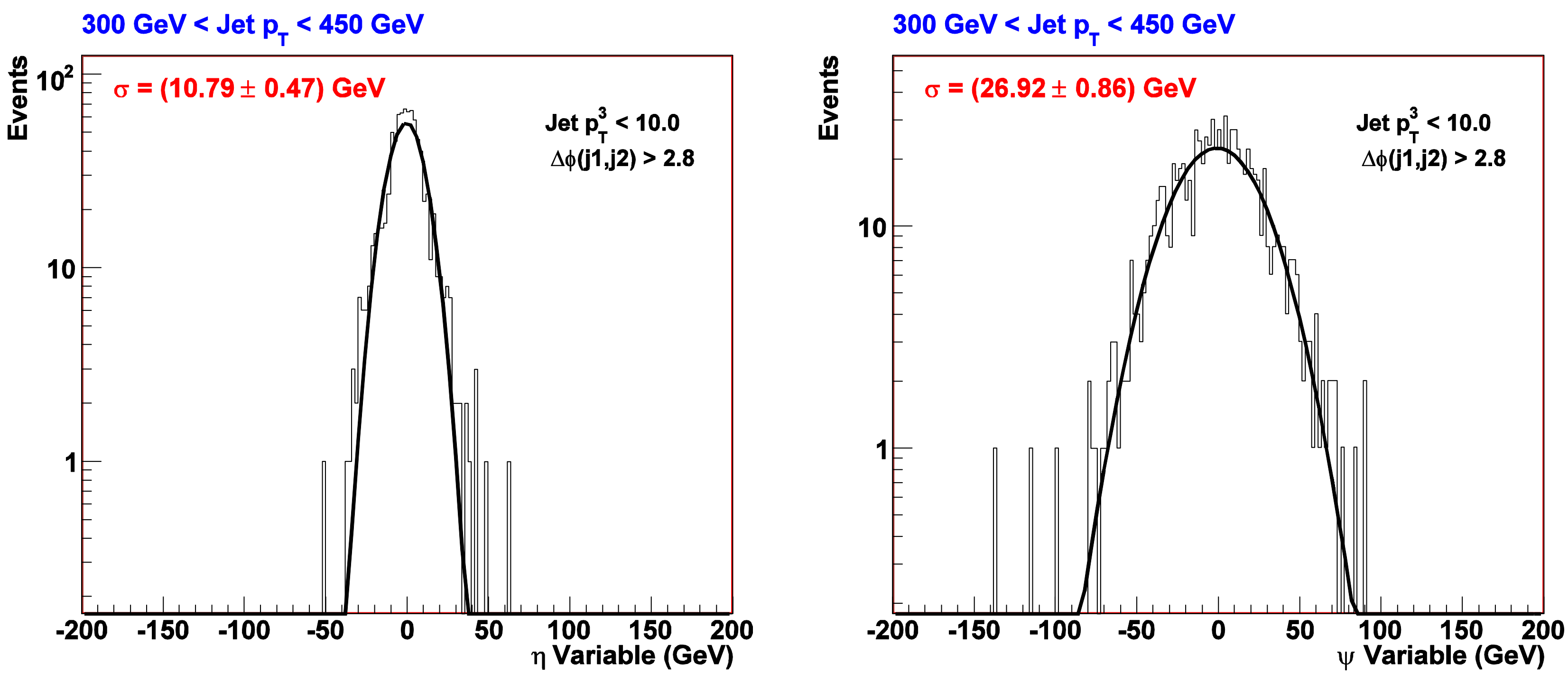




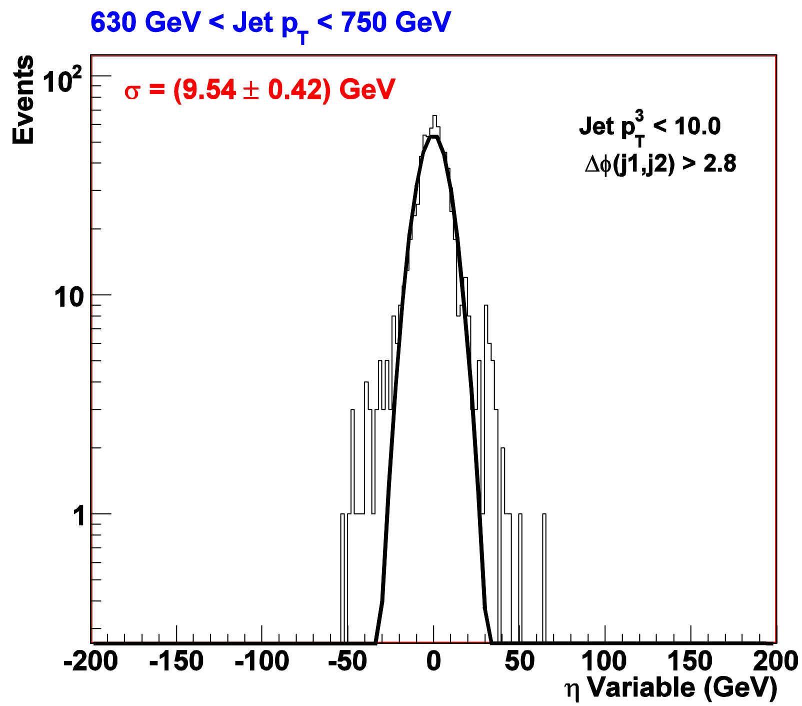
- ✓ Data sample divided in 6 pT regions
- ✓ Eta and Psi variables were fitted with single gaussians

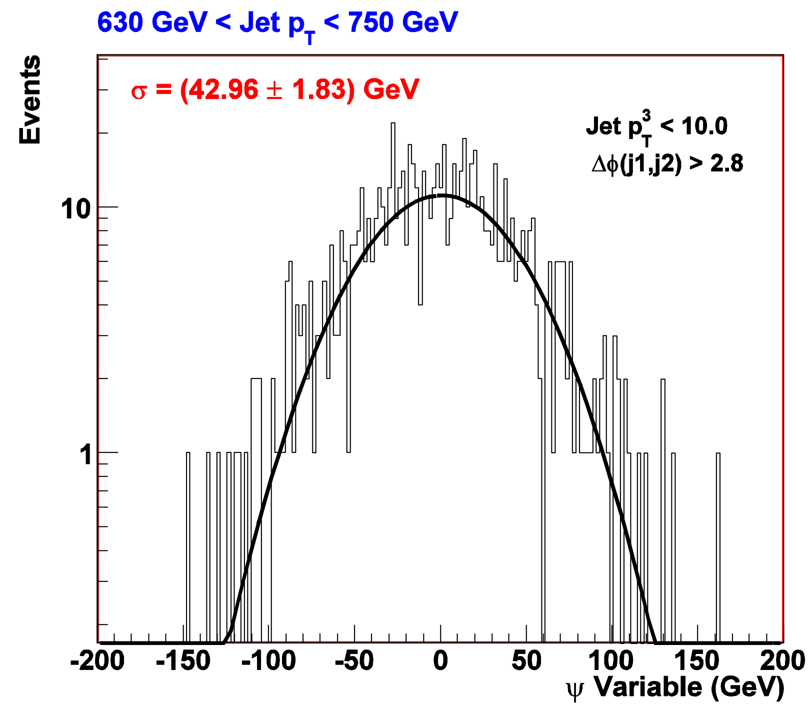
Distributions of the 2 kT components



- ✓ Data sample divided in 4 pT regions
- ✓ Eta and Psi variables were fitted with single gaussians

Distributions of the 2 kT components

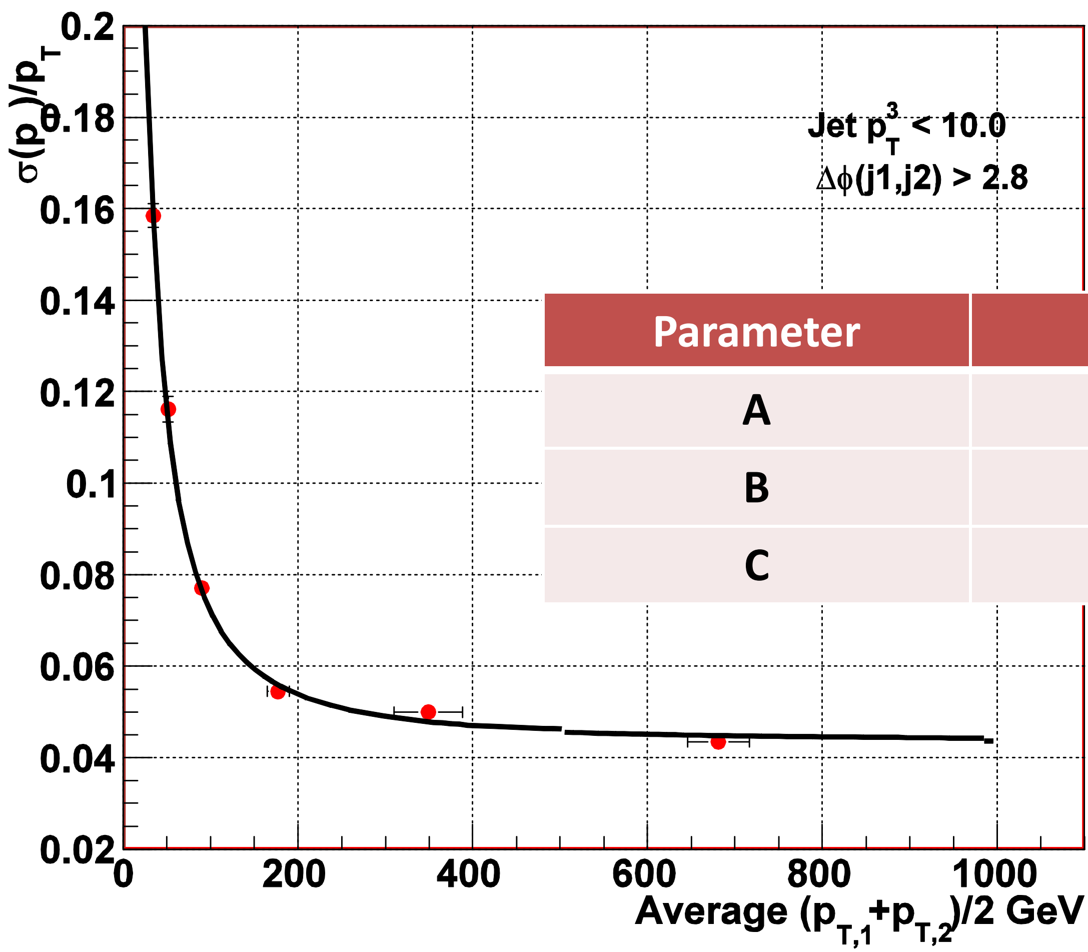




- ✓ Data sample divided in 6 pT regions
- ✓ Eta and Psi variables were fitted with single gaussians

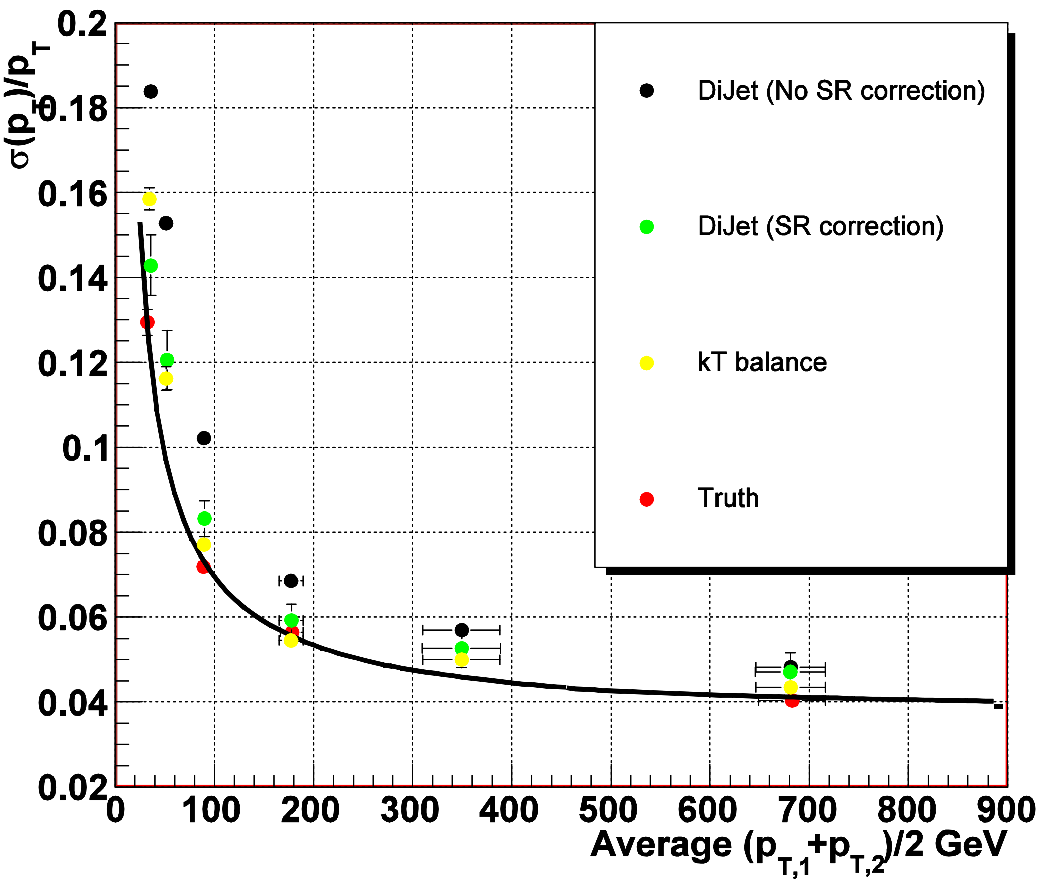
kT balance resolution

$$\frac{\sigma(E_T)}{E_T} \approx \frac{a}{\sqrt{E_T}} \oplus \frac{b}{E_T} \oplus c$$



Parameter	Value	Error
A	0.3	± 0.2
B	4.9	± 0.9
C	0.042	± 0.003

Comparision of Dijet and kT methods



$$\frac{\sigma(E_T)}{E_T} \approx \frac{a}{\sqrt{E_T}} \oplus \frac{b}{E_T} \oplus c$$

- ✓ Truth resolution selecting pT bins by using CALO info
- ✓ Two leading particle jets were matched against calo jets($\Delta R < 0.1$)

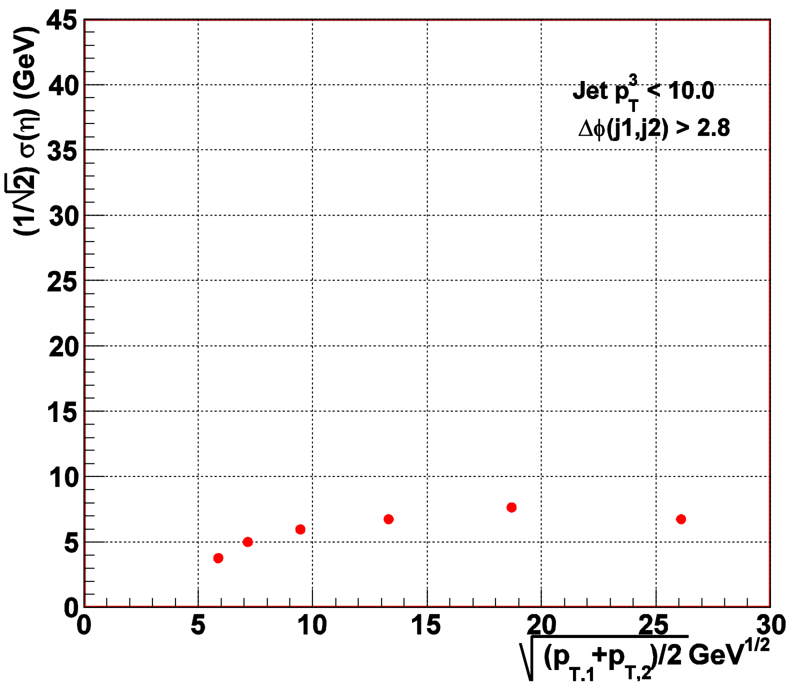
Parameter	Value	Error
A	0.55	± 0.06
B	2.4	± 0.9
C	0.034	± 0.002

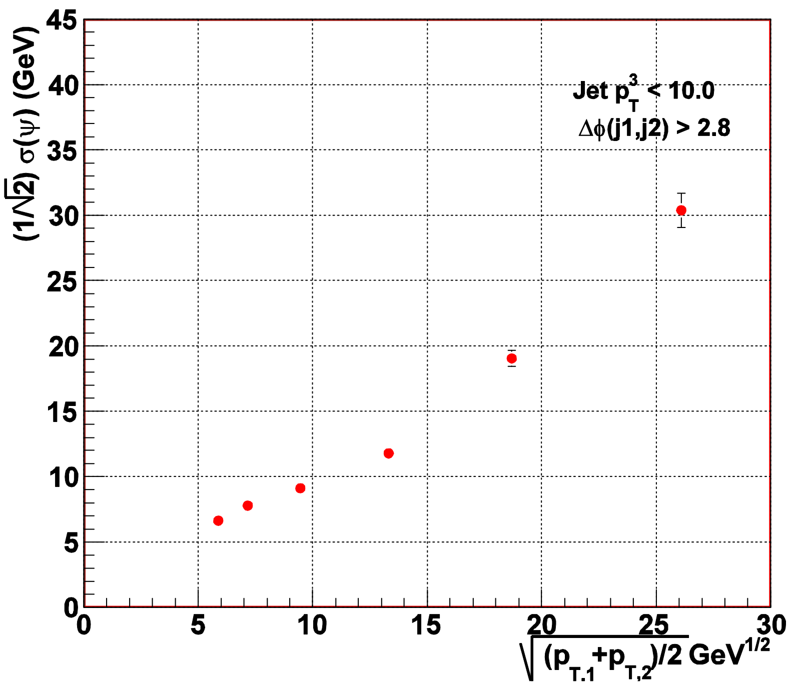
Summary and Plans

- First look at two data-driven techniques to measure jet energy resolutions: Dijet Balance and kT
- Process larger data set to further study the soft radiation correction using pT ranges and extend to all Eta regions
- Look at TOPOCluster Jets
- Study systematic uncertainties (DeltaPhi)

Backup slides

Distributions of the 2 kT components





- ✓ Width of Psi component has an approximately linear dependence with sqrt(pT)
- ✓ Width of Eta component is more flat, specially at high pT
- ✓ Eta resolution has weaker dependence with energy, as expected

Comparision of Dijet and kT methods

Method vs pT bins (GeV)	DijetBalance (No SR)	DijetBalance (after SR correction)	kT Balance
25 – 40	0.183 ± 0.002	0.142 ± 0.007	0.158 ± 0.003
40 – 60	0.152 ± 0.002	0.120 ± 0.007	0.116 ± 0.003
80 – 100	0.102 ± 0.001	0.083 ± 0.004	0.077 ± 0.002
160 – 200	0.068 ± 0.001	0.059 ± 0.004	0.054 ± 0.002
300 – 400	0.057 ± 0.001	0.052 ± 0.004	0.050 ± 0.002
630 – 750	0.048 ± 0.001	0.047 ± 0.004	0.043 ± 0.002