Studies of Jet Energy Resolution

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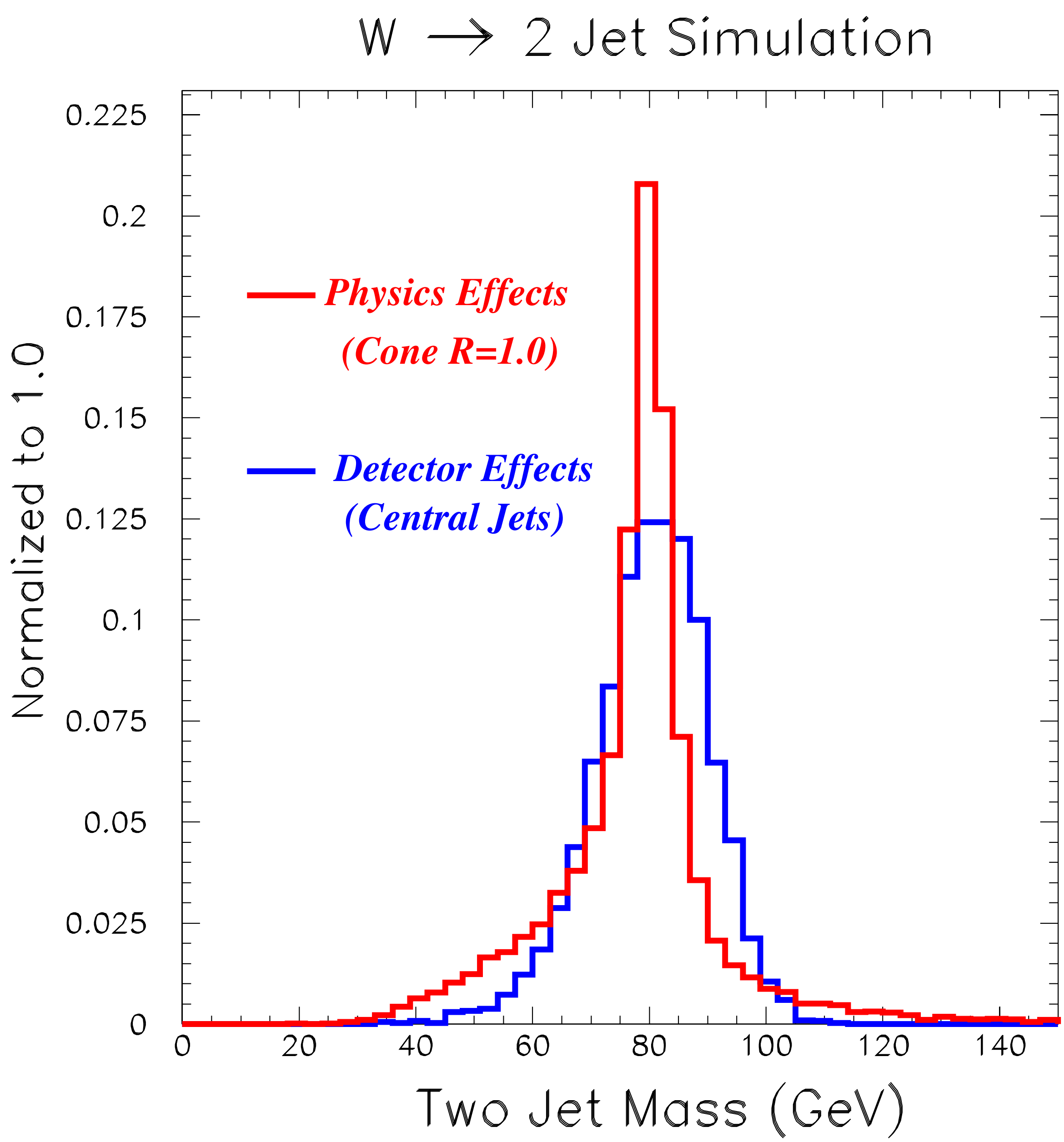
(for the CDF Collaboration)

...to improve CDF-II 2-jet Mass Resolution

1. Physics Effects:
   - $W \to jj$ Simulation
2. Detector Resolution:
   - MC + Run I data (γ-jet, 2-jet)

Full CDF detector (not only calorimetry) to correct at "tower level" rather than at "jet level"

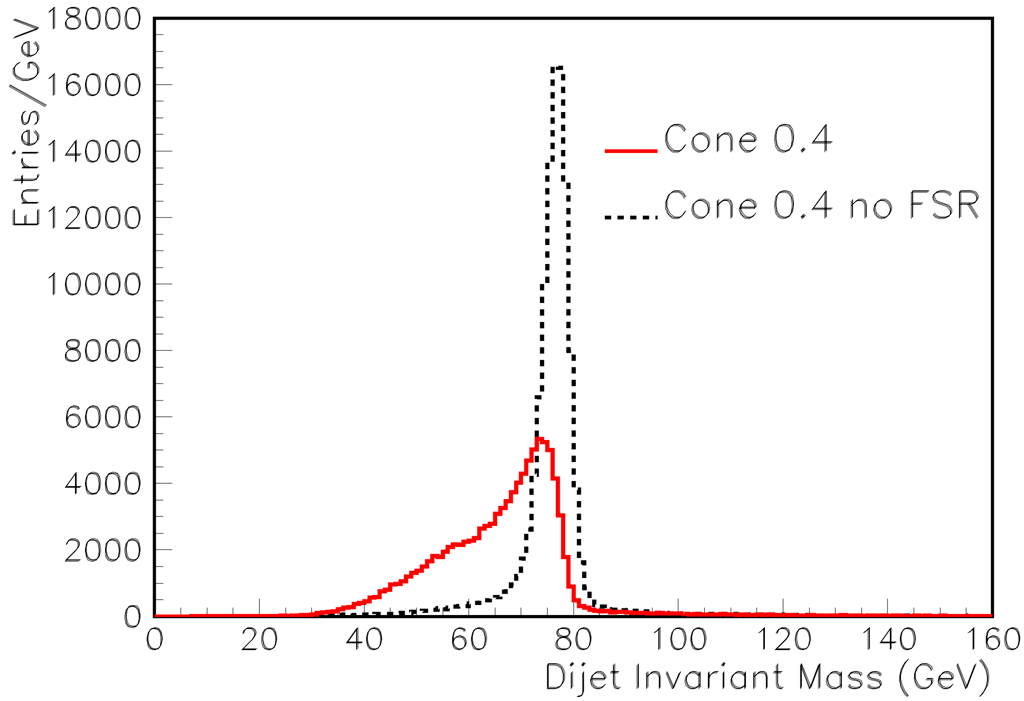
Comparison of Pure Physics Effects and Pure Detectors Effects



Physics Effects

Particle level study of a typical peak-hunting case, $W \to q\bar{q}$. Four main physics effects:

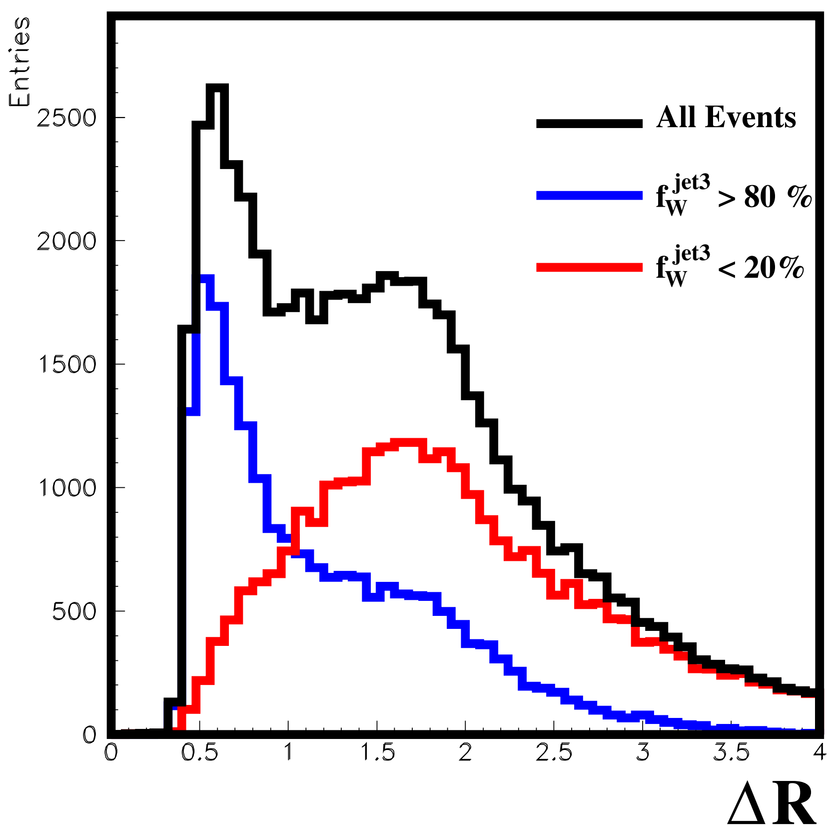
- Natural Width of the W
- Underlying event fluctuation (Mainly gaussian contribution)
- Final State Radiation (FSR)
- Misidentified jets from Initial State gluon Radiation (ISR)



The FSR study

In order to reduce low-mass tail, we investigated:

- ☞ Algorithm Effects: "Cone", "K_T" algorithms compared and found equivalent (for this physics).
- ☞ Merging Extra-Jets: Forming multi-jet mass using jet from FSR and shunning the ISR jets.
- ☞ Extra Jet Cuts: Third jet cuts ($E_T > 8$ GeV) improve S/B but a fraction of signal is lost.



Improving Detector Resolution

$\sim 2/3$ of jet energy carried by charged particles ($\pi^{\pm}, K^{\pm}, \ldots$) but jet algorithm makes no use of Tracking information (CTC).

CTC: $\Delta p/p \simeq 0.002\, p$ CAL: $\Delta E/E \simeq \frac{0.5}{\sqrt{E}}$

☞ Complementary Info from CTC & CAL

PYTHIA Study of the Potential Improvement:

Monitoring how resolution changes from a *perfect detector* condition to *real detector* ($\gamma + jet$ MC events)

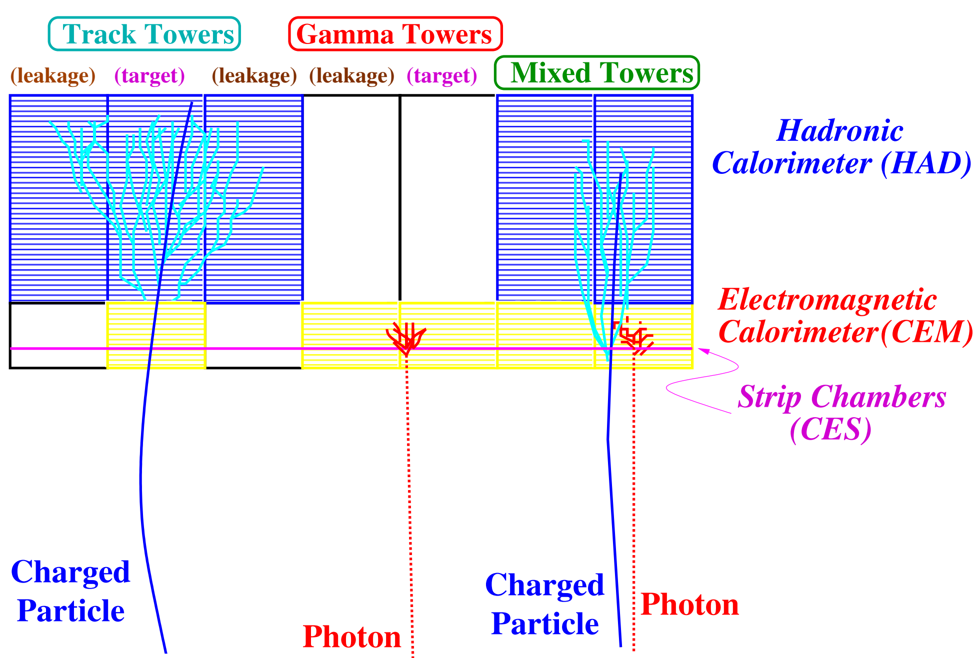
	$P_T^{\gamma} > 15$	$P_T^{\gamma} > 50$ GeV
Perfect Detector	4.8%	1.9%
Perfect but 350 MeV cut	5.1%	2.3%
Perfect ID	7.1%	3.2%
Smear Tracks in CCAL	16%	8.8%
Detector Resolution	19%	11%

✎ Potential $\times 3$ improvement, but achieving *Perfect ID* is difficult (for overlapping π^0,neutrons,...)

Classification Method

Flag towers depending on which kind of particles (γ's or charged) plunge in.

- Track Tower: An associated track but not a Shower Max cluster (i.e. overlapping π^0)
- Gamma Tower: A Shower Max cluster but not an associated track
- Mixed Tower: Both track and CES cluster
- Leakage Tower: Neither, and is adjacent to other energetic tower(s)
- Not Assigned: Neither and isolated



Tower Energy assignment

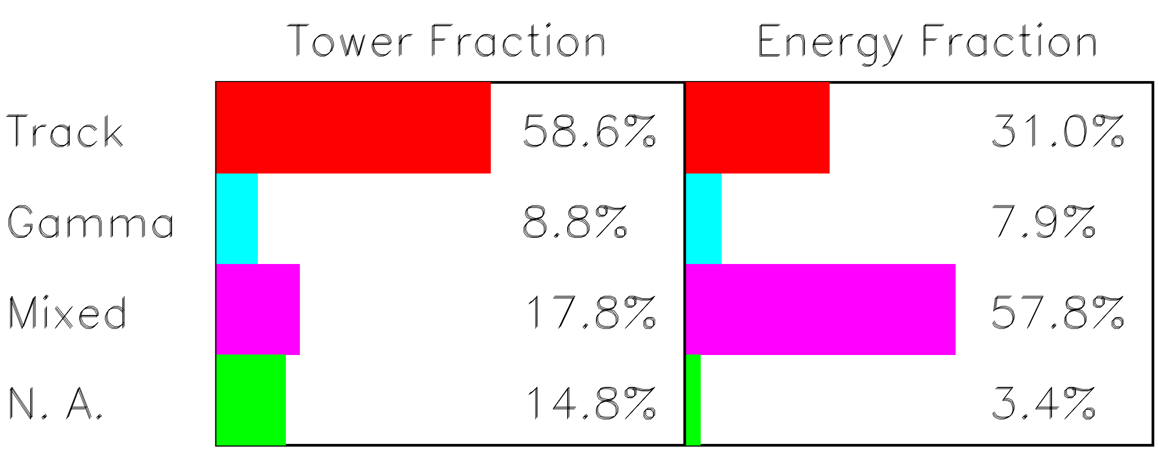
Energy assignments follow naturally:

Track Tower	Track P_T
Gamma Tower	EM Calorimeter
Mixed Tower	Combination:

$$\sum P_T^{\text{trk}} + (\text{CEM - CEM}_{\text{trk}}) + k \cdot \text{HAD}$$

Leakage Tower	0
Not Assigned	(EM + HAD)$\times$ scale factor

Example from Run I γ+ jet data:



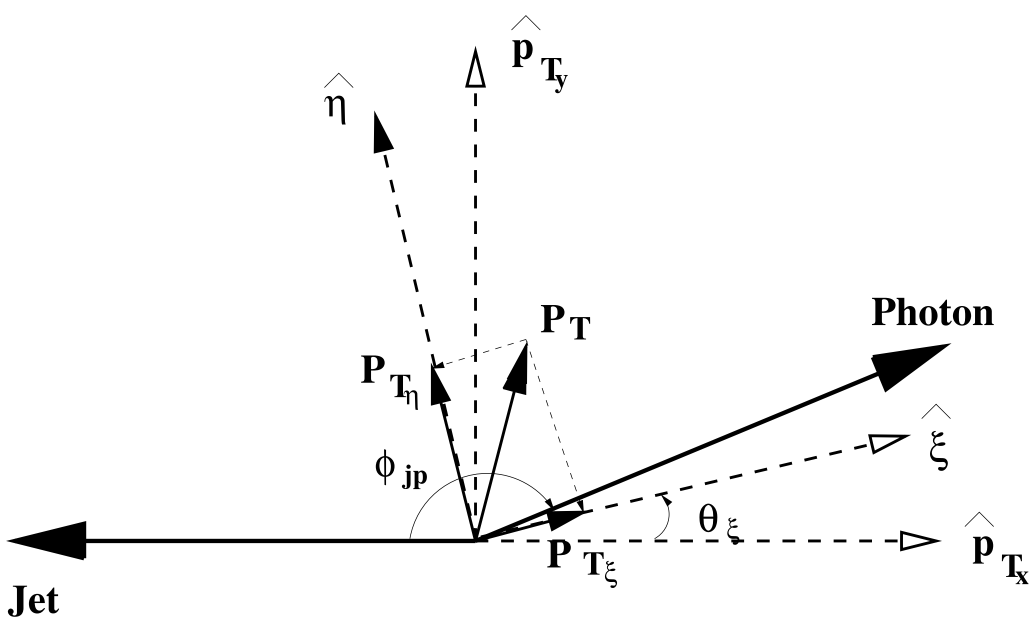
Test on Data

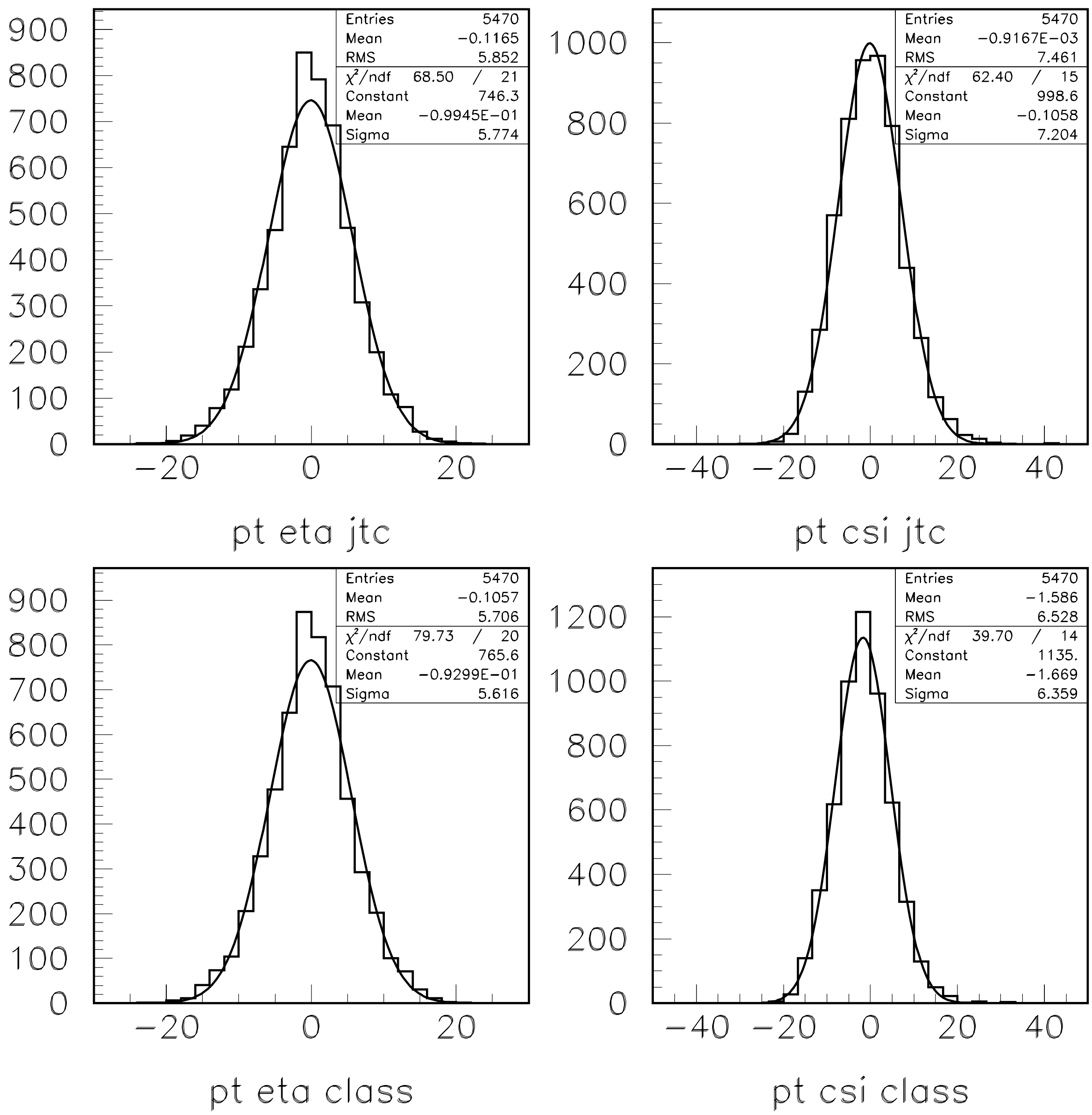
P_T balancing of two back-to-back objects

☞ QCD production of γ+ Jet events

Central γ and Jet $0.1 < |\eta^j| < 0.7$
$25 < P_T^\gamma < 55$ GeV, Only 1 Jet $P_T > 8$ GeV, ≤ 1 VTX
Photon Isolation in 0.4 cone <1 GeV

We use the UA2 "Bisector" method to reduce the gluon radiation effects $\vec{P_T} = \vec{P}_T^{jet} + \vec{P}_T^{\gamma}$

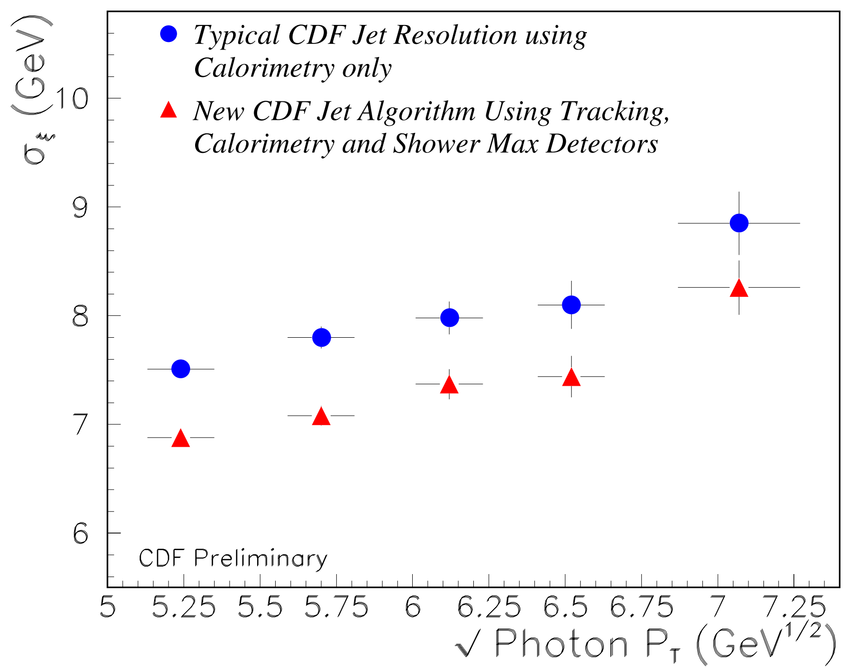




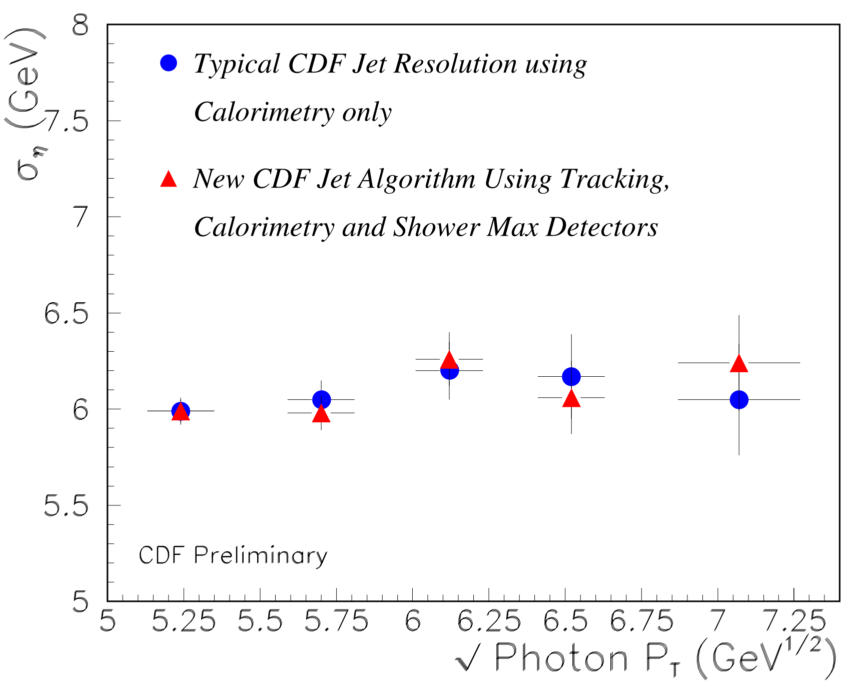
γ-Jet P_T balancing projected along bisectors η and ξ

(Events in 25< P_T^γ <30 GeV bin shown)

P_{T_ξ} sensitive to detector resolution + gluon radiation

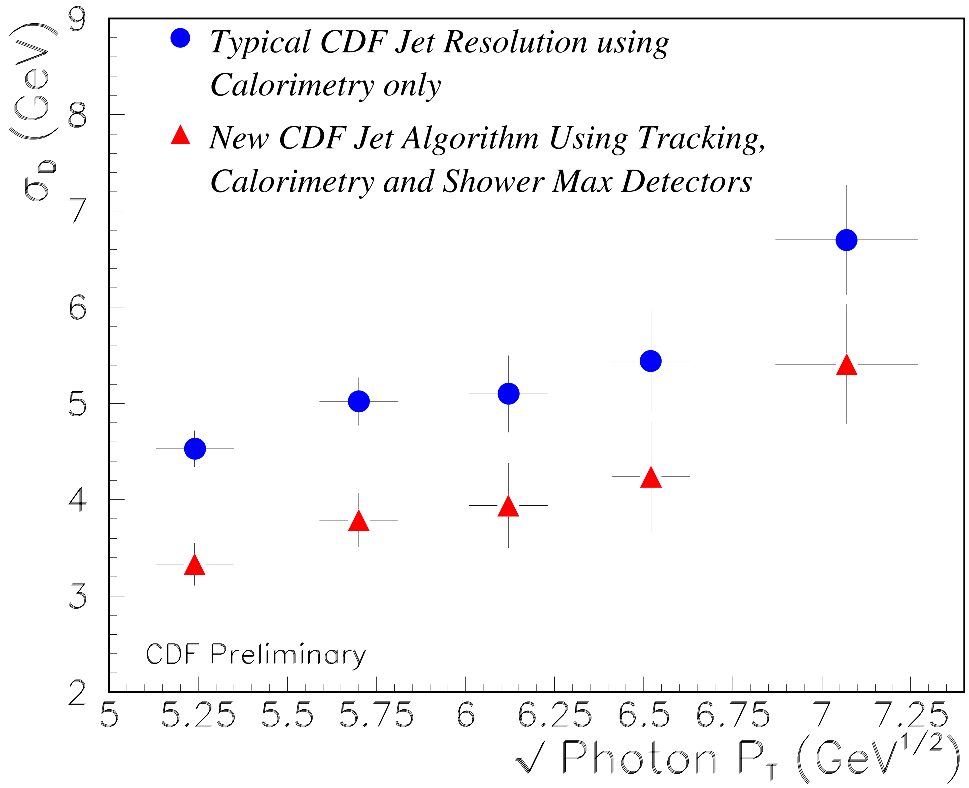


P_{T_η} sensitive to gluon radiation

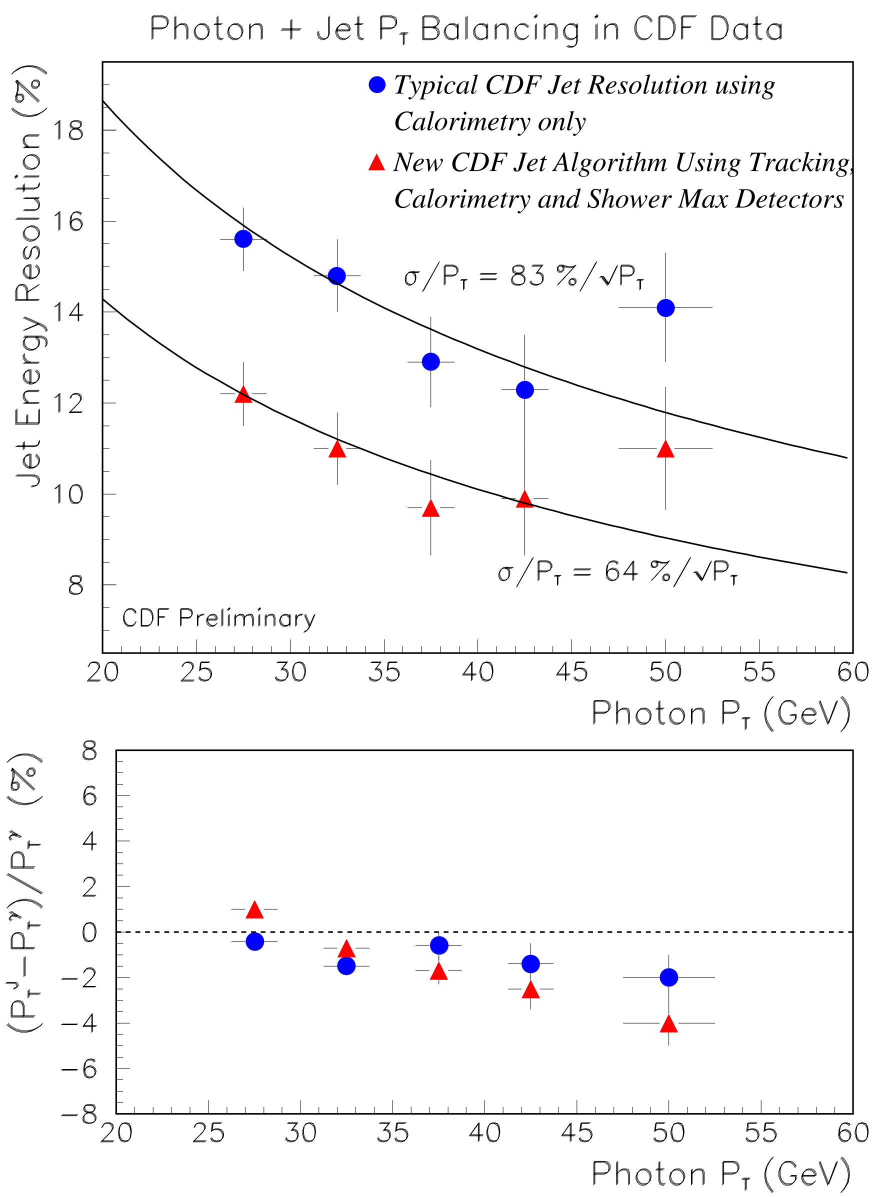


Assuming soft effects are isotropic in azimuth, we can remove that contribution from σ_ξ in quadrature obtaining an effective Detector Resolution σ_D

$$\sigma_D = \sqrt{\sigma_\xi^2 - \sigma_\eta^2}$$



Jet Energy Resolution



Algorithm parameters as a function of the (raw) Jet P_T

Conclusions

We studied Physics and Detector effects and developed a new method to correct for low energy non-linearities of the Central Calorimeter response.

Much more detector information available:

- $R - \phi$ view of Shower Max
- Left-Right PM balance for EM/HAD
- Preshower
- Crack Chambers

We plan to extend it to Plug Calorimeter.
It will be part of official CDF-II software,
resulting in 1 correction word/tower,
☞ independent of the Jet Algorithm