Studies of Jet Energy Resolution at CDF

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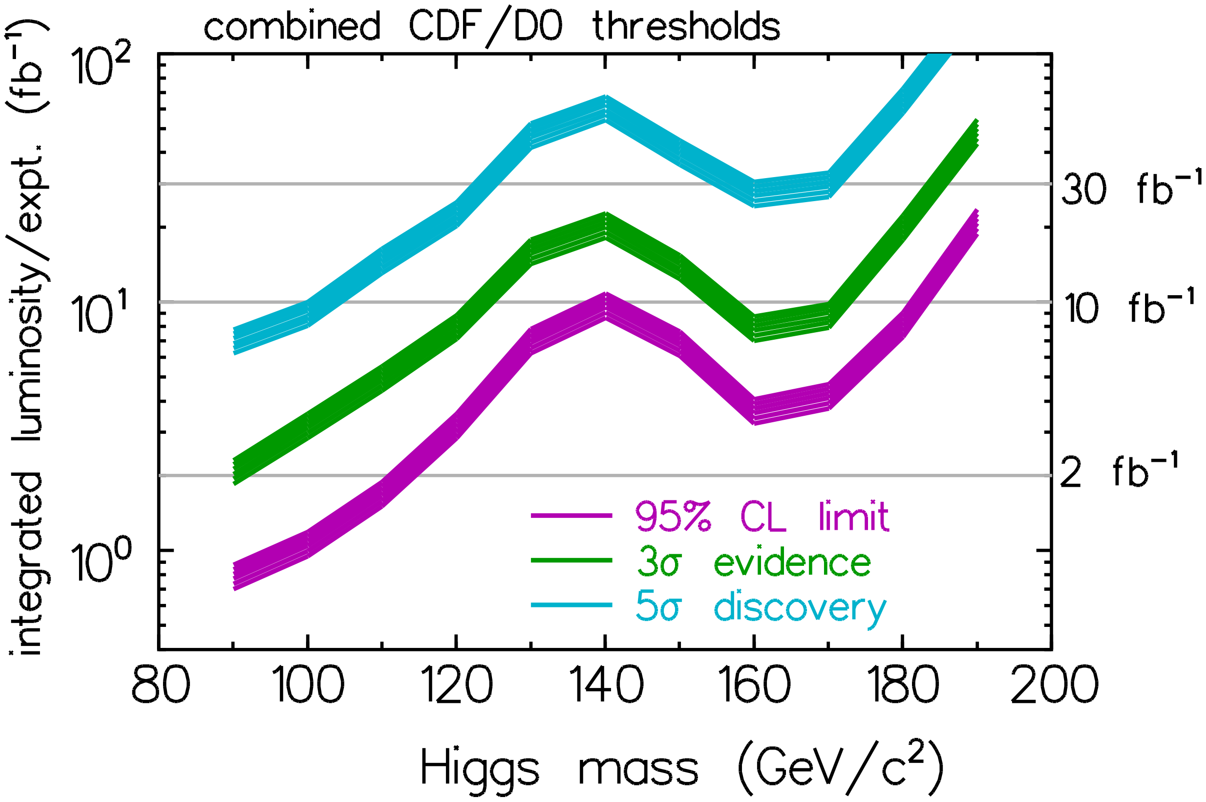
Fermilab Higgs/SUSY Workshop

First comprehensive study for the Run II Higgs search at Tevatron.

`http://fnth37.fnal.gov/higgs.html`

Ultimately the sensitivity will depend on

- ✔ *Amount of integrated luminosity delivered*
- ✔ *Performance of the b-tagging algorithms*
- ☞ Better dijet ($b\bar{b}$) mass resolution

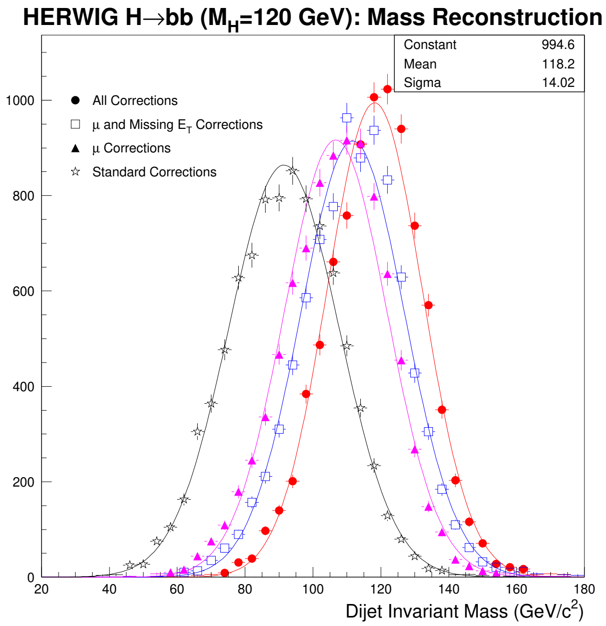


Jet Energy Resolution

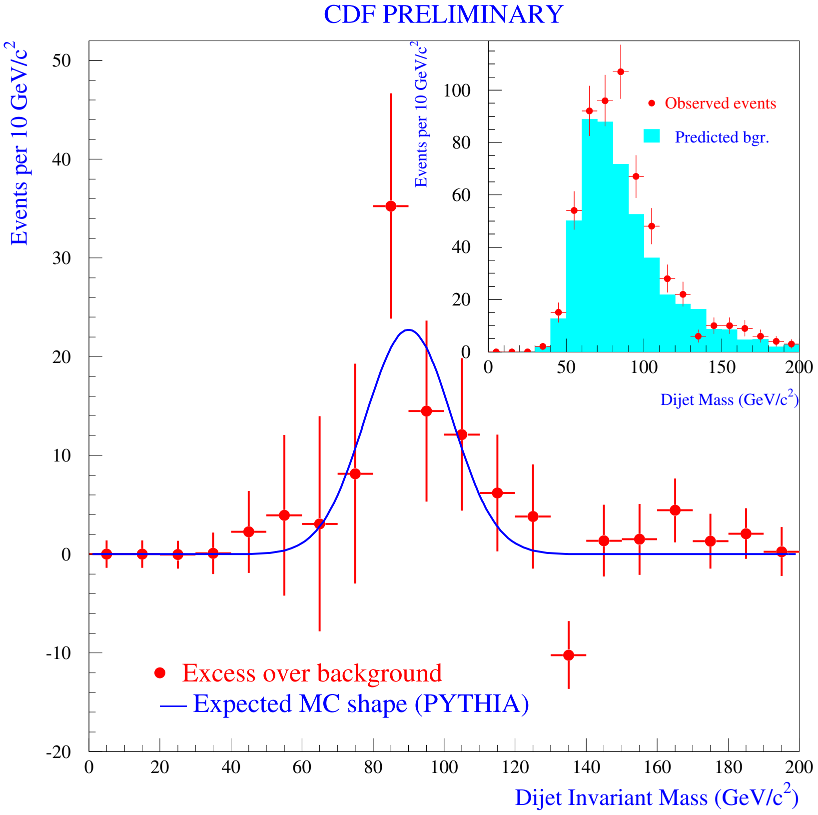
Specific jet corrections

Most useful quantities found:

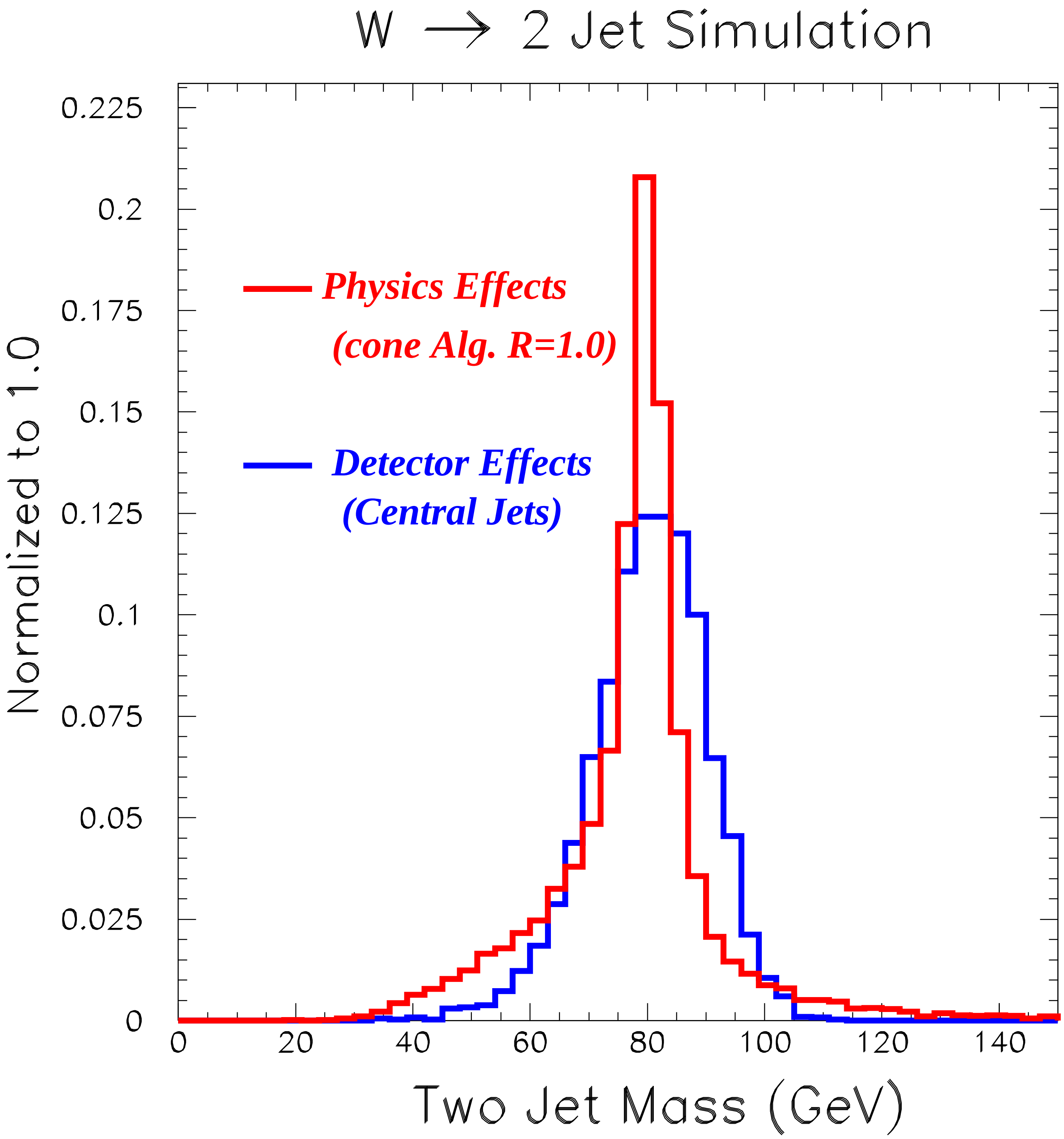
- The muon momentum
- MET projection along each jet
- Jet charged fraction



Applied to Run I data ⇒ We see $Z \to b\bar{b}$:



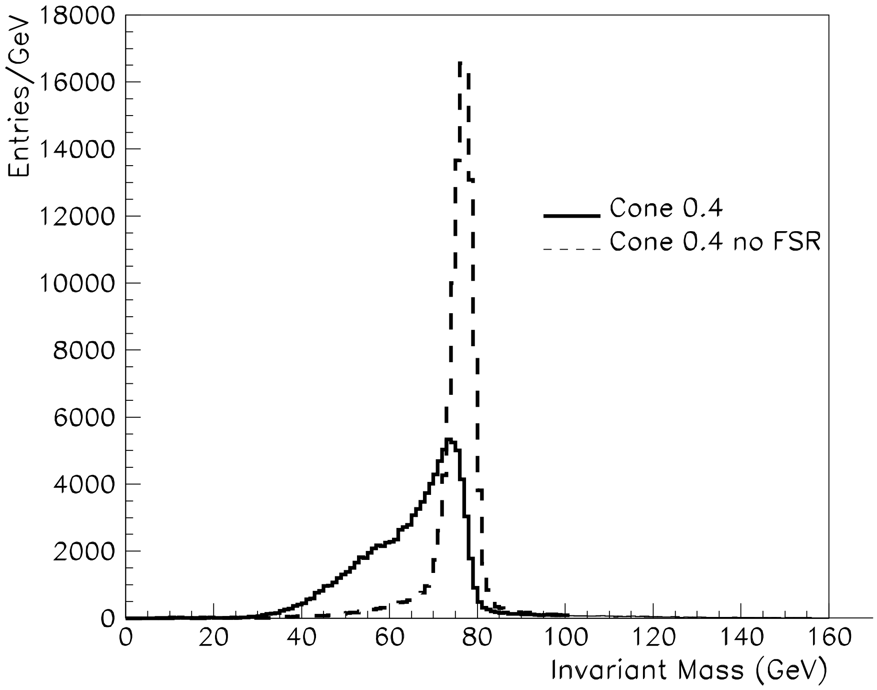
Comparison of Pure Physics Effects and Pure Detectors Effects



Physics Effects

Study at particle level performed in a typical peak-hunting case, $W \to q\bar{q}$. Four main physics effects:

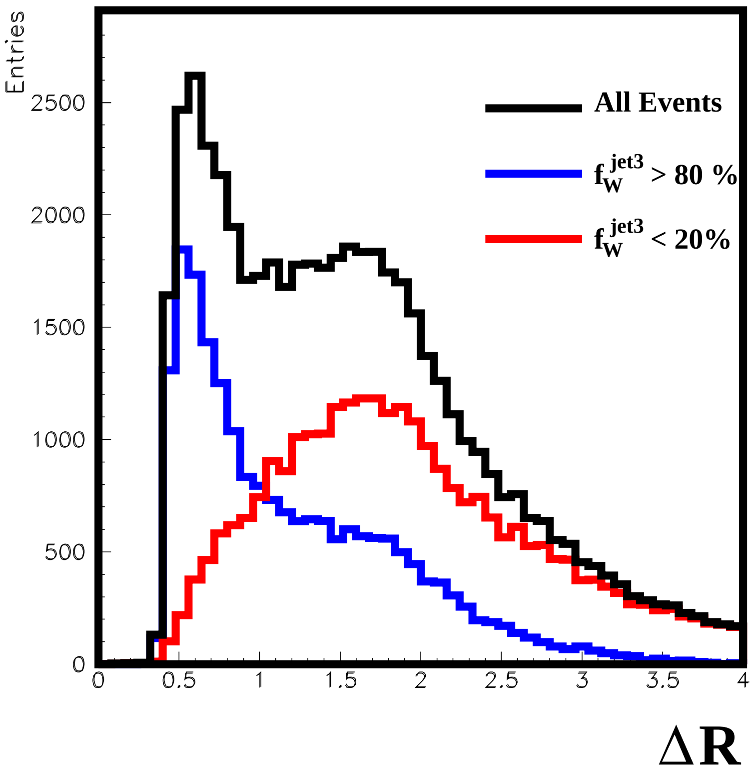
- The natural Width of the W
- Underlying event fluctuation (Mainly gaussian contribution)
- Final State Radiation (FSR)
- Misidentified jets from initial state gluon radiation (ISR)



The FSR study

In order to reduce low-mass tail, we investigate the following:

- **Algorithm Effects:** "Cone", "K_T" and *ad hoc* "ABC" algorithms have been compared and they were found to be equivalent (at least 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 ($E_T > 7$ GeV) improve S/B but a fraction of signal is lost.



Improving Detector Resolution

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

CTC: $\Delta p/p = 0.002p$ CAL: $\Delta E/E = \frac{0.8}{\sqrt{E}}$

☞ Complementary Information 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)

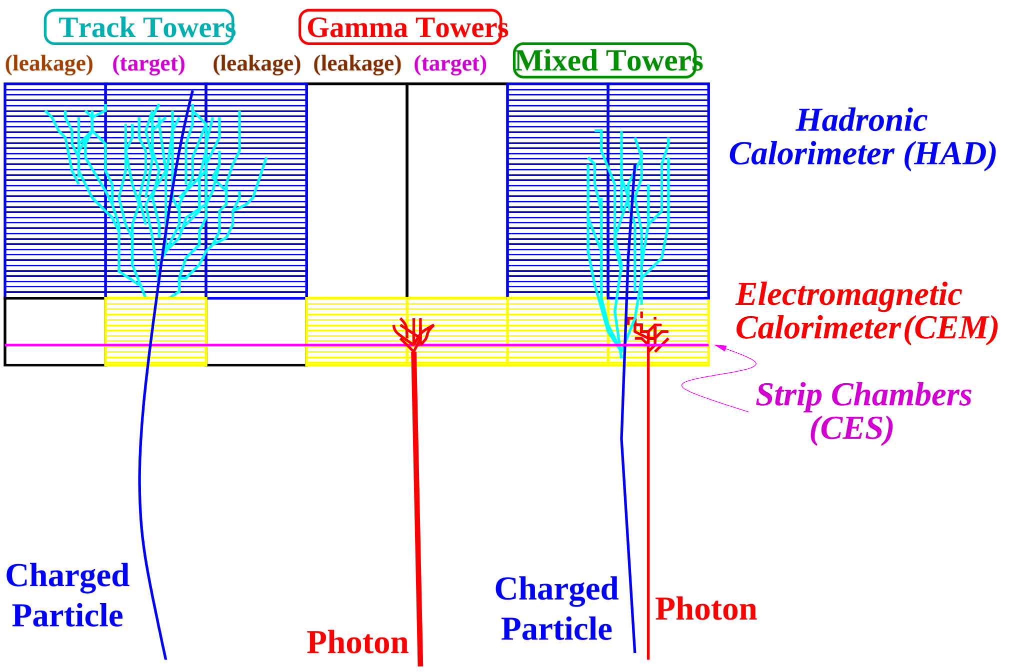
	$P_T^{\gamma} > 15$ GeV	$P_T^{\gamma} > 50$ GeV
Perfect detector	4.8%	1.9%
Perfect but 350 MeV cut	5.1%	2.3%
Perfect ID	7.1%	3.2%
Tracks Nominal, $80\%/\sqrt{E}$	16%	8.8%
Detector resolution	19%	11%

✎ Potential $\times 3$ improvement, but achieving *Perfect ID* is difficult (problems with 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 (indicating an 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
Leakage Tower	0
Not Assigned	(EM + HAD)$\times$ scale factor

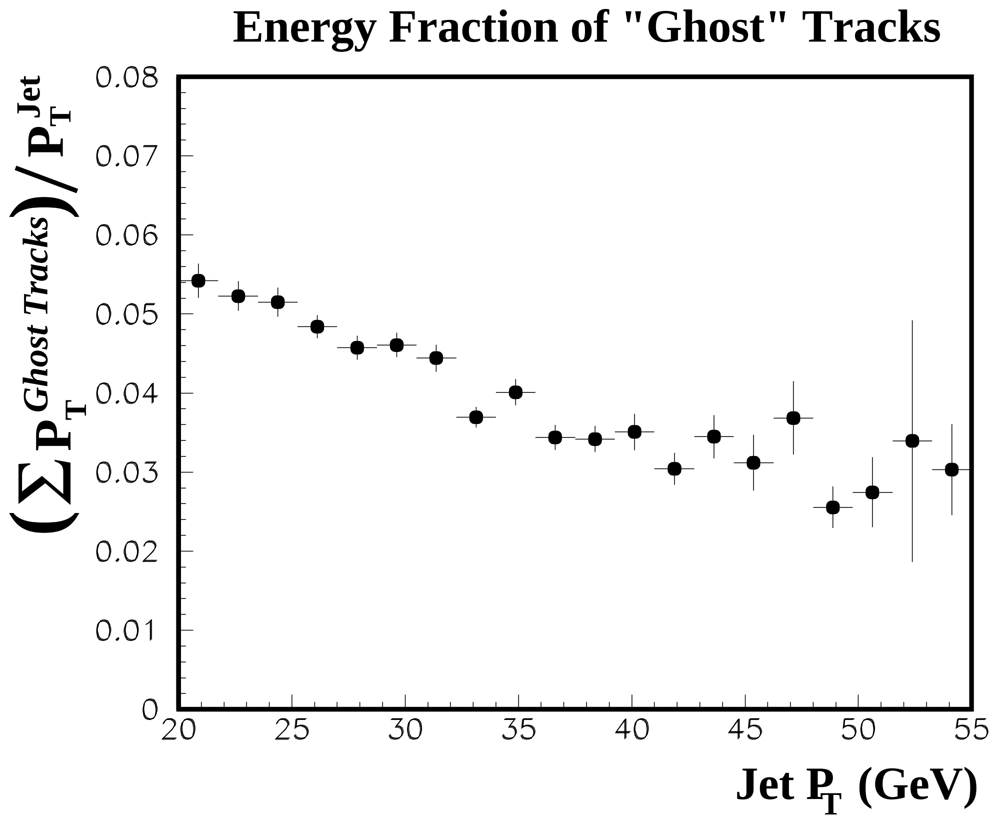
	Fraction	Energy
Track	58.60 %	31.00%
Gamma	8.8%	7.9%
Mixed	17.8%	57.8%
N. A.	14.8%	3.4%

Tracks to Non-Energetic Towers

Sometimes a track is associated to a tower with *no energy deposit* in both CEM and HAD (cracks, stoppage into the coil,...)

The classification method *recovers* this energy from *"Ghost"* tracks figuring their P_T in.

✎ This energy is otherwise lost in a calorimeter only reconstruction!



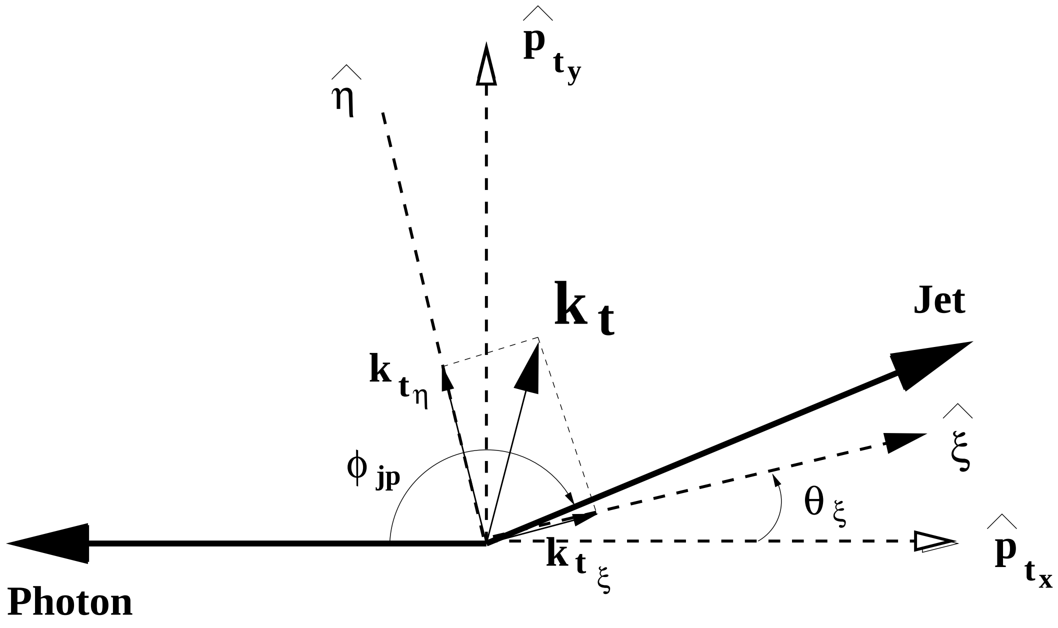
Test New Algorithms on Data

No Perfect Way to Do This

- Test dijet mass resolution on Run I data is difficult, only few events
- Other methods involve P_T balancing of two back-to-back object

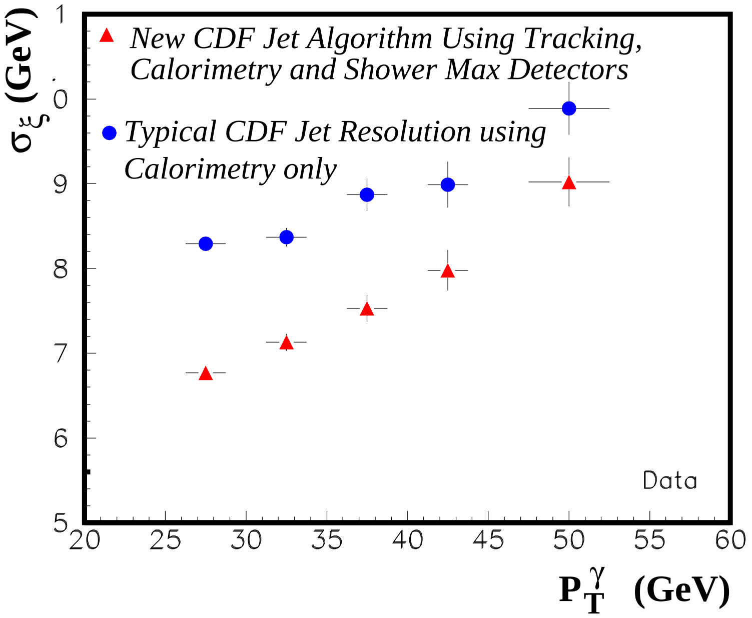
☞ For Now QCD production of γ+ jet Events

We use the UA2 "Bisector" method to reduce the gluon radiation effects ($\vec{k_t} = \vec{P}_t^{jet} + \vec{P}_t^{\gamma}$)

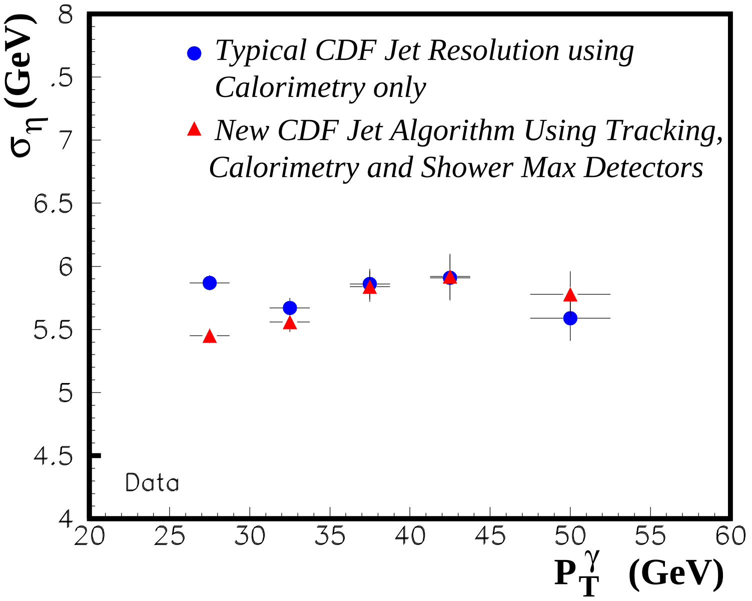


k_t Component Distributions

k_{t_ξ} component is sensitive to detector resolution + gluon radiation



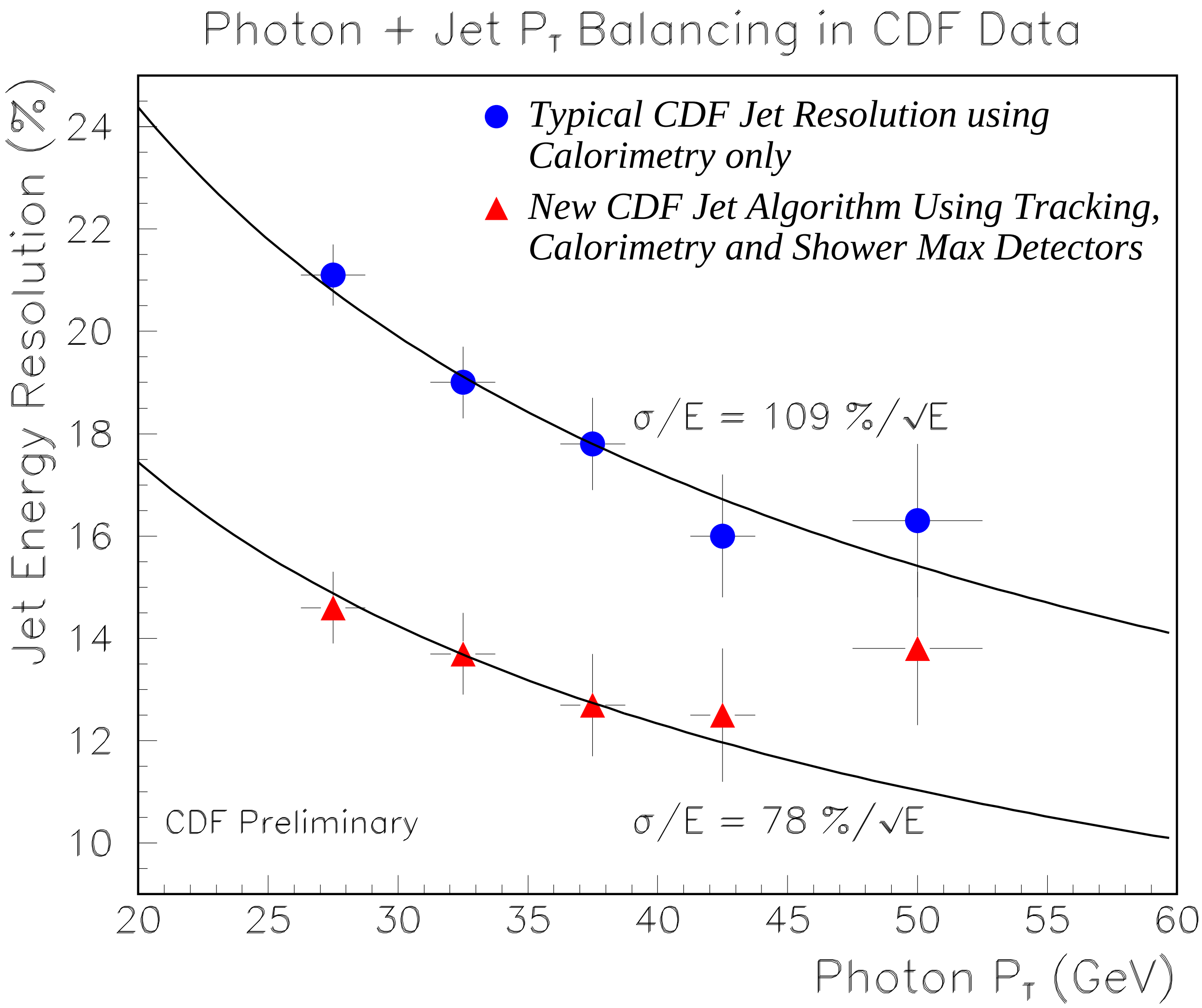
k_{t_η} component is sensitive to gluon radiation



Detector Resolution: σ_D

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

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



Current Projects:
Beyond The Previous Analysis

<u>Much more detector information to use:</u>

- $z - \phi$ view of shower max
- Hadron calorimeter in classification
- EM Phototube balance
- HAD phototube balance
- Preshower
- Crack Chamber