Improving Higgs Sensitivity with Calorimeter Cell Weighting at DØ

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- Motivation
- The Jet Energy Resolution Working Group at DØ
- The DØ Calorimeter
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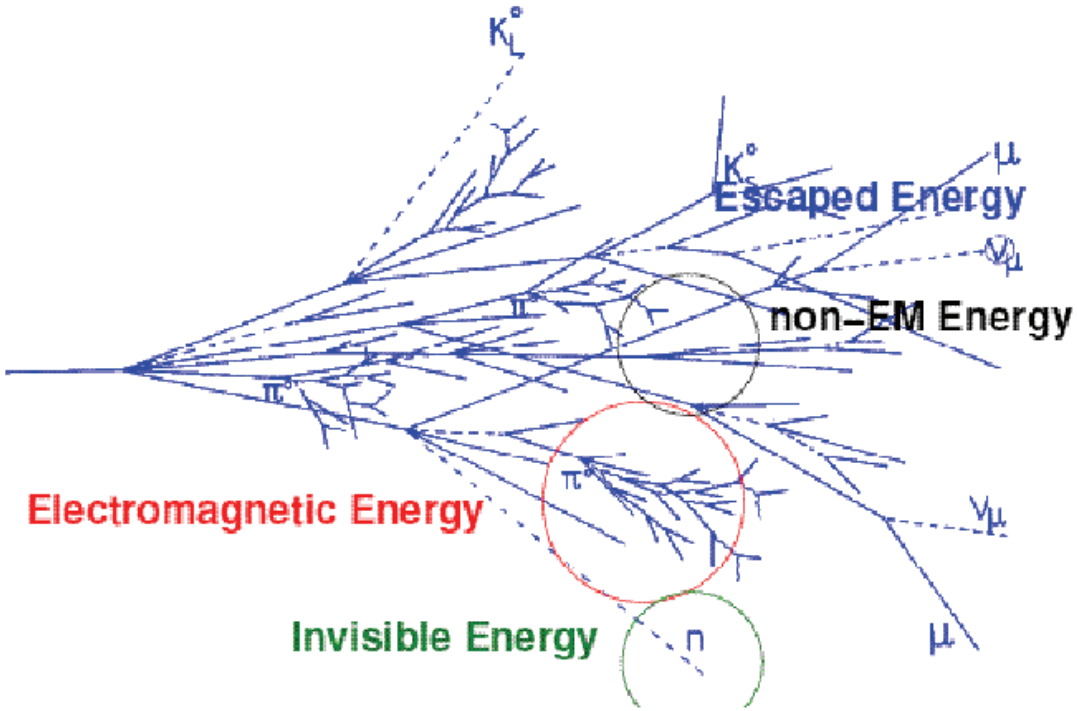
- Summary

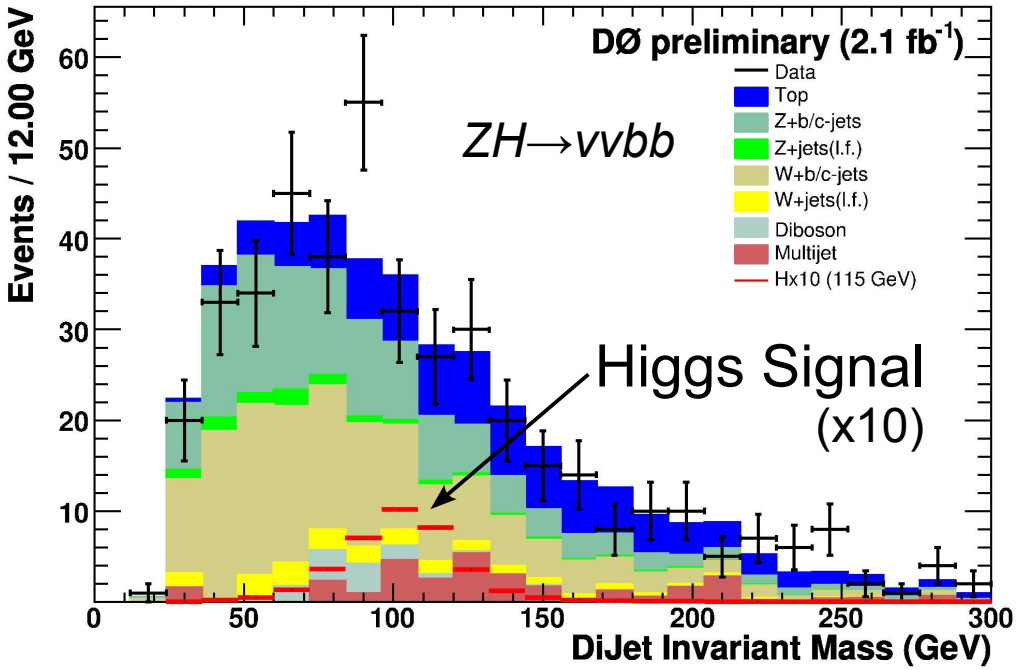


A typical hadronic shower: *~50% EM deposits, ~25% non-EM, ~25% invisible energy*

image by J. Proudfoot

Motivation

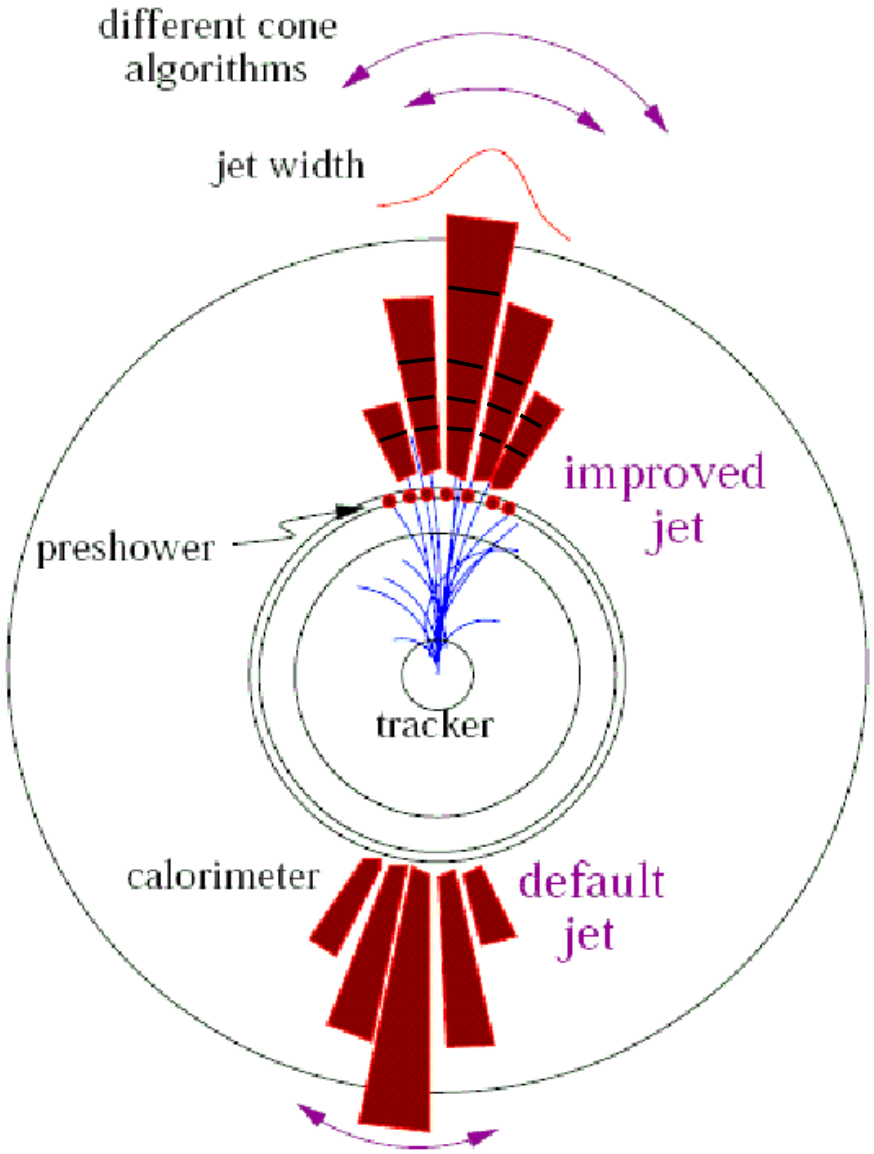
- Jet energy resolution → dijet mass resolution → *Higgs sensitivity*



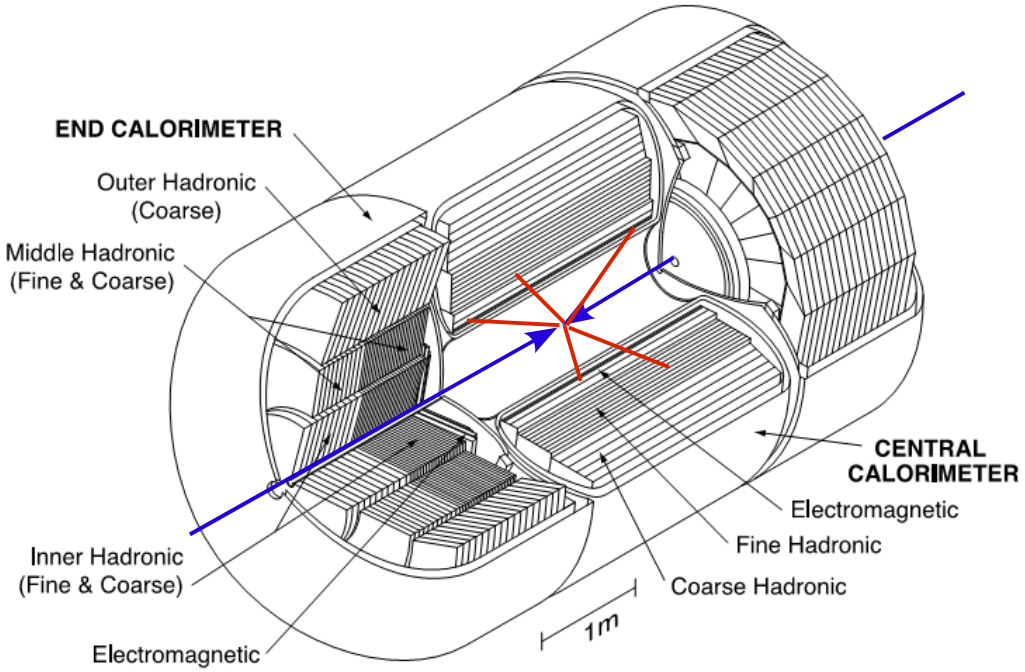
- Jet energy resolution also very important for top mass & many other analyses involving jets
- Overall aim is to improve quality of physics program at DØ

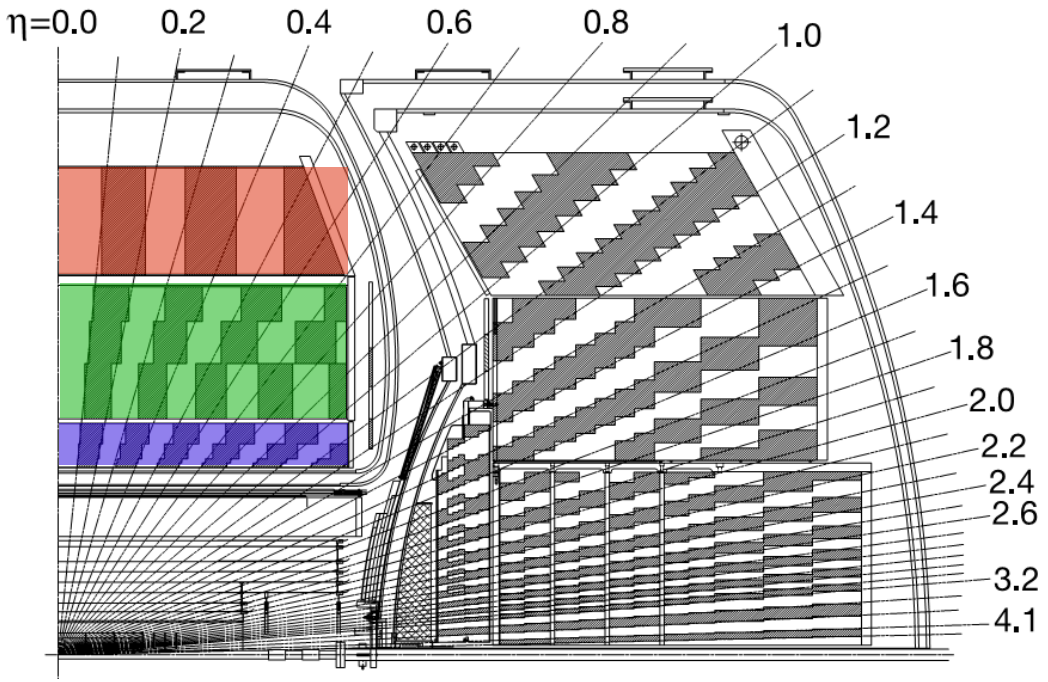
The DØ Jet Energy Resolution Working Group

- Adding extra detector information to the default calorimeter jet
  - Preshower
  - Tracks
  - Muons
- Improving treatment of calorimeter information
  - Cell Weighting
  - Jet Width / Cone Size
  - *b*-Jet Response
- Correcting to parton level (*b*-jets)
  - Semileptonic Decay
  - Multivariate Approaches



The DØ Calorimeter

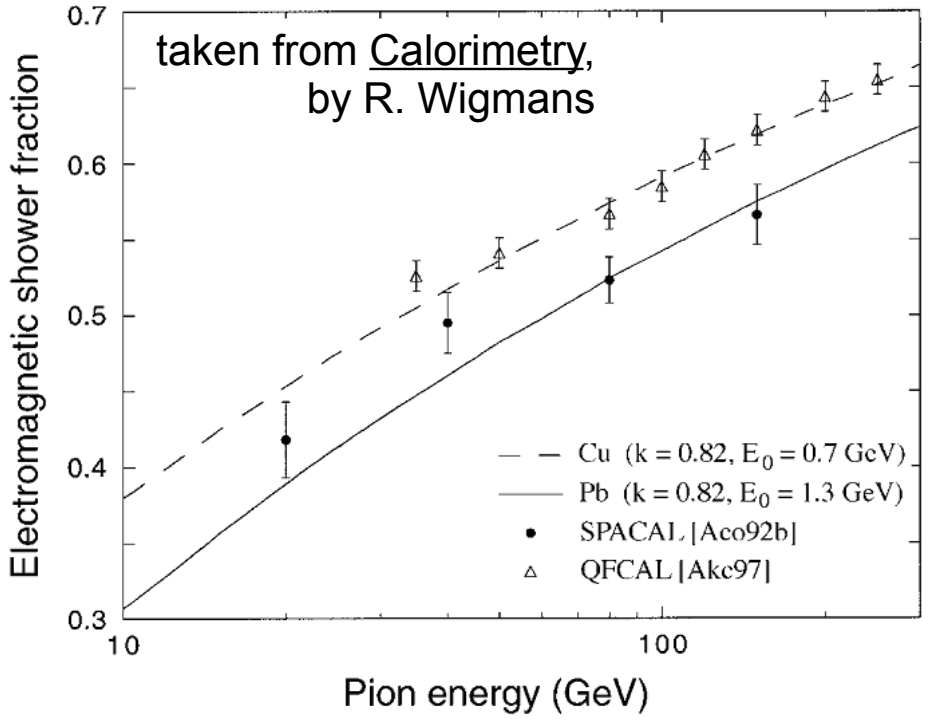


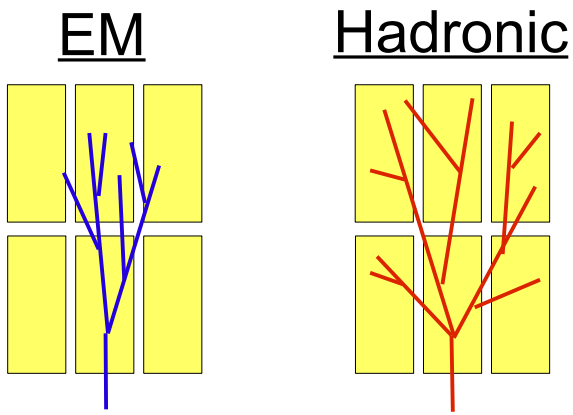


- Liquid argon active medium, mostly uranium absorber plates
- Divided into EM, fine hadronic & coarse hadronic layers, with varying absorber composition and cell depth
- Composed of cells roughly 0.1x0.1 in η-φ space, with transverse size comparable to typical shower size
- Jet reconstruction: cone algorithm groups towers of energetic cells

Introduction to Cell Weighting

- Jet deposits include both EM showers and hadronic showers; EM fraction increases with jet energy
- DØ's calorimeter no longer compensates for energy lost in hadronic showers—cells respond less to hadrons than to EM particles (e/h > 1)
- *Central concept: find which cells have hadronic deposits, boost their energies to compensate for difference in response*
- Use cell energy to discriminate between hadronic and EM deposits in cells with similar properties

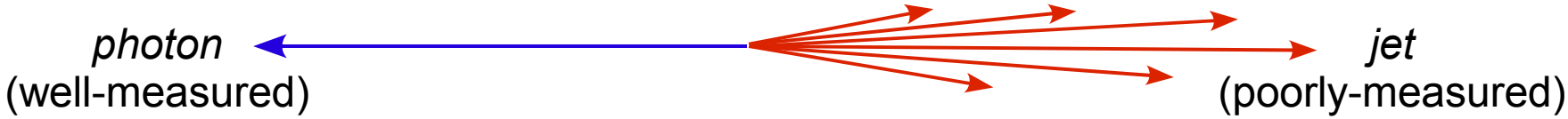




Hadronic showers deposit less energy per cell

Our Implementation of Cell Weighting

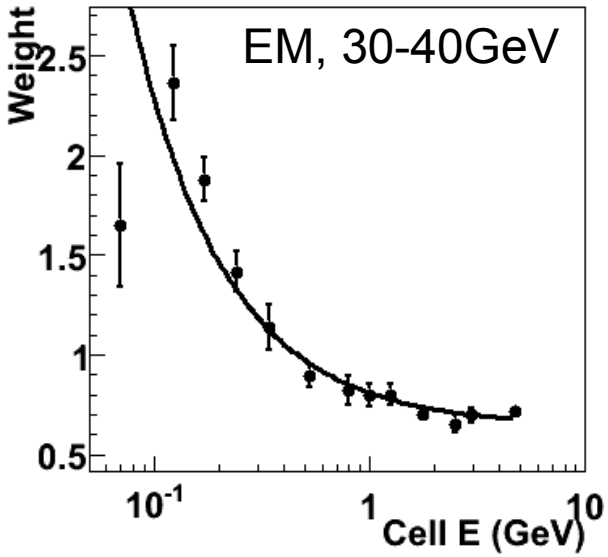
- Method based on work done in H1 [Wellisch et al, 1994]
- Want to minimize jet energy resolution to derive cell weights $w(E_{cell}, E_{jet}, \text{cell type})$—weighted jet energy is $\Sigma_{\text{cells in jet}}\ w(...)*E_{cell}$
- Minimized quantity: $X^2(w) = \langle(\Delta E(w))^2\rangle + \lambda*\langle E(w) - E_{raw}\rangle$
  - ΔE: measure of departure of weighted E from "true" jet E
    - In MC simulation, can cheat by using particle jet E
    - In γ+jet data, photon provides true jet E estimate: $E' = p_T^{\gamma}*\cosh(\eta^{jet})$

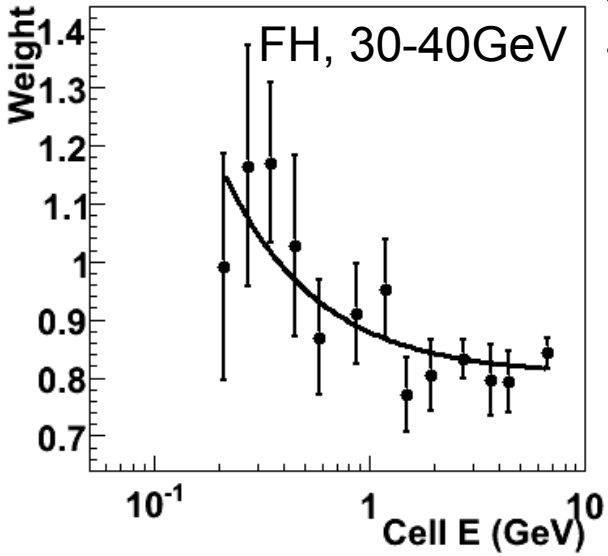


  - Lagrange multiplier term preserves jet energy scale
- 3 cell types: EM, fine hadronic (FH), coarse hadronic (CH)
- Bin in cell energy & jet energy, then fit to recover continuity

Weight Trends vs. Cell Energy

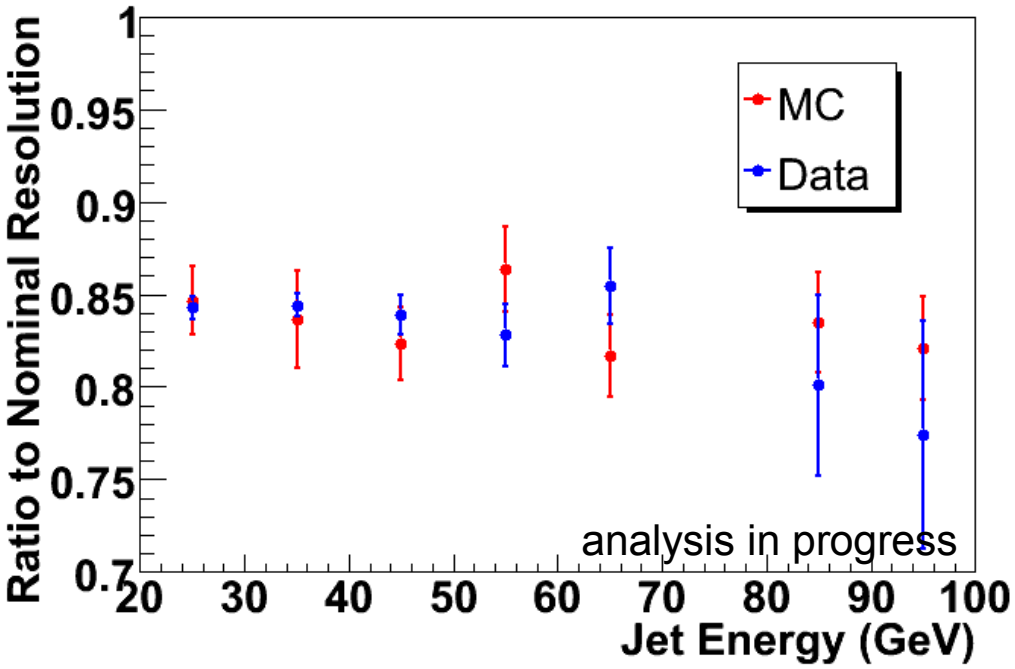
- Weights derived with simulated data, using particle jet energy
- As expected, weights highest at low cell energy—low-energy cells more likely to have hadronic deposits
- Weights reach asymptote at high cell energy—highest-energy cells very likely to have EM deposits
- FH weights smaller than EM, since FH already designed for hadronic showers
- Poor fit at low cell energy due to noise, pileup, multiple interactions

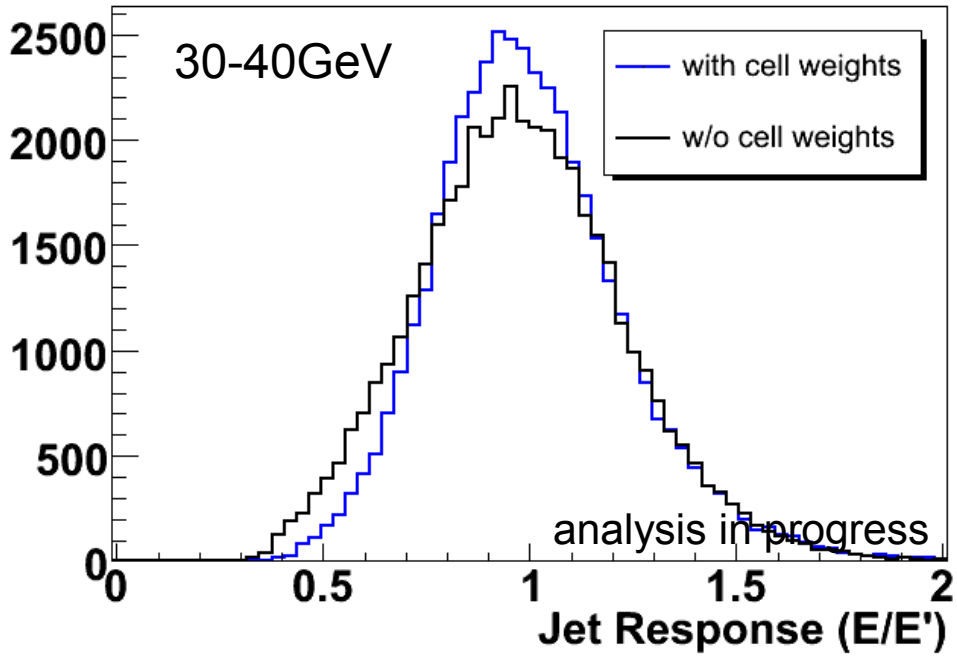




analysis in progress

Results in Photon+Jet Events





- ~15% improvement in data, but...
- Method used here only works for photon+jet events—used photon p_T even when applying weights
- Work is ongoing to make method more broadly applicable
- Realistic goal: 10% improvement in jet energy resolution

Summary

- DØ is pursuing many techniques for improving Higgs limits and strengthening physics program
- Improving the jet energy resolution is crucial for low-mass Higgs searches and many other physics analyses
- Cell weighting improves resolution by performing off-line compensation for energy lost in hadronic showers
- Work is ongoing to broaden our method while maintaining 10% improvement in real data