SiD: Separating Detector Performance from PFA Confusion

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LCWS08 11/17/08

Overview

- Calibrations
- Perfect pattern recognition
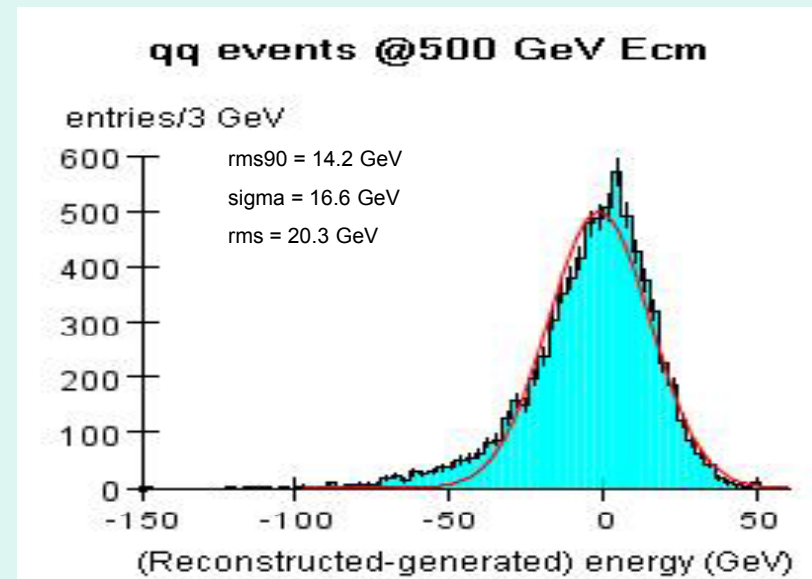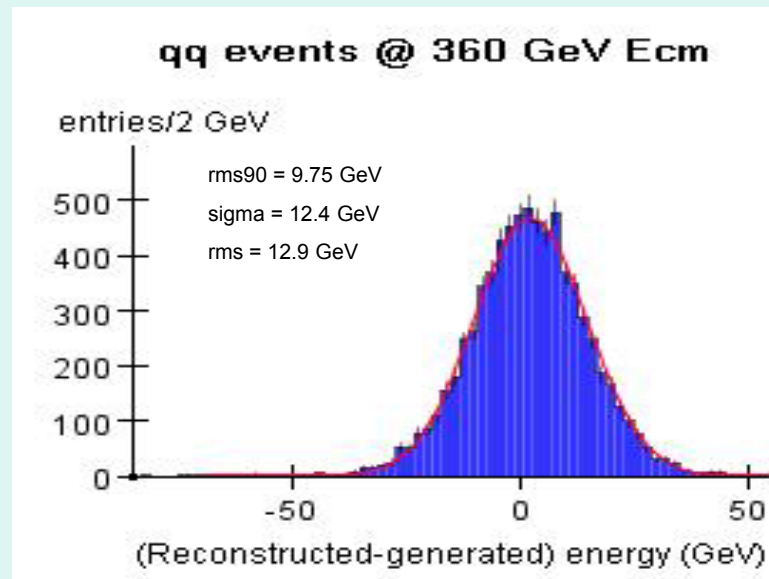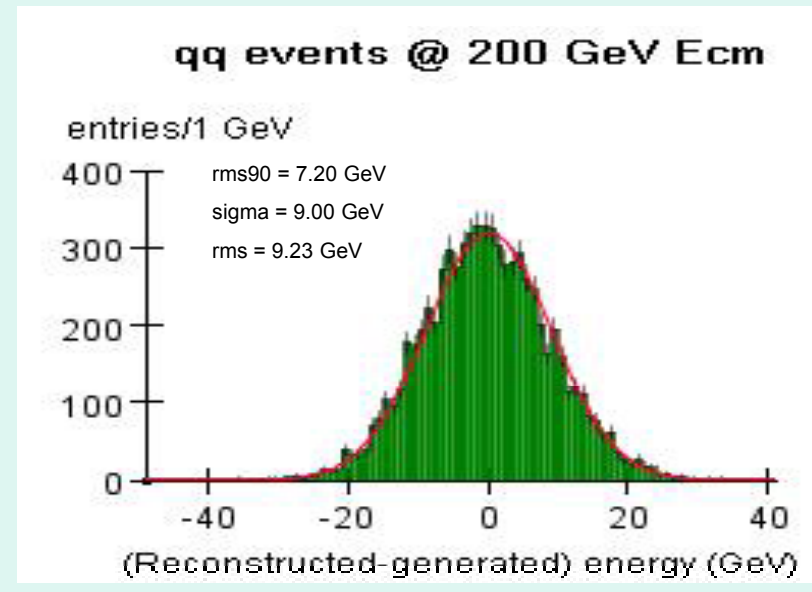- Efficiency and purity of hit assignments
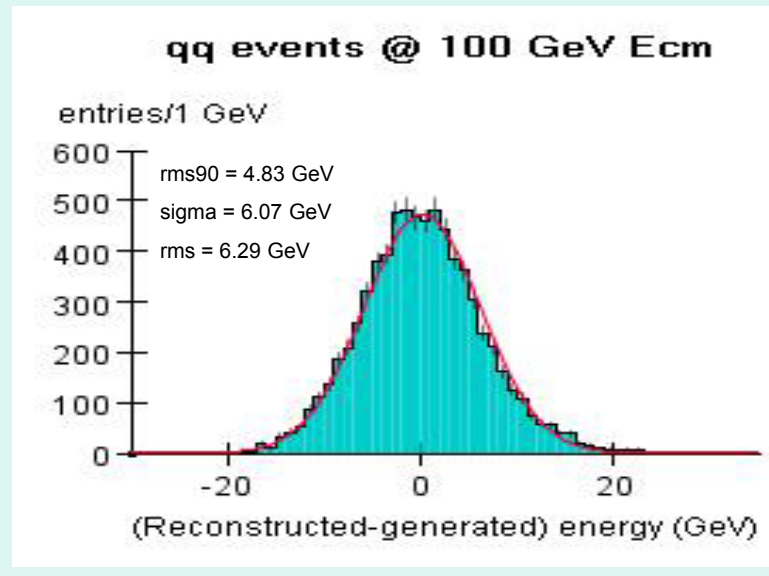- Summary

Calibrations

- Simple sampling fractions – provide a single sampling fraction per (sub)calorimeter. Allows an estimate of cluster energy independent of source.

- Particle type dependent calibration – provide conversion from a set of calorimeter hits (cluster) to energy assuming known source (photon or hadron).

Simple sampling fractions:procedure
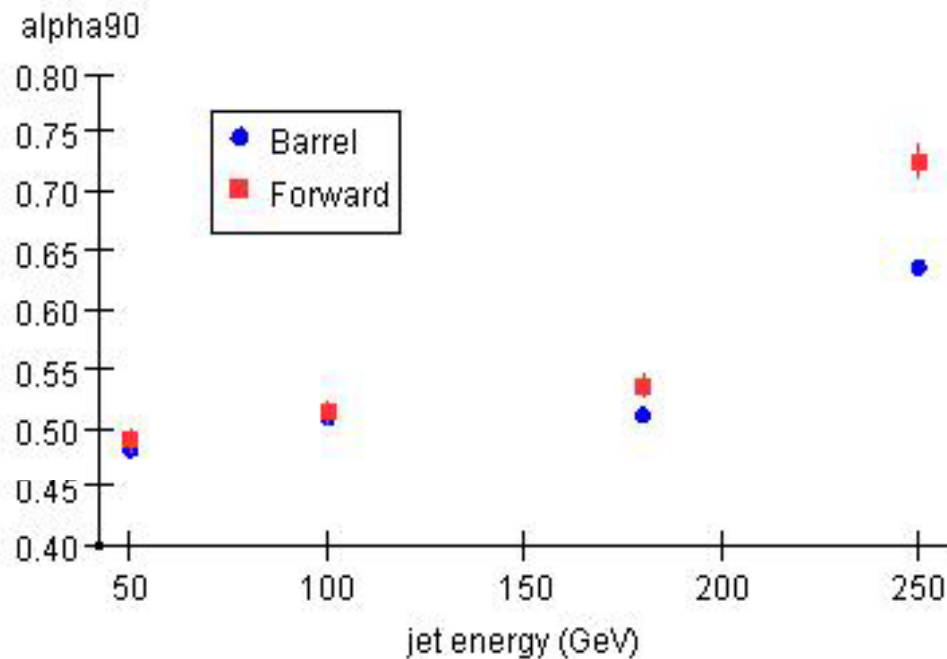
- Look at qq events at fixed energies (q = uds).

- No radiation, no prompt neutrinos, total energy known.

- Sum energy deposits for each calorimeter per event.

- Use equal # events from Ecm = (100,200,360,500) GeV.

- Fit for sampling fractions minimizing dE/sqrt(E).

- * caveat: The digital calorimeters have a significant polar
  angle dependence, which is included in following results.

Simple sampling fractions: results

qq events @ 100 GeV Ecm

entries/1 GeV

rms90 = 4.83 GeV
sigma = 6.07 GeV
rms = 6.29 GeV

(Reconstructed-generated) energy (GeV)

qq events @ 200 GeV Ecm

entries/1 GeV

rms90 = 7.20 GeV
sigma = 9.00 GeV
rms = 9.23 GeV

(Reconstructed-generated) energy (GeV)

qq events @ 360 GeV Ecm

entries/2 GeV

rms90 = 9.75 GeV
sigma = 12.4 GeV
rms = 12.9 GeV

(Reconstructed-generated) energy (GeV)

qq events @500 GeV Ecm

entries/3 GeV

rms90 = 14.2 GeV
sigma = 16.6 GeV
rms = 20.3 GeV

(Reconstructed-generated) energy (GeV)

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Simple sampling fractions: results
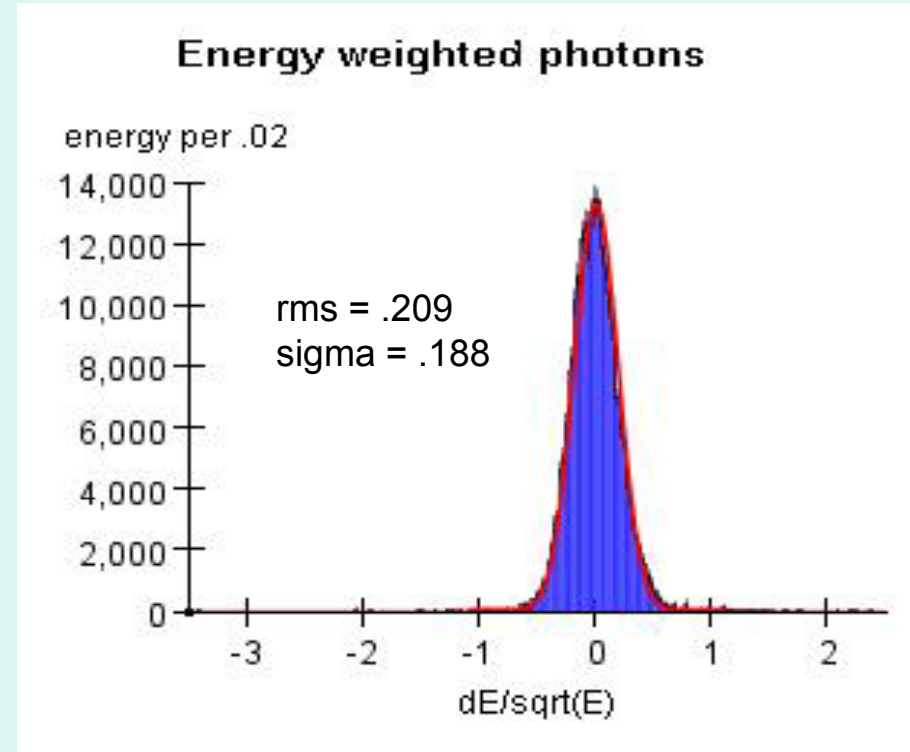

sid02: Calorimetry only: alpha90 vs jet energy

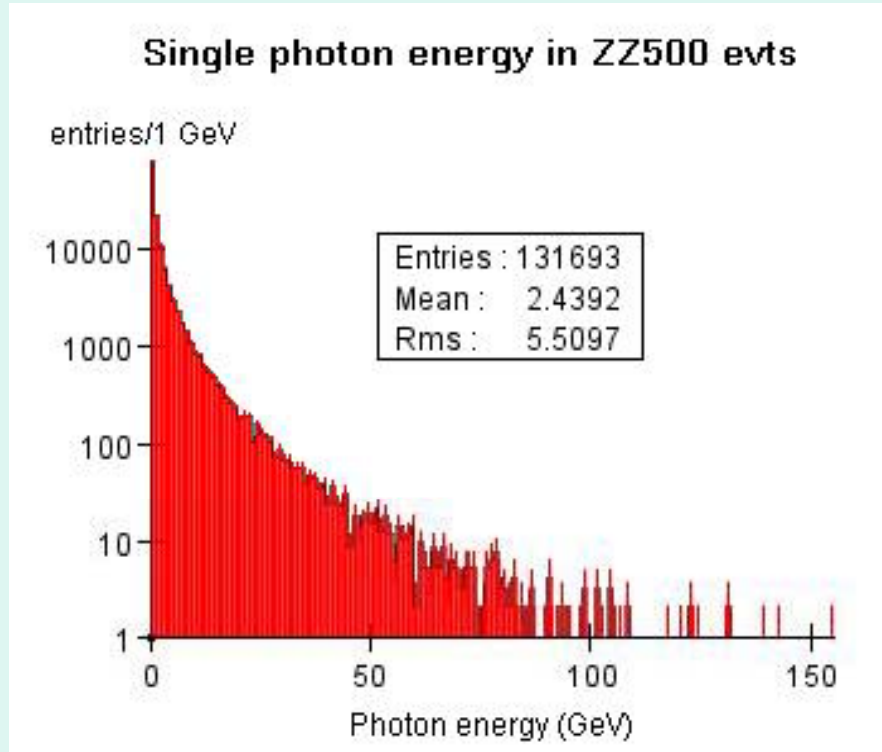- Until leakage becomes significant (beyond 180 GeV jets), sid02 behaves as ~ 50%/sqrt(E) calorimetric detector. (Using rms90).
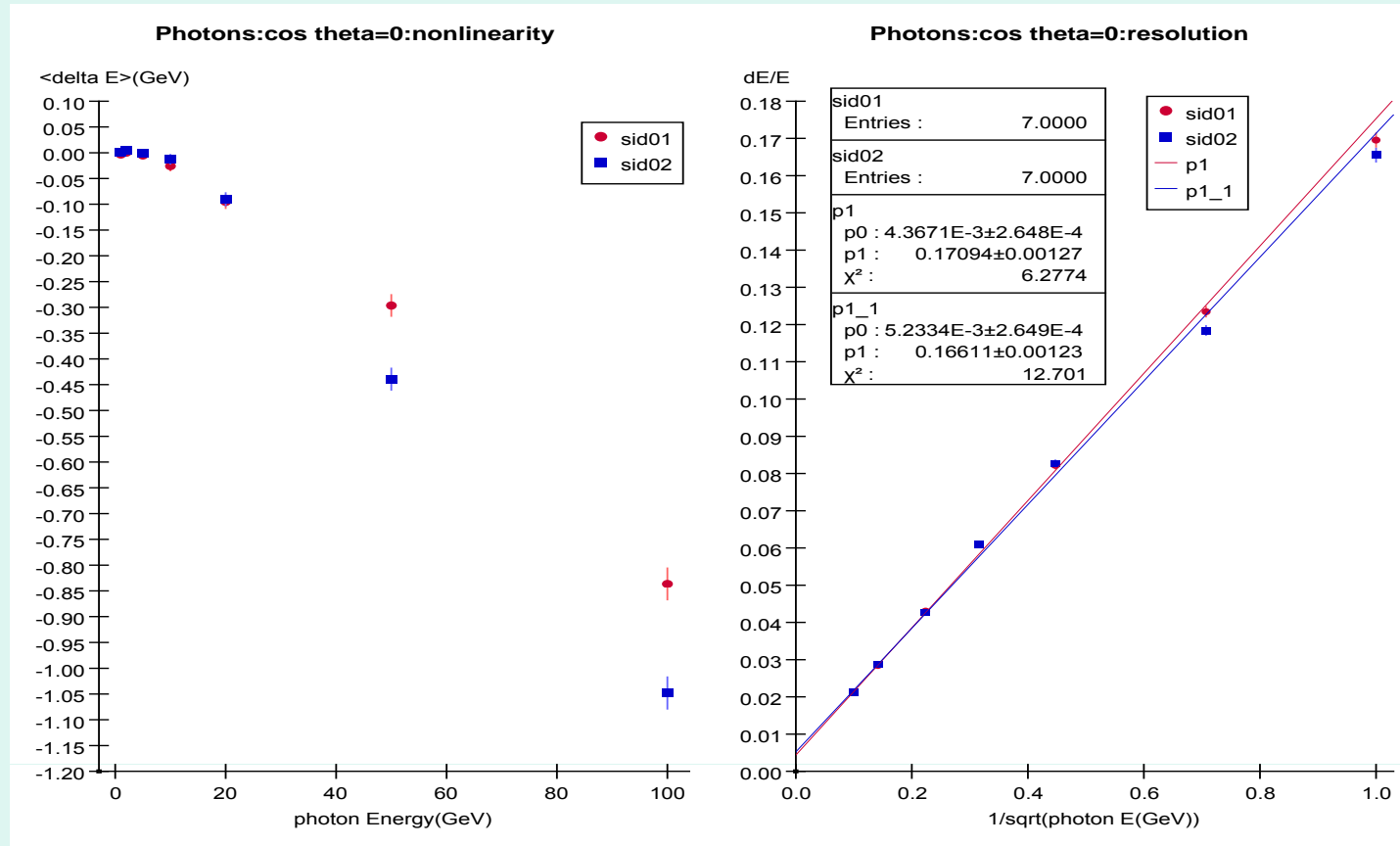
Calibration: procedure

- Calculate sampling fractions separately for photons and neutral hadrons.

- For neutral hadrons, add a nonlinearity correction.

- What energy, angle, particle type distribution?

- Use particles from ZZ events at 500 GeV.

- Check photon results with single photons.

- Check neutral hadron results with n,nbar and k0l in 1:1:2 ratio.

Calibration results: Photons
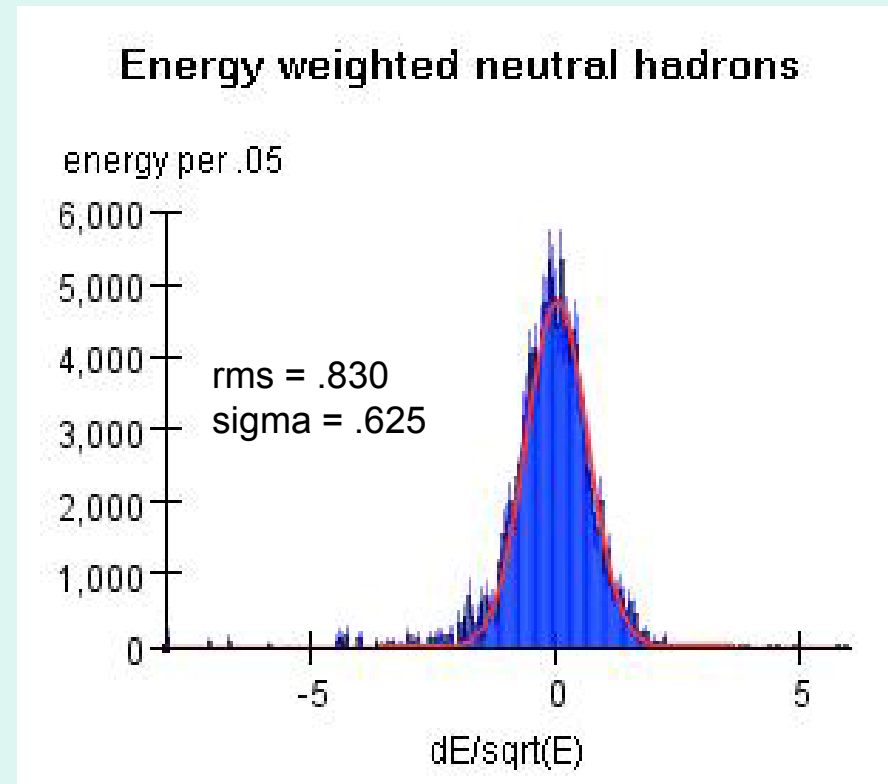

Single photon energy in ZZ500 evts

entries/1 GeV

Entries : 131693
Mean :   2.4392
Rms :   5.5097

Photon energy (GeV)

Energy weighted photons

energy per .02

rms = .209
sigma = .188

dE/sqrt(E)

- Effective photon resolution of 19%

Single photons at 90 degrees

Photons:cos theta=0:nonlinearity

<delta E>(GeV)

- sid01
- sid02

photon Energy(GeV)

Photons:cos theta=0:resolution

dE/E

sid01
Entries : 7.0000

sid02
Entries : 7.0000

p1
p0 : 4.3671E-3±2.648E-4
p1 : 0.17094±0.00127
χ^2 : 6.2774

p1_1
p0 : 5.2334E-3±2.649E-4
p1 : 0.16611±0.00123
χ^2 : 12.701

- sid01
- sid02
— p1
— p1_1

1/sqrt(photon E(GeV))

Calibration results: Neutral hadrons

single neutral hadron energy in ZZ500 evts

entries/1 GeV

Entries : 13559
Mean : 11.709
Rms : 16.204

neutral hadron energy (GeV)
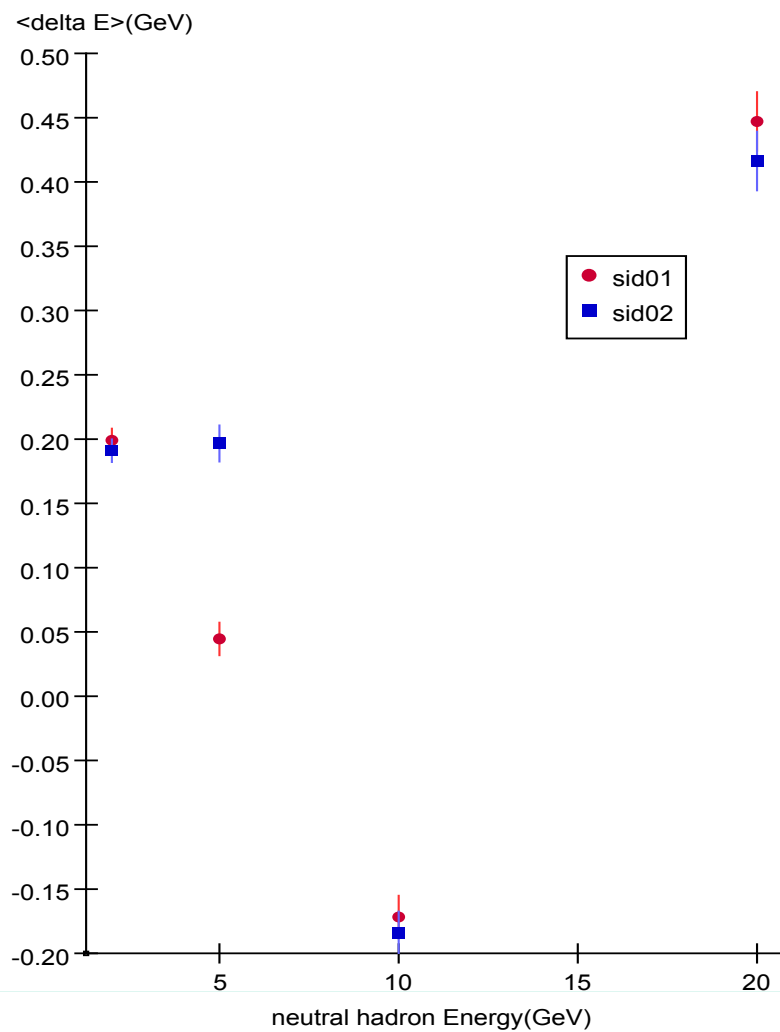
Energy weighted neutral hadrons

energy per .05

rms = .830
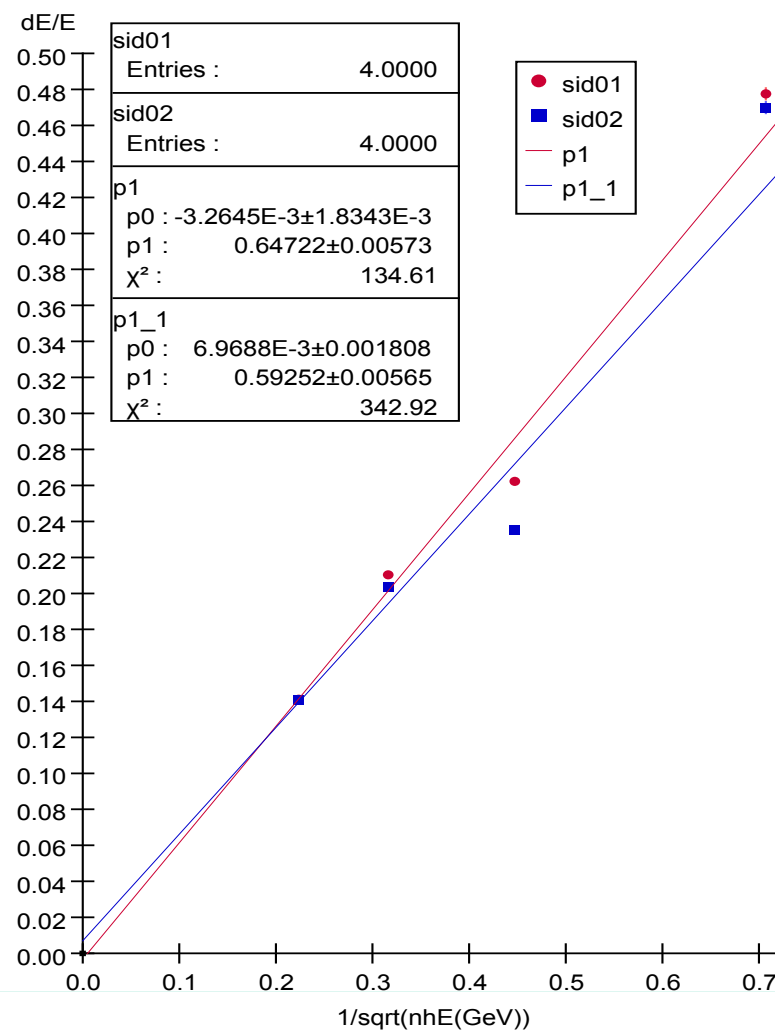sigma = .625

dE/sqrt(E)
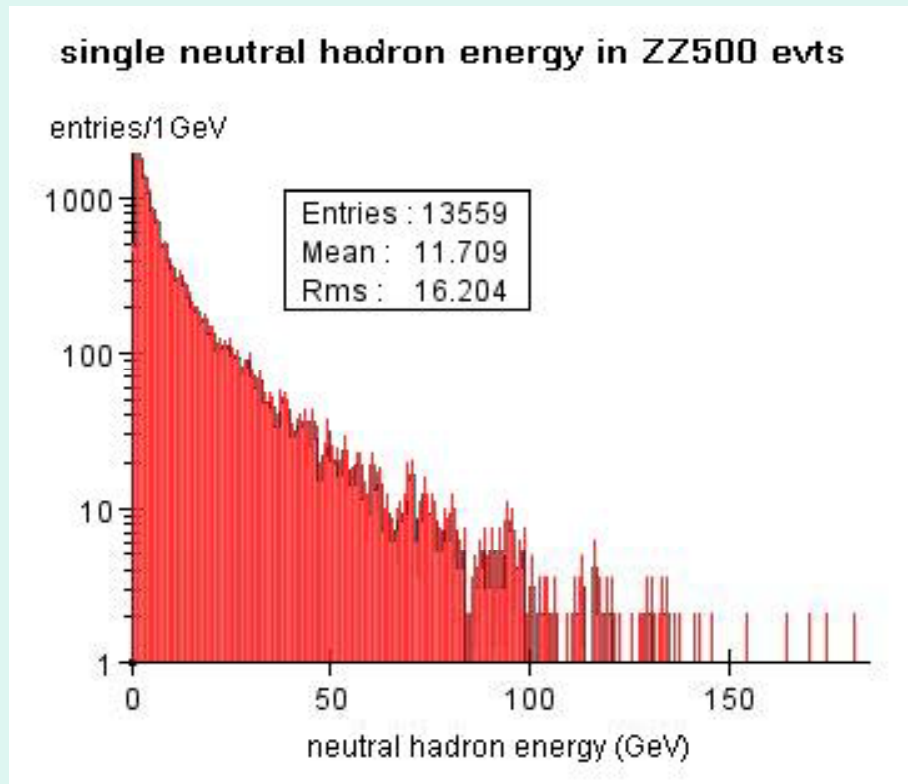
- Effective neutral hadron resolution of 63%

Neutral hadrons at 90 degrees

Neutral hadrons:cos theta = 0:nonlinearity

<delta E>(GeV)

Neutral hadrons:cos theta=0:resolution

dE/E

sid01	
Entries :	4.0000
sid02	
Entries :	4.0000
p1	
p0 : -3.2645E-3±1.8343E-3	
p1 : 0.64722±0.00573	
X^2 :	134.61
p1_1	
p0 : 6.9688E-3±0.001808	
p1 : 0.59252±0.00565	
X^2 :	342.92

sid01
sid02
p1
p1_1

sid01
sid02

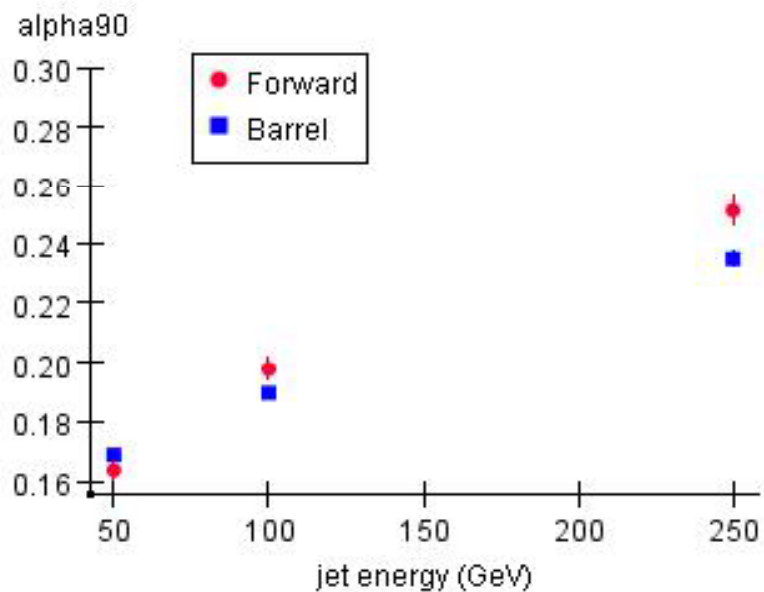neutral hadron Energy(GeV)

1/sqrt(nhE(GeV))
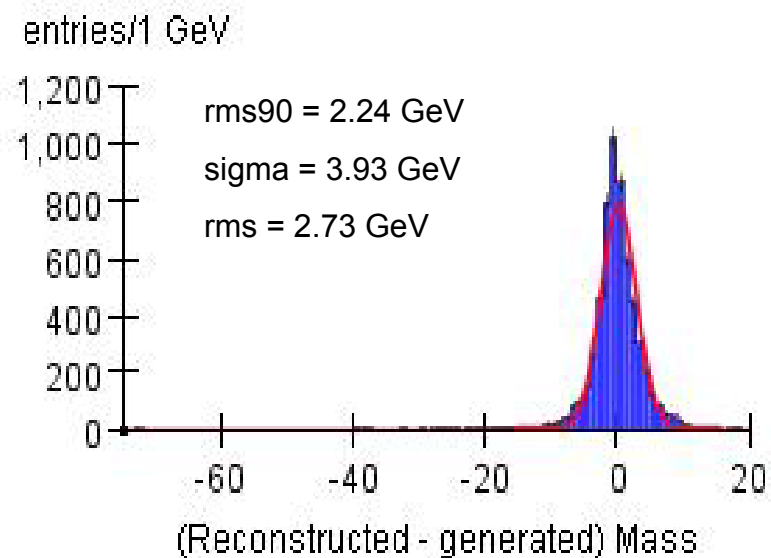
Perfect pattern recognition reconstruction

- Cheat tracking

- Cheat clustering

- Final state particles?

- Use previously described calibration.
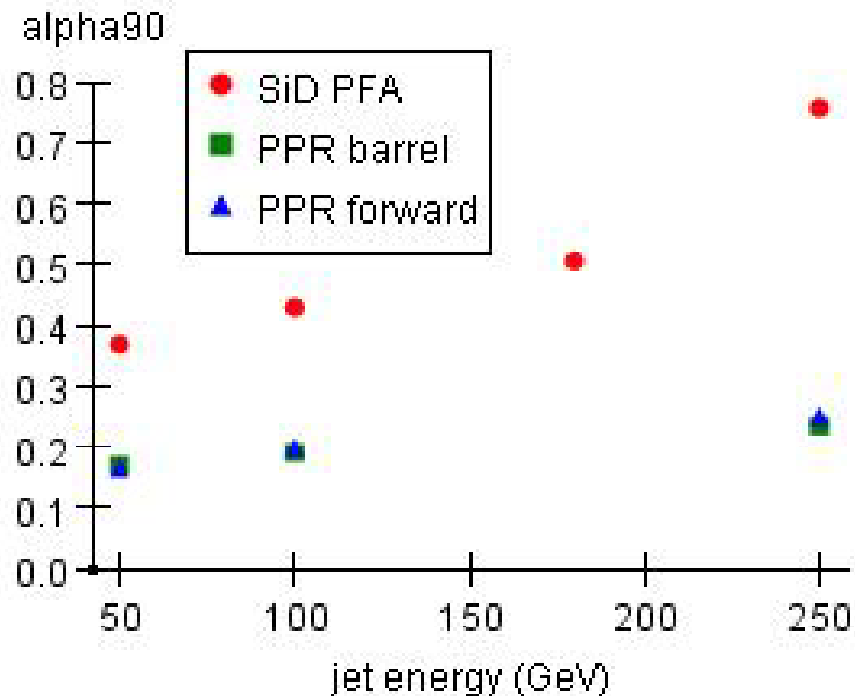
PPR Results

PPR: sid02: qq events @ fixed energy

alpha90

- ● Forward
- ■ Barrel

jet energy (GeV)

PPR: sid02: Mass residuals in ZZ500 events

entries/1 GeV

rms90 = 2.24 GeV

sigma = 3.93 GeV

rms = 2.73 GeV

(Reconstructed - generated) Mass

- (dM/M)90 = 2.46%

Current SiD PFA performance

sid02: jet energy resolution

- Still a wide gap.
- Same calibration.
- Potential for significant improvement through pattern recognition.

From Mat in April

Confusion matrix

- Output from Ron's diagnostic routines shows where all of the energy is going:

| ZZ	Truth: photon	Truth: tracked particle	Truth: neutral hadron	Sum
Reco: photon	108,368	5,979	4,247	118,594 Purity: 91.4%
Reco: tracked particle	8,679	227,475	15,539	251,693 Purity: 90.4%
Reco: neutral hadron	6,905	22,673	42,666	72,244 Purity: 59.1%
Unused	1,037	9,177	2,214	12,428
Sum	124,989 Effic: 86.7%	265,304 Effic: 85.7%	64,666 Effic: 66.0%	

Diagonal elements: correct ID
Off-diagonal elements: mis-identified energy
Charged-neutral confusion especially bad...

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Current performance

$e^+e^- \to Z(\nu\nu) \, Z(qq)$ @ 500 GeV for sid01 (q=uds), $|\cos\vartheta|<0.8$

μ_{90}: -1.96 GeV

rms_{90}: 4.37 GeV

Dijet mass residual (GeV/c^2)
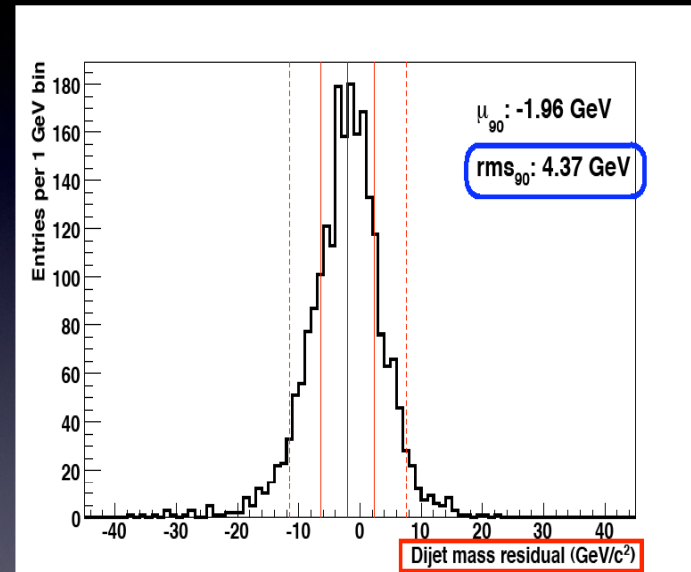
For comparison: 4.61 GeV in March (with old calibration)
4.87 GeV at January SLAC workshop
5.46 GeV at October FNAL workshop (NonTrivialPFA)

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Current algorithm with cheat tracking, rms90 = 3.6 GeV

Efficiency and purity of hit assignments

- PPR – ~100%
- SiD PFA – need to measure. Still a wide gap between PPR and SiD PFA performance.

Summary

- Can measure SiD performance as a calorimeter.

- Cheating on hit assignments show PFA potential.

- Studying confusion matrix may well guide algorithmic improvements.