

# SiD PFA Status and Calorimeter Performance

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SiD Design Study Meeting

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# Overview

- PFA goals for the LOI
- Progress since Boulder
- Current performance
- Use in benchmarking analysis
- The LOI

# From Mat at Boulder

## What are the goals?

- Most critical: Demonstrate acceptable physics performance for LOI
  - Without this we are dead in the water
  - Not the end, though: Algorithms will continue to improve post-LOI
- Give guidance on detector design choices
  - Input given on some sid02 decisions (e.g. HCAL depth)
  - Now is not the time to start another round of detailed optimization!
  - ... but post-LOI we may want to think again.

# PFA goals for the LOI

- A stable reconstruction program: -> Output reconstructed particles to be used for analyses of LOI benchmark processes.
- To be run on full SM and data sample.
- Improvements, bug fixes, etc. may warrant rerunning full sample, executive decision will be needed.

# Again from Mat

## What are the goals?

- So what is “acceptable physics performance”?
- The real answer will come from benchmark analyses.
  - ... including jet-finding, jet flavour ID, PID, efficiency, etc etc etc
  - Both absolute performance & performance relative to ILD/4th matter
- We use some PFA-centric tests as a prerequisite:
  - Look for dijet mass resolution of 3-4% (comparable to  $\Gamma$  for W, Z)
    - Want  $\Delta M_Z/M_Z \sim 3-4\%$  for dijet mass residuals in  $e^+e^- \rightarrow Z(\nu\nu) Z(qq)$  @ 500 GeV ( $q=u,d,s$ )
    - Want  $\Delta E_{CM}/E_{CM} \sim 3-4\%$  for  $e^+e^- \rightarrow qq$  ( $q=u,d,s$ )
- This is not the physics -- this is what you need before it makes sense to try and do the physics.

# Progress

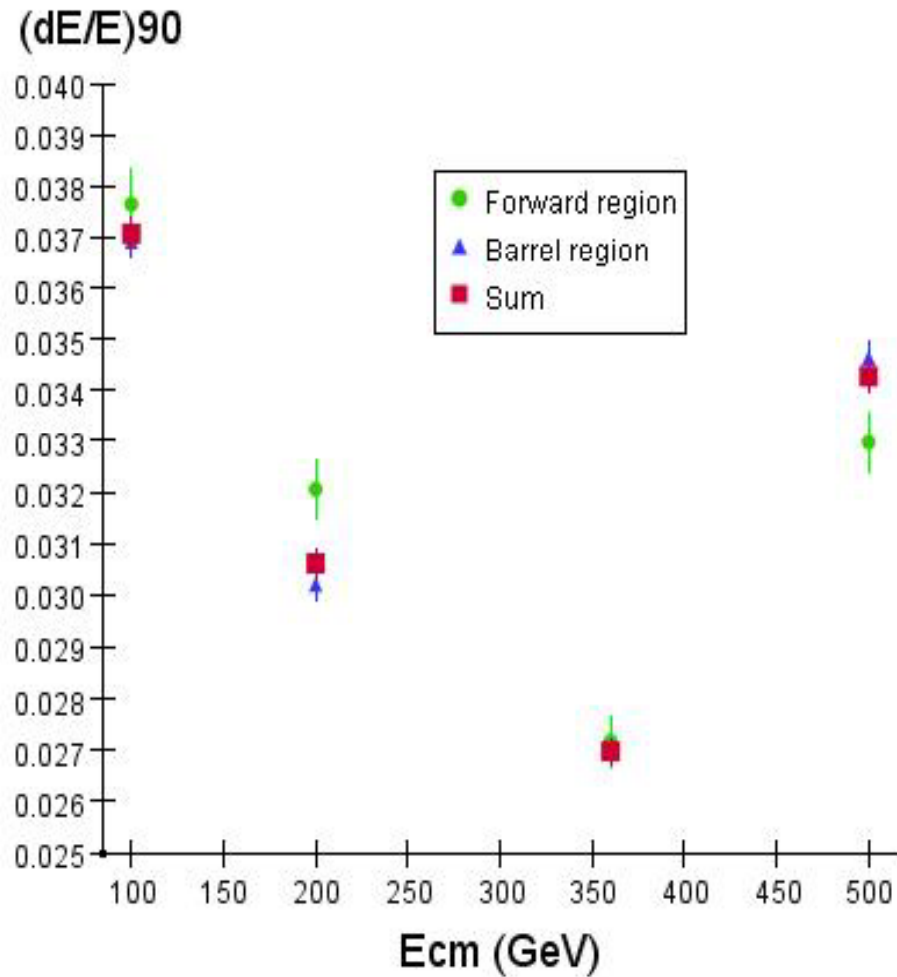
- UI PFA completely refactored: Maintainability issue, critical with Mat's departure.
- Muon hits handled in a consistent way (although probably not optimal)
- First pass lepton ID
- Full tracking now the default
- Production release of the lcsim package
- Output usable by benchmarking group
- Fixed error in running FastMC on simulated data
- Critical decisions: sid02 is the default detector, and full tracking will be used.

# Current performance

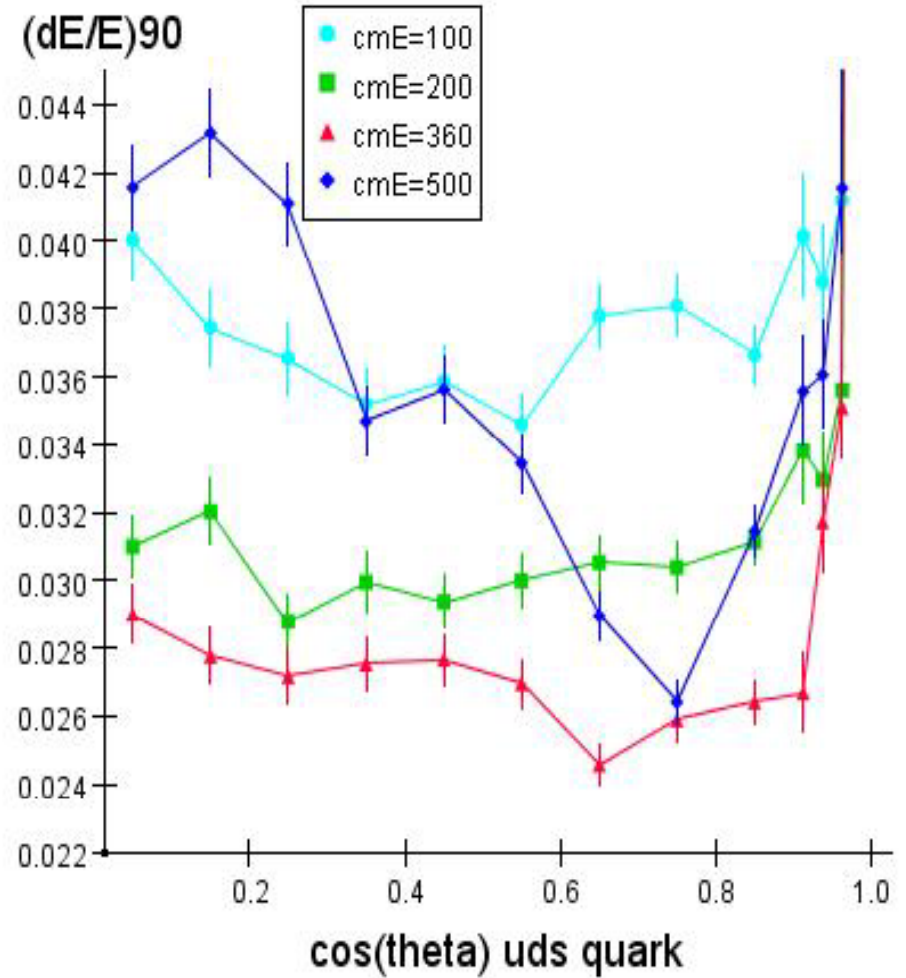
- Benchmarking analyses are what count!
- PFA tests are what is shown.
- In following slides, Prod == sid02, full tracking. (no cheating)
- For comparisons, PPR == perfect pattern recognition (cheat on tracking, cheat on calorimeter hit assignments)
- FastMC == Fast Monte Carlo (Use pythia final state particles with smearing, tuned to give Pandora-like results for a super-detector.
- CalOnly == pure calorimeter energy measurement.

# qq(uds) events at fixed Ecm

Prod: Event energy resolution vs Ecm



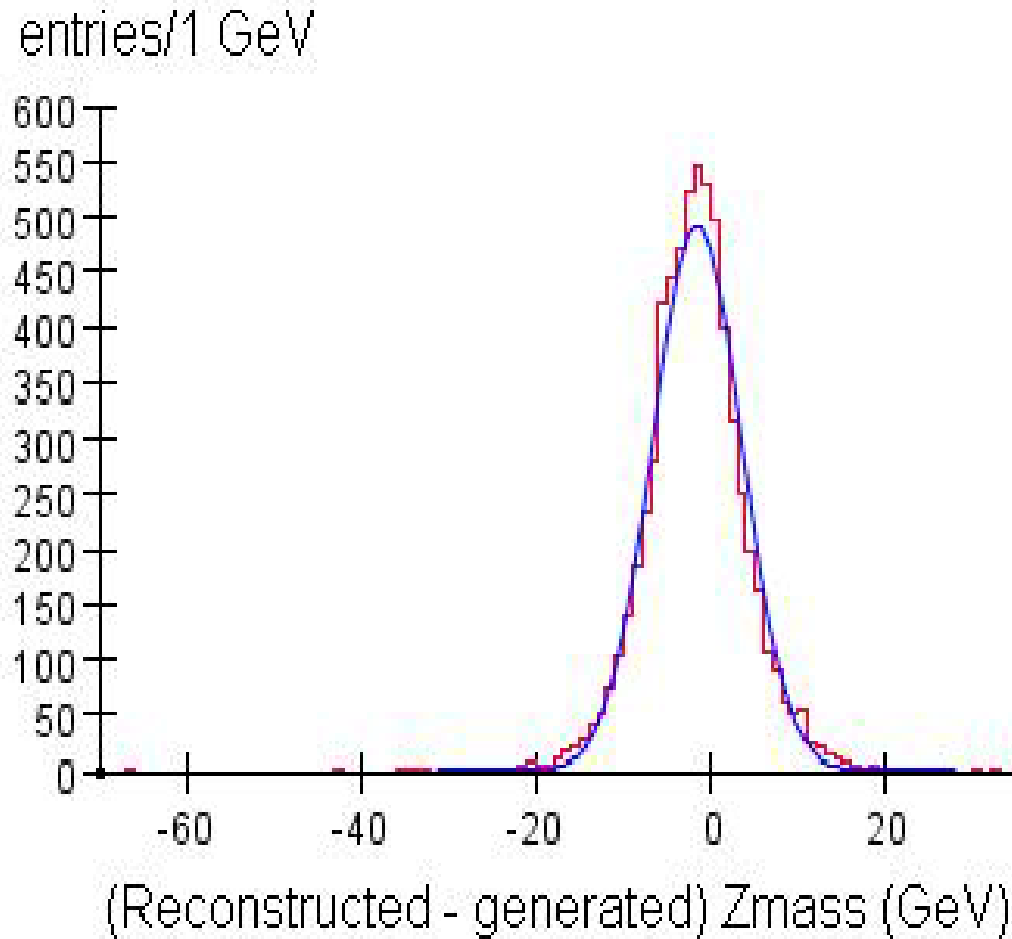
Prod: Event energy resolution vs  $\cos(\theta)$





## ZZ events at 500 GeV, max cos(theta) < 0.95

### ZZ events @ 500 GeV Ecm



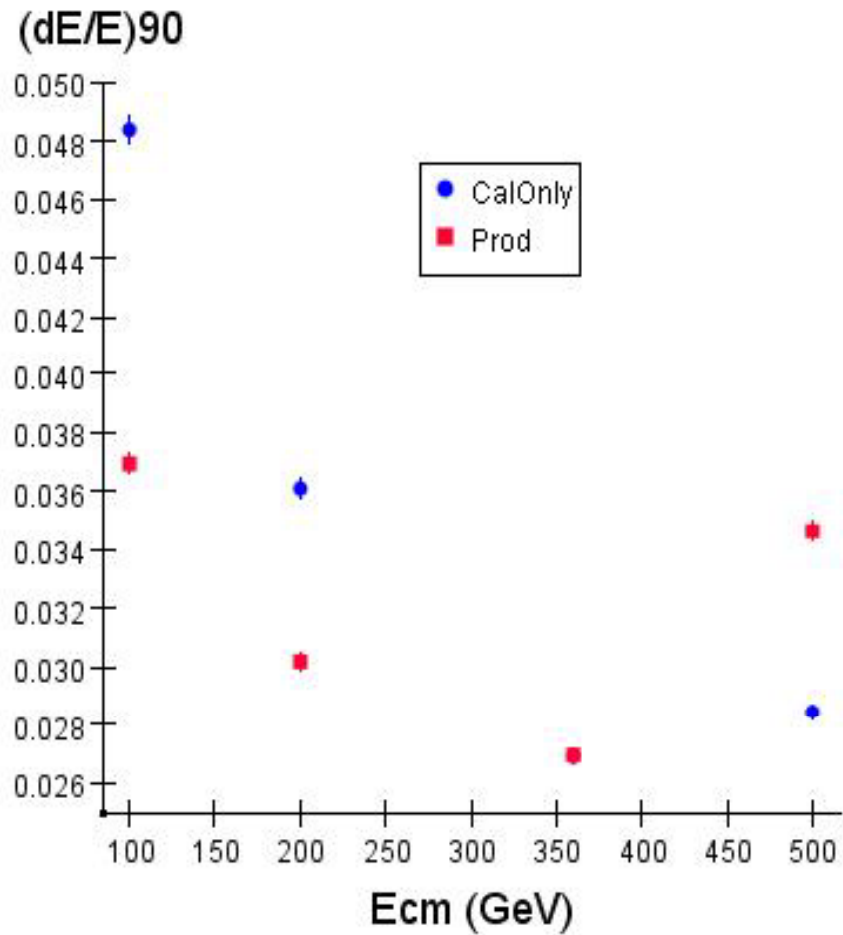
- Full rms = 5.71 GeV
- Sigma(gauss) = 5.11 GeV
- rms90 = 4.00 GeV
- (dM/M)90 = 4.48%

# Current performance

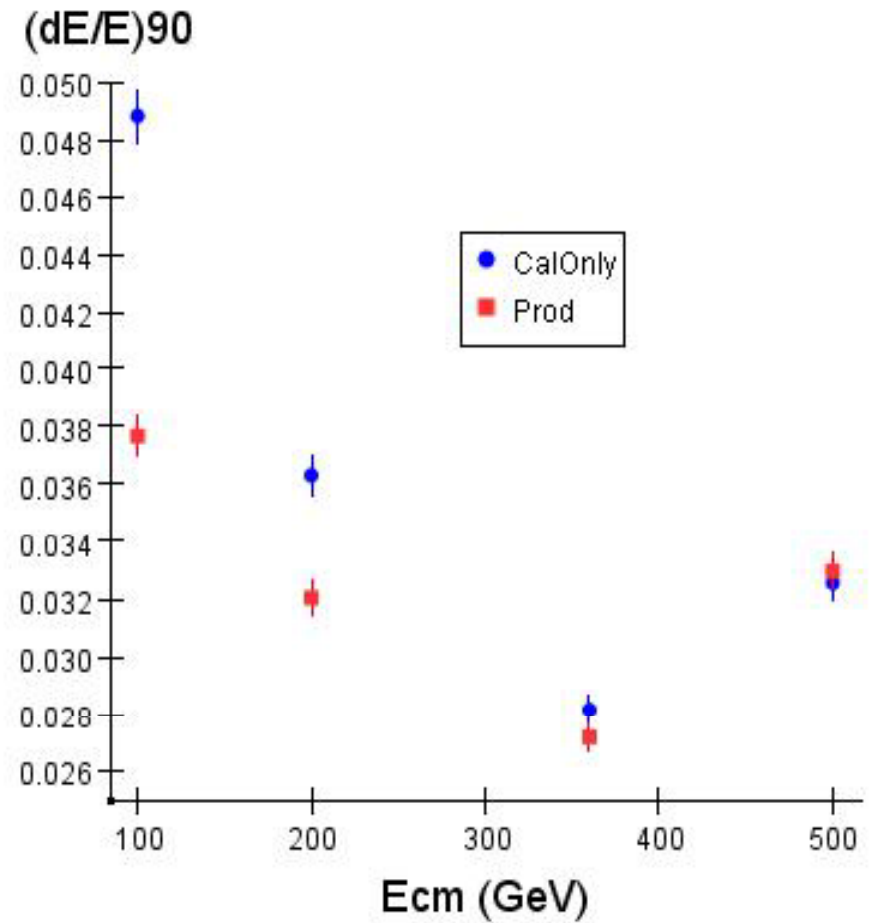
- I could stop here. The previous slides are the current status of PFA development.
- Try to put in perspective by comparisons.
- CalOnly – using only the calorimeters (no tracking) what is the energy resolution for sid02?
- Cheat tracking – quantify resolution loss using full tracking package.
- PPR – the potential of Pflow: if we could only make perfect associations.
- FastMC – our only real connection to physics output vs detector design. Since most of the analyses are/were being developed with FastMC, comparison of results with PFA package may help quantify energy resolution -> physics results.
- What about scintillator? And Pandora?

## Comparison of CalOnly and Prod Event energy resolution

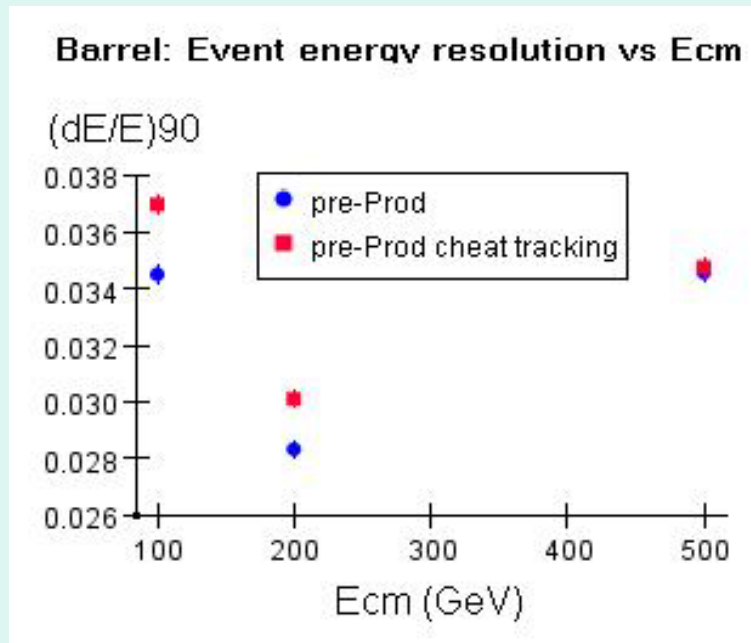
Barrel: Event energy resolution vs Ecm



Forward: Event energy resolution vs Ecm



## Comparison of cheat vs real tracking



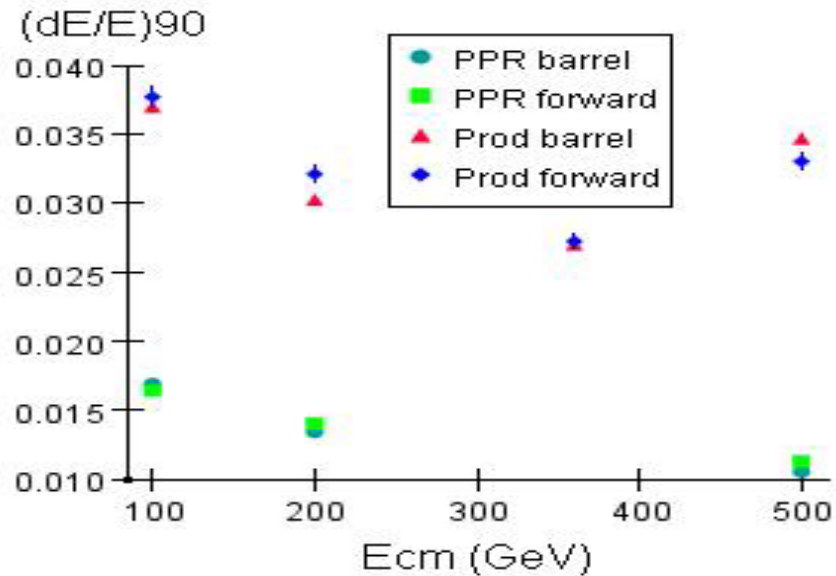
(dM/M)90

	Cheat tracking	Full tracking
Barrel	4.28%	4.73%
Forward	3.72%	3.96%
Both	4.04%	4.33%
Combined	4.08%	4.45%

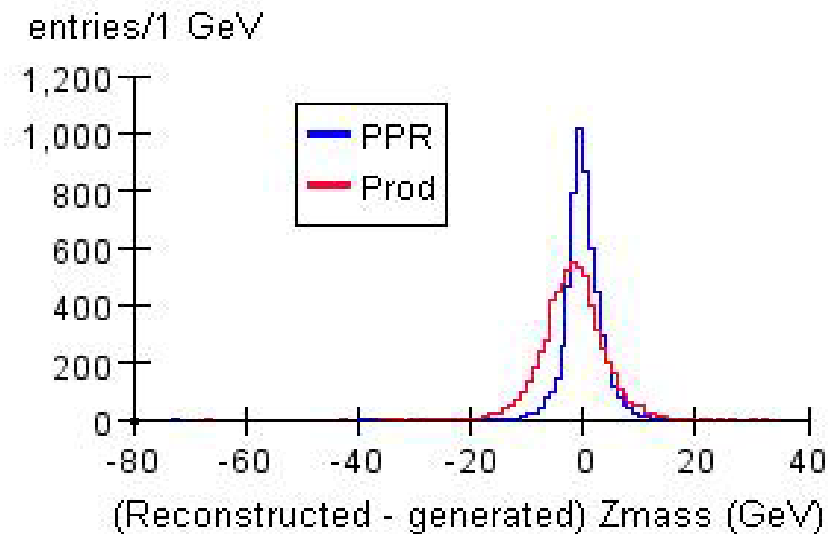
- Energy resolution worse by 6-7% for  $E_{cm} < 200$  GeV
- Mass resolution worse by 9%, mainly due to barrel region
- Full tracking has pt cut ( $>200$  MeV) and impact parameter cut. No kink reconstruction or tracks from vees.
- Marcel once reported (from Mark Thompson) that kink and vee reconstruction improved resolution  $\sim 5\%$ .
- Excellent result!

# Comparison of PPR and Prod reconstruction

Event energy resolution vs Ecm



Mass residuals in ZZ events @ 500 GeV Ecm

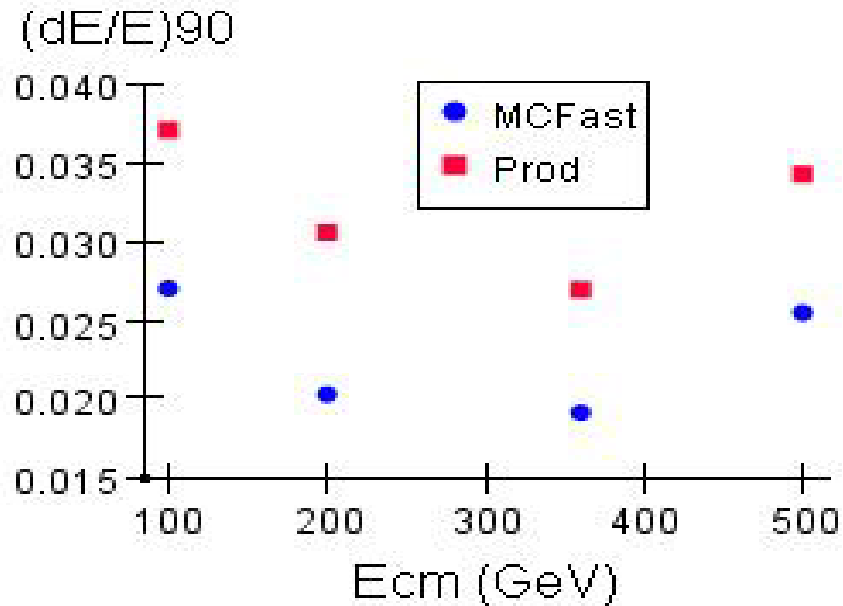


- We see why the emphasis on pattern recognition

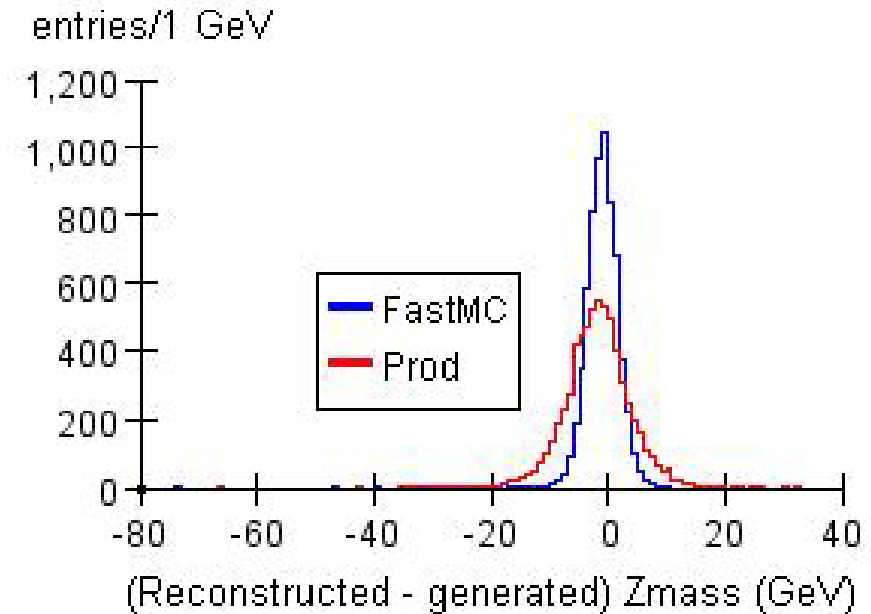
	PPR	Prod
RMS90	2.24 GeV	4.00 GeV
dM/M	2.46%	4.48%

# Comparison of FastMC and Prod reconstruction

Event energy resolution vs Ecm



Mass residuals in ZZ events at 500 GeV Ecm



- Interesting that FastMC gives better mass resolution than PPR, with much worse energy resolution.

	FastMC	Prod
RMS90	2.01 GeV	4.00 GeV
dM/M	2.23%	4.48%

# Current performance caveats

- Mat reported at Boulder similar performance for low energy jets as pandora ... using sid01\_scint, cheat tracking, and comparing to Marcel's sidish detectors. But ...
- Scint -> rpc ~ 10% worse jet energy resolution. Cheat tracking to real tracking -> 7% worse jet energy resolution.
- This is where we are.

# Lepton ID



# Benchmark analyses

- Reconstruction output seems suitable.
- Comparison of FastMC with Prod may well guide us in post LOI detector optimization.

# Preliminary $t\bar{t}$ analysis?

# For the LOI

# Summary