SiD PFA Status and Calorimeter Performance

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SiD Design Study Meeting

11/15/08

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.

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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 Γ 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.

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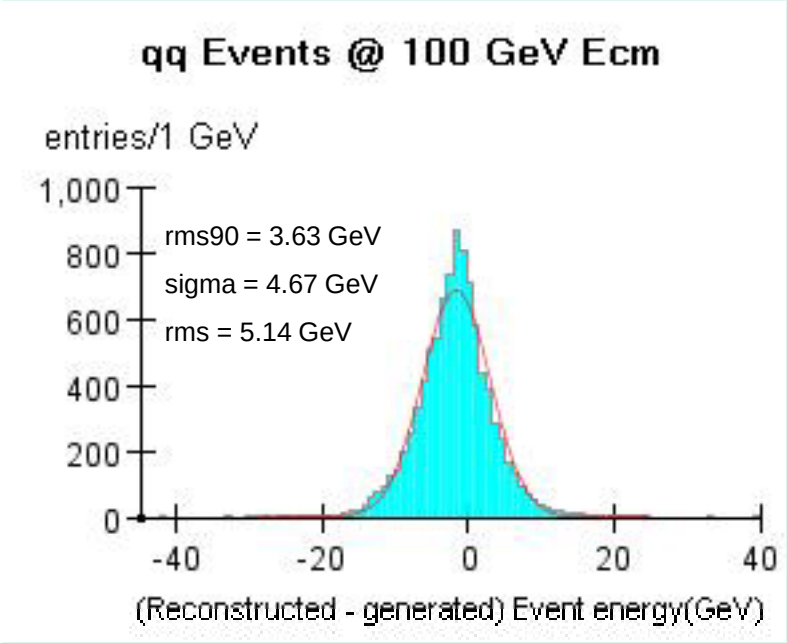
Progress

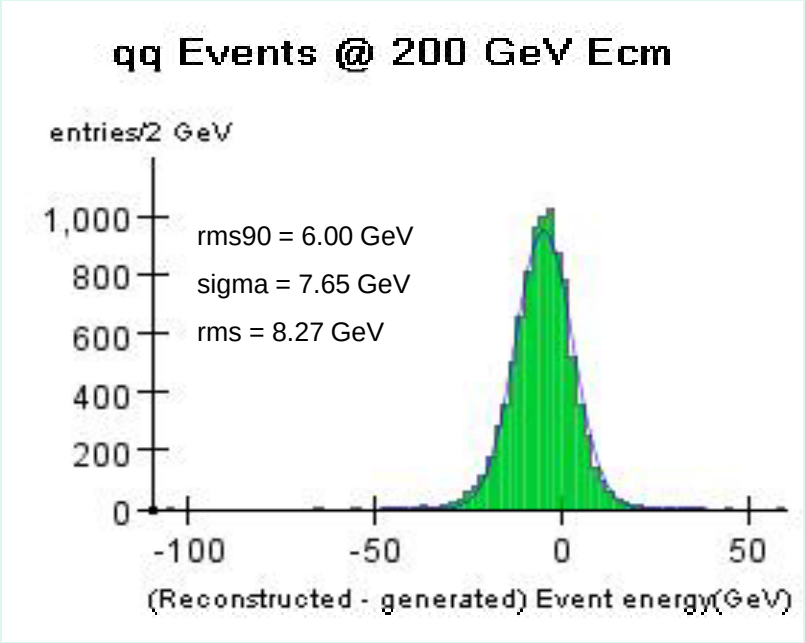
- UI PFA completely refactored: Code reorganized to be maintainable, critical with Mat's departure.
- Muon hits handled in a consistent way (although probably not optimal)
- First pass lepton ID
- Full tracking now the default
- Production release of the lcsim package
- Output usable by benchmarking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

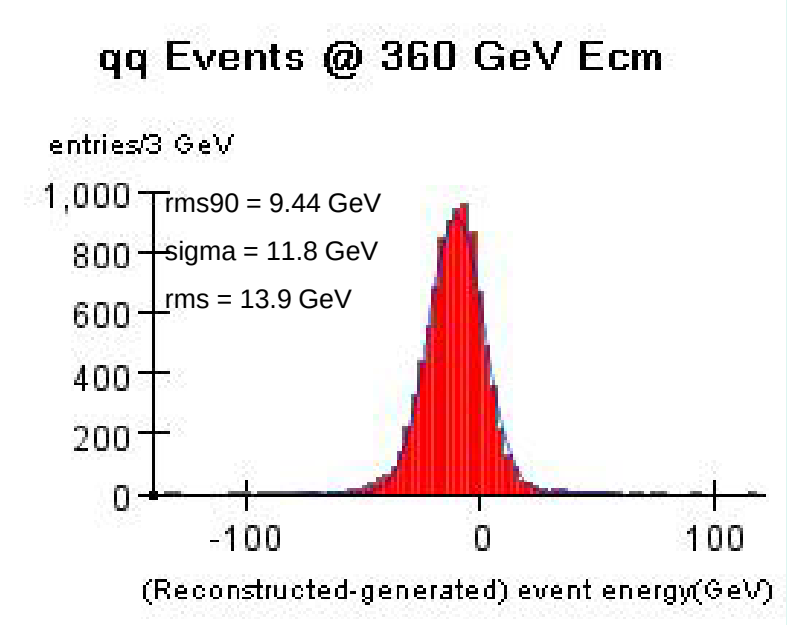
Current performance

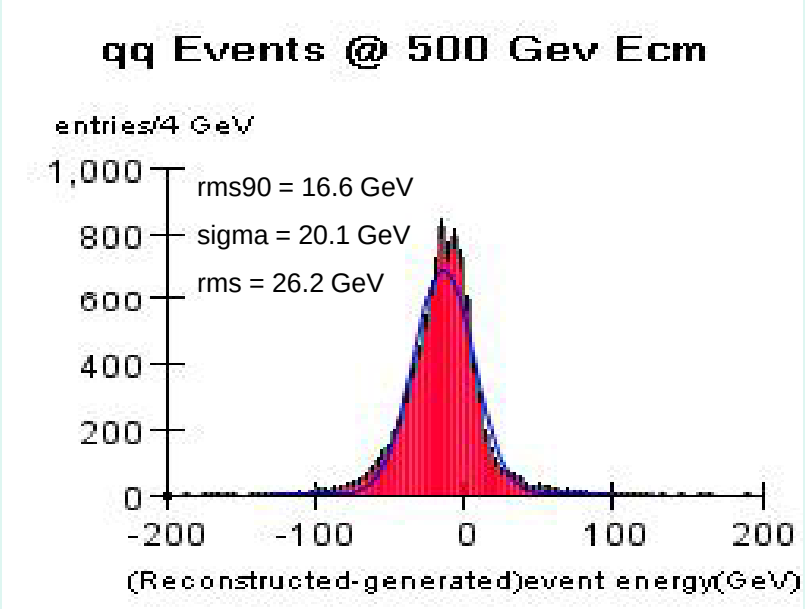
- Benchmarking analyses are what count!
- PFA tests are what is shown.
- In following slides, Prod == sid02, full tracking. (no cheating)
- For comparisons, PPR == perfect pattern recognition (cheat on tracking, cheat on calorimeter hit assignments)
- FastMC == Fast Monte Carlo (Use pythia final state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

qq(uds) events at fixed Ecm









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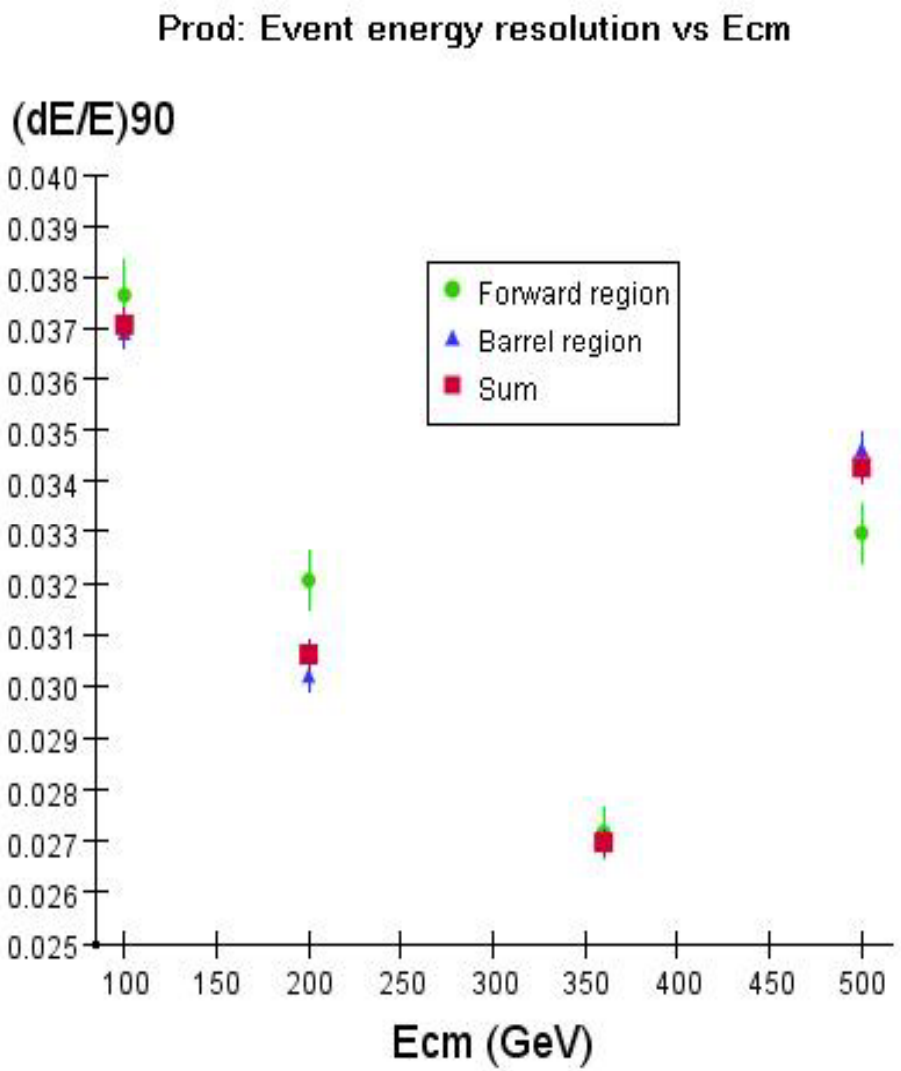
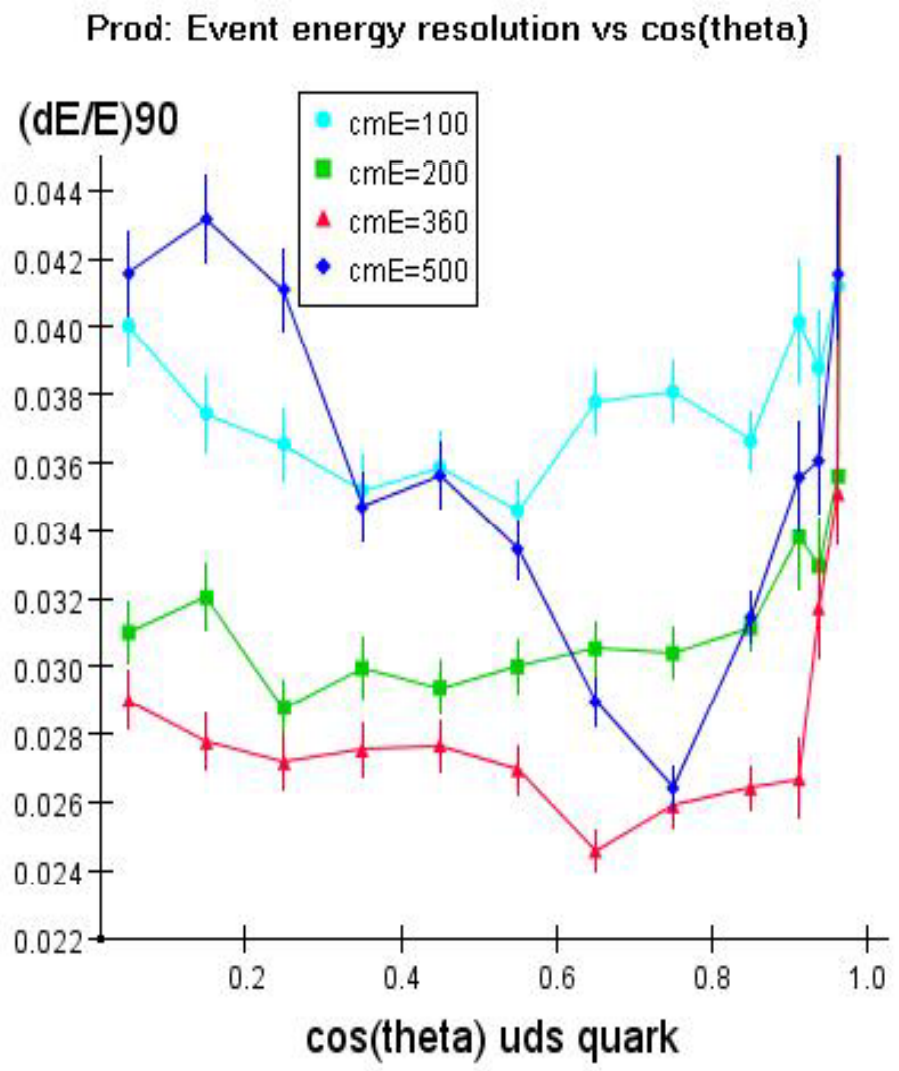
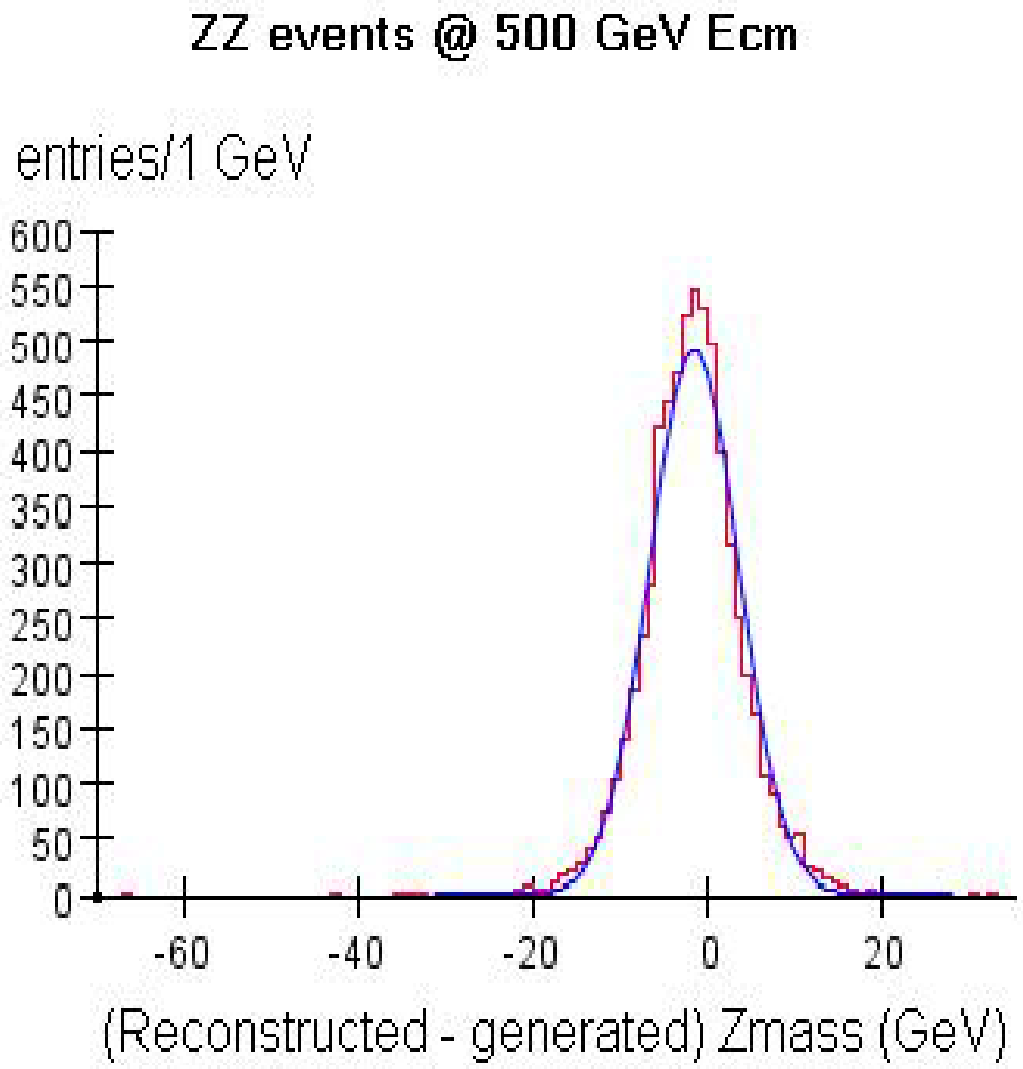


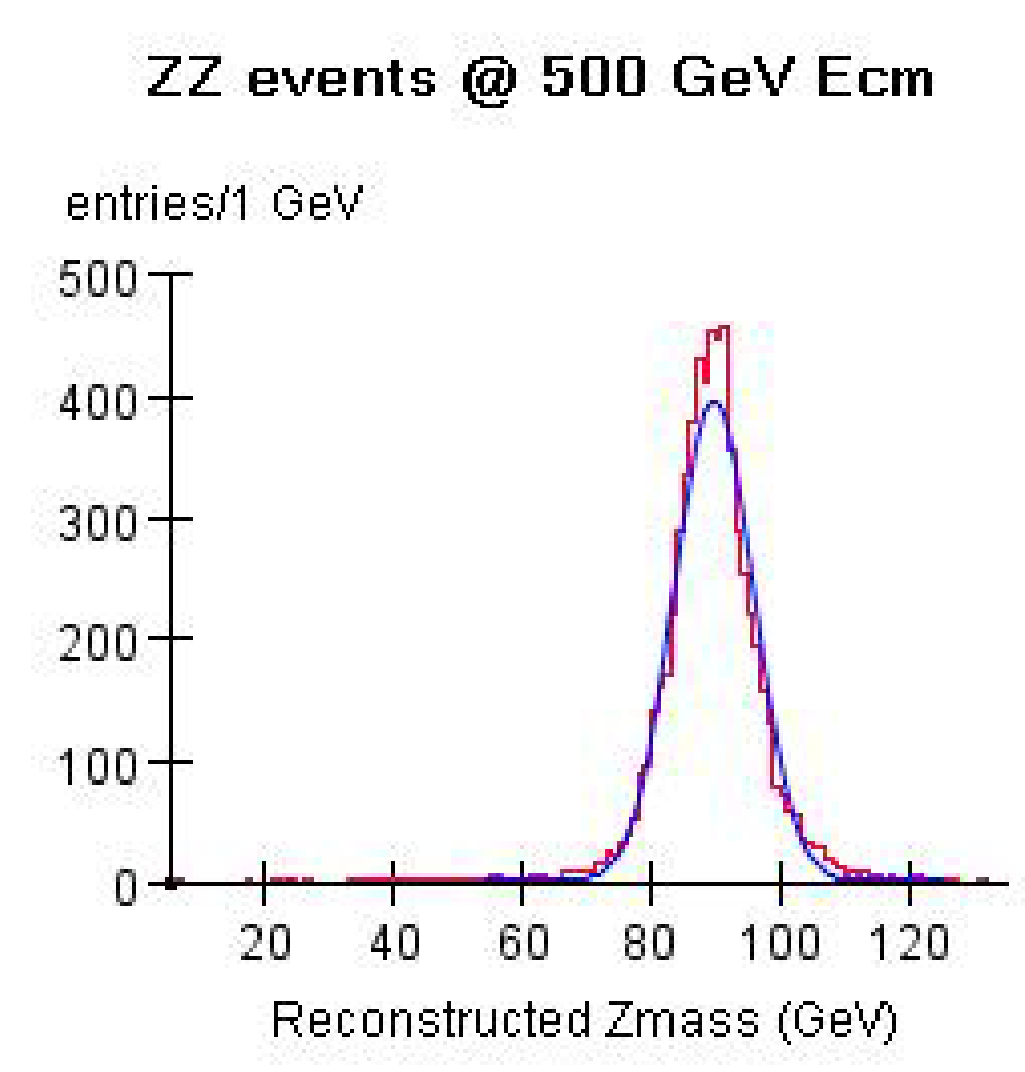


ZZ events at 500 GeV, max cos(theta) < 0.95



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

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

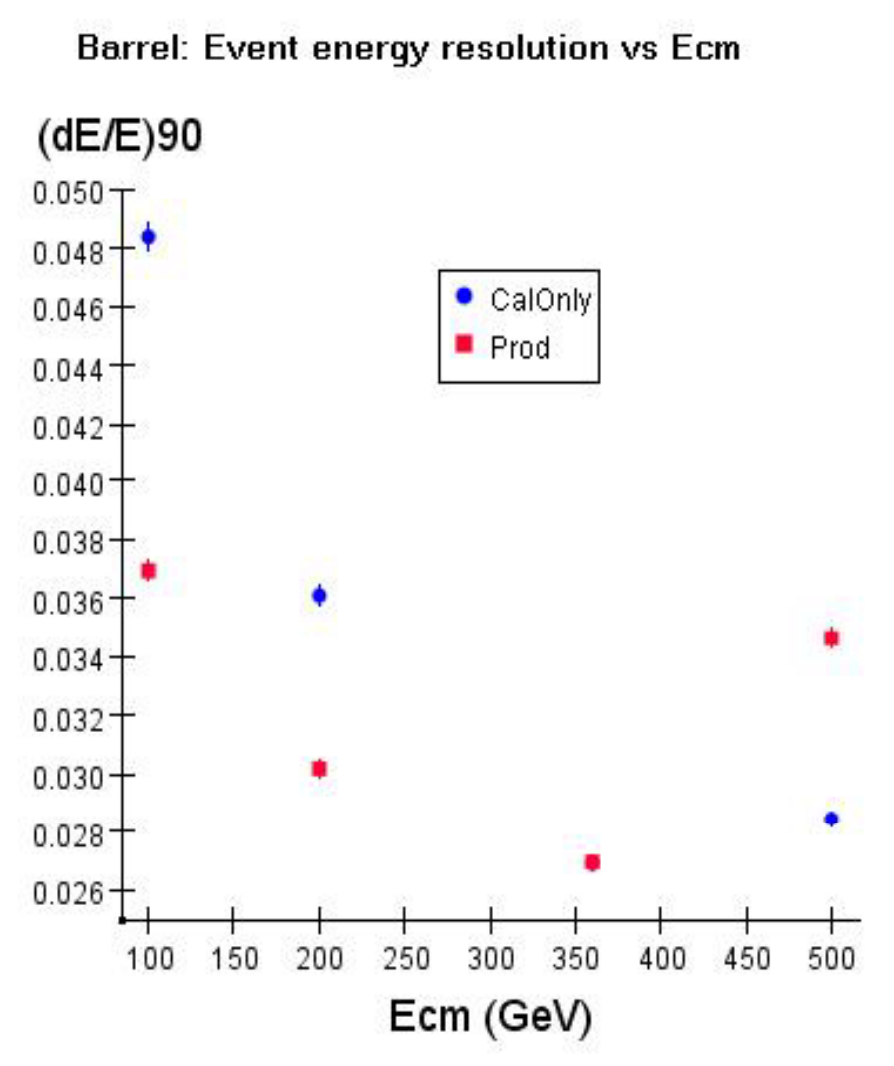


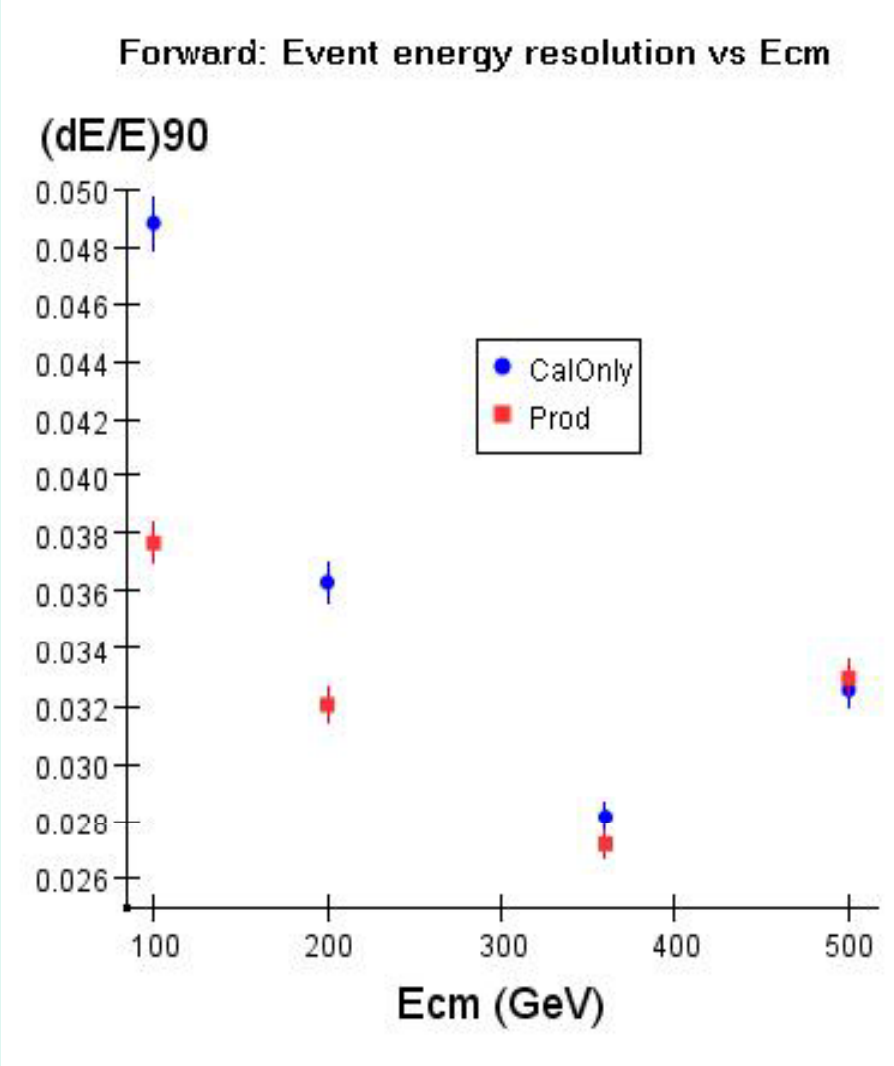
- Sigma(gauss) = 6.19 GeV

Current performance

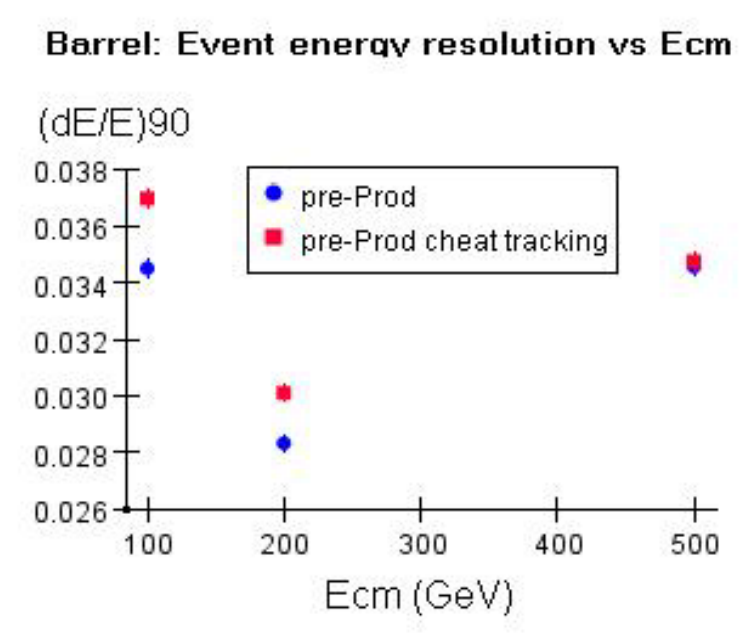
- I could stop here. The previous slides are the current status of PFA development.
- Try to put in perspective by comparisons.
- CalOnly – using only the calorimeters (no tracking) what is the energy resolution for sid02?
- Cheat tracking – quantify resolution loss using full tracking package.
- PPR – 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





Comparison of cheat vs real tracking

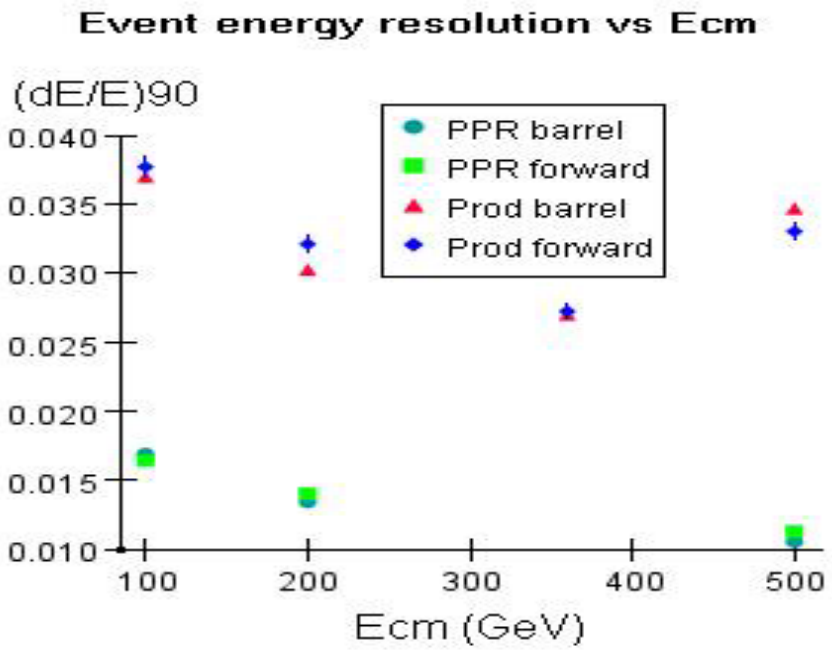


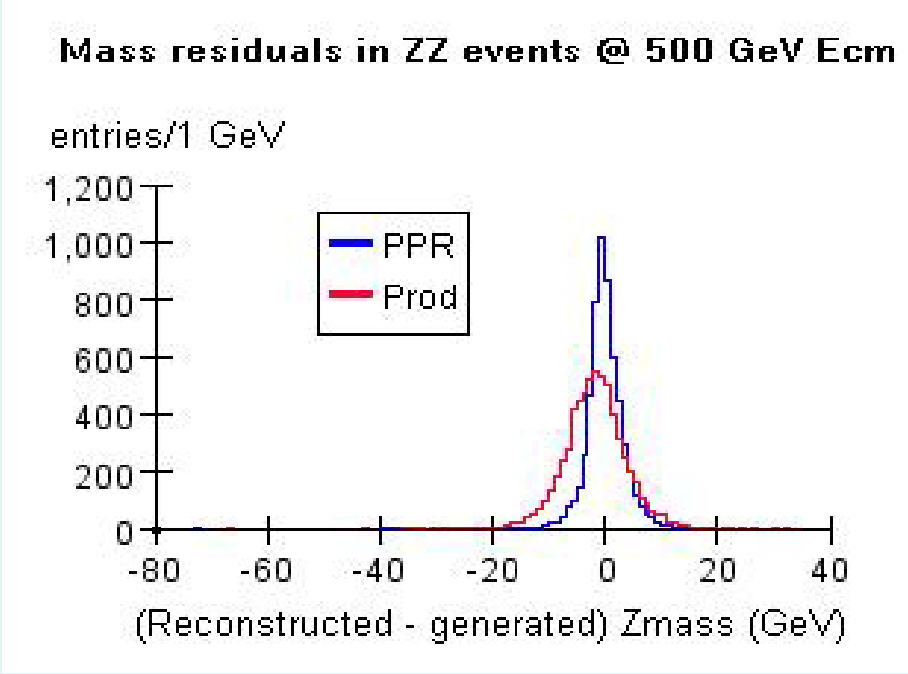
(dM/M)90

	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 Ecm < 200 GeV
- Mass resolution worse by 9%, mainly due to barrel region
- Full tracking has pt cut (>200MeV) and impact parameter cut. No kink reconstruction or tracks from vees.
- Marcel once reported (from Mark Thompson) that kink and vee reconstruction improved resolution ~ 5%.
- Excellent result!

Comparison of PPR and Prod reconstruction

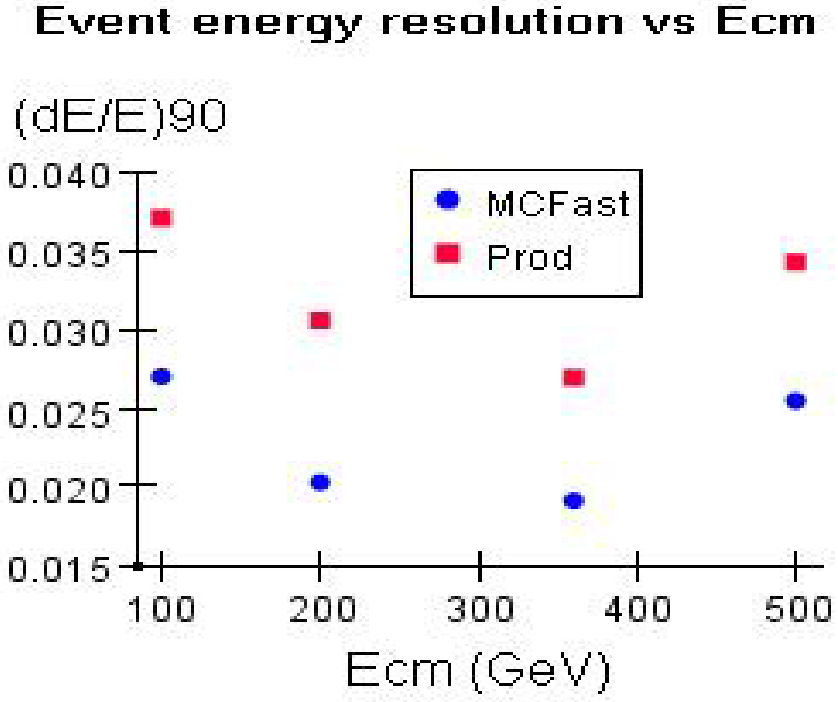


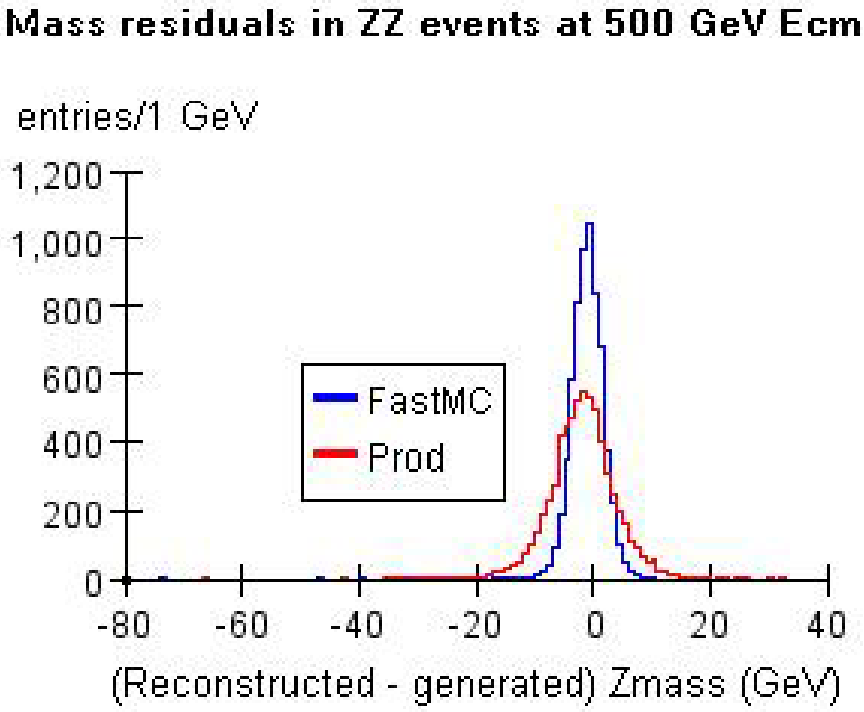


- We see why the emphasis on pattern recognition

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

Comparison of FastMC and Prod reconstruction

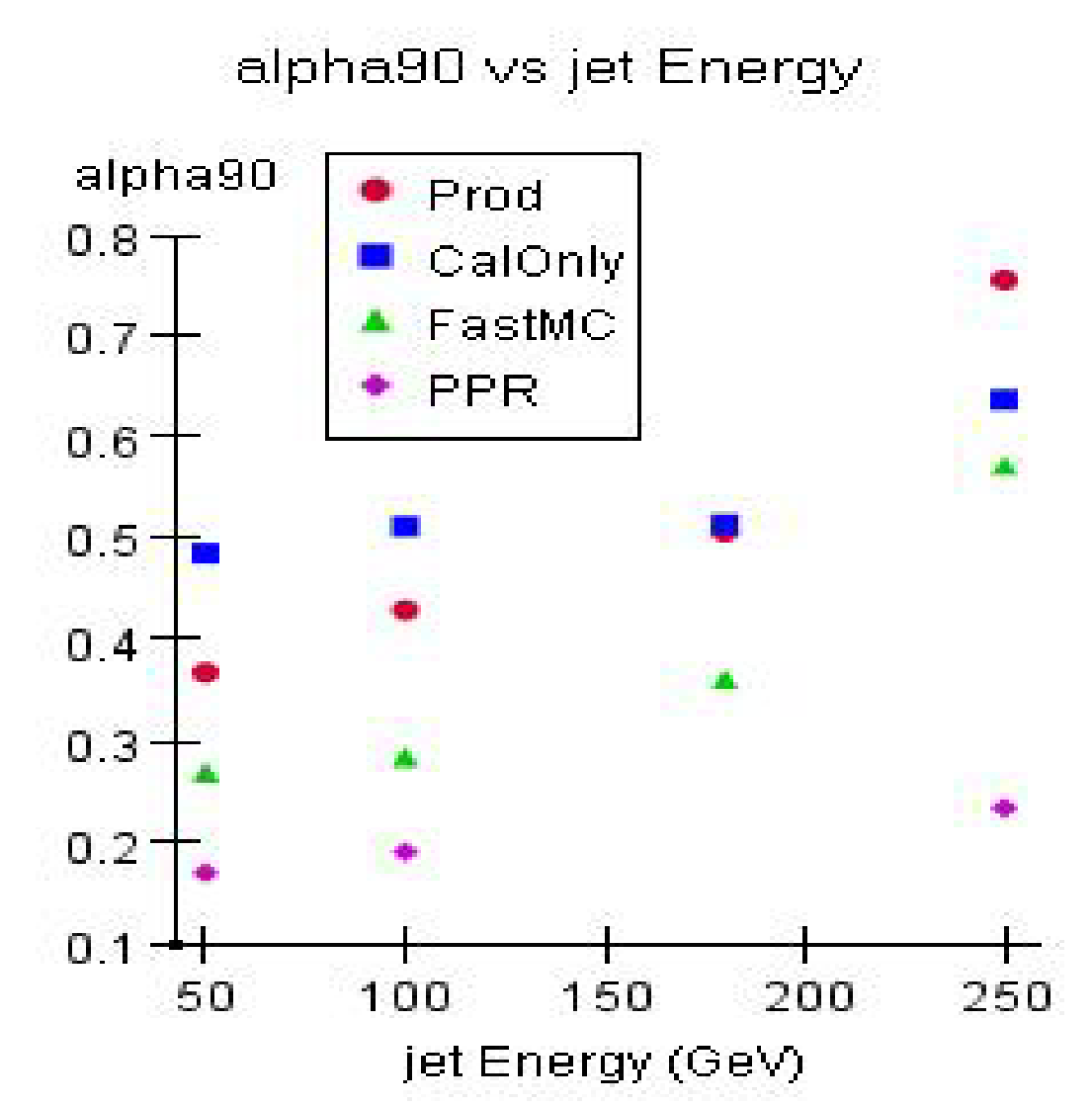




	FastMC	Prod	(PPR)
RMS90	2.01 GeV	4.00 GeV	(2.24 GeV)
dM/M	2.23%	4.48%	(2.46%)

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

Jet energy resolution



- dE/E = alpha/sqrt(E)

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.

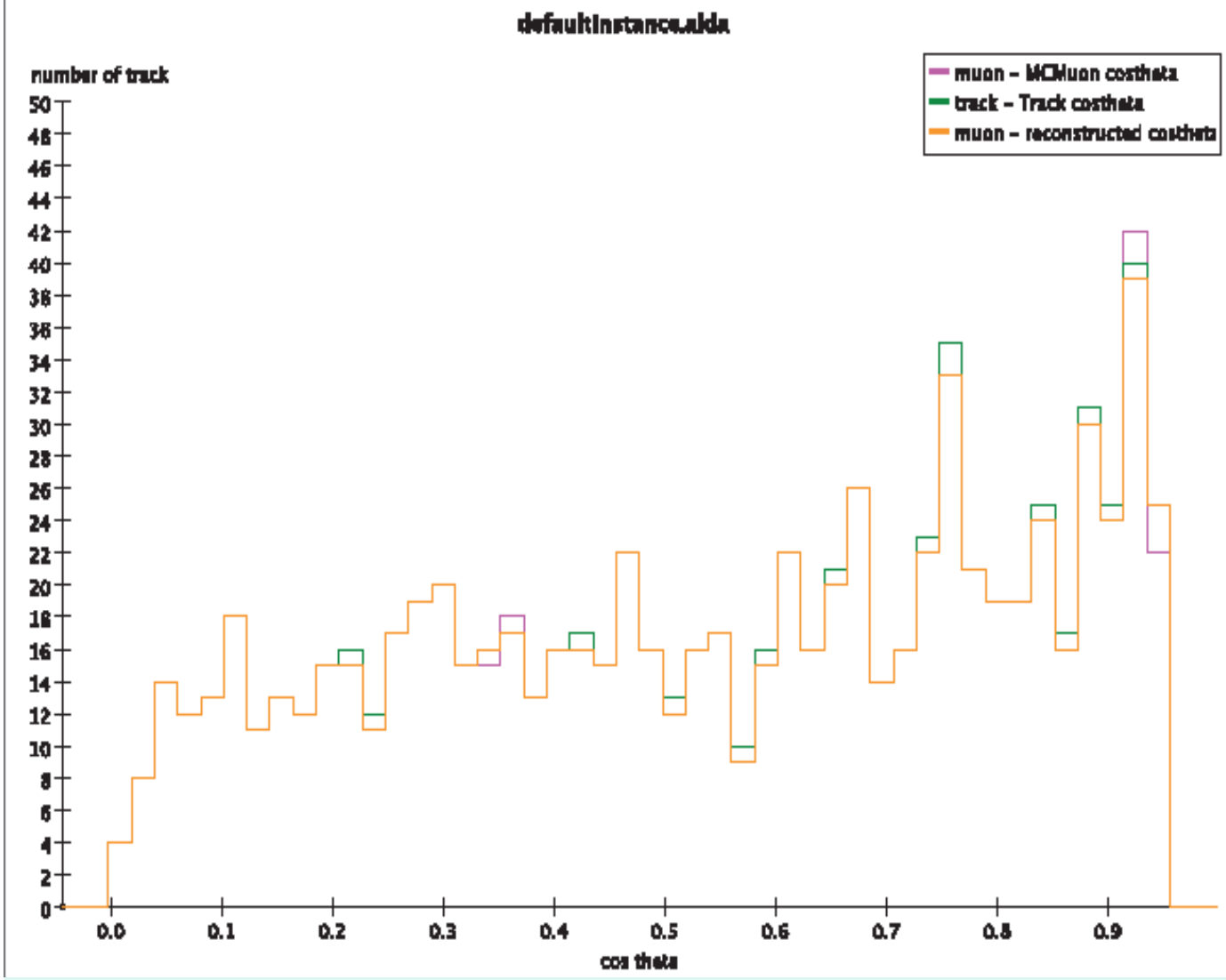
Lepton ID

- The test samples have no prompt leptons. (uds quarks, no neutrinos)
- Need physics processes to test lepton ID.

Muons

- Code from Tae Jeong did not make it into production release. (Many places it should have been caught, can spread blame around).
- Prod reconstruction output has no identified muons.
- Problems have been identified and fixed, and a post-reconstruction identifier is being developed.

Plot after fixing



Sample:
10GeV Muon
1000 events.
Preselection :
$\cos(\theta) < 0.95$

MC Muon 816
Full Track 818
RecoMuon 803

Effi. = 98%

Electrons

- Tim looked at electrons in the ZH sample, and found only ~50% efficiency for electrons > 20 GeV.
- He has developed an algorithm for identifying these electrons, again can be done post-reconstruction.

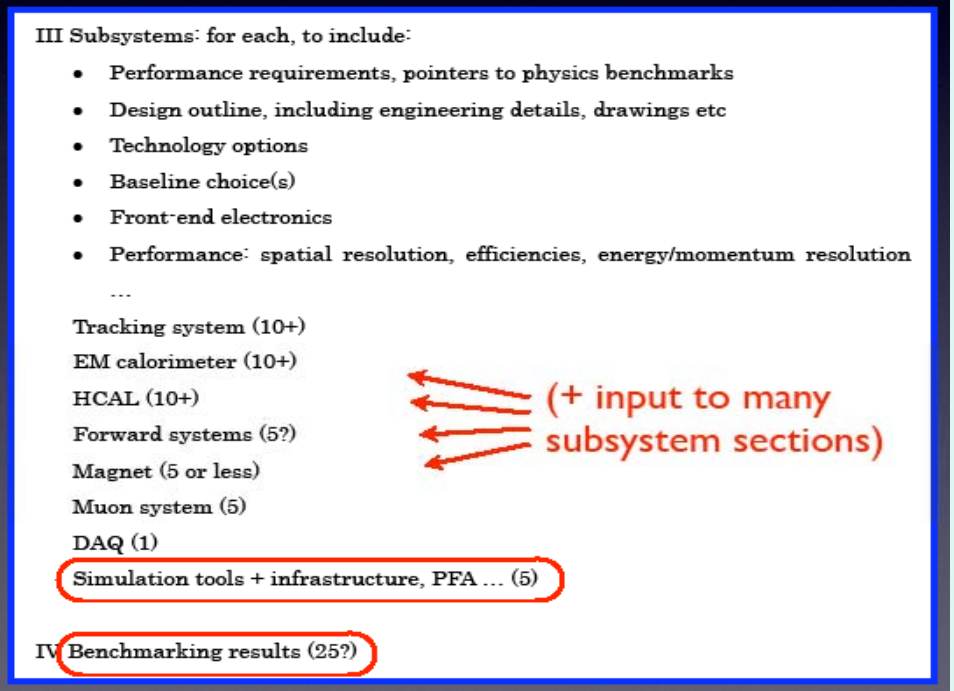
Benchmark analyses

- Reconstruction output seems “suitable”.
- Feedback from benchmarking group has been essential to get to this point, and is even more critical now as LOI deadline nears.
- Comparison of FastMC with Prod may well guide us in post LOI detector optimization.

“suitable”: In ttbar events, the reconstruction output has been run through vertexing/flavor tagging process, yielding a mass plot.

The LOI

- Broadly, PFA group has four things to do:
  1. Converge on a stable PFA version, freeze it, and use for production.
  2. Help analysts use the PFA output & fix inevitable bugs/problems
  3. Document the work done
  4. Continue improving PFA
- Note that there is some tension (esp. #1 vs #4). Care needed.
- Usual plan: Long supporting note + LOI contributions.
- Details & responsibilities to be thrashed out in the next few days.



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Summary

- We have a full reconstruction package with NO cheating.
- SM and data sample processing well under way.
- Original performance goals, even with caveats, not quite met (We’re not out of ideas, we’re out of time). Actual performance on test samples has been documented.
- Benchmark analyses starting to use PFA output.
- Since a second reconstruction pass is far from given, should now concentrate on improvements that can be applied post-reconstruction.