

# PFA Studies in SiD

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# Outline

- The goals
- Status & plans of PFA implementations
- Progress since October workshop
- Outlook

## Not in this talk:

- Intro & fundamentals of PFA
- PandoraPFA

# The goals

- Study the **physics performance** of the detector
  - ... particularly the benchmark channels
- **Optimize the detector design** quantitatively
- Make informed, rational **technology choices**

To do these with confidence, we need a **robust, high-performance PFA**.

- Rule of thumb: dijet mass resolution  $\sim 3$  to  $4$  GeV.

# List of existing PFAs + brief status

Obvious question these days: which still have manpower?

- **Steve Magill: Track following + E/p clustering**
  - Still moving (wrapping up?).
  - See Steve's parallel session talk.
- **Lei Xia: Density-based clustering.**
  - Algorithm was looking promising, but progress stalled (lack of time).
  - No time for PFA development in foreseeable future, but still modularizing & supporting existing packages.
- **NIU/NICADD group: Directed tree clustering**
  - No time for PFA development, but still supporting existing packages
- **Mat Charles: NonTrivialPFA & ReclusterDTree**
  - NonTrivialPFA is now stable (release 1.0 in CVS)
  - ReclusterDTreeDriver is unstable (snapshot release 0.1 in CVS)
  - Working part-time on PFA development (split with BABAR + others)

# Side note on manpower

Important not to forget that there are other people working on modules, infrastructure, benchmarking, tools, etc:

- Ron (see previous talk)
- Dima (looking into PFA/tracking interface)
- Ray, Lawrence (testing/benchmarking PFA output)
- Ray, Marcel, George (PandoraPFA -- see next talk)
- Qingmin (photon-finding)
- ... and more besides (apologies!)

# Progress since October

- **Steve Magill's PFA**

- Improved clustering (now using DTree)
- New results coming up.

- **NonTrivialPFA & ReclusterDTreePFA**

- New algorithm
- Improvements in resolution (but still quite a long way to go)
- MIT group (Ray Cowan + Lawrence Bronk) have just started program of running PFA on detector design variants.

See also Ron & Marcel's talks, and talks in PFA parallel session.

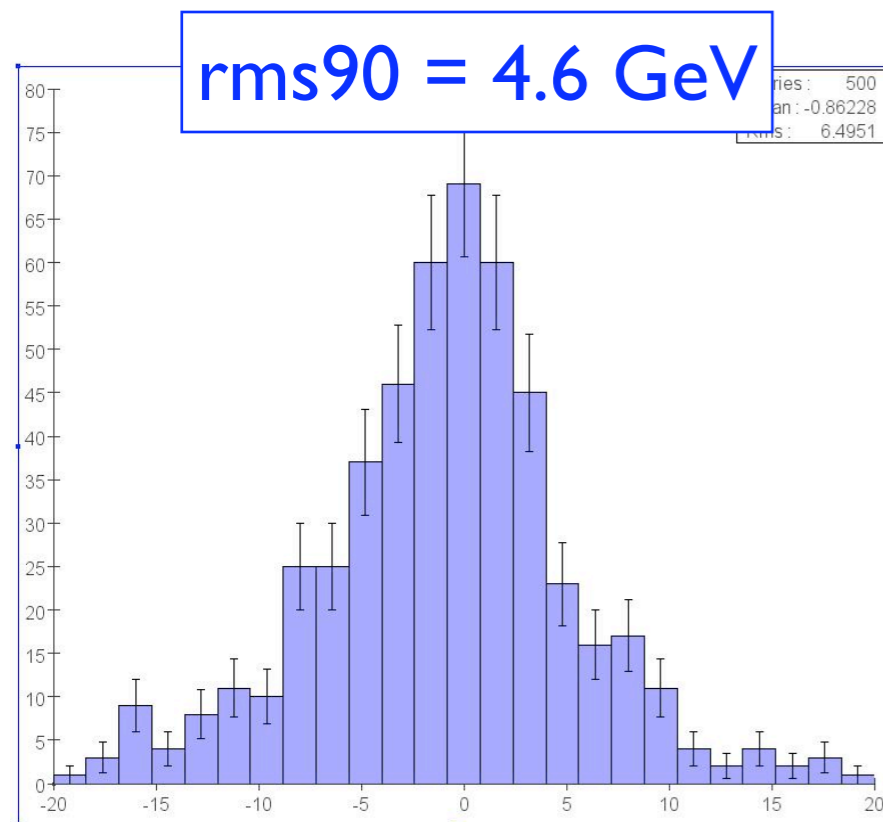
# Progress (Steve): PFA summary

- **Current implementation** (updated since October):
  - Track-MIP association
  - Track-cluster association (DT clustering, E/p)
  - Photon finding (DT & NN clustering, H-matrix ID)
  - Neutral hadron finding (DT clustering, cluster merges w/ cone algorithm)
- Algorithm parameters **tuned only on single-particle events** (W/Scint HCAL). Process-independent!
- **Steve plans to release code soon** (after final tuning).

# Progress (Steve): Z-pole performance

Showing dijet invariant mass for events with  $|\cos\theta| < 0.9$

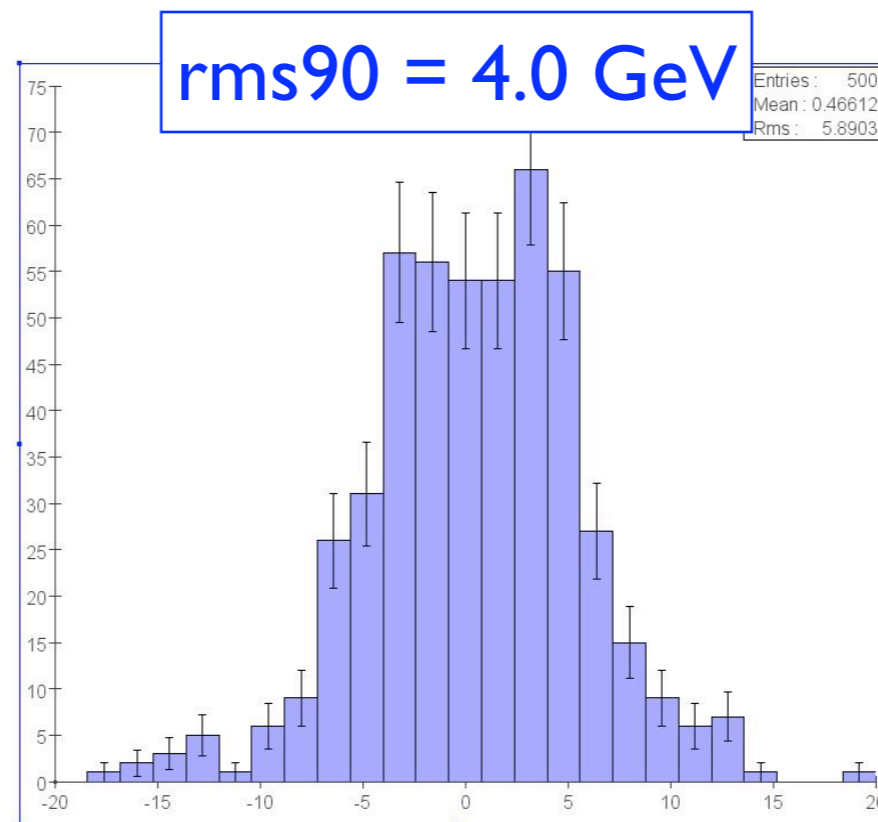
KT algorithm used to find 2 jets.



sid01

Steel/RPC HCAL

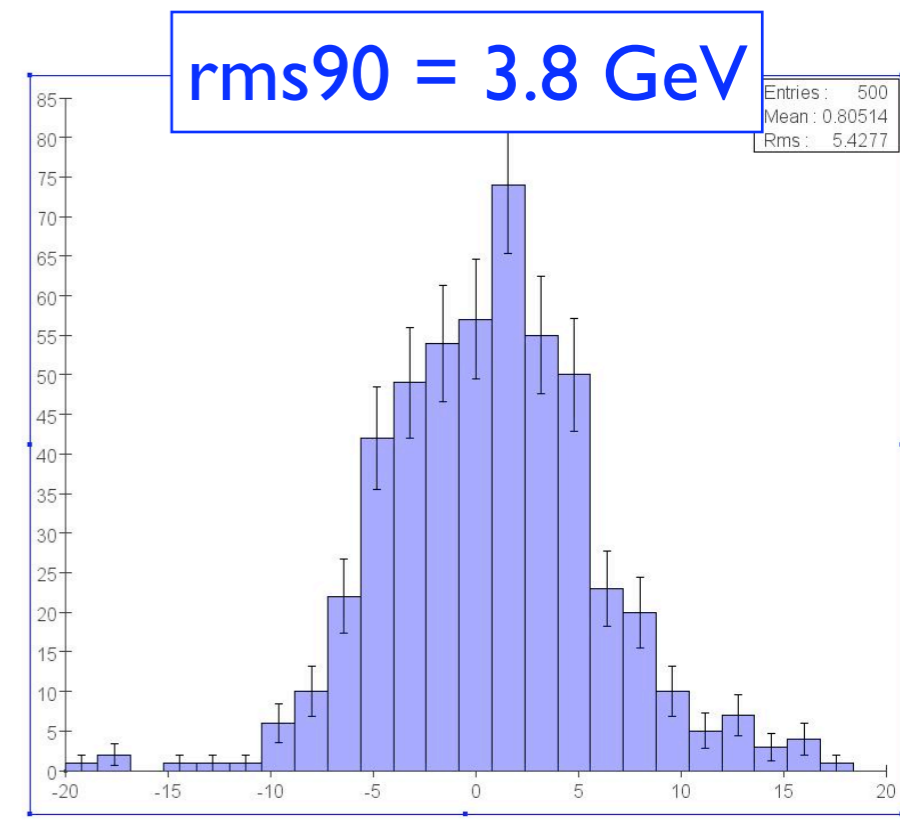
ECAL radius 125cm



acme0605

W/Scint HCAL

ECAL radius 125cm



acme0605

W/Scint HCAL

ECAL radius 175cm

Scint HCAL helps a lot for this algorithm.

- That wasn't the case for perfect PFA... possibly due to E/p checking?

Bigger ECAL radius helps a bit (but be careful of stat. uncertainty)



# Progress (Iowa): Algorithm development

## New(ish) approach: iterative reclustering

- **Basic premise** presented at FNAL in October:
  - Break hadronic showers into **digestible pieces**.
  - Use **geometrical information** to link them...
  - ... taking into account **E/p** and other nearby showers.
- **Now coded up & running.** Approach has evolved:
  - Use **fuzzy clustering** to for unassigned hits (fragments)
  - Use **DirectedTree** clusterer to define “envelope” clusters
  - Introduce **E/p veto** if wrong by more than  $2.5\sigma$
  - **Recoded MIP-finder** to do better with shower “tentacles”
  - Aggressive second pass to match clusters to tracks

# Progress (Iowa): Performance

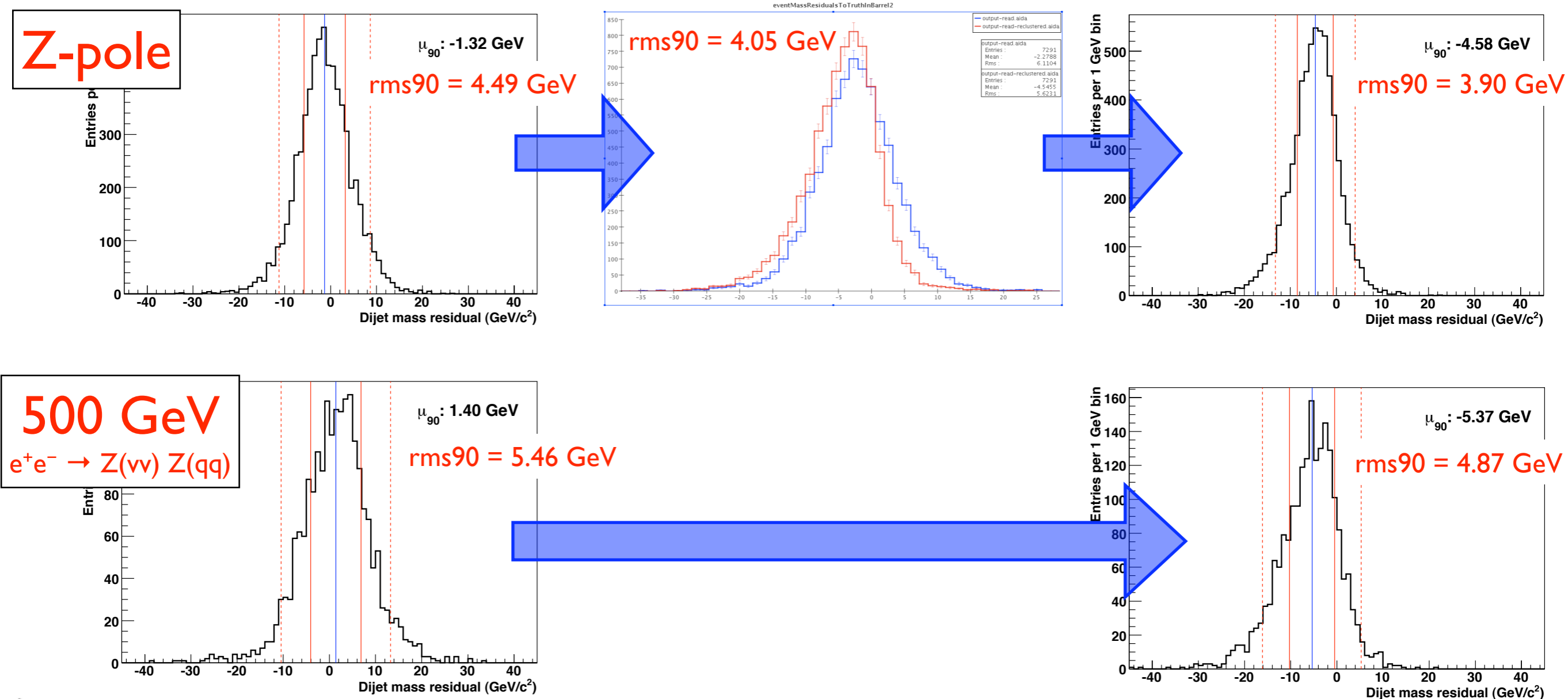
Showing dijet invariant mass for events with  $|\cos\theta| < 0.8$ .

Detector design: sid01 (Steel/Scint HCAL)

Non Trivial PFA  
(previous algorithm)

Reclustering  
Shown on Nov 28th

Reclustering+DTree  
Shown on Jan 9th

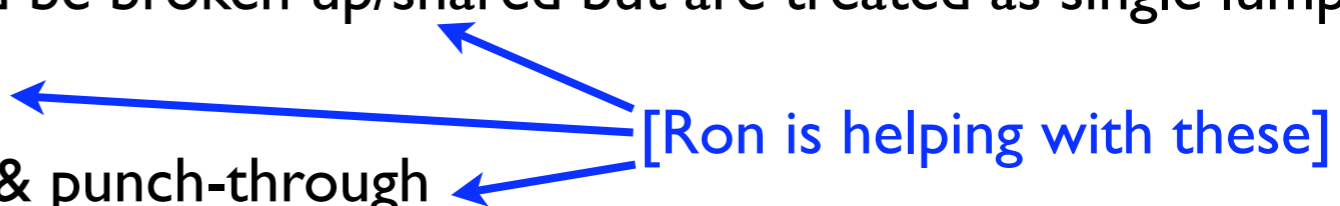


# Progress (Iowa): Tools & plans

## Some useful tools:

- Ron's cluster analysis package (picks out confusion matrix)
- Cheaters for various pieces
- Global  $\chi^2$  based on E/p (not quite trustworthy yet...)

## Plans & known problems:

- Currently limited to rms90  $\sim$  4.3 GeV even when cheating on linkage -- need to understand why & break through.
    - Candidate: Some fragments get thrown away  $\Rightarrow$  lose neutral energy
    - Candidate: Large clumps that should be broken up/shared but are treated as single lump
    - Candidate: Impurities in photon list
    - Candidate: E/p goes bad for muons & punch-through
  - Over-aggressive assignment of clusters to tracks can force mistakes
  - MIP-finding still not 100% efficient (clear by eye)
- [Ron is helping with these]
- 

# Comparisons & benchmarks

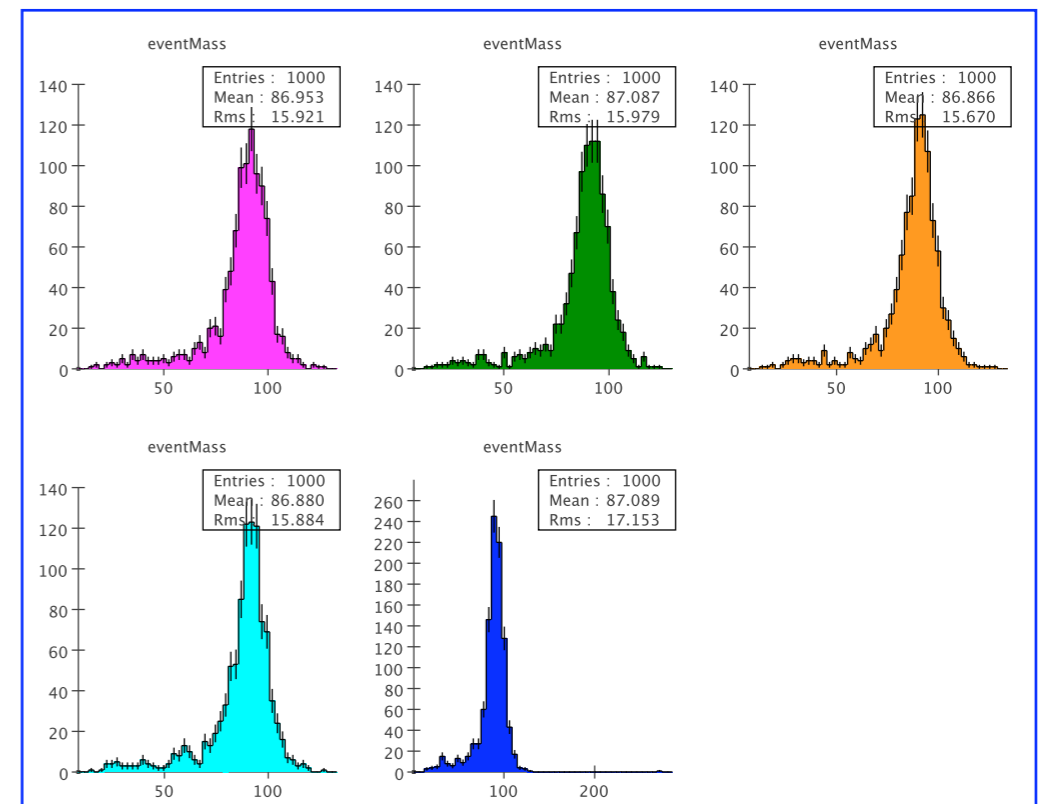
Still not at the point where PFA can unambiguously say which detector design is better.

Z-pole results  
(sorry Marty!)

rms90	sid01	acme0605
Steve PFA	4.6 GeV	4.0 GeV
NonTrivialPFA	4.5 GeV	4.1 GeV
ReclusterDTree	3.9 GeV	3.9 GeV

... but important to start thinking about this now, doing trial runs, looking for obvious patterns

MIT group (Ray & Lawrence) just got started on survey of design variants with Iowa PFA code.  
[Example: # HCAL layers]



# Other things on the radar

- Dual-readout
  - Promising idea (for both confusion and  $\sigma_{\text{NH}}$  terms)
  - Software issue: Tricky to implement in our framework
  - See Adam's talk this afternoon
- Tracking improvements

# Outlook

- PFA is critical for SiD (& most generic LC detectors)
- Given near-term manpower, very unlikely to meet original LOI schedule.
- Extended schedule (+6 months?) is not a sign to relax!
  - If we are serious about SiD, must not lose momentum on PFA
  - We may actually have less (time $\times$ manpower) than before.
- Current PFA experts will not be around forever
  - Critical to maintain expertise (takes a long time to develop)
  - Need to consciously recruit & train new experts.
  - Vital to consolidate progress & make it accessible to others.
  - Put your code in CVS! Document it! Get others using it!
  - General interest in writing a NIM, though no concrete plans.
- Despite the gloom, we are making progress!