PandoraPFA

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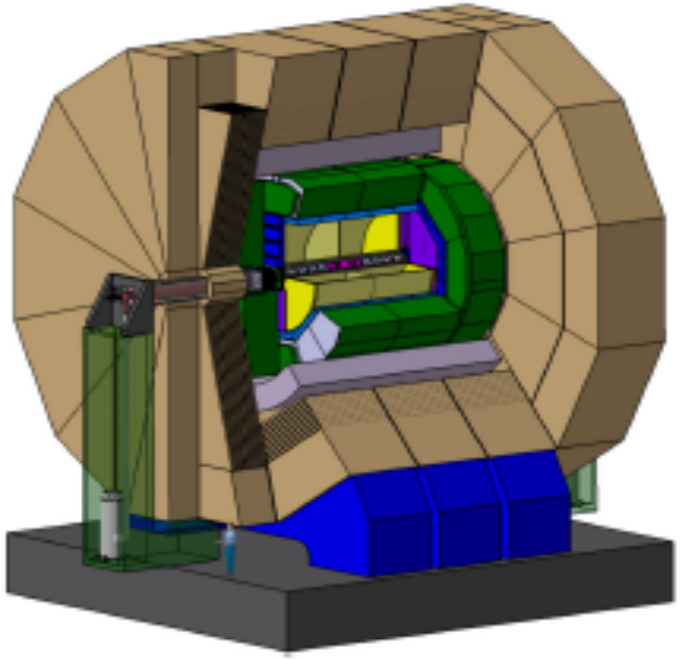
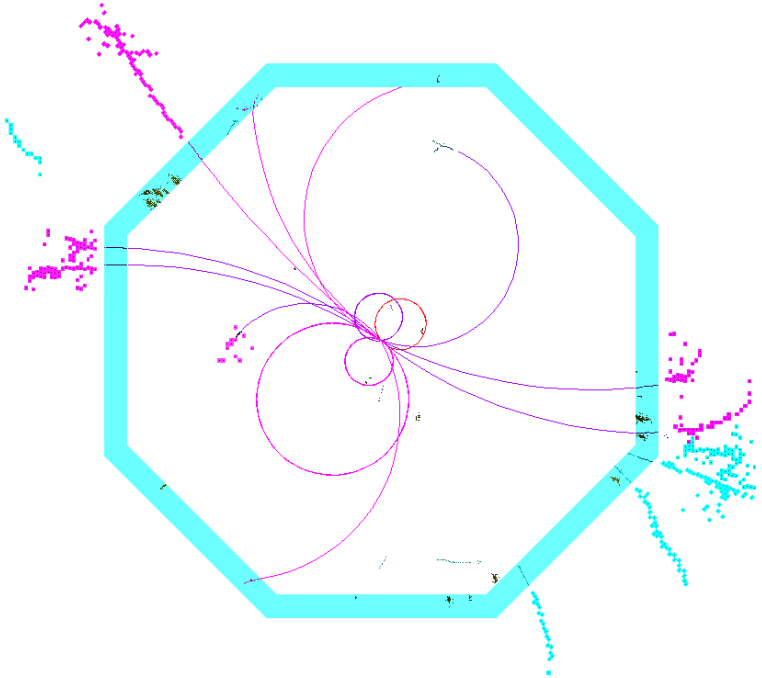




PandoraPFA New

Since the LoI:

- ★ Complete rewrite of PandoraPFA
  - Old code obsolete - unsupported

Advantages of PandoraPFANew:

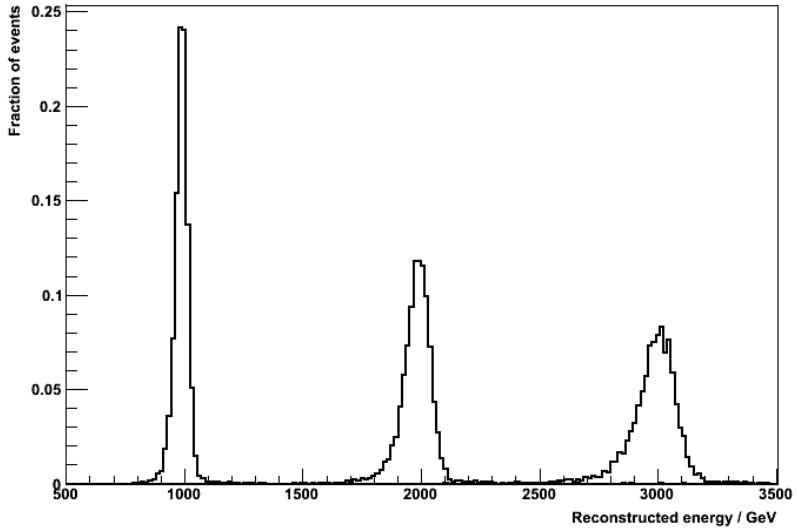
- ★ By design, initial version had (almost) identical performance
  - Some subsequent improvements
- ★ From a software perspective
  - Code is well designed and sensibly structured
  - Better software performance
    - faster
    - smaller memory footprint
- ★ Well tested
  - Extensively debugged for CLIC CDR
  - But used CLIC_ILD (modified version of ILD00)

★ From a physics perspective, a number of advantages

- Somewhat better resolution, particular at higher energies

ILD

E_{JET}	RMS_{90}/E_J
45 GeV	3.6 %
100 GeV	3.1 %
180 GeV	3.0 %
250 GeV	3.3 %

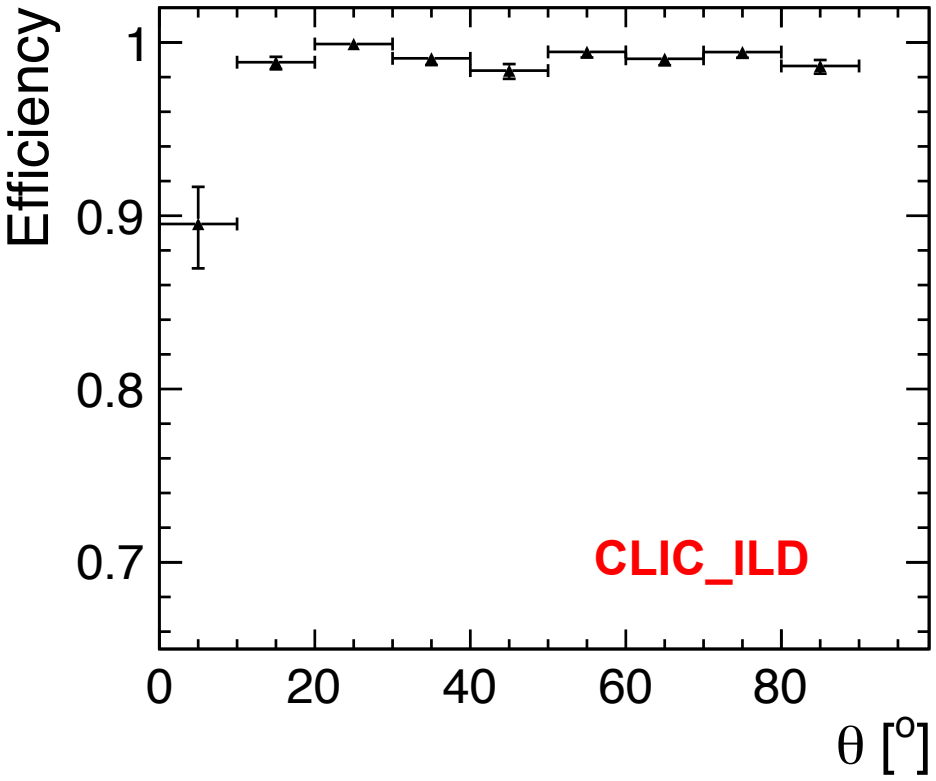


CLIC_ILD

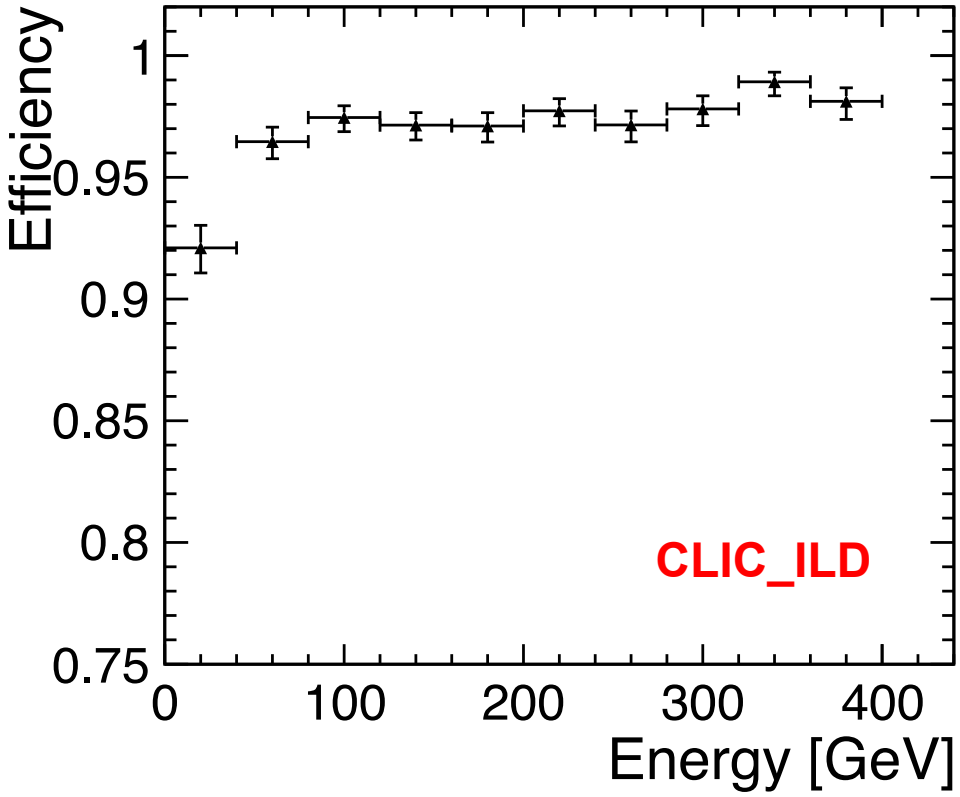
E_{JET}	RMS_{90}/E_J
45 GeV	3.6 %
100 GeV	2.9 %
250 GeV	2.8 %
500 GeV	3.0 %
1 TeV	3.2 %
1.5 TeV	3.2 %

- **Much better treatment of particle ID**

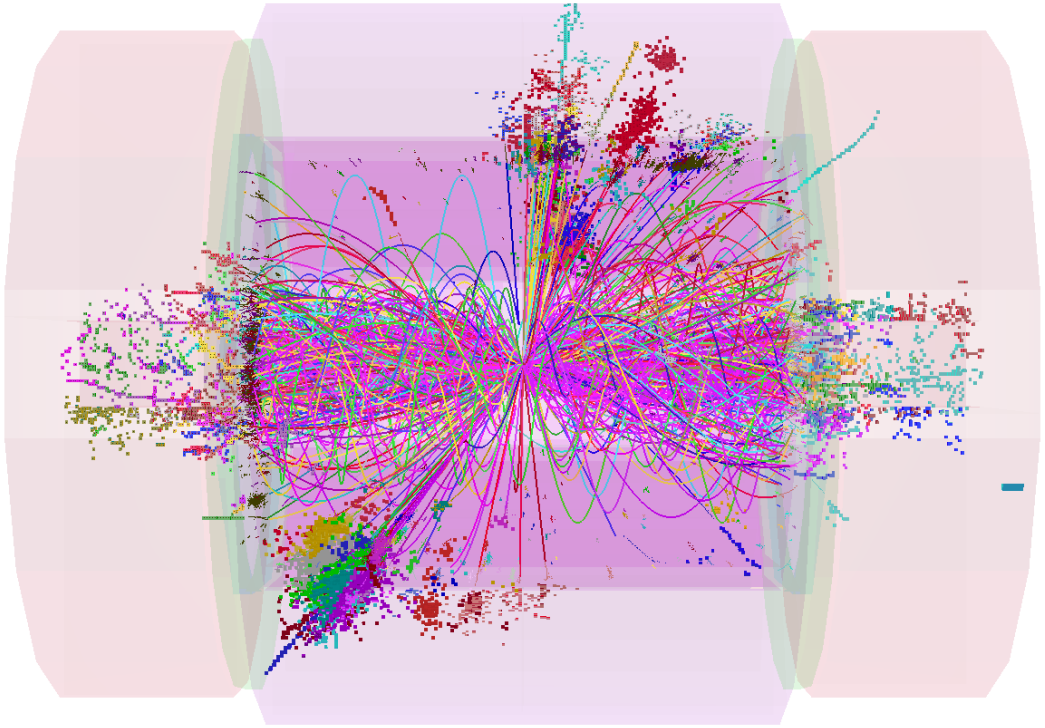
Muons



Electrons



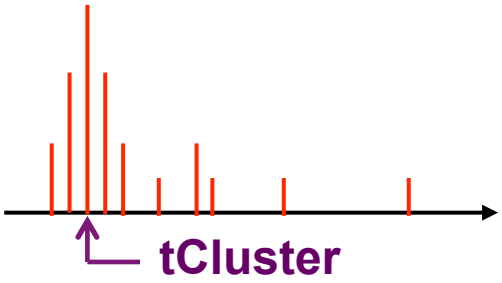
- **Now a powerful clustering and particle flow framework which can cope with complex events**

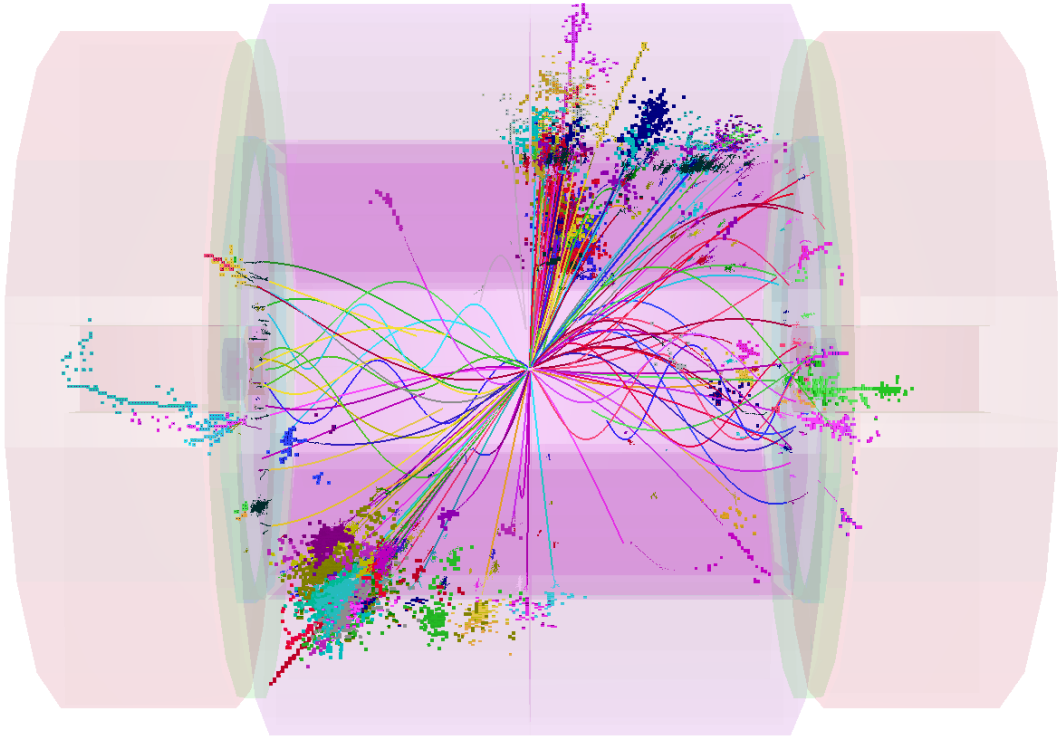


CLIC_ILD

e.g. a 3 TeV event at CLIC with 1.2 TeV of pile-up overlaid

- **Reconstructed PFOs clean enough to use cluster times to reject background**





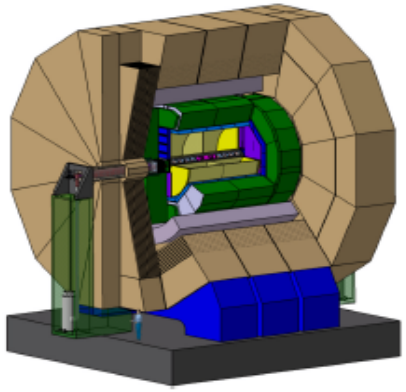
From CLIC_ILD to ILD_O1

PandoraPFA and ILD_O1

- ★ Recent IlcSoft changes should have no direct impact on PandoraPFA
- ★ However a number of potential indirect impacts

Isolate specific detector and software details, creating self-describing hits, tracks, etc.

Pandora Client Application



ILD/Marlin

API

Run-time registered algorithms/tools and object book-keeping

Pandora Framework

Algorithm Manager
CaloHit Manager
Cluster Manager, etc.

MarlinPandora - Pandora

★ **MarlinPandora:**
- **Providing calibrated energies for each calorimeter cell,**
- **Quality cuts for all tracks and calorimeter cells,**
- **Specifying information about inner-detector tracks and their relationships (kinks, prongs, split tracks)**

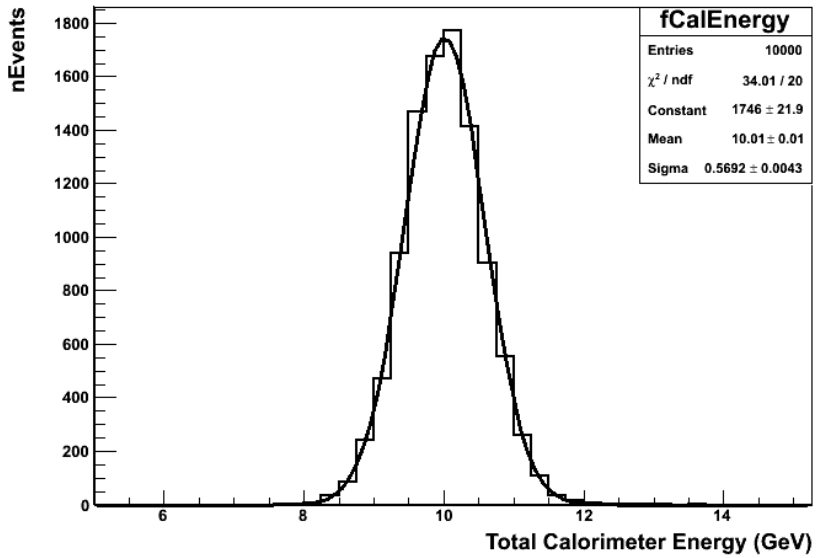
★ **Changes in PandoraPFA performance can result from**
- **Calibration**
- **New tracking software**
  - **New features**
  - **Non-optimal quality cuts**
- **Current lack of track and relationships (kinks, prongs,…)**
- **Mokka related**
  - **New features in modified/new drivers**
  - **Dead material (i.e. one thing we would like to know)**

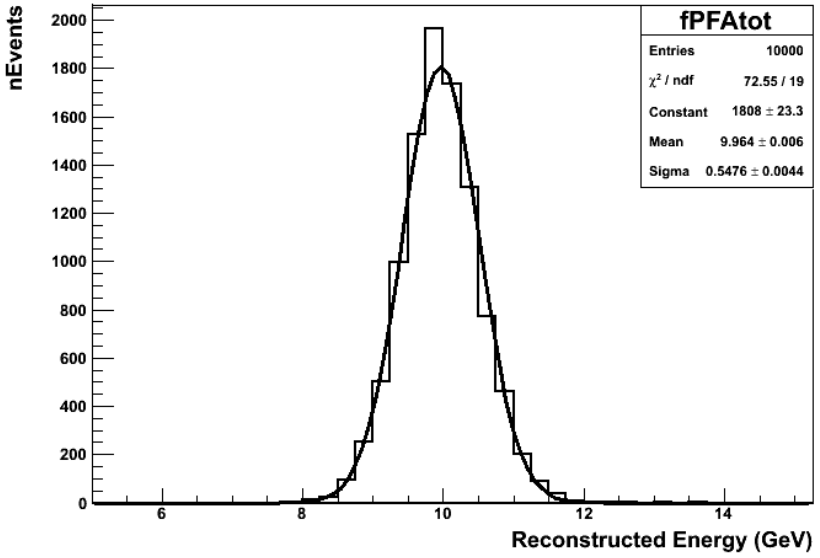
1) Calibration

★ **Two aspects:**

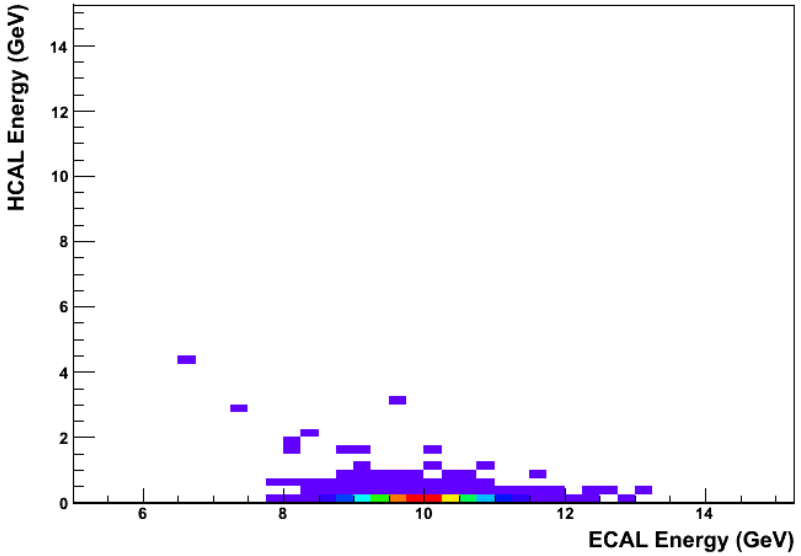
- **Calibration of raw calorimeter energies – ADC to GeV**
- **Correction to raw energy used internally by PandoraPFA**
  - **if all is well this is a small correction**
  - **accounts for effects such as not all hits being used in PFOs**

ECAL Calibration

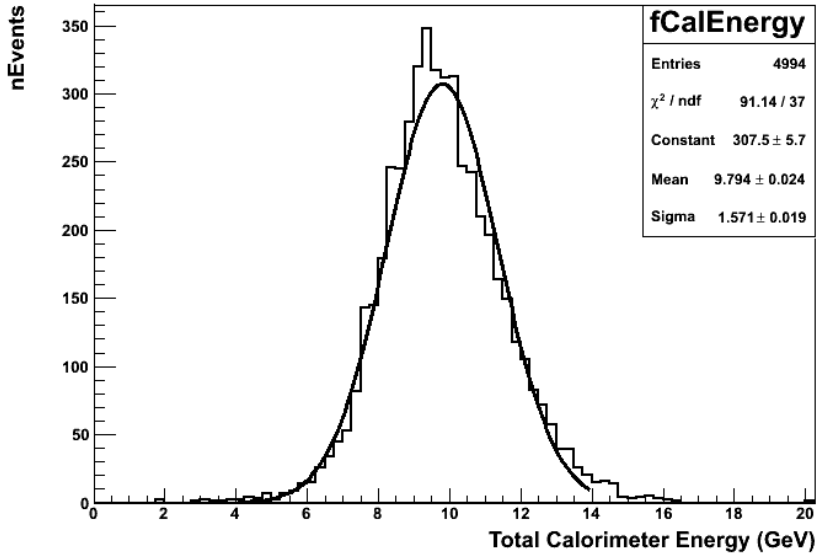


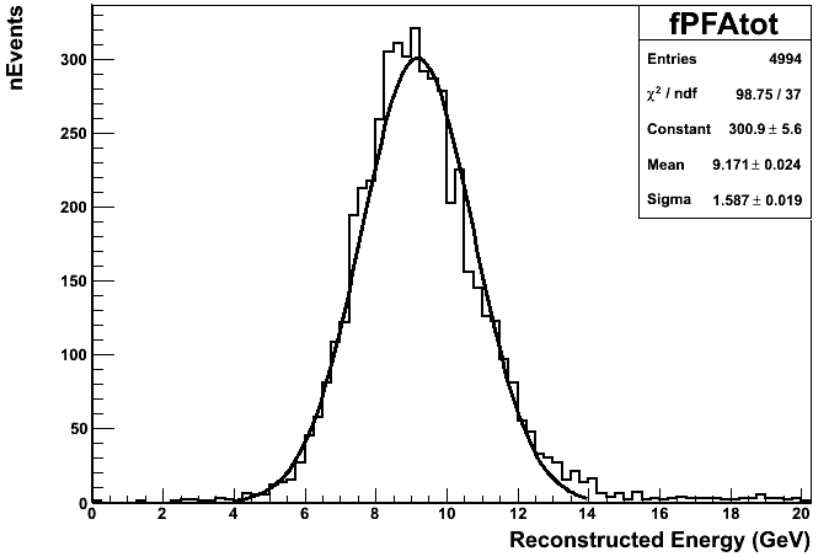


- ECAL calibration rather straightforward.
- Change **CalibrECAL** from 40.91, 81.81 to 42.91, 85.82
- Pandora constants:
  - ECAL_To_EM_GeV=1.00
  - HCAL_To_EM_GeV=1.00

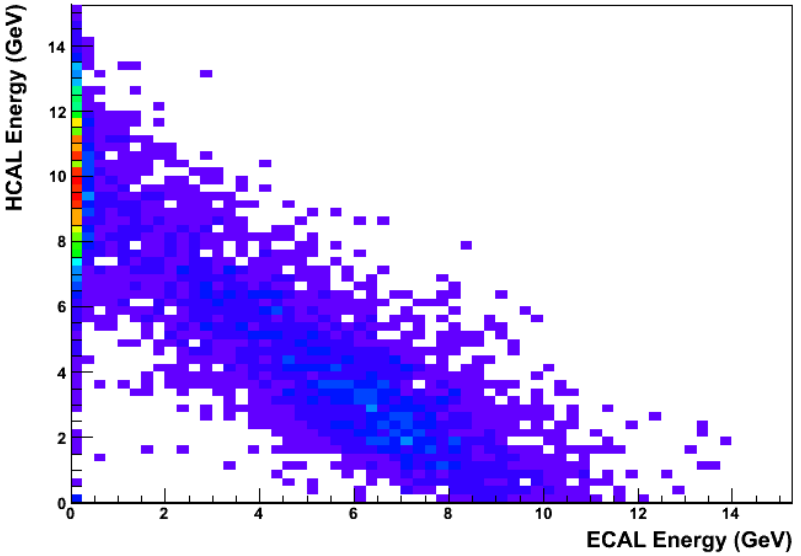


HCAL Calibration





- ★ HCAL calibration more difficult:
  K_L energy divided between ECAL/HCAL
- ★ Optimise for jet energy reconstruction
  CalibrHCAL from 34.80 to 58.60
- ★ Pandora constants:
  ECAL_To_HAD_GeV = 1.05
  HCAL_To_HAD_GeV = 1.00



Calibration looks fine

Now Look at Z→uds

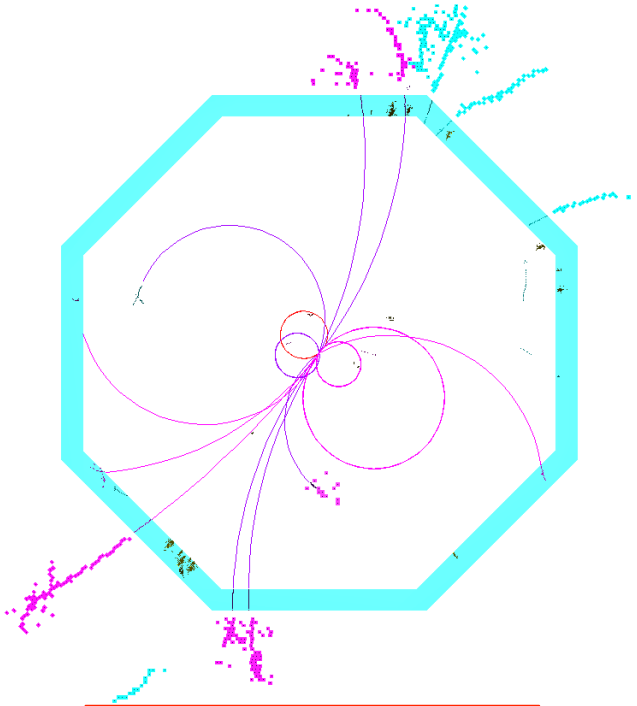
- ★ Assess PFA performance using Zs at different energies decaying at rest into light quarks
  - two back-to-back jets
- ★ Use IlcSoft v01-13-05 version of Mokka to process same stdhep files for both ILD_00 and ILD_O1_v02
  - Same physics lists, etc.
  - In simulation change only detector model
- ★ Reconstruct events with IlcSoft v01-13-05:

  i) using old tracking/calibration with ILD00
  (previously validated steering file)

  ii) new tracking/calibration with ILD_O1
  (new steering file from ILDConfig repository

NOTE: technically not possible to run new tracking with ILD00 or old tracking with ILD_O1

★ **Different simulation of same generated events –**
no direct event-by-event comparison is possible



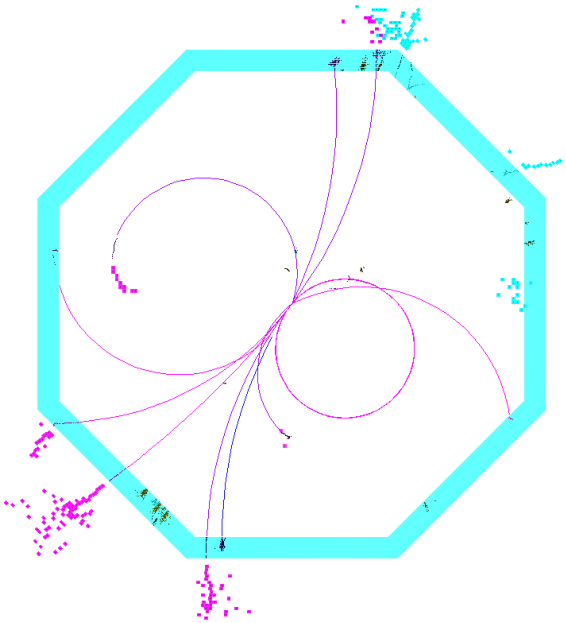
Event 1

Same 91GeV Z→uds stdhep file

Same physics list and Mokka version

IlcSoft v01-13-05

Same PandoraPFA



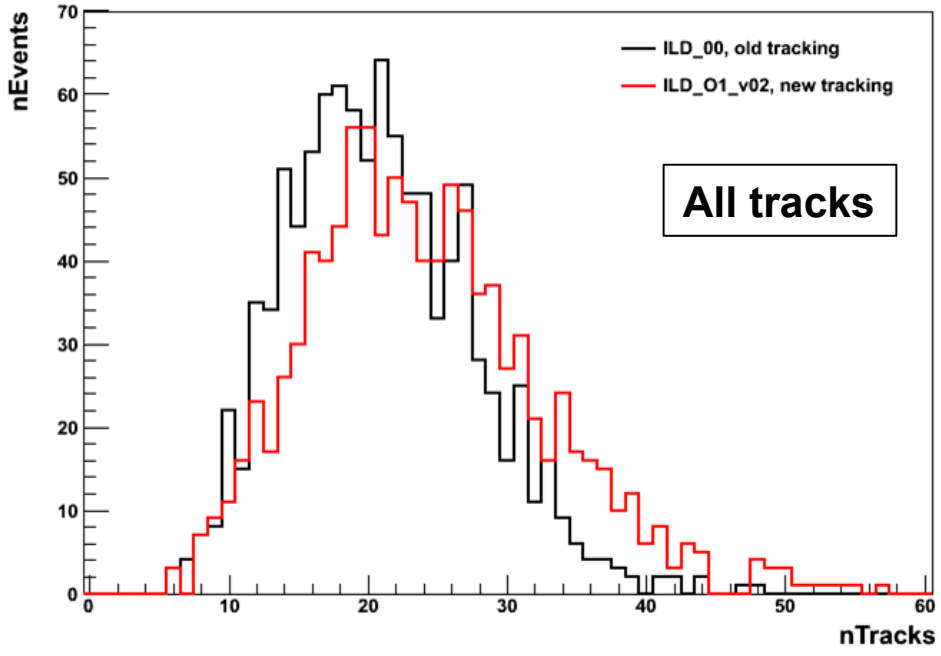
ILD_00
Old Tracking/
Calibration

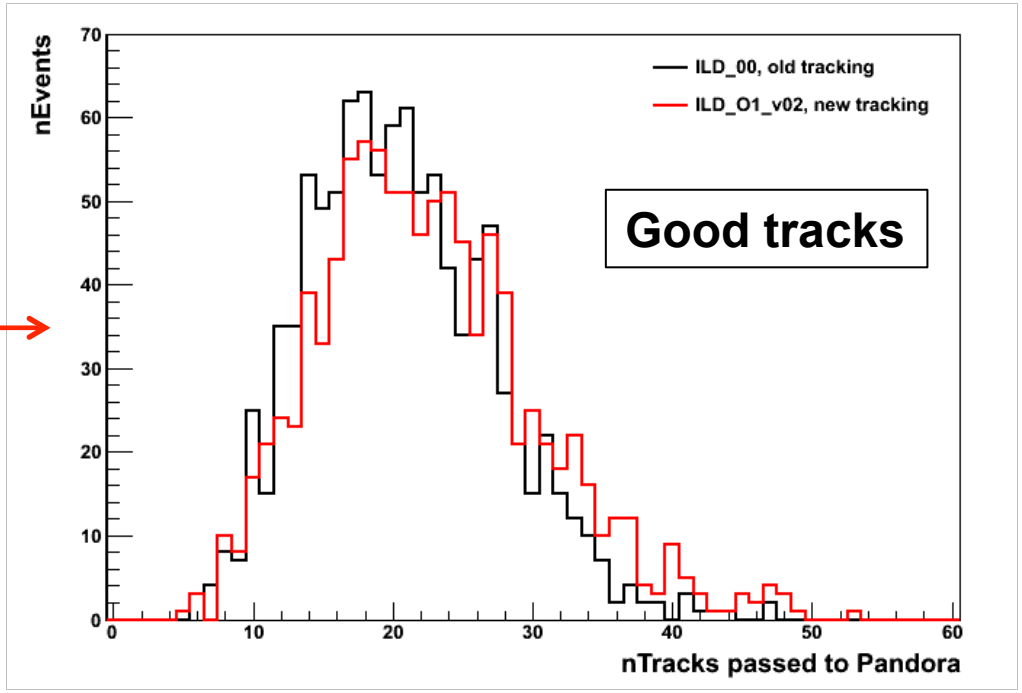
ILD_O1_v02
New Tracking/
Calibration

★ **Can only make statistical comparisons**

2) Tracking Changes

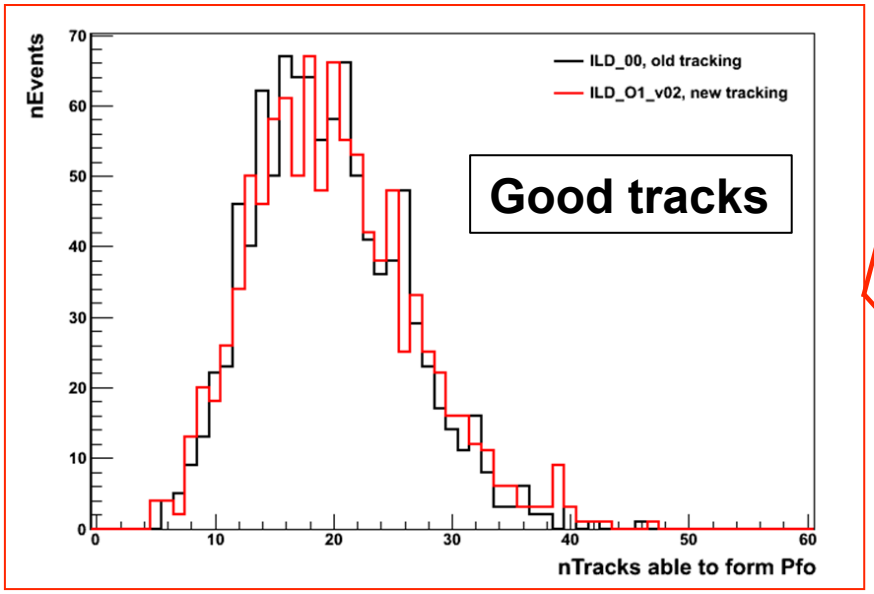
- ★ New track reco: track quality cuts in MarlinPandora may not be appropriate:
  - For first tests, simply apply old cuts
- ★ KinkFinder and V0Finder processors, do not yet work with new tracks
  - Kinks and V0s not used (should be a relatively small effect)
- ★ First compare numbers of "good" tracks

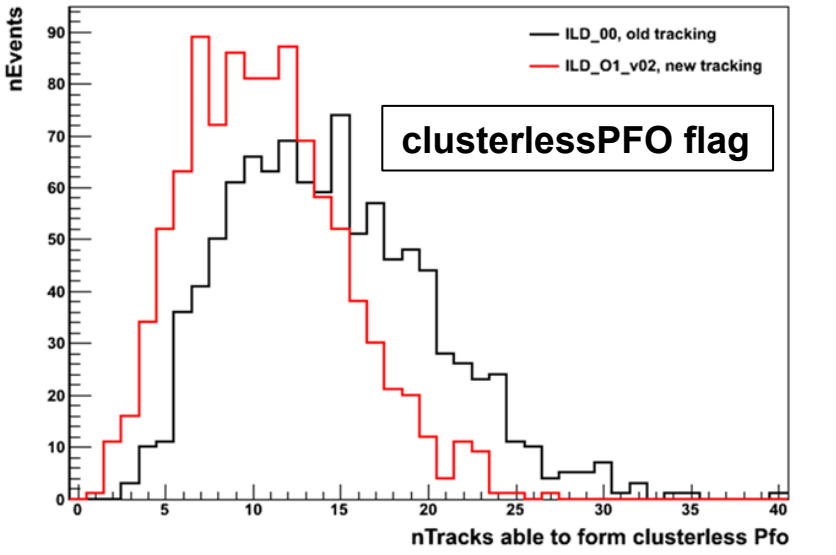


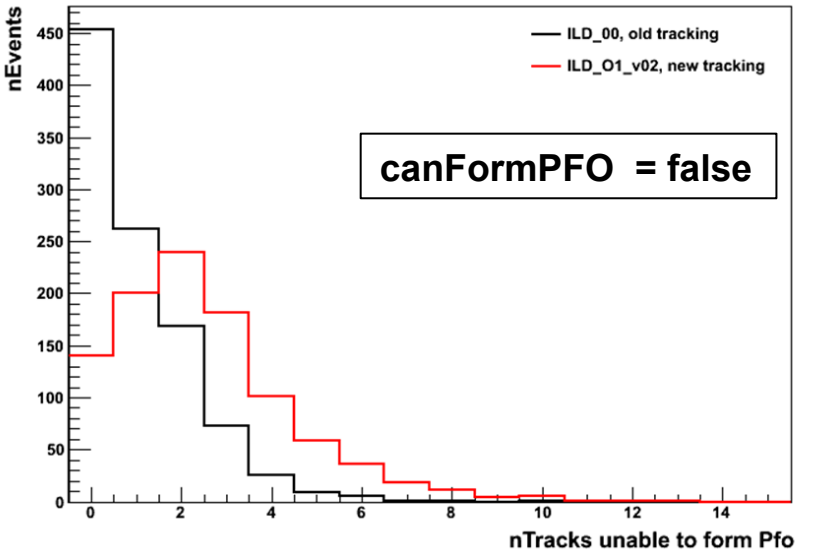


Tracking Changes

- **MarlinPandora also specifies a number of track properties which tell the algorithms how to use the tracks:**
  - **CanFormPfo flag**
  - **CanFormClusterlessPfo flag**

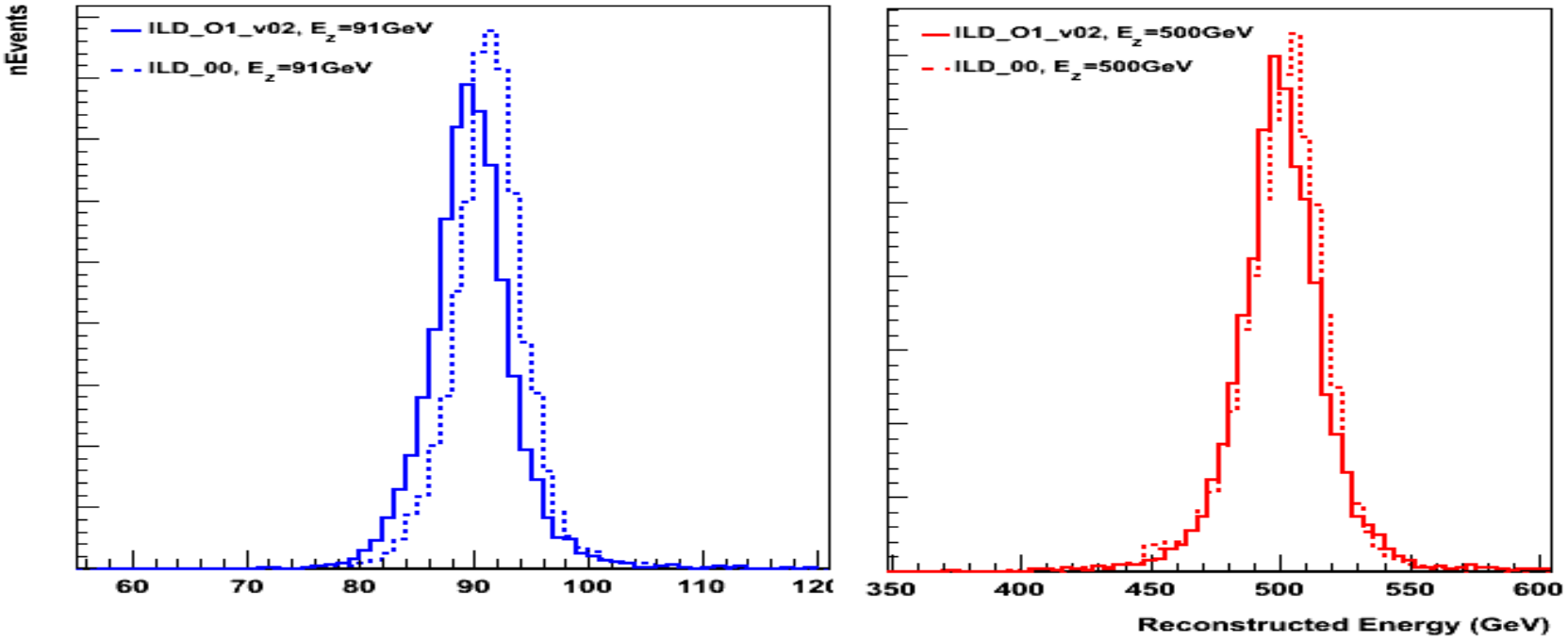






Z→uds Results

★ Degradation in jet energy resolution especially at E_Z=91GeV

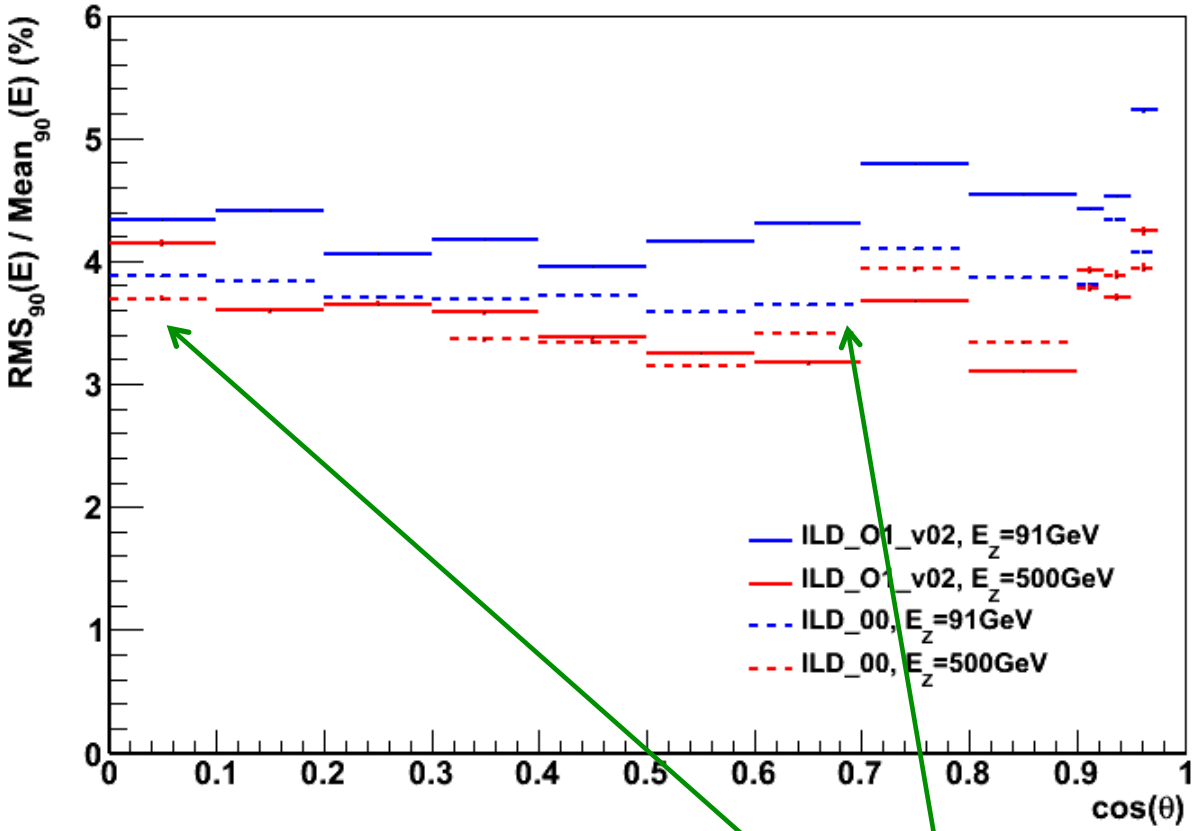


$RMS_{90}(E_j)/<E_j>$	91GeV	500GeV
ILD_00	3.69 ± 0.05 %	3.40 ± 0.05 %
ILD_O1_v02	4.15 ± 0.05 %	3.48 ± 0.05 %

12 % @ 91 GeV

2 % @ 500 GeV

★ No obvious angular dependence of effect at 91 GeV



★ Some structure at 500 GeV

- ILD_O1 better in endcap
- Degradation near theta cosθ = 0

Suspicious Minds

- ★ For low jet energies
  - calorimeter resolution is largest contribution to jet energy resolution
  - low energy tracks is important
- ★ For higher jet energies
  - confusion dominates everything
- ★ Finger of suspicion points at:
  - interface between new tracking and Pandora
  - worse HCAL resolution – can account for some of the effect…

Summary

- ★ There are issues with PFA reconstruction of ILD_O1
- ★ Origin is uncertain
  - suspicion it is related to low energy tracks
  - possible some impact of HCAL resolution
  - but could be related to new drivers
  - or related to the inclusion of material

The problem

- ★ Many changes
  - PandoraPFA
  - New tracking
  - New drivers
  - Dead material
- ★ Hard to identify statistically

The ideal way forward

- ★ Break down problem
  - one aspect at a time
- ★ e.g. run old and new tracking on ILD_O1
  - could compare reconstructed tracks
  - but this is not possible

Conclusions

- ★ There are issues with PFA reconstruction of ILD_O1
- ★ Origin is uncertain
  - don't have a good quick way of identify source

Options

- ★ Live with degraded performance, but…
  - could indicate a more serious problem
  - lose any handle on understanding impact of material
  - a significant step backwards from LoI

- ★ Fix it – but not trivial and will take weeks not days
  - need stable software underneath
  - any new MC studies require large event samples
  - need to coordinate tracking/PFA