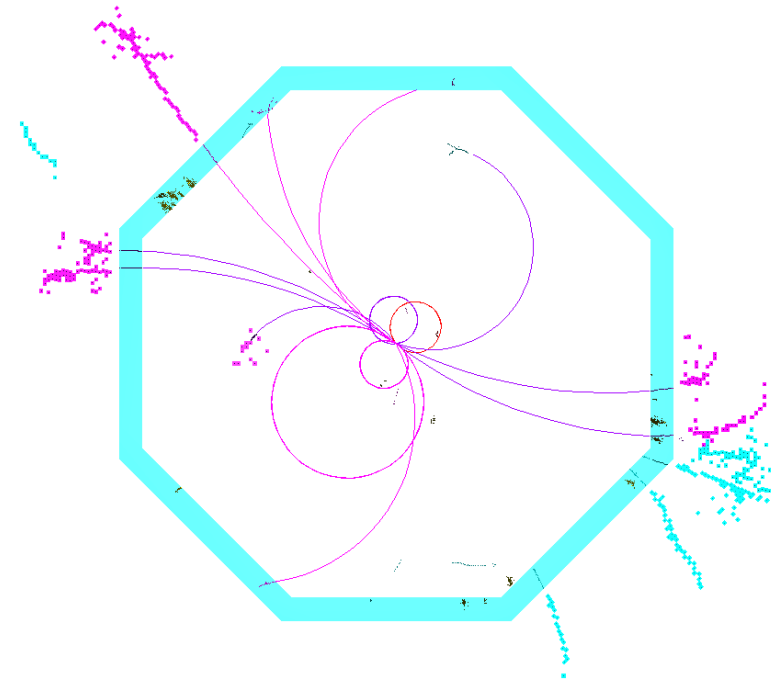
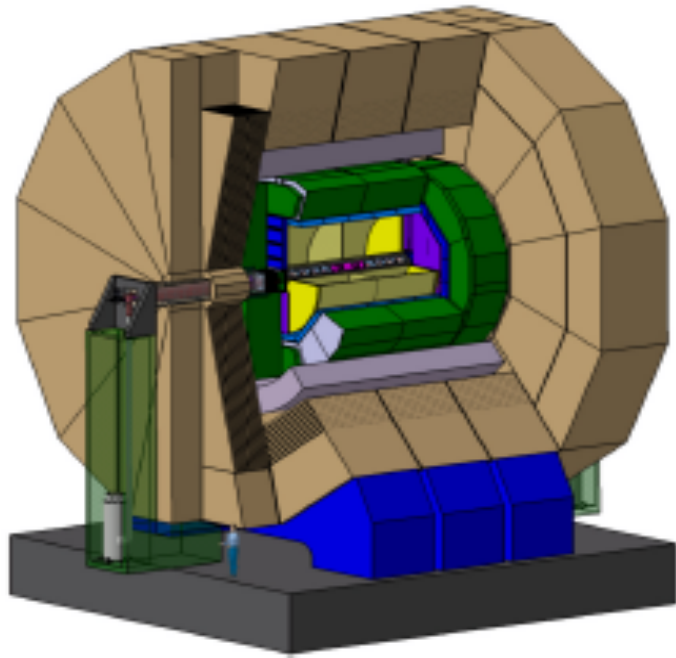




# PandoraPFA

Mark Thomson  
mostly reporting on work done by John Marshall





# PandoraPFA New



## Since the Lol:

- ★ **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**

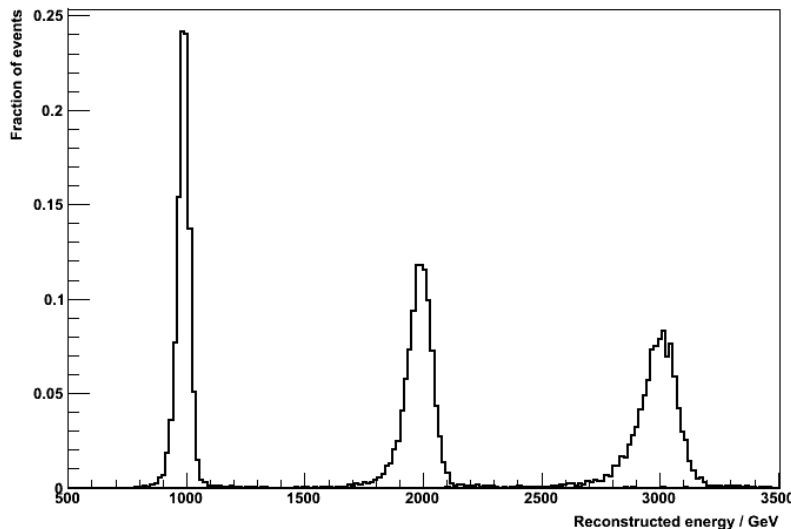


$E_{\text{JET}}$	$\text{RMS}_{90}/E_J$
45 GeV	3.6 %
100 GeV	3.1 %
180 GeV	3.0 %
250 GeV	3.3 %

**CLIC\_ILD**



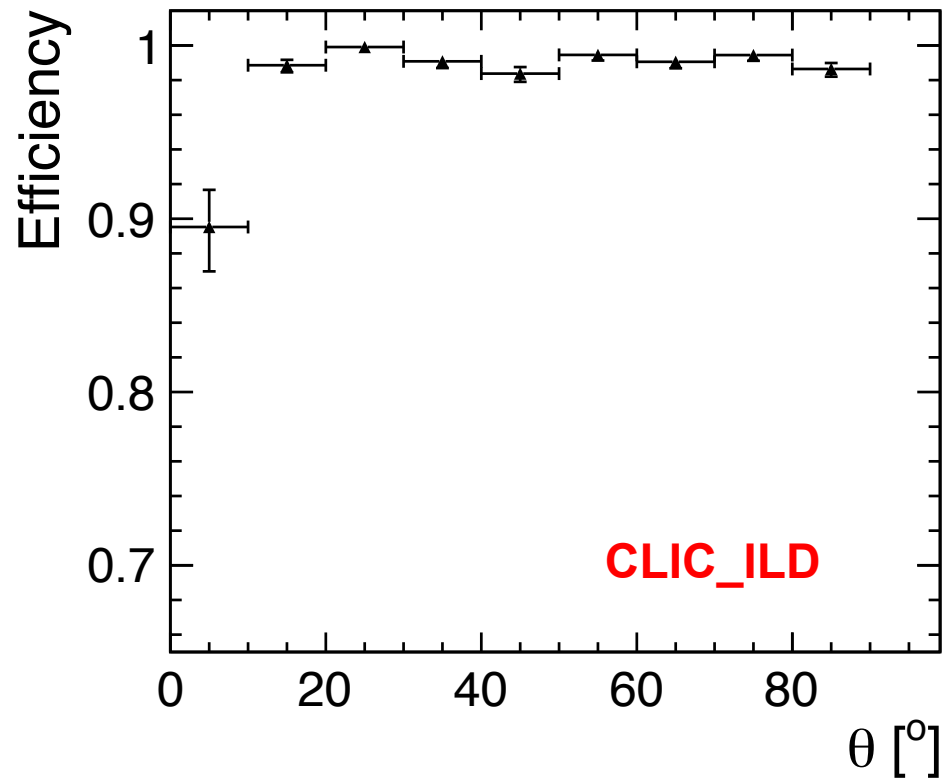
$E_{\text{JET}}$	$\text{RMS}_{90}/E_J$
45 GeV	3.6 %
100 GeV	2.9 %
250 GeV	2.8 %
500 GeV	3.0 %
1 TeV	3.2 %
1.5 TeV	3.2 %



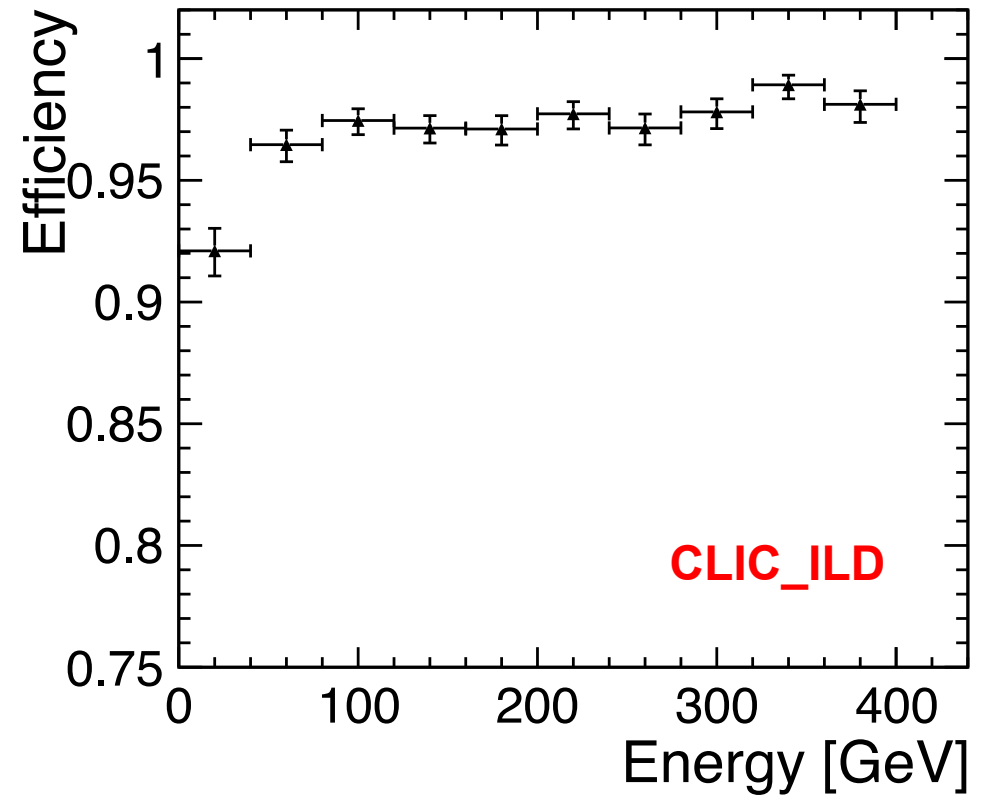


- **Much better treatment of particle ID**

### Muons



### Electrons





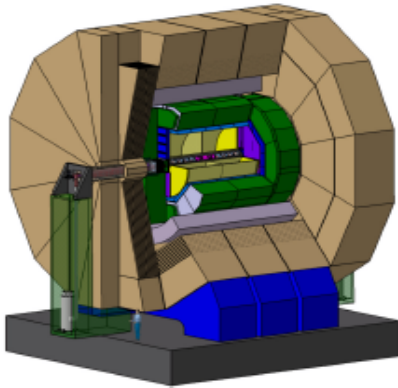
# PandoraPFA and ILD\_01



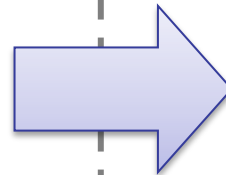
- ★ Recent IlcSoft changes should have no **direct** impact on PandoraPFA
- ★ However a number of potential **indirect** impacts

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 is responsible for:

- 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)

## ★ Possible changes in PandoraPFA performance 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

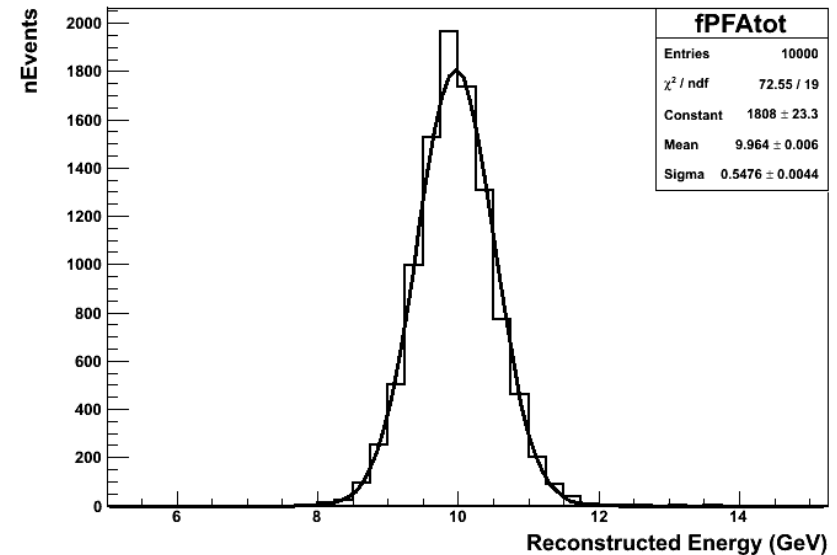
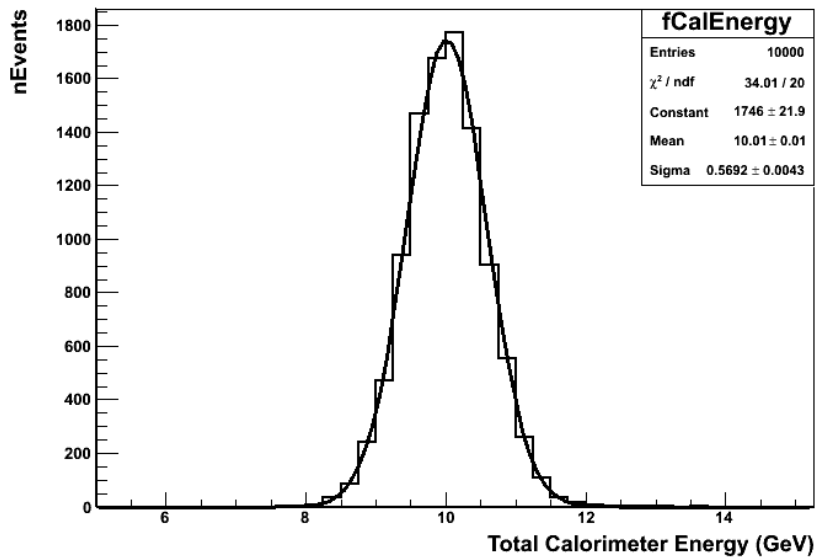


## ★ Two aspects:

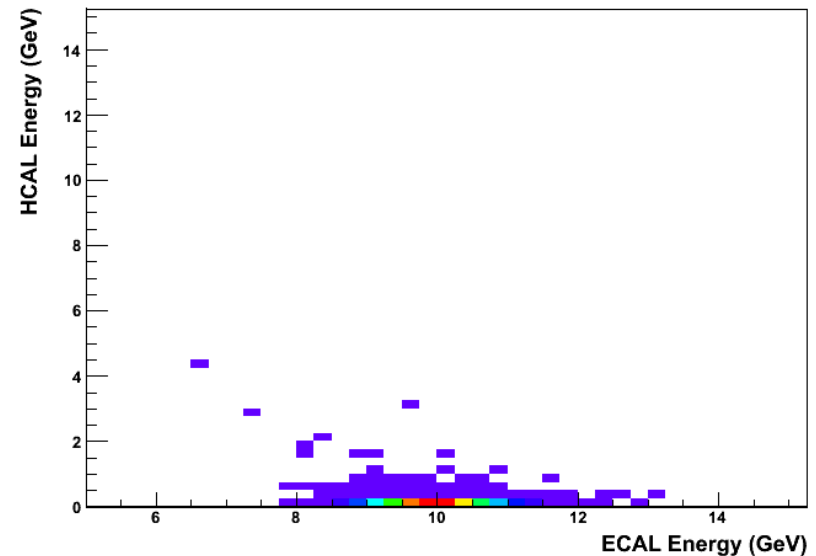
- Calibration of raw calorimeter energies – ADC to GeV
- Correction to raw energy used internally by PandoraPFA
  - if all is well this is a small correction
  - accounts for effects such as not all hits being used in PFOs



# ECAL Calibration



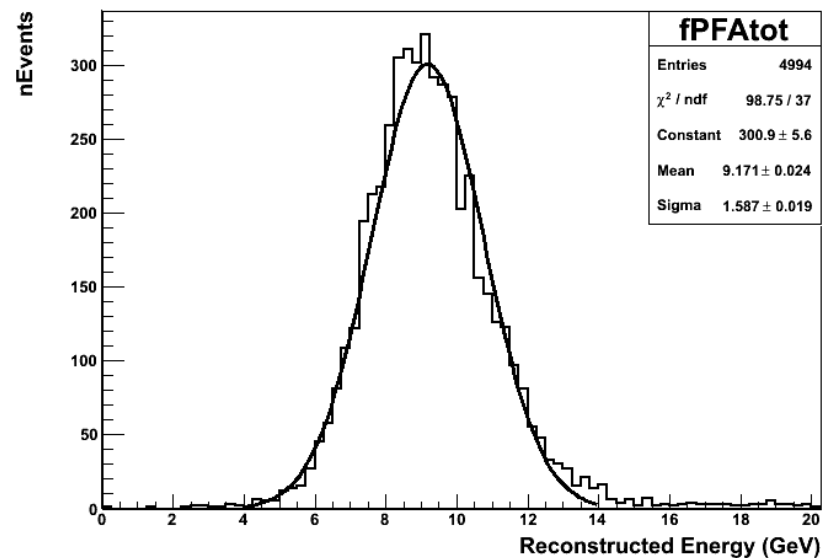
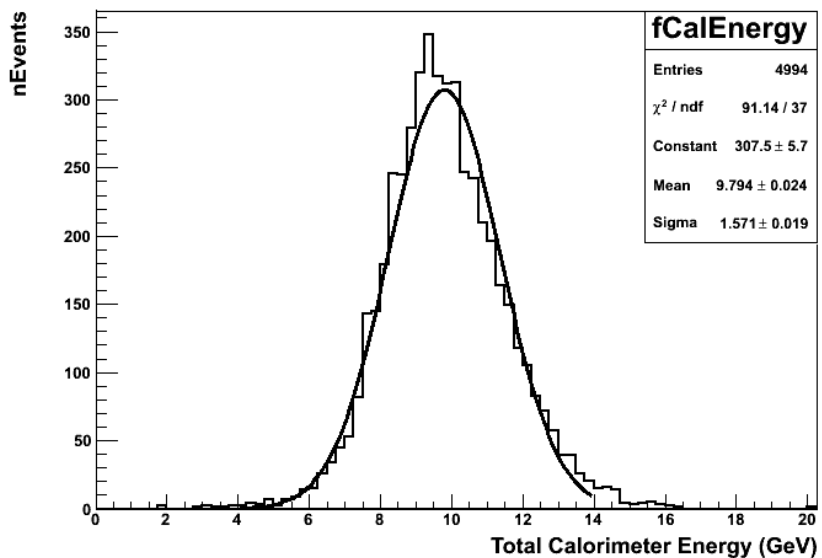
- ★ ECAL calibration rather straightforward.
- ★ Change CalibrECAL from 40.91, 81.81 to 42.91, 85.82
- ★ Pandora constants:  
ECAL\_To\_EM\_GeV=1.00  
HCAL\_To\_EM\_GeV=1.00



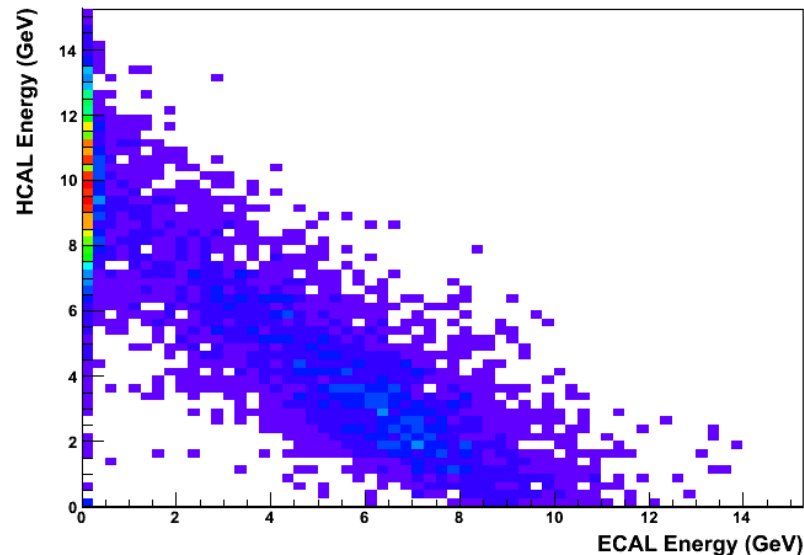




# HCAL Calibration



- ★ 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 $Z \rightarrow uds$

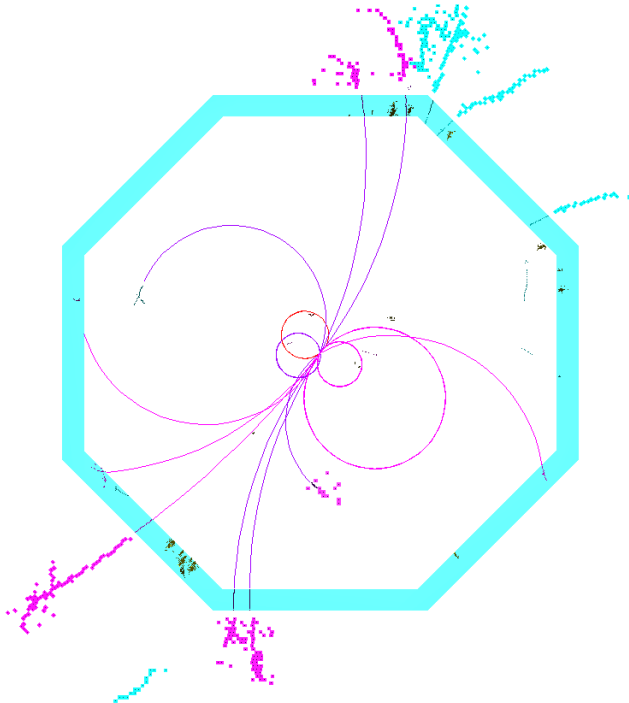


- ★ Assess PFA performance using Zs at different energies decaying at rest into light quarks
  - **two back-to-back jets**
- ★ Use IlcSoft v01-13-05 version of Mokka to process same stdhep files for both **ILD\_00** and **ILD\_O1\_v02**
  - **Same physics lists, etc.**
  - **In simulation change only 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**



**ILD\_00  
Old Tracking/  
Calibration**

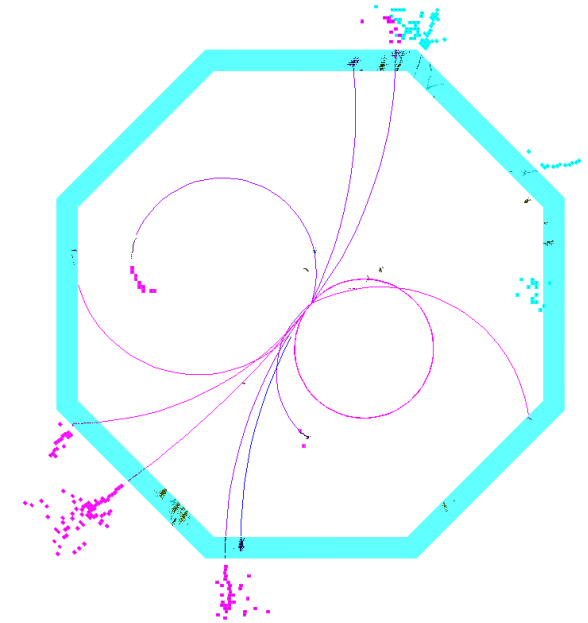
**Event 1**

**Same 91GeV  
Z→uds stdhep  
file**

**Same physics  
list and Mokka  
version**

**IlcSoft v01-13-05**

**Same  
PandoraPFA**



**ILD\_O1\_v02  
New Tracking/  
Calibration**

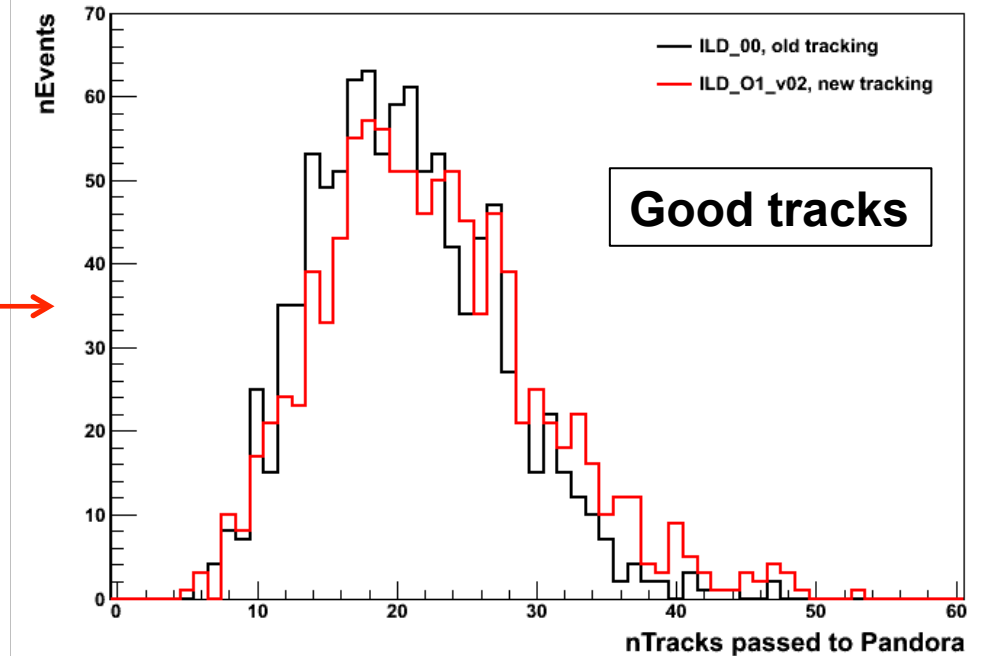
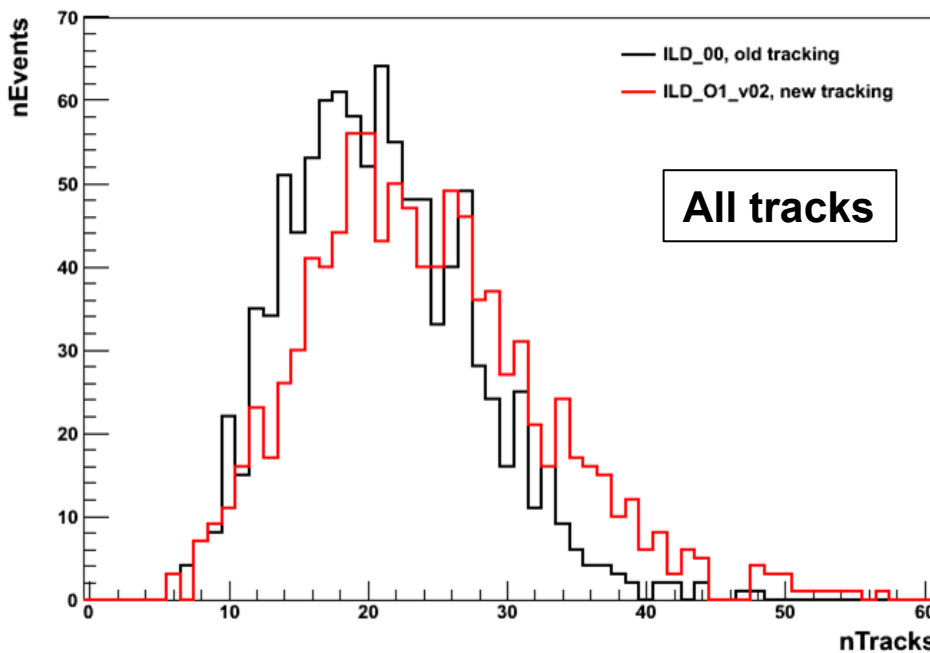
★ **Can only make statistical comparisons**



# 2) Tracking Changes



- ★ **New track reconstruction: track quality checks in MarlinPandora may not be appropriate:**
  - **For first tests, apply old “sensible” track quality cuts, but nothing directed at specific pathologies in either the old or the new tracking software.**
- ★ **Cannot assume that track-relationship information, provided by KinkFinder and V0Finder processors, can be used safely.**
  - **Therefore Kinks and V0s not used (should be a relatively small effect)**
- ★ **First compare numbers of “good” tracks**



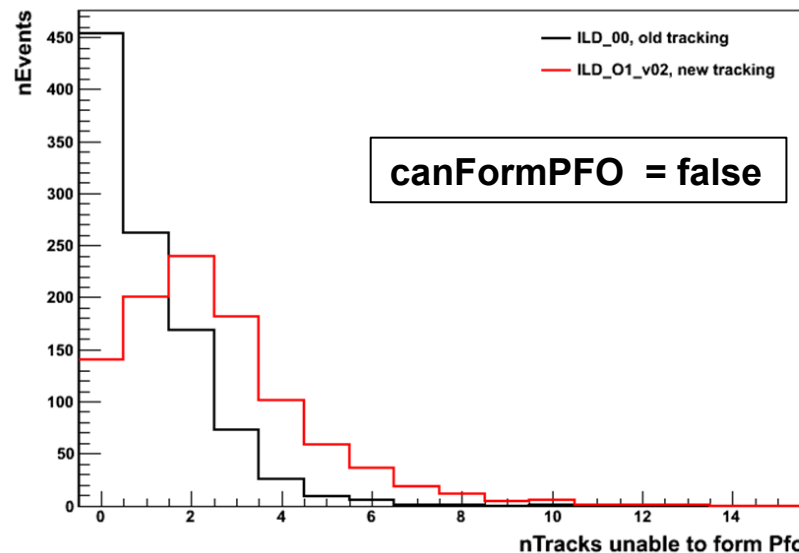
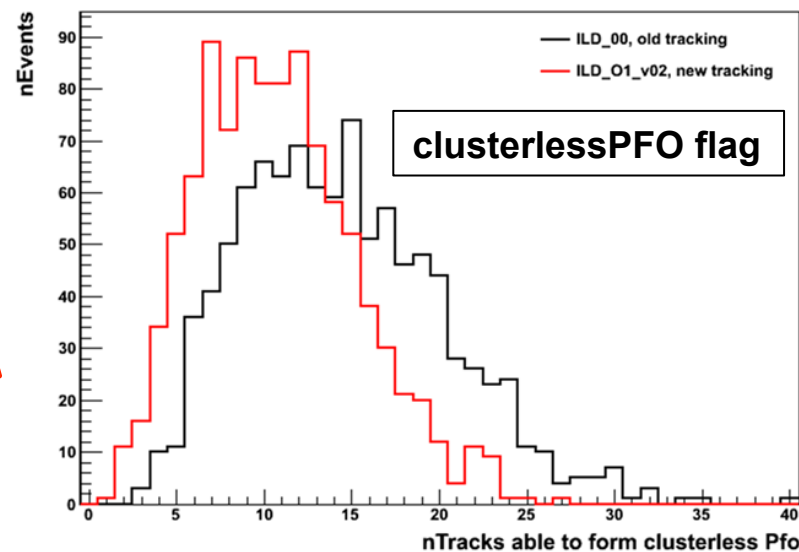
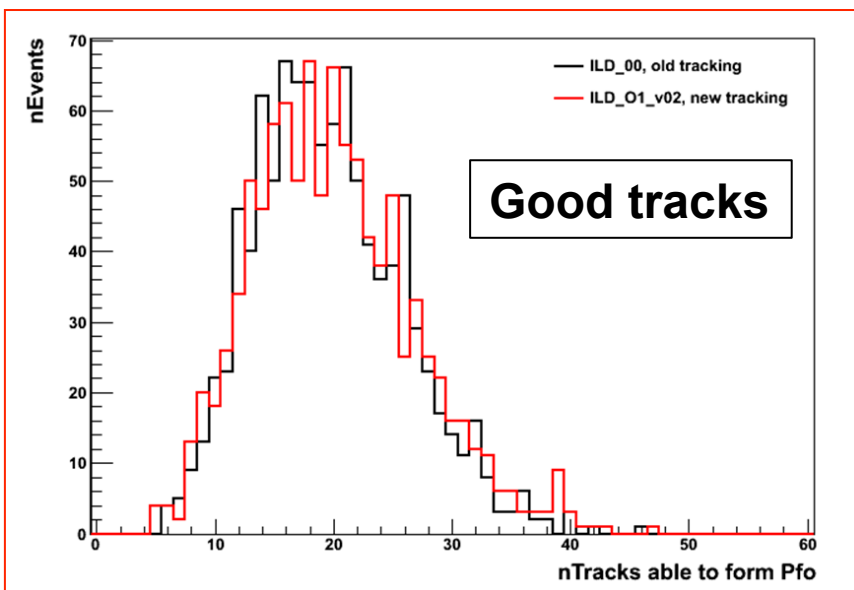


# Tracking Changes



★ MarlinPandora also specifies a number of important properties, which tell Pandora algorithms how to use tracks they receive:

- CanFormPfo flag
- CanFormClusterlessPfo flag

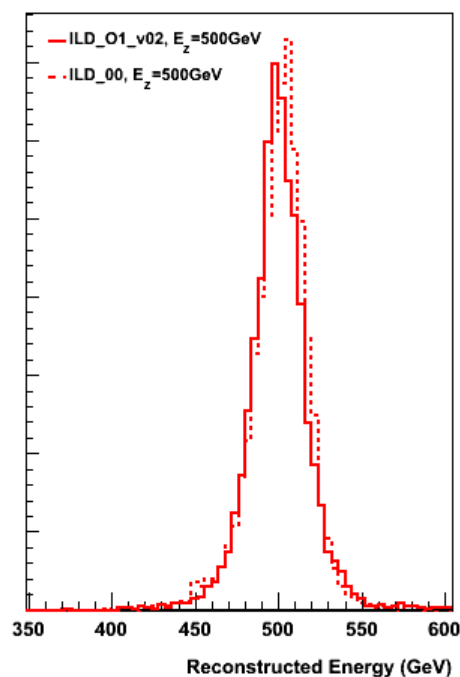
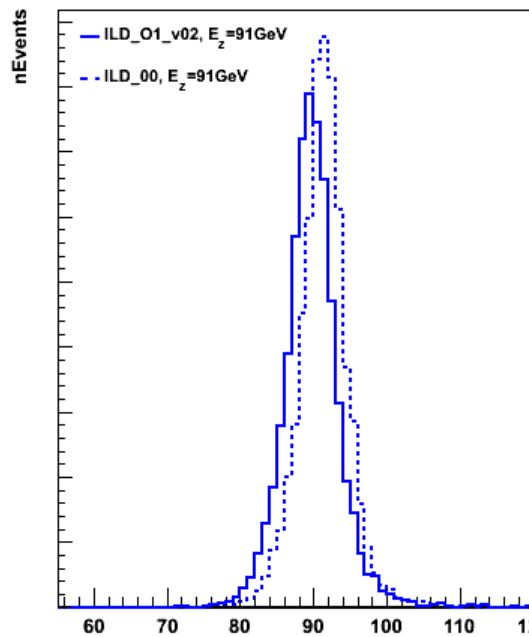
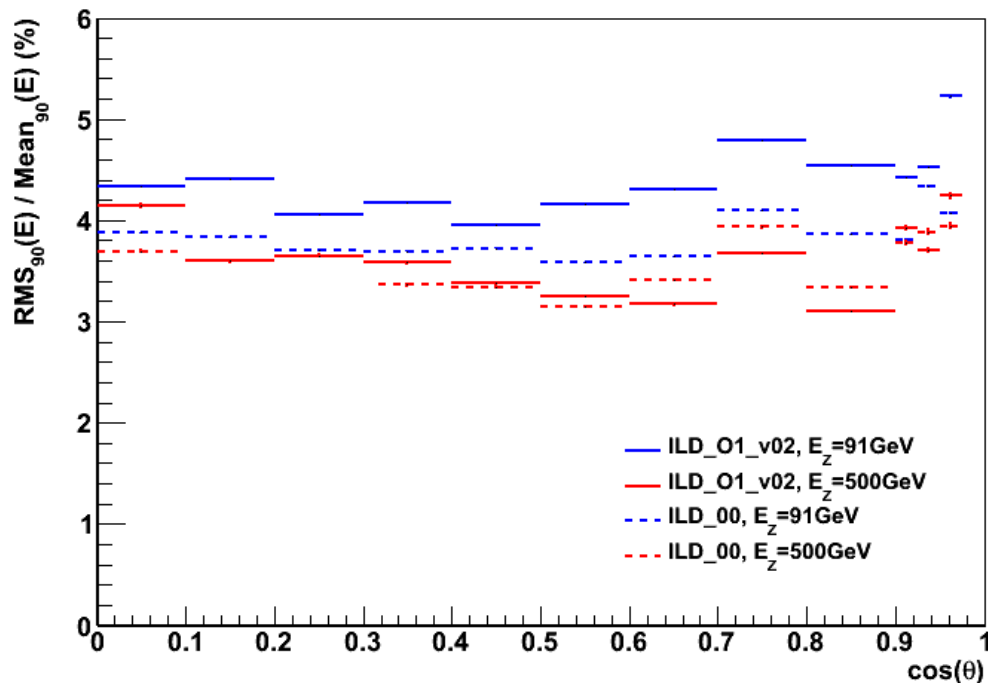




# Z → uds Results



- ★ Jet energy reconstruction results indicate problems.
- ★ Sizeable at  $E_z=91\text{GeV}$ , decreases at  $E_z=500\text{GeV}$ .



$\text{RMS}_{90}(E_j)/\langle E_j \rangle$	91GeV	500GeV
ILD_00	$3.69 \pm 0.05 \%$	$3.40 \pm 0.05 \%$
ILD_O1_v02	$4.15 \pm 0.05 \%$	$3.48 \pm 0.05 \%$



# Summary



- ★ There are issues with PFA reconstruction of ILD\_O1
- ★ Origin is uncertain
  - suspicion it is related to low energy tracks
  - 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 Lol
- ★ Fix it
  - non-trivial – requires weeks not days of work
  - need to coordinate tracking/PFA