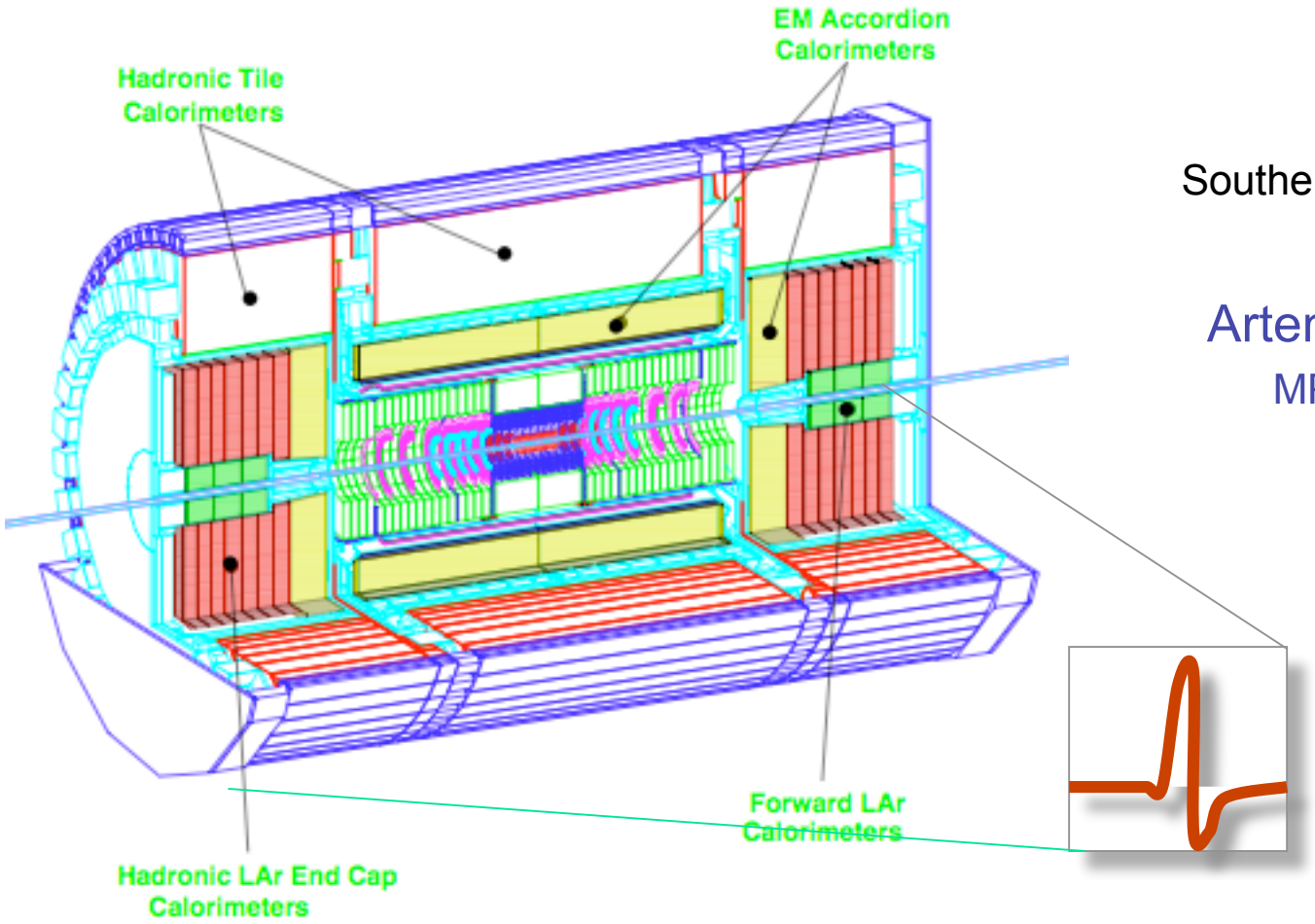
LAr Calorimeter Monitoring



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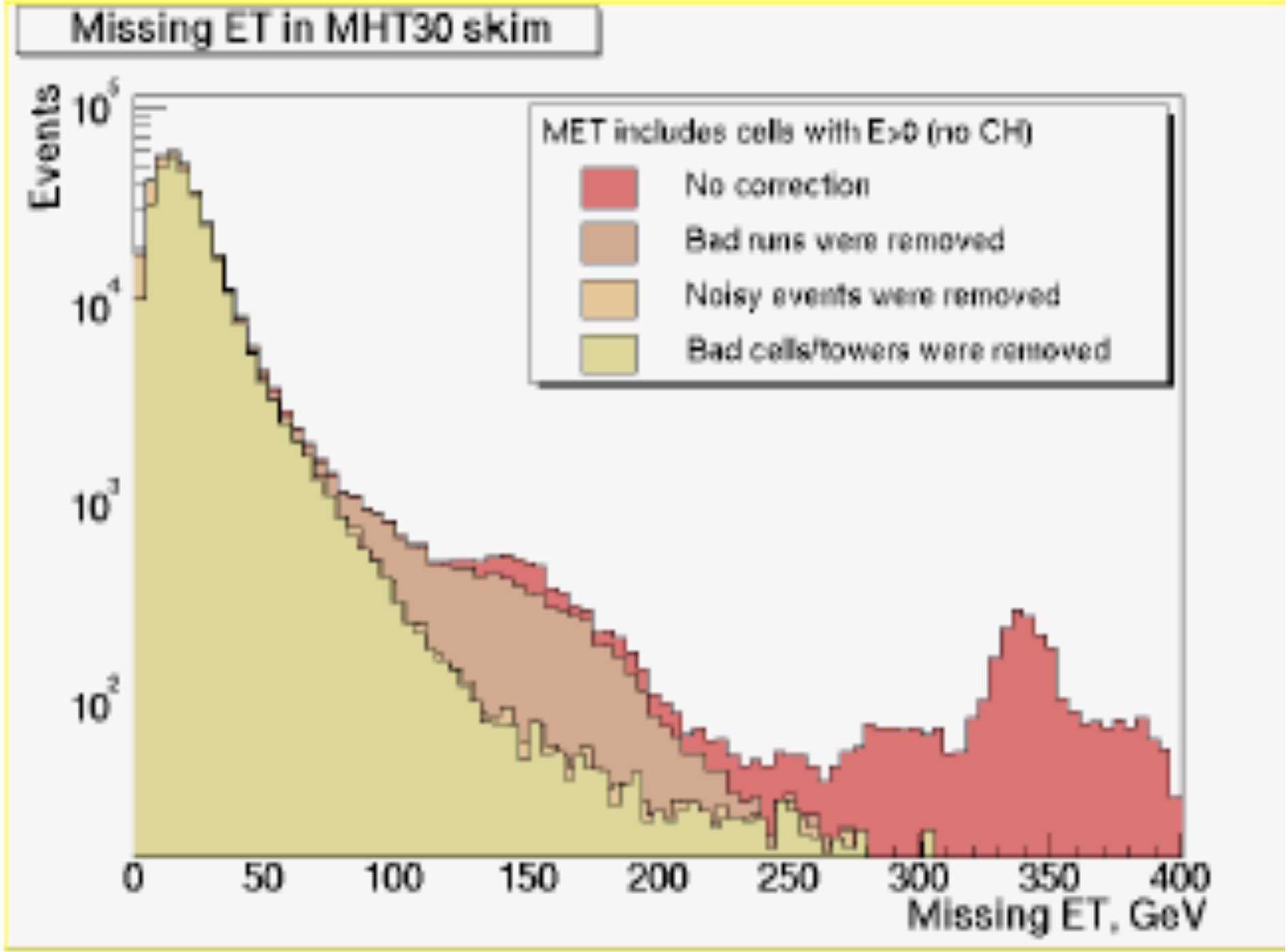
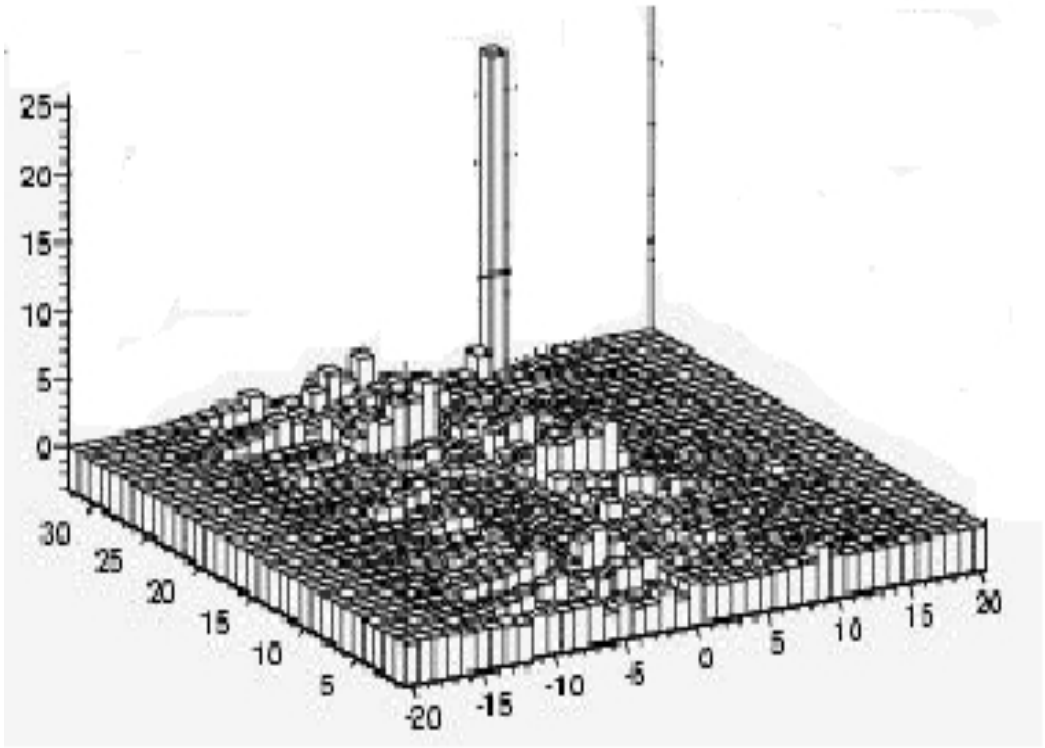
Sep. 16, 2008

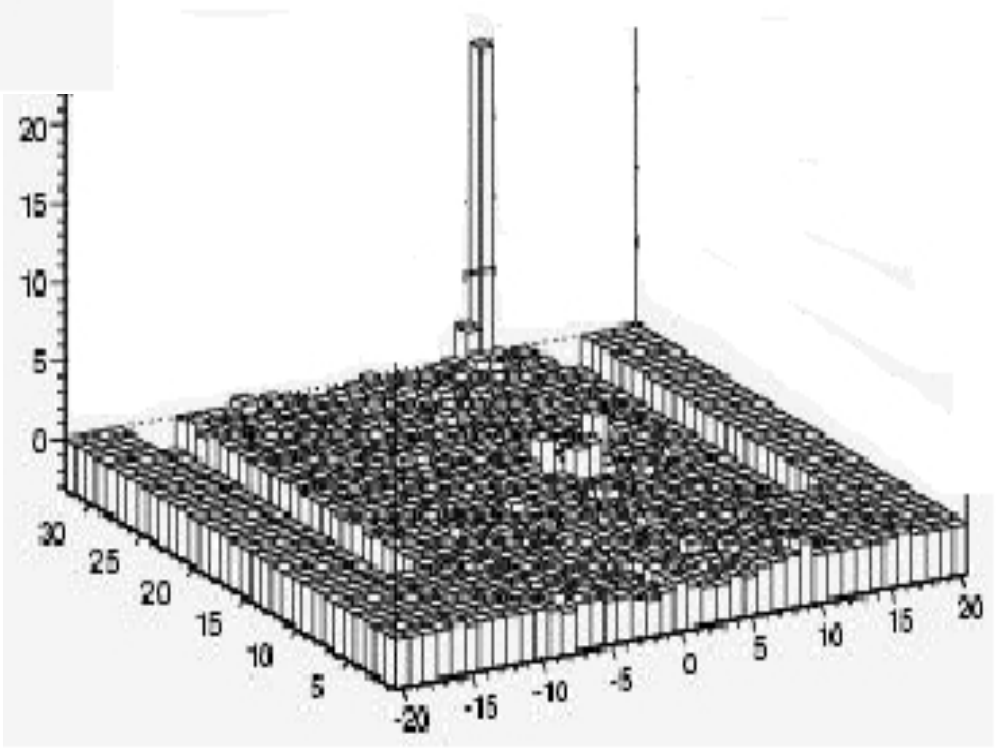

“Chance favors the prepared mind.”
Louis Pasteur

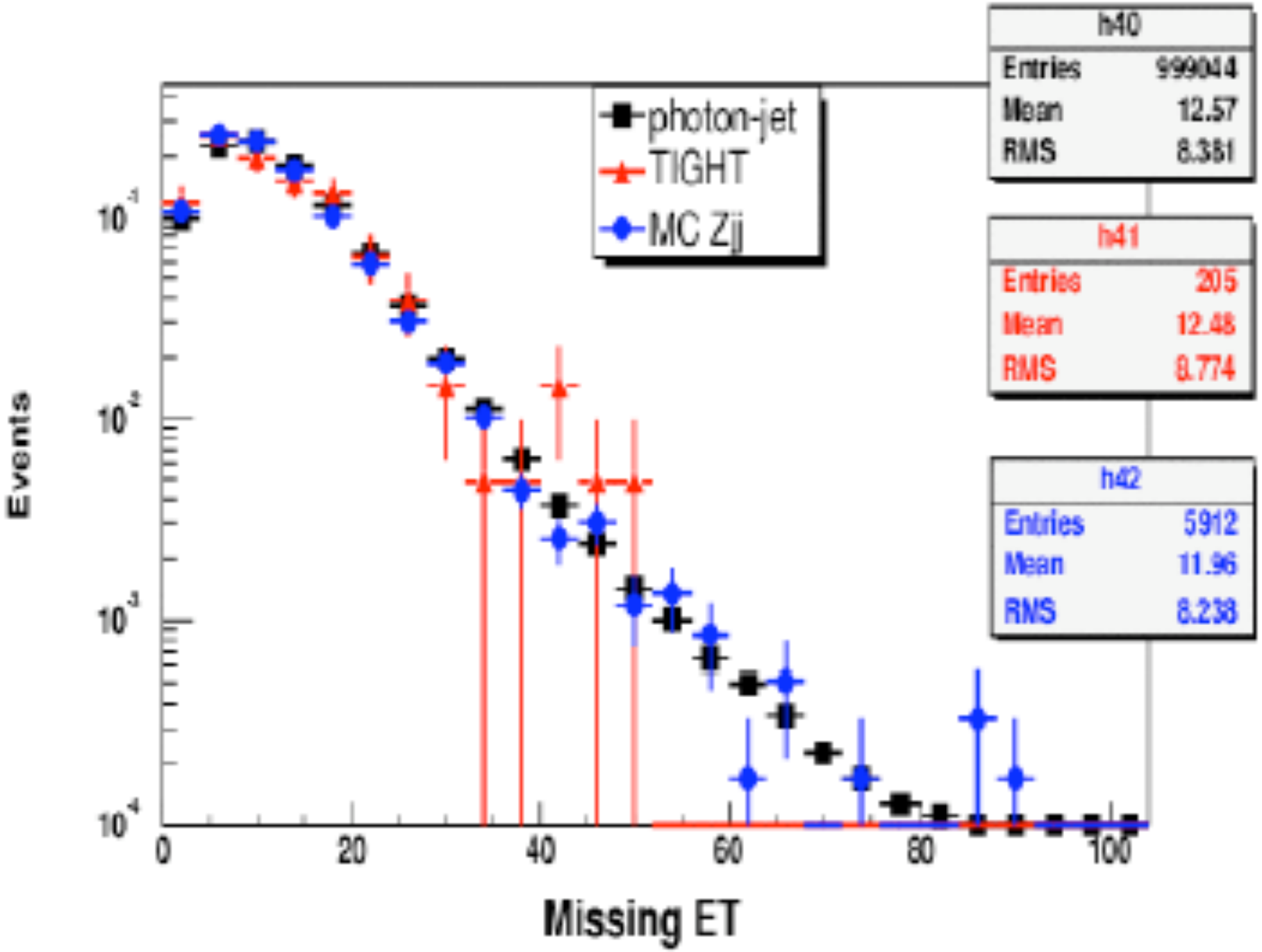

Missing ET in MHT30 skim
Events
MET includes cells with E>0 (no CH)
No correction
Bad runs were removed
Noisy events were removed
Bad cells/towers were removed
0
50
100
150
200
250
300
350
400
Missing ET, GeV



Which one is correct?

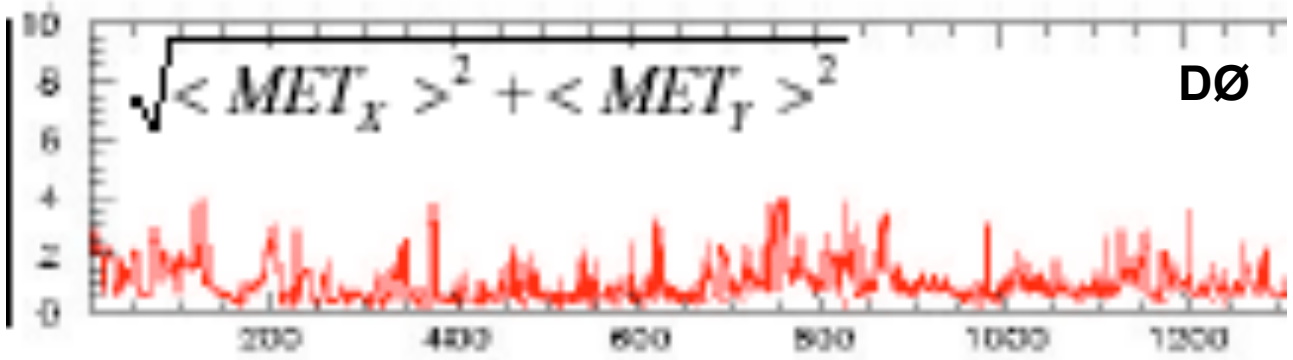
…and why?




photon-jet
TIGHT
MC Zjj
h40
Entries 999044
Mean 12.57
RMS 8.381
h41
Entries 205
Mean 12.48
RMS 8.774
h42
Entries 5912
Mean 11.96
RMS 8.238
Events
Missing ET
0
20
40
60
80
100

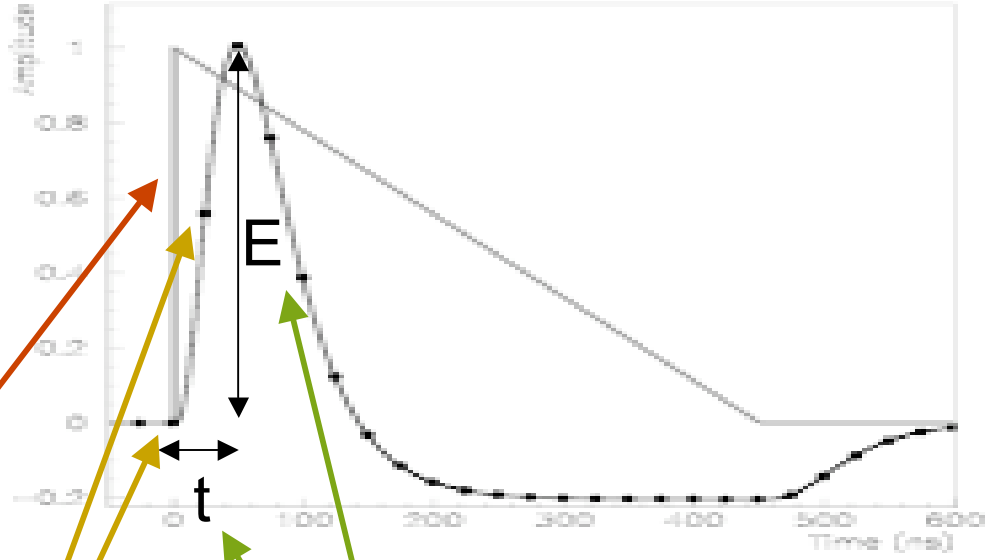
Monitoring & Data Quality

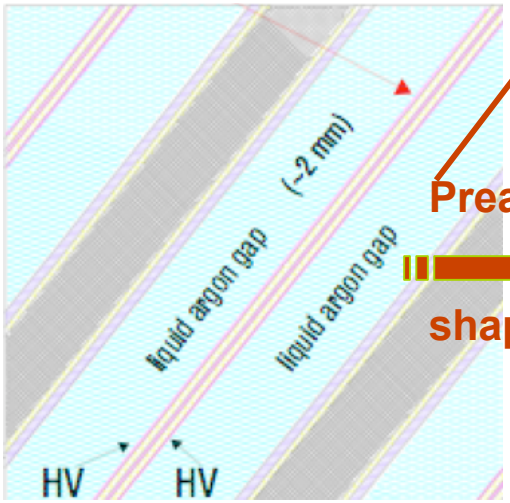
- The mechanisms by which ensure data adheres to
  - Our model of the detector
    - Inevitably there will be modifications to this model as the real ATLAS detector brings in data
    - But good Mon/DQ facilitates to minimize the time this takes
    - **And the data must adhere to this 'corrected' model!**
  - A stable behavior
    - Erratic episodes are marked as 'bad', at least initially
    - 'Stable' depends on when you ask the question
      - Later understanding will produce refinements which will improve the data quality, and the % of data that has good quality
- Formal quantification of data quality avoids biases which invalidate physical conclusions from analysis



The Calorimeter Chain

- Charge to FEBs from detector
- Sampled 5 times
  - Buffered in SCAs
  - OFCs applied in DSPs
  - *E,t,q* per cell
- Digitization to readout system





Preamp

shaping

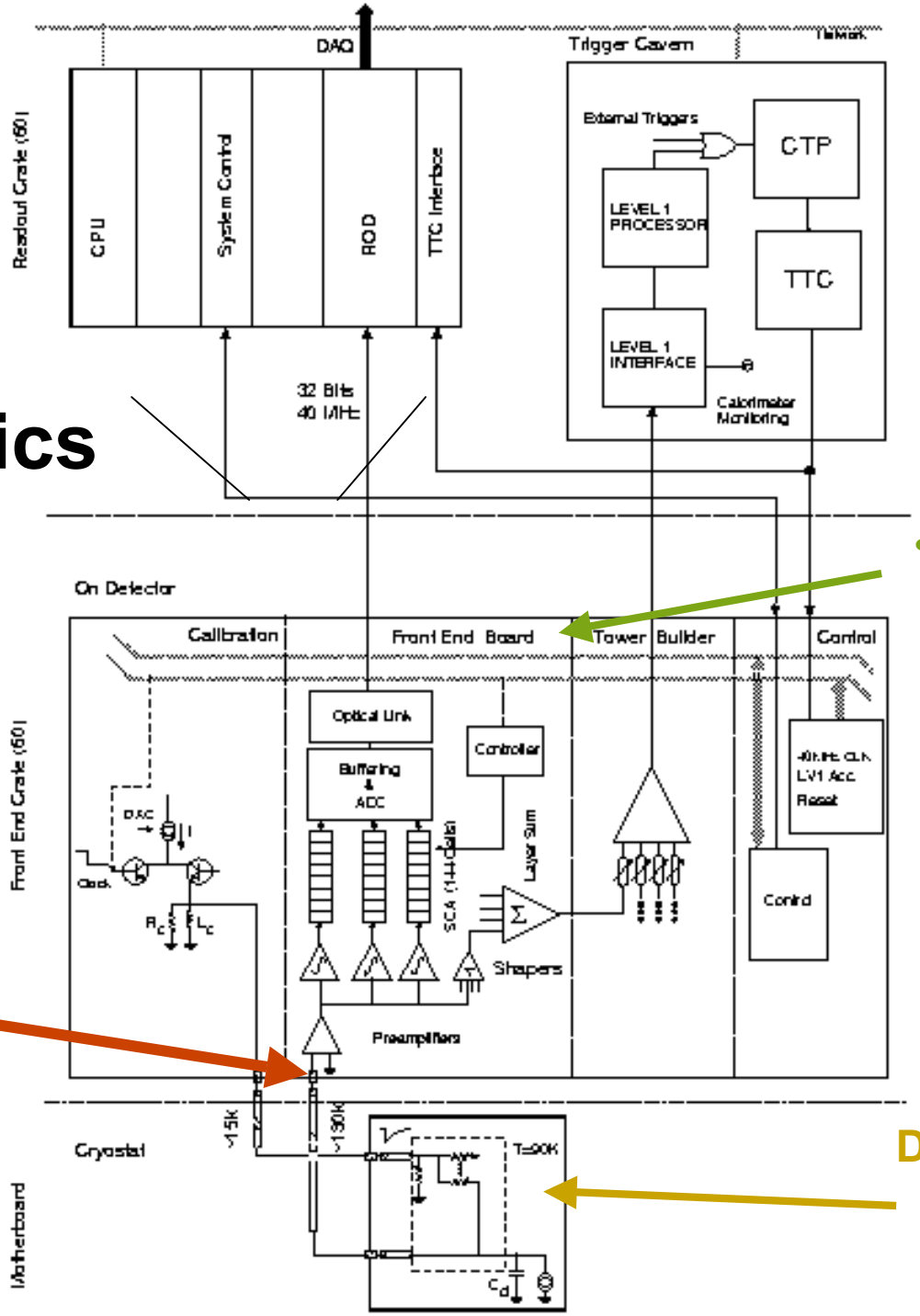
Front Ends (buffering, digitization)

OFC's

Cells (E,t,q)

Physics (clusters, Etmiss)

Readout, Calibration & Diagnostics



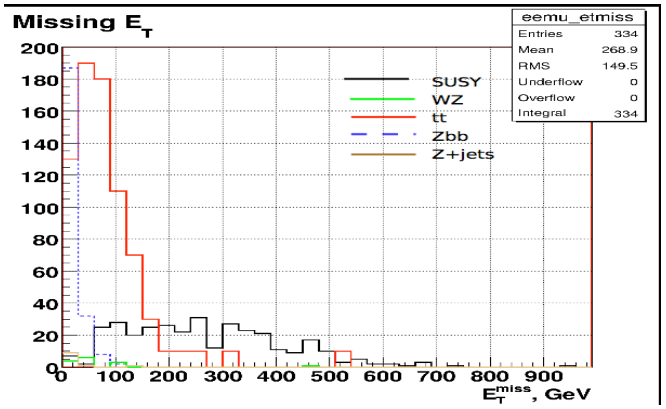
- readout integrity
  - Parity
  - BC ID #
  - SCA info.

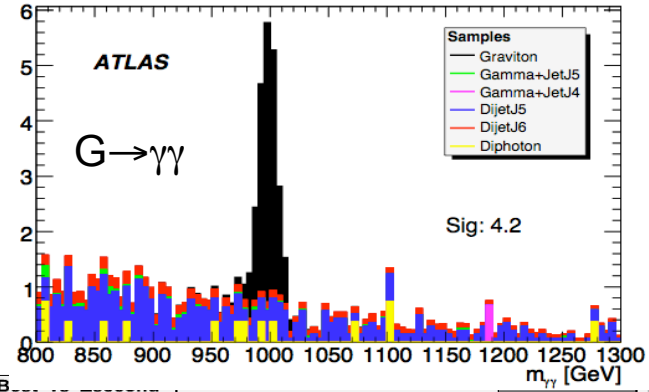
calibration signal injection @ Preamps:
- Pedestal
- Ramp
- Delay runs

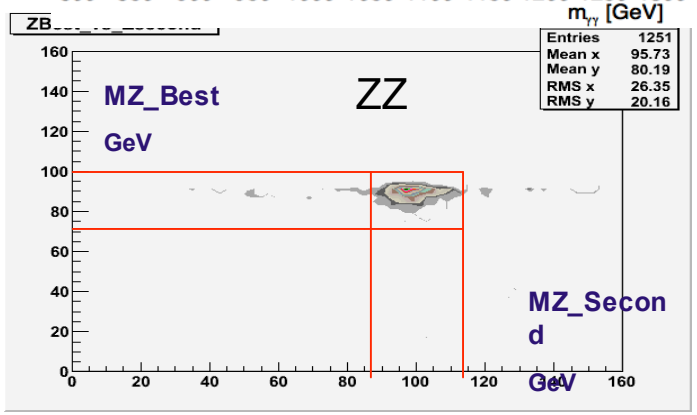
Diagnostics
- eg. LAr temp

Considerations from Physics Analysis

- QCD: looking for evidence of quark compositeness
  - Rutherford scattering … excess of very high Pt jets
  - Pitfalls: high E calibration, hot cells in a locale
- SUSY: looking for evidence of LSP production
  - Very high Etmiss values
  - Pitfalls: Hot cells, coherent noise
- Exotics: looking for RS gravitons
  - Very high mass diphotons
  - Pitfalls: noise impact on γ isolation, false positives
- Higgs: diphoton decay, 4 electron decay (ZZ*)
  - Narrow EM resonances on a continuum
  - Pitfalls: Noise, unstable electronics
- Top
  - Jet calibration, Etmiss resolution
  - Pitfalls: All of the above

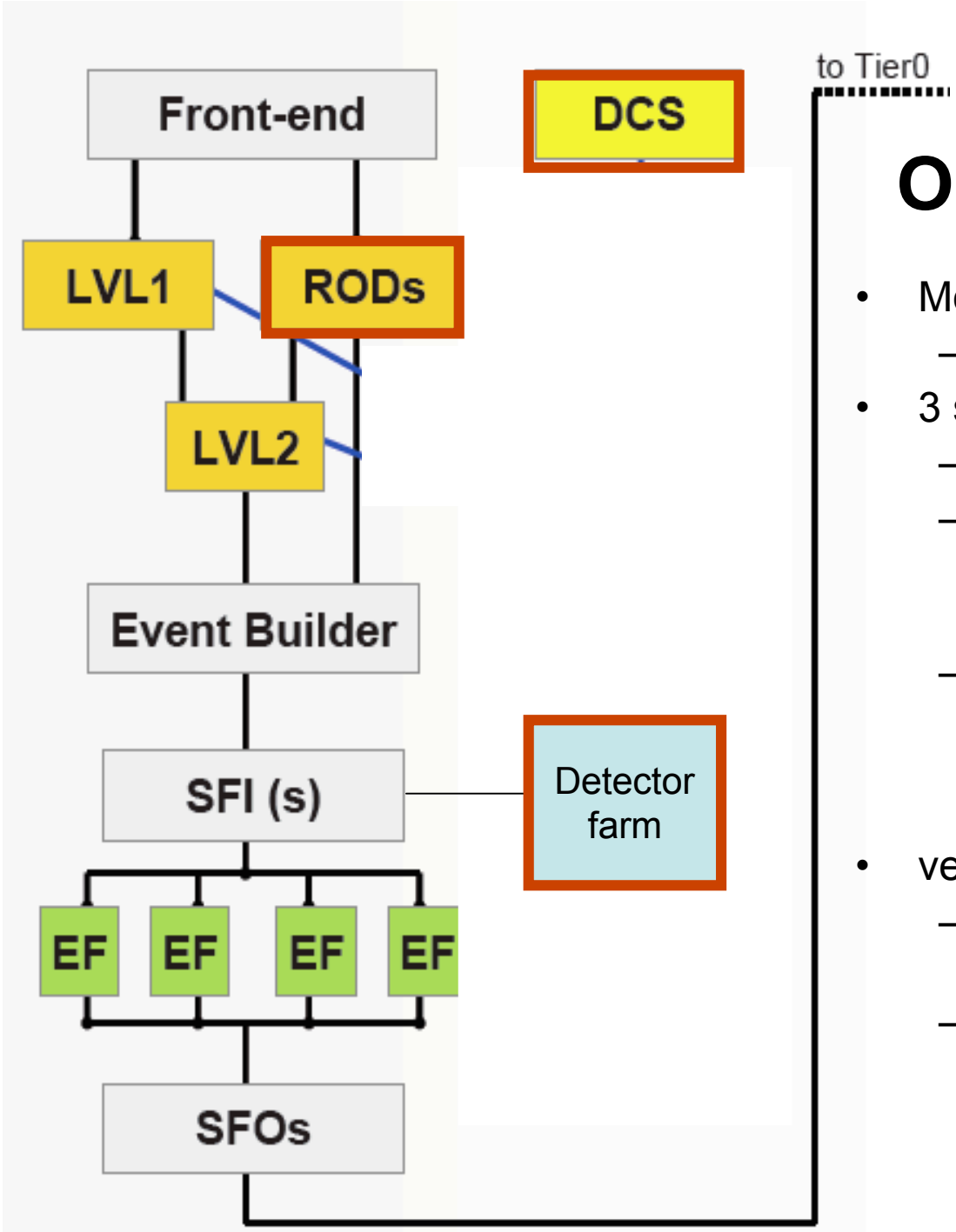






Step 1: LAr Monitoring

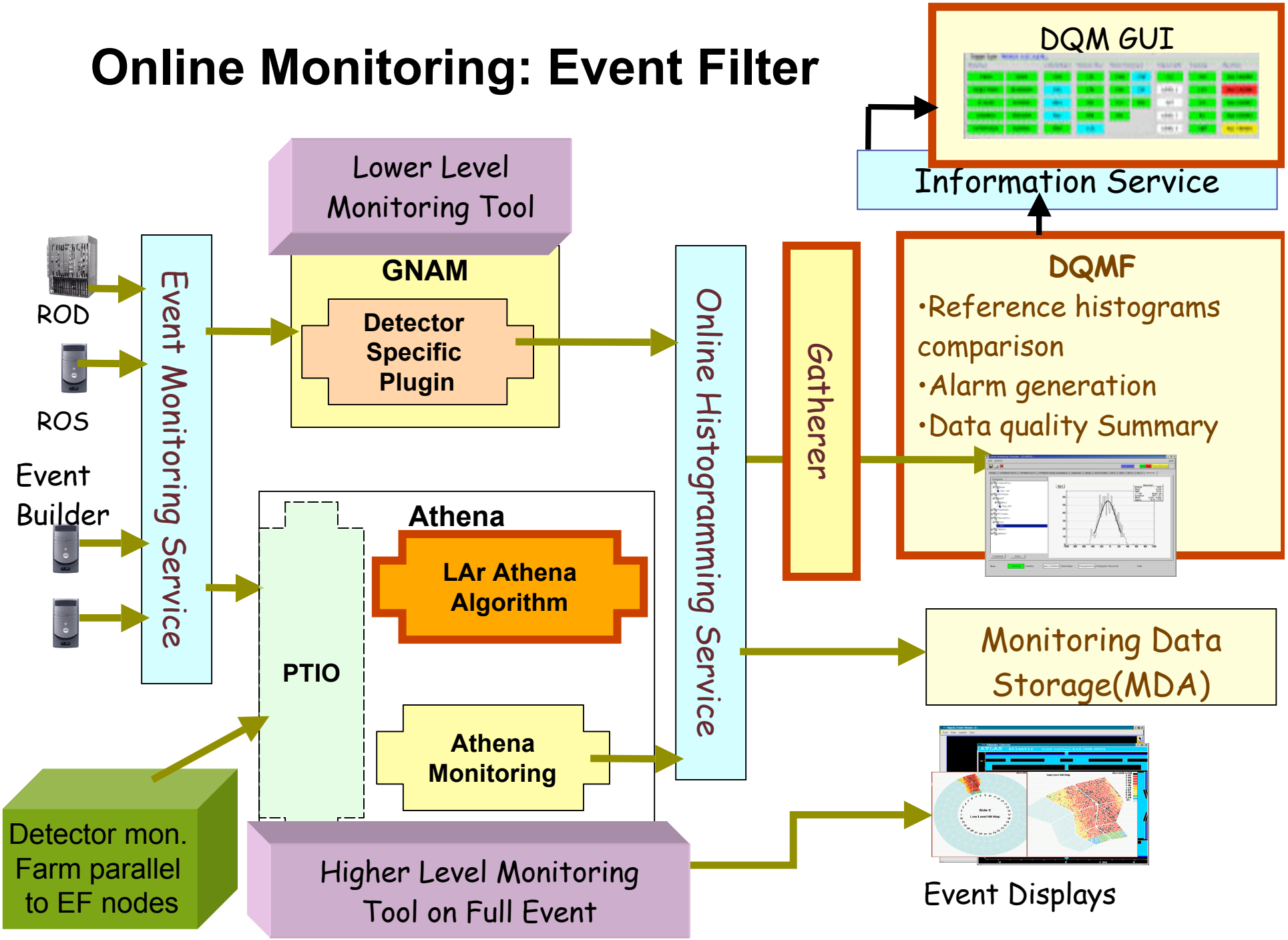
- Two distinct emphases:
  - Calibration run monitoring (pedestal, ramp, delay)
  - Physics run monitoring (cosmics, collisions)
- Within these, LAr examines two types of information
  - Diagnostic
  - Data events or event fragments
- Physics run monitoring is done with online and offline manifestations
  - Online for quick looks, fast response, debugging
  - Offline for detail and completeness, final DQ assessment
- Calibration run monitoring purely offline
- Athena Packages
  - LArCalorimeter/LArMonTools: data integrity, digits, RawChannels
  - Calorimeter/CaloMonitoring: CaloCells and CaloClusters



Online Monitoring

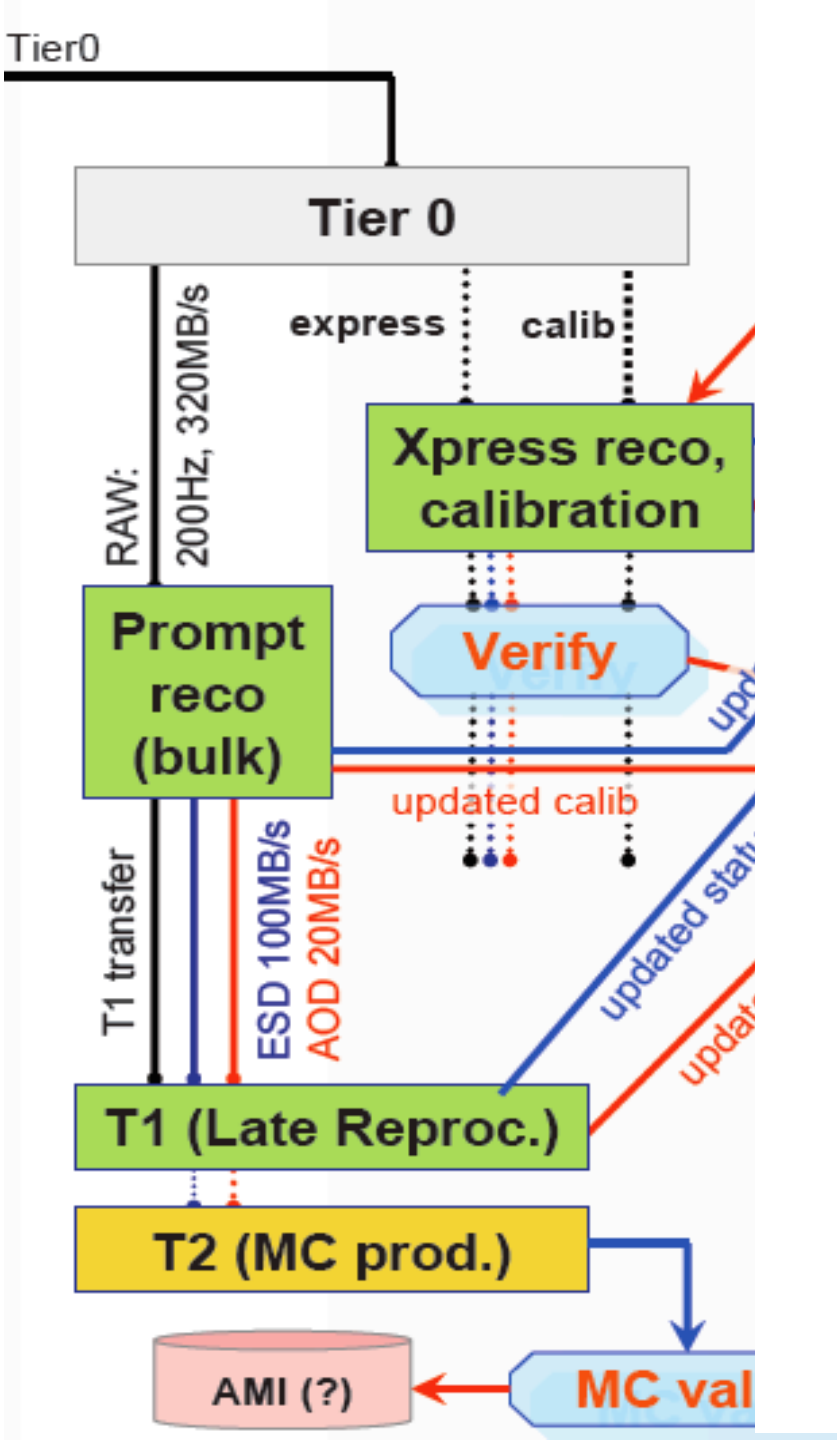
- Monitoring in trigger/DAQ system
  - Full event assembled in EF level
- 3 sources of data for LAr
  - DCS
  - DSPs
    - data integrity
    - Basic digits histograms
  - Online detector monitoring farm
    - AthenaPT mechanism
    - offline algorithms run in online system
- vectors, histograms transmitted to
  - I(formation)S(erver) & O(nline)H(isto) servers
  - Accessed by
    - Gatherer (parallel monitoring)
    - OHP(resenter) display
    - DQMF: data quality assessment

Online Monitoring: Event Filter



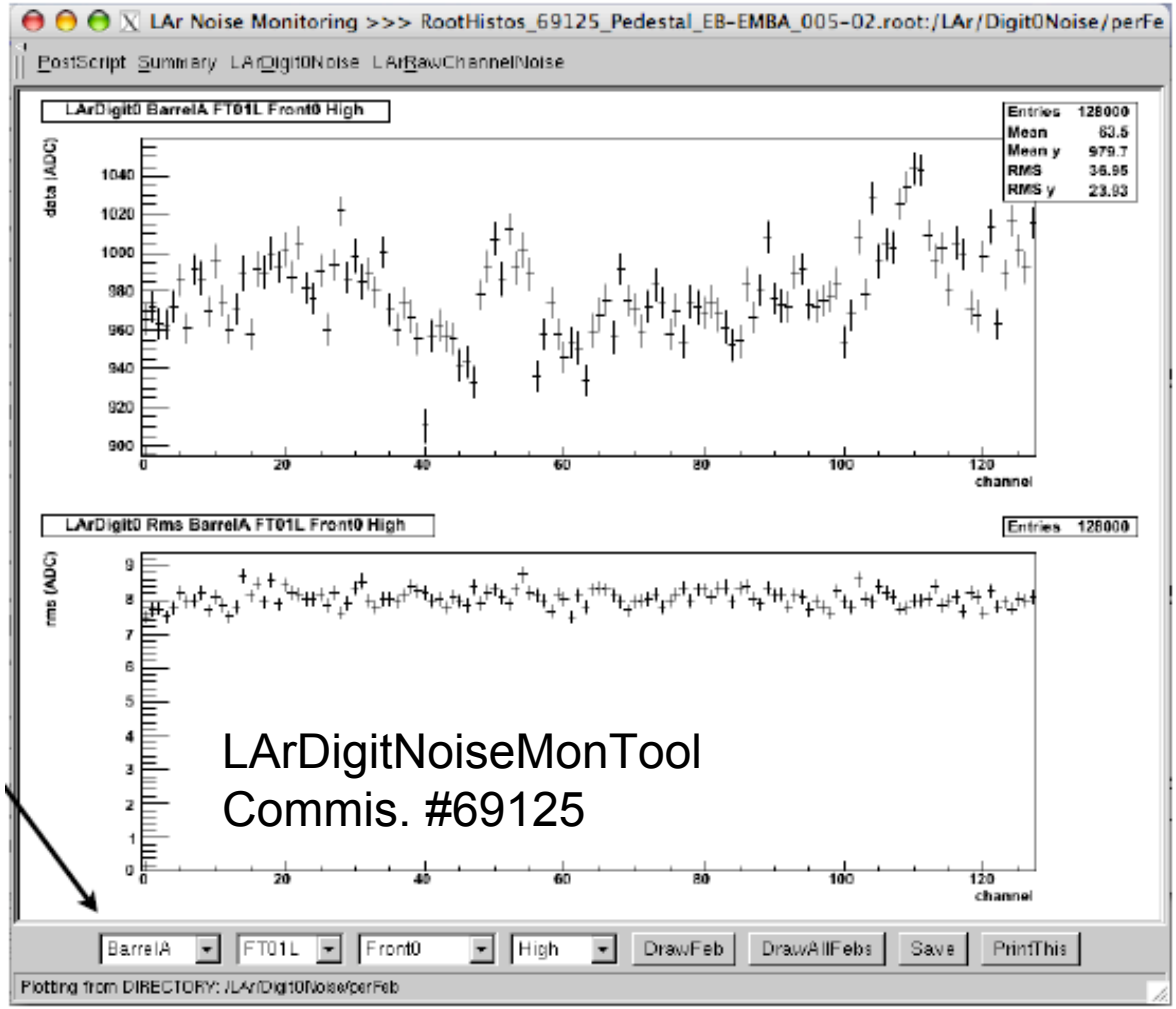
Offline Monitoring

- Performed in Tier0/1
  - Online services replaced by offline ones and .root files
- Tier0
  - 'AthenaPT' in offline mode
  - full reconstruction better than available online
  - Express stream
    - High Pt triggers (e.g. $Z \rightarrow ll$)
    - 1-2 hrs
    - Initial calibration
    - 'signal' monitoring
  - Bulk streams
    - Jet/Etmiss, μ, e/γ, min-bias, B
    - ~1day
    - Updated calibration
    - Noise monitoring, more detailed signal monitoring



LAr rootMacros Framework

- Use ROOT as standalone browser platform
- Top level menus
  - Navigate histogram folder hierarchy
    - Histograms from different tools
  - Permit display in different contexts (rate, crate…)
  - Allow overlay of references
- Incorporates tabs, dialog boxes
- For each Athena tool
  - Corresponding macro
  - Both LArMonTools & CaloMonitoring

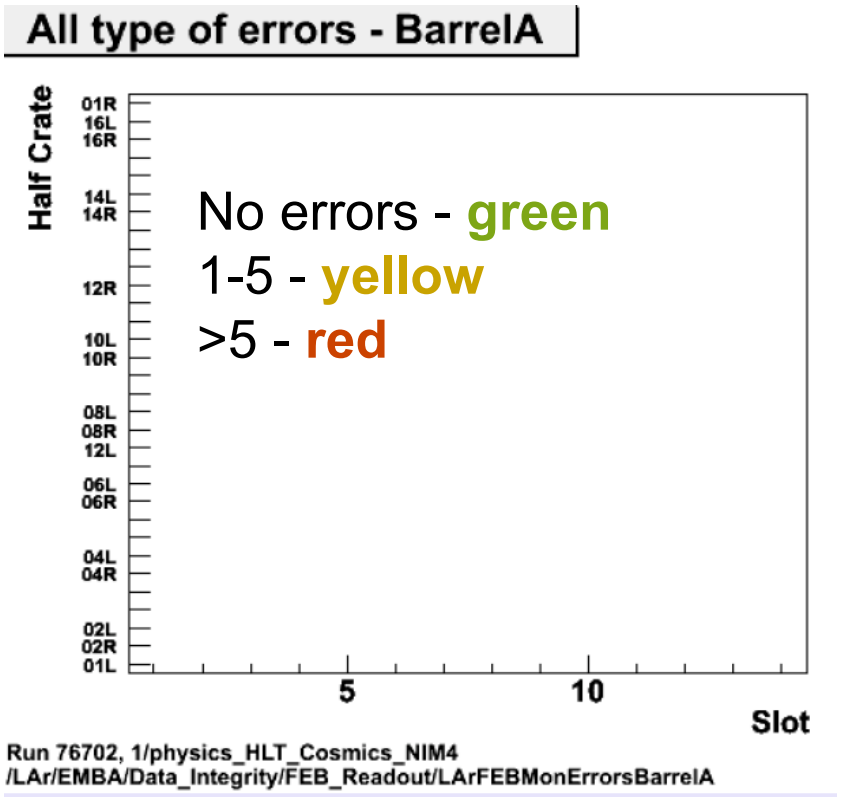


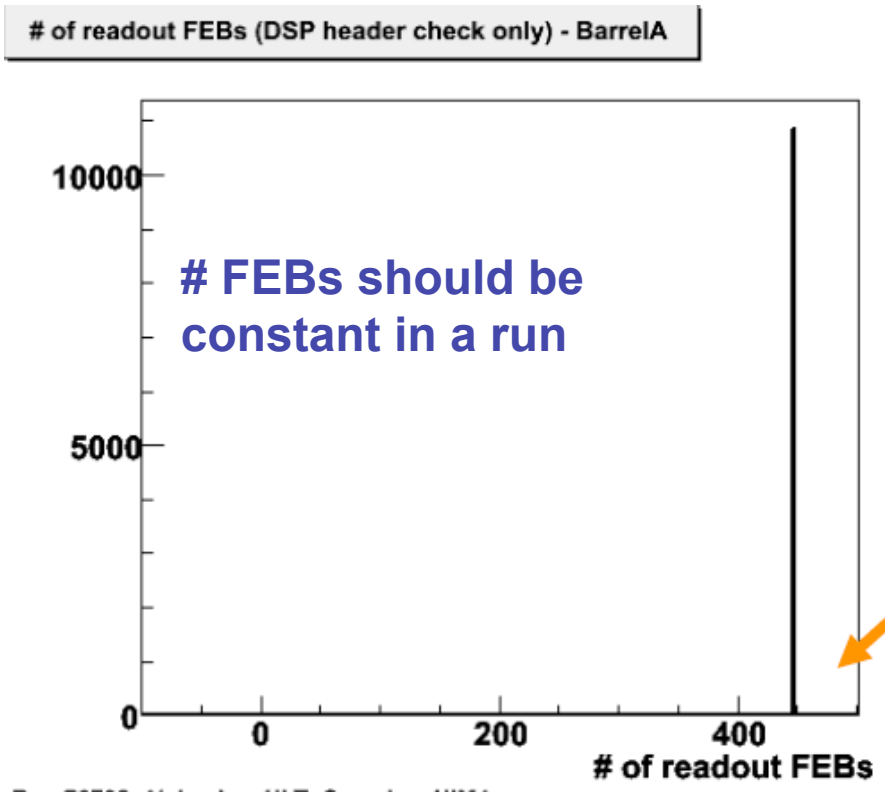
DCS Monitoring

- Electronics diagnostics
  - ROD crate V, I, T
  - LVPS V and T
- LAr properties
  - Temperature impacts scale
    - Density, *e* velocity
    - 2% per degree K
  - Purity
    - less effect (fast shaping)
- Information about state (e.g. ready) & status (e.g. OK, FATAL)
  - To LAr DCS DQ calculator in Oracle archive

Data Integrity: LArFEBMon

- Athena algorithm
  - used in calibration runs and online in physics runs
  - Parity, BCID, SCA status, gain mismatch btwn samples…
    - Any errors identified reflect serious problems in DAQ chain

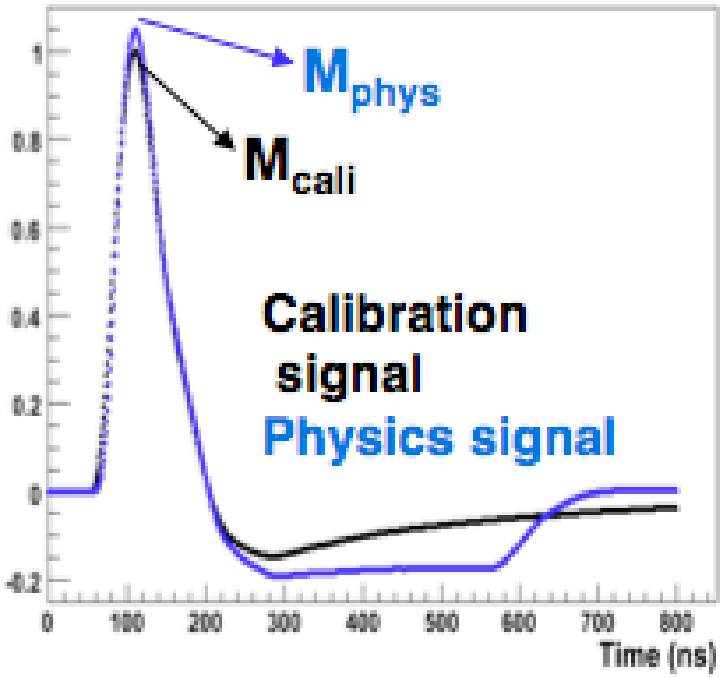




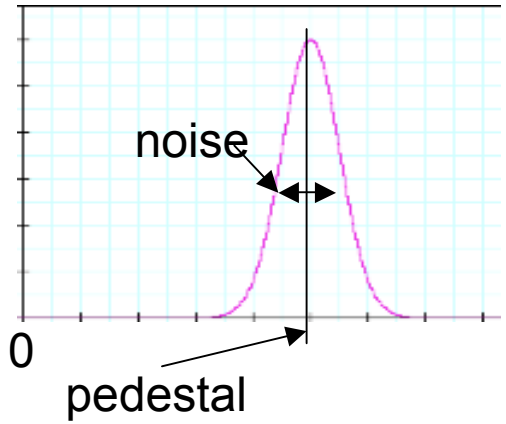
Calibration Runs

- Readout electronics has many complexities
  - Analog preamps, shaping, SCA buffers,
  - Digital electronics: ADCs
  - Need to
    - know they work (monitor)
    - quantify their performance (calibrate)

- Procedure:
  - inject a known pulse at beginning of electronics chain
    - At electrodes except for FCal
  - See how electronics behaves
    - Dead channels most direct to spot
  - Properties of pulse to control:
    - Scan pulse height (vary in 'ramp')
    - Scan pulse timing (vary in 'delay')



•Must attain 0.1% linearity over gain range
•Timing to 1 ns with respect to physics pulse
•Shape, especially at rise, should reflect physics shape



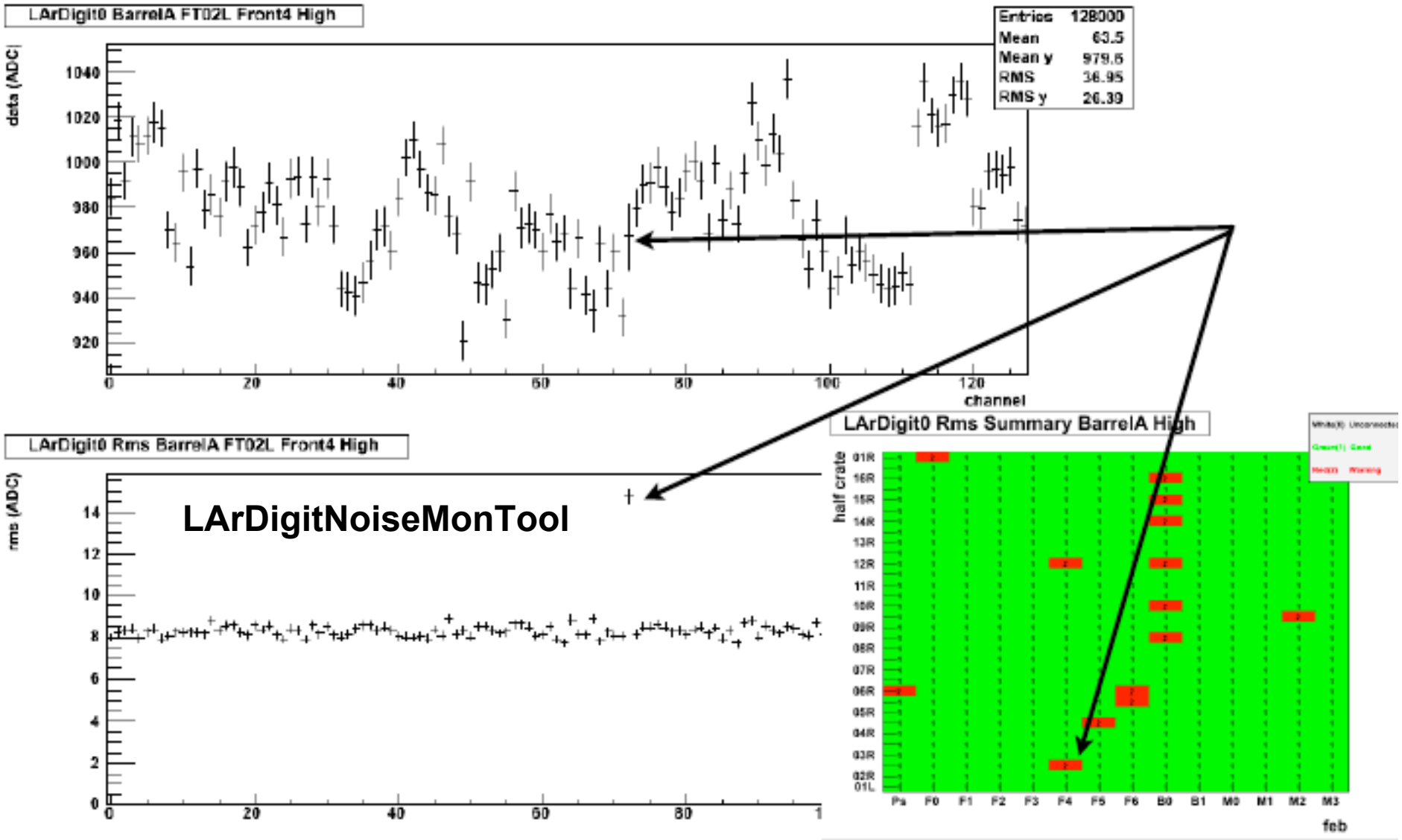
Pedestal Monitoring

- Pedestal is arbitrary signal which puts whole noise distribution in the positive
  - Each channel a bit different
  - Noise very dependent on eta, layer
- A ‘pedestal run’
  - establish this level for the electronics path impacting each cell
  - Measure the size, symmetry and stability of noise per channel

- LArSCANoiseMonTool: pedestal dispersion for 144 cells in SCA (i.e. different samples)
  - Look for faulty SCAs
- LArOddCellsMonTool: channels 3x noise from pedestal (use DB or 1st 1k evts)
  - Sensitive to HV (2V, ~1MHz) noise bursts (ground loops)
- LArDigitNoiseMonTool:
  - compute pedestal/noise for all chan
  - Total noise/coherent noise calculation
  - 2 chan correlations
- LArFebNoiseMonTool: FEB as a scope by triggering on highest ADC sample
  - Can see 17 MHz and HV burst problems
  - Visual, expert-level tool

EMBA run 69125 high gain

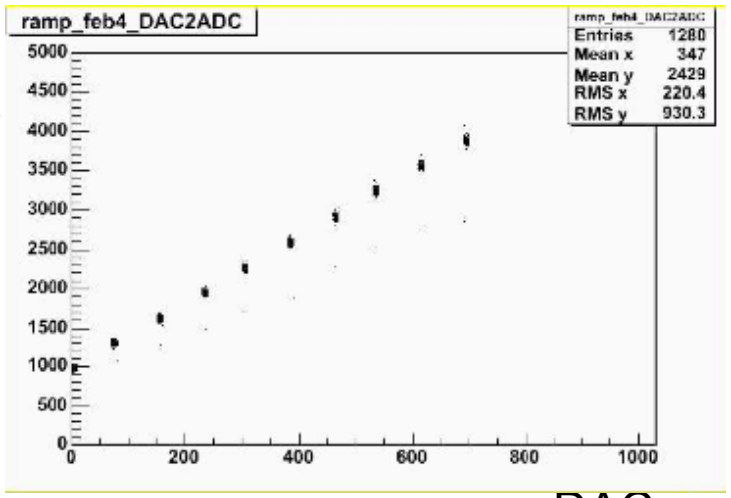
Example: highNoiseHG BarrelAFT02LFront4Channel072

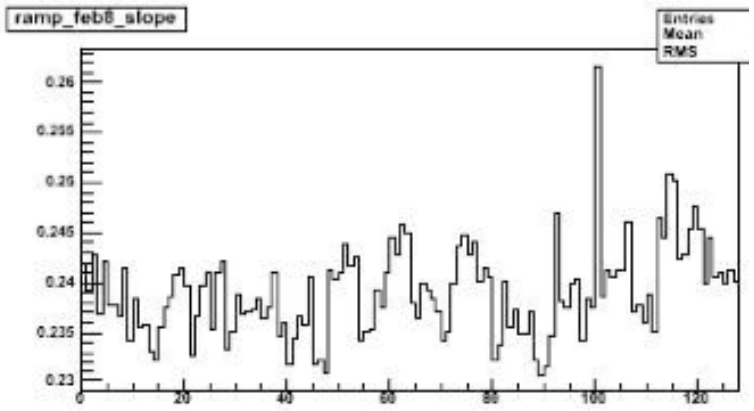


Ramp Monitoring

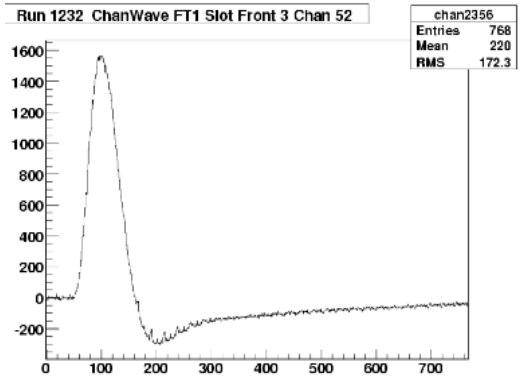
$$F = ADC2DAC \times DAC2\mu A \times \mu A2MeV \times f_{samp}$$

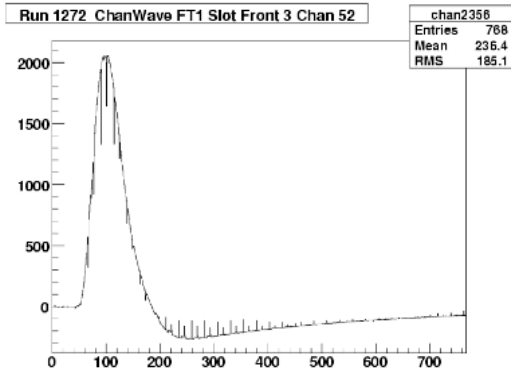
- Vary an input DAC value
  - readout the ADC value for each sample: fit to get peak
- Three gains: low, medium, high
  - For each, obtain output vs. input for each channel
    - Fit this
    - Slope and offset
    - Saturation/non-linearities
- Monitoring generally uses the slopes
  - Now done in LArRampBuilder
  - Ntuple output which is viewed with appropriate rootMacros (in development for ramps and delays)



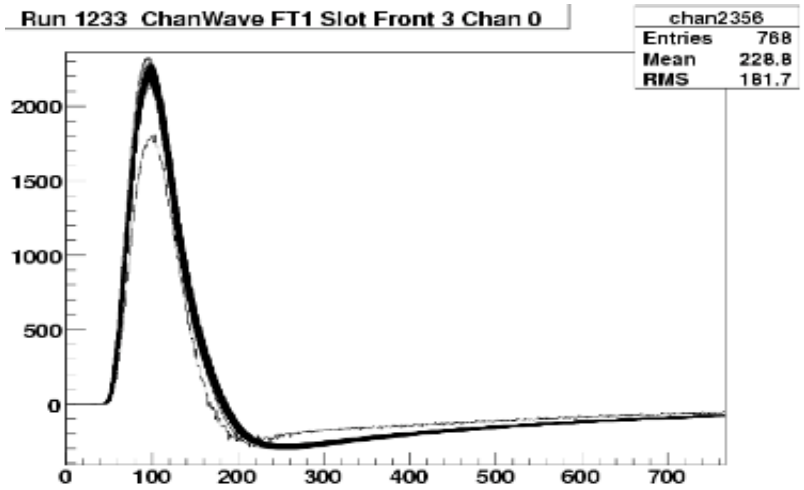


Delay Monitoring



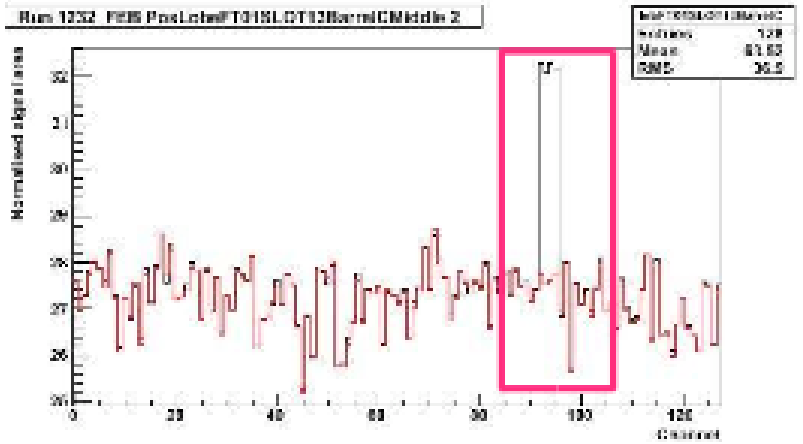


- Vary a 'delay' associated with each channel's signal
  - 1 ns increments
  - 25 iterations with different delays gives full pulse with 1ns sampling



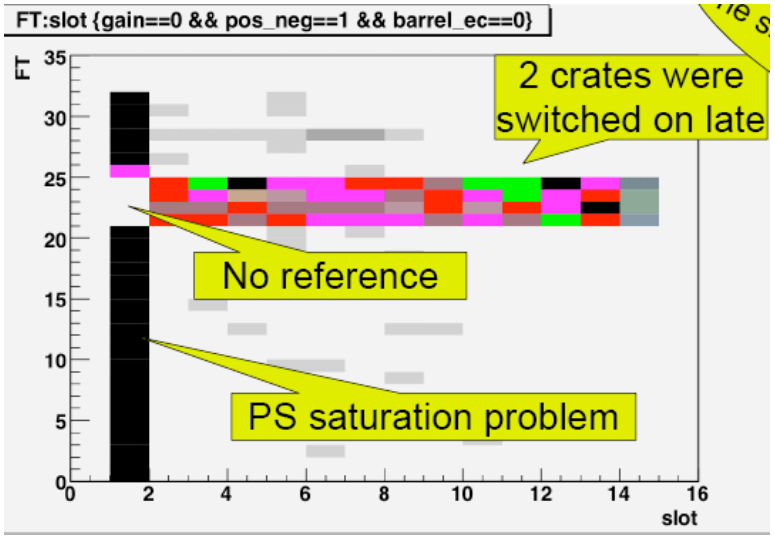
- Resulting data gives
  - Time of peak and its stability (jitter)
  - Shape of pulse, incl. width

- LArCaliWaveBuilder
  - Does calculations in processing step
  - Check DB to see if n% deviation
  - Ntuple output to be run on by rootMacros



- Monitoring primarily an offline effort
  - Automated processing
  - Runs aborted if LArFEBMon indicates readout problem
  - Stress stability over accuracy early: basic checks will be # of descrepant channels per FEB, for instance
  - To view the offline results for the shifter: web display:

Under construction:



88469_88342_88349 - run 1	Castor	archive	Barrel_EMEC	15 Sep 2008 02:00:37
Partition : Barrel	logfile	listFEBs	DQMFcheck	

x Pedestal JOB : Pedestal_88469_Barrel_EB-EMBA_LOW (DONE-SUCCESS) DONE-SUCCESS
x Pedestal JOB : Pedestal_88469_Barrel_EB-EMBC_LOW (DONE-SUCCESS) DONE-SUCCESS
x Delay JOB : Delay_88342_Barrel_EB-EMBA_LOW (DONE-SUCCESS) DONE-SUCCESS
x Delay JOB : Delay_88342_Barrel_EB-EMBC_LOW (DONE-SUCCESS) DONE-SUCCESS
x OFC JOB : OFC_88342_Barrel_EB-EMBA_LOW (DONE-SUCCESS) DONE-SUCCESS
x OFC JOB : OFC_88342_Barrel_EB-EMBC_LOW (DONE-SUCCESS) DONE-SUCCESS
x tauR JOB : tauR_88342_Barrel_EB-EMBA_LOW (DONE-SUCCESS) DONE-SUCCESS
x tauR JOB : tauR_88342_Barrel_EB-EMBC_LOW (DONE-SUCCESS) DONE-SUCCESS
x PhysWave JOB : PhysWave_88342_Barrel_EB-EMBA_LOW (DONE-SUCCESS) DONE-SUCCESS
x PhysWave JOB : PhysWave_88342_Barrel_EB-EMBC_LOW (DONE-SUCCESS) DONE-SUCCESS
x OFCPhys JOB : OFCPhys_88342_5_Barrel_EB-EMBA_LOW (DONE-SUCCESS) DONE-SUCCESS
x OFCPhys JOB : OFCPhys_88342_5_Barrel_EB-EMBC_LOW (DONE-SUCCESS) DONE-SUCCESS
x OFCPhysOnePhase JOB : OFCPhysOnePhase_88342_5_Barrel_EB-EMBA_LOW (DONE-SUCCESS) DONE-SUCCESS
x OFCPhysOnePhase JOB : OFCPhysOnePhase_88342_5_Barrel_EB-EMBC_LOW (DONE-SUCCESS) DONE-SUCCESS
x OFCPhys JOB : OFCPhys_88342_25_Barrel_EB-EMBA_LOW (DONE-SUCCESS) running -> done
x OFCPhys JOB : OFCPhys_88342_25_Barrel_EB-EMBC_LOW (DONE-SUCCESS) running -> done
x Ramp JOB : Ramp_88349_Barrel_EB-EMBA_LOW (DONE-SUCCESS) DONE-SUCCESS
x Ramp JOB : Ramp_88349_Barrel_EB-EMBC_LOW (DONE-SUCCESS) DONE-SUCCESS

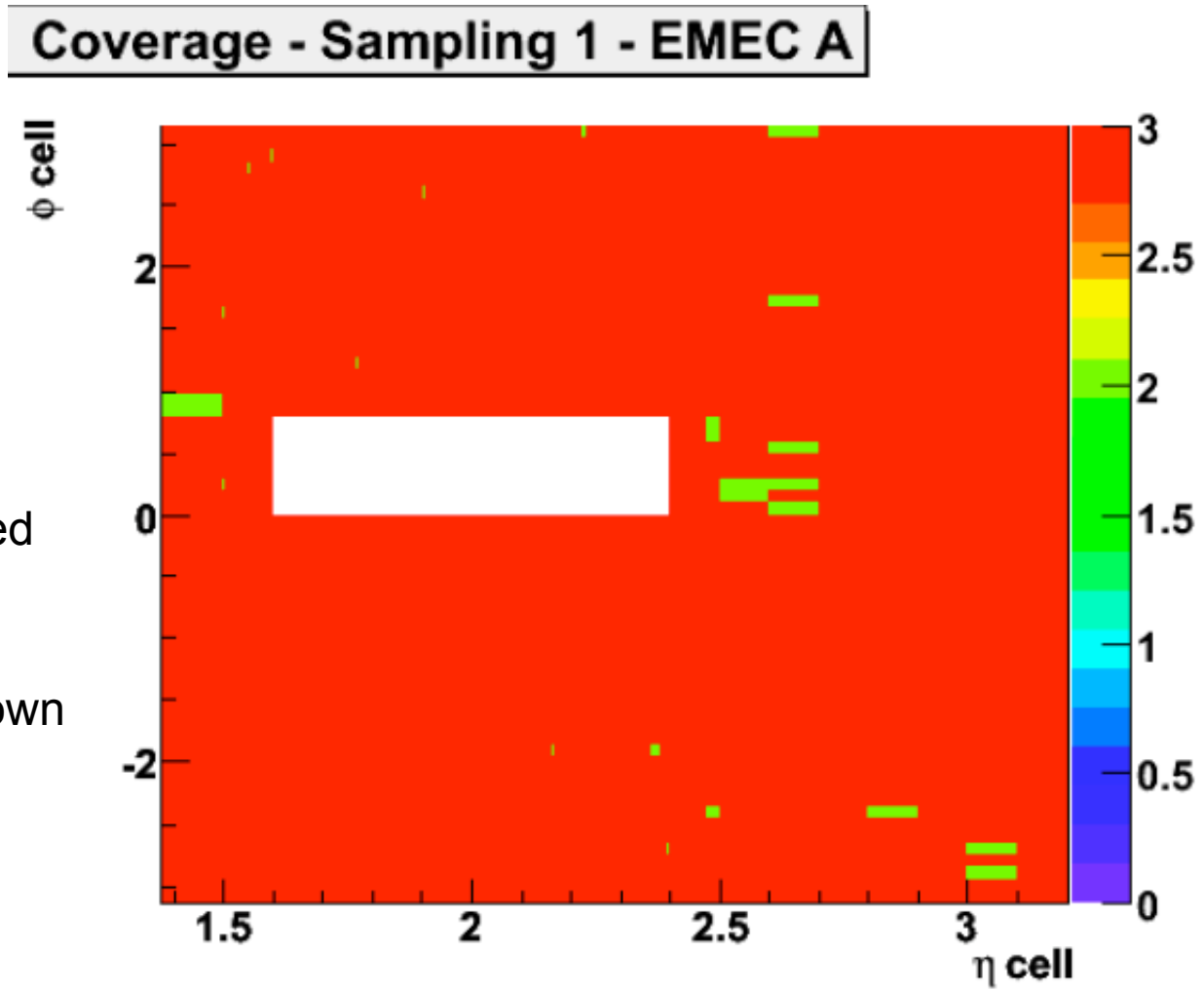
Partition : EMEC	logfile	listFEBs	DQMFcheck	

x Pedestal JOB : Pedestal_88469_EndCap_EB-EMECA_LOW (DONE-SUCCESS) DONE-SUCCESS

Web status display

Conditions status: LArCoverageMonTool

- 1 = in readout
- 2 = readout, calib
- 3 = readout, calibrated & not bad
  - It is important to keep track of known bad channels

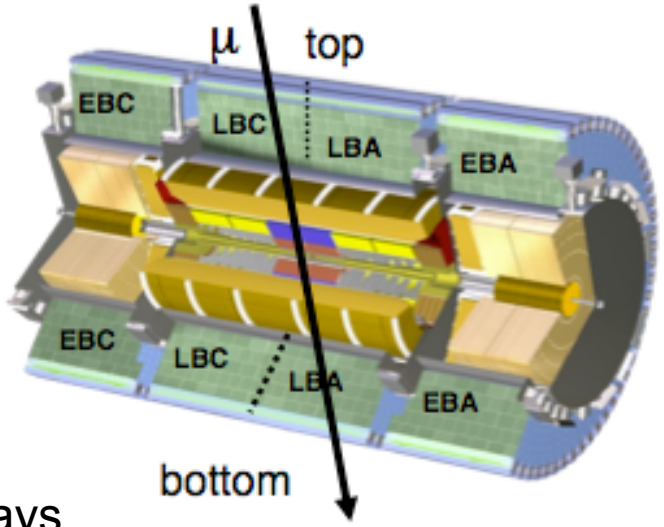


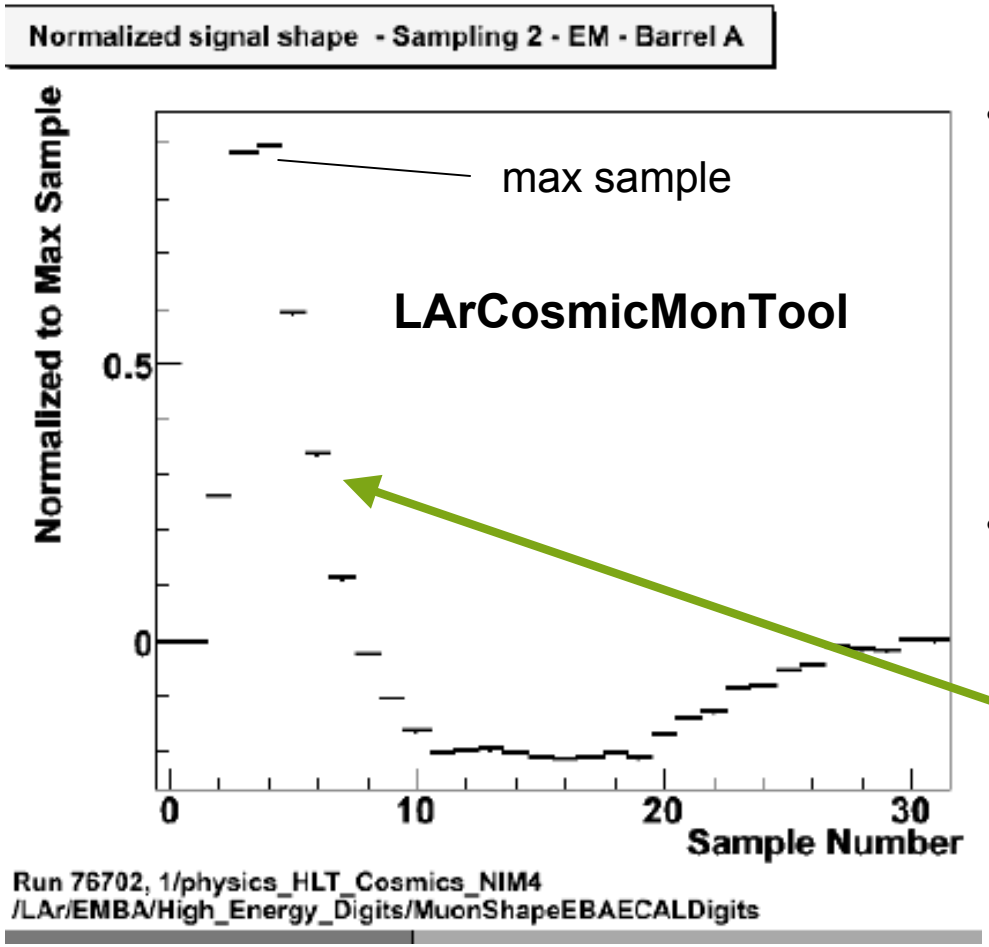
Monitoring with Physics

- Both online and offline elements employed
  - Ultimately, readout integrity and basic digits: DSPs
  - Cells
    - Mostly post-OFC quantities (E,t,q): LArRawChannel, CaloCell
    - when have high E samples: digits written out (provides oscilloscope capability)
  - Clusters (CaloCluster)
    - LArMuID for muons
    - TopoCluster algorithm

- Typical jobOptions (for cosmics AND collisions, despite names!)
  - LArFEBMon
  - LArCoverage: overview of channel conditions availability
  - LArCosmicsMonTool: signal digits and sliding window plots
  - CaloCellVecMon: cell rate, average E and noise
  - CaloClusterCosmicsMon: topoCluster rate, average E and noise

Cosmic ray run Monitoring

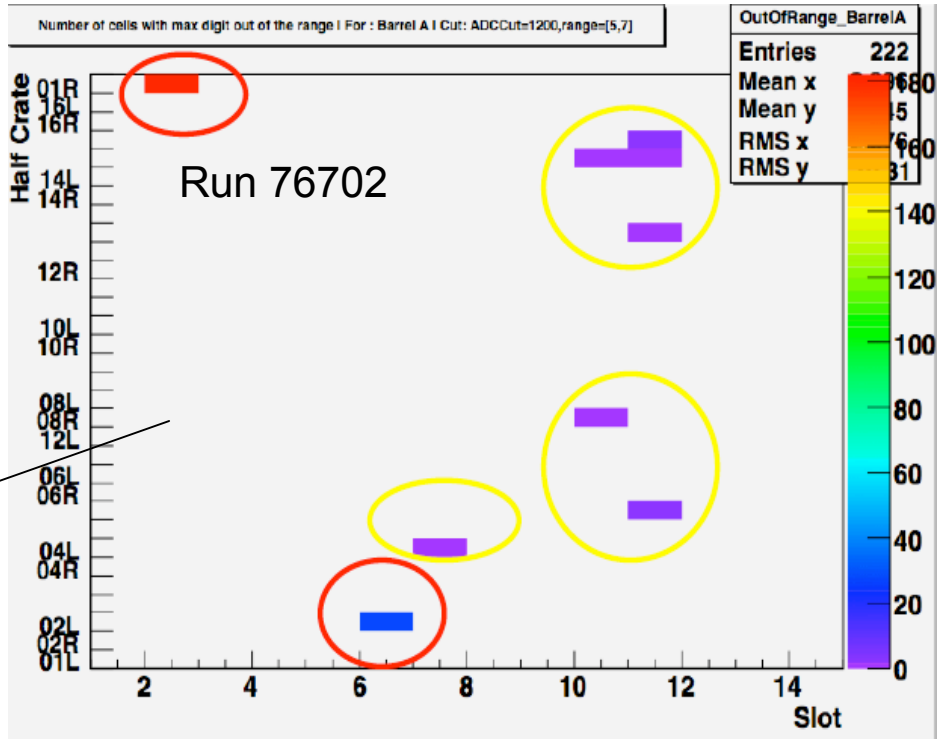


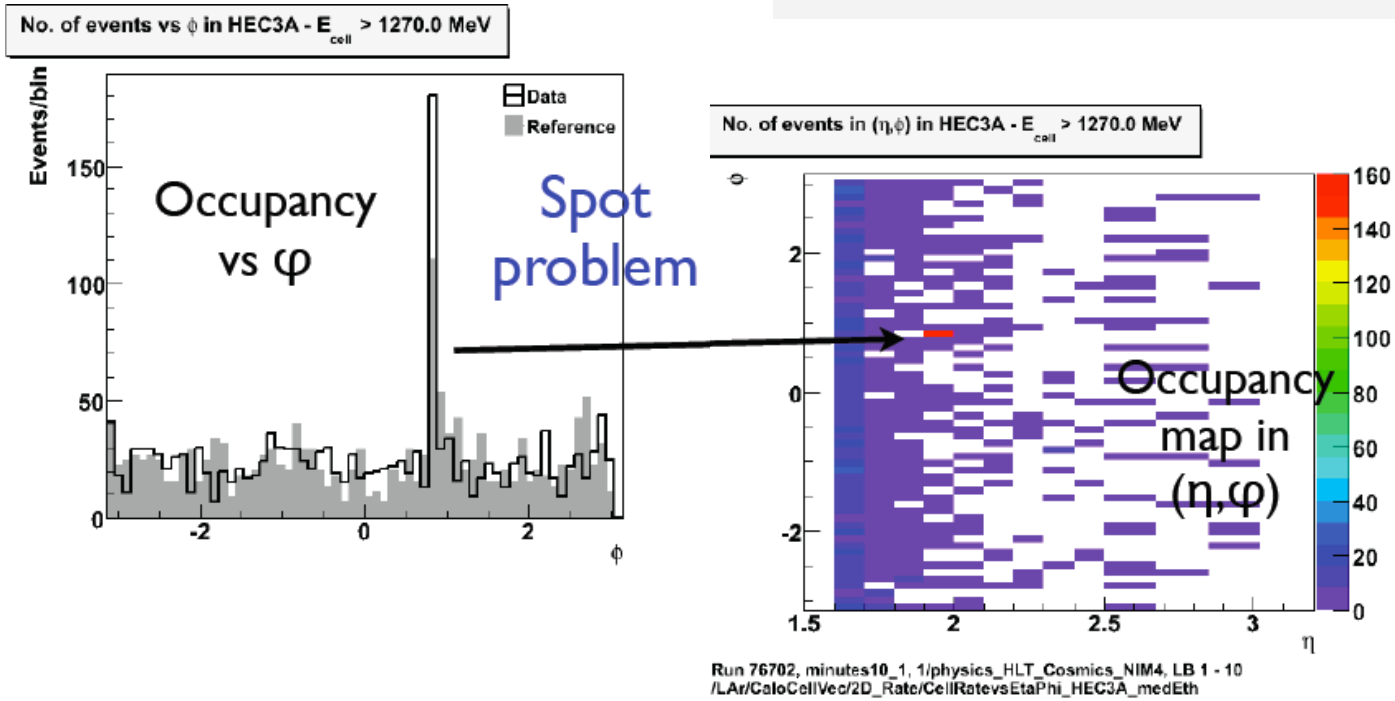


- Cosmic rays
  - Valuable first signals from physical particles
  - Tile: low noise, good identification
  - LAr: high noise, difficult identification
- Monitoring strategies
  - ROI in LAr around Tile signal
  - Look at digits when trigger on high E cells
    - Normalize each pulse and average

Signal problems in cosmic runs

- Threshold # times max sample out of range: LArDigitMon
- Rate of Cells with E > threshold
  - CaloCellVecMon





Collisions Monitoring

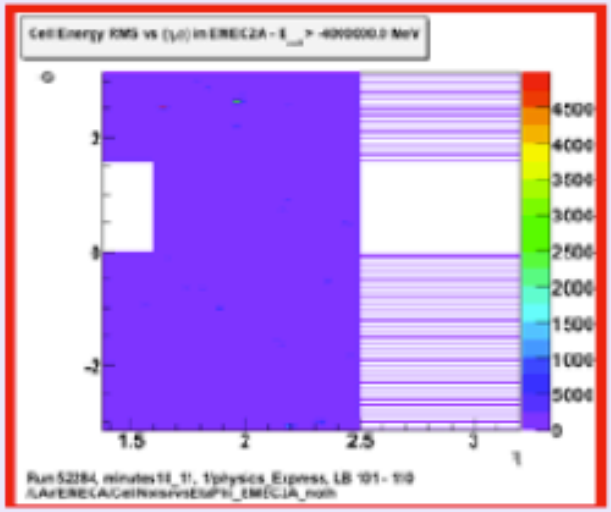
- Large energy deposition and high data rate: ‘correct’ timing
- How well building blocks of Jets/Etmiss/egamma observed
  - Cells
  - Clusters: intermittent noise issues
- Different streams (groups of triggers) have different roles
  - Muons: cell, cluster w/LArMuID
  - 2e: cluster/cell signal
  - Jets: cluster/cell signal
  - Min-bias: noise (cluster and cell level)
- **F**(inal)**D**(ress)**R**(ehearsal)
  - FDR1 (Winter) and FDR2 (+2b/c, Spring&Summer)
  - Several pb^{-1} processed thru offline chain
    - reconstruction → streaming → monitoring
  - realistic mix of events (*sans* EM fakes)

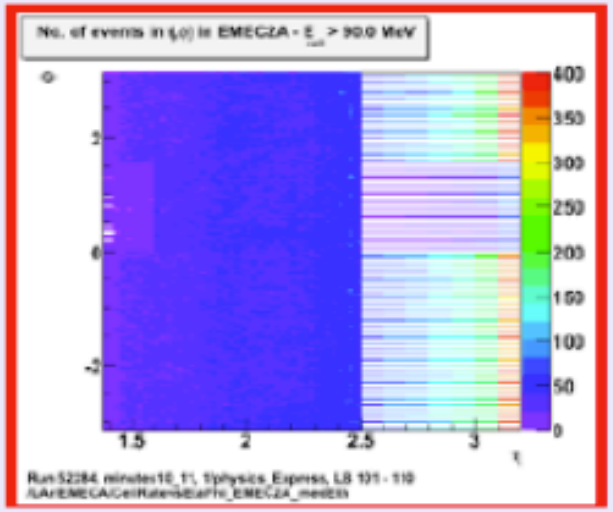
Dead Crates

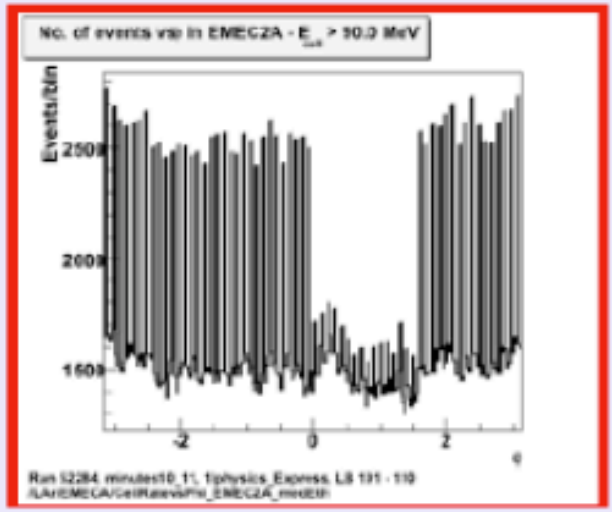
Run 52284, minutes10_11, 1/physics_Express LAr/EMECA

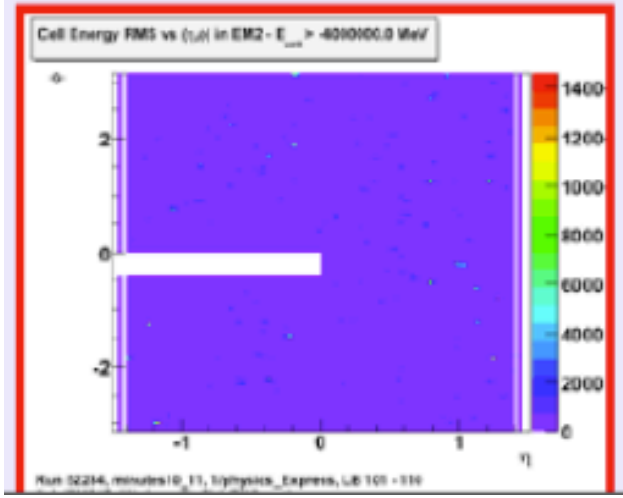
[Only Red] [Only Yellow] [Only Green]

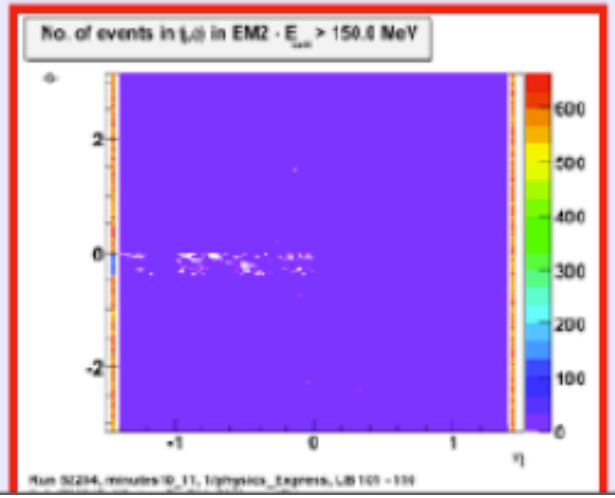
CaloCell-VecMon







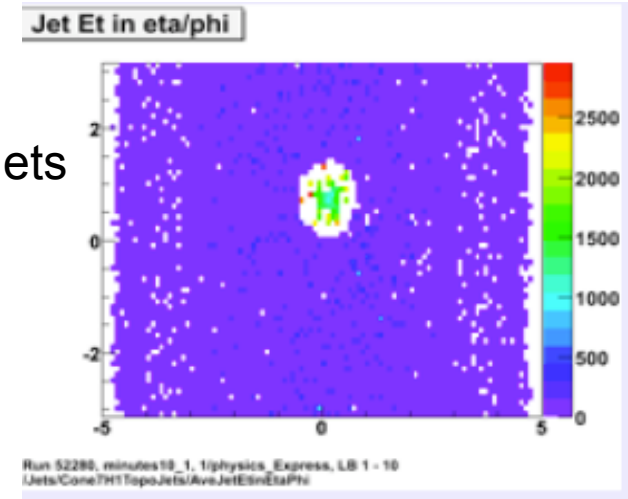




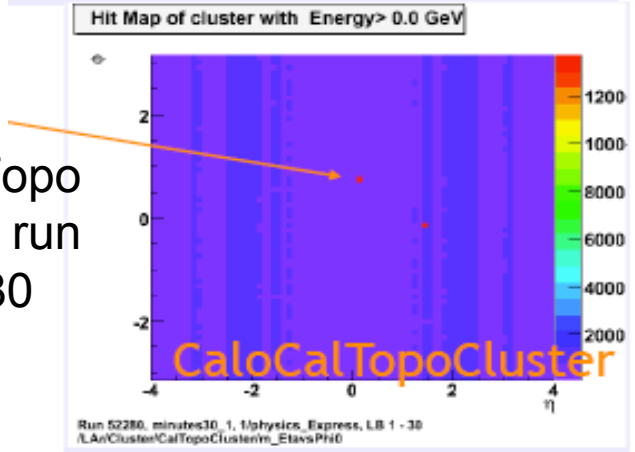
CaloCluster-CosmicsMon

- Directly linked to physics observables
  - If it shows up in clusters, it's probably impacting physics
- Size gives a granularity
  - easier to observe than cells
  - more precise than jets

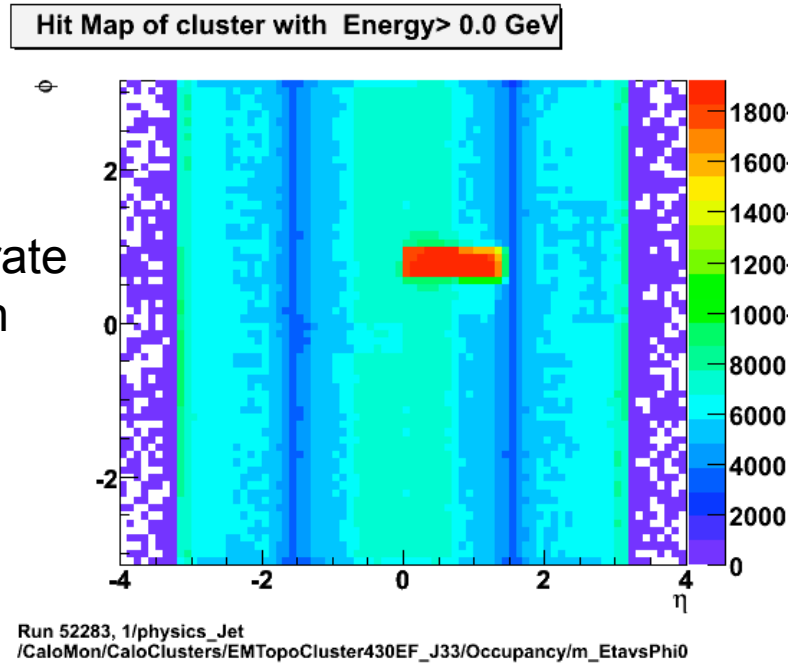
Jets



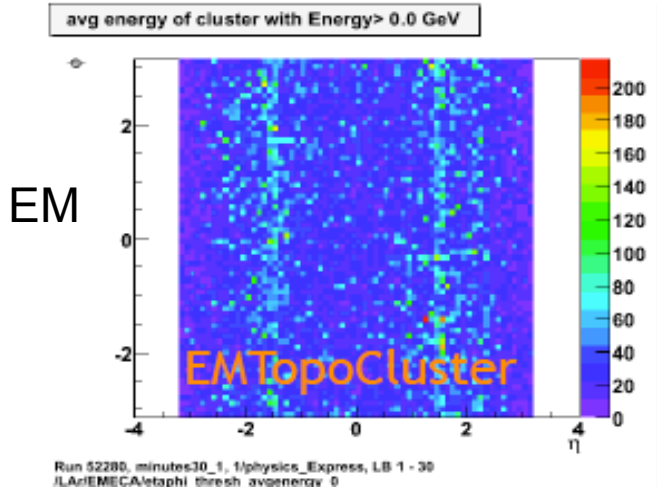
CalTopo FDR run 52280

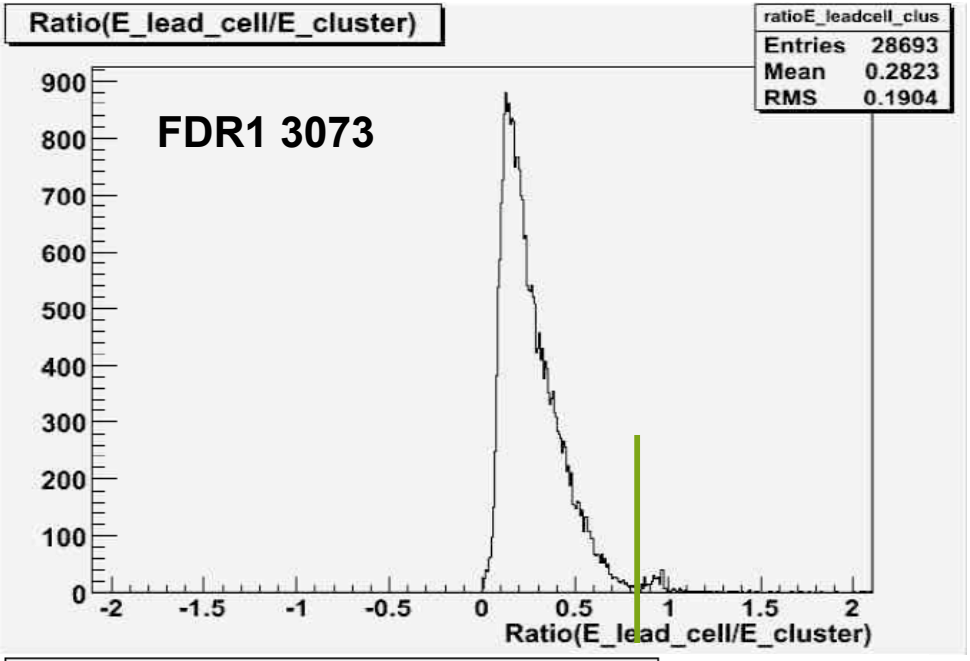


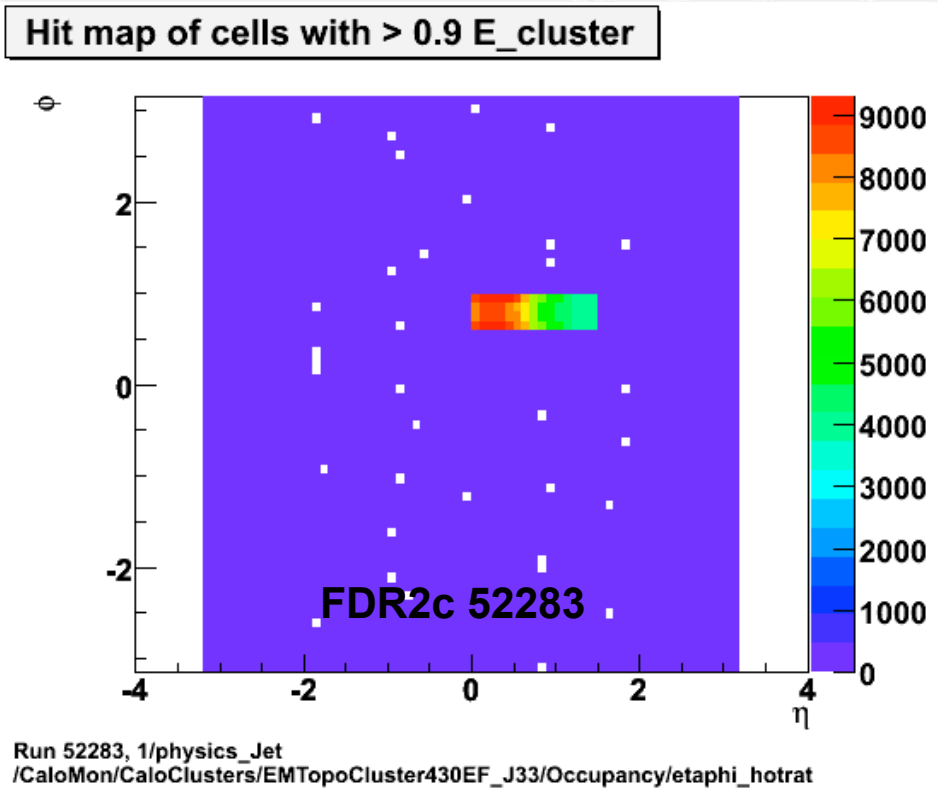
Noisy crate FDR run 52283



EM







Cluster Properties

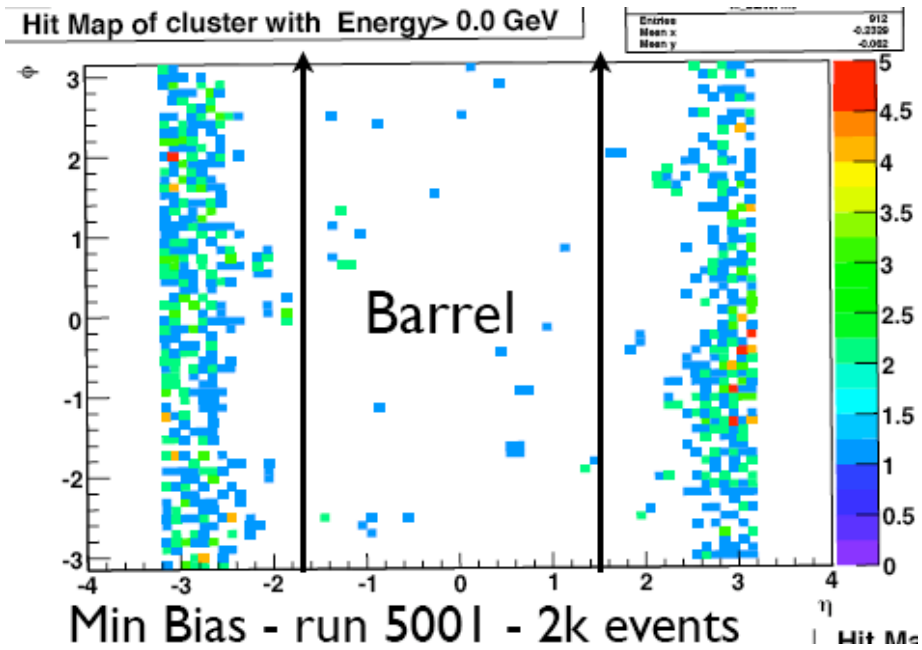
- Distribution of energy within clusters
  - EM fraction, moments…
  - Should adhere to behavior from physics showers
- Currently monitor leading cell energy fraction
- Planning to combine with Tile

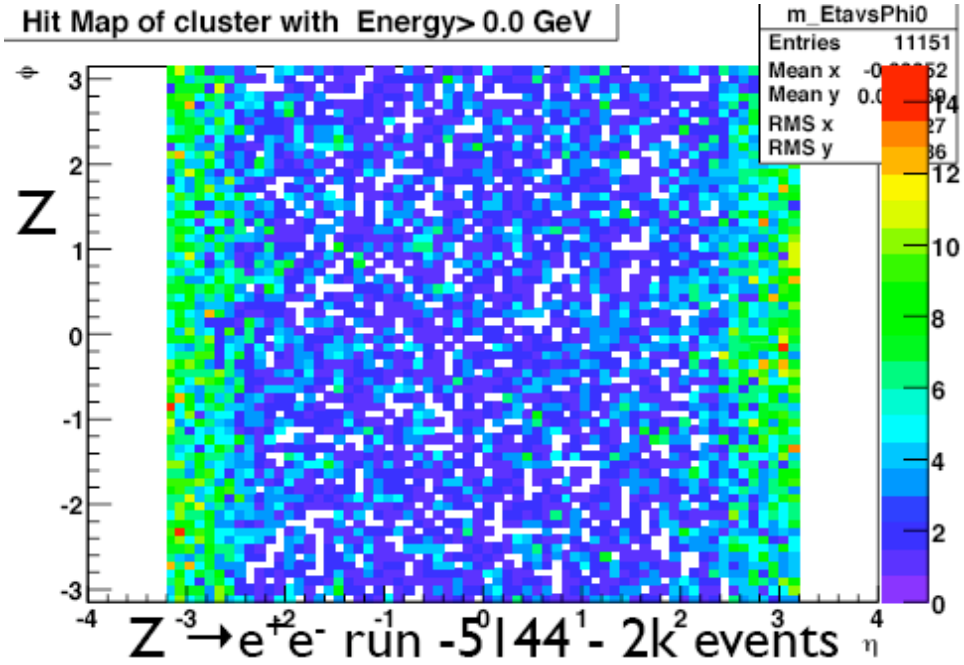
FDR run 5001

Trig Type	MB	2e15i
rate	10Hz	<1Hz
Time for 2K ev	3min (3 or 6 LB)	30 min or more

Trigger -aware monitoring

- Trigger selection
  - changes distributions substantially as expected
    - High pt triggers raise rate of cluster reconstruction
  - reduce rates per plot
    - argues against detailed lumi-block monitoring at low luminosity





Step 2: Data Quality & LAr

- This is the process by which data is formally determined to be good or bad for analysis
  - Monitoring info. Is the input
  - Algorithms run on this information to produce a result and ***status***
    - There are 200 cells with E>1 TeV: status ***Bad***!
    - Online result can be modified offline
      - With new conditions data: these 200 cells are known bad channels
      - If rest of calorimeter okay: DQ → ***Good***
  - Automation needed to identify bad cells or regions
    - Compensates also for inexperienced, non-expert shifters

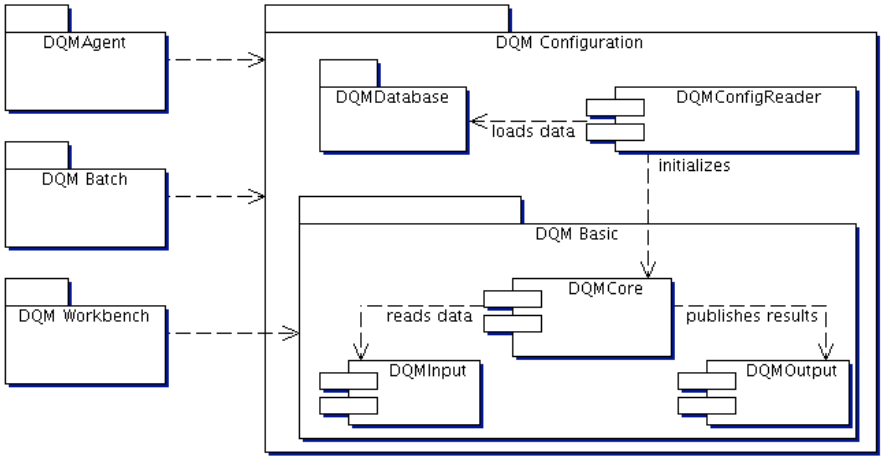
- LAr DQ assessed for eight regions
  - EMBA/C, EMECA/C, HECA/C and FCALA/C
  - Calibration runs DQ based primarily on LArFEBMon for now
  - Most physics runs CaloMonitoring DQ done per run
    - LArRawChannels results currently done with lumi-block granularity

D(ata)**Q**(uality)**M**(onitoring)**F**(ramework)

- A software framework for assessing data quality
  - Input is monitoring results (histograms, vectors…)
  - Apply algorithms to these
    - ROOT C++
    - Configuration parameters
      - Thresholds, ranges, etc.

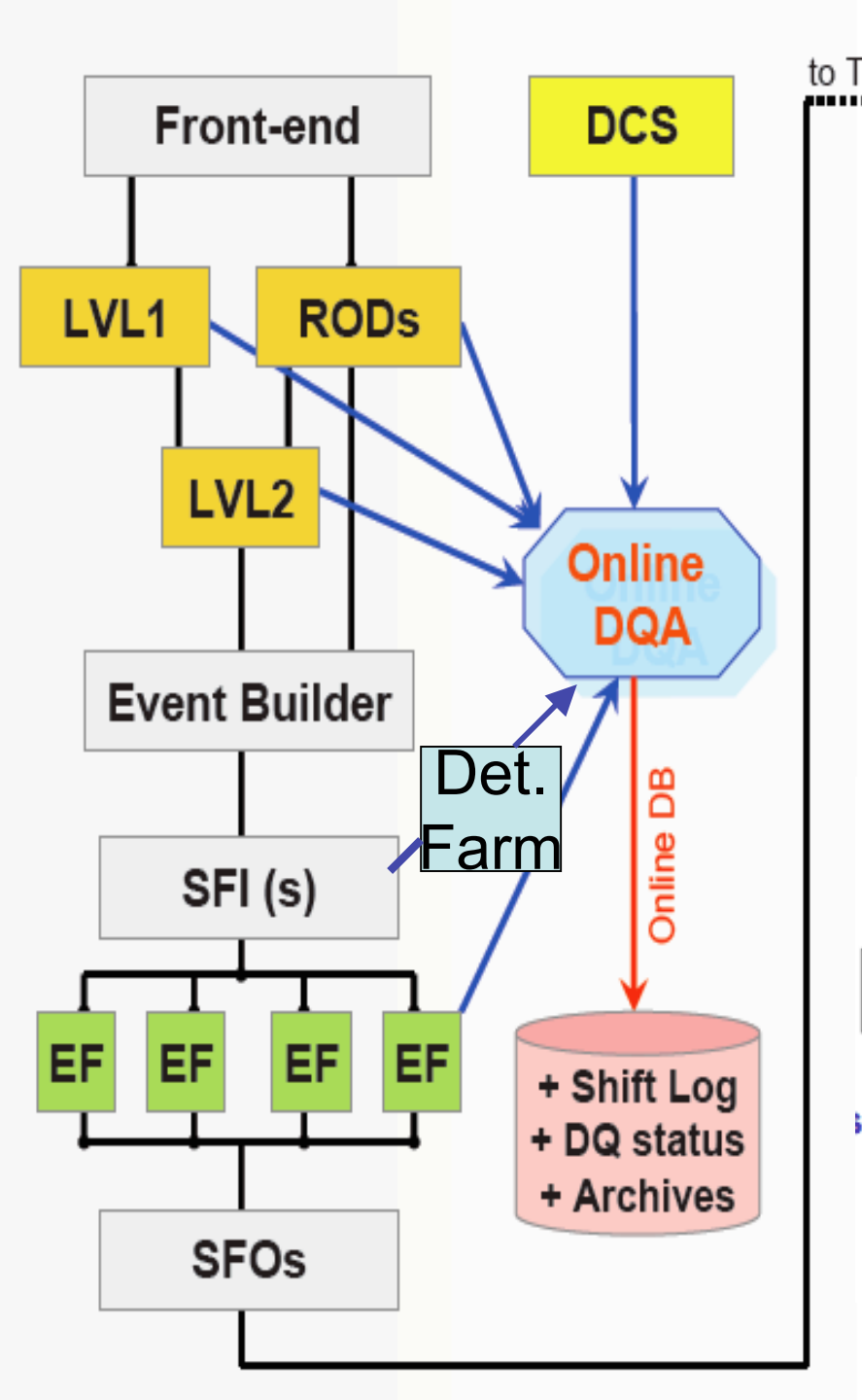
- Three types of instance
  - Online
  - Offline

  See next slides
  - Workbench (see tutorial)
    - Standalone in ROOT
    - .root input
    - By hand run of DQAlgorithms and specification of DQConfig



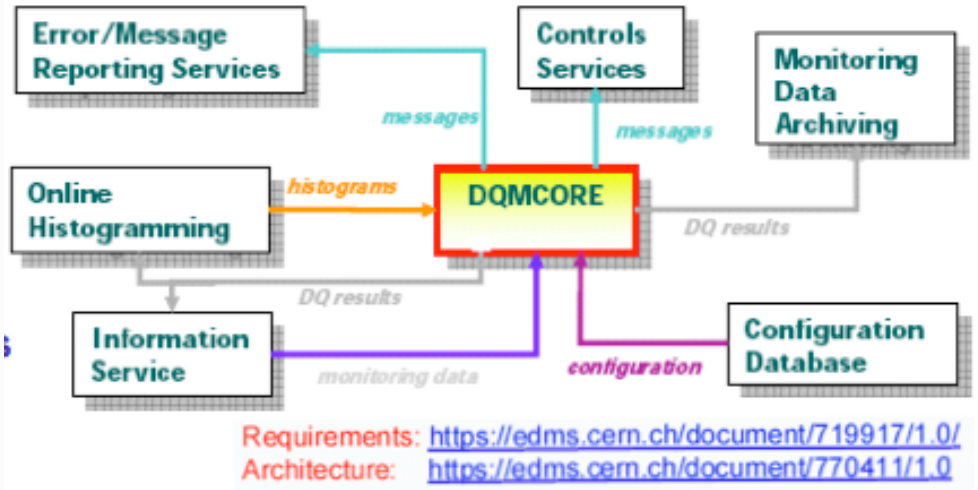
DQAlgorithms

BasicHistoCheck.cxx
BinThreshold.cxx
KurtosistTest.cxx
BasicStatCheck.cxx
Chi2Test.cxx
RootFit.cxx
BinContentComp.cxx
SideBand.cxx
Bins_Diff_FromAvg.cxx
GraphTest.cxx
SkewnessTest.cxx
BinsFilledOutRange.cxx
KolmogorovTest.cxx



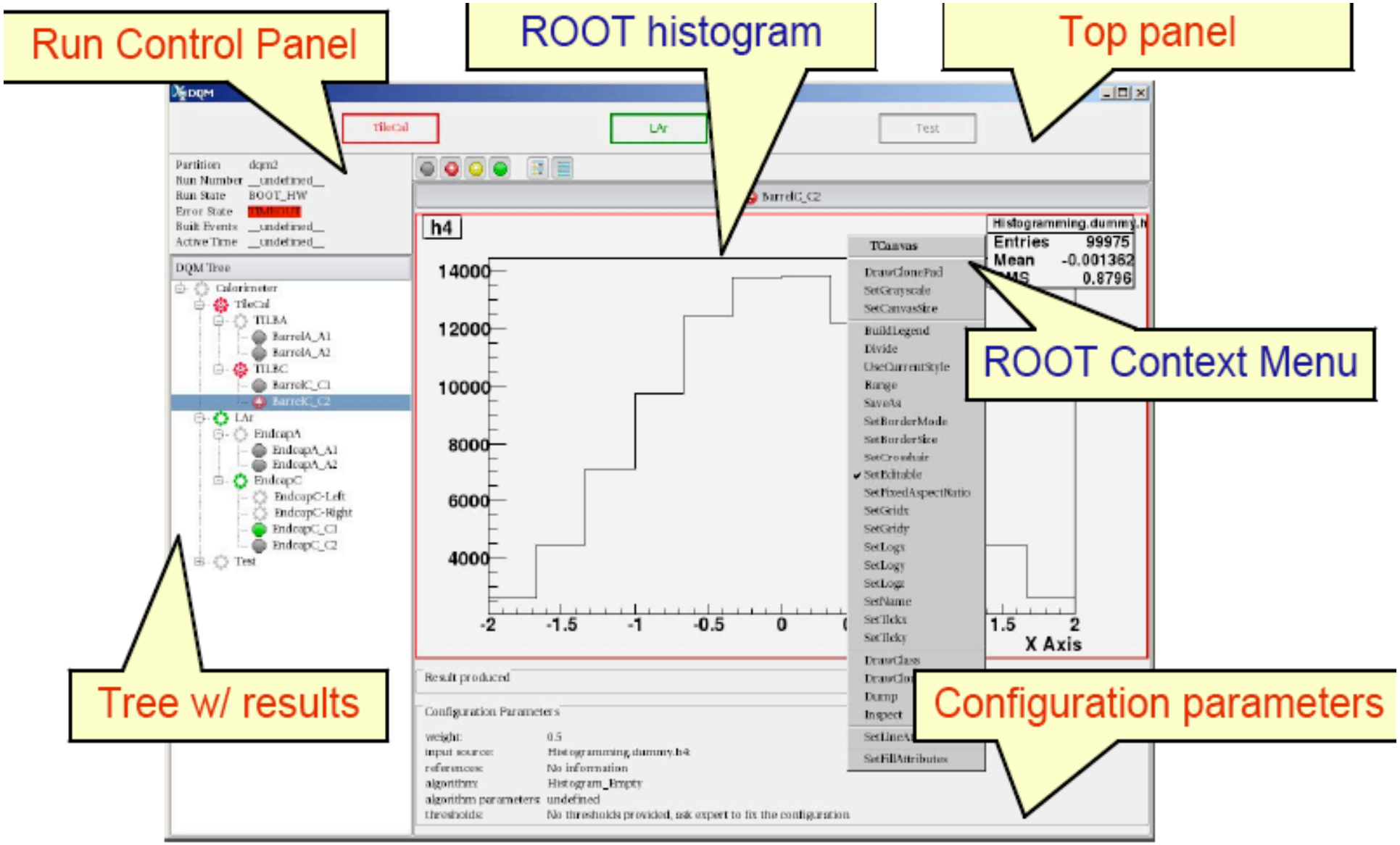
DQ in the online system

- Histograms from OH post-Gatherer
  - Configuration
  - Results can include histograms: all archived



Requirements: https://edms.cern.ch/document/719917/1.0/
Architecture: https://edms.cern.ch/document/770411/1.0

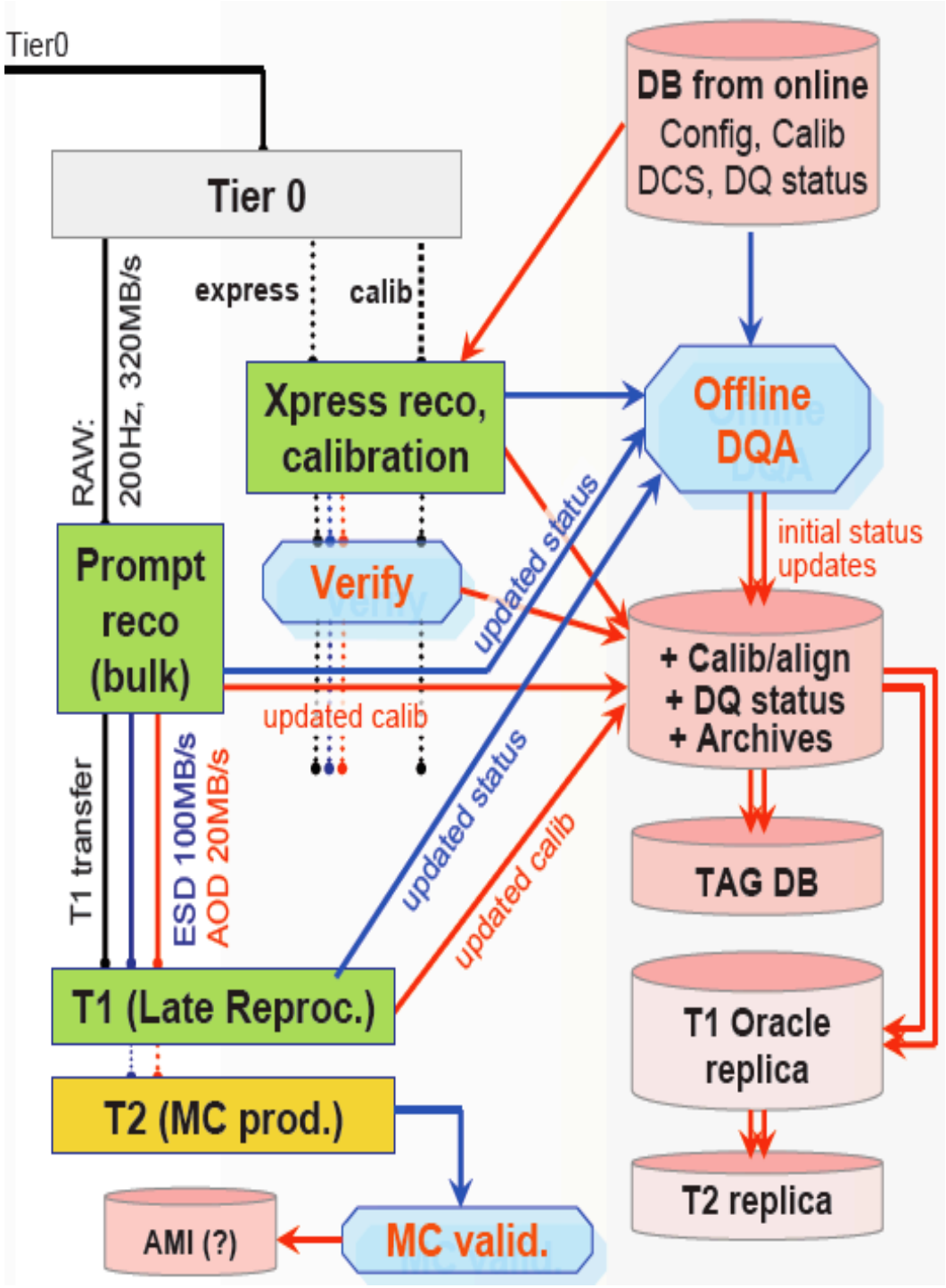
Details: http://indico.cern.ch/conferenceDisplay.py?confId=a057209


Run Control Panel
ROOT histogram
Top panel
ROOT Context Menu
Tree w/ results
Configuration parameters
DQM
TileCal
LAr
Test
Partition dqm2
Run Number __undefined__
Run State BOOT_HW
Error State
Built Events __undefined__
Active Time __undefined__
DQM Tree
Calorimeter
TileCal
TILBA
BarrelA_A1
BarrelA_A2
TILBC
BarrelC_C1
BarrelC_C2
LAr
EndcapA
EndcapA_A1
EndcapA_A2
EndcapC
EndcapC-Left
EndcapC-Right
EndcapC_C1
EndcapC_C2
Test
BarrelC_C2
h4
14000
12000
10000
8000
6000
4000
-2
-1.5
-1
-0.5
0
1.5
2
X Axis
Histogramming.dummy.h
Entries 99975
Mean -0.001362
0.8796
TCanvas
DrawClonePad
SetGrayscale
SetCanvasSize
BuildLegend
Divide
UseCurrentStyle
Range
SaveAs
SetBorderMode
SetBorderSize
SetCrosshair
SetEditable
SetFixedAspectRatio
SetGridx
SetGridy
SetLogx
SetLogy
SetLogz
SetName
SetTickx
SetTicky
DrawClass
Dump
Inspect
SetFillAttributes
Result produced
Configuration Parameters
weight: 0.5
input source: Histogramming/dummy/h4
reference: No information
algorithm: Histogram_Empty
algorithm parameters: undefined
thresholds: No thresholds provided, ask expert to fix the configuration

DQ in the offline system

- Primarily in Tier0
  - FDR
  - M* weeks ⇒ Beam
  - Operate on .root files

- 'han' is offline framework
  - wraps around DQMF
  - Web-display with hierarchical organization of monitoring



http://atlasdqm.cern.ch/tier0/FDR2c/results_FDR2c.html

DQ for Physics Runs

- LAr implemented in most recent FDR2c
  - Trigger aware, no time granularity (whole runs)

FDR2c Monitoring

***Indicates reconstruction is in progress; histograms represent accumulated statistics and are temporary.

Run Number	T0 Iteration	Streams
52300	1	[physics_Express] [NoStream] [physics_Bphys] [physics_Egamma] [physics_Jet] [physics_Muon]
	2	[physics_Express]
52283	1	[physics_Express] [physics_Bphys] [physics_Egamma] [physics_Jet] [physics_Muon]
	2	[physics_Express]
52280	1	[physics_Express] [physics_Bphys] [physics_Egamma] [physics_Jet] [physics_Minbias] [physics_Muon]
	2	[physics_Express]

Run 52283, 1/physics_Jet: Monitoring and Automatic Checks

CaloMon - Red

CaloClusters - Red

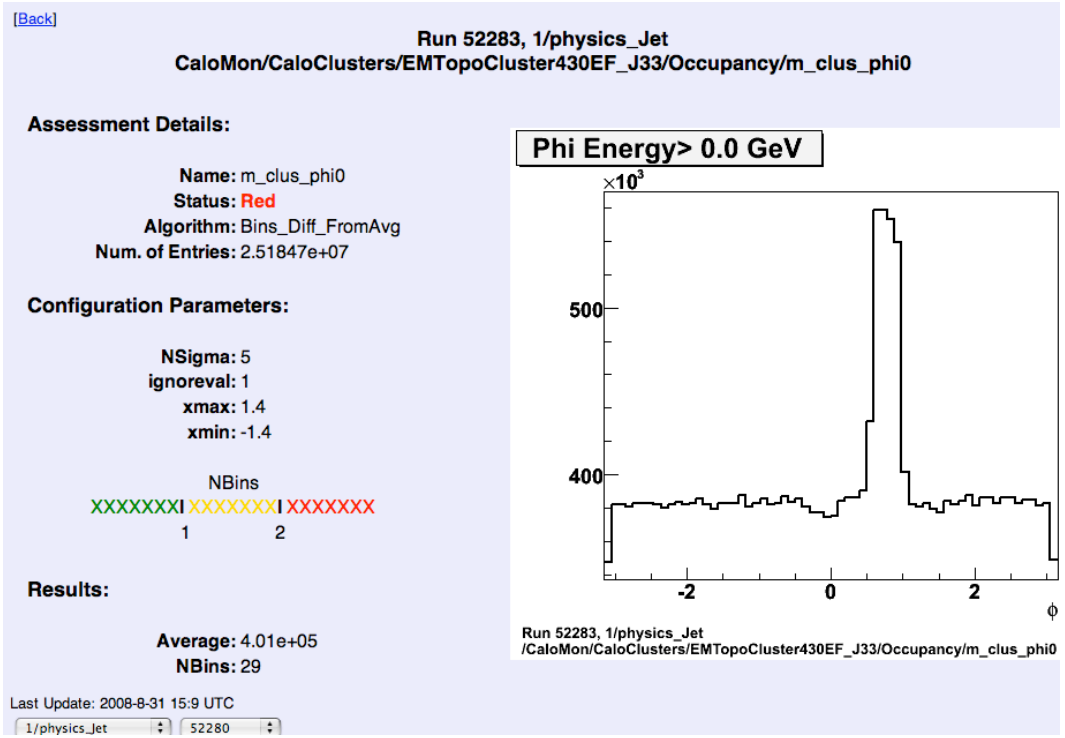
CaloCalTopoClusterEF_J33 - Red

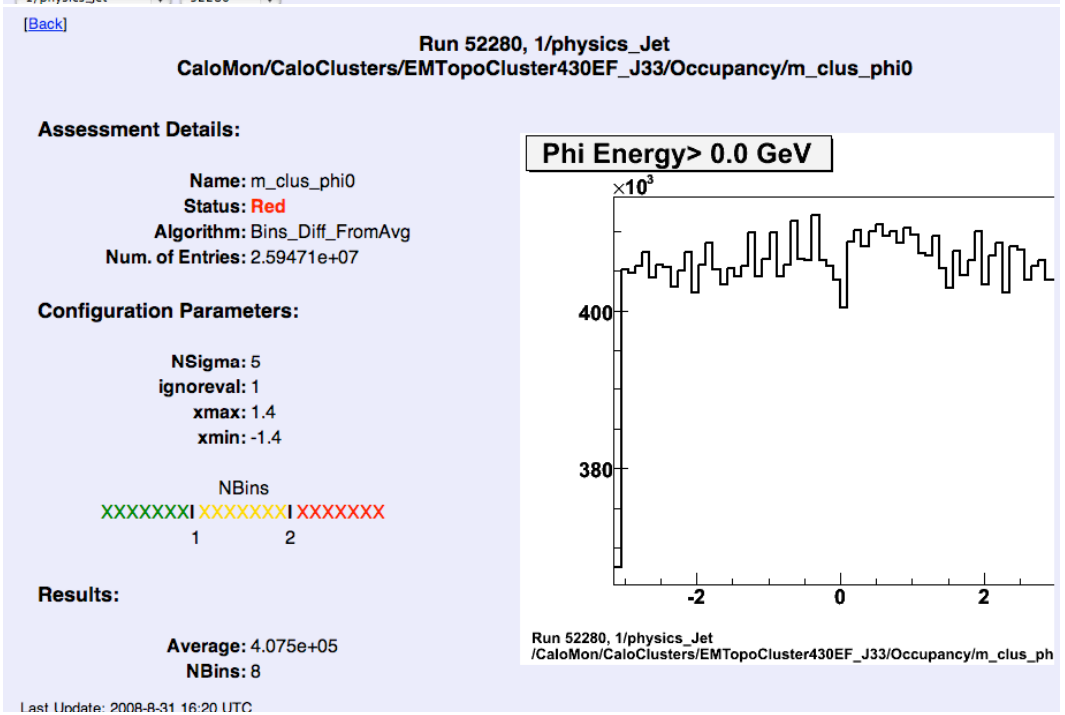
Occupancy - Red

... or display directories at current level

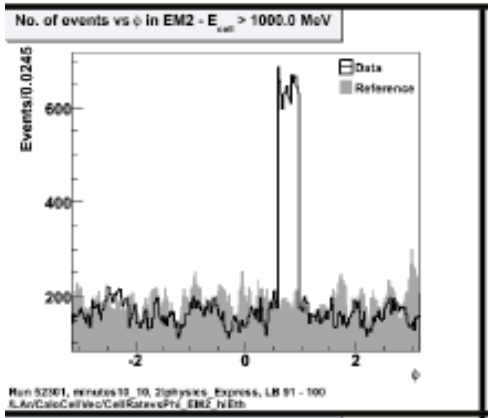
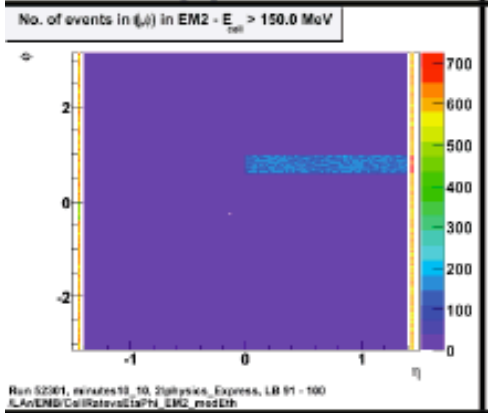
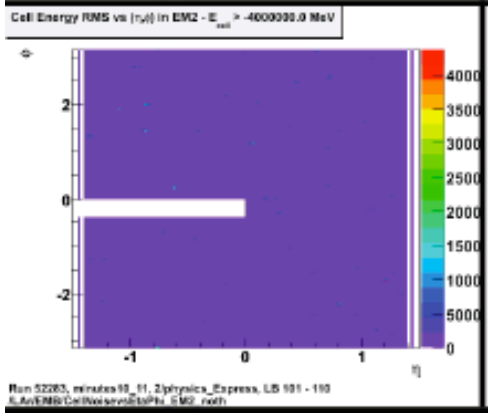
Offline Display

- Presented in web-browser
  - Navigable tree for each run
    - Stream
    - Subsystem
    - Monitoring tools
    - Final page has histogram array
- For each histogram
  - Click enlarges
  - DQ status given
  - Dialogs to show comparison plots

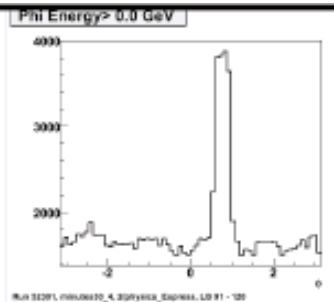
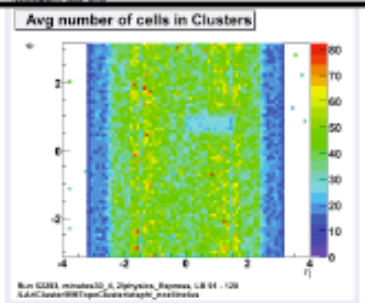
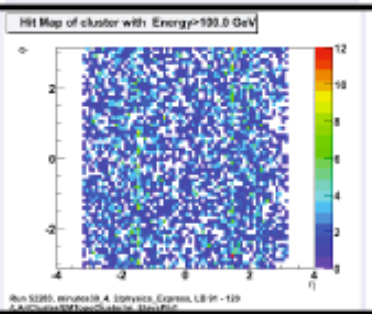
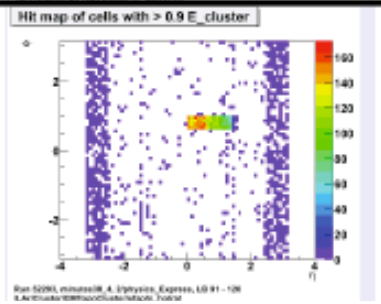




Cell DQ

	Thresholded Cell rate in Phi-24 plots	Bins_Diff_Average NSigma=4 .01%xNBins<NBins<.1% xNBins
	Thresholded Cell rate in eta/phi-24 plots	Bins_Diff_Average NSigma=4 .01%xNBins<NBins<.1% xNBins
	Cell RMS in eta/phi-24 plots	Bins_Diff_Average NSigma=4 .01%xNBins<NBins<.1% xNBins

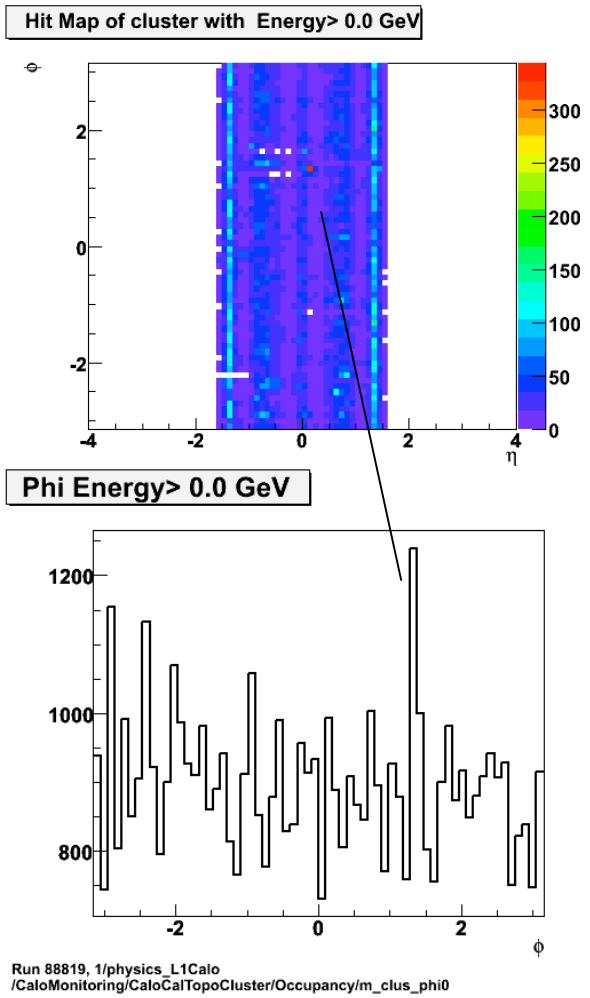
Cluster DQ

	Cluster rate in Phi-3 eta regions x2 clusters=6 plots	Bins_Diff_Average NSigma=4 .01%xNBins<NBins<.1%xNBins
	Number of Cells in clusters in eta/phi- check 3 diff eta regions	Bins_Diff_Average NSigma=4 .01%xNBins<NBins<.1%xNBins
	Number of Clusters in eta/phi	Bins_Diff_Average NSigma=4 .01%xNBins<NBins<.1%xNBins
	Clusters with 1 cell having .9 of total energy- check 3 diff eta regions	Bins_Diff_Average NSigma=4 .01%xNBins<NBins<.1%xNBins

Conclusions

- A broad range of tools in use for over 3 years
  - Online, offline and standalone
  - Two matur(ing!) packages for calibration and physics runs
    - LArMonTools
    - CaloMonitoring
  - A steadily improving understanding of how to do DQ
- Some major in-progress items
  - DSP monitoring
  - Ramp/delay outputs → rootMacros automated monitoring
  - Fuller set of cell/cluster level plots (e.g. shower shapes)

Beams data, clusters



Acknowledgments: Haleh Hadavand, Francesco Spano, Benjamin Trocme, Lee Sawyer, Ram Dhillipudhi, Jessica Leveque, Michel Lefebvre, Yuriy Ilchenko, Tayfun Ince

Thanks for physics plots: Pavel Zarzhitsky, Azzedine Kasmi, Kamile Dindar