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ATLAS Calorimetry:

Cosmic Ray Commissioning



Overview



- Cosmics in ATLAS
- Analysis: What to Look For and How to Find It
 - Example Runs and Events
- Cosmics as a Background
 - Spectrum of high energy hits and missing transverse energy
- Travel
- Acknowledgements



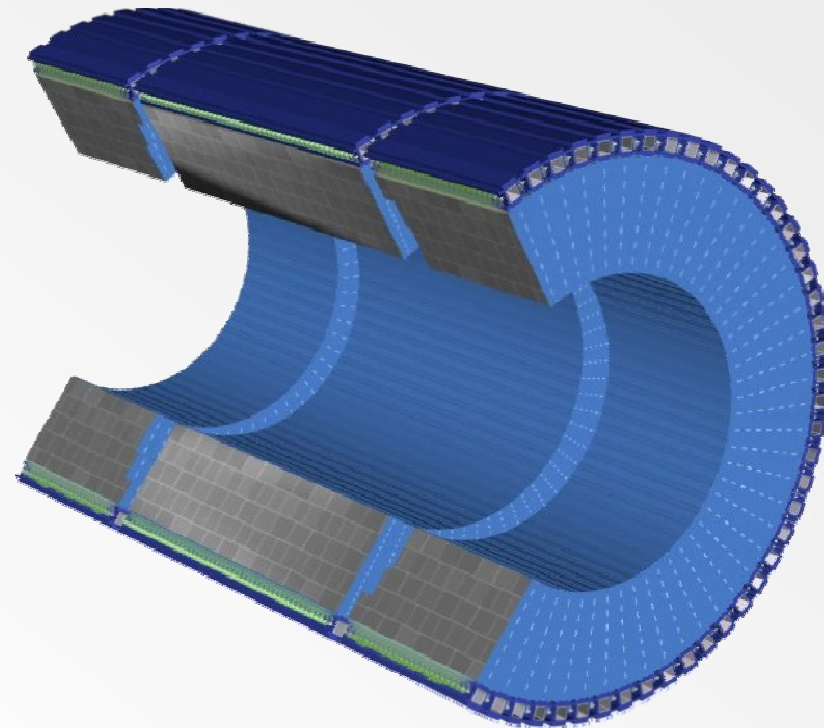
Cosmics in ATLAS: Why?

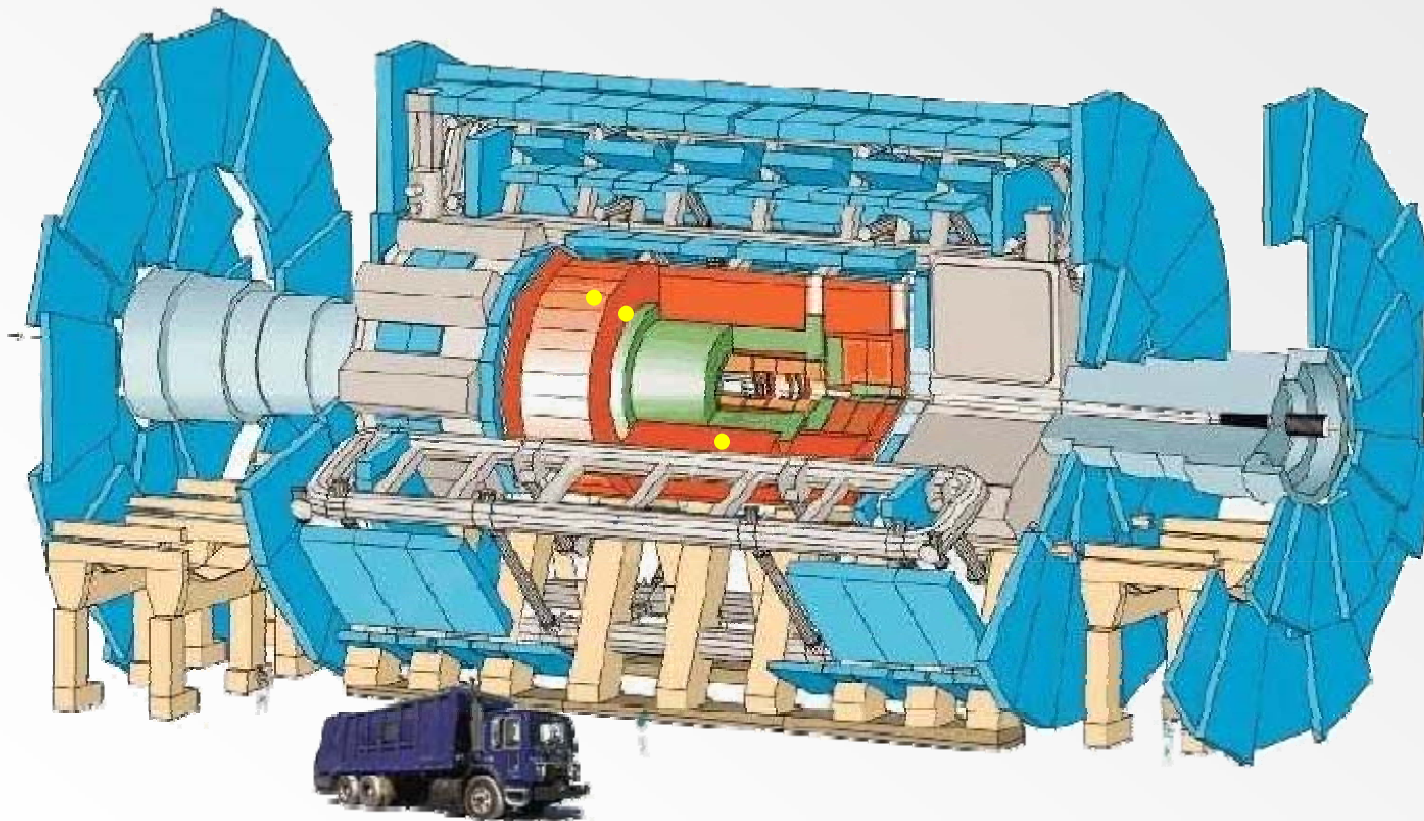


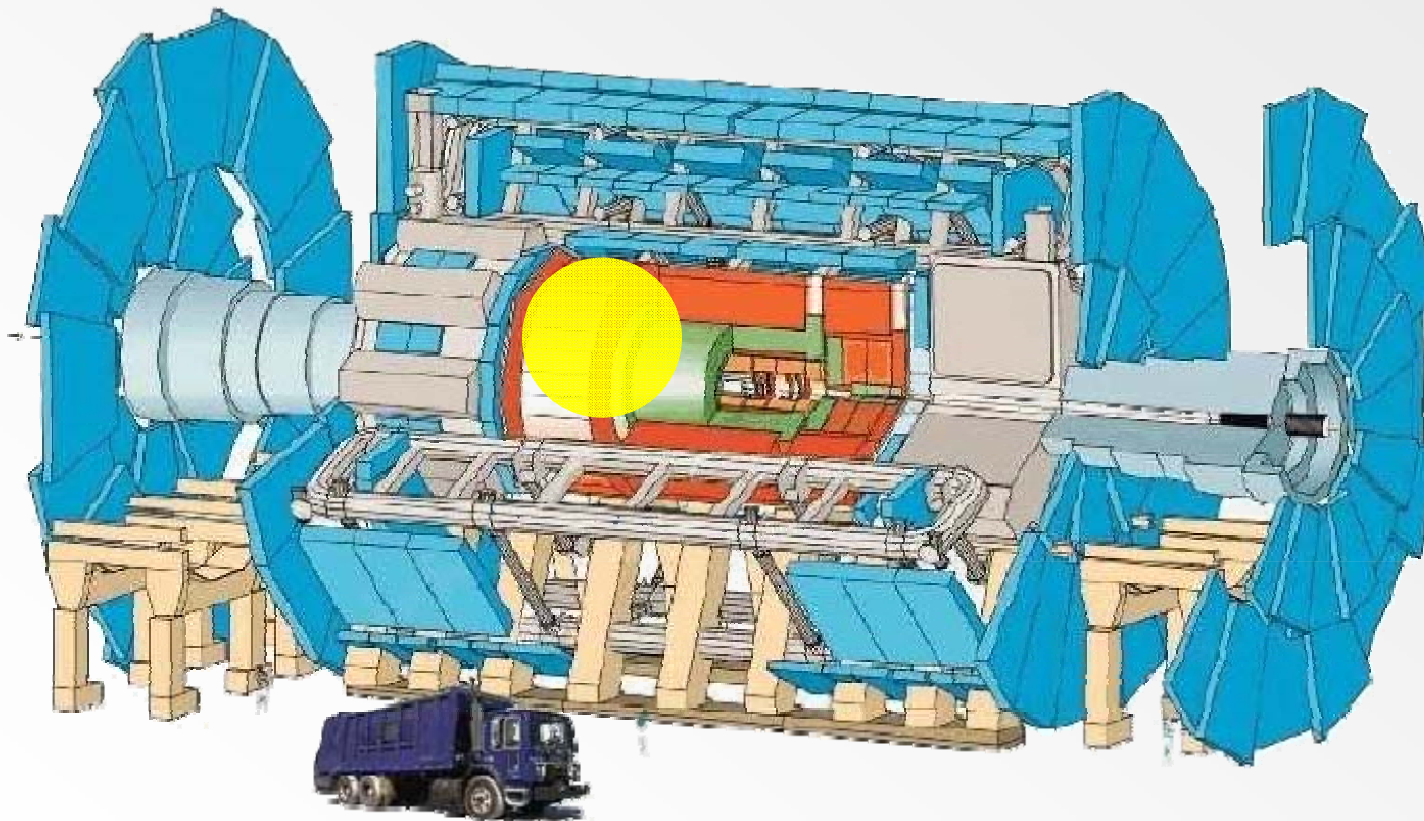
- Analysis of cosmic ray events provides valuable information about the status of detector modules and triggering mechanisms
 - Identify and tag malfunctioning cells
 - Ensure proper calibration and function of reconstruction software
- Determine frequency and impact of significant cosmic events as a background to beam collision events

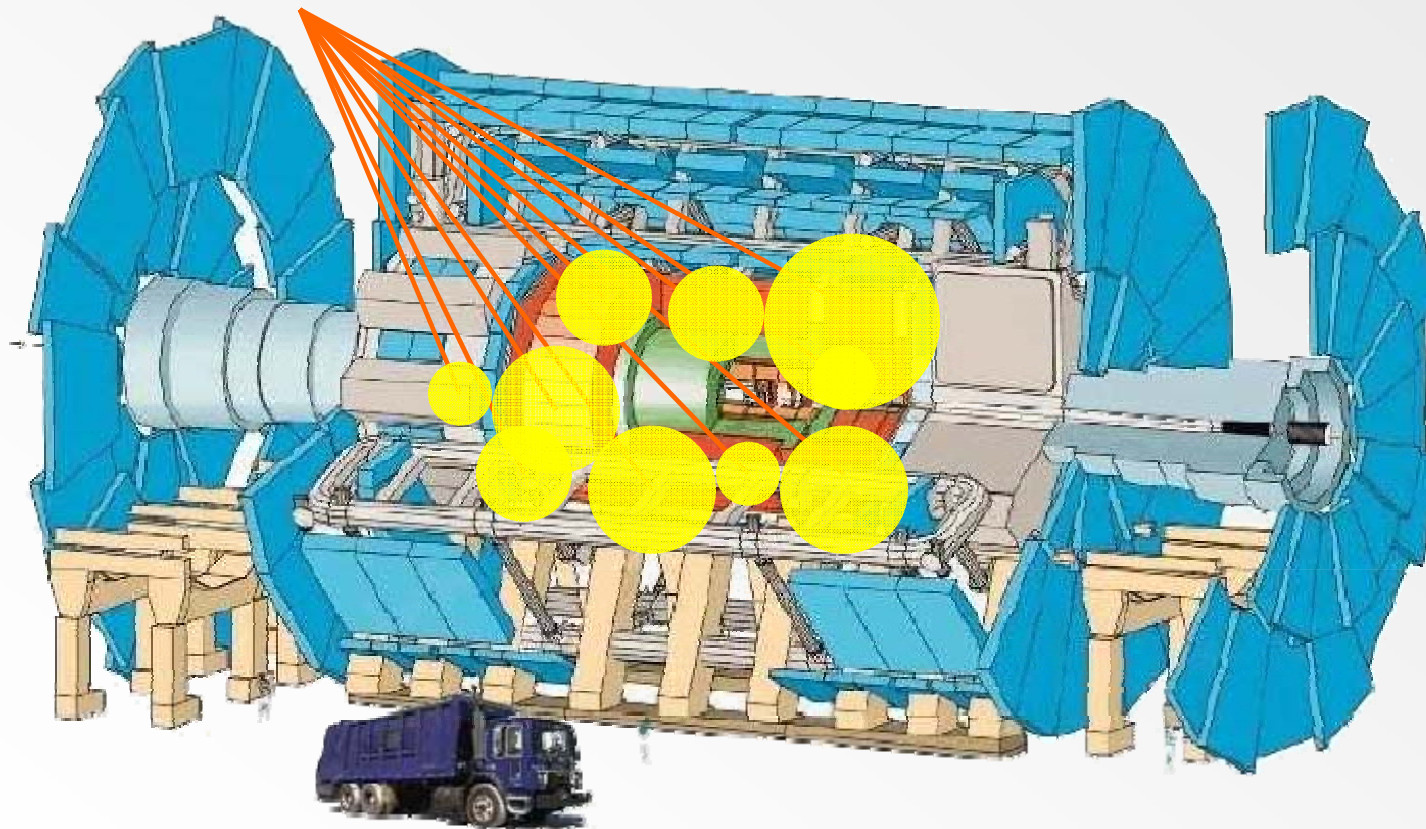
- Data collection: Detector is left on, typically overnight
- Trigger: coincidence of high energy on both top and bottom of detector

- At best, there are 12 Φ modules on top and 12 Φ modules on bottom that can be used as triggers.











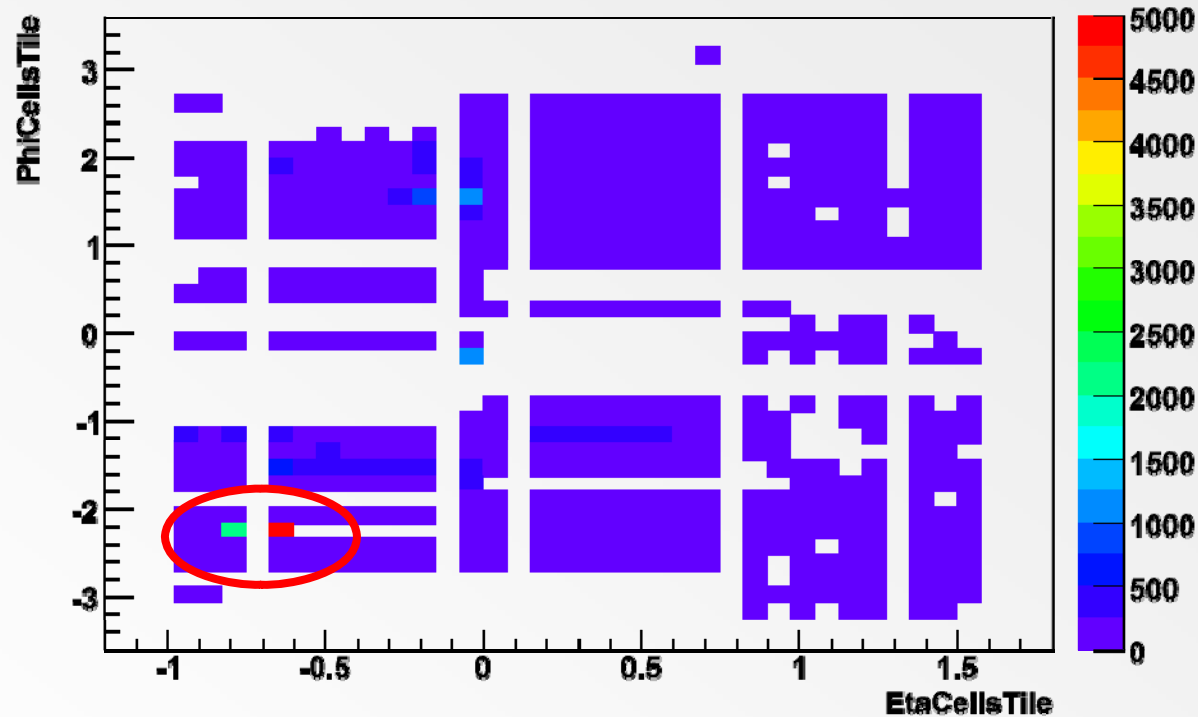
Analysis - The Basic Process



- Data is stored in raw format, then converted to more amiable ntuple (through Athena)
- Distribution of energy across detector is examined to find and cut malfunctioning cells
- Use ROOT to find and characterize high-energy events
- Events are reconstructed for further examination (through Atlantis or other event displays)

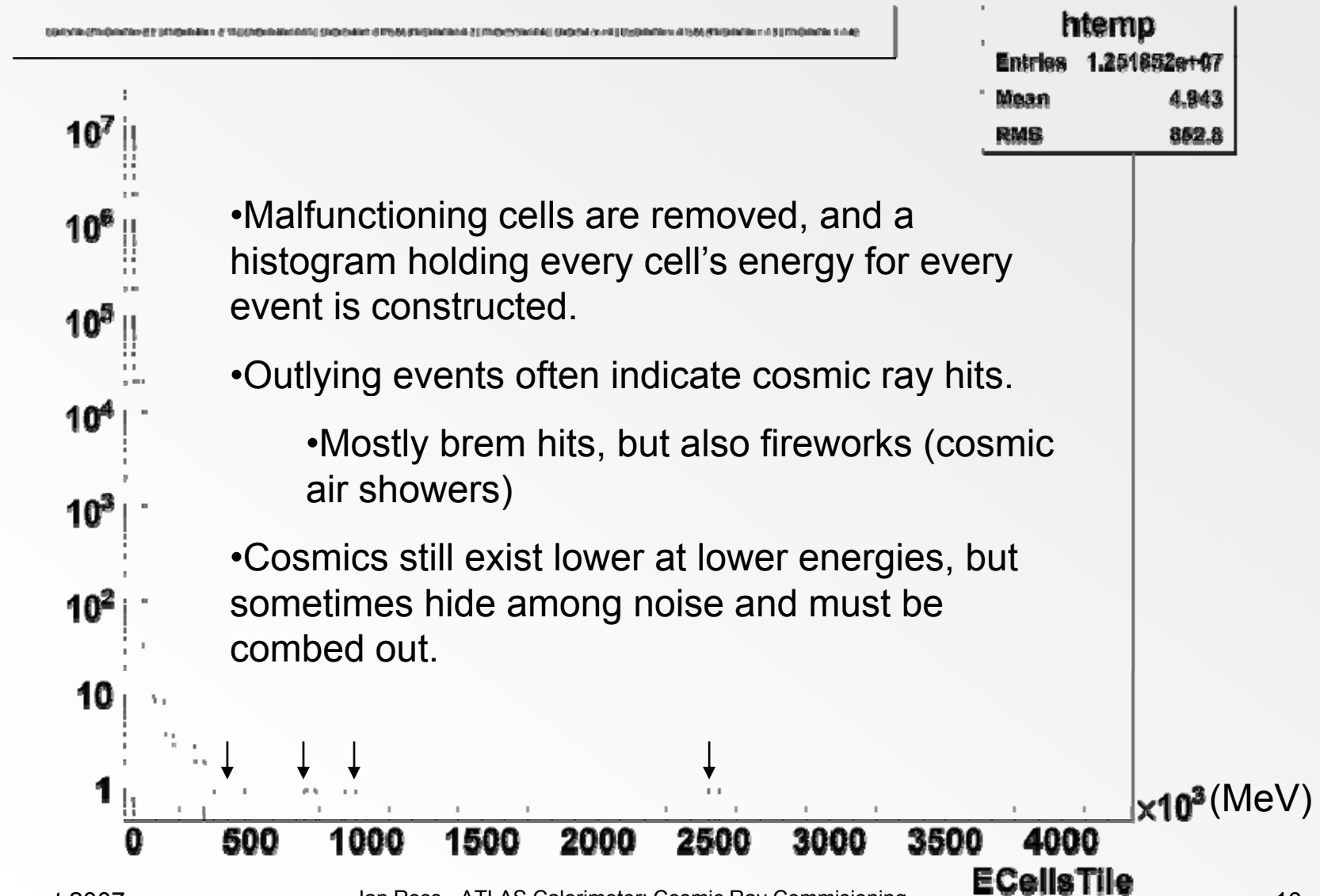
Example: Run 11000

PhiCellsTile:EtaCellsTile {ECellsTile>400}

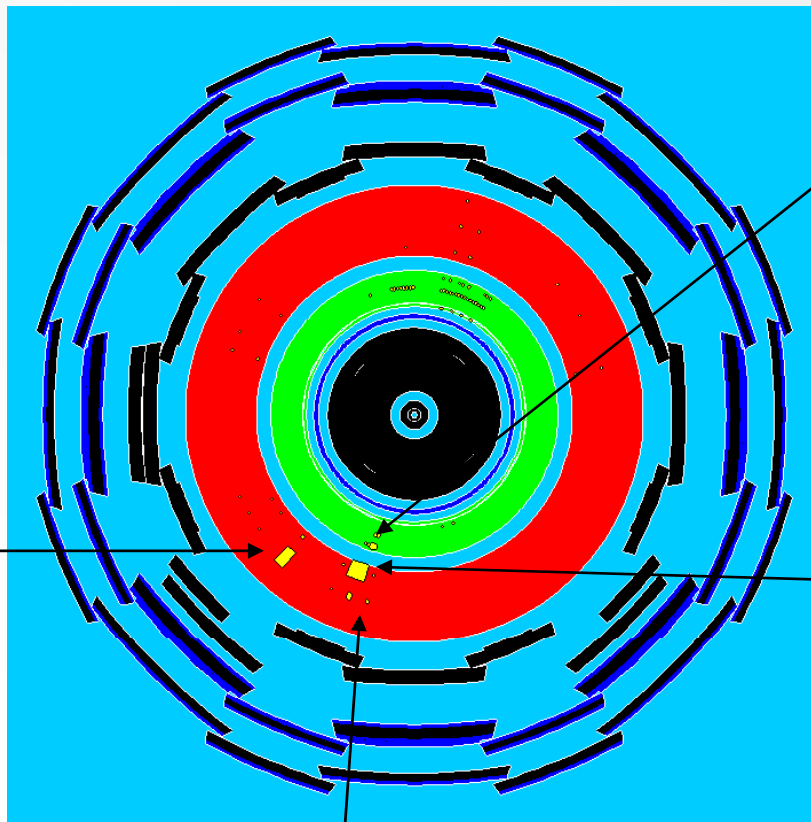


- Plot displays how many times during the run a cell reported an energy of >400 MeV
- Cells in lower left are malfunctioning: way too many high-energy events
 - LBC41 – Known problem cell that has since been fixed

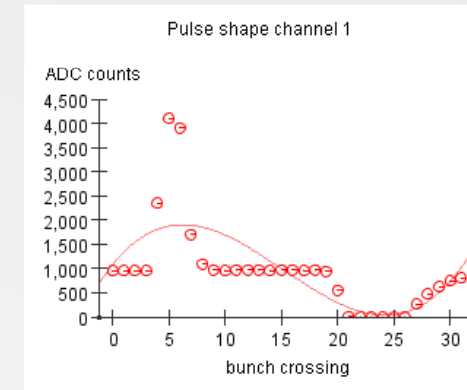
Picking out the Cosmics



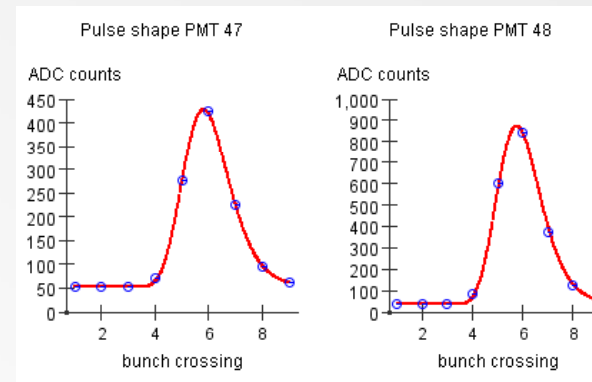
Cosmic ray strikes detector and slows down, radiating energy as it does so



Bremsstrahlung hit

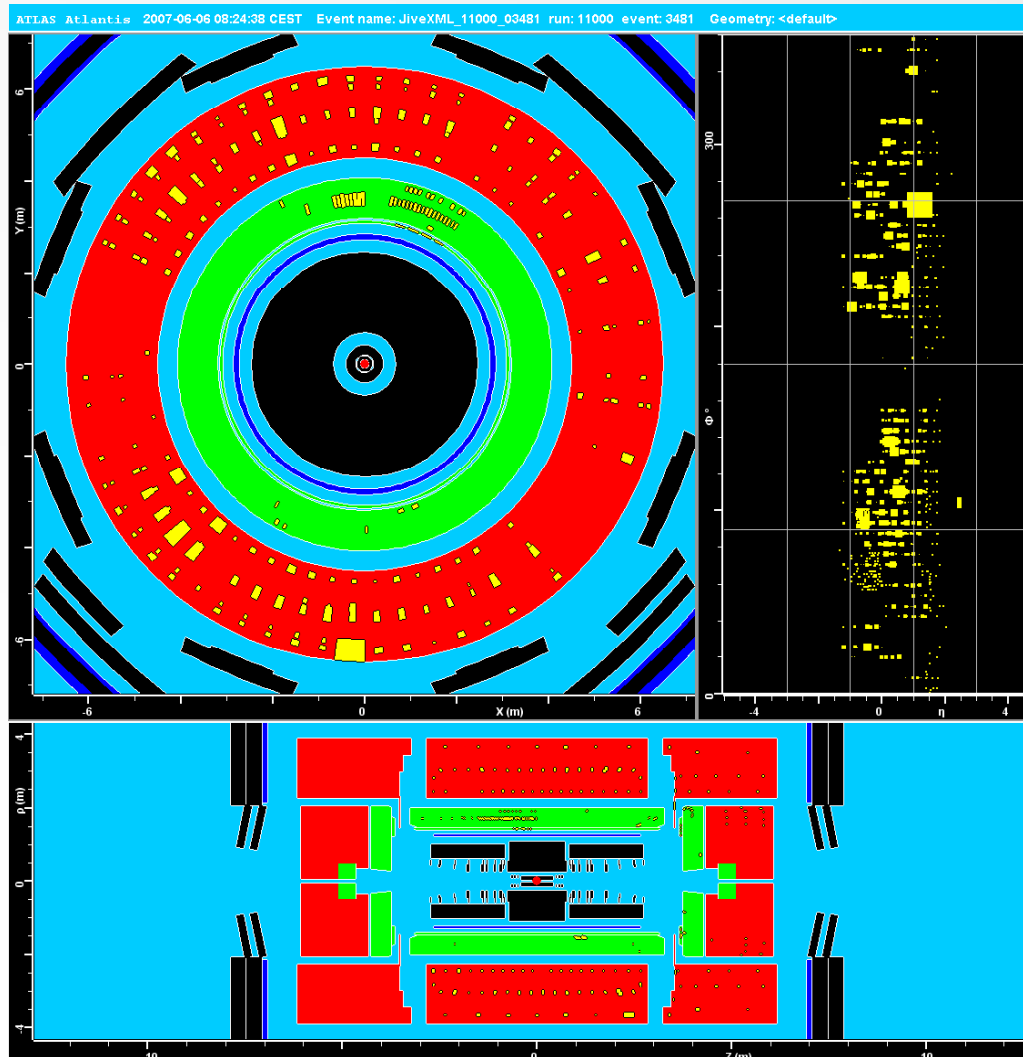


Liquid Argon pulse



Tile Calorimeter pulse

Bad cell
(LBC41)



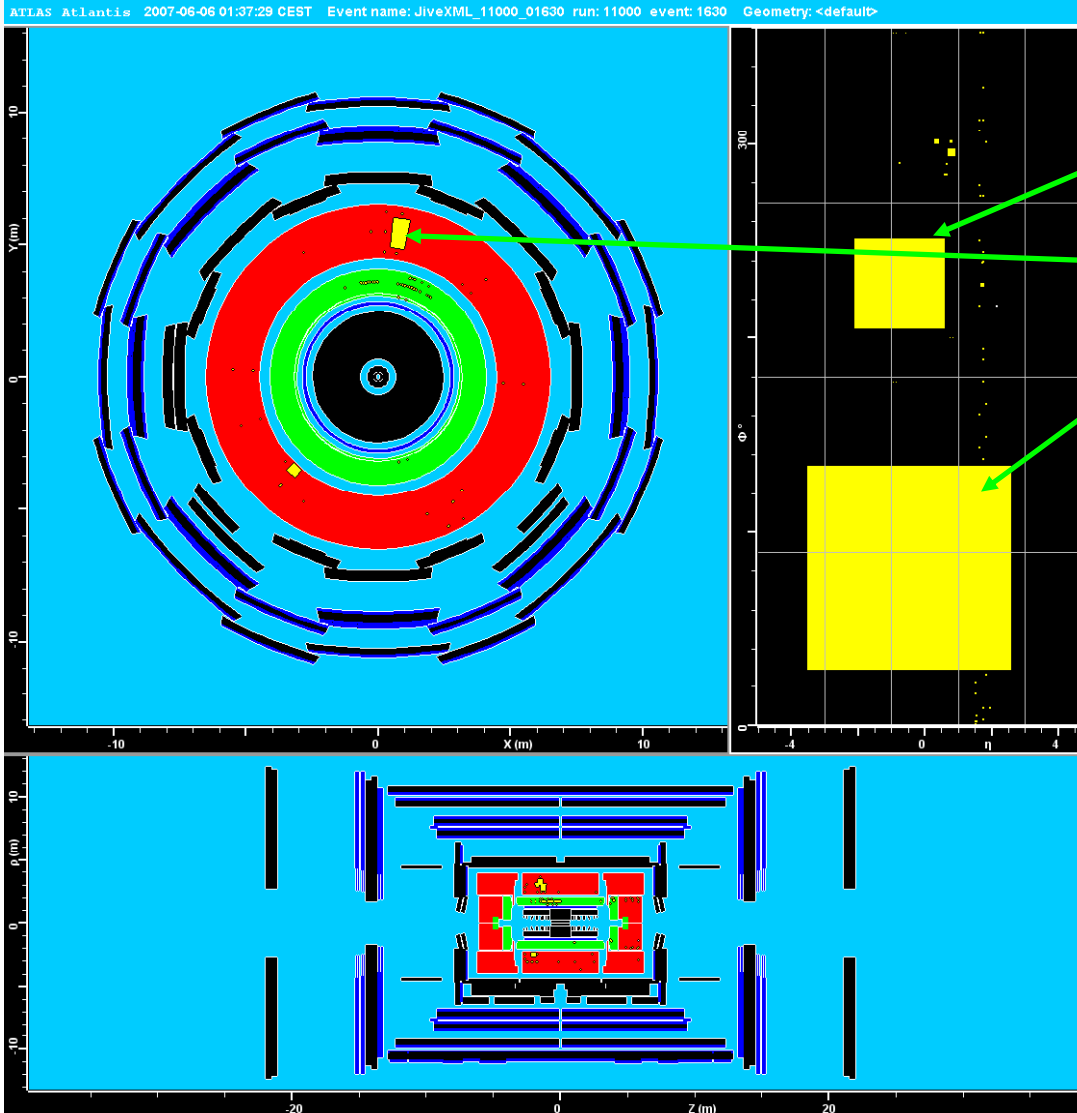
Air shower event

Cosmic ray collides with air particle, causing a cascade of energetic particles to shower over the detector

Much rarer than Brem hits.

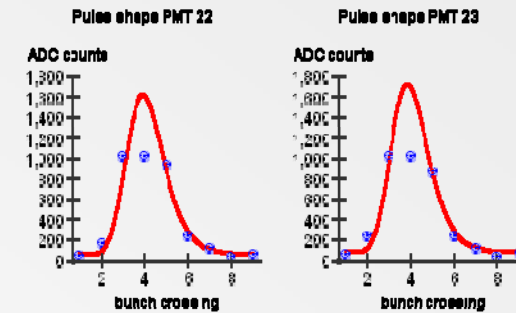
773 GeV spread across entire active detector

Largest single hit was 73 GeV



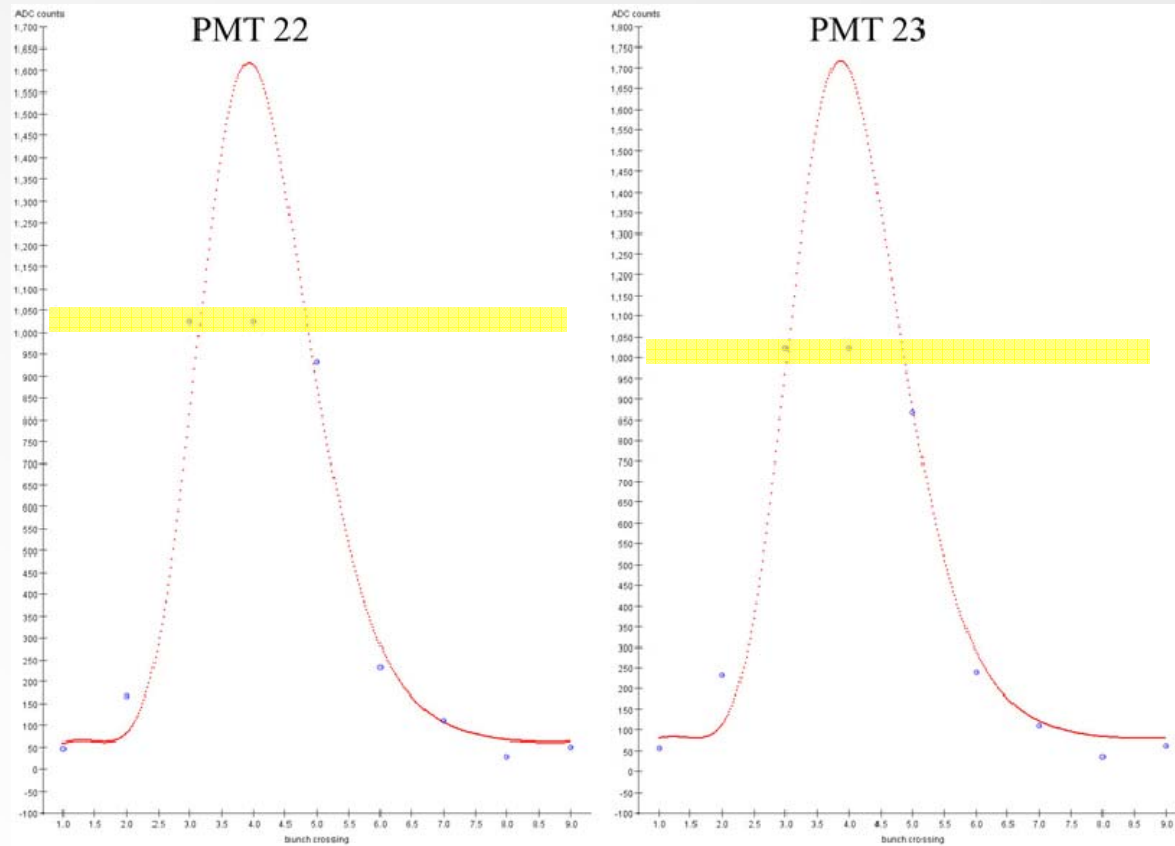
Tile LBC41: known to be malfunctioning during the run

Enormous amount of energy in this cell!



PMTs are saturating!

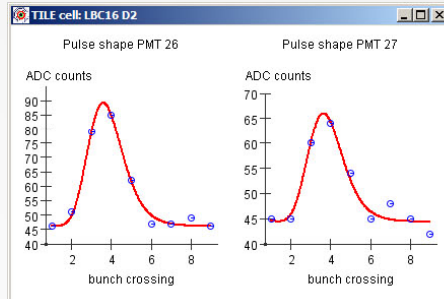
LBC15 B5 TILE cell:
 id = 5/1/-1/14/4/1/0/0
 E Max = 2496.36 GeV
 ET Max = 2263.30 GeV
 ET Sum = 2477.43 GeV
 $\eta = -.4500 \pm .1000$
 $\Phi = 81.6 \pm 5.6^\circ$



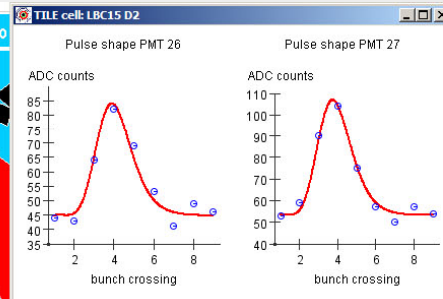
- Saturation occurs at 1023 ADC counts
- Calibration fits pulse, de-weighting the saturated samples by assigning them with a very large error in the fit

Pulse shape of neighbors indicates real physics hit

0.79 GeV

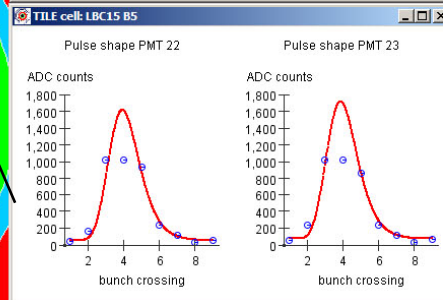
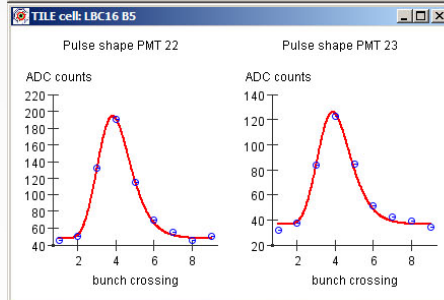


6 01:37:29 CEST Event name: JiveXML_11000_01630



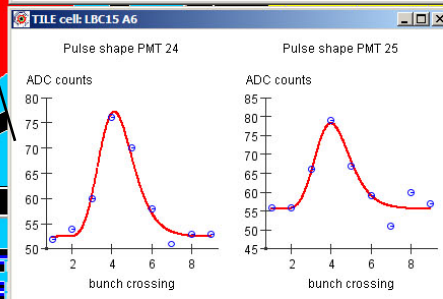
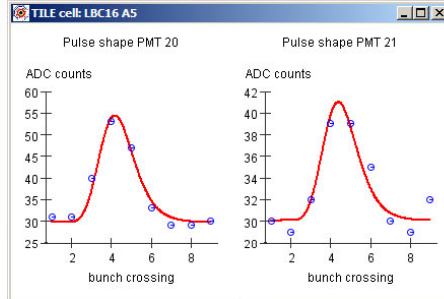
1.13 GeV

2.87 GeV

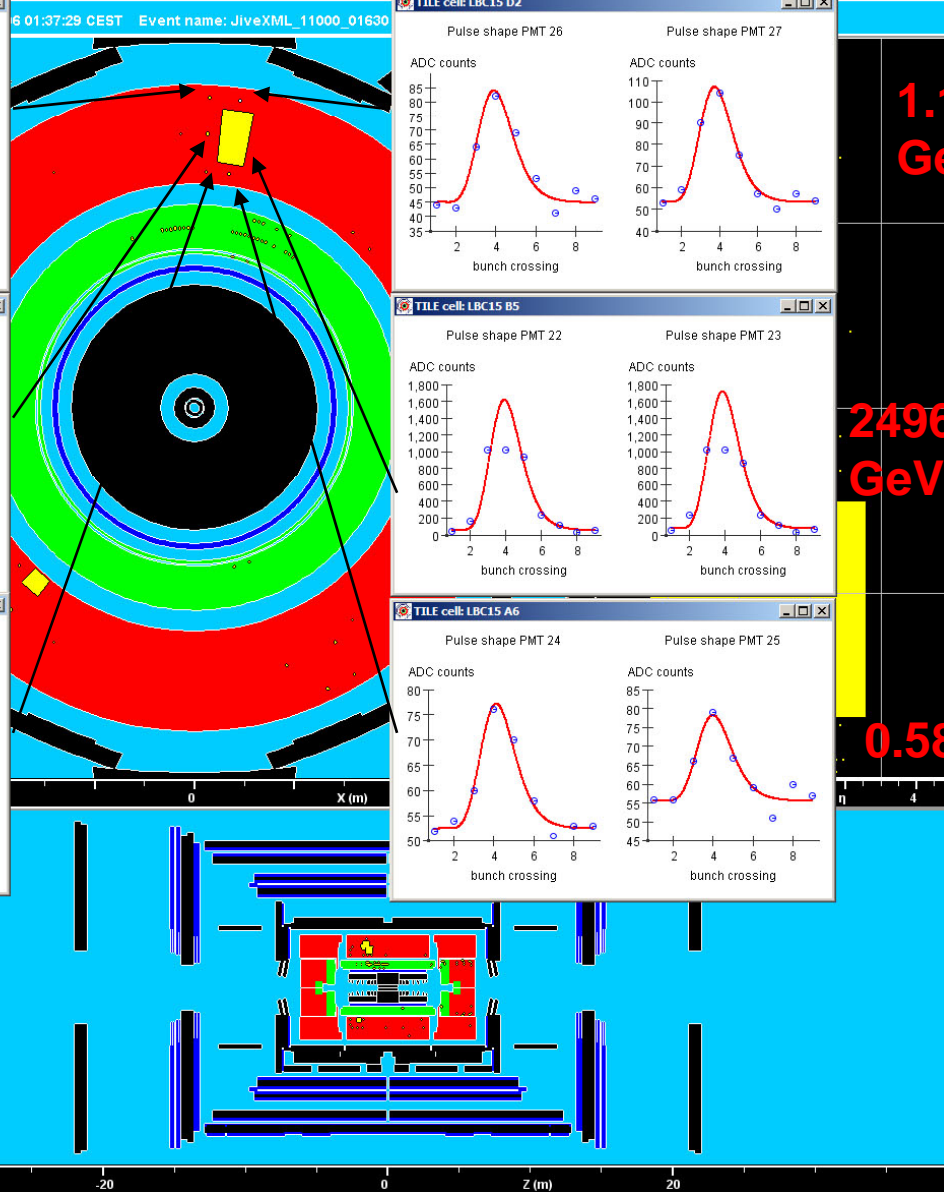


2496.36 GeV

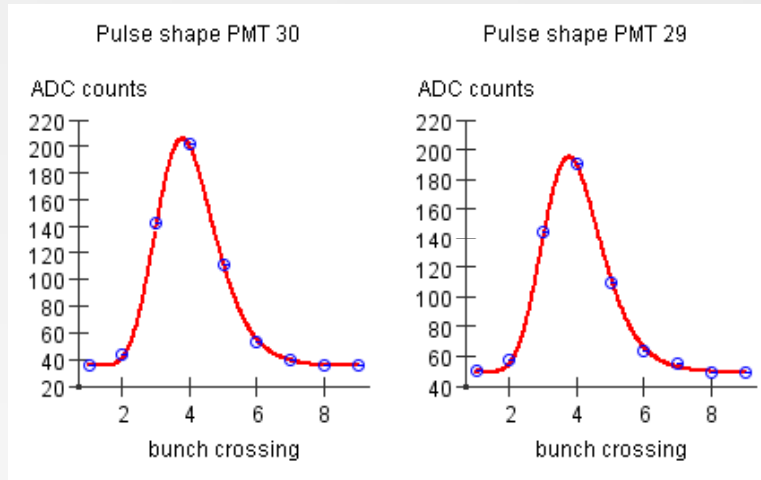
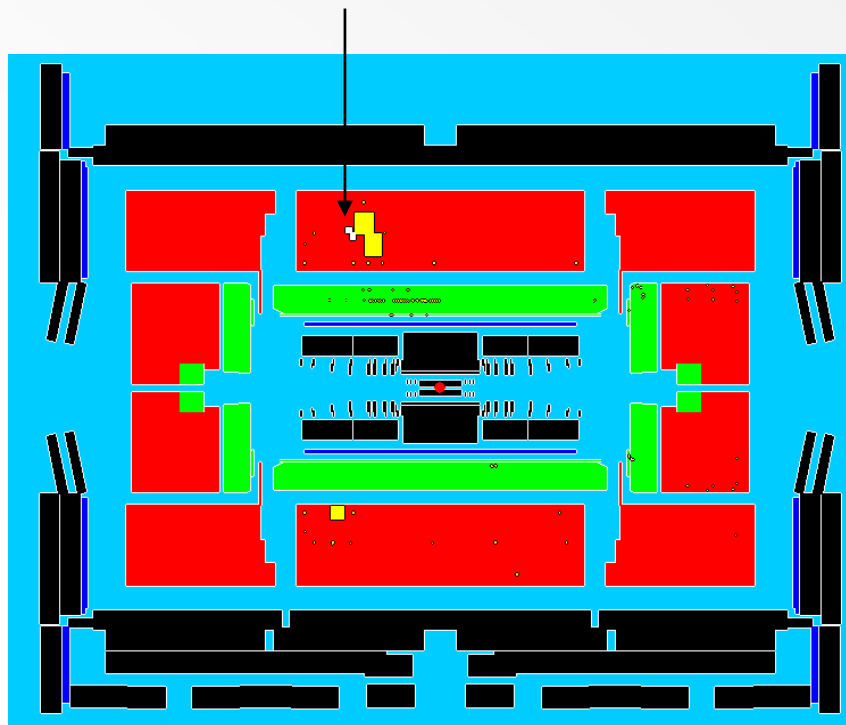
0.43 GeV



0.58 GeV



The next cell (in Eta) also recorded a significant pulse for this event



LBC15 B6 TILE cell:
 id = 5/1/-1/14/5/1/0/0
 E Max = 246.78 GeV
 ET Max = 213.64 GeV
 ET Sum = 214.50 GeV
 $\eta = -.5500 \pm .1000$
 $\Phi = 81.6 \pm 5.6^\circ$



Cosmics as a Background



- We would like to know how often high energy cosmics will appear as a background in ATLAS events of interest.
- More specifically, we would like to know what kind of effects these cosmics may have on the transverse energy balance.
- Sam Posen and I have constructed a spectrum to get an idea of how frequently cosmics could potentially disrupt ATLAS



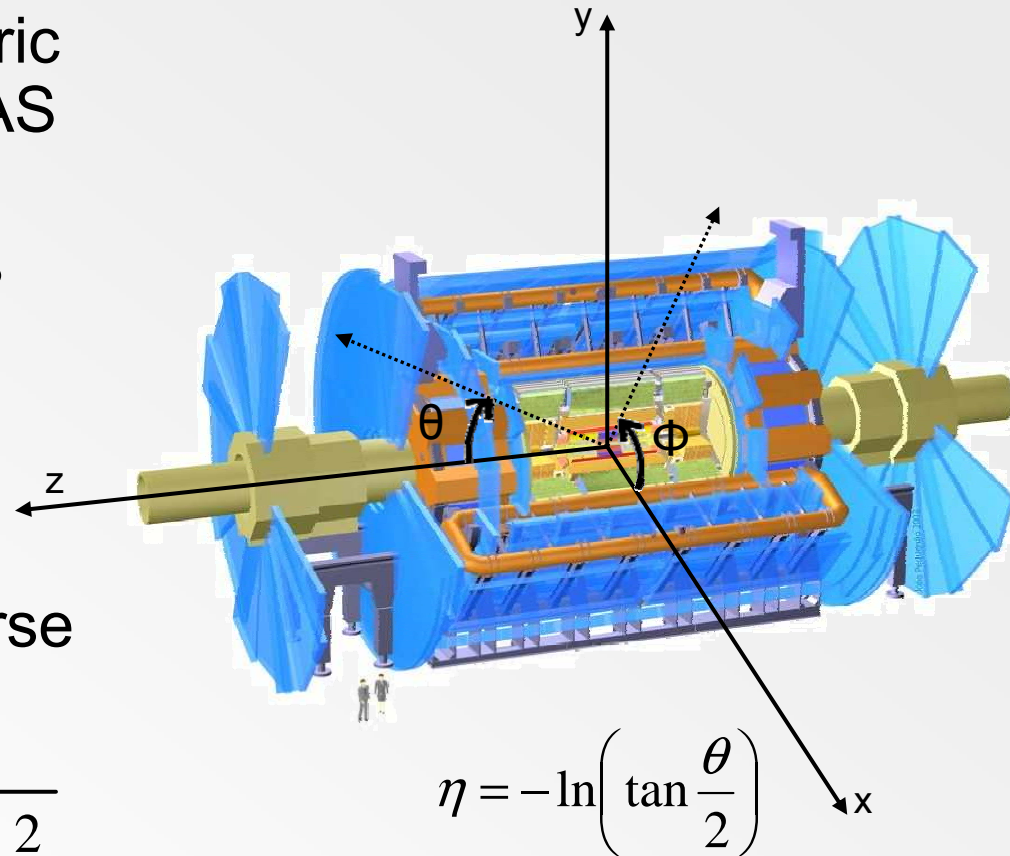
Why ETransMiss?



- Barring any new physics, events in the LHC run should have balancing transverse energy and momentum.
 - Missing transverse energy can imply exotic new physics (like SUSY!)
- Cosmic rays can disrupt this balance, potentially leading to ‘fake’ ETMiss signals.
- Cataloging all significant cosmic events can give insight into this effect.

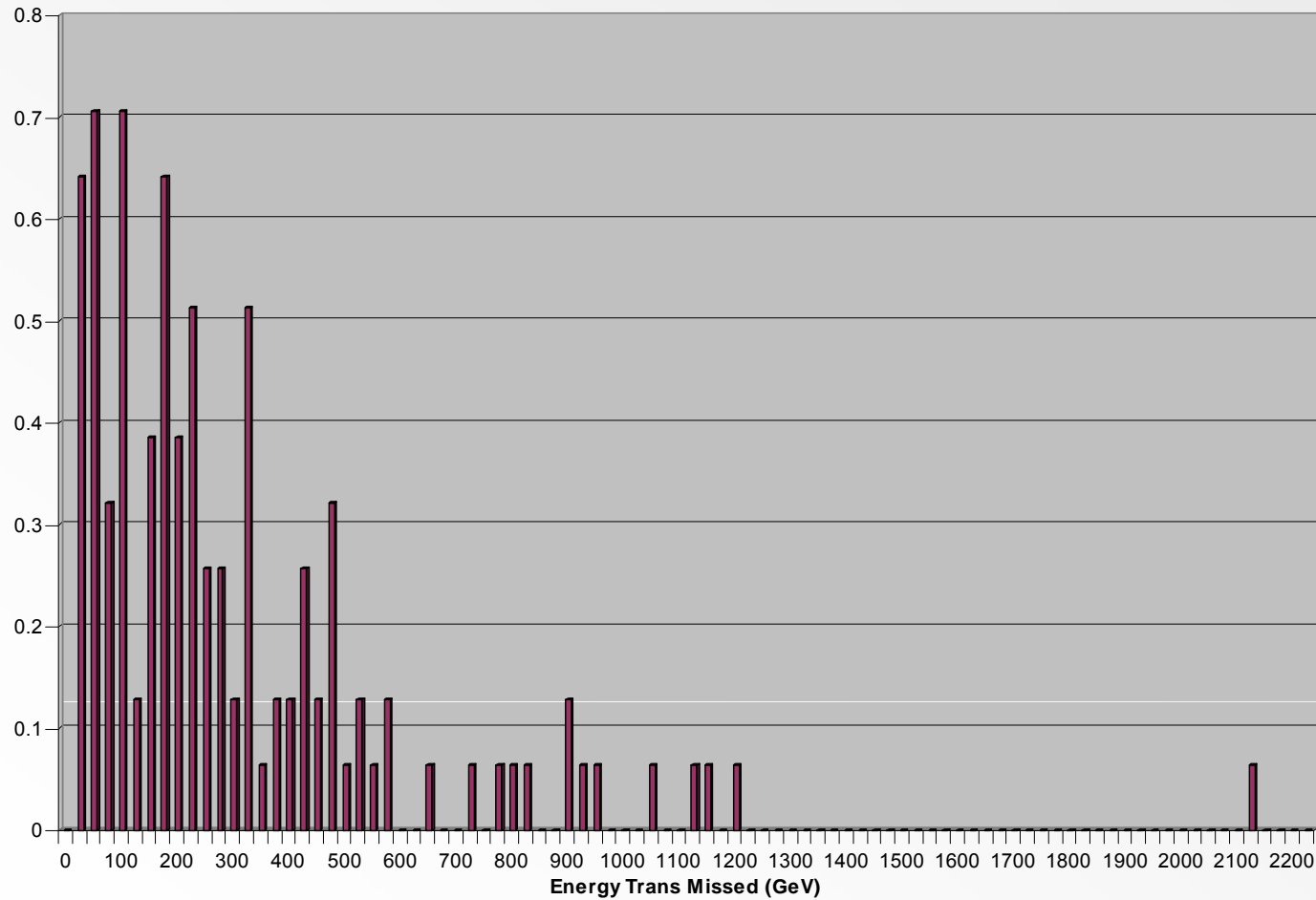
- Every cell has an geometric address in standard ATLAS coordinates (Φ, η).
- The energy of each cell is ‘projected’ into $E_x(i), E_y(i)$.
- Summing over all of the properly functioning cells yields a total E_x and E_y .
The total missing transverse energy is:

$$E_{TransMiss} = \sqrt{E_x^2 + E_y^2}$$



Current Spectrum

ETransMiss in Events/Day





Travel!



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Acknowledgements



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Questions?