Commissioning of the ATLAS calorimeters with cosmic muons

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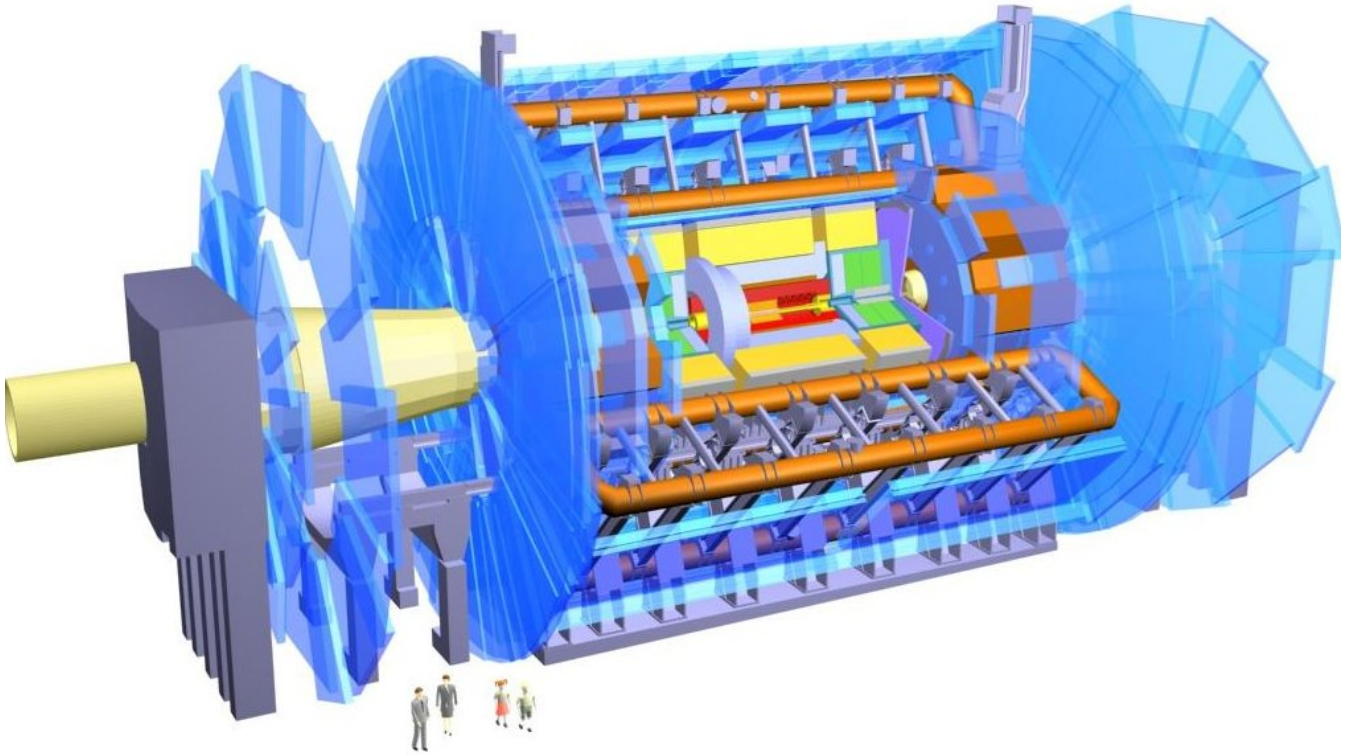
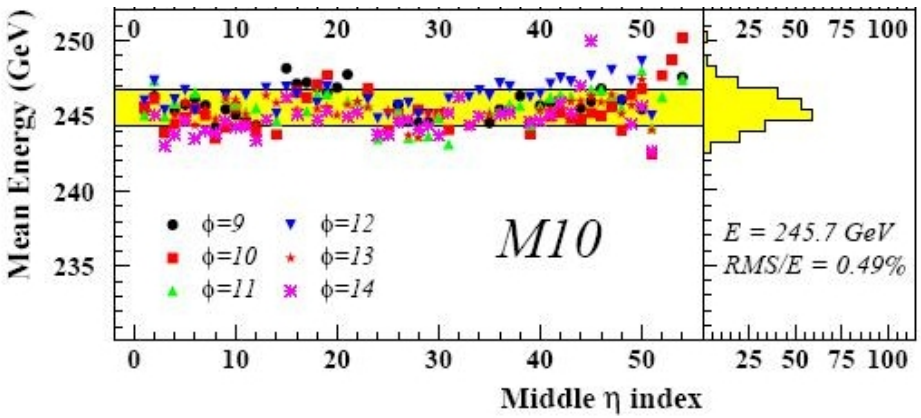
Summary



1. Commissioning
   - Motivations
   - Setup
   - Muon signal
   - Cosmics runs
2. Analysis
   - Timing aspects
   - Energy response
   - Prospective

Motivations

- The uniformity has already been measured with an accuracy of $\sim 0.5\%$ with early 2000 testbeam data



- Done only for a few modules
- The calorimeters are now located in the cavern
  - electronics installed, cables progressively plugged
  - cryostat filled with liquid argon
  - HV is applied
  - EM and hadronic calorimeters can take combined runs

- Before the LHC startup, **cosmic muons** could be used to:
  1. test monitoring tools, find bugs, ...
  2. check the uniformity of the energy response at the level of $1-2\%$
  3. intercalibrate in time the cells at the level of 1ns
- Are there enough muons reaching the calorimeters?

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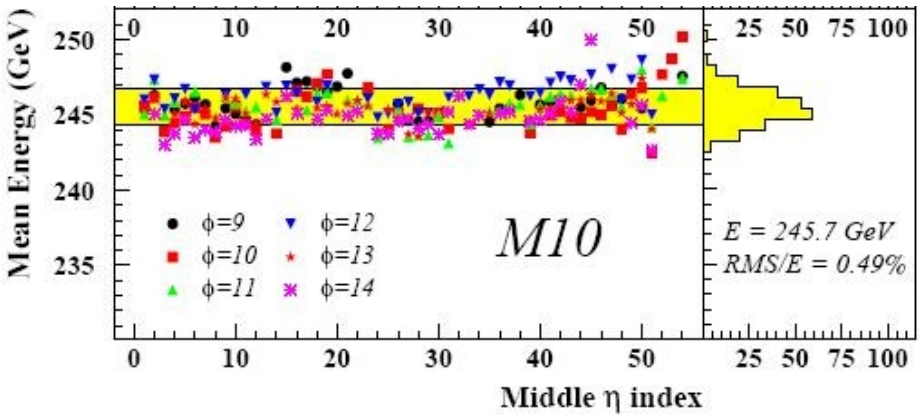

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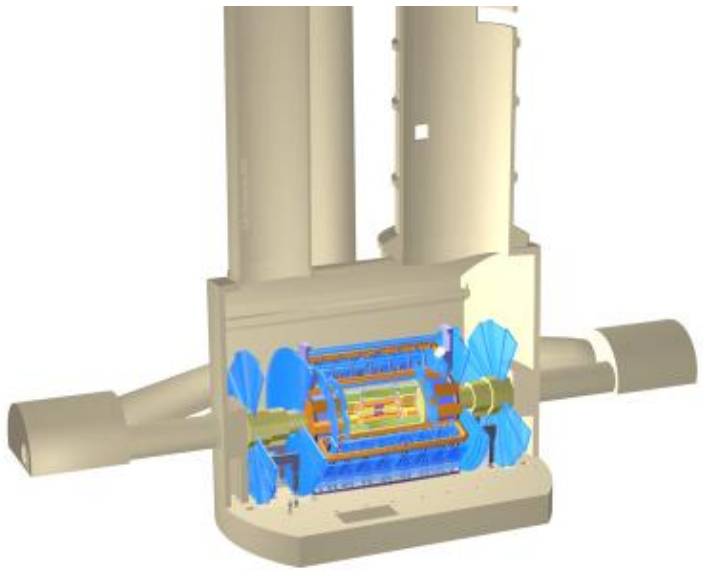
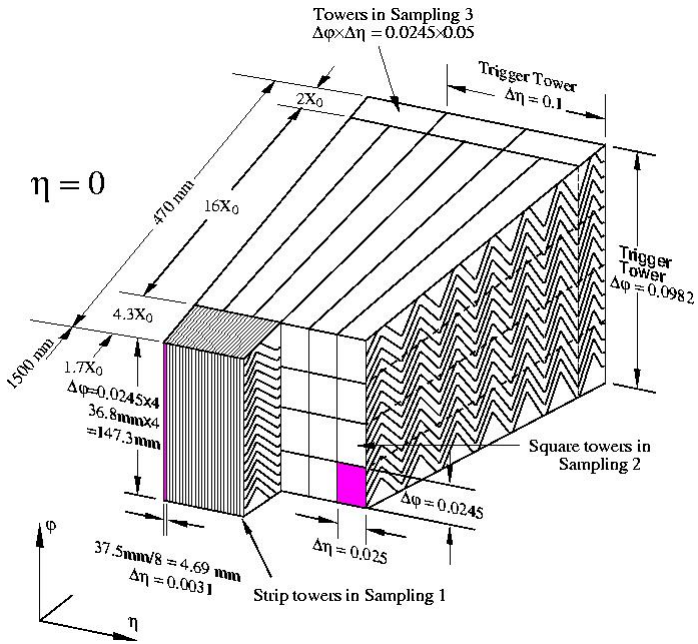
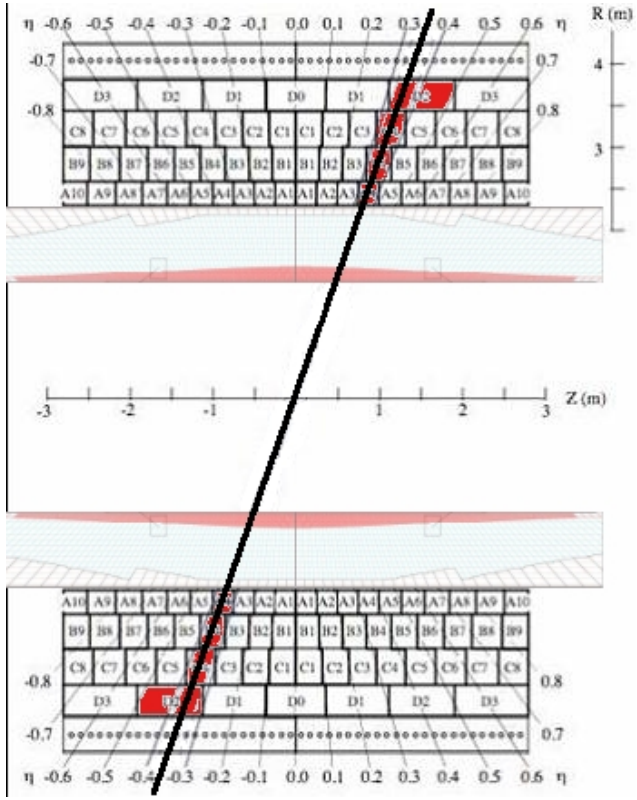


Setup

- The tile calorimeter detects well the muons
  $\Longrightarrow$ provides the trigger signal
- From a detailed GEANT simulation of the cosmic flux, the cavern and the shafts, we expect
  - a 1Hz rate of top-bottom coincidences
  - due essentially to the access shafts
  - higher statistics around $\eta = 0.3$
  - very few events beyond $|\eta| = 0.8$





Concerning the electromagnetic calorimeter:

- absorbing Pb plates and electrodes have an accordeon geometry
- liquid argon in the gaps as the active material
- the signal is shared by 2 neighboring cells in ϕ

Muon signal

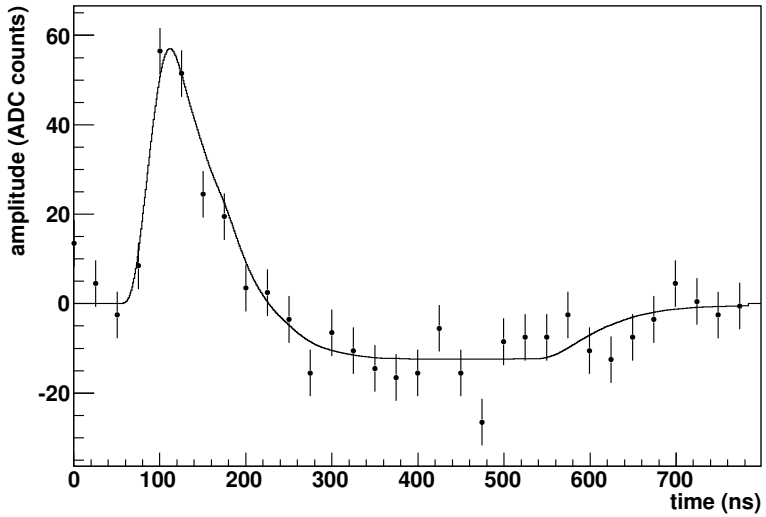
Can we see a muon in the EM calorimeter?

- events are **asynchronous**
- signals are of **small amplitude**
- **non-projective** trajectory

To overcome these difficulties:

- use the time information from the tiles
- use more than 5 samples
- use the front strips

From cosmic data



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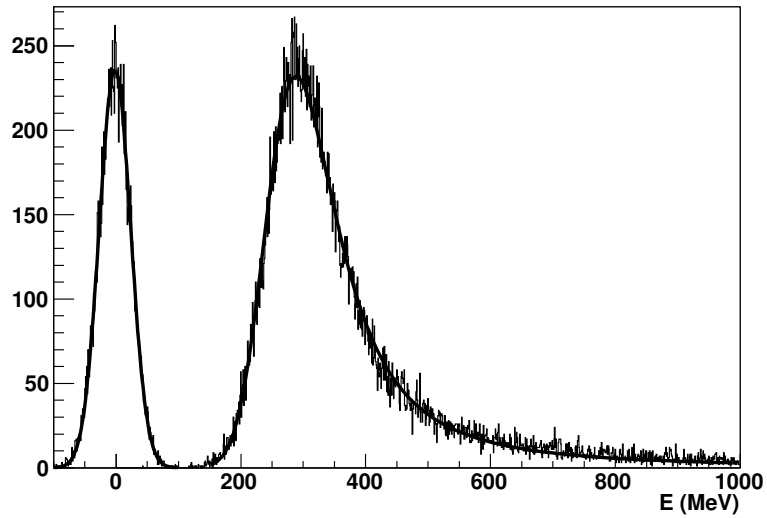

- muons energy deposits follow a Landau distribution
- affected by the size of the LAr gaps and possible miscalibration
- no sensitivity to variations in the width of the absorbers and to the material in front
- not at the energy scale of the electrons

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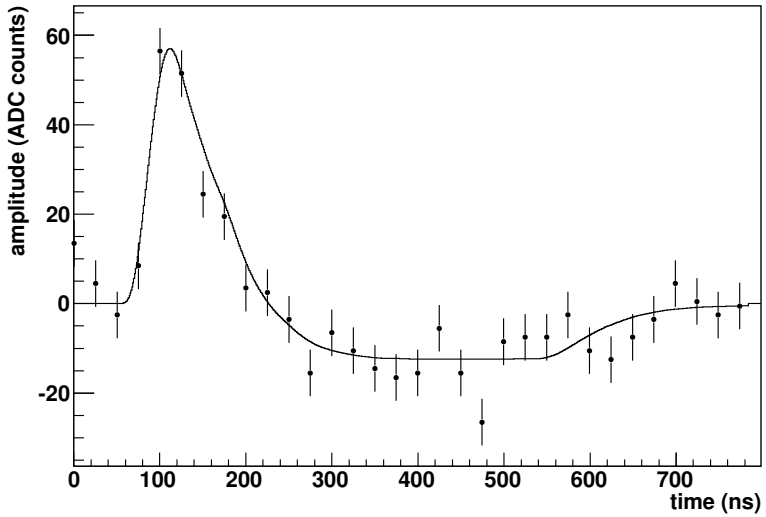

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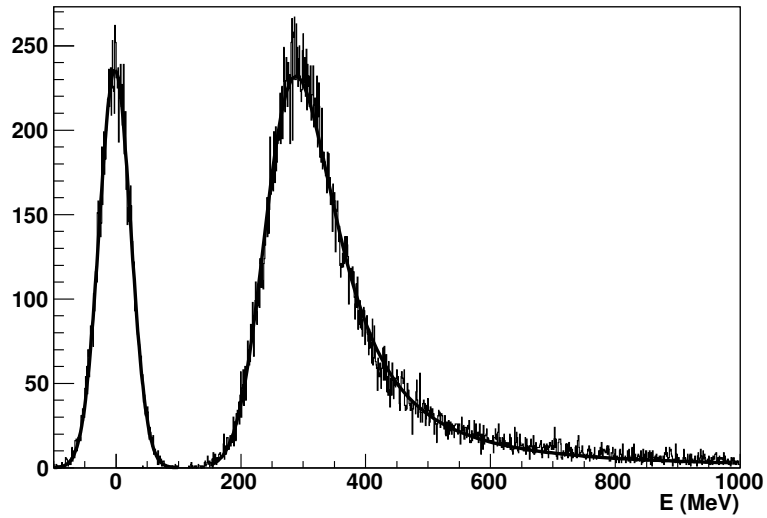

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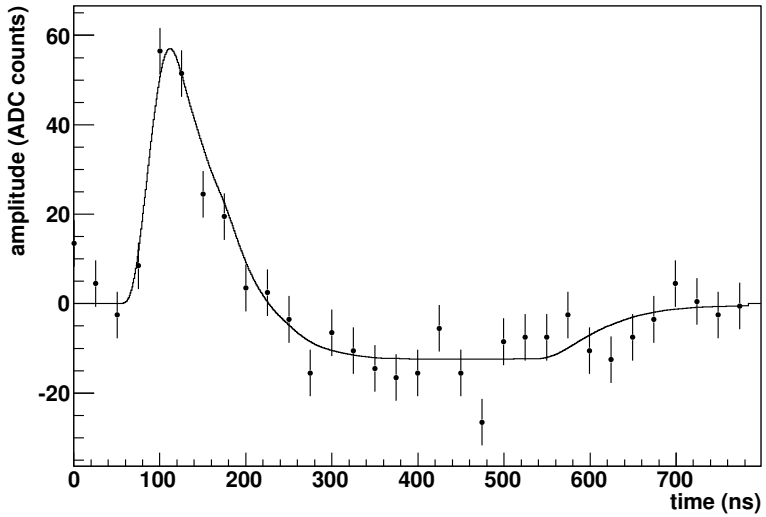

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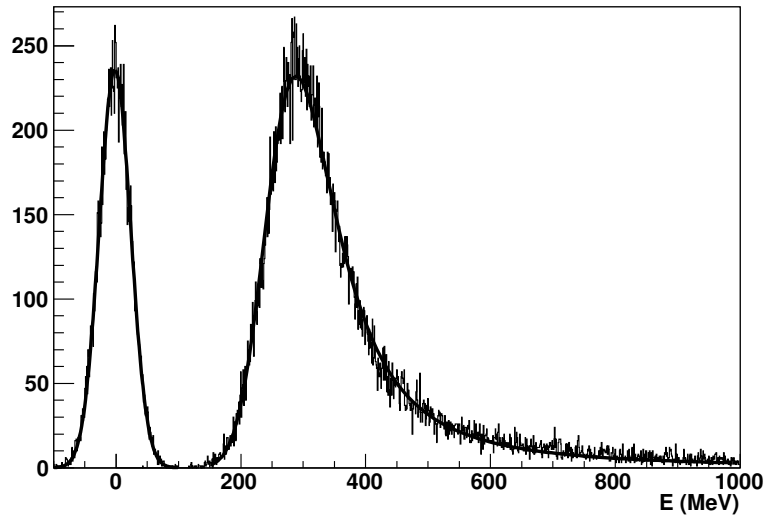

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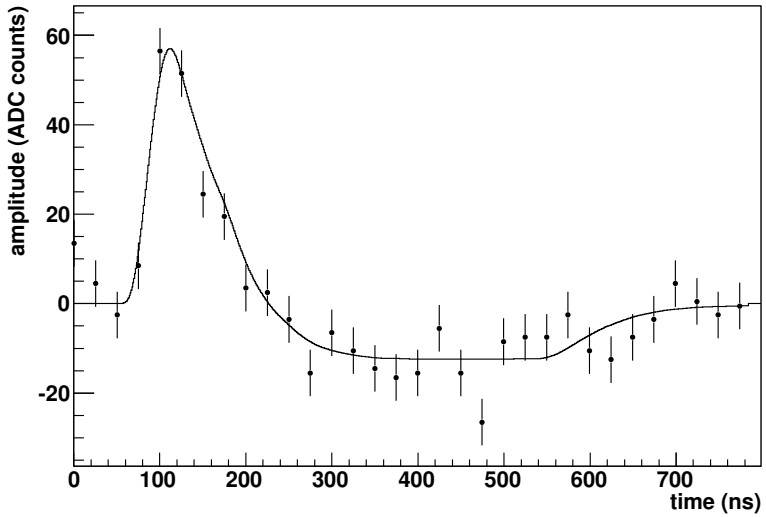

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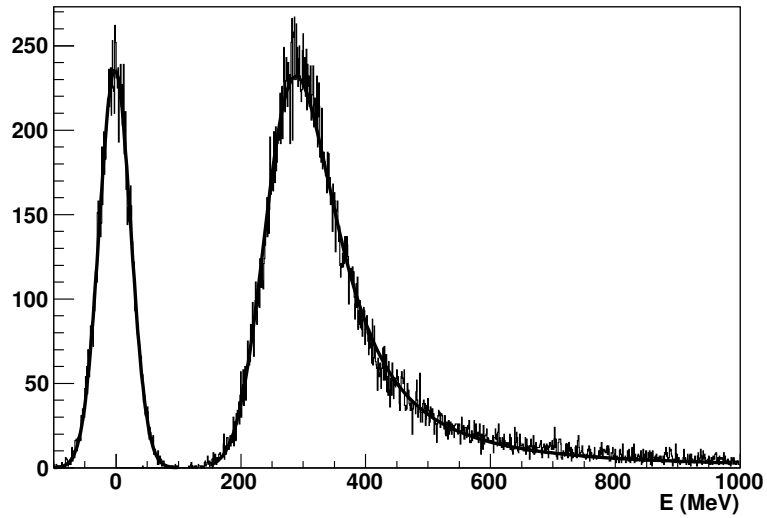

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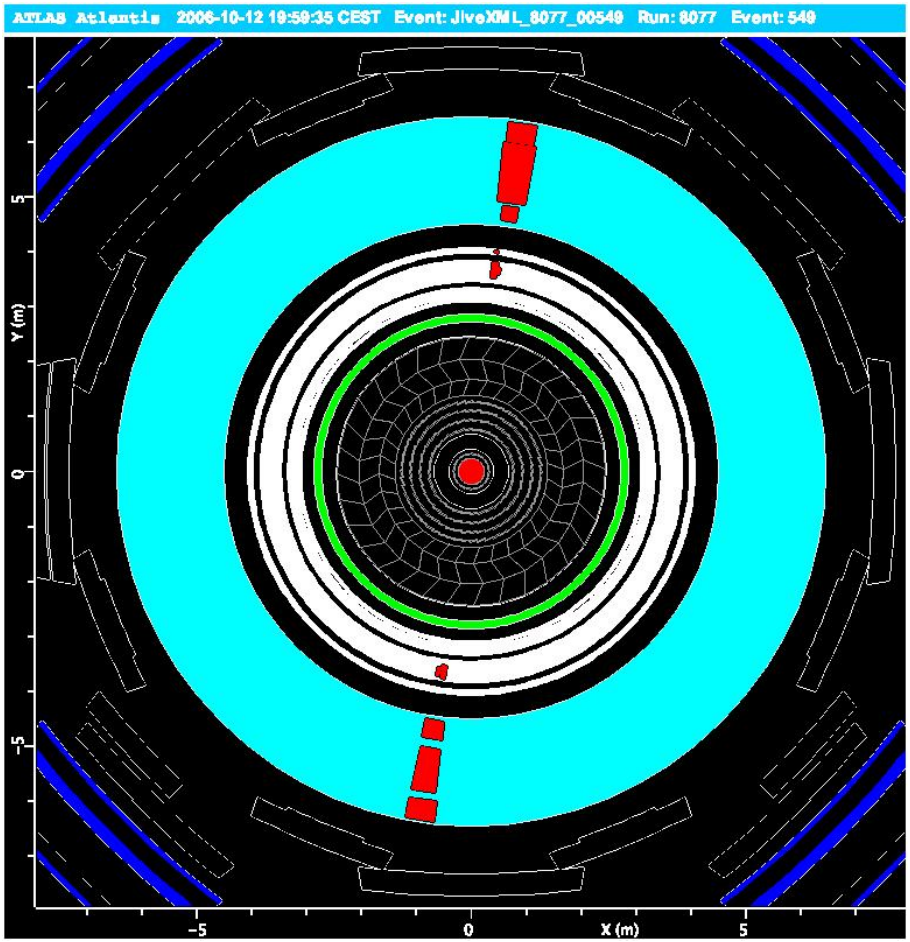
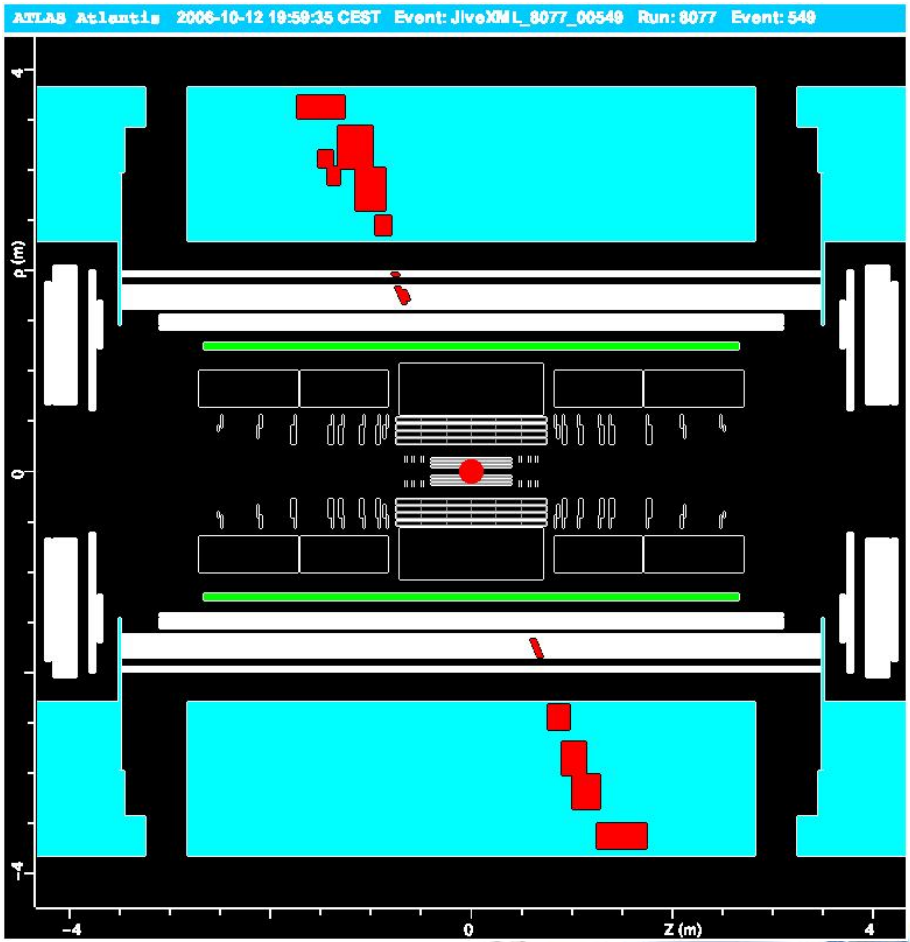
Cosmics runs

- Cosmics runs were taken in Aug-Sep-Nov 2006 with a limited coverage
- 1 triggered event every ~ 30 seconds
- ~ 30000 muons observed out of 80000 triggered events in 72 hours
- ~ 6000 are considered as projective





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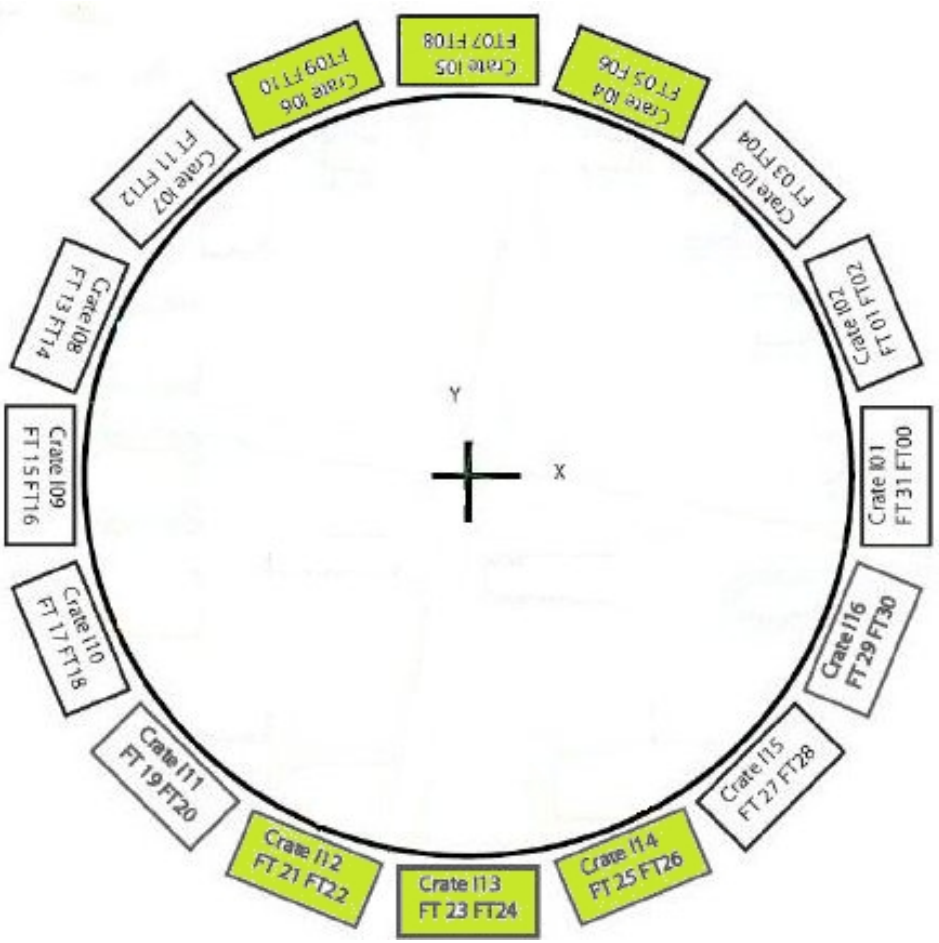
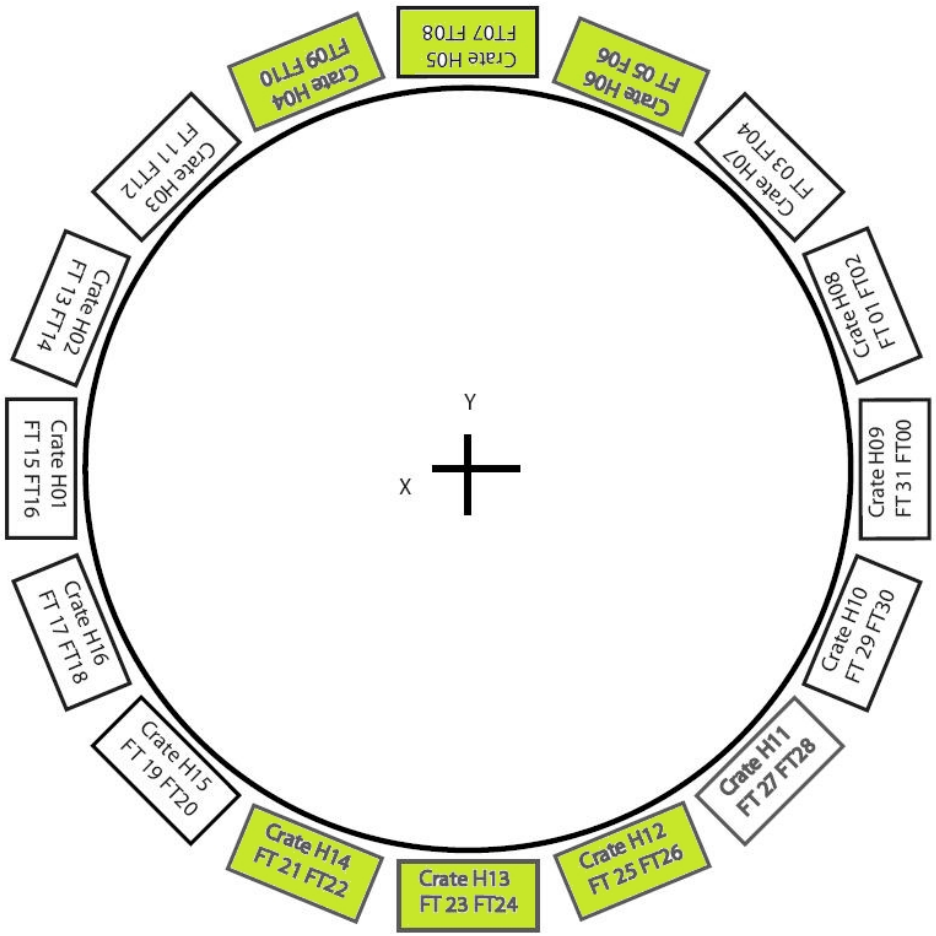
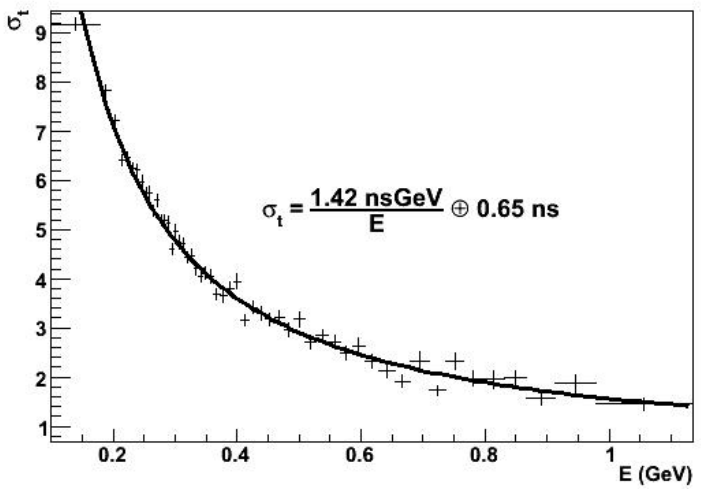


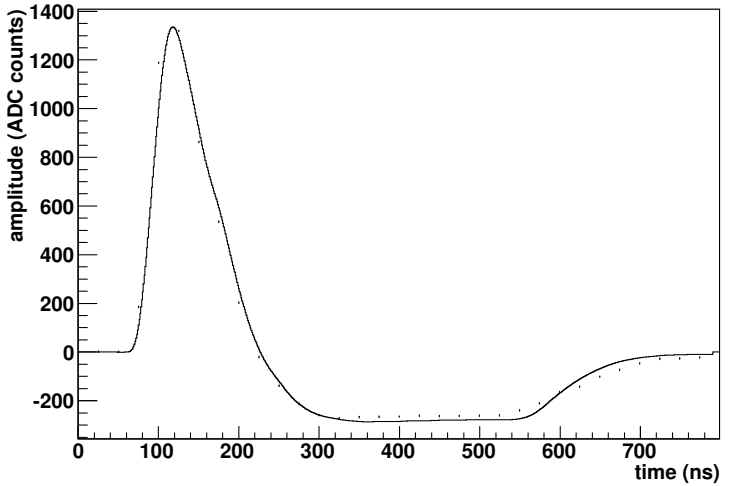


the ATLAS Experiment

Timing aspects

- Use the time given by the hadronic calorimeter and correct for the time-of-flight
- Low energy deposits won't be useful to intercalibrate in time
- Large energy deposits leave signals that can be used as reference





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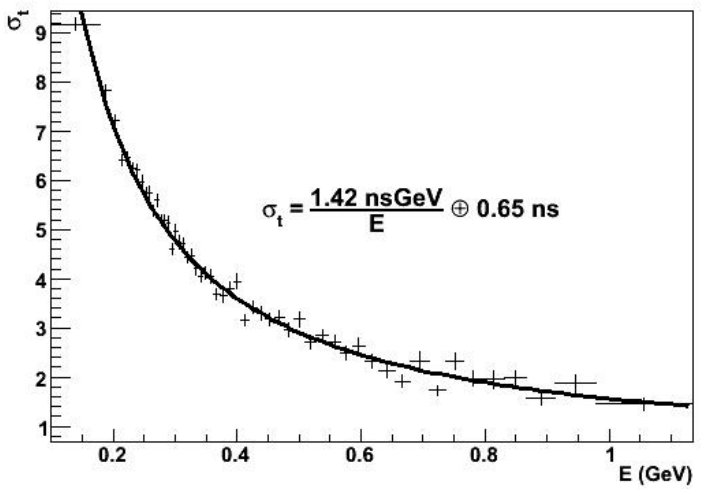
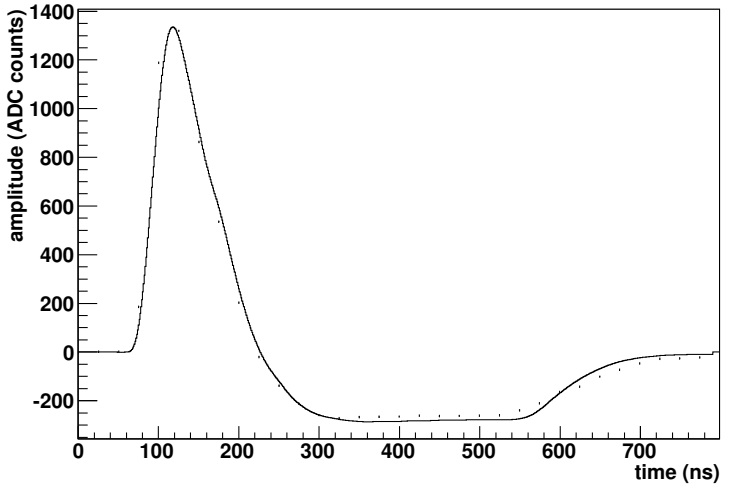
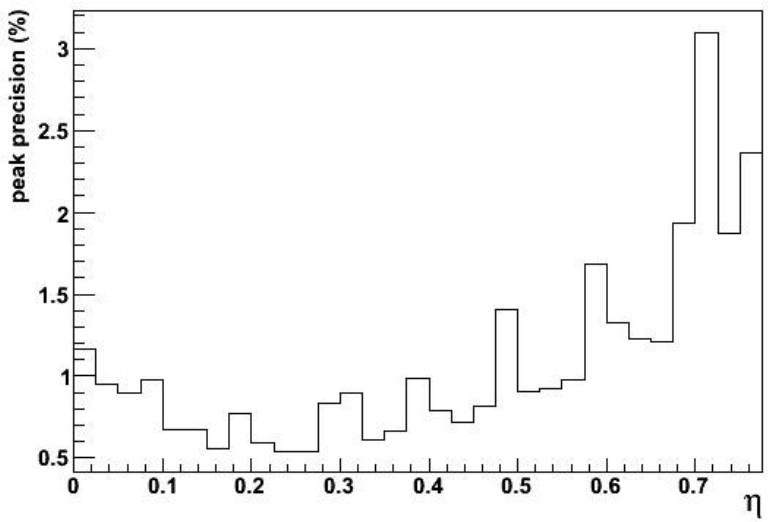
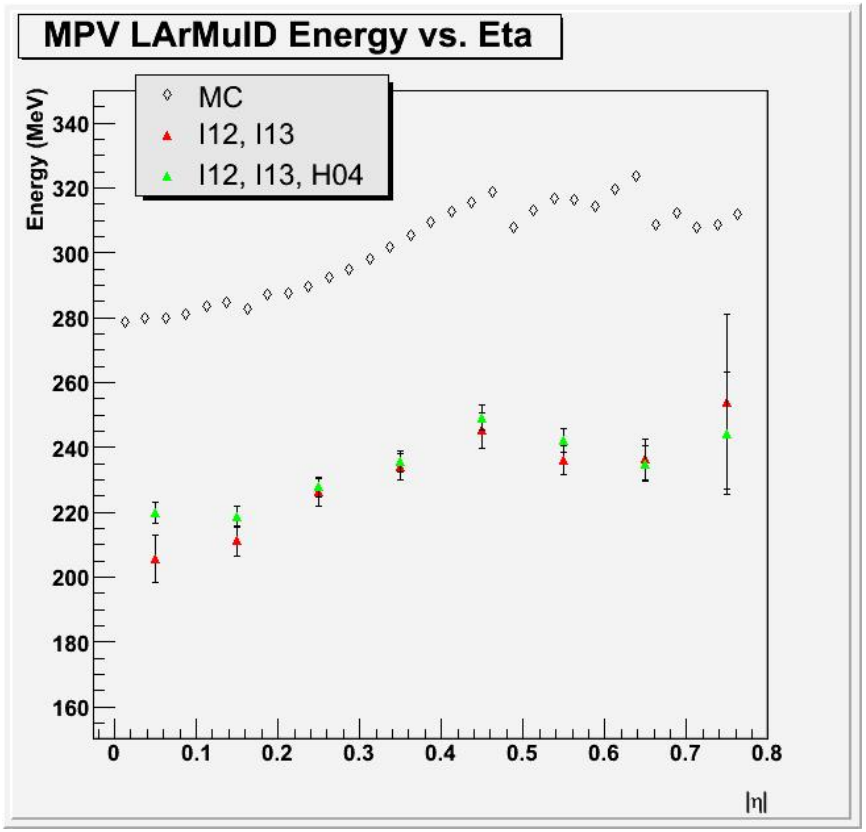




Energy response

- By using 29 samples instead of 5, we reduce the noise from $31MeV \rightarrow 16MeV$
- Will have to correct for the argon depth varying along η
- We can integrate data in ϕ to check uniformity in η
- Eventually unfold top/bottom and left/right as the statistics increases

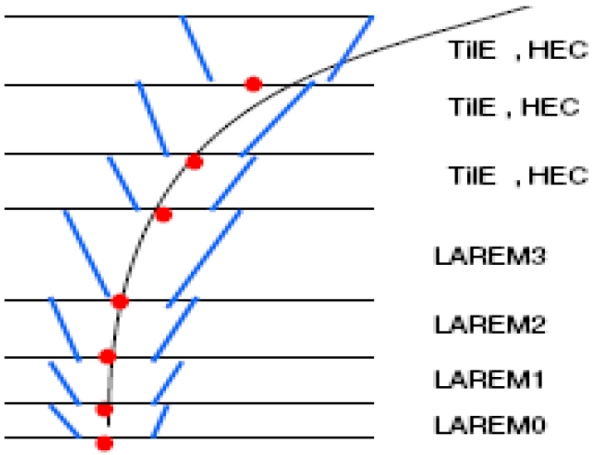




Prospective

- Data taking in progress over nights and weekends during March and April 2007
  - would provide around 200-300k projective events
  - uncertainty will quickly be dominated by systematic effects
    (e.g. non-projectivity, uncertainty on the pulse's time, ...)
- Last week: first cosmic run with common LArEM/Tiles/Muon Chambers readout using tiles+RPC triggers
  $\Longrightarrow$ could have runs in October/September using the RPC trigger
- Detecting muons in the calorimeters could add valuable information
  - To do the correspondance between tracks in the inner detector and what is seen in the muon spectrometers
  - To detect catastrophic energy deposits that occur
    $\Longrightarrow$ improve the resolution

Muon Spectrometers



Inner Detectors