First look for "catastrophic" energy losses of muons with ATLAS Testbeam data

Konstantinos Bachas
ATLAS Muon Group, University of Thessaloniki

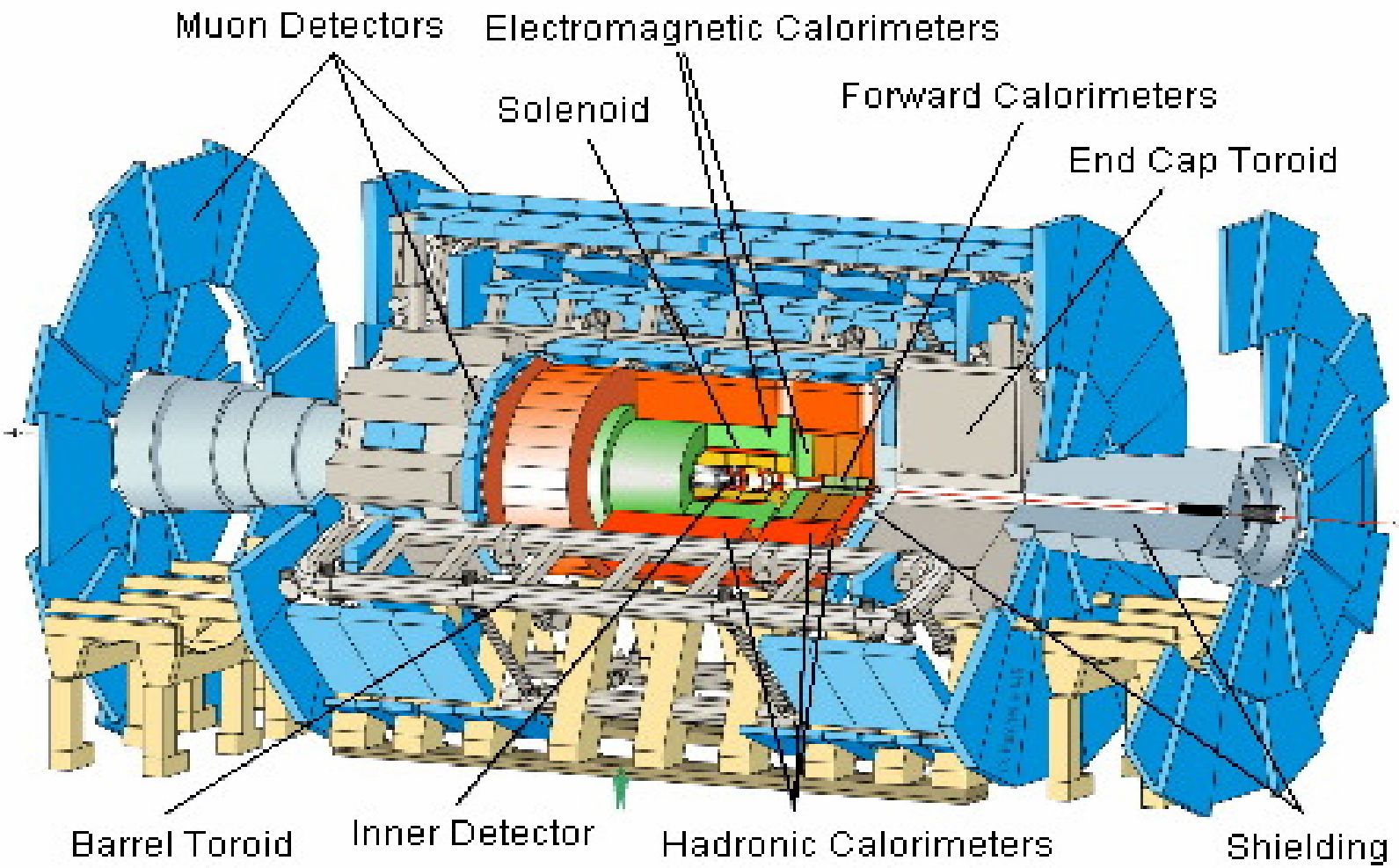
In collaboration with

Samira Hassani, Jean Francois Laporte, Rosy Nicolaidou
SACLAY Muon Software Group

Outline

- Experimental setup of CERN's H8 Testbeam in 2004
- Theoretical summary of "catastrophic" muon energy losses
- Reconstruction tools
- Analysis strategy for Testbeam
  - Muon energy losses in the Hadronic Tile Calorimeter
  - Muon selection criteria
- Conclusions

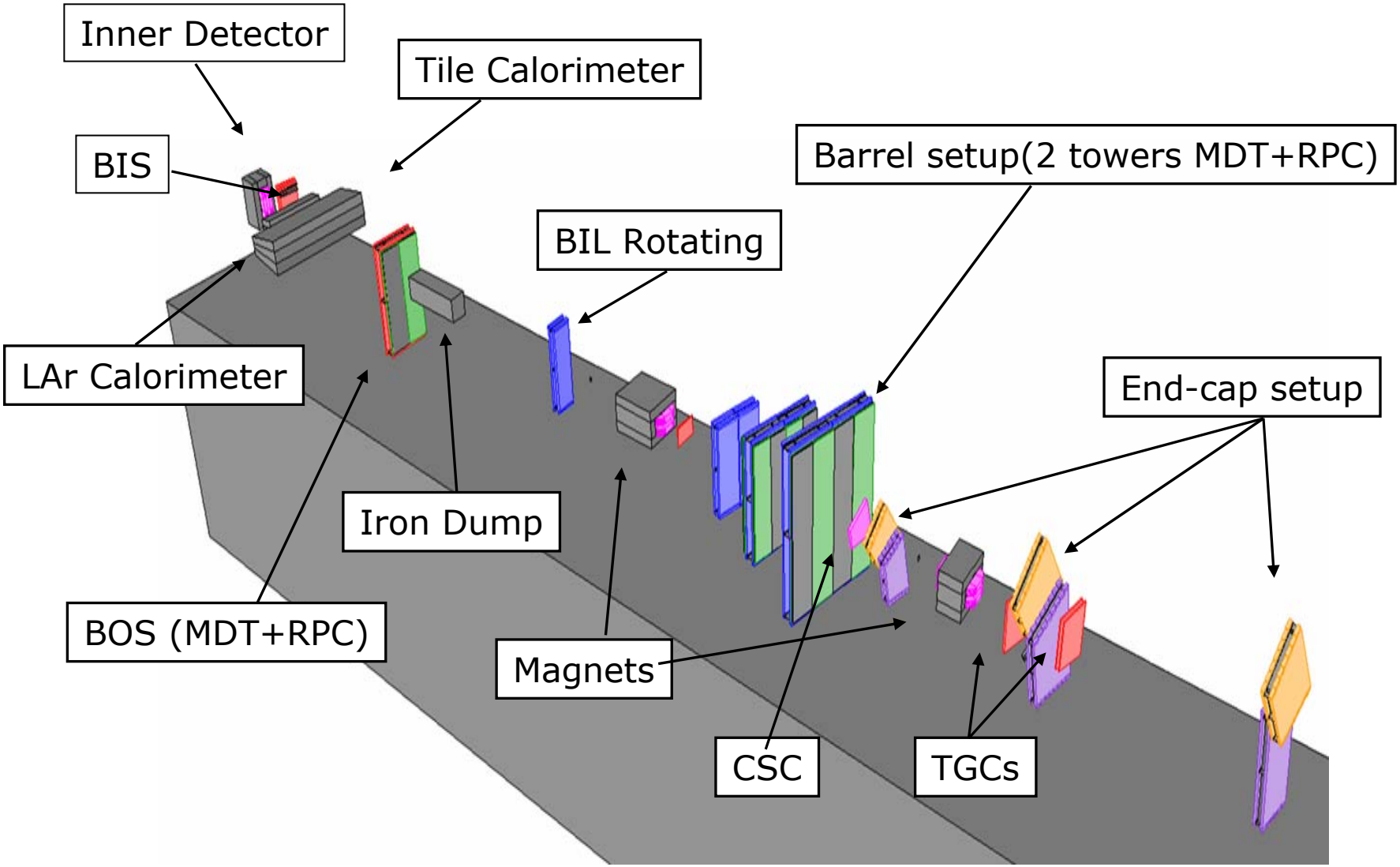
The ATLAS detector



H8 Testbeam at CERN

- An ATLAS "rehearsal" was performed during the data taking period of CERN's H8 Testbeam
- Fragments from all ATLAS sub-detectors were installed in the beam line constituting 1/8 of the ATLAS detector
- Lots of data were taken
  - ~4.6 TB of data, stored on CASTOR
- From the Testbeam we gained experience:
  - In combined and stand-alone detector performance studies
  - In combined detector operation

Testbeam setup in 2004

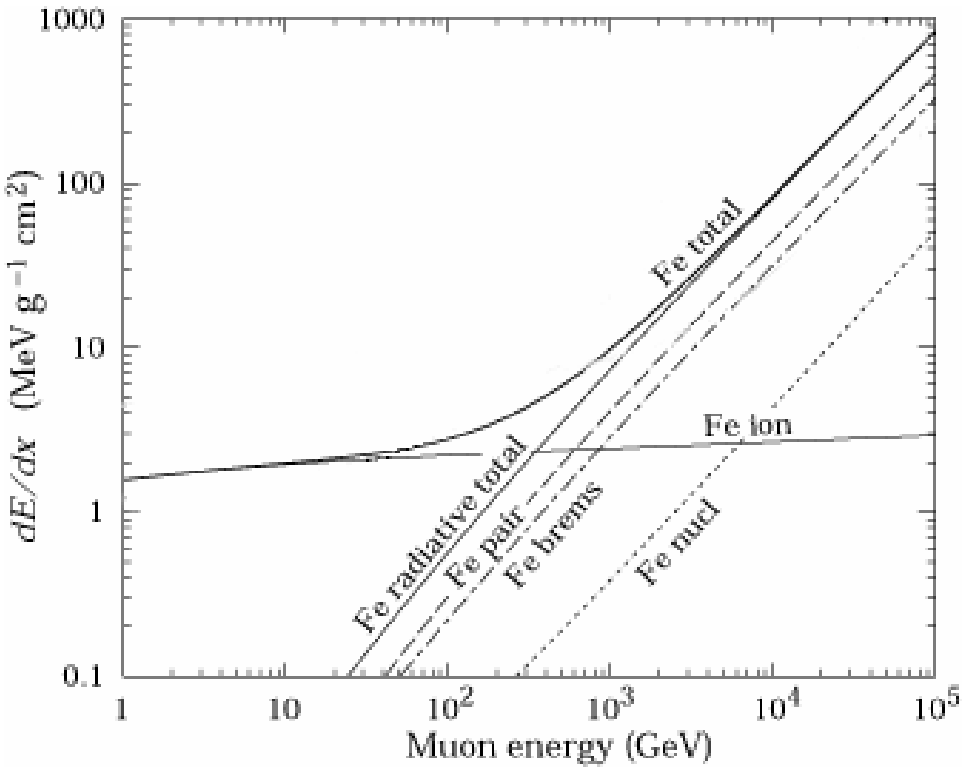


The issues…

- What is muon “catastrophic” energy loss?
- Why care about it?
- Where in the ATLAS detector we expect “catastrophic” losses?

What is muon "catastrophic" energy loss?

- Muons traveling through matter lose energy due to ionisation.
- Beyond the critical energy E_c(a few hundred GeV in iron), the loss is dominated by radiative mechanisms:
  - Brehmsstrahlung
  - δ-rays
  - Photo-nuclear interactions
  - Pair production
- The probability that a muon suffers a severe energy loss,"Catastrophic", in iron increases for $E>E_c$



Why care about it?

- Catastrophic losses can "spoil" the Higgs Golden Channel

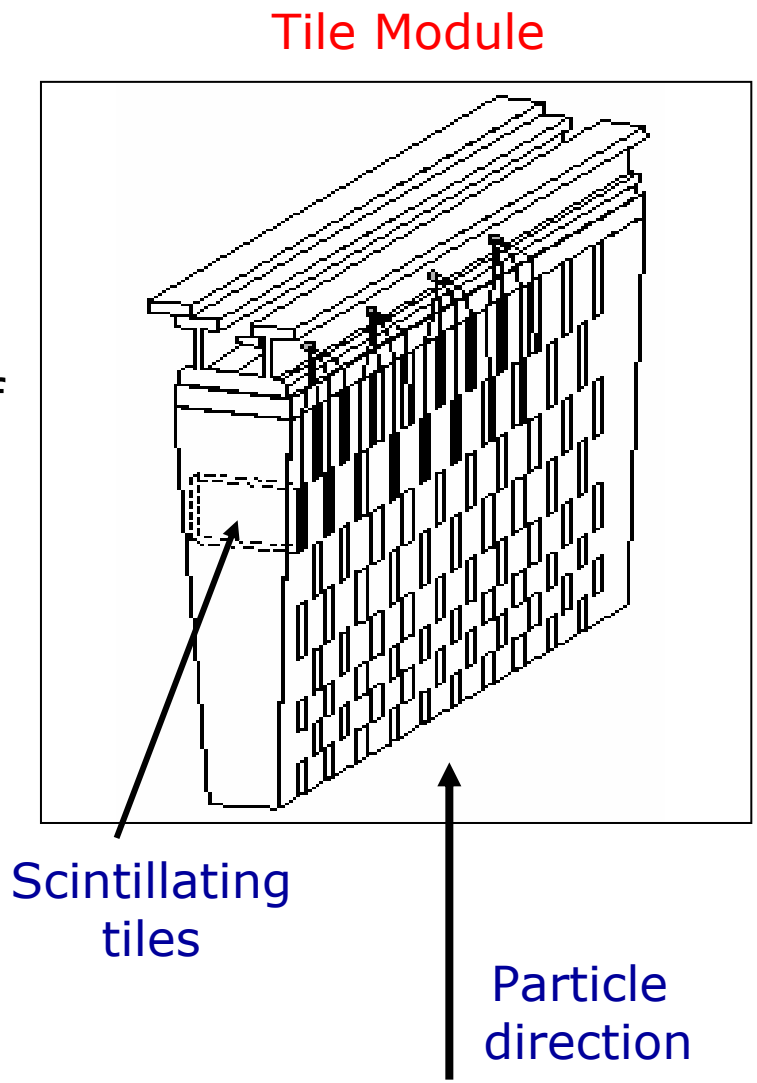
$$H \rightarrow ZZ^{(*)} \rightarrow 4\mu$$

  or any other process with energetic muons in the final state

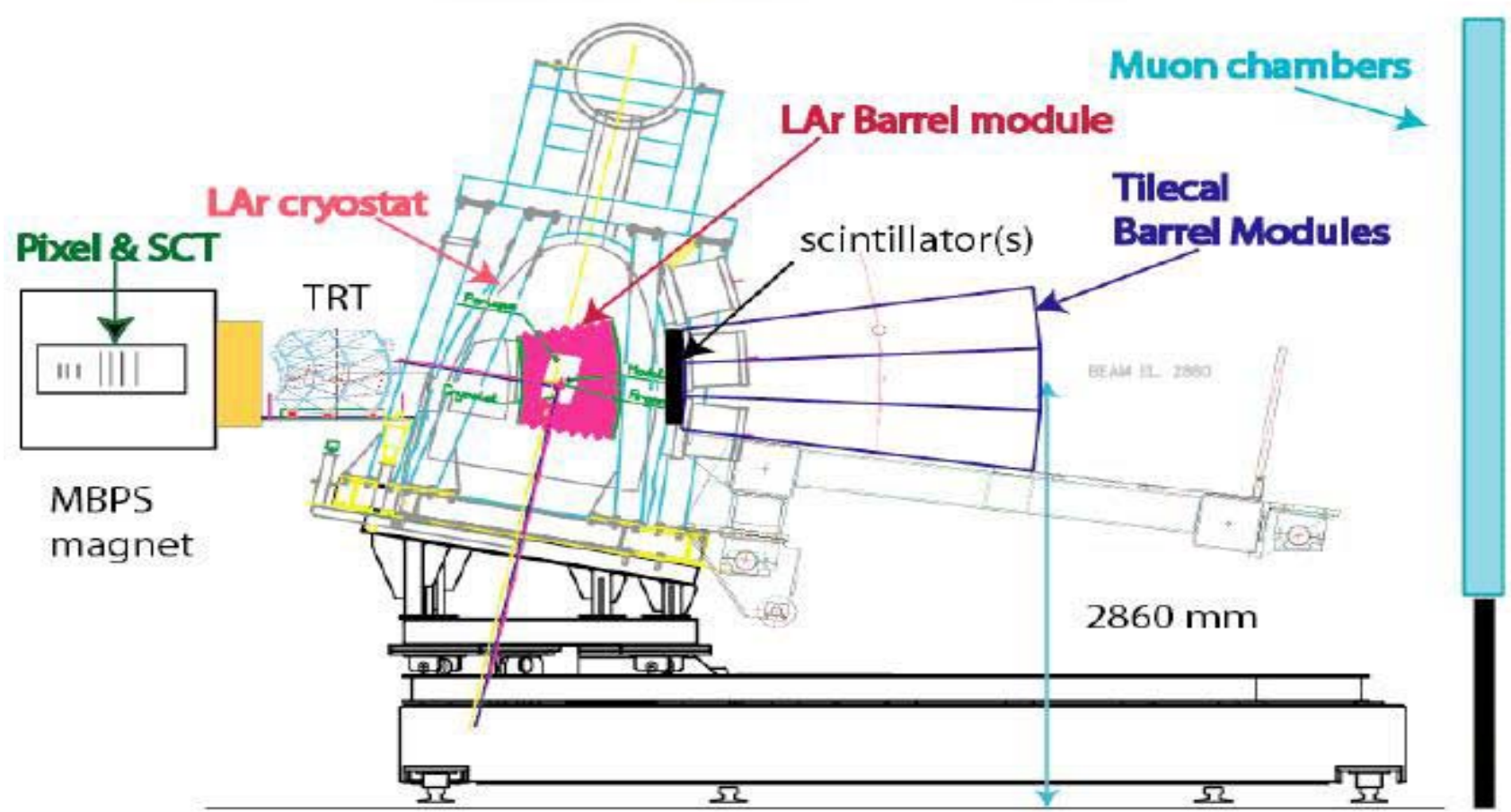
- In ATLAS the aim is:
  - Identify muons that suffered catastrophic loss
  - Correctly reconstruct their energy to increase momentum resolution and muon reconstruction efficiency

Where in ATLAS we expect "catastrophic" losses?

- Tile Modules are made of iron (absorber) and scintillating tiles
  - Muons traverse ~100 X_0 in Tile losing on average ~3GeV due to ionisation.
- A small but significant fraction of high momentum muons will undergo a "catastrophic" loss of their energy.
- Main goal of this study is to investigate muon energy losses in the Tile Calorimeter, combining information from the Muon System



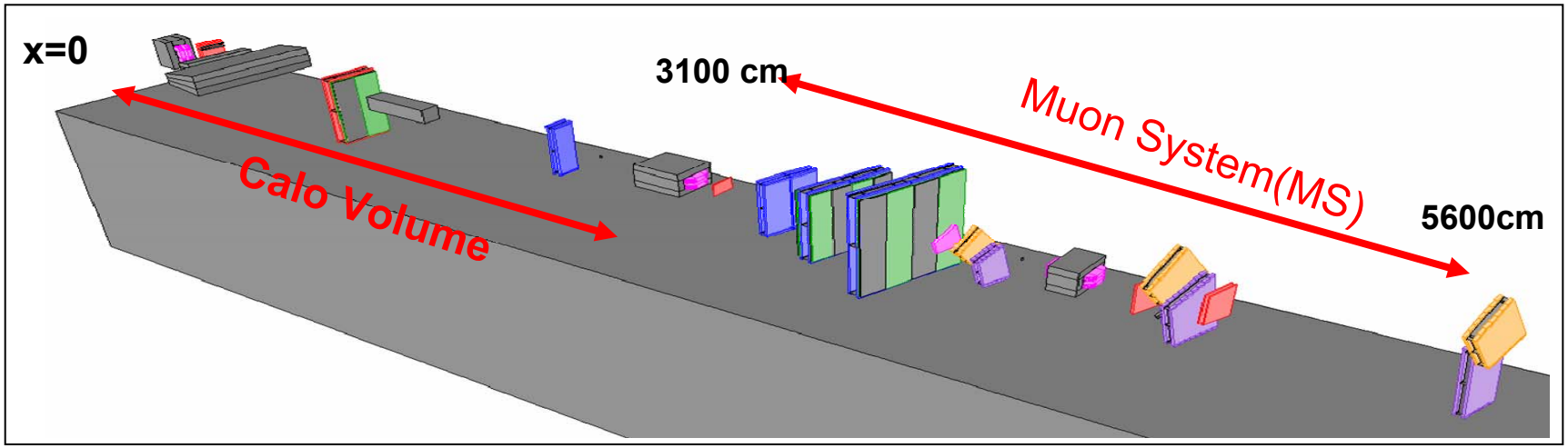
Testbeam setup-Zoom on Calorimeters



Analysis framework

- Reconstruction is done in software package Muonboy using the official ATLAS framework Athena
- Muonboy output consists of:
  - Track segments from both barrel and end-cap chambers
  - Fully reconstructed muon tracks
  - Backtracked tracks up to the perigee point at x=0
    - Corrections for energy losses in material are performed inside Muonboy and the fluctuations of energy loss are taken into account in the covariance matrix propagation given by Muonboy
- Analysis on combined data with all sub-detectors in H8 functional

Back-tracking in Muonboy



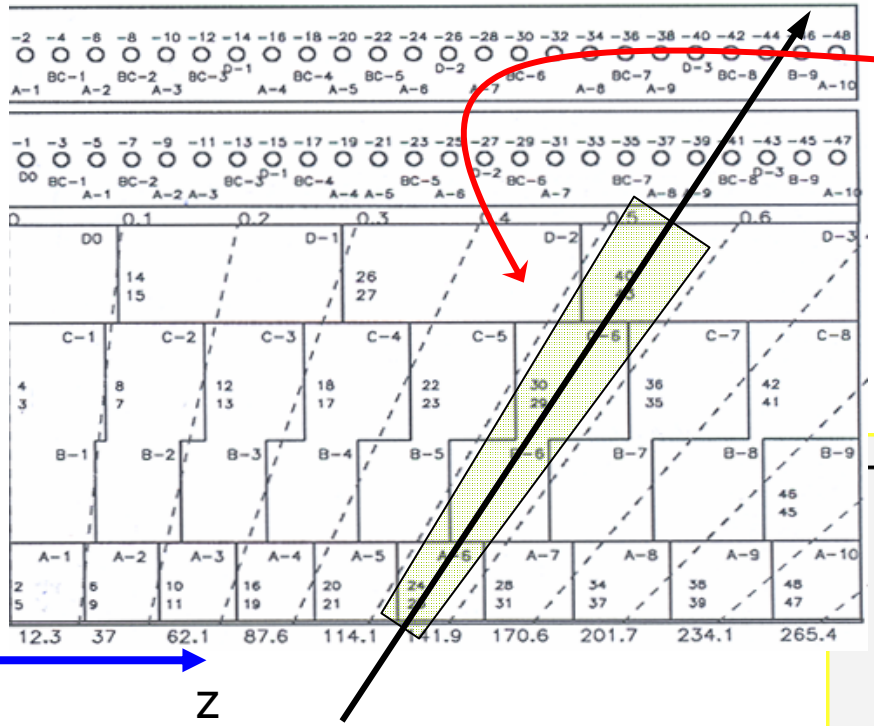
- Muonboy back-tracking extrapolates tracks from the Muon System backwards to the Inner Detector
  - Back-tracking starts at the MS entrance (3100cm) and can stop at any point up to the perigee point at x=0
- Provides track information at the entrance of Muon System and Calorimeters and at the perigee point (x=0)

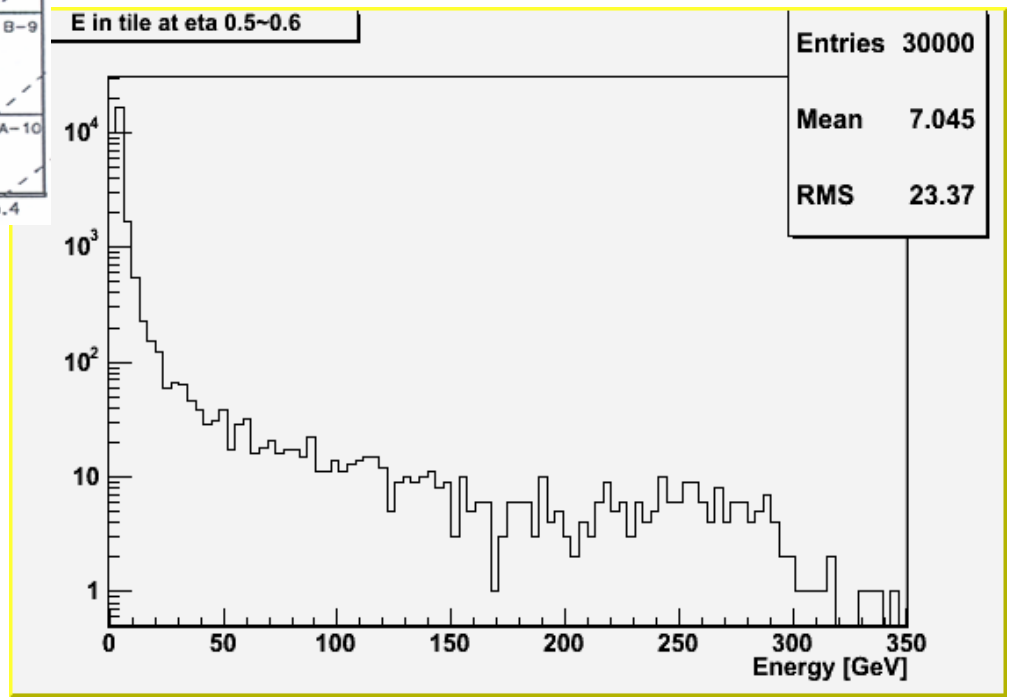
Analysis strategy

In order to compute the energy in the Tile Calo:

- In ATLAS, one would have to construct a cone ($\Delta R=\sqrt{\Delta\varphi^2 \times \Delta\eta^2}$) around the track in the Tile and sum-up the energy in that region
- Unfortunately detectors in H8 do not use the same coordinate system (η, φ)
  - Calorimeters use their own local coordinate system whereas Muonboy uses H8/ATLAS system
- For a first approach, we divided the tile η range [0,1] to η=0.1 sectors and summed-up the energy from the corresponding cells.
  - For the data set of this analysis, the beam was hitting at η≈0.55
  - Beam energy of the analysed run=350 GeV. No magnetic field present

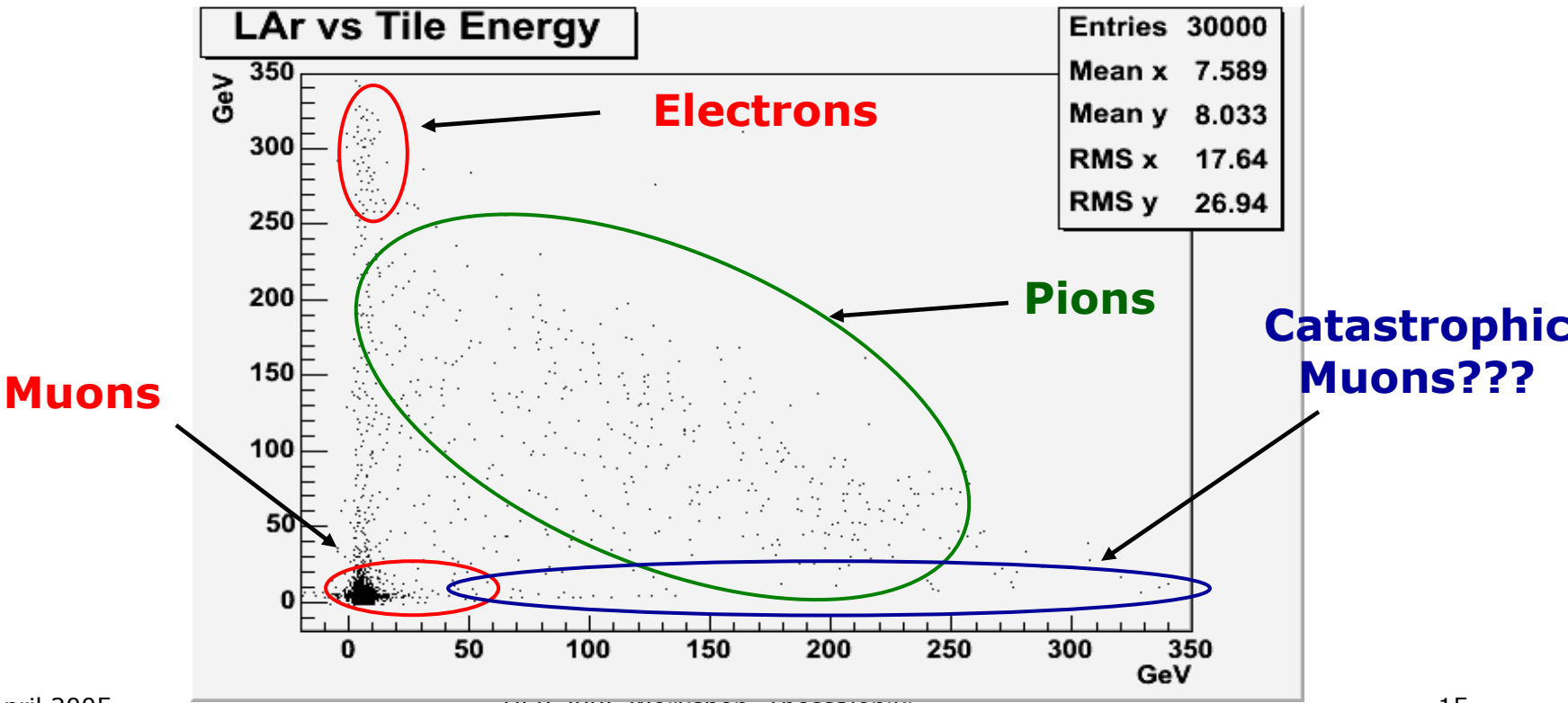
Summing-up Energy from Tile cells





Selection of Muons

- Although beam type is muons, we expect a considerable contamination from pions
  - Must apply cuts on tracks to distinguish between particles



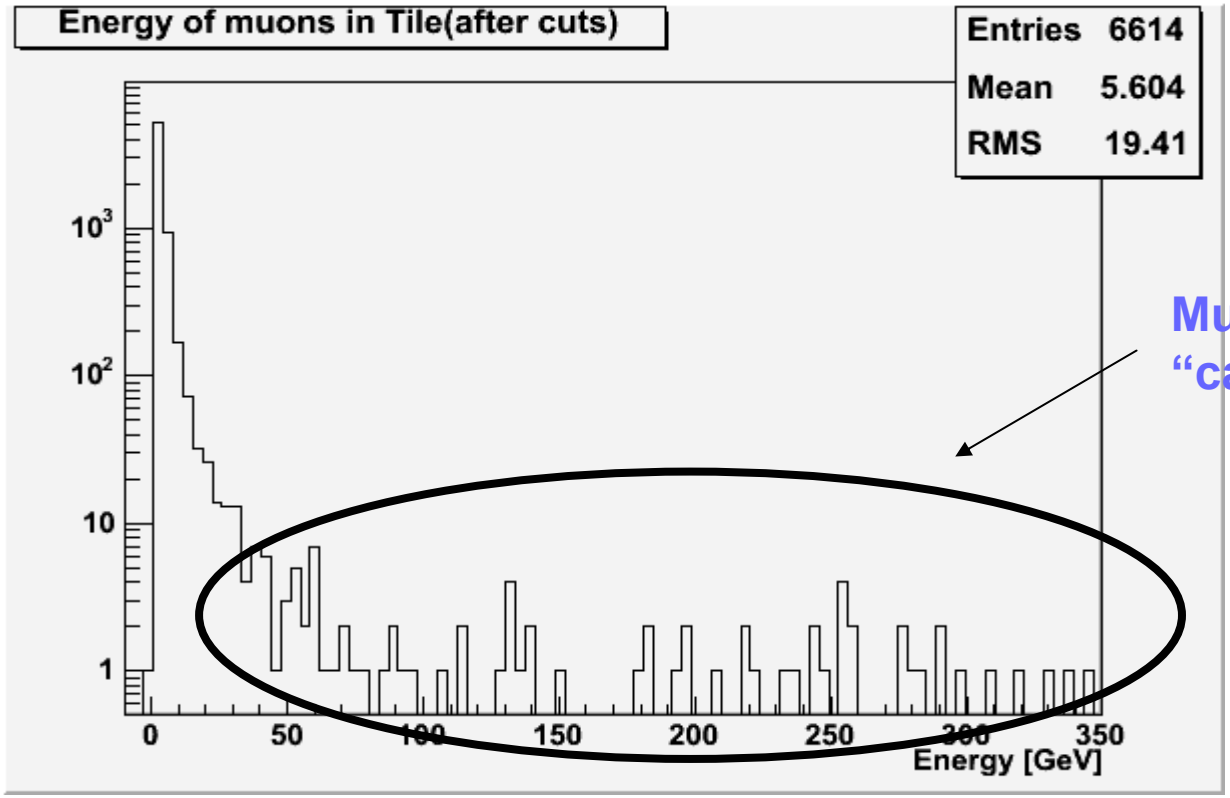
Selection of Muons contd…

- Cuts in the Muon Spectrometer
  - Ask for tracks reconstructed with all barrel and end-cap chambers
  - Measurement of the φ coordinate using information from the Resistive Plate Chambers (RPCs)

  These are very tight cuts. Relaxing these criteria is under study
- Cuts in the LAr Calorimeter
  - Total Energy deposition in the LAr Calorimeter <10 GeV

Energy in Tile from selected muons

- **To a first approach, requiring an energy deposition in Tile>10 GeV and in LAr<10GeV, on the selected muons, gives a ~4,5% probability for such a loss.**



Conclusions

- Parametrize the energy losses and correct for the "catastrophic" ones using the information from the cells.
- Implement these corrections in Muonboy if they are found to be better
- All the machinery is in place for such a study
- Analysis on the ATLAS like environment using simulated data is ready to start.