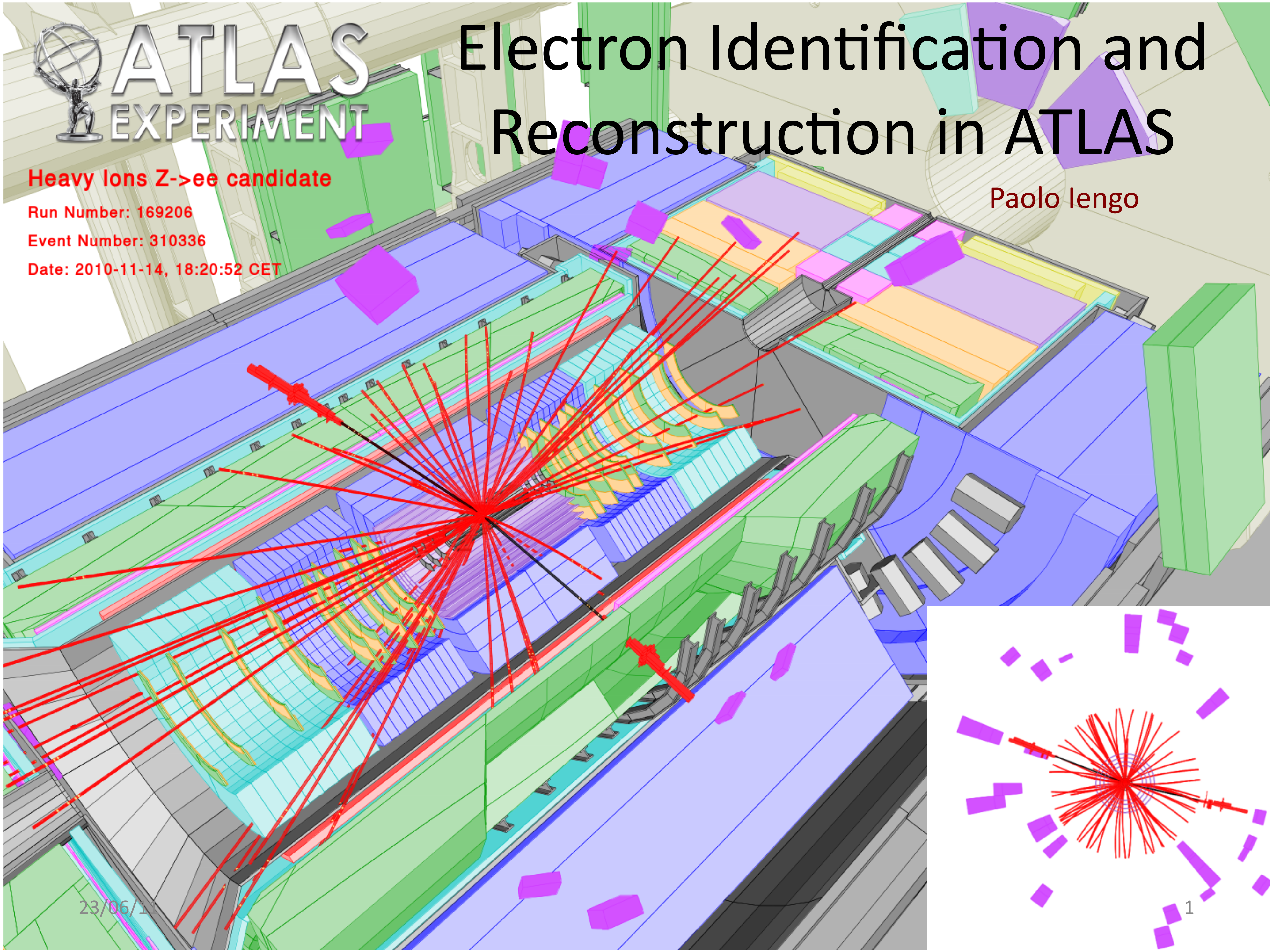
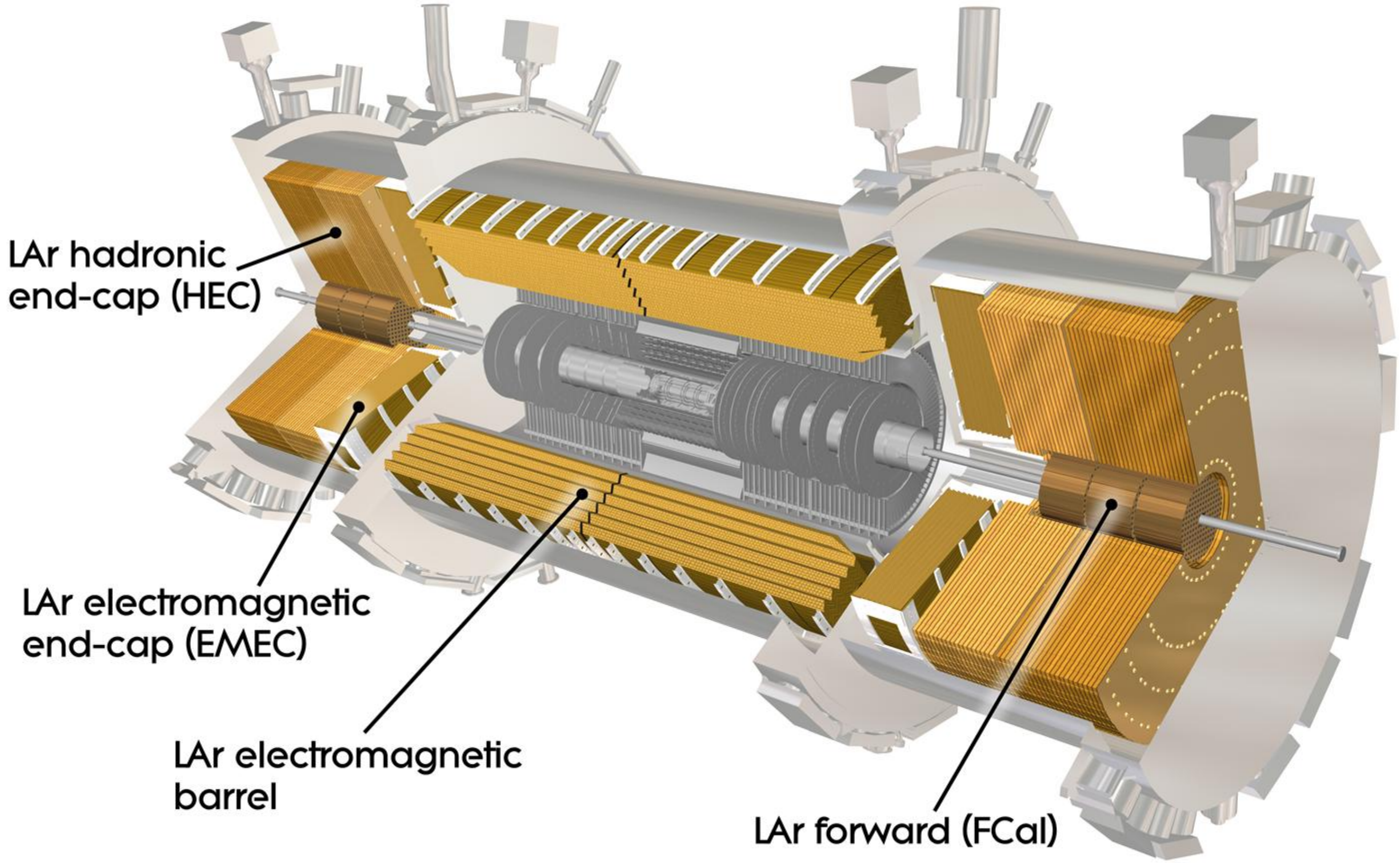
Electron Identification and Reconstruction in ATLAS

Paolo Iengo

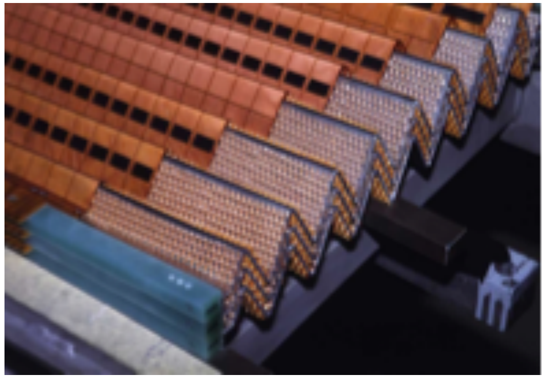


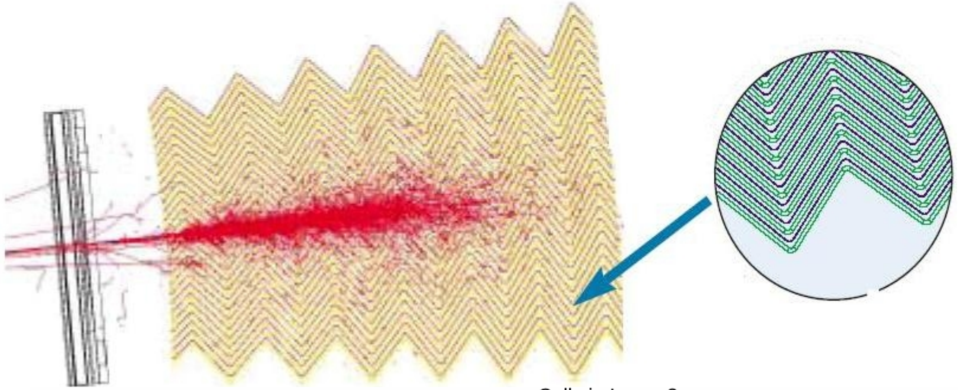
ATLAS LAr Calorimeter

Active material: Liquid Argon
Absorber: Pb (EMB)



ATLAS LAr EM calorimeter



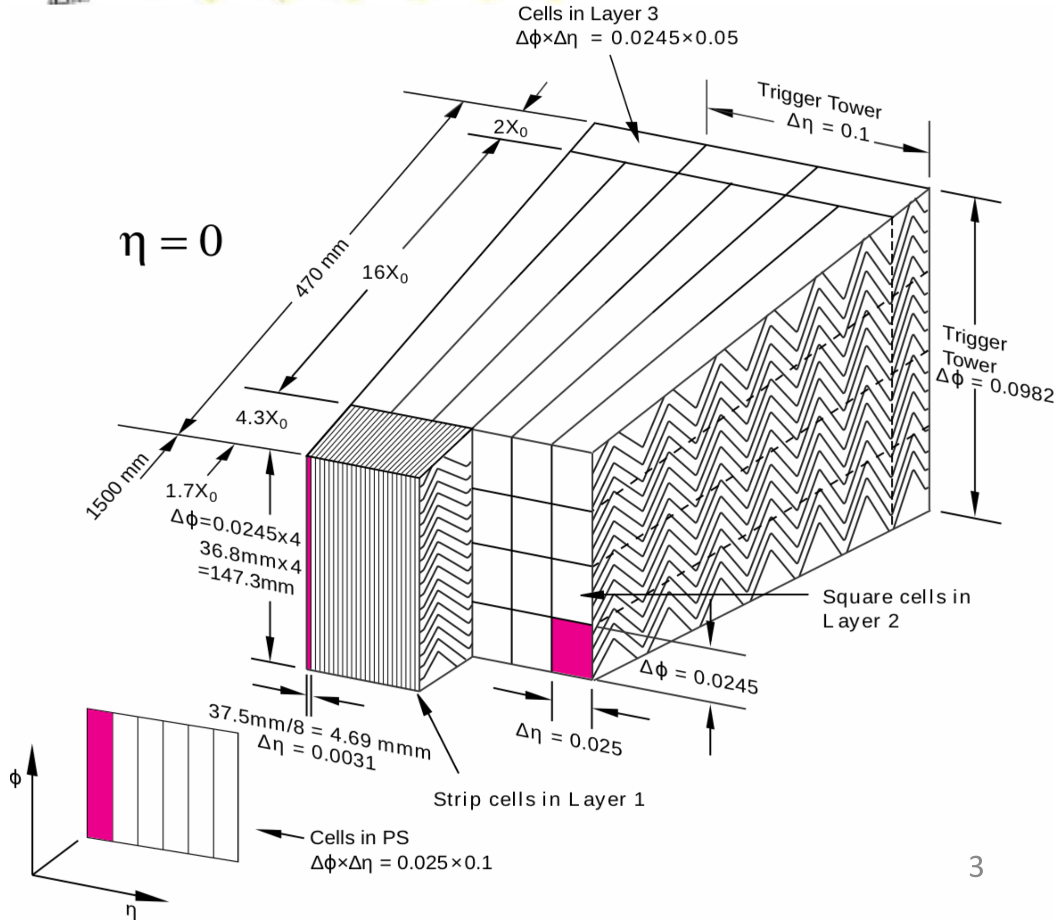


Segmentation in (eta, phi)
Segmentation in depth, 3 layers:
- Strips, Middle, Back
- Strips highly segmented: good rejection π^0/γ

$24\ X_0$ in total
Presampler up to |eta| =1.8

Energy resolution:

$$\frac{\sigma(\mathbf{E})}{\mathbf{E}} = \frac{10\%}{\sqrt{\mathbf{E}}} \oplus 0.7\%$$



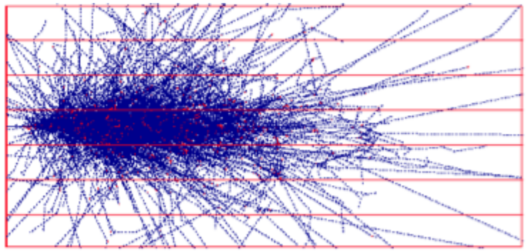
Measured objects

- So far we have discussed about e^+, e^-, γ, n, p, π…
- From the point of view of the detected quantities we should rather talk of measured objects

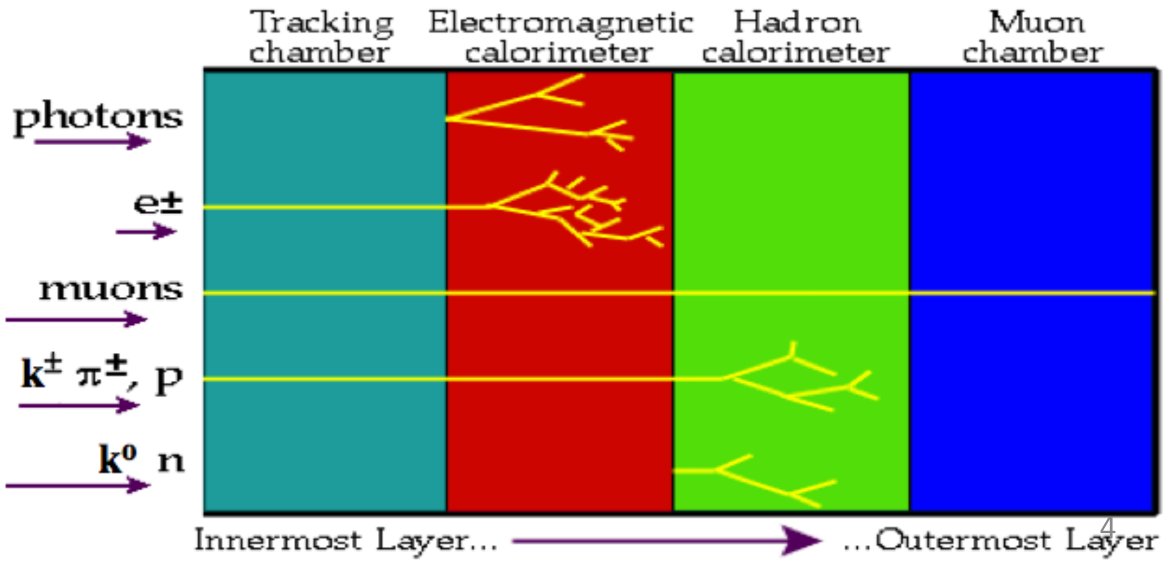
Electromagnetic objects Jets MET

Electromagnetic objects:

- Measured by EM calo + ID + HCal
- Electrons or photon
- EM calo cannot distinguish electrons from photons
- Need a match with ID charged tracks



EM objects



e/γ Reco & Id process

…
1010101010101010
111010001110010…

NB: Reconstruction is not just fitting a track!

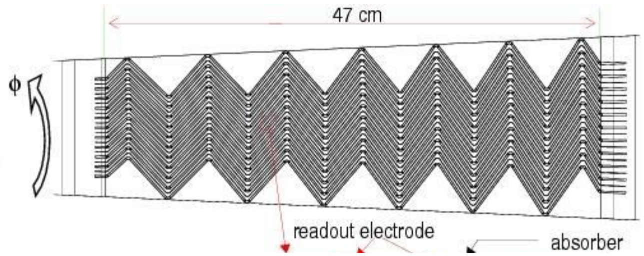
- Energy measurement in each Calo cell (at 'EM scale')
- Put calo cells together (clusterization) to measure EM shower energy deposit
- Match with tracks in ID
- Apply energy calibration for specific object
- Identification based on discriminating variables from EMCalo, ID, HCAL

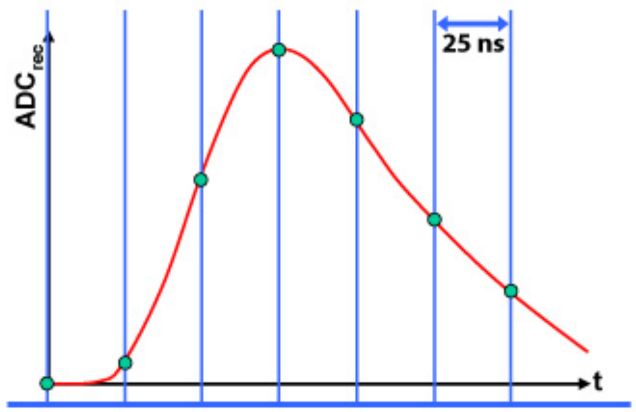
Hi there!

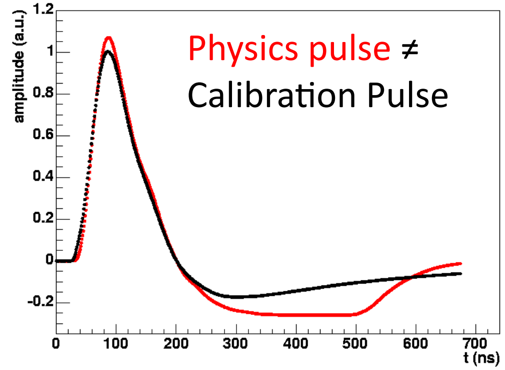
This is the cluster-seeded approach other apprroaches exsist (e.g. track-seeded) but will not be considered here

From digit to raw cell energy

- Signal pulse of the ATLAS calormeters are sampled every 25ns (LHC bunch crossing frequency)
- Normally 5 samples around the peak are stored
- Peak is reconstructed from ADC value of the samples → Optimal Filtering
- From peak value to current induced in the detector → calibration
- From measured current to deposited energy → sampling fraction

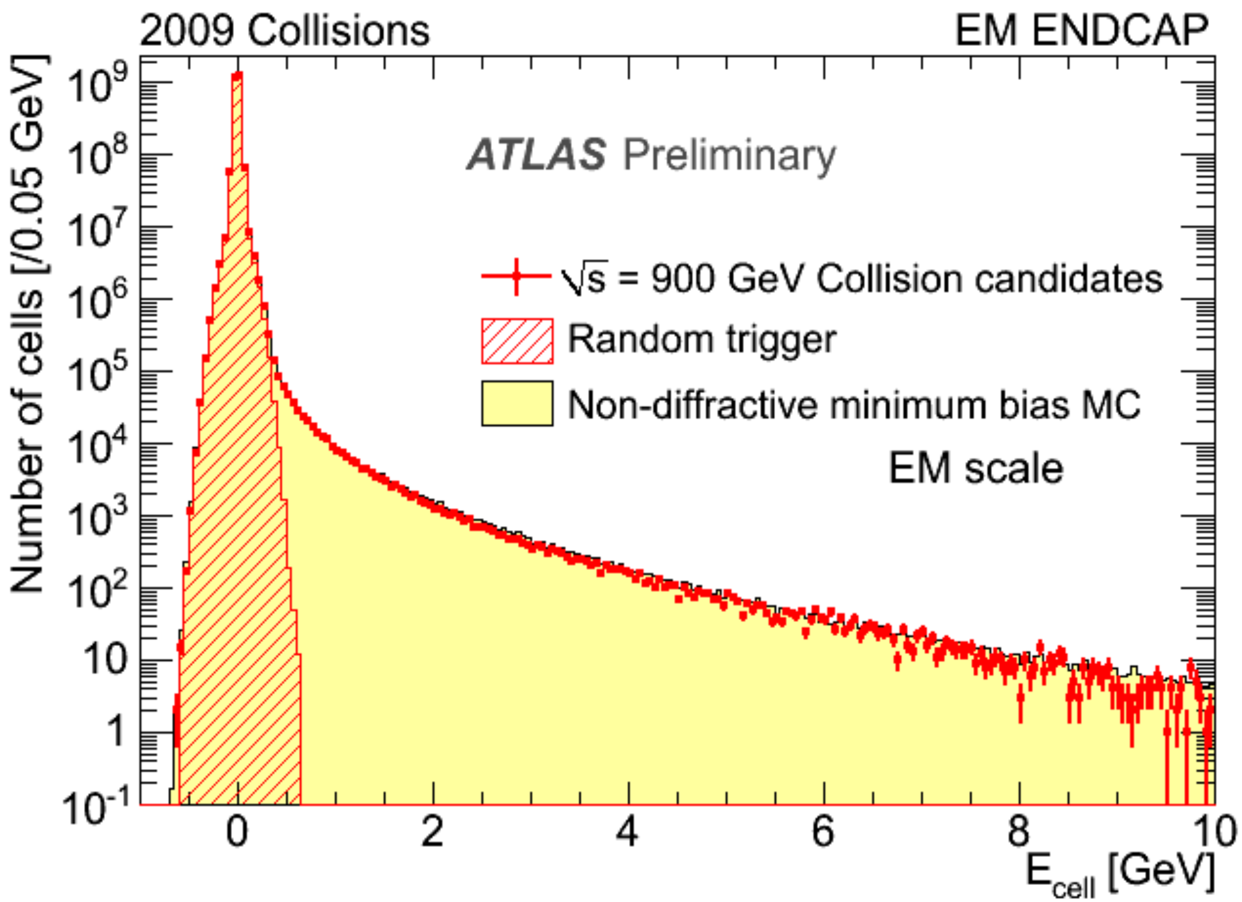






$$E_{\mathrm{cell}} = F_{\mu\mathrm{A}\rightarrow\mathrm{MeV}} \cdot F_{DAC\rightarrow\mu\mathrm{A}} \cdot \frac{1}{\frac{\mathrm{M_{phys}}}{\mathrm{M_{cali}}}} \sum_{i=1}^{M_{\mathrm{ramps}}} R_i \left[\sum_{j=1}^{N_{\mathrm{samples}}} a_j \left(s_j - p \right) \right]^i$$

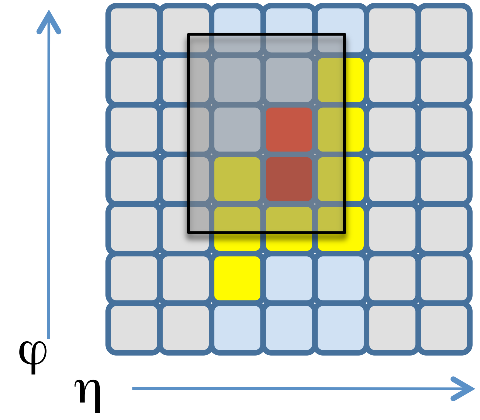
Calo cell energy distribution

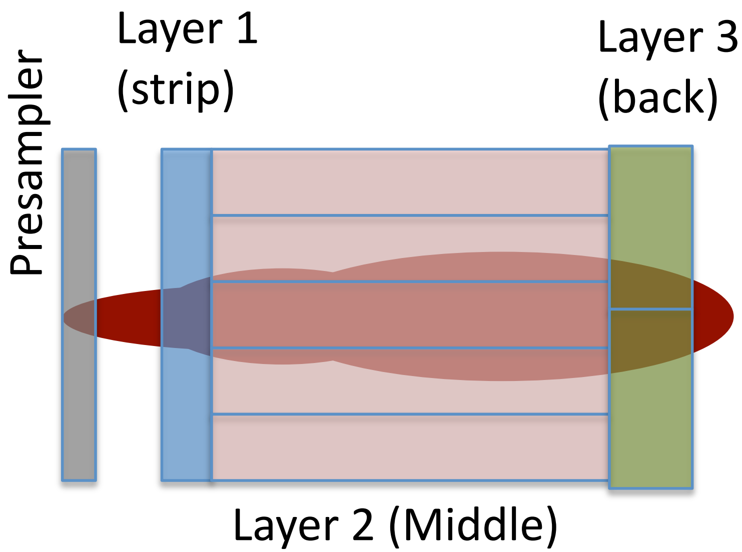


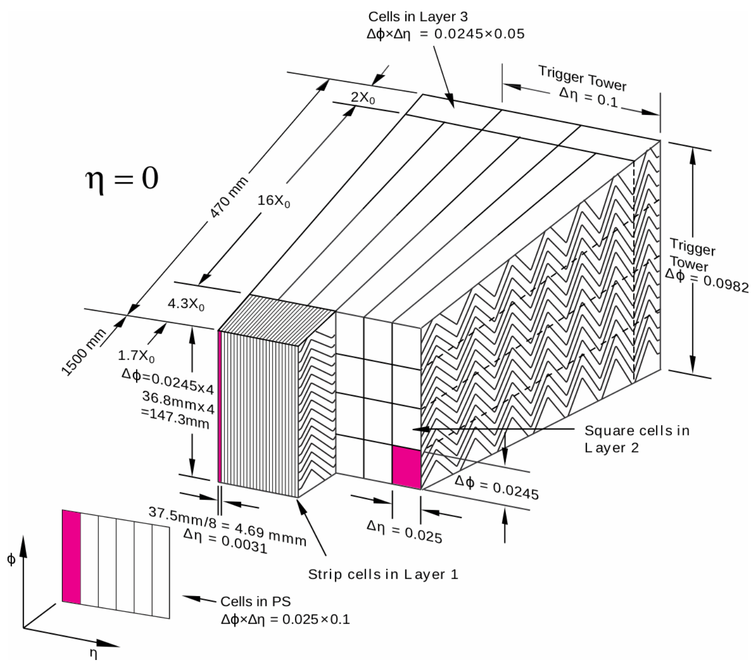
- Good agreement between data and MC
- No correction for dead material applied on the individual cells

Reconstruction: find an EM cluster

- Sliding window algorithm (3x5 cells in middle layer)
- Pre-cluster creation
- Pre-cluster with E_T>2.5GeV seed e/g reconstruction
- Cluster barycentre is computed



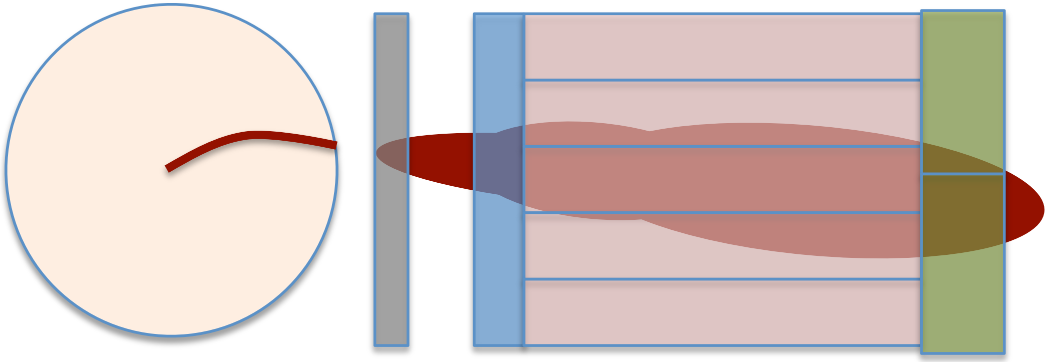




Reconstruction: find EM object

- Track matching with ID
  - Track match → Electron candidate
  - No track match → Photon candidate
  - Conversion vertex → Electrons from photon conversion cand
- Re-definition of cluster size according to object hypotesis
- Apply dedicated object energy calibration

A this point we have our electron candidate



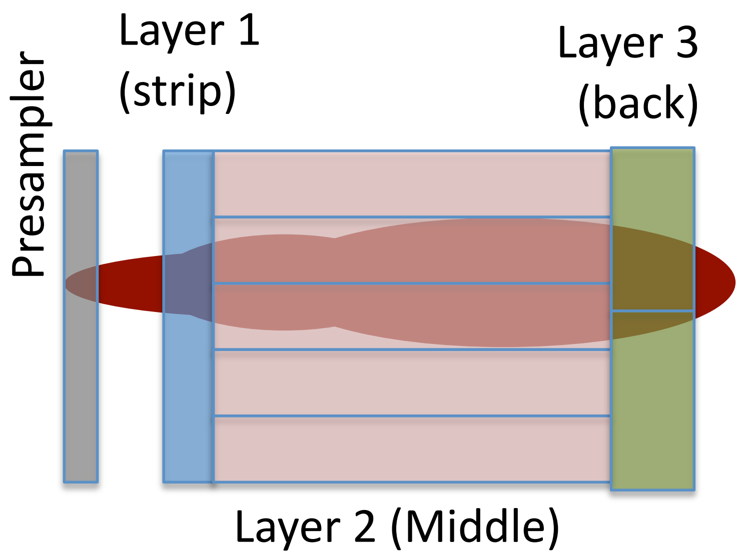
Reconstruction: find electron energy

- Final cluster energy is corrected for:
- Energy deposited before the calorimeter
- Lateral leakage (energy deposited utside the cluster)
- Longitudinal leakage (energy deposited beyond the EM calorimeter)

$$E_{reco} = \lambda(E_{off} + w_{ps}E_{ps} + E_1 + E_2 + w_3E_3)$$

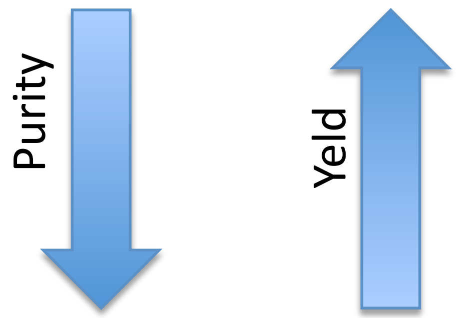
A this point we have our electron candidate and his energy

My energy is 3.4 GeV



Identification

- Once an electron object candidate has been found it must be identified
- The selected object can be a fake (e.g. a QCD jet)
- Identification based on discriminating variables
- Depending on variables used and cuts applied the electron candidates can have a different degree of purity
- According to identification cuts applied in ATLAS we define three categories of electrons:
  - Loose
  - Medium
  - Tight

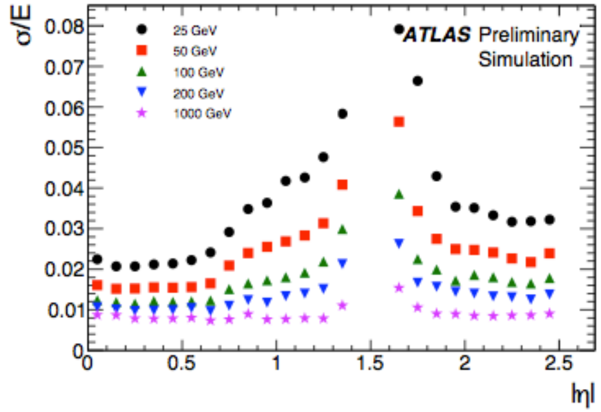


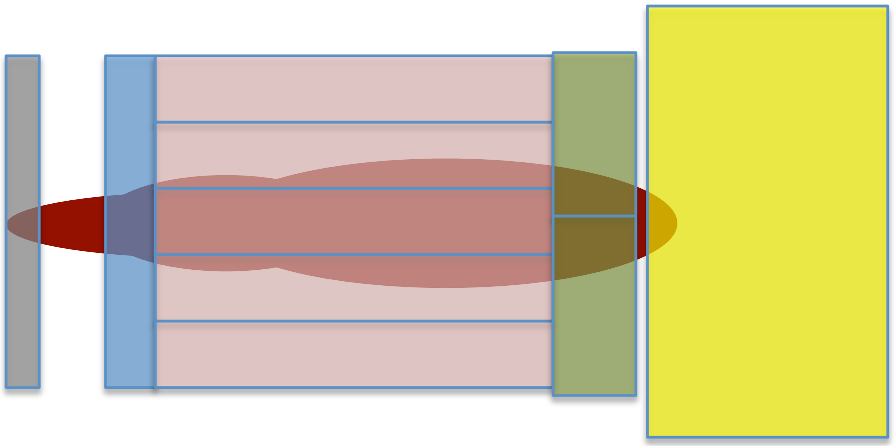
Choice of which electron identification cut is used depends on the analysis

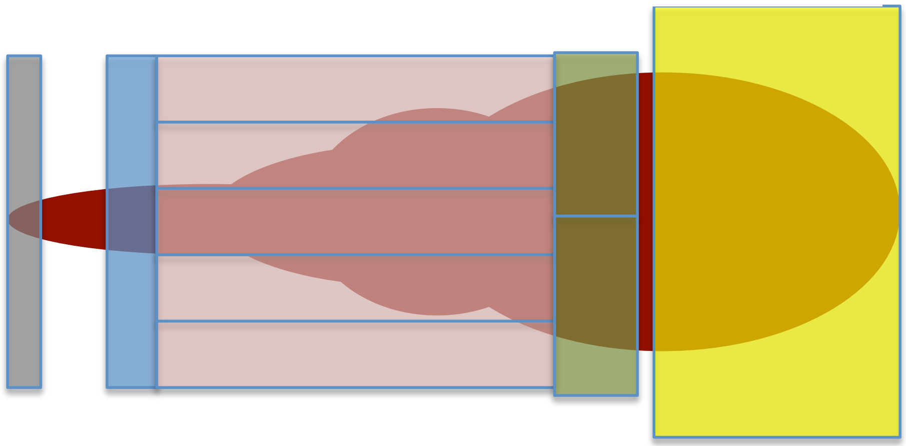
Identification

Loose electron and photon cuts		
Acceptance of the detector	$\lvert\eta\rvert < 2.47$ for electrons, $\lvert\eta\rvert < 2.37$ for photons ($1.37 < \lvert\eta\rvert < 1.52$ excluded)	-
Hadronic leakage	Ratio of E_T in the 1st sampling of the hadronic calorimeter to E_T of the EM cluster (used over the range $\lvert\eta\rvert < 0.8$ and $\lvert\eta\rvert > 1.37$)	R_{had1}
	Ratio of E_T in the hadronic calorimeter to E_T of the EM cluster (used over the range $\lvert\eta\rvert > 0.8$ and $\lvert\eta\rvert < 1.37$)	R_{had}
Middle layer of the EM calorimeter	Ratio in η of cell energies in 3×7 versus 7×7 cells.	R_η
	Lateral width of the shower	w_2

- Loose electron cuts:
  - Detector acceptance:esclude regions not fully equipped
  - Hadronic leakage
  - Shower shape in middle layer







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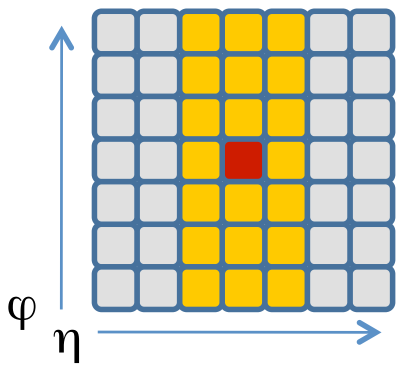
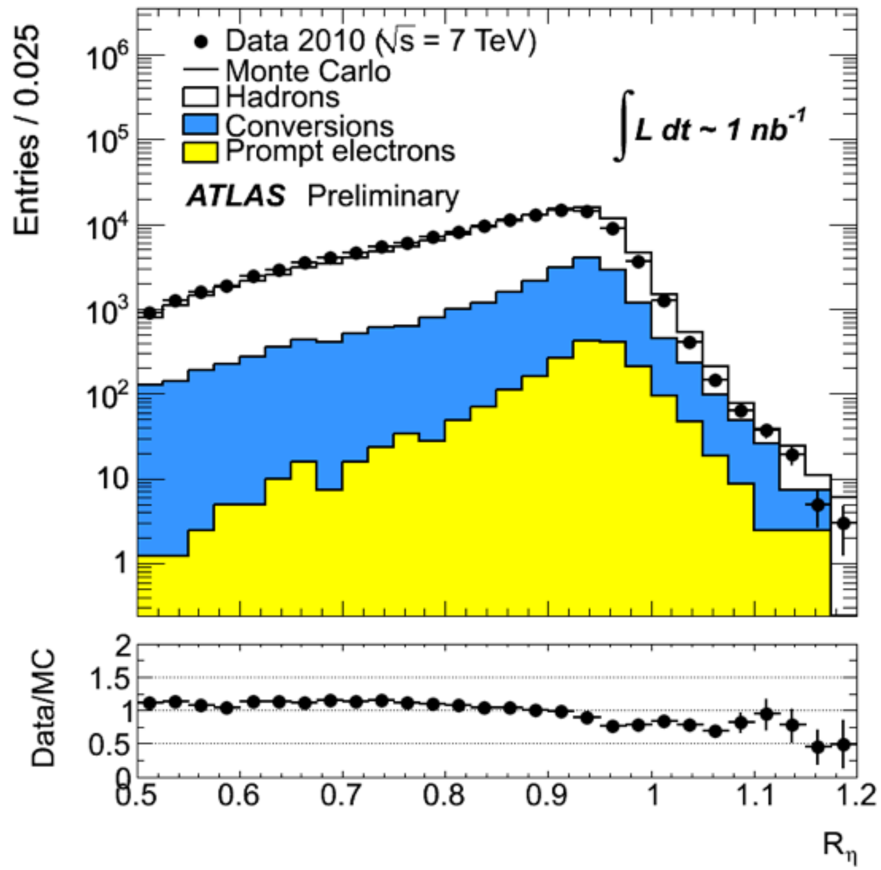


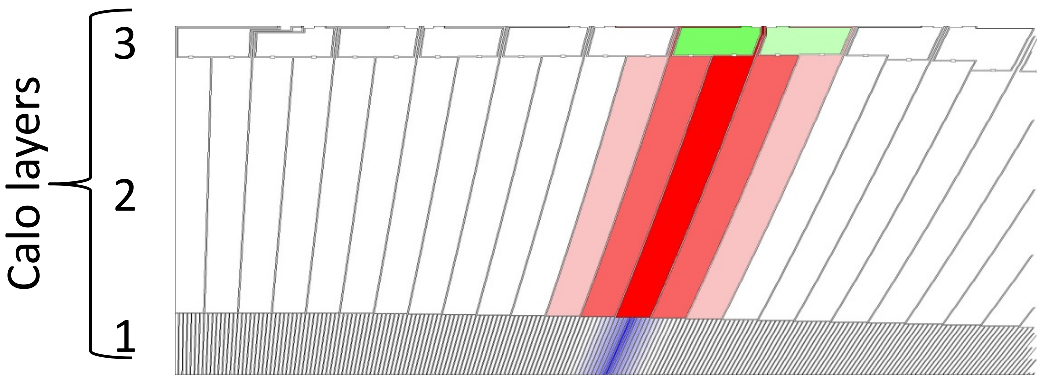
$$R\eta = \frac{\sum E(\Delta\eta \times \Delta\varphi = 3\times7)}{\sum E(\Delta\eta \times \Delta\varphi = 7\times7)}$$

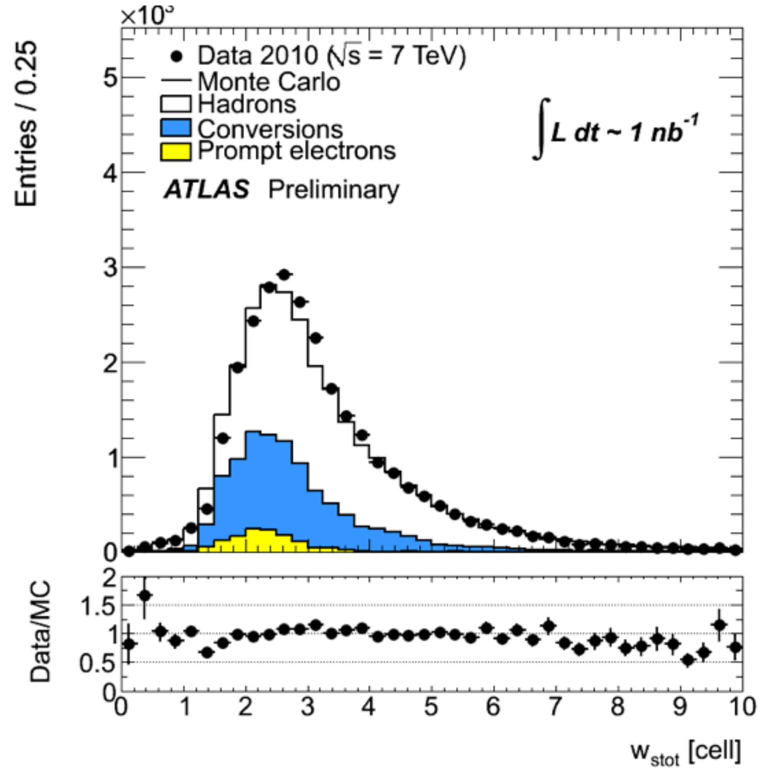


Identification

Medium electron cuts (in addition to the loose cuts)		
Strip layer of the EM calorimeter	Total lateral shower width (20 strips)	w_{stot}
	Ratio of the energy difference between the largest and second largest energy deposits over the sum of these energies	E_{ratio}
Track quality	Number of hits in the pixel detector (at least one)	-
	Number of hits in the pixels and SCT (at least seven)	-
	Transverse impact parameter (<5 mm)	d_0
Track matching	$\Delta\eta$ between the cluster and the track in the strip layer of the EM calorimeter	$\Delta\eta_1$

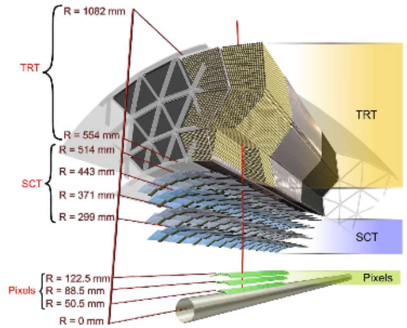
- Medium electron cuts: loose+
  - Shower shape in strip layer
  - Track quality
  - Cluster/Track matching



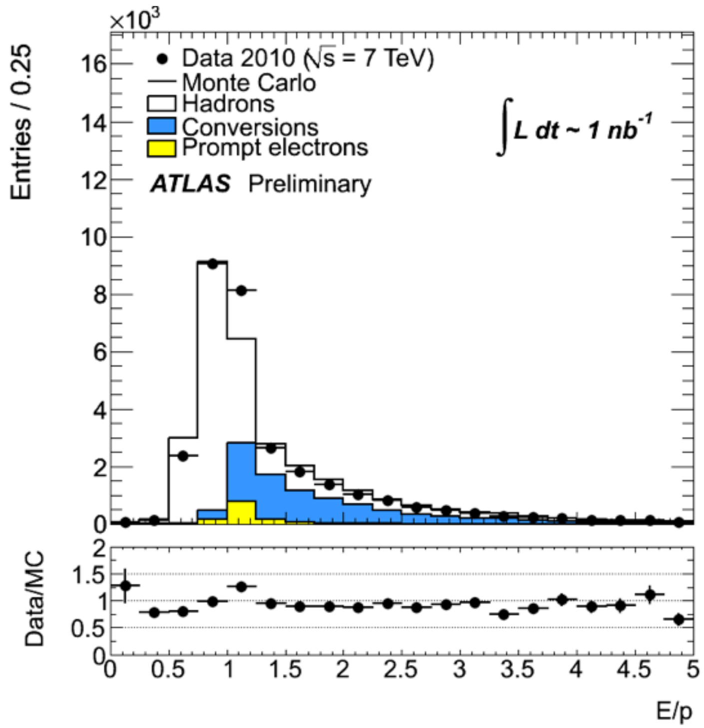


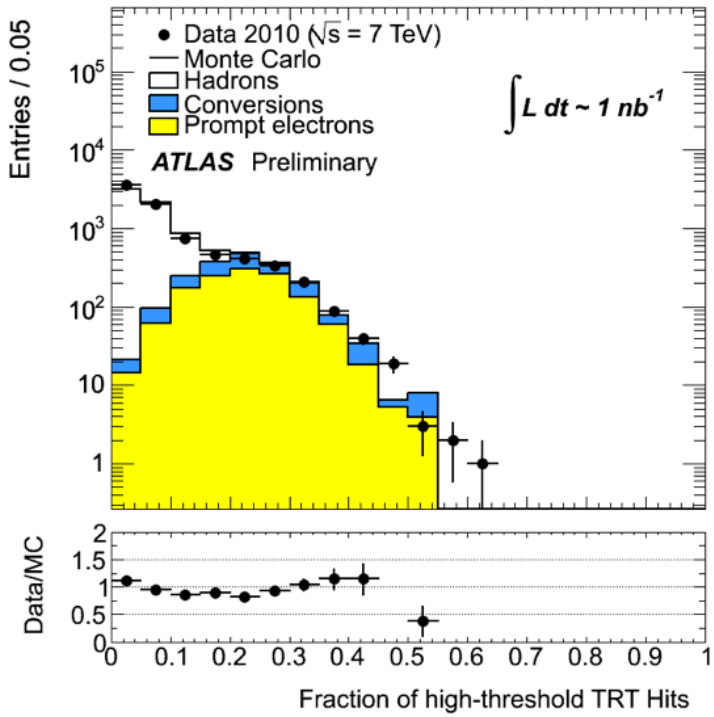
Identification

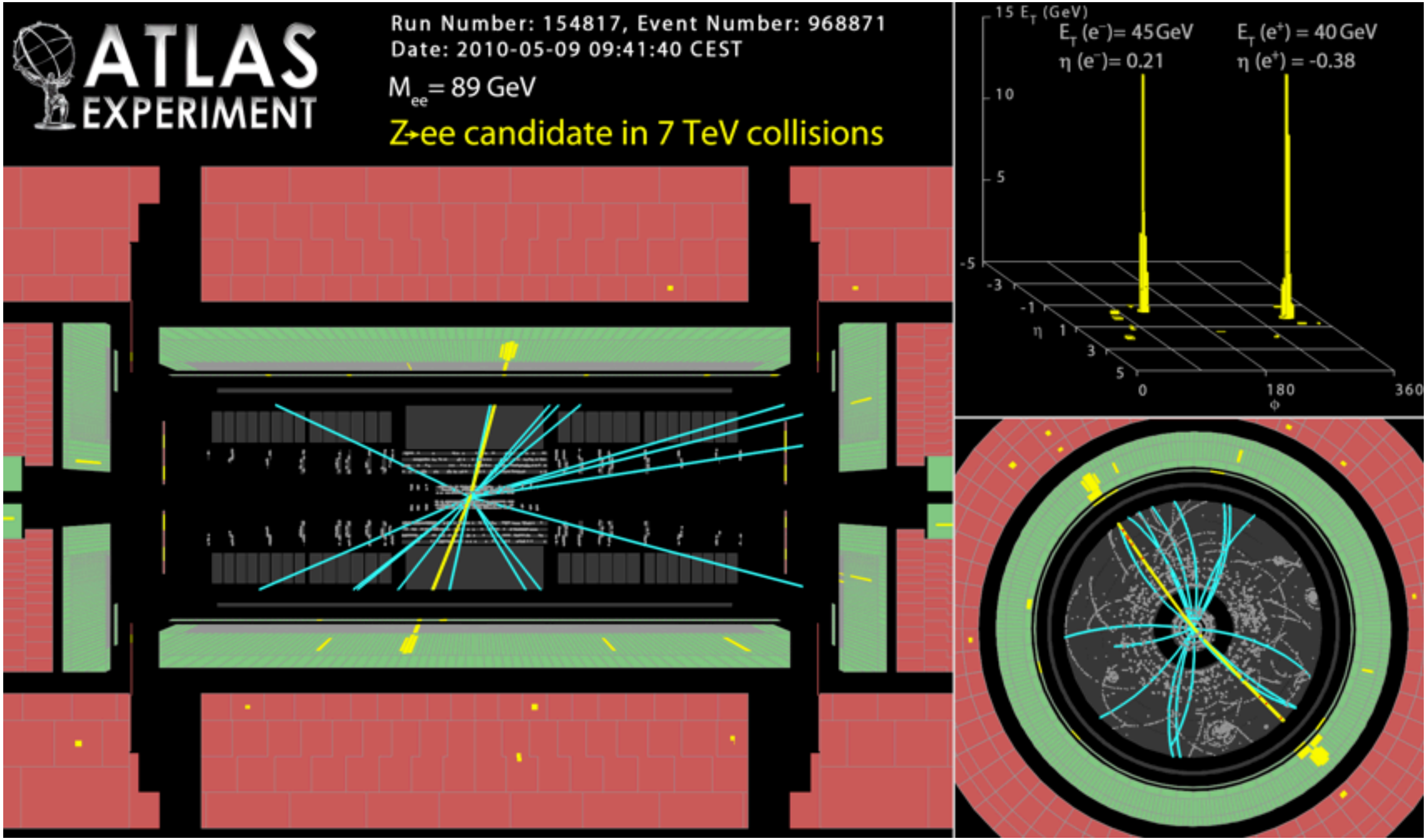
Tight electron cuts (in addition to the medium electron cuts)		
B-layer	Number of hits in the B-layer (at least one)	
Track matching	$\Delta\phi$ between the cluster and the track in the middle layer of the EM calorimeter	$\Delta\phi_2$
	Ratio of the cluster energy to the track momentum	E/p
TRT	Total number of hits in the TRT (used over the acceptance of the TRT, $\|\eta\| < 2.0$)	-
	Ratio of the number of high-threshold hits to the total number of TRT hits (used over the acceptance of the TRT, $\|\eta\| < 2.0$)	-



- Tight electron cuts: medium+
  - More stringent cuts on track matching and ID info







Computing the invariant mass of two electron candidates is only the last step of a long and laborious process!!