Title: Photon identification with the ATLAS detector

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Abstract: TBA

Photon identification with the ATLAS detector

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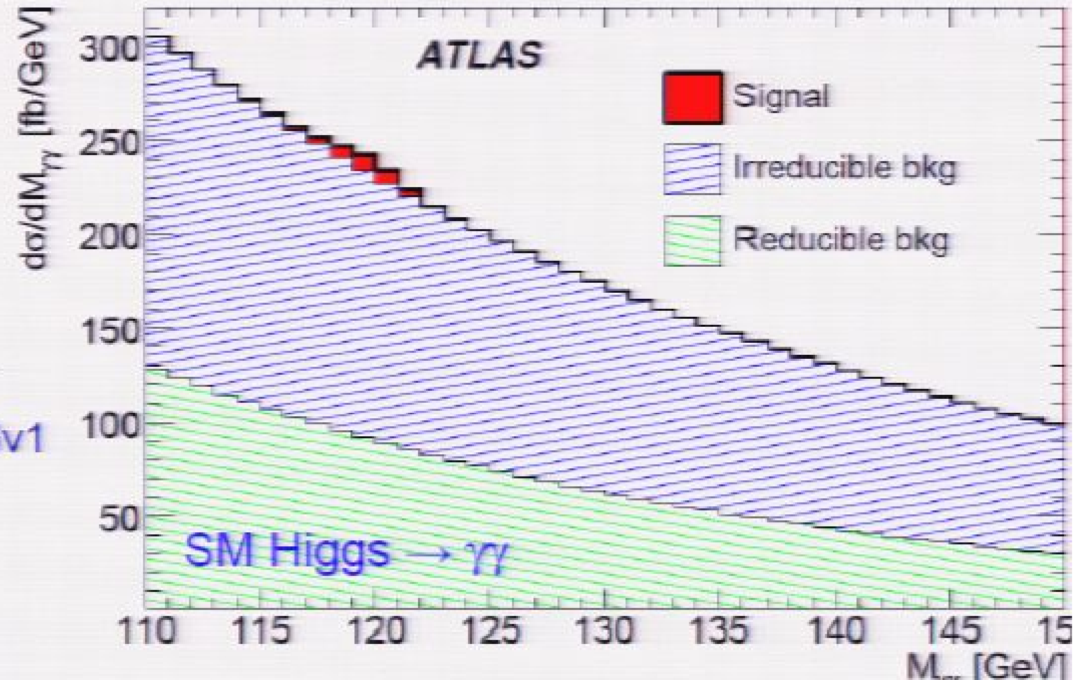
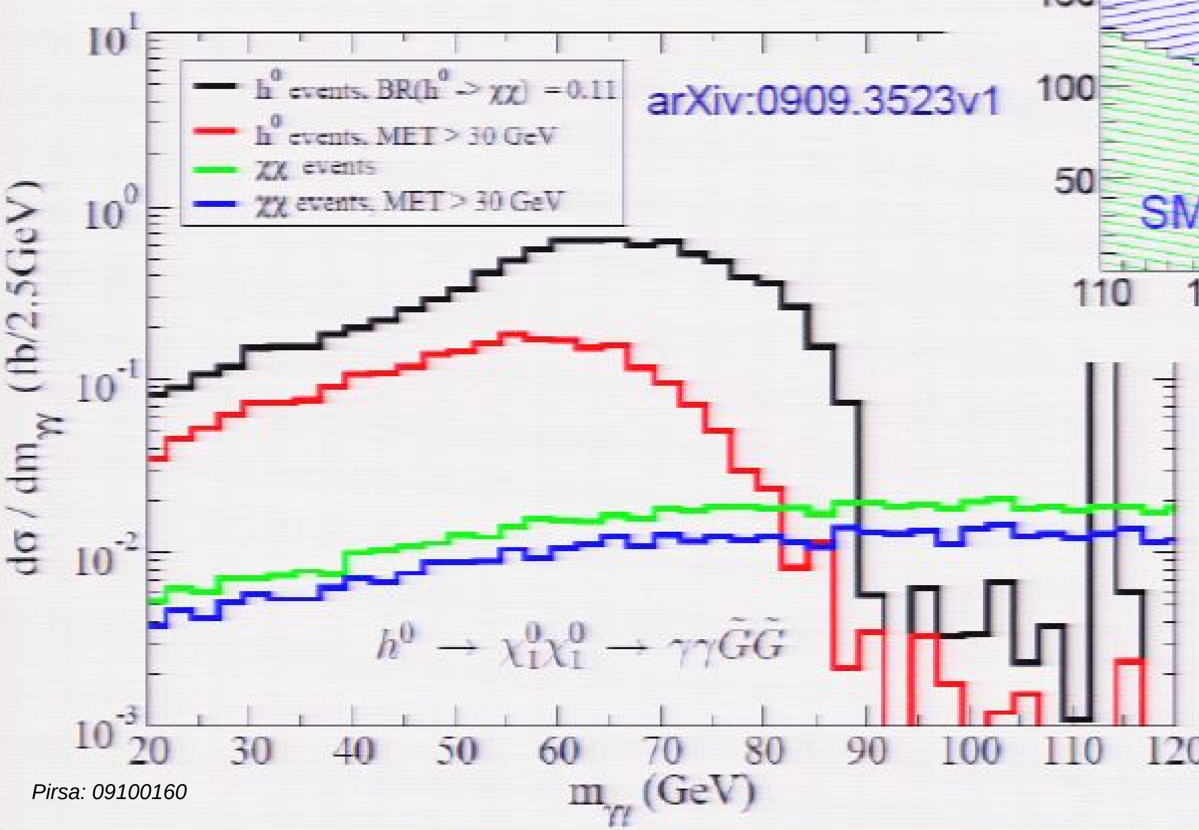
Physics with Photons

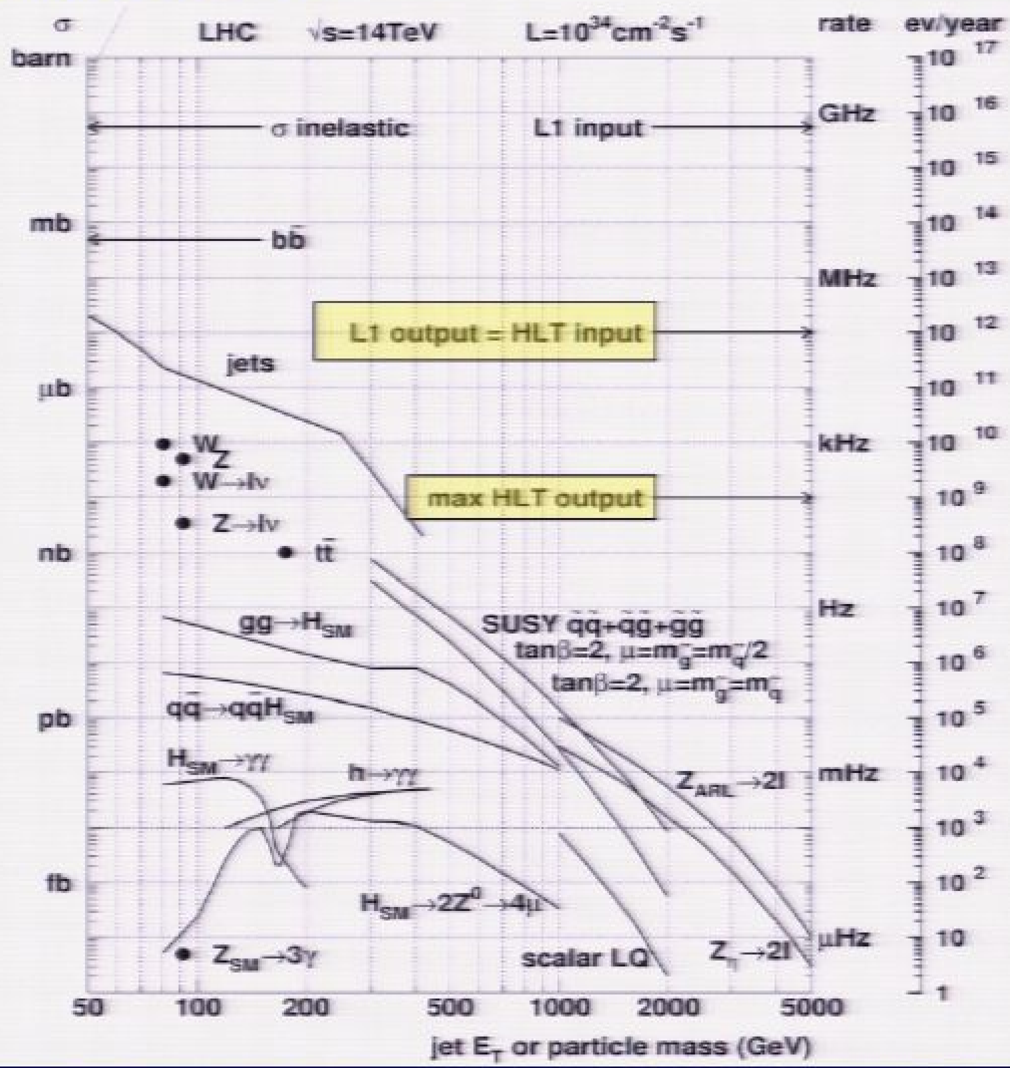
- Events containing photons can be used to explore new physics such as :
  - Higgs $\rightarrow \gamma\gamma$
  - Graviton $\rightarrow \gamma\gamma$
  - Techni-colour particles (π_{tc})
  - SUSY





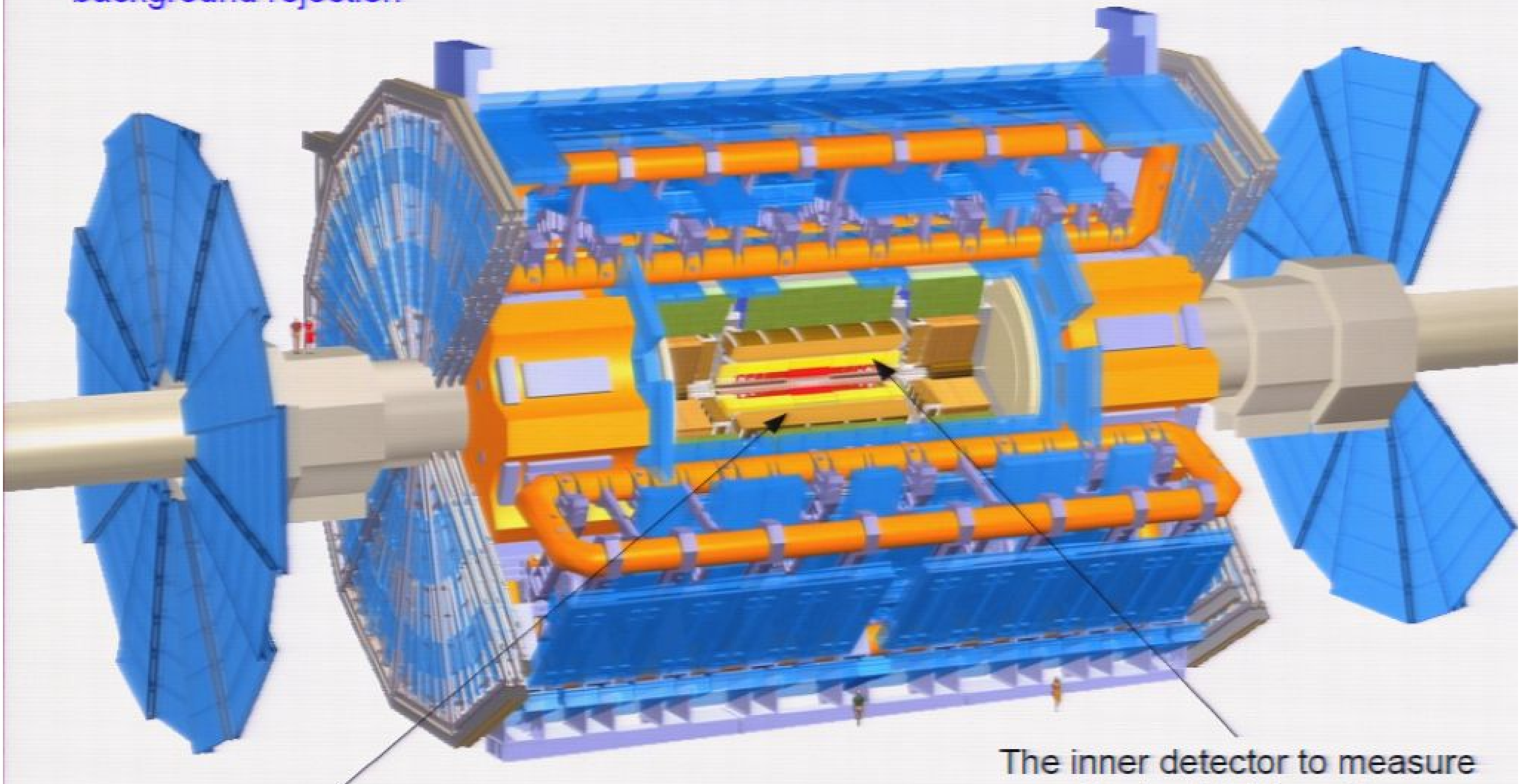
Physics with Photons

- The cross-sections of these processes are very small compared to the QCD background :
  → very good jet rejection is needed



The ATLAS detector

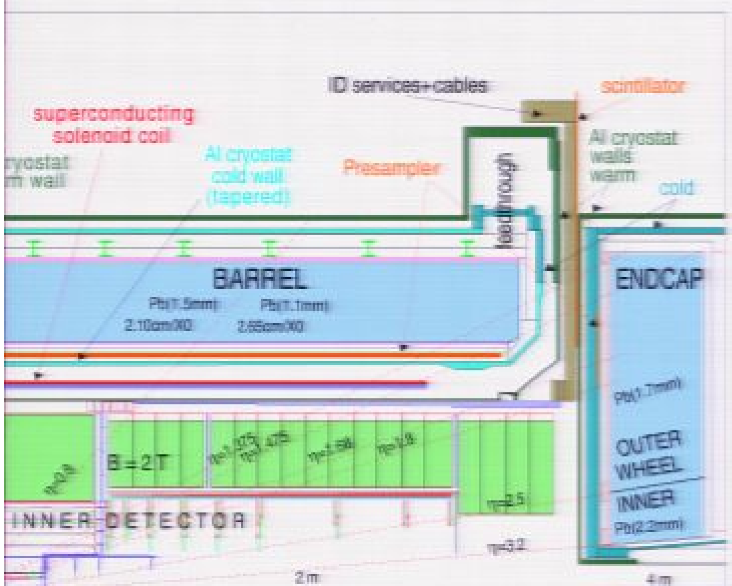
- The ATLAS detector was designed to identify the particle identity with a very good background rejection

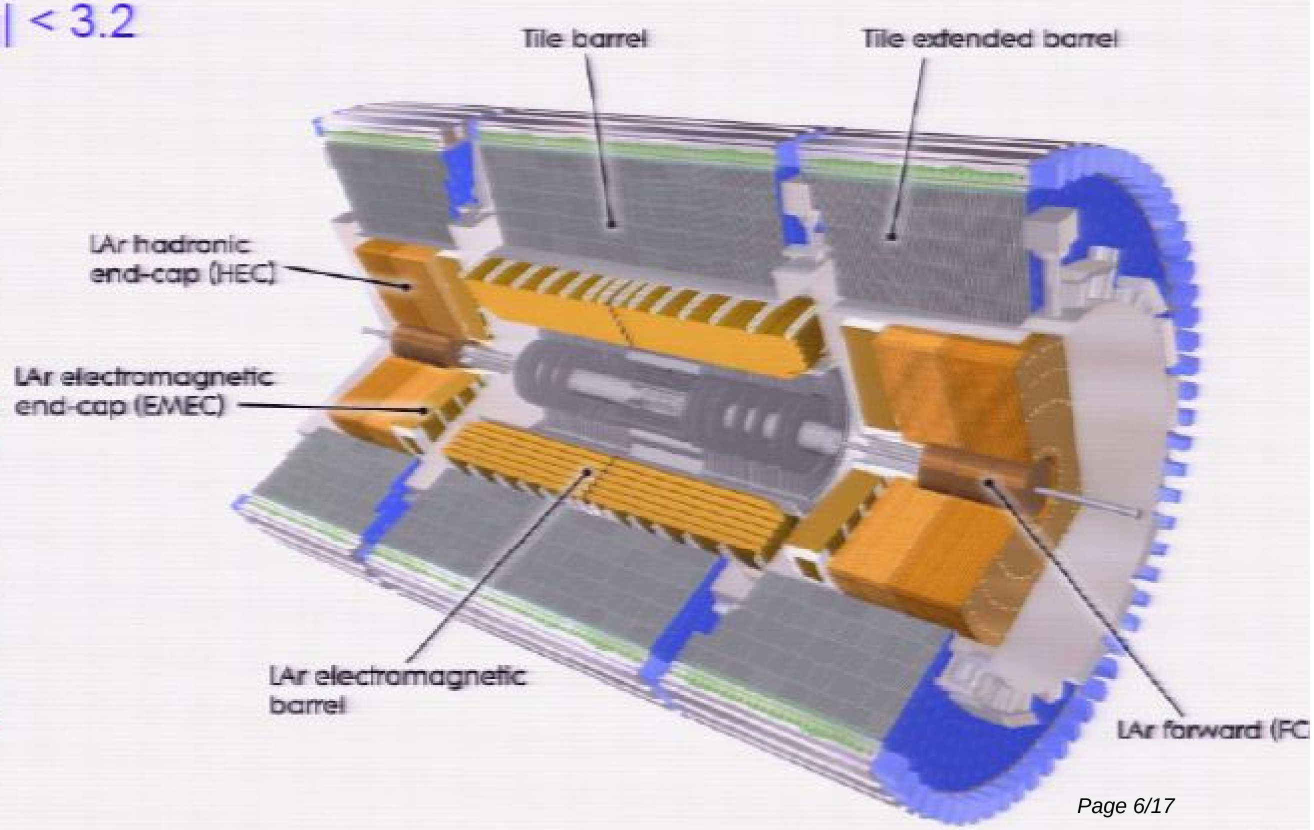


The Electro-Magnetic Calorimeter

- The EM calorimeter uses liquid argon as the active detector medium :
  - intrinsic linear behavior
  - stability of response over time
  - intrinsic radiation-hardness
- Lead absorbers
- LAr EM barrel : $|\eta| < 1.375$
- LAr EM end-cap : $1.375 < |\eta| < 3.2$
- FCal : $3.1 < |\eta| < 4.9$

Resolution : $10.1\%/\sqrt{E}$(GeV) +0.17%
~ 1.5 % for 60 GeV photon





The Electro-Magnetic Calorimeter

- The main photon background are :
  - $\pi^0 \rightarrow \gamma\gamma$
  - Hadronic jet
  - Electrons

- Accordio-shape absorbers and electrodes
- The EM is divided in three layers :
  - To measure the shower shape
- The high granularity allows to reduce the $\pi^0 \rightarrow \gamma\gamma$ background.

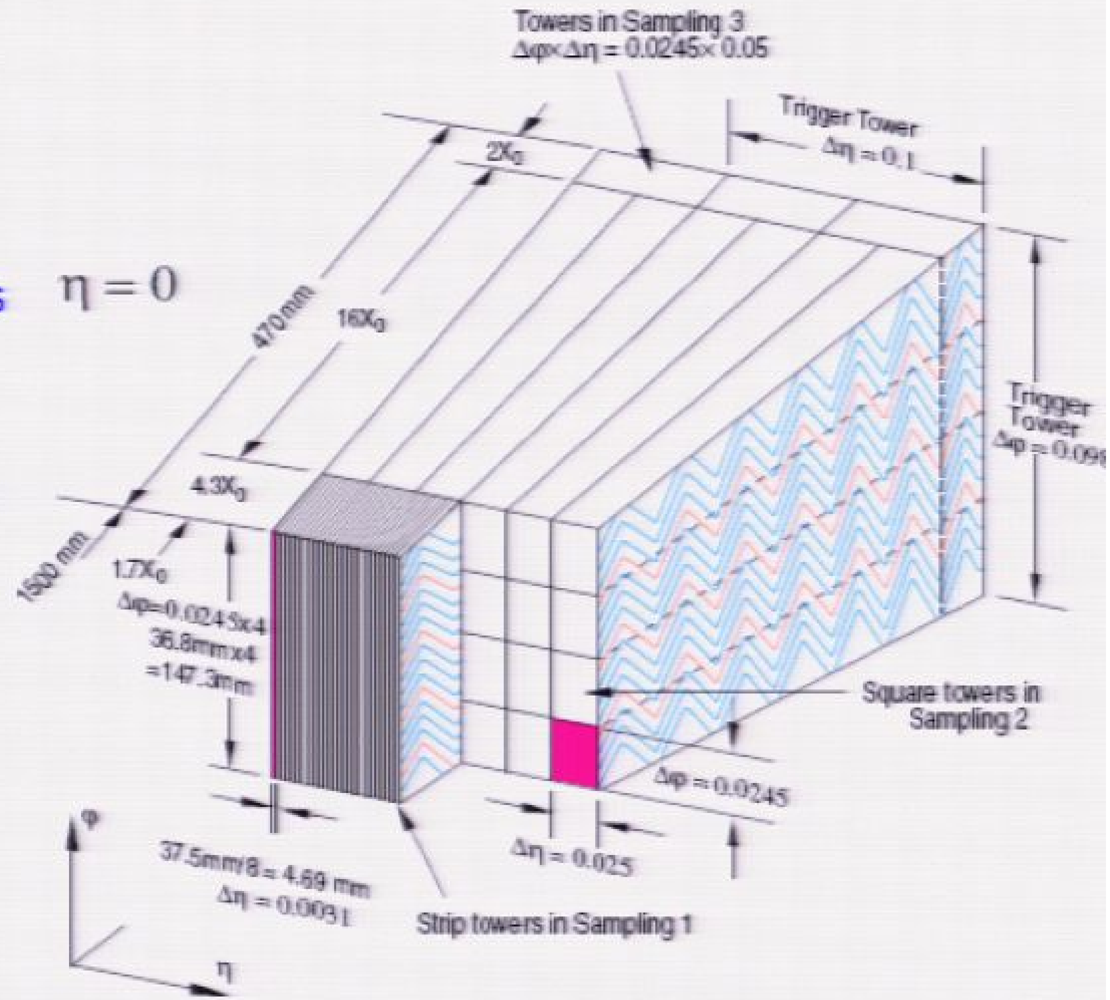
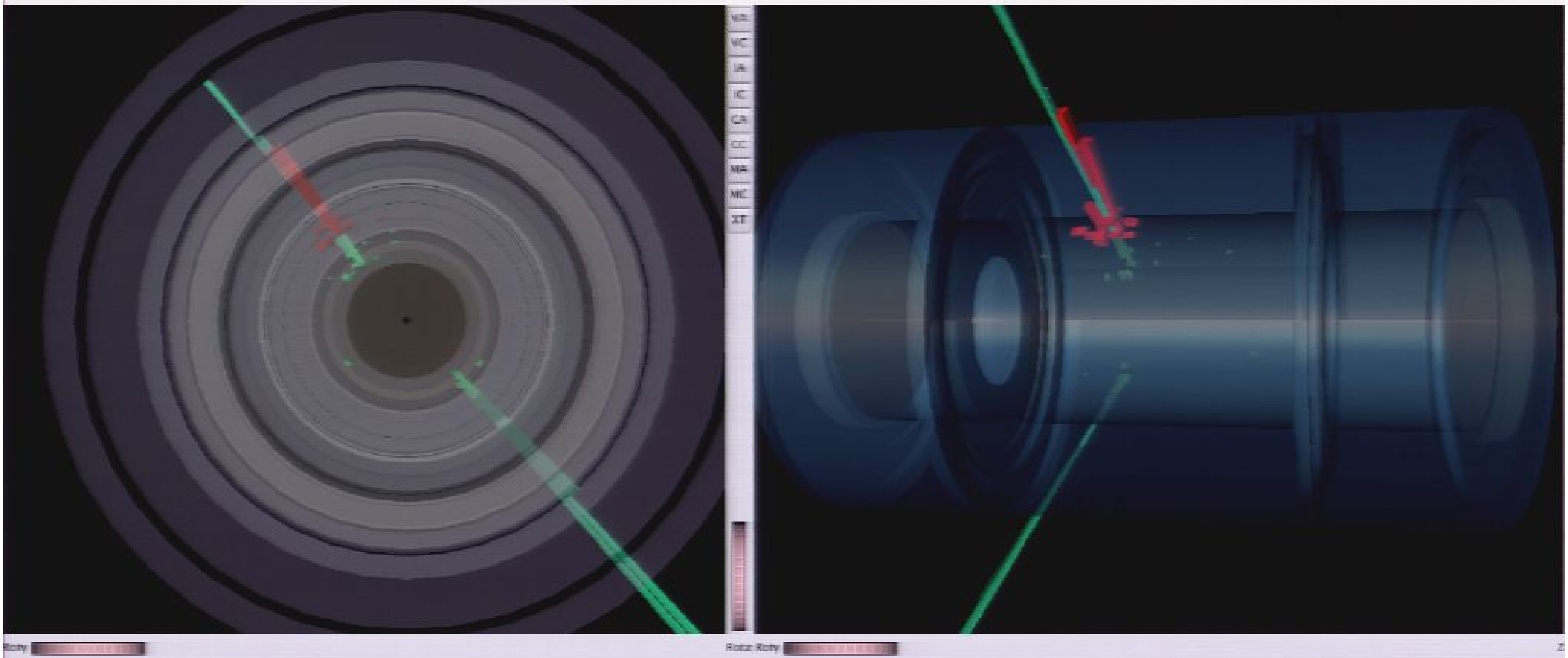


Figure 2-ii Readout granularity of the EM calorimeter.

Shower shape (from full simulation)



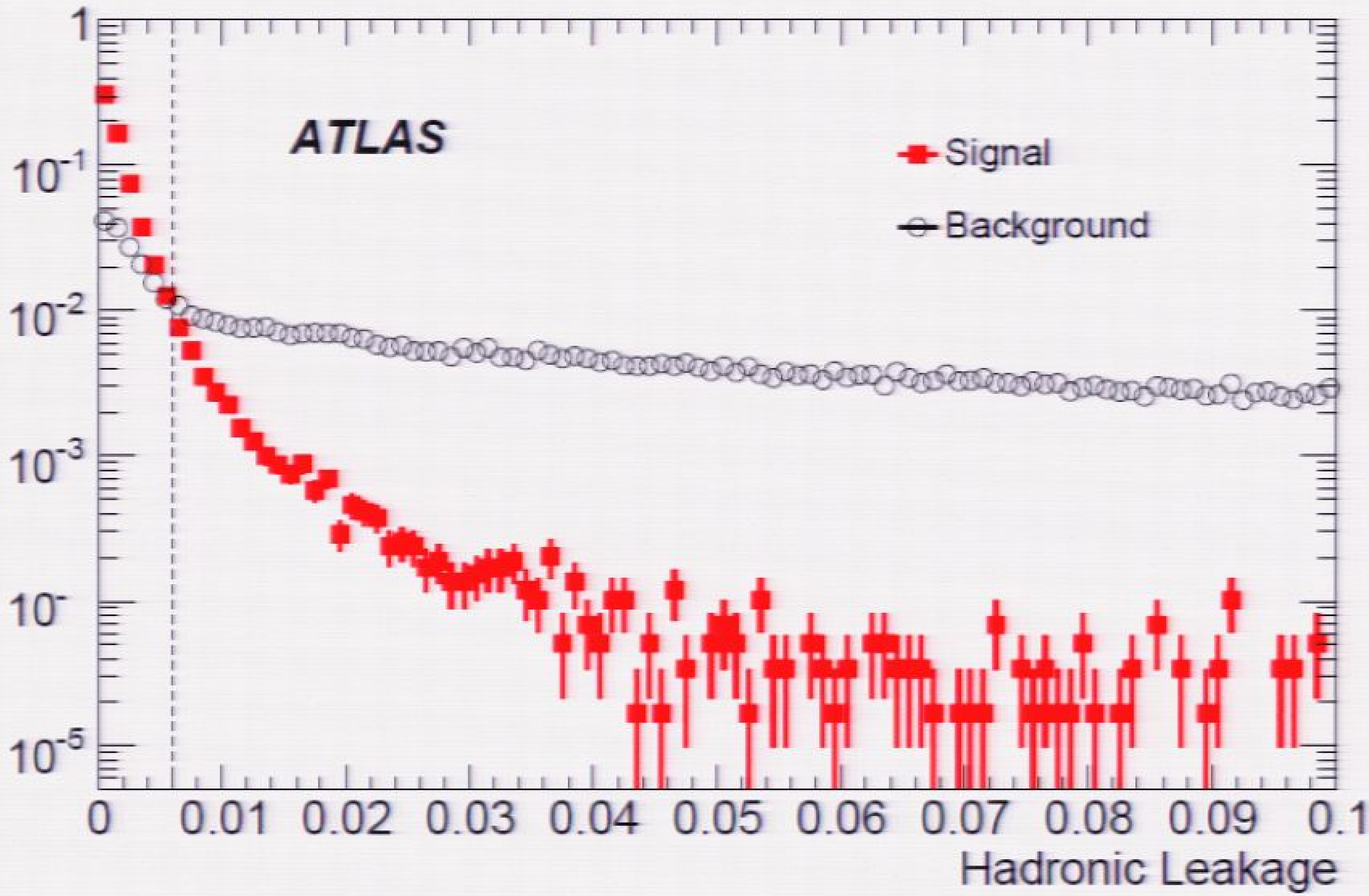
Energy deposited per cell in the calorimeter (Green : EM cal., Red : hadronic cal.) for a γ-jet event from the full simulation of the ATLAS detector

The shower shape variables

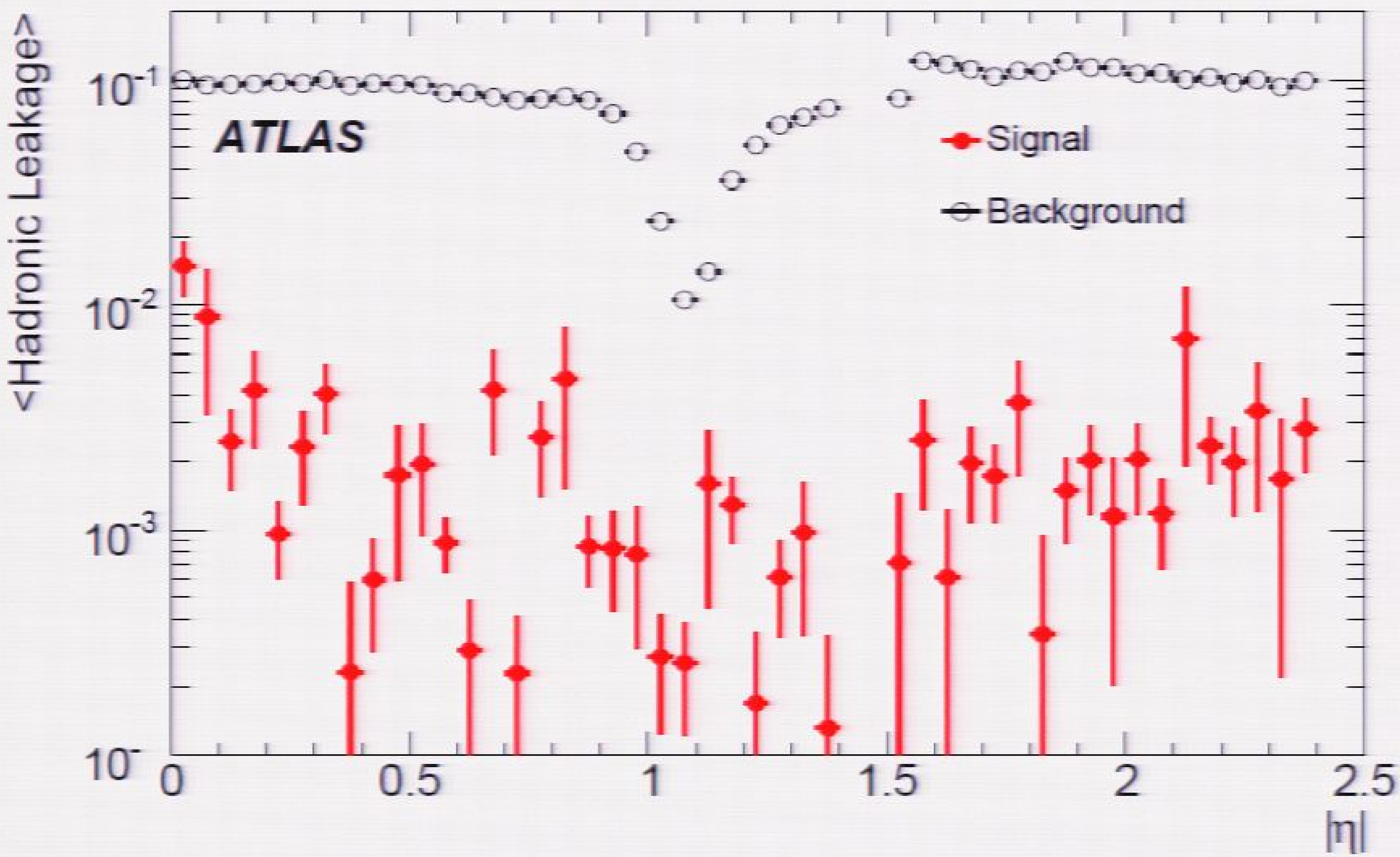
- Shower shape variables are used to identify a photon :
  - Different samplings of the EM calorimeter
  - Hadronic leakage in the hadronic calorimeter
  - Isolation using a cone around the photon

- ATLAS uses a cut-based method to identify electron and photon :
  - Log-likelihood ratio based
  - Covariance-matrix based
    - Have been developed but will not be used in early data

The shower shape variables (from MC)
Example of the hadronic leakage



The shower shape variables
Example of the hadronic leakage



Photon Efficiency and rejection factor (cut-based method)

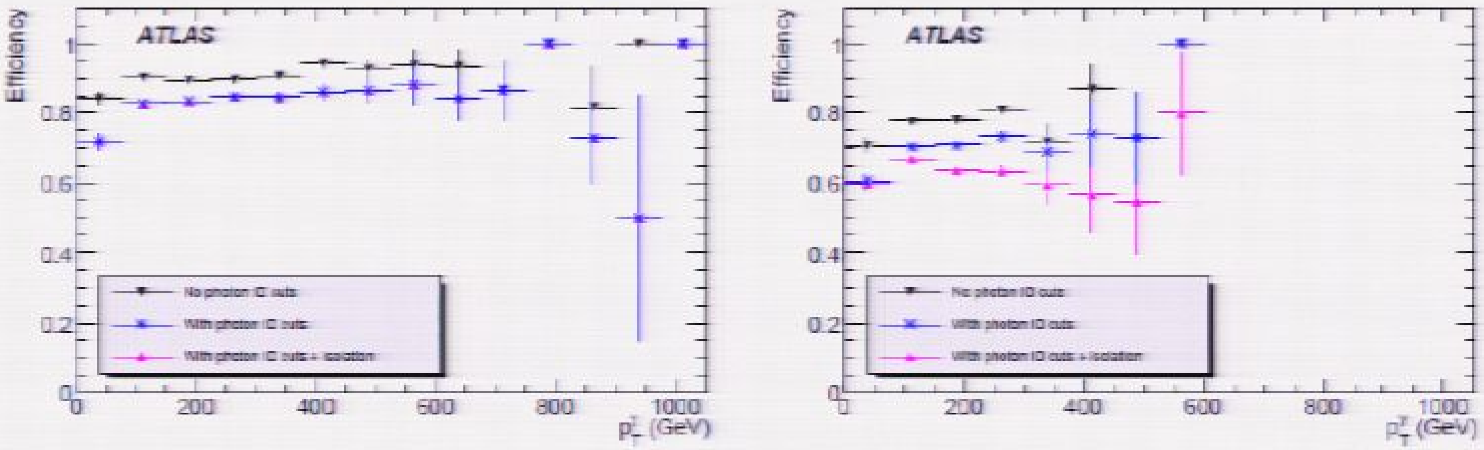


Figure 15: Photon efficiency in the 500 GeV graviton sample as a function of p_T for barrel (left) and end-cap (right) calorimeters.

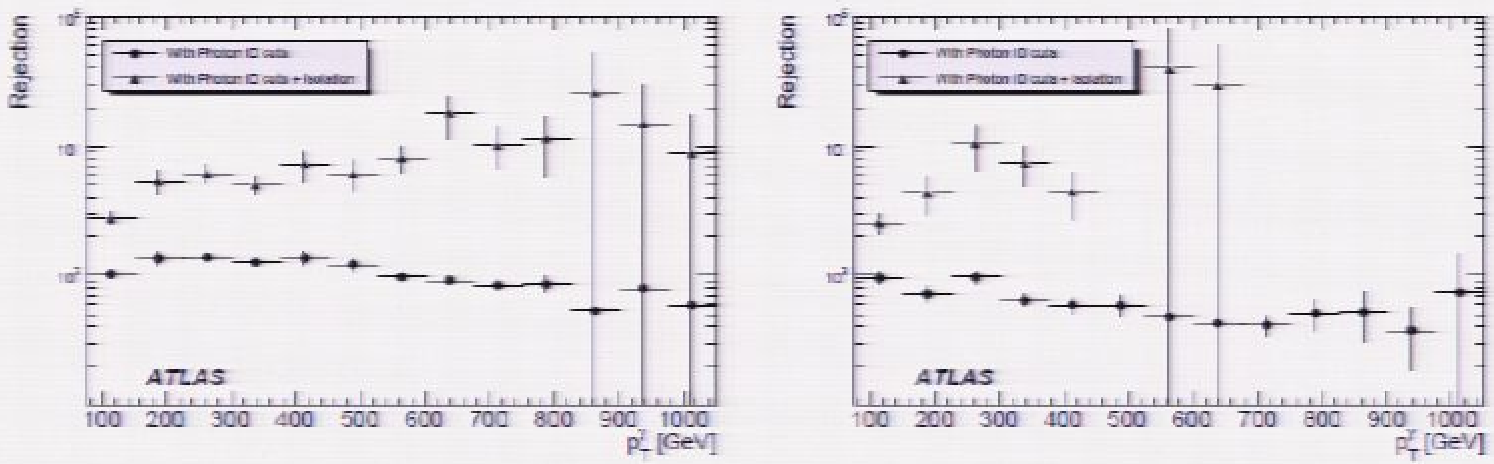
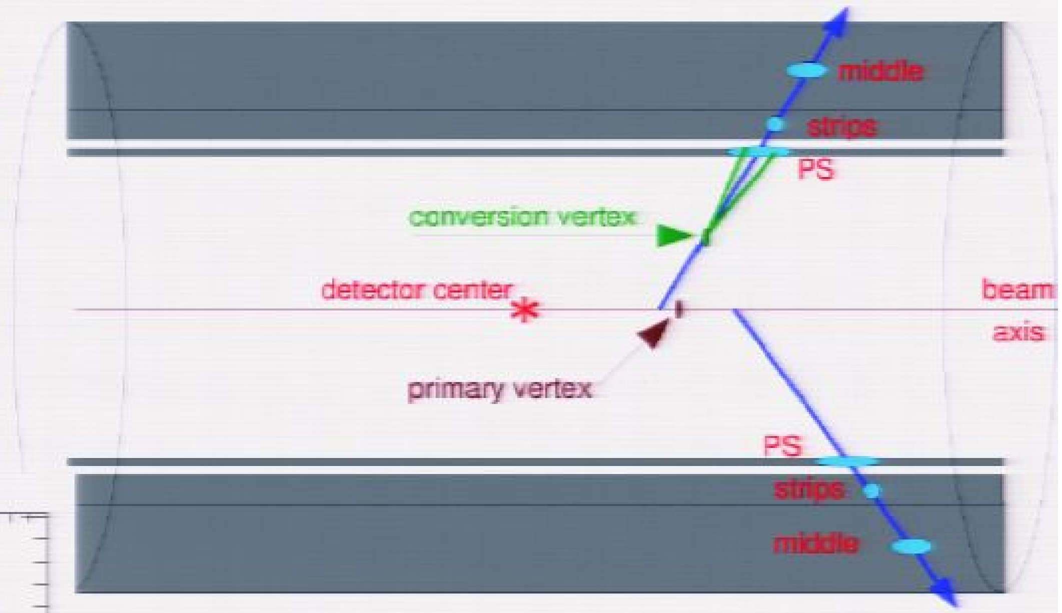
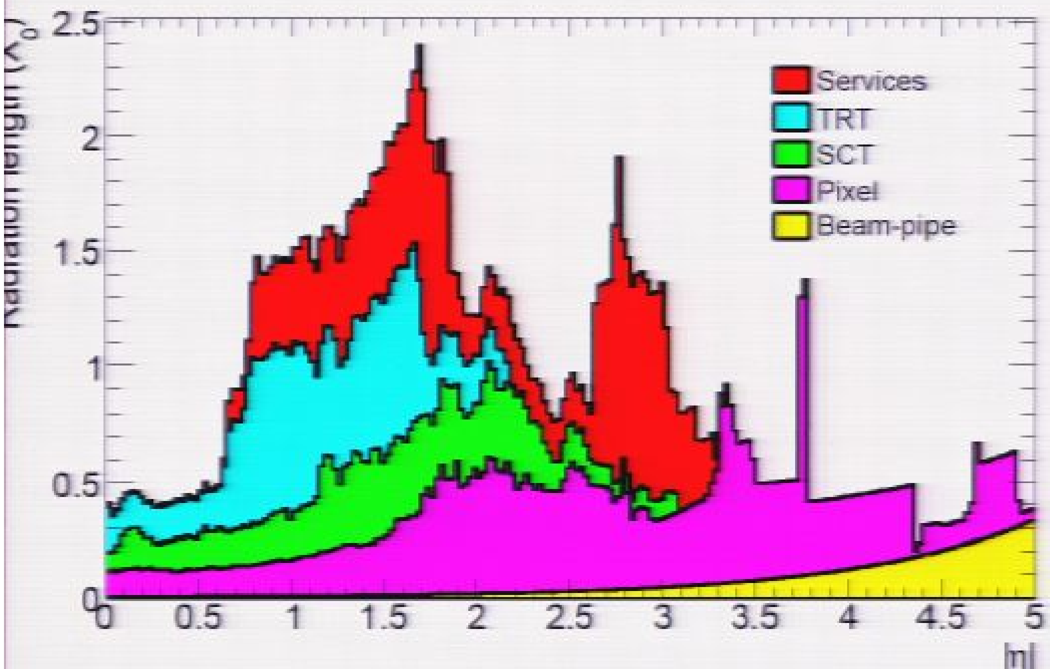


Figure 16: Fake-photon rejection as a function of p_T of the reconstructed photon object for high-p_T binned di-jet samples in the barrel (left) and end-cap (right) calorimeters.

Converted photon

- A photon can convert into two electrons by crossing the Inner Detector
  - 57 % $H \rightarrow \gamma\gamma$ events have at least one converted photon
- A converted photon can start the shower before the first layer of the EM calorimeter





Material in the inner detector as a function of |η|.

Converted photon

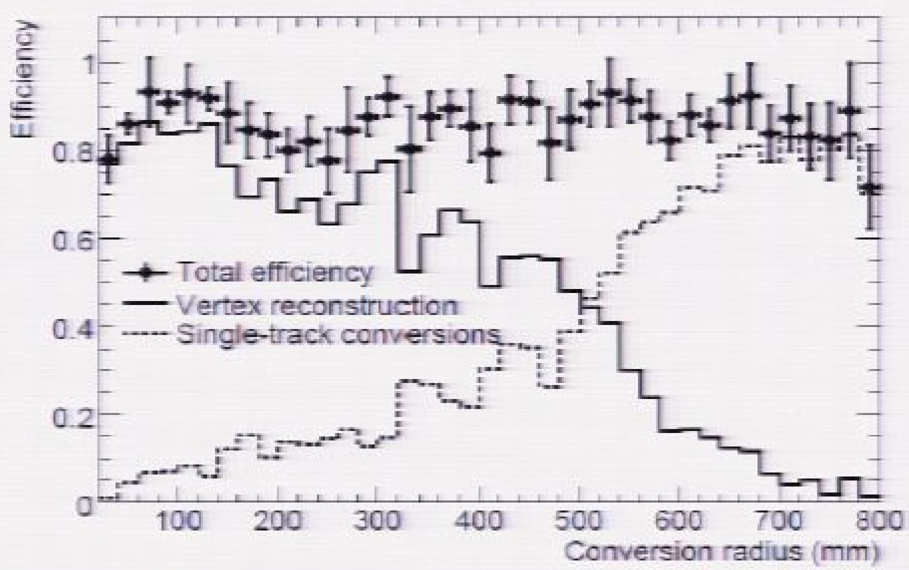
- The electrons coming from the photon conversion :
  - Track in the inner detector
  - Energy deposited in the EM calorimeter
- To reconstruct converted photon :
  - Find the tracks associated to an EM cluster
  - Reconstruct the conversion vertex using the two tracks
- To reconstruct the vertex :
  - All possible pairs of tracks with opposite signs are examined
  - Cuts are applied on each combination :

Cut	Efficiency	Rejection
Polar angle	0.7070	10.8
Radial distance between first hits	0.7049	12.5
Minimum distance	0.6970	16.5
Vertex radius	0.6959	16.6
Minimum arc length	0.6935	40.3
Maximum arc length	0.6890	111.6
Distance in z	0.6870	111.9

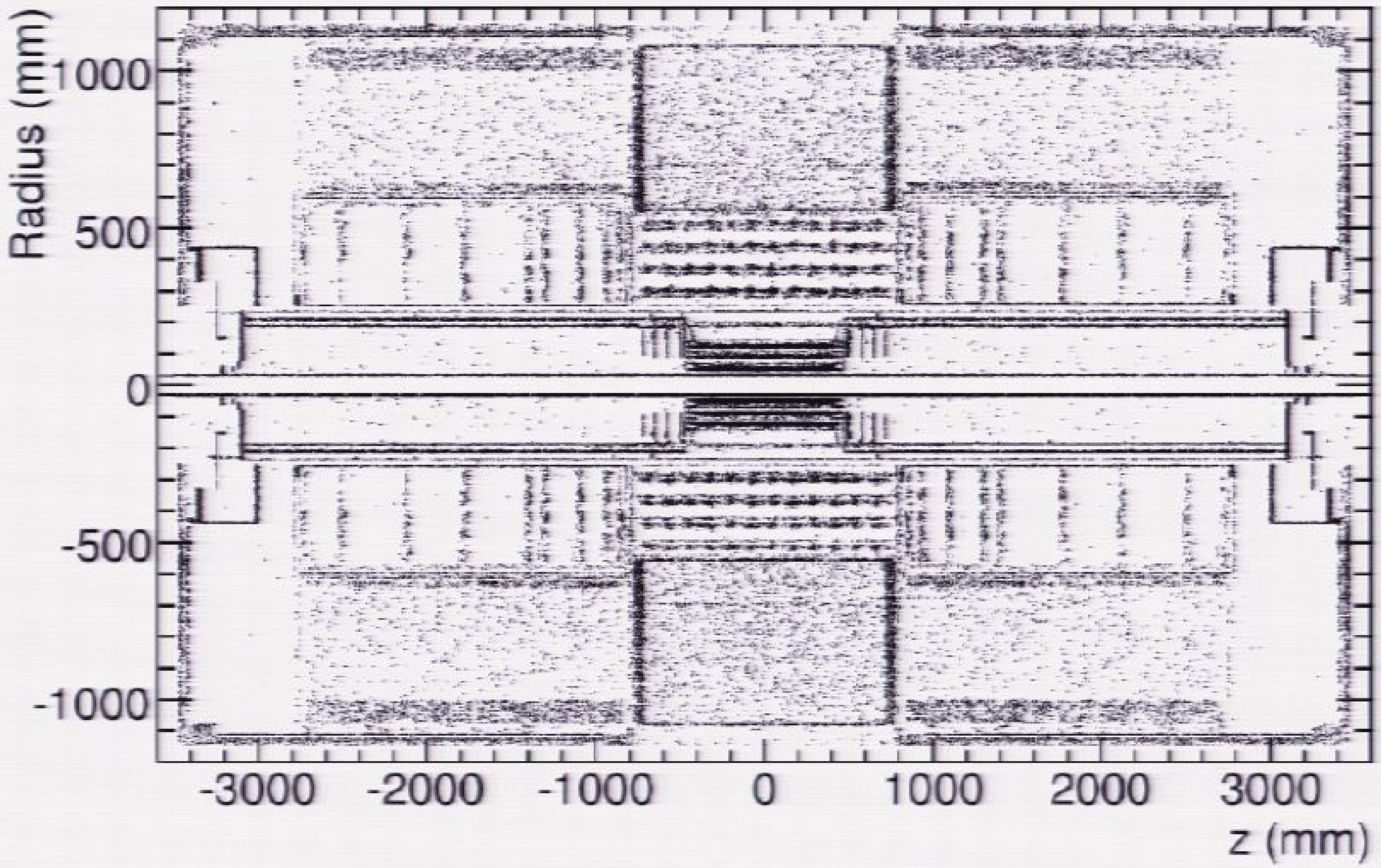
Converted photon

- Single track conversion :
  - Conversions are asymmetric in energy (most of the energy can be given to the electron or positron)
  - Conversion can happen late in the inner detector (TRT)

    => Only one track is reconstructed
  - After having tried to find two tracks passing the cuts, the remaining tracks are examined on an individual basis :
    - To be considered as a single track conversion :
      - First hit beyond the pixel vertexing layer
      - Track should be electron-like using the TRT information
    - Conversion vertex candidate is reconstructed at the position of the first track hit



Mapping of the detector using Converted photons



Location of the inner detector material as obtained from the true positions of simulated photon conversions in minimum-bias events

Conclusions

- Photon reconstruction is necessary for many signal researches
- Due to the low cross-section of these processes :
    - High photon efficiency
    - High background (QCD) rejection
- The selection cuts were developed using MC
    - Could be improved using multi-variable method, but need to know very well the detector