Improvement of the identification of the primary particles in the EM Calorimeter

ECAL LHCb

Moreno Sarria, Diego Milanés, Lorena Bucurú

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ECAL Detector

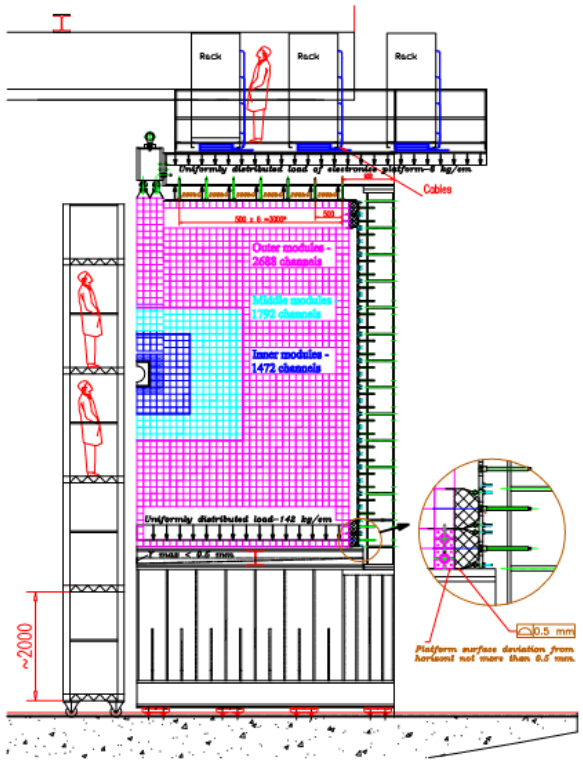

Figure: The ECAL detector

https://cds.cern.ch/record/494264/files/cer-2248788.pdf

ECAL Detector

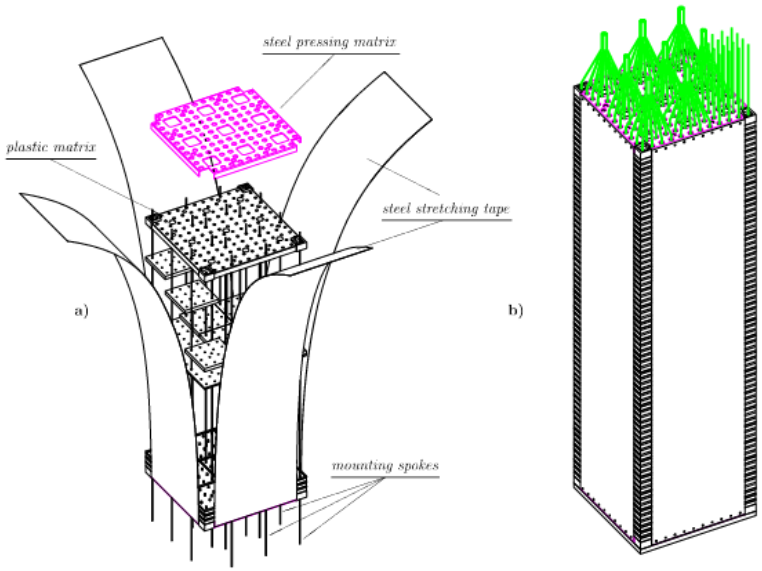

Figure: ECAL module structure

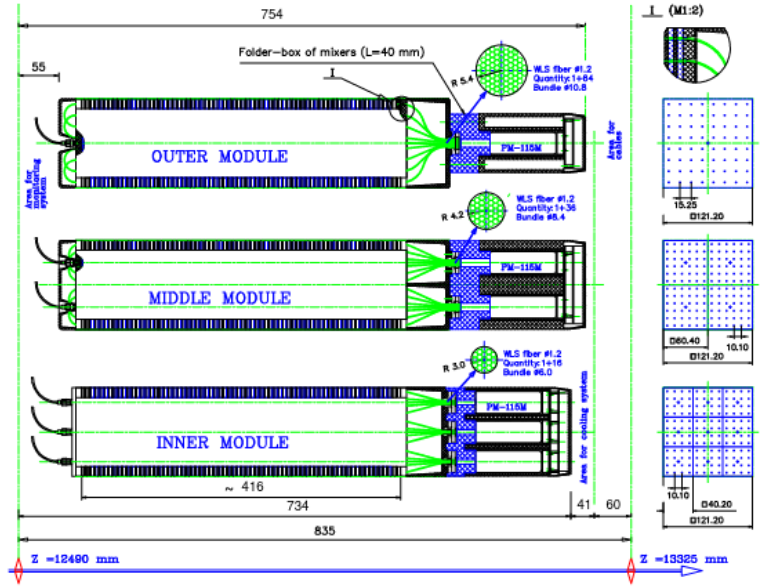

Figure: ECAL sections modules

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Process of interest

For high energies, there are a processes that could be problematic:

1. Neutral pions (π^0) desintegrating in two photons.
2. Similar showers produced by photons and electrons.

ECAL Detector

The Cells of the detector are very large (even for the inner section), making it difficult to identify the primary particle.

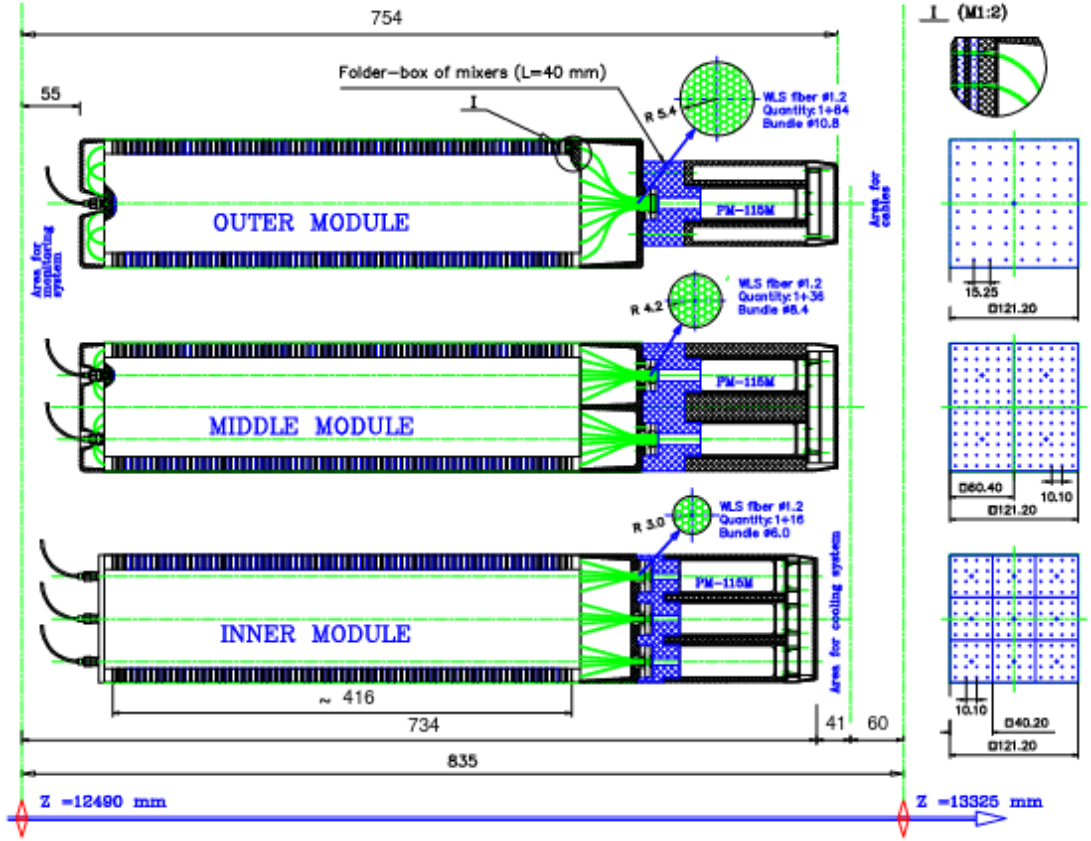

Figure: ECAL sections modules

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ECAL Detector

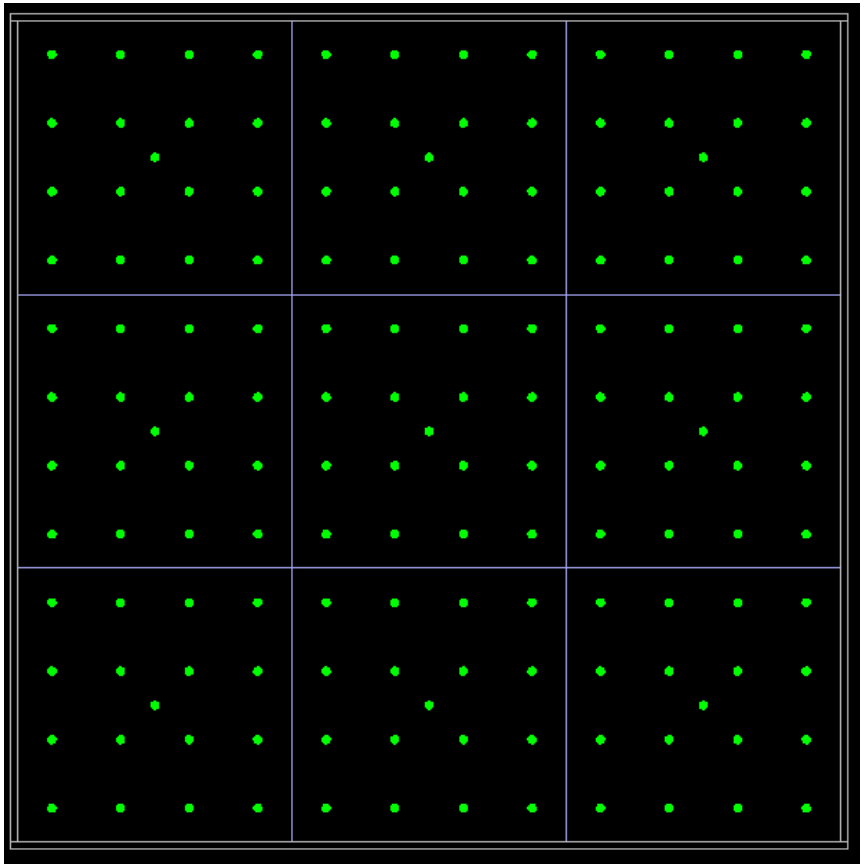

Figure: ECAL module front view

https://cds.cern.ch/record/494264/files/cer-2248788.pdf

Even for the inner section, the granularity is very large to differentiate the events of one photon and a π^0 desintegrating into two nearly parallel photons.

Machine Learning Implementation

A machine learning could be a useful tool to improve the indentification of events with γ, e^- and π^0.

Figure: SciKit Learn library for machine learning implementation in python

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ECAL Geometry

First, reproduce the EM calorimeter geometry. Aerogel was used for the scintillator plates.

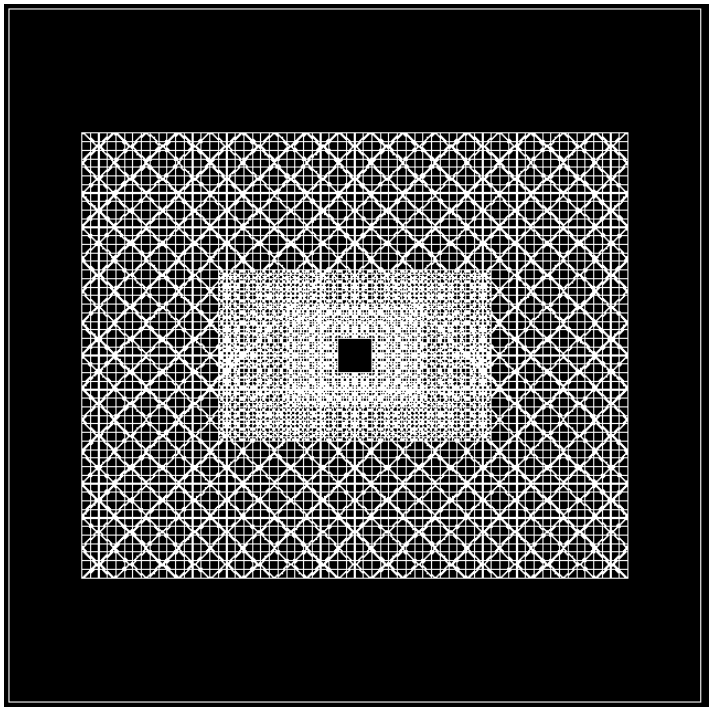


Figure: ECAL geometry in Geant4

ECAL Inner Section Geometry

Isolate the inner section of the calorimeter to study forward events.

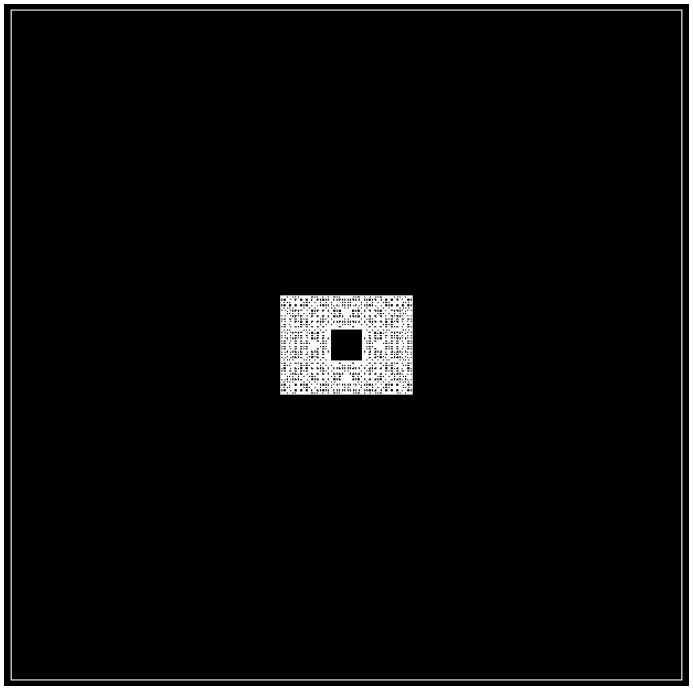


Figure: The geometry of the inner section of ECAL in Geant4

ECAL Inner Section Geometry (Cropped)

After some runs, particles generate a shower in a fraction of the total detector. Therefore, the detector was cropped to concentrate in a narrowed portion of it.

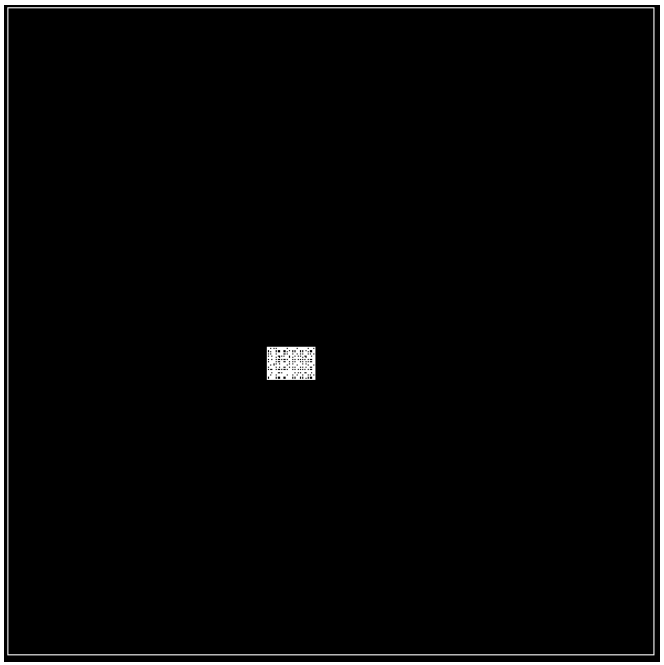


Figure: The geometry of the inner section of ECAL in Geant4

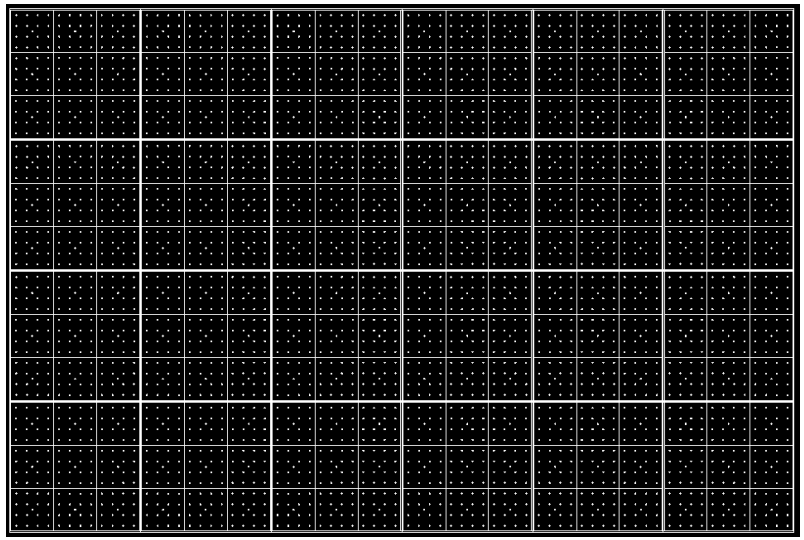


Figure: The geometry of the inner section of ECAL in Geant4 (zoomed)

Distribution of photon production in scintillator plates

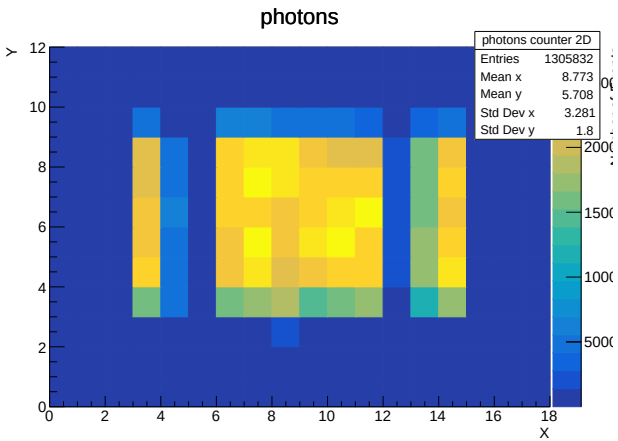


Figure: Distribution of photons production in scintillator plates for a γ primary particle

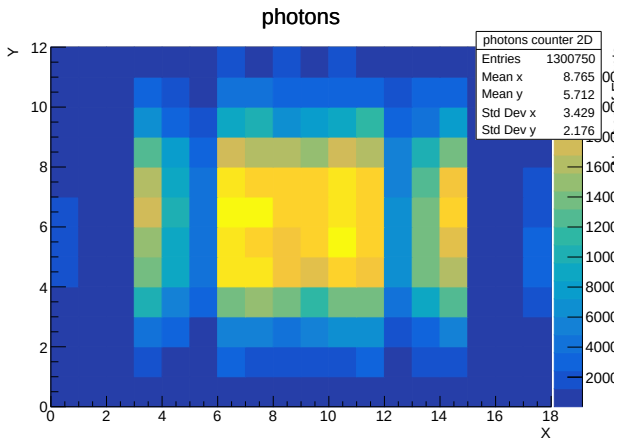


Figure: Distribution of photons production in scintillator plates for a π^0 primary particle

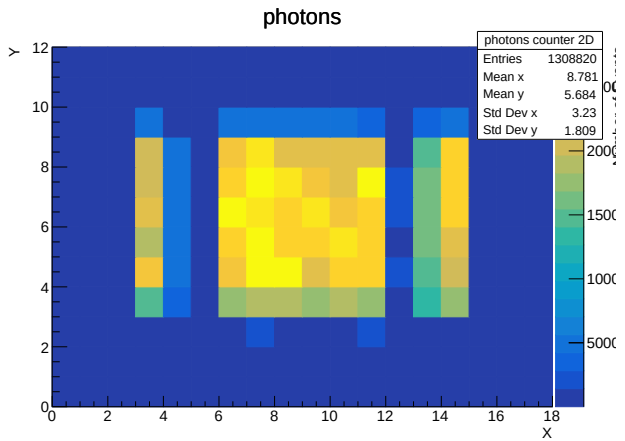
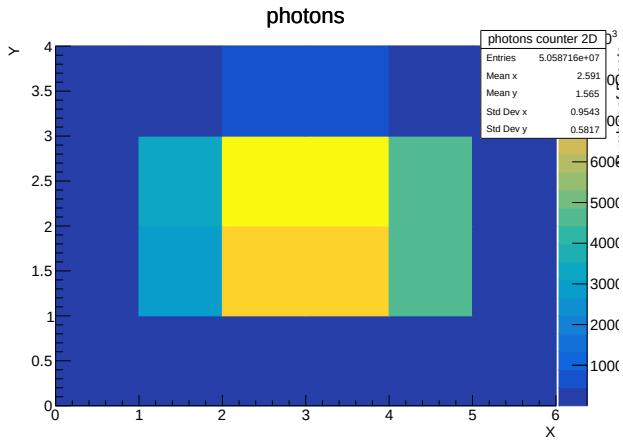


Figure: Distribution of photons production in scintillator plates for a e^- primary particle

Distribution of photon production in lead plates



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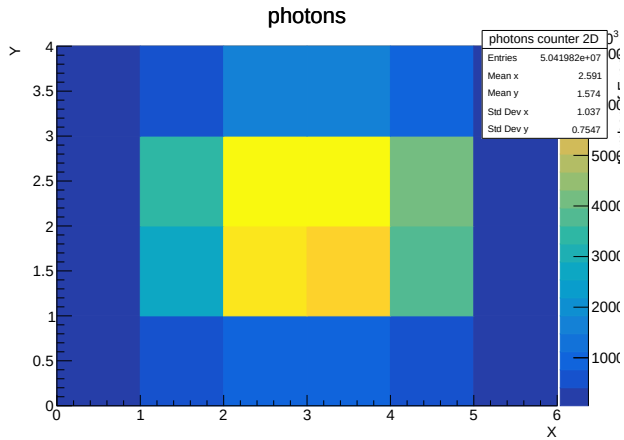

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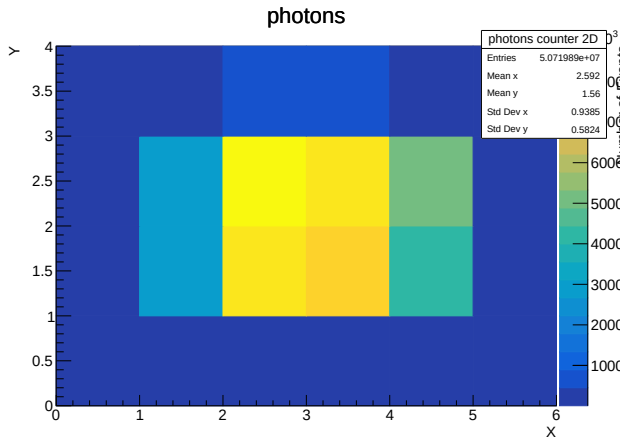

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Distribution of electrons production in scintillator plates

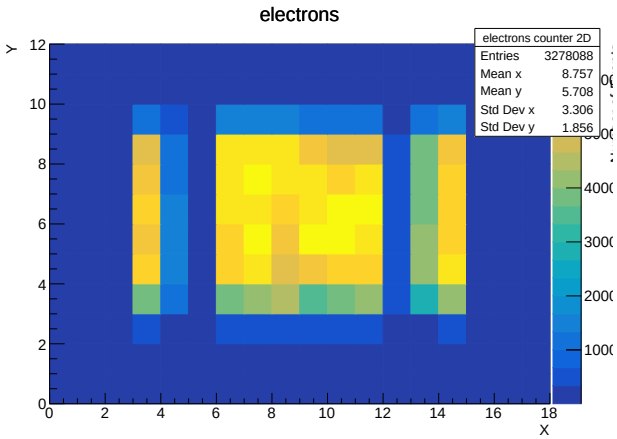
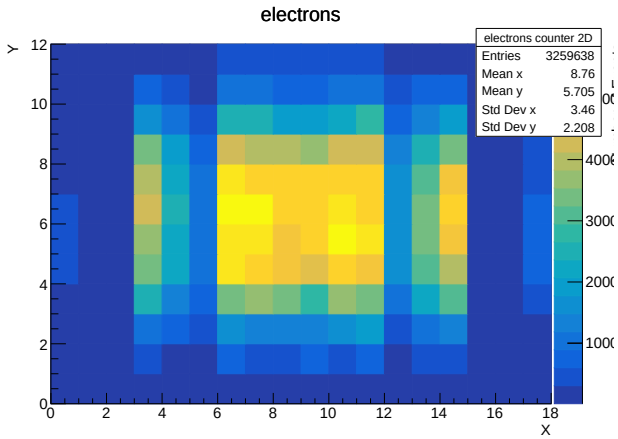


Figure: Distribution of electrons production in scintillator plates for a γ primary particle



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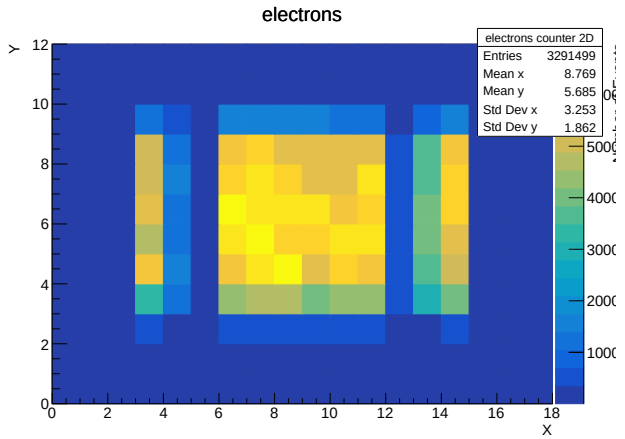

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Distribution of electrons production in lead plates

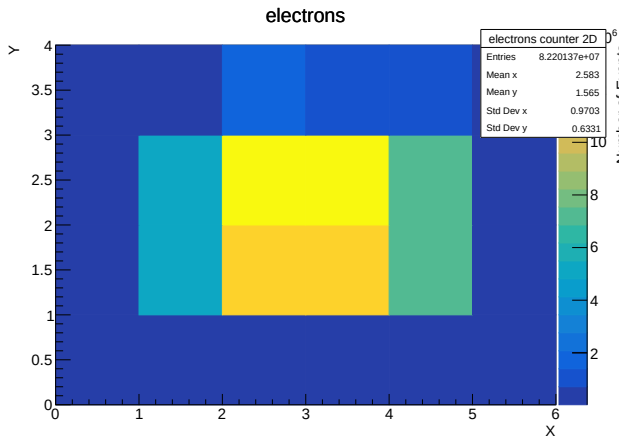
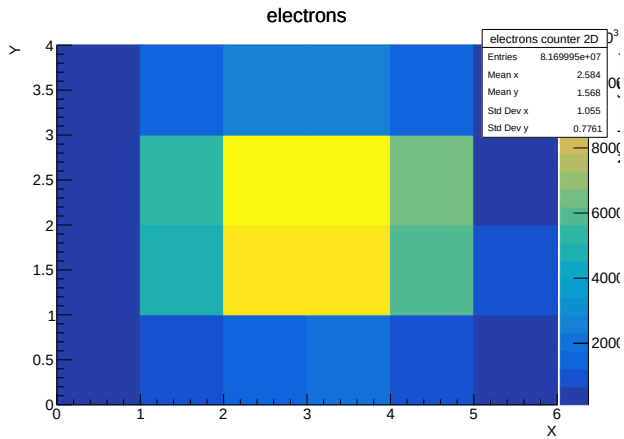


Figure: Distribution of electrons production in lead plates for a γ primary particle



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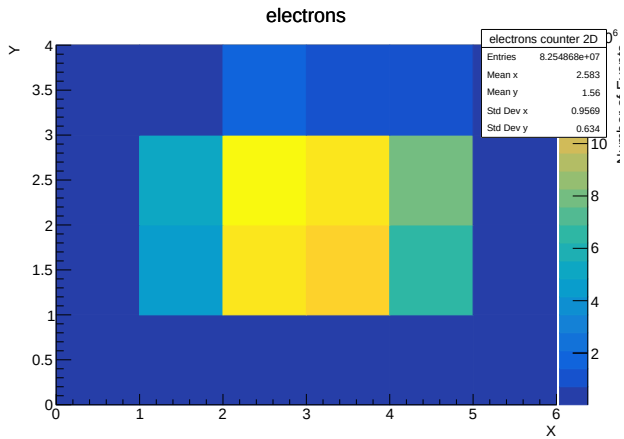


Figure: Distribution of electrons production in lead plates for a e^- primary particle

Distribution of energy deposit in scintillator plates

The energy deposit and step lenght of the particle when it interacts with the plates is also considered.

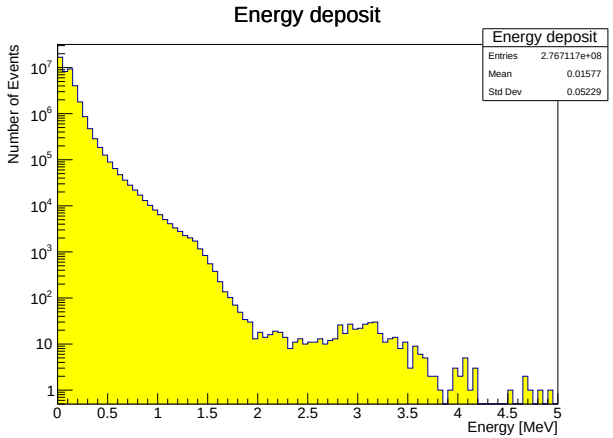
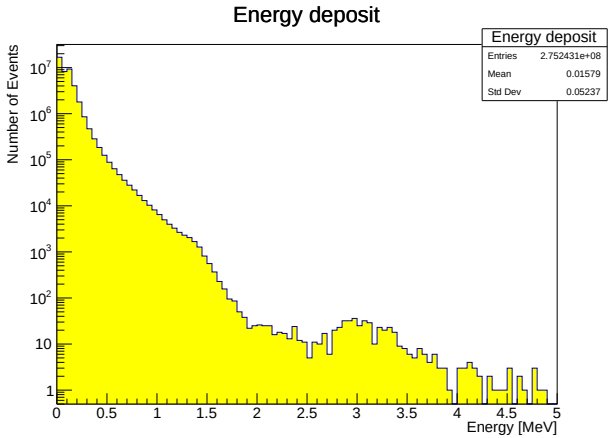


Figure: Distribution of energy deposit of particles interaction with scintillator plates for a γ primary particle



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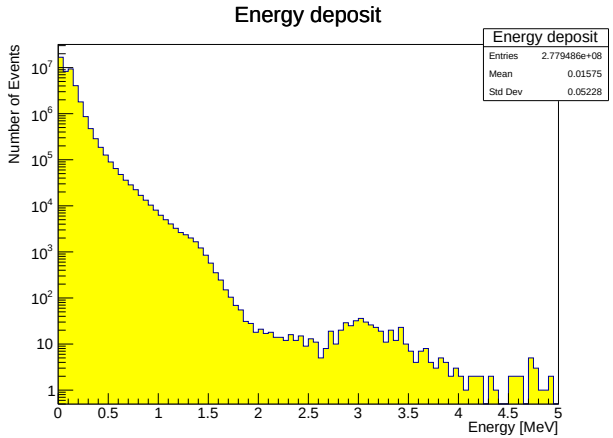


Figure: Distribution of energy deposit of particles interaction with scintillator plates for a e^- primary particle

Distribution of step lenght in scintillator plates

The energy deposit and step lenght of the particle when it interacts with the plates is also considered.

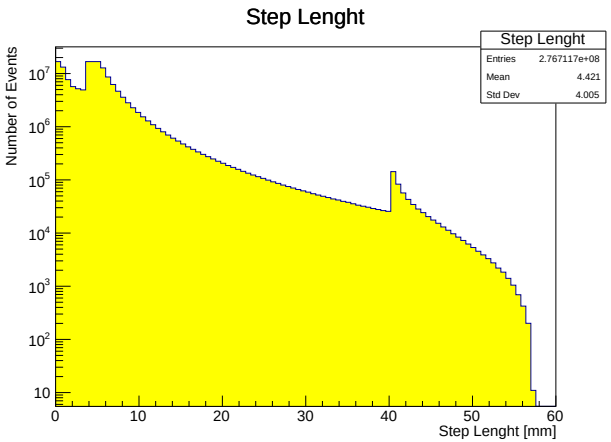
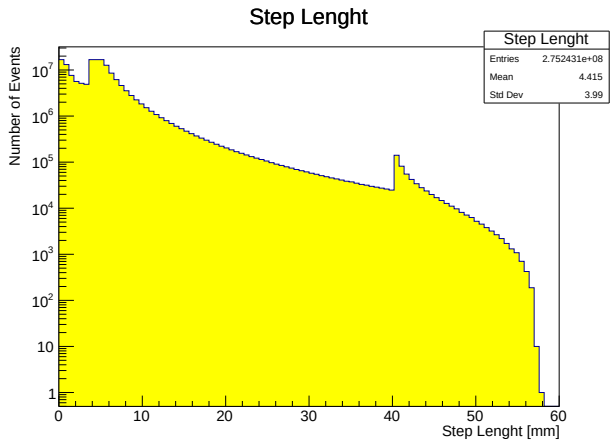


Figure: Distribution of step lenght of particles interaction with scintillator plates for a γ primary particle



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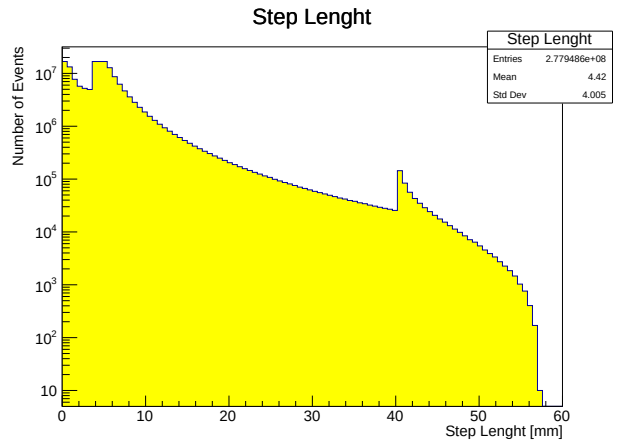


Figure: Distribution of step lenght of particles interaction with scintillator plates for a e^- primary particle

Significative cells

Since, this is considerable information for a classifier, Kolmogorov test is used to collect cells with significative information for the events classification. The test was performed in the distributions of photons and electrons creation in each material for the three possible primaries. This was performed with the energy and the step lenght as well.

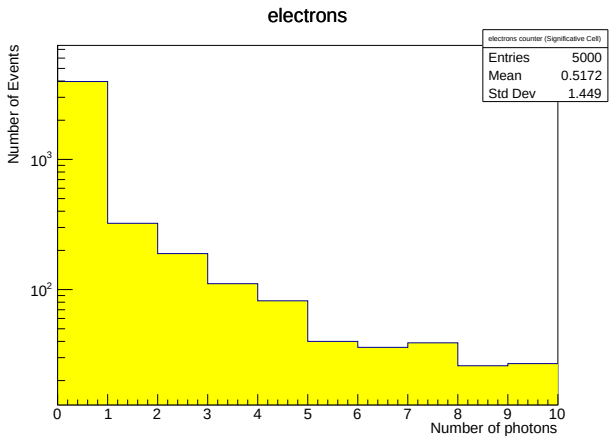
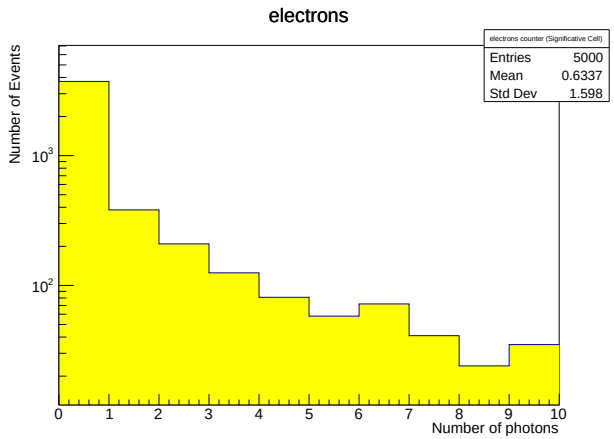


Figure: Number of produced photons in the scintillator for a γ primary particle in a significative cell.



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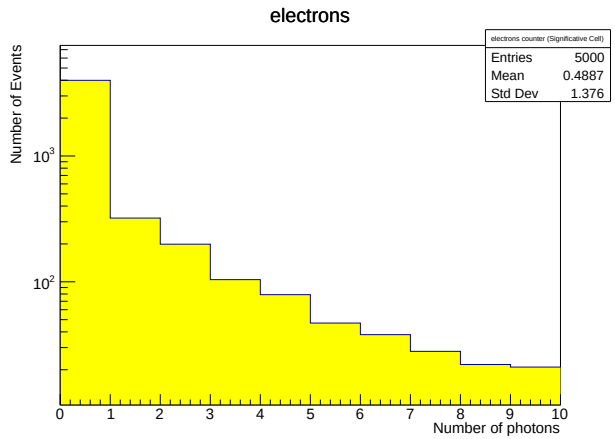

Figure: Number of produced photons in the scintillator for a e^- primary particle in a significative cell.

Non significative cells

Since, this is considerable information for a classifier, Kolmogorov test is used to collect cells with significative information for the events classification. The test was performed in the distributions of photons and electrons creation in each material for the three possible primaries. This was performed with the energy and the step lenght as well.

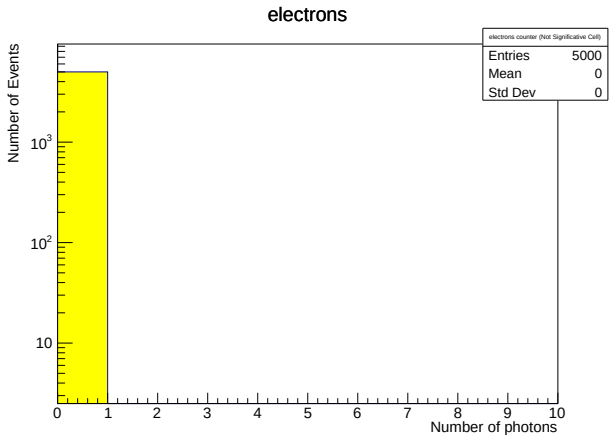

Figure: Number of produced photons in the scintillator for a γ primary particle in a non significative cell.

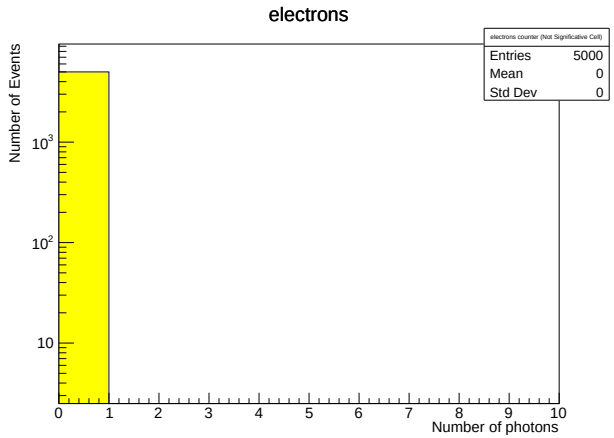

Figure: Number of produced photons in the scintillator for a π^0 primary particle in a non significative cell.

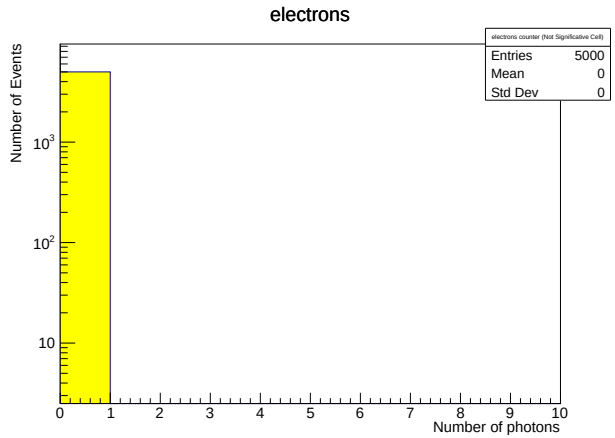

Figure: Number of produced photons in the scintillator for a e^- primary particle in a non significative cell.

Results of the machine learning implementation

Five types of classifiers were tested.

Classifier	Result
MultinomialNB	0.45
BernoulliNB	0.55
Perceptron	0.33
SGDClassifier	0.33
PassiveAggressiveClassifier	0.33

Thank you!