Study of Nearby Effects at the Interaction Point of the PLUME detector at the LHCb

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Overview

1. About the Geant4 Simulation
2. One Module Analysis
3. Two Module Analysis
4. Random Perpendicular Beam
5. Random Angle Beam

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One Module Detector

The detector simulates a module of PLUME. The geometry consists of three cylinders that represent:

- The quartz tablet.
- A PMT window.
- A PMT detector.

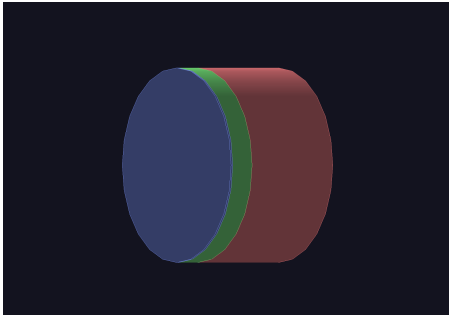

Figure: Sketch of the detector simulates with Geant4.

Two Modules Detector

For some analyses, a second module was implemented at 220 mm from the first module, to represent the two layers of PLUME.

Figure: Sketch of two modules simulated with Geant4.

Primary Beam

For the first part of the analyses, an electron of 6 GeV was shot perpendicularly to the center of the detector.

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Photon Creation in the Quartz

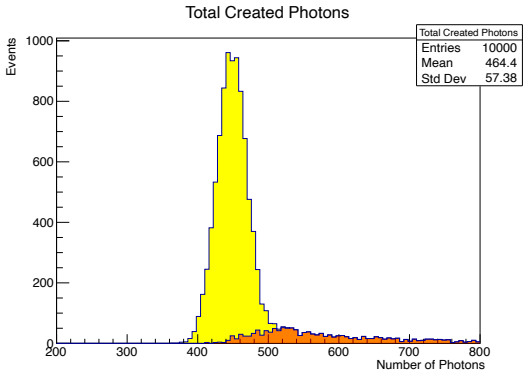

Figure: Histogram of (yellow) the total created photons in the quartz tablet, (red) the total created photons in the quartz tablet where the event has secondary photons.

At first we tried to reproduce the results of the TDR, counting the number of photons created in the quartz tablet. We got a similar shape, but different mean.
We also noticed a tail at large number of created photons. This tail is due to secondary photons.

Secondary electrons creation

The number of secondary electrons was also considered. Those secondary electrons are the responsible of the secondary photons.

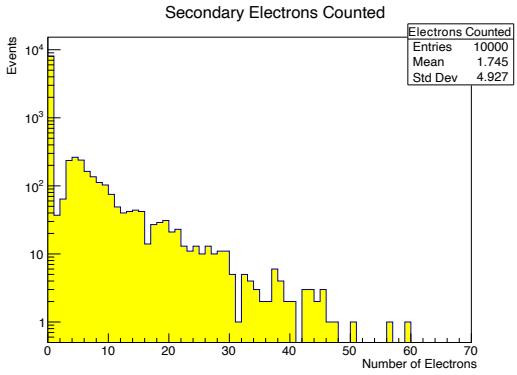

Figure: Secondary electrons produced in the quartz tablet.

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Comparison Between Modules

When the second module was added, we compared the number of created photons in the quartz of each module. Most of the events produce 400 to 500 photons in each module, and the values grater that 600 are due to secondary photons.

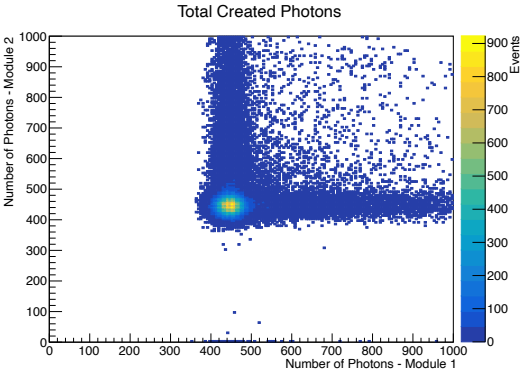

Figure: Photons created in the quartz tablet for each module.

Hit position and Angle

We also studied how the electron reach to the second module. The quartz tablet has a radius of 5 mm, then, for a few events, the electron reach close to the edge of the tablet.

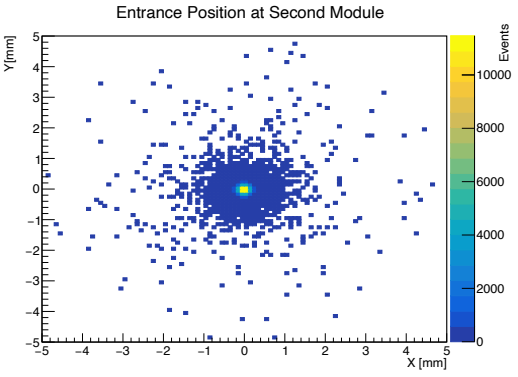

Figure: Position in which the electron hits the second module.

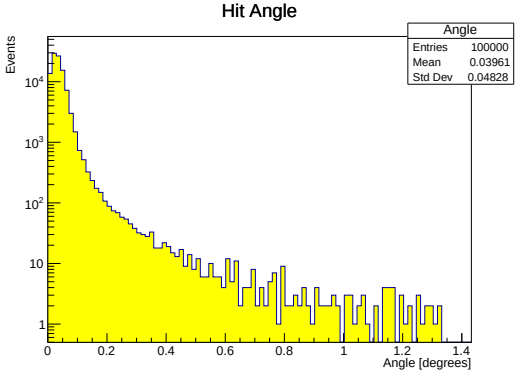

Figure: Azimuthal angle in which the electron hits the second module.

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Primary configuration

For this analysis we configured the primary electron such that:

1. The particle hits perpendicularly the detector.
2. The entrance point is random with an uniform distribution in the effective area.

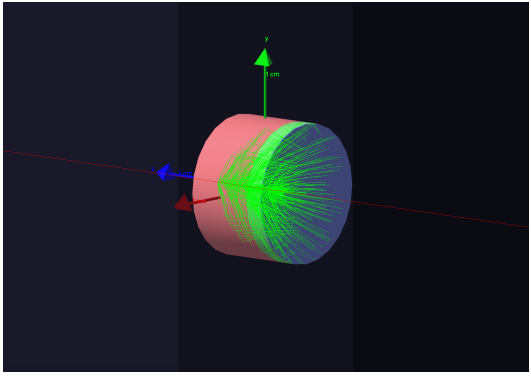

Figure: Sketch of the configuration for random perpendicular analysis.

Zones division

For the analysis we divided the effective area in 5 regions of the same area. With this division, each zone have almost the same amount of events.

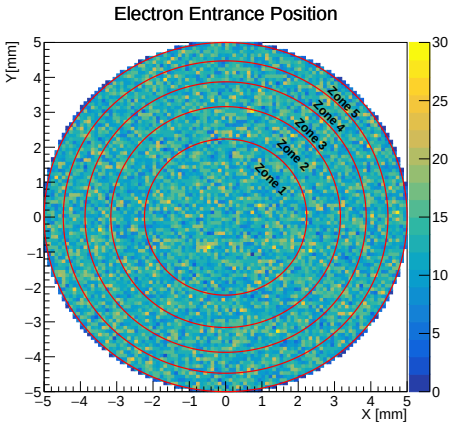

Figure: Division for the effective area.

Photon Creation in the Quartz Tablet

For this configuration, integrating over all the zones, .

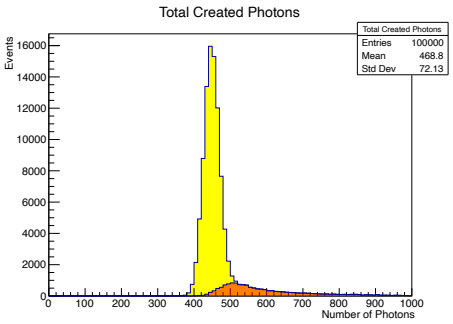

Figure: Histogram of (yellow) the total created photons in the quartz tablet, (red) the total created photons in the quartz tablet where the event has secondary photons.

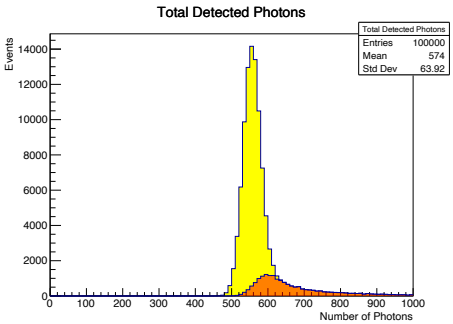

Figure: Histogram of (yellow) the total detected photons in the quartz tablet, (red) the total created photons in the quartz tablet where the event has secondary photons.

Mean Detected Photons in the Quartz

For this case, the mean of reflected photons is much smaller than the number of photon with no reflections in the detector module.

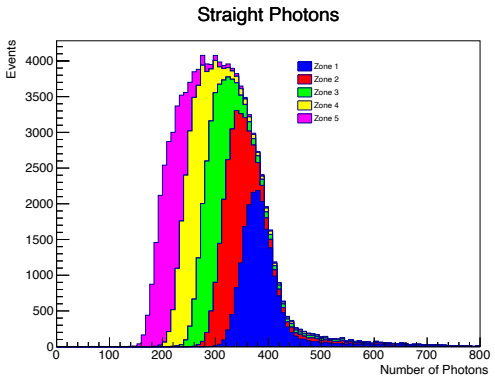

Figure: Photons with no reflections produced in the quartz tablet.

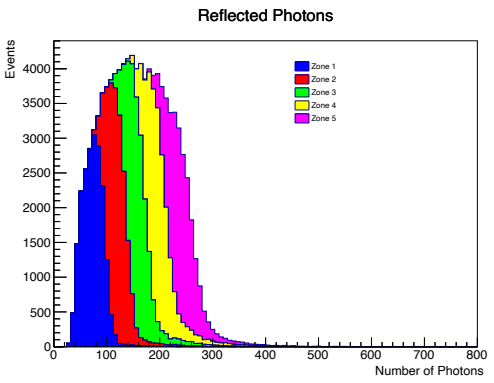

Figure: Photons with at least one reflection produced in the quartz tablet.

Photon Detection by Position

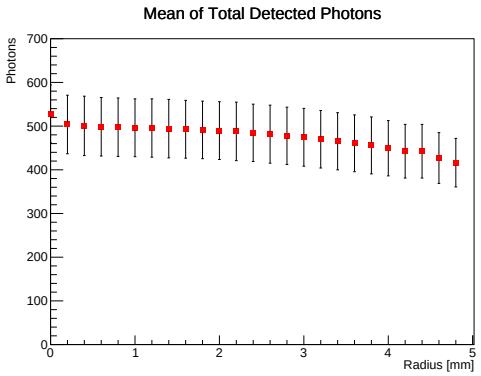

Figure: Mean of total detected photons depending on the entrance position of the primary electron.

As it is shown, the number of photons that are detected decreases as the primary electron hits the detector module closer to the module.

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Primary configuration

In this configuration the primary particle:

1. Starts at the beginning of the detector.
2. The azimuth varies in an uniform distribution from 0 to 60 degrees.

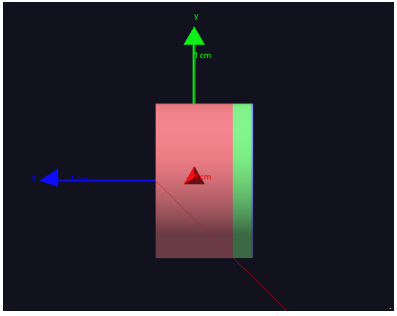

Figure: Sketch of the configuration for random angle analysis.

Photons Created in the Quartz

For the total photons created in the quartz, we got similar results as in the analysis performed by shooting the particle perpendicularly to the center of the cylinder.

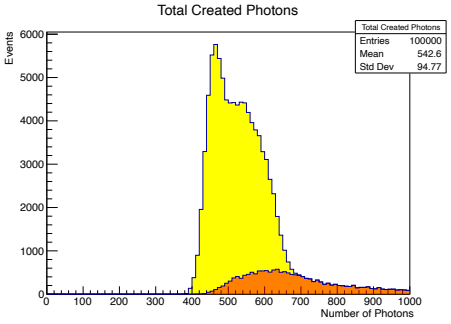

Figure: Histogram of (yellow) the total created photons in the quartz tablet, (red) the total created photons in the quartz tablet where the event has secondary photons.

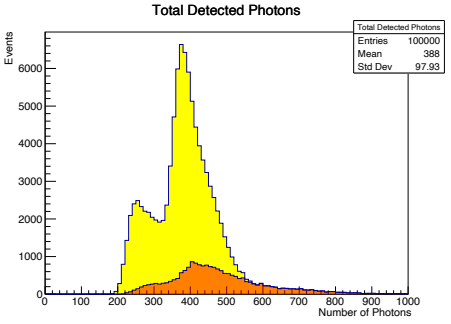

Figure: Histogram of (yellow) the total detected photons in the quartz tablet, (red) the total created photons in the quartz tablet where the event has secondary photons.

Mean Detected Photons in the Quartz

Moreover, the mean number of straight photons is larger than the mean number of reflected photons.

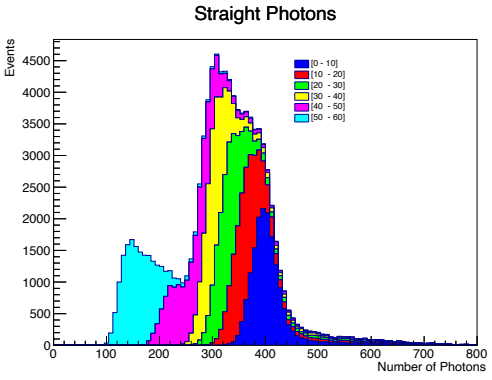

Figure: Photons with no reflections produced in the quartz tablet.

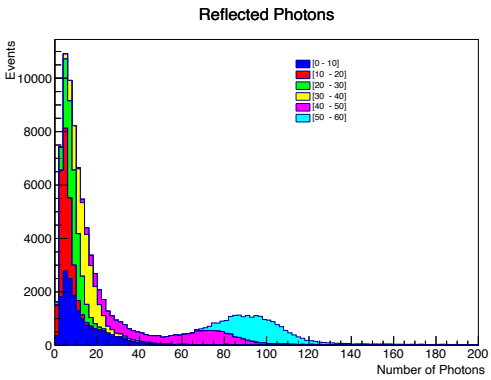

Figure: Photons with at least one reflection produced in the quartz tablet.

Mean Detected Photons in the Quartz

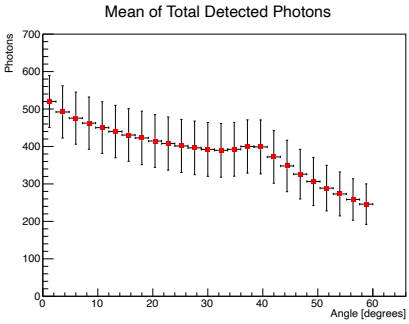

Figure: Mean of total detected photons for a given hit angle.

We considered the detected photons. A photon is considered detected when it arrives the PMT detector tablet (the last cylinder in the simulation). The mean number of detected photons was taken for 25 ranges of angles between 0 and 60 degrees.

Conclusions

From these analyzes, we can say that:

1. The number of Photons produced by the primary electron has a normal distribution, the secondary photons add a tail at the end of the distribution.
2. If the particle hits perpendicularly the detector randomly in the effective area, the results are similar that the beam hitting the center of the quartz.
3. When the azimuthal angle varies, the distribution of detected and created photons change. It is due to geometrical reasons, and because some photons do not reflect inside the quartz, escaping the detector.

Next steps

Finally, we are working on:

1. Add a recovery cylinder to the module.
2. Add a glue layer between the Quartz and the PMT window.

The End