Calorimeter Geometric Factor

Calo meeting 28/04/2023

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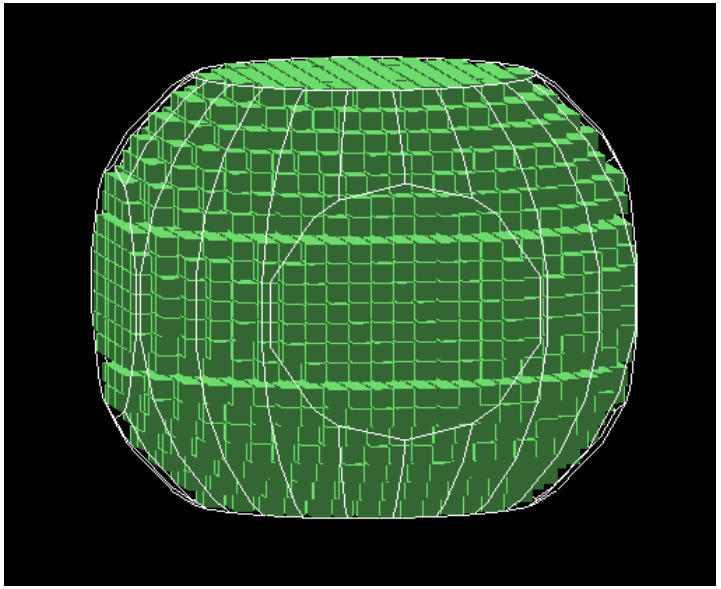
Detector Geometry

HerdSoftware
Calorimeter version: spherical
Calorimeter filler: carbon fiber (2.000 g/cm^3)



LYSO crystals with PhotoDiode Packages

Empty space in the envelope is filled with carbon fiber

HerdSoftware Algorithms

Base of analysis:
-CaloTrackInfoAlgo: estimate various types of track (in LYSO, in CALO envelope,…)

-CaloAcceptanceCut: select only events on the base of track length and distance of the track from the CALO envelope

-PolarAngleCut: select only events inside a certain polar angle: simulate earth shadow

CaloAcceptanceCut Algorithm

Different track types:

- TrackLengthCaloCm: track in CALO envelope in cm
- TrackLengthCaloX0: approximated track in CALO envelope in X0 (used a mean radiation length of the calo to transform cm in X0)
- TrackLengthLYSOX0: approximated track length in LYSO (calculated from the track length in CALO envelope)
- ExactTrackLengthCaloX0: exact track length in CALo envelope in X0 (calculated considering the intersections of the track with every crystal)
- ExactTrackLengthLYSOX0: exact track length in LYSO in X0 (calculated considering the intersections of the track with every crystal)

CaloAcceptanceCut Algorithm

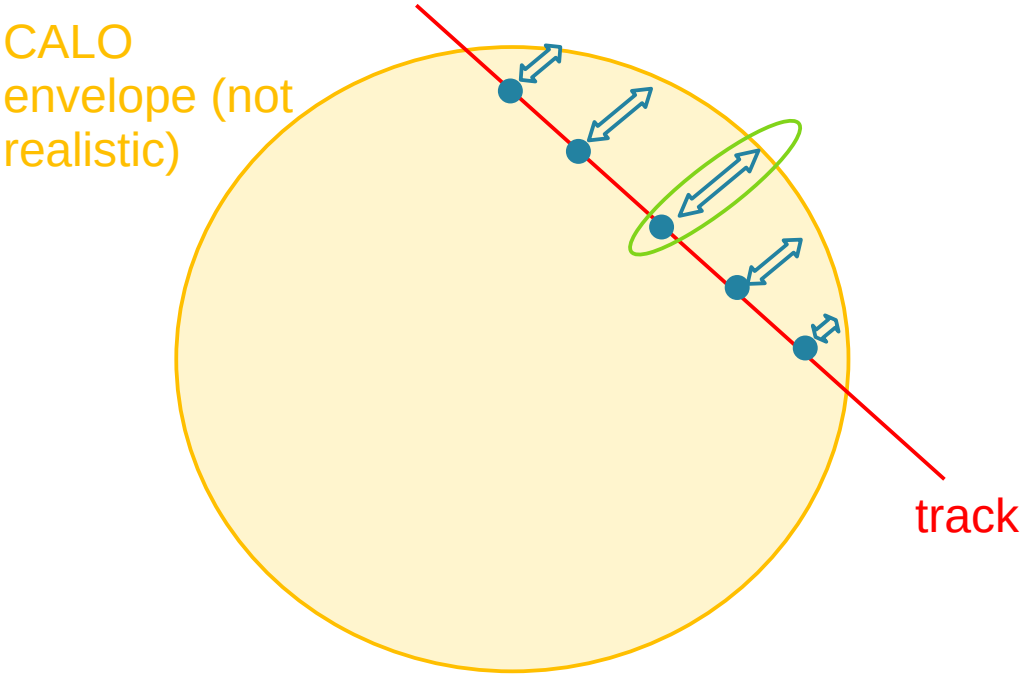
Different track types:

- TrackLengthCaloCm: no info on how much active volume (LYSO) is traverdsed by the track
- TrackLengthCaloX0: no info on how much active volume (LYSO) is traverdsed by the track and approximation of using a mean radiation length of the calo
- TrackLengthLYSOX0: approximated
- ExactTrackLengthCaloX0: exact track length in CALO envelope in X0
- ExactTrackLengthLYSOX0: exact track length in LYSO in X0

CaloAcceptanceCut Algorithm

Another cut on the trackMaxDistanceFromEnvelope variable:
-5 point at a distance of 1/6 of track length in cm are selected
-their distance from the envelope is estimated
-the biggest of these distances is compared with trackMaxDistanceFromEnvelope:

if > → event is accepted
if < → event is rejected



Simulations

Very High statisics of geantini simulated: 10^6 (but a lot more are not simulated but taken into account thanks to checkAcceptance in simulation datacard)
Generation surface: spherical

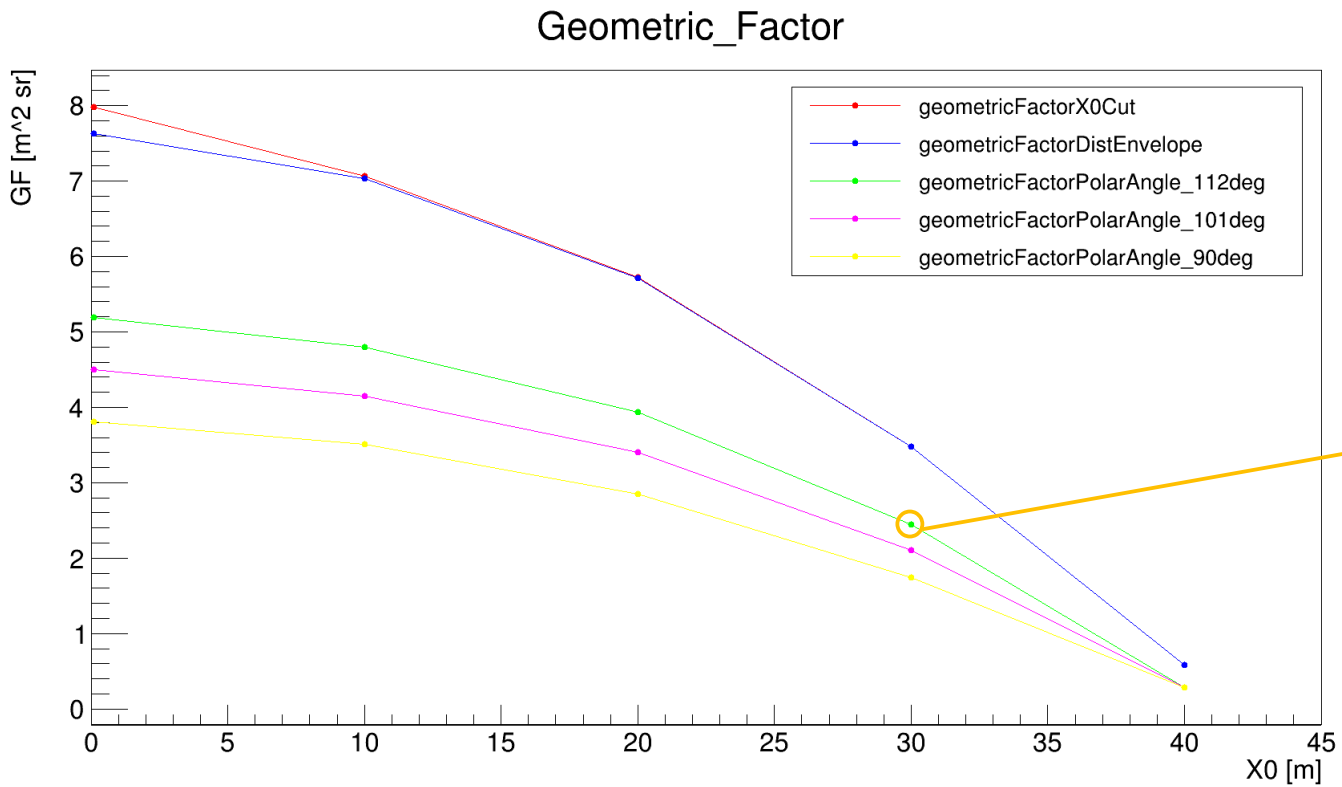
Geometric Factor Calculation

$GF_{generation\_surface} = 4 * pi * pi * R * R$

R = radius of the generation surface

$$GF_{calorimeter} = GF_{generation\_surface} * N_{selected} / N_{tot}$$

Geometric Factor - ExactTrackLengthLYSOX0



2.44 m^2 sr

Geometric Factor

Selections:
30 X0
1 RM
112 deg

Track Type	Geometric Factor [m^2 sr]
• ExactTrackLengthLYSOX0	2.44
• ExactTrackLengthCaloX0	2.70
• TrackLengthLYSOX0	2.21
• TrackLengthCaloX0	2.54

The mean radiation lightens LYSO and loads carbon fiber

Track length in X0 are very similar to ExactTrackLength in X0 only for random directions, not for preferential ones

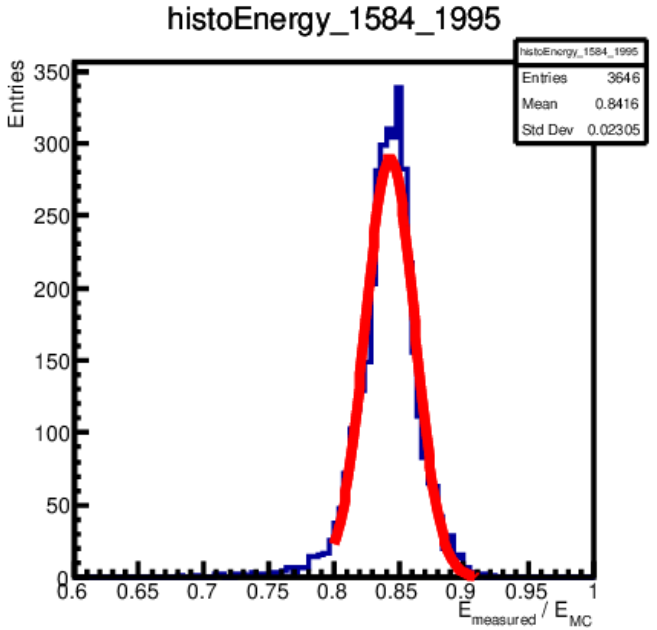
Energy resolution for electrons

Hypotesis

- About 3*10^5 electrons simulated in energy range 100 GeV – 20 TeV with spectrum E^{-1}
- Only Monte Carlo truth is used
- Analysis for energy bin (bin equal log x: every energy bin has the same simulated statistics)

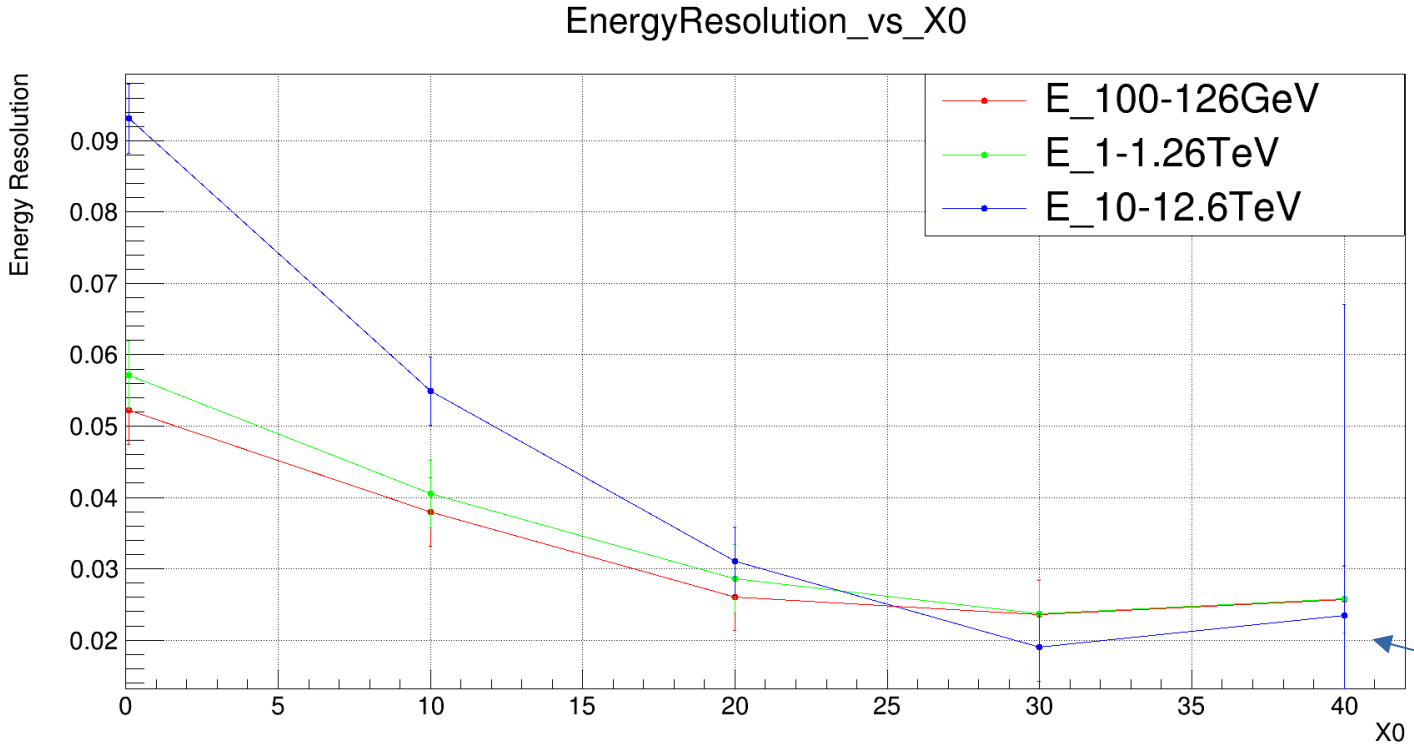
Confidence level method

- Perform a selection on the events based on total exact track length in LYSO
- Build histogram of (energy measured / primary energy)
  - Energy measured = sum of energy releases in every crystal
- Find the peak of the histogram with a Logarithmic Gaussian fit
- Integrate bin right and left to reach 68% of total events in the histogram



Histogram built with a selection of minimum exact track length in LYSO of 30 X0

Energy resolution

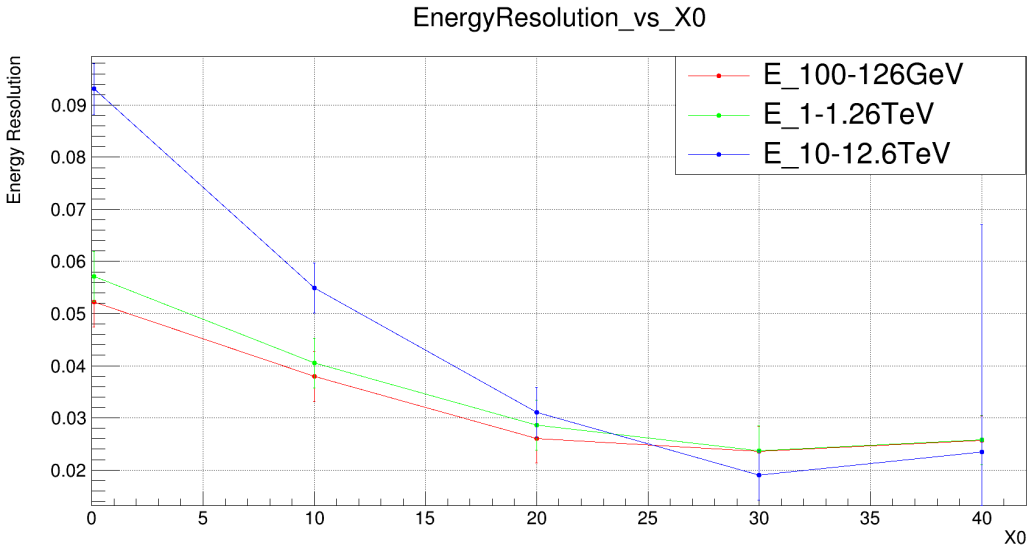


To be updated using a much bigger statistics

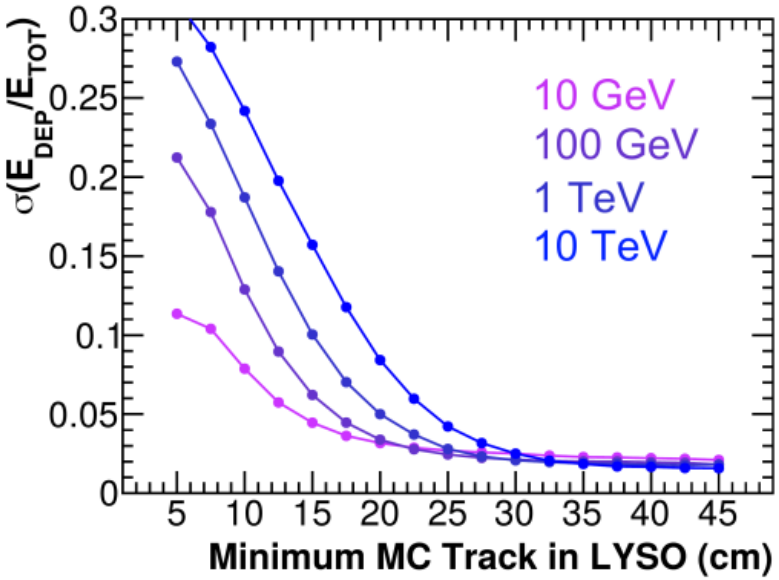
Bad fit, just a matter of small statistics used up to now in this study

Spherical vs Prysmatic Calo

Spherical CALO

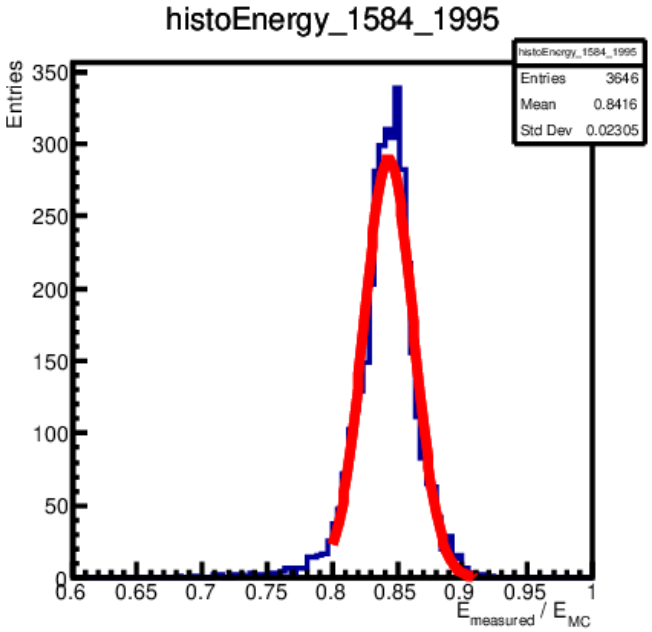


Prysmatic CALO



- Similar performance for strong X0 track length cuts
- Much better performance for spherical CALO for low X0 track length cuts

Energy lost



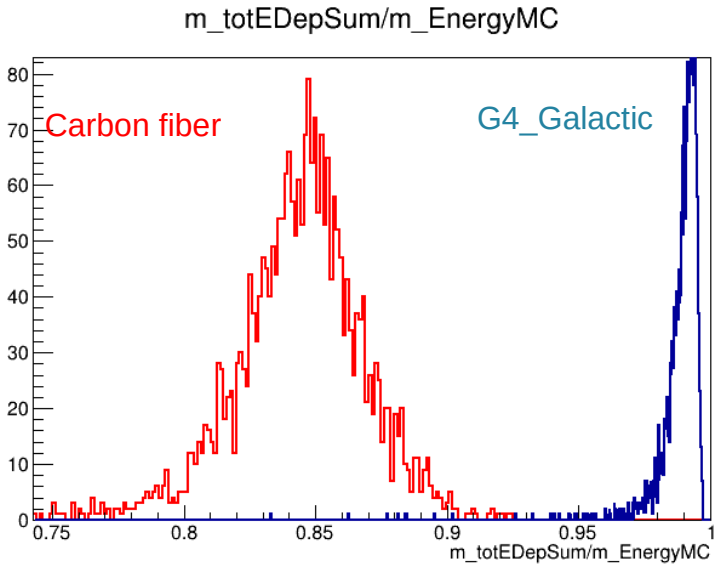
We observed in all the energy range studied (100 GeV – 20 TeV) that the energy released in the crystals is peaked at 85% of the primary energy. Where is the energy lost?

Energy lost

Simulated 10^4 electrons @ 100 GeV
Two different geometries:

-CALo filler is carbon fiber (that of the previous slides)

-CALO filler is G4_Galactic (very near to vacuum)



If the empty spaces between crystals are filled with G4_Galactic, more than 99% of the primary energy is released in the crystals → a lot of energy is lost in the carbon fiber