Measuring the electron energy:
a first study using GEANT4

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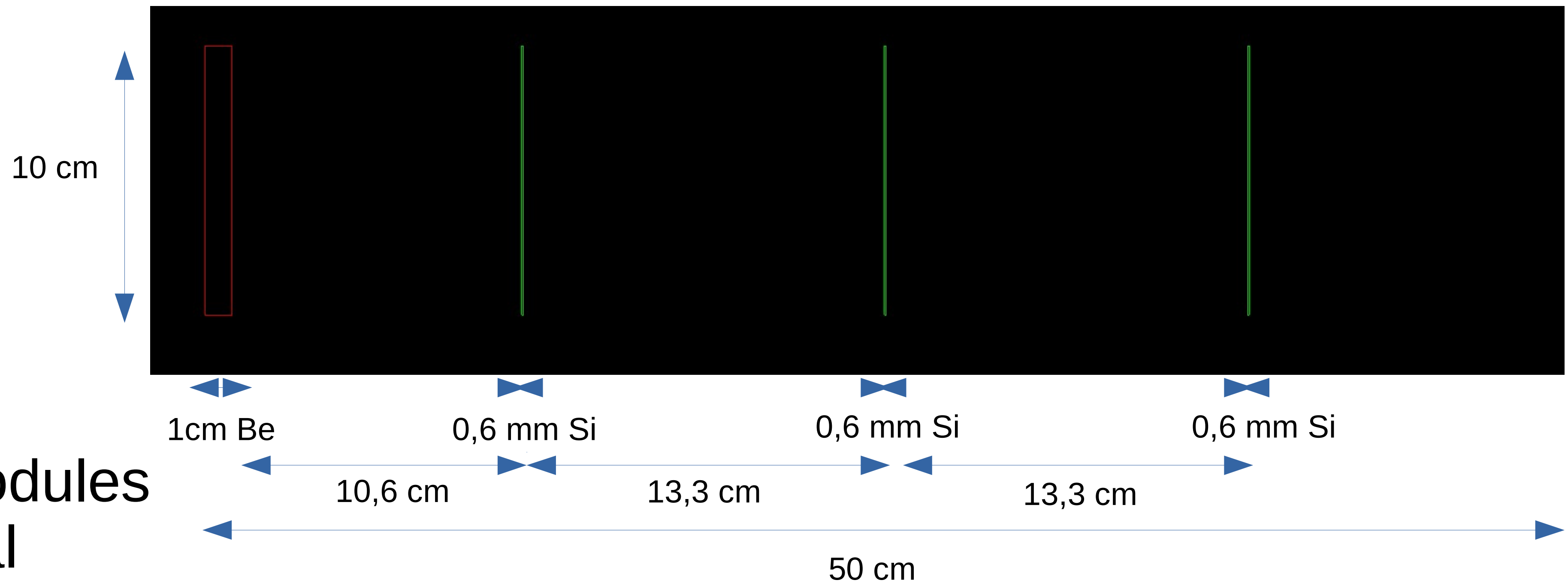
Apparatus setup

Single module:

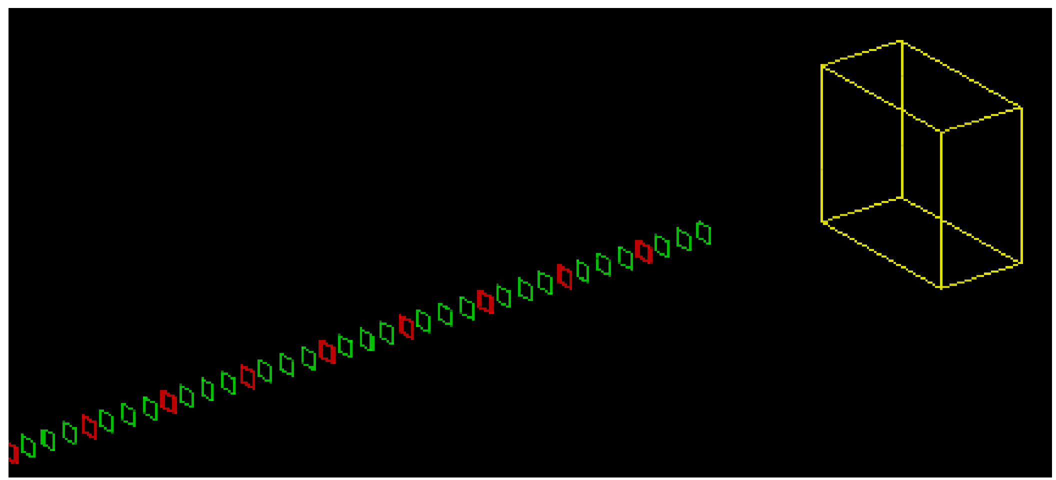


50 modules in total

CsI Calorimeter: 50 cm thickness ~27X_0

1 m x 1 m

Distance between last Si and CsI calorimeter: 1 m



Only the energy deposit of the e^- in the calorimeter is plotted (the muon is removed)

STEP 1: $\theta_e = 0$ $\varphi_e = 0$, $E_e = 1, 2, 10$ GeV. e^- start at 1st module

Start at the center of Be: Multiple Scattering

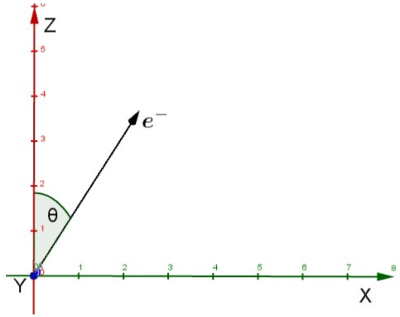
angular spread of ~2 mrad on θ_e (at E_e~1 GeV)

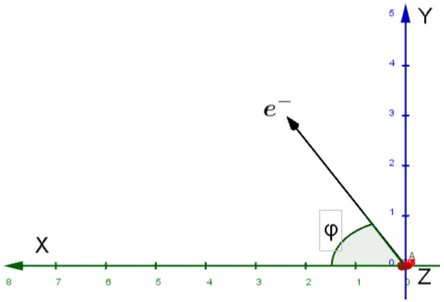
1.a) E_e = 1 GeV

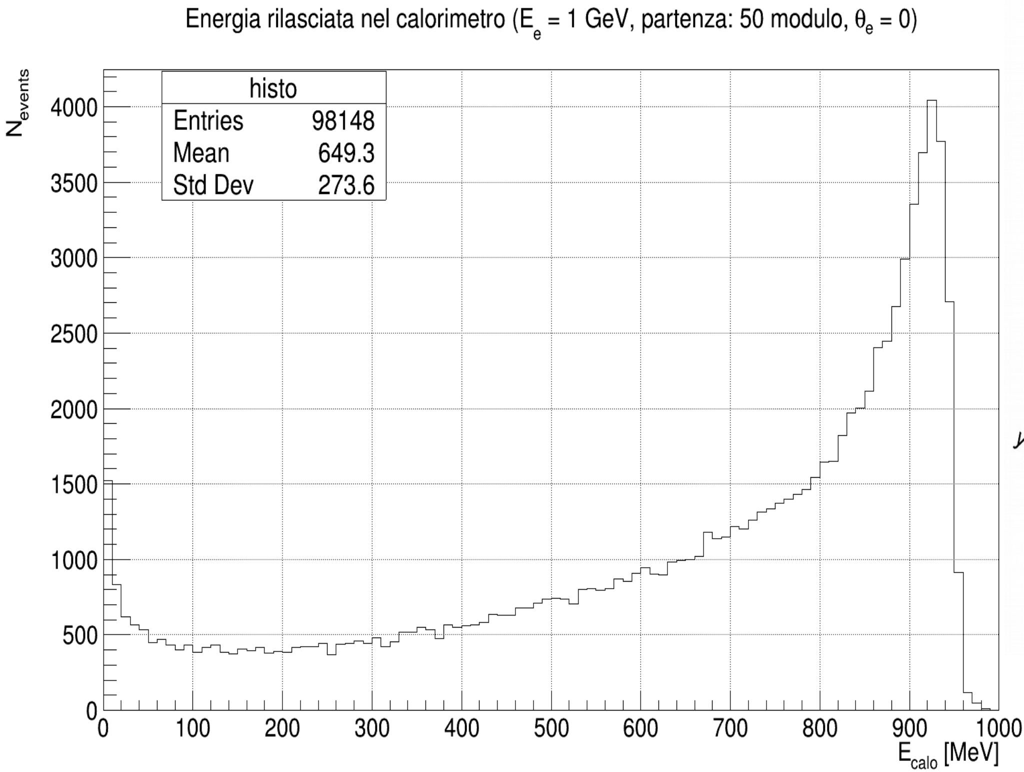
N_e = 100k

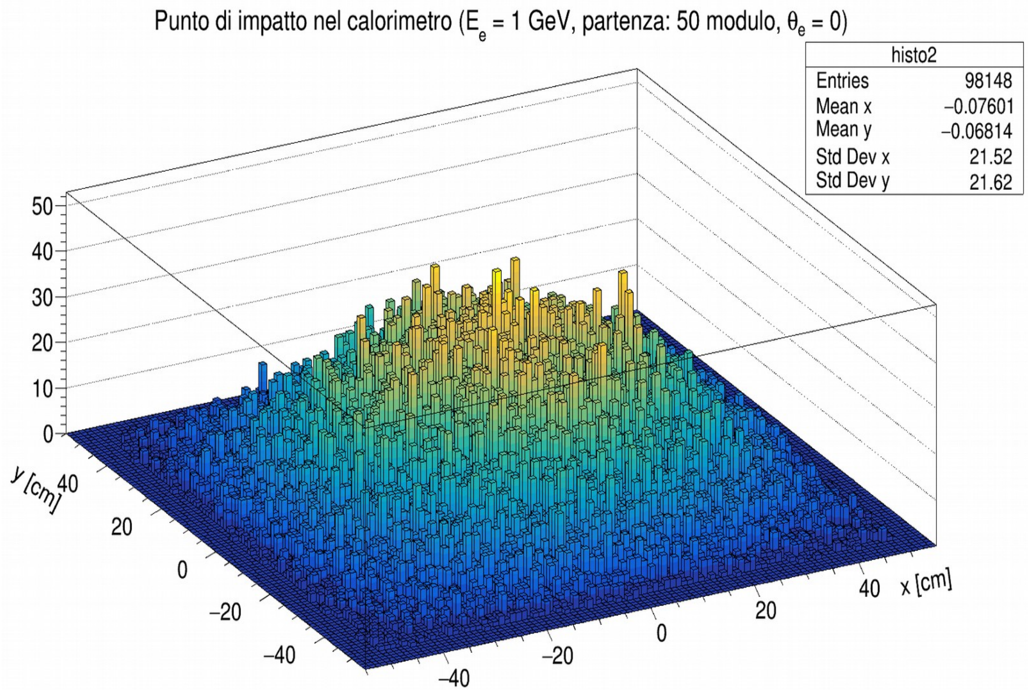
N_e (E_{cal}>0) = 98148

- ~98% of electrons reach the calorimeter





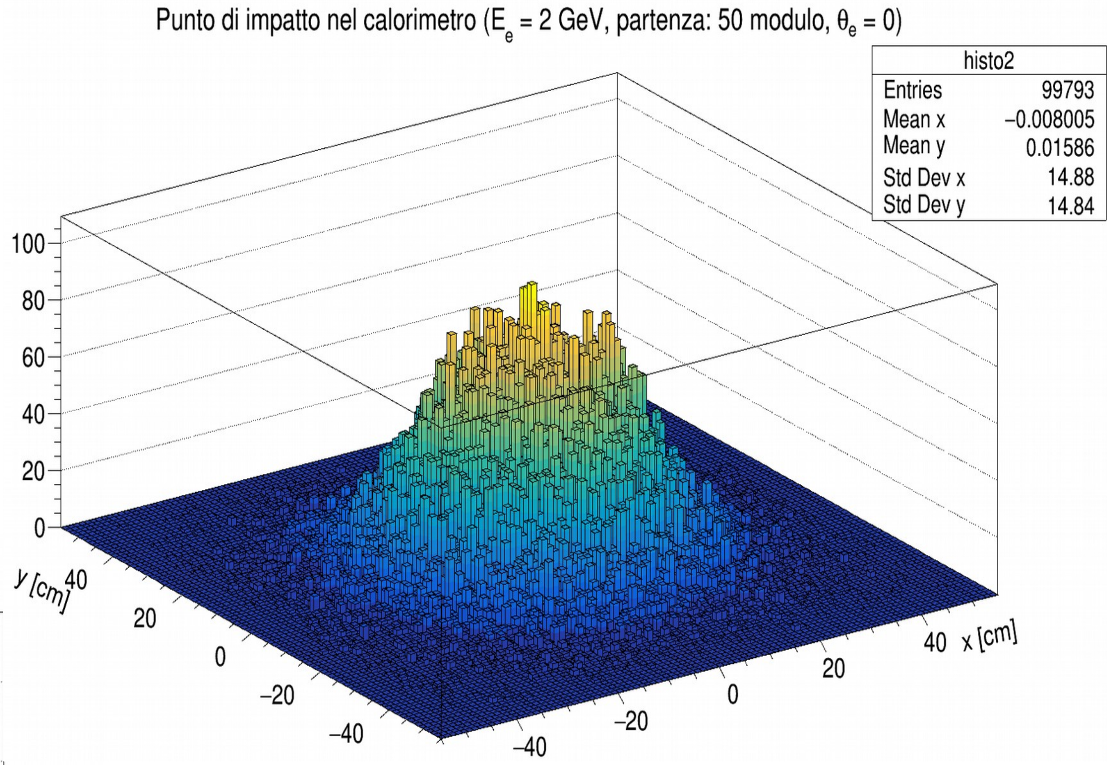


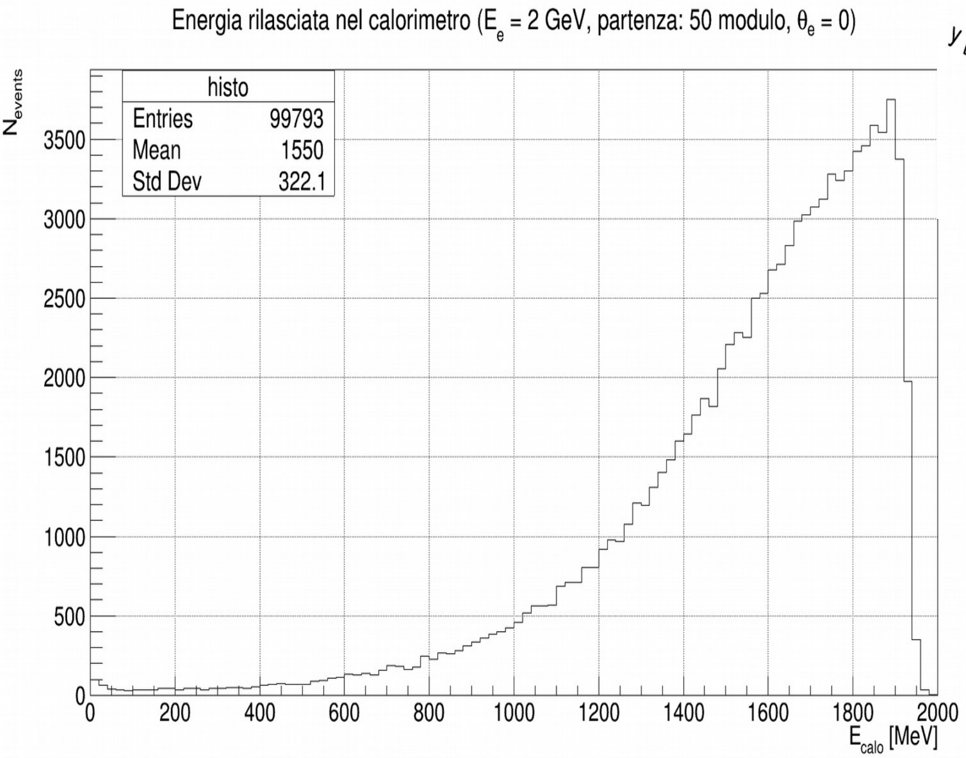


1.b) E_e = 2 GeV

N_e = 100k

N_e (E_{cal}> 0) = 99793





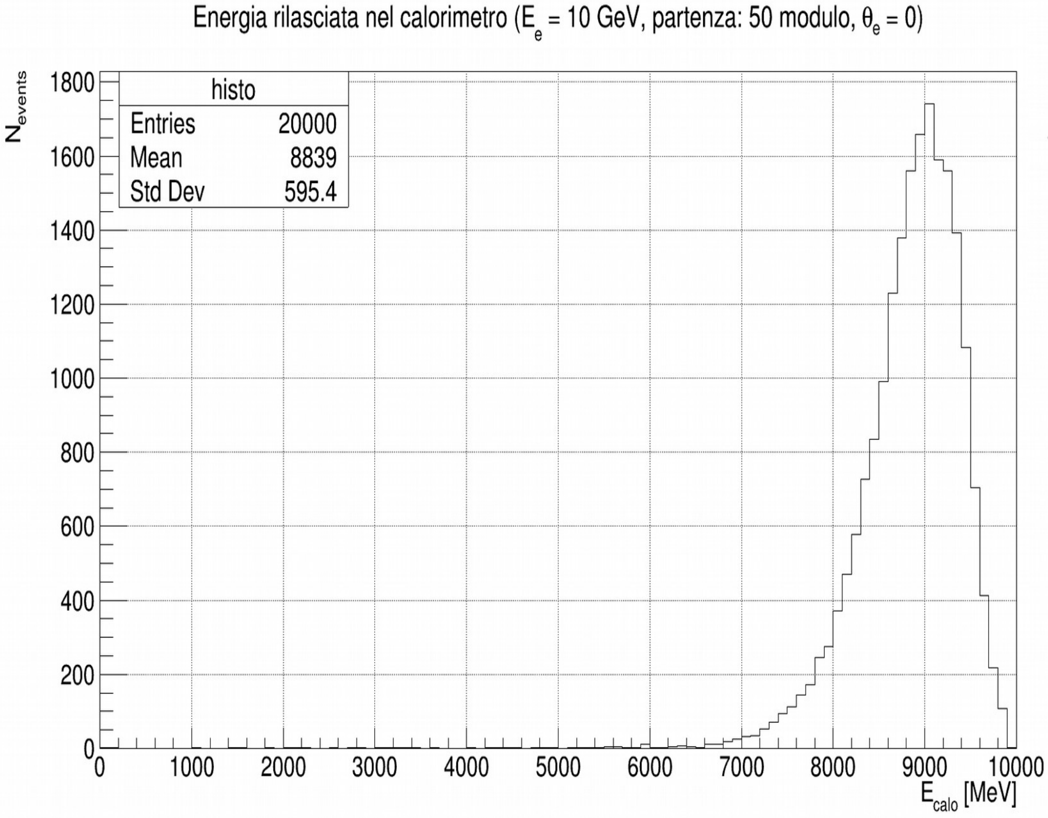
- 99,7% of events reach the calorimeter
- 93,2% of events with E_{calo} > 1 GeV

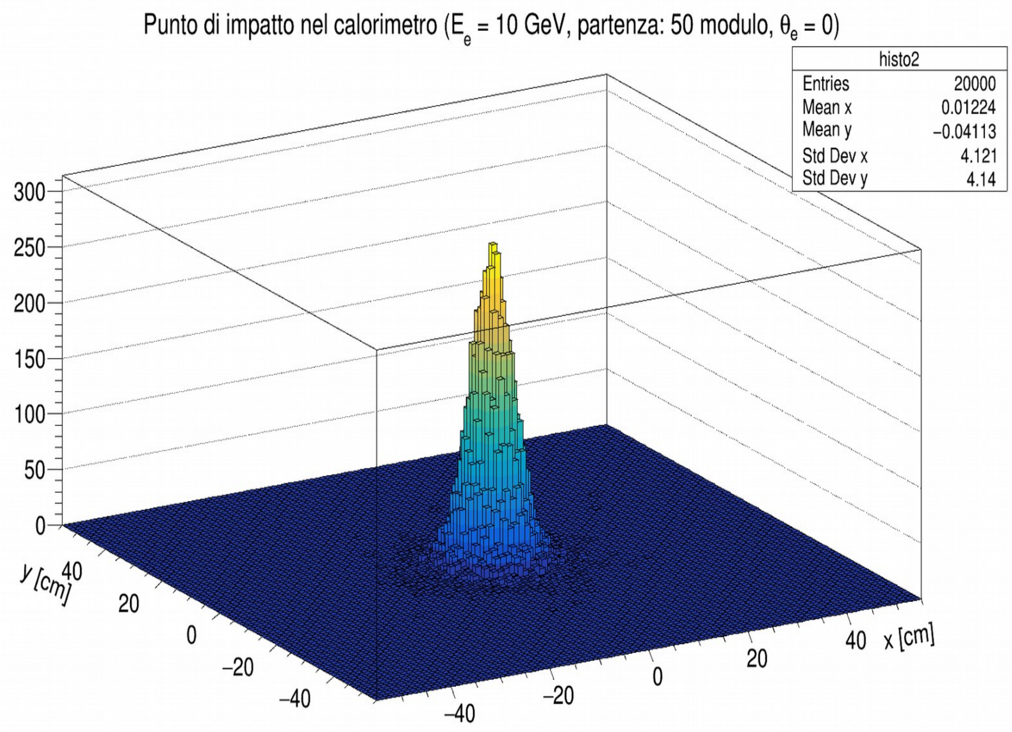
1.c) E_e = 10 GeV

N_e = 20k

N_e (E_{cal} > 0) = 20k

- All the events reach the calorimeter





STEP 2: $\theta_e = 0$ $\varphi_e = 0$, E_e = 1, 2, 10 GeV. e^- start at 25th module

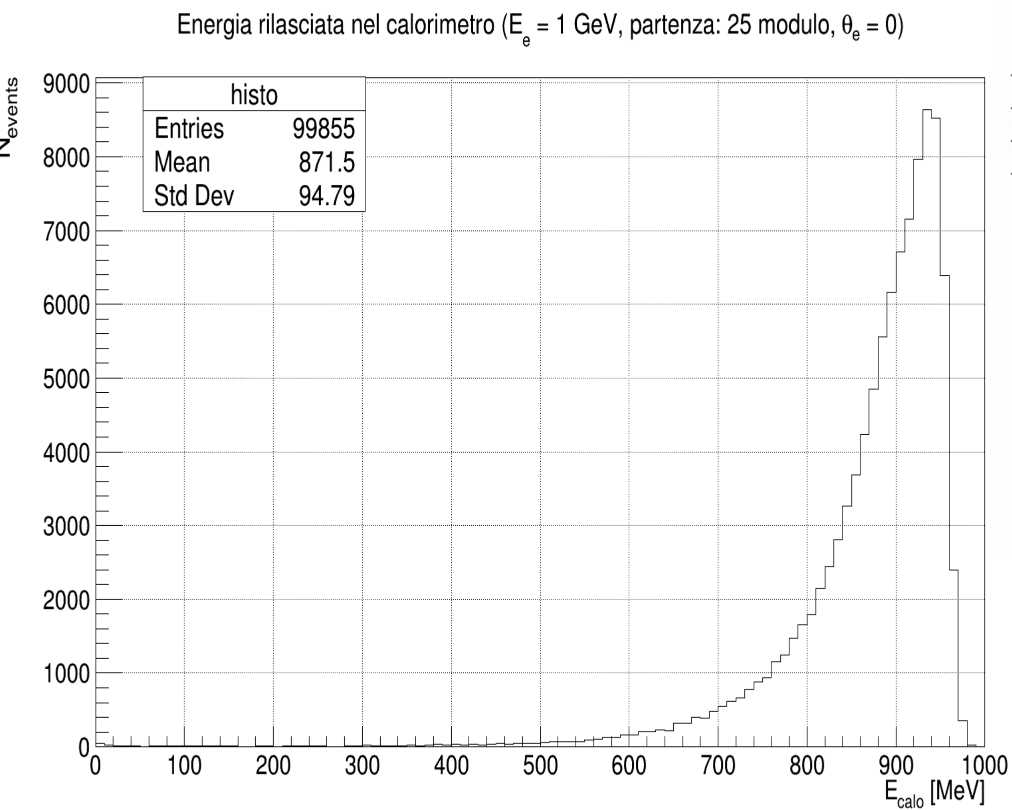
Larger angular acceptance

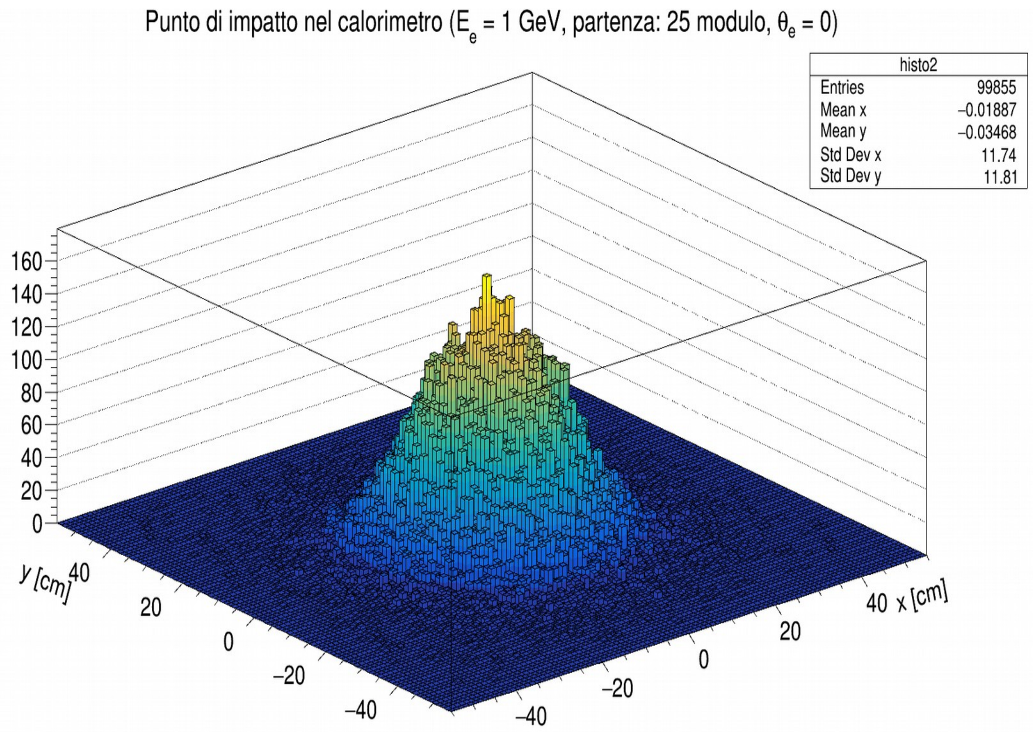
2.a) E_e = 1 GeV

N_e = 100k

N_e (E_{cal}> 0) = 99855

- 99,8% of events reach the calorimeter

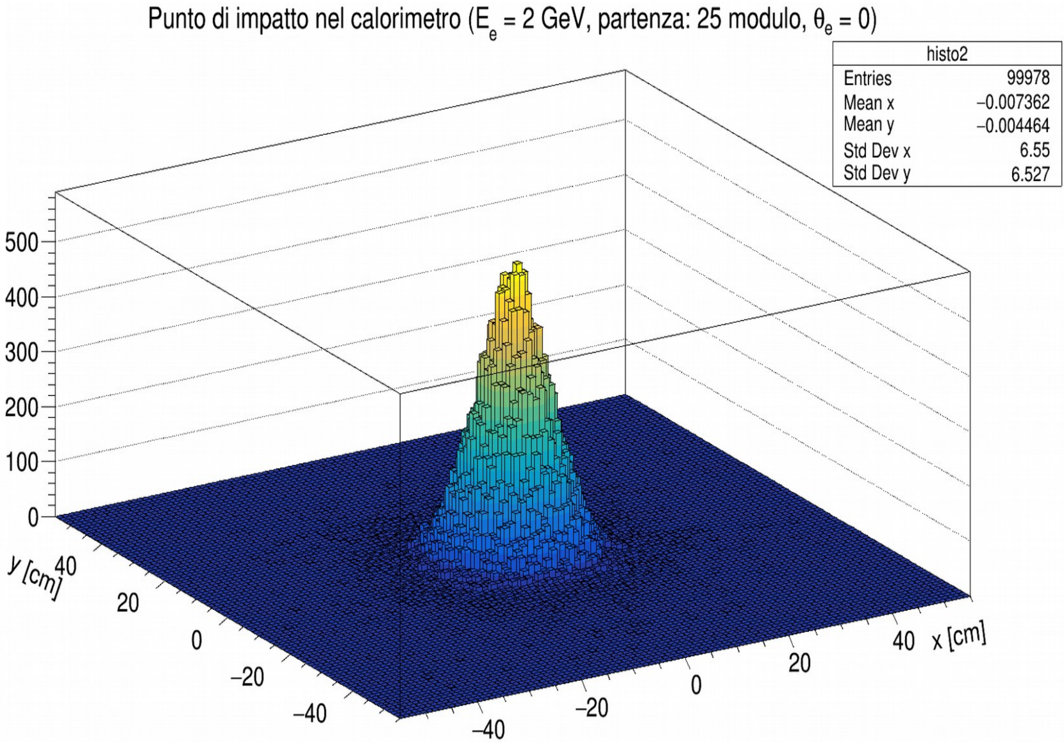


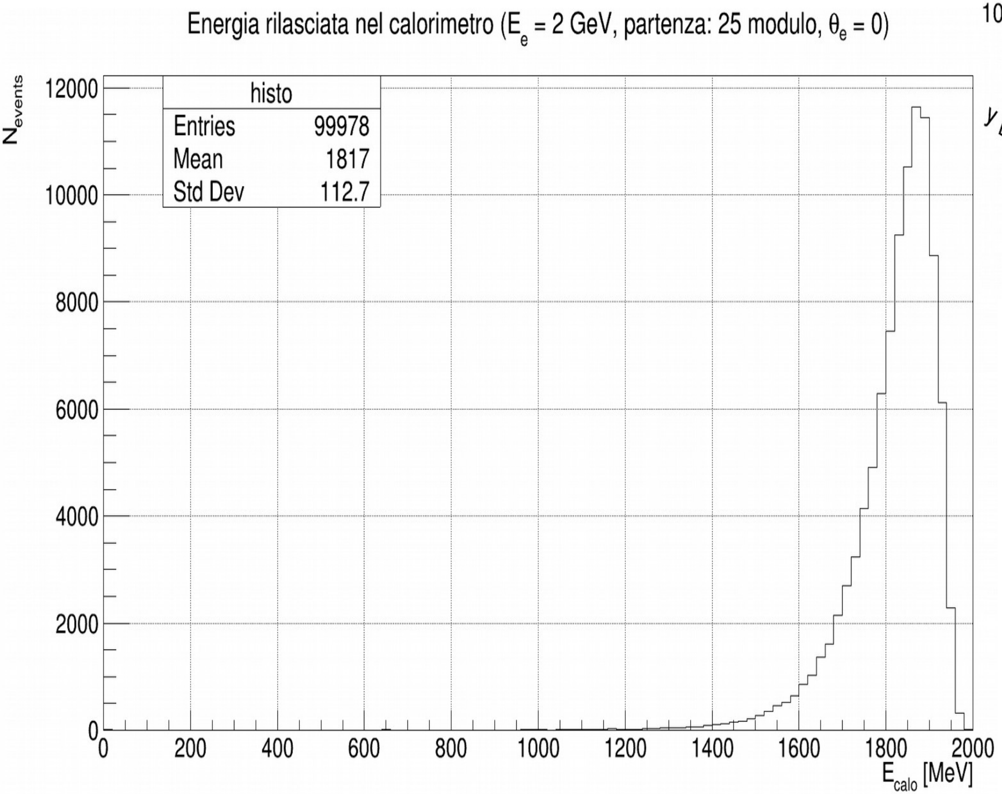


2.b) E_e = 2 GeV

N_e = 100k

N_e (E_{cal}> 0) = 99978



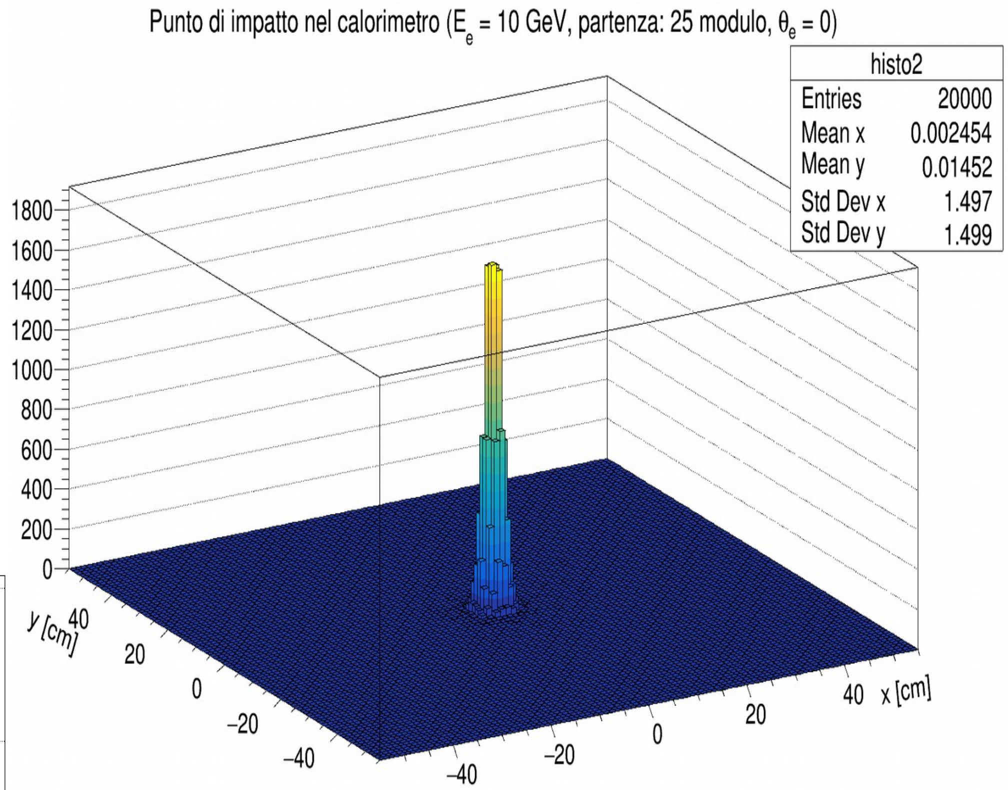


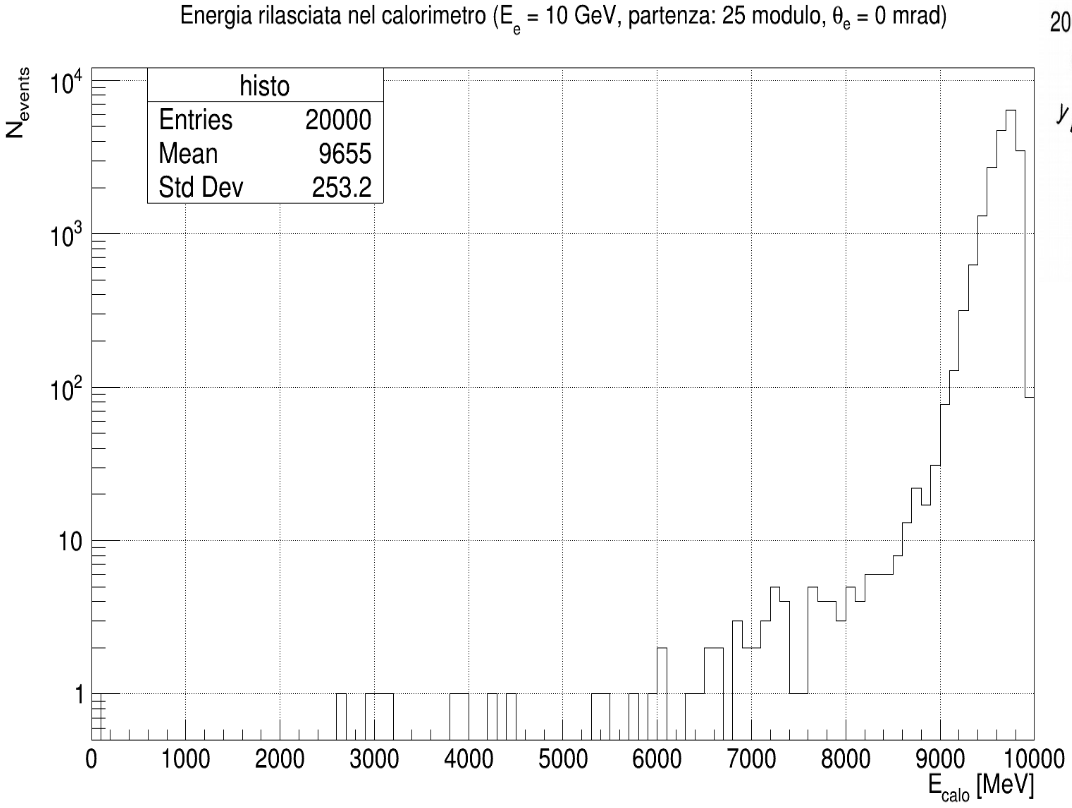
- >99,9% of events reach the calorimeter
- 99,8% of events with E_{calo} > 1 GeV

2.c) E_e = 10 GeV

N_e = 20k

N_e (E_{cal}> 0) = 20k





STEP 3: E_e = 1, 2, 10 GeV $\theta_e = \theta_e(E_e)$. e^- start at 1st module

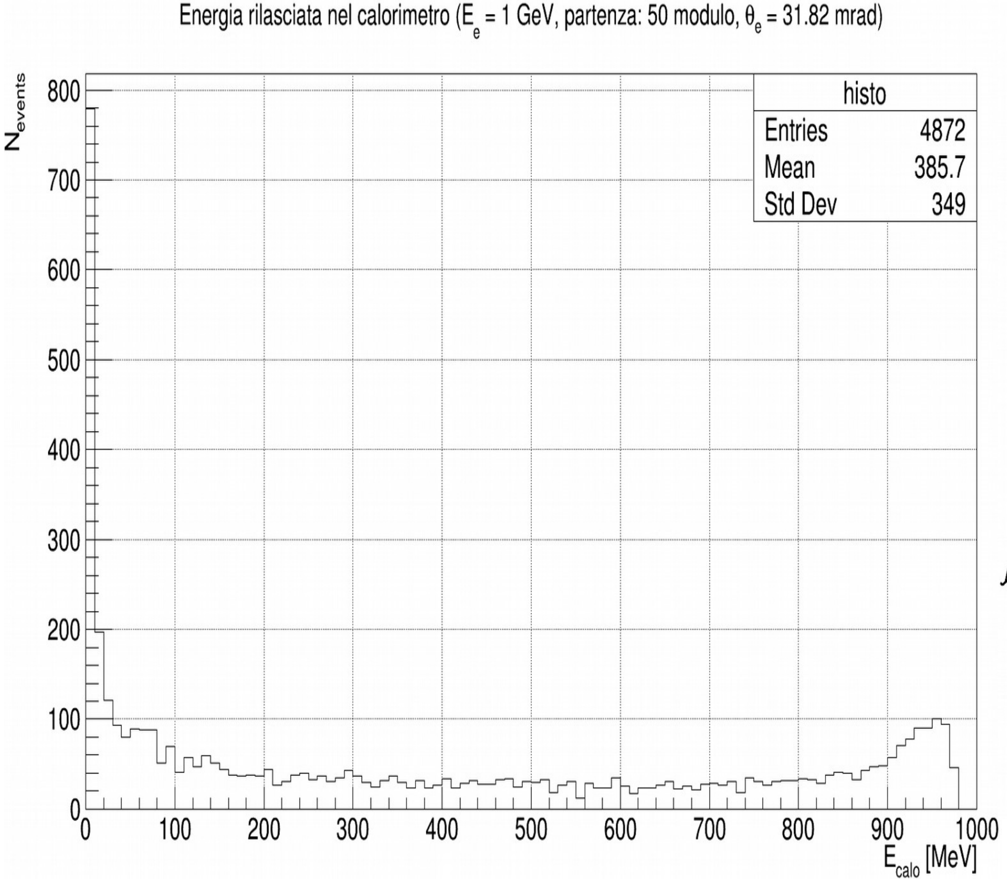
3.a) E_e = 1 GeV, θ_e = 31,82 mrad, $\varphi_e = 0$ → After 26 m $x_c \approx$ 80 cm

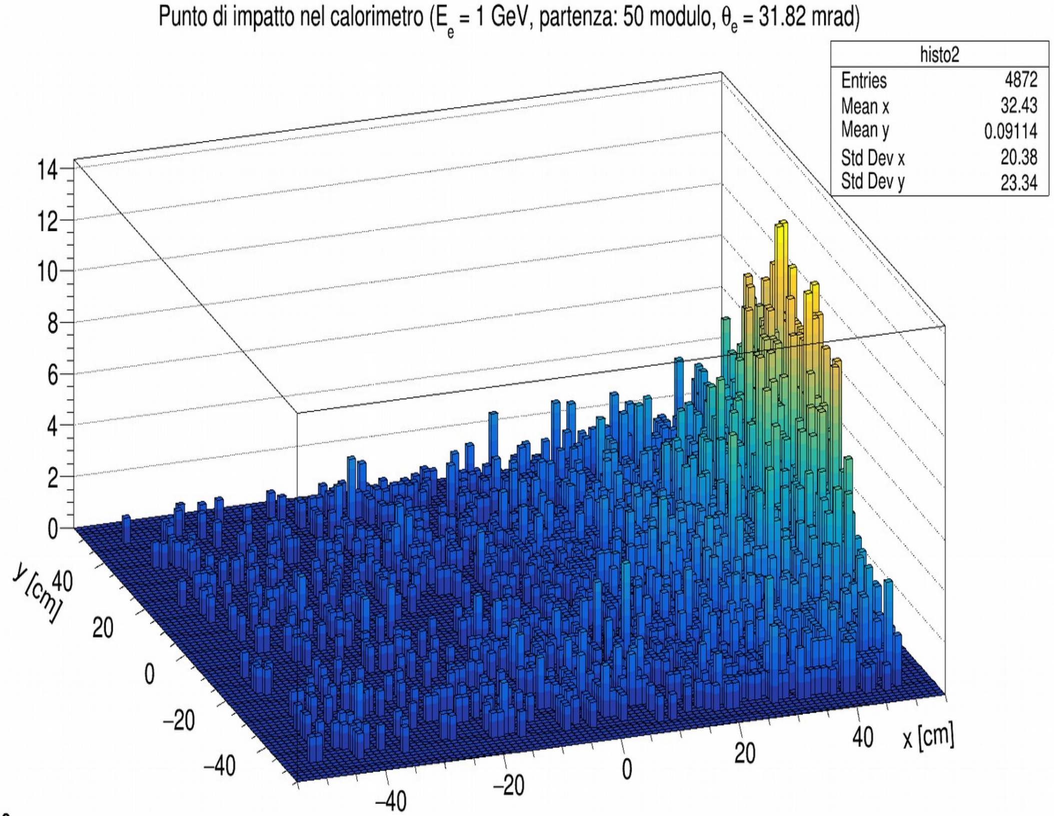
N_e = 100k

N_e (E_{cal}> 0) = 4872

Out of calorimeter

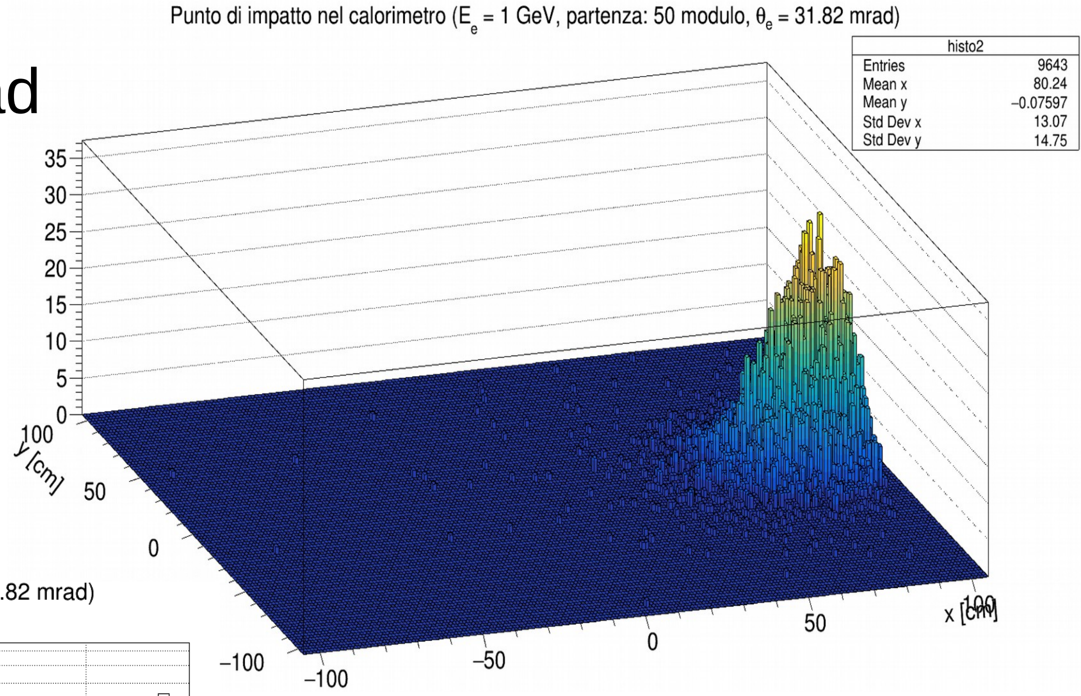
- 4,8% of events reach the calorimeter

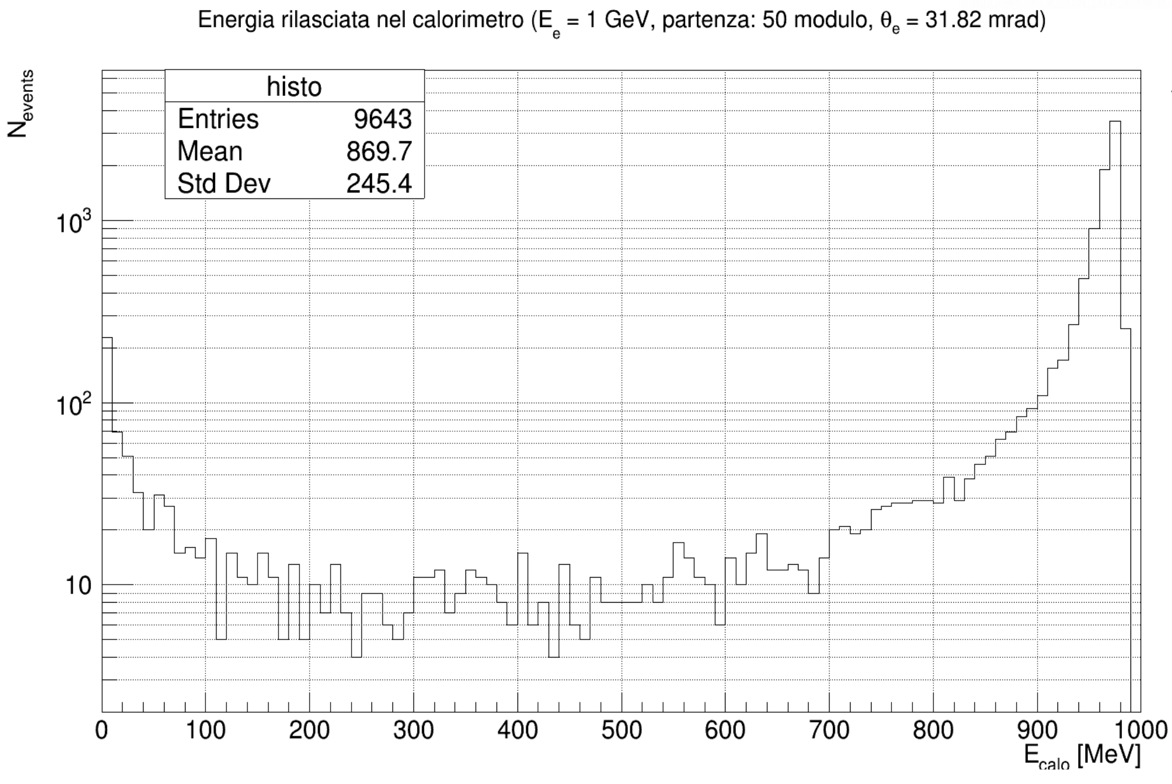




3.a.1) E_e = 1 GeV, θ_e = 31,82 mrad φ_e = 0

With a 2 m x 2 m calorimeter





N_e = 10k

N_e (E_{cal}> 0) = 9643

- 96,4% of events reach the calorimeter

3.b) E_e = 2 GeV, θ_e = 22,44 mrad φ_e = 0

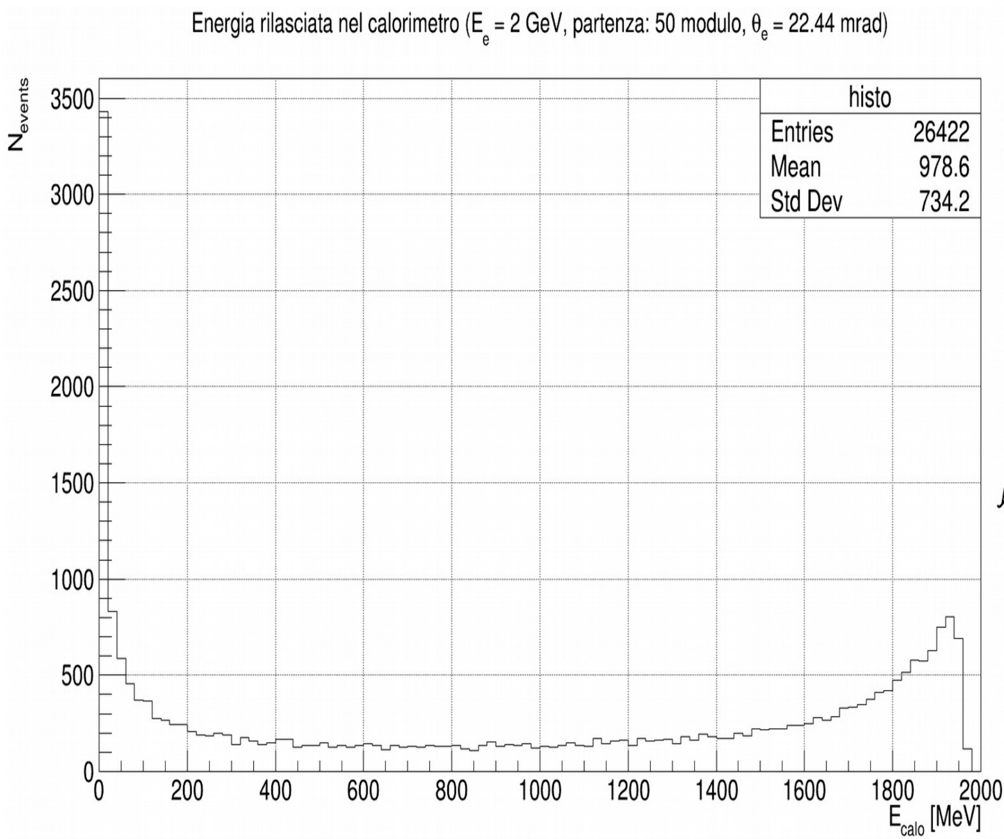
→ After 26 m $x_c \approx$ 58 cm

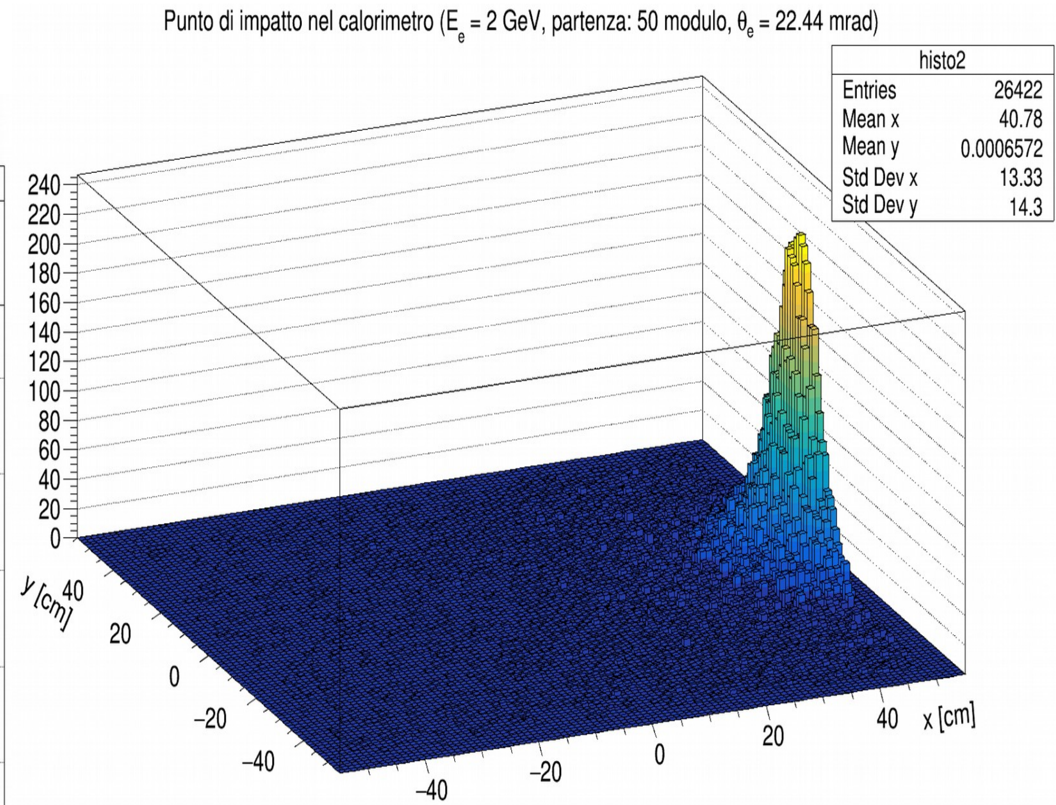
Out of calorimeter

N_e = 100k

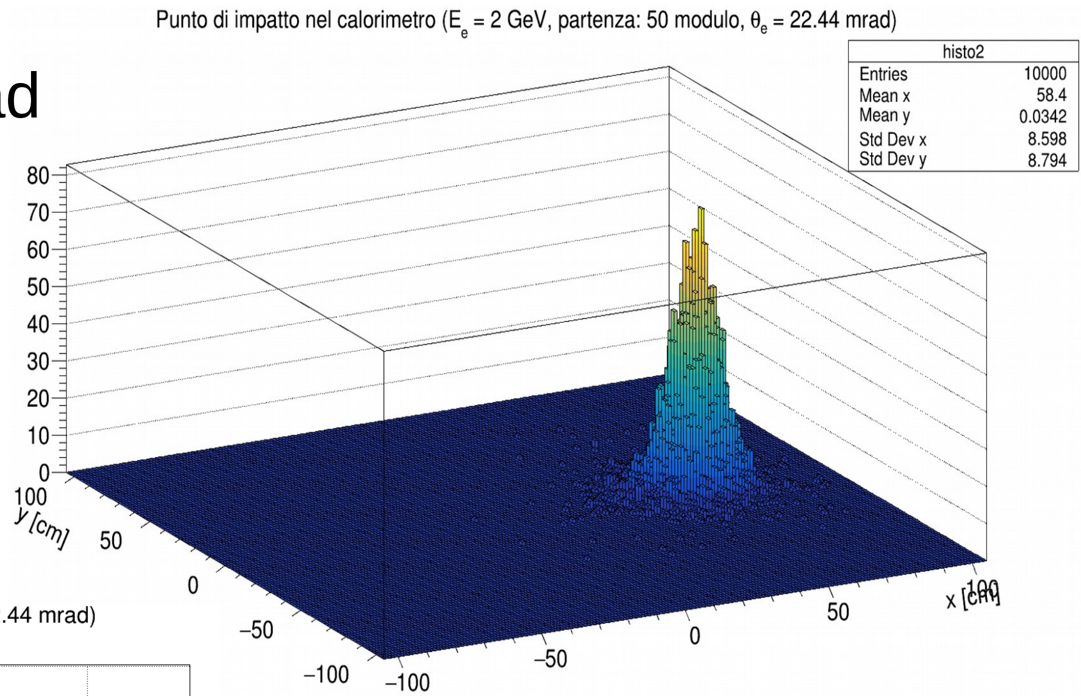
N_e (E_{cal}> 0) = 26422

- 26,4% of events reach the calorimeter
- 13,6% of events with E_{calo} > 1 GeV

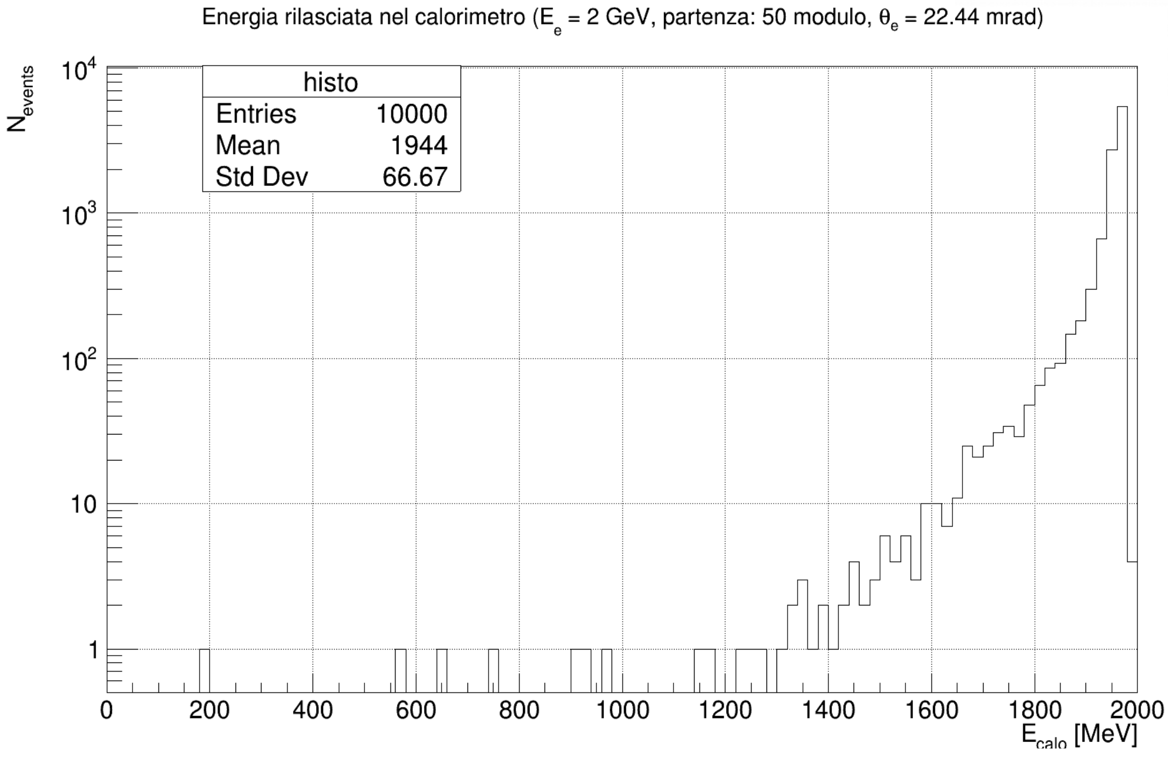




3.b.1) E_e = 2 GeV, θ_e = 22,44 mrad φ_e = 0



With a 2 m x 2 m calorimeter



N_e = 10k

N_e (E_{cal}> 0) = 10k

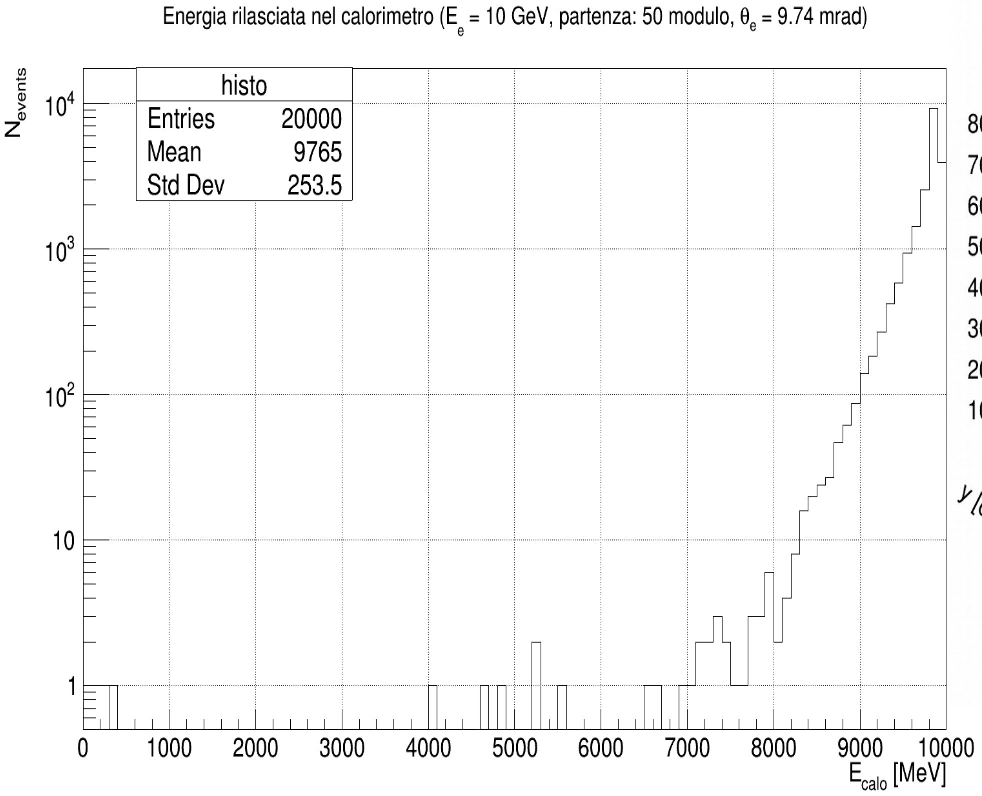
3.c) E_e = 10 GeV, θ_e = 9,74 mrad φ_e = 0

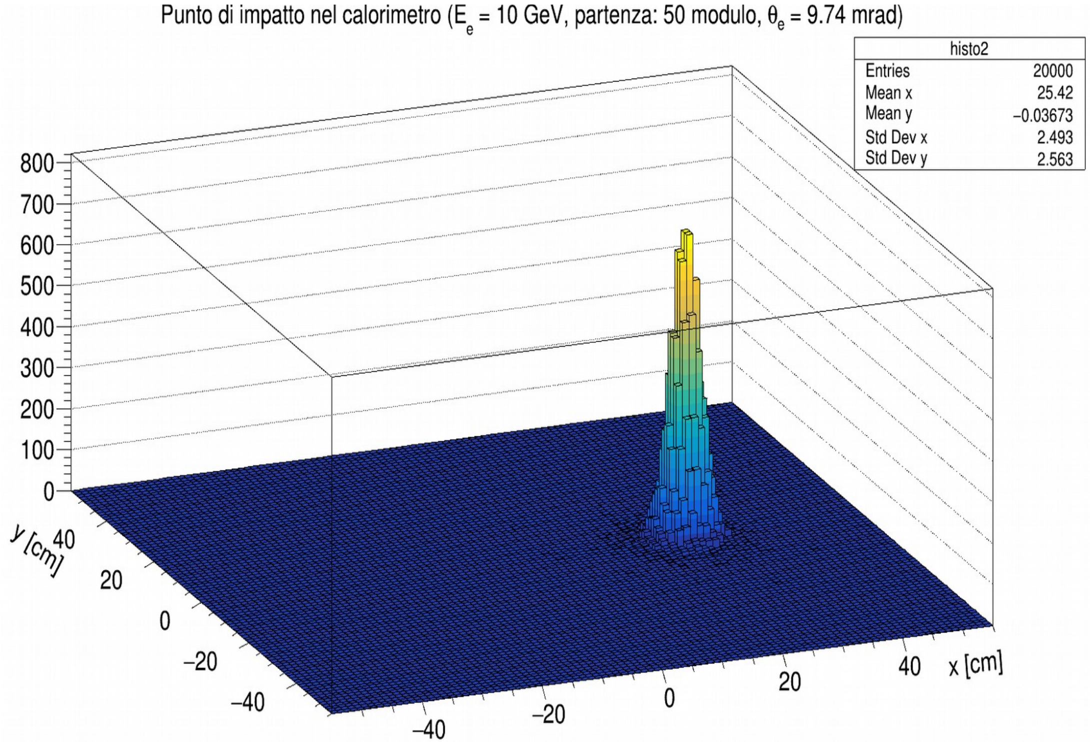
➔ After 26 m $x_c \approx$ 25 cm

Hits the calorimeter

N_e = 20k

N_e (E_{cal}> 0) = 20k





STEP 4: E_e = 1, 2, 10 GeV $\theta_e = \theta_e(E_e)$. e^- start at 25st module

4.a) E_e = 1 GeV, θ_e = 31,82 mrad, φ_e = 0

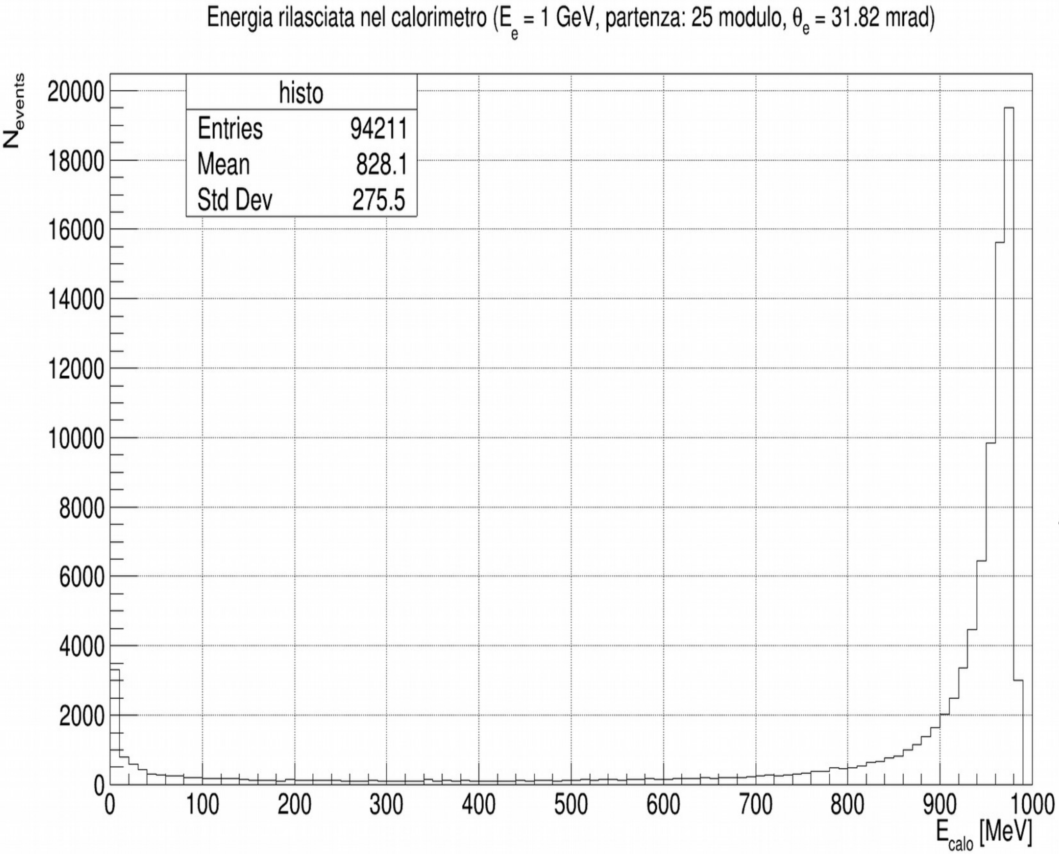
→ After 13,5 m $x_c \approx$ 43 cm

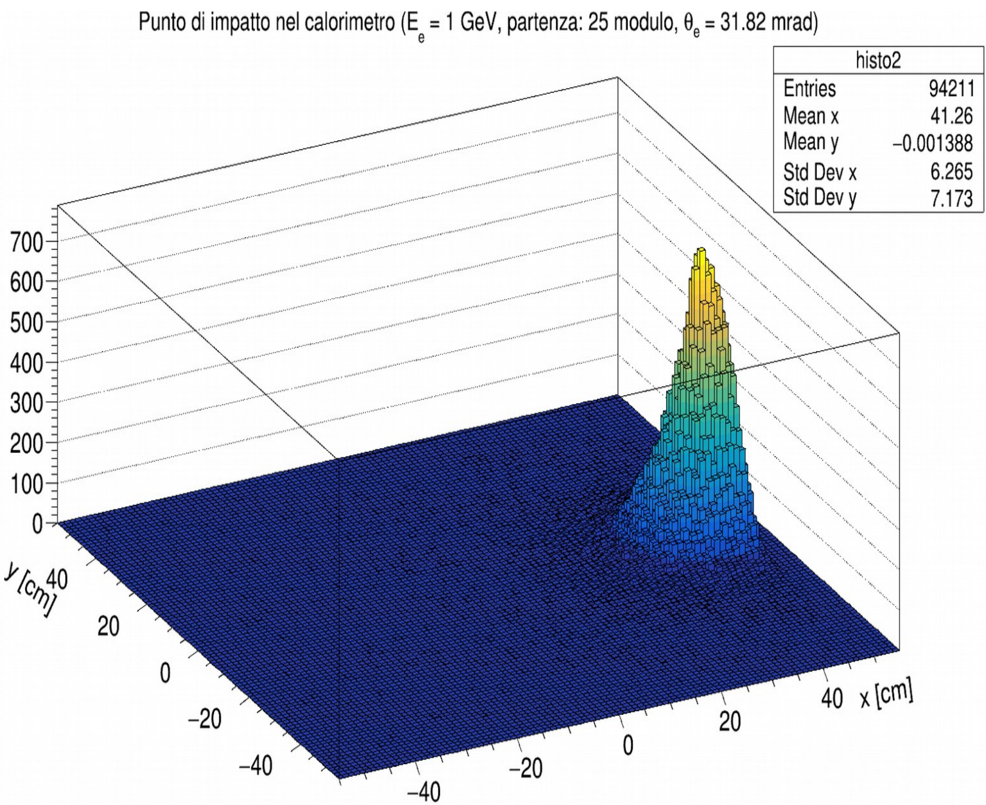
Hits the calorimeter

N_e = 100k

N_e (E_{cal}> 0) = 94211

- 94,2% of events reach the calorimeter





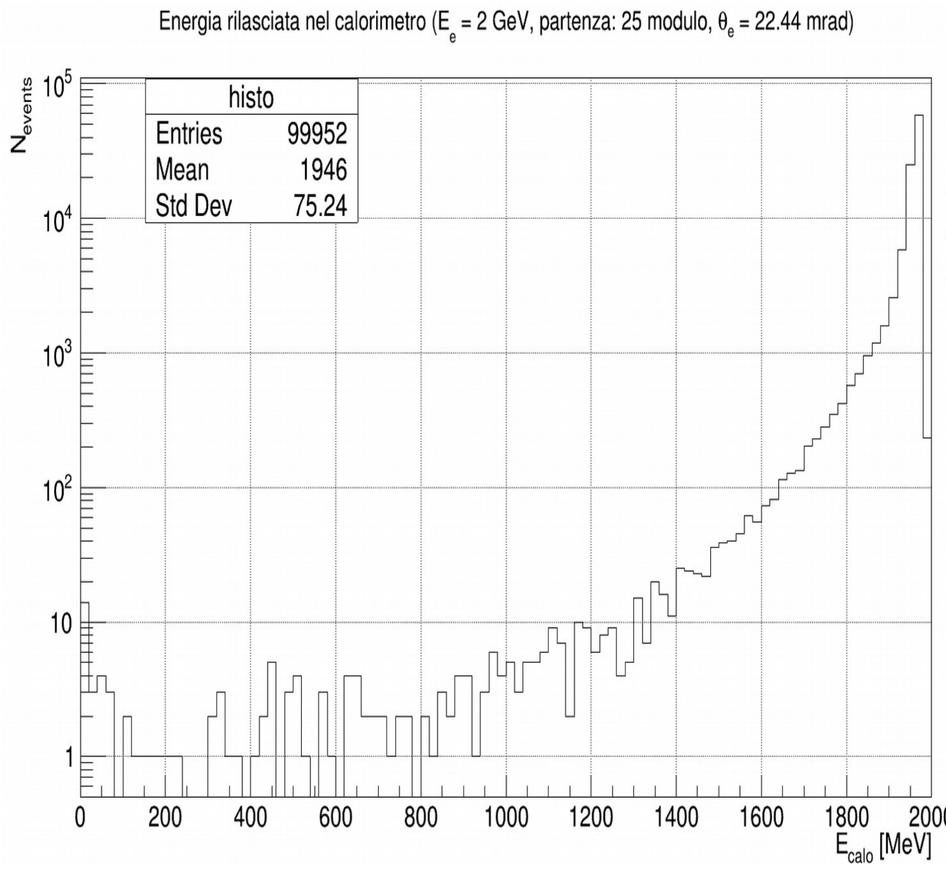
4.b) E_e = 2 GeV, θ_e = 22,44 mrad, φ_e = 0

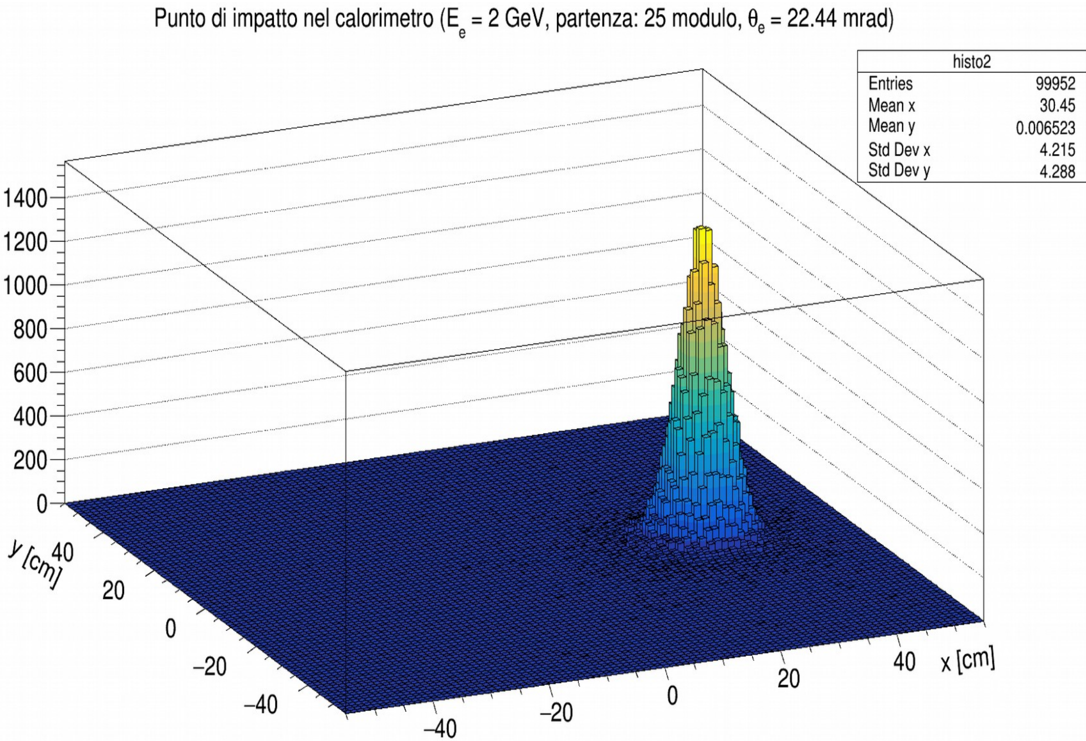
N_e = 100k
N_e (E_{cal}> 0) = 99952

- >99,9% of events reach the calorimeter
- 99,8% of events with E_{calo} > 1 GeV

→ After 13,5 m $x_c \approx$ 30 cm

Hits the calorimeter





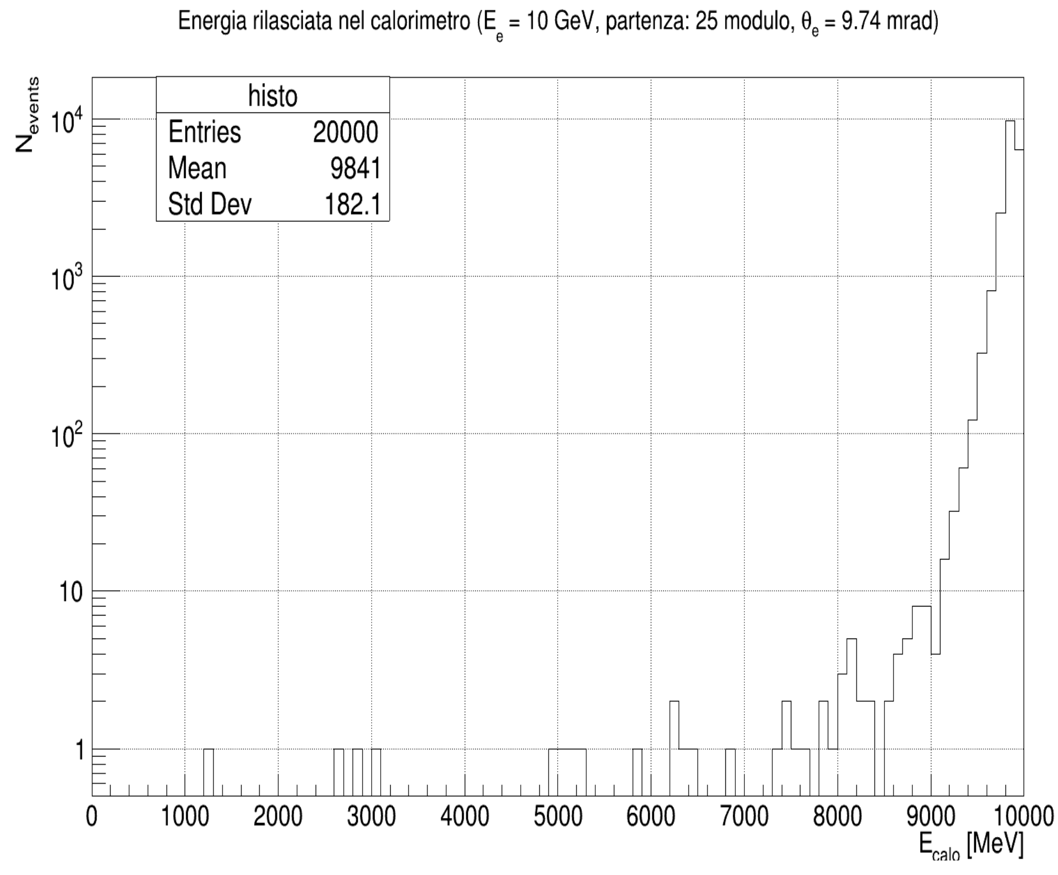
4.c) E_e = 10 GeV, θ_e = 9,74 mrad, φ_e = 0

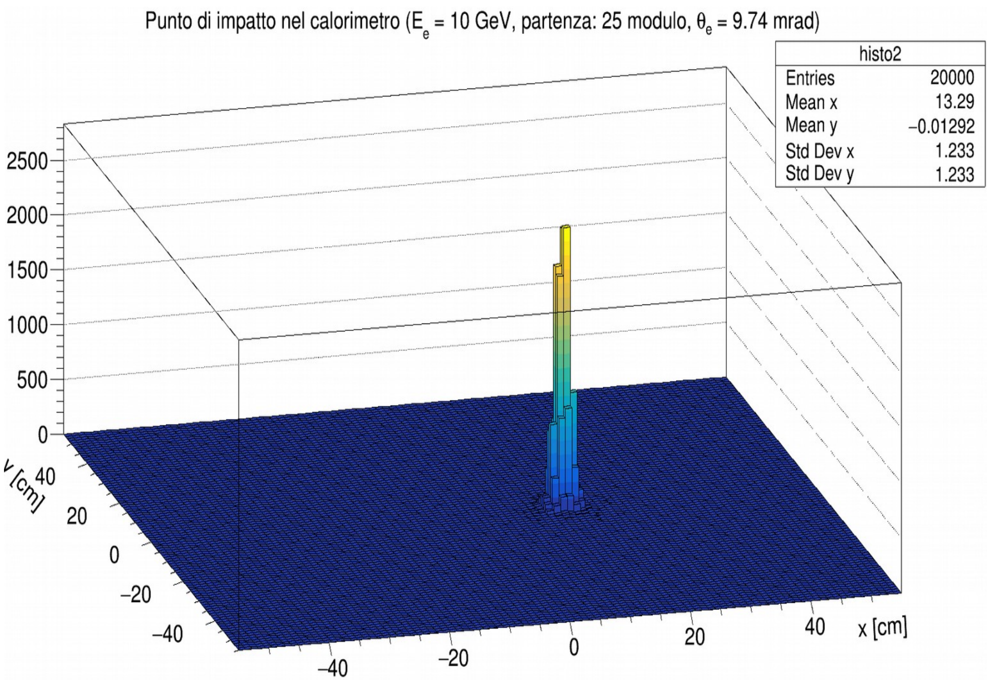
N_e = 20k

N_e (E_{cal}> 0) = 20k

→ After 13,5 m $x_c \approx$ 13 cm

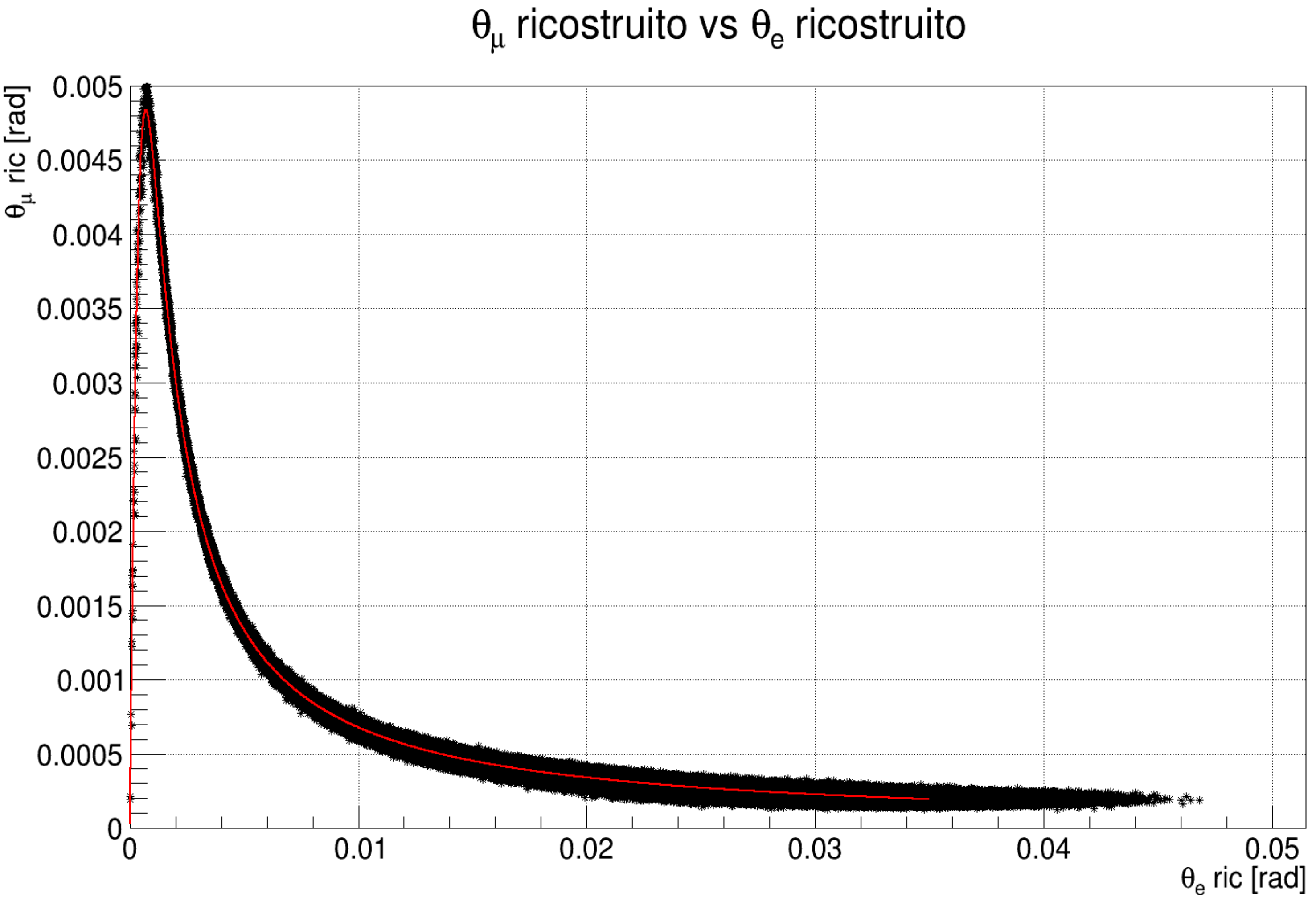
Hits the calorimeter





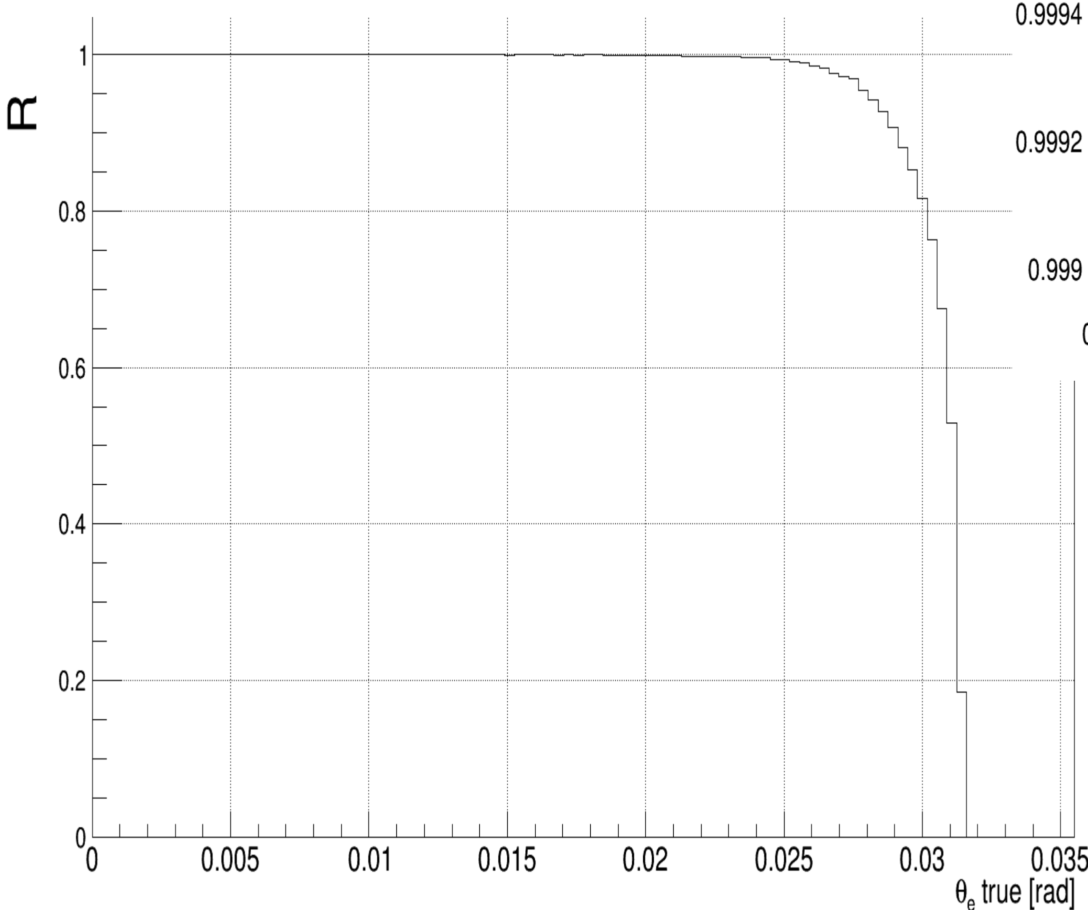
STEP 5: θ_e [0, 35 mrad] generated according to LO distribution.
φ_e generated uniformly between [0, 2π], $E_e = E_e(\theta_e)$

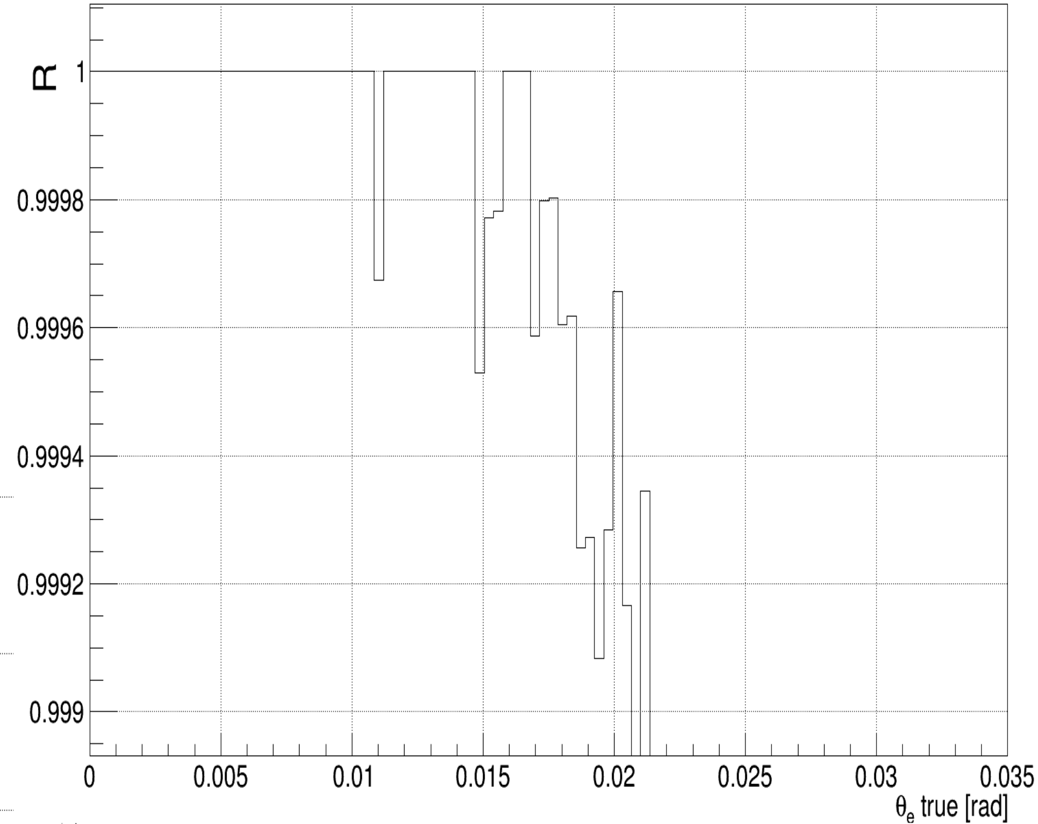
e^- start at 25th module



θ_e^{ric} obtained applying a gaussian smearing to θ_e,
with σ = MS effect in a single module

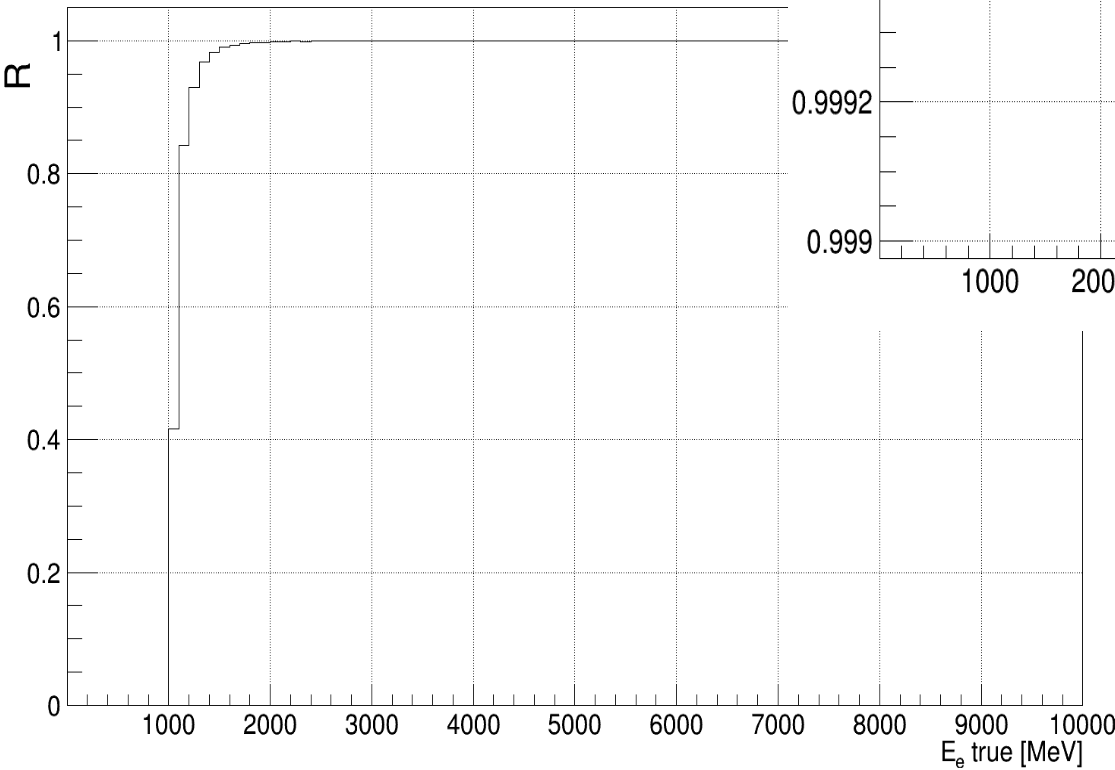
$$R = \frac{N_e(E_{cal} > 1GeV)}{N_e}$$

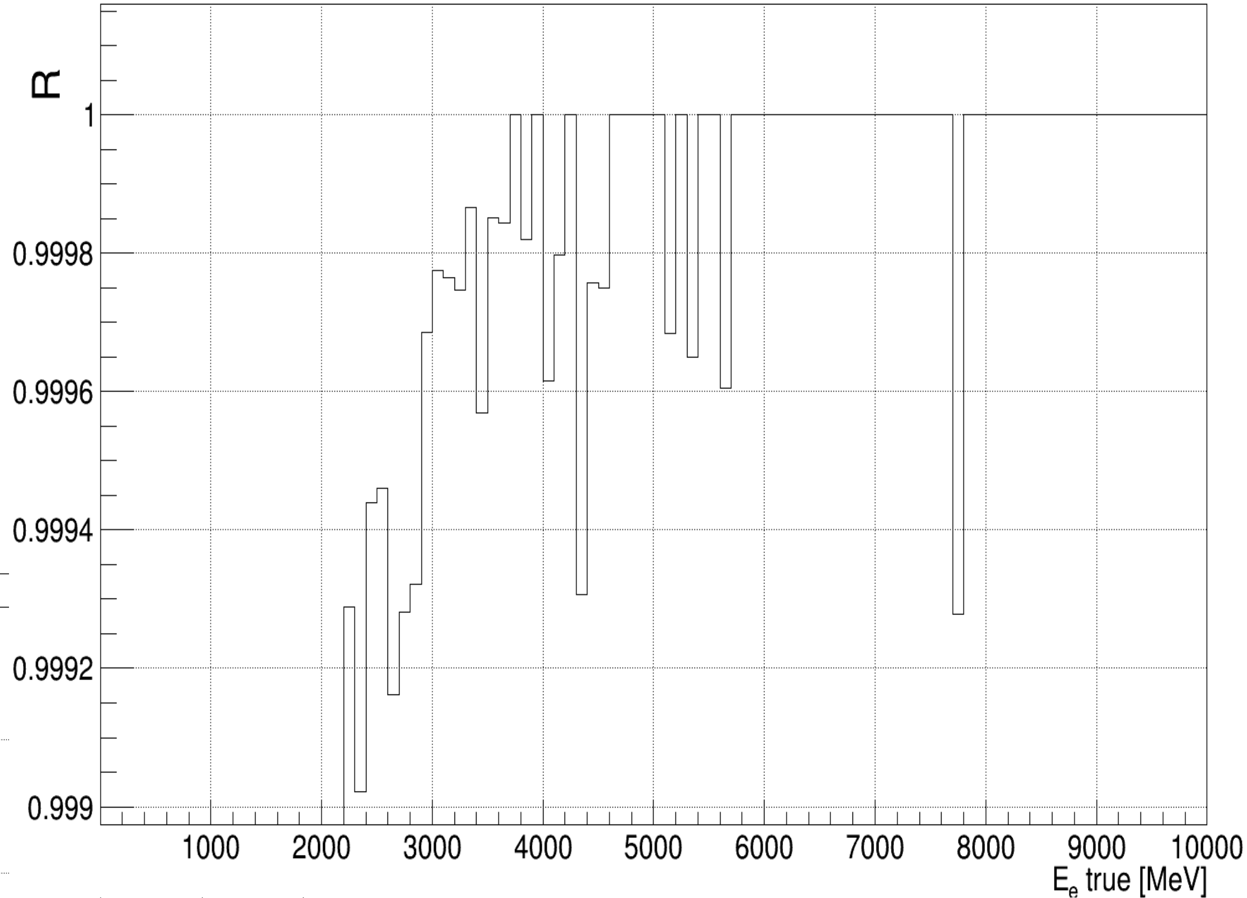




R < 99,9% if θ_e > 22mrad

R < 99,9% when E_e < 2,2 GeV





Conclusions

- A 2 m x 2 m calorimeter (like Na48 one) is necessary in order to reconstruct the electron energy in range of 1 - 2 GeV when this electrons start from the first module.
- A 1 m x 1 m calorimeter allows a reconstruction of >95% of low energy electrons (1 - 2 GeV) starting from the 25th module.
- Applying an energy cut of E_{cal} > 1 GeV allows to use the calorimetric measure of the electron energy for 99,9% (or higher) of the events with E_e > 2,2 GeV (θ_e < 22mrad).
- Simulation is very simple: there is no tracking reconstruction (to be implemented), no material outside the detector and we took out the energy deposit of the muon.
- We didn't include correlation between energy deposit with other variables (like position of the cluster, angle of emitted electron, hit multiplicity in the Si planes, etc...)
- An inefficiency above 10^{-5} on the normalisation is important? (can be eliminated as overall normalization by a fit to the constraint at q^2~0?)

Please consider this results as preliminary

I would like to thank Prof. Stefano Di Falco for his precious help with this simulation and for making me understand how to work with Geant4.