Herd work-shop,
Xi'an, 2019/12/09

Istituto Nazionale di Fisica Nucleare
SEZIONE DI FIRENZE

GF measurement of HERD using HerdSoftware

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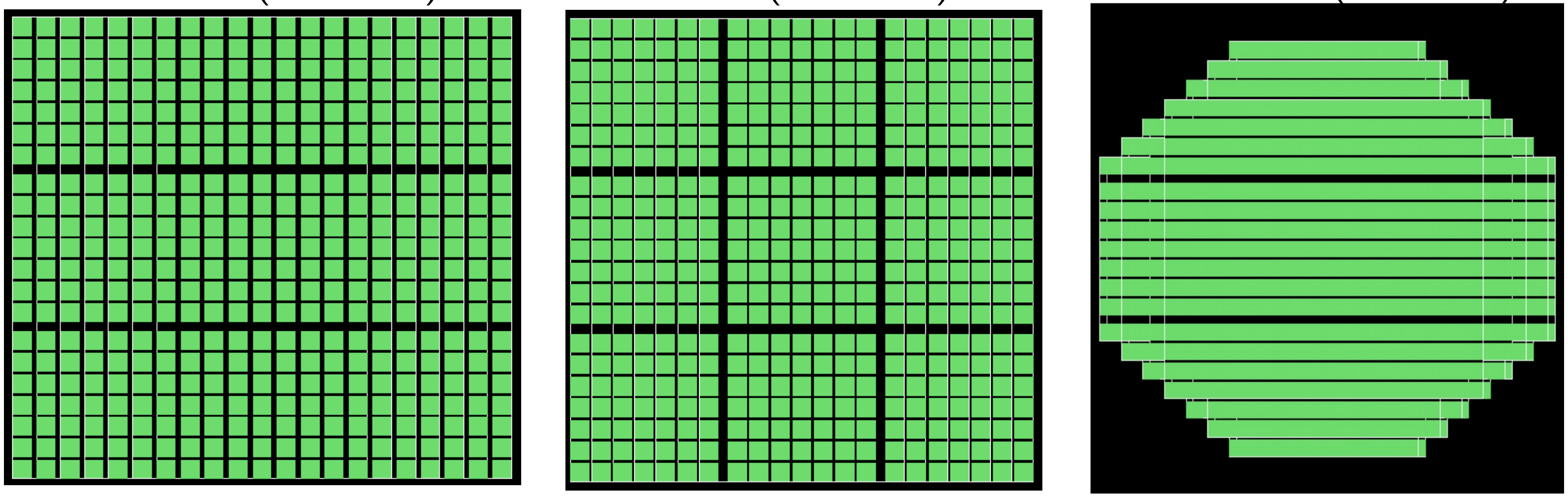
MC Calorimeter in HerdSoftware (12/2019)

- 21 vertical layers, 21x21 crystals (for the big vertical layers), crystal side: 3 cm.
- gap || x = 0.8 cm, gap || y = 0.4 cm, gap || z = 0.4 cm, bigger gaps = 1.5 cm.

ZvsX view (Y=const) ZvsY view (X=const) YvsX view (Z=const)

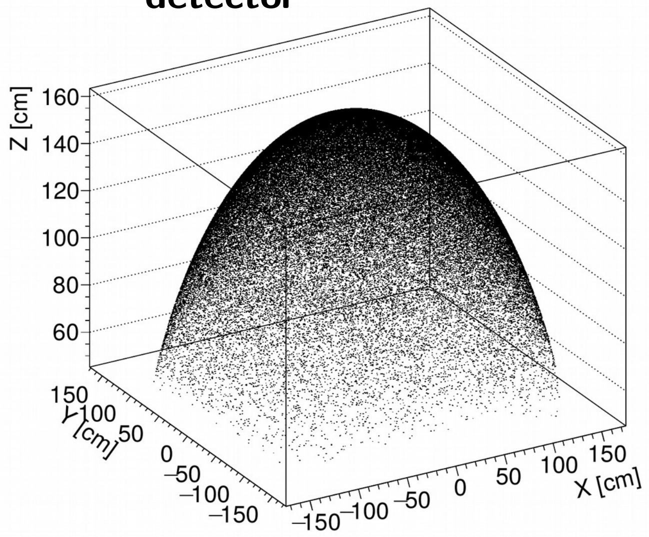


- Maximum x length = 21*(3+0.8) - 0.8 = 79 cm = LX
- Maximum y length = 21*(3+0.4) – 3*0.4 + 1.5*2 = 73.2 cm = LY
- Maximum z length = 21*(3+0.4) – 3*0.4 + 1.5*2 = 73.2 cm. = LZ

GGS particle generation validation.

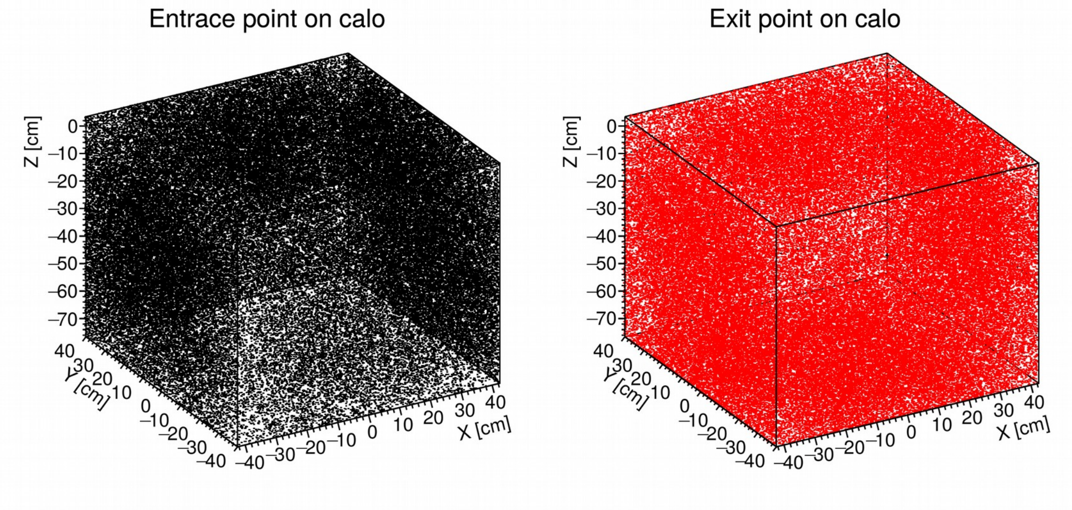
- Using the generator of GGS
  - simulation of a isotropic flux from a spherical surface, center = center of the Calo (0,0,-36.6), R=300 cm. geantino particles.
- Validation of the GGS generator:
  - using a sphere generation surface and a plane detector placed in different position inside the sphere.
  - The GF can be exactly computed using Sullivan formula and compared with the one extracted from the MC simulation.
  - For each configurations the GF is consistent with the expected.

Generated particles which hit the planar detector



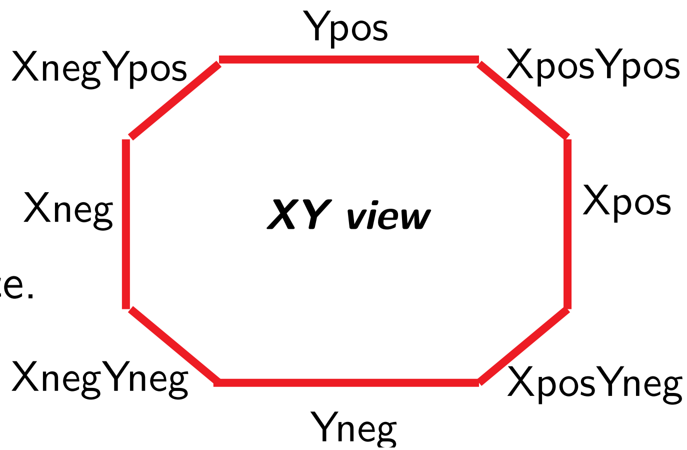
GGS simulation acceptance check

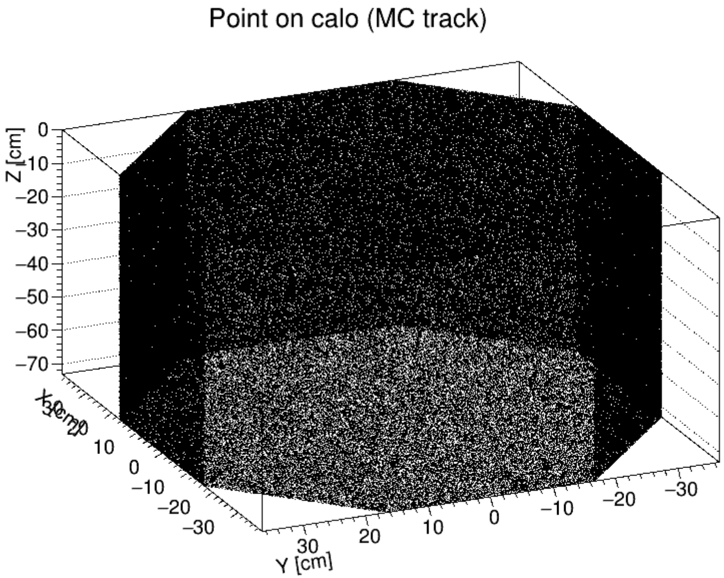
- Since a large generation surface is used, a lot of generated particles are out of the detector acceptance.
- Acceptance check to simulate interesting particles only:
  - MC acceptance is larger than the true Calo acceptance.
  - The number of discarded particles is saved, thus it is possible to compute the geometrical factor of the detector.
- Selecting particles which hit an "Enlarged Calo", which is a box $= 80\text{x}80\text{x}85\ \text{cm}^3$, excluding the bottom surface

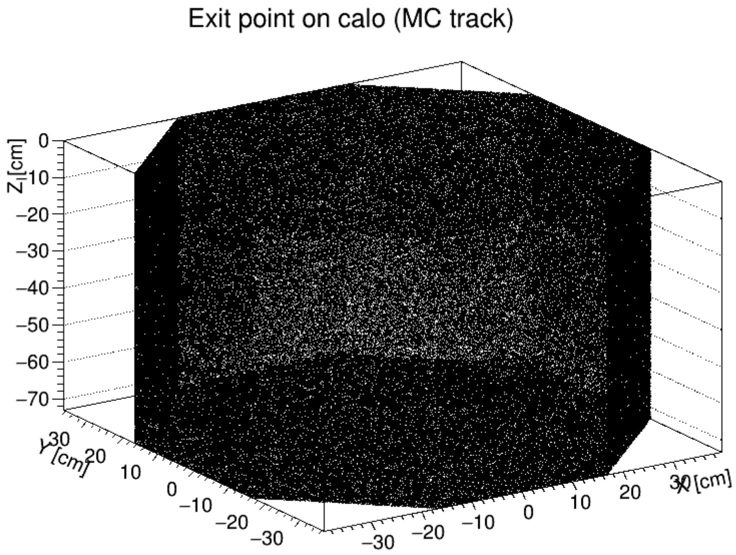


Calo acceptance definition

- 10 planes define the detector surface.
- A particle is in acceptance if:
  - The track intersects a Calo surface, excluding the bottom surface.
  - The track length in the Calo is > of a given threshold (X0).

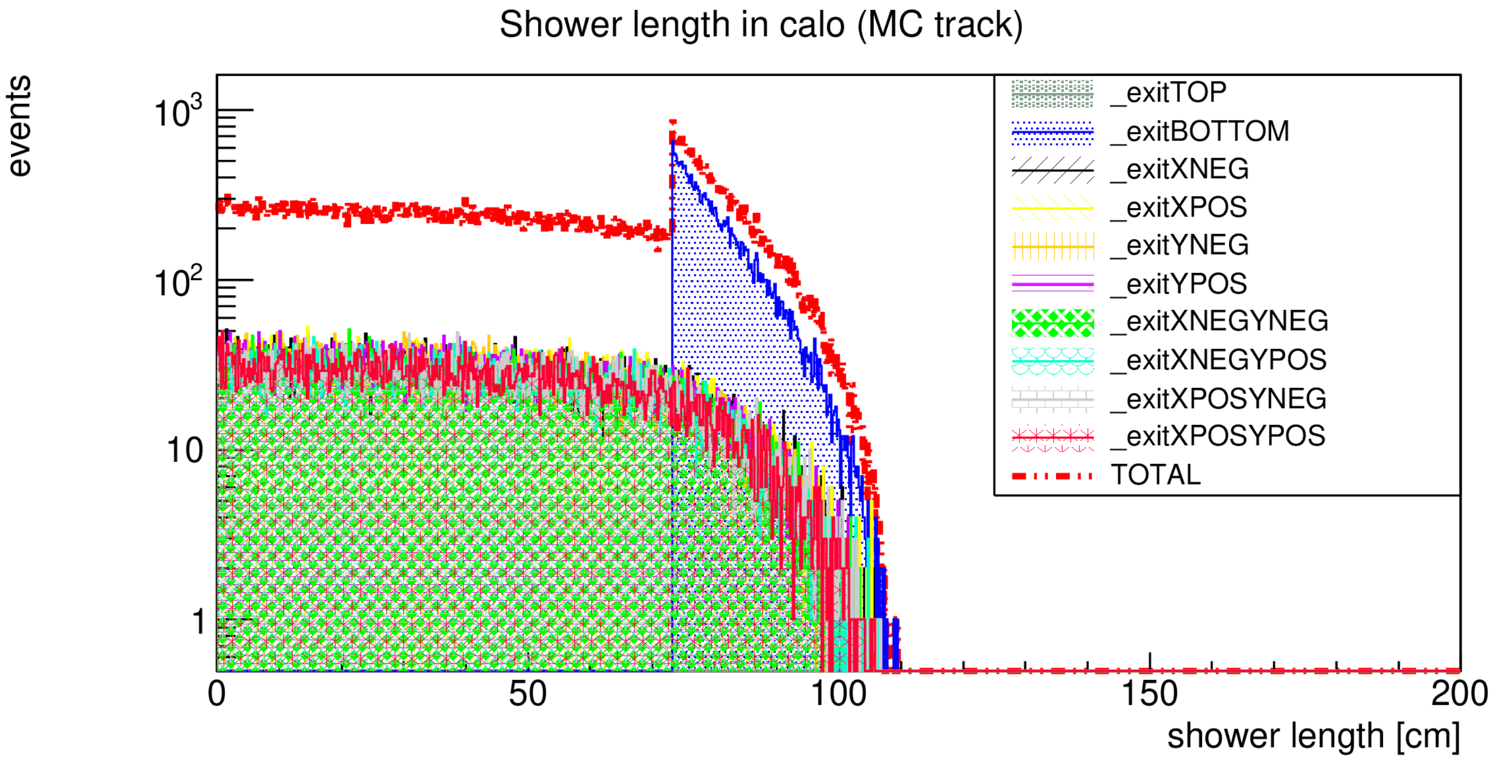






Track length for particle from the TOP

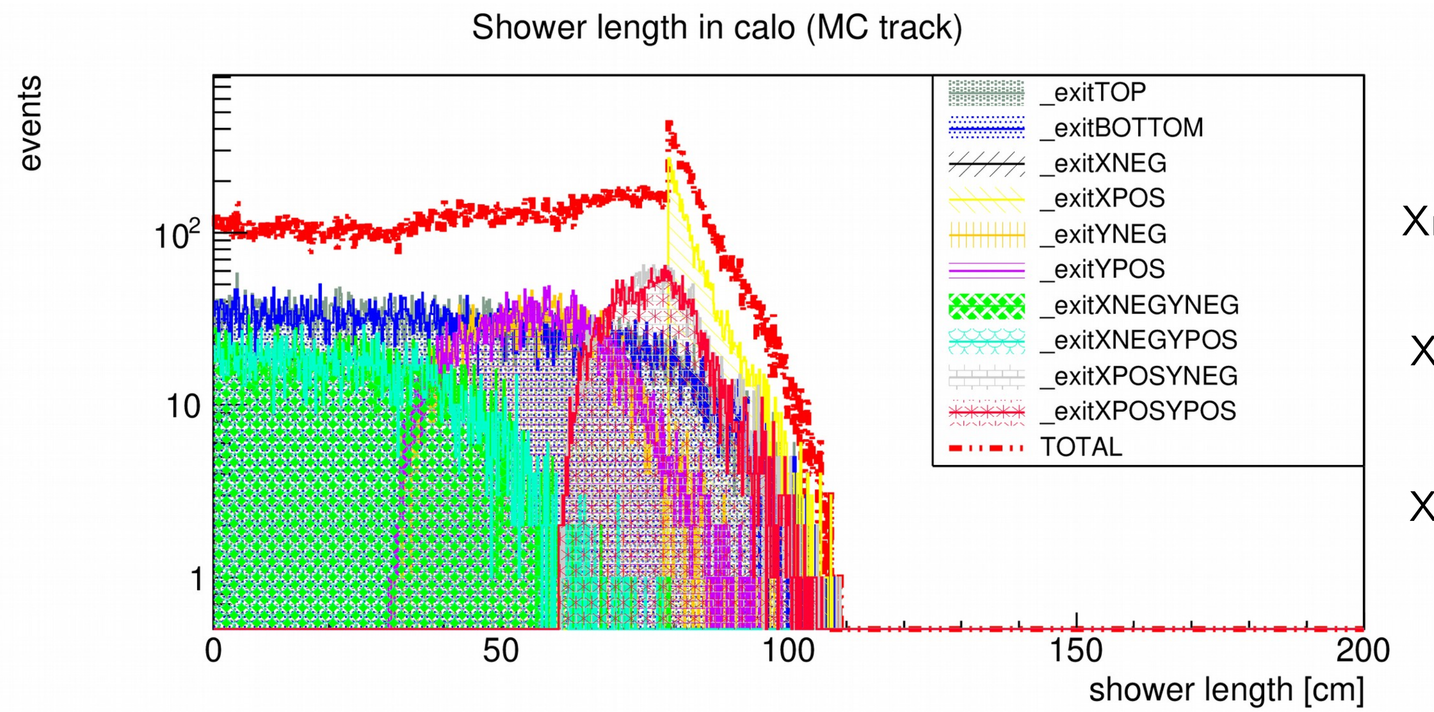
- Only TOP surface activated as entrance surface.

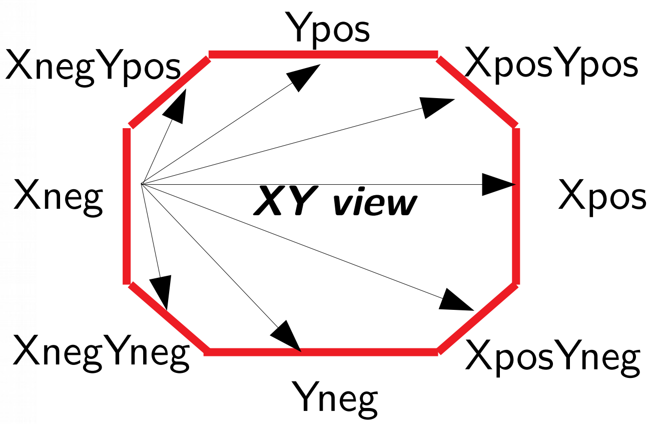


- The probability to get long track length is big if the exit point is in the bottom surface

Track length for particle from XNEG

- Only XNEG surface activated as entrance surface.

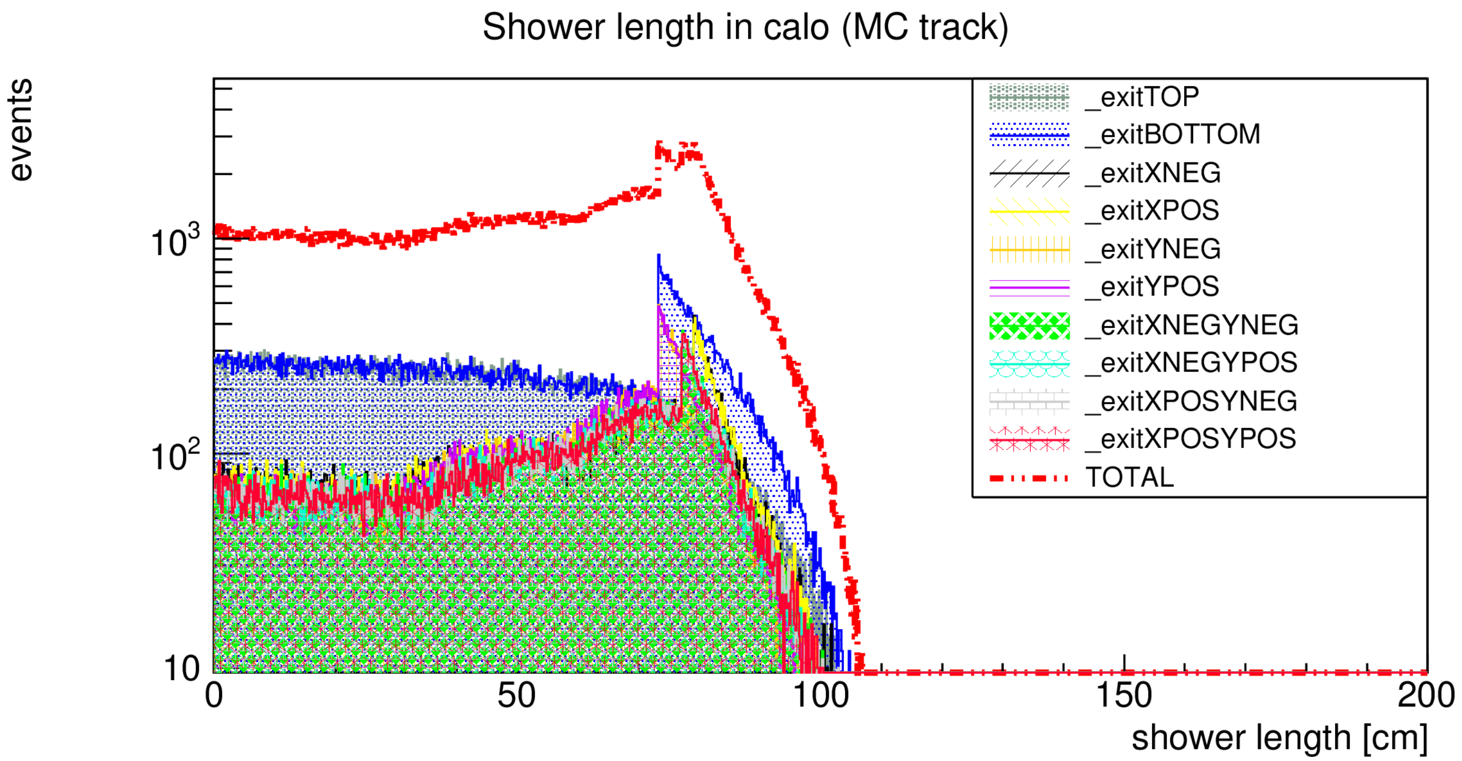




- Exit point in XPOS translates in big track length.

Track length for all the particle

- All the entrance surface are excluding the BOTTOM



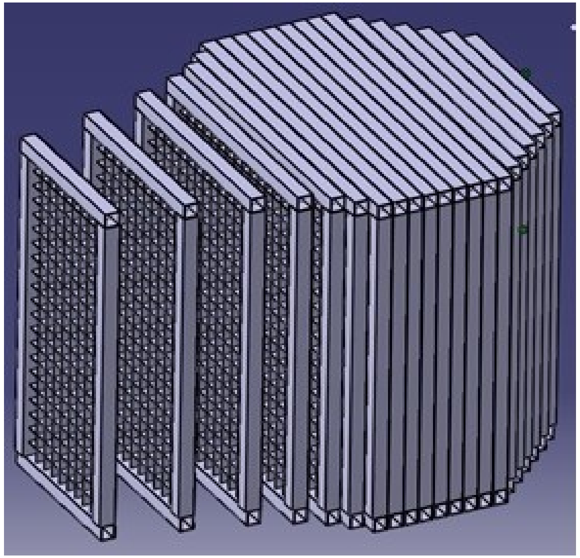
- The distribution is very complicated since it is the sum of all the configuration.

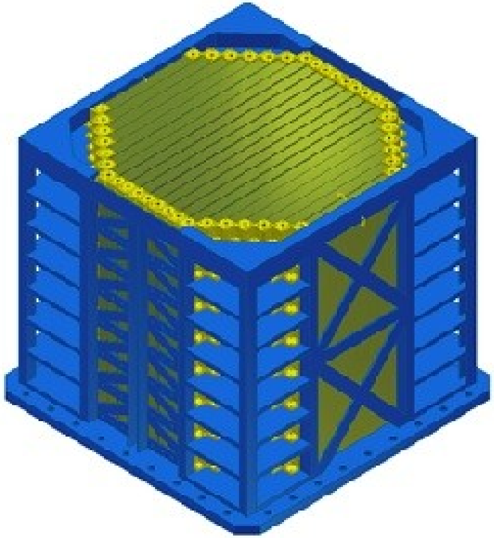
GF in function of the track length

- Testing the acceptance with different minimum track length configuration in 4 cases.
- Track length in cm should be converted in shower length in X0.
- The true computation of the track length in X0 depends on the position of each cubes:
  - Now an approximation is used:
    - Track_X0 = Track_cm * MeanActiveFraction * LYSO_X0
    - LYSO_X0 = 1.1 cm
    - MeanActiveFraction = 0.581323659.
  - Exact calculation will be soon integrated in HerdSoftware (see Jorge C. talk).

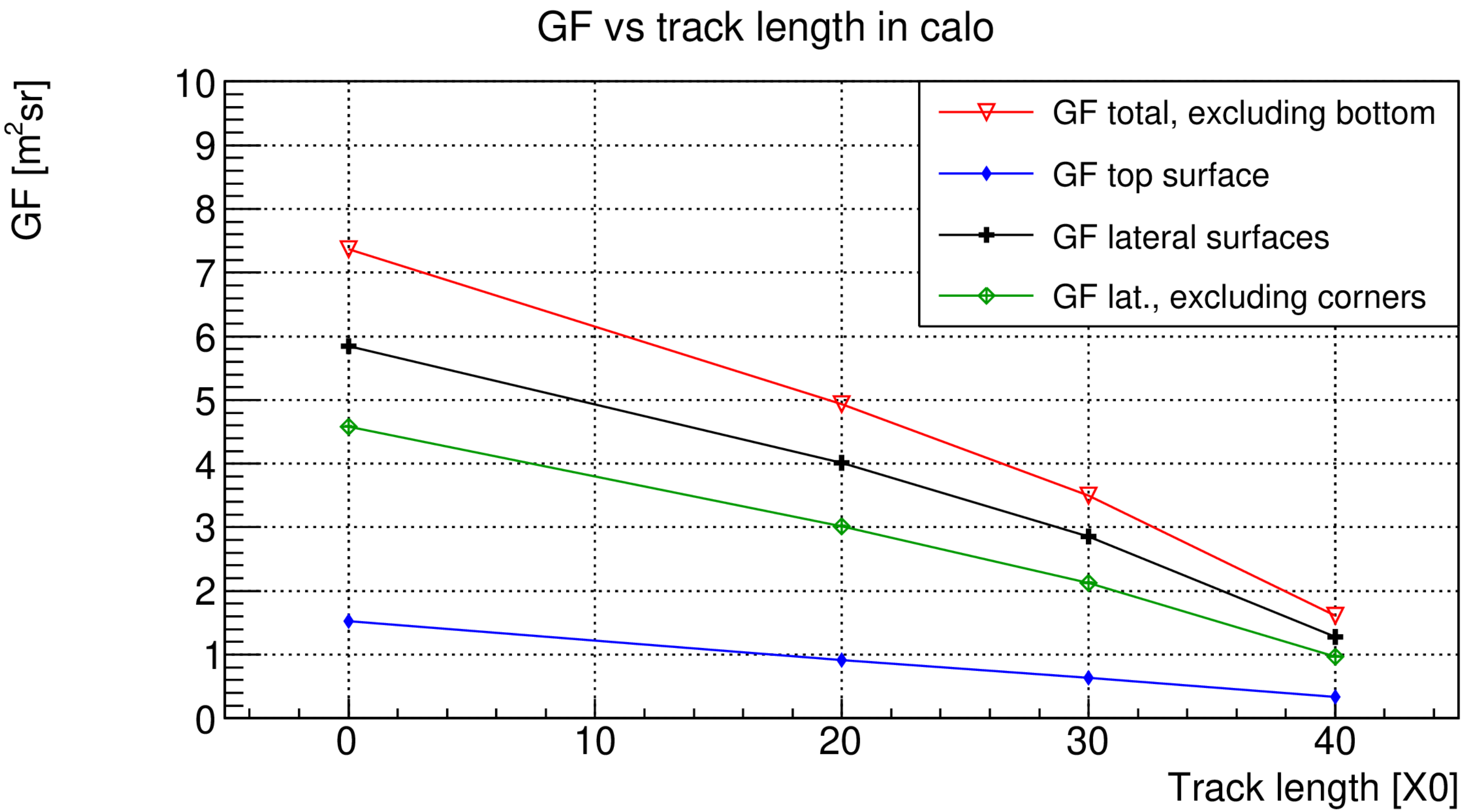
Tested geometric configurations

- Main purpose: test the impact of the lateral surfaces with respect to the total acceptance
- We focus on the Calo "corners" since looking at the mechanical structure of the calorimeter (preliminary), the corners are covered with a lot of material.
- Is not clear if the tracker can completely cover the corner.





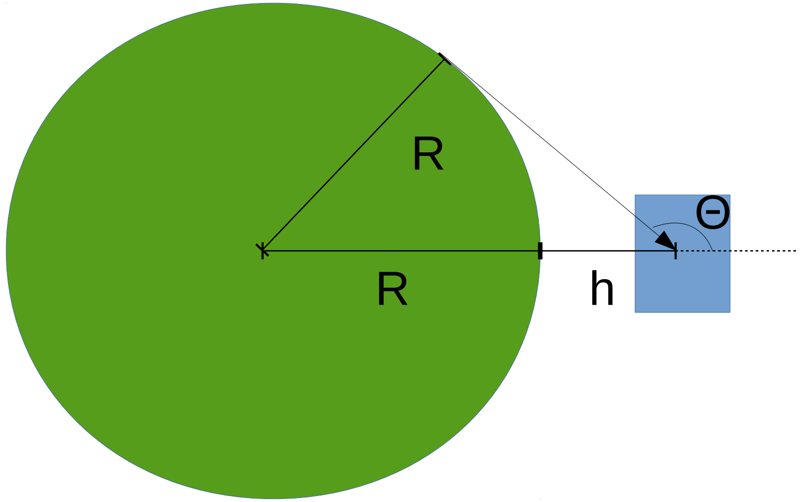
Geometrical factor vs track length



- With a cut in between 30 and 40 X0 the total GF is ~ 3.5 m^2sr. In this cofig. If we reject particles entering from the corners we lost about 1.5 m^2sr.

Earth shadow and zenit angle cut.

- The Earth could stops particle arriving below the horizon (polar angle A $>$ 90 deg).
- Rough approximation: the Earth limits the maximum polar angle:



$$\Theta_E = \frac{\pi}{2} + \mathrm{acos}\left(\frac{R_E}{R_E + h}\right)$$

$R_E \sim 6370$ km

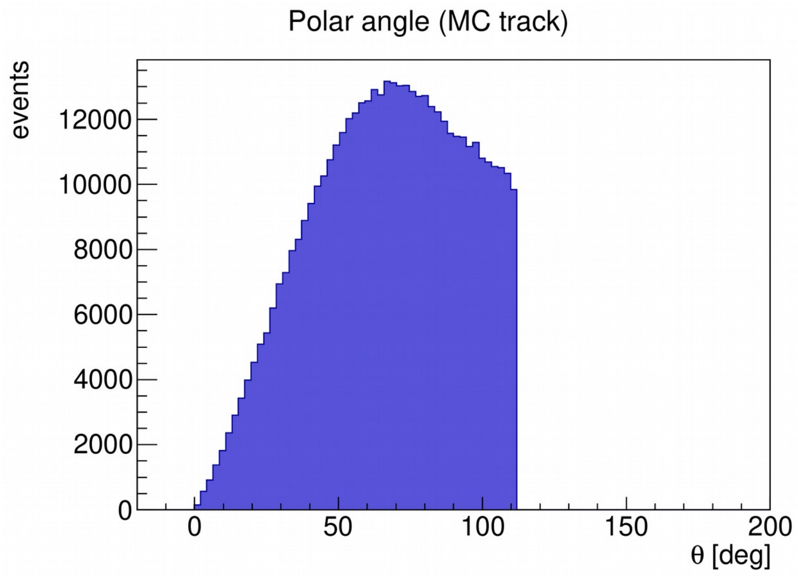
H $\sim$ 500 km

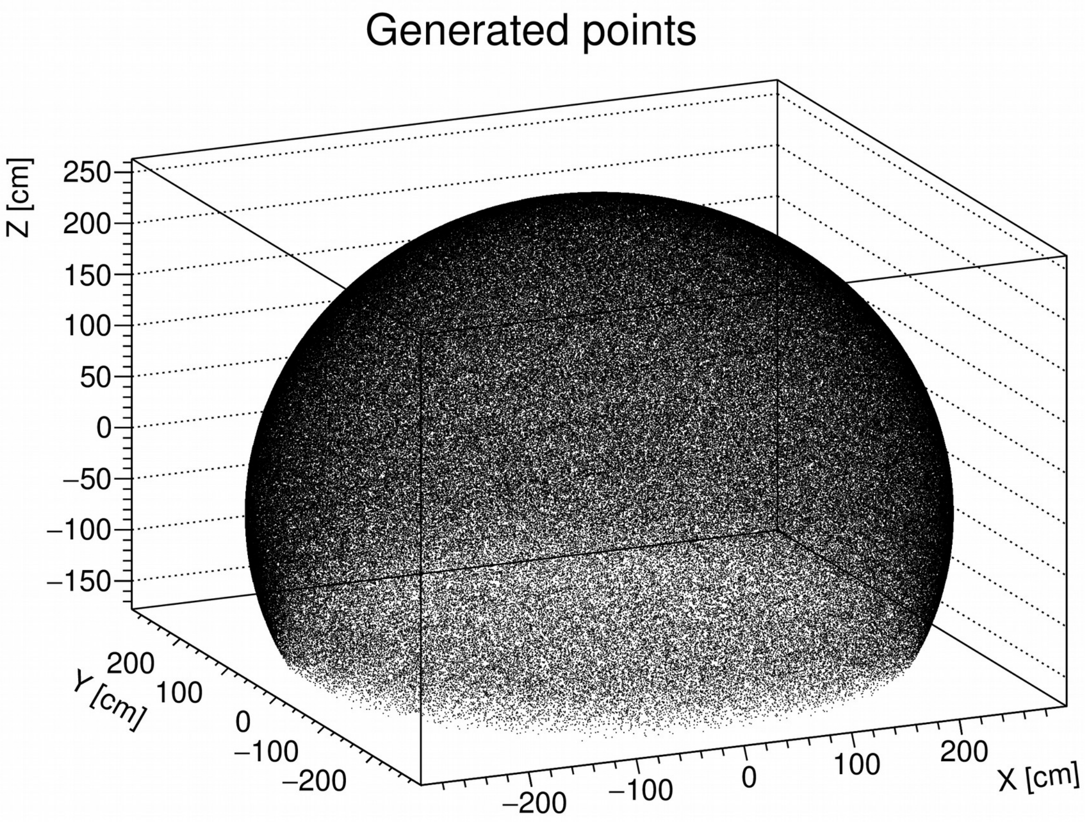
$\Theta_E \sim 112$ deg

- For Herd Θmax $=$ 112° since the Θ angle is defined as 180 – polar, thus the downward direction has Θ $=$ 0.

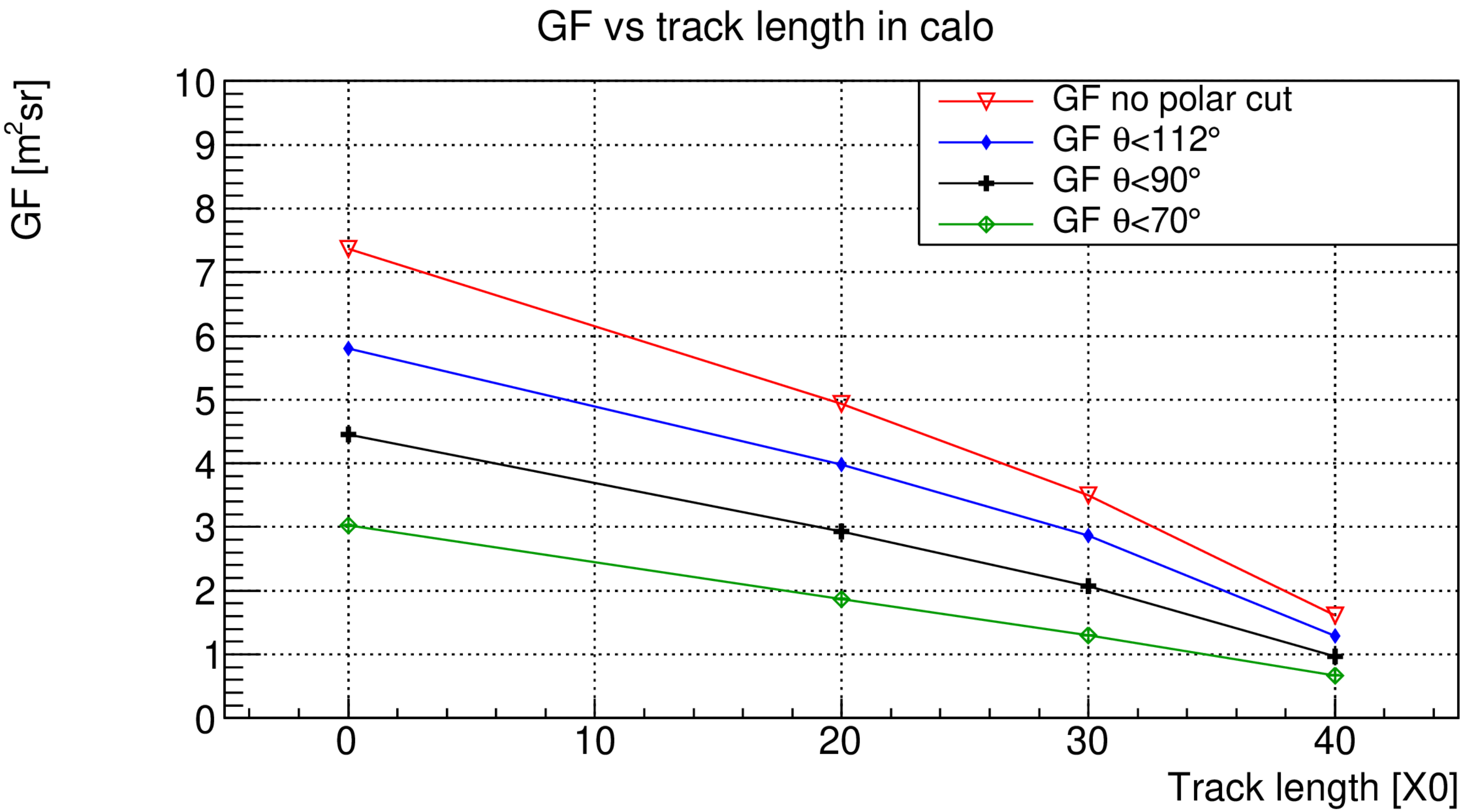
Polar angle cut checks

- Check the polar angle and the starting point of the track after the polar angle cut





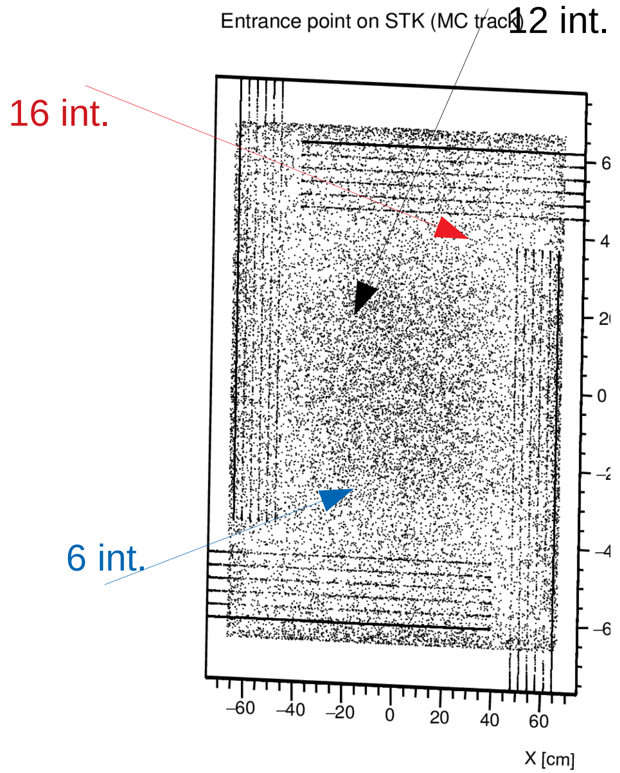
Geometrical factor vs polar angle cut

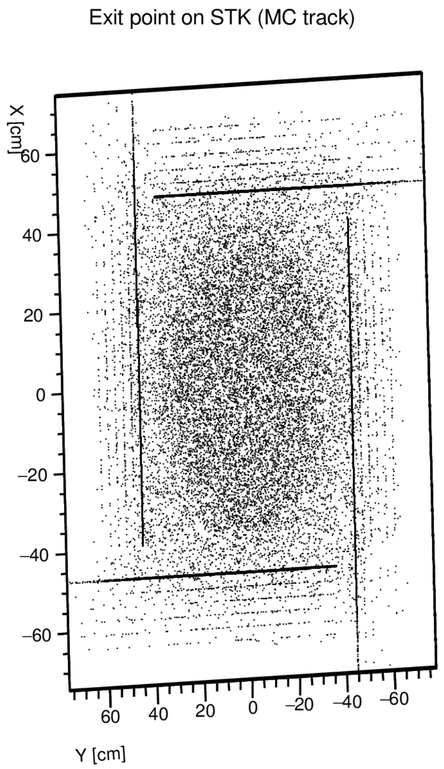


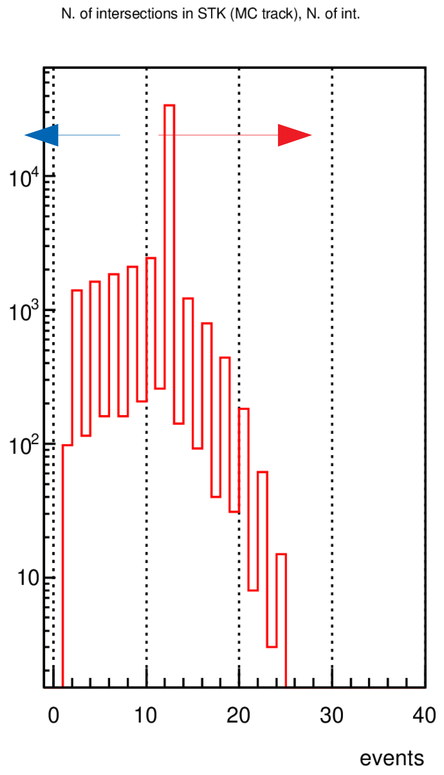
- The blue line is the maximum GF that we can obtain if we consider the Earth shadow. If the calorimeter is surrounded by a lot of structure the black line should be more realistic.

Entrance and exit point in STK

- Taking into account the current STK geometry: The intersections between the true particle track and the STK are computed. Particle with the number of intersection below a given threshold are rejected.

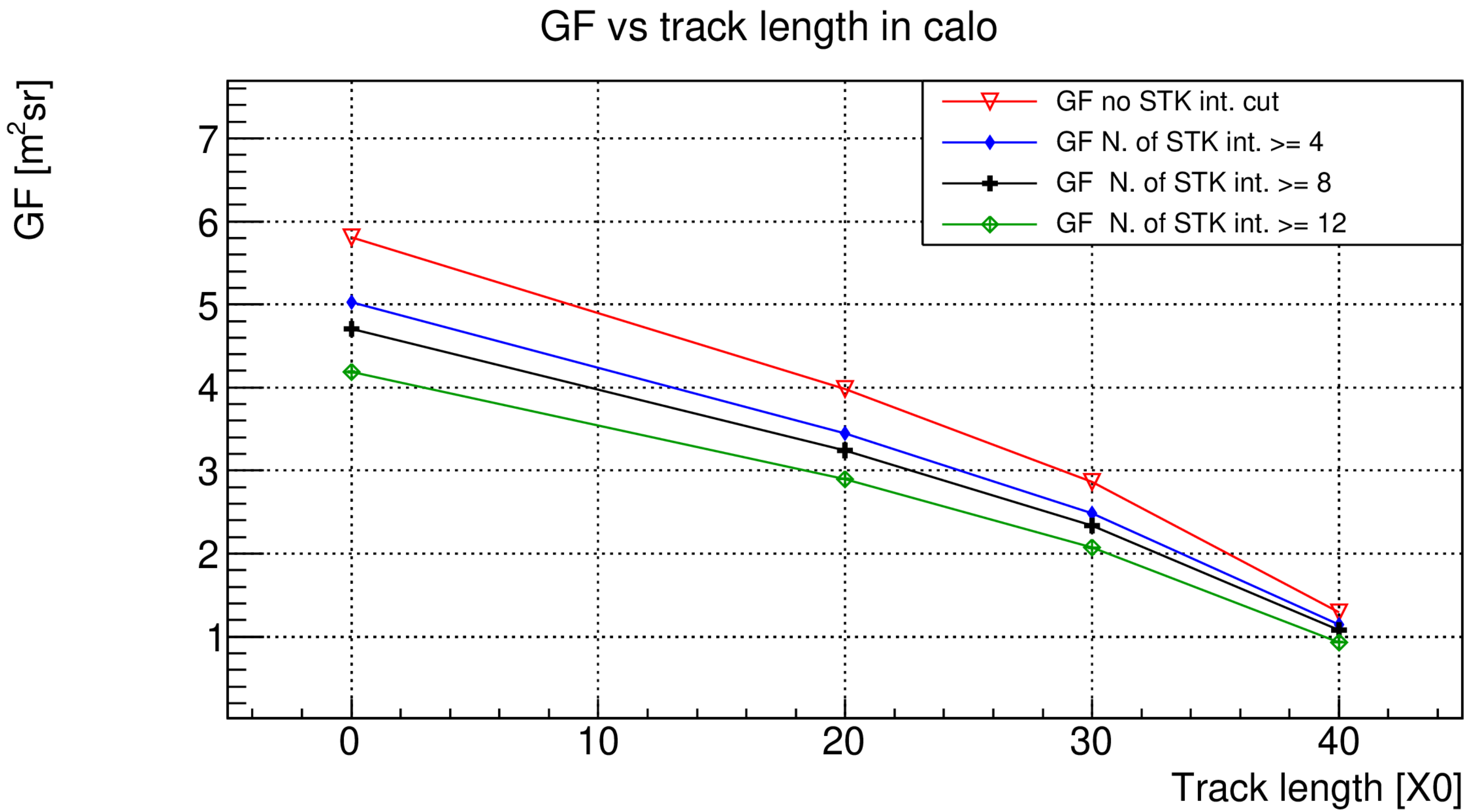






Entrance and exit point in STK

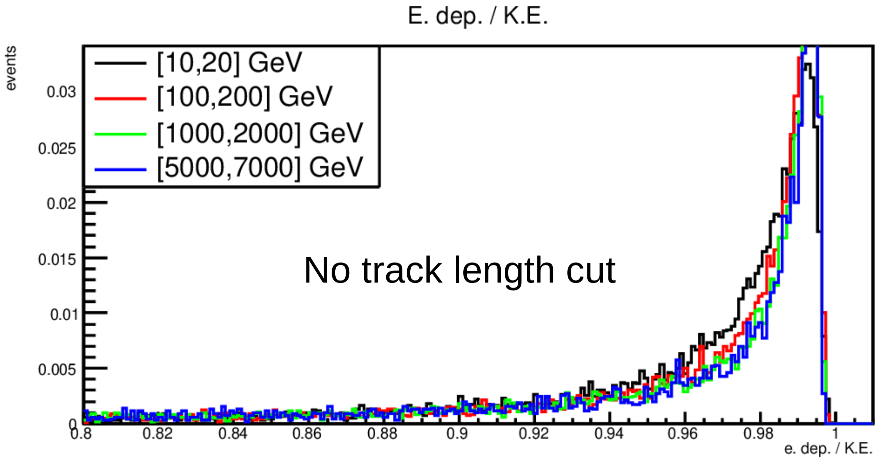
- Using 112 polar angle cut, using all the Calo faces (excluding bottom), requiring a different number of intersections of the MC track with the STK layers

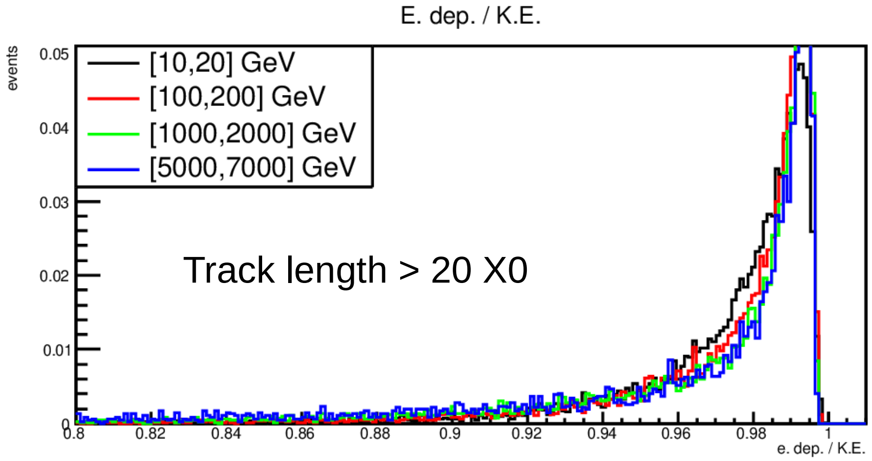


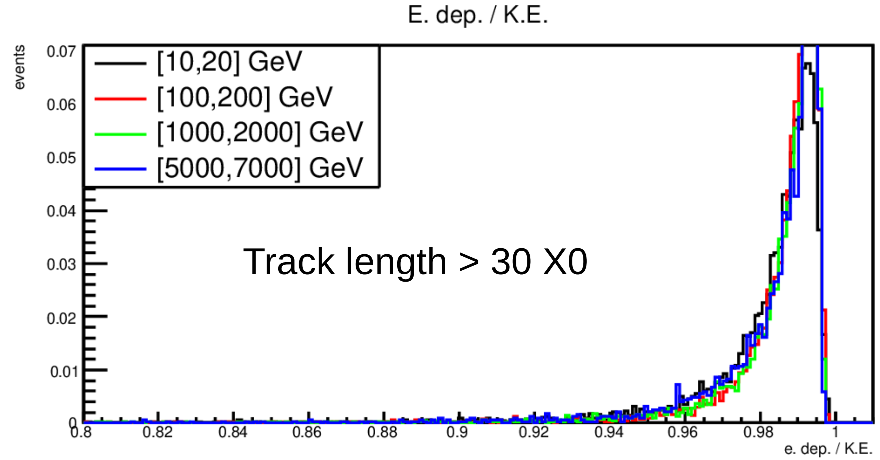
First simulations of spectra with HerdSoftware

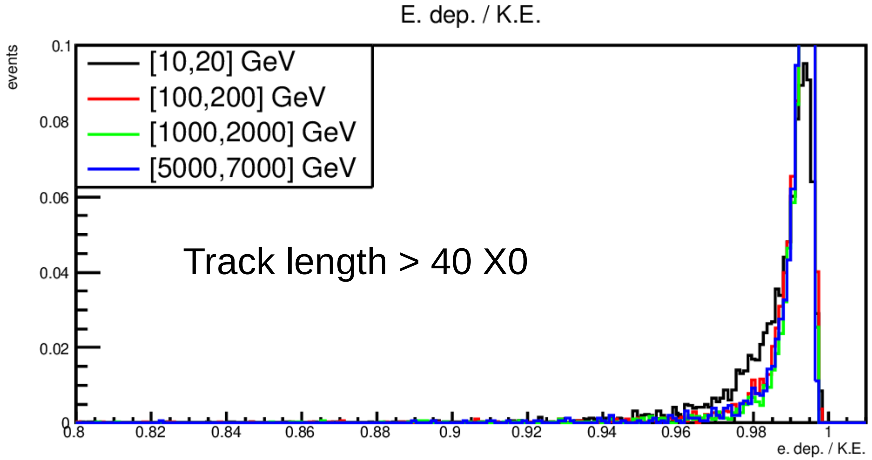
- Using HerdSoftware baseline geometry we simulated
  - 1 M events of electrons, from 10GeV to 10 TeV,
  - E^{-1} spectrum,
  - Spherical generation, with the MC acceptance check.
- The GGS output is digitized and the variables used for the acceptance computation are also added.
  - First time that this is done for a production!
  - Should be validated in next months.
  - Proton between 10GeV and 100 TeV are also produced to start the study of e/p rejection factor.
- First look of electrons, energy resolution in function of the track length.

E. dep. / kinetic energy for electrons

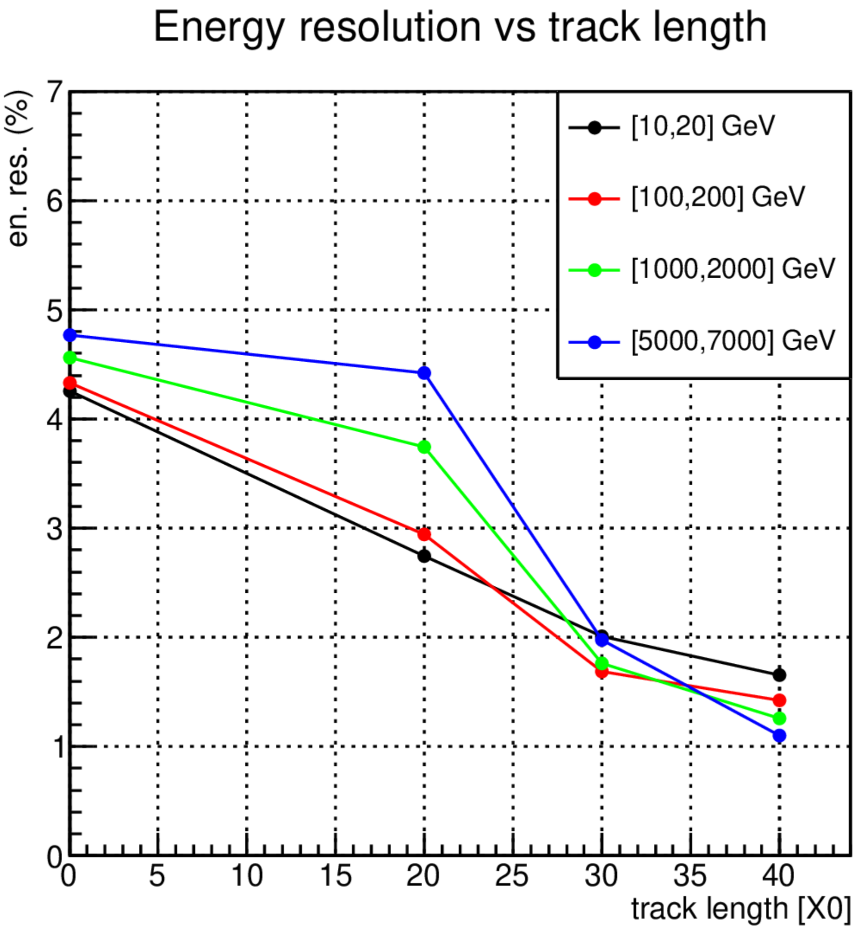


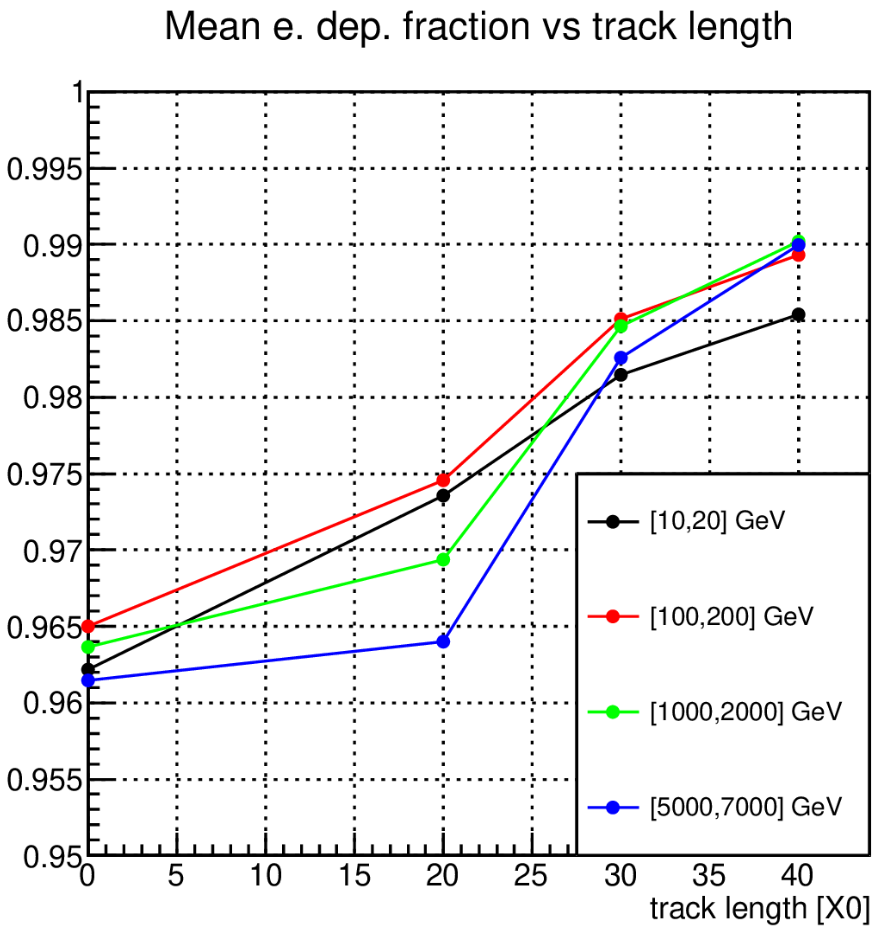






Electron energy resolution.





Conclusion

- The GF is measured using GEANT4 MC and genatino generated from a sphere.
- A requirement about the track length in the Calo is added to select well contained EM showers.
- The final results discussed in this presentation takes into account also the STK (with the current geometry):
  - for track length $>$ 30X0, a number of intersections of the MC track with STK layers $>=$ 10, a cut on the polar angel $>$ 112 deg, **the GF is** $\sim$ **2.5 m2sr,** which is consistent with previous measurement.
- The algorithms used for this analysis were recently added to HerdSoftware.
- First look @ electron MC (no passive material is simulated so far):
  - we can get an energy resolution $<\sim$2% from 10 GeV to 5 TeV with 30 X0 $\rightarrow$ 2.5 m2sr
- To do: protons, FIT, SCD, update track length algo, ... a lot of work!