Istituto Nazionale di Fisica Nucleare
SEZIONE DI FIRENZE

Bari, 16/10/2019

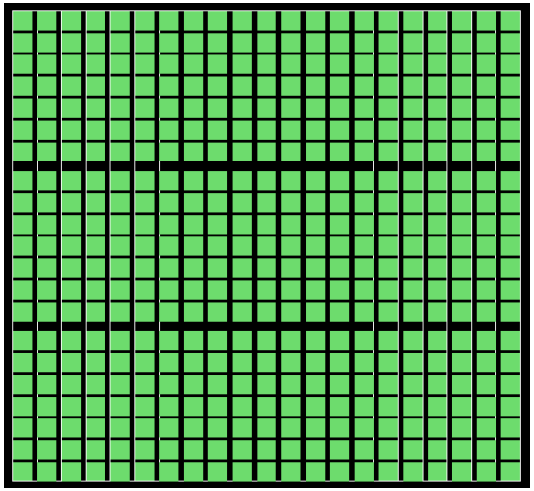
The HERD geometrical factor (GF) measured with geantinos.

Lorenzo Pacini, INFN Firenze,
lorenzo.pacini@fi.infn.it

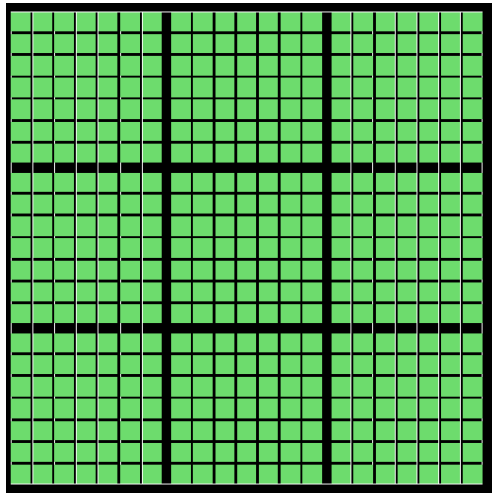
The Calo geometry in HerdSoftware

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

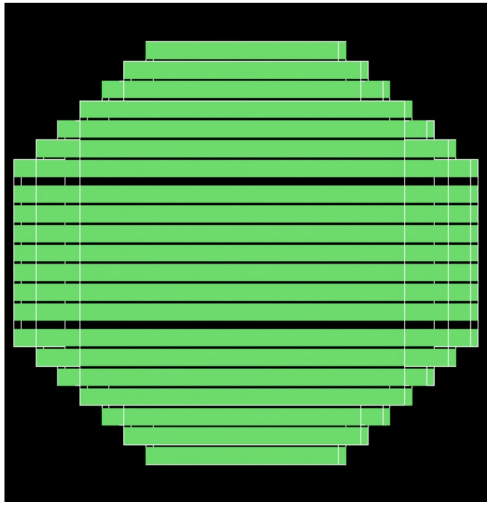
ZvsX view (Y=const)



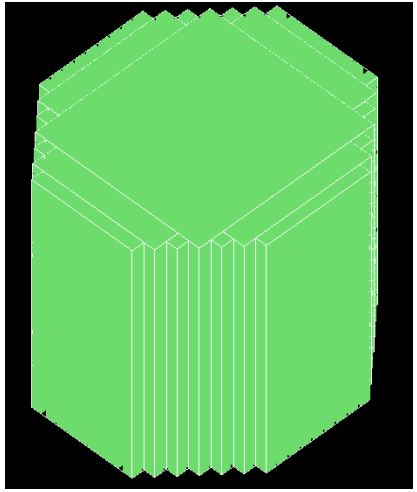
ZvsY view (X=const)



YvsX view (Z=const)

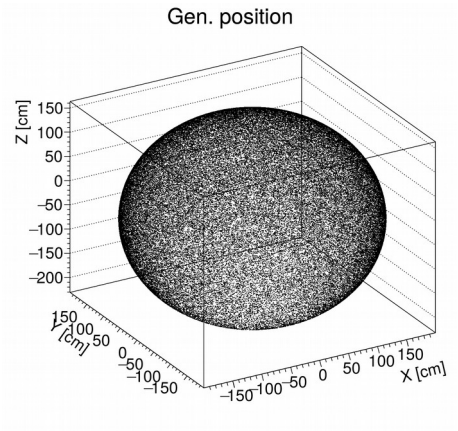


θ=φ=45 deg

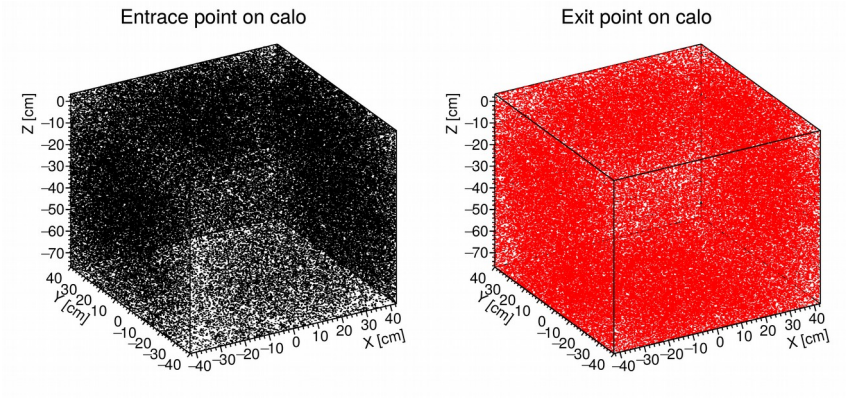


The GGS simulation

- Using the generator of GGS, which I validated for the simulation of a isotropic flux from a spherical surface.
- Generation surface: center = center of the Calo (0,0,-36.6), R=300 cm.
- Inside the simulation is present a acceptance check (https://git.recas.ba.infn.it/herd/HerdSoftware/wikis/User's-manual/Acceptance-check-in-MC), which allows to simulate only events which hit an enlarged version of the calorimeter. This feature is very useful to avoid the simulation of a huge number of events out of acceptance and it is also used for this study.



Enlarged Calo used for the acceptance check



10 M geantino events are simulated.

The main algorithms

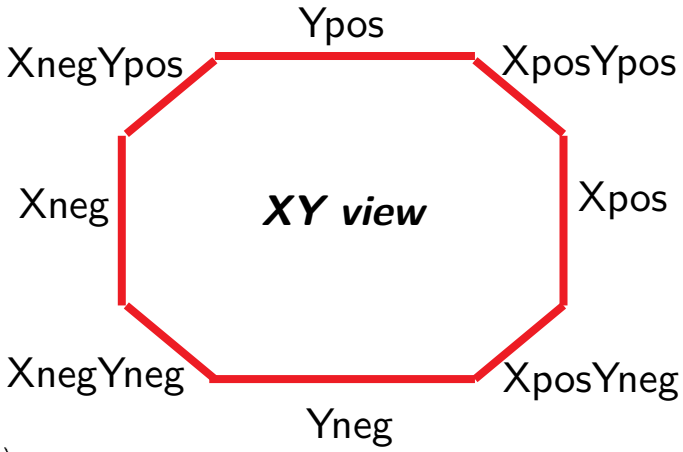
- ComputeCaloAccInfo: using the MCTruth, computes the entrance and exit points of the primary particle inside the Calo, the track length in cm and X0.
- CaloAcceptanceCut: rejects events which does not enter from the top or lateral calo surfaces, and rejects events with a track length below a given threshold
- MCAcceptanceHisto: make several plots.
- Some other secondary algorithms are involved:
  - Count events at a given stage of the analysis.
  - Count events discarded by the MC acceptance check.
  - Open TApplication to open root canvas during the processing.
  - Close TApplication and finalize the analysis.

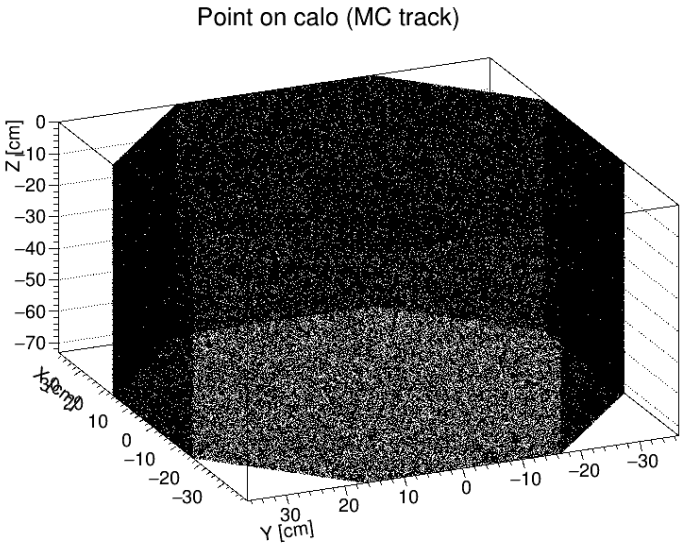
An example of config. file.

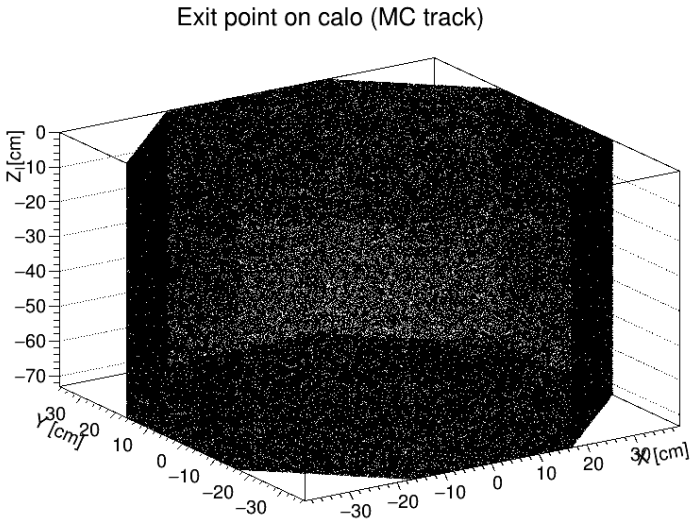
```
EventLoop
  Set printModulo 100000
  # Produce a histogram for all the events
  Sequence allHisto
    # Initialize and count events w/o cuts
    Algo OpenTApplAtFinalize openTApp
    Algo CountDiscarded countDiscarded
    Algo CountEvents countEvents_start

    #Compute the variable for Calo acc check
    Algo ComputeCaloAccInfo computeCaloAccInfo

    # Acc cut w/o shower length sel
    Algo CaloAcceptanceCut mcAcceptanceCut
    Algo CountEvents countEvents_afterCut
    Algo MCAcceptanceHisto mcAcceptanceHistoSel

    # Acc cut with shower length > 20 X0
    Algo CaloAcceptanceCut mcAcceptanceCut_20X0
      Set trackLengthCaloX0 20.
    Algo CountEvents countEvents_afterCut_20X0
    Algo MCAcceptanceHisto mcAcceptanceHistoSel_X20cm

    # Acc cut with shower length > 30 X0
    Algo CaloAcceptanceCut mcAcceptanceCut_30X0
      Set trackLengthCaloX0 30.
    Algo CountEvents countEvents_afterCut_30X0
    Algo MCAcceptanceHisto mcAcceptanceHistoSel_X30cm

    # Acc cut with shower length > 40 X0
    Algo CaloAcceptanceCut mcAcceptanceCut_40X0
      Set trackLengthCaloX0 40.
    Algo CountEvents countEvents_afterCut_40X0
    Algo MCAcceptanceHisto mcAcceptanceHistoSel_X40cm

    # Finalize the sequence
    #Algo WaitClickOnExitCanvas exitCanvas

  EndSequence
```

Entrance and exit points

- 79x73x73 cm3, <u>no track length check</u>:
  - 10 planes define the detector surface.
  - The bottom surface is not activated as entrance surface

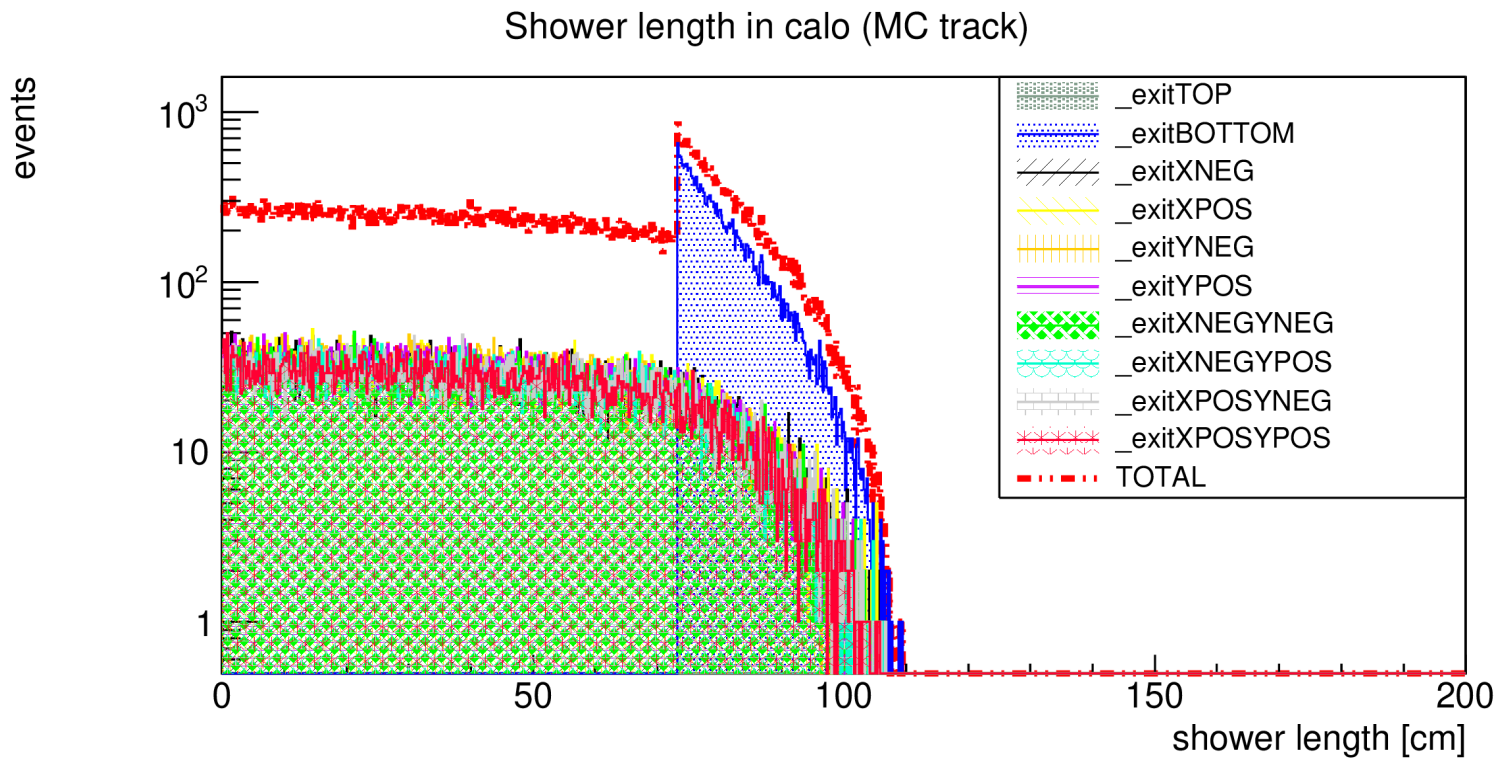






Track length in Calo

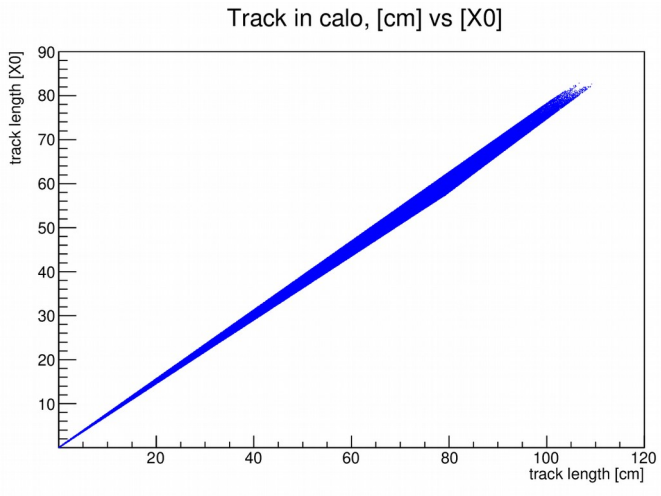
- For this plot only the TOP surface activated as entrance surface.

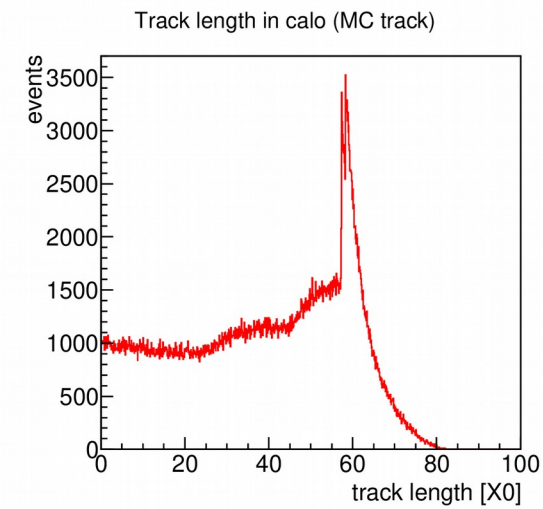


- The probability to get long track length is large if the exit point is inside the bottom surface

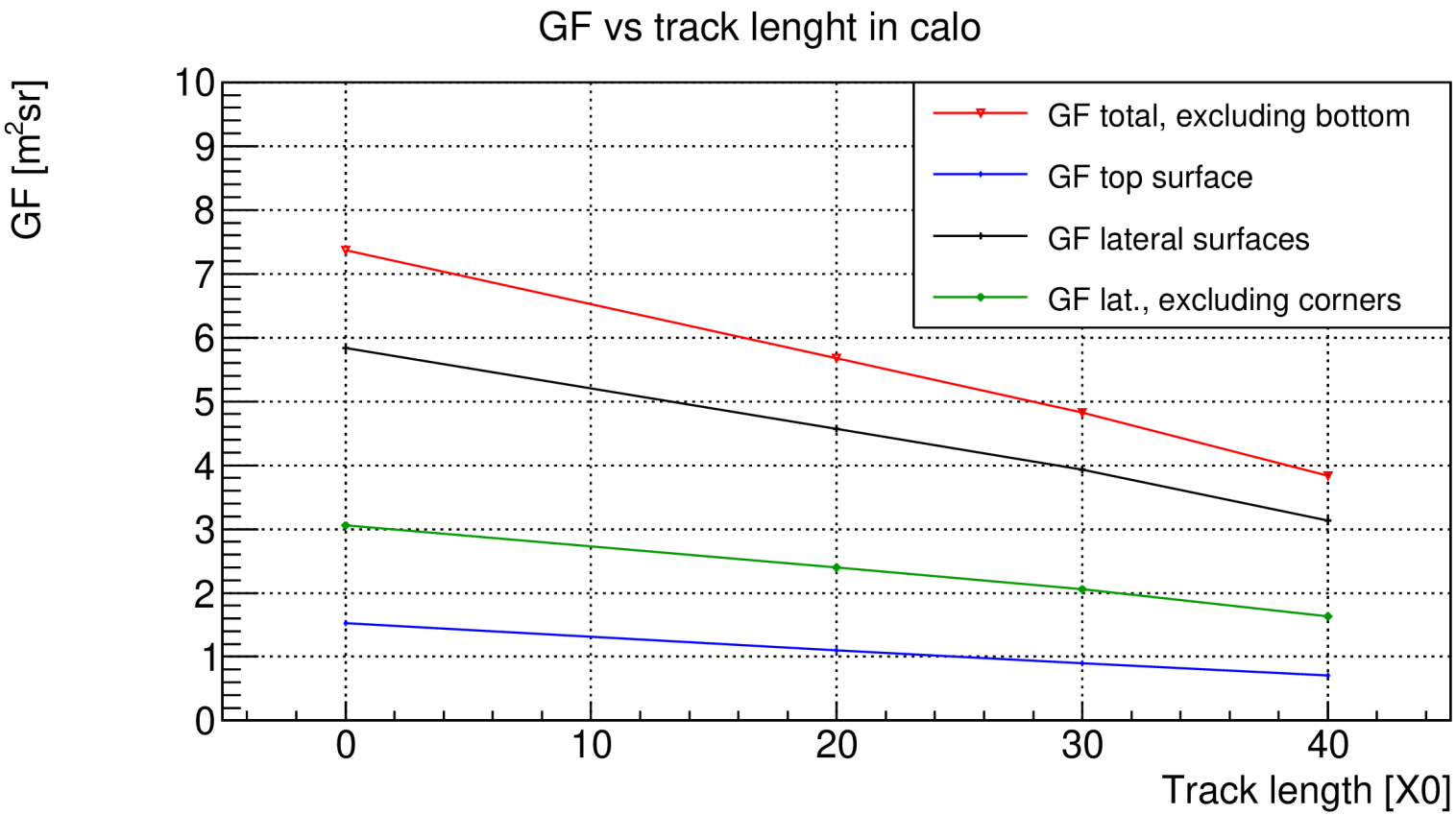
Track length in Calo (X0)

- Using the mean active material fraction for the conversion between cm and X0 is used, considering the 3 projections of the track:
  - Z mean fraction = 21*3/(21*3 + 18*0.4 + 2*1.5)
  - X mean fraction = 21*3/(21*3 + 20*0.8)
  - Y mean fraction = 21*3/(21*3 + 18*0.4 + 2*1.5)
  - Pseudo code: LengthX0_proj = LengthCm_proj * proj_meanFraction / LYSO_X0
  - LYSO_X0 = 1.1 cm





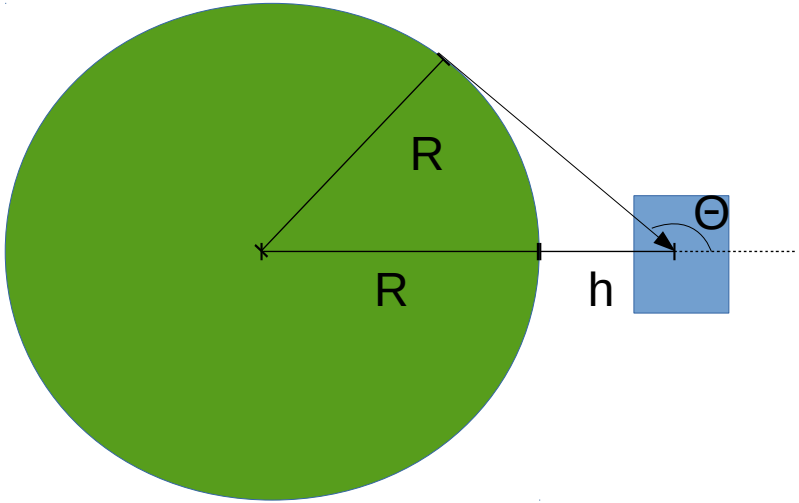
First measurement of GF



- With a cut in between 30 and 40 X0 the total GF is ~ 4.5 m^2sr. In this cofig. if we reject particles entering from the corners (ie surface which are not parallel to a coordinate axis) we lost about 1.5 m^2sr.

A new algorithm: polar angle cut

- The new algorithm is a cut studied to reject events which coming from the earth.
- Rough approximation: the Earth limits the maximum polar angle:



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

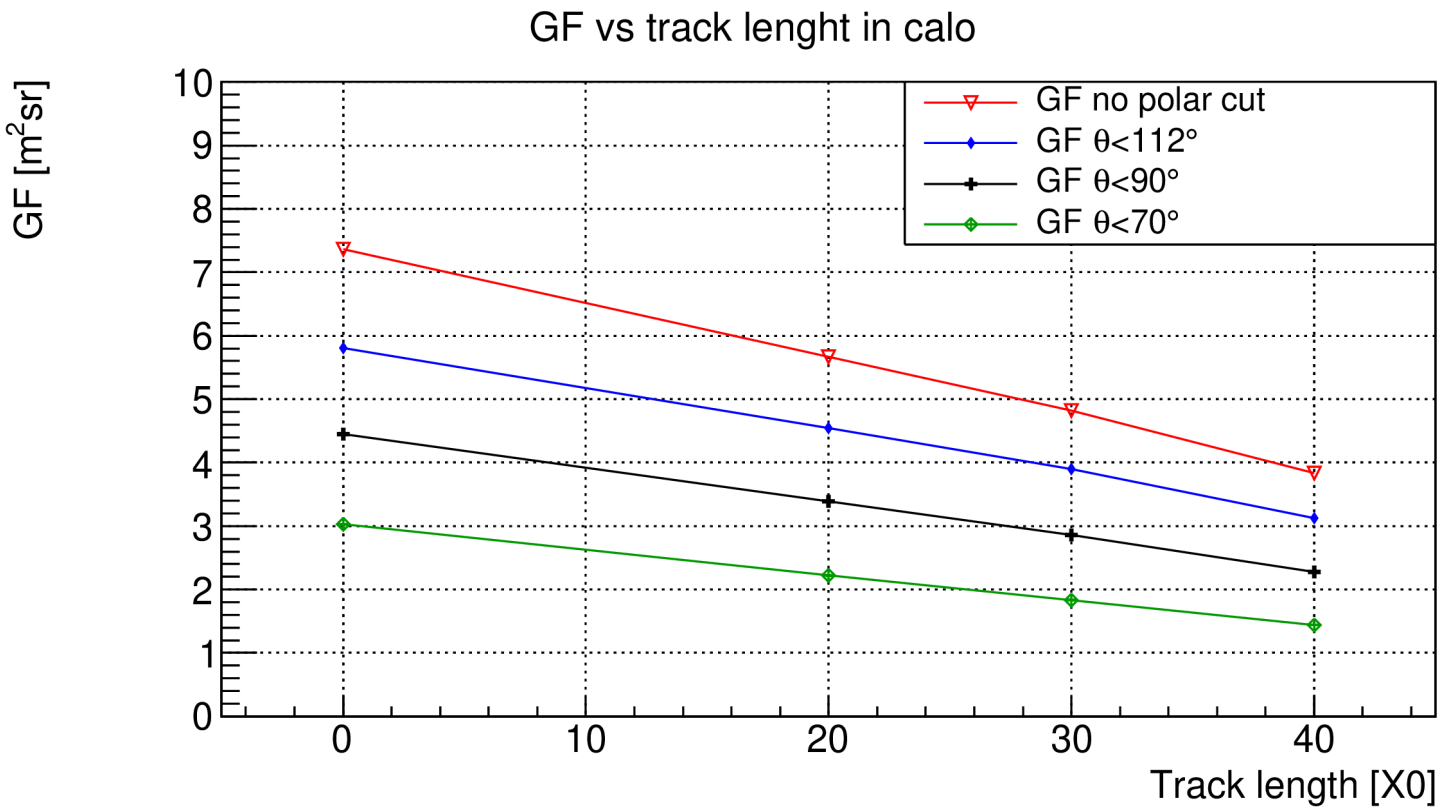
$R_E \sim 6370$ km

$H \sim 500$ km

$\Theta_E \sim 112$ deg

- For Herd $\Theta max = 112°$ since the Θ angle is defined as 180 – polar, thus the downward direction has $\Theta = 0$.
- Thus this cut is a simple cut regarding the polar angle so far but in the future the Earth shadow can be taken into account with not trivial algorithm.

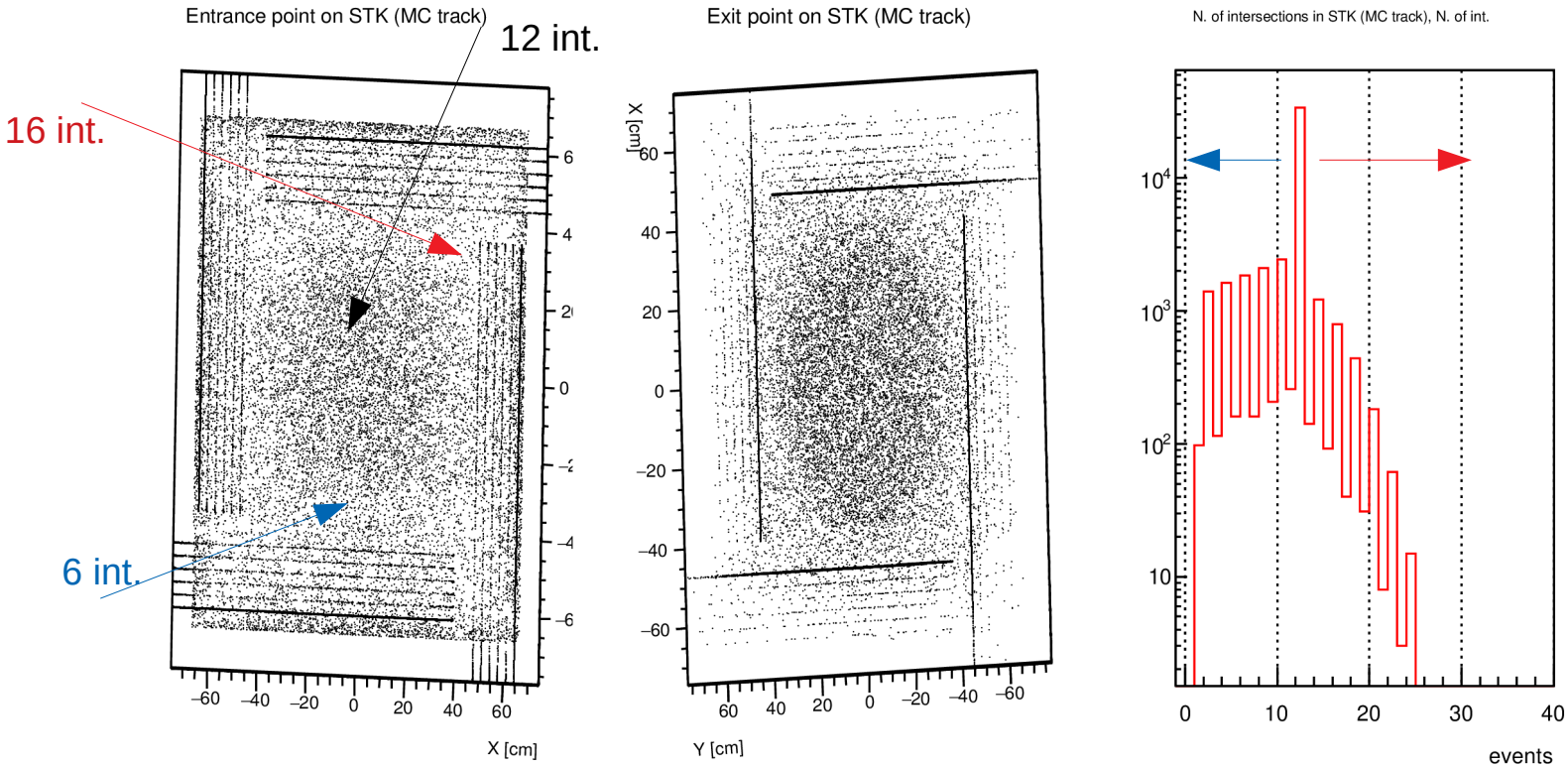
GF with different polar angle cuts.



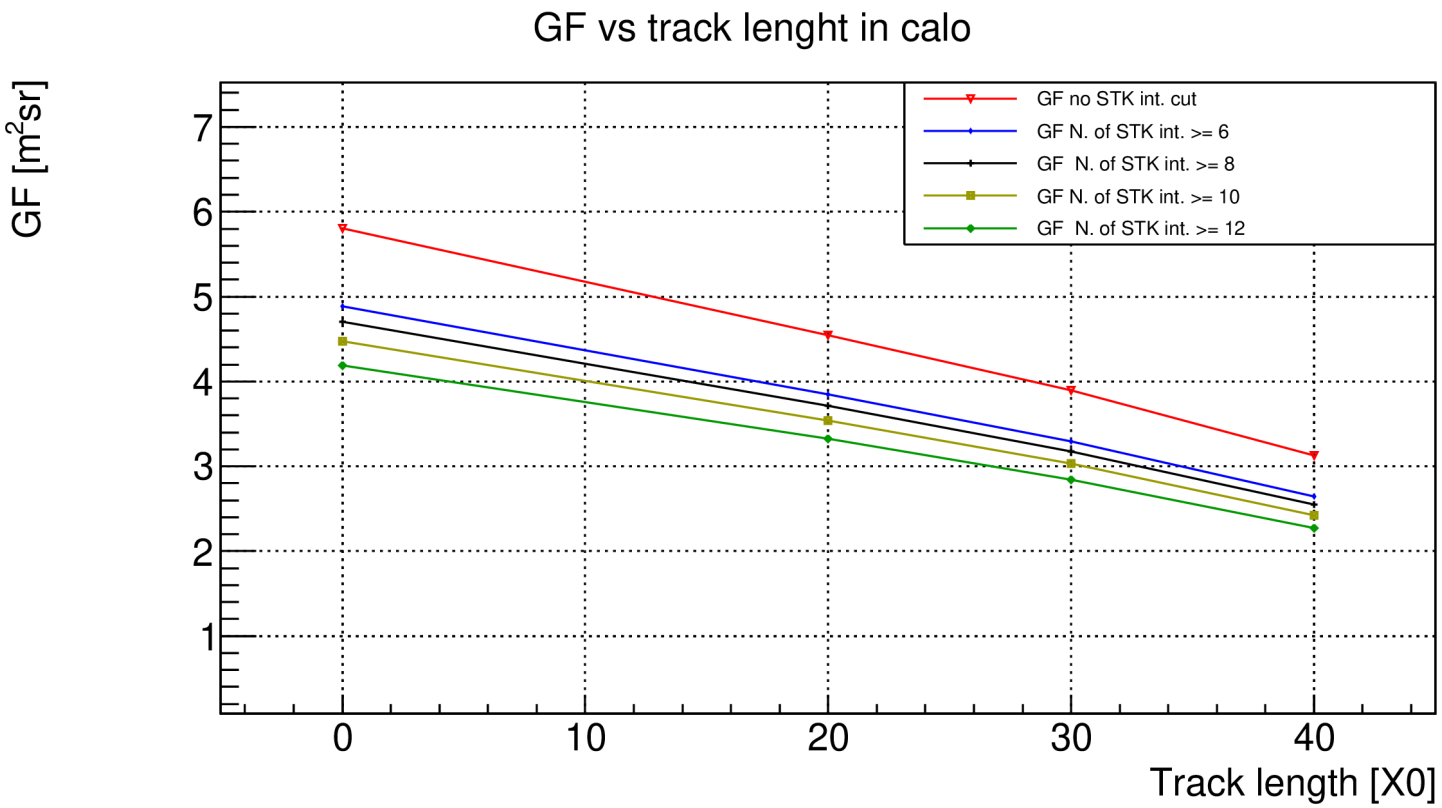
- The blue line is the maximum GF that we can obtain if we consider the Earth shadow.

2 algorithms regarding the STK

- ComputeSTKAccInfo: computes the number of intersections between the true track and the STK layers.
- STKIntersectionsCut: rejects events with a number of intersections < of a threshold.



GF with different STK int. cuts.



- Using 112 polar angle cut, all the faces excluding the bottom.
- A typical configuration, 30 X0 track length, 10 STK int., the GF is $\sim$ 3 m^{2}sr (consistent with the expected).

Add my algorithms to HerdSoftware

- Since a acceptance cut based on the particle track is needed in several analysis I will add some algorithms to HerdSoftware asap.
- Not all the algorithms will be added, e.g. algorithms to open TApplication, count events and make histograms will not be added
- In my opinion is important to share the following algorithms (let me know if you have suggestions):
  - ComputeCaloAccInfo: using the MCTruth, computes the entrance and exit point of the primary particle in the Calo, the track length in cm and X0.
  - CaloAcceptanceCut: rejects events which does not enter from the top or lateral calo surfaces, and rejects event with a track length minor of a given threshold.
  - ComputeSTKAccInfo: using the MCThruth, computes intersections between the track and the STK layers.
  - STKIntersectionsCut: rejects events with a number of intersections $<$ threshold.
- The name of the algorithm can change in the final version.

Conclusion

- GGS + EA + HerdSoftware have been used to produce and analyze a HERD simulation.
- Using geantinos, the calculation of the GF with several configuration.
- In a typical situation the results give 3 m^2sr, which is similar to previous study.
- This calculation takes into account the current geometry of the Calo, the STK and a rough approximation of the Earth shadow.
- No selection efficiency (trigger, shower, tracking...) is taken into account so far.
- Thanks to the design of the analysis, it is possible to merge some algorithms to HerdSoftware but I need:
  - Write the comments of the class in order to make a proper doxygen documentation (almost done)
  - Write a description on the wiki page (to do)
  - Adjust the name of the algorithms and the objects (maybe StkAccInfo $\rightarrow$ StkInterestions).

Please if you want to use an acceptance cut in your EA analysis please tell me and I will provide/modify/update my code even before the merging in HerdSoftware