First implementation of an acceptance check in the GEANT4 HERD Monte Carlo simulation.

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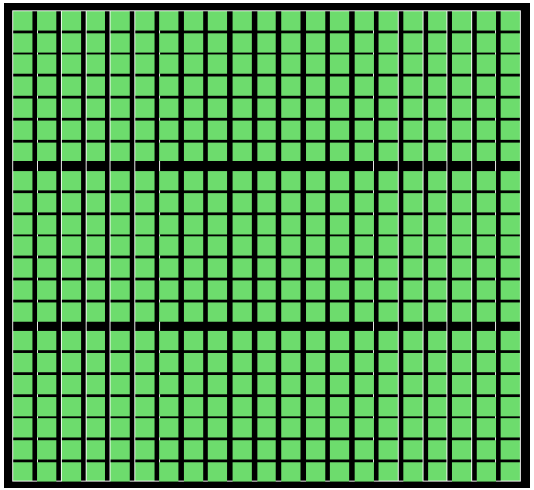
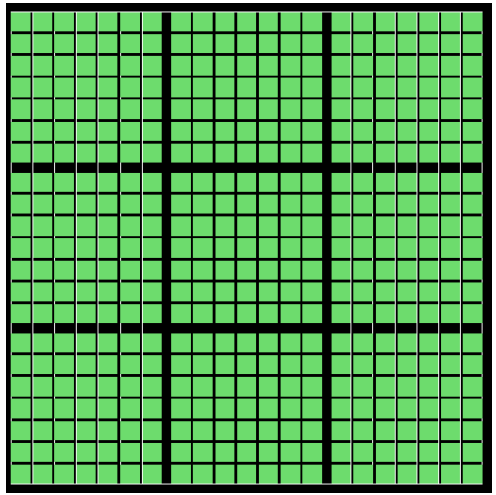
MC Calorimeter (06/2019)

- 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.

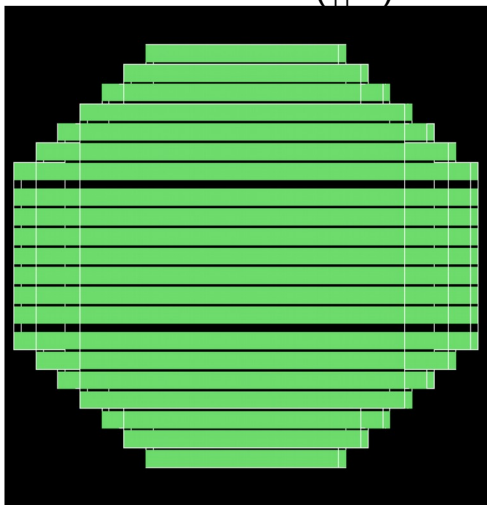
YZ view (|| X)



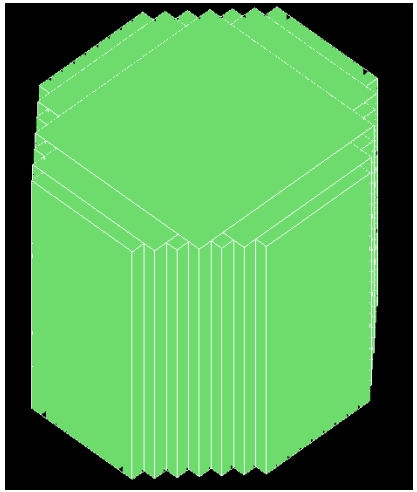
XZ view (||Y)



XY view (||Z)



θ=φ=45 deg



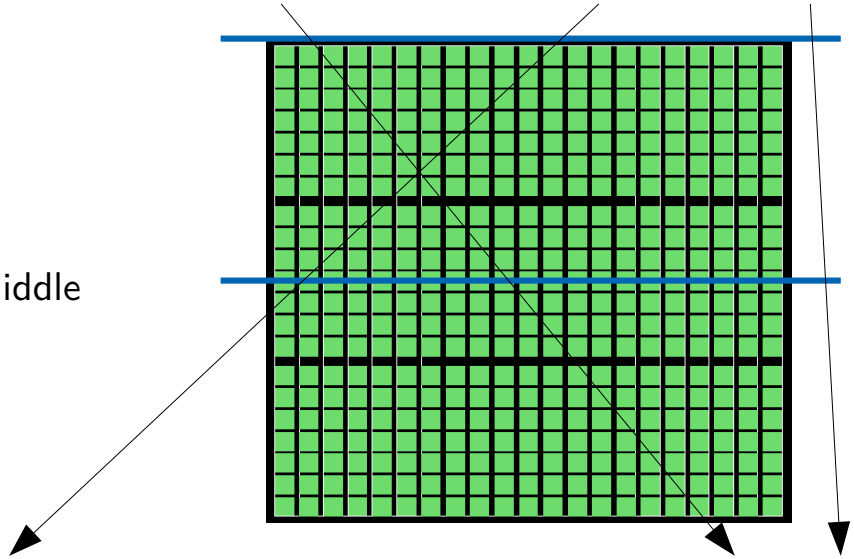
- Maximum x length = 21*(3+0.8) - 0.8 = 79 cm = LX
- Maximum y length = 21*(3+0.4) – 3*0.4 + 1.5*2 = 73.2 cm = LY
- Maximum z length = 21*(3+0.4) – 3*0.4 + 1.5*2 = 73.2 cm. = LZ

Purpose an acceptance check

- In order to simulate an isotropic flux, a large generation surface will be used.
- A lot of generated particles are out of the detector acceptance, so:
  - A large amount of data are not useful for the most of the studies (which require particles inside acceptance).
  - The computing time is not optimized.
- Acceptance check:
  - Simulate only particle generated inside an acceptance.
  - The number of discarded particles is saved, thus it is possible to compute the geometrical factor of the detector.
- Two acceptance categories are defined in ParametricGeo (HerdSoftware).
- The latter take into account the calorimeter (calo) only so far.
- The latter are configurable by external data-cards.

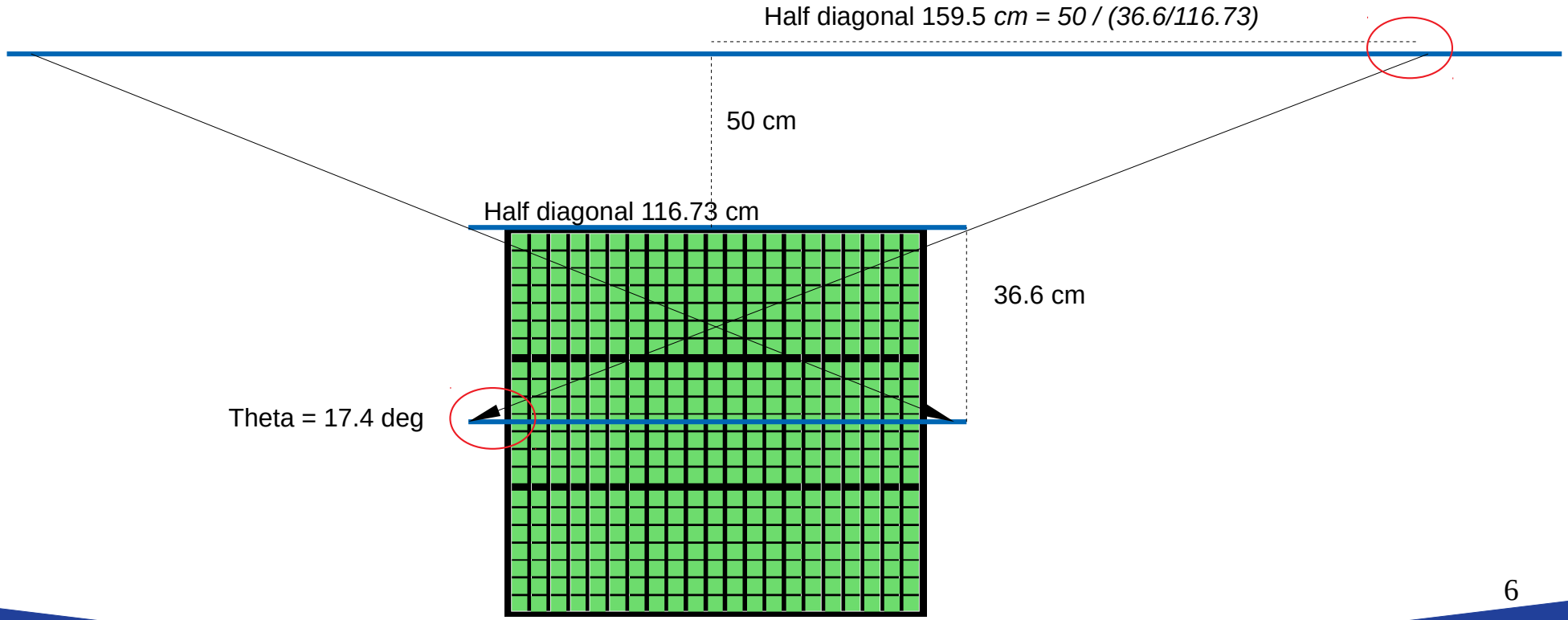
First MC accpetnace

- First MC acceptance, named “MCCaloAcc1”, includes particles entering from the top surface.
- It is larger than the “true acceptance” in order to include possible contamination due to out of acceptance particles.
- For the MC acceptance all the surfaces (including the top one) are approximated as recatangle.
- This acceptance requires:
  - the trajectory intercepts the top square: 85x80 cm (LX+6 x LY+6.8) at Z = 0 cm
  - the trajectory intercepts the same rectangle placed in the middle of the calorimeter, Z = 36.6 cm (LZ/2)21 vertical layers, 21x21 crystals (for the bigger layers), crystal side: 3 cm.



Plane generation surface

- The generation plane must be large enough to include all the possible trajectories in acceptance.
- Z quote = 50 cm, X width = Y width = 350 cm (>160*2cm), Θ = [0,90]; φ = [0,360]



Gemetrical factor of this acc.

- GF computed with the Sullivan formula: 9716.33 cm^2sr
- With the MC, using geantino @ 10 GeV:
  - GF of the generation plane: Area*π = 384845 cm^2sr
  - GF of MCCaloAcc1: (Nsel/Ntot) * $A\pi = (9730 \pm 31)$ cm^2sr
- Test with different generation plane:
  - Z quote = 25 cm $\rightarrow$ GF = (9730 ± 31) cm^2sr
  - Z quote = 100 cm $\rightarrow$ GF = (9716 ± 31) cm^2sr
  - Z quote = 0 cm $\rightarrow$ GF = (9757 ± 31) cm^2sr
  - Z quote = 100 cm, XY 1000x1000 cm^2 $\rightarrow$ GF = (9743 ± 31) cm^2sr

MCCaloAcc1 configuration file.

- Is it possible to configure the parameters which define the MCCaloAcc1 using the geometry data-card of GGS (option -gd). Here an example which configure the default values (only for example, since the geometry data-card is not needed if the parameters are equal to the default ones):

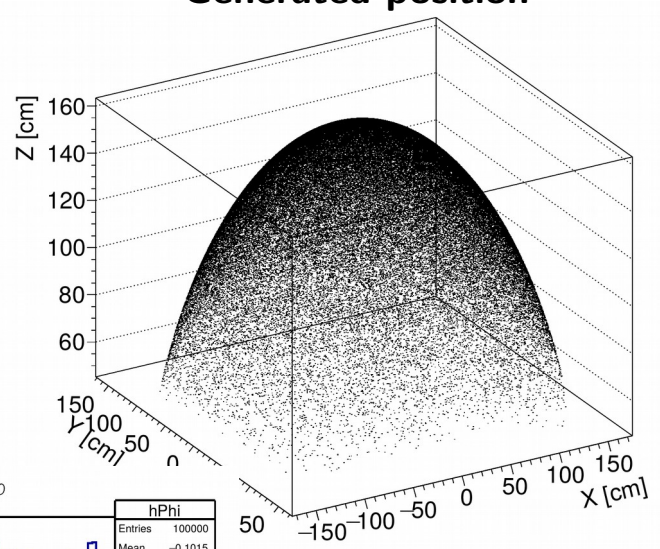
```
/herd/geometry/parametric/acceptance/MCCaloAccType 1
/herd/geometry/parametric/acceptance/caloTOPXwidth 85
/herd/geometry/parametric/acceptance/caloTOPYwidth 80
/herd/geometry/parametric/acceptance/caloTOPZquote 3
/herd/geometry/parametric/acceptance/caloBOTTOMXwidth 85
/herd/geometry/parametric/acceptance/caloBOTTOMYwidth 80
/herd/geometry/parametric/acceptance/caloBOTTOMZquote -76
```

- The default unit for the width and quote is [cm].

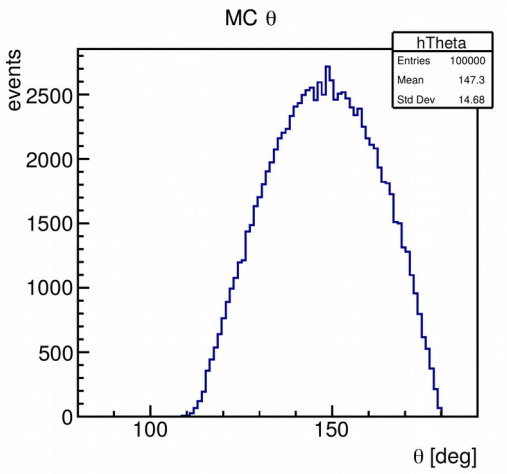
Test the spherical generation of GGS.

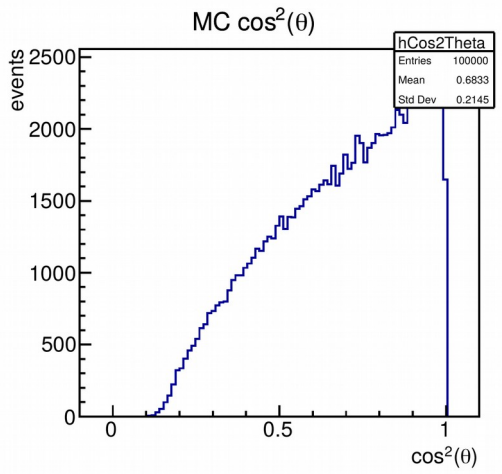
- Using a hemisphere for the generation: R = 200 cm.
- Center = center of the calo = (0,0,-36.6)
- GF obtained with this generation: (9705 ± 31) cm^2sr
- It is consistent with respect to the Sullivan result: 9716 cm^2sr

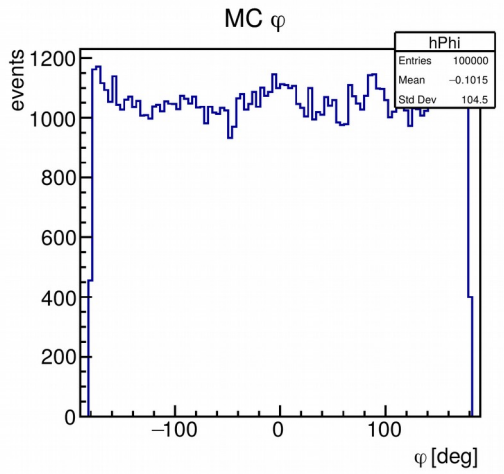
Generated position



Generated angles

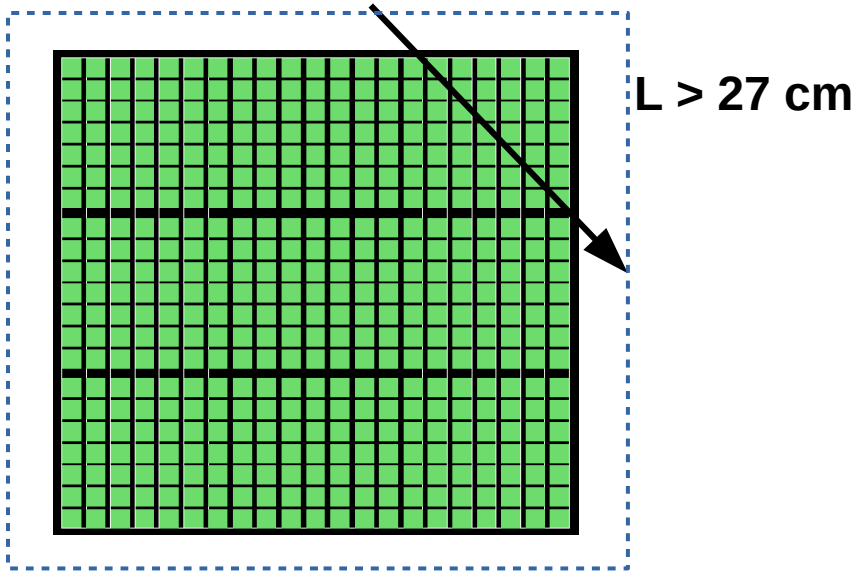






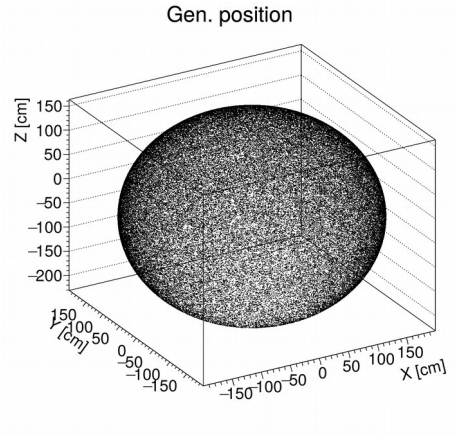
Second MC acceptance: MCCaloAcc2

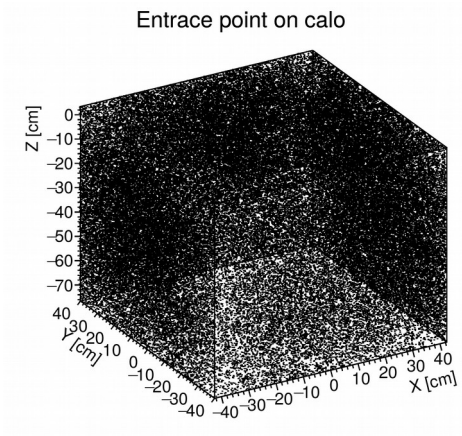
- Selecting particles with a shower length in the Enlarged Calo $>\sim$ 20 X0.
- "Enlarged Calo" is a box with the height = 80 cm, and the edge defined by the top plane (80x85 cm^2).
- LYSO X0 $\sim$ 1.16 cm $\rightarrow$ 20 X0 $\sim$ 23.2 cm in crystals.
- Using 27 cm assuming ~20% of "passive" material, so far this material is vacuum.
- In summary "MCCaloAcc2" requires:
  - the trajectory intercepts the top or lateral surfaces of the enlarged cube: 85x80x80 cm^3.
  - the trajectory length in enlarged calo (85x80x80 cm^3) is $>$ 27 cm,

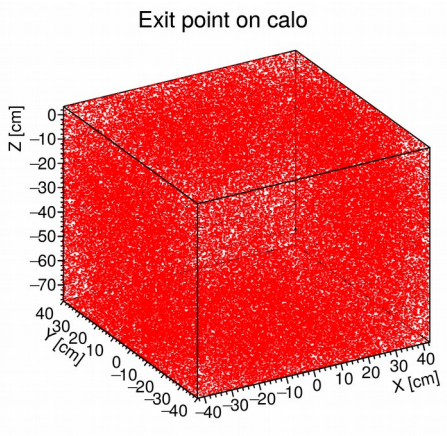


Entrance and exit points

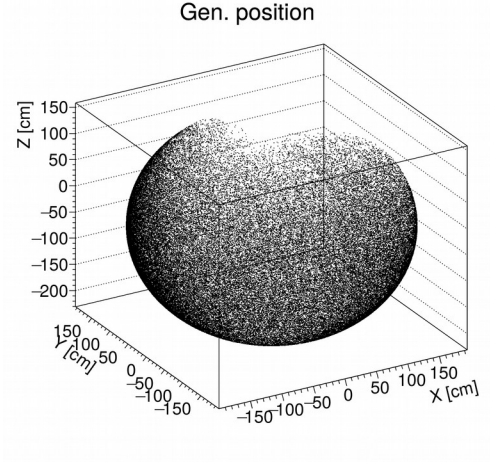
- Standard MCCaloAcc2

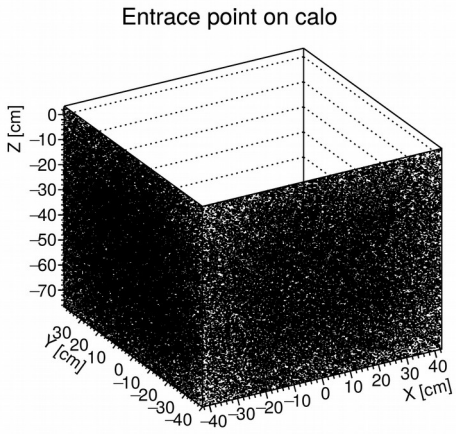


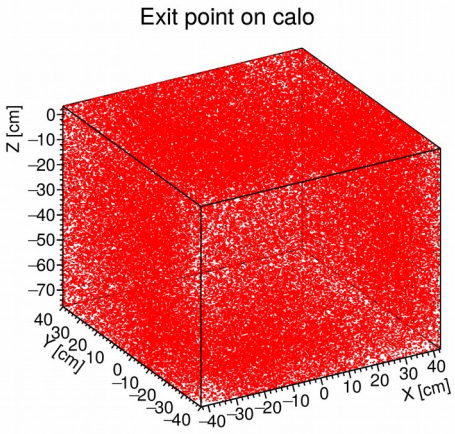




- Test: only X left (X negative) and Y left (Y negative) surfaces are activated as entrance surfaces







GF of MCCaloAcc2

- No analytical analysis available.
- The generation surface is a sphere, R = 200 cm, center = center of the calo, GF sphere: 1579136 cm^2sr.
- GF of MCCaloAcc2 = (76687 ± 77) cm^2sr ~ 7.7 m^2sr.
- Test using the TOP surface as the entrance surface: GF: (15775 ± 15) cm^2sr ~ 1.6 m^2sr.
- Testing shower length = 0, requiring the entrance point on the top surface:
  - GF expected = 80x85xπ = 21362 cm^2sr.
  - GF measured with the MC = (21364 ± 21) cm^2sr ~ 2.1 m^2sr
  - Same test with the bottom surface: (21355 ± 21) cm^2sr.
  - Same test with Y right surface: (21360 ± 21) cm^2sr. (Y right → (21360 ± 21) cm^2sr)
- Same test with X left (and right) surface.
  - GF expected = 80x80xPi = 20106 cm^2sr.
  - GF measured with the MC = (20122 ± 20) cm^2sr. (X right → (20096 ± 20) cm^2sr)

MCCaloAcc2 config file

- An example which configures the default values of MCCaloAcc2

```
/herd/geometry/parametric/acceptance/MCCaloAccType 2
/herd/geometry/parametric/acceptance/caloShowerLenght 27
/herd/geometry/parametric/acceptance/caloTOPXwidth 85
/herd/geometry/parametric/acceptance/caloTOPYwidth 80
/herd/geometry/parametric/acceptance/caloTOPZquote 3
/herd/geometry/parametric/acceptance/caloBOTTOMXwidth 85
/herd/geometry/parametric/acceptance/caloBOTTOMYwidth 80
/herd/geometry/parametric/acceptance/caloBOTTOMZquote -76
/herd/geometry/parametric/acceptance/selectTOPcalo 1
/herd/geometry/parametric/acceptance/selectBOTTOMcalo 0
/herd/geometry/parametric/acceptance/selectXLEFTcalo 1
/herd/geometry/parametric/acceptance/selectXRIGHTcalo 1
/herd/geometry/parametric/acceptance/selectYLEFTcalo 1
/herd/geometry/parametric/acceptance/selectYRIGHTcalo 1
```

- If shower length is $= 0$, shower length check is not applied
- NOTE: the TOP and BOTTOM planes must be equal otherwise the algorithm can not work properly so far.

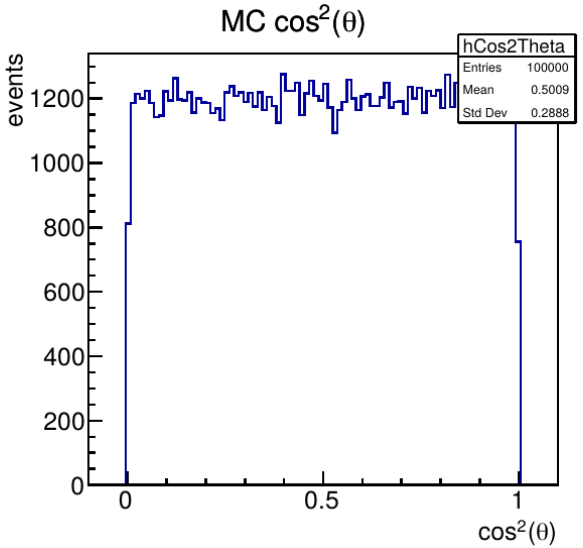
Conclusion

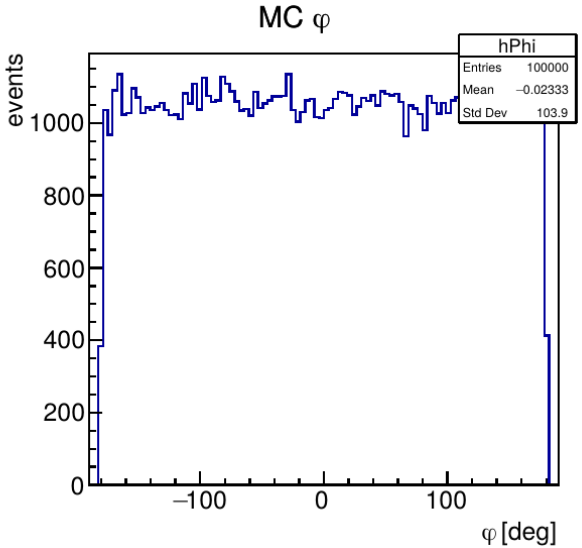
- Two MC acceptance categories has been defined.
- MCCaloAcc1:
  - It is validated using Sullivan formula.
  - The generation surface can be a plane or a sphere.
  - The GGS sphere generation is also validated.
- MCCaloAcc2
  - Validated observing the entrance and exit points
  - GF with different configurations are consistent each others.
- Both the acceptances using external can be configure using external-data-card. Please see the wiki page for further description: https://git.recas.ba.infn.it/herd/HerdSoftware/wikis/User's%20manual/Acceptance%20check%20in%20MC
- About $10^{\hat{}7}$ geantinos are simulated with the MCCaloAcc2, and shower length $= 0$, to measure the geometrical acceptance of the calorimeter with different requirements.

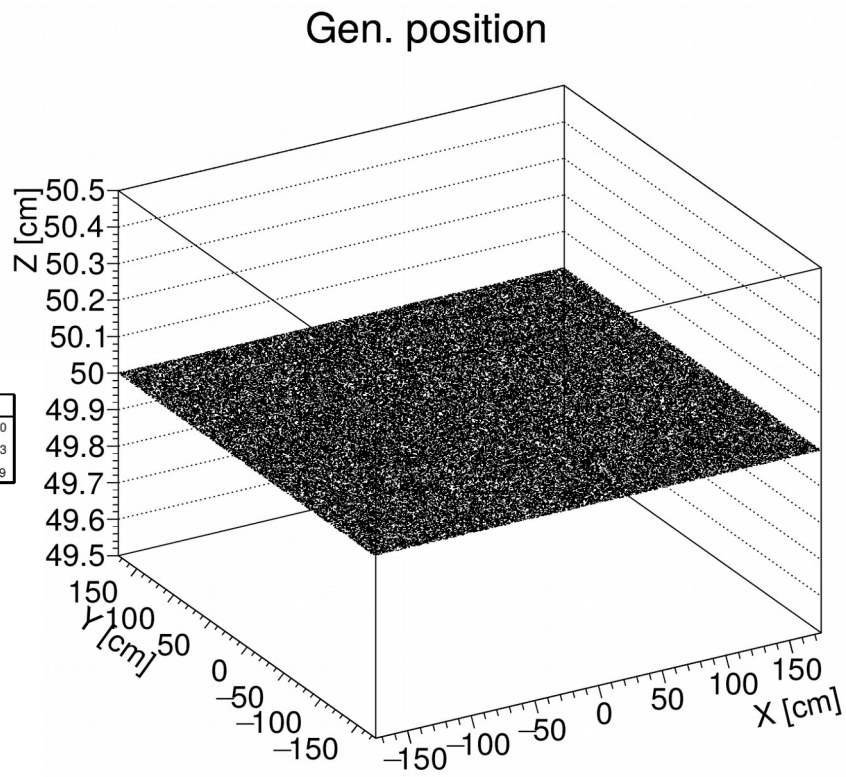
Backup slide

Plane generation test

- No acceptance check
- Geantino.
- Plane : 350x350 cm2, Z = 50 cm

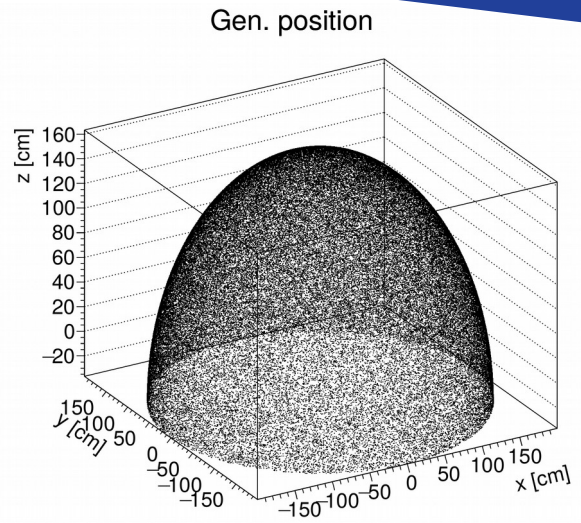


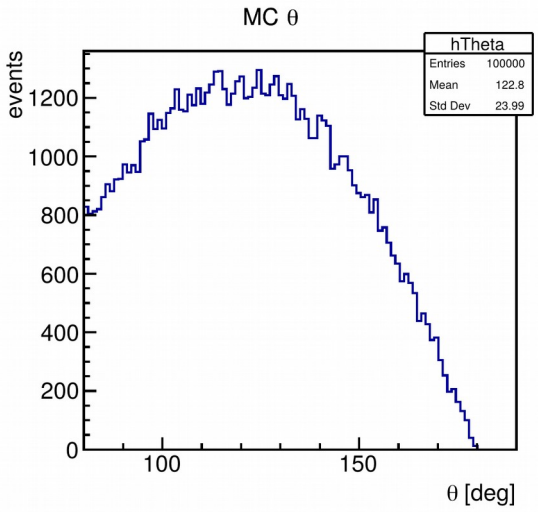


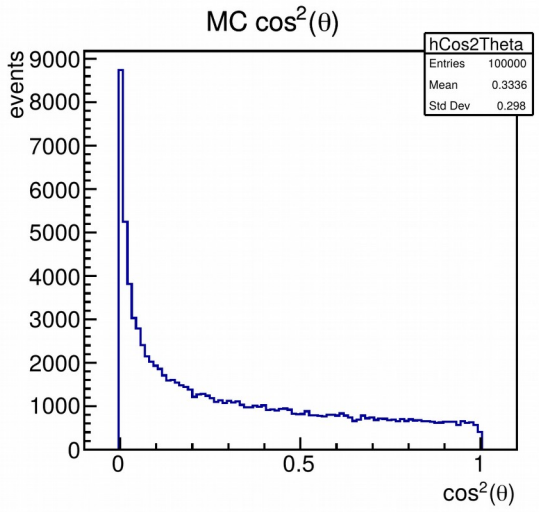


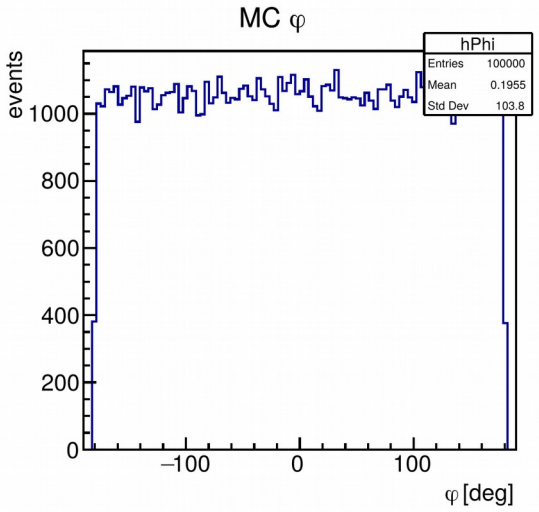
Shpere gen. Test

- No acceptance check.
- Geantino.
- R = 200 cm
- Center = center of the Calo (0,0,-36.6)









Shpere gen. Test: particle in a circle

- Acceptance check: single circular plane: center (0,0,0), R = 60cm.
- Geantino.
- R = 200 cm
- Center = center of the Calo (0,0,-36.6)

Expected acc: pi*Aplane = 35530 cm2sr
Calculated (Nsel/Ngen * pi * Ahemisphere) =
4535/100000 * 789568 = 35800+-500!