



Developments in Simulation

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X FOOT Collaboration Meeting, 24 May 2021

Outline

1. Update of wiki page
2. GS2021 campaign
3. After the last design of magnet system: the new 12C_200new campaign
4. Proposed strategies for next production
5. New developments available in FLUKA

1) Update of Simulation data Wiki page (May 15th)

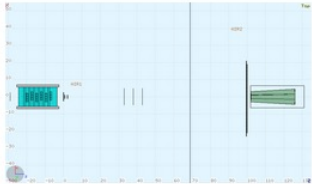
<http://arpg-serv.ing2.uniroma1.it/twiki/bin/view/Main/FOOTAvailableSimulation>

CNAO2020/2021 MC studies

Files are available on tier3 at

`/gpfs_data/local/foot/Simulation/CNAO2020`

A campaign tag denominated CNAO2020 has been made available in the [NewGeom](#) and Master branches of SHOE.



There are different type of files.

A) primitive [EventStruct](#) files

1. 12C_C_200.root (10⁷ C primaries on C target, 284246 events on file)
2. 12C_C2H4_200_1.root and 12C_C2H4_200_2.root (both for 10⁷ primaries on [C2H4](#) target, 198215 and 197621 events on file respectively)
3. 12C_C_200em.root (10⁷ C primaries on C target, 284376 events on file) with transport of e+/e- and photons with 500 keV cut
4. 12C_C2H4_200em_1.root and 12C_C2H4_200em_2.root (both for 10⁷ primaries on [C2H4](#) target, 197224 and 197248 events on file respectively) with transport of e+/e- and photons with 500 keV cut
5. 12C_C2H4_200notr_n.root (n=1,2,3,4,5) Untriggered simulation (2 10⁶ primaries each one)

B) SHOE root files (corresponding to the above listed ones)

1. 12C_C_200_shoe.root
2. 12C_C2H4_200_1_shoe.root and 12C_C2H4_200_2_shoe.root
3. 12C_C_200em_shoe.root with transport of e+/e- and photons with 500 keV cut
4. 12C_C2H4_200em_1_shoe.root and 12C_C2H4_200em_2_shoe.root with transport of e+/e- and photons with 500 keV cut

C) SHOE root files with the addition of region crossing (corresponding to the above listed ones)

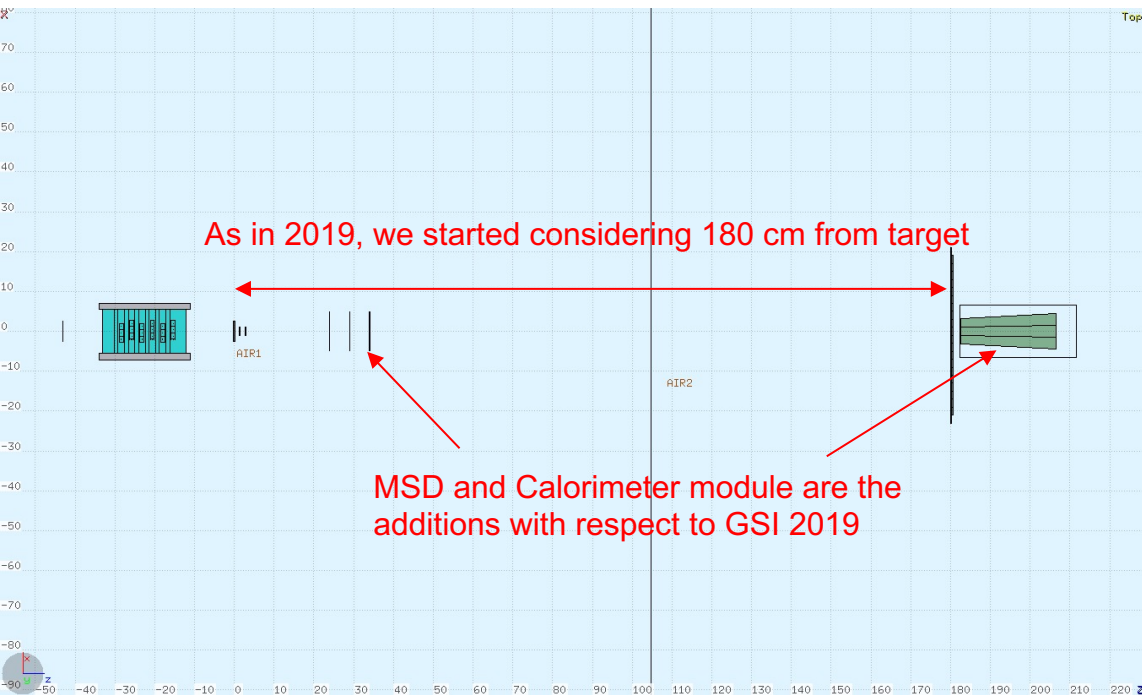
1. 12C_C_200_shoereg.root
2. 12C_C2H4_200_1_shoereg.root and 12C_C2H4_200_2_shoereg.root
3. 12C_C_200em_shoereg.root with transport of e+/e- and photons with 500 keV cut
4. 12C_C2H4_200em_1_shoereg.root and 12C_C2H4_200em_2_shoereg.root with transport of e+/e- and photons with 500 keV cut

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1. Update of wiki page
2. **GS2021 campaign**
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2.1) The GSI2021 campaign

The new GSI2021 has been implemented in the newgeom branch of SHOE



The campaign considers 2 runs:

- 1) run 200: Projectile ^{16}O 200 MeV/u
- 2) run 400: Projectile ^{16}O 400 MeV/u

Notice:

While running SHOE for decoding and reconstruction, instead of the usual `-run 1`, use the switches:

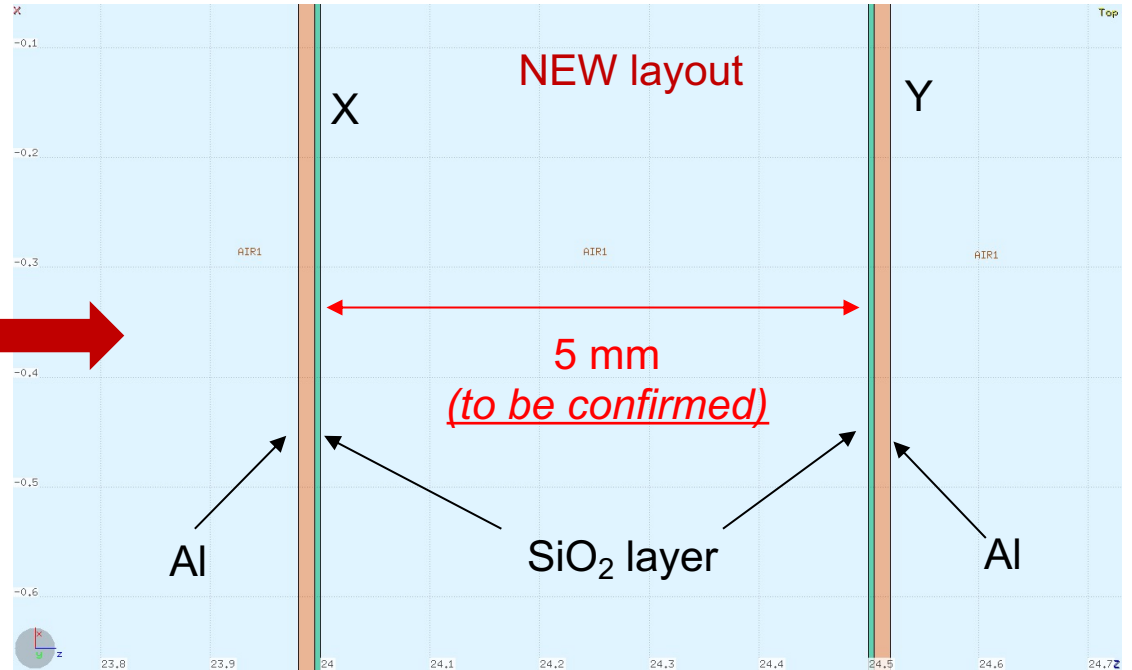
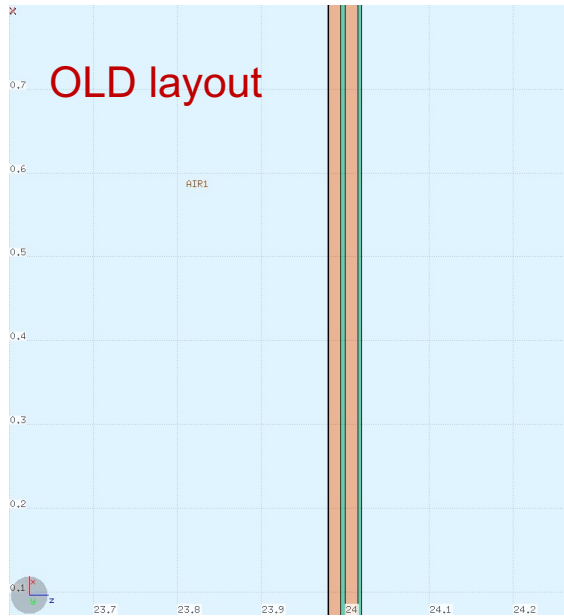
`-exp GSI2021 -run 200`

or

`-exp GSI2021 -run 400`

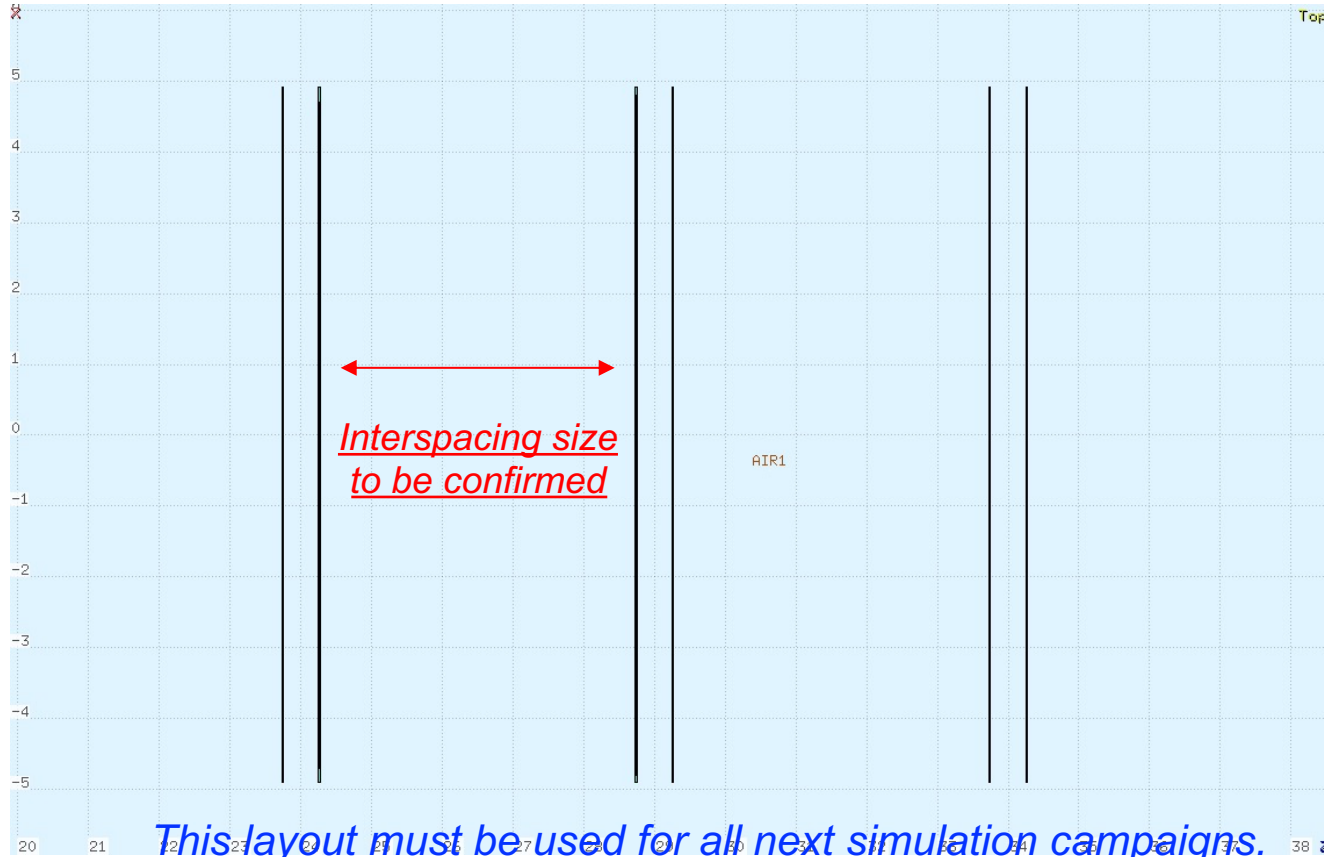
2.2) The GSI2021 campaign: new MSD layout

Following prescriptions from Pg group the MSD geometrical layout of each pair of X-Y sensors has changed (*new TAMSDparGeo, TAMSDdetector.geo*):



Region numbering/labelling remains the same

2.3) The GSI2021 campaign: new MSD layout



2.4) The GSI2021 campaign: test of production

While waiting for definitive layout, 10⁶ primaries have been simulated for both 200 and 400 runs. Available on tier3 at: /gpfs_data/local/foot/Simulation/GSI2021

To give an idea of space occupancy (shoe root files):

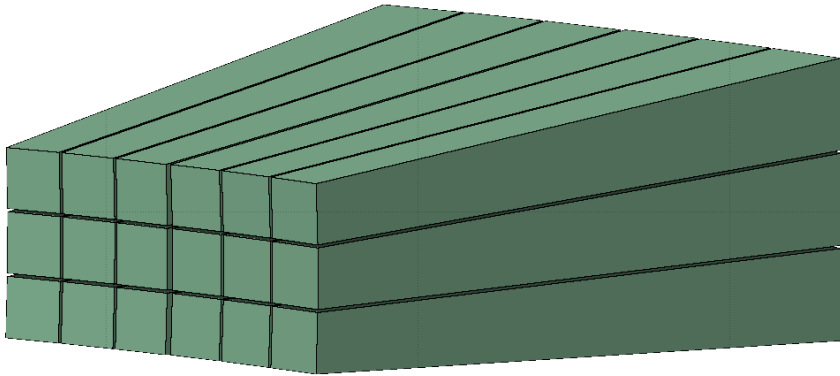
<i>Multiply by 10 for a "normal" useful production</i>			200 MeV/u	400 MeV/u	
"triggered"	e.m. transport OFF	No region crossings	0.22 Gb	0.31 Gb	x26
"untriggered"	e.m. transport OFF	No region crossings	3.4 Gb	8 Gb	
"triggered"	e.m. transport OFF	With region crossings	0.57 Gb	0.76 Gb	x21
"untriggered"	e.m. transport OFF	With region crossings	7.6 Gb	16 Gb	
"triggered"	e.m. transport ON	No region crossings	0.84 Gb	0.76 Gb	??
"untriggered"	e.m. transport ON	No region crossings	17Gb	22Gb	
"triggered"	e.m. transport ON	With region crossings	1.3 Gb	1.3 Gb	x25
"untriggered"	e.m. transport ON	With region crossings	24 Gb	33 Gb	

e.m. ON = 500 keV, 50 keV in gases

2.6) The GSI2021 campaign: next developments

Geometry of Calorimeter can be constructed using the new truncated pyramids FLUKA bodies (*thanks to L. Scavarda & M. Penna*)

- Simplified geometry (this will change Region Numbering)
- It will allow in a much easier way to add a second calorimeter module, in case it will be ready



Two 3x3 modules side by side

Questions:

- When this possibility will become certain?
- Should we implement this in simulation since now?
(*not today: a new TACAParGeo is needed*)
- Should we consider a separate campaign?

2.7) The GSI2021 campaign: some numbers MC truth

^{16}O - C target 5 mm – 10^6 primaries

Only charged secondaries produced in target

Preliminary

Z	A	In Calo 200 MeV/u	In Calo 400 MeV/u
1	1	635	1414
2	4	2252	4330
3	6	265	437
4	7	98	215
5	11	353	514
6	11	313	579
6	12	736	1060
7	14	1125	1398
7	15	2513	2706
8	15	2051	2391

Notice:
 $\sigma(400 \text{ MeV/u}) < \sigma(200 \text{ MeV/u})$
but narrower angular distribution

2.8) The GSI2021 campaign: some numbers MC truth

^{16}O – C_2H_4 target 5mm – 10^6 primaries

Only charged secondaries produced in target

Z	A	In Calo 200 MeV/u	In Calo 400 MeV/u
1	1	510	1019
2	4	2016	3828
3	6	241	436
4	7	77	196
5	11	322	625
6	11	398	625
6	12	809	1003
7	14	1092	1527
7	15	1837	2617
8	15	2408	2680

Preliminary

It seems important to collect a statistics at least a factor 10 larger for both energies and targets

See Aafke's talk tomorrow.

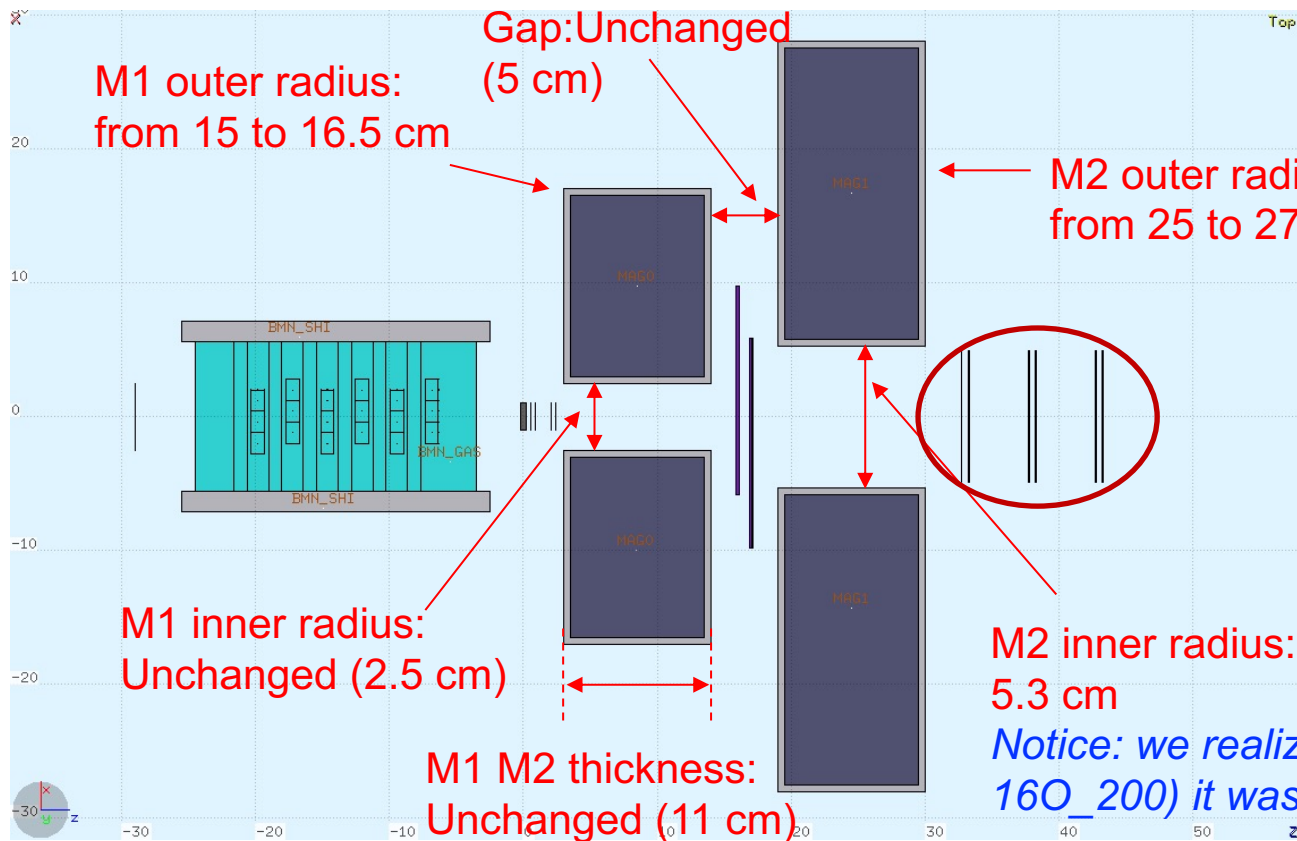
More detailed discussion at next physics meeting

Outline

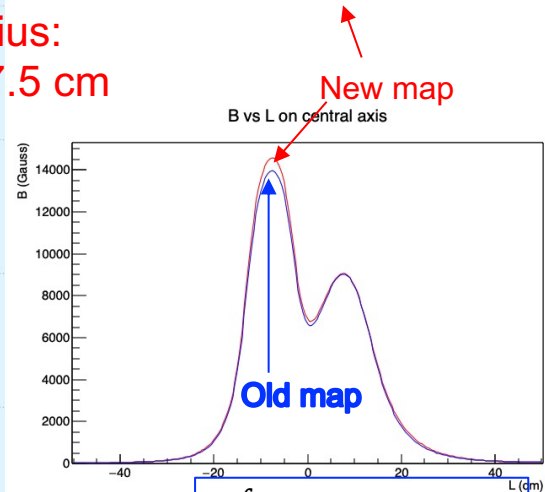
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3.1) The new 12C_200new campaign (new magnets and map)

12C_200new has been implemented in the newgeom branch of SHOE



`./data/SigmaPhi_FOOTrefsys.table`

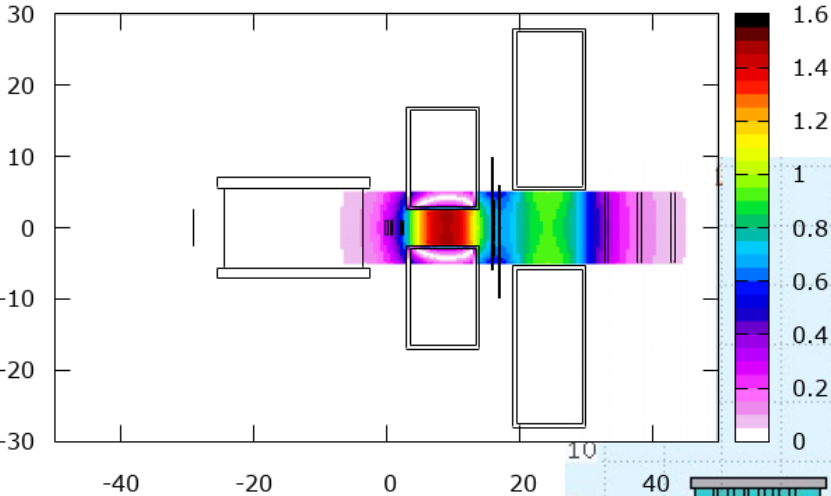


$$\int B dz = 0.327 Tm$$

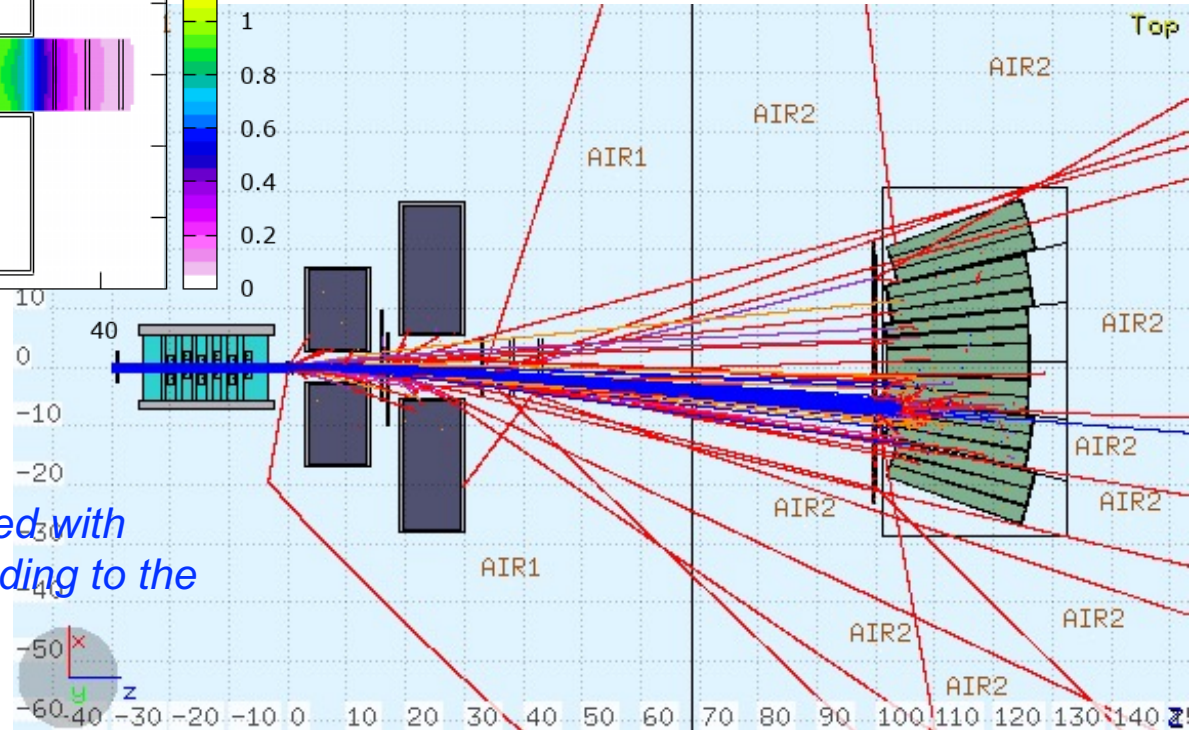
Notice: we realized that before (12C_200, 160_200) it was set to 5.7 cm by mistake

3.2) The new 12C_200new campaign

Plot #5



A small test production, 10^6 primaries, is on tier3 at: /gpfs_data/local/foot/Simulation/12C_200new



Notice:
the new map has B_y reversed with respect to the old map: bending to the right instead of left

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4.1) Proposal in view of next data taking(s)

Final geometry will be eventually frozen only after the actual survey of apparatus in Cave A.

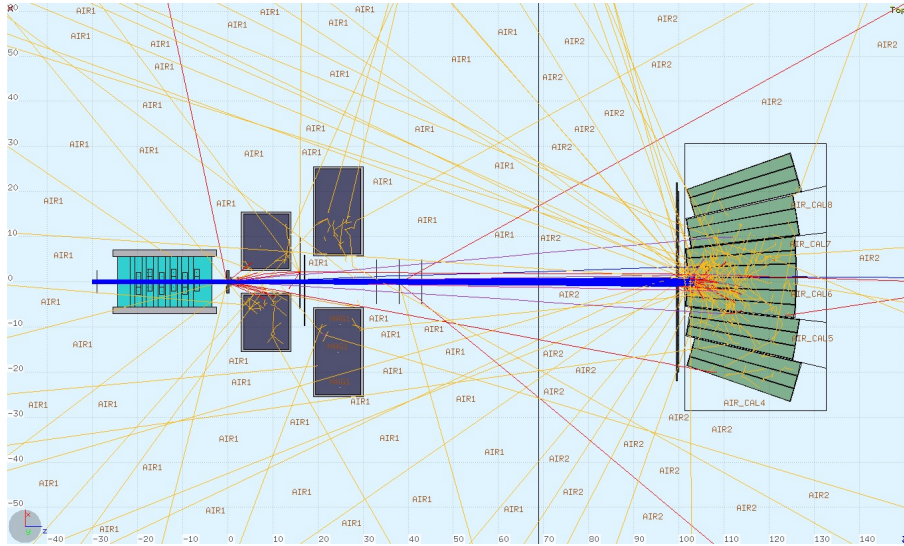
Therefore:

- 1) Before July 2021: let us produce only simulation with “triggered” output
- 2) Shall we consider 2 calorimeter modules in advance? (it’s not free of charge: the production of secondary particles, neutrons etc., and therefore output size, depends on the number of crystals)
- 3) Hypothesis of moving TW+Calo to explore different angles: it can be considered at MC truth, forgetting detectors, already with the setup aligned at 0 degrees
- 4) After July 2021, with final geometry:
 - a. High statistics “triggered” simulation.
 - b. Partial statistics with full “untriggered” simulation
- 5) Low energy cut for δ -rays: still to be discussed in detail:
 - a. region-dependent choice of cut
 - b. the whole production or a limited sample?

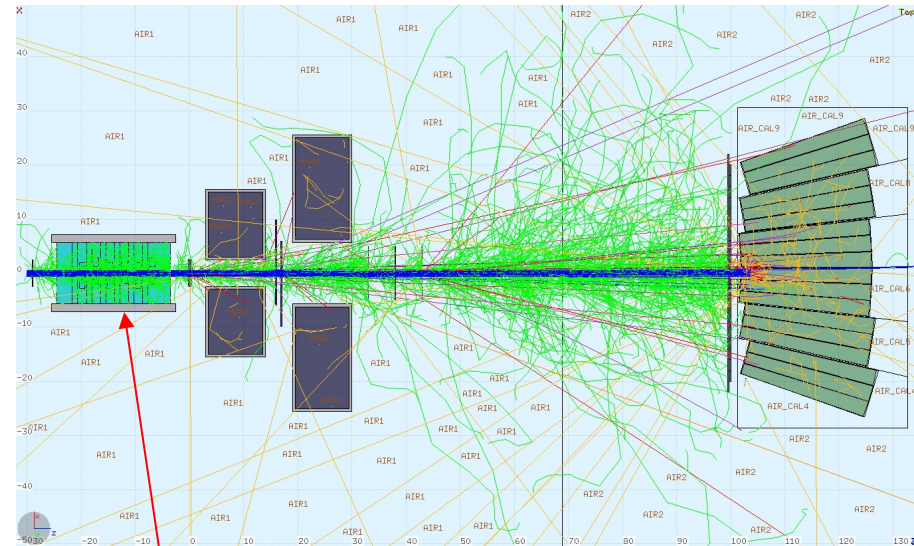
4.2) Proposal in view of next data taking(s)

The 500 keV cut for $e^+/e^-/\gamma$ was known to be too high in gases.

500 keV



50 keV (green tracks are δ -rays)

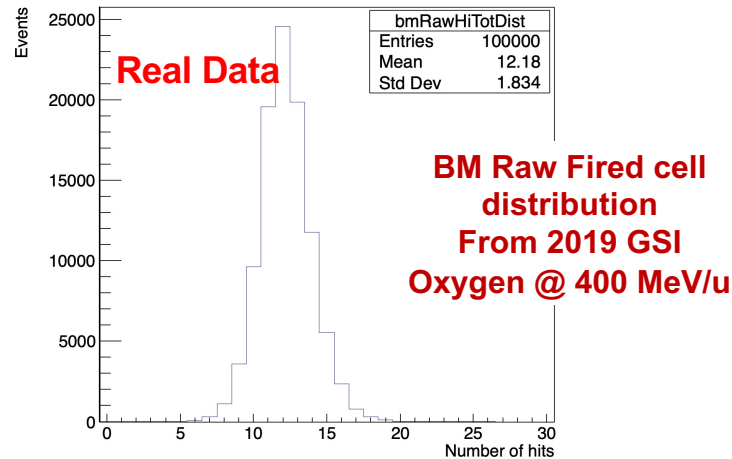
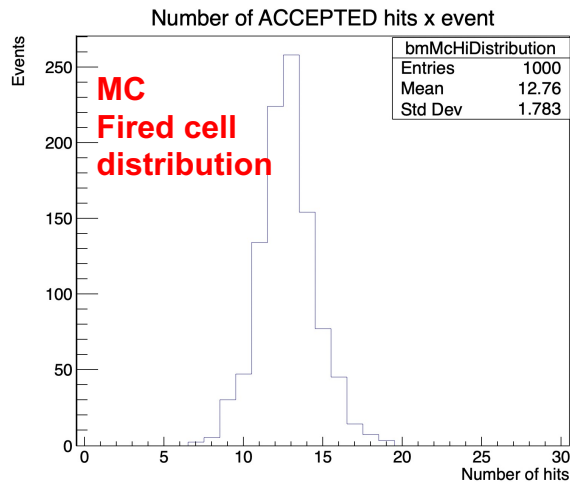


Impact on BM has been studied

4.3) δ -ray impact on Beam Monitor Simulation

A threshold in MC energy releases has to be considered in order to reproduce the fired cells distribution of experimental data

With a threshold of **10 KeV** on single MC energy releases in BM, and applying efficiency factors, MC prediction is very close to the experimental fired cells distribution



BM track reconstruction efficiency turns out to be ~independent from that threshold cut:

100 KeV cut: 978/1000 events with 1 reco track

10 KeV cut: 970/1000 events with 1 reco track



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5.1) New features in FLUKA

A new production version of FLUKA has been released (2021.2). Not yet considered for FOOT (*apart from some experimental production for the FOOT neutron group*)

It includes some features which were not yet available for the public. Some may be important for us. Among them:

- 1) **Pointwise transport of low energy neutrons with correlated interactions is now available**
- 2) Runge-Kutta based transport in electric fields is implemented for vacuum and gas regions
- 3) **Optional Runge-Kutta based transport in magnetic field in vacuum and gas regions**
- 4) **New physics model for coherent elastic scattering of hadrons on nuclei**
- 5) New treatment for quasi-elastic scattering of hadrons on nuclei
- 6) **Transport and in-flight decay of excited residual nuclei**
- 7) **Improved nuclear mass/decay/deexcitation database**
- 8) **Revised hadron-nucleus interaction cross sections**
- 9) **Revised cross sections for proton - light ion interactions**
- 10) Non monochromatic scintillation light emission and transport

5.2) New features in FLUKA

The new version cannot immediately be used for FOOT: **some routines need to be modified**

We also need to make checks and preliminary work about the new features:

- 1) **The new optional Runge-Kutta based transport in magnetic field can be interesting (more precise) but it requires some study**
- 2) **A check on possible differences in cross sections for energies of our interest is going to be performed**

Thank you