Update on FLUKA Simulation

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for the Milano Group

FOOT Collaboration Meeting
June 2020

Outline and Introduction

- Since last collaboration meeting the geometry of the electronic apparatus has remained subtantially unchanged.
- There were some upgrades concernning FLUKA models and simulation parameters
- Different tests and event productions were performed, mostly upon specific requests, often introducing small changes in geometry (*e.g.: longer distance for ToF in case of high energy, small shifts for bending compensation*)
- All progresses have been reported during the monthly Physics Meetings
- Here we try to:
  A) summarize the main achievements and
  B) give a comprehensive list of what is available for the whole collaboration

Main Milestones since last Collaboration Meeting

New FLUKA version used for FOOT
https://agenda.infn.it/event/21751/contributions/109778/attachments/70309/87686/FLUKA_Sim_Update.pdf

Evaluation of 4He cross sections at 700 MeV/u
https://agenda.infn.it/event/21774/contributions/109796/attachments/71082/89069/SezDUrto_4He700MeVu.pdf

Simulation of 4He interactions at 700 MeV/u
https://agenda.infn.it/event/21775/contributions/109809/attachments/71546/89876/GB_4He700sim.pdf

New event production at 200 and 700 MeV/u
https://agenda.infn.it/event/21776/contributions/109817/attachments/72264/91076/FLUKA_Sim_Update.pdf

Introduction of $e^+e^-\gamma$ transport
https://agenda.infn.it/event/21777/contributions/109831/attachments/72741/91886/FLUKA_Sim_Update.pdf

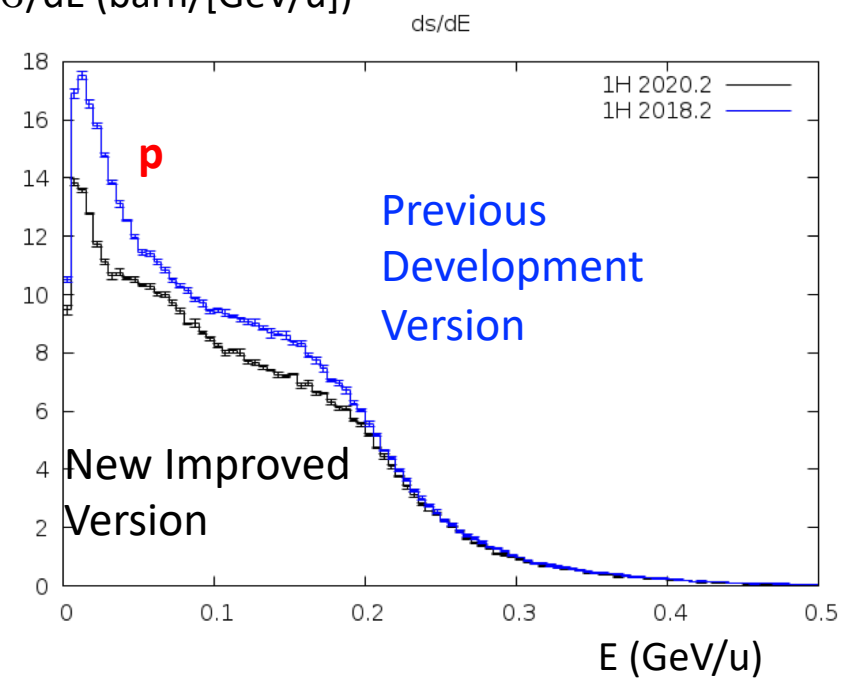
New FLUKA release and upgrade of physics models

dσ/dE (barn/[GeV/u]) ıanges in predicted Cross Sections

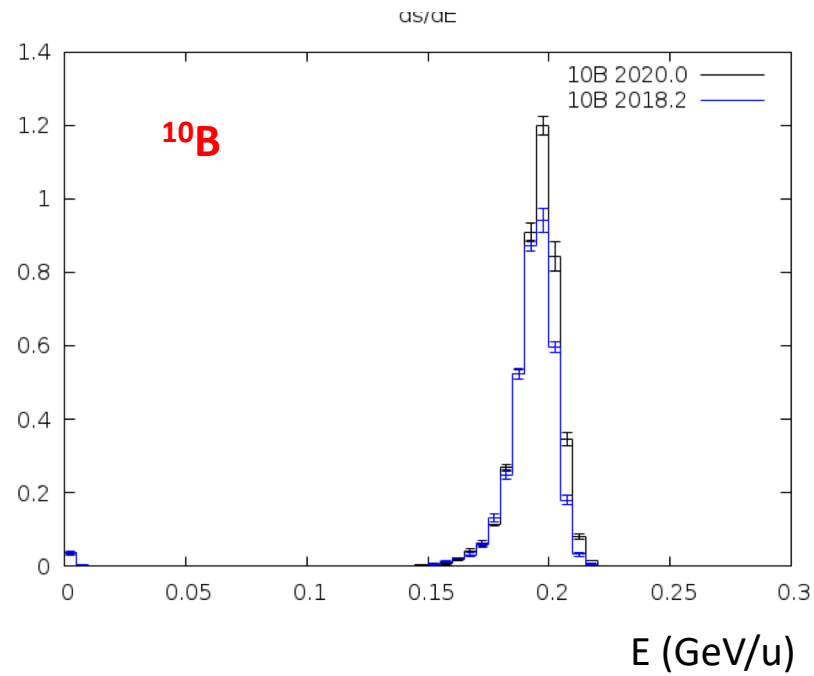
^{12}C-C collisions at 200 MeV/u

Some relevant changes for protons, He. Small changes for most of all other fragments

dσ/dE (barn/[GeV/u])



dσ/dE (barn/[GeV/u])



https://agenda.infn.it/event/21751/contributions/109778/attachments/70309/87686/FLUKA_Sim_Update.pdf

Cross Section Estimate. An example

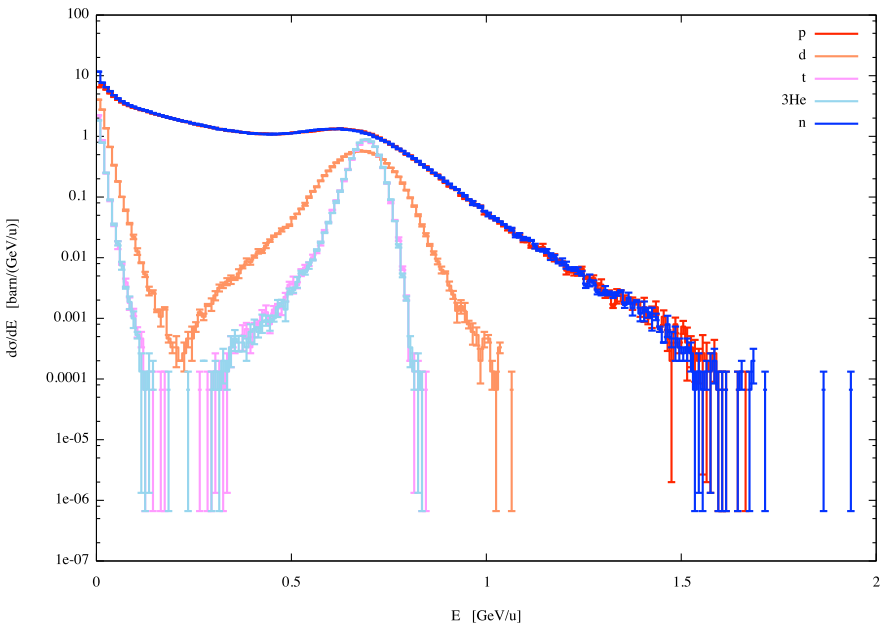
^{16}O-C_2H_4 collisions at 200 MeV/u

Total σ(mbarn)	2018	2020	diff
$^{16}O + C_2H_4 \rightarrow {}^{1}H+X$	7793.6 ± 0.1%	7230.5 ± 0.1%	7%
$^{2}H+X$	2006.1 ± 0.1%	2095.5 ± 0.1%	~5%
$^{4}He+X$	2771.6 ± 0.1%	3055.0 ± 0.1%	10%
$^{6}He+X$	18.1 ± 0.5%	21.7 ± 1.3%	~20%
$^{6}Li+X$	200.4 ± 0.2%	217.5 ± 0.3%	~9%
$^{7}Be+X$	93.0 ± 0.2%	100.5 ± 0.5%	8%
$^{10}B+X$	74.5 ± 0.2%	74.0 ± 0.5%	~1%
$^{10}C+X$	15.4± 0.6%	15.7 ± 0.9%	~2%
$^{11}C+X$	122.6 ± 0.2%	122.0 ± 0.3%	<1%
$^{12}C+X$	179.9 ± 0.2%	174.1 ± 0.5%	3%
$^{13}C+X$	102.4 ± 0.2%	99.4 ± 0.5%	3%
$^{14}C+X$	28.5 ± 0.4%	27.7 ± 0.7%	3%

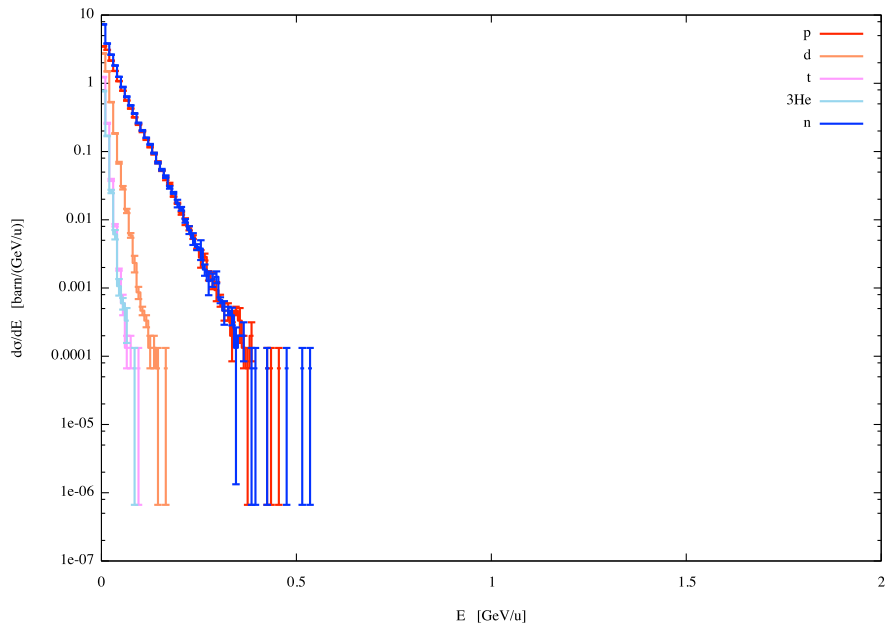
Cross Section Estimate for possible ^{4}He run at «high» energy

^{4}He + C 700 MeV/u dσ/dE

Forward



Backward



fragment	σ (forward) [barn]		
^{1}H	1.471	+/- 0.2	%
^{2}H	0.197	+/- 0.1	%
^{3}H	0.104	+/- 0.3	%
^{3}He	0.101	+/- 0.2	%
n	1.552	+/- 0.2	%

https://agenda.infn.it/event/21774/contributions/109796/attachments/71082/89069/SezDUrto_4He700MeVu.pdf

Available MC files: update of FOOT Wiki page

List and description of avalilable Simulation files is now updated in
http://arpg-serv.ing2.uniroma1.it/twiki/bin/view/Main/FOOTAvailableSimulation

FOOTAvailableSimulation < Main < TWiki

Tags: create new tag view all tags

Available Simulation datasets on the tier3

- Available Simulation datasets on the tier3
- Latest MC files *(Update: 8 June 2020)*
  - Performance studies
  - GSI data/MC studies
- Older MC productions available on the tier3 *(Update: 6 September 2017)*

Latest MC files *(Update: 8 June 2020)*

Two main productions are documented in this page:

- Electronic setup performance studies: MC with full geometry (newgeom_v1.0)
- GSI data/MC studies (E.g. with a geometry consistent with the data taking setup at GSI of April 2019)

Performance studies

The ?latest? MC that should be used is now kept on the Bologna Tier3 under the folder

`/gpfs_data/local/foot/Simulation/newgeom_v1.0/`

This production makes use of the full geometry including the calorimeter.

Summary of latest available files - 1

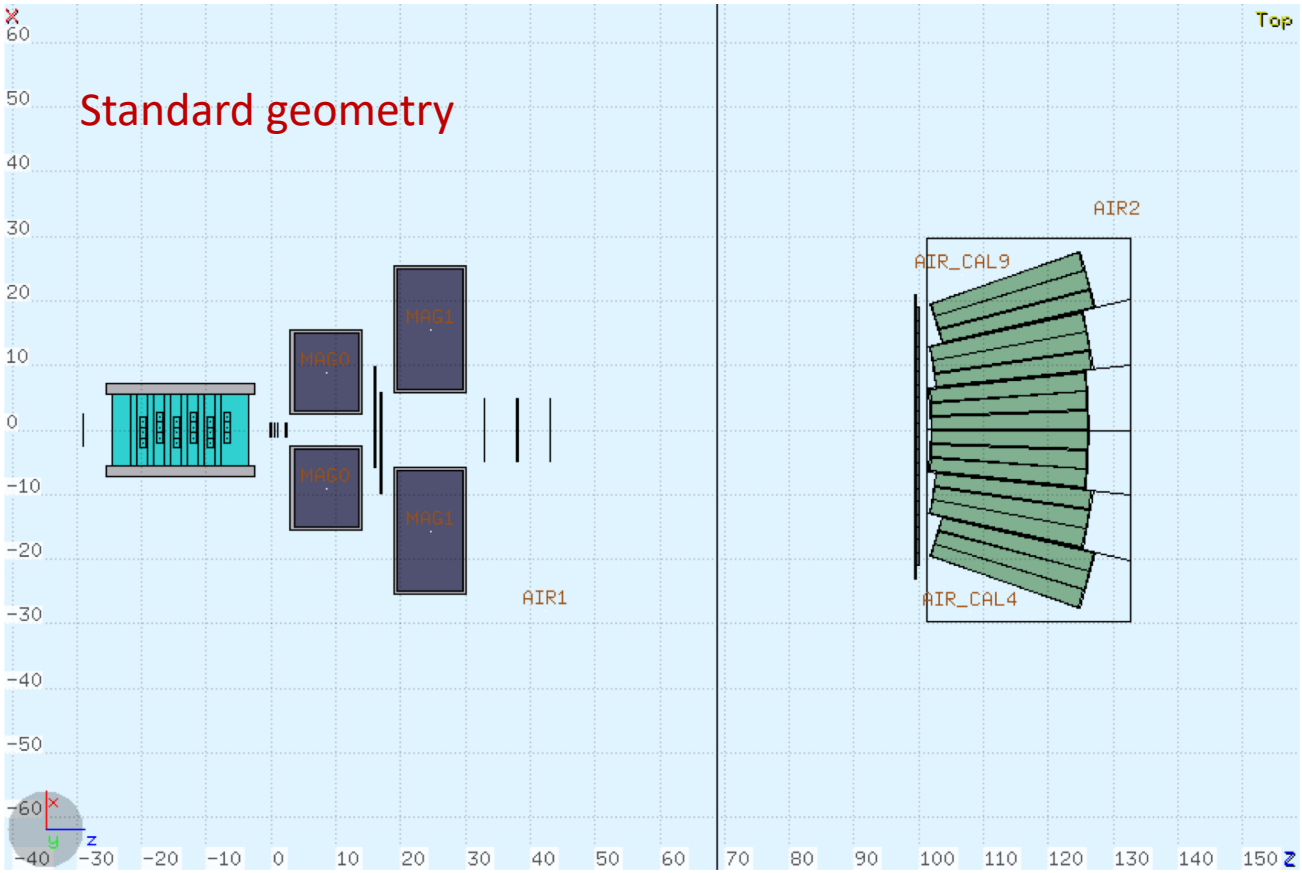
/gpfs_data/local/foot/Simulation/newgeom_v1.0

All produced with 2020.0 version

"untriggered" files (all events are written onto output)

12C_C_200notr_*n*.root *(n=1,2,3,4,5)* ➞ ^{12}C at 200 MeV/u on C, 5 mm ρ=1.83 g/cm^3

2 10^6 primaries each



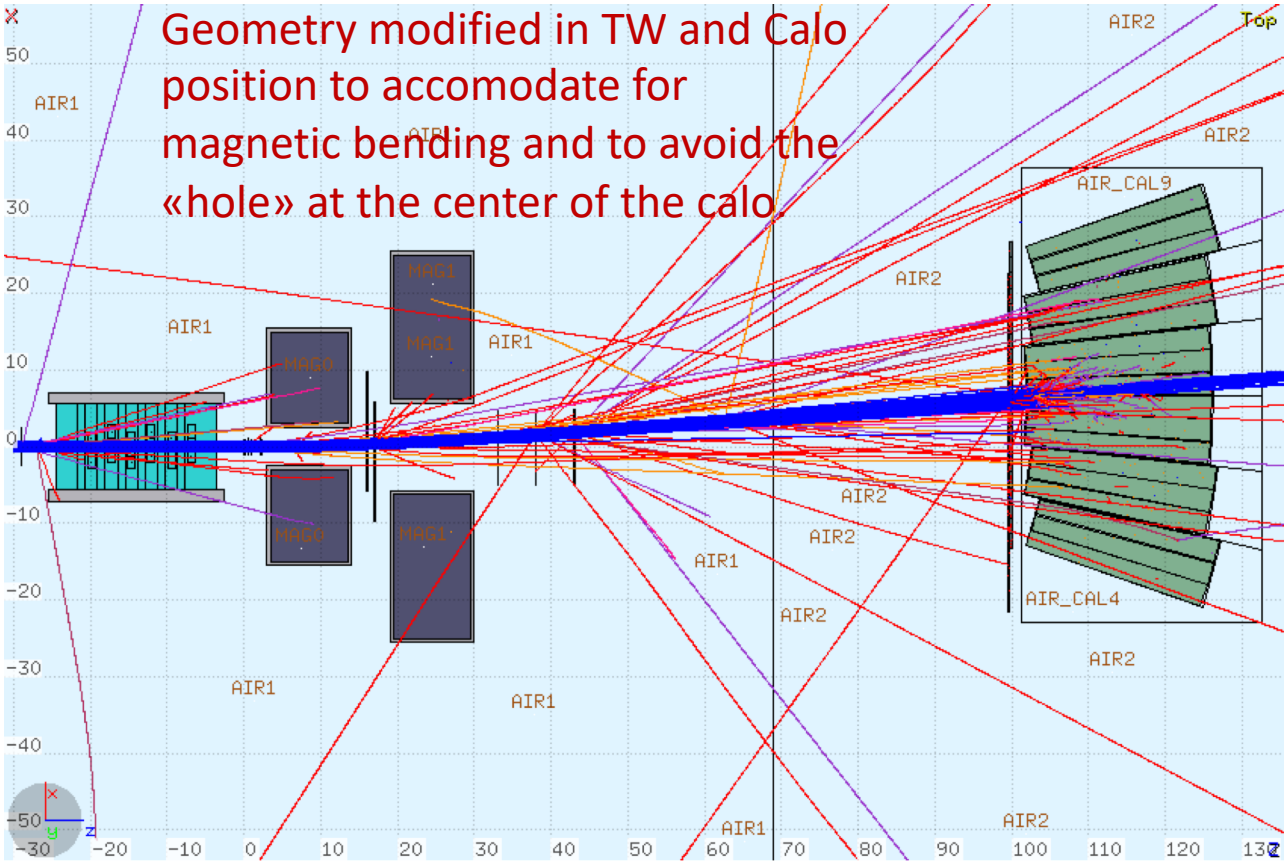
Summary of latest available files - 2

/gpfs_data/local/foot/Simulation/newgeom_v1.0 **All produced with 2020.0 version**

"triggered" files (only events with ≥ 1 inelastic interaction in targt are written onto output)

16O_C_200_1.root → ^{16}O at 200 MeV/u on C, 5 mm ρ=1.83 g/cm^3, 10^7 primaries

16O_C2H4_200_ *n*.root *(n=1,2,3,4,5)* → ^{16}O at 200 MeV/u on C_2H_4, 5 mm ρ=0.94 g/cm^3 , 10^7 primaries each

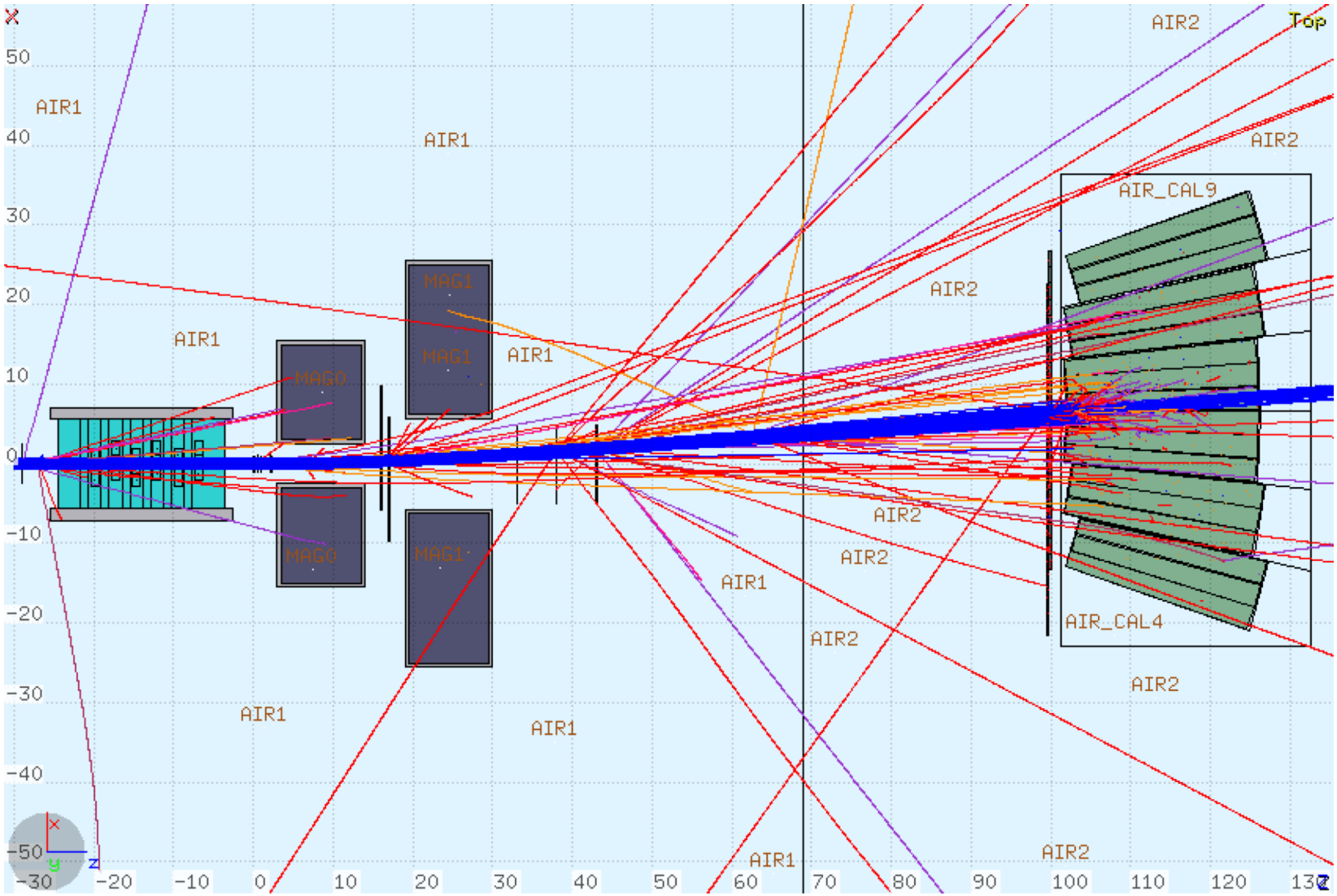


The e.m. transport

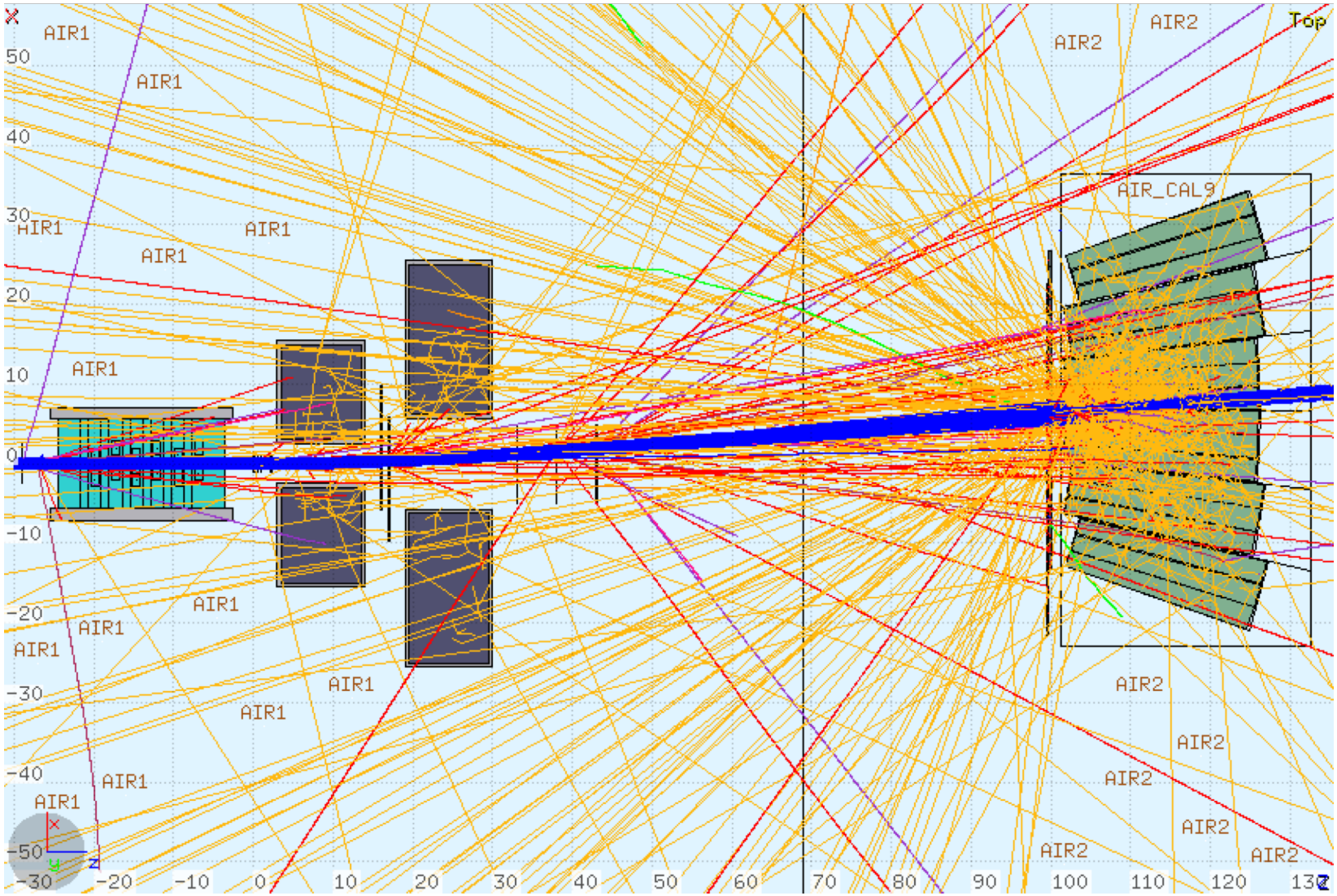
- So far the attention was to concentrated on the study of detector response/acceptance for hadronic fragments.
- Since the beginning we avoided to activate transport and interactions of e^+ e^- γ in order to save CPU and disk space.
- This was obtained by imposing a very high energy cut (1 GeV). This means (in FLUKA) that these particles are produced but they deposit their energy in the same point of creation.
- Motivated by the needs of neutron analysis, we tested a new simulation production by re-activating transport of these particles with 1 MeV cut (both prod. and transport) for e^+e^- and 0.5 MeV for γ (so to include photons from e+e- annihilation). Delta-ray production with the same 1 MeV cut was activated
- As a further simplification, e^+e^- transport is switched off inside magnets and BGO. Photon transport is allowed everywhere, since it does not affect computing resources significantly

https://agenda.infn.it/event/21777/contributions/109831/attachments/72741/91886/FLUKA_Sim_Update.pdf

New Production with e.m. transport ON – 1



New Production with e.m. transport ON – 2



Summary of latest available files - 3

/gpfs_data/local/foot/Simulation/newgeom_v1.0 **All produced with 2020.0 version**

B) "triggered" files (only events with ≥ 1 inelastic interaction in targt are written onto output)

16O_C2H4_200em_ *n*.root *(n=1,2,3,4,5)* → ^{16}O at 200 MeV/u on C_2H_4, 5 mm ρ=0.94 g/cm^3 e.m. transport activated , 10^7 primaries each

16O_C_700_1.root → ^{16}O at 700 MeV/u on C, 5 mm ρ=1.83 g/cm^3 , 5 10^6 primaries

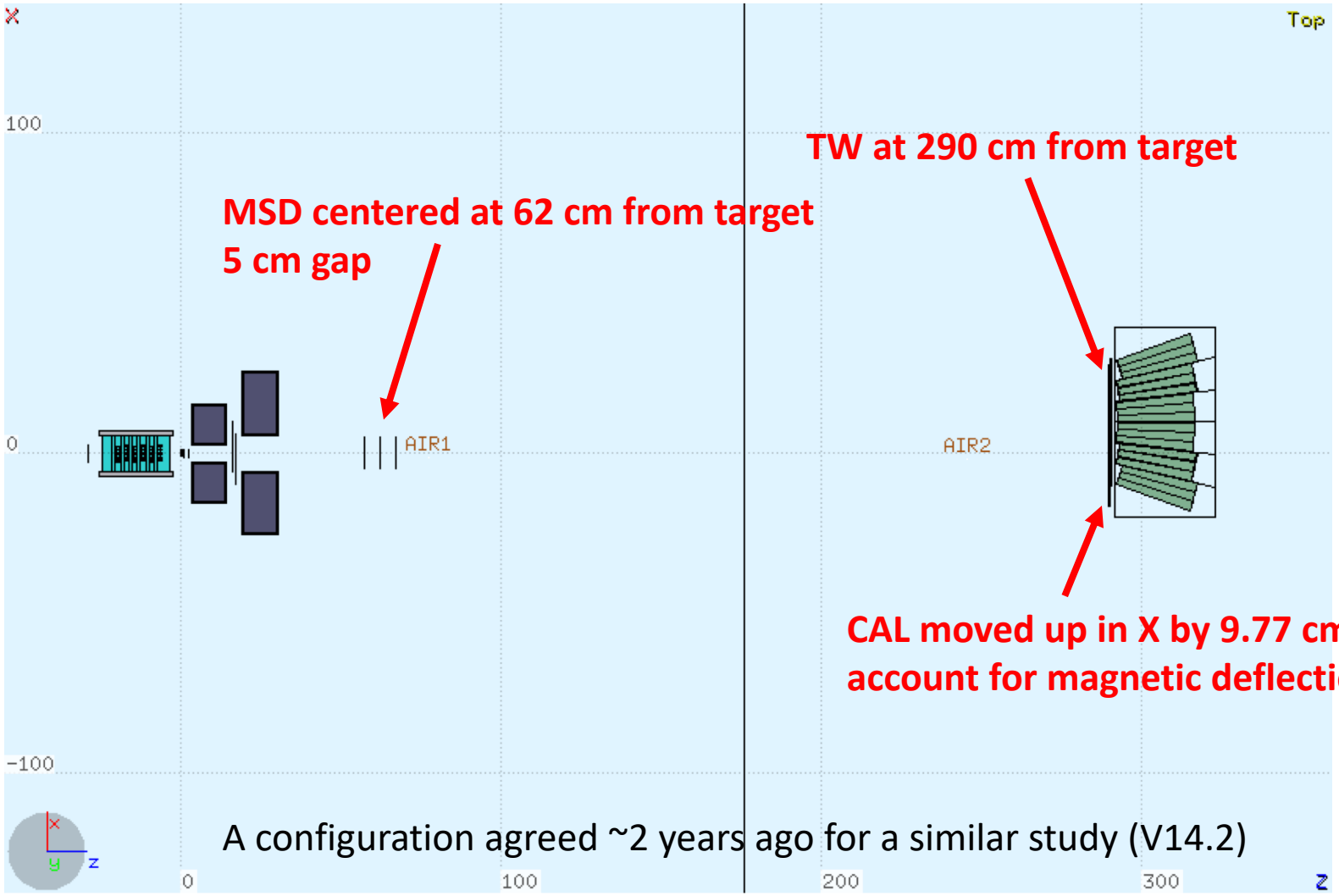
16O_C2H4_700_1.root → ^{16}O at 700 MeV/u on C_2H_4, 5 mm ρ=0.94 g/cm^3 , 5 10^6 primaries

16O_C2H4_700em_ *n*.root *(n=1,2,3,4,5)* → ^{16}O at 700 MeV/u on C_2H_4, 5 mm ρ=0.94 g/cm^3 e.m. transport activated, 10^7 primaries each

1H_C2H4_200em_1.root → p at 200 MeV/u on C_2H_4, 5 mm ρ=0.94 g/cm^3 e.m. transport activated, 10^7 primaries

1H_C2H4_700em_1.root → p at 700 MeV/u on C_2H_4, 5 mm ρ=0.94 g/cm^3 e.m. transport activated, 10^7 primaries

700 MeV/u runs: Modified Full Geometry of Electronics Apparatus –



MSD centered at 62 cm from target
5 cm gap

TW at 290 cm from target

CAL moved up in X by 9.77 cm to account for magnetic deflection

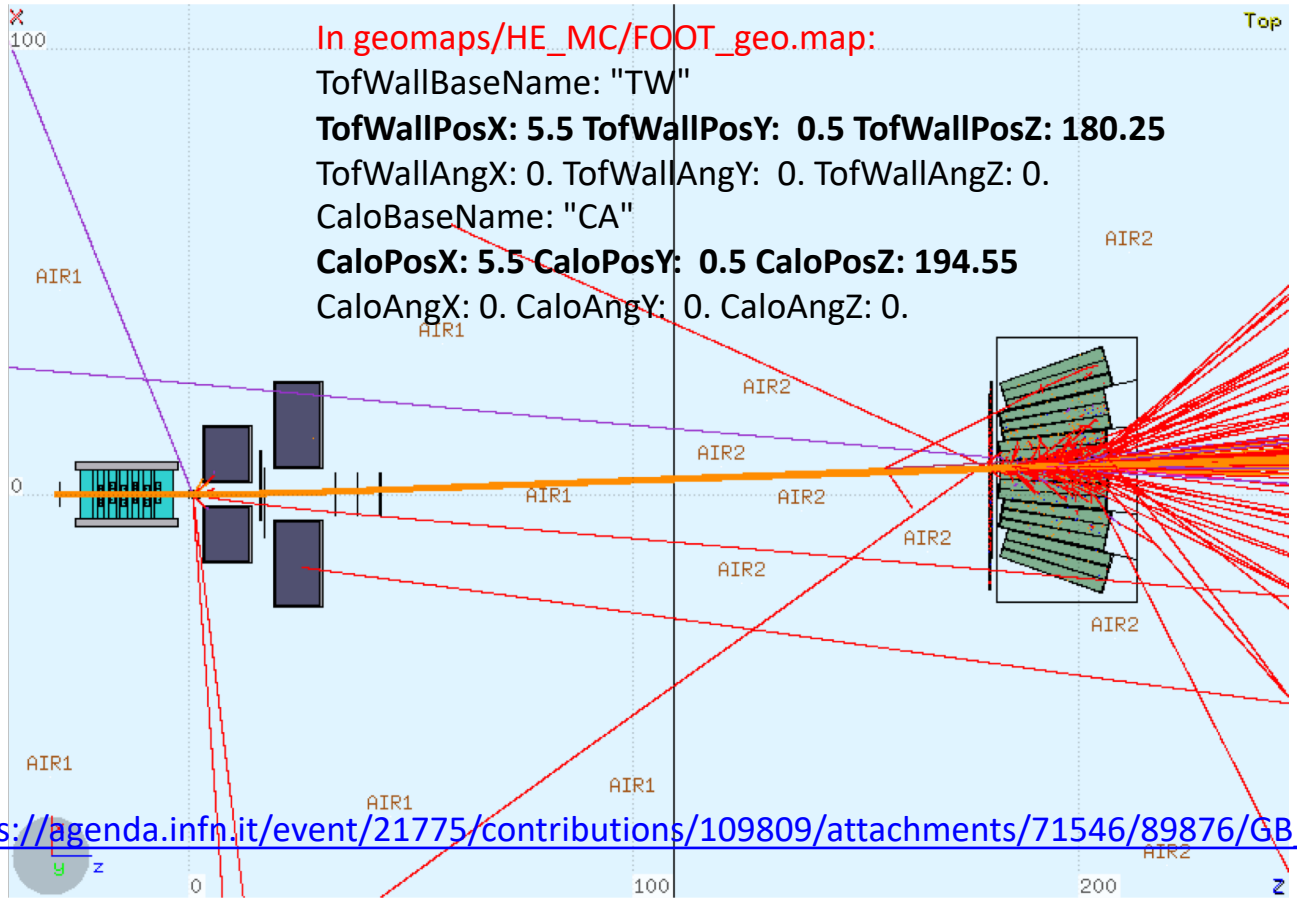
A configuration agreed ~2 years ago for a similar study (V14.2)

Other available files - 1

/gpfs_data/local/foot/Simulation/newgeom_v1.0/HE_MC **produced with 2020.0 version**

"triggered" files (only events with ≥ 1 inelastic interaction in target are written onto output)

4He_C_700_ *n*.root *(n=1,2)* ➞ ^{4}He at 700 MeV/u on C, 5 mm ρ=1.83 g/cm^3, 5 10^6 primaries each



https://agenda.infn.it/event/21775/contributions/109809/attachments/71546/89876/GB_4He700sim.pdf

Other available files - 2

B) /gpfs_data/local/foot/Simulation/newgeom_v1.0/GSI **produced with 2018 version**

GSI geometry without Target

"triggered" files (only events with ≥ 1 inelastic interaction in target are written onto output)

GSI_O200_NoTg.root → ^{16}O at 200 MeV/u 10^4 primaries

GSI_O200_NoTg.root → ^{16}O at 400 MeV/u 10^4 primaries

C) /gpfs_data/local/foot/Simulation/newgeom_v1.0/Old **produced with 2018 version**

Newgeom without Calorimeter

16O_C_200_1.root

12C_C_200_1.root

Probably now obsolete or not interesting

Files for GSI 2019 comparison

/gpfs_data/local/foot/Simulation/GSI2019

They are still the old ones produced in 2019.

If considered useful for GSI analysis of electronic apparatus (or other case study) simulations can be produced again using the new FLUKA version

Software changes to be committed

In case other FOOT users wish to run FLUKA simulations on their own:
<u>the inclusion of e.m. transport is not yet committed to the master branch.</u>

In order to generate a correct input file there are changes that have to be introduced in shoe/libs/src/TAMCbase/TAGparGeo.cxx

Maybe we can consider an additional parameter file

Other changes concern materials, and they probably should be considered in shoe/libs/src/TAMCbase/TAGbaseMaterials.cxx

Furthermore: it is now necessary to increase the size of arrays for the Crossing bank. Some people (we) need it. Not yet propagated to SHOE. To be discussed

To be modified to this purpose:

- The include file mgdraw.inc in shoe/Simulation/ROUTINES/
- The include file EventStruct.hxx in shoe/libs/src/TAMCbase

➡ ***To be discussed with software managers***

Questions and possible to do list

1) **Do we need to schedule new specific productions?**

2) **Do we need to produce additional runs for the case of GSI run of 2019?**

3) **Use of the new pyramid bodies (PYX, PYY, PYZ) to generate the Calo geometry**

4) **Introduce a quenching Z-dependent function to weight energy deposition in scintillators to take directly into account Birks' law**

5) **Suggestions:**
   a) **in order to have some more organic and well organized production runs, some coordinated physics & analysis planning is recommended.**
   b) **First priority: define as soon as possible the setup for next data taking (CNAO, Heidelberg,…) to provide dedicated simulated data sets for evaluation studies**

Thank you for the attention