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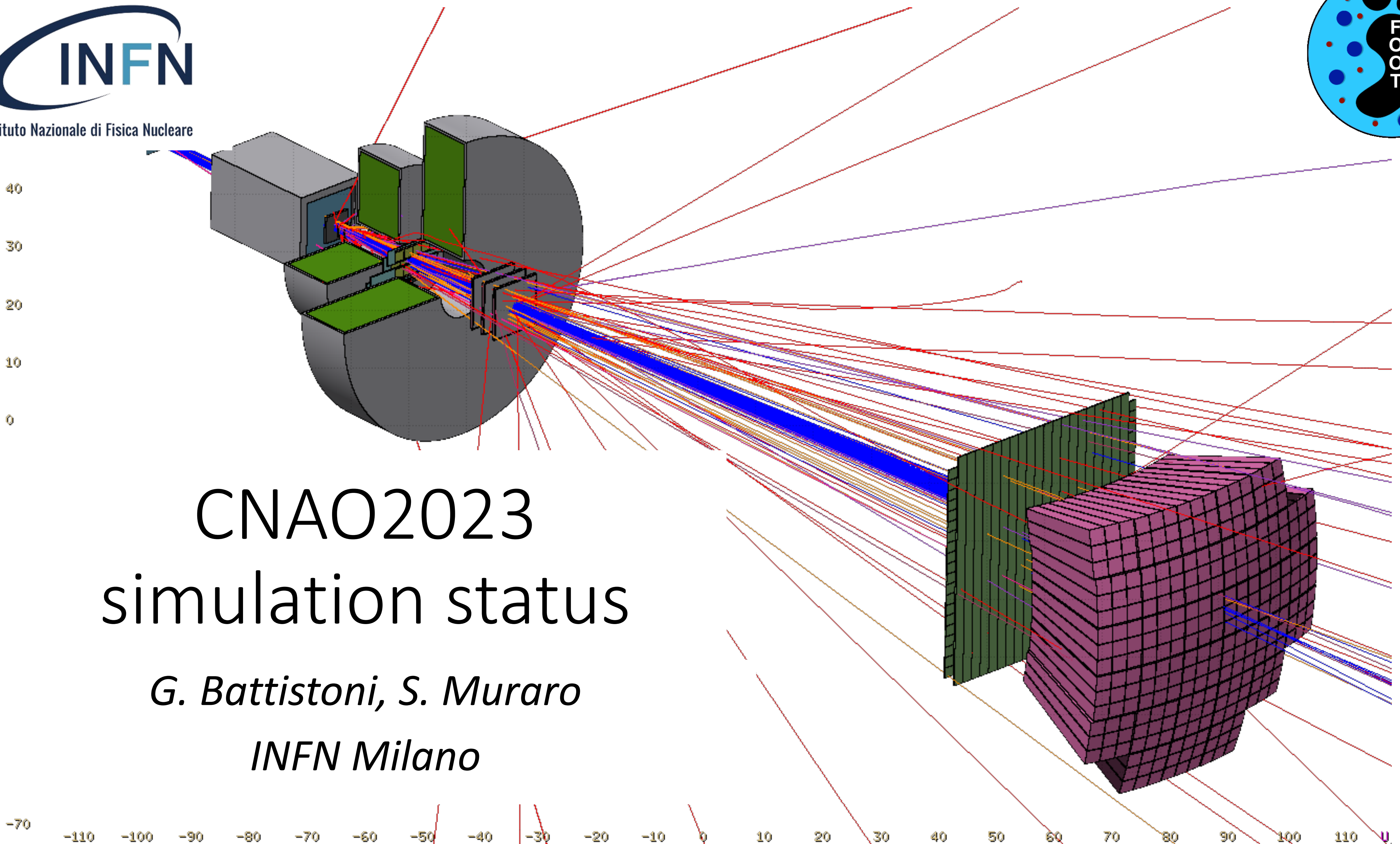
Istituto Nazionale di Fisica Nucleare

FOOT



CNAO2023 simulation status

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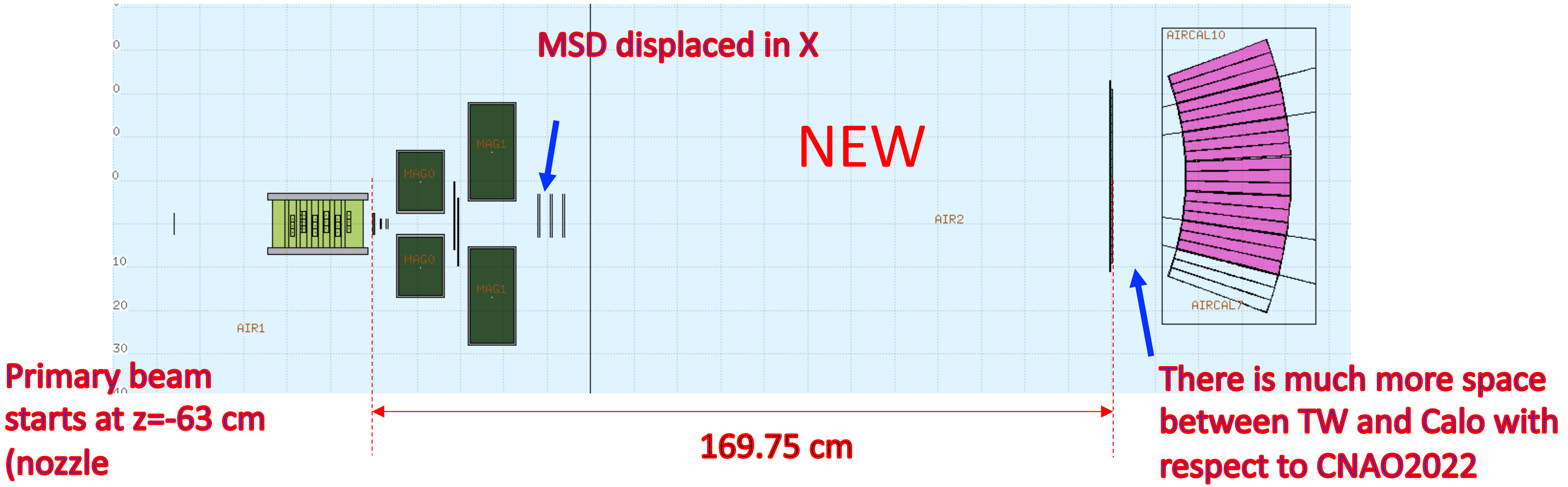
INFN Milano

Introduction

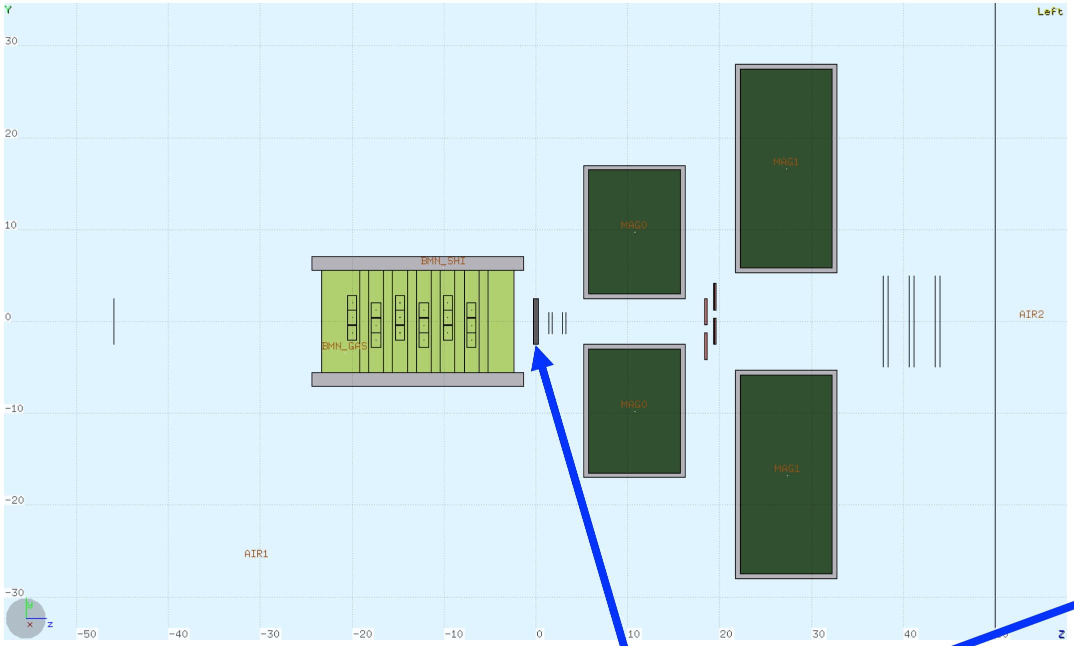
The new campaign **CNAO2023_MC** has been updated to take into account the geometrical survey

We have still the calculated magnetic map. We have not yet received the results of LNF measurements

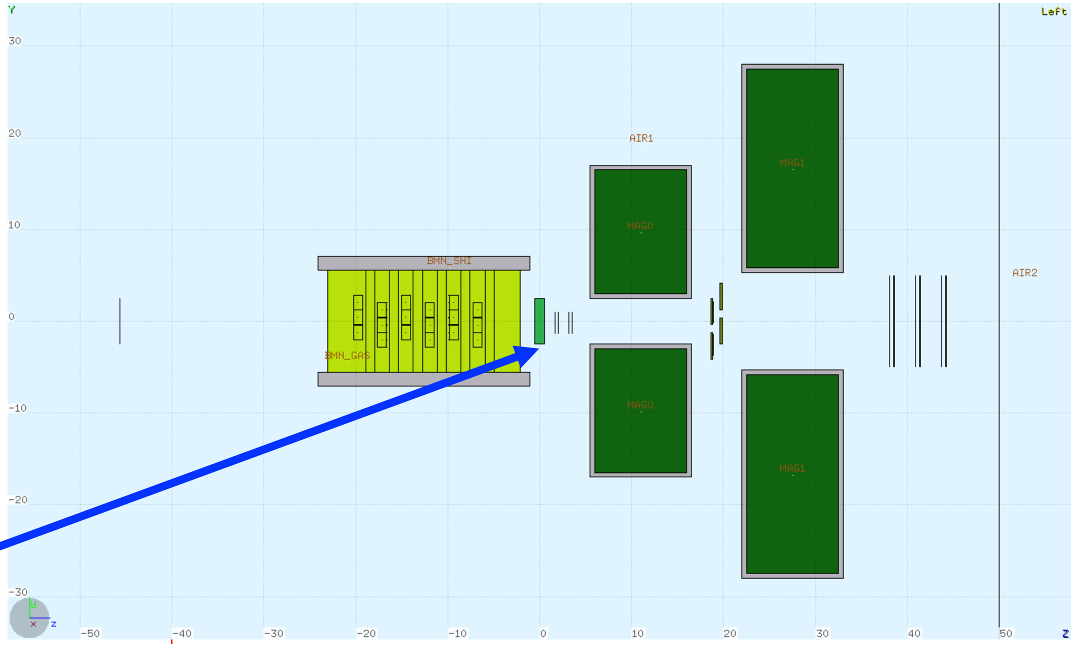


New CNAO2023_MC design: 3 runs in the campaign

Run 1: C target 5mm (^{nat}C)



Run 2: C_2H_4 target 10 mm



The z=0 position is always kept at the center of the target, therefore coordinates of center of pre- and post-target elements are moved by 0.25 cm in Run 2

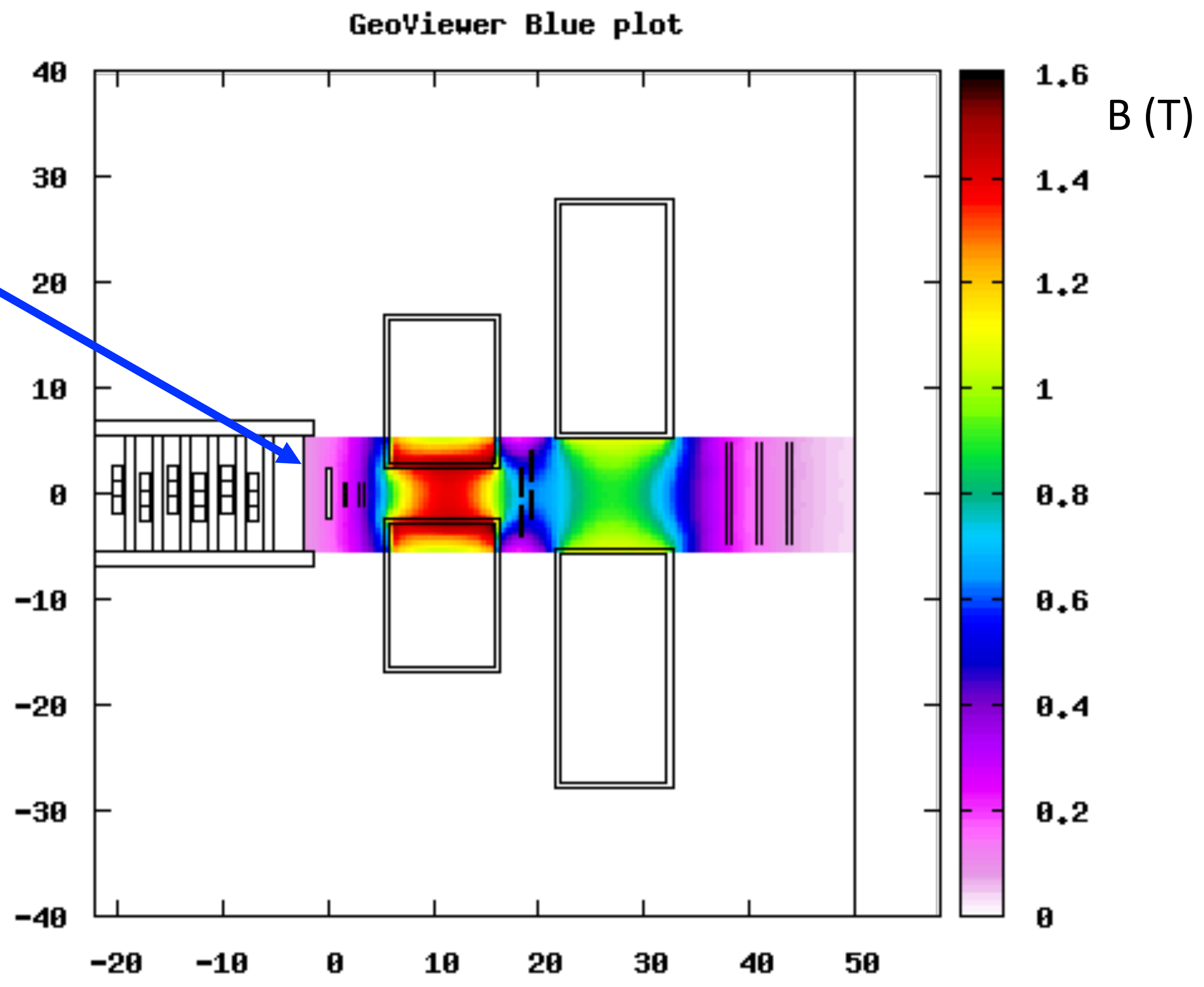
There is also a Run 3: Air target (same geometry as Run 1)

Magnetic Field

We might have an unsufficient extension of the magnetic map in the BM region

<u>To be checked</u>

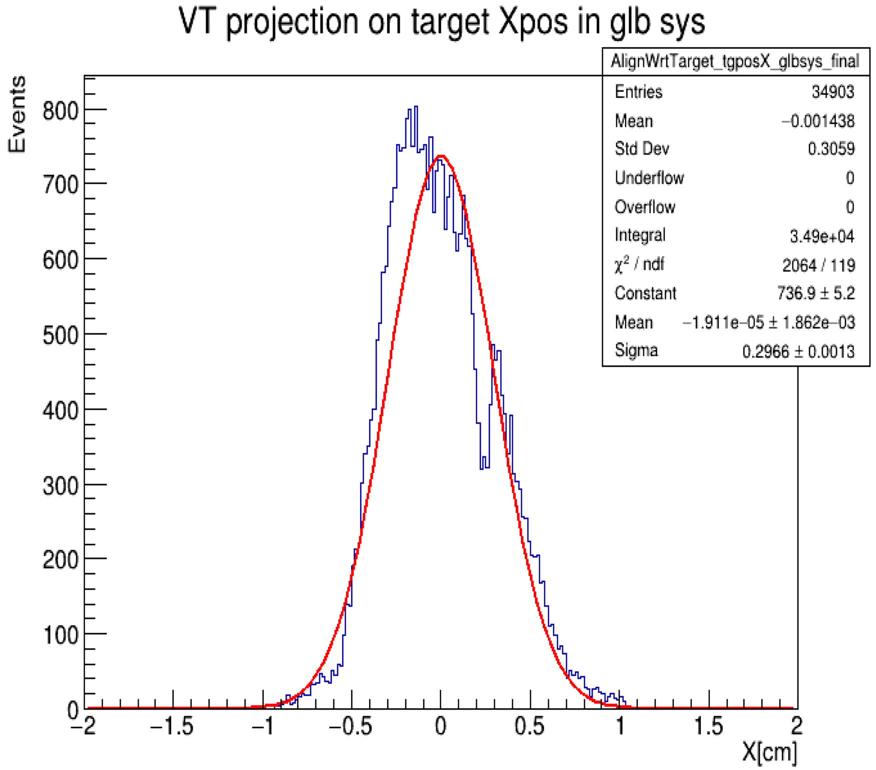
(and hopefully move to the measured map as soon as possible)

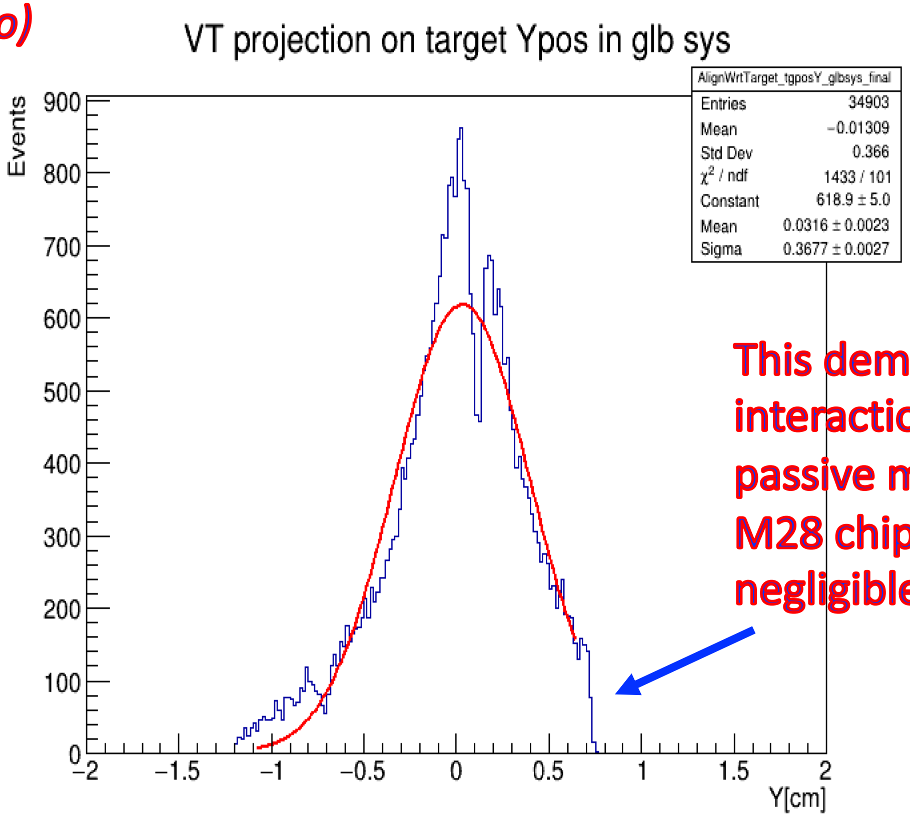


Could this have some impact? (See Yun's talk on Beam Monitor status at CNAO2023)

Beam Shape

Beam shape and position taken from approximate fits in VTX for run 6102 *(see TAGdetector_1(2,3).geo)*



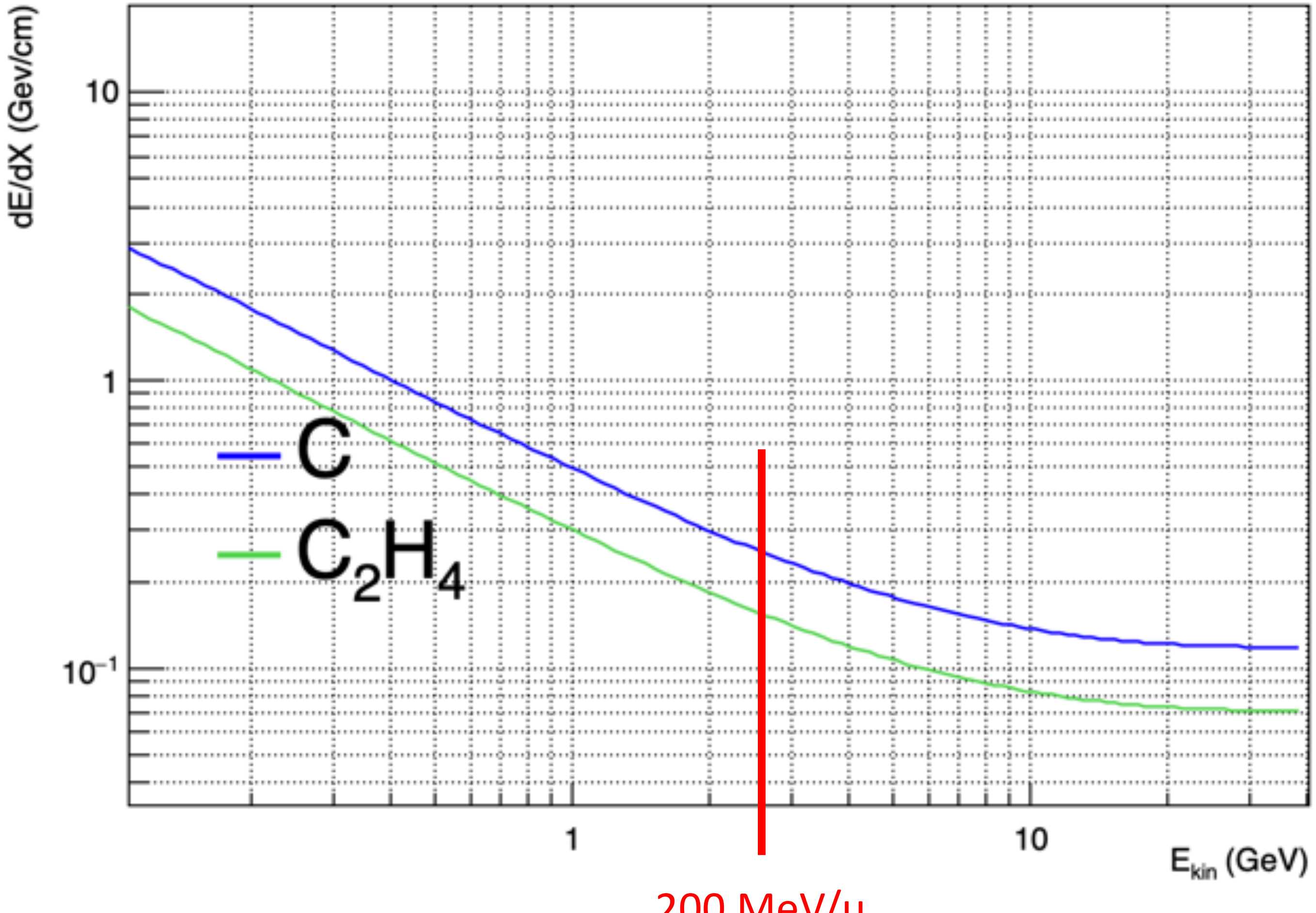


This demonstrates that interactions in the passive materials around M28 chips might be non negligible

Asymmetrical, not centered

The issue of energy loss in target

See Physics Meeting of 9 June 2021:
https://agenda.infn.it/event/25079/contributions/127084/attachments/82194/107977/FOOT_PhysicsMeeting_GSI2021-2.pdf

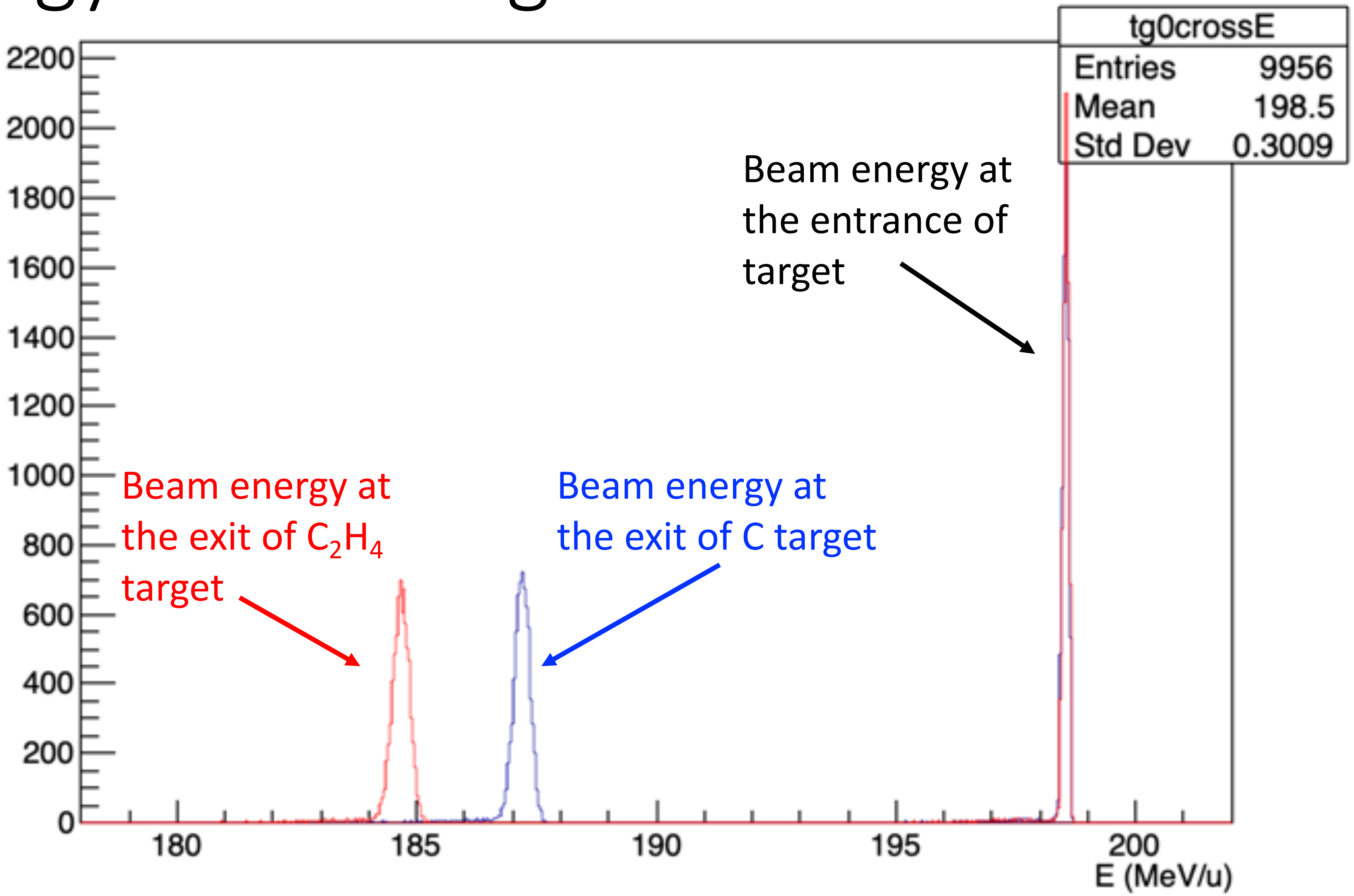


@2.4 GeV (200 MeV/u):
dE/dx in ^{nat}C (ρ=1.83 g/cm3) ~0.27 GeV/cm
dE/dx in C_2H_4 (ρ =0.94 g/cm3) ~0.16 GeV/cm

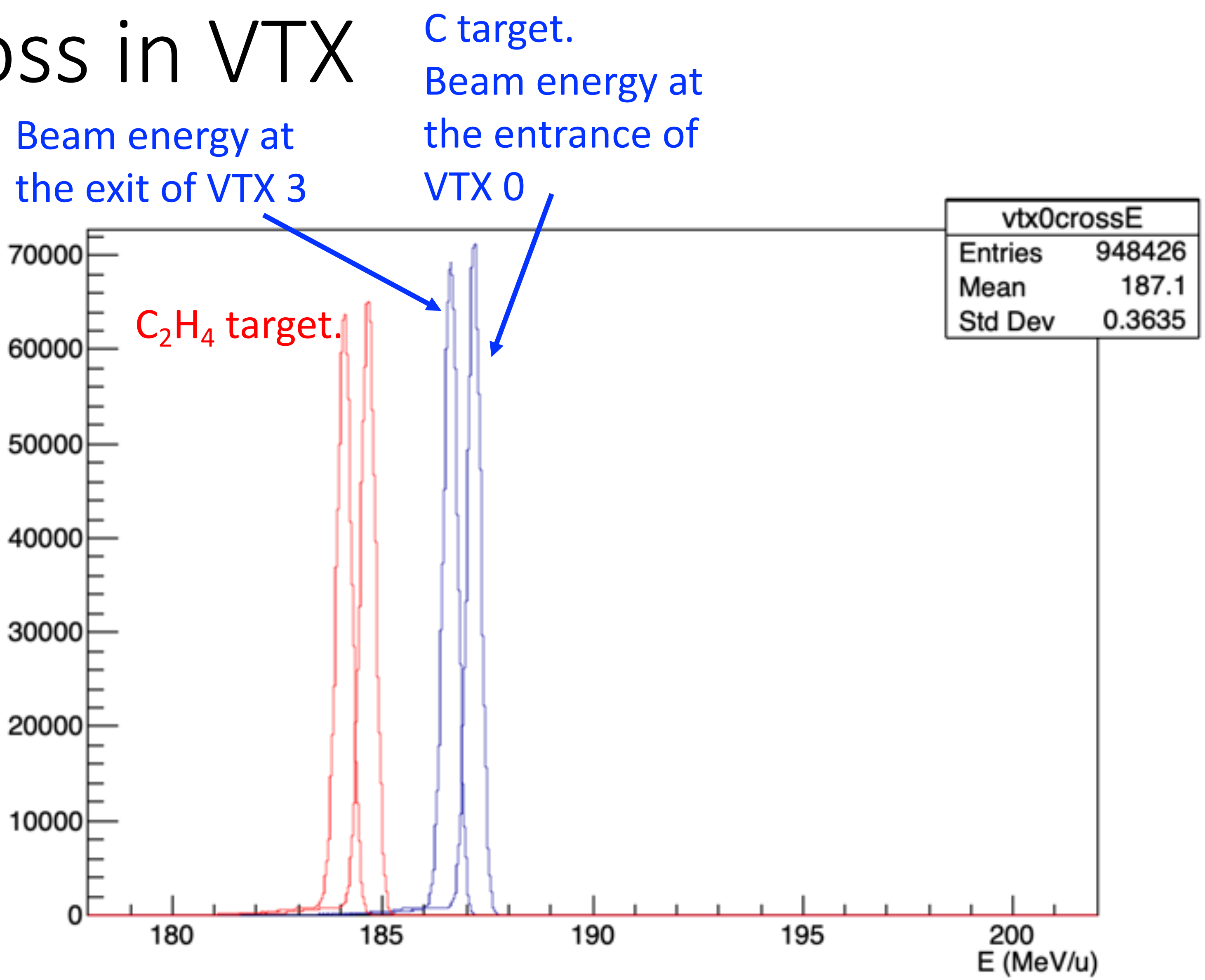
But:
In 0.5 cm of C dE/dx ~ 0.135 GeV

dE/dx in C_2H_4 > dE/dx in C

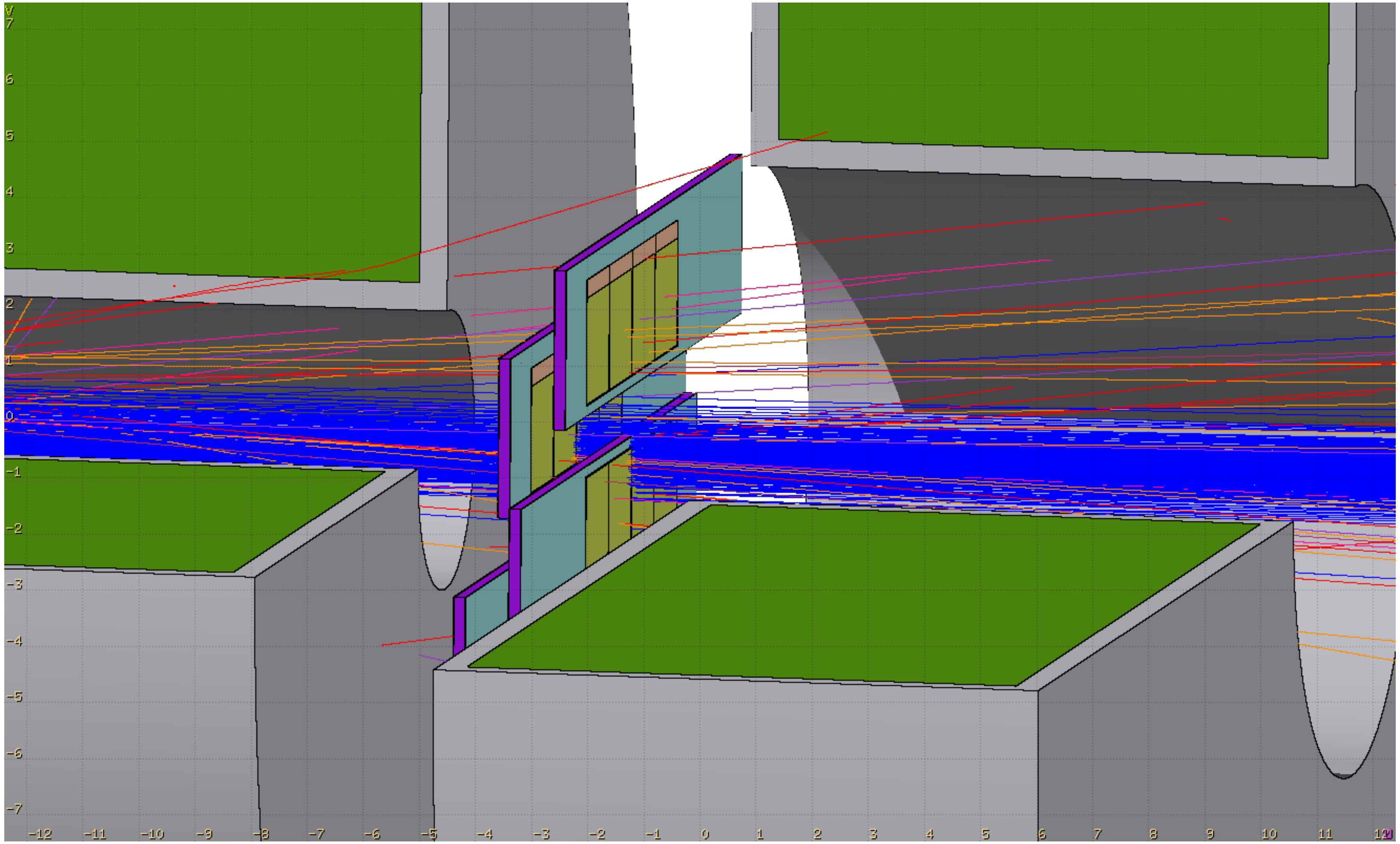
Energy loss in Target



Energy loss in VTX

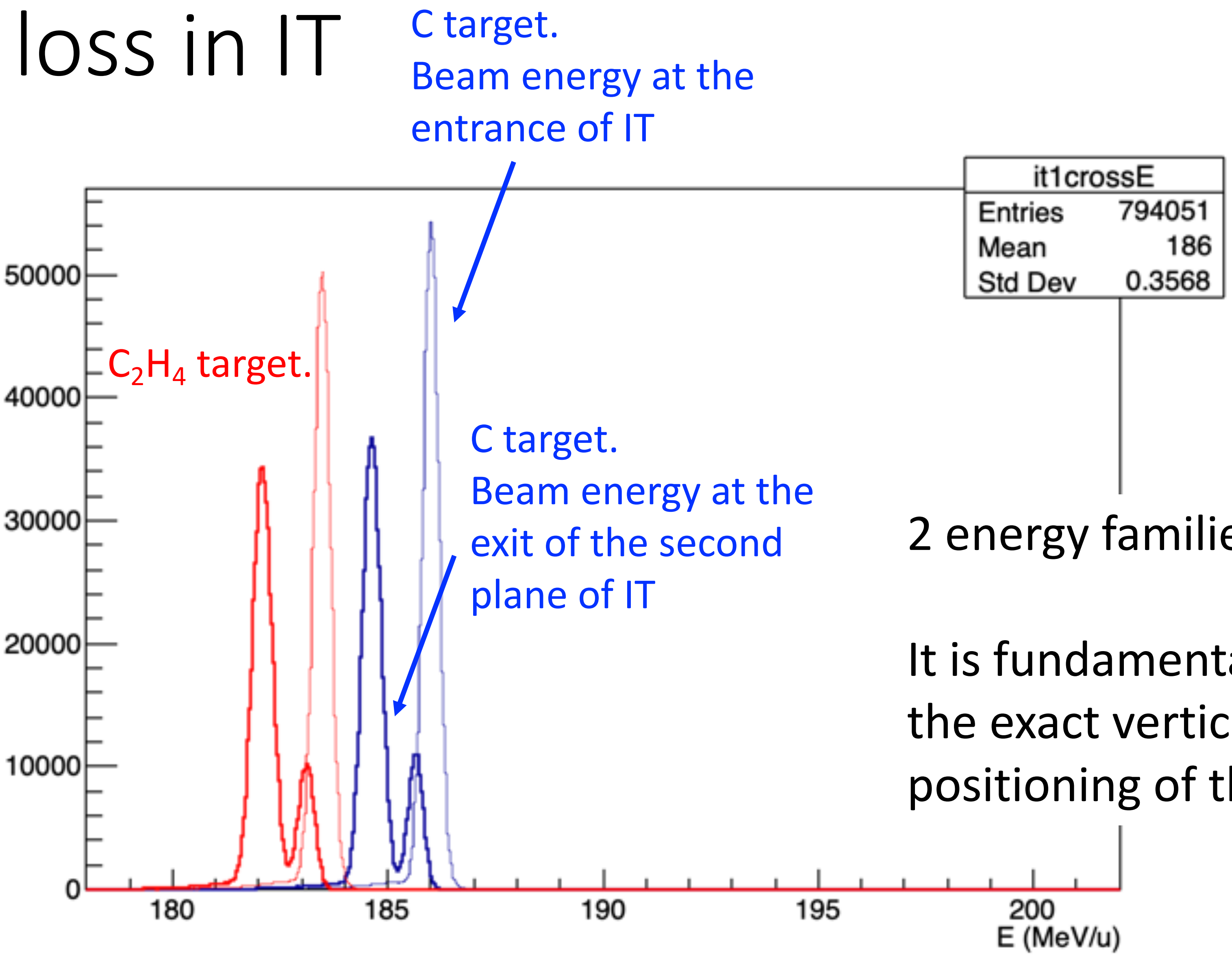


The case of IT



A fraction of tracks crosses only one ladder of IT

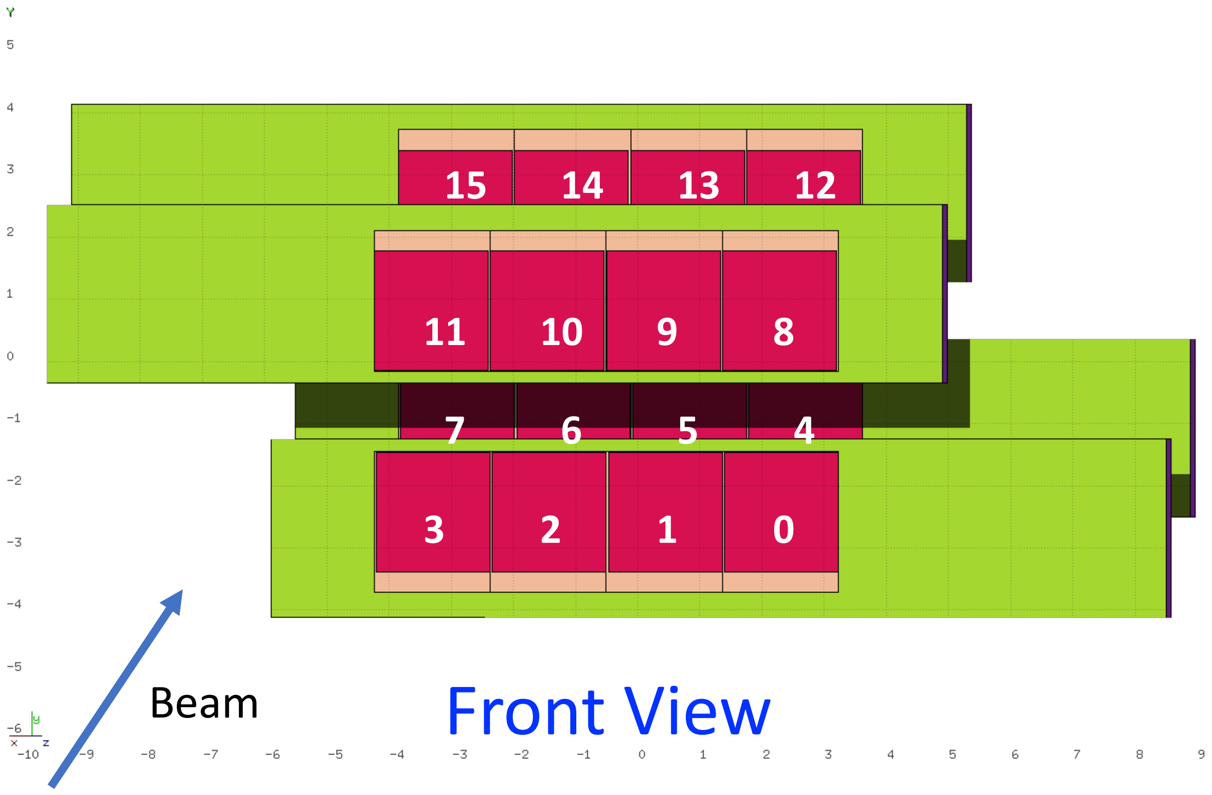
Energy loss in IT

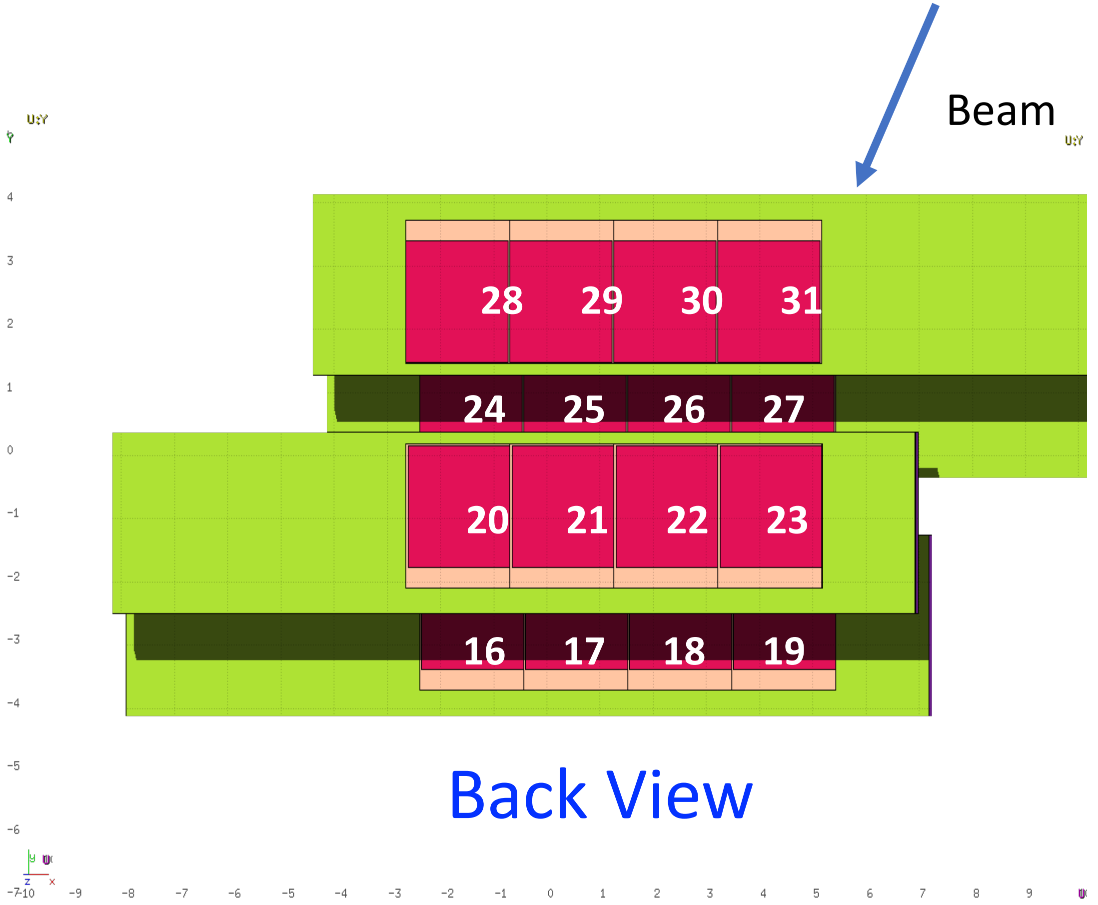


2 energy families after the IT

It is fundamental to verify the exact vertical positioning of the IT ladders

First checks of IT: sensors numbering

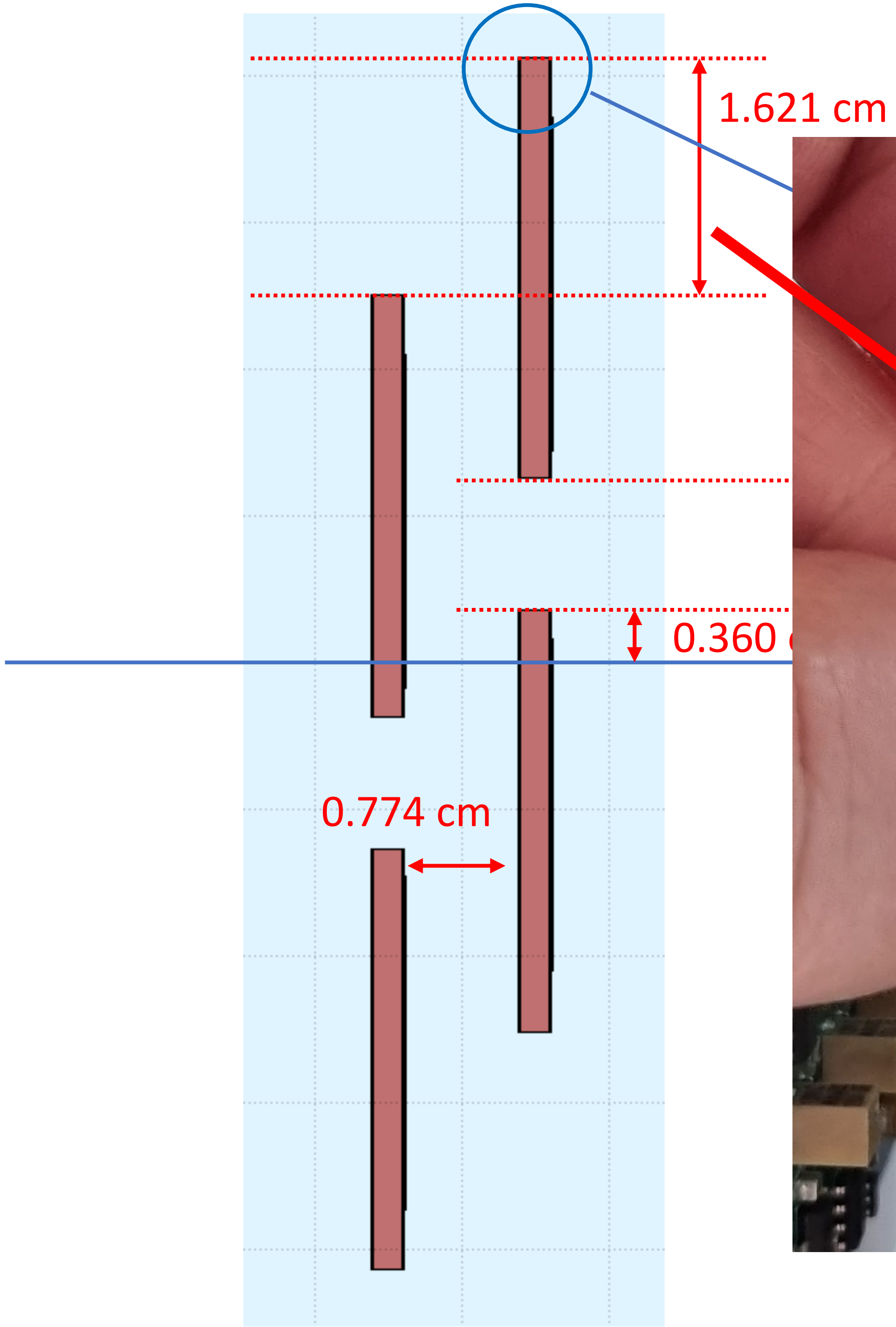


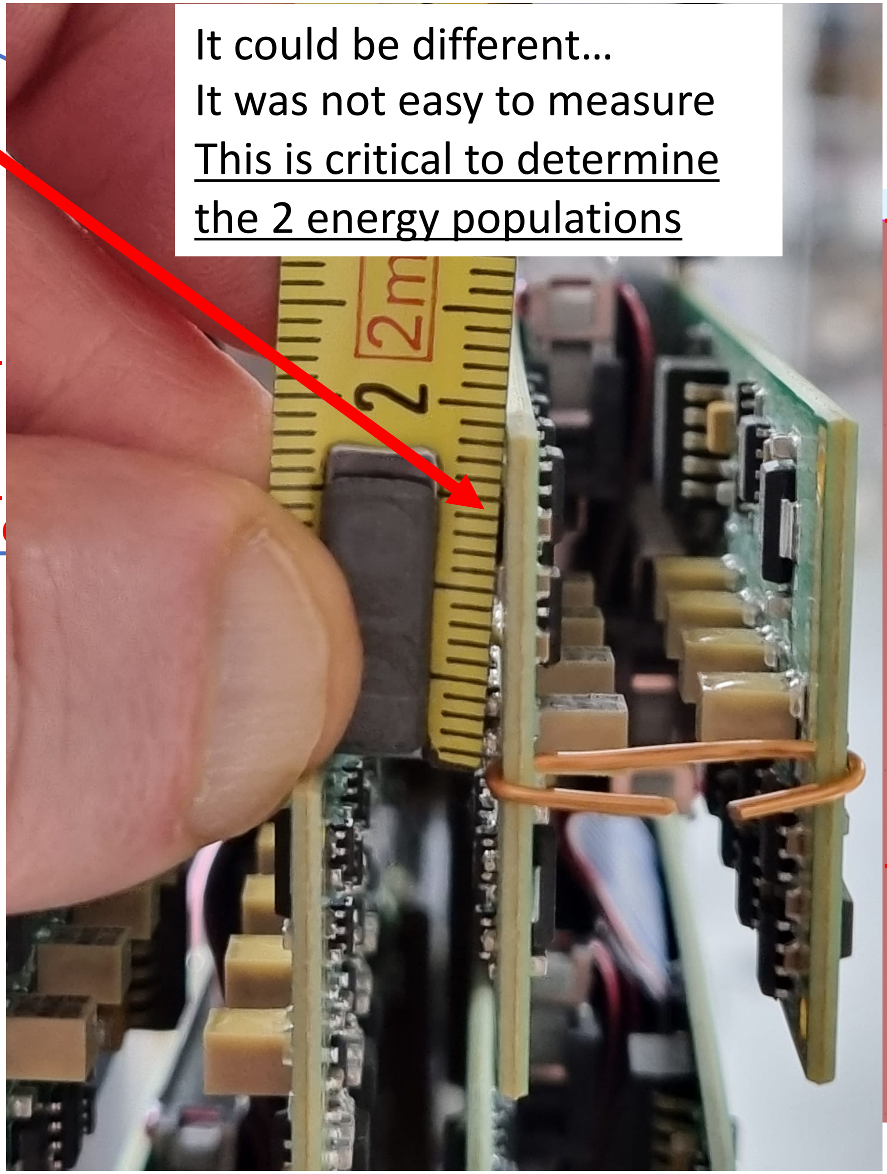


Seems OK

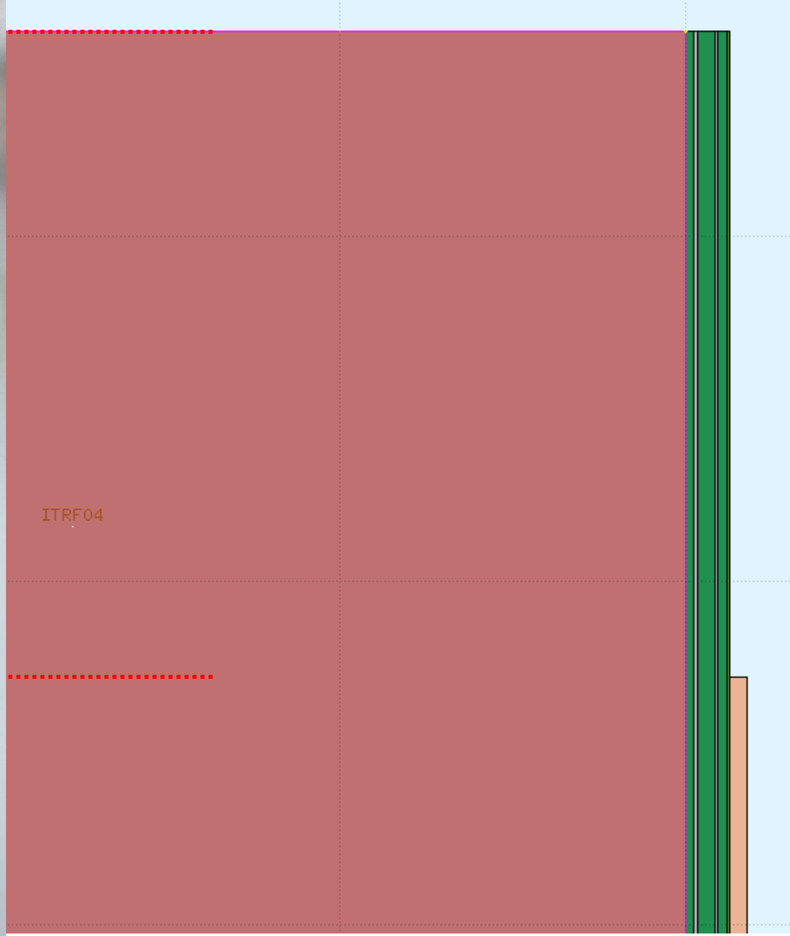
IT simulation has included (since 2016/2017) passive materials around sensors. The missing elements are readout boards which however are quite outside the lateral acceptance

Numbers to be checked for IT

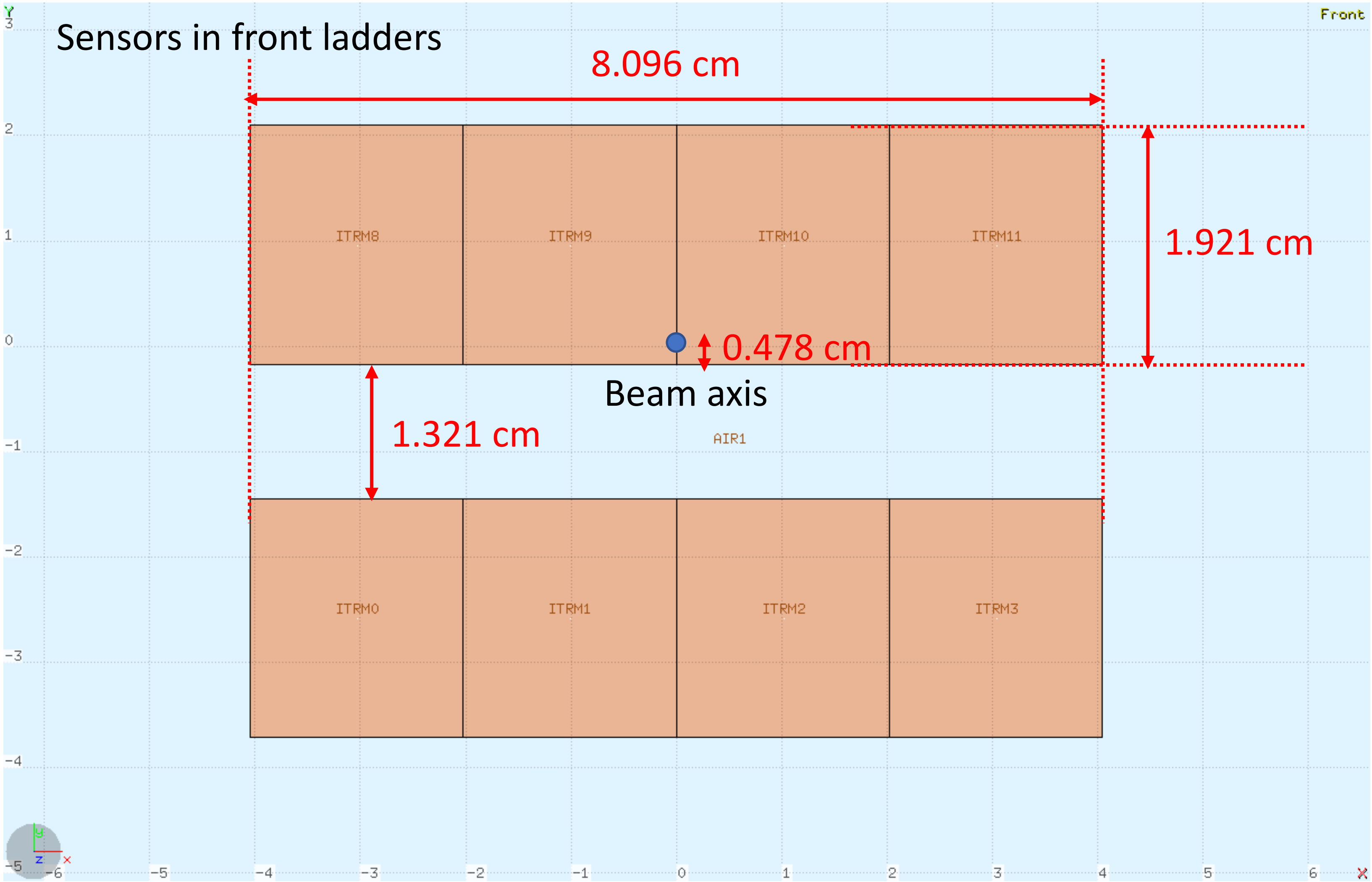




It could be different…
It was not easy to measure
<u>This is critical to determine</u>
<u>the 2 energy populations</u>



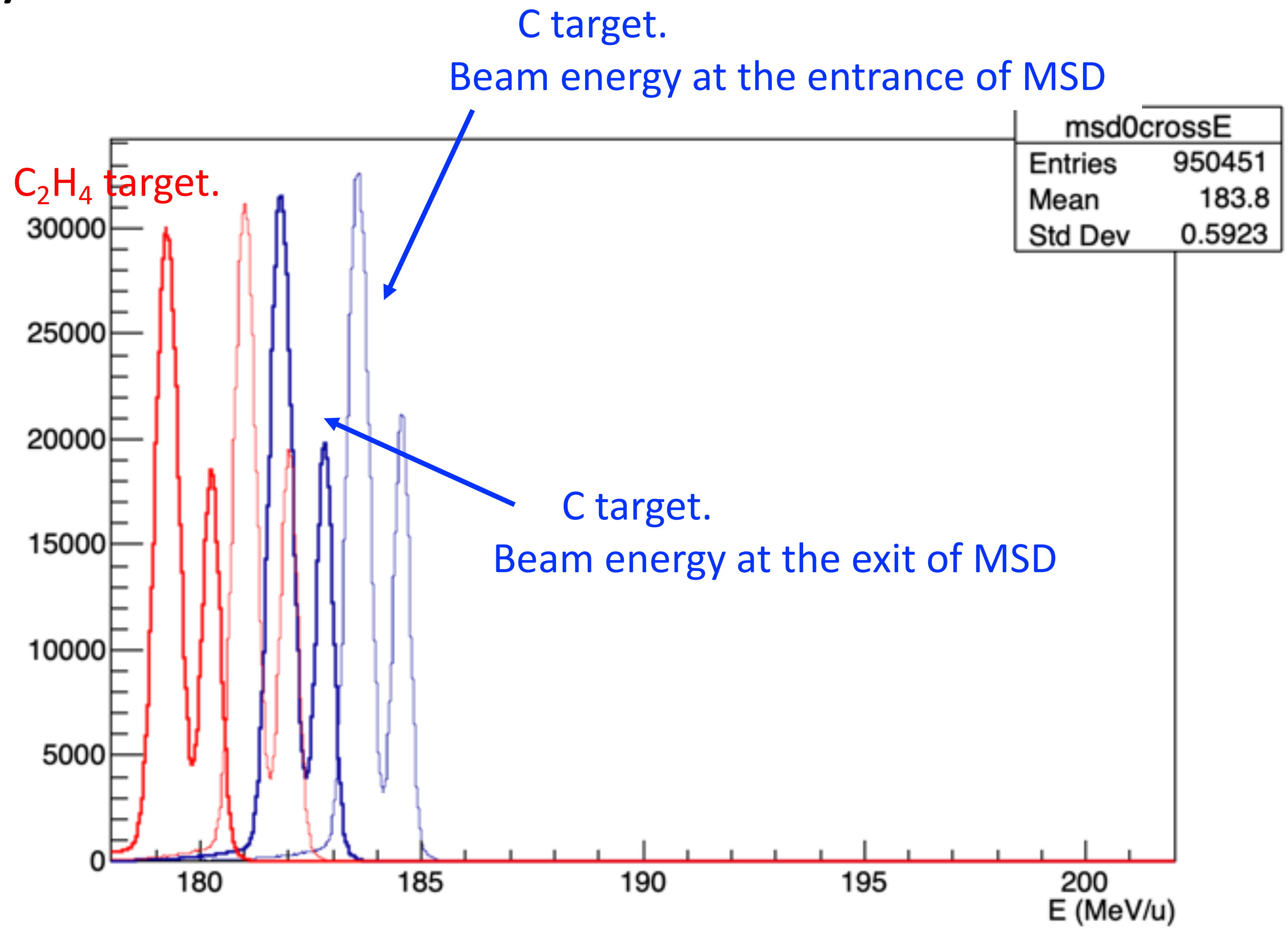
Numbers to be checked for IT x-z view



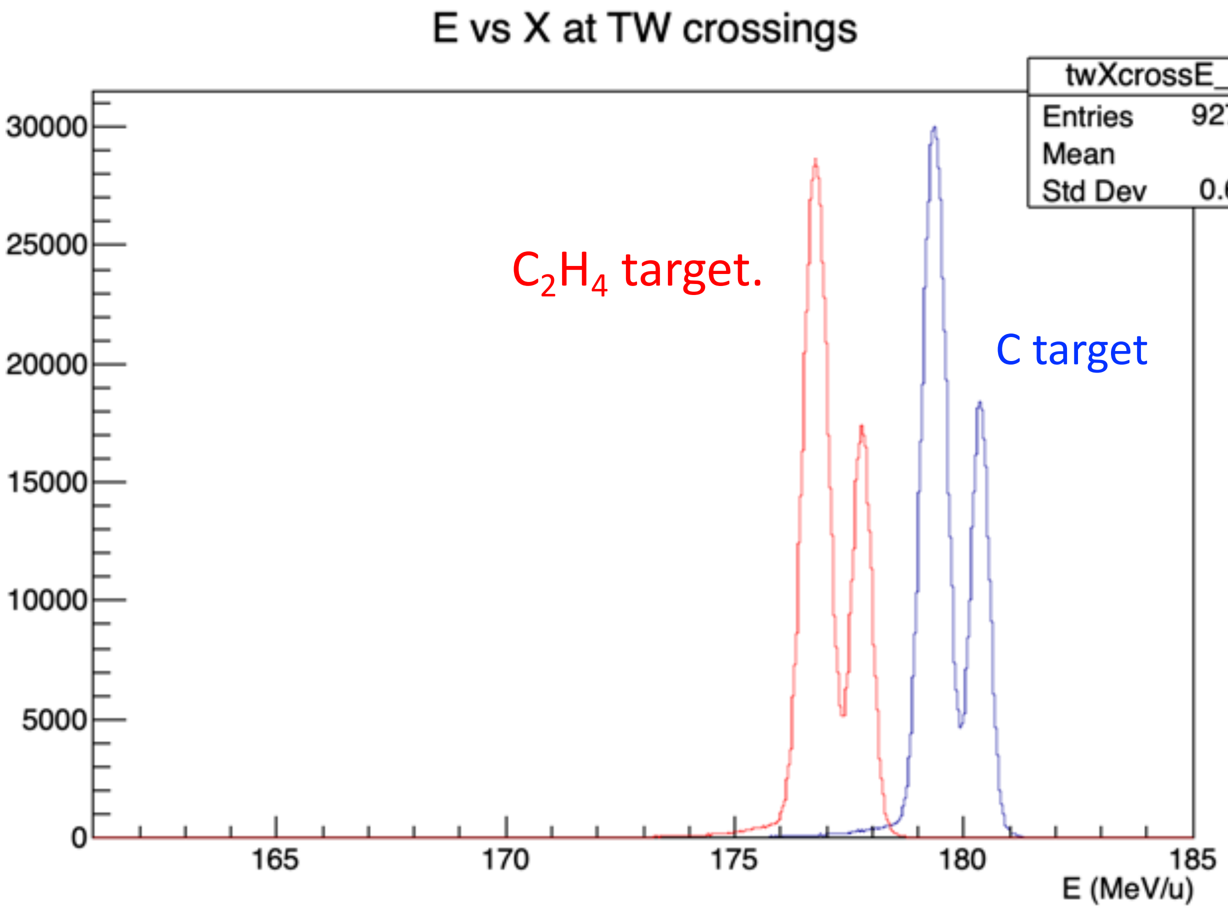
We ask the experts to check carefully all these numbers:

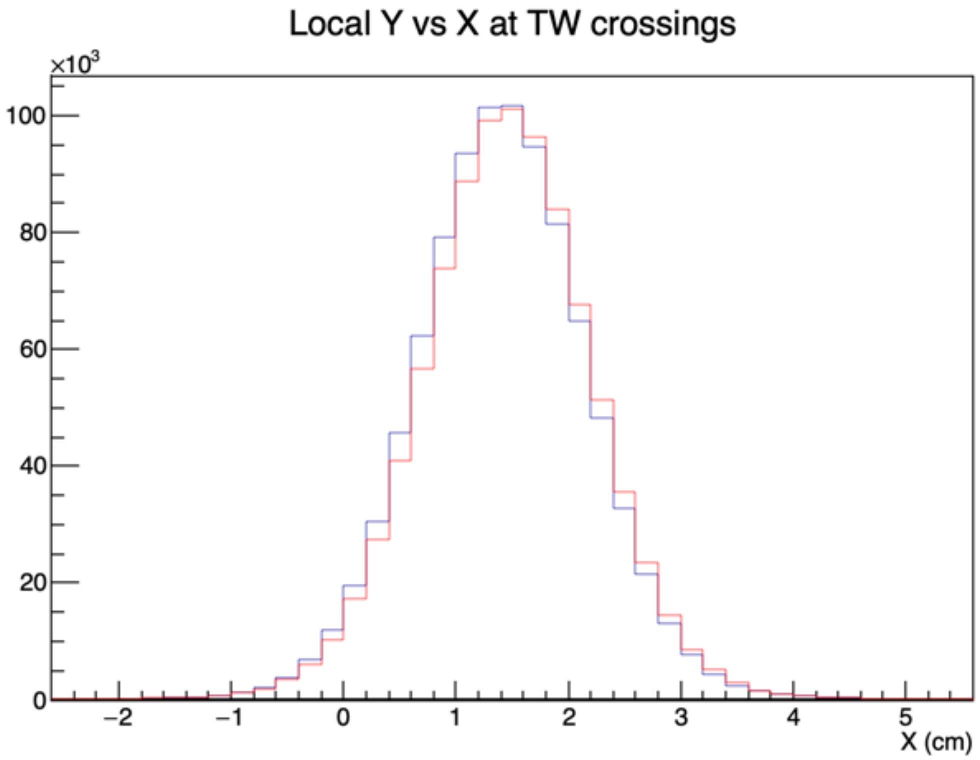
It was not easy to do that at CNAO with the full detector mounted

Energy loss in MSD



Energy at TW

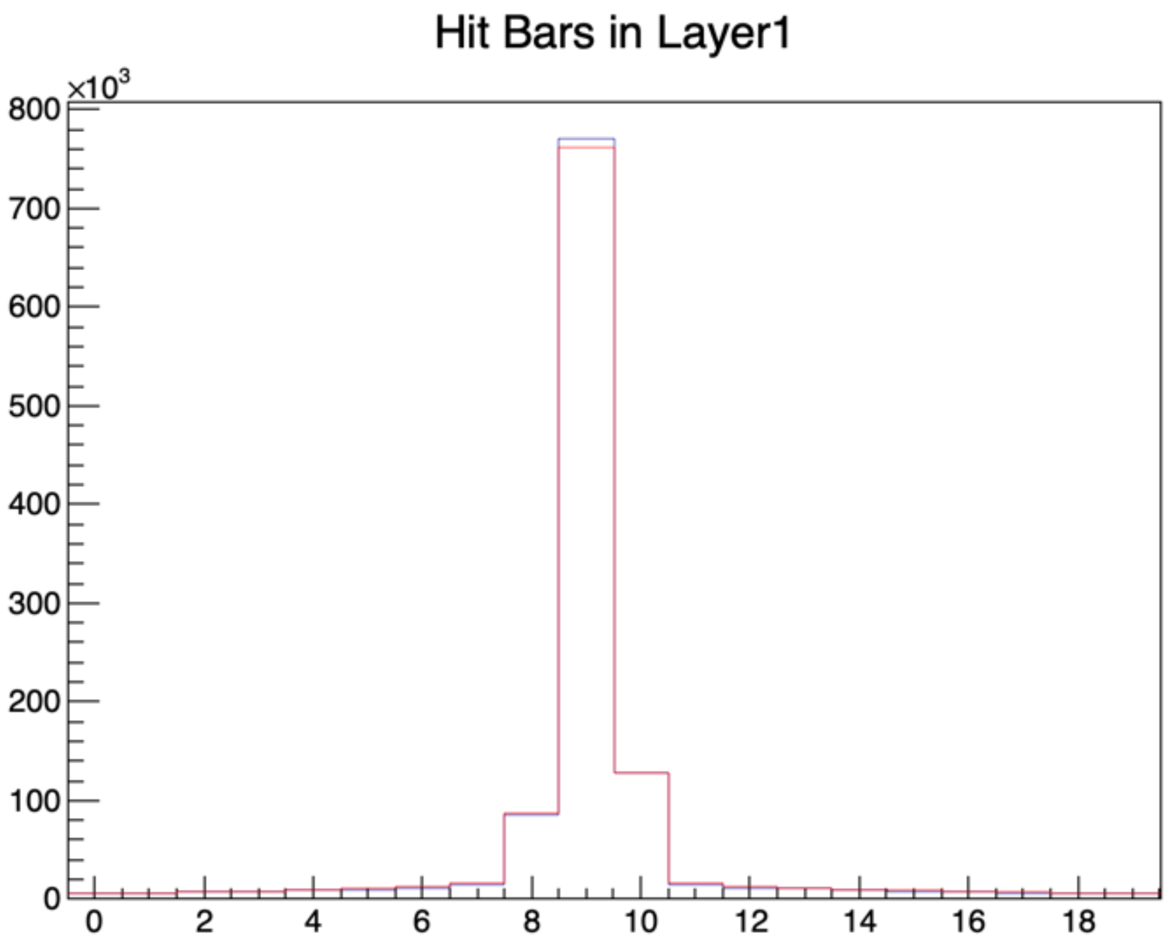




A small shift in the X position of the beam spot in TW exists

➡ With the magnets, the run with AIR target is something from the point of view of bending…

TW



This is achieved by a shift in X of 10.04 cm (survey: 11.5) and in Y of -0.9 cm

Some issues conflicting with geometrical survey

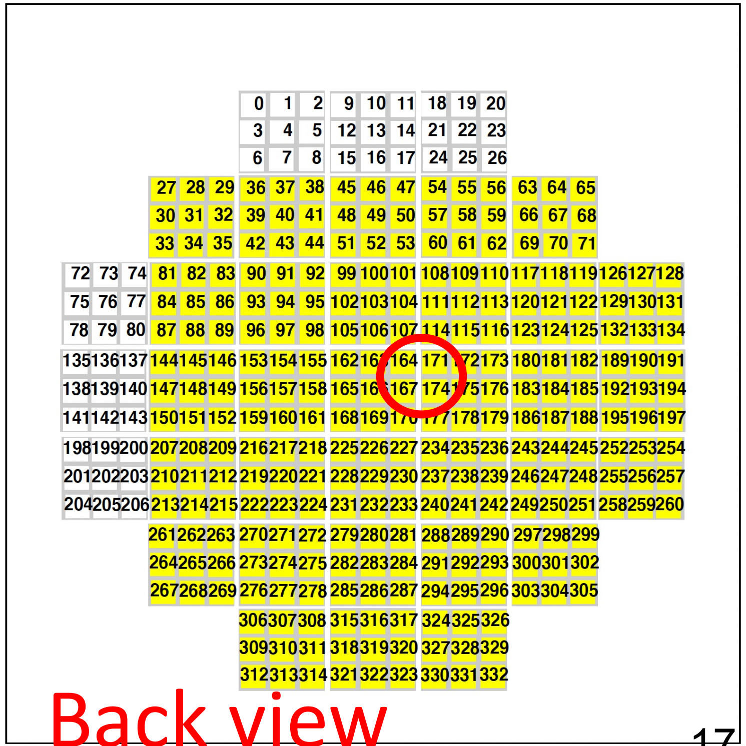
- We have moved TW to have primary beam centered on bar 9 of TW, according to results from a couple of runs:

x =1.4, y=0.89 run 4224 (C target) *local coordinates*

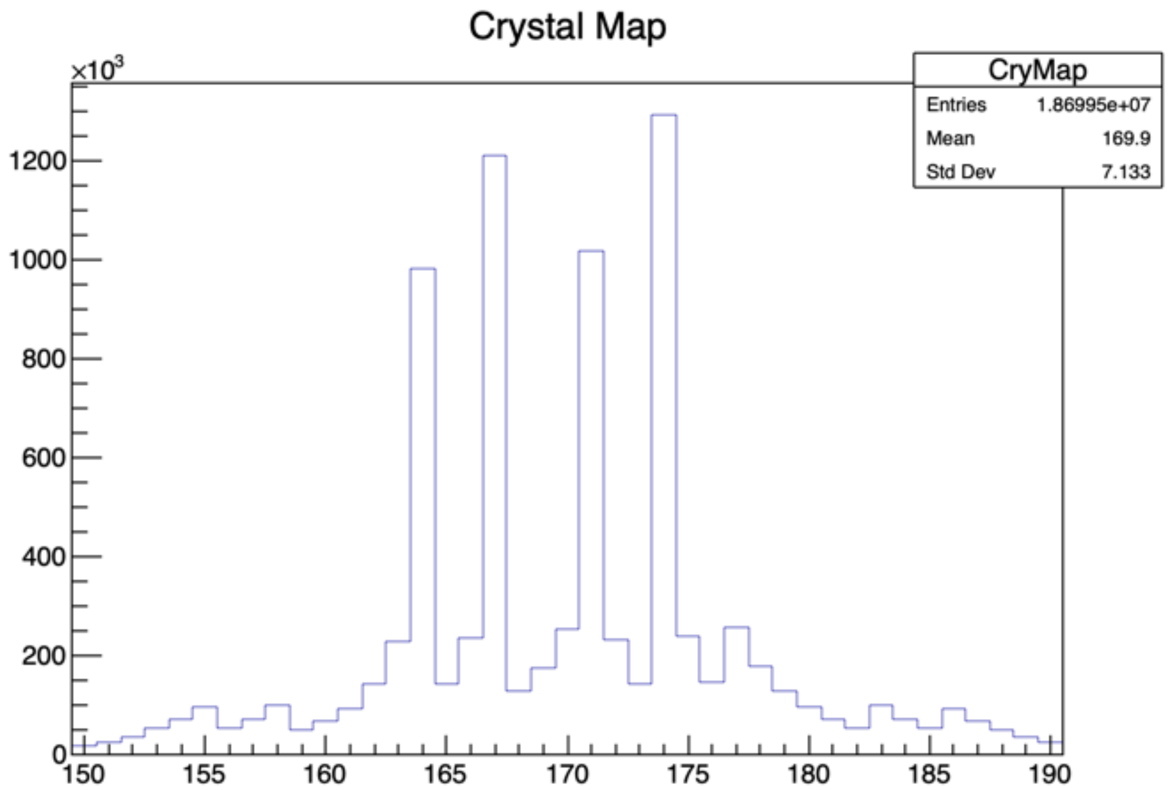
x=1.42, y=0.89 run 4124 (C_2H_4 target)

- We have moved CALO so to have crystals no. 164,167,171,174 (as from Francesca's instructions) as the most frequently hit

Crystal ID to be mapped with Board/channel (Back view, side readout boards)



CALO



This is achieved by a shift in X of 9.5 cm (survey: 11) and in Y of -1 cm

However in simulation crystal positions are very regularly spaced, not really matching the real situation

Available files:

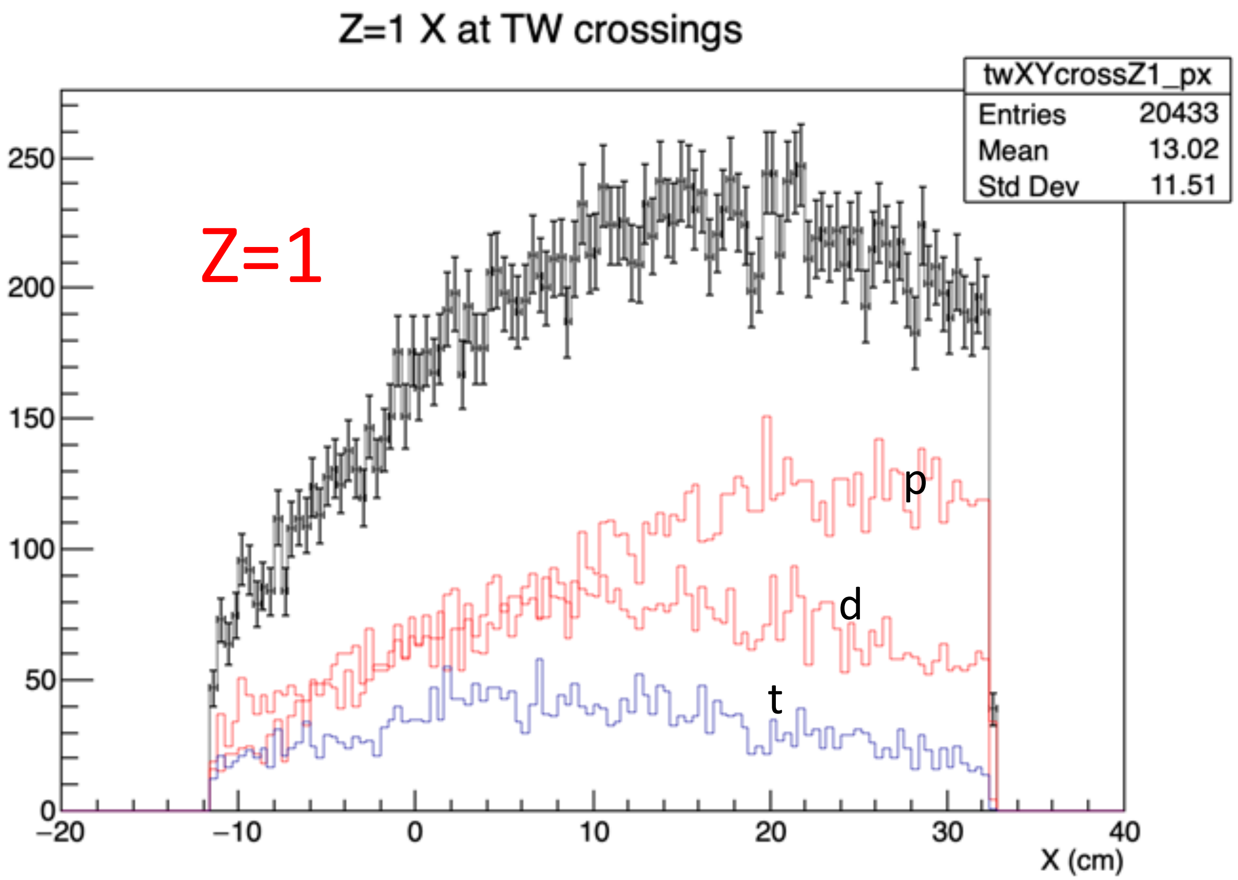
In Tier1 at /storage/gpfs_data/foot/shared/SimulatedData/CNAO2023_MC/

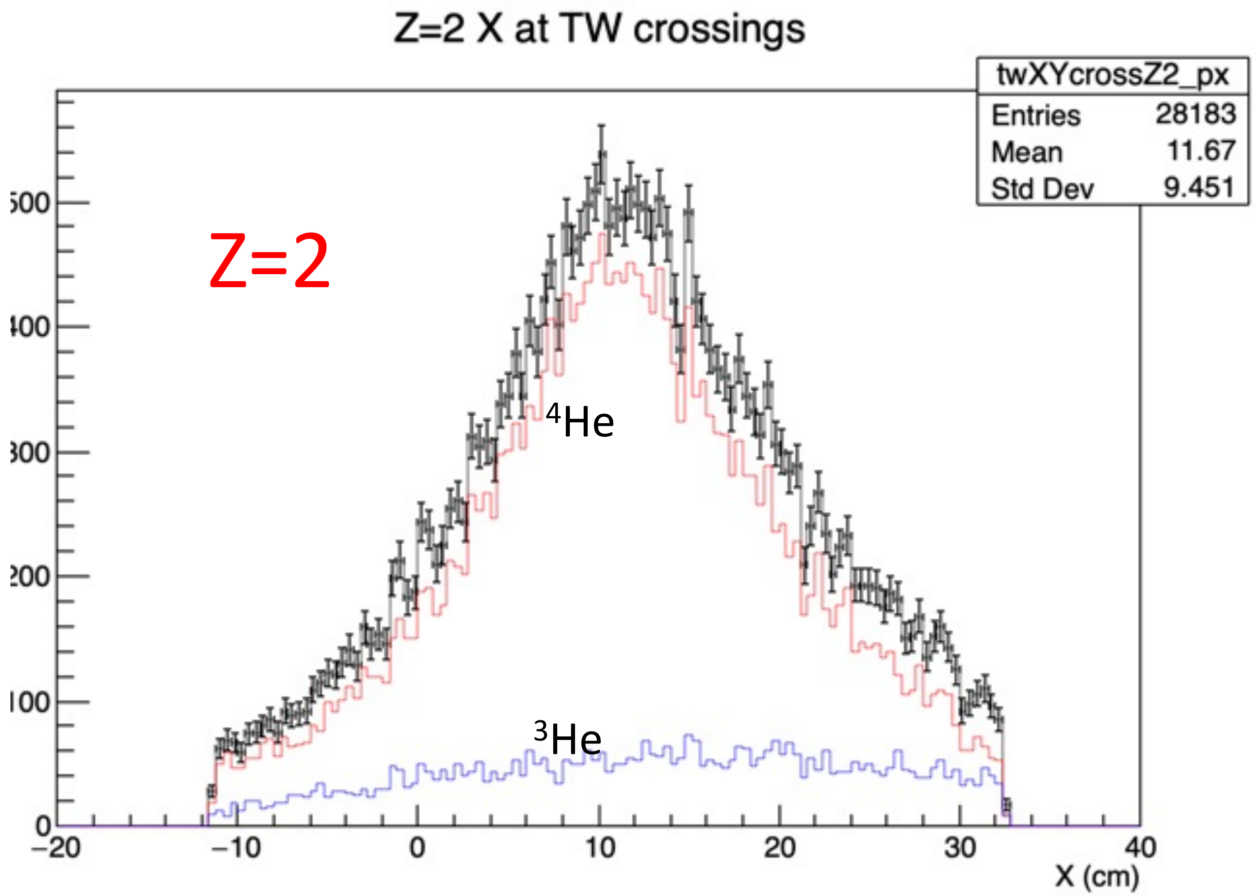
		-exp CNAO2023_MC
12C_C_200_1.root	10^6 primaries	-run 1
12C_C2H4_200_1.root	10^6 primaries	-run 2
12C_AIR_200_1.root	10^6 primaries	-run 3

Only a small sample of events to perform general checks, while waiting for:
- Improvements in IT geometry
- True (measured) magnetic map

Production and tracking of e^+, e^-, γ was not included at this stage

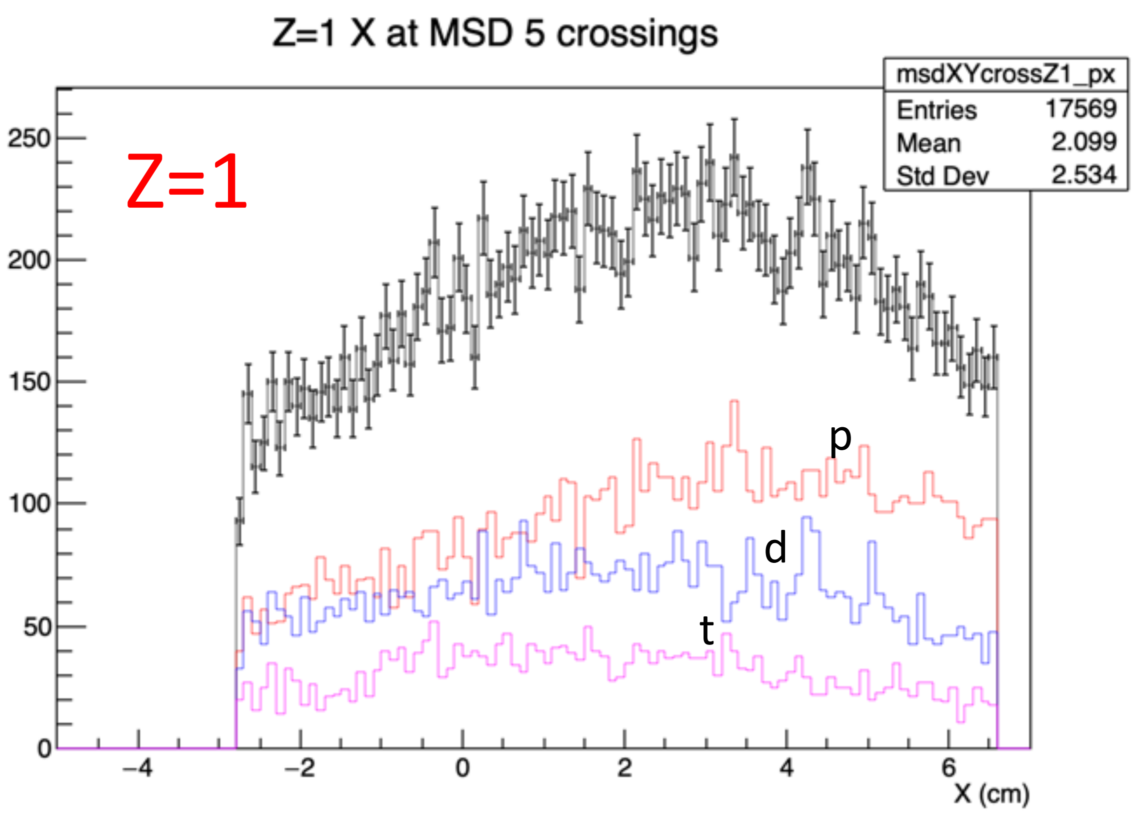
Geometrical acceptance: lateral distribution in TW

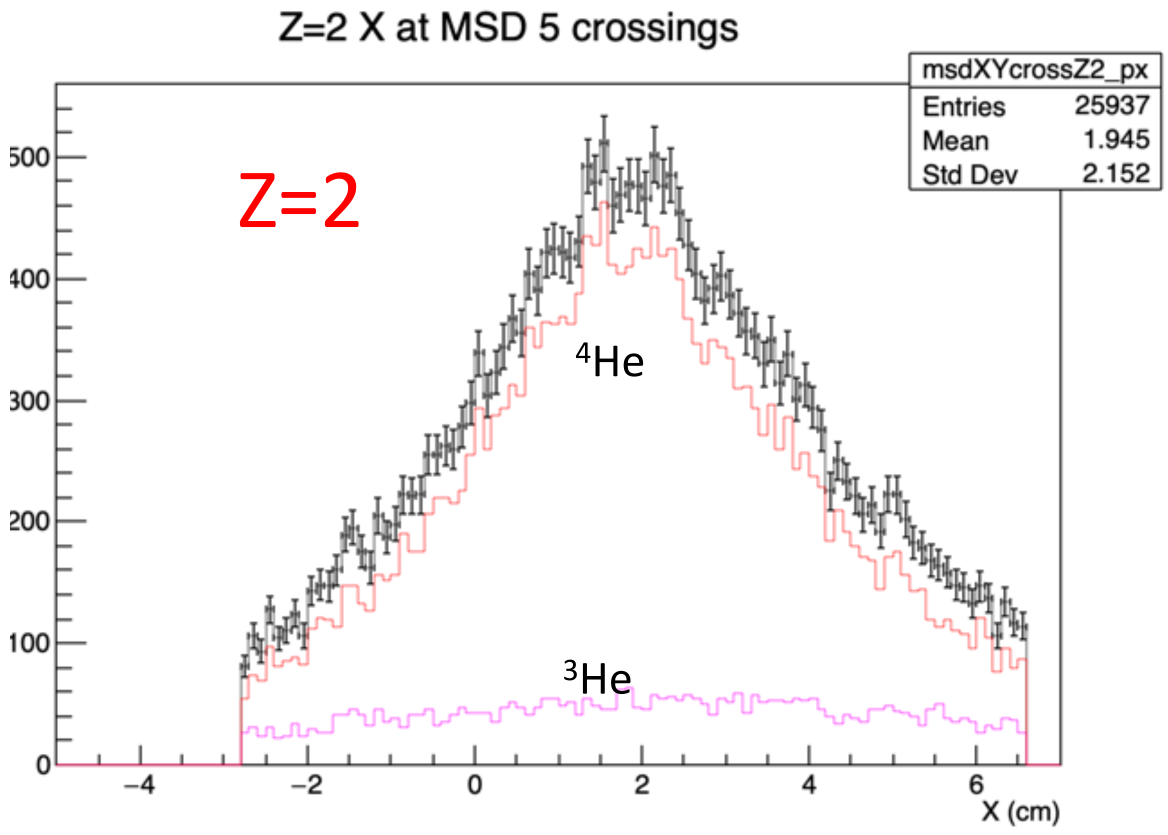




No problem for Z>2

Geometrical accetance: lateral distribution in MSD

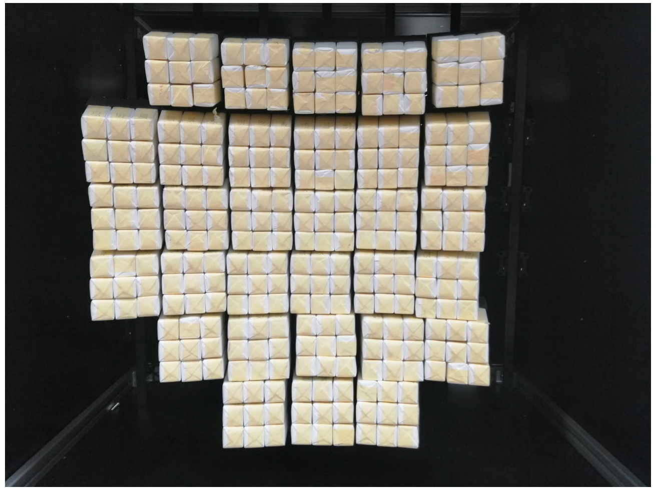


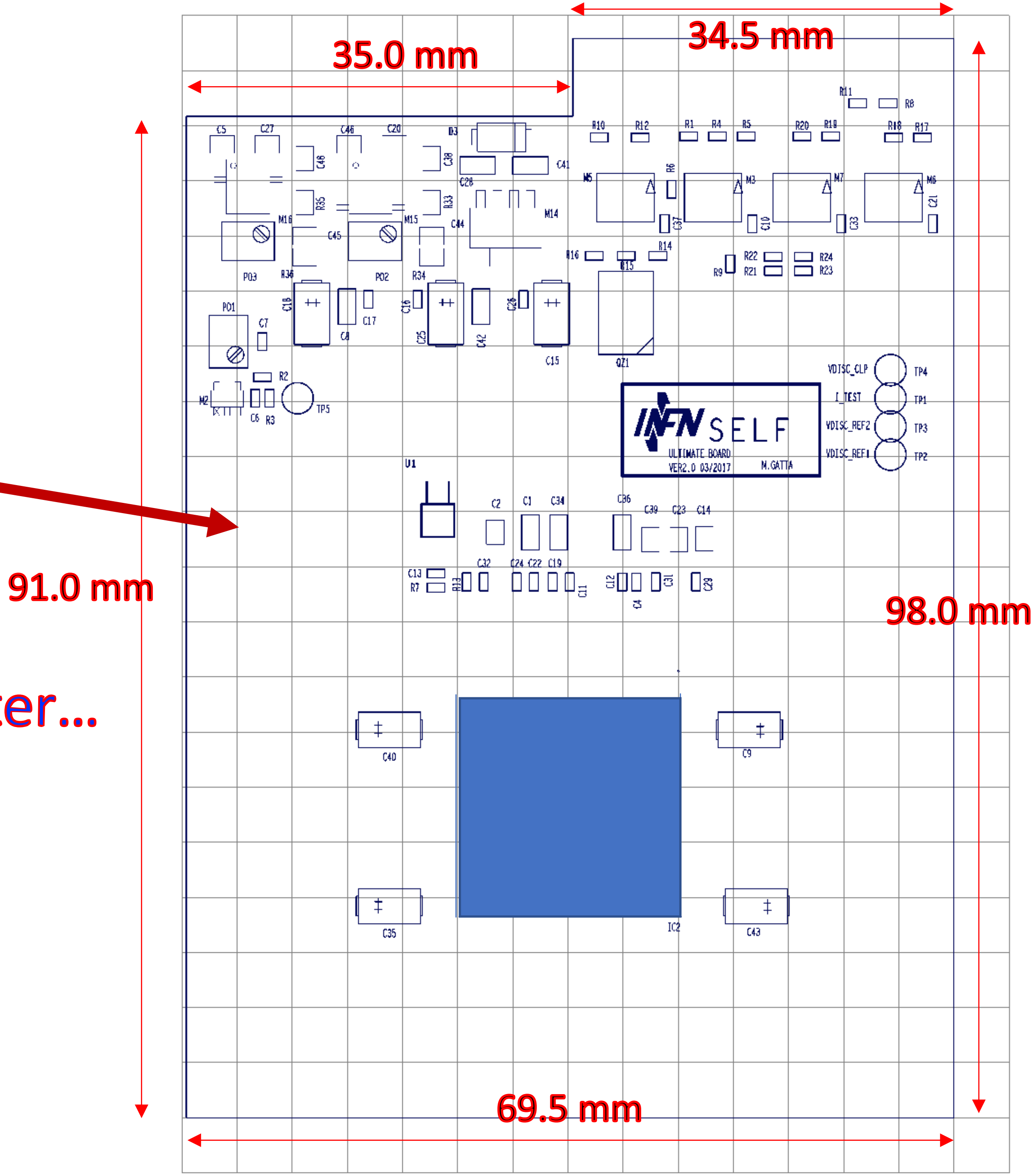


The shift applied to MSD seems to be satisfactory

Pending issues

1. IT geometry benchmarking
2. True Magnetic Map
3. Passive materials in VTX not yet implemented
4. Passive materials in MSD not yet implemented
5. More realistic geometry of calorimeter…



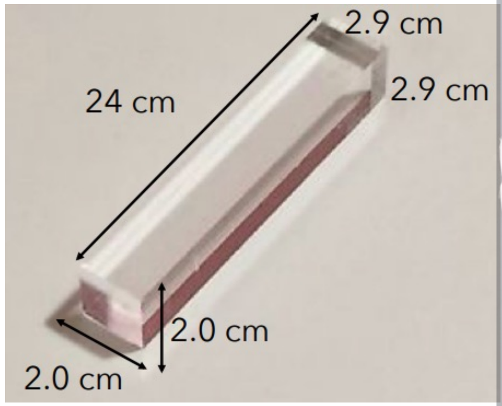


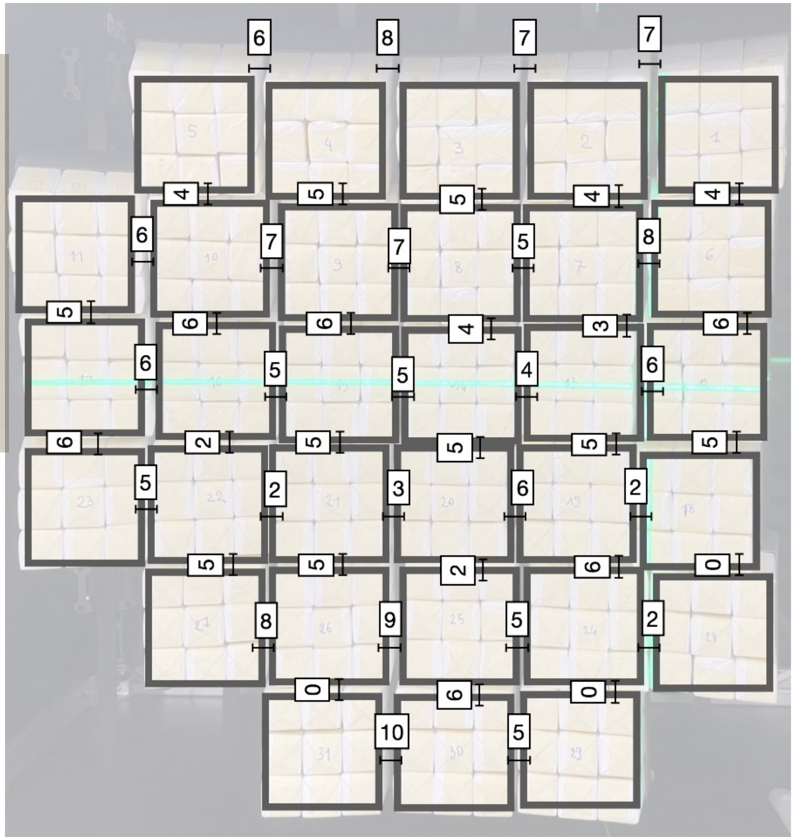
FLUKA geometry of the FOOT Calo: status

A. Mereghetti

CNAO

Introduction



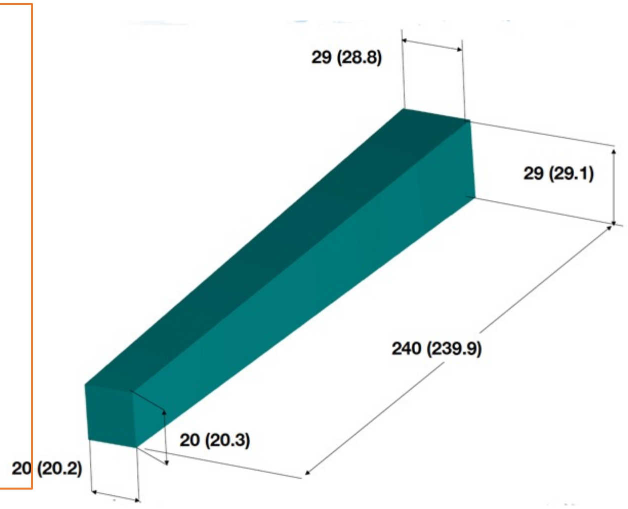


The FOOT Calorimeter («Calo») is made of 333 BGO crystals in the complete configuration

- 37 modules of 3x3 crystals;
- A crystal has the shape of a truncated pyramid;
- The crystals are (ideally) arranged as a pointing structure

For technical reasons, a single crystal is modelled in the FLUKA geometry of the FOOT experimental set up **as the volume delimited by 6 planes**

- While the crystal is identified by a single combination of planes (i.e. 1 logical operation), <u>the volume outside of the crystal is identified by (at least) 6 logical operations</u>;
- The user can define this region as «the volume outside of the crystal» i.e. the logical opposite of the crystal;
- At simulation initialisation FLUKA has to logically translate (a.k.a. "parenthesis expansion") such a definition in the above-mentioned (at least) 6 logical operations;



Rationale

Defining the volume outside of the (up to) 333 crystals is extremely complex: the user has to properly combine all the regions outside of each crystal

- Current implementation (by E. Lopez Torres) of the macro dealing with the FLUKA geometry in the FOOT Calo in Shoe:
  - Defines the air region around all crystals in a unique module;
  - Defines the air region around all the modules;
- All the air region are defined as the combination of the volumes «outside of each crystal» / «outside of each module»;
  - When many CALO modules are used, FLUKA may crash while logically translating (i.e. performing parentheses expansion) the definition of all the air regions, unless some precautions are taken, often complex to implement;

A lot of manual editing of the FLUKA geometry was sometimes necessary to have a single configuration of the FOOT calo working.

Proposal for a new version and Status of Code

Re-write the macro such that the air region(s) around crystals/modules no longer require any logical translation (i.e. parenthesis expansion) by FLUKA at simulation initialisation

- Why CNAO?
  - SYNERGY: on a different project, we need to carry out a similar task, i.e. to build a (portion of) FLUKA geometry in a programmatic way, repeating a basic geometry on a regular grid;
- Why A. Mereghetti?
  - Author of the FLUKA LineBuilder, i.e. a python program for building FLUKA geometries of accelerator beam lines;
  - The LineBuilder is currently used by the FLUKA team @ CERN for every calculation involving (almost) any CERN machine;

Status

- Code: python;
- Public git repo on github;
- Classes for handling FLUKA entities:
  - bodies, including 3D rotations/translations;
  - Regions;
  - Geometries, including writing/reading files;
- Classes for organising basic object(s) (e.g. a crystal) in a grid;
  - This operation must include the “hive”;

At the same time, we try to overcome assumptions made so far

- Crystals not all of the same lateral size;
- Irregular alignment of crystals;
- Irregular spacing among modules;

…+merge code into shoe: parsing input info and function calls

To-do

- Implement cloning of basic object(s);
- Irregular spacing of crystals inside the modules and of modules in the Calo;

Conclusions:

- A first sample of a ~stable simulation for CNAO2023 is available for first evaluation. *Calibration files for TW (Z-id) might require some checks*
- In order to reproduce observed alignment some difference in Δx of TW and CAL had to be introduced with respect to survey measurements: *Magnetic field? Tilt of setup? Difference in materials (dE/dx)?*
- Magnetic field implementation and tracking, provided the map is correct, is under control. *Warning: in case some rotation of the magnet system is needed, some non-straightforward work may be needed*
- IT presence may introduce some features in the energy distribution: *the knowledge of the correct geometry of the device is essential for a correct analysis*
- A high statistics production will be meaningful when the main issues have been checked

Fraction of primary interactions in different regions

Total no. of Processed Events: 1000000

Perc. of interactions in Air: 0.92%
Perc. of interactions in STC: 0.15%
Perc. of interactions in BM: 0.13%
Perc. of interactions in TGT: 3.66%
Perc. of interactions in VTX: 0.12% (no passive material around!)
Perc. of interactions in IT: 0.46%
Perc. of interactions in MSD: 0.52% (no passive material around!)
Perc. of interactions in TW: 3.08%
(remaining fraction interacts in CALO)