FOOT simulation summary

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Outline

- FLUKA version in use

- CNAO2022_MC campaign: last changes

- Modification of 12C_200_2023 campaign

- Update of Twiki Simulation page

- Discussion in view of future developments

New FLUKA respin: *FLUKA2021.2.9*

We announced the release of a new production version of FLUKA (2021.2), which includes some new features as point-wise cross sections for E<20 MeV neutrons
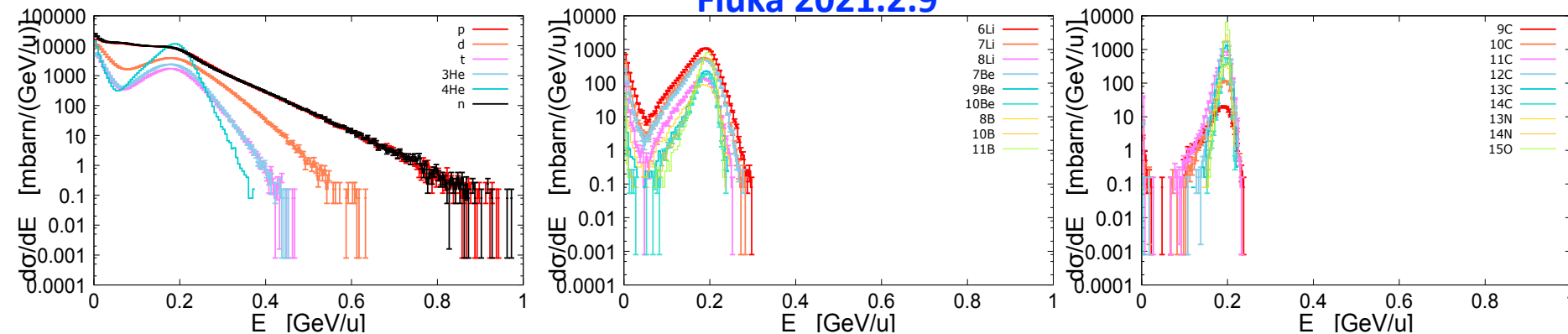
^{16}O+C @ 200 MeV/u
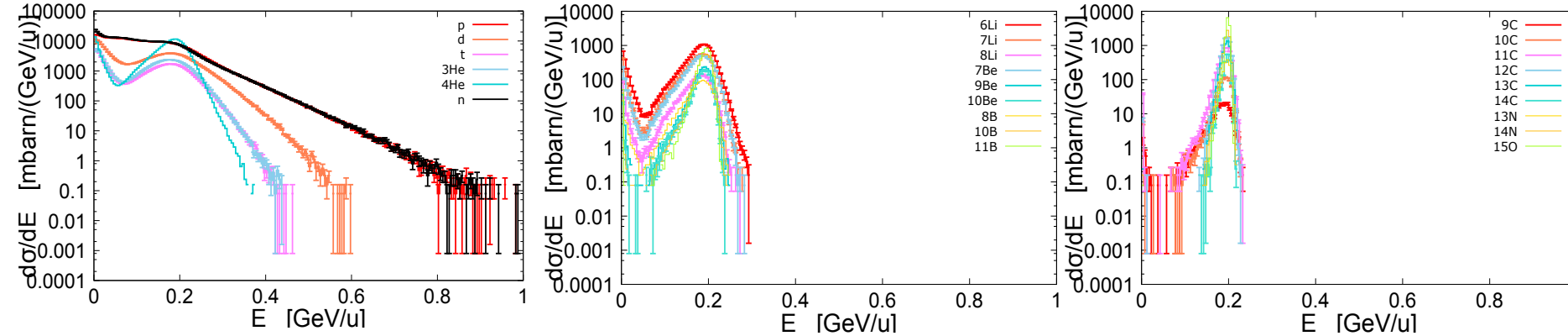
We tested it against version 2020.0.10 and previous 2021.2 respins to search for possible differences in cross sections:

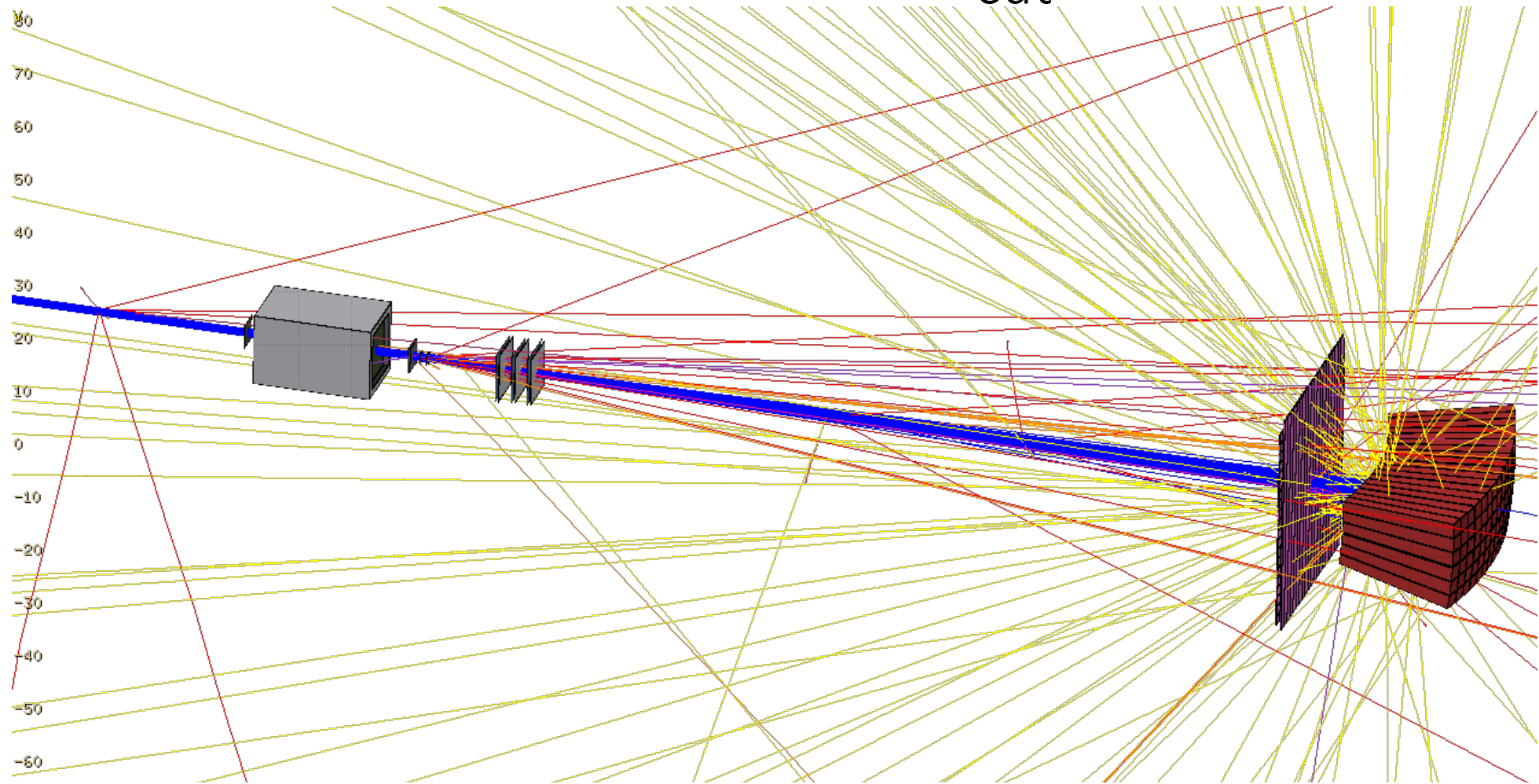➔ **No significant difference comes out from our comparison**
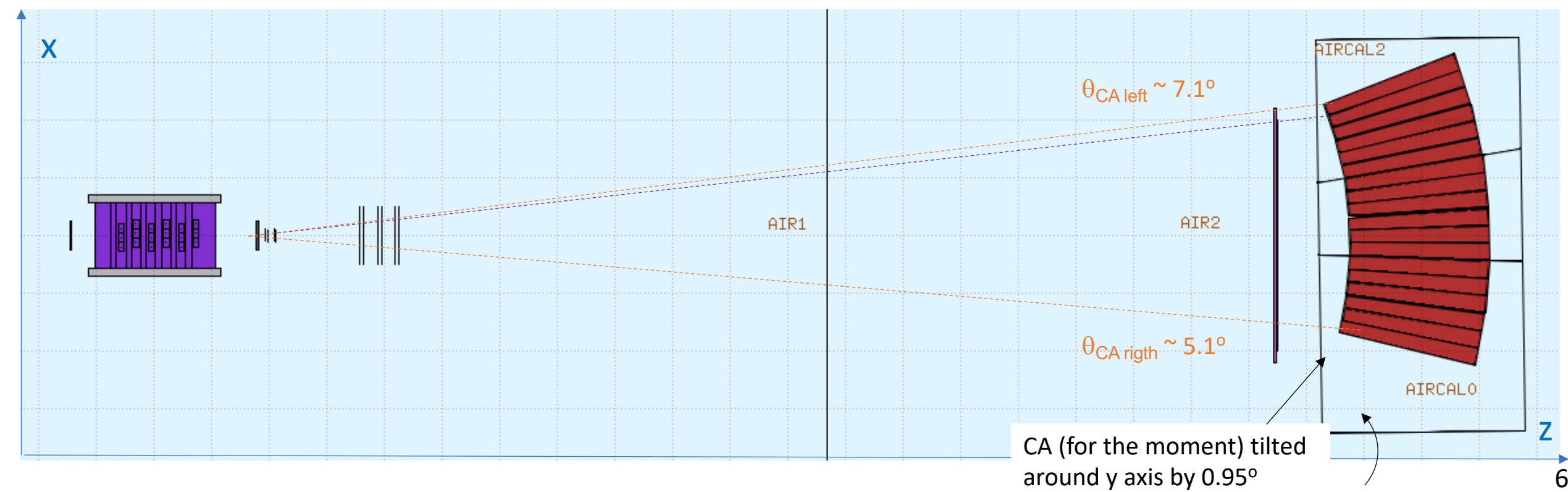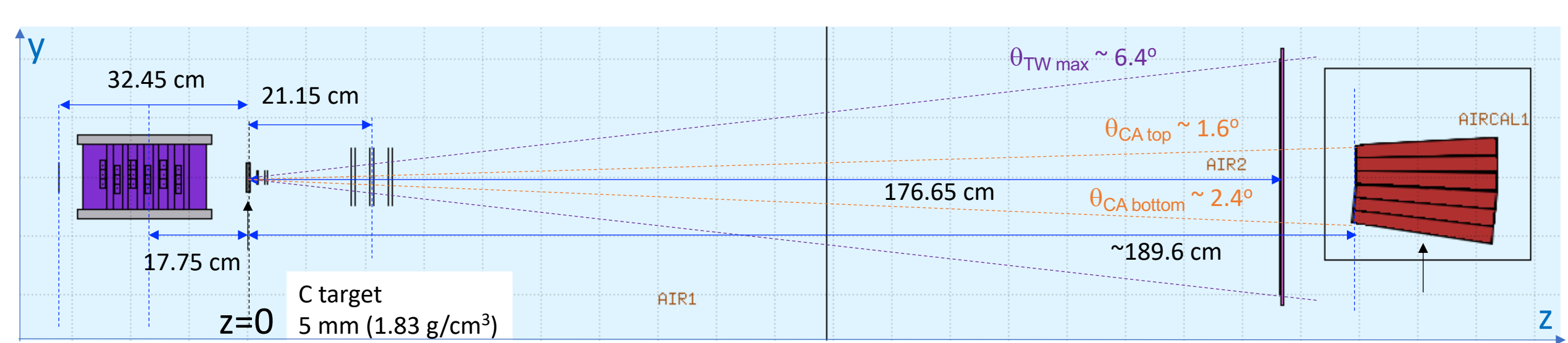
We starteed to make use of the **FLUKA 2021.2.9 version**

Modification of the CNAO2022_MC campaign

300 events + photons (E_{cut} > 500 keV)

This simulation includes photons with 500 keV energy cut

Top diagram (y-z plane):

y

32.45 cm

21.15 cm

$\theta_{TW\ max} \sim 6.4°$

$\theta_{CA\ top} \sim 1.6°$

AIR2

176.65 cm

$\theta_{CA\ bottom} \sim 2.4°$

AIRCAL1

~189.6 cm

17.75 cm

AIR1

z=0 C target
5 mm (1.83 g/cm³)

z

Bottom diagram (x-z plane):

x

AIRCAL2

$\theta_{CA\ left} \sim 7.1°$

AIR1

AIR2

AIRCAL0

$\theta_{CA\ rigth} \sim 5.1°$

CA (for the moment) tilted
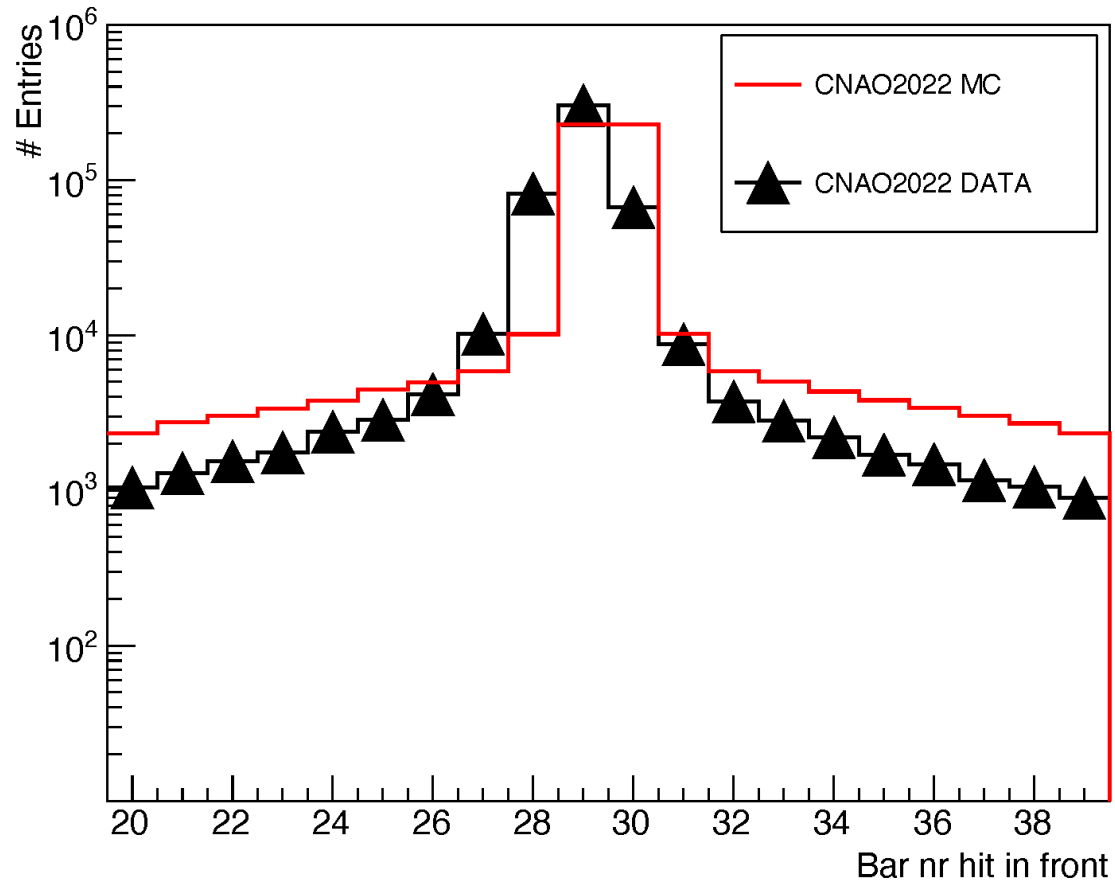around y axis by 0.95°

z

6

New positioning of the TW
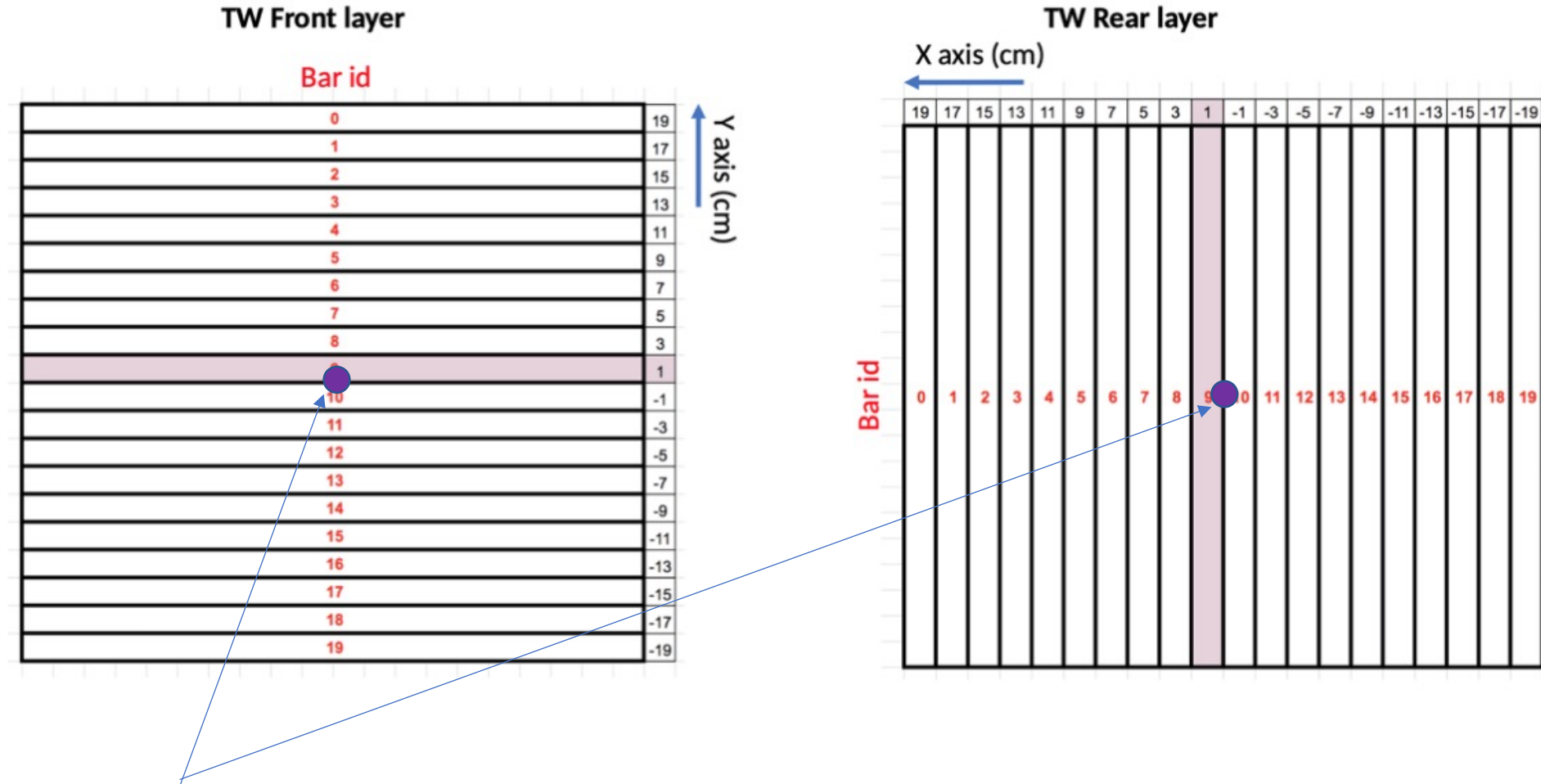
In the first production, we positioned the TW in such a way to shoot primary axis just between the 2 central bars: this did not match the real situation

Front Layer

Rear Layer
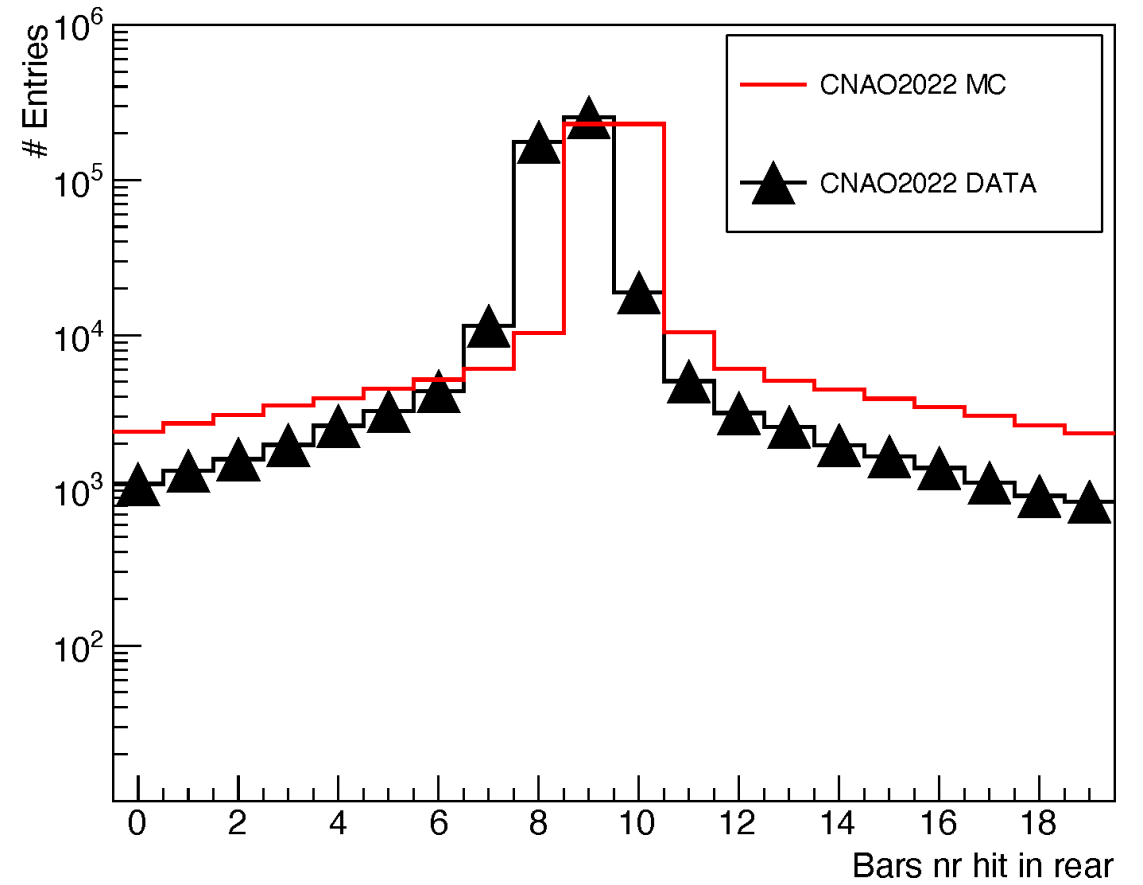
(Data analyzed by A. Kraan)

After change in geometry

Hit Bars in Layer1

LayBars1	
Entries	5645838
Mean	9.011
Std Dev	2.014

Front Layer

Hit Bars in Layer0

LayBars0	
Entries	5674611
Mean	8.686
Std Dev	2.037

Rear Layer
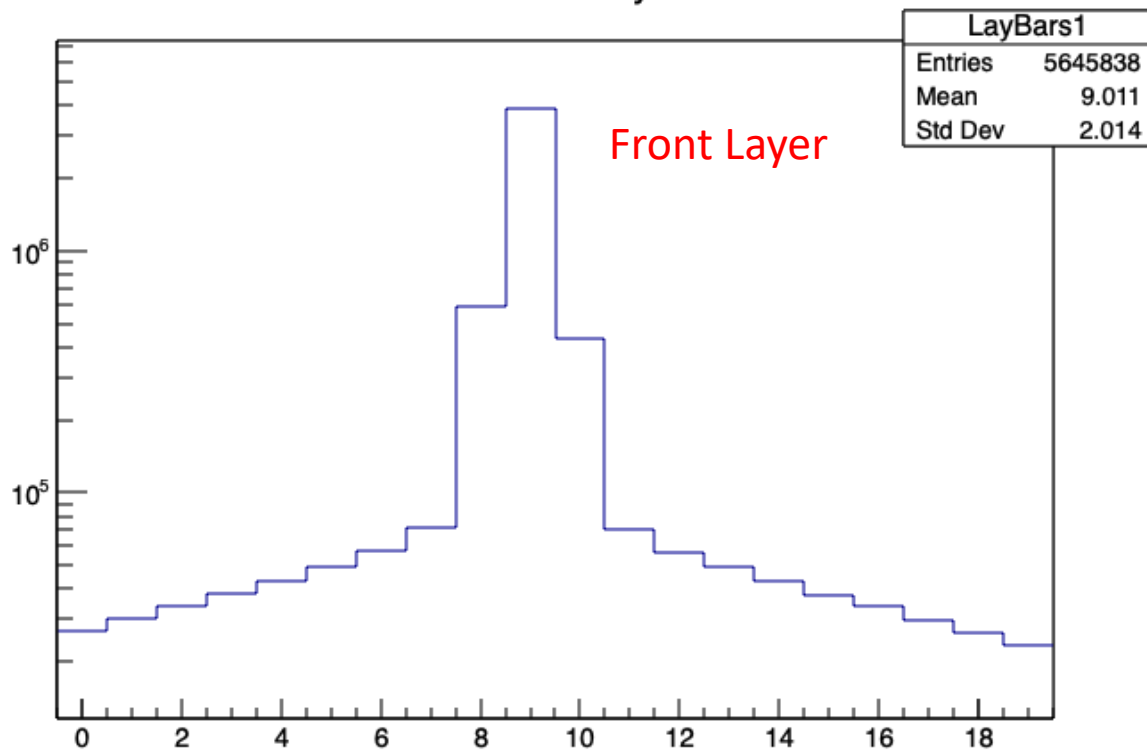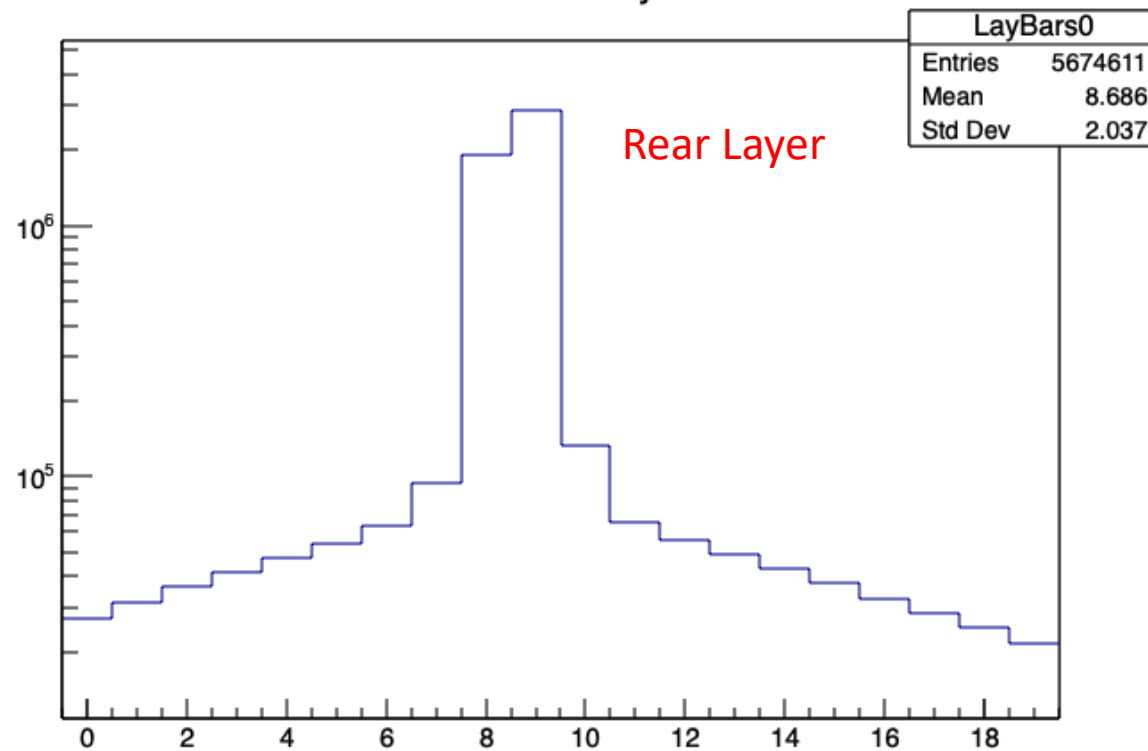
New positioning of the calorimeter

CA back view

In addition, also **Calo** was moved so to have primary axis hitting **crystal #26**
Initially crystal #25 was considered

New production

Now copied in Tier1

12C_C_200dec_1_shoereg.root   5 10^6 events

12C_C_200dec_2_shoereg.root   5 10^6 events

RUN NUMBER

-exp CNAO2022_MC -run **201**

Warning:
the CNAO2022_MC campaign will be now updated (thus changing FOOT.geo etc.)

No. of interactions of primaries for 5 milions of events

No. of interactions in Air: 54419   Before TG: 16128   After TW: 1705

No. of interactions in STC: 7292
No. of interactions in BMN: 6485
No. of interactions in TGT: 181960 (3.64%)
No. of interactions in VTX: 5835
No. of interactions in MSD: 26621
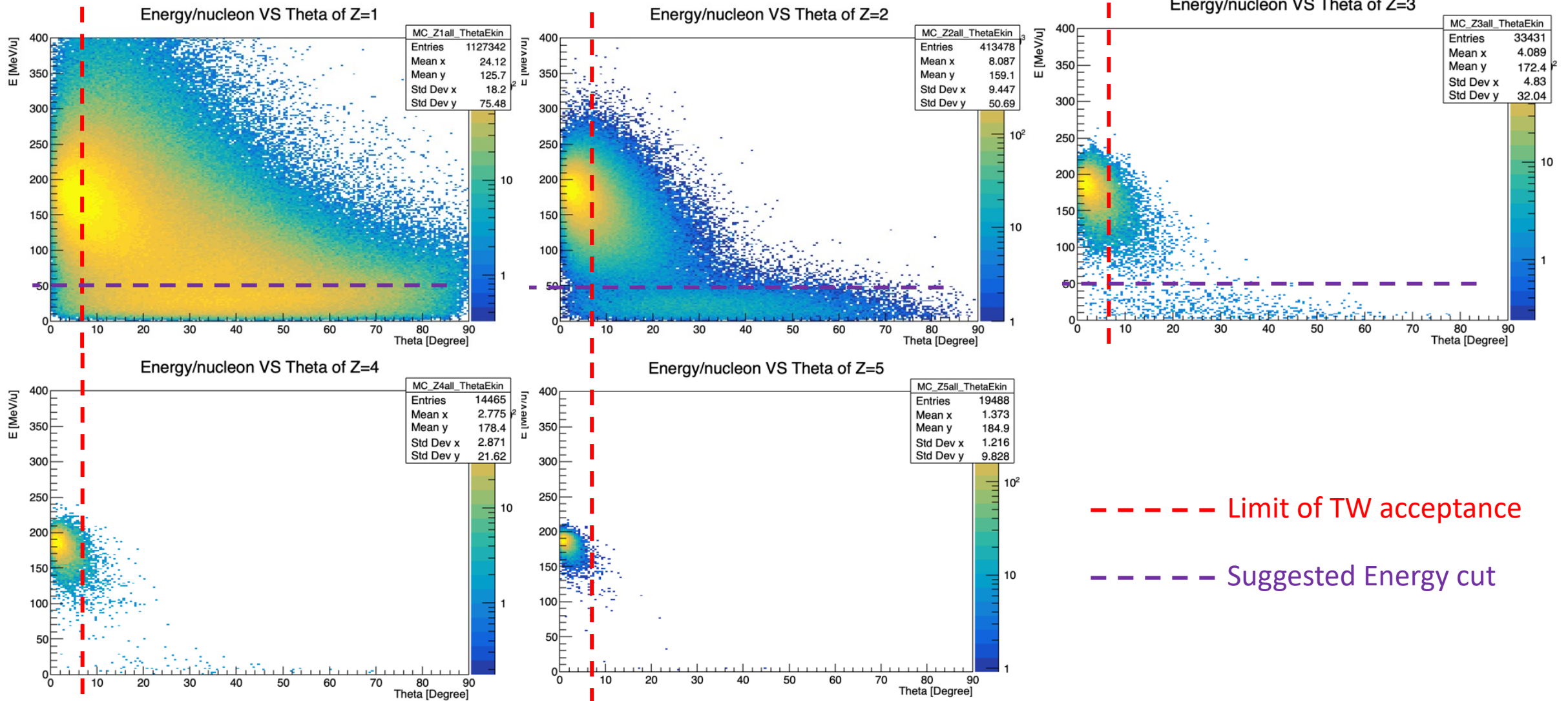No. of interactions in TWL: 153245

No. of primaries interacting before target: 29905

We have to pay attention to interactions in TW while attempting to use the calorimeter to identify isotopes produced in target: Tracking is essential. Beyond primaries, also fragments from target reinteract in TW.

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Energy/Angle distributions of secondary particles produced in target

Multiplicity of secondary charged particles arriving at TW

Multiplicity of Charged in TW

Chtw	
Entries	1e+07
Mean	0.09325
Std Dev	0.4987

All charged particles

All charged particles with E>50 MeV/u (~97% of total)

Charged particles actually produced in target (~59% of total)

Most of dangerous background is produced in Air
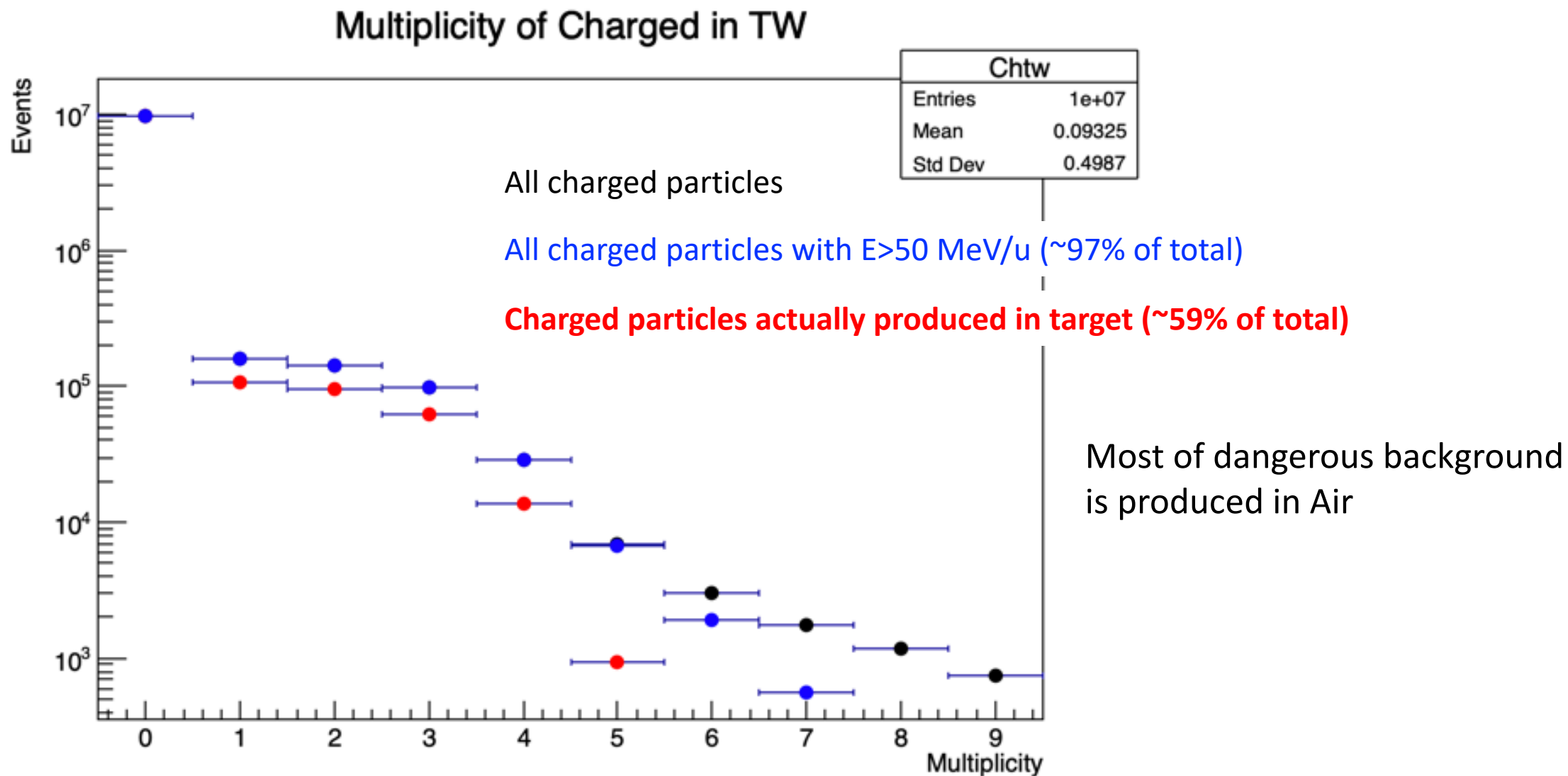
Modification of the new Full Detector Simulation Campaign to train and test
Tracking & Reconstrution

12C_200_2023 initial design

All detector distances were equal to those of previous full detector MC campaigns (12C_200new)
In particular, the distance from target to TW

12C_200_2023 new design

Considering that we won't expect to have TW at 1 m from target, we considered the distance chosen for CNAO2022 data taking

175 cm
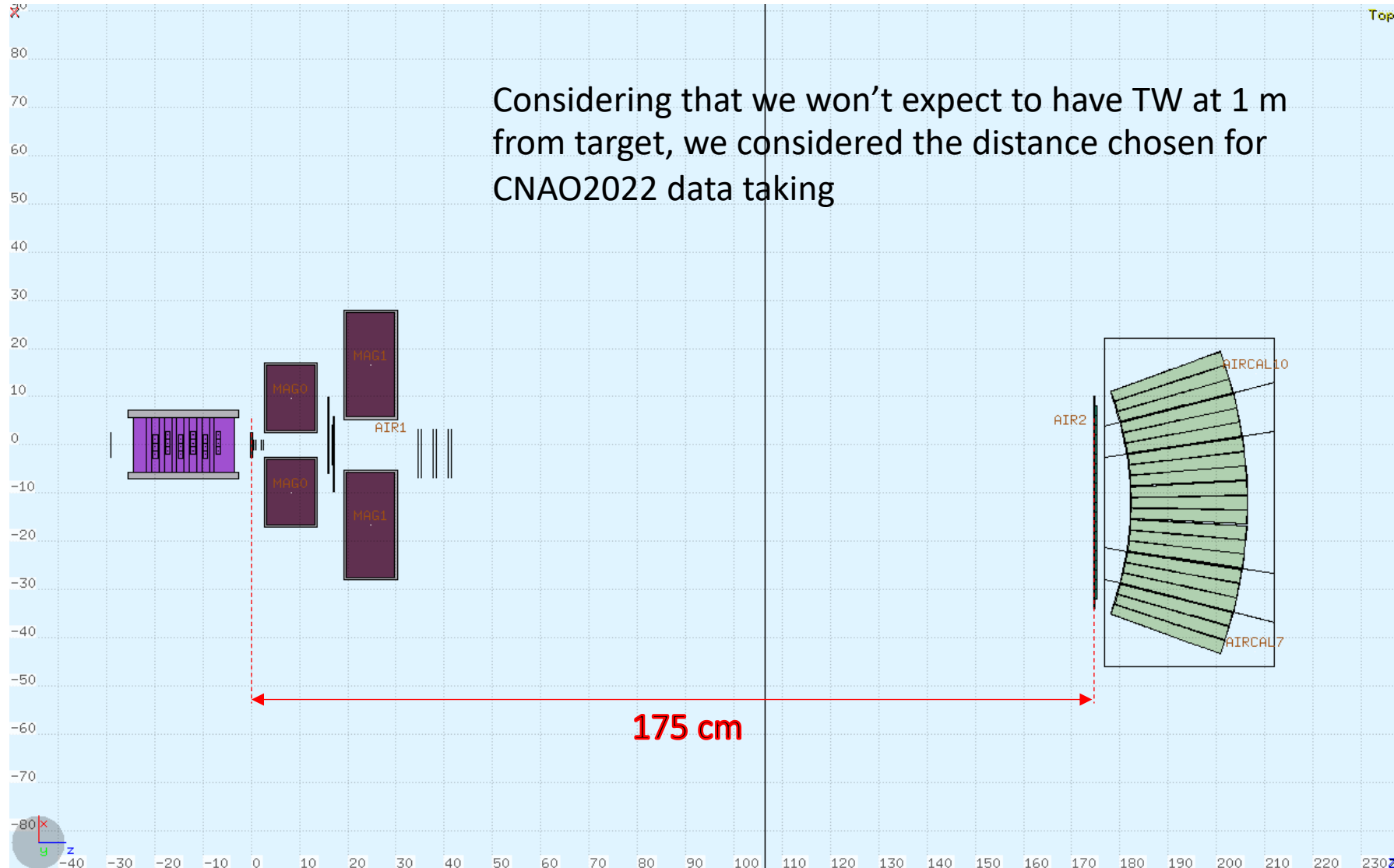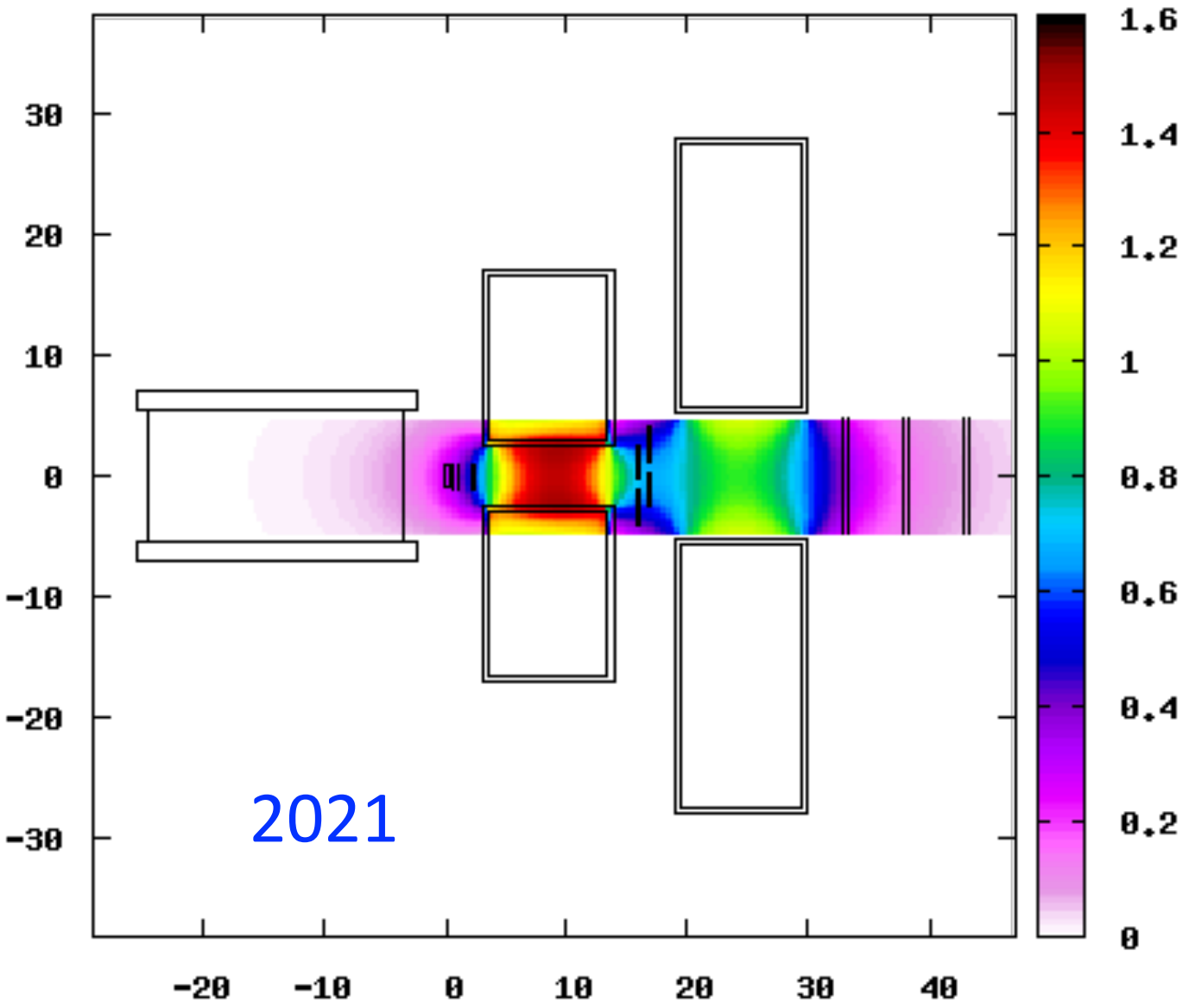
MAGNETIC FIELD: 2D-map comparison

Plot #5

GeoViewer Green plot

2021
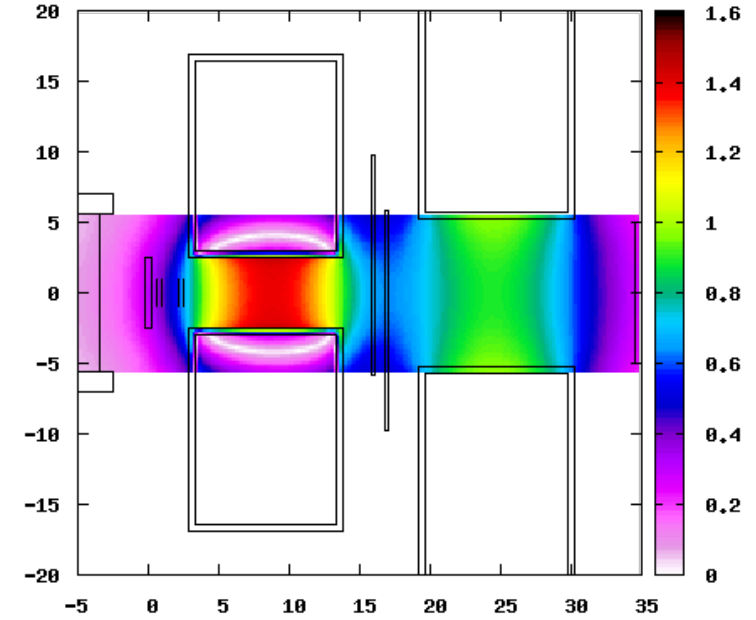
2023

B-intensity map superimposed to the FOOT geometry (y VS z view)

Compensation for beam axis deflection (200 MeV/u case): MSD

-1.8 cm

-1.8 cm
lateral shift for MSD
@200 MeV/u   Z=6

Distribution of x coordinates (global reference frame) for primaries

Y vs X at MSD crossings

msdXYcross_px	
Entries	7170
Mean	−1.814
Std Dev	0.2151

X (cm)
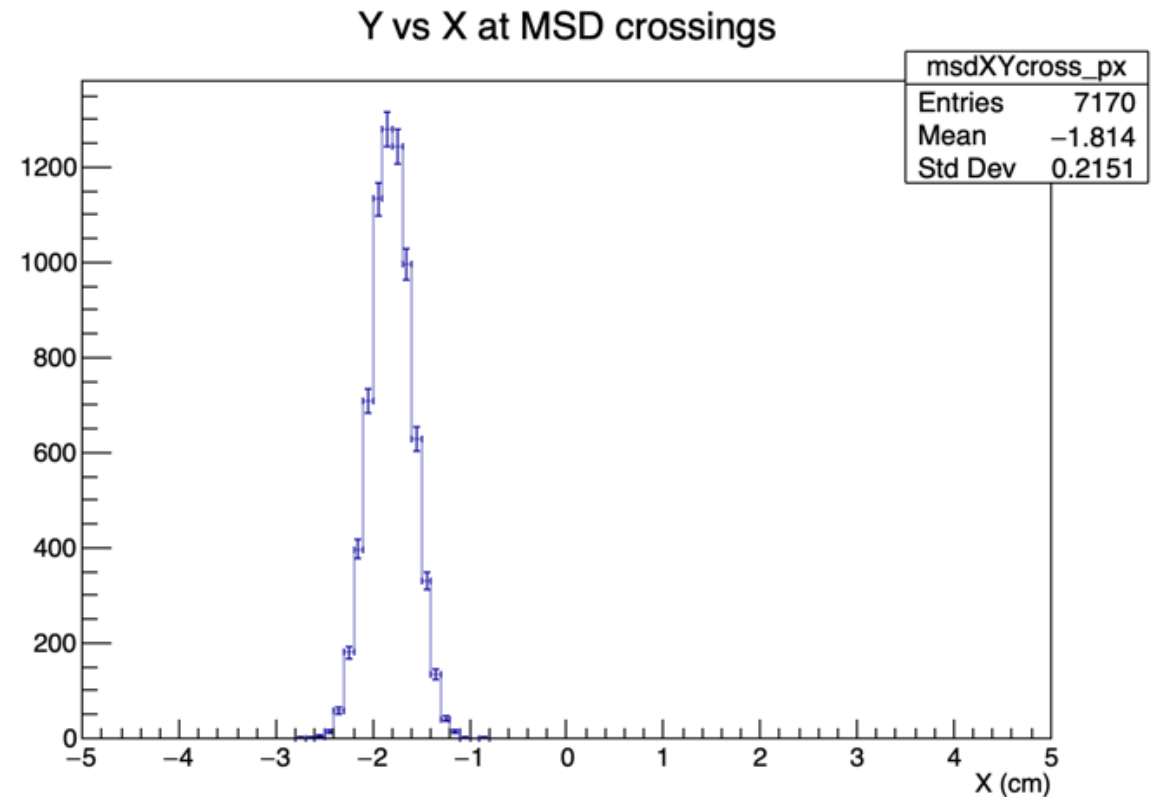
Compensation for beam axis deflection (200 MeV/u case):
TW + CALO

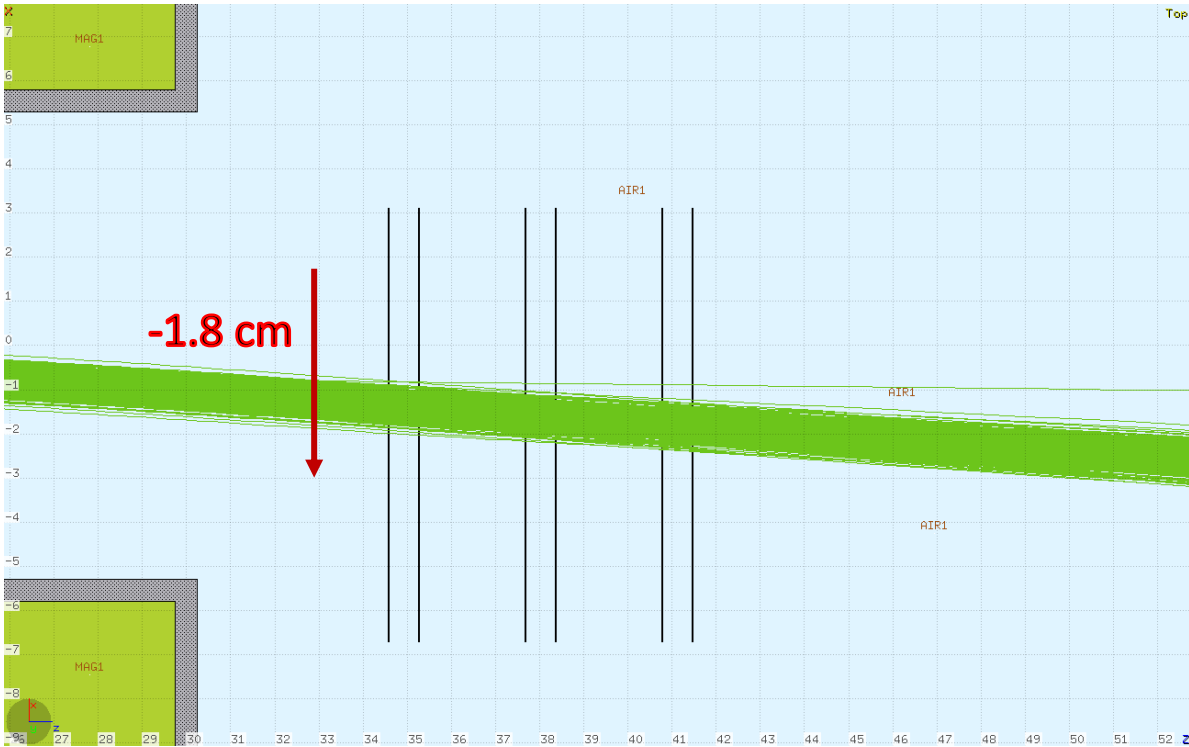Distribution of x coordinates (global reference frame) for primaries

Y vs X at TW crossings

twXYcross_px	
Entries	7129
Mean	−11.02
Std Dev	0.8525
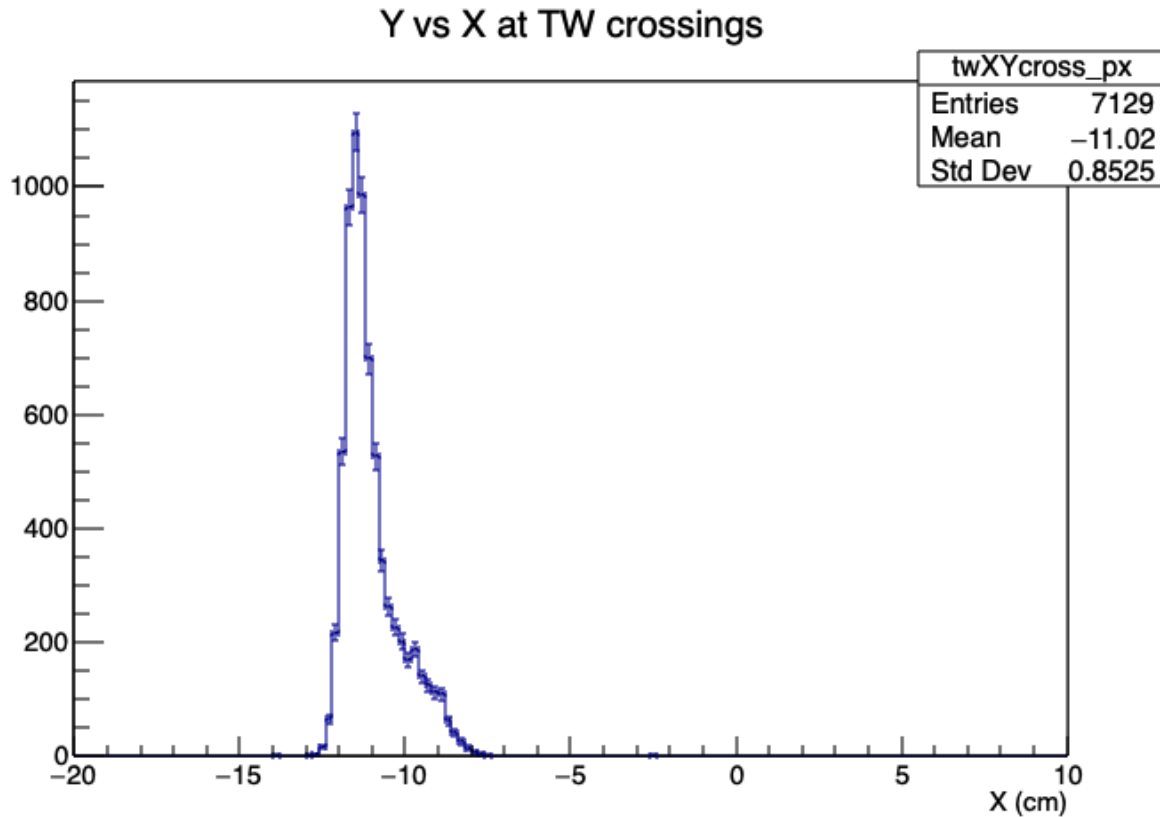
-11 cm
lateral shift for TW and Calo
@200 MeV/u   Z=6

-11 cm
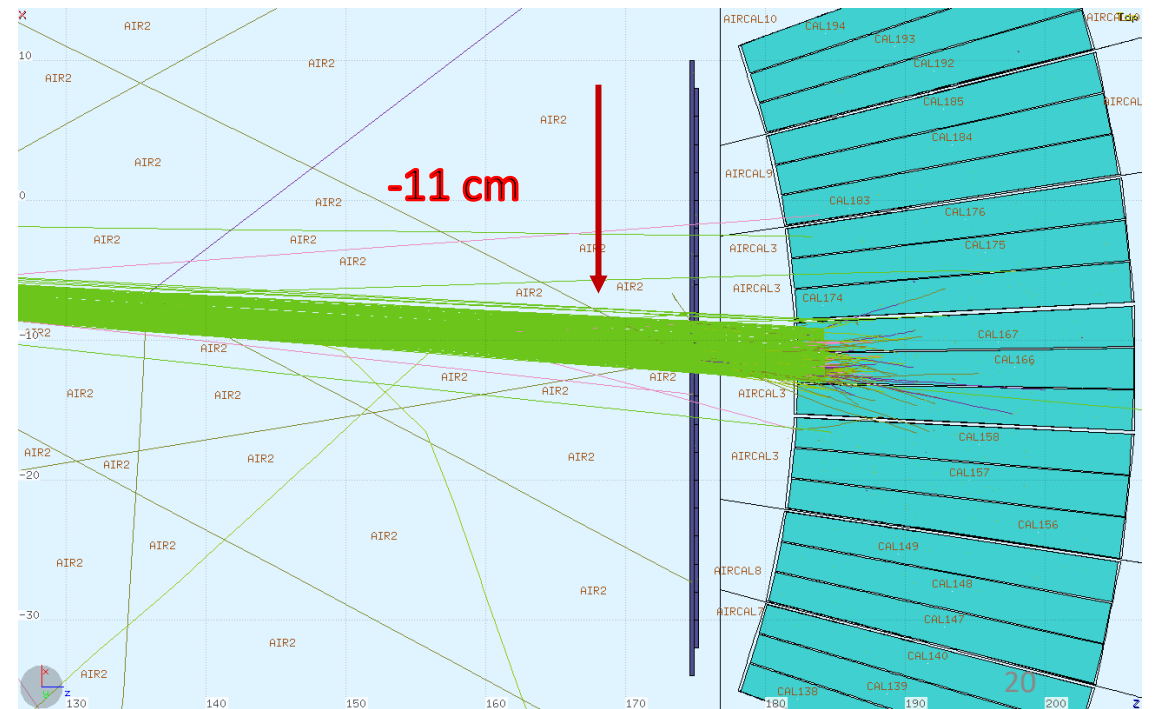
New production

12C_C_200new_1_shoereg.root $5 \cdot 10^6$ events

12C_C_200new_2_shoereg.root $5 \cdot 10^6$ events

To be copied in Tier1

-exp 12_200_2023 -run 200

Warning:

the 12C_200_2023 campaign will be now updated (thus changing FOOT.geo etc.)

No. of interactions of primaries for 5 milions of events

Very Similar to CNAO2022, as expected

No. of interactions in Air: 39311

No. of interactions in STC: 7330
No. of interactions in BMN: 6006
No. of interactions in TGT: 182670 (3.64%)
No. of interactions in VTX: 5878
No. of interactions in IT: 26666 ⟵ New piece of detector
No. of interactions in MSD: 26418
No. of interactions in TWL: 153485

Multiplicity of secondary charged particles arriving at TW

Multiplicity of Charged in TW

Chtw	
Entries	1e+07
Mean	0.09956
Std Dev	0.5151

All charged particles

All charged particles with E>50 MeV/u (~97% of total)

Charged particles actually produced in target (~56% of total. Slightly less than for CNAO2022, maybe not very significant)

As previously shown, most of dangerous background is produced in Air
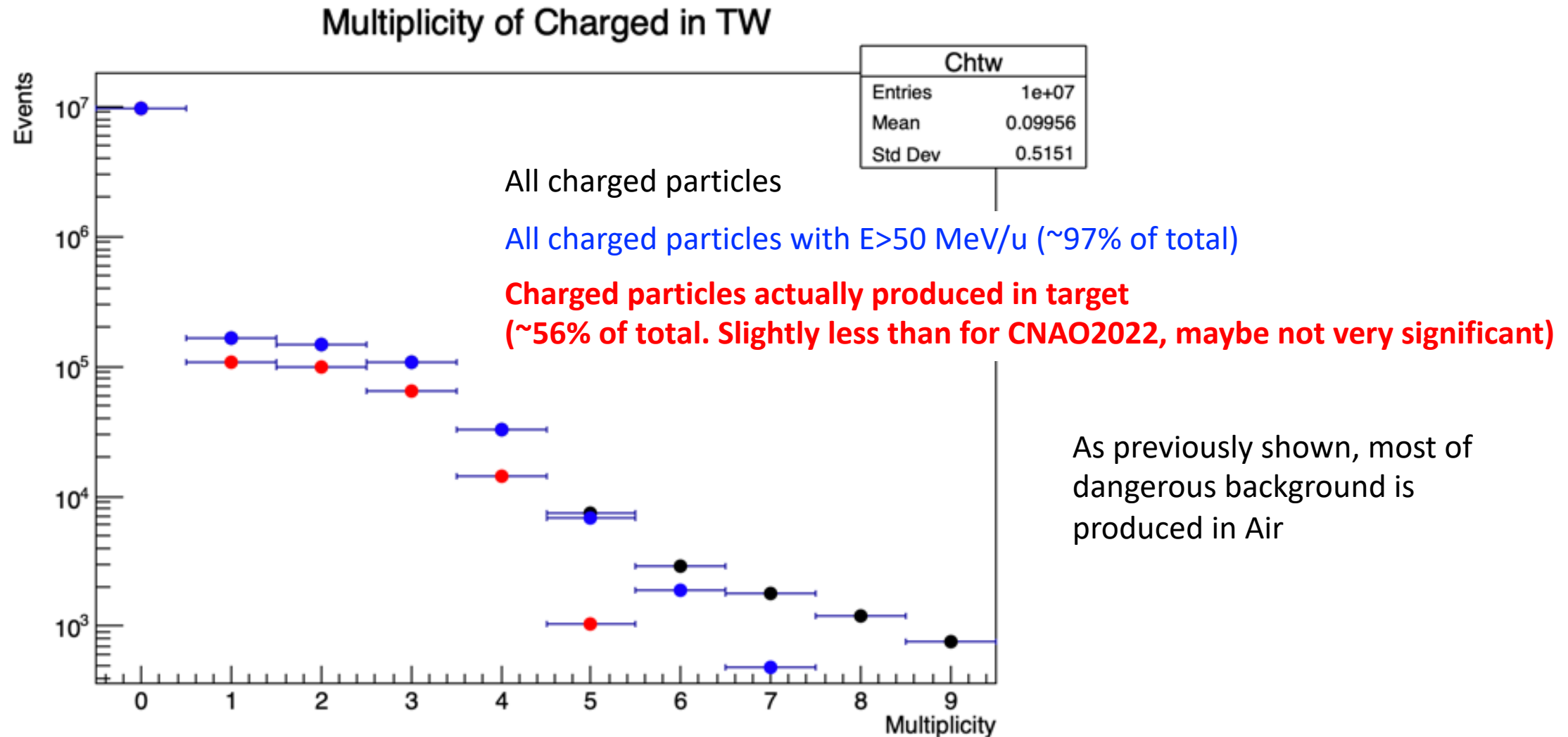
TWiki simulation page updated

Latest MC files *(Update: May 2023)*

The productions are documented in this page concern the Electronic setup.

There are simulated data productions for physics analysis adopting specific setups with incomplete geometry:
- GSI data/MC studies (E.g. with a geometry consistent with the data taking setup at GSI of April 2019)
- Preparation of CNAO2020/CNAO2021 data takings.
- Simulation of GSI2021 campaign (July 2021)
- Simulation of HIT2022 campaign (September 2022)
- Simulation of CNAO2022 campaign (November-December 2022)

A production for physics studies purposes with the complete Electronic setup (12C; 200 Mev/u).

Full electronic detector simulation 12C_200_2023

The setup includes the whole detector with the magnetic map received in 2023. The primary (12C) energy is 200 Mev/u.

A campaign tag denominated 12C_200_2023 will be available in the newgeom and Master branches of SHOE. Run number: 200

Files will be available on tier1 in the next future.
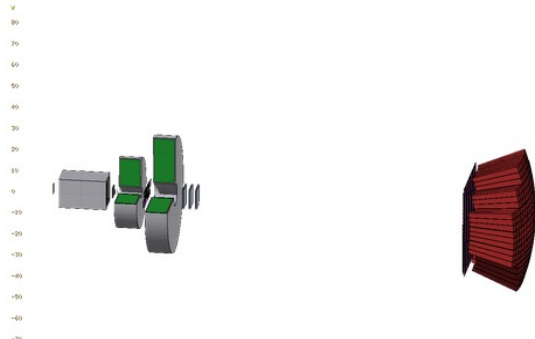
CNAO2022 MC studies

Files are available on tier1 at

`/storage/gpfs_data/foot/shared/SimulatedData/CNAO2022_MC`

A campaign tag denominated CNAO2022_MC has been made available in the newgeom and Master branches of SHOE. The setup includes SC, Target, VTX, MSD, TW and twelve 3x3 calorimeter modules. There are 2 run numbers: 200 and 201 related respectively to the November and December runs. The primary (12C) energy is 200 Mev/u. November run: detector test December run: to be used for physics analysis
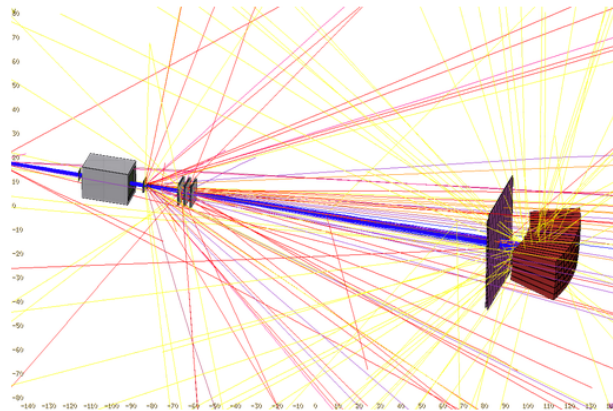

The available files are those relative to 12C on C target, 5 mm thick with density 1.83 g/cm^3: 200.61 Mev/u. The available root files are "untriggered" simulations (all primary events are recorded) are saved as SHOE root-files where also the region number is recorded. The files are:
1. 12C_C_100_1_shoereg.root (5 10^6 primaries)
2. 12C_C_200_2_shoereg.root (5 10^6 primaries)

In view of further MC developments

As in the past, there are **details missing**:

1. Frames and printed circuit boards around VTX, MSD…

2. Cardboard wrapping of TW; Wrapping of the crystals of CALO

3. Tyvec foil in front of calorimeter

4. Correct positioning of detectors. So far, just TW and CALO are fixed.

5. Full calo geometry without parentheses writing by MakeGeo

6. …
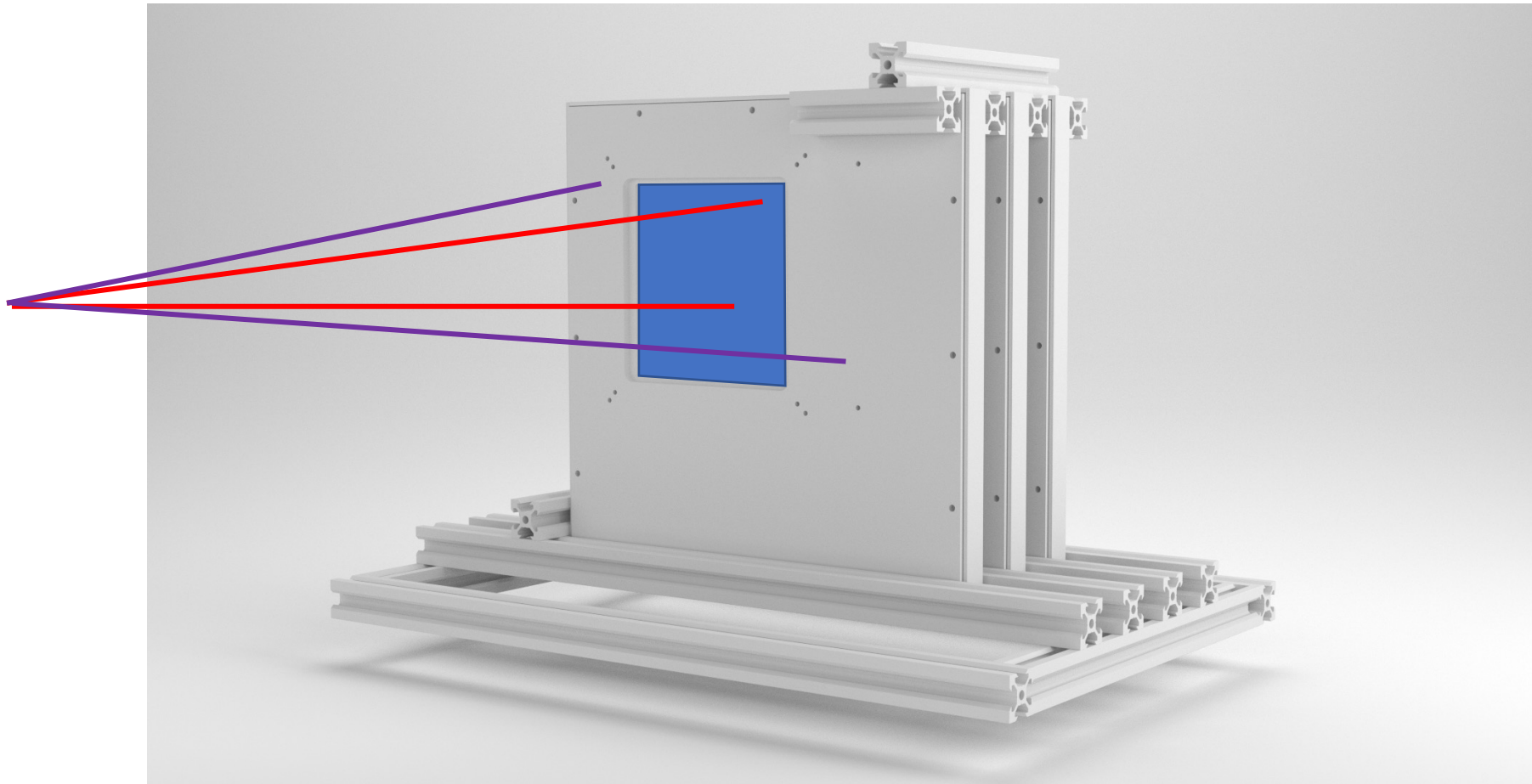
Fragments from the interaction in the MSD frame can reach the TW

Backup

In the fragmentation trigger run, a good fraction of events are given by <u>primary beam interacting outside the VTX sensor area</u>, probably on the detector frame.
The number of VTX vertex per event in run 5491 (CNAO2022 fragmentation trigger) have a high contribution in 0, but selecting the events in which the BM reconstructs one track at the center of the detector, the VTX vertex distribution has the usual shape, as in 5472 (CNAO2022 Minimum Bias)

5491 (frag trig)

VT_vtx_num	
Entries	6784
Mean	1.299
Std Dev	2.121

5491 (frag trig) + BM 1 track at center

VT_vtx_num	
Entries	741
Mean	1.746
Std Dev	2.309

5472 (MB)

VT_vtx_num	
Entries	7299
Mean	1.152
Std Dev	1.473