Including δ-rays in Simulation. What happens to global tracking?

Work in progress…

Milano Group

Which Energy for δ-rays?

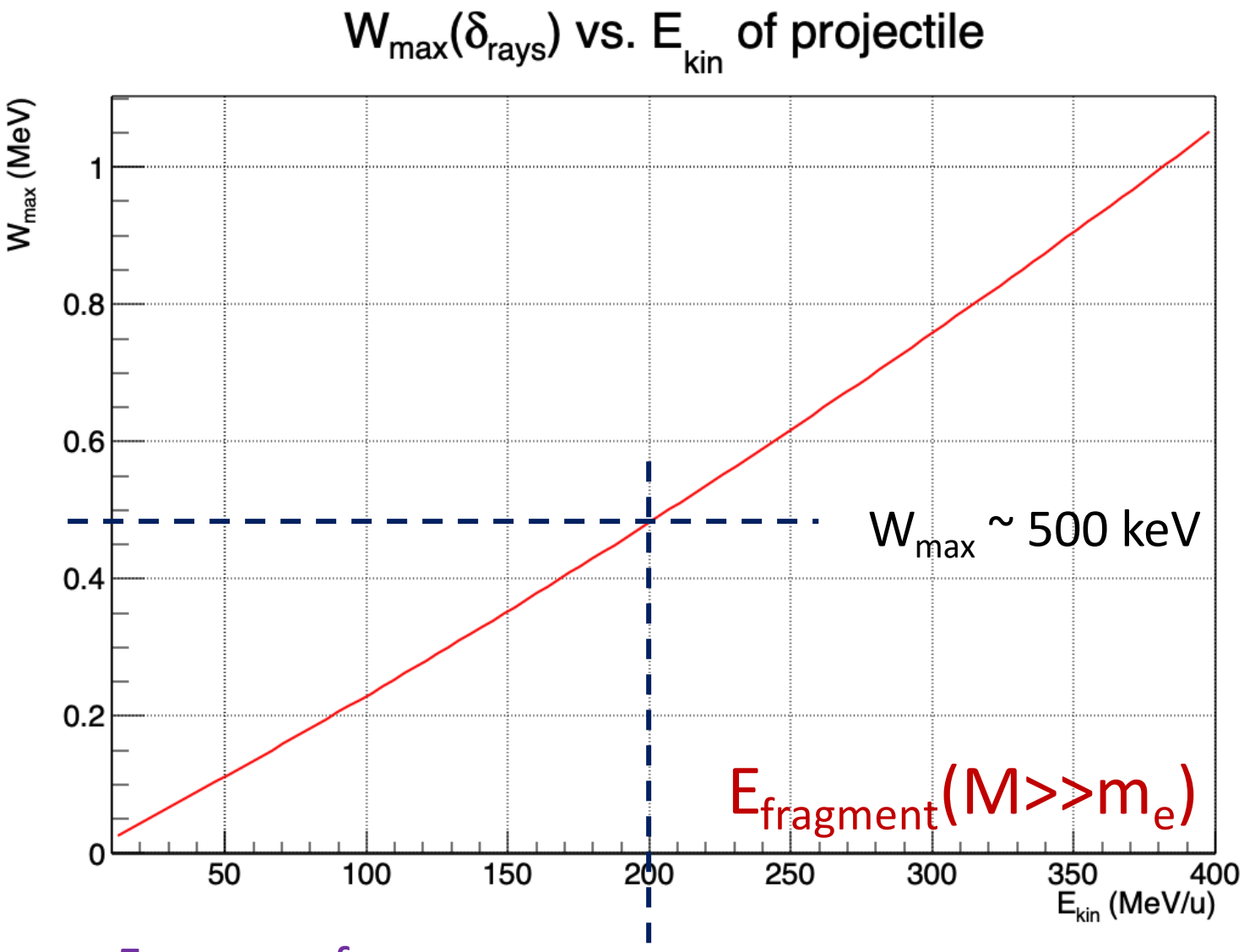
$$\frac{d^2N}{dTdx} = \frac{1}{2} K z^2 \frac{Z}{A} \frac{1}{\beta^2} \frac{F(T)}{T^2}$$

Energy range of δ-rays in real life: $I \ll T \leq W_{\max}$

Energy range of δ-rays in MC: $E_{cut} < T \leq W_{\max}$

$$W_{\max} = \frac{2m_e c^2 \beta^2 \gamma^2}{1 + \underbrace{2\gamma m_e/M + (m_e/M)^2}}$$

Negligible term for us: $M >> m_e$

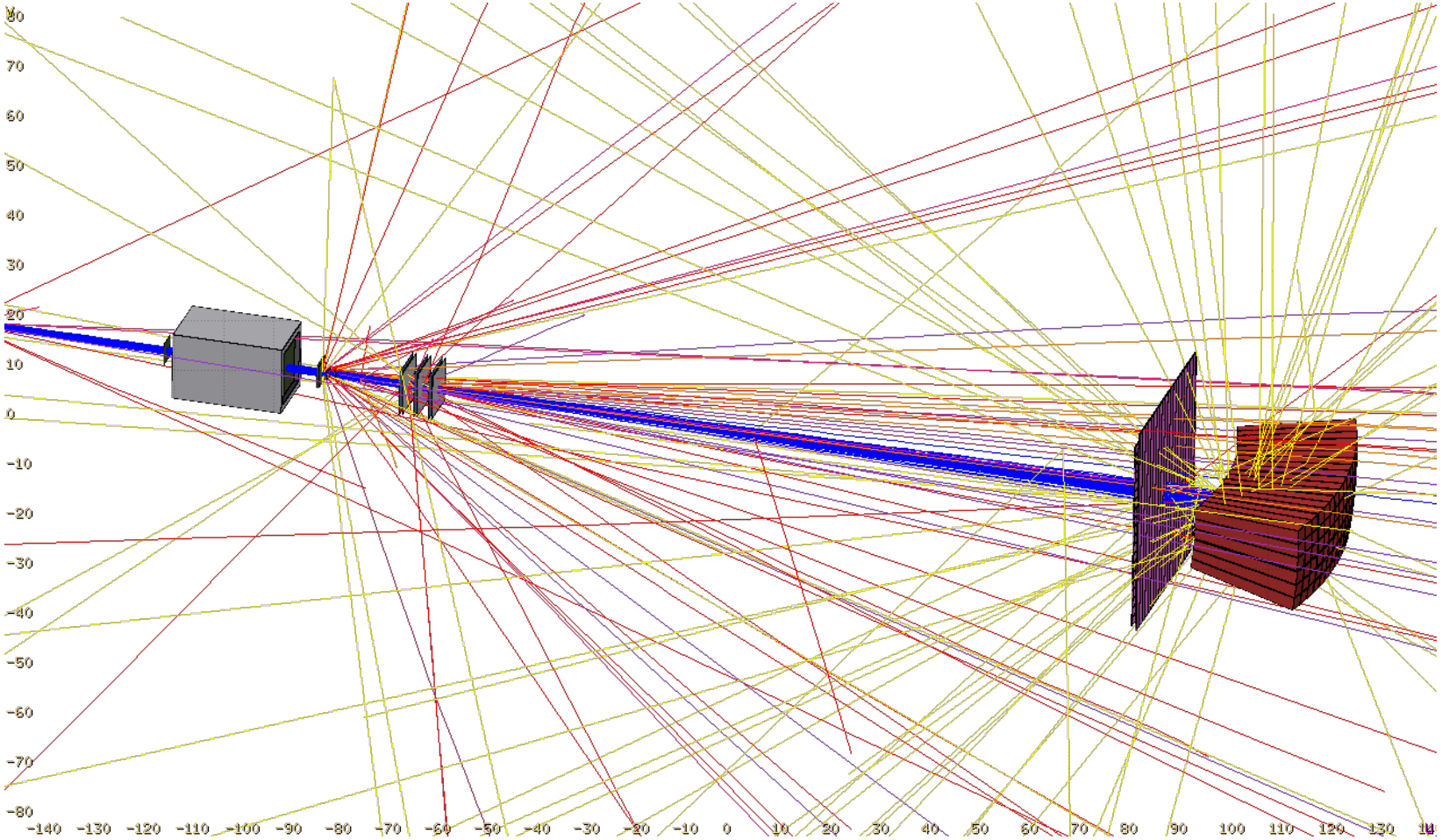


For our reference energy:
at 200 MeV/u β ~ 0.568 γ~1.215

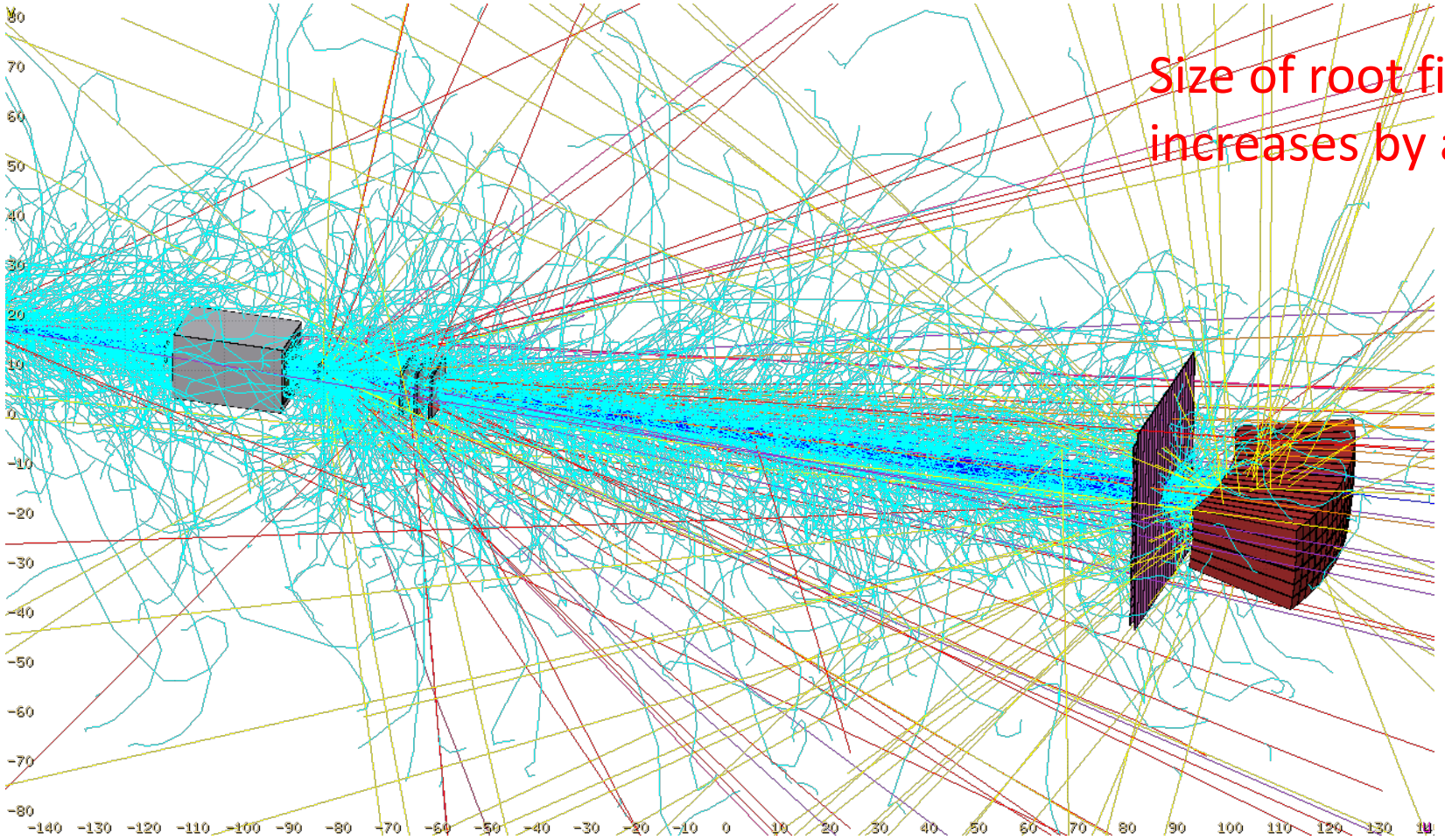
Min. energy:
The lowest possible value in FLUKA is 1 keV
*Let's try **50 keV**... (in most detectors corresponds to a negligible range)*

CNAO2022_MC campaign

100 events. No δ-rays

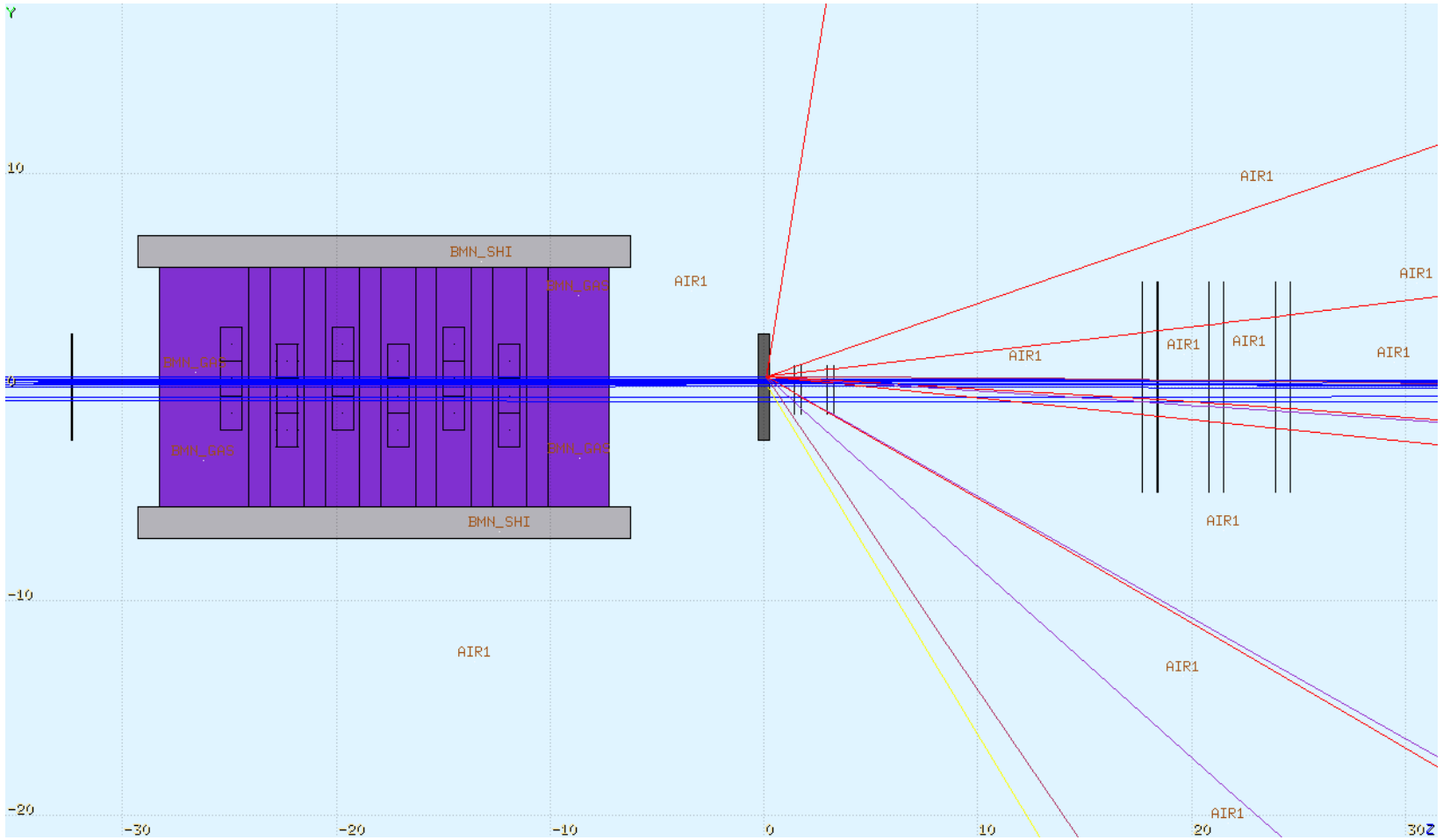


100 events. With δ-rays (E_{cut} = 50 keV)

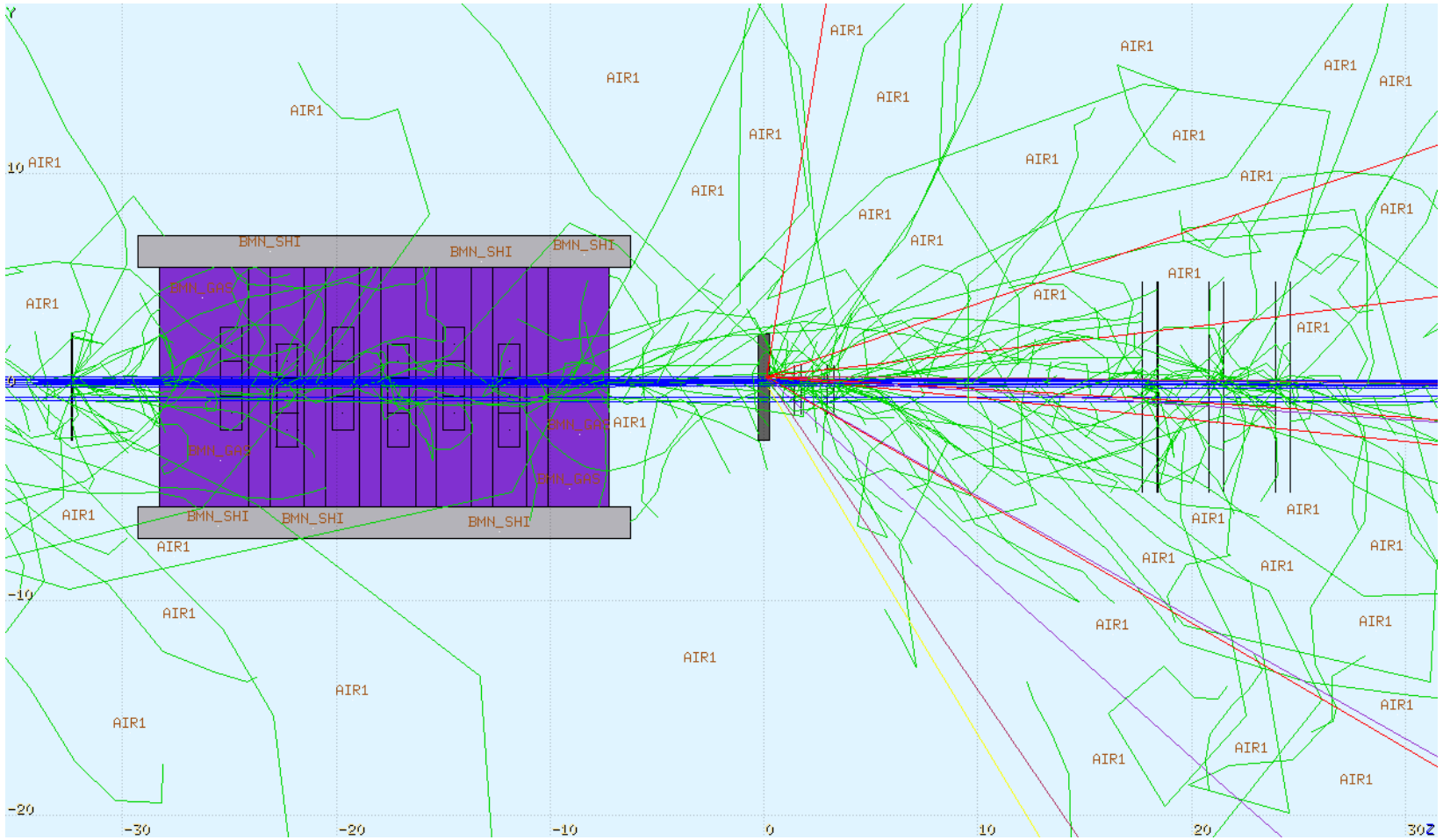


Size of root file (hits are saved) increases by a factor of 6.2

10 events. Details of first section. No δ-rays



10 events. Details of first section. With δ-rays (E_{cut} = 50 keV)



Question: could there be a double-counting in VTX?

Is it trues that at simulation level clustering in VTX is derived from exp. data where δ-rays already exist?

No. of processed events: 50000
No. of TW points found: 49630
No. of MSD tracks found: 60007
No. of VTX tracks (incl. primary) Theta<10 deg: 105623
No of MSD tracks with 3 layers: 10179 10179 0
==== Global tracking ====
No. of Global Tracks: 89510
No. of Global Tracks with a TW point found: 89510
No. of Global Tracks with Theta<10 deg: 89510
No. of Global Tracks with a TW point with Theta<10 deg: 89510

No δ-rays

No. of processed events: 50000
No. of TW points found: 627
No. of MSD tracks found: 60117
No. of VTX tracks (incl. primary) Theta<10 deg: 105392
No of MSD tracks with 3 layers: 4978 4978 0
==== Global tracking ====
No. of Global Tracks: 757
No. of Global Tracks with a TW point found: 757
No. of Global Tracks with Theta<10 deg: 757
No. of Global Tracks with a TW point with Theta<10 deg: 757

With δ-rays

What's happening????

Genfit Reconstruction

Kalman preselection strategy: Sept2020
N measure in global tracking: 11

Questions and considerations

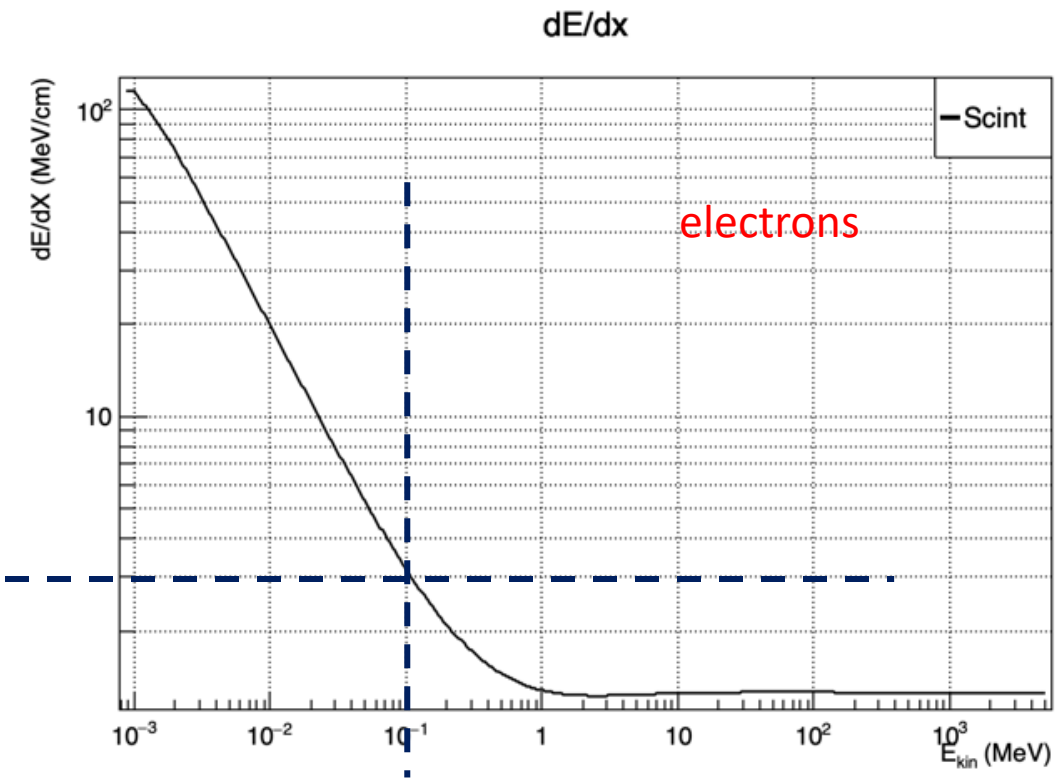
- Why TW points are lost? (under investigation)
- Notice however that the no. of tracks in VTX remain ~the same. Not shown here, but also BM tracks are OK
- Instead, ~50% of MSD tracks are lost

Warning! There are considerations to be done:

- Which are the detection thresholds in simulation reconstruction? For instance in TW there is a 100 keV default*
- It is useless to spend time (and disk) to generate particles which will not be detected. This should be studied more accurately

**M. Toppi, private communication, in some campaigns this value was changed*

Example of concerns and unsolved questions: let's take the case of TW Scintillator



@TW threshold value (100 keV) dE/dx(e^-) = 2 MeV/cm

➔ max (linearized) range is 0.18 mm

➔ Totally contained and releases locally all its energy

Even @500 keV the max electron range wold be ~2 mm, but we have seen that the max energy for a δ-ray produced by a heavy particle (200 MeV/u) is < 500 KeV!

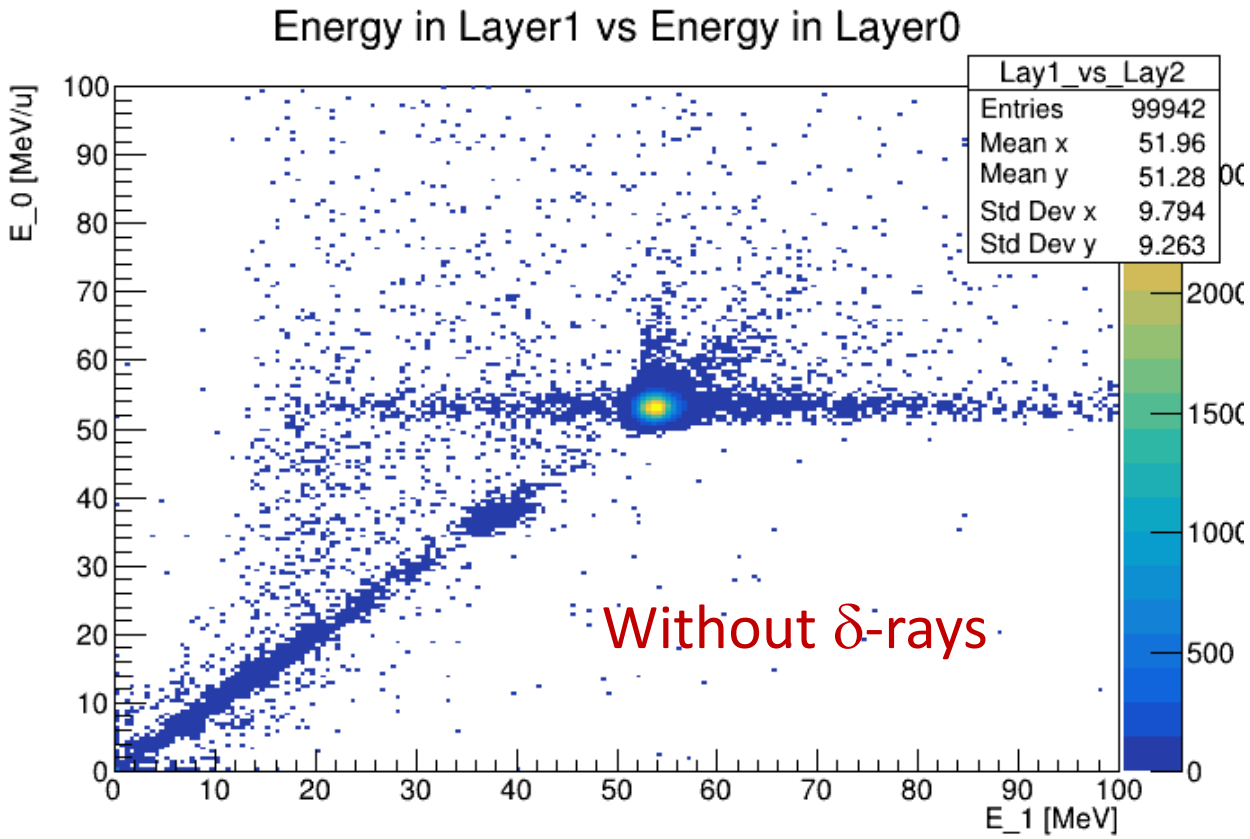
➔ Therefore all δ-rays produced in TW sould be locally contained!

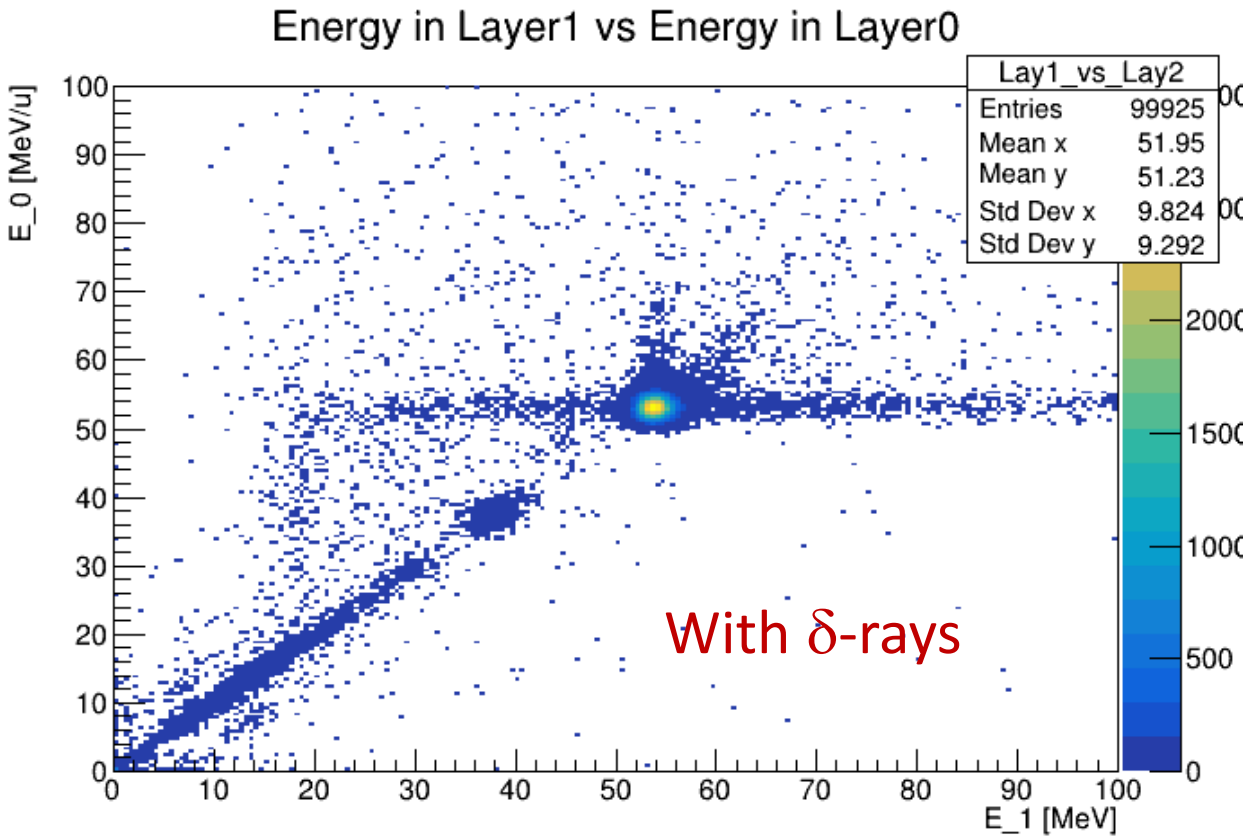
➔ The average amount of energy deposited in a bar (at least in FLUKA) must be the same irrespectively of explicit production of δ-rays. Only the spatial distribution of energy depositionwill change.

Then:

1. Given those range and threshold values, is it worthwhile to generate δ-rays in the scintillator?
2. If δ-rays in TW seems to be a-priori not harmful, why are we losing TW points?

Correlation in E_deposited in TW: Layer0 vs Layer1 (MC truth before reconstruction)





Apparently nothing changes...