# DP status and prospects

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DIPARTIMENTO DI SCIENZE DI BASE E APPLICATE PER L'INGEGNERIA
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# What happened so far/outlook

- Two research lines have been clearly identified:
  - Range monitoring
  - Patient monitoring
- DP has been successfully integrated in the CNAO - INSIDE2 setup
- Preparation for clinical trial is ongoing
- Papers are in preparation:
  - DP detector paper → JINST
  - Range monitoring paper → special issue of IEEE-TRPMS (Special Topic on Particle Therapy) ?

# .. a long time ago..

- .. there was the 'range monitoring' problem:
  - how to provide, online, during the treatment, the BP position.
- The idea was:
  - Use charged secondary fragments production point distribution → correlate with BP → monitor online the position.
- This idea is of difficult implementation!
  - Poor statistics (in a 'per PB approach')
  - The ***detected*** distribution is not easily converted in the ***production*** distribution that is the one really correlated to the BP
- Since the data taking occurred in late 2017 it was already clear that several PB have to be packed together in order to allow enough statistics to be collected to reach a sub cm precision
  - The 'unfolding' procedure has also an impact on the achievable precision on the BP position.

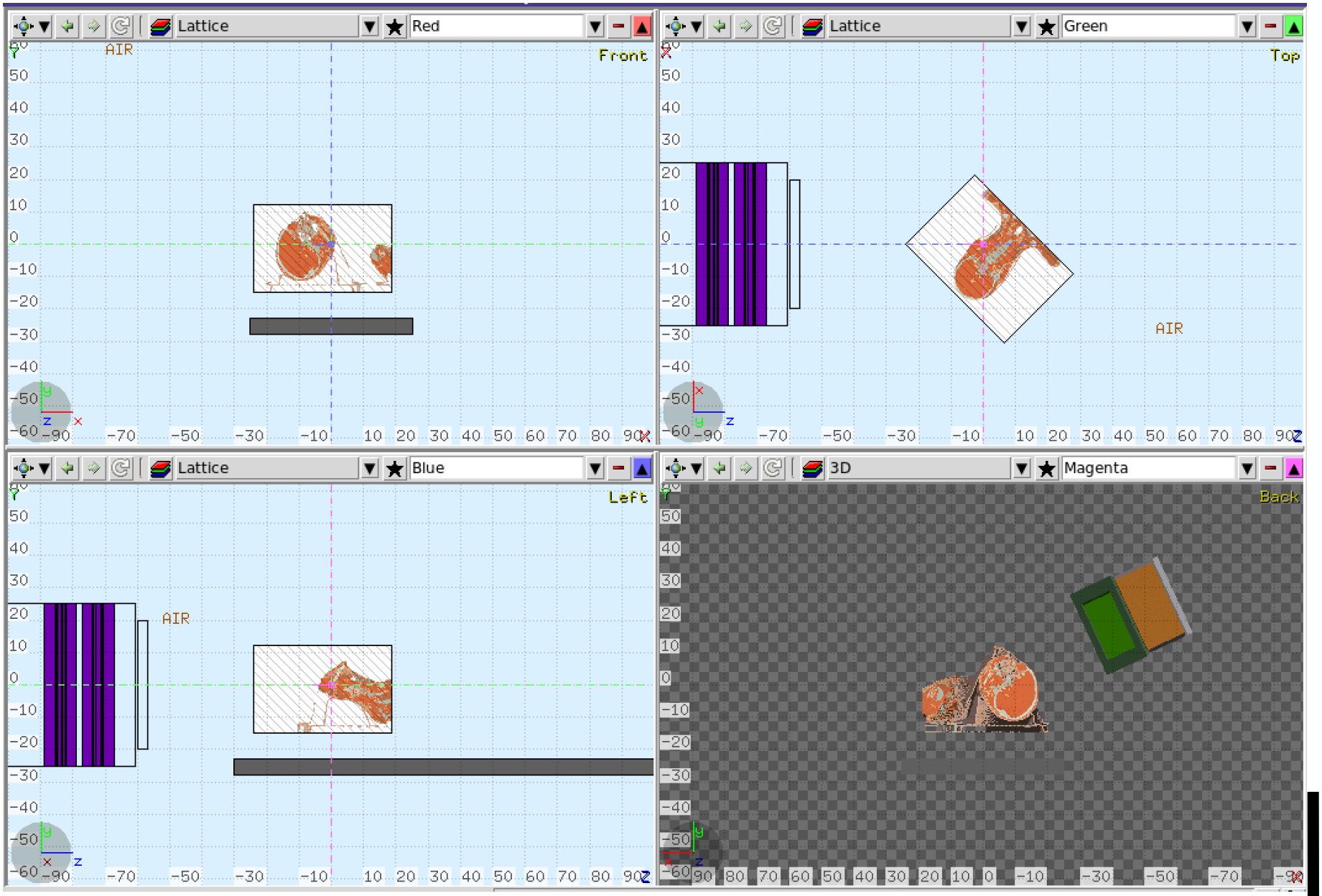
# … finally the long awaited simulation…

**Simulation with FLUKA of a real treatment @ CNAO**

**Real patient.**

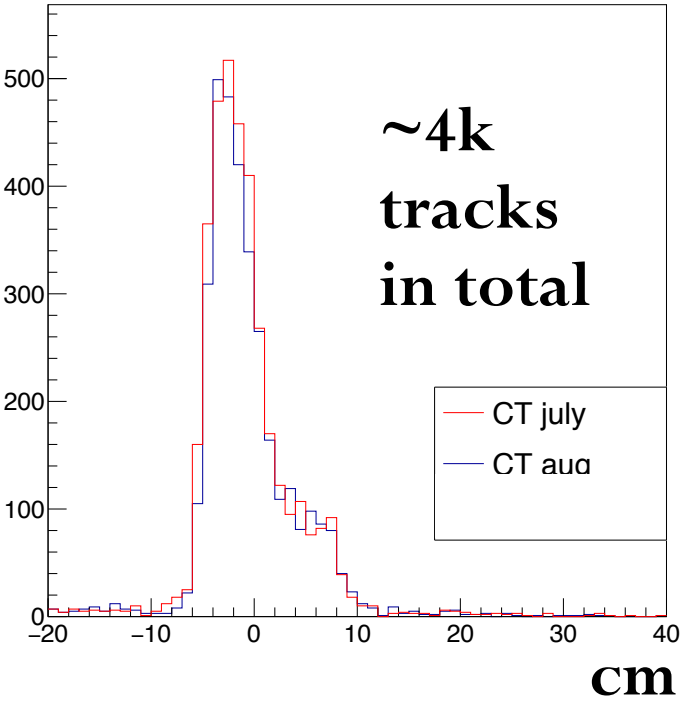
**Real positioning.**

**One fraction of $^{12}C$ ions**

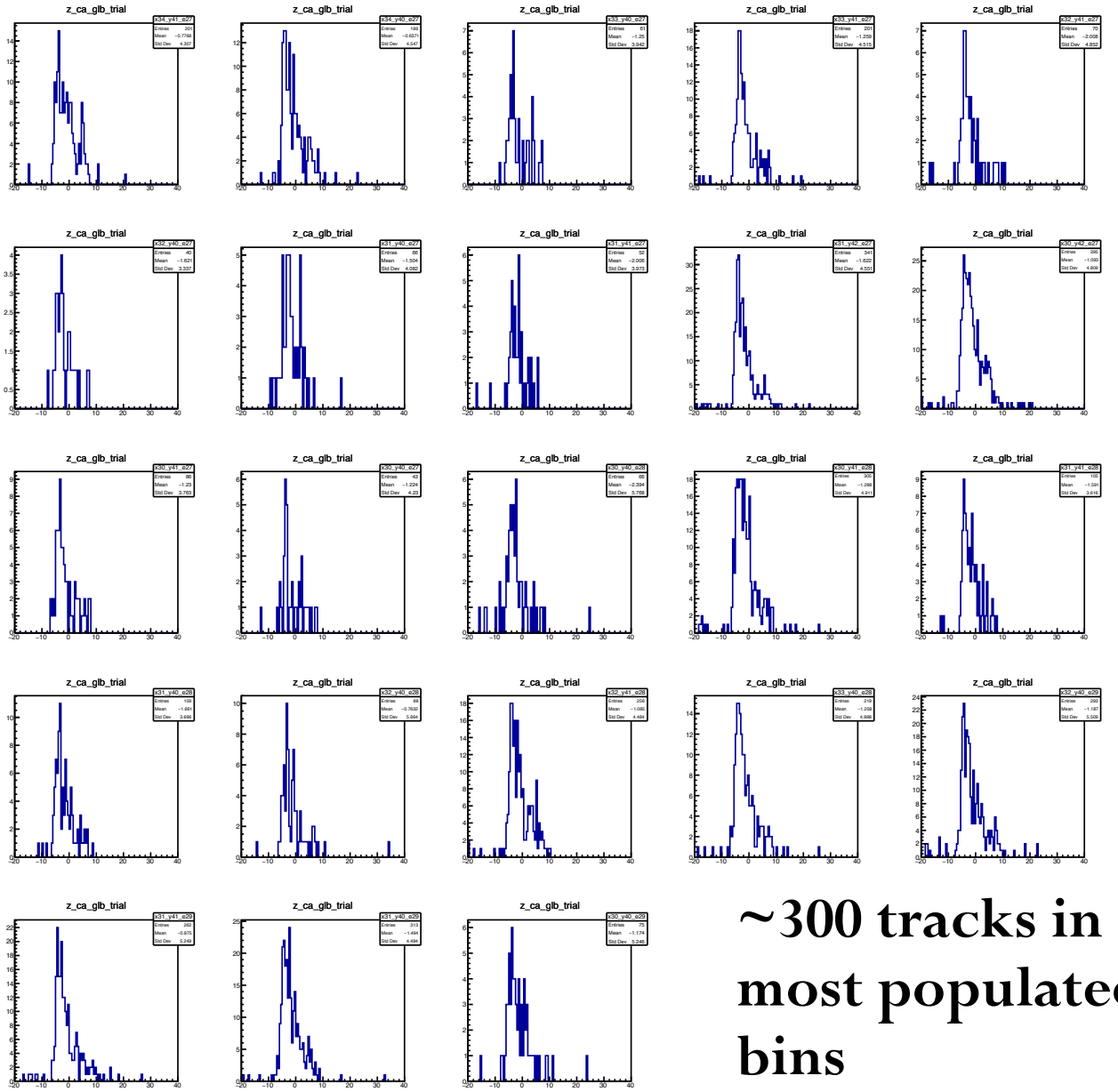


# How many tracks?

**MC simulation!**



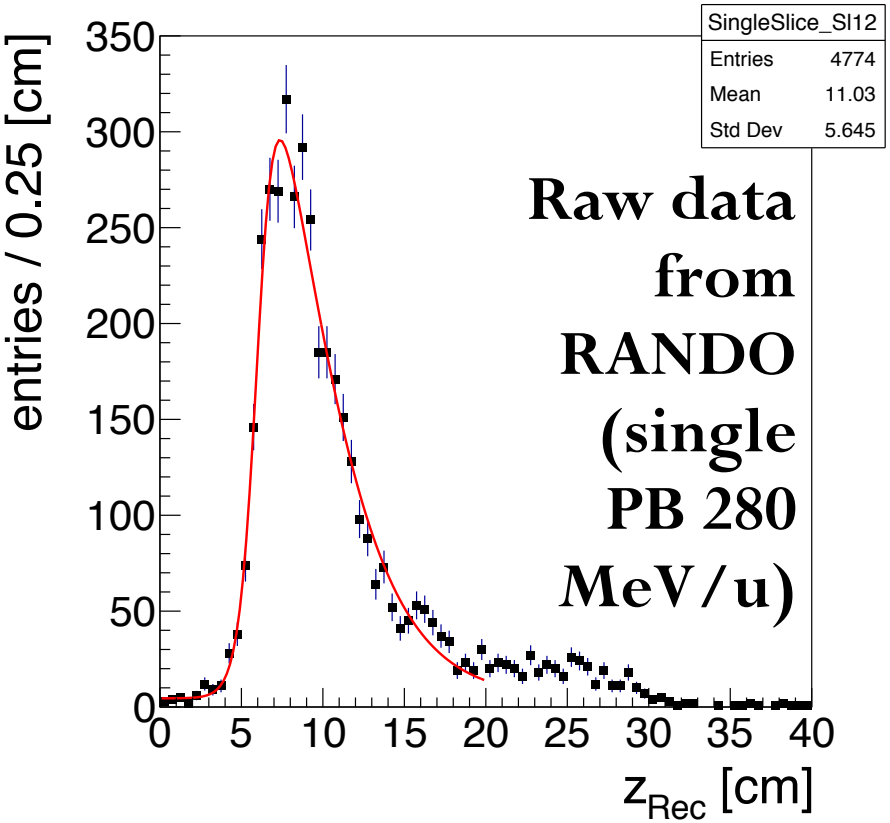

**4k tracks are 5x5x3 = 75 PB (Volume = 1cm x 1cm x 6mm)**



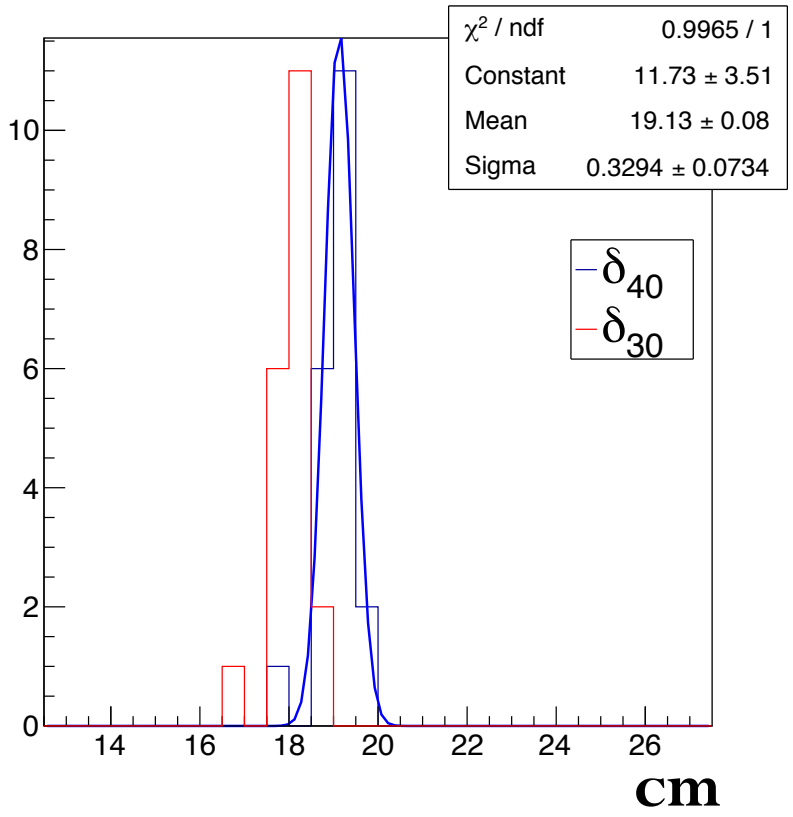

**~300 tracks in most populated bins**

# Range monitoring: is it feasible?

- Example: use collected data on rando and try to perform a fit, do the same on MC unfolded distributions… Used similar statistics to a single slice on 1cmx1cm area in clinical like conditions..




**4k tracks from a single PB! (single x,y,z tgt position)**



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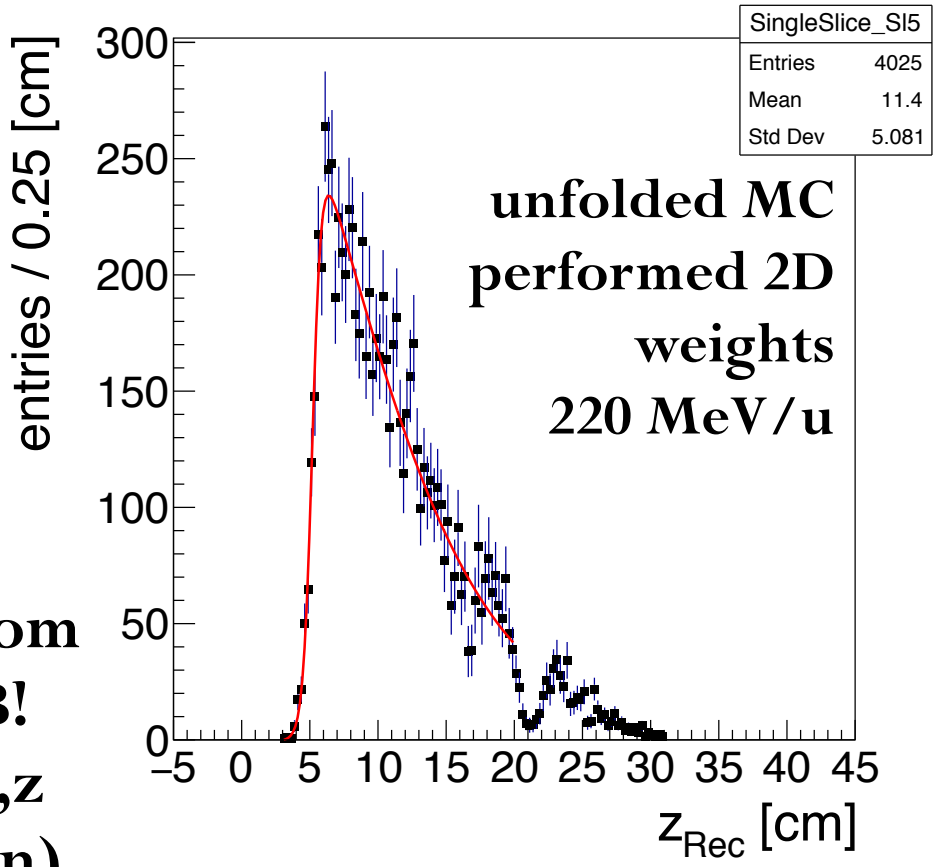
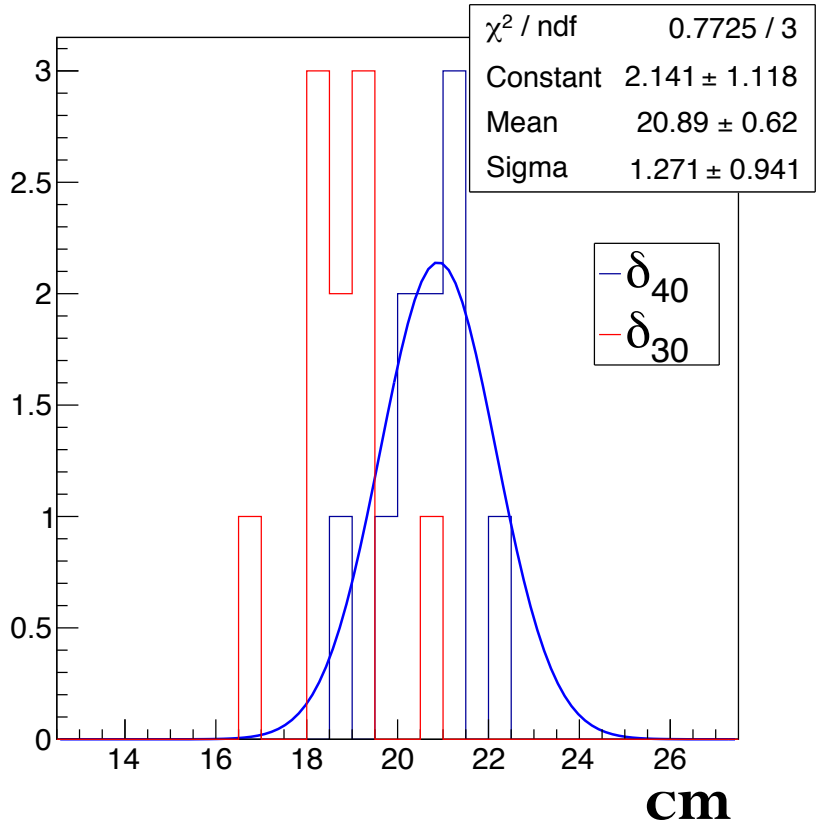



**4k tracks (after re-weight) from a single PB! (single x,y,z tgt position)**

# Unfolding

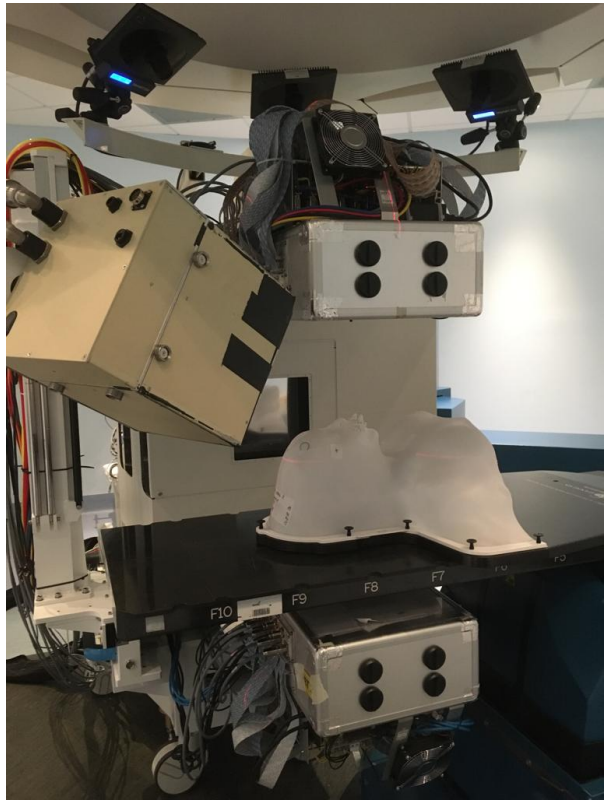
- The unfolding problem is loosing its appeal as times goes by..
  - We still need to understand the impact of the additional uncertainty added on the spectra
  - We still need to understand what is the best variable to go back to: currently worked using the production Z… But this cannot be used for 'fitting' the BP position. Now switched to rhoZ … WEPL is the next on the list…
- We're going to finish the MLEM study: still need to understand uncertainties, and spectra…

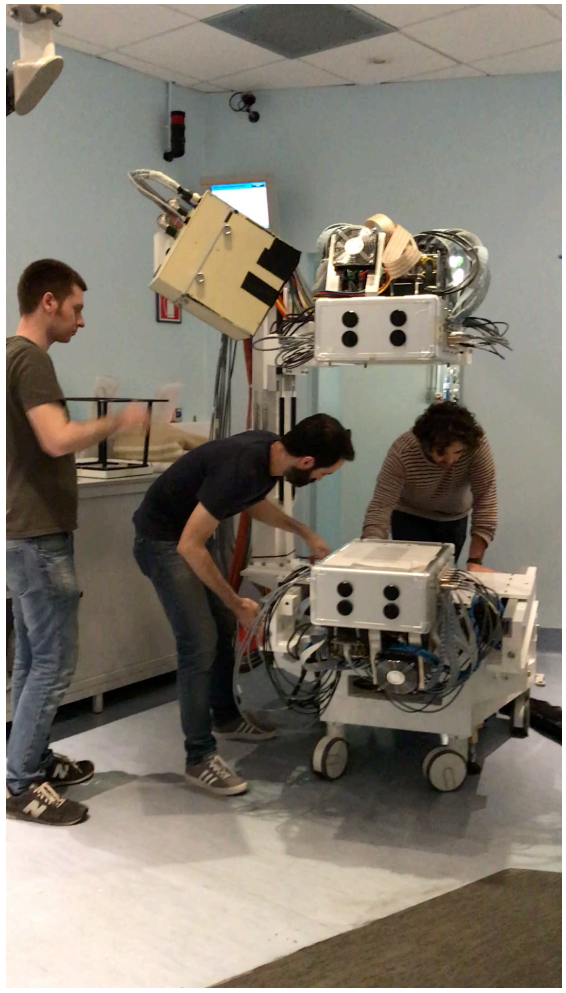
# Range monitoring: next steps

- The question about feasibility of range monitoring is still open. But now we have in our hands all the tools for answering ..
  - With Marta and Micol a final effort started. Deadline: end of the year at latest.
  - Answer will be documented inside and article (to be submitted to IEEE-TRPMS??)
  -

# .. in the meanwhile..

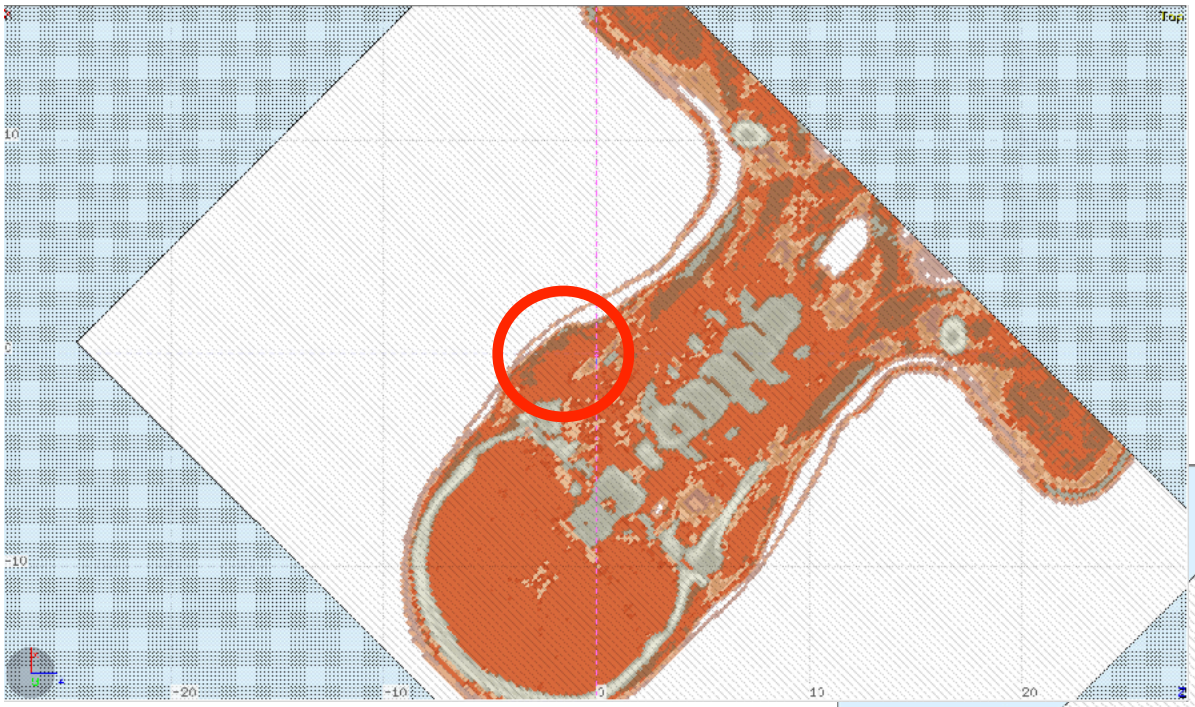
- The CNAO - INSIDE2 integration happened!!!
  - Smooth - easy! great success..Thanks to M. Magi…



Test on RANDO will happen in november

# From RM to patient monitoring

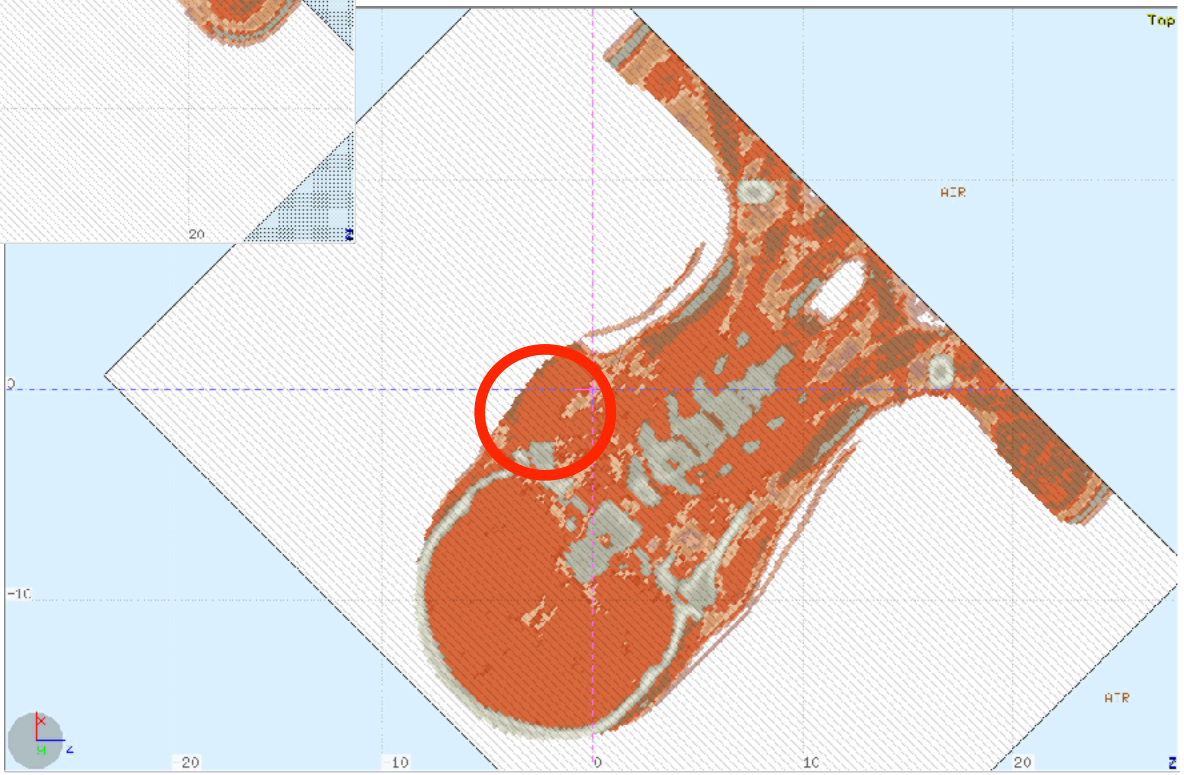


CT_13-07-2017

Can we say anything if a large toxicity shows up during a treatment?

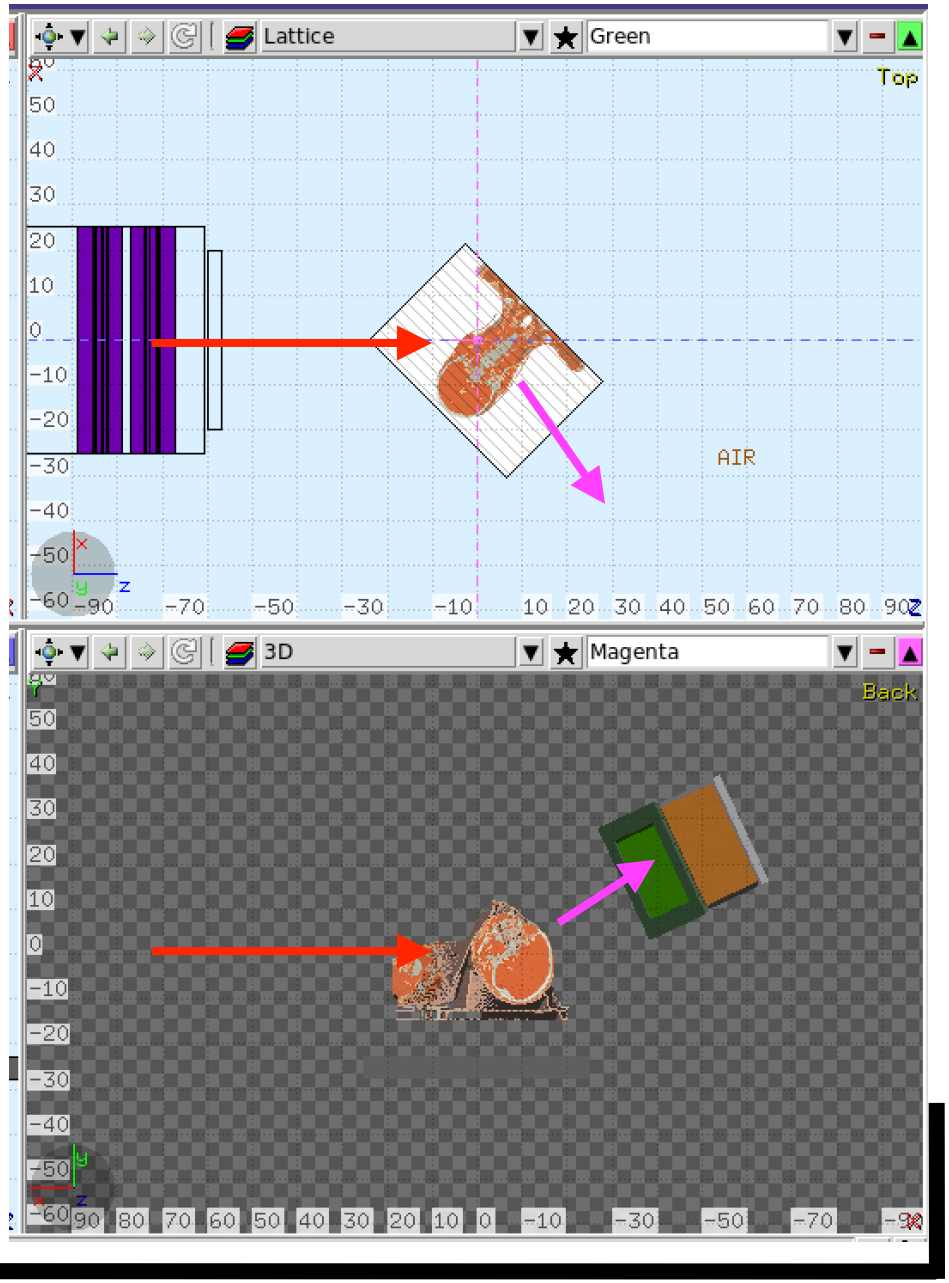
**Monitoring the patient during the different fractions is a huge priority for CNAO**

CT_07-08-2017

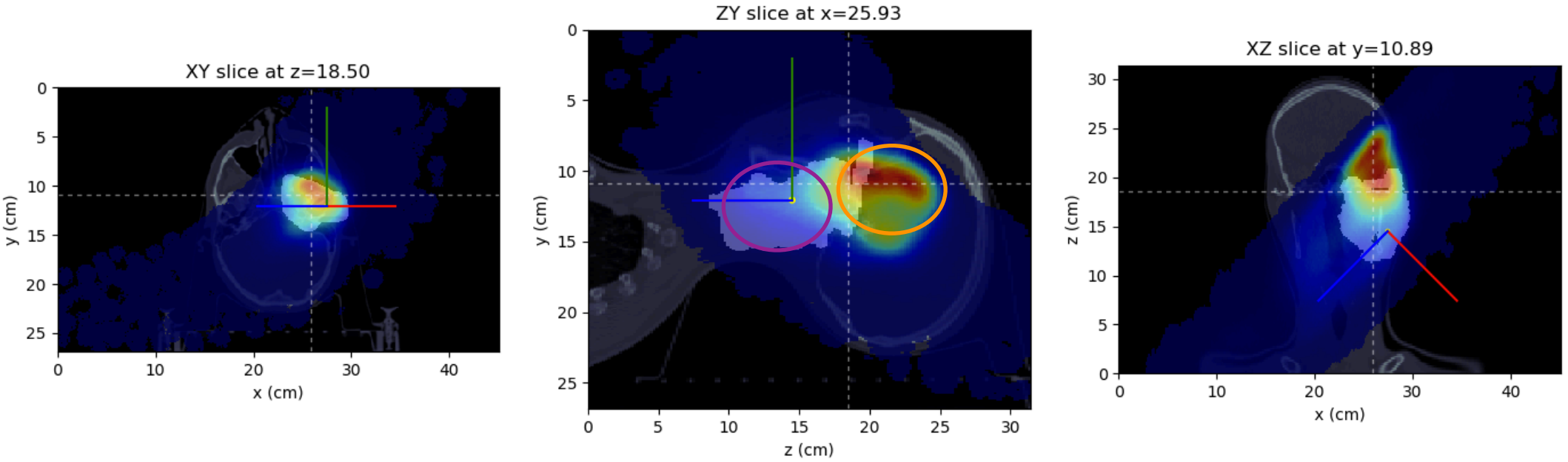


# Putting the hands in front..

- Things to keep in mind:
  - The DP is ~ always on the 'wrong' side [fixed position, determined by the INSIDE2 integration constraints]: we shoot from the left and we have the fragments that have to traverse all the patient to exit and be detected
  - The charged particles production is anti-correlated with the PTV: we produce fragments when we enter the patient, not when we arrive close to the target volume



# The trial simulation: a first glimpse

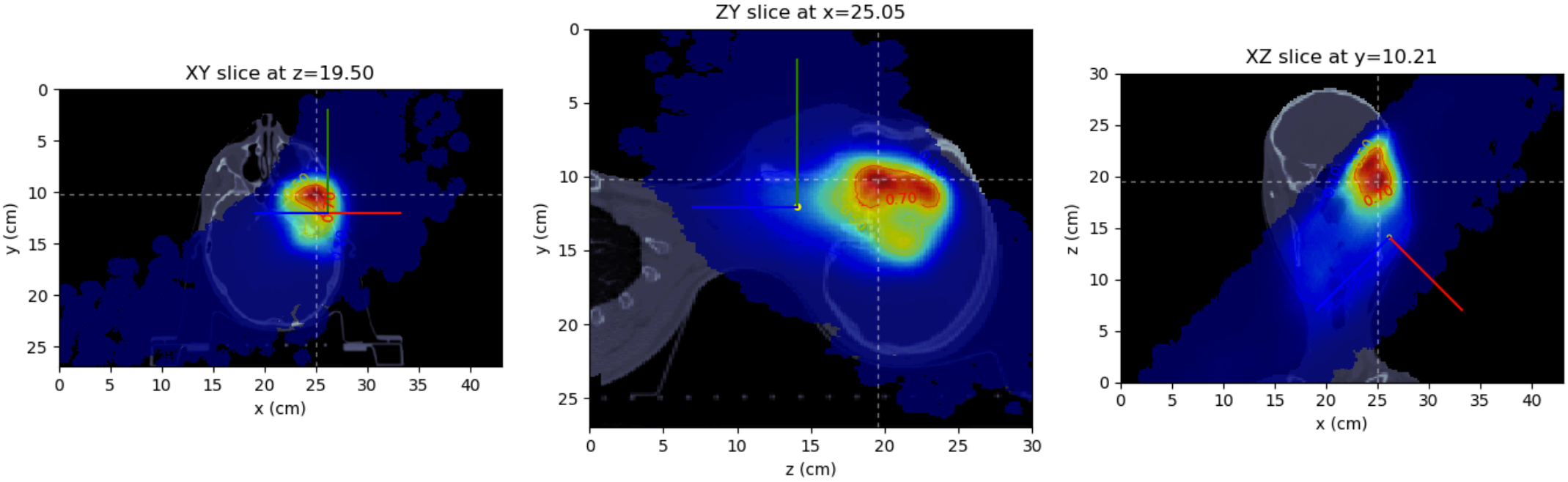



Why we do see POCAs far away from the PTV?

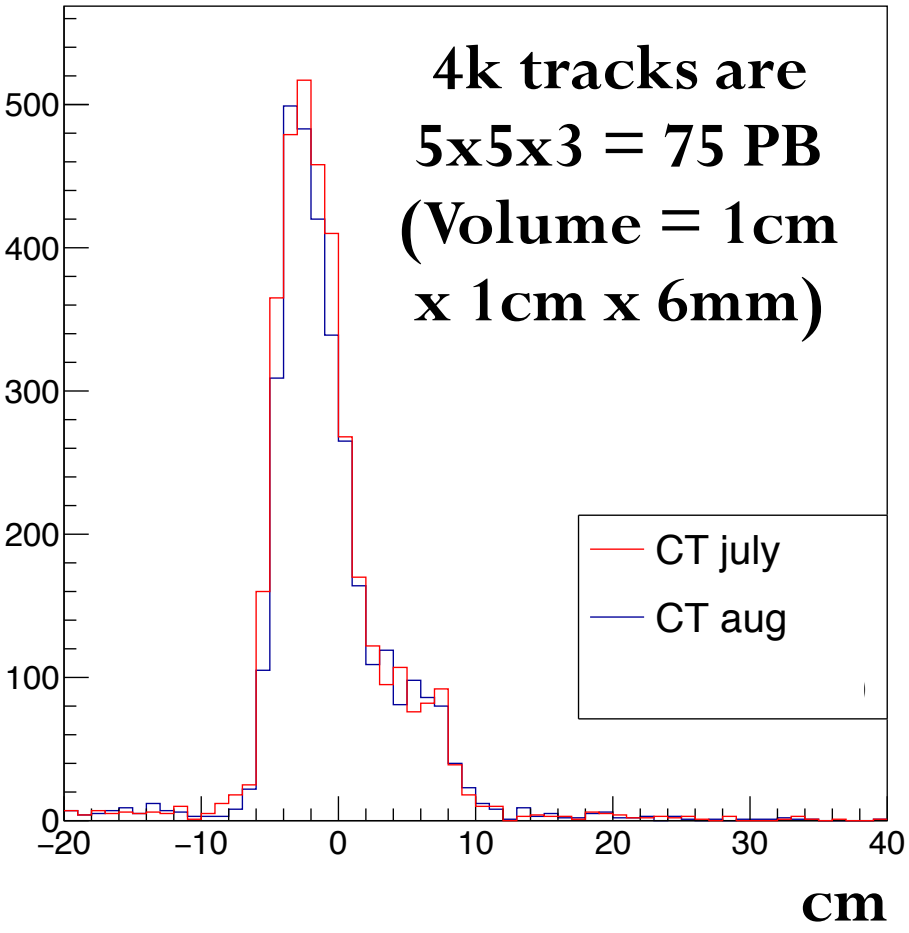
POCAs are reconstructed in 'space' as POCA wrt PB incoming direction. They lay (**within the resolution of several mm**) along the PB direction and they are mostly produced at the entrance point inside the patient. They are more energetic if they are produced near the entrance in the body and they are absorbed by the traversed matter

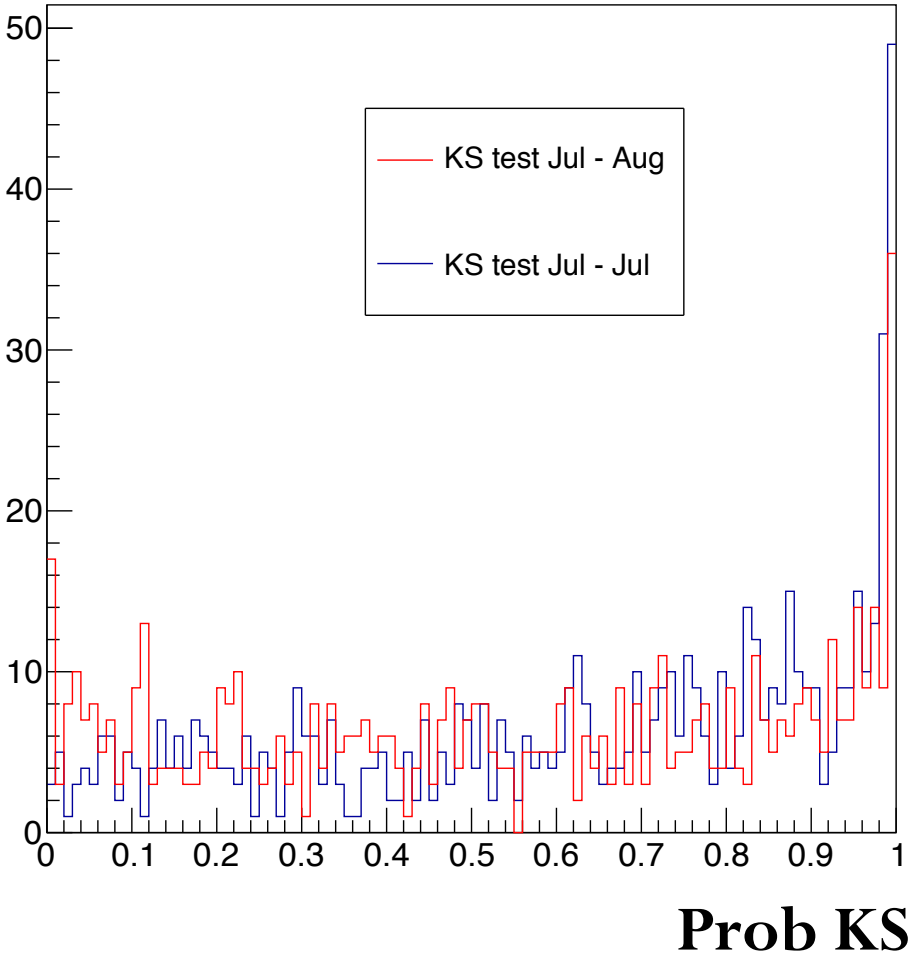
# Conclusion (preliminary)

- With this example, we can conclude that we're going to have a very hard time to spot even LARGE morph. variations….
  - The results of the two CTs are largely compatible, however we need to perform a more detailed/quantitative 3D study to assess our 'resolution'…
  - In the meanwhile we have used the '1D' projections along the PB direction to perform a quantitative comparison



# Going to 1D… (still #mainagioia)



# Next steps

- Before drawing some final conclusions…
  - We need to investigate our potential in other cases: Marta will explore other CTs and fields to see if we can hope to be more sensitive in different conditions
  - We need to implement a quantitative test exploiting the full 3D information
- Starting from Jan -Feb we're going to have plenty of data from patients during the clinical trial…
  - We need to be ready for the data processing, data-MC simulations…
- At some point the problem of 'going online' will have to be faced… not before answering the question about our 'precision'…

# Articles

- The first DP article is being written…
  - Goal: circulate something to the ARPG collaboration by mid nov.
  - Will document the hardware. Just the hardware. Will be the reference paper for all other publications…

PREPARED FOR SUBMISSION TO JINST

**The Dose Profiler: a novel detector for Particle Therapy treatments online monitoring.**

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  - A 'software' related paper (documenting the unfolding and precision in clinical like conditions) will be prepared shortly after. Goal: before end of the year documenting 2D reweighing, MLEM in the landscape of range monitoring applications