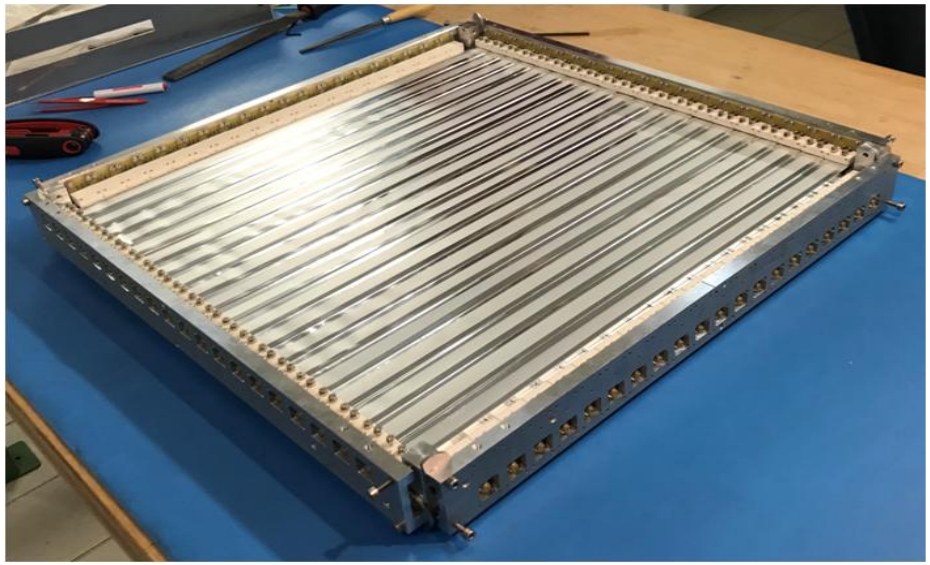
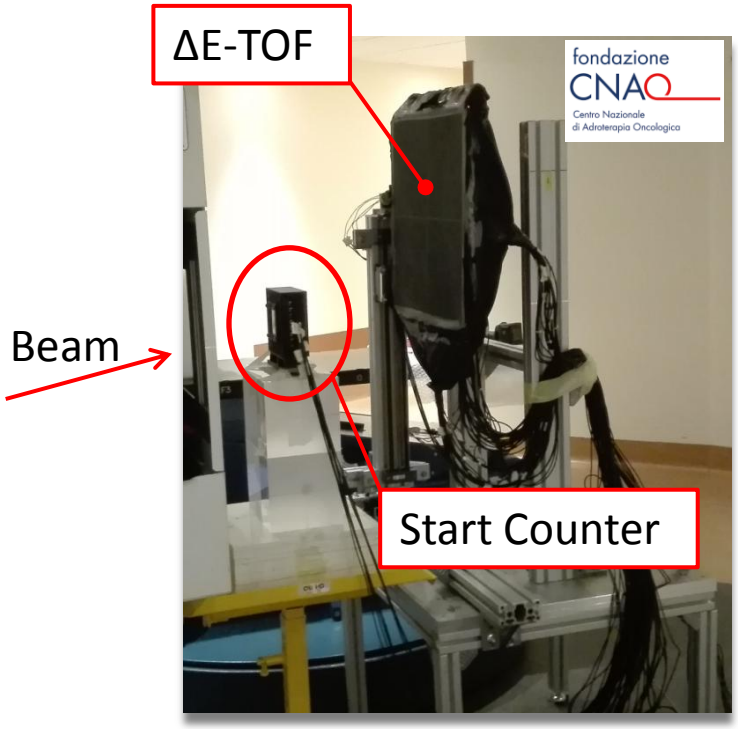
TOF wall space and time resolution studies



VII FOOT Collaboration Meeting

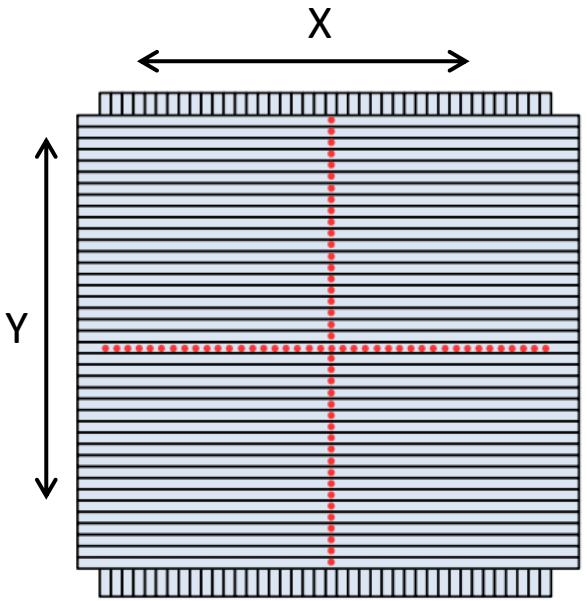
Rome 4-6 December 2019

Measurement set-up for detector calibration



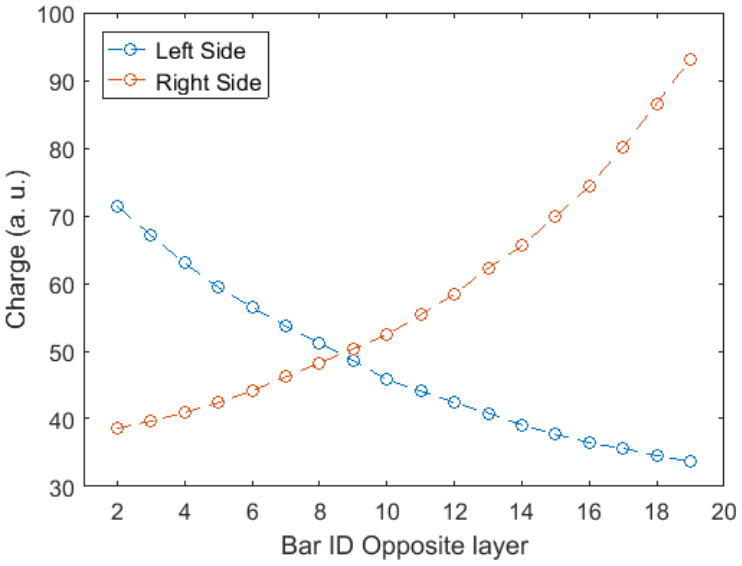
Particles:
- P 60 MeV
- C 115 MeV
- C 260 MeV
- C 400 MeV

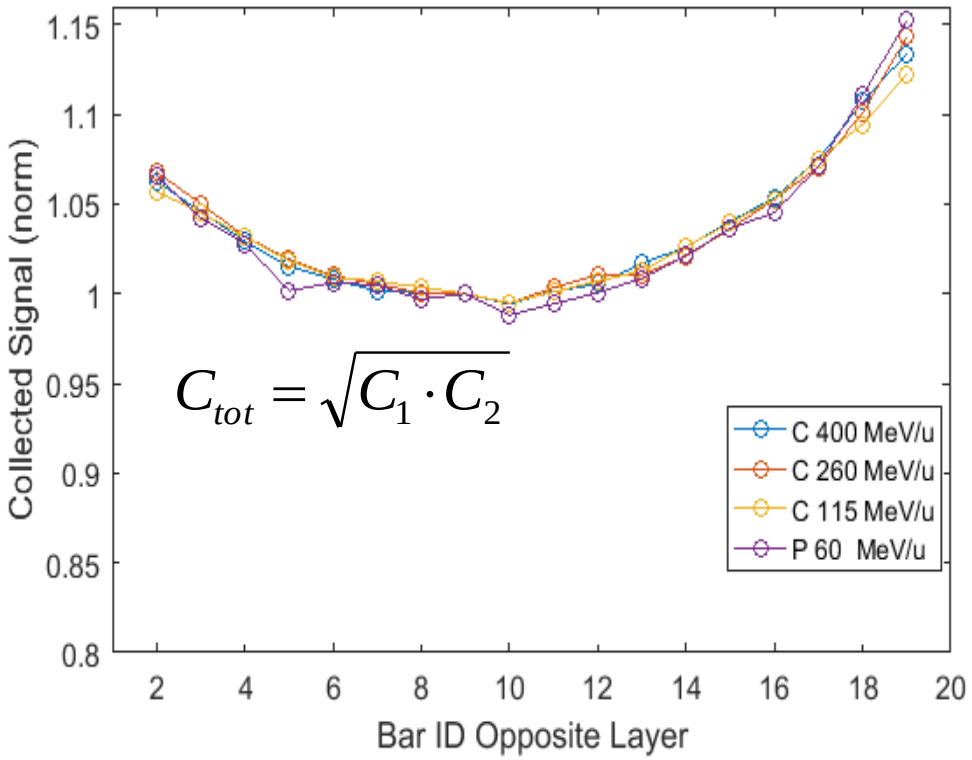
ΔE-TOF was moved on X and Y directions (2 cm step) in order to irradiate different parts of the detector



Light attenuation along the bar

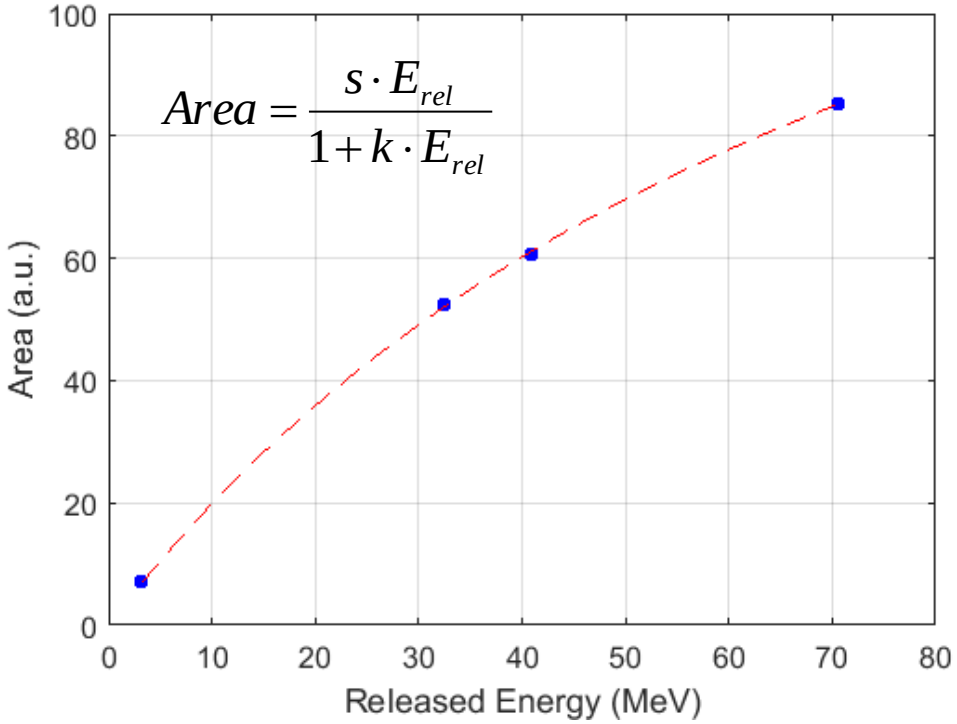
The areas of the signals collected at both sides of the triggered bar were combined to obtain a parameter related to the released energy.





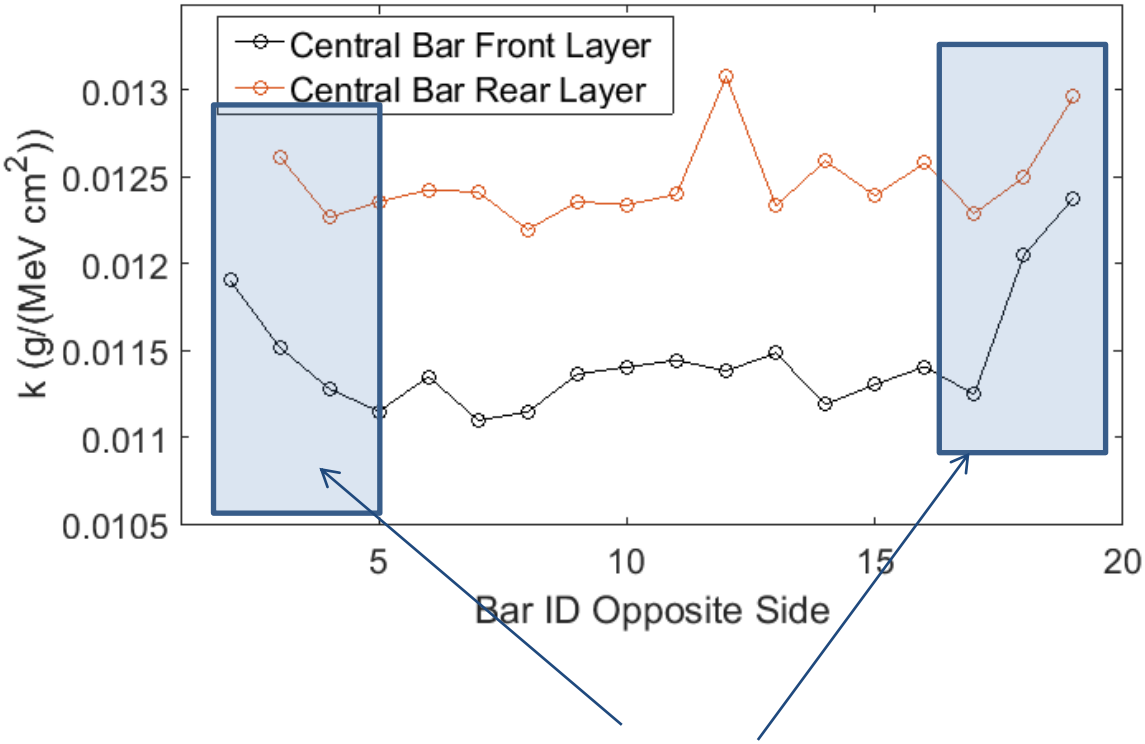
Energy Calibration

The signal collected in each point was calibrated in terms of released energy, taking into account the expected energy deposition for each beam (FLUKA Monte Carlo simulations).



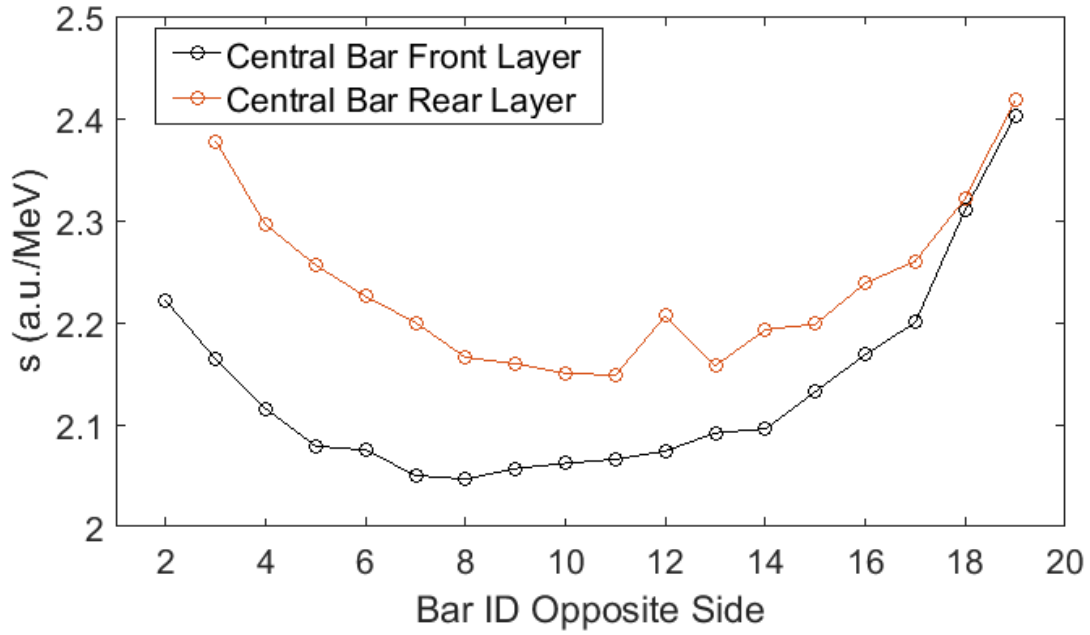
Energy Calibration (2)

This values are compatible, as expected, with the ones found with the previous prototypes (same scintillator material, different wrapping, SiPMs, coupling).



At the two edges the parameter seems to increase (SiPM saturation effect?)

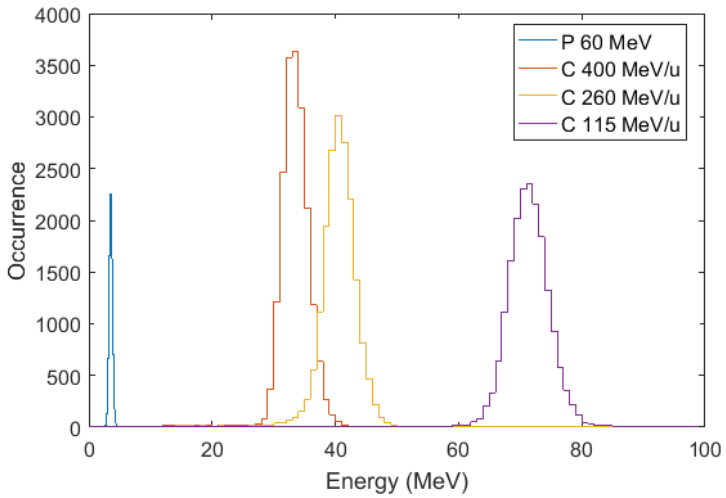
Energy Calibration (2)



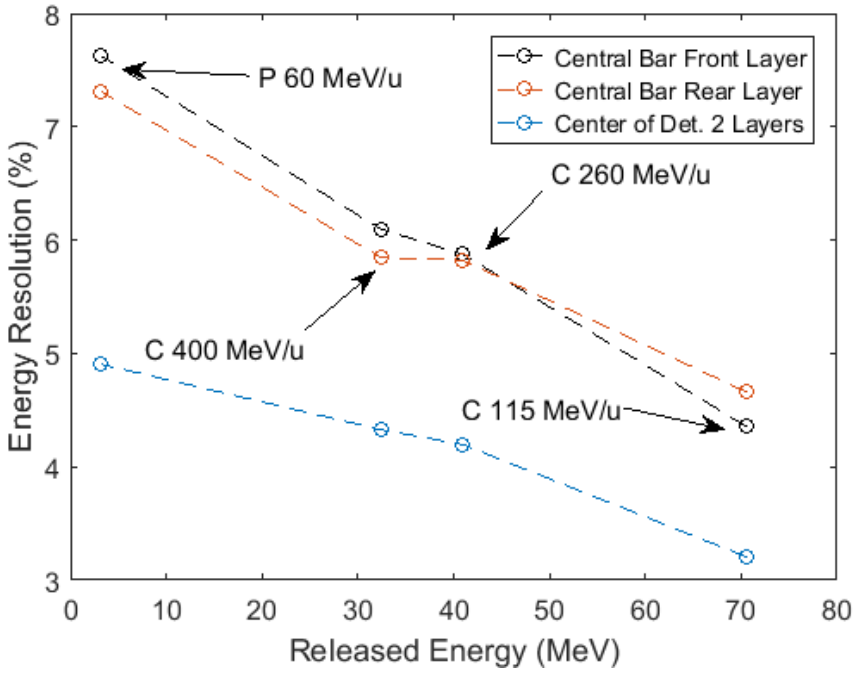
The linear parameter reproduce the trend of the total collected signal, so it is not expected to be constant along the bar.

Energy Resolution

After calibration, the spectrum of the energy deposited in a bar was obtained



The energy resolution is expressed as the ratio between the standard deviation of the distribution and its center



Time Resolution

Time resolution between the central bar of one layer and each bar of the orthogonal layer for Carbon ions.

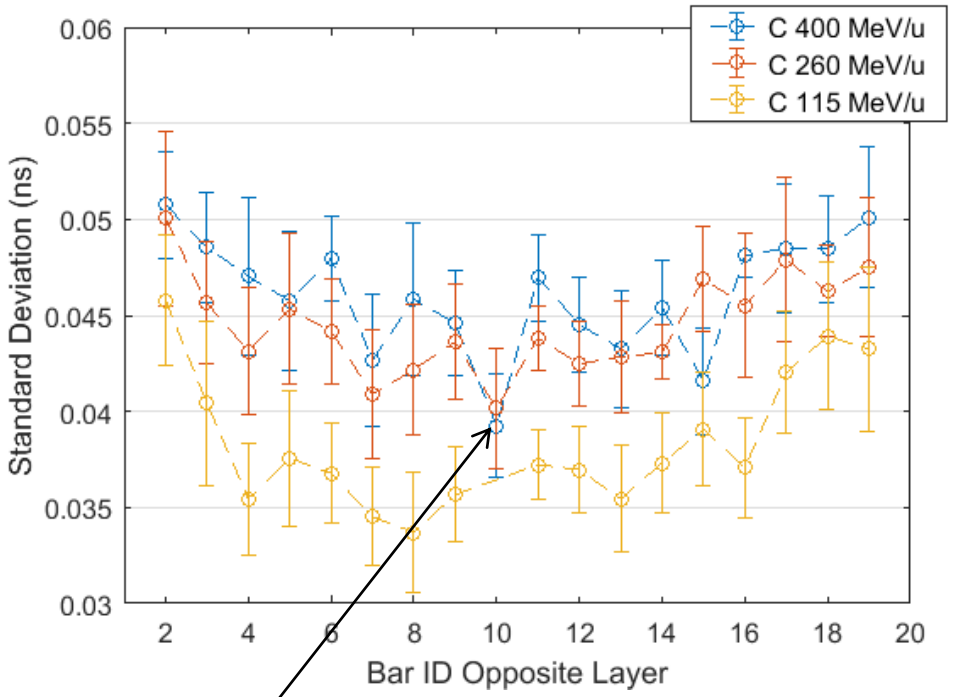
$$\Delta T = T_H - T_V$$

A standard deviation between 35 ps and 50 ps was obtained along the whole bar with Carbon Ions.

Remember that, in FOOT:

$$\mathrm{TOF} = \frac{\mathrm{T_H} + \mathrm{T_V}}{2} - \mathrm{T_{SC}}$$

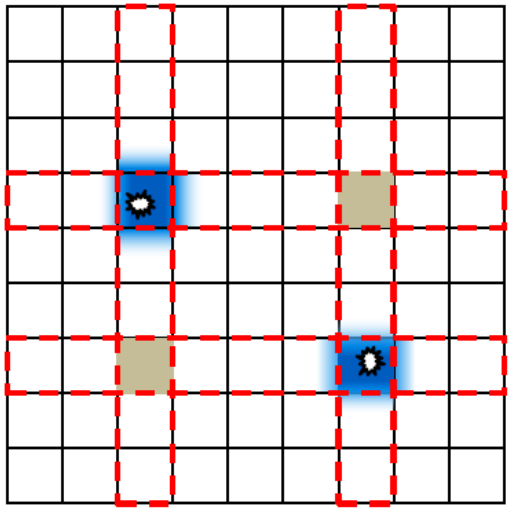
So contribution to TOF resolution will be of about 20 to 25 ps



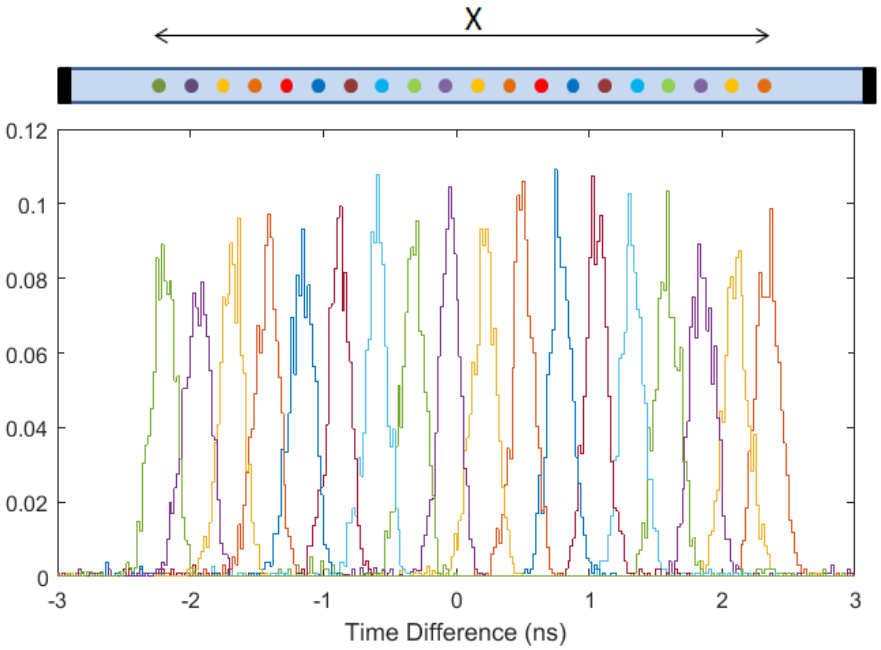
No difference in time resolution between two bars read-out by the same DRS, and bars connected to different boards. Inter-board alignement recovers completely the clock skew.

Hit position

- Hit position can be identified by combining the triggers in the two layers
- In case of multiple hits in the TOF detector, the identification of the interaction position could be ambiguous



Multiple hits can be disambiguated by comparing the timestamps of the two sides of the triggered bars



Next steps

- We finalized the procurement of two PMTs with wide dynamic range so to investigate the role of SiPM saturation in the energy resolution
- We are finalizing the procurement of the mechanical stages for the detector calibration
- A rework of the detector to improve the mechanical frame is scheduled for the first part of the next year
  - optical separation between bars
  - light tight encapsulation
  - references for installation in the whole system
  - no needs for others scintillators or detectors

Next Data Taking

- CNAO 9-11/12/2019
  - Test of timing and energy resolution as a function of the OV
  - Energy response with several carbon energies
- Two data tacking are foreseen for the first half of the next year:
  - A data tacking with PMTs to investigate SiPM saturation contribution (also in a treatment room)
  - A data tacking with the full detector for an extensive calibration (experimental room is required).

Papers

- We finalized the publication of the paper about the first fragmentation measurement with the detector prototype!

ELSEVIER

Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment

Volume 953, 11 February 2020, 163146

Fragment charge identification technique with a plastic scintillator detector using clinical carbon beams