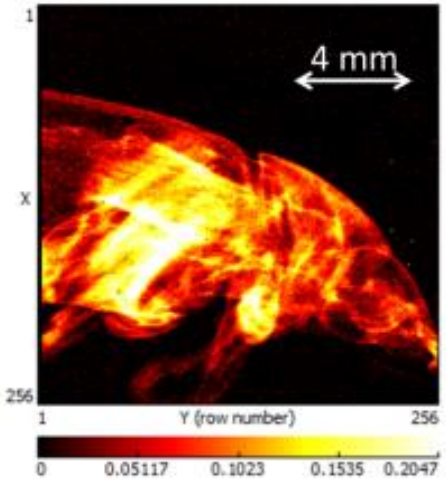


Characterization of primary and secondary radiation in heavy ion therapy

Iván Dario Caicedo Sierra
October 15th, 2013.
ESR7 of the ARDENT Initiative

ARDENT
Advanced Radiation Dosimetry European Network Training

ÚSTAV TECHNICKÉ A EXPERIMENTÁLNÍ FYZIKY
ČVUT V PRAZE

Medipix
Collaboration

What about the ESR7?

Name: Iván Darío Caicedo Sierra

Institution: IEAP at the CTU in Prague

Nationality: Colombian

Age: 24

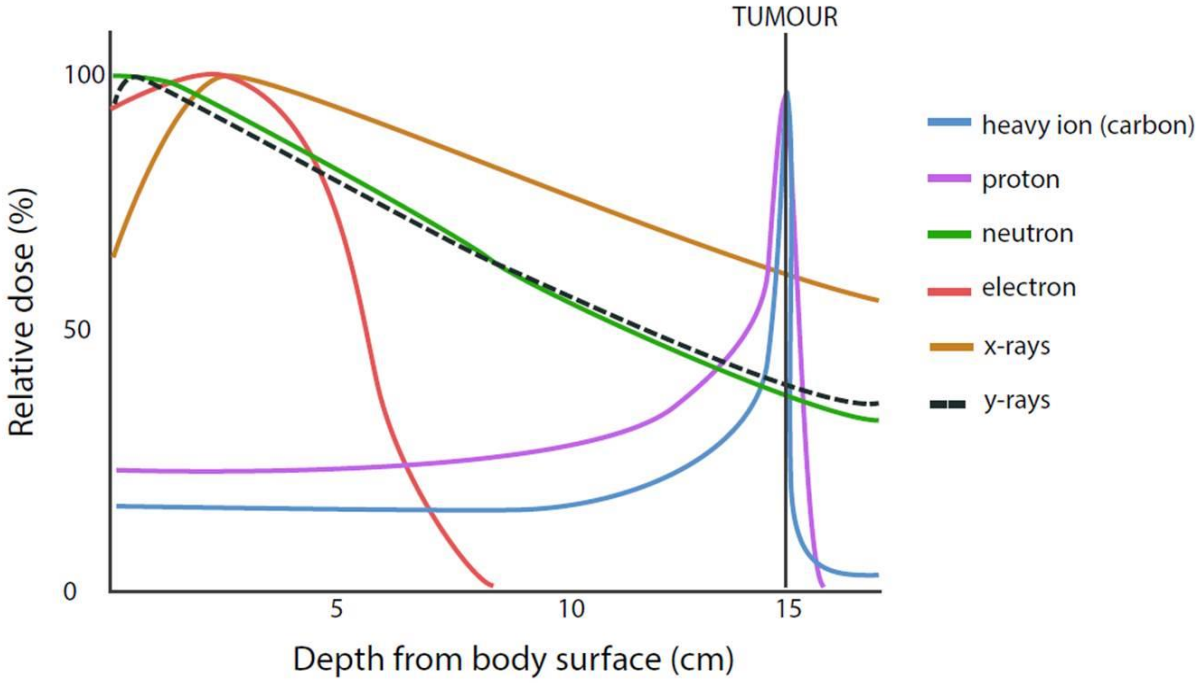
Education: Master of Science – Physics, at the Universidad de Los Andes in Bogotá, Colombia.

Working field: Radiation detection -and data analysis- using hybrid pixel semiconductor detectors (Medipix type)

Status: Waiting for a Visa at the other side of the planet.

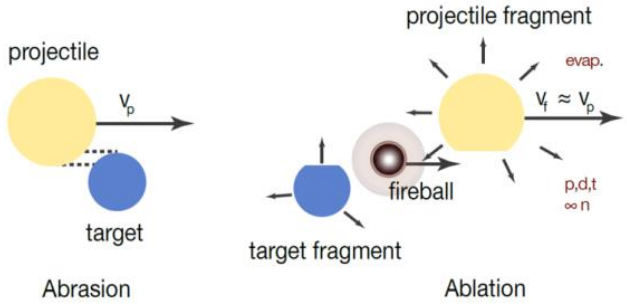
Why Ion Therapy?

Highly localized energy deposition and enhanced biological effect on tumour cells

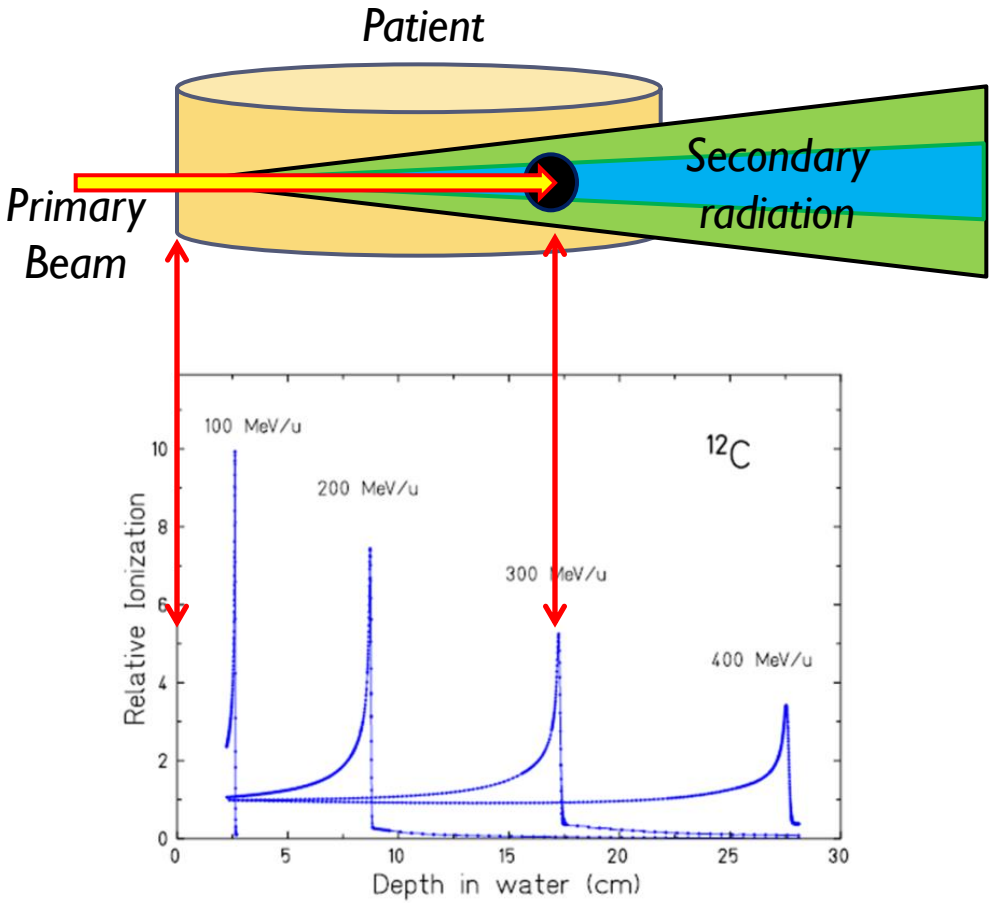


Relative depth-dose profile of different radiotherapy modalities

Secondary radiation: Friend and foe.



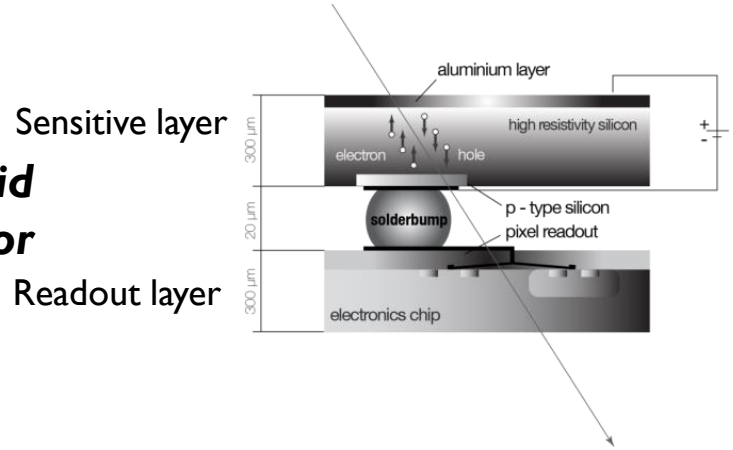
Fragmentation of nuclei while traversing the patient

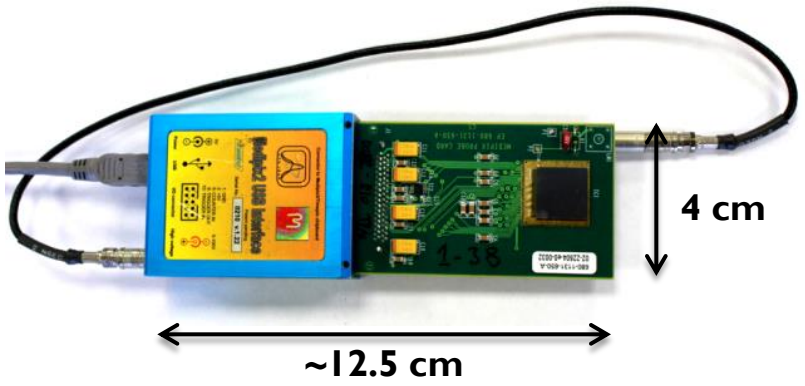


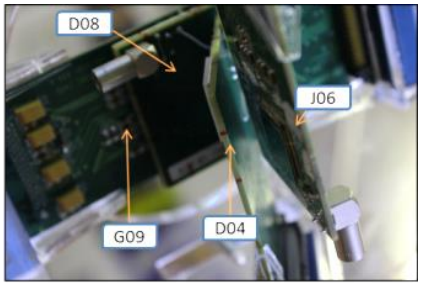
Measured Bragg curves of 12C ions penetrating a water phantom. (Taken from Schardt et al., GSI Scientific Report *2007*, p. 373, 2008 *)*

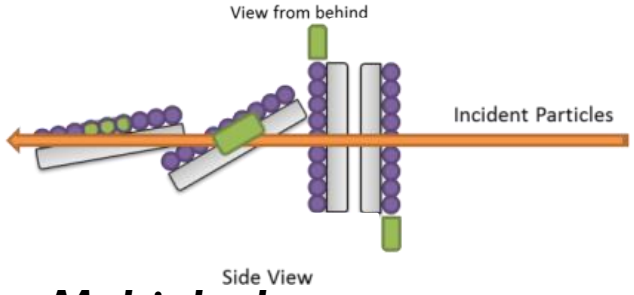
Arrays of Timepix semiconductor detectors

Timepix hybrid pixel detector

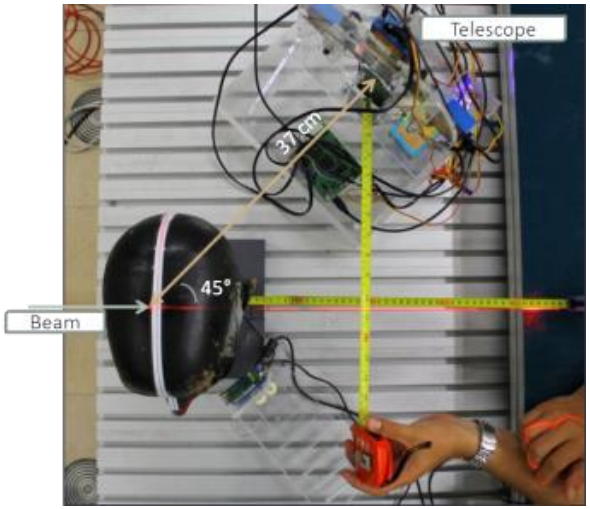






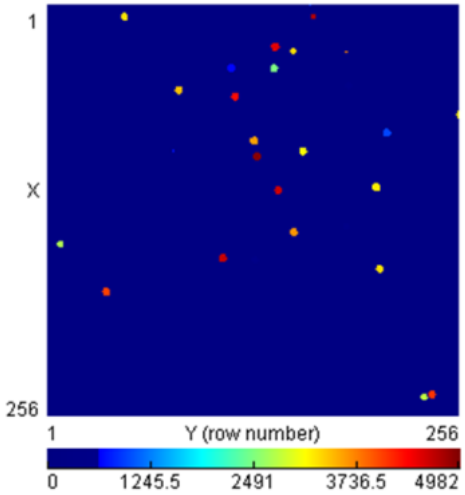


Multiple detector arrays

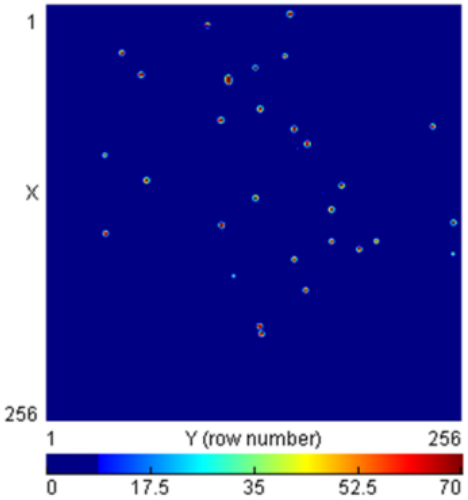


Setups irradiated at the HIT

Data analysis: Characterization



Arrival Time of the particle to the detector



Energy deposition of the particle on the detector

↓

Techniques for particle discrimination

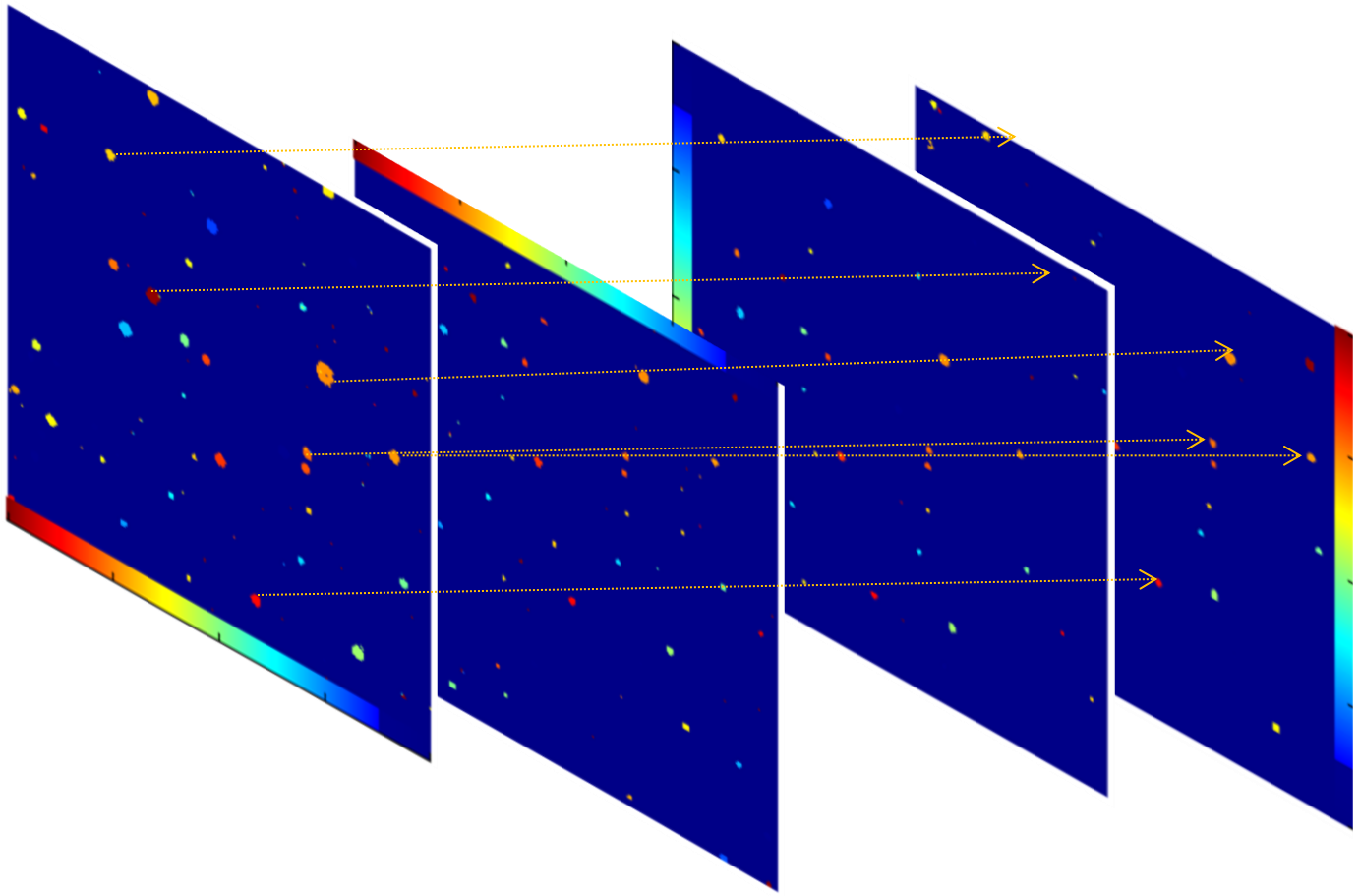
<u>Cluster:</u>

Group of adjacent pixels, corresponding to a single particle/detected event

Different tasks:

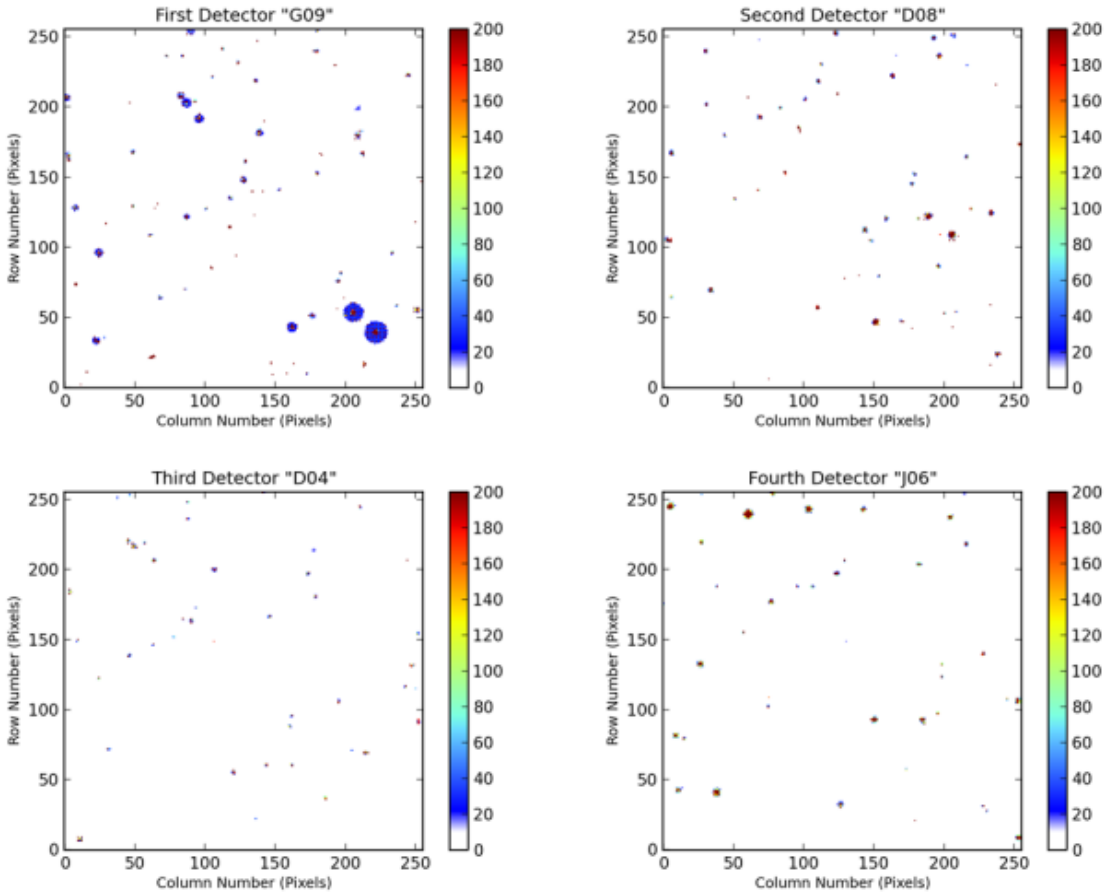
- *Cluster identification*
- *Determination of geometric parameters for each cluster*

Data analysis: Tracking



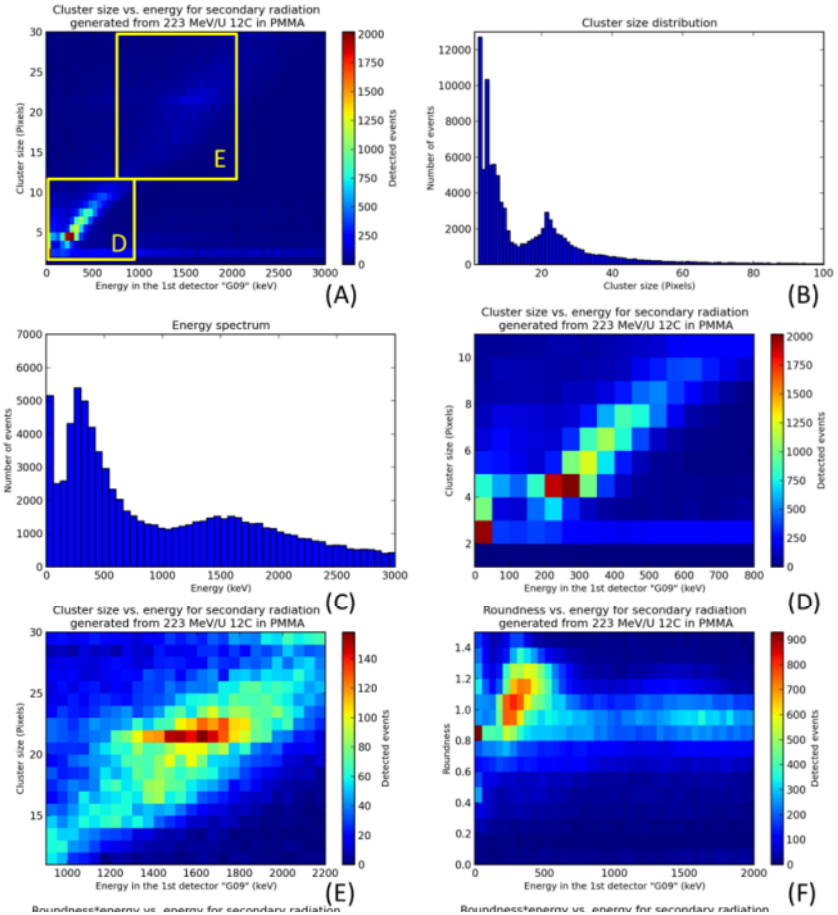
Identification of coincident events → *Particle tracking*

Multi-parameter analysis



Data acquisition and processing in different detectors of the array

Multi-parameter analysis



Multi-Parameter Analysis (Geometric +Energy analysis)

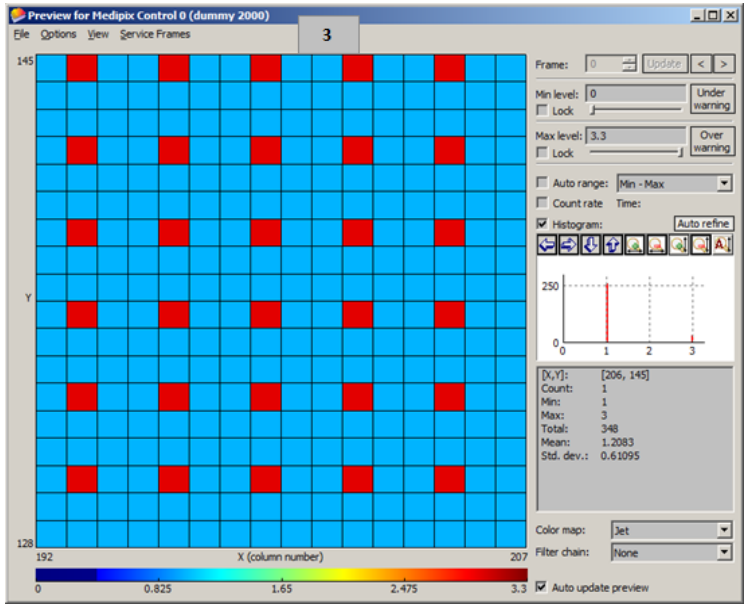
→ **Example for a cylindrical plastic phantom**

The same analysis was also made for a head simulator and plastic phantoms with other dimensions

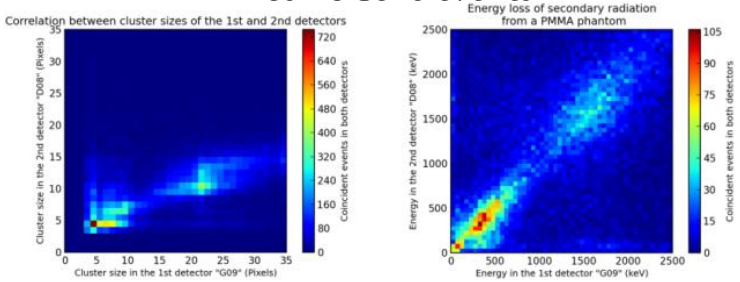
Characterization of coincident events

A single pixel is only allowed to measure either time or energy, but a more complete characterization would be possible by measuring both of them.

What about some pixels measuring time while others measure energy?

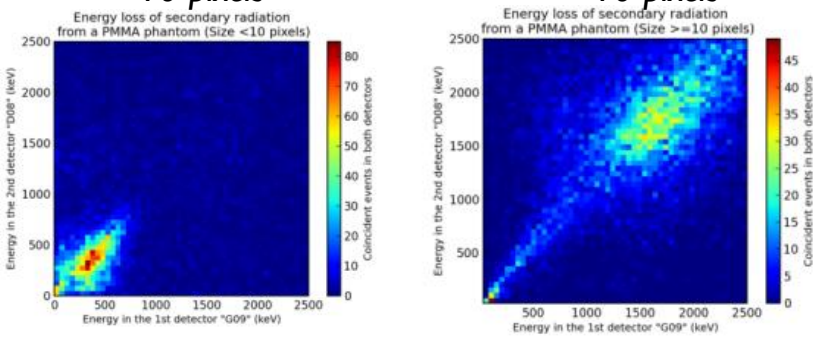


All coincident events



Cluster size <10 pixels

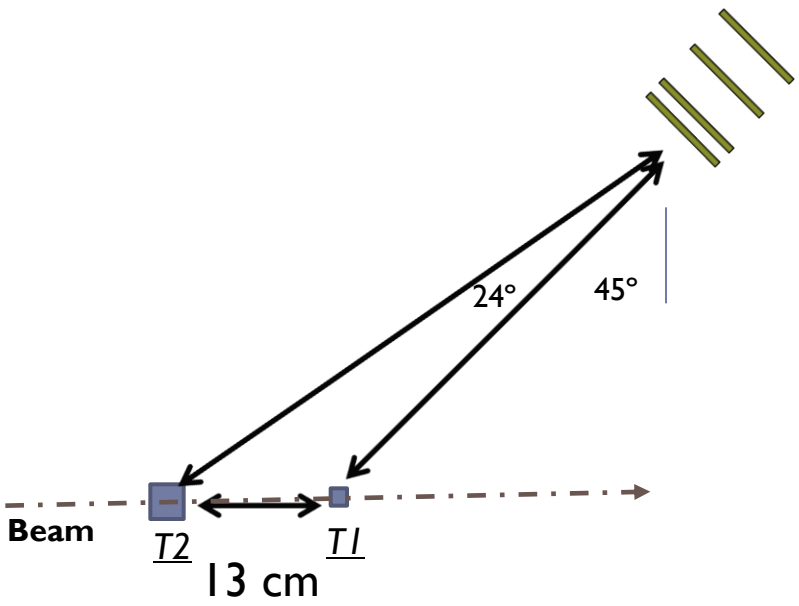
Cluster size >= 10 pixels

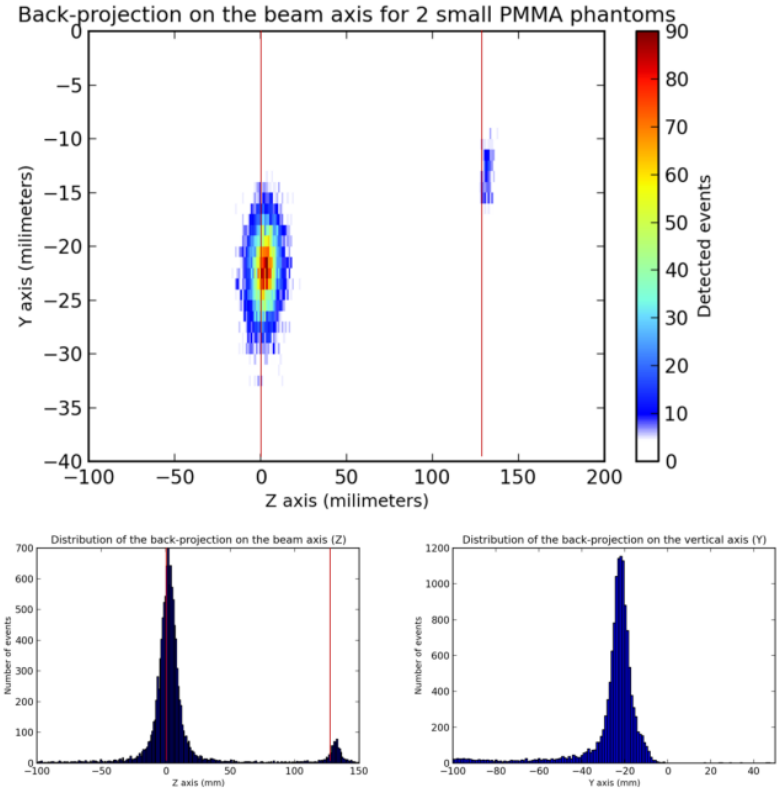


Energy correlation of coincident events in two parallel detector layers of a telescope

Vertex reconstruction

Tracking of secondary fragments allows to reconstruct their origin along the beam axis. This reconstruction can be used for a real-time high-resolution treatment verification.





Conclusions

- Data acquired using a novel technique allowed to identify and track single particles, simultaneously.

- Custom-made software tools were developed for data analysis of radiation detected from an Ion Therapy treatment.

- Secondary radiation was characterized using coincident arrays of semiconductor detectors.
  ⟶ Future verification of patient treatments?

WHAT IS NEXT?

Further measurements with higher statistics for a complete characterization of the radiation field and more precise dose verification.

Assesment of the implementation of detectors and software tools in real time as a source of information for treatment planning systems.