UNIVERSITY OF LIVERPOOL

A study of secondary particle production from carbon ion beam for radiotherapy using silicon pixel detectors and water phantom

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Annual HEP meeting
May 19,2022 (Liverpool, UK)

Introduction

Radiation therapy:

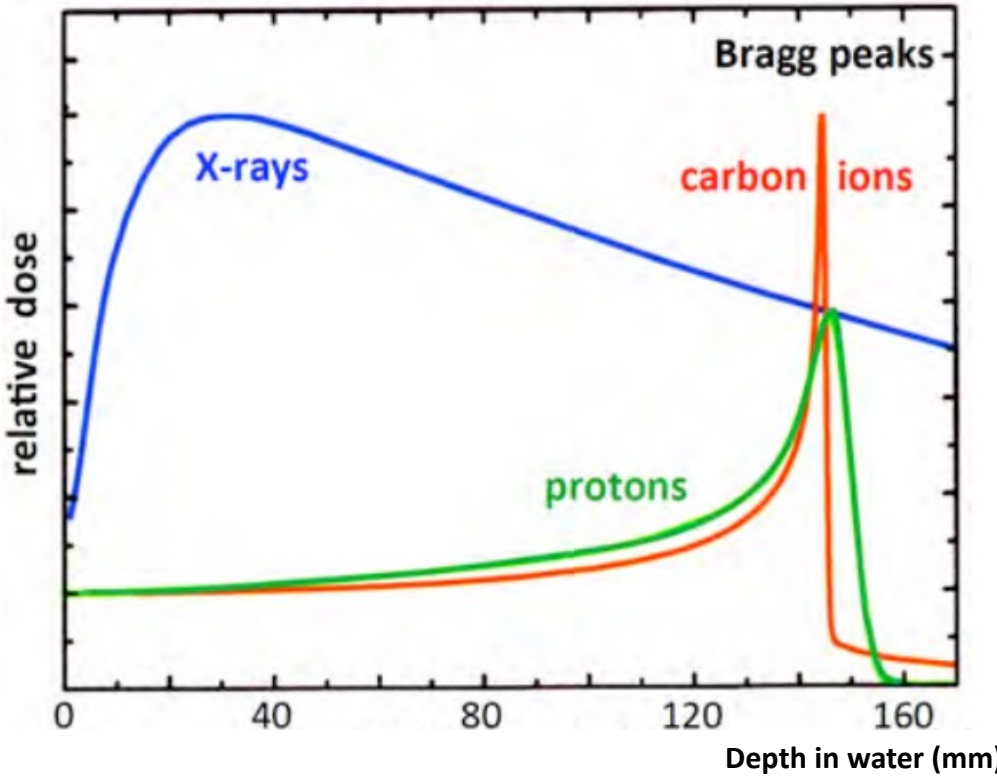
Radiotherapy aims to damage the cancer cells by delivering the maximum radiation dose to the tumor position and low dose to the surrounding healthy tissue.

Research Aims:

1- Simulation study → monitor the primary beam → produced secondary radiation of hadron therapy (Carbon therapy) with water phantom, using Geant4 Monte Carlo software.

2- Secondary particle radiation → monitor the characteristics of the primary ion beam → measuring change particles coming out of the interactions between the ion beam and the molecules in the water.

3- Measurements → silicon pixel detectors such as Timepix3 to compare with simulations.



U. Amaldia , J. Balossob , M. Dosanjhc , et al.

Semiconductor Tracking Detectors

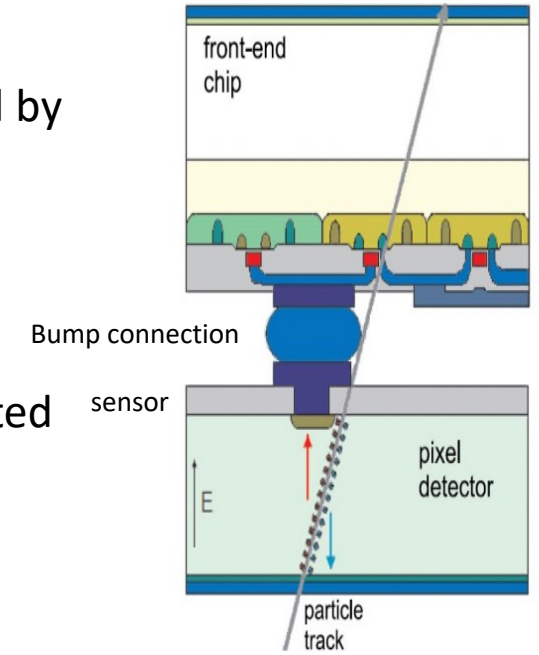
Hybrid pixel detector

Silicon sensor → bump bonded to an ASIC based front-end electronics. The 14.1mm × 14.1mm sensor chip features 256 × 256 pixels each of 55µm × 55µm in size.

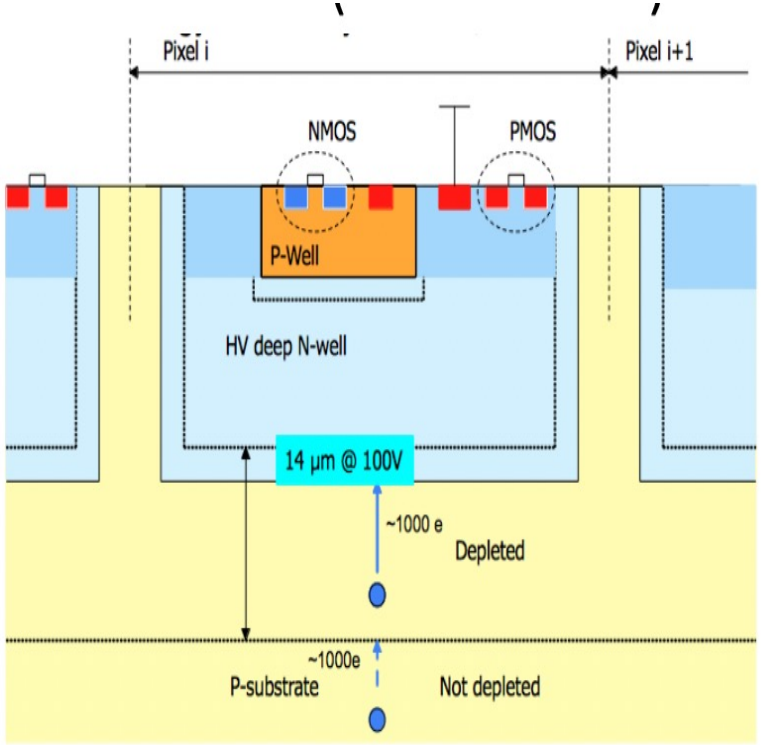
These detectors → measure the ionisation caused by charged particles.

HV-CMOS detector

- Readout and digitization electronics can be integrated on the same chip with the pixel array
- Very small pixel sizes are possible high → granularity
- Low mass detector giving less scattering
- Good speed and good radiation tolerance (HV-CMOS)



Hybrid



CMOS electronics placed inside the diode (inside the n-well)

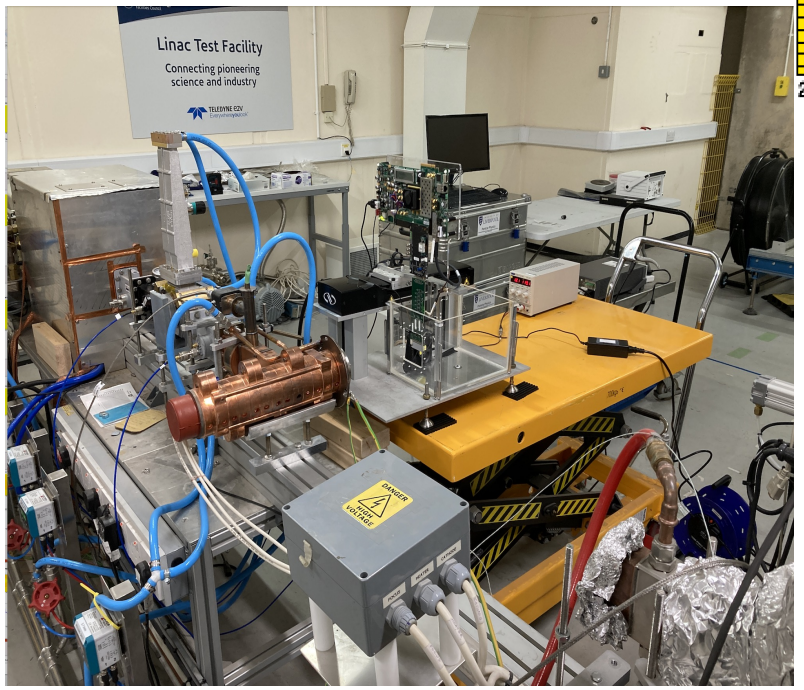
HV-CMOS

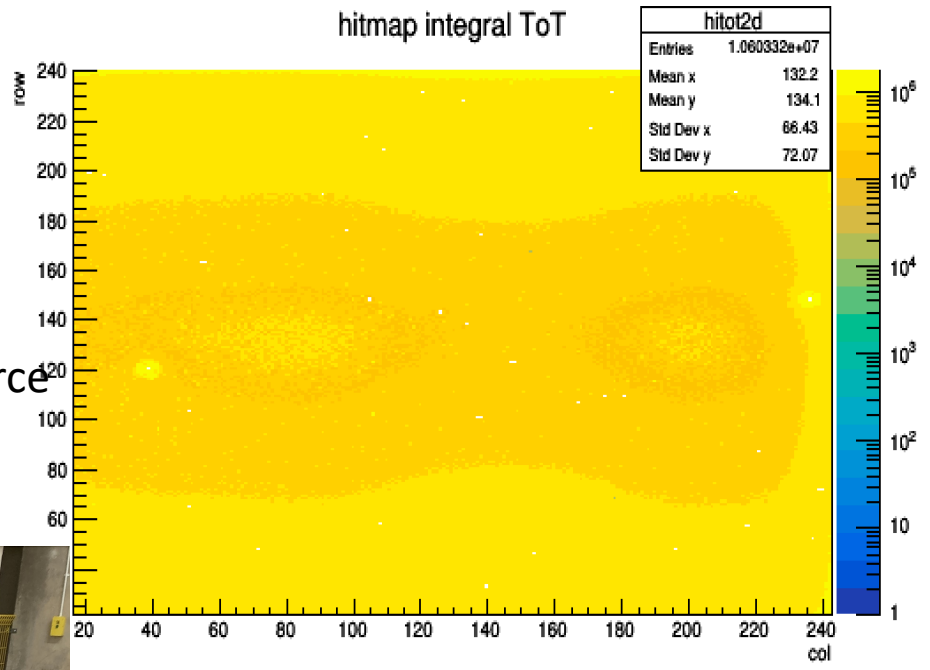
*Daniel Muenstermann

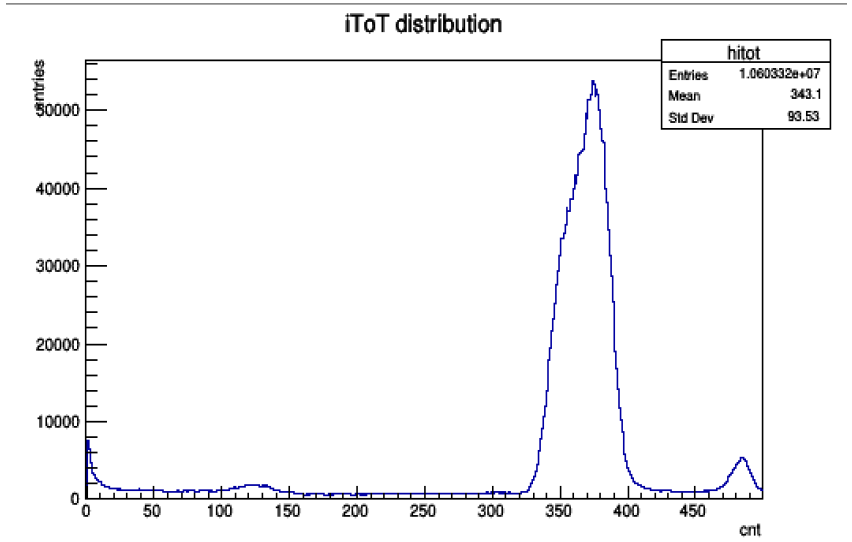
Data analysis of electron beam by using Timepix3 detector

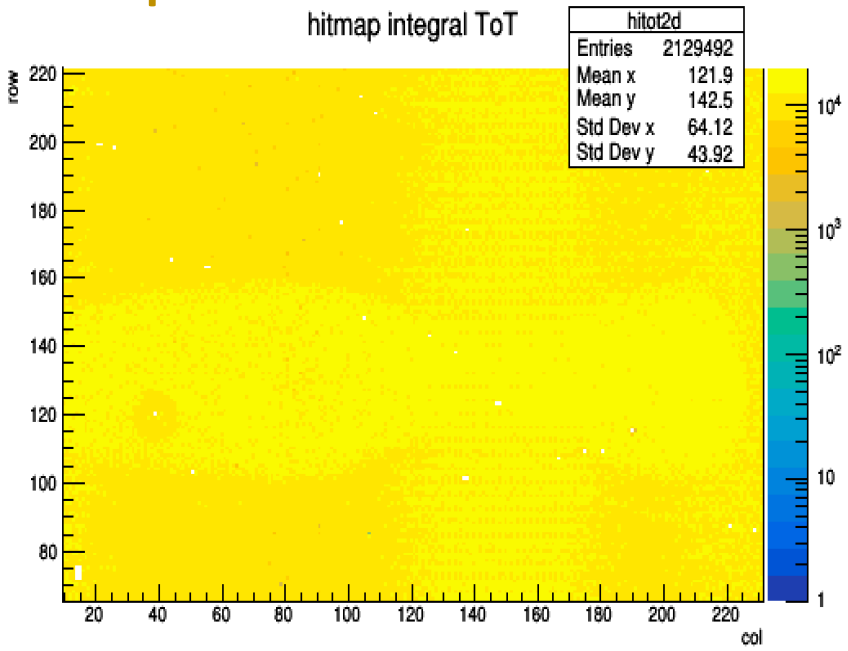
Test beam 2022 01 31 Daresbury

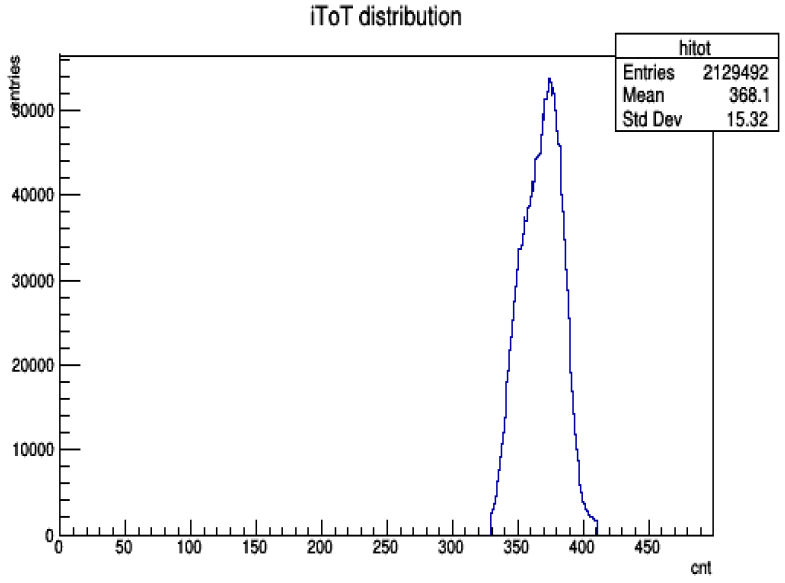
- *Beam: electron*
- *Energy: 6 MeV*
- *Current:* 110mA
- *bias -80V* ,100Hz
- 22.5mm distance from beam source
- Medium: Air







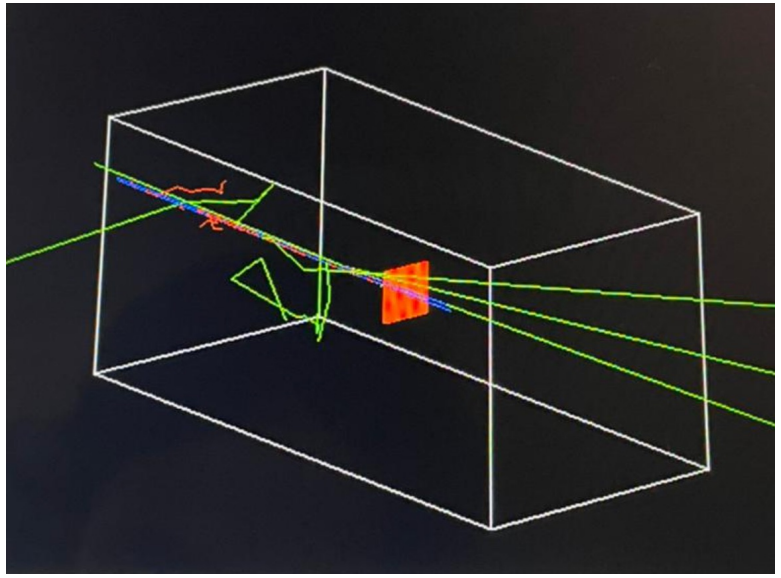




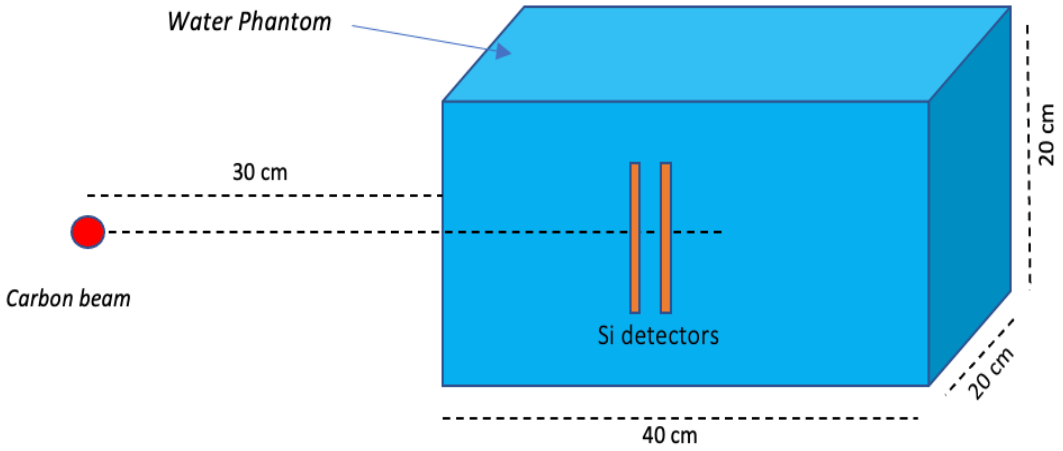
Carbon Therapy Simulation

- Geant4 toolkit version 10.03.
- Physics list: QGSP_BIC_HP.
- Beams: Carbon ion
- Energy: *3.48 GeV*
  Event. no: 1M
- Medium: Water
- Particle ‘s energy stops

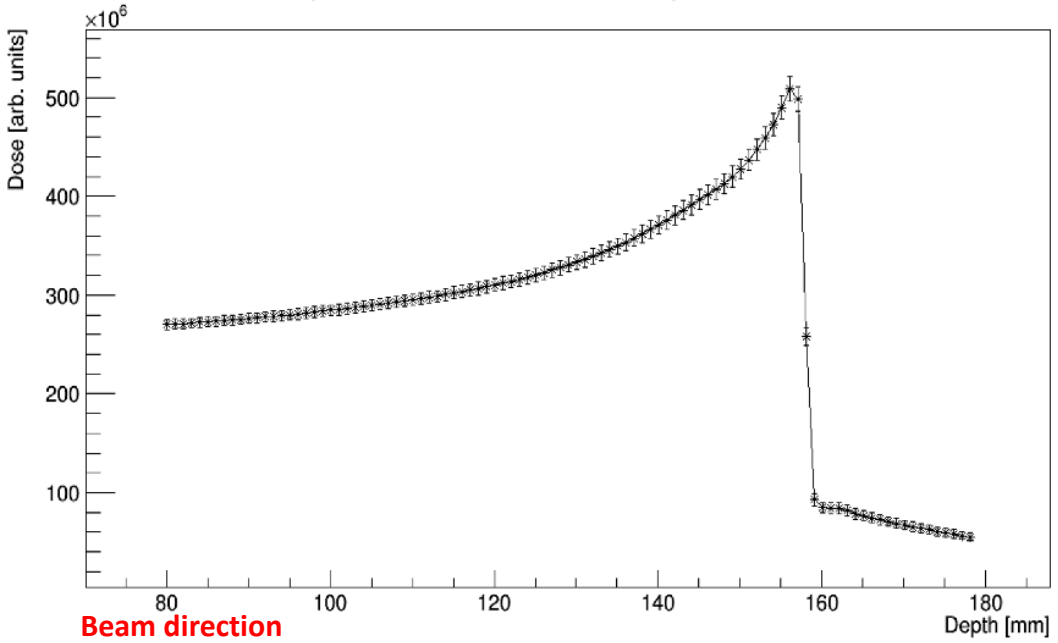
→ highest dose



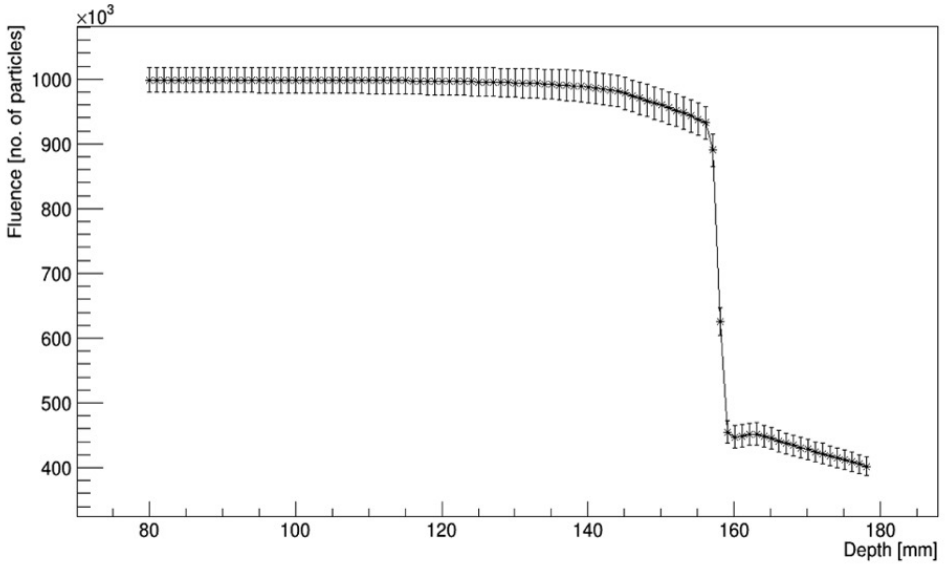
- As energy reduces, stopping power increases.
- Size of detectos: 1x1cm^2



Depth vs Dose of Carbon ion at *3.48 GeV* (Bragg Peak of Carbon ions)



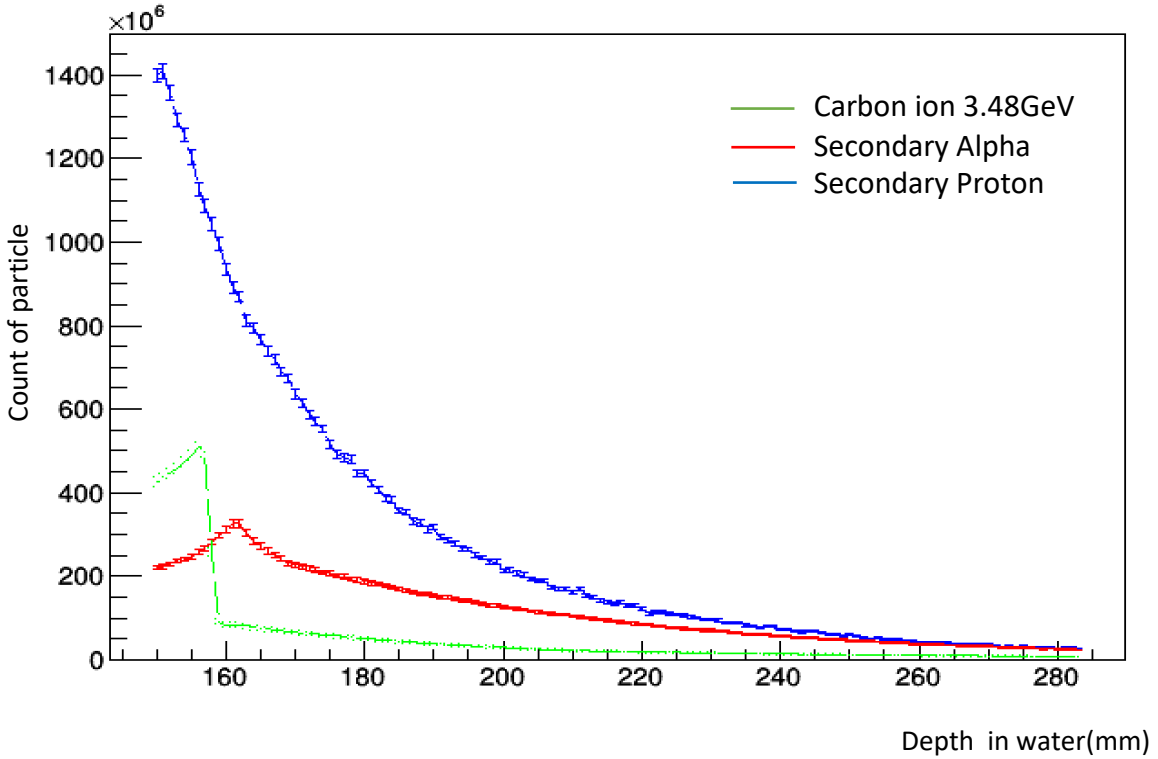
Beam direction



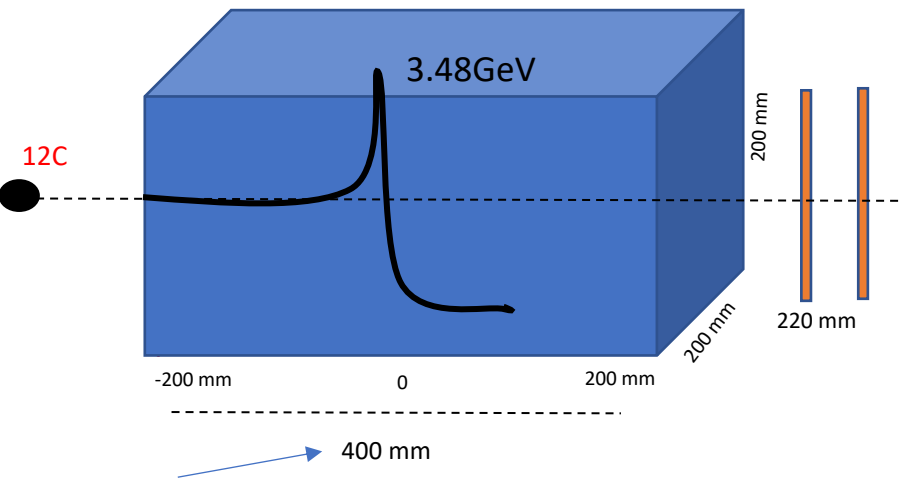
Depth vs Fluence of Carbon ion at *3.48 GeV*

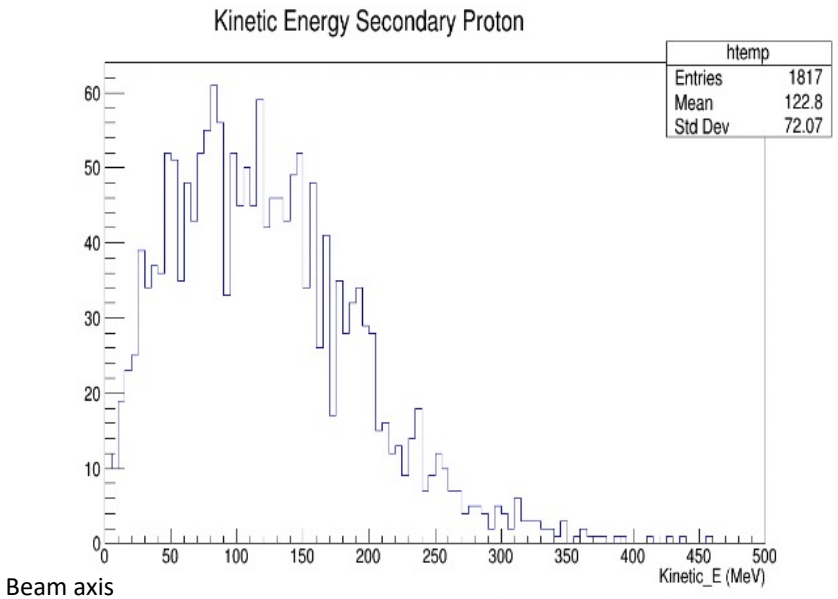
Secondary Particle Contributions

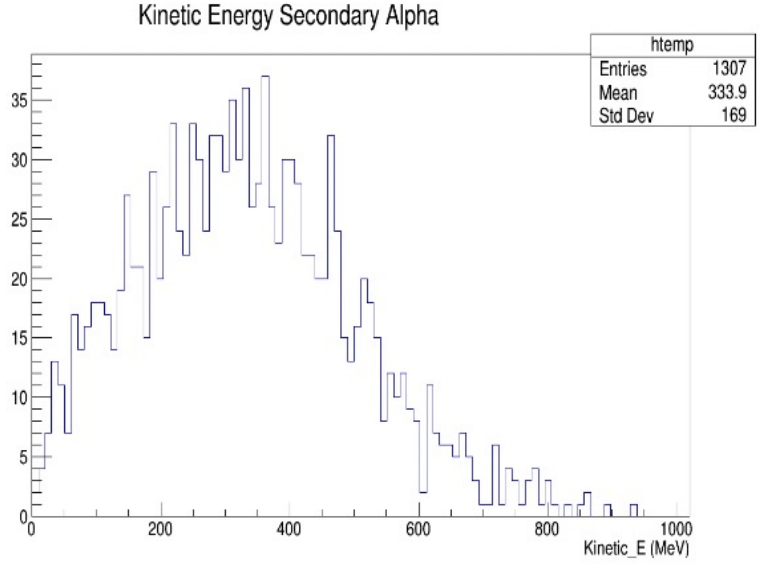
- Protons have longer range than the primary particle (carbon ion).
- Secondary particles (tail) appear until at ~ 280 mm.



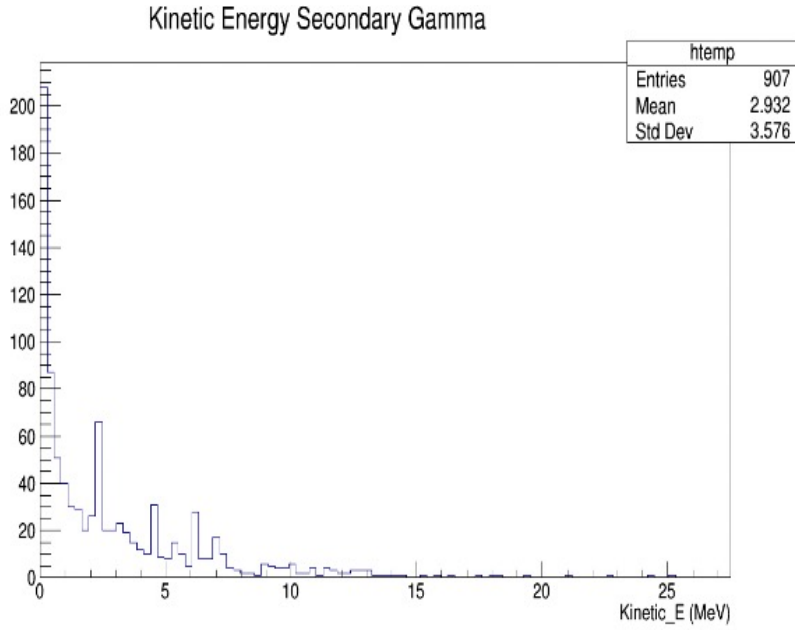
Secondary Particle Contributions

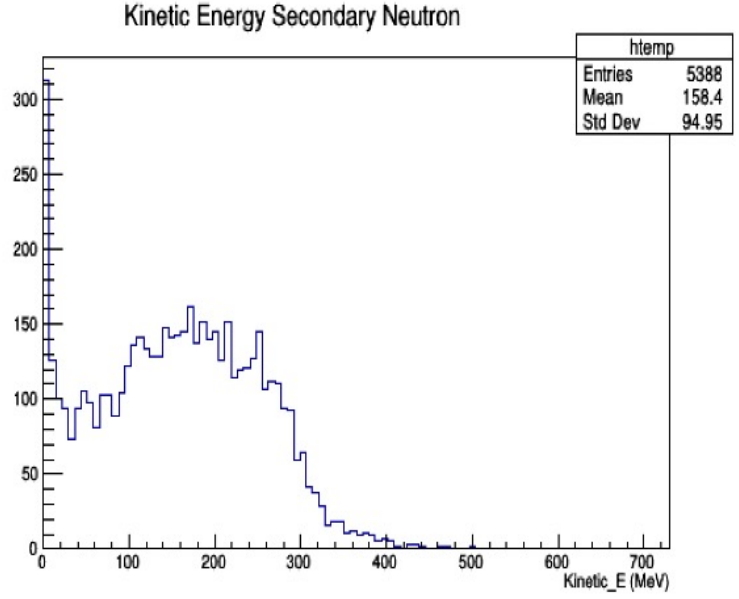






particle	Entries	Kinetic Energy
Proton	1817	122.8
Alpha	1307	333.9
Gamma	907	2.932
Neutron	5388	158.4





Next Steps and Outook

- In the next stage the secondary particles radiation will be used to monitor the characteristics of the primary ion beam.

- Doing measurements with silicon pixel detectors such as hybrid pixel detector Timepix3 and a new HV-CMOS detector ‘HVTrack’

Thank you!

Any questions?