UNIVERSITY OF LIVERPOOL

A Study of Secondary Particle Production from Carbon Ion Beam for Radiotherapy by Using Silicon Pixel Detectors and Water Phantom

Shaikah Moslat Alsubayae

2nd year PhD Student

Advisors: *Prof. Gianluigi Casse, Dr. Carlos Chavez and Dr. Jon Taylor*

Department of Physics – High Energy Physics

First Year Presentation
June14,2022 (Liverpool, UK)

Introduction

Radiation therapy:

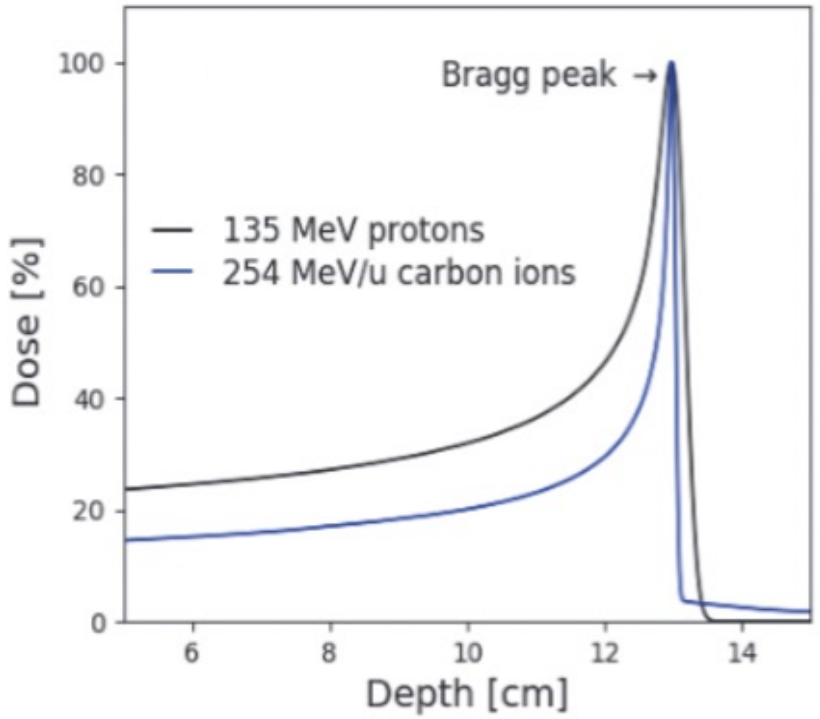
Radiotherapy aims to damage the cancer cells by delivering the maximum radiation dose to the tumor position and low dose to the surrounding healthy tissue[1].

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].

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.

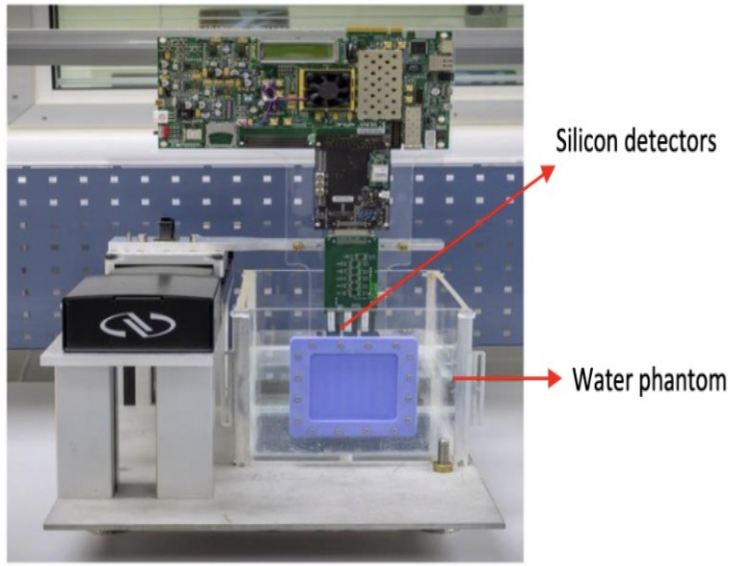
3- Measurements → silicon pixel detectors such as Timepix3 to compare with simulations.



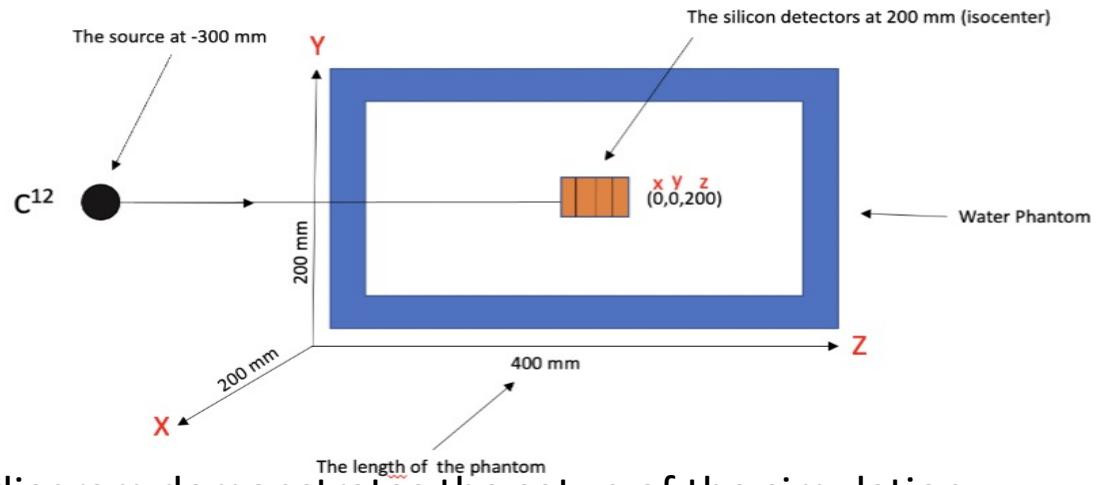
Depth dose profiles of a 135 MeV proton and a 254 MeV/u carbon ion beam in water[1].

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 2x2cm^2

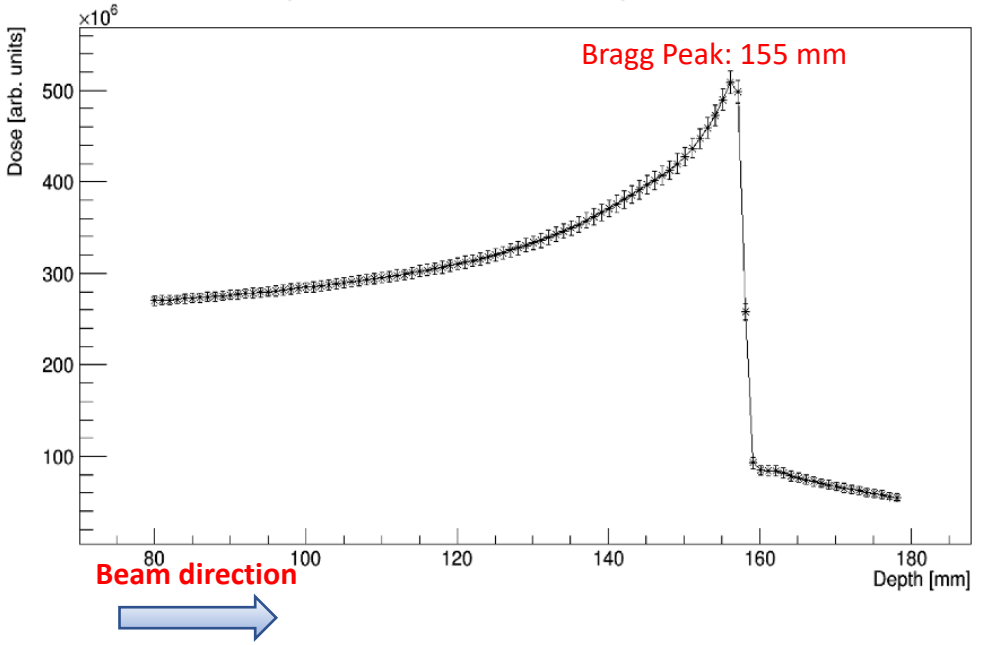


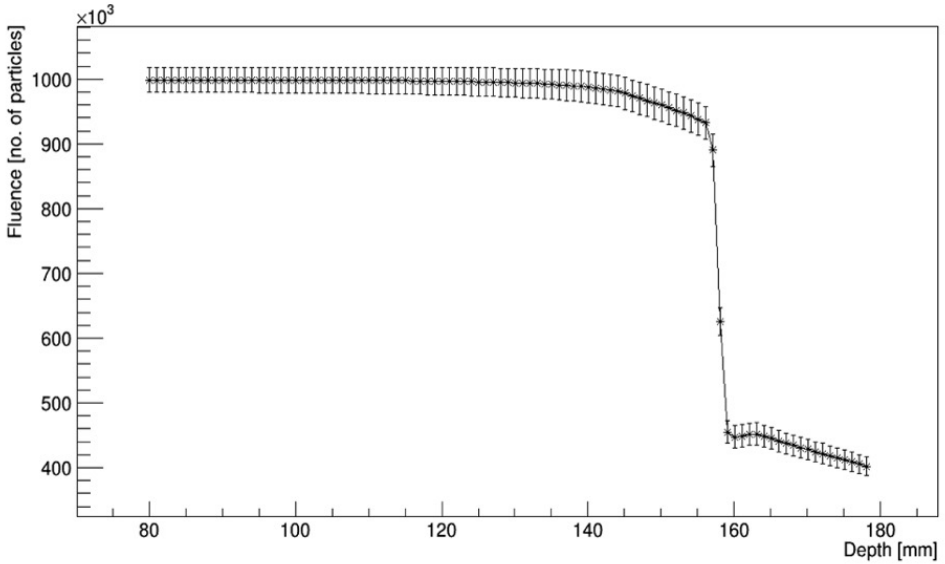
A system design of water phantom and Silicon detector.



This diagram demonstrates the setup of the simulation

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

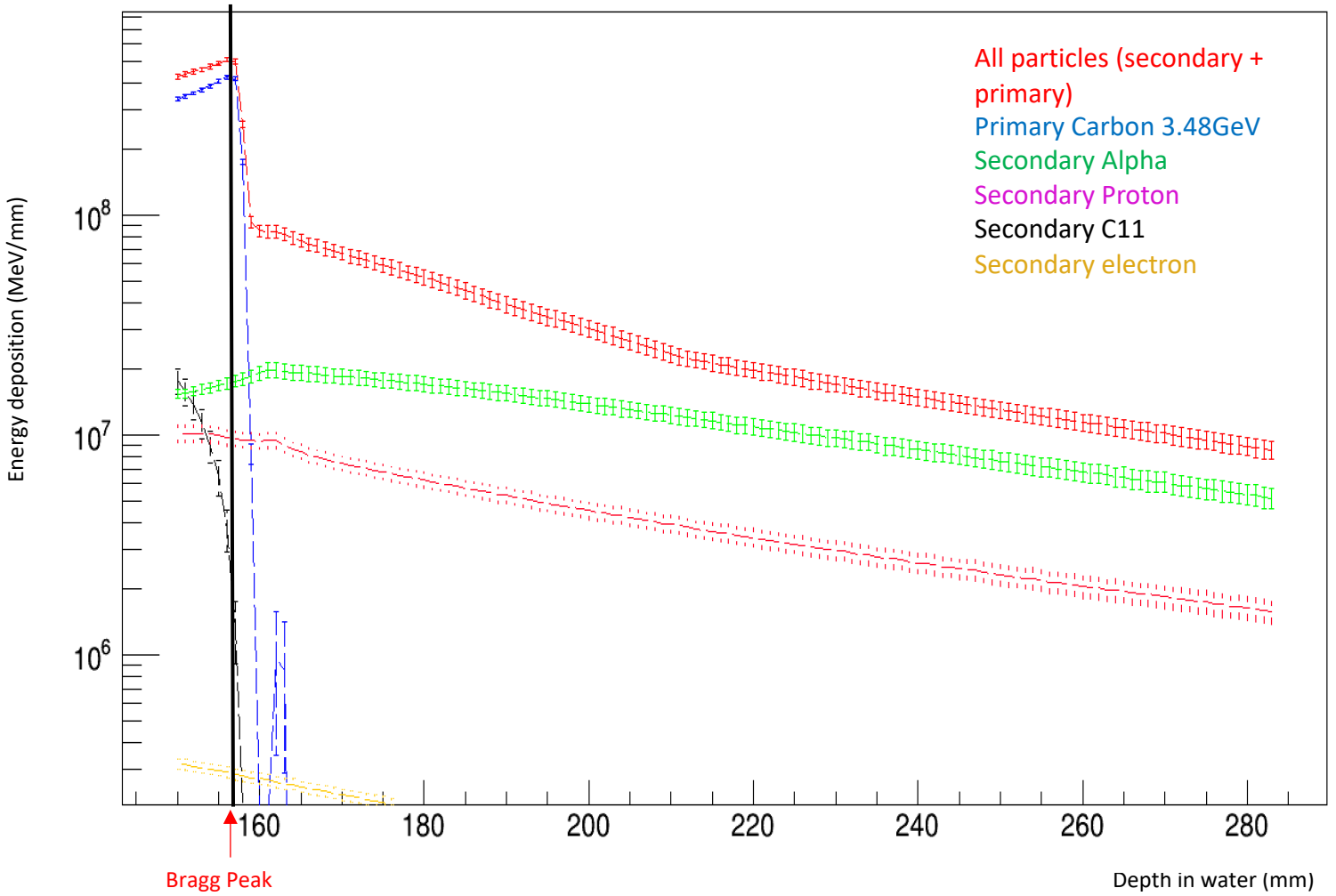




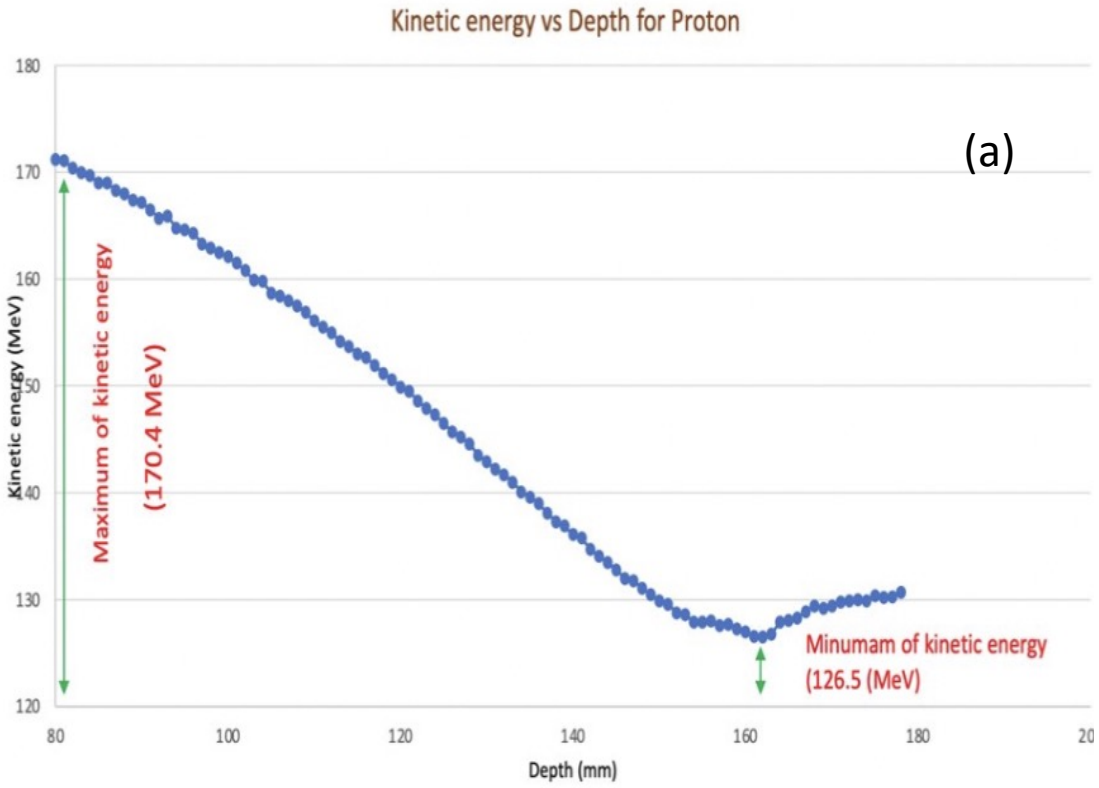
Depth vs Fluence of Carbon ion at *3.48 GeV*

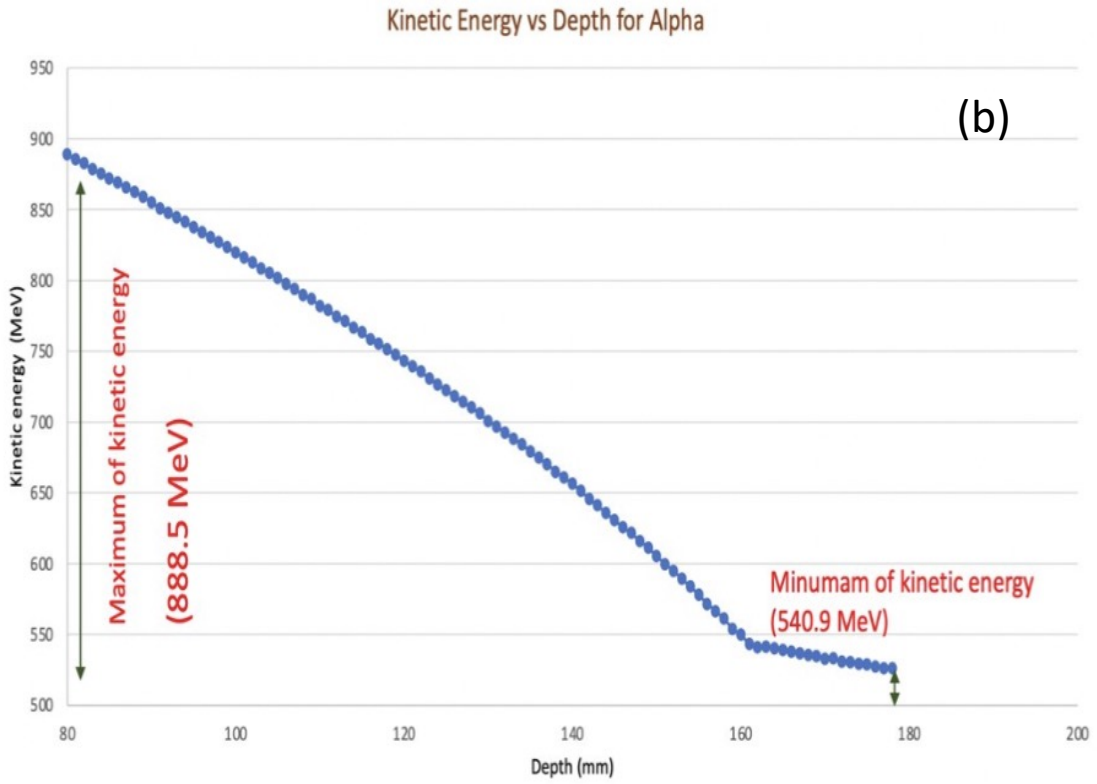
Secondary Particle Contributions

- Secondary alpha particles and protons have longer tail than the primary particle (carbon ion).
- Secondary particles (tails) appear until at ~ 280 mm.



Secondary Particle Contributions





Energy distribution due to secondary proton (a) and (b) secondary alpha from 3.48 GeV Carbon beam in water.

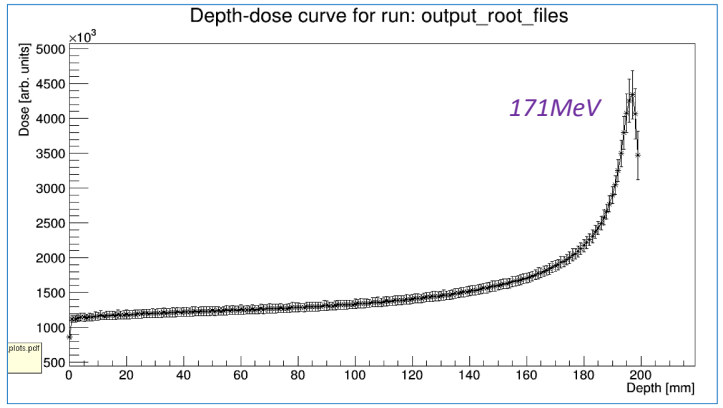
Secondary Particle Contributions

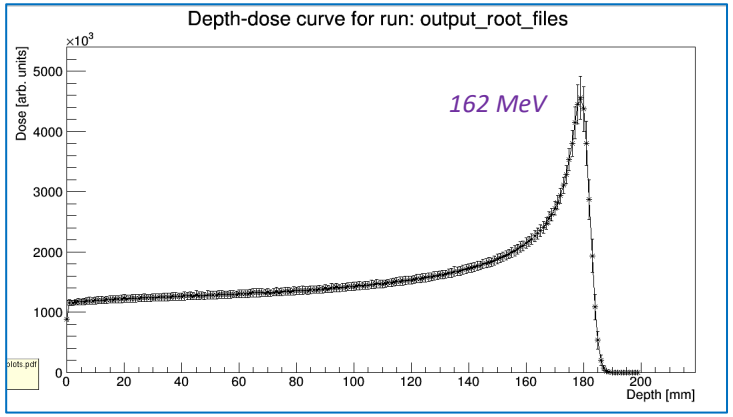
At different depth (50,100,155 mm) → From the simulation of carbon ion

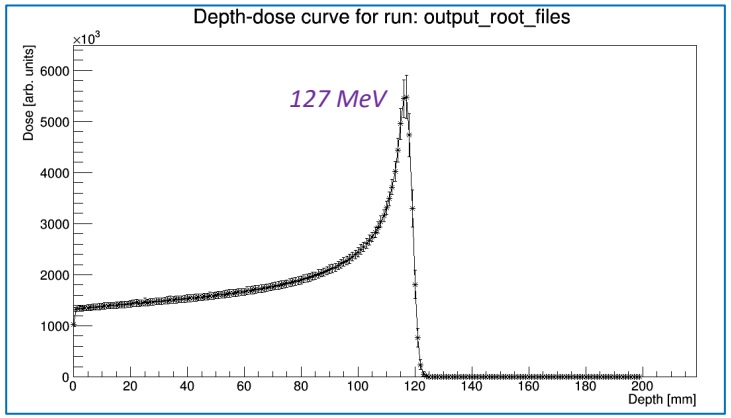
The secondary protons have been simulated at different energies (171,162 and 127 MeV) → Corresponding to carbon ion of 3.48 GeV

The Bragg Peaks of protons are respectively at (195,185 and 120 mm)

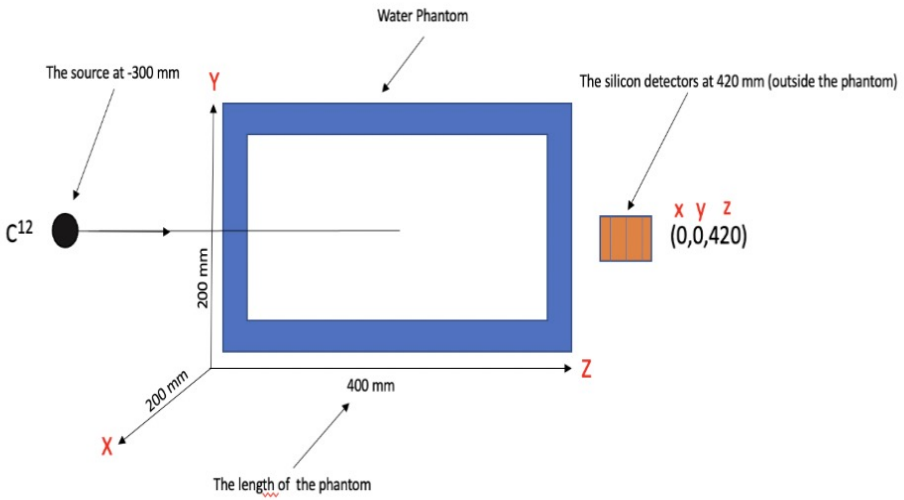
Bragg peaks of secondary proton for (171,162 MeV) → After Bragg peak of Carbon beam

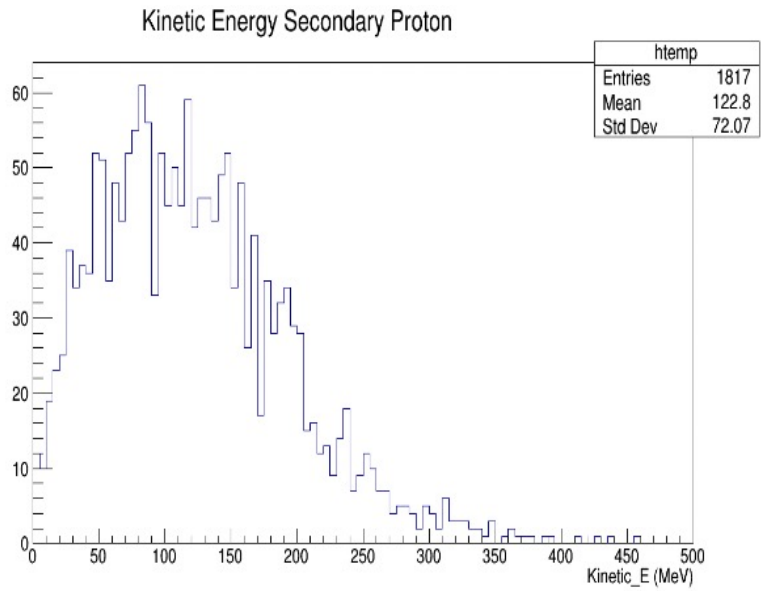


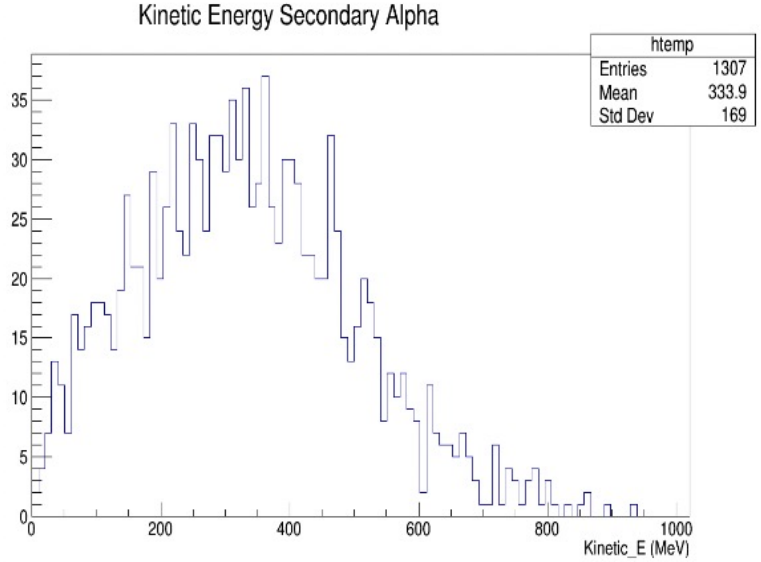




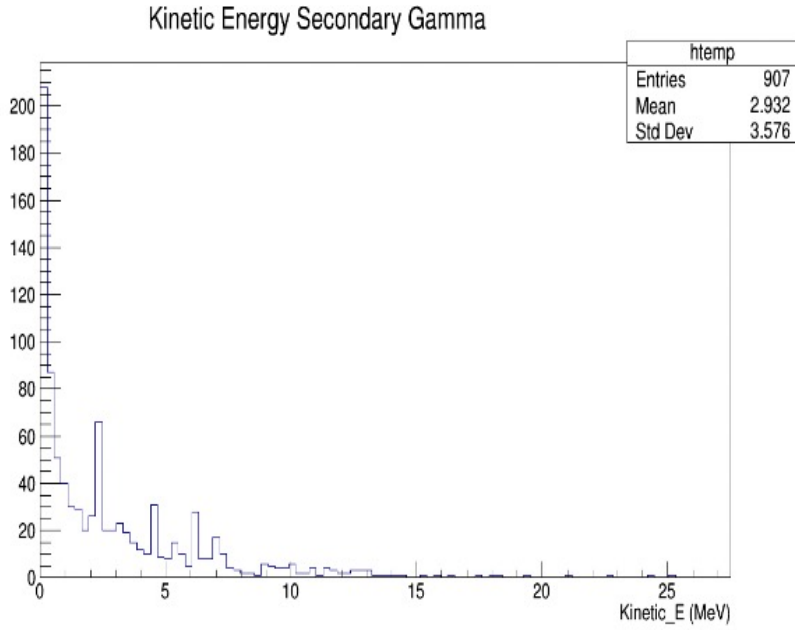
Secondary Particle Contributions

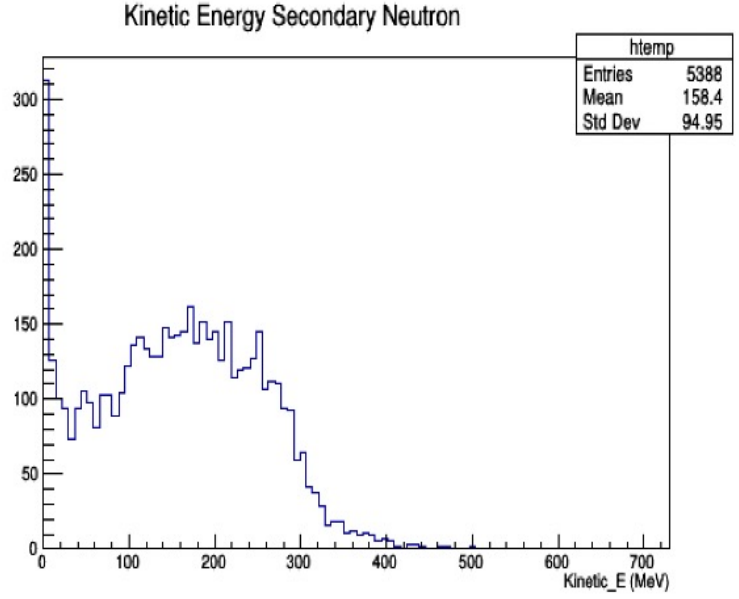






particle	Entries	Kinetic Energy
Proton	1817	122.8
Alpha	1307	333.9
Gamma	907	2.932
Neutron	5388	158.4





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’

References:

[1] Tordis Johnsen Dahle. “Studies of the Relative Biological Effectiveness and Biological Dose in Proton and Carbon Ion Therapy”. In: (2020)

[2] Sea Agostinelli et al. “GEANT4—a simulation toolkit”. In: Nuclear instruments and methods in physics research section A: Accelerators, Spectrometers, Detectors and Associated Equipment 506.3 (2003), pp. 250–303.

Thank you!

Any questions?