Fragmentation of 120 and 200 MeV/u ^{4}He in water

M. Rovituso *[1], *C. Schuy*[1], *R. Pleskac*[1], *D. Izraeli*[2], *E. Piasetzky*[2], *M. Krämer*[1], *and M. Durante*[1]
[1]GSI, Darmstadt, Germany; [2]Tel Aviv University, Israel

At present there is a growing interest for cancer therapy using fast Helium ions for the treatment of specific types of tumors. In the late 1960s Lawrence Berkley Laboratory (LBL) introduced radiation therapy with helium ions in patients with metastatic carcinoma [1] . By December 2012 more than 2000 patients with different cancer types have been treated [2].

The therapeutic benefits of using helium beams are lower projectile fragmentation compared to heavier ions like carbon, a sharper lateral beam profile and higher RBE compared to protons. Therefore helium seems to be a good candidate for tumor therapy, particularly suitable for the treatment of pediatric patients.

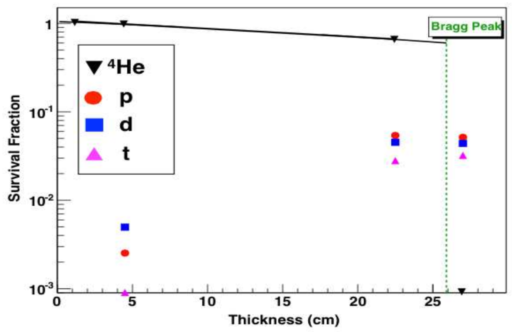

Figure 1: Measured attenuation and fragment buildup of 200 MeV/u ^{4}He in water (preliminary results).

In the present work the attenuation of the primary beam and buildup of fragments were measured as well as their angular and kinetic energy distribution. The measurements were performed in the QS cave of HIT, Heidelberg, with 120 and 200 MeV/u ^{4}He beams impinging on a water target.

The experimental setup was composed of two plastic scintillators of 1 and 9 mm thickness (respectively named START and VETO) and a 14 cm long barium fluoride scintillator (BaF_2). The START detector monitors and counts the incident primary ions, whereas VETO and BaF_2 are used as a ΔE - E telescope for particle identification after the target. Kinetic energy spectra are obtained by using the inverse Time-Of-Flight (TOF) technique [3] between START and BaF_2.

The absorption of primary helium ions as a function of water depth was studied by comparing the amount of incident ions impinging on the water target to the number of

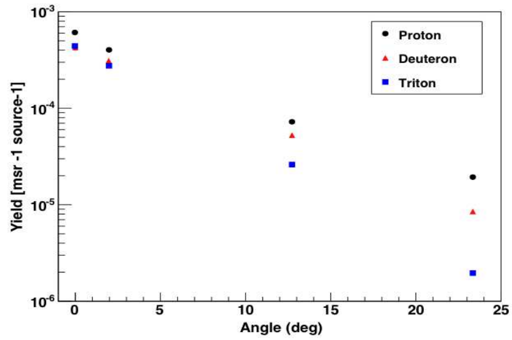

Figure 2: Angular distribution of protons, deuterons and tritons from 120 MeV/u ^{4}He impinging 4.5 cm of water (preliminary results).

outgoing helium ions after the target. The survaving fraction versus the thickness of the water target is presented in Fig. 1. While the number of helium ions is decreasing with increasing target thickness due to nuclear fragmentation processes, the number of fragments is increasing (buildup of protons, deuterons and tritons). The fraction of primary ions reaching the Bragg peak position is approximately 65%. An example of the measured angular distributions of hydrogen isotopes is presented in Fig. 2. The produced fragments are forward peaked and show a broad distribution which reaches angles of more than 25 degrees. The proton yield is higher than the one of deuterons and tritons, especially at larger angles. This can be attributed to the isotropic distribution caused by evaporation following the nuclear reaction.

Acknowledgments

I would like to thanks Dr. Thomas Haberer who offers all the needed beam time and to the ”accelerator's guys” for their great job. A special thanks to Dr. Stephan Brons for his support, availability and kindness. A big thanks to Dr. Dieter Schardt, his collaboration is always precious for us.

References

[1] J. R. Castro et al., ”Clinical results in heavy particle radiotherapy”, Annual Report 1980, Lawrence Berkley Laboratory

[2] M. Jermann, ”Particle therapy statistics in 2013”, Int. J. Part. Ther. 2014, 1, 40-43

[3] K. Gunzert-Marx, ”Nachweis leichter Fragmente aus Schwerionenreaktionen mit einem BaF_2-Teleskop-Detektor”, PhD Thesis, TU of Darmstadt, 2004.

* Work supported by HGS-HIRe.

DOI:10.15120/GR-2015-1-APPA-HEALTH-12