Contribution ID: **21** Type: **not specified**

Design of DTL for acceleration of ions with charge-to-mass ratio of 1/2 with a potential production of radioisotopes

Background and Aims

Radio-frequency linear accelerators (LINACS) are used as the first stage of particle acceleration for injection into a synchrotron. Ion accelerator complexes have found a crucial place in the medical field for cancer treatment. In that field, LINAC design requirements are very strict concerning their dimension, but at the same time, they need to be able to accelerate various particle types with different charge-to-mass ratios. On the other hand, in the last few decades, there is a growing interest in the use of alpha-emitting radioisotopes for target therapies in nuclear medicine, such as Astatine-211 (211At). It has been shown that such radioisotopes could be more efficiently produced with linear accelerators compared to conventional cyclotron-based methods.

In this study, the initial results of the Drifting Tube LINAC (DTL) design for the acceleration of ions with q/m=1 and q/m=1/2 have been reported for the use of the injection into the synchrotron and potential production of radioisotopes.

This study has been done under WP7.4 of HITRIplus project –Linac Injector Design (Advanced conceptual design of an optimized linac injector for multiple ions at 10 MeV/u).

Methods

Following WP7.4 of the HITRIplus project, the main design requirements for efficient LINAC structure in medical facilities have been identified in terms of its length, output energy, and type of accelerated particles. Additional design constraints have been considered for fixed parameters such as operational frequency and input energy.

To accomplish mentioned design requirements, the four possible cases (each with two separate tanks of DTL structure) have been considered with different output energy of the first tank and the type of possible particles which can be accelerated per tank.

As input parameters, the geometry of both tanks in each case has been used and the corresponding EM field distribution has been simulated using Poisson Superfish codes. From simulation results, the accelerator output parameters (e.g. tanks output energies, total DTL length, and all accelerator's figure of merits) have been extracted for the intercomparison of the four proposed DTL structures. Validation of the proposed simulation workflow has been done by benchmarking output parameters of each DTL case with a well-known LINAC structure: LINAC4. Mentioned DTL structure parameters have been evaluated against initial design requirements.

Conclusions

Four possible DTL structures have been developed for the acceleration of particles of charge-to-mass equal to 1 and 1/2, or just for 1/2, with capabilities for the potential production of radioisotopes. Following the accelerator's output parameters for each of the structures and initial requirements, the most favorable DTL structure has been chosen as one of the possible candidates for injector linac for the WP7.4 HITRIplus project.

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