95MeV/u ^{12}C nuclear fragmentation measurements on thin targets for hadrontherapy

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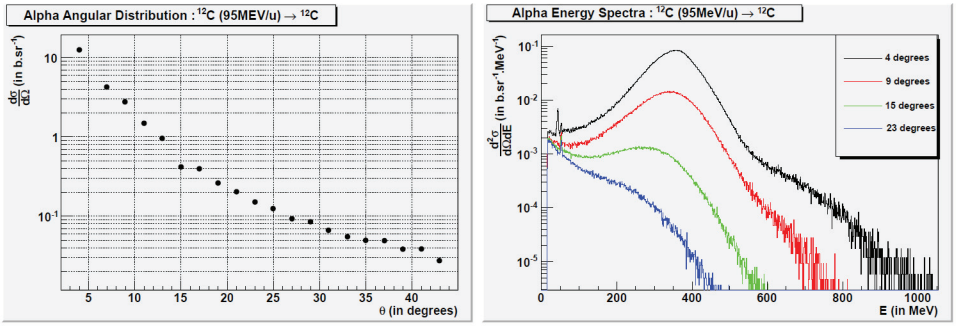
To keep the benefits of the use of carbon ions in radiation therapy, a very high accuracy on the dose location is required. A part of the uncertainties on the dose deposition rely on the fragmentation of the ion along its path in the patient (fragmentation tails behind the tumor, RBE fluctuation in depth). Up to now, the simulation codes are not able to reproduce the fragmentation process with the required accuracy for clinical treatments. The constraints on nuclear models and fragmentation cross sections in the energy range used in hadrontherapy (30 to 400MeV/u) are not yet sufficient.

A first experiment, on thick water equivalent targets has been performed on May 2008 at GANIL. The goals were the measurements of energy and angular distributions of the fragments coming from the nuclear reaction between 95MeV/u ^{12}C and thick PMMA targets. Comparisons between experimental data and Geant4 simulations (BIC, QMD, INCL) show discrepancies up to one order of magnitude for production rates. The shapes of the angular and energy distributions are also not well reproduced.

To improve the models and reach the precision required for a reference simulation code for hadrontherapy, a second experiment has been performed on thin targets on May 2011 at GANIL. The experimental set-up included five three stages ΔE-E telescopes composed of two Si detectors (thickness: 150µm and 1mm) and one CsI scintillator (thickness: 10cm). These telescopes were mounted on rotating stages to cover angles from 0 to 45°. We have measured the double differential cross section ($\frac{\partial^2\sigma}{\partial E\,\partial\Omega}$) of fragments resulting of the nuclear reaction from 95MeV/u ^{12}C ions with thin targets (C; CH_2; Ti; Al; Al_2O_3). The data of this experiment are still under analysis but the energy calibration of the detectors and the identification of the fragments have been achieved. As shown in the figures for the ^{4}He particles, the first results of fragments production (from proton to carbon) on the carbon targets are already available. The double differential cross sections for the other targets will be soon available. The experimental setup and the results for the different targets will be presented.



(a) ^4He angular distribution (b) ^4He energy spectra at five different angles.

Fig.1: Preliminary results for the reaction ^{12}C(95MeV/u) → ^{12}C.

Comparisons with Geant4 simulations will be achieved in order to evaluate the accuracy of the nuclear reaction models (BIC, QMD...) included in the Geant4 toolkit for hadrontherapy purposes.