Dosimetric studies for the irradiation of biological samples with protons at the 3 MV Tandem accelerator (National Centre of Accelerators, Seville)

1 National Centre of Accelerators (CNA), 41092 Seville, Spain.
2 GSI Helmholtz Centre for Heavy Ion Research, 64291 Darmstadt, Germany.
3 Department of Atomic, Molecular and Nuclear Physics (FAMN), University of Seville, 41012 Seville, Spain.
4 University Hospital San Cecilio, 18012 Granada, Spain.
5 University of Granada, 18012 Granada, Spain.
6 University Hospital Virgen Macarena, 41009 Seville, Spain.

Abstract

The study of the DNA damage due to ionizing radiation is of great interest for the scientific community. In order to understand the correlation between the exposure to different kinds of radiation (with different values of linear energy transfer, LET) and the DNA damage produced, many studies have been carried out. Here we present the modifications carried out on the Basic Nuclear Physics beam line at the 3MV Tandem accelerator installed at the National Centre of Accelerators (CNA) in Seville, Spain, in order to perform dosimetry studies and cell culture irradiation with low energy proton beams. An important goal of this work is to provide proton beams with sufficiently low and homogeneous intensity in a wide area, in order to assure a uniform dose delivery onto the whole cell sample surface.

Experimental techniques:

- Beam line at 30 degrees after the switching magnet of the 3MV Tandem accelerator at CNA.
- Au target of 5.4 mg/cm² thickness to scatter and obtain a homogenous beam profile onto the cell samples.
- Kaption window (diameter of 44mm and thickness of 10µm).
- Ionization chamber (IC) with two air gaps of 6.5mm and Vc=400V. With this IC calibrated, the delivered dose can be monitored directly in front of the biological samples.
- After going thorough the IC, the protons continue towards a movable sample holder with six irradiation positions.

Beam line scheme:

Experimental techniques:

- Beam line at 30 degrees after the switching magnet of the 3MV Tandem accelerator at CNA.
- Au target of 5.4 mg/cm² thickness to scatter and obtain a homogenous beam profile onto the cell samples.
- Kaption window (diameter of 44mm and thickness of 10µm).
- Ionization chamber (IC) with two air gaps of 6.5mm and Vc=400V. With this IC calibrated, the delivered dose can be monitored directly in front of the biological samples.
- After going thorough the IC, the protons continue towards a movable sample holder with six irradiation positions.

Beam diagnostics with Gafchromic EBT3 films

RadioChromic film calibration for absolute dose quantification

Radiochromic films analysis: scanner and calibration

RadioChromic films are calibrated for absolute dose measurements when irradiated by photons

IC dosimetry

- The fluence F of the protons in front of the biological samples is proportional to the change output of the chamber and can be determined from the calculated energy loss in the two air gaps.
- The dose deposited at a given depth in the sample is proportional to the fluence F and the specific energy loss dE/dx (1).

Dose results: film vs Ionization Chamber

Cell sample irradiation: preliminary results

NCT-7 line of human breast cancer in the medium of the culture

Conclusions and perspectives

- A homogenous and flat beam profile achieved by using a gold target for scattering (5.4mg/cm²);
- Calibration of the Gafchromic EBT3 film response in absolute dose for protons in the plateau region of the Bragg curve;
- First irradiations of cell cultures were performed.

Further steps:

- Irradiation and analysis of further biological samples;
- Calibration in dose of the EBT3 films for higher LET conditions (as it happens when the Bragg peak is placed at the active layer);
- Dosimetric analysis and irradiation of cells in the region of the Bragg peak (RBE study).

Bibliography