Proton irradiation of cancer cells at the 3MV Tandem Accelerator (National Centre of Accelerators, Seville)

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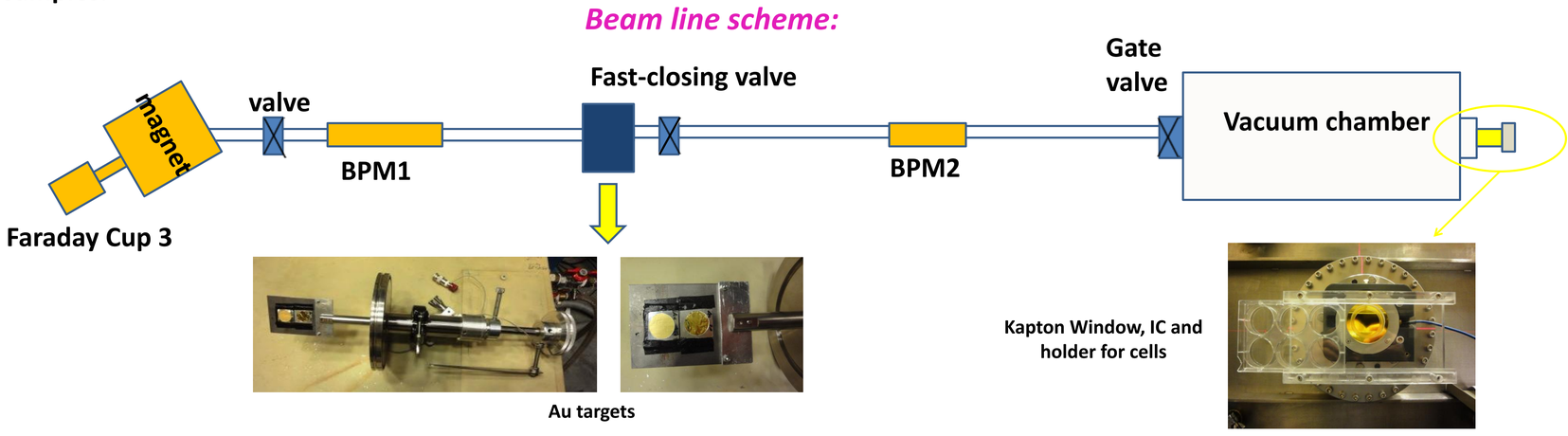
Abstract

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, as well as the work that we carried out in order to optimize the proton beam profile for the first breast cancer cell irradiation at CNA. An important goal of this work is to provide a proton beam with low and homogeneous intensity in a wide area, in order to assure a uniform dose delivery onto the whole cell sample surface.

Experimental beam line setup:

- Basic Nuclear Physics beam line 30 degrees at exit of the 3MV Tandem accelerator at CNA.
- Two Au targets (2.0 mg/cm^2 and 5.4 mg/cm^2) to scatter and obtain a homogenous beam profile onto the cell samples.
- Kapton window (diameter of 44mm and thickness of 50µm).
- Ionization chamber (IC) with two air gaps of 6.5mm and V_{IC}=400V. With this IC calibrated, the absorbed dose on the cells can be known and controlled.
- Plexiglass holder for biological samples.

Beam line scheme:



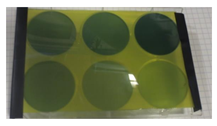
Au targets

Kapton Window, IC and holder for cells

Picture of the beam line

Beam diagnostics: profile and energy

RadioChromic film: beam profile monitor

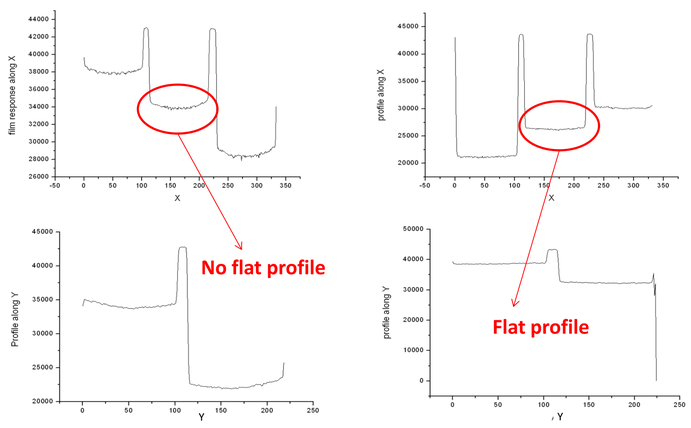


EBT3 radiochromic film. *Left:* irradiated film with different doses; *right:* transversal section of the EBT3

Characteristics:

- Direct coloration by the absorption of energetic radiation
- No chemical, thermal or optical development.
- Radiochromic reaction: solid-state polymerization, where the film turns blue proportionally to radiation dose

Au target of 2.0 mg/cm^2 Au target of 5.4 mg/cm^2

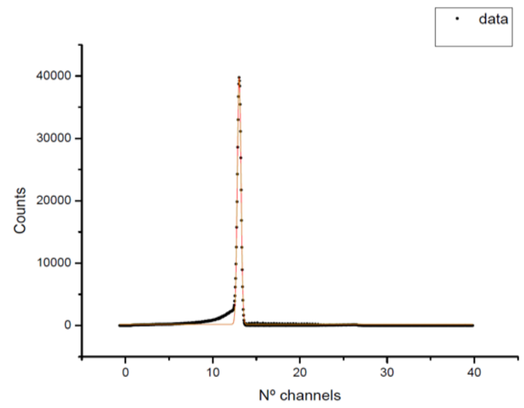


Proton beam profile after the two scatter targets along x and y directions

Silicon detector: energy of the beam

- 500 µm Si detector
- Triple alpha source (^{239}Pu, ^{241} Am, ^{244} Cm) for energy calibration
- OMDAQ acquisition system

Proton beam energy incident onto the cells:
Ep = 3.645 ± 0.045 MeV

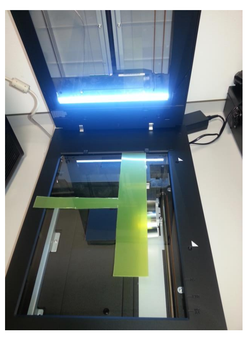


Proton beam spectrum. Because of the current delivered by the accelerator, in order to not saturate the Si detector, a 1mm thick copper plate with a hole of 0.5 mm was placed in front of the detector active surface

Dose measurements

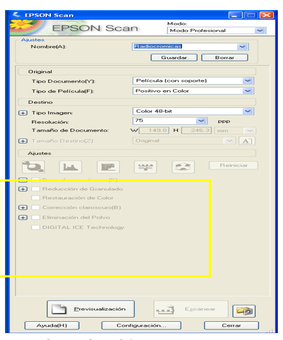
RadioChromic film calibration for absolute dose quantification

Radiochrominc films analysis: scanner and calibration



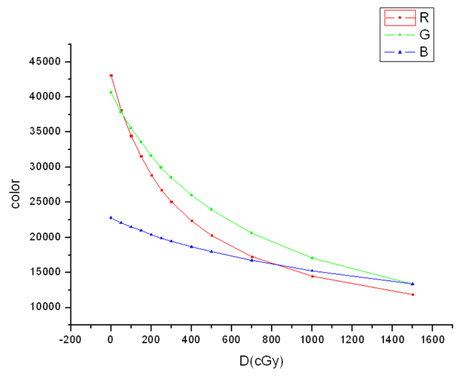
EPSON scanner

No colour corrections activated



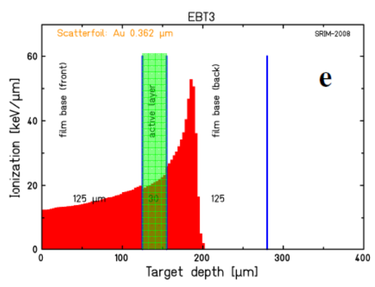
PC interface for film image acquisition

Scanner response for films irradiated by photons produced by a clinical Linac



Under the condition of a source to surface distance (100cm) and 1.5 cm of solid water above the film, **100MU** delivered by the Linac correspond to **100cGy**

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



For energies below the Bragg peak , the dose calibration with photons, in a first preliminary approach, is also valid for protons

A first cell culture irradiation

Breast cancer cells in culture medium

Cells irradiated with energies below the Bragg peak

Confocal microscope analysis

Vertical cuts (step of 15 nm, cell thickness 7-10 µm)

GOAL: to study the damage produced in the cell nuclei at different depths

Bibliography

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(4) D. Guirado et al. "Low dose radiation hyper-radiosensitivity in multicellular tumour spheroids", The British Journal of radiology, 85, 1398-1342, 2012