



Contribution ID: 54

Type: **Poster presentation**

Irradiation of cell cultures with laser-generated protons and X-rays

Laser-based particle sources allow for investigating biological effects of radiation at high instantaneous dose rates. We have run two experiments including the irradiation of monolayer cell cultures at total dose values of 3-12 Gy.

The first one, at the Laser Laboratory for Acceleration and Applications (L2A2), makes use of an X-ray source driven by a 35 fs pulsed laser with 1 mJ pulse energy at 1 kHz shot rate which is focalized on a rotating copper plate to generate bremsstrahlung up to some tens of keV. This radiation has been applied to 36 cell samples with a mean dose rate of about 100 mGy/s. An ionization chamber has been implemented for real-time flux control.

At the VEGA-3 laser of CLPU (1 PW, 27 J at 1 Hz maximum pulse rate), a proton source developed by IGFAE has been combined with a magnetic energy selector from i3M to obtain a quasi-monoenergetic, 5 MeV beam which was guided through a thin vacuum window. Here, 27 cell samples have been exposed to proton pulses at a single-shot dose of about 150 mGy.

The same human lung adenocarcinoma cell line (A549) has been employed in the two campaigns. Biological samples were prepared by local collaborators (IDIS, IBFG) and analysed in terms of colony formation, cell proliferation, and the quantification of DNA double-strand breaks. Comparative data have been obtained with X-rays from a clinical, 6 MV linac.

We present the development and characterization of the radiation sources, their performance during the irradiation process, practical aspects of sample manipulation, and the results of the biological essays.

Funded by Generalitat Valenciana, ref. CIAICO/2022/008, and CLPU, experiment 00562-0101. Supported by the Government of Castilla y León, ref. CLP263P20, co-financed with FEDER funds.

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Session Classification: Poster Session