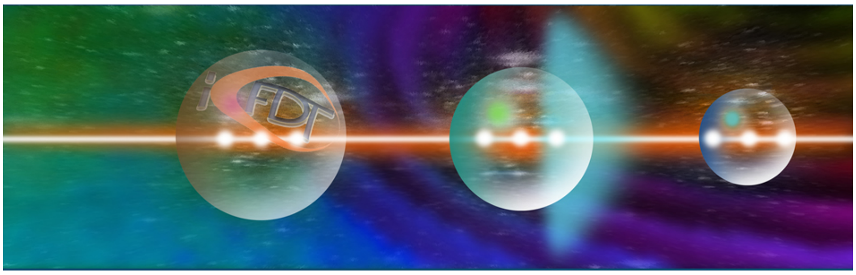

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Colour centres in lithium fluoride crystals for Bragg-curve imaging of low-energy proton beams by fluorescence microscopy

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Recently, novel solid-state radiation detectors, based on the photoluminescence of stable point defects in lithium fluoride (LiF) crystals, have been used for advanced diagnostics of the segment up to 27 MeV of the TOP-IMPLART proton linear accelerator for protontherapy applications, under development at ENEA C.R. Frascati.
Due to the peculiar particle-matter interactions, in the LiF crystals low-energy proton beams generate a spatial distribution of aggregate F2 and F3+ color centers, whose efficient red-green photoluminescence is emitted in the visible spectral range. It was found that their visible emission is proportional to the proton fluence. After irradiation, the stored latent information was acquired as an optical PL image by a fluorescence microscope under blue-light excitation and the signal intensity resulted to be locally proportional to the energy deposited by low-energy protons in a wide interval of dose.
By mounting the LiF crystals in two different irradiation geometries, the wide PL dynamic range, combined with the high intrinsic spatial resolution, allowed obtaining two-dimensional (2D) images of both the beam transverse intensity distribution and of the overall Bragg curves, each one in a single exposure, directly performed in air.
The versatility offered by the optical fluorescence microscope allows acquiring well resolved energy depth profiles in different portions of the beam, in order to clearly identify the Bragg peak positions and their intensity ratios: the estimation of the proton beam energy components was derived on the basis of the free Montecarlo simulation software SRIM (the Stopping and Range of Ions in Matter) for different operating conditions of the accelerator and successfully compared with its dynamical behavior.
In the case of mono-energetic proton beams, the full Bragg curves were reconstructed by taking into account finite proton energy bandwidth and saturation of defects concentration.
Taking into account that these passive LiF detectors are easy to handle, as insensitive to ambient light and no development process is needed, the results are encouraging for a full three-dimensional (3D) reconstruction of the energy deposited by proton beams in matter.

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