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Proton Therapy - Bragg Peak monitoring through Prompt-Gamma: Detection and Instrumentation

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Radiotherapy, one of the techniques used to treat cancer, can be divided into conventional (gamma and electrons) and particle or ion beam therapy. The latter, realized mainly with protons or carbon nuclei, has been highly anticipated due to its dose deposition profile with a monoenergetic beam characterized by a high deposition region at a particular depth - the Bragg Peak.
Dose deposition profile affects the risk to the surrounding healthy tissues and the existence of a Bragg Peak allows to increase the dose in the target region, whilst minimizing the dose to surrounding healthy tissues, reducing the risk of the technique.
There are advantages and disadvantages in the use of protons or carbon nuclei. The lateral spreading and straggling are more influent in lighter ions, such as protons, but in heavier ions, like carbon, we have a high Linear Energy Transfer (LET) which does more biological damage. Also, we see the presence of a tail after the Bragg Peak due to nuclear interactions which cause fragmentation. For that reason, we need better shielding and technical components in the hardware used in those treatments, which increases the final price when using heavy ions in this type of therapy.
In a typical treatment with this kind of therapy, a multienergetic beam is used and we will have a Spread-Out Bragg Peak (SOBP) instead of the typical Bragg Peak. The control and monitoring of the Bragg Peak location can further increase the precision of the treatment. One way to perform this monitoring is to measure the prompt-gamma detected perpendicular to the incident proton beam. The prompt-gamma detection in the orthogonal direction to the proton beam allows a more precise determination of the position of the Bragg Peak. For that purpose, a detector with a GSO scintillator crystal connected to a SiPM is being studied. A set of blades in front of the sensor will act as a collimator to ensure that only perpendicular photons to the sensor are detected. Currently SiPM coupled to GSO crystals time and amplitude response are being studied to design a data acquisition (DAQ) for the full prototype with a number of sensors in the order of magnitude of 100.

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