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Slim-edge and non-uniformly irradiated 3D silicon pixel detectors for forward physics experiments

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The ATLAS Forward Physics (AFP) project plans to install 3D silicon pixel detectors 210 m away from the interaction point and very close to the beamline at a radius of about 2-3 mm. This implies the need of slim edges in the order of 100 µm for the sensor side facing the beam to minimise the dead area. Another challenge is an expected non-uniform irradiation of the pixel sensors with high radiation levels of about 5e15 neq/cm2 for the detector edge close to the beam and orders of magnitude lower radiation levels for the detector part away from the beam.

To study if these requirements can be met using slightly-modified IBL FE-I4 3D pixel sensors, standard IBL devices are diced to obtain slim edges and are irradiated with 23 MeV protons non-uniformly through an Aluminium mask. The performance was studied with test beams and source scans. The efficiency in the irradiated region was found to be similar to the one in the non-irradiated region except for the transition area between both, where a much lower efficiency was seen. A follow-up study for a position-resolved fluence monitoring was set up to check whether this effect can be explained by a possibly higher effective fluence at the edge of the Aluminium mask.

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