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Proton Hardness Factor at the Bonn Cyclotron Irradiation Site

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The proton irradiation site at the Bonn Isochronous Cyclotron is in operation since 2021.
The accelerator typically provides a 14 MeV (˜12.5 MeV on DUT) proton beam with a few mm width and currents of 1 μA and to the site.
DUTs are irradiated in a cooling box at < -20 ℃, mounted on a XY-motorstage, which is moved row-wise through the beam on a grid-like pattern.
Dedicated diagnostics enable online beam monitoring with relative uncertainties of a few %, allowing beam-driven irradiations,
resulting in highly-precise and uniform fluence distributions.
Cross-check measurements of the beam-based fluence determination method used in Bonn are compared to the typical (metallic) foil activation,
yielding consistent results while the beam-based method has an uncertainty of a few %.
Recent measurements of the proton hardness factor, using 150 μm thin, passive LFoundry sensors, yield a hardness factor of $\kappa = 3.74 \pm 0.12$,
agreeing with the previous value with significantly lower uncertainty. Implications of the low-energy protons on the measured hardness factor and
limitations for DUT irradiations in Bonn are discussed.

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