SUPPLEMENTARY MATERIAL

Sample preparation

The first set of samples are grown on commercially available 350 µm thick GaN substrates (Lumilog) of 2” using metal organic chemical vapour deposition (MOCVD) in an Aixtron 6 Closed Coupled Showerhead. A thin n-doped GaN buffer layer is first deposited followed by a 10 µm not-intentionally-doped (nid) layer of GaN. For the pin diodes, a p-doped GaN layer (0.5µm) followed by a 30 nm p+ GaN layer are added to the structure. An ohmic contact (Ti/Al/Ni/Au) is deposited on the back side and annealed at 750°C. For Schottky diodes, Pt/Au is deposited on top of the nid GaN layer. For pin diodes, Ni/Au is deposited on top the p+ layer and annealed at 500°C for 4 minutes.

The second set of samples are grown by MOCVD but on 2” sapphire substrates. After a 2µm GaN buffer layer, a n-doped GaN layer (4µm) is grown followed by a nid layer of GaN. We varied the thickness of the nid-layer L (layer L= 1µm, 2µm, 4µm, 10µm). For pin diodes; p and p+ GaN layers are added, as for the first set. The mesa is etched using a BCl3 Cl2 inductive coupled plasma (ICP-RIE) and an n contact (Ti/Al/Ni/Au) is deposited on the bottom of the mesa (n-GaN) and annealed at 750°C for 30 seconds. The p contact of (Ni/Au) is deposited on the top of the mesa for pin diodes and annealed at 500°C for 4 minutes. Pt/Au is used for Schottky diodes and is annealed at 300°C for 5 minutes.

The diodes presented in this work are square with dimensions of 800µm×800µm, but we also studied 300µm×300µm and 200µm×200µm.

After cleanroom processing the samples were cut and glued on carrier chips or on a PCB, and finally wired bonded with micrometric gold wires.

Proton beam and measurement details

The isochrone cyclotron delivers proton pulses with a duration of 7 ns and a frequency of 25 MHz (and thus a 40 ns bunch separation). The line provides protons with a fix energy of 64.8 MeV while the beam can be tuned to specific proton current densities between 10 nA/cm2 (without any diffuser) and 2fA/cm2(with a diffuser which broadens and homogenizes the beam). The proton beam without diffuser has a Gaussian shape with a width of about 4,2 mm in one direction, and a larger extension (1,5 cm) in the other direction, therefore a proton beam current of 100pA corresponds to current density of 132 pA/cm^2. During irradiation the diodes are positioned at the centre of the beam using a mechanical translation stage. The measured sample is in the air at room temperature and the diodes are connected to a Keithley 2450 Source-meter, which applies the bias and measures the current. During irradiation the Keithley and the connection cables are placed outside of the irradiation field and are shielded by blocks of PMMA to prevent signal noise and irradiation damage.

Table 1: Comparison of general characteristics of devices that are used in proton therapy centers for QA applications, and of devices that have been proposed in literature for dosimetry applications in proton beam lines. A main distinction is done in devices depending on the type of technology applied. Spatial resolution and time resolution are fundamental parameters when evaluating the performance of different dosimetry devices.

	TECHNOLOGY	SPACE RESOLUTION	TIME RESOLUTION	IN USE FOR QA	PROTON BEAM PROFILE
FARADAY CUPS	Faraday cups	No	Few µs	Yes	No
HYBRID MATERIAL SCINTILLATORS (US,2024)[1]	Scintillators (hybrid material) + photodiodes	35-40µm	1µs	Yes	Yes
PLASTIC SCINTILLATOR (EPFL, 2024)[2]	Plastic scintillator (PDMS) + CMOS	400µm	7 kHz (µs)	No	Yes
DIAMOND DIODES(INFN, 2024)[3,4]	Solide state detector (diamond)	0.0078 mm²	Tens of ns	No	Yes
SIC DIODES (2024, STLAB)[5,6]	Solide state detector (SiC)	1x1mm²	Few µs	No	Yes
SILICON STRIPS (PRIMA, INFN)[7–10]	Silicon strips + YAG:Ce scintillating calorimeter,	200µm	80 kHz (µs)	Yes	Yes
TIMEPIX3, SI(CERN)[11]	Solide state detector (Silicon)	55µm	Ns	No	Yes
GAN DIODES (THIS WORK)	solide state detector (GaN)	100 µm	150ms	No	Yes
GAFCHROMIC FILM EBT3 (ASHLAND)[12]	Film	25µm	Hours	Yes	Yes
MATRIXX PT/ONE (IBA)[13]	Ionization chambers array	7,6 mm	20 ms	Yes	No

LYNX (IBA)[14]	Si scintillators+CCD	500µm	Data not available	Yes	Yes
MYQA PHOENIX (IBA)[15]	Solide state detector - a-Si:H	200µm	Data not available	Yes	Yes

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15. https://www.iba-dosimetry.com/product/myqa-phoenix

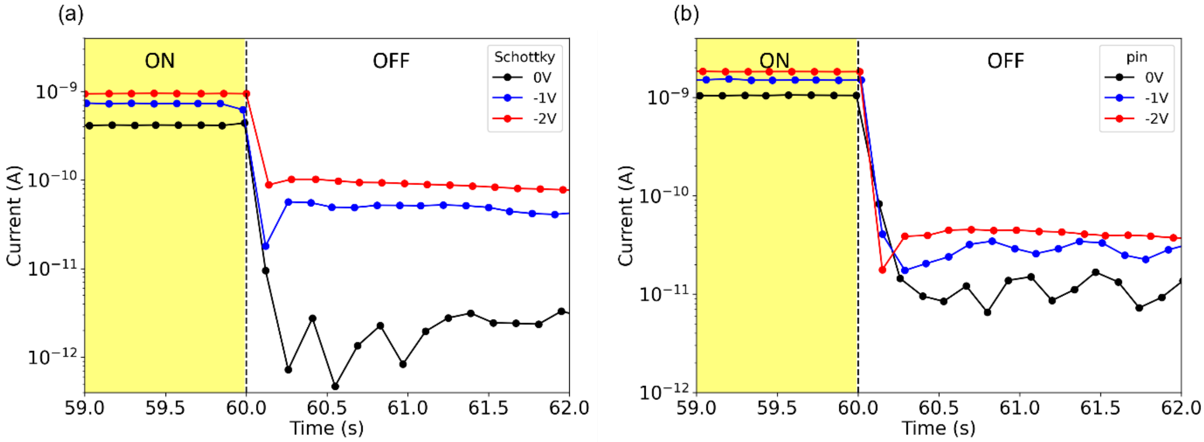

Figure S1: Detail of the time response transient shown in figure 2(c)-(d) for Schottky (a) and pin (b) diodes. The transient ON-OFF is limited by the experimental set-up and corresponds to 150ms.

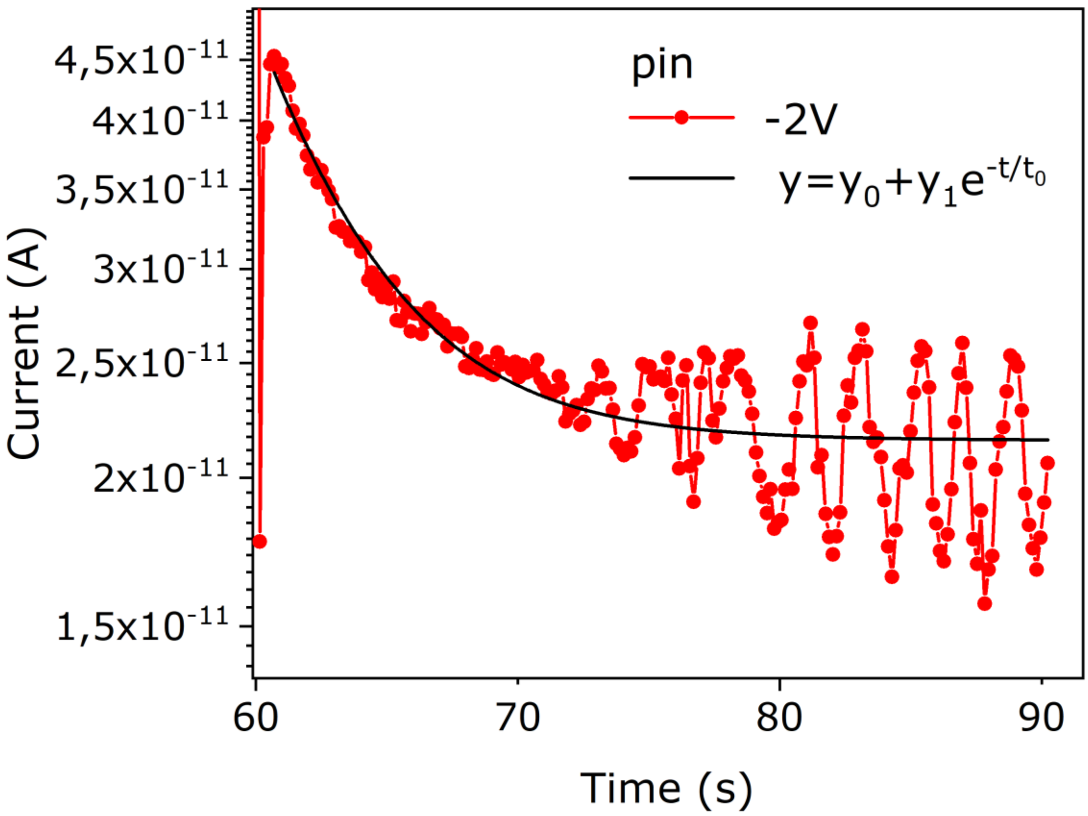

Figure S2: Exponential fit $y = y_0 + y_1e^{-t/t0}$ of the transient time of a pin GaN diode biased at -2V after the ON-OFF transient of 150ms during proton irradiation (64.8MeV, 132pA/cm²).

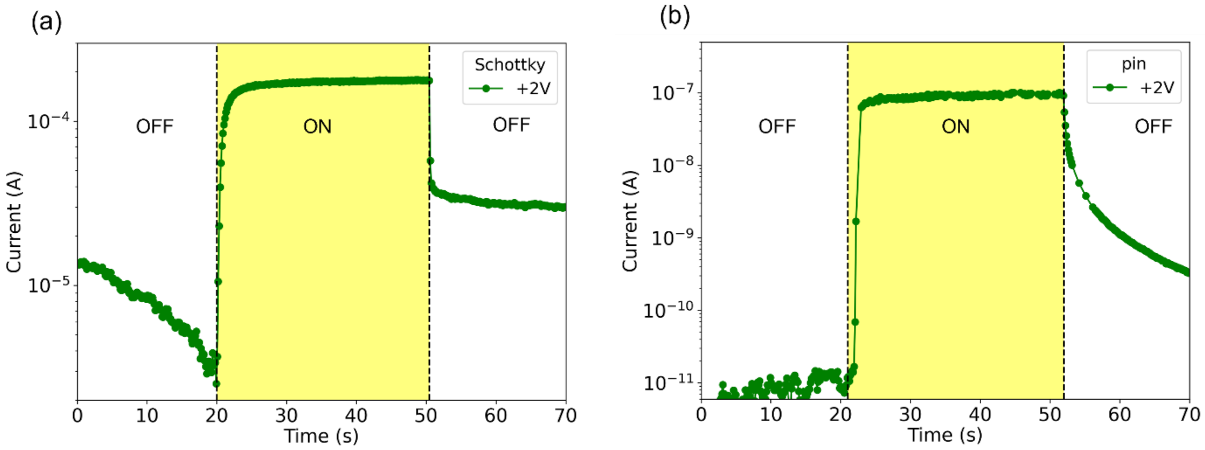

Figure S3: (a) Time response (Current in log scale) for Schottky diode on GaN in positive bias (2V). (b) Time response for pin diode on GaN in positive bias (2V).

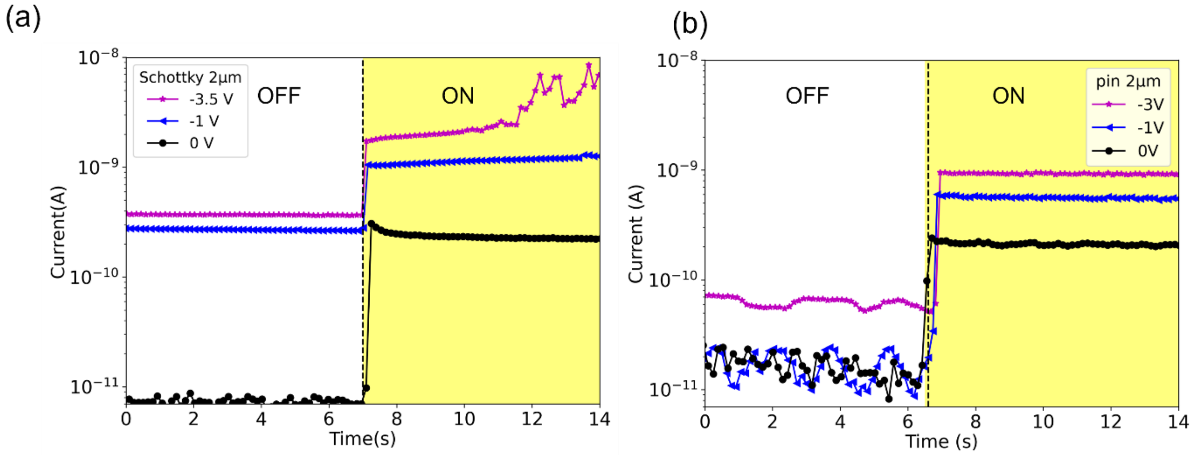

Figure S4: (a-b) Time response of a Schottky and pin diode ((a) and (b) respectively) on sapphire with an active region of 2µm. The response is measured at different biases and represented as a function of time. The beam is initially off and then turned on, the yellow area indicates when the proton beam is turned on (132 pA/cm²).

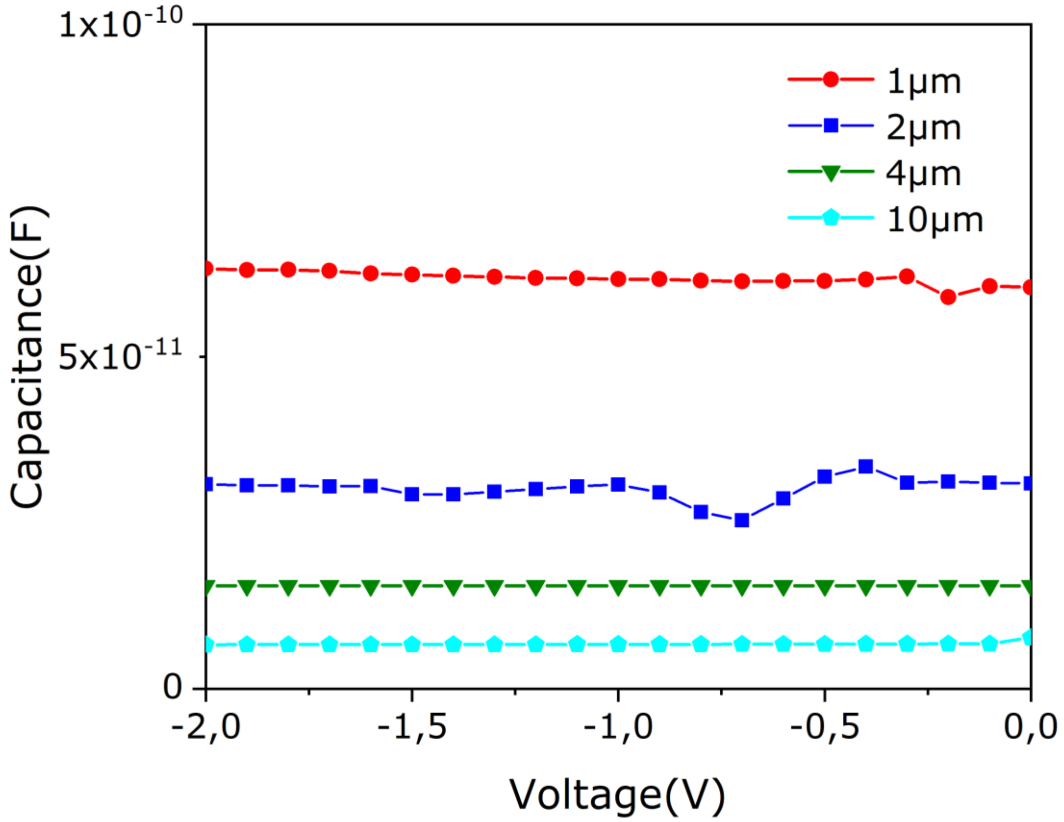

Figure S5: C-V measurement of GaN Schottky diodes on Sapphire at 20kHz, for the samples with different nid layer thicknesses, as reported in the legend. The Capacitance values at 0V are used for the calculation of the depletion layer thickness.