Commissioning and testing of the first IBA S2C2

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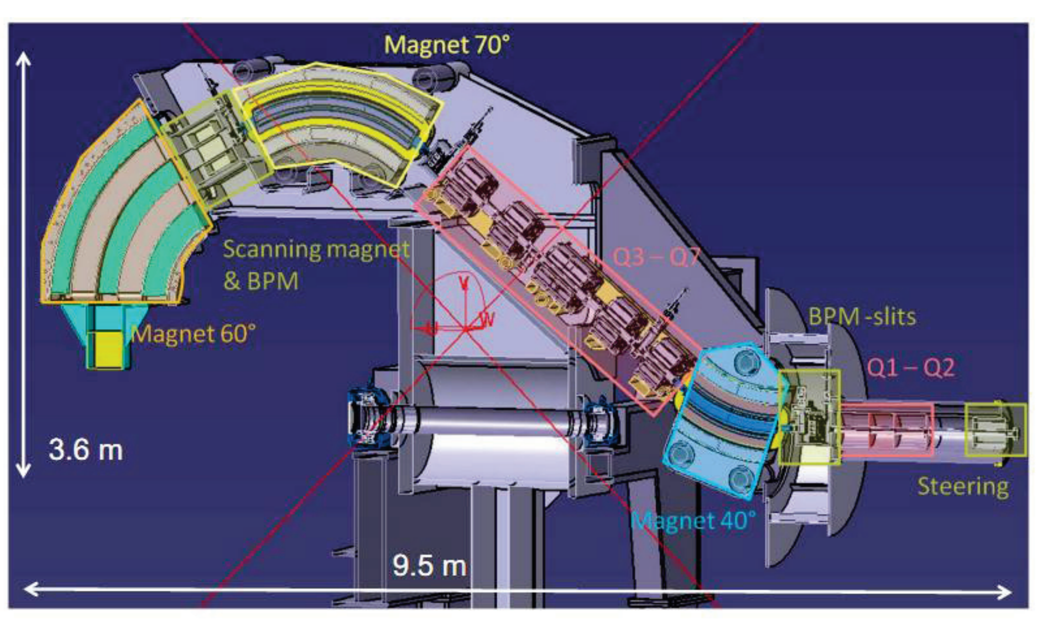
ABSTRACT

The first unit of the IBA superconducting synchrocyclotron (S2C2), used in the Proteus®ONE compact proton therapy solution, has been installed and commissioned in Nice.
In this communication, we will present some selected results of the commissioning with the main focus on the accelerator aspects, showing the influence of machine parameters on beam properties like stability, energy and intensity, which are key elements in proton therapy applications.

Proteus®ONE LAYOUT

Fig. 1 : The S2C2 in the test facilities in Louvain-la-Neuve (Belgium) and a schematic layout of the attached Proteus®ONE gantry system.



Nominal beam energy	230 MeV
Max clinical charge at isocenter	4.5 pC
Energy spread at nominal beam energy	~400 keV
Pulse repetition rate	1000 Hz
Pulse duration	~10 µs
RF frequency range	60–90 MHz

S2C2 TIMING

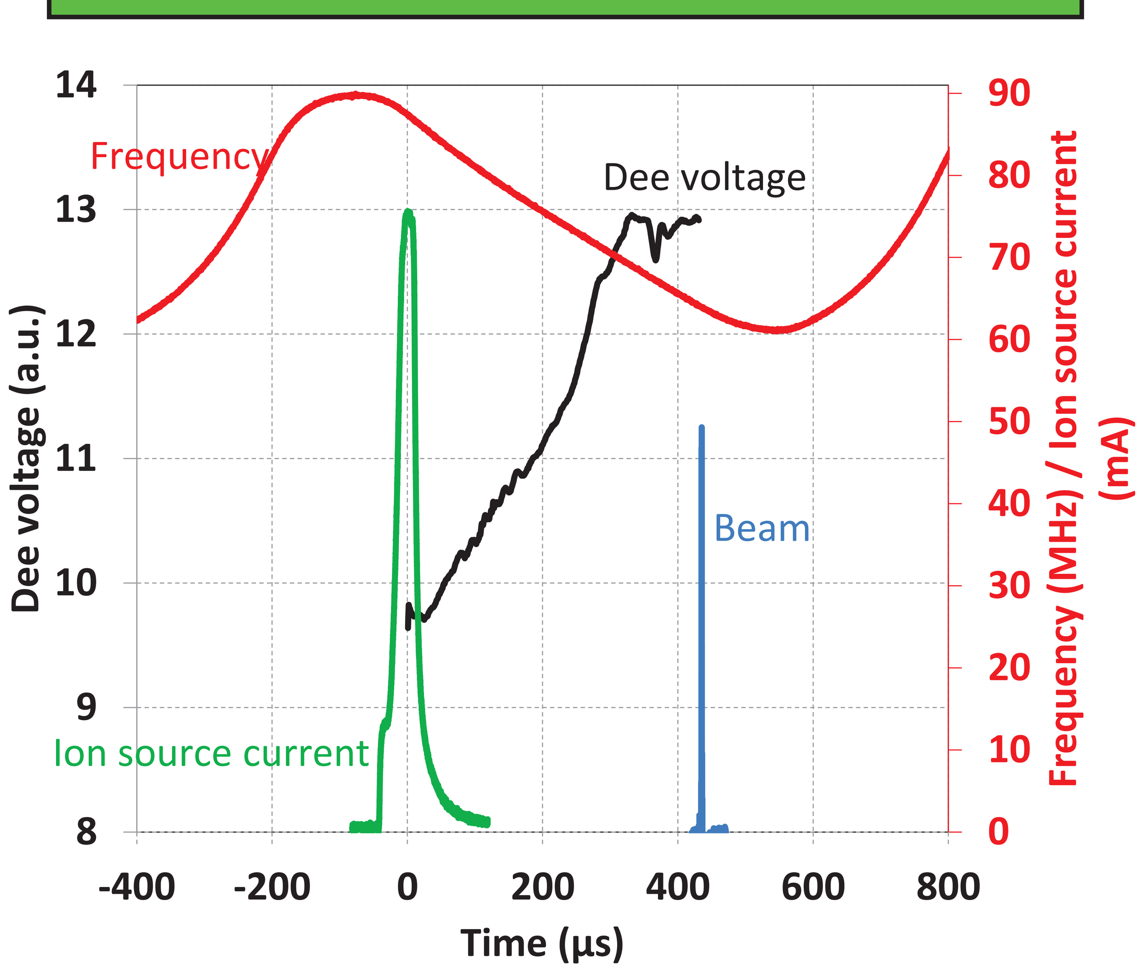


Fig. 2 : Timing properties of the S2C2 in the Proteus®ONE system: the source timing (green), dee voltage regulation (black), RF frequency sweep (red) and the beam signal (blue).

EMITTANCE

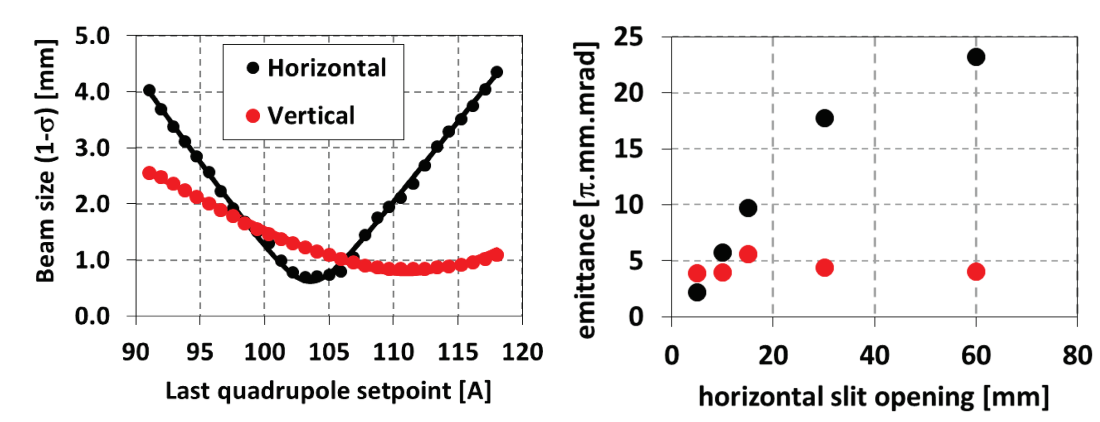


Fig. 3 : (Left) the horizontal and vertical beam spot size on the degrader position (≈2.0 m after the S2C2 exit port) (Right) the evolution of the horizontal and vertical emittance as a function of a horizontal slit, installed before the degrader.

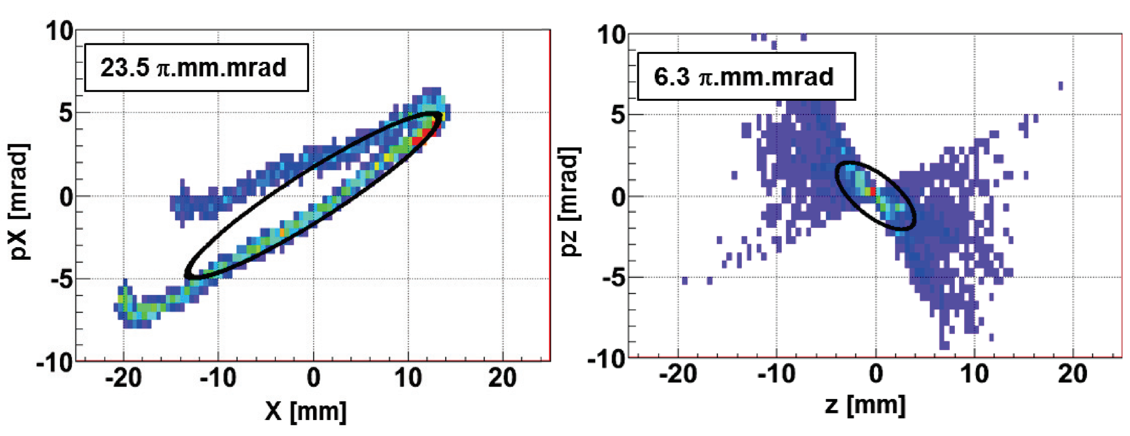


Fig. 4 : Simulated horizontal and vertical emittance at the exit port of the S2C2.

PULSE CHARGE MODULATION

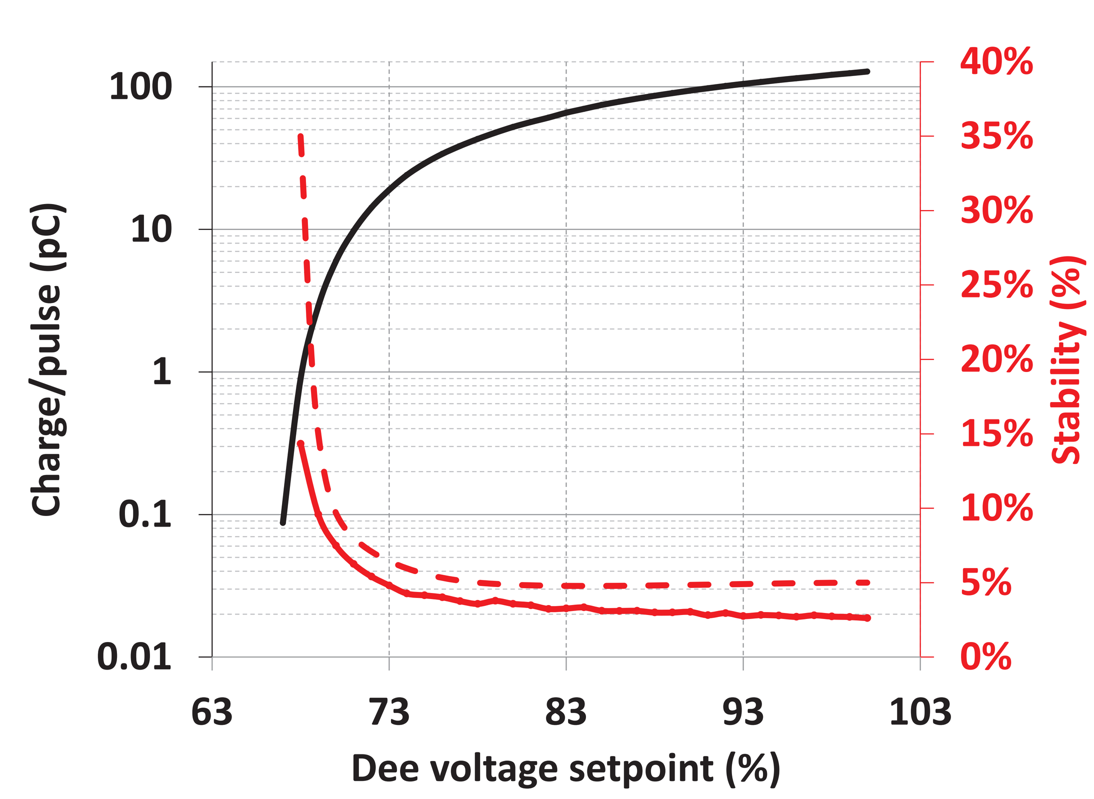


Fig. 5 : (Black) Pulse charge as a function of the dee voltage setpoint, expressed as % of the maximum allowed setpoint. (Red) Stability of the pulse charge, observed over 1000 pulses. The dashed line indicates the specification on the stability of the pulse charge in Pencil Beam Scanning.

BEAM ENERGY

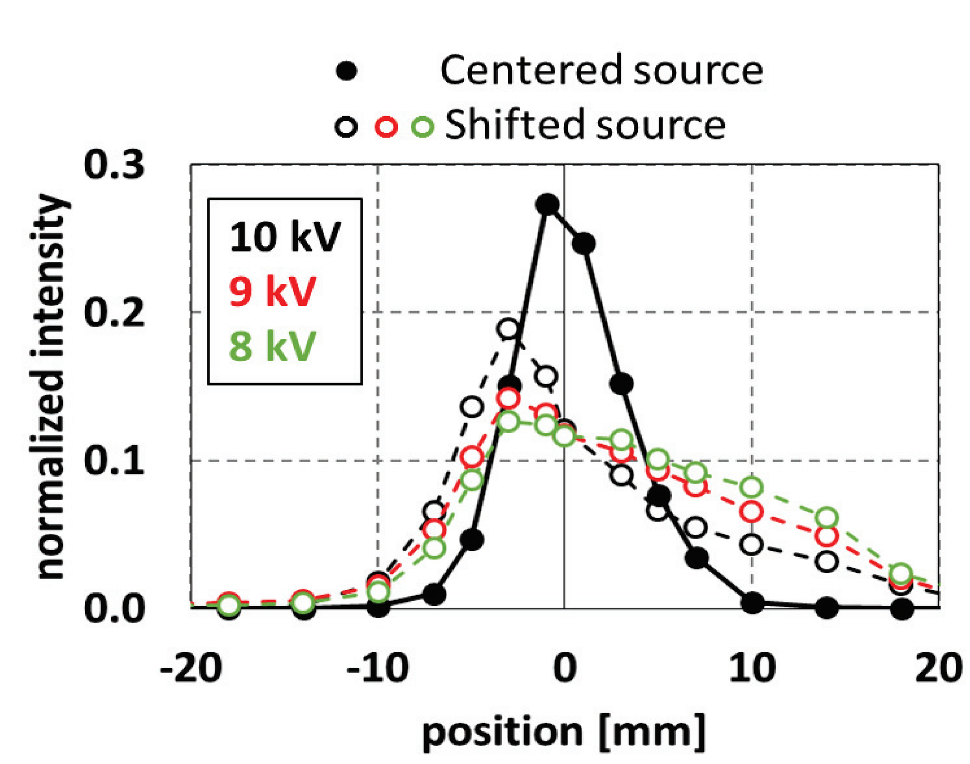


Fig. 6 : Beam profile observed at the end of the Energy Selection System (ESS, see Fig. 1) as a function of dee voltage for a centered (filled symbols) and a shifted source (open symbols) in the S2C2.

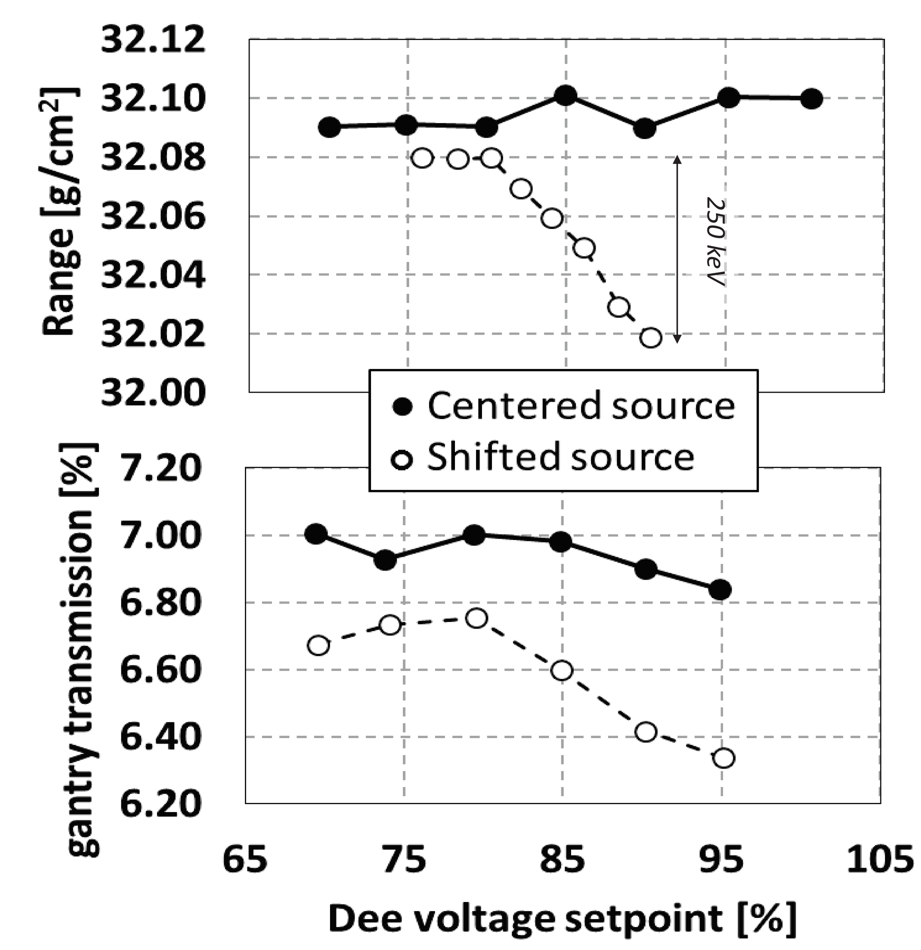


Fig. 7 : Measured range at isocenter (top) and measured gantry transmission (bottom) as a function of dee voltage for a shifted and a centered source.

DEE VOLTAGE REGULATION

Dee voltage regulation is needed to accurately control the RF amplitude at capture and to avoid beam loss due to the bucket size area fluctuations.

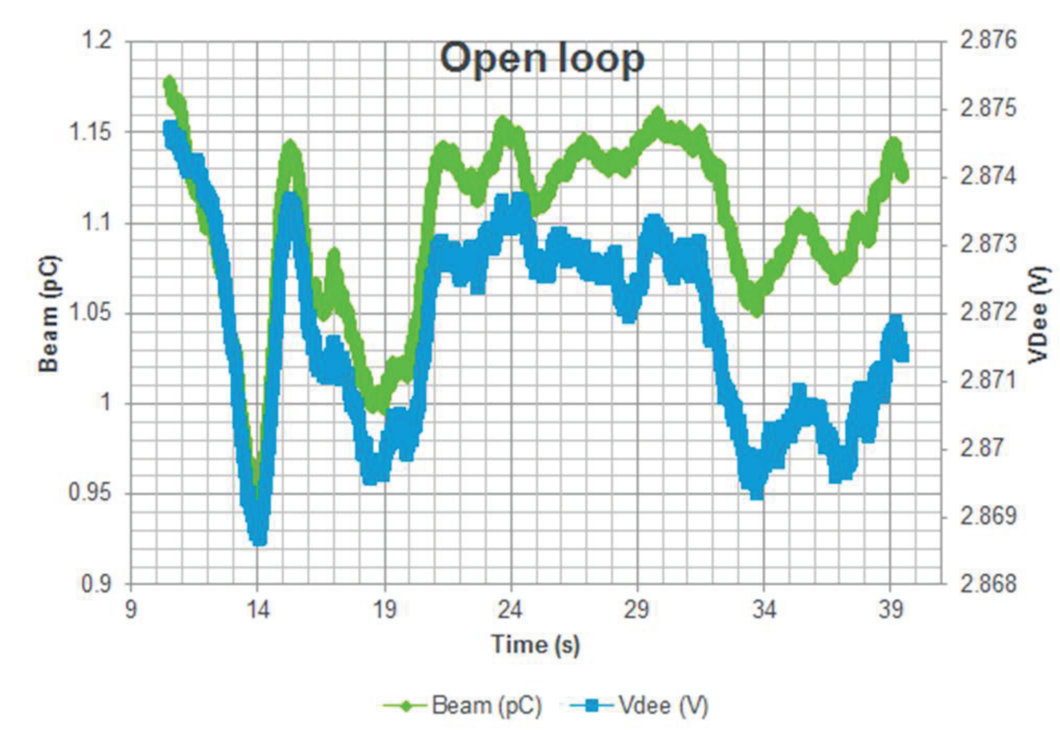


Fig. 8 : Slow fluctuations of the dee voltage amplitude influences the beam intensity over longer period (without regulation).

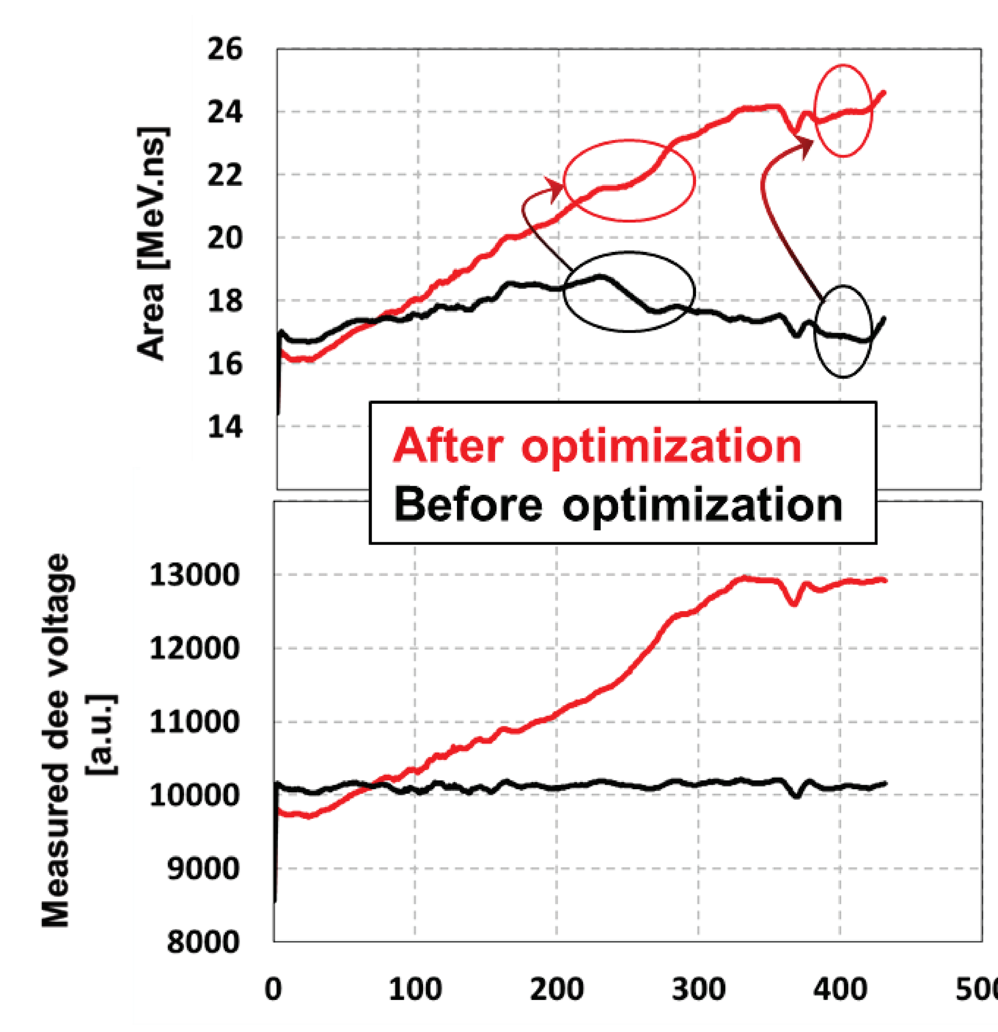


Fig. 9 : Measured dee voltage and calculated bucket area of the separatrix before and after optimization of the dee voltage profile during acceleration, to prevent beam losses.

CONCLUSION

During the clinical commissioning of the S2C2 with the Proteus®ONE system, challenges encountered have been investigated in depth. Solutions presented in this contribution have been successfully implemented.