Characterization of a High Resolution Air Filled Ion Chamber Array Technology for Proton Therapy QA

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PURPOSE

To investigate the feasibility of a new ionization chamber array technology for machine and patient plan quality assurance in proton therapy.

This technology is intended to be used in 2D/3D detectors with the goal to improve dosimetric performances of available commercial solutions.

MATERIALS AND METHODS

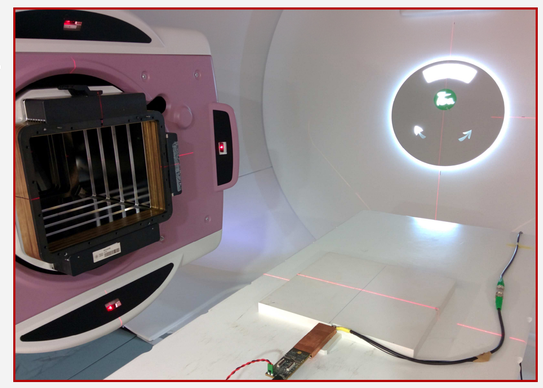
Prototype under test: a linear array of air vented ionization chambers developed by IBA Dosimetry GmbH, consisting of 80 pixels with 3.5 mm spatial resolution, 1 mm inter-electrode distance and 4 mm^3 sensitive volume. Main technological features are:

- sensitivity independence on dose per pulse;
- low energy dependence;
- high radiation hardness.

Performed study: measurements of basic dosimetric performances and of machine/patient QA with clinical PBS proton beams.

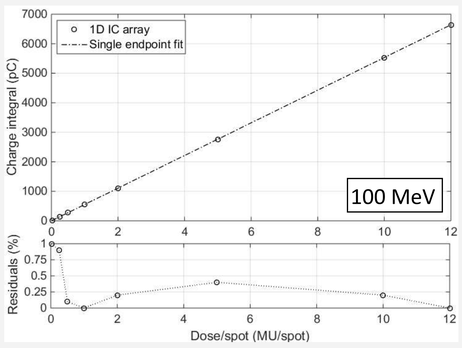
Facility: IBA Proteus 235 cyclotron (226 MeV maximum energy , 6.2 nA maximum treatment current and 4.6 mm spot sigma in air at 165 MeV proton energy).

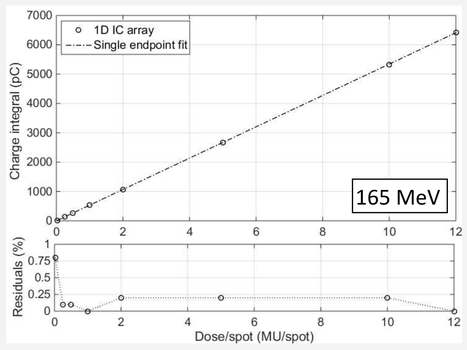
The picture shows the detector placed in a plastic phantom in a 360° gantry treatment room for characterization at the Proton Therapy Center Czech s.r.o.

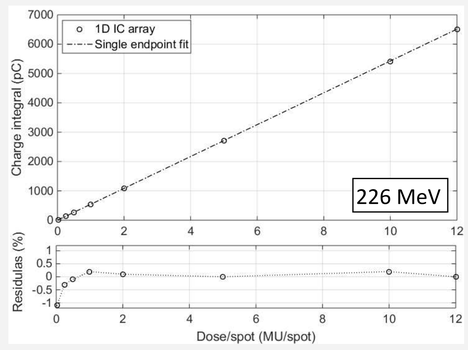


RESULTS

1. Dosimetric Performances: Dose Linearity & Charge Collection Efficiency

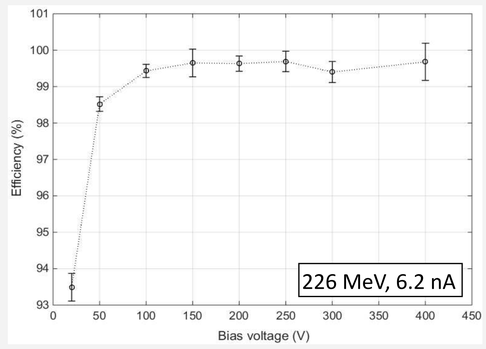






Detector response for different energies is linear within ±1%. Measured dose ranges from 5cGy up to 30Gy.

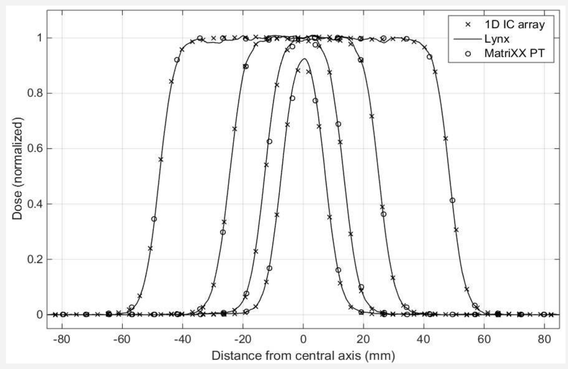
Charge collection efficiency is higher than 99% already at 100 V, reaching 99.7% ± 0.3% at 250 V.



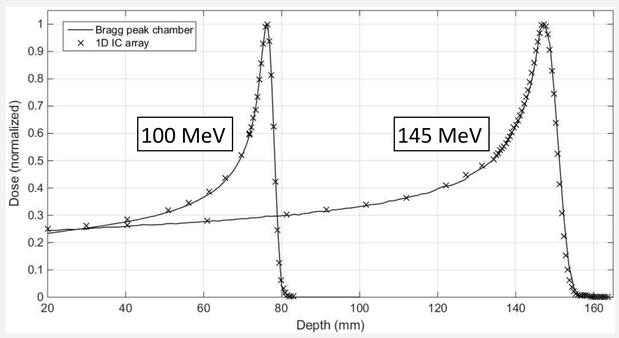
2. Machine Quality Assurance

Excellent penumbra definition of uniform proton maps. Reference detectors:

- MatriXX PT (IBA Dosimetry GmbH): air IC array with 7.6 mm resolution;
- Lynx (IBA Dosimetry GmbH): scintillator based, 0.5 mm resolution.



Measured pristine Bragg peaks in very good agreement with reference Bragg peak chamber (PTW).



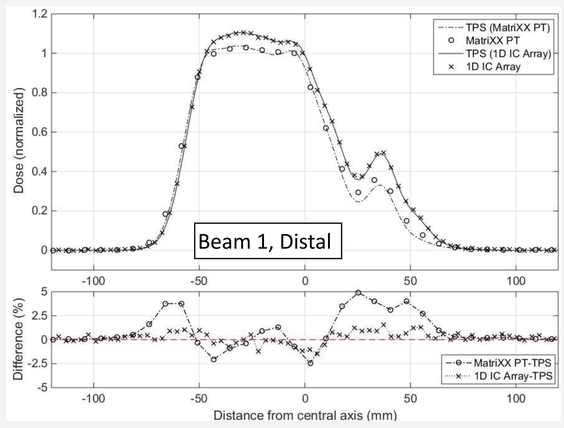
3. Patient Plan Verification

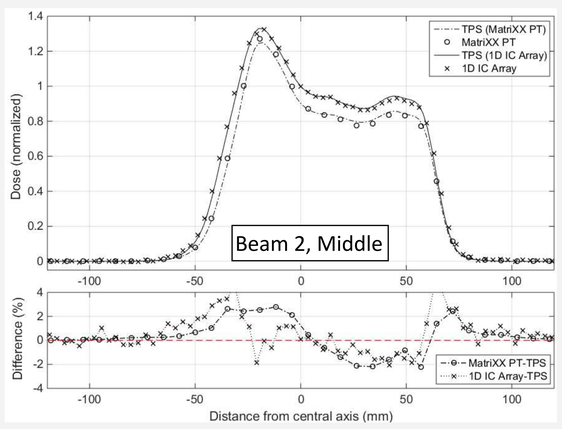
Clinical localization: prostate.

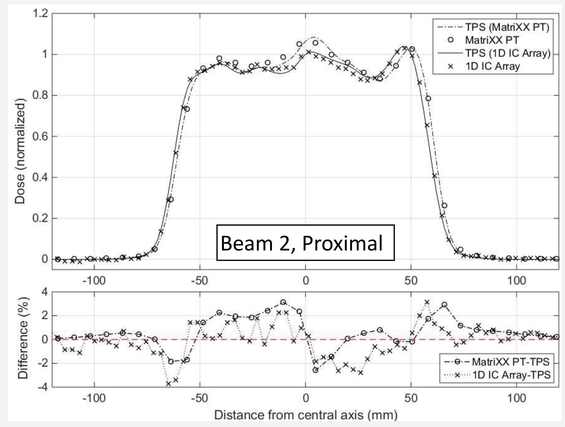
Planned treatment: IMPT, 2 different beams, energy range 143 — 210 MeV. Dose distributions measured in the distal, middle and proximal part of the tumor volume (i.e. at 23, 20 and 17 cm depth, respectively) and compared with TPS and MatriXX PT.

TPS distributions were calculated in order to take into account different setup for MatriXX PT and the 1D IC array.

Average difference with TPS is always below 1%. Performances are generally comparable with MatriXX PT, a better definition is achieved when modulation of dose is high.







CONCLUSIONS

The array represents a valuable tool for the characterization of treatment proton beams where high dosimetric performance, radiation hardness and high spatial resolution are required. This technology appears to be promising for patient plan quality assurance as well, even if in this case a 2D detector would be necessary.

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