Commissioning of an Elekta Versa HD linac with flattening filter-free beam technology

S. Canino[1], M. Licandro[1], I. Løvik[1], D. Pingitore[2], G. Scalzo[1]
1. Medical Physics Unit, "Pugliese-Ciaccio" Hospital, Catanzaro, Italy
2. Radiotherapy Unit, "Pugliese-Ciaccio" Hospital, Catanzaro, Italy

Aim of the study

This work presents the commissioning of a Versa HD™ linear accelerator (Elekta AB) at the "Pugliese-Ciaccio" Hospital in Catanzaro, Italy. In the High Dose Rate Mode the linac operates with high energy flattening filter-free (FFF) photon beams of 6MV and 10MV.

Materials and Methods

The Versa HD™ linac is equipped with two high energy photon beams with flattening filter (6 and 10 MV FF) and two high energy flattening filter-free photon beams (6 and 10 MV FFF). The linac is equipped with the Agility dynamic MLC composed of 160 leaves with 5mm width at isocentre

.The measurements were performed with an IBA Blue Phantom2 and Omni-Pro Accept 7 software. For radiation fields in the range 40x40 cm^2 to 4x4 cm^2 a Scanditronix-Wellhofer CC13 ionisation chamber with a 0,13 cc volume was used, while a Scanditronix-Wellhofer CC04 ionisation chamber with a 0,04cc volume was used in the range 5x5 cm^2 to 1x1 cm^2. A Dose1 electrometer was used for absolute dose dosimetry. The measurements were performed according to the IAEA TRS-398 protocol.

The measurements were performed with the linac operating in the High Dose Rate Mode, with a dose rate of 1300MU/min and 2200MU/min for the 6MV FFF and 10MV FFF beams respectively. Preliminary measurements were performed in order to verify the IC linearity with dose rate for both relative and absolute dosimetry. Inplane and cross plane profiles were measured at SSD = 90 cm for 2x2, 3x3, 5x5, 10x10, 15x15, 20x20, 30x30 and 40x40 cm^2 open fields at the depths of d_{max}, 5, 10 and 20 cm. Percentage Depth Dose (PDD) profiles were measured for 1x1, 2x2, 3x3, 4x4, 5x5, 7x7, 10x10, 15x15, 20x20, 30x30 and 40x40 cm^2 open fields.

Results

Profiles of flattening-filter free beams have a different aspect than a flattening filter beam. In figure 1 crossplane profiles for a 6MV FFF beam for field sizes from 40x40 to 2x2 are shown. The profiles are normalized to the centre of the beam. The field dimensions for FFF beams cannot be defined in terms of FWHM as the relative dose at the nominal field edge changes in terms of field size, as shown in table 1.

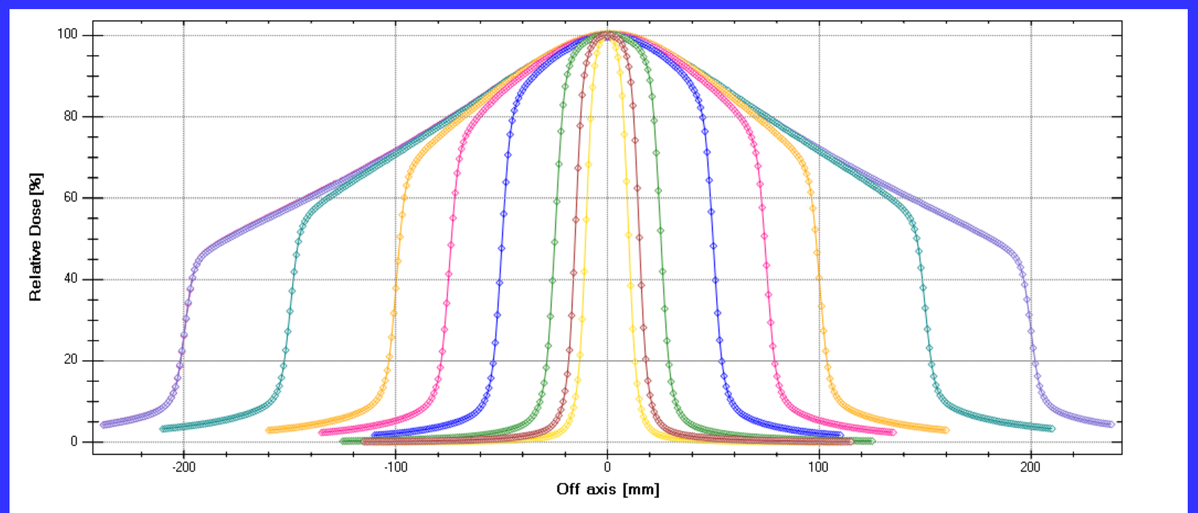
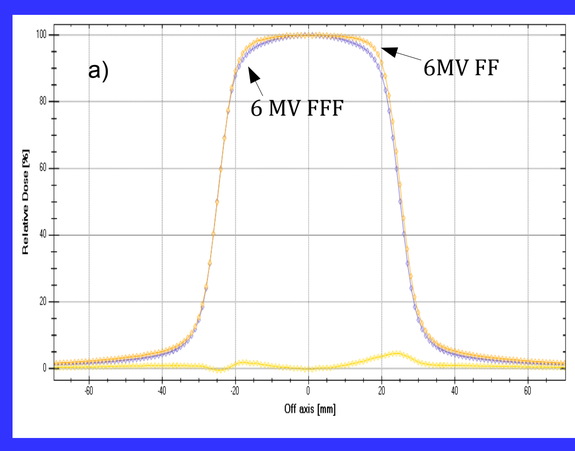


Figure 1. 6MV FFF crossplane profiles for field sizes from 40x40 to 2x2.

Field	40x40	30x30	20x20	15x15	10x10	5x5	3x3	2x2
6MV FFF	27,4	33,5	38,9	43,5	47,4	51,50	53,5	52,1
10MV FFF	23,5	27,6	33,6	39,1	44,7	50,30	53,3	52,1

Table 1. Percentage dose value at nominal field edge position for various field sizes.

While the FFF profiles are significantly different than FF beam profiles for large field sizes (figure 2), this difference diminishes as the field size decreases. For field sizes 5x5 and below the percentage difference between a FFF and a FF profile is less than 5% for both energies, as shown in figure 3.



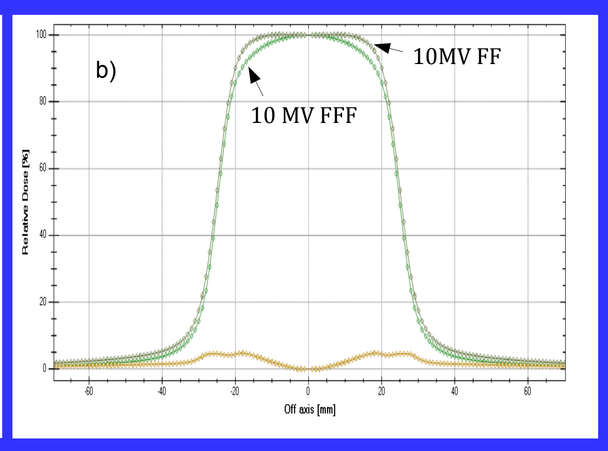


Figure 3, Crossplane profiles for 5x5 field for a) 6MV FF and 6MV FFF and their difference, b) 10MV FF and 10MV FFF beams and their difference.

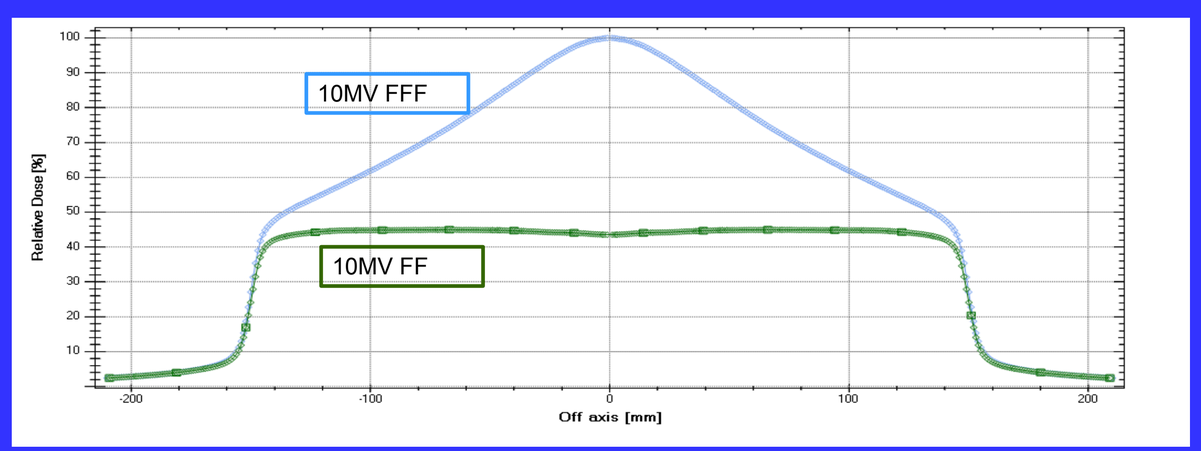


Figure 2. Crossplane profiles for a 30x30 field for 10MV FF and 10 MV FFF beams.

The PDDs for the FFF beams differ from the FF beams as the field size increases, as shown in figure 4. For example, the Quality index (D200/D100) for the field sizes shown in figure 4 are for the 5x5 field 0,59 and 0,58, for the 10x10 field 0,61 and 0,60, and for the 40x40 field 0,66 and 0,63 for the 10MV FF and 10 MV FFF beams respectively.

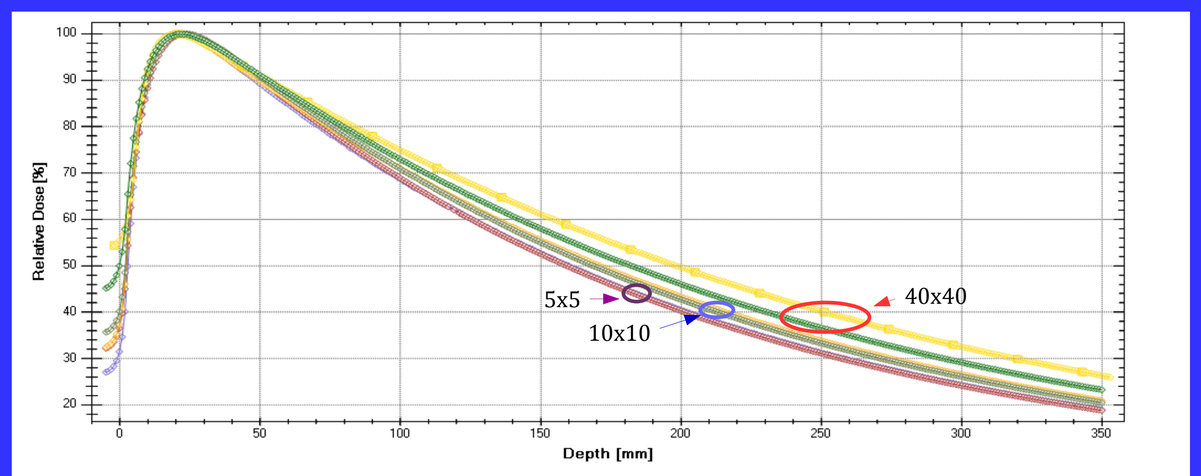


Figure 4. PDD for 5x5, 10x10 and 40x40 fields for 10MV FF and 10MV FFF beams.

Conclusion

In terms of in- and cross-plane profiles and PDDs the FFF beams are comparable to FF beams for small fields but not for larger field sizes. Further studies are however necessary in order to investigate the clinical use of FFF beams compared to FF beams for different treatment techniques.

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