

## I. INNOVATION/IMPACT:

While the dosimetric characteristics of the TrueBeam STx linear accelerator (Varian Medical Systems, Palo Alto CA) flattening-filter-free (FFF) energy modes have been aptly described<sup>1</sup>, there is a paucity of existing information in the literature on expectations related to the commissioning experience and expected nominal values for the TrueBeam linac. Furthermore, given the differences between the MLC characteristics between the TrueBeam and TrueBeam STx and the lack of peer-reviewed information available for the new electron scattering foil geometry, a summary of the mechanical and dosimetric properties of this new treatment unit is desirable.

## II. INTRODUCTION

One of the latest linear accelerators, the TrueBeam (Varian Medical Systems, Palo Alto, CA) and its stereotactic counterpart, the TrueBeam STx, have different characteristics than other linear accelerators, including several high dose rate FFF photon modes, reengineered electron modes with new scattering foil geometries, updated imaging hardware/software, and a novel control system. We have performed a comprehensive evaluation of three TrueBeam linacs at three different institutions and report on our commissioning experience.

## III. METHODS AND MATERIALS

For the three TrueBeam machines presented in this work, the following photon energies were commissioned: 6X, 6XFFF, 10X, 10XFFF, and 15X. The following electron energies were commissioned for all sites: 6, 9, and 12 MeV. Additionally, 15 and 18 MeV electrons were commissioned at one site and, 16 and 20 MeV at the other two. All data collection and testing was performed in accordance with the national practice and industry guidelines such as AAPM Task Groups (TG) 142 and 106, and according to Varian specified guidelines for procedures such as MLC dosimetric leaf gap (DLG). Comparative analysis was performed on various beam parameters including mechanical isocenter accuracy, MLC transmission and DLG, photon and electron percent depth doses (PDDs), beam profiles, relative photon output factors and electron cone factors, in order to determine the agreement between machines.

## IV. RESULTS AND DISCUSSION

### A. Mechanical isocenter accuracy

During machine acceptance, gantry/collimator isocentricity was measured for each machine using Varian's Isolock procedure. Results were similar for all three institutions ranging from 0.265-0.283 mm; these values fall well within the Varian specification of 0.5 mm. Larger variations were observed for the couch/gantry/collimator isocenter axis where radii ranged from 0.464-0.675 mm across the institutions. These results are all within the Varian specification of 0.75 mm.

### B. Photon Measurements

The largest variation in machine parameters was observed with the measured MLC DLG. The average DLGs for 6, 10 and 15 MV photons were  $1.95 \pm 1.15$ mm,  $2.22 \pm 1.30$  mm, and  $2.20 \pm 1.24$  mm, respectively. MLC transmission showed minimal variation across the three institutions, with the standard deviation ranging from 0.01% - 0.13% for all energies (Fig 3). Interestingly, the largest transmission values were observed for 10X for all institutions. Minimal variation was observed among relative photon output factors; the maximum standard deviation for all output factors was 0.011 with the largest deviations occurring for smaller field sizes. Photon beam profiles were also plotted, with the largest deviations occurring in the penumbra regions, as shown for 10 MV 10x10 cm<sup>2</sup> profiles in Fig 1.

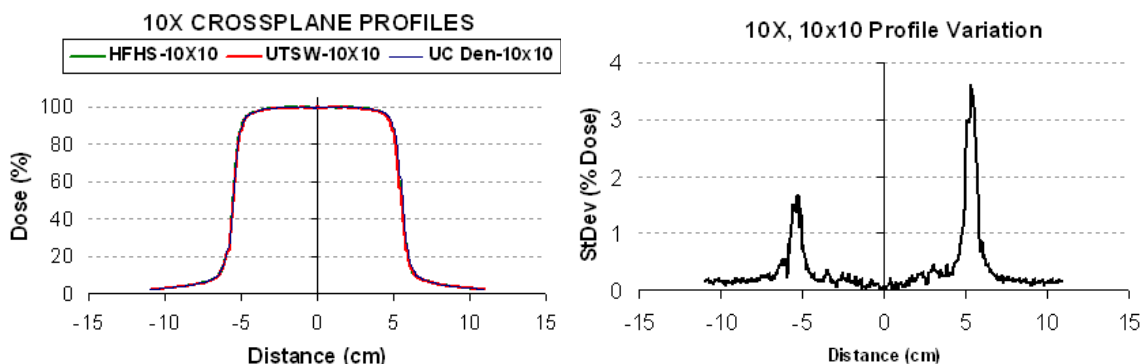


Figure 1. Crossplane 10 MV beam profile comparison (left) and profile variation (standard deviation of dose with distance) (right)

A comparison of photon PDD curves for all three institutions is illustrated in Fig 2. While overall agreement is good, some deviation was observed in the buildup region of the curve. This deviation increased with increasing field size.

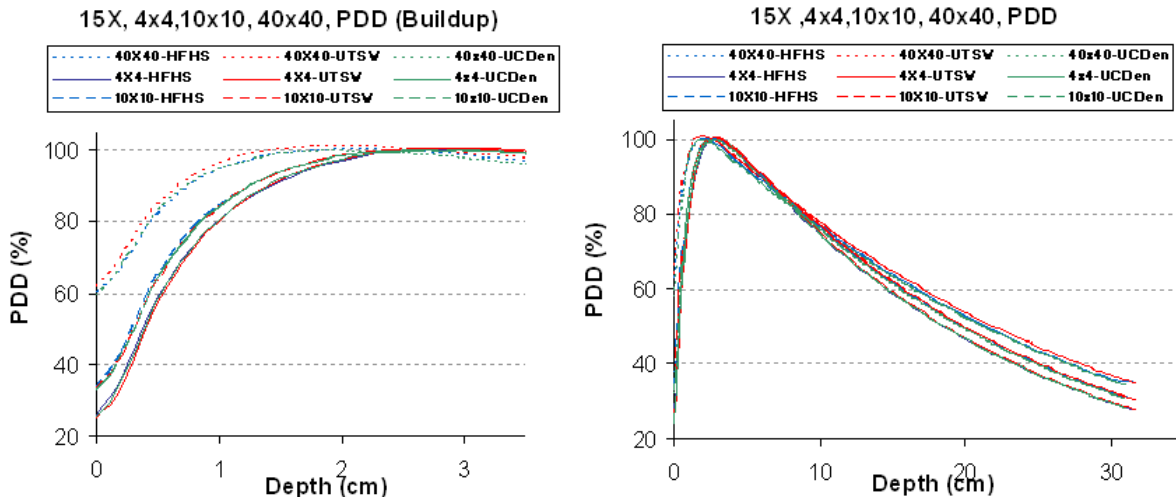


Figure 2 Percent depth dose curves for 15MV photons. Maximum discrepancy was 1.4% for the 40x40 field size.

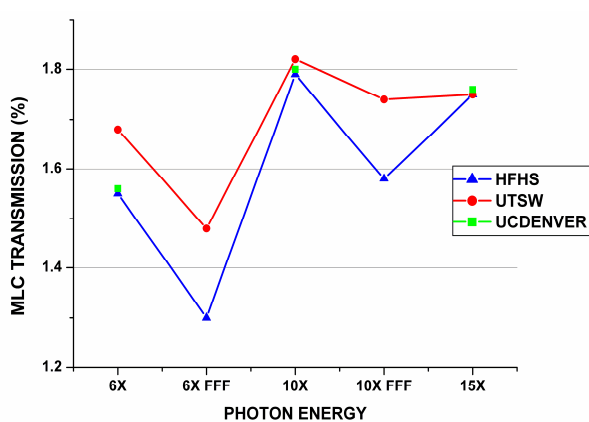


Figure 3 MLC transmission values.

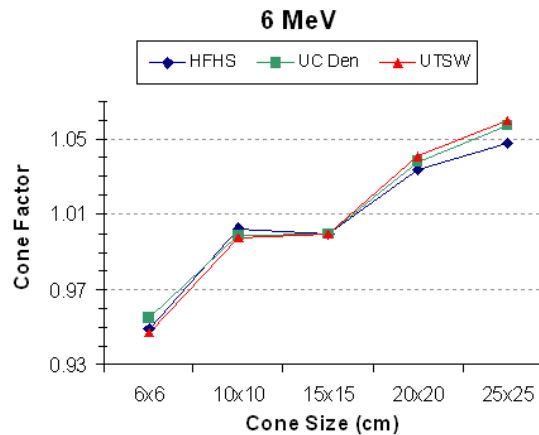


Figure 4 Electron cone factors for 6 MeV

### C. Electron Measurements

Electron cone factors were well matched for 6, 9, and 12 MeV. Standard deviations did not exceed 0.006 for any energies or cone sizes. The largest deviations occurred at 6 MeV (Fig. 4). PDD parameters for 9 and 12 MeV show excellent agreement (Table 1).

	9 MeV				12 MeV			
	Dmax (cm)	R50 (cm)	R90 (cm)	Rp (cm)	Dmax (cm)	R50 (cm)	R90 (cm)	Rp (cm)
HFHS	1.98	3.50	2.67	4.37	2.80	4.93	3.82	6.05
Denver	2.07	3.61	2.77	4.49	2.82	5.01	3.89	6.15
UTSW	2.08	3.63	2.78	4.50	2.78	5.08	3.94	6.21
Mean ± SD	2.04±0.06	3.58±0.07	2.74±0.06	4.45±0.08	2.80±0.02	5.01±0.08	3.89±0.06	6.14±0.08

Table 1. Electron beam parameters for three institutions.

### V. CONCLUSIONS

Overall, strong agreement was observed for all institutions. This comprehensive set of multi-institutional data may serve as a benchmark for other institutions embarking on TrueBeam commissioning.

1. J. Hrbacek, S. Lang, and S. Klock, "Commissioning of photon beams of a flattening filter-free linear accelerator and the accuracy of beam modeling using an anisotropic analytical algorithm," *Int J Radiat Oncol Biol Phys* **80**, 1228-1237 (2011).