TG51 Photon Calibration
at the University of Michigan

Lars Ewell, September 25, 2002

Introduction

In an earlier document [1], the motivation for implementing a TG51 machine calibration was described. Since that time, the photon part of the calibration has been performed on EX2. This document, along with the worksheets that are included with the actual protocol describe this photon calibration.

Procedure

6x Photons

The procedure for 6x photons followed closely what was described in the TG51 protocol. In particular, a depth dose curve for a 10x10cm beam with an SSD of 100cm was taken. This was necessary to obtain the depth dose at 10cm, $\%\mathrm{dd}(10)_x$, that was in turn required to obtain the quality conversion factor, k_q. The measurement was done using the Med Tech tank which is ~38x38x38cm, larger than 30x30cm required by the protocol. For details, see the TG51 worksheets located in the EX2 Monthly QA three ring binder and/or the EX2 data-book, both located in the EX2 control room.

15x Photons

The procedure for 15x photons also followed the protocol closely. In addition to what was required to determine the beam quality for the 6x beam, the 15x measurement required a 1mm piece of Pb be placed 70 $\pm$ 1 cm from the source in order to block/control electron contamination. For the EX2 machine, the lower wedge mount provided a convenient mount point for this Pb sheet. The Pb sheet was mounted on the clear plastic part of a wedge mount. According to Varian schematics, the plastic sheet is 69.8 cm from the source. The sheet was located at a distance of 12.85 cm to the flat part of the collimator head (away from the attachment point pivot). This is consistent with the 57.4cm distance from the front pointer mount to the source. The Pb sheet was centered on the plastic using the field light.

Results

6x Photons

In Figure 1, we see the normalized depth dose curve for 6x photons. As indicated above, the data for this plot are located in the EX2 log-book in the control room. In addition, the data are located in ASCII files in the ewell/data/depthdose directory of the ITD Solaris cluster. As can

[1] see TG51.pdf located in the Physics/Clinical Physics/Tg51 folder.

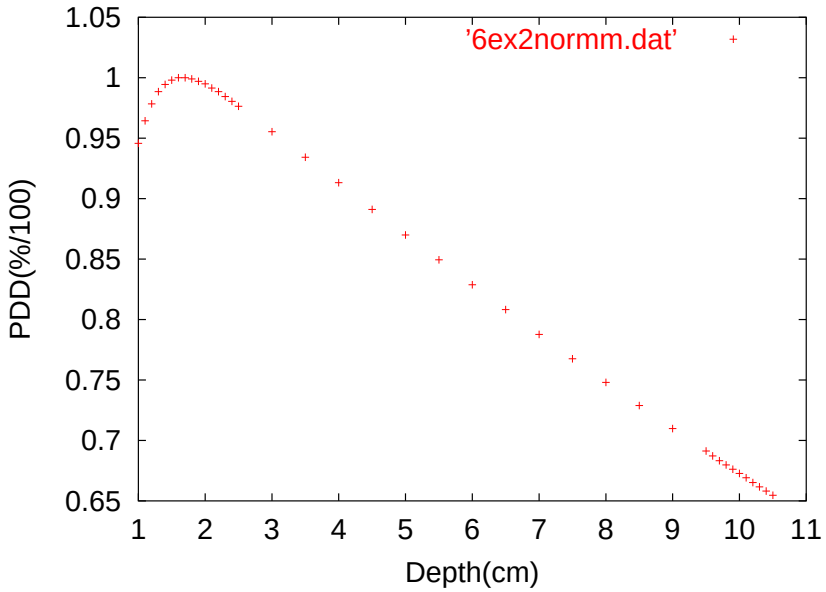

Figure 1. 6X Depth Dose.

be seen in this figure, d_{max} occurs at a depth of about 1.6cm.

In Figure 2, the same curve is shown expanded around a depth of 10cm. In this plot, the displacement correction ($0.6 \times r_{cav}$) is subtracted from the measured depth, per the protocol[2]. From this figure, we see that the depthdose at 10 centimeters that is needed to determine the quality conversion factor, k_q, for the TG51 protocol is $\%dd(10)_x = 66.5\%$. Using this value, we linearly interpolate [3] between the values of 66.0 and 71.0 listed in Table 4 to obtain a value of k_q= 0.995.

Now that the quality conversion factor is known, we can finally determine the TG51 dose rate of the machine. The correction factors obtained in the most recent (8/27/02) machine calibration are: M_{raw} = 32.22 nC for 200MU, P_{ion} = 1.003, P_{TP} = 1.017[4]. These are then multiplied to obtain the corrected electrometer reading [5] M=32.87nC. So we have for the 6MV TG51 dose rate at 10cm depth

[2] In the TG21 protocol, this displacement correction is included in the *replacement (gradient) correction*, P_{repl}. On the current (TG21) monthly QA sheets, this factor is included in the chamber-phantom factor F_{cp} .

[3] $\frac{71.0-66.0}{0.990-0.996} = -833.33$, $\frac{71.0-66.5}{0.990-k_q} = -833.33 \rightarrow k_q = \frac{829.50}{833.33} = 0.995$

[4] $P_{elec} = P_{pol} = 1$.

[5] See part 9 of the worksheet.

6X Depth Dose

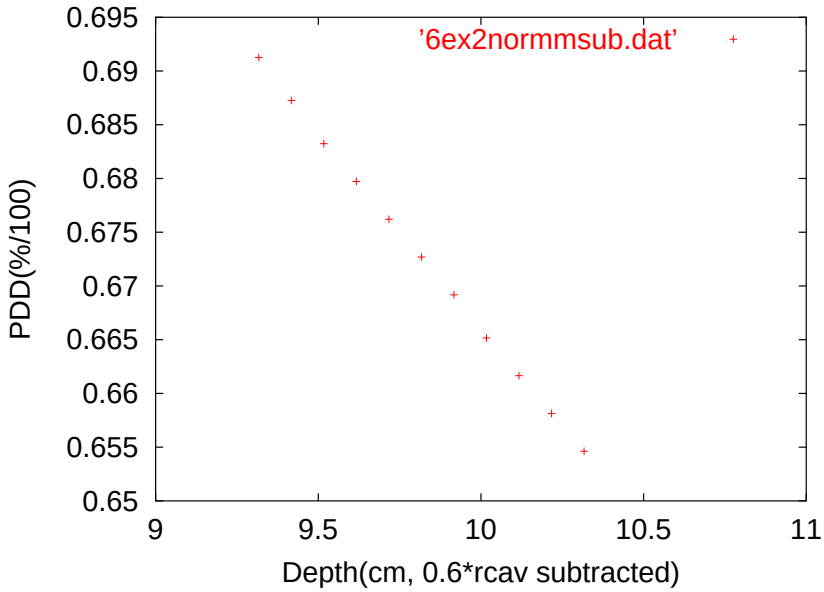

Figure 2. 6X Depth Dose.

$$\begin{aligned} dose\ \ rate_{6MV} &= \frac{Mk_qN_{D,w}^{^{60}Co}}{MU} \\ &= \frac{(32.87nC)(0.995)(4.946\times10^9Gy/C)}{200MU} \\ &= 0.809cGy/MU. \end{aligned}$$

15x Photons

For 15x photons, there is potential electron contamination from the machine head to consider. TG51 therefore recommends that a 1mm sheet of Pb be placed between the source and the detector in order to block/control the amount of electron contamination. In Figure 3, we see 15X depth dose curves with (green) and without (red) the Pb shielding in place. In Figure 4, we see the same curve expanded around a depth of 10cm. The Pb shielded data is shifted to the right of the unshielded data indicating that the Pb is indeed blocking electron contamination as is intended. From this curve, we obtain a value of $\%\mathrm{dd}(10)_x = 78.6\%$. Similar to the 6x value, we obtain for TG51 15x: $dose\ \ rate_{15MV} = 0.809cGy/MU$.

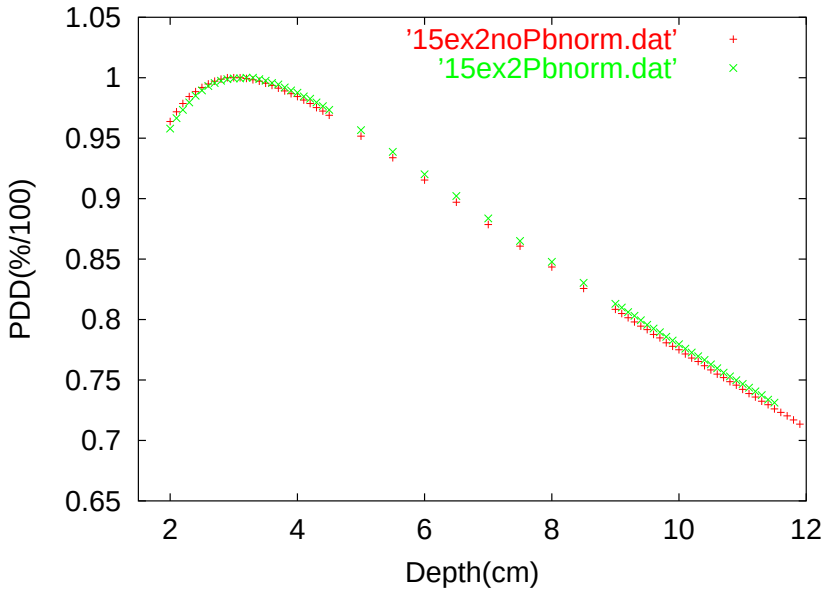

Figure 3. 15X Depth Dose. Pb(green) and no Pb(red).

Comparisons

Several different TG21/TG51 comparisons[6,7] have been published. Table 1 shows how these published results compare to the measured EX2 results. These results represent the TG51 to TG21 ratio of the absorbed dose to water at a depth of 10cm. As can be seen in the table, the results of this study are within 1% of the values of these published results. In addition, the trend of the 6MV ratio being greater than the 15MV ratio is also followed.

Conclusion

A TG51 photon calibration has been completed for the EX2 machine here at the University of Michigan. The results of this calibration are very close (within 1%) to the TG21 values, and are also close to previously published TG51/TG21 ratios.

The main advantage of the TG51 protocol lies in the fact that the ion chamber is calibrated at an ADCL in water. This more closely models the actual measurements conducted during routine

[6] *Comparison between TG-51 and TG-21: Calibration of photon and electron beams in water using cylindrical chambers*, S. H. Cho et. al, Journal of Applied Clinical Medical Physics, Volume 1, Number 3, Summer 2000.

[7] *Reference Dosimetry in clinical high-energy photon beams: Comparison of the AAPM TG-51 and AAPM TG-21 dosimetry protocols*, M. S. Huq and P. Andreo, Medical Physics, Vol. 28, Issue 1, 1/01.

[8] Note: Photon "energy" for Cho et al. and Huq and Andreo was 18MV.

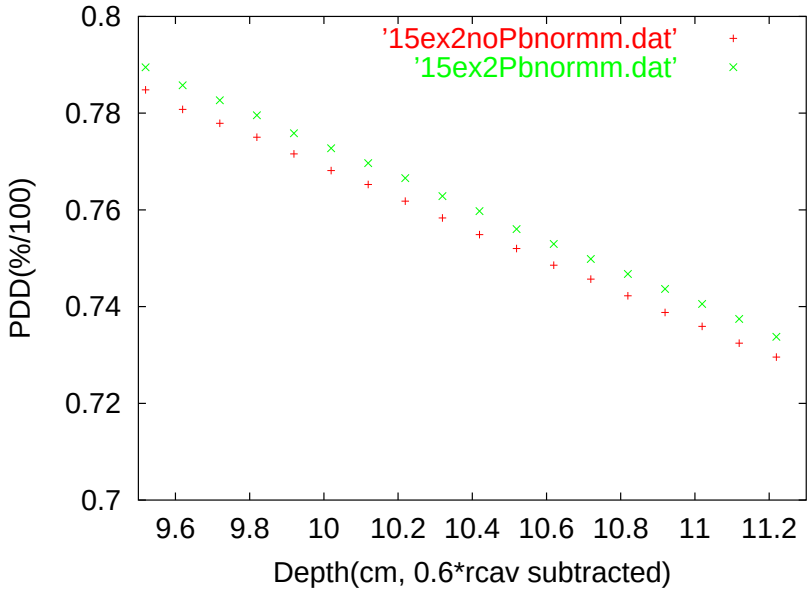

Figure 4. 15X Depth Dose. Pb(green) and no Pb(red).

Table 1: TG51/TG21 Output Calibration Ratios

Authors	6MV	15MV[8]	Measurement Conditions	Chamber
Cho et al.	1.008	1.002	10cm depth, 100cm SSD	Exradin A12
Huq and Andreo	1.009	1.007	10cm depth, 100cm SSD	NE 2571
This Study	1.010	0.998	10cm depth, 90cm SSD	Exradin A12

clinical machine QA, and is therefore more straightforward.