STANDARD WEDGE AND TRAY TRANSMISSION VALUES FOR VARIAN, SEIMENS, ELEKTA/PHILIPS ACCELERATORS; A QUALITY ASSURANCE TOOL

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Introduction

The Radiological Physics Center (RPC), through it's on-site dosimetry review visits to institutions participating in NCI cooperative clinical trials, has accumulated wedge and tray transmission data for approximately 5000 wedges on nearly 1100 Varian, Siemens and Elekta/Philips accelerators since 1985 and nearly 350 tray transmission measurements since 1995. The majority of the wedges used for specific make and models of accelerator are manufactured by the vendor and are similar in design. From time to time, however, the vendor will change its wedge design, which in turn affects the wedge transmission value. The vast majority of the blocking trays, regardless of make and model of accelerator, can be classified as thin or thick trays whose transmission depends solely on the photon beam energy. We believe we can predict the wedge and tray transmission value for a particular nominal energy, wedge angle, tray thickness and make and model of accelerator. The data presented here can be used to predict the wedge and tray transmission for most wedges and trays in clinical use today to within 2%. These data also serve as a redundant QA tool that may identify potential problems.

Materials and Methods

- Measurements were made on a series of Varian, Siemens and Elekta/Philips accelerators. The make and models of those listed here reflect those in current use and most often seen by the RPC.
  1. Varian – Clinac 4/80, 4/100, 6/100, 6, 600C, 18, 1800, 20, 2100C, 2300C, and 2500.
  2. Siemens – Mevatron 6, 12, 20, 60, 63, 64, 67, 6740, 74, 77, KD series, MD series, and MX series.
  3. Elekta/Philips – SL 75-5, 18, 20 and 25.
- Nominal energies from 4-25 MV, wedge angles from 15° – 60° and thin and thick trays.
- The RPC tray transmission factor (TF) is defined as:

  $$TF\ (10x10,\ 5^{*}\ cm) = \frac{\text{tray ioniz. (10x10, 5 cm)}}{\text{open ioniz. (10x10, 5 cm)}}$$

- The RPC wedge transmission factor (WTF) is defined as:

  $$WTF(10x10,\ 5^{*}cm) = \frac{\text{wedged ioniz. (10x10, 5cm)}}{\text{open ioniz. (10x10, 5cm)}}$$

  At 100 cm SSD/SAD in a water phantom. The WTF's ionization readings are averaged over heel-in and heel-out wedge orientations (if applicable) and centering of ion chamber is assured by measurements in multiple collimator orientations.

  *For energies>15 MV, depth is 7 cm and after 1/2000 for all energies, depth is 10 cm.

Results

- The wedge transmission data for the manufacturer's standard wedges on most makes and models of accelerators exhibit a gaussian distribution with a standard deviation of ± 2%.

- The distribution of the wedge transmission factor data is often bimodal exhibiting more than one standard factor for each wedge angle.

- Some of the wedge transmission data for differing makes and models of accelerators for a specific manufacturer, dependent on energy and wedge angle, are in good agreement.

- The tray transmission data, is not dependent on make and model of accelerator, but rather the beam energy.

- There appear to be two types of trays in clinical use today; thin and thick trays.

Conclusions

1. For each combination of nominal wedge angle, energy, and accelerator make and model, a "standard" wedge transmission factor can be assigned.

2. Frequently, there is more than one "standard" wedge transmission factor for a given make and model of accelerator. (The RPC has not captured data to determine whether the different wedges represent different sizes, composition or location of wedges).

3. The same or similar wedges are used on different makes and models of accelerators by the same manufacturer.

4. There are two types of blocking trays in clinical use today, thin and thick trays.

5. These mean standard wedge and tray transmission values provide a good redundant check of an institution's own measured values.

6. With few exceptions, these data can be used to predict the wedge and tray transmission factors for most wedges and trays in clinical use today to within ± 2%.

Table I: Standard Wedge Transmission Values for Varian Accelerators

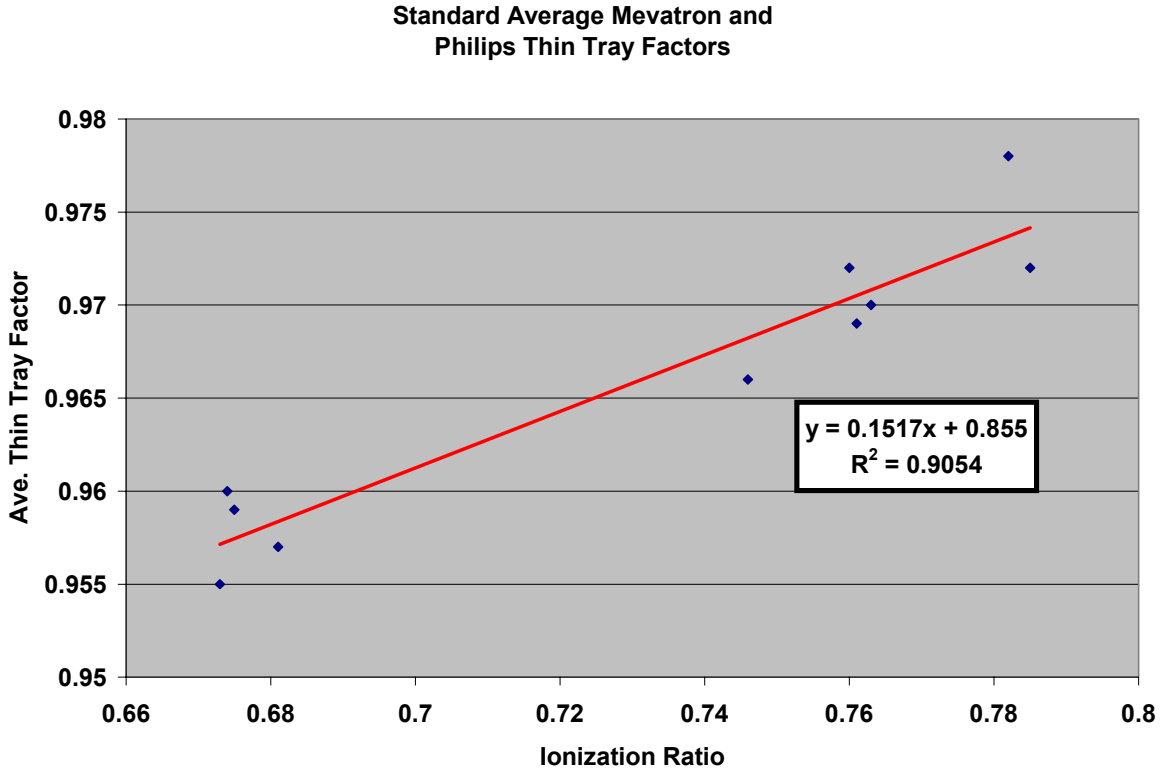
					15 deg wedge			30 deg wedge			45 deg wedge			60
Machine Model	**Energy**	**Ion Ratio**	**Std Dev**	**N**	**WTF**	**Std Dev**	**N**	**WTF**	**Std Dev**	**N**	**WTF**	**Std Dev**	**N**	**WTF**
Cl 4	4 MV	0.619	0.009	90	0.795	0.006	21	0.755	0.009	77	0.578	0.012	89	0.489
Cl 4/100	4 MV	0.631	0.006	31	0.776	0.008	7	0.736	0.004	6	0.495	0.011	10	0.491
					0.805	0.006	16	0.764	0.006	16	0.589	0.005	16	
Cl 600C	4 MV	0.632	0.005	8	0.769	0.011	4	Insufficent Data			0.477	0.004	5	0.394
Cl 6, Cl 6X	6 MV	0.664	0.012	38	0.780	0.008	3	0.627	0.003	5	0.617	0.008	9	0.425
					0.827	0.003	8	0.777	0.009	17	0.651	0.008	11	0.459
					0.873	0.004	6							
Cl 6/100	6 MV	0.661	0.006	140	0.780	0.002	9	0.643	0.015	27	0.481	0.010	32	0.418
					0.823	0.006	80	0.704	0.005	4	0.569	0.006	6	0.455
								0.783	0.007	78	0.614	0.008	98	
Cl 600C	6 MV	0.665	0.005	66	0.708	0.002	8	0.545	0.003	8	0.499	0.007	62	0.418
					0.780	0.002	27	0.631	0.004	37				
Cl 18	10 MV	0.733	0.005	63	0.892	0.007	45	0.752	0.009	8	0.696	0.007	20	0.511
								0.803	0.005	50				
Cl-1800	6 MV	0.687	0.024	89	0.788	0.013	49	0.638	0.006	52	0.485	0.006	72	0.419
								0.706	0.009	9	0.572	0.008	13	
Cl-1800	10 MV	0.739	0.003	16	0.814	0.004	6	0.681	0.002	6	0.536	0.006	10	0.451
					0.850	0.004	5	0.751	0.005	4	0.626	0.007	6	
Cl-1800	15 MV	0.760	0.002	18	0.824	0.003	12	0.697	0.003	12	0.556	0.003	15	0.449
Cl-1800	18 MV	0.784	0.002	52	0.830	0.004	25	0.706	0.004	28	0.514	0.010	7	0.443
											0.570	0.004	40	
											0.652	0.007	5.000	
Cl-20	15 MV	0.758	0.007	20	0.854	0.004	10	0.758	0.004	11	0.642	0.006	17	0.452
Cl-20	18 MV	0.780	0.004	14	0.859	0.002	10	0.767	0.003	10	0.650	0.003	13	0.442
Cl-2100,	6 MV	0.674	0.004	180	0.711	0.004	14	0.547	0.003	6	0.493	0.009	178	0.414
-2100 C, 2100 CD					0.783	0.007	53	0.632	0.008	94	0.507	0.006	24	
Cl-2100	10 MV	0.735	0.003	38	0.751	0.002	3	0.602	0.002	3	0.530	0.006	34	0.448
-2100 C, 2100 CD					0.813	0.002	16	0.680	0.003	16				
Cl-2100	15 MV	0.761	0.002	28	0.820	0.008	18	0.692	0.008	23	0.527	0.004	23	0.445
-2100 C, 2100 CD											0.554	0.003	5	
Cl-2100	18 MV	0.782	0.009	110	0.768	0.003	12	0.629	0.002	15	0.521	0.005	88	0.439
-2100 C, 2100 CD					0.827	0.006	42	0.703	0.005	54	0.566	0.003	19	
Cl-2300	6 MV	0.674	0.004	35	0.773	0.007	12	0.625	0.008	15	0.493	0.012	33	0.408
-2300C, 2300 CD														
Cl-2300	15 MV	0.762	0.003	10	0.813	0.005	6	0.684	0.005	6	0.531	0.014	9	Ins
-2300C, 2300 CD														
Cl-2300	18 MV	0.783	0.002	15	Insufficent Data			0.700	0.005	6	0.519	0.003	8	0.430
-2300C, 2300 CD														
Cl-2500, 2500C	6 MV	0.675	0.005	23	0.783	0.004	11	0.635	0.005	12	0.489	0.006	13	0.419
					0.821	0.003	6	0.709	0.005	7	0.577	0.005	8	
Cl-2500, 2500C	24 MV	0.805	0.003	22	0.832	0.005	11	0.710	0.004	11	0.508	0.004	5	0.428
					0.861	0.004	6	0.770	0.006	7	0.578	0.003	7	
											0.658	0.006	9	

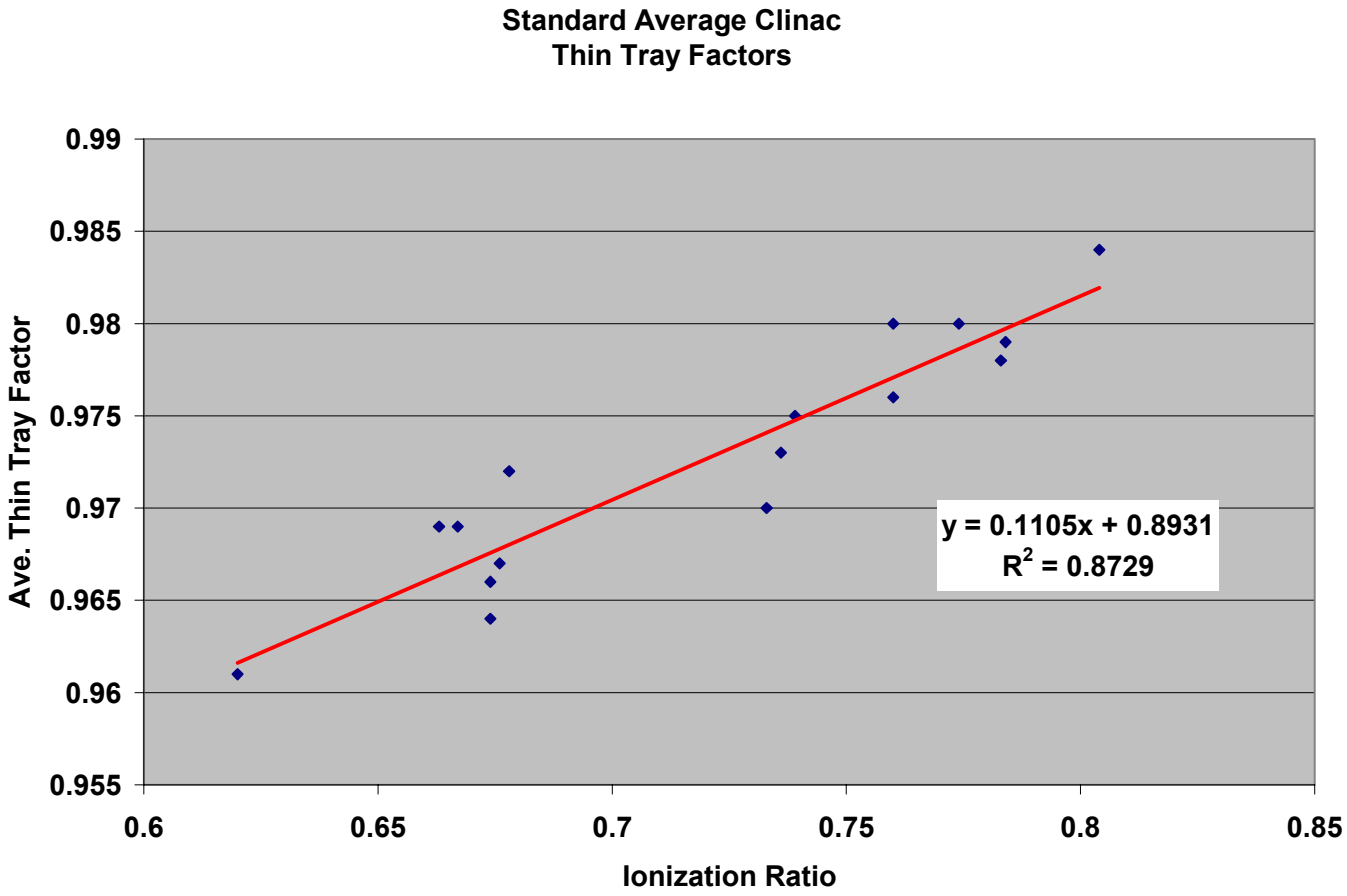
Table 2: Standard Wedge Transmission Values for Siemens Accelerators

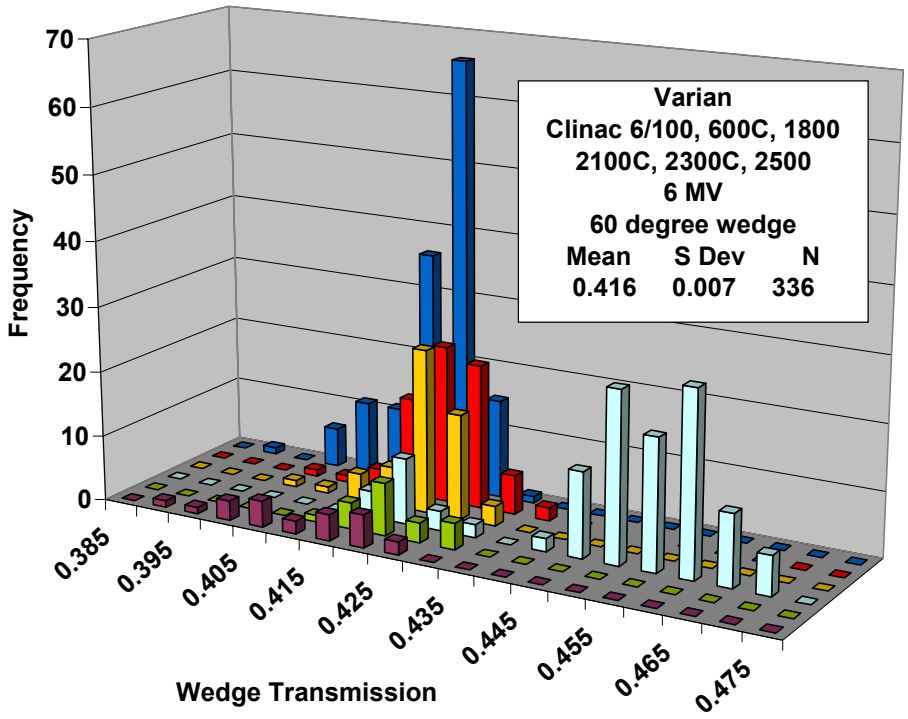
					15 deg wedge			30 deg wedge			45 deg wedge			60
Machine Model	Energy	Ion Ratio	Std Dev	N	WTF	Std Dev	N	WTF	Std Dev	N	WTF	Std Dev	N	WTF
Mev 12	8 MV	0.716	0.008	6	Insufficent Data			Insufficent Data			0.694	0.007	5	Ins
Mev 12	10 MV	0.736	0.008	13	Insufficent Data			0.719	0.004	9	0.696	0.008	11	0.685
Mev 20	15 MV	0.767	0.005	5	Insufficent Data			Insufficent Data			0.640	0.006	5	0.611
Mev 6	6 MV	0.672	0.009	13	Insufficent Data			0.684	0.009	12	0.636	0.008	3	Ins
Mev 60, 63, 64	4 MV	0.611	0.016	9	0.705	0.003	6	0.638	0.007	3	0.513	0.006	6	0.481
Mev 67, 6740	6 MV	0.675	0.006	43	0.685	0.004	5	0.523	0.005	5	0.317	0.007	11	0.350
					0.742	0.005	20	0.714	0.005	25	0.563	0.005	31	0.535
Mev 74, 77	10 MV	0.742	0.006	33	0.782	0.002	19	0.757	0.003	25	0.388	0.007	5	0.592
											0.620	0.003	28	
Mev 77	15 MV	0.766	0.003	12	0.794	0.002	10	0.770	0.003	11	0.637	0.005	12	0.608
Mev 77	18 MV	0.785	0.004	7	0.802	0.003	5	0.777	0.002	5	0.647	0.003	6	0.619
Mev KD, KD2, KDS	6 MV	0.682	0.007	57	0.683	0.004	13	0.518	0.007	21	0.316	0.009	35	0.342
					0.745	0.003	13	0.716	0.004	17	0.565	0.005	21	0.538
Mev MD, MD2	6 MV	0.674	0.004	39	0.684	0.005	11	0.518	0.006	9	0.313	0.005	17	0.339
					0.740	0.004	7	0.713	0.005	6	0.560	0.003	6	0.533
Mev MX, MX2, MXE	6 MV	0.678	0.005	22	Insufficent Data			Insufficent Data			0.317	0.007	5	0.346
											0.338	0.006	5	

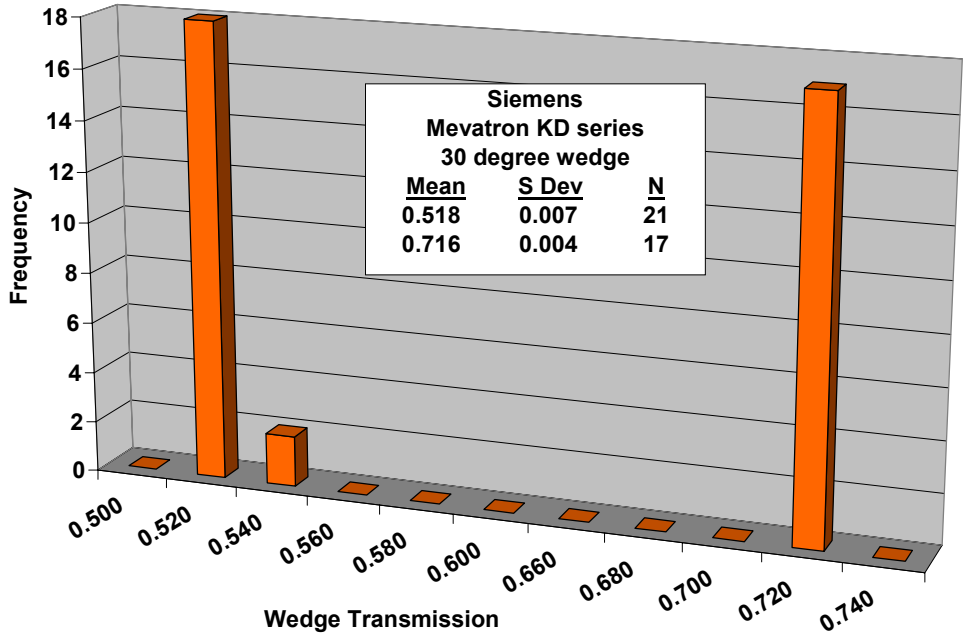
Table 3: Standard Wedge Transmission Values for Elekta/Philips Accelerators

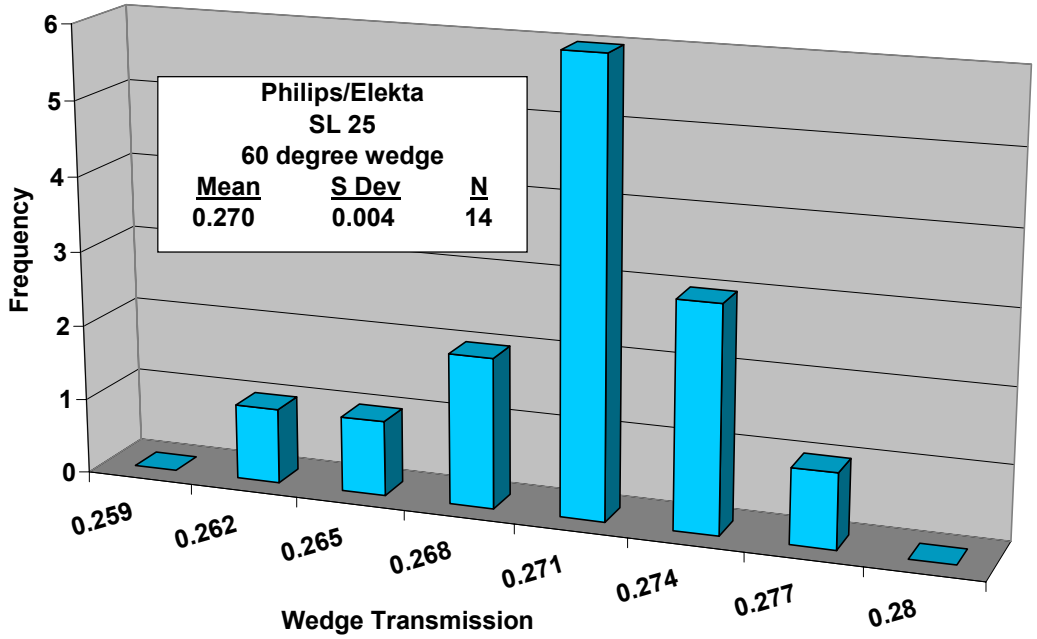
					60 deg wedge		
Machine Model	Energy	Ion Ratio	Std Dev	N	WTF	Std Dev	N
SL 18	6 MV	0.761	0.008	7	0.269	0.005	7
SL18	15 MV	0.761	0.008	7	0.283	0.004	7
SL 20	6 MV	0.680	0.008	19	0.271	0.007	13
SL 20	18 MV	0.776	0.004	12	0.279	0.007	11
SL 25	6 MV	0.681	0.010	15	0.270	0.004	14
SL 25	25 MV	0.800	0.003	12	0.268	0.005	13
SL 75-5	6 MV	0.680	0.003	15	0.261	0.010	14

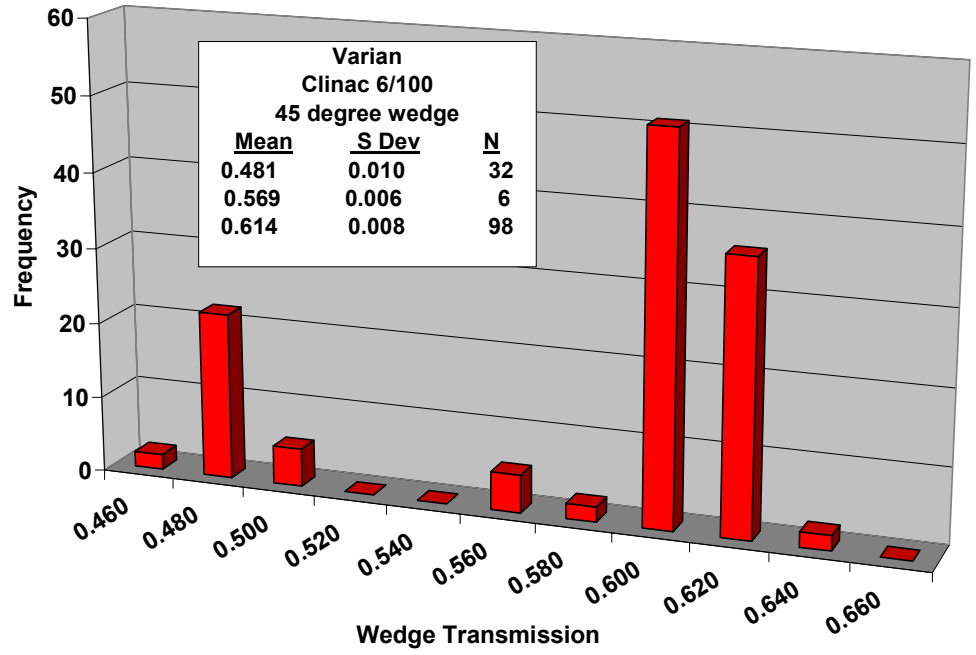


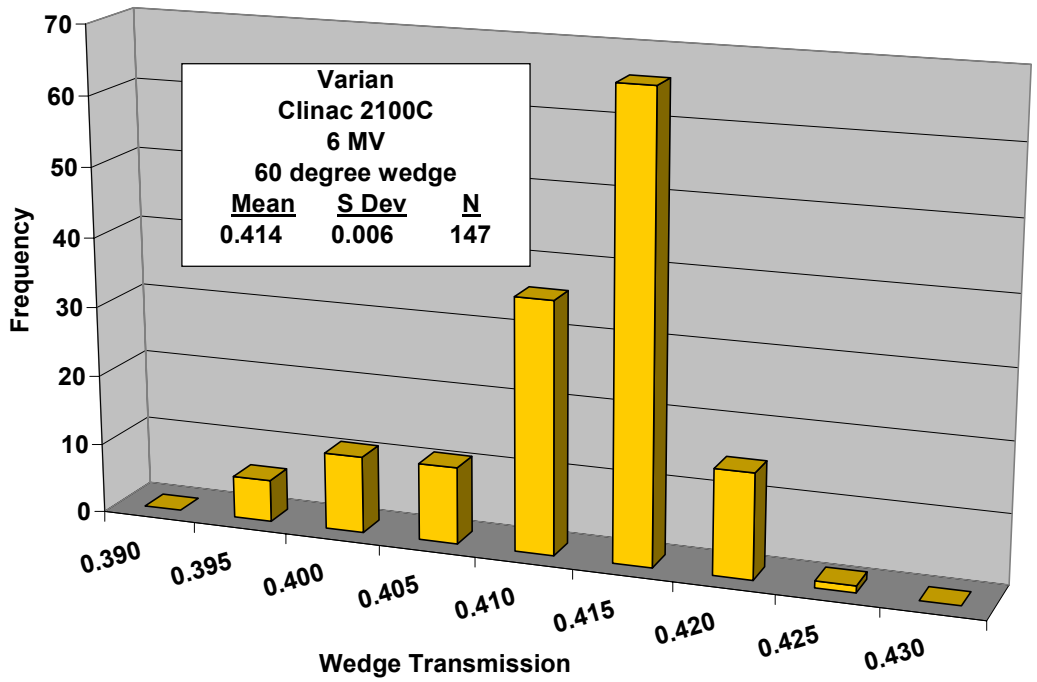

Standard Average Clinac
Thin Tray Factors
Ave. Thin Tray Factor
0.99
0.985
0.98
0.975
0.97
0.965
0.96
0.955
0.6
0.65
0.7
0.75
0.8
0.85
Ionization Ratio
y = 0.1105x + 0.8931
R2 = 0.8729


Varian
Clinac 6/100, 600C, 1800
2100C, 2300C, 2500
6 MV
60 degree wedge
Mean S Dev N
0.416 0.007 336
Frequency
70
60
50
40
30
20
10
0
0.385
0.395
0.405
0.415
0.425
0.435
0.445
0.455
0.465
0.475
Wedge Transmission


Siemens
Mevatron KD series
30 degree wedge
Mean S Dev N
0.518 0.007 21
0.716 0.004 17
Frequency
18
16
14
12
10
8
6
4
2
0
0.500
0.520
0.540
0.560
0.580
0.600
0.660
0.680
0.700
0.720
0.740
Wedge Transmission


Philips/Elekta
SL 25
60 degree wedge
Mean S Dev N
0.270 0.004 14
Frequency
6
5
4
3
2
1
0
0.259
0.262
0.265
0.268
0.271
0.274
0.277
0.28
Wedge Transmission


Varian
Clinac 6/100
45 degree wedge
Mean S Dev N
0.481 0.010 32
0.569 0.006 6
0.614 0.008 98
Frequency
60
50
40
30
20
10
0
0.460
0.480
0.500
0.520
0.540
0.560
0.580
0.600
0.620
0.640
0.660
Wedge Transmission


Varian
Clinac 2100C
6 MV
60 degree wedge
Mean S Dev N
0.414 0.006 147
Frequency
70
60
50
40
30
20
10
0
0.390
0.395
0.400
0.405
0.410
0.415
0.420
0.425
0.430
Wedge Transmission