

Experiences Commissioning the FFF mode on Varian Truebeam in a Small Radiotherapy Centre

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**Lingen Davies
Cancer Fund**

Registered Charity Number 1160922



Shrewsbury



Royal Shrewsbury Hospital



Shrewsbury Radiotherapy Department

- 2 Linacs (Varian iX and Varian TrueBeam)
- Aria 11 with Eclipse Planning system
- 6 Eclipse Planning Work stations + 2 Somovision work stations
- 1 Toshiba wide bore CT scanner
- Extended day working – capacity issues

Flattening Filter Free

- Came with the TrueBeam
- Commissioning SABR
- Faster Treatment – SABR Applications



Commissioning TrueBeam (April 2013)

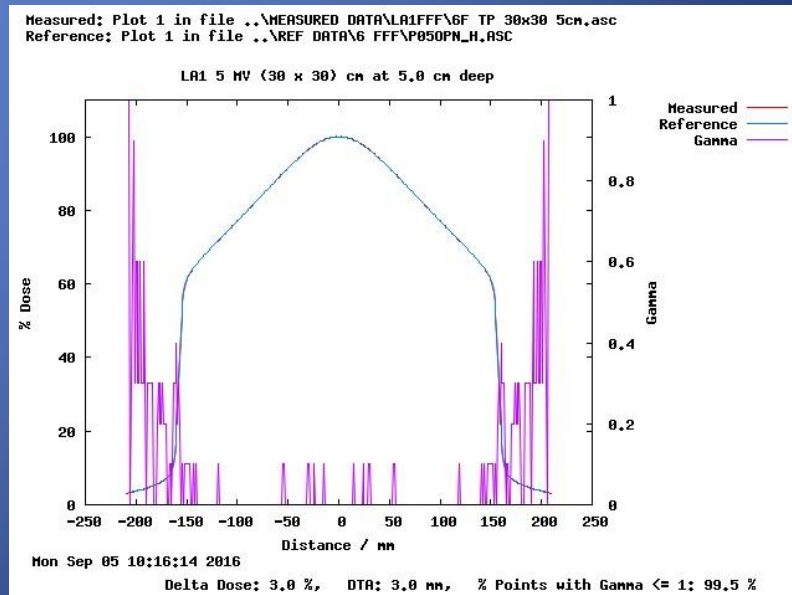
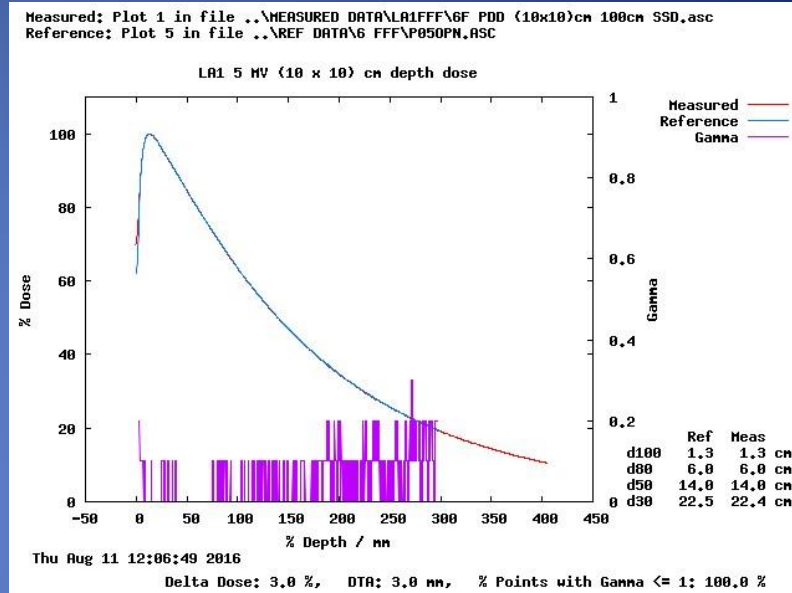
- Shielding requirements for FFF – modify bunker
- Limited commissioning time
- Limited scientific staff
- Limited knowledge of FFF beams
- Collect beam data and analyse later

Process

- Collect Beam data
 - Depth doses/profiles
 - MLC data
 - Output factors
 - Determine absolute dosimetry
- Check data matches Varian gold standard
- Create FFF beam model in Eclipse

Beam Check Program

- Compares measured data to reference data and performs gamma analysis
- Parameters for gamma analysis chosen by user (usually 3 % / 3 mm)
- Program provides % points with $\gamma \leq 1$, plus a graph with plots for measured data, reference data and gamma values
- 6 FFF reference data taken from Varian website

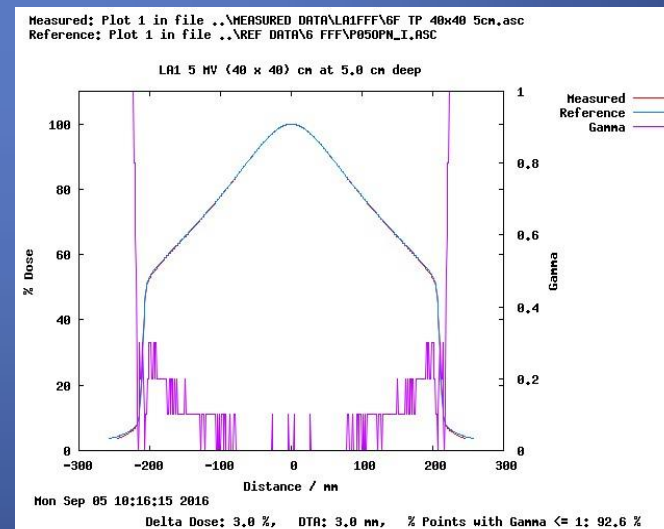
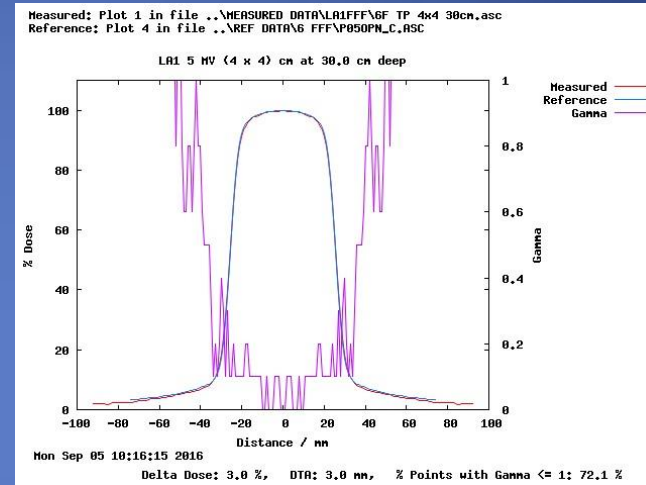


Beam Check Results

Depth Dose

Field Size (cm)	% Points with Gamma ≤ 1	
	3 % / 3 mm	1 % / 1 mm
3 x 3	100.0	99.9
4 x 4	100.0	99.9
6 x 6	100.0	100.0
8 x 8	100.0	99.9
10 x 10	100.0	99.9
20 x 20	100.0	99.5
30 x 30	100.0	96.2
40 x 40	100.0	95.1

Profiles



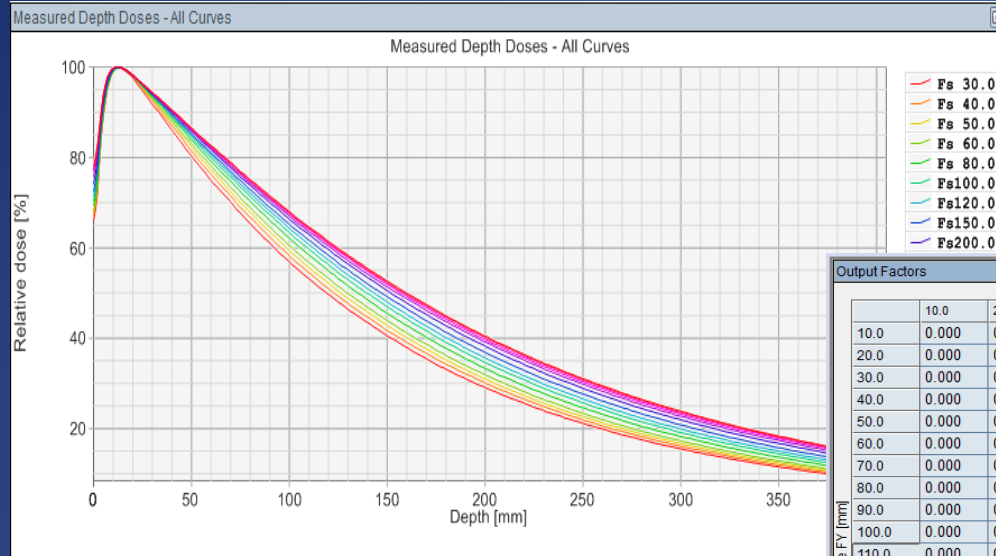
Absolute dosimetry

- Measured TPR_{20/10}:
6X FFF - 0.632
10X FFF - 0.707
- Use standard Farmer chamber. Volume averaging effects small enough to ignore
- Reference dosimetry as standard – must include Ion Recombination!

Ion Recombination

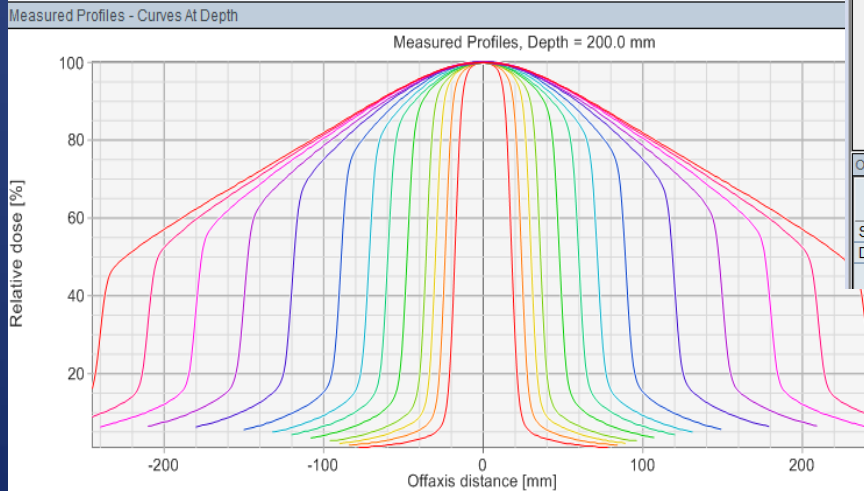
- 2 Voltage technique F_{ion} : 1.014 6FFF, 1.025 10FFF
- Relative FS effects $<0.2\%$
- PDD dose/pulse changes F_{ion} could be applied
- Out of field penumbra F_{ion} dose/pulse changes $\sim 20\%$ therefore should also consider correction – OAR dose accuracy

Data Input into Eclipse



Output Factors

	Field size FX [mm]											
	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0
10.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30.0	0.000	0.000	0.845	0.859	0.868	0.877	0.882	0.887	0.890	0.893	0.895	0.897
40.0	0.000	0.000	0.860	0.878	0.889	0.900	0.906	0.912	0.916	0.920	0.923	0.925
50.0	0.000	0.000	0.869	0.890	0.902	0.915	0.923	0.930	0.934	0.939	0.942	0.946
60.0	0.000	0.000	0.878	0.901	0.915	0.930	0.939	0.948	0.953	0.958	0.962	0.966
70.0	0.000	0.000	0.883	0.908	0.924	0.939	0.949	0.959	0.965	0.971	0.975	0.979
80.0	0.000	0.000	0.889	0.914	0.932	0.949	0.960	0.970	0.977	0.984	0.988	0.993
90.0	0.000	0.000	0.892	0.919	0.937	0.955	0.966	0.977	0.984	0.992	0.997	1.002
100.0	0.000	0.000	0.896	0.923	0.942	0.961	0.973	0.984	0.992	1.000	1.005	1.011
110.0	0.000	0.000	0.899	0.927	0.946	0.965	0.977	0.989	0.998	1.006	1.012	1.018
120.0	0.000	0.000	0.901	0.930	0.950	0.969	0.982	0.995	1.003	1.012	1.018	1.024
130.0	0.000	0.000	0.902	0.932	0.952	0.972	0.985	0.998	1.007	1.016	1.022	1.028
140.0	0.000	0.000	0.904	0.933	0.954	0.974	0.988	1.002	1.010	1.019	1.026	1.032
150.0	0.000	0.000	0.905	0.935	0.956	0.977	0.991	1.005	1.014	1.023	1.030	1.036
160.0	0.000	0.000	0.906	0.936	0.957	0.979	0.993	1.007	1.016	1.025	1.032	1.039
170.0	0.000	0.000	0.907	0.937	0.959	0.980	0.994	1.009	1.018	1.027	1.035	1.042
180.0	0.000	0.000	0.907	0.938	0.960	0.982	0.996	1.010	1.020	1.030	1.037	1.044
190.0	0.000	0.000	0.908	0.939	0.961	0.983	0.998	1.012	1.022	1.032	1.039	1.047
200.0	0.000	0.000	0.909	0.940	0.962	0.985	0.999	1.014	1.024	1.034	1.042	1.050
210.0	0.000	0.000	0.909	0.941	0.963	0.986	1.000	1.015	1.025	1.035	1.043	1.051

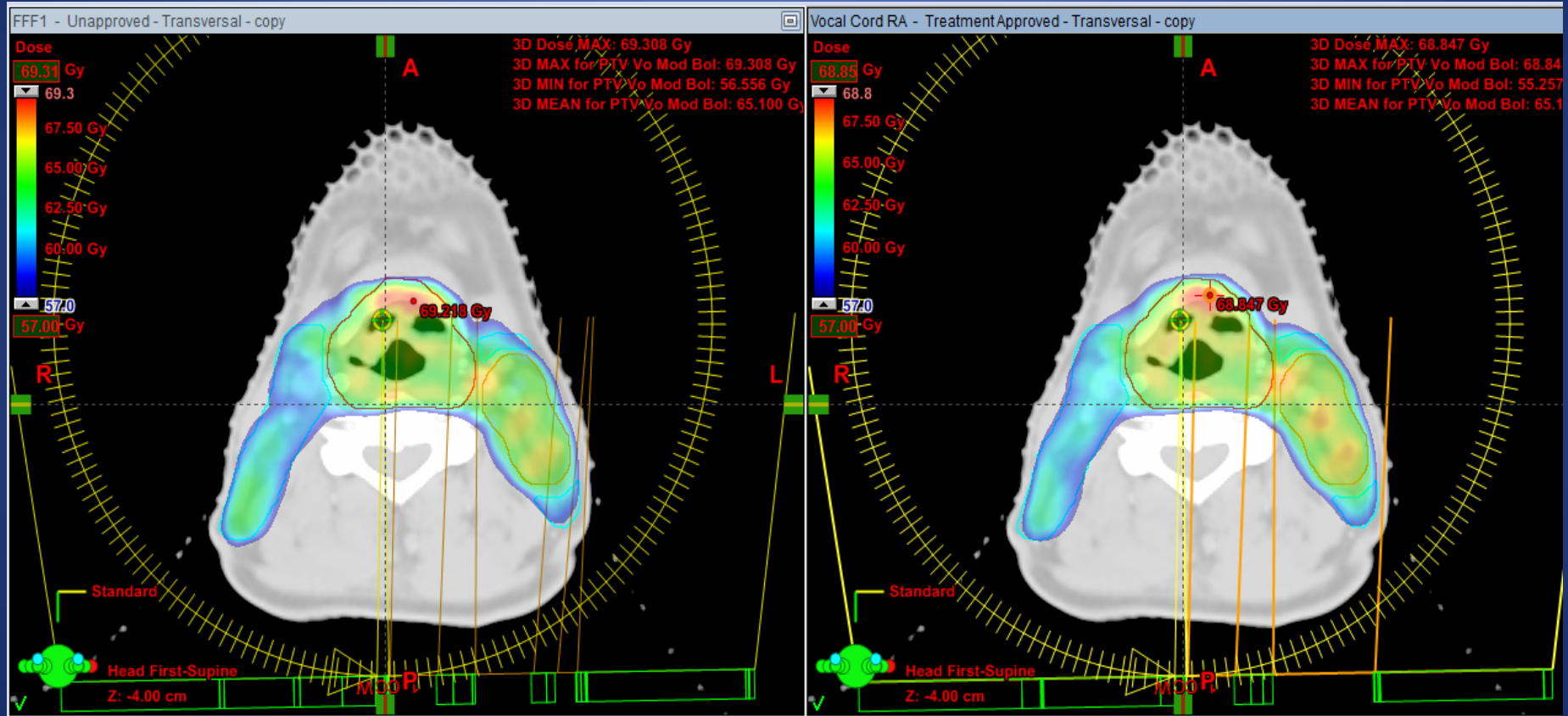


Output Factors - Parameter View

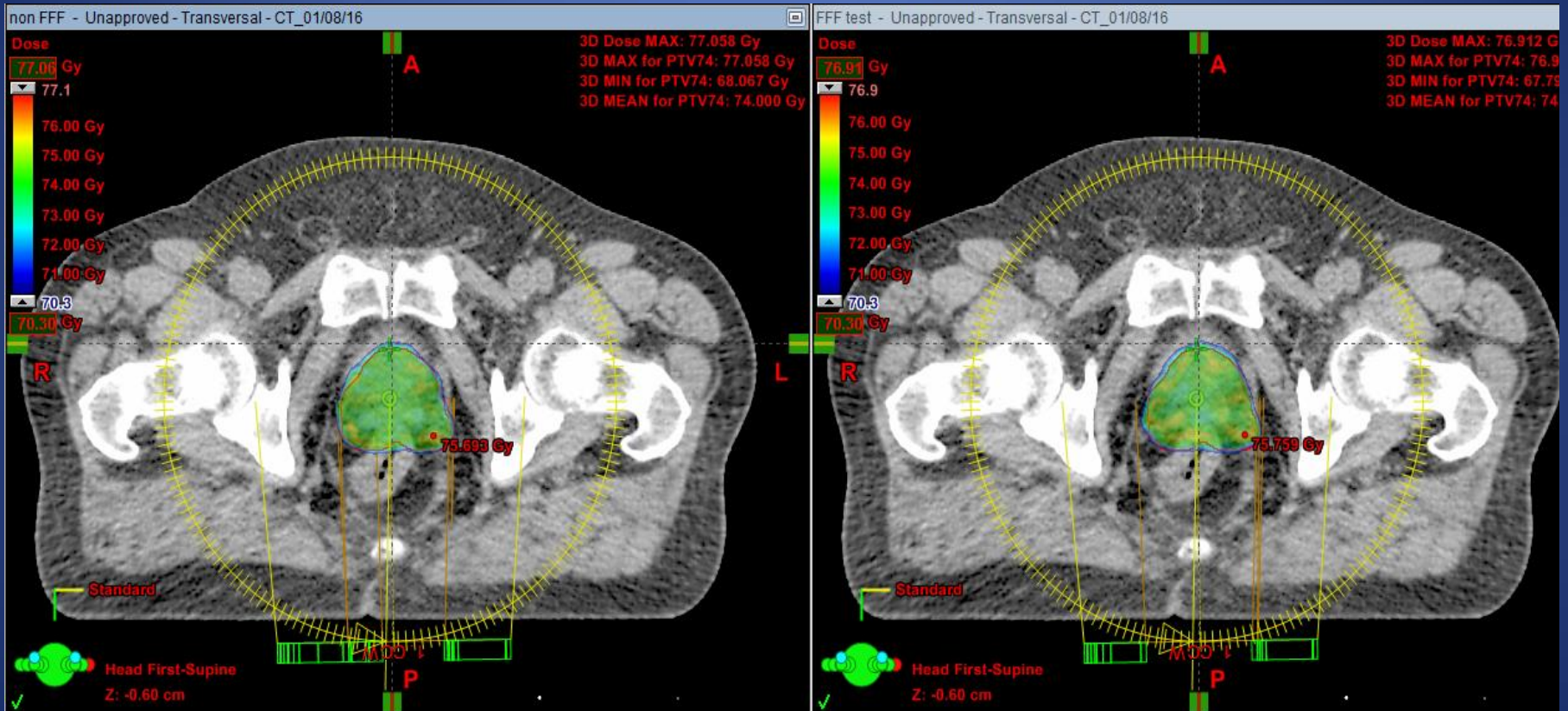
Source-phantom distance [mm]	1000.0
Detector depth from phantom surface [mm]	100.0

Fs 400.0 D200

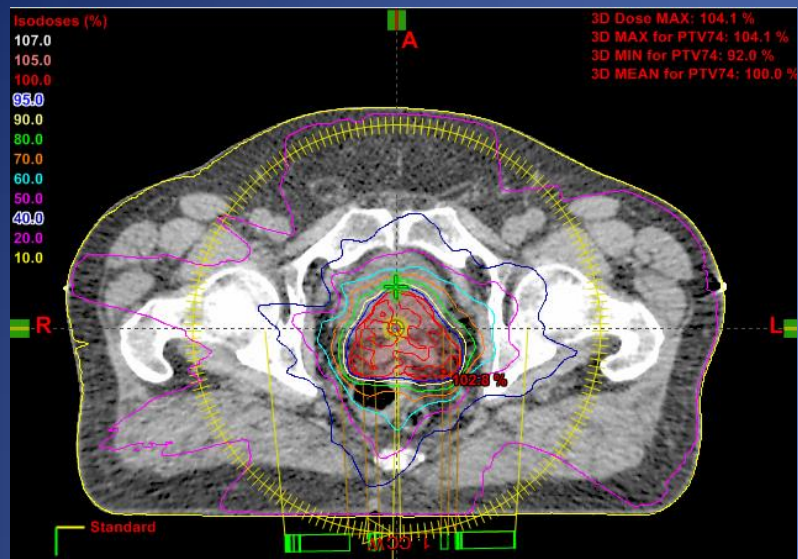
Plan Comparison – H+N



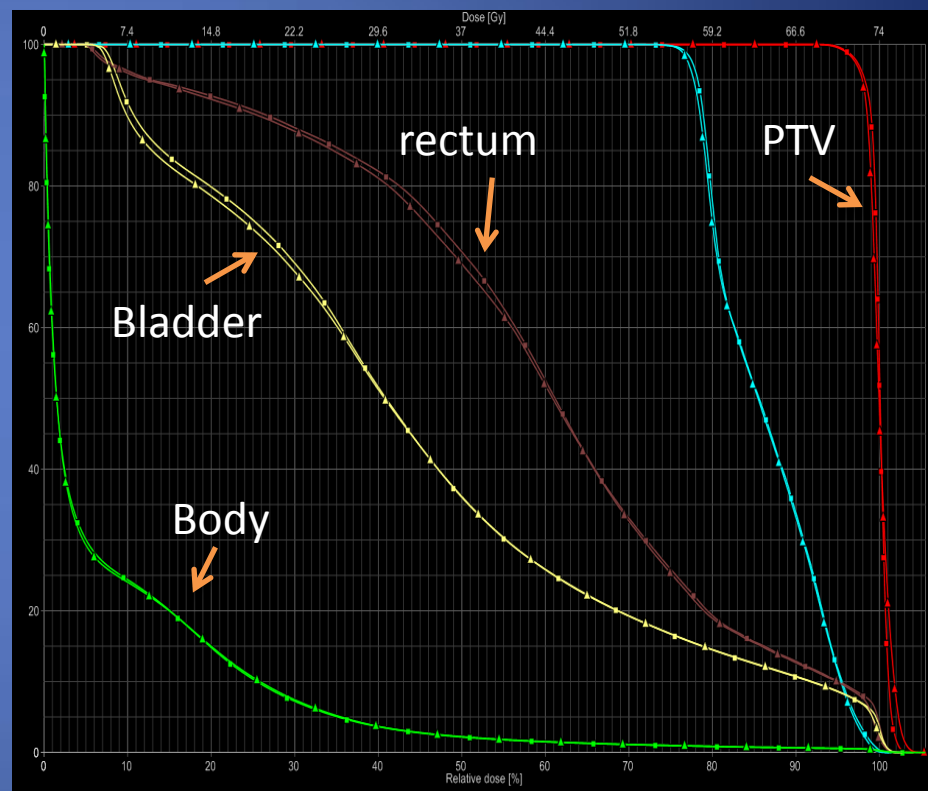
Plan Comparison – Prostate



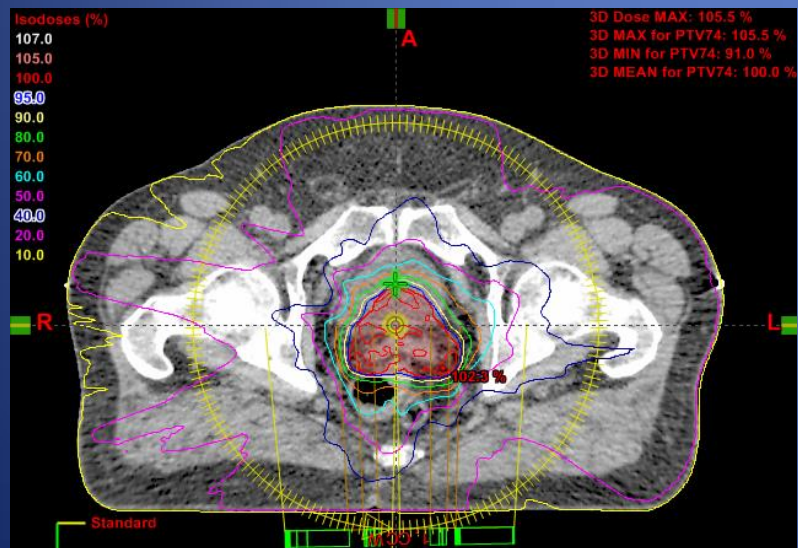
6X



Lower Dose Regions



6FFF



DVH for 6X and 6FFF plans

No advantage in speed for non-SABR treatments

MLC Properties

General Control Points Leaf Positions Debug

Index	Meterset Weight	Gantry Rtn [deg]	Dose Rate [MU/min]	Gantry Speed [deg/s]	MU/deg
1	0.0000	179.0			
2	0.0017	178.0	86.743	4.800	0.301
3	0.0050	175.9	86.743	4.800	0.301
4	0.0083	173.9	86.743	4.800	0.301
5	0.0117	171.9	86.743	4.800	0.301
6	0.0150	169.8	86.743	4.800	0.301
7	0.0183	167.8	86.743	4.800	0.301
8	0.0217	165.8	86.743	4.800	0.301
9	0.0250	163.7	86.743	4.800	0.301
10	0.0292	161.7	109.785	4.800	0.381
11	0.0334	159.7	109.785	4.800	0.381
12	0.0377	157.6	109.785	4.800	0.381
13	0.0419	155.6	109.785	4.800	0.381
14	0.0461	153.6	109.785	4.800	0.381
15	0.0503	151.5	109.785	4.800	0.381
16	0.0545	149.5	109.785	4.800	0.381
17	0.0587	147.5	109.785	4.800	0.381
18	0.0626	145.4	99.035	4.800	0.344
19	0.0664	143.4	99.035	4.800	0.344
20	0.0702	141.4	99.035	4.800	0.344
21	0.0740	139.3	99.035	4.800	0.344
22	0.0779	137.3	102.006	4.800	0.354
23	0.0818	135.3	102.006	4.800	0.354
24	0.0857	133.2	102.006	4.800	0.354
25	0.0896	131.2	102.006	4.800	0.354
26	0.0933	129.2	94.101	4.800	0.327
27	0.0969	127.1	94.101	4.800	0.327

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OK Cancel Apply Help

Same speed

Field Properties

General Geometry Room Geometry Accessories Calculation

Control Points Reference Image Setup Notes Comment Debug

Index	Meterset Weight	Gantry Rtn [deg]	Dose Rate [MU/min]	Gantry Speed [deg/s]	MU/deg
3	0.0050	175.9	111.305	4.800	0.386
4	0.0083	173.9	111.305	4.800	0.386
5	0.0117	171.9	111.305	4.800	0.386
6	0.0150	169.8	111.305	4.800	0.386
7	0.0183	167.8	111.305	4.800	0.386
8	0.0217	165.8	111.305	4.800	0.386
9	0.0250	163.7	111.305	4.800	0.386
10	0.0292	161.7	140.870	4.800	0.489
11	0.0334	159.7	140.870	4.800	0.489
12	0.0377	157.6	140.870	4.800	0.489
13	0.0419	155.6	140.870	4.800	0.489
14	0.0461	153.6	140.870	4.800	0.489
15	0.0503	151.5	140.870	4.800	0.489
16	0.0545	149.5	140.870	4.800	0.489
17	0.0587	147.5	140.870	4.800	0.489
18	0.0626	145.4	127.077	4.800	0.441
19	0.0664	143.4	127.077	4.800	0.441
20	0.0702	141.4	127.077	4.800	0.441
21	0.0740	139.3	127.077	4.800	0.441
22	0.0779	137.3	130.889	4.800	0.454
23	0.0818	135.3	130.889	4.800	0.454
24	0.0857	133.2	130.889	4.800	0.454
25	0.0896	131.2	130.889	4.800	0.454
26	0.0933	129.2	120.746	4.800	0.419
27	0.0969	127.1	120.746	4.800	0.419
28	0.1005	125.1	120.746	4.800	0.419
29	0.1041	123.1	120.746	4.800	0.419
30	0.1077	121.0	120.855	4.800	0.420
31	0.1113	119.0	120.855	4.800	0.420
32	0.1150	117.0	120.855	4.800	0.420

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Advantage in speed for SABR treatments

Field Properties

General Geometry Room Geometry Accessories Calculation

Control Points Reference Image Setup Notes Comment Debug

Index	Meterset Weight	Gantry Rtn [deg]	Dose Rate [MU/min]	Gantry Speed [deg/s]	MU/deg
19	0.0620	143.4	600.000	1.874	5.336
20	0.0684	141.4	600.000	1.659	6.029
21	0.0750	139.3	600.000	1.627	6.145
22	0.0809	137.3	600.000	1.815	5.508
23	0.0868	135.3	600.000	1.815	5.508
24	0.0927	133.2	600.000	1.815	5.508
25	0.0986	131.2	600.000	1.821	5.490
26	0.1044	129.2	600.000	1.856	5.389
27	0.1101	127.1	600.000	1.856	5.389
28	0.1159	125.1	600.000	1.856	5.389
29	0.1217	123.1	600.000	1.856	5.389
30	0.1278	121.0	600.000	1.759	5.685
31	0.1339	119.0	600.000	1.759	5.685
32	0.1399	117.0	600.000	1.759	5.685
33	0.1457	114.9	600.000	1.855	5.391
34	0.1507	112.9	600.000	2.158	4.633
35	0.1563	110.9	600.000	1.910	5.234
36	0.1626	108.8	600.000	1.691	5.913
37	0.1698	106.8	600.000	1.497	6.681
38	0.1781	104.8	600.000	1.286	7.778
39	0.1879	102.7	600.000	1.094	9.143
40	0.1994	100.7	600.000	0.929	10.768
41	0.2096	98.7	600.000	1.052	9.509
42	0.2191	96.6	600.000	1.127	8.876
43	0.2280	94.6	600.000	1.205	8.301
44	0.2369	92.6	600.000	1.205	8.301
45	0.2458	90.5	600.000	1.205	8.301
46	0.2550	88.5	600.000	1.169	8.557
47	0.2636	86.4	600.000	1.248	8.012
48	0.2712	84.4	600.000	1.410	7.092

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Max dose rate FFF faster

Field Properties

General Geometry Room Geometry Accessories Calculation

Control Points Reference Image Setup Notes Comment Debug

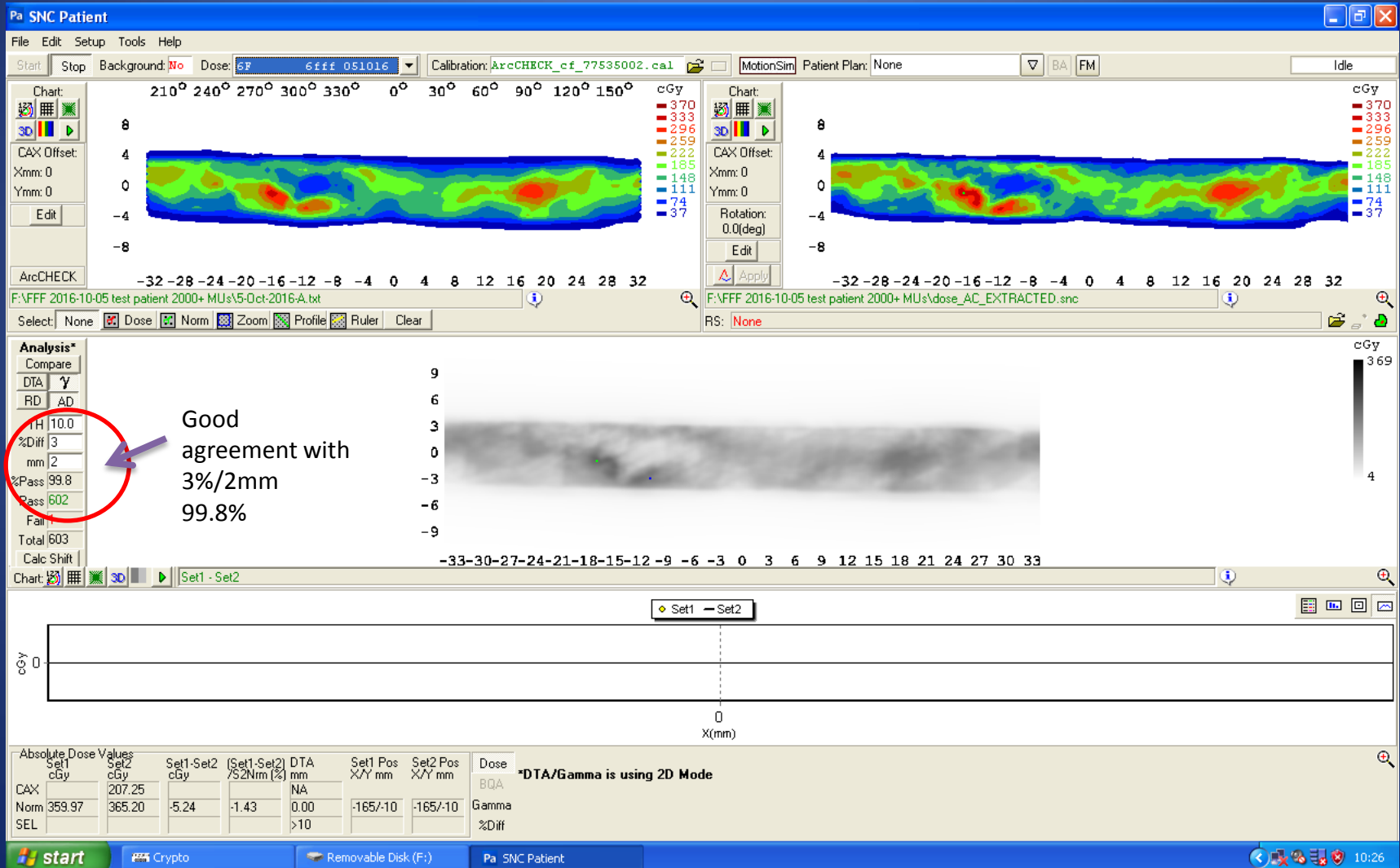
Index	Meterset Weight	Gantry Rtn [deg]	Dose Rate [MU/min]	Gantry Speed [deg/s]	MU/deg
19	0.0657	143.4	1400.000	4.604	5.068
20	0.0706	141.4	1400.000	4.578	5.097
21	0.0756	139.3	1400.000	4.578	5.097
22	0.0805	137.3	1400.000	4.585	5.089
23	0.0855	135.3	1400.000	4.585	5.089
24	0.0904	133.2	1400.000	4.585	5.089
25	0.0954	131.2	1400.000	4.585	5.089
26	0.1007	129.2	1400.000	4.246	5.495
27	0.1060	127.1	1400.000	4.246	5.495
28	0.1114	125.1	1400.000	4.246	5.495
29	0.1167	123.1	1400.000	4.246	5.495
30	0.1219	121.0	1400.000	4.363	5.348
31	0.1271	119.0	1400.000	4.363	5.348
32	0.1323	117.0	1400.000	4.363	5.348
33	0.1375	114.9	1400.000	4.363	5.348
34	0.1433	112.9	1400.000	3.878	6.017
35	0.1500	110.9	1400.000	3.433	6.798
36	0.1574	108.8	1400.000	3.038	7.679
37	0.1649	106.8	1400.000	3.026	7.711
38	0.1726	104.8	1400.000	2.940	7.936
39	0.1803	102.7	1400.000	2.940	7.936
40	0.1880	100.7	1400.000	2.940	7.936
41	0.1963	98.7	1400.000	2.732	8.540
42	0.2052	96.6	1400.000	2.555	9.132
43	0.2145	94.6	1400.000	2.447	9.535
44	0.2233	92.6	1400.000	2.563	9.105
45	0.2309	90.5	1400.000	3.002	7.772
46	0.2373	88.5	1400.000	3.505	6.657
47	0.2431	86.4	1400.000	3.960	5.893
48	0.2480	84.4	1400.000	4.603	5.069

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Verification of FFF plans

ArcCheck – need version compatible for FFF beams.



Quality Control

Largely duplicates standard photon QC

- Output (vs DR, Linearity etc)
- Beam Quality
- Beam Profiles (Flatness: deviation from baseline measurement)
- DLG / Sweeping Gap
- 'Standard' IMRT / VMAT plans (Arc Check)
- X-Ray : Light Field alignment

Final Stages

- External Audit – We have audited another centre - in agreement and maybe favour returned?



- Plan of action for breakdown
- Ready for clinical use

Acknowledgements

- Mr Paul Evans
- Mr Mike Alexander
- Miss Catherine Heyward
- Miss Kirsten Hughes