Multi Channel Vaginal Applicator: Commissioning and a novel optimisation method

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THE BRIGHT ALLIANCE

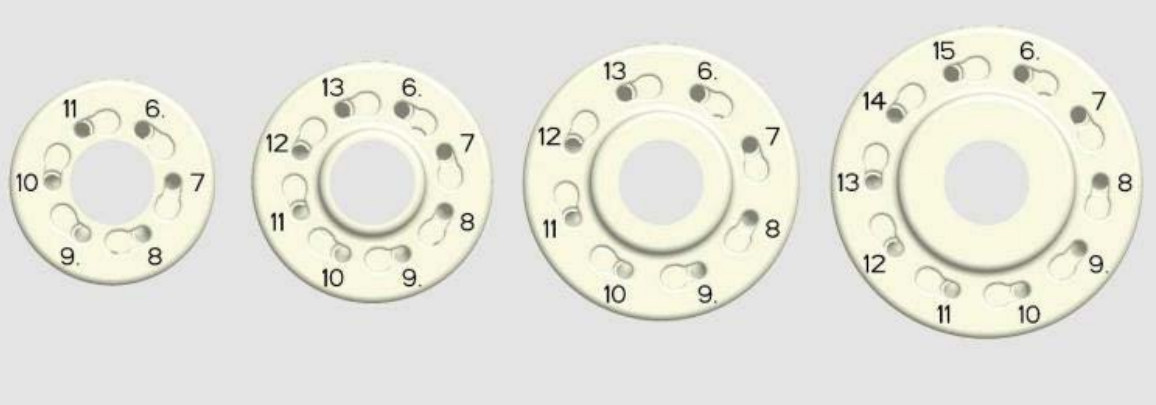
1.

Introduction

VMC applicator

Images courtesy of Elekta

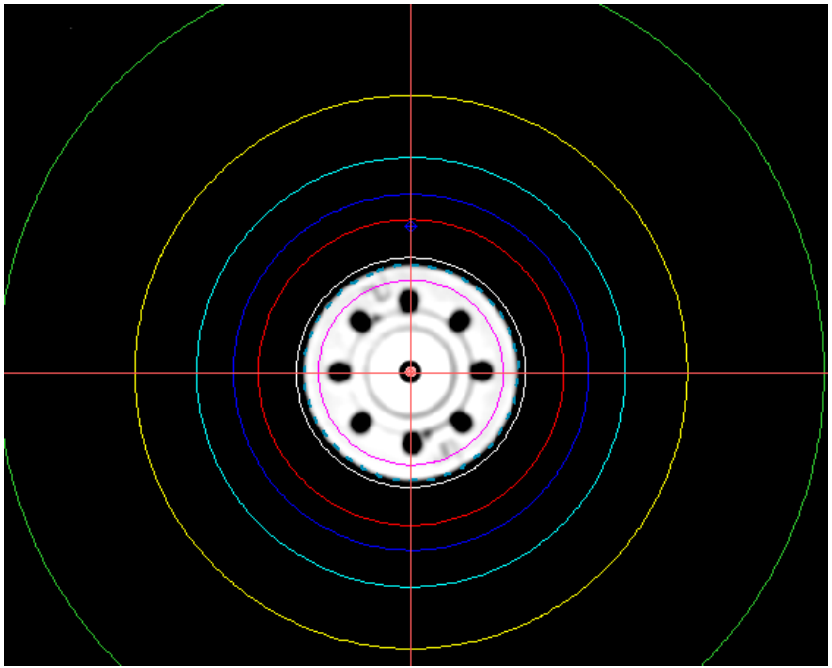
Elekta Vaginal CT/MR Multi Channel Applicator Set

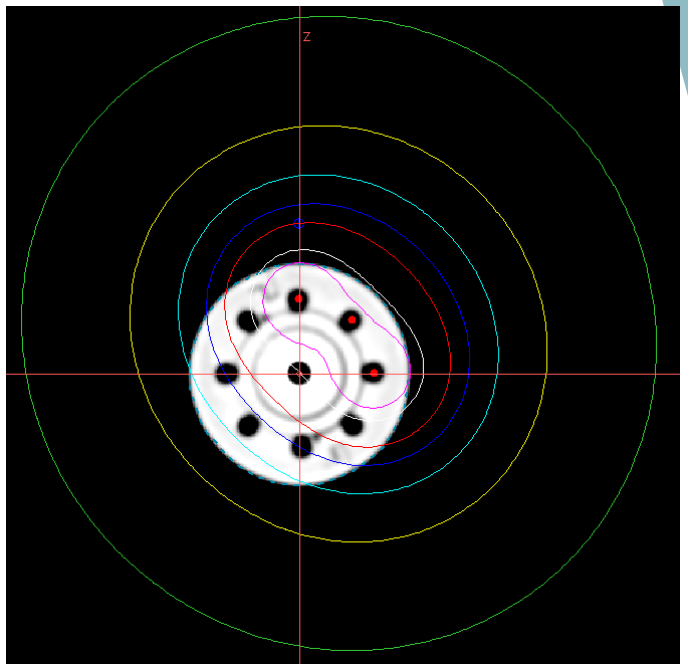


Diameter (mm)	25	30	35	40
No. Channels	6	8	8	10

Images courtesy of Elekta

Dose Distributions





2.

Commissioning

Physical Inspection - Applicator

- Each part of each cylinder inspected for cracks/damage – none found
- Each cylinder dimensions measured with Vernier callipers

Diameter (mm)		Length (mm)	
Specification	**Measured**	**Specification**	**Measured**
25	25.0	189	188.9
30	30.0	189	188.9
35	35.0	189	189.0

Physical Inspection – Cuffed catheters

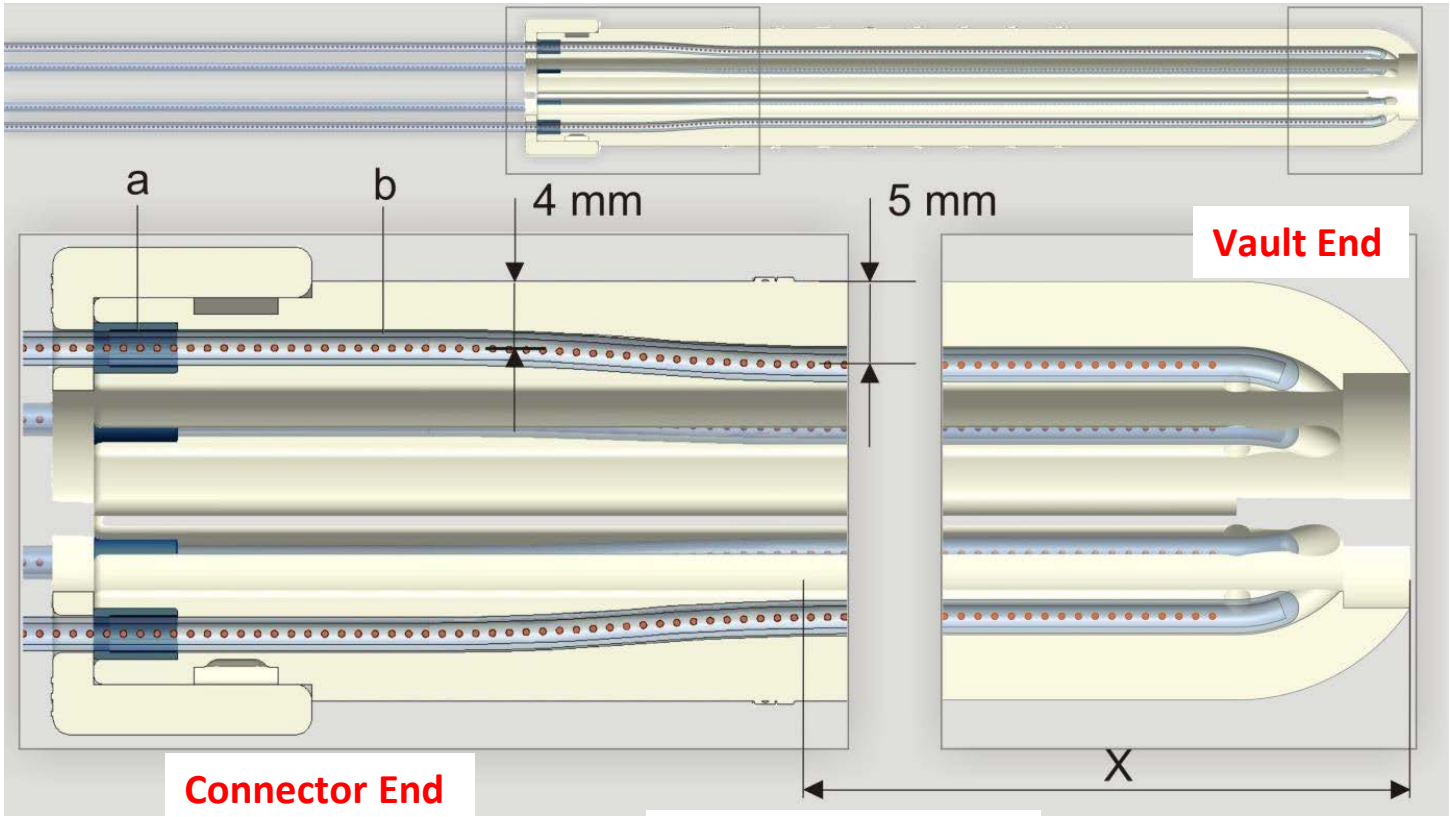
- Sterile, single use flexible catheters with cuff to lock in position
- Visual inspection for any damage – none found
- Inserted into each channel of all applicators to ensure sits flush and cylinder locks correctly
- Length measured with Vernier callipers

Position	Length (mm) Specification	Length (mm) Measured
Tip to cuff	114	114.0
Total Length	193	193.0

CT imaging

- CT acquired of each applicator – 1 mm slice thickness
- Imported into Oncentra
- Assessed;
  - Internal defects – none found
  - Applicator diameter – Oncentra measure tool
  - Distance from channel centre to surface

CT imaging – Channel Distance



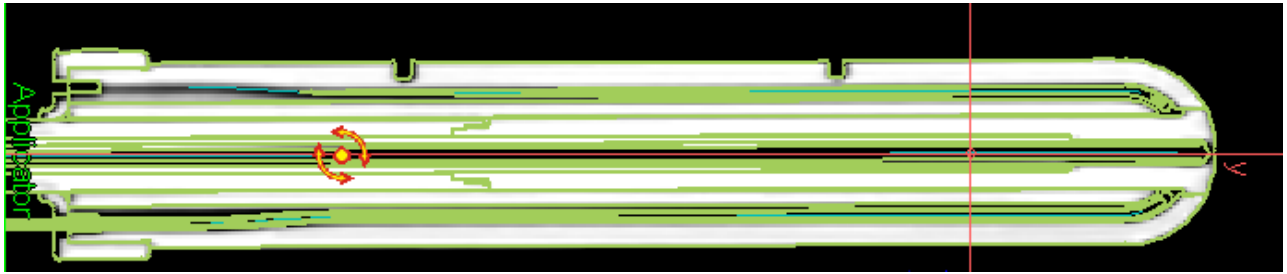
Images courtesy of Elekta

CT imaging – Results

Parameter	Applicator (mm)	Specification (mm)	Largest deviation (mm)
Applicator Diameter	30	30	- 0.2
Dwell position to surface distance (vault end)	All	5	± 0.1
Dwell position to surface distance (connector end)	All	4	± 0.1
Point of divergence	35	137.8	+ 2.2

CT imaging – Applicator Library Matching

- Oncentra library applicator matched to each cylinder
- Best to use 3+ anchor points to get rotation and orientation correct
- Use rotation and translation tools to get perfect match
- Structure and dwell positions assessed – matches very well
- Faster than catheter reconstruction



Source Position Checks - Catheter

Source position simulator:

- Cuffed catheter most distal dwell position 1288 mm
- Marked using gold 294 (288) mm marker wire
- Checked using source position simulator
- Measured 288.5 ± 0.5 mm
- Checked with active source using RTQA film, dwell position 1288
- Measured 1288.5 ± 0.5 mm

Source Position Checks – IV tube

Autoradiographs;

- Taken with Pantak Orthvoltage unit and RTQA film
- Source position simulator, dwell position 300 mm
- Measured distance from end of inner tube to centre of ‘source’
- Expect 5 mm offset
- Measured 5.5mm ± 0.5 mm

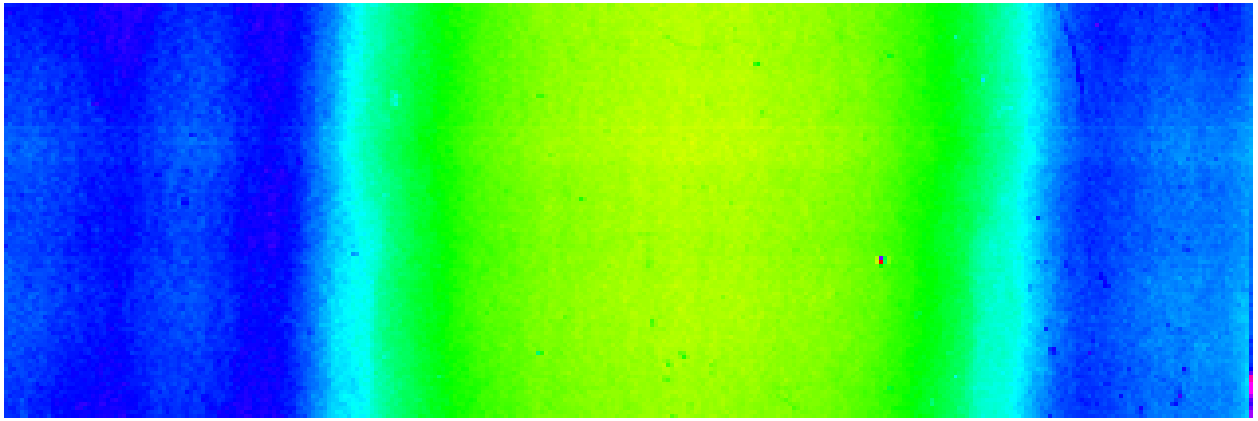
Film Verification

- Test plan created in Oncentra for 25 mm and 35 mm applicators .
- EBT3 films calibrated with 300 kV orthovoltage beam
  - Filter 1, 50 kV 50 cm SSD, 12 cm x 6 cm cone
- Film wrapped around applicator with 2 cm soft bolus backscatter

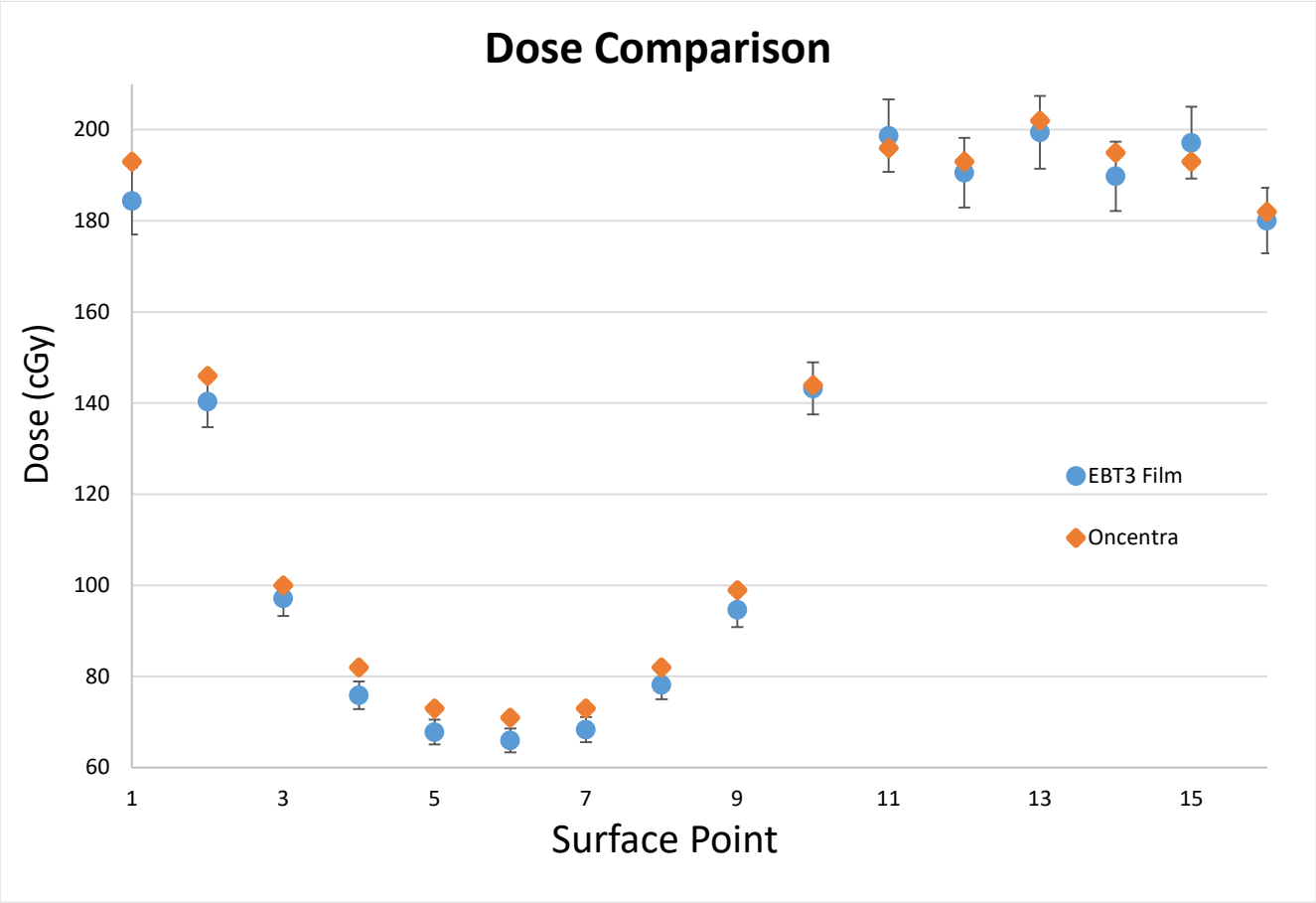
Film Verification – 35 mm applicator

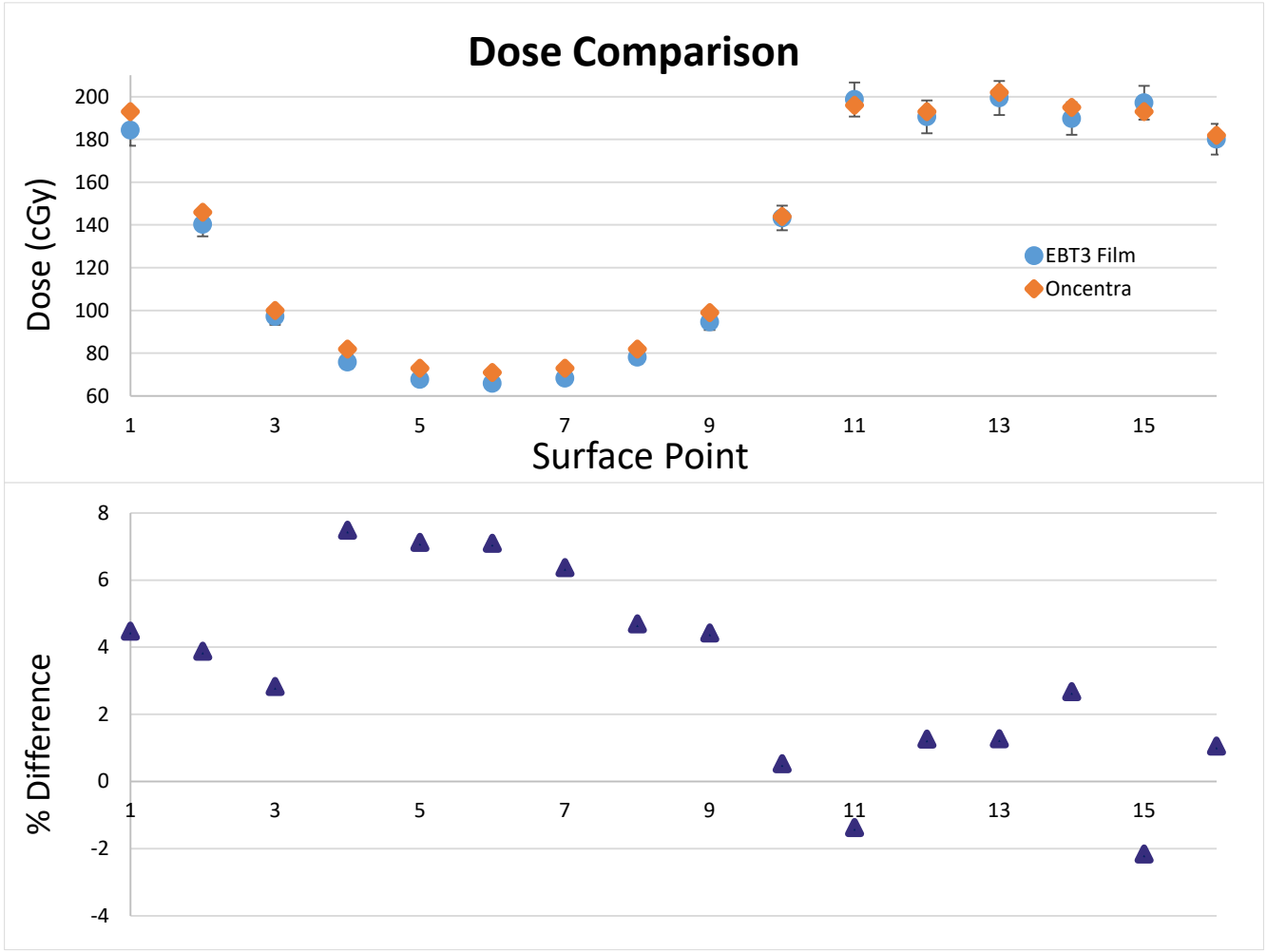
- 4 adjacent surface channels activated
- 2 Gy prescribed and geometric volume optimisation to surface
- 16 circumference dose points compared
- Highest dose discrepancy was 8 %
- Estimated film uncertainty ± 4 %

35 mm Results



35 mm Results




Dose Comparison
Dose (cGy)
200
180
160
140
120
100
80
60
1
3
5
7
9
11
13
15
Surface Point
EBT3 Film
Oncentra
% Difference
8
6
4
2
0
-2
-4

Other Tests

- Visual check of catheter final dwell position with cylinder open
- End-to-end test with all channels
- Independent dose checks with RadCalc with dose points (< 0.2%)

3.

A Novel Optimisation Method

Protocols

Imaging

- CT scan
- RO to contour PTV
- Optimise to PTV volume

Non-Imaging

- RO to specify applicator diameter, length, ‘segment’
- Optimise to dose points

Non-Imaging Advantages

- Significantly faster
- No CT dose
- Simple applicator fixation – no patient transfers

Expect to use non-imaging protocol for most patients

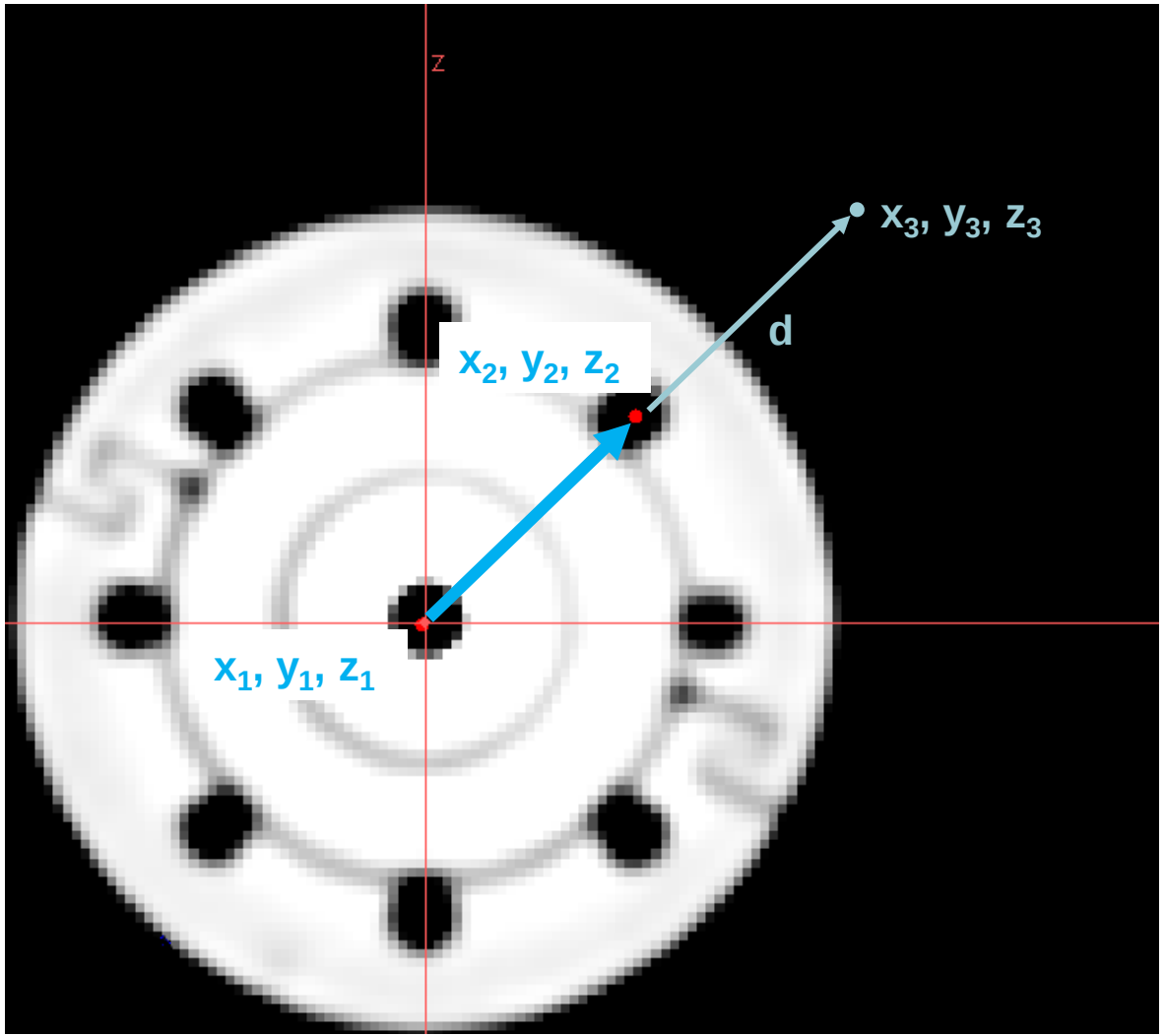
Oncentra - Dose Points

- No target volume, dose points must be used to define prescription
- Need to create a set of dose points a distance d from applicator surface for required channels
- No simple way to efficiently define dose points in 3 dimensions in Oncentra
- For example you can only specify catheter points in fixed directions

Oncentra - Dose Points

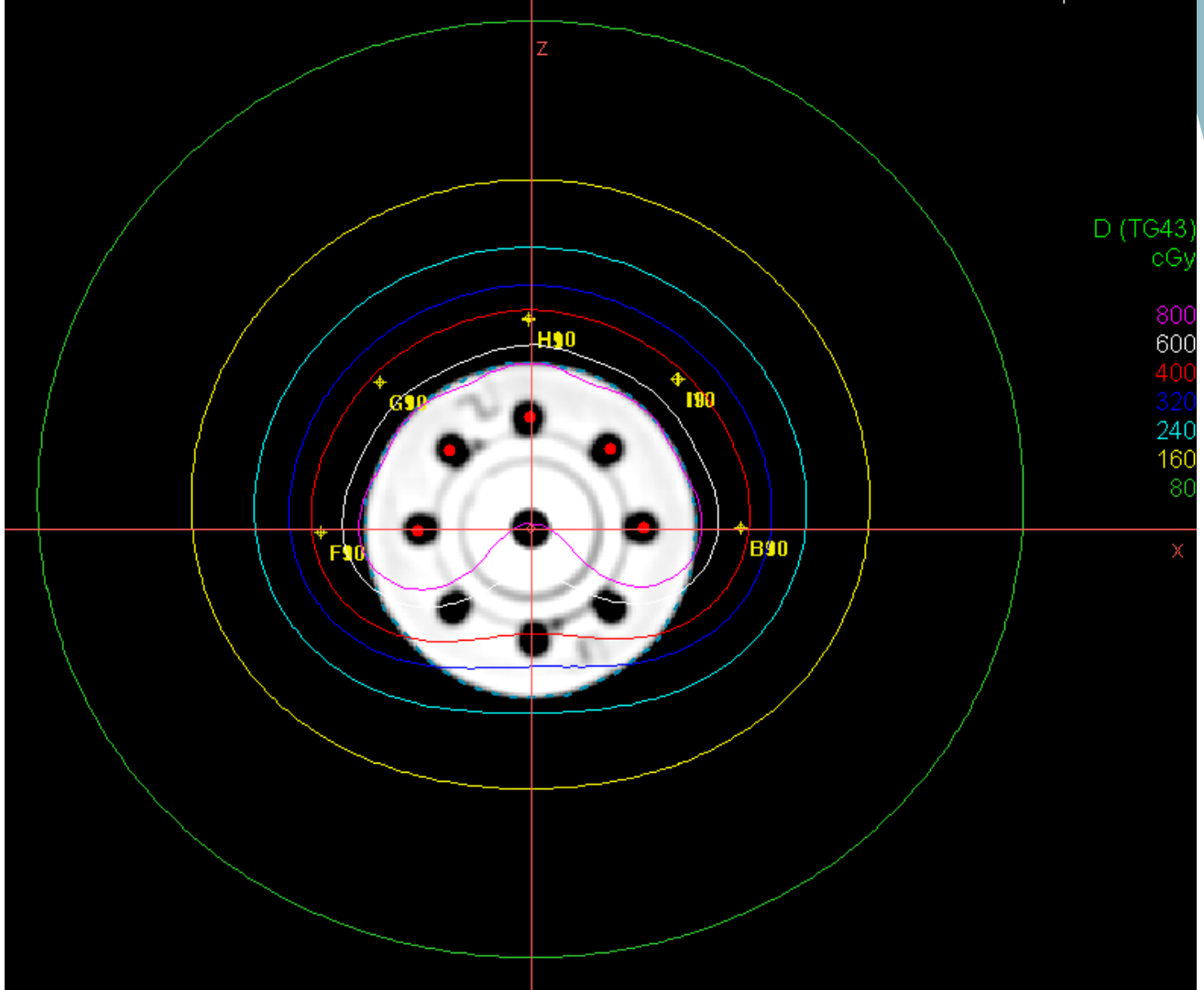
Solution:

Use vector geometry to generate coordinates for a set of dose points at a specified distance from the centre of required channels.


z
x_3, y_3, z_3
d
x_2, y_2, z_2
x_1, y_1, z_1

Dose Point Extrapolator

1	Applicator diameter =		35	mm									Prescription depth =		5	mm	
2		Central				Catheter 9			Vector								
3	Source Pos	x1	y1	z1	Source Pos	x2	y2	z2	x	y	z	Vector length	Applicator Points	x3	y3	z3	Coord Sys A
4	288	1.4	-1067.2	1.4	288	1.9	-1059.9	-9	0.5	7.3	-10.4	12.716	I1	2.29	-1054.16	-17.18	Patient
5	286	1.4	-1069.2	1.4	286	2	-1061.7	-10	0.6	7.5	-11.4	13.659	I2	2.44	-1056.21	-18.35	Patient
6	284	1.4	-1071.2	1.4	284	2	-1063.6	-10.6	0.6	7.6	-12	14.217	I3	2.42	-1058.25	-19.04	Patient
7	282	1.4	-1073.2	1.4	282	2	-1065.5	-11	0.6	7.7	-12.4	14.609	I4	2.41	-1060.23	-19.49	Patient
8	280	1.3	-1075.2	1.4	280	2	-1067.5	-11.1	0.7	7.7	-12.5	14.698	I5	2.48	-1062.26	-19.60	Patient
9	278	1.3	-1077.2	1.4	278	1.9	-1069.5	-11.1	0.6	7.7	-12.5	14.694	I6	2.31	-1064.26	-19.61	Patient
10	276	1.3	-1079.2	1.4	276	1.9	-1071.5	-11.1	0.6	7.7	-12.5	14.694	I7	2.31	-1066.26	-19.61	Patient
11	274	1.3	-1081.2	1.4	274	1.9	-1073.5	-11.1	0.6	7.7	-12.5	14.694	I8	2.31	-1068.26	-19.61	Patient
12	272	1.3	-1083.2	1.4	272	1.9	-1075.5	-11.1	0.6	7.7	-12.5	14.694	I9	2.31	-1070.26	-19.61	Patient
13	270	1.2	-1085.2	1.4	270	1.9	-1077.5	-11.1	0.7	7.7	-12.5	14.698	I10	2.38	-1072.26	-19.60	Patient
14	268	1.2	-1087.2	1.4	268	1.9	-1079.5	-11.1	0.7	7.7	-12.5	14.698	I11	2.38	-1074.26	-19.60	Patient
15	266	1.2	-1089.2	1.4	266	1.8	-1081.5	-11.1	0.6	7.7	-12.5	14.694	I12	2.21	-1076.26	-19.61	Patient
16	264	1.2	-1091.2	1.4	264	1.8	-1083.5	-11.1	0.6	7.7	-12.5	14.694	I13	2.21	-1078.26	-19.61	Patient
17	262	1.2	-1093.2	1.4	262	1.8	-1085.5	-11.1	0.6	7.7	-12.5	14.694	I14	2.21	-1080.26	-19.61	Patient
18	260	1.2	-1095.2	1.4	260	1.8	-1087.5	-11.1	0.6	7.7	-12.5	14.694	I15	2.21	-1082.26	-19.61	Patient
19	258	1.1	-1097.2	1.4	258	1.8	-1089.5	-11.1	0.7	7.7	-12.5	14.698	I16	2.28	-1084.26	-19.60	Patient
20	256	1.1	-1099.2	1.4	256	1.7	-1091.5	-11.1	0.6	7.7	-12.5	14.694	I17	2.11	-1086.26	-19.61	Patient
21	254	1.1	-1101.2	1.4	254	1.7	-1093.5	-11.1	0.6	7.7	-12.5	14.694	I18	2.11	-1088.26	-19.61	Patient
22	252	1.1	-1103.2	1.4	252	1.7	-1095.5	-11.1	0.6	7.7	-12.5	14.694	I19	2.11	-1090.26	-19.61	Patient
23	250	1.1	-1105.2	1.4	250	1.7	-1097.5	-11.1	0.6	7.7	-12.5	14.694	I20	2.11	-1092.26	-19.61	Patient
24	248	1	-1107.2	1.4	248	1.7	-1099.5	-11.1	0.7	7.7	-12.5	14.698	I21	2.18	-1096.88	-15.35	Patient
25	246	1	-1109.2	1.4	246	1.6	-1101.5	-11.1	0.6	7.7	-12.5	14.694	I22	2.01	-1098.88	-15.35	Patient
26	244	1	-1111.2	1.3	244	1.6	-1103.5	-11.1	0.6	7.7	-12.4	14.609	I23	2.01	-1100.86	-15.34	Patient
27	242	1	-1113.2	1.3	242	1.6	-1105.5	-11.1	0.6	7.7	-12.4	14.609	I24	2.01	-1102.86	-15.34	Patient
28	240	1	-1115.2	1.3	240	1.6	-1107.5	-11.1	0.6	7.7	-12.4	14.609	I25	2.01	-1104.86	-15.34	Patient
29	238	0.9	-1117.2	1.3	238	1.6	-1109.5	-11.1	0.7	7.7	-12.4	14.613	I26	2.08	-1106.87	-15.34	Patient


Z
H90
G90
I90
F90
B90
D (TG43)
cGy
800
600
400
320
240
160
80
X

Conclusions

- The applicator is now ready for clinical use with Flexitron system
- Potential patients identified
- Ongoing improvements to dose point program to improve efficiency

Acknowledgements

Thanks to Dr Stephen Thompson and Ms Soo Min Heng for their contributions.

Any questions?