Rules Based Treatment Planning: Improving Seed Placement, Dosimetry and Ease of Delivery in LDR Brachytherapy

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Practice at Edinburgh Cancer Centre

1. Two Stage process 2001 – 2009
2. Single Stage (Real Time) 2009 – present
3. Boost implants in 2016
4. Salvage implants in 2016
5. Therastrand 6 seed strands with standard spacing in 2015

Factors contributing to the accuracy of seed placement in the prostate

NHS Lothian

I. Mechanical Factors
II. Delivery Factors
III. Treatment Planning Factors

Mechanical Factors

1) Calibration of the Grid / Needle combination with the Ultrasound Grid
2) Calibration of the Ultrasound with the Treatment Planning System
3) Plugged vs Plug-less Needles
4) Cut strands vs custom loaded needles

Delivery Factors

1) Pubic Arch / Size of the Prostate
2) Large amounts of Calcium
3) “Spongy” or “Hard” Prostate
4) Difficult needle positions (coordinates) in the treatment plan which require steering
5) Deposition of strands

Theragenics Therastrand AgX100 with 2.75 mm spacer on both ends

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Real location of Seeds at Base
Z -0.00

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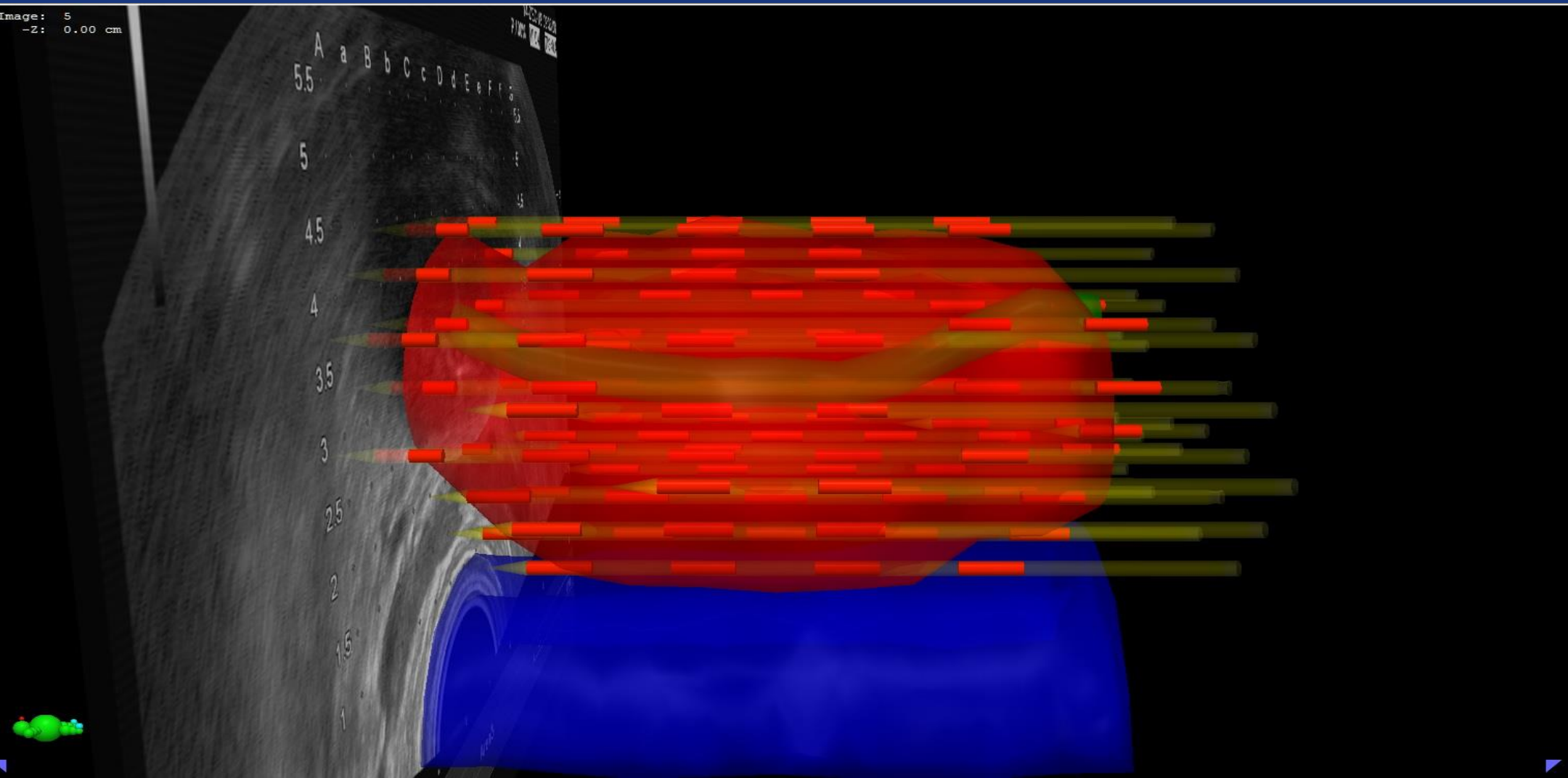
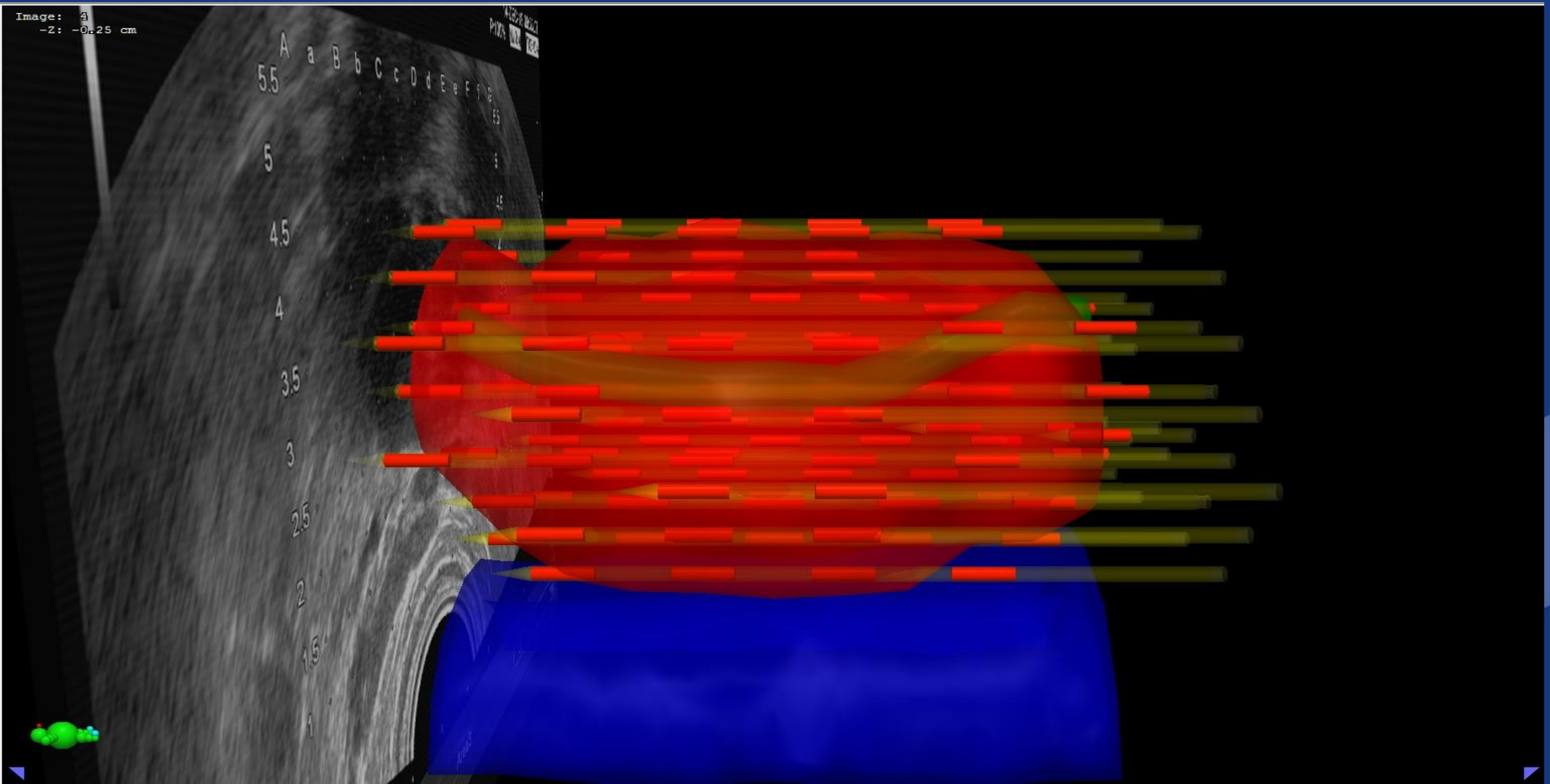


Real location of Seeds at Base
Z -0.25



Tracking the Deposition of Strands I

Tracking the Deposition of Strands II

Seeds beyond the Apex

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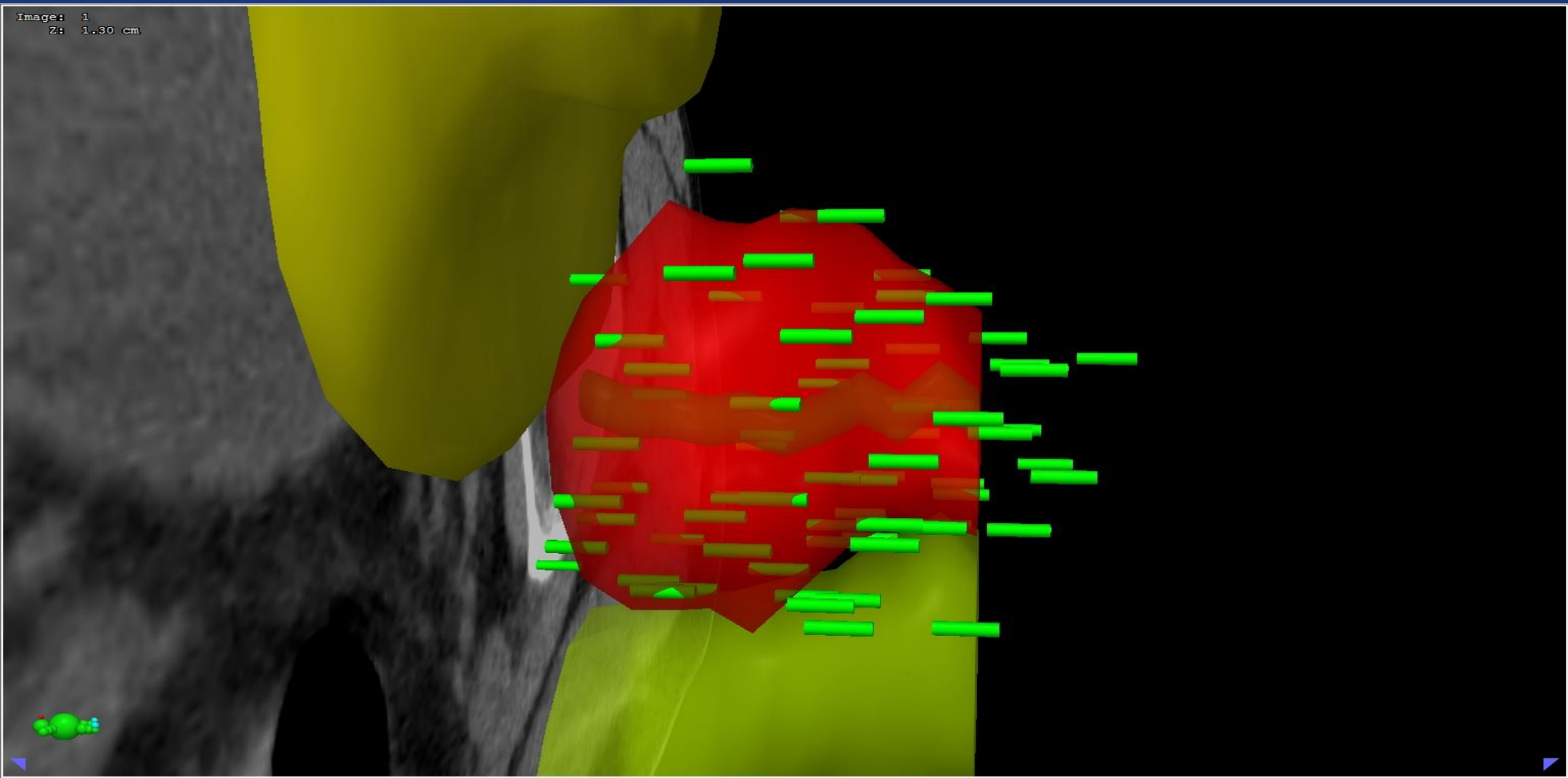
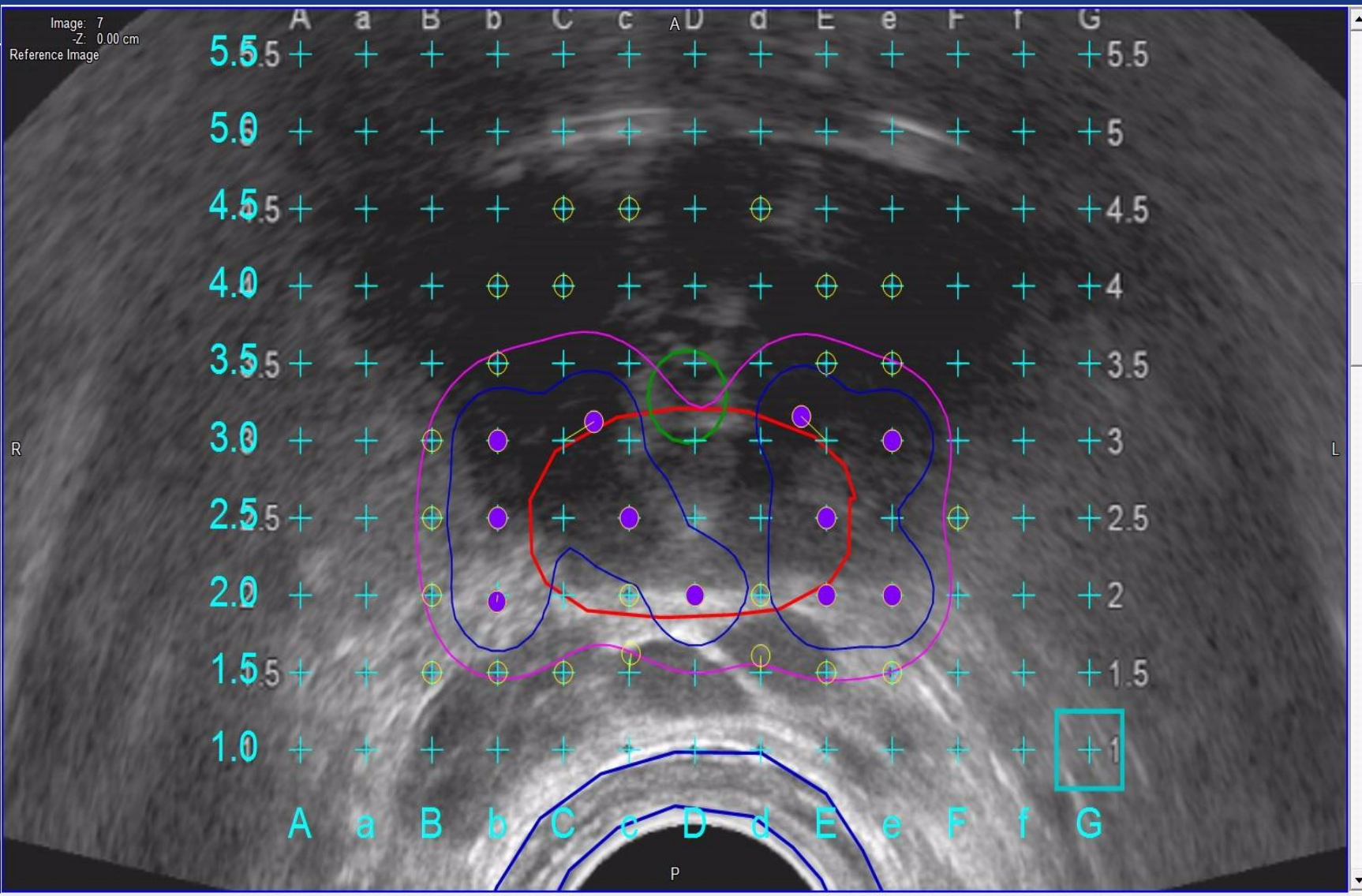


Treatment Planning Factors

1. Location of needles in relation to each other (nearest neighbour)
2. Steering
3. Split needles
4. Single seeds

NO Rules Treatment Plan



Prescription Dose/Isodose Levels

115.0 Gy | Modify...

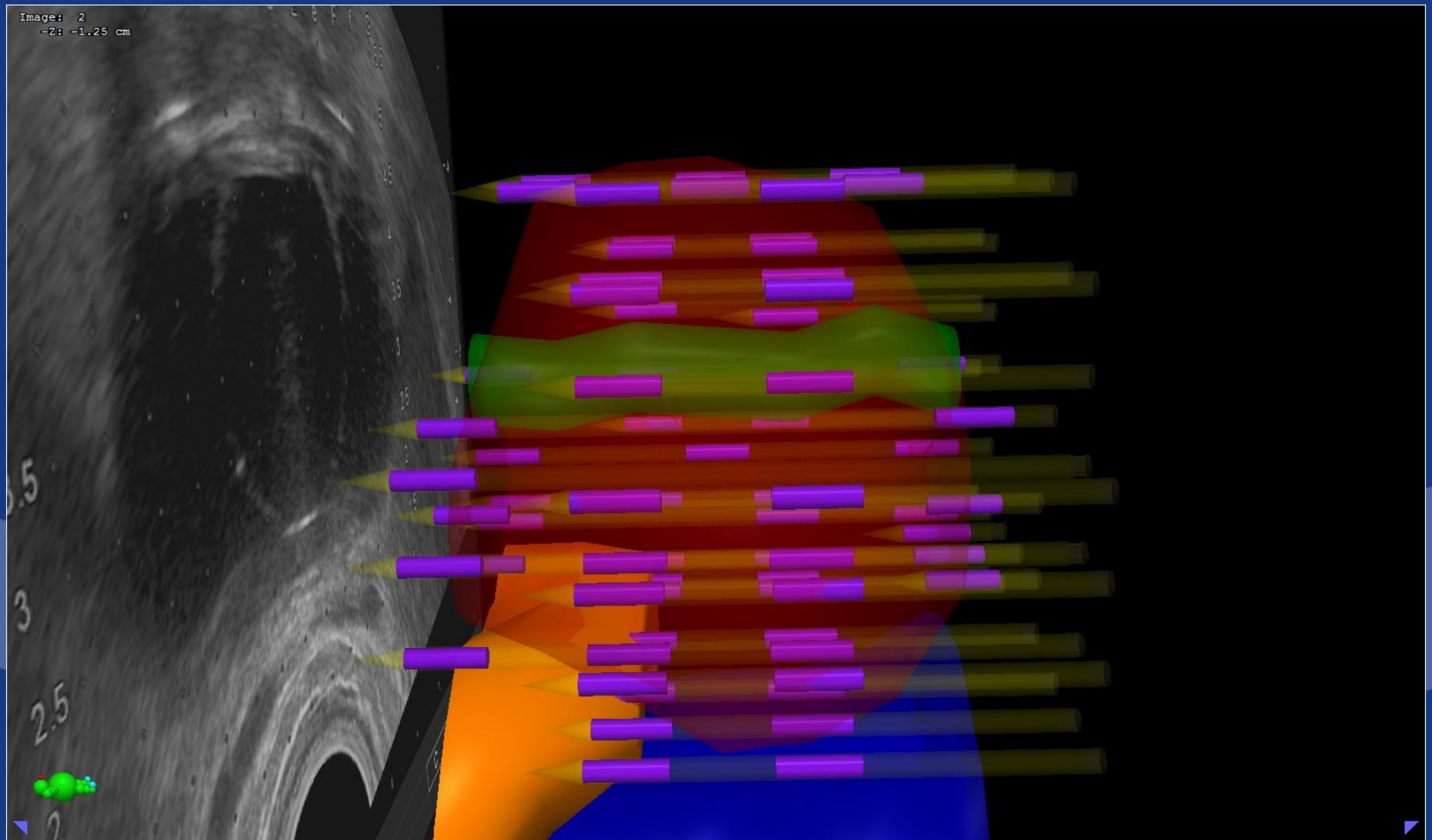
Dose (Gy)	Dose (%)	Color
230.00	200.0 %	
201.21	175.0 %	
172.50	150.0 %	
143.71	125.0 %	
115.00	100.0 %	
79.31	69.0 %	
57.50	50.0 %	

Activity: 0.376 U / 0.296 mCi

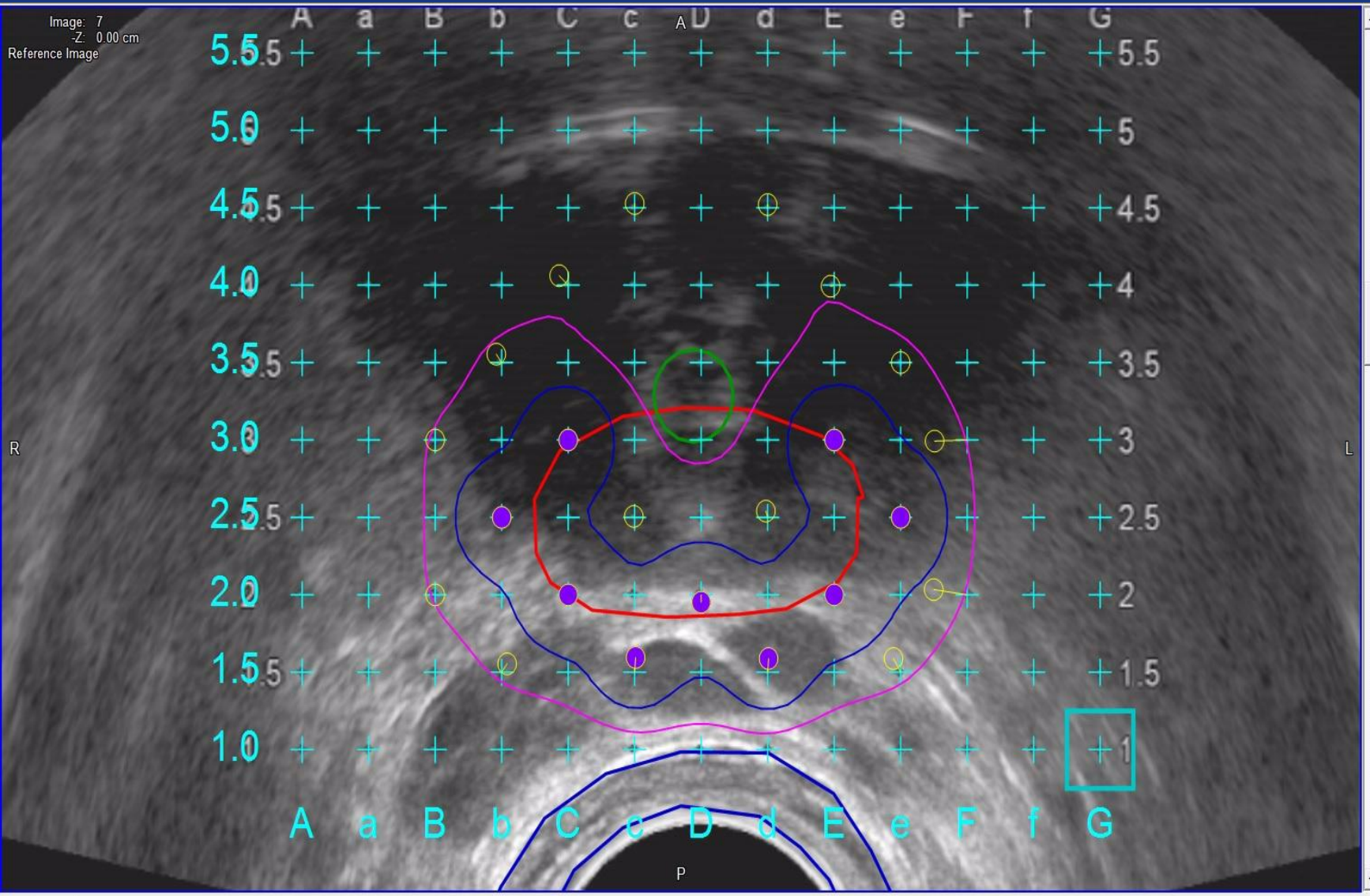
Prostate	V100%	99.69%
Prostate	V150%	61.59%
Prostate	V200%	27.92%
Prostate	D90%	122.22%
Rectum	V100%	0.07cm³
Rectum	D2cm³	62.03%
Urethra	V100%	0.78cm³
Urethra	V150%	0.00cm³

- [x] Show Landmarks
- [x] Show Dose Points
- [x] Show Needle Paths
- [ ] Show Seed Counts
- [ ] Show Needle Numbers
- [x] Show Isodose Contours

NO Rules Treatment Plan



Rules Based Treatment Plan



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115.00	100.0 %	
79.31	69.0 %	
57.50	50.0 %	

Activity: 0.376 U / 0.296 mCi

Prostate	V100%	99.50%
Prostate	V150%	71.24%
Prostate	V200%	29.22%
Prostate	D90%	123.80%
Rectum	V100%	0.03cm³
Rectum	D2cm³	60.56%
Urethra	V100%	0.72cm³
Urethra	V150%	0.00cm³

- [x] Show Landmarks
- [x] Show Dose Points
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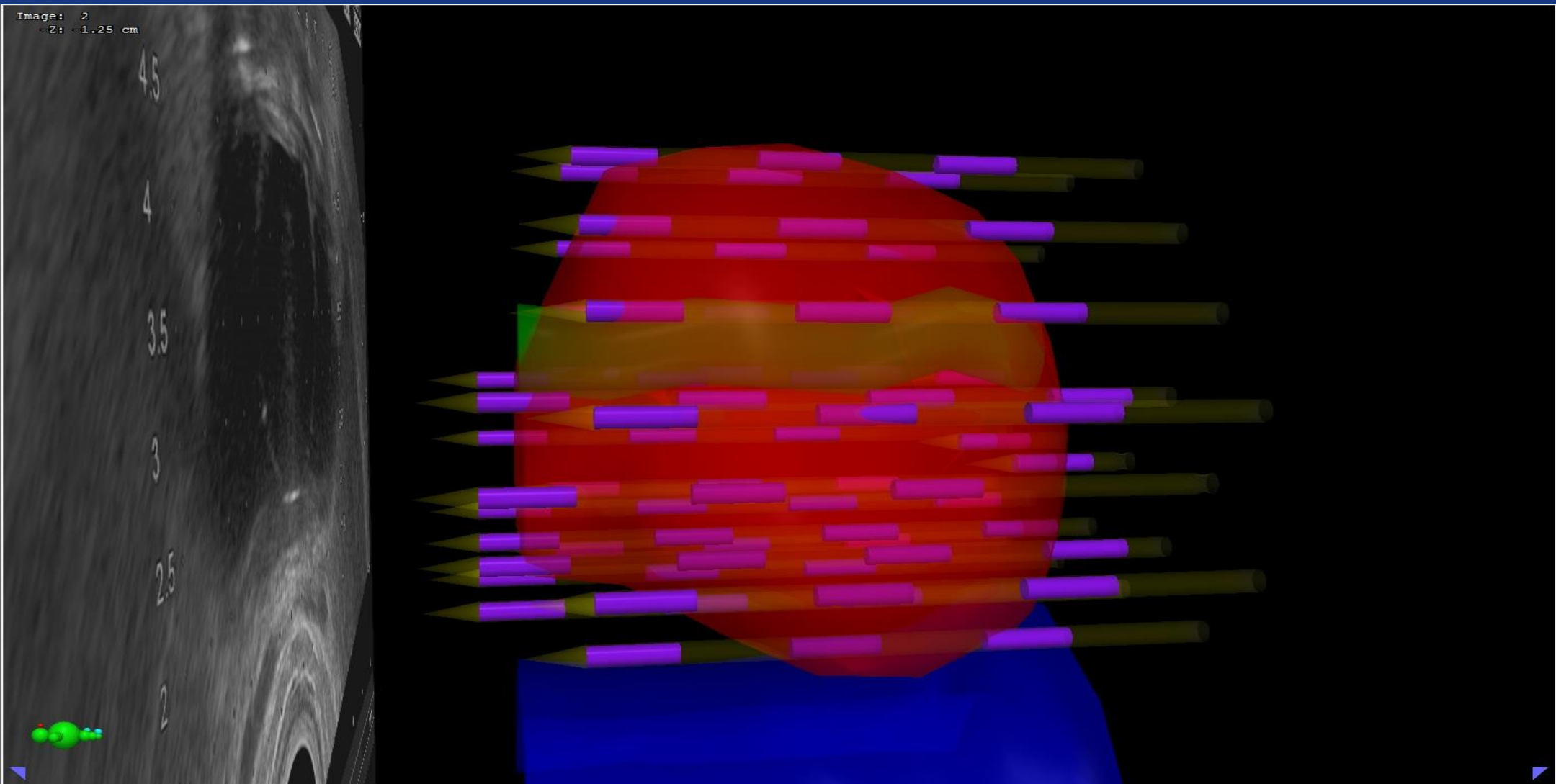
Rules Based Treatment Plan



Rules vs No Rules Treatment Planning

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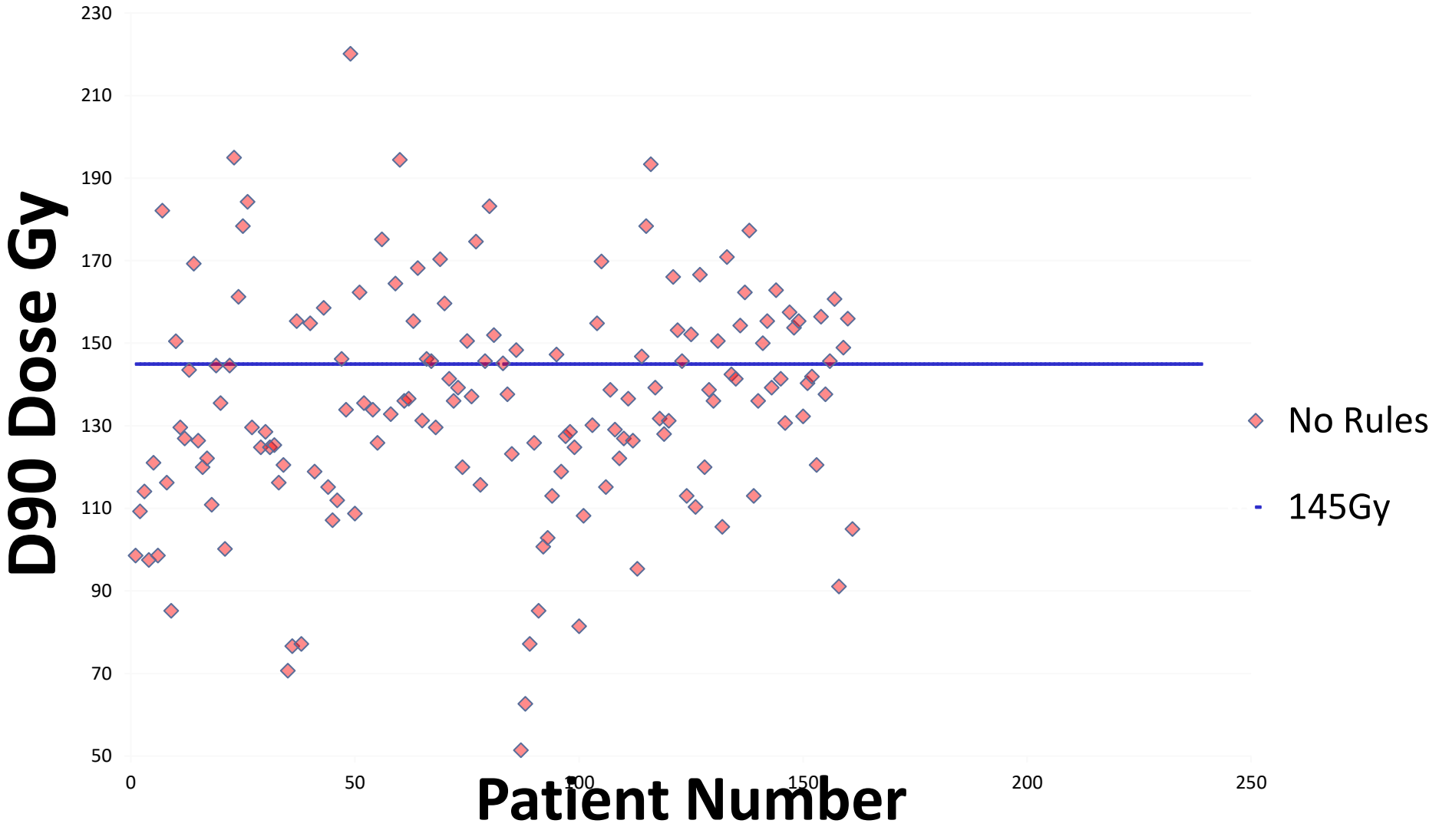
Prescribed Dose 115 Gy	**Rules Plan**	**No Rules Plan**
Total Activity U	**26.32**	**26.69**
V100	**99.5%**	**99.69%**
V150	**71.2%**	**61.6%**
V200	**29.2%**	**27.9%**
D90	**123.5%**	**122.2%**
Number of seeds	**70**	**71**
Number of splits	**0**	**6**
Number of single seeds	**2**	**15**
Number of needles	**23**	**40**

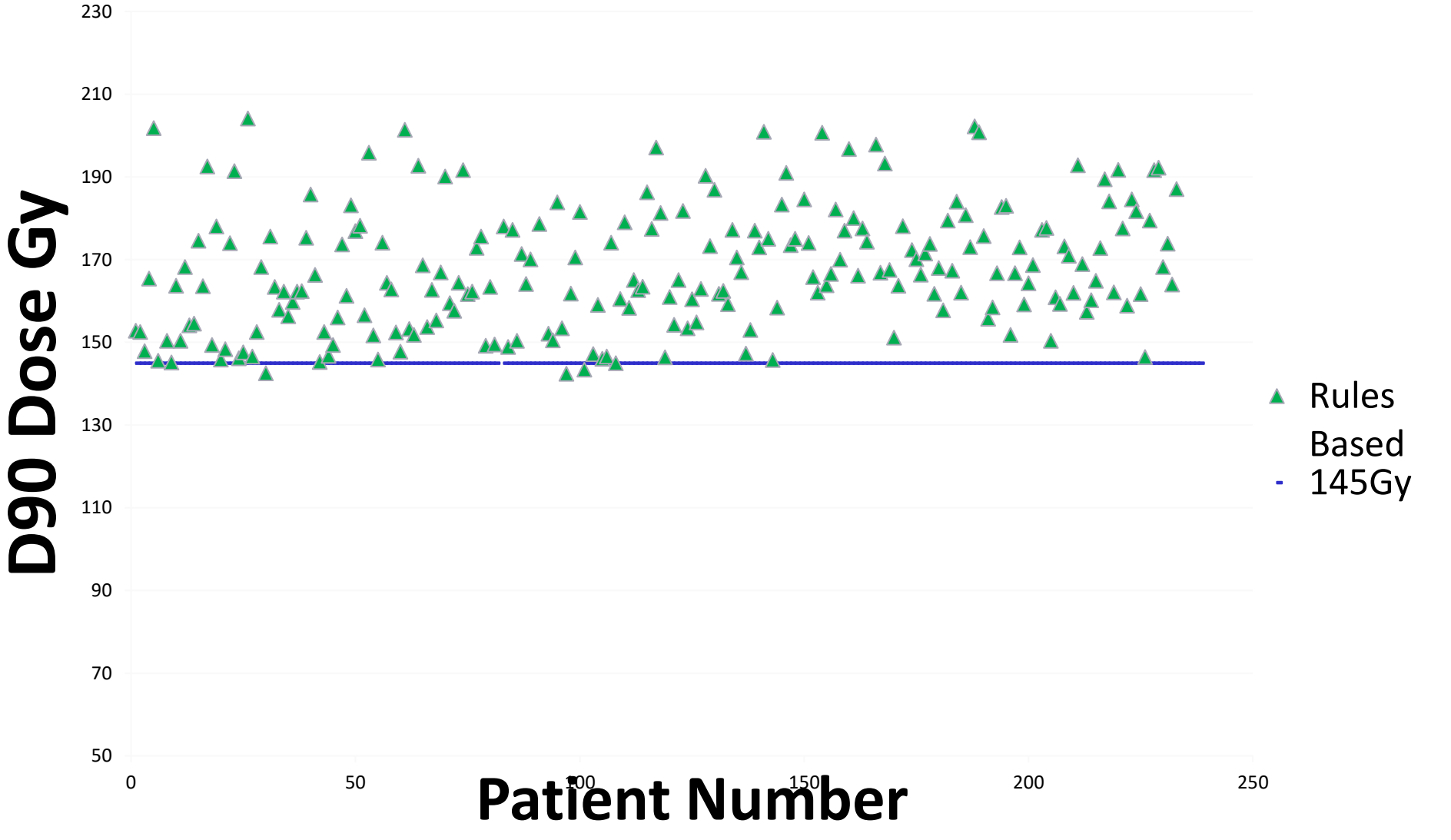
Rules for LDR treatment planning

1. **Never position two needles next to each other (positioning on the diagonal is acceptable). This provides a maximum spacing greater than 5 mm between the needles. Diagonal distance is 7.07 mm and provides adequate separation**
2. **Avoid Steering needles when possible**
3. **Try to avoid split needles and single seeds**
4. **Review each slice and determine the number of seeds per slice. Pull needles forward into next slice to "smooth out" the dose distribution**
5. **Start on either side of the big D line at the bottom row (or one up depending on the location of the rectum)**
6. **Fill in the positions around the circumference of the prostate insuring the 100% Isodose line extends approximately 3mm beyond the edge of the prostate excluding the rectum.**
7. **Add needles to fill in the interior of the prostate ensuring the urethra remains in the 100– 125% dose range. The 150% isodose line should never cover any part of the Urethra.**
8. **Isodose lines that dip below 100% around the Urethra at the base are acceptable due to image quality of the bladder in the base slice.**
9. **Continue to remove excess seeds from the plan especially beyond the apex.**
10. **Try to achieve the target values for the V150 ≤ 70% and V200 ≤ 30% (higher values are acceptable if the PTV has been identified and the OARs are within tolerance) and D90 values > 100% of the prescribed dose.**

Scatter Plot of D90 No Rules



Scatter Plot of D90 Rules



How Significant are the “Rules” on D90 and V100 values

	Rules Based	No Rules
Number of Patients	504	440
Mean D90 Dose (Gy)	164.5	135.3
D90 Standard Deviation	14.9	27.36
D90 Range Max (Gy)	216.3	220.2
D90 Range Min (Gy)	139.5	51.4
Mean V100 (%)	94.5	85.7
V100 Standard Deviation	2.9	10.6

No Rules VS Rules based treatment planning on Biochemical Recurrence

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Year	Biochemical Recurrence No Rules	Biochemical Recurrence Rules	Year	Biochemical Recurrence No Rules	Biochemical Recurrence Rules
8/2001	3	na	2010	3	0
2002	8	na	2011	3	0
2003	10	na	2012	3	0
2004	8	na	2013	1	1
2005	6	na	2014	2	2
2006	5	na	2015	na	4
2007	5	na	2016	na	2
2008	3	na	2017	na	1
2009	4	na	2018	na	1
			TOTALS	64/440	11/504