



Multiple Metastases SRS Treatments

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Overview



- UK benchmarking exercise for multiple brain metastases: variation in practice
- Separate isocentre planning for multiple mets
- Single isocentre planning for multiple mets

UK National Benchmarking Exercise, 2016

	TPS	Version	Algorithm	Treatment	MLC (width)	Technique
Number						
1	Multiplan	5.21	Ray tracing (PB)	Cyberknife	Cones	Multiple non-coplanar beams
2	Pinnacle	9.8	Collapsed cone	Novalis	HD120 (2.5mm)	Static conformal
3	GammaPlan	11.0	TMR10	GammaKnife	Cones	Multiple non-coplanar beams
4	GammaPlan	10.1	TMR10	GammaKnife	Cones	Multiple non-coplanar beams
5	GammaPlan	10.1	TMR10	GammaKnife	Cones	Multiple non-coplanar beams
6	iPlan	4.52	Pencil beam	Novalis	HD120 (2.5mm)	Static conformal / circular collimators
7	GammaPlan	10.1	TMR10	GammaKnife	Cones	Multiple non-coplanar beams
8	GammaPlan	11.0	TMR10	GammaKnife	Cones	Multiple non-coplanar beams
9	Tomotherapy Pinnacle	5.1 9.8	Collapsed cone (both)	Tomotherapy Elekta	n/a Agility (5mm)	Helical tomotherapy VMAT
10	GammaPlan	10.1	TMR10	GammaKnife	Cones	Multiple non-coplanar beams
11	Multiplan	5.21	Ray tracing (PB)	Cyberknife	Cones	Multiple non-coplanar beams
12	Multiplan	5.21	Ray tracing (PB)	Cyberknife	Cones	Multiple non-coplanar beams
13	iPlan	4.5	Pencil beam	Truebeam STx	HD120 (2.5mm)	Dynamic conformal arcs
14	Monaco	5.1	Monte Carlo	Elekta	Versa HD (5mm)	VMAT
15	GammaPlan	10.1	TMR10	GammaKnife	Cones	Multiple non-coplanar beams
16	Pinnacle	9.6	Collapsed cone	Elekta	Beam Mod (4mm)	Static conformal
17	Eclipse	11.0	AAA	Truebeam STx	HD120 (2.5mm)	VMAT
18	Tomotherapy	2.0	Convolution/Superposition (CC)	Tomotherapy	n/a	Helical tomotherapy
19	iPlan	4.51	Pencil beam	Novalis	HD120 (2.5mm)	Static conformal and dynamic conformal arcs
20	iPlan	4.54	Pencil beam	Varian 2100ix	Cones	Non-coplanar arcs

Report of Planning Benchmark Cases for the NHS England
SRS/SRT commissioning programme, RTTQA, 2016

Example Benchmarking Case – 7 Brain Mets

6 Case 2 – Seven metastases

Datasets provided: CT and multiple MR sequences (1mm Transverse Sections). The following structures were provided: GTV1 to GTV7, Brainstem, Chiasm, Eye_L, Eye_R, Lens_L, Lens_R, OpticNerve_L, OpticNerve_R, PituitaryFossa, Brain-GTV

65 year old man; radical resection for NSCLC 10 months previously. MR brain performed following acute presentation with partial seizures demonstrated 7 lesions, consistent with metastases. No other past medical history, otherwise fit, KP 90. CT thorax, abdomen and pelvis showed no extra-cranial relapse.

6.1 Submission overview

17 plans were submitted for this case:

- 2 Cyberknife
- 7 Gammaknife
- 7 Linac-based
- 1 Tomotherapy

Centres 11, 16 and 17 did not submit data for this plan.

Centre 14 commented that this case would be treated with whole brain radiotherapy.

Centre 9 only submitted a plan treating PTV1 (others were <2cc).

Example Benchmarking Case – 7 Brain Mets

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
GTV	Centre																					mean	1 S.D
1	PCI	0.86	0.75	0.86	0.90	0.85	0.73	0.90	0.88	0.74	0.91		0.81	0.80	0.89	0.89			0.58	0.66	0.75	0.81	0.10
2	PCI	0.89	0.73	0.82	0.91	0.85	0.77	0.88	0.83		0.92		0.88	0.85	0.87	0.87			0.63	0.68	0.61	0.81	0.10
3	PCI	0.86	0.69	0.72	0.85	0.84	0.51	0.79	0.79		0.85		0.84	0.73	0.72	0.82			0.34	0.59	0.49	0.71	0.15
4	PCI	0.65	0.66	0.60	0.78	0.71	0.54	0.71	0.58		0.78		0.80	0.59	0.80	0.75			0.21	0.45	0.52	0.63	0.16
5	PCI	0.77	0.67	0.62	0.82	0.74	0.37	0.81	0.63		0.82		0.84	0.67	0.74	0.80			0.35	0.50	0.56	0.67	0.16
6	PCI	0.77	0.62	0.66	0.82	0.74	0.45	0.84	0.72		0.80		0.82	0.68	0.68	0.81			0.29	0.42	0.54	0.67	0.16
7	PCI	0.69	0.65	0.59	0.79	0.76	0.43	0.69	0.67		0.79		0.80	0.54	0.67	0.77			0.30	0.38	0.63	0.63	0.15
1	GI	3.57	2.42	2.87	2.72	3.05	2.80	2.76	2.73	3.69	2.72		3.32	2.97	3.55	2.71			3.27	3.00	3.38	3.03	0.37
2	GI	3.47	2.95	3.16	3.34	3.26	3.94	3.27	3.11		3.34		4.10	3.96	5.99	3.30			5.20	4.42	5.24	3.88	0.90
3	GI	3.79	3.02	3.69	2.80	3.19	3.51	2.73	3.37		2.80		4.38	3.40	7.69	2.82			4.17	3.00	3.55	3.62	1.19
4	GI	4.32	3.64	3.75	3.22	3.69	3.78	3.61	3.52		3.22		6.20	4.38	10.24	3.18			3.12	4.02	5.36	4.33	1.78
5	GI	4.14	3.30	3.14	3.39	3.08	3.23	3.44	2.97		3.39		5.13	3.93	8.27	3.34			5.00	3.64	4.18	3.97	1.32
6	GI	4.07	3.31	3.54	3.07	3.04	3.72	3.23	3.14		3.07		4.76	4.99	6.88	3.07			2.66	4.02	4.34	3.80	1.06
7	GI	5.25	3.61	3.44	3.11	3.30	4.37	3.89	3.65		3.11		6.85	5.72	9.79	3.14			3.85	3.99	5.89	4.56	1.79

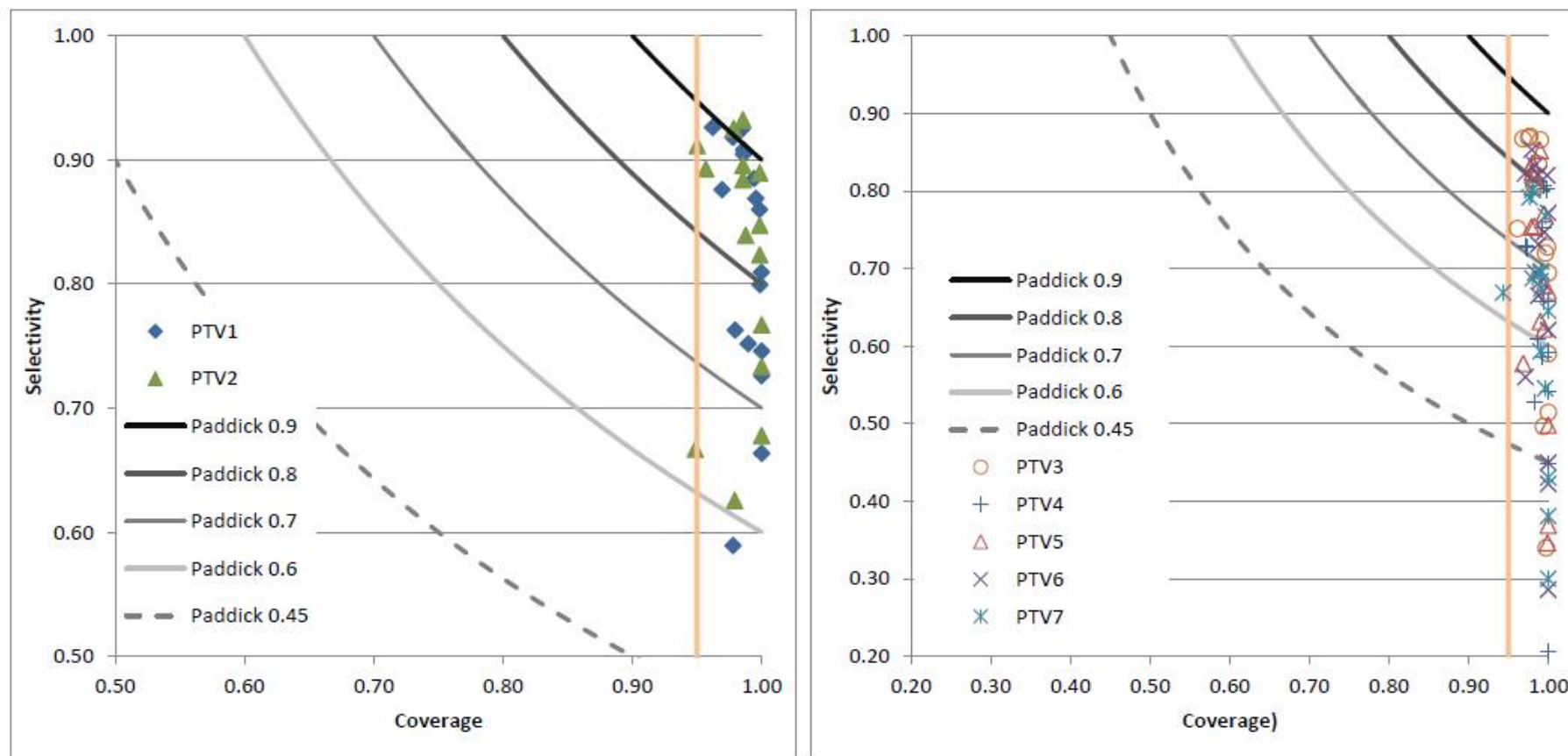
Target coverage ratio = PTV V100% (cc) / GTV or PTV volume (cc)
 Selectivity index = PTV V100% (cc) / Body V100% (cc)
 Paddick conformity index (PCI) = Coverage * Selectivity
 Gradient index (GI) = Body V50% (cc) / Body V100% (cc)

Centres results which are more than 2 S.D from the mean are highlighted in **dark yellow**. Centres results which are 1 to 2 S.D from the mean are highlighted in **light yellow**.
 N.B. PTV V100% is also known as Treated Target Volume (TTV)
 Body V100% is commonly known as Prescription Isodose Volume (PIV)

VMAT (5mm MLC)

Clinically WB-RT

Example Benchmarking Case – 7 Brain Mets



Figures 4 and 5. Coverage versus selectivity for the 7 targets in planning case 2: two larger lesions (7.4cc, 1.3cc, left), and five smaller (0.1 – 0.6cc, right).

The orange line marks the 95% PTV coverage, centres falling below this are highlighted in the table above.

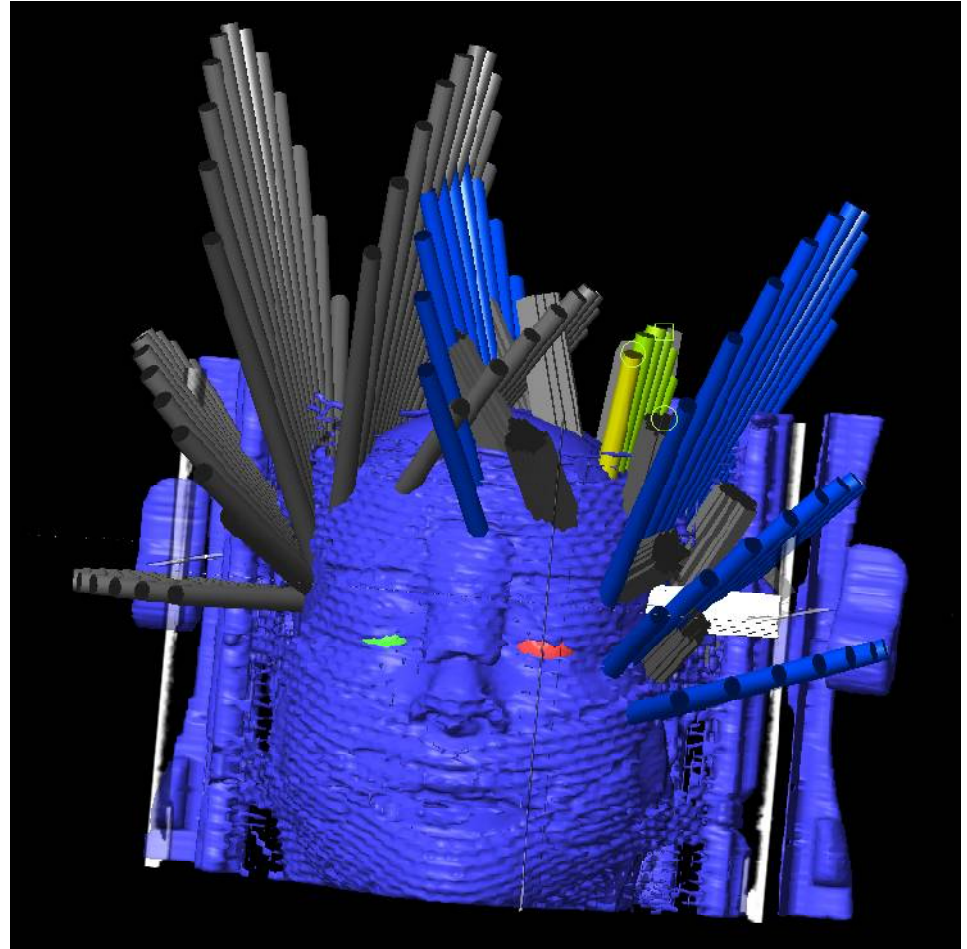
NHSE Benchmarking Exercise: Conclusions

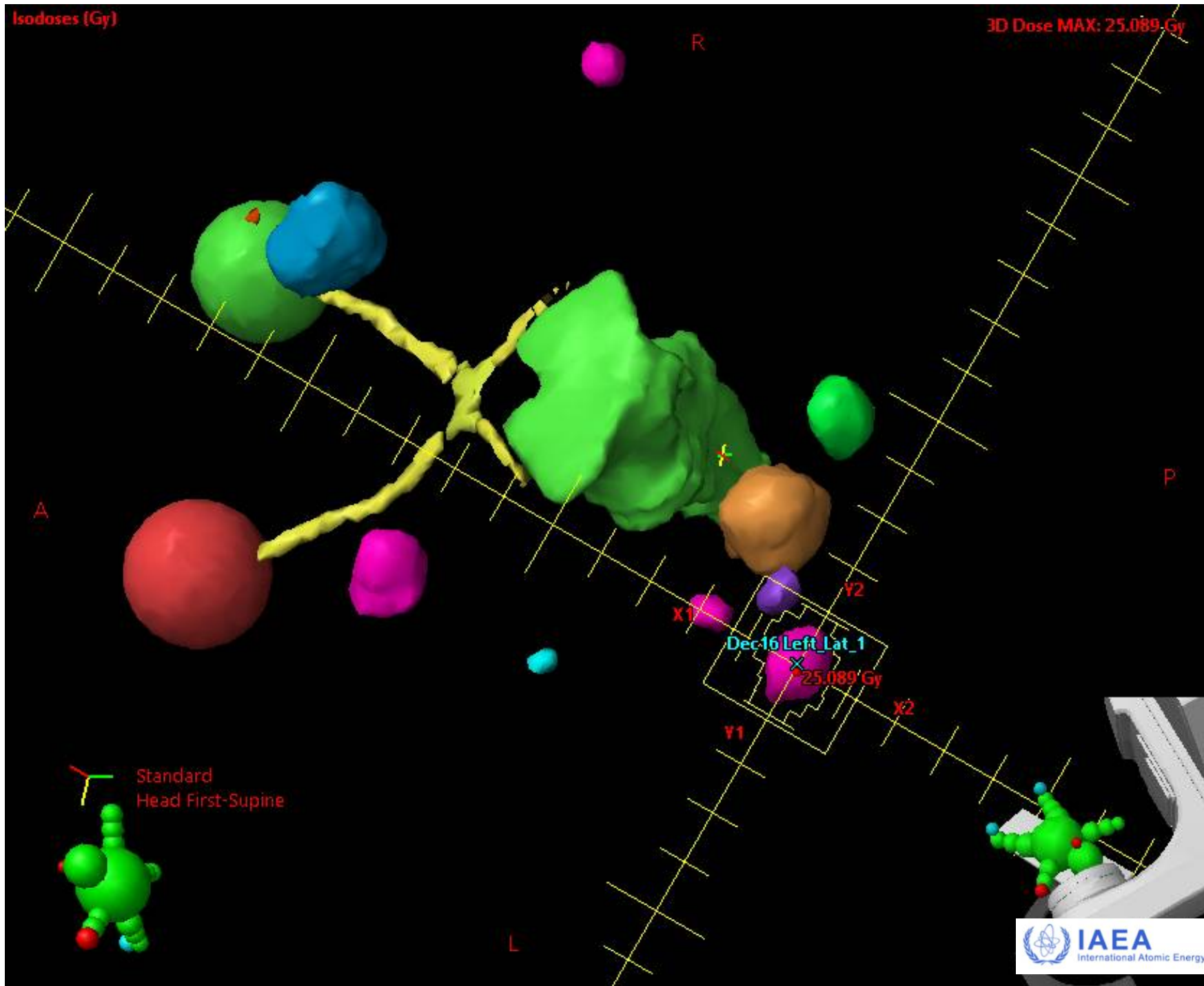


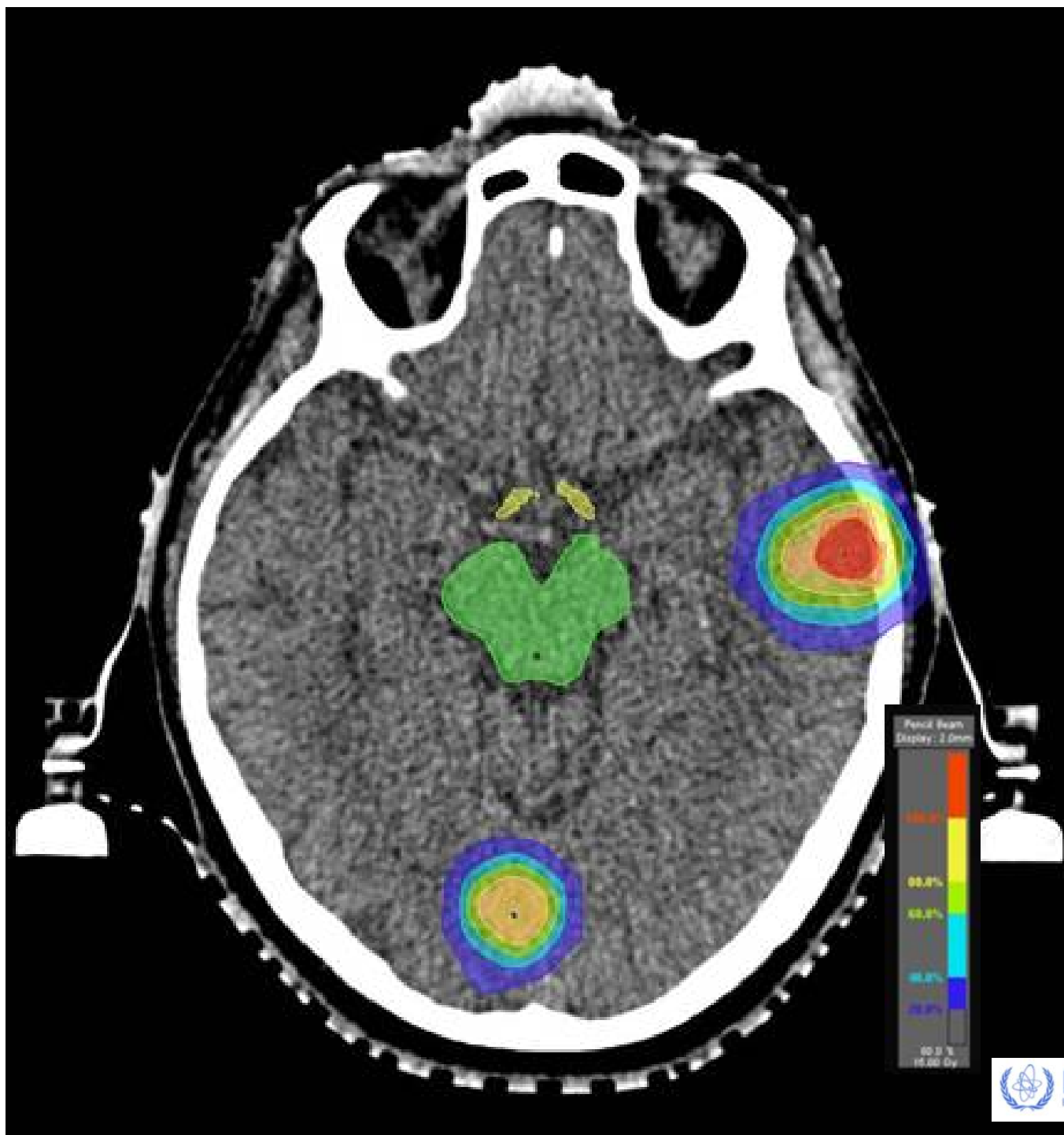
- Different approaches and priorities across the country
- Some of the variation due to technique
- Largest differences for “selectivity” – spillage of prescription dose outside PTV
- Some centres treating more normal tissue than PTV (selectivity < 0.5)
- **Centres encouraged in first instance to compare results to others with similar equipment / approaches**

Separate Isocentre Planning

- Total treated volume should be < 20 cc
- Total of 10 lesions
- March 2016:
 - 3 circular collimator plans
 - 2 static conformal plans (3 metastases)
- December 2016:
 - 2 circular collimator plans
 - 2 static conformal plans



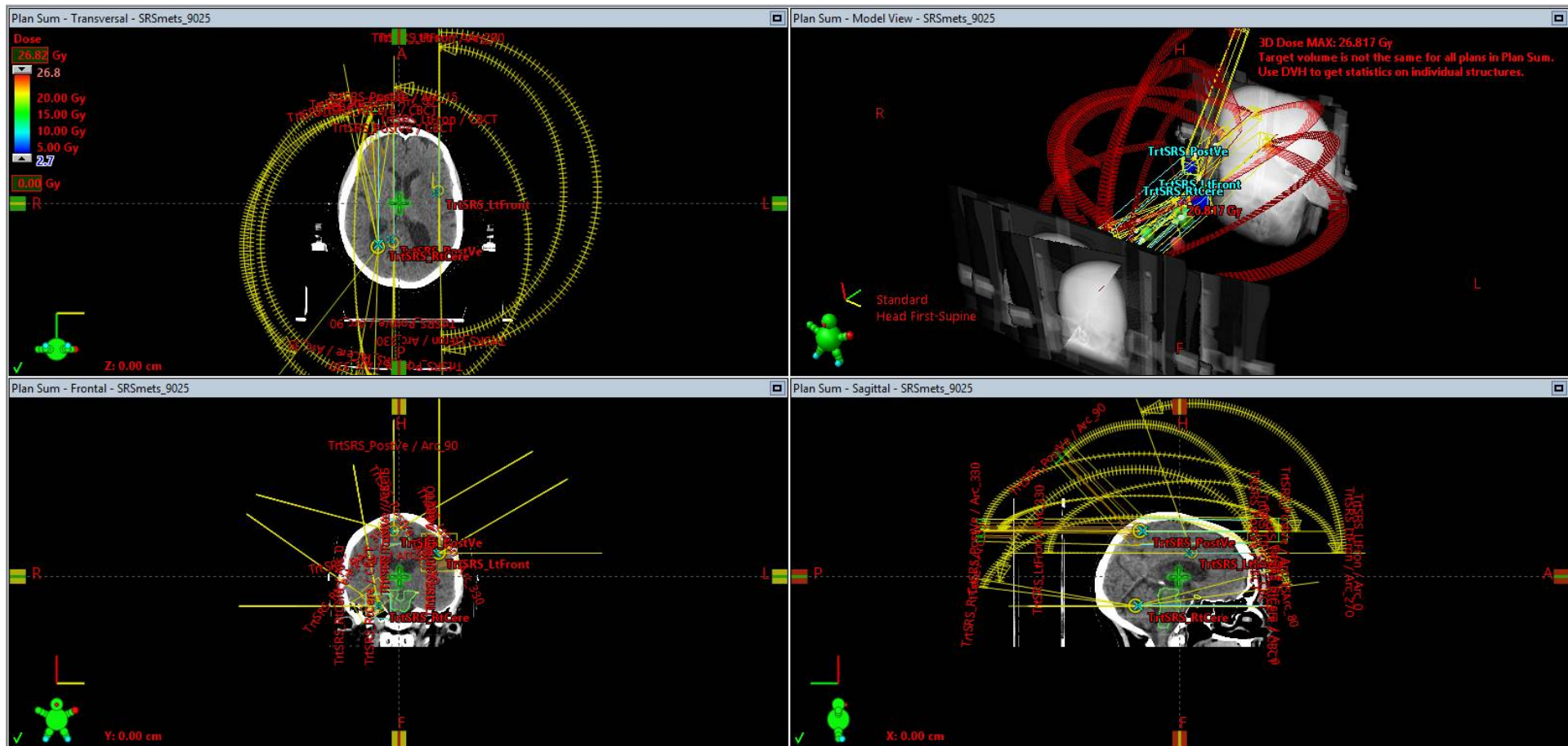




Considerations for Separate Isocentre Approaches



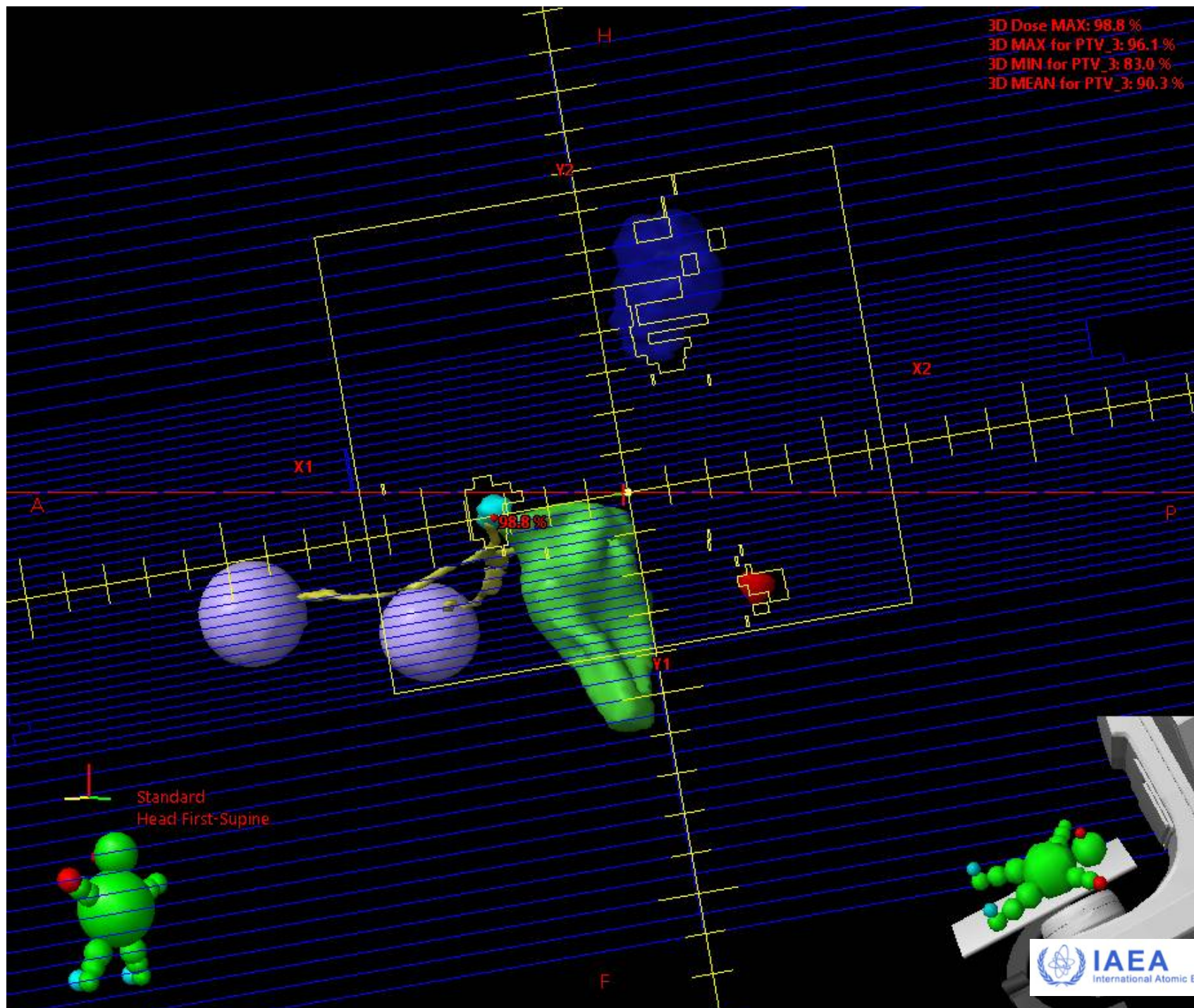
- Potentially very time consuming to plan
- Avoiding beam overlap and previously treated areas
- Multiple set-ups for treatment
- Time consuming to deliver – potential limiting factor
- Where to confirm CT-MR registration?

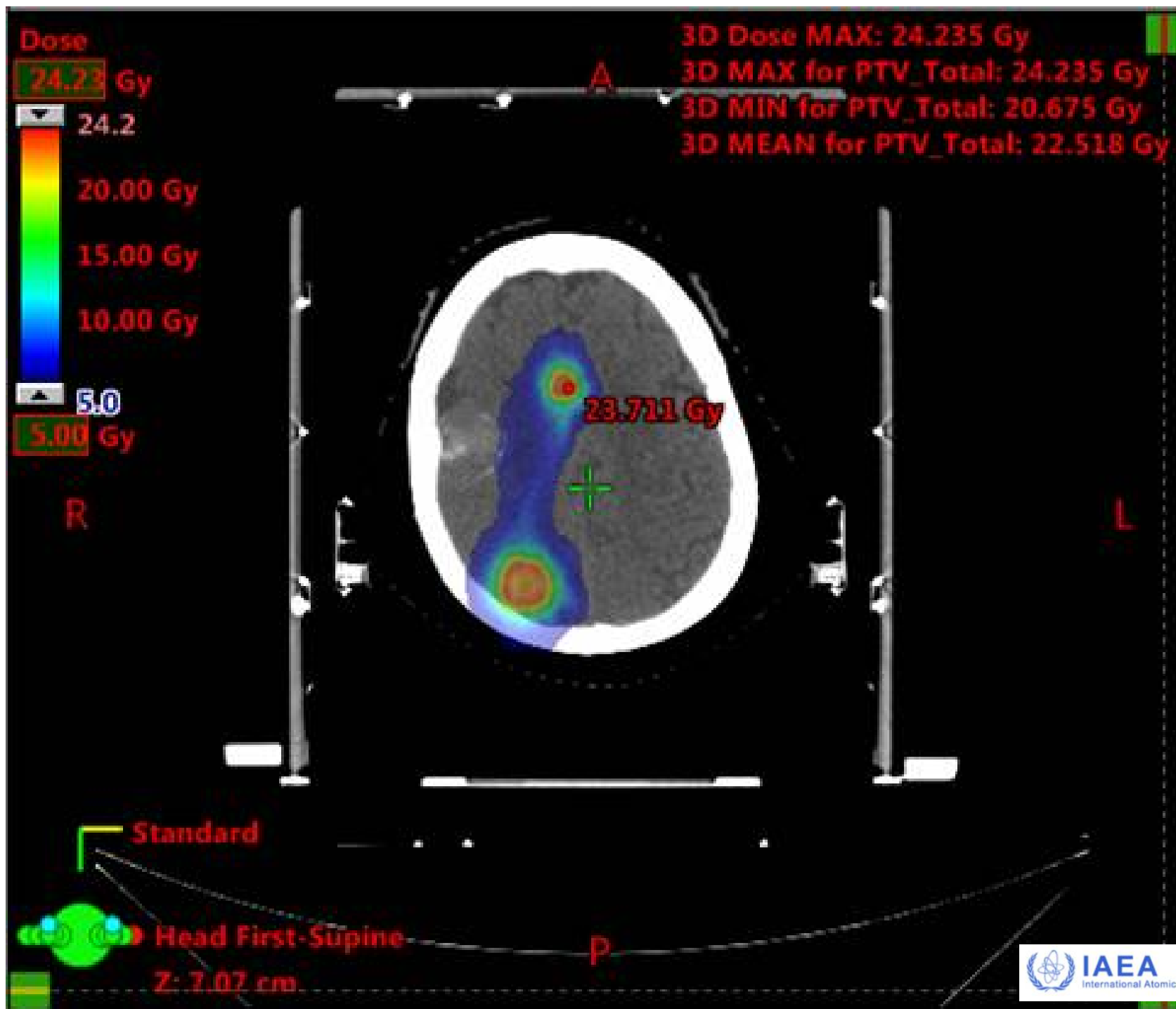


Single Isocentre VMAT Approach



- Beam overlap potentially less significant (arcs)
- Can use optimisation objectives to avoid other mets
- Still a multiple set-up for treatment
- Much more complex and difficult to QA





Single Isocentre VMAT Approach



- High plan quality and extreme clinical efficiency: will likely replace multiple isocentre techniques (Clark, G.M. et al., 2012)
- ESTRO 2016
 - Significant improvement in C.I. (c.f. SCF)
 - Lower whole-brain volumes at 2, 5 and 12.5 Gy



**SRS Treatment Planning for Multiple Metastasis with a
Single Isocentre Approach using RapidArc**

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Plan Quality



Published in final edited form as:

Neurosurgery. 2014 October ; 75(4): 409–418. doi:10.1227/NEU.0000000000000448.

Comparison of Plan Quality and Delivery Time between Volumetric Arc Therapy (RapidArc) and Gamma Knife Radiosurgery for Multiple Cranial Metastases

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Results—Compared to Gamma Knife, multi-arc VMAT improved median plan conformity ($CI_{VMAT} = 1.14$, $CI_{GK} = 1.65$; $p < 0.001$) with no significant difference in median dose fall-off ($p = 0.269$), 12Gy isodose volume ($p = 0.500$), or low isodose spill ($p = 0.49$). Multi-arc VMAT plans were associated with markedly reduced treatment time. A predictive model of the 12Gy isodose volume as a function of tumor number and volume was also developed.

Conclusion—For multiple target SRS, 4-arc VMAT produced clinically equivalent conformity, dose fall-off, 12 Gy isodose volume, and low isodose spill, and reduced treatment time compared to GK. Due to its similar plan quality and increased delivery efficiency, single-isocenter VMAT radiosurgery may constitute an attractive alternative to multi-isocenter radiosurgery for some patients.

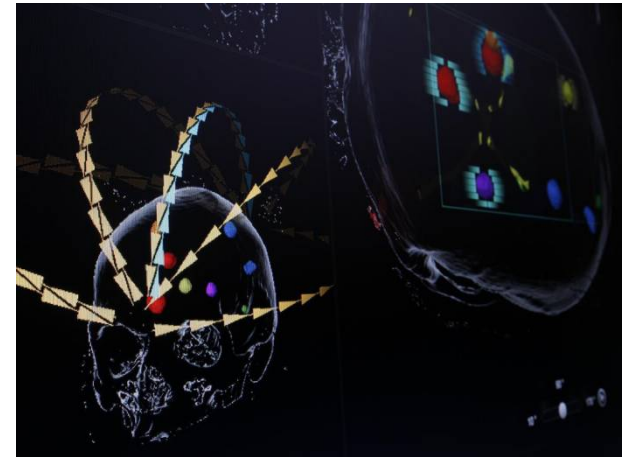
Considerations for Single Iso Techniques



- Avoid dose bridging
- Contra-indications e.g. location?
- Should ONLY be considered when full 6DoF corrections are available and intra-fractional immobilisation well-quantified(Winey, B. and Bussiere, M., 2014)
- How to QA?

The Future of Multiple-Mets on Linacs

- Elements (BrainLab)
 - Dynamic conformal arcs
 - MU and time-efficient
 - Up to 10 metastases without repositioning
 - ExacTrac
- HyperArc (Varian)
 - Non-coplanar VMAT on TrueBeam / EDGE
 - MU and time-efficient
 - CBCT and OSMS
 - Multiple metastases without repositioning
 - Fully automated delivery



Images courtesy of Brainlab (top) and Varian (bottom)

*any
questions?*

