



Preparation and Planning for Lung SABR

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Overview



- Defining the treatment target
- Characteristics of a SABR plan
- Considerations for planning
- Planning techniques



Defining the Treatment Target

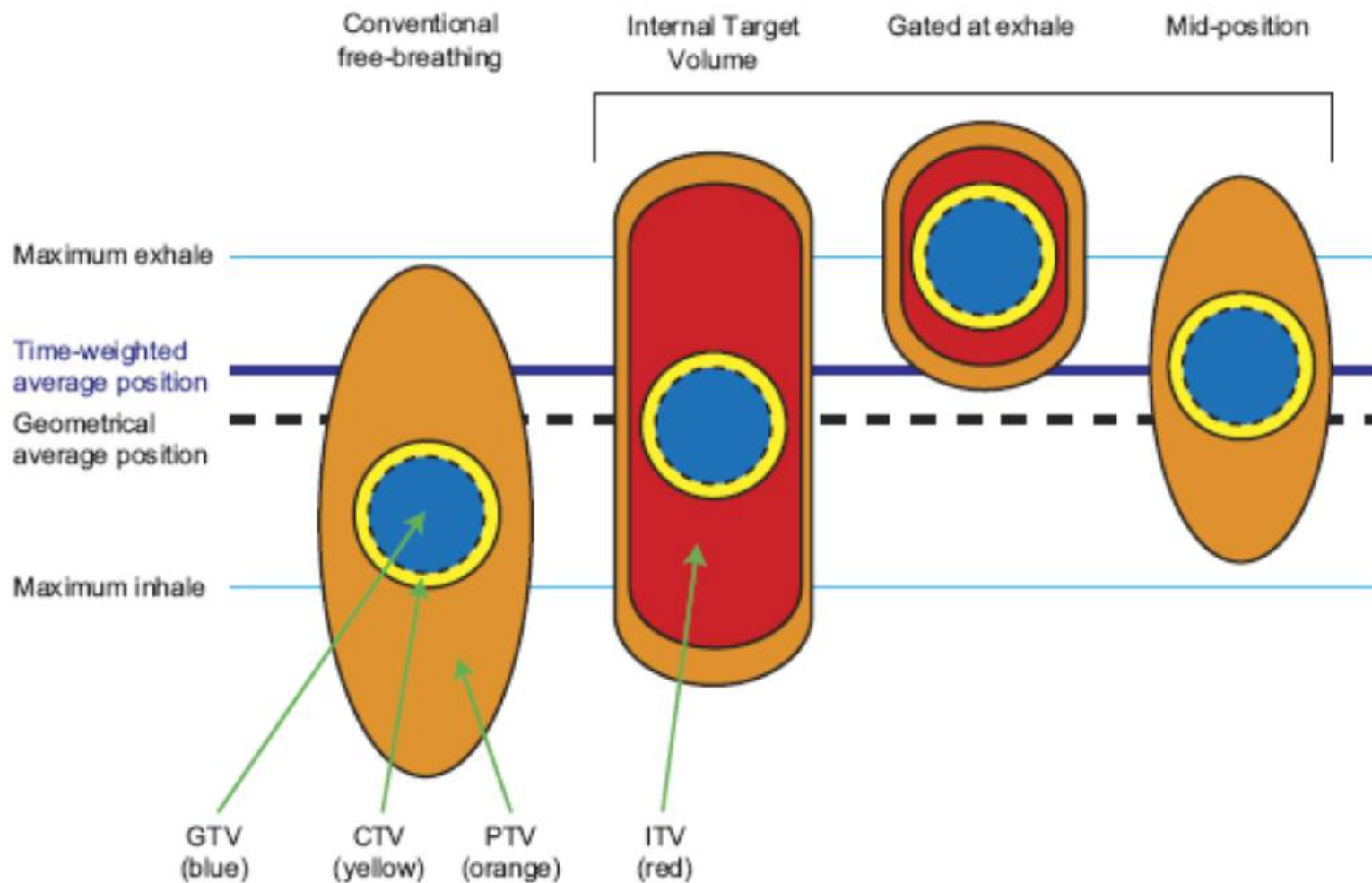


Fig. 1. Schematic overview of different treatment-planning concepts: conventional free-breathing, internal target volume (ITV), gating (at exhale), and mid-position. GTV = gross tumor volume; CTV = clinical target volume; PTV = planning target volume.

PTV Margins



- PTV margins depend on:
 - Immobilisation
 - Assessment of tumour motion
 - Available methods for on-treatment verification imaging and correction
 - Methods for correcting intra-fraction motion e.g. repositioning
- Each centre needs to confirm adequacy of PTV margins with their chosen methods

PTV Margins



- Adequacy of PTV margin should be based on an understanding of how the steep dose gradients and high fraction doses of SABR affect the accuracy of traditional margin recipes
- Typically 3 – 5 mm for 4D-CT planning
- ≥ 10 mm cranio-caudal typically required for 3D-CT (even with breathing suppressed)



Characteristics of SABR Plans

AAPM TG 101: SABR Planning Aims



- A limited volume of tissue...is targeted for treatment through exposure to a very high dose per fraction
- Hotspots are often deemed to be acceptable
- The volume of normal tissue receiving high doses outside the target should be minimised
- The gradient describing the dose fall-off outside the target should be sharp

UK: SABR Lung Planning Constraints



- PTV $D_{95\%} \geq 100\%$
- PTV $D_{99\%} \geq 90\%$
- PTV D_{\max} 110% - 140%
- Conformity, dose gradient, $V_{20\text{Gy}}$ constraints

UK SABR Consortium Guidelines v 5.1 (Jan 2016)

*100% is the prescription isodose

Dose Conformity Requirements



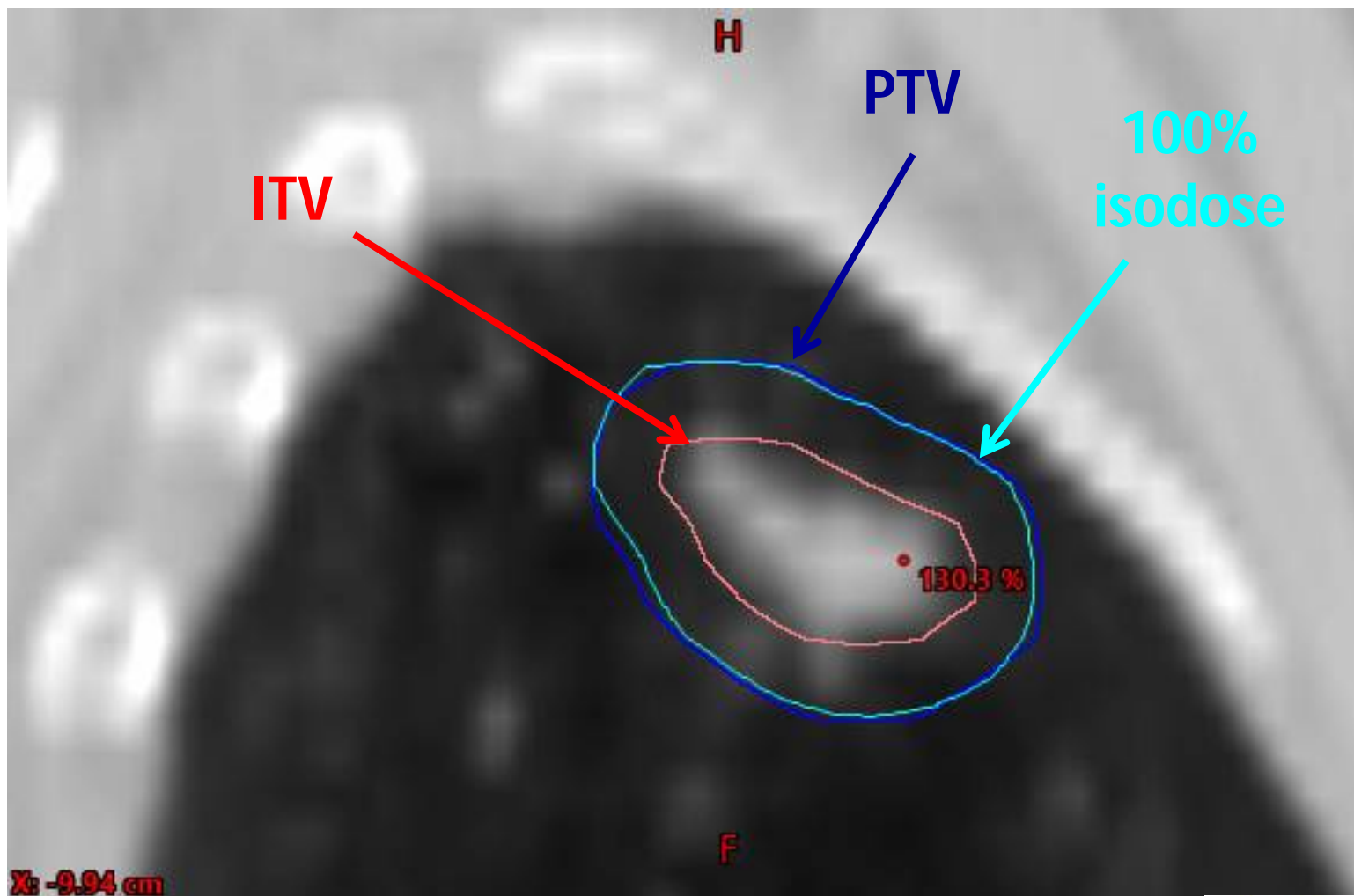
(i) 3 fractions

Vol(PTV) (cc)	Vol(100%) / Vol(PTV)		Vol(50%) / Vol(PTV)		Max dose >2cm		V20 (%)	
	tolerance	minor dev	tolerance	minor dev	tolerance	minor dev	tolerance	minor dev
<20	<1.25	1.25-1.40	<12	12-14	<35.1Gy	35.1-40.5Gy	<5	5-8
20-40	<1.15	1.15-1.25	<9	9-11	<37.8Gy	37.8-43.2Gy	<6	6-10
>40	<1.10	1.10-1.20	<6	6-8	<37.8Gy	37.8-43.2Gy	<10	10-15
60-90	<1.10	1.10-1.20	<5	5-7	<37.8Gy	37.8-43.2Gy	<10	10-15
>90	<1.10	1.10-1.20	<4.5	4.5-6.5	<37.8Gy	37.8-43.2Gy	<10	10-15

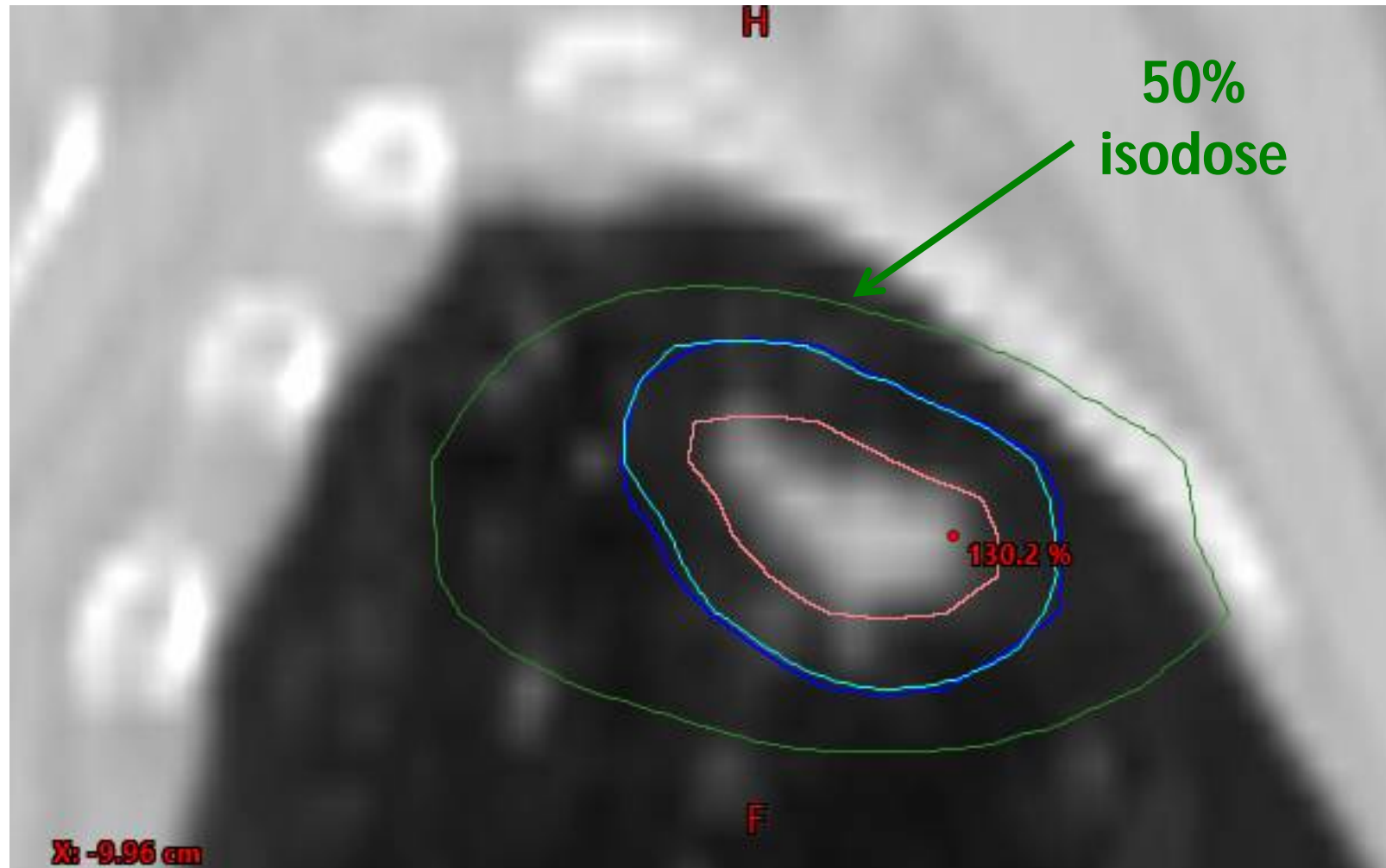
(ii) 5-8 fractions

Vol(PTV) (cc)	Vol(100%) / Vol(PTV)		Vol(50%) / Vol(PTV)		Max dose >2cm		V20 (%)	
	tolerance	minor dev	tolerance	minor dev	tolerance	minor dev	tolerance	minor dev
<20	<1.25	1.25-1.40	<12	12-14	<35.8Gy	35.8-41.3Gy	<5	5-8
20-40	<1.15	1.15-1.25	<9	9-11	<38.5Gy	38.5-44.0Gy	<6	6-10
>40	<1.10	1.10-1.20	<6	6-8	<38.5Gy	38.5-44.0Gy	<10	10-15
60-90	<1.10	1.10-1.20	<5	5-7	<38.5Gy	38.5-44.0Gy	<10	10-15
>90	<1.10	1.10-1.20	<4.5	4.5-6.5	<38.5Gy	38.5-44.0Gy	<10	10-15

Highly Conformal Prescription Isodose

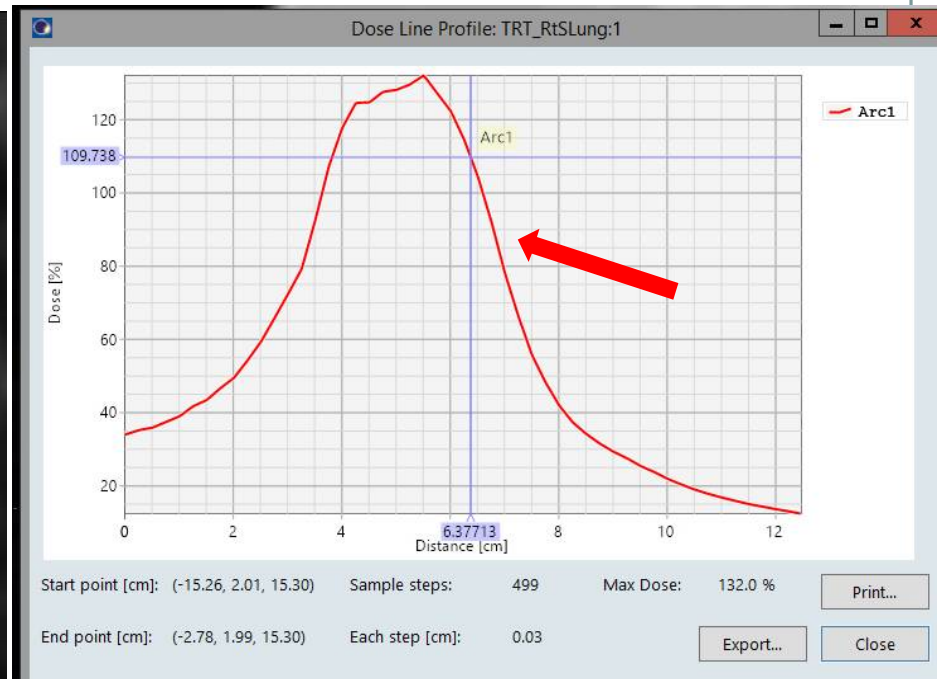
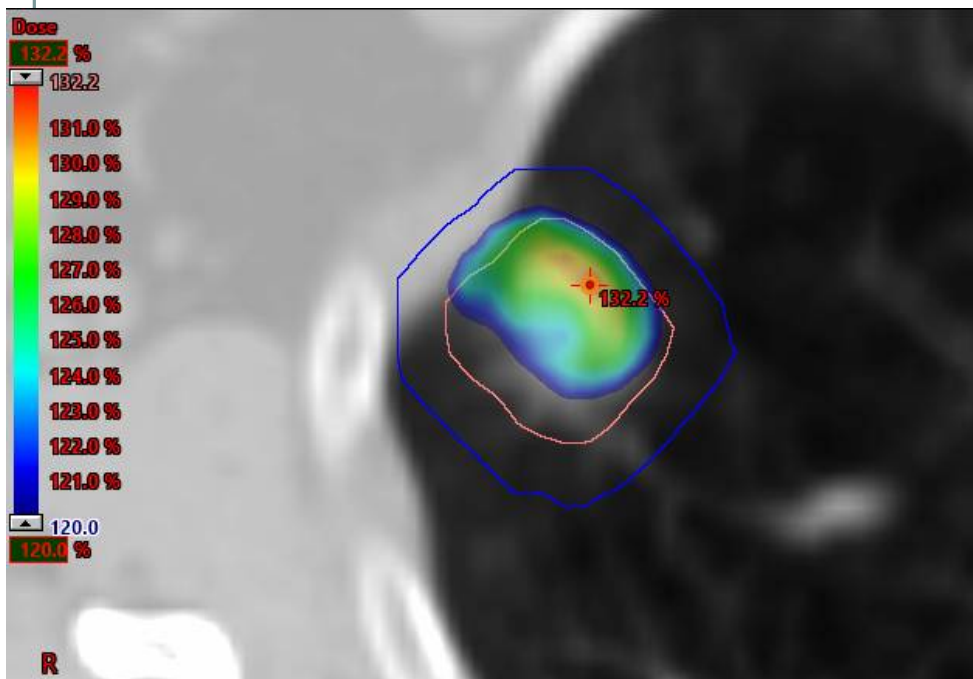


Compact 50% Dose Region



110% - 140% Hotspots in PTV

- Facilitates steep dose gradient at edge of PTV





Considerations for Planning

Enhanced Interplay Effect?



- Interplay effect blurs out for standard treatment courses (mean dose relatively insensitive to interplay)
- Hypo-fractionation – potentially less blurring
- Dosimetric impact for SABR can be neglected for 6 MV RapidArc as long as 2 VMAT arcs are used (Ong, C. et. al, 2011)
- Use of high dose rate modes e.g. FFF to speed up delivery and reduce intra-fraction motion – what effect does this have?

Dose Calculation



- MUST use a heterogeneity correction
- MUST use a Type B or Monte Carlo algorithm (model lateral electron transport)
 - Type A overestimate dose at edge of PTV (risk of under-dose)
 - Type A underestimate low-dose spread
- Dose grid ≤ 3 mm (preferably ≤ 2 mm; AAPM TG-101)

Choice of Energy

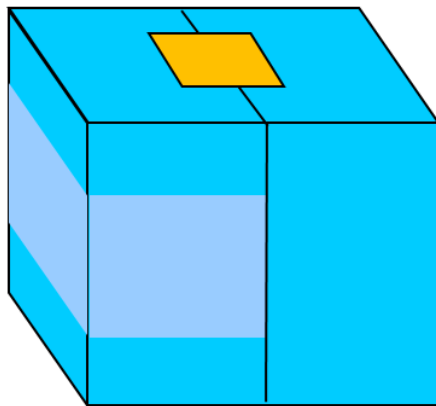


- Use lower energy beams only (e.g. 6 MV)
 - High energies have wider penumbra – increase in penumbral broadening at the edge of PTV in lung SABR
 - Small fields used in SABR – effects of lateral electronic disequilibrium are worse for higher energies
 - Problems associated with build-up

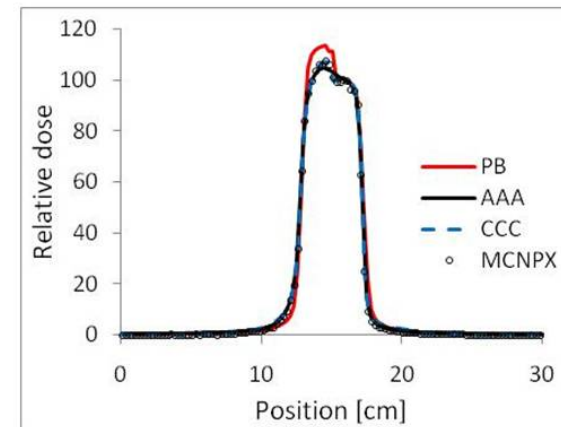
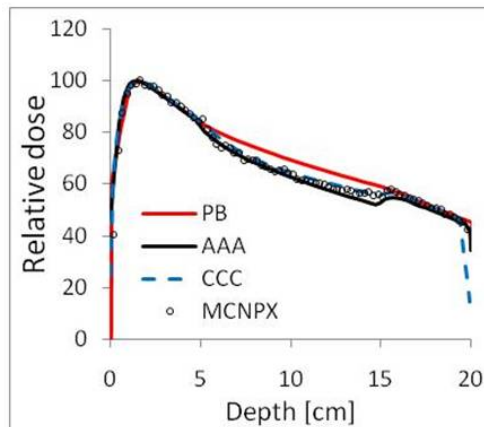
Choice of Algorithm / Energy



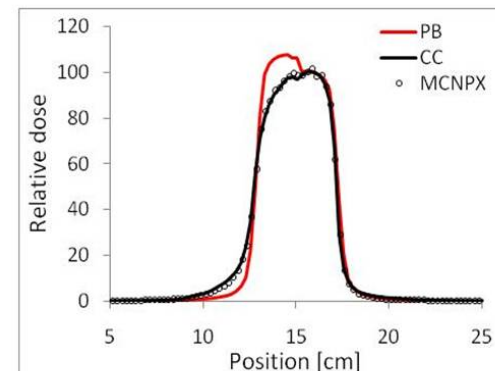
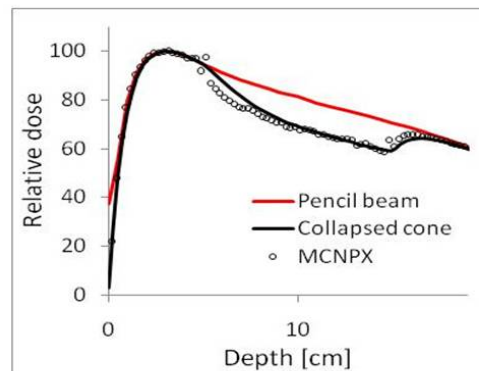
6 MV, 4x4



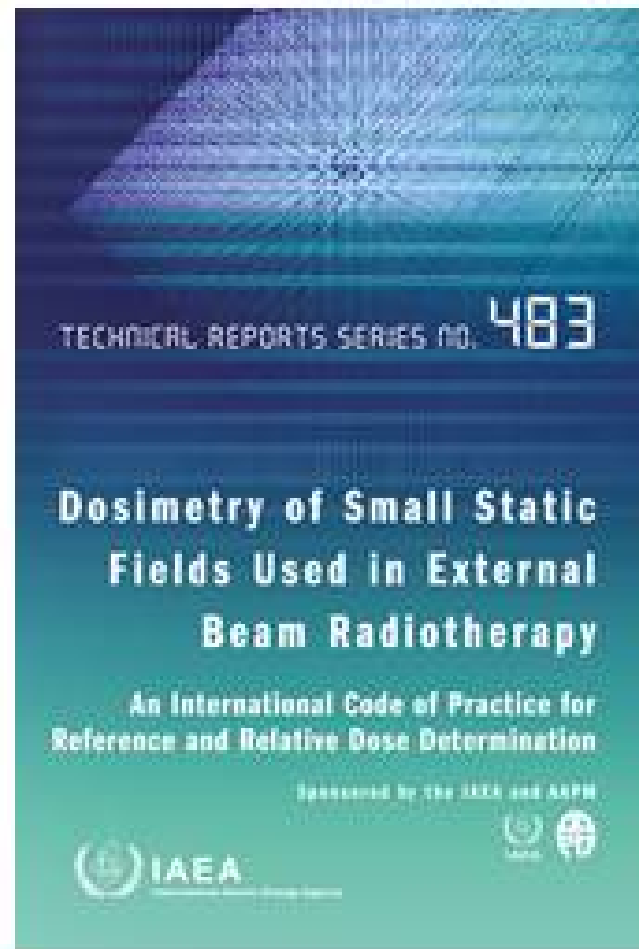
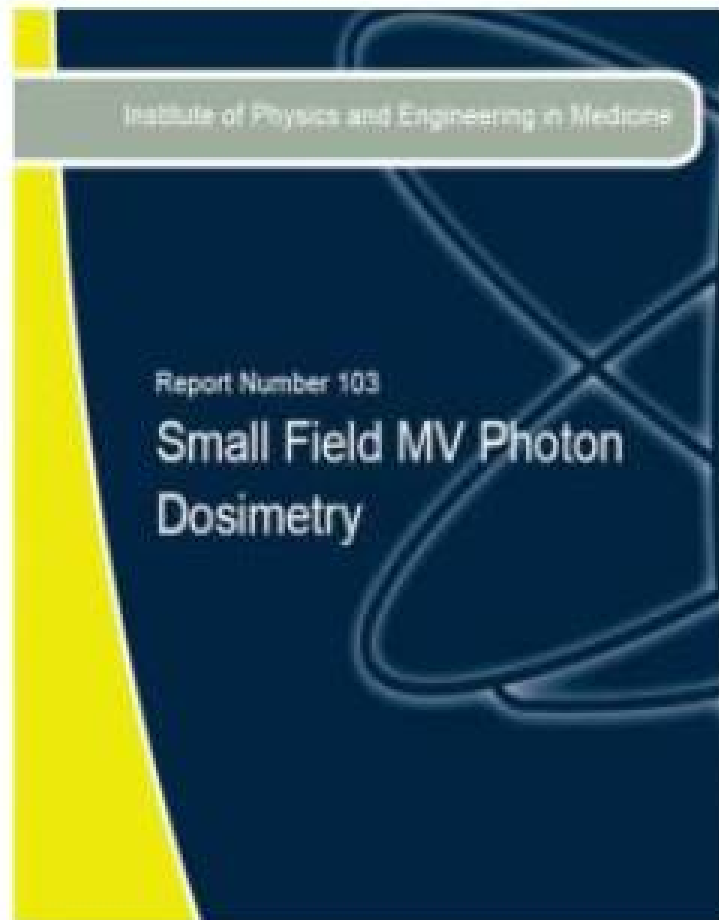
30x30x20 cm phantom with lung insert (relative density 0.3)



15 MV, 4x4



Small Field Dosimetry – see Wednesday's Talk



Small Field Modelling – see Wednesday's Talk



- SABR (particularly with IMRT and VMAT) routinely uses small fields and beamlets < 10 mm
- For very small fields, can have lateral electronic disequilibrium even on the on central axis
- Beam properties (PDD, field width, output factors) are different in small fields
- **TPS must be commissioned specifically for small fields**



Planning Techniques for SABR Lung

Planning Techniques for SABR Lung



- Multiple static conformal fields (SCF)
 - Can include non-coplanar fields
- Fixed field IMRT
- Volumetric Modulated Arc Therapy (VMAT)
- Tomotherapy
- Robotic mounted linac (Cyberknife® by Accuray)

Planning Techniques for SABR Lung



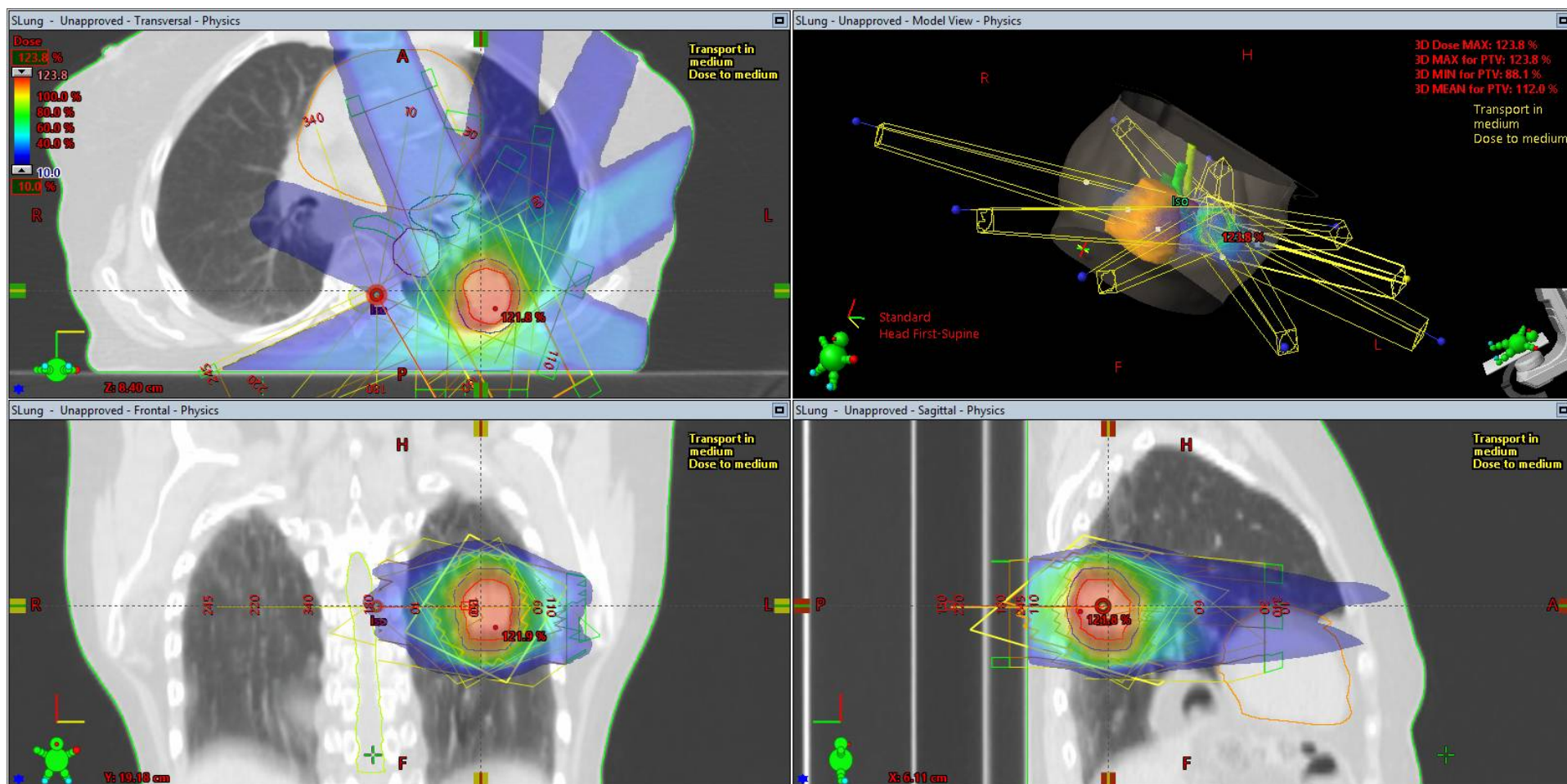
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Static Conformal Fields

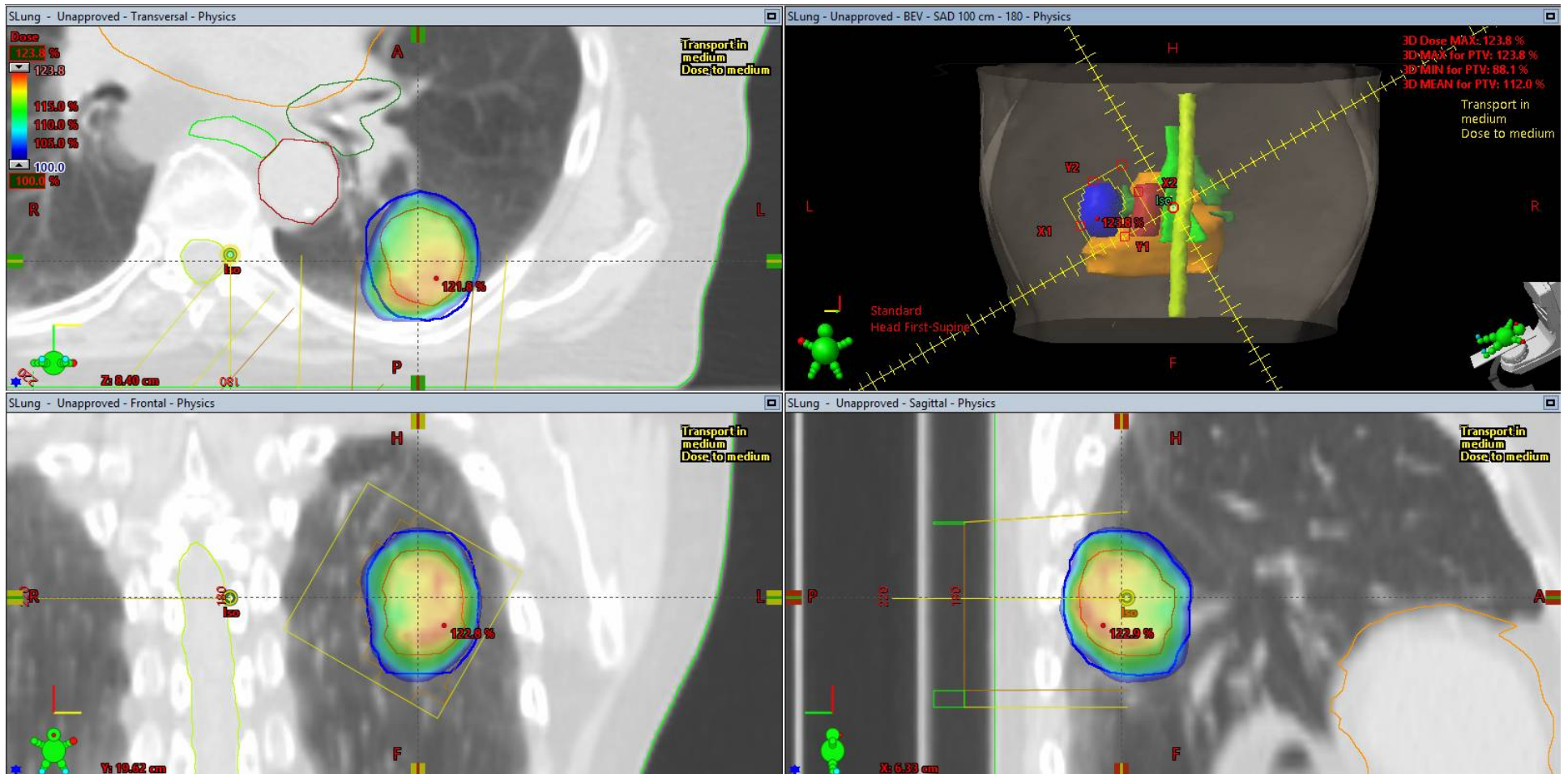


- Usually need at least 7 non-opposed fields
- Ideally co-planar for ease of delivery
- Place beams to avoid OARs
- No overlap on skin surface
- May require additional OARs to be outlined if non-coplanar e.g. bowel, liver (scan entire liver, especially for lower lobe)

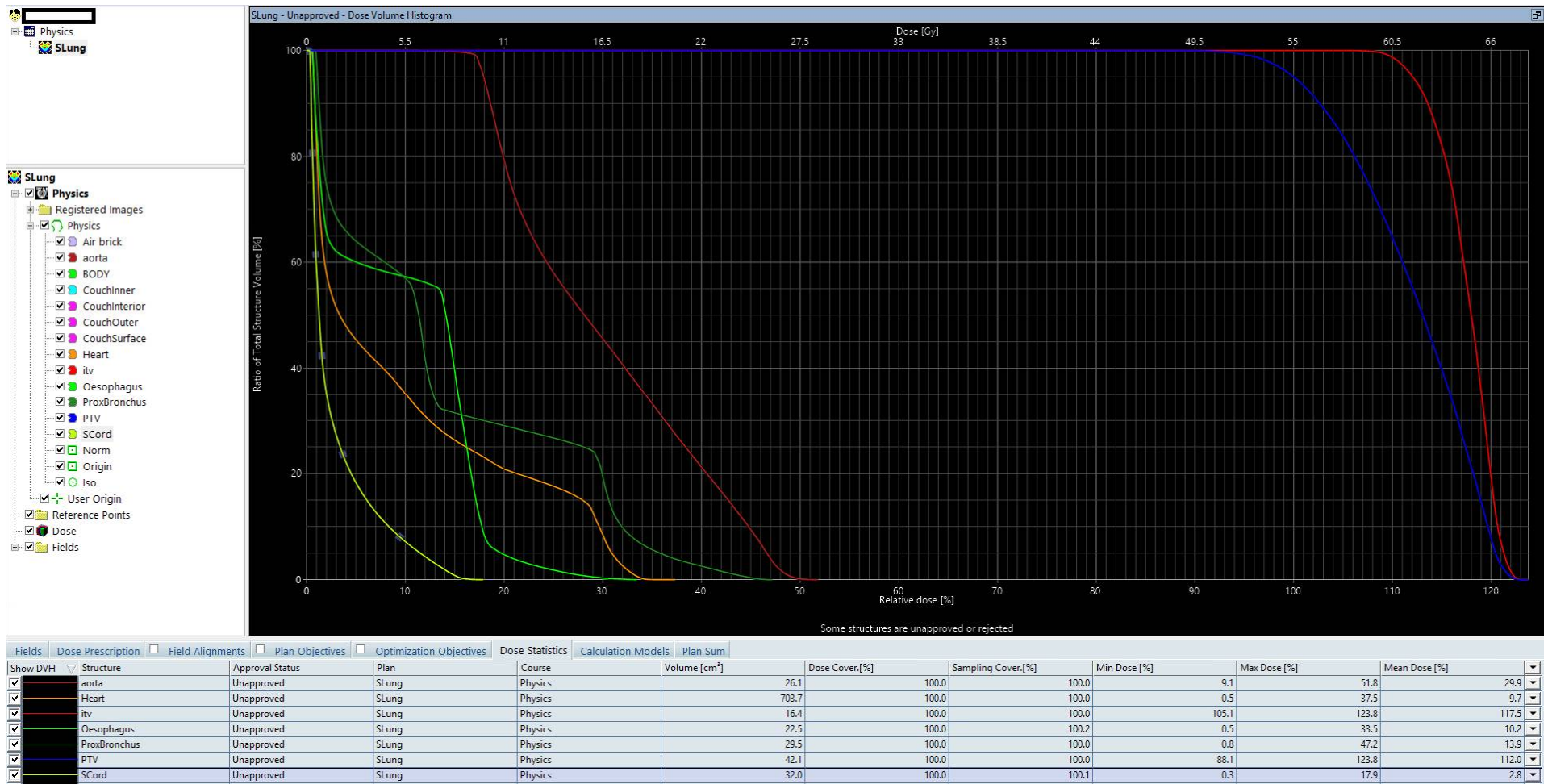
Static Conformal Fields



Static Conformal Fields



Static Conformal Fields

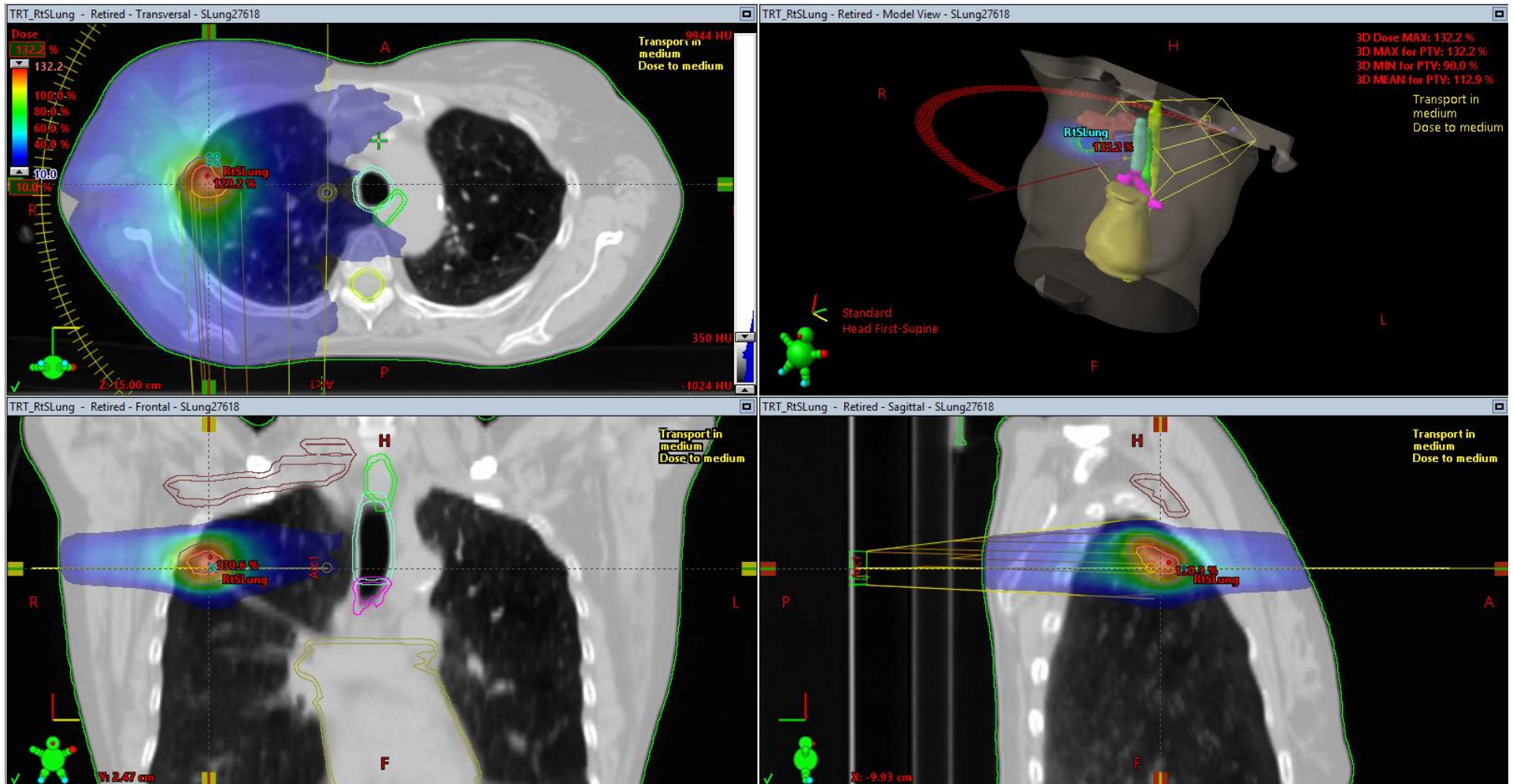


VMAT

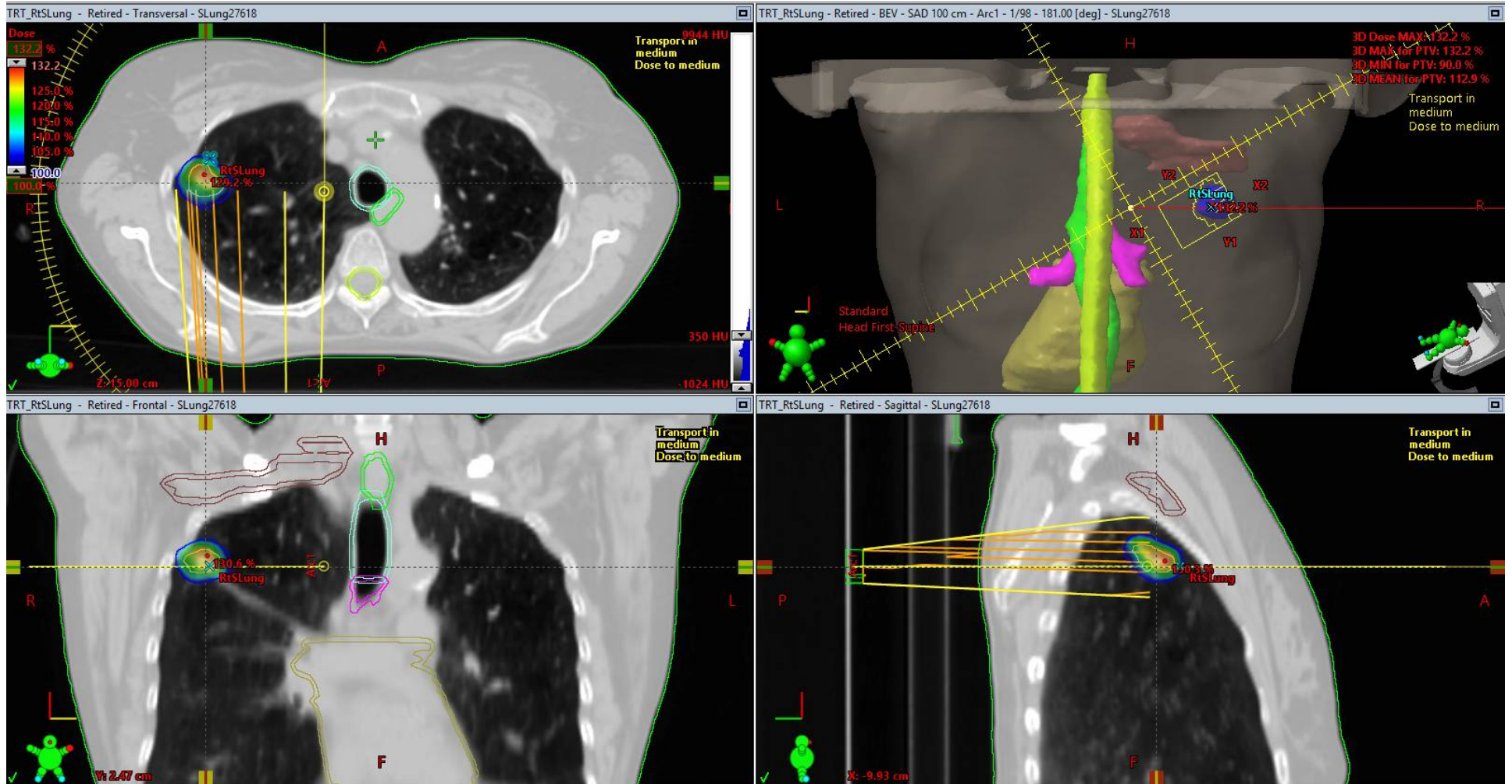


- Can achieve a good plan in most cases with a single half arc with couch = 0° (but consider interplay)
- Avoid OARs using optimisation objectives
- Appropriate for 4D-scanned patients
- Consider patient-specific QA

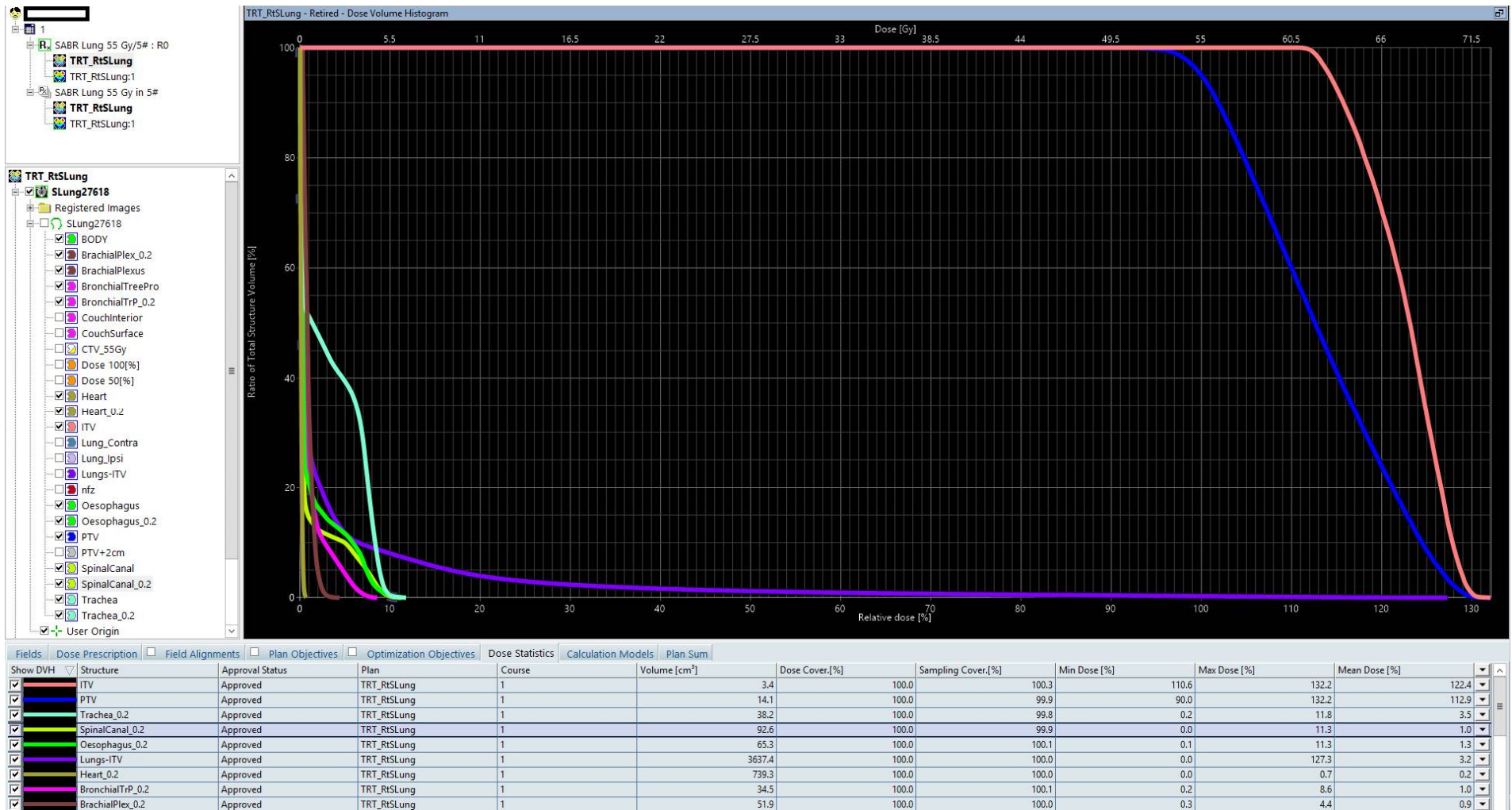
VMAT



VMAT



VMAT



Summary



- PTV margins are specific to local practice
- SABR plans are characterised by highly conformal dose distributions, with steep dose gradients and inhomogeneity across the PTV
- Algorithm, energy, small field modelling and interplay effect should all be considered

