



Planning and Delivery for SRS & fSRT

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Overview



- Specialist equipment
- Immobilisation for SRS and fSRT
- Localising the GTV
- Treatment planning
- Image guidance



Specialist Equipment

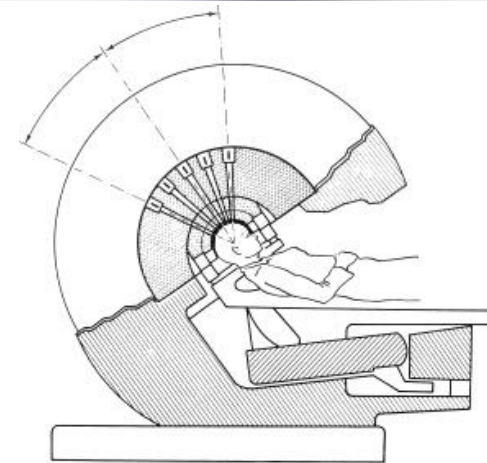
Dedicated Equipment

Cyberknife™ (Accuray)



- Long treatment times
- Not flexible
- Marginal gains for Cyberknife
- **Modern linacs have caught up!**

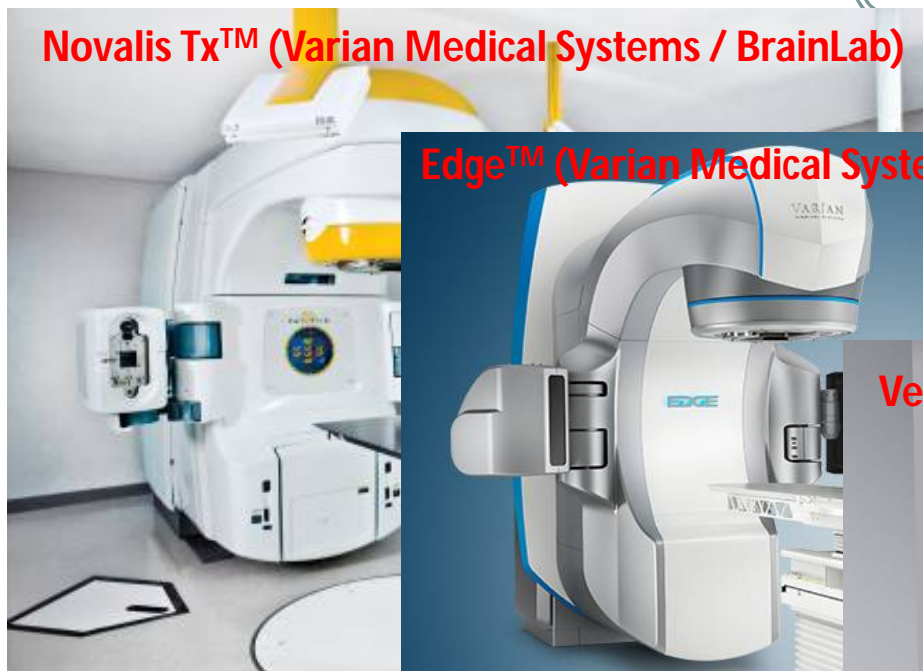
Gamma Knife Icon™ (Elekta)



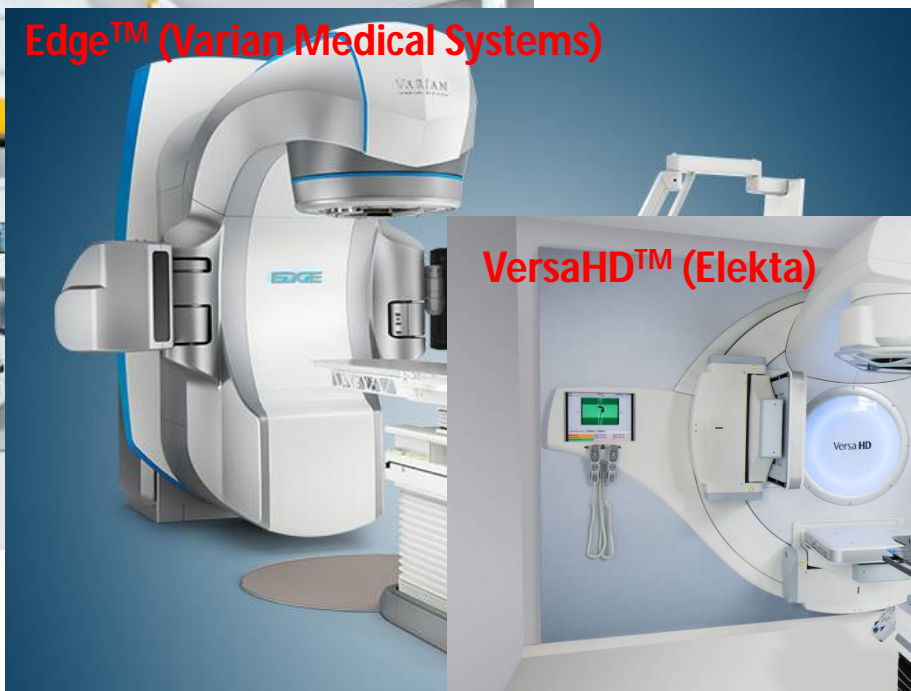


Specialist Stereotactic Linear Accelerators

Novalis Tx™ (Varian Medical Systems / BrainLab)



Edge™ (Varian Medical Systems)



VersaHD™ (Elekta)



Specialist Stereotactic Linear Accelerators



- Standard features:

- Integrated image-guidance
- Non-coplanar
- 6DoF couch
- Monitor
- Integrated
- High dose
- \pm conical
- Improved

But, the line between
specialist and modern non-
specialist linacs has
significantly blurred



Immobilisation for SRS & fSRT

“Stereotactic”



- Historically refers to use of a 3D, external co-ordinate system for precise geometric localisation of a target
- External co-ordinate systems used for SRS of functional disorders prior to the invention of CT / MRI



Image courtesy of Elekta

“Stereotactic”

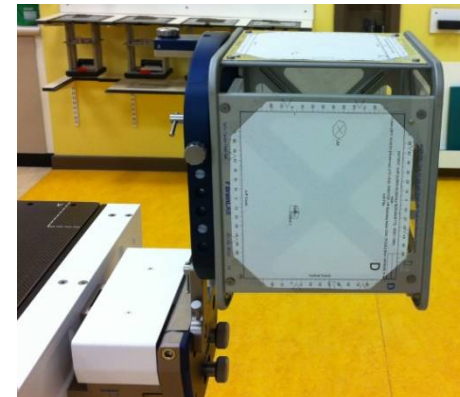


- With rapid advances in IGRT, the need for external frame of reference is diminishing
- Contemporary meaning: treatment requiring high geometric precision
- ~~Stereotactic Radiosurgery?~~

Frame-Based SRS

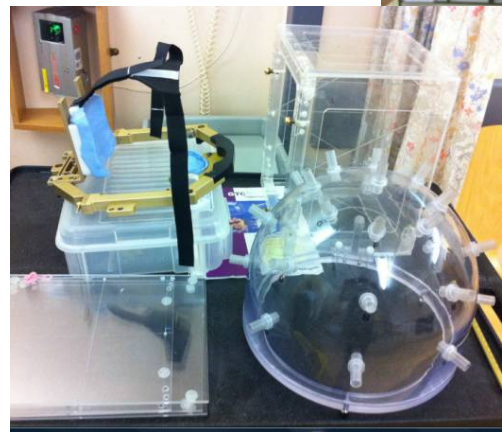
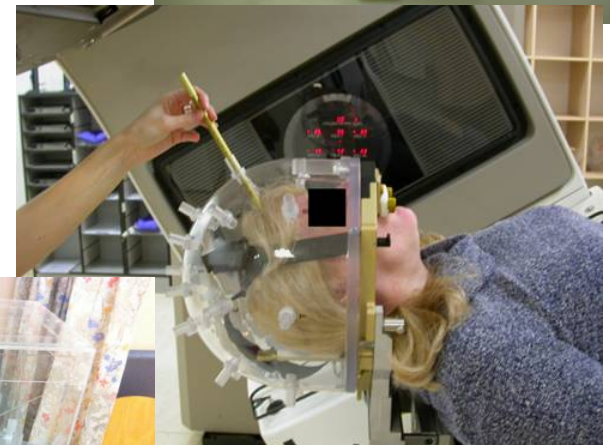


- Historical gold standard – reliable immobilisation and target localisation
- Prior to kV / CBCT imaging on linacs
- Significant disadvantages
 - Patient discomfort
 - Risk of injury
 - Logistical difficulties
 - Possibility of frame slipping
 - Not suitable for fractionated treatments



Re-locatable Frames

- e.g. Gill-Thomas-Cosman frame (1992):
 - Non-invasive
 - Repositionable to ≤ 1 mm
 - Introduced possibility to fractionate – **Stereotactic Radiotherapy (fSRT)**



Specialist Stereotactic Mask Systems



Encompass
by Q-Fix



BrainLab

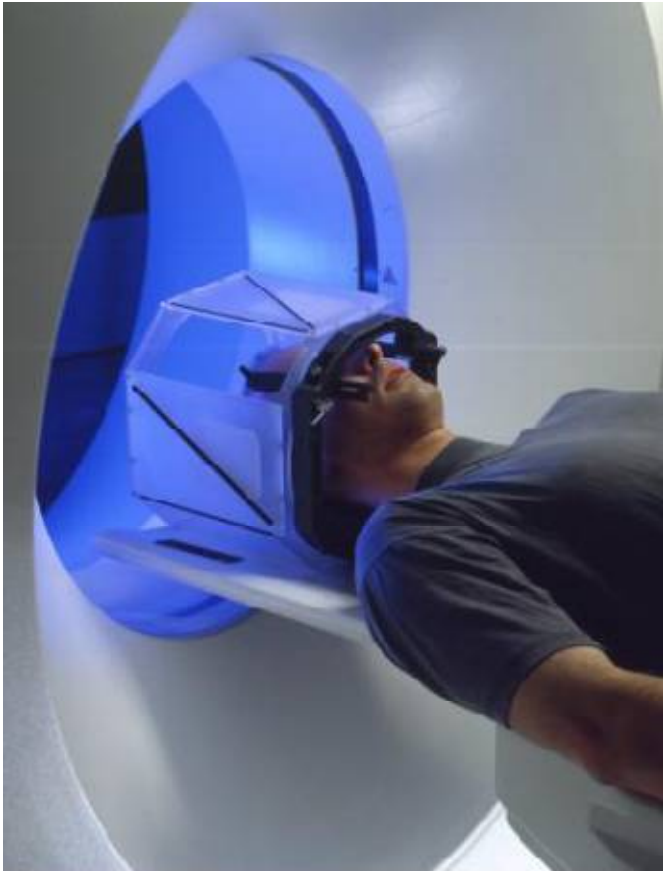
- ~ 50% more rigid than standard thermoplastic
- \pm biteplate to minimise rotation (useful if no 6 DoF)



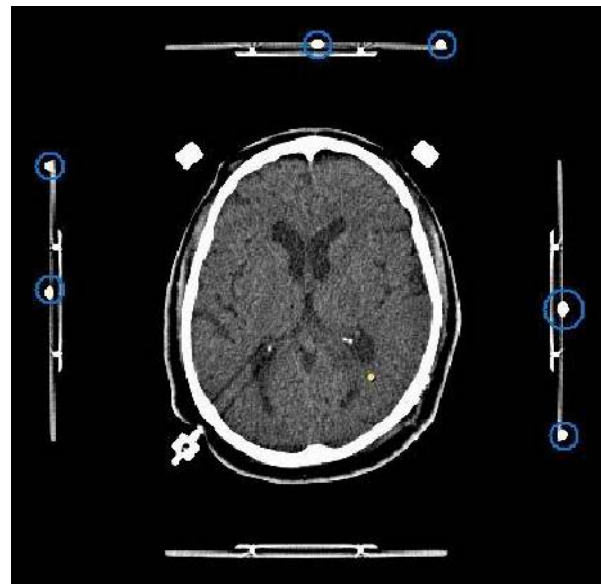
Localisation

(defining the tumour position relative to the external co-ordinate system)

Localisation of the GTV



- Patient is CT scanned with localiser box over the frame / mask
- Radio-opaque fiducial wires are used to define the external co-ordinate system



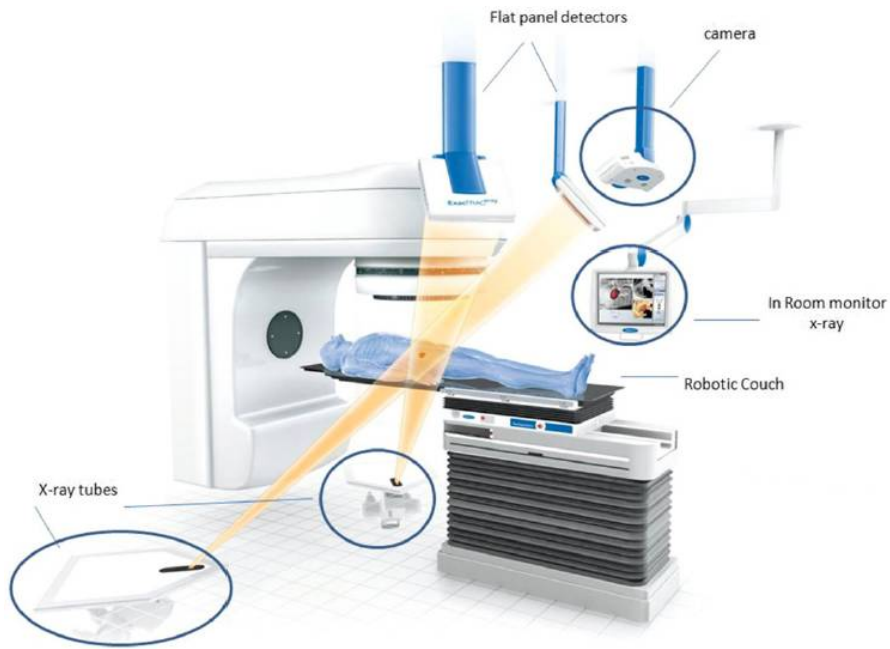
Localisation using
the fiducial rods in
the specialist TPS

Localisation of the GTV



- Target positioners ("TAPOS") printed using a calibrated printer and carefully taped to a second localiser box
- TAPOS are used to align isocentre to the lasers and check beam's eye views
- The localiser box is removed before IGRT and treatment

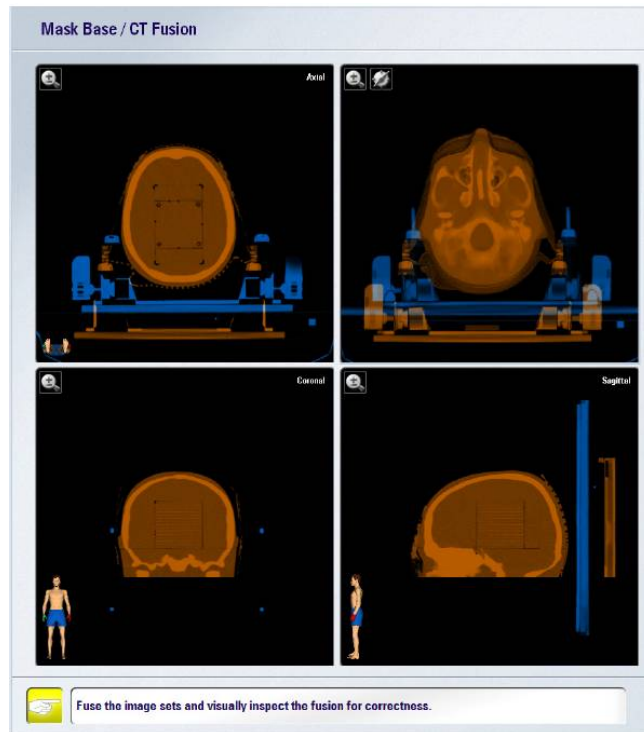
Localisation of the GTV



- Alternatives to TAPOS e.g. Brainlab mask with ExacTrac and iPlan
- Second localiser box replaced by infra-red array
- Uses infra-red pre-positioning
- Followed by IGRT to confirm position



Localisation of the GTV



- Can also use a 3rd party planning system (no localisation)
- Localise in the ExacTrac software, infra-red pre-positioning
- Followed by orthogonal kV imaging to confirm position



Planning SRS and fSRT Treatments

PTV Margin

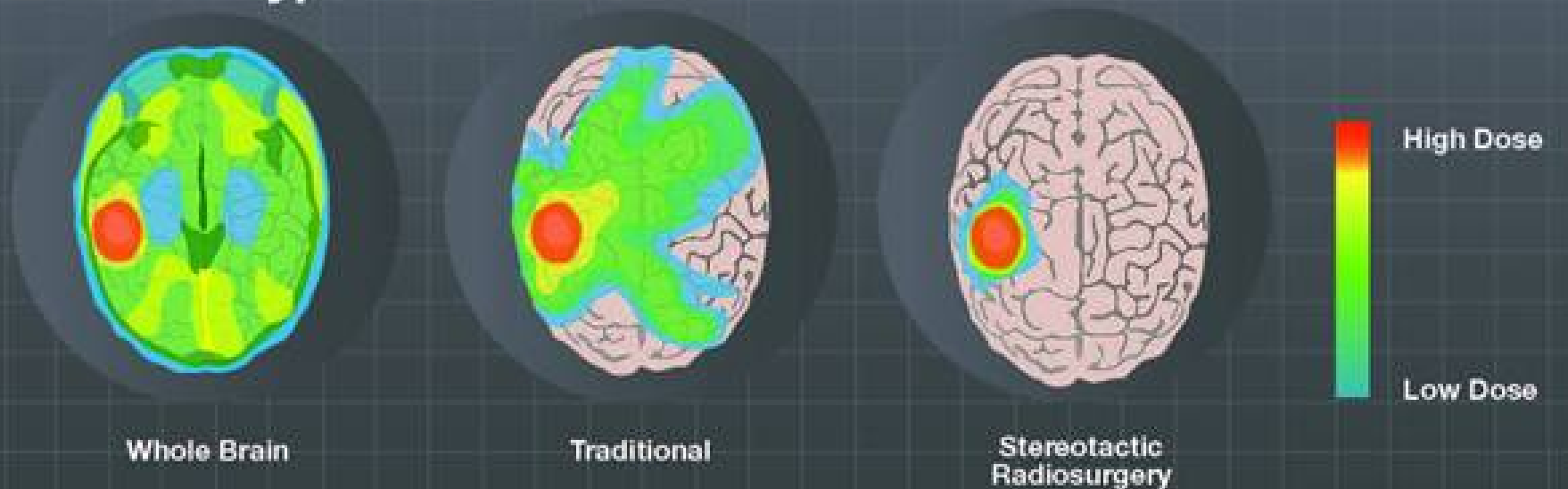


- Common to treat with 0-1 mm PTV margin (especially SRS)
- PTV margins often derived (at least initially) from published experience of other centres. This should not replace:
 - Local QA protocols, including thorough end-to-end testing
 - Consideration of issues such as multi-modality localisation
 - Pre-treatment imaging
 - Evaluating intra-fraction motion
 - Peer review of CTV outlines!

Characteristics of an SRS / fSRT Plan



Different Types of Brain Radiation



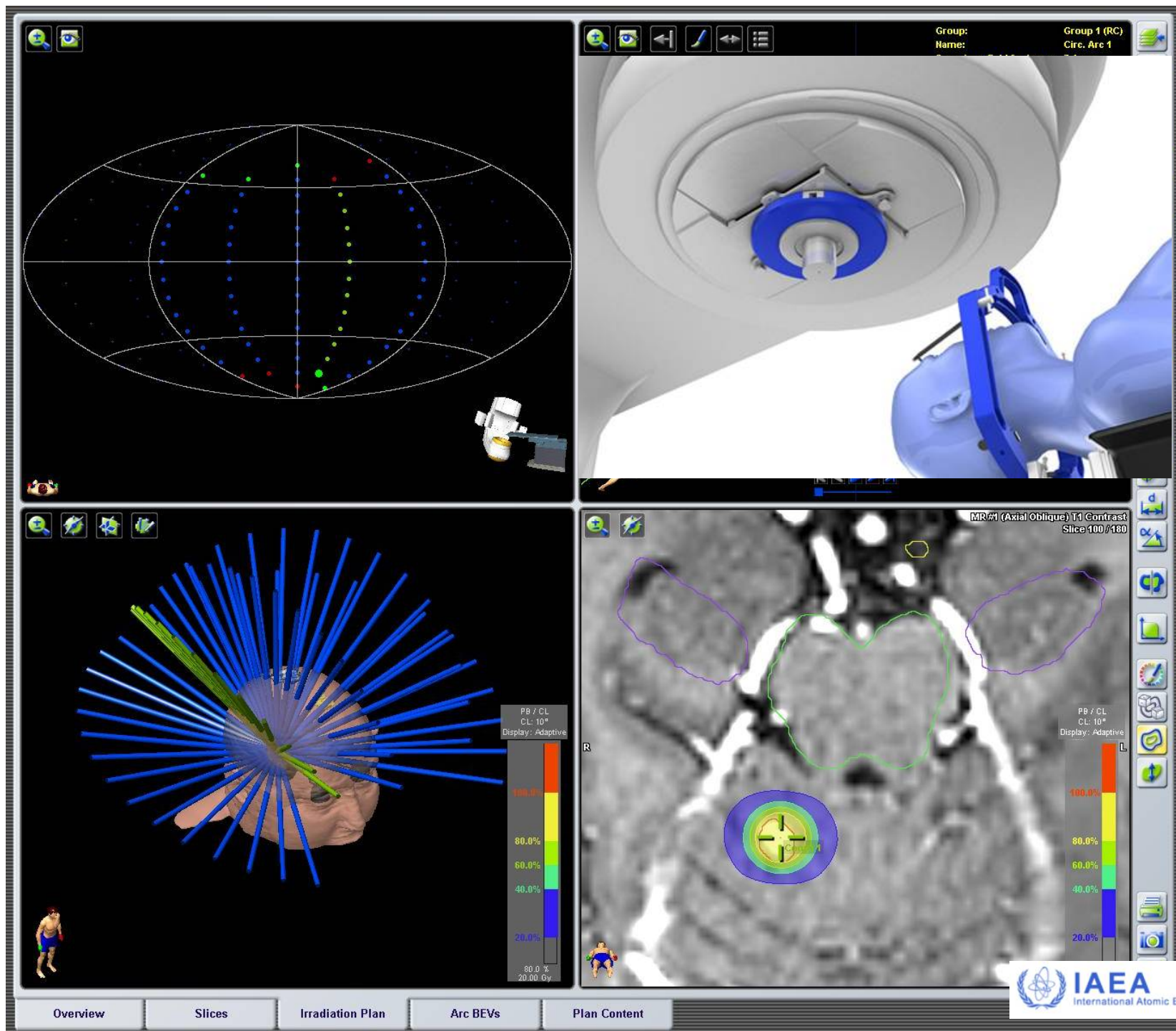
- Highly conformal prescription isodose
- Inhomogeneous PTV dose – hotspots
- Typically prescribe to ~ 80% isodose (linac-based)
- Steep dose gradients at edge of PTV

www.brainlab.org

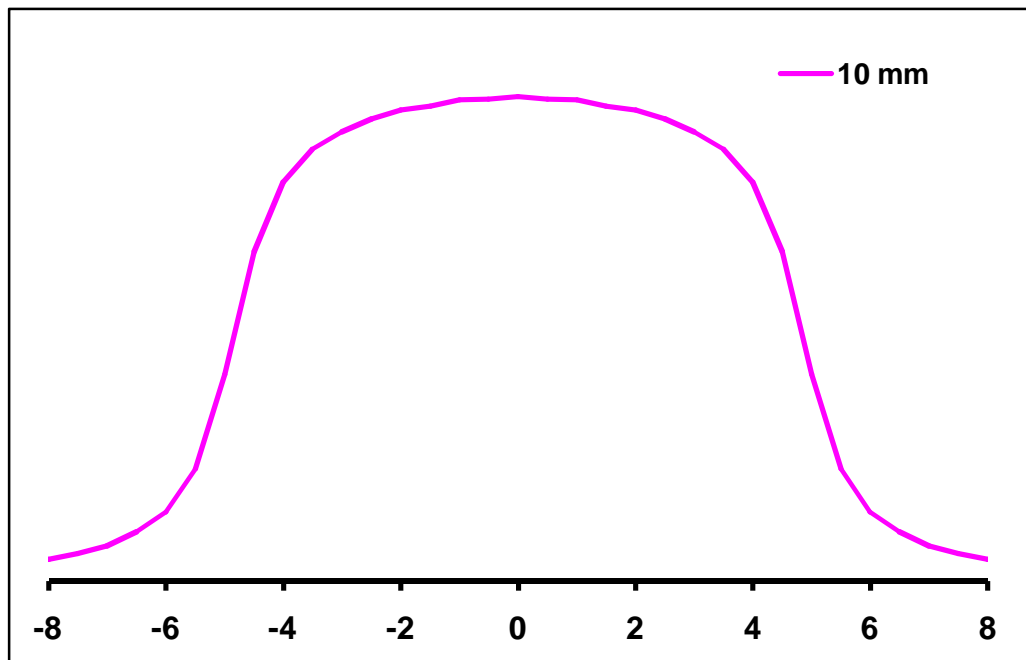
SRS Planning



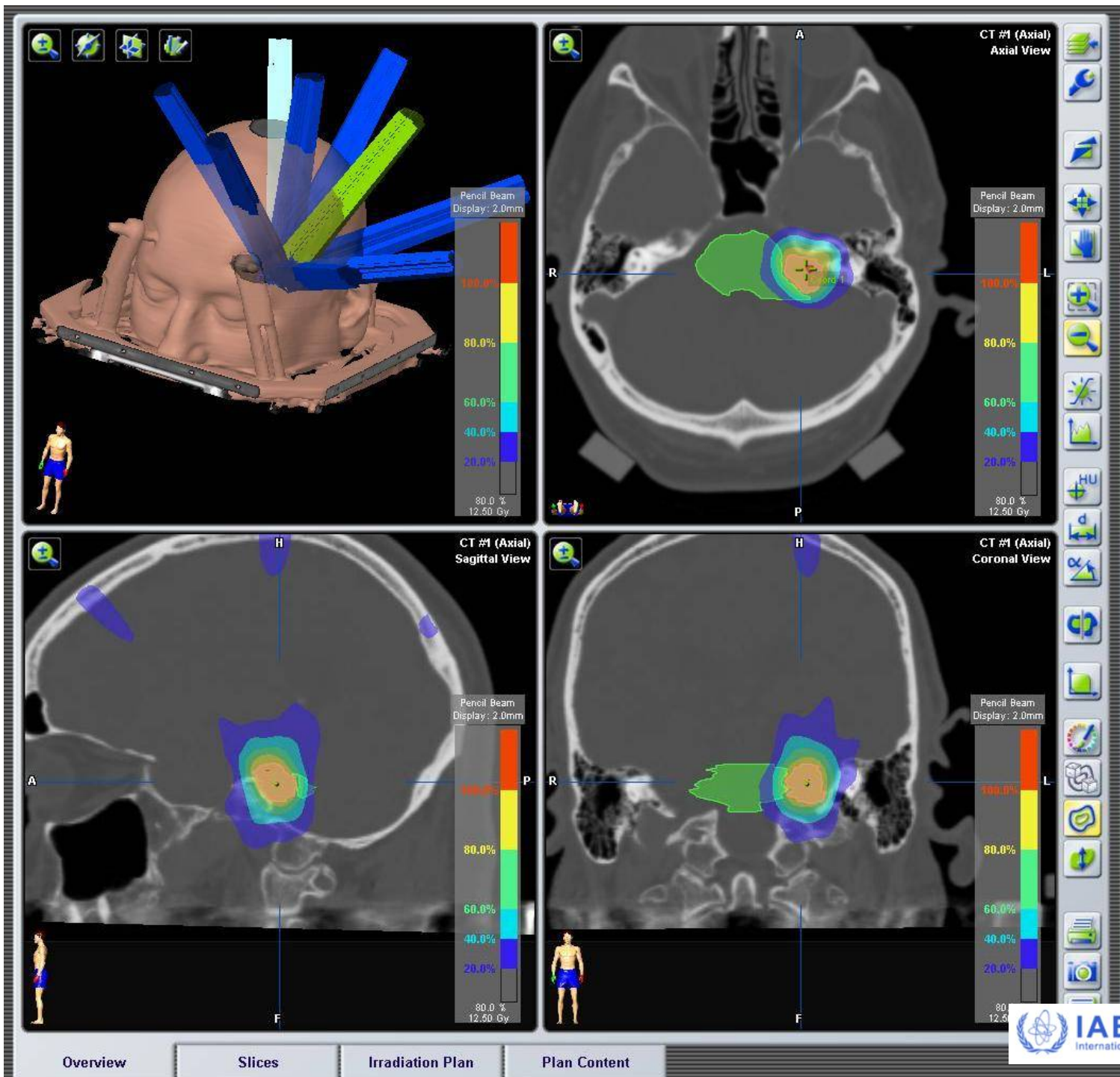
- Similar principles to SABR lung, except:
 - Potentially smaller targets (for single fraction $\leq 3\text{cm}$)
 - 1 mm dose grid appropriate
 - Algorithm type not necessarily as critical

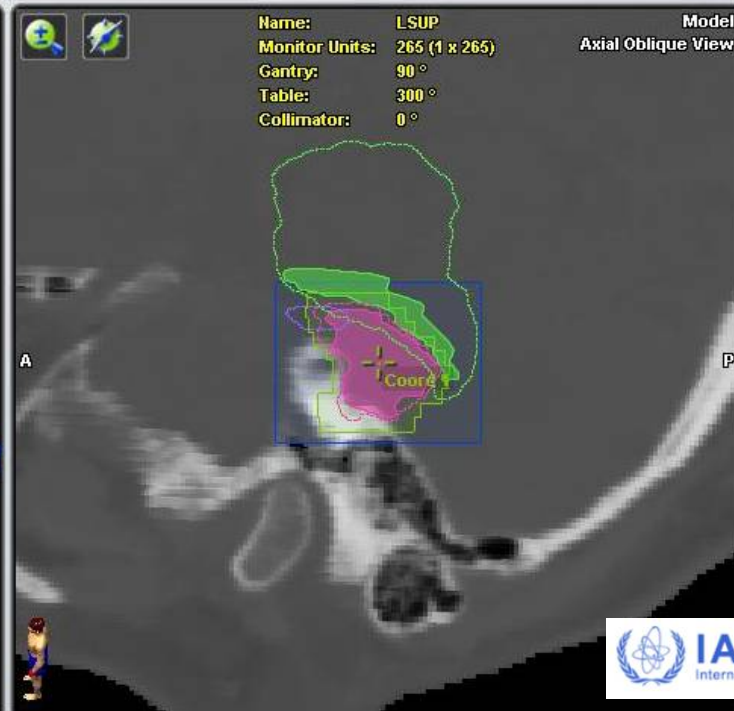
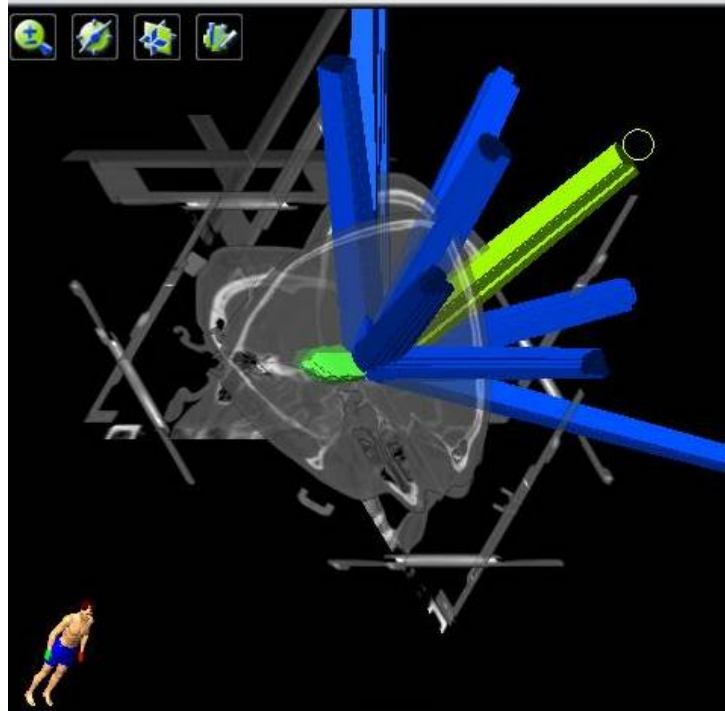
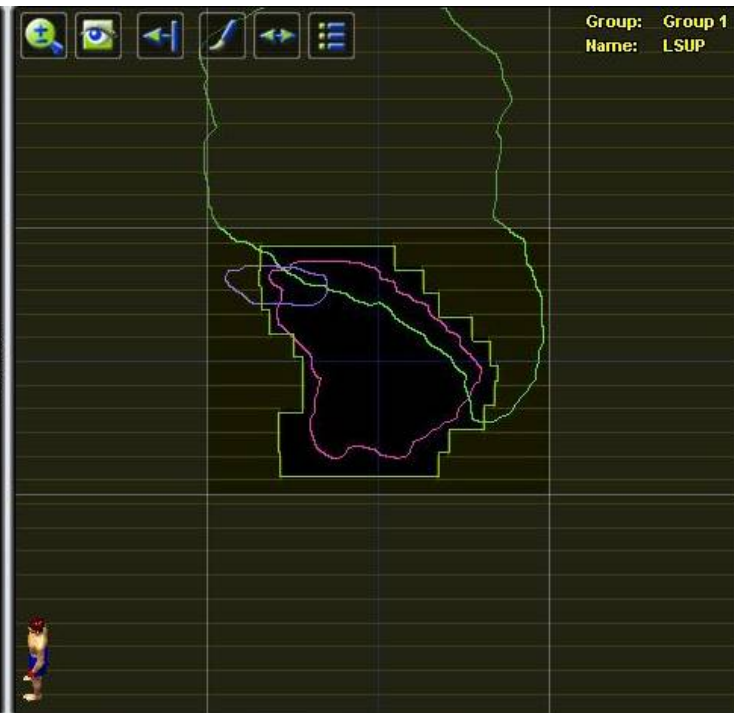
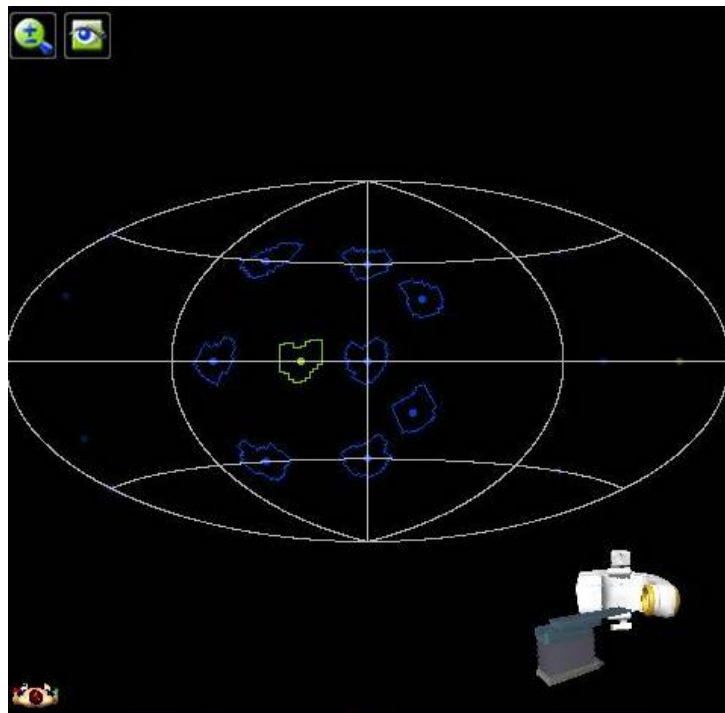


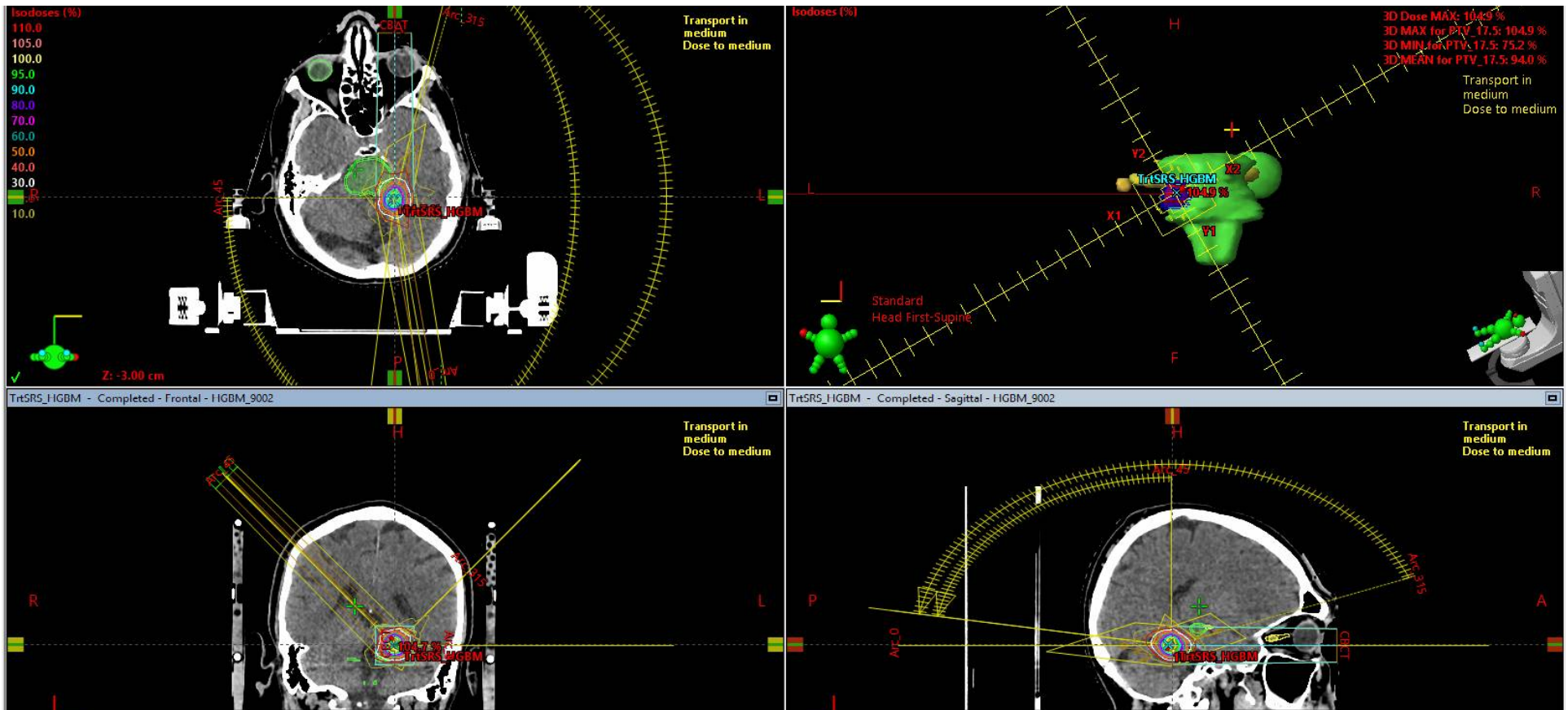
Why Prescribe to 80%?



- At 80%, we are in a steep part of the penumbra
- Allows for steep dose gradient outside PTV
- Hotspots in PTV acceptable (ablative treatment, less normal tissue in PTV)
- Increases requirement for geometric accuracy







A comparison of SRS plan quality when using VMAT vs non-coplanar static conformal fields.

R. Brass¹, L. Howard¹, M. Gilmore¹.

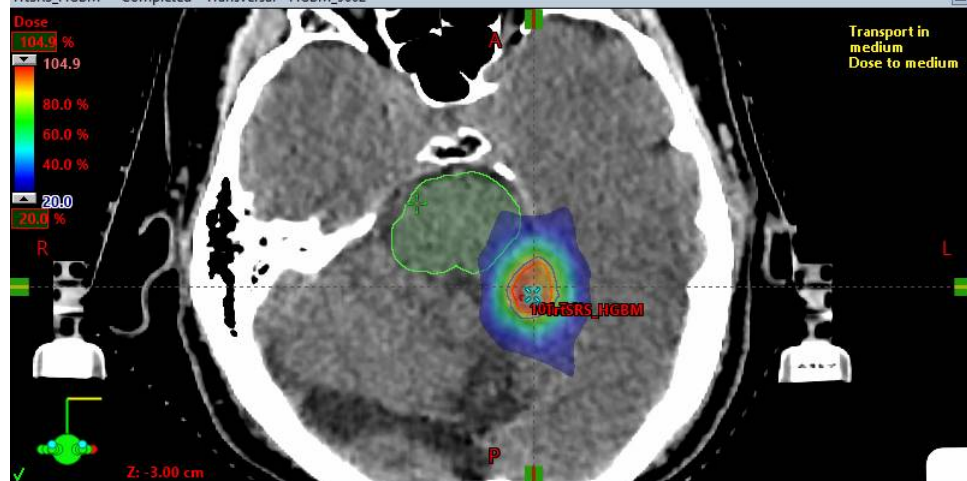
¹The Clatterbridge Cancer Centre, Physics, Bebington, United Kingdom.

Purpose or Objective

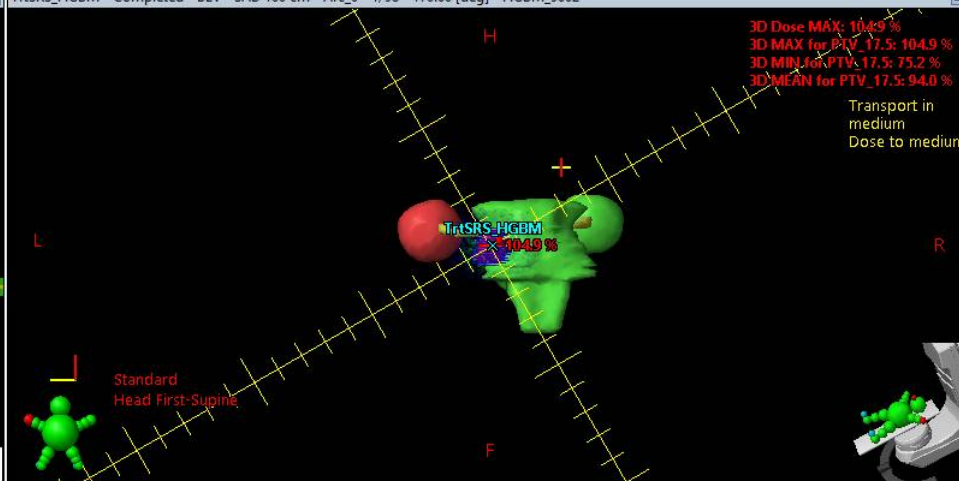
To produce a VMAT multi-arc solution in Eclipse for SRS patients with at least equivalent plan quality to previously used static conformal field (SCF) technique. To establish a plan quality tool based on acceptable plan quality metrics for SRS patients.

- ESTRO 2017. Improvement in Paddick C.I. for VMAT (mean 0.81) compared with SCF (mean 0.64)
- Paddick G.I. not useful, especially for small volumes
- NTOF reduced to ~ 0 for VMAT

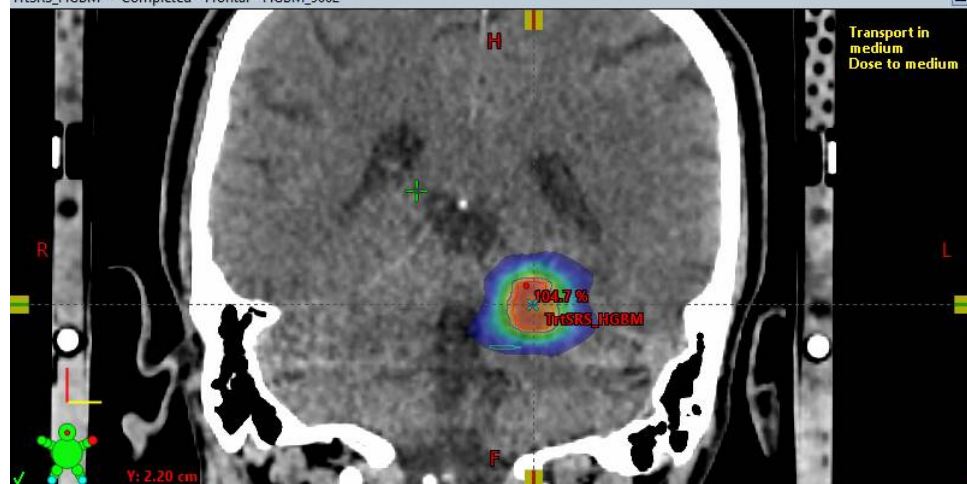
TrtSRS_HGBM - Completed - Transversal - HGBM_9002



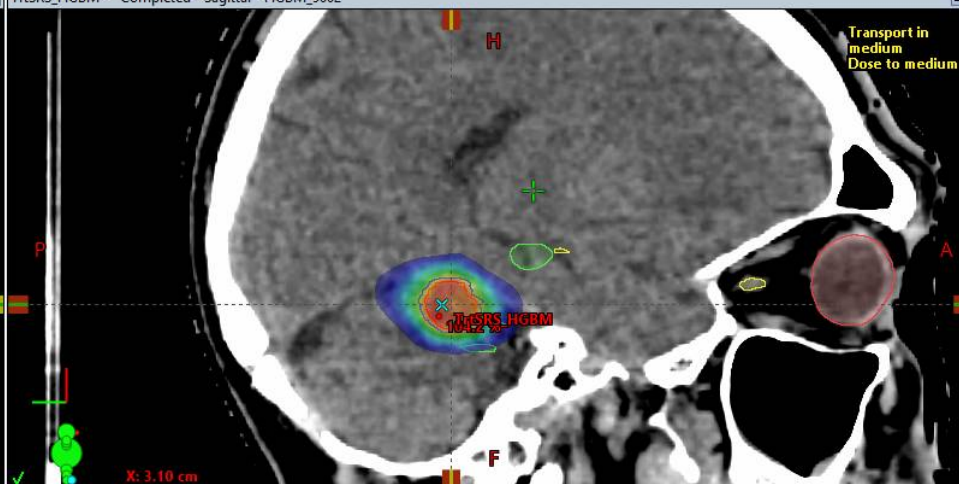
TrtSRS_HGBM - Completed - BEV - SAD 100 cm - Arc_0 - 1/98 - 170.00 [deg] - HGBM_9002

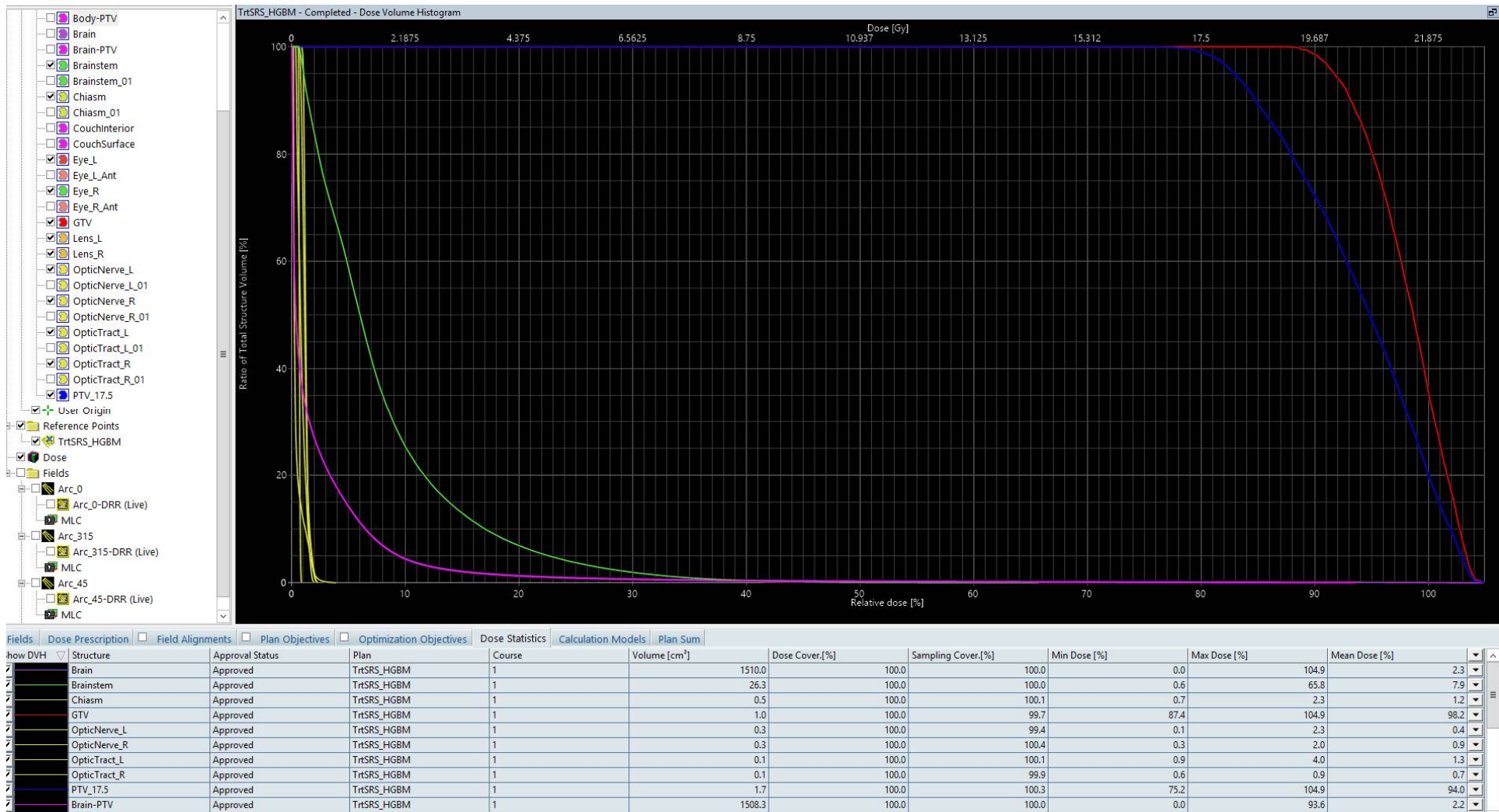


TrtSRS_HGBM - Completed - Frontal - HGBM_9002



TrtSRS_HGBM - Completed - Sagittal - HGBM_9002

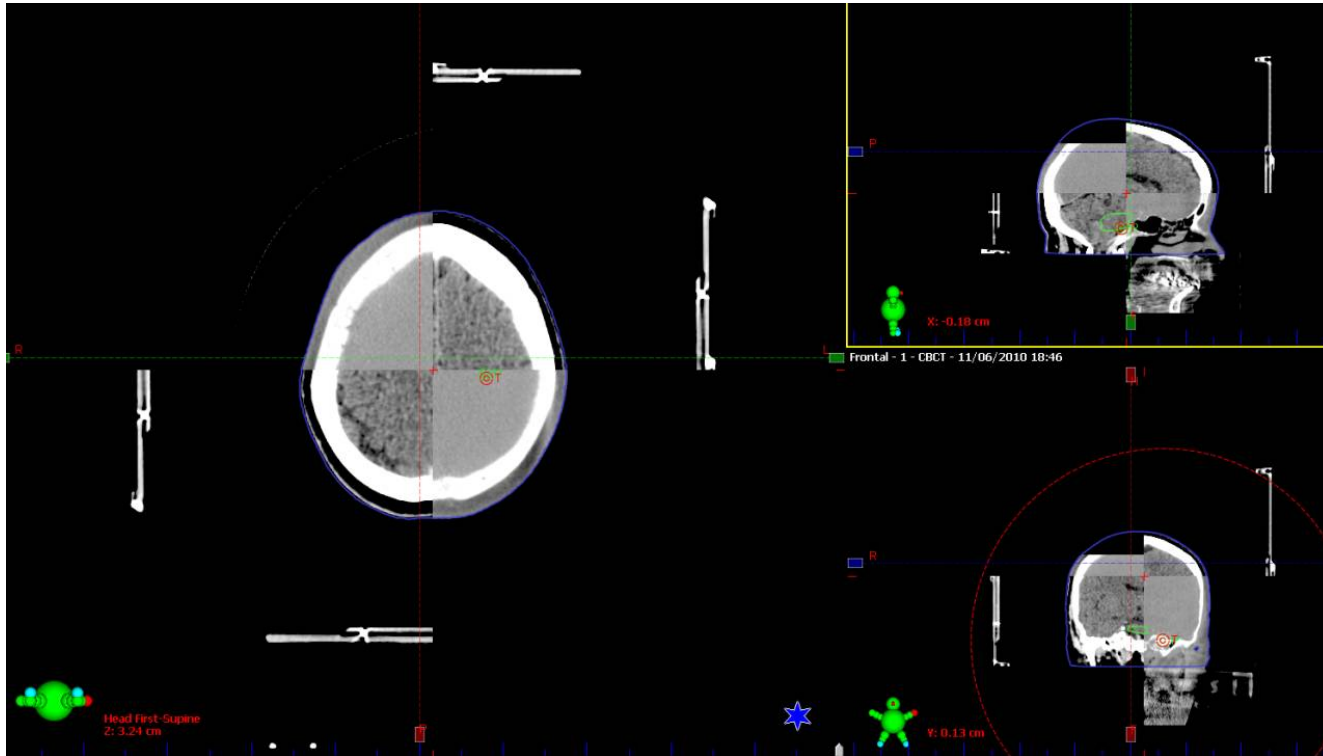






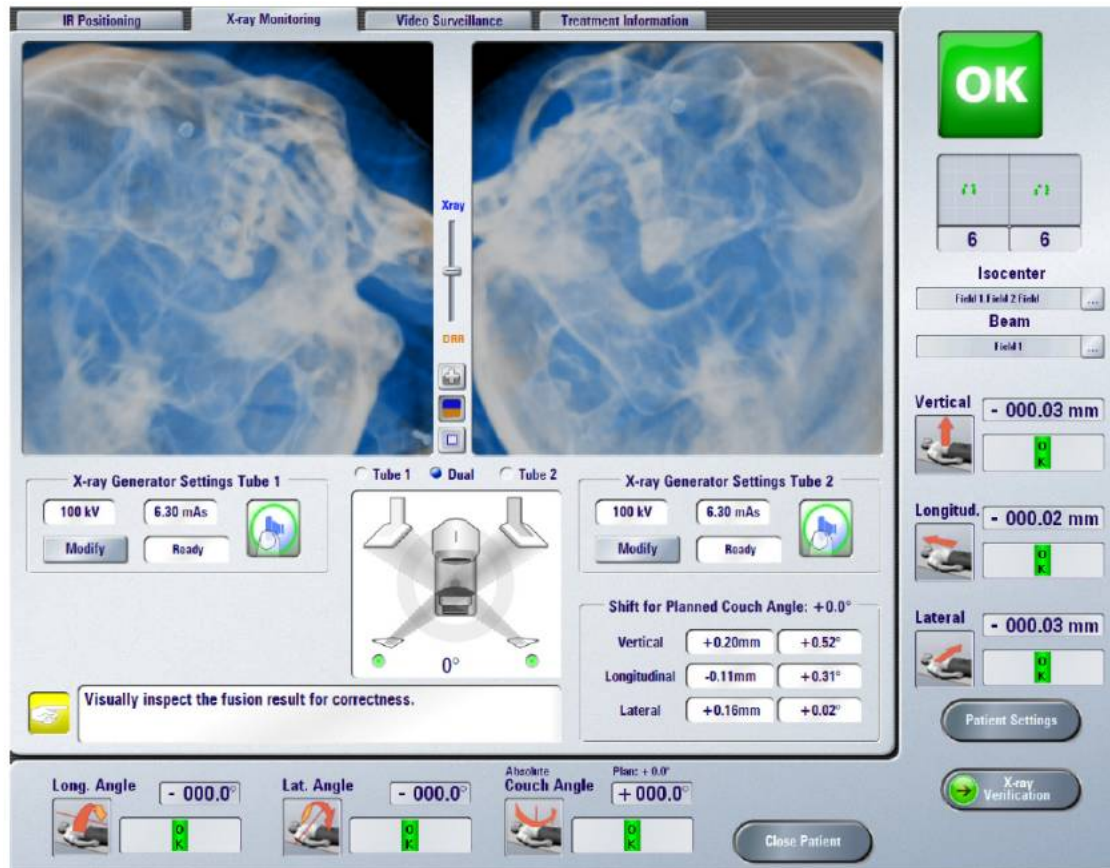
IGRT for SRS and fSRT

Cone-Beam CT



- Modern linacs: detect and apply ≤ 1 mm translations
- + 6DoF – gold standard for verification of initial set-up
- Couch = 0°

Stereoscopic kV



- Detect and correct small positional errors (0.5 mm and 1°)
- Non-coplanar imaging: intra-fraction motion
- Overall system accuracy within tolerances appropriate for radiosurgery (Lamba et.al 2009; Solberg et al. 2008; Ramakrishna et al. 2010)

Surface-Guided Radiotherapy



- Surface tracking, not IGRT (monitoring intra-fraction motion)
- However, can be used to pre-position patient ready for IGRT
- Non-ionising, continuous monitoring

Summary



- The line between dedicated stereotactic linacs and modern non-dedicated linacs is significantly blurred
- Modern SRS uses stereotactic masks rather than frames
- With IGRT, the need for an external frame of reference is diminishing
- Patient set-up must be verified before treatment

Any Questions?

