



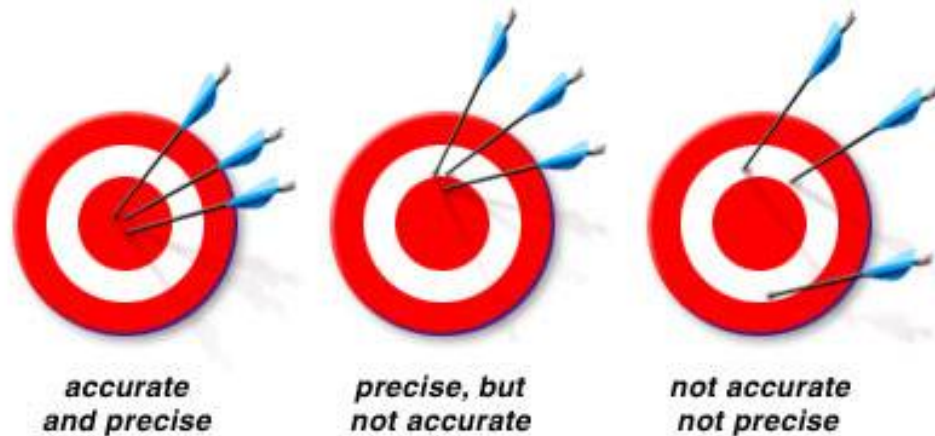
Ensuring Accuracy and Precision in SRS

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Overview



- Sources of uncertainty in SRS
- Geometric uncertainties
- End-to-end testing



Uncertainties in SRS



Table 7.1 Estimated uncertainties in intracranial SRS deliveries in terms of a peripheral isodose surface conforming to a clinically defined target surface

Source of errors	Standard deviation (mm)
Imaging studies (resolution and distortions)	0.5–1.5
Mechanical alignment and setup errors	0.3–1.0
Tissue/target motion	0.5–1.0
Treatment planning	0.5–1.0
Overall (quadrature)	1.3–2.2

Overall procedural accuracy with modern equipment / techniques can be conservatively estimated to be less than **1 – 2 mm, or better**

Chin, L.S., and Regine, W.F. (2015). Principles and Practice of Stereotactic Radiosurgery (2nd Edition). Springer.

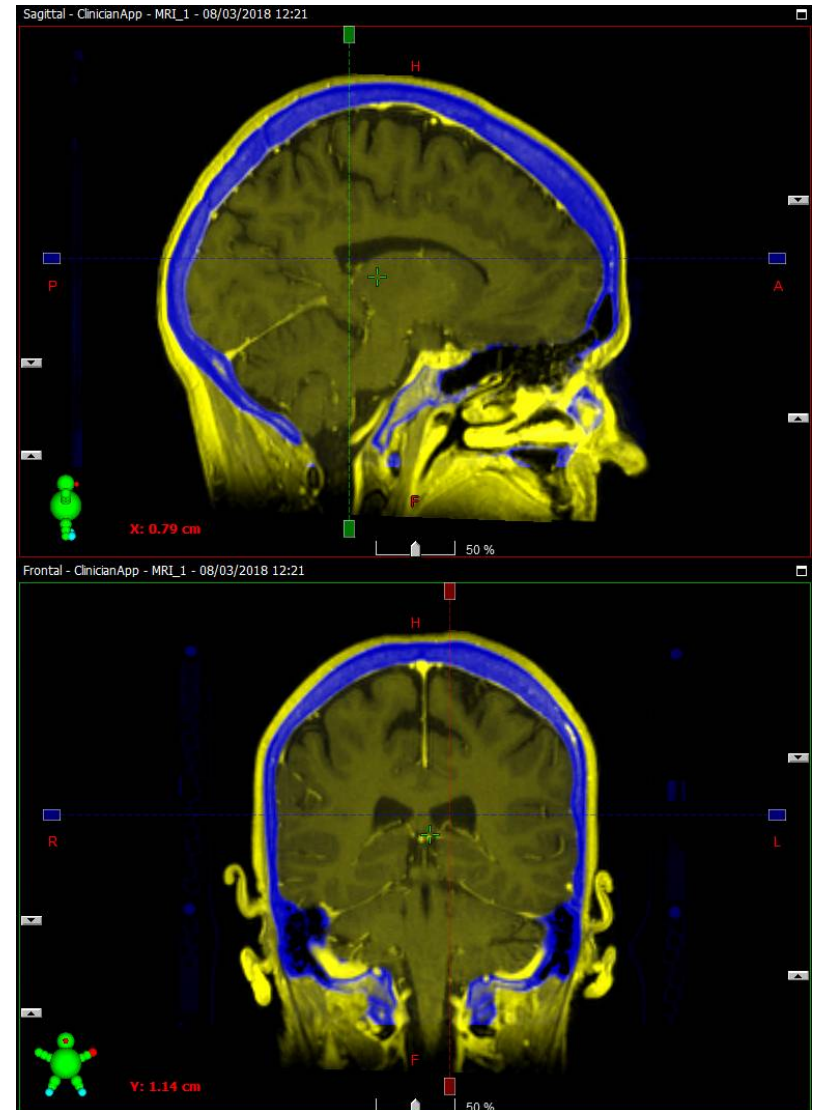
Geometric Uncertainties in SRS



- Most centres use 0 – 1 mm PTV
- Residual geometric uncertainties (assuming pre-treatment IGRT) can be divided into two main sources:
 - Intra-fraction motion
 - ✦ Correctable with IGRT between treatment fields
 - Mechanical / process systematic errors
 - ✦ Need to minimise

CT & MR Imaging

- Major sources of uncertainty intrinsic to all SRS units
- Slice thickness / image resolution / spatial distortions / slice position error
- Image co-registration errors
 - Automatic image registration?
 - Inter-observer error?
 - How to deal with multiple targets?
- Are the errors detectable / correctable?



Target Outlining

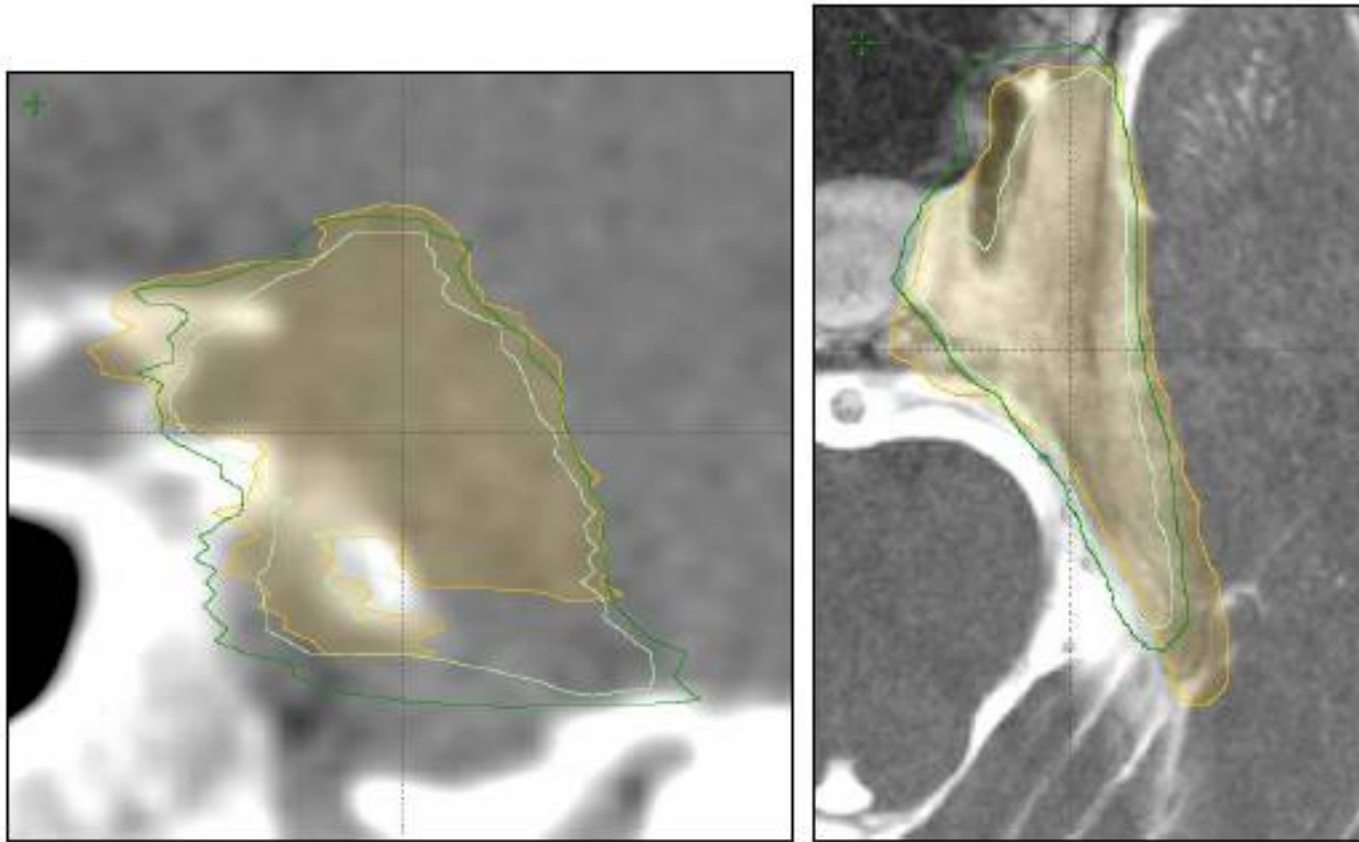


Figure 2 The coronal (left) and coronal (right) images with the ERG max GTV (dark green), ERG min GTV (light green) and the submitted GTV (orange)

Isocentre



Several isocentres that need to be aligned:

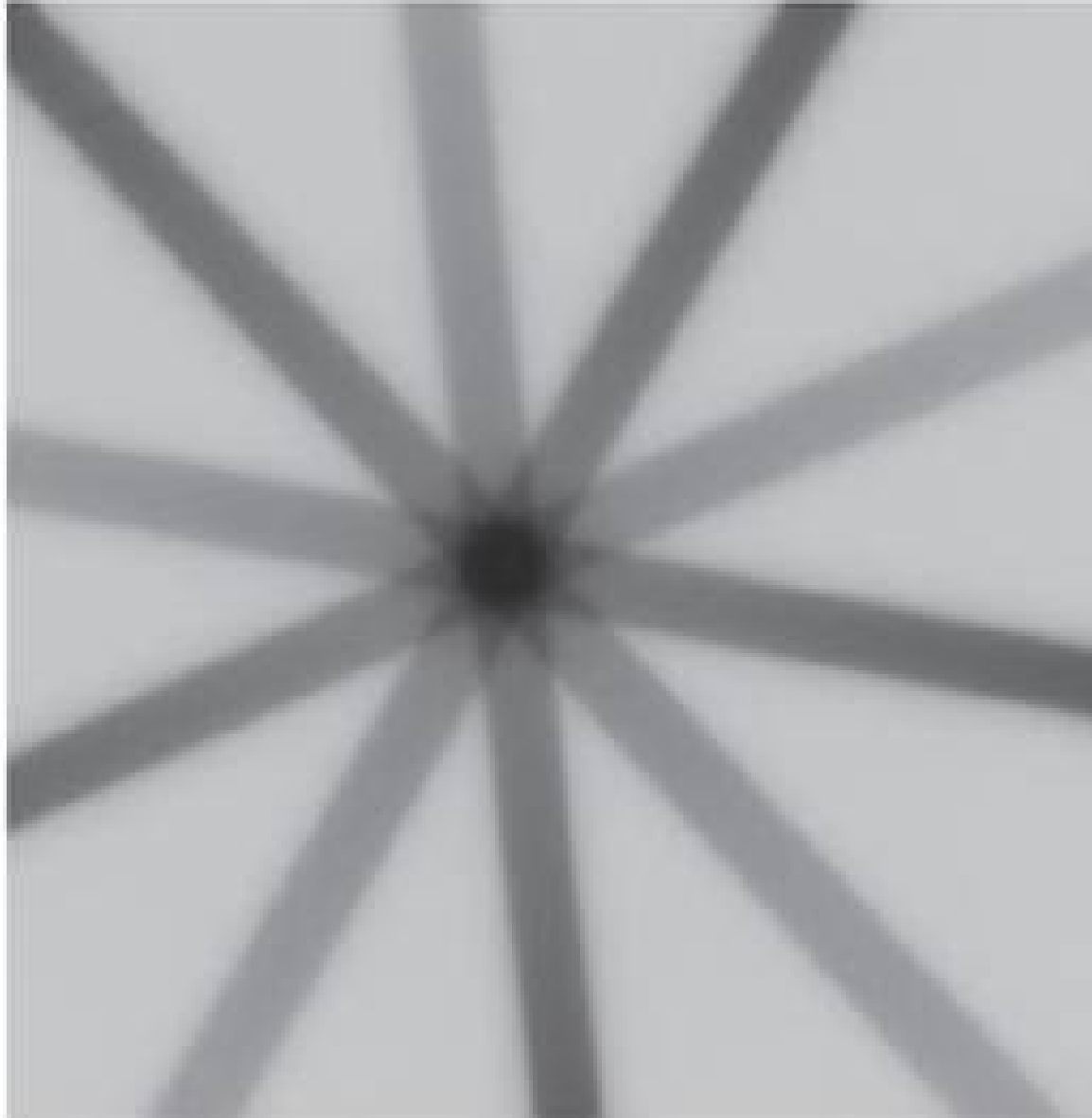
- Mechanical
 - ✦ Gantry
 - ✦ Couch
 - ✦ Collimator
- Radiation
 - ✦ Gantry (energy specific)
 - ✦ Collimator (energy specific)
- kV isocentre (CBCT and planar imaging)
- 3rd party imaging e.g. ExacTrac, AlignRT

Isocentre



- Ideally: a point in space
- Reality: sphere or ellipsoid
- Which isocentre are the lasers aligned to?
- Optimise to energy used for SRS
- Test multiple isocentres at once (examples to follow)

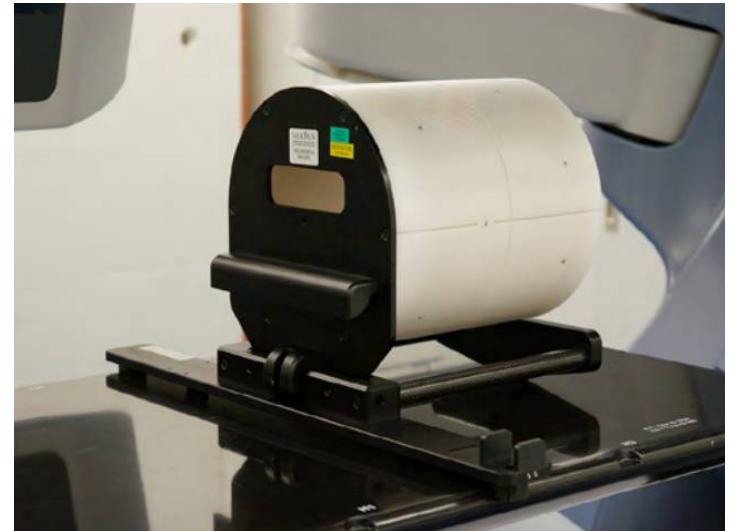
Radiation vs. Mechanical Gantry

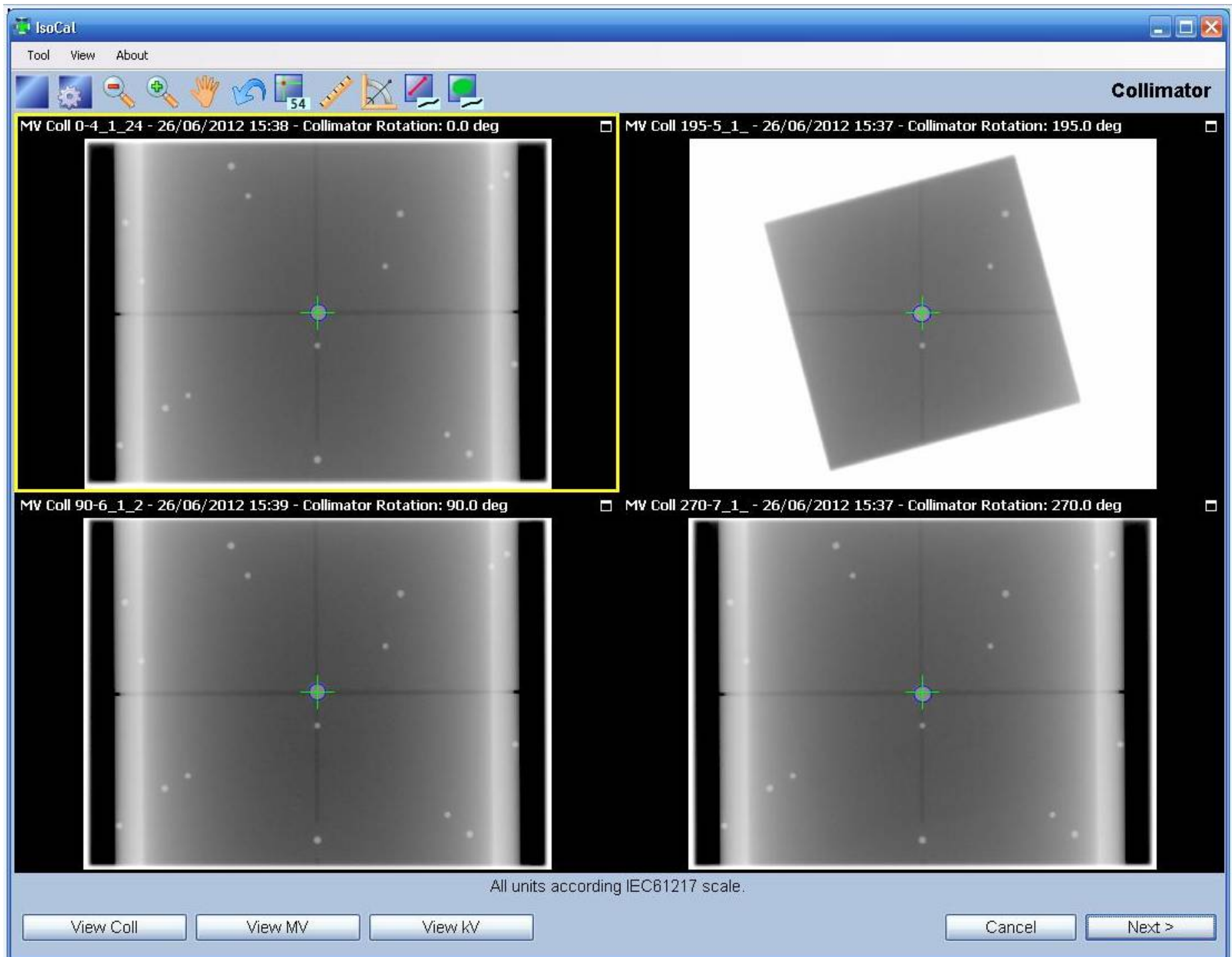


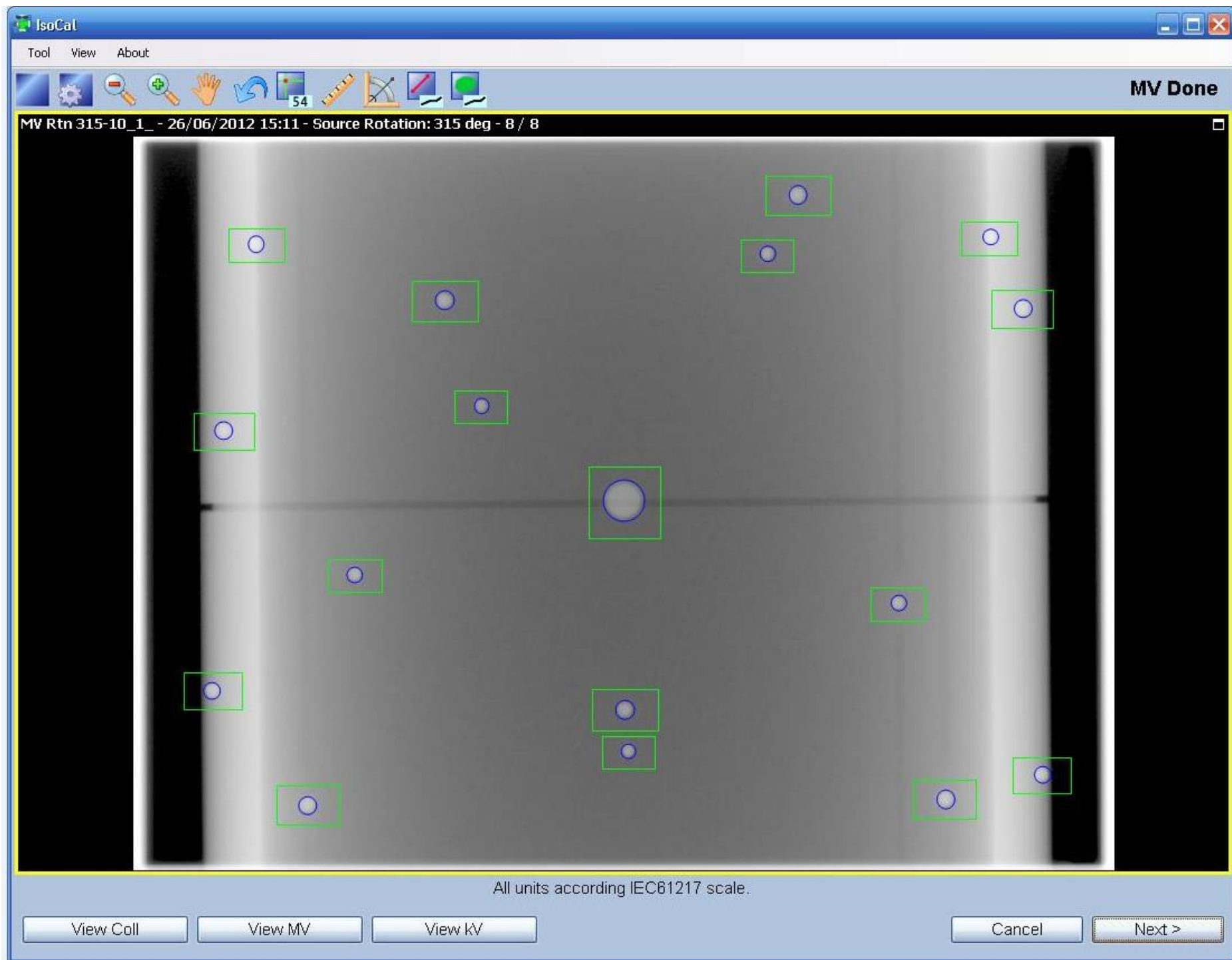
MV vs. kV – Varian Isocal



- Radiographically determines:
 - MV treatment isocentre vs. phantom (lasers)
 - MV treatment isocentre vs. MV and kV imaging panels
- Corrects MV-kV misalignment
- Tolerance for re-calibration ± 0.3 mm (TrueBeam / Edge)

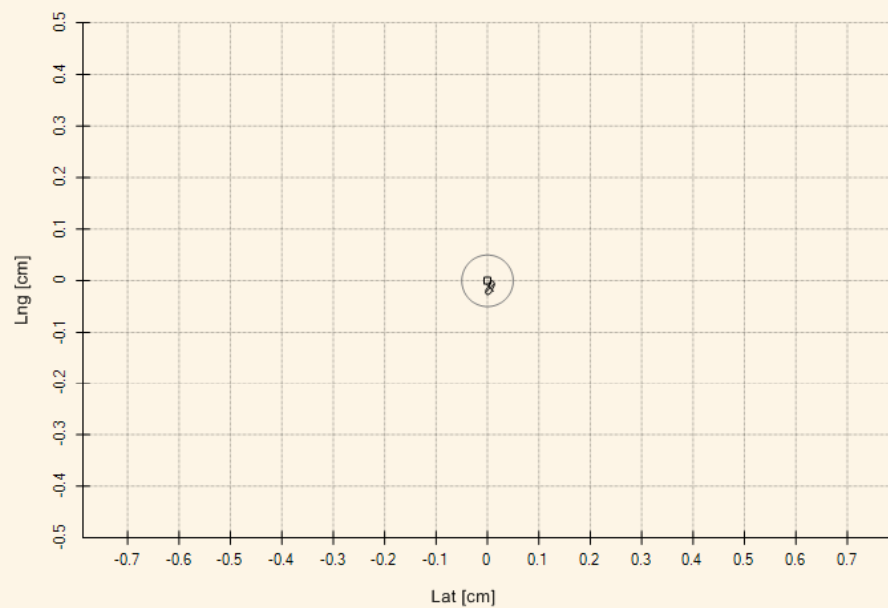




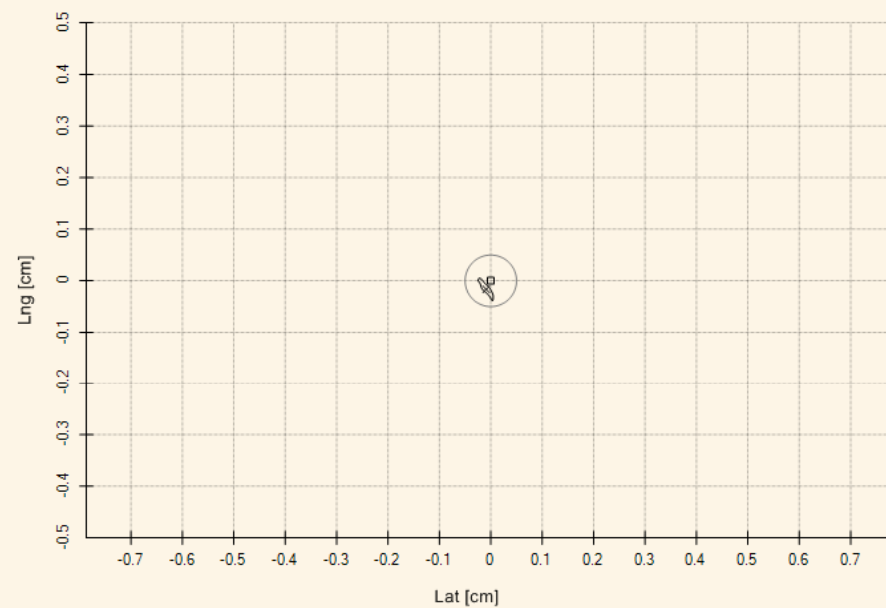


Verification of Isocenter Calibration is ok.

MV Imager Shifts



kV Imager Shifts



Max Deviation from Central Beam [cm] 0.032

In-plane Imager Rotation MV [°] -0.058

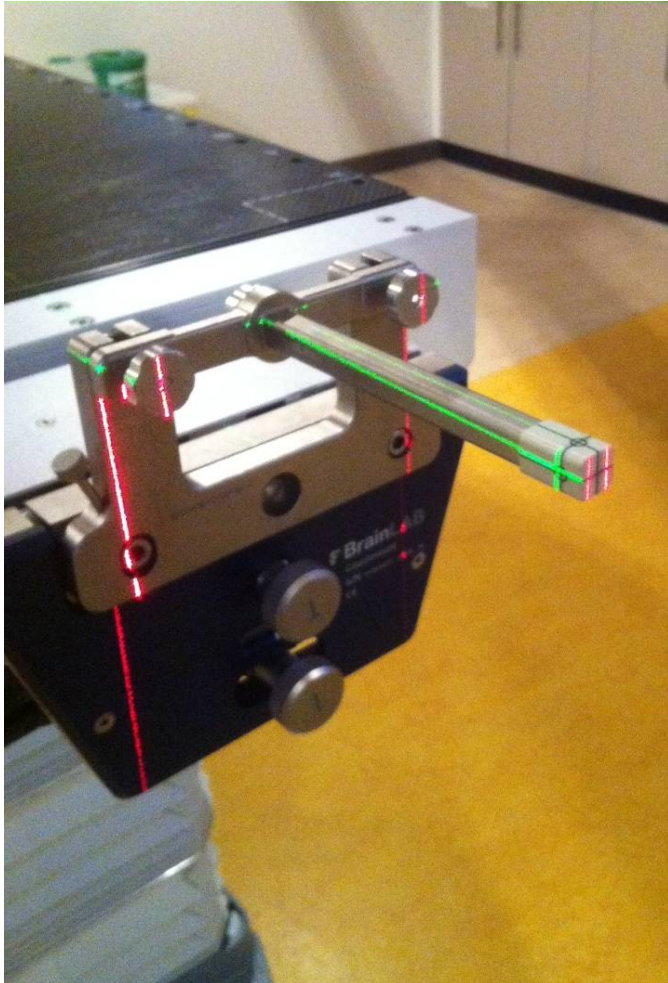
Max Imager Shift MV [cm] 0.027

	Lat	Lng	Vrt
Phantom Position [cm]	+0.056	+0.016	-0.099

In-plane Imager Rotation kV [°] +0.038

Max Imager Shift kV [cm] 0.039

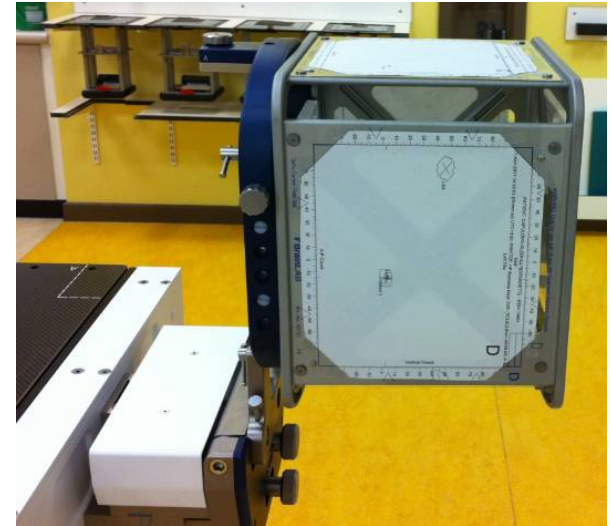
Winston-Lutz Test



- Acquire MV / kV images of ball bearing at various collimator, gantry and couch angles (MLC or cones)
- Check distance: centre of ball bearing to centre of field
- ≤ 0.5 mm achievable on stereotactic linacs
- Determine necessary frequency in own centre. For relocatable collimators: every SRS treatment day

Patient Set-up Uncertainties

- Determine residual uncertainty for **immobilisation** with a **specific IGRT strategy**
- Frameless stereotaxis inherently image-guided
- Ideally verify after shifts – residual error?
- Tolerance for applying shifts?



End-to-End Localization Accuracy



- The whole treatment chain, from imaging to treatment, should be tested in an end-to-end manner
- At acceptance, commissioning and periodically as part of the SRS QA programme
- Ideally a hidden target test with an anthropomorphic phantom – phantom should follow the entire patient pathway

End-to-End Localization Accuracy



Don't assume the manufacturer has tested this!

FIELD SAFETY NOTICE / PRODUCT NOTIFICATION

Subject: iPlan RT Radiation Treatment Planning Software: Potentially incorrect patient positioning when using multiple localized CT image data sets.

Product Reference: iPlan RT / iPlan RT Dose (all versions)

Date of Notification: November 19, 2014

Individual Notifying: Markus Hofmann, MDR & Vigilance Manager

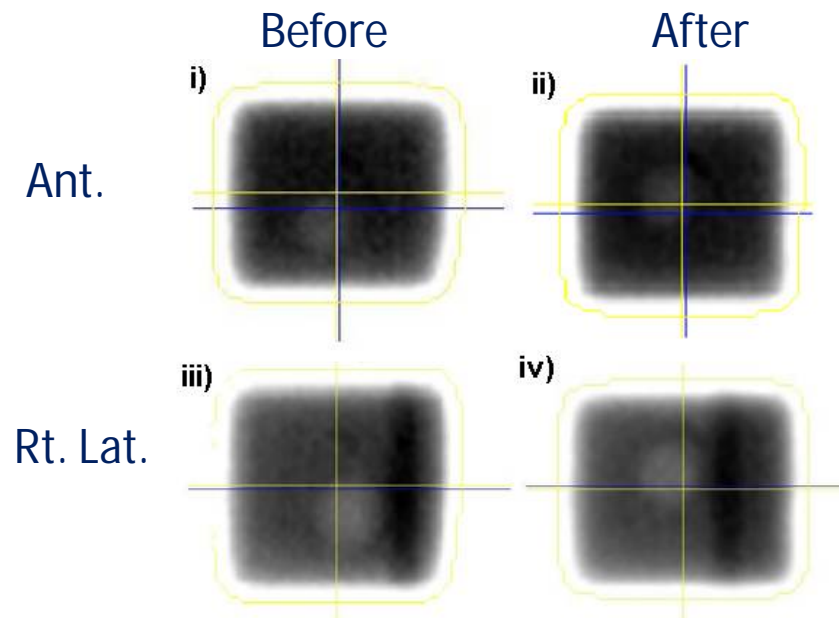
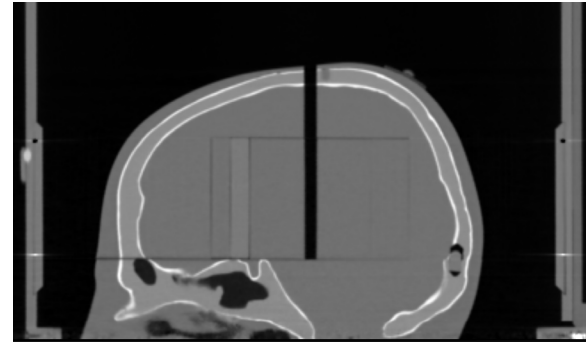
Brainlab Identifier: **CAPA-20141112-001173**

Type of action: Advice regarding use of device; Device modification.

We are writing to advise you of potentially incorrect patient positioning at the linear accelerator (linac) when using iPlan RT treatment plans containing multiple localized CT scans under specific circumstances.

Each centre must verify for themselves

End-to-End Localization Accuracy



Summary



- There are many sources of geometric uncertainty in SRS
- Important to characterise the uncertainties, and minimise where possible
- Be aware of sources of error that aren't detectable / correctable
- End-to-end testing is essential

Any Questions?

