ST. VINCENT'S PRIVATE HOSPITAL
Elm Park

JCI Accredited

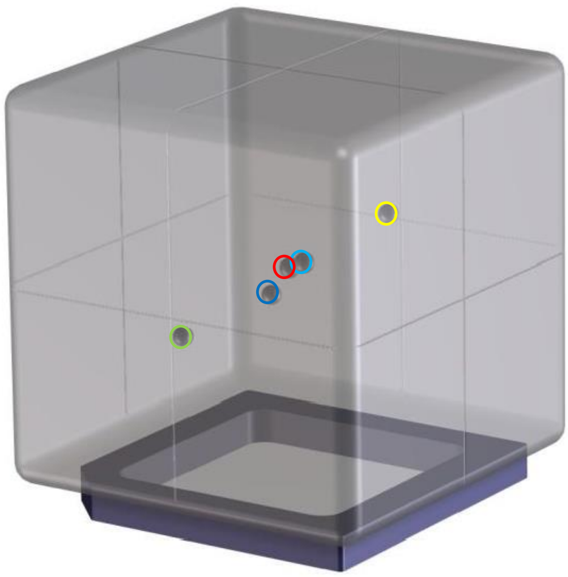
Assessing the Isocentre Agreement on an Elekta Versa HD equipped with AlignRT (VisionRT)

Background: Quality assurance (QA) on Linacs can be comprehensive and time-consuming. The coincidence of the treatment isocentre and imaging isocentres is important for accurate positioning and treatment in radiotherapy. Various reports have published guidelines recommending tolerance values for the agreement between the radiation isocentre and imaging isocentres.

AAPM TG-142 [1] (Linac QA with SRS Guidelines)	≤ 1 mm for SRS/SBRT ≤ 2 mm for Standard Treatments
AAPM TG-147 [2] (Non-Radiographic Positioning Systems)	≤ 2 mm / 1 mm of Isocentre
IPEM Report 81 [3] (Linac QA – Isocentre Coincidence)	≤ 1 mm
CPQR Guidelines [4] (Linac CBCT QA – Isocentre Coincidence)	≤ 1 mm

Surface Guided Radiation Therapy (SGRT) is routinely used at St. Vincent's Private Hospital (SVPH), using AlignRT for treatment techniques such as SBRT and DIBH. To have confidence in the system and ensure the system will accurately position and monitor the patient during treatment, AlignRT must be coincident with the MV isocentre, CBCT isocentre, and kV isocentre. The purpose of this document is to outline a procedure to assess the agreement between the different isocentres, while simultaneously being able to re-calibrate the AlignRT isocentre if required.

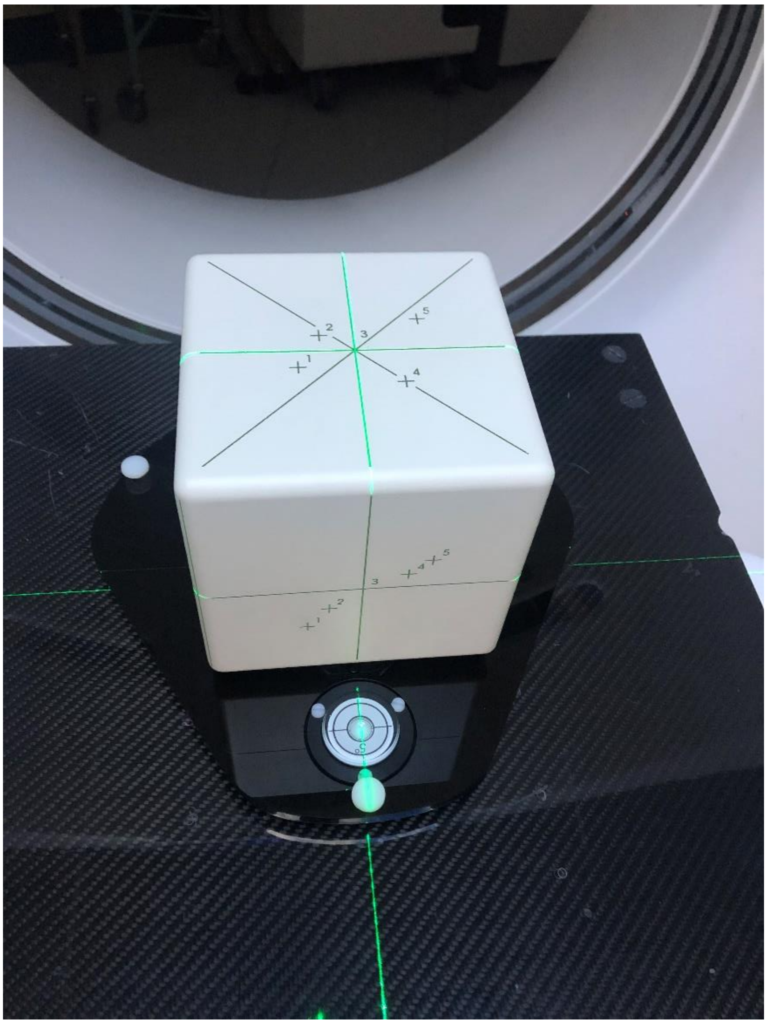
Phantom Description: The phantom used for this process is the MV Calibration Cube Phantom provided by VisionRT. The phantom has a total of five internal spheres, with four spheres located asymmetrically around a central sphere. The five spheres facilitate radiographic analysis while AlignRT can monitor the phantom surface.



Setup of QA Test: A CT scan of the MV calibration cube is required to prepare the treatment beams in the Treatment Planning System – in SVPH the planning system is the Elekta Monaco

1. Align the MV calibration cube to the external CT lasers, ensuring that all rotations are removed as much as possible.
2. Acquire a CT scan with a 1.25 mm slice width (SRS protocol).
3. Contour the 'External' surface of the phantom in the treatment planning system.
4. Place the treatment isocentre at the centre of the phantom (at the centre of sphere 3).
5. Create four 10x10 cm MV images at cardinal gantry angles, four kV setup fields, and a CBCT setup field.
6. Create a Winston-Lutz plan using a field size of 2x2 cm at a minimum of 4 gantry angles. The Winston-Lutz images can be assessed using commercial software or in-house software packages.

Using Mosaiq Record and Verify System, create the phantom patient for imaging and assign reference images.



Equipment / Software:

Elekta Versa HD Linac

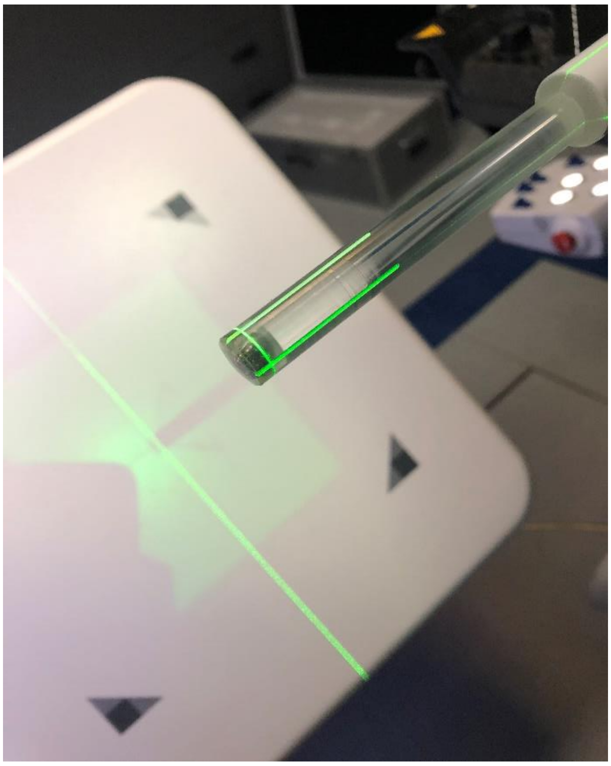
- XVI (X-Ray Volumetric Imager)
- iViewGT and EPID
- Precise Couch / Hexapod 6D Couch
- Ballbearing Phantom

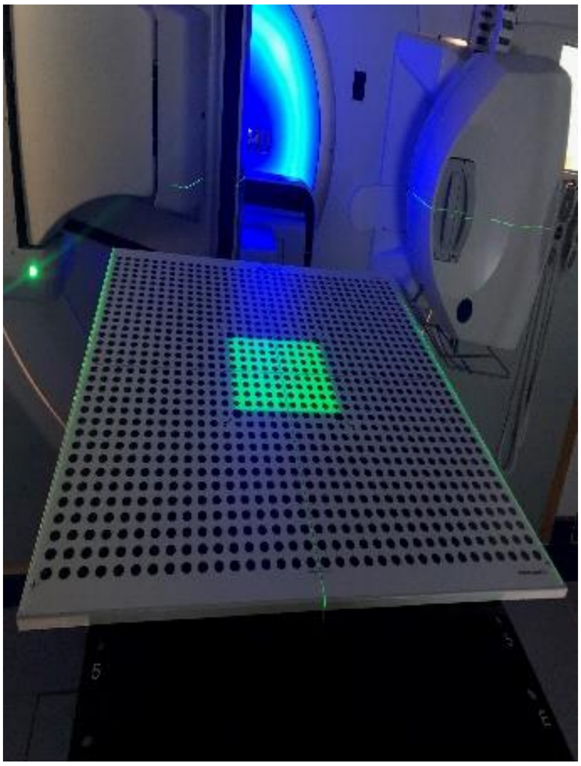
VisionRT

- AlignRT (Version 5)
- MV Isocentre Calibration Cube

Software for analysis of Winston-Lutz test Images

Method: Prior to using the below process, it is recommended to have a baseline performance of your Linac and AlignRT system in the form of Winston-Lutz test analysis, MV-kV isocentre congruence and a valid AlignRT monthly calibration.

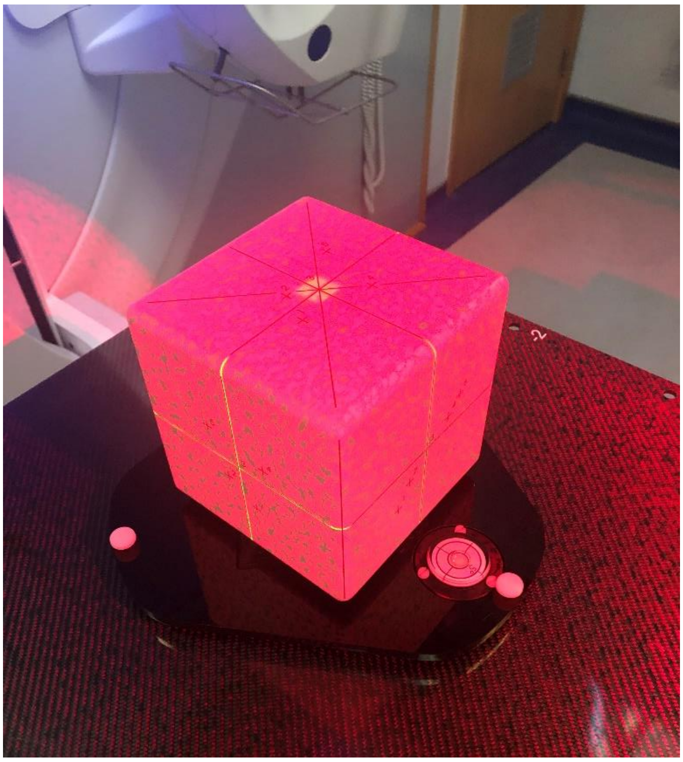




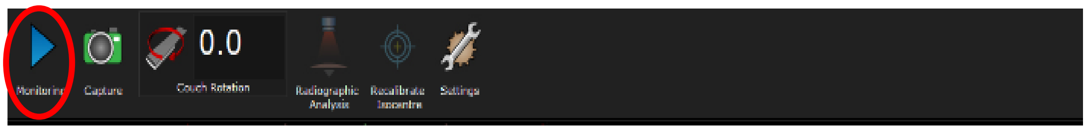
Phantom Setup: The method uses the MV Isocentre Calibration workflow within the AlignRT software to position the phantom. The position of the phantom, as determined by AlignRT's calibration workflow, will be the basis for the isocentre coincidence test and all isocentre positions will be relative to this position in couch coordinates. AlignRT can also be re-calibrated if required during the same QA session based on departmental tolerances.

1. Log in to the AlignRT application as a Physics user.
2. On the main menu, select **System Maintenance > MV Isocentre Calibration**

3. Set the gantry, collimator and couch rotation to 0 degrees. Retract the kV imaging arm and imaging panels.
4. Place the phantom onto the levelling plate with the arrow pointing towards the gantry and level out the rotations. A second level can be used to aid the initial setup. Align the phantom to the room lasers.

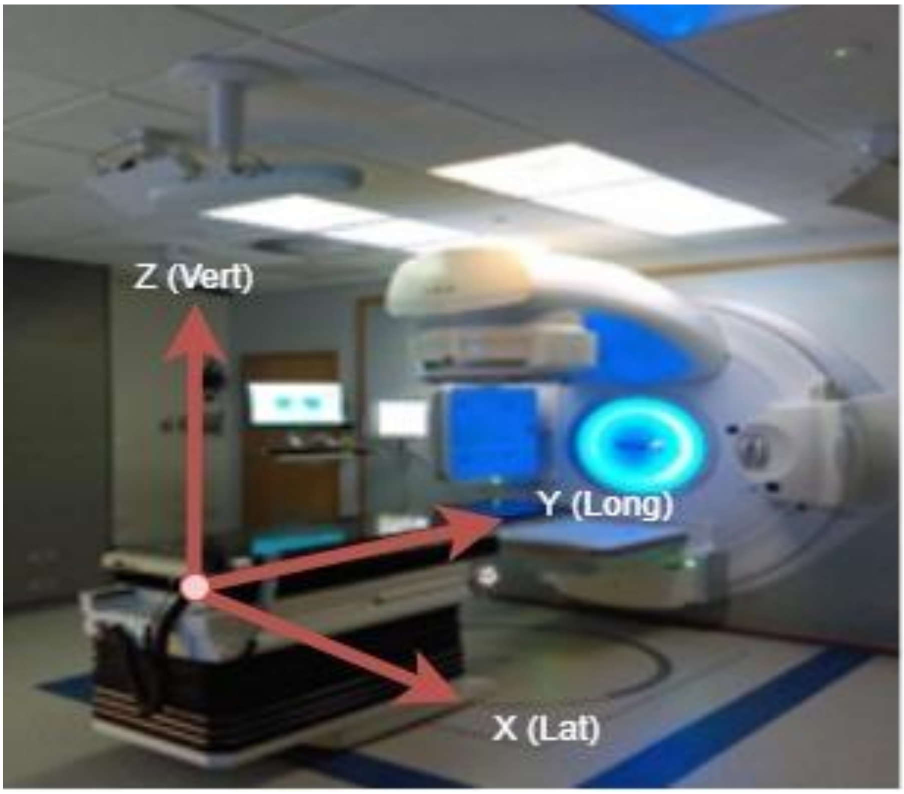


5. Start monitoring the phantom position against the ideal phantom position within AlignRT. Ensure the room lighting is similar to the lighting conditions used during calibration \ treatment.



6. Adjust the phantom position so all delta values are 0 (± 0.1 mm \ 0.1º).
7. Pause monitoring to 'save' the delta values of the current phantom position.

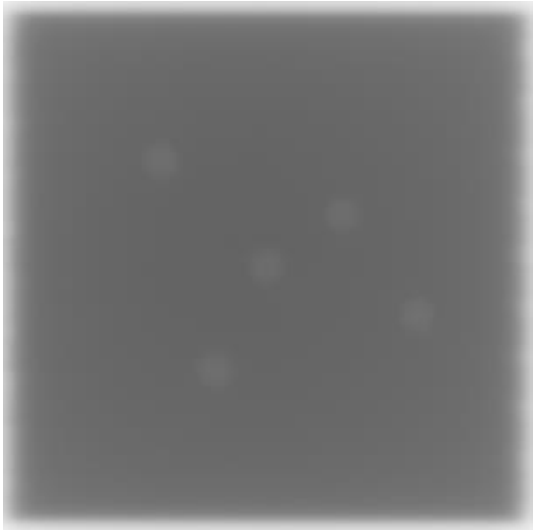
Assessing Isocentre Coincidence: All values were recorded in couch coordinates with respect to the phantom position determined by AlignRT.



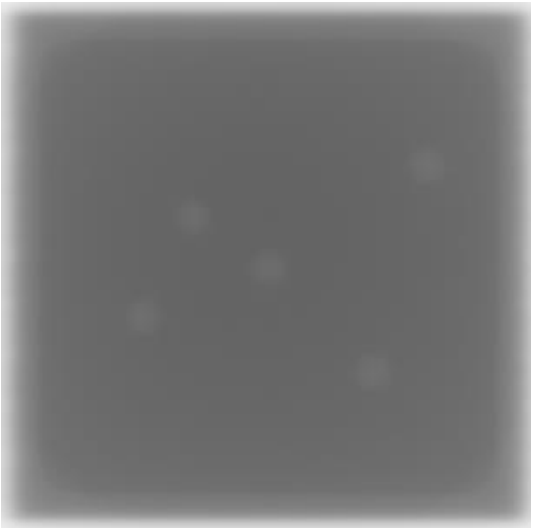
1. Using the iView imaging panel, acquire four 10x10 cm MV images at the four cardinal gantry angles. Acquiring the MV images using alternative collimator angles can minimise the effect of any MLC offset in calibration when using 'Field Centre' during AlignRT calibration. Images were acquired using the following geometry:
    a. Gantry 180, Collimator 180
    b. Gantry 90, Collimator 180
    c. Gantry 0, Collimator 0
    d. Gantry 270, Collimator 0
2. Acquire four planar kV images with the source at each cardinal angle. Images were acquired with F0 Filter and S10 collimator using XVI software.
3. Using the 2x2 cm 'Winston-Lutz Fields', acquire images of the central sphere in the phantom at each cardinal angle with a minimum of two opposing collimator angles to account for any offset in MLC calibrations. Images were acquired using the 'Single Image Acquisition' method in iView GT for the following acquisitions: Gantry 180, Gantry 90, Gantry 0 and Gantry 270.
4. Export all images to the required folder in your department for analysis.

MV Isocentre: The MV images will be analysed to determine the MV isocentre position relative to AlignRT using the MV isocentre calibration workflow. The four MV images acquired are the following:

Gantry 180, Collimator 180



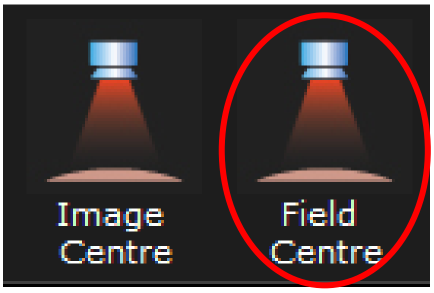
Gantry 90, Collimator 180



Gantry 0, Collimator 0

Gantry 270, Collimator 0

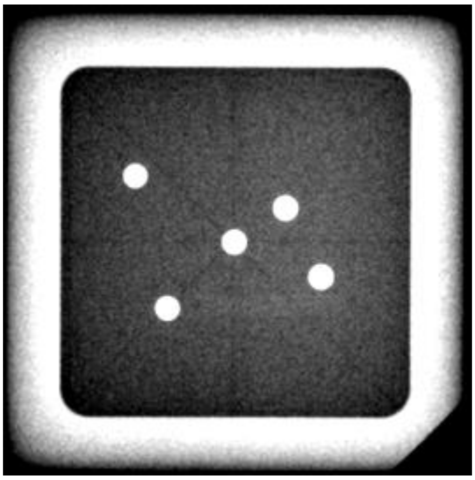
1. Place the MV images into the **VRTQAPhantom** folder for analysis.
2. Select **Radiographic Analysis > Field Centre**. 'Field Centre' is used as the centre of the imaging panel is not established to the required accuracy.

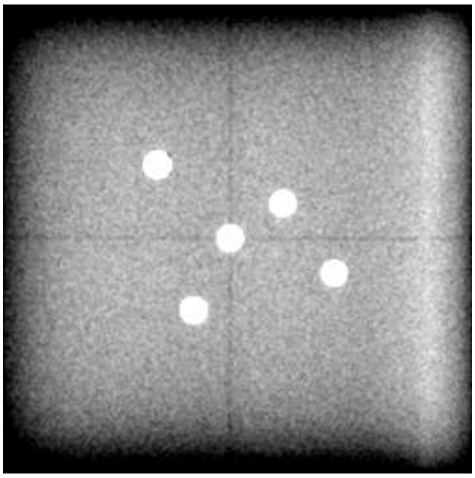


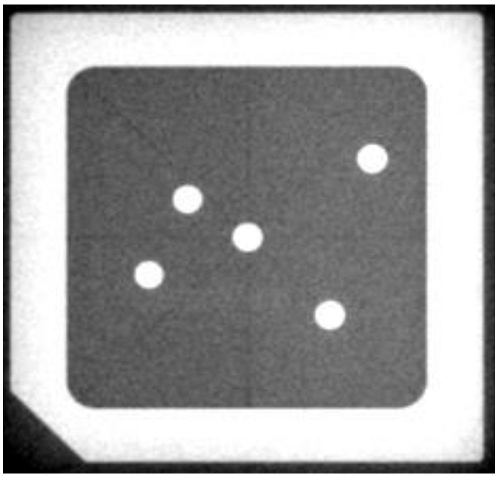
3. The results of the radiographic analysis will be displayed. If the difference between AlignRT and the MV isocentre exceeds the departmental tolerance, the AlignRT system can be recalibrated at this time.
   a. Select **Recalibrate Isocentre** to apply the calculated corrections.

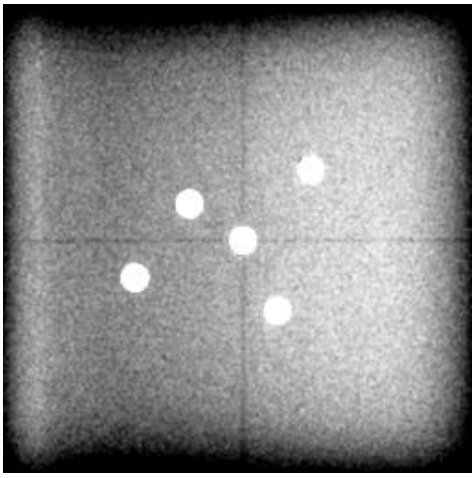
4. Record the values for the position of the MV isocentre relative to the AlignRT isocentre.

kV Isocentre: The kV images will be analysed to determine the centre of the phantom (Central Sphere) relative to the flex corrected image centre. This will provide 2D registration accuracy for the kV system using the phantom position aligned to the isocentre using AlignRT. The four kV images acquired are the following:

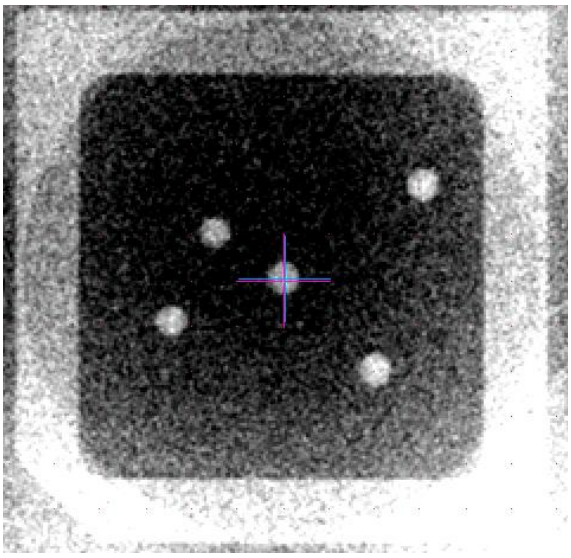

Source Position 180 Degrees


Gantry 90, Collimator 180


Source Position 0 Degrees

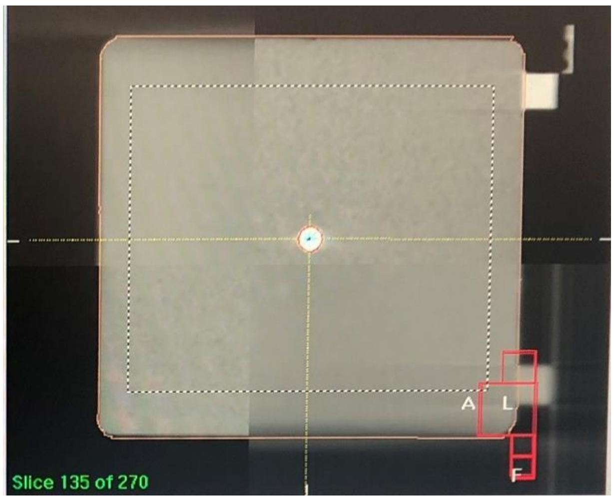

Source Position 270 Degrees

1. Using the XVI software, highlight the image to analyse.
2. Select **Tools > Show Centre** and record the coordinates for the flex corrected image centre.
3. Select **Tools > Service > Display Pixel Factor Information**. Manually select the centre of the phantom and record the coordinates.
4. The difference in the phantom position and flex corrected image centre is the position of the kV isocentre relative to the AlignRT isocentre (4 Pixels = 1mm).



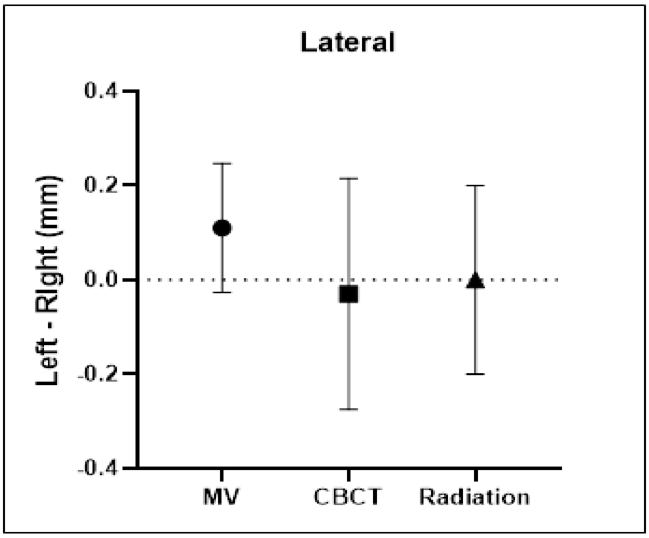
2D kV Analysis: The purple cross indicates the image centre while the blue cross represents the user defined phantom centre.

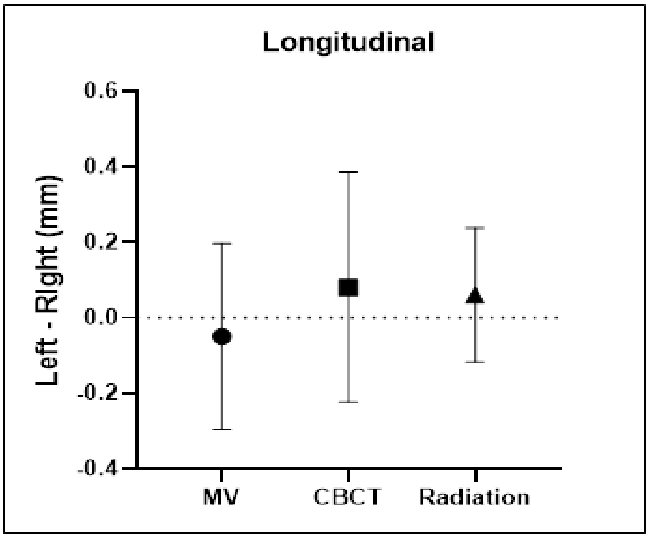
Comparison to CBCT Position: Acquire a cone beam CT (CBCT) of the phantom and register it with the reference image, acquired with 1.25 mm CT slice width (GE Discovery CT Scanner). The CBCT scan was acquired with F0 filter and S10 collimator.
Perform an automatic or manual match in the XVI software. If automatic registration is performed ensure there are no gross errors remaining. An example of an acquired CBCT is below.

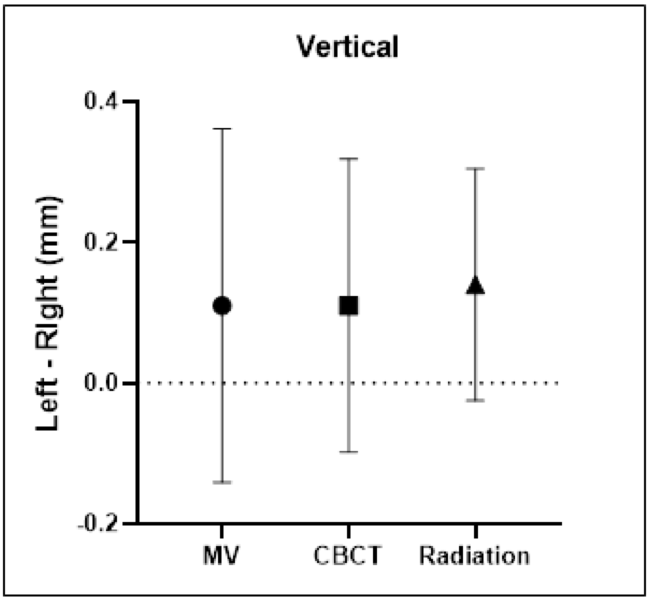


Radiation Isocentre Position: The coincidence of the radiation and mechanical isocentres can also be determined. Commercial software or free-to-use software can be used to analyse the images. The radiation isocentre can be defined as the centre of the MLC defined field. The deviation from the centre of the MLC defined field and centre of the ceramic sphere, positioned using AlignRT, can be determined as the gantry rotates and the average radiation isocentre position relative to the AlignRT isocentre can be established.

QC Conclusion:







The QC was performed over a number of weeks on two different Versa HD Linacs. A new AlignRT monthly plate calibration was performed at the beginning of each new month and the same MV calibration cube was used throughout. The three graphs above highlight the agreement between the MV, CBCT and average radiation isocentre position relative to the AlignRT isocentre when using the MV cube positioned to the AlignRT isocentre. The kV isocentre relative to the AlignRT isocentre was assessed by 2D registration accuracy of the central sphere in the MV cube phantom positioned using AlignRT. The average difference of all kV images between the centre of the sphere (AlignRT Isocentre) and the image centre (kV isocentre) was 1.5 pixels (horizontal) and 1 pixel (vertical) with a maximum difference of 2 pixels.

The AlignRT isocentre required recalibration on one occasion based on an MV isocentre tolerance of 0.5 mm. The high level of agreement is attributed to the plate calibration being performed each month. This process could identify a drift in the AlignRT isocentre and could be corrected by performing an MV isocentre calibration.

Rotations were not a primary focus during this work. Although it was noted that the maximum rotational differences between the AlignRT surface alignment and CBCT were 0.4^{o}, 0.3^{o} and 0.4^{o} for roll, pitch and yaw respectively.

The single MV cube set-up used throughout the QC process is more efficient than alternative multi-phantom methods, and reduces associated set-up errors.

Appendix A: Workflow Diagram