isoPath

Instruction

Isocentre and isocentre path measurement method following Schiefer et al. (2015)*

*H. Schiefer, N. Ingulfsen, J. Kluckert, S. Peters, and L. Plasswilm, “Measurements of Isocentre Path Characteristics of the Gantry Rotation Axis with a Smartphone Application," Medical Physics 42, 1184 – 1192 (2015)

View online: http://dx.doi.org/10.1118/1.4906248
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Download isoPath

This instruction is covering the current version of isoPath which is specified below:	
isoPath Version 1.9	2019/03/03

Disclaimer:
IsoPath is provided to check the laser positions relative to the mechanical gantry isocentre. It is strongly recommended to apply an independent measurement method when the lasers have to be re-adjusted.
By using isoPath, the user agrees to carry the full responsibility for all damages and harms of any kind which could emerge by the installation and use of isoPath or could be correlated to it. The user accepts that the isoPath providers have no responsibility for all damages and harms of any kind which could emerge by the installation and use of isoPath or could be correlated to it.

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1. Purpose of the isoPath application

In radiotherapy, linear accelerators are used to treat patients first of all suffering from cancer. The mechanical isocentre (intersection of the gantry and collimator rotation axes of the linear accelerator) is an important reference point, defining the origin of the machine coordinate system. The room lasers which are used to position the patient, should intersect in the isocentre. The rotation axis should additionally be stable in space when the gantry is rotated. These requirements are especially high when high conformal irradiation techniques are applied to the patient.

IsoPath is a scientific measurement tool suitable to measure the mechanical isocentre position and the isocentre path relative to the room lasers. The measurement accuracy of the isocentre coordinates is in the range of 0.002 to 0.003 mm, the isocentre path points are measured with an accuracy of about 0.02 mm. The integral measurement time is about five minutes, when the gantry rotation axis is tested.

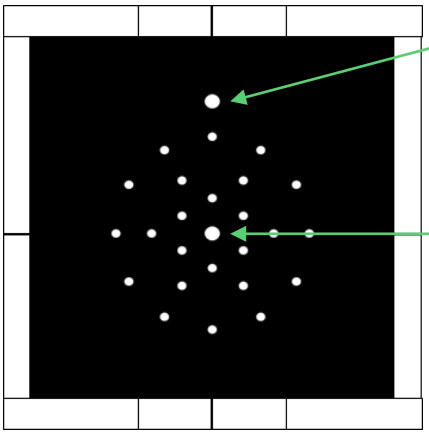
The coincidence of the irradiation (or imaging) isocentre with the mechanical isocentre has to be performed with other measurement methods.

2. Material

Marker platelet

The marker detection algorithm in the app is adapted to the marker distribution shown in figure 1. You MUST therefore use a printout of the marker platelet which you can find on the last page of this instruction.
Print out the marker platelet in a suitable scale. The isoPath default value for the distance from the centre marker (Z) to the orientation marker (O) is 19.5 mm. (This value is adapted to the imaging properties of the iPhone camera; a deviation smaller than 5 mm should be acceptable.) You can input your own measured Z-O distance in your printout in the “Settings” menu of isoPath. The Z-O distance is used to calculate the scaling factor from pixels to millimeters.

Figure 1: Marker platelet
The connections of the central lines in the image frame intersect in the centre marker, Z. They are used to position the platelet with respect to the laser cross.



Orientation Marker (O)
It is used to find and identify the measurement markers (smaller circles).

Centre Marker (Z)
It defines the position of the laser cross and is used to find and identify the measurement markers.

Fixation of the marker platelet at the front pointer

Construct a front pointer fixation with a ferromagnetic ground plate, as shown in figure 2. Put a magnetic rubber sheet on the back side of the marker platelet.

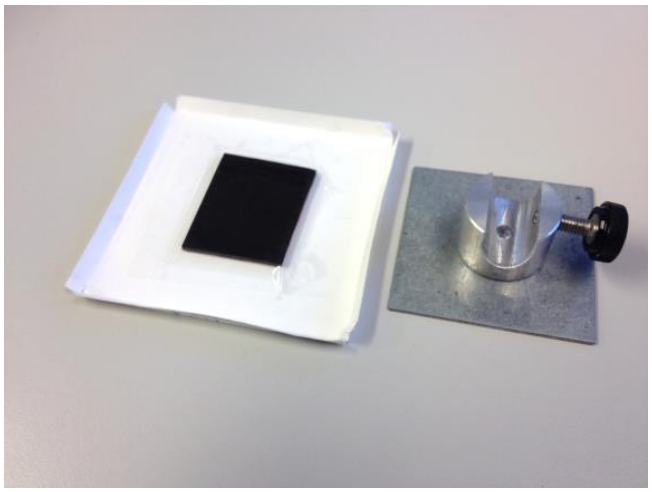
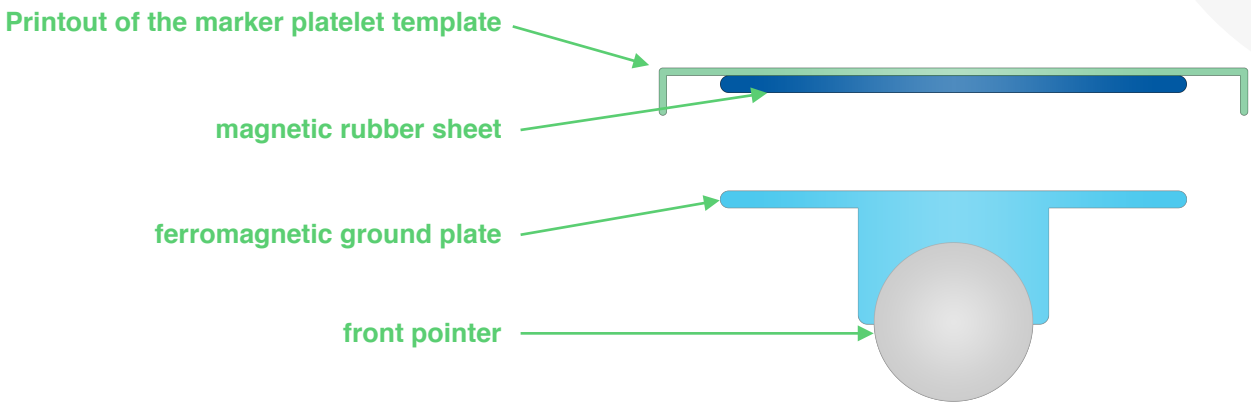


Figure 2:
Left: A magnetic rubber sheet glued to the printout of the marker platelet allows positioning the marker platelet exactly with respect to the lasers. The frame is bended in order to bring the laser indicators in congruence with the lateral lasers.



Fixation of the smartphone on the treatment table

The position of the smartphone has to be fixedly in space. (This means that the image matrix has to be fixed to the room coordinate system.) This can be achieved when the smartphone is fixed to the treatment table and the camera settings, first of all the zoom, are constant during measurement.
You have to construct a suitable fixation by yourself. We recommend constructing a fixation which can be attached to the table with an indexing bar. This allows to auto-setup the table before measurement. Since isoPath recalls the same camera setup as used for the last measurement, you can save setup time.

The smart phone fixation presented in this paper does not fulfill these requirements and is therefore not ideal. Nevertheless, it is shown in figure 2. Try to follow the way described above!

Measurement prerequisites

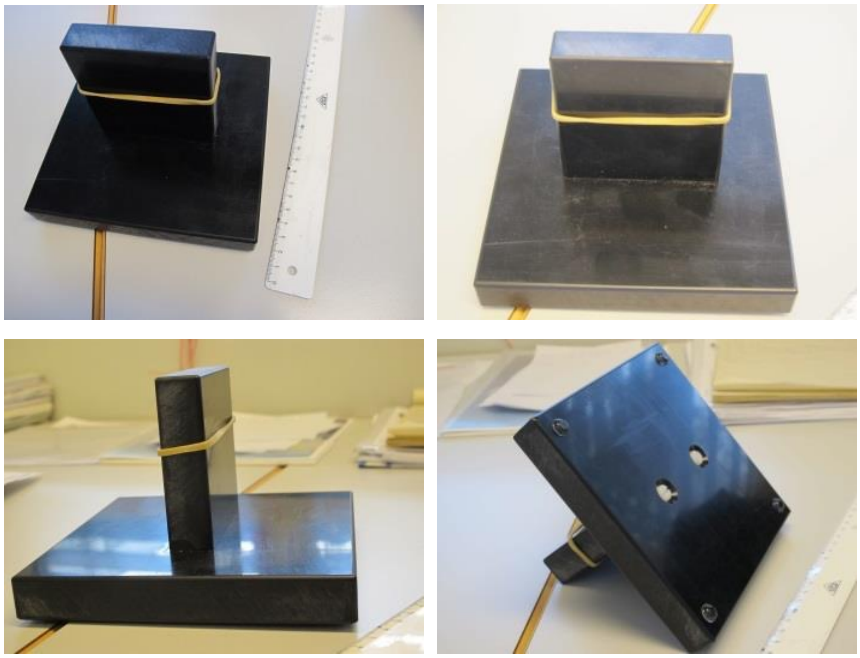


Figure 3:
Smartphone fixation tool used in the image gallery.
Please, try to find a more suitable solution, see above!

Before measurements, check the lasers next to the area of the (expected) isocentre. The following claims have to be fulfilled before measurement:

- the sagittal laser is oriented vertically
- the planes of the (lateral) coronal lasers coincide

3. Setup of the app

When you open the app for the first time, *isoPath* will ask you to set up your profile. Press *„Get Started“* and enter your profile information. This information will help you organize your measurements and can be automatically integrated in an export file. Your information will not be shared with any third party nor with the developers.

After completing your first profile, you'll get to the main menu of isoPath. There you find several menus, which are explained in detail in the following sections.

Profile

In the profile menu, you can edit profiles by tapping on the arrow, choose a profile for the next measurement by tapping on it or add a new profile with the *„Plus“-Symbol*. Profiles are meant to organize your measurements when working with several people and different machines.

Settings

In the settings menu, you can adjust all the settings of the measurement. The parameters are explained below, but you can find a short description of them also in the app by tapping the tiles.

Capt. Delay (sec)

Time interval of the image acquisition in seconds. Try to acquire at minimum 30 images during a full gantry rotation.
Default: 2.0

Image-Size

Sets the width of the captured images in pixels. The height is adjusted automatically.
Default: 480.0

C-O-Distance (mm)

Distance between the centre marker and the orientation marker in mm. (→2. Material/marker platelet)
Default: 19.5

Cam-Distance (cm)

Distance between the camera of your smartphone and the marker platelet in centimeters. A small distance brings in the effect that the isocentre movement parallel to the gantry rotation axis is measured with a higher resolution, while on the downside the geometrical linearity of the

imaging system is slightly reduced, especially at the edge of the image.
Default: 40.0

Delete Images

When „Delete Images“ is set to „YES“, all images of your measurements (except for the first picture of every series) are going to be deleted after the evaluation in order to reduce the amount of data storage needed.

Batch-Mode

You can enable or disable the Batch-Mode at any time. When activated, isoPath will save your files and prepare an e-mail to export the result values automatically after a measurement.

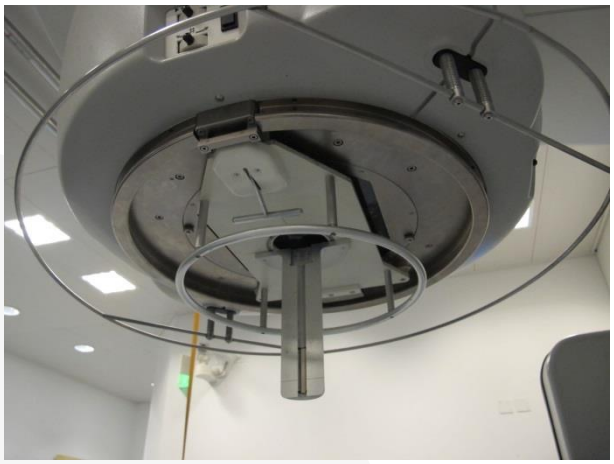
Smaller Capture Delay and larger image-size values need more memory, but a better time and space resolution. Insufficient memory can force an isoPath crash. The measurements in the Medical Physics article were performed with the default values.

Files

In the files menu, you find all your saved measurement files and can review or delete them. Please note that your files are saved on the device only, but can be exported as text files easily.

Review a file by simply tapping on it. You will get to the result screen (→ *5. Evaluation*). Delete a file by tapping on the paper basket icon. It will start to wiggle. Tap again to delete it. Please be aware that there’s no way to restore deleted files.

4. Measurement



Step 1: Fix the front pointer holder to the gantry head.

Step 2: Mount the front pointer.

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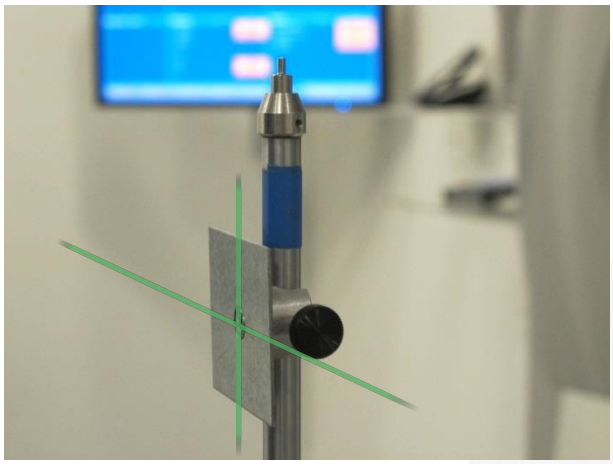
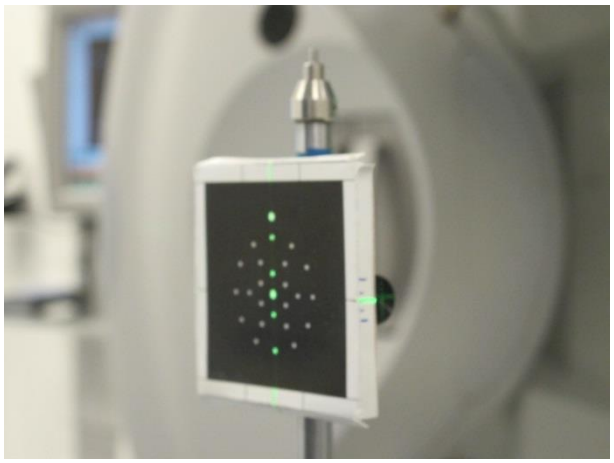
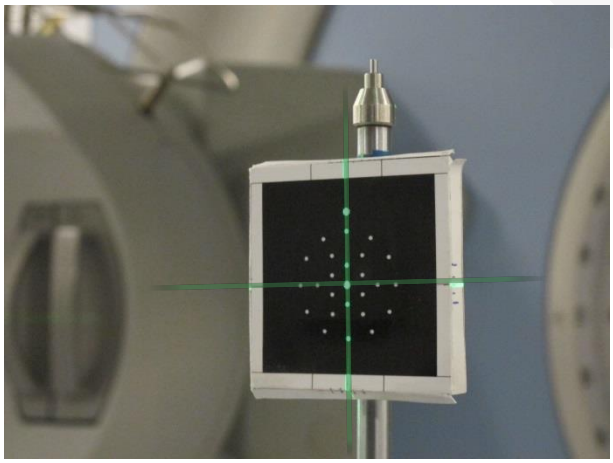
Step 3: Set the gantry to + or - 180°



Step 4: Switch on the lasers. Mount the front pointer fixation on the front pointer with its centre next to the laser cross.



Step 5: Put the marker platelet (with the magnetic rubber sheet, see above) on the ground plate.



Step 6: Align the marker platelet with the lasers. The laser cross is in the centre marker, when the laser intersect with the centre lines in the lateral frame of the marker platelet.

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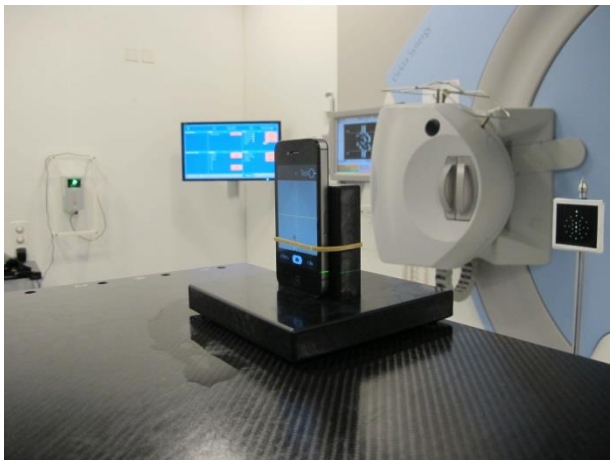
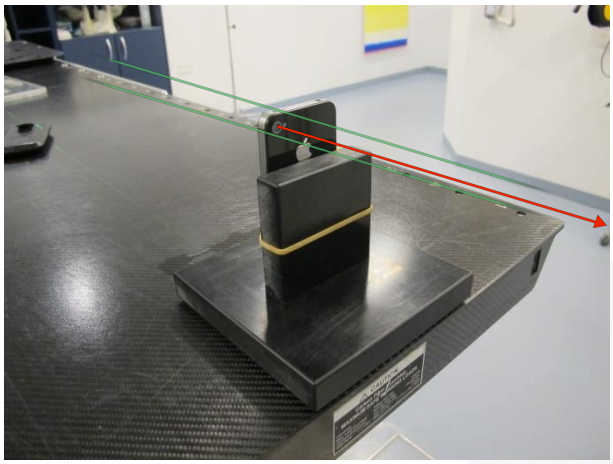
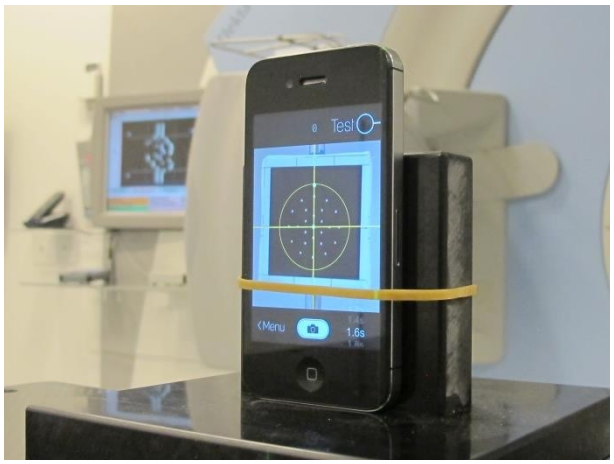


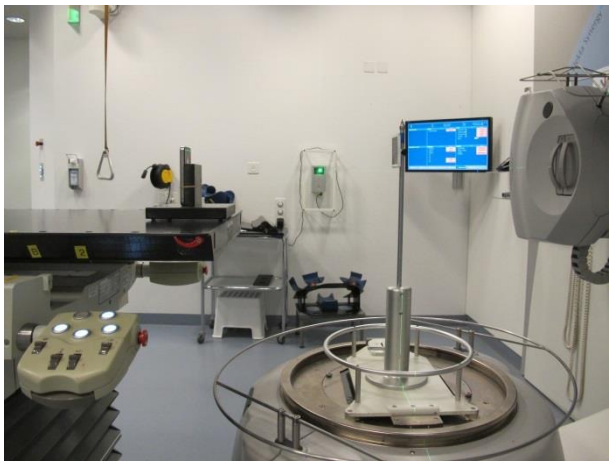
Step 7: Fix the smartphone to the smartphone holder, which is fixed to the treatment table. Table lateral is 0 mm. (We recommend that your holder can be mounted to an indexing bar. The table coordinates are then always identical.) The camera to marker platelet distance is 20 to 40cm.



The optical axis of the smartphone camera is in parallel (within some mm) to the gantry rotation axis. This means that the lasers intersect in the camera lenses in front of the smartphone. The smartphone is in parallel to the marker platelet.

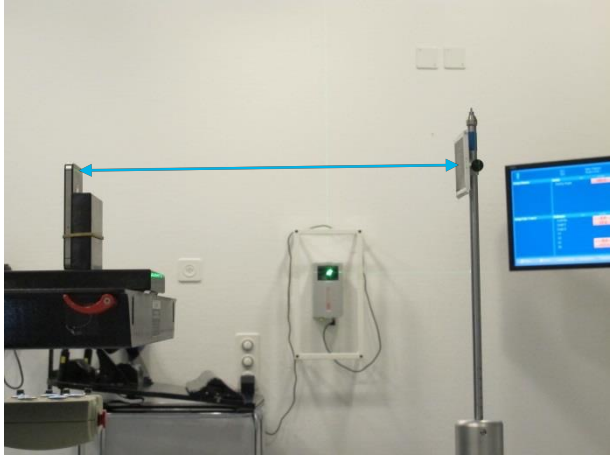


Step 8: Start isoPath and go to „Start Capture“. Align the treatment table position and the camera zoom (it will be saved for the next acquisition). The centre marker has to be in the centre of the yellow crosshairs, and the orientation marker should be on the yellow circle.

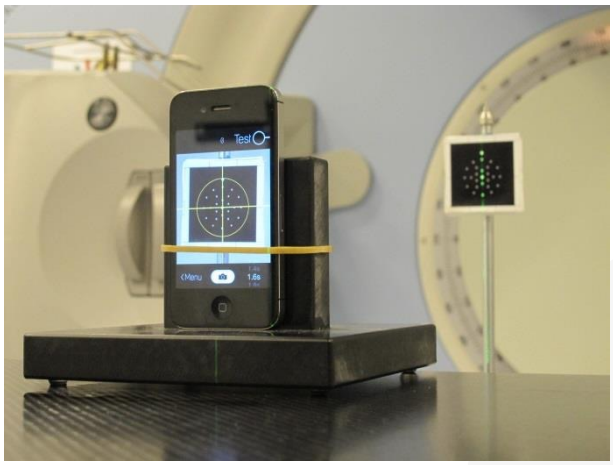


Lateral view when the marker platelet and the smartphone camera are aligned. The optical axis of the camera and the centre marker coincide with the expected gantry rotation axis.

Instruction



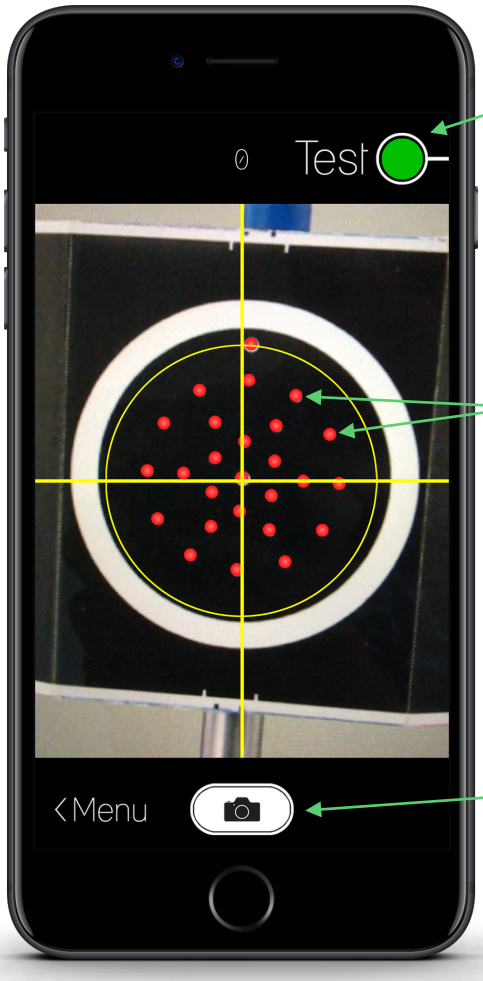
The distance between the camera lenses and the marker platelet should be between 25 and 40 cm.



Step 9: In order to avoid image artifacts, which can impede the automated marker detection, switch of the lasers.

Step 10: Press the Test Button. When all markers have been properly detected, the test button will turn green. Detected markers will be marked with a red dot.

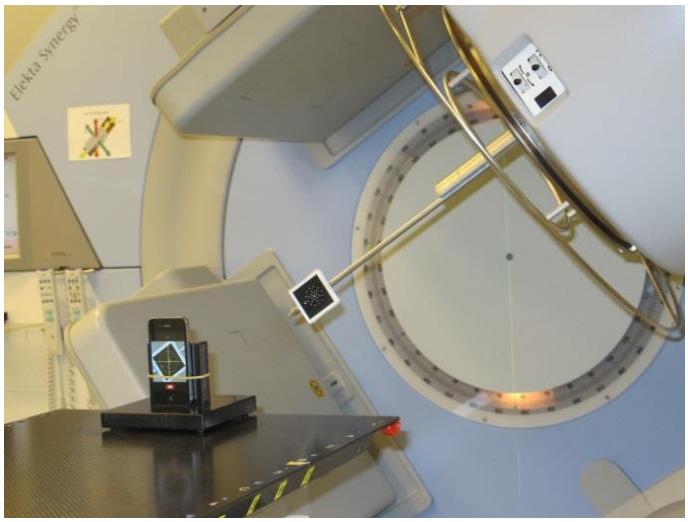
Step 11: In order to start the measurement, press the Photo Button. The image at 180° is acquired. Then start rotating the gantry. The further image acquisition will automatically continue when the gantry starts moving. You don't have to press the photo button again.



Test Button
Press to start the detection test. When all markers are detected, it will turn green, otherwise it will stay red.

Detected Markers
will be marked with red dots.

Photo Button
Press to start the acquisition.



Step 13: Rotate the gantry by 360° ± 2°. After it has stopped moving, isoPath will stop the acquisition automatically. You can also press the photo button again to stop, but you don't have to.

5. Evaluation

Result message

Directly after the stop of the acquisition, isoPath will start computing. If you have an older iPhone, this may take a little while. Once isoPath has finished, it will bring you to the evaluation screen and show you the result in a popup message.

It shows you the position of the isocentre relative to the laser cross as well as the diameters of the path in x- and y-axis. It is strongly recommended to apply an independent measurement method when the lasers have to be re-adjusted.

Press „OK“ to close the message and get to the evaluation screen.

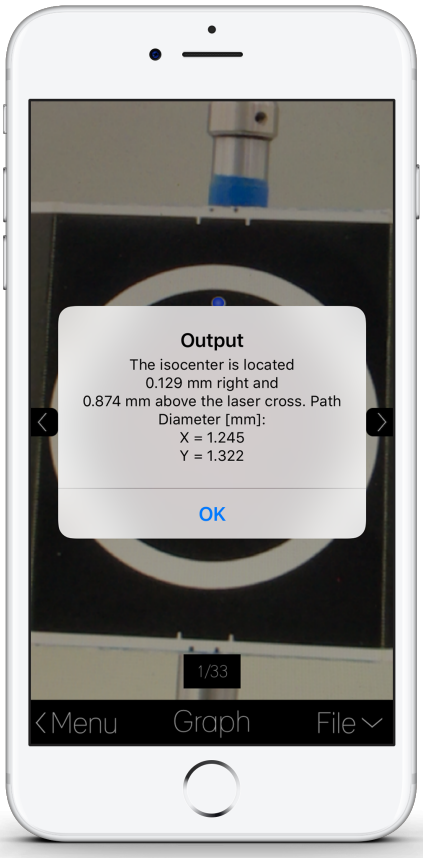


Figure X: an exemplary result message in the evaluation screen.

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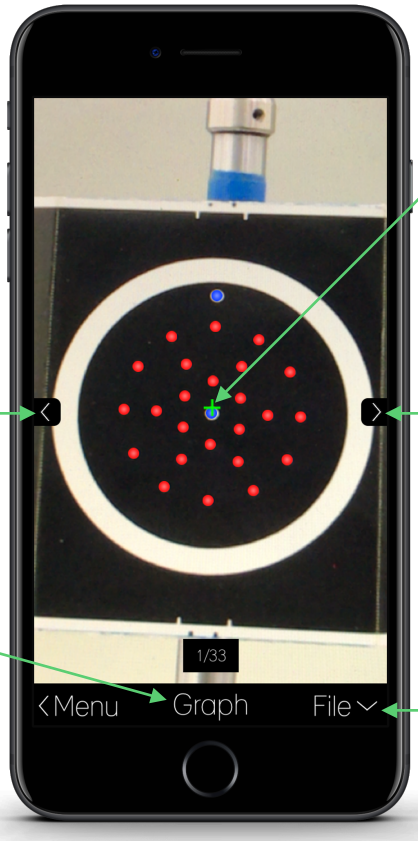
Evaluation screen

The evaluation screen shows you all the images taken for this measurement. In every picture, all the markers are labelled with a red (or in case of the centre marker and the orientation marker blue) dot, while the isocentre is represented by a green cross. If the cross is red and blinking, that means that the distance of the measured isocentre is more than 1 mm away from the intersection of the lasers.
You can go through the image series by tapping the arrows on the side of the image view.

By tapping on the Graph Button you will get to the graph menu, where you can find the movement of the isocentre in parallel to the gantry rotation axis (Gantry angle = 0° corresponds to z = 0mm), and the mean isocentre path points in the x-y-plane.



Isocentre
The green cross marks the isocentre. It will be shown red and blinking at high deviation from the laser intersection.

Left arrow
Tap to get to the previous image.

Right arrow
Tap to get to the next image.

Graph menu
In the graph menu, you can find two representations of the isocentre path.

File menu
Here you can find the Save and E-Mail option.

When you tap on File, three further options will show up: *Save*, *Data* and *PDF*. With *Save*, you can save the measurement with a custom name. Please note, that your measurement will be saved automatically when Batch Mode is activated (→ *3. Setup of the app/Settings*). By tapping on *Data*, isoPath will create a new email, addressed to the e-mail address of your current profile, with a text file with all the measurement data attached. With activated Batch Mode, this email will be created automatically directly after the calculation. Please note that isoPath will never send any emails by itself.

The third option *PDF* will create a PDF-file with the measurement results, including the graphs for Z-Coordinates and Mean Pathpoints. This PDF will be attached to an e-mail for export.

Export file

All parameters in the export file are defined in the following structure:

<Parameter name>
picture,point,x,y
value 1
value 2
…
End<Parameter name>

Most parameter names are self-explaining. The parameter names will not change when isoPath is updated. But the position of the parameters in the text file is not fixed. In a later version it will be possible to select the parameters that should be included in the export file.

MarkerCoordinatesPixel:	Pixel marker coordinates x and y for Z, O, and 12 marker pairs → 26 points per image
abValues	Variables calculated iteratively to find the point with the smallest path (corresponding finally to the isocentre path). 12 marker pairs → 12 ab pairs (In a later version, each ab pair is exported once-only.)
PathCoordinates12Pixel	for each marker pair: isocentre path coordinates in pixel x and y. Number of path points = number of images
PathCoordinates12MM	see above. mm instead of pixels
MeanPathPointsMM	mean of 12 calculated paths, derived from PathCoordinates12MM.
PathDiameterMM	the diameter of the isocentre path in x- and y-axis
StDevOfPathcoordinatesPixel	related to MeanPathPointsMM. For a circle, the following equation is valid: $2^{0.5}$ x StDev(coordinates of all points of the circle) = radius of the circle StDevOfPathcoordinatesPixel is used to calculate the radius which fits to the isocentre path.

Path_Length12Pixel	Length of the isocentre path. It is used to iteratively calculate a and b.
Isocentre12Pixel	Isocentre coordinates in pixel
MeanAndStdevIsocentrePixel	Mean and standard deviation of the isocentre relative to the lasers in pixel. The isocentre is the gravity point of the isocentre path. The path points are equally weighted. Due to the accelerating and decelerating process of the gantry rotation, the images acquired at the beginning and the end are over-weighted.
MeanAndStdevIsocentreRelLasersMM	Mean and standard deviation of the isocentre relative to the lasers in mm. The isocentre is the gravity point of the isocentre path.
MeanIsocentreWeighted	Mean and standard deviation of the isocentre relative to the lasers in pixel. The isocentre is the gravity point of the isocentre path. The path points are weighted according to the gantry angle difference to the following image.
ZCoordinatesToAnglesMM	The z-coordinate of the isocentre. (Gantry angle = 0° corresponds to z = 0 mm)
SineCurveToZCoords	... and sub parameters, which define a fit to the sinus function applied to the pixel sum of all marker pair distances: The sum depends on the camera to marker platelet distance. See appendix in the electronic version of the medical physics article cited in the beginning of this document.

6. Appendix

Coincidence of the optical crosshair intersection with the collimator rotation axis and the lasers

You can also apply isoPath to check the coincidence of the optical crosshair intersection with the collimator rotation axis and the lasers when the gantry angle is 90° or 270°. The smart phone is fixed on the treatment table (rotated by + or – 90°) and oriented in parallel to the AB axis. The marker platelet is fixed on the crosshair platelet. Z is in coincidence with the laser cross or the optical cross hair, depending what you are intended to check. The frame sides are in plane with the central square containing the markers.
The measurement method is no further discussed here. For further information contact johann.schiefer@kssg.ch

Instruction

Print out

Use this sheet as a print out for your marker platelet. Don’t forget to measure the distance between the orientation marker and the centre marker (centre to centre) and adjust the value of C-O-Distance (mm) in the settings accordingly.