

GafChromatic QuiCk Phantom™ with EBT3P/3+P Film and FilmQA Pro™ for Radiation Therapy Dosimetry Applications

I. SCOPE

The protocol applies to GafChromatic™ EBT3P and EBT3+P films exposed in GafChromatic QuiCk Phantom™ with a linear accelerator and analyzed using FilmQA Pro™ software. It provides an efficient method for setting up, exposing and analyzing the film and ultimately generating a dose map for comparison of the measured dose to the treatment plan. This protocol will, in particular, enable a quicker and more accurate process for IMRT plan verification.

II. EQUIPMENT AND MATERIALS

GafChromatic QuiCk Phantom™



Figure 1: GafChromatic QuiCk Phantom™

GafChromatic™ EBT3P/3+P films



Figure 2a: GafChromatic™ EBT3P



Figure 2b: GafChromatic™ EBT3+P

Calibration and reference strips - either cut from EBT3P or provided in the EBT3+P package

Linear Accelerator

Epson 10000XL or 11000XL flatbed scanner with 48-bit rgb color depth and transparency adapter

FilmQA Pro 3.0™ software (version 3.2.4958.17738 released 07/29/2013 or any later version)

Two-pin patient positioning index bar

III. PROCEDURE

III-A. Phantom Setup

Step A1: Chose a two-pin patient positioning index bar fitting the couch. Different treatment couches may require different positioning bars. More information is available from manufacturer of the index bars. For example, CIVCO Medical Solutions manufactures a series of the Lok-Bars (http://www.civco.com/ro/products/couchtop_overlays/accessories/lok-bars/).

Step A2: Place and tighten the index bar to the treatment couch as shown in Fig 3.



Figure 3 Place and secure index bar onto the treatment couch

Step A3: Carefully lower the bottom plate of the GafChromic QuiCk Phantom™ onto the couch. As shown in Figure 4, the bottom plate has a groove and holes to fit the index bar.

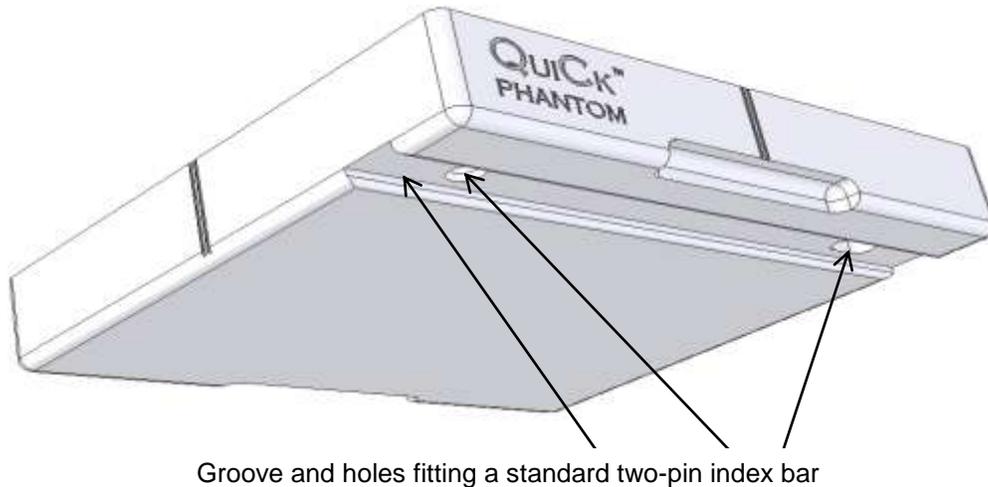


Figure 4: Underside of the bottom plate of the GafChromic Quick Phantom™

The fit should be tight and there should not be any play once the phantom is in position as shown in Figure 5

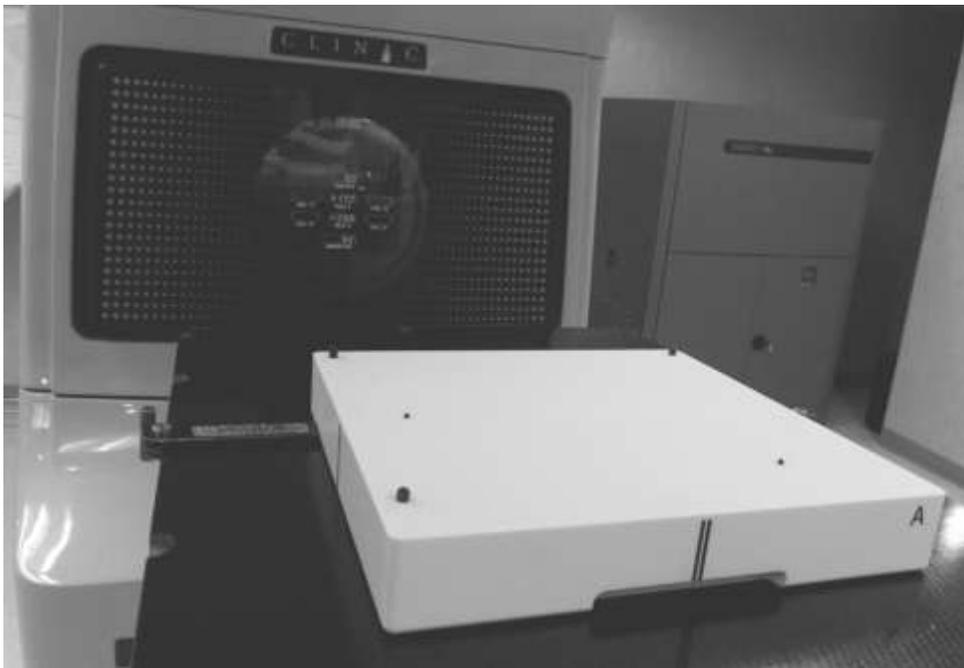


Figure 5: Bottom plate of the phantom locked into position on the index bar

Step A4: Place a sheet of GafChromic™ EBT3P or EBT3+P film onto the bottom plate of the phantom (Note: if GafChromic™ EBT3+P is used, tear off the reference strip before loading the patient film). The two asymmetric film positioning pins shown in Figure 6 allow only one possible placement of the film, automatically identifying the position and orientation of the film placement. Figure 7 shows the film in position.

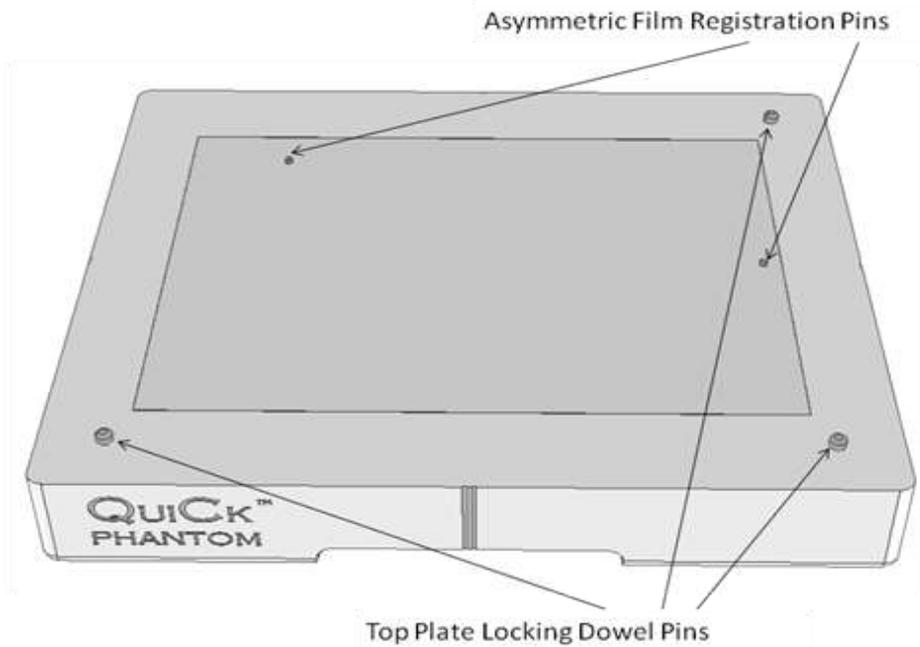


Figure 6: Top view of the bottom plate of the GafChromic QuiCk Phantom™

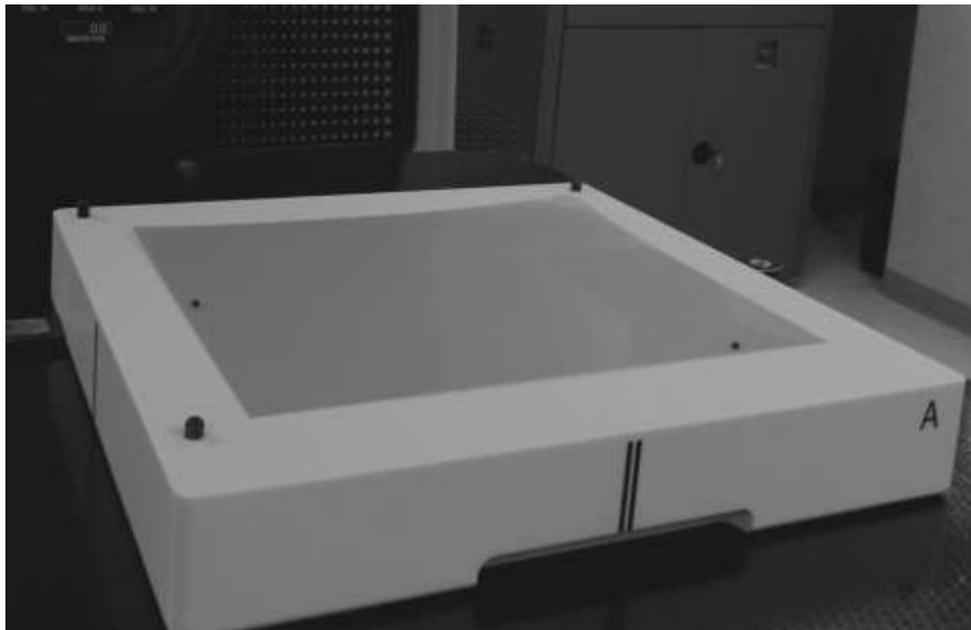


Figure 7: GafChromic™ EBT3P Film placed in the phantom

Step A5: Place the top plate of the phantom onto the bottom plate. With the three asymmetric locking pins shown in Figure 6 and matching holes in the top plate the phantom fits together in only one way.



Figure 8: Finished setup of the GafChromic QuiCk Phantom™ on treatment couch

The phantom can also be rotated by 180° and set up as shown in Figure 9.



Figure 9: Alternate setup with phantom rotated 180°

Step A6: Use the lasers and the crosshairs in the MLC light field to identify the isocenter of the radiation field and move the gantry and couch to align the isocenter to coincide with the isocenter of phantom as indicated by the engraved lines (Figure 10).



Figure 10: Isocenter alignment of phantom and radiation field

Step A7 Once setup of the phantom is complete, record all the location numbers of the Linac treatment couch position and index bar location. These values can be input and used for subsequent rapid setup of the phantom.

III B. Treatment Planning

Step B1: Either scan the GafChromic QuiCk Phantom™ in the CT simulator normally used to define the phantom in the TPS and generate the dose in the phantom when the patient treatment plan is delivered to the phantom.

Step B2: When user-generated phantom images are used for treatment planning it is essential to be aware of the phantom material's attenuation factors. The CT images are for geometric defining only. Due to the different response of the phantom to the kV x-rays in the CT simulator and the MV x-rays of the treatment system the density of the phantom should be manually overridden to be 1.00 before it is input into the TPS. (A technical description and energy dependence information on the Plastic Water® used in the phantom can be found from CIRS web site (<http://www.cirsinc.com/products/solution/42/plastic-water/?details=specs>)).

III C. Patient Film Exposure

Step C1: Obtain a sheet of EBT3P or EBT3+P film. If GafChromic™ EBT3+P is used, tear off the reference strip. Mark the EBT3+P sheet and reference strip so they are identified as a pair.

Step C2: With the phantom set up as described in Section IIIA, fit the film sheet in the phantom – the registration holes allow only one orientation as shown in Figure 7. Then place the top plate of the phantom.

Step C3: Check the alignment of the laser and MLC light field with the phantom's etched lines.

Step C4: Follow your normal QA procedure for exposing the IMRT plan. One can either apply all fields to the phantom to expose a single film, or expose films one field at a time.

Step C5: Remove the top plate of the phantom and take out the exposed film. Place the film in a box or envelope to keep from prolonged exposure of the light and keep the film outside the treatment room. Record the time of day of the film exposure. The film will be scanned and analyzed as described in **Section IV**.

Step C6: Place another patient film for exposure or make calibration or reference film strips.

III D. Calibration/Reference Film Exposure

Step D1: For GafChromic™ EBT3+P use the film strip matching the sheet used for patient film exposure. For EBT3P cut an 8" x 10" sheet parallel to 8" dimension into strips about 1½" wide.

Step D2: With the phantom set up as described in Section IIIA, place a film in the center of the bottom plate of the phantom and put on the top plate. Note: the orientation of the film during exposure is not important, but it must be at the center of the phantom

Step D3: Expose the film using an open radiation field of at least 10x10 cm to provide a large area of uniform exposure.

Step D4: A typical calibration can be performed using 4 points – three exposures plus an unexposed film. The dose values for the calibration points should be arranged in the series D, 1/2D, 1/4D and 0 where D is a dose about 10-30% greater than the maximum dose on the patient film.

When exposing a reference film use a dose between 80-100% of the maximum on the patient film

III E. Film Analysis

Note: More detailed description of the sections covered in Step E1 to E9, including step-by-step instructions, instructional videos, other white papers and presentations, can be found at www.filmqapro.com.

Step E1: Connect an Epson 10000XL scanner to the computer, turn on the scanner and activate the FilmQA Pro software. The FilmQA Pro™ screen has three windows. The Case Data Selector Window is to the left, the Image Window in the center and Analysis

Window to the right. Under the line “**Case Object Management**” at the bottom of the Case tree in the left hand window click “**Add new case object**” – see Figure 11

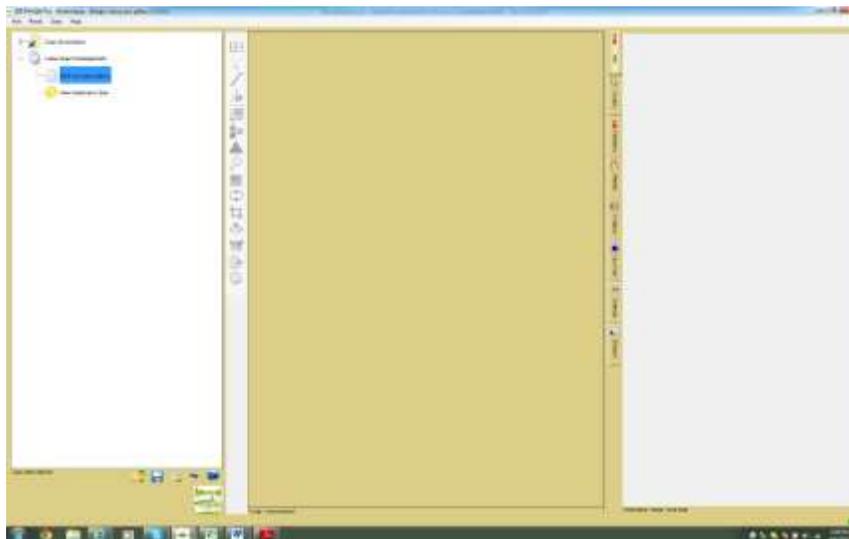


Figure 11: FilmQA Pro™ Opening screen

Step E2: Select “**Dose to Plan Comparison**” from the drop down menu – Figure 12.

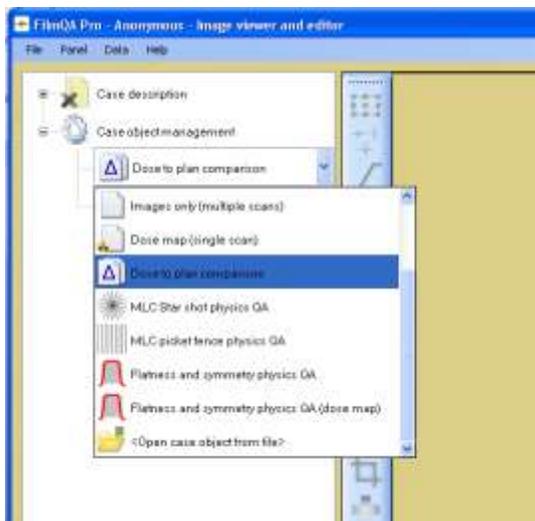


Figure 12A: Add new “**Case Object**”

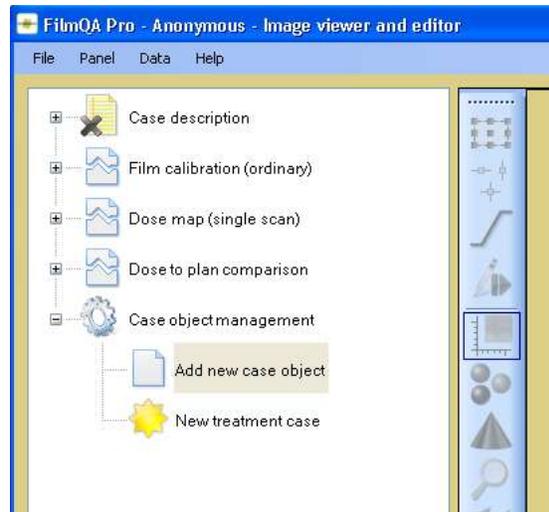


Figure 12B: Case Objects Generated

Noted that two more objects (“**Calibration**” and “**Dose Map**”) are created along with the “**Dose to Plan Comparison**” Object, since this latter object is dependent upon the other two objects.

Step E3: Expand the Calibration Case Object and right click on **“Data Calibration Film (empty)”**. Click on **“Scan Image Calibration Film”**. Alternately an image could be loaded by selecting **“Open image Calibration Film”**.

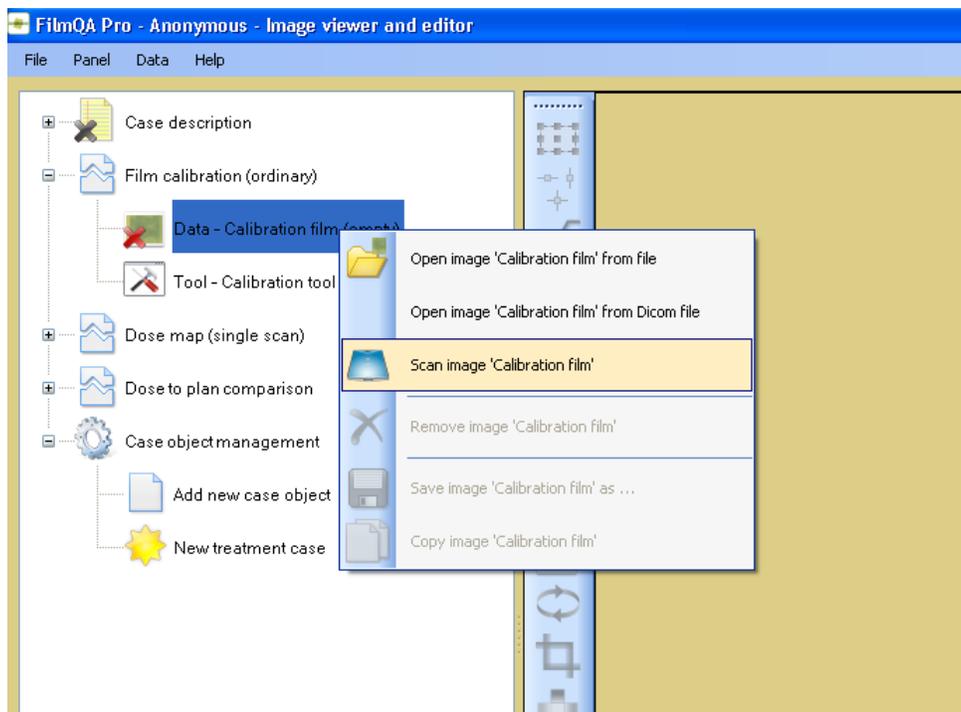


Figure 13: Opening Epson Scan utility to scan an image

The Epson Driver Window appears. Choose the settings shown in Figure 14A

Mode:	Professional mode
Document type:	Film
Film type:	Positive film
Image type:	48-bit color
Resolution:	72 dpi

If color correction icons are active (see red arrow in Fig. 14A) they must be deactivated. Open the Configuration window (Fig. 14B) and check **“No Color Correction”**. The icons should appear gray (see green arrow, Fig. 14C).

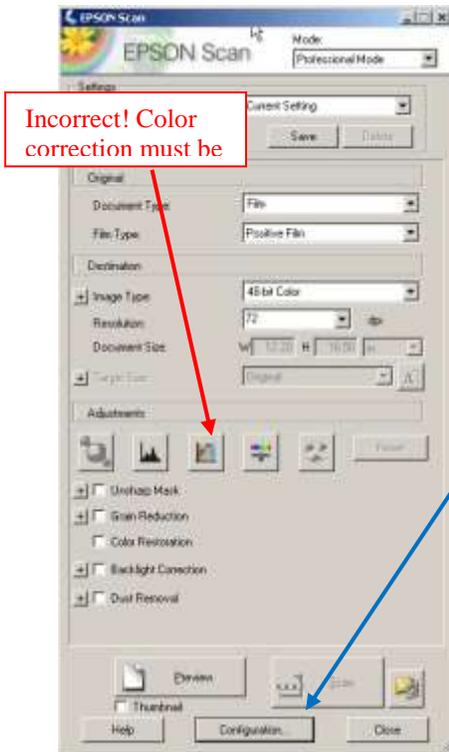


Figure 14A

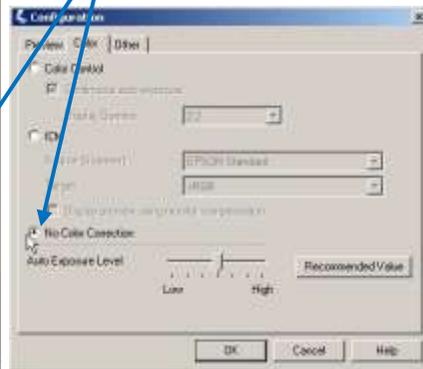


Figure 14B

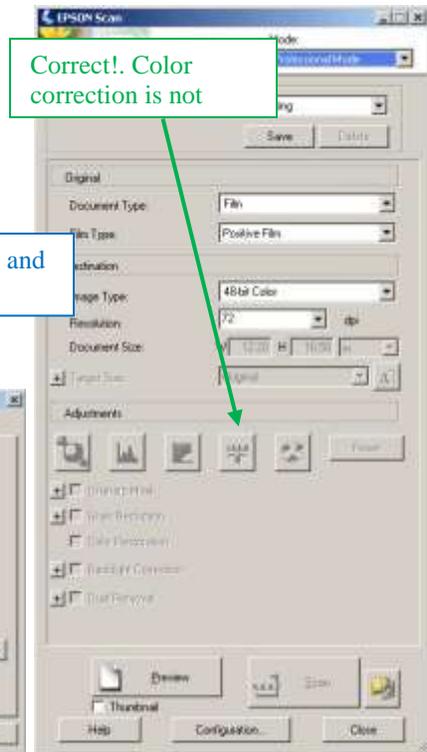


Figure 14C

Step E4: Place calibration films in the center of the scanner for scanning (Figure 15).

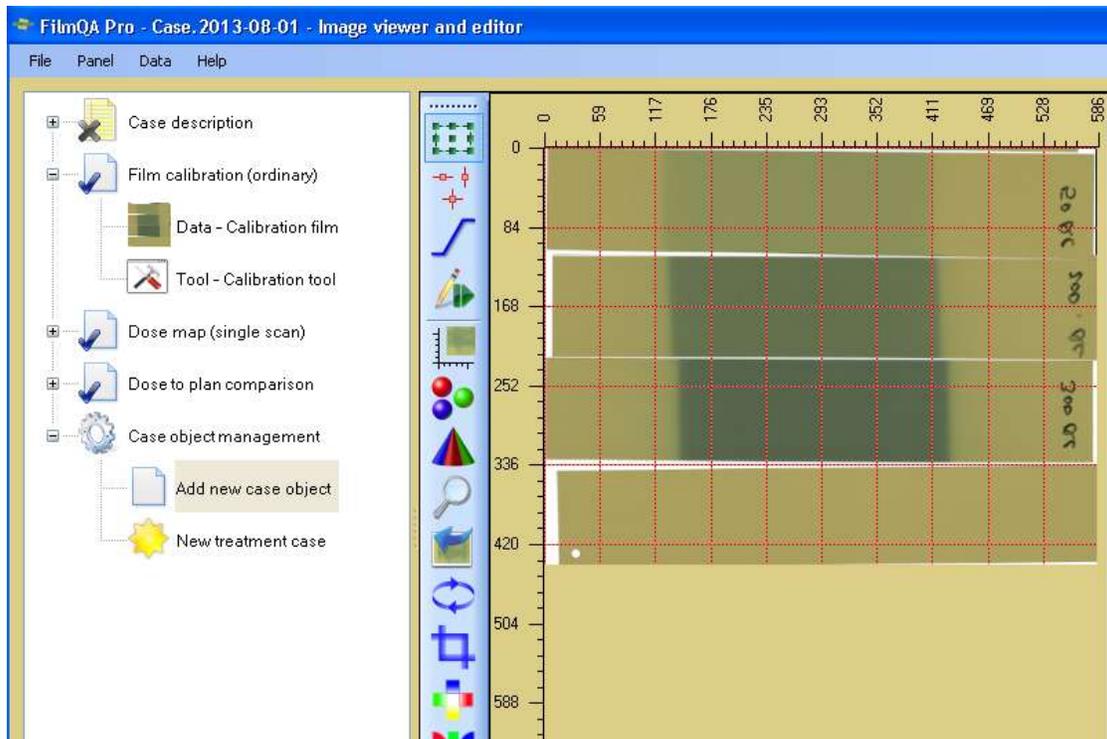


Figure 15: The scanned image of the calibration film strips

Step E5: Click the “**Selection Frame Tool**”  at the top of the toolbar and draw regions of interest (Figures 16A and 16B) at the center of the calibration strips.

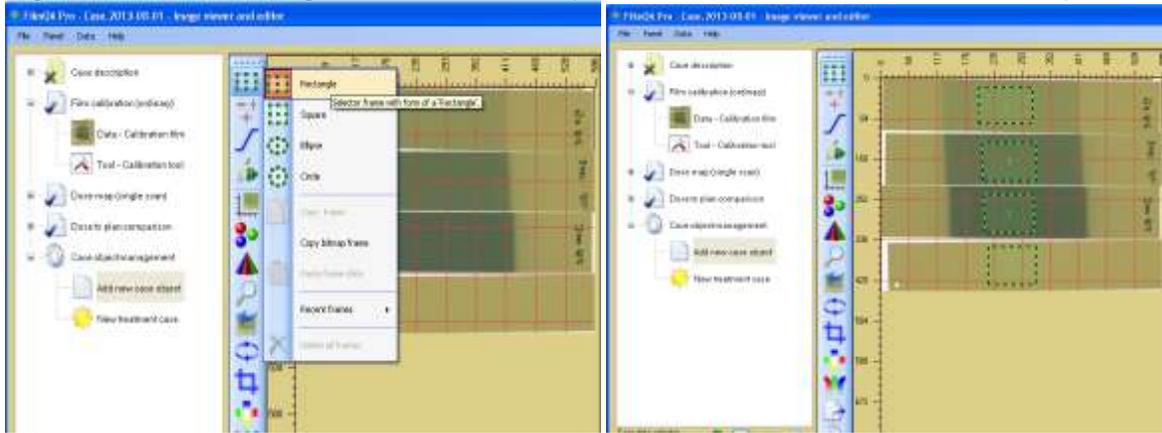


Figure 16A: Selection Frame Tool

Figure 16B: Regions of interest selected

Step E6: Click the “**Tool-Calibration tool**” (Figure 17A) and then click  icon to populate the dose table with color values (Figure 17B).

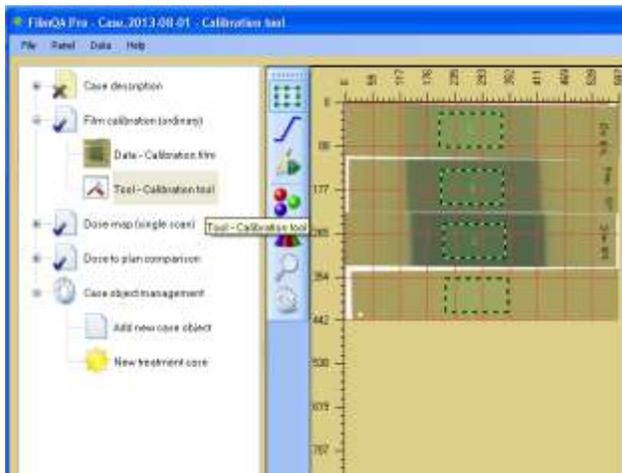


Figure 17A: Calibration tool

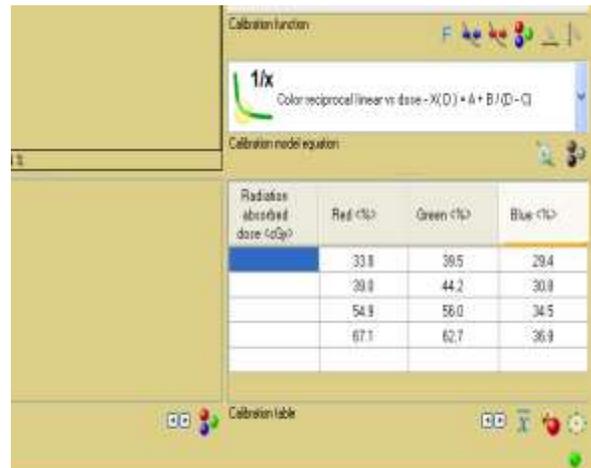


Figure 17B: Auto color channel values

Step E7: Type in the dose values, or copy and paste them from another application. The calibration curves (Figure 18) appear when the last value dose value is input.

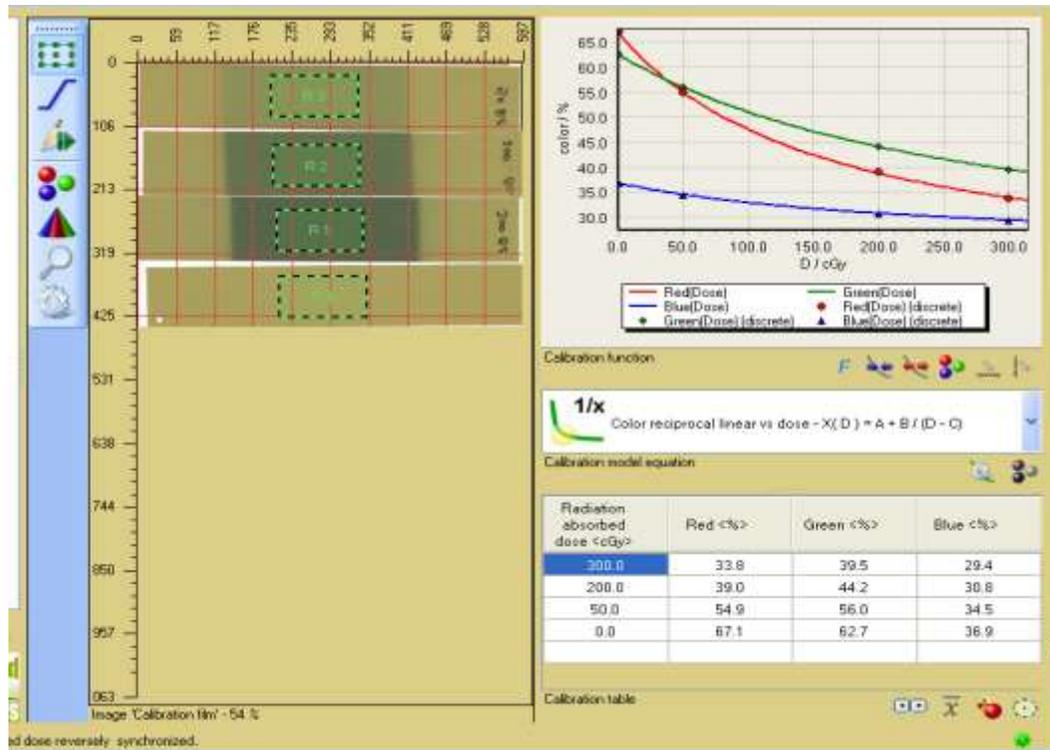


Figure 18: Calibration curve generated

Step E8: Expand the **Dose map Object** by clicking “**Dose map (single scan)**”. Then right-click “**Data-dose film (empty)**” and either scan a patient film, or load a saved image from file.

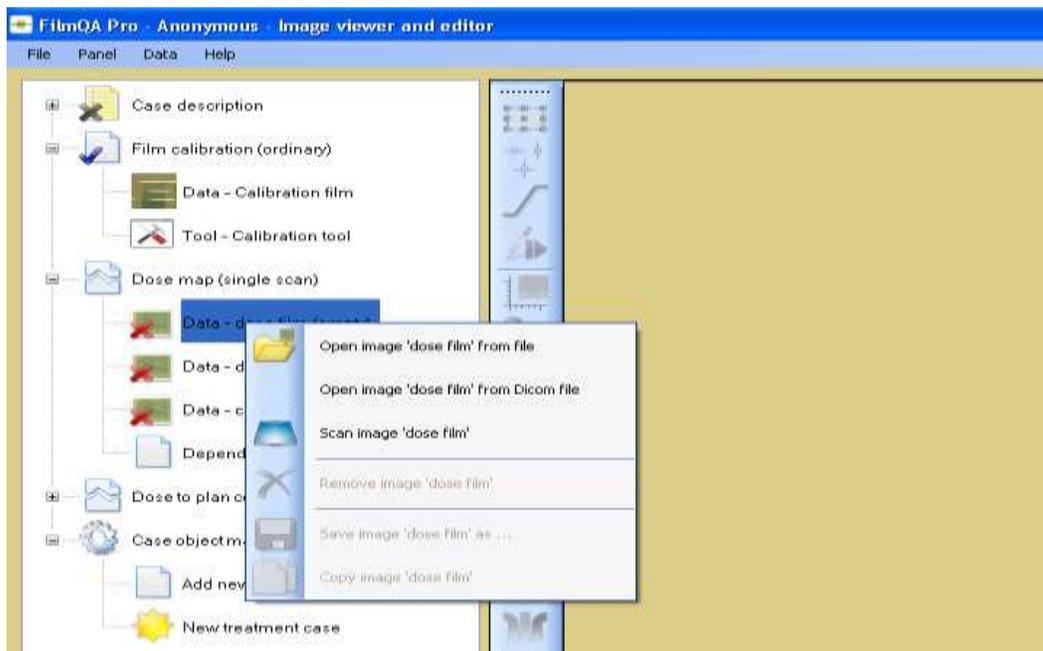


Figure 19: Load or Scan Patient Film for Analysis

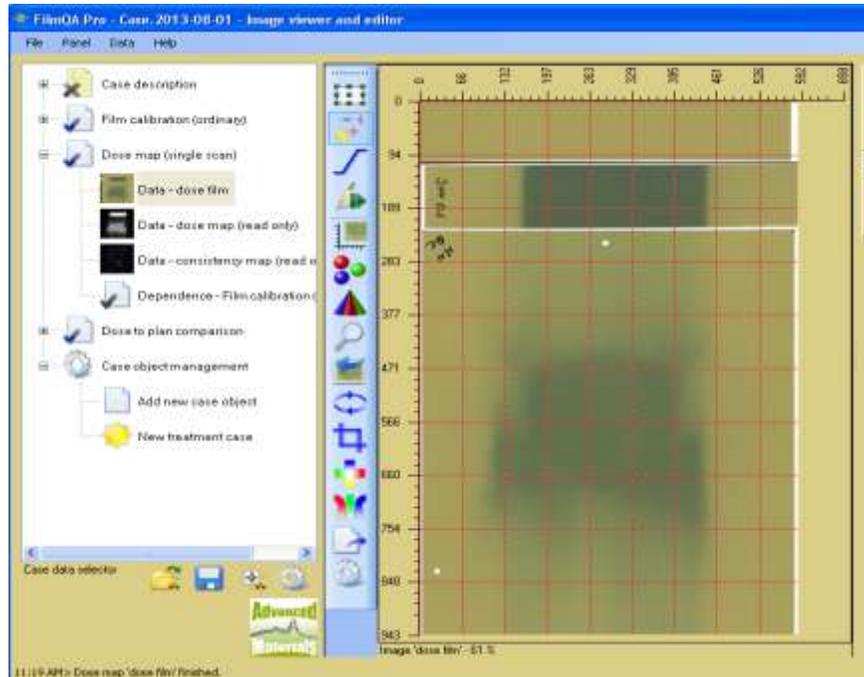


Figure 20: Dose Film along with two reference films loaded

Step E9, dose film fiducial detection:

Click the fiducial registration icon  on the toolbar to activate the fiducial tool, scroll down to “**Known registration templates**” and then “**Gafchromic with isocenter**”.

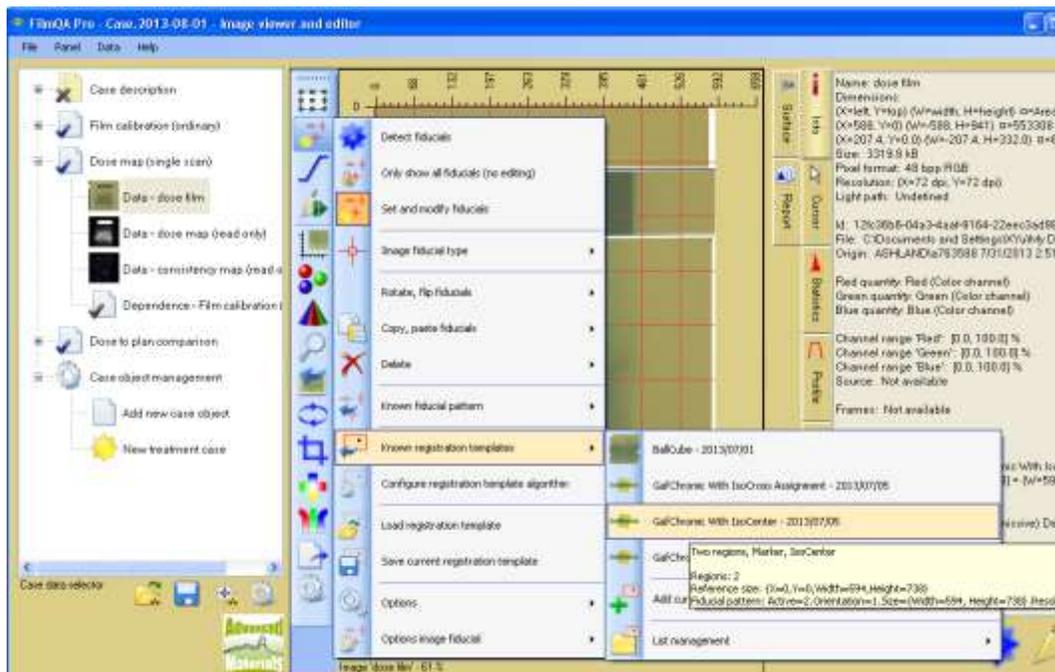


Figure 21: Gafchromic with Isocenter Assignment

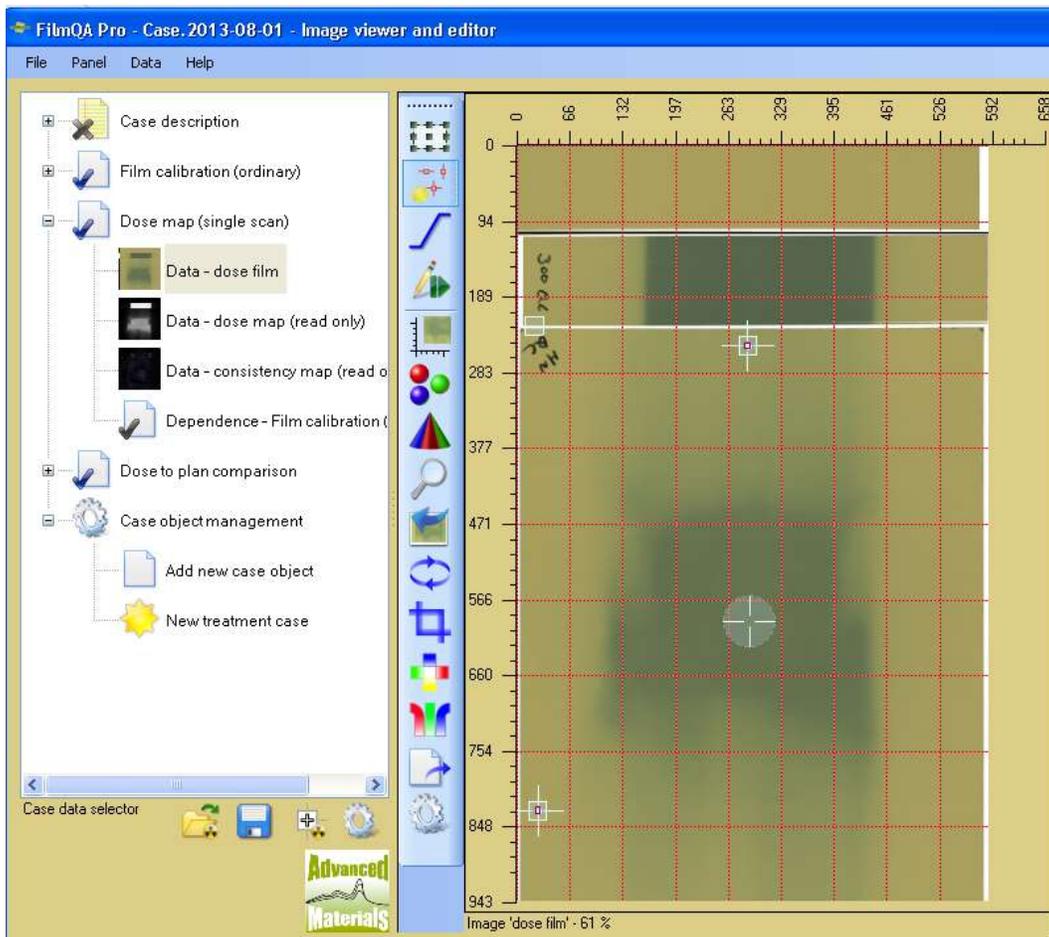


Figure 22: Isocenter assigned

Noted that the isocenter is automatically assigned along with two general fiducial points aligned with the two registration holes on the EBT3P or EBT3+P films. An additional fiducial mark point is also added for film orientation determination.

Step E10: Use frame selection tool  to mark a region on the exposed reference film strip (Figure 23). Right click the area to designate it as a calibration region. The second reference film strip is unexposed. Repeat for the process to mark the calibration region. It is recommended to scan at least two reference films with the patient film films – one film unexposed and one exposed to 80-100% of the expected maximum dose to the patient film. This is the “One-scan” Measurement Protocol (see Lewis D., Micke A., Yu X, Chan M.: “An Efficient Protocol for Radiochromic Film Dosimetry combining Calibration and Measurement in a Single Scan”, Medical Physics, 39 (2012) 10, pp. 6339). Detailed step-by-step instructions to apply the “One-scan” Protocol are available in the White Papers section at www.filmqapro.com.

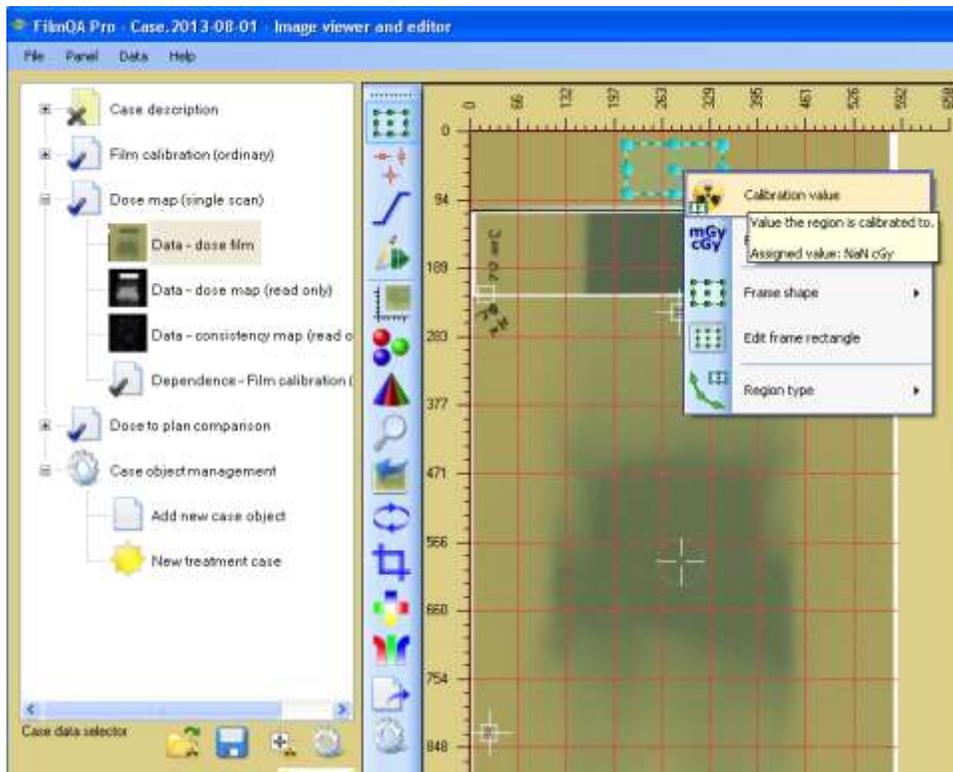


Figure 23: Selection of the reference dose region

Step E10: Right click on the calibration area of a reference film and type in the dose value. Repeat for all reference films.

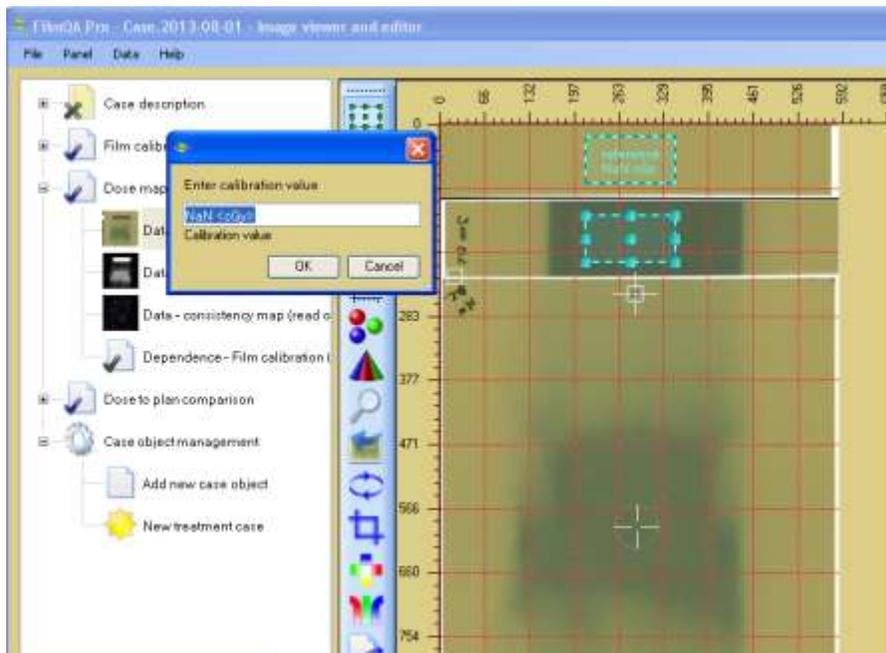


Figure 24: Input of the calibration values for the reference regions

Step E11: Right click “Dose map (single scan)” and select “Dose mapping method”, “Recalibration using reference region” and “Dose linear scale” (Figure 25). Then re-click “Dose map (single scan)” and select  to rebuild the dose map (Figure 26).

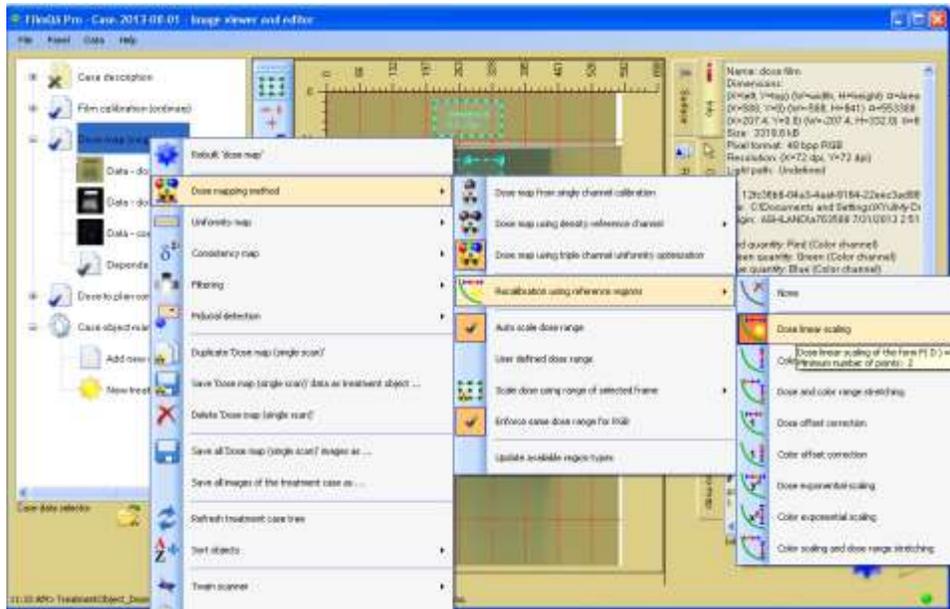


Figure 25: Rebuilding dose map

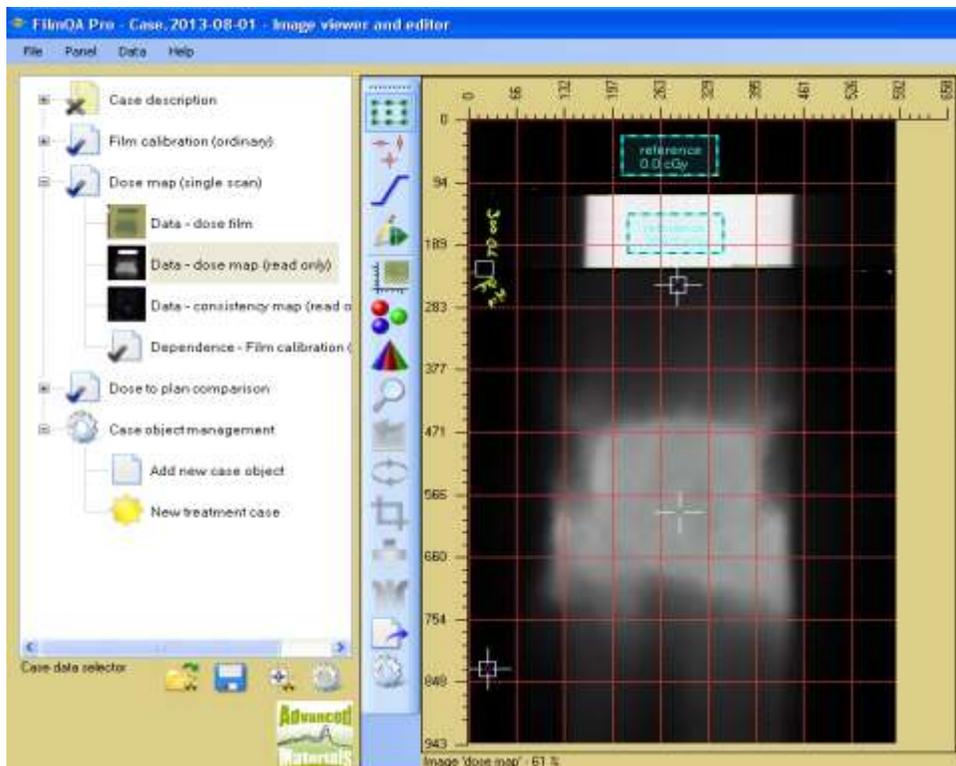


Figure 26: Dose map generated

Step E12: Click  to expand the “**Dose to Plan Comparison**” object in the case tree. Then right click “**Data-treatment plan(empty)**” and select an option to load the treatment plan – either a file with format specific to a TPS, from a tiff file or a dicom file.

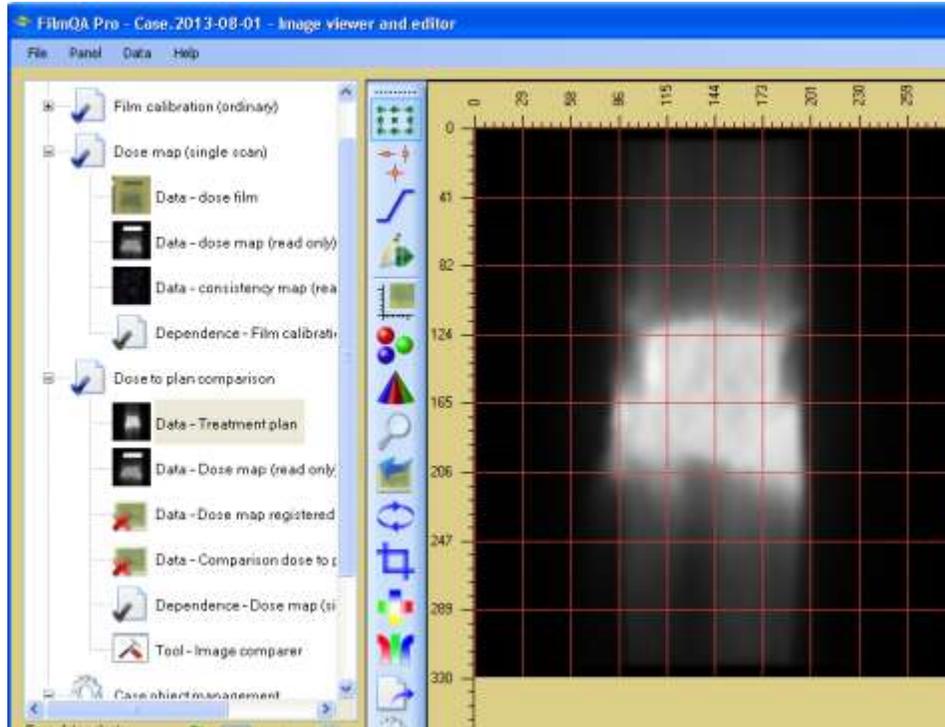


Figure 27: Treatment Plan Loaded

Step E13: Dose to Treatment Plan Comparison: Click “**Tool-Image comparer**” at the bottom of the treatment object. In most cases, the software will automatically register the dose map to the plan (Figure 28).

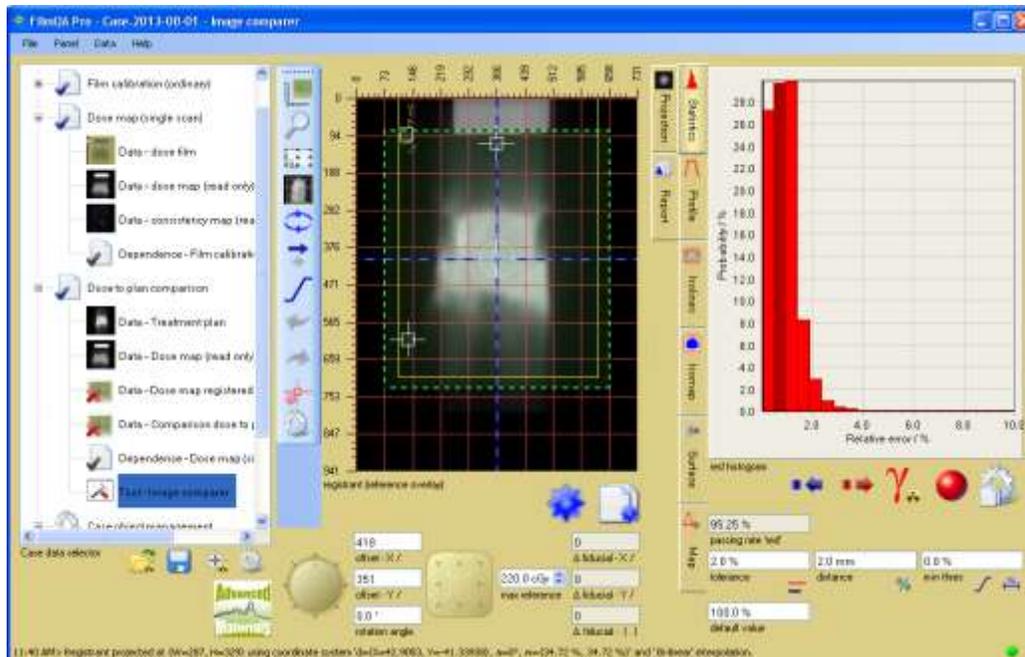
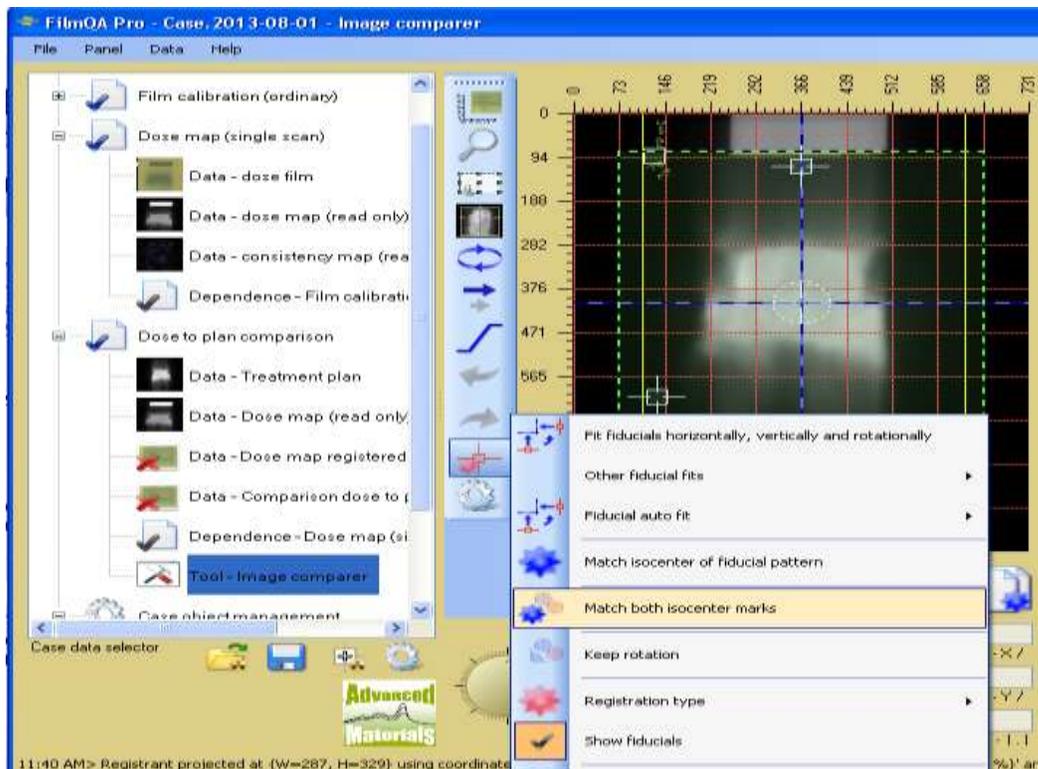


Figure 28: Dose to plan comparison

Step E15: If automatic fitting fails, the fiducial pattern can be fit manually by clicking the “Fiducial fit” icon and selecting **”Match both isocenter marks”** – see Figure 29.



.Figure 29: Manual fiducial fit

Step E16: The dose-map to plan alignment can also be fine-tuned. Click to activate the image movement icon  and use the  icon to toggle between coarse and fine movement. Also by right-clicking the  icon you can select the size of the movement steps. Control xy movement with the square button in Figure 31 or click the button and use the keyboard arrows.

Right-click the image movement icon again and select **“Show rotation pole”**. Then drag the rotation pole to the center of the exposed area or re-click the image movement icon and select **“Move pole to center cross”**. Movement of the dose map about the rotation pole can be accomplished by rotating the circular wheel with the cursor. Alternatively click the button and rotate the image with the mouse wheel or keyboard arrows.

Note that after refining the alignment the rotational and translational offsets from the automated fit are recorded in the cells next to the movement buttons.



Figure 33: Alignment fine tuning tools