RODOMS 5.0 User Manual

Oct 2017

Contents

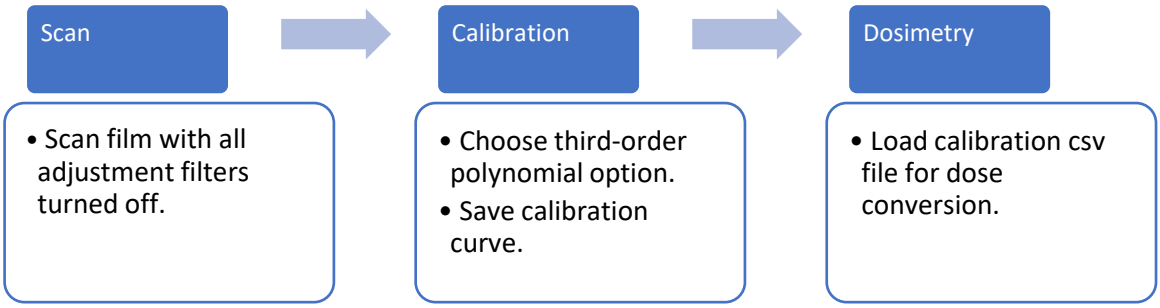
1. Physics Overview

RODOMS was developed to streamline the procedure of film calibration and dosimetry analysis, using automation whenever applicable.

As with any dosimeter, the dosimeter signal needs to be related to dose. In the present case, the dosimeter signal is the film's net GSV, which is the greyscale value of the dosimetry film subtracted from an unexposed film. The use of an unexposed film serves the purpose of correcting for non-uniformity of the scanning region. To convert net GSV to dose, RODOMS supports two methods: absolute dosimetry and relative dosimetry. Throughout this document, absolute means that film net GSV is converted to dose in unit of Gy by applying a calibration function. This is the method most people are familiar with. Relative dosimetry means that if net GSV is linear with dose, then we can use film to directly compare with the relative dose distribution calculated by the TPS. This dose linearity is not a natural behaviour of the film but can be achieved by adjusting scanning settings. The two methods are described in detail below:

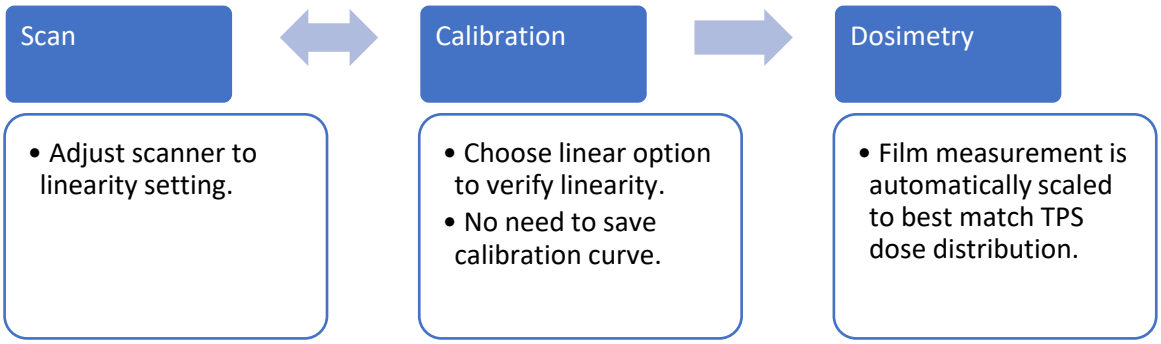
(1) Absolute dosimetry

Films should be scanned with all adjustment filters switched off. In the calibration step, perform a third-order polynomial regression and save the calibration curve to a .csv file, which will be loaded in the dosimetry step to convert dosimetry film measurements into unit of dose.



(2) Relative dosimetry

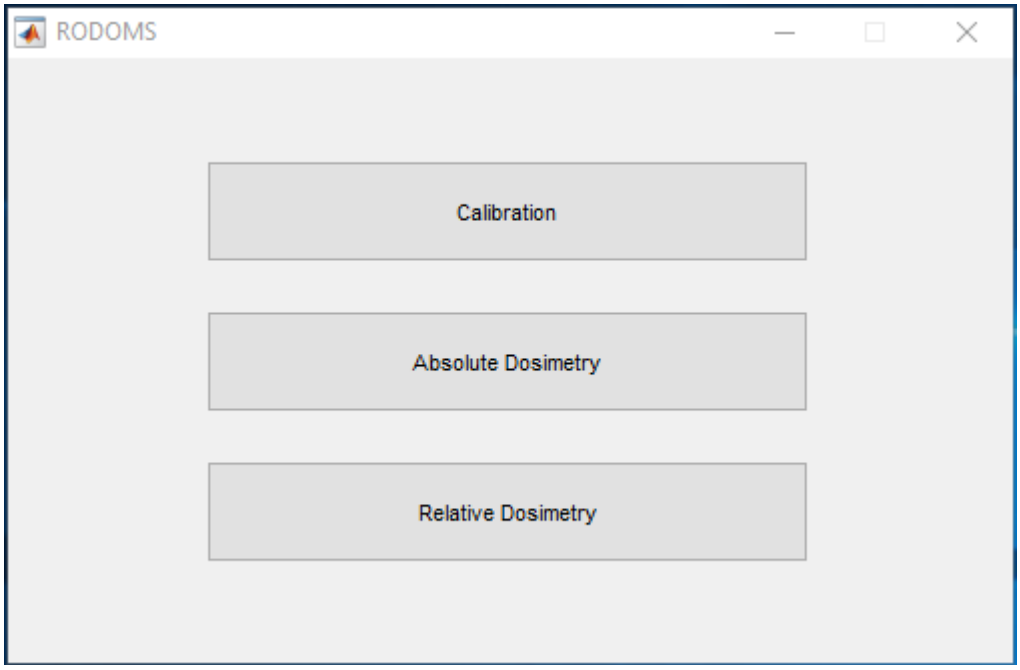
Adjust scanner settings such that net GSV becomes linear with dose in the clinically relevant dose range. Note that the arrow between scan and calibration is double headed as you will need to use a trial-and-error approach to test out different scanner settings in order to find out the setting that yields dose linearity (referred to as linearity setting). Once linearity is established, there is no need to save calibration curve as the software will apply the best fitting scaling factor to scale film measurement to dose.



2. Launch interface

At the start of the RODOMS program, the application launch interface is displayed. From here user can select from the following three applications:

- Calibration (see section 3)
- Absolute Dosimetry (see section 4)
- Relative Dosimetry (see section 5)



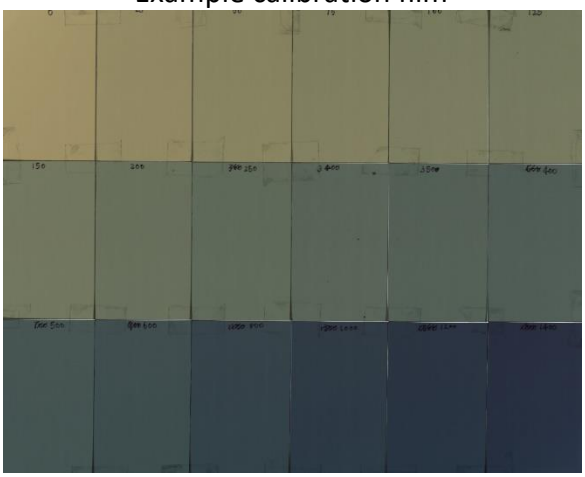
3. Calibration

Two scans are required for film calibration:

- An unexposed film
- All the calibration film strips taped back together to form one film and scanned as one image

Example unexposed film

Example calibration film



RODOMS subtracts the calibration film from the unexposed film to correct for non-uniformity in the scanner. Therefore, both films should be placed in the same position on the scanner bed. A cardboard cut-out template can be used for accurate placement.

It is important that both films should be scanned at 127 dpi and both scans should have the same dimension and scanner settings.

The steps to be taken are numbered on the push buttons. Please follow them in order:

(1) Load Unexposed Film

Navigate to the folder containing the film scans and load the unexposed film. After the first file is loaded RODOMS will remember and open to this directory (with option to change) in subsequent steps.

(2) Load Calibration Film

(3) Enter and Record Calibration Dose

In the column provided, enter the calibration dose in cGy. The order should be from left to right, top to bottom as each film strip appears in the calibration film. Up to 24 dose levels are supported. If less than 24 levels were used, simply leave the unused cells empty.

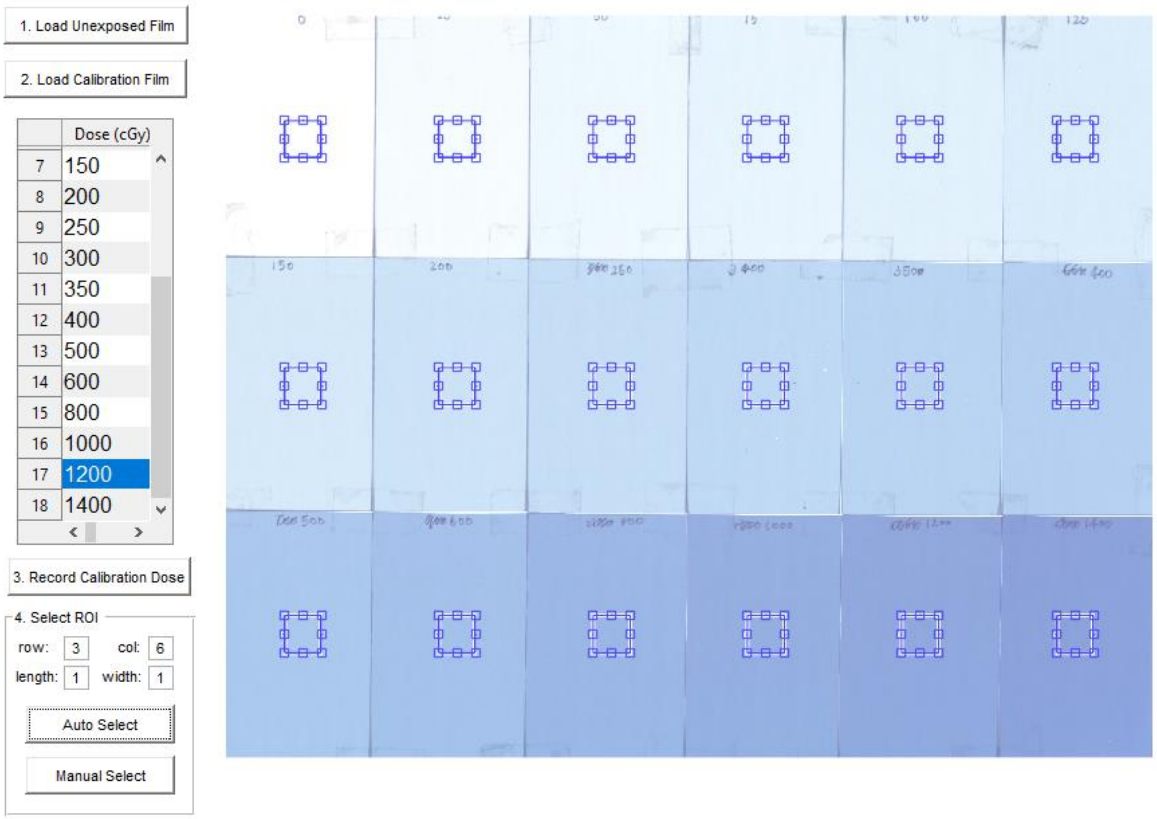
Once all the dose levels are entered, click on '**Record Calibration Dose**'.

(4) Select ROI

The ROI of each dose region can be selected using either automatic or manual method.

- Auto selection

If all the film strips have equal dimensions and the film image doesn't contain borders (as shown below), auto selection is the easiest approach. Enter the number of rows and columns in the calibration film, and the desired length and width in cm of the ROI, then click on '**Auto Select**'. A rectangular ROI will be placed in the centre of each dose region automatically. Please note that the software will read in each region from left to right then top to bottom. Therefore please ensure the dose levels entered in step 3 are in the same order.



- Manual selection

ROI for each dose region can be drawn manually. Click on '**Manual Select**', then use the mouse to draw a rectangle in the first dose region. A second rectangle of the same size will appear at the top left corner. Drag the selection to the desired location and double click to accept. Repeat this process until ROIs for all dose regions are selected. The number of ROIs RODOMS generates will match the number of dose levels entered in step 3.

(5) Select Color Channel

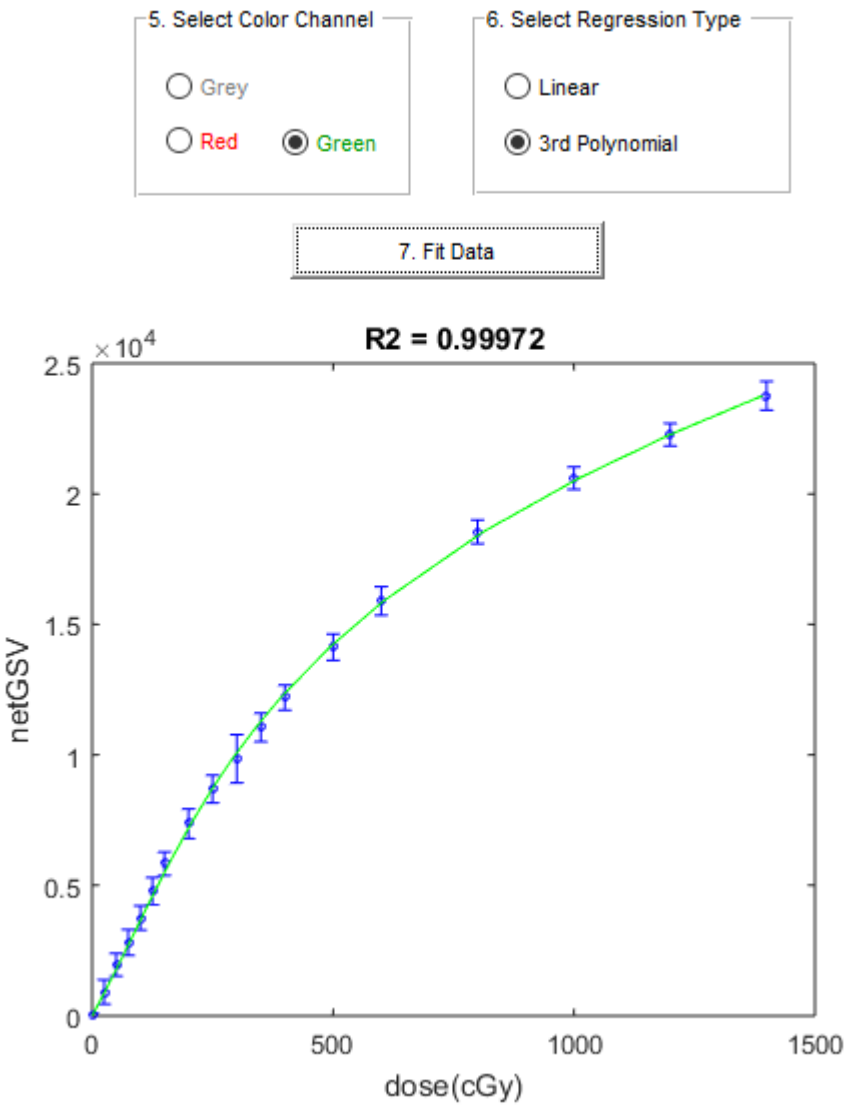
Select the color channel to be analysed. If the films were scanned as greyscale image, choose 'Grey'. If the films were scanned as RGB image, choose either 'Red' or 'Green'. Blue channel is not given as an option here because it is dominated by noise and should not be used for dosimetry.

(6) Select Regression Type

RODOMS fits net GSV to dose levels using either a linear fit for relative dosimetry or third order polynomial function for absolute dosimetry.

(7) Fit Data

Click on '**Fit Data**', average net GSV and uncertainty (2 standard deviations) are displayed in blue. Selected fit-line is plotted in green with R-squared value displayed at the top of the graph.



(8) Save Calibration Data (for polynomial fit)

For absolute dosimetry using a third order polynomial fit, the calibration function should be saved as a csv file.

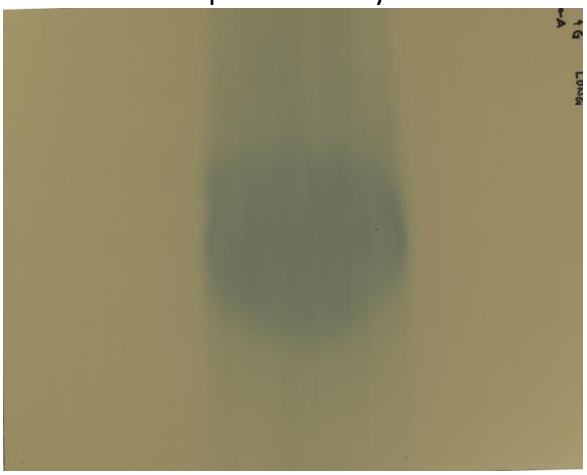
4. Absolute Dosimetry

Two scans are required for absolute dosimetry:

- An unexposed film
- A dosimetry film

Example unexposed film

Example dosimetry film



RODOMS subtracts the calibration film from the unexposed film to correct for non-uniformity in the scanner. Therefore, both films should be placed in the same position on the scanner bed. A cardboard cut-out template can be used for accurate placement.

It is important that both films should be scanned at 127 dpi and both scans should have the same dimension and scanner settings.

The steps to be taken are numbered on the push buttons. Please follow them in order:

(1) Select color channel

In the Film Scan panel, select the color channel to be analysed. The selection should be consistent with film calibration. Choose R for red, G for green, or Gy for greyscale.

(2) Load dosimetry film

(3) Load unexposed film

[OPTIONAL] Rotate or/and flip film

If film is not scanned in the same orientation as the dose map, there are four tools to manipulate the film image: clockwise rotation, counter-clockwise rotation, flipping upside down and flipping left to right.

[OPTIONAL] Select ROI

If there is substantial marking or border in the film image, image registration may be more challenging. Click on '**Select ROI**' to define the region to be analysed, excluding marking or border on the film.

(4) Load dosimetry film

RODOMS supports four treatment planning systems and the files required for each TPS are listed below:

- RayStation / Eclipse
  DICOM RT plan and planar DICOM dose

- TomoTherapy
  Select the orientation of film placement. Choose C for Coronal or S for Sagittal.
  Load DICOM RT plan and 3D DICOM dose

- Pinnacle (not well tested)
  Planar ASCII dose

(5) Apply ROI

Click on '**Apply ROI'**. A rectangle box will appear which has the same dimensions as the film image. Keep the dimensions unchanged and drag the box to roughly the area corresponding with the film scan. Once satisfied with its positioning, double click the mouse to accept.

(6) Image registration

In the Image Processing panel, click on '**Registration**'. Translation and rotation will be applied to the film image so that its coordinates are matched to those of the dose map. Once the process is complete, a message box will pop up to indicate so. Please click on '**OK**'. Occasionally the registration will not be successful. In that case, click on '**Reset**' next to the Registration button, then repeat from step (5).

[OPTIONAL] Iso-shift calculation

In some circumstances, it might be helpful to determine the difference of isocentre position between the one used in set-up (representative of optical isocentre) and the one chosen by image registration (representative of radiation isocentre). To use this function, laser positions should be clearly marked on the film scan. ***For TomoTherapy, the red laser positions should be marked, not the green laser.***

Click on '**H Laser**', then move mouse over to the film image and click on either the left or right laser. Click on '**V Laser**', then move mouse over to the film image and click on either the top or bottom laser. Click on '**Calc Shift**', the difference between two isocentre positions in horizontal and vertical directions will be displayed in unit of millimetre.

It is noted that the accuracy of iso-shift calculation depends on film rotation.

(7) Refine ROI

Click on '**Refine ROI**', then drag the mouse over the film image to refine ROI, excluding any white border left as a result of image registration. The selection can be changed by clicking on '**Reset**' next to the Refine ROI button and redo the selection.

(8) Convert to Dose

Click on '**Convert Film GSV to Dose**', then select the calibration file saved from calibration (refer to section 3 – step 8).

[OPTIONAL] Dose scaling

Sometimes a plan is delivered multiple times to produce a stronger signal. The film measurement can be scaled down to produce the fraction dose that is comparable with TPS calculation. For example, if the plan is delivered to film twice, a 0.5 scaling factor should be entered. Other times, the uncertainties in film scanning and handling may require slight scaling adjustment. User can inspect profile comparisons and use a trial-and-error approach to scale film measurement multiple times until a best match is achieved.

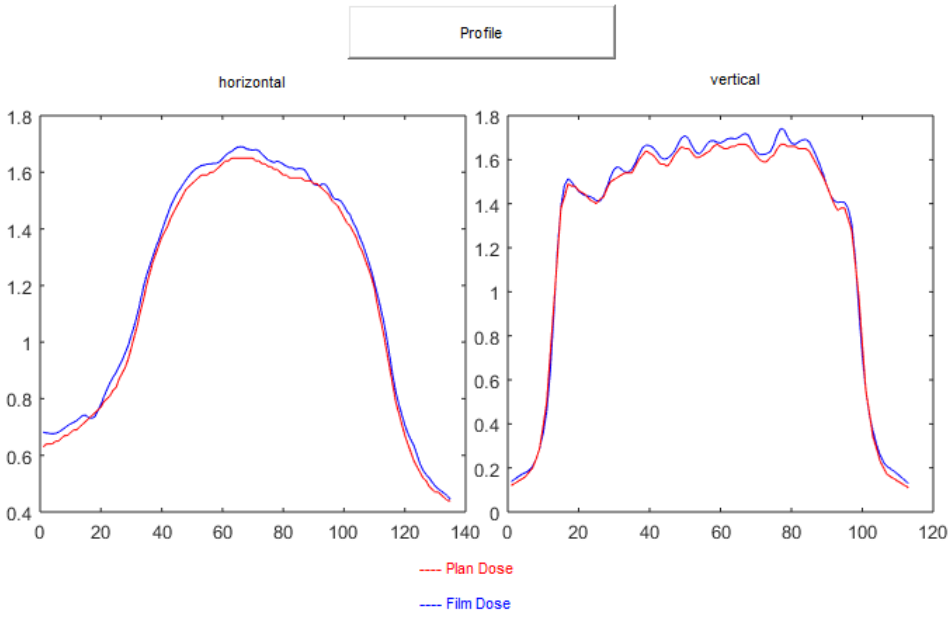
Enter the scaling number (e.g 1.05 to scale dose up by 5%) then click on '**Scale**'. This scaling process can be repeated. Please note that each scaling is performed in addition to the previous calculation.

QA ANALYSIS

The QA Analysis panel provides both qualitative and quantitative tools that may be used in any order.

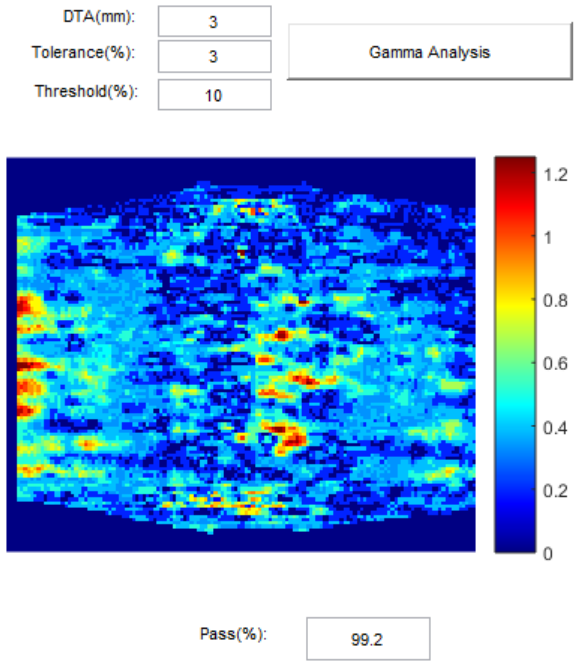
- **Profile comparison**

Click on '**Profile**', then click anywhere on the film image. TPS calculated plan dose (shown in red) and film measured dose (shown in blue) profiles will be plotted together for comparison in horizontal and vertical directions. Drag the selected point and move it across the film image. Profiles will be updated in real time.



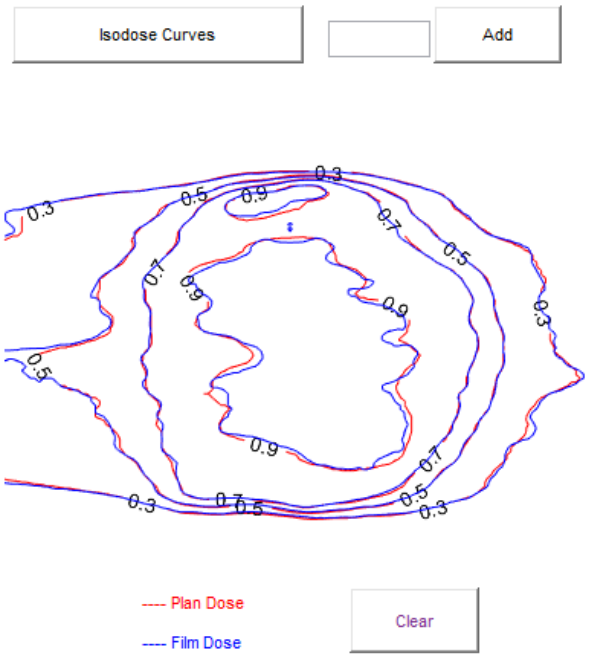
- **Gamma analysis**

Input DTA in millimetres, dose tolerance and threshold in percentage value, then click on '**Gamma Analysis**'. Gamma map and statistics will be generated.



- **Isodose comparison**

There are two ways of plotting isodose curves. Click on '**Isodose Curves**', default isodose levels of 30%, 50%, 70%, 90% are plotted. TPS calculated plan dose is shown in red and film measured dose is shown in blue. To add a custom level, enter the desired isodose percentage (e.g. 95 for 95%), then click on '**Add**'. The figure can be cleared by pressing '**Clear**'.



- **Point dose comparison**

Click on '**Point Dose**', then move mouse over to the film image and click on 10 different points (***please make sure to have 10 clicks***). Plan calculated dose and film measured dose will be shown in the given table together with percentage difference. The absolute mean percentage difference is also shown below the table.

QA REPORT

Enter the Physicist name and date (press enter for current date), then click on '**Report**'. A PDF report will be generated and user can save it to a desired location.

5. Relative Dosimetry

Two scans are required for absolute dosimetry:

- An unexposed film
- A dosimetry film

RODOMS subtracts the calibration film from the unexposed film to correct for non-uniformity in the scanner. Therefore, both films should be placed in the same position on the scanner bed. A cardboard cut-out template can be used for accurate placement.

It is important that both films should be scanned using linearity settings, in greyscale, at 127 dpi and both scans should have the same dimension and scanner settings.

The steps to be taken are numbered on the push buttons. Please follow them in order:

(1) Load dosimetry film

(2) Load unexposed film

[OPTIONAL] Rotate or/and flip film

If film is not scanned in the same orientation as the dose map, there are four tools to manipulate the film image: clockwise rotation, counter-clockwise rotation, flipping upside down and flipping left to right.

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[OPTIONAL] Iso-shift calculation

In some circumstances, it might be helpful to determine the difference of isocentre position between the one used in set-up (representative of optical isocentre) and the one chosen by image registration (representative of radiation isocentre). To use this function, laser positions should be clearly marked on the film scan. ***For TomoTherapy, the red laser positions should be marked, not the green laser.***

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It is noted that the accuracy of iso-shift calculation depends on film rotation.

(6) Refine ROI

Click on '**Refine ROI**', then drag the mouse over the film image to refine ROI, excluding any white border left as a result of image registration. The selection can be changed by clicking on '**Reset**' next to the Refine ROI button and redo the selection.

(7) Convert to Dose

Click on '**Convert to Dose**', then position the cursor to roughly the centre of the dose map and double click to accept. It should be noted that the program samples along the horizontal line of the selected point and uses all pixels from the left most position to the selected point to calculate a regression best-fit function to convert film intensity readings to dose. The sampling should cover the dose range of the particular case on hand. Normally this will be achieved by placing the selection somewhere near the centre of the dose map. However, if the dose distribution is asymmetrical, the selection point should be placed such that a good coverage

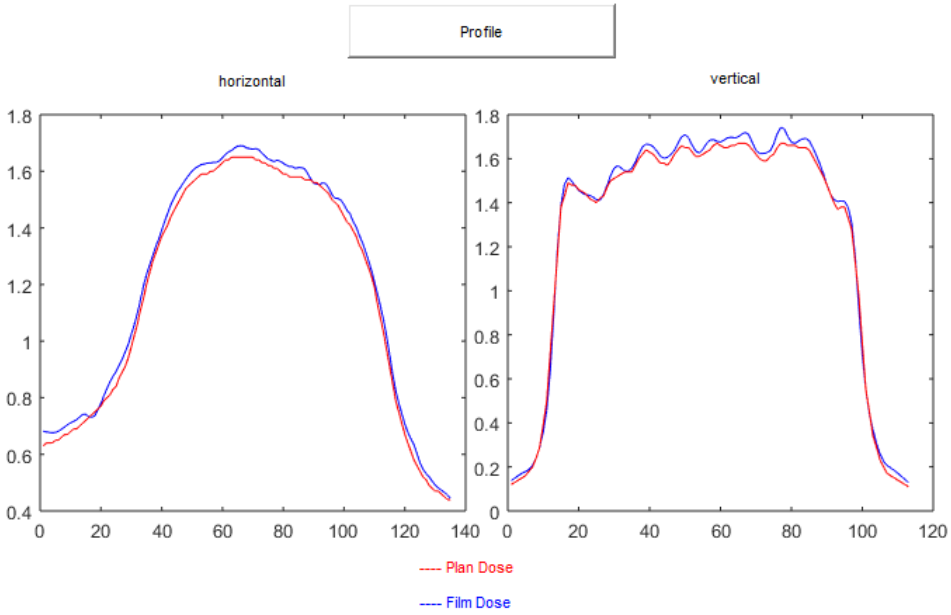
of dose range can be achieved. The dose conversion can be changed later by clicking on '**Reset**' and repeating the selection.

QA ANALYSIS

The QA Analysis panel provides both qualitative and quantitative tools that may be used in any order.

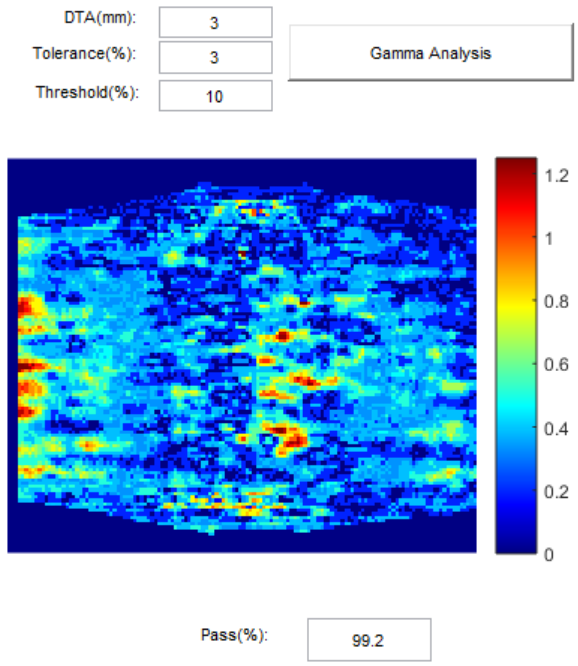
- **Profile comparison**

Click on '**Profile**', then click anywhere on the film image. TPS calculated plan dose (shown in red) and film measured dose (shown in blue) profiles will be plotted together for comparison in horizontal and vertical directions. Drag the selected point and move it across the film image. Profiles will be updated in real time.



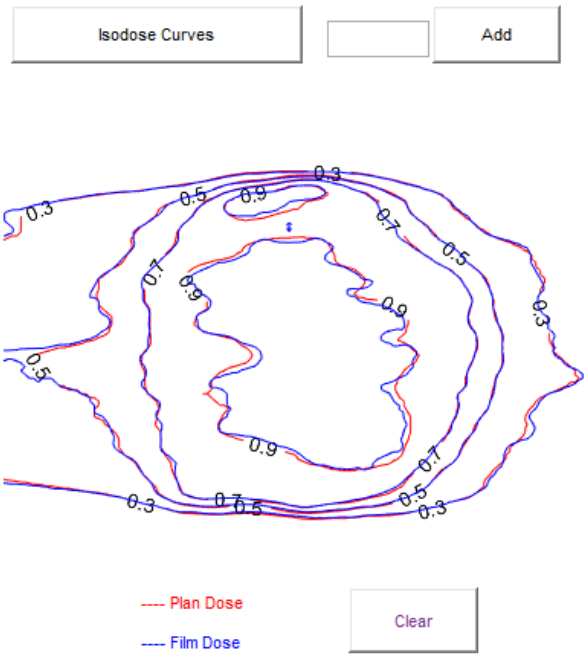
- **Gamma analysis**

Input DTA in millimetres, dose tolerance and threshold in percentage value, then click on '**Gamma Analysis**'. Gamma map and statistics will be generated.



- **Isodose comparison**

There are two ways of plotting isodose curves. Click on '**Isodose Curves**', default isodose levels of 30%, 50%, 70%, 90% are plotted. TPS calculated plan dose is shown in red and film measured dose is shown in blue. To add a custom level, enter the desired isodose percentage (e.g. 95 for 95%), then click on '**Add**'. The figure can be cleared by pressing '**Clear**'.



- **Point dose comparison**

Click on '**Point Dose**', then move mouse over to the film image and click on 10 different points (***please make sure to have 10 clicks***). Plan calculated dose and film measured dose will be

shown in the given table together with percentage difference. The absolute mean percentage difference is also shown below the table.

QA REPORT

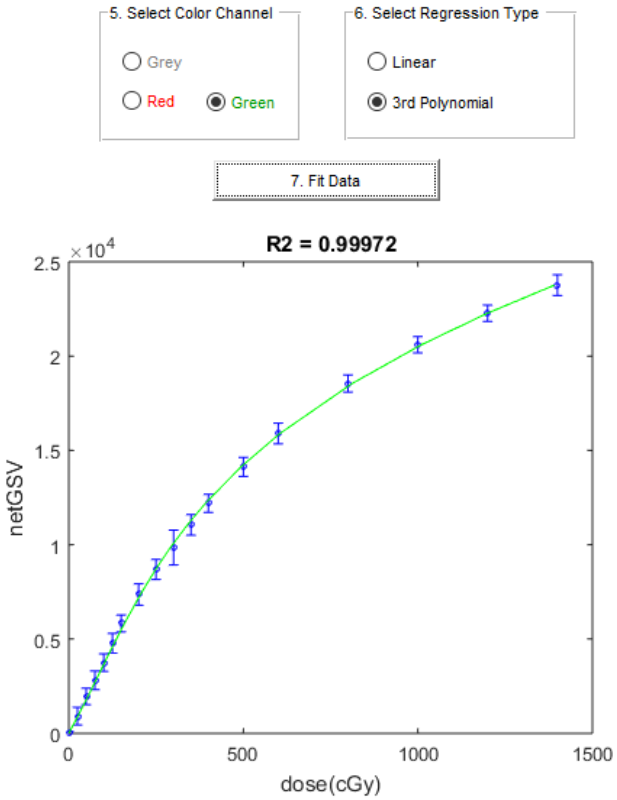
Enter the Physicist name and date (press enter for current date), then click on '**Report**'. A PDF report will be generated and user can save it to a desired location.

6. REV Film Calibration and Scanner Settings Summary

EBT3 film from batch #11091602 was calibrated on Kenny on 10 May 2017 for both relative dosimetry (linearity method) and absolute dosimetry for dose up to 14Gy. The results and recommended scanner settings are summarised below.

6.1 Absolute Dosimetry, High Dose (up to 14Gy)

At high dose range (up to 14Gy), green channel is recommended for absolute dosimetry.



The following scanning settings should be used:

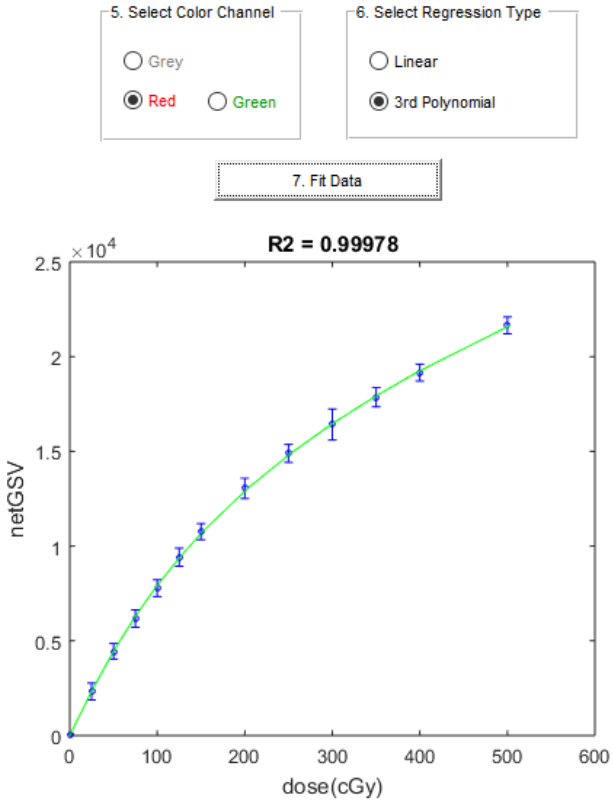
Color adjustment options	Off
Resolution (dpi)	127
Color format	48-bit RGB
File format	TIFF

Calibration file is saved to:

G:\PHYSICS\06 Dosimetry Equipment\15 Film Dosimetry\EBT3\REV film calibration 20170510\
exposure 14h\calibration GREEN 14Gy.csv

6.2 Absolute Dosimetry, Low Dose (up to 5Gy)

At low dose range (up to 5Gy), red channel is recommended for absolute dosimetry.



The following scanning settings should be used:

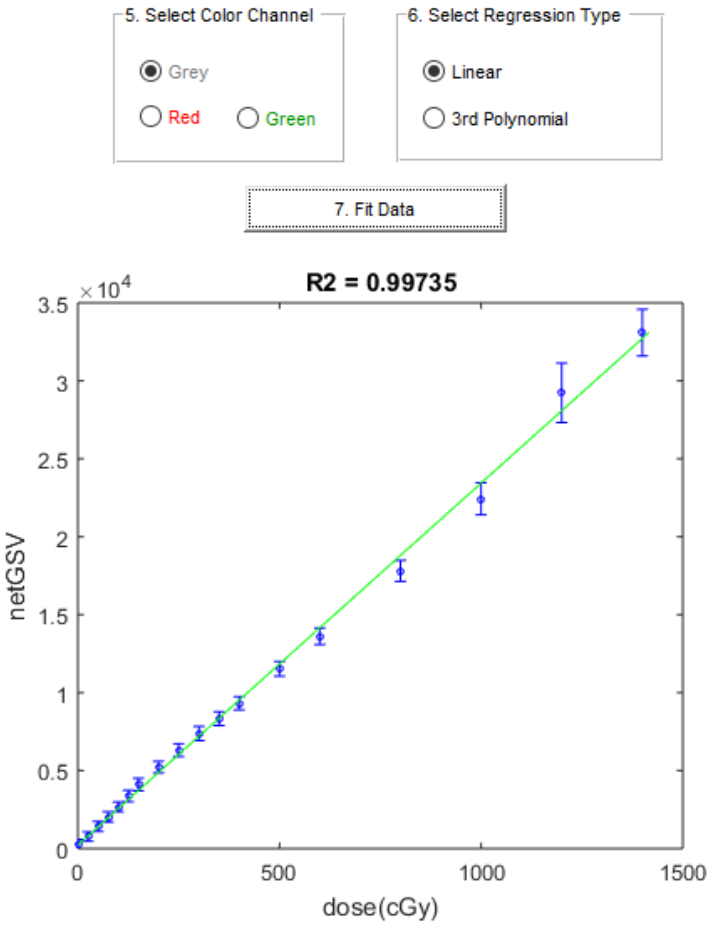
Color adjustment options	Off
Resolution (dpi)	127
Color format	48-bit RGB
File format	TIFF

Calibration file is saved to:

G:\PHYSICS\06 Dosimetry Equipment\15 Film Dosimetry\EBT3\REV film calibration 20170510\
exposure 14h\calibration RED 5Gy.csv

6.3 Relative Dosimetry

EBT3 film is suitable for relative dosimetry for dose up to 14Gy and greyscale image is recommended.



The following scanner settings should be used. calibration film and an unexposed film were scanned with the following parameters:

Color adjustment options	On
Resolution (dpi)	127
Auto-exposure	On
Histogram r	4
Brightness	-10
Contrast	+10
Color format	16-bit greyscale
File format	TIFF