Code of Practice: How to create a verification plan for OCTAVIUS in TomoTherapy

*Foreword: This note describes the implementation of OCTAVIUS with a TomoTherapy planning system ("*Accuray Planning Station*"). All included figures are related to verison 5.1.0.4 of the planning system.*

1 TPS dose calculation on the OCTAVIUS phantom

1.1 Preparations

Before the treatment plan can be calculated on the OCTAVIUS phantom a few preparation for system settings in the TomoTherapy Planning System have to be made:

- Establish Dicom-Export-Destination in TomoTherapy Planning System, preferably a third party treatment planning system (here: Oncentra Masterplan, Theranostic).
  Hint: A hardware drive cannot be addressed as a DICOM export destination.
- Import the kVCT-Scan of the OCTAVIUS phantom (with CT bottom part) into the TomoTherapy planning system from the third party treatment planning system, i.e. using ID = "_phantom". PTW recommends using the smallest achievable slice thickness.
- Mark the OCTAVIUS phantom with x-ray opaque markers at the isocenter and place the zero CT-line at the middle of the phantom, so an automatic detection of the isocenter and the green laser position could be guaranteed.

1.2 Performing the TPS dose calculation

Latest TomoTherapy systems are delivered with a treatment planning system that is divided into the actual patient planning station and the delivery quality assurance module (DQA Station). While the treatment plan for a certain patient has been approved on the patient planning station, call the DQA-Station on your computer for verification purposes. At first, the desired treatment plan has to be selected. Therefore open the Data Selection Dialog by clicking on the Icon "Select Patient" (Fig. 1).

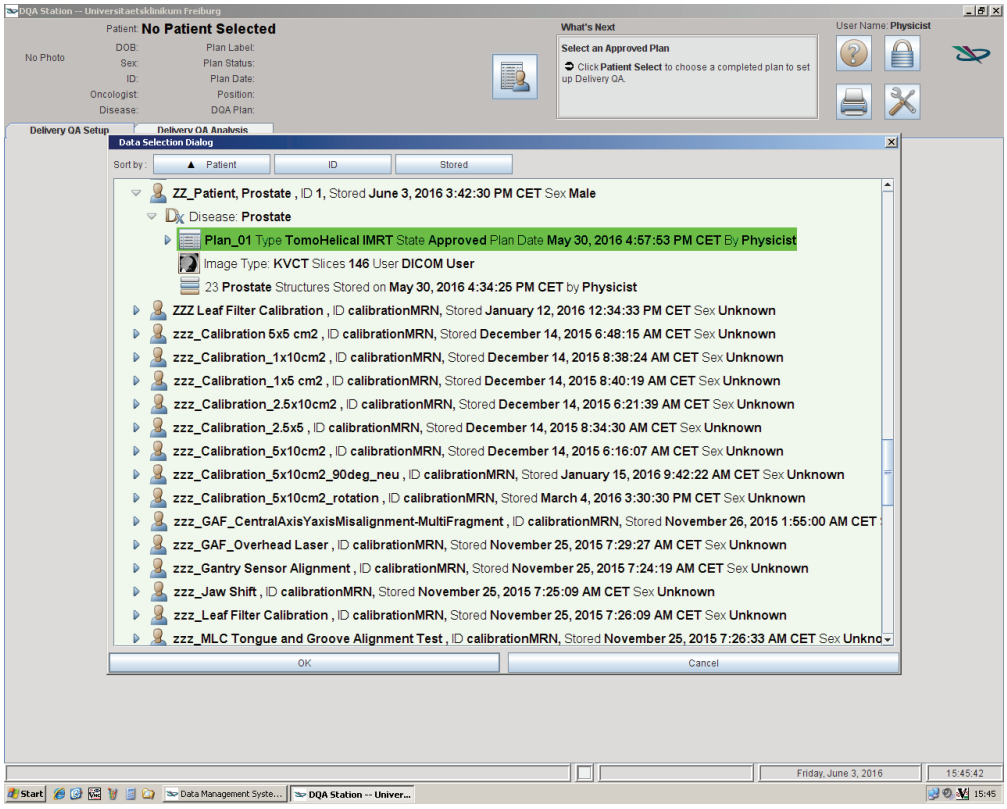

Fig. 1: Selection of the treatment plan that should be verified with OCTAVIUS

Select 'Delivery QA Setup' from register tab and click on "Phantom selector" (Fig. 2). The "Phantom Selector" is only available if a patient's treatment plan was selected in the previous step.

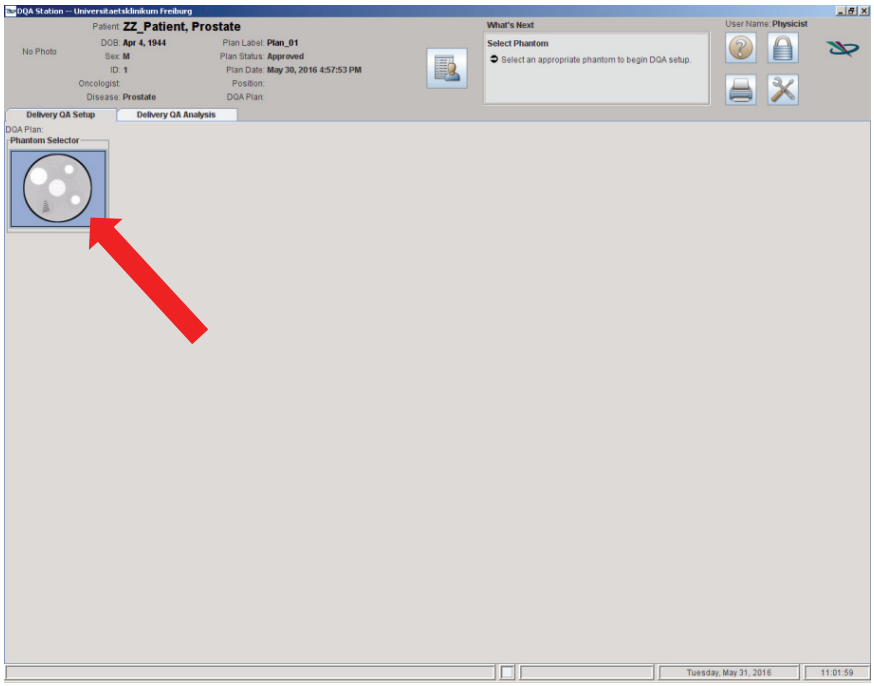

Fig.1: The "Phantom Selector" in Tomotherapy Planning System

Select the CT scan from the OCTAVIUS phantom from the verification phantom list (Fig. 3).

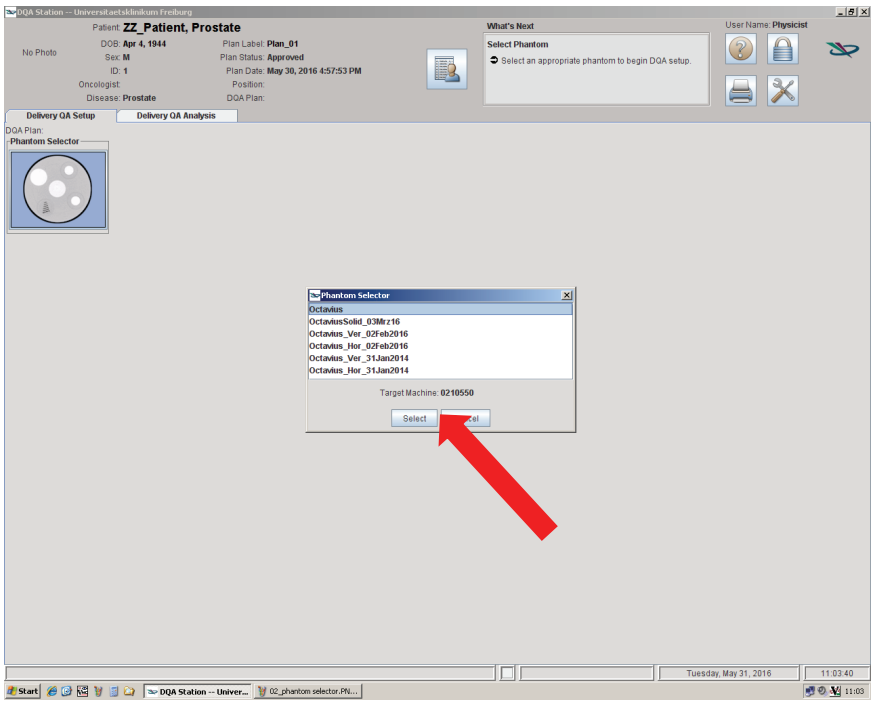

Fig. 3: The "Phantom Selector" with various phantoms. Choose the desired phantom (will be highlighted) and click then on "Select".

After the desired phantom was selected, the dialog in Fig. 4 will pop up ("Image Value-to-Density-Calibration Table Editor"). In this window you have to select an "Image Value-to-Density-Calibration Table" by highlighting the desired table. This table will be used for the conversion of HU-values to density values. By clicking on "Select" a plot of the calibration curve will be presented (Fig. 4).

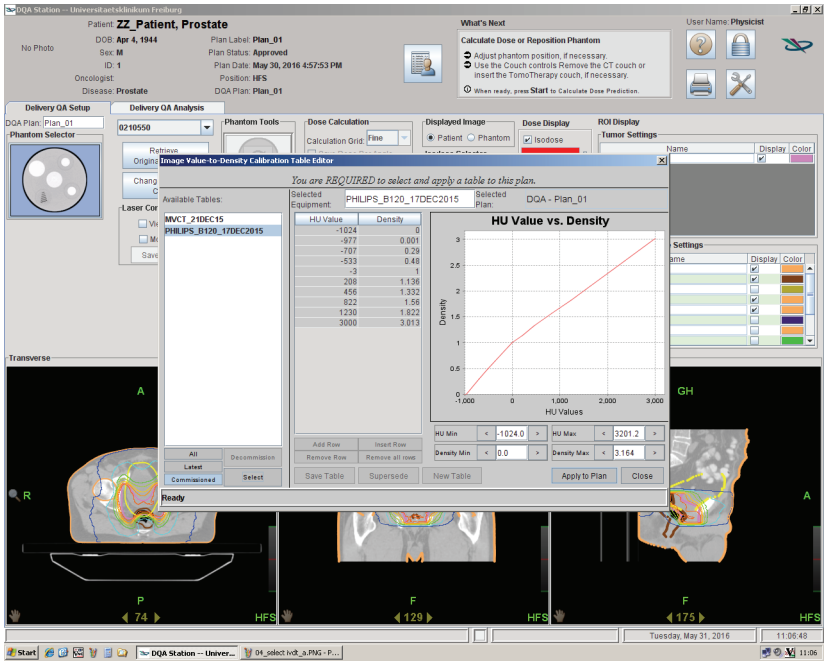

Fig. 4: The "Image Value-to-Density-Calibration Table". This table contains different CT calibration curves used for dose calculation in the following procedure. The calibration curve is exemplary shown in the presentation window.

Click then on "Apply to Plan". A "Confirmation" window will pop up (Fig. 5). Exit this window with "Close".

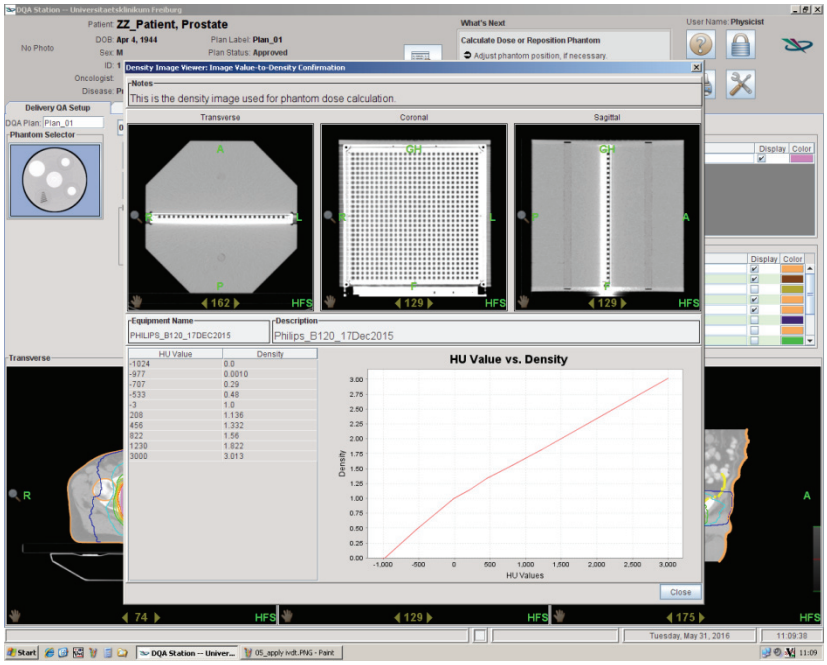

Fig. 5: The "Image Value-to-Density Confirmation".

The kVCT-scan of the OCTAVIUS phantom may not necessarily come from the TomoTherapy CT and, consequently, the patient couch may not be equal to the TomoTherapy treatment couch. Since the couch could have a strong influence on the measurement it should be taken into account for the DQ-planning. In order to receive correct dose calculation results on the OCTAVIUS phantom remove the CT couch and insert the TomoTherapy couch.
Click on "Change Phantom Couch". A window will pop were you can place a red line on the bottom of the OCTAVIUS phantom (Fig. 6). By clicking on "Remove Couch" any image information beneath the red line

is removed. With “Insert Couch” the TomoTherapy treatment couch model will be inserted at the same position. Confirm the replacement with “OK”.

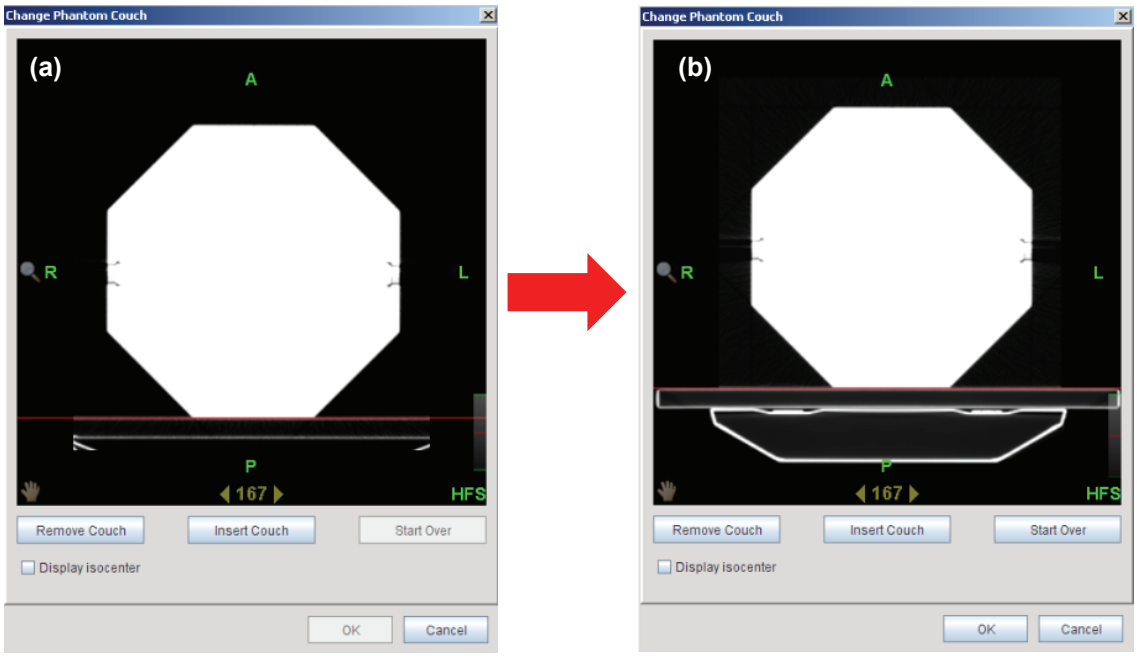

Fig. 6: Replacement of an arbitrary patient couch included in the CT data set of the OCTAVIUS phantom (a) with the TomoTherapy treatment couch (b).

Move to “Laser Control” and click on “View Lasers”. The machine isocenter will be presented by the green lines, while the red lines present the reference indicators (Fig. 7).

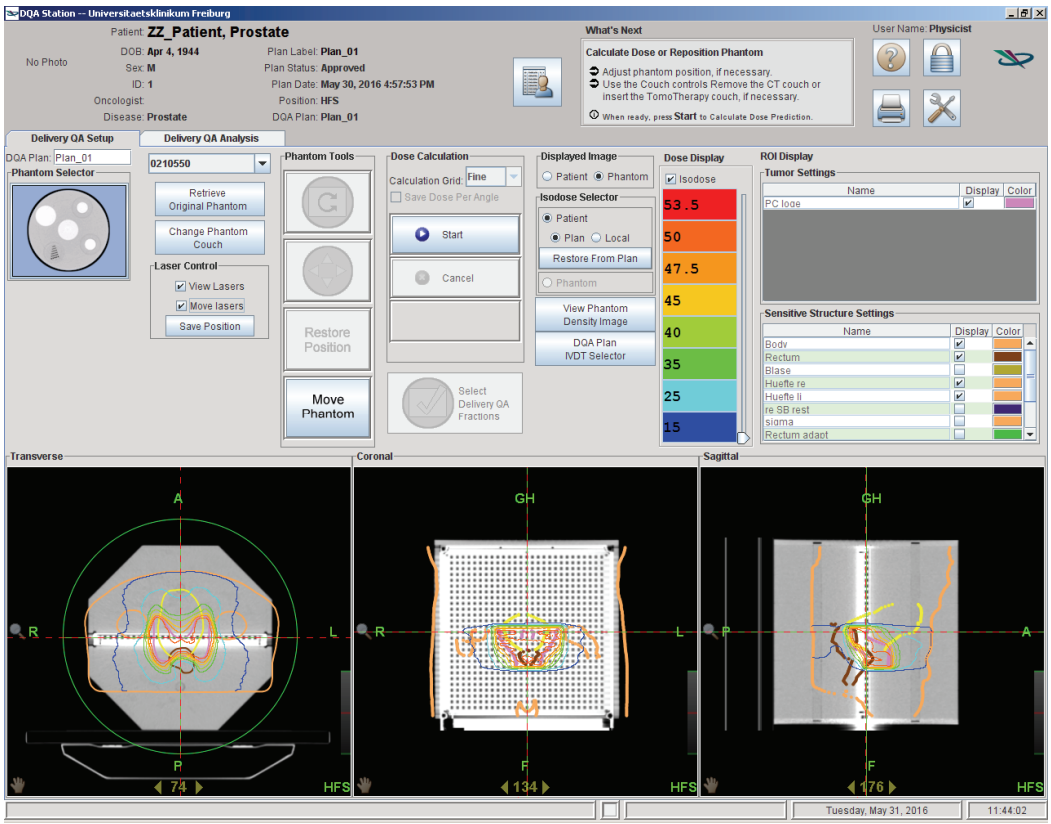

Fig. 7: Exemplary display of an overlay of the patient’s dose distribution with the CT data set of the OCTAVIUS phantom. The phantom matches the patient’s dose distribution completely.

In order to align the lasers click on “Move Lasers”, zoom the transverse, coronal and sagittal phantom view and select the mid slices to visualize the centered markers (the green lasers should be in the center of each view). Then place the red lines on the x-ray opaque markers of the OCTAVIUS phantom. Ideally, the red and green lasers now lie on top of each other and all lasers meet the center of the ionization chambers (Fig 7.). Click on “Save Position” to lock the laser position.

If the OCTAVIUS phantom has to be placed in a different position (i.e. a steep gradient has to be placed in the optimal position, or because the overlay of the patients dose distribution dose not match the phantom volume entirely) click on “ Move Phantom” and move the phantom in X,Y and Z-direction (Fig.8). PTW recommends to position the OCTAVIUS phantom in a way that the target volume is located in the center of each view.
After locking the phantom position with “Lock Phantom Position” place the red lines on the x-ray opaque markers of the OCTAVIUS phantom and lock the laser position. Now the red and the green lasers do not lie on top of each other due to the phantom shift (Fig. 8).

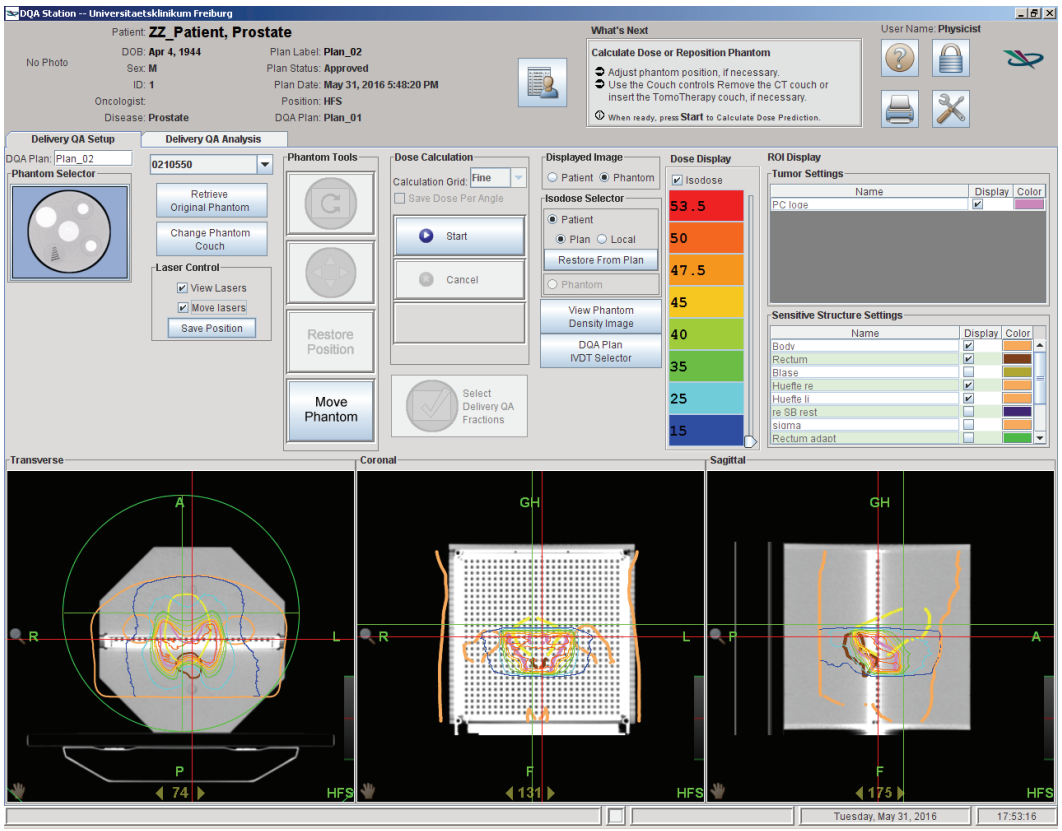

Fig. 8: Exemplary display of an overlay of the patient’s dose distribution with the CT data set of the OCTAVIUS phantom. The phantom had to be moved to better match the patient’s dose distribution.

Once the phantom is finally positioned the 3D dose calculation could be started. The calculation grid should be set to “Fine”, then click on the button “Start” and the calculation starts as could be seen in Fig. 9. A progressbar displays information about the calculation status (red circle).

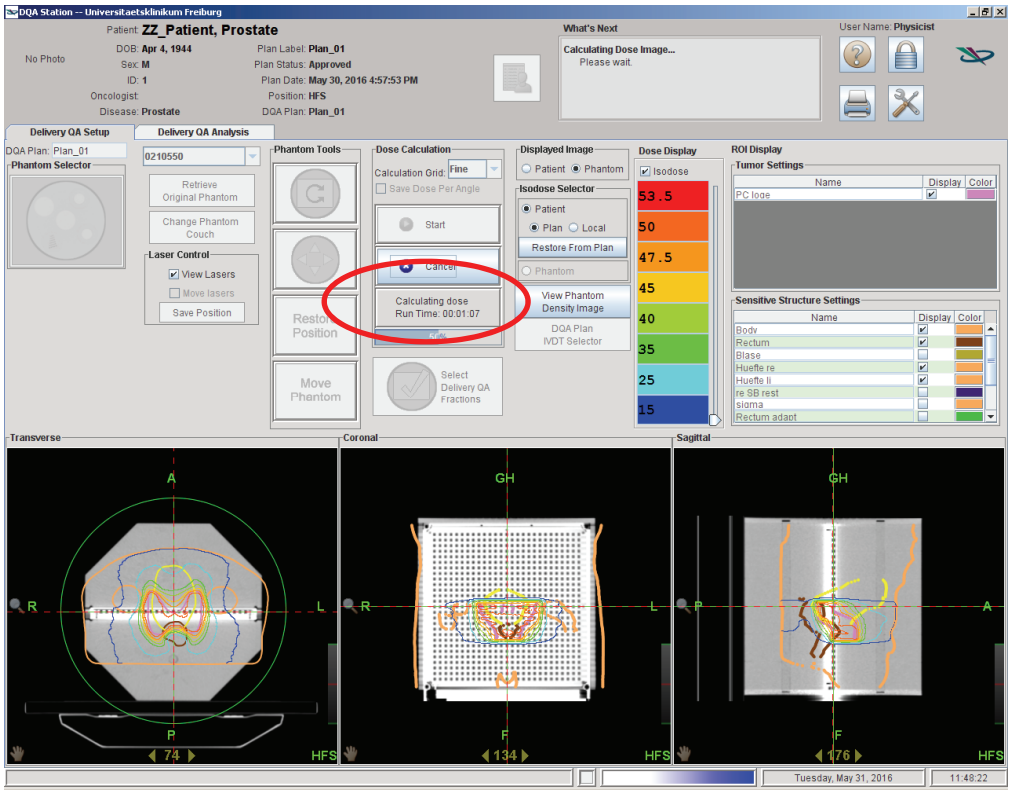

Fig. 9: Display of the dose calculation progress

After dose calculation the button “Select Delivery QA Fractions” is enabled. A click on this button opens the “Fraction Selector” dialog (Fig. 10). For each listed fraction, a DQA procedure will be generated.Click on “Accept”. The following dialog gives an overview of the planned QA procedures. Continue with “Proceed”.

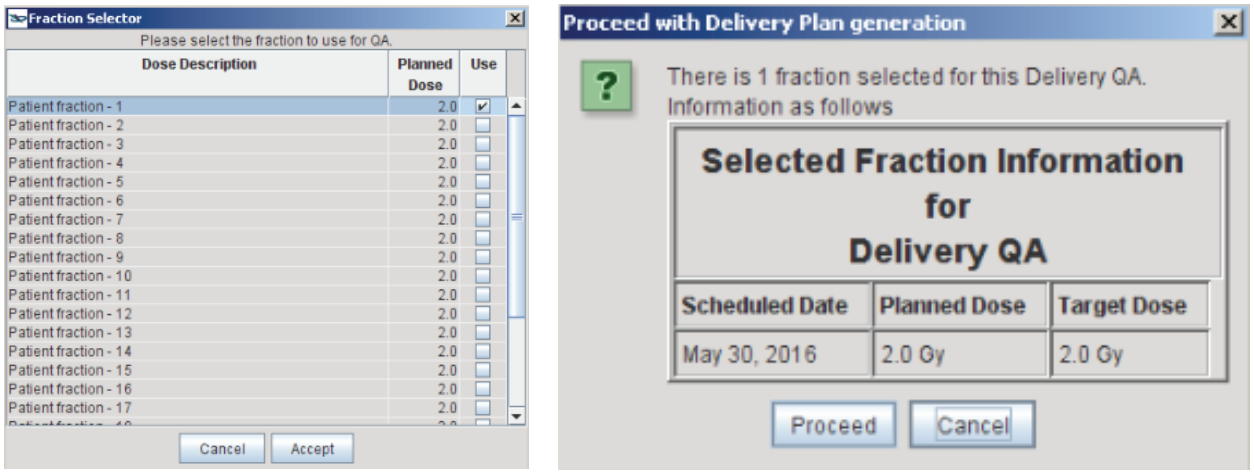

Fig. 10: Creation of a delivery QA procedure with the “Fraction Selector” dialog (left). A following dialog gives an overview of the planned QA procedures.

A message appears saying that the DQA-plan is now ready for delivery. Continue with “OK”.

In order to compare the calculated verification planning with measured data in VeriSoft, the verification plan has to be exported from the TPS. In “Accuray DQA station”, data cannot be exported while the actual phantom calculation is still opened. Thus, for data export click on “Display Tools menu” and close the calculation module with “Clear Selected Patient” (Fig. 11).

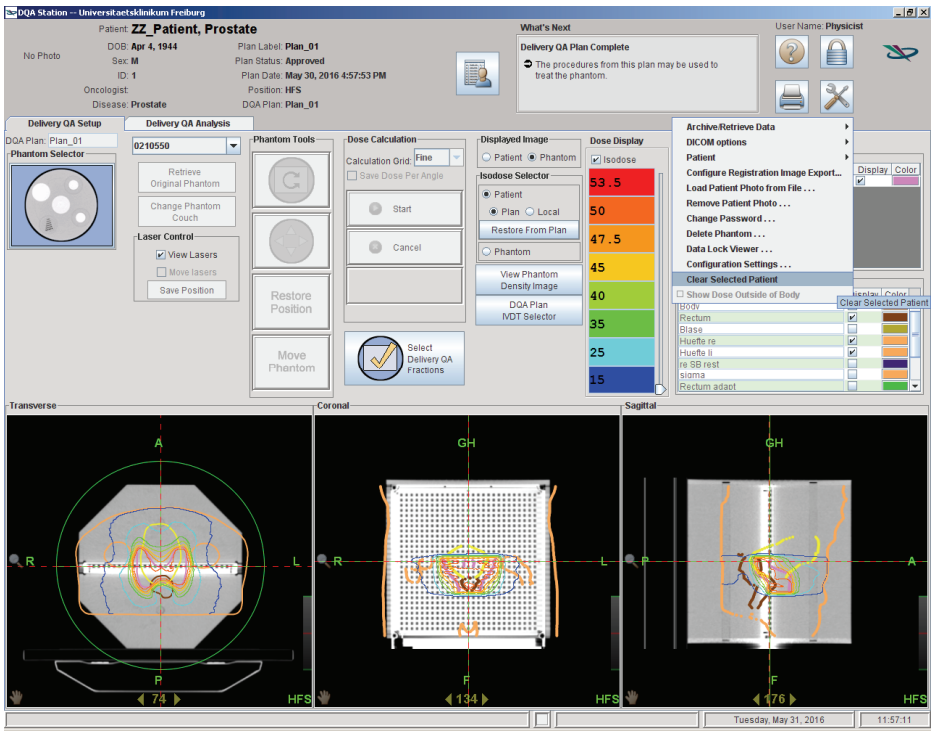

Fig. 11: Data export step I. Starting the data export from the TPS.

Continue by clicking on “DICOM options” and “Export items…”.

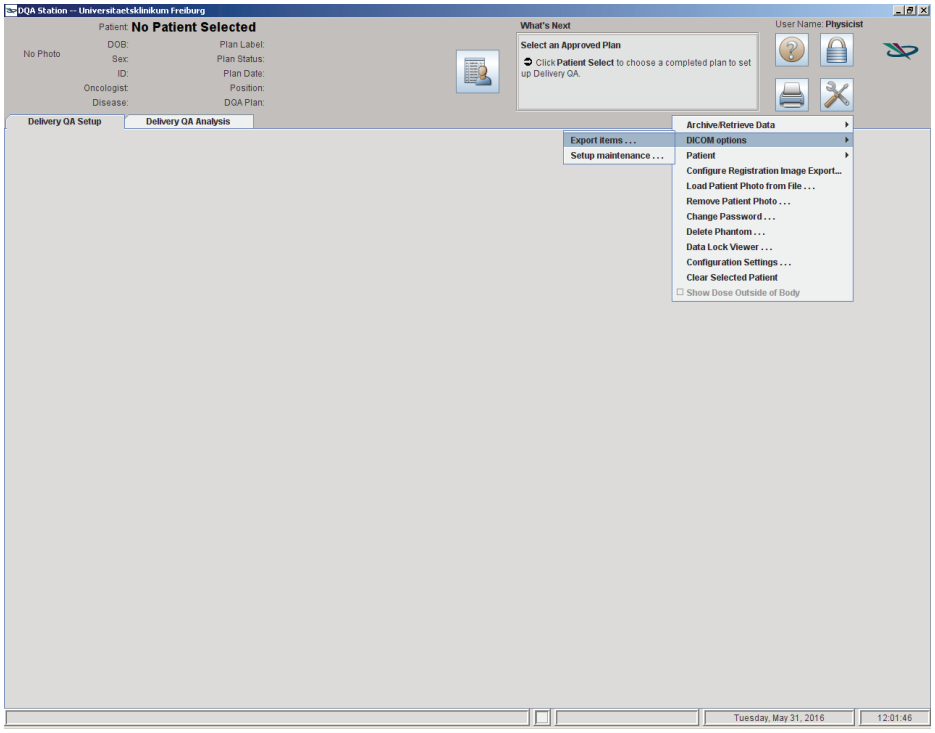

Fig. 12: Data export step II.

A patient / treatment list appears. Select the desired DQA-plan and the “Delivery_QA_Dose” highlighted in dark blue. Choose your export destination with “Export to” (Fig. 13).

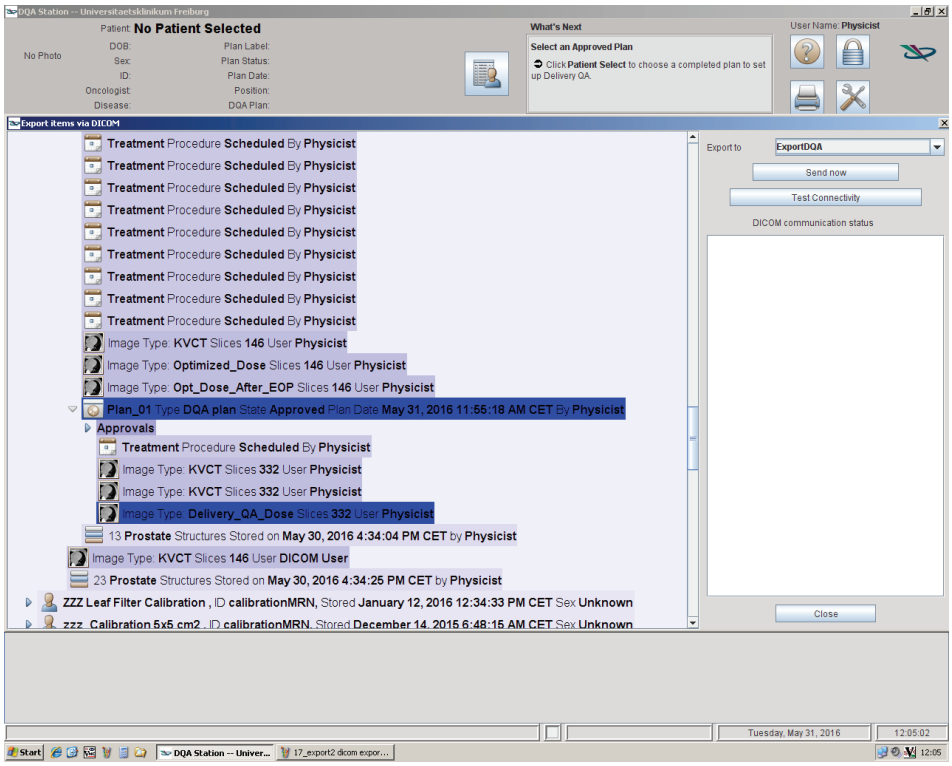

Fig. 13: Data export step III. Definition of the data that should be exported and the export destination.

Click in the right window “Send now” and the export will be performed. Then wait until the messages “RTDose Object sent“, “RTPlan Object sent“ and finally “Request succeeded” is displayed.

2 Performing verification measurement with OCTAVIUS

2.1 Performing the cross-calibration

2.1.1 Creating a simple treatment scenario for cross-calibration in the TPS

You can either perform a cross calibration by measuring the dose in the phantom using a chamber plate (available for Farmer chamber, Semiflex chamber and PinPoint chamber) or calculate the expected dose by means of your TPS as described in the following:
Start the TomoTherapy Planning Station and insert a new plan to calculate the cross-calibration values for the OCTAVIUS detector in the octagonal phantom. Then place a cylinder ROI (i.e. length 5 cm, diameter 10 cm) in the CT of the phantom (Fig. 14). The central chamber has to be positioned in the isocenter.

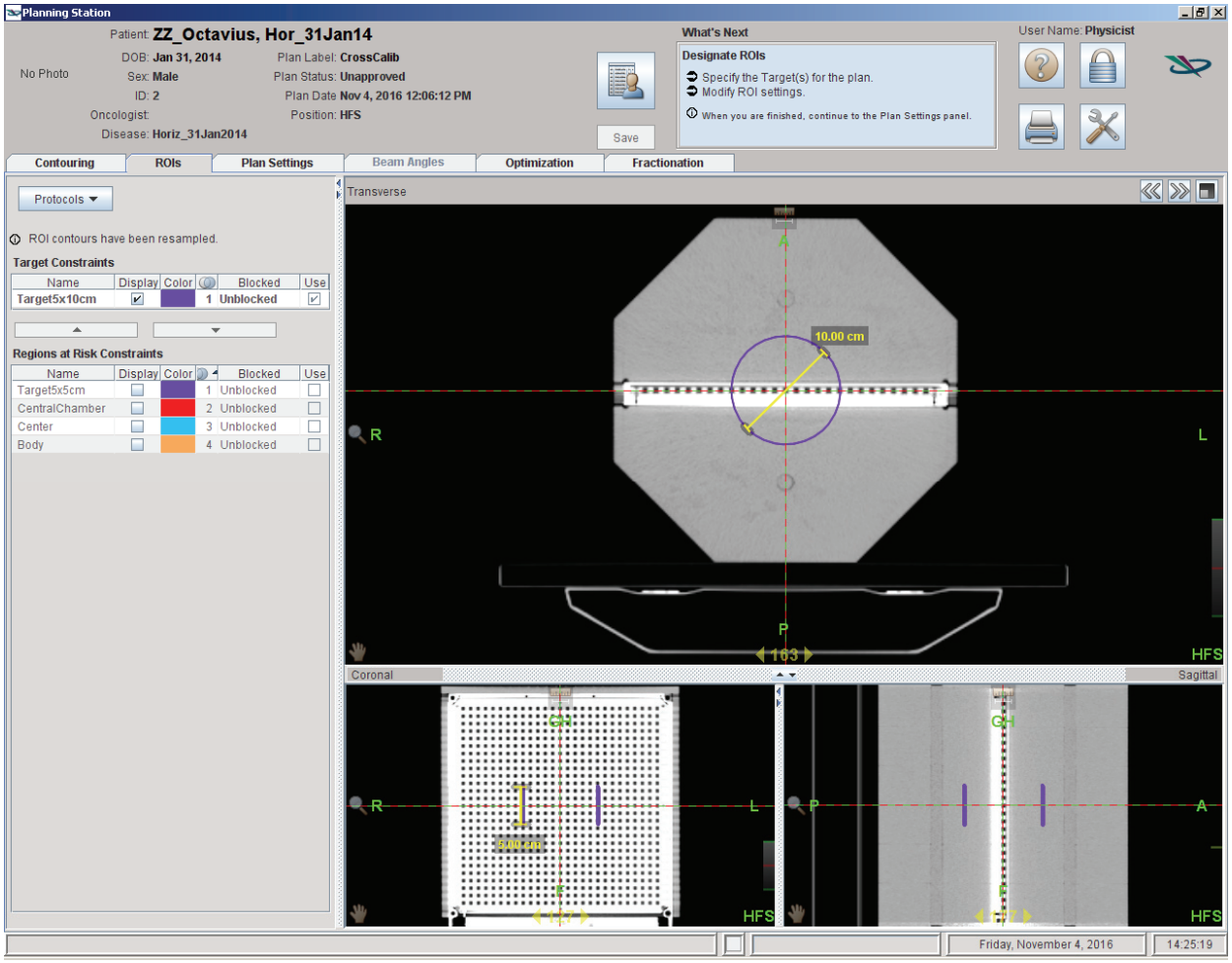

Fig. 14: Exemplary definition of a cylinder ROI (leght 5 cm, diameter 10 cm) in the CT dataset.

Assign a certain dose to the cylinder ROI (i.e. 2 Gy) and calculate the plan for a helical field (Fig. 15). Read out the isocentric dose from the calculated plan (Fig. 16) and copy it to a nice and clean post-it selected for this purpose only. Note, since in the TomoTherapy Planning Station inverse treatment planning is performed, the isocentric dose can slightly differ from the prescribed structure dose.

Approve the plan and deliver the field in QA mode on the TomoTherapy machine.

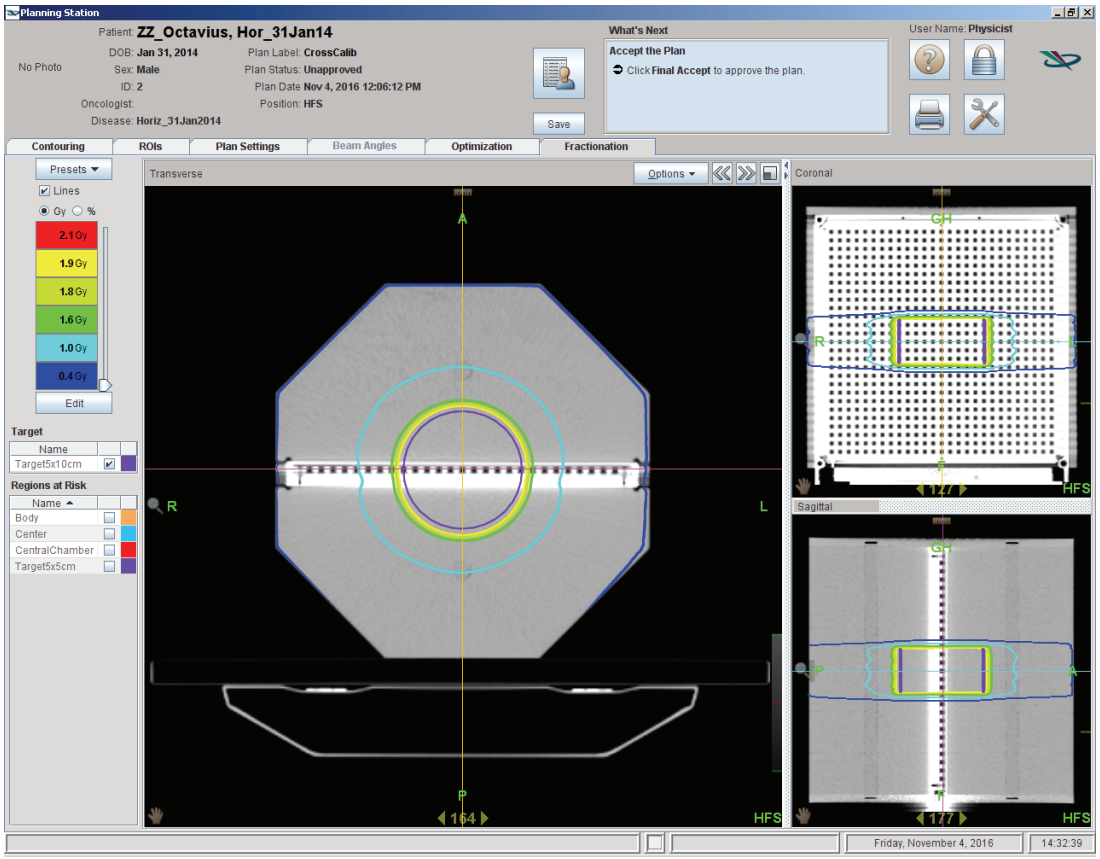

Fig. 15: Calculated phantom dose for the cylinder ROI assigned with an exemplary dose of 2 Gy.

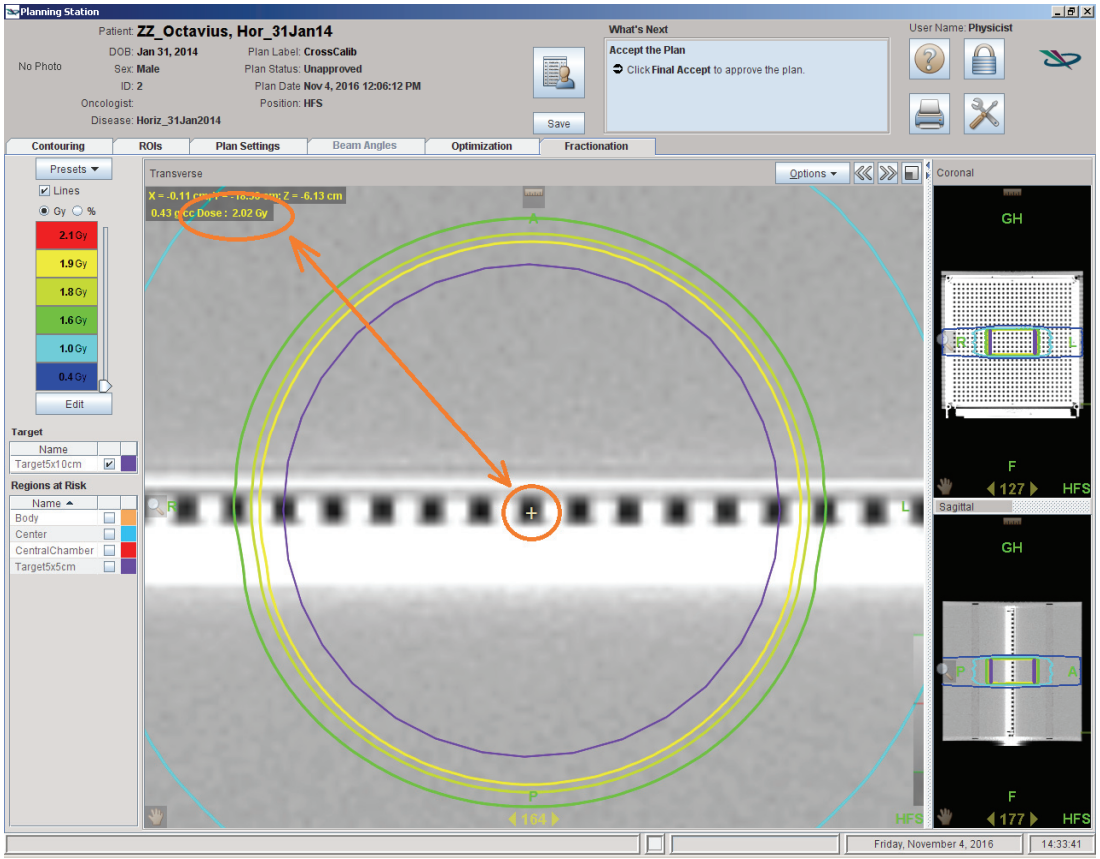

Fig. 16: Display of the isocentric dose of the calculated plan.

2.1.2 Hardware & software setup

Experimental Setup:
Carefully set up the OCTAVIUS phantom in the desired position using the red lasers for alignment. To simplify the alignment the positioning device with adjustable legs could be used.
Make sure all cables are properly connected and initialize the phantom.

Note: Depending on the detector (OCTAVIUS 729 or OCTAVIUS 1500), the phantom bottom parts are characterized by different shaped air cavities. These cavities account for the difference detector response at different beam angles. Due to varying detector designs, the cavities have different forms and, consequently, each phantom bottom part is related to a certain detector. Hence, make sure the right bottom part of the OCTAVIUS phantom is affixed.

Launch the VeriSoft application. From the 'Tools' menu, make sure the correct devices are selected from the 'Measurement options' menu. For example:

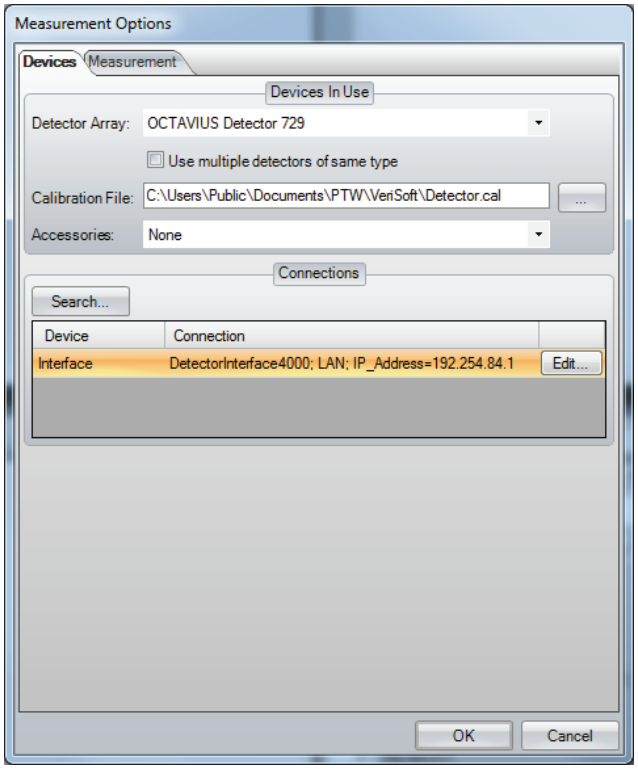

Fig. 17: Selection of measurement devices in VeriSoft

Make sure you have copied the detector calibration file to an accessible data folder and point the software to this 'Calibration File'.
Use the 'Search' button to automatically connect to the selected devices.

If there is no connection to the devices possible, it might be your firewall that prohibits the connection to an external device. In this case press **Ctrl** + **Alt** + **A**. A button "Firewall" appears. This button allows you to stop your local firewall.

Note: Make sure your firewall is switched on again if you use your computer for other purposes.
For detailed information about network connections with PTW devices visit the trouble shooting page on the PTW website (http://www.ptw.de/support_overview.html?&cId=3571)

In the 'Options' menu, set the preferences. For example, set up the connection to a DICOM server if you intend to connect VeriSoft to your DICOM server (Fig. 18). You might need help from your IT-department for the settings.

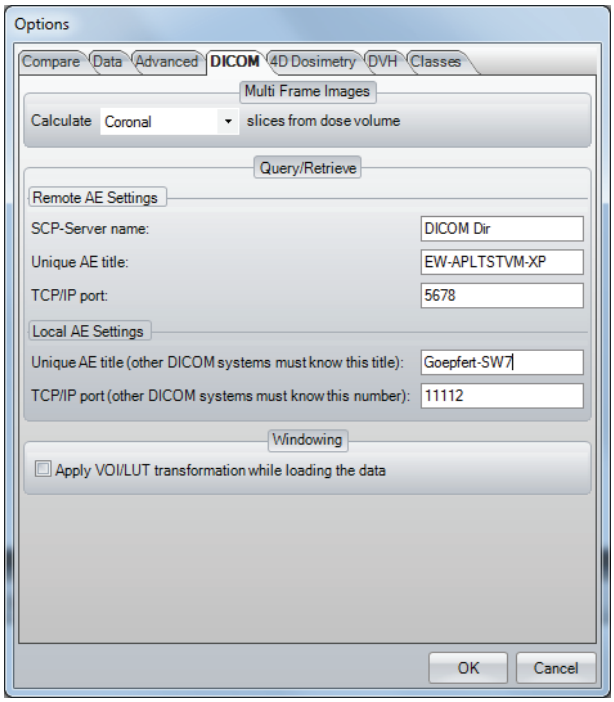

Fig. 18: Exemplary adjustment of the 'DICOM' tab in the 'Options' menu in VeriSoft

2.1.3 Performing the measurement for cross calibration

From the 'Edit' menu, open the 'Measurement parameters' dialog box (see Fig. 19).

First, make sure the 'Show dialog on next measurement' is checked to prevent inadvertent use of inappropriate correction factors for absolute dosimetry during measurements.

Select the 'Cross calibration' option and fill out the 'Expected value' text box with the value you have neatly copied down on the clean and dedicated Post-it:

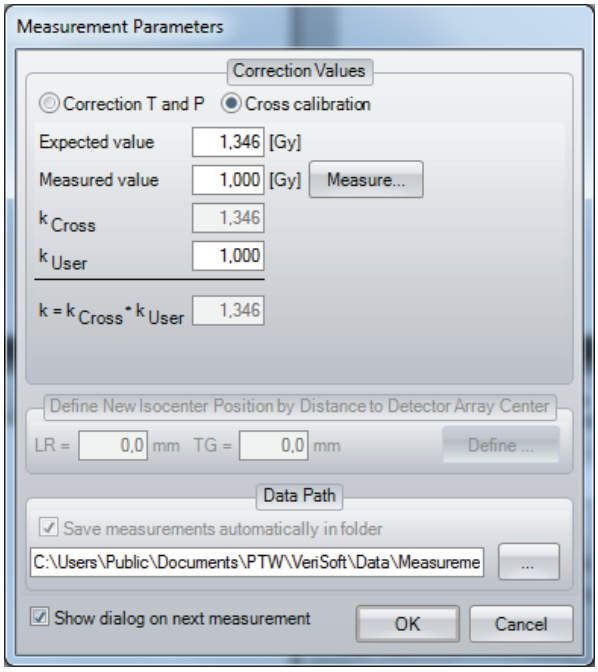

Fig. 19: Exemplary adjustment of the dialog box 'measurement parameters'

Note: In performing the cross calibration procedure like this, you assume that the TPS calculation for the calibration field is accurate at the isocenter and you avoid all impact from the daily output variations of the LINAC in your validation measurements.

Click on the ‘Measure’ button. The ‘Measurement’ window will now open automatically and if no zero measurement has been performed within the specified time period, you will be prompted to perform one before proceeding.

Deliver the approved plan designed before for cross-calibration (see 2.1.1).

Note: Repeat the measurement at least three times to make sure the electronics and detector are well warmed up and the signal is stable. Press “Start” to do so. The measurement will be discarded. Therefore it is advisable to store the OCTAVIUS phantom in an environment that has the same ambient temperature as the treatment room to avoid gradual temperature changes in the phantom during the course of the measurements.

Accept the measurement.
The cross calibration correction factor is now automatically calculated, filled out and this value will be used until explicitly modified again by the user.

Perform one additional verification measurement:
Re-measure the calibration field with the newly acquired cross calibration factor to make sure the measured value of the central chamber agrees with the expected TPS value within 0.5%.

*Note: It is good practice to store this verification measurement for every measurement session for possible future reference. For example, save. as ‘6MV_10x5_date.mcc’. The simple *.mcc format is largely sufficient for this purpose.*

3 Performing patient plan verification with OCTAVIUS

3.1.1 OCTAVIUS dose measurements

Set up the phantom and Verisoft software as described in the previous paragraphs.
Make the patient's verification plan ready for delivery and move the gantry to its starting position.
Start the OCTAVIUS measurement:

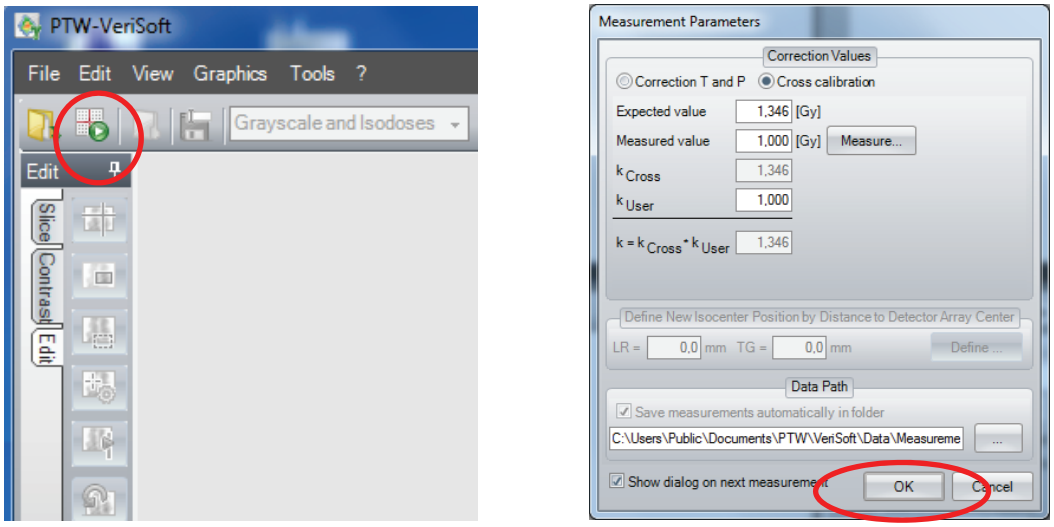

Fig. 17: Exemplary adjustment of the dialog box 'measurement parameters'. The OCTAVIUS measurement starts by clicking on 'OK'.

The measurement window appears showing the actual dose delivered to the detector.

Start the treatment delivery.
Stop the OCTAVIUS measurement upon completion of the delivery by clicking on "Stop". Save the measured data in *.mcc file format, and click on "Accept" to automatically return to the VeriSoft analysis software.

3.1.2 OCTAVIUS dose evaluation

Open the calculated 3D dose export in the 'Data Set A' window (File – Data Set A - Open … *Select your path*). A dialog box „DICOM Isocenter Position" appears. VeriSoft calculates the isocenter position depending on the adjustments in this dialog.
When the dcm image origin coincides with the isocenter, there is no need to import the corresponding RTplan. Selecting the first option only 'Use DICOM tag ImagePositionPatient …' will then suffice to assure correct 3D alignment between measured and imported 3D dose distribution. If the dcm image origin not coincides with the isocenter enable additionally the second option and select the appropriate path to the RTPlan file (Fig. 18).

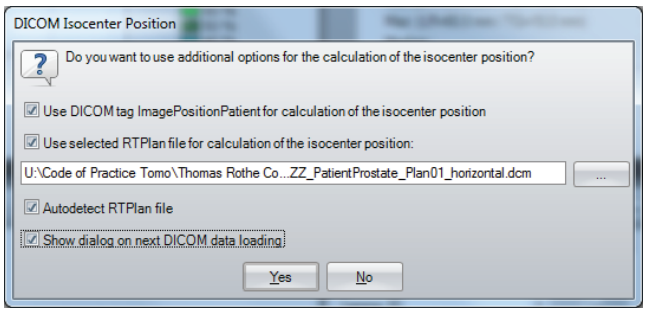

Fig. 18: The dialog box 'DICOM isocenter position' appears when the TPS dose matrix is opened

Open the measurement in ´Data Set B´ window (File – Data Set B - Open… Select your path).
Select the coronal view to enable a comparison of both planned and measured dose matrices. Figure 19 shows an example:

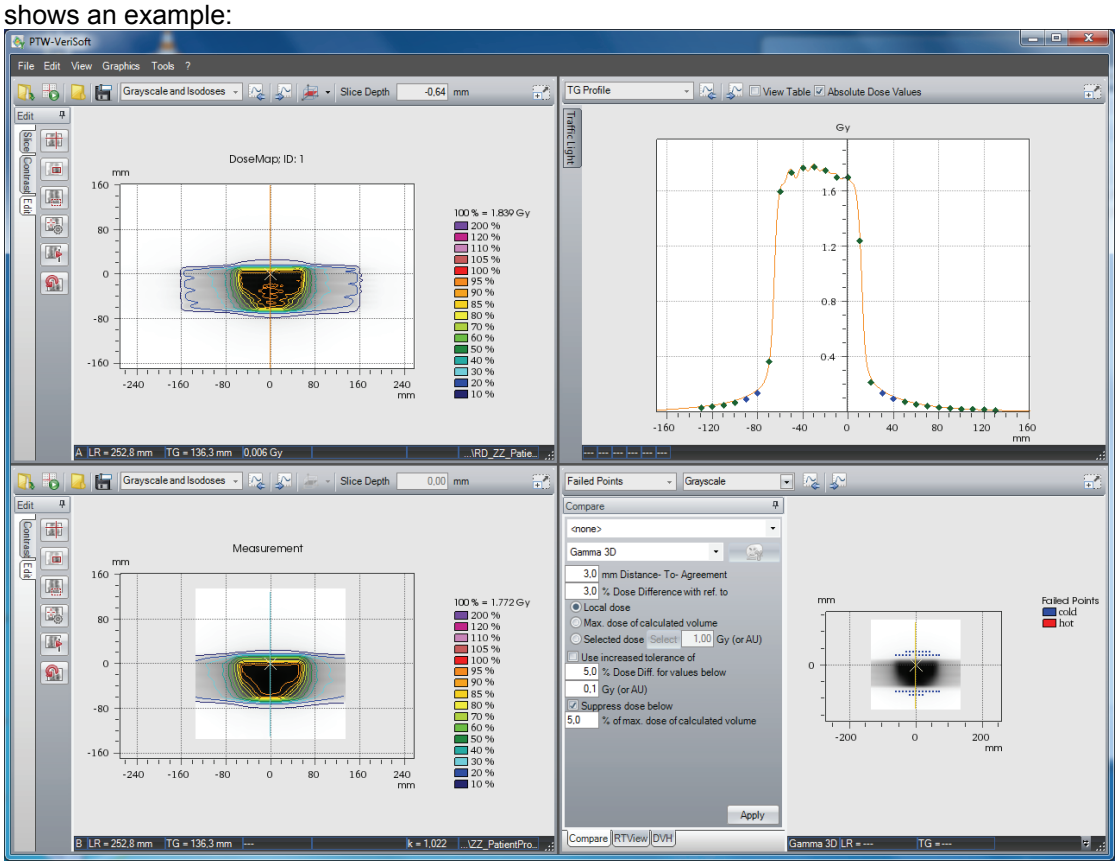

Fig. 19: Exemplary presentation of a verification plan. Dataset A shows the TPS dose matrix. Dataset B represents the measured dose distribution.

Thank you to Dr. Thomas Rothe from Medical Center – University of Freiburg who provided all necessary information.

Disclaimer

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