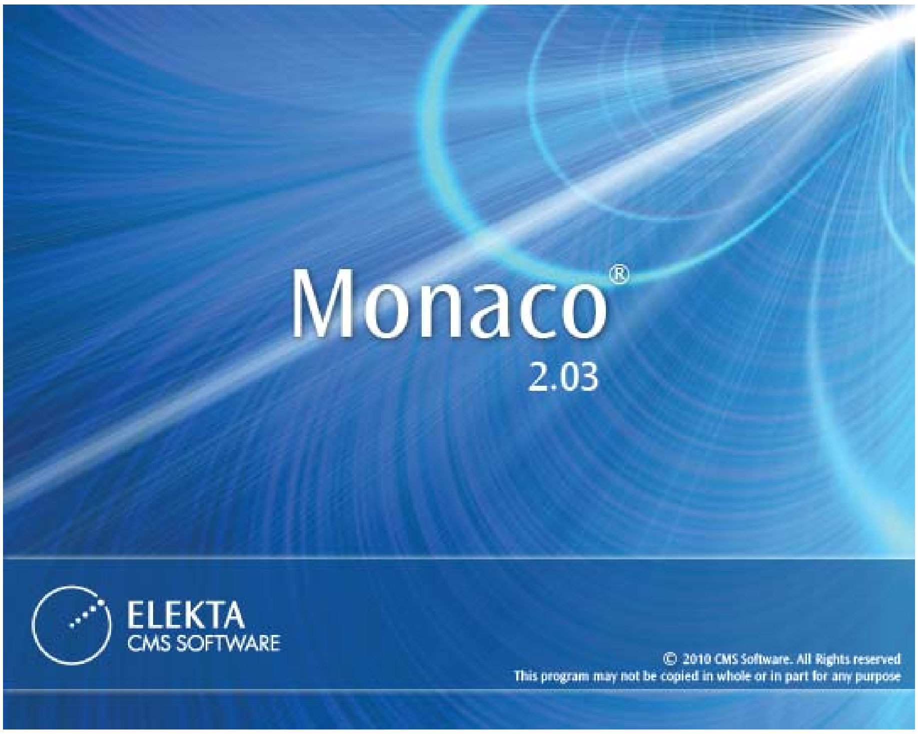
Code of practice: Create a verification plan for OCTAVIUS in CMS Monaco®

1.1 CMS SOFTWARE, Monaco® IMRT[1] plan QA

1. Before starting with IMRT plan QA

A first hint is to keep a good CT scan of the PTW 2D-ARRAY inside the relevant measuring phantom (PTW OCTAVIUS, PTW RW3 slab phantom, ...) in Monaco database, already with the external contour and an interest point exactly placed in the effective measurement point of the PTW 2D-ARRAY (helpful for isocenter placement), that is the middle of the central chamber (7.5 mm below the surface of the detector).



In Monaco there's a section of the database dedicated to QA purposes, called "QA clinic"; here are some useful tips for the users:

- import and save in the QA clinic each QA phantom image set to be used for IMRT plan QA with a name different than any possible patient image set, because the phantom image set is copied into the same data location as patient image sets every time a new QA plan is created;

[1] in this document, IMRT is used in the widest meaning and includes all the LINAC and MLC based techniques, with fixed and dynamic gantry

- name the external contour of the phantom the same name used for the external contour of a patient. The phantom is not available if the external contour names of the phantom and the patient are not the same. The user may prefer to duplicate several times the external contour of the phantom (using different possible names) and decide every time is needed which one is to be considered the external contour, editing and saving the modified phantom (Figure 1):

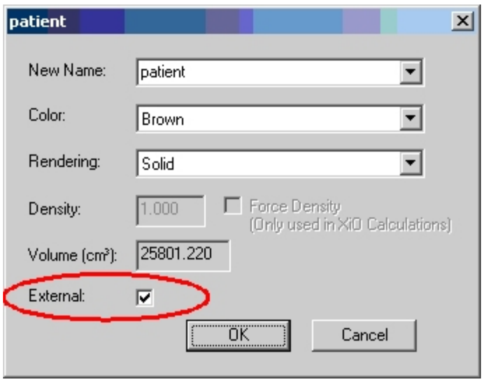


Figure 1 - Monaco structure properties window: the user has to put a checkmark on "External" to tell Monaco what structure is the external contour

- a valid CT-to-ED conversion file has to be present inside the QA clinic and assigned to the phantom.

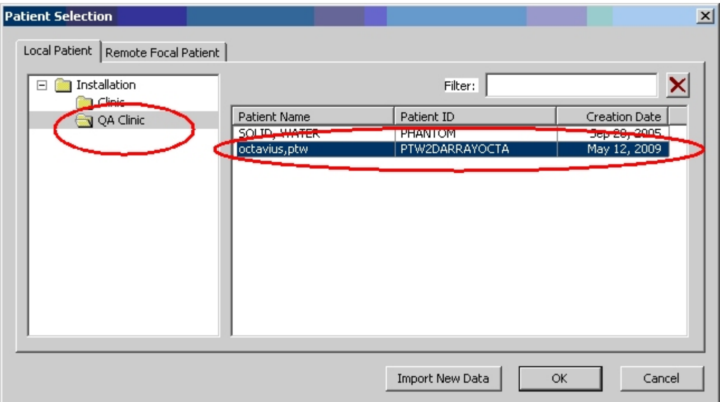


Figure 2 - Monaco "Patient Selection" window

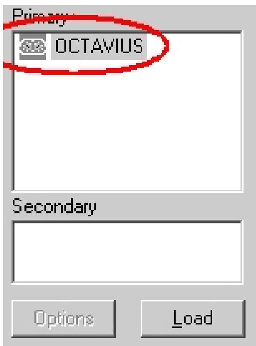


Figure 3 - This is Monaco image set selection list; note the name "OCTAVIUS" different than usual patient image set names, like "CT1", "CT2", "CTn"

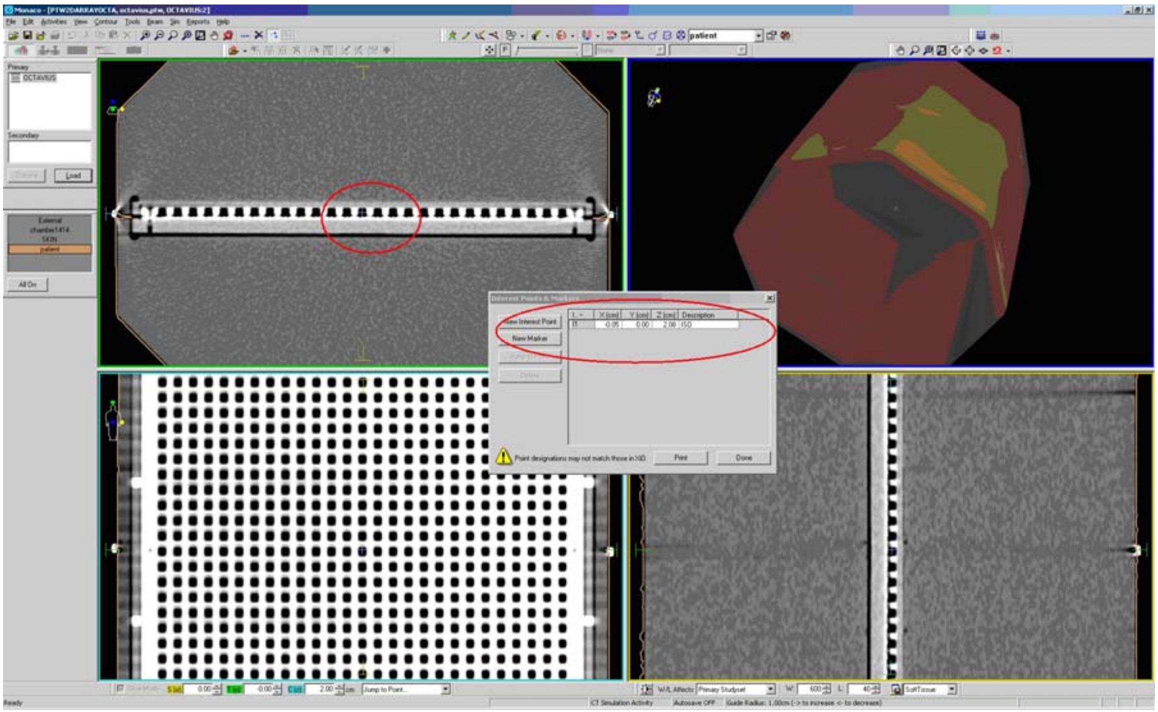


Figure 4 - Example of CT scan with external contour and interest point

2. Creation of IMRT plan QA

Every time one or more IMRT plans are calculated and saved inside Monaco patient database, it's possible to recalculate these plans on a different CT image set, that is typically a "detector + phantom setup" CT image set.

The user should follow the steps here below described:

- load an IMRT plan already calculated and saved with a valid dose distribution, identified by the following icon:

- click on "IMRT QA" button (Figure 5);

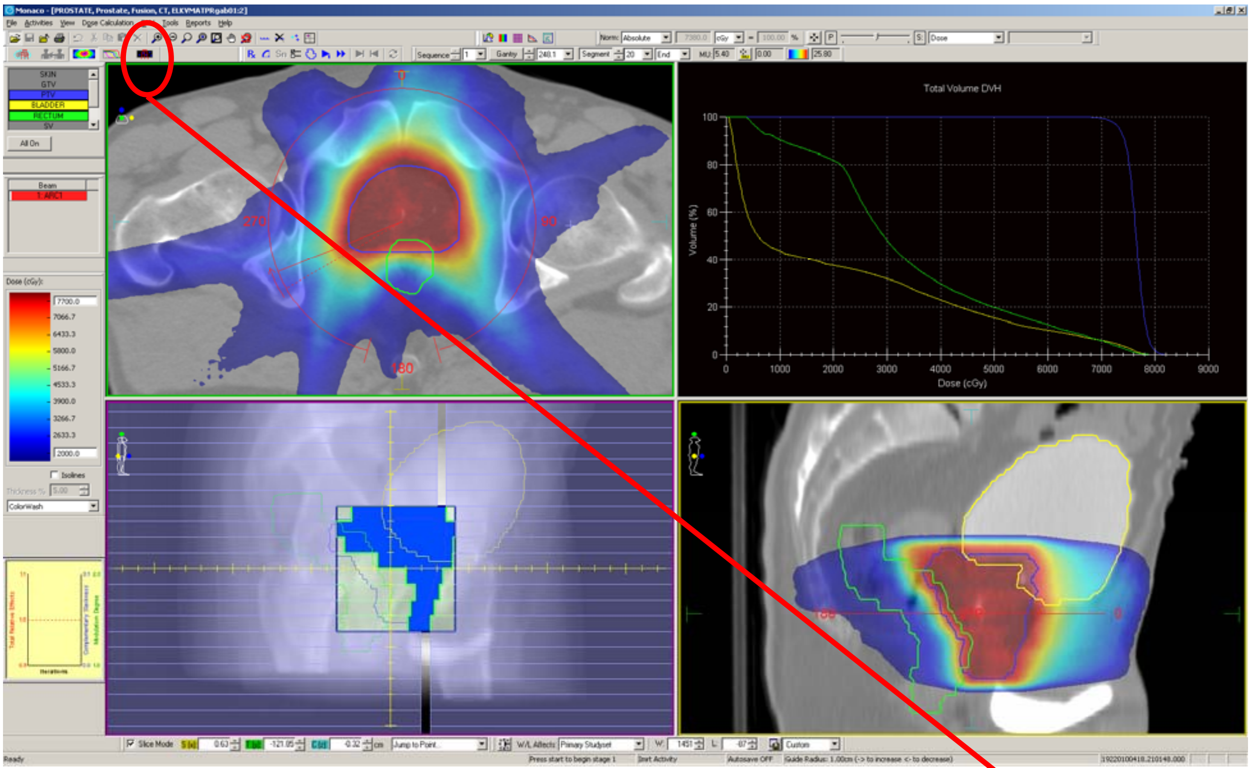
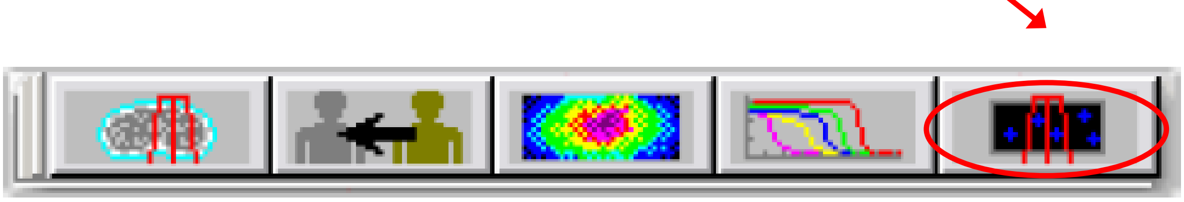


Figure 5 - Monaco "IMRT Planning" window and Activity Toolbar (zoomed below)



- select the QA phantom image set to be used for IMRT plan QA (Figure 6 and Figure 7) and the desired calculation parameters (for clinical patient QA, suggested algorithm is Monte Carlo, a grid spacing of 0.3 cm is recommended, in case of Monte Carlo a variance between 0.5% and 2% is recommended);

  HINT: if the aim of the IMRT plan QA is to check independently each single field at nominal gantry angle (0°, using the PTW 2D-ARRAY inside the PTW RW3 slab phantom, for example), then the user has to select "All Beams/Sequences at nominal angles";
  HINT: if the aim of the IMRT plan QA is to check the full plan at once, with a single measurement, keeping the original gantry angles (using the PTW 2D-ARRAY inside the PTW OCTAVIUS phantom, for example), then the user has to set "All Beams/Sequences at original plan angles";
  HINT: if the user has to force the electron density of the QA phantom to 1.00 or any other value, a checkmark should be placed next to the "Uniform Density Override" option and the desired electron density value should be typed in;

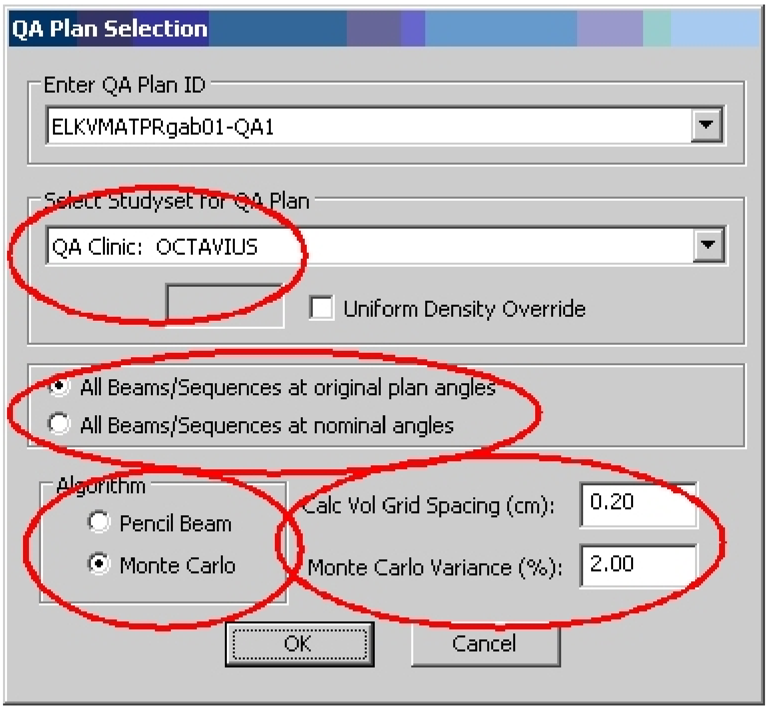


Figure 6 - Monaco "QA Plan Selection" window

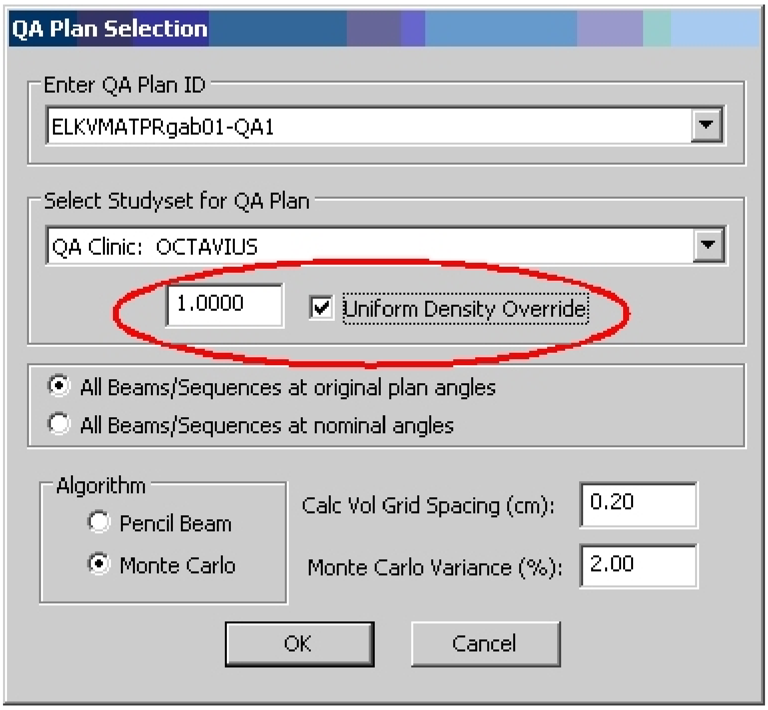


Figure 7 - Monaco "QA Plan Selection" window

- set the isocenter location of the plan being recalculated for QA aims (Figure 8);
  HINT: here the user can take advantage of having saved the "detector + phantom setup" CT image set with an interest point exactly placed in the effective measurement point;
  HINT: in Monaco, the calculation region volume encompasses all structures listed on the prescription dialog. Monaco requires for patient contours to be contiguous; if the user desires a smaller calculation region, it can delete external contours from the superior and inferior slices. In any case, for Monaco versions 2.03.01 or earlier the calculation region center is always in the middle of the calculation region volume, so it's not necessarily coincident with the isocenter of the plan nor the effective measurement point of the detector;

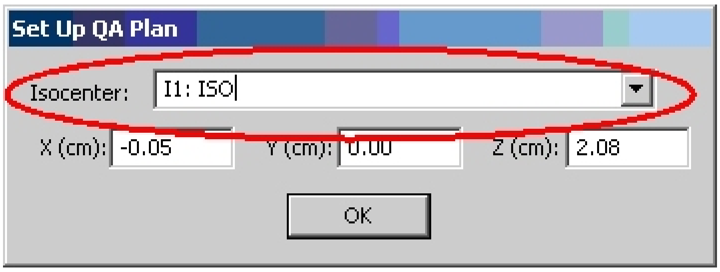


Figure 8 - Setting the right isocenter location

- if needed, the user may create any interest points to get dose values at the end of the calculation, using the command "Tools | Interest Points & Markers" (Figure 9);
  HINT: evaluating Monte Carlo doses have inherent statistical uncertainty, it's recommended to sample a user defined volume instead of a point. For example, radius value should be approximately the radius of the chamber;

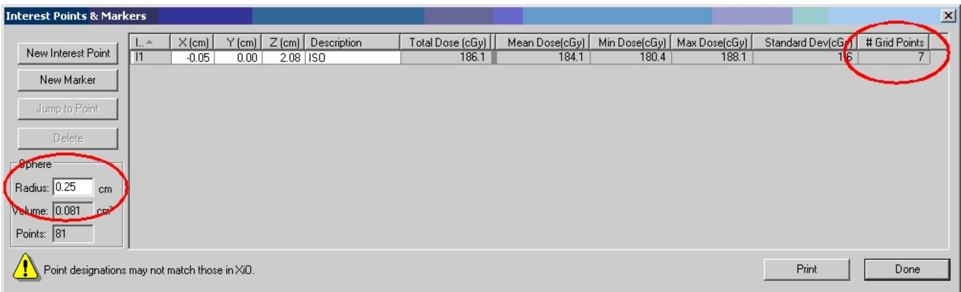


Figure 9 - Monaco "Interest Points & Markers" window

- before starting the dose calculation, the user may need to add also an open field as simple “calibration plan” with only one homogeneous field, having a field size of 10 cm x 10 cm, gantry and collimator angles of 0°, beam quality and isocenter position identical to those of the IMRT fields of the plan to be checked, monitor units adjusted to an isocenter dose Dcal = 1.00 Gy, for example. This calibration field is always treated as the first field of a verification session and the central axis dose Dm is measured with the PTW 2D-ARRAY, to obtain a calibration factor f = Dcal/Dm, which is used for the correction of all later verification measurements. This procedure could be suggested according to the following considerations: although the PTW 2D-ARRAY is already calibrated in absorbed dose to water, normally each measurement must be corrected for different air pressure and temperature, for the used photon quality and for possible non-water equivalent properties of the phantom. To avoid these corrections, which are time-consuming and susceptible to errors, the use of a simple calibration field with a known dose, which is delivered before each verification measurement, could be a good method, having also the additional advantage that it also corrects for possible deviations in the output calibration of the linear accelerator. To add an open field, the user should click on the "New Beam" button and enter relevant information (Figure 10 and Figure 11):

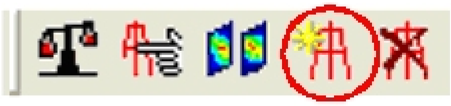


Figure 10 - Monaco "New Beam" button

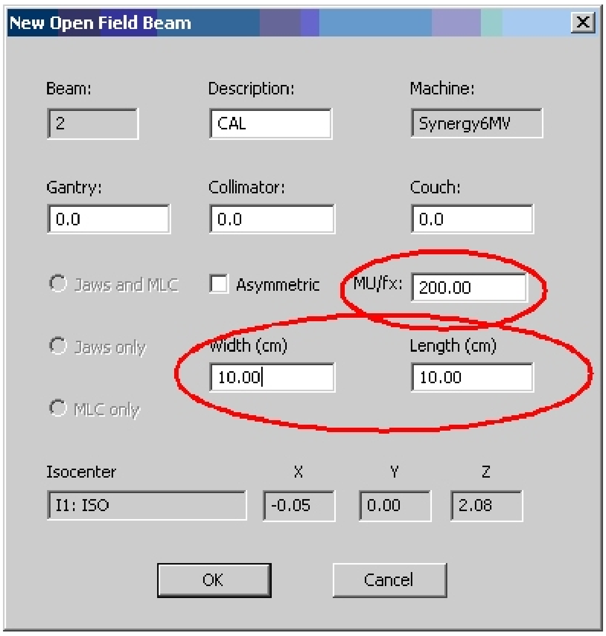


Figure 11 - Monaco "New Beam" window

- to start the dose calculation, click on the "Start Dose Calculation" button (Figure 12);

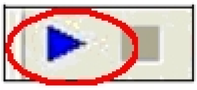


Figure 12 - Monaco " Start Dose Calculation" button

3. Exporting the 2D / 3D dose matrices for comparison between calculation and measurement

Before considering each single scenario, the user may be interested in the following considerations, arising from the different opportunities offered by VeriSoft version 4.x, in particular Gamma 3D feature that requires a 3D calculated dose matrix exported by the TPS:

	VeriSoft “Gamma 2D” method	**VeriSoft “Gamma 3D” method**
to check independently each single field at nominal gantry angle (0°), using the PTW 2D-ARRAY inside the PTW RW3 slab phantom, for example	in this case, the user can export the 2D calculated dose matrix in ASCII text file format (suggested method for “Gamma 2D”, see 3.1 section) or the 3D calculated dose matrix in DICOM RT (see 3.2 section)	in this case, the user has necessarily to export the 3D calculated dose matrix in DICOM RT, see 3.2 section
to check the full plan at once, with a single measurement and keeping the original gantry angles, using the PTW 2D-ARRAY inside the PTW OCTAVIUS phantom, for example	in this case, the user can export the 2D calculated dose matrix in ASCII text file format (suggested method for “Gamma 2D”, see 3.1 section) or the 3D calculated dose matrix in DICOM RT (see 3.2 section)	in this case, the user has necessarily to export the 3D calculated dose matrix in DICOM RT, see 3.2 section

3.1 Exporting the 2D dose matrices from CMS SOFTWARE, Monaco® in ASCII text file format

Here are the steps that users should follow:

- when the dose calculation process has finished and a valid dose distribution is present, keep ON each single field if the aim is to check independently each single field at nominal gantry angle (0°), repeating this procedure for each field of the plan, or keep ON all available fields of the plan, if the aim is to check the full plan at once, with a single measurement and keeping the original gantry angles (in the "Beam Visibility" dialog box, using the checkboxes under the "Dose" column);

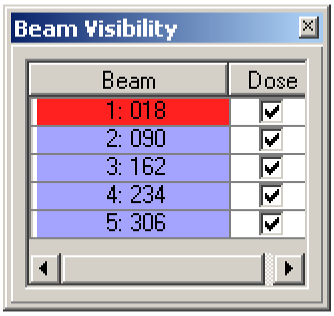


Figure 13 - Monaco beam and dose visibility control

- select the desired 2D section (in general it's a coronal slice) passing through the effective measurement point of the detector, whose dose matrix has to be exported (Figure 14);

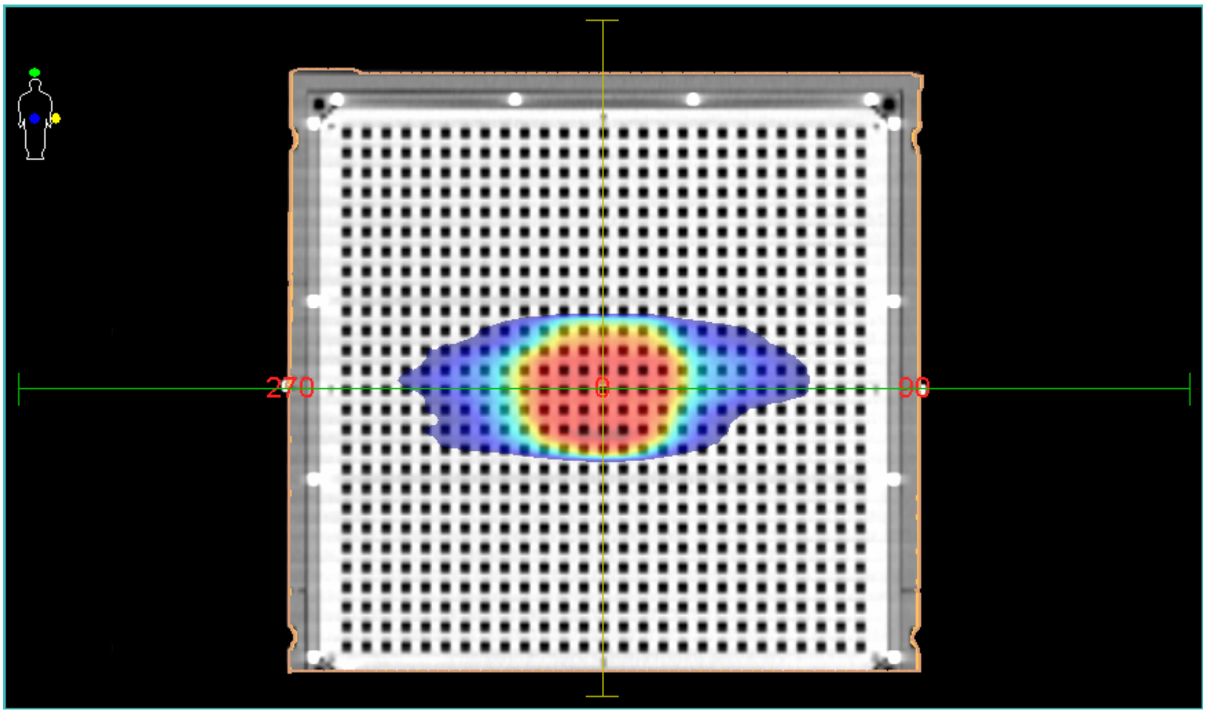


Figure 14 - selection of the 2D section (for example, coronal slice) whose dose matrix has to be exported

- click on the "Dose Export Tool" button (Figure 15);

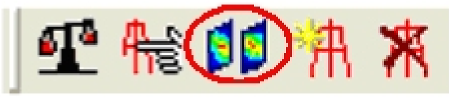


Figure 15 - Monaco " Dose Export Tool" button

- as the "Dose Profiles" window opens, chose the desired 2D dose matrix and chose between "All Beams" or "Individual Beams" (Figure 16);

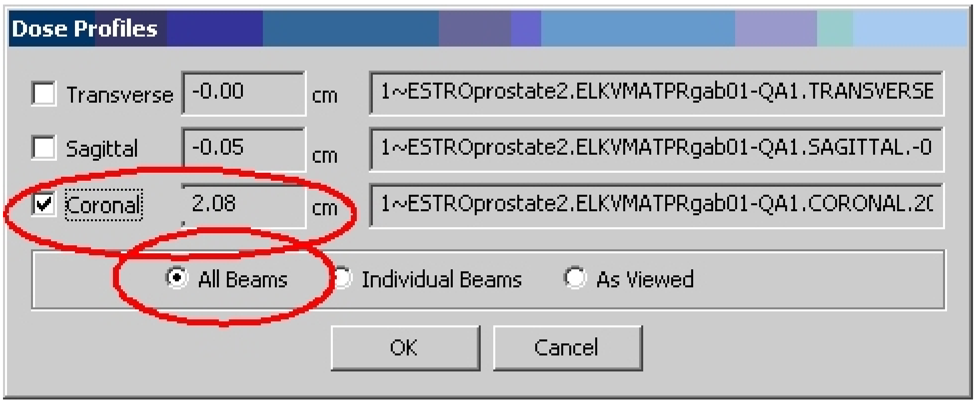


Figure 16 - Monaco " Dose Profiles" window

- the file(s) will be available on your Monaco PC in a folder called "...\focaldata\QA".

3.2 Exporting the 3D dose matrices from CMS SOFTWARE, Monaco® in DICOM RT format

Here are the steps that users should follow:

- when the dose calculation process has finished and a valid dose distribution is present, use the command "File | DICOM Export..." (Figure 17);

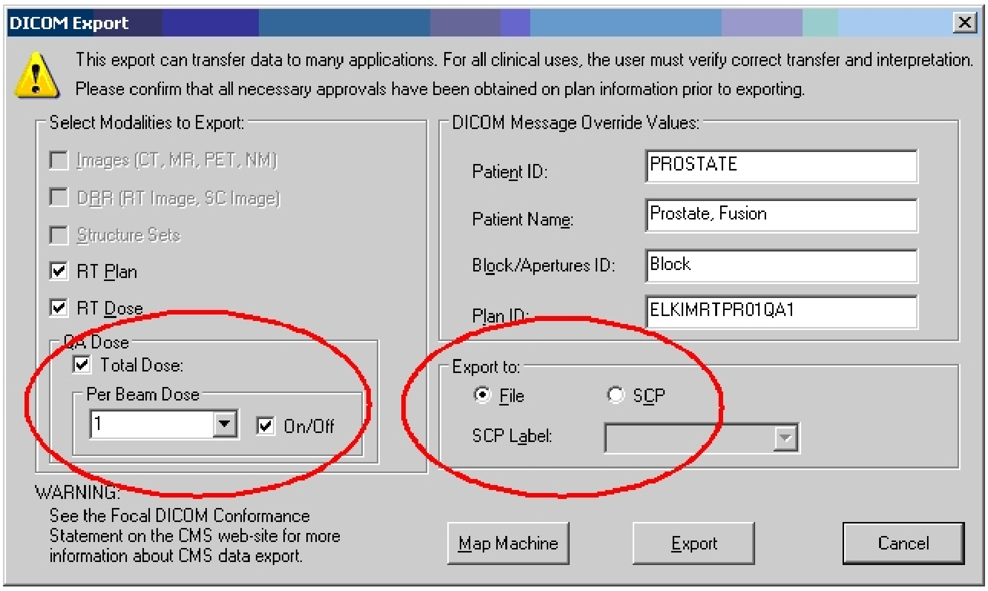


Figure 17 - Monaco "DICOM Export" window

- here, when "Total Dose" is checked, the total composite dose for all the beams in the QA plan is exported; when individual beams are checked in the "Per Beam Dose" section, individual beam doses are exported; when the "Total Dose" option and the "Per Beam Dose" options are checked, a total dose and all per beam dose files are exported.
  HINT: if the user selects "RT Plan" as a modality to export, Monaco activates the Map Machine feature. Click the "Map Machine" button and map the machine name shown to a machine name that the receiving system will recognize.
  HINT: select the location to where you will be exporting by selecting "File" or "SCP". If you select "File", the file will be located on your Monaco PC in a folder called "...\focaldata\DCMXprtFile". If you select "SCP", you must then select an SCP Name, related to a configured DICOM receiver.

Thank you to Gabriele Rinaldi from Tema Sinergie, Italy, who provided this information.

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