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RapidArc QA Test Procedures for C-Series Machines

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Document Title	*RapidArc QA Test Procedures for C-Series Machines*
Abstract	This document provides information and test procedures for C-Series machines and is intended solely as a supplemental document. For complete information concerning components, safety instructions, installation, maintenance, troubleshooting, etc., refer to the applicable Varian product Operator's Manual. This document does not replace the Varian Operator's Manual. Carefully read all instructions prior to use. Observe all contraindications, warnings and precautions noted in these instructions. Failure to do so may result in patient and/or user complications. This publication is the English-language original.
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Contents

Chapter 1 Introduction

Purpose

Note: *This document is not intended to define RapidArc® specifications for Clinical use. Typical results are provided as a guideline for the tests, but the users must determine the Clinical tolerances appropriate for their equipment. The IPA-RD is used by Varian installation and upgrades team to perform all tests required for acceptance.*

The purpose of this document is to provide a high level description of the RapidArc QA files as well as simple instructions for using them. This document and its accompanying files are not and should not be considered as any form of recommendation from Varian on what constitutes a complete RapidArc machine QA program.

For a discussion on RapidArc machine QA, the reader is encouraged to refer to: Ling et al., *Commissioning and Quality Assurance of RapidArc™ Radiotherapy Delivery System*, Int. J. Radiation Oncology Biol. Phys., Vol. 72, No. 2, pp. 575–581, (2008). Additional RapidArc bibliography can be found on the MyVarian website (search for "RapidArc Bibliography").

The RapidArc QA files described in this document are designed after the work in this paper and can be used to reproduce similar tests.

Scope

This document and its accompanying RapidArc QA files are provided for Varian linear accelerators equipped with either the Millennium 120 MLC or the Millennium HD120 MLC and RapidArc.

NOTICE: The test plans are designed for 6MV X-ray beam and a dose rate of 600MU/min. Changing the dose rate may change the desired test parameters since changing the dose rate will result in different gantry and MLC leaf speeds for Tests 2 and 3.

Managing the Plans

This document describes how to acquire test images using DICOM RT mode on C–Series machines. This procedure is appropriate for infrequent performance of this test sequence, but may be cumbersome to perform on a regular basis. The RapidArc QA files can be also delivered on C-Series, and images acquired, using a record and verify system. The plans must have appropriate approval status.

Imaging and Evaluation Tools

The procedures described in this document are designed to be performed with the aS1000 PortalVision MV imager using Integrated Image mode. Use of the aS500 or aS500-II imagers may result in saturation or other image anomalies that could cause inaccurate results. Customers with the aS500 and aS500-II imagers, or customers who do not have the Integrated Image license, should use film or other devices to perform these procedures.

All image acquisitions are performed using the Integrated Image mode. This mode requires a dosimetry calibration as described in your MV imager documentation.

Note: *For Portal Dosimetry customers, the Integrated Image calibration is also used for Portal Dosimetry pre-treatment QA measurements. A qualified medical physicist should determine the appropriate calibration settings for both Portal Dosimetry and RapidArc QA.*

This document describes evaluation of the images using OBI tools. Users of the ARIA OIS RO suite of applications may perform the same evaluations using the Offline Review workspace. Users with the Portal Vision Advanced Imaging (PVAI) application should refer to Appendix A Evaluation of Test 2 Using Portal Vision Advanced Imaging (PVAI) and Appendix B Evaluation of Test 3 Using Portal Vision Advanced Imaging (PVAI) for guidance on performing the procedures.

Note: *Accurate evaluation of the images requires at least 5 digits of precision for the histogram values. Using fewer than 5 digits of precision may result in rounding of values, and therefore inaccurate results. The following applications provide sufficient precision:*

- *OBI 1.6 or higher*
- *ARIA Offline Review*
- *PVAI 1.6.15 or higher*

Note: *For non-ARIA users, all evaluations must be performed using the OBI or PVAI (version 1.6.15 or later) tools. When using OBI, you can open saved images from the OBI maintenance workspace, which allows you to perform the analysis following the imaging session. When using PVAI, you must perform the analysis* ***during the image acquisition process****; you cannot perform the evaluations after the images are saved.*

NOTICE: Calibration of the accelerator's dosimetry monitoring system should be performed following the guidance provided in CTB-GE-228. Dose calibration that significantly exceeds 1.0 cGy/MU at Dmax may stress the dosimetry system beyond its design capabilities, resulting in inaccurate or erratic results of the following tests.

Visual Cues

This publication uses the following visual cues to help you find information:

WARNING: A warning describes actions or conditions that can result in serious injury or death.

CAUTION: A caution describes hazardous actions or conditions that can result in minor or moderate injury.

NOTICE: A notice describes actions or conditions that can result in damage to equipment or loss of data.

Note: *A note describes information that may pertain to only some conditions, readers, or sites.*

Tip: *A tip describes useful but optional information such as a shortcut, reminder, or suggestion, to help get optimal performance from the equipment or software.*

Contacting Varian Customer Support

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The my.varian.com website provides contact information, product documentation, and other resources for all Varian products.

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3. Choose an option:
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   - If you have an account, go to the next step.
4. Enter your user name and password.
5. Browse the information and then click the link that corresponds to what you want to do:
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Chapter 2 List and Description of RapidArc QA Files

Section 1

The test files described in this section are discussed in the Pre-requisites for RapidArc QA section of Ling et al.

1. Test 0.1: DMLC Dosimetry

   DMLC dosimetry — Measure the output at gantry angles 0°, 180°, 90° and 270° for a 4×10 cm DMLC field with a 0.5 cm slit to test the effect of gravity on leaf position and Clinac dosimetry system.

   - File for Millennium 120 MLC: **T0.1_Dosimetry_M120.dcm**
   - File for HD120 MLC: **T0.1_Dosimetry_HD120.dcm**

2. Test 0.2: Picket Fence test versus gantry angle

   Picket fence test at stationary gantry angle — for subsequent comparison with tests during RapidArc.

   - File for Millennium 120 MLC: **T0.2_PicketFenceStatic_M120.dcm**
   - File for HD120 MLC: **T0.2_PicketFenceStatic_HD120.dcm**

Section 2

The files described in this section refer to Tests 1, 2, and 3 in Ling at al. For detailed description of the tests, their intent, and expected results, refer to the paper.

1. Test 1.1: Picket Fence test during Rapid Arc

   Picket fence test during RapidArc — to test the effect of gantry rotation on the MLC positional accuracy.

   - File for Millennium 120 MLC: **T1.1_PicketFenceRA_M120.dcm**
   - File for HD120 MLC: **T1.1_PickectFenceRA_HD120.dcm**

   Note: *If the portal imager is used, it is not possible to acquire an image similar to figure 3 in Ling et al. That image was acquired with a film. It is possible to add images from tests 0.2 and 1.1 to replicate the double exposed film.*

2. Test 1.2: Picket Fence test during RapidArc with intentional errors

Picket fence test during RapidArc with intentional errors — to demonstrate that test 1.1 can detect sub-millimeter errors during rapid arc.

- File for Millennium 120 MLC: **T1.2_PicketFenceError_M120.dcm**
- File for HD120 MLC: **T1.2_PicketFenceError_HD120.dcm**

3. Test 2: Accurate control of Dose Rate and Gantry Speed during RapidArc delivery

   The Test 2 files correspond to the procedure described in Chapter 3 Image Acquisition and Evaluation of Test 2: Dose Rate – Gantry Speed Test. This test uses 7 combinations of dose-rate, gantry range and gantry speed to give equal dose to seven 1.8 cm strips in a RapidArc field.

   - File for Millennium 120 MLC: **T2_DoseRateGantrySpeed_M120_Rev01.dcm**
   - File for HD120 MLC: **T2_DoseRateGantrySpeed_HD120_Rev01.dcm**

4. Test 3: Accurate control of Leaf Speed during RapidArc delivery

   The Test 3 files correspond to the procedure described in Chapter 4 Image Acquisition and Evaluation of Test 3: MLC Leaf Speed Test on page 25. This test uses 4 combinations of leaf speed and dose-rate to give equal dose to four strips in a RapidArc field.

   - File for Millennium 120 MLC: **T3_MLCSpeed_M120_Rev01.dcm**
   - File for HD120 MLC: **T3_MLCSpeed_HD120_Rev01.dcm**

Note: *The arrangement of leaf speeds for this test is changed with respect to the article in order to allow delivery of the test on a clinical system. The leaf speeds are as follows: 1.4 cm/s, 2.0 cm/s, 0.8 cm/s, and 0.4 cm/s.*

Chapter 3 Image Acquisition and Evaluation of Test 2: Dose Rate – Gantry Speed Test

Dose Rate – Gantry Speed Test Procedure

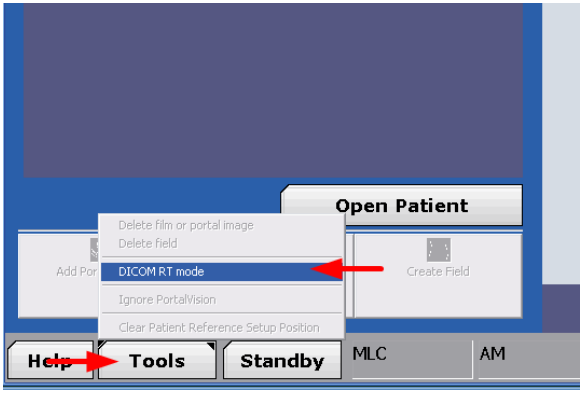
Note: *The steps in the following procedure use the MV imager to acquire test images. The same evaluation can be done with different measurement devices (such as film).*

Note: *The MV imager needs to be calibrated for the Integrated Imaging Acquisition Technique for the energy mode and the dose rate used in the RapidArc QA plans, i.e. 6x, 600MU/min.*

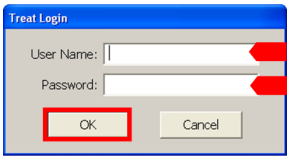
Note: *The MV imager should be positioned so that the lateral and longitudinal positions are equal to 0. Images acquired in the following steps were acquired at 100 cm source-to-image plane distance.*

1. Extract the RapidArc QA files to a location accessible from both the 4DITC and OBI workstations.

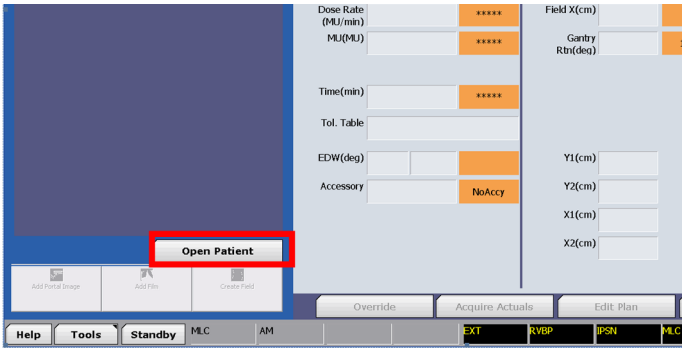
   Typically, the I: drive is used to store files that will be accessible from the 4DITC Treatment console.
2. Log in to the 4DITC treatment application.
3. Select **Tools** > **DICOM RT mode**.



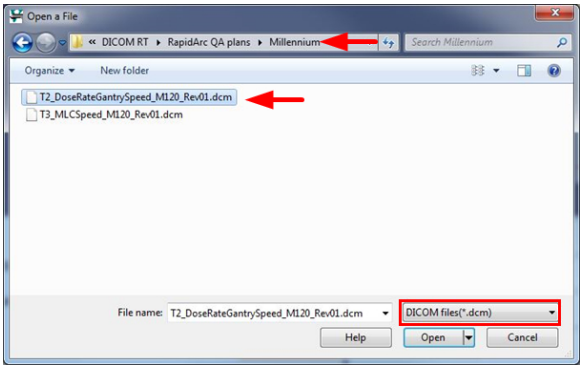
4. Enter your user name and password to authorize DICOM RT mode.



5. Select **Open Patient** to open the DICOM RT file with the test plan.

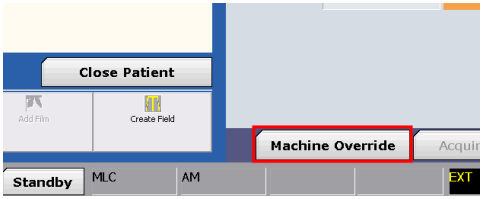


6. Navigate to the folder with DICOM RT files.
   The folder must be accessible from the 4DITC and OBI workstations.
7. Select the file with tests for the MLC model used, and click **Open**.

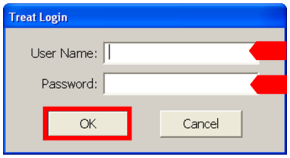


Note: *The test files do not contain Second Channel Integrity Check (SCIC) data. The treatment application may issue a warning to confirm changes before using the plan. If a warning is issued, enter your login credentials and click Continue. You must have the 4D Treatment Console local user right OVR Second Channel Integrity Check to override SCIC.*

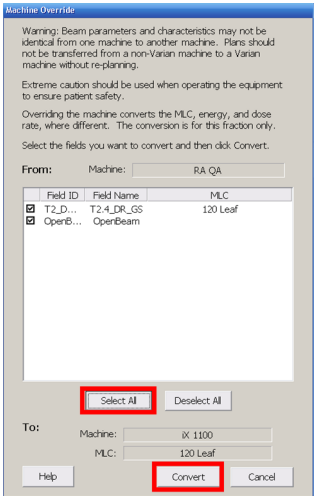
8. Select **Machine Override**.



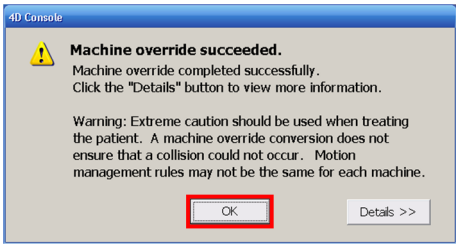
9. Enter your username and password to authorize the Machine Override.



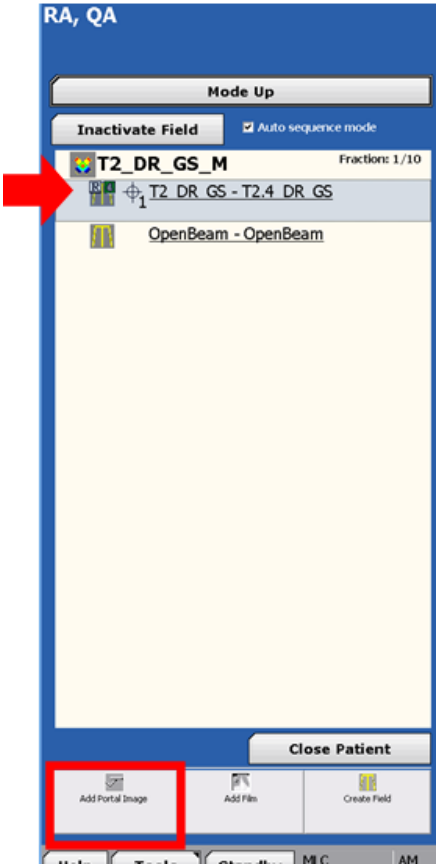
10. Click **Select All** and click **Convert**.



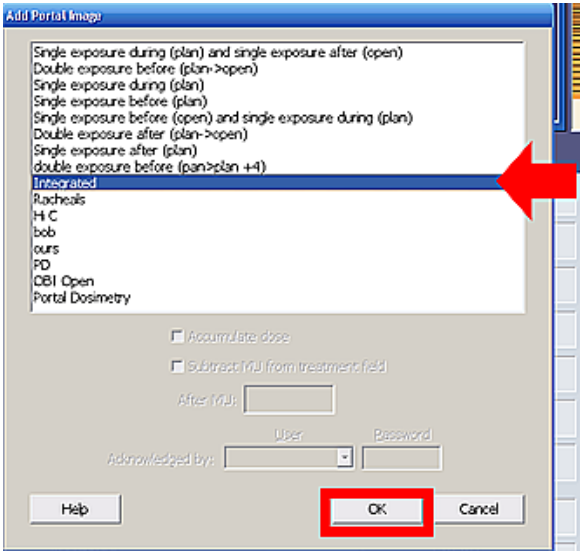
A message displays telling you that the machine override was successful.



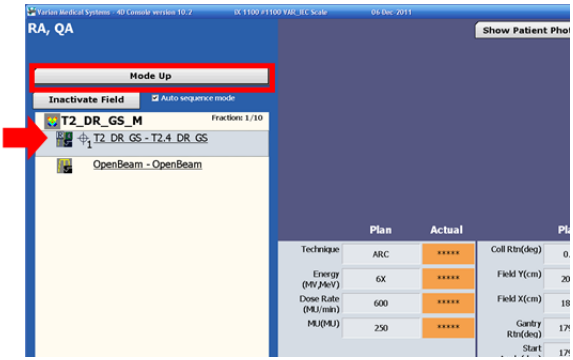
11. Click **OK** to acknowledge the message.
12. Complete the following steps to add a portal image.
    a. Highlight the first field and click **Add Portal Image**.



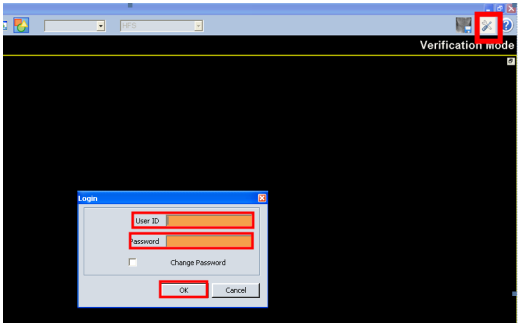
    b. Select **Integrated template** and click **OK**.



13. Repeat step 12 to add an integrated image template to the second field.
14. Highlight the first field and click **Mode Up**.

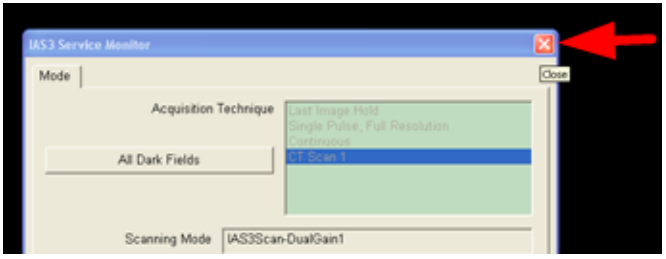


15. At the OBI workstation, click the **Maintenance mode** button and enter your login credentials to change the mode.

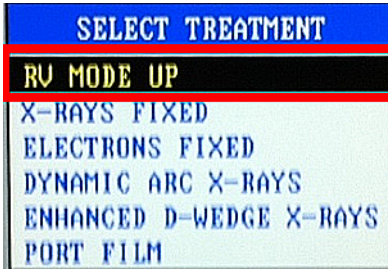


Note: *Customers without OBI can use PortalVision Advanced Imaging (version 1.6.15 or later) to evaluate images acquired in steps 1 through 14, steps 17 through 20, and step 30 in this procedure. See* Appendix A Evaluation of Test 2 Using Portal Vision Advanced Imaging (PVAI) *on page 38*

16. Close the OBI Maintenance IAS3 Service Monitor.



17. Select **RV MODE UP** on the Clinac console.

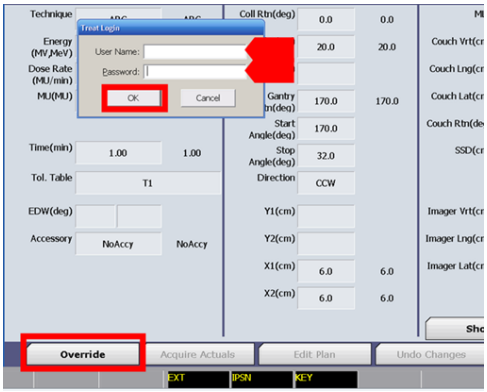


18. Extend the imager and move the C-Series accelerator to its starting position.

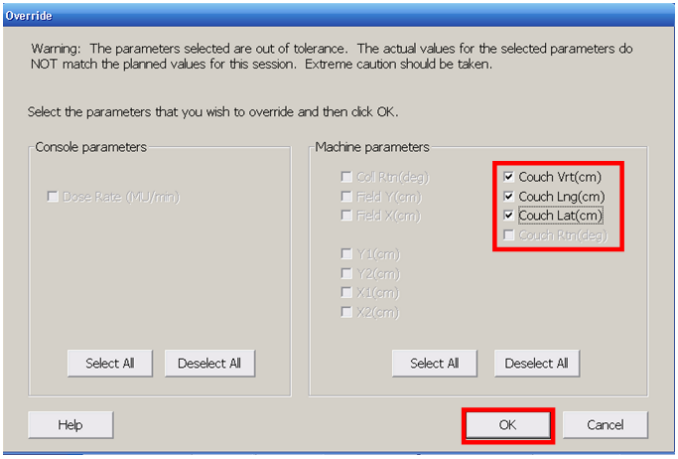
    To avoid possible collisions, retract the couch and check to ensure clearance of the rotating gantry.

19. At the 4DITC workstation, override the couch parameters.

    a. Click **Override** and enter your login credentials.



    b. Select the couch parameters to be overridden and click **OK**.



20. Deliver the first beam.

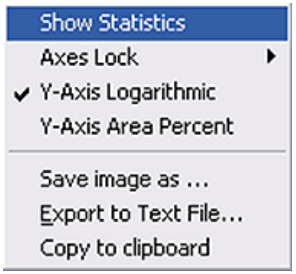
    The acquired image will be displayed on the OBI workstation.

21. Make sure that the Graticule is enabled and the filter is set to **None**.

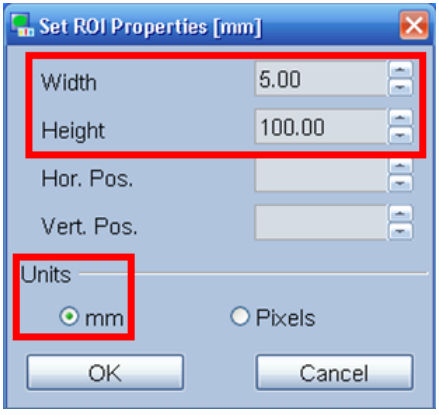
22. Click the **Histogram** button to enable the Area Histogram and draw a Region of Interest (ROI).

The Histogram window appears

23. Right-click the histogram and select **Show Statistics** from the context menu.



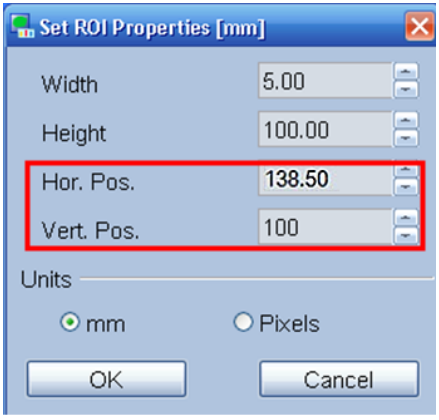
24. Right-click the ROI corner and select **Set ROI Properties** from the context menu.
25. Make the following selections and click **OK**:
    - Unit: mm
    - Width: 5
    - Height: 100



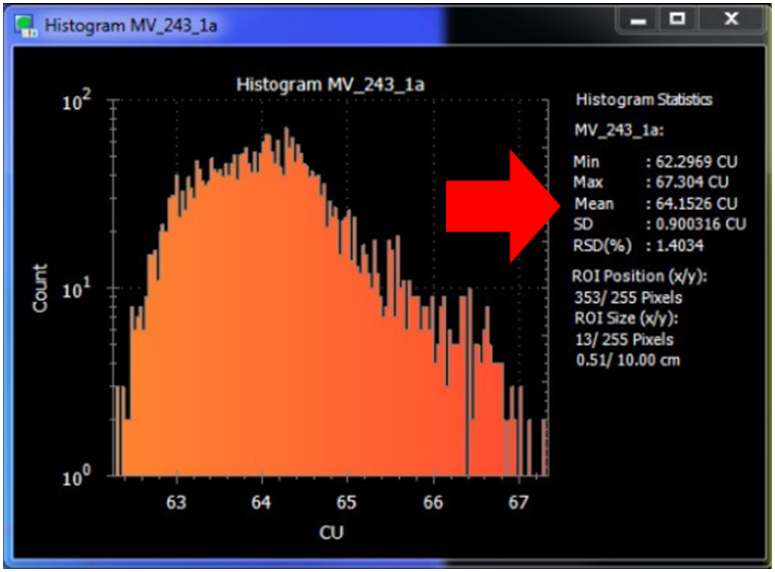
26. Center the ROI within the first vertical band by setting the horizontal and vertical positions for Band 1 (see table below) and clicking **OK**.

The ROI should be centered on the graticule horizontal axis, and centered within the band on the graticule vertical axis.

Band	Center of Band (Graticule)	ROI Hor. Pos.	ROI Vert. Pos.
1	−6 cm	138.5 mm	100 mm
2	−4 cm	158.5 mm	
3	−2 cm	178.5 mm	
4	0 cm	198.5 mm	
5	+2 cm	218.5 mm	
6	+4 cm	238.5 mm	
7	+6 cm	258.5 mm	

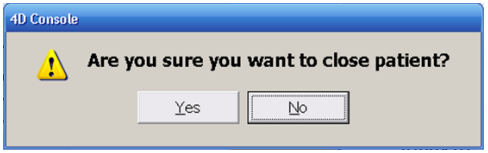


27. Write down the mean pixel value indicated by the histogram statistics.



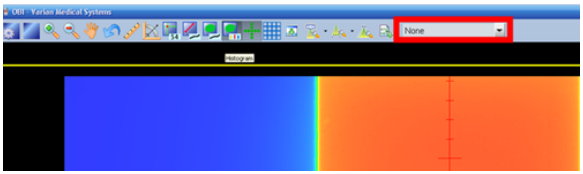
28. Repeat steps 26 to 27 for Bands 2 through 7 (see table in step 26).

    To take into account fluence variation across the beam, an open field beam profile at the same position is needed. The open beam appears as the second field in the plan.
29. Deliver the second field in the plan.
30. When the 4DITC console asks for confirmation to close the patient, leave the dialog box open (DO NOT click either Yes or No).

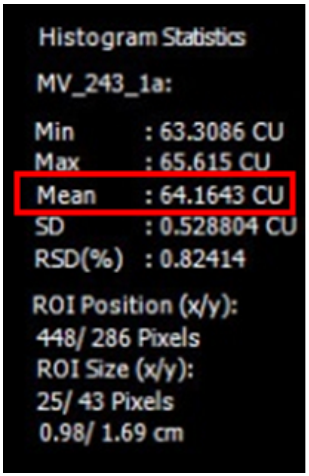


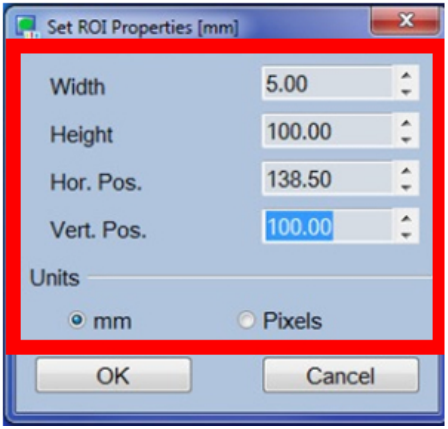
The acquired image of the open field is displayed on the OBI workstation.

31. Ensure that the filter is set to **None**.



32. Repeat steps 21 through 28 to record open field pixel values at the same ROIs as the RapidArc field.





33. Calculate the RapidArc field pixel values, normalized to the open field pixel values, using the following formula:

$$R_{\mathrm{corr}}(x) = \frac{R_{\mathrm{DR-GS}}(x)}{R_{\mathrm{Open}}(x)} \cdot 100$$

Where:

- $R_{DR-GS}(x)$ is the Mean pixel value at a given ROI in the RapidArc field;
- $R_{corr}(x)$ is the normalized Mean pixel value at the same ROI in the RapidArc field;
- $R_{Open}(x)$ is the Mean pixel value at the same ROI in the open field.

34. Calculate the deviation of each ROI using the following formula:

$$diff(x) = \frac{R_{corr}(x)}{\bar{R}_{corr}} \cdot 100 - 100$$

Where

$\bar{R}_{corr}$ is the average of $R_{corr}(x)$ for all seven strips.

Machines using these plans will typically achieve numbers below 3% for each $Diff(x)$.

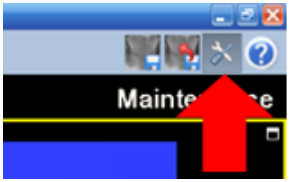
35. Calculate the average of the absolute value of all $diff(x)$ values:

$$Diff_{abs} = \left|\overline{diff(x)}\right|$$

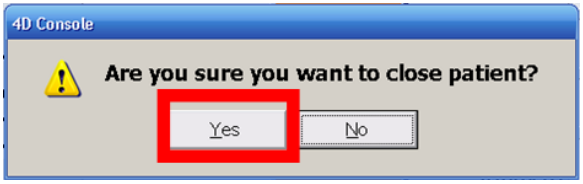
Machines using these plans will typically achieve numbers below 1.5% for $Diff_{abs}$.

Note: *The typical values presented here are not Varian specifications. Typical results are provided as a guideline for the tests, but the users must determine the Clinical tolerances appropriate for their equipment.*

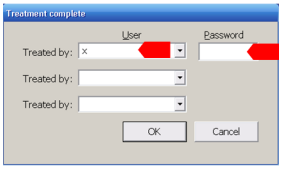
36. Click the **Maintenance mode** button to exit OBI Maintenance mode.



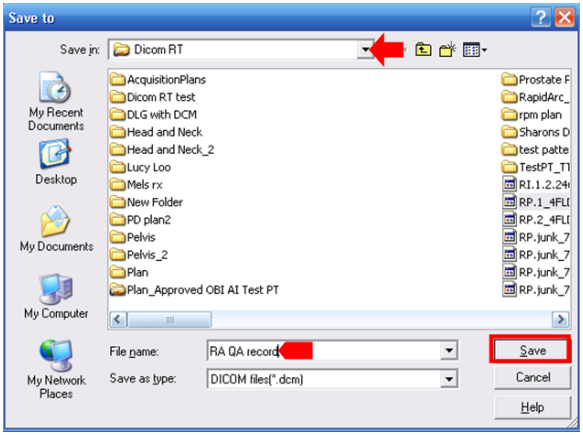
37. At the 4DITC workstation, click **Close Patient** and click **Yes** to confirm the action.



38. Complete the treatment.



39. Enter the file name and location and click Save to save the treatment record.


Save to
Save in:
Dicom RT
My Recent Documents
Desktop
My Documents
My Computer
My Network Places
AcquisitionPlans
Dicom RT test
DLG with DCM
Head and Neck
Head and Neck_2
Lucy Loo
Mels rx
New Folder
PD plan2
Pelvis
Pelvis_2
Plan
Plan_Approved OBI AI Test PT
Prostate F
RapidArc_
rpm plan
Sharons D
test patte
TestPT_T1
RI.1.2.24
RP.1_4FL
RP.2_4FL
RP.junk_7
RP.junk_7
RP.junk_7
RP.junk_7
File name:
RA QA record
Save as type:
DICOM files(*.dcm)
Save
Cancel
Help

Chapter 4 Image Acquisition and Evaluation of Test 3: MLC Leaf Speed Test

MLC Leaf Speed Test Procedure

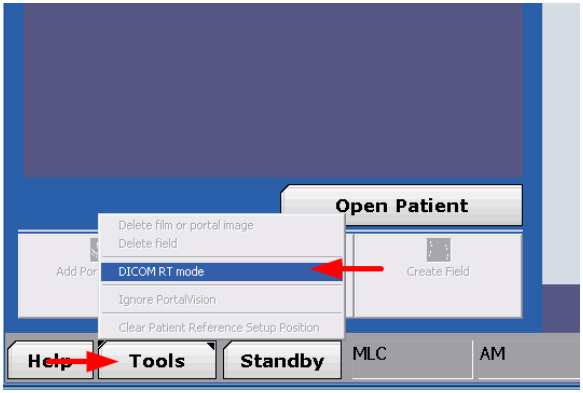
Note: *The steps in the following procedure uses the MV imager to acquire test images. The same evaluation can be done with different measurement devices (such as film).*

Note: *The MV imager needs to be calibrated for the Integrated Imaging Acquisition Technique for the energy mode and the dose rate used in the RapidArc QA plans, i.e. 6x, 600MU/min.*

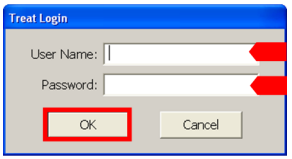
Note: *The MV imager should be positioned so that the lateral and longitudinal positions are equal to 0. Images acquired in the following steps were acquired at 100 cm source-to-image plane distance.*

1. Extract the RapidArc QA files to a location that is accessible from both the 4DITC and OBI workstations.

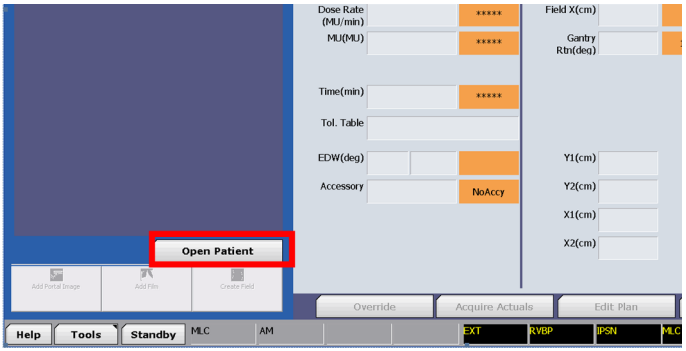
   Typically, the I: drive is used to store files that will be accessible from the 4DITC Treatment console.
2. Log into the 4DITC Treatment application.
3. Select **Tools** > **DICOM RT mode**.



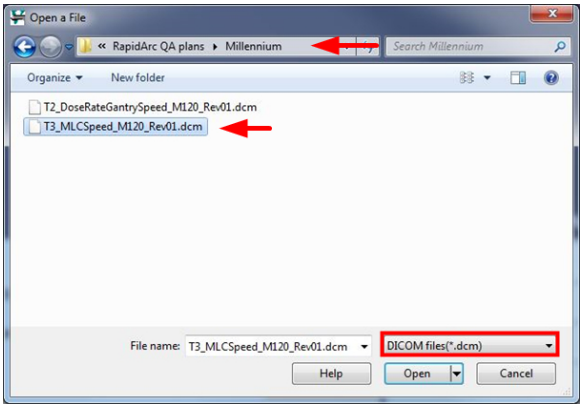
4. Enter your user name and password to authorize DICOM RT mode.



5. Select **Open Patient** to open the DICOM RT file with the test plan.

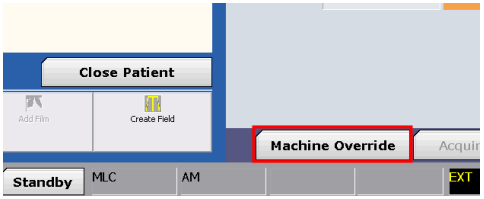


6. Navigate to the folder with DICOM RT files.
   The folder must be accessible from the 4DITC and OBI workstations.
7. Select the file with tests for the MLC model used, and click **Open**.

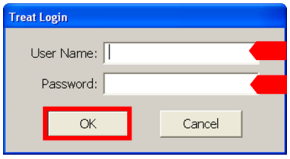


Note: *The test files do not contain Second Channel Integrity Check (SCIC) data. The treatment application may issue a warning to confirm changes before using the plan. If a warning is issued, enter your login credentials and click Continue. You must have the 4D Treatment Console local user right OVR Second Channel Integrity Check to override SCIC.*

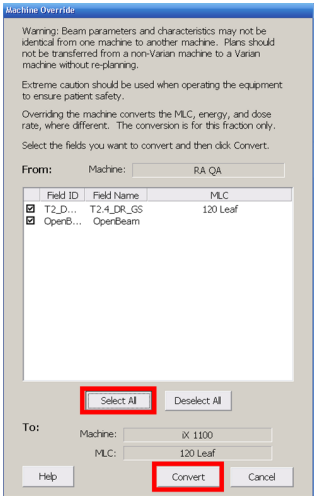
8. Select **Machine Override**.



9. Enter your username and password to authorize the Machine Override.

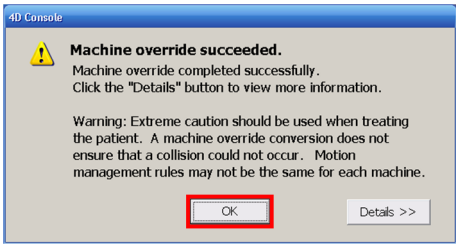


10. Click **Select All** and click **Convert**.



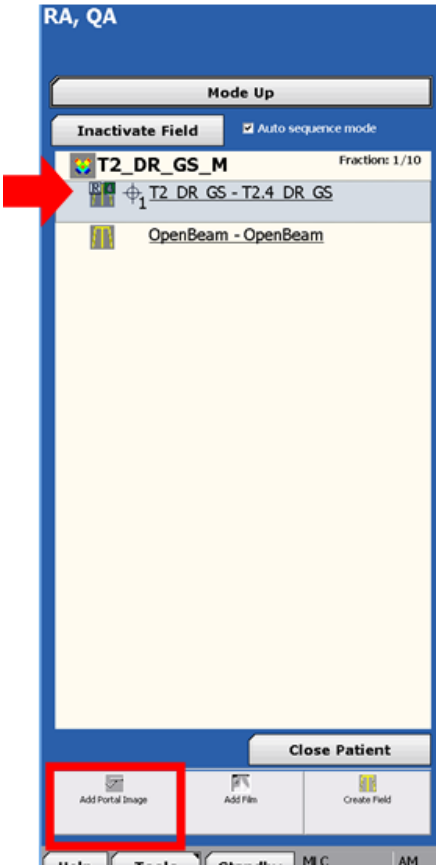
A message informs you that the machine override was successful.

11. Click **OK** to acknowledge the message.

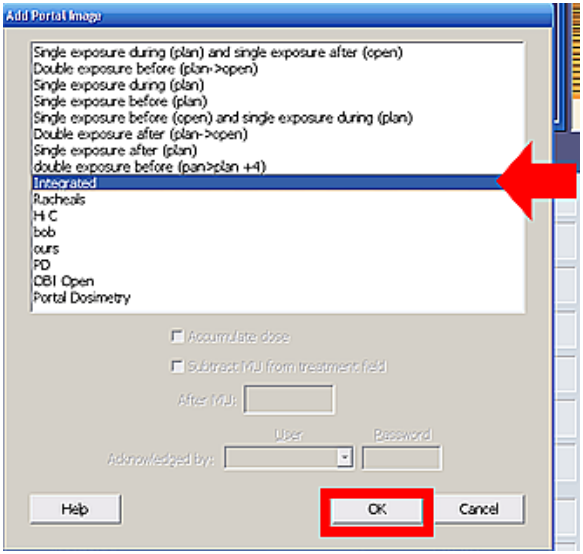


12. Complete the following steps to add a portal image.

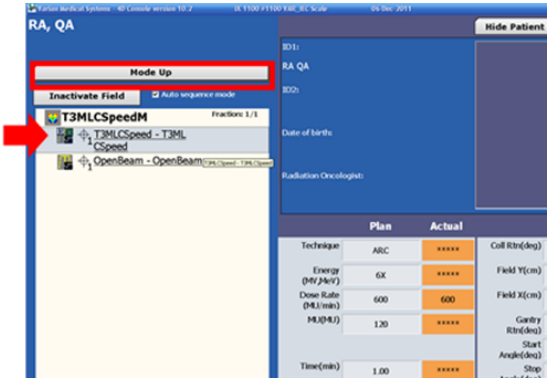
a. Highlight the first field and click **Add Portal Image**.



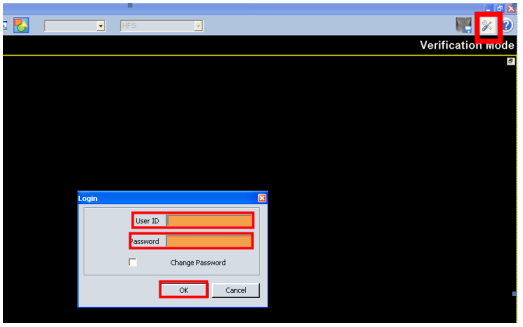
b. Select **Integrated template** and click **OK**.



13. Repeat step 12 to add an integrated image template to the second field.
14. Highlight the first field and click **Mode Up**.

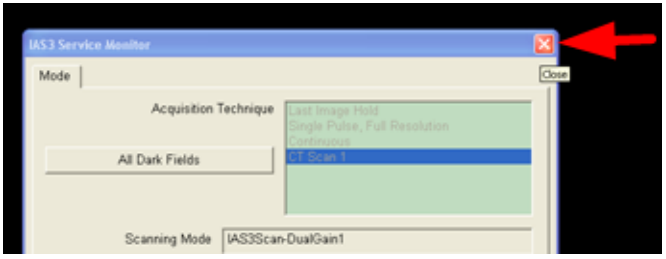


15. At the OBI workstation, click the **Maintenance mode** button and enter your login credentials to change the mode.

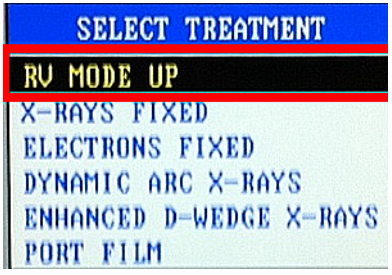


Note: *Customers without OBI can use PortalVision Advanced Imaging (version 1.6.15 or later) to evaluate images acquired in steps 1 through 14, steps 17 through 20, and step 29 in this procedure. See* Appendix B Evaluation of Test 3 Using Portal Vision Advanced Imaging (PVAI) *on page 43*

16. Close the OBI Maintenance IAS3 Service Monitor dialog box.



17. Select **RV MODE UP** on the Clinac console.

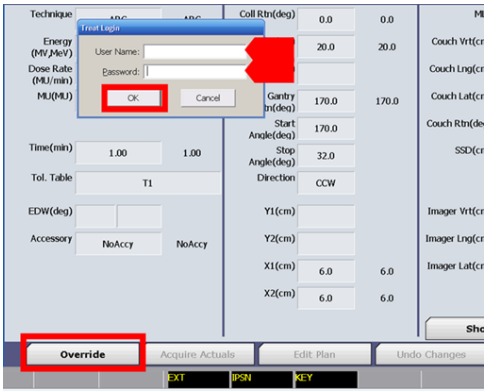


18. Extend the imager and move the C-Series accelerator to its starting position.

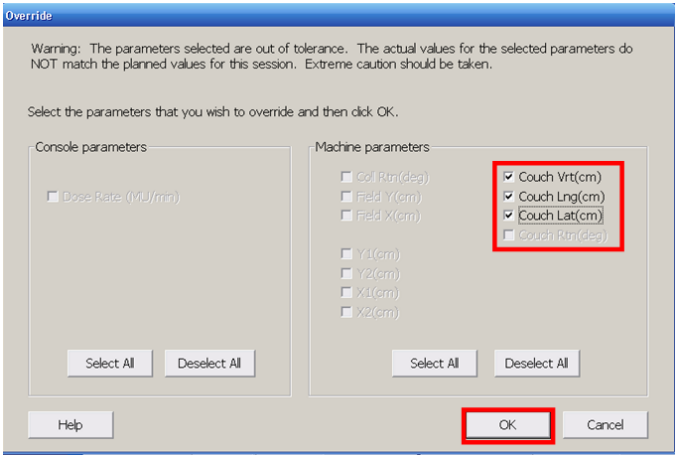
    To avoid possible collisions, retract the couch and check to ensure clearance of the rotating gantry.

19. At the 4DITC workstation, override the couch parameters.

    a. Click **Override** and enter your login credentials.



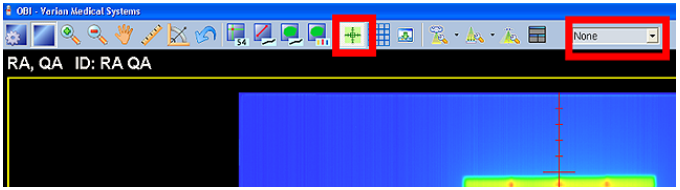
    b. Select the couch parameters to be overridden and click **OK**.



20. Deliver the first beam.

    The acquired image will display on the OBI workstation.

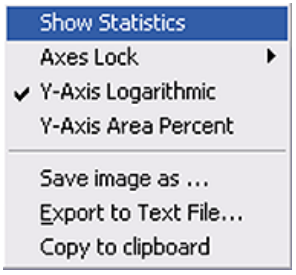
21. Ensure that the Graticule is enabled and the filter is set to **None**.



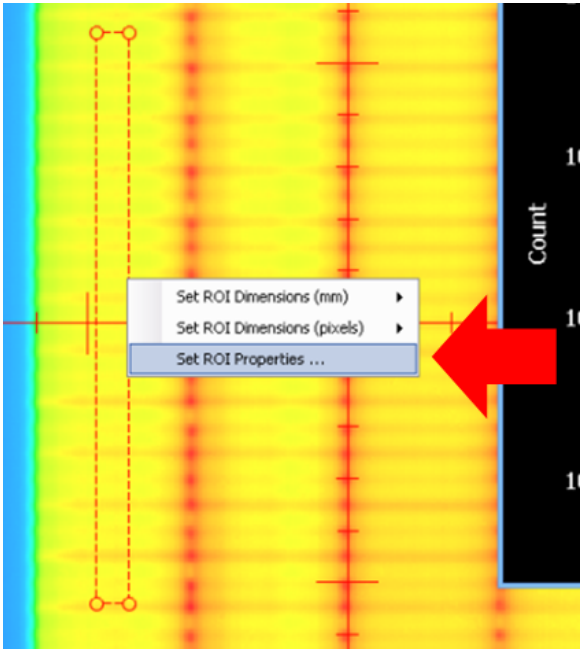
22. Click the **Histogram** button to enable the Area Histogram and draw a Region of Interest (ROI).

The Histogram window appears

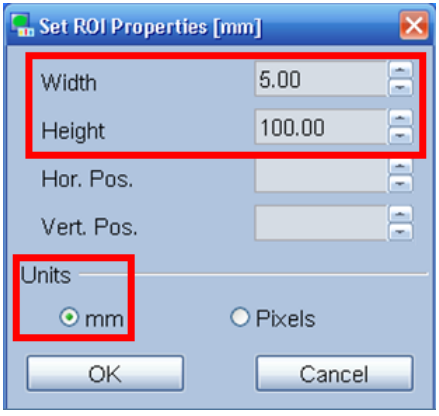
23. Right-click the histogram and select **Show Statistics** from the context menu.



24. Right-click a corner of the ROI and select **Set ROI Properties** from the context menu.



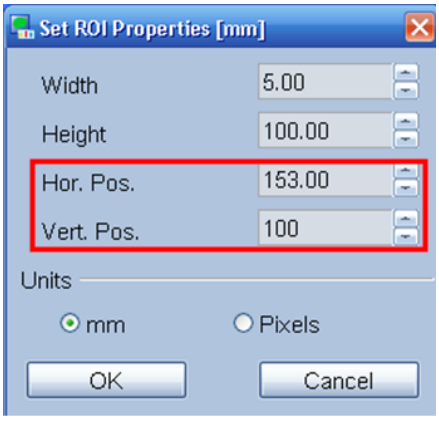
25. Make the following selections:
    - Unit: mm
    - Width: 5
    - Height: 100



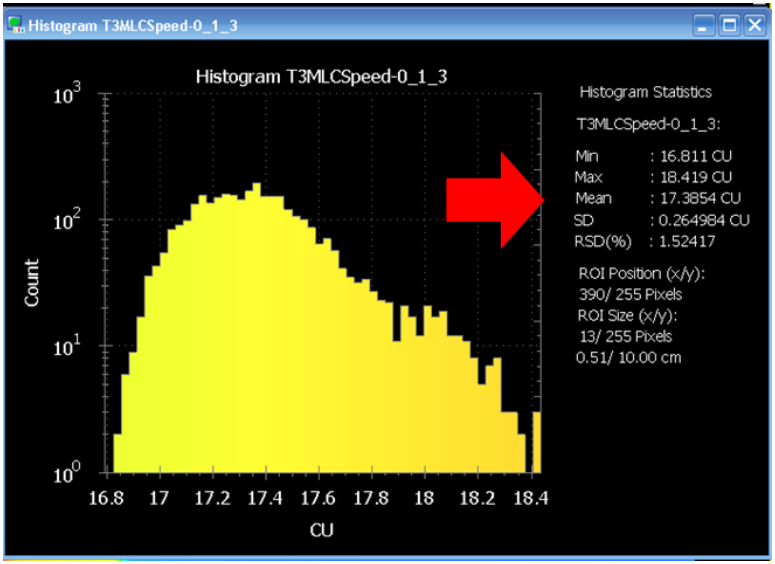
26. Center the ROI within the first vertical band by setting the horizontal and vertical positions for Band 1 (see table below) and clicking **OK**.

The ROI should be centered on the graticule horizontal axis, and centered within the band on the graticule vertical axis.

Band	Center of Band	ROI Horiz. Pos.	ROI Vert. Pos.
1	−4.5 cm	153.0 mm	100 mm
2	−1.5 cm	183.0mm	
3	+1.5 cm	213.0 mm	
4	+4.5 cm	243.0 mm	



27. Write down the mean pixel value indicated by the histogram statistics.

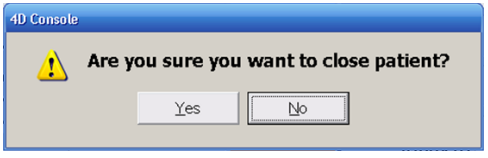


28. Repeat steps 26 to 27 for Bands 2 through 4 (see table in step 26).

    To take into account fluence variation across the beam, an open field beam profile at the same position is needed. The open beam appears as the second field in the plan.

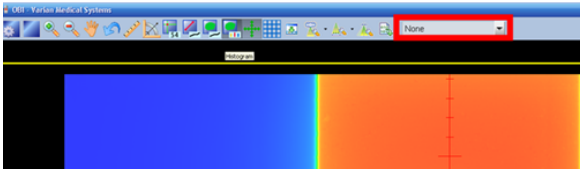
29. Deliver the second field in the plan.

    When the 4DITC console asks for confirmation to close the patient, leave the dialog window open (DO NOT click either button).



    The acquired image of the open field displays on the OBI workstation.

30. Ensure that the filter is set to **None**.



31. Repeat steps 21 through 28 to record open field pixel values at the same ROI as the test image.
32. Calculate the RapidArc field pixel values, normalized to the open field pixel values, using the following formula:

$$R_{corr}(x) = \frac{R_{LS}(x)}{R_{Open}(x)} \cdot 100$$

Where:

- $R_{corr}(x)$ is the normalized Mean pixel value for a given RapidArc measurement ROI
- $R_{LS}(x)$ is the Mean pixel value for the same ROI
- $R_{Open}(x)$ is the Mean pixel value at the same ROI in the open field

33. Calculate the deviation of each ROI using the following formula:

$$diff(x) = \frac{R_{corr}(x)}{\bar{R}_{corr}} \cdot 100 - 100$$

Where

$\bar{R}_{corr}$ is the average of $R_{corr}(x)$ for all four ROIs.

Machines using these plans typically achieve numbers below 3% for each $diff(x)$.

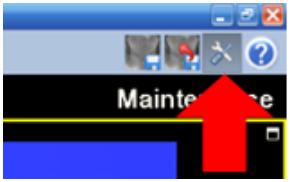
34. Calculate the average of the absolute value of all $diff(x)$ values:

$$Diff_{abs} = \left|\overline{diff(x)}\right|$$

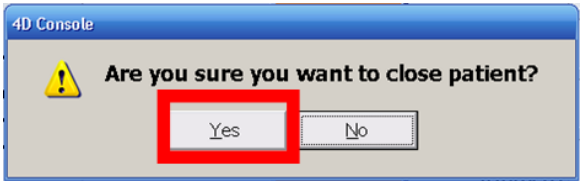
Machines using these plans will typically achieve numbers below 1.5% for $Diff_{abs}$.

Note: *The typical values presented here are not Varian specifications. Typical results are provided as a guideline for the tests, but the users must determine the Clinical tolerances appropriate for their equipment.*

35. Click the **Maintenance mode** button to exit OBI Maintenance mode.

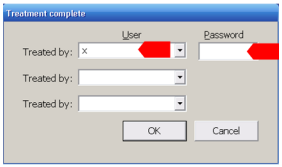


36. At the 4DITC workstation, click **Close Patient** and click **Yes** to confirm the action.



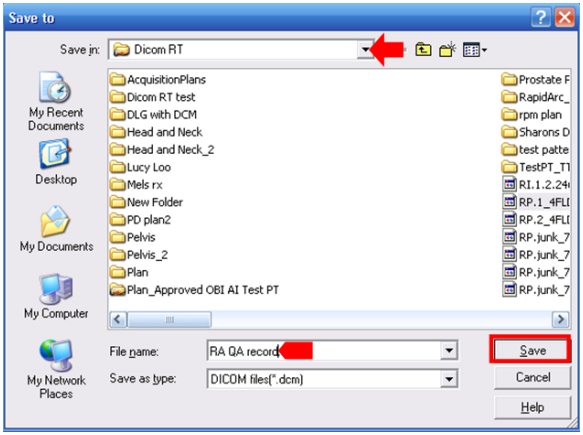
The Treatment Complete dialog box appears.

37. Enter your user name and password and click **OK** to complete the treatment.



The Save to dialog box appears

38. Enter the file name and location and click **Save** to save the treatment record.



Appendix A Evaluation of Test 2 Using Portal Vision Advanced Imaging (PVAI)

Overview and Procedure

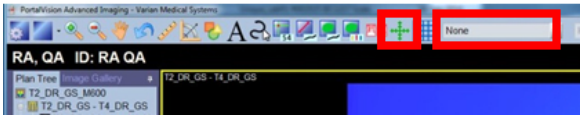
The procedure described in Dose Rate – Gantry Speed Test Procedure on page 12 is performed using OBI, and can alternately be performed using ARIA Offline Review. Customers without OBI or Offline Review can perform these procedures using the PortalVision Advanced Imaging (PVAI) application (version 1.6.15 or later).

Note: *When using PVAI you must perform this analysis* ***during the image acquisition session****; you cannot perform the evaluations after the image acquisition session is closed.*

After successful irradiation of all fields as described in Dose Rate – Gantry Speed Test Procedure (steps 1 through 14, steps 17 through 20, and step 30), the acquired images can be evaluated in the PortalVision Advanced Imaging application as described in the following steps.

The acquired image will be displayed in the PortalVision Advanced Imaging application.

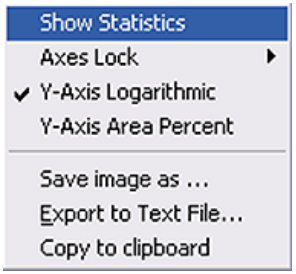
1. Ensure that the graticule is enabled and the filter is set to **None**



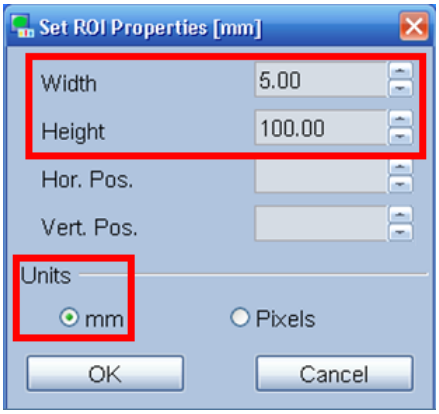
2. Click the **Histogram** button to enable the Area Histogram and draw a Region of Interest (ROI).

The Histogram window appears

3. Right-click the histogram and select **Show Statistics** from the context menu.



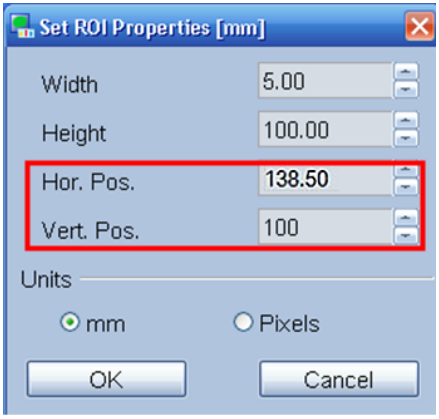
4. Right-click the ROI corner and select **Set ROI Properties** from the context menu.
5. Make the following selections:
   - Unit: mm
   - Width: 5mm
   - Height: 100mm



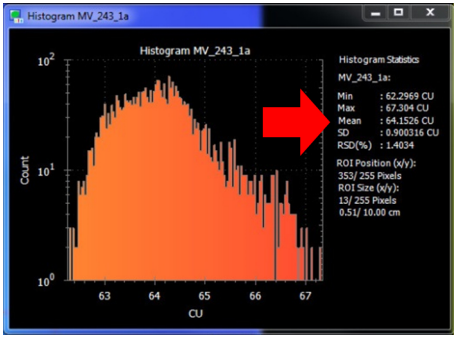
6. Center the ROI within the first vertical band by setting the horizontal and vertical positions for Band 1 (see table below) and clicking **OK**.

   The ROI should be centered on the graticule horizontal axis, and centered within the band on the graticule vertical axis.

Band	Center of Band (Graticule)	ROI Hor. Pos.	ROI Vert. Pos.
1	−6 cm	138.5 mm	100 mm
2	−4 cm	158.5 mm	
3	−2 cm	178.5 mm	
4	0 cm	198.5 mm	
5	+2 cm	218.5 mm	
6	+4 cm	238.5 mm	
7	+6 cm	258.5 mm	



7. Write down the mean pixel value indicated by the histogram statistics.



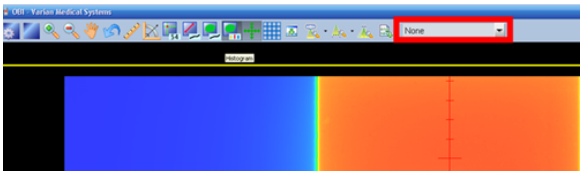
8. Repeat steps 6 to 7 for Bands 2 through 7 (see table in step 6).

   To take into account fluence variation across the beam, an open field beam profile at the same position is needed. The open beam appears as the second field in the plan.

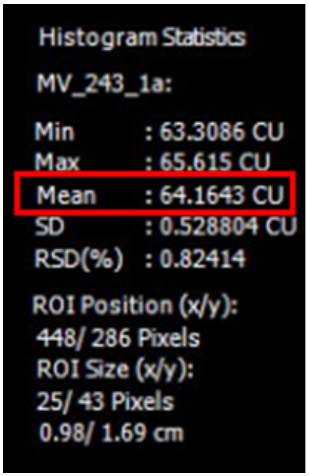
9. Deliver the second field in the plan.

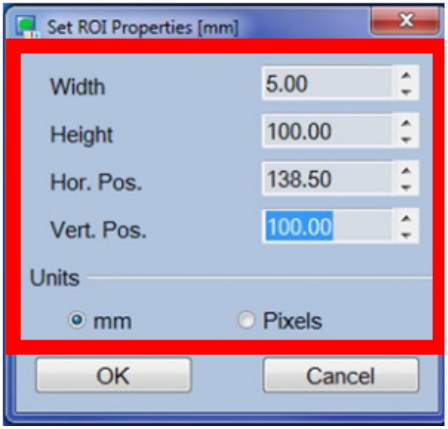
   The acquired image of the open field displays in the PortalVision Advanced Imaging application (version 1.6.15 or later).

10. Make sure the filter is set to **None**.



11. Repeat steps 1 through 8 to record open field pixel values at the same ROIs as the RapidArc field.





12. Calculate the RapidArc field pixel values, normalized to the open field pixel values, using the following formula:

$$R_{\mathrm{corr}}(x) = \frac{R_{\mathrm{DR-GS}}(x)}{R_{\mathrm{Open}}(x)} \cdot 100$$

Where:

- $R_{DR-GS}(x)$ is the Mean pixel value at a given ROI in the RapidArc field;

- $R_{corr}(x)$ is the normalized Mean pixel value at the same ROI in the RapidArc field;
- $R_{Open}(x)$ is the Mean pixel value at the same ROI in the open field.

13. Calculate the deviation of each ROI using the following formula:

$$\text{diff}(x) = \frac{R_{\text{corr}}(x)}{\bar{R}_{\text{corr}}} \cdot 100 - 100$$

Where:

$\bar{R}_{corr}$ is the average of $R_{corr}(x)$ for all seven strips.

Machines using these plans will typically achieve numbers below 3% for each $diff(x)$.

14. Calculate the average of the absolute value of all $Diff(x)$ values:

$$Diff_{abs} = \overline{|diff(x)|}$$

Machines using these plans will typically achieve numbers below 1.5% for $Diff_{abs}$.

Note: *The typical values presented here are not Varian specifications. Typical results are provided as a guideline for the tests, but the users must determine the Clinical tolerances appropriate for their equipment.*

15. Exit the PortalVision Advanced Imaging application.

Appendix B Evaluation of Test 3 Using Portal Vision Advanced Imaging (PVAI)

Overview and Procedure

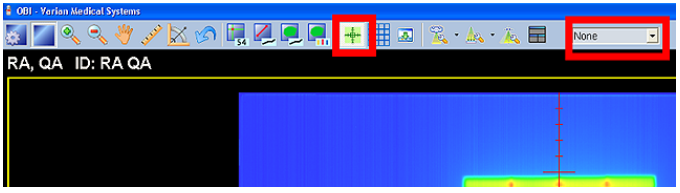
The procedures described in MLC Leaf Speed Test Procedure on page 25 are performed using OBI, and can alternately be performed using ARIA Offline Review. Customers without OBI or Offline Review can perform these procedures using the PortalVision Advanced Imaging (PVAI) application (version 1.6.15 or later).

Note: *When using PVAI you must perform this analysis* ***during the image acquisition session****; you cannot perform the evaluations after the image acquisition session is closed.*

After successful irradiation of all fields as described in MLC Leaf Speed Test Procedure (steps 1 through 14, steps 17 through 20, and step 29) the acquired images can be evaluated in the PortalVision Advanced Imaging application as described in the following steps.

The acquired image will be displayed in the PortalVision Advanced Imaging application.

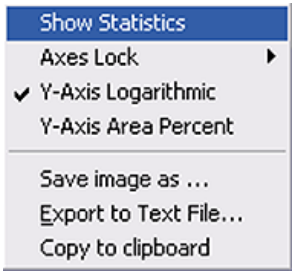
1. Make sure the graticule is enabled and the filter is set to **None**.



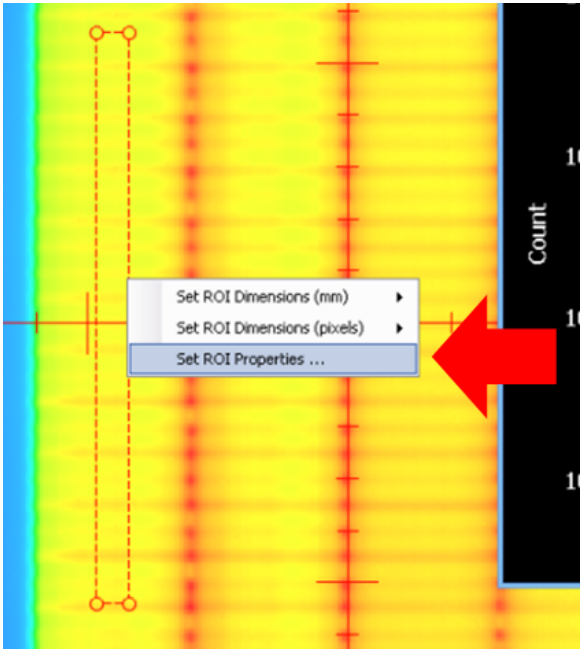
2. Click the **Histogram** button to enable the Area Histogram and draw a Region of Interest (ROI).

The Histogram window appears

3. Right-click the histogram and select **Show Statistics** from the context menu.



4. Right-click a corner of the ROI and select **Set ROI Properties** from the context menu.



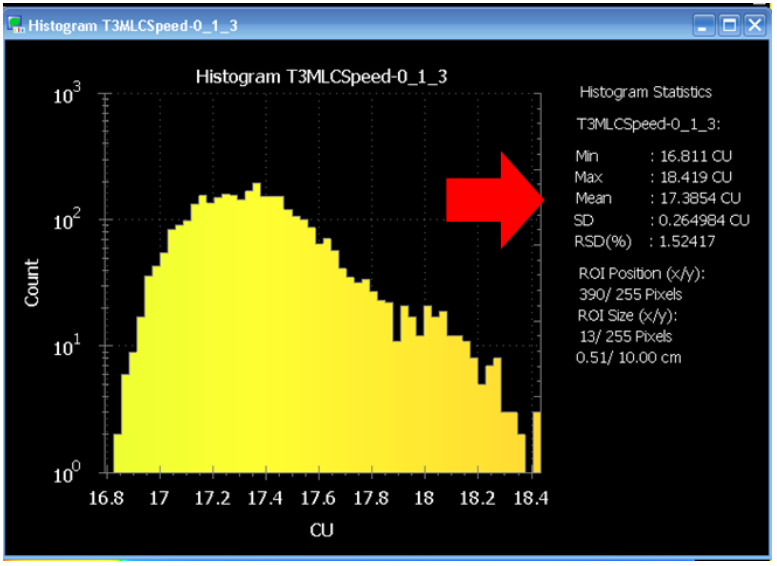
5. Make the following selections:
   - Unit: mm
   - Width: 5mm
   - Height: 100mm

6. Center the ROI within the first vertical band by setting the horizontal and vertical positions for Band 1 (see table below) and clicking **OK**.

   The ROI should be centered on the graticule horizontal axis, and centered within the band on the graticule vertical axis.

Band	Center of Band	ROI Horiz. Pos.	ROI Vert. Pos.
1	−4.5 cm	153.0 mm	100 mm
2	−1.5 cm	183.0mm	
3	+1.5 cm	213.0 mm	
4	+4.5 cm	243.0 mm	

7. Write down the mean pixel value indicated by the histogram statistics.



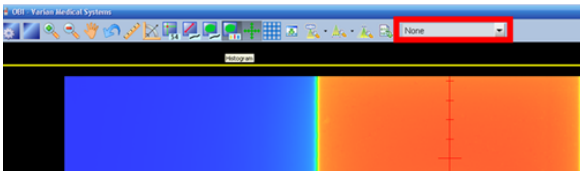
8. Repeat steps 6 to 7 for Bands 2 through 4 (see table in step 6).

   To take into account fluence variation across the beam, an open field beam profile at the same position is needed. The open beam appears as the second field in the plan.

9. Deliver the second field in the plan.

   The acquired image of the open field displays in the PortalVision Advanced Imaging application (version 1.6.15 or later).

10. Make sure the filter is set to **None**.



11. Repeat steps 2 through 8 to record open field pixel values at the same ROI as the test image.
12. Calculate the RapidArc field pixel values, normalized to the open field pixel values, using the following formula:

$$R_{corr}(x) = \frac{R_{LS}(x)}{R_{Open}(x)} \cdot 100$$

Where:

- $R_{corr}(x)$ is the normalized Mean pixel value for a given RapidArc measurement ROI
- $R_{LS}(x)$ is the Mean pixel value for the same ROI
- $R_{Open}(x)$ is the Mean pixel value at the same ROI in the open field

13. Calculate the deviation of each ROI using the following formula:

$$diff(x) = \frac{R_{corr}(x)}{\bar{R}_{corr}(x)} \cdot 100 - 100$$

Where $\bar{R}_{corr}(x)$ is the average of $R_{corr}(x)$ for all four ROIs.

Machines using these plans typically achieve numbers below 3% for each $diff(x)$.

14. Calculate the average of the absolute value of all $diff(x)$ values:

$$Diff_{abs} = \overline{|diff(x)|}$$

Machines using these plans will typically achieve numbers below 1.5% for $Diff_{abs}$.

Note: *The typical values presented here are not Varian specifications. Typical results are provided as a guideline for the tests, but the users must determine the Clinical tolerances appropriate for their equipment.*

15. Exit the PortalVision Advanced Imaging application.