MegaQA Program: User Manual
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Overview:

The MegaQA program is a system for performing routine accelerator photon quality assurance tasks using the amorphous silicon electronic portal imaging device (EPID) attached to most accelerators. Quality assurance is performed by acquiring a series of EPID images and comparing them to initially established baselines. Software has been written in the Matlab programming language to quickly and accurately analyse the images.

The initial program and software was instituted at the Calvary Mater Newcastle hospital by Peter Greer in 2006. The analysis software was streamlined and updated in 2010 by Brian King.

The tests that are performed as part of the MegaQA program are listed in Table 1. For more details see the section “MegaQA Test Analysis”.

Table 1: Tests included in the MegaQA program.

Test	Image Field	Collimator	Energy
Central axis	10x10 cm	90, 270	6 MV
Beam profile	20x20 cm	0	6 MV 18 MV
EDW	EDW	0	6 MV 18 MV
Relative response	30x40 cm	0	6 MV 18 MV
Dose response	10x10 cm	90	6 MV 18 MV
Asymmetric jaws	Various asymmetric	0, 90	6 MV

All tests are optional, with the exception of the central axis test, as the other tests use the output of the central axis test in order to align the images.

The results of each test are stored in a machine specific Excel workbook at the completion of the test. This allows for analysis of long term trends in the results.

Initial Setup:

Before setting up a new MegaQA program ensure that up to date floodfield images have been acquired in integrated image mode for the dose rate that will be used to acquire the images. The floodfield image must be acquired with the imager at the same position that will be used during the tests. The floodfield image must not be changed in order to consistently compare images to baselines.

It is recommended that a verification plan be created to reliably and repeatably measure the same set of fields at each session. The field details can be found in Appendix A.

An output Excel workbook must be configured for each accelerator that will be included in the MegaQA program. This Excel workbook contains the results of each test, as well as machine specific test tolerances and baseline information. This Excel workbook has a particular format that must be adhered to. A template Excel workbook has been included with this document.

The tolerances defined for each machine can be found in the output Excel workbook in the sheet called Tolerances. Minimum and maximum allowed values for each test can be defined in the appropriate columns of this sheet. If no value is specified, no check will be performed for that parameter during the MegaQA test. A list of the tests and specifications that are checked are given in Table 2.

Table 2: List of tests and specifications that are checked by the MegaQA software. IP refers to In-plane profiles and CP refers to cross-plane profiles.

Test	Parameter
Central axis	IP Central axis (pixels)
Central axis	CP Central axis (pixels)
Beam Profile	IP - Field Width (mm)
Beam Profile	CP - Field Width (mm)
Beam Profile	IP - Maximum difference from baseline(%)
Beam Profile	CP - Maximum Difference from baseline (%)
Beam Profile	IP - Standard Deviation from baseline (%)
Beam Profile	CP - Standard Deviation from baseline (%)
Beam Profile	IP - Profile Flatness (%)
Beam Profile	CP - Profile Flatness (%)
Beam Profile	IP - Profile Symmetry (%)
Beam Profile	CP - Profile Symmetry (%)
EDW	IP - Maximum Difference from baseline (%)
EDW	CP - Maximum Difference from baseline (%)
EDW	IP - Standard Deviation from baseline (%)
EDW	CP - Standard Deviation from baseline (%)
Relative Response	IP - Maximum Difference from baseline (%)
Relative Response	CP - Maximum Difference from baseline (%)
Relative Response	IP - Standard Deviation from baseline (%)
Relative Response	CP - Standard Deviation from baseline (%)
Relative Response	IP - Profile Flatness (%)
Relative Response	CP - Profile Flatness (%)
Relative Response	IP - Profile Symmetry (%)
Relative Response	CP - Profile Symmetry (%)
Dose Response	Central axis dose – current
Dose Response	Central axis dose – baseline
Dose Response	Dose Change from baseline (%)
Asymmetric Jaws	Jaw 1 Position (mm)
Asymmetric Jaws	Jaw 2 Position (mm)
Asymmetric Jaws	Jaw Gap (mm)
Asymmetric Jaws	Junction Dose (%)

The MegaQA software will read either standard dicom images or text files output from Varian’s Portal Dosimetry software in DXF format. As the normalization of the two file types is different, all files to be analysed must be in only a single file format. No mixing and matching of file formats is supported. In either case, the files to be analysed must be exported from the record and verify system (assuming that a verification plan was set up as recommended). In the case of files exported in DXF format, the images are scaled to CU units and an off-axis profile is included in the images. If the scaling factor or off-axis profile are changed, this will affect the results of the test. Images exported in dicom format do not have this issue.

MegaQA Directories

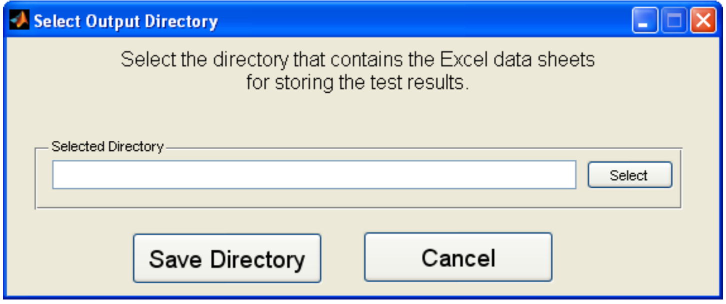
The output Excel workbook for all machines must be located in a single directory (the “output” directory). Each machine should have a defined “data” directory where images acquired for that particular machine will be stored. The images acquired during each test session must be stored in individual subdirectories.

Establishing baselines:

After the verification plan has been setup in the treatment database, baselines for each test must be established. This entails simply running the verification plan and acquiring images for each test that is to be performed. The images should be stored in a subdirectory of the “data” directory for the given machine.

Software Configuration

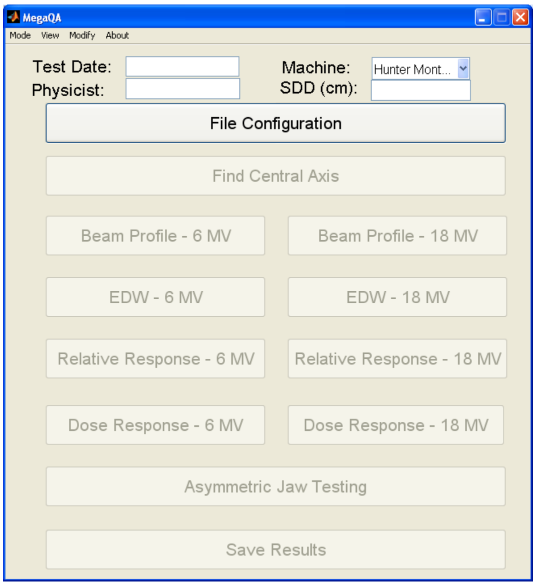
When starting the MegaQA software for the first time, the user will be prompted for the location of the output directory, as shown in Figure 1. When the directory is selected, it will be scanned for Excel workbooks that match the required MegaQA format. At least one valid Excel workbook must be present in the specified directory. The output directory can be viewed at any later time by accessing the “View>Output Directory” menu option from within the MegaQA software. It can be changed by accessing the “Modify>Output Directory” menu option from within the MegaQA software. Changing the output directory will affect the available machines to test and may also affect the baselines and parameter tolerances.


Select Output Directory

Select the directory that contains the Excel data sheets for storing the test results.

Figure 1: Configuring the output directory for MegaQA.

When the output directory has been configured, the main MegaQA window will appear, as shown in Figure 2. A list of available machines (as determined by the Excel workbooks present in the output directory) is given in the “Machine” drop-down menu. The file format of the test images can be set using either the “Mode>Dicom” or “Mode>DXF” menu option. The default mode is “DXF” but the software will store the selection for future use. The software can also be configured to use either “Full Test” or “Partial Test” mode by selecting the appropriate option under the “Mode” menu. In “Full Test” mode, before the data can be saved in the output sheet, all tests that can be performed using the acquired images must be performed. In “Partial Test” mode, the data can be saved in the output sheet as long as a single test has been performed. The default mode is “Full Test” but the software will store the selection for future use.



Test Date:
Physicist:
Machine: Hunter Mont...
SDD (cm):

Figure 2: The main MegaQA window.

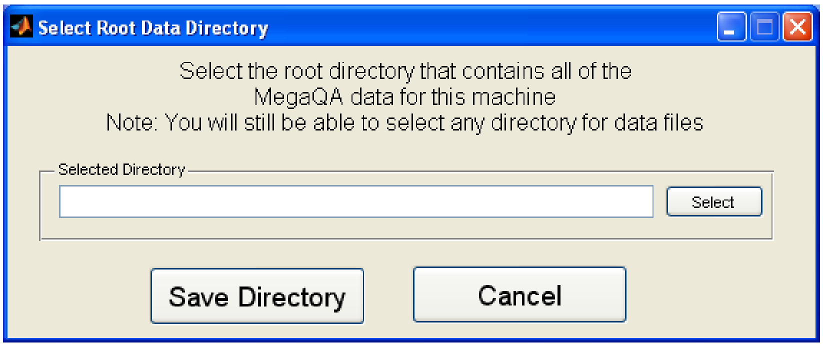
Machine Configuration

Each machine to be tested must be configured using the MegaQA software. There are several things that must be configured for each machine:

- Data directory – This is the root directory where all data files for the machine will be stored. The images acquired during each test session should be stored in individual subdirectories beneath the specified data directory. Each session’s images must, as a minimum, be stored in their own individual directory.
- Baseline directory – This is the directory where the baseline images are stored.
- Baseline files – Specify which files in the baseline directory correspond to which images.
- SDD offset – Specify the offset between the Epid detector plane and the nominal Epid position (in cm). This is necessary to accommodate different imager position calibration schemes that may be used. If the imager position is calibrated such that the nominal position corresponds to the position of the imager detector layer, this offset is 0.
- The minimum and maximum allowed values for each individual test.

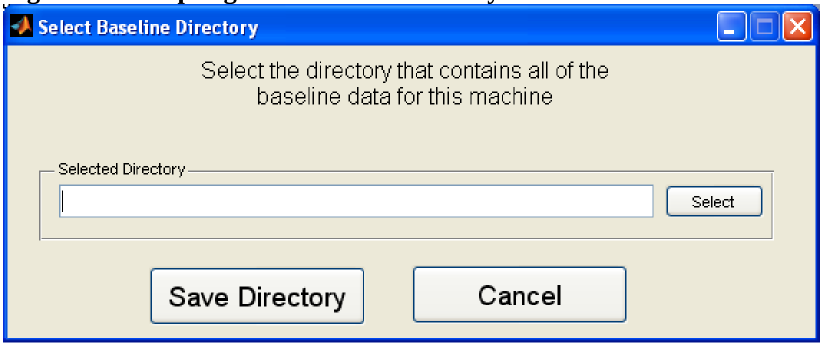
All of this information is stored in the machine Excel workbook. The test specifications are stored in the sheet called “Tolerances” and must be set directly from within Excel. All other configuration information is stored in the sheet called “File Details”. The information on the “File Details” sheet can be set directly from within Excel if desired or, if missing, will be prompted for automatically by the MegaQA software when the “File Configuration” button is clicked. The automatic process is recommended and is explained below.

When a machine is selected in the “Machine” drop-down menu and the “File Configuration” button is clicked to start the test, the appropriate Excel workbook is opened and the information in the “File Details” sheet is read. Each piece of missing information will be prompted for. If the data directory is not specified in the “File Details” sheet, a window will appear as in Figure 3. If the baseline data directory is not specified in the “File Details” sheet, a window will appear as in Figure 4. If the baseline files have not been set, a window will appear as in Figure 5. This window is the standard MegaQA file selection window. See appendix B for detailed information on the file selection window. The files in the specified baseline directory must be matched to the appropriate energy and field configurations using the “Data Files” drop-down menus. Only files in the appropriate file format (dcm or dxf) will be shown. The software will attempt to automatically determine the proper configuration based on the file names and labels within the file. The selections can be changed if required. See appendix C for the file naming scheme that MegaQA prefers. The selections that are given as “N/A” are not required for the baseline files and can not be changed. If the detector offset has not been set, a window will appear as in Figure 6. Cancelling any of these windows will stop the file configuration process and the analysis will stop. Once all of this information has been defined, the information will be saved in the output sheet and the actual test process will begin. This is explained in detail in the next section.



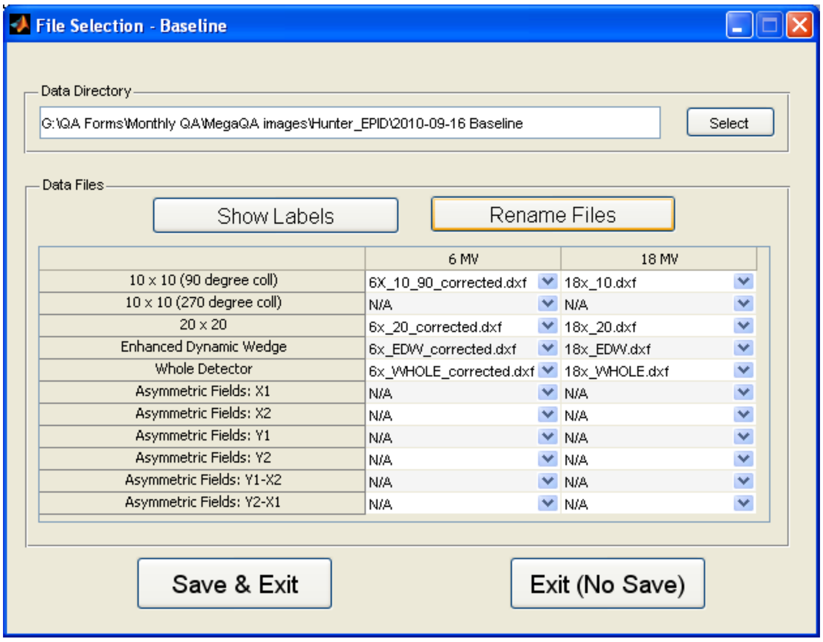
Select the root directory that contains all of the
MegaQA data for this machine
Note: You will still be able to select any directory for data files

Figure 3: Prompting for root data directory.



Select the directory that contains all of the
baseline data for this machine

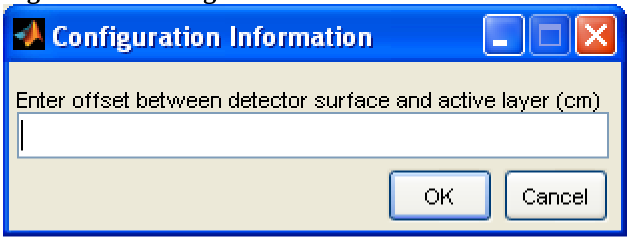
Figure 4: Prompting for baseline data directory.



G:\QA Forms\Monthly QA\MegaQA images\Hunter_EPID\2010-09-16 Baseline

	6 MV	18 MV
10 x 10 (90 degree coll)	6X_10_90_corrected.dxf	18x_10.dxf
10 x 10 (270 degree coll)	N/A	N/A
20 x 20	6x_20_corrected.dxf	18x_20.dxf
Enhanced Dynamic Wedge	6x_EDW_corrected.dxf	18x_EDW.dxf
Whole Detector	6x_WHOLE_corrected.dxf	18x_WHOLE.dxf
Asymmetric Fields: X1	N/A	N/A
Asymmetric Fields: X2	N/A	N/A
Asymmetric Fields: Y1	N/A	N/A
Asymmetric Fields: Y2	N/A	N/A
Asymmetric Fields: Y1-X2	N/A	N/A
Asymmetric Fields: Y2-X1	N/A	N/A

Figure 5: Selecting the baseline files.

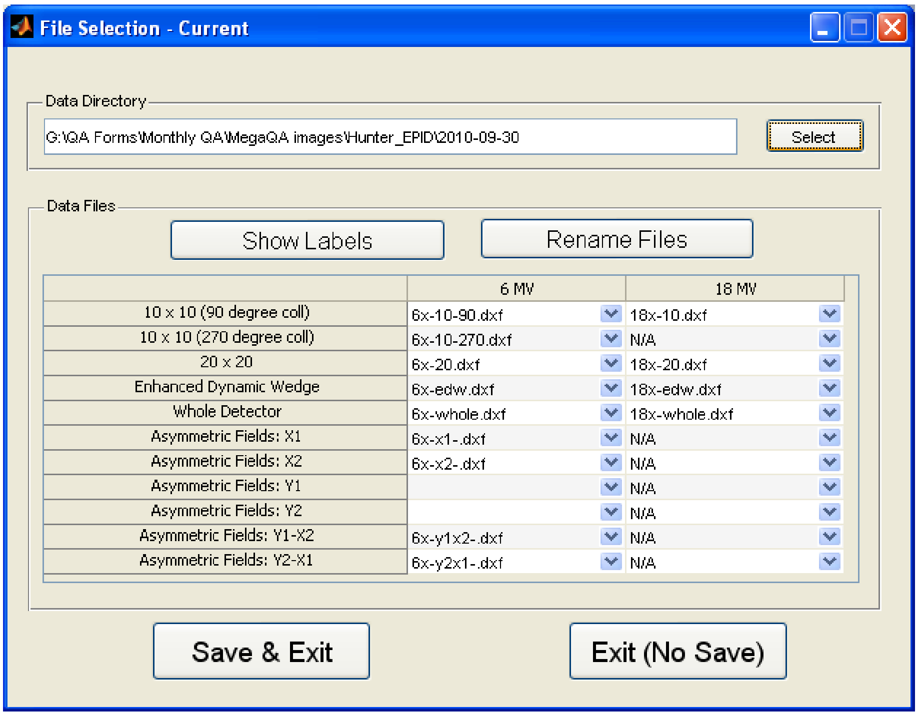


Enter offset between detector surface and active layer (cm)

Figure 6: Specifying the detector offset.

MegaQA Test Analysis

To analyse the acquired images, enter the date that the images were acquired, the physicist name and source-detector-distance in the appropriate boxes. Then select the machine where the images were acquired from the “Machine” drop-down menu and click the “File Configuration” button. At this point, the software will read the selected Excel workbook to try to extract information about the data directory and baseline files. If this information is not present, the software will ask the user to provide it (see the “Machine Configuration” section). Next, the software will ask the user to specify where the images to be analysed are stored. This is done with the standard MegaQA file selection window. An example is shown in Figure 7. Select the appropriate directory and ensure that all required files have been properly selected. See the Asymmetric jaws test section for the proper field naming scheme in the asymmetric jaws test. If the file selection process is cancelled, the data analysis will stop. When the files have been configured properly, the “Save & Exit” button should be clicked. This will cause the file selection window to close, the “File Configuration” button on the main MegaQA window to turn green and the “Find Central Axis” test to be enabled.



Data Directory: G:\QA Forms\Monthly QA\MegaQA images\Hunter_EPID\2010-09-30

Data Files

	6 MV	18 MV
10 x 10 (90 degree coll)	6x-10-90.dxf	18x-10.dxf
10 x 10 (270 degree coll)	6x-10-270.dxf	N/A
20 x 20	6x-20.dxf	18x-20.dxf
Enhanced Dynamic Wedge	6x-edw.dxf	18x-edw.dxf
Whole Detector	6x-whole.dxf	18x-whole.dxf
Asymmetric Fields: X1	6x-x1-.dxf	N/A
Asymmetric Fields: X2	6x-x2-.dxf	N/A
Asymmetric Fields: Y1		N/A
Asymmetric Fields: Y2		N/A
Asymmetric Fields: Y1-X2	6x-y1x2-.dxf	N/A
Asymmetric Fields: Y2-X1	6x-y2x1-.dxf	N/A

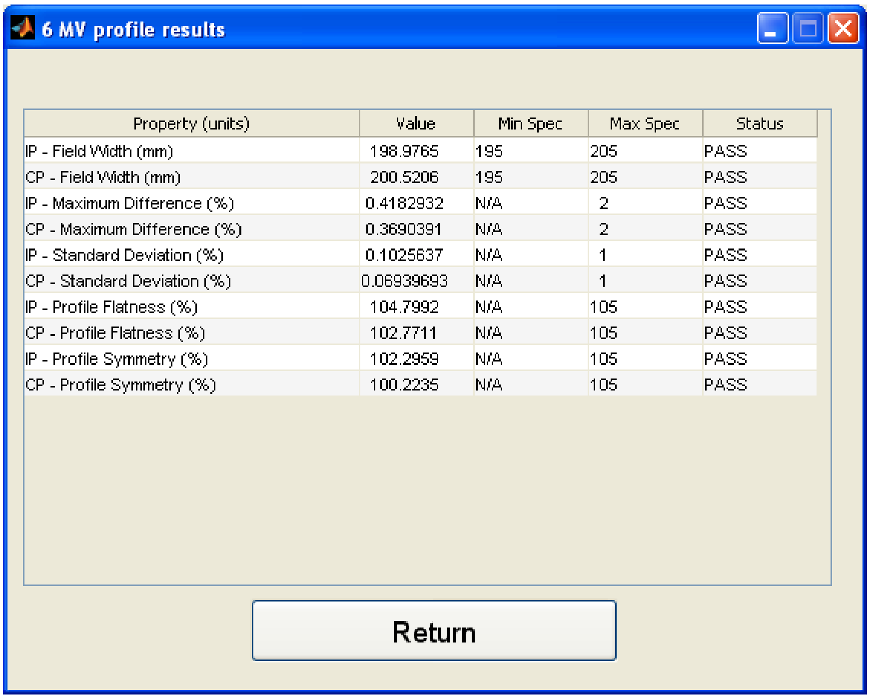
Figure 7: Selecting files to analyse with the "File Selection" window.

Find Central Axis Test

The "Find Central Axis" test must be completed before any other tests can be performed. This test uses the two images of 10 cm fields with collimator positions of 90 and 270 degrees. It finds the centre pixel of these images (as defined by the full-width-half-maximum of in-plane and cross-plane profiles. All other tests shift the images such that the centre pixel will be consistent with those in the baseline images. The "Find Central Axis" test produces a results window that shows the calculated central axis pixel. Clicking the "Return" button in the results window completes the test, causing the "Find Central Axis" button to turn green and all other available tests to be enabled. Tests that require files that were not configured in the "File Selection" window will not be enabled.

Beam Profile Tests

These tests use the 20 cm square field images. They are used to verify the consistency of the accelerator beam profile over time. The images are normalized to 1 at the central axis. The images are compared to the baseline 20 cm images and the symmetry and flatness of profiles through the centre pixel are calculated. Specifications for all of these parameters are read from the Excel output sheet. When the test is complete, a results window will appear showing the status of each parameter as shown in Figure 8. Additionally, an image comparison window will appear which will allow visual inspection of the images as shown in Figure 9. For more details on the Image Comparison window see the documentation for the ImageCompare function. Clicking the "Return" button in the results window signifies completion of the test and the test button turns green.



Property (units)	Value	Min Spec	Max Spec	Status
IP - Field Width (mm)	198.9765	195	205	PASS
CP - Field Width (mm)	200.5206	195	205	PASS
IP - Maximum Difference (%)	0.4182932	N/A	2	PASS
CP - Maximum Difference (%)	0.3690391	N/A	2	PASS
IP - Standard Deviation (%)	0.1025637	N/A	1	PASS
CP - Standard Deviation (%)	0.06939693	N/A	1	PASS
IP - Profile Flatness (%)	104.7992	N/A	105	PASS
CP - Profile Flatness (%)	102.7711	N/A	105	PASS
IP - Profile Symmetry (%)	102.2959	N/A	105	PASS
CP - Profile Symmetry (%)	100.2235	N/A	105	PASS

Figure 8: Results window for the 6 MV beam profile test.

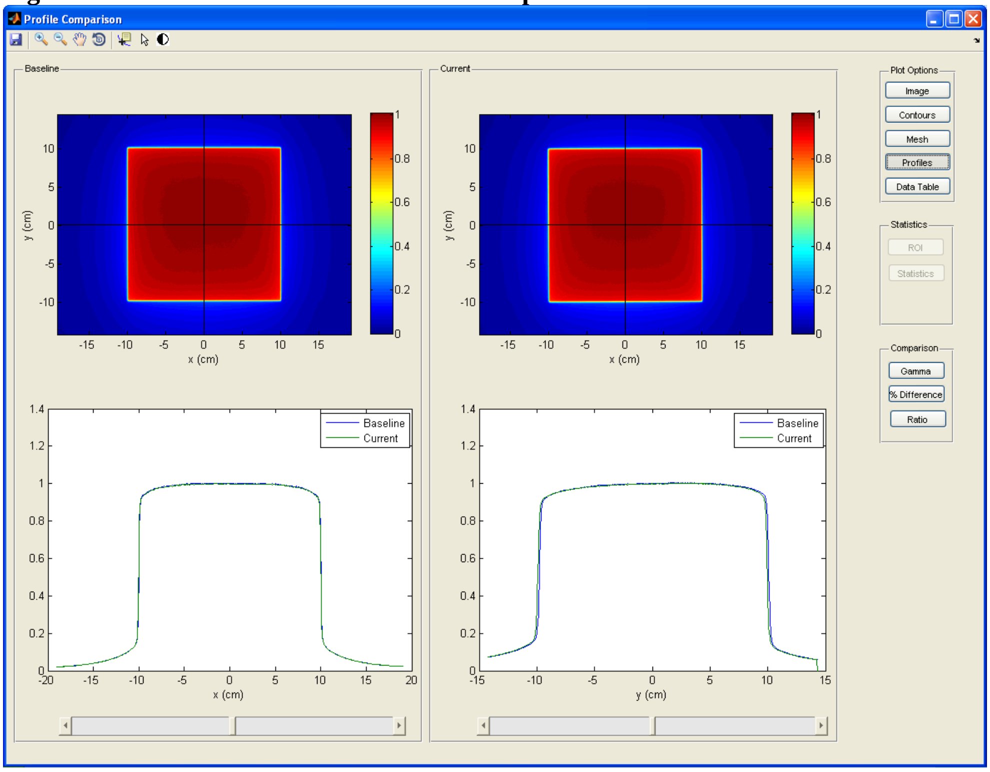


Figure 9: The image comparison window for the 6MV beam profile test.

Enhanced Dynamic Wedge Test
These tests use the enhanced dynamic wedge images. They are used to verify the consistency of wedge fields over time. The images are normalized to 1 at the central axis. The images are compared to the baseline dynamic wedge images. Specifications for the parameters are read from the Excel output sheet. When the test is complete, a results window will appear showing the status of each parameter (similar to that produced by the beam profile test). Additionally, an image comparison window will appear (similar to that produced by the beam profile test). Clicking the “Return”

button in the results window signifies completion of the test and the test button turns green.

Relative Response Test
These tests use the whole detector images. They are used to verify the stability of all pixels over time. The images are normalized to 1 at the central axis. The images are compared to the baseline whole detector images and the flatness and symmetry of profiles through the central pixel are computed. Specifications for the parameters are read from the Excel output sheet. When the test is complete, a results window will appear showing the status of each parameter (similar to that produced by the beam profile test). Additionally, an image comparison window will appear (similar to that produced by the beam profile test). Clicking the “Return” button in the results window signifies completion of the test and the test button turns green.

Dose Response Test
These tests use the 10 cm (collimator 90) images. They are used to verify the stability of central axis dose response over time. The images are compared to the baseline 10 cm images and the change in the central axis signal compared to the baseline is computed. In this test, no normalization of the images is performed. Specifications for the parameters are read from the Excel output sheet. When the test is complete, a results window will appear showing the status of each parameter (similar to that produced by the beam profile test). Additionally, an image comparison window will appear (similar to that produced by the beam profile test). Clicking the “Return” button in the results window signifies completion of the test and the test button turns green.

Asymmetric Jaws Test
This test is composed of four identical tests, each testing how well asymmetric jaw fields are matched at the centre under different conditions. In each test, one image is acquired with one collimator (eg. X1) in an open position and the complementary jaw (eg. X2) set to the zero position. A second image is acquired with the jaw positions reversed. These two images are combined together and the signal in the junction area is examined. The jaw offset and junction dose increase are computed for each pair of images. The jaw combinations are shown in Table 3.

Table 3: Asymmetric jaw test configurations. The “file selection” column tells which entry in the “File Configuration” dialog should be used for each file.

Collimator	Image 1		Image 2	
Angle	closed jaw	file selection	closed jaw	file selection
0	X1	X1	X2	X2
0	Y1	Y1	Y2	Y2
90	Y1	Y1	X2	Y1-X2
90	Y2	Y2	X1	Y2-X1

At the end of each stage, a results window will be shown, as well as an image of the composite image formed by the combination of the two asymmetric images. This image is displayed in an Extended Image window and can be manipulated to allow examination in more detail. See documentation of the EImage function for more information on how to use the Extended Image window. A zoomed in profile through the junction is also shown in a separate window. Clicking the “Return” button in the results window signifies completion of the test for the current jaw configuration and the next one will be processed. When all configurations have been tested, the test button turns green.

Saving Results

When all of the desired tests have been completed, the results can be saved in the Excel output sheet. This is accomplished by clicking the “Save Results” button. When this is clicked, a window will open that will accept any optional comments that the user may want to add. The comments will be included in the output Excel worksheet with the test results. The test results are output to four separate sheets contained in the output workbook. The test results can then be tracked over time for each machine. To select a new machine for testing, click the “Unlock” button next to the machine drop-down menu. This will reset all of the completed tests and remove all of the calculated results from memory. To start a new test at any time, click the “File Configuration” button and select a new set of files to analyse.

Appendix A: MegaQA Treatment Fields

Table 4 gives the necessary details for configuring a treatment plan to acquire the images necessary for performing the MegaQA analysis. In all cases, the EPID must be set to the same position (105 cm source-detector-distance is assumed here). All images are acquired with a gantry angle of 0 degrees. The 18 MV measurements must have an extra 2 cm of Perspex added to the top of the imager for build-up.

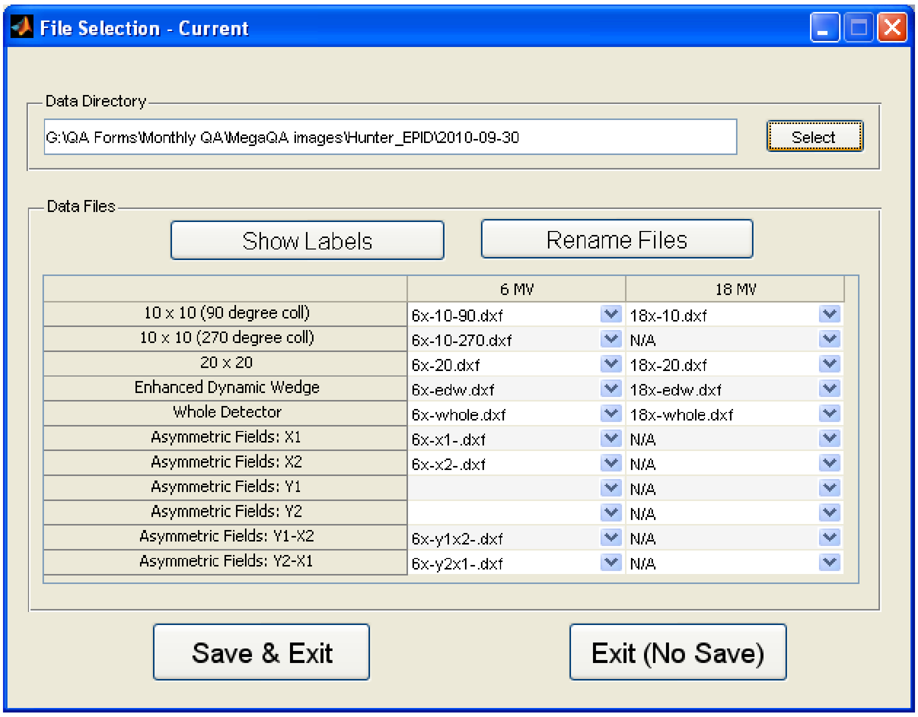
Table 4: Field details for setup of MegaQA treatment plan

Field ID	Energy	MU	Collimator	X1	X2	Y1	Y2	Other
6X Whole	6	100	0	19.5	19.5	14.5	14.5	
6X 20x20	6	100	0	10	10	10	10	
6X EDW	6	100	0	10	10	10	10	EDW60IN
6X AsymX2	6	40	0	10	0	10	10	
6X AsymX1	6	40	0	0	10	10	10	
6X AsymY2	6	40	0	10	10	10	0	
6X AsymY1	6	40	0	10	10	0	10	
6X AsymY1X2	6	40	90	10	0	10	10	
6X AsymY2X1	6	40	90	0	10	10	10	
6X 10_90	6	100	90	5	5	5	5	
6X 10_270	6	100	270	5	5	5	5	
18X Whole	18	100	0	19.5	19.5	14.5	14.5	buildup
18X 20x20	18	100	0	10	10	10	10	buildup
18X EDW	18	100	0	10	10	10	10	buildup, EDW60OUT
18X 10x10	18	100	0	5	5	5	5	buildup

Appendix B: The MegaQA File Selection Window

An example of the MegaQA file selection window is shown in Figure 10. There are two main sections: The “Data Directory” section, where the directory containing the relevant files is selected, and the “Data Files” section, where the files in the data directory are matched against the required images for later analysis.

A valid data directory must be selected using the “Select” button before the “Data Files” section is activated. When a valid directory is selected, all files with the appropriate extension in the directory will be loaded into the drop-down menu options in the file selection table. The user can manually select any file in the directory to match with any of the images that MegaQA is expecting. The user also has the option of selecting a blank entry to signify that no file matches a particular image. Blank entries will affect which MegaQA tests are available.



Data Directory: G:\QA Forms\Monthly QA\MegaQA images\Hunter_EPID\2010-09-30

	6 MV	18 MV
10 x 10 (90 degree coll)	6x-10-90.dxf	18x-10.dxf
10 x 10 (270 degree coll)	6x-10-270.dxf	N/A
20 x 20	6x-20.dxf	18x-20.dxf
Enhanced Dynamic Wedge	6x-edw.dxf	18x-edw.dxf
Whole Detector	6x-whole.dxf	18x-whole.dxf
Asymmetric Fields: X1	6x-x1-.dxf	N/A
Asymmetric Fields: X2	6x-x2-.dxf	N/A
Asymmetric Fields: Y1		N/A
Asymmetric Fields: Y2		N/A
Asymmetric Fields: Y1-X2	6x-y1x2-.dxf	N/A
Asymmetric Fields: Y2-X1	6x-y2x1-.dxf	N/A

Figure 10: An example file selection screen.

If the “Show Labels” button is clicked, the available entries in the drop-down menus will display the field label stored in each file instead of the file name. For dicom files, this information is found in the RTImageLabel dicom tag while for DXF files, this information is found in the FieldId field of the header. Duplicate entries will have a “-1”, “-2” etc appended. This functionality can be useful if the file names are not descriptive, as may be the case when the images are exported from the record and verify database.
The “Show Labels” button is actually a toggle button that allows the display to be changed back and forth between showing the file names and the field labels. The text on the button changes to indicate the effect of clicking the button.

The “Rename Files” button provides a simple way of renaming all of the files (with the appropriate extension) in the directory such that the file names will match the field labels stored within the file. This can be useful if the file names are not descriptive, as may be the case when the images are exported from the record and verify database.

Appendix C: MegaQA data file naming scheme

The MegaQA files can have any desired names. The only requirement is that all files from a single session must be stored in the same directory. However, there is a preferred naming scheme that simplifies the act of selecting the appropriate files. If this naming scheme is followed, the proper files will be automatically selected by the MegaQA program when a data directory is selected. (NOTE: The file names and field labels must both follow the naming scheme in order for automatic file selection to work properly. Any fields where the software can not unambiguously determine the proper file must be manually selected by the user. The preferred naming scheme is given in Table 5. The matching is case-insensitive.

Table 5: File naming convention used by MegaQA

Energy (MV)	Field size (cm)	Collimator (deg)	Preferred name	Other options
6	10x10	90	6x-10-90	6x 10_90, 6x_10_90
6	10x10	270	6x-10-270	6x 10_270, 6x_10_270
6	20x20	0	6x-20	6x 20x20, 6x_20
6	EDW	0	6x-EDW	6x EDW, 6x_EDW
6	30x40	0	6x-Whole	6x Whole, 6x_Whole
6	X1		6x-x1-	6x AsymX1, 6x AsyX1, 6x_x1_
6	X2		6x-x2-	6x AsymX2, 6x AsyX2, 6x_x2_
6	Y1		6x-y1-	6x AsymY1, 6x AsyY1, 6x_y1_
6	Y2		6x-y2-	6x AsymY2, 6x AsyY2, 6x_y2_
6	Y1X2		6x-y1x2-	6X AsymY1X2, 6x AsyY1X2, 6x_y1x2
6	Y2X1		6x-y2x1-	6X AsymY2X1, 6x AsyY2X1, 6x_y2x1
18	10x10	0	18x-10	18x 10x10, 18x 10_10, 18x_10
18	20x20	0	18x-20	18x 20x20, 18x_20
18	EDW	0	18x-EDW	18x EDW, 18x_EDW
18	30x40	0	18x-Whole	18x Whole, 18x_Whole