BeamScheme Documentation

Release 0.50-beta

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CHAPTER

ONE

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CHAPTER

TWO

INTRODUCTION

Welcome to BeamScheme. This software will assist you in extracting 1D profiles from 2D datasets and calculating various parameters on the profiles. BeamScheme can open various image and 2D array file formats such as SNC MapCheck, PTW 720, IBA Matrix and StarTrack, XiO, DICOM, jpg, etc. Parameters such as field size, field centre, penumbra, flatness and symmetry are calculated. Profiles can be taken at any angle, offset or thickness. Profiles can be exported to a text file for further processing. Results can be printed or exported to PDF. BeamScheme is not intended to replace the commercial software available with 2D arrays, but to complement it.

This manual assumes that you are familiar with using your operating system. If you are not then please consult the appropriate documentation and on-line help. BeamScheme can run on a variety of operating systems and while a thorough knowledge of your specific system is not necessary some basic knowledge such as running files will be an advantage.

CHAPTER

THREE

CONVENTIONS IN THIS MANUAL

Various typefaces and punctuation symbols are used to indicate actions that the user must perform. Here is a list of these actions and their meanings.

- Words in a courier font indicate letters that must be typed in on the keyboard. These will usually be data that should be typed into a field.
- Words between single quotes, e.g. 'Start', usually indicate the name of a menu option, field or button.
- Words between angular brackets, e.g. <Enter>, indicate a key that should be pressed. A combination of keys is indicated by a dash '-', for example <Alt-F> means you should press the <Alt> key and the <F> key together. Keys following each other are indicated by a comma ',', for example <Alt-F,S> means that you should press the <Alt> key together with the <F> key, release them and then press the <S> key.
- An icon like this  indicates important information about which you should be aware.
- A hint or short cut is shown like this  .

It should be mentioned here that when this manual uses the word 'field' it is referring to a place in the program window where data is entered and not a radiation treatment field unless it is specifically stated.

CHAPTER

FOUR

SYSTEM REQUIREMENTS

BeamScheme can run on a variety of platforms and operating systems. Currently EPS is compiled for:

- Windows 7 or higher
- Fedora 26 running KDE 5 with Qt 5.6

The program needs approximately 5 MB of disk space to install. A 19” monitor or larger is not essential but will make viewing easier. BeamScheme should not be viewed at a resolution of less than 1280x1024. Other linux versions such as GTK based may be available on request.

CHAPTER

FIVE

INSTALLATION

Installing the Beam Scheme is simple, but if you are concerned that you cannot do it ask your System Administrator or Physicist to do it for you.

5.1 Uninstalling previous versions

It is no longer necessary to uninstall previous versions of BeamScheme before installing a new version. Please note that the installation utility will not backup any image or 2D array files in the directory. You will need to do this yourself. If, for any reason, you still want to uninstall the program please follow the instructions below:

5.1.1 Under Windows

In Windows open the 'Control Panel' from the main menu, double click 'Programs and Features', (previously known as 'Add Programs') and click on the 'BeamScheme' entry. Select 'Uninstall' or 'Remove'. When BeamScheme has been removed close 'Programs and Features' and close the 'Control Panel'

5.1.2 Under Linux

Delete the files in the installation directory. If you have any desktop shortcuts or menu links delete those as well.

5.2 Installing a new version under Windows

Insert your media containing the installation files. Using Windows Explorer navigate to the drive that you inserted. Select the folder containing the files for your site. Double click on the 'setup' program and follow the on screen instructions. It is best to simply accept the default installation values.

5.3 Installing a new version under Linux

Insert the media containing the installation files and mount it. Copy the tar file to the directory where you want to install it. Extract it to this directory. Make sure that the executable has execute permissions. If necessary create a link to the executable and place it in your path.

CHAPTER

SIX

RUNNING BEAMSCHEME

Contents:

6.1 Running BeamScheme under Windows

Double click the 'BeamScheme' icon  on the desktop. Alternatively select 'Start, All Programs, BeamScheme, BeamScheme' on the Start Menu.

6.2 Running BeamScheme under Linux

Open a terminal window. Change to the directory where you installed BeamScheme. At the prompt enter:

```
./beamscheme &<enter>
```

Alternatively you can create a link to the application and place it on your desktop. Refer to your system documentation for details.

CHAPTER

SEVEN

USING BEAMSCHEME

Using BeamScheme is simple. There are two profiles, a horizontal or X profile and a vertical or Y profile. The X profile is displayed in the top right quadrant or pane of the screen. The Y profile is displayed in the bottom left quadrant. The result are displayed in the bottom right quadrant. The opened image, fluence or 2D array file is displayed in the top left quadrant. The status bar at the bottom of the screen communicates error messages and warnings. Profiles and results are calculated automatically when a profile is changed or a file is opened.

7.1 The Menu Bar

The menu bar allows you to open datasets, export profiles, edit protocols and print results. Some functions are duplicated on the toolbar in *The Image Pane*. Menu options can also be reach using shortcut keys by press <alt> and the underlined character. Available options are:

7.1.1 The File Menu

The file menu options are:

File, Open

Opens a dialogue box to select an image, dose map or 2D array file to load. See *Supported File Formats*

This function can also be accessed using the Open File button  on *The Image Pane* toolbar.

 If you do not see the file you want make sure you have selected the correct file type.

File, Exit

Exits the program

 No profiles, data or results are saved.

7.1.2 The Export Menu

The export menu allows you to export the X and Y profiles in text form.

Export X Profile

Opens a dialogue box to select the location and name of the text file to save the profile to. The profile is saved as a series of ordered pairs (position, value), with each pair on a new line. The file can be imported into a spreadsheet using the CSV format or opened in a text editor.

Export Y Profile

Opens a dialogue box to select the location and name of the text file to save the profile to. The profile is saved as a series of ordered pairs (position, value), with each pair on a new line. The file can be imported into a spreadsheet using the CSV format or opened in a text editor.

7.1.3 The Protocol Menu

The protocol menu allows you to edit protocols and to save them:

Editing Protocols

Selecting "Protocol, Edit" in the menubar allows existing protocols to be edited. The Result window changes to the Edit Protocol window. The parameters are displayed in a grid with the left hand column giving the parameter name and the right hand column giving the parameter equation. Click in the appropriate block to edit. You can also use <ctrl-c> and <ctrl-v> to copy and paste.

To create a parameter section heading leave the equation area blank. Parameter names may be indented by putting spaces in front.

Functions available are:

- *Save protocol*
- *Add line*
- *Delete line*
-  *Exit editing*

Save protocol

When in editing mode opens the save dialog to save the protocol. It is highly recommended that you do not save over existing protocols. Instead give the changed protocol a unique name. Protocols saved in other directories will not be identified by the program. If you cancel the dialog you will return to the editing mode.

 Do not save over a predefined protocol.

 Do not save the protocol in any other directory.

Add line

Inserts a blank line into the parameter list. Click on the line above which you wish to add the new parameter. Click "Add line" . Edit the parameter name and equation.

Delete line

Deletes a line in the parameter list. Click on the line you wish to delete. Click "Delete line" -.

Exit editing

Aborts editing leaving the parameter set unchanged.

7.1.4 Page Preview

The Print option opens the print preview page. The profiles and results may be examined before saving as a PDF  or printing  a hard copy of the page. When you are finished the preview page can be closed using the Exit button  . You may use the menu options or the toolbar buttons.

Save PDF

Opens a dialogue box to select the name and location of the Portable Document Format (PDF) file you wish to save the results to.

Print

Opens a dialogue box to select the name and location of the printer you want to print a hard copy on.

7.1.5 The Window Menu

The Window menu allows you to maximise and/or restore the individual panes as follows:

- Image : Maximise the Image pane
- X Profile : Maximise the X Profile pane
- Y Profile : Maximise the Y profile pane
- Results : Maximise the Results pane
- Restore : Restore all panes to their default configuration

7.1.6 The Help Menu

Access this documentation. You may also view an "About" box with a description of BeamScheme, the Licence and a list of credits.

7.2 The Profile Panes

The profile pane displays the pixel, dose, fluence or detector values under the corresponding profile on the image pane. The profile pane can be maximised in the application window by clicking the maximise button . Individual

profile values can be read by hovering the mouse cursor over the section of profile in question. The profile pane can be returned to its original state by clicking the minimise button  .

The profiles are altered by the Offset, Width and Angle spin boxes.

7.2.1 Offset

Moves the profile away from the centre of the detector or image. Values can be negative or positive. Values can be incremented or decremented via the up and down arrows in the spin box. Values can be entered manually via keyboard.

 Hint: You can change the offset quickly by clicking with the mouse on the image.

7.2.2 Width

Widens the profile symmetrically around the profile centre. Values can be increased or decreased by using the up and down arrows respectively in the spin box. Values can be entered by keyboard. Default value is 1. This means the value will always be odd and will increment by 2. Only positive values are allowed. If an even value is entered via the keyboard the profile width will be the next lowest odd value.

7.2.3 Angle

Increments or decrements the profile angle. Values can be increased or decreased by using the up and down arrows respectively in the spin box. Values can be entered by keyboard. The zero angle is in the middle of the image left hand size. The X profile starts at angle 0 and the Y profile at angle 90. The X profile can have values between -44 and 45 degrees. The Y profile can have values between 46 and 135 degrees.

7.3 The Image Pane

The image pane displays the image, 2D array values, dose or fluence map. The image pane can be maximised in the application window by clicking the maximise button  . The image can be windowed using the slider on the right hand side of the image. The image pane can be returned to its original state by clicking the minimise button  . You can quickly move the profiles to an appropriate point on the image by clicking on this point with the mouse.

The image pane contains a tool bar with buttons that allow various operations can be carried out on the image. The File Open  , Print  and Exit  buttons are shortcuts to the equivalent menu bar functions. Other functions available are:

-  *Invert*
-  *Normalise to CAX*
-  *Normalise to MAX*
-  *Centre Field*

7.3.1 Invert

Inverts the grey scale values using the formula:

$$NZ = max - Z + min$$

Where *max* and *min* are the image maximum and minimum respectively. *Z* is the current pixel value and *NZ* is the new pixel value.

 If you don't want an image background level normalise the image first before inverting.

7.3.2 Normalise to CAX

Normalises the image so that the central axis (CAX) value of the image is 100 and the minimum is zero using the formula:

$$NZ = \frac{(Z - min) * 100}{cax - min}$$

Where *cax* and *min* are the image central axis value and minimum respectively. *Z* is the current pixel value and *NZ* is the new pixel value.

7.3.3 Normalise to MAX

Normalises the image so that the maximum of the image is 100 and the minimum is zero using the formula:

$$NZ = \frac{(Z - min) * 100}{max - min}$$

Where *max* and *min* are the image maximum and minimum respectively. *Z* is the current pixel value and *NZ* is the new pixel value.

7.3.4 Centre Field

Shifts the image by the value of the X and Y field centres. The pixel value at the new index is determined using bi-linear interpolation from the four nearest neighbour pixels from the original image. Image wrap around is not used. Pixels on the leading edge of the image are lost and pixels on the trailing edge are duplicated. This function is intended for fine field adjustments only.

 This function changes the original image data.

7.4 The Results Pane

Results may be viewed in the Results pane. For a description of the various parameters calculated please see *Parameters*.

If some parameters are not visible the scroll bar on the right hand side of the pane can be used to scroll down or up to the results.

When the protocol edit mode is selected the Results pane changes to the *Edit Protocol* pane.

CHAPTER

EIGHT

SUPPORTED FILE FORMATS

Source	File Extension	Description
DICOM	*.dcm	Dicom CT or RT image files uncompressed
MapCheck	*.txt	MapCheck text files
PTW	*.mcc	PTW 729 array files only at this stage
IBA	*.opg	IBA Matrix and StarTrack opg files
Image	*.bmp	Windows bitmap
	.tif,.tiff	Tagged Image format files.
	.jpg,.jpeg	Joint Photographic Expert Group files
HIS	*.his	Raw unstructured data
XiO	None	Elekta XiO dose plane export text file
iPlan	None	BrainLab iPlan dose plane text file

As the 2D array files have all been reverse engineered there is absolutely no guarantee of BeamScheme operating correctly on them. If you have a file that is causing BeamScheme to crash or is giving strange results please forward the file along with a description of the problem to alanphys@yenzakahle.co.za.

8.1 DICOM

Beamscheme will read most uncompressed DICOM image formats including CT and RI (electronic portal image device). Compressed DICOM files must first be uncompressed using a PACS such as Conquest.

8.2 MapCheck

Beamscheme will read SNC MapCheck I and II text files with or without dose calibration.

8.3 PTW

Beamscheme will read single plane acquisition PTW 729 array files. 1500 array is not supported at this time.

8.4 IBA

Beamscheme will read single plane acquisition IBA StarTrack and Matrixx array files. Multiple frames are summed and averaged

8.5 Image

Beamscheme will various 2D image formats such as Windows bitmap (BMP), Tagged Image Format files (TIFF) and Joint Photographic Expert Group (JPEG) files. For colour images only the red channel is imported. It is recommended that only monochromatic images are used for analysis. Colour images can be converted to monochrome using tools such as GIMP or ImageJ.

8.6 HIS

Very little information exists on the HIS file format. It seems to have been used by Perkin-Elmer to export X-ray images. Elekta provide it as an image export format. It appears to consist of a 100 byte header (50 16 bit integers) followed by 16 bit integers giving the image data in rows. Integers 9 and 10 appear to give the number of rows and colums respectively.

8.7 XiO

The Elekta XiO or Monaco dose plane export is a text file with a 16 line header followed by dose or fluence values. The file is not associated with any particular extension and is identified by the first line value. If dose values were exported in Gy these are converted into cGy on import.

 Care should be taken opening XiO files on Windows computers as the CR/LF combination can cause problems.

8.8 iPlan

The BrainLab iPlan dose plane export is a text file with a header followed by a separator line followed by one or more dose planes. The dose planes are prefixed by the orientation. The file is identified by the first 8 characters of the first line. If dose values were exported in Gy these are converted into cGy on import.

 The dose plane orientation is from left to right and may be mirrored from what is displayed on the iPlan depending on the patient orientation.

CHAPTER

NINE

ALGORITHMS

There is an amazing amount of difference in the calculation of supposedly standard parameters between the different vendors. Not only do the definitions of parameters differ but factors such as whether values are interpolated or not or whether field centering is applied have a significant affect on the calculation of the parameters. It is important that the user understand how BeamScheme calculates the various parameters as this will be the first stop in an investigation into any discrepancy between values calculated by BeamScheme and values calculated by vendor supplied software.

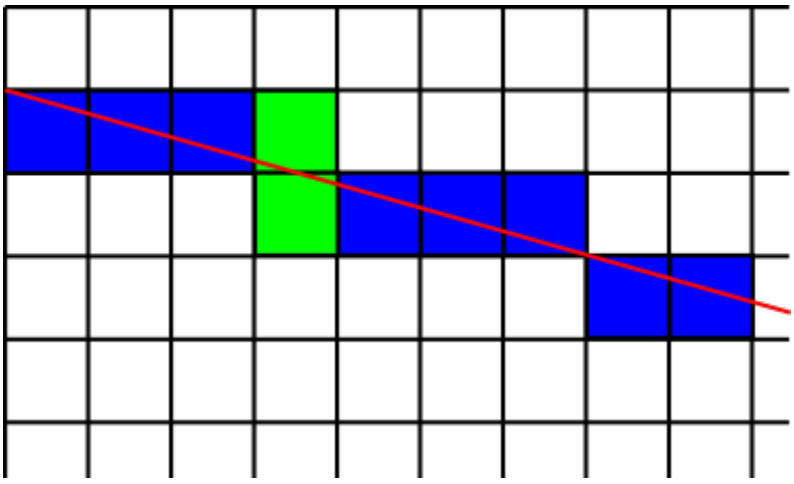
BeamScheme makes absolutely no assumptions about the data in contrast to some commercial products which require parameters such as the field size or SSD to be set. It does not perform any beam centering, and no SSD correction is made. No background correction is assumed. The profile or detector centre is defined as half the profile or detector height or width.

The profile is taken from the windowed data. This can have a serious impact on parameters such as field size and penumbra depending on how the window is chosen. The upshot is that defects in the image such as dead pixels or detectors can be reduced by appropriate windowing.

Calculation of the profiles and parameters are discussed in the following sections.

9.1 Diagonal/Skew Profiles

Diagonal or skew profiles introduce a number of inaccuracies, which is probably why none of the major vendors offer them. However, if these inaccuracies are understood then skew profiles may yield a lot of useful information. The problem is simple. Consider the following situation.



The squares represent pixels or detectors from a 2D dataset. The red line is an ideal skew profile. If the profile completely bisects a square or detector that value is added to the actual profile (blue square). The problem occurs where the ideal profile partially bisects a square or adjacent squares (green squares). There are a number of possible

schemes to solve this such as selecting the nearest pixel or interpolating between adjacent pixels. BeamScheme calculates the length of the profile and then increments an index sequentially along this length. The index is separated into its x and y components which are rounded off to give the pixel indexes along the profile. While the potential does exist for pixels to be skipped or selected twice this is a more robust method and less open to interpretation.

The situation is made worse by the introduction of wide profiles. A wide profile is a profile more than one pixel wide. BeamScheme uses a similar algorithm to that above in that for each index along the profile the normal to the profile is calculated and a second index is sequentially incremented and separated into its x and y components to give the correct pixel. The pixel values are summed. This is done symmetrically on either side of the ideal profile. Thus, the width of the profile will always be odd. This is because an even width will introduce asymmetry in the profile which can lead to further problems.

Skew wide profiles are clipped at the edge of the detector area. This means that the start and finish of wide profiles should be treated with caution and may not be a reflection of reality. The array/image edge will tend to be blurred depending on how skew the profile is.

A similar problem occurs where the profile crosses field edges. If the wide profile is not perpendicular to the field edge this will blur the field edge and increase the penumbra.

9.2 Parameters

All parameters are calculated relative to the central axis (CAX) value unless otherwise specified. The CAX is defined as half the profile or detector width or height. Where there is an even number of detectors or pixels and these straddle the CAX the average of the two detectors or pixels is taken.

The following parameters may be calculated:

9.2.1 Field Parameters

Field Edge

The field edges are defined at the first point from the centre of the profile where the profile reaches the 50% value, i.e.:

$$\frac{CAX}{2}$$

Where *CAX* is the value of the profile on the central axis (CAX).

Since version 0.5 BeamScheme no longer does automatic grounding of the profile, i.e. reducing the minimum to zero. This means that if you want the grounded field size you must *explicitly* normalise or window the image.

The algorithm searches symmetrically out from the profile centre on both sides of the profile to these points. If the 50% value lies between measured points the field edge is interpolated. The value reported is the linear distance from the profile centre to the field edge. The left and right field edge of the profile is given.

 Profiles are no longer grounded automatically. This can lead to differences in results from previous version.

 Noisy data can lead to a reduced field edge value being reported.

Field Centre

The field centre (*FC*) is defined as the distance in cm from the centre of the detector to the centre of the field and is calculated as the half the difference between the distance from the profile centre to the right and left *Field Edge*:

$$FC = \frac{d(RE) + d(LE)}{2}$$

Where *d(RE)* and *d(LE)* are the linear distances from the profile centre to the right and left field edges respectively.

Field Size

The field size (*FS*) is defined as the distance from the left *Field Edge* to the right *Field Edge*:

$$FS = d(RE) - d(LE)$$

Where *d(RE)* and *d(LE)* the linear distances from the profile centre to the right and left field edges respectively.

 Noisy data can lead to a inaccurate field size being reported.

 The right and left field edges are affected by the set window levels.

9.2.2 Penumbra Parameters

Penumbra 90%-10%

The 90%-10% penumbra is defined as the distance from the first point on the profile at 90% of the CAX value to the first point that reaches 10% of the CAX value:

$$Penumbra(90 - 10) = abs(d(P_{10\%}) - d(P_{90\%}))$$

$$P_{10\%} = CAX * 0.1$$

$$P_{90\%} = CAX * 0.9$$

Where d($P_{10\%}$) and d($P_{90\%}$) are the linear distances to the 10% and 90% profile values respectively as defined above. The algorithm searches symmetrically out from the profile centre on both sides of the profile to these points. The left and right field penumbra of the profile is given.

Since version 0.5 BeamScheme no longer does automatic grounding of the profile, i.e. reducing the minimum to zero. This means that if you want the grounded field size you must *explicitly* normalise or window the image.

 Profiles are no longer grounded automatically. This can lead to differences in results from previous version.

 Noisy data can lead to an inaccurate penumbra value being reported.

Penumbra 80%-20%

The 80%-20% penumbra is defined as the distance from the first point on the profile at 80% of the CAX value to the first point that reaches 20% of the CAX value:

$$Penumbra(80 - 20) = abs(d(P_{20\%}) - d(P_{80\%}))$$

$$P_{20\%} = CAX * 0.2$$

$$P_{80\%} = CAX * 0.8$$

Where d($P_{20\%}$) and d($P_{80\%}$) are the linear distances to the 20% and 80% profile values respectively as defined above. The algorithm searches symmetrically out from the profile centre on both sides of the profile to these points. The left and right field penumbra of the profile is given.

Since version 0.5 BeamScheme no longer does automatic grounding of the profile, i.e. reducing the minimum to zero. This means that if you want the grounded field size you must *explicitly* normalise or window the image.

 Profiles are no longer grounded automatically. This can lead to differences in results from previous version.

 Noisy data can lead to an inaccurate penumbra value being reported.

Penumbra 90%-50%

The 90%-50% penumbra is defined as the distance from the first point on the profile at 90% of the CAX value to the first point that reaches 50% of the CAX value or field edge:

$$Penumbra(90-50) = abs(d(P_{50\%}) - d(P_{90\%}))$$

$$P_{50\%} = CAX * 0.5$$

$$P_{90\%} = CAX * 0.9$$

Where d($P_{50\%}$) and d($P_{90\%}$) are the linear distances to the 50% and 90% profile values respectively as defined above. The algorithm searches symmetrically out from the profile centre on both sides of the profile to these points. The left and right field penumbra of the profile is given.

Since version 0.5 BeamScheme no longer does automatic grounding of the profile, i.e. reducing the minimum to zero. This means that if you want the grounded field size you must *explicitly* normalise or window the image.

 Profiles are no longer grounded automatically. This can lead to differences in results from previous version.

 Noisy data can lead to an inaccurate penumbra value being reported.

9.2.3 Symmetry Parameters

Area Symmetry

The area symmetry is the normalised difference between the right and left areas under the profile up to the *field edges*:

$$100 \cdot \frac{RA - LA}{RA + LA}$$

Where *RA* and *LA* are the area under the profile from the profile or detector centre to the right and left *Field Edge* respectively.

 The area symmetry is affected by the field centre. If the field is slightly offset you can use the "Centre field" tool  to correct any offset.

 Some programs use a mulitplicative factor of 200.

Maximum Dose Ratio

the maximum dose ratio symmetry (also called the point difference quotient) is the maximum ratio between the left and right profile values at the same distance from the profile or detector centre:

$$100 \cdot maximum \left[\frac{P(dL)}{P(dR)}, \frac{P(dR)}{P(dL)} \right]$$

for *dR* = -*dL* from 0 to 80% of the field size

 The ratio symmetry is affected by the field centre. If the field is slightly offset you can use the "Centre field" tool  to correct any offset.

Percent Symmetry

Percent symmetry is the ratio symmetry expressed as a percentage:

$$(RS - 1) * 100)$$

where *RS* is the *Maximum Dose Ratio*.

Point Difference

The point difference (also called maximum variation) is the maximum absolute difference between the left and right profile values at the same distance from the profile or detector centre:

$$100 \cdot \frac{P(dL) - P(dR)}{cax}$$

for *dR* = -*dL* from 0 to 80% of the field size

 The point difference symmetry may be affected by the field centre. If the field is slightly offset you can use the "Centre field" tool  to correct any offset.

9.2.4 Flatness Parameters

Dose Difference

The flatness dose difference parameter is the normalised difference between the maximum and minimum profile values taken over 80% of the field size:

$$100 \cdot \frac{max - min}{max + min}$$

Where *max* and *min* are the profile maximum and minimum respectively.

 The *max* and *min* may be affected by the set window levels.

Dose Ratio

Dose ratio flatness is the ratio of the maximum profile value to the minimum profile value expressed as a percent taken over 80% of the field size:

$$100 \cdot \frac{max}{min}$$

Where *max* and *min* are the profile maximum and minimum respectively.

 The *max* and *min* may be affected by the set window levels.

Mean Value

The mean value dose parameter is the normalised average between the maximum and minimum profile values taken over 80% of the field size:

$$\frac{100}{cax} \cdot \frac{max + min}{2}$$

Where *max* and *min* are the profile maximum and minimum respectively and *cax* is the profile centre value.

 The *max*, *min* and *cax* may be affected by the set window levels.

Flatness L90/L50

The 90%/50% isodose ratio is defined as the ratio of the distance to the first point on the profile at 90% of the CAX value to the first point that reaches 50% of the CAX value or field edge. :

$$L90/L50 = maximum \left[\frac{dl(P_{90\%})}{dl(P_{50\%})}, \frac{dr(P_{90\%})}{dr(P_{50\%})} \right]$$

$$P_{50\%} = CAX * 0.5$$

$$P_{90\%} = CAX * 0.9$$

Where dl($P_{50\%}$) and dl($P_{90\%}$) are the linear distances to the 50% and 90% profile values respectively on the left side of the profile as defined above, and dr($P_{50\%}$) and dr($P_{90\%}$) are the linear distances to the 50% and 90% profile values respectively on the right side of the profile as defined above. The algorithm searches symmetrically out from the profile centre on both sides of the profile to these points. The maximum ratio between the left and right sides is taken.

Since version 0.5 BeamScheme no longer does automatic grounding of the profile, i.e. reducing the minimum to zero. This means that if you want the grounded field size you must *explicitly* normalise or window the image.

 Profiles are no longer grounded automatically. This can lead to differences in results from previous version.

 Noisy data can lead to an inaccurate penumbra value being reported.

Flatness L80/L50

The 80%/50% isodose ratio is defined as the ratio of the distance to the first point on the profile at 80% of the CAX value to the first point that reaches 50% of the CAX value or field edge. :

$$L80/L50 = maximum\left[\frac{dl(P_{80\%})}{dl(P_{50\%})}, \frac{dr(P_{80\%})}{dr(P_{50\%})}\right]$$

$$P_{50\%} = CAX * 0.5$$

$$P_{80\%} = CAX * 0.8$$

Where dl($P_{50\%}$) and dl($P_{80\%}$) are the linear distances to the 50% and 80% profile values respectively on the left side of the profile as defined above, and dr($P_{50\%}$) and dr($P_{80\%}$) are the linear distances to the 50% and 80% profile values respectively on the right side of the profile as defined above. The algorithm searches symmetrically out from the profile centre on both sides of the profile to these points. The maximum ratio between the left and right sides is taken.

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9.2.5 Deviation Parameters

MAX/CAX

MAX/CAX flatness is the ratio of the CAX profile value to the maximum profile value expressed as a percent taken over 80% of the field size:

$$100 \cdot \frac{max}{cax}$$

Where *max* and *cax* are the profile maximum and central axis values respectively.

 The *max* and *cax* are affected by the set window levels.

Maximum Variation

This is the maximum variation in the ration of the absorbed dose at any point in the flattened area to that of the central axis expressed as a percentage difference between the lowest and highest value of this ratio.

$$100 \cdot \frac{max - min}{cax}$$

Practically though this has been implemented as:

$$100 \cdot maximum\left[\frac{max - cax}{cax}, \frac{min - cax}{cax}\right]$$

Where *max*, *min* and *cax* are the profile maximum, minimum and central axis values respectively.

 The *max*, *min* and *cax* are affected by the set window levels.

CHAPTER

TEN

PROTOCOLS

From version 0.5 BeamScheme supports definable protocol and parameter sets. A library of standard protocols is supplied. These may be edited and renamed or new protocols defined.

10.1 Selecting a protocol

Use the drop down list in the Results window to select the desired protocol. The parameters and results are displayed in the grid below.

10.2 Defined protocols

BeamScheme has a library of standard protocol sets. Do not alter these protocols. Instead copy them and create your own sets if you wish to make changes. There is considerable variation in the implementation of the protocols by different vendors. BeamScheme attempts to provide the consensus implementation, but there is no guarantee that this will match a particular vendor.

The available predefined protocols are:

10.2.1 Default

This protocol gives the parameters as calculated by previous versions of BeamScheme.

The defined parameters are

- *Field Edge*
- *Field Centre*
- *Field Size*
- *Penumbra 90%-10%*
- *Penumbra 80%-20%*
- *Penumbra 90%-50%*
- *Area Symmetry*
- *Maximum Dose Ratio*
- *Percent Symmetry*
- *Dose Difference*

- *Dose Ratio*
- *MAX/CAX*

Flattened field

BeamScheme uses 80% of the *field size* as the flattened area.

10.2.2 AFFSAPS-JORF

Photon Profile Parameters

The defined photon parameters are:

- *Field Centre*
- *Field Size*
- *Penumbra 80%-20%*
- *Maximum Dose Ratio*
- *Mean Value*
- *MAX/CAX*

Electron Profile Parameters

The defined electron parameters are:

- *Field Centre*
- *Field Size*
- *Penumbra 80%-20%*
- *Maximum Dose Ratio*
- *Flatness L90/L50*
- *Maximum Variation*

Flattened field

BeamScheme uses 80% of the *field size* as the flattened area.

10.2.3 DIN

Photon Profile Parameters

The defined photon parameters are:

- *Field Centre*
- *Field Size*
- *Penumbra 80%-20%*
- *Maximum Dose Ratio*
- *Dose Ratio*

Electron Profile Parameters

The electron profile parameters are the same as the photon profile parameters.

Flattened field

BeamScheme uses 80% of the *field size* as the flattened area.

10.2.4 IEC 60976

Photon Profile Parameters

The defined photon parameters are:

- *Field Centre*
- *Field Size*
- *Penumbra 80%-20%*
- *Maximum Dose Ratio*
- *Mean Value*
- *Maximum Variation*

Electron Profile Parameters

The defined electron parameters are:

- *Field Centre*
- *Field Size*
- *Penumbra 80%-20%*
- *Maximum Dose Ratio*
- *Flatness L90/L50*
- *Maximum Variation*

Flattened field

BeamScheme uses 80% of the *field size* as the flattened area.

10.2.5 Elekta

Photon Profile Parameters

The defined photon parameters are:

- *Field Centre*
- *Field Size*
- *Penumbra 80%-20%*
- *Maximum Dose Ratio*
- *Mean Value*
- *Maximum Variation*

Electron Profile Parameters

The defined electron parameters are:

- *Field Centre*
- *Field Size*
- *Penumbra 80%-20%*
- *Maximum Dose Ratio*
- *Flatness L90/L50*
- *Maximum Variation*

Flattened field

BeamScheme uses 80% of the *field size* as the flattened area.

10.2.6 Siemens

Photon Profile Parameters

The defined photon parameters are:

- *Field Centre*
- *Field Size*
- *Penumbra 80%-20%*
- *Area Symmetry*
- *Dose Difference*
- *MAX/CAX*

Electron Profile Parameters

The electron parameters are the same as the photon parameters

Flattened field

BeamScheme uses 80% of the *field size* as the flattened area.

10.2.7 Varian

Photon Profile Parameters

The defined photon parameters are:

- *Field Centre*
- *Field Size*
- *Penumbra 80%-20%*
- *Point Difference*
- *Dose Difference*

Electron Profile Parameters

The electron parameters are the same as the photon parameters

Flattened field

BeamScheme uses 80% of the *field size* as the flattened area.

CHAPTER

ELEVEN

ERRORS AND TROUBLE SHOOTING

BeamScheme has sophisticated error checking and detection. Error messages and warnings are displayed in the Status Bar. During the operation of the program you may encounter a variety of warning and error messages. There are three types of messages.

1. Informational: These give details of the programs working. These messages have a grey background. No action is required they are for information only. For example the startup message "BeamScheme initialised correctly'.
2. Actional: The program is requiring some kind of response from you. These messages have a yellow background. For example "Click Point A"
3. Error: The program has detected an error condition. These messages are displayed with a red background. Some errors will not allow you to continue until the error has been corrected. In this case the area or areas with the error will be highlighted in red.

Some common error messages and their causes are discussed below:

11.1 Unrecognised file

BeamScheme does not recognise this type of file. Please check that the file is in the list of *Supported File Formats*. Also check that the file does not contain compression or encryption.

11.2 File error, no data found

BeamScheme could not find readable image data in the file. The file may contain compression or be corrupt.

11.3 This software can not read compressed or 24-bit color files

The DICOM image is compressed or contains a colour image. Decompress the image using a PACS system such as CONQUEST or convert the colour image to monochrome using an editor such as the GIMP.

11.4 Unable to load DICOM header segment. Is this really a DICOM compliant file?

The file extension is ".dcm" but BeamScheme cannot find valid DICOM header tags. Try and open the file in another DICOM reader.

11.5 This file does not have enough data for the image size

The DICOM file size is less than the image dimensions multiplied by the pixel depth. Check that the file is not corrupted or compressed.

11.6 File error, corrupt file

A fatal error occurred while trying to read the file. Try and open it with another reader. If this works and you feel BeamScheme should be able to read this file please contact *Technical Assistance*.

Other errors may from time to time be generated by the operating system. These will generally be in the form of a dialogue box requiring acknowledgement. Please refer to the appropriate documentation and/or contact technical assistance.

CHAPTER

TWELVE

TECHNICAL ASSISTANCE

There are, of course, no bugs in the software. However, it may happen that the software does not behave in a manner you expect or generates results that you think are wrong. If so, we would like to know about it. Likewise, if you feel BeamScheme should be doing something that it isn't, please tell us.

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CHAPTER

THIRTEEN

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