Prism Beam Data File Description

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1 Introduction

This document serves two purposes. It describes the format of the beam data file, and it specifies the data contained in the beam data file. This information, together with the information contained in a related report [1], should enable the reader to create a beam data file suitable for use with the Prism external beam dose computation program. This could be done by writing a beam data entry and editing utility program, or by providing software adjunct to an automated beam scanning system. The Prism Dose Computation Methods report [1] should be read first, for information regarding the meanings of these variables and methods for measuring them.

The file described by this report contains only data used by the Prism dose computation program. The Prism graphical user interface uses additional beam data, such as descriptive text labeling the different wedges available for a machine, and conversion factors from the Prism machine setting conventions to the various therapy machine manufacturer's conventions. This information is described in the Prism system implementation report [2].

2 Format of the Beam Data File

The beam data file is a text file containing all of the information necessary for conducting dose calculations according to the protocol outlined in the Prism Dose Calculation Specification. Each section of the beam data file consists of a beam name enclosed in double quotes followed by all of the information corresponding to the given beam.

We follow a convention for assigning beam names, but no program depends on this convention. The only requirements are that each beam have a unique name, and that same name must appear in the corresponding block of information in the beam data file used by the graphical user interface code [2]. The first part of a beam name is an abbreviation of the name of the treatment machine that produces the beam. The second part of a beam name is the nominal energy at which the treatment machine is operated since many of the tabulated quantities depend on the energy. In the case of electron beams, the nominal applicator size forms a third component of the beam name since many of the tabulated values also depend on the applicator size.

Every section of the file that pertains to a beam is preceeded by the integer 1 which is a flag indicating that data follows. A flag value of 0 at the end of the beam data signifies that no more data is to be read from the file. The dose computation program ignores any text that comes after the no more data flag allowing comments to be placed in the file at the end of the beam data.

The beam data file is an ordinary ASCII text file. It contains beam names, integers, and real numbers, the last of which may be expressed with between 5 and 10 decimal digits of accuracy. It is possible to separate the entries in the beam data file by an arbitrary number of spaces, tabs, and newlines. Commas, periods, or other separators are not allowed. The only other stylistic restriction applies to the beam name which *must* be enclosed in double quotes. It is advisable to arrange the beam data file so that it can be easily read by a human being using a text editor. Therefore, it is best to place numbers which are not part of an array on lines of their own and to organize arrays so that there are no more than 5 or 6 numbers per line. Comments are only allowed after the end of the beam data. Maintaining a separate annotated copy of the data associated with each beam type is a good way to keep track of what information is stored in the beam data file. See Appendix

A for an abbreviated example of what a beam data file looks like.

When Prism is started, all of the information contained in the beam data file is read in and stored for use during operation. The information corresponding to each beam is contained in a separate beam data record which is part of an array of beam data records indexed by beam name. When a dose computation is initiated, the dose computation program matches the beam name provided by the input stream to a beam name stored in the beam data record array and uses the appropriate beam data record in the computation.

3 Data Contained in the Beam Data File

The following is a list of the data contained in the beam data file associated with a single beam. The data are listed in the same order found in the beam data file together with descriptions of the meanings of the various pieces of information and the names of the corresponding variables in the dose computation program. All arrays and tables listed below consist of real numbers and all flags listed are integers. Unless otherwise indicated, all entries are obligatory as is the order in which they appear.

Each section of data begins with:

- more data flag (*more_data*)

  Here, 1 means that data corresponding to some beam follows
  and 0 means that there is no more data to be read.

The first two pieces of information found in the beam data file for any beam are:

- beam name (*beam_name*)

  This consists of a string containing the machine name followed by the nominal energy in MV and possibly the nominal applicator size in cm.
  (e.g. "CLINAC2500-24MV", "SL20-12MV-10")

- class identification flag (*class_id*)

  This flag specifies the particle type - photon, neutron, or electron.
  (photon = 1, neutron = 2, electron = 3)

All other information is dependent on whether the beam is a photon, neutron, or electron beam.

3.1 Photon and Neutron Beams

The beam data file contains the following information corresponding to photon and neutron beams. Here OCR means off-center ratio, TPR means tissue-phantom ratio, and SPR means scatter phantom ratio.

- calibration distance (*cal_distance*)

  The distance in cm from the beam virtual source to the calibration measurement point expressed as a real number.

- calibration factor (*cal_factor*)

  A real number equal to the calibration factor in rads per machine unit.

- collimator identification flag (*collimator_id*)

  Designates the type of collimator employed. (rectangular = 1, multileaf = 2)
  Note that a rectangular collimator may be a symmetric, combination, or variable jaw collimator.

If the collimator is a multileaf collimator, then the beam data file contains the following two entries:

- virtual source diameter (*vsrc_diam*)

  A non-negative real number representing the diameter of the circular field that is used to determine the minimum allowed output factor contribution for a multileaf collimator.

- collimator constant (*coll_const*)

  A real number between 0 and 1 which determines the weights applied to the two components of the output factor for a multileaf collimator.

Otherwise, if the collimator is a rectangular collimator, then the beam data file contains the following piece of information:

- tray factor (*tray_factor*)

  A real number representing the transmissivity of the tray which holds blocks.

The remainder of these items are relevant to both rectangular and multileaf collimated cases:

- number of field sizes for which output factors are stored (*n_outputs*)

  This is an integer between 2 and 12.

- field sizes for which output factors are stored (*out_fieldsize*)

  This is an array of length *n_outputs* ordered from smallest to largest.

- output factors (*output_factor*)

  The array of output factors corresponding to the output field sizes.

- number of fanlines for which OCR's are stored (*ocr_n_fanlines*)

  This is an integer between 2 and 48.

- fanline ratios at which OCR's are tabulated (*ocr_fan_ratios*)

  This is an array of length *ocr_n_fanlines* ordered from smallest to largest.
  The smallest value is 0.0 which represents the beam central axis.
  A value of 1.0 represents the beam edge and a value greater than 1.0 represents a fanline past the field edge.

- number of field sizes for which OCR's are stored (*ocr_n_fields*)

  This is an integer between 2 and 12.

- field sizes at which OCR's are stored (*ocr_fields*)

  This is an array of length *ocr_n_fields* ordered from smallest to largest.

- number of depths for which OCR's are stored (*ocr_n_depths*)

  This is an integer between 2 and 12.

- depths for which OCR's are stored (*ocr_depths*)

  An array of length *ocr_n_depths* ordered from shallowest to deepest.

- table of OCR's (*ocr_table*)

  A three dimensional array containing the OCR's corresponding to the range of field sizes, depths, and fanlines specified above. The first index of the array pertains to the field size, the second index corresponds to the depth, and the third index refers to the fanline ratio. During the reading process, the third index is incremented first, the second index second, and the first index is incremented last. The lower indices correspond to smaller field sizes, depths, and fanline ratios. The first off-center ratio in each series, which has fanline ratio = 0.0, should be 1.0.

- number of wedges (*wedge_count*)

  This is an integer between 0 and 12.

The following five items are only provided if $wedge_count > 0$. The association between wedge numbers (corresponding to their order here) and the text describing the wedge is contained in another file, described in [2].

- number of positions where wedge attenuations are listed (*wedge_n_positions*)

  This is an integer from 2 to 48.

- positions where wedge attenuations are listed (*wedge_positions*)

  An array of length *wedge_n_positions* listed in cm from negative to positive.

- number of depths at which wedge profiles are listed (*wedge_n_depths*)

  This is an integer from 1 to 12.

- depths at which wedge profiles are listed (*wedge_depths*)

  An array of length *wedge_n_depths* ordered from smallest to largest.

- table of wedge profiles (*wedge_profile*)

  This table is a three dimensional array in which the lower index entries represent lower wedge numbers, shallower depths, and lower positions with respect to the central axis. The first index corresponds to wedge number, the second index corresponds to depth, and the last index corresponds to position. When the table is read in, the third index is incremented first, the second index is incremented second, and the first index is incremented last.

The rest of the listed information must be present for all photon and neutron beams.

- number of field sizes for which TPR's are stored (*tpr_n_fields*)

  This is an integer between 2 and 12.

- field sizes for which TPR's are stored (*tpr_fields*)

  An array of length *tpr_n_fields* ordered from smallest to largest.

- number of depths for which TPR's are stored (*tpr_n_depths*)

  This is an integer between 2 and 48.

- depths for which TPR's are stored (*tpr_depths*)

  This is an array of size *tpr_n_depths* ordered from shallowest to deepest.

- table of TPR's (*tpr_table*)

  The two dimensional table of TPR's in which the earlier entries correspond to smaller field sizes and shallower depths. The first index refers to field size and the second index refers to depth. During reading, the second index is incremented first and the first index is incremented second.

- number of radii for which scatter phantom ratios are stored (*spr_n_radii*)

  This is an integer between 2 and 12.

- radii at which SPR's are stored (*spr_radius*)

  This is an array of size *spr_n_radii* listed from smallest to largest.

- number of depths for which SPR's are stored (*spr_n_depths*)

  This is an integer between 2 and 48.

- depths for which SPR's are stored (*spr_depth*)

  An array of length *spr_n_depths* listed from smallest to largest.

- table of SPR's (*spr_table*)

  The two dimensional array of SPR's with smaller indices corresponding to smaller radii and shallower depths. The first index pertains to the radius and the second index pertains to the depth. When the table is read, the second index is incremented first and the first index is incremented second. These ratios are used to calculate the effects of blocks.

- number of depths for which zero field size TPR's are stored (*tpr0_n_depths*)

  This is an integer between 2 and 48.

- depths for which zero field size TPR's are stored (*tpr0_depths*)

  This is an array of size *tpr0_n_depths* ordered from smallest to largest.

- zero field size TPR's (*tpr0_values*)

  These are the zero field size TPR's corresponding to the tpr0_depths.

3.2 Electron Beams

The following quantities characterize electron beams in the beam data file. As in the previous section, the parameters are listed in the same order as found in the beam data file. The word "energy" below refers to the nominal energy of the machine unless otherwise indicated.

- energy of the beam in the cutout plane (*initEnergy*)

  This is a real number equal to the initial energy of the beam in MeV, not the nominal energy. It is a function of machine, energy, and applicator size.

- practical range (*Rp*)

  This is the range (of depth) in cm over which the electrons contribute dose expressed as a real number.
  It depends on the machine, energy, and applicator size.

- applicator size (*app_size*)

  This is the actual physical dimension of the applicator open field at the cutout plane not the number listed in the beam name. It is a real number.

- virtual source to collimator distance in cm (*SCD*)

  This is a real number dependent on machine, energy, and applicator size.

- virtual source to skin distance in cm (*VSSD*)

  This is a real number determined by the ISL method and corresponds to 100 nominal SSD or the distance to the phantom surface at which the depth dose data was measured. It is machine, energy, and applicator size dependent.

- collimator height in cm above the skin (*z_coll*)

  This variable is a real number which is a function of machine only but which nevertheless must be supplied separately for each beam.

- beam penumbra (*penumbra*)

  This real number depends on the machine, energy, and applicator size.

- angular divergence of an electron pencil when scattered by air (*thetaAir*)

  This quantity is a real number which is a function of machine, energy, and applicator size.

- number of fluence to dose depths (*f2d_num*)

  This is an integer specifying the number of entries in the following table.

- fluence to dose table (*fluence_to_dose*)

  Fluence to dose conversion factors calculated by the external program f2d.p. The tabulated quantities are central axis values and depend only on the effective depth. The table is stored as an array with one data point for each mm of effective depth down to the depth of the practical range. This array is of length *f2d_num*. Lower indices correspond to shallower depths. The table entries depend on the machine, energy, and applicator size.

- number of photon depth dose entries (*depth_dose_num*)

  This is an integer representing the number of entries in the photon depth-dose table.

- photon depth-dose table (*photon_dd_table*)

  Depth-dose table for the dose imparted by x-rays produced via bremsstrahlung.
  This table is an array of central axis values, one for each mm of effective depth down to the depth at which the photon dose becomes negligible. This array contains *depth_dose_num* values. Lower indices correspond to shallower depths. The tabulated values are functions of machine, energy, and applicator size.

- number of values in the root mean square weighting table (*rms_num*)

  This integer gives the length of the root mean square weighting table.

- root mean square weighting table (*RMSwt_table*)

  This table is used in the mulitple Coulomb scattering calculation.
  It is an array of factors measured along the central axis with one value for each mm of effective depth down to the depth of the practical range. This array has *rms_num* entries. Lower indices correspond to shallower depths. These values adjust the beam spread with depth to correspond to the observed shape and vary according to machine, energy, and applicator size.

- number of air profile measurements (*air_num*)

  This is an integer denoting the range of the second index of the air profile table.

- air profile table

  This table is a two dimensional array containing the relative off-axis beam profile measured in air in the x and y directions in 0.5 cm increments. The first index takes on two values, 1 meaning measurements in the x-direction and 2 meaning measurements in the y-direction. The second index ranges over the number of measurements taken in the coordinate directions. The range of the second index runs from 1 to *air_num*. The values are ordered so that as the second index increases so does the off-axis distance that the values correspond to, ranging from the smallest negative distances to the largest positive distances. The values in this table change with machine, energy, and applicator size.

References

[1] Ira J. Kalet, Jonathan Jacky, Paul Cho, and Mark Martin. Prism dose computation methods. Technical Report 93-09-01, Radiation Oncology Department, University of Washington, Seattle, Washington, 1993.

[2] Ira J. Kalet and Jonathan Unger. Prism system implementation. Technical Report 93-09-02, Radiation Oncology Department, University of Washington, Seattle, Washington, 1993.

A A Sample Beam Data File Fragment

The following is a fragment of an example beam data file, which corresponds to the 6 MV photon beam generated by the Clinac 2500. The comments on the right hand side are included only to elucidate the meanings of the table entries and would *not* be present in the actual beam data file.

```
        1                                                       more_flag
"CLINAC2500-6MV  "                                              beam_name
        1                                                       class_id
 100.00000                                                      cal_distance
   1.00000                                                      cal_factor
        1                                                       collimator_id
     0.974                                                      tray_factor

       12                                                       n_outputs

   3.00000   4.00000   5.00000   7.50000  10.00000             out_fieldsize
  12.50000  15.00000  17.50000  20.00000  25.00000
  30.00000  40.00000

   0.87300   0.91900   0.93700   0.97100   1.00000             output_factor
   1.02000   1.03600   1.04700   1.05800   1.07400
   1.08600   1.09000

       21                                                       ocr_n_fanlines

   0.00000   0.20000   0.50000   0.60000   0.70000             ocr_fan_ratios
   0.80000   0.85000   0.90000   0.92000   0.94000
   0.96000   0.98000   1.00000   1.02000   1.04000
   1.06000   1.08000   1.10000   1.15000   1.20000
   1.50000
```

⋮

etc.

```
      16                                                        tpr0_n_depths

 0.00000   0.50000   1.00000   1.50000   4.00000               tpr0_depths
 5.00000   7.50000  10.00000  12.50000  15.00000
17.50000  20.00000  22.50000  25.00000  27.50000
30.00000

 0.05400   0.74100   0.91900   1.00000   0.90700               tpr0_values
 0.82700   0.68600   0.59400   0.53700   0.44100
 0.39000   0.34700   0.29200   0.09200   0.24400
 0.21600

      1                                                         more_flag
```

⋮

data for additional beams

```
      0
```

annotated examples and comments go here — *more_flag:* end of data

⋮