myQA iON 2.1 RT Beam Data Requirements

SITE INFORMATION

Institution Name	
IBA Dosimetry customer number	
Institution address	
Contact person	
Phone	
Email	

To initiate the beam modelling process, please submit both the "Data Requirements" sheet along with all relevant measurement files (scans) associated with all LINAC energies to be verified.

CHECKLIST

Here is the checklist of the data requirements, you can find the details of each item in the coming chapters.

- ☐ Treatment device data
- ☐ Absolute dose calibration data
- ☐ Measurements
    - ☐ Depth dose curves with detector information
    - ☐ Output factors with detector information
    - ☐ Cross Profiles (incl. the maximum field), various depths (same SSD as DDC)
    - ☐ Diagonal for maximum field, ca. 15-50mm depth (same SSD as DDC)
- ☐ Appendix 1: Varian: DLG Measurements Form
- ☐ Appendix 2: Elekta Ag: DLG Measurements Form
- ☐ Appendix 3: Measurements of Output Factors
- ☐ Appendix 4: SRS Cones Measurement
- ☐ Appendix 5: Electron Applicator Data
- ☐ Appendix 6: Tomotherapy Commissioning Guide

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TREATMENT DEVICE DATA

LINAC Vendor & Model				
MLC • Type • Number • Width of the leaves				
Energy and fluence mode (FF/FFF)				
LINAC name(s)[1]				
Treatment Planning System, Version)				

[1] Specify the LINAC name as used in the tag (300a,00b2) "Treatment Machine Name" in DicomRT-plan files.

ABSOLUTE DOSE CALIBRATION DATA

The Absolute dose calibration factor for reference field size must be provided together with the Source-to-Surface Distance (SSD) and measurement depth, for each beam quality to be verified.

LINAC Energy				
Reference field size (mm)				
SSD (mm)				
Measurement Depth (mm)				
Dose per 100 MU *(calibrated to water)* ○ cGy ○ Gy				

MEASUREMENTS

As part of the Beam data verification audit, your measured data will be validated as is. As such, IBA Dosimetry strongly suggests to provide all measured data which is/will be used for TPS beam modelling. In general, the more data is provided, the more reliable verification will be.

Only measurements originally acquired in water phantom may be submitted for beam modelling. In-air or solid phantom measurement data are not currently within scope of the beam data audit.

Measured data can be submitted as files with types *.asc (IBA or Eclipse),*.mcc, *.D, *.PX_, *PY_,*.dat,

*.txt or *.snctxt

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Output factor data can be submitted as text files or tables, please include the **SSD**, **measurement depth** and the **detector** used for measuring the output factors by filling in appendix 2.

If the correction for the effective point of measurements or other correction factors were applied to the measurements, as well as any type of the data post processing (shifts, smoothing etc.), please provide details in the Comments section.

NOTE:

If you are not able to provide a full measured dataset from the TPS beam data collection, a subset of data can be used for the verification process. At minimum, a submitted dataset has to include three types of measurements listed below for the range of small, medium and large field sizes.

Minimum scope of data required for Beam data verification:
1. Depth Dose Curves (DDC), also known as Percentage Depth Dose (PDD)
2. Output Factors (OF), also known as in water output ratio Scp or total scatter correction factor (TSCF)
3. Cross Profiles (CP), also known as Off Center Ratios (OCR). This includes in-plane and cross-plane profiles at same SSD as depth dose data. It is desirable to provide diagonal profiles of the maximum field size.

For Tomotherapy, please submit the form without Dose-Monitor Unit Calibration and OF measurement Setup.Once the beam model has been received, kindly refer to Appendix 6 for the Tomotherapy Commissioning Guide.

Detectors

Please specify detector(s) used for measurements. If more than one detector has been used, it is very important to specify the detector type used for each measurement.

	Depth dose curves	Profile measurements	Output Factors
Detector Manufacturer &Type			

MLC CALIBRATION

There are two recommended options to determine the MLC and collimators calibration.

Option 1:

(Usually for Varian customer) A set of Dosimetric Leaf Gap (DLG) measurements. The ionization chamber readings (collected charge) should be provided. Please fill Appendix 1 for the detailed measurements and configurations.

Option 2:

(Usually for Elekta customers) A set of DLG measurements must be provided using the DLG plans provided by IBA Dosimetry. The ionization readings (collected charge or similar) must be provided. Please fill Appendix 2 for the detailed measurements and configurations.

COMMENTS

Please use this space to share any additional information about your measurements with IBA Dosimetry.

____

____

____

____

____

____

I confirm that the data and measurements are correct to my knowledge.

Customer Signature: ____

Printed Name: ____

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Appendix 1

VARIAN: DLG MEASUREMENTS FORM

If there is more than one energy, please make a copy of the following tables and fill in the measurements respectively for each energy.

DLG Measurement Form

x- and y- collimator positions [mm]	X:	Y:
Measurement conditions	☐ In phantom, measurement depth [mm]: ________ ☐ In air ☐ Build-up cap	
Detector:		
DLG value (as used in TPS) [mm]		
Leaf-Transmission (as used in TPS) (%)		
Comments		

Leaf transmission measurements

	MU	Measurement
Open field		
Carriage A closed/transmission		
Carriage B closed/transmission		

DLG measurements

Gap width [mm]	Gap center position [mm]		MU	Measurement
	Start	End		

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Appendix 2

ELEKTA AG: DLG MEASUREMENTS FORM

Notes:

- "Elekta AG": abbr. for Elekta Linacs with Agility MLC.
- LINAC and MLC Model: Currently, DLG-measurements are implemented only for Elekta LINACs with Agility MLC.
- DLG plans are provided from IBA Dosimetry.
- Measurements should be provided as 'raw' detector readings (i.e., collected charge [nC] or similar); conversion to dose [Gy] is not necessary.
- Leaf-Transmission measurements: "open" and "closed" leaf transmission measurement needs to be specified.
- DLG measurements: Specify measurements for a number of different gap (slit) widths. For each sweep, specify the measurement value (detector reading, see above).

If there is more than one energy, please make a copy of the following tables and fill in the measurements respectively for each energy.

General information and results

x- and y- collimator positions [mm]	X:	Y:
Measurement conditions	In phantom (RW3. PMMA) SSD: 1000 mm Depth: 50 mm	
Detector:		
Comments:		

Leaf transmission measurements

	MU	Measurement
Open field	100	
Leaves closed-transmission	100	

Gap width [mm]	Gap center position [mm]		MU	Measurement
	Start	End		
5	-60	60	100	
6	-60	60	100	
8	-60	60	100	
10	-60	60	100	
12	-60	60	100	

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Appendix 3

MEASUREMENTS OF OUTPUT FACTORS

If there is more than one energy, please make a copy of the following table and fill in the measurements respectively for each energy.

LINAC name				
Energy and fluence mode (FF/FFF)				
SSD [mm]				
Measurement depth [mm]				
Field size		Relative output factor (Minimum three digits after thedecimal; No field size correction factors applied)	Detector name (Manufacturer, exact name, and type)	Field size correction factors already applied? If yes, please state it.
X [mm]	Y [mm]			

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Appendix 4

SRS-CONE-MEASUREMENTS FORM

General information, LINAC name and beam quality

Institution name	
LINAC name(s)	
Beam energy and fluence mode (FF/FFF)	
SSD / Measurement depth (mm)	
Page number:	

SRS-cone-collimator information:

Applicator ID	Diameter [mm]	Source-collimator-distance [mm]	Collimator length [mm]	Dose for 100 MU [Gy]

Please add more pages if needed

Notes:

- SRS-cone -collimator information has to be provided for each LINAC/beam energy/fluence mode with which the listed SRS-cones are used.
- If the SRS-cones are used on several LINACs with different cone output factors, one Appendix 3 form is required for every LINAC.
- If the number of SRS-cone-collimators exceeds the number of rows in the table, multiple (numbered) pages of Appendix 3 may be submitted for a given LINAC/beam energy/fluence.
- **Applicator ID:** value of ApplicatorID tag (300a,0108) in DICOMplan.
- **Diameter[mm]:** nominal collimator diameter at isocenter.
- **Source-collimator-distance [mm]:** position of the *top* of the collimator, measured from the source.
- **Collimator length [mm]:** length of the collimator.

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Appendix 5

ELECTRON APPLICATOR DATA

Electron beam models are provided as generic beam models produced from Varian´s representative beam data for the TrueBeam LINAC and Elekta´s standardized beam data for the accelerated-go-life program. These models can be customized in a variety of ways: range, output factor, field width and virtual source-surface distance. If a generic beam model exists, only these values are required and can be entered in this Appendix 5, table 1. If no generic model exists, base data requirements will need to be specified on a case-by-case basis.

Notes:

- Generic beam data for Varian is available for beam energies:
  6, 9, 12, 15, 16, 18, 20 and 22 MeV
  and applicator sizes:
  60x60, 100x60, 100x100, 150x150, 200x200, 250x250 mm
- Generic beam data for Elekta is available for beam energies:
  6, 8, 9, 12, 15 and 18 MeV
  and applicator sizes:
  60x60, 100x100, 140x140, 200x200, 250x250 mm
- Fill in ONE LINE in table 1 FOR EACH energy-applicator combination for which generic beam data is available. If such data do not exist, fill in ONE LINE in table 2 FOR EACH energy-applicator combination.
- Abbreviations:
  R_{max} = depth at maximum for SSD 1000 mm
  R_{50} = depth of 50% of maximum dose for SSD 1000 mm
  R_{OF} = depth at which the output factor ($D_{normalized}$) was measured, if different from R_{max}
  R_{FW50} = depth at which the field width FW_{50} was determined, if different from R_{max}
  $D_{normalized}$ = dose at Rmax or ROF for 100 MU, and SSD 1000 mm
  virtSSD = apparent virtual SSD
  FW_{50} = field width at 50% Dmax in depth R_{max} or R_{FW50}
  extended SSD = SSD at which the measurements of virtSSD have been performed

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Table 1: Data requirements for Generic Electron Beam Models

Institution name	
LINAC name (s)	
Extended SSD of meas. For virtSSD (mm)	
Page number:	

ID	Energy [MeV]	AppX [mm]	AppY [mm]	R_{max} [mm]	R_{50} [mm]	$D_{normalized}$ [Gy/100 MU]	R_{OF} [mm] (if not R_{max})	virtSSD [mm]	FW_{50} [mm]	R_{FW50} [mm] (if not R_{max})
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
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1.9										
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Please add more pages if needed

Table 2: Data requirements for custom electron beam models

Institution name	
LINAC name (s)	
Extended SSD of meas. For virt SSD	
Detector(s) used for DDC	
Page number:	

ID	Energy [MeV]	AppX [mm]	AppY [mm]	Rmax [mm]	R_{50} [mm]	$D_{normalized}$ [Gy/100 MU]	R_{OF} [mm] (if not R_{max})	virtSSD [mm]	FW_{50} [mm]	R_{FW50} [mm] (if not R_{max})	DDC file name
1.1											
1.2											
1.3											
1.4											
1.5											
1.6											
1.7											
1.8											
1.9											
1.1											
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Notes:

Please supply files as named in the last column in a human readable format (e.g. . *.asc (IBA or Eclipse), *.mcc, *.D, *.PX_, *PY_,*.dat, *.txt or *.snctxt.

- Please supply in-water cross-profiles in addition to depth-dose-curves
- Please note if measurement conditions deviate from standard (SSD = 1000 mm)
- Please note detector type for DDC
- Do not supply in air measurements.

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Appendix 6

TOMOTHERAPY COMMISSIONING GUIDE (SMC_FS_04 v 1.0)

1. Introduction

The Tomotherapy beam model was derived from the standard beam data set provided by Accuray, for field lengths of 10, 18, 25 and 50 mm and field widths up to 400 mm. Additional measurement data for fields as small as 10 mm x 6.25 mm was used to calibrate all static parameters, i.e., leaf transmission and leakage, jaw positions, primary spectrum and accelerator head scatter.

However, Tomotherapy LINACs differ in their dynamic properties, such as dose rate, leaf travel times and leaf latency times. For these reasons, it may be necessary to tune a number of parameters for each machine individually. Ideally, these parameters would be determined by creating simple treatment plans for a phantom and delivering the plans to an ionization chamber in the phantom. Alternatively, the parameters can also be determined by comparison of patient treatment plans with the TPS calculations.

2. Configuration Files

There are two configuration files that determine different aspects of the dynamic behavior of the treatment machine.

2.1 Dose Rate Calibration Database

The dose rate calibration database TomoTherapyDictionary.xml. This file is mandatory. It provides the values for dose rate and field size correction for the 3 nominal field widths 10, 25 and 50 mm. The entries are specific for each machine, which is identified by its unique TreatmentMachineName.

The file format for *TomoTherapyDictionary.xml*:

```
<?xml version="1.0" encoding="utf-8"?>
<TomoTherapyCalibration>
        <Mapping TreatmentMachineName="0210399" NominalFieldWidth="10"
         DoseRate="849.3" FieldEdgeCorrection="0.0" OpeningTime="18"/>
        <Mapping TreatmentMachineName="0210399" NominalFieldWidth="25"
         DoseRate="851.0" FieldEdgeCorrection="0.0" OpeningTime="18"/>
        <Mapping TreatmentMachineName="0210399" NominalFieldWidth="50"
         DoseRate="851.0" FieldEdgeCorrection="0.0" OpeningTime="18"/>
</TomoTherapyCalibration>
```

Notes:

- The valid values for the tag NominalFieldWidth are “10”, “25” and “50” (mm). The tag is mandatory.
- Mappings for more than one TreatmentMachineName can be specified.
- The mandatory tag DoseRate gives the effective dose rate in MU per minute.
- The tag FieldEdgeCorrection is optional. It gives a correction of the jaw position in mm. Negative values make the field width smaller. The field edge correction defaults to zero.

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- The tag OpeningTime is optional. It gives the time in milliseconds that a leaf needs to travel from the open to the closed position (and vice versa). The time defaults to 0, i.e., instantaneous movement.

2.2 Latency Correction Database

The latency correction database TomoTherapyLatencyDictionary.xml. This file is optional. It provides the values for modelling the leaf-movement latency of a specific LINAC. The entries are specific for each machine, which is identified by its unique TreatmentMachineName.

The file format for *TomoTherapyLatencyDictionary.xml*:

```
<?xml version="1.0" encoding="utf-8"?>
<TomoTherapyLatency>
      <Mapping TreatmentMachineName="0210399" Period="200"
       Slope="1.032" Offset="-0.862"/>
      <Mapping TreatmentMachineName="0210399" Period="500"
       Slope="1.005" Offset="0.281"/>
      <Mapping TreatmentMachineName="0210399" Period="1000"
       Slope="1.002" Offset="0.725"/>
</TomoTherapyLatency>
```

Notes:

- The valid values for the tag Period are between “200” and “1000” (ms). The tag is mandatory.
- Mappings for more than one TreatmentMachineName can be specified.
- The mandatory tag Slope gives the slope of the linear latency correction (unitless). A neutral value is 1.0.
- The mandatory tag Offset gives the offset of the linear latency correction (ms). A neutral value is 0.0.
- The values can be taken from a TomoTherapy machines.xml file. Period corresponds to ‘x’, Slope corresponds to ‘y’, Offset corresponds to ‘z’.
- On how to create such a file, see the example of a LatencyCurveData entry as exported from the Tomotherapy TPS below.

3. Dose Rate Calibration

The DICOM plan data does not contain information about a dose rate for a specific machine. Therefore, a (fictitious) dose rate needs to be supplied that can be used to convert the DICOM data into monitor units for dose calculation. This calculation dose rate (CDR) depends on field length.

One way to determine this CDR is to calculate with myQA iON a number of patient cases for each field length, ideally with various pitch and gantry period values, and chose a CDR that minimizes the difference between TPS dose and Monte Carlo dose.

An alternative would be to set up a number of phantom treatment plans and determine the CDR via direct measurement. A suggested setup of these plans could be like follows:

The tests are performed as treatment plans for one or two cylindrical target volumes in the "Cheese-Phantom," see Langen KM et al., Med Phys 37(9) 4817-4853 (2010). Dose is measured with an ionization chamber inside the targets A and B and a designated organ-at-risk C.

ROI name	Diameter	Length	Position	Prescription
Target A	60 mm	80 mm	centred	100%
Target B	60 mm	80 mm	off-axis up	100%
OAR C	60 mm	80 mm	off-axis down	20%

Table 3-1 Definitions of ROI in the Cheese-Phantom

Treatment plans are exported as DICOM and re-computed in myQA iON. Latency correction is applied if available/desired. In addition to measured dose, the calculated dose distribution of the TPS can be used. Tests should be designed to cover the variation in pitch, gantry period and leaf open times.

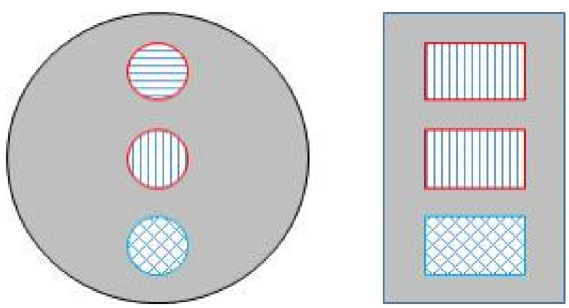

Figure 3-1 Schematic configuration of target volumes A and B, red, the organ at risk, blue and measurement positions in the cheese phantom.

The first set of tests aims to keep rotation period and leaf open time distribution constant, and therefore needs to modify target prescription with pitch. The test is to be repeated for all three collimator settings.

Test	Test name	Description
1.1	Field_10_PITCH_0.1	central target, prescription 4 Gy
1.2	Field_10_PITCH_0.2	central target, prescription 2 Gy
1.3	Field_10_PITCH_0.4	central target, prescription 1 Gy
2.1	Field_25_PITCH_0.1	central target, prescription 5 Gy
2.2	Field_25_PITCH_0.2	central target, prescription 2.5Gy
2.3	Field_25_PITCH_0.4	central target, prescription 1.5 Gy
3.1	Field_50_PITCH_0.1	central target, prescription 10 Gy
3.2	Field_50_PITCH_0.2	central target, prescription 5 Gy
3.3	Field_50_PITCH_0.4	central target, prescription 2.5 Gy

Table 3-2 Tests and descriptions

Additional tests can be performed in this manner, changing gantry period and prescription dose, to arrive at a better coverage of the variation in these parameters in clinical cases.

The ideal CDR for each field width minimizes the error between measurements and Monte Carlo calculations.

4. Field Size Correction and Leaf Opening Time

These parameters are experimental and do not need to be changed from default.

Field size (length) correction affects both longitudinal jaw positions by the specified amount (as defined in the isocenter distance). A negative value reduces the field length. Field length correction requires a high-resolution measurement of the longitudinal cross profile at isocenter distance with a detector of suitably small volume, or a film measurement. Any change of the jaw position will translate into a dose change that is pitch dependent, so normally the dose rate needs to be re-calibrated. The primary purpose of this parameter is to give users the opportunity to investigate effects of changes of jaw position calibration.

Leaf opening time is a parameter that does not change the dose calibration. By setting this parameter to a non-zero value, the actual movement of the leaves is simulated. A value of zero assumes instantaneous opening of the leaves. Notice that the average time the leaf is open is not affected. A typical value is 18 ms. The primary purpose of this parameter is to give users the opportunity to investigate effects of inclusion of leaf movement in the dose calculation

5. Latency Correction

Latency correction is applied to the TPS-exported DICOM plan files to correct leaf opening times for machine-dependent effects. The values of this correction can be found in the <machineID>_machine.xml file accessible from the TPS. They are stored in this format:

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dosimetry-info@iba-group.com | www.iba-dosimetry.com | Registration Court: Local Court (Amtsgericht) Nürnberg, HRB 4262
Managing Directors: Olivier Legrain, Jean-Marc Bothy, Soumya Chandramouli | VAT Reg No: DE132815519 | St.-Nr. 241/115/72638
WEEE-Reg.-Nr. DE 65960409 | Commerzbank AG | IBAN: DE23 7608 0040 0165 8967 00 | SWIFT/BIC: DRESDEFF760

```xml
<latencyCurveData Type="[Lcom.tomotherapy.tomo.auto.tcorba.TFloatTriplet;">
          <latencyCurveData Type="com.tomotherapy.tomo.auto.tcorba.TFloatTriplet">
            <x Type="java.lang.Float">200.0</x>
            <y Type="java.lang.Float">1.032</y>
            <z Type="java.lang.Float">-0.862</z>
          </latencyCurveData>
          <latencyCurveData Type="com.tomotherapy.tomo.auto.tcorba.TFloatTriplet">
            <x Type="java.lang.Float">300.0</x>
            <y Type="java.lang.Float">1.004</y>
            <z Type="java.lang.Float">1.786</z>
          </latencyCurveData>
          <latencyCurveData Type="com.tomotherapy.tomo.auto.tcorba.TFloatTriplet">
            <x Type="java.lang.Float">400.0</x>
            <y Type="java.lang.Float">1.014</y>
            <z Type="java.lang.Float">-0.867</z>
          </latencyCurveData>
          <latencyCurveData Type="com.tomotherapy.tomo.auto.tcorba.TFloatTriplet">
            <x Type="java.lang.Float">500.0</x>
            <y Type="java.lang.Float">1.005</y>
            <z Type="java.lang.Float">0.281</z>
          </latencyCurveData>
          <latencyCurveData Type="com.tomotherapy.tomo.auto.tcorba.TFloatTriplet">
            <x Type="java.lang.Float">600.0</x>
            <y Type="java.lang.Float">1.009</y>
            <z Type="java.lang.Float">-1.529</z>
          </latencyCurveData>
          <latencyCurveData Type="com.tomotherapy.tomo.auto.tcorba.TFloatTriplet">
            <x Type="java.lang.Float">800.0</x>
            <y Type="java.lang.Float">1.002</y>
            <z Type="java.lang.Float">0.906</z>
        </latencyCurveData>
        <latencyCurveData Type="com.tomotherapy.tomo.auto.tcorba.TFloatTriplet">
          <x Type="java.lang.Float">1000.0</x>
          <y Type="java.lang.Float">1.002</y>
          <z Type="java.lang.Float">0.725</z>
        </latencyCurveData>
  </latencyCurveData>
```


Whereby the x-value maps to Period, the y-value maps to Slope and the z-value maps to Offset. The above *TomoTherapyLatencyDictionary.xml* is derived from this example. The parameters would be applied like this:

*SimulatedOpeningTime [ms] = DICOMOpeningTime [ms] * Slope + Offset [ms].*

Thus, neutral values are Slope = 1 and Offset = 0, so that

SimulatedOpeningTime = DICOMOpeningTime.

A change to the latency correction, or its omission, may require a new calibration of dose rates.

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