LIAC Quality Assurance

Index

Terms and Definitions

c_{pl}	Material dependent scaling factor to convert ranges and depths measured in plastic phantoms into the equivalent values in water.
CTV	Clinical Target Volume
$D_{w,Q}$	Absorbed dose to water at the reference depth, z_{ref}, in a water phantom irradiated by a beam of quality Q. The subscript Q is omitted when the reference beam quality is ^{60}Co. Unit: gray (Gy).
E_0, E_z	Mean energy of an electron beam at the phantom surface and at depth z, respectively. Unit: MeV.
h_{pl}	Material dependent fluence scaling factor to correct for the difference in electron fluence in plastic compared with that in water at an equivalent depth.
HVL	Half-value layer, used as a beam quality index for low and medium energy X ray beams.
$k_{Q,Qo}$	Factor to correct for the difference between the response of an ionization chamber in the reference beam quality Q_o used for calibrating the chamber and in the actual user beam quality Q. The subscript Q_o is omitted when the reference quality is ^{60}Co gamma radiation (i.e. the reduced notation k_Q always corresponds to the reference quality ^{60}Co).
k_{sat}	Factor to correct the response of an ionization chamber for the lack of complete charge collection (due to ion recombination).
k_{TP}	Factor to correct the response of an ionization chamber for the effect of the difference that may exist between the standard reference temperature and pressure specified by the standards laboratory and the temperature and pressure of the chamber in the user facility under different environmental conditions.
MP	Medical Physicist
MU	Monitor Unit(s)
$N_{D,w,Qo}$	Calibration factor in terms of absorbed dose to water for a dosimeter at a reference beam quality Q_o. The product M_{Qo} $N_{D,w,Qo}$ yields the absorbed dose to water, $D_{w,Q0}$, at the reference depth z_{ref} and in the absence of the chamber. The subscript Q_o is omitted when the reference quality is a beam of ^{60}Co gamma rays. Unit: Gy/C or Gy/rdg.
OaR(s)	Organ(s) at Risk
$(OF)_D^{\alpha}$	Output Factor for the applicator whit diameter D and bevel angle α
PDD	Percentage depth dose.
P_{eff}	The effective point of measurement of an ionization chamber. For the standard calibration geometry, i. e. a radiation beam incident from one direction, P_{eff} is shifted from the position of the center towards the source by a distance which depends on the type of beam and chamber. For plane-parallel ionization chambers P_{eff} is usually assumed to be situated in the center of the front surface of the air cavity.
PTV	Planning Target Volume
Q	General symbol to indicate the quality of a radiation beam. A subscript 'o', i.e. Q_o, indicates the reference quality used for the calibration of an ionization chamber or a dosimeter.
rdg	Value, in arbitrary units, used for the reading of a dosimeter.
R_{50}	Half-value depth in water (in g/cm^2), used as the beam quality index for electron beams.
r_{cyl}	Cavity radius of a cylindrical ionization chamber.
R_p	Practical range (in g/cm^2) for electron, proton and heavy ion beams.
RO	Radiation Oncologist
RU	Radiant Unit
SAD	Source–axis distance.
SSD	Source–surface distance.
z_{max}	Depth of maximum dose (in g/cm^2).
z_{ref}	Reference depth (in g/cm^2) for in-phantom measurements. When specified at zref, the absorbed dose to water refers to $D_{w,Q}$ at the intersection of the beam central axis with the plane defined by z_{ref}.

1 General

This document describes the Quality Assurance (QA) procedures to be performed on LIAC (the Device), according to the relevant international protocols [1,2,4,10].
The first task to be performed before any clinical use of the Device is the Acceptance Test . The Acceptance Test Procedure is described in the document LIAC Dosimetric Characterization [21]. After the Acceptance Test, the dosimetric characterization of LIAC is performed, in compliance to the IORT International Guidelines [1,2,4,10].
LIAC Dosimetric characterization is described in reference [21].
The last task to be performed is the reference measurements for several dosimetric QA: Long-term stability of the dosimetric monitoring system (points 5 and 10 of Table 5), Symmetry and flatness of the field (point 8 of Table 5), Beam Quality (point 9 of Table 5).
The QA program to be carried out, with the corresponding value of tolerance and frequency, is reported in Table 1 .

Parameter	Tolerance	Frequency
1. Movements and stopping operation of motors	functional	at least every week and before every treatment.
2. Emergency devices	functional	at least every week and before every treatment
3. Integrity of the applicators	integer	at least every week and before every treatment
4. Optic and acoustic warning devices	functional	at least every week and before every treatment
5. Long-term stability of the dosimetric monitoring system	±3%*	at least every week and before every treatment
6. Short-term stability of the dosimetric monitoring system (repeatability)	±1%	monthly
7. Linearity of the dosimetric monitoring system	±1%	monthly
8. Symmetry and flatness of the field	Symmetry: ±3%; Flatness: ±3% for applicators with diameter ∅=100, 80, 70, 60 mm; ±9% for applicators with diameter ∅=40, 50 mm; ±12% for applicator with diameter ∅=30 mm	monthly
9. Beam Quality (R50)	±2 mm or ±4% (reference applicator ∅=100 mm)	monthly
10. Long-term stability of the dosimetric monitoring system *Reference dosimetry*	±2%** * * Performed with the recommended dosimeter under reference and non reference conditions	Biennial or after any substitution or modification of the hardware that constitutes Monitor system or collimation system

Table 1: Principal periodic QA

Any relevant maintenance intervention implies the execution of the appropriate QA; hereafter we illustrate the most important cases.
Magnetron substitution implies QA 5,6 and 9. E-gun substitution implies QA 5,6 8 (on the reference applicator only) and 9.

Any substitution or modification of the hardware that constitutes Monitor system or collimation system (e.g. Monitor chambers, applicator holder) implies necessarily the execution of reference dosimetry.
LIAC instructions of use are described in the LIAC Operator Guide [20]. The LIAC is meant to be handled by personnel (operators) duly trained by the user (responsible authority); the training process and documents for every User profile is described in [20].
Hereafter the correct procedures to execute QA are described.

1.1 Movements and stopping operation of motors

Verify that the remote control is properly connected to the mobile unit. The movements and stopping operation of motors QA program to performed is reported in Table 2.

Mobile Unit Movements	Result			
WHEELS MOTION translation movement				
UP and DOWN Head lifting and lowering movement	UP limit		DOWN limit	
PITCH Head rotation movement	PITCH limit sup		PITCH limit inf	
ROLL Head rotation movement	ROLL limit sup		ROLL limit inf	

Table 2: Movements and stopping operation of motors check

The trials must be performed choosing both High Speed and Low speed.
The test must be executed at least every week and before any clinical use. Any additional information on LIAC movements can be found in **LIAC Operator's Guide,** Sordina S.p.A.[20]; a worksheet can be found in ***Appendix: QA worksheets*** of the present document.

1.2 Emergency devices

Emergency devices must be verified pressing the safety button on the control rack (EmerRack) and the safety button on the mobile structure (EmerStat).
Before performing the Test, verify LIAC Status is Ready ; the Ready status is indicated by the green LED on the Master board panel and by the green lamp on the mobile structure.
Press any emergency button and verify that the LIAC Status is Alarm; the alarm status is indicated by the red LED on the Master board panel and by the red lamp on the mobile structure.
Check on LIAC Alarms Menu (Master Board) that the correct alarm is evidenced.
Release the emergency button and reset the alarm trough LIAC Master Board.
Check that LIAC status get back to Ready.
The test must be executed at least every week and before any clinical use.
Any additional information on LIAC emergency devices can be found in LIAC Operator's Guide, Sordina S.p.A.[20].

1.3 Integrity of the applicators

Applicators must be handled with care and undergo visual checks. Please replace the units which do not have the original integrities and transparency.
The test must be executed at least every week and before any clinical use.
Any additional information on LIAC applicators can be found in LIAC Operator's Guide, Sordina S.p.A.[20].

1.4 Optic and acoustic warning devices

The test consists in verifying that the four LEDs (red, green, yellow, white) on the rack, the four lamps (red, green, yellow, white) on the mobile structure and acoustic warning devices work correctly.
The lamps represent the equipment statuses:

- red ("Alarm"): the equipment has detected an alarm;
- green ("Ready"): the equipment is ready to start either irradiation or "Simulation" step;
- yellow ("Beam on"): irradiation is on;
- white ("Wait"): the equipment has been switched on for a period shorter than the Preheating time.

Switch on LIAC and verify that the white LED on the rack and the white lamp on the mobile structure are on (Wait status). After Preheating time, verify that the green LED on the rack and the green lamp on the mobile structure are on (Ready status).
Press the start button one time only, verify that the yellow LED and the yellow lamp are flashing (Simul status) and intermittent buzzer works. Press again the start button and verify that, during the irradiation, the yellow LED on the rack is on and buzzer works. Press the stop button to interrupt the irradiation. Press any emergency button and verify that the LIAC Status is Alarm; the alarm status is indicated by the red LED on the Master board panel and by the red lamp on the mobile structure.
Check on LIAC Alarms Menu (Master Board) that the correct alarm is evidenced.
Release the emergency button and reset the alarm trough LIAC Master Board.
Check that LIAC status get back to Ready.
Any additional information on LIAC optic and acoustic warning devices can be found in LIAC Operator's Guide, Sordina S.p.A.[20].
The test must be executed at least every week and before any clinical use.

1.5 LIAC dosimetric system Long-Term Stability

The trial consists in verifying the stability of the LIAC dosimetric system respect to the charge collected by a plane parallel ionization chamber put in a solid phantom @ R_{100} for each energy. The ratio between the MU displayed by the LIAC DOSE board and the charge collected, corrected for ambient conditions [1], is monitored and can't excess 3% respect to the reference value. The reference value of the ratio between MU and charge collected had to be evaluated performing a measurement during the Reference Dosimetry with the same setup used in QA. The scheme is reported below.

DATE	**30/12/2009**
Electrometer	**Scanditronix DOSE 1**
Ionisation Chamber	**IBA PPC05**
Phantom	**PMMA**
Test	**LIAC Dosimetric system Stability**
Tolerance	**St.Dev.%(MU1/nC) < 3%**

T	21,0
P	980,0
$K_{T,P}$	1,037
K_T	1,003

Energy (MeV)			**Energy (MeV)**			**Energy (MeV)**			**Energy (MeV)**		
10			**8**			**6**			**4**		
Date	**MU1/nC**	**Stability**	**Date**	**MU1/nC**	**Stability**	**Date**	**MU1/nC**	**Stability**	**Date**	**MU1/nC**	**Stability**
12/12/09	11,32	Reference Value	12/12/09	16,34	Reference Value	12/12/09	23,04	Reference Value	12/12/09	28,81	Reference Value
30/12/09	11,29	-0,3%	30/12/09	16,25	-0,6%	30/12/09	22,98	-0,2%	30/12/09	28,76	-0,2%

Table 3: Stability of the LIAC dosimetric system, 10 MeV model

The measurement must be executed at least weekly and anyway before every clinical use of the device.

Warning LIAC must satisfy QA request on stability immediately after pre heating time (20 minutes after switching it on); Users should not execute any pre irradiation greater than 200 MU of the plane parallel ionization chamber before executing QA dosimetric system stability.

1.6 LIAC dosimetric system Short-Term Stability (Repeatability)

The trial consists in checking the repeatability of the LIAC dosimetric system respect to the charge collected by a plane parallel ionization chamber put in a solid phantom @ R100. The ratio between the MU displayed by the LIAC DOSE board and the charge collected is monitored in a short period (five consecutive irradiations). The percentage standard deviation between the ratios must be less than 1% for five consecutive irradiations. The scheme is reported below

DATE		**28/01/2010**				
Electrometer		**Scanditronix Dose1**			**T**	22,0
Ionisation Chamber		**PTW Roos**			**P**	1000,0
Test		**LIAC Dosimetric system Stability**			**$K_{T,P}$**	1,020
Tolerance		**dev.st (UM/nC) < 1%**			**K_T**	1,007
Energy		**10 MeV**				
R_{100}		**14,00 mm**				
PRF		**10 Hz**				
Measure	**Time (s)**	**MU1**	**MU2**	**Charge (nC)**	**MU1/nC**	**MU2/nC**
1	28	200	190	100,30	1,994	1,894
2	27	200	190	99,35	2,013	1,912
3	27	200	190	99,90	2,002	1,902
4	26	200	190	100,10	1,998	1,898
5	26	200	189	100,30	1,994	1,884
Avg.		200	190	99,99	**2,000**	1,898
St.Dev.		0,00	0	0,39	0,008	0,010
St.Dev.%		0,00	0	0,39	**0,396**	0,542

Table 4: Stability of the LIAC dosimetric system, 10 MeV energy

The measurement must be executed at least monthly.

Warning LIAC must satisfy QA request on stability immediately after pre heating time (20 minutes after switching it on); Users should not execute any pre irradiation greater than 200 MU of the plane parallel ionization chamber before executing QA dosimetric system stability.

1.7 LIAC dosimetric system Linearity

The measurement consists in checking the linearity of the LIAC dosimetric system response respect to the charge collected by a plane parallel ionization chamber (p.p.i.c.) put in a solid phantom @ R_{100}. The scheme is reported on Table 5

DATE		**24/09/2010**		
Measurement		**LIAC dosimetric system linearity**		
Electrometer		**DOSE 1 SW**		
Ionisation Chamber		**PPC05**		
Phantom		**PMMA**		
Tolerance		**The value St.Dev.% respect to UM1/nC must be 1% maximum**		
Energy		**10 MeV**		
PRF		**10 Hz**	**Gy/UM1**	**1,00E-02**
Build Up		**10,0 mm**		
# Meas	**Gy**	**MU**	**nC**	**MU/nC**
2	3	300	5,29	56,71
3	10	1000	17,73	56,40
4	20	2000	35,27	56,71
5	30	3000	52,96	56,65
Avg.				**56,62**
St.Dev.				0,15
St.Dev.%				**0,26**

Table 5: linearity measurement model

The value of the percentage standard deviation respect to MU/nC must be 1% or less.
The measurement should be executed at least monthly.

1.8 Symmetry and flatness

Symmetry and flatness tests must be executed using an appropriate 3D motorized water phantom or appropriate radio chromic films as discussed in [1,2,10].
A beam profile must be measured at the depth of maximum depth deposition, with maximum e-beam energy. The field size is the distance between the 50% isodose points on the left and the right side of a beam profile referred to the central axis dose. The flattened area of a profile (homogeneous zone) is the 80% of the field size (for all fields). D_{max} is the maximum dose value inside the flattened area and D_{min} is the minimum dose value inside the flattened area as showed in Figure 1[1,2,4,10].

1.8.1 Flatness

Homogeneity is the indicator for the flatness of a profile. Homogeneity is evaluated as Percentage Dose Ratio $\left(\frac{D_{\max}}{D_{\min}}\right)\cdot 100$. Absorbed dose variation inside the 80% of the field size (defined as the area of the 50% isodose), must be less than 3% (9% for applicators with diameter ∅ = 40, 50 mm, 12 % for applicator with diameter ∅ = 30 mm).

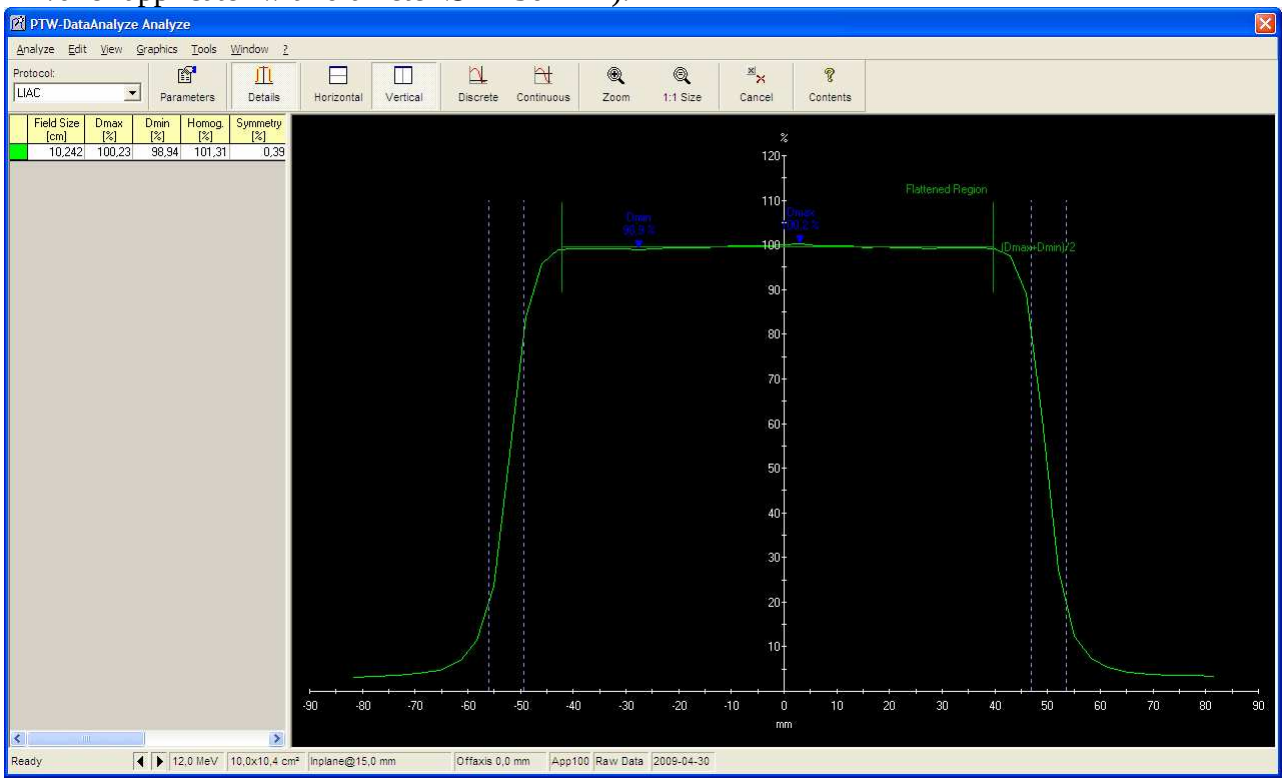


Figure 1:Profile measured with the PTW instruments (MP3 XS water phantom set, equipped with a diode for PTW electrons as field detector and Semiflex chamber as reference detector) and analyzed with software for acquirement and analysis Mephisto mc2 data.

1.8.2 Symmetry

Indicator for the symmetry of a profile is the maximum variation within the flatness region:
$\left(D(x)-D(-x)\right)_{\max}$

$x \in Flatness\,\mathrm{Re}\,gion$

Maximum absorbed dose difference between points equidistant from central beam axis, inside the 80% of the field size (defined as the area of the 50% isodose), must be less or equal to 3%.

Warning: Before performing these tests, be sure that the detectors do not have saturation problems and their volume is adequate to measure the chosen fields. Additional information can be found in LIAC Dosimetric characterization [21] .

1.9 Beam quality

Beam Quality tests must be executed using an appropriate 3D motorized water phantom or appropriate radio chromic films as discussed in [1,2,10].
Measurements consist in checking Percentage Depth Dose (PDD) curves in order to check e-beams energy stability.
The value of R50 parameter [1], defined as the penetration depth in water which the depth dose deposition is equal to 50% of its maximum value, must be equal to the value measured during Acceptance Test within tolerance range of ±2 mm or ±4% [1,2,10].
Expected values are reported in Table 6; Figure 2 shows typical PDD curves for any energies available with LIAC.

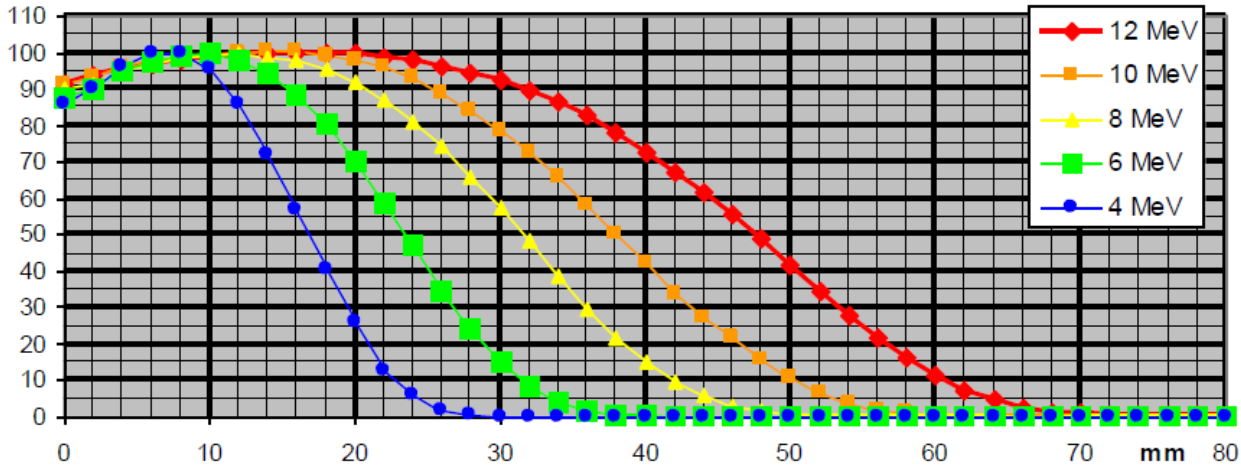


Figure 2: LIAC PDD Curves

LIAC Mod 10 MeV	**R_{50}**	**LIAC Mod 12 MeV**	**R_{50}**
Nominal Energy (MeV)	**Expected values (mm)**	Nominal Energy (MeV)	**Expected values (mm)**
4	16	6	22
6	22	8	30
8	30	10	39
10	39	12	46

Table 6: R50 Values of LIAC beams with reference applicator

This test should be executed monthly.

1.10 Long-term stability of the dosimetric monitoring: Reference dosimetry

Reference dosimetry shall be performed at least every 2 years or after any substitution or modification of the hardware that constitutes Monitor system or collimation system. Reference Dosimetry of LIAC is described in Sordina Documentation [21].

2 Record and Verify

LIAC User should record the QA tests on the forms reported in appendix of the present Document; these worksheets will allow a steady calculus procedure for all LIAC parameter to be set.

3 LIAC clinical settings

The following parameter must be programmed before any IORT irradiation:

1. Applicator diameter and bevel angle;
2. E-beam energy;
3. MU;
4. Time limit.

Hereafter it is described the correct procedure for the setting of the parameters.

3.1 Applicator selection

Applicator is chosen by the Surgeon and the Radiotherapy Oncologist in order to guarantee the best possible irradiation of the CTV without damaging healthy tissues and OaRs. RO communicate the choice to the Nurse who will be responsible for the correct finding and to MP (or the Radiation Technologist) who will set the correct applicator diameter on LIAC Master Board; the effective diameter is checked electronically and irradiation is not allowed if the value set is different from the one detected (see chapter 8 of LIAC User Guide, ref. 20).

3.2 Energy selection

E-beam energy is chosen by the RO according to the thickness of tissue to be treated. RO communicates to MP (or the Radiation Technologist) the energy value. The energy value is set trough LIAC Master board; the correctness of the value must be checked on Dose Board (see chapter 8 of LIAC User Guide, ref. 20).

3.3 MU calculus

RO prescribes the dose at a certain isodose level (typically 90% or less frequently 80% or 100%). RO communicates to MP dose prescription and MP has to calculate MU needed to deliver the required dose. MU Calculus Procedure is hereafter reported:
The Ratio between MU and cGy has been previously determined during the LIAC clinical dosimetry, as described in **LIAC dosimetric characterization, [21]** Sordina S.p.A.
The ratio MU/cGy is given by

$$\left(\frac{MU}{Gy}\right)_D^{\alpha}\Bigg|_{\overline{E}} = 1\cdot \left(OF\right)_D^{\alpha}\Big|_{\overline{E}} \qquad \alpha \in [0°,15°,30°,45°] \qquad D \in [3,4,5,6,7,8,10\,cm]$$

Because the ratio MU/cGy has been set to 1 for reference applicator and $\left(OF\right)_D^{\alpha}$ is the Output Factor for the applicator of diameter **D** and bevel angle **α**.

The correct amount of MU necessary to deliver the prescribed dose at the prescribed isodose is given by the equation:

$$MU = \frac{(prescribed\ Dose)\cdot(MU/Gy)_{now}}{prescribed\ ISODOSE}$$

Being

$$\left(\frac{MU}{cGy}\right)_{now} = (corr\ \ factor)\cdot \frac{K_{P,now}}{K_{P,CALIB}} \left(\frac{MU}{cGy}\right)_{CALIB}$$

where

$$corr\ \ factor = \frac{(MU/nC)_{now}}{(MU/nC)_{CALIB}} \frac{(K_T)_{CALIB}}{(K_T)_{now}}$$

and $K_T = \frac{273.16 + T(°C)}{293.16}$, $K_P = \frac{1013}{P(mBar)}$.

Further details can be found in **LIAC Dosimetric characterization,** Sordina S.p.A.[21].

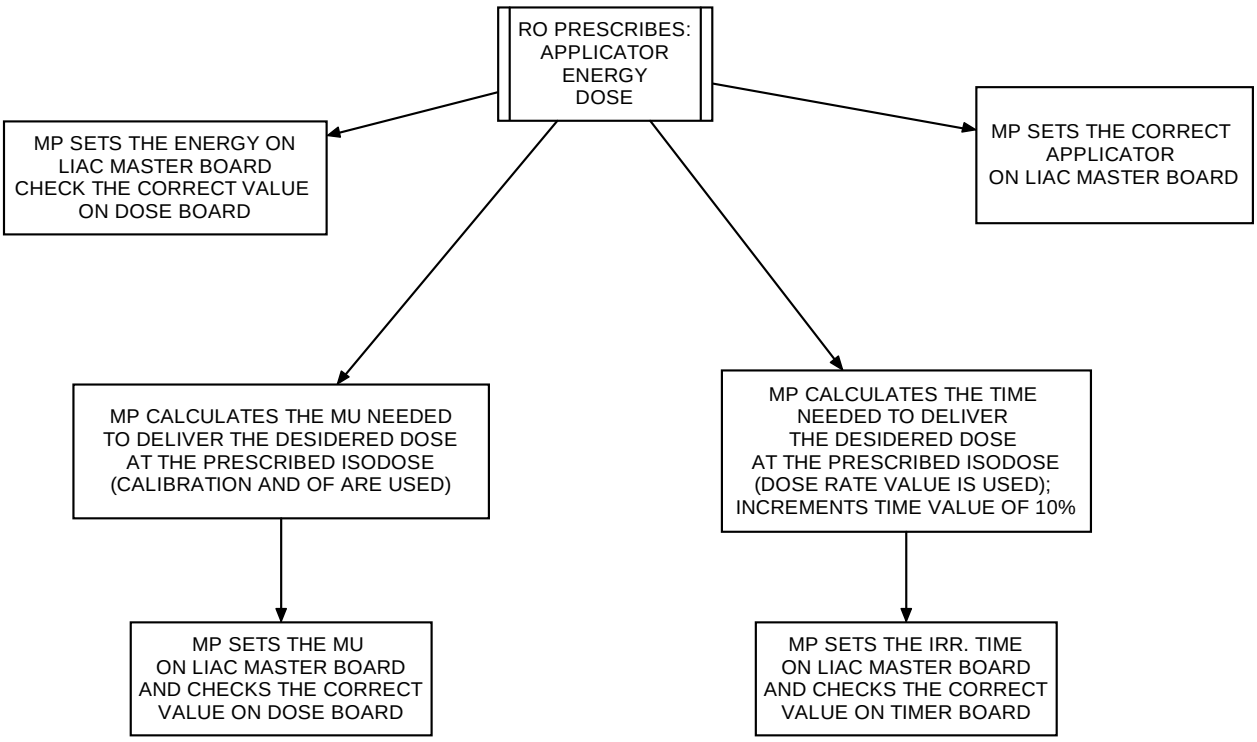
3.4 Time Limit

Irradiation Time Limit must be set as an additional safety in case of a contemporary failure of the two independent LIAC monitor chambers. The Time limit to be set is given by the expected time multiplied by a factor 1.1, as expressed

$$Time\ (s) = 1{,}1\cdot \frac{DR^{\bar{E}}_{D,\alpha}}{Dose@z_{\max}\,[cGy]} \quad \text{being } [DR] = \frac{cGy}{s}.$$

Where $DR^{\bar{E}}_{D,\alpha}$ is the Dose Rate corresponding to the applicator with diameter **D** and bevel angle **α** at the energy $\bar{E}$.
The value of the Dose Rate for every applicator, energy and bevel angles during commissioning has been evaluated by MP, and recorded on a worksheet as the one presented in the Apeendix of in **LIAC Dosimetric characterization,** Sordina S.p.A.[21].
The calculus is performed by MP after the RO has communicated the Dose prescribed, and it is independent from the MU calculus. Time Limit is set trough LIAC Master Board the correctness of the value must be checked on Timer Board (see chapter 8 of **LIAC User Guide**, ref. 20).

The whole process is described in the following flow chart:



IORT treatment parameters must recorded in the worksheet reported in the appendix 3.14; the worksheet has been prepared following the recommendations of **Prescribing, recording, and reporting electron beam therapy ICRU Report, No. 71 (ICRU, 2004)**, [3].

Appendix: QA worksheets

3.5 LIAC movements

Radiant Unit Movements	Result			
SPEED LOW 1				
WHEELS MOTION translation movement				
UP and DOWN Head lifting and lowering movement	UP limit		DOWN limit	
PITCH Head rotation movement	PITCH limit sup		PITCH limit inf	
ROLL Head rotation movement	ROLL limit sup		ROLL limit inf	
SPEED LOW 2				
WHEELS MOTION translation movement				
UP and DOWN Head lifting and lowering movement	UP limit		DOWN limit	
PITCH Head rotation movement	PITCH limit sup		PITCH limit inf	
ROLL Head rotation movement	ROLL limit sup		ROLL limit inf	
SPEED HIGH 1				
WHEELS MOTION translation movement				
UP and DOWN Head lifting and lowering movement	UP limit		DOWN limit	
PITCH Head rotation movement	PITCH limit sup		PITCH limit inf	
ROLL Head rotation movement	ROLL limit sup		ROLL limit inf	
SPEED HIGH 2				
WHEELS MOTION translation movement				
UP and DOWN Head lifting and lowering movement	UP limit		DOWN limit	
PITCH Head rotation movement	PITCH limit sup		PITCH limit inf	
ROLL Head rotation movement	ROLL limit sup		ROLL limit inf	

3.6 LIAC Emergency Devices

MARK WITH A THICK *V*		OK	NO
EMERGENCY DEVICES	EMER RACK		
	EMER STAT LEFT		
	EMER STAT RIGHT		

3.7 Applicators Integrity

MARK WITH A THICK *V* IF THE COMPONENT IS INTEGER					
DIAMETER (mm)	HOLDER	TERMINAL BEVEL ANGLE			
		0°	15°	30°	45°
100					
80					
70					
60					
50					
40					
30					

3.8 Optic and Acoustic Warning Devices

MARK WITH A THICK *V* IF THE COMPONENT IS WORKING				
LIAC STATUS	COLOR	RACK LEDS	RU LAMPS	BUZZER
ALARM	RED			N.A.
READY	GREEN			N.A.
BEAM ON	YELLOW		N.A.	
SIMUL	YELLOW FLASHING		N.A.	
WAIT	WHITE			N.A.

3.9 Short Term Repeatability

date	
electrometer	
Detector	
Test	Short Term Repeatability
Tolerance	

Energy		A	Notes:				
PRF							
z_{MAX}							
Meas	Time	MU1	MU2	nC	pulses	MU1/nC	MU2/nC
1							
2							
3							
Avg.							
St.Dev.%							

Energy		C	Notes:				
PRF							
z_{MAX}							
Meas	Time	MU1	MU2	nC	pulses	MU1/nC	MU2/nC
1							
2							
3							
Avg.							
St.Dev.%							

Energy		B	Notes:				
PRF							
z_{MAX}							
Meas	Time	MU1	MU2	nC	pulses	MU1/nC	MU2/nC
1							
2							
3							
Avg.							
St.Dev.%							

Energy		D	Notes:				
PRF							
z_{MAX}							
Meas	Time	MU1	MU2	nC	pulses	nC/MU1	MU2/nC
1							
2							
3							
Avg.							
St.Dev.%							

T	
P	
$K_{T,P}$	
K_T	

3.10 Long Term Repeatability

date	
electrometer	
Detector	
Test	LIAC Dosimetric system Stability
Tolerance	St.Dev.%(MU1/nC) < 3%

T	
P	
$K_{T,P}$	
K_T	

Energy (MeV)			Energy (MeV)			Energy (MeV)			Energy (MeV)		
A			B			C			D		
Date	MU1/nC	Stability	Date	MU1/nC	Stability	Date	MU1/nC	Stability	Date	MU1/nC	Stability
CAL. DATE		Reference Value	CAL. DATE		Reference Value	CAL. DATE		Reference Value	CAL. DATE		Reference Value
QA DATE			QA DATE			QA DATE			QA DATE		

3.11 Linearity

date	
electrometer	
Detector	
Test	LIAC dosimetric system linearity
Tolerance	The value St.Dev.% respect to MU1/nC must be 1% maximum

Energy		A	
PRF			
z_{MAX}			
# Meas	MU	nC	MU/nC
1	300		
2	1000		
3	2000		
4	3000		
Avg.			
St.Dev.			
St.Dev.%			

Energy		C	
PRF			
z_{MAX}			
# Meas	MU	nC	MU/nC
1	300		
2	1000		
3	2000		
4	3000		
Avg.			
St.Dev.			
St.Dev.%			

Energy		B	
PRF			
z_{MAX}			
# Meas	MU	nC	MU/nC
1	300		
2	1000		
3	2000		
4	3000		
Avg.			
St.Dev.			
St.Dev.%			

Energy		D	
PRF			
z_{MAX}			
# Meas	MU	nC	MU/nC
1	300		
2	1000		
3	2000		
4	3000		
Avg.			
St.Dev.			
St.Dev.%			

3.12 Symmetry and flatness of the fields

Applicator Diameter (cm)	Profile	Flatness	Symmetry
10	X		
10	Y		
8	X		
8	Y		
7	X		
7	Y		
6	X		
6	Y		
5	X		
5	Y		
4	X		
4	Y		
3	X		
3	Y		

3.13 Beam Quality

LIAC	**R_{50} (mm)**	
Nominal Energy (MeV)	**REFERENCEVALUE**	**MEASURED VALUE**
A		
B		
C		
D		

3.14 IORT Treatment worksheet

Patient Data			LIAC Data				
ID Number			S/N				
Name			Nominal Energy				
Surname			E-beam	R_{100} (cm)		R_{80} (cm)	
Birth date				R_{90} (cm)		R_{50} (cm)	
Sex	Male	Female	Applicator	diameter (cm)		bevel angle (°)	
Pre Operative Diagnosis							
Pathology							
Localization							
Notes							
DOSE ON PTV							
PTV DESCRIPTION				Isodose Prescription (%)			
ICRU Reference point (cm)		Dose @ ICRU RP Ref. Condition (Gy)					
Dose @ ICRU RP (Gy)		MAX Dose @ PTV (Gy)		MIN Dose @ PTV (Gy)			
E-BEAM MODIFIERS (BOLUS, RP DISC, ETC)							
DESCRIPTION							
PLACEMENT							
ORGANS AT RISK							
Organs at Risk							
OaR protection							
IORT STAFF							
Surgeon							
Radiotherapy Oncologist							
Medical Physicist							
Radiotherapy Technologist							

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