

Package 8

INSTRUCTION SHEET, DATA SHEET AND RESULTS REPORTING FORM FOR THE STEP 6 AUDIT

This package contains the following forms:

Instruction Sheet for TLD and film 2D profile quality audit for small photon MLC shaped fields;

Data Sheet for TLD and film 2D profile quality audit for small photon MLC shaped fields;

Certificate for the step 6 audit;

Film handling instructions for DANs.

TLD and FILM POSTAL DOSE QUALITY AUDIT FOR X RAY BEAMS:

INSTRUCTION SHEET

Step 6: TLD and film 2D profile quality audit for small photon MLC shaped fields

Please irradiate the TLDs during the period:

and return them to the address given in the covering letter. Timely response will improve the accuracy of your results. Should the TLDs arrive late, please irradiate them as soon as possible but no later than one month after their receipt. If you are unable to carry out the irradiation, please **RETURN** the TLD set, marking it 'UNEXPOSED'.

GENERAL INSTRUCTIONS

The package contains a solid polystyrene phantom, four TLDs and two film cassettes.

Of the four TLDs, two black TLD capsules are for irradiation. One TLD has a white mark and must not be irradiated; it is used to record environmental influences during transport and storage. The red TLD capsule is to be used when imaging the phantom.

Two cassettes are supplied containing radiochromic film for irradiation. These cassettes should not be opened to maintain the film positioning and to avoid excessive exposure to UV light.

1. CT-scan the phantom, export images to the treatment planning system (TPS) and calculate monitor units (MU) as if for a patient to deliver 2 Gy to the TLD and 8 Gy to the film at 10 cm depth.
2. Irradiate the TLDs and films as instructed in the Technical Instruction (Sections B, C and D) as if they were inside a patient. Ensure that the treatment unit is functioning properly. Label each TLD and film in accordance with the irradiation conditions used.
3. It is recommended to irradiate all TLDs and films in the same session. If this is not possible, please provide the irradiation dates for each TLD and film.
4. After the TLD and film irradiations, measure the beam output in the reference conditions (Section E).
5. Fill in the Data Sheet. An evaluation of the TLD and film results are only possible if these forms are complete.
6. Return TLDs, films and the Data Sheet to the [DAN] within ONE WEEK after the irradiation.

SPECIAL NOTE: Please protect the TLD capsules and radiochromic film cassettes from accidental irradiation, heat (e.g. sunshine), and excessive humidity during storage. Do not store TLDs and films in a place where accidental exposure to radiation could occur.

CONFIDENTIALITY: The TLD and film results of individual centres are kept confidential by the DAN staff and will not be disseminated without the written permission of the participating radiotherapy centre. The statistical distribution of the results may be reported anonymously to the relevant authorities or published.

The TLD equipment sent to you represents a significant investment in cost, time and effort to the [DAN]. Failure to return the TLDs may be reported to your local authorities.

TECHNICAL INSTRUCTIONS

A. Aim of the TLD and film 2D profile quality audit for small photon MLC shaped fields

The purpose of this TLD and film audit is to check the dose and the dose distribution calculations performed by the treatment planning system (TPS) for small photon MLC shaped fields as used for patient treatments. Increasingly complex treatments require more sophisticated dose measuring and modelling techniques that consider not only the magnitude of the dose but the shape and localization of the dose profile delivered using MLC shaped fields. This is particularly relevant for stereotactic and intensity modulated radiation therapy (IMRT) in order to make optimal use of the capabilities of more complex equipment. An independent experimental verification of the 2D dose profiles calculated by treatment planning systems using film dosimetry is an important step in the improvement of quality assurance in radiotherapy and therefore an important extension of the [DAN] programme.

The absorbed dose to water at a 10 cm depth in a solid phantom for a 2 cm × 5 cm field will be checked using TLDs. The 2D dose profiles (in-plane and cross-plane) normalized to the central axis dose for a 2 cm × 5 cm and 2 cm × 2 cm MLC shaped field will be verified using radiochromic film. A solid phantom composed of polystyrene slabs will be used for this quality audit.

You are requested to calculate the number of monitor units required to irradiate the TLDs and films at a depth of 10 cm to the specified dose, according to the TPS used in your clinical practice for patients. The TLD measured absorbed doses and film measured dose profiles will be compared to the dose calculations from your TPS for the MLC shaped field sizes at the location of the TLDs and films.

B. Preparation of the solid phantom configuration for imaging and TPS dose calculations

To perform this quality audit, it is necessary to use the solid polystyrene phantom provided by the [DAN]. This phantom has an overall dimension of 15 cm × 15 cm × 15 cm and can include one of two 2 cm slabs, one that can accommodate a TLD on the central axis and the other a film in a plane at 10 cm depth. There is 5 cm slab beyond the dosimeters for adequate scatter conditions.

1. The solid polystyrene phantom configuration for imaging is shown below in Fig. 1. Prior to irradiation of the dosimeters, the solid phantom should be imaged with a CT. For the imaging procedure, the solid phantom will be configured with the slab containing the 'red imaging' capsule which is to remove the effect of the air cavity. This 'red imaging' TLD will have to be removed prior to irradiating the audit TLD and should be saved in case the phantom has to be imaged again.
2. The phantom's CT images will be exported to the TPS.
3. A treatment plan with a single 2 cm × 5 cm field will be generated to deliver 2 Gy to the location of the TLD on the central axis at a physical depth of 10 cm. A second and third treatment plan will also be generated for 2 cm × 5 cm and 2 cm × 2 cm MLC shaped fields, respectively, to deliver 8 Gy to the location of the film plane on the central axis at a physical depth of 10 cm. The plan can be generated either using an SSD or SAD

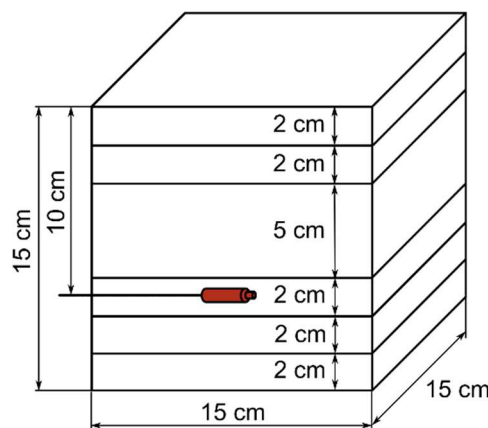


FIG. 1. The solid polystyrene phantom configuration for the imaging for treatment planning of small photon MLC shaped fields.

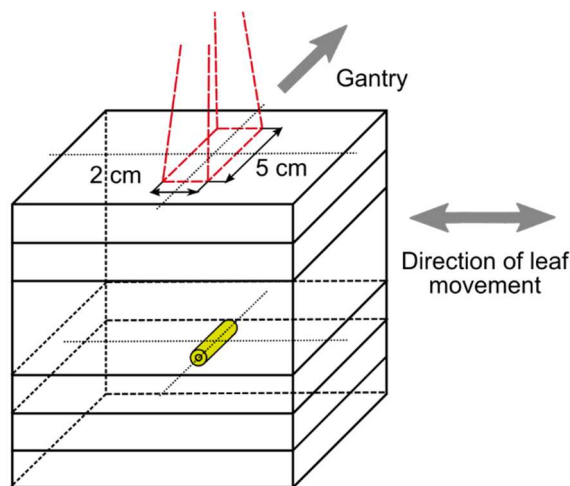


FIG. 2. The solid polystyrene phantom showing the irradiation of the TLD.

technique as long as the TLD and film irradiation setups are consistent with the plan. The photon beam energy (less than 12 MV) most often used clinically should be used.

4. Obtain the number of monitor units to deliver a dose of 2 Gy and 8 Gy to water at the centre of the TLD capsule and film plane, respectively, according to the procedure used in your daily practice for patient treatments.

C. Irradiation of the TLD capsules

1. Assemble the solid phantom configuration as illustrated below in Fig. 2.
2. Set your therapy unit for a vertical beam with $2\text{ cm} \times 5\text{ cm}$ field size shaped by an MLC at the distance from the source used in the treatment plan above.
3. Insert a TLD into the TLD slab. The longitudinal axis of the TLD must be placed parallel to the long dimension of the MLC field (Fig. 2).
4. Before irradiation, recheck whether the alignment, field size and distance are correct.
5. Irradiate the phantom with the number of monitor units as calculated above by the TPS (1st plan) to deliver 2 Gy to the TLD placed on axis at 10 cm physical depth.
6. Remove the TLD from the phantom and label it appropriately.
7. Repeat steps 3 to 6 for the second TLD.

D. Irradiation of radiochromic films

1. Assemble the solid phantom configuration and setup in relation to the linac as illustrated below in Fig. 3. The 2 cm slab containing the TLD insert must be replaced with the 2 cm film slab.
2. Make sure your therapy unit is set for a vertical beam with $2\text{ cm} \times 5\text{ cm}$ field size shaped by an MLC at the distance from the source used in the treatment plan above.
3. Insert the first film cassette for the $2\text{ cm} \times 5\text{ cm}$ field into the film slab. The long dimension of the film cassette must be parallel to the long dimension of the MLC shaped field (Fig. 3).
4. Before irradiation, recheck whether the alignment, field size and distance are correct.
5. Irradiate the phantom with the number of monitor units as calculated by the TPS (2nd plan) above to deliver 8 Gy to the film placed at 10 cm physical depth in a homogeneous polystyrene solid phantom.
6. Remove the film cassette from the phantom.
7. Set up your therapy unit for a vertical beam with $2\text{ cm} \times 2\text{ cm}$ field size shaped by an MLC at the distance from the source used in the treatment plan above.
8. Insert the second film cassette for the $2\text{ cm} \times 2\text{ cm}$ field into the film slab keeping the same orientation of the phantom in relation to the linac and the same orientation of the collimator (Fig. 4).

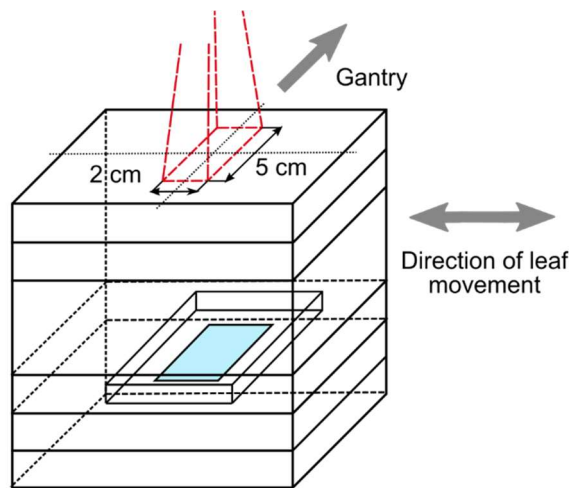


FIG. 3. The solid polystyrene phantom showing the irradiation of the film with a 2 cm × 5 cm MLC shaped field.

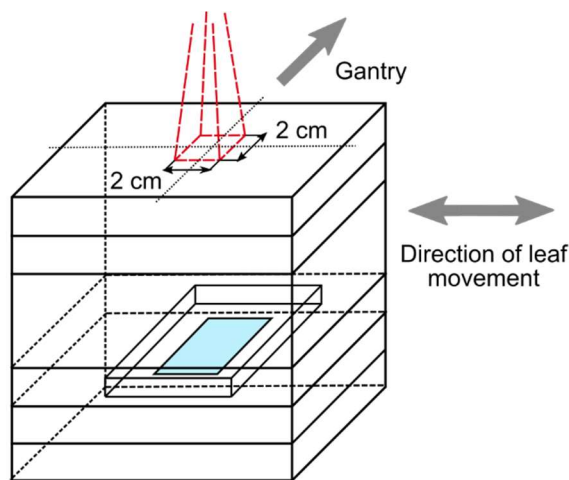


FIG. 4. The solid polystyrene phantom showing the irradiation of the film with a 2 cm × 2 cm MLC shaped field.

9. Repeat steps 4 to 6 for the second film cassette irradiation for the 2 cm × 2 cm MLC shaped field size. Deliver 8 Gy to the second film using the number of monitor units as calculated by the TPS (3rd plan) above.

E. Absorbed dose measurements with an ionization chamber

Determine experimentally the absorbed dose to water in the reference conditions for the radiation beam used for the TLD measurements above according to your usual dosimetry code of practice (dosimetry protocol) and complete the data sheet.

F. Treatment planning system dose profile calculations

Generate in-plane and cross-plane dose profiles for the 2 cm × 5 cm and 2 cm × 2 cm MLC shaped fields at 10 cm depth under the same conditions as used to irradiate the films. The dose profiles must have a 1 mm resolution to generate a smooth curve in the low dose region, penumbra and central high dose regions. Data should be provided for 2 cm beyond the edge of the field in each direction. These dose values along with the position with respect to the central axis should be provided in an Excel spreadsheet for comparison to the film measurements.

TLD AND FILM POSTAL DOSE QUALITY AUDIT FOR X RAY BEAMS

DATA SHEET

Step 6: TLD and film 2D profile quality audit for small photon MLC shaped fields

It is of great importance for the TLD evaluation that the information requested below be completed. Please complete Part II if additional absorbed dose to water determination was made by ionization chamber measurements.

Individuals responsible

Radiation oncologist
name *position*

Medical physicist
name *position*

Name of institution

Address

Telephone number

Fax number

E-mail

Form completed by

Name

Position Medical physicist Radiation oncologist Technician
Other:

On the day

<i>day</i>	<i>month</i>	<i>year</i>			

Irradiation performed by:

Name

Position Medical physicist Radiation oncologist Technician
Other:

Previous participation in an external audit or inter-institution comparison for this beam

No

Yes Date

Please also give information on participation in any other audit:

FOR HOSPITAL STAFF (PHYSICIST, ONCOLOGIST, TECHNICIAN)

A. Specifications of the treatment unit

The treatment unit used for this audit is of the type

.....
model *manufacturer* *serial number* *production year*
installed in the year

The manufacturer's stated beam energy is.....

The beam is with without the flattening filter and is commissioned as standard SRS SRT beam.

The beam quality is characterized by one of the following:

- $D_{20}/D_{10} =$ (10 cm \times 10 cm at SSD = 1 m)
- $TPR^{20/10} =$ (10 cm \times 10 cm at a constant source detector distance of cm)
- other conditions:

B. Beam output used for patient treatment planning

Treatment Planning System used is Software version.....

The reference absorbed dose to water per monitor unit which is used for treatment planning for patients in daily routine is: Gy/MU.

It refers to a depth of cm in water for a cm \times cm field size at:

SSD =cm	OR	SDD =cm
fixed source surface distance		fixed source detector distance
<i>SSD set-up</i>		<i>Isocentric set-up</i>

C. Irradiation of the TLD capsules and films

(see Sections B, C and D of the Instruction Sheet)

The irradiations of TLD capsules and films were performed on the following date:

□	□	□	□	□
<i>day</i>	<i>month</i>	<i>year</i>		

The TLD capsules were irradiated at:

SSD =cm	OR	SAD =cm
fixed source surface distance		fixed source to centre of the TLD distance
<i>SSD set-up</i>		<i>Isocentric set-up</i>

NOTE: Please provide the [DAN] with a printout copy of the treatment plan summary including the monitor unit calculation and isodose distribution showing the isodose line going through the center of the TLD(s) or films for the each treatment plan generated.

TLD Irradiation: TLDs were irradiated using a 2 cm \times 5 cm field, with an absorbed dose rate of Gy/MU at the 10 cm irradiation depth.

TLD Irradiation #1: MU	D = Gy
TLD Irradiation #2: MU	D = Gy

Film Irradiation #1: Film was irradiated using a 2 cm \times 5 cm field, with an absorbed dose rate of Gy/MU at the 10 cm irradiation depth. The collimator angle was degrees.

Film Irradiation #1: MU D = Gy

Film Irradiation #2: Film was irradiated using a 2 cm × 5 cm field, with an absorbed dose rate of Gy/MU at the 10 cm irradiation depth. The collimator angle was degrees.

Film Irradiation #2: MU D = Gy

For each of the film irradiation treatment plans, the in-plane and cross-plane dose profiles with a 1 mm resolution, including the low dose regions, penumbra and central high dose region, should be provided to the DAN in an Excel spreadsheet as a table of normalized dose values and the position with respect to the central beam axis for comparison to the film measured dose profiles. Data should be provided for the range of 2 cm beyond the edge of the field in each direction.

ADDITIONAL REQUEST FOR MEDICAL PHYSICISTS

A. Determination of the absorbed dose to water by ionization chamber in the reference conditions

Measurements were performed by

.....
name *position*

On the day □□□ □□□ □□□□□
day *month* *year*

The absorbed dose rate to water in this beam was determined by using a dosimeter system composed of an ionization chamber

manufacturer *model*

and an electrometer.....

manufacturer *model*

The Co-60 calibration factor of the dosimeter system (**ionization chamber TOGETHER with electrometer**) was:

- R/scale unit (exposure calibration factor N_X)
- or Gy/scale unit (air kerma calibration factor N_K)
- or Gy/scale unit (absorbed dose to water calibration factor $N_{D,w}$).

If any other calibration factor is used please specify:

.....

The above stated calibration factor was determined by the following laboratory/manufacturer..... on the following date

and refers to a temperature of°C and a pressure [*units*] of..... [*units*].

The absorbed dose to water in this beam was measured under the following conditions:

- water plastic – *please specify material*
- field size: cm × cm
- distance:

SSD = **OR** SAD =
SSD set-up *Isocentric set-up*

The depth of the geometrical centre **or** the P_{eff} of the ionization chamber in phantom was cm.

Please give your reading results:

- Average electrometer reading [*scale units*]
- Measurement performed during MU
- Temperature°C
- Pressure [*units*]..... [*units*]
- Electrometer scale
- Electrometer voltage

The absorbed dose to water per MU in this beam was determined by the following code of practice (dosimetry protocol):

.....

Please give detailed explanation of your procedure to determine the dose at the position of the centre of the TLD capsule based on the measurement described above. Please provide all factors you have used:

.....
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The resulting dose rate in the reference conditions was: Gy/MU.

Please give a detailed explanation of your procedure to determine the dose at the position of the centre of the TLD for 2 cm × 5 cm field at 10 cm depth based on the measurements described above. Please provide all factors you have used:

.....
.....
.....
.....

STEP 6 AUDIT CERTIFICATE

[DAN letterhead]

RESTRICTED

[DAN] TLD POSTAL DOSE QUALITY AUDIT

Institution: *Institution name*
Address: *Institution address*
Country: *Country name*

TLD batch no: *xxx*
TLDs irradiated by: *Name*
Date of irradiation: *yyyy-mm-dd*
Evaluation: *yyyy-mm-dd*

STEP 6: RESULTS OF TLD MEASUREMENTS FOR HIGH-ENERGY PHOTON BEAMS SHAPED BY AN MLC

Radiation unit	Beam	Field [cm × cm]	TPS model	User stated dose [Gy]	DAN (measured) dose [Gy]*	DAN mean dose [Gy]*	% deviation relative** to DAN mean dose	<u>DAN mean dose</u> / <u>User stated dose</u>
		2 × 5						

* The uncertainty in the TLD measurement of the dose is $x.x\%$ (1 standard deviation); this does not include the uncertainty intrinsic to the dosimetry protocol (see IAEA TRS-398).
 ** % deviation relative to DAN measured dose = $100 \times (\text{User stated dose} - \text{DAN mean measured dose}) / \text{DAN mean measured dose}$. A relative deviation with negative (positive) sign indicates that the user estimates lower (higher) dose than what is measured; a patient would therefore receive higher (lower) dose than what is intended by the factor given in the last column.
 Agreement within $\pm x\%$ between the user stated dose and the [DAN] measured dose is considered satisfactory.

Signature

 [TLD Officer] – [DAN]

Date:

 yyyy-mm-dd

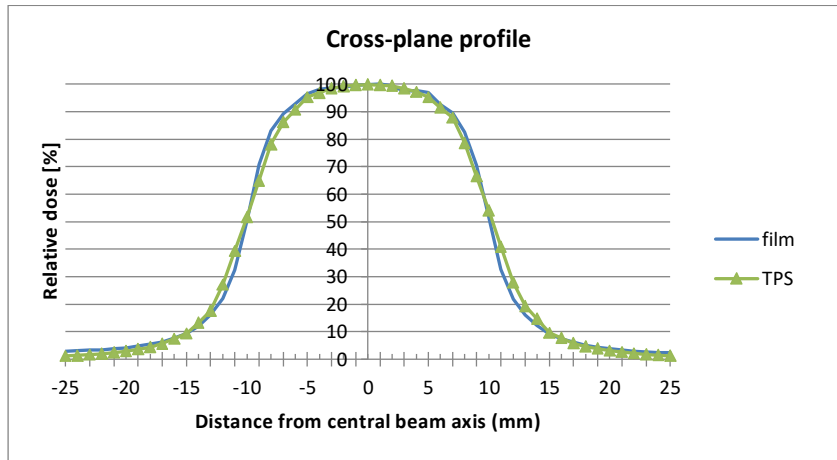
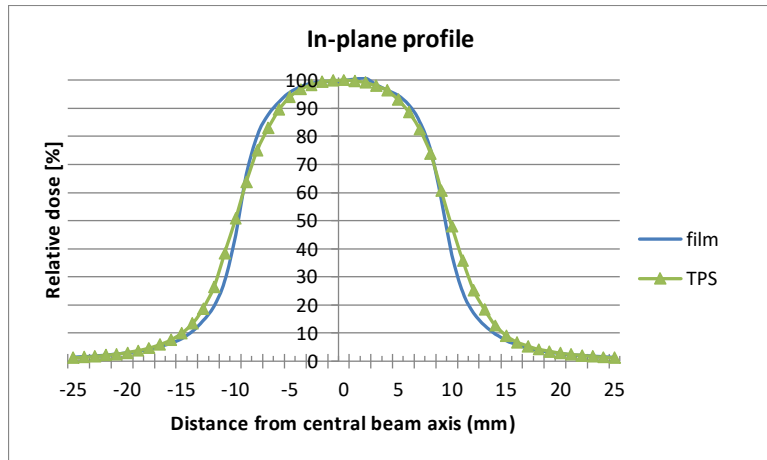
Signature

 Head – [DAN]

IMPORTANT NOTICE: This information is provided only as an independent verification of the hospital dosimetry practices. **IT DOES NOT CONSTITUTE A STATEMENT WITH REGARD TO THE QUALITY OF RADIOTHERAPY TREATMENTS.**

STEP 6: TLD AND FILM 2D PROFILE QUALITY AUDIT FOR SMALL PHOTON MLC SHAPED FIELDS

Institution:	<i>Institution Name</i>	TPS:	<i>TPS Model</i>	Films irradiated by:	<i>Family Name</i>
Address:	<i>Institution Address</i>	Radiation unit:	<i>Name of the Radiation Unit</i>	Date of irradiation:	<i>yyyy-mm-dd</i>
Country:	<i>Country Name</i>	Beam:	<i>xx MV</i>	Evaluation:	<i>yyyy-mm-dd</i>
		Field size:	<i>yy cm × yy cm</i>		



RESULTS OF COMPARISONS BETWEEN TPS AND FILM PROFILES FOR HIGH-ENERGY PHOTONS

In-plane profile				Cross-plane profile			
Rel. Dose	TPS field size [mm]	Film field size [mm]	Film-TPS [mm]	Rel. Dose	TPS field size [mm]	Film field size [mm]	Film-TPS [mm]
	Y	Y			X	X	
80%	14.9	15.7	0.9	80%	15.8	16.7	0.9
50%	19.8	19.1	-0.7	50%	20.4	20.0	-0.4
20%	25.3	23.3	-2.0	20%	25.3	24.4	-0.9

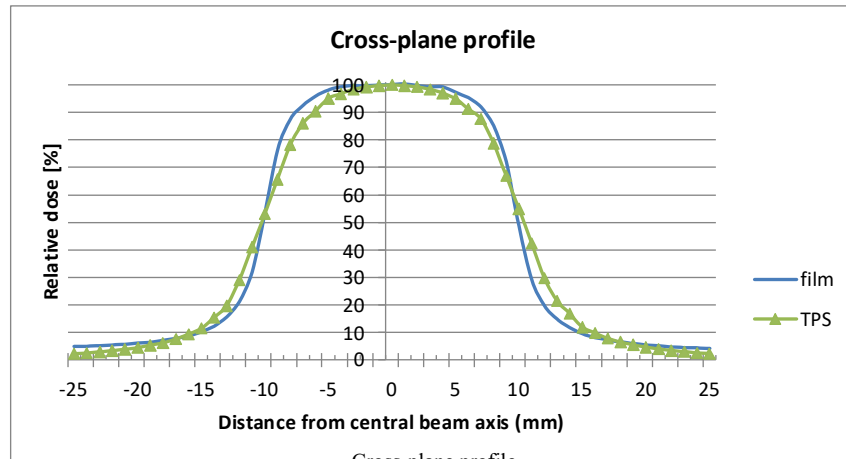
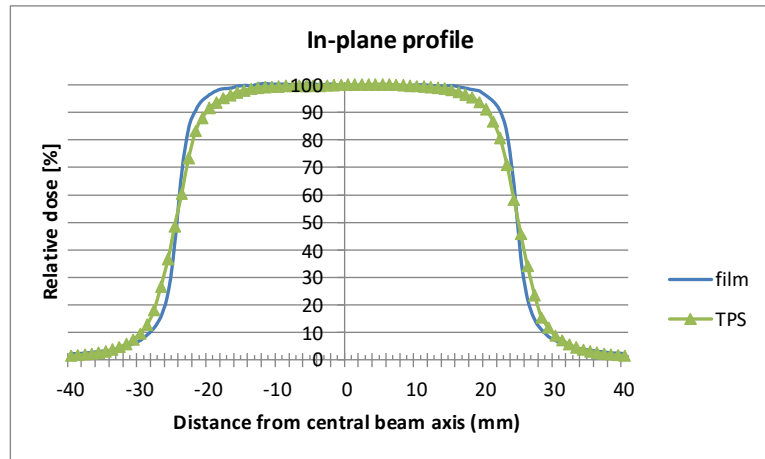
Date:
yyyy-mm-dd

.....
Signature

CRP: STEP 6 - TLD AND FILM 2D PROFILE QUALITY AUDIT FOR SMALL PHOTON MLC SHAPED FIELD SIZES

Institution:	<i>Institution Name</i>	TPS:	<i>TPS Model</i>	Films irradiated by:	<i>Family Name</i>
Address:	<i>Institution Address</i>	Radiation unit:	<i>Name of the Radiation Unit</i>	Date of irradiation:	<i>yyyy-mm-dd</i>
Country:	<i>Country Name</i>	Beam:	<i>xx MV</i>	Evaluation:	<i>yyyy-mm-dd</i>
		Field size:	<i>yy cm × yy cm</i>		

RESULTS OF COMPARISONS BETWEEN TPS AND FILM PROFILES FOR HIGH-ENERGY PHOTONS



Rel. Dose	TPS field size [mm] Y	Film field size [mm] Y	Film-TPS [mm]
80%	44.9	46.2	1.3
50%	49.6	49.4	-0.3
20%	54.5	52.7	-1.8

Rel. Dose	TPS field size [mm] X	Film field size [mm] X	Film-TPS [mm]
80%	16.1	17.3	1.2
50%	20.4	20.0	-0.4
20%	24.8	24.0	-0.8

Date:
yyyy-mm-dd

.....
Signature

FILM HANDLING INSTRUCTIONS FOR DANs

Step 6: TLD and film 2D profile quality audit for small photon MLC shaped field sizes

GENERAL GUIDANCE

1. Radiochromic film (e.g. EBT2 or EBT3) analysis is conducted by the designated Film Measurement Centre (FMC) within the DAN. The FMC stores, prepares, loads film cassettes, ships, receives and analyzes the radiochromic films.
2. Radiochromic film and loaded film cassettes should be stored in such a manner as to avoid accidental irradiation, heat (e.g. sunshine), exposure to UV light and excessive humidity. The film should be kept in a dark location.
3. Radiochromic film must not be handled with bare hands. Cotton gloves must be worn when touching the film. In addition, the film should not be folded or damaged mechanically, as that will cause artefacts to appear when scanning irradiated films.
10. Further detailed information can be found in the AAPM's Task Group Report No. 55, entitled "Radiochromic Film Dosimetry".

TECHNICAL GUIDANCE

Radiochromic film preparation procedures:

1. The FMC should note the batch of the film used and to not mix batches.
2. The film will be cut by the FMC from a full sheet of radiochromic EBT2 film as shown in Fig.1. The film can be cut with a very sharp pair of scissors or other sharp cutting device (a 1 mm strip along the cut line will not be usable for dosimetry purposes). Any person handling the film must wear cotton gloves.
3. Once the film has been cut it must be stored in a black envelope until it is used. A small piece of film from the bottom of the full sheet as indicated in Fig.1 will be retained for a background reading to be used with each set of two films sent for measurements.
4. The radiochromic film will be positioned into the two phantom film cassettes by the FMC, as shown in Fig. 2. The film will be placed against the positioning lip and the top of the cassette will then be placed over the film, applying pressure to the cover such that the pins can mark the film and hold it in place.
5. The film will be held in position by the positioning pins located in each film cassette as shown in Fig. 2. The pin marks on the film will also serve to orient the film and locate the central axis on the film.
6. Once the film is positioned within the polystyrene film cassette, the film cassette, a black envelope containing the background piece of film and remaining polystyrene slabs will be sent to the local hospital who will carefully assemble the solid phantom prior to irradiation according to the instructions provided.

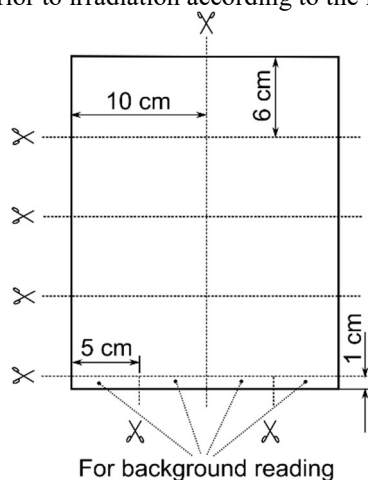


FIG. 1. The template and dimensions for cutting a full sheet of a radiochromic film.

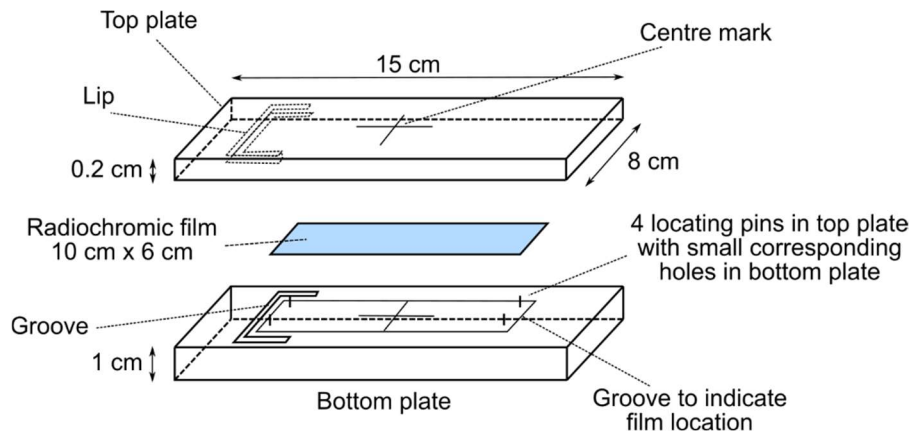


FIG.2. The placement of the radiochromic film within the polystyrene film cassette.

7. When the films return from the local hospital, the cassettes will be unloaded, handled and stored in the same manner indicated above until they are analyzed. The film storage envelopes must be labelled accordingly.