Proton Liver Phantom

Guidelines for ***Planning and Irradiating*** the Proton Liver Phantom.
Revised September 2024

The Proton liver phantom contains an imaging and dosimetric insert. The insert contains two targets. There are two orthogonal sheets of radiochromic film passing through the center of the target and one TLD capsule within 0.5 cm of the center of each target. The phantom also contains normal structures: one to the left of the insert and the other to the right of the insert. Each structure holds a TLD capsule.

We require that each institution to keep the phantom for no more than 2 weeks. During this two-week period, the institution will image, plan, irradiate the phantom and return it to our office. Thank you for your cooperation.

If you have any questions, please contact the Radiation Quality Assurance Laboratory at:

Phone: (713)-745-8989
Email:RQLAB@mdanderson.org

DOSIMETRY INFORMATION TO BE SUBMITTED:

The following information is required to submit when return the phantom (should be include in the shipping box):

- Original hard copy of the Summary of the treatment plan from the treatment planning system (TPS)
- Original hard copy isodose distributions in the coronal and sagittal planes through the target center. Please ensure that each plane fills an entire page and that a scale is printed on the page.
- A completed **Proton Liver Phantom Institution Information** form.
- A copy of results patient specific QA measurements.

Data to be upload to OneDrive - A folder has been created with your institution name on OneDrive. It will be shared with you via email. Please upload digital treatment planning data in the DICOM format which include CT images along with 3D composite RTDose, RTStructure and RTPlan. **Please compress the file before upload to avoid the file corrupt during the process.**

- **Please note, if unable to do the above please send a CD with all the requested data with the phantom.**

- **DICOM data submit for analysis must be with CT images. We cannot process the data with MR images.**

DOSE PRESCRIPTION:

IGRT is mandatory.

Approved Heterogeneity corrections must be used.

The prescribed dose to each target is 6 Gy (RBE). The prescription isodose line is planned to encompass 95% of PTV. A composite plan demonstrating the composite doses to the target volumes, liver and normal tissues must be submitted. **Please see treatment planning addendum for further instructions.**

PTV:

- **CTV = GTV** (Note that this differs from the protocol). Define ITV based on the institution's method of accounting for respiratory motion.

- PTV = ITV + 0.4 cm minimum in all. The tumors will be labeled GTV1 and PTV1 for the tumor towards the superior portion and GTV2 and PTV2 for the tumor towards the inferior portion of the phantom.

- Prescribed dose of 6 Gy(RBE) to PTV1 and PTV2.

- Maximum dose of 9 Gy(RBE) allowed within the PTV. Maximum dose of 7.2 Gy(RBE) allowed outside the PTV.

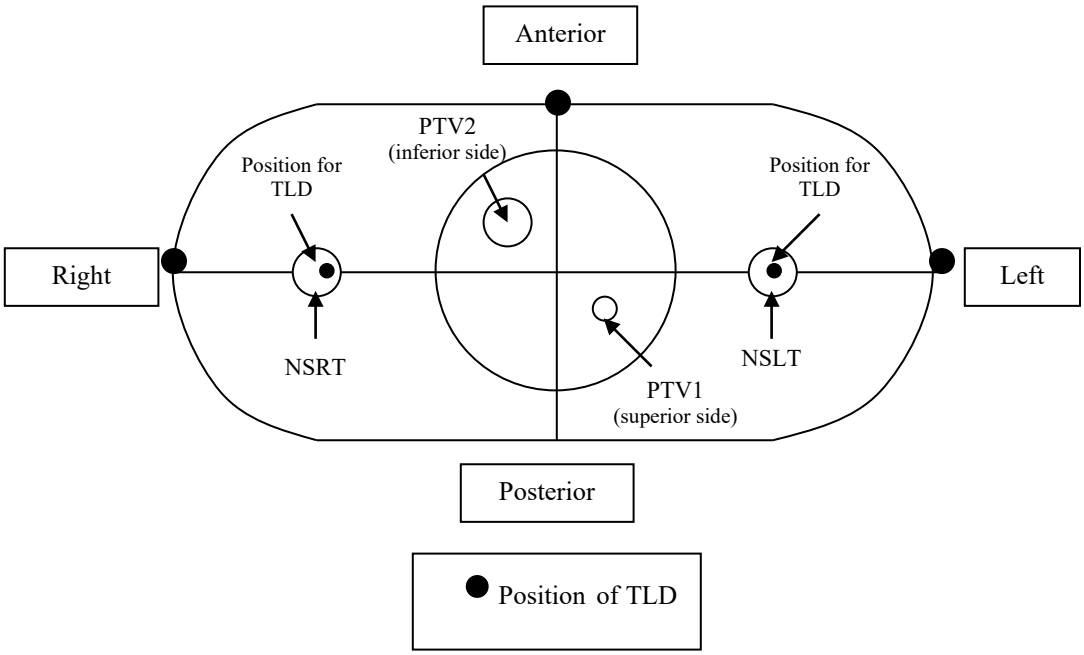
- DVHs shall be calculated for the liver (liver minus the GTV), each normal structure and each target lesions (CTV and PTV).

Critical Normal Structures:

- Constraints over the normal structures are specified in the following table

Normal structure	Volume	Dose
Normal structure	10%	≤ 1.2 Gy(RBE)
Normal liver	70%	≤ 1.2 Gy(RBE)

Cross sectional view of the phantom:



Notes:

- **You need to deliver 6 Gy (RBE) to each PTV (in 1 or more fractions).**
- **Please ignore all markings on the external shell of the phantom; use your own system to position the phantom.**

The phantom should be imaged, planned and irradiated as if it were an actual protocol patient, incorporating all of your customary quality assurance checks.

- Material included in box for the phantom:
  Liver Phantom, with 3 set of TLD capsules taped to the shell (2 on left side, 2 on right side and 2 on anterior side)
  Dosimetric insert
  Rubber hose
  Two acrylic rod containing TLD in one of the ends,
  Envelope with background film and TLD (hidden from your view; please don't try to find it)

- Material included in box for the reciprocating platform (If needed by institution):
  Motor driver
  Motor to platform linkage
  2D Reciprocating platform

If reciprocating platform is not used, skip points 6, 7, 9, 11, 17, 19, 23

Procedures:

1. Fill the phantom with water:
   - **1.1.** Thread the rubber hose into the filler hole placed on the base of the phantom.
   - **1.2.** Fill slowly with water (the rubber hose stretches over most faucets). There is a breathing hole on the phantom, make sure it is open, to allow the pressure to release. You may need to jiggle the phantom to release air trapped inside the cavity.
   - **1.3.** Remove hose and replace acrylic screw.
2. Allow the phantom to sit with water in it for 10 min. to check for leaks**.**
3. Look in the insert space and check for water leakage. If you find any water, call us at 713-745-8989. If not, proceed to the next step**.**
4. Position the insert. Make sure that the insert is in its correct position by making small rotations of the insert around its central axis. When it is in the correct position it will **lock** in place by an indentation at the base of the insert.
5. Position the acrylic rods in each one of the holes following the color code. Insert the side with the screw. You will see a TLD capsule in each one of the cavities closed with the screw**.**
6. Assemble the 2D reciprocating platform and motor drive system per the attached instructions. Assemble it on the CT couch so that the phantom and the platform can be imaged.
7. The motor driver for the platform will have been programmed to simulate the manner in which your institution instructs its patients to breathe during the 4D CT.
8. Position and CT the phantom as you would a patient. **You may wish to scan with 1.5 mm slices especially near the target to better identify the TLD capsules**. NOTE: There are TLD on the external shell of the phantom to give us an estimate of the CT dose to the target.
9. Turn on the motor drive and acquire your CT images for treatment planning. Turn off motor driver once CT process is completed. Disassemble the reciprocating platform.
10. Remove all inserts from the phantom during planning process. **REMOVE WATER FROM PHANTOM**. Store phantom and inserts in a dry place**.** Store insert and phantom where they will not be irradiate.
11. Segment the phantom images contouring the skin, liver (insert), normal structures, PTVs, and positioning rod. **Please see Treatment Planning Addendum for further instruction.** Note that the CTV = GTV. PTV = ITV + 0.4 cm (minimum). Also contour all the TLD volumes. Please use the following names for these contours:
    PTV1_TLD for the TLD within the PTV1,
    PTV2_TLD for the TLD within the PTV2,
    NSLT_TLD for the TLD within the normal structure on the left side
    NSRT_TLD for the TLD within the normal structure on the right side
    - The dimensions of the TLD volume are approximately 10 mm long by 2 mm diameter
    - The outside dimensions of the TLD capsules are 15 mm long by 4 mm diameter; the TLD axis is normal to the axial plane. (The capsules and the TLD should be visible on CT image – W/L may need to be adjusted)
12. Plan the treatment as specified in the DOSE PRESCRIPTION above.
13. Repeat steps 1 and 2.
14. Look in the insert space and check for water leakage. If you find any water call us at 713-745-8989. If not, follow the instructions in step 5 to position the insert again and proceed to the next step.
15. Perform your customary QA of the plan prior to irradiating the phantom.

16. Irradiate the TLD block according to the instructions provided.
17. Assemble the 2D reciprocating platform and motor drive system per the attached instructions. Assemble it on the treatment machine couch so that the phantom and the platform can be irradiated.
18. Position the phantom as you would a protocol patient. Try to avoid positioning the axial film at the abutment of adjacent MLC leaves or adjacent arcs. Abutting fields or leaves on the film may increase the uncertainty of the measurement.
19. Turn on the motor drive.
20. Perform all the verification needed to confirm the final position of the phantom.
21. **REMOVE THE TLD CAPSULES LOCATED ON THE EXTERNAL SHELL**. Put them into the designated container.
22. Irradiate the phantom with the developed plan.
23. Turn off the motor drive and put each part of the motion table into its shipping box.
24. Remove the insert and place it in the box.
25. Remove the acrylic rods from holes and place them in the box.
26. Please verify that there is no water in the insert space. If you find any water, call us at 713-745-8989.
27. Remove the screw on the base of the phantom and drain the water from the phantom.
28. Put all the material set in their boxes.
29. Make sure that the container with the external TLD's and the rubber hose are in the box.
30. Include the dosimetry data discussed above. Complete the attached forms. Be sure to include the scale used on the images coming from your TPS.
31. Return the complete package to the RQALab. Return labels were included.

Proton Liver Phantom Institution Information

Institution: _____

Address: _____

_____

Person performing irradiation: _____

Person to receive report: _____

Email address: _____

Phone Number: _____

Person to call in case of questions: _____

Phone Number: _____ Email address: _____

Treatment Unit:

Manufacturer: _____ Model: _____

In-house specification: _____

Proton Energy Nom _____(MeV) Range: _____ cm

1. For the phantom irradiation, technique used was (check one)
   - ☐ Pencil Beam Scanning (PBS) / IMPT (variable intensity pencil beam scanning).
   - ☐ Uniform Scanning.
   - ☐ Passive Scattering.

2. Collimation technique: ☐ Multileaf ☐ Solid Aperture

3. Range modulation technique:
   - ☐ Range modulator wheel ☐ Range shifters
   - ☐ Both RMW and shifters ☐ Other, please describe _____

4. Compensator technique:
   - ☐ Solid compensator / bolus ☐ Other, please describe _____

Please enclose original copies of your treatment plans. Include the coronal and sagittal planes through the target center. Include scaling factors for each plane.

Treatment Planning System:

Manufacturer: _____ Model:_____

Software:_____ Algorithm:_____ Version:_____

Treatment Planning Details:

For pencil beam scanning - was a range shifter or energy absorber used? □ No □ Yes _____

For pencil beam scanning - was repainting used? □ No □ Yes _____

If yes, #_____ layer repaintings #_____ volume repaintings

Number of isocenters for final plan (please check): □ One □ Two

Which target was irradiated first? □ PTV1 □ PTV2

Method to Account for Respiratory Induced Target Motion used for phantom (If applicable):

Please describe your method: □ Gating □ Breath hold □ MIP

_____

_____

_____

_____

Motion management system: _____

IGRT used for phantom setup: _____

Treatment of Phantom:

Date of Irradiation: _____

Dose specified is to: □ Muscle □ Water

and is: □ Physical □ Biological - RBE used is _____

Indicate the dose delivered to the TLD as determined by your treatment planning system

TLD	Mean Dose (cGy(RBE))
PTV1_TLD	
PTV2_TLD	
NSLT_TLD	
NSRT_TLD	

Results of QA:_____

_____

Did you adjust the MU based on these results? □ No □Yes If so, how much?_____

Attach copies of the treatment plan including slices in the sagittal, axial and coronal film planes.

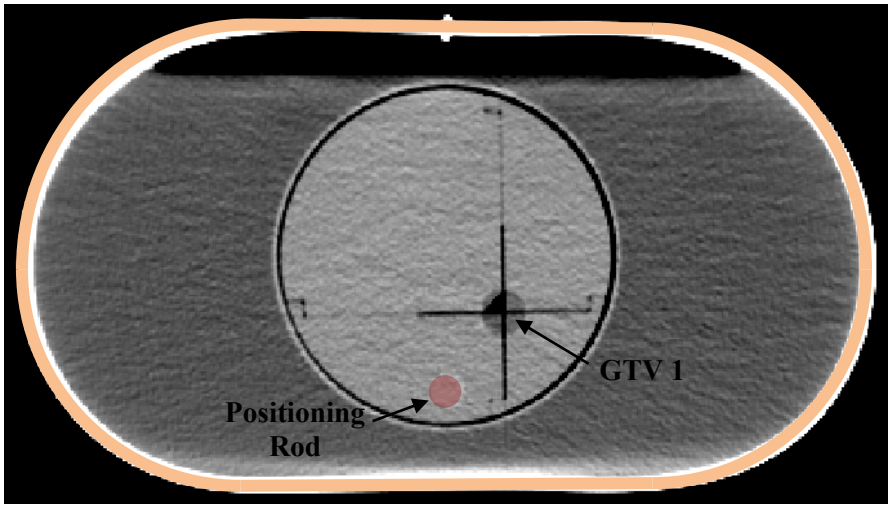
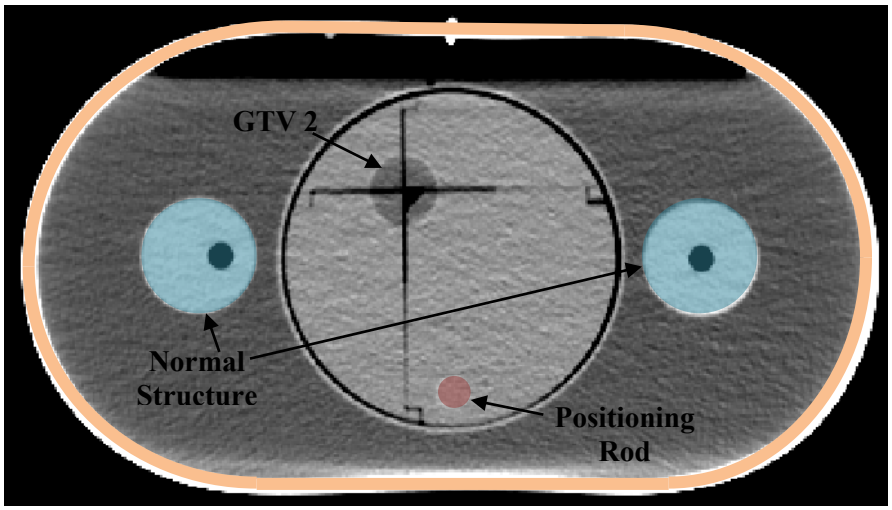
Comments: _____

_____

_____

For Office Use Only	TLD Batch	Film Batch	Phantom ID # **Proton PL-**	Code **Inst#**	Date Sent **NP**	Date Rec'd

Proton Treatment Planning Addendum

After following step 11 of the phantom Procedures and contouring the skin, normal structures, positioning rod, liver and PTVs, the relative stopping power of a few materials need to be overridden. The table below lists the measured relative stopping powers of each material within the liver phantom. You may need to override the structures if your planning system predicts a stopping power different from that listed in the table. Note that the positioning rod may not need to be overridden if the treatment beams are not passing through the material.

Material	Rel. SP
PVC - Skin	1.25
PBT – Normal Structures (NS)	1.21
Acrylic - Positioning rod	1.21