Alex Murray

Planning Assignment (3 field rectum)

Use a CT dataset of the pelvis. Create a CTV by contouring the rectum (start at the anus and stop at the turn where it meets the sigmoid colon). Expand this structure by 1 cm and label it PTV.

Create a PA field with the top border at the bottom of L5 and the bottom border 2 cm below the PTV. The lateral borders of the PA field should extend 1-2 cm beyond the pelvic inlet to include primary surrounding lymph nodes. Place the beam isocenter in the center of the PTV and use the lowest beam energy available (note: calculation point will be at isocenter).

Contour all critical structures (organs at risk) in the treatment area. List all organs at risk (OR) and desired objectives/dose limitations, in the table below:

Organ at risk	Desired objective(s)	Achieved objective(s)
Bladder	$V_{45\ Gy}$ < 40% D_{max} < 51 Gy	$V_{45\ Gy}$ = 38.07 % D_{max} = 47.002 Gy
Bowel	$V_{40\ Gy}$ < 30%	$V_{40\ Gy}$ = 9.50 %
Right Femoral Head	$V_{30\ Gy}$ < 25% $V_{40\ Gy}$ < 5%	$V_{30\ Gy}$ = 90.91 % $V_{40\ Gy}$ = 6.84 Gy
Left Femoral Head	$V_{30\ Gy}$ < 25% $V_{40\ Gy}$ < 5%	$V_{30\ Gy}$ = 92.70 % $V_{40\ Gy}$ = 10.78 %

a. Enter the prescription: 45 Gy at 1.8 /fx (95% of the prescribed dose to cover the PTV). Calculate the single PA beam. Evaluate the isodose distribution as it relates to CTV and PTV coverage. Also where is/are the hot spot(s)? Describe the isodose distribution, if a screen shot is helpful to show this, you may include it.

The isodose distribution has a slight curve downward in the middle of the field. With the beam entering only on the posterior of the patient there is a rather large area of 110% at the posterior and it is cooler near the anterior of the patient. With 100% normalization, 92.81% of the CTV is receiving 95% of the prescribed dose and 85.73% of the PTV is receiving 95% of the prescribed dose. The hot spot is located about 2 cm from the posterior surface of the patient and is 65.6 Gy, or 145.8% of the prescribed dose.

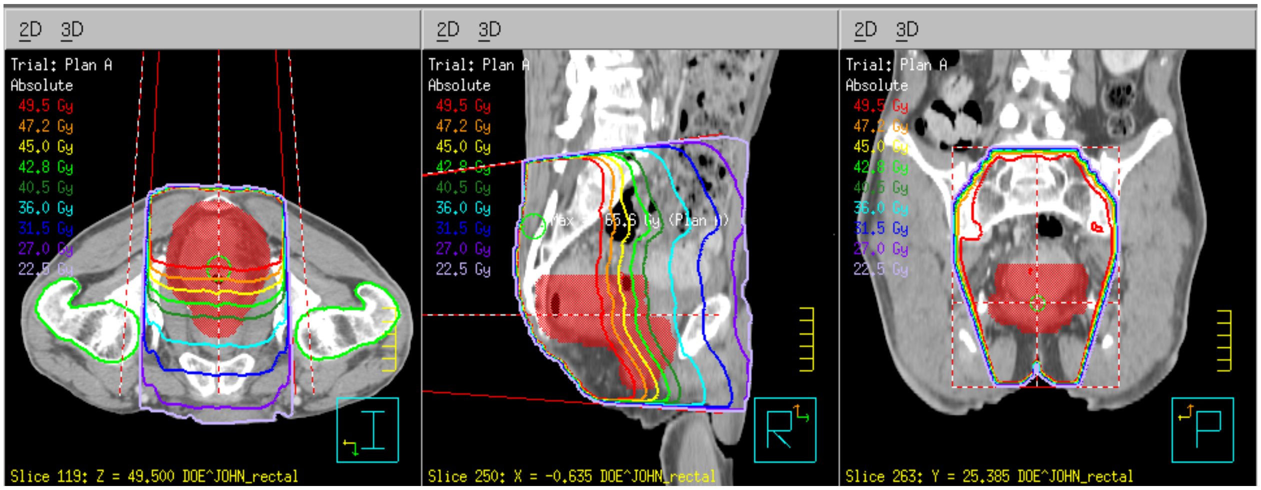


Image 1. Visualization of the isodose distribution of a single 6 MV PA field.

b. Change to a higher energy and calculate the beam. How did your isodose distribution change?

The isodose distribution has the same general shape as the lower energy beam, but the higher energy isodose lines fall deeper in comparison. The hot spot for the higher energy beam is lower at 60.2 Gy (133.8%) compared to the lower energy beam and is located 0.5 cm more anterior than the hot spot for the lower energy beam. Now, 93.21% of the CTV is covered by the 95% isodose line and 86.11% of the PTV is covered by the 95% isodose line.

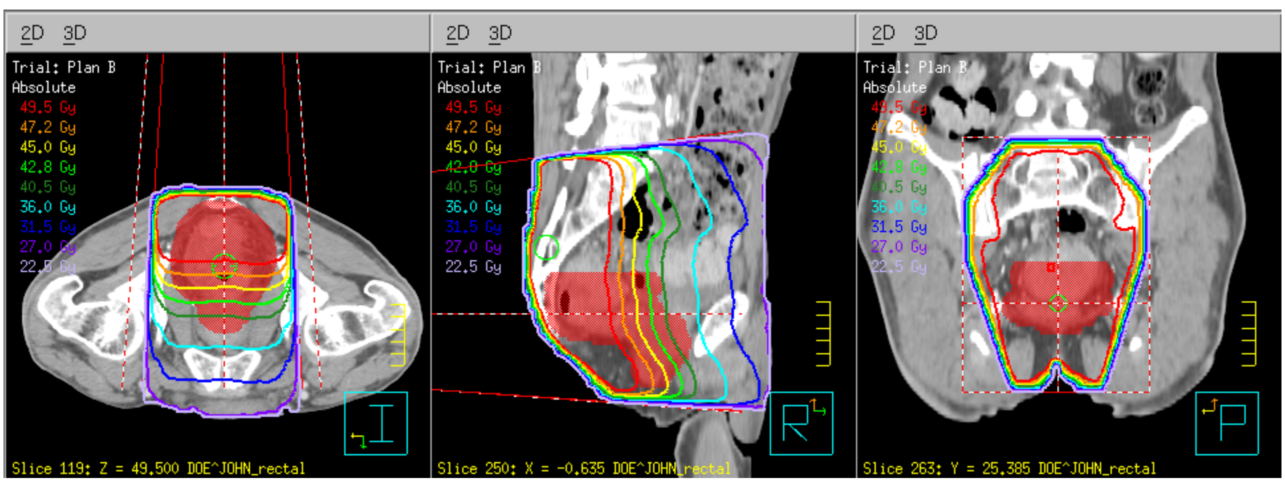


Image 2. Visualization of the isodose distribution of a single 10 MV PA field.

c. Insert a left lateral beam with a 1 cm margin around the ant and post wall of the PTV. Keep the superior and inferior borders of the lateral field the same as the PA beam. Copy and oppose the left lateral beam to create a right lateral field. Use the lowest beam energy available for all 3 fields. Calculate the dose and apply equal weighting to all 3 beams. Describe this dose distribution.

There is now dose laterally to the borders of the PA field, although it's a pretty low dose. The isodose lines fall deeper than the single PA field up until the anterior border of the lateral fields, where the dose falls off quickly, allowing the anterior aspect of the patient to receive less dose. The area of higher dose is smaller compared to the single PA field. The hot spot has increased to 61.2 Gy (136%) and has moved laterally about 2 cm and inferiorly about 5 cm. 93.61% of the CTV and 86.84% of the PTV are covered by the 95% isodose line.

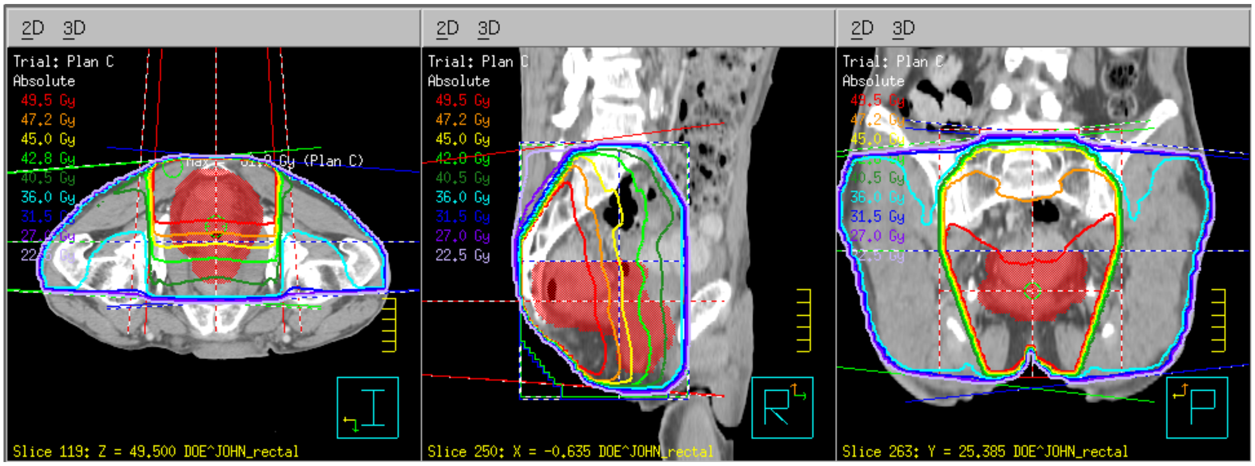


Image 3. Visualization of the isodose distribution of 3 field arrangement using 6 MV beam energies and equal weighting.

d. Change the 2 lateral fields to a higher energy and calculate. How did this change the dose distribution?

There is less dose laterally to the single PA field and the isodose lines themselves are flatter. The hot spot decreased to 58.1 Gy (129.1%) and is still in relatively the same location as the 3 field arrangement using 6 MV beam energies for all fields. 95.05% of the CTV and 88.49% of the PTV are covered by the 95% isodose line, which is higher compared to the previous plan.

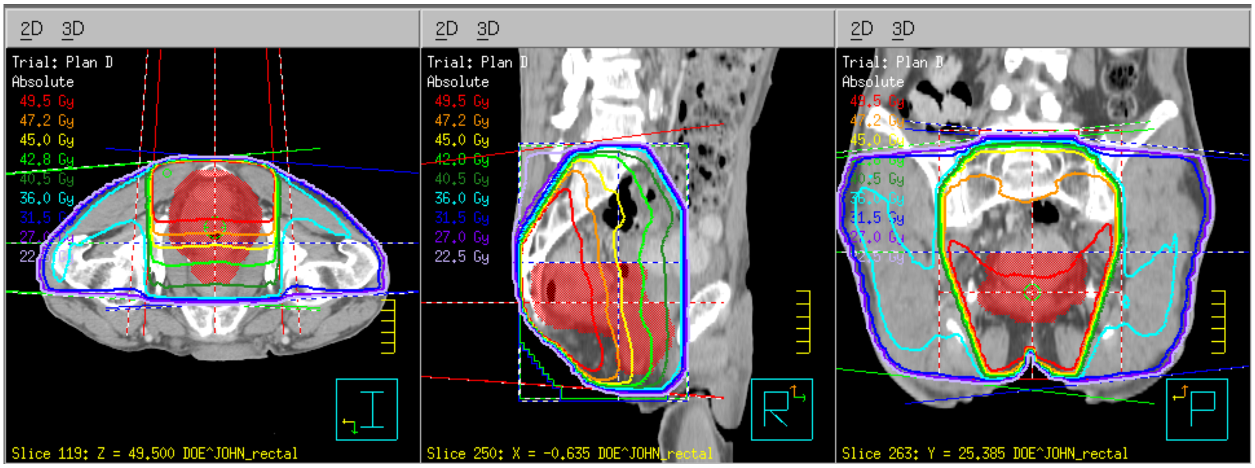


Image 4. Visualization of the isodose distribution of 3 field arrangement with 6 MV PA beam and 10 MV lateral beams.

e. Increase the energy of the PA beam and calculate. What change do you see?

The area of 36 Gy (light blue isodose line) laterally to the PA field got slightly smaller and the isodose lines fall just a little deeper. The hot spot decreased to 56.7 Gy (126%) and moved medially about 1 cm. Coverage of the 95% isodose line increased to 95.43% of the CTV and 89.14% of the PTV.

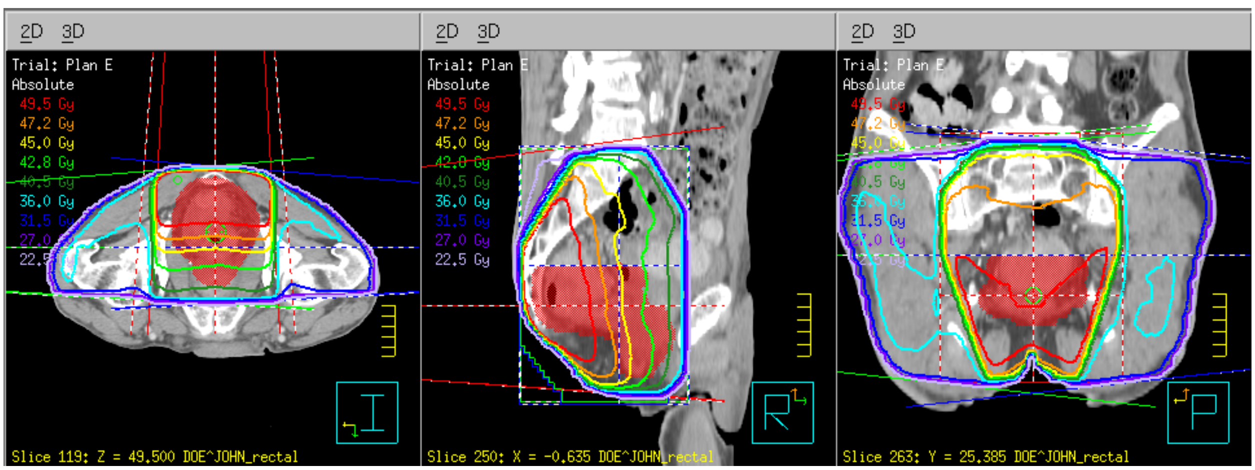


Image 5. Visualization of the isodose distribution of 3 field arrangement using 10 MV beam energies and equal weighting.

f. Add the lowest angle wedge to the two lateral beams. What direction did you place the wedge and why? How did it affect your isodose distribution? (To describe the wedge orientation you may draw a picture, provide a screen shot, or describe it in relation to the patient. (e.g., Heel towards anterior of patient, heel towards head of patient..)

I used 10 degree physical wedges and placed them such that the heel was towards the posterior of the patient which makes sense because the patient is thinnest posteriorly and I need to push the dose anteriorly or towards the toes

of the wedges. The hot spot decreased to 53.6 Gy (119.1%). The coverage of the 95% isodose line increased to 98.98% of the CTV and 95% of the PTV.

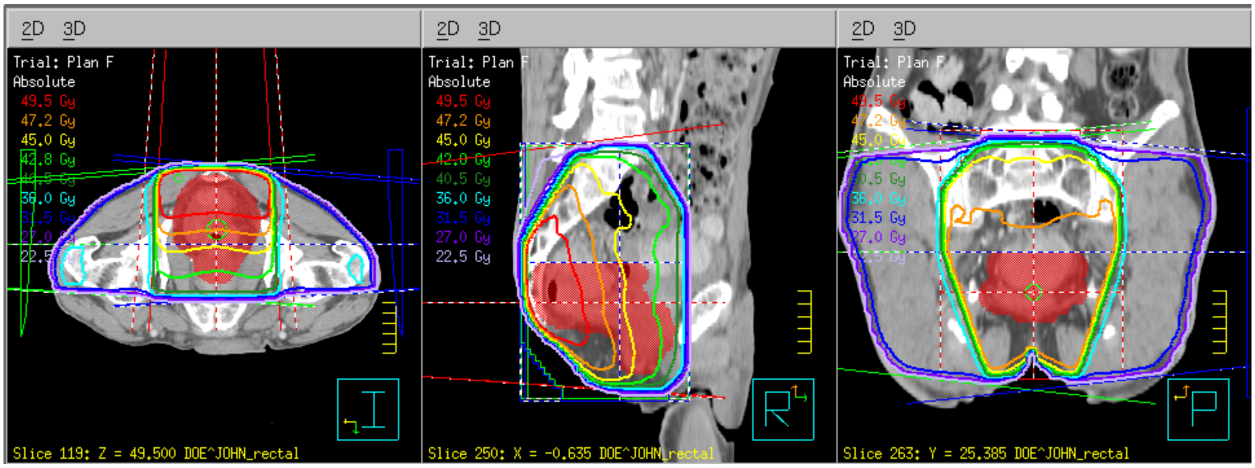


Image 6. Visualization of the isodose distribution of 3 field arrangement using 10 MV beam energies, equal weighting, and 15 degree wedges on the later fields.

g. Continue to add thicker wedges on both lateral beams and calculate for each wedge angle you try (when you replace a wedge on the left, replace it with the same wedge angle on the right). What wedge angles did you use and how did it affect the isodose distribution?

I used 30, 45, and 60 degree wedges.

30 degree: **The 30 degree wedges decreased the area of higher dose located posteriorly in the patient and pushed the isodose lines more anteriorly to the anterior boarder of the lateral fields. The hot spot decreased to 50.5 Gy (112.2%) and 95% isodose line coverage increased to 100% of the CTV and 98.27% of the PTV.**

45 degree: **When using 45 degree wedges, the area of 110% disappeared completely and the hot spot was decreased to 48.9 Gy (108.7%) and 100% of the CTV and PTV are covered by the 95% isodose line.**

60 degree: **When using 60 degree wedges, the dose is pushed so much anteriorly that there is a good sized area of 110% of the prescribed dose near the anterior boarders of the lateral fields and areas of higher dose laterally to the PA field. The hot spot is 51.7 Gy (114.9%) and is located at the anterior boarder of the lateral fields about 8.5 cm from the patient's right side.**

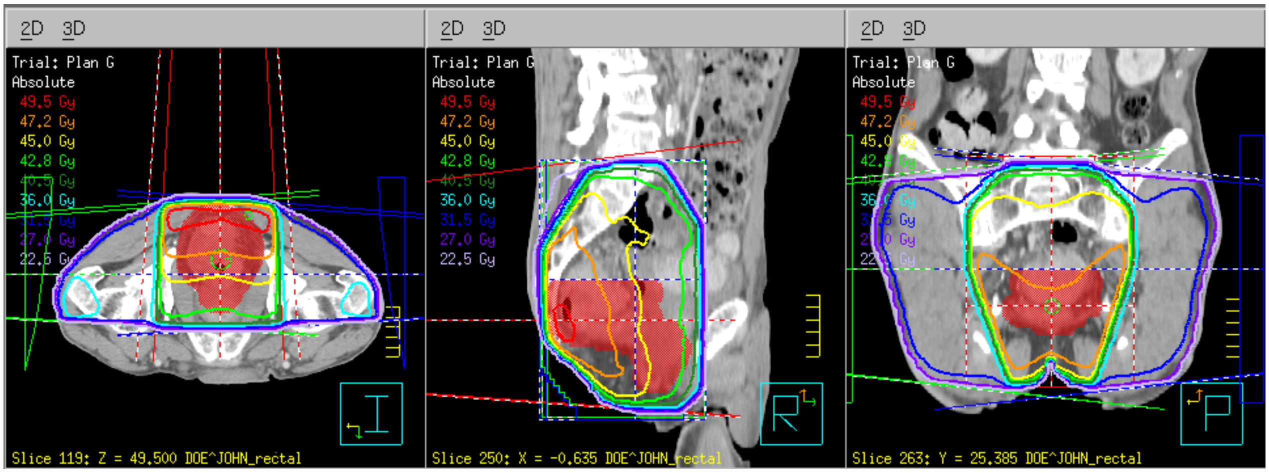


Image 7. Visualization of the isodose distribution of 3 field arrangement using 10 MV beam energies, equal weighting, and 30 degree wedges on the lateral fields.

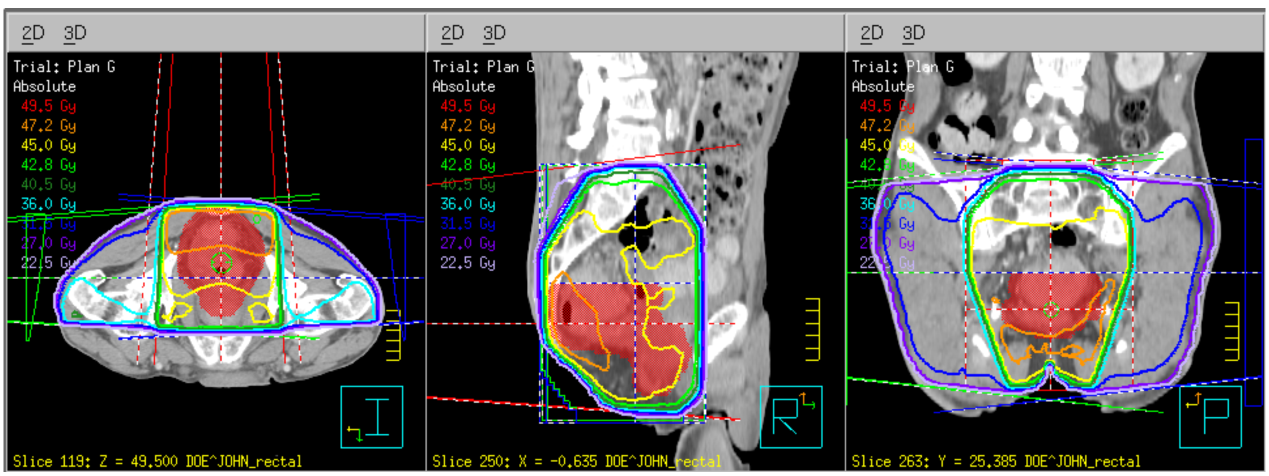


Image 8. Visualization of the isodose distribution of 3 field arrangement using 10 MV beam energies, equal weighting, and 45 degree wedges on the lateral fields.

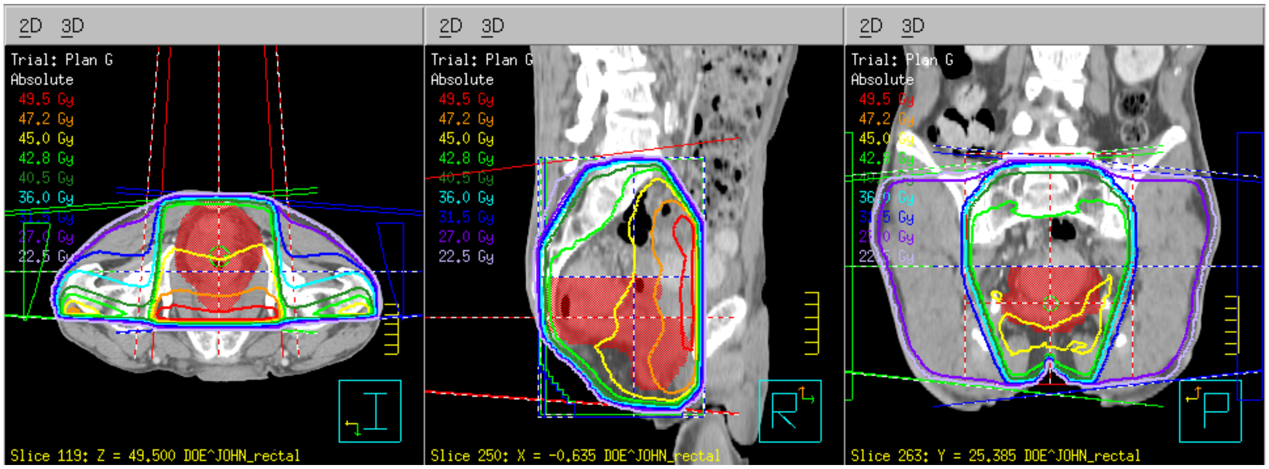


Image 9. Visualization of the isodose distribution of 3 field arrangement using 10 MV beam energies, equal weighting, and 60 degree wedges on the lateral fields.

h. Now that you have seen the effect of the different components, begin to adjust the weighting of the fields. At this point determine which energy you want to use for each of the fields. If wedges will be used, determine which wedge angle you like and the final weighting for each of the 3 fields. Don't forget to evaluate this in every slice throughout your planning volume. Discuss your plan with your preceptor and adjust it based on their input. Explain how you arrived at your final plan.

For my final plan I decided on using 10 MV beam energy for all 3 fields because of the patient's large separation and use 45 degree wedges on both lateral fields with the heel to the posterior of the patient. When evaluating all of the different wedges in section g of this lab it was demonstrated that 45 degree wedges pushed the dose more anteriorly to increase the PTV coverage of the 95% isodose line and decreased the area of higher dose located posteriorly in the patient. I had to weight the beams slightly to achieve a more uniform dose distribution. I weighted the PA 31.5%, the right lateral 34.61% and the left lateral 33.89%. Because we typically like to see the 100% isodose line covering 95% of the PTV at this facility, I normalized to 99.3% to increase PTV coverage of the 100% isodose line to 97.03%. We just recently commissioned a new Varian TrueBeam treatment machine that has 15 MV beam energy available. Unfortunately, the training institution does not have 15 MV available. Ideally, I would have used 15 MV in this case to further decrease the area of high dose and decrease the hot spot.

i. In addition to the answers to each of the questions in this assignment, turn in a copy of your final plan with the isodose distributions in the axial, sagittal and coronal views. Include a final DVH.

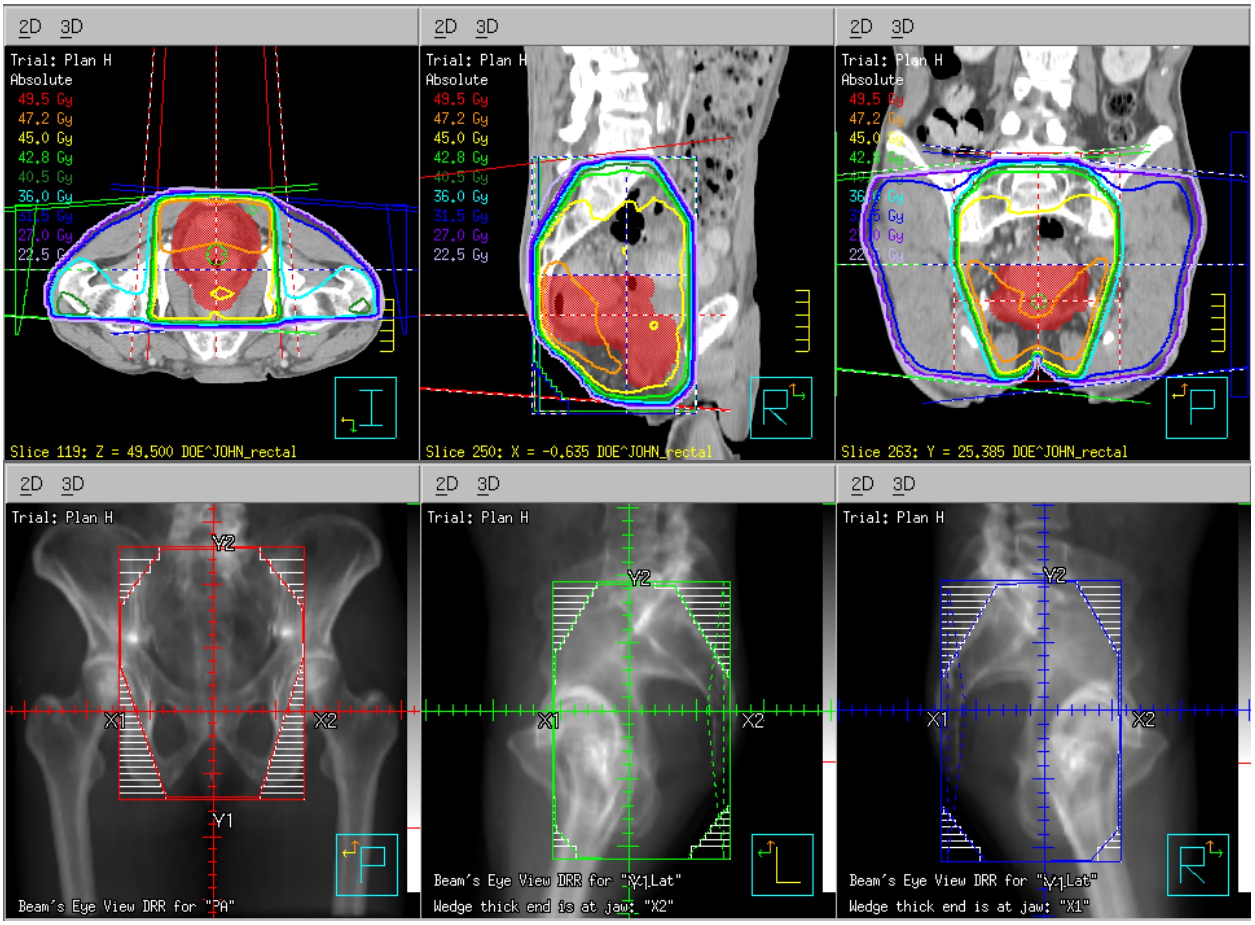
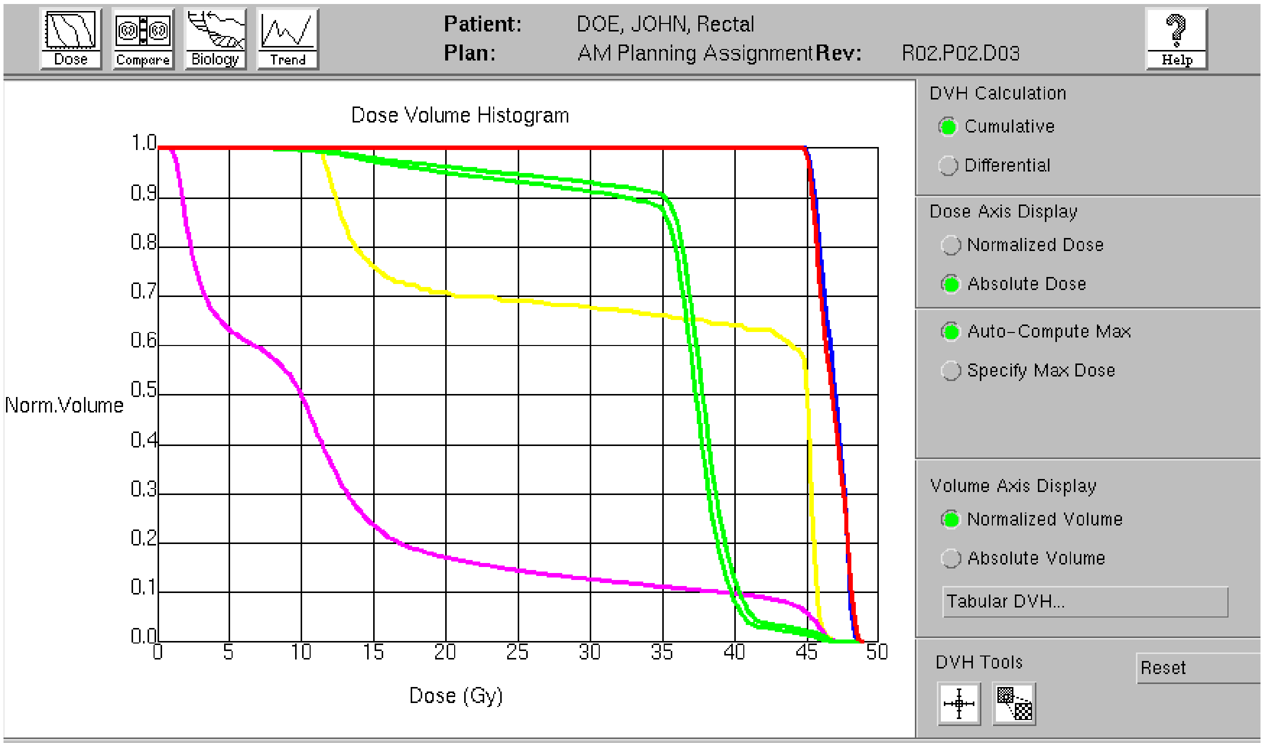


Image 10. Isodose distribution and blocks for final 3 field plan.



ROI Statistics Compute

Line Type	ROI	Trial or Record	Min.	Max.	Mean	Std. Dev.	% Outside Grid	% > Max	Generalized EUD
yellow	Bladder	Plan H	10.858	47.002	34.838	14.469	0.00 %	0.00 %	--
magenta	Bowel	Plan H	0.168	46.923	12.606	12.638	0.00 %	0.00 %	--
blue	CTV	Plan H	44.809	48.495	46.877	0.926	0.00 %	0.00 %	--
green	Femur_L	Plan H	5.794	46.834	36.783	5.598	0.00 %	0.00 %	--
green	Femur_R	Plan H	5.556	46.469	35.977	6.027	0.00 %	0.00 %	--
red	PTV	Plan H	43.119	48.781	46.762	1.021	0.00 %	0.00 %	--

Image 11. DVH of final 3 field plan.

4 field pelvis

Using the final 3 field rectum plan, copy and oppose the PA field to create an AP field. Keep the lateral field arrangement. Remove any wedges that may have been used. Calculate the four fields and weight them equally. How does this change the isodose distribution? What do you see as possible advantages or potential disadvantages of adding the fourth field?

> **There is less dose laterally to the PA beam and the 95% isodose line fills the rectangular area where the 4 beams intersect. Some advantages of adding a fourth field is that it takes some of the weight off of the lateral beams which, in turn, lowers**

the dose to the femurs. The constraint for the right femur is V40 Gy < 5%. For the 4 field plan, the V_{40} is 0.11%, which falls well within the desired constraint. For the 3 field plan, the V_{40} is 6.84%, which is not meeting the constraint. Another advantage to adding a fourth beam is that it decreases area of high dose located at the posterior of the patient. The fourth beam also pulls the isodose lines down to cover more of the PTV. 100% of the PTV is covered by the 95% isodose line. Disadvantages of adding a fourth beam is that the bladder and bowel are now being treated through and receive more dose compared to a 3 field beam arrangement. In the 3 field plan there is no 22.5 Gy (light purple) isodose line that goes past the anterior boarders of the lateral fields, compared to the 4 field plan which has the 22.5 Gy isodose line falling through the anterior portion of the patient.

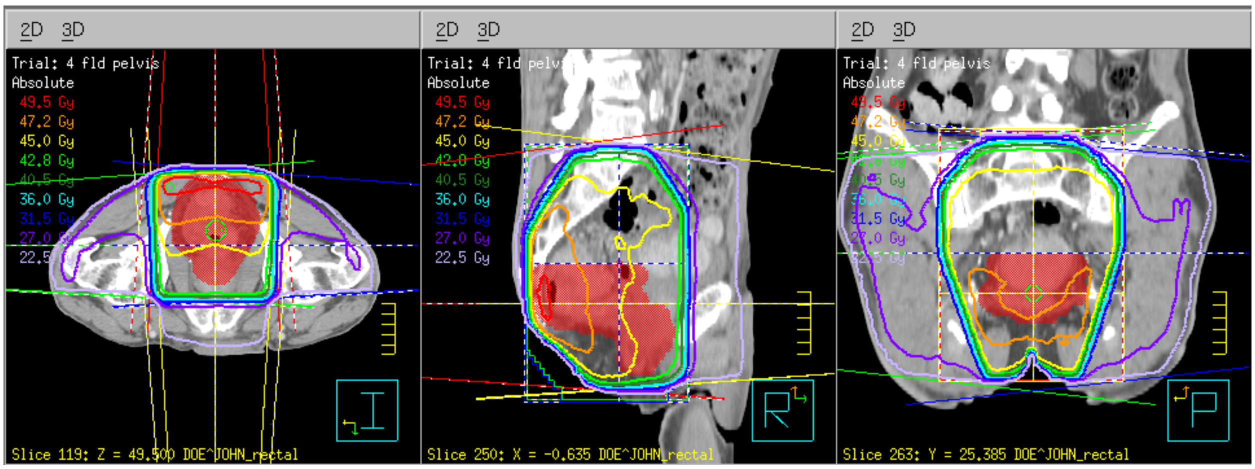
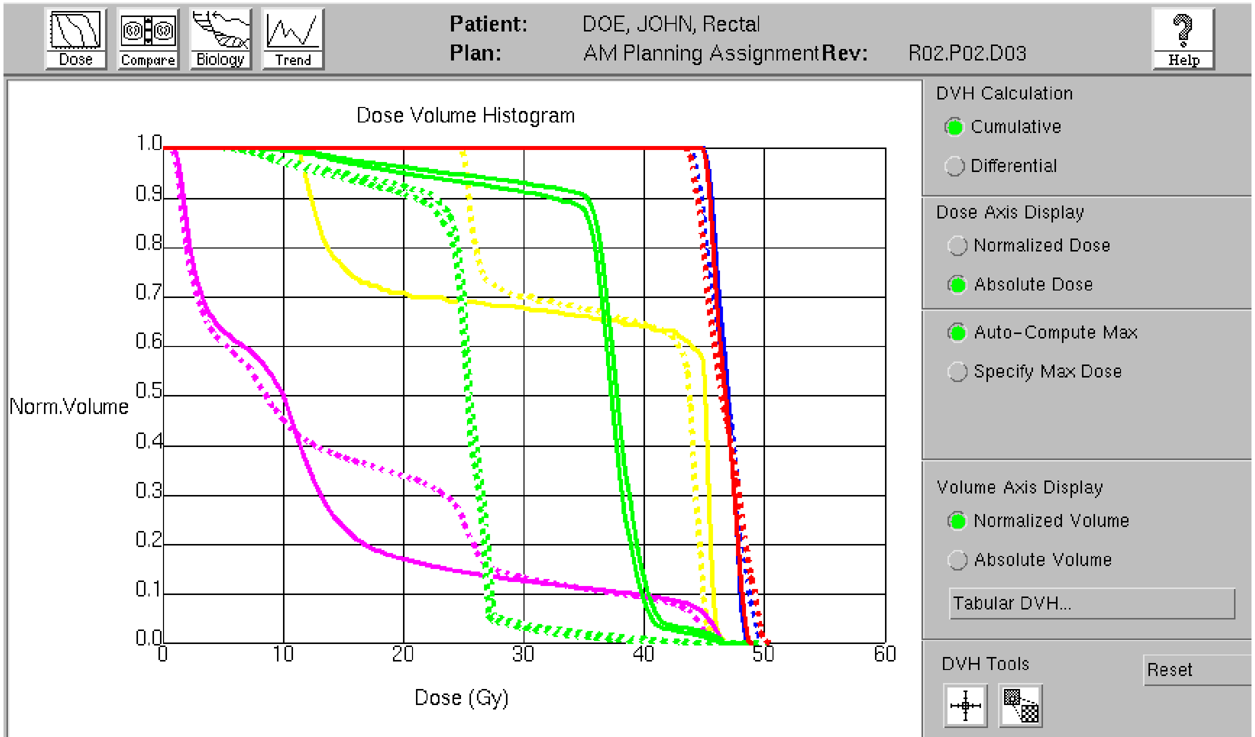


Image 12. Visualization of the isodose distribution of 4 field arrangement using 10 MV beam energies and equal weighting.



ROI Statistics

Compute

Line Type	ROI	Trial or Record	Min.	Max.	Mean	Std. Dev.	% Outside Grid	% > Max	Generalized EUD
solid yellow	Bladder	Plan H	10.858	47.002	34.838	14.469	0.00 %	0.00 %	--
dotted magenta	Bowel	4 fld pelvis	0.205	45.833	14.167	13.688	0.00 %	0.00 %	--
solid magenta	Bowel	Plan H	0.168	46.923	12.606	12.838	0.00 %	0.00 %	--
dotted blue	CTV	4 fld pelvis	43.791	49.881	46.754	1.537	0.00 %	0.00 %	--
solid blue	CTV	Plan H	44.809	48.495	46.877	0.926	0.00 %	0.00 %	--
dotted green	Femur_L	4 fld pelvis	4.025	43.629	25.040	4.453	0.00 %	0.00 %	--
solid green	Femur_L	Plan H	5.794	46.834	36.783	5.598	0.00 %	0.00 %	--
dotted green	Femur_R	4 fld pelvis	3.847	42.975	24.457	4.533	0.00 %	0.00 %	--
solid green	Femur_R	Plan H	5.556	46.469	35.977	6.027	0.00 %	0.00 %	--
dotted red	PTV	4 fld pelvis	43.186	50.288	46.621	1.750	0.00 %	0.00 %	--
solid red	PTV	Plan H	43.119	48.781	46.762	1.021	0.00 %	0.00 %	--

Image 13. DVH comparing final 3 field plan to 4 field plan. The solid lines are the 3 field plan and the dashed lines are the 4 field plan.