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March Case Study

March 29, 2012

Left Chest Wall and Supraclavicular Irradiation Using Photon and Electron Energies

History of Present Illness: RC is 46 year-old Pakistani woman who presented to her primary care physician in early March 2011 with an abnormal appearing left breast. Following physical examination of the breast, the physician scheduled the patient to have a mammogram on March 22, 2011. The mammogram results revealed a Breast Imaging-Reporting and Data System (BI-RADS) category 4 mass, accompanied by peau d' orange changes in the skin. BI-RADS is a quality assurance tool designed to standardize mammography reporting, reduce confusion in breast imaging interpretations, and facilitate outcome monitoring. The category 4 rating suggested a suspicious abnormality (2-95% malignant) that should be considered for biopsy.[1] Peau d' orange refers to a swollen, pitted appearance of the skin similar in appearance to the skin of an orange. Tumor infiltrates or obstructs the lymphatic drainage of the breast and breast skin causing edema of the breast.[2] It was noted that RC had several nodes present at time of mammogram and was scheduled to undergo a biopsy later that same day. The biopsy revealed invasive lobular carcinoma of the left breast and axilla. The patient had a Magnetic Resonance Imaging (MRI) of both breasts on March 22, 2011 and later a Positron Emission Tomography (PET) Scan on April 12, 2011 both of which did not demonstrate distant metastasis. Following diagnostic workup, the patient was staged as T4d N1 M0 inflammatory, estrogen receptor positive (ER+), progesterone receptor (PR+) breast cancer. The patient was subsequently referred to medical oncology for adjuvant chemotherapy consisting of dose dense Adriamycin and cyclophosphamide followed by 4 cycles of Taxol, to which she had a partial response. While undergoing chemotherapy she had a Computed Tomography (CT) scan of the chest, abdomen, and pelvis on July 30 and a bone scan on Aug 3, 2011, both demonstrating no evidence of metastasis.

On November 10, 2011, RC underwent a modified radical mastectomy of the left breast. The breast contained multifocal residual disease with at least 5 separate foci of disease, the largest measuring 3.8 cm in size with 15 lymph nodes removed, 13 of which contained tumor. The clinical pathology showed evidence of extra capsular extension, grade 2, with closest margin more than a centimeter resulting in a pathological stage of T_2 and 3A. RC has been referred to radiation oncology to discuss adjuvant radiotherapy to the left chest wall and regional lymph nodes.

Past Medical History: The patient has a history of hypertension and reflux disease, both of which are controlled be medication. Since her mastectomy in November 2011, the patient has been experiencing discomfort, pain and a pulling sensation when attempting to abduct her left arm. She has been prescribed pain medication which assists with the discomfort.

Family/Social History: RC is married and has three children. She speaks very little English and relies on her family to interpret for her. At time of consultation, Google translator was used in the exam room as a method of translating from English to Urdu. The patient has three brothers and two sisters. One of her brothers has a smoking history and has been diagnosed with lung cancer. She denies any use of tobacco, alcohol or drug use.

Medications and Allergies: RC currently takes atenol to control hypertension, Prilosec® for gastrointestinal issues and tamoxifen as part of her breast cancer drug regimen. She also takes Percocet® for pain, and a stool softener when needed. She states that she is allergic to morphine.

Diagnostic Imaging: RC was scheduled for a bilateral mammogram on March 22, 2011. During the mammogram, the radiologist noted erythema and peau d' orange changes in the outer quadrant skin of the left breast and elected to perform and ultrasound. The ultrasound showed skin thickening and edema involving the lower inner and outer quadrants of the breast. Multiple lymph nodes were also present in the left axilla with the largest measuring 1.0 x 0.8 cm. Both areas were scheduled for an ultrasound guided biopsy for pathological review. The patient's continued diagnostic workup included an MRI scan on March 25, 2011 and a PET scan on April 12, 2011. Both scans supported the current finding of masses in the left breast and axilla, while subsequently ruling out distant metastasis beyond the left axilla.

Oncologist Recommendations: The radiation oncologist reviewed the current findings with the patient and her husband, who aided in translating for the patient, and offered a post-operative course of radiation to the left chest wall and axilla. The treatment fractionation was 2 Gy/fraction for 25 fractions for a total dose of 50 Gy to the entire chest wall and axilla, with a 10 Gy electron boost in 5 fractions for a total dose of 60 Gy. The patient and her husband were in agreement with the radiation oncologist's recommendation and were given an appointment time to return for simulation.

Simulation: The radiation therapist explained the simulation process to the patient and her husband, who translated the process. The patient was then positioned on the AccuFix™ Quest™Carbon Fiber Breast Board (Figure 1) with her left arm raised and a leg roll was placed under her knees for additional

comfort. Wires were placed at the medial and lateral borders of the chest wall and on the surgical scar (Figure 2) to assist with field delineation during planning. A scan was obtained using a Philips Big Bore multi-slice CT unit. The scanned area included the upper neck to the mid abdomen, utilizing a scan slice thickness of 3mm. The chest wall and supraclavicular isocenters were placed by the radiation therapist per the radiation oncologist's written instructions and the scan data was sent to dosimetry for treatment planning. The patient was tattooed and given an appointment to return to begin treatment.

Treatment Planning: The CT dataset was sent to dosimetry and imported into the Philips ADAC Pinnacle treatment planning system. The lungs, heart, and cervical spinal cord were contoured by the dosimetrists and the resident radiation oncologist contoured the internal mammary nodes (IMN). All contours were review by the attending radiation oncologist. The dosimetrists also contoured the wires placed during simulation so that densities could be overridden to that of air for treatment planning. The radiation oncologist wished to treat the chest wall with extended tangents fields and the axillary and supraclavicular nodes with a supraclavicular field. The supraclavicular field was designed by the medical dosimetrist with a 340° gantry angle, inferior border slightly superior to the level of the left clavicular head, medial border at the left lateral edge of the cervical vertebral bodies and lateral border bisecting the left femoral head. A medial block was added to diminish scatter to the spinal cord and a lateral superior corner block added to protect soft tissue. The oncologist extended the lateral border to better cover the at risk lymph nodes and adjusted the superior corner block. The dosimetrists then constructed the requested extended tangent fields, but upon review of these fields the physician disapproved of the amount of lung, heart and contralateral breast present. It was then suggested by the medical dosimetrist that steep tangent fields with adjacent photon-electron mixed would offer acceptable coverage of the IM nodes while limiting the dose to the underlying lung and heart structures (Figures 3 and 4). Steep tangent fields were constructed with a medial gantry angle of 325° and a lateral tangent angle of 145°. The couch and collimator angles of both fields were set to match the inferior border of the supraclavicular field and the slope of the patient's chest wall. Blocks were also added to the medial and lateral tangent fields to shield the heart and left lung. The supraclavicular field was calculated to a point 2cm superior and 4cm lateral to the central axis (CAX) for a daily dose of 2Gy/fraction for 25 fractions totaling 50Gy (Figure 5). The tangent fields were optimized using step-and-shoot segments (Figures 7 and 8) with 0.5cm bolus over the chest wall to achieve a conformal dose distribution. Given the patient's diagnosis of inflammatory breast cancer, the physician requested that 0.5cm bolus be used daily for treatments delivering a dose of 2Gy/fraction for 25 fractions totaling 50Gy (Figure 5). The use of bolus, a tissue equivalent material, is necessary to provide adequate dose buildup to the skin surface. [3]

The internal mammary dose distribution was achieved by using an 80% electron, 20% photon beam mix (Figure 6). Often a single electron beam can offer adequate coverage of the IM nodes, but given the thickness of the patient's chestwall dual electron energies of 12 MeV and 16 MeV were needed to cover the nodes and limit the dose to the heart and lung. The electron fields abutted the medial border of the medial tangent field on the skin surface, but were given an angle of 330° that caused a mismatch at depth (Figure 9). The mismatch of field edges at depth aided in minimizing the increased dose caused by the ballooning of the lower electron isodose lines into the adjacent photon field. The constricting of the higher electron isodose lines caused a cold spot superficially necessitating the use of a photon field. A 6MV photon field was added with a gantry angle of 340° and overlapped into the medial tangent photon field by 8mm (Figures 10 and 11). The chosen gantry angle beam overlap increased uniform dose distribution in this area as well as at depth and simultaneously decreased the dose at the skin surface. The physician requested bolus to be added daily to the photon IM field in an effort to increase skin dose given the patient's pathology. Once all treatment fields were combined to show a composite dose distribution, the dosimetrist evaluated the plan and added/adjusted step and shoot segment in an effort to compensate for internal scatter. The radiation oncologist reviewed and approved the final 50 Gy composite plan and associated dose volume histogram (Figures 12 and 13). Clinical electron boost fields were setup after 50Gy was delivered to the chest wall (Figure 14). The fields encompassed the patient's scar and chest wall defect and delivered an additional 10Gy with 9MeV electron for a dose totaling 60Gy to the chest wall.

All treatment plans were checked by a physicist for accuracy. The physicist's second check utilized a spreadsheet program that was expected to agree with ADAC Pinnacle plan within 3%. Each field received an independent second check (Figures 15-19).

Conclusion: Simultaneous treatment of superficial and deep areas of interest can pose problems not easily remedied by the use of a single energy. This case study was chosen to highlight the advantages that mixed energy treatment planning can have when trying to avoid certain structures and adequately cover others. The addition of bolus aided in the shifting of isodose curves to the skin surface to treat the skin of the chest wall. It was expected that the patient would have an increased skin reaction and when this occurred, bolus was used for treatment three times per week (Monday, Wednesday and Friday) as opposed to daily. The patient's skin reaction eventually progressed to moist desquamation and required skin care from the nursing staff. This continued beyond the completion of treatment until care was no longer required.

Figure 1: Affix ™ QFix™ Breast Board.

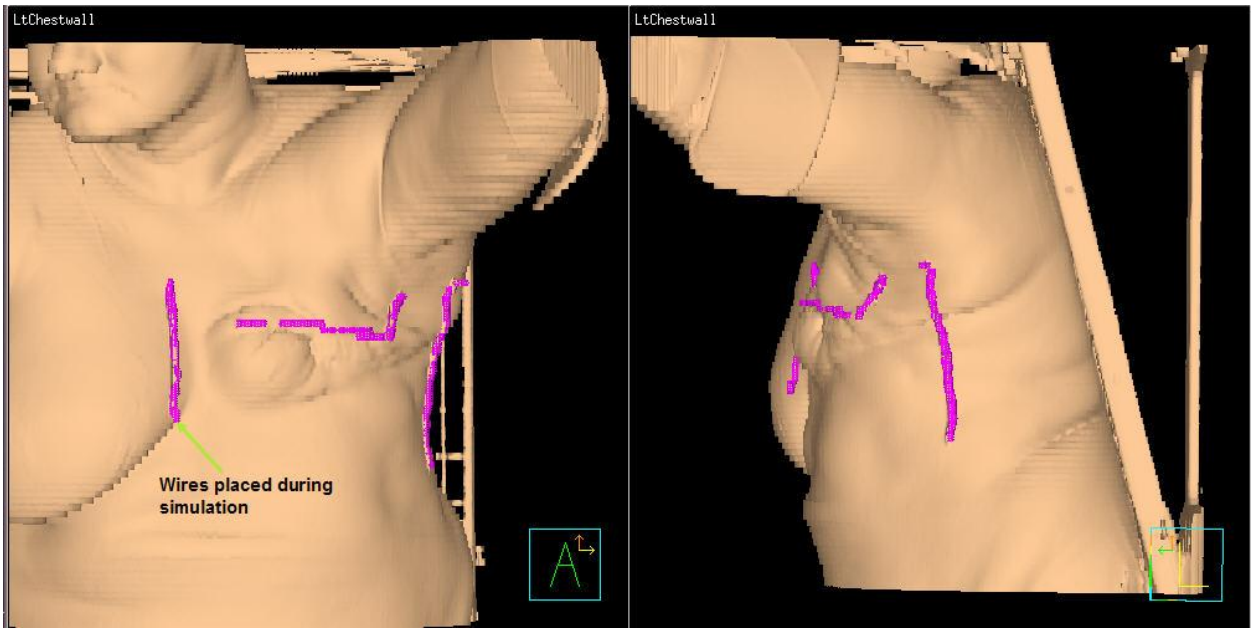


Figure 2: Patient positioned on breast board with wires.

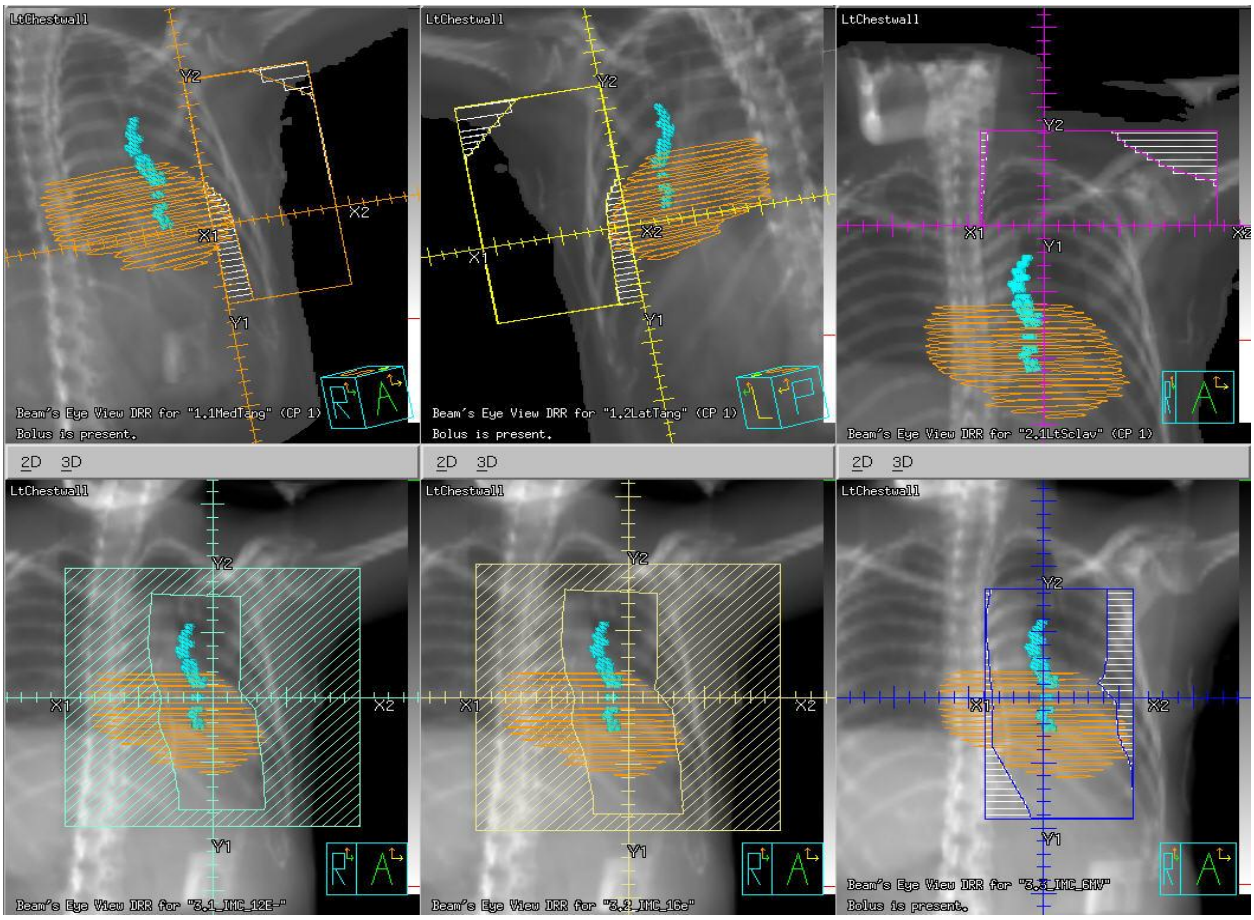


Figure 3: Physician approved treatment fields with IM nodes and heart contours.

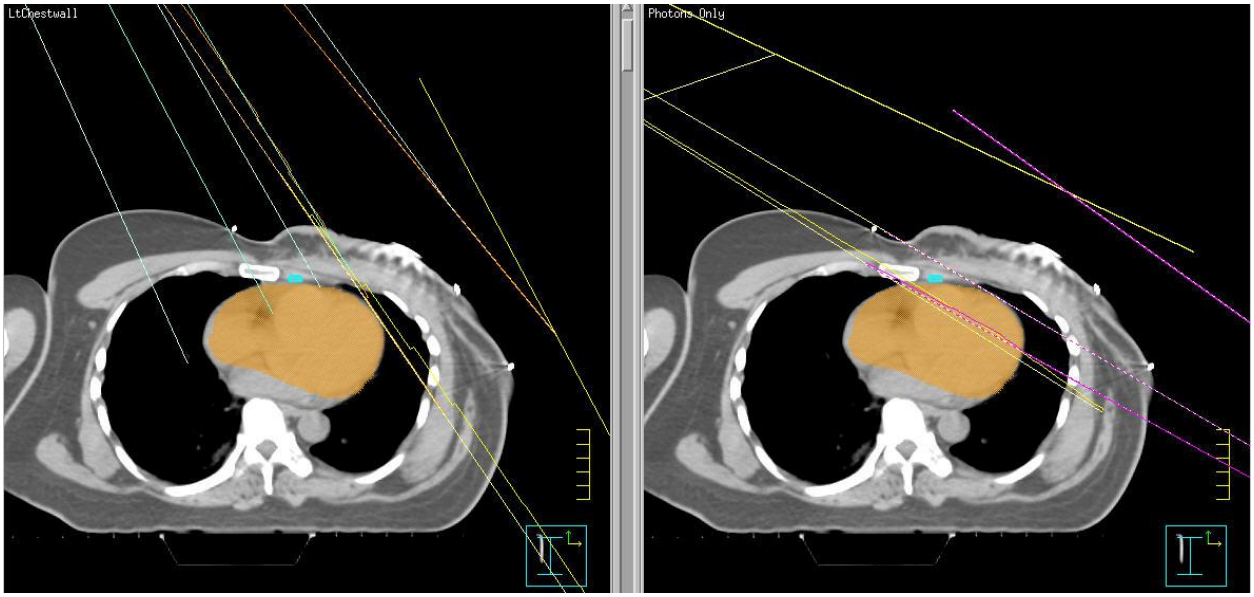


Figure 4: Comparison of steep tangent field with abutting electron fields versus extended tangent fields.

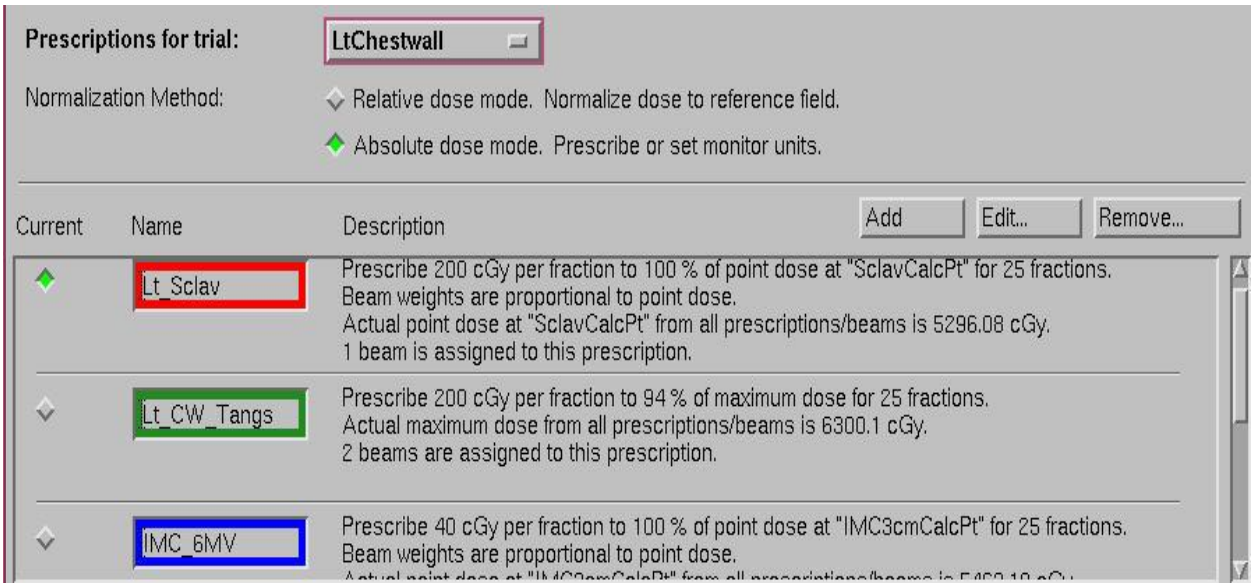


Figure 5: Prescription for left supraclavicular and tangent fields.

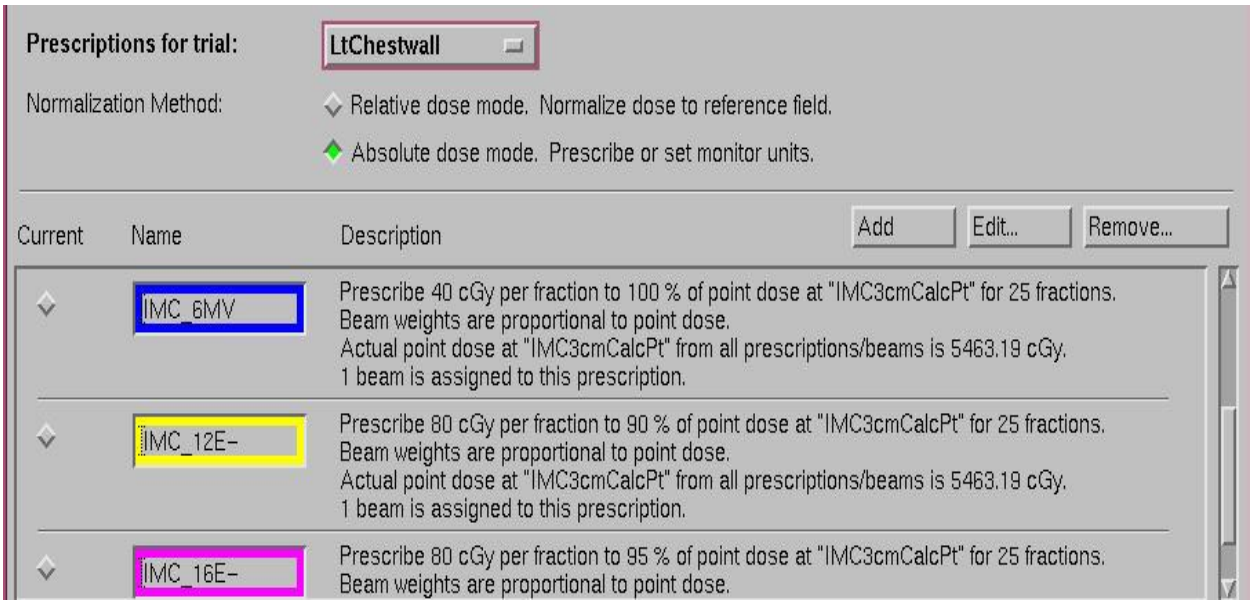


Figure 6: Prescriptions for electron and photon IM nodal fields.

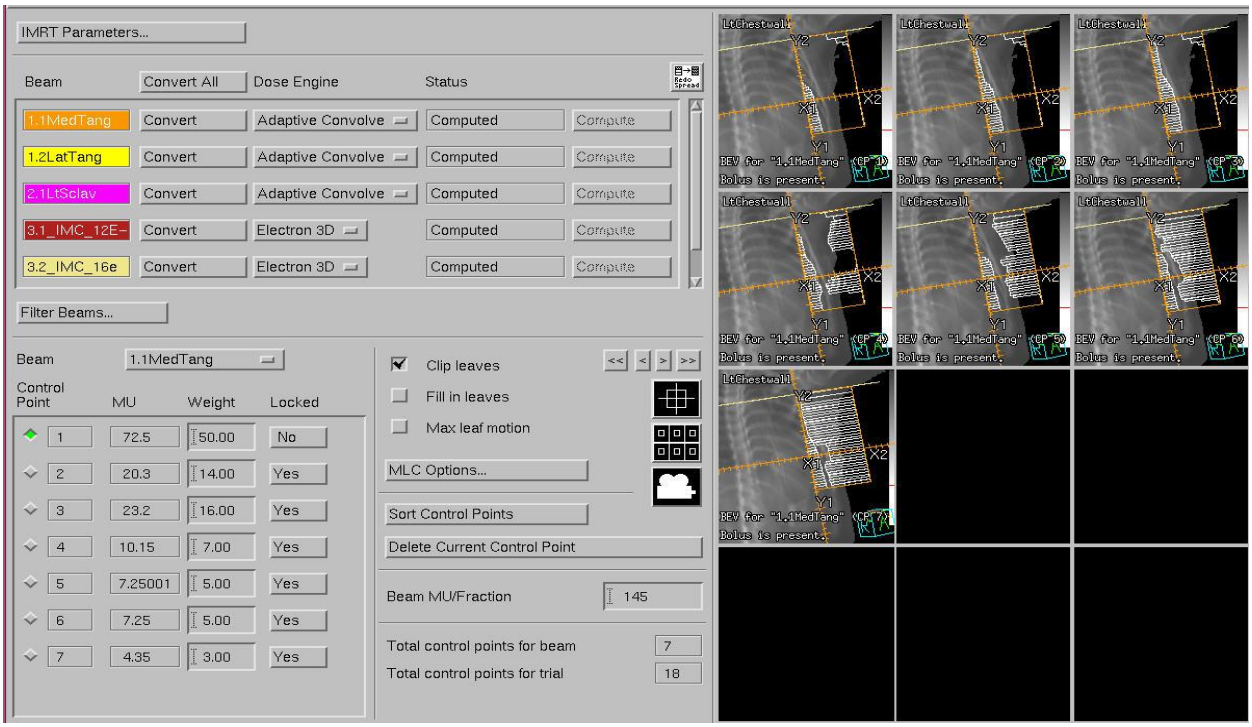


Figure 7: Step and Shoot segments for medial chest wall tangent.

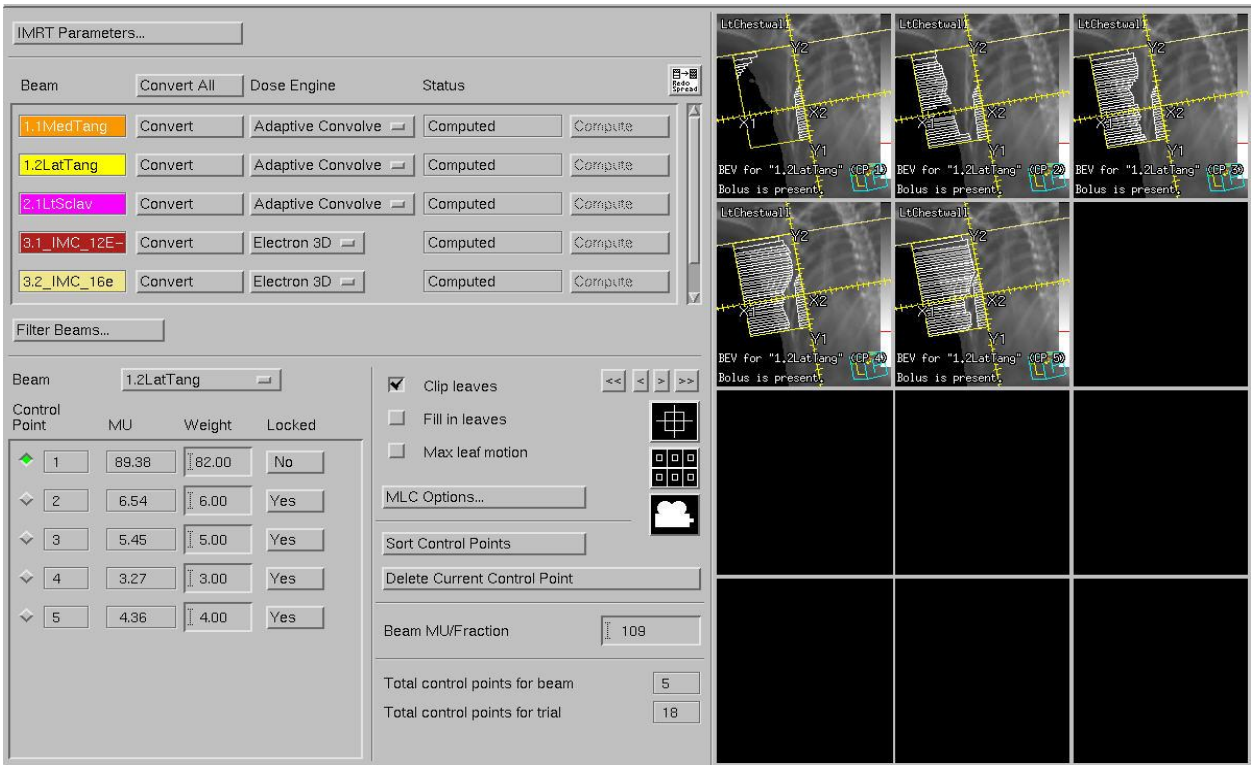


Figure 8: Step and shoot segments for lateral tangent chest wall.

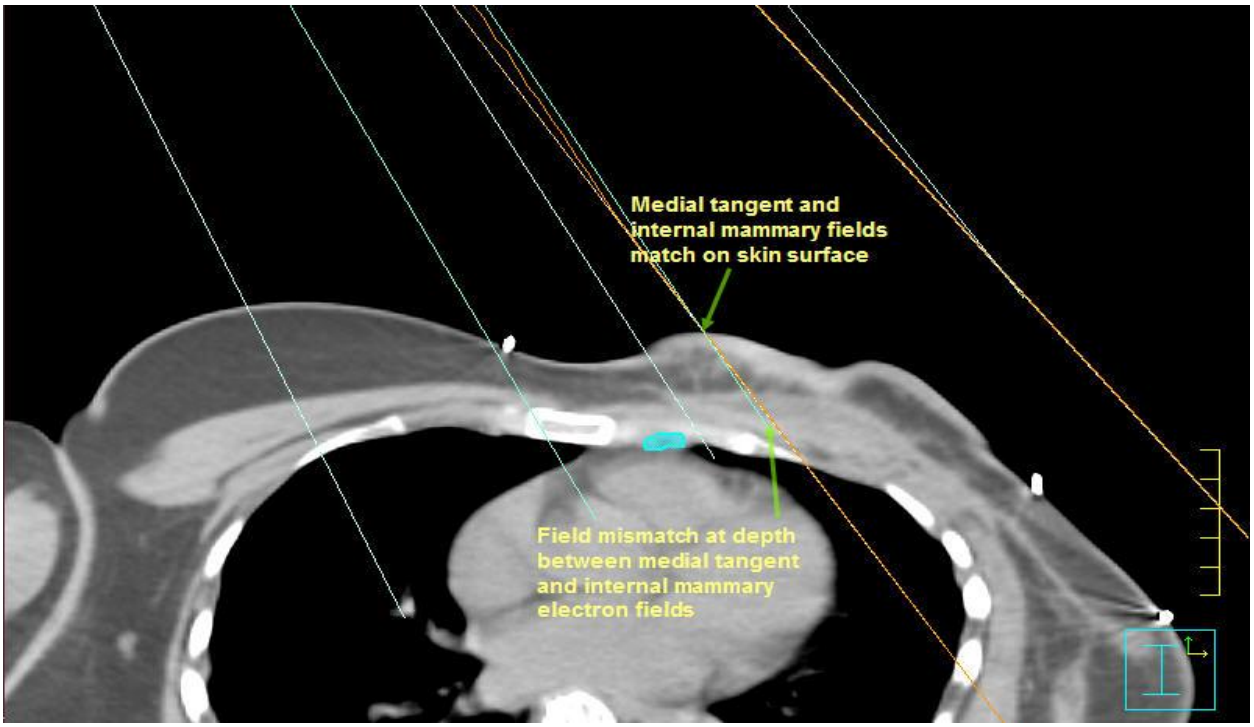


Figure 9: Abutment of IM electron fields and medial tangent field.

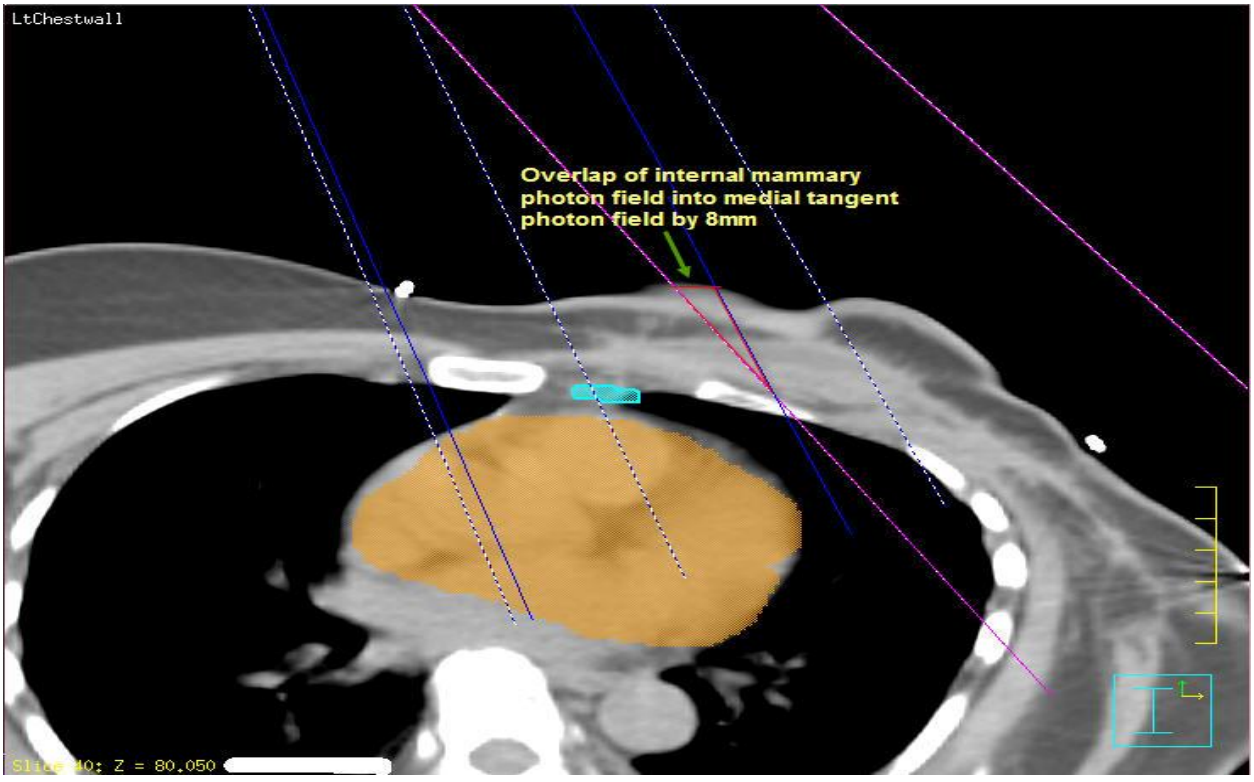


Figure 10: Overlap of IM photon field into medial tangent field.

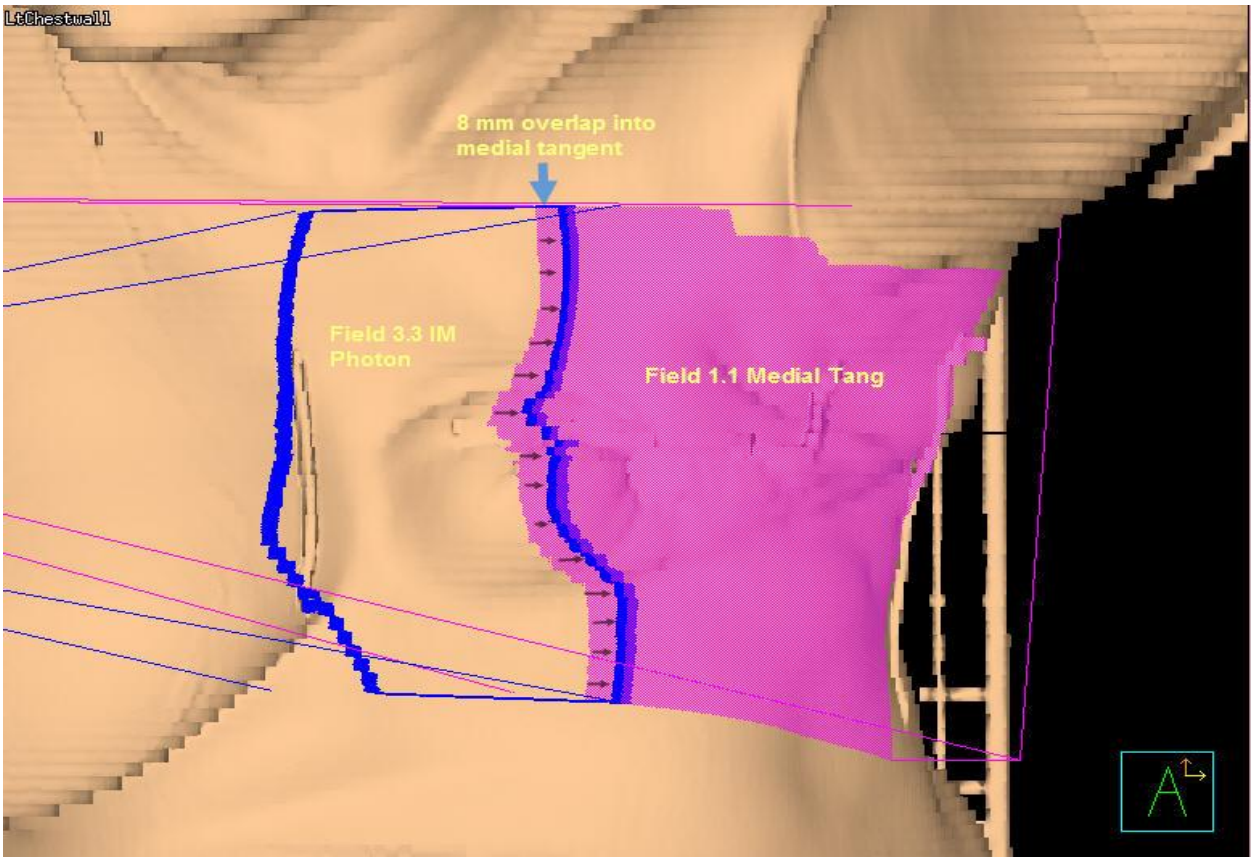


Figure 11: Overlap of IM photon field into medial tangent field.

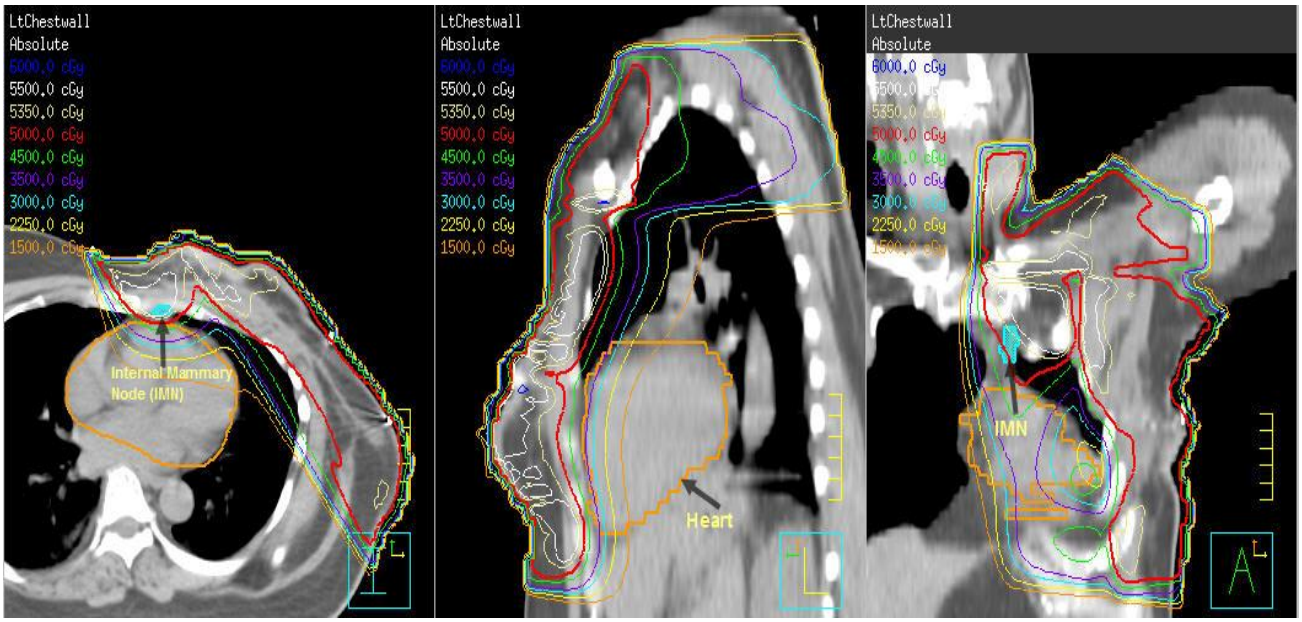


Figure 12: Composite isodose distribution for all fields.

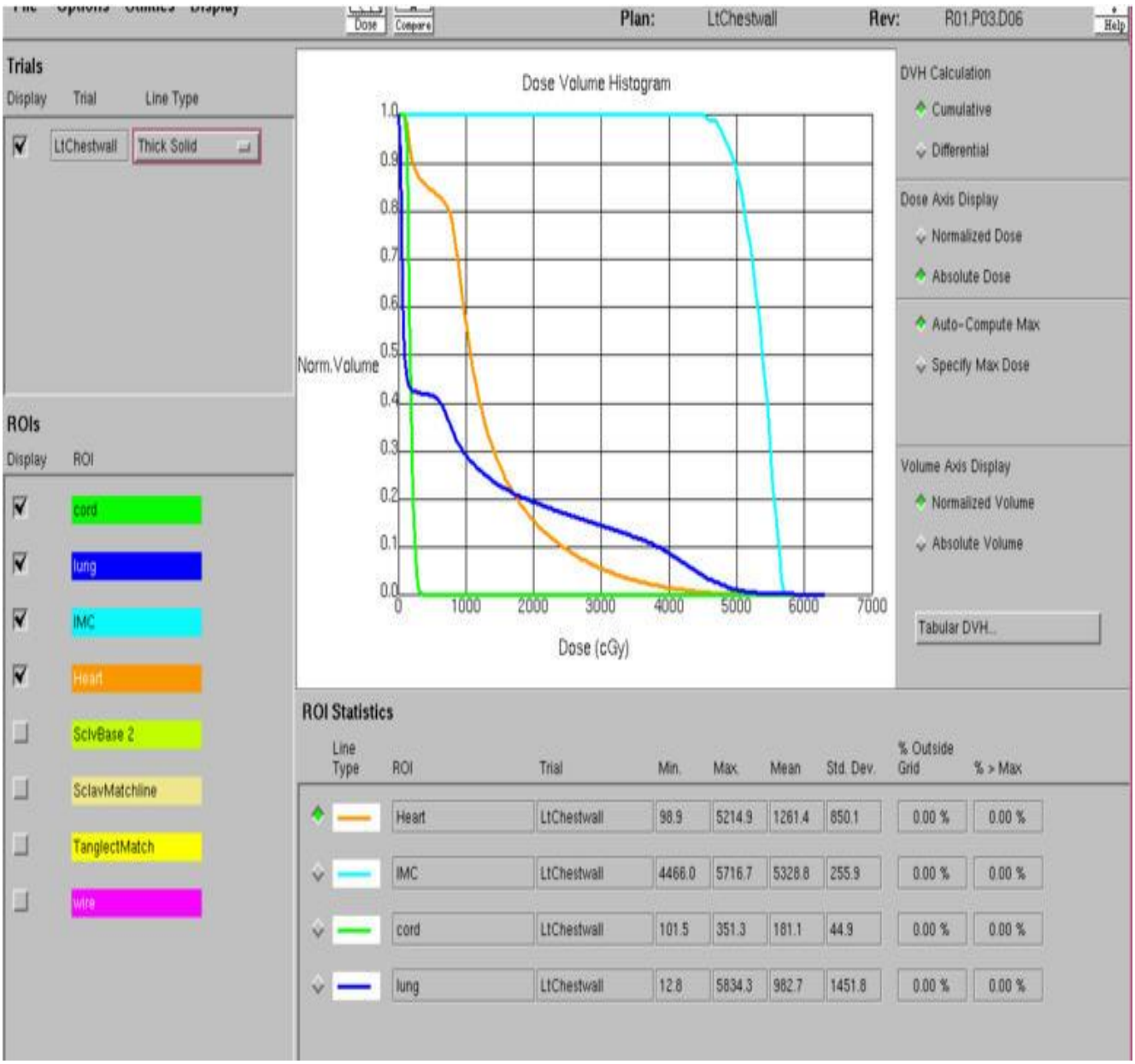


Figure 13: Dose volume histogram of composite plan.

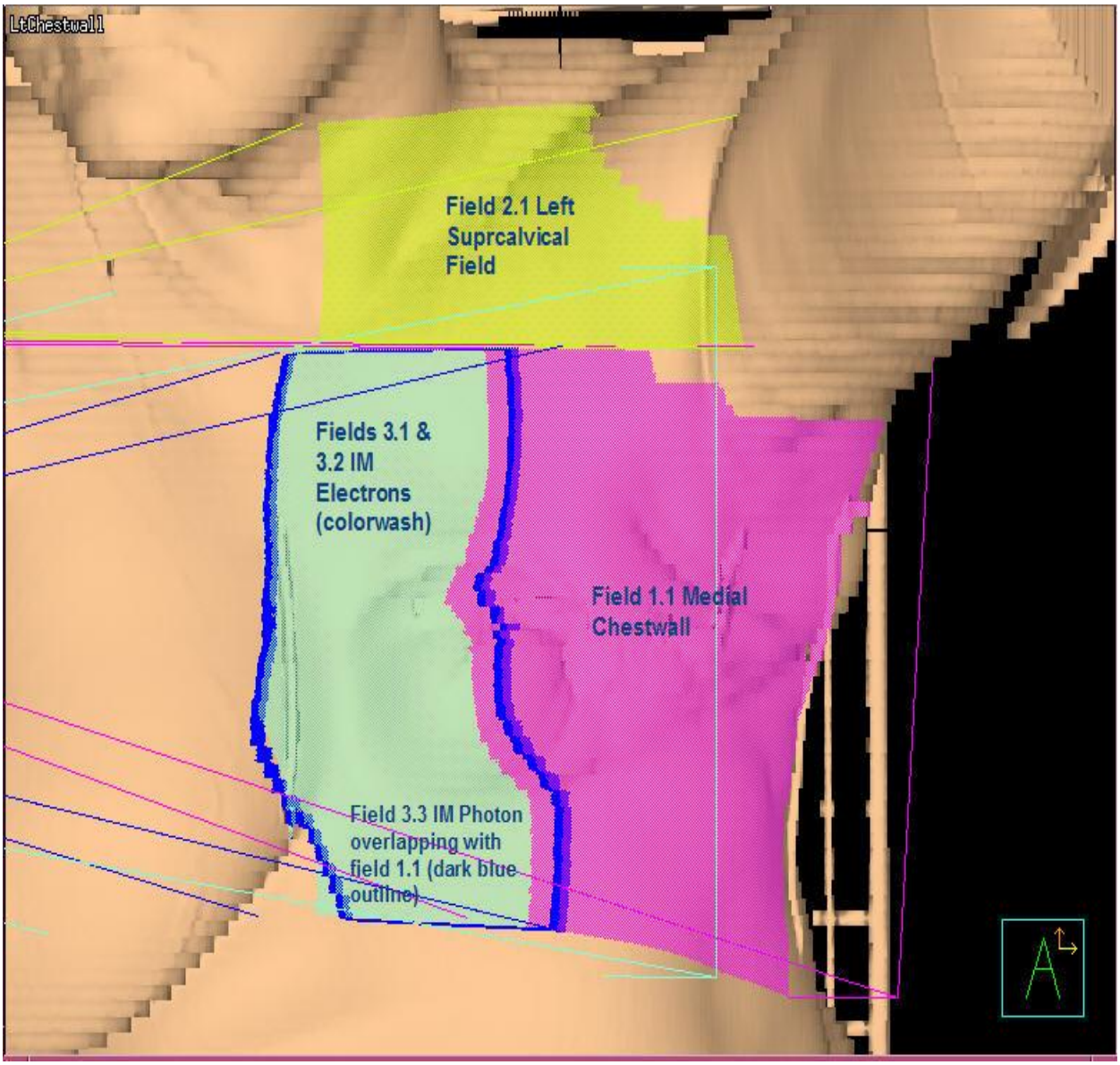


Figure 14: 3D Image of supraclavicular field, medial tangent field and photon/electron IM fields.

Monitor Unit Verification Spreadsheet, Ver. 1.2, Oct 28, 2003					
Dose to point FORWARD IMRT			Radiation Oncology,		Medical Center
Patient Name					
Rad Onc ID					
Field ID	1.1	Energy / Machine	Cl600C / 6MV 21EX	Date	1/4/2012
Segment #'s	1	0	0	0	Unblocked
Coll F.S (cm)	12.1	12.1	12.1	12.1	12.1
%Blocking	30	50	90	0	0
Under Block? 0/1	0	0	1	0	0
Blocked FS / bk Area	10.12	8.56	11.48	12.10	12.10
Adjusted Size	10.12	8.56	11.48	12.10	12.10
%MU	80	7	13	0	0
Depth	4.72	4.72	4.72	4.72	4.72
SPD	103.38	103.38	103.38	103.38	103.38
ISQ	0.964	0.964	0.964	0.964	0.964
Wedge angle	0	0	0	0	0
Tray? 0/1	0	0	0	0	0
Other Att F*	0	0.00	0.00	0.00	0.00
OAD (cm)	3.92	3.92	3.92	3.92	3.92
OAWD(cm) heel(+),toe(-)	0.00	0.00	0.00	0.00	0.00
TMR	0.935	0.931	0.938	0.940	0.940
ROP	1.000	0.987	1.005	1.009	1.009
WF	1.000	1.000	1.000	1.000	1.000
OAF	1.011	1.011	1.011	1.011	1.011
OAWF	1.000	1.000	1.000	1.000	1.000
ISQ	0.964	0.964	0.964	0.964	0.964
Total Att F	1.000	1.000	1.000	1.000	1.000
MU	145				
Eff MU	116.00	10.15	18.85	0.00	0.00
Dose	105.70	9.09	0.10	0.00	0.00
Sum Dose	114.89				
Plan dose	116.40				%MU sum
dose/plan dose %	98.70%	Initials	MR		100

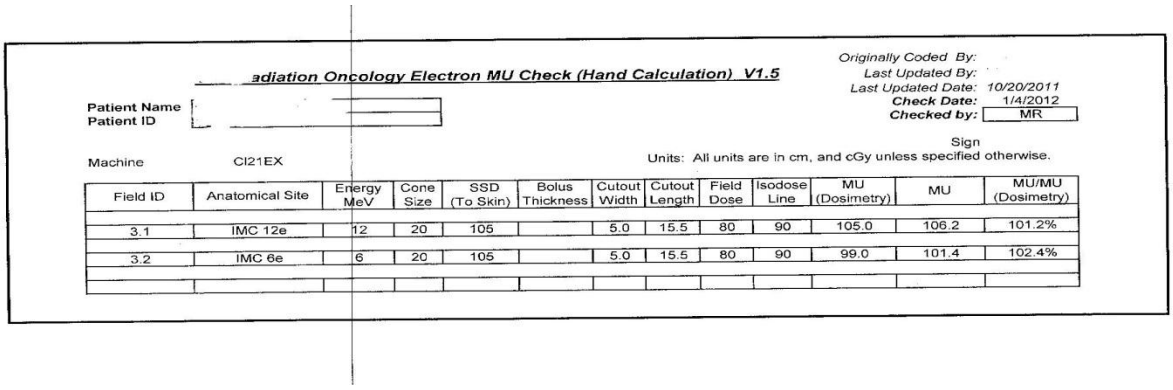
Figure 15: Field 1.1 Medial tangent chest wall physics check.

Monitor Unit Verification Spreadsheet, Ver. 1.2, Oct 28, 2003					
Dose to point FORWARD IMRT			Radiation Oncology,		Medical Center
Patient Name		LtCW			
Rad Onc ID					
Field ID	~~1.1~~ 1.2	Energy / Machine	CI600C / 6MV 21EX	Date	1/4/2012
Segment #'s	1	0	0	0	Unblocked
Coll F.S (cm)	13.8	13.8	13.8	13.8	13.8
%Blocking	30	50	90	0	0
Under Block? 0/1	0	1	1	0	0
Blocked FS / bk Area	11.55	9.76	13.09	13.80	13.80
Adjusted Size	11.55	9.76	13.09	13.80	13.80
%MU	88	5	7	0	0
Depth	9.00	9.00	9.00	9.00	9.00
SPD	96.77	96.77	96.77	96.77	96.77
ISQ	1.100	1.100	1.100	1.100	1.100
Wedge angle	0	0	0	0	0
Tray? 0/1	0	0	0	0	0
Other Att F*	0	0.00	0.00	0.00	0.00
OAD (cm)	3.92	3.92	3.92	3.92	3.92
OAWD(cm) heel(+),toe(-)	0.00	0.00	0.00	0.00	0.00
TMR	0.816	0.805	0.823	0.827	0.827
ROP	1.005	0.994	1.014	1.014	1.014
WF	1.000	1.000	1.000	1.000	1.000
OAF	1.011	1.011	1.011	1.011	1.011
OAWF	1.000	1.000	1.000	1.000	1.000
ISQ	1.100	1.100	1.100	1.100	1.100
Total Att F	1.000	1.000	1.000	1.000	1.000
MU	109				
Eff MU	95.92	5.45	7.63	0.00	0.00
Dose	87.46	0.23	0.03	0.00	0.00
Sum Dose	87.72				
Plan dose	86.90				%MU sum
dose/plan dose %	100.94%	Initials	MR		100

Figure 16: Field 1.2 Lateral tangent chest wall physics check.

Monitor Unit Verification Spreadsheet, Ver. 1.2, Oct 28, 2003					
Dose to point FORWARD IMRT			Radiation Oncology,		Medical Center
Patient Name		LtCW			
Rad Onc ID					
Field ID	2.1	Energy / Machine	CI600C / 6MV 21EX	Date	1/4/2012
Segment #'s	1	0	0	0	Unblocked
Coll F.S (cm)	9.9	9.9	9.9	9.9	9.9
%Blocking	10	20	10	0	0
Under Block? 0/1	0	1	0	0	0
Blocked FS / bk Area	9.39	4.43	9.39	9.90	9.90
Adjusted Size	9.39	4.43	9.39	9.90	9.90
%MU	78	5	17	0	0
Depth	3.00	3.00	3.00	3.00	3.00
SPD	103.58	103.58	103.58	103.58	103.58
ISQ	0.960	0.960	0.960	0.960	0.960
Wedge angle	0	0	0	0	0
Tray? 0/1	0	0	0	0	0
Other Att F*	0	0.00	0.00	0.00	0.00
OAD (cm)	4.29	4.29	4.29	4.29	4.29
OAWD(cm) heel(+),toe(-)	0.00	0.00	0.00	0.00	0.00
TMR	0.978	0.972	0.978	0.979	0.979
ROP	0.994	0.943	0.994	0.994	0.994
WF	1.000	1.000	1.000	1.000	1.000
OAF	1.018	1.018	1.018	1.018	1.018
OAWF	1.000	1.000	1.000	1.000	1.000
ISQ	0.960	0.960	0.960	0.960	0.960
Total Att F	1.000	1.000	1.000	1.000	1.000
MU	214				
Eff MU	166.92	10.70	36.38	0.00	0.00
Dose	158.70	0.59	34.59	0.00	0.00
Sum Dose	193.88				
Plan dose	199.70				%MU sum
dose/plan dose %	97.09%	Initials	MR		100

Figure 17: Field 2.1 Left supraclavicular physics check.



adiation Oncology Electron MU Check (Hand Calculation) V1.5

Originally Coded By:
Last Updated By:
Last Updated Date: 10/20/2011
Check Date: 1/4/2012
Checked by: MR

Patient Name
Patient ID

Machine CI21EX

Sign

Units: All units are in cm, and cGy unless specified otherwise.

Field ID	Anatomical Site	Energy MeV	Cone Size	SSD (To Skin)	Bolus Thickness	Cutout Width	Cutout Length	Field Dose	Isodose Line	MU (Dosimetry)	MU	MU/MU (Dosimetry)
3.1	IMC 12e	12	20	105		5.0	15.5	80	90	105.0	106.2	101.2%
3.2	IMC 6e	6	20	105		5.0	15.5	80	90	99.0	101.4	102.4%

Figure 18: Fields 3.1 and 3.2 electron IM node physics check.

Monitor Unit Verification Spreadsheet, Ver. 1.2, Oct 28, 2003
Dose to point FORWARD IMRT **Radiation Oncology, Medical Center**

Patient Name		**LtCW**			
Rad Onc ID					
Field ID	**3.3**	**Energy / Machine**	**CI600C / 6MV 21EX**	**Date**	**1/4/2012**
Segment #'s	**1**	**0**	**0**	**0**	**Unblocked**
Coll F.S (cm)	**12.7**	**12.7**	**12.7**	**12.7**	**12.7**
%Blocking	**18.6**	**50**	**90**	**0**	**0**
Under Block? 0/1	**0**	**1**	**1**	**0**	**0**
Blocked FS / bk Area	11.46	8.98	12.05	12.70	12.70
Adjusted Size	11.46	8.98	12.05	12.70	12.70
%MU	**100**	**0**	**0**	**0**	**0**
Depth	**2.94**	2.94	2.94	2.94	2.94
SPD	**102.85**	102.85	102.85	102.85	102.85
ISQ	**0.974**	0.974	0.974	0.974	0.974
Wedge angle	**0**	0	0	0	0
Tray? 0/1	**0**	0	0	0	0
Other Att F*	**0**	0.00	0.00	0.00	0.00
OAD (cm)	**1.27**	1.27	1.27	1.27	1.27
OAWD(cm) heel(+),toe(-)	**0.00**	0.00	0.00	0.00	0.00
TMR	0.982	0.979	0.982	0.983	0.983
ROP	1.005	0.987	1.009	1.009	1.009
WF	1.000	1.000	1.000	1.000	1.000
OAF	1.003	1.003	1.003	1.003	1.003
OAWF	1.000	1.000	1.000	1.000	1.000
ISQ	0.974	0.974	0.974	0.974	0.974
Total Att F	1.000	1.000	1.000	1.000	1.000
MU	**42**				
Eff MU	**42.00**	**0.00**	**0.00**	**0.00**	**0.00**
Dose	**40.47**	**0.00**	**0.00**	**0.00**	**0.00**
Sum Dose	**40.47**				
Plan dose	**40.40**				**%MU sum**
dose/plan dose %	**100.16%**	**Initials**	**MR**		**100**

Figure 19: Field 3.3 IM node photon physics check.

References

1. Zonderland H. Introduction to breast imaging reporting and data system. Web site. http://www.radiologyassistant.nl/en/4349108442109. Accessed March 23, 2012.
2. Buchholz BB, Haffty B. Breast cancer: locally advanced and recurrent disease, post mastectomy radiation, and systemic therapies. In: Halperin E, Perez C, Brady L, eds. *Principles and Practice in Radiation Oncology.* 5th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2008:1293.
3. Khan F. Treatment planning II: patient data, corrections, and set-up. In: *The Physics of Radiation Therapy.* 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2003:259.