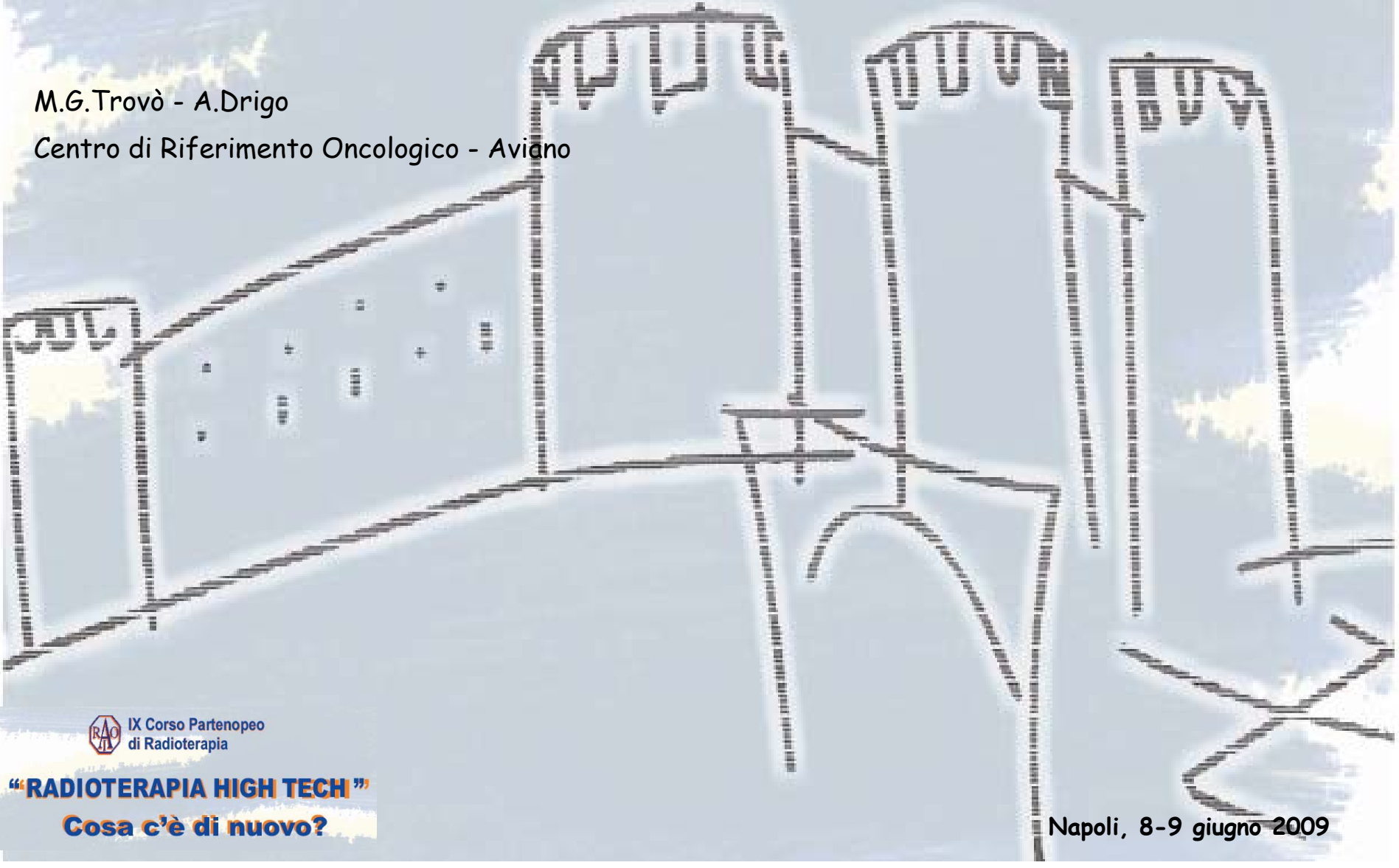
Impiego del software Planned Adaptive™ in Tomoterapia

M.G.Trovò - A.Drigo

Centro di Riferimento Oncologico - Aviano

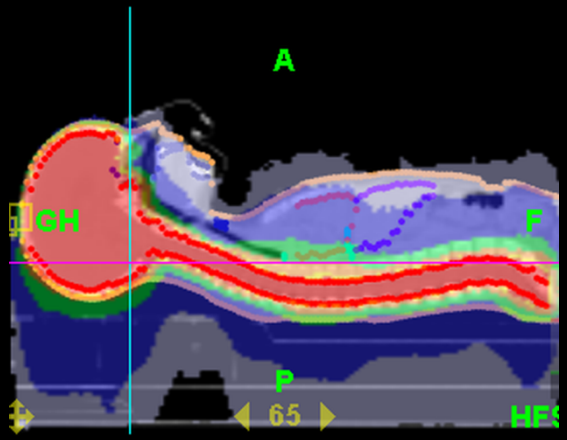


IX Corso Partenopeo di Radioterapia

"RADIOTERAPIA HIGH TECH"

Cosa c'è di nuovo?

Napoli, 8-9 giugno 2009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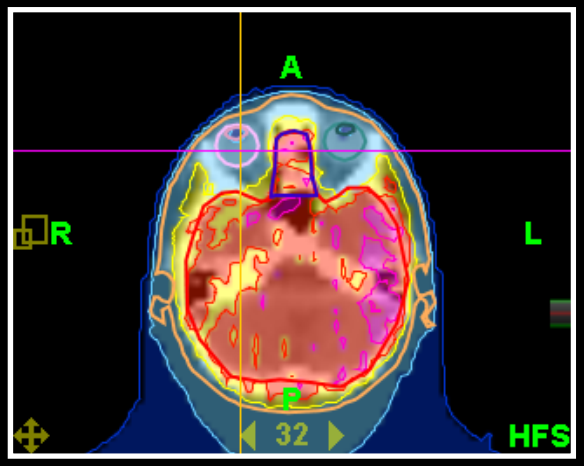
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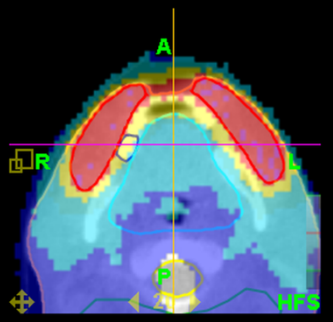
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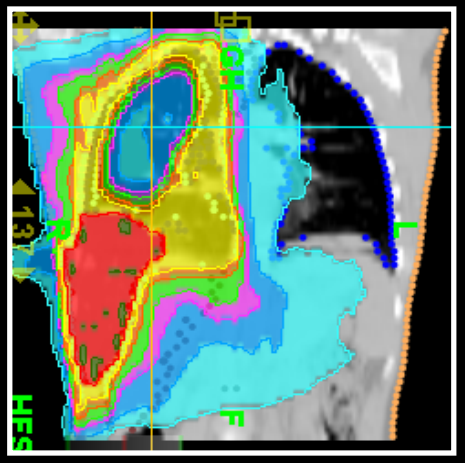
IMRT ⇒ IGRT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131
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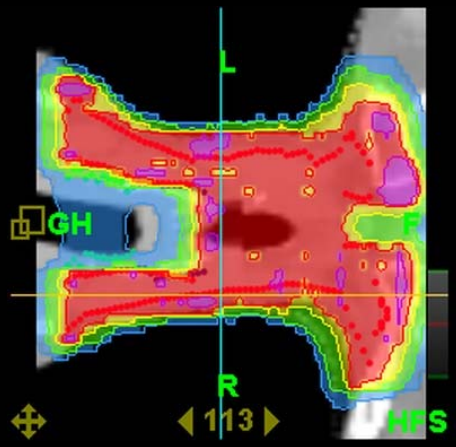
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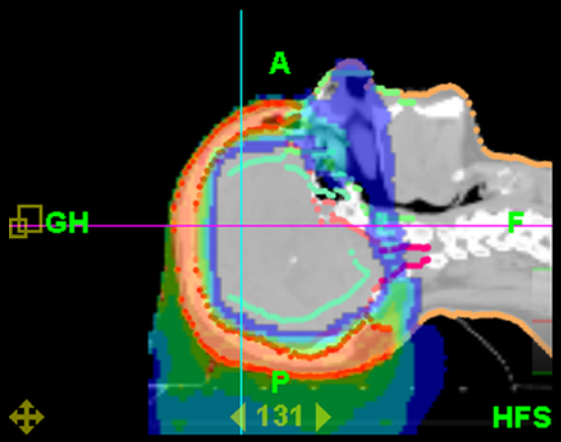
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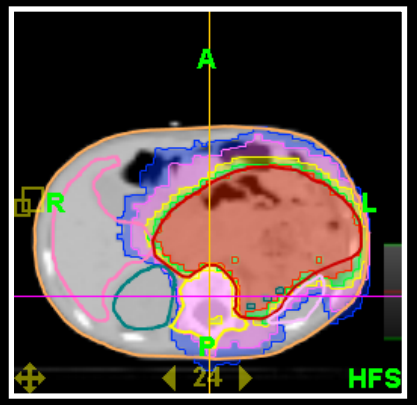
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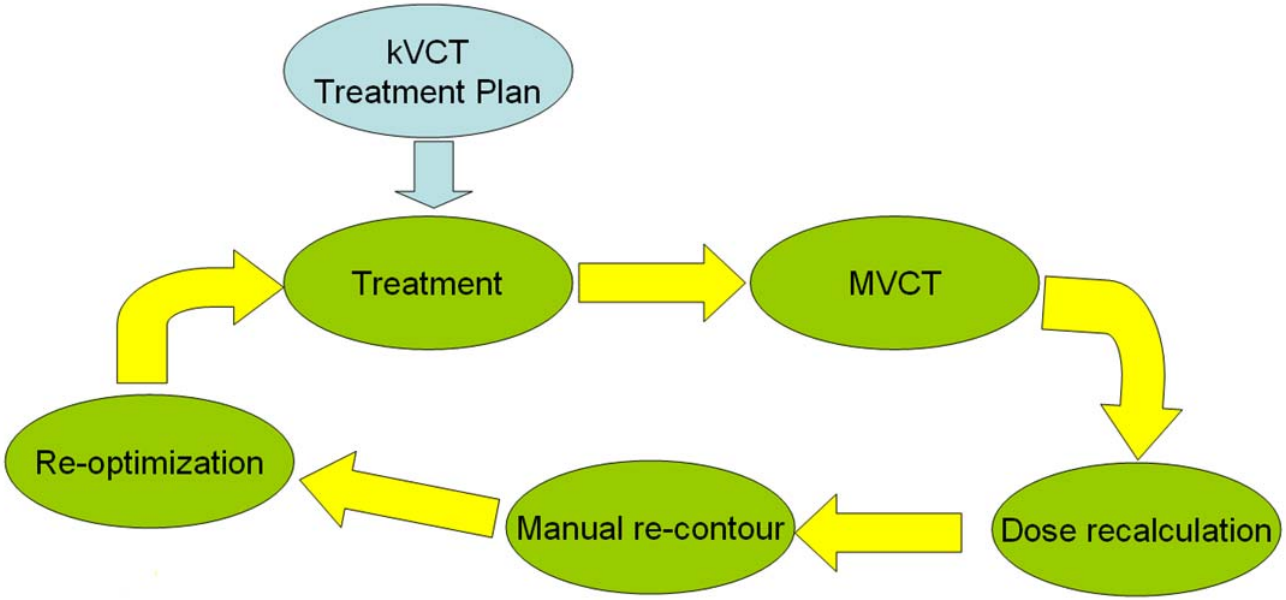
Tomotherapy Hi ART

Highly Integrated Adaptive Radiotherapy

- *La tecnica IMRT permette di creare piani di trattamento estremamente conformati anche su target complessi con notevole risparmio di organi a rischio vicini al target*
- *Questo comporta la necessità di controllare cosa si sta irradiando, perché sbagliare anche di poco significa sbagliare il trattamento*
- *Nel corso del trattamento possono intervenire variazioni rispetto alla situazione di pianificazione, che riguardano non solo il set up del paziente, ma anche le dimensioni del target (shrinking), la posizione degli organi a rischio circostanti, il contorno esterno del paziente (perdita di peso)*
- *tutti questi fattori devono essere tenuti sotto controllo $\Rightarrow$ IGRT*
- *Risparmio degli organi a rischio e controllo della dose sono le basi per l' attuazione della "dose escalation"*

PLANNED ADAPTIVE



Una volta preso atto delle variazioni, serve valutare quanto queste incidano sul trattamento e se necessario ripianificare

⟹ *Terapia "adattativa"*

Il tutto nel tempo più breve possibile

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James Renaud, Slav Yartev, Rashid Dar, and Jake Van Dyk
Medical Dosimetry, Vol. xx, No. x, pp. xxx, 2009 --- in press

Ecc.

gli studi sono *Studi volti a:*

- *Quantificare la variazione volumetrica dei vari organi;*
- *Valutare quanto le variazioni incidono sulla distribuzione di dose in riferimento ai vari organi;*
- *Individuare quali sono i parametri più significativi (V_{20}, $D_{5,}$ ecc)*
- *Verificare se esistono correlazioni tra i diversi parametri (V, D, organo, malattia)*
- *Individuare strategie di lavoro (quando applicare adaptive, con che frequenze, ecc)*
- *stabilire dei criteri per la ripianificazione*

Int. J. Radiation Oncology Biol. Phys., Vol. 64, No. 4, pp. 1237–1244, 2006

0360-3016/06/$–see front matter

ELSEVIER

doi:10.1016/j.ijrobp.2005.11.012

PHYSICS CONTRIBUTION

A TECHNIQUE FOR ADAPTIVE IMAGE-GUIDED HELICAL TOMOTHERAPY FOR LUNG CANCER

Chester R. Ramsey, Ph.D.,* Katja M. Langen, Ph.D.,† Patrick A. Kupelian, M.D.,† Daniel D. Scaperoth, M.D.,* Sanford L. Meeks, Ph.D.,† Stephen L. Mahan, Ph.D.,* and Rebecca M. Seibert, M.S.*

*Department of Radiation Oncology, Thompson Cancer Survival Center, Knoxville, TN; †Department of Radiation Oncology, M. D. Anderson Cancer Center Orlando, Orlando, FL

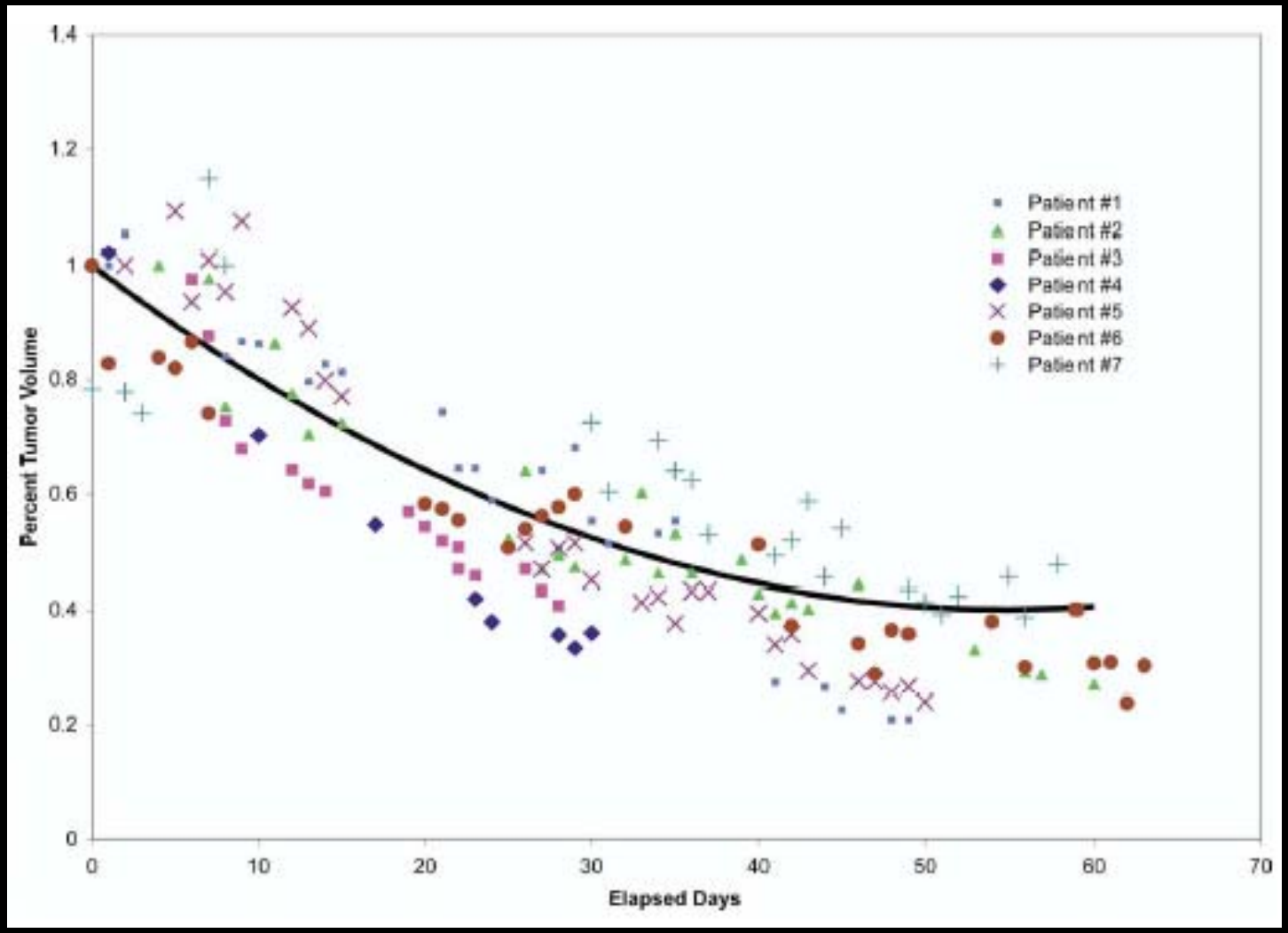
Purpose: The gross tumor volume (GTV) for many lung cancer patients can decrease during the course of radiation therapy. As the tumor reduces in size during treatment, the margin added around the GTV effectively becomes larger, which can result in the excessive irradiation of normal lung tissue. The specific goal of this study is to evaluate the feasibility of using image-guided adaptive radiation therapy to adjust the planning target volume weekly based on the previous week's CT image sets that were used for image-guided patient setup.

Methods and Materials: Megavoltage computed tomography (MVCT) images of the GTV were acquired daily on a helical tomotherapy system. These images were used to position the patient and to measure reduction in GTV volume. A planning study was conducted to determine the amount of lung-sparing that could have been achieved if adaptive therapy had been used. Treatment plans were created in which the target volumes were reduced after tumor reduction was measured.

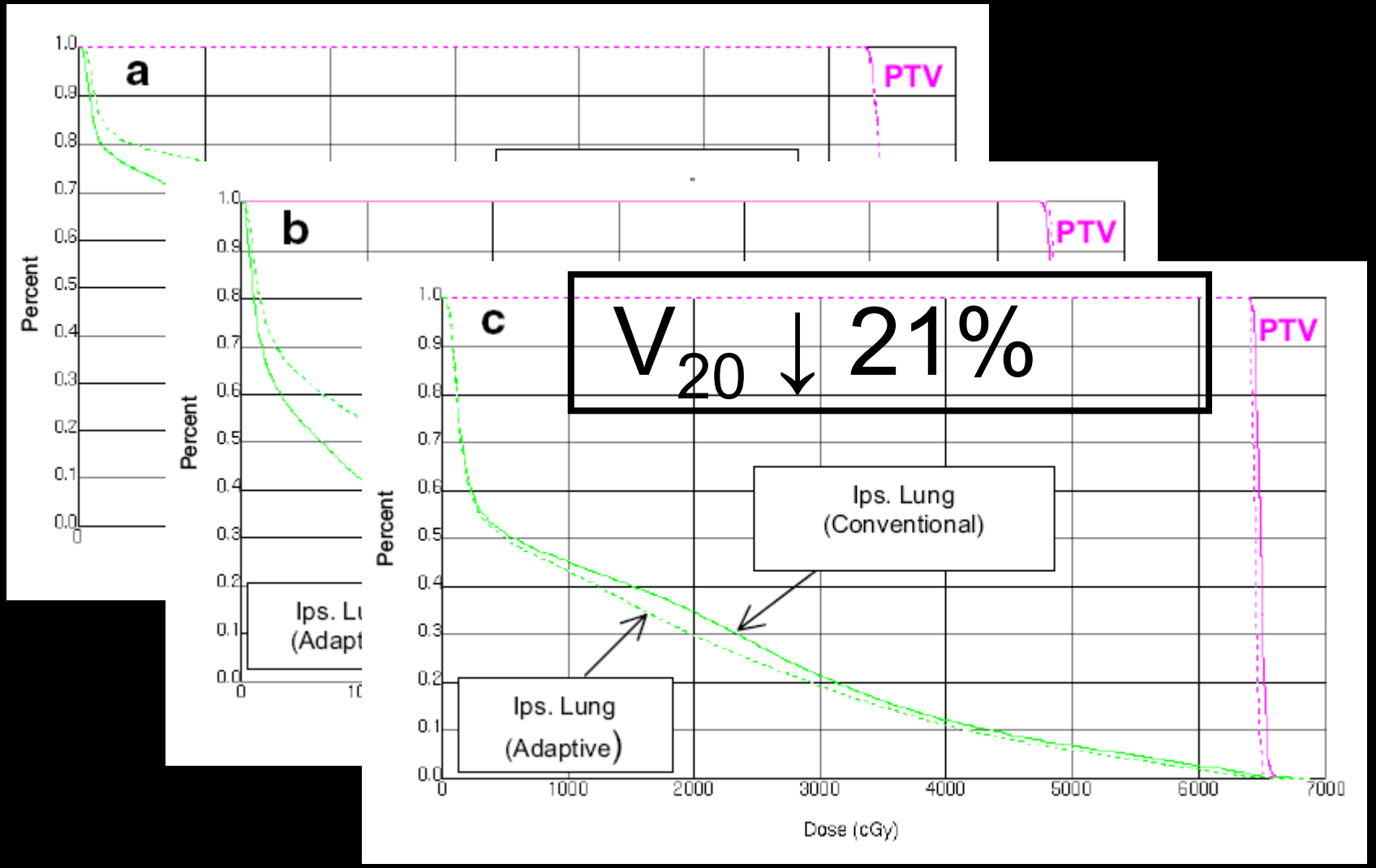
Results: A total of 158 MVCT imaging sessions were performed on 7 lung patients. The GTV was reduced by 60–80% during the course of treatment. The tumor reduction in the first 60 days of treatment can be modeled using the second-order polynomial $R = 0.0002t^2 - 0.0219t + 1.0$, where R is the percent reduction in GTV, and t is the number of elapsed days. Based on these treatment planning studies, the absolute volume of ipsilateral lung receiving 20 Gy can be reduced between 17% and 23% (21% mean) by adapting the treatment delivery. The benefits of adaptive therapy are the greatest for tumor volumes ≥25 cm^3 and are directly dependent on GTV reduction during treatment.

Conclusions: Megavoltage CT-based image guidance can be used to position lung cancer patients daily. This has the potential to decrease margins associated with daily setup error. Furthermore, the adaptive therapy technique described in this article can decrease the volume of healthy lung tissue receiving above 20 Gy. However, further study is needed to determine whether adaptive therapy could result in the underdosing of microscopic extension.

ART


1.4
1.2
1
0.8
0.6
0.4
0.2
0
Percent Tumor Volume
0
10
20
30
40
50
60
70
Elapsed Days
Patient #1
Patient #2
Patient #3
Patient #4
Patient #5
Patient #6
Patient #7

ART


a
PTV
b
PTV
c
PTV
$V_{20} \downarrow 21\%$
Ips. Lung
(Conventional)
Ips. Lung
(Adaptive)
Percent
Dose (cGy)
0
1000
2000
3000
4000
5000
6000
7000

Int. J. Radiation Oncology Biol. Phys., Vol. 69, No. 4, pp. 1316–1322, 2007

0360-3016/07/$–see front matter

ELSEVIER

doi:10.1016/j.ijrobp.2007.07.2369

PHYSICS CONTRIBUTION

ADAPTIVE RADIOTHERAPY PLANNING ON DECREASING GROSS TUMOR VOLUMES AS SEEN ON MEGAVOLTAGE COMPUTED TOMOGRAPHY IMAGES

CURTIS WOODFORD,* SLAV YARTSEV, PH.D.,* A. RASHID DAR, M.D.,*† GLENN BAUMAN, M.D.,*† AND JAKE VAN DYK, M.SC.*†

*London Regional Cancer Program, London Health Sciences Centre, London, Ontario, Canada; and
†The University of Western Ontario, London, Ontario, Canada

Purpose: To evaluate gross tumor volume (GTV) changes for patients with non–small-cell lung cancer by using daily megavoltage (MV) computed tomography (CT) studies acquired before each treatment fraction on helical tomotherapy and to relate the potential benefit of adaptive image-guided radiotherapy to changes in GTV.
Methods and Materials: Seventeen patients were prescribed 30 fractions of radiotherapy on helical tomotherapy for non–small-cell lung cancer at London Regional Cancer Program from Dec 2005 to March 2007. The GTV was contoured on the daily MVCT studies of each patient. Adapted plans were created using merged MVCT–kilovoltage CT image sets to investigate the advantages of replanning for patients with differing GTV regression characteristics.
Results: Average GTV change observed over 30 fractions was −38%, ranging from −12 to −87%. No significant correlation was observed between GTV change and patient's physical or tumor features. Patterns of GTV changes in the 17 patients could be divided broadly into three groups with distinctive potential for benefit from adaptive planning.
Conclusions: Changes in GTV are difficult to predict quantitatively based on patient or tumor characteristics. If changes occur, there are points in time during the treatment course when it may be appropriate to adapt the plan to improve sparing of normal tissues. If GTV decreases by greater than 30% at any point in the first 20 fractions of treatment, adaptive planning is appropriate to further improve the therapeutic ratio. © 2007 Elsevier Inc.

Int. J. Radiation Oncology Biol. Phys., Vol. 71, No. 5, pp. 1563–1571, 2008

0360-3016/08/$–see front matter

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doi:10.1016/j.ijrobp.2008.04.013

PHYSICS CONTRIBUTION

ASSESSMENT OF PAROTID GLAND DOSE CHANGES DURING HEAD AND NECK CANCER RADIOTHERAPY USING DAILY MEGAVOLTAGE COMPUTED TOMOGRAPHY AND DEFORMABLE IMAGE REGISTRATION

CHOONIK LEE, PH.D.,* KATJA M. LANGEN, PH.D.,* WEIGUO LU, PH.D.,† JASON HAIMERL, M.S.,† ERIC SCHNARR, PH.D.,† KENNETH J. RUCHALA, PH.D.,† GUSTAVO H. OLIVERA, PH.D.,† SANFORD L. MEEKS, PH.D.,* PATRICK A. KUPELIAN, M.D.,* THOMAS D. SHELLENBERGER, M.D., D.M.D.,†§ AND RAFAEL R. MAÑON, M.D.*

Departments of *Radiation Oncology and †Head and Neck Surgery, M. D. Anderson Cancer Center Orlando, Orlando, FL; ‡TomoTherapy, Inc., Madison, WI; and §Department of Head and Neck Surgery, The University of Texas M. D. Anderson Cancer Center, Houston, TX

Purpose: To analyze changes in parotid gland dose resulting from anatomic changes throughout a course of radiotherapy in a cohort of head-and-neck cancer patients.

Methods and Materials: The study population consisted of 10 head-and-neck cancer patients treated definitively with intensity-modulated radiotherapy on a helical tomotherapy unit. A total of 330 daily megavoltage computed tomography images were retrospectively processed through a deformable image registration algorithm to be registered to the planning kilovoltage computed tomography images. The process resulted in deformed parotid contours and voxel mappings for both daily and accumulated dose–volume histogram calculations. The daily and cumulative dose deviations from the original treatment plan were analyzed. Correlations between dosimetric variations and anatomic changes were investigated.

Results: The daily parotid mean dose of the 10 patients differed from the plan dose by an average of 15%. At the end of the treatment, 3 of the 10 patients were estimated to have received a greater than 10% higher mean parotid dose than in the original plan (range, 13–42%), whereas the remaining 7 patients received doses that differed by less than 10% (range, −6–8%). The dose difference was correlated with a migration of the parotids toward the high-dose region.

Conclusions: The use of deformable image registration techniques and daily megavoltage computed tomography imaging makes it possible to calculate daily and accumulated dose–volume histograms. Significant dose variations were observed as result of interfractional anatomic changes. These techniques enable the implementation of dose-adaptive radiotherapy. © 2008 Elsevier Inc.

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doi:10.1016/j.ijrobp.2007.10.067

PHYSICS CONTRIBUTION

ACTUAL DOSE VARIATION OF PAROTID GLANDS AND SPINAL CORD FOR NASOPHARYNGEAL CANCER PATIENTS DURING RADIOTHERAPY

CHUNHUI HAN, PH.D., YI-JEN CHEN, M.D., PH.D., AN LIU, PH.D.,
TIMOTHY E. SCHULTHEISS, PH.D., F.A.C.R., AND JEFFREY Y. C. WONG, M.D.

Division of Radiation Oncology, City of Hope National Medical Center, Duarte, CA

Purpose: For intensity-modulated radiotherapy of nasopharyngeal cancer, accurate dose delivery is crucial to the success of treatment. This study aimed to evaluate the significance of daily image-guided patient setup corrections and to quantify the parotid gland volume and dose variations for nasopharyngeal cancer patients using helical tomotherapy megavoltage computed tomography (CT).

Methods and Materials: Five nasopharyngeal cancer patients who underwent helical tomotherapy were selected retrospectively. Each patient had received 70 Gy in 35 fractions. Daily megavoltage CT scans were registered with the planning CT images to correct the patient setup errors. Contours of the spinal cord and parotid glands were drawn on the megavoltage CT images at fixed treatment intervals. The actual doses delivered to the critical structures were calculated using the helical tomotherapy Planned Adaptive application.

Results: The maximal dose to the spinal cord showed a significant increase and greater variation without daily setup corrections. The significant decrease in the parotid gland volume led to a greater median dose in the later phase of treatment. The average parotid gland volume had decreased from 20.5 to 13.2 cm^3 by the end of treatment. On average, the median dose to the parotid glands was 83 cGy and 145 cGy for the first and the last treatment fractions, respectively.

Conclusions: Daily image-guided setup corrections can eliminate significant dose variations to critical structures. Constant monitoring of patient anatomic changes and selective replanning should be used during radiotherapy to avoid critical structure complications. © 2008 Elsevier Inc.

CRO
AVIANO

Tomotherapy Hi ART
Highly Integrated Adaptive Radiotherapy

Esperienza CRO Aviano

- Maggio 2006: inizio trattamenti con Tomoterapia
- Marzo 2007: software Planned Adaptive
- Tipologia casi: craniospinali, polmoni, ORL, esofago, sarcomi (distretti differenziati), encefalo, prostata
- 400 piani di trattamento ad oggi

CRO
AVIANO

Tomotherapy Hi ART
Highly Integrated Adaptive Radiotherapy

Le cause più comuni per l' applicazione del Planned Adaptive sono:

- Variazioni nel target (tumor shrinking)
- Variazioni anatomiche (OAR, body)
- Perdita di peso
- *Presenza di artefatti dovuti a materiali ad alta densità*

L' impiego del Planned Adaptive è finalizzato alla:

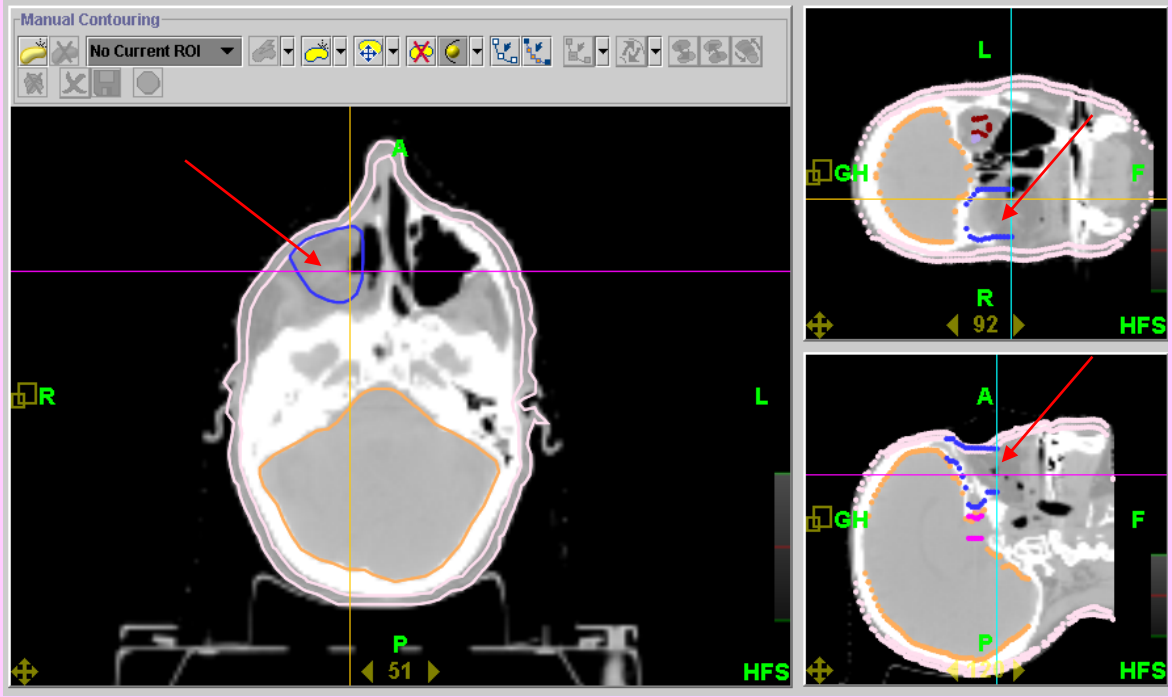
- Valutazione delle variazioni della dose erogata tramite gli istogrammi dose – volume, con particolare riguardo alla copertura del target e alla eventuale irradiazione di organi a rischio

- Ripianificazione (se necessario)

CRO
AVIANO

Tomotherapy Hi ART
Highly Integrated Adaptive Radiotherapy

- Planned Adaptive è stato utilizzato per 16 pazienti (5 %)
  - 8 casi per problemi di artefatti
  - 8 casi per variazioni anatomiche (7 ripianificazioni)

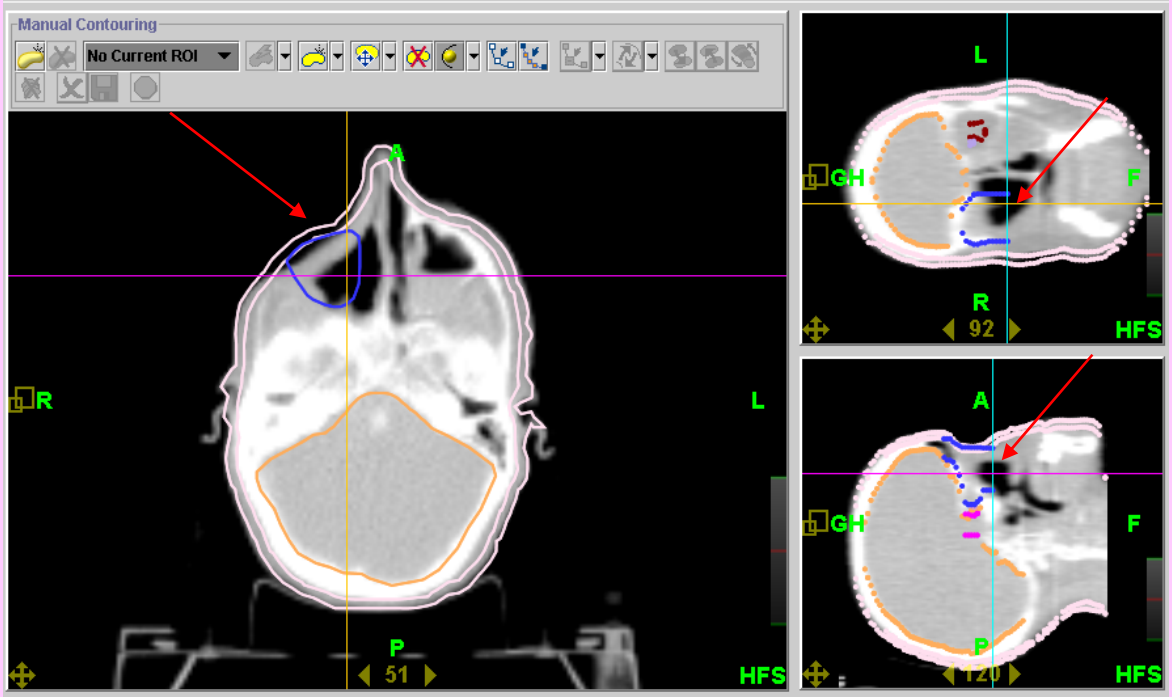


Carcinoma del seno mascellare

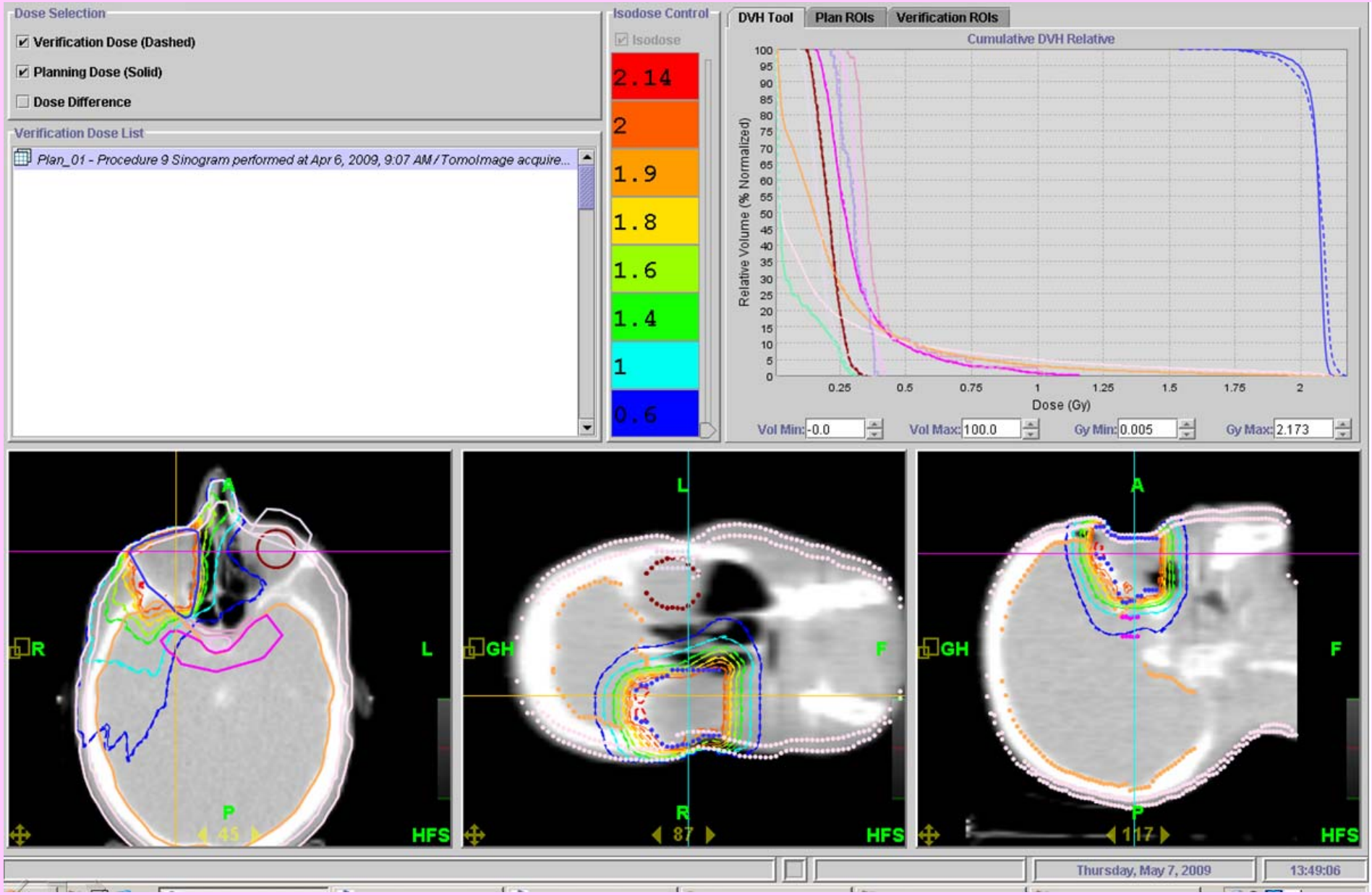
dose prescritta:

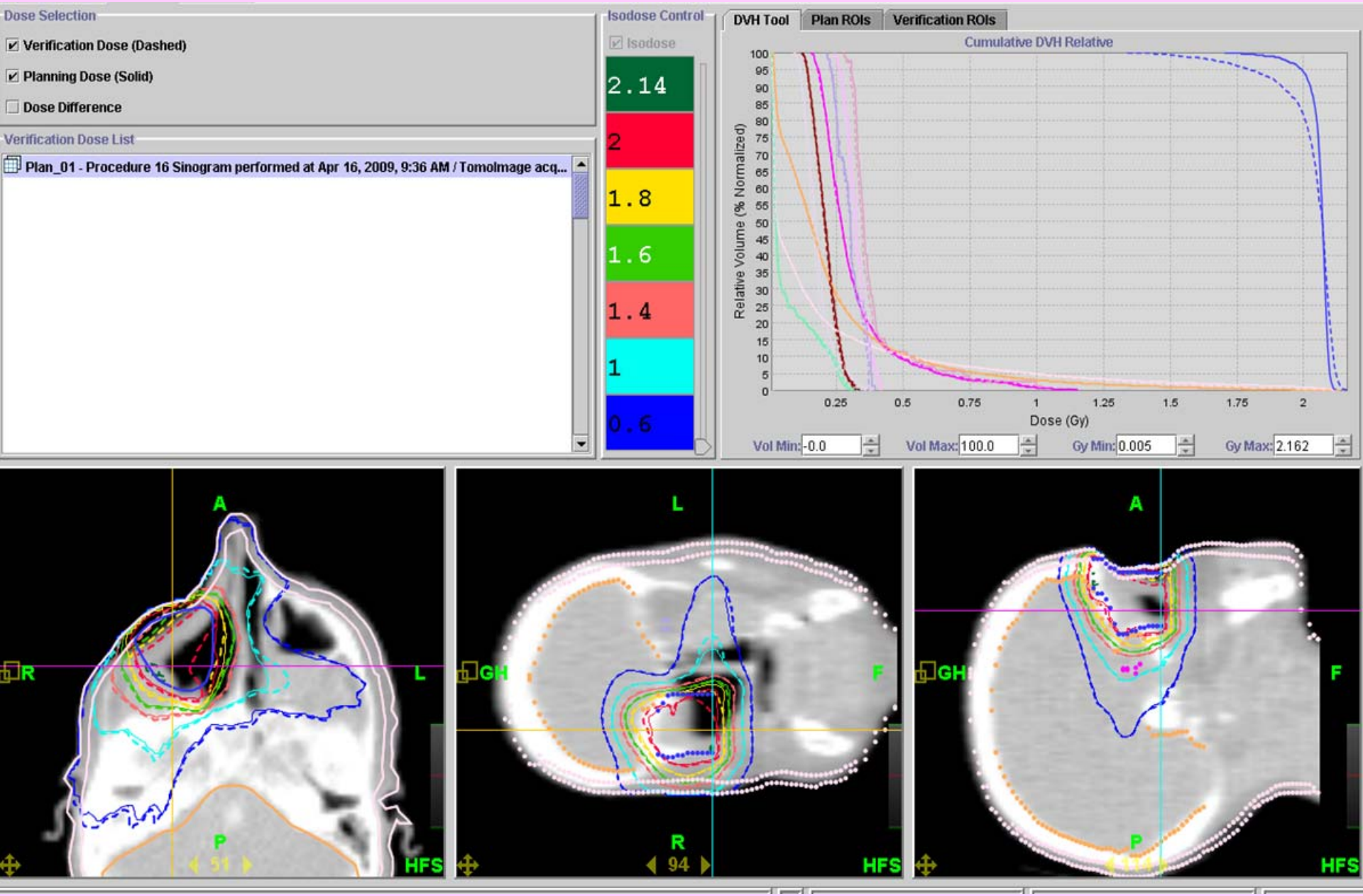
50 Gy in 25 frazioni

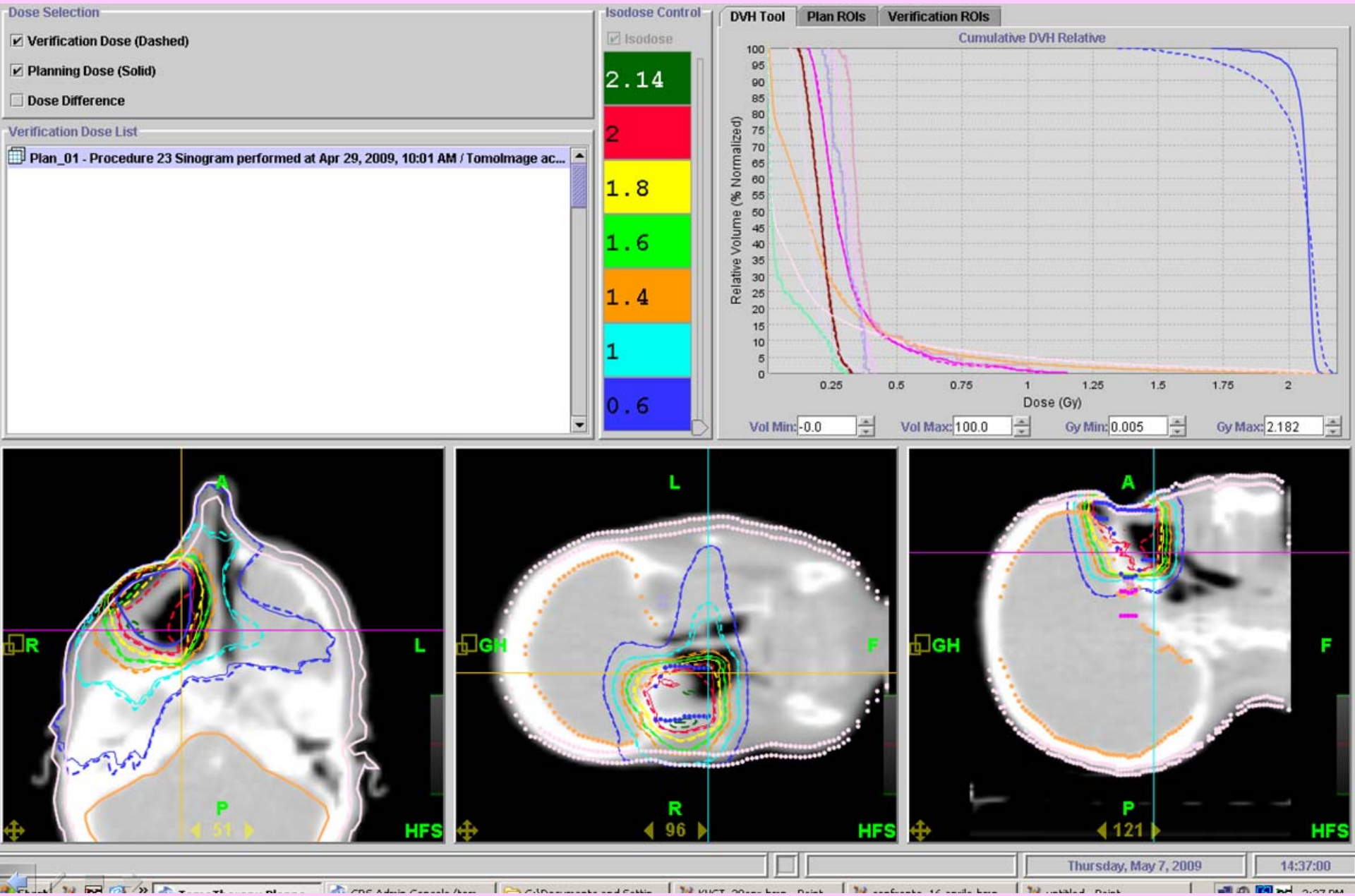
Planning Image



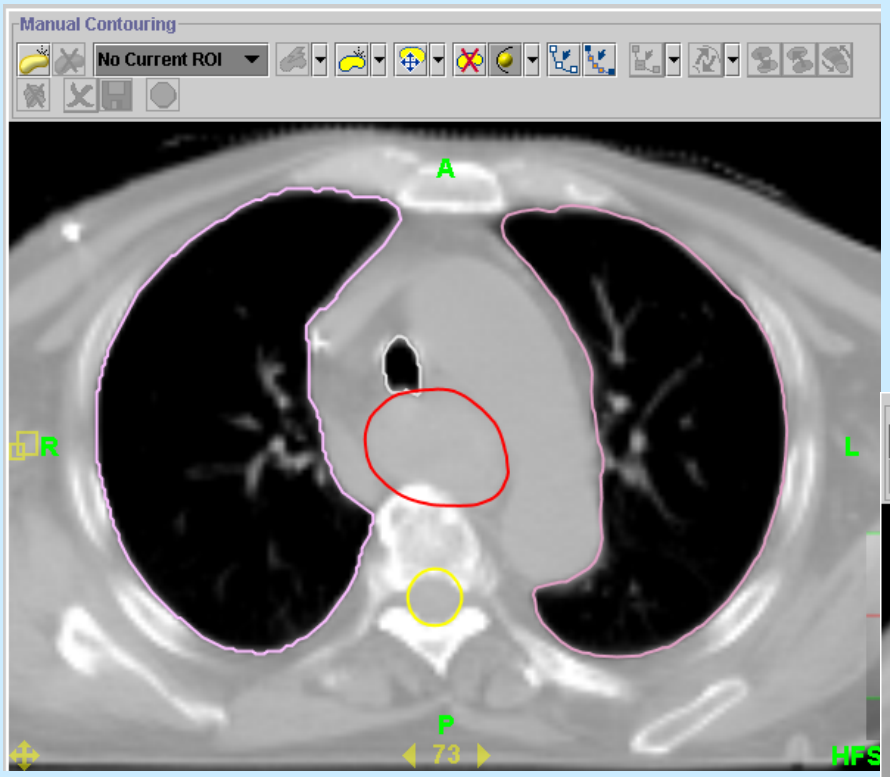
MVCT dopo 10 giorni
dall' inizio del trattamento


Dose Selection
Verification Dose (Dashed)
Planning Dose (Solid)
Dose Difference
Verification Dose List
Plan_01 - Procedure 9 Sinogram performed at Apr 6, 2009, 9:07 AM / TomoImage acquire...
Isodose Control
Isodose
2.14
2
1.9
1.8
1.6
1.4
1
0.6
DVH Tool
Plan ROIs
Verification ROIs
Cumulative DVH Relative
Relative Volume (% Normalized)
Dose (Gy)
Vol Min: -0.0
Vol Max: 100.0
Gy Min: 0.005
Gy Max: 2.173
A
R
L
P
45
HFS
L
GH
F
R
87
HFS
A
GH
F
P
117
HFS
Thursday, May 7, 2009
13:49:06


Dose Selection
Verification Dose (Dashed)
Planning Dose (Solid)
Dose Difference
Verification Dose List
Plan_01 - Procedure 16 Sinogram performed at Apr 16, 2009, 9:36 AM / TomoImage acq...
Isodose Control
Isodose
2.14
2
1.8
1.6
1.4
1
0.6
DVH Tool
Plan ROIs
Verification ROIs
Cumulative DVH Relative
Relative Volume (% Normalized)
Dose (Gy)
Vol Min: -0.0
Vol Max: 100.0
Gy Min: 0.005
Gy Max: 2.162
A
R
L
P
HFS
L
GH
F
R
94
HFS
A
GH
F
P
HFS

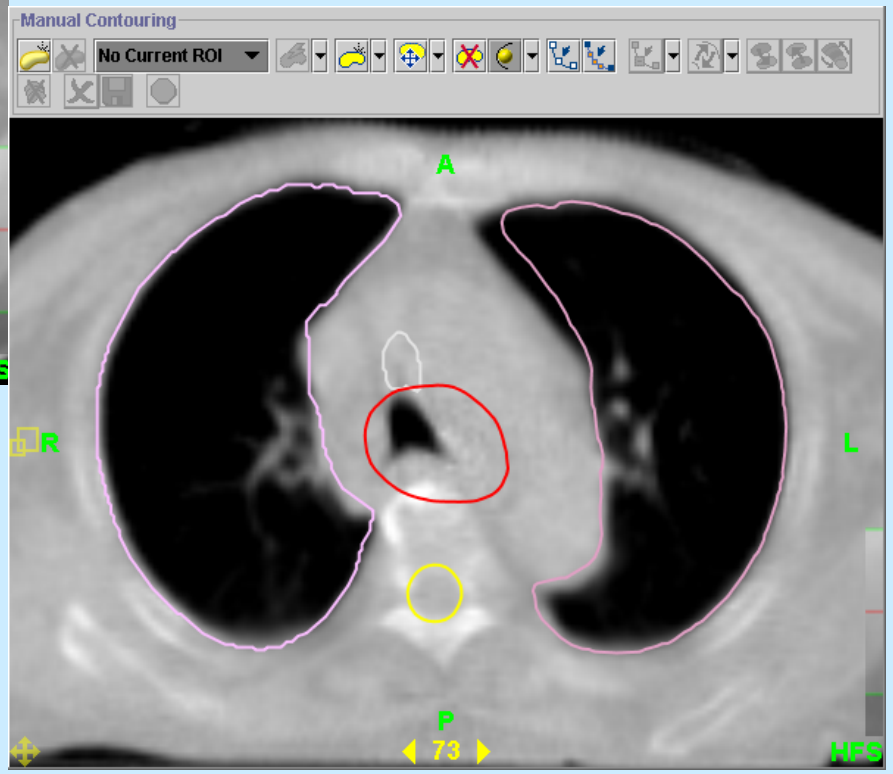

Dose Selection
Verification Dose (Dashed)
Planning Dose (Solid)
Dose Difference
Verification Dose List
Plan_01 - Procedure 23 Sinogram performed at Apr 29, 2009, 10:01 AM / TomoImage ac...
Isodose Control
Isodose
2.14
2
1.8
1.6
1.4
1
0.6
DVH Tool
Plan ROIs
Verification ROIs
Cumulative DVH Relative
Relative Volume (% Normalized)
Dose (Gy)
Vol Min: -0.0
Vol Max: 100.0
Gy Min: 0.005
Gy Max: 2.182
A
R
L
P
51
HFS
L
GH
F
R
96
HFS
A
GH
F
P
121
HFS
Thursday, May 7, 2009
14:37:00

Planning image



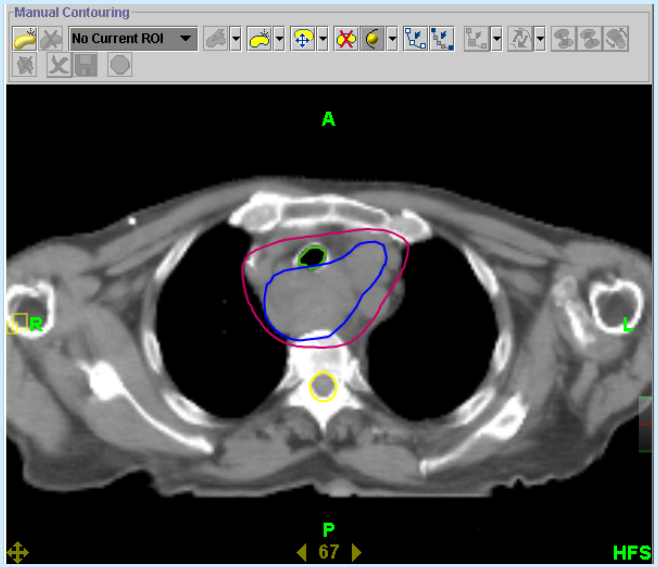
Esofago Cervicale

- 50 Gy al PTV
- 60 Gy al GTV
- 25 frazioni
- chemioterapia concomitante

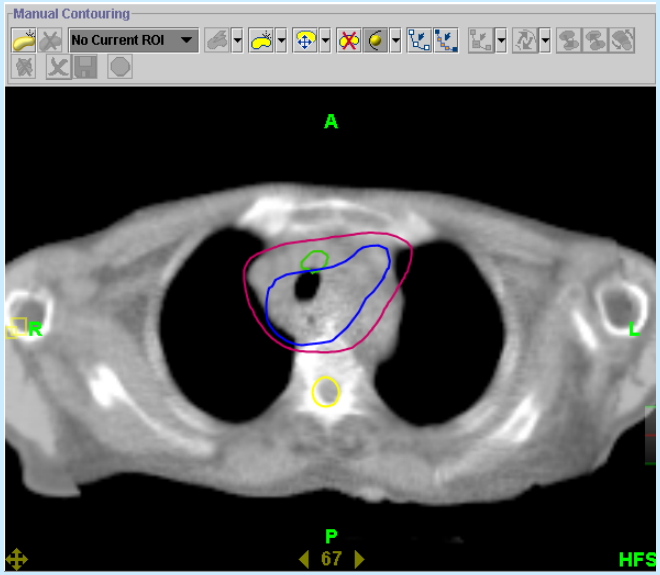


MVCT alla prima seduta

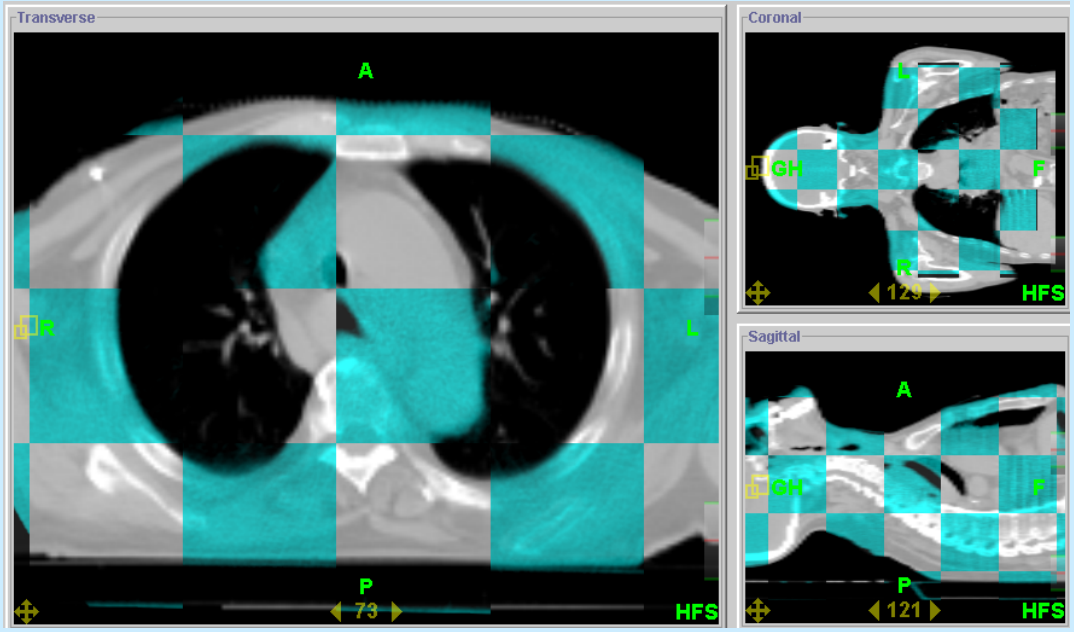
Image planning



MVCT



MVCT



TomoTherapy Planned Adaptive -- 0210071

What's Next

Evaluate Dose

➲ Evaluate the verification dose.

User Name: Drigo Annalisa

Compute Dose | Evaluate | Planning

Dose Selection

- ☑ Verification Dose (Dashed)
- ☑ Planning Dose (Solid)
- ☐ Dose Difference

Verification Dose List

Plan_01 - Procedure 5 Sinogram performed at Mar 18, 2009, 12:31 PM / TomoImage acq...

Isodose Control

☑ Isodose

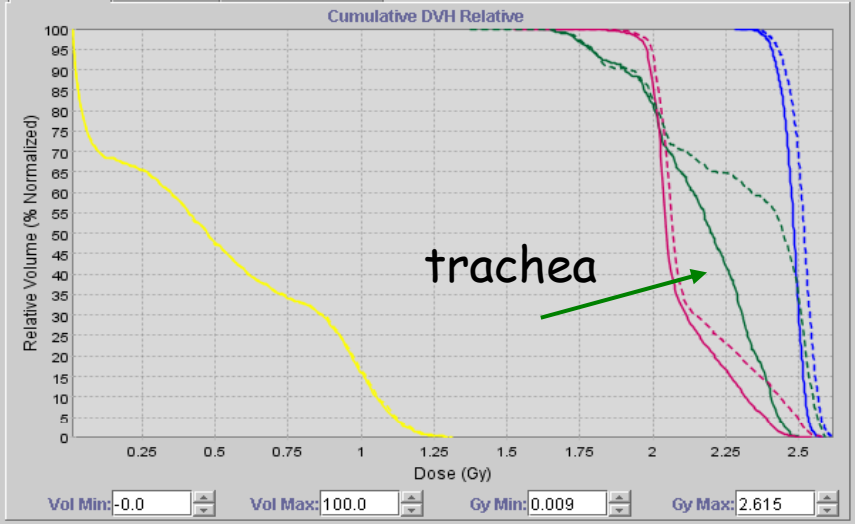
2.4

2

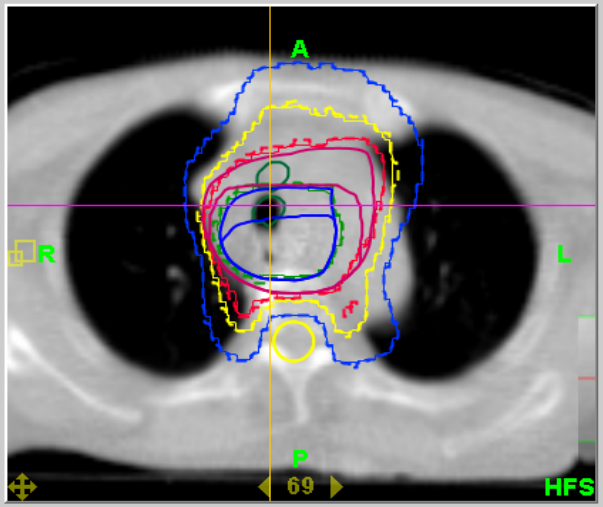
1.8

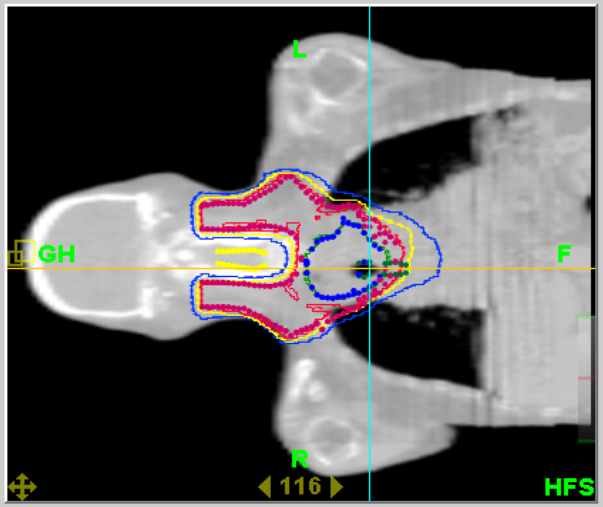
1.4

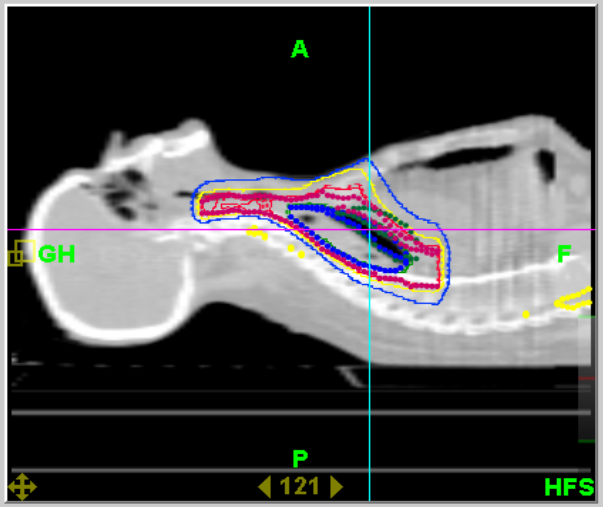
DVH Tool | Plan ROIs | Verification ROIs



Vol Min: -0.0 Vol Max: 100.0 Gy Min: 0.009 Gy Max: 2.615





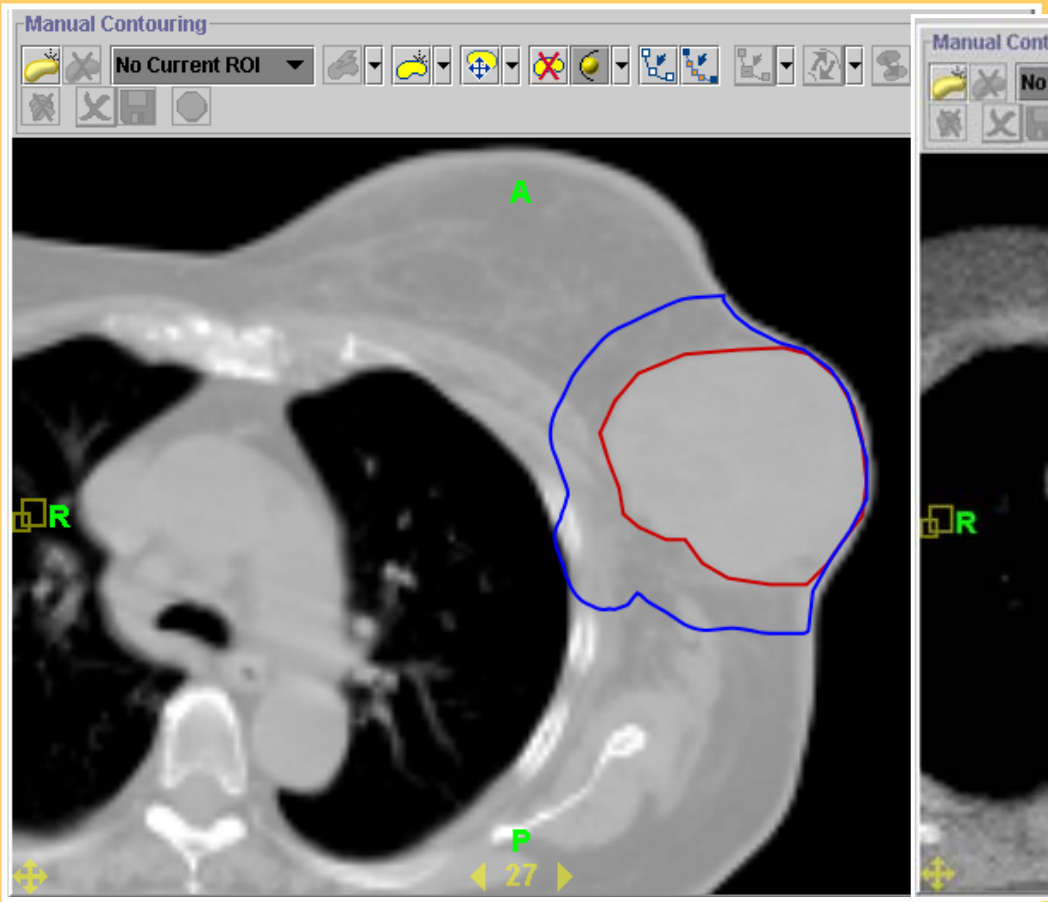


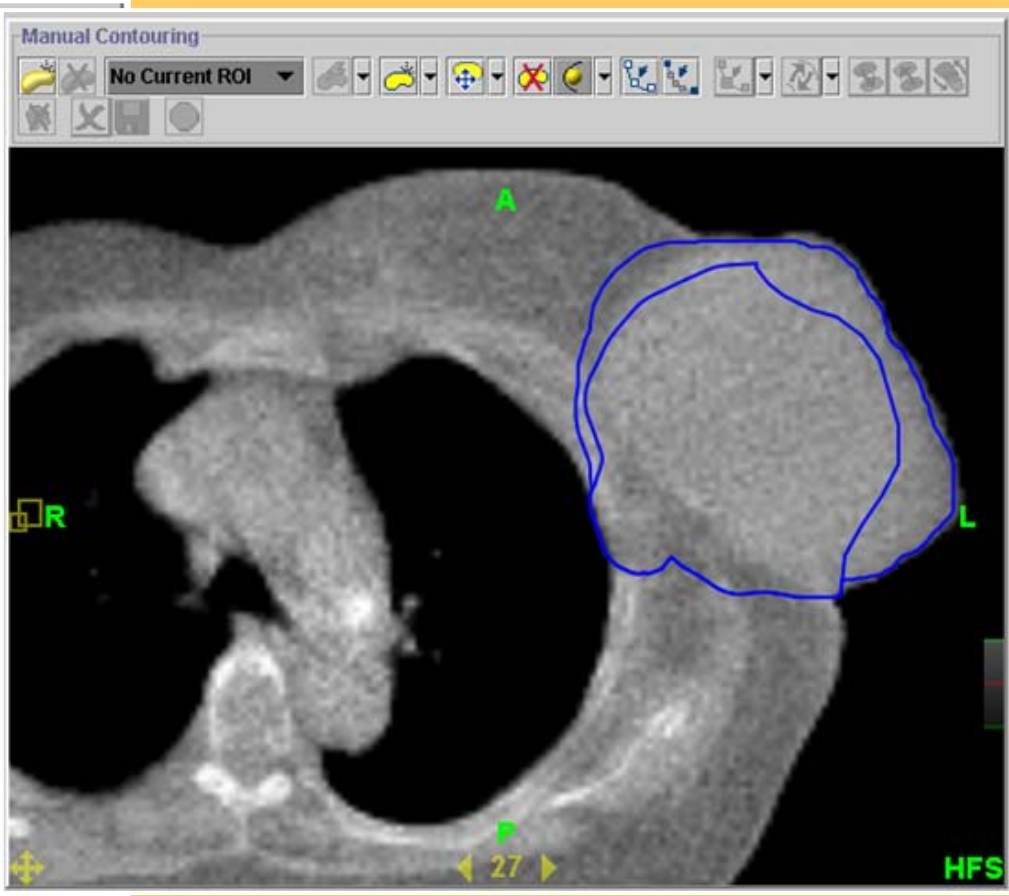
Thursday, May 7, 2009 15:31:10

Start | TomoTherapy Planne... | CRS Admin Console (tom... | seq31.bmp - Paint | untitled - Paint | seq4.bmp - Windows Pict... | 3:31 PM

Image planning

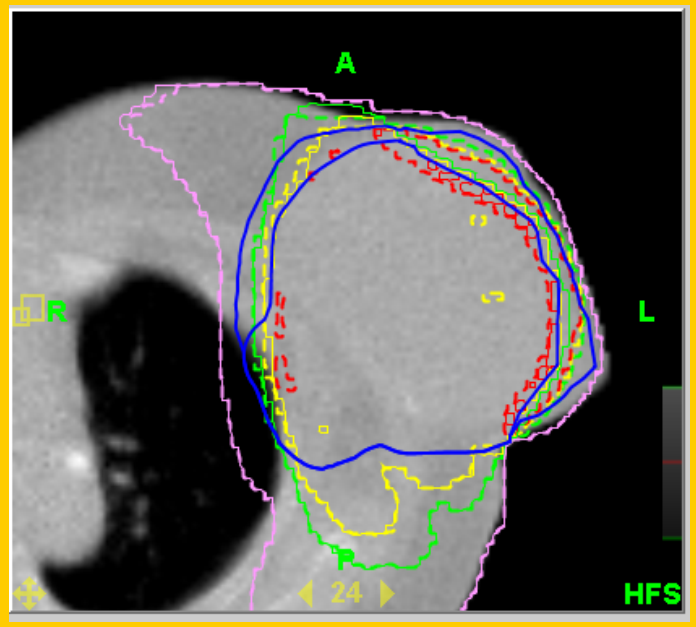
MVCT

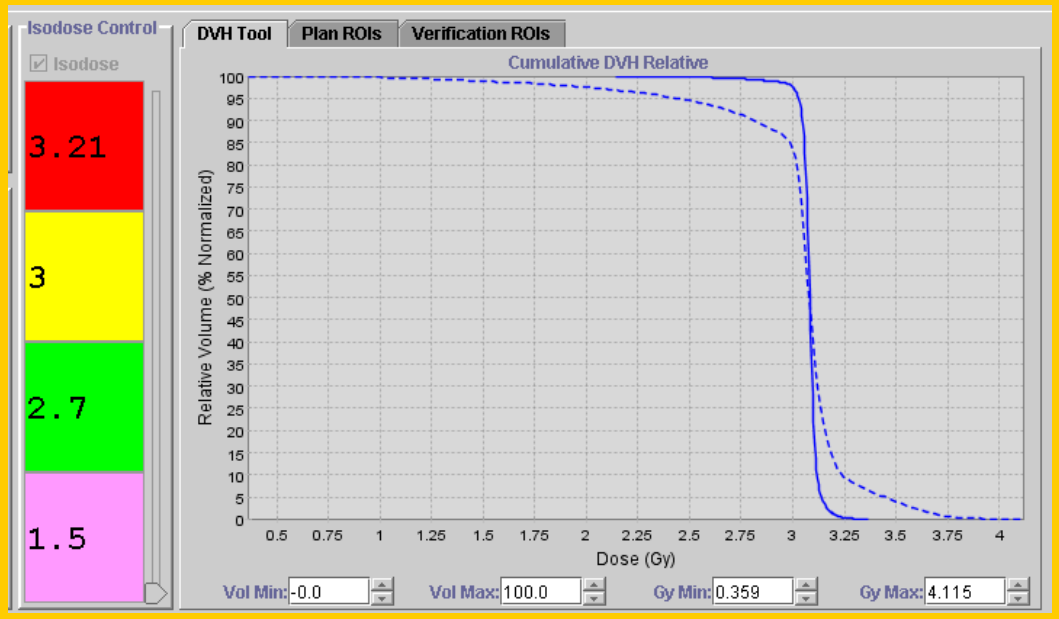




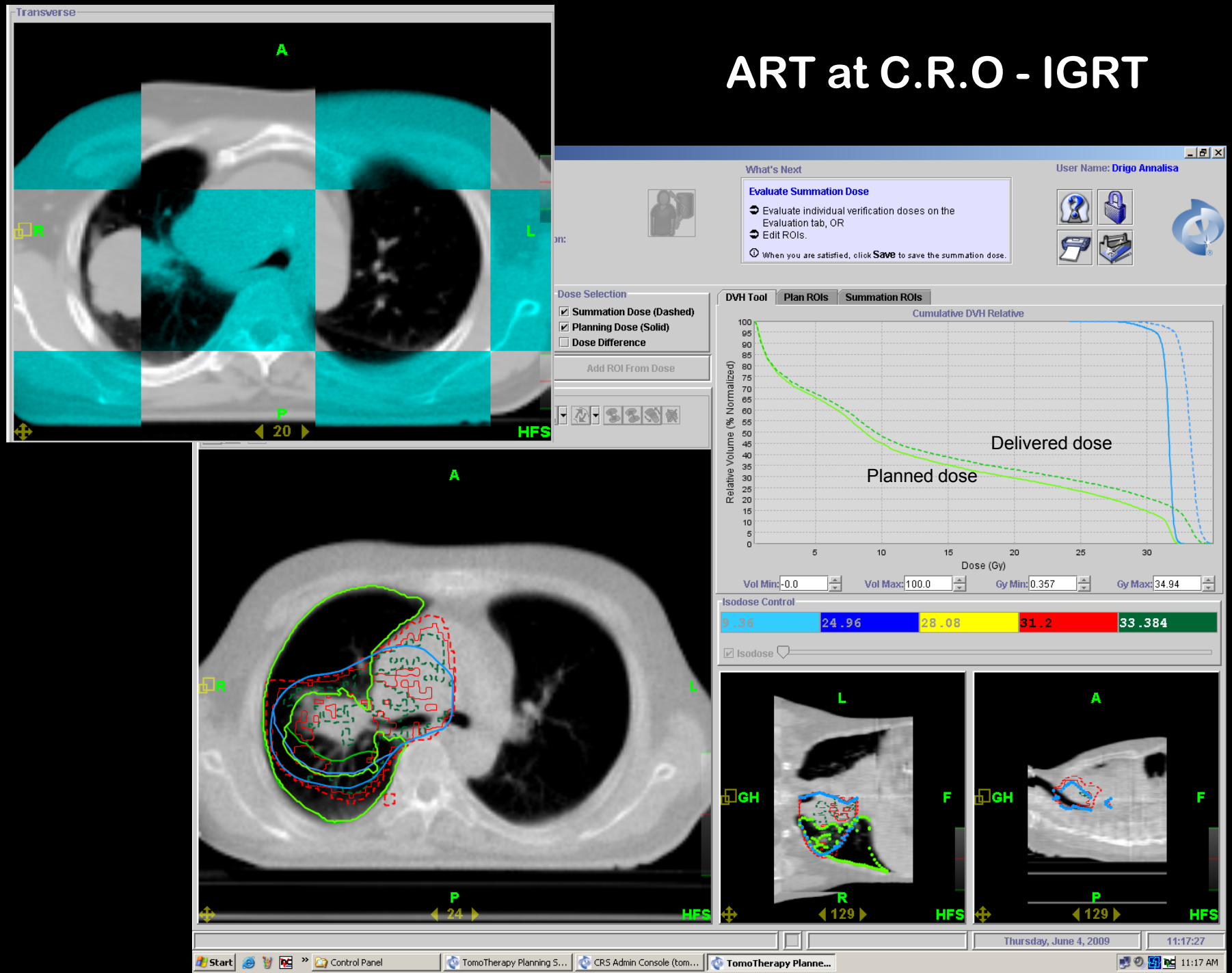
Massiva recidiva linfonodale da ca mammella

DOSE PRESCRITTA 45 Gy in 15 frazioni


A
R
L
24
HFS


Isodose Control
Isodose
3.21
3
2.7
1.5
DVH Tool
Plan ROIs
Verification ROIs
Cumulative DVH Relative
Relative Volume (% Normalized)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
2.75
3
3.25
3.5
3.75
4
Dose (Gy)
Vol Min: -0.0
Vol Max: 100.0
Gy Min: 0.359
Gy Max: 4.115

ART at C.R.O - IGRT

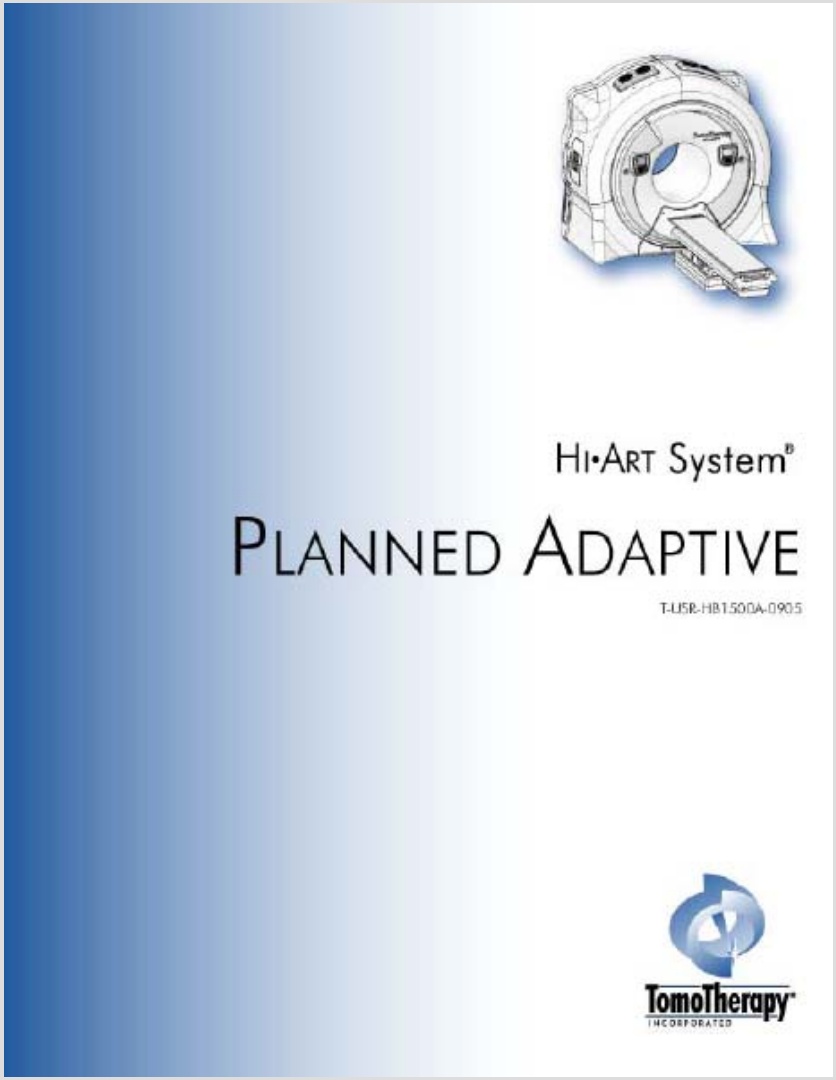


bando per la Ricerca Oncologica 2006
PROGRAMMI INTEGRATI ONCOLOGIA (PIO)

PROGETTO N. 6
TOMOTHERAPY TECHNOLOGY ASSESSMENT IN RADIATION ONCOLOGY

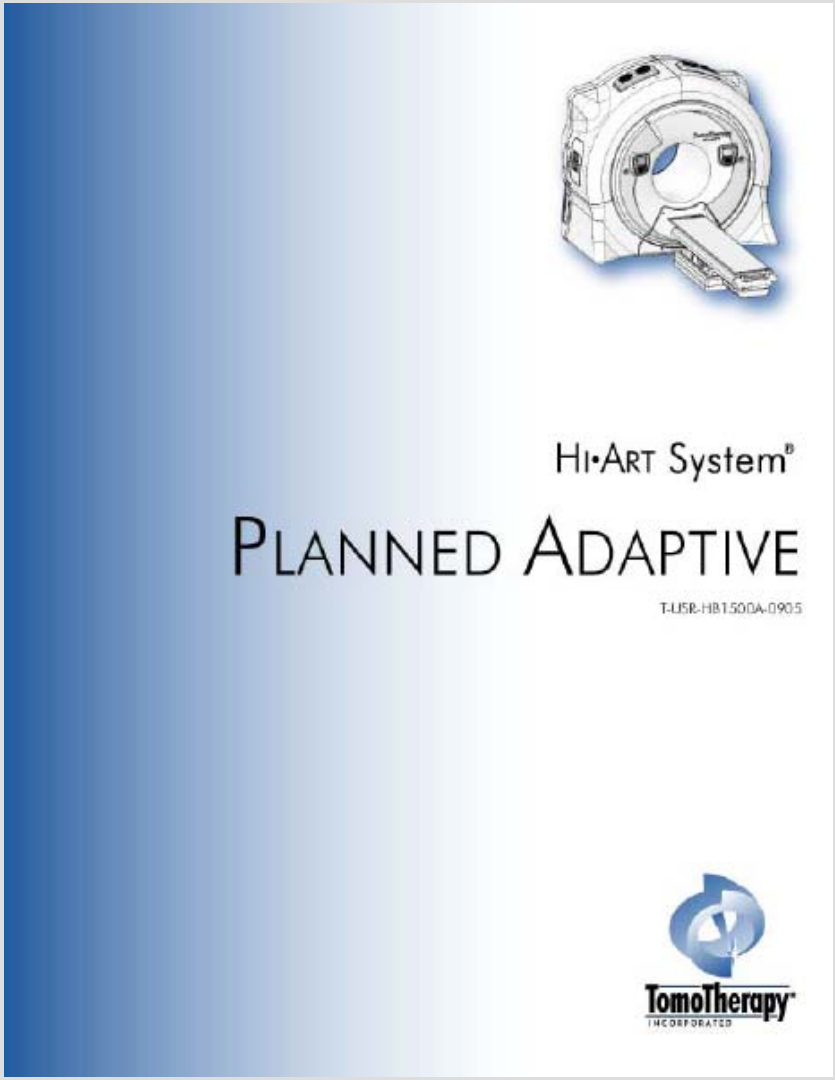
Valutare il valore aggiunto e l'impatto clinico, organizzativo ed economico dell'apparecchiatura di Tomoterapia (IMRT elicoidale + IGRT + ADAPTIVE) rispetto ad una apparecchiatura convenzionale per IMRT

unità partecipanti	responsabili scientifici	tema sottoprogetti
CRO AVIANO	**M.G. Trovò**	**Planned adaptive**
HSR MILANO	F. Fazio - N.Di Muzio	ipofrazionamento
ASMN R.EMILIA	C.Iotti -M. Iori	biological target volume
AOU MODENA	F. Bertoni	Tomotherapy TBI



Obbiettivi e Finalità

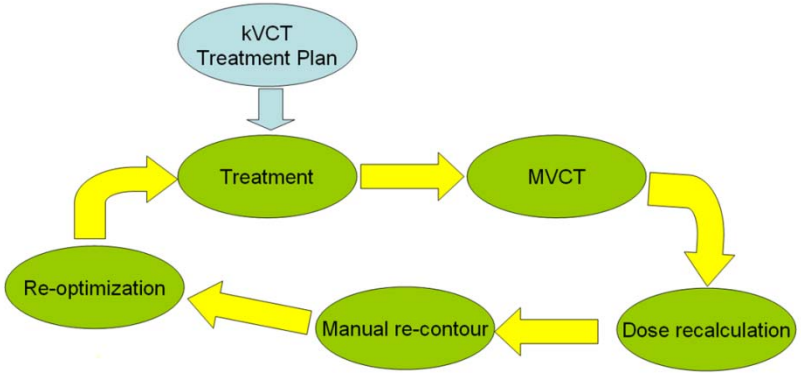
- Valutare le prestazioni offerte dal software
- Definire dei protocolli di applicazione del software
- Valutare le conseguenze dosimetriche (efficacia)
- Valutare le conseguenze organizzative (efficienza)

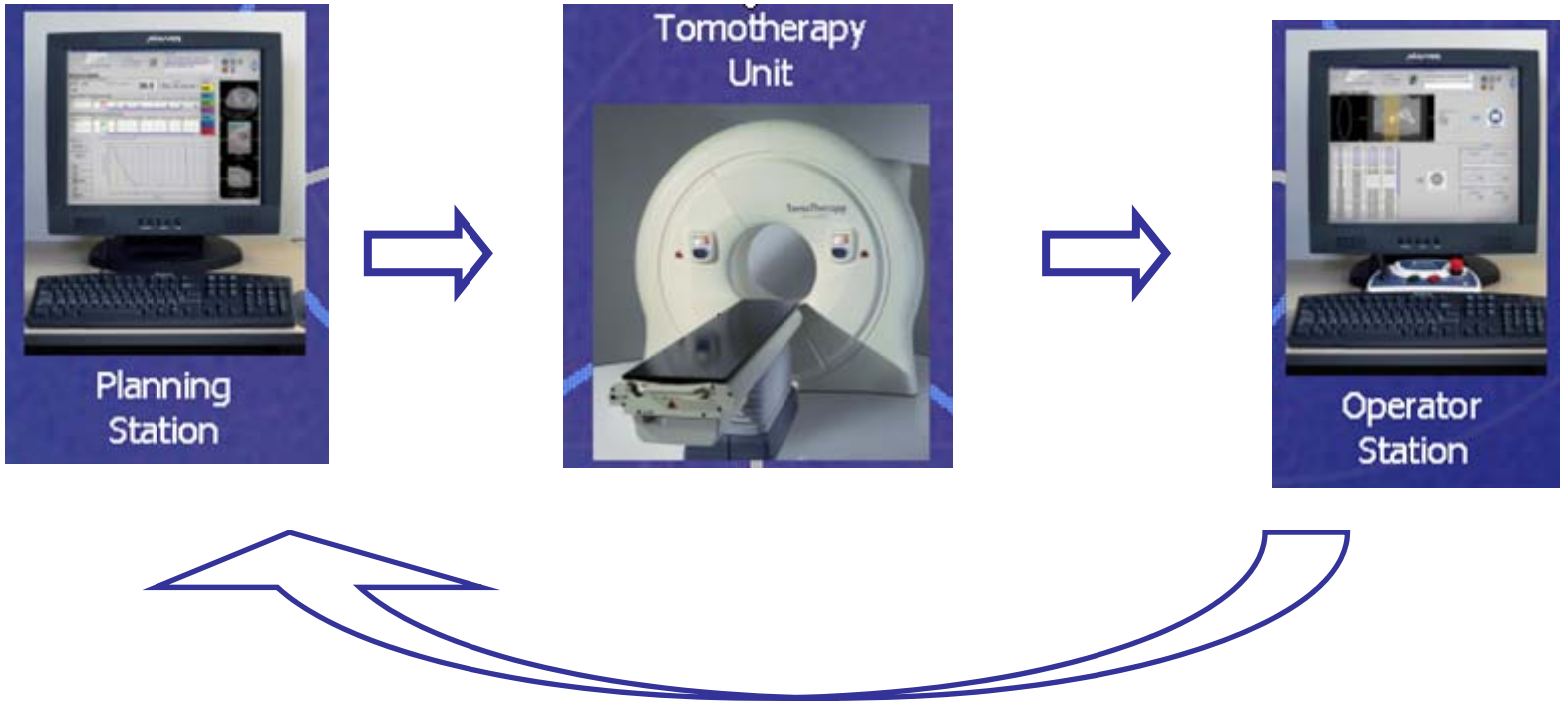


Il software permette

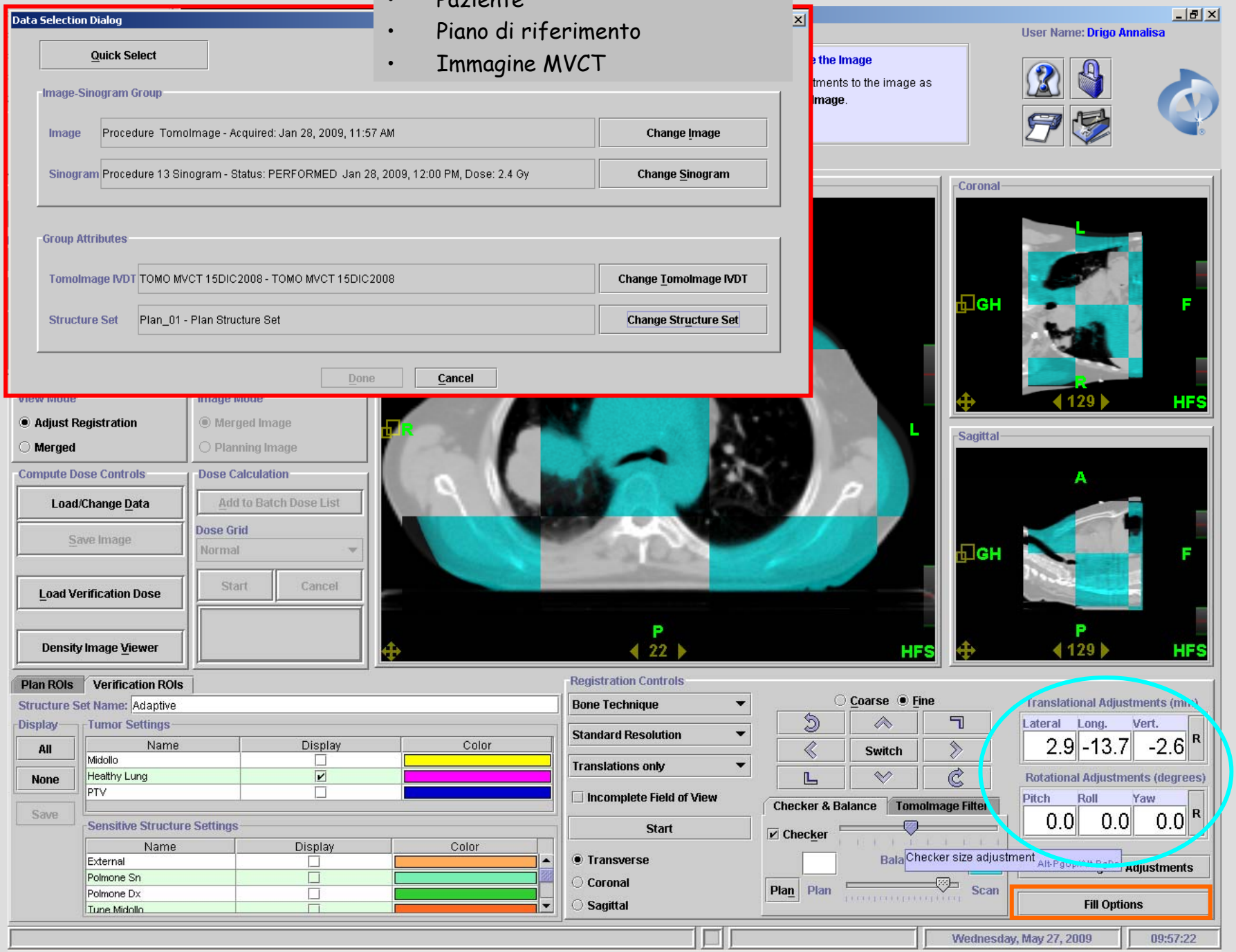
- Il confronto giornaliero tra l' anatomia di pianificazione e l' anatomia di trattamento
- il calcolo della dose effettivamente rilasciata al paziente
- la correzione delle discrepanze tra dose pianificata e dose effettivamente impartita

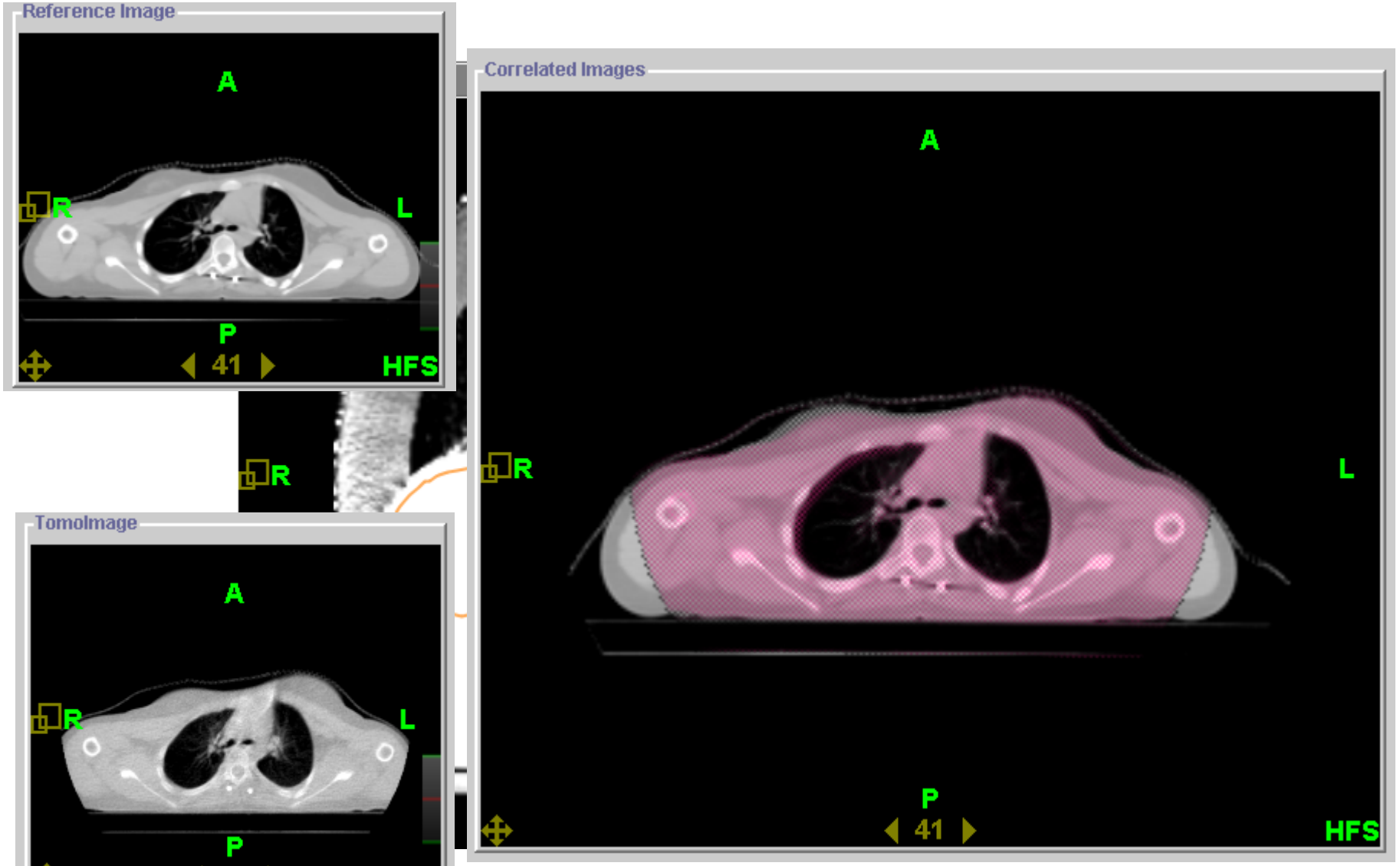
PLANNED ADAPTIVE

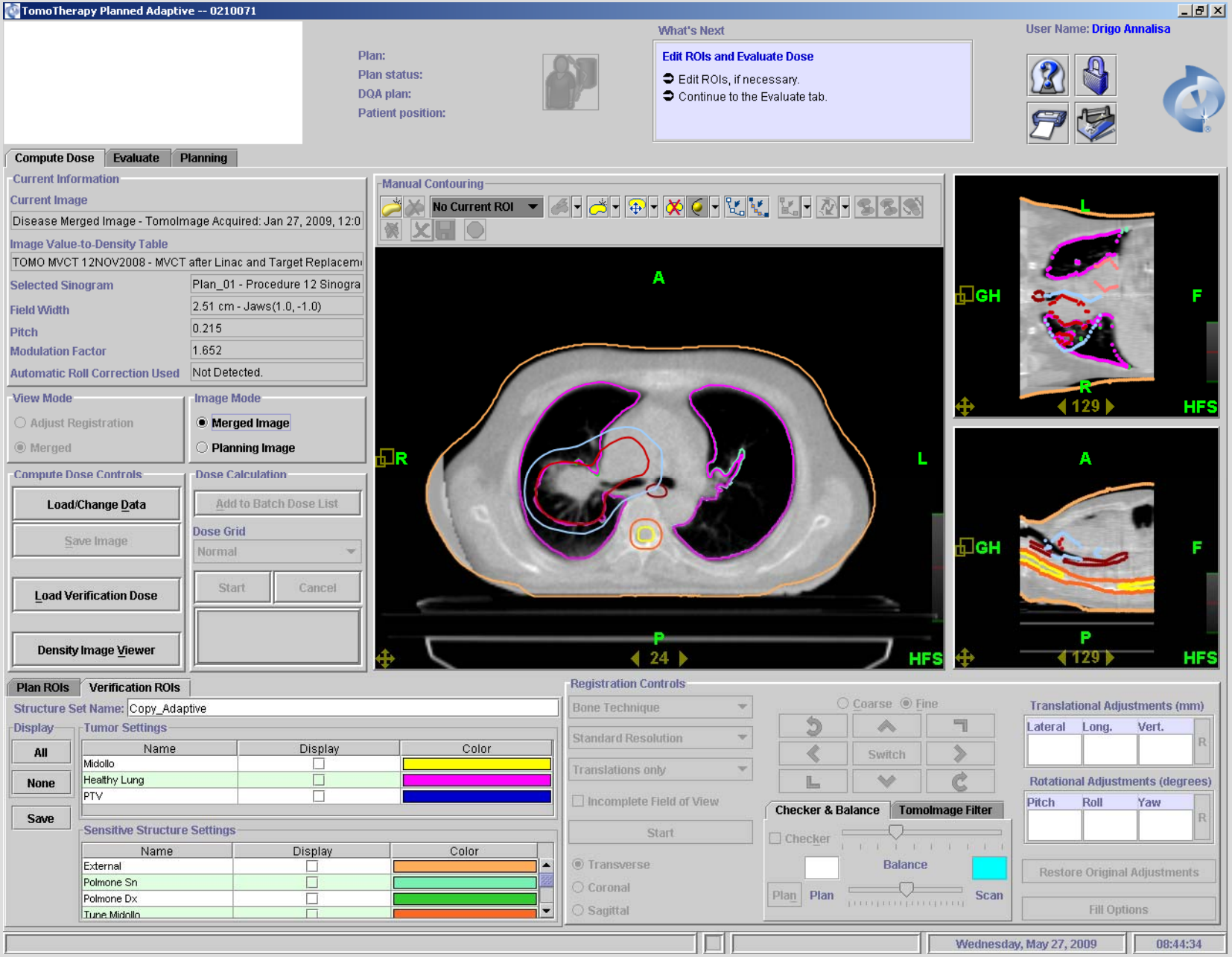


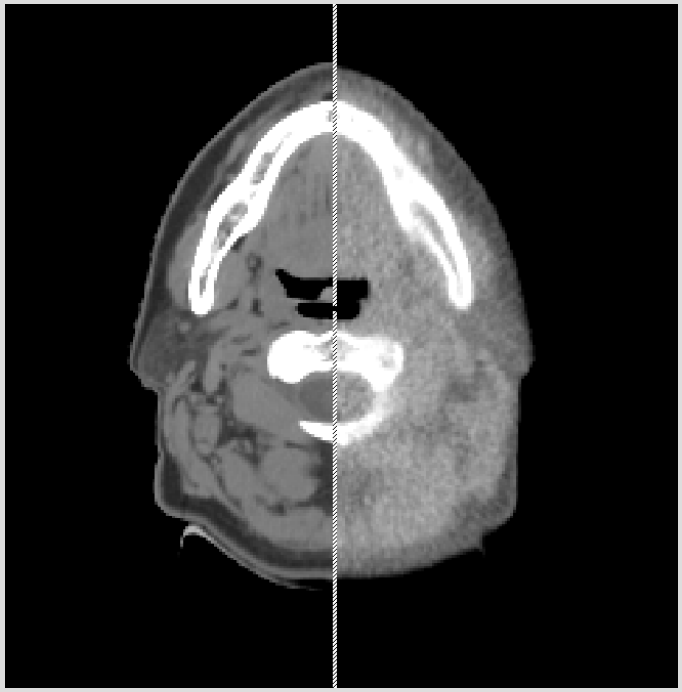


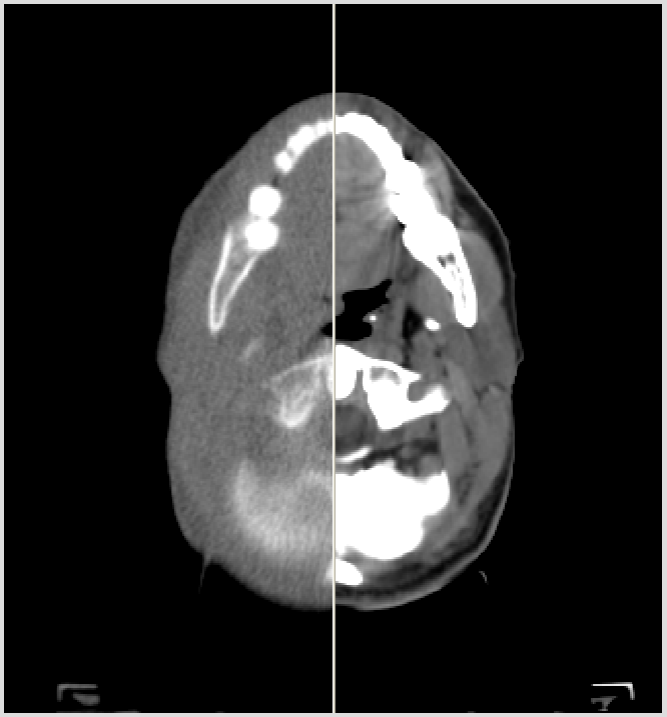
- Paziente
- Piano di riferimento
- Immagine MVCT

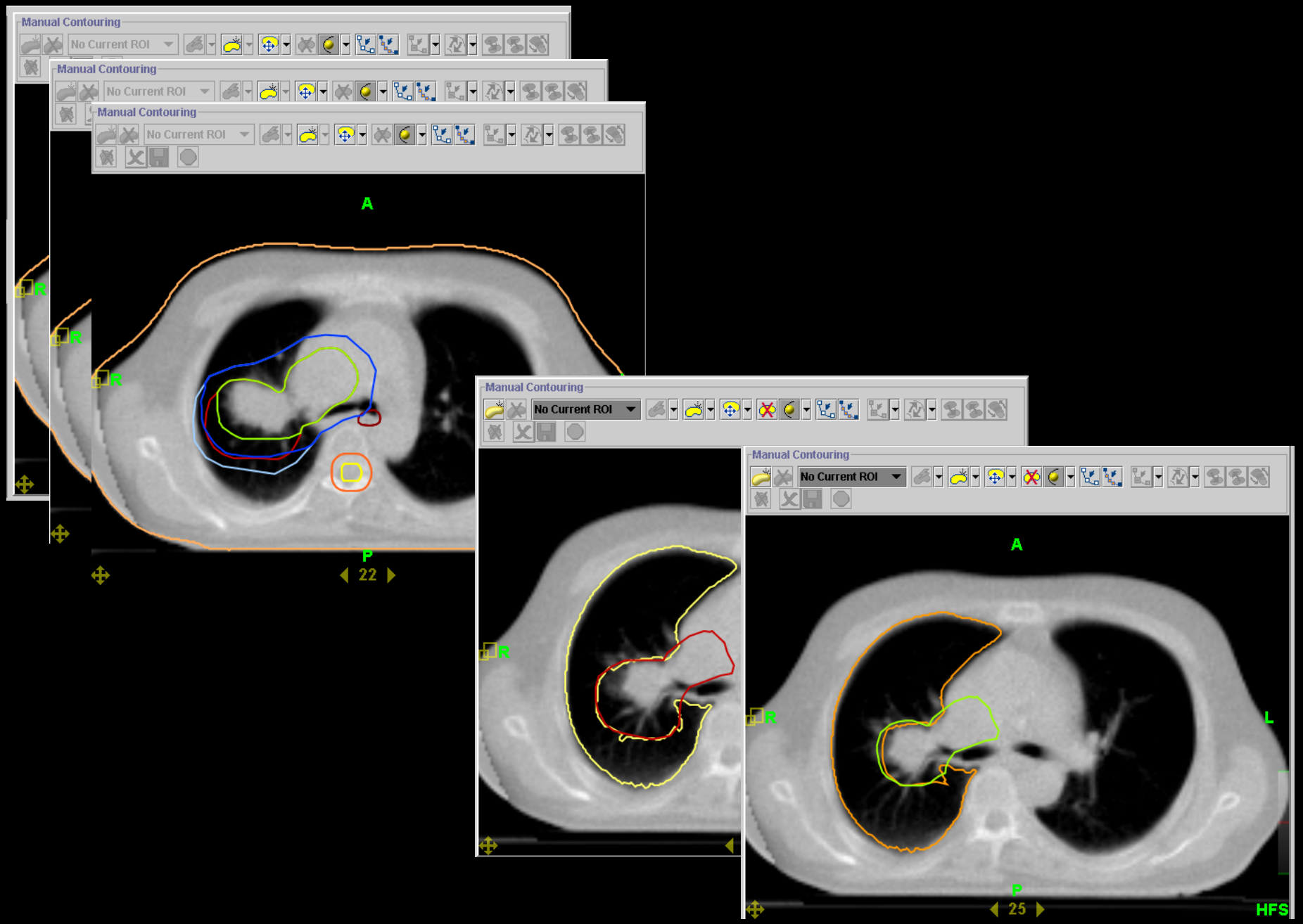


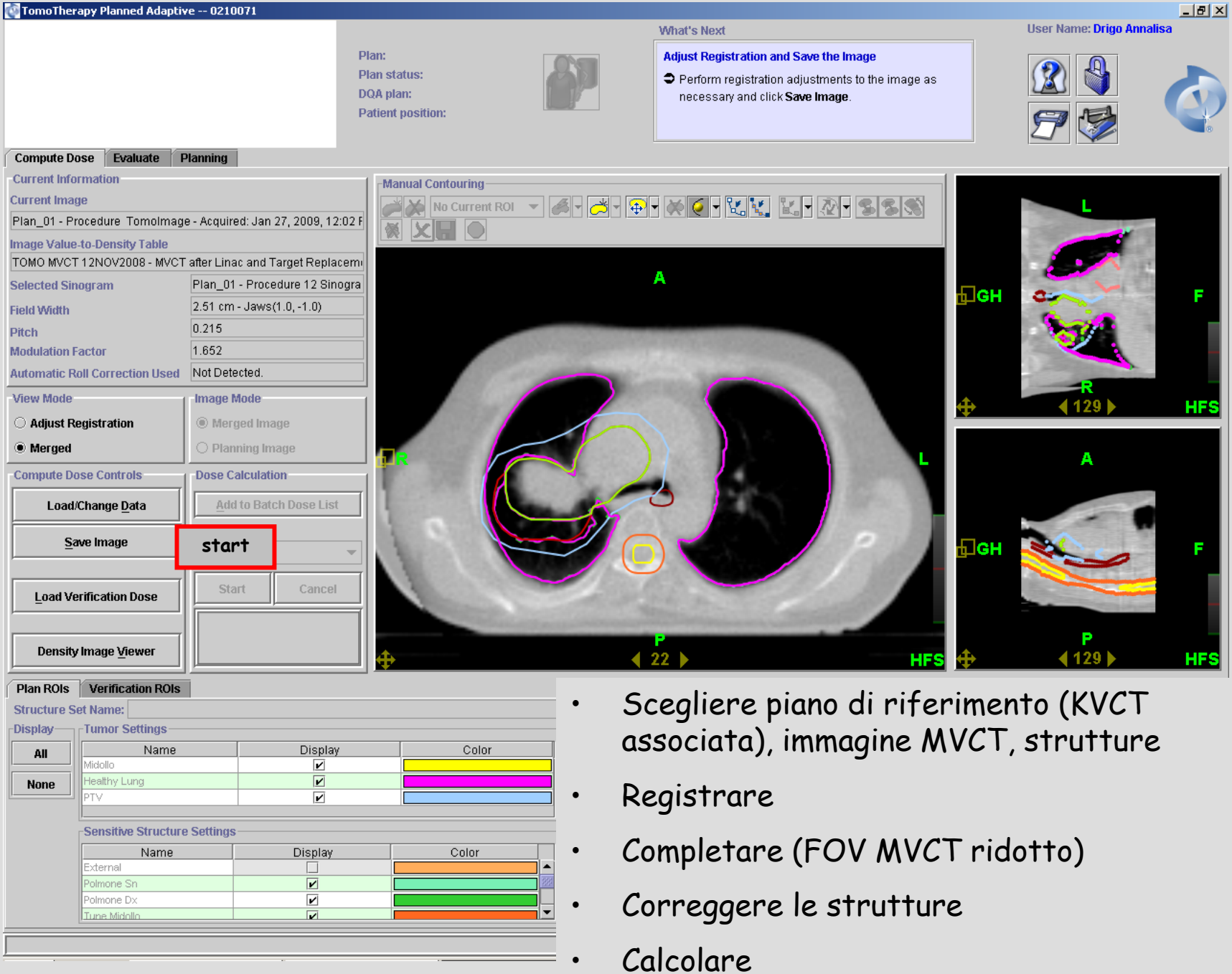

Reference Image
A
R
L
P
41
HFS
R
TomoImage
A
R
L
P
39
HFS
Correlated Images
A
R
L
P
41
HFS


TomoTherapy Planned Adaptive -- 0210071
Plan:
Plan status:
DQA plan:
Patient position:
What's Next
Edit ROIs and Evaluate Dose
Edit ROIs, if necessary.
Continue to the Evaluate tab.
User Name: Drigo Annalisa
Compute Dose
Evaluate
Planning
Current Information
Current Image
Disease Merged Image - TomoImage Acquired: Jan 27, 2009, 12:0
Image Value-to-Density Table
TOMO MVCT 12NOV2008 - MVCT after Linac and Target Replacem
Selected Sinogram
Plan_01 - Procedure 12 Sinogra
Field Width
2.51 cm - Jaws(1.0, -1.0)
Pitch
0.215
Modulation Factor
1.652
Automatic Roll Correction Used
Not Detected.
View Mode
Adjust Registration
Merged
Image Mode
Merged Image
Planning Image
Compute Dose Controls
Load/Change Data
Save Image
Load Verification Dose
Density Image Viewer
Dose Calculation
Add to Batch Dose List
Dose Grid
Normal
Start
Cancel
Manual Contouring
No Current ROI
A
R
L
P
24
HFS
L
GH
F
R
129
HFS
A
GH
F
P
129
HFS
Plan ROIs
Verification ROIs
Structure Set Name: Copy_Adaptive
Display
All
None
Save
Tumor Settings
Name
Display
Color
Midollo
Healthy Lung
PTV
Sensitive Structure Settings
Name
Display
Color
External
Polmone Sn
Polmone Dx
Tune Midollo
Registration Controls
Bone Technique
Standard Resolution
Translations only
Incomplete Field of View
Start
Transverse
Coronal
Sagittal
Coarse
Fine
Switch
Checker & Balance
TomoImage Filter
Checker
Balance
Plan
Plan
Scan
Translational Adjustments (mm)
Lateral
Long.
Vert.
R
Rotational Adjustments (degrees)
Pitch
Roll
Yaw
R
Restore Original Adjustments
Fill Options
Wednesday, May 27, 2009
08:44:34

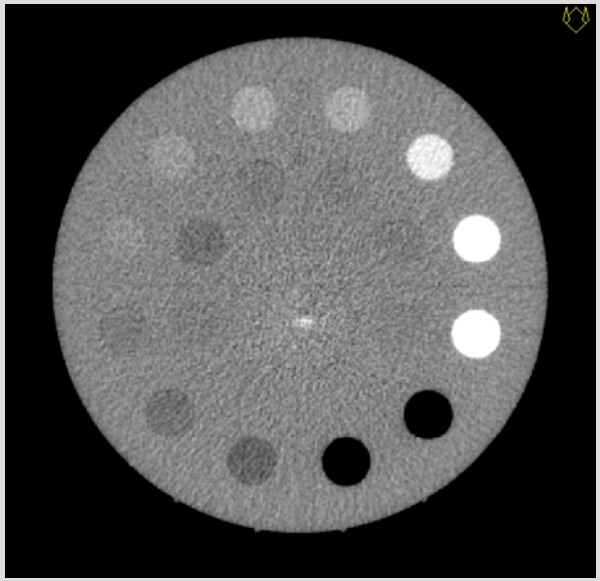


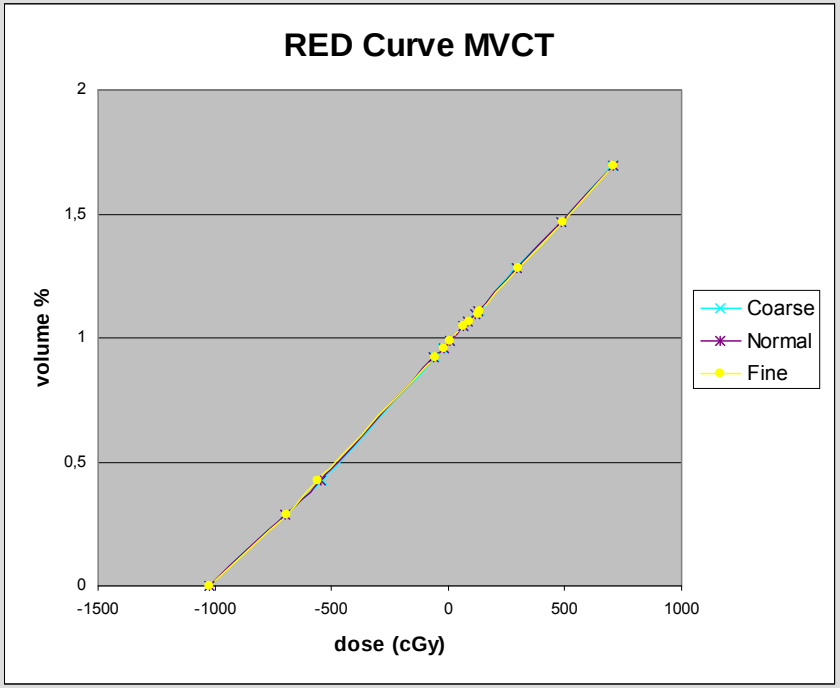



Manual Contouring
No Current ROI
A
R
P
22
Manual Contouring
No Current ROI
A
R
L
P
25
HFS



- Scegliere piano di riferimento (KVCT associata), immagine MVCT, strutture
- Registrare
- Completare (FOV MVCT ridotto)
- Correggere le strutture
- Calcolare




RED Curve MVCT
volume %
2
1,5
1
0,5
0
-1500
-1000
-500
0
500
1000
dose (cGy)
Coarse
Normal
Fine

INSTITUTE OF PHYSICS PUBLISHING PHYSICS IN MEDICINE AND BIOLOGY

Phys. Med. Biol. **50** (2005) 4259–4276 doi:10.1088/0031-9155/50/18/002

The use of megavoltage CT (MVCT) images for dose recomputations

K M Langen[1], S L Meeks[1], D O Poole[1], T H Wagner[1], T R Willoughby[1], P A Kupelian[1], K J Ruchala[2], J Haimerl[2] and G H Olivera[2]

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[2] TomoTherapy, Inc., Madison, WI 52717, USA

E-mail: Katja.Langen@orhs.org

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Online at stacks.iop.org/PMB/50/4259

Technology in Cancer Research and Treatment
ISSN 1533-0346
Volume 7, Number 6, December 2008

Consistency Check of Planned Adaptive® Option on Helical Tomotherapy

www.tcrt.org

This study aims to evaluate a new Planned Adaptive® software (TomoTherapy Inc., Madison, WI) of the helical tomotherapy system by retrospective verification and adaptive re-planning of radiation treatment. Four patients with different disease sites (brain, nasal cavity, lungs, prostate) were planned in duplicate using the diagnostic planning kVCT data set and MVCT studies of the first treatment fraction with the same optimization parameters for both plan types. The dosimetric characteristics of minimum, maximum, and mean dose to the targets as well as to organs at risk were compared. Both sets of plans were used for calculation of dose distributions in a water-equivalent phantom. Corresponding measurements of these plans in phantom were carried out with the use of radiographic film and ion chamber. In the case of the lung and prostate cancer patients, changes in dosimetric parameters compared to data generated with the kVCT study alone were less than 2%. Certain changes for the nasal cavity and brain cancer patients were greater than 2%, but they were explained in part by anatomy changes that occurred during the time between kVCT and MVCT studies. The Planned Adaptive software allows for adaptive radiotherapy planning using the MVCT studies obtained by the helical tomotherapy imaging system.

Maximilien Schirm[1]
Slav Yartsev, Ph.D.[1,2,*]
Glenn Bauman, MD[1,2]
Jerry Battista, Ph.D.[1,2]
Jake Van Dyk, M.Sc.[1,2]

[1]London Regional Cancer Program
London Health Sciences Center
790 Commissioners Road East
London, Ontario, Canada
[2]The University of Western Ontario
London, Ontario, Canada

TomoTherapy INCORPORATED

Reference: 4065

Product Advisory Notice

TomoTherapy® HI•ART System®

April 27, 2009

Dear TomoTherapy Customer,

As a result of input received from TomoTherapy HI-ART customers, an MVCT planning issue has been identified that we would like to bring to your attention.

Issue:

An issue has been discovered when generating treatment plans created from MVCT images. This issue does not affect treatment plans created with diagnostic CT images. Specifically, CT pixel values for MVCT images may drift over time due to changes of the MVCT beam quality which results from variations in machine performance, e.g. target wear. In specific cases, month to month checks of the CT pixel values have shown changes as large as 3%, with 4% changes over the course of a year.

Treatment plans which use the MVCT images without an updated Image Value to Density Table (IVDT) could result in inaccurate dose calculations. A 4% change in pixel values could result in a 1-3% change in calculated dose, depending on the depth.

Product Affected:

This only affects treatment plans created with MVCT images for all HI-ART System configurations. This does not affect treatment plans created with diagnostic CT images.

Recommended User Action:

1. Check existing IVDTs created for MVCT images with a new MVCT image of the TomoPhantom with density plugs inserted to ensure the table values are still correct.
2. Periodically verify the accuracy of the IVDTs created for MVCT images.
3. Verify the accuracy of IVDTs created for MVCT images following target or linac replacement.
4. Continue to perform patient DQA, as this will detect dose discrepancies prior to treatment.

www.TomoTherapy.com 1240 Deming Way | Madison, WI 53717-1954 | 608-824-2800 | Fax 608-824-2996

TomoTherapy Planned Adaptive -- 0210071

Plan:
Plan status:
DQA plan:
Patient position:

What's Next

Evaluate Dose

➲ Evaluate the verification dose.

User Name: Drigo Annalisa

Compute Dose | Evaluate | Planning

Dose Selection

- [x] Verification Dose (Dashed)
- [x] Planning Dose (Solid)
- [ ] Dose Difference

Verification Dose List

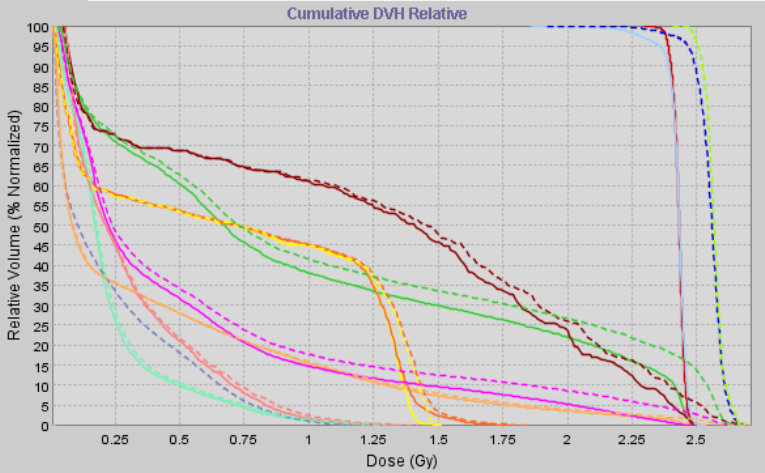
Plan_01 - Procedure 12 Sinogram performed at Jan 27, 2009, 12:04 PM / TomoImage ac...

Isodose Control

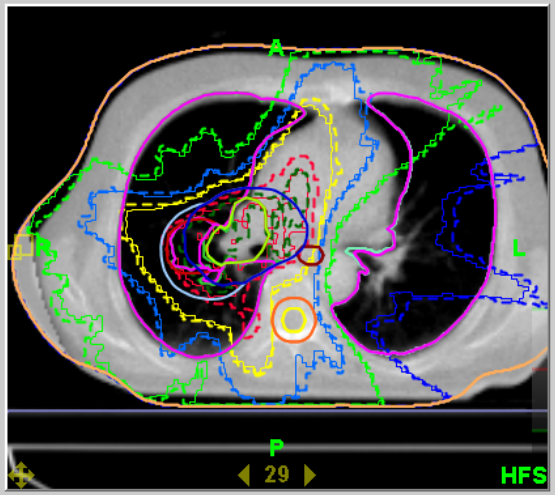
- [x] Isodose

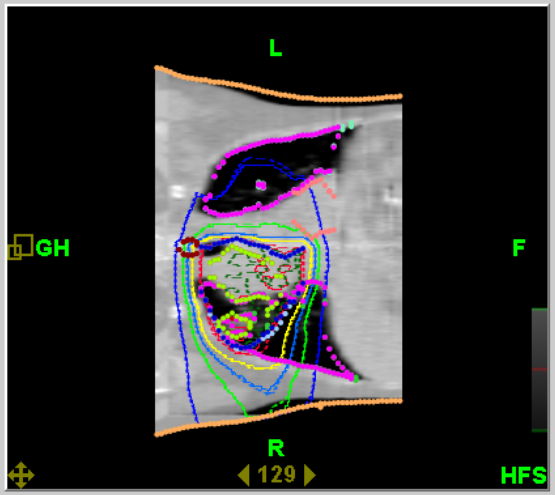
2.568
2.4
1.68
1.2
0.72
0.2

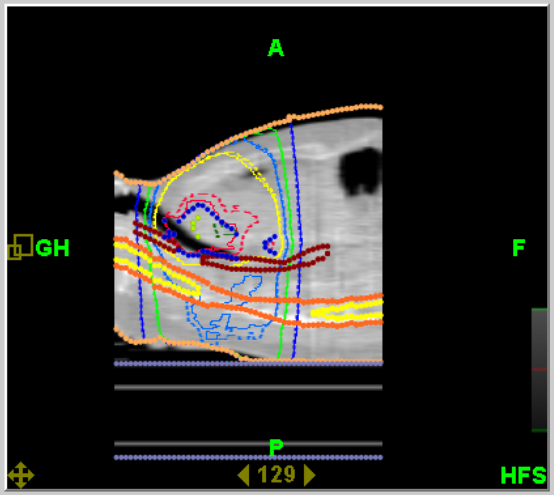
DVH Tool | Plan ROIs | Verification ROIs



Vol Min: -0.0 Vol Max: 100.0 Gy Min: 0.008 Gy Max: 2.708

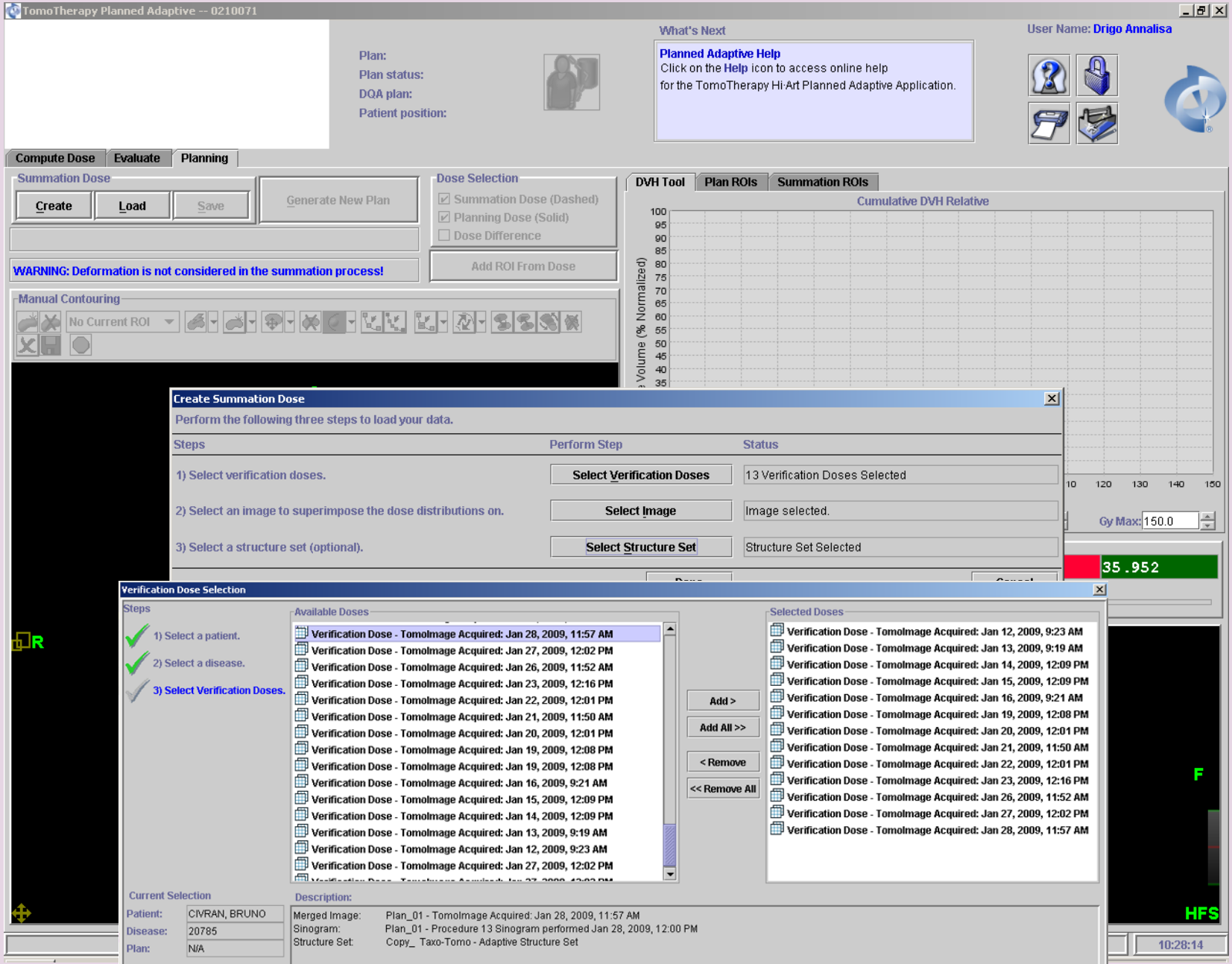


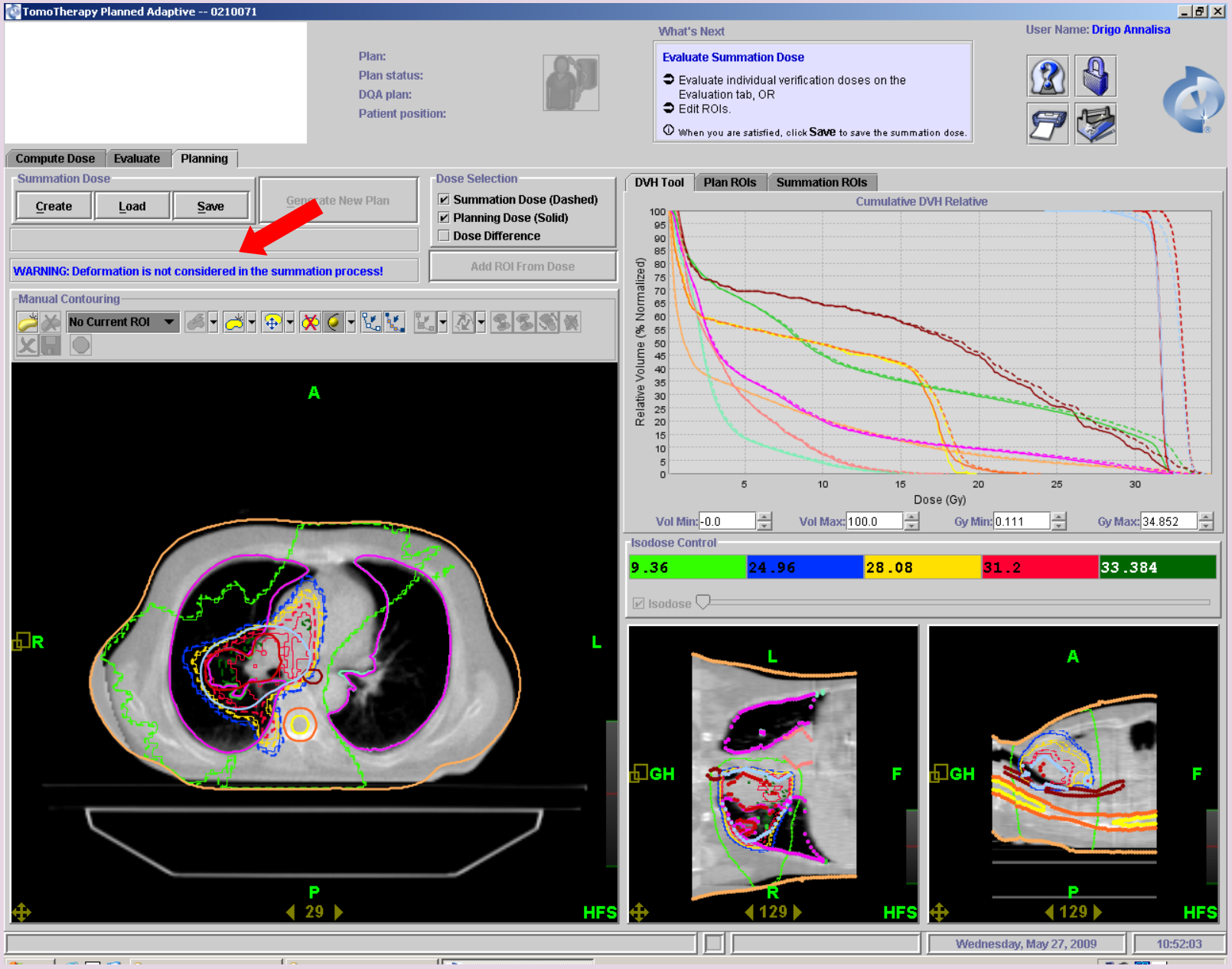


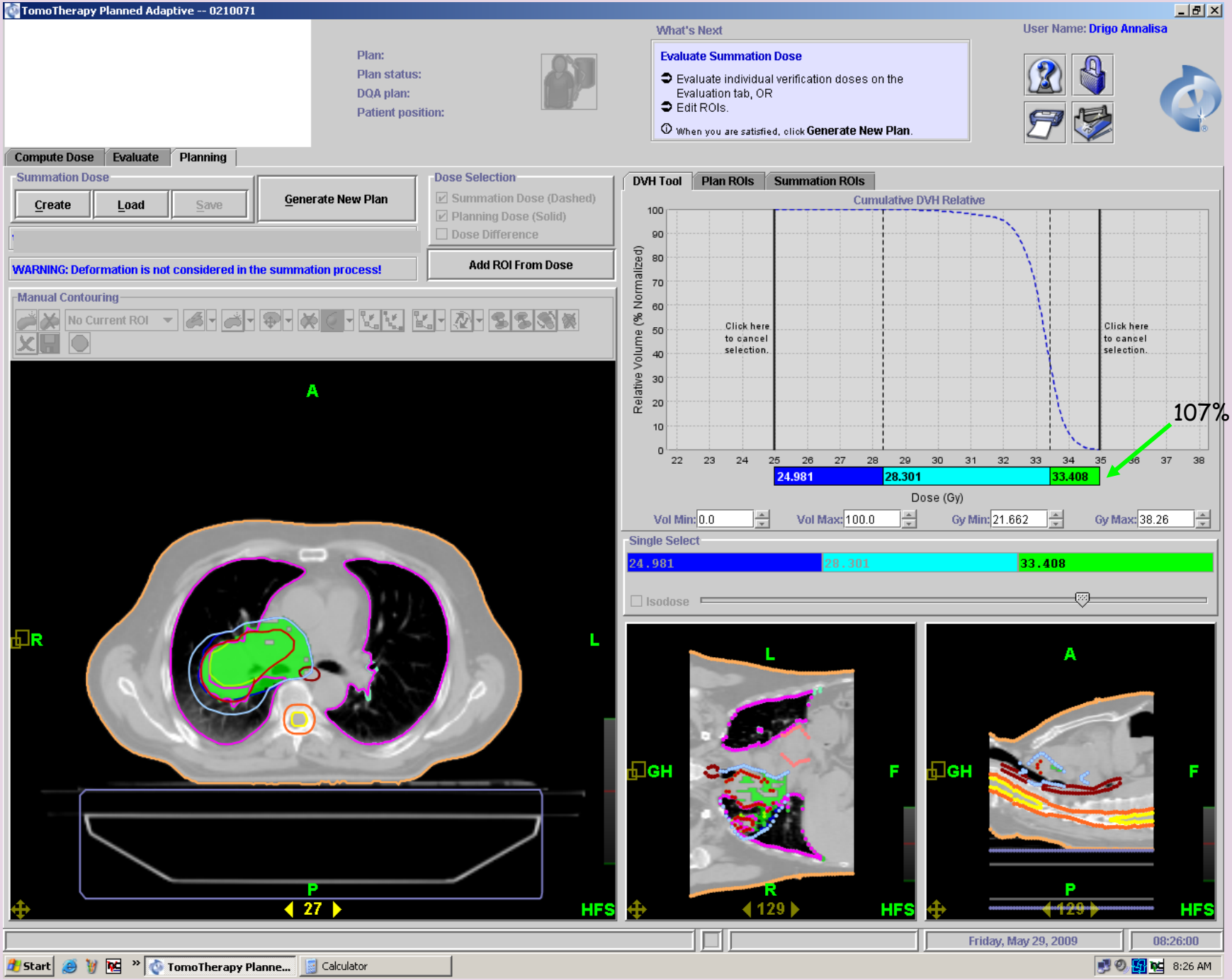


Wednesday, May 27, 2009 08:50:28


TomoTherapy Planned Adaptive -- 0210071
Plan:
Plan status:
DQA plan:
Patient position:
What's Next
Evaluate Doses
From the Verification Dose List, select a dose to evaluate.
User Name: Roggio Antonella
Compute Dose
Evaluate
Planning
Dose Selection
Verification Dose (Dashed)
Planning Dose (Solid)
Dose Difference
Verification Dose List
Plan_01 - Procedure 1 Sinogram performed at Jan 12, 2009, 9:26 AM / TomoImage acquir...
Diff Control
Isodose
0.2
0.175
0.15
0.1
DVH Tool
Plan ROIs
Verification ROIs
Differential DVH Relative
Relative Volume (% Normalized)
Dose (Gy)
Vol Min: 0.0
Vol Max: 7.798
Gy Min: -0.039
Gy Max: 0.245
A
R
L
P
29
HFS
L
GH
F
R
129
HFS
A
GH
F
P
129
HFS
Thursday, May 28, 2009
17:40:30
Start
TomoTherapy Planning S...
TomoTherapy Planne...
5:40 PM


TomoTherapy Planned Adaptive -- 0210071
Plan:
Plan status:
DQA plan:
Patient position:
What's Next
Planned Adaptive Help
Click on the Help icon to access online help
for the TomoTherapy Hi·Art Planned Adaptive Application.
User Name: Drigo Annalisa
Compute Dose
Evaluate
Planning
Summation Dose
Create
Load
Save
Generate New Plan
Dose Selection
Summation Dose (Dashed)
Planning Dose (Solid)
Dose Difference
Add ROI From Dose
WARNING: Deformation is not considered in the summation process!
Manual Contouring
No Current ROI
DVH Tool
Plan ROIs
Summation ROIs
Cumulative DVH Relative
Volume (% Normalized)
Gy Max:
150.0
35.952
Create Summation Dose
Perform the following three steps to load your data.
Steps
Perform Step
Status
1) Select verification doses.
Select Verification Doses
13 Verification Doses Selected
2) Select an image to superimpose the dose distributions on.
Select Image
Image selected.
3) Select a structure set (optional).
Select Structure Set
Structure Set Selected
Verification Dose Selection
Steps
1) Select a patient.
2) Select a disease.
3) Select Verification Doses.
Available Doses
Verification Dose - TomoImage Acquired: Jan 28, 2009, 11:57 AM
Verification Dose - TomoImage Acquired: Jan 27, 2009, 12:02 PM
Verification Dose - TomoImage Acquired: Jan 26, 2009, 11:52 AM
Verification Dose - TomoImage Acquired: Jan 23, 2009, 12:16 PM
Verification Dose - TomoImage Acquired: Jan 22, 2009, 12:01 PM
Verification Dose - TomoImage Acquired: Jan 21, 2009, 11:50 AM
Verification Dose - TomoImage Acquired: Jan 20, 2009, 12:01 PM
Verification Dose - TomoImage Acquired: Jan 19, 2009, 12:08 PM
Verification Dose - TomoImage Acquired: Jan 19, 2009, 12:08 PM
Verification Dose - TomoImage Acquired: Jan 16, 2009, 9:21 AM
Verification Dose - TomoImage Acquired: Jan 15, 2009, 12:09 PM
Verification Dose - TomoImage Acquired: Jan 14, 2009, 12:09 PM
Verification Dose - TomoImage Acquired: Jan 13, 2009, 9:19 AM
Verification Dose - TomoImage Acquired: Jan 12, 2009, 9:23 AM
Verification Dose - TomoImage Acquired: Jan 27, 2009, 12:02 PM
Add >
Add All >>
< Remove
<< Remove All
Selected Doses
Verification Dose - TomoImage Acquired: Jan 12, 2009, 9:23 AM
Verification Dose - TomoImage Acquired: Jan 13, 2009, 9:19 AM
Verification Dose - TomoImage Acquired: Jan 14, 2009, 12:09 PM
Verification Dose - TomoImage Acquired: Jan 15, 2009, 12:09 PM
Verification Dose - TomoImage Acquired: Jan 16, 2009, 9:21 AM
Verification Dose - TomoImage Acquired: Jan 19, 2009, 12:08 PM
Verification Dose - TomoImage Acquired: Jan 20, 2009, 12:01 PM
Verification Dose - TomoImage Acquired: Jan 21, 2009, 11:50 AM
Verification Dose - TomoImage Acquired: Jan 22, 2009, 12:01 PM
Verification Dose - TomoImage Acquired: Jan 23, 2009, 12:16 PM
Verification Dose - TomoImage Acquired: Jan 26, 2009, 11:52 AM
Verification Dose - TomoImage Acquired: Jan 27, 2009, 12:02 PM
Verification Dose - TomoImage Acquired: Jan 28, 2009, 11:57 AM
Current Selection
Patient:
CIVRAN, BRUNO
Disease:
20785
Plan:
N/A
Description:
Merged Image:
Plan_01 - TomoImage Acquired: Jan 28, 2009, 11:57 AM
Sinogram:
Plan_01 - Procedure 13 Sinogram performed Jan 28, 2009, 12:00 PM
Structure Set:
Copy_ Taxo-Tomo - Adaptive Structure Set
<< Back
Next >>
Finish
Cancel
R
F
HFS
10:28:14


TomoTherapy Planned Adaptive -- 0210071
Plan:
Plan status:
DQA plan:
Patient position:
What's Next
Evaluate Summation Dose
Evaluate individual verification doses on the Evaluation tab, OR
Edit ROIs.
When you are satisfied, click Save to save the summation dose.
User Name: Drigo Annalisa
Compute Dose
Evaluate
Planning
Summation Dose
Create
Load
Save
Generate New Plan
WARNING: Deformation is not considered in the summation process!
Dose Selection
Summation Dose (Dashed)
Planning Dose (Solid)
Dose Difference
Add ROI From Dose
Manual Contouring
No Current ROI
DVH Tool
Plan ROIs
Summation ROIs
Cumulative DVH Relative
Relative Volume (% Normalized)
Dose (Gy)
Vol Min: -0.0
Vol Max: 100.0
Gy Min: 0.111
Gy Max: 34.852
Isodose Control
9.36
24.96
28.08
31.2
33.384
Isodose
A
R
L
P
29
HFS
L
GH
F
R
129
HFS
A
GH
F
P
129
HFS
Wednesday, May 27, 2009
10:52:03


TomoTherapy Planned Adaptive -- 0210071
Plan:
Plan status:
DQA plan:
Patient position:
What's Next
Evaluate Summation Dose
Evaluate individual verification doses on the Evaluation tab, OR
Edit ROIs.
When you are satisfied, click Generate New Plan.
User Name: Drigo Annalisa
Compute Dose
Evaluate
Planning
Summation Dose
Create
Load
Save
Generate New Plan
Dose Selection
Summation Dose (Dashed)
Planning Dose (Solid)
Dose Difference
Add ROI From Dose
WARNING: Deformation is not considered in the summation process!
Manual Contouring
No Current ROI
DVH Tool
Plan ROIs
Summation ROIs
Cumulative DVH Relative
Relative Volume (% Normalized)
Click here to cancel selection.
Click here to cancel selection.
107%
24.981
28.301
33.408
Dose (Gy)
Vol Min: 0.0
Vol Max: 100.0
Gy Min: 21.662
Gy Max: 38.26
Single Select
24.981
28.301
33.408
Isodose
A
R
L
P
27
HFS
L
GH
F
R
129
HFS
A
GH
F
P
129
HFS
Friday, May 29, 2009
08:26:00
Start
TomoTherapy Planne...
Calculator
8:26 AM

TomoTherapy Planned Adaptive -- 0210071

Plan:
Plan status:
DQA plan:
Patient position:

What's Next

Evaluate Summation Dose

- Evaluate individual verification doses on the Evaluation tab, OR
- Edit ROIs.

When you are satisfied, click **Generate New Plan**.

User Name: Drigo Annalisa

Compute Dose | Evaluate | Planning

Summation Dose

Create | Load | Save | Generate New Plan

WARNING: Deformation is not considered in the summation process!

Dose Selection

- Summation Dose (Dashed)
- Planning Dose (Solid)
- Dose Difference

Add ROI From Dose

Manual Contouring

No Current ROI

DVH Tool | Plan ROIs | Summation ROIs

Cumulative DVH Relative

Relative Volume (% Normalized)

Click here to cancel selection.

Click here to cancel selection.

24.981 | 28.301 | 33.408

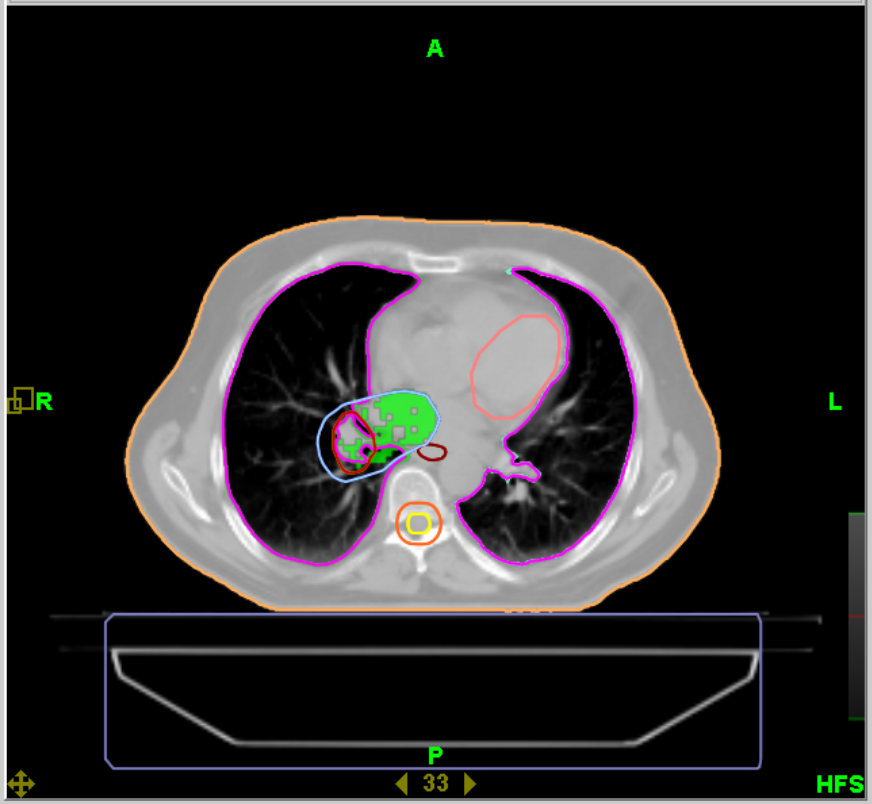
Dose (Gy)

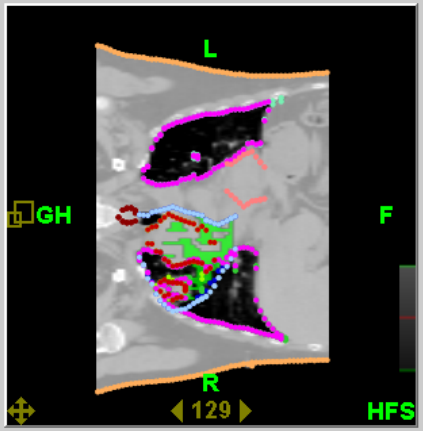
Vol Min: 0.0 Vol Max: 100.0 Gy Min: 21.662 Gy Max: 38.26

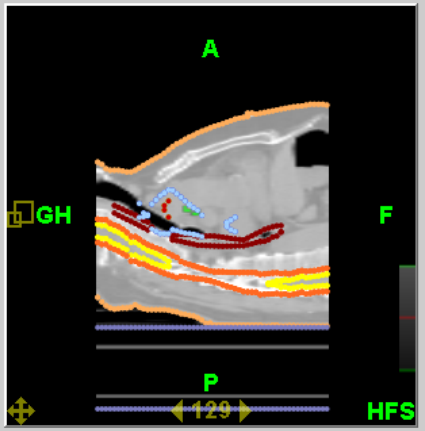
Single Select

24.981 | 28.301 | 33.408

Isodose

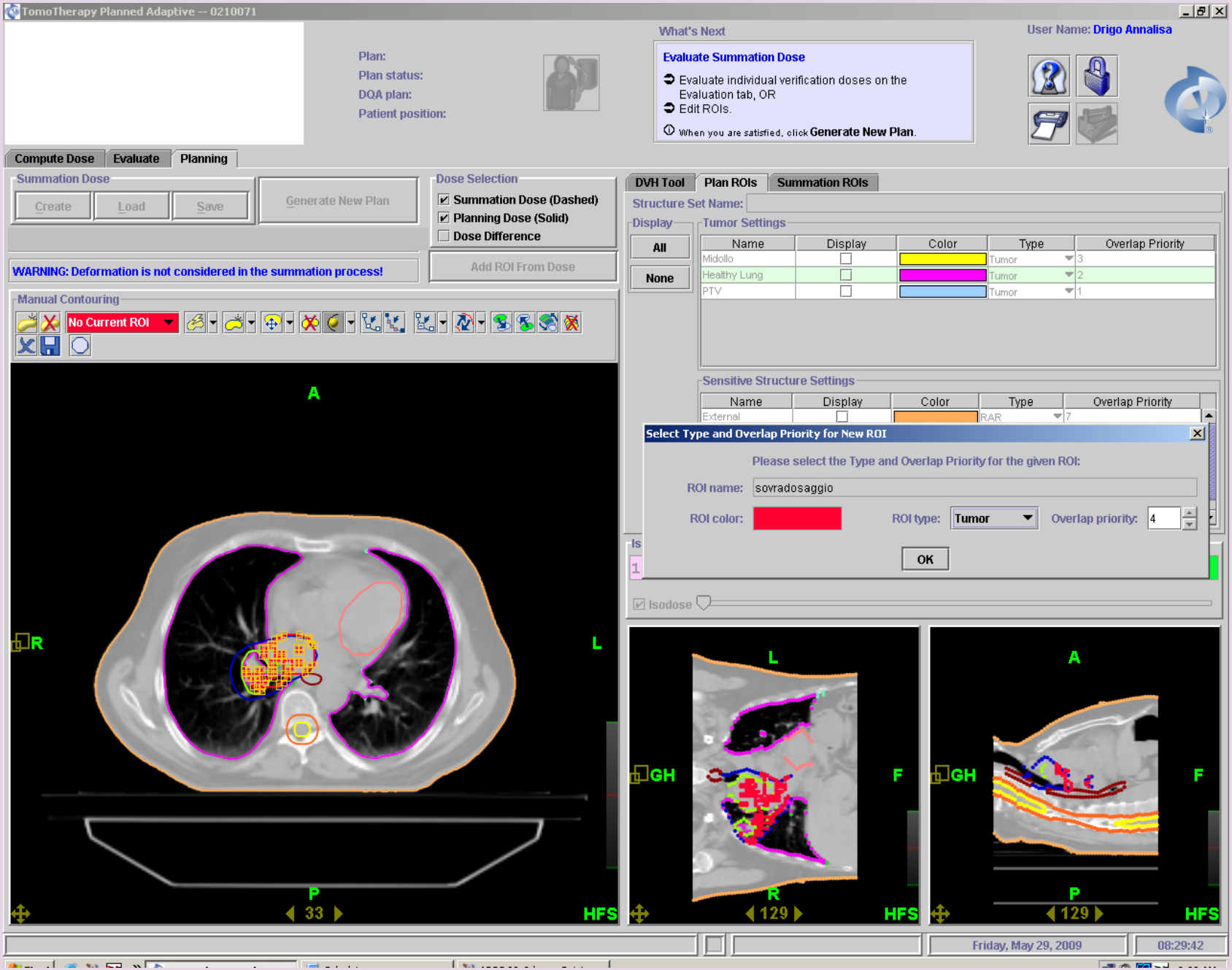


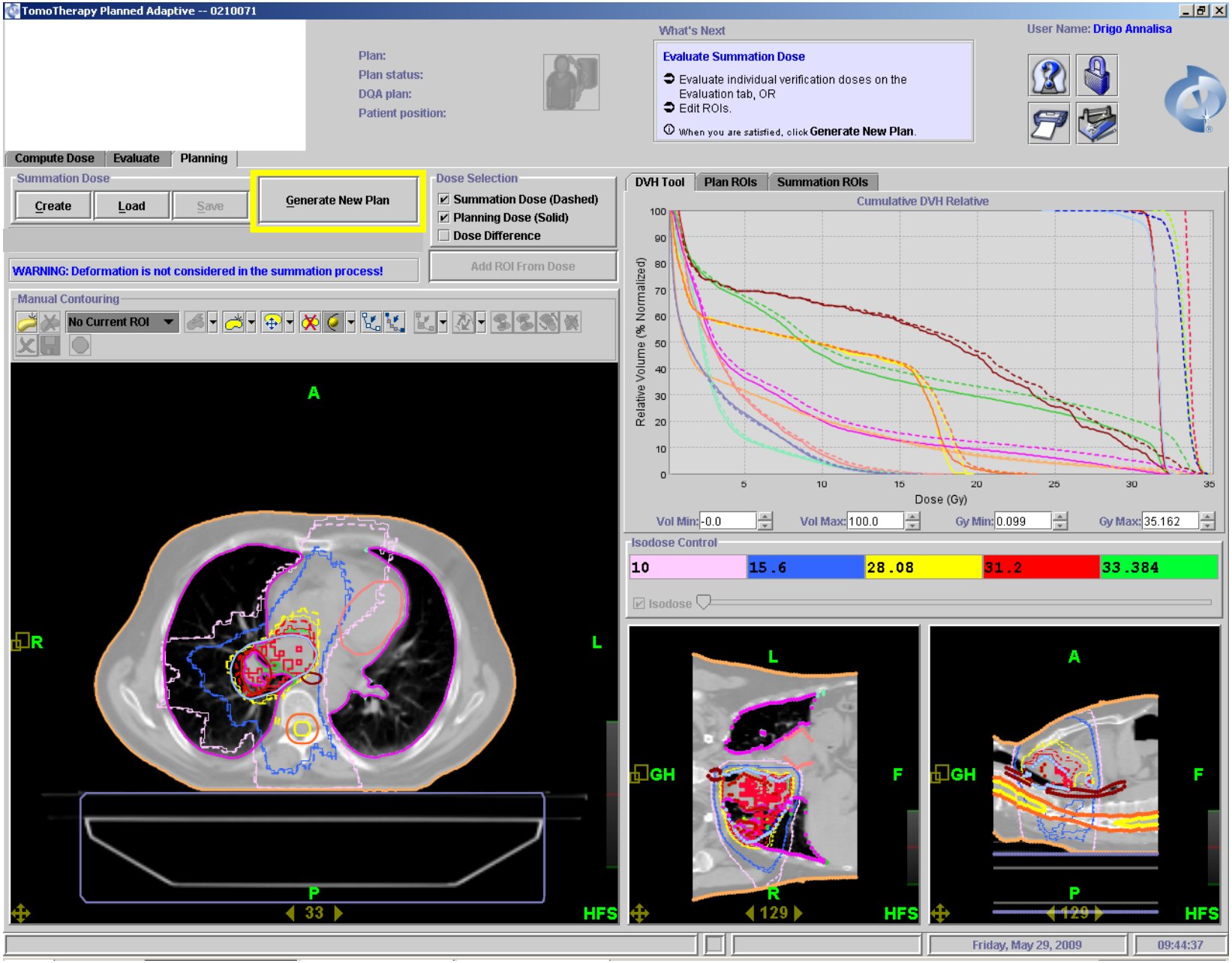




Friday, May 29, 2009 08:26:54

Start | TomoTherapy Planne... | Calculator | ADDROI_1.bmp - Paint | 8:26 AM


TomoTherapy Planned Adaptive -- 0210071
Plan:
Plan status:
DQA plan:
Patient position:
What's Next
Evaluate Summation Dose
Evaluate individual verification doses on the Evaluation tab, OR
Edit ROIs.
When you are satisfied, click Generate New Plan.
User Name: Drigo Annalisa
Compute Dose
Evaluate
Planning
Summation Dose
Create
Load
Save
Generate New Plan
Dose Selection
Summation Dose (Dashed)
Planning Dose (Solid)
Dose Difference
Add ROI From Dose
WARNING: Deformation is not considered in the summation process!
Manual Contouring
No Current ROI
DVH Tool
Plan ROIs
Summation ROIs
Structure Set Name:
Display
All
None
Tumor Settings
Name
Display
Color
Type
Overlap Priority
Midollo
Healthy Lung
PTV
Tumor
Sensitive Structure Settings
External
RAR
Select Type and Overlap Priority for New ROI
Please select the Type and Overlap Priority for the given ROI:
ROI name:
sovradosaggio
ROI color:
ROI type:
Tumor
Overlap priority:
4
OK
Isodose
A
R
L
P
33
HFS
GH
F
129
Friday, May 29, 2009
08:29:42


TomoTherapy Planned Adaptive -- 0210071
Plan:
Plan status:
DQA plan:
Patient position:
What's Next
Evaluate Summation Dose
Evaluate individual verification doses on the Evaluation tab, OR
Edit ROIs.
When you are satisfied, click Generate New Plan.
User Name: Drigo Annalisa
Compute Dose
Evaluate
Planning
Summation Dose
Create
Load
Save
Generate New Plan
Dose Selection
Summation Dose (Dashed)
Planning Dose (Solid)
Dose Difference
Add ROI From Dose
WARNING: Deformation is not considered in the summation process!
Manual Contouring
No Current ROI
DVH Tool
Plan ROIs
Summation ROIs
Cumulative DVH Relative
Relative Volume (% Normalized)
Dose (Gy)
Vol Min: -0.0
Vol Max: 100.0
Gy Min: 0.099
Gy Max: 35.162
Isodose Control
10
15.6
28.08
31.2
33.384
Isodose
A
R
L
P
33
HFS
L
GH
F
R
129
HFS
A
GH
F
P
129
HFS
Friday, May 29, 2009
09:44:37

- IGRT con riposizionamento giornaliero del paziente
- Modifica dei contorni al cambiare delle strutture anatomiche
- Valutazione della Dose basata su un'immagine giornaliera MVCT
- adattamento della dose di un piano non più corretto
- Sistema integrato
- Rapido confronto tra dose pianificata e dose erogata (per frazione)
- Disponibilità del set di contorni di pianificazione
- Somma su frazioni diverse
- Possibilità di individuare aree di sovradosaggio o sottodosaggio

- Qualità dell' immagine non ottimale per la ricontornazione
- No possibilità di confrontare con PET o NMR
- Necessità di acquisire immagini MVCT estese
- Ricontornazione manuale
- Procedure ridondanti
- No possibilità di confrontare tra loro immagini MVCT successive
- Attenzione nell' interpretazione dei DVH
- No disponibilità di funzioni statistiche
- Revisione dosi e vicoli nel nuovo piano

grazie per l'attenzione