Informatics tools supporting ATC activities

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School of Medicine

Div. of Bioinformatics and Outcomes Research Software developments

- Supported by
  - WUSTL
  - Tomotherapy (NTCP, TCP)
  - Varian (some dose calc and planning)
  - NIH R01s (data extraction, review, modeling)
  - RPC (Film QA, Monte Carlo dose calcs)
  - ATC (Extraction, DICOM, review, export, data mining, image registration, multi-modality, ?)

Outline

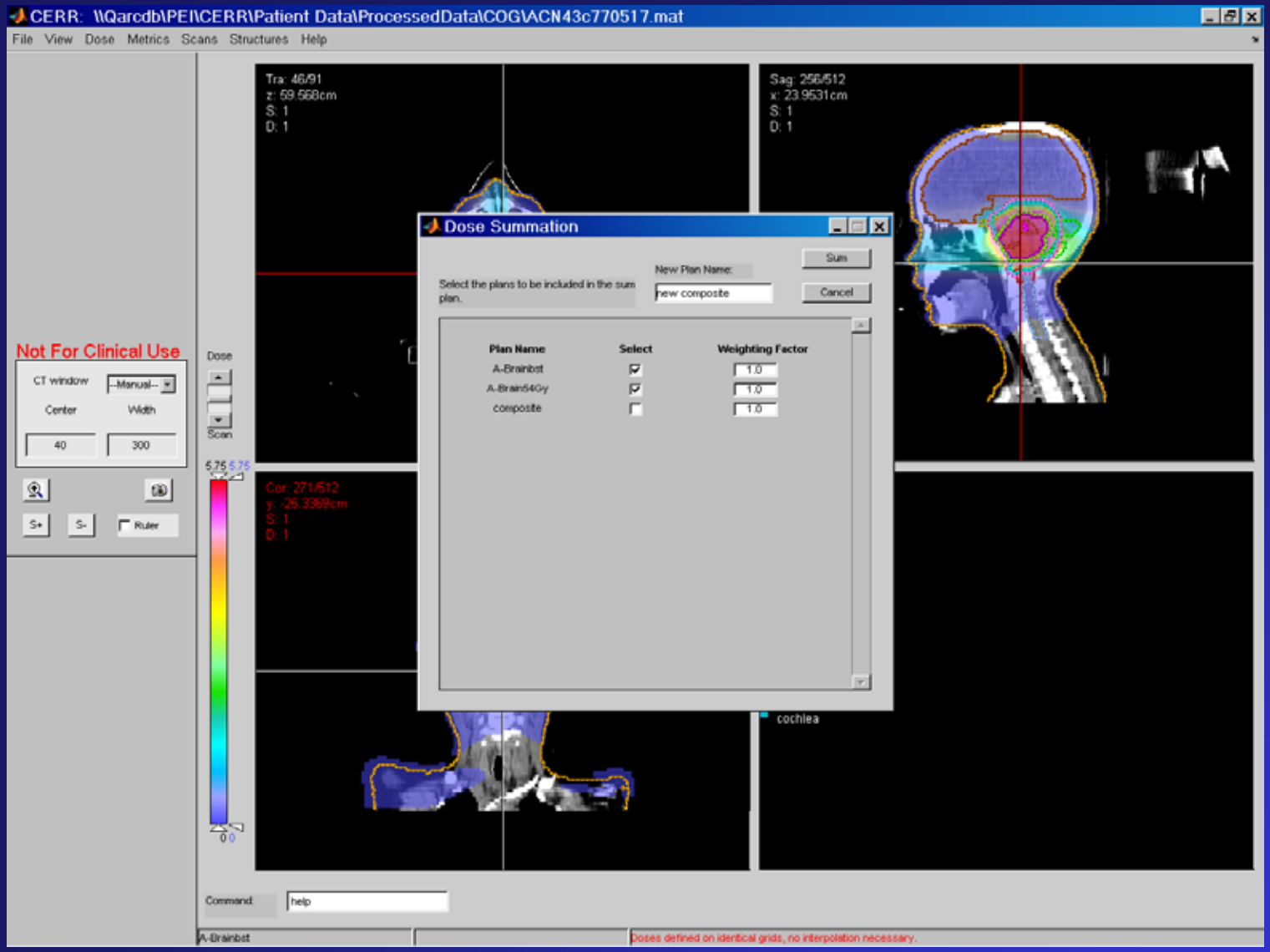
- CERR developments for ATC
  - Batch import developments
  - QARC integration/migration
  - Ovarian Ca RTOG trial update
- CERR developments for RPC
  - Monte Carlo dose re-calculations
  - Film QA tool
- New general capabilities
  - Deformable imaging extension
  - Veriseed US-based planning
  - DICOM I/O
  - Ca-grid capable version
  - Web-based plan review tools
- New outcomes analysis example (acute esophagitis)
- Current goals

CERR developments for ATC

- Batch-importing tool for CERR at ITC
  - Reduces effort
  - Increases reporting data made available (reports, thumbnails)
  - Error logging
  - Current working version
  - Ongoing testing

CERR developments for ATC

- Support of use of CERR at QARC
  - High up-time
  - Successful importing
  - Migration of Ulin customizations onto latest stable version of CERR



(Image couresy Ken Ulin)

CERR developments for ATC

- GYN RTOG trial update
  - Specialized needs
    - Review of contours from one CT (bladder full) onto another fused CT (bladder empty)
    - Need to review submissions simultaneously with two PIs

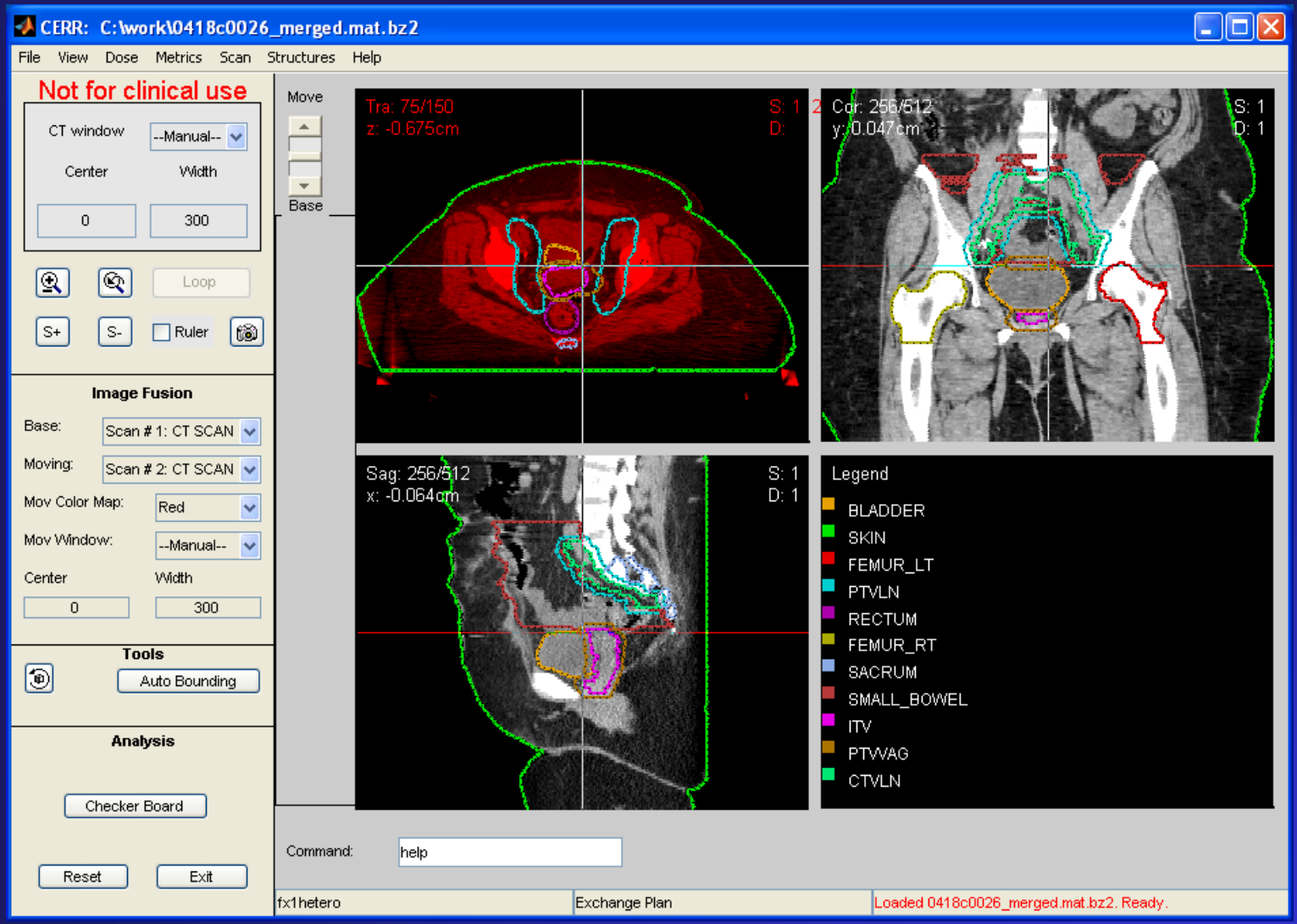
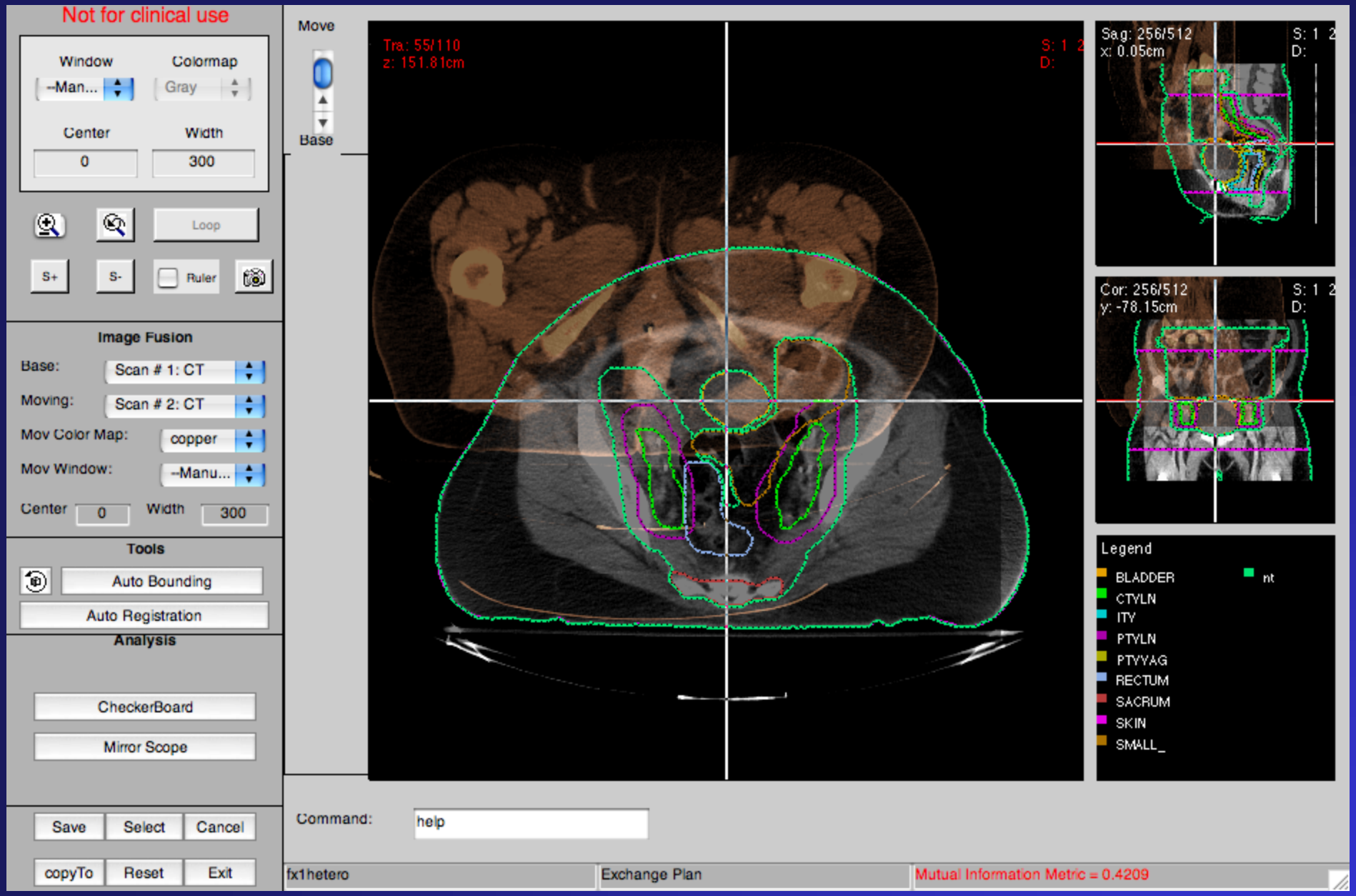

CERR: C:\work\0418c0026_merged.mat.bz2
File View Dose Metrics Scan Structures Help
Not for clinical use
CT window --Manual--
Center Width
0 300
Loop
S+ S- Ruler
Image Fusion
Base: Scan # 1: CT SCAN
Moving: Scan # 2: CT SCAN
Mov Color Map: Red
Mov Window: --Manual--
Center Width
0 300
Tools
Auto Bounding
Analysis
Checker Board
Reset Exit
Move
Base
Tra: 75/150
z: -0.675cm
S: 1
D:
Cor: 256/512
y: 0.047cm
S: 1
D: 1
Sag: 256/512
x: -0.064cm
S: 1
D: 1
Legend
BLADDER
SKIN
FEMUR_LT
PTVLN
RECTUM
FEMUR_RT
SACRUM
SMALL_BOWEL
ITV
PTVVAG
CTVLN
Command: help
fx1hetero
Exchange Plan
Loaded 0418c0026_merged.mat.bz2. Ready.

Image registration


Not for clinical use
Window
Colormap
--Man...
Gray
Center
Width
0
300
Loop
S+
S-
Ruler
Image Fusion
Base:
Scan # 1: CT
Moving:
Scan # 2: CT
Mov Color Map:
copper
Mov Window:
--Manu...
Center
0
Width
300
Tools
Auto Bounding
Auto Registration
Analysis
CheckerBoard
Mirror Scope
Save
Select
Cancel
copyTo
Reset
Exit
Move
Base
Tra: 55/110
z: 151.81cm
S: 1 2
D:
Sag: 256/512
x: 0.05cm
S: 1 2
D:
Cor: 256/512
y: -78.15cm
S: 1 2
D:
Legend
BLADDER
CTVLN
ITV
PTVLN
PTVVAG
RECTUM
SACRUM
SKIN
SMALL_
nt
Command:
help
fx1hetero
Exchange Plan
Mutual Information Metric = 0.4209

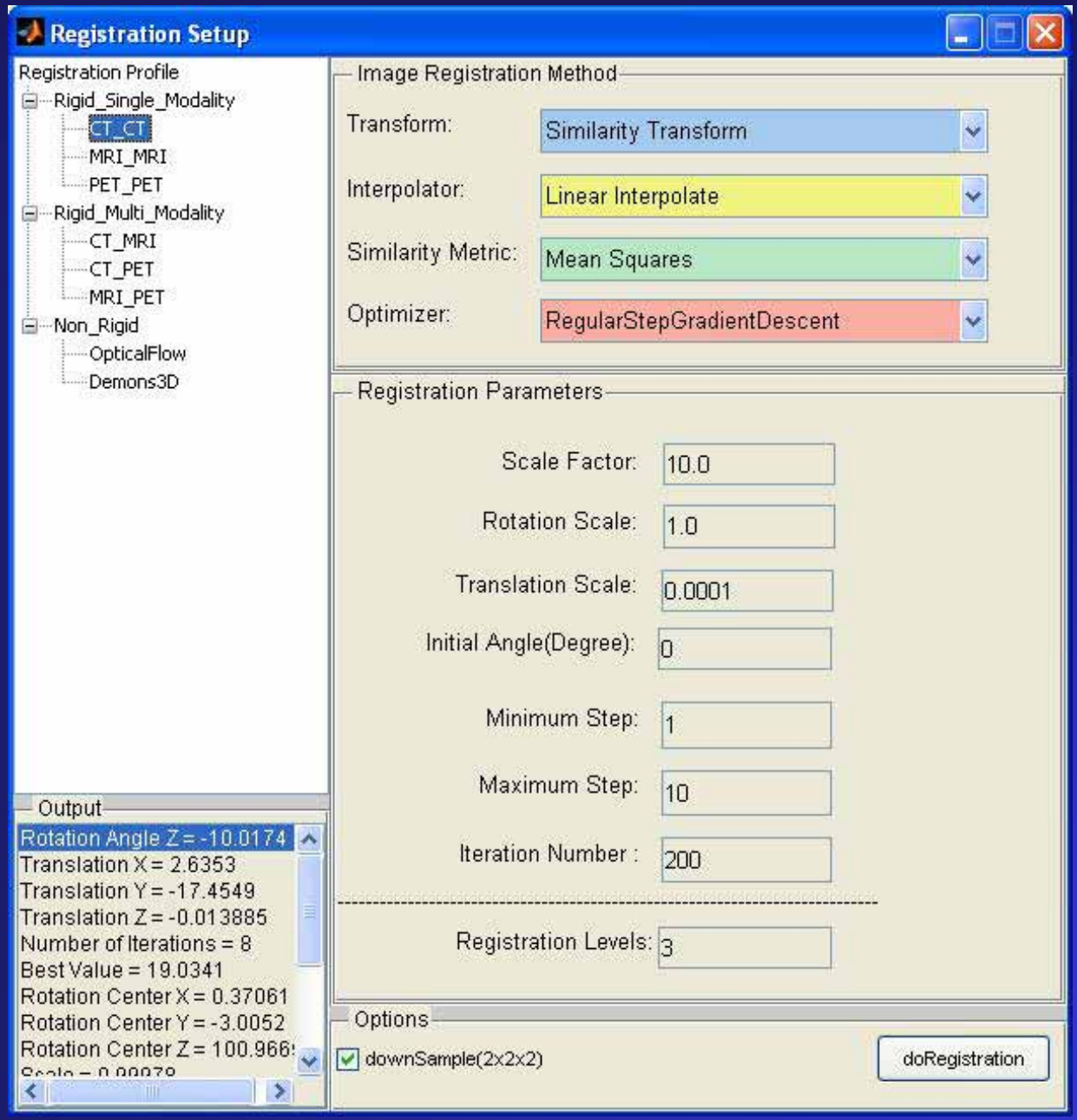
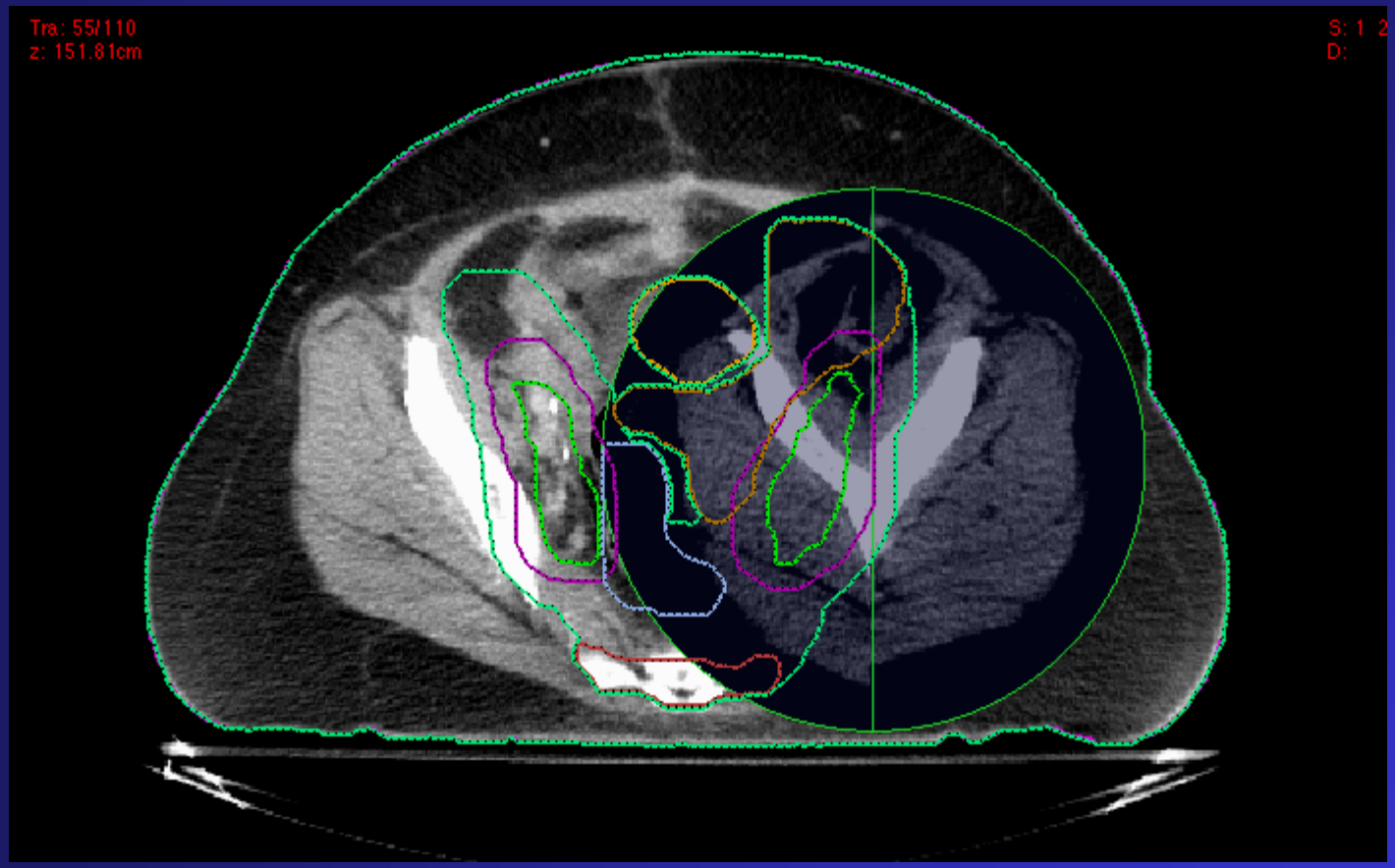
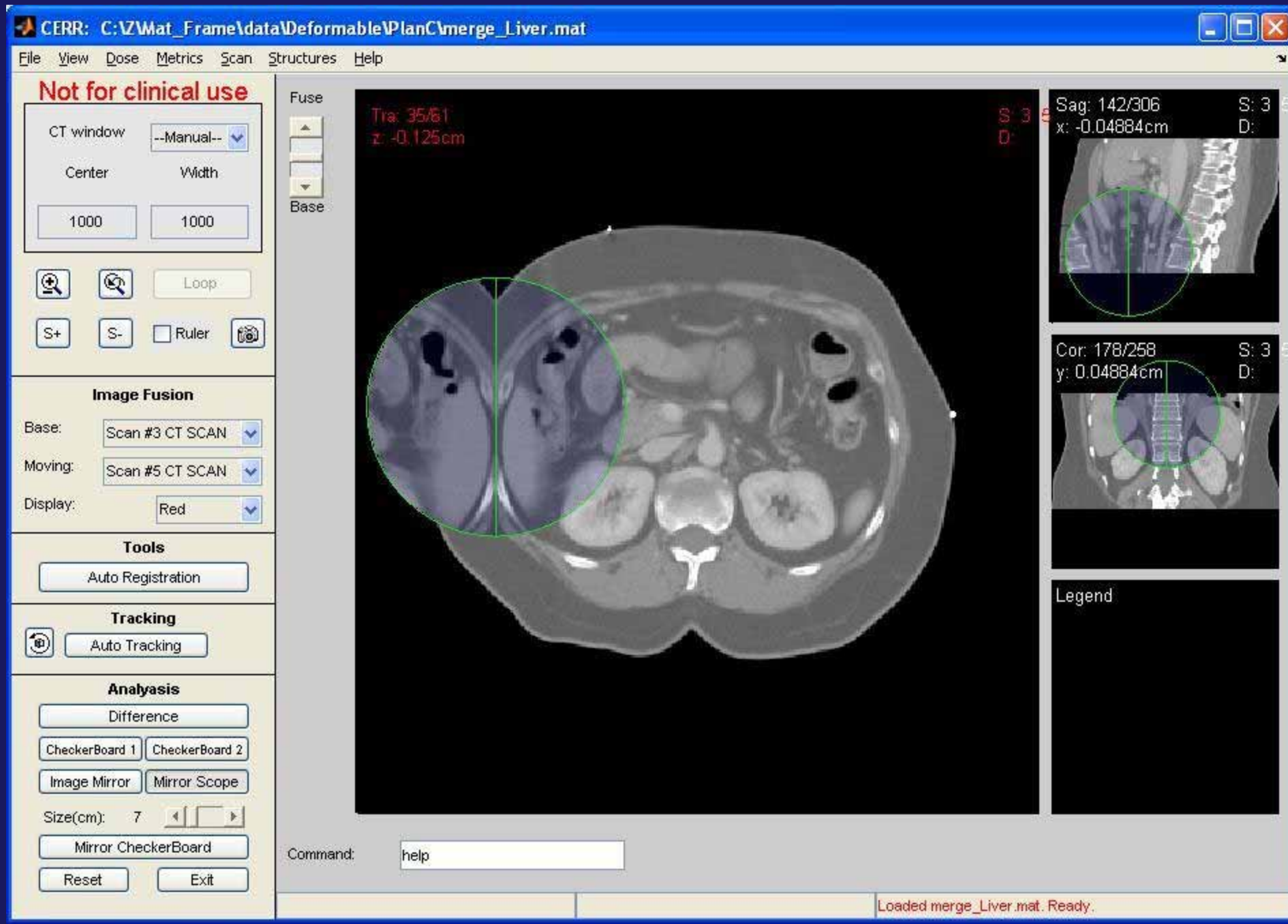

Registration Setup
Registration Profile
Rigid_Single_Modality
CT_CT
MRI_MRI
PET_PET
Rigid_Multi_Modality
CT_MRI
CT_PET
MRI_PET
Non_Rigid
OpticalFlow
Demons3D
Image Registration Method
Transform:
Similarity Transform
Interpolator:
Linear Interpolate
Similarity Metric:
Mean Squares
Optimizer:
RegularStepGradientDescent
Registration Parameters
Scale Factor:
10.0
Rotation Scale:
1.0
Translation Scale:
0.0001
Initial Angle(Degree):
0
Minimum Step:
1
Maximum Step:
10
Iteration Number :
200
Registration Levels:
3
Output
Rotation Angle Z = -10.0174
Translation X = 2.6353
Translation Y = -17.4549
Translation Z = -0.013885
Number of Iterations = 8
Best Value = 19.0341
Rotation Center X = 0.37061
Rotation Center Y = -3.0052
Rotation Center Z = 100.966
Options
downSample(2x2x2)
doRegistration

Image registration QA

Mirror-scope




CERR: C:\Z\Mat_Frame\data\Deformable\PlanC\merge_Liver.mat
File View Dose Metrics Scan Structures Help
Not for clinical use
CT window --Manual--
Center Width
1000 1000
Loop
S+ S- Ruler
Image Fusion
Base: Scan #3 CT SCAN
Moving: Scan #5 CT SCAN
Display: Red
Tools
Auto Registration
Tracking
Auto Tracking
Analysis
Difference
CheckerBoard 1 CheckerBoard 2
Image Mirror Mirror Scope
Size(cm): 7
Mirror CheckerBoard
Reset Exit
Fuse
Base
Tra: 35/61
z: -0.125cm
S: 3
D:
Sag: 142/306
x: -0.04884cm
S: 3
D:
Cor: 178/258
y: 0.04884cm
S: 3
D:
Legend
Command: help
Loaded merge_Liver.mat. Ready.

CERR developments for the RPC

- Monte Carlo recalculation tool
  - Recomputation of phantom dose distributions
  - Ongoing development (Jing Cui)
  - Ongoing validation (D Followill and Scott Davidson)
  - Linkage to film QA
  - Linkage to treatment plan data
  - Data display within CERR

Monte Carlo head model

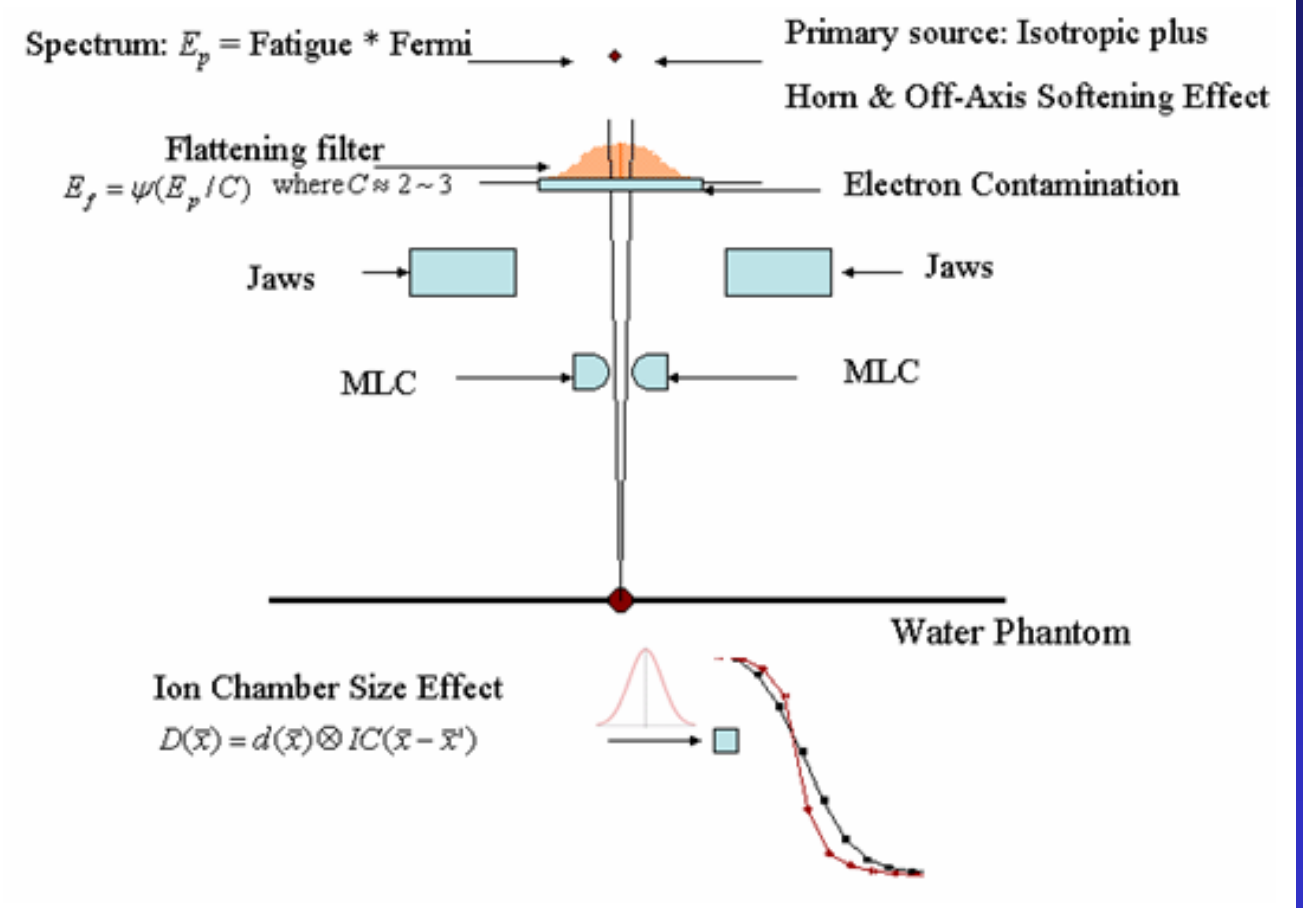
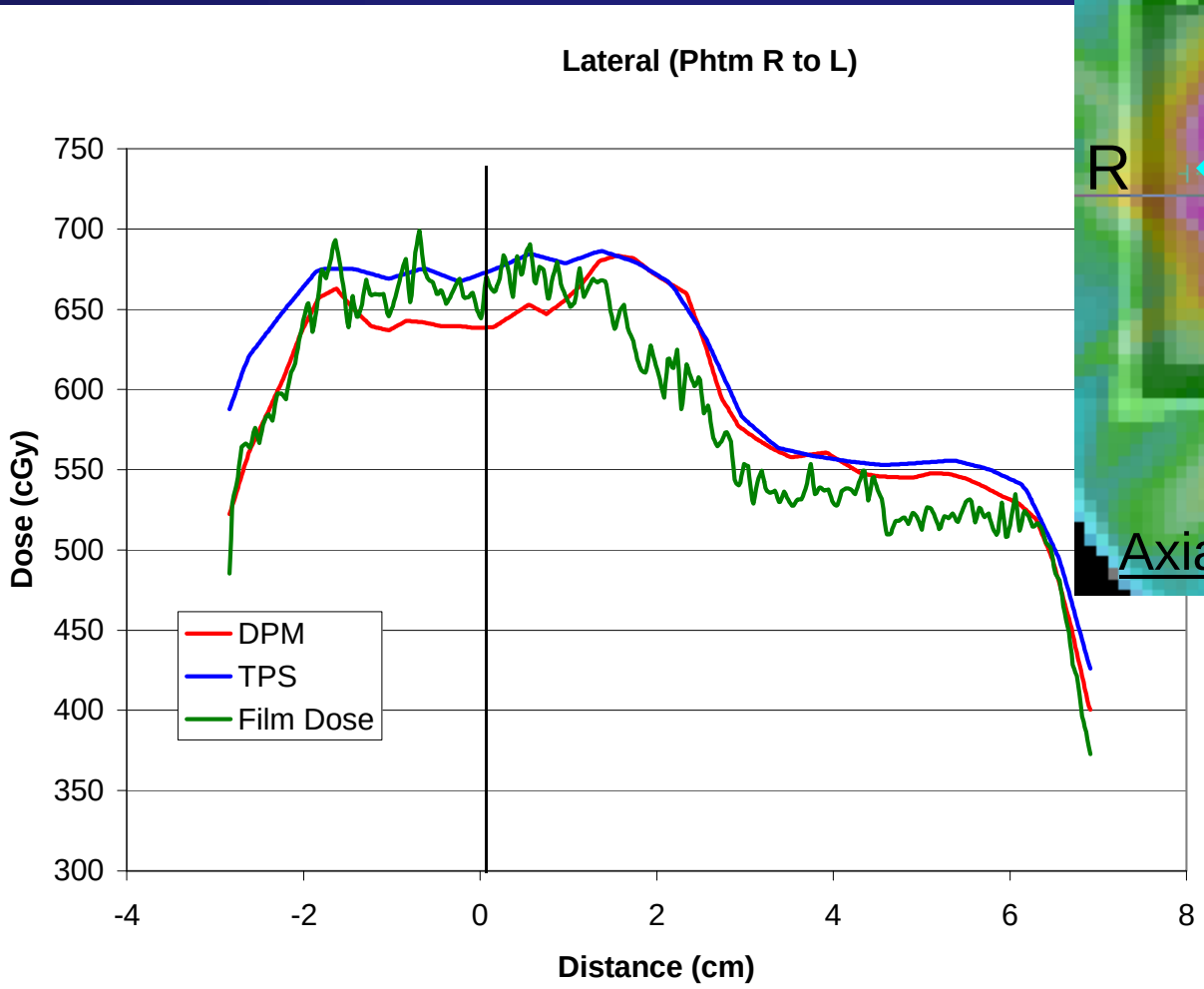


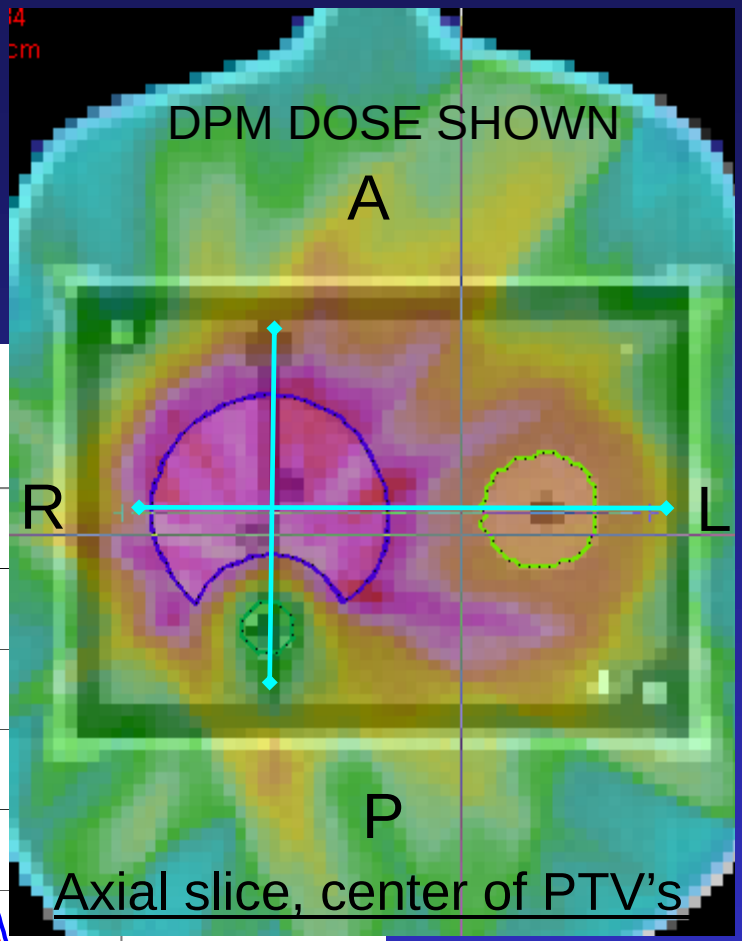
Figure 1. The source model diagram (not proportional)

(Cui, Willcut, Davidson et al.)

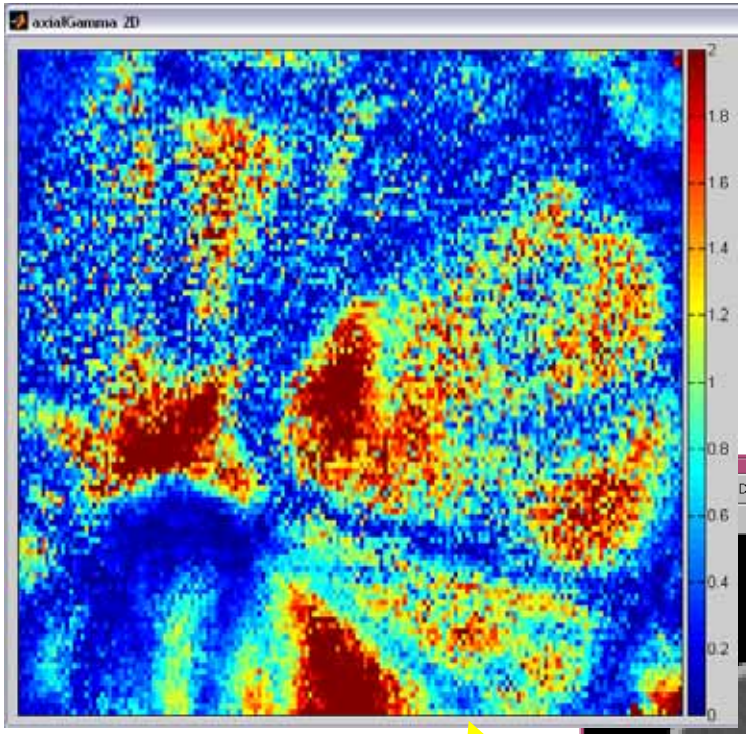
Varian 6 MV, IMRT

Head & Neck

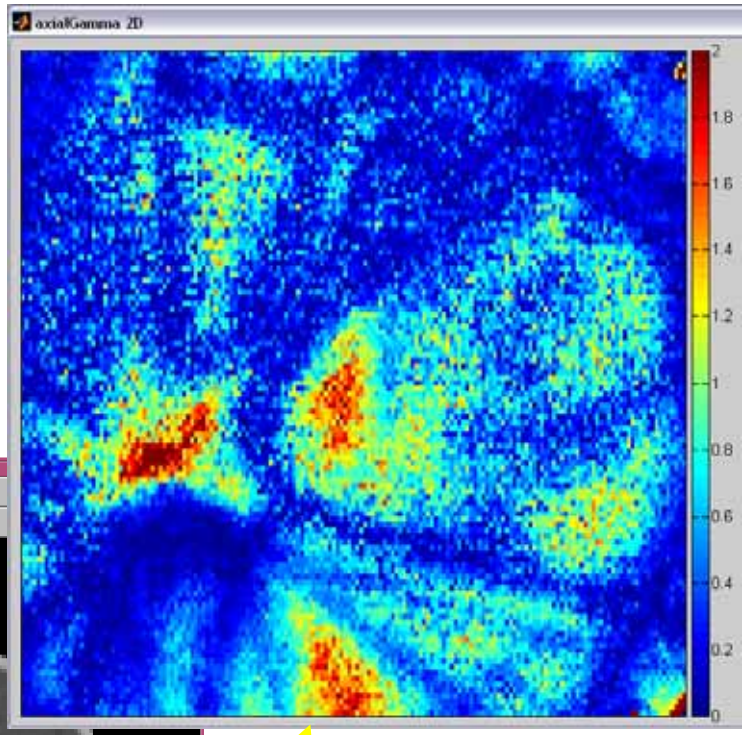




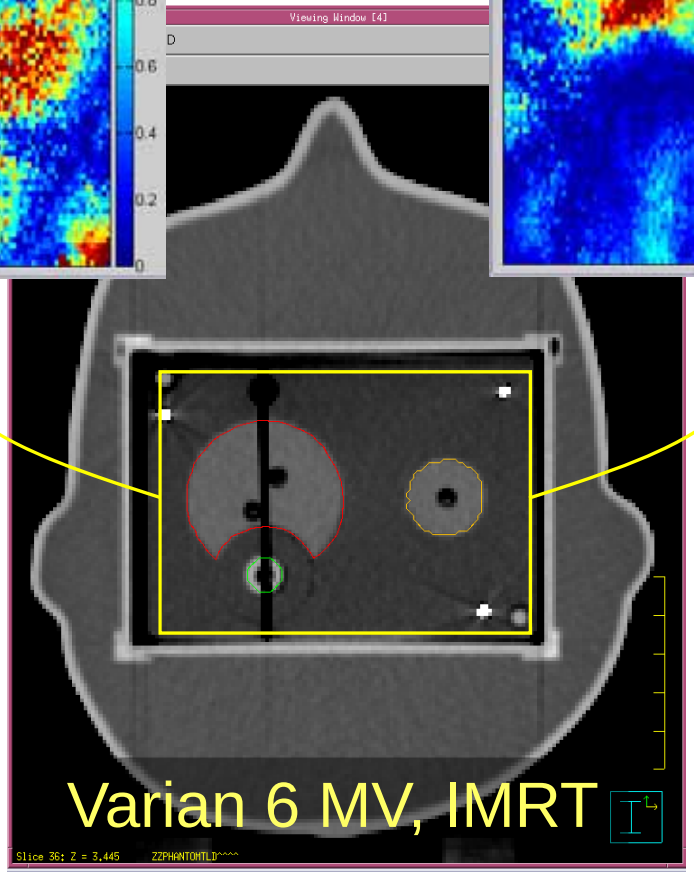
Slides courtesy
Scott Davidson



NOTE: Aspect ratio not 1 to 1



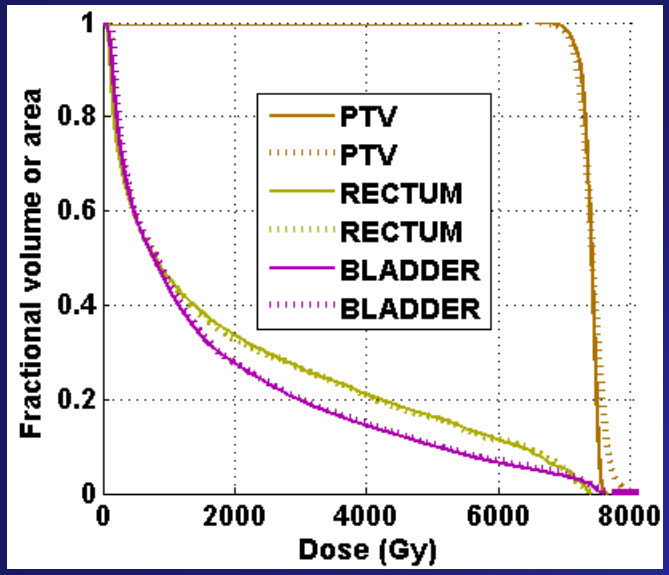
Pinnacle vs. Meas.
±3%/2mm
~53% pixels pass



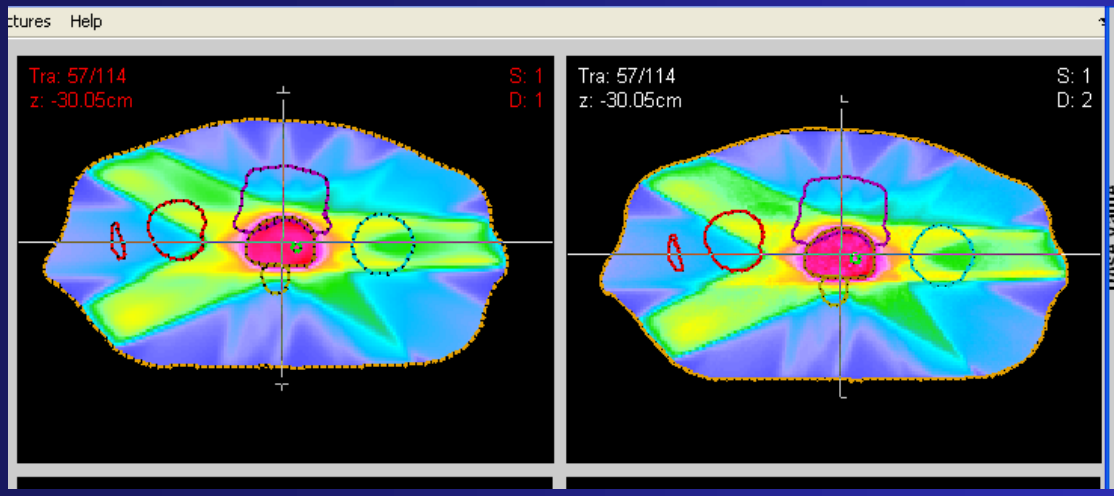
DPM vs. Meas.
±3%/2mm
~81% pixels pass

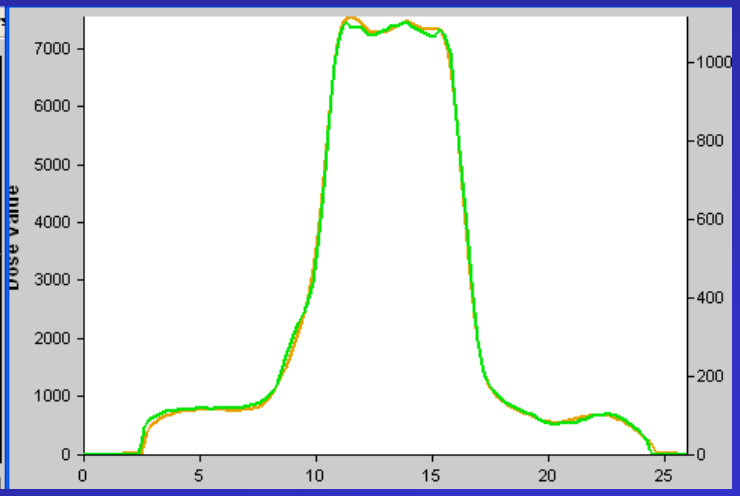
Slides courtesy
Scott Davidson

Comparison with Pinnacle



Dotted - MC
Solid-Pinnacle

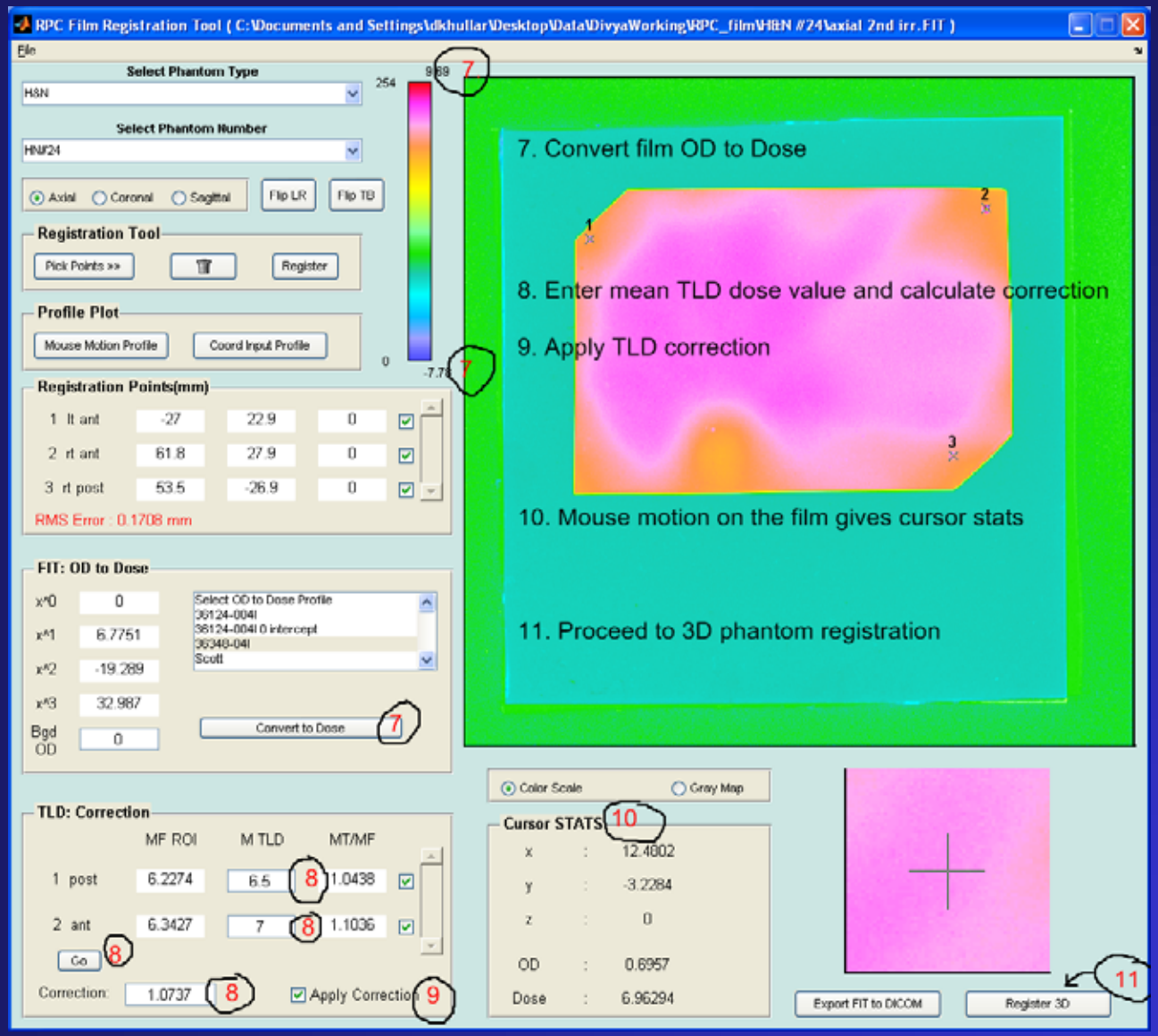


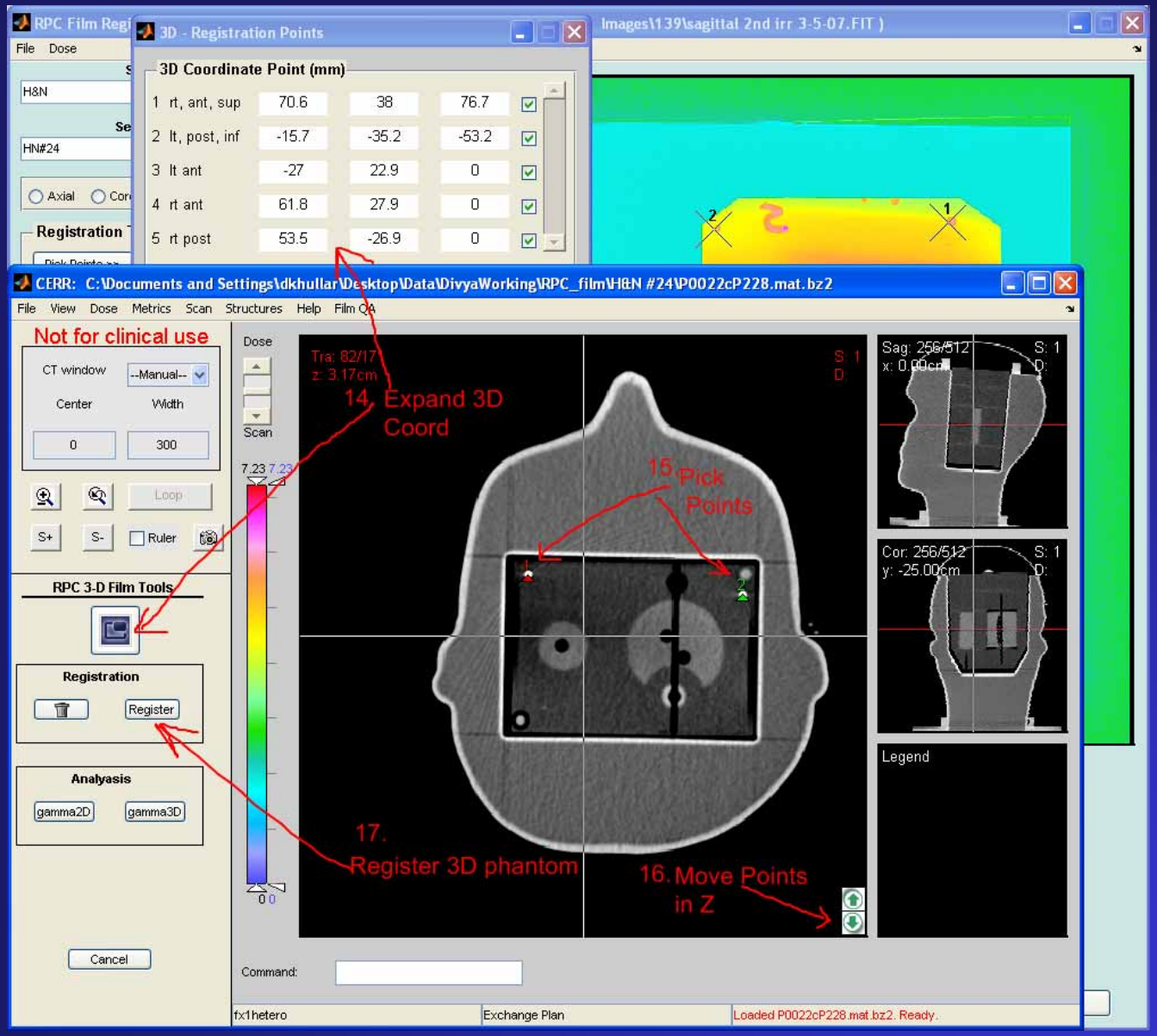


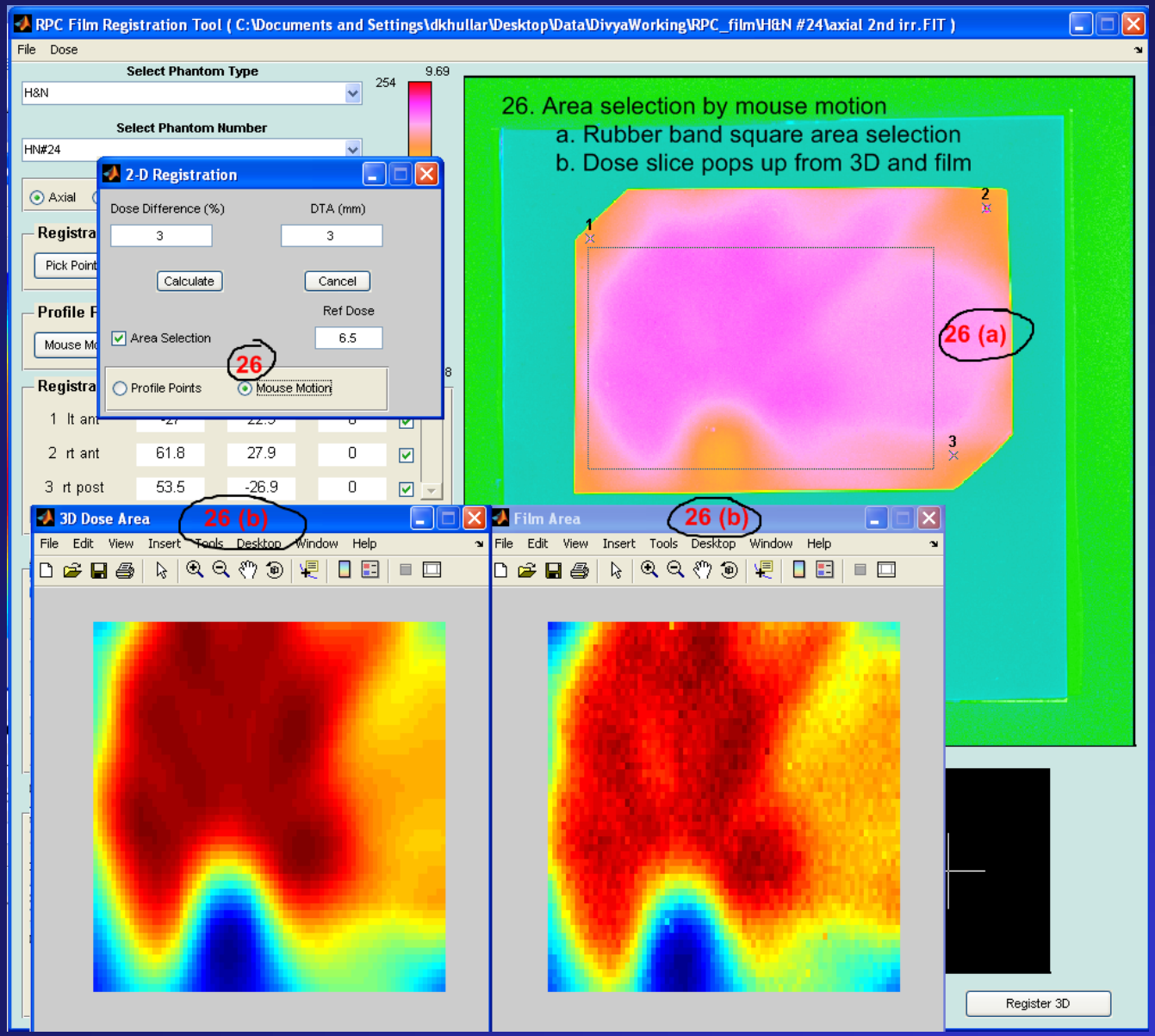
Pinnacle

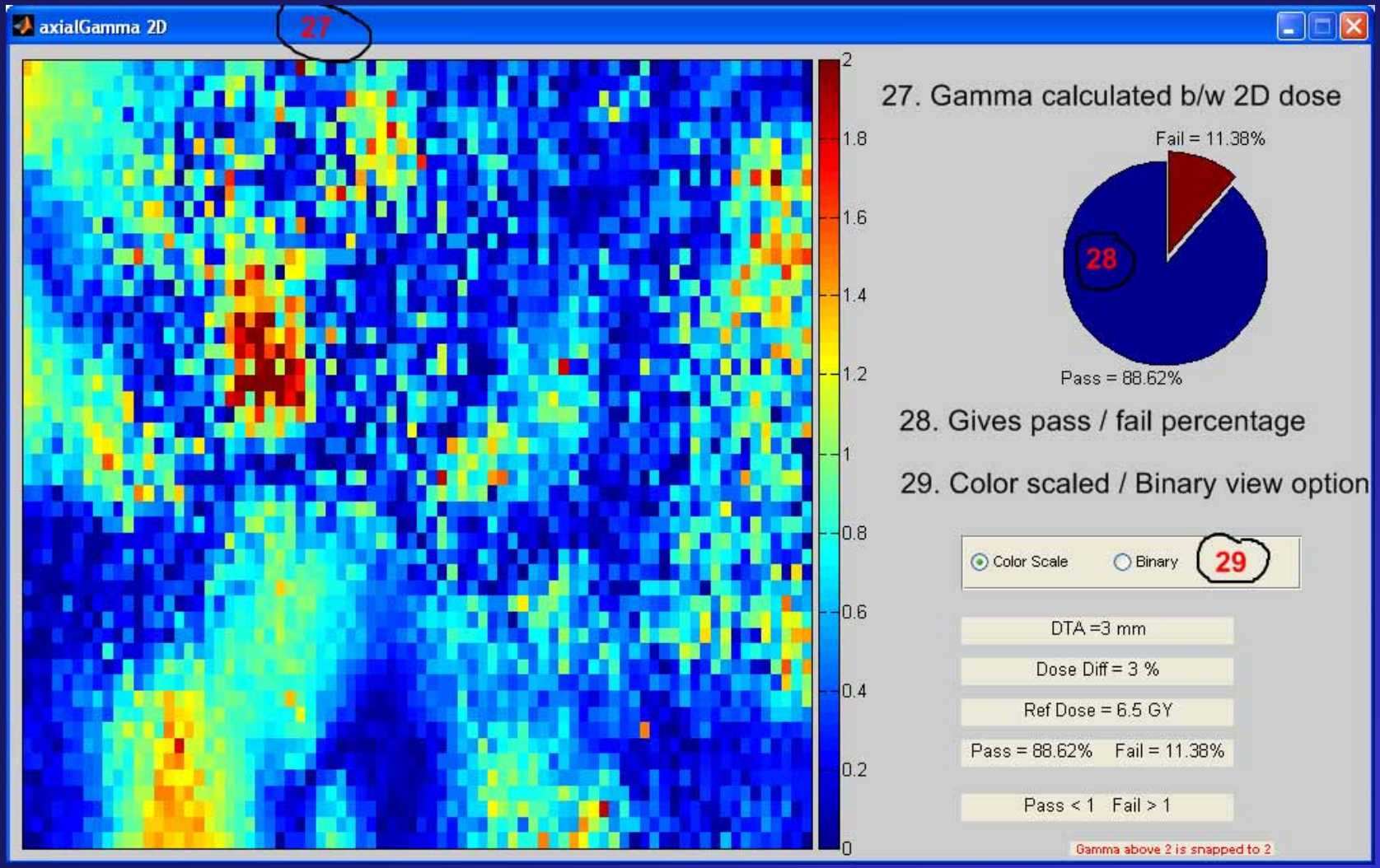
Our Monte Carlo

Green- MC; Gold-Pinnacle

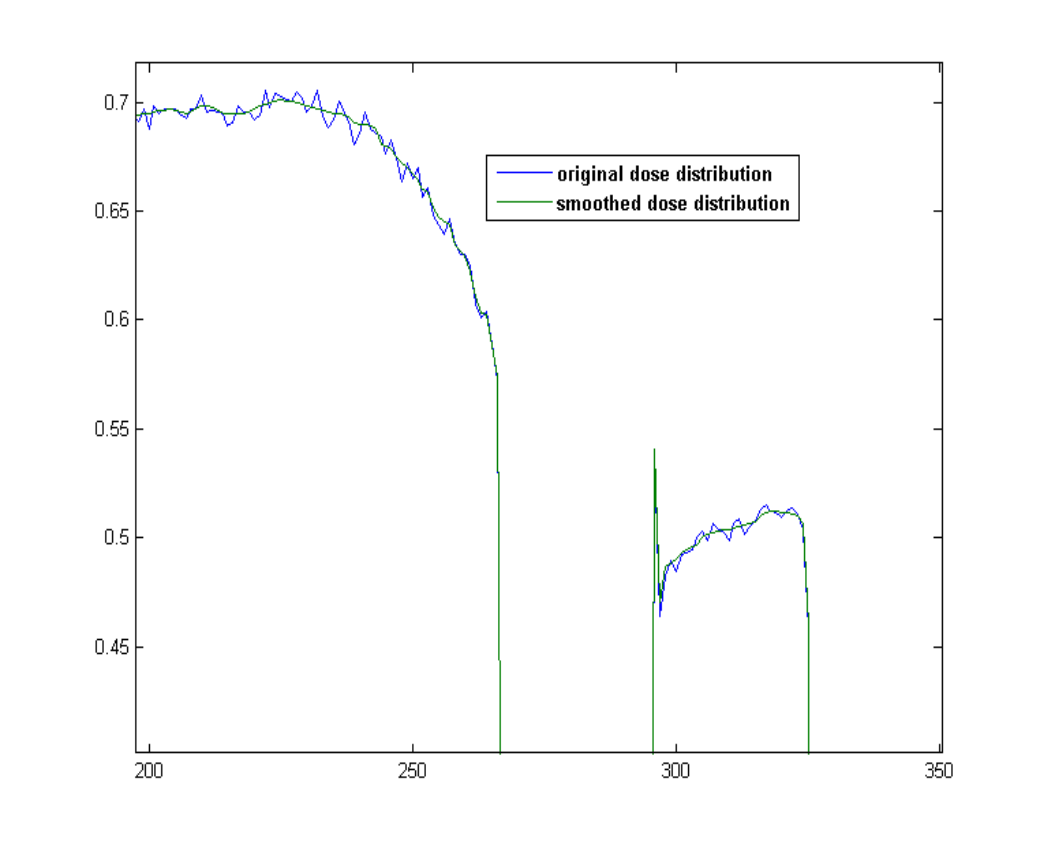

RPC Film Registration Tool (C:\Documents and Settings\dkhullar\Desktop\Data\DivyaWorking\RPC_film\H&N #24\axial 2nd irr.FIT)
File
Select Phantom Type
H&N
Select Phantom Number
HNF24
Axial
Coronal
Sagittal
Flip LR
Flip TB
Registration Tool
Pick Points >>
Register
Profile Plot
Mouse Motion Profile
Coord Input Profile
Registration Points(mm)
1 lt ant -27 22.9 0
2 rt ant 61.8 27.9 0
3 rt post 53.5 -26.9 0
RMS Error : 0.1708 mm
FIT: OD to Dose
x^0 0
x^1 6.7751
x^2 -19.289
x^3 32.987
Bgd OD 0
Select OD to Dose Profile
36124-004I
36124-004I 0 intercept
36348-04I
Scott
Convert to Dose
TLD: Correction
MF ROI M TLD MT/MF
1 post 6.2274 6.5 1.0438
2 ant 6.3427 7 1.1036
Go
Correction 1.0737
Apply Correction
254
9.89
0
-7.78
7. Convert film OD to Dose
8. Enter mean TLD dose value and calculate correction
9. Apply TLD correction
10. Mouse motion on the film gives cursor stats
11. Proceed to 3D phantom registration
1
2
3
Color Scale
Gray Map
Cursor STATS
x : 12.4802
y : -3.2284
z : 0
OD : 0.6957
Dose : 6.96294
Export FIT to DICOM
Register 3D


RPC Film Regi
File Dose
H&N
HN#24
Axial
Registration
3D - Registration Points
3D Coordinate Point (mm)
1 rt, ant, sup 70.6 38 76.7
2 lt, post, inf -15.7 -35.2 -53.2
3 lt ant -27 22.9 0
4 rt ant 61.8 27.9 0
5 rt post 53.5 -26.9 0
Images\139\sagittal 2nd irr 3-5-07.FIT)
CERR: C:\Documents and Settings\dkhullar\Desktop\Data\DivyaWorking\RPC_film\H&N #24\P0022cP228.mat.bz2
File View Dose Metrics Scan Structures Help Film QA
Not for clinical use
CT window --Manual--
Center Width
0 300
Loop
S+ S- Ruler
RPC 3-D Film Tools
Registration
Register
Analysis
gamma2D gamma3D
Cancel
Dose
Scan
7.23 7.23
0 0
Tra: 82/17
z: 3.17cm
S: 1
D:
14. Expand 3D Coord
15. Pick Points
17. Register 3D phantom
16. Move Points in Z
Sag: 256/512
x: 0.00cm
Cor: 256/512
y: -25.00cm
Legend
Command:
fx1hetero
Exchange Plan
Loaded P0022cP228.mat.bz2. Ready.

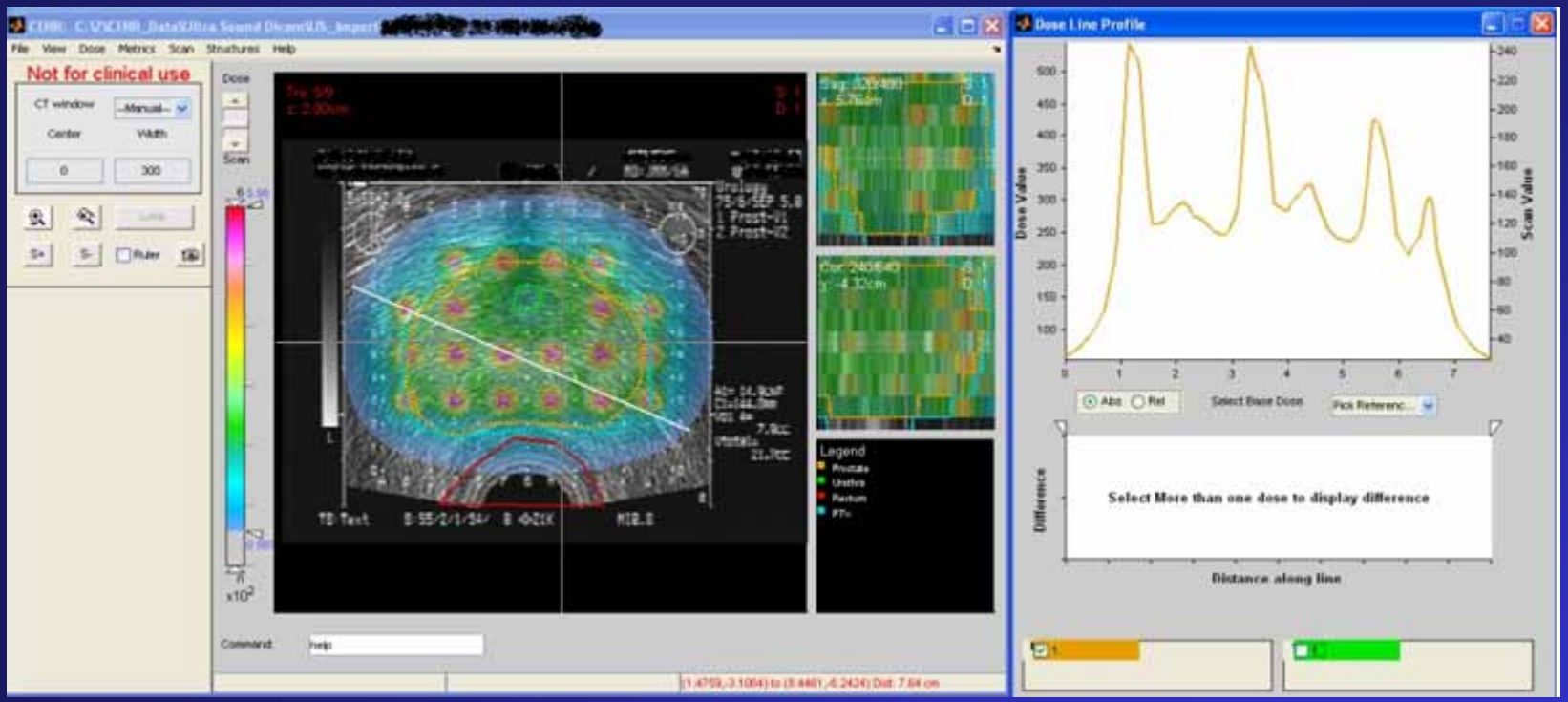

RPC Film Registration Tool (C:\Documents and Settings\dkhullar\Desktop\Data\DivyaWorking\RPC_film\H&N #24\axial 2nd irr.FIT)
File Dose
Select Phantom Type
H&N
Select Phantom Number
HN#24
254
9.69
Axial
Registra
Pick Point
Profile F
Mouse M
Registra
1 lt ant
2 rt ant 61.8 27.9 0
3 rt post 53.5 -26.9 0
2-D Registration
Dose Difference (%)
DTA (mm)
3
3
Calculate
Cancel
Ref Dose
Area Selection
6.5
26
Profile Points
Mouse Motion
26. Area selection by mouse motion
a. Rubber band square area selection
b. Dose slice pops up from 3D and film
1
2
3
26 (a)
3D Dose Area
26 (b)
File Edit View Insert Tools Desktop Window Help
Film Area
26 (b)
File Edit View Insert Tools Desktop Window Help
Register 3D


axialGamma 2D
27
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
27. Gamma calculated b/w 2D dose
Fail = 11.38%
28
Pass = 88.62%
28. Gives pass / fail percentage
29. Color scaled / Binary view option
Color Scale
Binary
29
DTA =3 mm
Dose Diff = 3 %
Ref Dose = 6.5 GY
Pass = 88.62% Fail = 11.38%
Pass < 1 Fail > 1
Gamma above 2 is snapped to 2

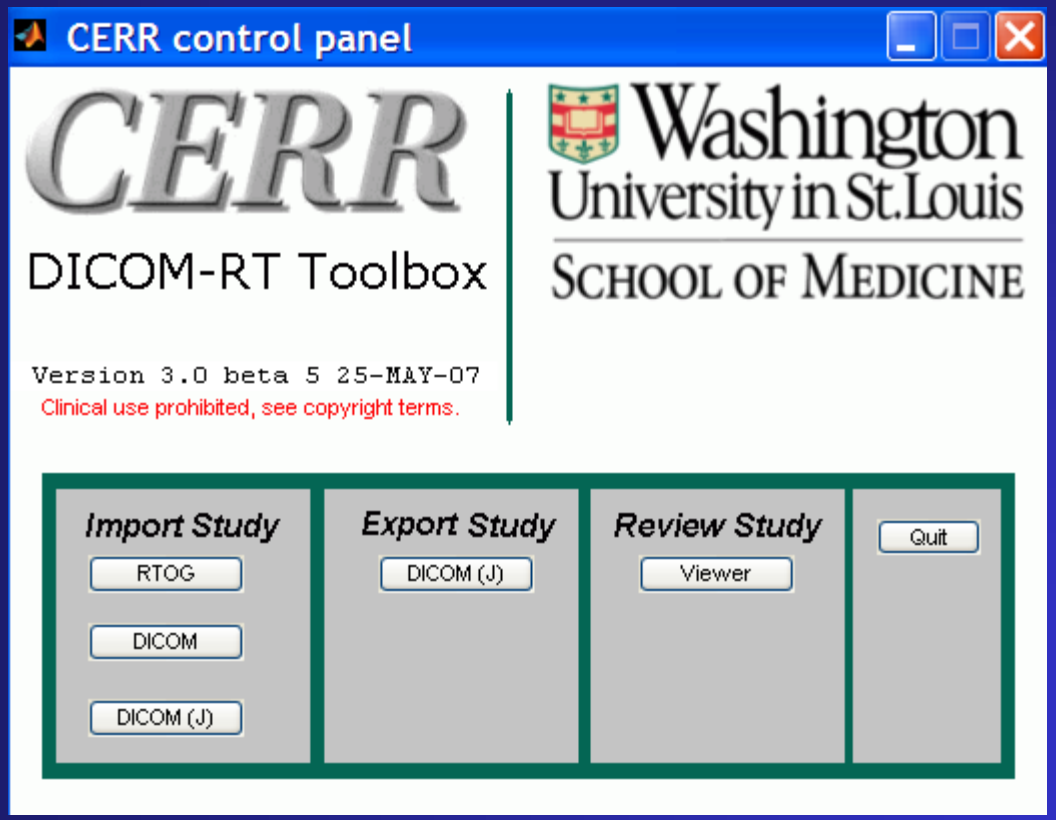
Film denoising (WUSTL & RPC collaboration)



Variseed import with ultrasound



CERR: A Computational Environment for Radiotherapy Research



Application of caGrid® Middleware to Facilitate Quality Assurance for Advanced Technology Radiation Therapy Clinical Trials

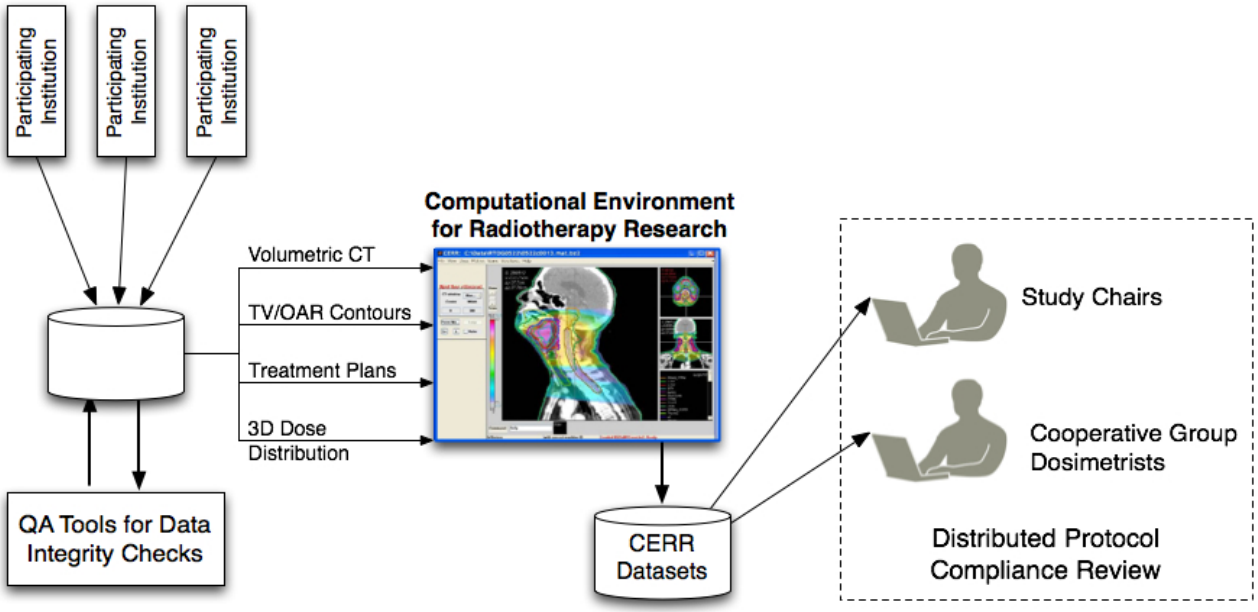
Joel H. Saltz[1], MD, PhD, Ashish Sharma[1], PhD, Tony C. Pan[1], MS,
Walter R. Bosch[2,3], DSc, Joseph O Deasy[3], PhD,
James A. Purdy[4], PhD

[1] Department of Biomedical Informatics, The Ohio State University, Columbus, OH
[2] Image-guided,Therapy QA Center, Washington University, St. Louis, MO
[3] Department of Radiation Oncology, Washington University, St. Louis, MO
[4] Department of Radiation Oncology, UC Davis Cancer Center, Davis, CA

Grid Computing and RT Clinical Trials

The caBIG In Vivo Imaging middleware is used to deploy existing CERR software as an integrated communication and review tool for Radiation Therapy clinical trials, institutional credentialing, and case quality assurance.

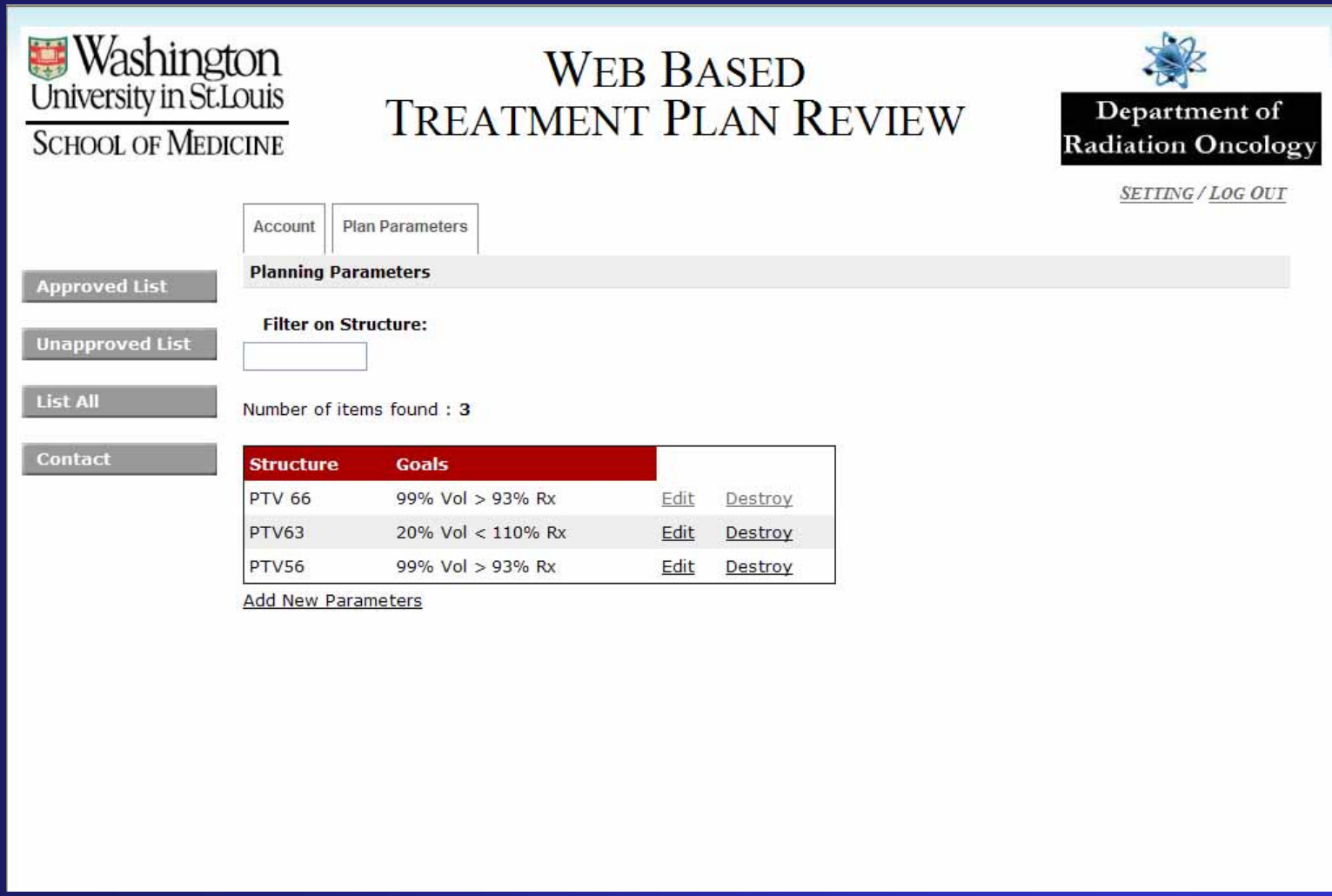
- Simplified distribution of data to reviewers
- Capture reviewer modifications for subsequent analysis



A Web-based and database-centric radiotherapy treatment plan review and reporting system

Divya Khullar, Dan Mullen, Walter Bosch,
and Joe Deasy,
Div. of Bioinformatics and Outcomes Research, and the Image Guided Therapy Center,
Dept of Radiation Oncology


WebTREV - Windows Internet Explorer
http://localhost:3000/plans/unapproved
WebTREV
Washington University in St. Louis
School of Medicine
WEB BASED TREATMENT PLAN REVIEW
Department of Radiation Oncology
SETTING / LOG OUT
Approved List
Unapproved List
List All
Contact
Unapproved Plans
Filter on Last Name:
Number of Plans found : 3
Plan ID
Last Name
First Name
Date Created
Date Approved
Planner
Planning System
Status
plan11
Approve
Apte
Aditya
Fri Apr 20 12:00:00 Central Daylight Time 2007
Divya
Tommo
unapproved
plan12
Approve
Mullen
Dan
Fri Apr 20 12:30:00 Central Daylight Time 2007
Jing
Pinnacle
unapproved
Plan16
Approve
Mast
Anand
Tue Mar 27 12:30:00 Central Daylight Time 2007
JD
Pinnacle
unapproved
Done
Local intranet
100%


Washington University in St. Louis
School of Medicine
Web Based
Treatment Plan Review
Department of Radiation Oncology
Setting / Log Out
Account
Plan Parameters
Approved List
Unapproved List
List All
Contact
Planning Parameters
Filter on Structure:
Number of items found : 3
Structure
Goals
PTV 66
99% Vol > 93% Rx
Edit
Destroy
PTV63
20% Vol < 110% Rx
Edit
Destroy
PTV56
99% Vol > 93% Rx
Edit
Destroy
Add New Parameters

Washington University in St. Louis
School of Medicine

Web Based Treatment Plan Review

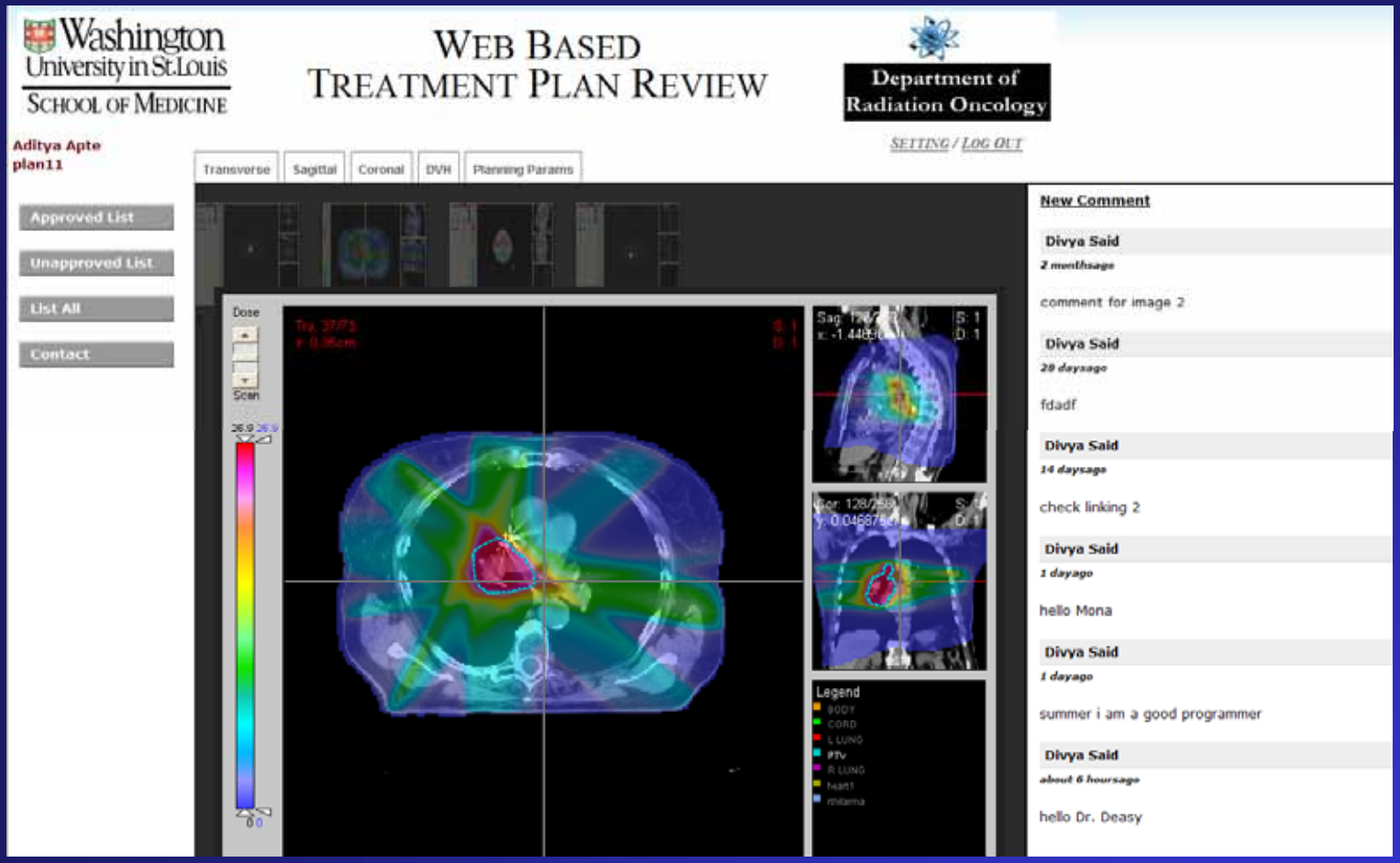
Department of Radiation Oncology

Aditya Apte
plan11

WASHINGTON UNIVERSITY IMRT DOSE QA TABLE

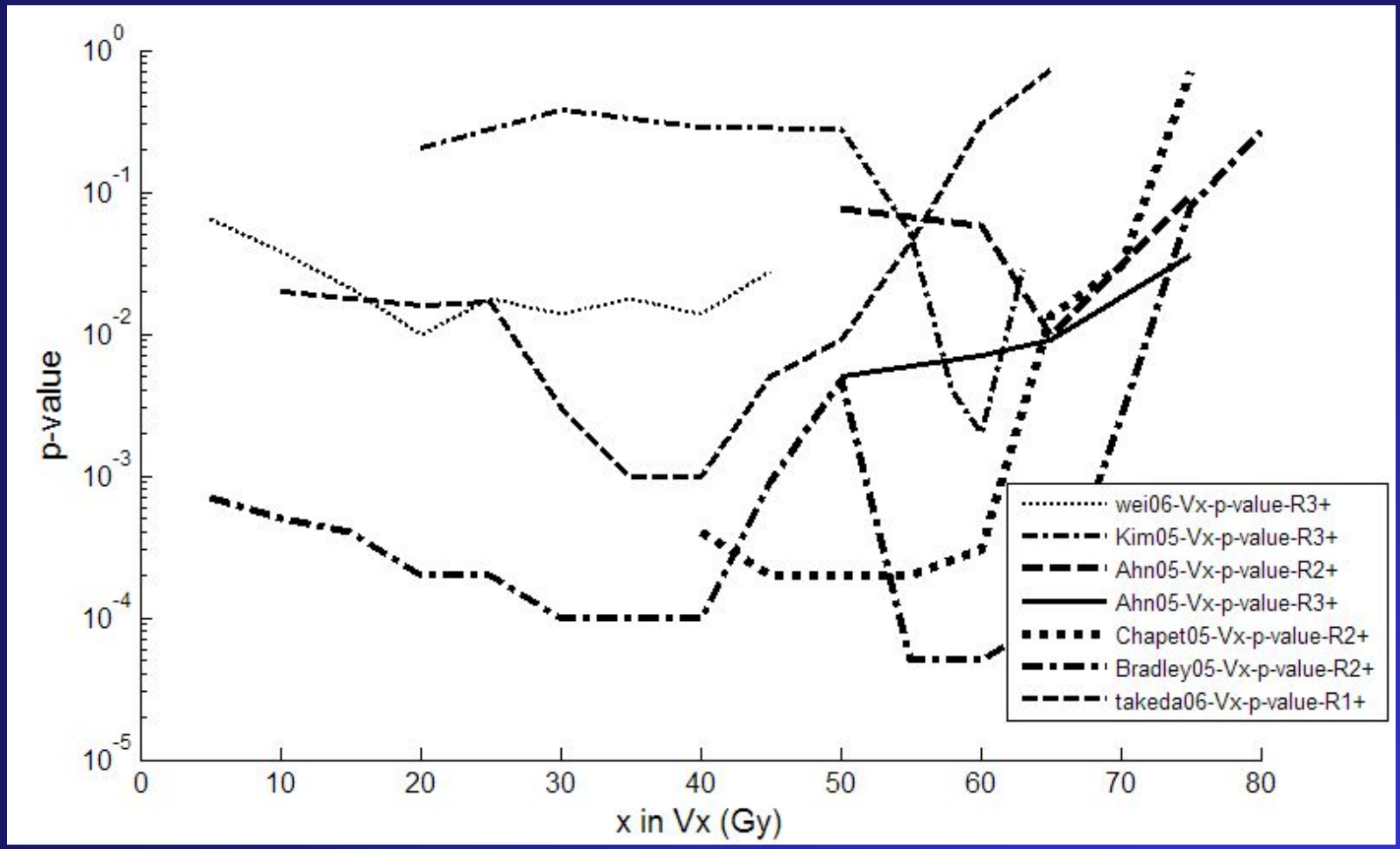
Head and Neck Target Volume Goals for Protocol 06-0001

ROI	Vol (cc)	Goal	Meet Goal				
PTV Coverage Goals							
PTV 66	46	99% Vol > 93% Rx (65.1 Gy)	Yes	93% Rx=	99.50%	6243 Gy	PTV 6
		20% Vol ≤ 110% Rx (77 Gy)	Yes	% Vol ≥ 102% Rx=	5%	6937 Gy	
				% Vol ≥ 110% Rx=	1%	7260 Gy	
				% Vol ≥ 120% Rx=	0%	N/A Gy	
PTV 63	75	99% Vol > 93% Rx (63 Gy)	Yes	99% Vol=	99.2% Rx	6249 Gy	PTV 6
		20% Vol ≤ 110% Rx (63 Gy)	Yes	20% Vol=	32.4% Rx	6526 Gy	
				10% Vol=	12.5% Rx	6728 Gy	
				2% Vol=	6.5% Rx	7234 Gy	
PTV 56	104	99% Vol > 93% Rx (56 Gy)	Yes	99% Vol=	99.9% Rx	6229 Gy	PTV 5
		20% Vol ≤ 110% Rx (56 Gy)	Yes	20% Vol=	34.5% Rx	6500 Gy	
				10% Vol=	13% Rx	6721 Gy	
				2% Vol=	4.5% Rx	7002 Gy	
Critical Structure Constraints							
Cord		0.1 cc Vol ≤ 45 Gy	Yes	0.1 cc =	3700 cGy		
				Max =	3894 cGy		
Brainstem		0.1 cc Vol ≤ 60 Gy	Yes	0.1 cc =	5834 cGy		
		1% ≤ 60 Gy		Max =	5994 cGy		
Brain		1% ≤ 60 Gy	No	60 Gy Volume=	1.50%		
		5 cc ≤ 65 Gy	Yes	5 cc Max =	6137 cGy		


Washington University in St.Louis
School of Medicine
Web Based Treatment Plan Review
Department of Radiation Oncology
SETTING / LOG OUT
Aditya Apte
plan11
Transverse
Sagittal
Coronal
DVH
Planning Params
Approved List
Unapproved List
List All
Contact
Dose
Scan
Legend
New Comment
Divya Said
2 monthsago
comment for image 2
Divya Said
20 daysago
fdadf
Divya Said
14 daysago
check linking 2
Divya Said
1 dayago
hello Mona
Divya Said
1 dayago
summer i am a good programmer
Divya Said
about 6 hoursago
hello Dr. Deasy

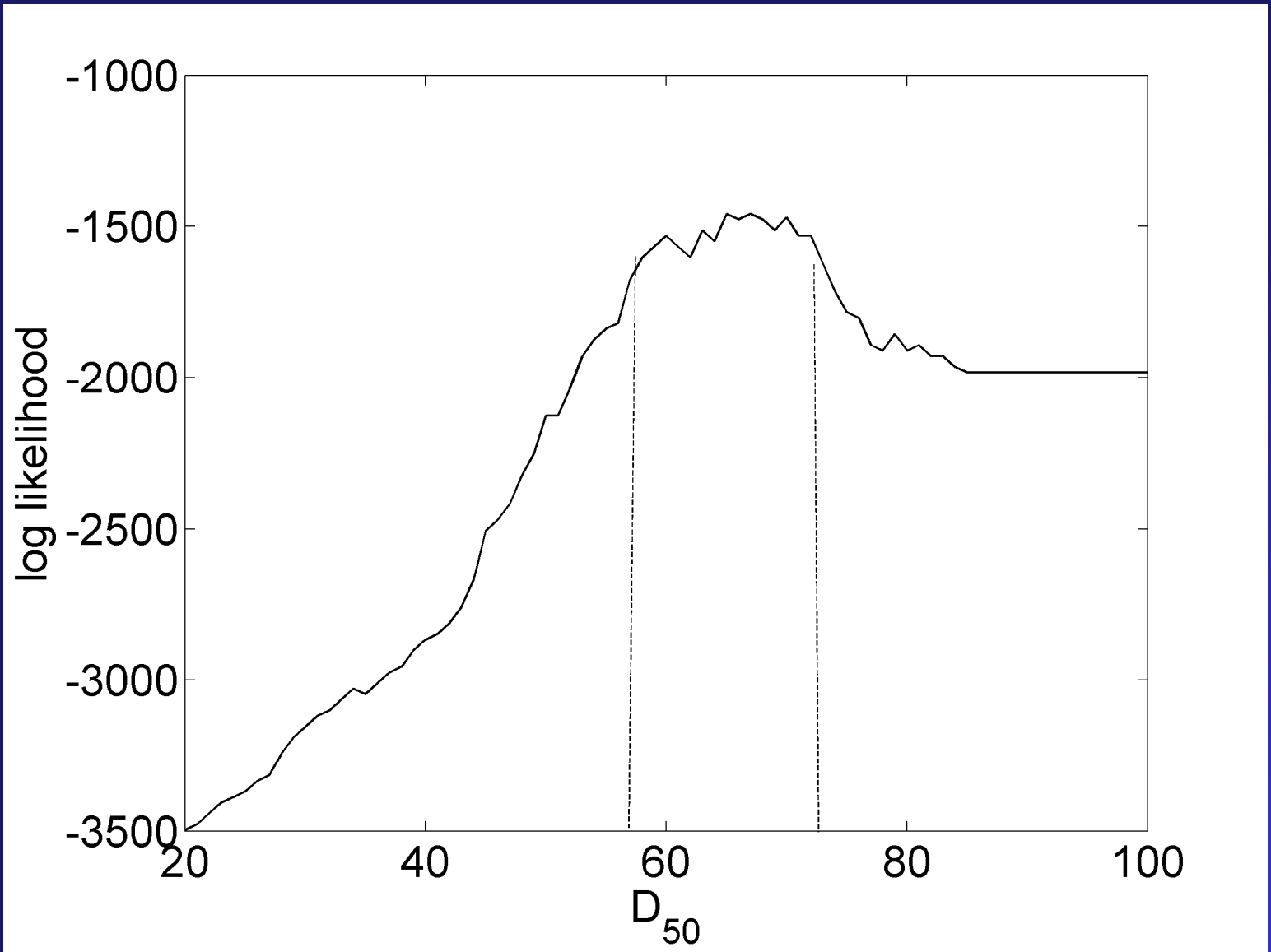
Mining RTOG/ITC data: acute esophagitis data from RTOG 93-11

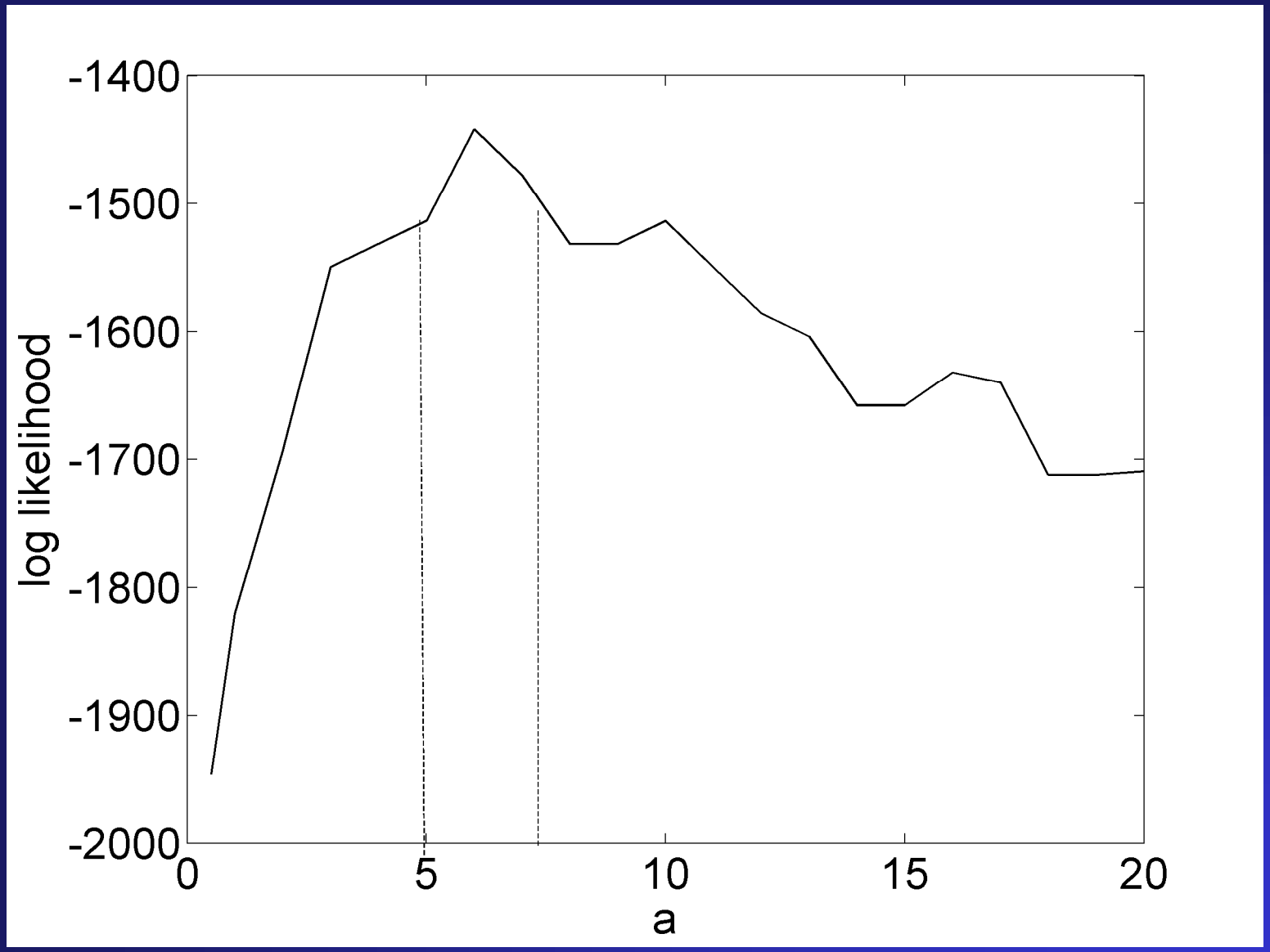
- Lung cancer external beam RT


p-value
x in Vx (Gy)
wei06-Vx-p-value-R3+
Kim05-Vx-p-value-R3+
Ahn05-Vx-p-value-R2+
Ahn05-Vx-p-value-R3+
Chapet05-Vx-p-value-R2+
Bradley05-Vx-p-value-R2+
takeda06-Vx-p-value-R1+

Add chemo effect to gEUD:

gEUD(a) + C


-1000
-1500
-2000
-2500
-3000
-3500
log likelihood
20
40
60
80
100
D50


-1400
-1500
-1600
-1700
-1800
-1900
-2000
log likelihood
0
5
10
15
20
a

Concurrent chemo was ‘worth’ about 16 Gy.

10 year old data: cutting edge results

Current priorities

- RPC
  - New features and bug fixes for film QA tool
  - [Film denoising]
  - Continued improvement of Monte Carlo tool
    - Speed review
    - Validation
    - [Support other resarch?]

Current priorities

- ATC
  - Finish batch review tool
  - Finish QARC migration
  - Viewer for RT-PACs
  - Tools for RTOG protocols
  - Fixing CT/structure mismatch problem from Eclipse exports

Future challenges

- Distributed plan review
- IGRT datasets/analysis
- Multi-modality plan review