

varian

Velocity™ 4.0

Imaging Informatics for Oncology Care Teams
AAMD Spring Meeting – April 2018

Soham Bose
Velocity Product Manager



Agenda

1. Velocity Overview
2. Deformable Image Registration Algorithm
3. Velocity 4.0 – The Upcoming Future

varian

Varian Medical Systems Velocity™ Fair Balance Safety Statement

Intended Use Summary

Velocity is a stand-alone software product that provides the physician a means for comparison of medical imaging data from multiple DICOM conformant imaging modality sources. It allows the display, annotating, volume rendering, registration and fusing of medical images as an aid during use by diagnostic radiology, oncology, radiation therapy planning and other medical specialties. Velocity is not intended for mammography diagnosis.

Important Safety Information

Velocity solutions present data and images using approximations for imaging and treatment planning data visualization and are to be used solely for informational purposes.

Medical Advice Disclaimer

Varian as a medical device manufacturer cannot and does not recommend specific treatment approaches. Individual treatment results may vary.

VARIAN CONFIDENTIAL/PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

Designed for all service lines

No longitudinal change

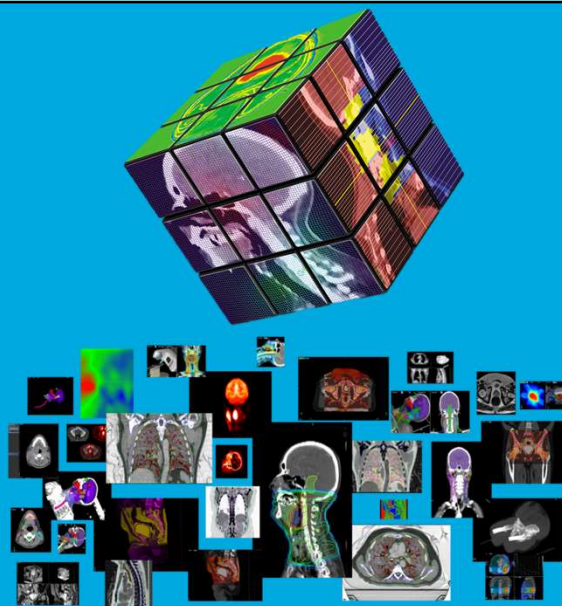
No alignment of image studies

Relies on text reports for knowledge

CHALLENGES TODAY WITH PACS

Velocity™ Background

- Built by radiation oncologists for oncology care teams
- **Oncology specific imaging informatics** solution developed in collaboration with Emory University
- Designed to assist in managing the rapid growth of **multi-modality imaging** data for RT treatment planning
- Installed in over 500 clinics globally
 - Used in over 50% of the top cancer care centers as claimed by U.S News
- Acquired by Varian in Spring 2014

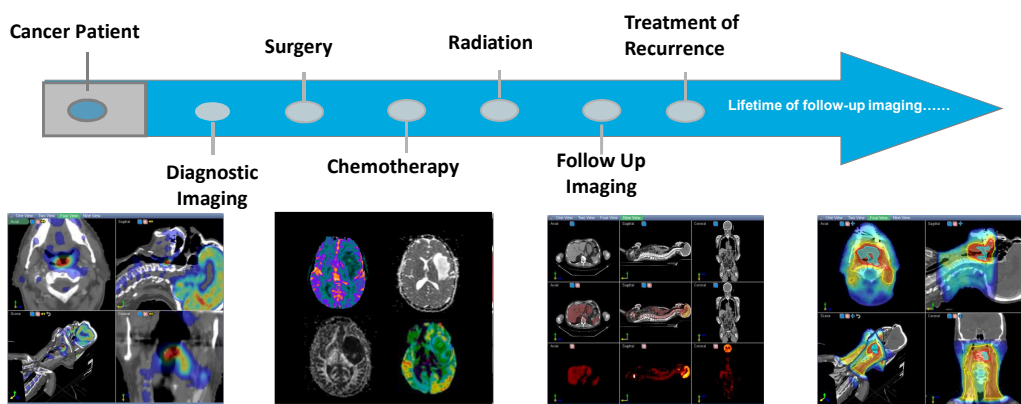


VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Image Guided Cancer Therapy

A struggle to integrate data



Explosion of data from disparate sources

Lack of imaging and treatment data integration

Inefficient care team collaboration

VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

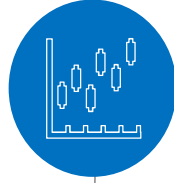
varian

Velocity™ HELPS YOU SEE THE PATIENT STORY



Measure

Measure every time point



Track

Track change over time



Share

Shared decision making

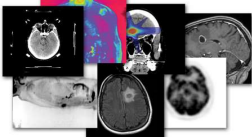
➤ Clinical Efficiencies

➤ Patient Outcomes

VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Velocity™ Features



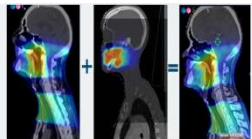
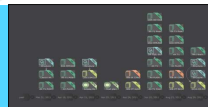
True Multi-Modality Image Registration

Deform CT, CBCT, PET, SPECT, MR, and RT Data for viewing and analysis

Vendor Neutral RT Archive

Store all DICOM / DICOM RT Files. Imaging, TPS, Structures.

View by Timeline, Frame of Reference, and Registration.



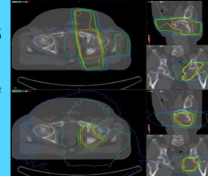
Track and Sum Dose

Track dose during a course of treatment and between courses of treatment.

Map dose from previous plans and incorporate dose and isodose structures into new plans.

Compare Plans from Different Modalities and Vendors

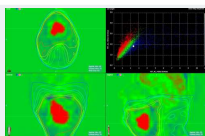
Compare dose distributions from linear accelerators, TomoTherapy, Cyberknife, Gamma Knife and brachytherapy plans. Combine doses using deformable registration.



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Velocity™ Features

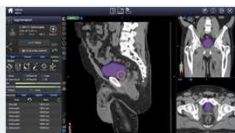
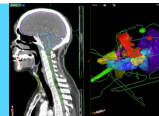


Combine Pre-Treatment, Treatment, and Post-Treatment Data

Quickly integrate all imaging and treatment data to assess the response to therapy at any spatial location.

Atlas Segmentation

Velocity provides a database of expert-defined atlas cases and allows you to create your own atlas cases.

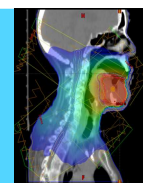


Contour Images in All Planes

Draw anywhere for real-time contouring in axial, sagittal and coronal views; Draw contours on one image slice and automatically propagate them. Intensity based tools such as the Quick Brush and Wand expedite time during contouring.

Adaptive Dose Accumulation

Velocity, Eclipse/ARIA, and Varian treatment machines allow clinicians to evaluate delivered dose and compare it to the original treatment plan, accounting for volumetric change in organs and anatomy.

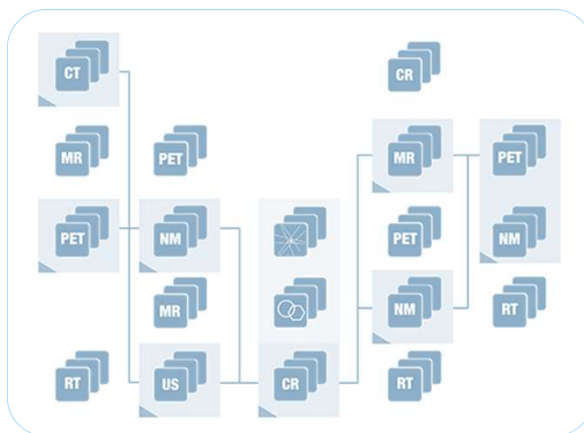


VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Longitudinal Patient Maps

Multidisciplinary teams see the patient's imaging and treatment history



Map unstructured imaging and treatment data across multiple time points.

Unified data storage system for efficient care team collaboration

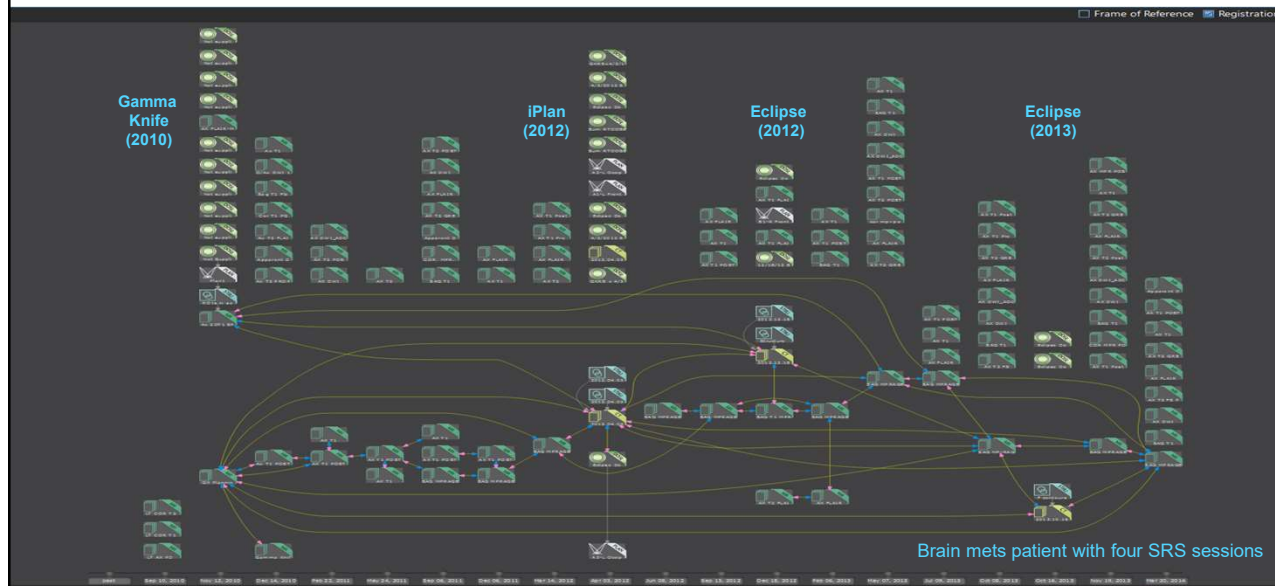
Shared decision making to extend the care team beyond the hospital

VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Tracking Metastatic Disease

“Seeing patients at follow-up, is there a new lesion?”



What did I treat yesterday?

How did I treat it?

Has the lesion changed?

What do I need to treat today?

Radiosurgical management requires dose accumulation of prior radiation and follow-up imaging

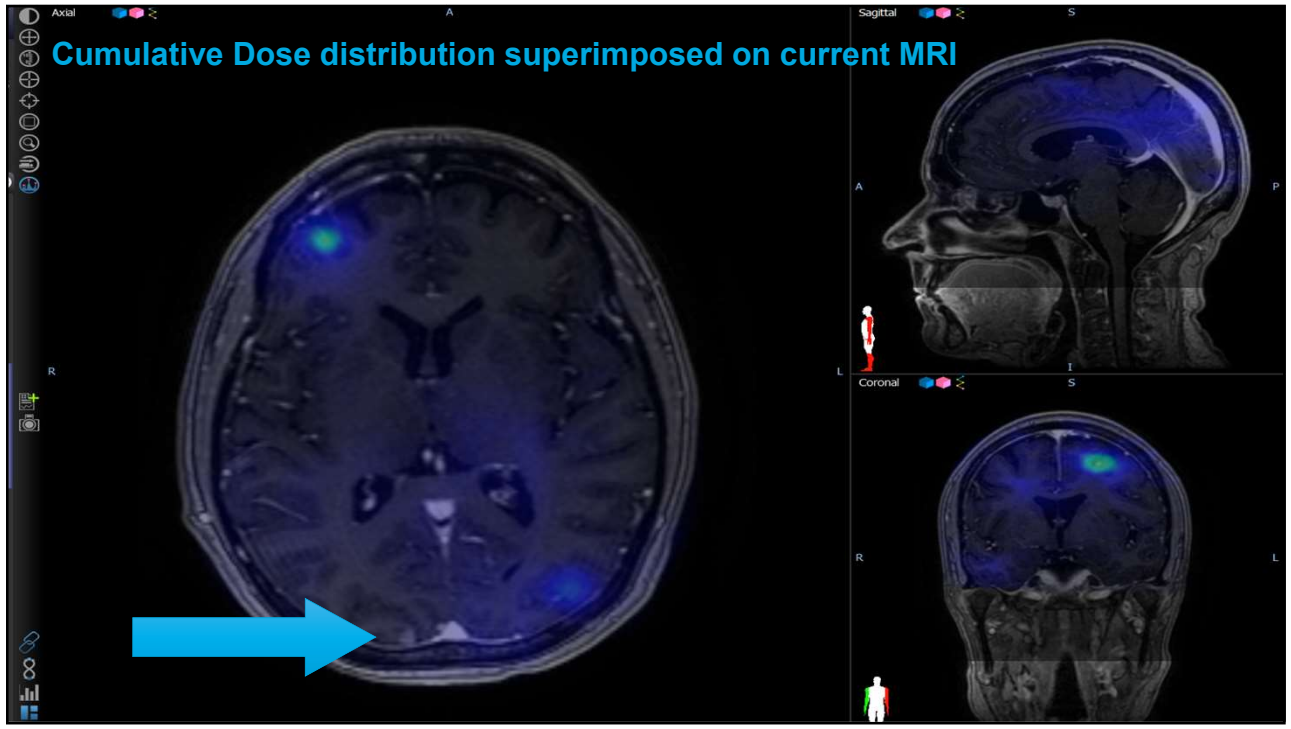
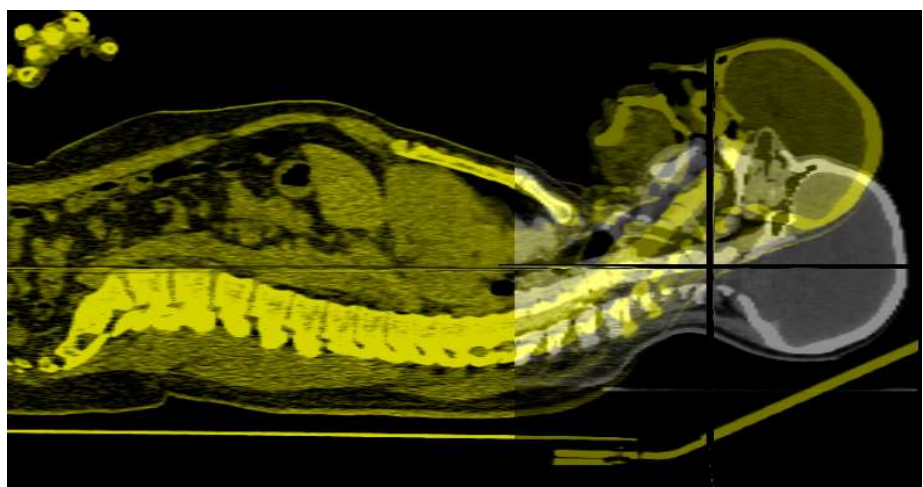


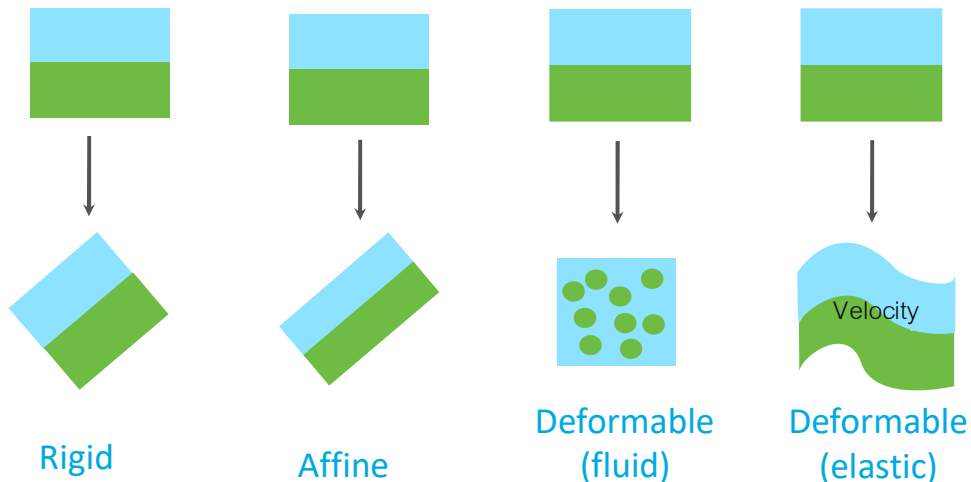
Image Registration Challenging PET-CT to SIMCT Case



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

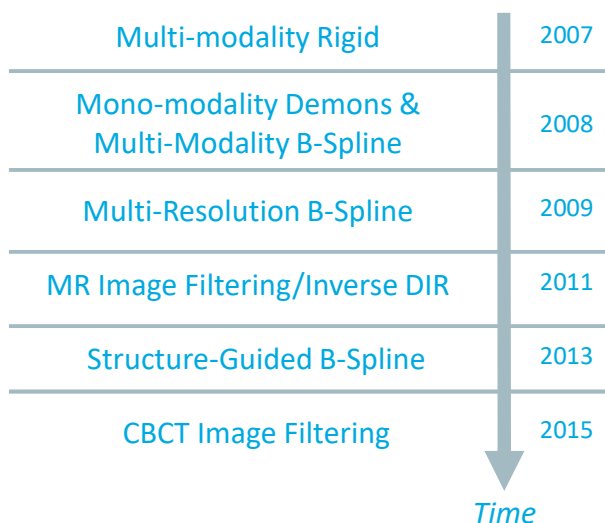
Image Registration



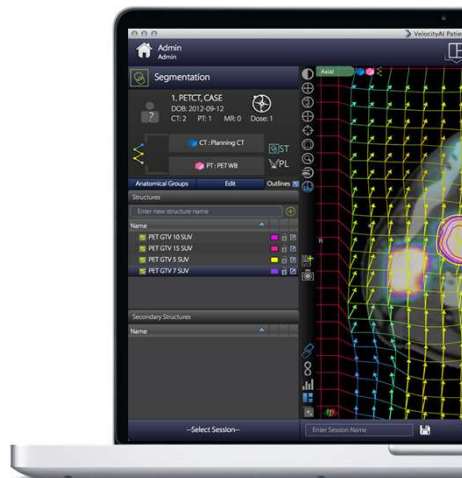
VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

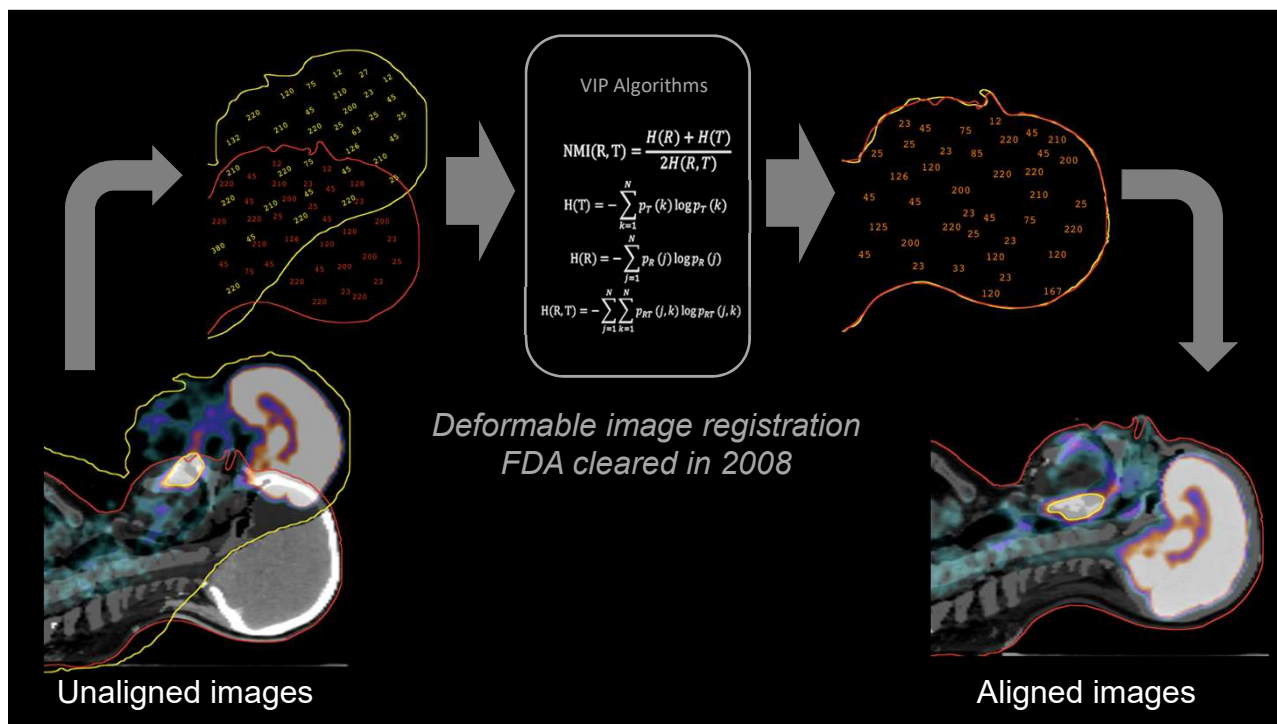
Evolution of Velocity Image Registration



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY



varian



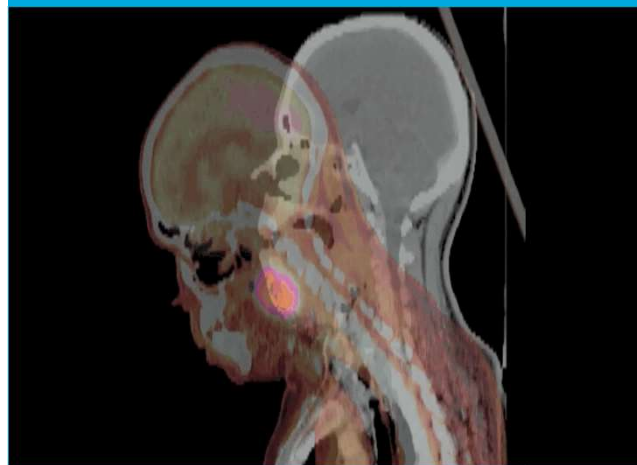
Velocity's™ Algorithm

Multi-Resolution Elastic B-Spline with Mutual Information

1. **Transformation** – alignments of image data
 2. **Similarity Metric** – quantification of the quality of the transform
 3. **Optimizer** – refines transformation to maximize metric
- Begins with “stiff” semi-rigid pliability to align overall anatomy between two volumes
 - Subsequent execution passes of the algorithm provide flexibility to deform the transform

Conservative approach with minimal elastic deformation to match underlying anatomy

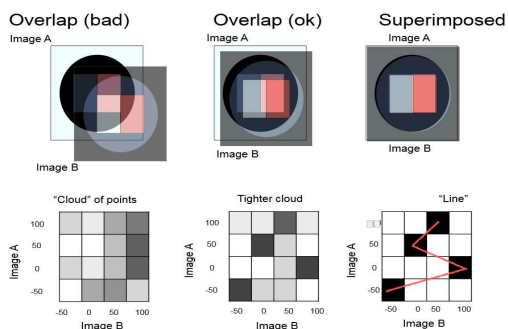
VARIAN CONFIDENTIAL/ PROPRIETARY. DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY



varian

Why Mutual Information?

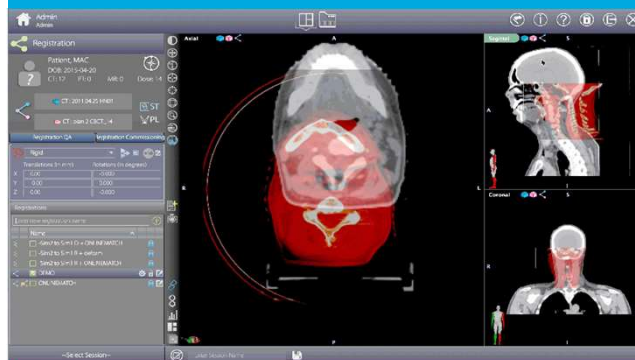
- Statistical characteristics of images
- Visualized as related to the joint histogram of the dataset



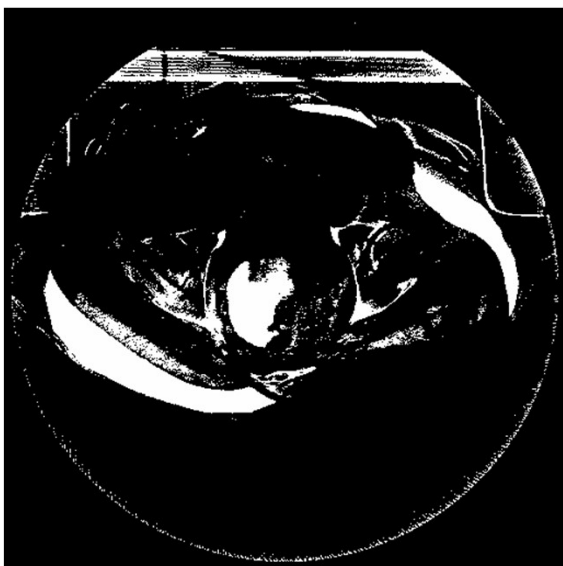
VARIAN CONFIDENTIAL/ PROPRIETARY. DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

What Clinical Benefits?

- Robust to noise and image differences
- Invertible



varian



VARIAN CONFIDENTIAL/ PROPRIETARY. DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

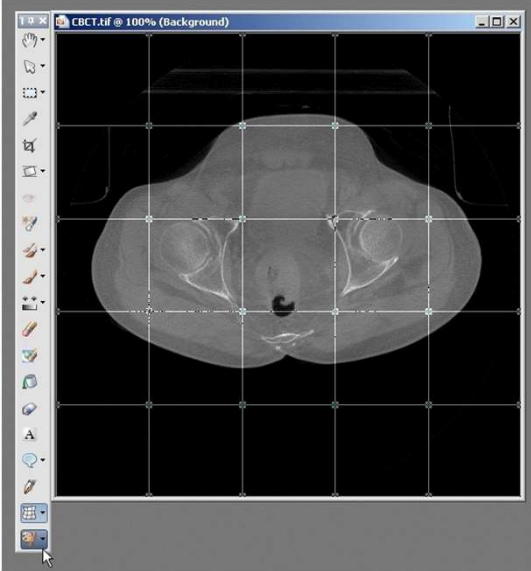
What is the metric doing?

This is the difference image between the moving and fixed image at each iteration (used optimization criteria)

- Black = zero difference
- White = maximum difference

Ideally, the whole image should be black

varian



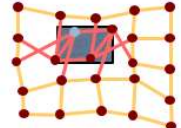
VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

Elastic B-Spline Model

1. Displacements defined on set of control points stretched over the image
2. For any arbitrary location, corresponding displacements deduced by interpolation of closest control points
3. Optimizer finds displacements in these control points

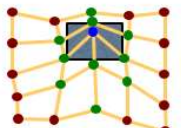
Regularization creates a smooth DVF

Unconstrained Deformable



Crossing over – usually clinically inappropriate

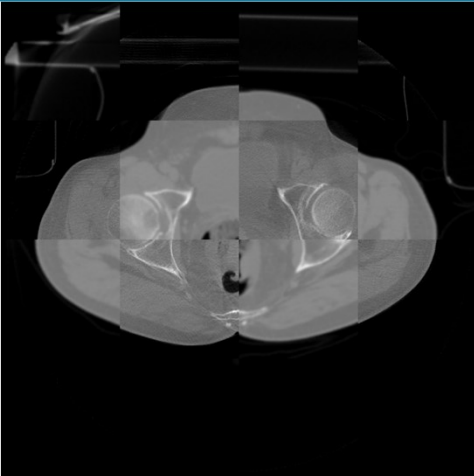
Constrained Deformable



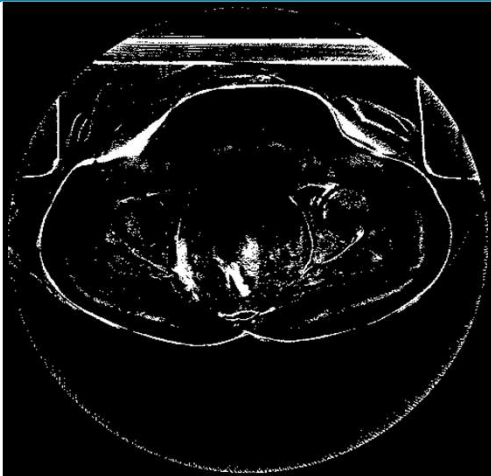
No crossing over or folding in the vector field

What is the Registration Doing?

The moving image mapped through the transform at each iteration, and the corresponding difference with the fixed image



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY



varian

Importance of QA

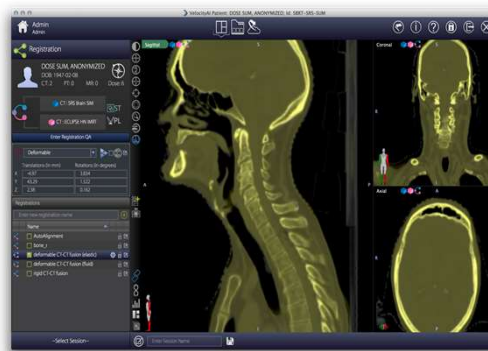
Qualitative QA is not enough

Fluid Deformable



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

Elastic Deformable

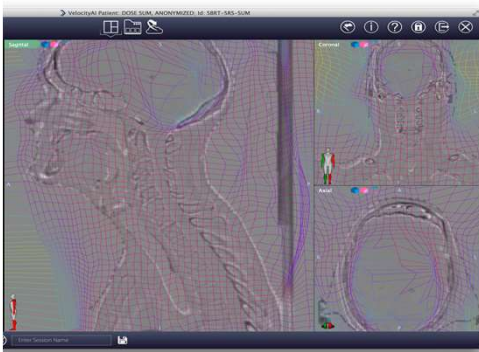


varian

Importance of QA

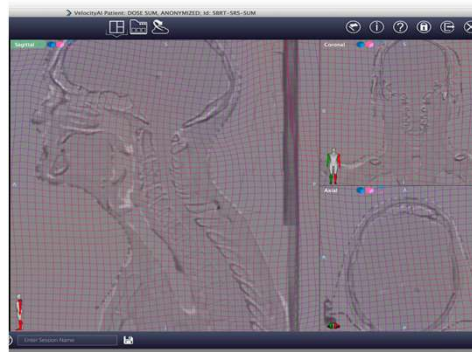
Vector map should illustrate clinical feasibility

Fluid Deformable



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

Elastic Deformable



varian

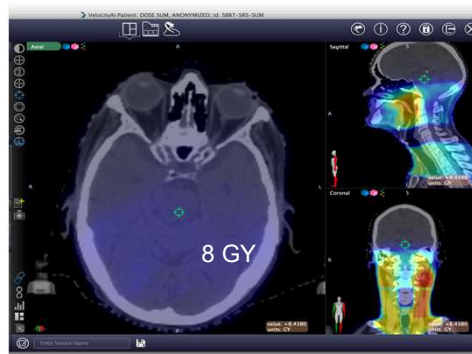
Importance of QA Implications for deformed dose

Fluid Deformable



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

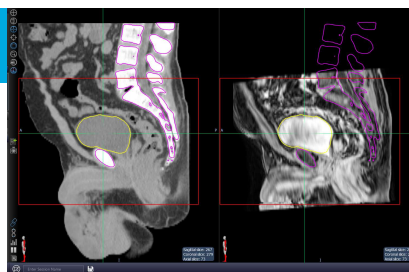
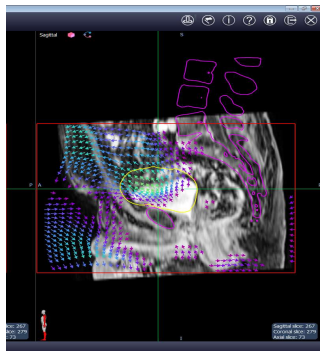
Elastic Deformable



varian

Velocity™ Advanced QA Toolkit Multi-Resolution Quality Assurance

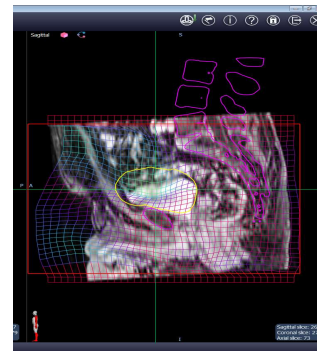
Vector Direction and Displacement



Validates voxel movement matches clinical expectations

Mesh visualization ensures no tears, crossings, or holes in the matrix

Vector Field Grid



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Image Registration

CT-SimCT Results



Rigid



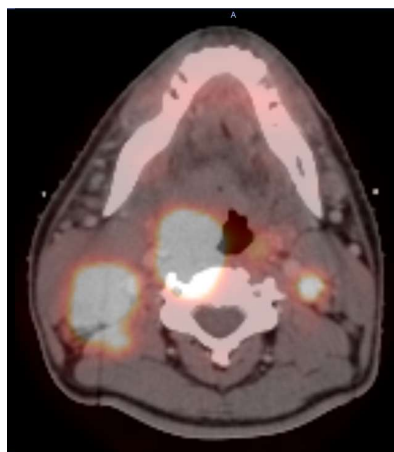
Deformable

VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

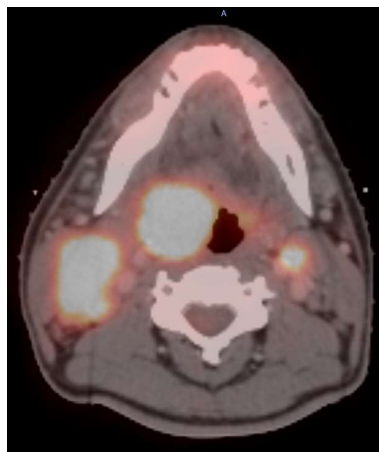
varian

Image Registration

PET-SimCT Chained Registration Results



Rigid



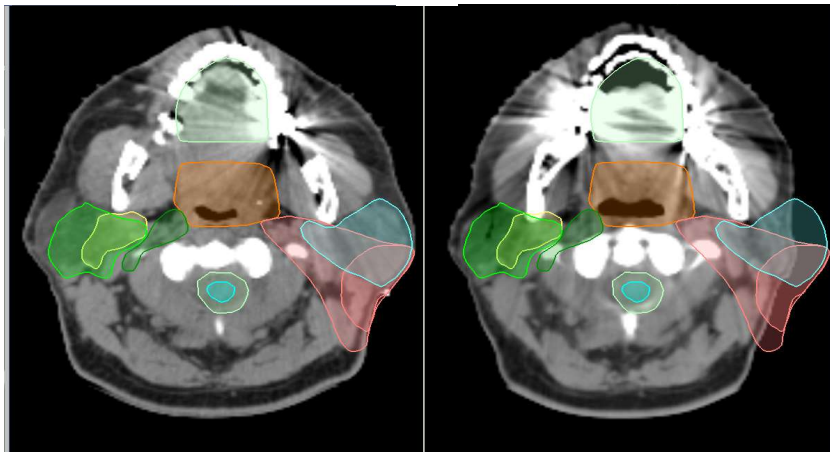
Deformable

VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Adaptive Recontouring

Rigid Problem



Initial CTSim

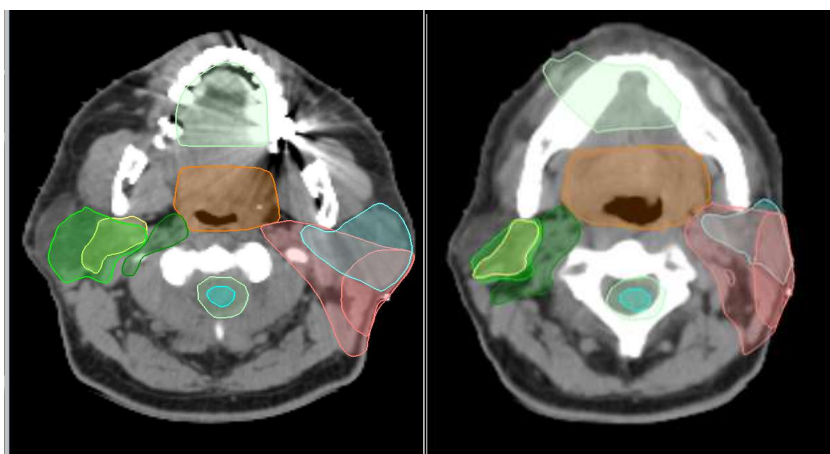
Mid Treatment CT

VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Adaptive Recontouring

Deformable Solution



Initial CTSim

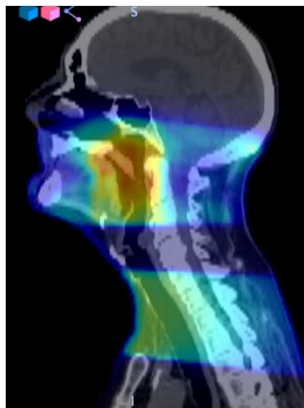
New CT with remapped contours

VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

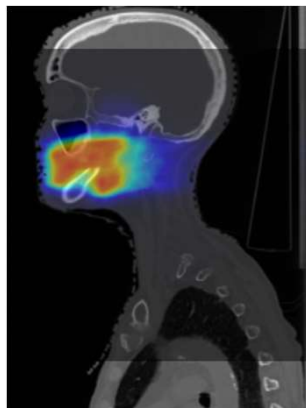
Dose Summation

Deform and accumulate dose from different vendors



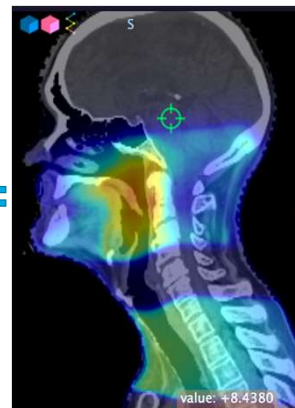
H&N Treatment

+



SRS Follow-up

=



Composite Dose

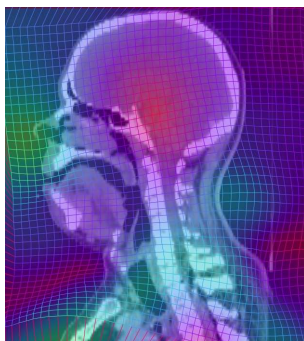
VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

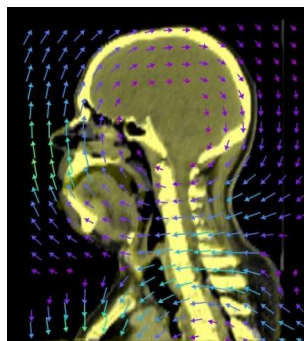
Velocity™ Advanced QA Toolkit

Multi-Resolution Quality Assurance

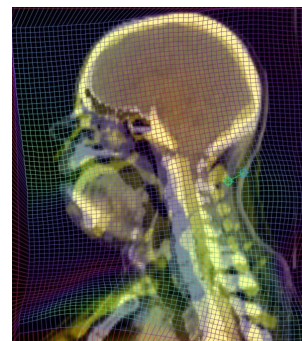
Jacobian and mesh visualization



Vector direction



Quantification of voxel displacement



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

<p>PET Wand</p> <p>33 VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY</p>	<h2>Velocity™ Contouring Tools</h2> <ul style="list-style-type: none">• Draw/erase with right/left mouse clicks• Quick brush conforms to HU intensity• Wand quickly contours<ul style="list-style-type: none">– PET uptake– MRI lesions• Mesh tool enables refinement and touchups in 3D <p>varian</p>
---	--

<h2>Velocity™ RT Plan Review Tools</h2> <p>34 VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY</p> <p>varian</p>

Velocity™ 4.0: IMAGING & TREATMENT ANALYTICS

M3i: Multi-Modality Motion Imaging

Use multiple images to make multi-modality decisions.

SmartReview

Use screenshots and annotations for collaboration and review.

ACTOR & ACTIVE Navigator

Two guided workflows to assist with radiotherapy adaptive process.

Track & Verify

Quantitatively track tumor characteristics across multiple volumes.

RapidSphere

Convert Y90 activity distributions to radiotherapy dose distributions.

Developer Mode

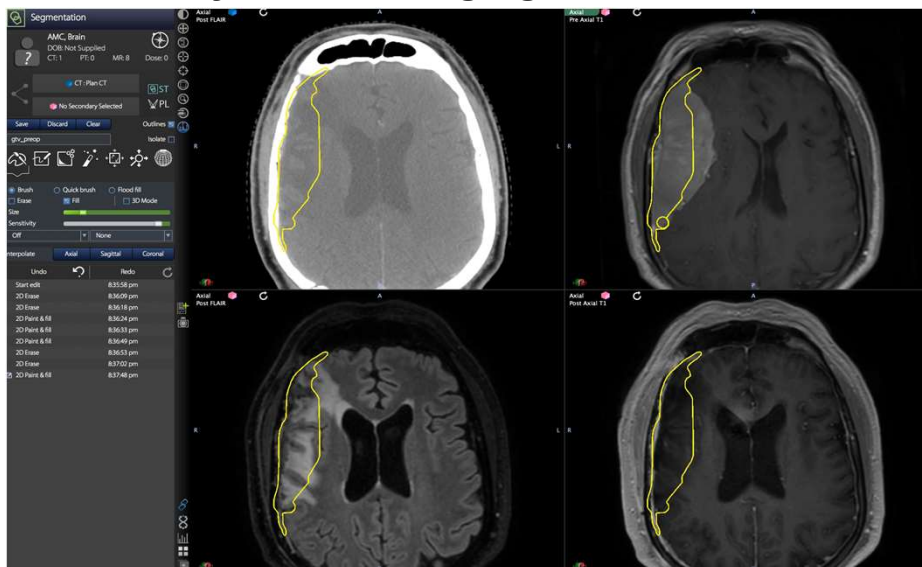
Streamline clinical workflows using API and ARIA automation.

VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Concept or work-in-progress – not available for sale and no guarantee of commercialization or features availability

M3i: Multi-Modality Motion Imaging

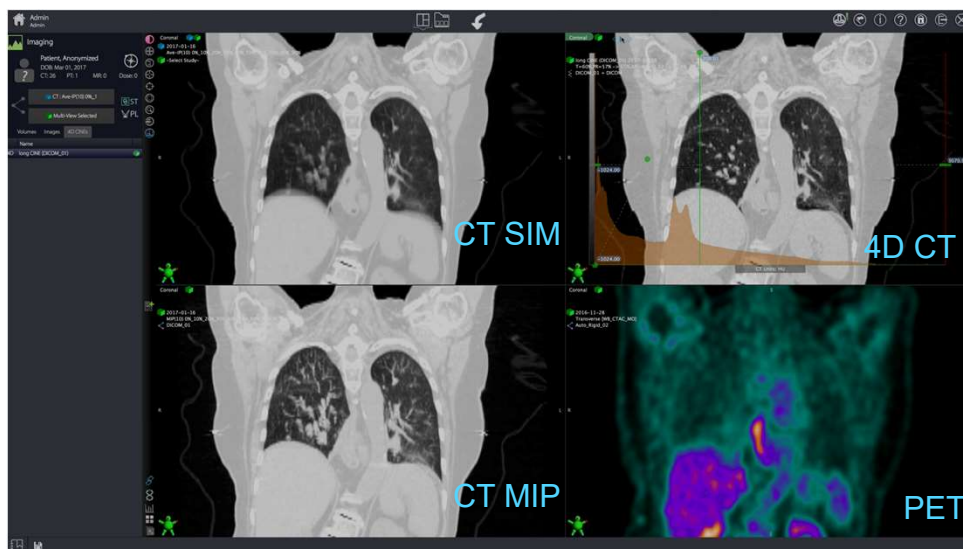


VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Concept or work-in-progress – not available for sale and no guarantee of commercialization or features availability

M3i: Multi-Modality Motion Imaging



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Concept or work-in-progress – not available for sale and no guarantee of commercialization or features availability

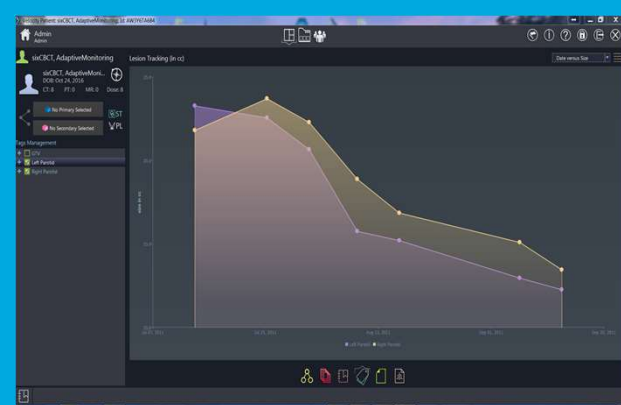
Track & Verify

Volumetric change over time

Quantitatively track tumor and OAR volumes across multiple volumes and time points

Tag	Jul 14, 2011	Jul 26, 2011	Aug 02, 2011	Aug 10, 2011	Aug 17, 2011	Sep 06, 2011	Sep 13, 2011
GTV	230.787	218.705	201.345	192.055	180.578	182.735	171.653
Left Parotid	23.272	22.551	20.661	15.752	15.196	12.948	12.249
Right Parotid	21.861	23.702	22.281	18.873	16.846	15.087	13.441

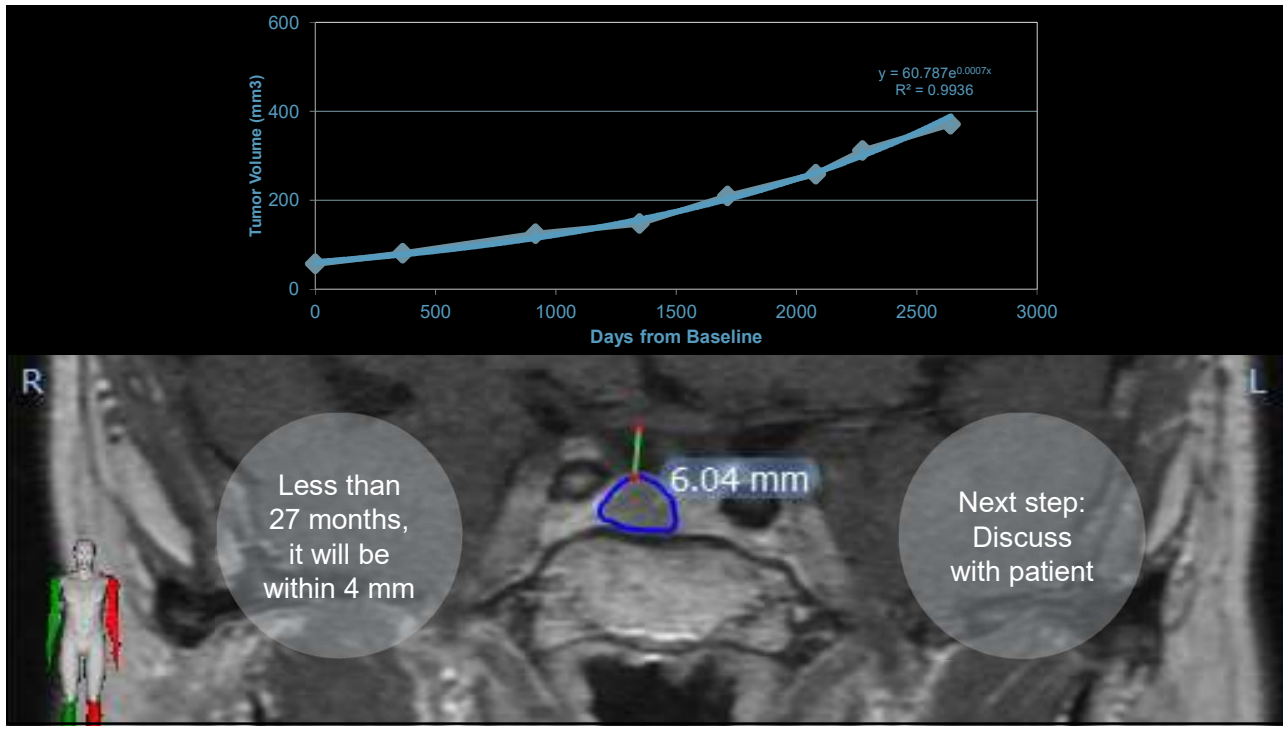
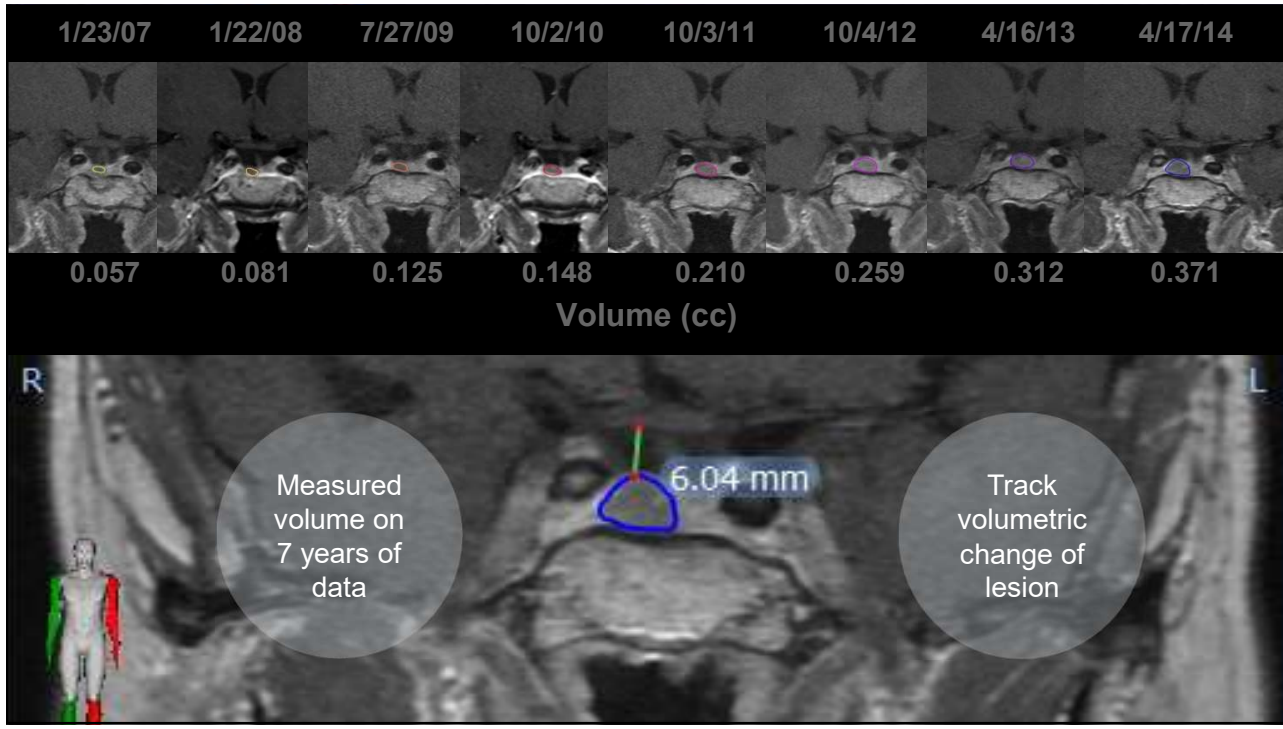
Date	Jul 14, 2011	Jul 26, 2011	Aug 02, 2011	Aug 10, 2011	Aug 17, 2011	Sep 06, 2011	Sep 13, 2011
Size (in cc)	230.787	218.705	201.345	192.055	180.578	182.735	171.653
Change from baseline	0	12.082	29.442	38.732	50.209	48.052	59.134
Change from previous	0	12.082	17.36	9.29	11.477	-2.157	11.082



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Concept or work-in-progress – not available for sale and no guarantee of commercialization or features availability



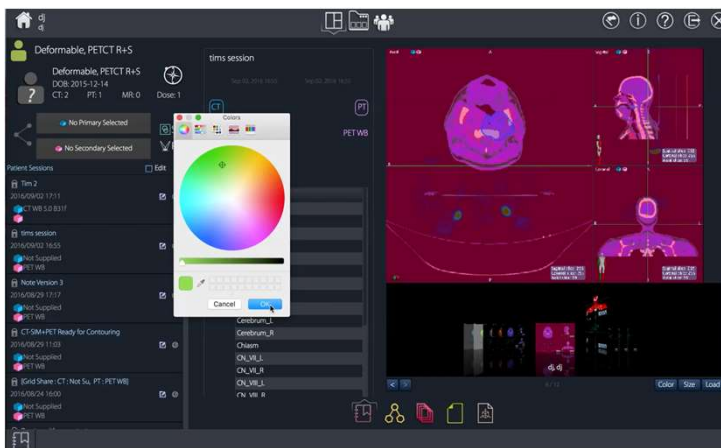
SmartReview – Session Collaboration

- “Sessions” are bookmarks that expedite recall of past work
- Screenshots, annotations and notes enhance collaboration of multi-disciplinary care teams

Consults

Chart Rounds

Tumor Boards



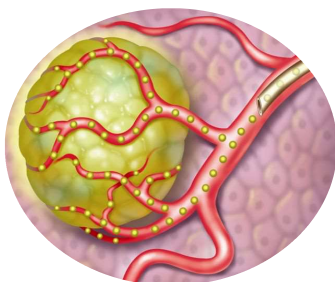
VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

RapidSphere – Integrating Cancer Care Teams

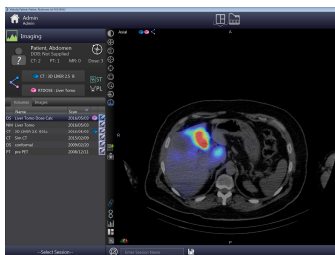
Velocity 4.0 introduces Y90 microsphere dosimetry

Tx Delivery



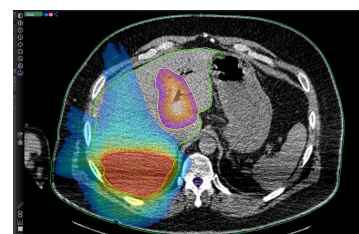
Injectable targeted radiotherapeutics emit beta particles delivering radiation primarily to tumor.

Tx Planning



Tumor dosimetry is calculated in Velocity from the SPECT imaging data which show the tumor uptake patterns.

Combined Therapy



Multi-modality deformable dose summation for combining Y90 dosimetry maps with external beam dose distributions including stereotactic body radiotherapy (SBRT).

VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Concept or work-in-progress – not available for sale and no guarantee of commercialization or features availability

ARIA®/Eclipse™ Sync

Velocity and ARIA/Eclipse now sync, eliminating manual data transfer. Velocity adds a save button that functions identically to save directly to ARIA/Eclipse, pushing onscreen data directly into the ARIA DB.

- Varian integration of software family will continue and provide long term benefits.
- Workflow with Sync/Save will eliminate repetitive work done in each of the systems due to automation.

VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

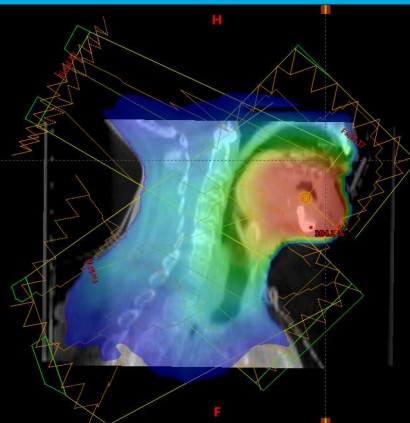
Concept or work-in-progress – not available for sale and no guarantee of commercialization or features availability

varian

Adaptive Planning

Present Day

- Subjective process
- Based on kV portal or CBCT images
 - Calculations not representative of CTSim
- Current challenges:
 - Couch shifts
 - Anatomical shifts and changes
 - Patient positioning
 - Partial CBCT coverage



44

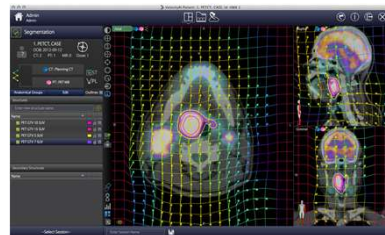
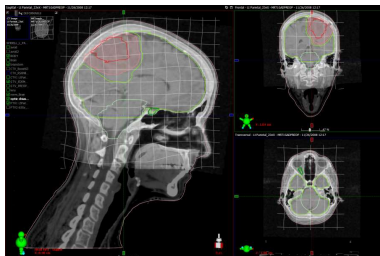
VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Adaptive Therapy

The necessary components

TrueBeam® <i>Treatment Machine</i>	Eclipse™ <i>Dose Calculation</i>	Velocity™ <i>Deformable Dose Mapping</i>
--	--	--

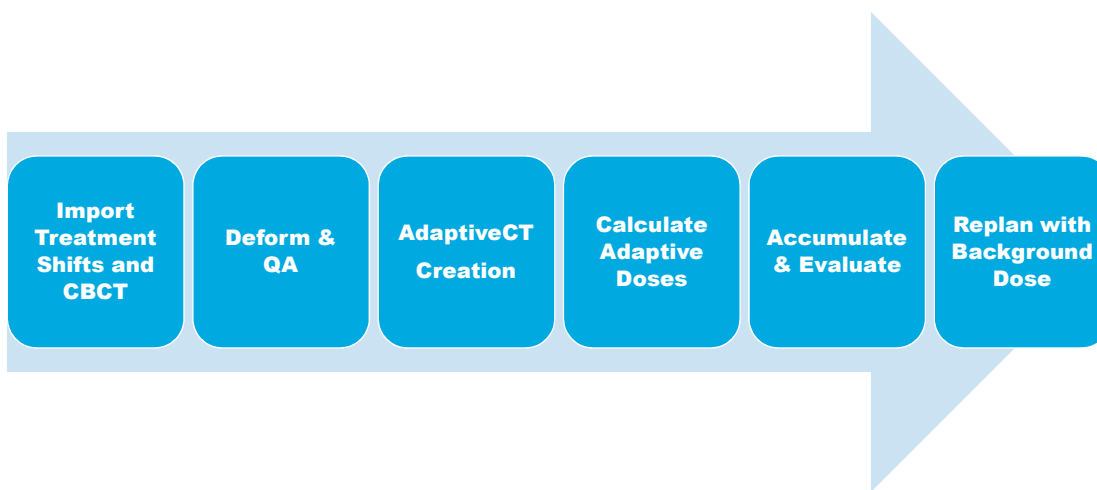


VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Adaptive Workflow

ACTOR & ACTIVE Dosimetry Navigators

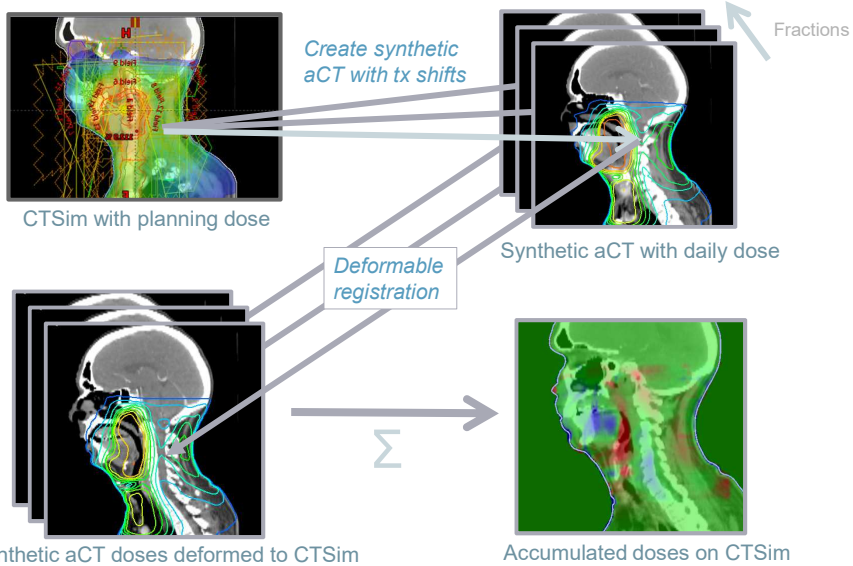


VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

Concept or work-in-progress – not available for sale and no guarantee of commercialization or features availability

varian

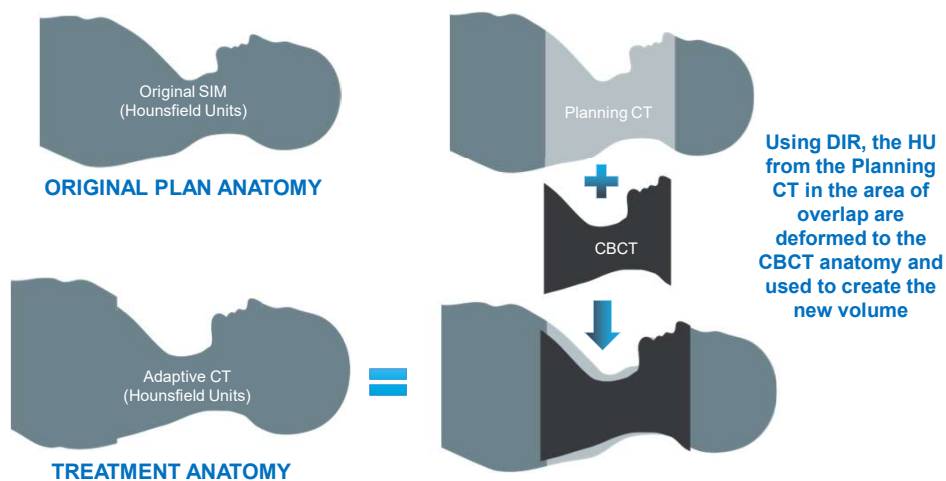
Adaptive Dose Tracking Workflow



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

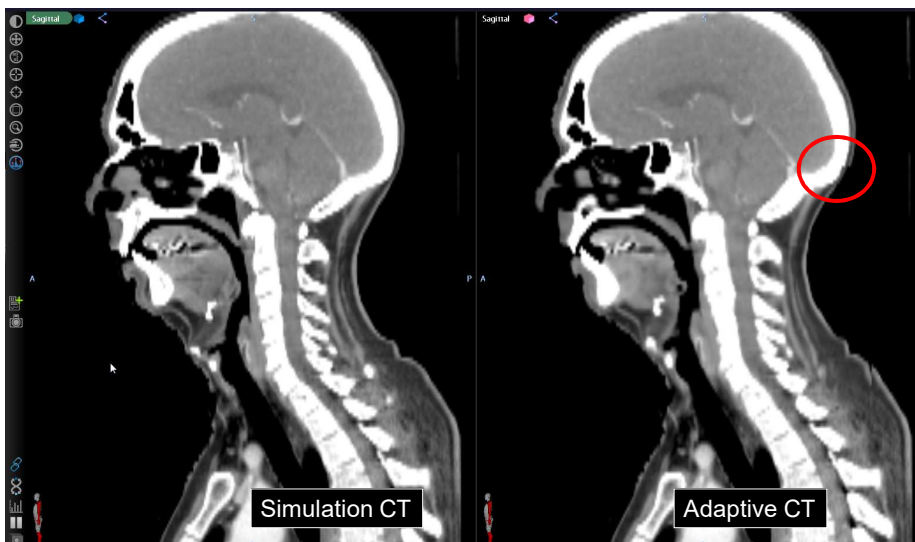
Create "Synthetic" or "Adaptive" CT



VARIAN CONFIDENTIAL/ PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

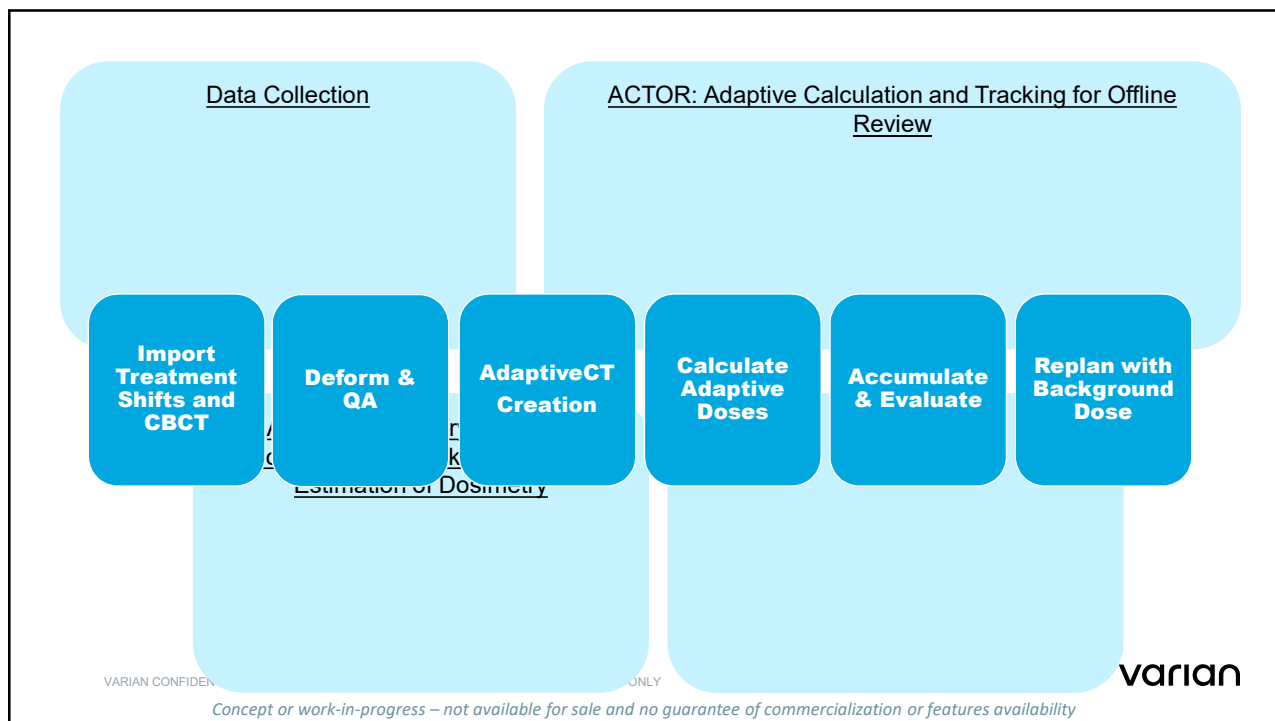
varian

AdaptiveCT Creation – Automatic HU Assignment



VARIAN CONFIDENTIAL/PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

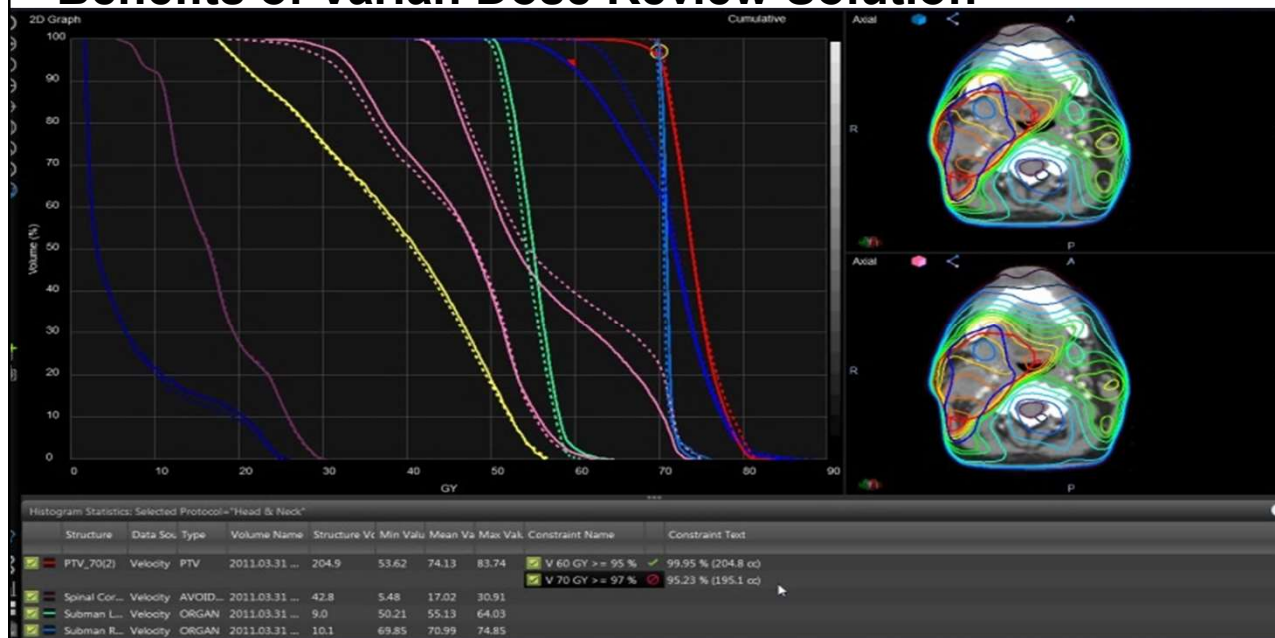


VARIAN CONFIDENTIAL/PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

Concept or work-in-progress – not available for sale and no guarantee of commercialization or features availability

Benefits of Varian Dose Review Solution



Benefits of Varian Dose Review Solution

Ability to compare:

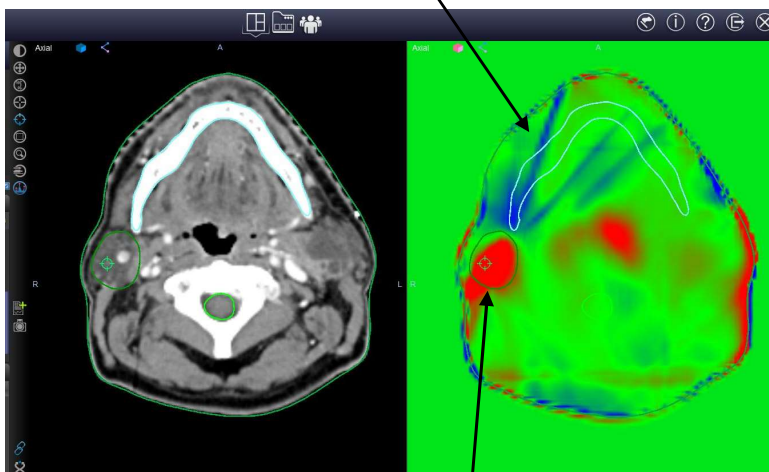
- Calculated daily dose vs planned daily dose
- Total delivered dose vs total planned dose
- Delivered DVH vs Planned DVH
- Volumetric display of under and over-dosing (hot and cold regions)

ACTOR & ACTIVE Dosimetry

Set up errors ("streaks")

Varian Solution

- Dose subtraction volume generated
 - ✓ Evaluate anatomical changes ("globs")
 - ✓ Visualize set up errors ("streaks")



Anatomical difference ("globs")

VARIAN CONFIDENTIAL/PROPRIETARY: DISCLOSED SOLELY FOR IMMEDIATE RECIPIENT ONLY

varian

(Thank you)





varian