



Montefiore Montefiore Einstein
Center for Cancer Care

Going Clinical with the Accuray Radixact™ System

The Montefiore Experience

Disclaimer

- The views expressed in the presentation are those of the presenters and do not necessarily reflect the views or policies of Accuray Incorporated or its subsidiaries.
- No official endorsement by Accuray Incorporated or any of its subsidiaries of any vendor, products, or services contained in this presentation is intended or should be inferred.

Financial Disclosure

- An honorarium is provided by Accuray for this presentation.

Montefiore Medical System

- Founded in 1888
- Over 20 primary and specialty centers serving the Bronx and Westchester regions of New York.
- Strong history of acquiring new technology for radiation oncology.

Radiation therapy with the world's first clinical 35 MV Betatron (1962)

Photograph courtesy of George Zacharopolous



Current Clinical Environment

- Staff has strong experience with Varian technology
 - Aria[®] Oncology Information System
 - Eclipse[™] External Beam Treatment Planning
 - TrueBeam[®] STx, Trilogy[®], 2 Clinac[®] 2100C
- Paperless medical records
 - All patient documentation and records kept to Aria[™]
 - Integrated with Epic electronic health record system

The Challenge

- Integrating the Radixact™ System into a Varian environment
 - Minimize the impact of introducing new technology
 - Seamless integration with clinical workflow
- Establish who will be leading the effort out of each clinical group
 - Therapist, Dosimetrist, Physicists
 - Train them early and have them intimately involved with incorporating the new technology before involving the rest of the staff
- Physicists are ultimately responsible for the success of integrating new technology in a Rad Onc clinic

Transition to Clinical Use

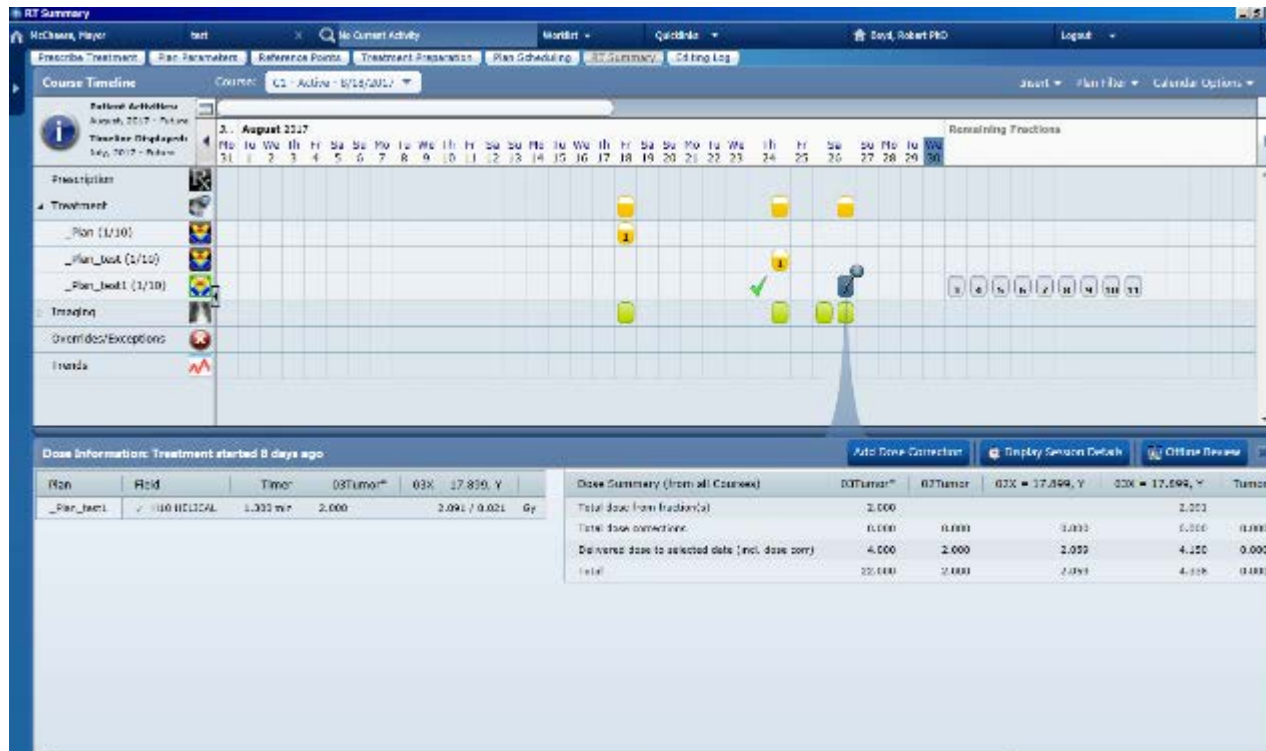
- Commissioning phase:
 - Used a RANDO phantom to validate the entire workflow from CT simulation to treatment delivery.
 - Developed the warm-up procedure for therapist to follow
 - PowerPoint presentation showing ***every step in detail*** including screen shots
 - Staff trained in emergency procedures
- Clinical initiation:
 - Slow ramp up of clinical load
 - 4 patients added per week
 - Allowed therapists to achieve comfort level

Aria® OIS Treatment Workflow

- Utilized Accuray OIS Connect™ Option and Varian DICOM Worklist Interface to integrate Radixact™ System with Varian OIS
- Treatment workflow:
 - Patient is scheduled in Aria® Time Planner for treatment
 - Patient is checked-in in Aria® Time Planner
 - Patient now appears in list at Radixact™ System treatment console
 - Patient is imaged and treated
 - Popup window appears on Aria™ workstation for charge capture.
 - Automatic transfer of fraction dose and MVCT/kVCT registration to Aria™
 - Physicians can review daily image registration in Aria™ Off-Line Review

Aria® OIS Treatment Workflow

- Therapist verify dose accumulation and image registration to Varian OIS with Varian RT Summary



Interrupted Treatments

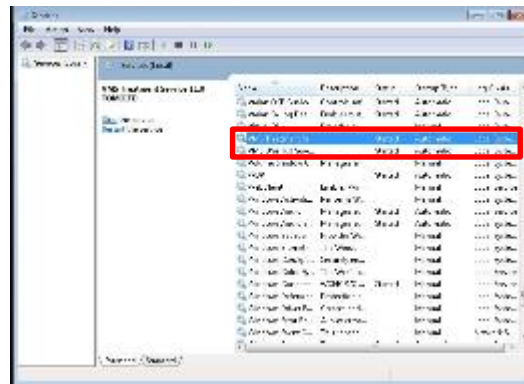
- Dose recording and CTrue™ Daily Image registrations can be sent manually from Accuray Precision™ Treatment Planning System in the case of a treatment interruption that is subsequently completed.

The screenshot displays the Accuray Precision Treatment Planning System interface. At the top, there are navigation tabs: Plan Details, Transferred Plans, Fraction Management, DICOM Series, Documents, and QA Plans. Below these is a search bar and a table of treatment series. The table has columns for Primary, Modality, Scan Type, Series Description, Series UID, Study UID, Scan Date, Export Status, and Export Percent. An 'Export Series' dialog box is open in the foreground, showing fields for Host Name (set to 'AriaRTRecord'), AE Title (set to 'TOMOITD'), IP Address (set to '10.115.23.198'), and Port (set to '104'). The dialog has 'OK' and 'Cancel' buttons.

Primary	Modality	Scan Type	Series Description	Series UID	Study UID	Scan Date	Export Status	Export Percent
*	CT	KVCT	HeadNeck	1.2.840.113619.2.55.3.14938...	1.2.840.113619.2.55.3.14938...	06 Jul 2017, 02:29:16 PM		0%
	RTSSET		PTV5040 - RTSS	1.2.840.114358.1403801414...	1.2.840.113619.2.55.3.14938...			0%
	RTRECORD		3008-423338364972825717-423338364972827329-4-0	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	RTRECORD		3008-423338364972825717-423338364972827329-3-0	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	RTRECORD		3008-423338364972825717-4233383...	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	CT		Multiplan couch-replaced CT series	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	RTRECORD		3008-423338364972825717-4233383...	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	RTRECORD		3008-423338364972825717-4233383...	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	RTRECORD		3008-423338364972825717-4233383...	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	RTPLAN		PTV5040	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	RTSSET		TomoTherapy Couch Replaced Stuc	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	RTDOSE		FINAL	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	RTDOSE		OPTIMIZATION	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...			0%
	CT	MVCT	CTrue Image Set	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...	13 Jul 2017, 03:01:38 PM		0%
	CT	MVCT	CTrue Image Set	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...	14 Jul 2017, 10:55:45 AM		0%
	CT	MVCT	CTrue Image Set	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...	17 Jul 2017, 02:57:05 PM		0%
	CT	MVCT	CTrue Image Set	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...	18 Jul 2017, 01:25:56 PM		0%
	CT	MVCT	CTrue Image Set	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...	18 Jul 2017, 10:12:05 AM	Completed	100%
	CT	MVCT	CTrue Image Set	1.2.840.114358.3008.201707...	1.2.840.113619.2.55.3.14938...	20 Jul 2017, 11:03:49 AM		0%

OIS Connectivity

- Therapists checks for VMS (Varian Medical System) services running on Windows workstation during morning warmup



- Physicists can ping connection from Accuray iDMS™ Data Management System to Varian OIS servers

Delivery System	Delivery Type	OIS Name	OIS Vendor	Server Name	Server Type	Local AE Title	AE Title	IP Address	Port	Action	Status
4010013_1000MU	TomoTherapy	ARIA	Varian1	RTPLAN-ARIA	RTPlanArchive	N1000_TDS	ykro101	10.85.5.62	106	Ping	Acknowledged
4010013_1000ML	TomoTherapy	ARIA	Varian1	RTRECORD-ARIA	RTRecordArchive	N1000_IDS	TUM01ID	10.113.23.190	101	Ping	Acknowledged
4010013_1000MU	TomoTherapy	ARIA	Varian1	WORKLIST-ARIA	WorklistDaemon	N1000_TDS	DCWLService	10.113.23.198	57200	Ping	Acknowledged

Daily Setup and Imaging

- Therapist images the entire PTV with MVCT
 - Yaw and Pitch corrections not applied but calculated for image registration to confirm patient setup
 - Pitch is critical for extended PTVs (GYN with para-aortic)
 - Yaw important for H&N setups
 - Translations and Roll corrections used to shift patient and starting gantry position

Treatment Planning Workflow

- Physicians contour target and critical structures in Eclipse™
- Attending physician approves structure set in Eclipse™
- Dosimetrist transfers CT image and structure set to Accuray Precision™ Treatment Planning System and generates plan
- Attending physician reviews plan in Accuray Precision™ System and approves for treatment
 - RTPlan, RTTS, and CT with couch replaced DICOM files transfers to Aria® automatically upon approval
- Physicist reviews plan in Accuray Precision™ Treatment Planning System and approves treatment plan for delivery in Aria®

Rescan Plans

- Typically we rescan kVCT images for prostate patients on 23rd fraction and H&N patients on 15th fraction and recalculate dose onto new CT image.
- Rescan kVCT uploaded to Accuray Precision™ Treatment Planning System and used in the Retreatment module
- Deformed dose distribution exported to Eclipse™ and associated with a plan
- Physicians review the dose distribution to determine if a new plan is appropriate.

Treatment Planning

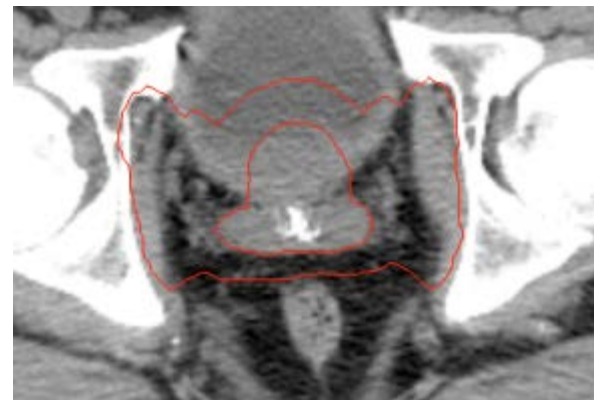
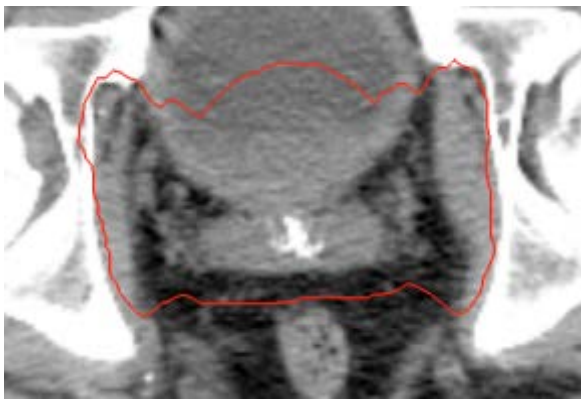
- Four concepts new to experienced Eclipse™ treatment planners:
 - Pitch
 - Target and critical structure overlap priority
 - Critical structure beam intersection
 - Modulation Factor and Leaf-open time (LOT)

Pitch

- Pitch is a complex concept but easy to deal with.
- Use published table for pitch selection
 - Dependent on field width, dose/fraction, and off-axis extent of PTV
 - Theoretical analysis of the thread effect in helical TomoTherapy, Chen et al., Medical Physics **38** 5948 (2011)
- Pitch is discussed in-depth during training and published tables are provided by Accuray
- Use the highest pitch possible to reduce fast leaf open times
 - Less stress on MLCs
 - Better measured QA results

Overlap Priority

- Every pixel is associated with one target and one critical structure (if one or more ROIs overlay the pixel)
 - Prescription PTV must have highest priority (left image)
 - The right image shows the effect of CTVs having higher priority than PTV for optimization (introduction of cavity)
 - Be careful of tuning structures inside prescription PTV






Overlap Priority

- Structures imported from Eclipse™ initially have priorities associated to location on structure list.
 - Planner should prioritize contours before planning
 - Physicist should check structure priority when reviewing plan
- Automatic generated skin contour is first on list of Eclipse™ structure set and therefore comes in as highest priority critical structure.
 - Will render all optimizations on critical structures void unless the overlap priority is set to last.

Beam Intersection

- Each critical structure has three possible relationships beam intersection:
 - Never: No beamlets pass through the structure
 - Allowed: Beamlets can pass through the structure
 - Exit Only: Beamlets can pass through the structure but only after passing through a target first

Critical Constraints					
	Name	Overlap Priority	Beam Intersection	<input type="checkbox"/>	Use
	avoid	1	Never	<input checked="" type="checkbox"/>	
	clip	2	Never	<input type="checkbox"/>	
	skin	3	Allowed Exit Only	<input type="checkbox"/>	

Beam Intersection

- Excellent tool for sparing critical structures
 - Improved rectal sparing in prostate plans
 - Improved residual parotid sparing in H&N plans
 - Critical structures in brain
- Can block shoulders and positioning device in H&N treatments
 - RapidArc™ cannot do this so we still rely on 9-field fixed beam IMRT on Varian linacs
 - Result is H&N treatments are more efficiently delivered on Radixact™ System

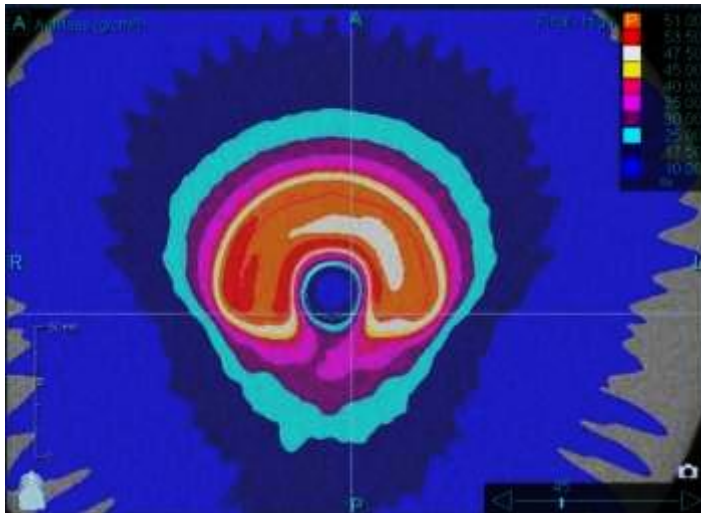
AAPM TG-119

- IMRT commissioning: multi-institutional planning and dosimetry comparison
- TG-119 is a useful tool for dosimetrists and physicists to understand the optimization engine.
- Contour sets downloadable from AAPM website
 - Mock prostate, mock Head & Neck, C-shape
- Results can be compared to institutions in TG-119 report

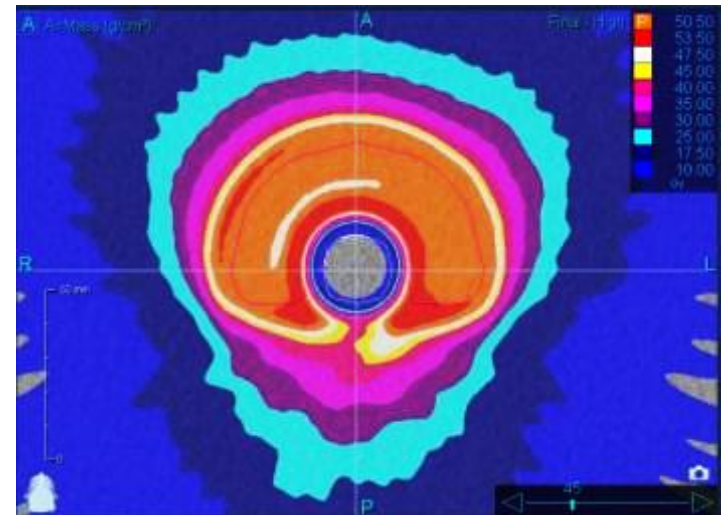
AAPM TG-119

- The C-Shape plan offers an excellent means to review impact of beam intersection on critical core structure

“Exit-only” beam intersection



“Never” beam intersection

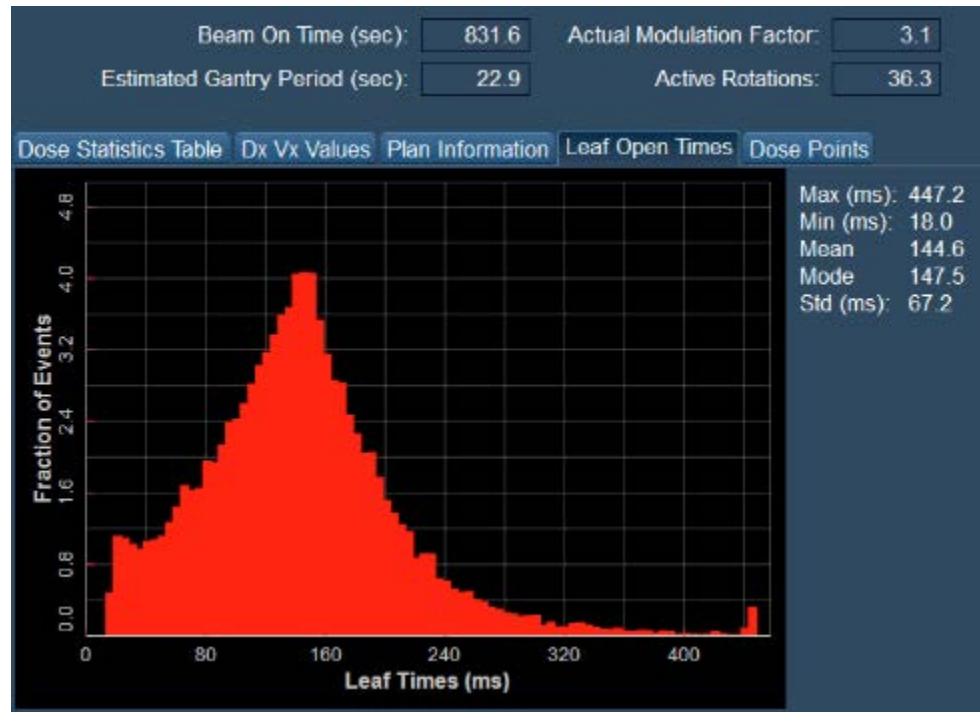


Modulation Factor

- The Modulation Factor (MF) is a parameter that allows planners to control highly modulated IMRT plans for complex target volumes and critical structure geometries.
 - Result is longer maximum leaf open times (LOT)
 - $MF = LOT_{\max} / LOT_{\text{mean}}$
- High MF values result in longer treatment times with marginal improvement to plan quality
 - Total treatment time = $LOT_{\max} \times 51 \times \text{active rotations}$
- Planners usually start with a high MF to achieve ideal IMRT plan then reduce MF until plan quality starts to degrade
 - Can be inefficient to search for ideal MF

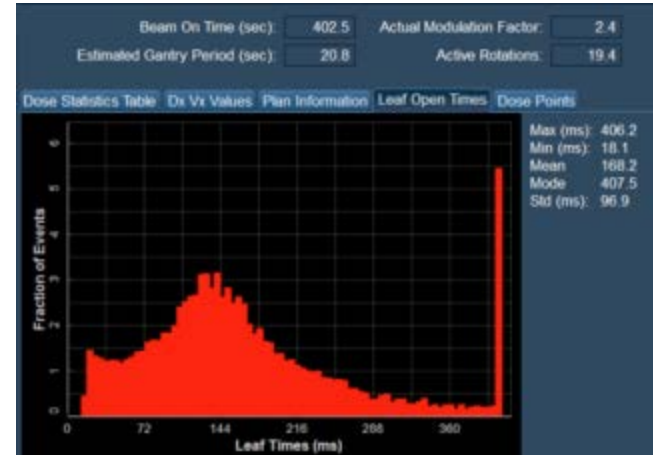
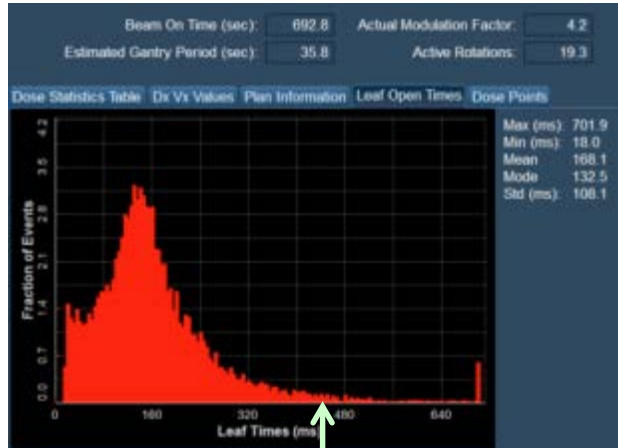
Leaf-Open Time (LOT)

- LOT distribution plot is an excellent tool for creating more efficient treatment deliveries



H&N planning

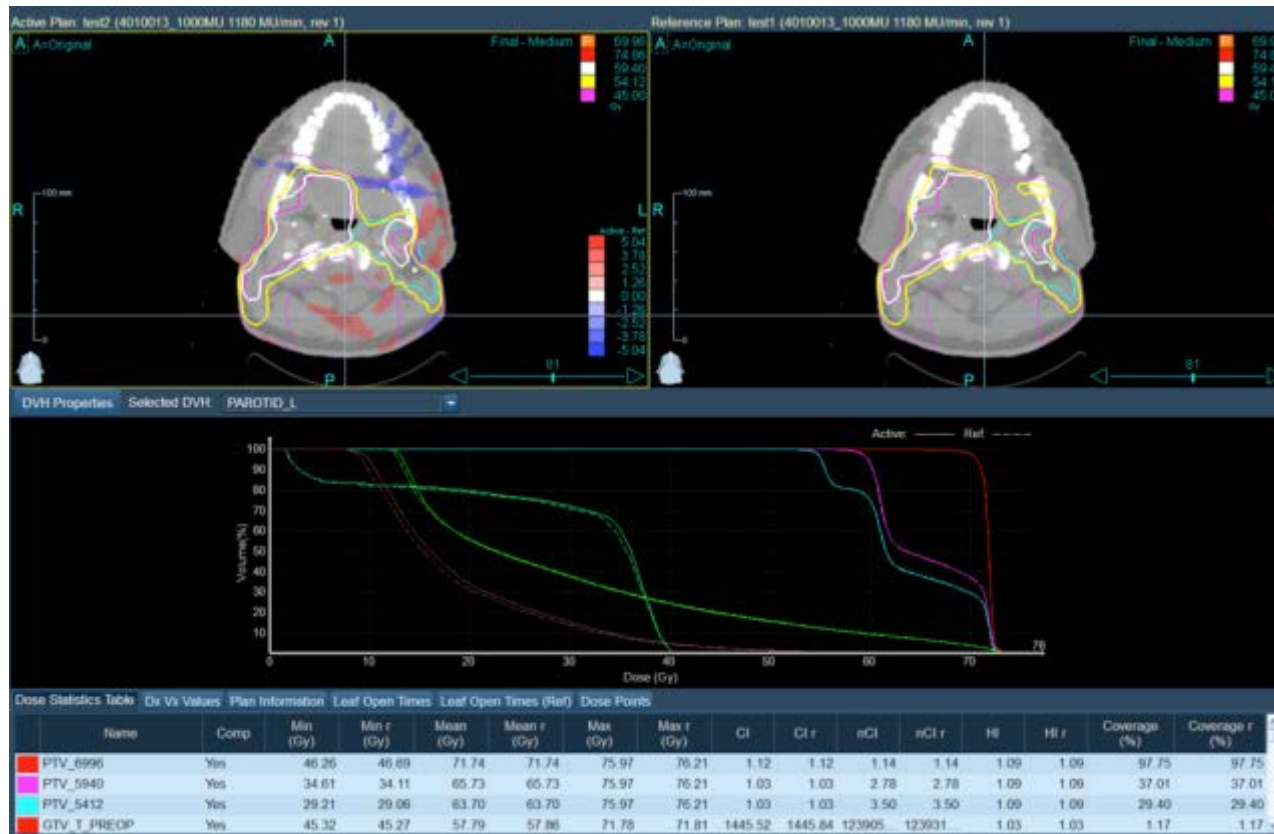
- 69.96 Gy SIB plan: 11 minutes, 40 seconds
- Visual inspection of LOT distribution led to a cutoff value of 300 msec.
 - New plan MF = $400/168 = 2.4$ (continued optimization for 100 iterations)
- New plan is **6 min, 45 secs**



400 msec cutoff

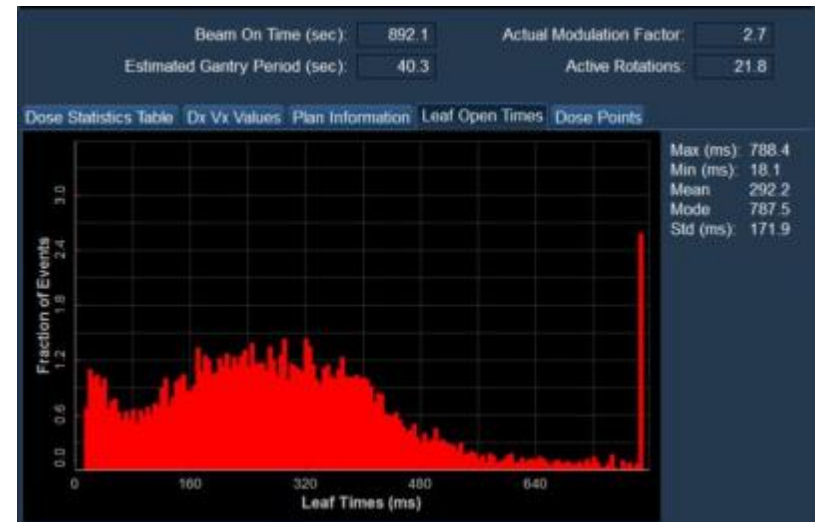
H&N planning

- Difference in plan quality is negligible



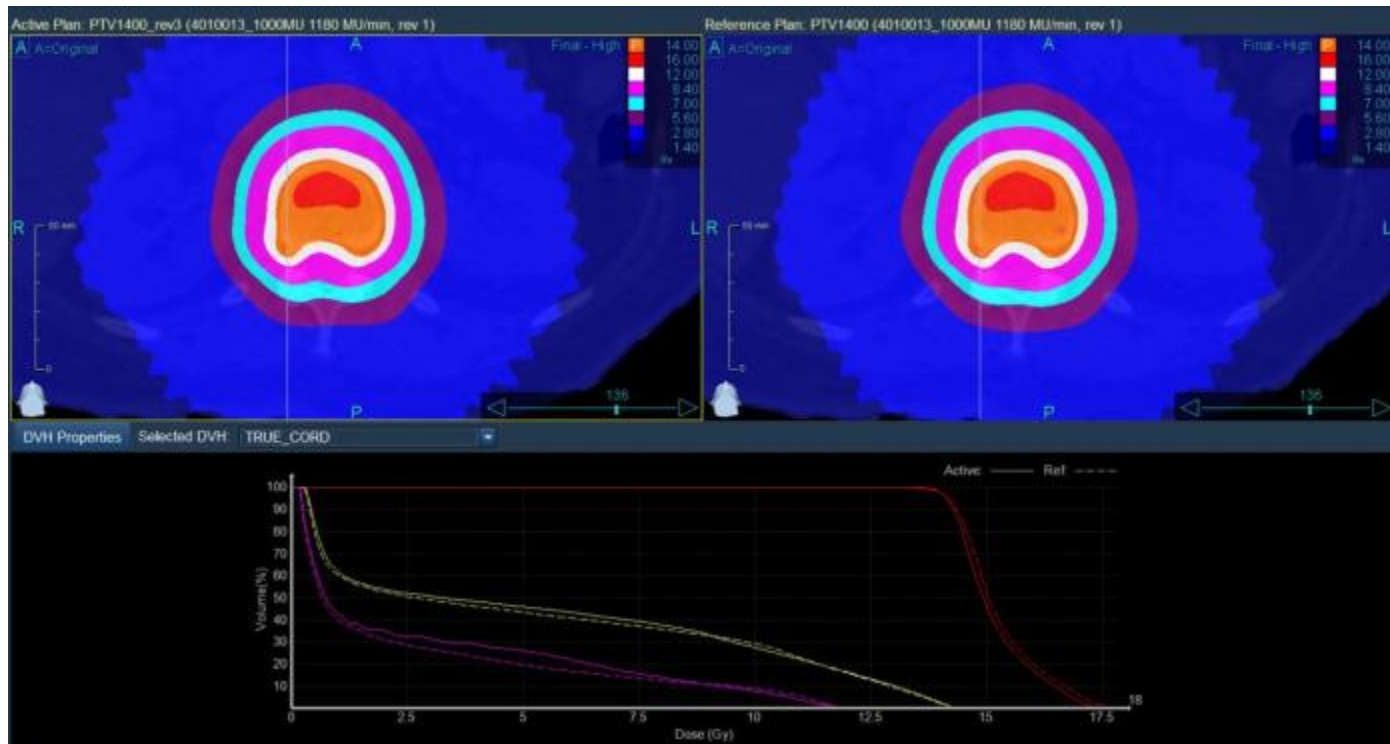
Spine SBRT

- Plan dose:12 Gy,1 fraction
 - Initial plan was 30 minutes long!
 - Treatment reduced to 15 minutes by reducing plan MF and changing pitch
 - Actual MF did not significantly change because the mean LOT shifted also



Spine SBRT

- Plan quality is comparable
 - Slightly more dose to critical structures but clinically acceptable



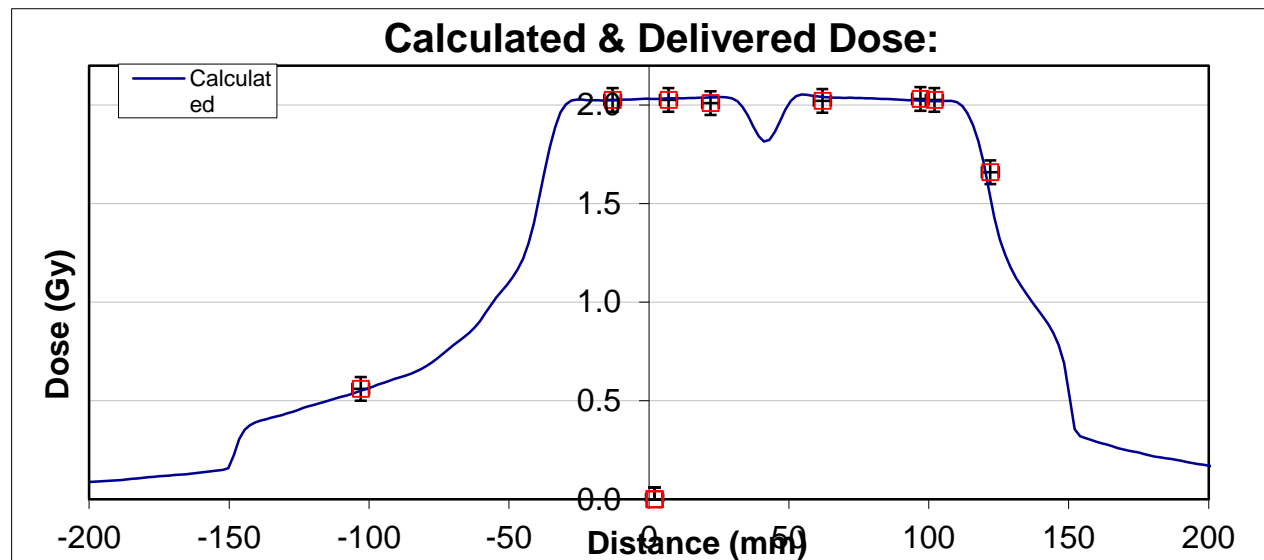
Physics – Clinical Preparations

- The Radixact™ System comes practically pre-commissioned after acceptance, however much work needed to be done to prepare.
 - Work with therapists establish clinical workflows
 - Work with dosimetrists to establish planning procedures
 - Establish physics quality control program
 - Final commissioning work
 - Beam scanning with water tank to verify profiles and depth doses
 - TomoPhant_5set dose calibration verification
 - TG-51 output
 - External TLD audit
 - IROC phantom test
 - Establish patient treatment plan QA procedure
 - Sun Nuclear ArcCheck™



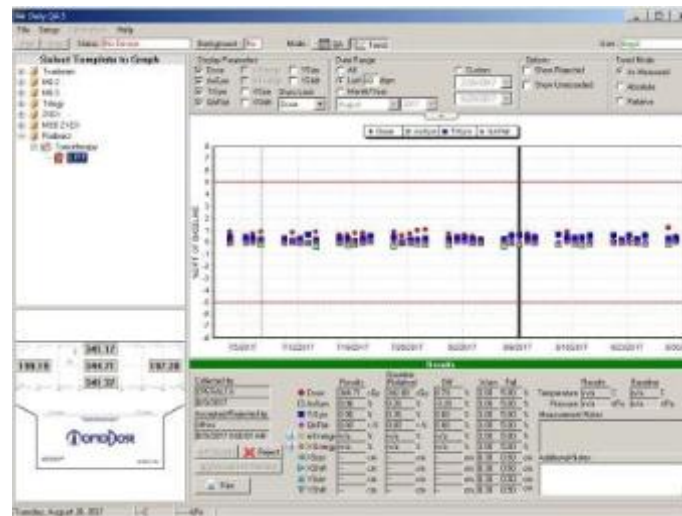
TomoPhant_5set plans

- The golden standard for output calibration
 - 10 plans, 6 measurement points per plan, minimize the difference between measurement and calculation of all points
- Performed during commissioning, output adjustment, machine revision, and major service



Physics - Daily QA

- TQA™ Daily QA is performed every day during warm up.
 - Data trends are reviewed by physics
- Output, field symmetry and flatness measured every day with Sun Nuclear TomoDose™ and monitored with Daily QA™3 software



Physics Monthly and Annual

- Used AAPM TG-148 guidelines for tests, frequency, and expected tolerances.
 - Newer technology not discussed in report will need testing also:
 - Static gantry treatments
 - Running start/stop y-jaws
- TQA™ Software can be used for a lot of the recommended tests.
 - Monthly – monitor chamber constancy
 - Monthly – rotational output variation
 - Monthly – transverse profile
- TQA™ Daily QA trend report included with monthly report

Weekly Chart Checks

- Aria™ Chart QA unavailable for physics weekly chart checks
 - Typically we task chart checks throughout the week and check them through Aria Chart QA
- Physics weekly chart check for patients on the Radixact™ System are tasked in Aria™ for Friday morning 6 AM.
 - This groups all the patients on the Radixact™ System into an easily identifiable time group
- Therapist prints patient treatment summary PDF every Thursday after treatment
 - Physicists have Thursday and Friday to complete weekly chart checks

Weekly Chart Checks

- Physicist uploads the Radixact™ System treatment summary into Aria™ and signs off on document as Physics weekly chart check.
- Physicist weekly check items:
 - Confirm “MU” delivered did not deviate more than 1% (usually less than 0.1%)
 - Confirm partial treatments were completed
 - Correct dose reporting in Aria Reference Points
 - Review image registrations and corrections

Adaptive Radiation Therapy

- PreciseART™ option provides an automated workflow for monitoring dose delivered to patients
 - Daily and cumulative dose
 - Report mechanism with customizable trends and alerts
- Work in progress – validation and commissioning of ART software
 - Phantom tests to verify the accuracy of dose calculations
 - Comparison of dose calculated on CTrue™ image guidance and kVCT patient images
 - Accumulation of patient data to determine appropriate ART dose monitoring criteria and automated reporting
 - Evaluate the efficacy of using CTrue™ images in lieu of kVCT for replanning

Summary

- A Radixact™ System can co-exist seamlessly in a Varian environment.
- Integration of the Radixact™ System into our clinic was successful largely in part because of preparations, training, and excellent support from Accuray Incorporated.
- Physicians are pleased because there was little disruption to the workflow they are accustomed to.
 - Physicians especially impressed by the target dose homogeneity in treatment plans!