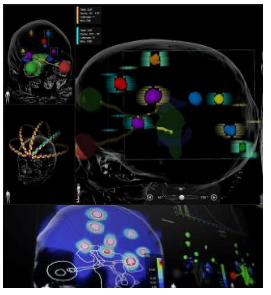
Nzhde Agazaryan, PhD, DABR, FAAPM

Professor of Radiation Oncology
Professor of Physics and Biology in Medicine

Chief of Clinical Medical Physics
Quality and Safety Officer

Department of Radiation Oncology
UCLA School of Medicine

Single Isocenter Treatment of Multiple Cranial Targets



David Geffen School of Medicine

UCLA radiation oncology

UCLA Health

Disclosures

Industry Grant, Brainlab

Consultant, Brainlab

Member, Novalis Accreditation Expert Panel

Credits

UCLA radiation oncology

- Tania Kaprealian, MD
- Steve Tenn, PhD
- Percy Lee, MD
- Robert Chin, MD
- Chris King, PhD, MD
- Amar Kishan, MD
- Pat Kupelian, MD
- Yingli Yang, PhD
- John Neylon, PhD
- Victoria Yu, PhD
- Jim Lamb, PhD
- Daniel Low, PhD
- Michael Selch, MD
- Michael Steinberg, MD

UCLA Neurosurgery

- Nader Pouratian, MD, PhD
- Isaac Yang, MD
- Ausaf Bari, MD, PhD
- Won Kim, MD
- Daniel Lu, MD, PhD
- Luke Macyszyn, MD, MA

Special Thanks To The Following Vendors:

Brainlab, Varian

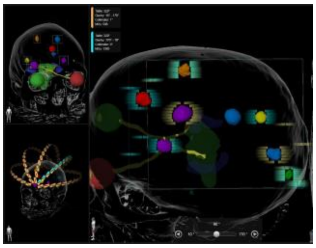
Sun Nuclear, Rtsafe, PTW

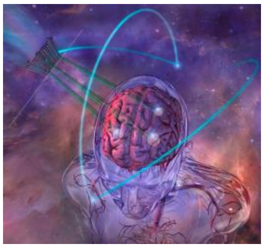
Mobius, Ashland, modusQA

Colleagues From Other Institutions:

- Antonio Desalles, MD, PhD
- Thierry Gevaert, PhD
- Alessandra Gorgulho, MD
- Paul Medin, PhD
- Javad Rahimian, PhD
- James Robar, PhD
- Peter Rosemark, PhD
- Daniel Saenz, PhD
- Manuel Todorovic , MS

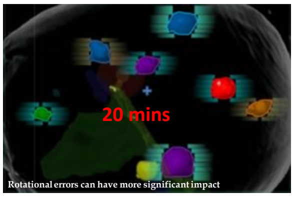
Enhanced Dynamic Conformal Arcs vs. Volumetric Modulated Arc Therapy (VMAT)

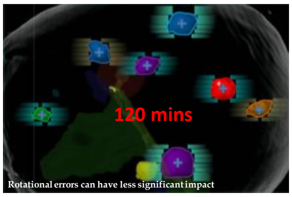




New Simultaneous Radiosurgery

Old Multi Isocenter Treatments

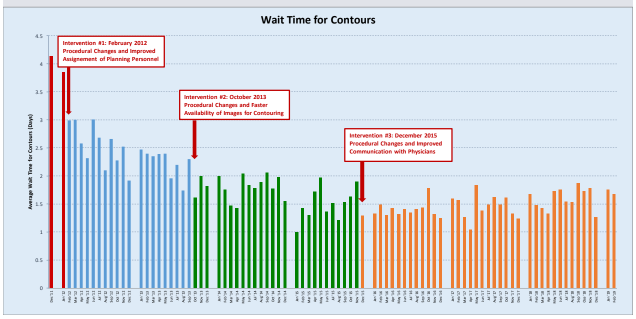




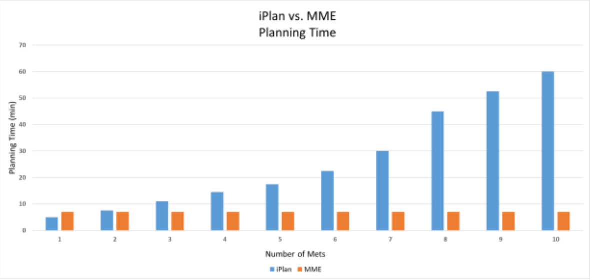
- Improved Patient Experience - Significant reduction in treatment times 20 mins vs. 2 hours
- Provider Benefits - One isocenter positioning and verification process 5 mins vs. 45 mins
- Increased Throughput - Faster and efficient planning process 30 mins vs. 2 hours

Patient Simulation to Contours Approved

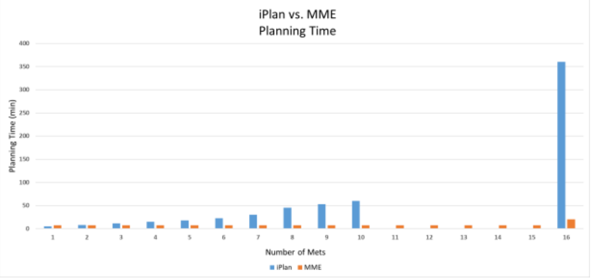
Interventions, Improvements and Sustainability



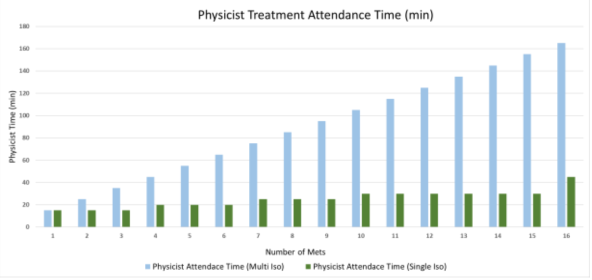
Treatment Planning Time (after approved contours)



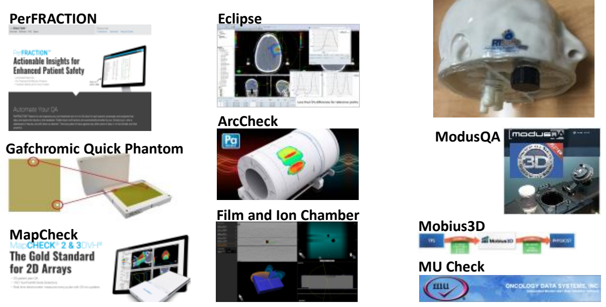
Treatment Planning Time (after approved contours)



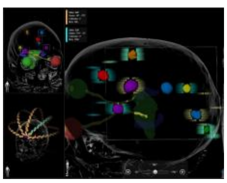
Physicist Treatment Attendance Time (Personal supervision prior to Tx Start Time)

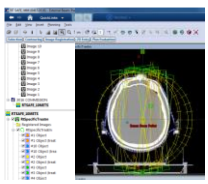


Commissioning and Validation

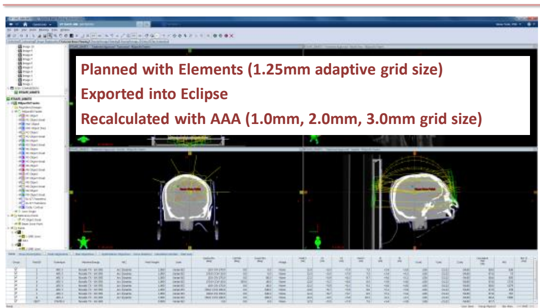


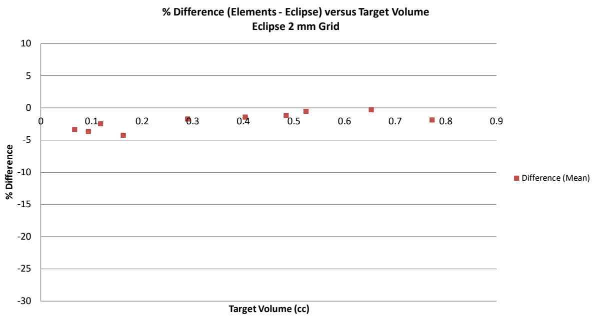
Multimets Calculation vs. Eclipse Calculation



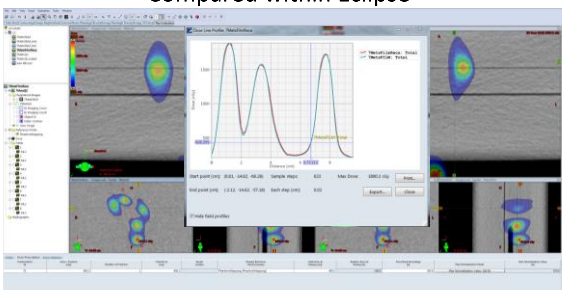


Elements™ Multiple Brain Mets (Pencil Beam) vs. Eclipse (AAA)

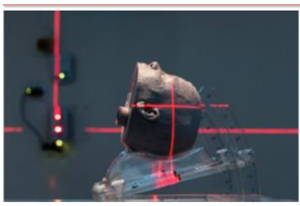




MultiMet Elements vs. AAA Compared within Eclipse



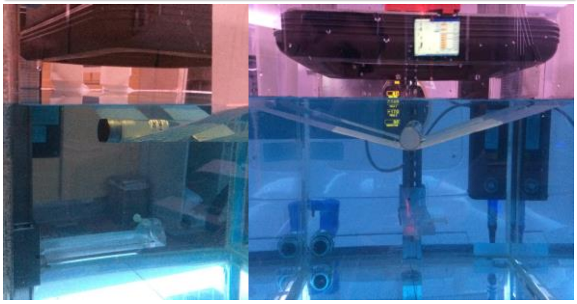
Radiation treatment of the patient-specific dosimetry phantom – RT Safe



Radiation treatment of the patient-specific dosimetry phantom

Calibration gel tubes irradiated to doses ranging from 0 up to 25 Gy with 5 Gy increments

Positioning the Calibration Tubes



Calibration Tubes Irradiated

Calibration gel tubes irradiated to doses ranging

from 0 up to 25 Gy with 5 Gy increments

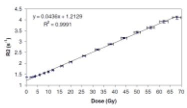
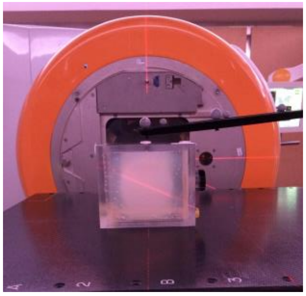


Figure 1. Relaxation rate R2 versus dose calibration data. A linear response is preserved for doses in the interval between 5 and 68 Gy.

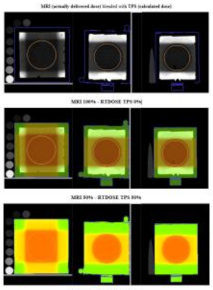
Irradiation with Novalis Tx – Four Field Plan



PART I: *Qualitative comparison*

Image registration between post-irradiation MRI and RTdose TPS data with structures of the Gel phantom. This is to demonstrate the coincidence of each treated target to its planned location.

MRI (actually delivered dose) blended with TPS (calculated dose)



MRI 100% - RTDOSE TPS 0%

MRI 50% - RTDOSE TPS 50%

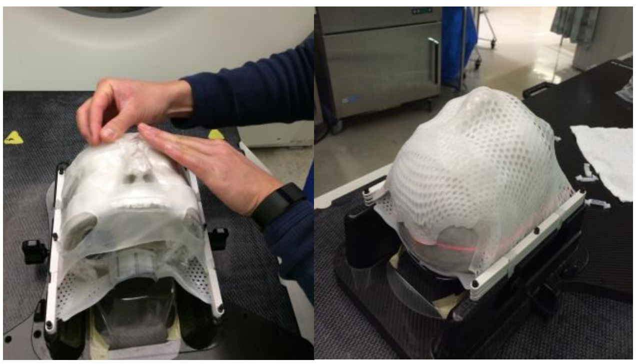
MRI 0% - RTDOSE TPS 100%

(Brightness and contrast adjusted so that only high dose areas are depicted)

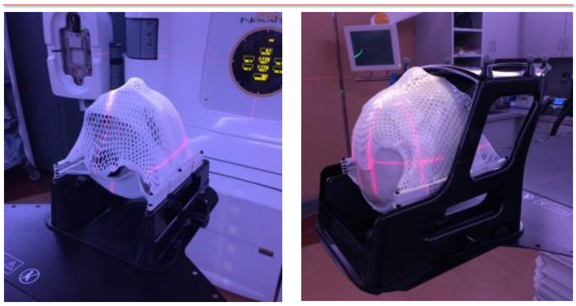
MRI (actually delivered dose) blended with TPS (calculated dose)

PART V: *DVH metrics comparison for the tumor structure*

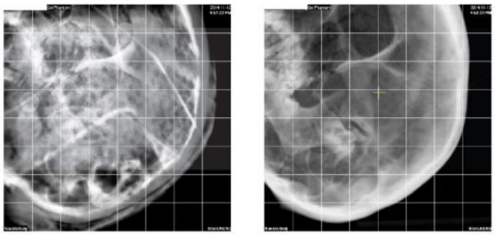
	Mean (Gy)		D50 (Gy)		D95 (Gy)	
Structure	TPS	Meas.	TPS	Meas.	TPS	Meas.
Tumor	21.51	20.94	21.56	20.86	21.02	19.43

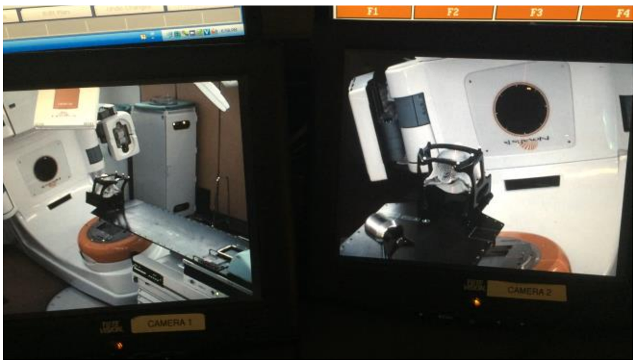


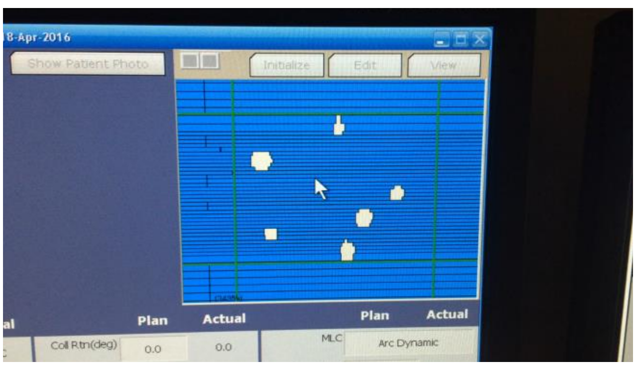
Irradiation Process of the patient-specific dosimetry phantom – RT Safe



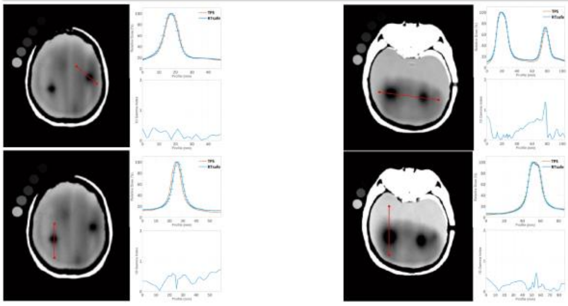
Irradiation Process of the patient-specific dosimetry phantom – RT Safe



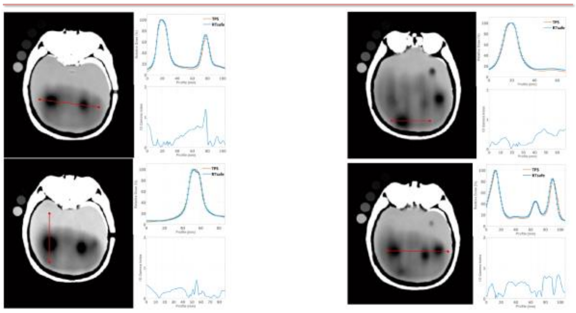




Patient-specific dosimetry results

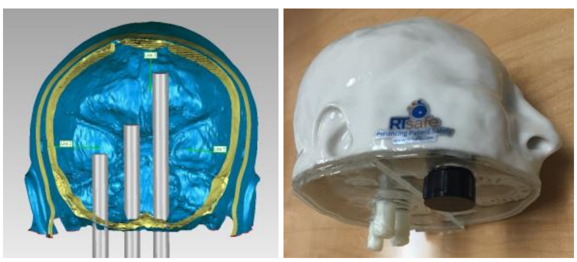


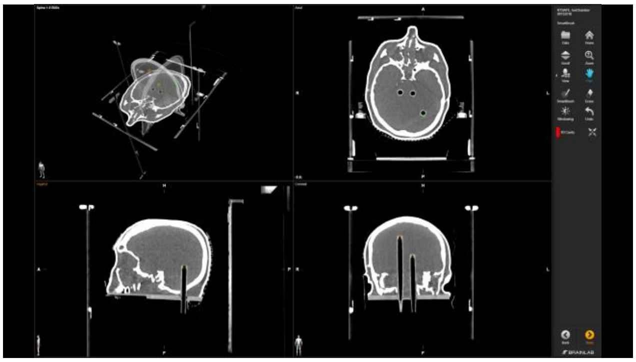
Patient-specific dosimetry results



Periodic QA Phantom

0.016 cm³





Absolute Dose Calculation and Ion Chamber Measurements

BRAINLAB　　BrainMetastases 1.0.0

Patient Name:	RTSAFE^IonChamber
Patient ID:	06152016
Plan Name:	RTSAFE_IC
Description:	UCLA Plan Option1 (not for clinical use) large 18Gy, small 18Gy

UCLA Health System

TREATMENT PARAMETERS

SUMMARY

Plan Intent : CURATIVE

PRESCRIPTION:

Object Name	Object Type	Dose / Fraction [Gy]	No. of Fractions	Prescribed Dose [Gy]	Prescribed Volume [%]	Volume [cm³]	Size [cm]	Margin [mm]
#1 Object (treated)	PTV	18.00	1	18.00	100.0	1.206	1.41	1.0
#2 Object (treated)	PTV	16.00	1	16.00	100.0	1.279	1.50	1.0
#3 Object (treated)	PTV	14.00	1	14.00	100.0	1.575	1.59	1.0

ISOCENTERS:

Short Name	External Coordinates (X/Y/Z DICOM (CT #1 (Axial))) [mm]
Coord 1	0.8 / -209.4 / 115.9

Absolute Dose Calculation – Cavity Object Statistics

BRAINLAB

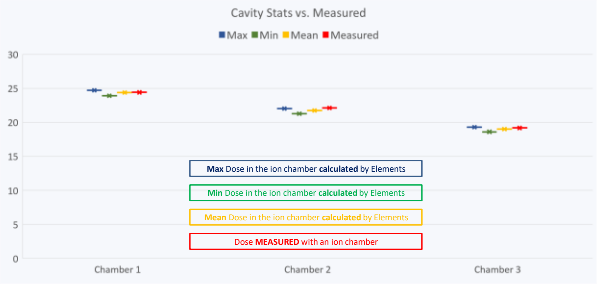
Patient Name:	RTSAFE^IonChamber
Patient ID:	06152016
Plan Name:	TheRTPlan
Description:	UCLA Plan Option1 (not for clinical use) large 16Gy, small 18Gy

UCLA Health System

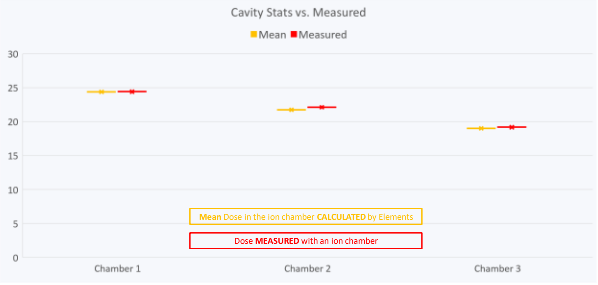
TREATED METASTASES

Object Name	Object Type	Volume [cm³]	Max Dose [Gy]	Mean Dose [Gy]	Min Dose [Gy]	CI
#1 Object (treated)	PTV	1.206	24.72	22.56	18.03	1.52
#2 Object (treated)	PTV	1.279	22.02	20.01	16.01	1.52
#3 Object (treated)	PTV	1.575	19.30	17.29	14.02	1.36

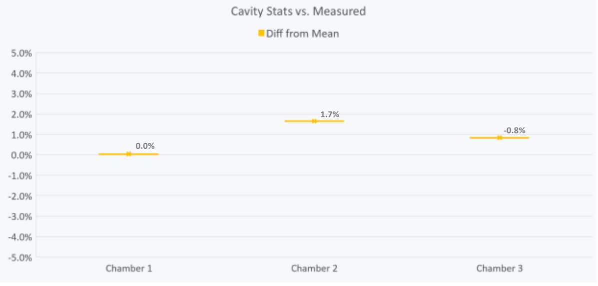
Absolute Dose Calculations vs. Measurements Results



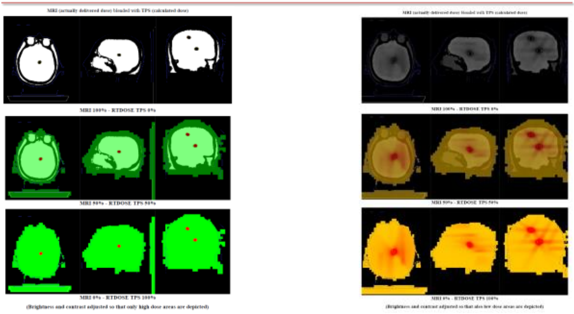
Absolute Dose Calculations vs. Measurements Results



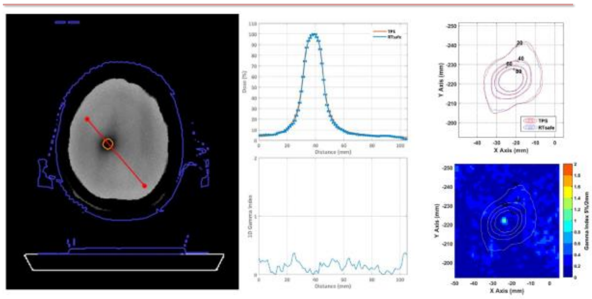
Absolute Dose Calculations vs. Measurements Results



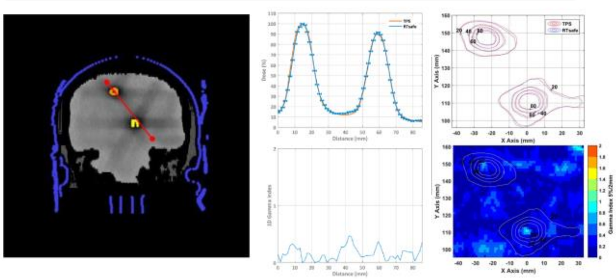
Three Target Plan Measurements with RT Safe Gel Phantom



Three Target Plan Measurements with RT Safe Gel Phantom



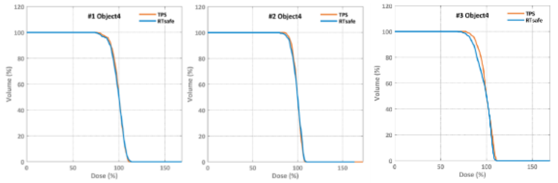
Three Target Plan Measurements with RT Safe Gel Phantom



Three Target Plan Measurements with RT Safe Gel Phantom

PART V: *DVH comparison*

Comparison between planned and measured relative dose distributions is presented in the following figures, in terms of cumulative Dose Volume Histograms (DVHs) for all PTVs. All dose distributions were normalized to the corresponding $D_{50\%}$ metric (i.e., the minimum dose received by at least the 50% of the volume) of each structure.

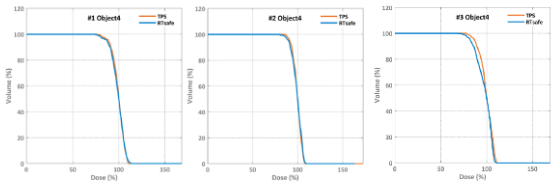


Three Target Plan Measurements with RT Safe Gel Phantom

The 0-12 Gy Gels provide accurate relative dose measurements in the 0-100% range

The 3-35 Gy Gels provide accurate relative dose measurements in the ~10-100% range

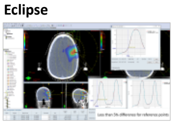
Some end users are interested in the DVHs of the healthy brain, requiring 0-12 Gy Gels



Patient Specific QA Methods

PerFRACTION

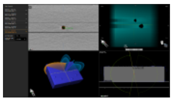
Eclipse



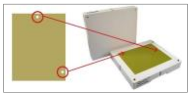
MapCheck

MU Check

Film and Ion Chamber

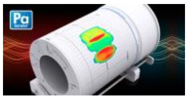


Gafchromic Quick Phantom

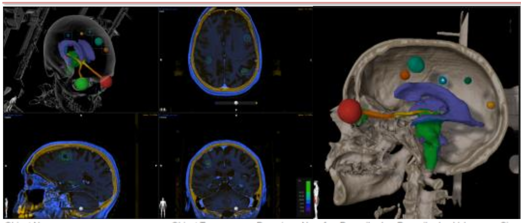


Fong Phantom

ArcCheck

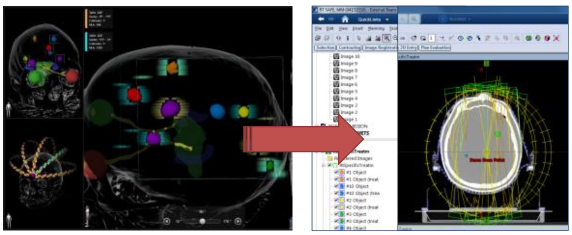


Clinical Case 1 - Five Metastases - 18 y.o. male with osteoblastic osteosarcoma



Object Name	Object Type DICOM	Dose / Fraction [Gy]	No. of Fractions	Prescribed Dose [Gy]	Prescribed Volume [%]	Volume [cm³]	Size [cm]
1LAtFrnt	PTV	18.00	1	18.00	99.0	$\boxed{0.568}$	1.11
2LInPrtl	PTV	18.00	1	18.00	99.0	0.294	0.88
3LPrtl	PTV	18.00	1	18.00	99.0	0.230	0.80
4LSuFrnt	PTV	18.00	1	18.00	99.0	$\boxed{2.590}$	1.96
5RFrnt	PTV	18.00	1	18.00	99.0	0.337	0.92

Multiple Mets Elements (Pencil Beam) vs. Eclipse (AAA)



MME vs. Eclipse AAA Calculations – Five Mets

Brainlab Multimets Dose Check Versus Eclipse AAA

Patient: 5 Mets MRN: 1010101 Date: 9/1/2017

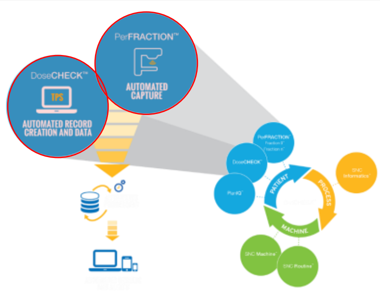
Eclipse Plan Name: 5metsPPL_AAA MME Plan Name: 5metsPPL

Field	1	2	3	4	5
MU	1124	1432	1466	1152	675
1LAtFrnt					
MME (cGy)	788.7	21.6	976.2	11.8	1.90
AAA (cGy)	770.7	25.7	875.0	11.8	1.60
% Diff	-2.34	15.95	-11.37	0.00	-18.75
%Diff total	-6.41				
2LInPrtl					
MME (cGy)	24.3	633.5	672.3	432.0	38.60
AAA (cGy)	24.5	636.3	668.9	420.8	37.40
% Diff	0.82	0.44	-0.51	-2.88	-3.21
%Diff total	-0.76				
3LPrtl					
MME (cGy)	20.10	826.70	20.50	524.80	408.00
AAA (cGy)	21.20	797.20	20.20	505.90	372.60
% Diff	5.19	-3.70	-1.49	-3.74	-9.50
%Diff total	-4.61				
4LSuFrnt					
MME (cGy)	823.40	952.20	6.70	14.00	2.90
AAA (cGy)	806.60	916.90	7.80	14.70	2.50
% Diff	-2.08	-3.85	14.10	4.76	-16.00
%Diff total	-2.82				
5RFrnt					
MME (cGy)	661.20	26.10	48.30	671.30	293.00
AAA (cGy)	656.80	27.40	40.90	620.50	263.30
% Diff	-0.67	4.74	-18.09	-8.19	-8.10
%Diff total	-5.06				

MU Check for Brain Metastases – Five Mets

Beam # / Setup	1 / SAD	2 / SAD	3 / SAD	4 / SAD	5 / SAD
Beam Description	Gantry: 10.0, 170.0,	Gantry: 170.0, 10.0,	Gantry: 10.0, 170.0,	Gantry: 350.0, 190.0	Gantry: 190.0, 350.0
Beam Name	1	2	3	4	5
DICOM Beam #	1	2	3	4	5
Machine	Novalis	Novalis	Novalis	Novalis	Novalis
Energy	6 MV Photon	6 MV Photon	6 MV Photon	6 MV Photon	6 MV Photon
Collimator (deg)	4.0	4	356	4	356.0
Table (deg)	285.0	355	355	35	90.0
Gantry (deg)	10 - 170	170 - 10	10 - 170	350 - 190	190 - 350
Jaws/Collimator					
X1 / X2	5.3 / 2.5	4.2 / 5.5	5.6 / 5.9	6.4 / 5.3	3.2 / 1.5
Y1 / Y2	3 / 6.7	4 / 3.2	3.7 / 1.5	4 / 1.7	6.7 / 2.5
MLC Segments	17	17	17	17	17
SSD (avg, cm)	82.54	93.54	93.54	87.88	92.17
Ref. Depth (avg, cm)	7.40	6.46	6.46	12.02	7.83
Eff. Depth (avg, cm)	5.37	4.53	4.53	10.16	6.07
Isocenter (cm)	(2.25, -20.49, -63.90)	(2.25, -20.49, -63.90)	(2.25, -20.49, -63.90)	(2.25, -20.49, -63.90)	(2.25, -20.49, -63.90)
TPS Calc Point (cm)	(4.47, -24.73, -63.89)	(3.88, -17.89, -64.24)	(4.47, -24.73, -63.89)	(3.88, -17.89, -64.24)	(3.88, -17.89, -64.24)
Mu Calc Point (cm)	(4.47, -24.73, -63.90)	(3.78, -17.79, -64.34)	(4.37, -24.73, -63.90)	(3.98, -17.79, -64.24)	(3.78, -17.79, -64.24)
TPS Dose	788.72	826.69	976.10	524.77	408.03
MuCheck Dose	777.90	816.41	928.74	555.25	425.52
TPS MU	1124.00	1432.00	1466.08	1162.00	675.00
MuCheck MU	1108.67	1414.20	1394.74	1229.50	703.93
% Difference	-1.36	-1.24	-4.86	5.81	4.29
Beam Notes	#* – Volume Avg tool used, with MuCheck point at (4.47, -24.73, -63.90)cm at distance of 0.10cm –*#	#* – Volume Avg tool used, with MuCheck point at (3.78, -17.79, -64.34)cm at distance of 0.10cm –*#	#* – Volume Avg tool used, with MuCheck point at (4.37, -24.73, -63.90)cm at distance of 0.10cm –*#	#* – Volume Avg tool used, with MuCheck point at (3.98, -17.79, -64.24)cm at distance of 0.13cm –*#	#* – Volume Avg tool used, with MuCheck point at (3.78, -17.79, -64.24)cm at distance of 0.10cm –*#
MLC Tip 0.08 MLC Trans 1.01 TPS Dose 3624.4 Calcd Dose 3603.8 % Diff -0.58 X1 Y1					

Sun Nuclear - SunCHECK™ QA web platform

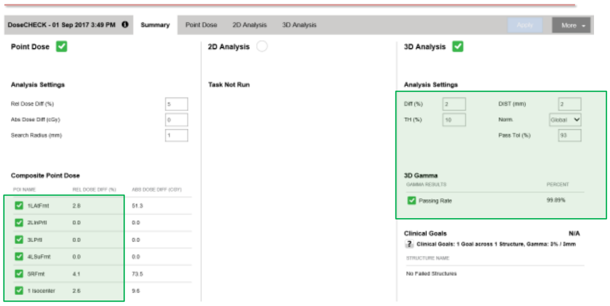


Secondary dose calculation DoseCHECK
3D secondary dose calculation and analysis

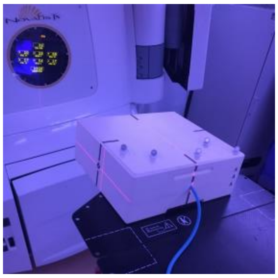
Log File Based QA
3D dose reconstruction using the log file

EPID Based QA
3D Pre-Treatment QA with EPID measurements

PerFraction Secondary Calculation (DoseCHECK) for Brain Metastases – Five Mets



Ion Chamber Measurement



-2.65 %

-2.93 %

Mean Calculated Dose
vs.
Ion Chamber Measurement

Ion Chamber Measurements for Brain Metastases – Five Mets

Ion Chamber: Type TN31016 3D - SN00338
Cross-Calibration: 25.50163654 | 2.5198079E+09 Gy/C
Electrometer: Pelec - - - - 1.000 | Scale - - - - - - 1.00E-09
TP Correction: Temp (°C) 21.0 | Pressure (mbar) 993.0 | P_{TP} = 1.014891

Beams	MU	Calculated Dose (Gy)	Ion Chamber Reading	Measured Dose (Gy)	% Diff
1	1124	7.4200	2.8330	7.2449	-2.42
2	1432	9.0200	3.4420	8.8023	-2.47
3	1466	0.0800	0.0330	0.0844	5.20
4	1162	0.1400	0.0439	0.1123	-24.70
5	675	0.0400	0.0100	0.0256	-56.41
Total Dose	5859	16.7000	6.3619	16.2695	-2.65

Left Superior Frontal Target (2.59cc)

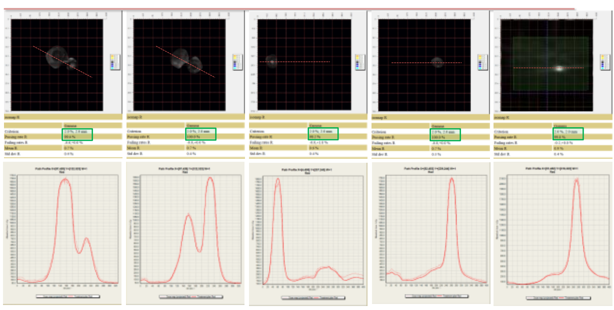
Ion Chamber: Type TN31016 3D - SN00338
Cross-Calibration: 25.50163654 | 2.5198079E+09 Gy/C
Electrometer: Pelec - - - - 1.000 | Scale - - - - - - 1.00E-09
TP Correction: Temp (°C) 21.0 | Pressure (mbar) 995.0 | P_{TP} = 1.014891

Beams	MU	Calculated Dose (Gy)	Ion Chamber Reading	Measured Dose (Gy)	% Diff
1	1124	6.6600	2.5800	6.5979	-0.94
2	1432	0.3600	0.1848	0.4726	23.82
3	1466	8.8800	3.2810	8.3906	-5.83
4	1162	0.0800	0.0260	0.0665	-20.32
5	675	0.0200	0.0064	0.0164	-22.20
Total Dose	5859	16.0000	6.0782	15.5440	-2.93

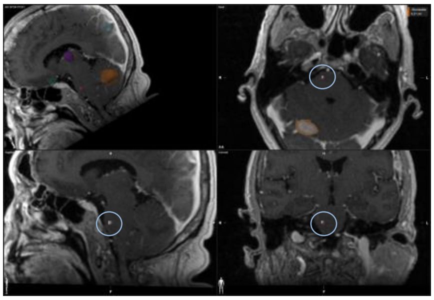
Left Anterior Frontal Target (0.568cc)

Object Name	Object Type DICOM	Dose / Fraction [Gy]	No. of Fractions	Prescribed Dose [Gy]	Prescribed Volume [%]	Volume [cm³]	Size [cm]
1LAtFrnt	PTV	18.00	1	18.00	99.0	0.568	1.11
2LInPrtl	PTV	18.00	1	18.00	99.0	0.294	0.88
3LPrtl	PTV	18.00	1	18.00	99.0	0.230	0.80
4LSuFrnt	PTV	18.00	1	18.00	99.0	2.590	1.96
5RFrnt	PTV	18.00	1	18.00	99.0	0.337	0.92

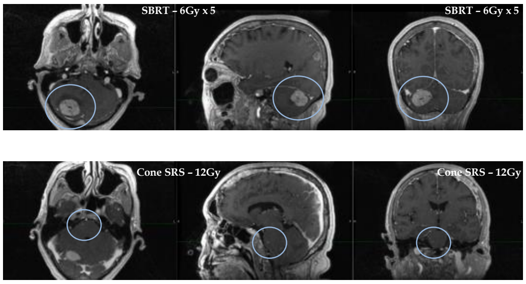
Film Measurements for Brain Metastases – Five Mets



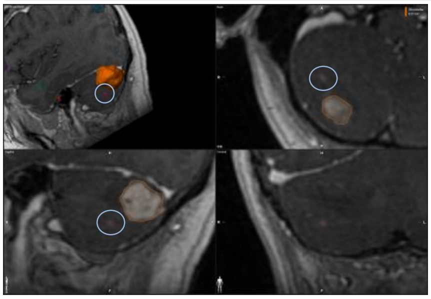
Clinical Case 2 – Seven Metastases - Conical Collimator 12 Gy to the Brainstem Target



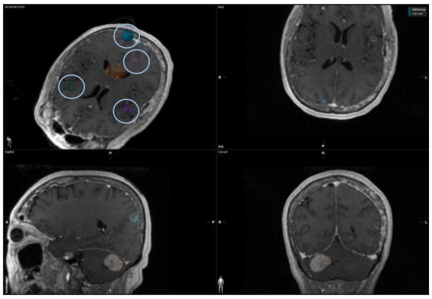
Clinical Case 2 – SBRT 6Gy x 5



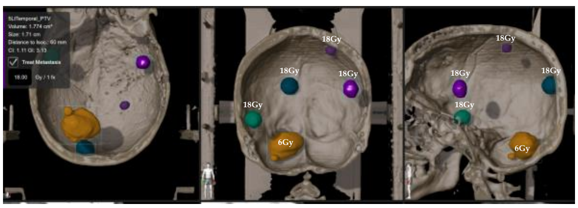
Clinical Case 2 – SBRT 6Gy x 5 to the Smaller Lesion Next to the Large Met



Clinical Case 2 – MultiMet Targets – 18Gy to Other Four Metastases

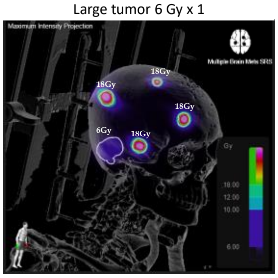


All Targets Planned in MME (Except Cone)

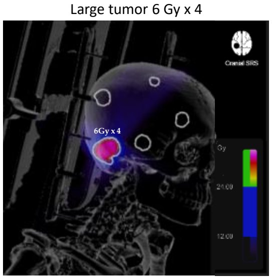


Composite Planning in Elements: Strategy

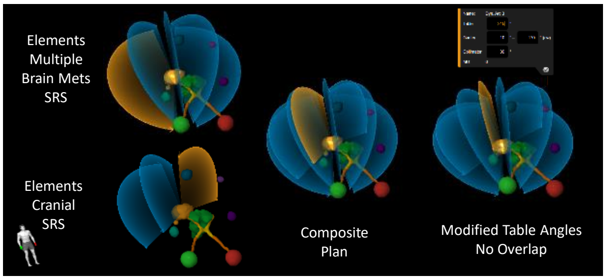
Four small tumors 18Gy x 1
Large tumor 6 Gy x 1



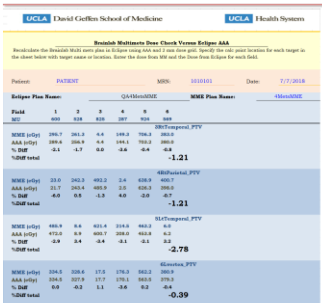
Large tumor 6 Gy x 4



Composite Planning in Elements: Selection of Table Positions



MME vs. Eclipse AAA Calculations – Four Mets



UCLA David Geffen School of Medicine — UCLA Health System

Brainlab Multimets Dose Check Versus Eclipse AAA

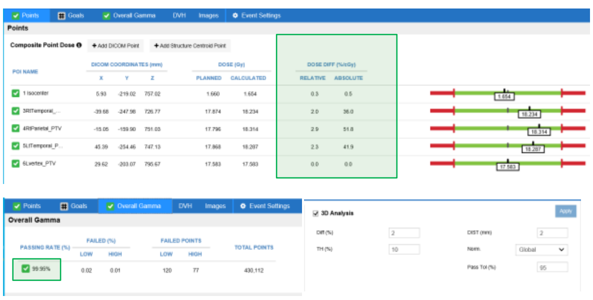
Recalculate the Brainlab Multi mets plan in Eclipse using AAA and 2 mm dose grid. Specify the calc point location for each target in the sheet below with target name or location. Enter the dose from MM and the Dose from Eclipse for each field.

Patient: PATIENT MRN: 1010101 Date: 7/7/2018

Eclipse Plan Name: QA4MetsMME **MME Plan Name:** 4MetsMME

Field	1	2	3	4	5	6
MU	600	828	828	287	924	869
3RtTemporal_PTV						
MME (cGy)	295.7	261.3	4.4	149.3	706.3	383.0
AAA (cGy)	289.6	256.9	4.4	144.1	703.2	380.0
% Diff	-2.1	-1.7	0.0	-3.6	-0.4	-0.8
%Diff total						-1.21
4RtParietal_PTV						
MME (cGy)	23.0	242.3	492.2	2.4	638.9	400.7
AAA (cGy)	21.7	243.4	485.9	2.5	626.3	398.0
% Diff	-6.0	0.5	-1.3	4.0	-2.0	-0.7
%Diff total						-1.21
5LtTemporal_PTV						
MME (cGy)	485.9	8.6	621.4	214.5	463.2	6.0
AAA (cGy)	472.0	8.9	600.7	208.0	453.8	6.2
% Diff	-2.9	3.4	-3.4	-3.1	-2.1	3.2
%Diff total						-2.78
6Lvertex_PTV						
MME (cGy)	334.5	328.6	17.5	176.3	562.2	380.9
AAA (cGy)	334.5	327.9	17.7	170.1	563.5	379.3
% Diff	0.0	-0.2	1.1	-3.6	0.2	-0.4
%Diff total						-0.39

PerFraction Secondary Calculation (DoseCHECK) for Brain Metastases – Four Mets



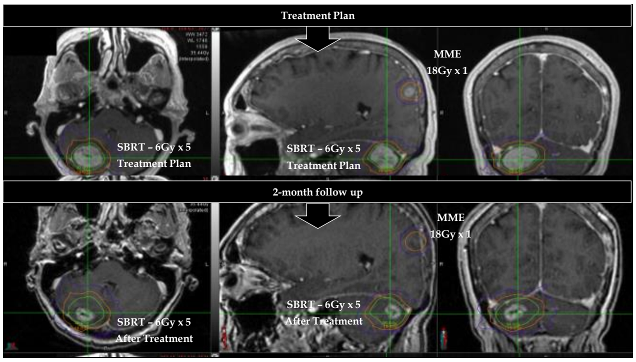
POI NAME	DICOM COORDINATES (mm) X	Y	Z	DOSE (Gy) PLANNED	CALCULATED	DOSE DIFF (%/cGy) RELATIVE	ABSOLUTE
1 Isocenter	5.93	-219.02	757.02	1.660	1.654	0.3	0.5
3RtTemporal_...	-39.68	-247.98	726.77	17.874	18.234	2.0	36.0
4RtParietal_PTV	-15.05	-159.90	751.03	17.796	18.314	2.9	51.8
5LtTemporal_P...	45.39	-254.46	747.13	17.868	18.287	2.3	41.9
6Lvertex_PTV	29.62	-203.07	795.67	17.583	17.583	0.0	0.0

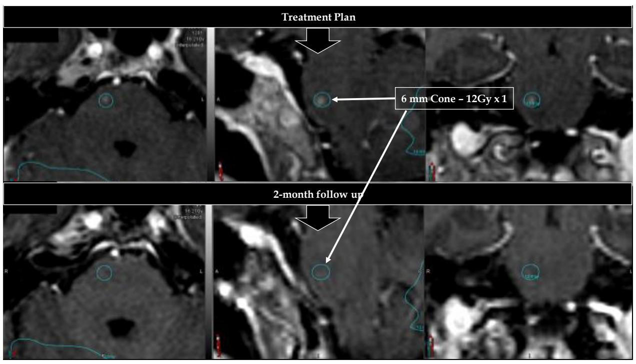
Overall Gamma

PASSING RATE (%)	FAILED (%) LOW	HIGH	FAILED POINTS LOW	HIGH	TOTAL POINTS
99.95%	0.02	0.01	120	77	430,112

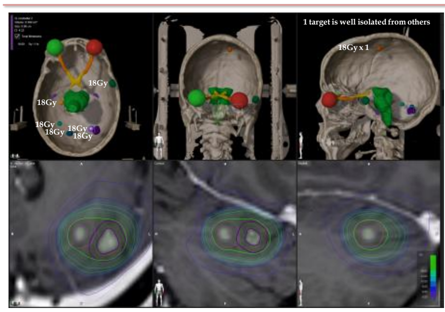
3D Analysis — Apply

Diff (%): 2 — DIST (mm): 2
TH (%): 10 — Norm.: Global
Pass Tol (%): 95





Clinical Case 3 - Seven Metastases

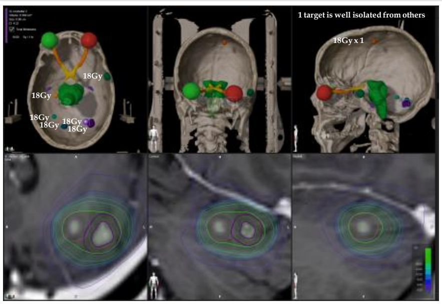


Inclusion of the Superior target

- **Will increase the isocenter to target distances. Rotational misalignments will become dosimetrically more significant.**
- **Ticker MLC leaf pairs will be used for Treatment.**
- **Target may fall outside of irradiation area.**

Clinical Case 3 - All Targets Planned in Multiple Mets Element

Clinical Case 3 - Seven Metastases

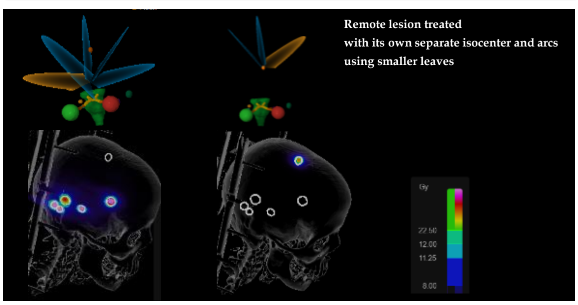


Contiguous V12 < 10cc
(includes the GTV volume)

MME produces:
More inhomogeneous distributions

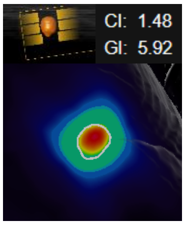
Larger volume of irradiation
because of the margins used

Composite Planning in Elements Multiple Brain Mets SRS

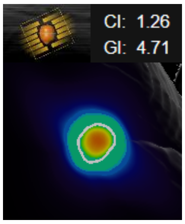


Improving Dosimetry with Separate Isocenter and Arcs

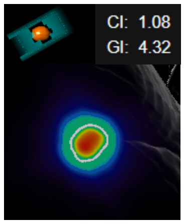
Elements Multiple Brain Mets SRS
5 mm leaves

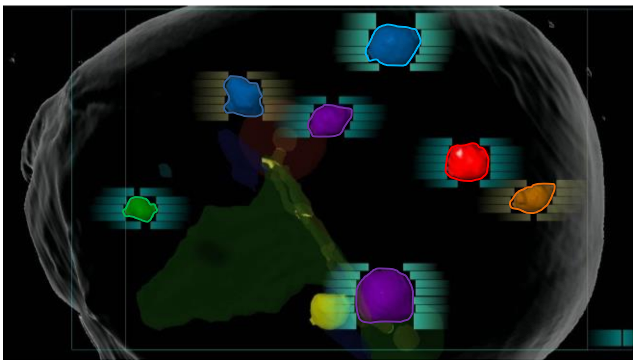


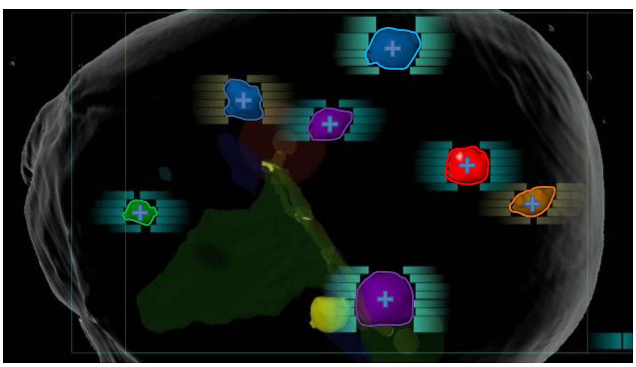
Elements Multiple Brain Mets SRS
2.5 mm leaves

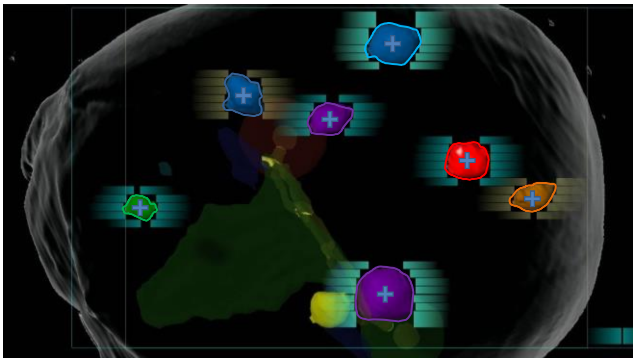


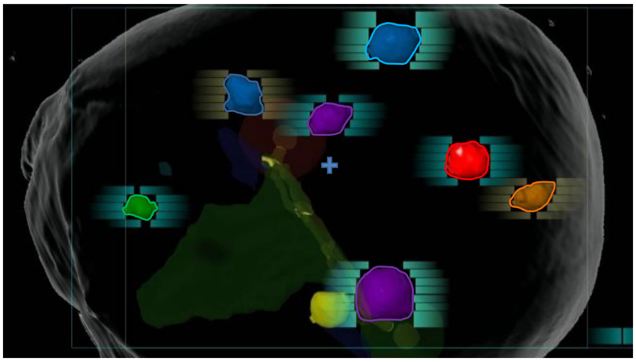
Elements Cranial SRS
2.5 mm leaves

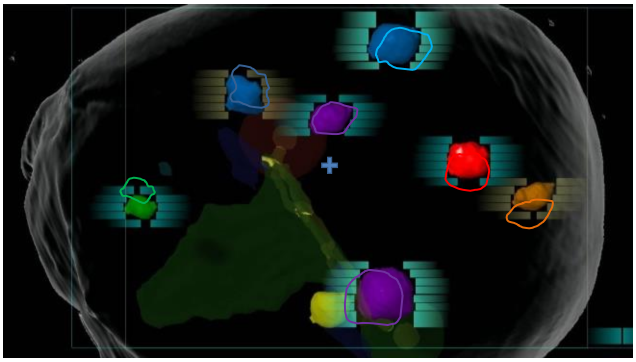


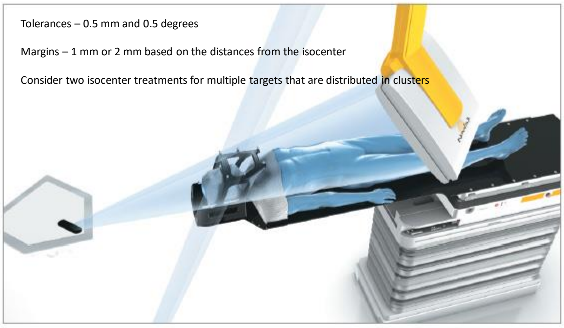


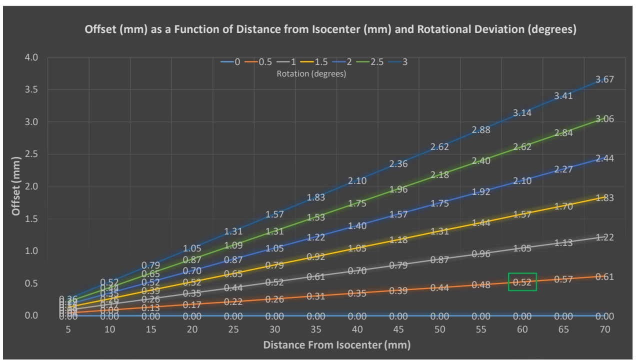




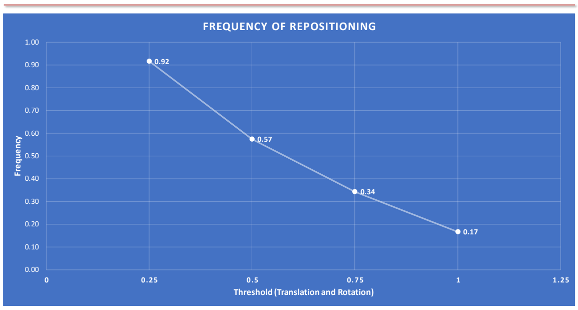




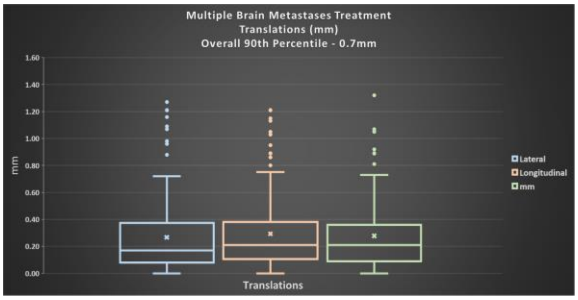




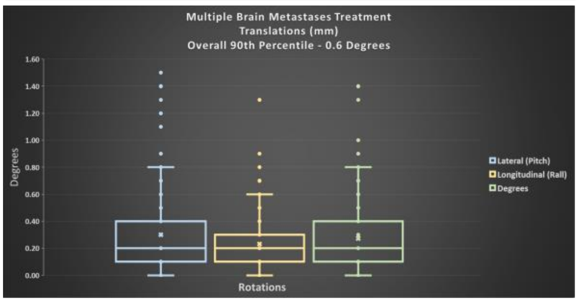
Intrafraction Motion of MME Patients – Frequency of Repositioning



Intrafraction Motion of MME Patients – Translations - 12 Patients and 74 Targets



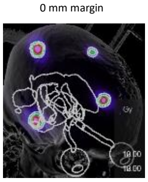
Intrafraction Motion of MME Patients – Rotations - 12 Patients and 74 Targets



V5, V10, V12 Values vs. Margins Used for Treatment Planning

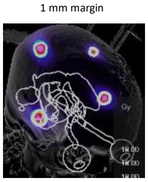
Cumulative TV = 3.2 cc
V5 = 73.1 cc
V8 = 30.9 cc
V10 = 22.1 cc
V12 = 15.9 cc

0 mm margin



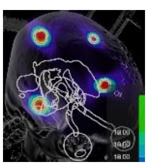
Cumulative TV = 5.4 cc
V5 = 95.9 cc
V8 = 43.6 cc
V10 = 30.0 cc
V12 = 22.6 cc

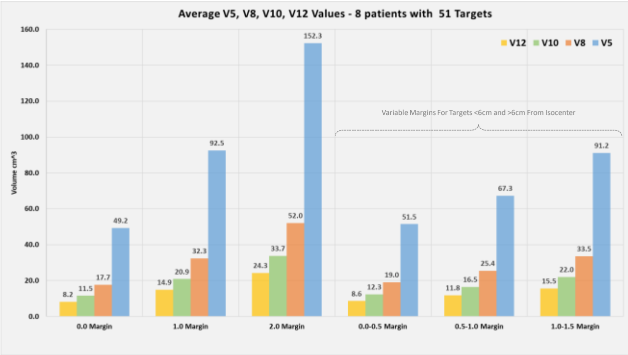
1 mm margin



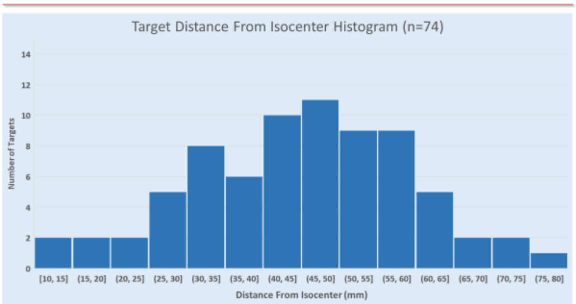
Cumulative TV = 8.5 cc
V5 = 152.5 cc
V8 = 63.7 cc
V10 = 43.8 cc
V12 = 32.8 cc

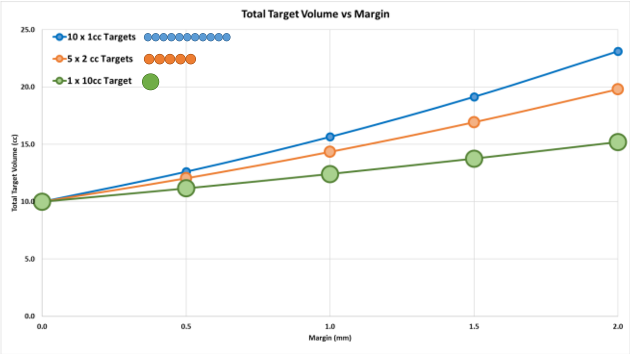
2 mm margin

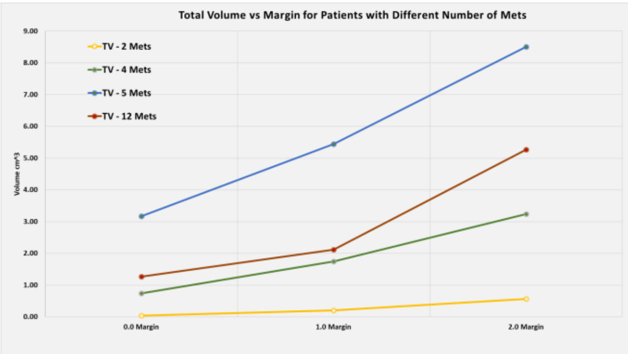


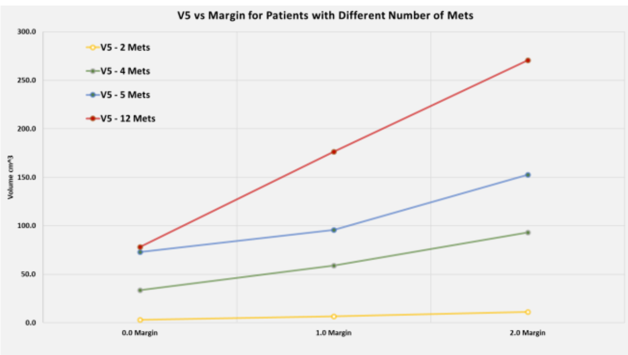


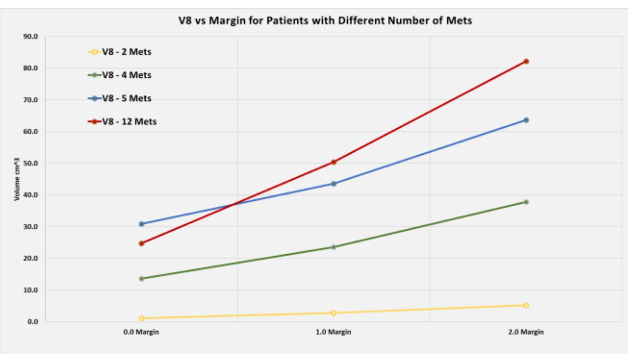
Histogram of Target Distances from Isocenters

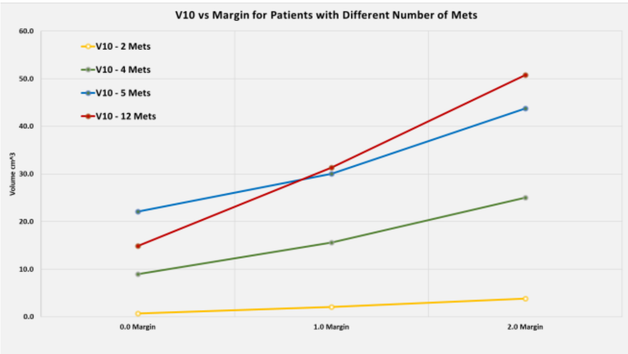


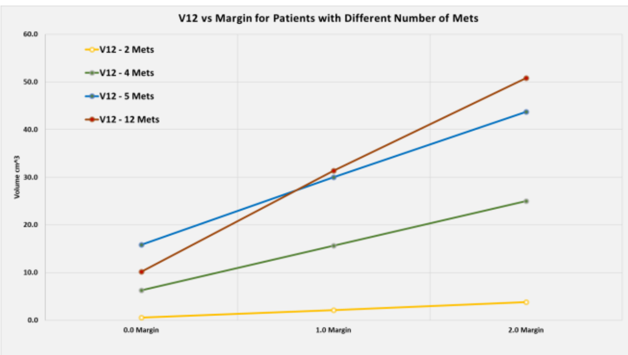


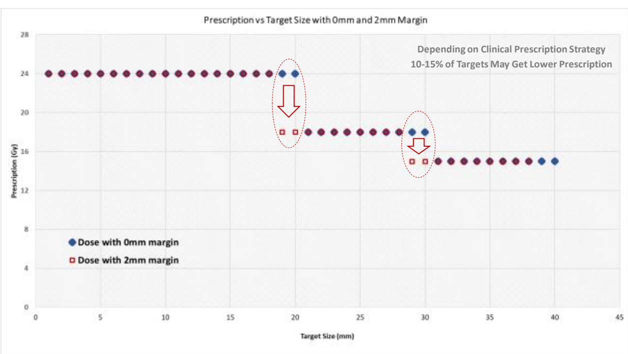

Total Volume vs Margin for Patients with Different Number of Mets
TV - 2 Mets
TV - 4 Mets
TV - 5 Mets
TV - 12 Mets
Volume cm^3
0.0 Margin
1.0 Margin
2.0 Margin

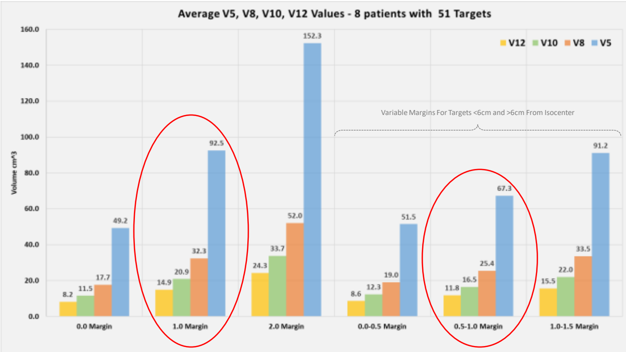

V5 vs Margin for Patients with Different Number of Mets
V5 - 2 Mets
V5 - 4 Mets
V5 - 5 Mets
V5 - 12 Mets
Volume cm^3
0.0 Margin
1.0 Margin
2.0 Margin


V8 vs Margin for Patients with Different Number of Mets
V8 - 2 Mets
V8 - 4 Mets
V8 - 5 Mets
V8 - 12 Mets
Volume cm^3
0.0 Margin
1.0 Margin
2.0 Margin


V10 vs Margin for Patients with Different Number of Mets
V10 - 2 Mets
V10 - 4 Mets
V10 - 5 Mets
V10 - 12 Mets
Volume cm^3
0.0 Margin
1.0 Margin
2.0 Margin


V12 vs Margin for Patients with Different Number of Mets
V12 - 2 Mets
V12 - 4 Mets
V12 - 5 Mets
V12 - 12 Mets
Volume cm^3
0.0 Margin
1.0 Margin
2.0 Margin


Prescription vs Target Size with 0mm and 2mm Margin
Depending on Clinical Prescription Strategy
10-15% of Targets May Get Lower Prescription
Prescription (Gy)
Dose with 0mm margin
Dose with 2mm margin
Target Size (mm)



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Professor of Physics and Biology in Medicine

Chief of Clinical Medical Physics
Quality and Safety Officer

Department of Radiation Oncology
UCLA School of Medicine

Patient Specific QA and IGRT Requirements

For Single Isocenter Treatment of Multiple Cranial Targets

David Geffen School of Medicine   UCLA radiation oncology   UCLA Health