

An evaluation of a high resolution film-less patient specific QA solution for mono-isocentric multiple metastasis radiosurgery plans with non-coplanar fields

October 25th 2019 - Frontiers of Radiosurgery Conference, Milan, Italy

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Acknowledgements



- From JTCC @ HMH

- *Alois Ndlovu, PhD*
- *Charles Khuu, CMD*
- *George Beninati, CMD*
- *Anthony Ingenito, MD*
- *Brett Lewis, MD, PhD*
- *Miriam Knoll, MD*
- *Stereo Physicists Team*
- *Stereo Dosimetrists Team*
- *Stereo Radiation Therapists Team*

Disclosures

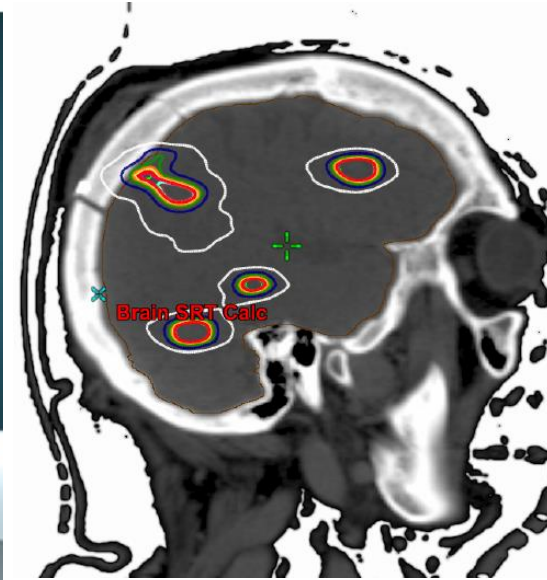
Non-financial collaboration on work with SRSSMapCheck with



Introduction – JTCC SRS/SRT clinical practice



<https://www.elekta.com/>



<https://www.varian.com/>

2 years ago - GammaKnife Radiosurgery/RT – **100%**

LINAC-based = **0%**

TODAY - GammaKnife Radiosurgery/RT – **85%**

LINAC-based = **15%**

Our goal - Improve on the % treated on LINAC-based SRS/SRT without compromising quality of plans and treatments

Introduction – JTCC SRS/SRT clinical practice

Of Interest for LINAC-based SRS/SRT

IGRT: Inter-fraction and Intra-fraction monitoring



Of Interest for LINAC-based SRS/SRT

Patient Specific QA

- * *Filmless QA* solution for small targets in radiosurgery
- * Measurements in coplanar and *non-coplanar* fields
- * *Mono-Isocentric* patient cases w *multiple metastasis*

SRSMapCheck

Filmless solution for SRS dosimetry

- 2D array for SRS applications
- 1,013 SunPoint® 2 Diodes, providing high resolution
 - 2.47 mm detector grid
 - 0.5 mm resolution
- Replaces film and standalone detector, expediting the workflow for time-sensitive patient QA
 - Provides absolute and relative dose in a single measurement

- Works with static, rotational, non-coplanar, FFF, cone and MLC fields¹
 - 6MV and 10MV
- With the StereoPHAN, supports irradiation from any gantry angle
 - Angular dependence, field size and pulse rate are accounted for and corrected to ensure accurate dose measurements
- Integration
 - Designed to insert into the StereoPHAN
 - Runs on SNC Patient™ software

<https://www.sunnuclear.com/solutions/patientqa/srsmatcheck>



Evaluation for SRS dosimetry – ref fields with 2D array

QA File Parameter

Patient Name :
 Patient ID :
 Date : 5/17/2019
 SSD :
 SDD :
 Depth :
 Energy :
 Gantry Angle :

Absolute Dose Comparison

Difference (%) : 2
 Distance (mm) : 2
 Threshold (%) : 10.0
 Use Global % : Yes

Summary (Gamma Analysis)

Total Points : 561
 Passed : 561
 Failed : 0
 % Passed : 100

Dose Values in cGy

	CAX	Norm	Max
SRS MC	98.40	97.81	98.54
Plan	97.55	97.78	97.79
SRS MC	0.85	0.03	0.75
-Plan			
% Diff	0.87	0.03	0.77

Coords (y,x) cm : 0,0 0.525,0.525

CAX Offset Set 2

X (mm) : 0
 Y (mm) : 0
 Z (mm) : 0
 Pitch (deg) : 0
 Roll (deg) : 0
 Yaw (deg) : 0

Notes

Reviewed By :

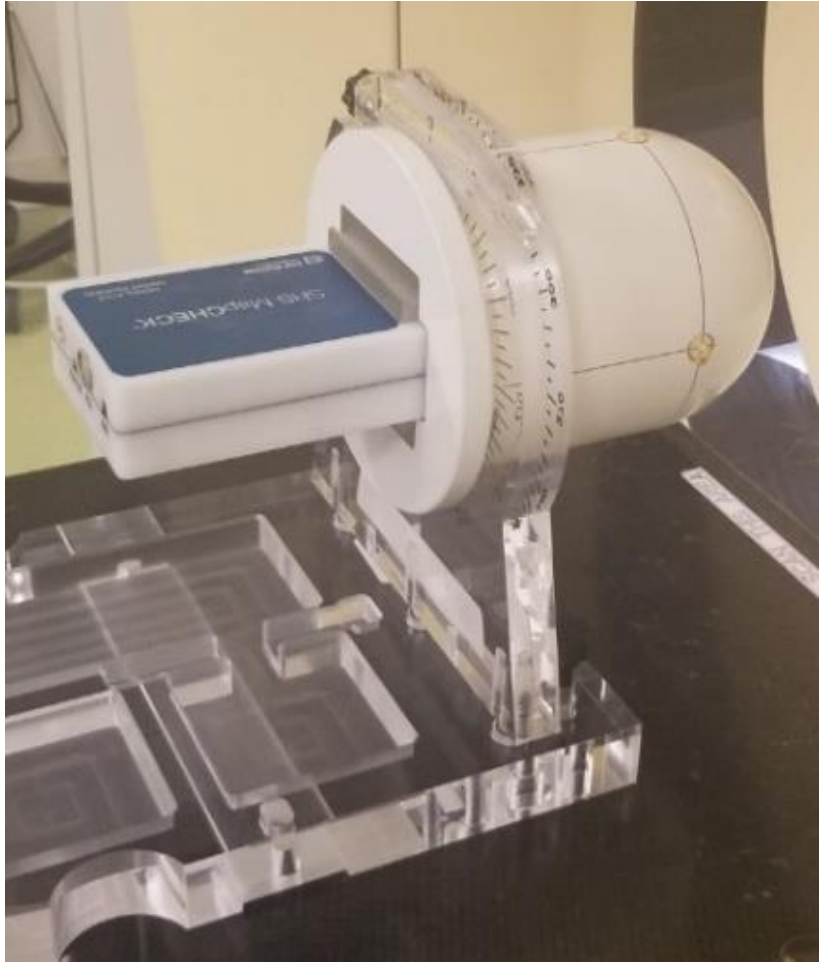
SRS MC StereoPHAN Angle(deg)=0

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Plan StereoPHAN Angle(deg)=0
 Dose Scaling Factor=1
 Isocenter Coordinates X=-0.75002 Y=-172.31 Z=-18.244

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SRS MC-Plan



100%
 100%
 97.4%
 94.6%
 81.3%

Evaluation for SRS dosimetry – Reference Fields

Reference Field Analysis for **2%/2mm** Gamma Index
10% Dose Threshold

Results for Gamma Index passing rates

Field Sizes	6MV	10MV	6MV-FFF	10MV-FFF
5x5cm	100%	100%	100.0%	100.0%
3x3cm	100%	100%	100.0%	100.0%
2x2cm	99%	97.40%	100.0%	95.4%
1x1cm	96.90%	94.60%	97.0%	97.3%
0.5 x 0.5cm	88.90%	81.30%	100.0%	76.9%

Total number of points Passing/Failing

Field Sizes	6MV	10MV	6MV-FFF	10MV-FFF
5x5cm	523/0	561/0	526/0	529/0
3x3cm	207/0	225/0	210/0	213/0
2x2cm	99/1	113/3	105/0	104/5
1x1cm	31/1	35/2	32/1	36/1
0.5 x 0.5cm	8./1	13/3	12./0	10./3

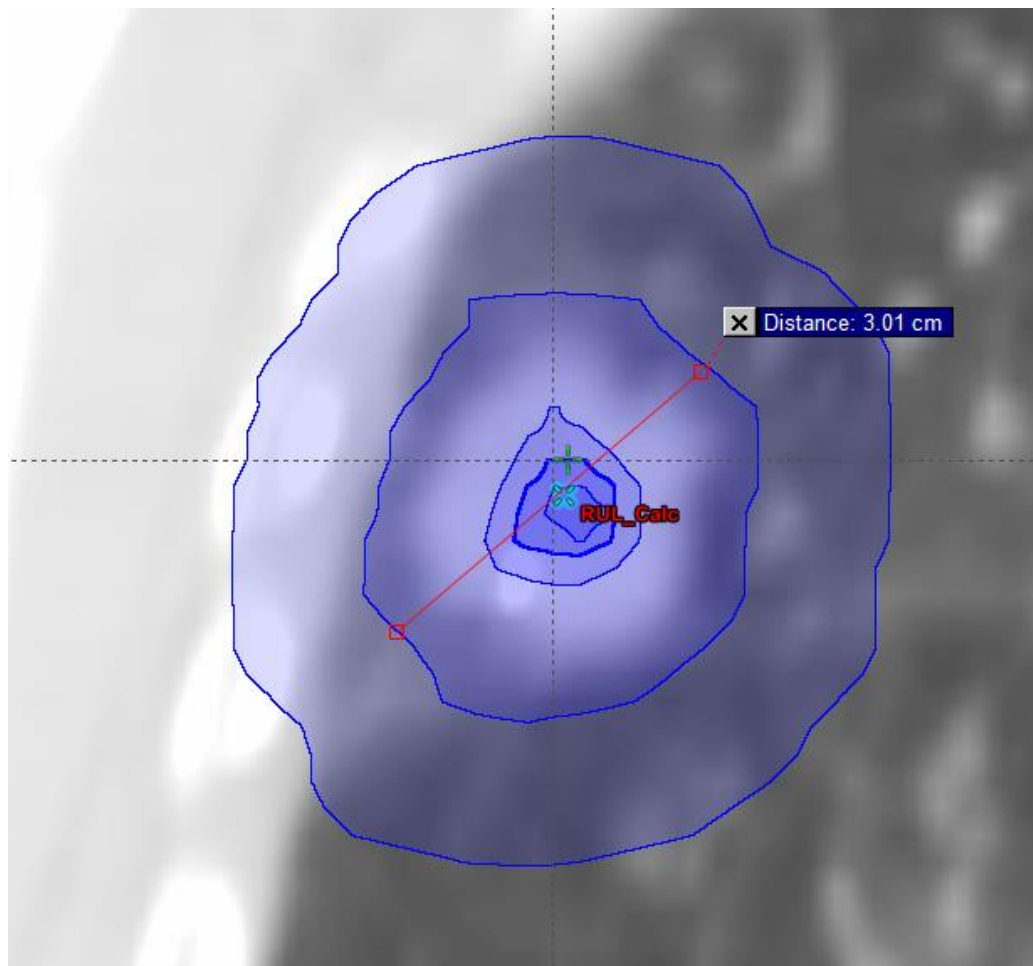
Reference Field **5cm x 5cm**

SAD = 100cm

Ion Chamber Measurement with Exradin A16

Energy	Planned (cGy)	Measured (cGy)	% diff
6MV	97.96	96.97	-1.01
10MV	98.48	96.24	-2.27
6MV-FFF	97.72	97.06	-0.68
10MV-FFF	98.26	96.7	-1.59

Evaluation for SRS dosimetry – PTV size



PTV5cm	72.3cc
PTV3cm	13.8cc
PTV1cm	0.7cc
PTV6mm	0.2cc
PTV3mm	0.03cc



Evaluation for SRS dosimetry; PTV size

Date: 5/17/2019

SRS MapCHECK QA of Dose Distribution

Hospital Name:

QA File Parameter

Patient Name :
 Patient ID :
 Date : 5/17/2019
 SSD :
 SDD :
 Depth :
 Energy :
 Gantry Angle :

Absolute Dose Comparison

Difference (%) : 2
 Distance (mm) : 2.0
 Threshold (%) : 10.0
 Use Global % : Yes

Summary (Gamma Analysis)

Total Points : 172
 Passed : 172
 Failed : 0
 % Passed : 100

Dose Values in cGy

	CAX	Norm	Max
SRS MC	1359.47	1732.49	1758.60
Plan	1395.13	1825.71	1932.35
SRS MC	-35.66	-93.21	-173.76
-Plan			
% Diff	-1.95	-5.11	-9.52
Coords (y,x) cm	0,0	-0.875,-0.175	

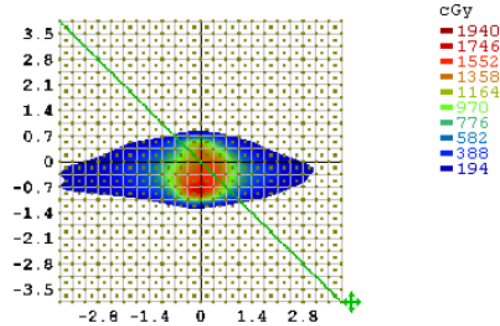
CAX Offset

Set 2
 X (mm) : -0.04
 Y (mm) : -0.81
 Z (mm) : 1.21
 Pitch (deg) : 0.00
 Roll (deg) : 0.00
 Yaw (deg) : 0.00

Notes

SRS MC

StereoPHAN Angle(deg)=0

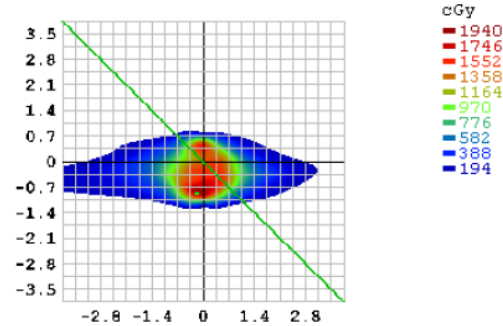


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Plan

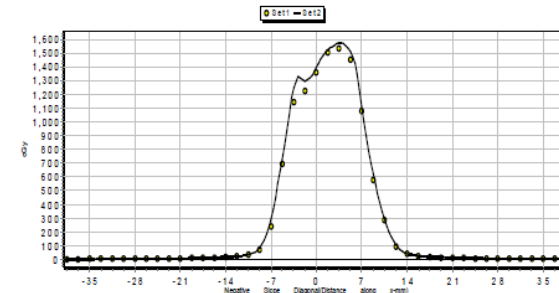
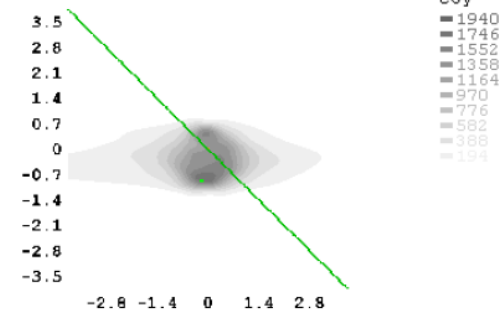
StereoPHAN Angle(deg)=0

Dose Scaling Factor=1
 Isocenter Coordinates X=-0.75002 Y=-172.31 Z=-18.244



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SRS MC-Plan



2%/2mm Gamma Index criteria

10% Dose Threshold

Gamma Index passing rates (%)

	<i>6xFFF</i>	<i>10xFFF</i>
<i>PTV5cm</i>	<i>100</i>	<i>100</i>
<i>PTV3cm</i>	<i>100</i>	<i>99.6</i>
<i>PTV1cm</i>	<i>100</i>	<i>99.5</i>
<i>PTV6mm</i>	<i>97.1</i>	<i>99.1</i>
<i>PTV3mm</i>	<i>100</i>	<i>98.3</i>

HUMC_TG101_Brain SRT-5fraction Prescriptions

Prescription	Total Dose
PTV1Rx	2500

HUMC_TG101_Brain SRT-5fraction Constraints

Priority	Structure Template	Structure Plan	Type	Prescription	Constraint	Goal	Lt Brain SRT	Pass/Fail
1	PTV1	PTV1_Lt Brain	Target	PTV1Rx: 2500cGy	V100% ≥	95%	99.498%	✓
2	PTV1	PTV1_Lt Brain	Target	PTV1Rx: 2500cGy	Max ≤	111-200%	139.084%	⚠
3	PTV1	PTV1_Lt Brain	Target	PTV1Rx: 2500cGy	Min ≥	90%	90.148%	✓
4	PTV1	PTV1_Lt Brain	Target	PTV1Rx: 2500cGy	CI using PTV1+1cm 100% ≤	2-3.5	1.063	✓
5	AllPTVs	PTV1_Lt Brain	OAR	PTV1Rx: 2500cGy	Hot Spot Within	139.084%	139.084%	✓
6	Right Optic Nerve	Rt Optic Nerve	OAR		V2300cGy ≤	0.2cc	0cc	✓
7	Right Optic Nerve	Rt Optic Nerve	OAR		V2500cGy ≤	0.035cc	0cc	✓
8	Left Optic Nerve	Lt Optic Nerve	OAR		V2300cGy ≤	0.2cc	0cc	✓
9	Left Optic Nerve	Lt Optic Nerve	OAR		V2500cGy ≤	0.035cc	0cc	✓
10	Chiasm	CHIASM	OAR		V2300cGy ≤	0.2cc	0cc	✓
11	Chiasm	CHIASM	OAR		V2500cGy ≤	0.035cc	0cc	✓
12	Right Cochlea	Rt Cochlea	OAR		V2500cGy ≤	0.035cc	0cc	✓
13	Left Cochlea	Lt Cochlea	OAR		V2500cGy ≤	0.035cc	0cc	✓
14	Brainstem	Brainstem	OAR		V2300cGy ≤	0.5cc	0cc	✓
15	Brainstem	Brainstem	OAR		V3100cGy ≤	0.035cc	0cc	✓
16	Spinal Cord	Cord	OAR		V1450cGy ≤	1.2cc	0cc	✓
17	Spinal Cord	Cord	OAR		V2300cGy ≤	0.35cc	0cc	✓
18	Spinal Cord	Cord	OAR		V3000cGy ≤	0.035cc	0cc	✓

ole Case



Lackensack
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Evaluation for SRS dosimetry – Clinical Example 1

Date: 5/17/2019

SRS MapCHECK QA of Dose Distribution

Hospital Name:

QA File Parameter

Patient Name : Lt Brain SRT
 Patient ID :
 Date : 5/17/2019
 SSD :
 SDD :
 Depth :
 Energy :
 Gantry Angle :

Absolute Dose Comparison

Difference (%) : 2.0
 Distance (mm) : 2.0
 Threshold (%) : 10.0
 Use Global % : Yes

Summary (Gamma Analysis)

Total Points : 647
 Passed : 641
 Failed : 6
 % Passed : 99.1

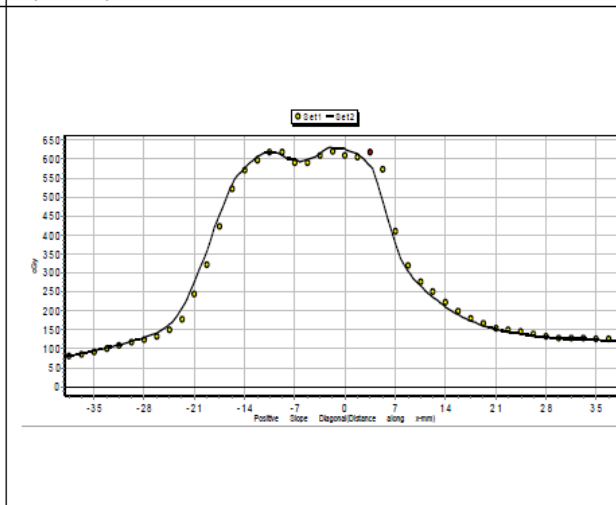
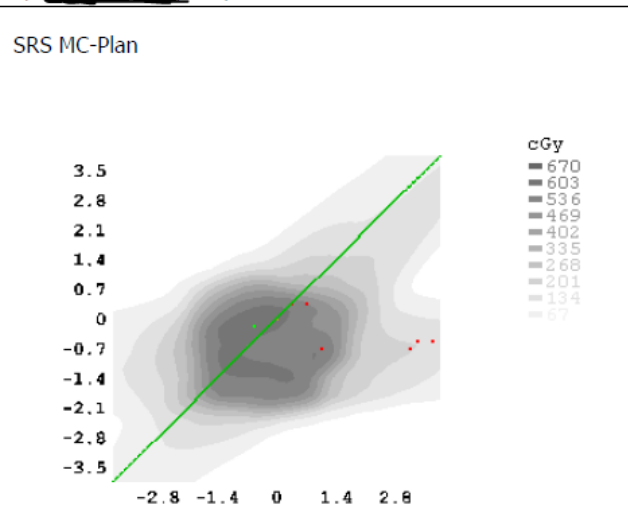
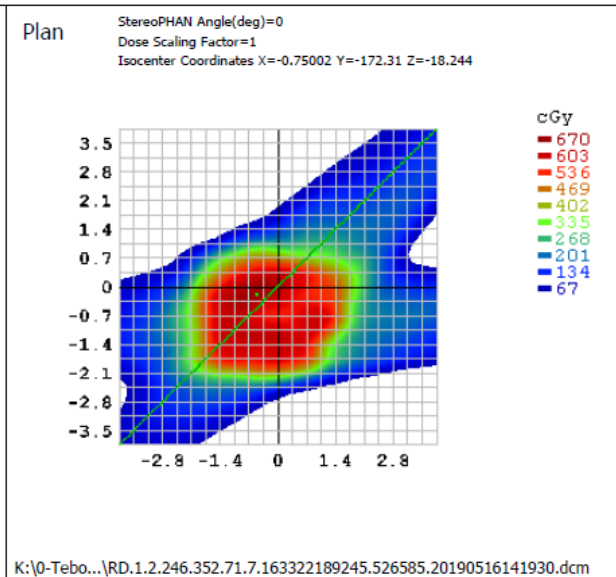
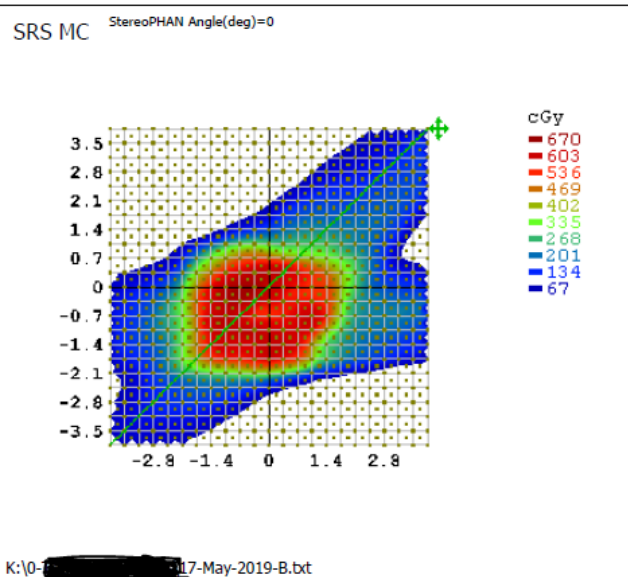
Dose Values in cGy

	CAX	Norm	Max
SRS MC	608.47	660.31	664.04
Plan	625.84	663.05	665.12
SRS MC	-17.36	-2.74	-1.08
-Plan			
% Diff	-2.62	-0.41	-0.16
Coords (y,x) cm	0,0	-0.175,-0.525	

CAX Offset

Set 2
 X (mm) : 0
 Y (mm) : 0
 Z (mm) : 0
 Pitch (deg) : 0
 Roll (deg) : 0
 Yaw (deg) : 0

Notes



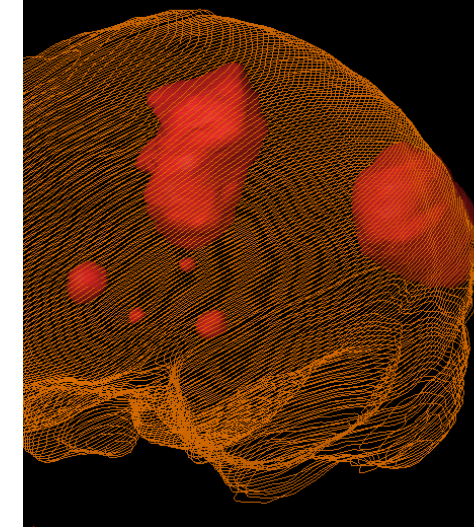
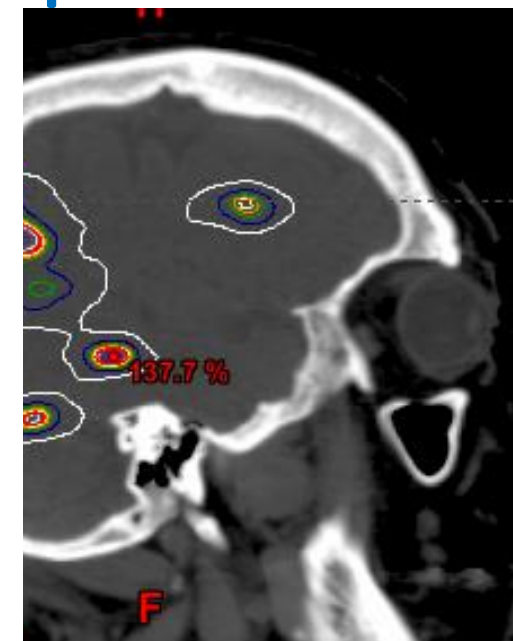
- GI pass of 100% based on 2%/2mm



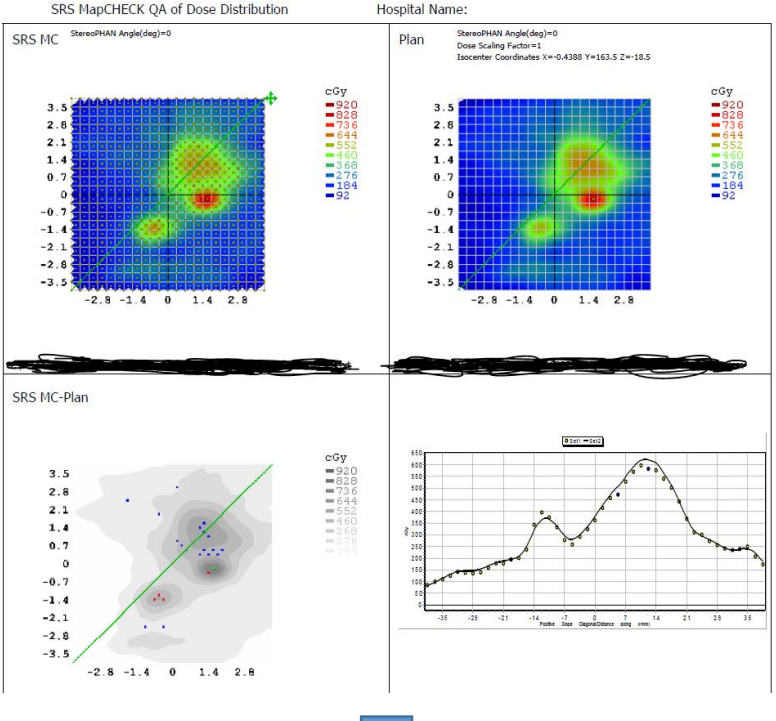
Brain 5arcSRT - HUMC_TG101_Brain SRT-5fraction Constraints

Example 2

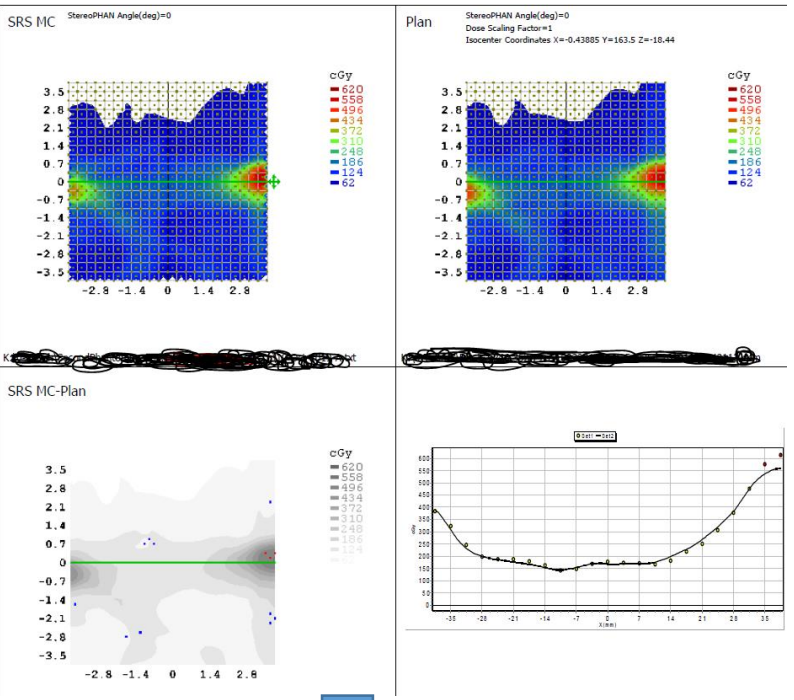
Priority	Structure Template	Structure Plan	Type	Prescription	Constraint	Goal	Brain 5arcSRT	Comment
1	PTV1	PTV1_L Frontal	Target	PTV_all: 3000cGy	V100% ≥	95%	100%	
2	PTV1	PTV1_L Frontal	Target	PTV_all: 3000cGy	Max ≤	111-200%	148.136%	
3	PTV1	PTV1_L Frontal	Target	PTV_all: 3000cGy	Min ≥	90%	103.223%	
4	PTV1	PTV1_L Frontal	Target	PTV_all: 3000cGy	CI using PTV1+1cm 100% ≤	2-3.5	1.359	
5	PTV2	PTV2_L Occipitat	Target	PTV_all: 3000cGy	V100% ≥	95%	98.091%	
6	PTV2	PTV2_L Occipitat	Target	PTV_all: 3000cGy	Max ≤	111-200%	140.036%	
7	PTV2	PTV2_L Occipitat	Target	PTV_all: 3000cGy	Min ≥	90%	91.585%	
8	PTV2	PTV2_L Occipitat	Target	PTV_all: 3000cGy	CI using PTV2+1cm 100% ≤	2-3.5	0.996	
9	PTV3	PTV3_R Frontal	Target	PTV_all: 3000cGy	V100% ≥	95%	100%	
10	PTV3	PTV3_R Frontal	Target	PTV_all: 3000cGy	Max ≤	111-200%	165.753%	



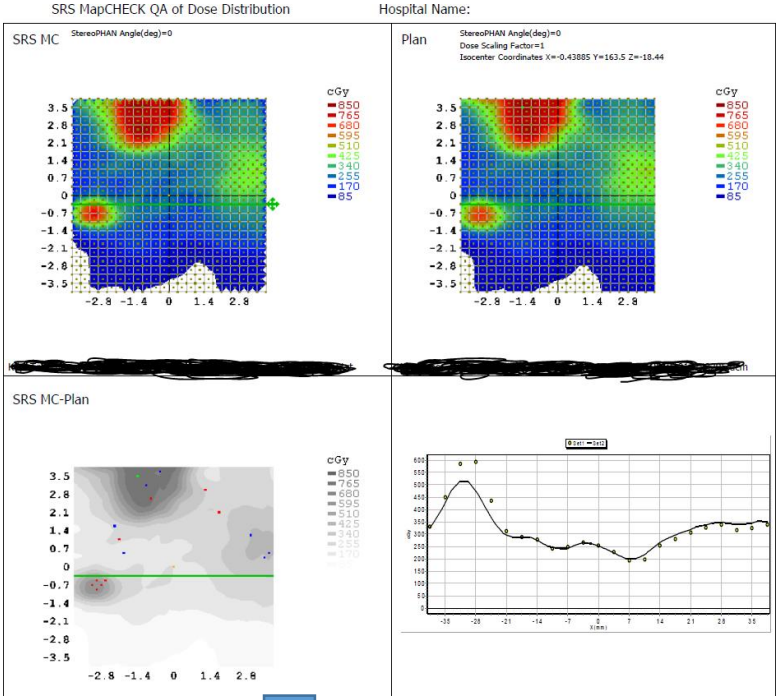
Evaluation for SRS dosimetry – 3 QA plans needed



Plan1 – PTV4,5&7
GI pass of 97.7% based on 2%/2mm



Plan2 – PTV1&3
GI pass of 98.4% based on 2%/2mm



Plan2 – PTV2&6
GI pass of 98.3% based on 2%/2mm

Summary of Clinical QA cases completed – Gamma analysis

	No of PTVs	No of Arcs	Couch angles	Total points	Gamma analysis based on 10% dose threshold				
					3%/3mm	3%/2mm	2%/2mm	2%/1mm	1%/1mm
QA1	1	2	0,0	948	99.3	98.4	95.7	86.6	70.2
QA2	1	2	0,0	504	100	100	99.8	98	92.1
QA3	2	5	0,0,30,90,330	930	99.7	99.5	98.4	89.1	73.5
QA4	3	5	0,0,30,90,330	1012	98.8	98.5	97.7	94.8	84.6
QA5	2	5	0,0,30,90,330	969	99.6	99.3	98.3	88	74.4
QA6	1	2	0,0	471	98.3	96.4	95.4	79	68.6
QA7	2	2	0,0	380			95.3		
QA8	1	4	0,0,270,315	1013	99.7	99.5	98.5	96.4	91.9
QA9	2	4	0,0,270,315	979	99.7	99.7	99.2	98	95.2
QA10	2	4	0,0,270,315	1013	99.5	97.8	96.7	83.2	66.8
QA11	1	3	0,0,270	890	99.7	98.8	98.5	92.2	83.3
QA12	1	3	0,0,45	647			99.1		
QA13	1	3	0,0,270	769			99.5		
QA14	1	2	0,0	434	97.7	97	96.5	92.2	90.3
QA15	1	2	0,0	657	99.2	98.5	96.3	91.6	85.2
QA16	1	2	0,0	483	99.6	99.4	98.1	96.5	89.6
QA17	1	3	0,0,90	802	99.9	99.6	99.1	92.1	77.6
QA18	1	3	0,0,90	813	100	99.9	99	93.1	83.6
QA19	1	2	0,270	895	100	100	99.4	96.5	83.7
QA20	1	2	0,0	530	99.1	97.5	95.3	88.9	78.7
QA21	4	4	0,0,90,330	1008	100	100	98.3	96.9	89.1
QA22	2	4	0,0,90,330	855	99.9	99.9	99.9	99.6	98.6
QA23	2	3	0,0,270	556	100	98.4	97.7	79.3	63.7
QA24	1	2	0,0	621	99.8	99.5	96.9	92.3	82.4
QA25	2	2	0,0	814	99.9	99.8	98.5	97.5	91.6
QA26	1	2	0,0	437	98.2	97.7	97	90.6	84.2
QA27	2	2	0,0	336	98.8	98.2	96.4	94	90.5
QA28	1	3	0,0,90	536	99.4	97	94.8	73.7	55.8
QA29	2	3	0,0,90	623	99.8	99.7	99.7	85.2	77.4
QA30	2	2	0,0	288			97.2		

Based on our evaluation, we will set our departmental criteria of SRSSMapCheck QA at 2%/2mm for a 95% pass

Tolerance limits and methodologies for IMRT measurement-based verification QA: *Recommendations of AAPM Task Group No. 218*

Moyed Miften, Arthur Olch, Dimitris Mihailidis, Jean Moran, Todd Pawlicki, Andrea Molineu, Harold Li, Krishni Wijesooriya, Jie Shi, Ping Xia, Nikos Papanikolaou, Daniel A. Low

First published: 14 February 2018 | <https://doi.org/10.1002/mp.12810> | Cited by: 56

**AAPM TG 218 recommended criteria
3%/2mm for a 95% pass**

Thanks for your Attention

