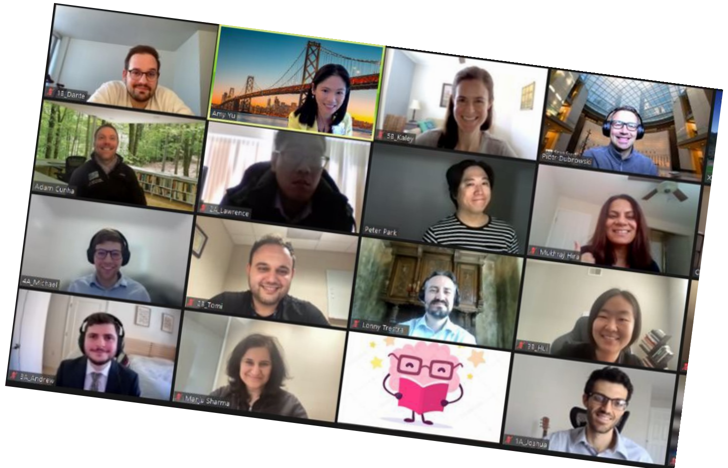
Northern California AAPM Chapter

- 3/2023 Mock exam:
  - FREE!!
  - This event is sponsored by Northern California Chapter of the AAPM
  - The examiners are Medical Physicists from UCSF, UC Davis, and Stanford around the Bay Area.
  - We will invite Southern California faculty to join the effort (we need volunteers!)
- Young Investigator's Symposium: This year will be in person!!
- 2023 Annual Chapter meeting



NORTHERN CALIFORNIA CHAPTER
AMERICAN ASSOCIATION *of* PHYSICISTS IN MEDICINE

Peter Park

Piotr Dubrowski

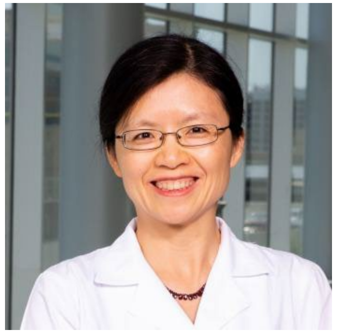
Monica Hira

Manju Sharma

Lonny Trestrail

Adam Cunha

Xuejun Gu



Sonja Dieterich

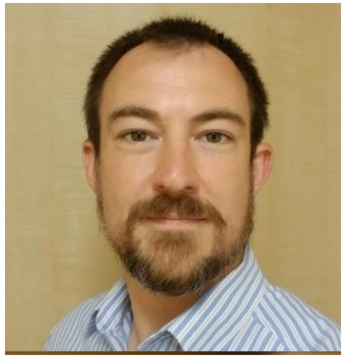
Benjamin Ziemer

Lawrie Skinner

Marian Axente

Olga Volotskova

Joe Blickenstaff



Amy Yu

Stanford MEDICINE

From translational research to clinical implementation

Amy S. Yu, Ph.D., DABR
Clinical Associate Professor

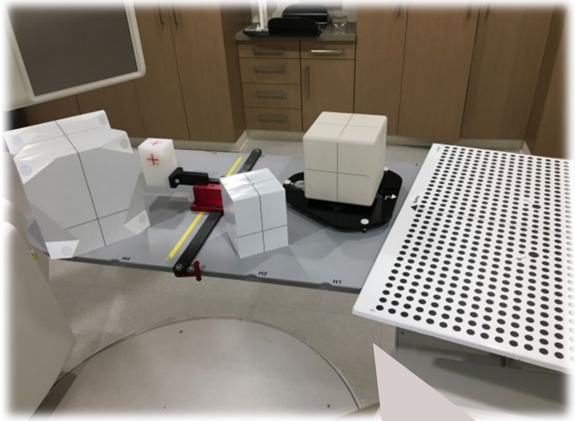
Department of Radiation Oncology, Stanford University, California, USA

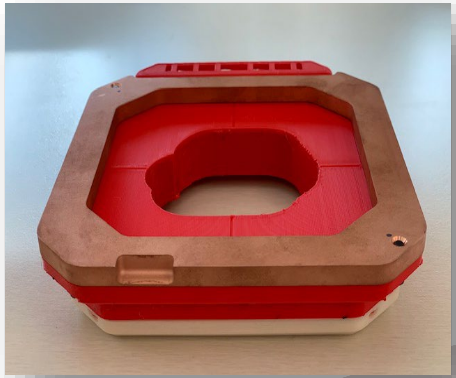
Discourse

Financial disclosure:

Patents on the presented QA phantom & 3D-printed electron cutout

Outline

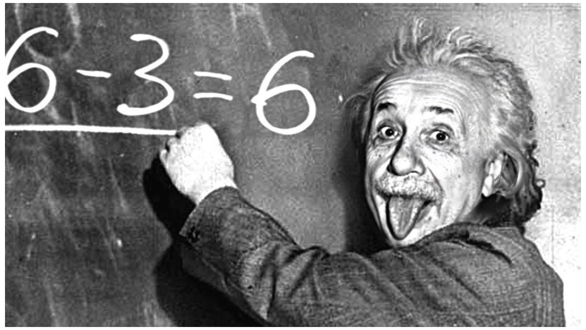




Quality Assurance

Treatment Delivery

Patient Education



Stanford MEDICINE

Patient Anxiety

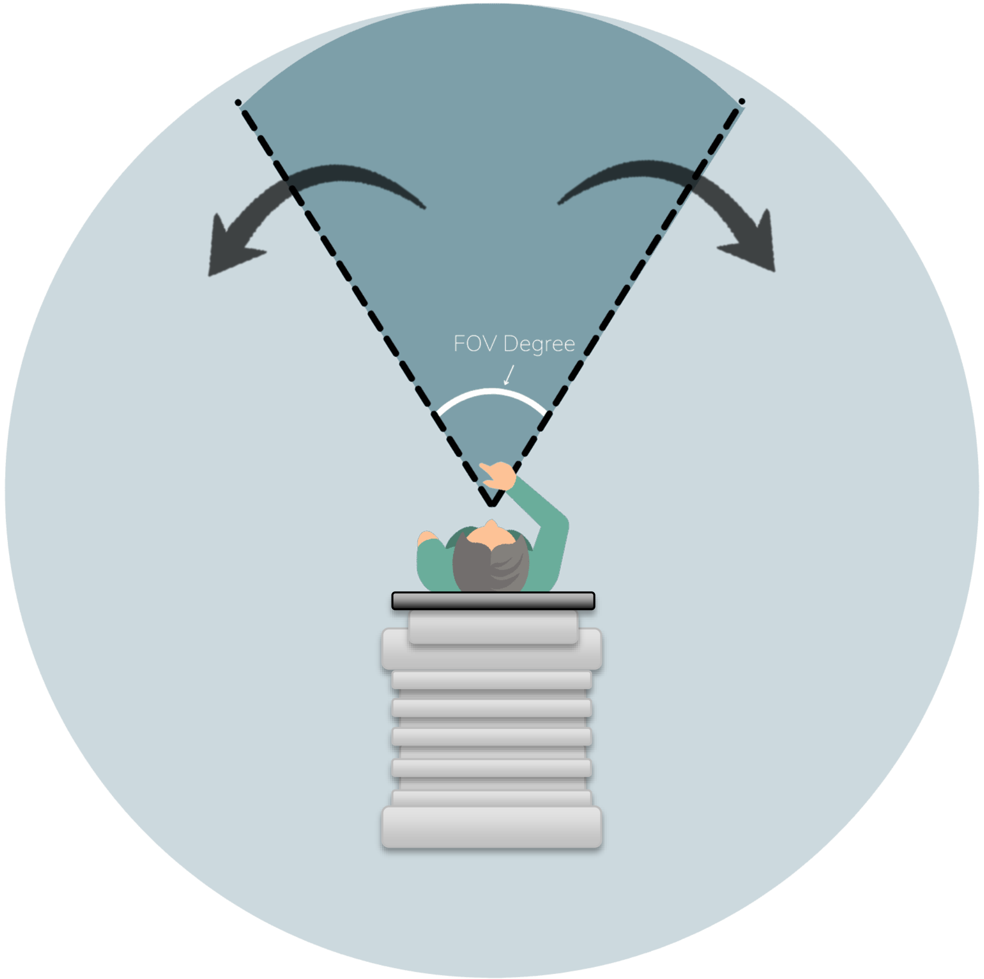
An Idea

- COVID-19
- Patient education classes
- Zoom classes?
- Immersion
- Educational videos show reduction in patient anxiety*

*Kumar et al. Int J Radiat Oncol Biol Phys. 2021 Apr 1;109(5):1165-1175.
https://www.newyorker.com/magazine/2020/04/27/embracing-the-chaotic-side-of-zoom

VR in Radiation Therapy

- Patient empowerment
  - Unrestricted movement
  - Controllable pacing
- First person experience
- 360-degree immersion



A patient experiencing being supine on a linac couch in VR

https://roundtablelearning.com/what-is-field-of-view-fov-less-than-100-words/

What is VR?

- Complete immersion in a simulated environment
- A useful tool
  - Education
  - Training
  - Gaming

Practicing surgery in FundamentalVR's surgical training app

VR Headsets

- $ to $$$$
- Upkeep
- Required accessories
- Wired/Wireless
- IT

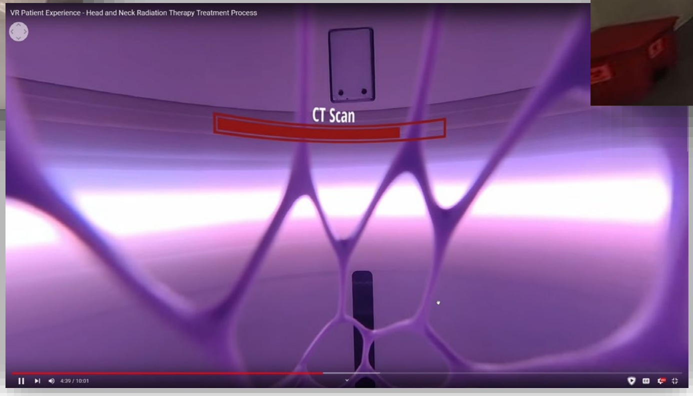
https://www.theverge.com/a/best-vr-headset-oculus-rift-samsung-gear-htc-vive-virtual-reality

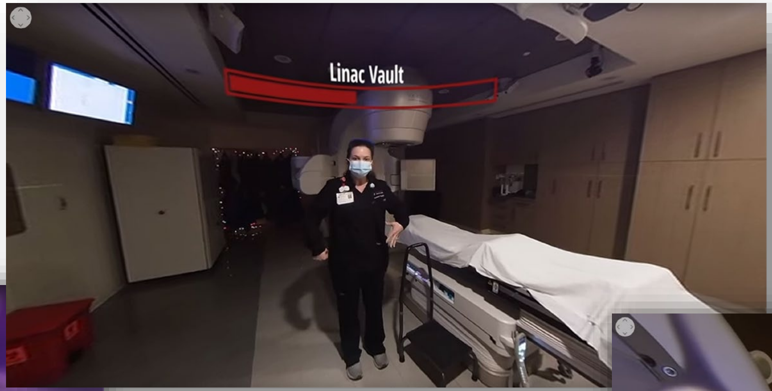
Cardboard VR Viewer

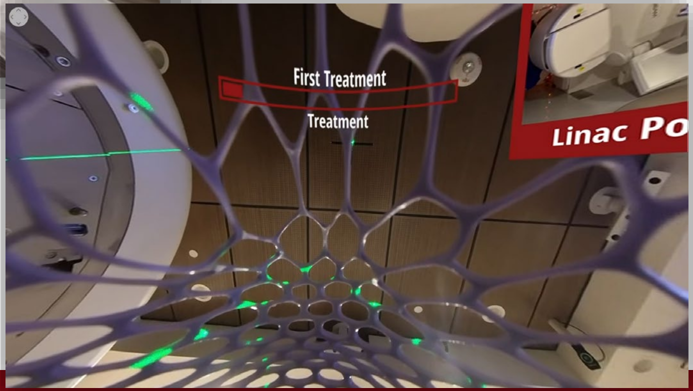
- Every patient gets their own
  - Usable at home
  - share with family, friends
- No cross contamination
- Low cost
- Reusable

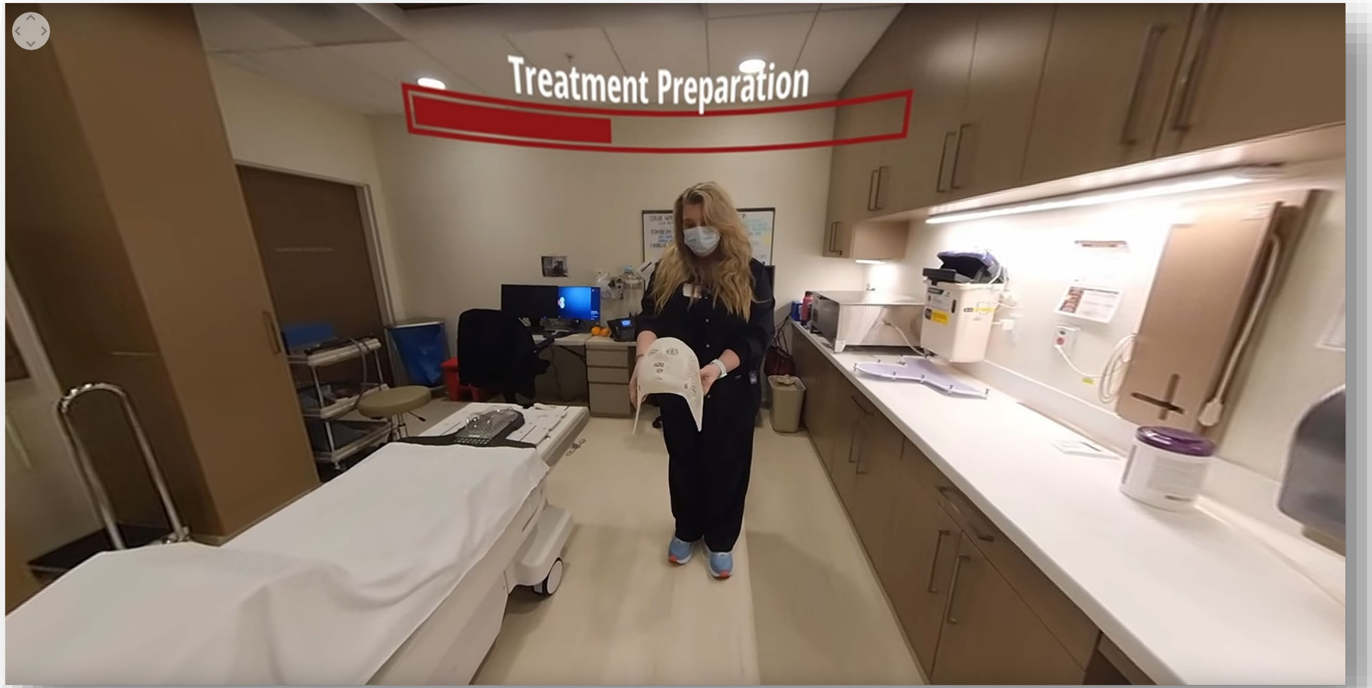
VR Video - Filming Format

Treatment preparation → CT simulation → Introduction to a linac vault → First treatment









https://youtu.be/jc6eQlxuhfU

Patient Virtual Reality (VR) Experience

Radiation Therapy Treatment

To watch the video, please enter the URL link (case-sensitive) below in your phone or computer internet browser or scan the QR Code below.

https://bit.ly/StanfordVR

Stanford HEALTH CARE STANFORD MEDICINE

To experience in VR, please select the icon in the lower right corner while viewing the video above in the YouTube app. For more assistance, please see:

https://bit.ly/360VRhelp

Survey

- Question types
  - 5-point Likert-type scale
  - Demographics
  - Yes or no
- Eligible participants
  - English speaking (English Video Version)
  - 18 years or older
  - Cancer diagnosis

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
(1)	(2)	(3)	(4)	(5)

Survey - Group A

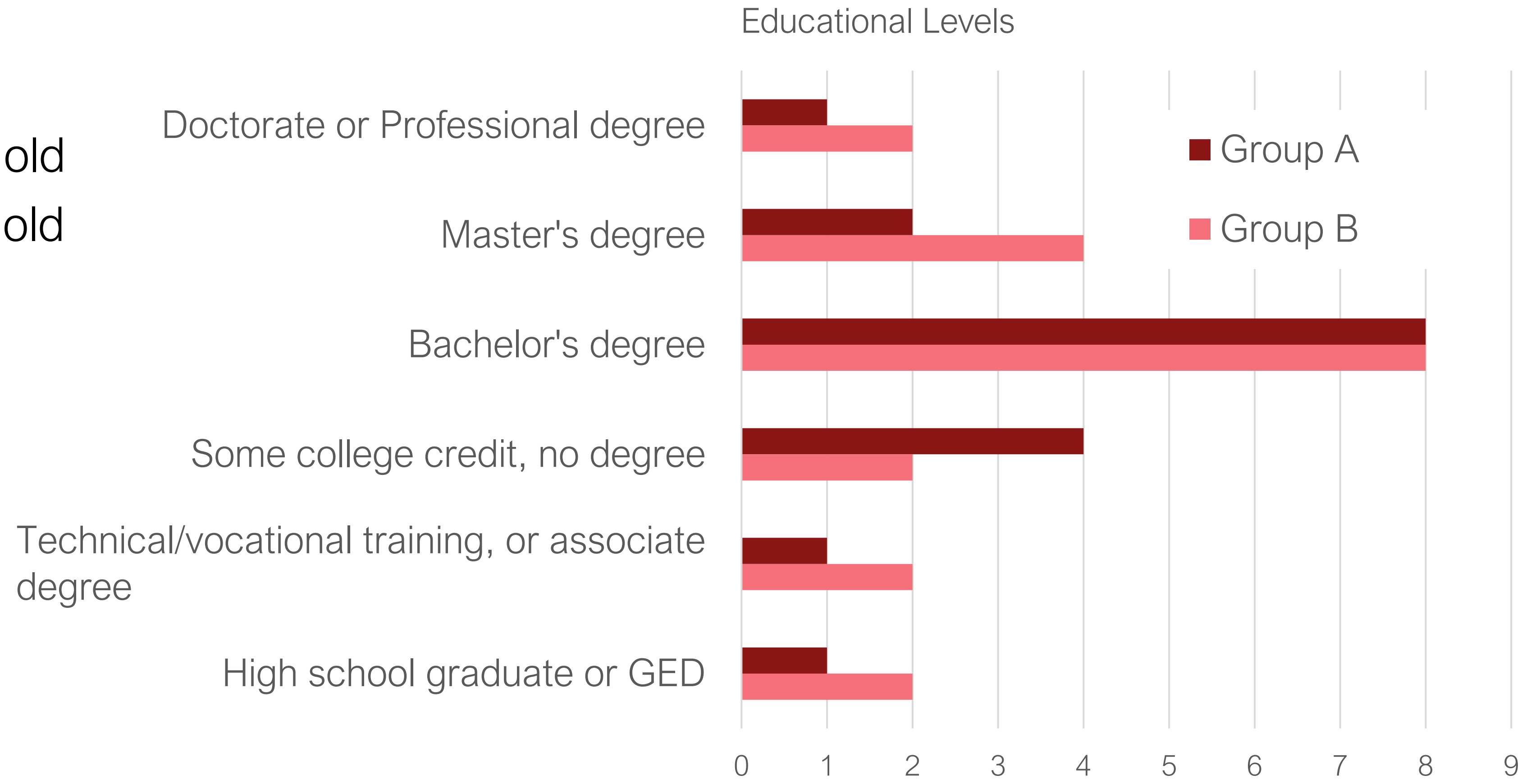
Post-consult → Introduction → Consent Form → Video → Survey

Survey - Group B

On treatment → Introduction → Consent Form → Video → Survey

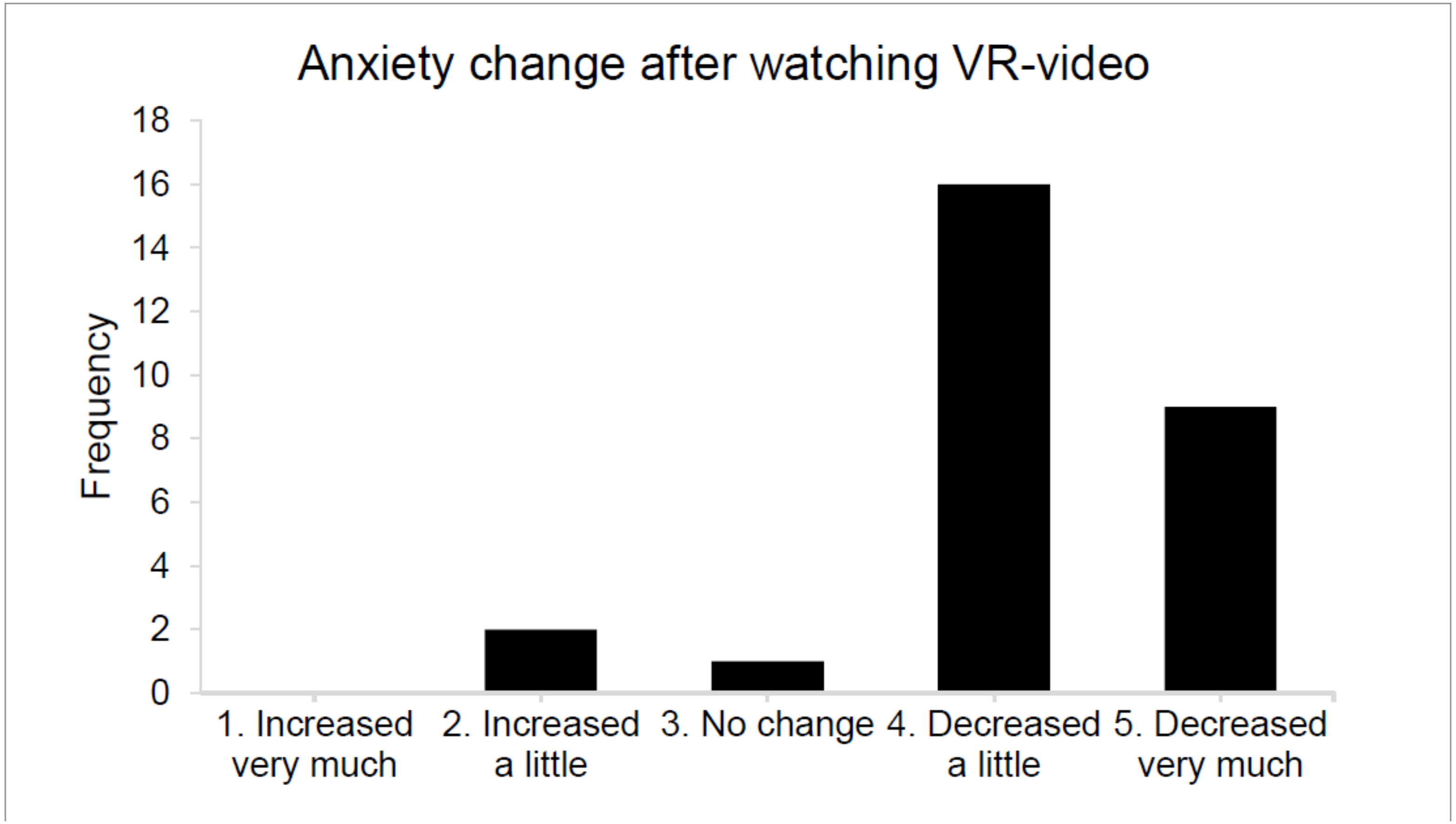
Survey Demographics

- Average age
  - Group A: 54 years old
  - Group B: 67 years old

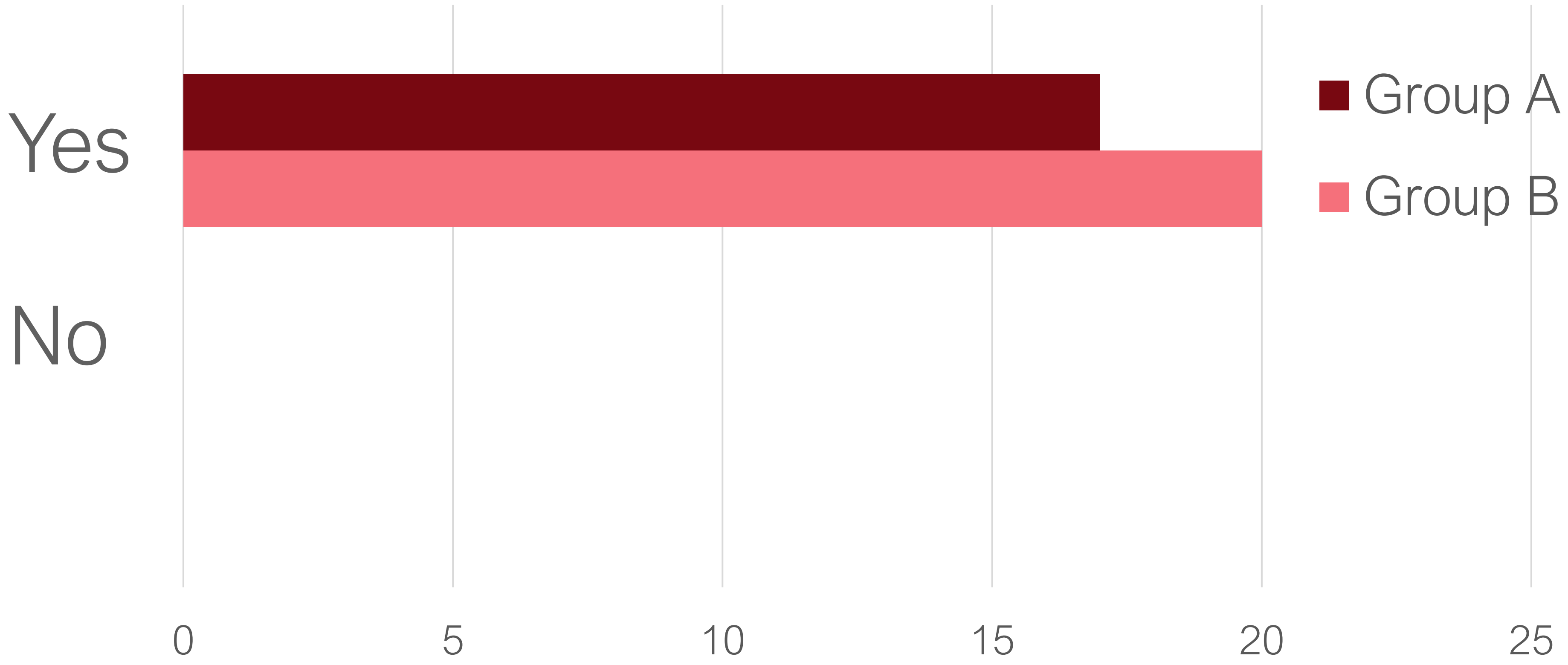


Stanford | MEDICINE

Survey – Group A (Post Consult)

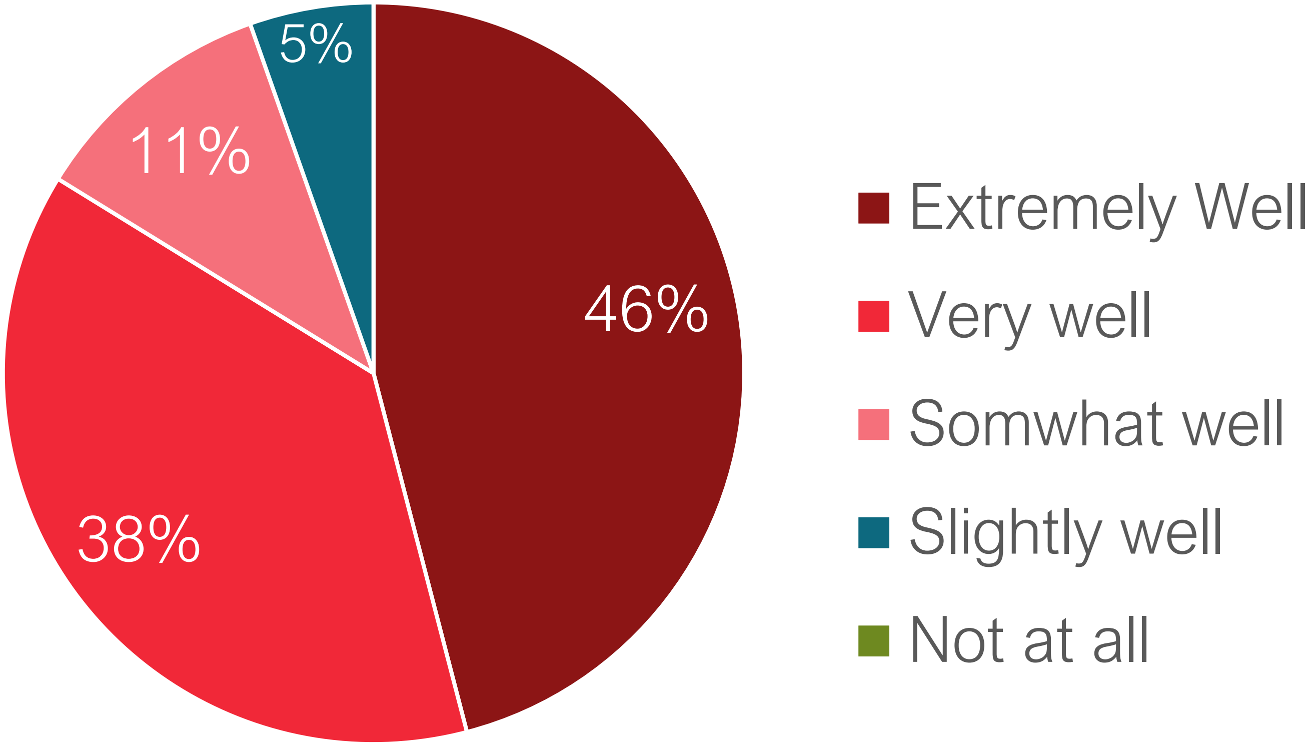


Did you feel the Virtual Reality (VR) aspect of the video(s) was helpful?

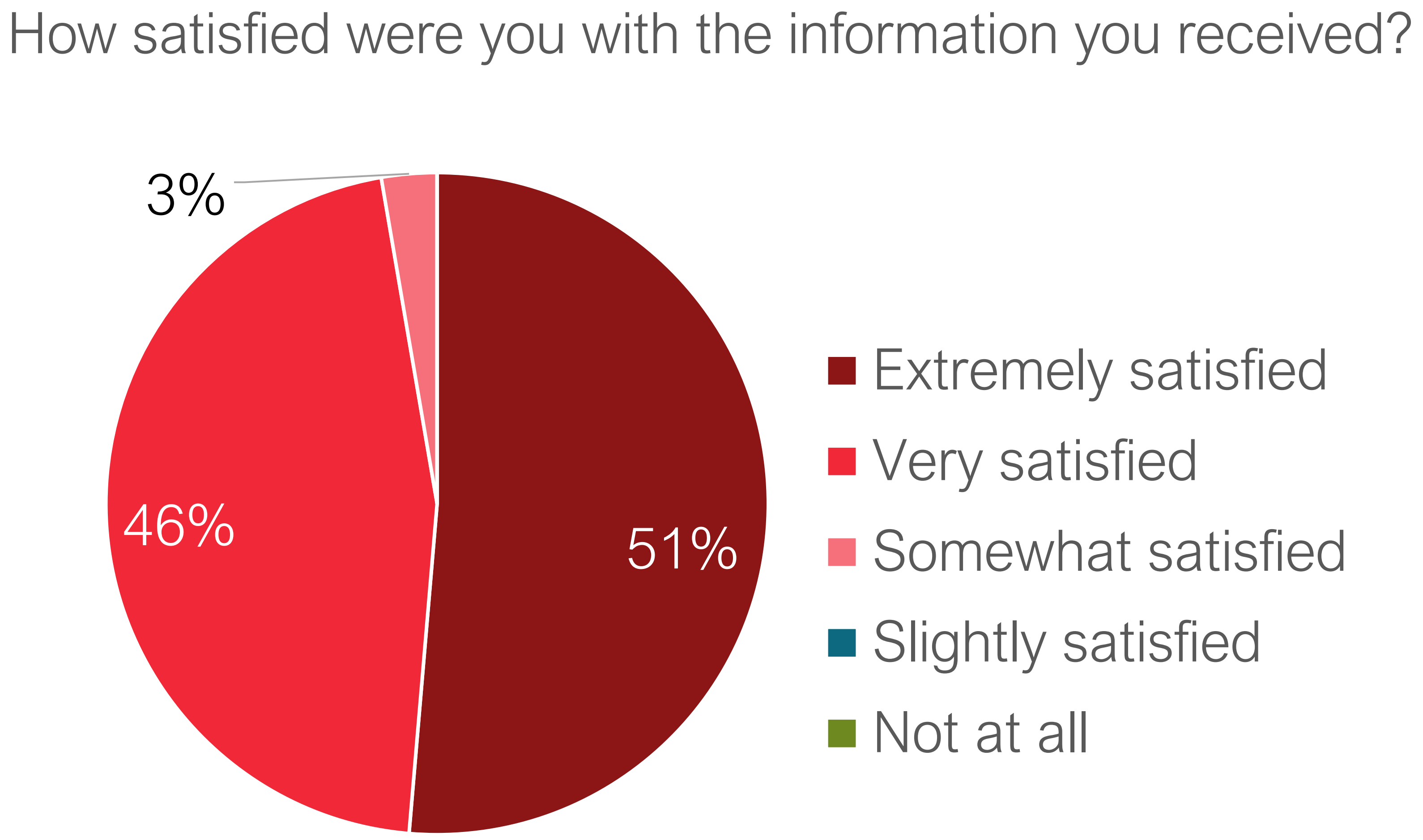


Additional Survey Data – Group A and B

How well did the video address your questions about radiation therapy?

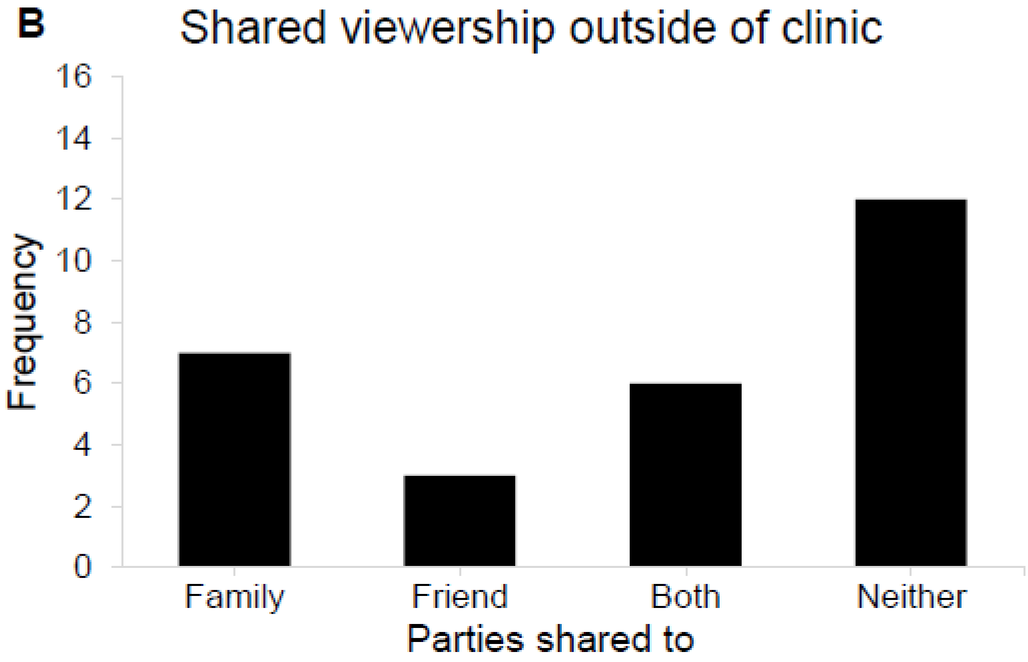


Additional Survey Data – Group A and B



Fun Facts

- Many patients showed the video to friends and family
- Many patients use the VR Viewer to watch other VR YouTube videos

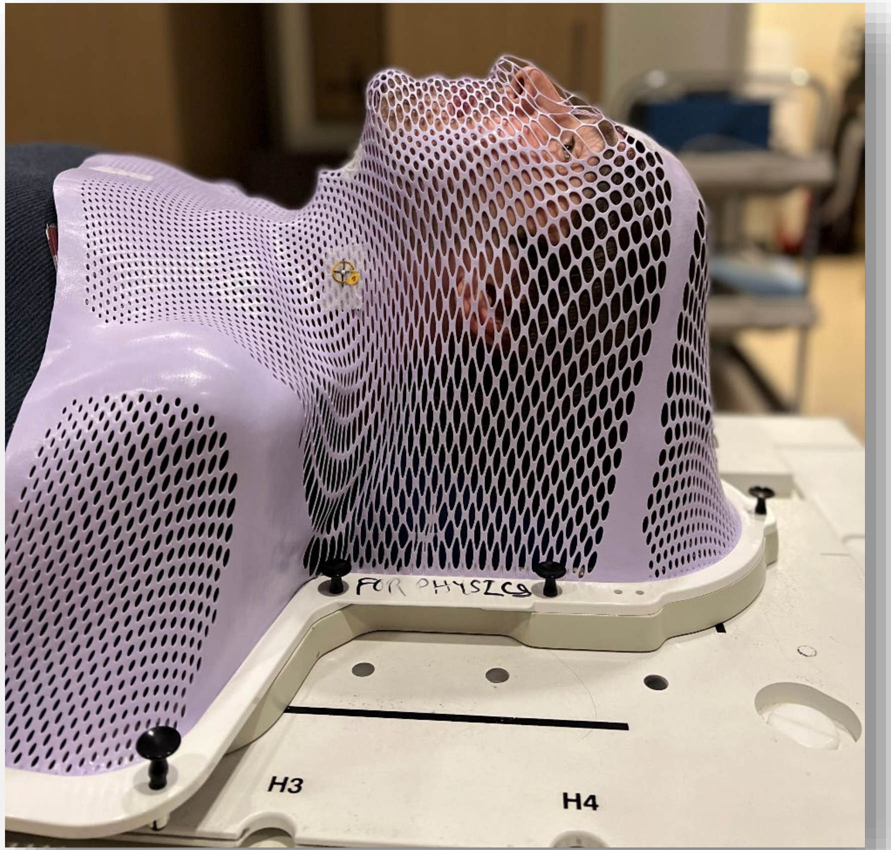


Comments

- "Keep continuing to do this...it shows that you care."
- "This is so cool!"
- "I wish other patients will be able to watch this."
- "I looked up a picture of a linear accelerator before coming in…the video is better." (Group A, Post Consult)
- "Wish I could have seen this before my treatment!" (Group B, On Treatment)

Conclusion

- Increase patient satisfaction
- Reduce patient stress and anxiety
- Supplement to traditional education
- Reduce strain on staffing

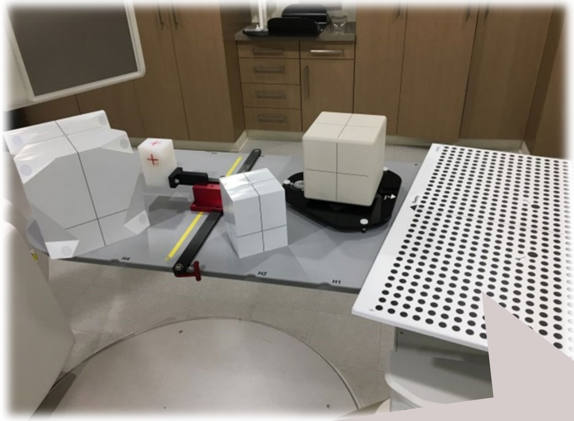


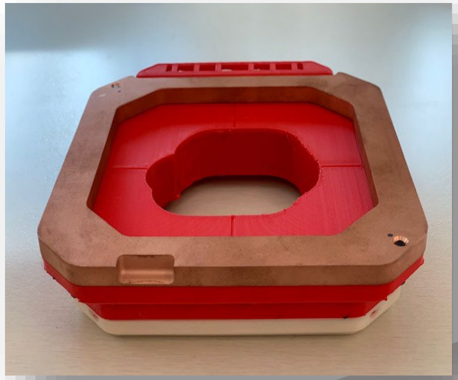
Mask anxiety in head and neck patients

https://www.oncolink.org/cancer-treatment/radiation/support/claustrophobia-and-anxiety-with-mask-use-for-radiation-therapy

2022 AAPM Innovation Award in Medical Physics Education

Outline

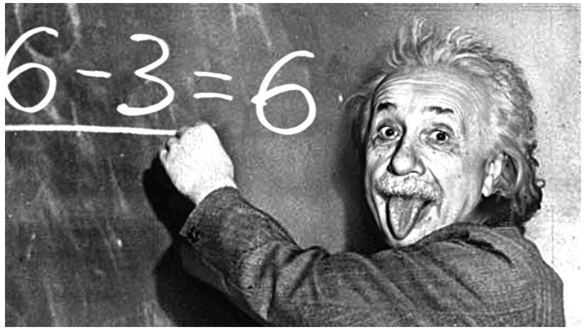




Quality Assurance

Treatment delivery

Patient education



Background

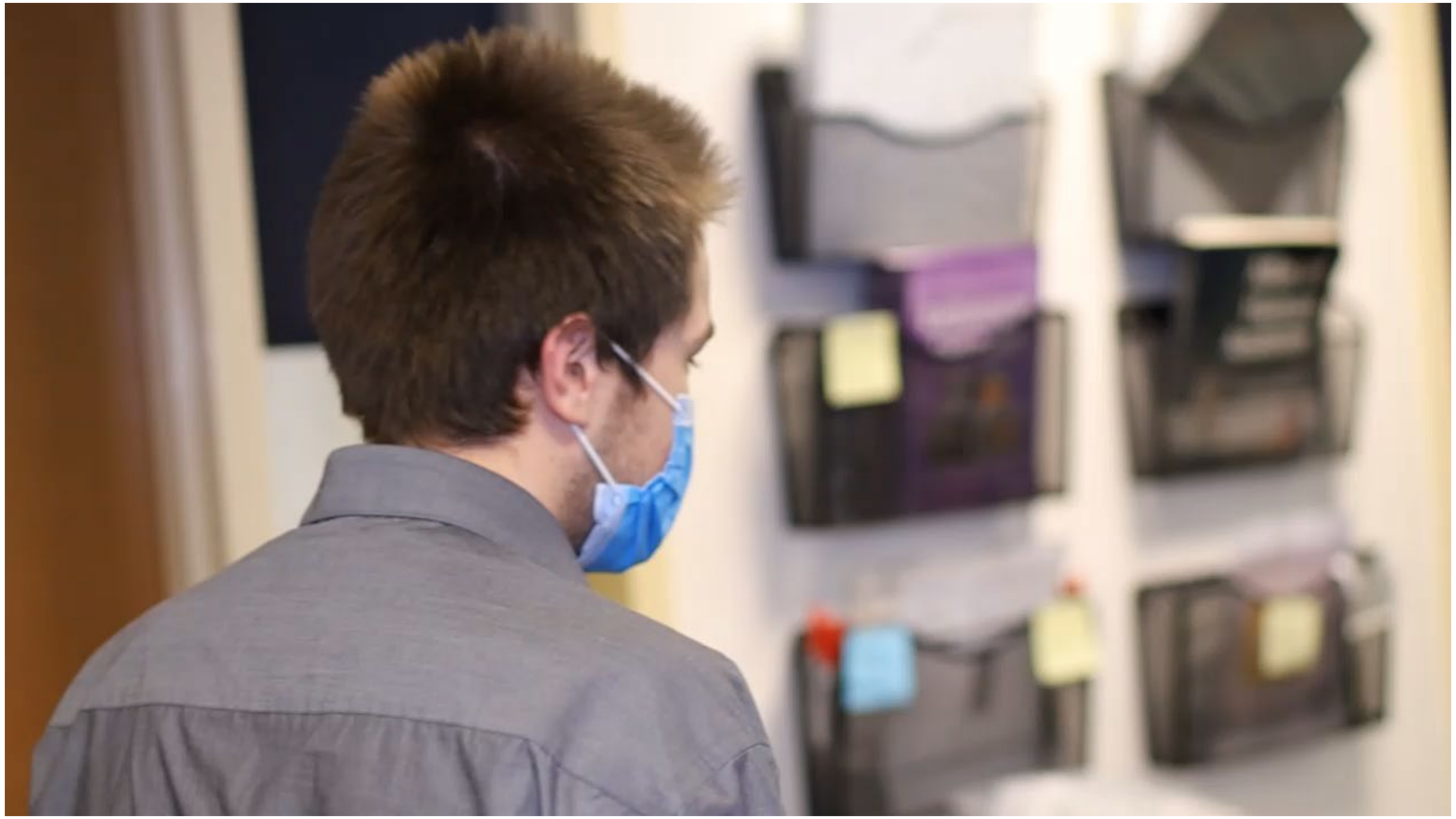
- Elec

A lot of requirements from OSHA (The Occupational Safety and Health Administration):

- Lead testing for employees
- Monitor the air in the room
- Maintain lead-free surface
- …..
- …..

fabricating secondary field shaping blocks

The current workflow

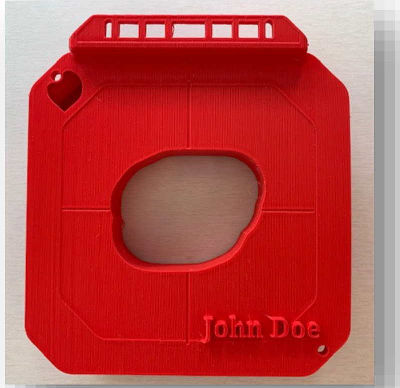


Solution?

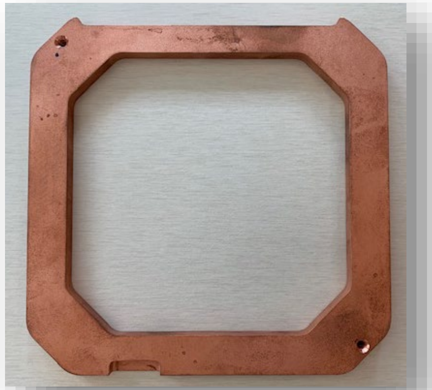
This work aims to provide streamlined and more precise electron radiotherapy by 3D printing techniques.

Components of the Cutout

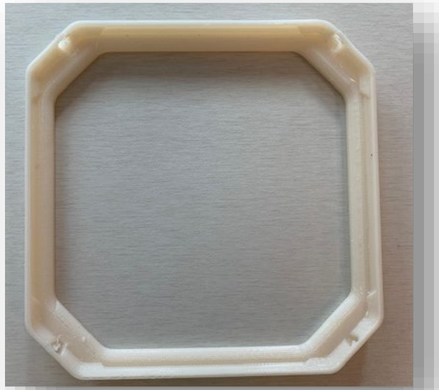
- A thin wall of 0.5 mm in thickness and 15 mm in height



3D printed shell



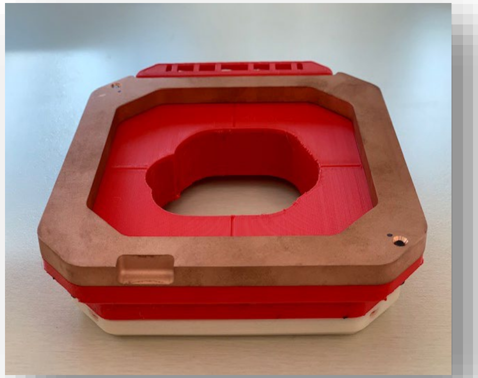
Copper frame



Bumper

Protective case

tungsten ball bearings

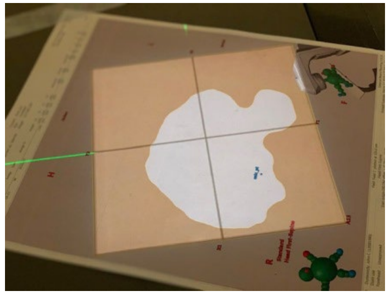


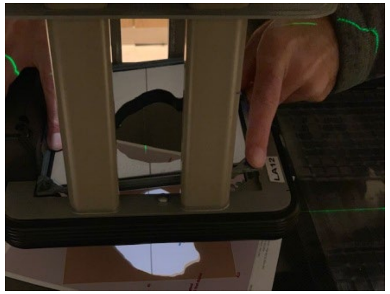
3D printed e cutout

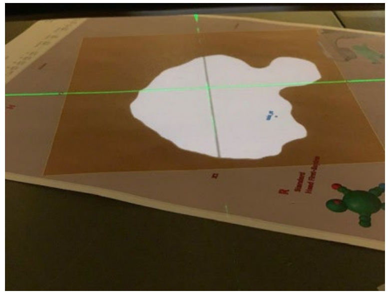
In the box

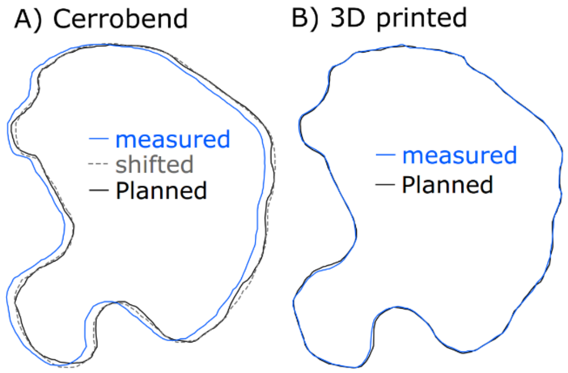
The Accuracy of the Field Shape

- The accuracy of the field shape is improved by 3D printed insert.
  - (A) The shift between the planned and the measured Cerrobend outline is 2.7$\pm$0.2 mm. Even after shift, the Cerrobend shape shows 1-2 mm deviations from the plan in several areas.
  - (B) The 3D printed cutout follows the planned outline with less than 0.5 mm shift and shape errors.







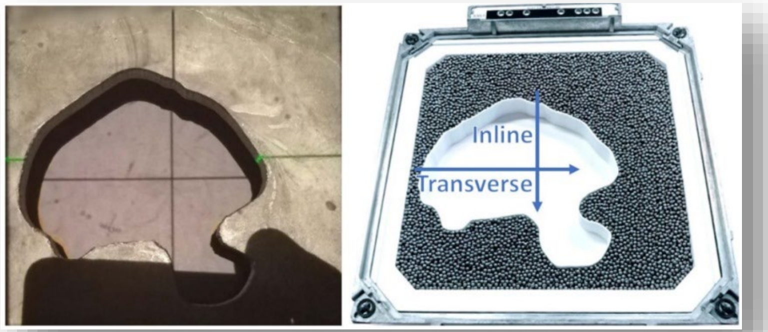


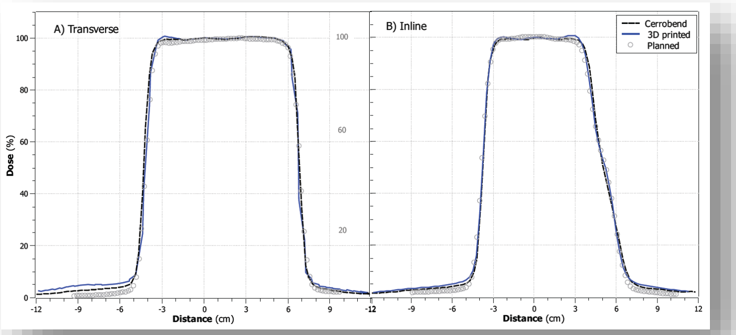
Align the field edge → Insert the cutout → Trace the outline

Skinner L, Fahimian BP, Yu AS (2019). PLoS ONE 14(6):e0217757.

3D Printed vs Standard Cutout

- Comparison of dose profiles between 3D printed and standard cutout





Energy (MeV)	Meas. Depth (cm)	Central axis output differences relative to Cerrobend cutout		
		7 cm circle (10x10)	Patient Cutout	5 cm circle (6x6)
6	1.5	0.7%	1.7%	2.3%
9	2.2	0.2%	1.6%	1.8%
12	3	0.2%	1.5%	1.7%
16	4	0.2%	1.4%	0.6%
20	5	0.4%	1.1%	0.6%

Skinner L, Fahimian BP, Yu AS (2019). PLoS ONE 14(6):e0217757.

Quality Assurance

- A QA procedure was developed to ensure the cutout is correctly filled and printed.
  - The printed insert is first visually inspected to make sure there is no major defect.
  - The proper tungsten ball bearings filling is measured the by weight
  - Field shape verification was performed by overlaying the cutout with a transparent printout from the TPS on transparent paper to compare the shape of the cutout.

$$W_{tot} \geq V_{BB} \cdot pf \cdot \rho_{BB} + W_{ins}$$

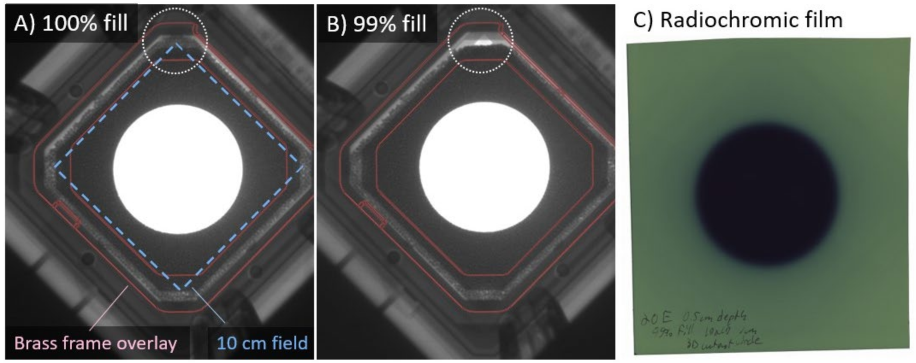
Packing fraction   BB density

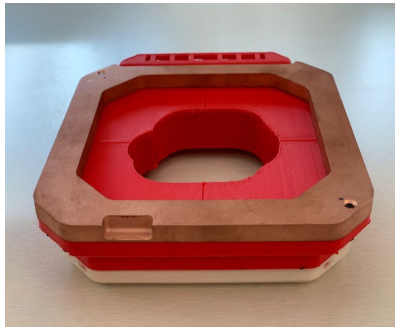
Tungsten spheres

0.6 · 17.5 g/cc = **10.5** g/cc

Quality Assurance

- MV image to see if the cutout is underfilled.
- ~1500-2000g per cutout (10x10)



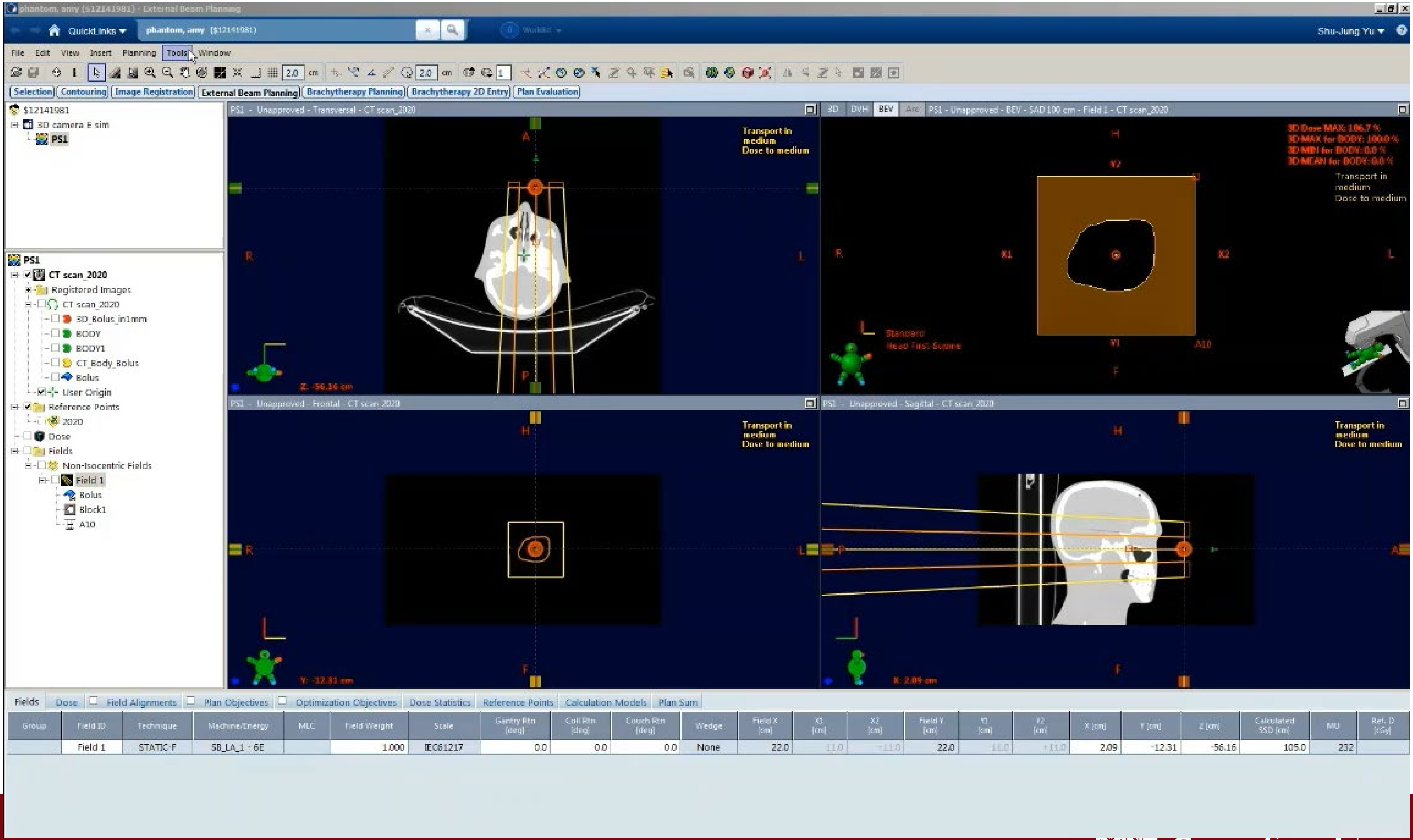


- Weight the cutout

QA				
	Volume (cc)	empty mass (g)	full mass (g)	Density (g/cc)
value	59.3	50	673	10.51
error	0	0.2	0.5	±0.41%

Breitkreutz D, Skinner L, Lo S, Yu AS J Appl Clin Med Phys. 2021;22(10):73–81.

The shining new way



Advantages and Cost

- Non-toxic material
- We can print the cutout on site
- Improve patient safety (print patient’s name and ID)
- If it is lost/broken, we can re-print it
- No more messy and toxic machine shop
- PLA is recyclable

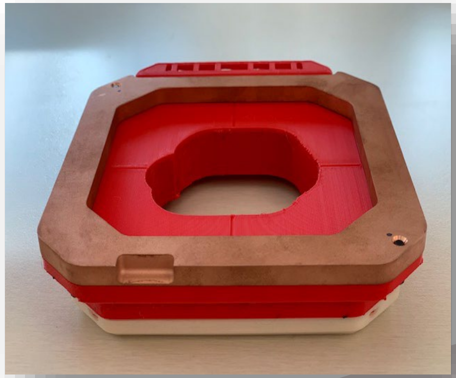
	\$ per $15x15cm^2$ cutout
Plastic shell	\$2
Tungsten BB’s (reusable)	\$250 (1kg)
3D printer	\$500-6000

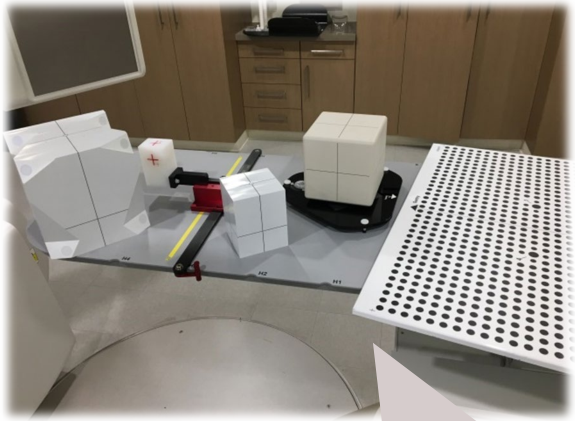
How to store the cutout?

Cerrobend cutout

3D printed cutout

Outline

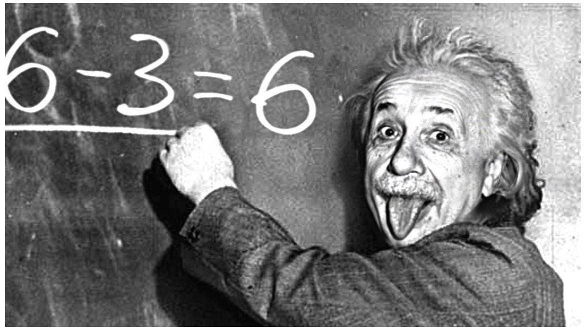




Quality Assurance

Treatment Delivery

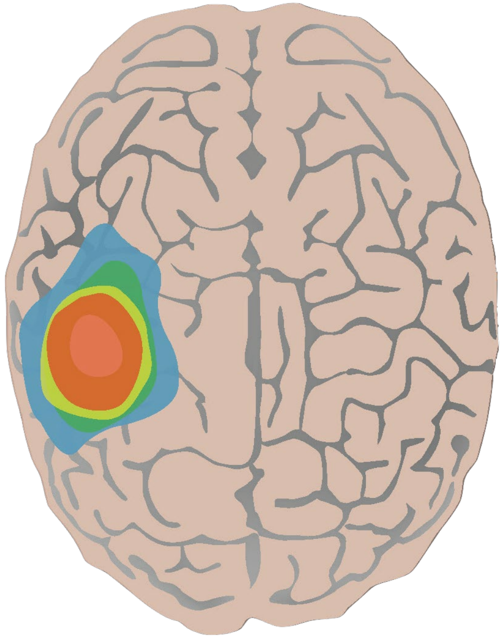
Patient Education



Shifting paradigms

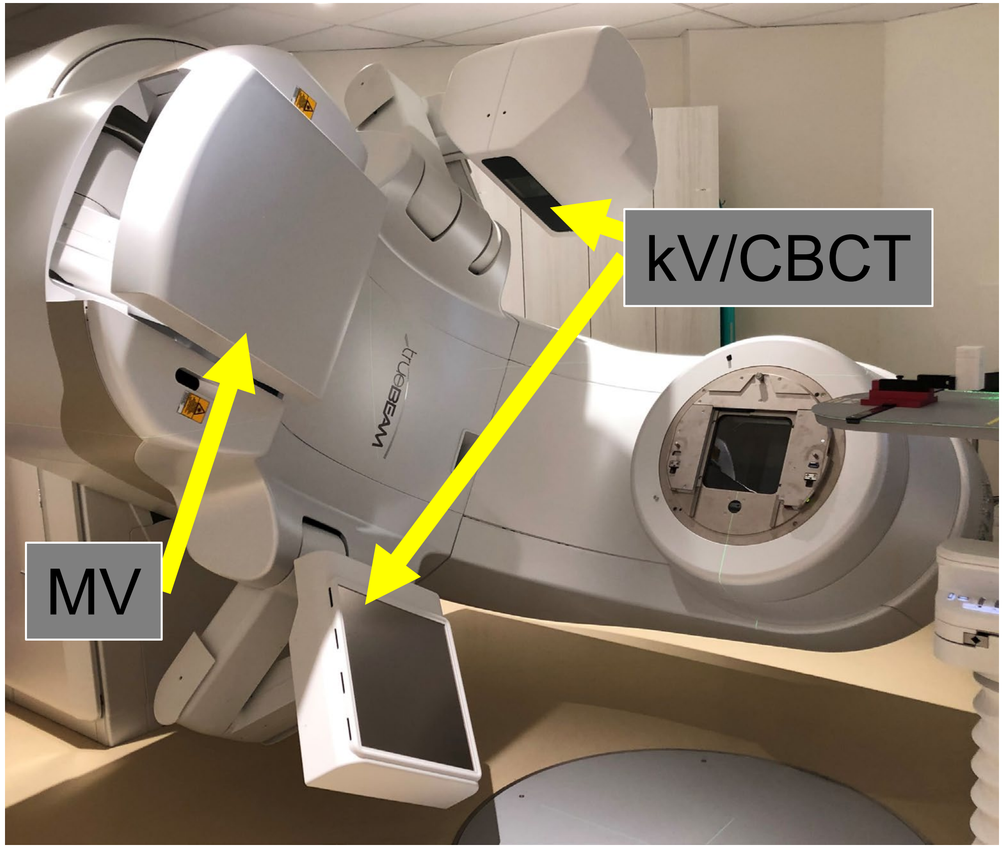
Whole Brain Radiation

Stereotactic Radiosurgery



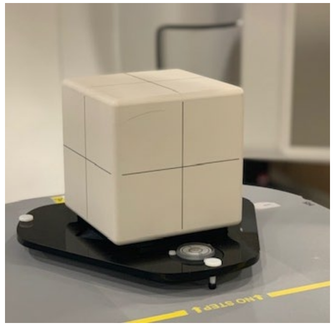
Escalating dose and decreasing margins ***requires*** sophisticated targeting techniques, such as radiographic or non-radiographic methods

Quality Assurance

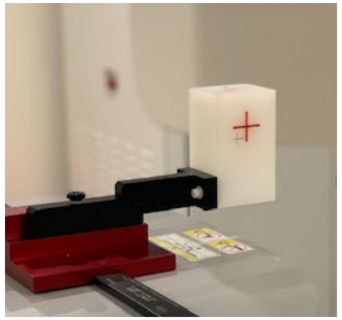


Winston-Lutz

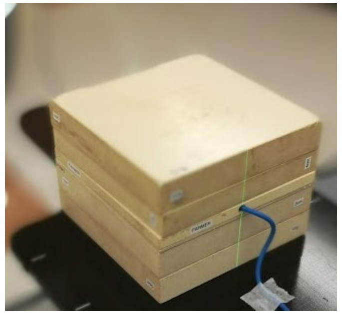
Surface imaging



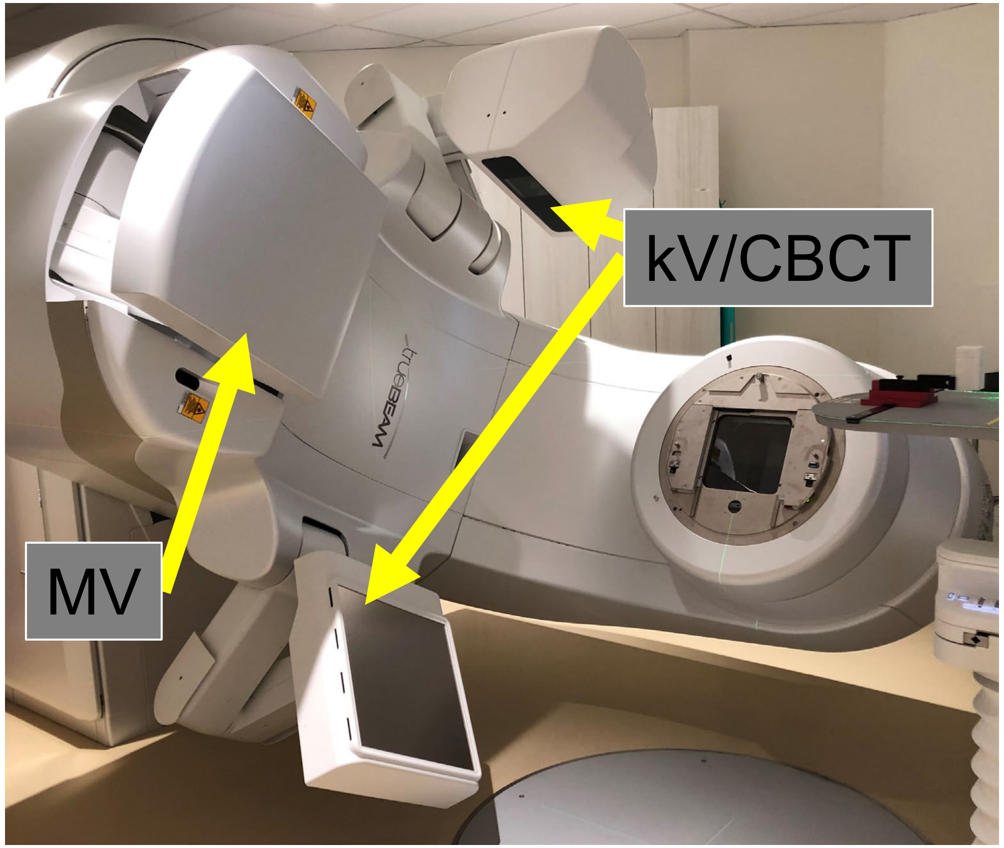
kV-MV coincidence



Film/Chamber



Something is missing…



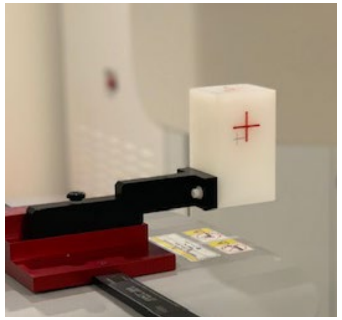
Off-axis
Winston-Lutz

?

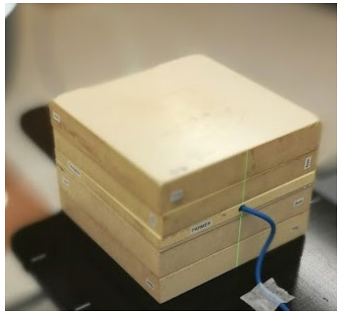
Rotational accuracy
Surface imaging

?

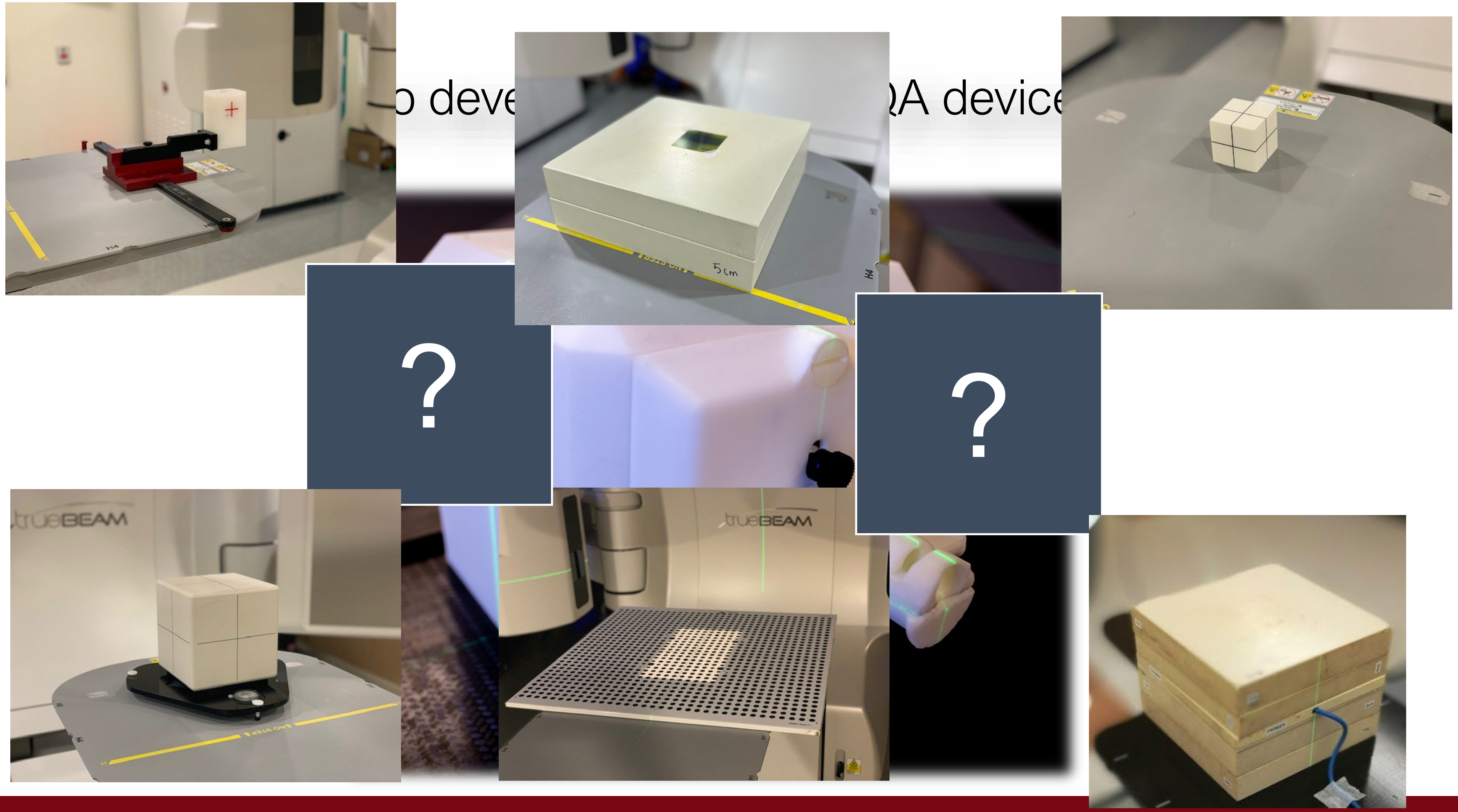
kV-MV coincidence



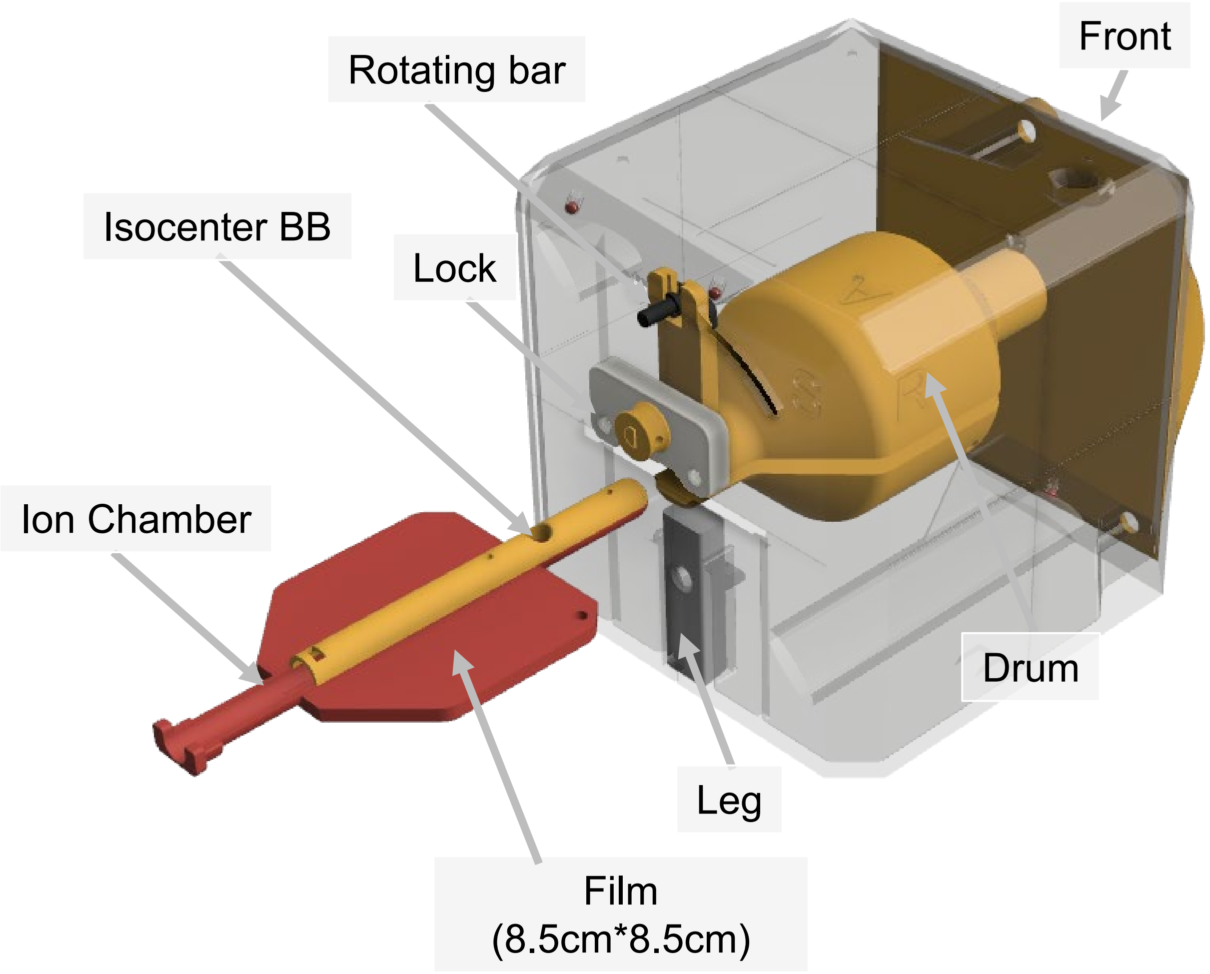
Film/Chamber

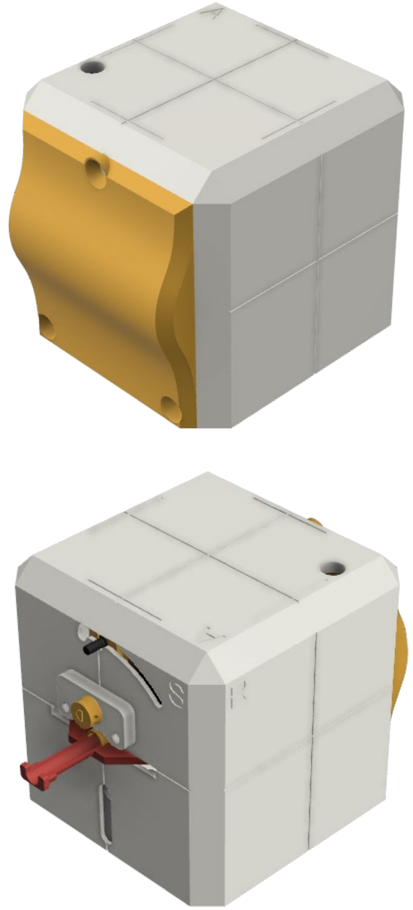


A novel-integrated QA phantom



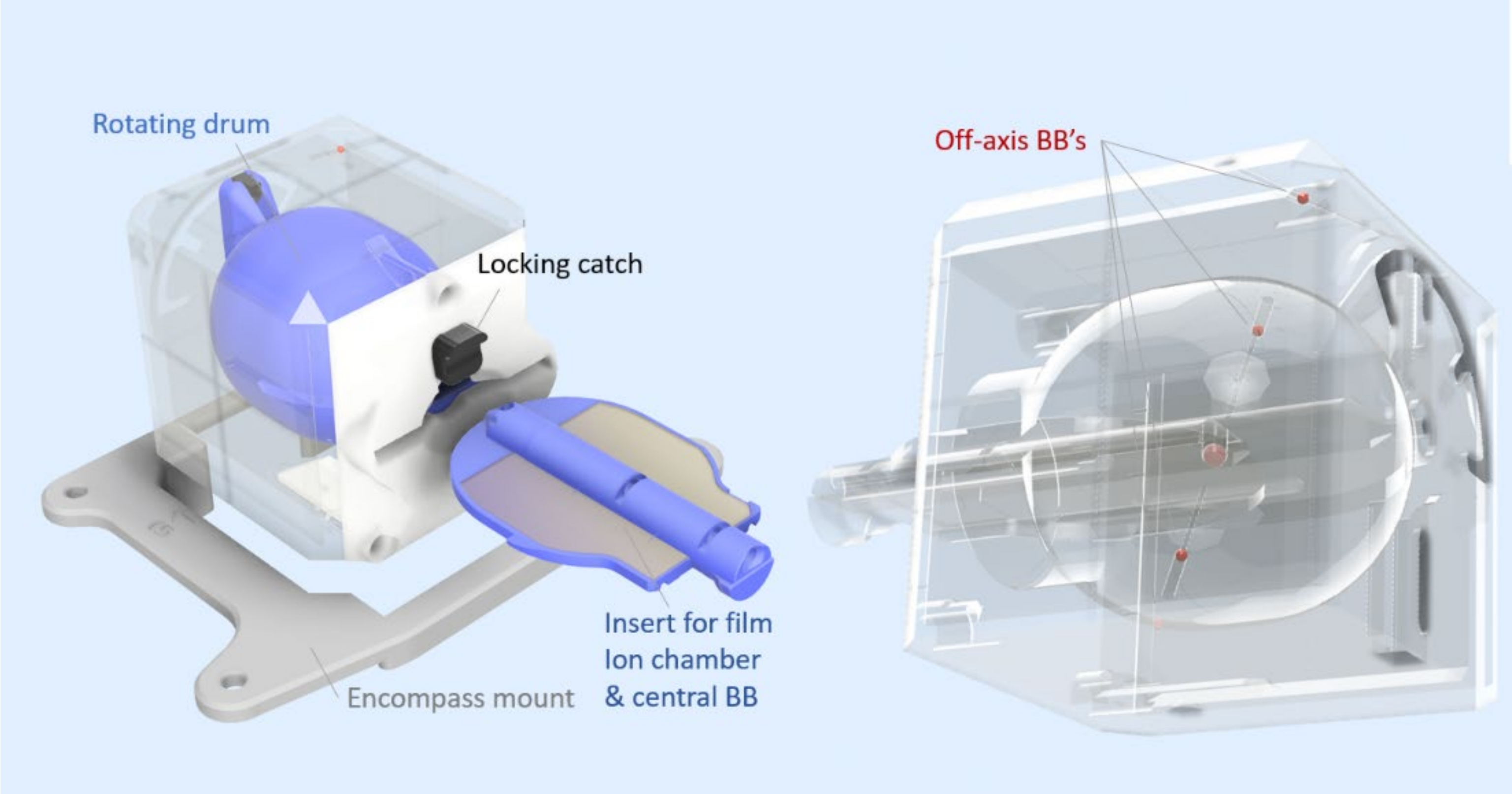
Design of Integrated Phantom (OneIso)





Capaldi D, Skinner L, Dubrowski P, Yu AS (2020). Phys. Med. Biol. 65, 115006

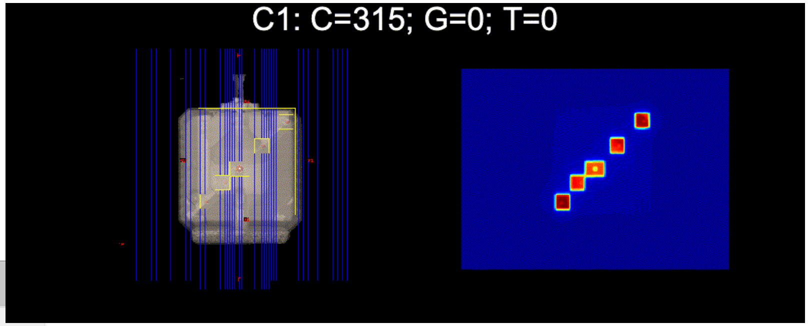
Design of Integrated Phantom (OneIso)



Capaldi D, Skinner L, Dubrowski P, Yu AS (2020). Phys. Med. Biol. 65, 115006

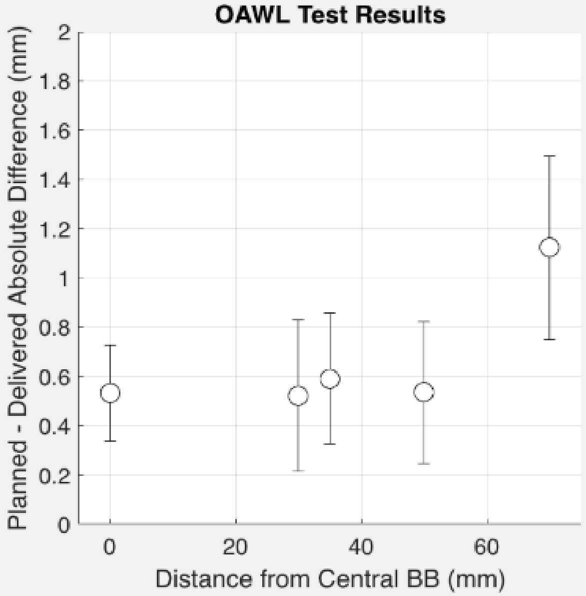
Current vs OneIso

In-house MATLAB® software



I. Open Folder | II. Analyze Each Field | III. Display Final Results

Display the final results of the OAWL Test



OAWL Test Results

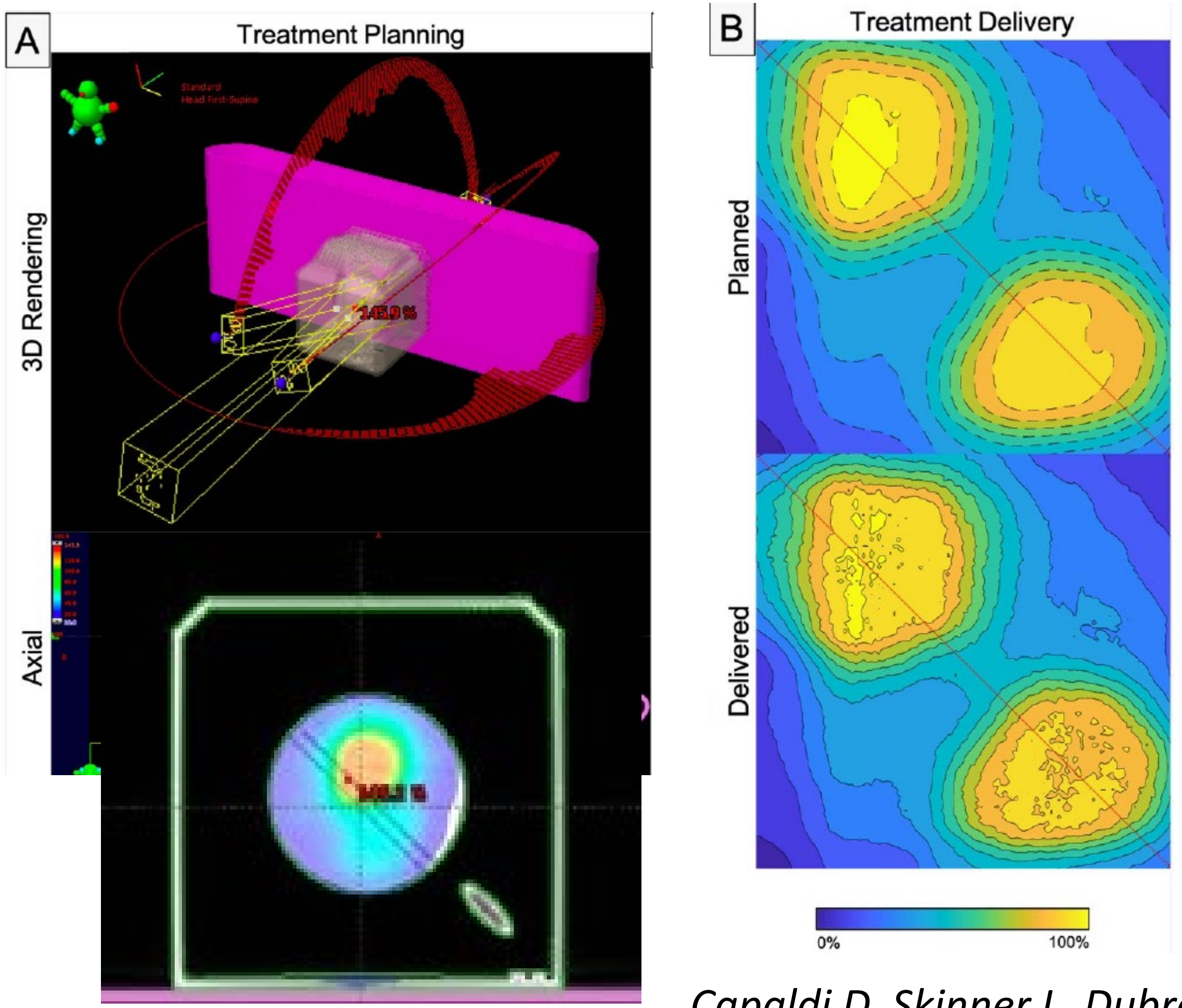
	0mm	30mm	35mm	50mm	70mm
C1	0.7714	0.5081	1.0980	0.1998	1.5893
C2	0.8578	0.8771	0.7747	1.0029	0.8408
C3	0.7353	1.0036	0.5167	0.6347	1.5679
C4	0.5940	0.1557	0.7557	0.3442	1.5001
G1	0.5294	0.8199	0.2788	0.2306	0.2861
G2	0.4255	0.1101	0.5890	0.6479	1.0092
G3	0.5143	0.0900	0.0972	0.9556	0.8095
G4	0.3521	0.5898	0.6248	0.6349	1.1087
T1	0.2908	0.2940	0.6505	0.0549	1.2204
T2	0.4014	0.5875	0.3424	0.6500	1.1378
T3	0.6475	0.7239	0.5885	0.5248	1.0386
T4	0.2578	0.5127	0.7810	0.5488	1.3712

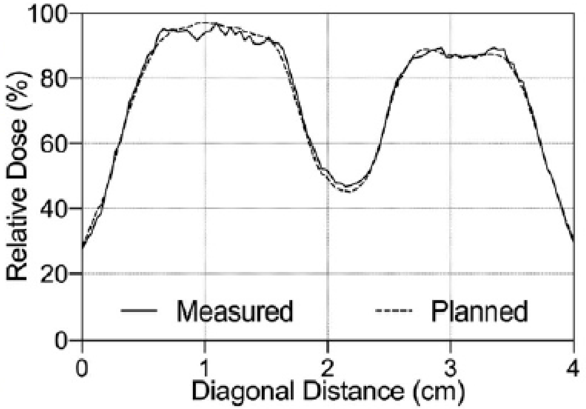
6. Display Results: Display Results

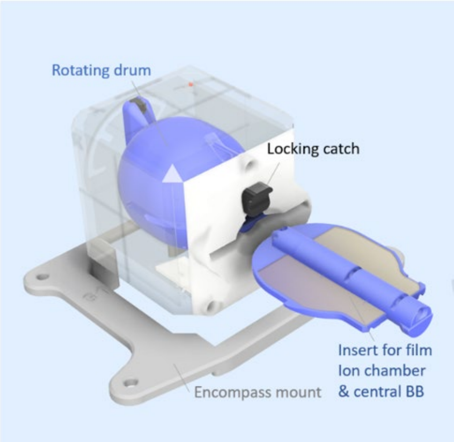
7. Save Results: PDF | CSV

Analysis of Off-Axis Winston-Lutz test.

Single-isocenter Multitarget (film)







Capaldi D, Skinner L, Dubrowski P, Yu AS (2020). Phys. Med. Biol. 65, 115006

Stanford MEDICINE

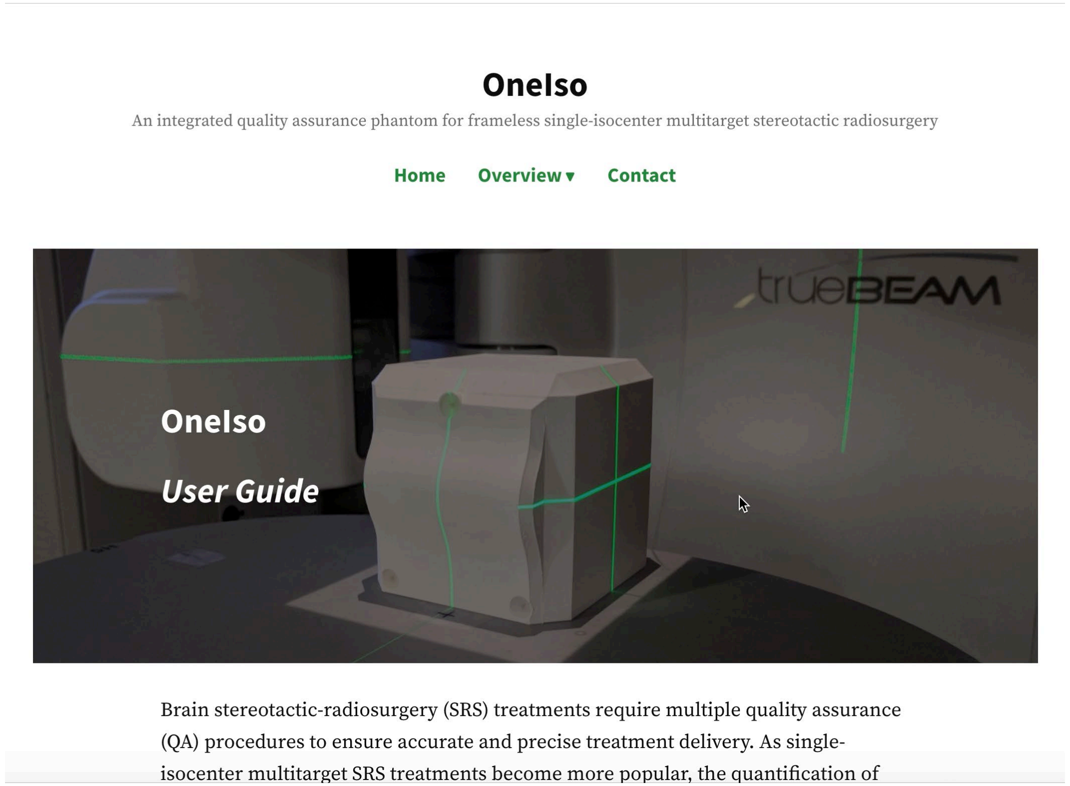
Dose Measurements (ion chamber)

	$\Delta(D_{OneIso} - D_{TPS})\%^{\dagger}$			Average	SD
	Day 1	Day 2	Day 3		
Plan 1	-1.41 %	-1.97 %	-2.30 %	-1.89 %	0.45 %
Plan 2	0.59 %	-0.30 %	-0.45 %	-0.05 %	0.56%
Plan 3	-2.35 %	-2.25 %	-2.63 %	-2.41 %	0.20 %
Plan 4	-2.78 %	-3.01 %	-3.39 %	-3.06 %	0.31 %
Plan 5	-0.50 %	-0.58 %	-1.21 %	-0.76 %	0.39 %
Plan 6	-0.03 %	-0.58 %	-0.89 %	-0.50 %	0.44 %
Plan 7	-0.36 %	-0.51 %	-0.94 %	-0.60 %	0.30 %
Plan 8	-2.14 %	-2.22 %	-2.67 %	-2.34 %	0.28 %
Plan 9, Target 1	-2.11 %	-1.64 %	-2.03 %	-1.93 %	0.25 %
Plan 9, Target 2	-1.67 %	-1.44 %	-1.58 %	-1.56 %	0.11 %
Plan 10, Target 1	2.04 %	1.71 %	1.96 %	1.90 %	0.17 %
Plan 10, Target 2	2.92 %	2.26 %	2.87 %	2.68 %	0.37 %
Plan 10, Target 3	2.50 %	2.60 %	2.27 %	2.46 %	0.17 %
			Average:	-0.62 %	0.31 %

	$\Delta(D_{SW} - D_{TPS})\%^{\dagger}$			Average	SD
	Day 1	Day 2	Day 3		
Plan 1	0.49 %	-0.15 %	1.42 %	0.59 %	0.79 %
Plan 2	1.85 %	0.67 %	0.62 %	1.05 %	0.70 %
Plan 3	-1.99 %	1.71 %	-1.35 %	-1.68 %	0.32 %
Plan 4	-3.35 %	-2.63 %	0.36 %	-1.87 %	1.97 %
Plan 5	0.94 %	0.72 %	1.60 %	1.09 %	0.46 %
Plan 6	0.26 %	0.03 %	0.57 %	0.29 %	0.27 %
Plan 7	-0.01 %	0.02 %	1.27 %	-0.42 %	0.73 %
Plan 8	-1.53 %	-2.01 %	-3.28 %	-2.27 %	0.90 %
Plan 9, Target 1	-3.34 %	-2.27 %	-3.53 %	-3.21 %	0.39 %
Plan 9, Target 2	-1.91 %	-1.76 %	-2.08 %	-1.92 %	0.16 %
Plan 10, Target 1	1.75 %	1.63 %	2.17 %	1.85 %	0.28 %
Plan 10, Target 2	2.64 %	2.77 %	2.60 %	2.67 %	0.08 %
Plan 10, Target 3	1.12 %	1.53 %	1.38 %	1.34 %	0.21 %
			Average:	-0.19 %	0.56 %

Patient's name:				
MRN:				
Pinpoint chamber measurement				
Daily output variation			Plan/Site name	C0 QA
E and dmax	10FFF	2.4cm		
10x10; SSD100			M1	13.76
Delivered dose	24	Gy	M2	13.76
M1	10.15		M3	
M2	10.16		Average	13.76
M3	10.15		Measured dose	32.53
Average	10.15333333		Caliculated dose	32.64
coversion factor	2.364	Gy/M	%diff	-0.35%

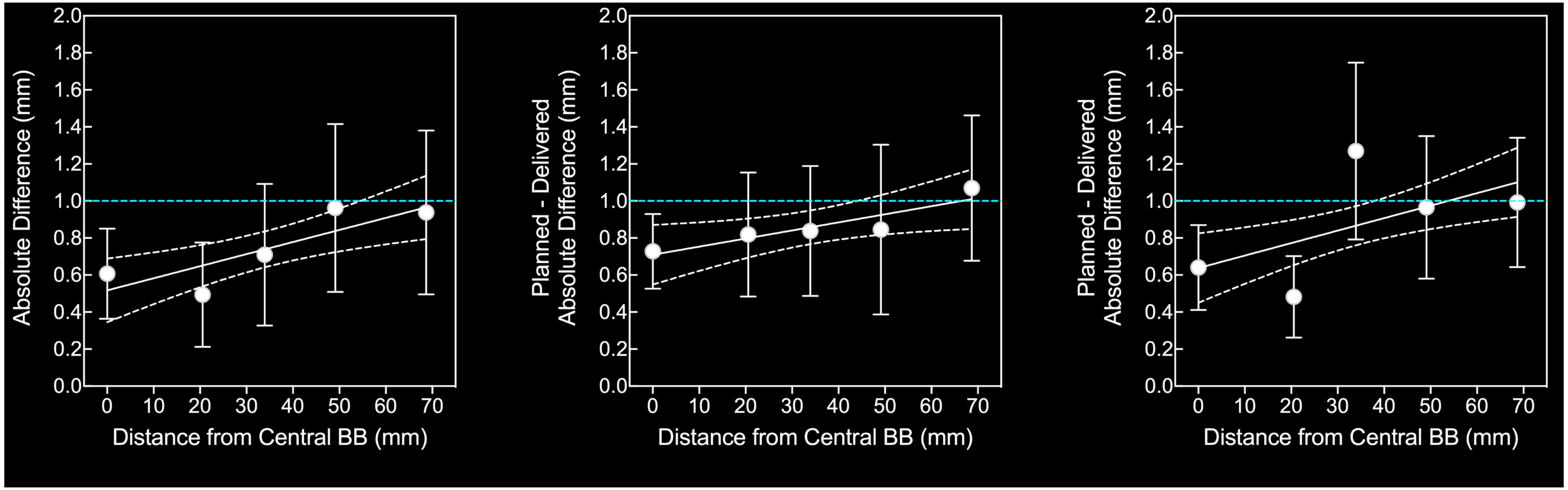
A Multi-Institutional Trial



https://oneiso.wordpress.com/

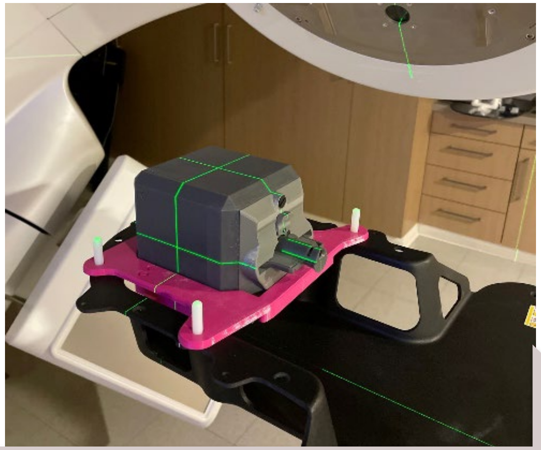
Off-axis Winston-Lutz Analysis

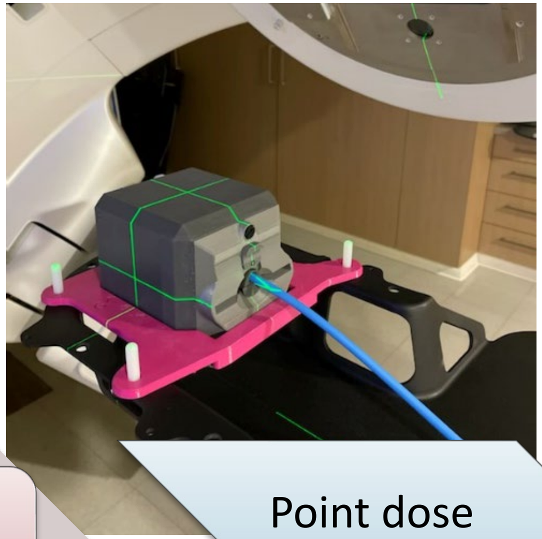
Center 1 *Center 2* *Center 3*

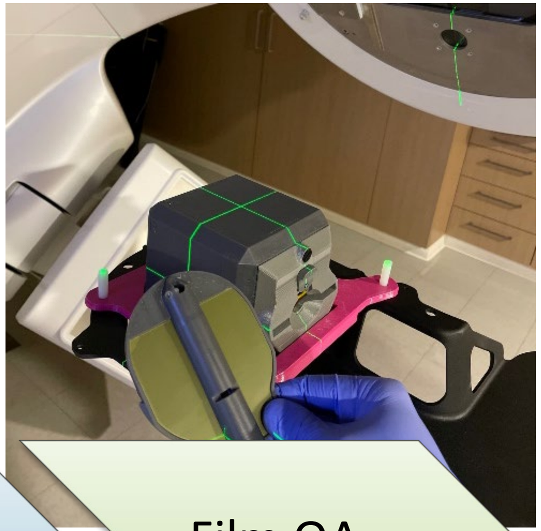


All three SRS machines ***exceeded*** the recommended accuracy tolerance at ***different distances*** away from isocenter, suggesting this measurement is ***machine dependent***

Workflow





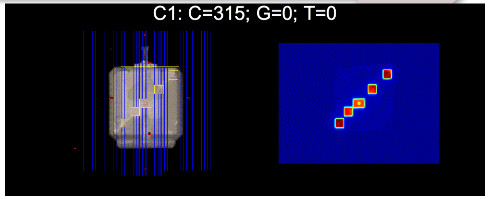


Send couch to predefined position and employ CBCT to fine adjust the location

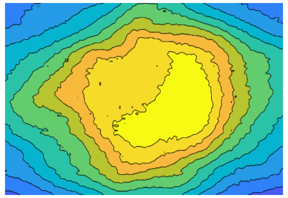
Off-Axis Winston-Lutz test

Point dose measurement

Film QA



Patient's name: MRN:				
Pinpoint chamber measurement				
Daily output variation			Plan/Site name	C0 QA
E and dmax	10FFF	2.4cm		
10x10; SSD100			M1	13.76
Delivered dose	24	Gy	M2	13.76
M1	10.15		M3	
M2	10.16		Average	13.76
M3	10.15		Measured dose	32.53
Average	10.15333333		Caliculated dose	32.64
coversion factor	2.364	Gy/M	%diff	-0.35%

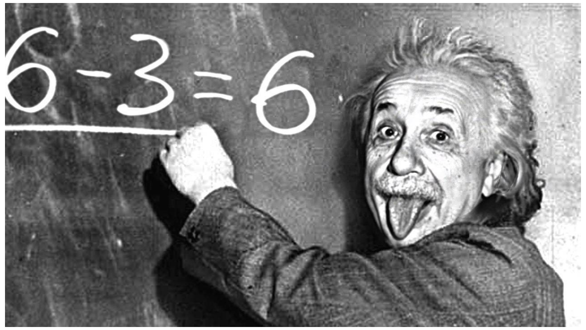


Patient Education

Treatment Delivery

Quality Assurance

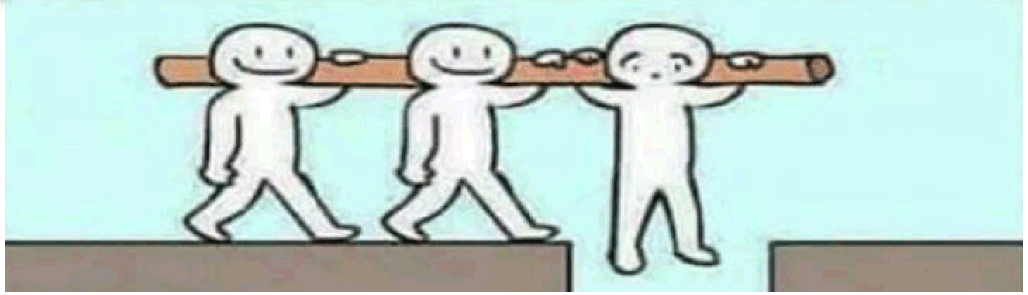
Show our value and provide better patient care



Acknowledgment

The Dream team!

Dante Capaldi
Piotr Dubrowski
Joseph Schulz
Lawrie Skinner
Ben Fahimian
Amy Yu



Thank you for your attention