From U to Esprit
-A Physicist Tribute To
Dr Steven Goetsch

LIJUN MA, PhD, FAAPM

2023 SC Winter Meeting

Los Angeles Universal Sheraton

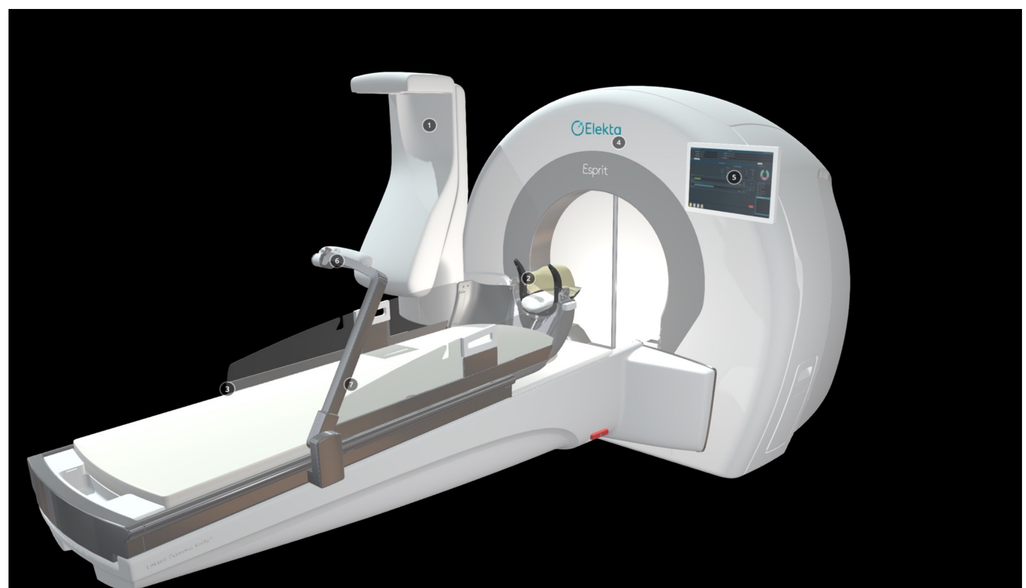
Southern California Chapter
American Association of Physicists in Medicine

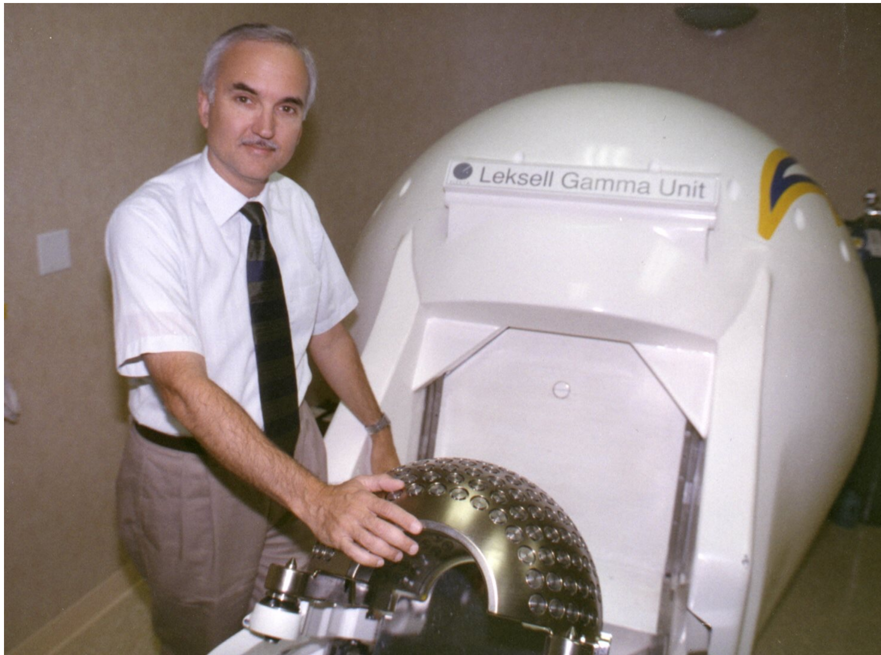
First World Championship Game AFL vs NFL

Leksell Gamma Knife
U (1967 1st Prototype)

LVII
SUPER BOWL

Leksell Gamma Knife
Esprit (2023 1st US Model)



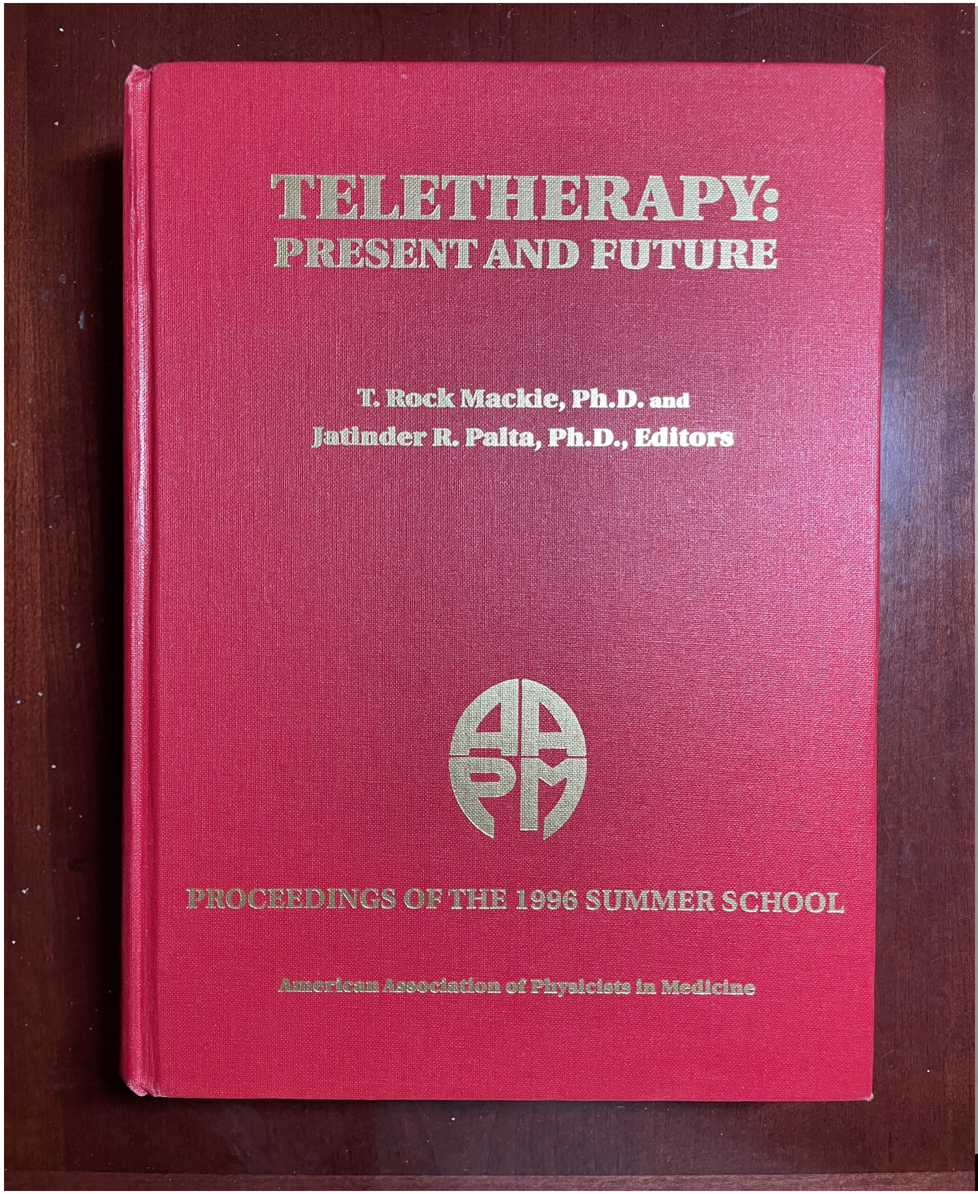


Steve hands down on U (1999)

Thumb up an Icon (2020)

Lifting Up The Old (1998)

Raising Up The Young (2006)



STEREOTACTIC RADIOSURGERY USING THE GAMMA KNIFE

Steven J. Goetsch, Ph.D.
San Diego Gamma Knife Center

work, indeed!

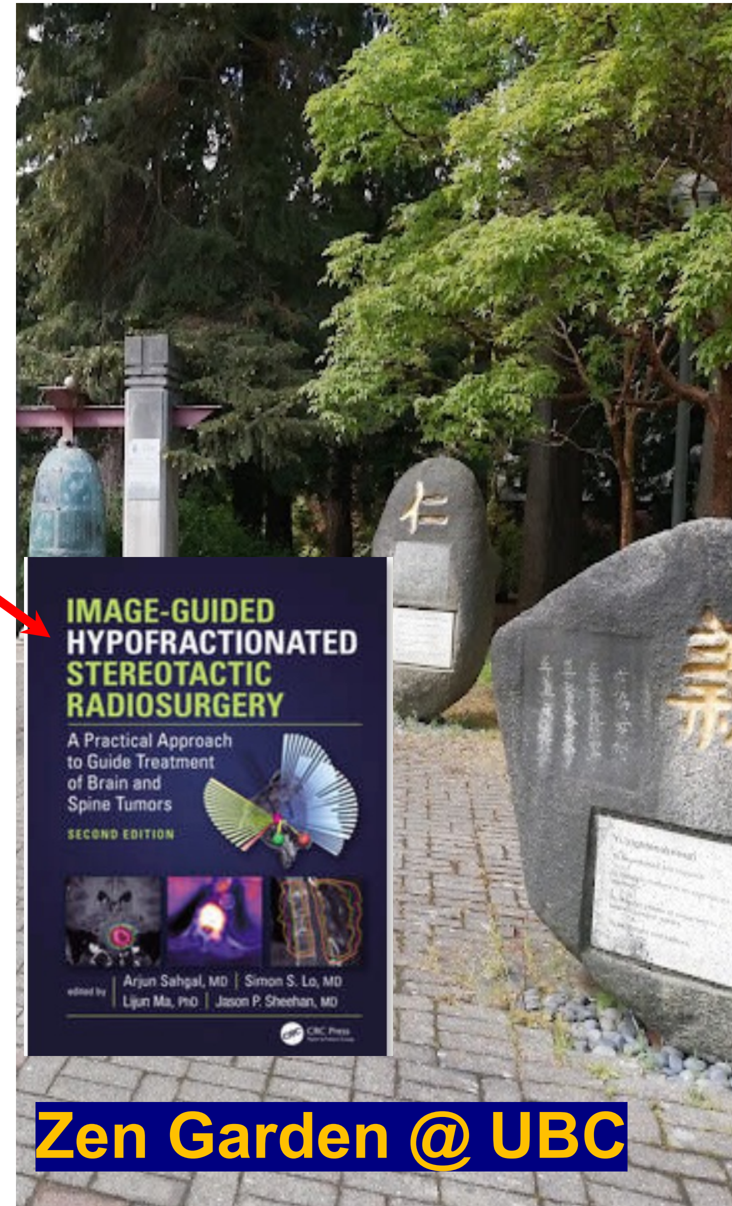
Linear accelerators do well with larger spherical lesions, such as brain mets and gliomas. A single isocenter with a large collimator (e.g., 20 to 40 mm diameter) may be nearly ideal for such a case. Arteriovenous malformations may often be well covered by 1 to 3 isocenters, particularly in non-eloquent brain areas. At this writing, linac radiosurgery systems alone have been used for fractionated stereotactic radiotherapy (SRT) (Dunbar 1994). A linac on a robotic arm developed at Stanford University Medical Center by Adler et al. is pioneering the introduction of frameless radiosurgery and has already treated several brain met patients (Cox 1993, Adler 1993). Hamilton and others at the University of Arizona have begun extracranial radiosurgery using a linear accelerator to stereotactically treat inoperable spinal tumors (Hamilton 1995).

3. GAMMA KNIFE TREATMENTS

A. Typical Timeline

Since the Gamma Knife is a single-purpose device, it has an enormous advantage in efficiency over many linac-based radiosurgery systems, which can often be used only "after hours," that is, after all conventional radiation therapy patients have had their daily treatments. Thus, linac-based systems (exclusive of dedicated radiosurgery systems) must be reassembled and the functionality and accuracy of pointing of the system must be checked each day. This can add 1 to 3 hours to treatment time, especially if adjustments are necessary. The Gamma Knife, by contrast, requires only a brief daily inspection and function test prior to use.

A typical Gamma Knife timeline would be as follows: the patient arrives at the Gamma Knife Center at 6:00 a.m. Initial blood pressure, respiration, O_2 saturation and other vital signs are taken by the nurse. An intravenous line is placed for use throughout the procedure for radiographic contrast and administration of drugs. A "cocktail" of anesthetic and relaxing agents are administered and topical anesthetic may be placed at temporal and occipital lobe locations of the four pin sites. At 7:00 a.m., the neurosurgeon and radiation oncologist arrive and begin to study the frame placement, while the physicist makes daily performance checks on the Gamma Knife and the computer and may check the functioning of the local PACS system. By 7:45 a.m. the frame has been placed and the patient is transported by wheelchair or gurney, fully awake and alert, to the radiology department, where a computerized tomography or magnetic resonance imaging study is performed, typically with IV contrast. By 8:30 the patient is in the nursing unit relaxing, while the radiographic scans are being transported to the planning computer. By 8:45 a.m., the neurosurgeon, radiation oncologist and physicist are at work outlining the tumor and planning the treatment. For a small tumor in a non-critical area, the planning process may take as little as 15 minutes. For a more



IJC International Journal of Cancer

Clinical Investigations | Free Access

Optimized intensity-modulated arc therapy for prostate cancer treatment†

Lijun Ma Ph.D., Cedric X. Yu D.Sc., Matthew Earl Ph.D., Tim Holmes Ph.D., Mehrdad Sarfaraz Ph.D., X. Allen Li Ph.D., David Shepard Ph.D., Pradip Amin M.D., Steven DiBiase M.D., Mohan Suntharalingam M.D., Carl Mansfield M.D., D.Sc. ... See fewer authors

First published: 26 October 2001 | https://doi.org/10.1002/ijc.1039 | Citations: 30

† The contents of this article do not necessarily reflect the position or the policy of the United States Department of Defense or the United States Army, and no official endorsement should be inferred.

Ranged Modulated Helical Electron Beams

US006878951B2

(12) **United States Patent**
Ma

(10) **Patent No.: US 6,878,951 B2**
(45) **Date of Patent: Apr. 12, 2005**

(54) **HELICAL ELECTRON BEAM GENERATING DEVICE AND METHOD OF USE**

(75) Inventor: **Lijun Ma**, Ellicott City, MD (US)

(73) Assignee: **University of Maryland**, Baltimore, MD (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/259,561**

(22) Filed: **Sep. 30, 2002**

(65) **Prior Publication Data**

US 2004/0079899 A1 Apr. 29, 2004

Related U.S. Application Data

(63) Continuation-in-part of application No. PCT/US01/10587, filed on Mar. 30, 2001.
(60) Provisional application No. 60/193,474, filed on Mar. 31, 2000.

(51) **Int. Cl.**[7] **G21K 1/02**
(52) **U.S. Cl.** **250/505.1**; 250/492.1; 315/505; 315/500
(58) **Field of Search** 250/492.1, 505.1

(56) **References Cited**

U.S. PATENT DOCUMENTS

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6,127,688 A * 10/2000 Wu 250/505.1
6,433,494 B1 * 8/2002 Kulish et al. 315/500

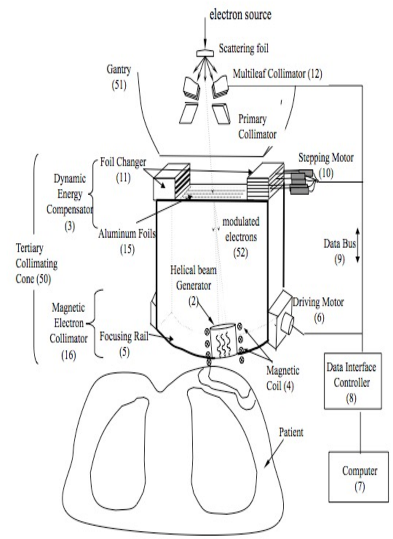
* cited by examiner

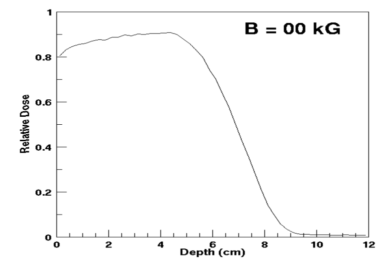
Primary Examiner—Nikita Wells
Assistant Examiner—Phillip A Johnston
(74) *Attorney, Agent, or Firm*—Sughrue Mion, PLLC

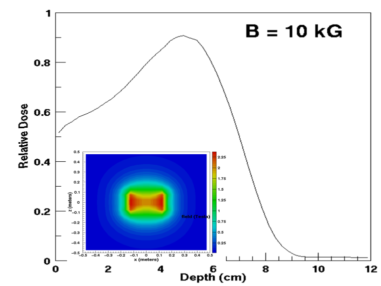
(57) **ABSTRACT**

A device for generating helical electron beams that can be used for radiation therapy is disclosed. The device contains a tertiary collimating cone that can be attached to a gantry of a linear accelerator or placed directly below the gantry. The tertiary collimating cone has a dynamic energy compensator and a magnetic electron collimator to modify the energy of electrons and to generate a helical trajectory. A multileaf collimator may be present within the tertiary collimating cone. A computer coordinates the movements of various components. The helical electron beam produced by this device can be targeted to tumors better and safer and reduce the amount of radiation hitting normal tissue than current devices.

34 Claims, 6 Drawing Sheets







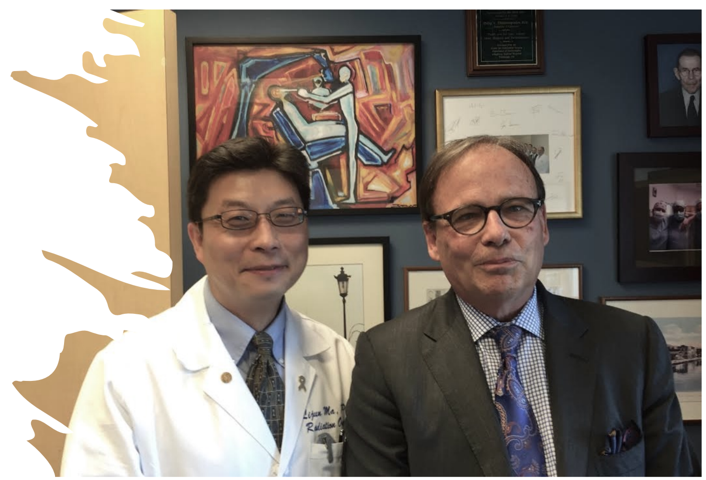
Medical Physics
The International Journal of Medical Physics Research and Practice

Dosimetric properties of magnetically collimated electron beams for radiation therapy

Lijun Ma[1,a)]

Finally - Gamma Knife Radiosurgery @ "The Best Place on Earth"

Dr. Lunsford pioneered US Leksell Gamma Knife radiosurgery, which transformed its business and world-wide clinical applications



MEDICAL PHYSICS
The International Journal of Medical Physics Research and Practice

Radiation measurement physics

A round-robin gamma stereotactic radiosurgery dosimetry interinstitution comparison of calibration protocols

R. E. Drzymala, P. E. Alvarez, G. Bednarz, J. D. Bourland, L. A. DeWerd, L. Ma, S. G. Meltsner, G. Neyman, J. Novotny Jr., P. L. Petti, M. J. Rivard, A. S. Shiu, S. J. Goetsch

First published: 30 October 2015 | https://doi.org/10.1118/1.4934376 |

MEDICAL PHYSICS
The International Journal of Medical Physics Research and Practice

Volume 48, Issue 7
July 2021
Pages e733-e770

AAPM Scientific Report | Free Access

Recommendations on the practice of calibration, dosimetry, and quality assurance for gamma stereotactic radiosurgery: Report of AAPM Task Group 178

Paula L. Petti, Mark J. Rivard, Paola E. Alvarez, Greg Bednarz, J. Daniel Bourland, Larry A. DeWerd, Robert E. Drzymala, Jonas Johansson, Keith Kunugi ... See all authors

First published: 10 March 2021 | https://doi.org/10.1002/mp.14831 | Citations: 8

SECTIONS PDF TOOLS SHARE

Figures References Related Information

Abstract

The American Association of Physicists in Medicine (AAPM) formed Task Group 178 (TG-178) to perform the following tasks: review in-phantom and in-air calibration protocols for gamma stereotactic radiosurgery (GSR), suggest a dose rate calibration protocol that can be successfully utilized with all gamma stereotactic radiosurgery (GSR)

Recommended

AAPM Task Group 198 Report: An implementation guide for TG 142 quality assurance of medical accelerators

Joseph Hanley, Sean Dresser, William Simon, Ryan Flynn, Eric E. Klein, Daniel Letourneau, Chihray Liu, Fang-Fang Yin, Bijan Arjomandy, Lijun Ma, Francisco Aguirre, Jimmy Jones, John Bayouth, Todd Holmes

Medical Physics

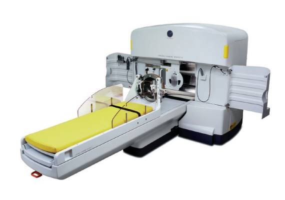
Gamma Knife Evolution

1967: 1st Gamma Knife® Prototype

1986: Leksell Gamma Knife® Model U introduced

1996: Leksell Gamma Knife® B introduced

1999: Leksell Gamma Knife® C introduced

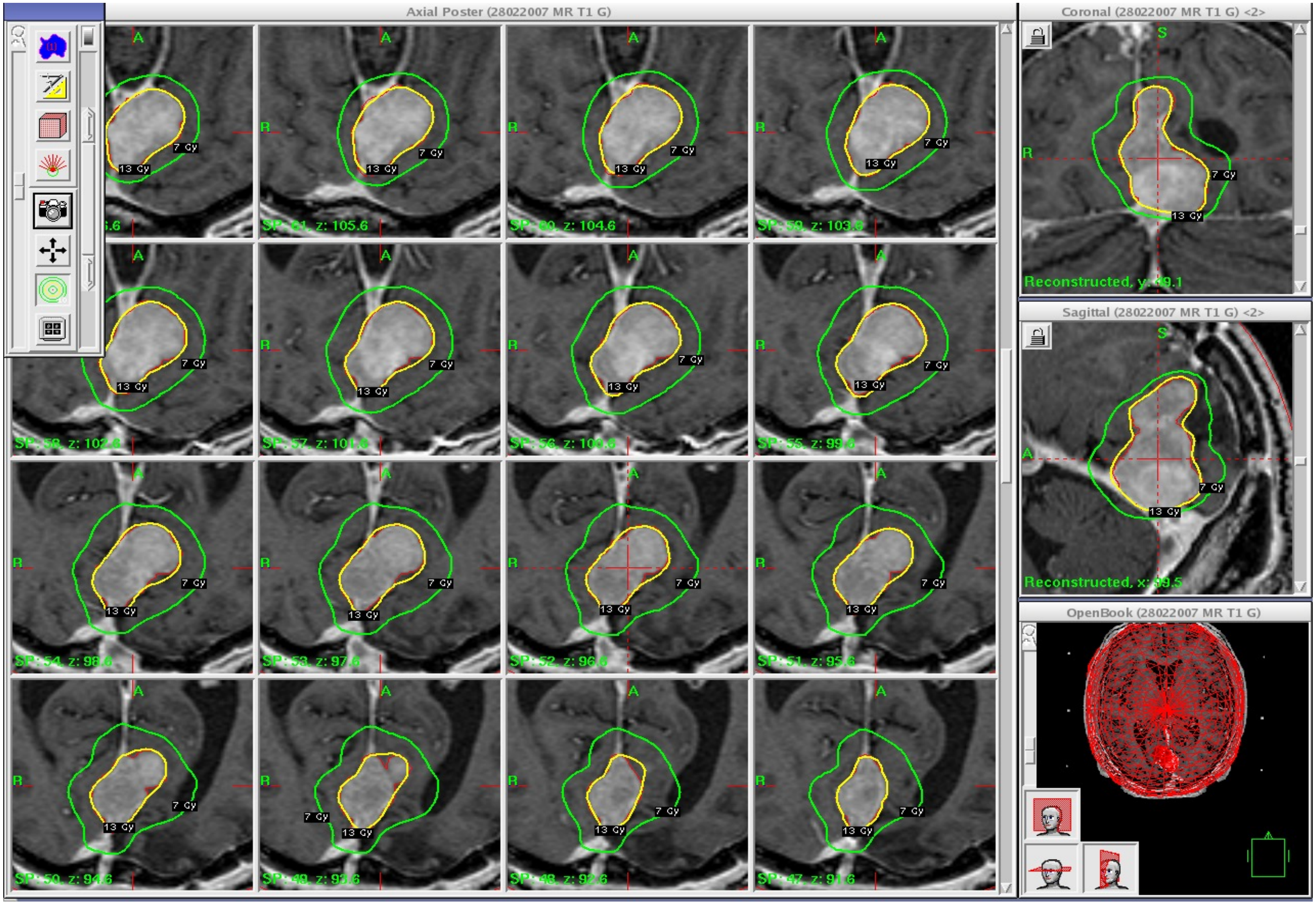


2004: Leksell Gamma Knife® 4C introduced

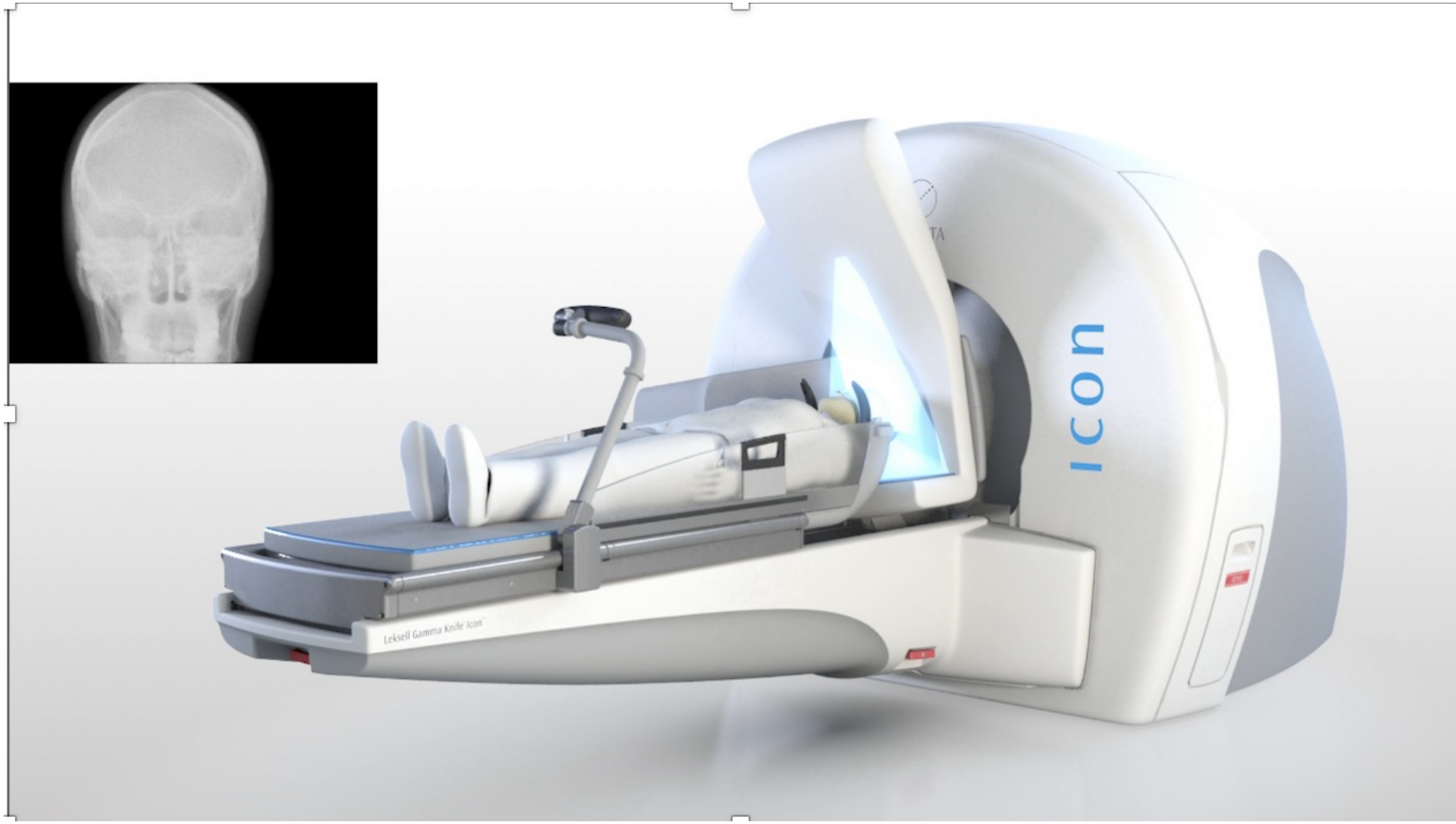
2006: Leksell Gamma Knife® Perfexion introduced

Perfexion = Perfect Response to Market Competition

Dose Conformity Approaches Perfect with Perfexion

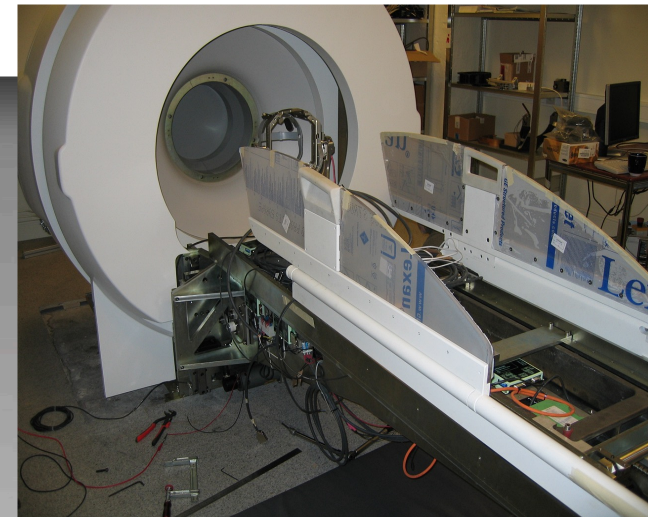


Leksell Gamma Knife Icon ~ 2016



A New Solution for Multi-Iso Tx = No Stop-and-Verify Required btw Isocenters

What Gives for Esprit in 2023 ?



FDA Approved
Late 2022

Radiosurgical Devices of the Future

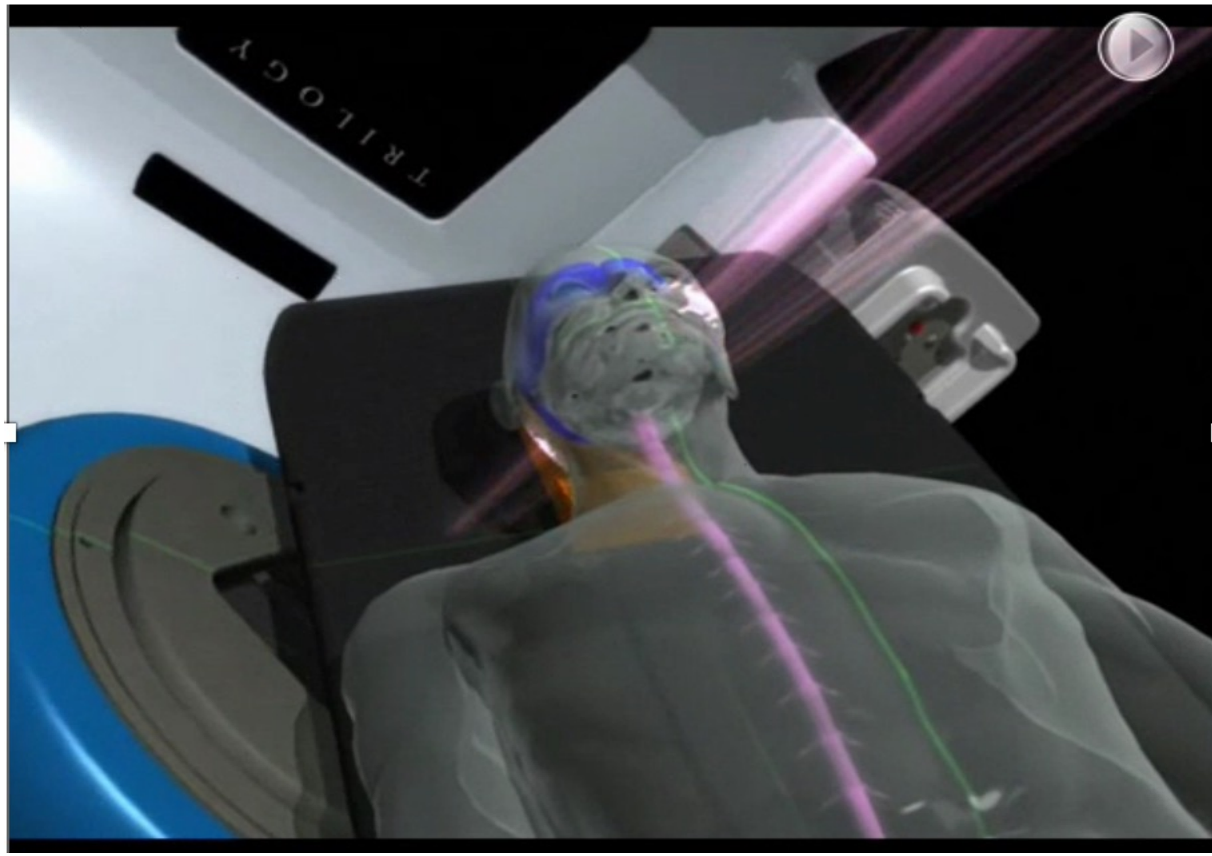
What I Would Like to See?

LIJUN MA

Treatment Delivery Paradigms

Subject /Object	Fix Beam	Move Beam
Fix Patient	Uveal proton	Linacs
Move Patient	Gamma Knife &…	TBD

Linac-based RT (n ~ 1)



Online imaging

High Dose Rate

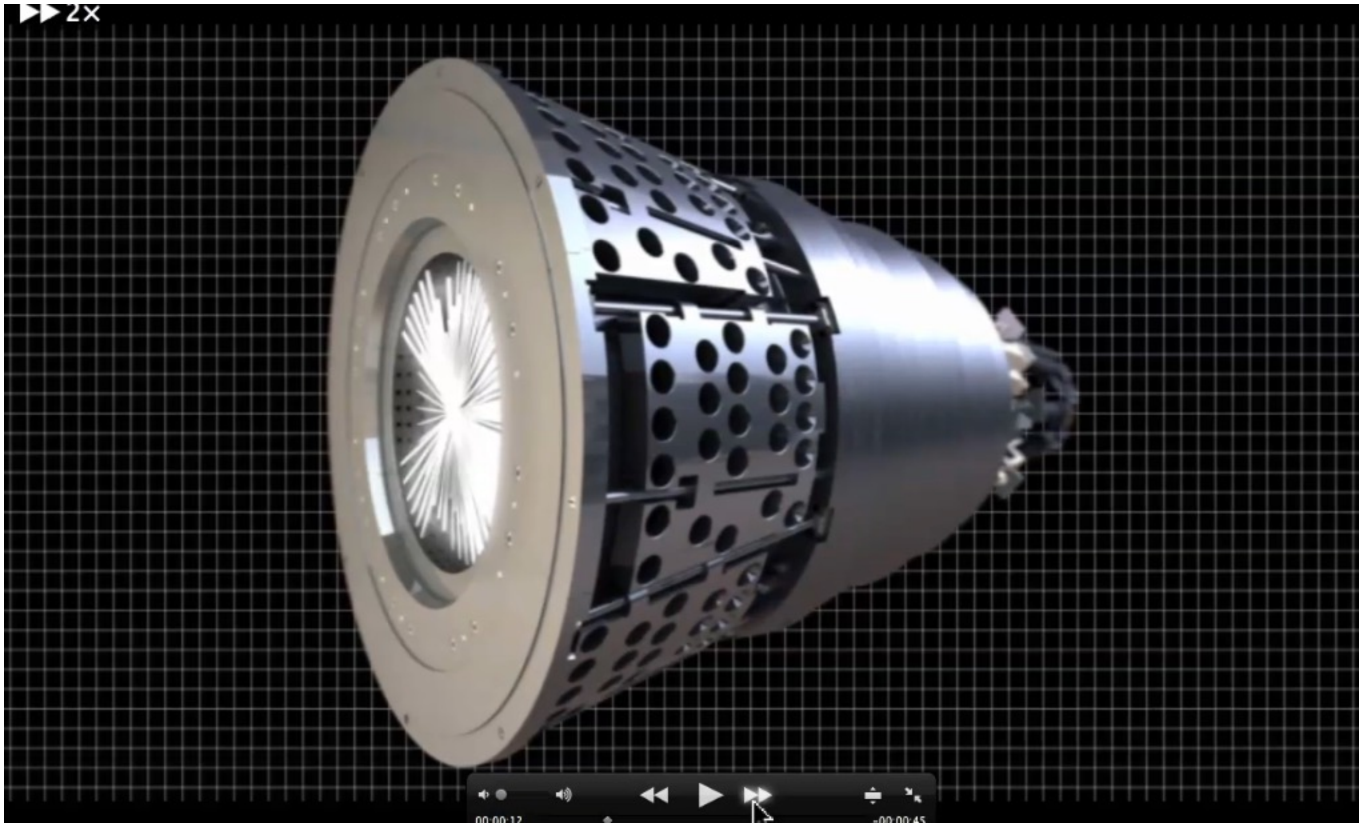
Modular Delivery

Video Courtesy of Varian (2013)

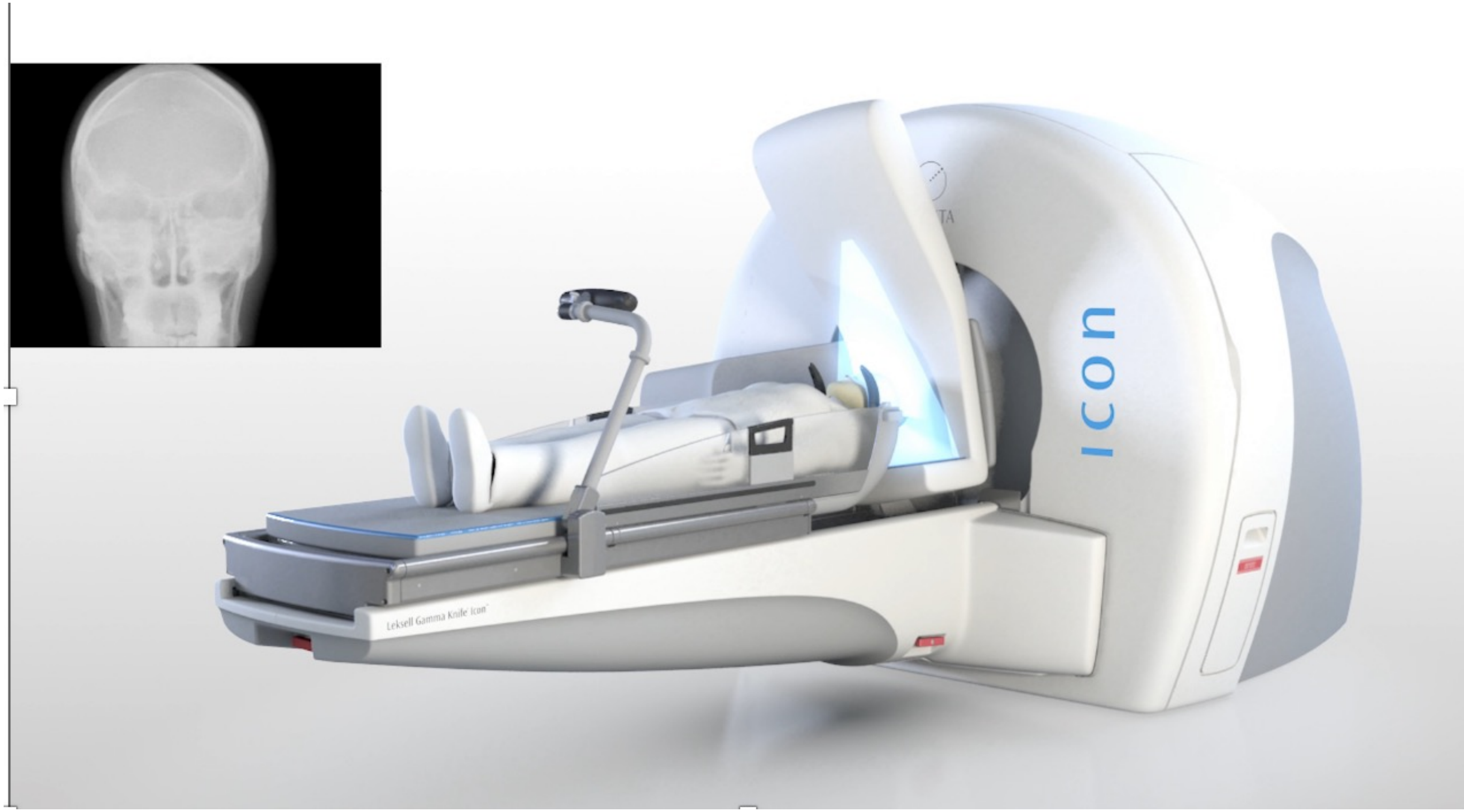
CyberKnife: Non-Isocentric (n ~ 0)

Courtesy of
Dr. Hiroshi Tanaka & Tokyo Kamagome

LGK Perfexion: Multi-isocenters (n ~10)

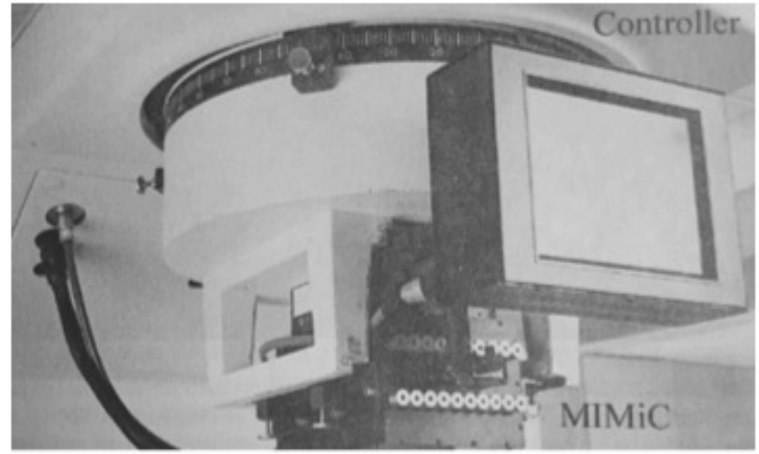


Elekta (2006)



Stockholm
(2016)

Geometric Focusing Spares the Normal Tissue Still the Best



Int. J. Radiation Oncology Biol. Phys., Vol. 45, No. 5, pp. 1325–1330, 1999

0360-3016/99/$–see front matter

ELSEVIER

PII S0360-3016(99)00340-5

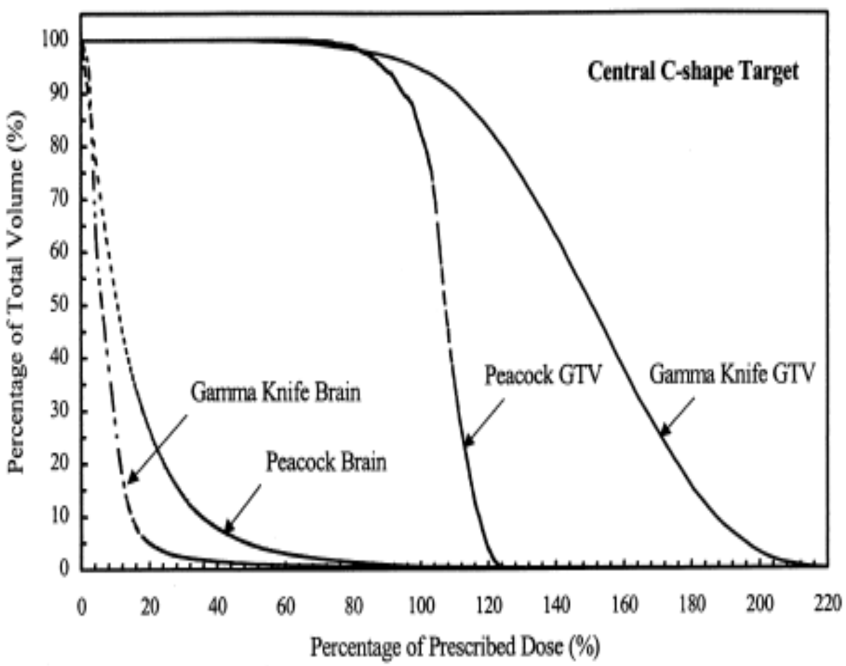
1999 IJROBP 45(5)

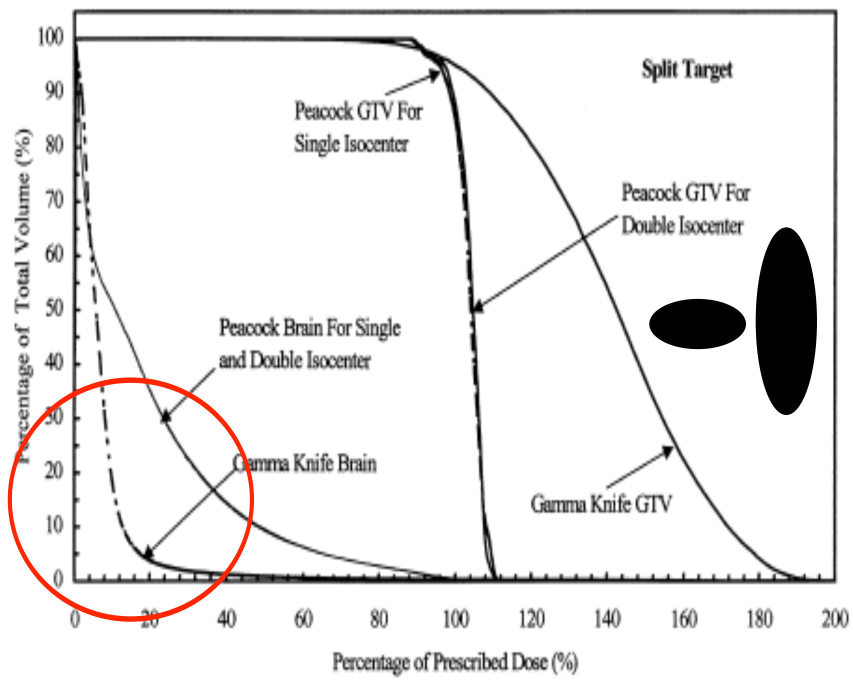
PHYSICS CONTRIBUTION

A DOSIMETRIC COMPARISON OF FAN-BEAM INTENSITY MODULATED RADIOTHERAPY WITH GAMMA KNIFE STEREOTACTIC RADIOSURGERY FOR TREATING INTERMEDIATE INTRACRANIAL LESIONS

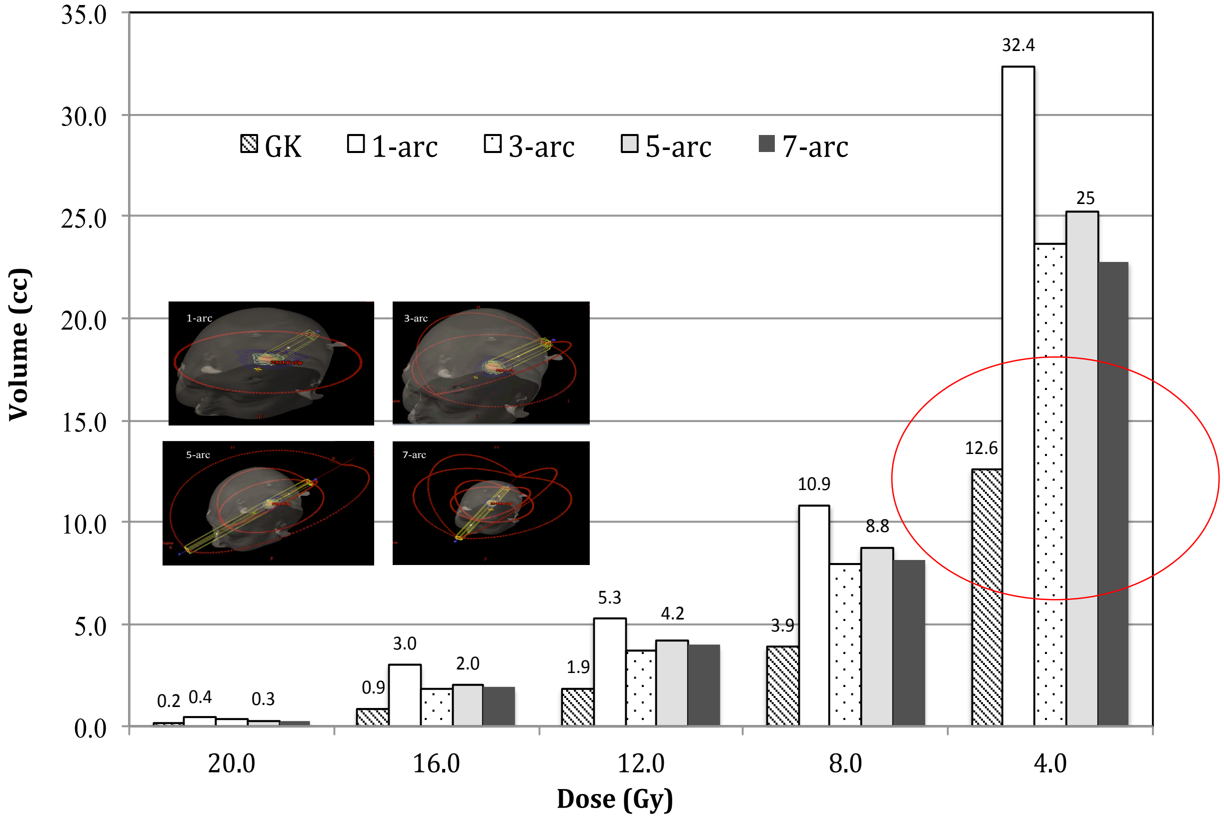
Lijun Ma, Ph.D.,* Ping Xia, Ph.D.,† Lynn J. Verhey, Ph.D.,† and Arthur L. Boyer, Ph.D.‡

Dose Spillage Terrible for Fan-Beam IMRT





Dose Interplays For Multi-Targets

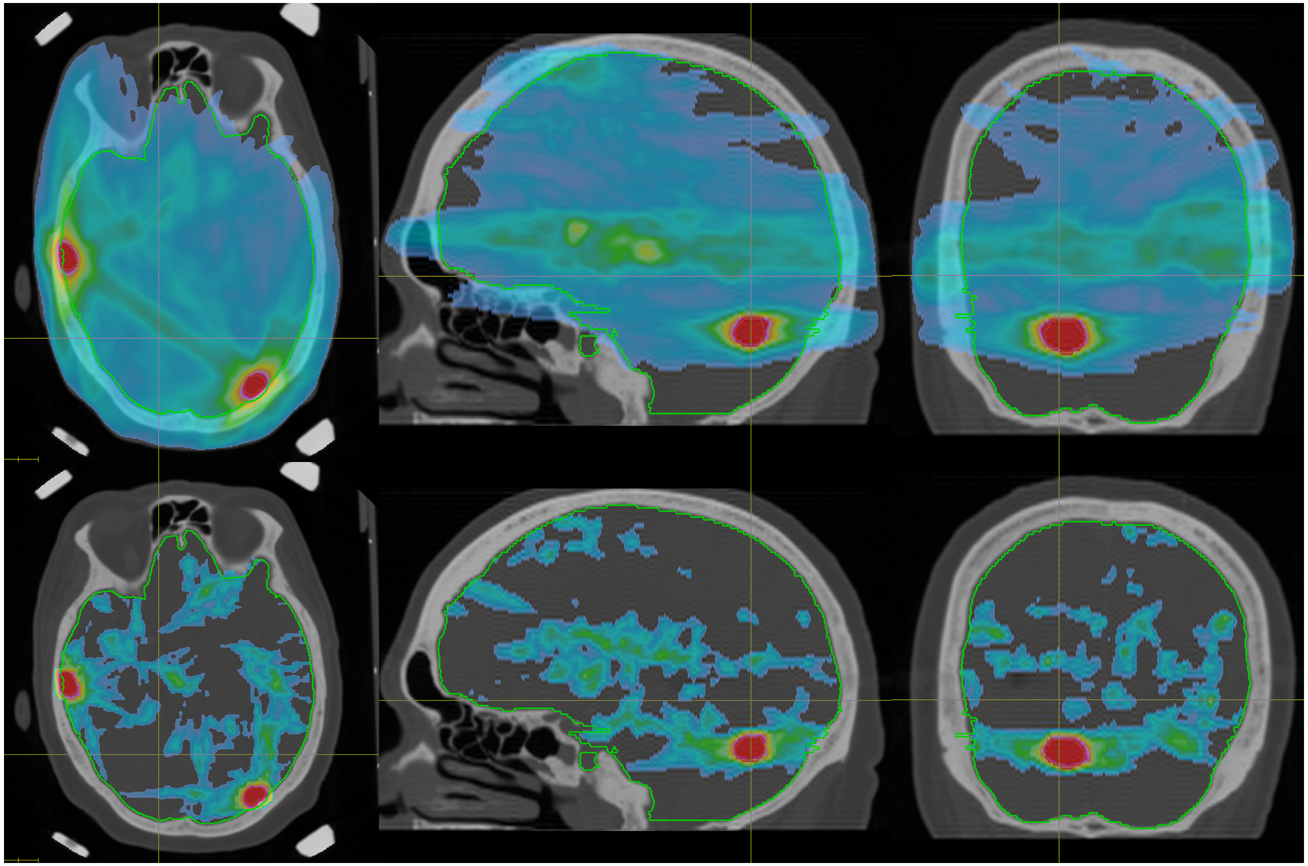


Variable dose interplay effects across radiosurgical apparatus in treating multiple brain metastases

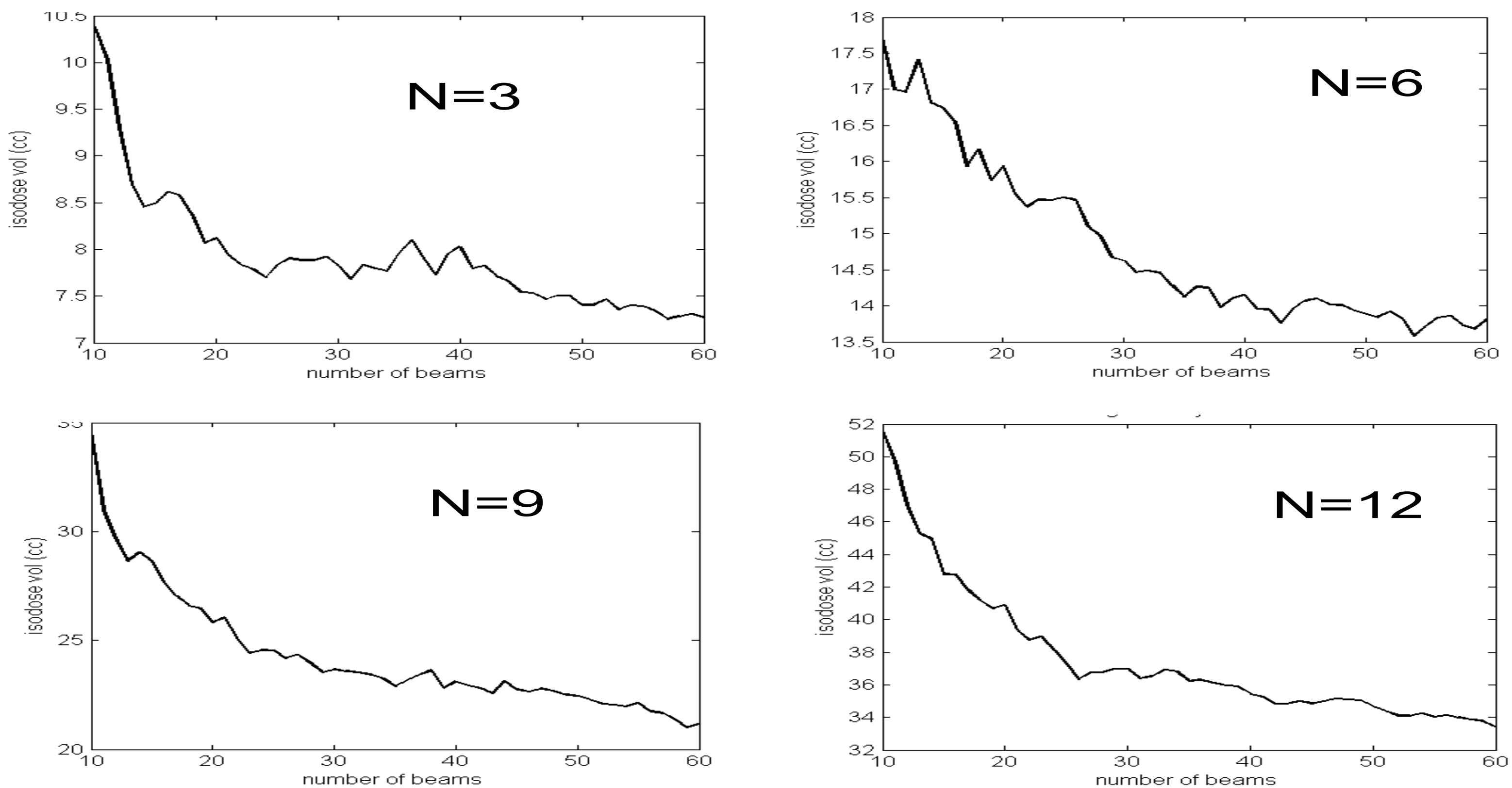
“ 4π ” Outperforms 3 Arc-VMAT

3-arc VMAT

Geo-Optimized
“4 π ”



Of Course, Multi-Targets Will Need More Beams To Be Optimal

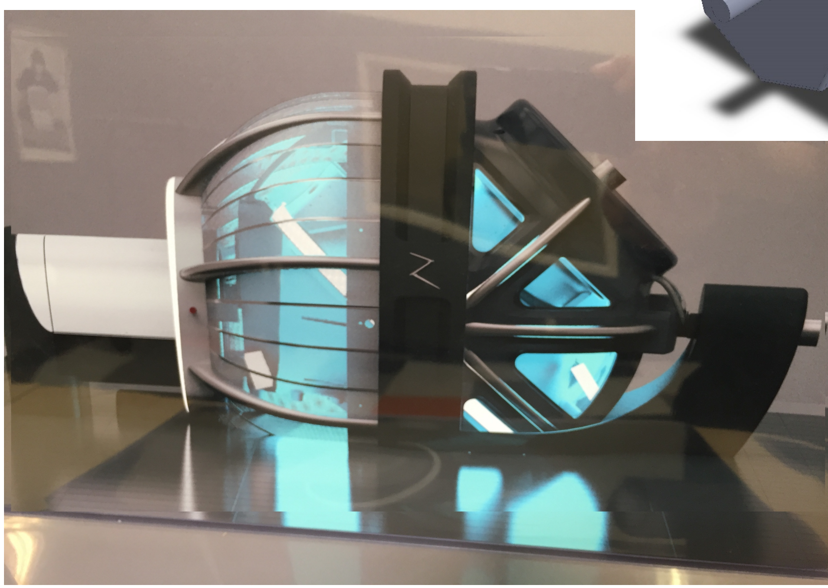


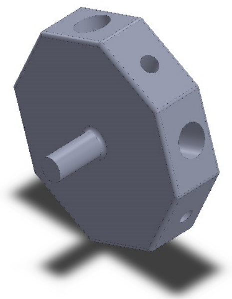
What Would I Like to See?

- **We Need A Sharper Knife Leveraging Geo-Focusing**
  Sharper means more Robust against uncertainties

- **We Need etc, etc**

Lo and behold: Zap-X





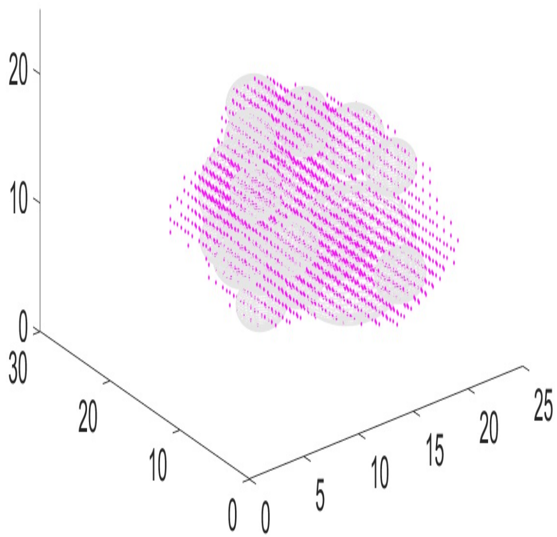
(1) **Self-Shielded**

(2) **Best X-rays**: 3-4 MV

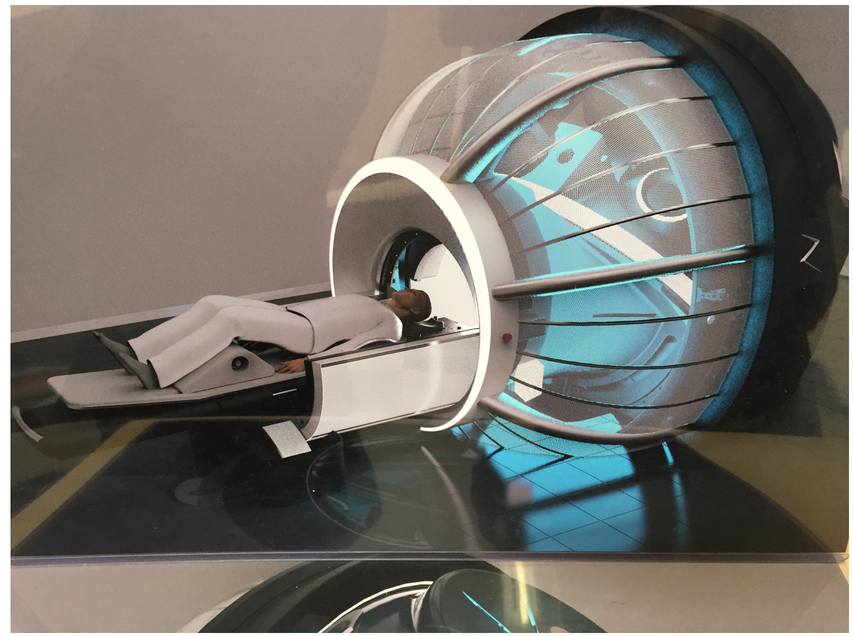
(3) **DOF**: Gyro-mounting
2π delivery

(4) **Rapid Beam Collimation**
(4 mm to 25 mm)

The Sharpest Knife One Can Get

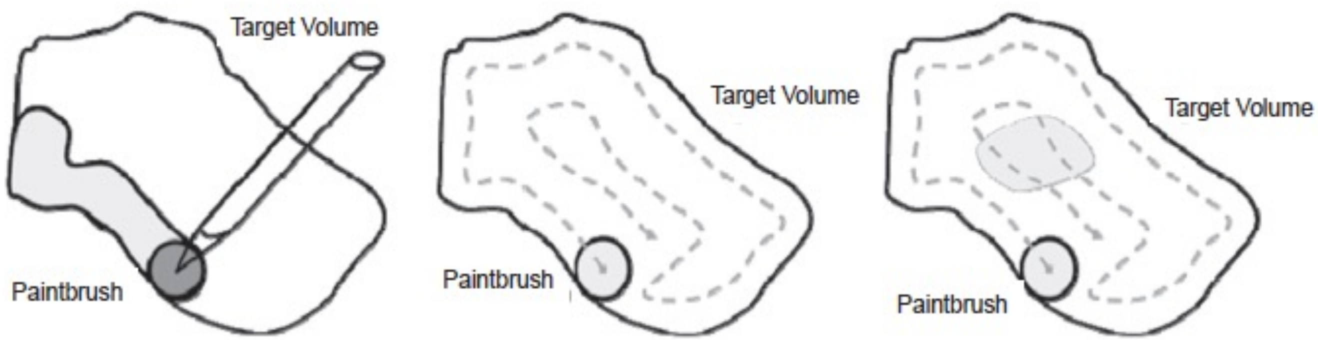


Dose Fall-Off Approaches
Theoretical Best



Adler J R etal (2017) Cureus 9(9): e1663. doi:10.7759/cureus.1663

What’s Next: Dynamic Spot Dose Painting



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 November 2009 (12.11.2009)

PCT

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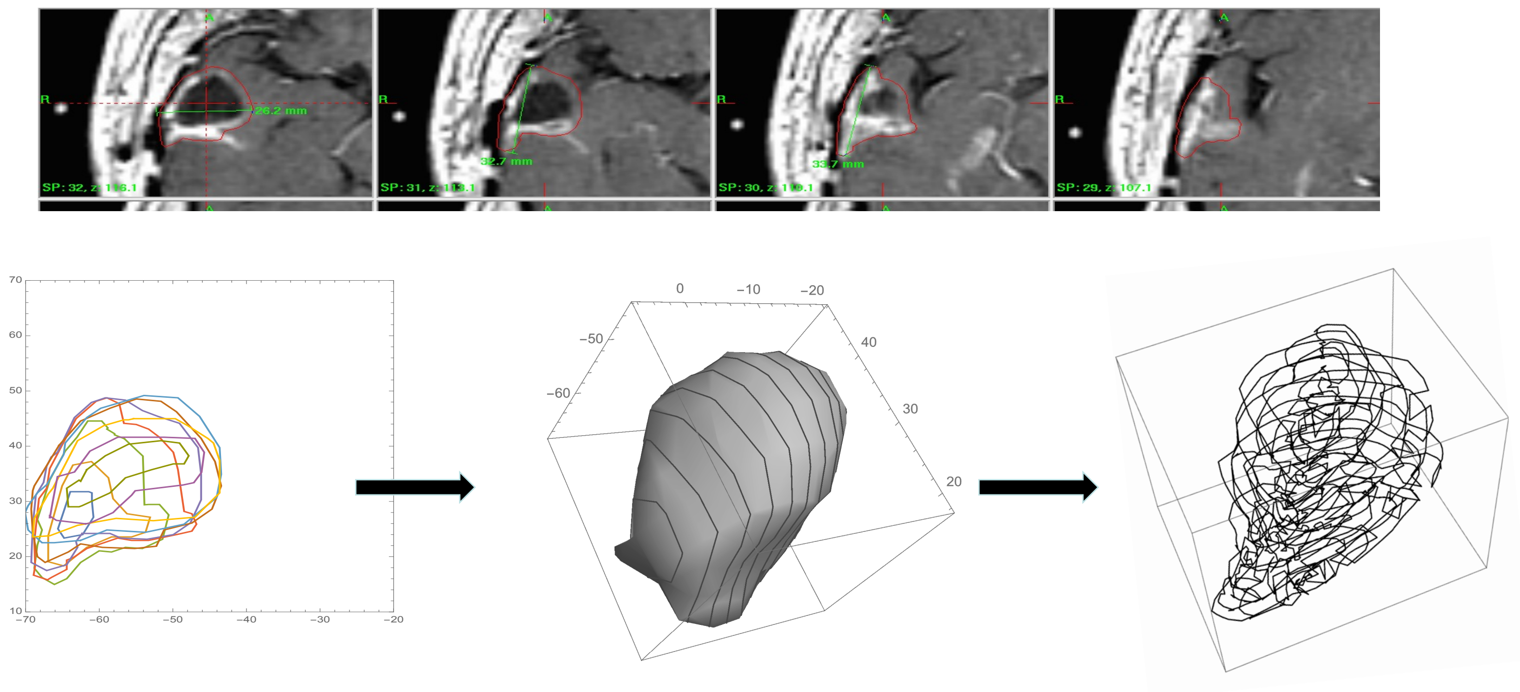
WO 2009/137010 A2

(51) International Patent Classification:
A61B 19/00 (2006.01) ***A61B 6/00*** (2006.01)
A61B 18/00 (2006.01)

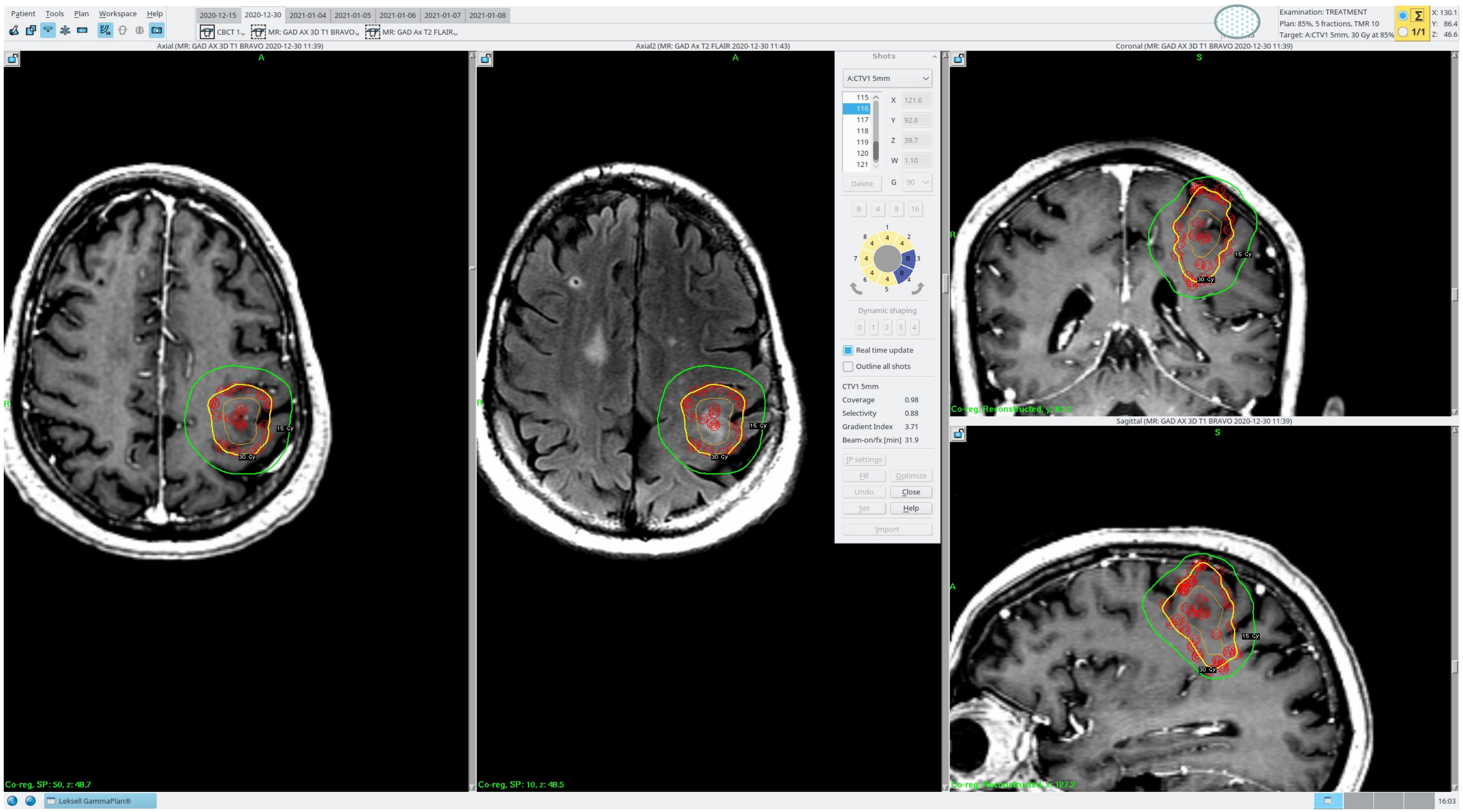
(21) International Application Number:

NM 87109 (US). **SWANSON, Nathan** [US/US]; 1304 Villa Sonrisa N.E., Albuquerque, NM 87113 (US). **MA, Lijun** [US/US]; N523 Nottingham Lane, Foster City, CA 94404 (US).

Prototype Implemented on GK



30 Gy/5Fx for 5 mm PTV Margin



(Unpublished Please Keep to Yourself)

Stereotactic radiosurgery, with Gamma SRS devices or with linear accelerator systems should not be entered into lightly

-Steve Goetsch

Thank you Steve

2022 MARVIN M.D. WILLIAMS PROFESSIONAL ACHIEVEMENT AWARD

Steven Goetsch, PhD

Steven Goetsch received his Doctorate in Medical Physics from the University of Wisconsin Madison in 1983. He had previously received a BS degree in Physics from Michigan State University and an MS in Health Physics from Northwestern University. After working as a Radiation Safety Officer in the Chicago area for four years, he spent five years as a graduate student in Madison, working under Frank Herbert Attix and Paul