WVU Medical Physics – Radiation Therapy

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West Virginia University

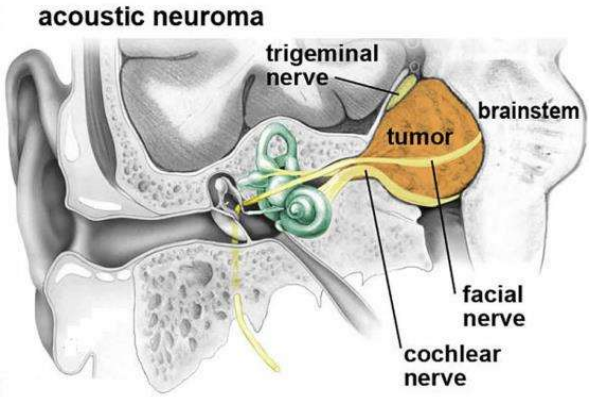
WVU Medicine
Radiation Oncology

Outline

- Radiation Therapy
  - Intro
  - THE LINAC
  - BRACHYTHERAPY
- WHAT MEDICAL PHYSICISTS DO
- CAREER PATHS
- HOW TO ENTER THE FIELD



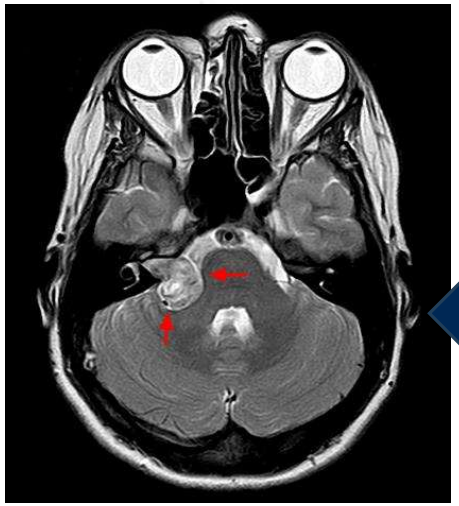

Doc Bruce Banner….
Genius Physicist…
Worked with Gamma Rays….
Gamma Rays won't make you the hulk, But we can use them to treat tumors…
Mark Ruffalo



Healthjade.net

Symptoms –

- Hearing loss
- Ringing in ears
- Vertigo
- Loss of balance
- Headaches
- Facial weakness



Healthjade.net

Diagnostic Imaging
Magnetic Resonance Imaging



News.thomasnet.com



dolpxy.com

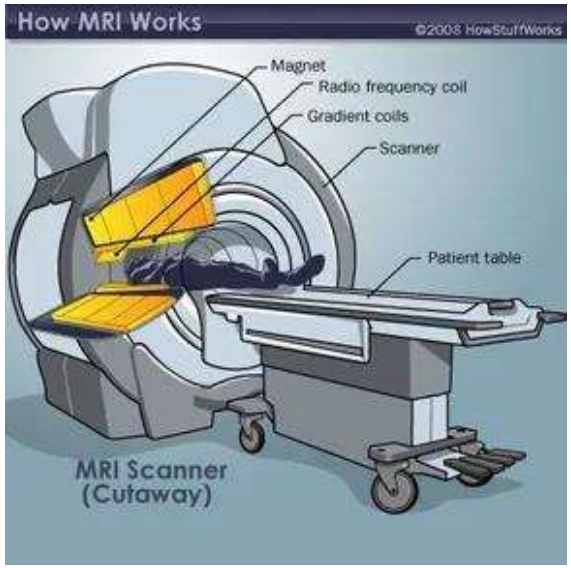
radiosurgery

TREATMENT

surgery

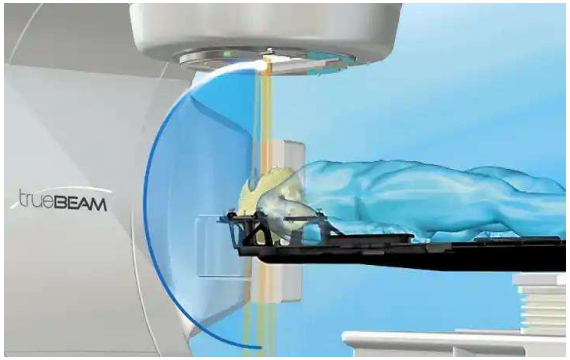
oto.wustl.edu







http://www.sprawls.org/resources/CTIMG/module.htm

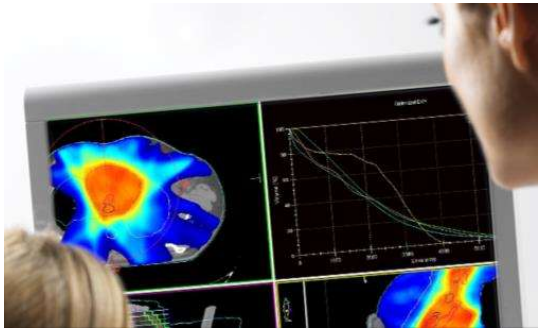


Varian.com



PET-CT

Siemens.com



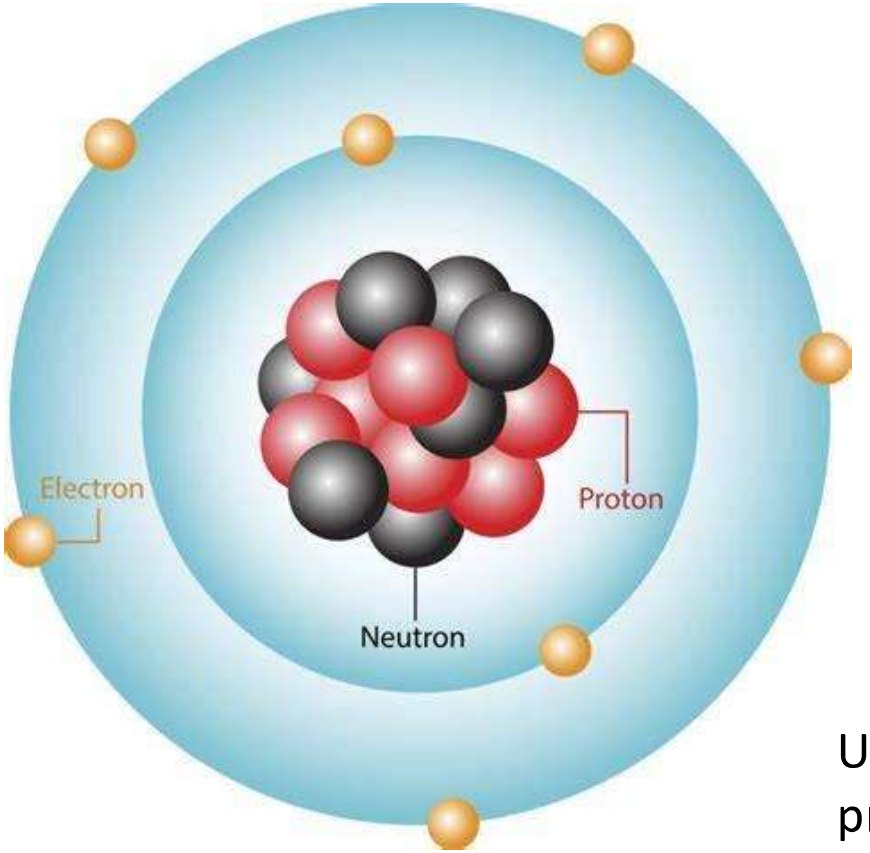
Captec-group.com



Elekta.com

Invented and developed by genius physicists (medical physicists)


SO, WHAT ARE GAMMA RAYS
ANYWAY ?



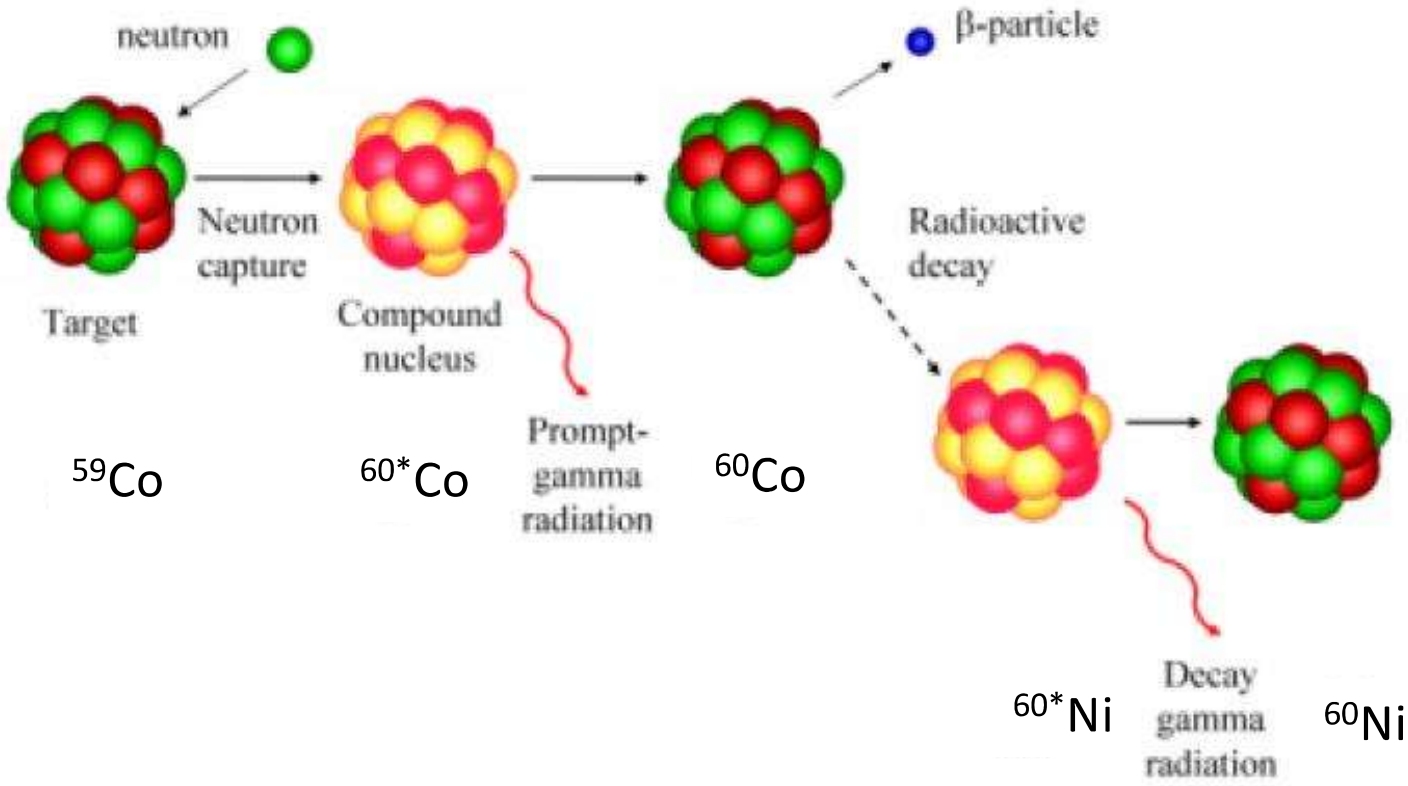
Broadlearnings.com

Atomic orbital energy levels

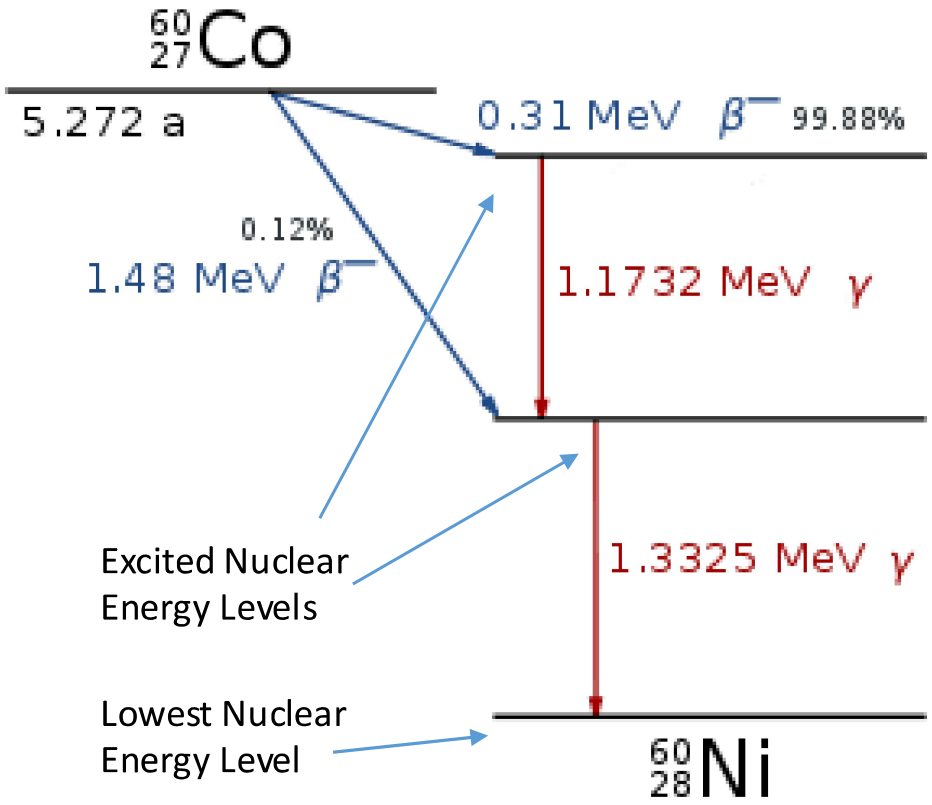
Nuclear energy levels

Unstable configurations of neutrons and protons leads to radioactive decay: one atom becomes another

Atomic Numbers
Co = 27
Ni = 28



https://reactor.osu.edu/neutron-activation-analysis

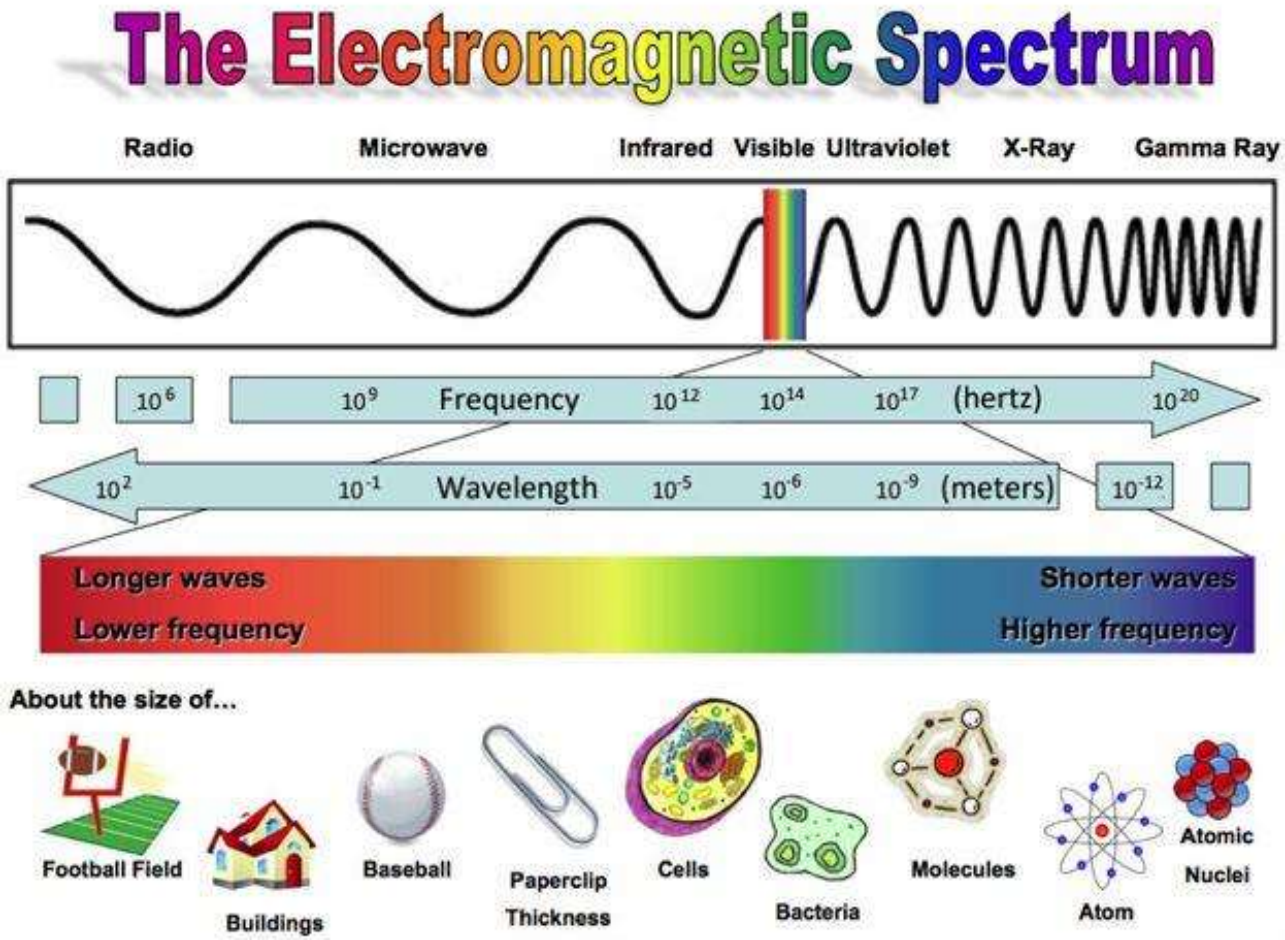


GAMMA RAYS

From transitions between nuclear energy levels

Oncologymedicalphysics.com

But what are gamma rays, really?



Nasaphysics.cet.edu

Gamma Rays are Photons.
They are also electromagnetic waves.

Just like visible light.

Gamma Rays have a higher energy than visible light.

They penetrate deep into the body.

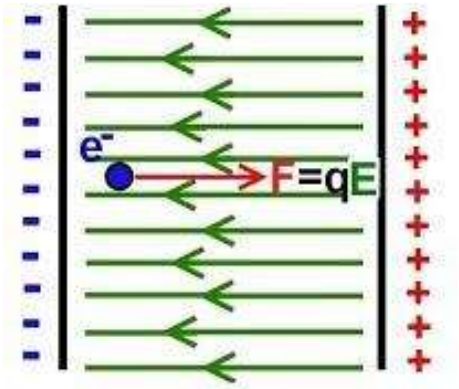
WE USE THEM FOR RADIATION THERAPY.

BUT THERE IS ANOTHER WAY TO MAKE PENETRATING RADIATION

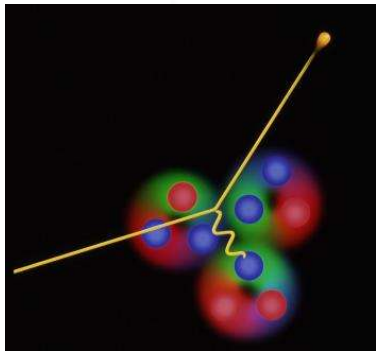


No, not with a wand…

Brehmsstrahlung



http://www.ilectureonline.com/lectures/subject/PHYSICS/5/307



https://fineartamerica.com/featured/art-of-electron-interacting-with-nucleus-.html

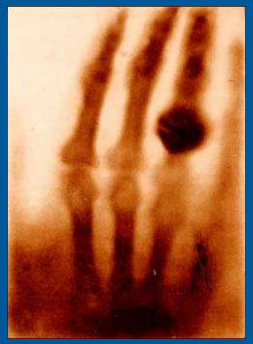


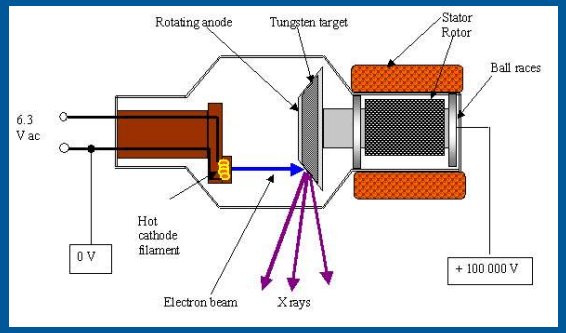
https://www.orau.org/health-physics-museum/index.html

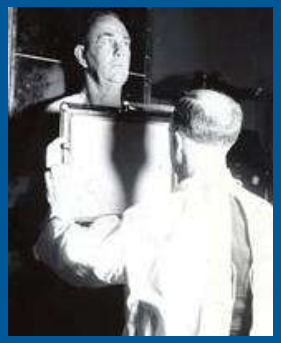








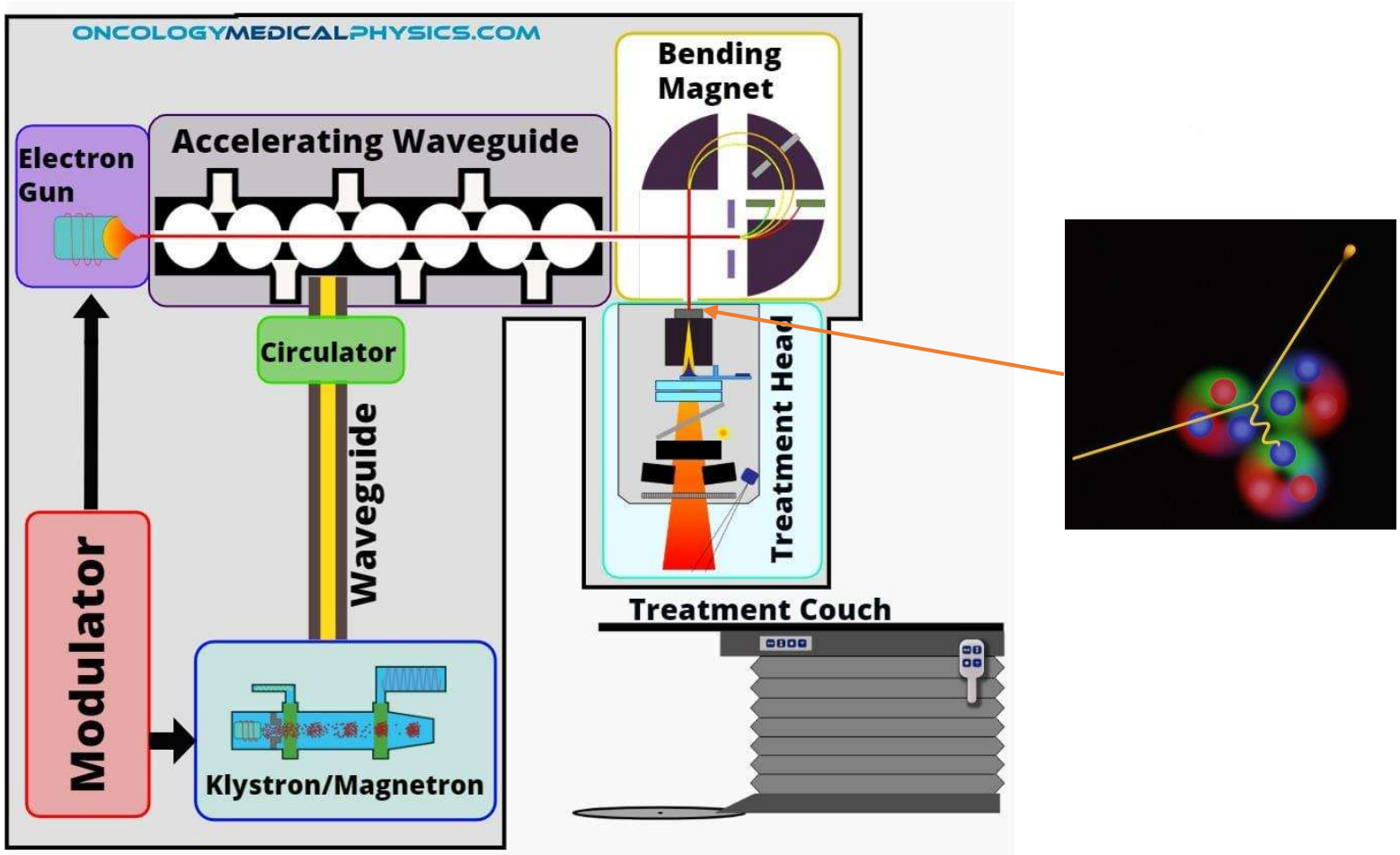








http://www.radiologyinfo.org



https://oncologymedicalphysics.com/introduction-to-clinical-linear-accelerators

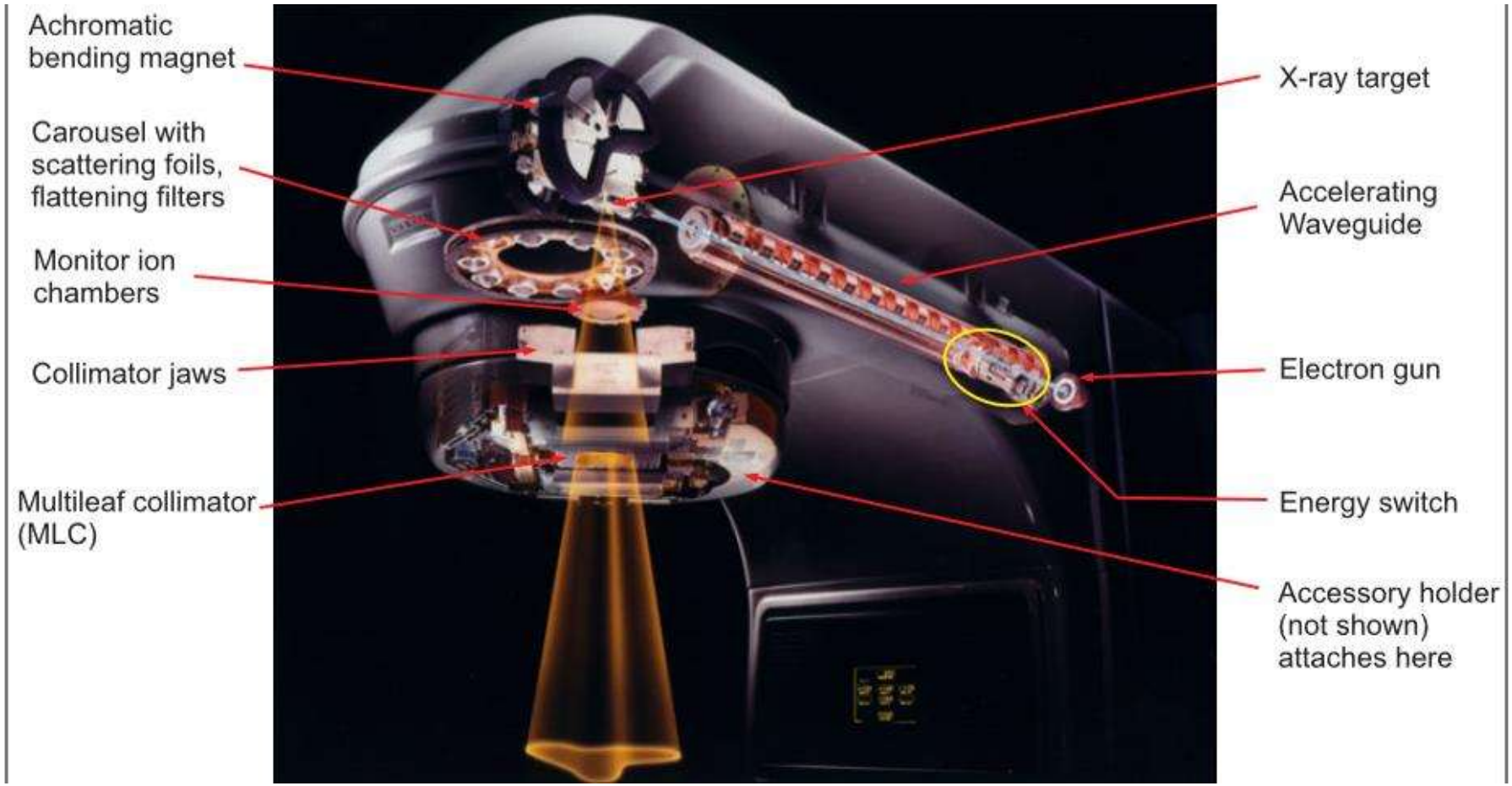
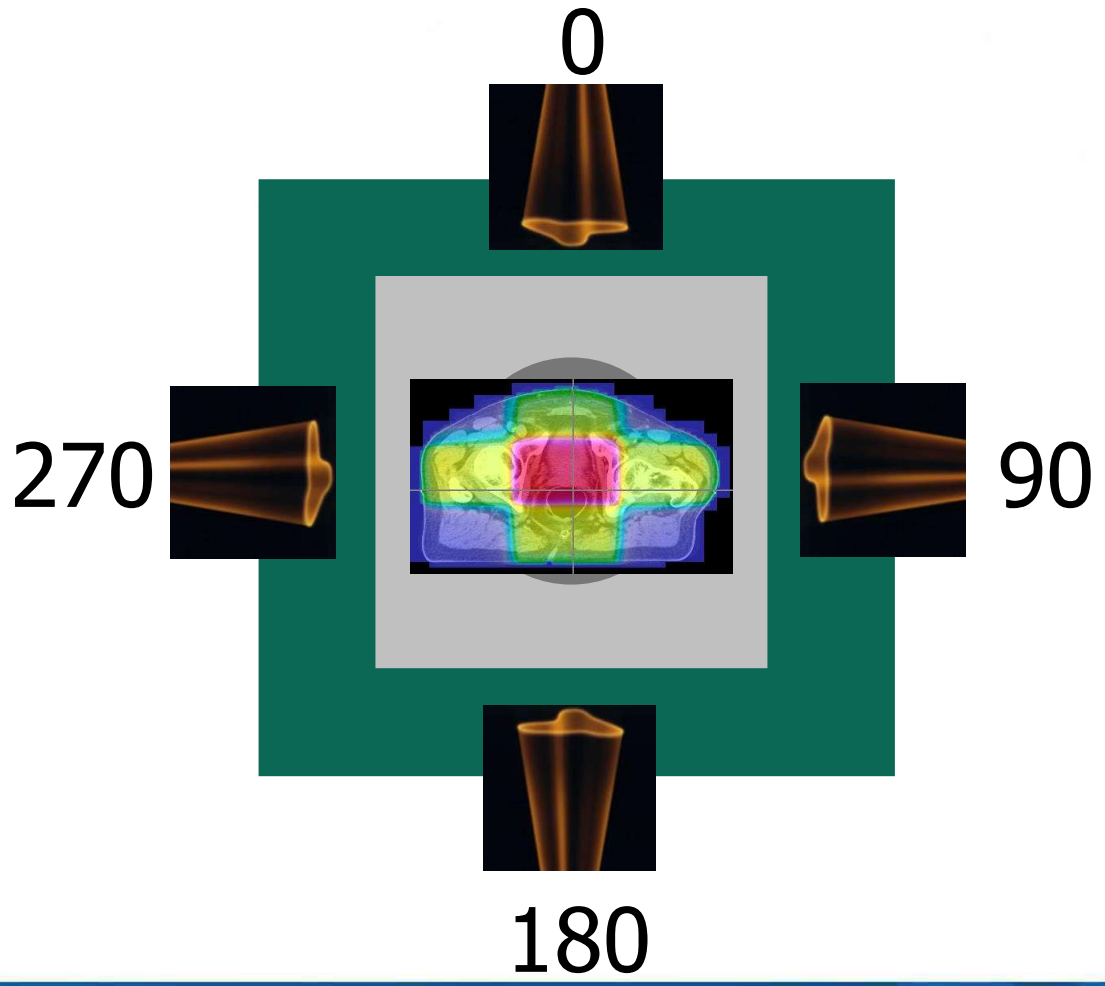
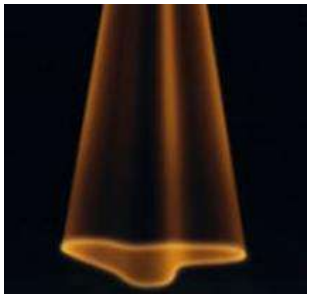


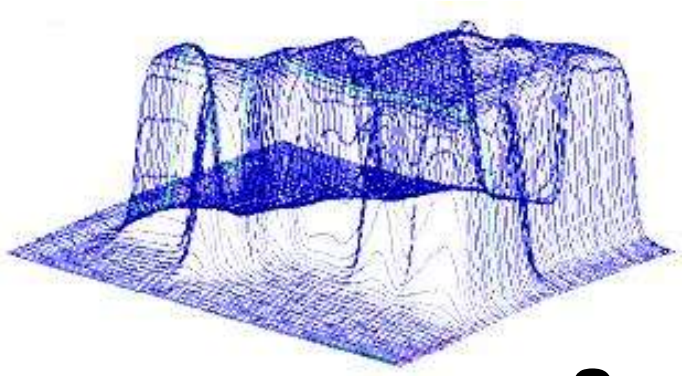
Image courtesy of Varian Medical Systems

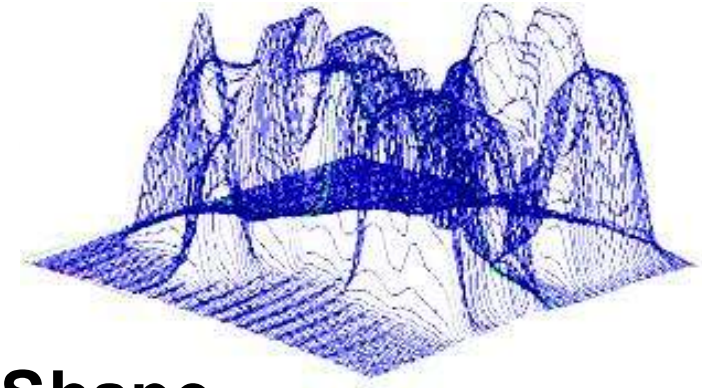

0
270
90
180



No Intensity Modulation

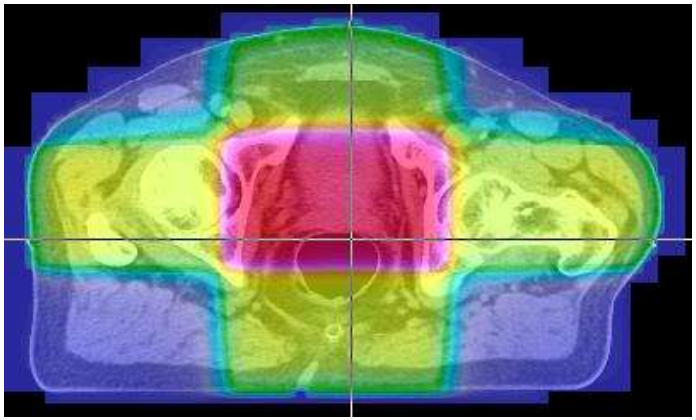
Intensity Modulation



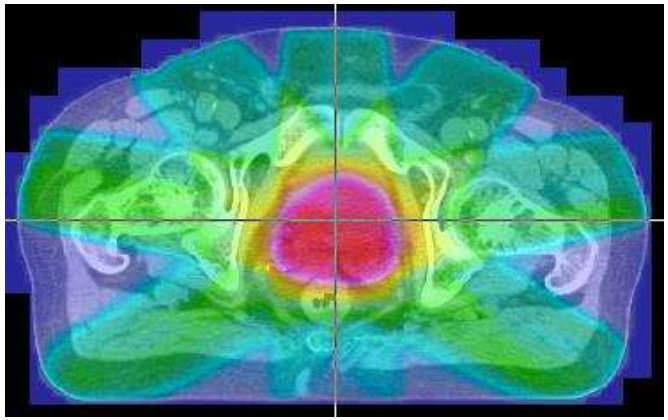


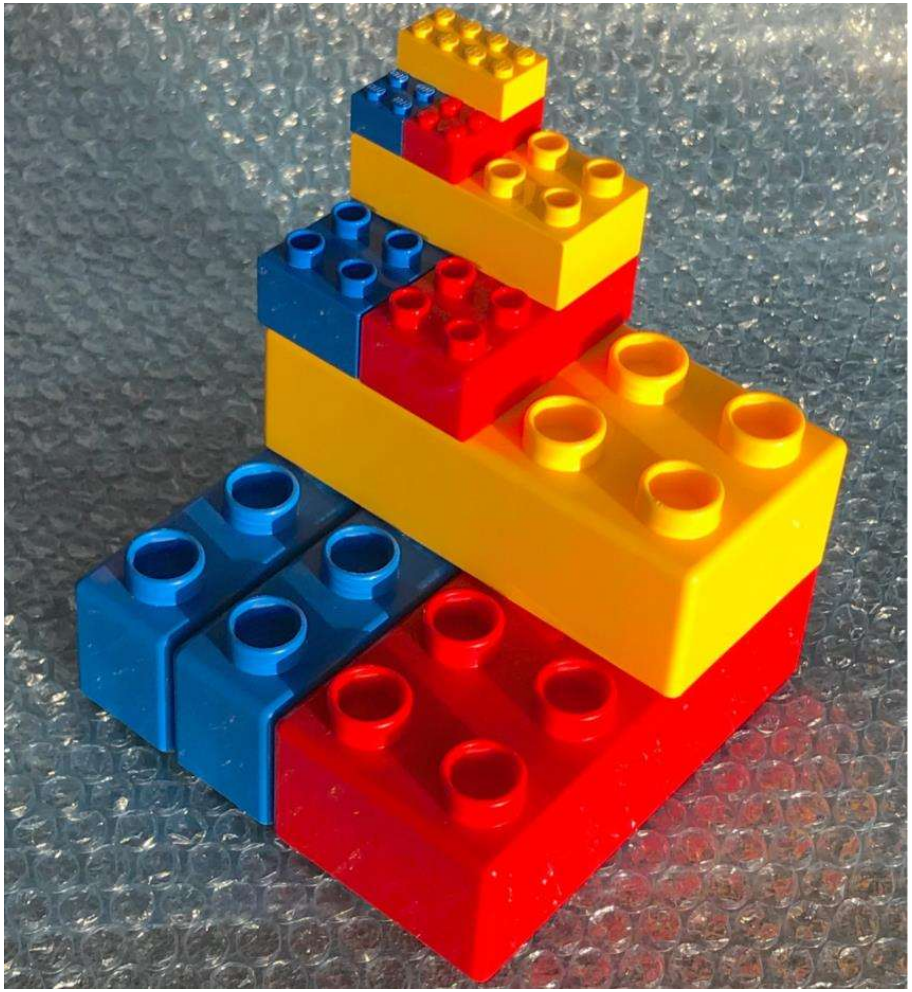
Same Shape

No Intensity Modulation

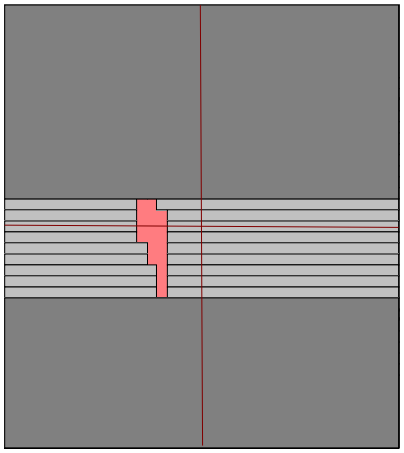


Intensity Modulation

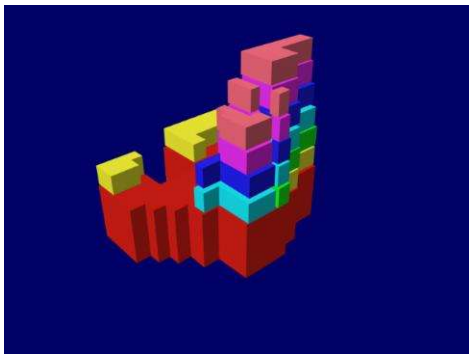




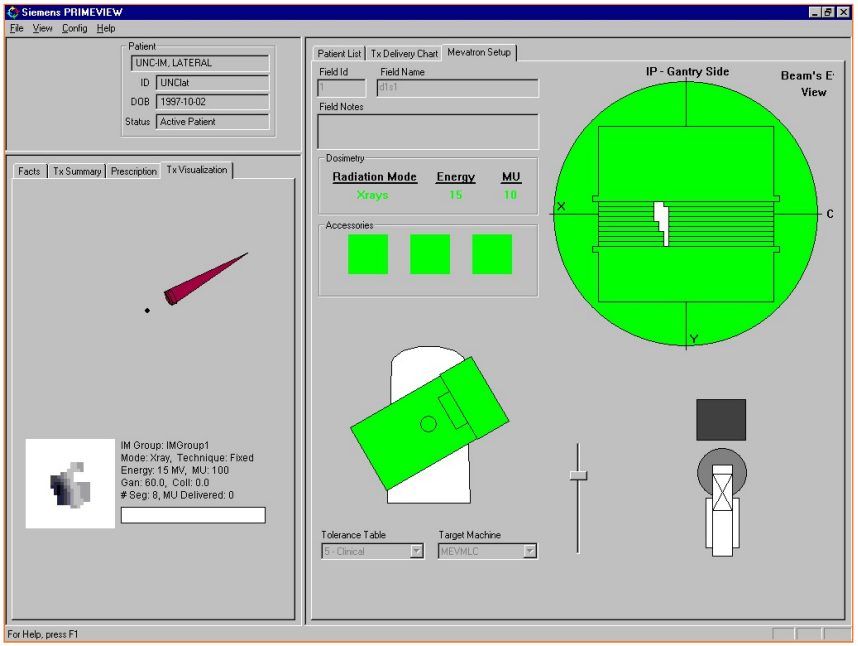
Segmental IMRT – Step and shoot



MLC Shape



Fluence



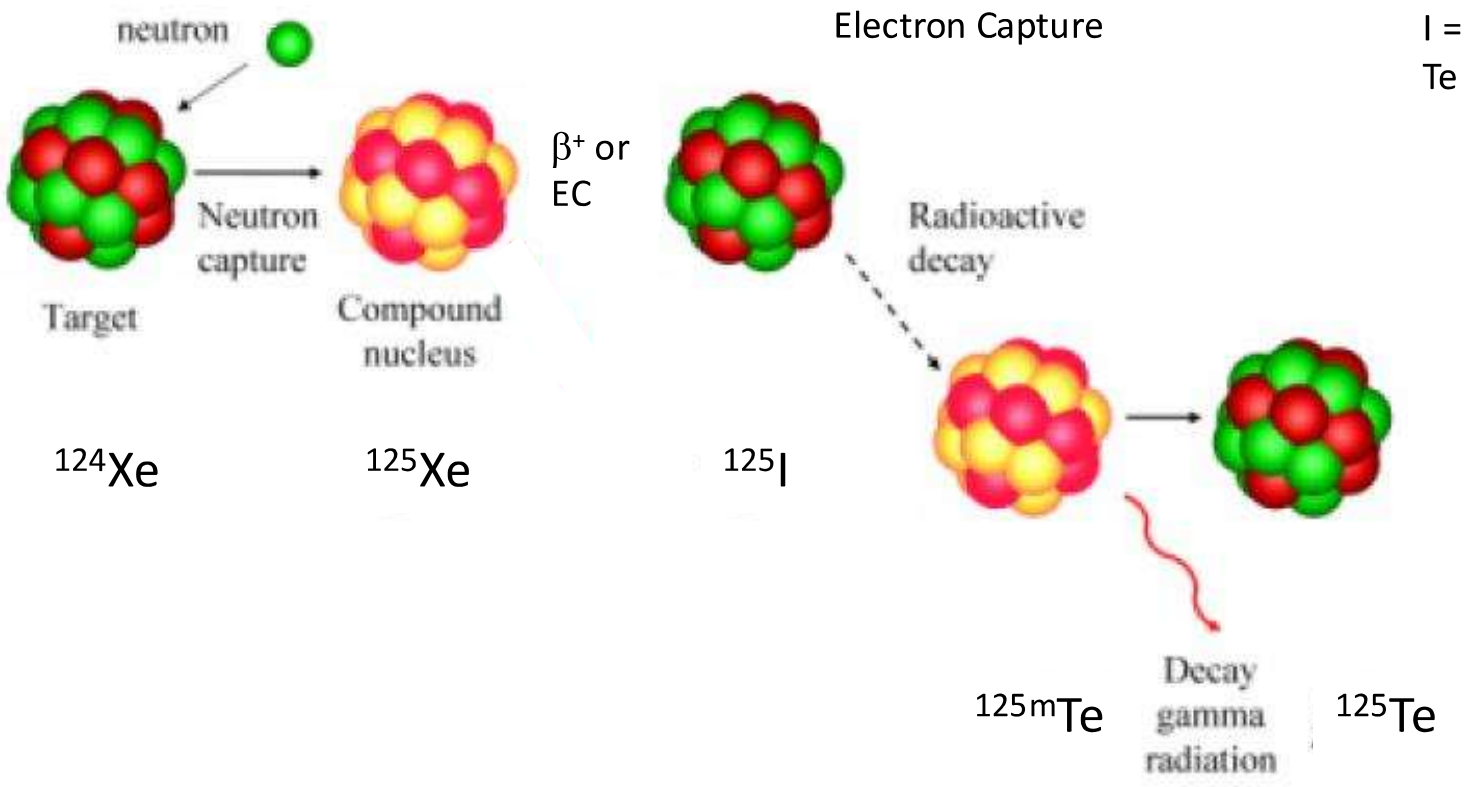
Control System

Courtesy of UNC

Outline

- TREATMENT
  - THE LINAC
  - BRACHYTHERAPY
  - QUALITY ASSURANCE
- WHAT MEDICAL PHYSICISTS DO
- CAREER PATHS
- HOW TO ENTER THE FIELD

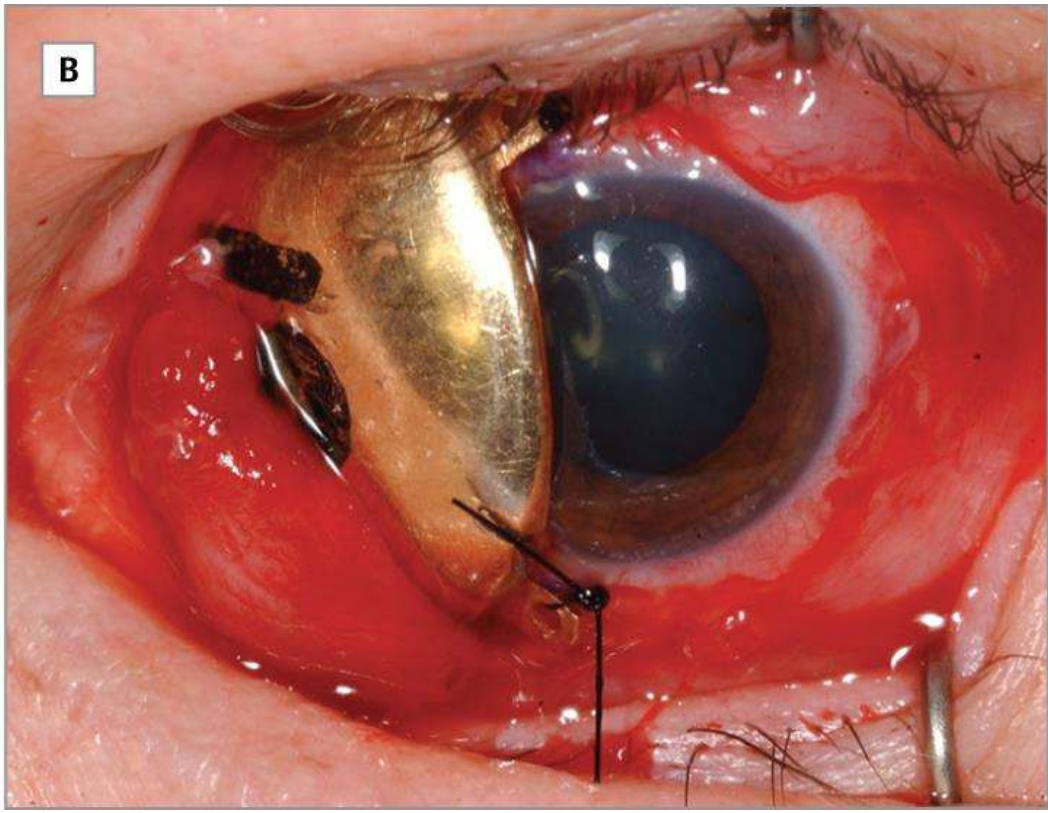
Atomic Numbers
Xe = 54
I = 53
Te = 52



^{124}Xe ^{125}Xe ^{125}I ^{125m}Te ^{125}Te

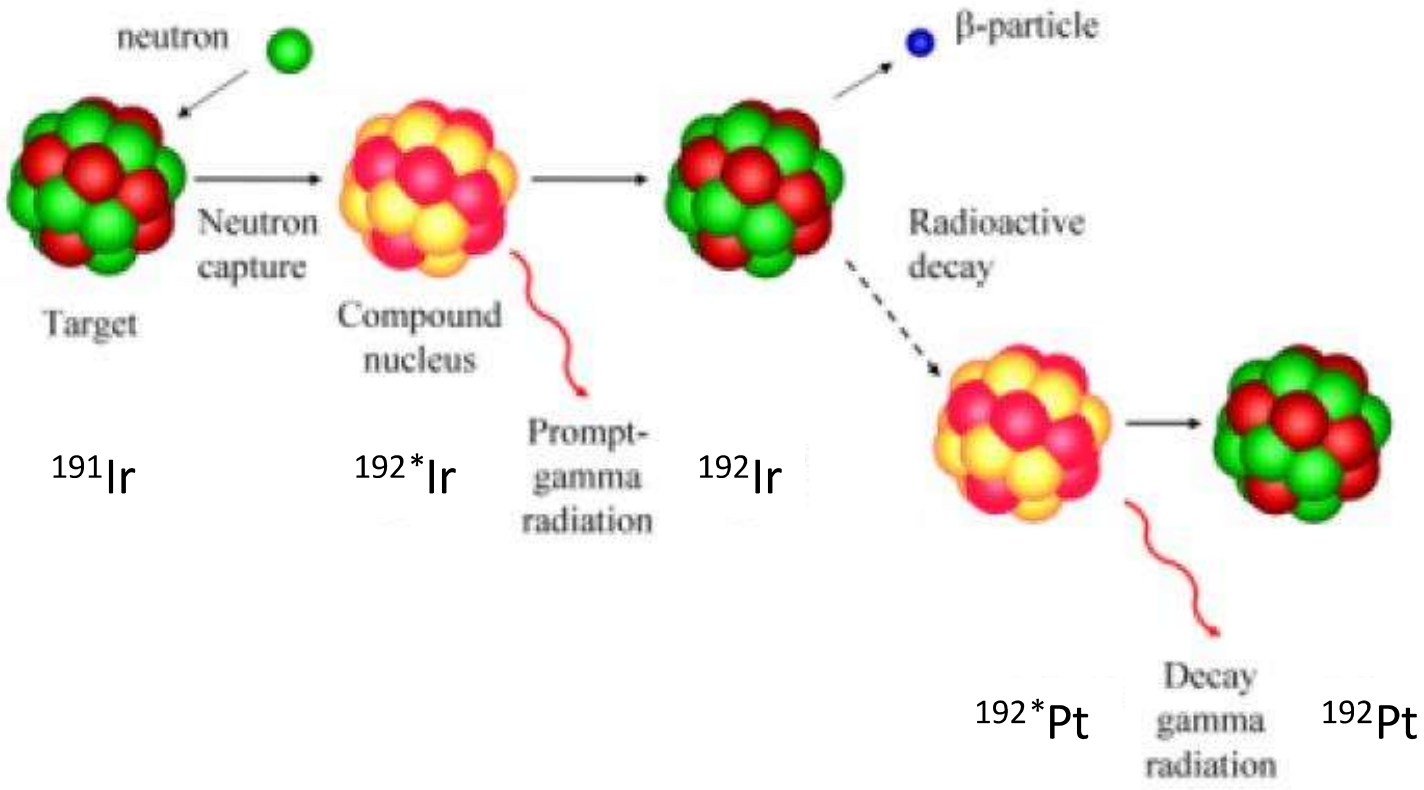
https://reactor.osu.edu/neutron-activation-analysis





JAMA Ophthalmol. 2014;132(6):691-696. doi:10.1001/jamaophthalmol.2014.86

Atomic Numbers
Ir = 77
Pt = 78



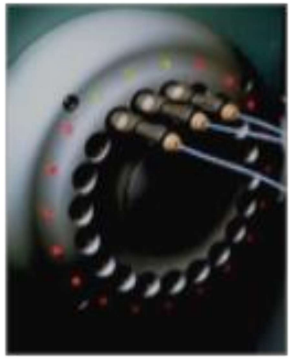
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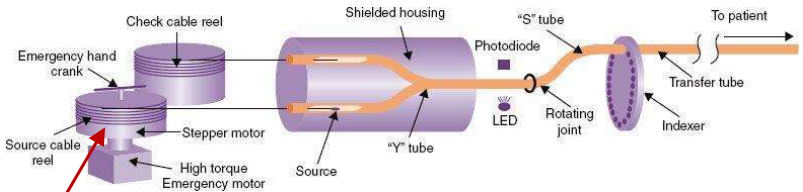
HDR Brachytherapy – treatment device

Indexer, multiple channels
20 to 40 depending on manufacturer

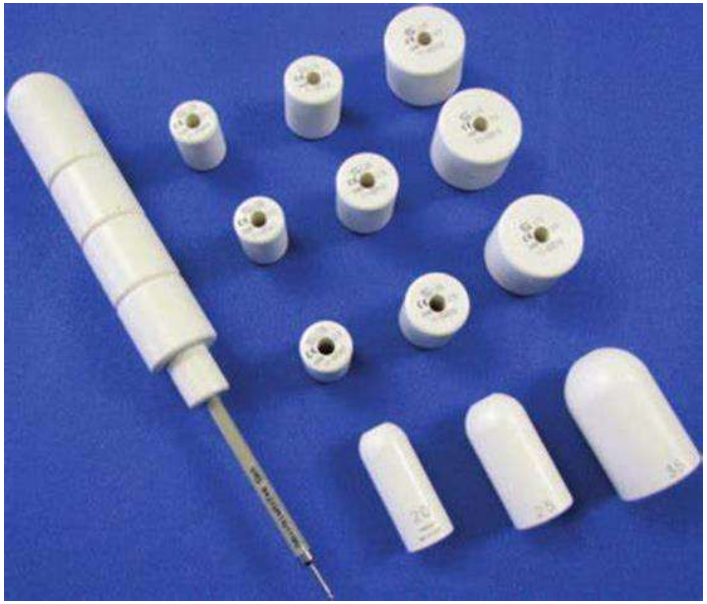








Stepper motor to advance source in fixed increments (aka steps)
Source transit speed of 50 cm/s




MR
MR Conditional


MR
MR Conditional


MR
MR Conditional

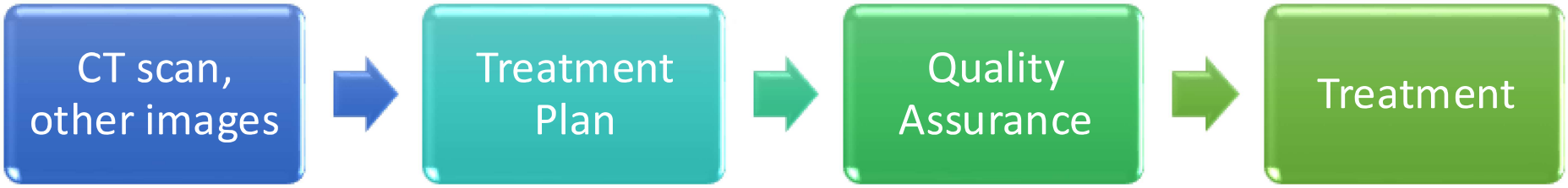
Outline

- DIAGNOSIS
  - THE CT
- TREATMENT
  - THE LINAC
  - BRACHYTHERAPY

- WHAT MEDICAL PHYSICISTS DO
  - QUALITY ASSURANCE
  - Many other hats….

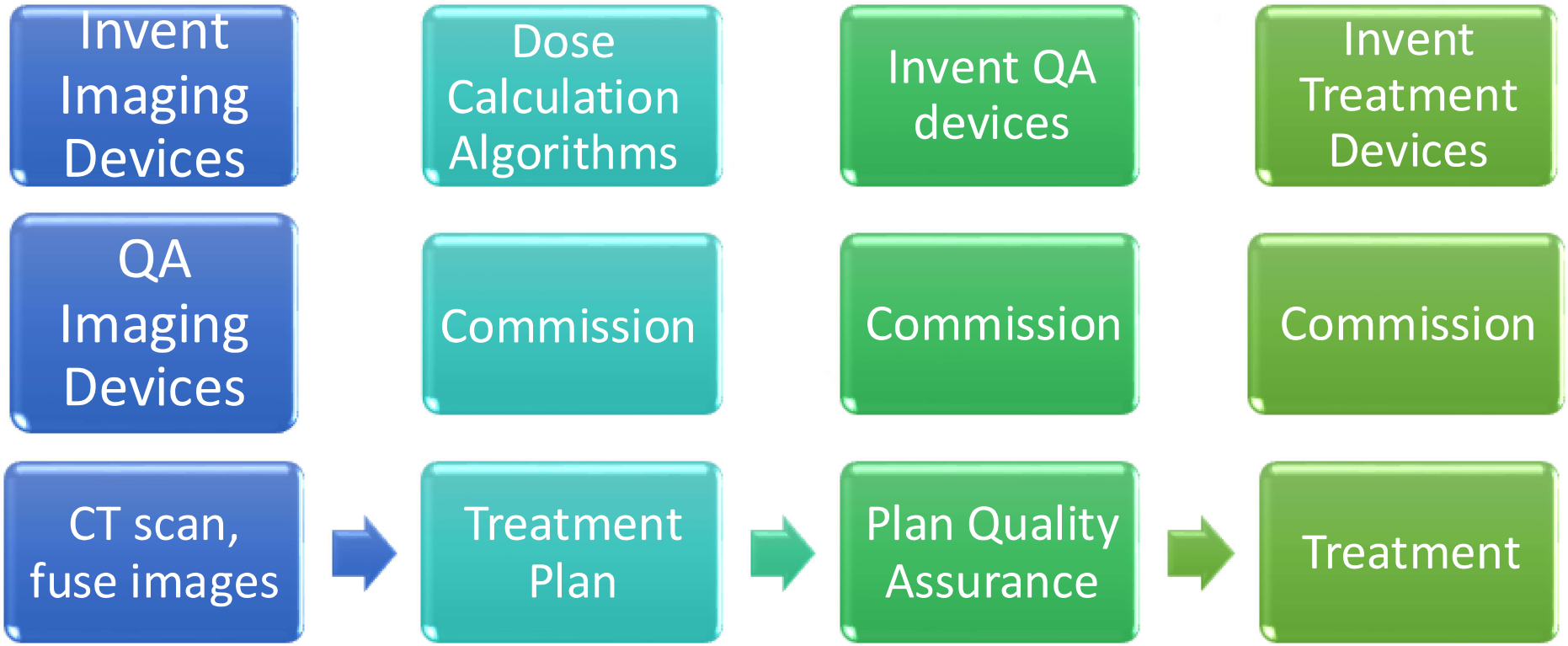
- CAREER PATHS
- HOW TO ENTER THE FIELD

Radiotherapy process



Medical physicists are involved in each of these steps, and more things behind the scenes

Radiotherapy process



Medical physicists are involved in each of these steps, and more things behind the scenes


MARVEL STUDIOS
GUARDIANS OF THE GALAXY
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WVU Medical Physics – Mary Babb Randolph Cancer Center



Alf Siochi, PhD
Dir. Of Medical Physics



Josh Hack, MS
Chief Physicist



April Shorthouse, MS



Mike Carroll, MS



Denisa Goia, MS

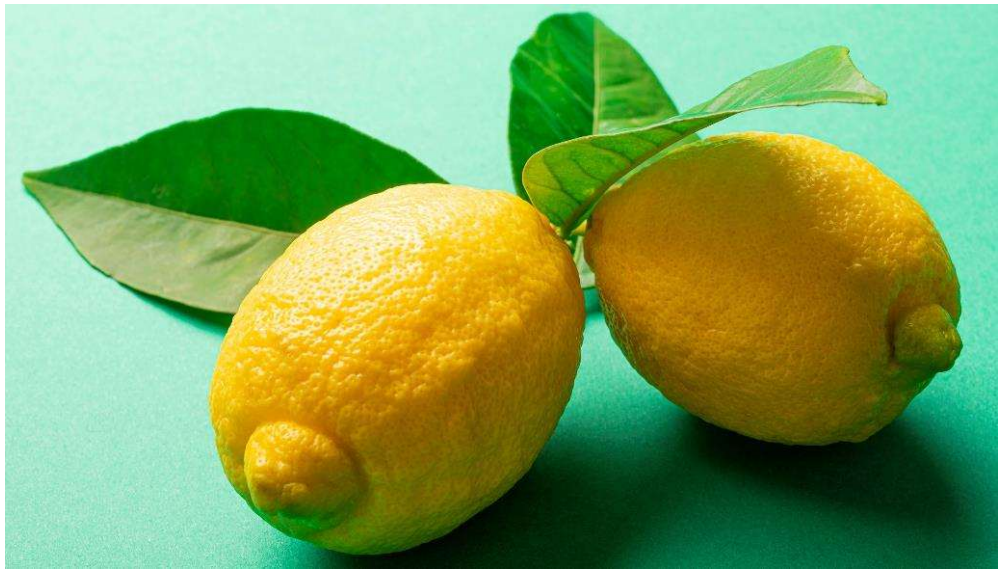
Wheeling Hospital Schiffler Cancer Center: Brian Kurko, Ernie Butler, Amber Hines
Thomas Memorial: Chera Gainer; Princeton Community Hospital: Larry Hambrick
Berkley Medical Center: Harold D'Souza




I like surprises




@TRENDIZISST



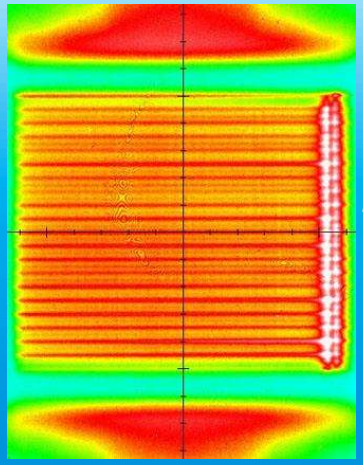





SALT
SUGAR

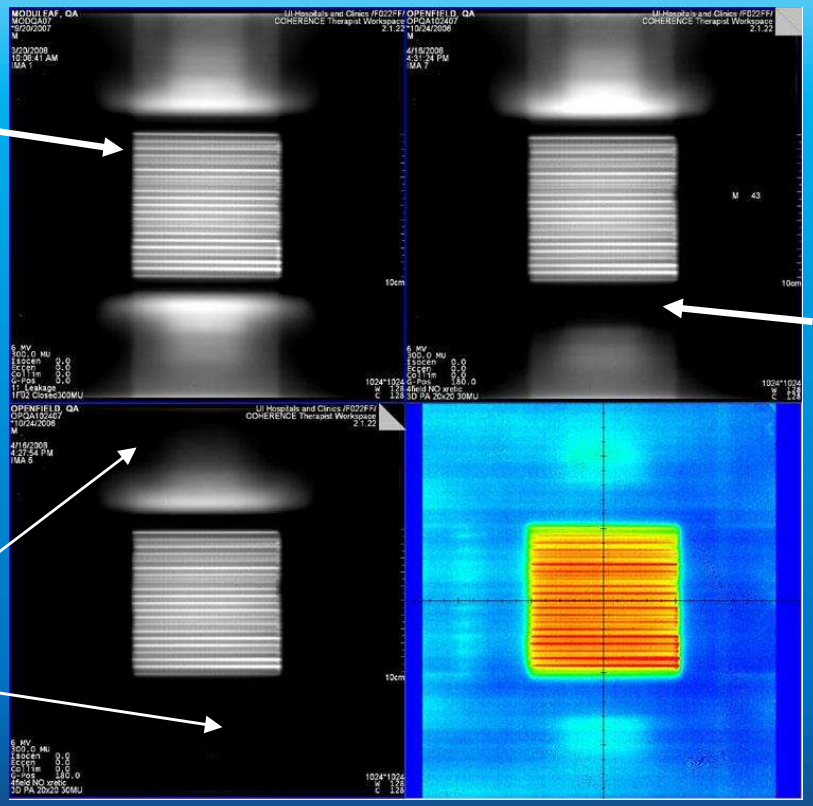


Missing Shielding – caught by prospective FTA



Manufacturer Configuration 10.4 x 12.4

Reduced field size 10.4x10.4



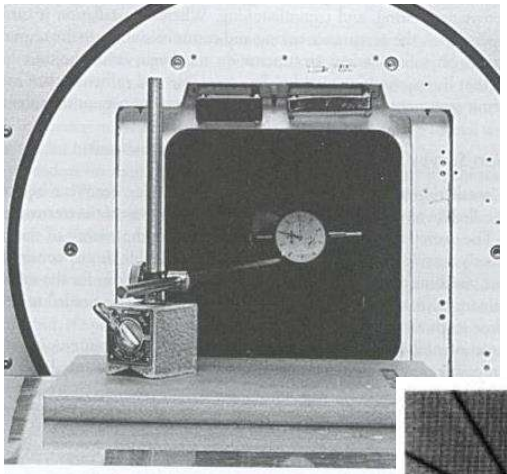
Lead added Y1 side

Lead added Y1 side & Linac MLC closed leaves behind Jaws

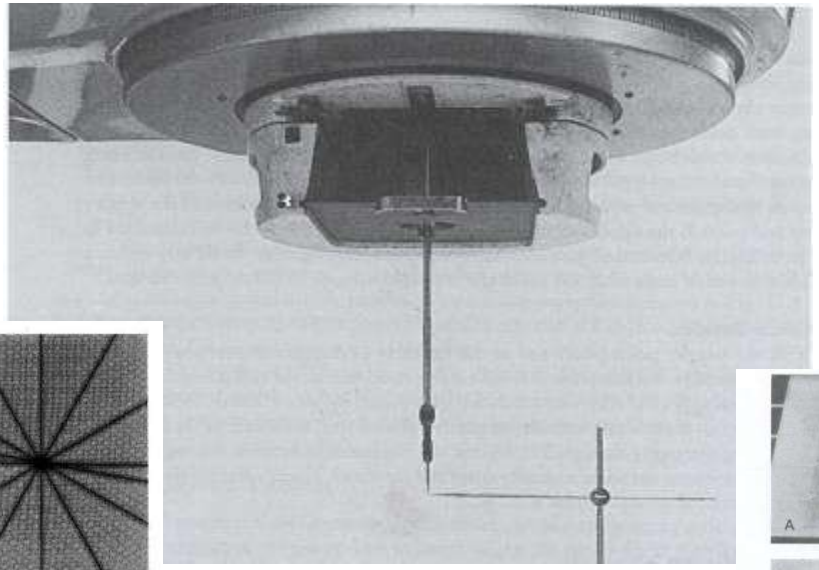
Lead both sides & Linac MLC closed leaves behind Jaws

Analysis done with DoseViewer.exe © Alf Siochi


EMERGENCY TELEPHONE
Dial 999 for Coastguard,
Police, Fire or Ambulance
BT
1
2
3



ition of jaw symmetry with the machinist's dial indicator. T
e right jaw.



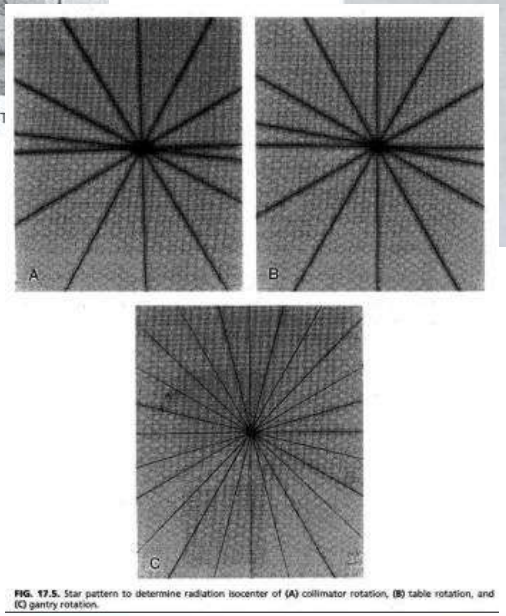


FIG. 17.5. Star pattern to determine radiation isocenter of (A) collimator rotation, (B) table rotation, and (C) gantry rotation.

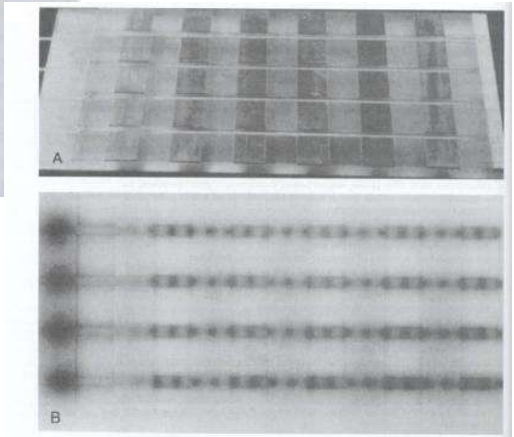
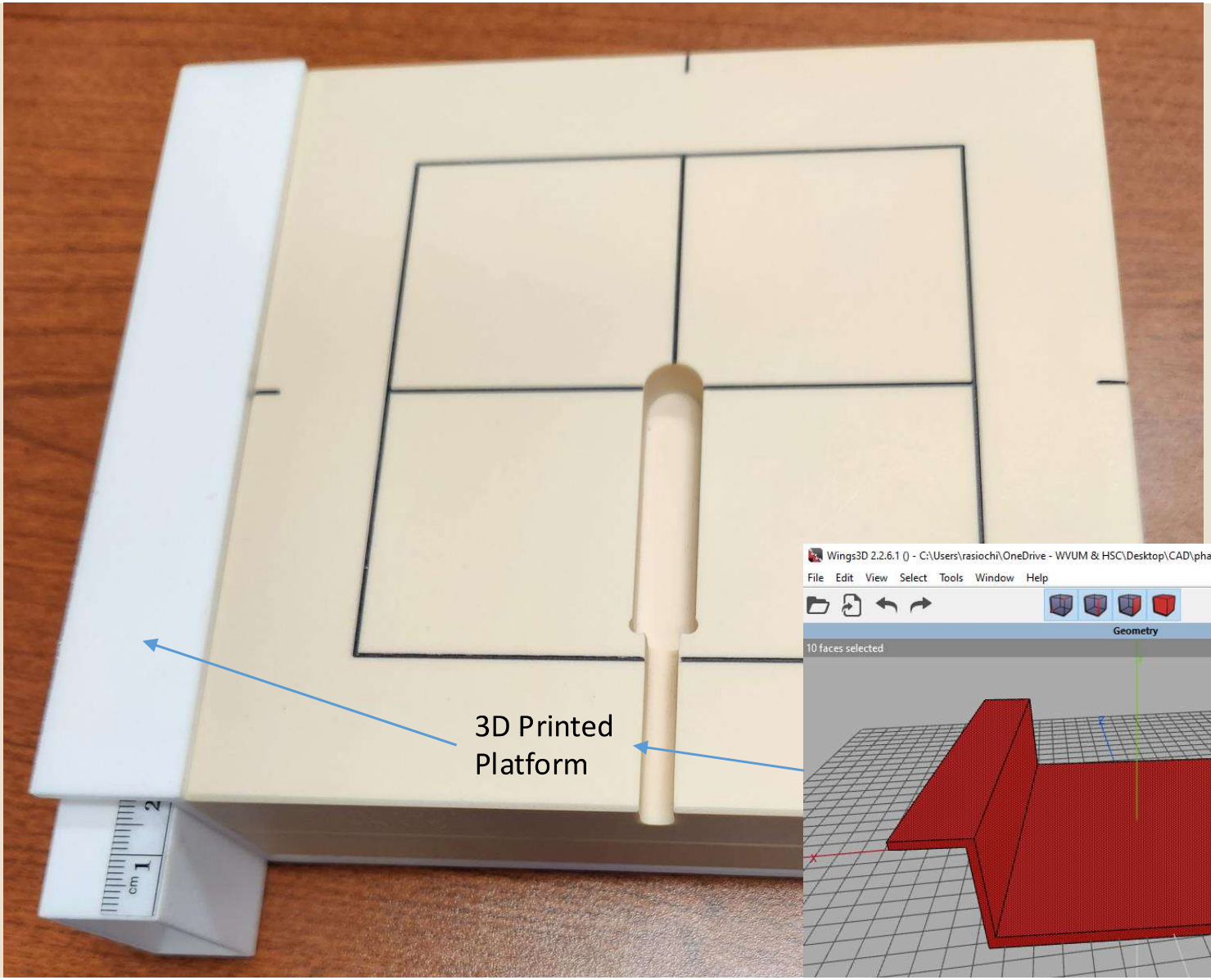


FIG. 17.8. Quality control test for HDR remote afterloaders. A: Test phantom to check the accuracy of source positioning. B: Autoradiograph of the test phantom showing dwell positions. (From Aldrich JE, Samant S. A test phantom for HDR daily quality control. *Activity* 1992;6:82, with permission.)

F. Khan, The Physics of Radiotherapy

DEVELOP
QUALITY
ASSURANCE
TOOLS

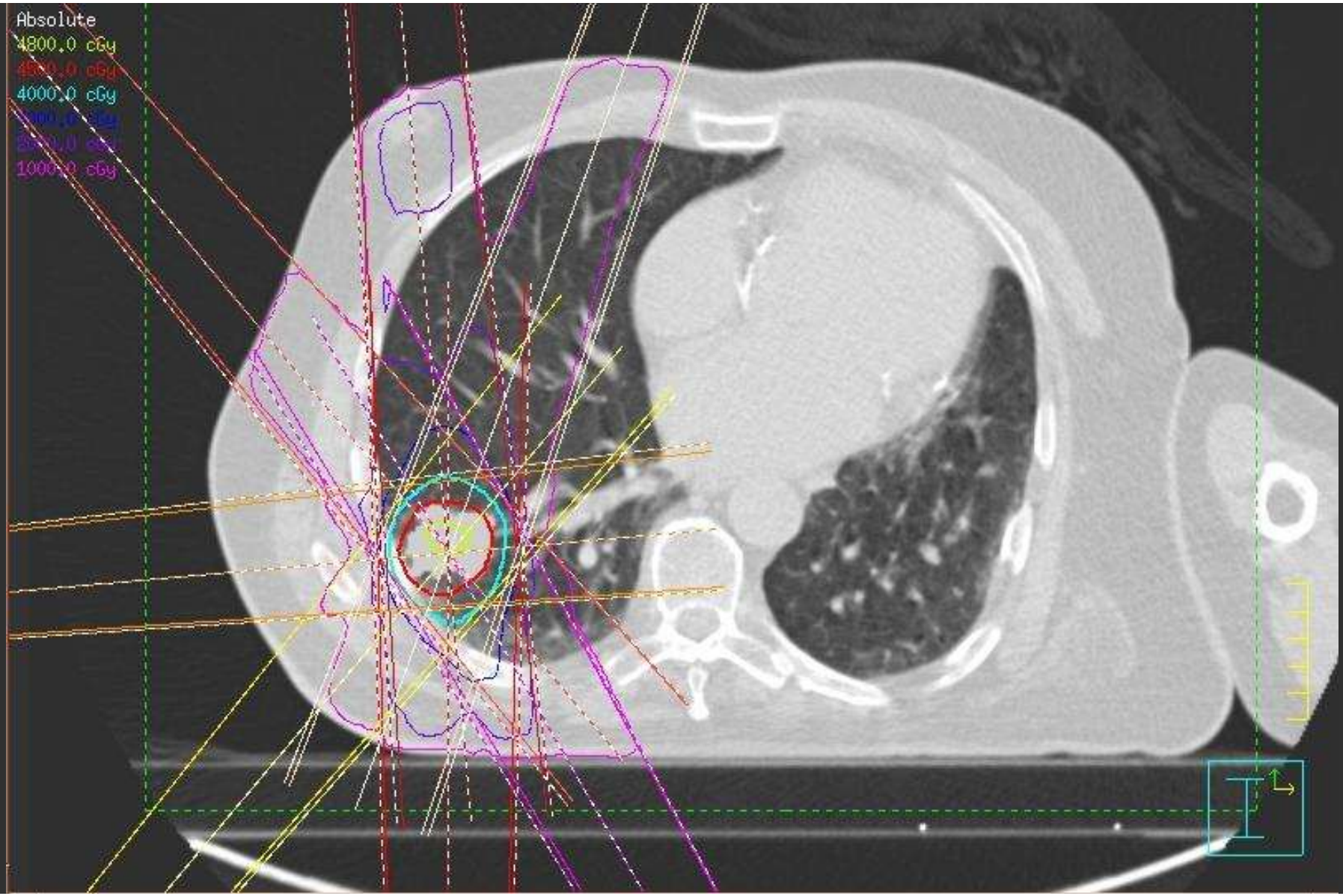


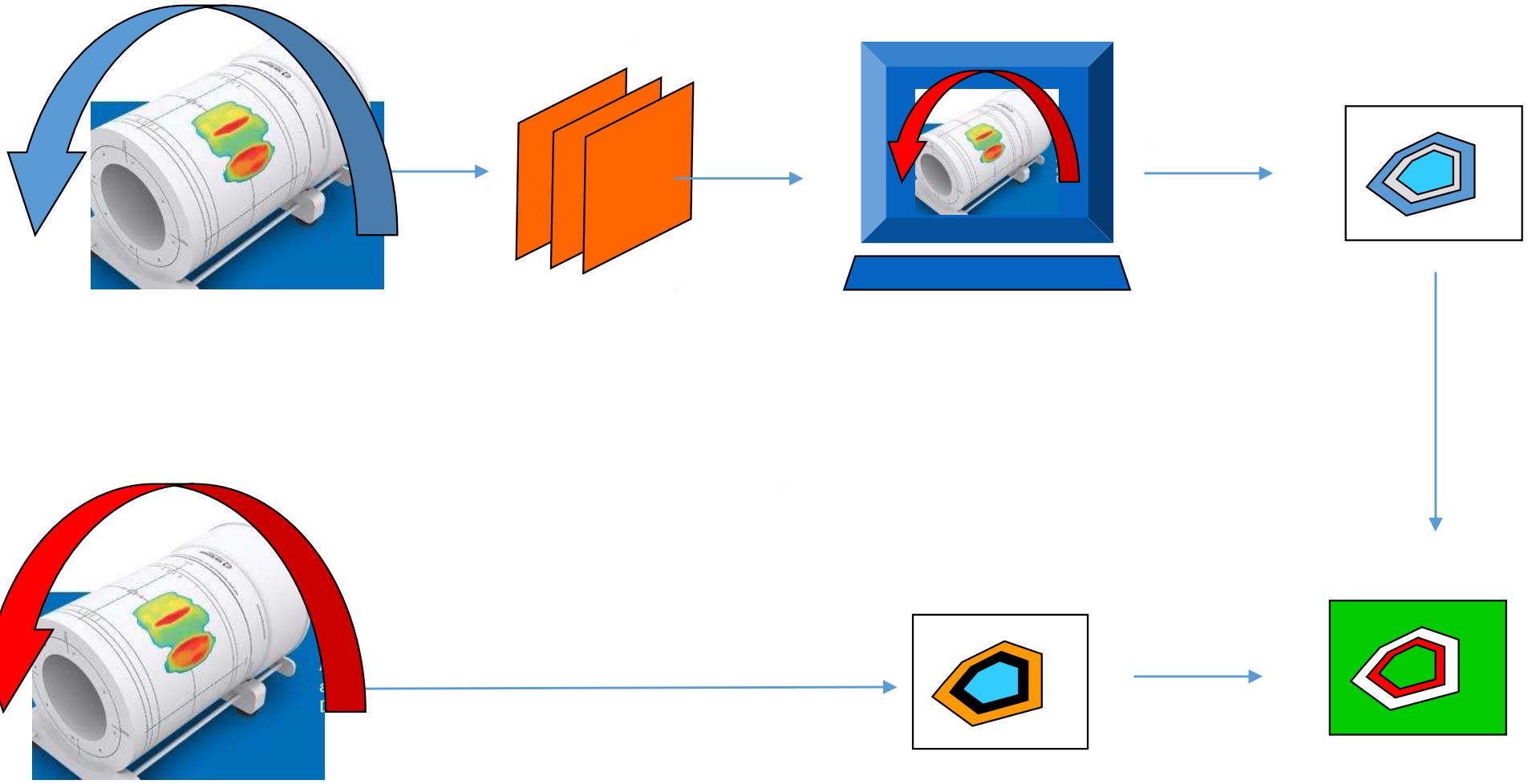


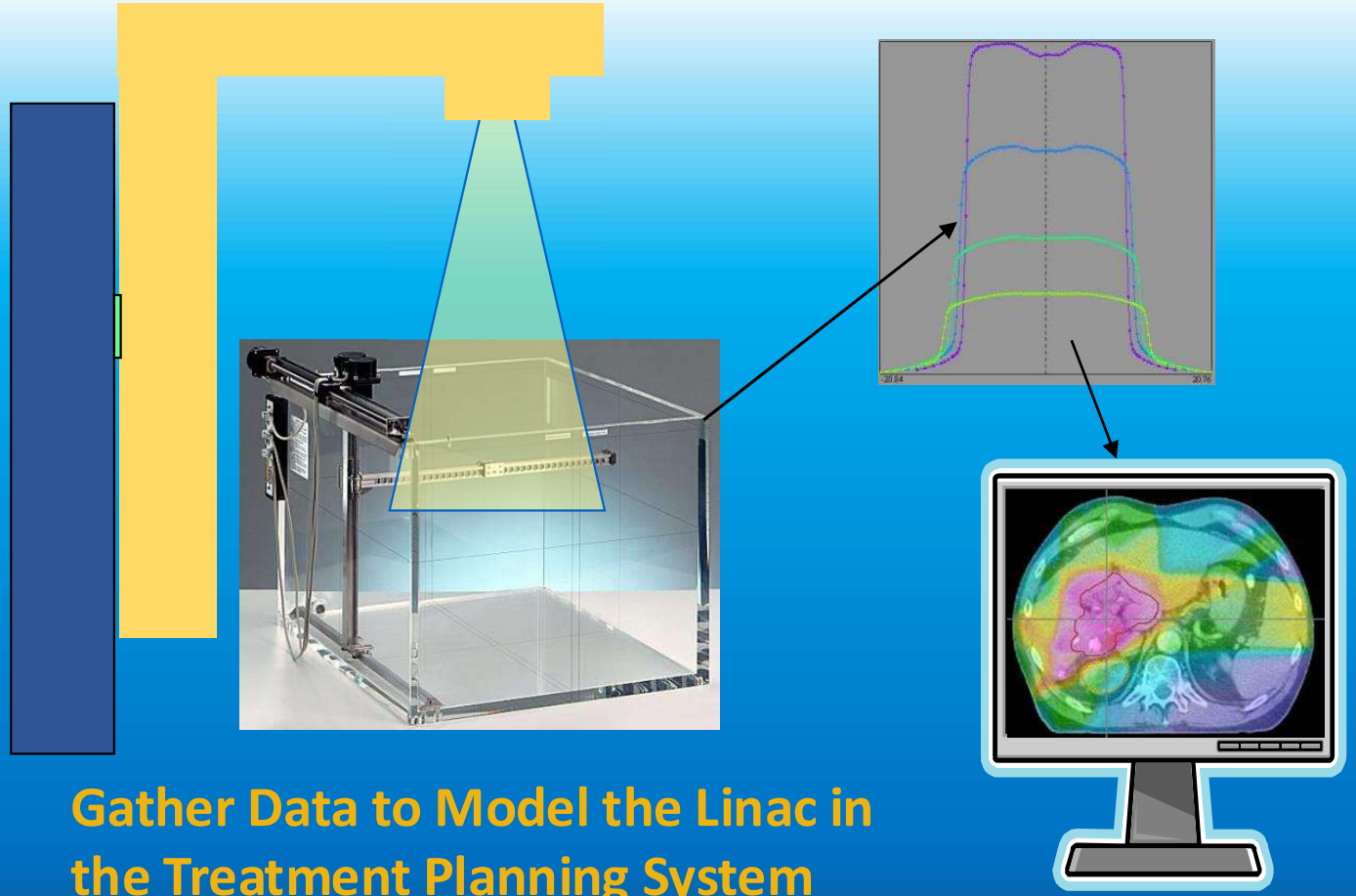
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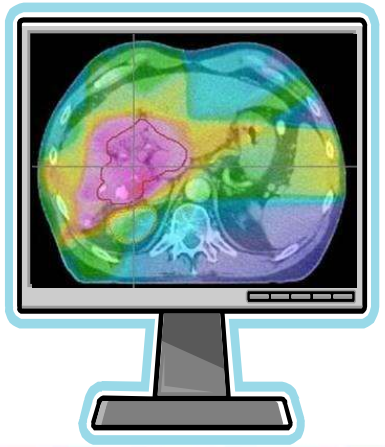


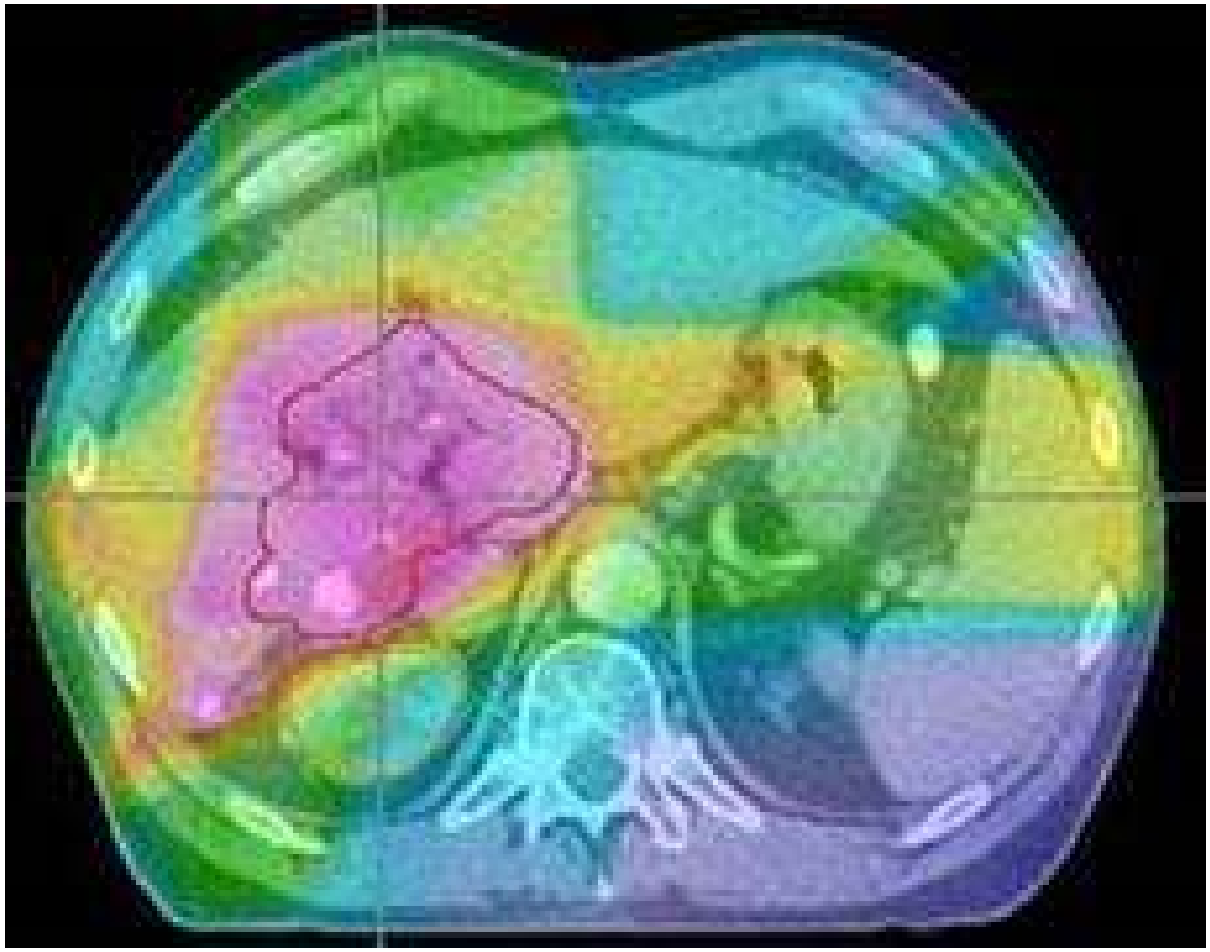

Absolute
4800.0 cGy
4000.0 cGy





Gather Data to Model the Linac in the Treatment Planning System



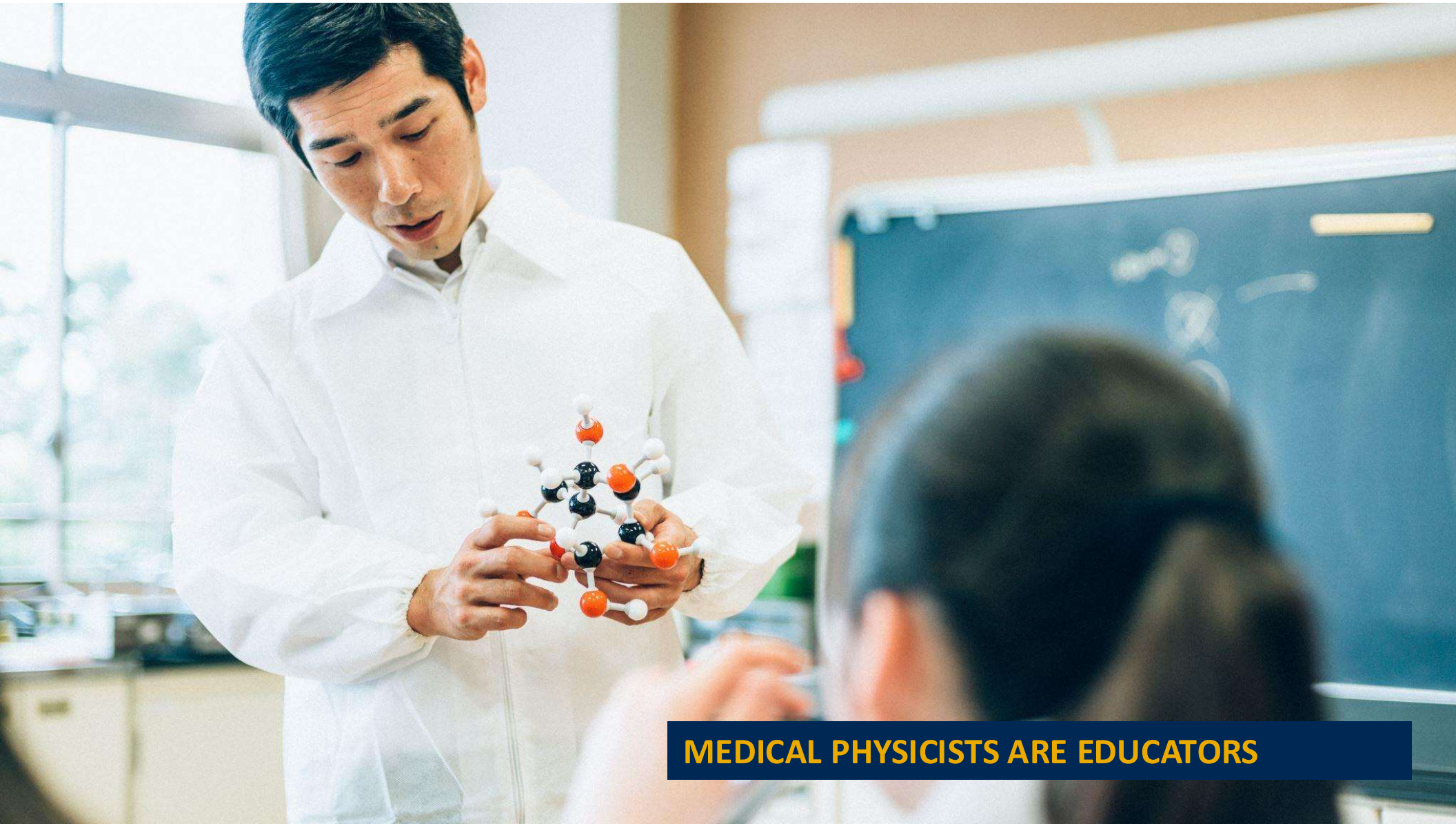


CREATE, CHECK, MODIFY TREATMENT PLANS

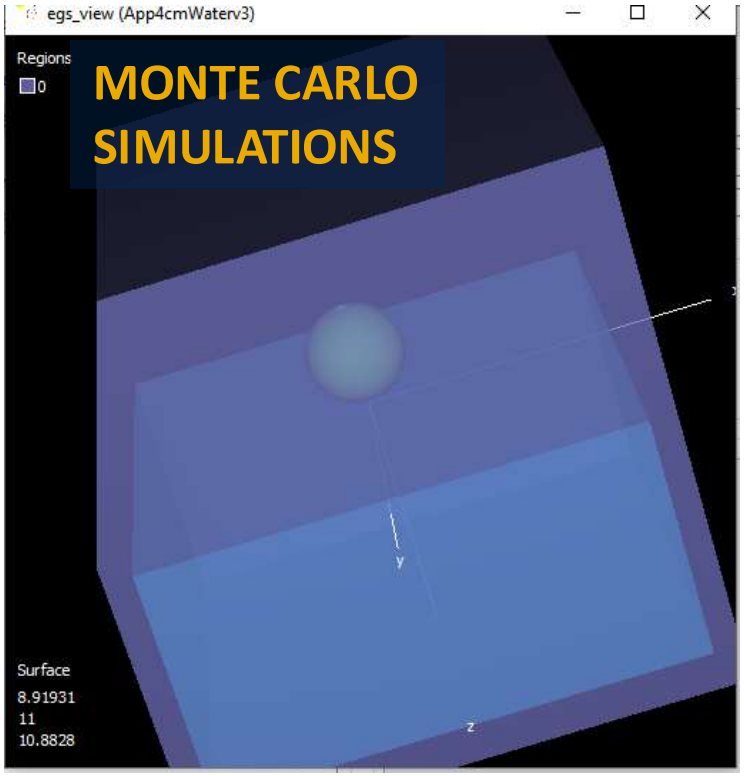

CONSULT WITH DOCTORS ON TREATMENT PLANS

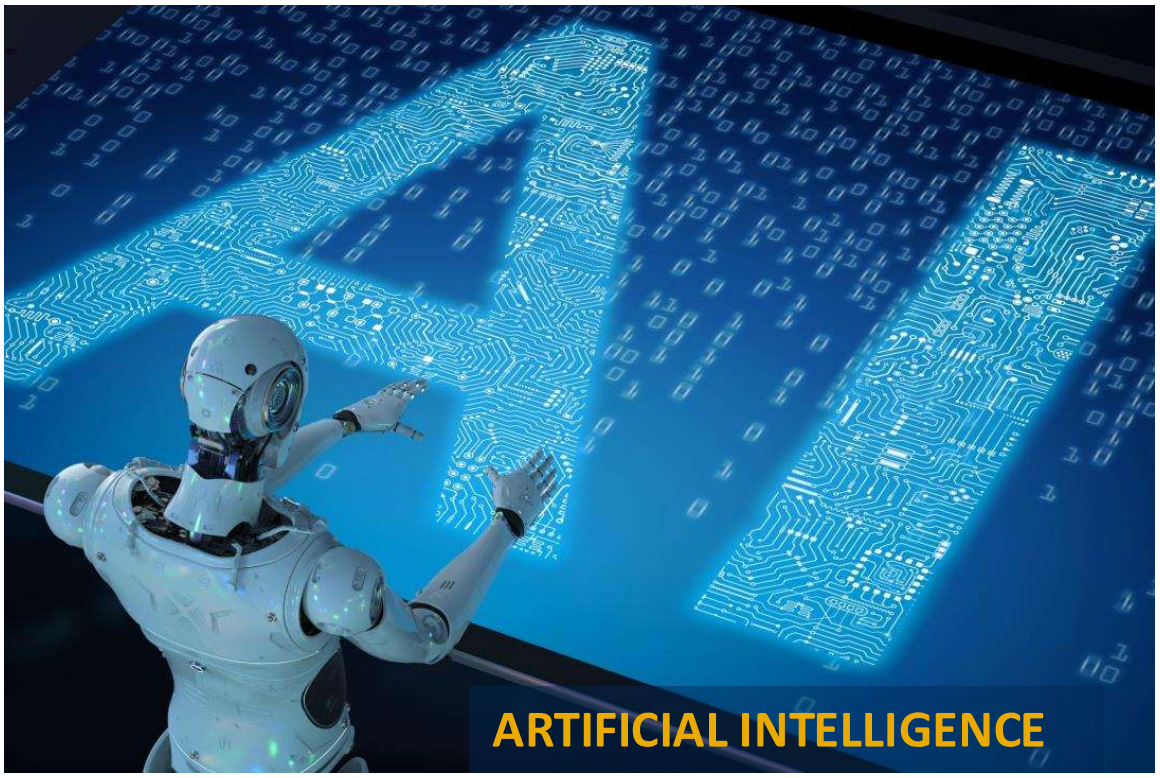

PARTICIPATE IN SPECIAL PROCEDURES,
SOME of which are IN THE Operating Room


MEDICAL PHYSICISTS INTERACT WITH PATIENTS


MEDICAL PHYSICISTS ARE EDUCATORS

Mountaineer Advanced Radiotherapy Computing and Informatics Applications (MARCIA)





https://patents.google.com/?inventor=ramon+alfredo+siochi&oq=ramon+alfredo+siochi&sort=new

ramon alfredo siochi

amon alfredo siochi;

present focused rad
O2004028633A1 • Ramon A
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PROTECTED VIEW Be careful—files from the Internet can contain viruses. Unless you need to edi

A1 search URL:

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1	search URL:	https://patents.google.com/?inventor=ramon+alfredo+siochi&s	
2	id	title	assignee
3	WO-2004028633-A1	System to present focused radiation treatment area	Siemens
4	DE-10250378-A1	Extended field area defining method for radio therapy	Siemens
5	JP-2003175118-A	Method for controlling radiation and system for contro	Siemens
6	JP-2003144564-A	Method and apparatus for reconstituting intensity ma	Siemens
7	US-6907282-B2	Intensity map resampling for multi-leaf collimator con	Siemens
8	DE-10141069-A1	Process to impart X-ray treatment by sequential move	Siemens
9	DE-10141068-A1	Method and system for controlling radiation delivery t	Siemens
10	JP-2002119603-A	Method for feeding ray to medical treatment area fror	Siemens
11	JP-2002136612-A	Method and apparatus for supplying radiation from ra	Siemens
12	JP-2001218858-A	Method and system for controlling radiation emission	Siemens
13	JP-2001224698-A	Method and system for defining intensity map for use	Siemens
14	US-6353655-B1	System and method for calculating fluence contributic	Siemens
15	DE-10002015-A1	Method and system for delivering radiation from a sou	Siemens
16	CA-2287586-A1	System and method for calculating scatter radiation	Siemens
17	JP-2000037467-A	Dosage correcting device and method for use in radiat	Siemens
18	US-6142925-A	Method and system for increasing resolution in a radic	Siemens
19	EP-0904805-A3	System and method for radiation therapy delivery	Siemens
20	EP-0905714-A2	Dynamic sub-space intensity modulation	Siemens
21	JP-H1071214-A	Method and device for controlling radiation output en	Siemens
22	JP-H1085347-A	Method and device for adjusting radiation outputs	Siemens
23			
24			

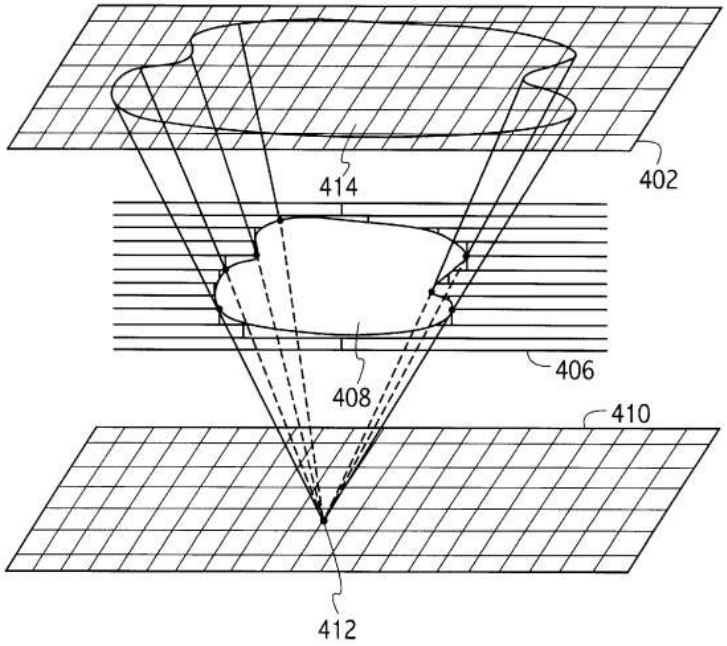


FIG. 4

Algorithm used in Dose Calculation

INVENT AND PATENT

MEDICAL PHYSICISTS DEPLOY NEW TECHNOLOGY

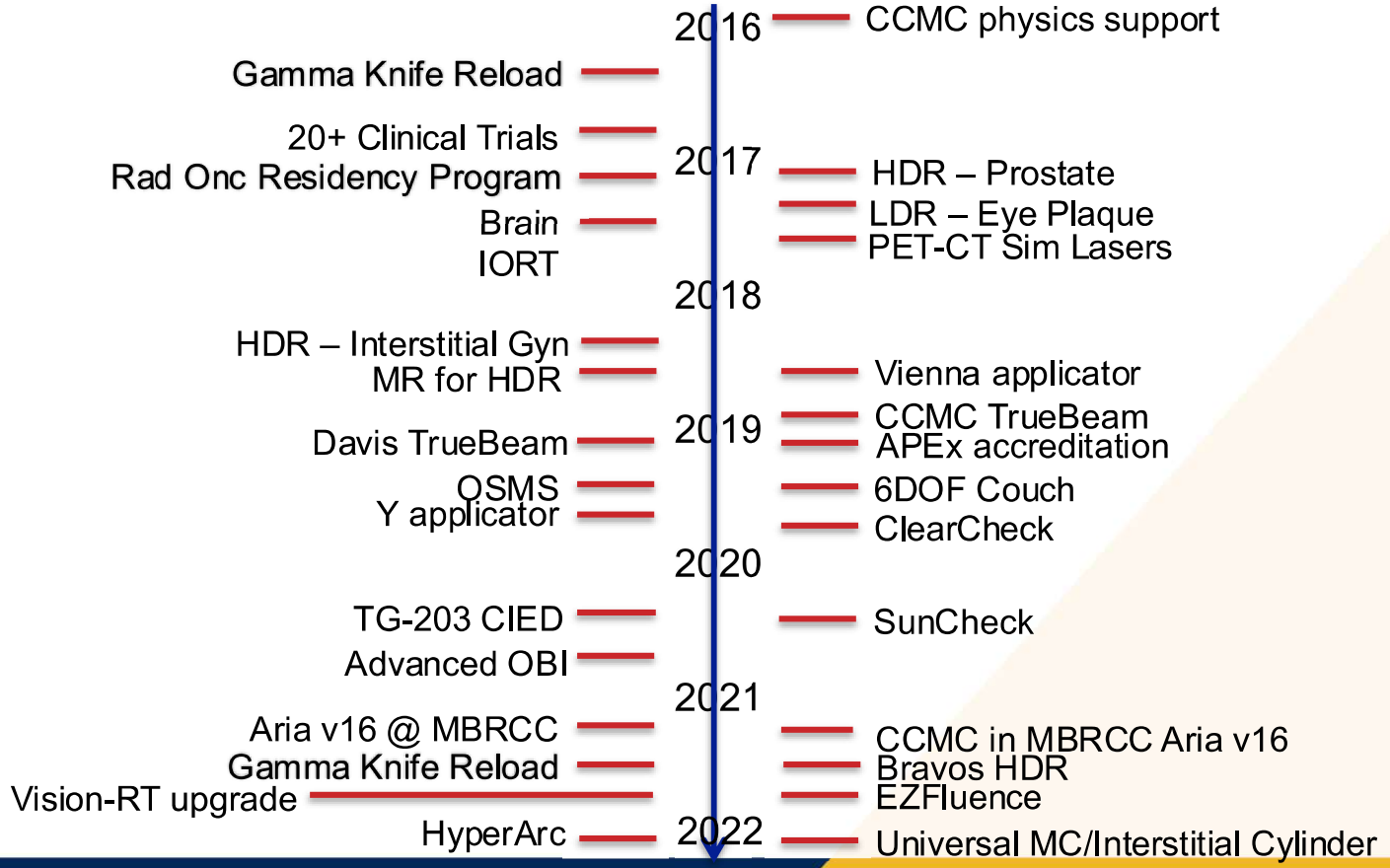
WVU 2010-2016





- 2010: Gamma Knife Perfexion
- 2011
- 2012: Trilogy/IGRT/RapidArc; SBRT
- 2013: TrueBeam; Fairmont - iX
- 2014
- 2015: 4+ Clinical Trials; Breast IORT; Medical Physics Division established; Gated RT; ACR accreditation
- 2016: EPIC-Aria interface

Accomplishments 2016 - 2022



https://www.infondrian.com/chartalert

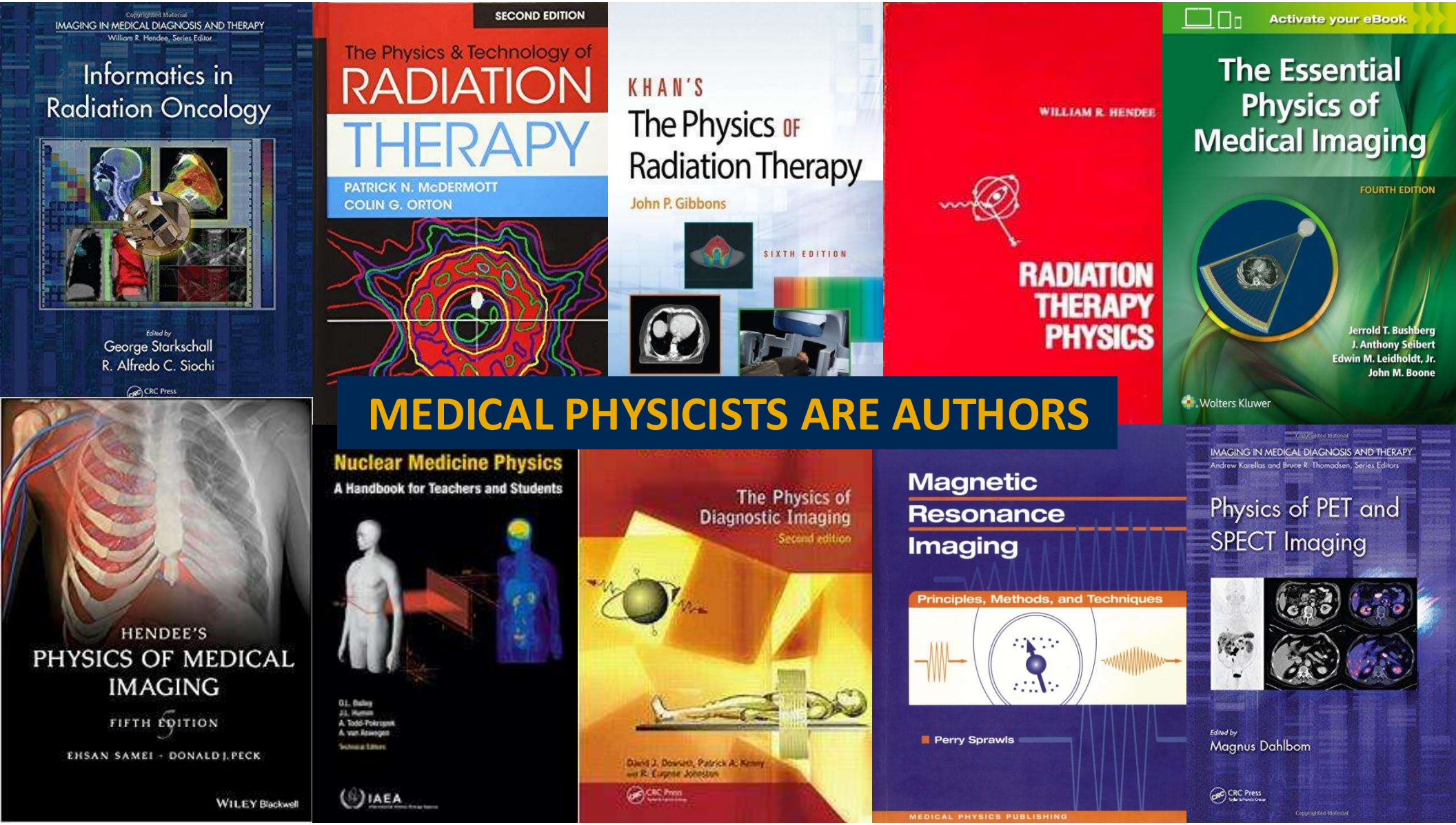
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MEDICAL PHYSICISTS ARE ENTREPRENEURS

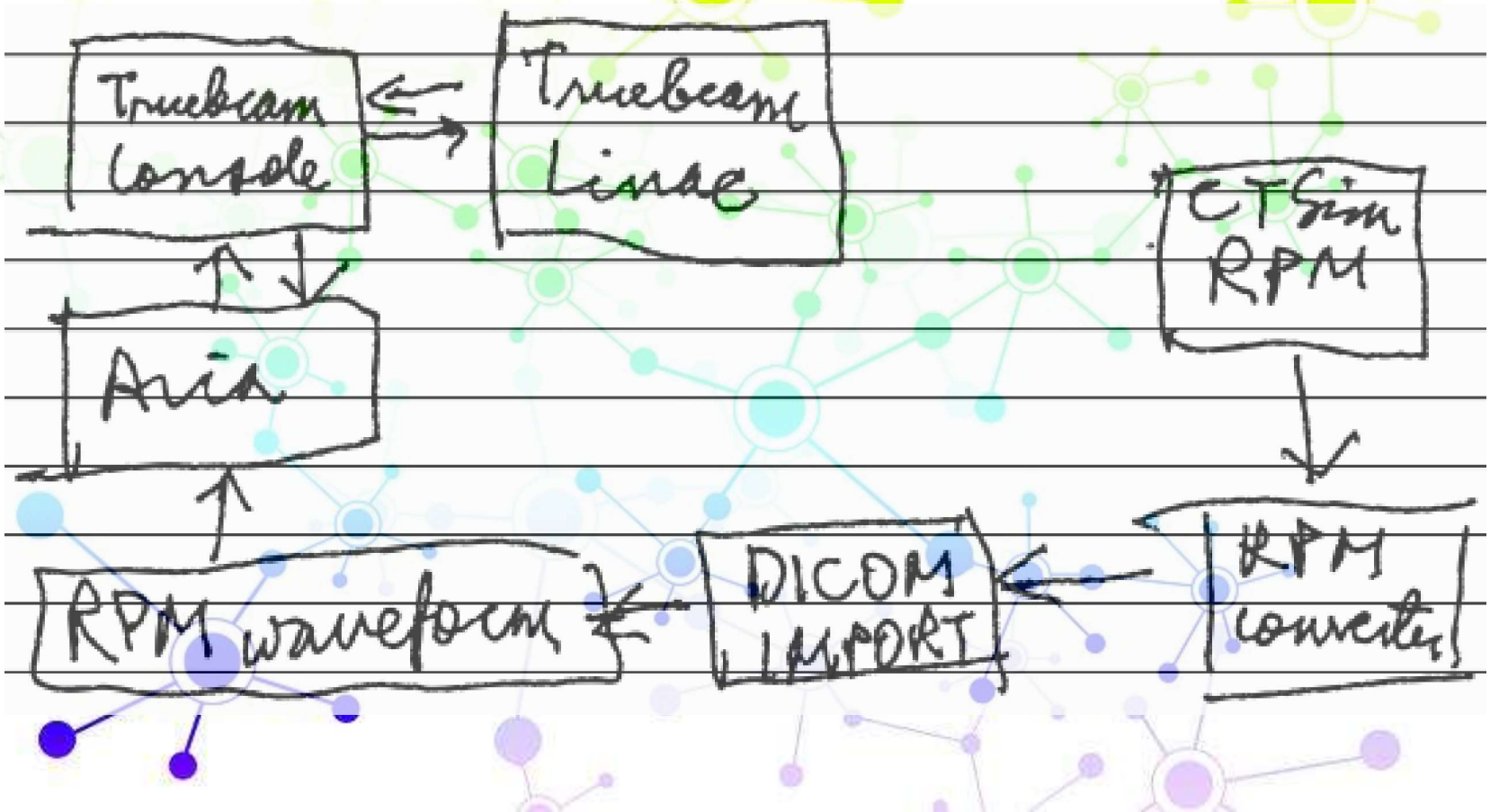


MEDICAL PHYSICISTS ARE AUTHORS

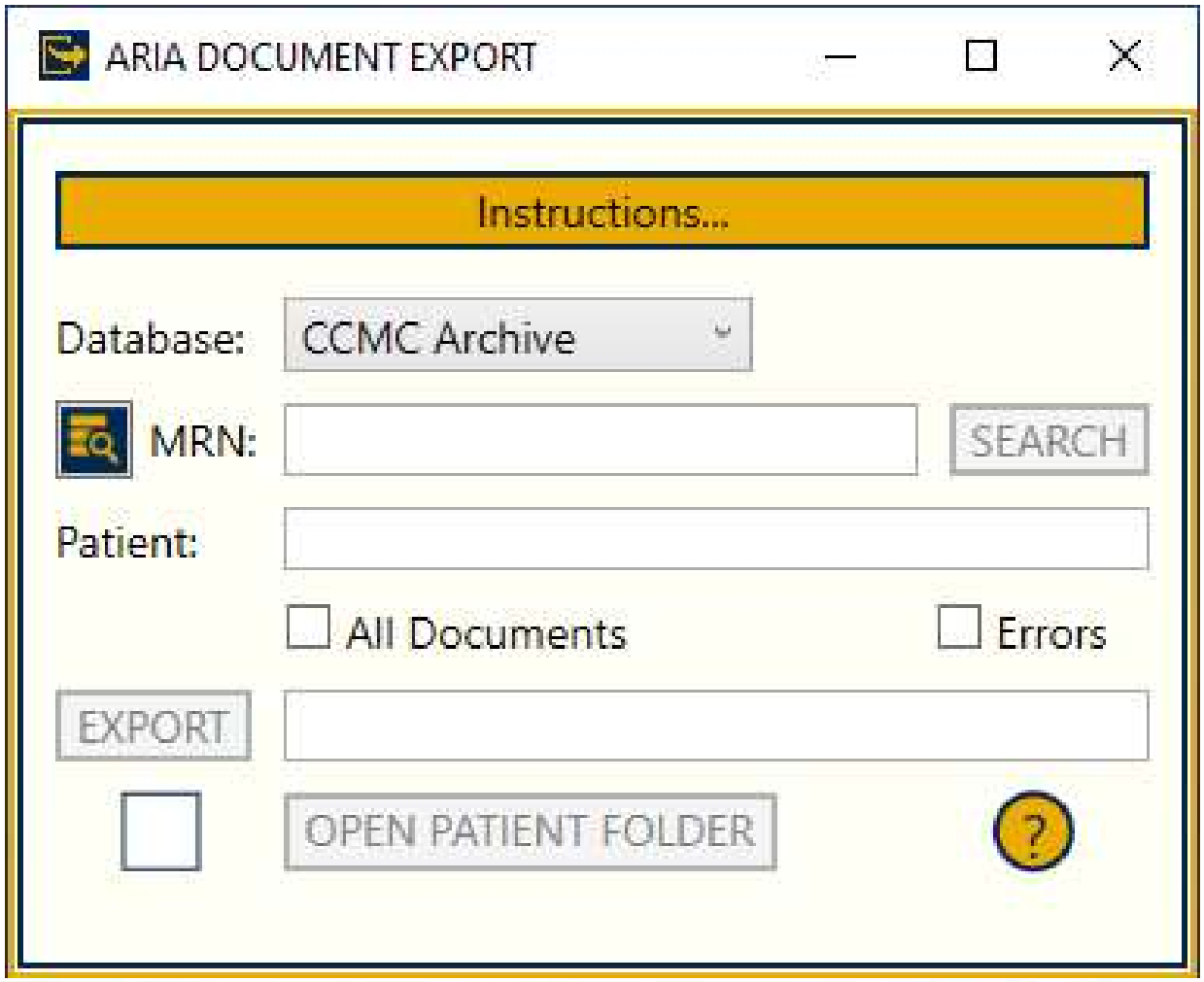

MEDICAL PHYSICISTS ALSO KNOW Information Technology

MEDICAL PHYSICISTS KEEP TRACK OF DATA

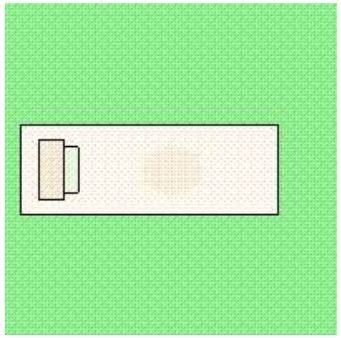
- **For Treatment**
- **For Research**

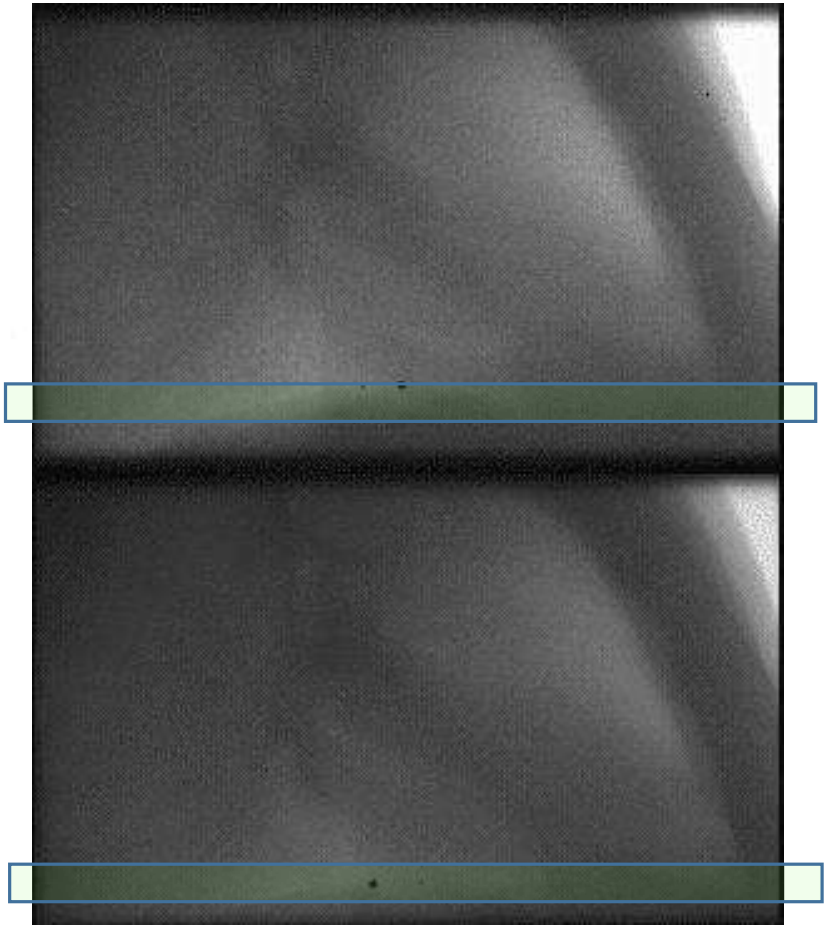


MEDICAL PHYSICISTS WRITE SOFTWARE




MISSION: IMPOSSIBLE

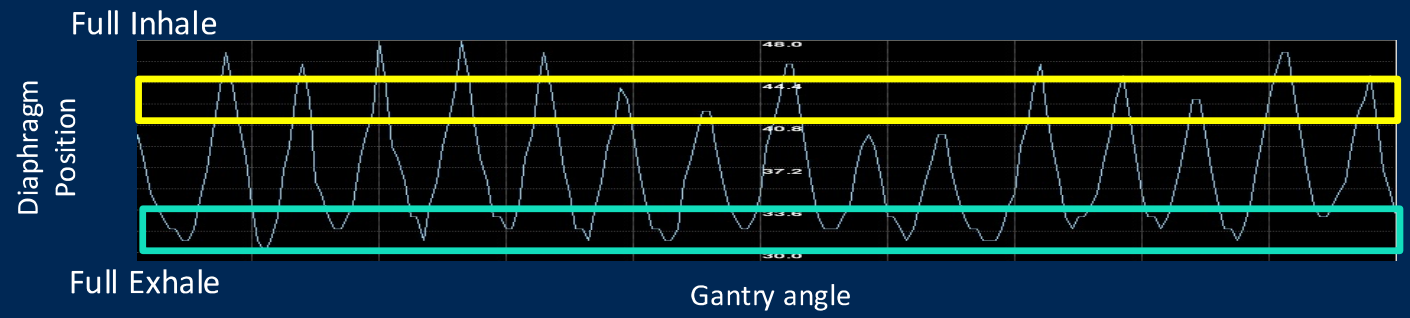




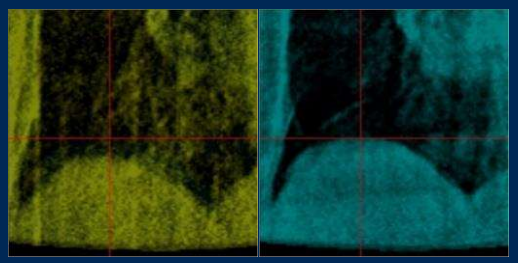
Solve Clinical Problems.
Reverse Engineer.
Develop and Deploy Solutions.

CLINICALLY MOTIVATED RESEARCH

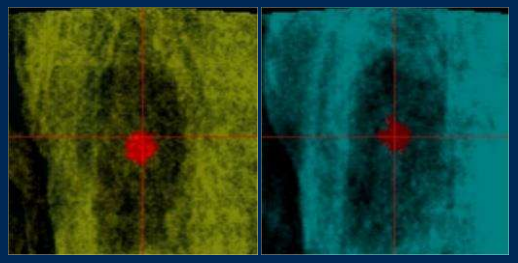
Tumor Motion from CBCT



Sort projections using the IHDA trace and reconstruct
Full Inhale and Full Exhale MV CBCTs.



Diaphragm motion



Tumor motion

Determine Diaphragm to Tumor motion ratio

Outline

- DIAGNOSIS
  - THE CT
- TREATMENT
  - THE LINAC
  - BRACHYTHERAPY
- WHAT MEDICAL PHYSICISTS DO
- CAREER PATHS
- HOW TO ENTER THE FIELD



CAREER PATHS

- ACADEMIA
  - PhD, Research, Teach, Clinical Service
- CLINIC
  - Academic departments, Hospitals, Clinics
- Industry
  - Device Manufacturers, Software Development
- Public Service
  - Regulatory (FDA, NRC), Research (NIH)
- Leadership Roles – in all areas
- And switching across careers.

Typical Pathway - CLINIC

- BS PHYSICS
  - or STEM field with certain physics courses
- MS in Medical Physics
- 2- Year Residency
  - Therapy
  - Diagnostic
  - Nuclear Medicine
- BOARD EXAMS

Less Common Pathway - Clinic



- Doctor of Medical Physics
  - Combines the MS medical physics and residency into one program
  - Vanderbilt, UNLV, UTHS, Wayne State
- NOT A PHD
- Professional degree, preparation for the clinic

Academic Career Pathway

- BS PHYSICS
  - or STEM field with certain physics courses
- PhD in Medical Physics
- 2- Year Residency
  - Therapy
  - Diagnostic
  - Nuclear Medicine

Non-Clinical Careers

- Clinical Career Pathways are still beneficial
  - especially in applications and device development in industry.
  - But a residency and board exams are not needed in many cases
- Non-clinical careers requiring or preferring board certification still need to follow a clinical pathway

WHY BECOME A MEDICAL PHYSICIST?

- ALWAYS EXCITING, ALWAYS LEARNING
  - NEVER A DULL MOMENT
  - FIELD KEEPS GROWING AND CHANGING
- FILL AN IMPORTANT NEED
  - An aging population means growing healthcare demands
- MAKE A DIFFERENCE
  - Don’t just go to work and punch a clock
  - Be part of a team that heals and cares




QUESTIONS?