Medical Applications

# of Particle Physics

HST2022 GROUP 3:

Alisher Arstanbek,

Funda Kaçan,

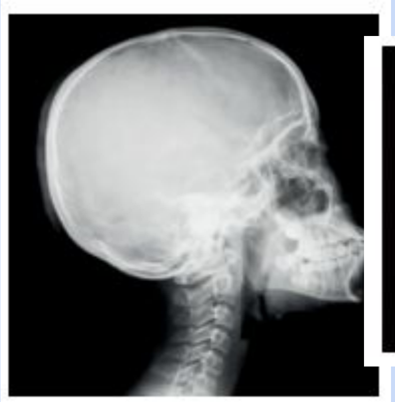
Janine Nauw,

Koko Dove

1) Curriculum and Classroom Connections

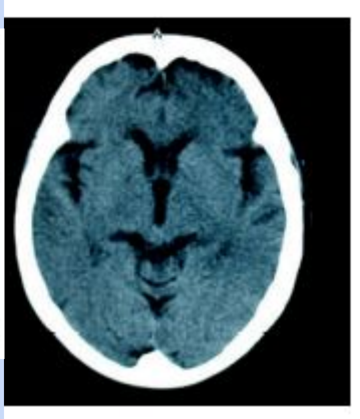
- Radiation (all)
- Medical imaging & therapy (the Netherlands)
- Electric and magnetic fields (all)
- Particle accelerators as an application (the Netherlands)

Echo

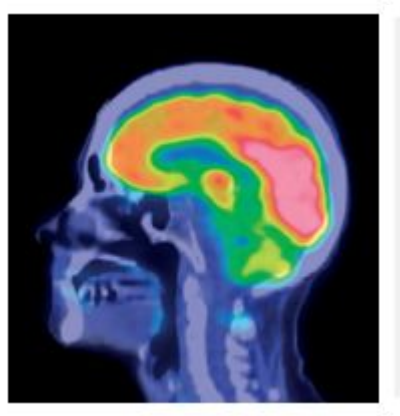


X-ray

MRI



CT



PET

gamma

1) Curriculum and Classroom Connections

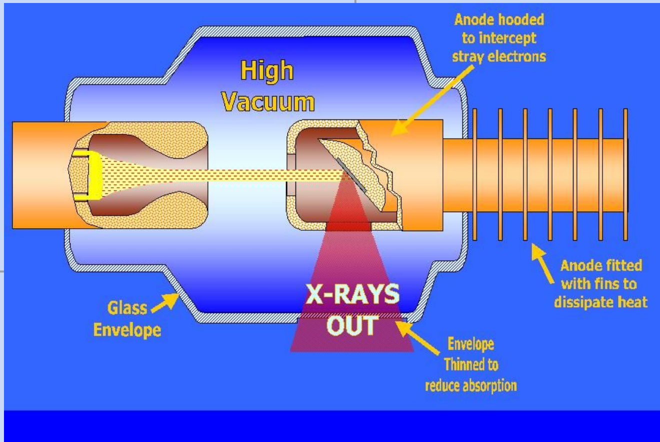
The part of the application of particle physics ’Applications of Modern Physics on Technology’, ‘X-rays and LASERs’ , ‘Scientific Research Centers’

Some of students’ objectives of that part ;

- Explain the effects of X-rays on organisms
- Explain the production process of X-rays
- Give examples to the usage of LASERs in technology
- Research and present the aim of scientific researches made in national and international SRCs like TÜBİTAK (national one) , CERN and NASA
- Discuss the possible effects of studies, done in SRCs, on science and technology
- Explain which medical imaging would be best for certain patients

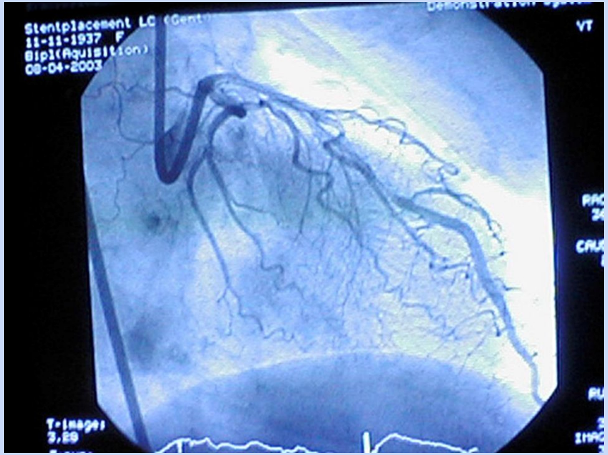
2) Key Ideas

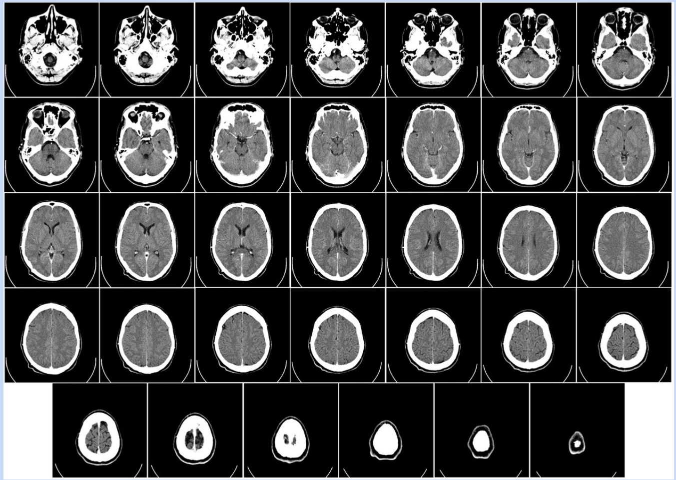
Imaging	Therapy
Detectors	Accelerators
• X-ray (and contrast fluid) • Nuclear diagnostics • Magnetic Resonance Imaging (MRI) • Computed tomography (CT) • Positron emission tomography (PET) • Single-photon emission computed tomography (SPECT) • Echo	• Radiation therapy • X-ray tube • Particle therapy



2) Key Ideas - Why does it matter?

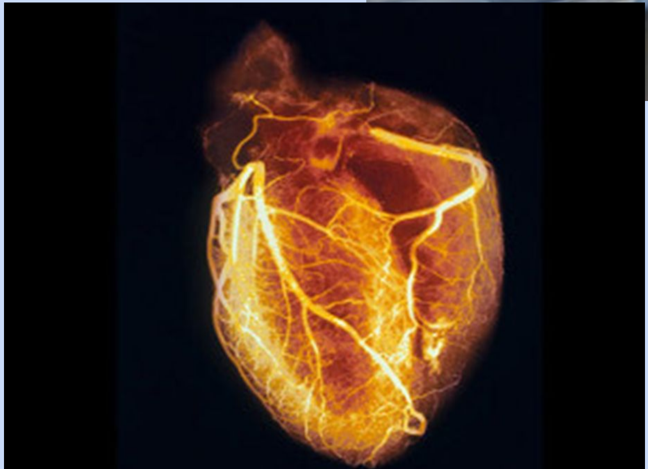
- Medical applications represent the largest use of particle physics!
- Students need to know why it is important - inspiration and career choices (girls!)
- Advances in scientific technology - early detection, targeted treatment
- Connections to biology - cancer, effect of radiation on organic matter.



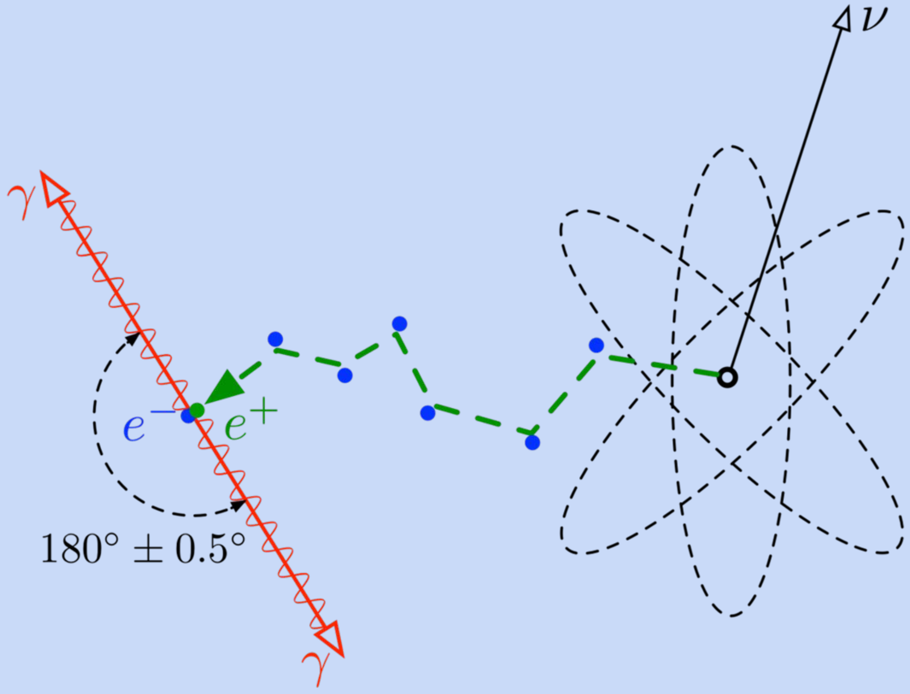


2) Key Ideas - Important Aspects for Teaching

- Types of radiation and their penetration depths
- Medical imaging techniques
- Therapies
- How each technology works
- Rationale for use



PET

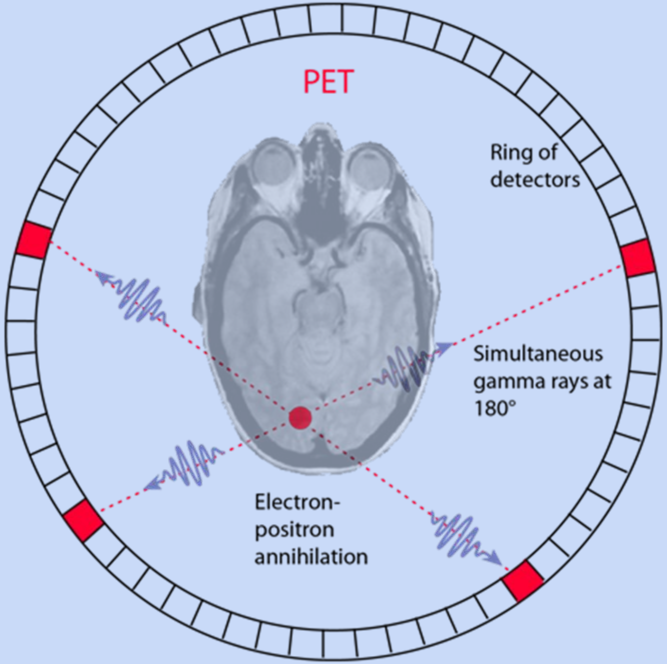


e^+ positron

e^- electron

ν neutrino

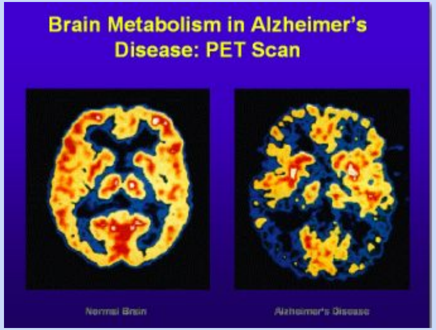
γ quantum/photon (511 keV)

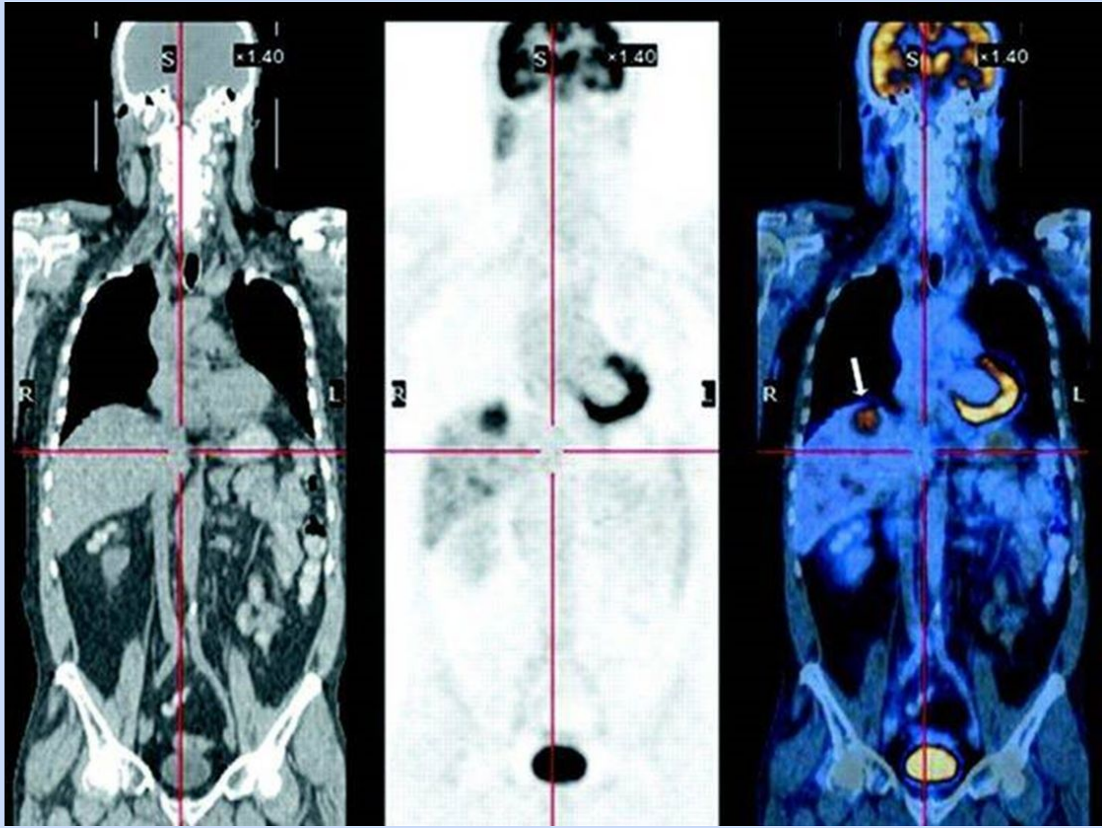


PET & CT

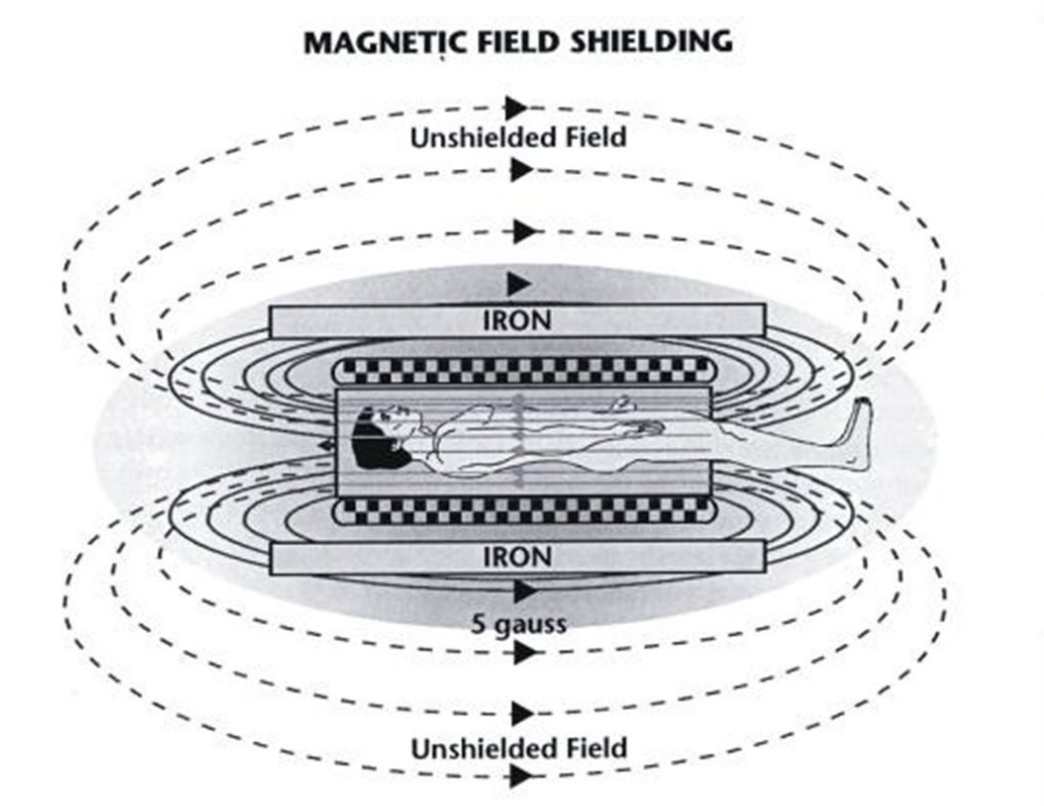
PET - body functions

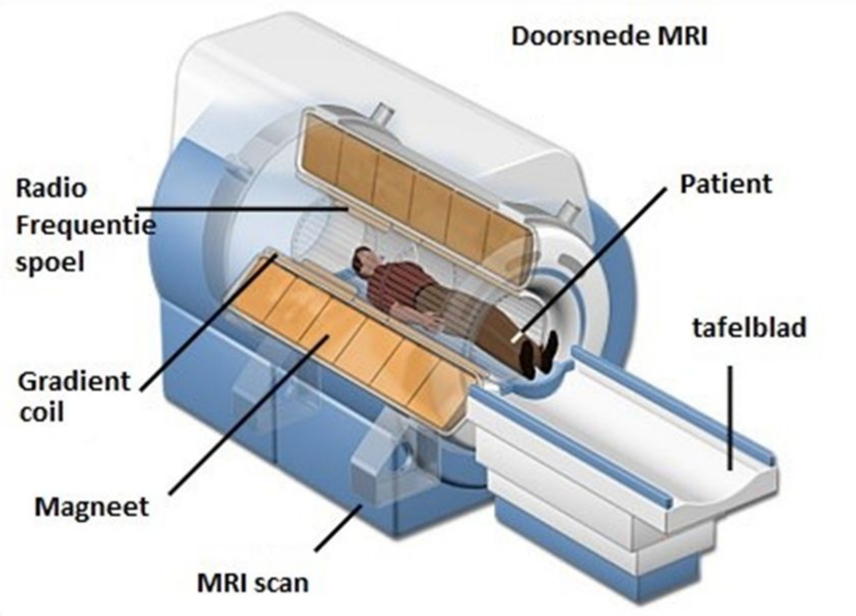
CT - anatomy



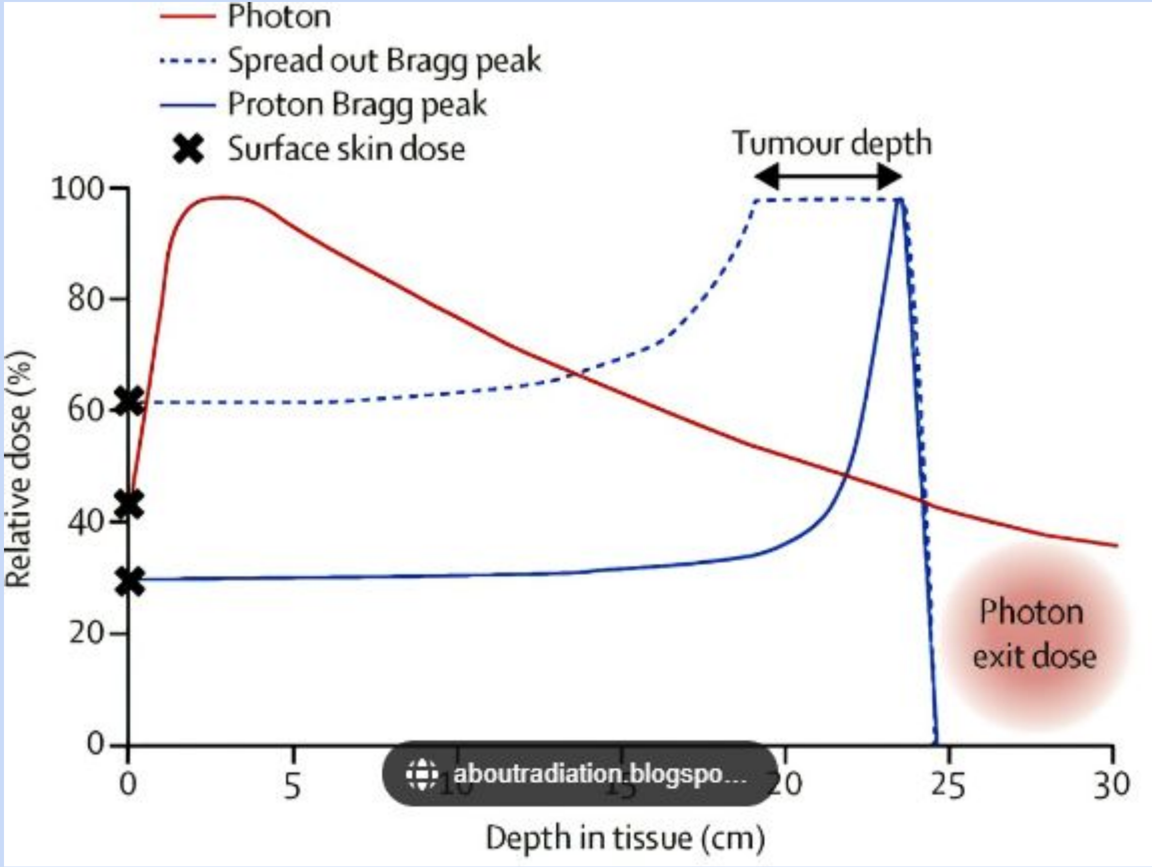


MRI


MAGNETIC FIELD SHIELDING
Unshielded Field
IRON
IRON
5 gauss
Unshielded Field


Doorsnede MRI
Radio
Frequentie
spoel
Patient
tafelblad
Gradient
coil
Magneet
MRI scan

X-ray/gamma vs. Proton therapy



3) Potential Students' Conceptions and Challenges

- Radiation is dangerous and something to be afraid of
- Protons and neutrons are the smallest known particles
- Difficulty distinguishing between uses of EMR of different wavelengths
- Difficulty distinguishing between the use of particles themselves
- Misunderstanding about ways cancer is treated
- Incomplete understanding about how imaging works
- Electrons are particles
- Photons are waves

4) Helpful Materials and Resources

cern.ch/PER

Natuurkunde Overal (Robert Bouwens, Noordhoff uitgevers) (in Dutch)

BINAS (in Dutch)

https://natuurkundeuitgelegd.nl/examenindex.php (in Dutch)

Presentation by Manjit Doosanjh

https://www.symmetrymagazine.org/article/november-2013/how-particle-physics-can-save-your-life

https://indico.cern.ch/event/505656/contributions/2178989/attachments/1286957/1914803/Medical_applications_-_Sparsh.pdf

https://iopscience.iop.org/book/978-0-7503-1444-2/chapter/bk978-0-7503-1444-2ch1#bk978-0-7503-1444-2ch1s2

https://seeiist.eu/

https://enlight.web.cern.ch/media/videos/virtual-particle-therapy-centre

5) Best Practice Example

4 pillars of technology:

- Accelerating
- Detecting
- Computing
- **Collaboration** - Interdisciplinary unit between Biology and Physics on Medical Application of Particle Physics

Discussions on topics like FLASH for cancer treatment to inspire the new generation to participate in such projects to make them a reality.

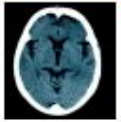
5) Best Practice Example

Imaging technique	physics	application	advantages	disadvantages
				Small radiation dose, soft tissue hardly visible
CT-scan				
			No radiation load	
	Reflection of sound wave			
Nuclear diagnostic				

DATA SHEET (BINAS)

- Techniques
- Physics
- Principle
- Application
- Example of an image

29 Medische beeldvorming

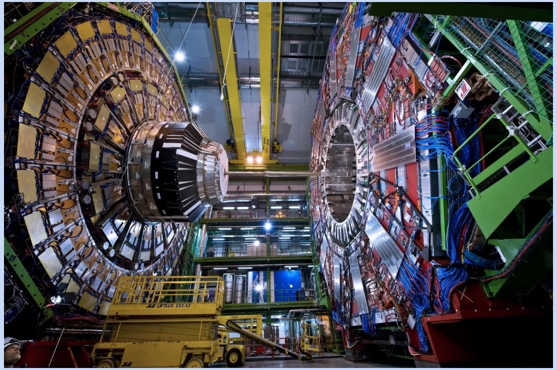
techniek	*fysische waarden*	*registratieprincipe*	*toepassingen*	*beeld*
echografie	frequentie geluidsgolven: 1-20 MHz routine; tot 50 MHz intraveneus	reflectie van ultrageluid 2D, 3D en 4D (3D in de tijd)	zwangerschapsonderzoek, sportblessures, doorstroming vaatbed (Doppler), afbeeldingen van buikorganen	
röntgenfoto	energie: 20-150 keV effectieve dosis: 0,01-0,1mSv	verzwakking van röntgenstraling 2D	skelet, mammografie, gebit, buikoverzicht, thorax, longen, spijsverteringskanaal	
doorlichting met röntgenstraling	energie: 50-125 keV effectieve dosis: 0,1-20 mSv	verzwakking van röntgenstraling in combinatie met röntgencontrastmiddelen; levert röntgenfilmpjes 2D	beeldvorming tijdens operaties, functieonderzoek (slikken, maag en darm), angio- en cardiografie (afbeelding en katheterisatie hart- en bloedvaten; stenting en dotterbehandelingen)	
CT (computer-tomografie)	effectieve dosis: 0,1-20 mSv	verzwakking van röntgenstraling vanuit 360° levert dwarsdoorsneden 3D beelden 4D datasets	kankeronderzoek, onderzoek naar zachte weefsels, spoedeisende hulp (letsels, bloedingen), perfusie (herseninfarct), afbeelding van het hart: 3D opname van orgaan binnen 0,5 s	
MRI (magnetic resonance imaging)	magneetveld: 0,1-12T frequentie radiogolven: 42,58 MHz T^{-1}	resonantie van protonspins met radiogolven in een uitwendig magnetisch veld (Zeemaneffect) 3D en 4D	onderzoek naar hersenen, gewrichten, buikorganen, hart- en hersenfunctie, diffusie van water in weefsels, doorbloeding van organen, borsten	
PET (positron-emissie-tomografie)	energie: 0,511 MeV effectieve dosis: 1,5-5 mSv	gelijktijdige registratie van fotonen uit annihilatie van positronen uit radioactief vervalproces geeft lokalisatie van radioactieve stof in 3D	weefselonderzoek, kankeronderzoek (vaak in combinatie met CT-scan), onderzoek naar transportprocessen stofwisseling	
gammacamera	effectieve dosis: 2-16 mSv	registreren van gammastraling uit radioactieve vervalprocessen 2D of 3D (SPECT: single photon emission computed tomography)	kankeronderzoek, opsporen van uitzaaiingen, hartfunctie (SPECT), onderzoek naar de fysiologie van organen	

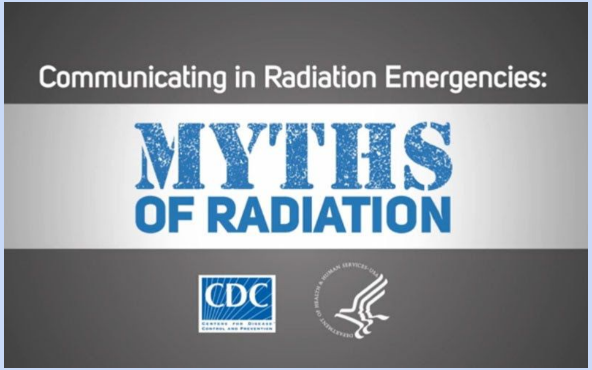
Imaging technique	**physics**	**application**	**advantages**	**disadvantages**
X-ray	*Absorption of X-ray radiation*	*Bones, theet, lungs*	*Cheep, fast*	**Small radiation dose, soft tissue hardly visible**
CT-scan	*Absorption of X-ray radiation*	*Soft tissue* *Cancer research*	*3D image, large contrast*	*High radiation load*
MRI	*Resonance of H-cores in dipole field*	*Brain, joints,*	**No radiation load**	*Blood flow*
Echo	**Reflection of sound wave**	*Pregnancy, blood flow*	*No radiation load, cheap, fast*	*No clear image,* *Not suitable bones*
Nuclear diagnostic	*Emitting radioactive radiation, radioactive decay*	*Using tracer, organ function,locate tumors*	*Good image of the processes in the body*	*Medium high radiation load*

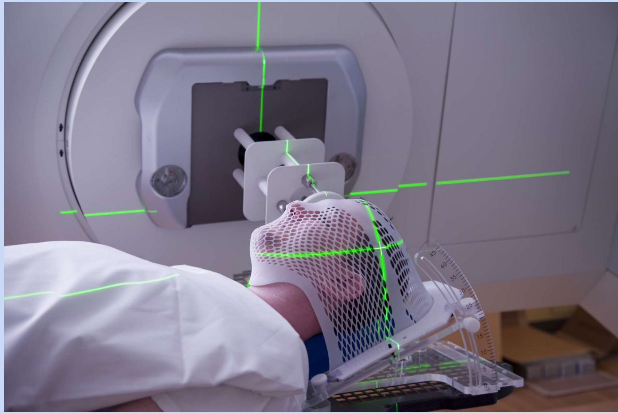
Summary

Teaching medical applications of particle physics should be part of the curriculum:

- The best example of application of particle physics research
- Information - Career opportunities
- Many misconceptions amongst students
- Practical example of the use of particle accelerators, particle detectors and treatments







Thank you for listening!