Special Topic: Medication and Physics

1. Introduction

The mechanism of life can be associated with electromagnetism and nuclear physics.

What is nuclear physics?

- This is the physics inside a nucleus, which contains protons and neutrons.
- Between protons and neutrons, there are different properties other than electromagnetism. → Nuclear Force (radiation, spins, etc.)

What is the relationship between medications and nuclear physics?

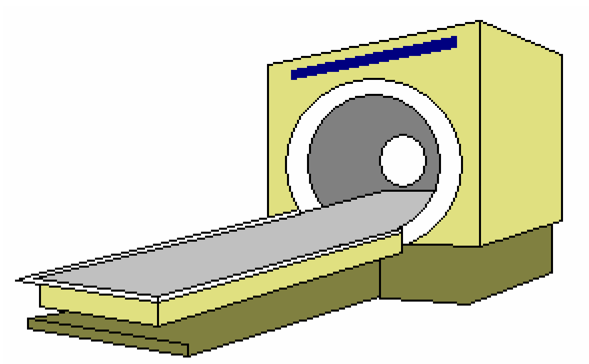
For a medication, if you use one of those, it is generally called **Nuclear Medicine**.

What are other important physics for the medication?

Electromagnetism, electromagnetic inductions, electromagnetic waves, optics

2. Examples for Medical Devices & Treatments

a) **MRI** (Magnetic Resonance Imaging)



→ The good capability of obtaining the images for soft tissues

→ Safer than others (e.g. x-rays, etc.)
Proton itself has a magnetic moment.

→Using an external magnetic field, the spin of proton gets resonated.

b) **PET** (Positron Emission Tomography)

The good capability of detecting the specific diseases, and diagnosing the specific organs

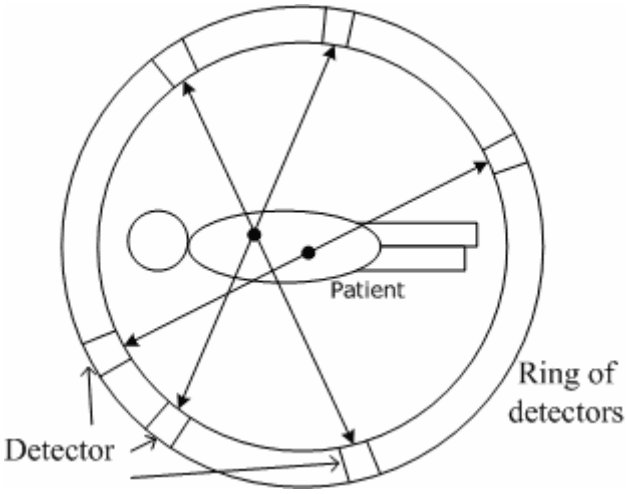
Table: Common radionuclides used in PET

Nuclide (half-life)	Production reactions	Common beam energies (MeV)	Diagnostic uses
^{11}C (20.4 m)	$^{14}N(p, \alpha)^{11}C$	14	Dopamine binding (brain) Heart metabolism Amino acid metabolism (cancer detection)
^{13}N (10.0 m)	$^{16}O(p, \alpha)^{13}N$ $^{13}C(p, n)^{13}N$	20 8	Heart blood flow Protein Synthesis
^{15}O (2.0 m)	$^{14}N(d, n)^{15}O$ $^{15}N(p, n)^{15}O$ $^{16}O(p, pn)^{15}O$	8 8 29	Brain blood flow Oxygen metabolism Blood volume
^{18}F (109.8 m)	$^{18}O(p, n)^{18}F$ $^{20}Ne(d, \alpha)^{18}F$	14 14	Glucose metabolism (all tissues) Dopamine synthesis (brain)

❖ For the procedure,

① Ingest radionuclides (^{11}C, ^{13}N, ^{15}O, and ^{18}F) in your body.

② Go into the detectors.



③ The radionuclides spontaneously emit γ-rays, and the detectors catch them.

c) **X-rays**

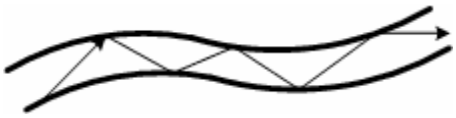
Electromagnetic Waves

❖ The property: X-rays are absorbed by the dense structure of bone much more than by soft tissue.

💣 It is safe, but still radioactive.

d) **Fiberscope**

Total internal reflection (Optics)

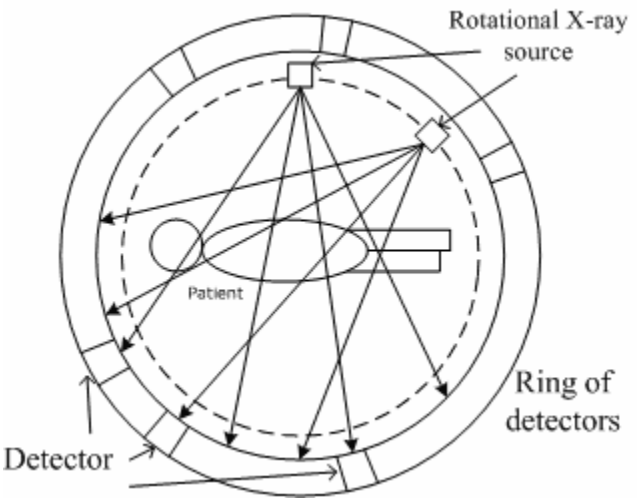


As a Technology

CT (Computed Tomography)

→ It is the technology to obtain two- or three-dimensional images.

c.f. CAT (Computed Axial Tomography)



3. Cancer Treatment with Proton Beam

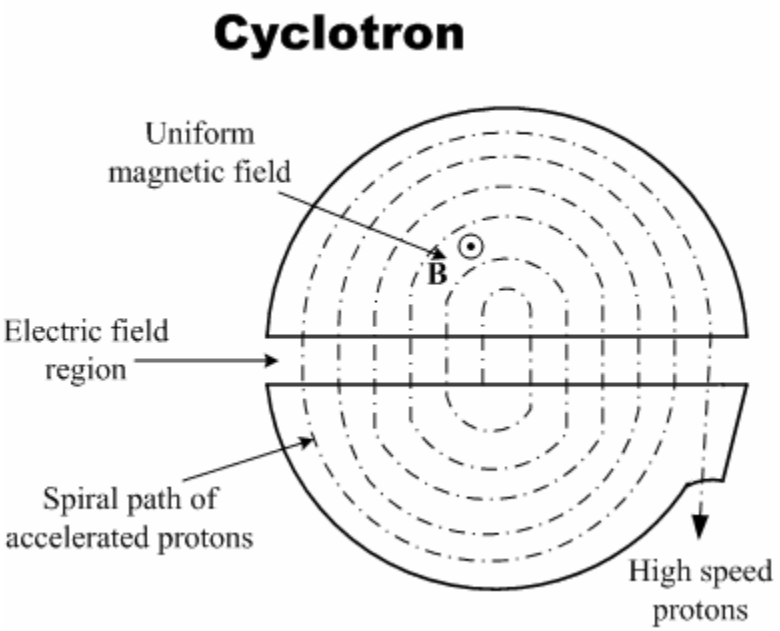
❖ <u>To destroy cancer cells, proton beam (protons with kinetic energy) is utilized for this treatment.</u>

✸ Preparation:

Use an idea of electric potential V
A proton gets a speed with a potential difference.

Use an idea of the Lorentz force
Using a magnetic field, the proton goes a circular orbit, and it is accelerated a longer distance in small space.

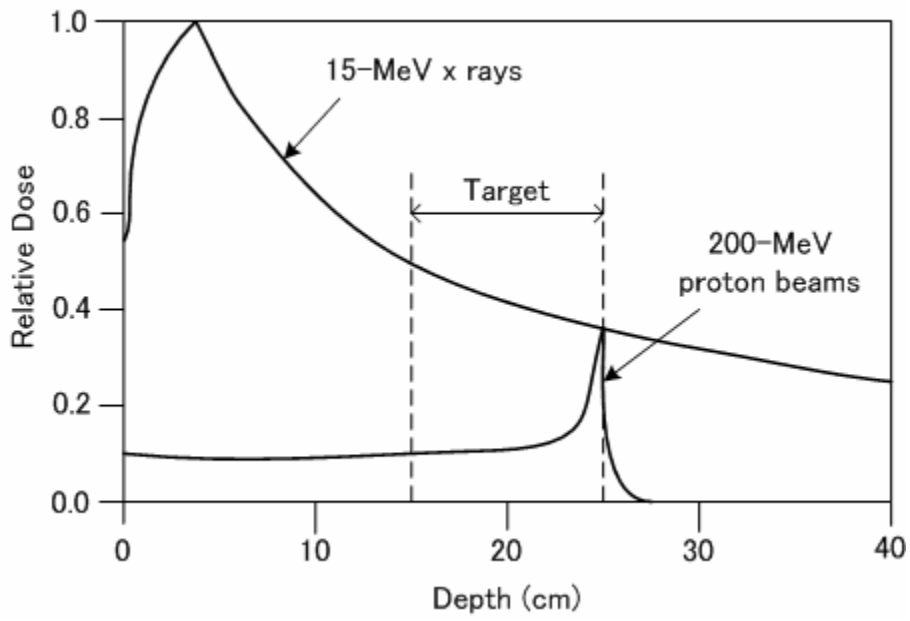
⇒ **The equipment is called <u>cyclotron</u>**.



✶The advantages of proton beam for cancer treatment:

→ It reaches the appropriate position of tumor with appropriate energy.

→ It does not destroy other healthy cells.



- Cancers and other diseases for the proton beam treatment:

Brain and spinal cord	➢ Isolated brain metastases ➢Pituitary adenomas ➢Arteriovenous malformations (AVMs)
Base of skull	➢Meningiomas ➢Acoustic neuromas ➢Chordomas and chondrosarcomas
Eye	➢Uveal melanomas ➢Macular degeneration
Head and neck	➢Nasopharynx ➢Oropharynx (locally advanced)
Chest and abdomen	➢Medically inoperable non-small-cell lung cancer ➢Chordomas and chondrosarcomas
Pelvis	➢Prostate ➢Chordomas and chondrosarcomas
Tumors in children	➢Brain ➢Orbital and ocular tumors ➢Sarcomas of the base of skull and spine

References

Physics Today, September 2002
Nuclear Physics, by John Lilley, Wiley