# Introduction to particle therapy
# &
# Status in India

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# The Cancer!

1. What cancer actually is?
2. Why so fear about cancer?
3. What if it is present in an essential organ of the body?
    1. Ex. Stomach, Pancreas, Lungs etc.
4. How it can be treated?

# How cancer occurs?

Cell Division / Death of old cells

Controlled by DNA

Growth of Human body

Damaged DNA

Repaired

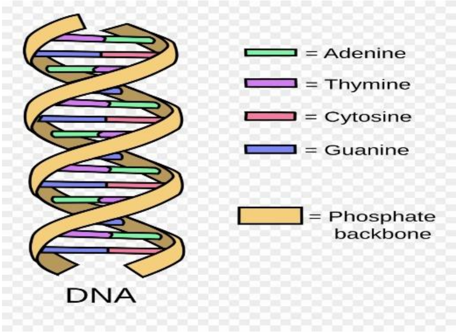
Wrongly Repaired

Cell Death

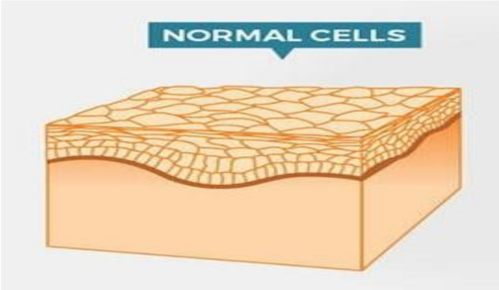
Uncontrolled Growth of cells

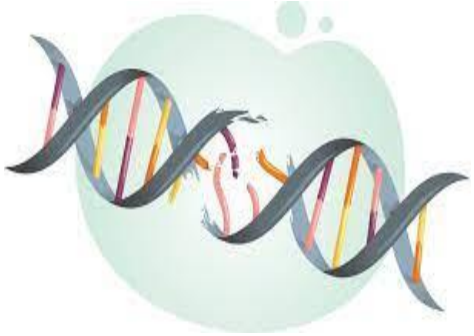
Cancer

Spread from one part to other: Malignant cancer

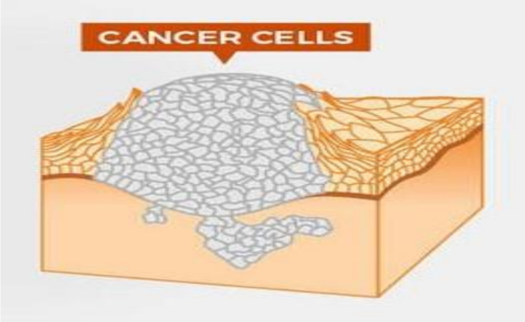



Normal DNA

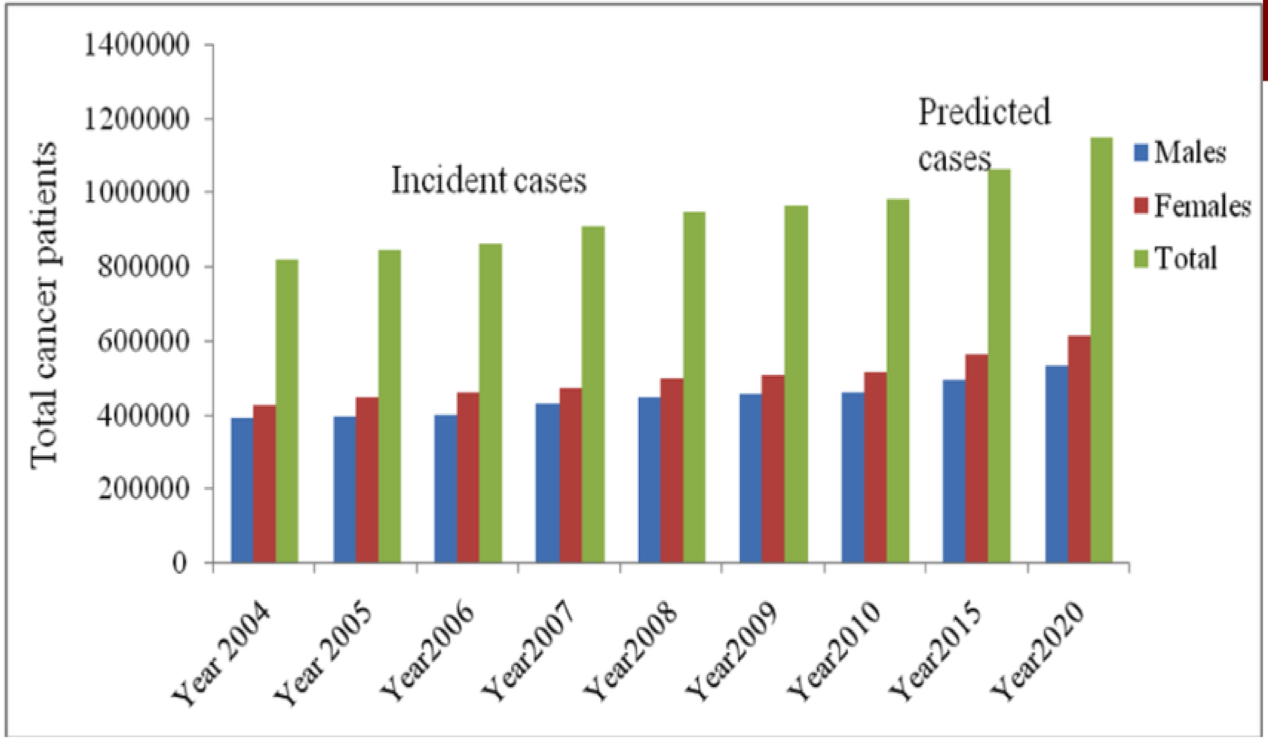


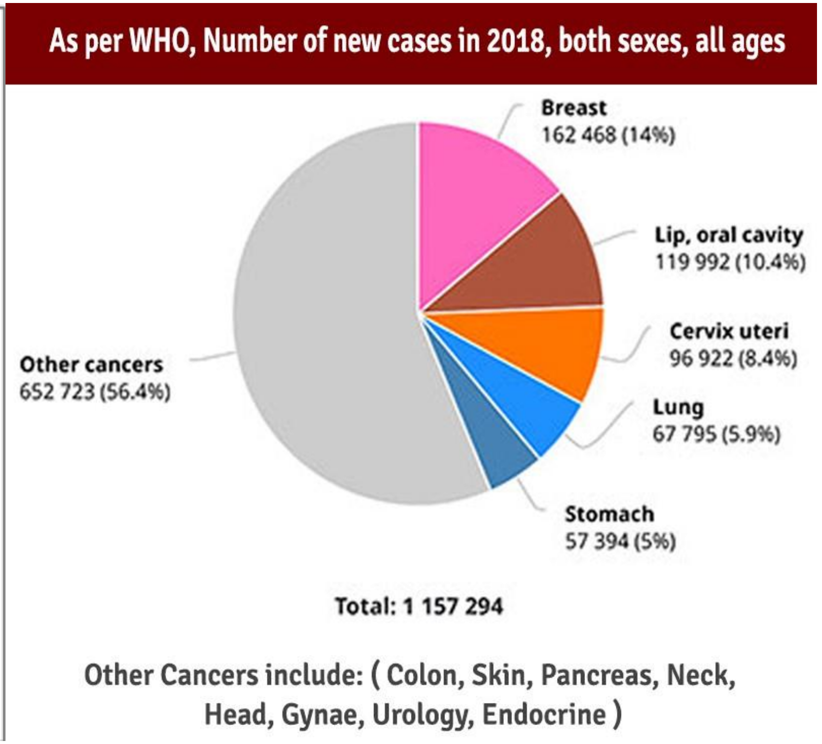



Damaged DNA

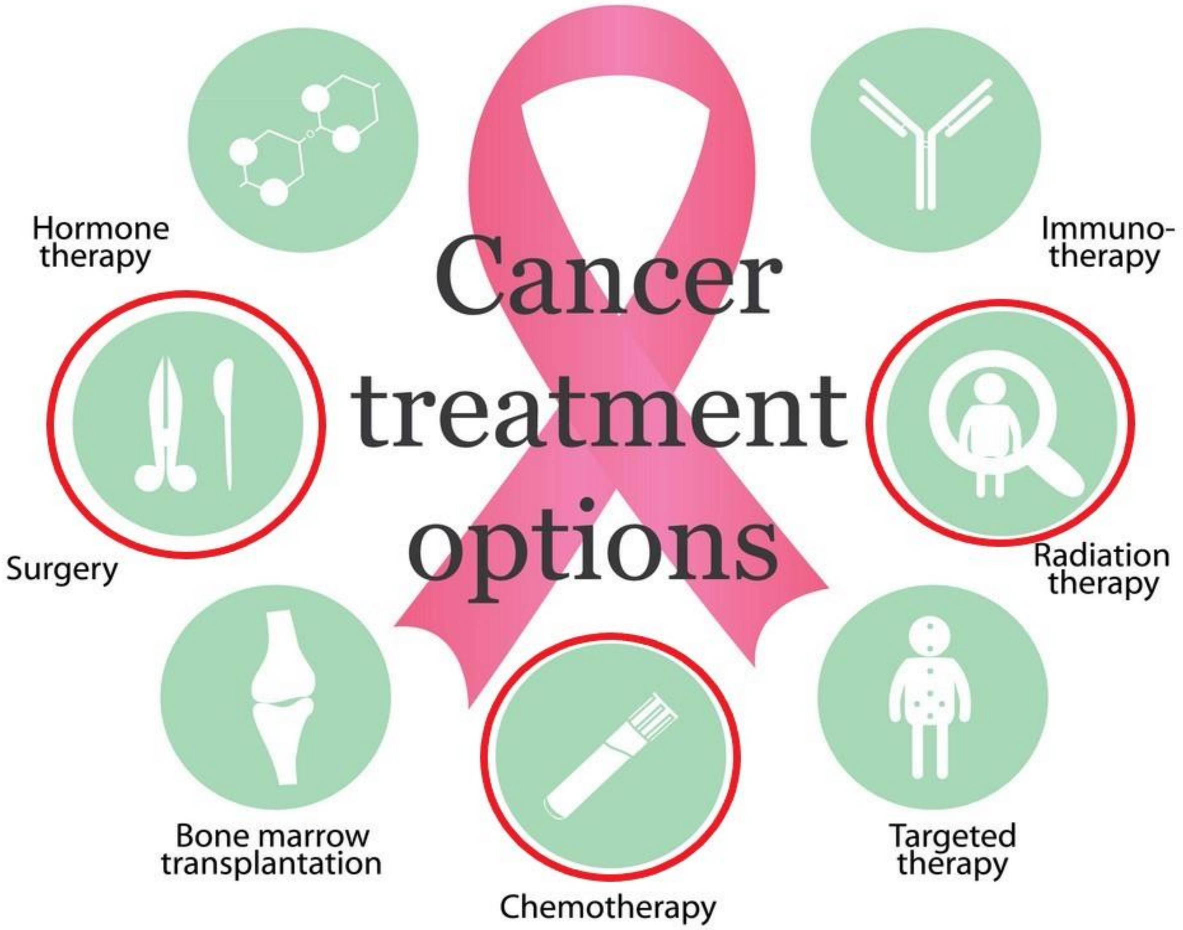


# Cancer incidence in India



# Treatment of caner



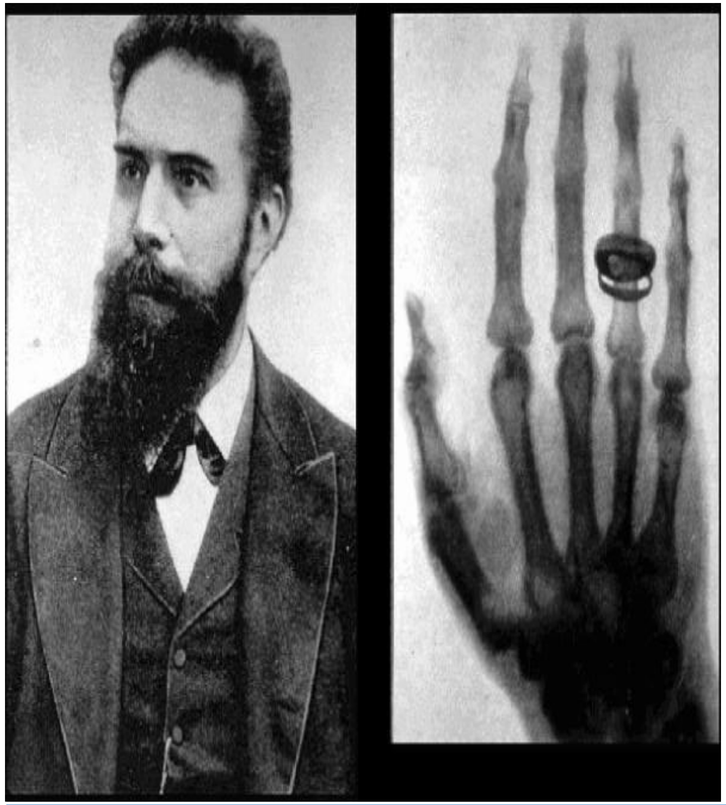
# Radiation Therapy

‘Treatment of cancer
By using
Ionising
Electromagnetic Radiation’

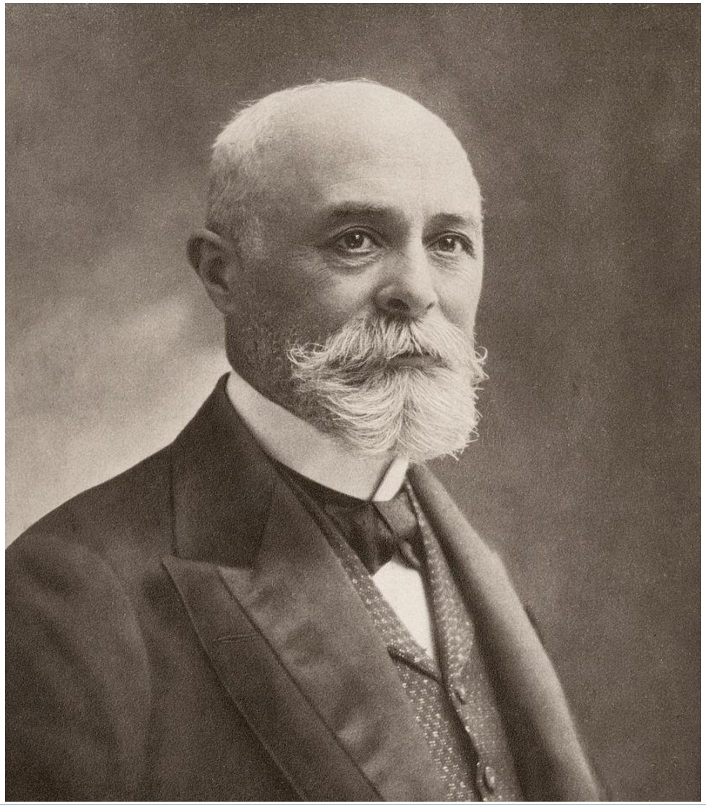
# Are these questions coming to your mind?

1. What are the ionising EM Radiation?
2. How they are produced?
3. How can they be used to kill the cancer cells?
4. How can we quantify the EM radiation?
5. How we will measure it?
6. How actually the whole treatment process is carried out in a cancer hospital?

# Evolution of Radiation Therapy



**Wilhelm Conrad Röntgen** discovered X-Rays on 8 November 1895



**Antoine Henri Becquerel** discovered Radioactivity in 1896

**Marie & Pierre Curie** Discovered Radium & Polonium in 1898

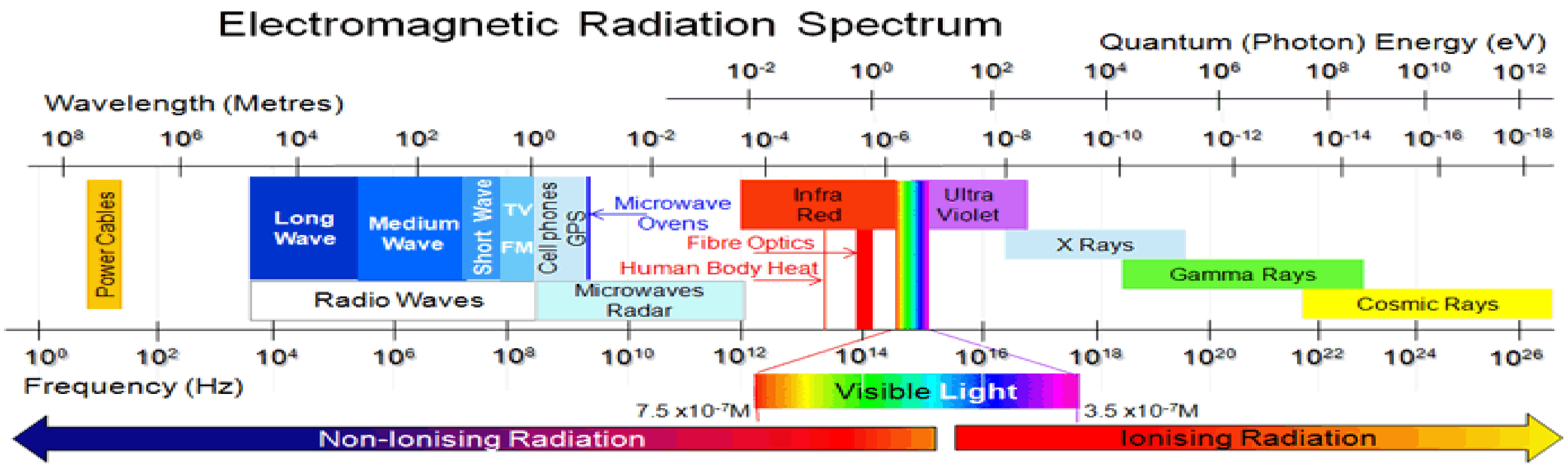
# Electromagnetic radiation

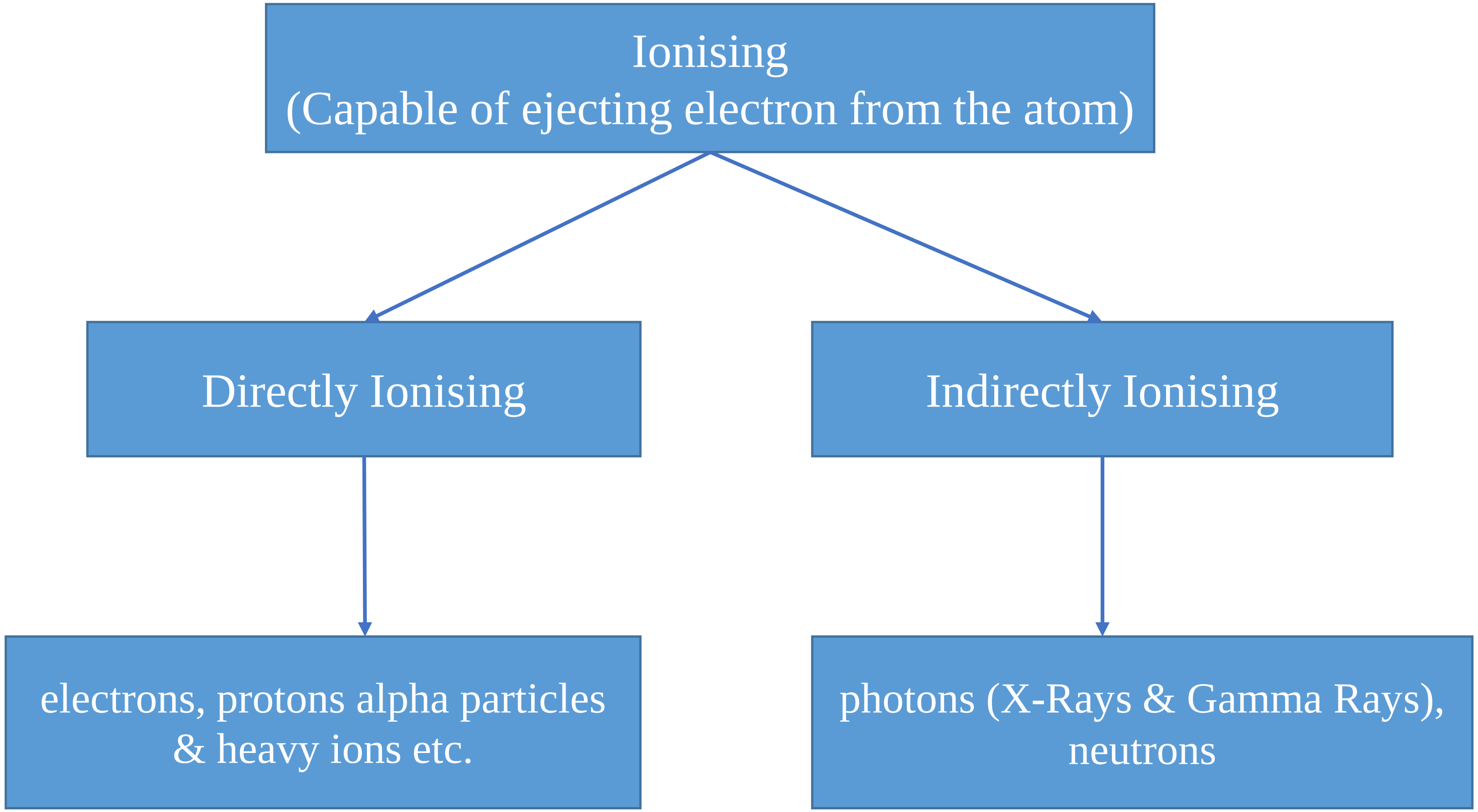
- **Electromagnetic Radiation:** Consists of small energy packets known as photons. The relation between the energy (E) & frequency (ν) of the electromagnetic wave is given by –

$$E = h\nu = h\,c/\lambda$$

(Where h is Planck's constant, $h = 6.62 \times 10^{-34}$ Joule sec)

- The whole range of available energy is called Electromagnetic Radiation Spectrum.




Ionising
(Capable of ejecting electron from the atom)
Directly Ionising
Indirectly Ionising
electrons, protons alpha particles & heavy ions etc.
photons (X-Rays & Gamma Rays), neutrons

# Sources of Ionising radiation

- Photons (Most widely used for treatment & the oldest one for cancer treatment)
  - X-Rays
    - Generated from a Linear accelerator (LINAC) – By bombarding high energetic electrons with a target material.
  - Gamma Rays
    - Emitted from the nucleus of radioactive atoms
    - Ex : Co-60, Cs-137, Ir-192 etc.

- Particle Beams
  - Electrons (Produced by the Linear Accelerator)
  - Protons (Produced by particle accelerators)
  - Heavy ions (Produced by particle accelerators)

# Absorbed Dose

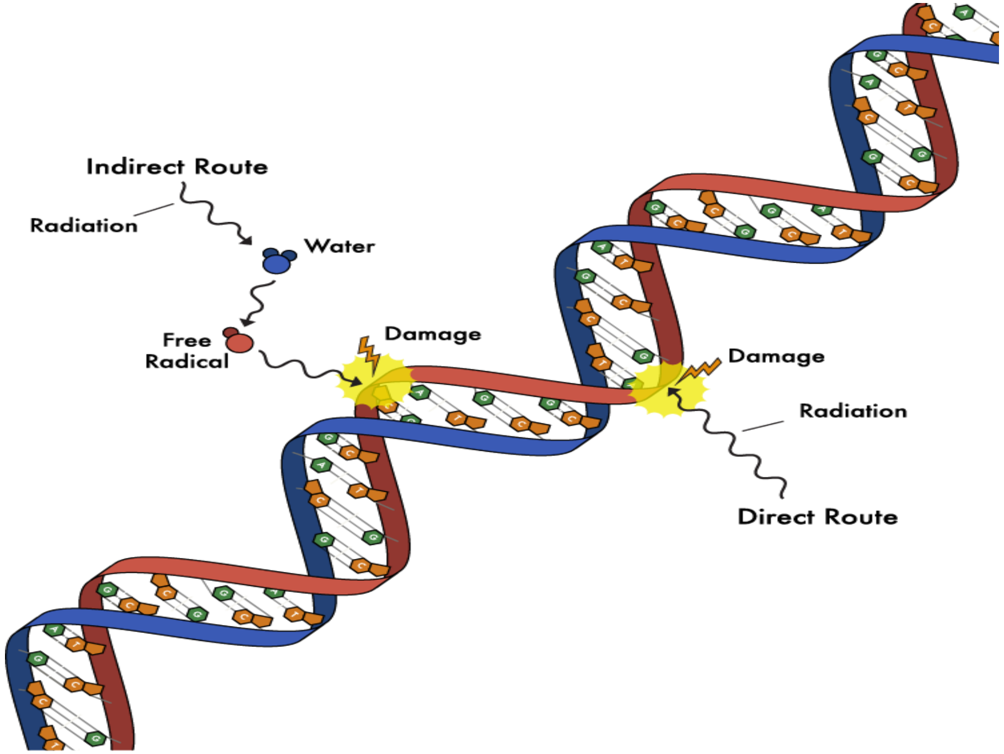
- When radiation interacts with the medium the energy from the radiation (photon / charged particle) is transferred to the medium. This energy is absorbed by the medium.
- Absorbed dose (D) : It is defined as the ratio of the energy deposited ($dE$ ) in a certain volume to the mass ($dm$) enclosed by the volume.

$$D = \frac{dE}{dm}$$ (Unit is J/kg, Special unit is Gray)

- Gray (Gy) = Is the SI unit of absorbed dose.
- While delivering radiation to the patient for treatment, we quantify it in terms of Dose rather than quantifying in terms of energy deposited.

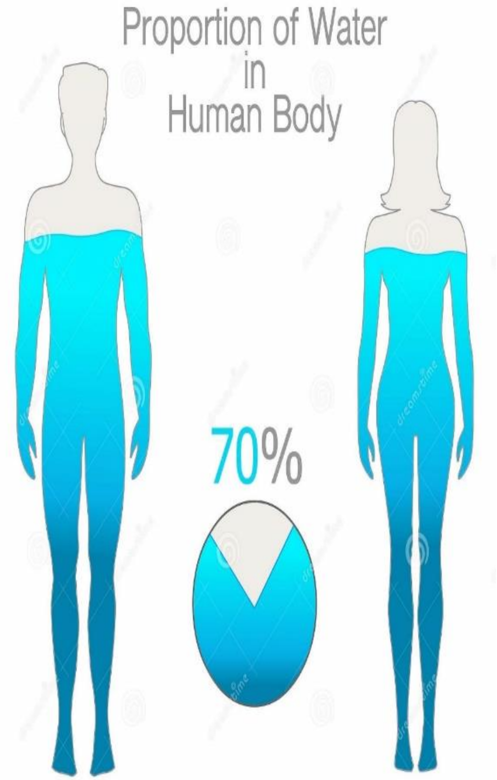
# Biological basis of Radiation Therapy

- Interaction of radiation with cells produces ionisation which breaks the molecules in DNA.
- The produced ionisation should be sufficient that they could not be repaired. This is the basis of treating cancer using ionising radiation.
- The extent of the cell damage can be quantified with relation to the given radiation dose (D).
- For cancer at different organs we need different amount of Dose to treat them.



# Measurement of Dose

- Can not be measured on patients.
- So the distribution of the dose inside the patient can be considered similar to that in water.
- While entering into the body the radiation gradually loose the energy due to interaction.
- Depending on the depth of tumour inside the body the dose calculated and delivered.
- The materials that are equivalent to human body in composition are called phantoms.
- We measure the dose in phantoms and translate it into the patient.

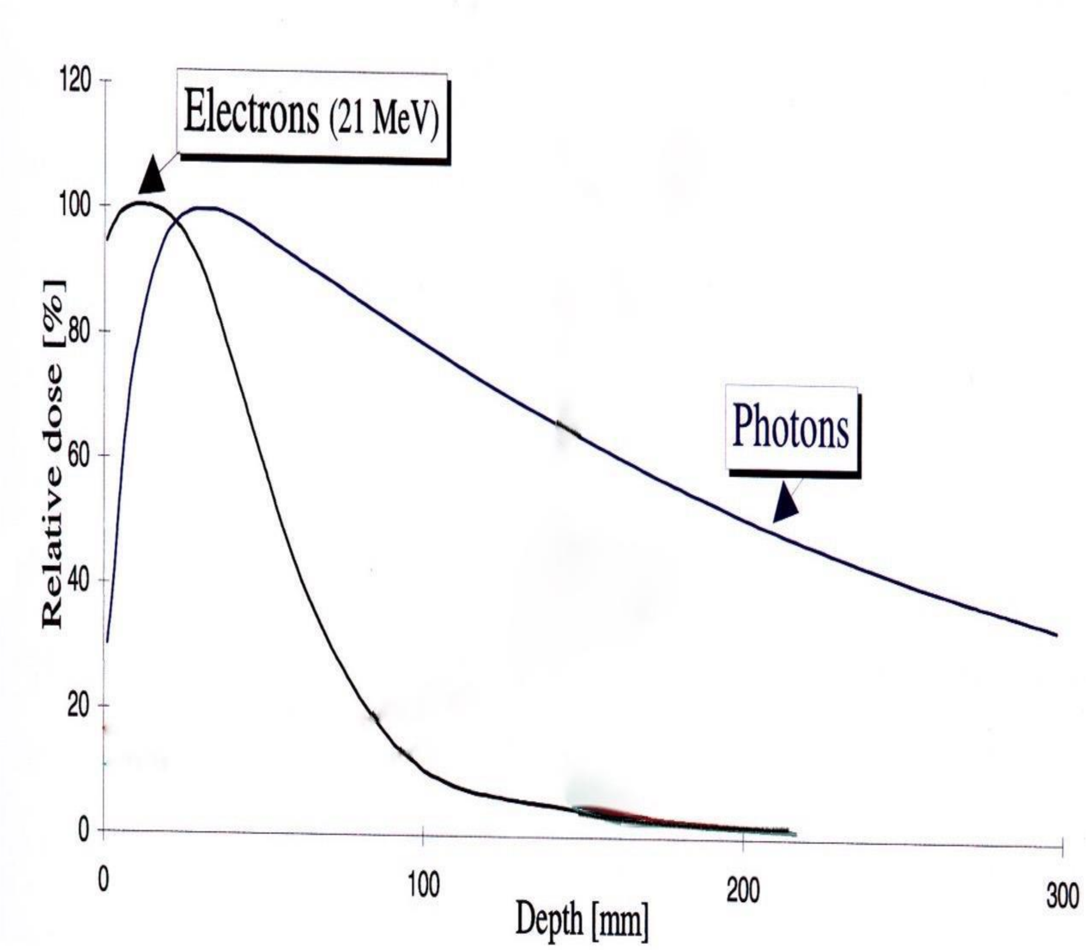



Phantom

# Dose distribution in water

- Photons being indirectly ionising particle first produce electrons in the medium by the process of ionisation.
- These electrons deposit their energy further in the medium.
- Electrons being, charged particle deposit their energy in every step they penetrate the medium by coulomb interaction.

*The depth can be considered as the location of a tumour inside the patient body.



# Workflow in Radiation Therapy

Diagnosis

↓

Imaging

↓

Defining the tumour & other organs

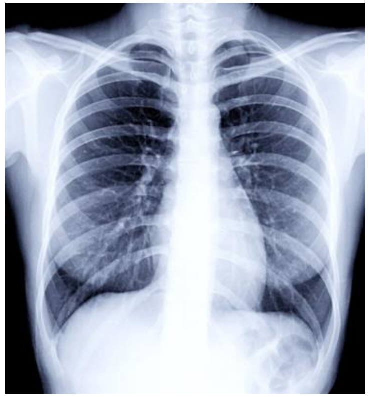
↓

Dose calculation
(Manually or by using computers)

↓

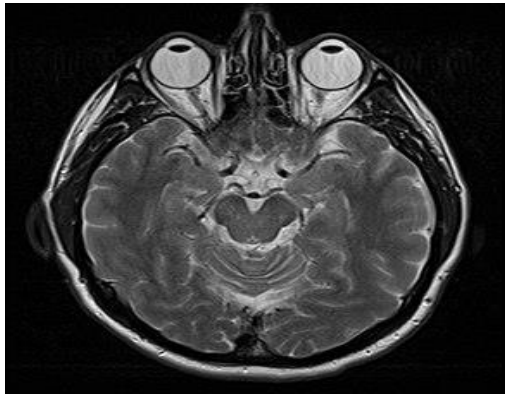
Treatment

# Medical imaging modalities



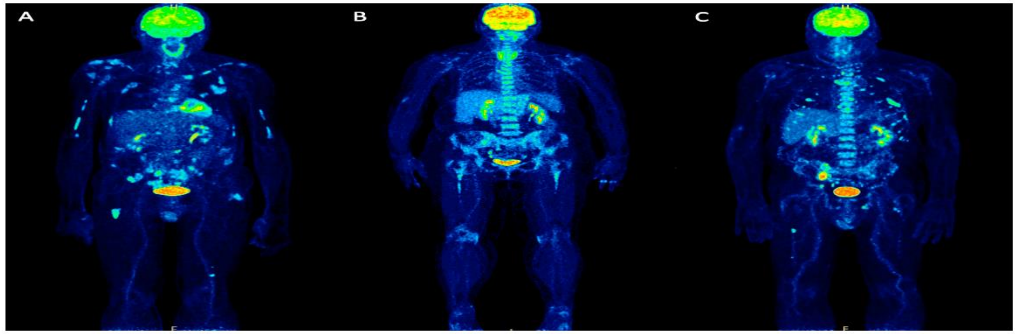
X-Ray (2D)

CT Image



MRI Image

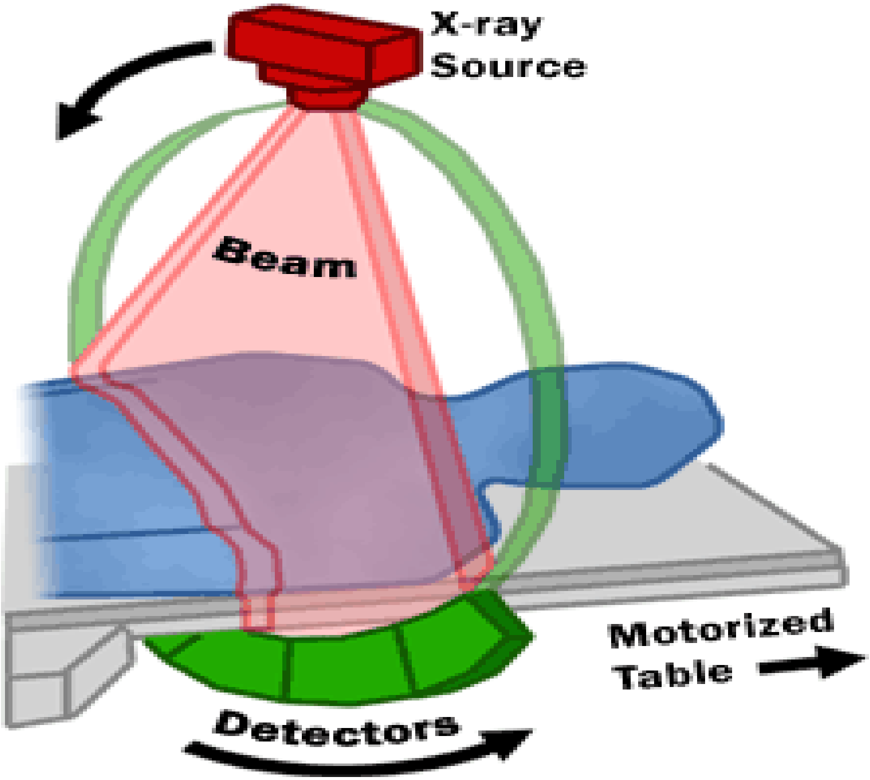
Ultrasound image




PET image

# Continued

*CT imaging is the choice for the Radiation Therapy.



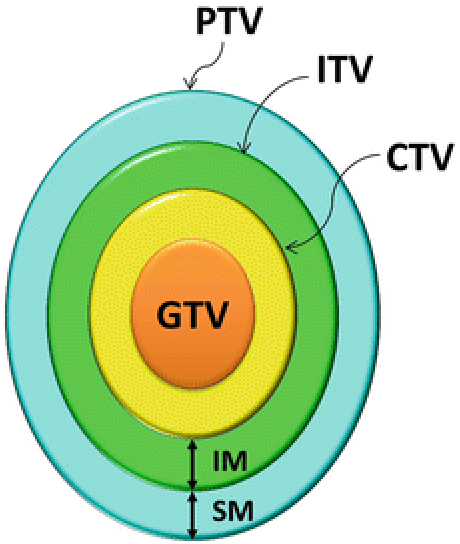

# Some Definitions

**GTV: gross tumor volume**, defined as visible tumor volume in images

**CTV: clinical target volume**, defined as GTV + subclinical/invisible invasion

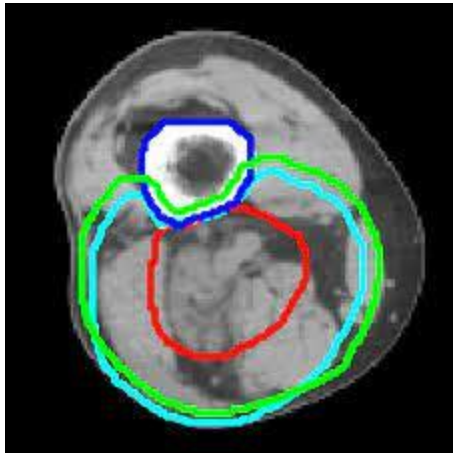
**ITV: internal target volume**, defined as CTV + IM (internal margin for organ motion)

**PTV: planning target volume**, defined as ITV + SM (setup margin for setup error)



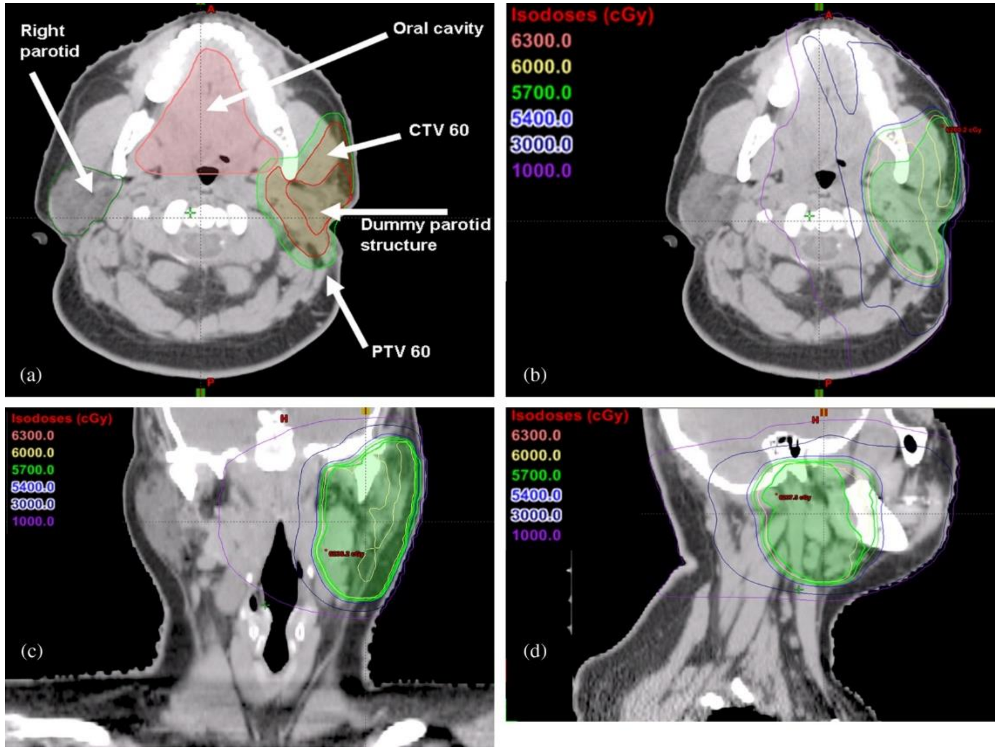

OAR: Organ at Risk is defined as the normal functioning organ near the target, needs to be saved from radiation

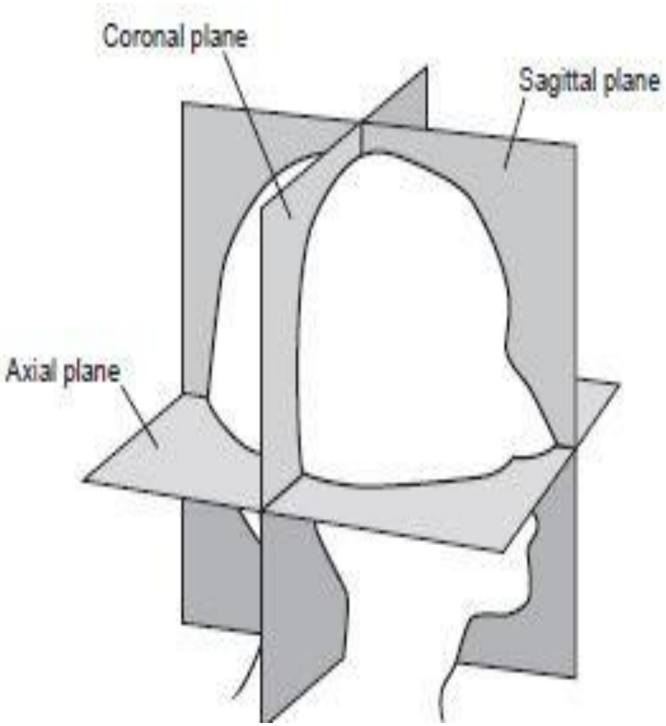
Image of the neck



Red : GTV
Cyan : CTV
Green : PTV
Blue : OAR

# Delineating Targets & OARS



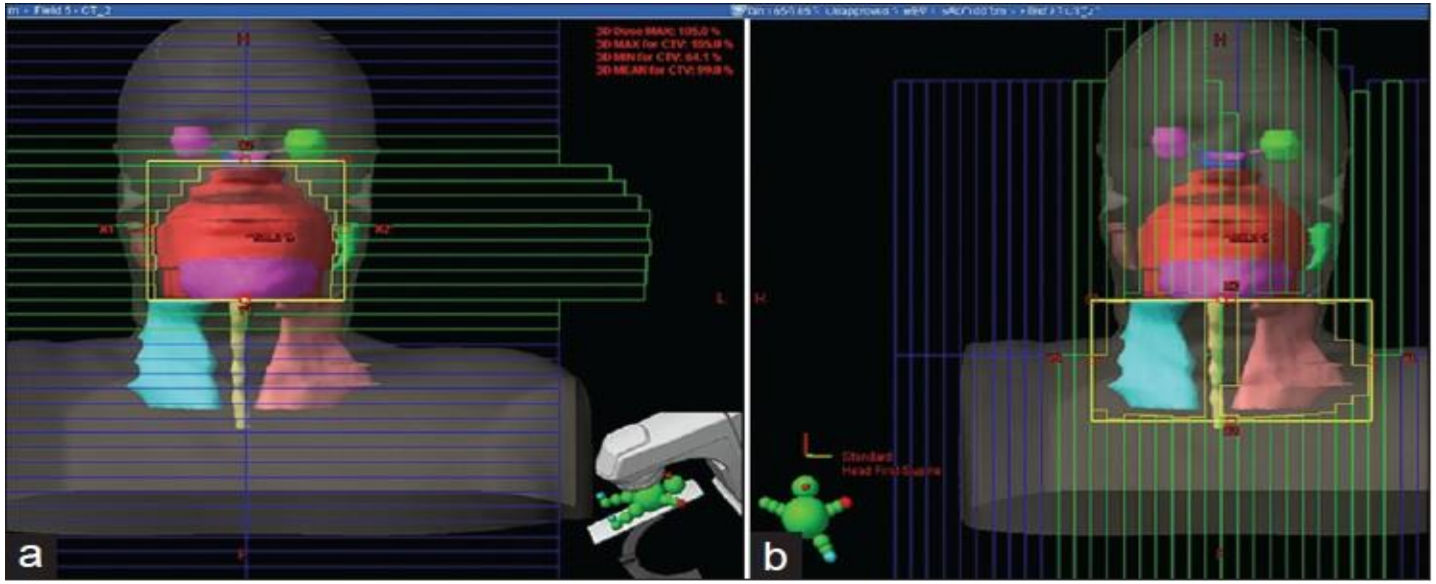
# Calculation of Dose (D)

## Manually

- The depth-dose data taken from the measurement are converted to tabular form.
- Depth of the treatment is found and the corresponding dose is calculated from the dose distribution table.

## Using Computer

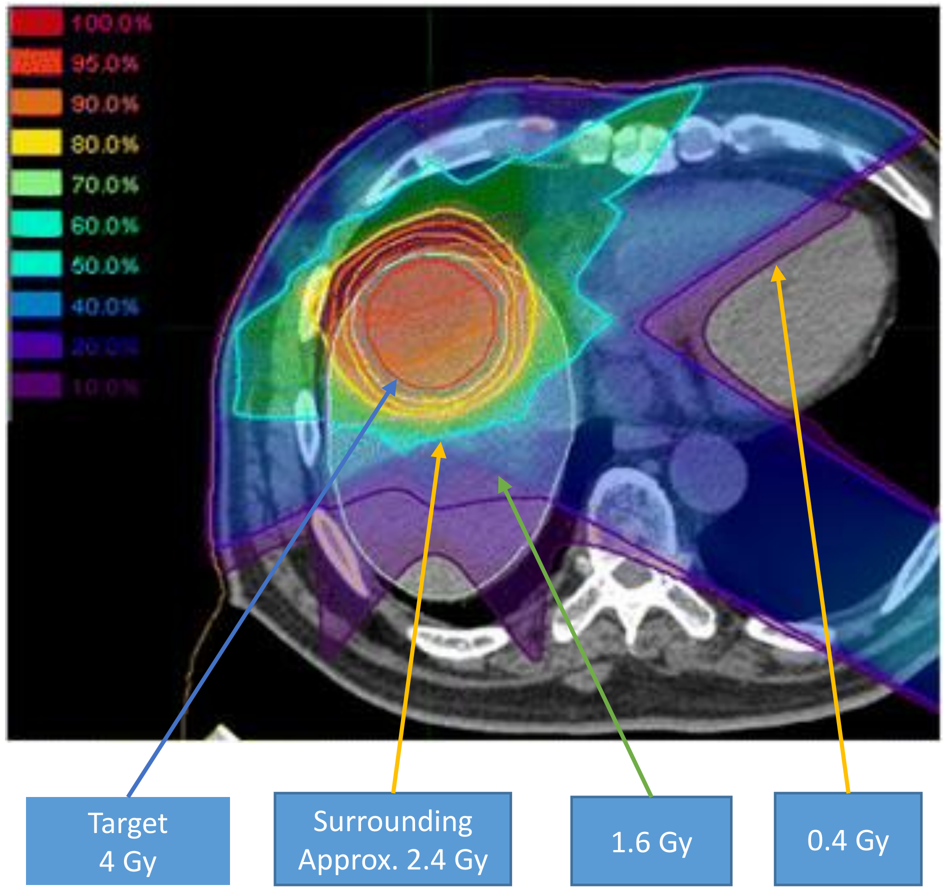
- Image of the patient is loaded in the computer.
- The area where the radiation is to be delivered is found and the dose is calculated in the computer.
- Computer uses sophisticated algorithms to find out the dose distribution.



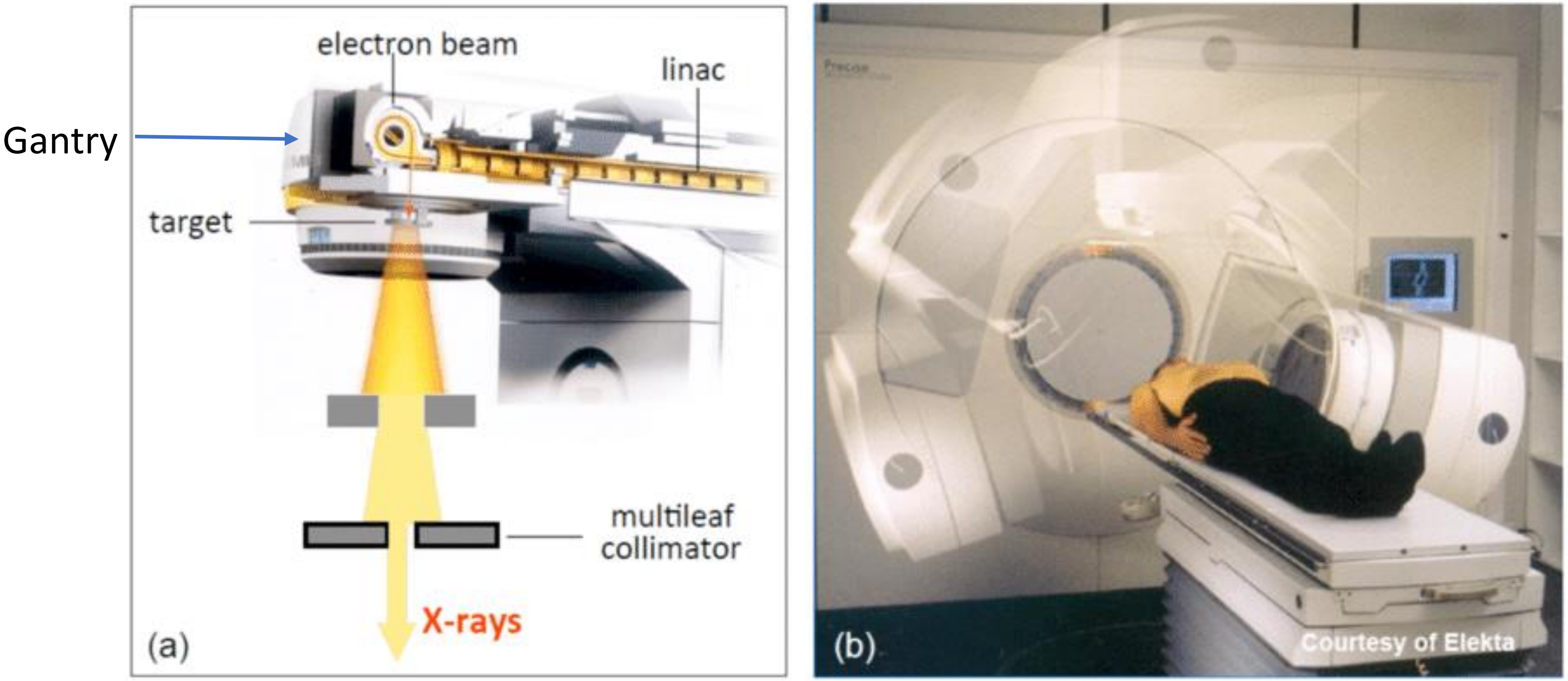
# Dose distribution inside patient

- Aim of treatment:
  - Maximum dose (damage) to tumour
  - Minimum dose (damage) to the surrounding normal tissues.
- Still, the beam deposit some amount of dose to the normal tissue during the exit.
- Let us assume the dose given to the target = 4 Gy

Thorax Region



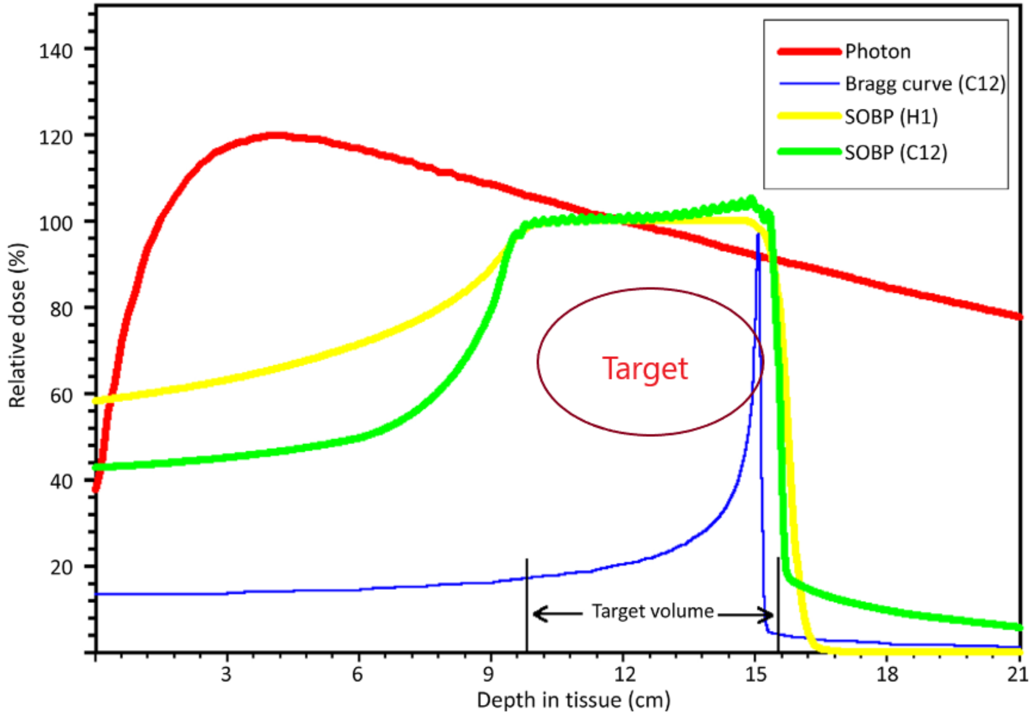
# Medical LINACS




*Multi leaf collimator are the device used to get the radiation of desired area.
*By increasing the width of the gap between the multi leaf collimator we can get the beam of radiation of our desired area.

# The need for particle therapy

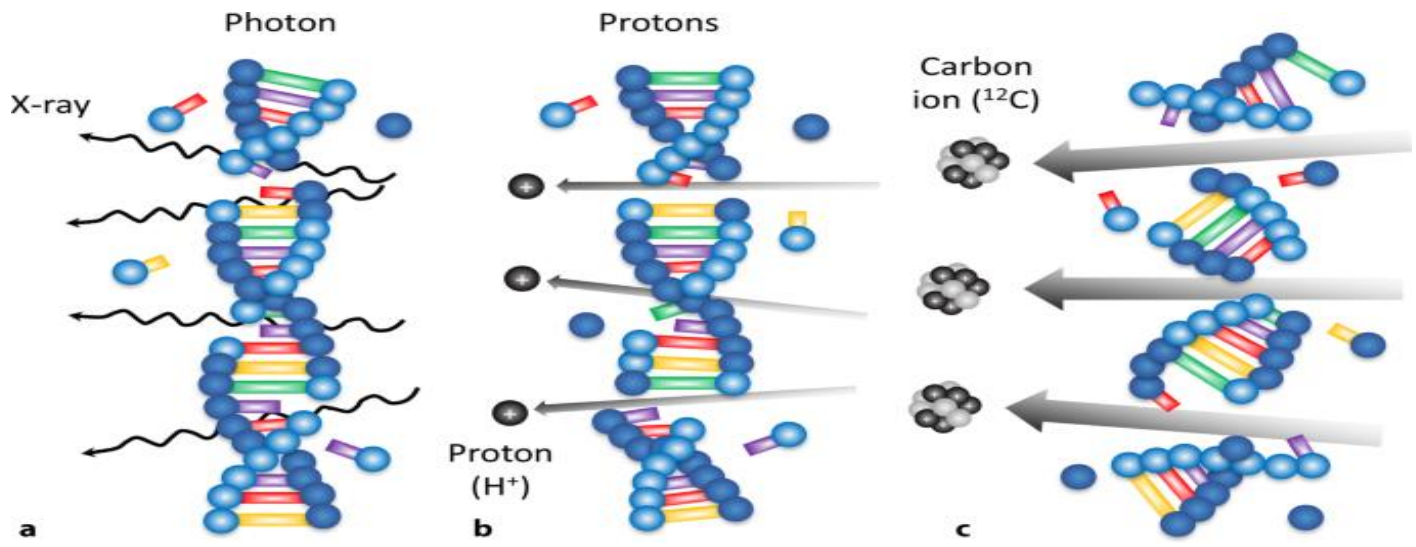
- In case of protons & carbon ion the dose deposition suddenly terminates after a certain depth following a peak dose deposition.
- This peak is called "Brag's Peak".
- The peak is very narrow to be covered by the whole tumour volume. This peak is widened according to the width of the spread of the tumour to cover it completely.
- The widened peak is called Spread out Bragg's Peak (SOBP).



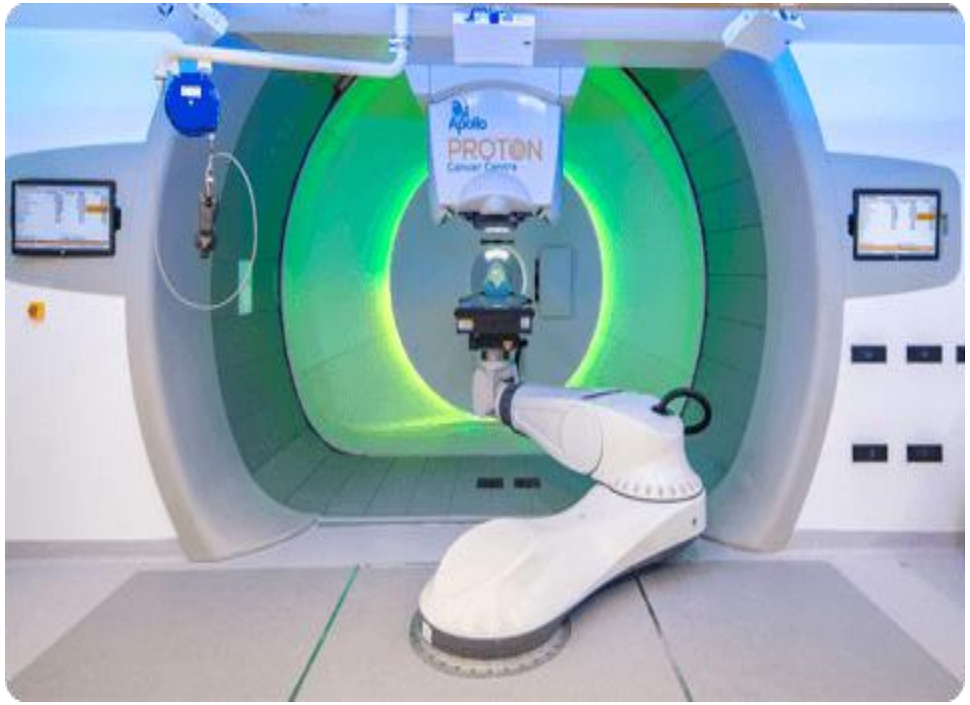

REVIEW ARTICLE : Particle therapy in the future of precision therapy
https://doi.org/10.1259/bjr.20200183

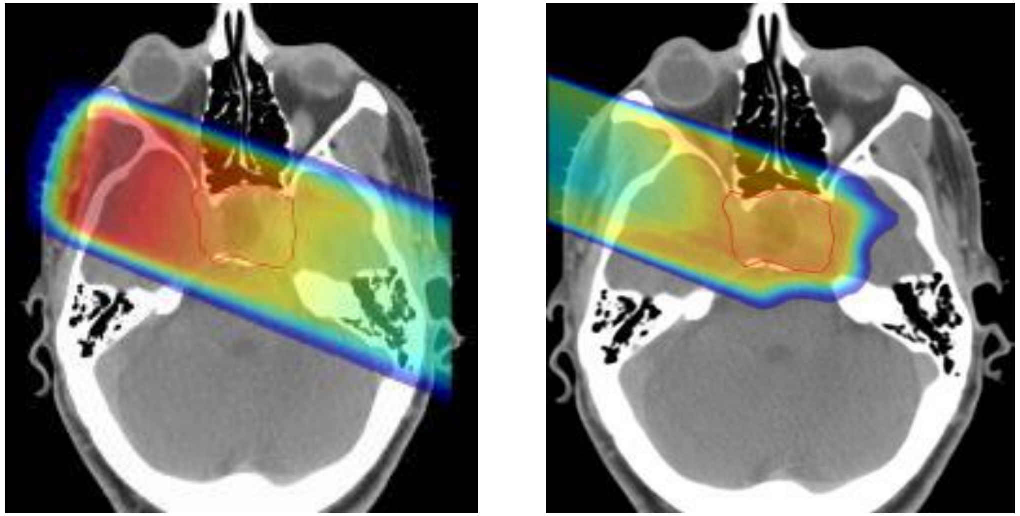
# Biological Effects

- Apart from the benefit of the negligible exit dose & Brag peak, another benefit of the particulate radiation is that, 'For the same delivered dose, the particulate radiation produce more damage to the target as compared to photons (X-rays & Gamma rays)'.
- This is called Relative Biological Effectiveness (RBE).



# Proton Therapy



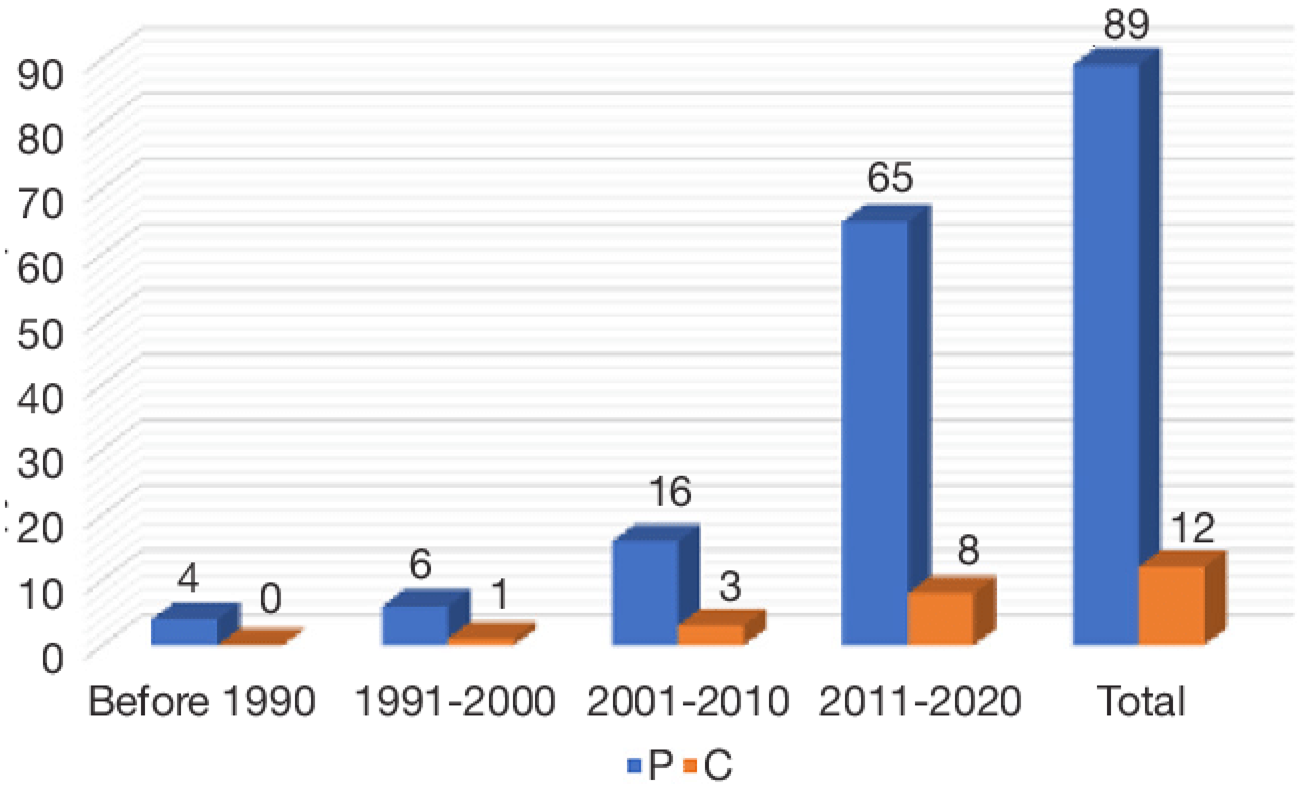



Photons Protons

Pituitary

# Overview of a particle therapy Center

# Current status in World



# Status in India

| Centre Name | Status |
|---|---|
| 1. Apollo Proton Cancer Centre, Chennai | Operational |
| 2. TATA Memorial Centre, Mumbai | Under Construction |
| 3. Health Care Global, Delhi | In Planning Stage |

* There is no C-12 ion therapy centre in India as on today.

# Challenges for particle therapy

- High cost of installation and maintenance (Approx. 550 crores each facility)
- High Cost of treatment ( Approx. 10 times than X-Ray photon treatment) (Around 25 Lakhs per treatment)

# Thank You