Radiotherapy
Nearly two-thirds of patients will receive radiotherapy as part of their treatment.

Half of all patients will receive radiotherapy as part of their curative treatment.

Radiotherapy

Surgery
Chemotherapy
Radiotherapy
Radiation therapy uses ionising radiation to kill cancer cells while causing minimal damage to surrounding healthy tissues.

Ionising radiation works by damaging the DNA of cancerous tissue leading to cellular death.

Ionising radiation is composed of subatomic particles, ions or atoms moving at very high speed, or electromagnetic waves that carry enough energy to free electrons from atoms.
Most common radiation is high energy X-rays which are capable of penetrating tissue to reach deep tumours.

Most common x-ray radiotherapy uses external beams of high energy x-rays.

X-rays cause damage in the target region, they can also damage healthy tissue both in front of, or behind, the tumour.

Many of the recent developments in X-ray therapy have sought to get more of the radiation to the tumour and less to the healthy tissue.

These developments have been tremendously successful in reducing the side-effects that many patients experience during and shortly after their radiotherapy treatment.

Treatment planning and methods have progressed vastly in recent years.
Dose distribution
conventional radiotherapy

Computer-controlled x-ray accelerators distribute precise doses to specific areas. Pattern of radiation delivery is determined using accurate computer modelling to perform optimisation and treatment simulation. Radiation dose is matches the 3-D shape of the tumour by controlling the radiation beam’s intensity.
X-rays are electromagnetic waves, like visible light, but with a much shorter wavelength and higher energy.
Proton beam therapy is a different type of radiotherapy, which uses a high energy beam of protons rather than X-rays to deliver a dose of radiotherapy to patients with cancer.

Like X-rays, high energy protons penetrate tissue to reach deep tumours.

Protons produce more ionisation (so cause more cellular damage) at one particular depth that is strongly dependant on the energy of the proton.

Compared to X-rays, protons cause less damage to healthy tissue lying in front of the tumour, and no damage at all to healthy tissue lying behind the tumour, which greatly reduces the side effects of the radiation therapy.
A proton is a particle with a positive charge in the nucleus of an atom.

An electron is a particle with a negative charge that circles the nucleus.

A neutron is a neutral particle in the nucleus.

The number of protons defines an element – its atomic number. Hydrogen has one proton, Carbon has 12 and Lead has 82.
Proton beams – how to make them

- Proton beams are created by “adding” an extra electron to Hydrogen so it becomes negatively charged (ionised).
- Ionised atoms are accelerated, using electromagnets and high voltages, to near the speed of light.
- Can be accelerated in a straight line using a linear accelerator or in a spiral using a cyclotron.

When the stream of Hydrogen ions leave the accelerator, they pass through a thin foil of Carbon, which strips off the electrons.

The beam of protons can then be steered and focussed using more magnets along evacuated pipes.
230 MeV Cyclotron for Proton Therapy

Cyclotron control room – iThemba LABS, South Africa
Massive structures that revolve around the patient so the proton beam can be directed very accurately from any angle.
X-rays lose their energy “exponentially” as they pass through tissue. Usually during radiotherapy, the x-rays are beamed from several different directions to maximise the dose at the target and minimise damage to healthy tissue.

Protons behave very differently and lose most of their energy at their limit of travel - the Bragg Peak. The distance protons travel depends on energy ....
.... There is reduced dose prior to the target tumour site and none after it.
The energy of the proton beam can be modulated slightly to give multiple Bragg Peaks. This Spread Out Bragg Peak (SOBP) can cover the full depth of the tumour.

Rotating stepped and segmented plastic wheels are rotated in the beam to modulate the proton’s energy.
X-ray and proton dose maps

Dose range
- 100%
- 95-100%
- 90-95%
- 80-90%
- 60-80%
- 40-60%
- 20-40%
- 10-20%