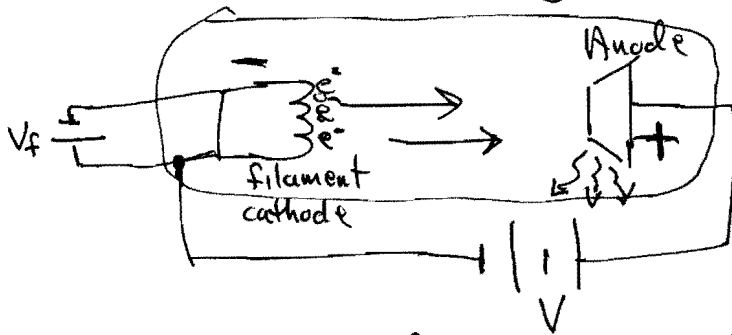


Linear Accelerators: (Chapter 9)

- developed in the late 1940's
- used to accelerate electrons to high ~~are~~ velocities ($\sim c$)

Standard X-Ray Unit



- standard x-ray unit need a voltage to accelerate the electrons across the tube.
- The higher the voltage, the higher the energy of the electrons.
- The electrons then hit the Anode target and produce x-rays by bremsstrahlung radiation.
- Max. energy depends on max. electron energy.
- To get higher & higher energies, the voltages need to be extremely high and causes problems with high voltage transformers

There are two main types of linear accelerators:

- 1) Traveling wave
- 2) Standing wave

In either case, electromagnetic radiation is used to accelerate the electrons in an accelerator tube.

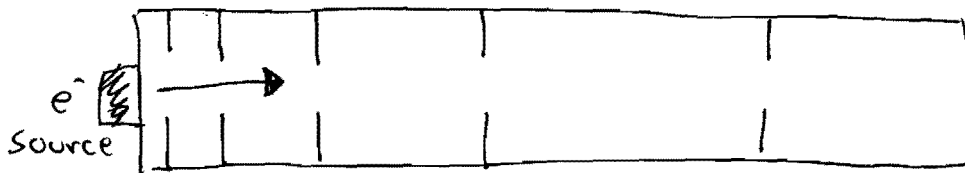
The e.m. radiation is in the microwave ~~to~~ range.

① Traveling Wave:

In a traveling wave accelerator, the electrons "hitch" a ride on the e.m. wave and are accelerated down the accelerator guide.

- This is similar to a surfer accelerating on the front edge of a wave.

- Traveling wave accelerator guides are built with circular disks in the guide placed at increasing distance along the guide



- These disks are used to effectively slow down the microwave so that the electron is slowly accelerated as the distance between the disks is increased

- The final energy of the electron is dependent on the length of the accelerator guide.

① Standing Wave Accelerator

- To increase the energy in a Traveling wave acc., one must increase the length of the acc. guide.
- This becomes impractical for higher energies.
- Also Trav. Wave. Acc. must somehow disperse all of the e.m. energy that is being sent down the guide.
- This is done with a dummy Load which absorbs any excess power at the end of the guide tube.
- Otherwise, the e.m. radiation would be reflected back into the acc. guide and cause

② Standing Wave Accelerator:

- Makes use of the interference of e.m. waves
- Uses two e.m. waves travelling in opposite directions which sum to provide more energy.
- Standing wave has \emptyset pts which are useless in accelerating electrons.
- It is possible to shift these points off-axis by the use of "side-coupled cavities"
- This allows the waveguide to be shorter

Major Components of Linac

- ① DC Power Source
 - modulator
- ② Microwave Power Source
 - Magnetron or klystron
 - RF Load (traveling wave)
 - SF_6
 - waveguides
- ③ Accelerator Section
 - accelerating guide (tube)
 - electron gun
- ④ Beam Handling Section
 - Bend magnet
 - target / foils
 - Flattening filter
 - ion chamber
 - collimators

① DC Power Source:

- Powers the e^- gun and microwave source
- Gives pulses of DC power to both simultaneously
- A unit known as a thyatron acts as a switch to provide pulses

② Microwave Power

- Microwaves are provided by either a Magnetron or Klystron.
- Klystron provides more power & is used in higher energy linacs
- Magnetrons are smaller & are used in low energy machines.
- Waveguides are used to transfer the microwaves from the source to the accelerating tube
- To prevent power loss - waveguides are insulated with an inert gas: SF_6 or Freon (sulfur hexafluoride)

③ Accelerator Section

- e-gun provides pulsed electrons into the tube
- kept a vacuum.

Betatrions:

- accelerates electrons to high energies (4-45 MeV)
- electrons are accelerated by an alternating magnetic field.
- electrons travel in circular orbits and are extracted when they reach the desired energy
- The electrons may be used directly or strike a target to produce x-rays.

Cyclotrons

- accelerate heavy charged particles (protons, deuterons, etc.)
- particles are confined to circular orbits by a magnetic field.
- particles are accelerated by an oscillating electric field.
- particles travel between two hollow metal sections call "dees" (because of their shape)
- electrons are not used in cyclotrons.
- particles are accelerated up to ~ 35 MeV.
- May be used to produce radionuclides (used for. N.M. studies)

Van De Graff:

- accelerates electrons up to about 2 MV.
- less penumbra than Co-60