Introduction to Radiation

1B: X-Ray Production

X-Ray Production

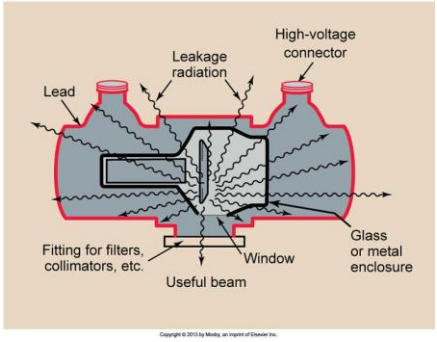
- To produce x-rays:
  - Source of free electrons
  - Acceleration of electrons
  - Focusing of electrons
  - Deceleration of electrons
- Electron-target interaction

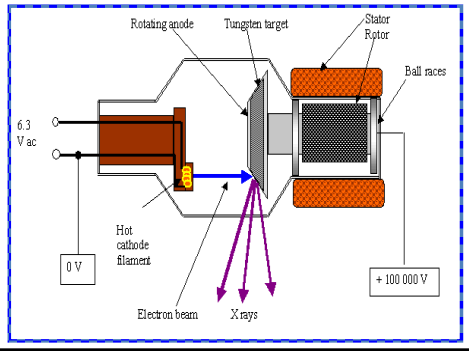
X-Ray Production (cont)

- Within the x-ray tube, the main parts are the cathode and anode
- Cathode generates electrons through a process called thermionic emission
- Number of electrons controlled by the milliamperes (mA)
- mA ultimately controls the number (quantity) of x-ray photons
- kVp (kilovoltage peak) provides acceleration for the electrons

X-Ray Production (cont)

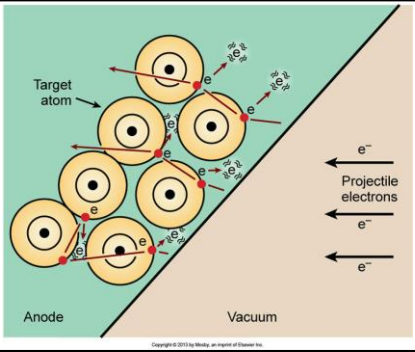
- Anode has a positive charge
- Provides a method of deceleration for the electrons
- X-rays are produced because of this interaction





Anode Heating

- Incident electron of low kinetic energy
- Kinetic energy of the electron converted into heat
- Electrons interact with outer shell electron
- Insufficient energy to ionize the atom
- Outer shell electrons raised to excited, or higher energy level
- Heat is emitted and outer shell electrons return to normal energy levels



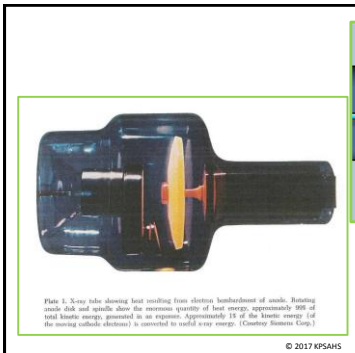
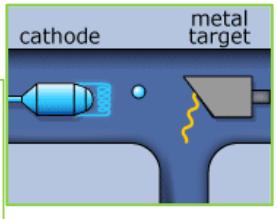


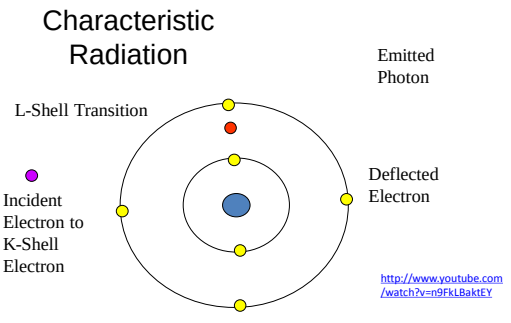
Plate 1. X-ray tube showing heat resulting from electron bombardment of anode. Rotating anode disk and spindle show the enormous quantity of heat energy, approximately 99% of total kinetic energy, generated in an exposure. Approximately 1% of the kinetic energy (of the moving cathode electrons) is converted to useful x-ray energy. (Courtesy Siemens Corp.)



Characteristic Radiation

- Incident electron of high kinetic energy
- K-shell interaction
- K-shell electron ejected and another electron moves in
- Energy difference is ejected as a characteristic photon
- Discrete energy of the photon

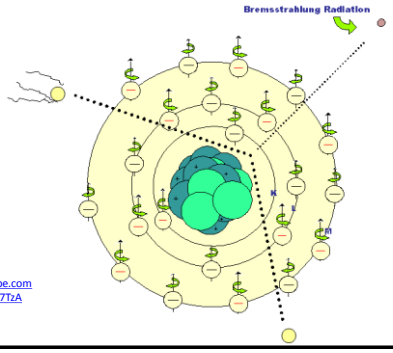
Characteristic Radiation



http://www.youtube.com/watch?v=n9FkLBaktEY

Bremsstrahlung Radiation

- High kinetic energy of motion
- Interaction with / around nucleus
- Energy of electron is reduced
  - "braking radiation"
- Energy difference ejected as bremsstrahlung photon (majority)
- Non-discrete energy of photons



http://www.youtube.com/watch?v=q-cTw1x7TzA

The X-ray Beam

- The x-ray beam is polyenergetic
  - Varying wavelengths and frequencies
- kVp (kiloVoltage peak) controls quality (and somewhat of the quantity of the beam)
- mA (milliamperes) controls quantity
- X-ray beam exiting the tube is known as primary radiation (primary beam)

The X-ray Beam (cont)

- X-rays interact in the patient
  - Some are absorbed
  - Some are scattered
  - Some go all the way through the patient
- Remaining x-rays exiting the patient are the image-forming x-rays
  - Remnant beam

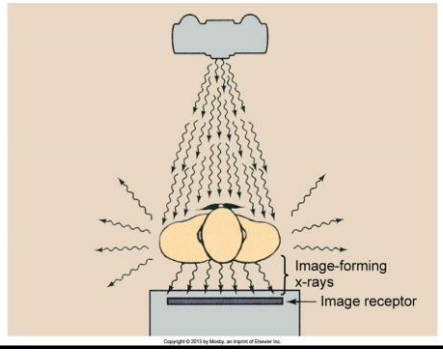


Image-forming
x-rays
Image receptor