Introduction of X-Ray

X-rays are a type of electromagnetic radiation.

•Other types of electromagnetic radiation are radio waves, microwaves, infrared, visible light, ultraviolet, and gamma rays.

•The types of radiation are distinguished by the amount of energy carried by the individual photons.

•All electromagnetic radiation consists of photons, which are individual packets of energy. For example, a household light bulb emits about 1021 photons of light (non-ionizing radiation) per second.

•The energy carried by individual photons, which is measured in electron volts (eV), is related to the frequency of the radiation.

X-rays ionize atoms.

•The energy required for ionization varies with the material (e.g., 34 eV in air, 25 eV in tissue) but is generally in the range of several eV.

•A 100 keV X-ray can potentially create thousands of ions.

•X-rays originate from atomic electrons and from free electrons decelerating in the vicinity of atoms (i.e., Bremsstrahlung).

X-Ray Production

•Radiation-producing devices produce X-rays by accelerating electrons through an electrical voltage potential and stopping them in a target.

•Many devices that use a high voltage and a source of electrons produce X-rays as an unwanted byproduct of device operation. These are called *incidental* X-rays.

•Most X-ray devices emit electrons from a cathode, accelerate them with a voltage, and allow them to hit an anode, which emits X-ray photons.

•These X-ray photons can be categorized as Bremsstrahlungor Characteristic.

Bremsstrahlung X-Rays

•When electrons hit the anode, they decelerate or brake and emit *Bremsstrahlung*(meaning *braking radiation* in German).

•Bremsstrahlungis produced most effectively when small charged particles interact with large atoms, such as when electrons hit a tungsten anode.

•However, Bremsstrahlungcan be produced with any charged particles and any target. For example, at research laboratories, Bremsstrahlunghas been produced by accelerating protons and allowing them to hit hydrogen.

Characteristic X-Ray

•When electrons change from one atomic orbit to another, *characteristic X-rays* are produced.

•The individual photon energies are characteristic of the type of atom and can be used to identify very small quantities of a particular element.

•For this reason, they are important in analytical X-ray applications at research laboratories.

X-Ray Regulations

The regulations on the handling of X rays are very similar to the regulations on standard radiation protection. The X-ray regulations in the European Union apply to those X-ray tubes and X-ray installations in which electrons are accelerated at least to 5 keV and in which they are limited to a maximum energy of 1 MeV. All installations in which electrons can be accelerated to energies beyond 1MeV are subject to the regulations of standard radiation protection.

Devices and installations that produce unwanted radiation, like old-fashioned TV screens, where electrons are accelerated up to energies of something like 20 keV, do not require a license if a dose rate of 1 μSv/h at a distance of 10 cm from the surface is not exceeded or if they are approved by the competent authority by way of a design approval.

The X-ray regulations, of course, mainly concern X-ray tubes used for X-ray diagnosis and X-ray therapy on humans. It is desirable to obtain the best X-ray image available for a particular radiation exposure. At the same time one should try to reduce the radiation exposure by improving the X-ray detection system and image reconstruction without affecting the image quality. The radiation

dose of the patient has to be documented. If the patient wants a copy for patients of the documentation about the received X-ray doses, it has to be provided to the patient