Lecture 13 Radiation Onclolgy

Radiation Oncology:
Tumors attacked with ionizing radiation

- Photons (gamma rays)
- High Energy Electrons
- Protons
- Other particles
- Brachytherapy: implants of beta emitters

Ionizing radiation causes damage within the cells, disrupts cellular processes, prevents accurate cell division.

The response of tumors and normal tissues to ionizing radiation depends on their proliferative patterns before therapy starts and during treatment.

Ionizing radiation kills cells through interactions with DNA and other target molecules.

Death is not instantaneous, but occurs when the cells try to divide but fail-a process termed abortive mitosis .

Radiation damage is manifest more quickly in tissues containing cells that are dividing rapidly.

Normal tissue compensates for the cells lost during radiation treatment by accelerating the division of the remaining cells. In contrast, tumor cells actually divide more slowly after radiation treatment, and the tumor may decrease in size.

Oncology: Cancer Treatments

- **Surgery:** First line of treatment for many solid tumors.
- **Radiation:** May be used in conjunction with surgery and/or drug treatments.
  Chemotherapy: A term used for a wide array of drugs used to kill cancer cells by damaging the dividing cancer cells and preventing their further reproduction.
- **Hormonal Treatments:** These drugs are designed to prevent cancer cell growth by preventing the cells from receiving signals necessary for their continued growth and division.
- **Specific Inhibitors:** This class of drugs is relatively new in the treatment of cancer. They work by targeting specific proteins and processes that are limited primarily to cancer cells or that are much more prevalent in cancer cells. Inhibition of these processes prevents cancer cell growth and division.
- **Antibodies:** This treatment involves the use of antibodies to target cancer cells. Antibodies used in the treatment of cancer have been manufactured for use as drugs. The antibodies may work by several different mechanisms, either depriving the cancer cells of necessary signals or causing the direct death of the cells. Because of their specificity, antibodies may be thought of as a type of specific inhibitor.
- **Biological Response Modifiers:** These treatments involve the use of naturally occuring, normal, proteins to stimulate the body's own defenses against cancer.
- **Vaccines:** The purpose of cancer vaccines is to stimulate the body'sdefenses against cancer. Vaccines usually contain proteins found on or produced by cancer cells. By administering these proteins, the treatment aims to increase the response of the body against the cancer cells.
- **Gene Therapies:**

http://www.cancerquest.org

Tumor types

- **Carcinoma** - a tumor derived from epithelial cells, those cells that line the surface of our skin and organs. Our digestive tract and airways are also lined with epithelial cells. This is the most common cancer type and represents about 80-90% of all cancer cases reported.

- **Sarcoma** -a tumor derived from muscle, bone, cartilage, fat or connective tissues.

- **Leukemia** - a cancer derived from white blood cells or their precursors. The cells that form both white and red blood cells are located in the bone marrow.

- **Lymphoma** - a cancer of bone marrow derived cells that affects the lymphatic system .

- **Myelomas** - a cancer involving the white blood cells responsible for the production of antibodies (B lymphocytes or B-cells).

NCI's Description

(www.cancer.gov)

- External radiation treatment does not make you radioactive.
- Treatments are usually scheduled every day except Saturday and Sunday.
- You need to allow 30 minutes for each treatment session although the treatment itself takes only a few minutes.
- It's important to get plenty of rest and to eat a well-balanced diet during the course of your radiation therapy.
- Skin in the treated area may become sensitive and easily irritated.
- Side effects of radiation treatment are usually temporary and they vary depending on the area of the body that is being treated.

Alpha Particles

(not widely used due to short range)

Produced in decay of **HEAVY** nuclei: $^{226}Ra \rightarrow {}^{222}Rn + {}^{4}He$)

Conservation of CHARGE (Z) $\quad 88 = 86 + 2$

Conservation of Nucleons (A) $\quad 226 = 222 + 4$

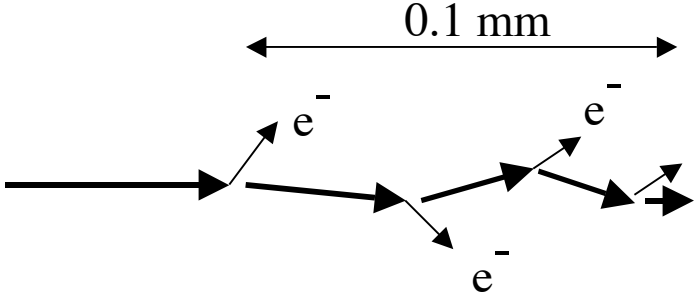
Conservation of ENERGY $\quad m(^{226}Ra)c^2 = m(^{222}Rn)c^2 + m(^{4}He)c^2 + \square$

Nuclear Energy
(MeV's)

Other alpha decays: $^{238}U \rightarrow {}^{234}Th + \square \quad (t_{1/2} = 4.5 \times 10^9 \text{ y})$

$^{232}Th \rightarrow {}^{228}Ra + \square \quad (t_{1/2} = 1.4 \times 10^{10} \text{ y})$

Alphas loose energy by IONIZATION



Short Range
High Specific Ionization/
Energy Deposited

Electrons/Betas

(beams and implants)

Electrons and Positrons are Beta-particles

$m = 9.1 \times 10^{-31}$ kg; $mc^2 = 0.511$ MeV

$q = \pm 1.6 \times 10^{-19}$ Coulombs

Neutron Rich Isotopes β^- decay: $^{234}Th \rightarrow {}^{234}Pa + e^- + \bar{\nu}$ ($t_{1/2} = 24.1$ d)

Conservation of CHARGE (Z) $90 = 91 - 1$

Conservation of Nucleons (A) $234 = 234 + 0$

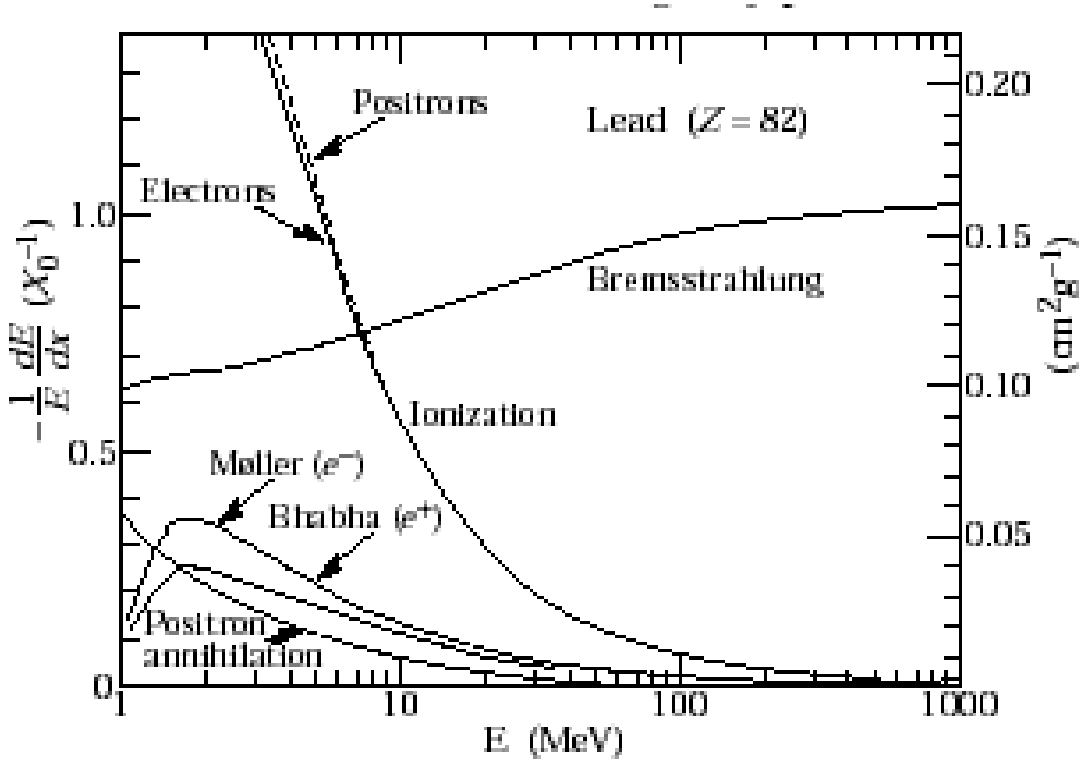
Conservation of ENERGY $m(^{234}Th)c^2 = m(^{234}Pa)c^2 + m(^{e})c^2 + \bar{\nu}$

Betas are PENETRATING (similar to gamma rays)

Longer Range than Alpha Particles

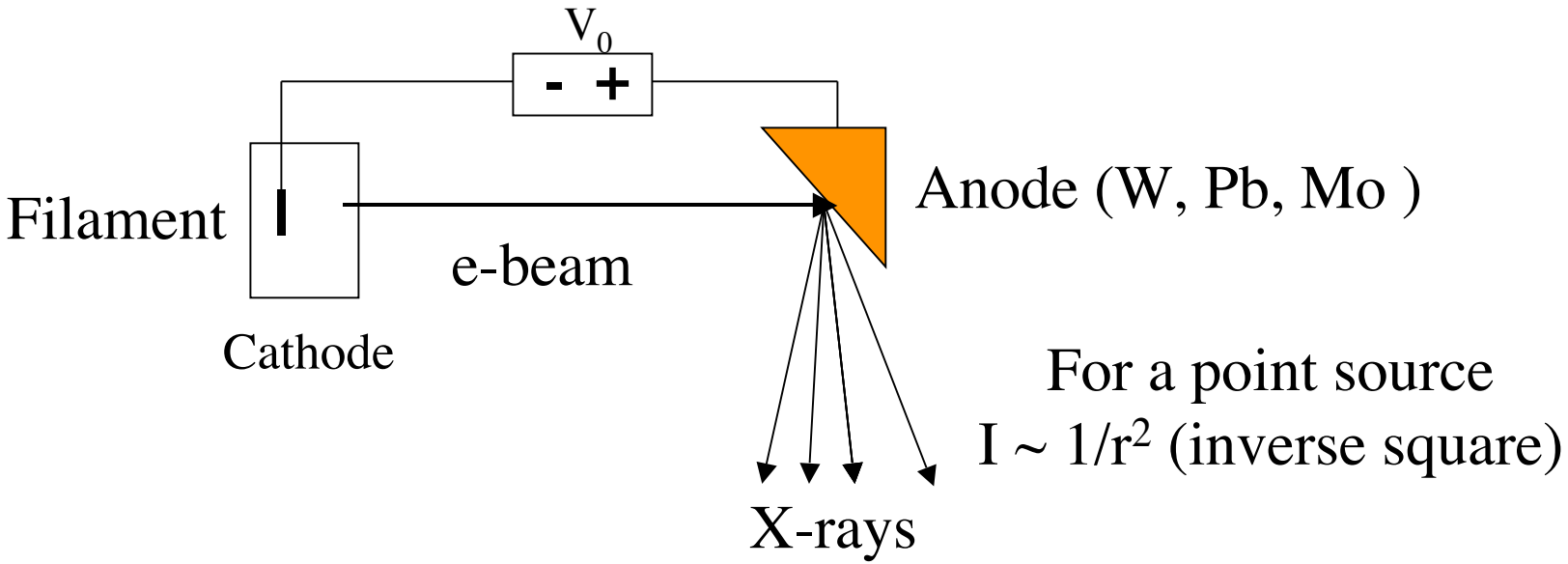
Lower Specific Energy Loss

Electron Energy Loss



X-ray Generation

- Electron Beam Incident on Cathode

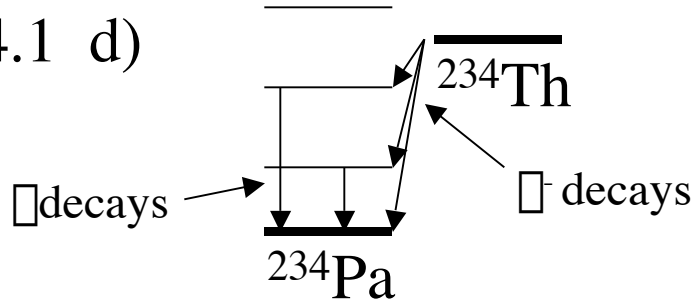


Gamma Rays (Photons)

Produced by Brehmstralung (of high energy electrons)

Produced in NUCLEAR TRANSITIONS

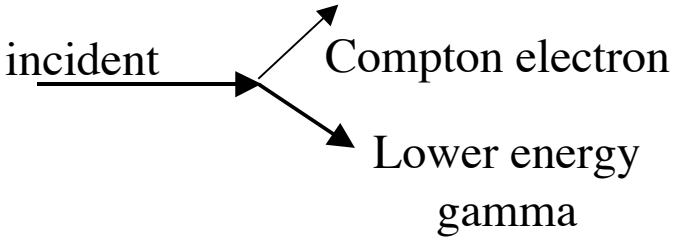
$^{234}Th \rightarrow {}^{234}Pa^{*} + e^{-} + \gamma \quad (t_{1/2} = 24.1\ d)$



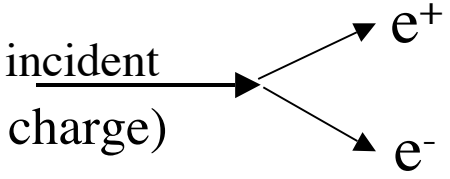
Photon interactions:

Photoelectric effect (ionizing)

Compton Scattering (ionizing)

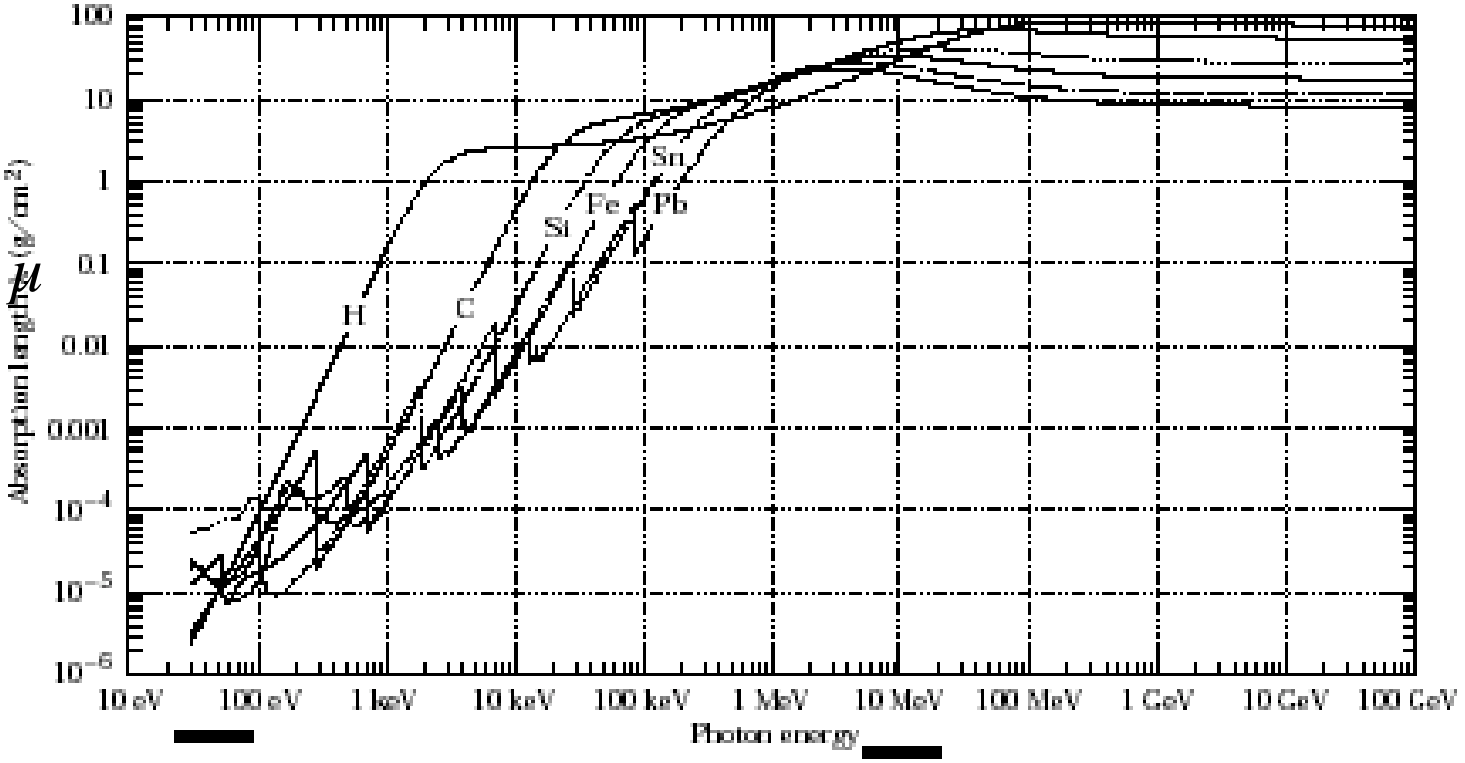


Pair Production (for $E_{\gamma} > 1.022$ MeV)



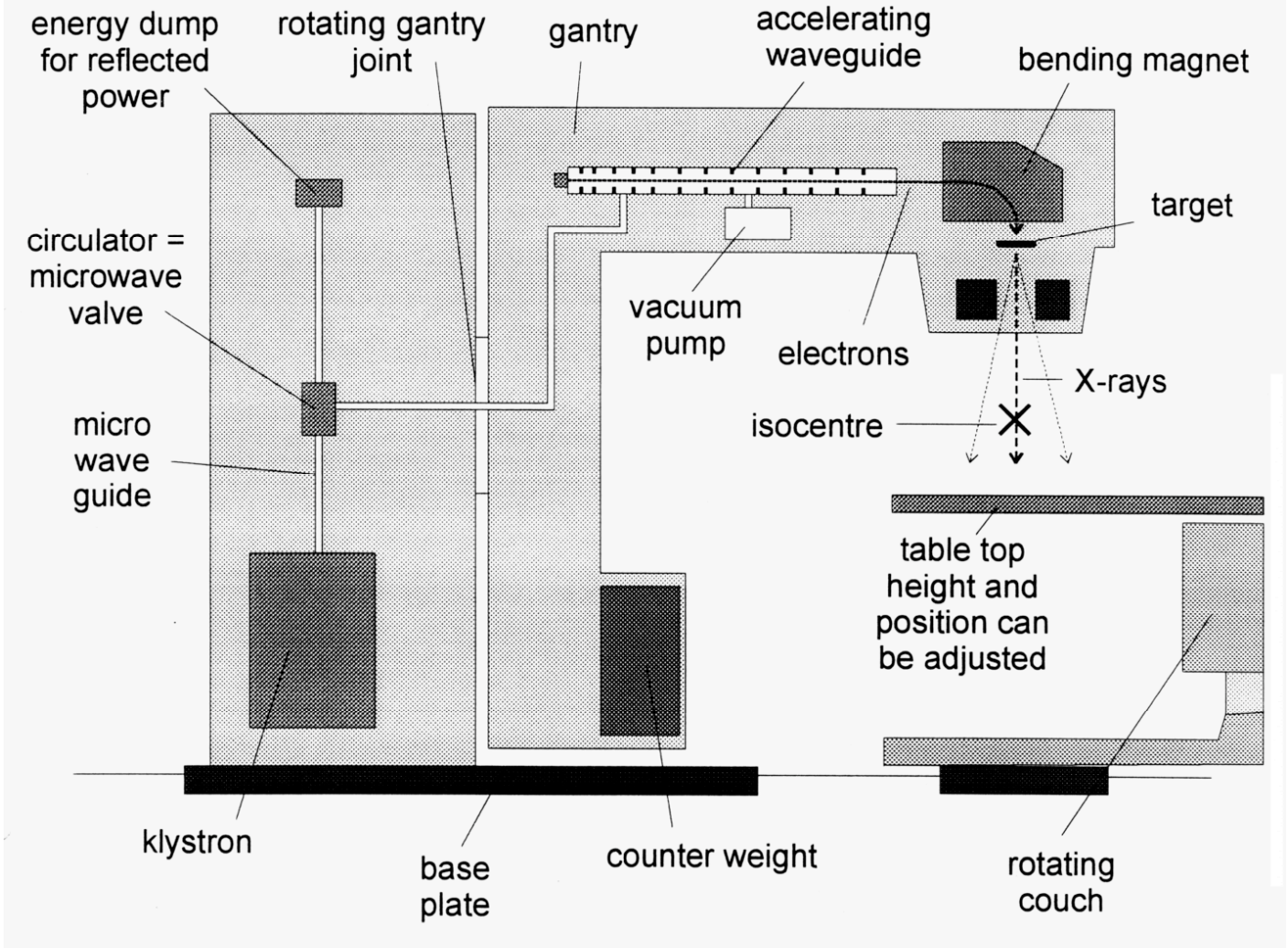
(conserves charge)

Photon Energy Loss



Radiography/CT **Radiation Oncology**

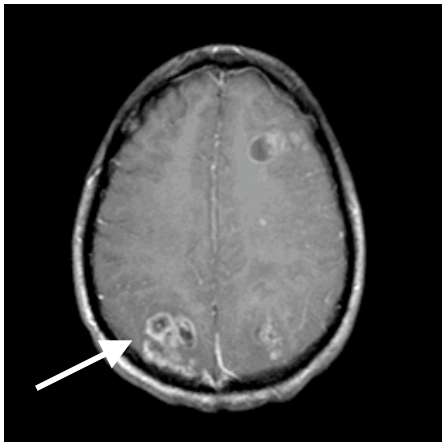
Medical Accelerator: LINAC



Medical Accelerator: LINAC

Varian Clinac® 600 and 600C/D

Brain Tumor



T_1 weighted MRI

Gamma Knife