

Outline

- · Brief history of radiation generators
- Betatrons
- Cyclotrons
- Linear accelerator: resonant cavities, magnetrons, klystrons, and waveguides
- Linear accelerator: components of the accelerator head
 - Thomotherapy

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General considerations for high-energy machine

- · Depth-dose properties:
 - High penetration
 - Delivery of maximum dose at a depth
 - Minimal low-energy electron contamination
 Skin sparing
- · Field flatness (not a requirement anymore)
- · Constant output and monitoring
- · Sharp field edges (penumbra)

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Evolution of radiation generators 1895 - Roentgen discovers X-rays 1913 W.E. Coolidge develops vacuum X-ray tube 1931 E.O. Lawrence develops a cyclotron. 1932 1MV Van de Graff accelerator installed, Boston, MA (USA) 1939 First medical cyclotron for neutron therapy. Crocker, CA (USA) 1946 20MeV electron beam therapy with a Betatron, Urbana, IL (USA) 1952 First Co-60 teletherapy units, Saskatoon (Canada) 1956 First MeV linear accelerator, Stanford, CA (USA) 1958 First proton beam therapy (Sweden)

- 1959 First scanning electron beam therapy, Chicago, IL (USA)
- 1976 First pion beam therapy, LAMPF, NM (USA)
- 1990 First hospital based proton therapy, Loma Linda, CA (USA)
- 1994 First C-ion facility HIMAC (Heavy-Ion Med. Accelerator in Chiba, Japan)

Yoichi Watanabe, MPHY5170/TRAD7170, http://www.tc.umn.edu/~watan016/Teaching.htm

















Linear Accelerators

- I. POWER SOURCE
 - 1. Why not DC: Problems of electrical breakdown, physical size of electrical equipment
 - 2. Apply technique of repeated pulses, V = nv
 - Need oscillating form of power supply
 - Leads to principle of cyclic and linear accelerators
 Wavelength has to be short enough to accelerate electrons in a
 - reasonable distance
 - 5. S-band microwave technology, developed for radar in WWII, has a frequency of \sim 3 GHz or $\lambda{=}\,10$ cm
 - 6. High power is also needed to ensure sufficient energy gain per cycle
 - P.J. Biggs, AAPM Review course 2010

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Magnetron Increasing the magnetic field eventually leads to a sudden drop in current Current between anode and cathode is not used in a power source If it stops the magnetron is blocked due to electron accumulation around the cathode P.J. Biggs, AAPM Review course 2010

























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Summary

- · Particle accelerators: circular and linear
- High energy x-ray machines use electron accelerator and a target
- Using electromagnetic wave rather than a static potential difference allows for higher beam energies and intensities



· P.J. Biggs, AAPM Review course 2010, available at

(updated in 2014)

- C.J. Karzmak, R.J. Morton, A primer on theory and operation of linear accelerators in radiation therapy, Med. Phys. Publishing corp., 1989
- E.B. Podgorsak, Radiation Physics for Medical Physicists, 2nd edition, Springer 2010, Chapters 13-14 (book available online through UT library)
- Podgorsak, E.B., Radiation Oncology Physics Handbook, IAEA 2005, Chapter 5 (available online)