Accelerators

Lecture (1)

Text books

- An Introduction to the Physics of Particle Accelerators by Mario Conte
- The physics of particle accelerator physics by Klaus
- An Introduction to the Physics of High Energy Accelerators by Edwards
- RF Linear Accelerators by Thomas Wangler
- Fundamentals of Beam Physics by Rosenzwing
- Particle Accelerator Physics by Wiedmann
- Handbook of Accelerator Physics and Engineering by Alex Chao
- An Introduction to Beam Physics by Martin Berz

Basic relativity review

- Relativistic parameters

$$\beta = \frac{v}{c} \qquad \gamma = \frac{1}{\sqrt{1-\beta^2}} = \frac{E}{E_0}$$

$$\beta = \sqrt{1 - 1/\gamma^2}$$

- Total energy (E), momentum (p) and kinetic energy (k)

$$E^2 = p^2c^2 + {m_0}^2c^4$$

$$\mathrm{E} = \gamma m_0 c^2$$

$$p = \gamma m_0 c$$

$$k = (\gamma - 1) m_0 c^2$$

Types of accelerators

- Accelerators can be classified into 3 groups

1) DC accelerators

Direct voltage accelerators, Van de Graff and Cockcroft-Walton cascade generator

2) Linear accelerators

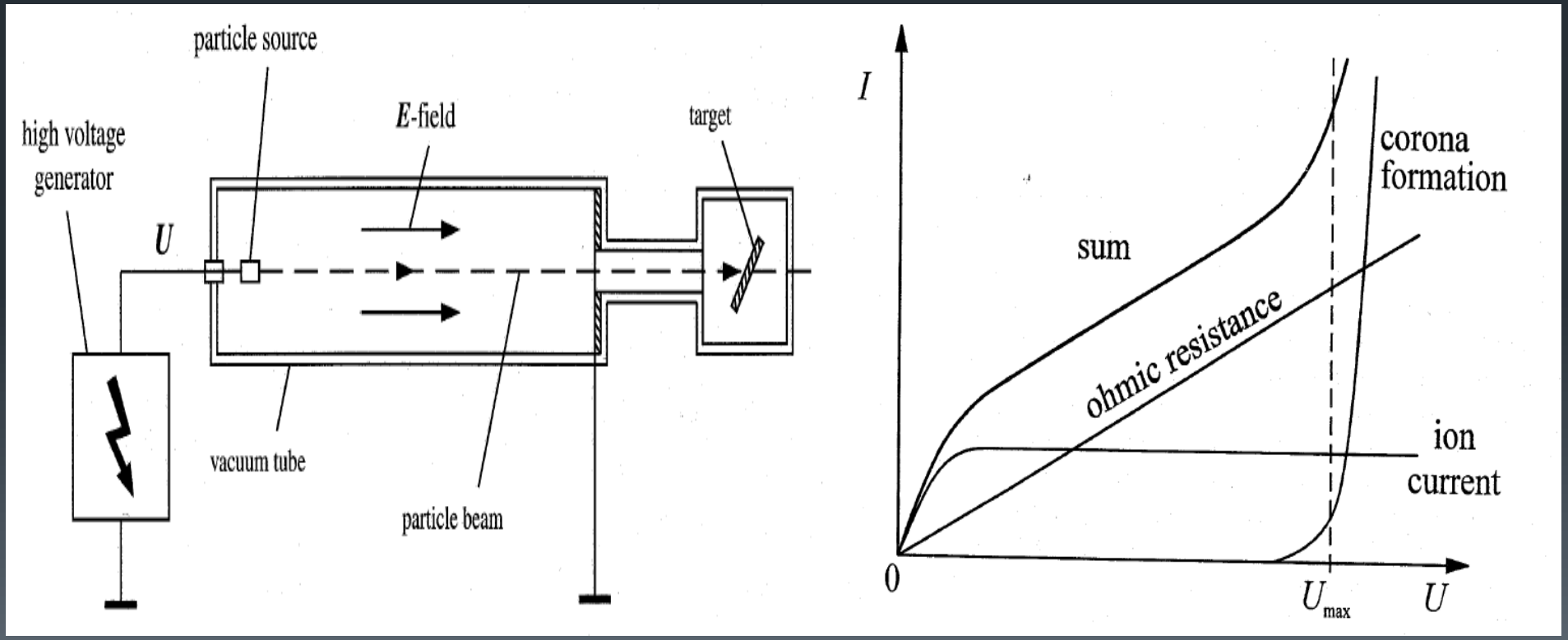
Wideröe's tube and Alvarez drift tube.

3) Circular accelerators

Cyclotron, Betatron, Microtron and Synchorotron.

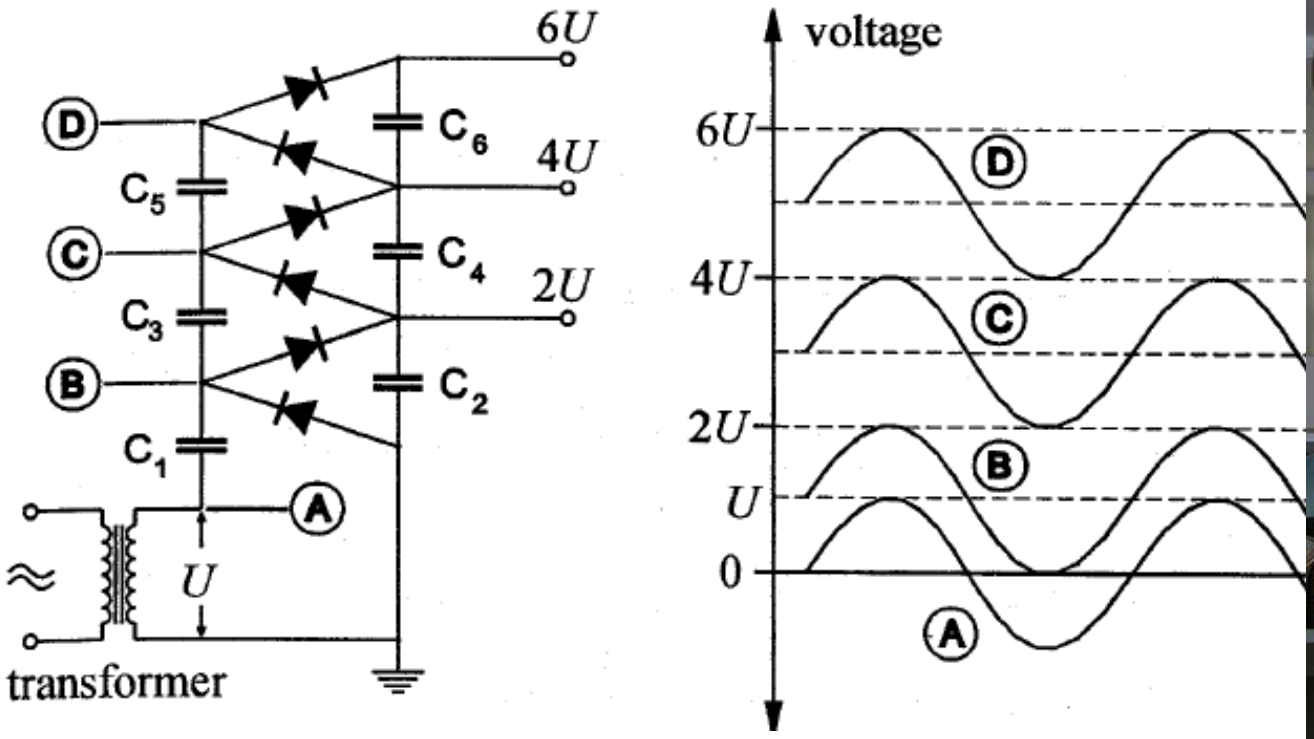
DC accelerators

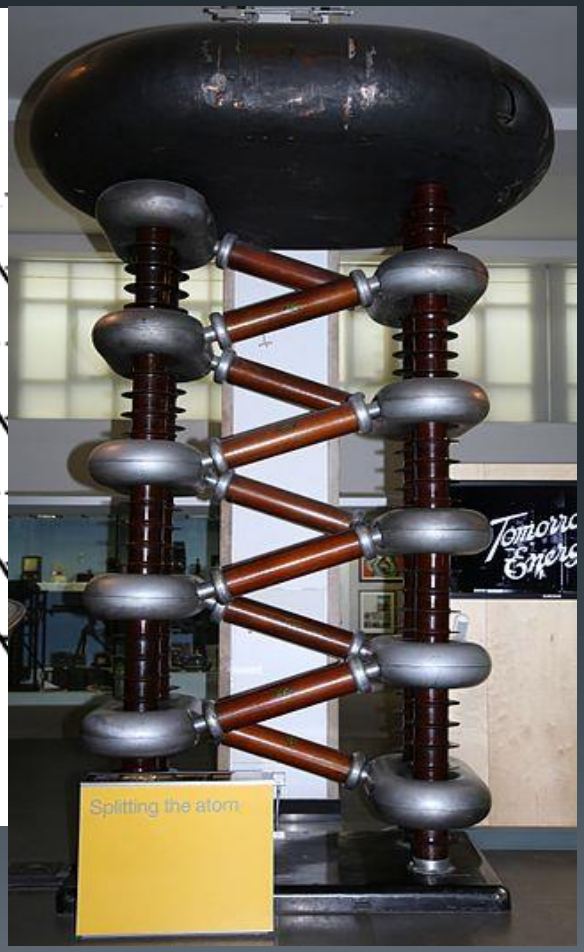
1- Direct Voltage accelerator



DC accelerators (cont.)

2 - The Cockcroft-Walton cascade generator

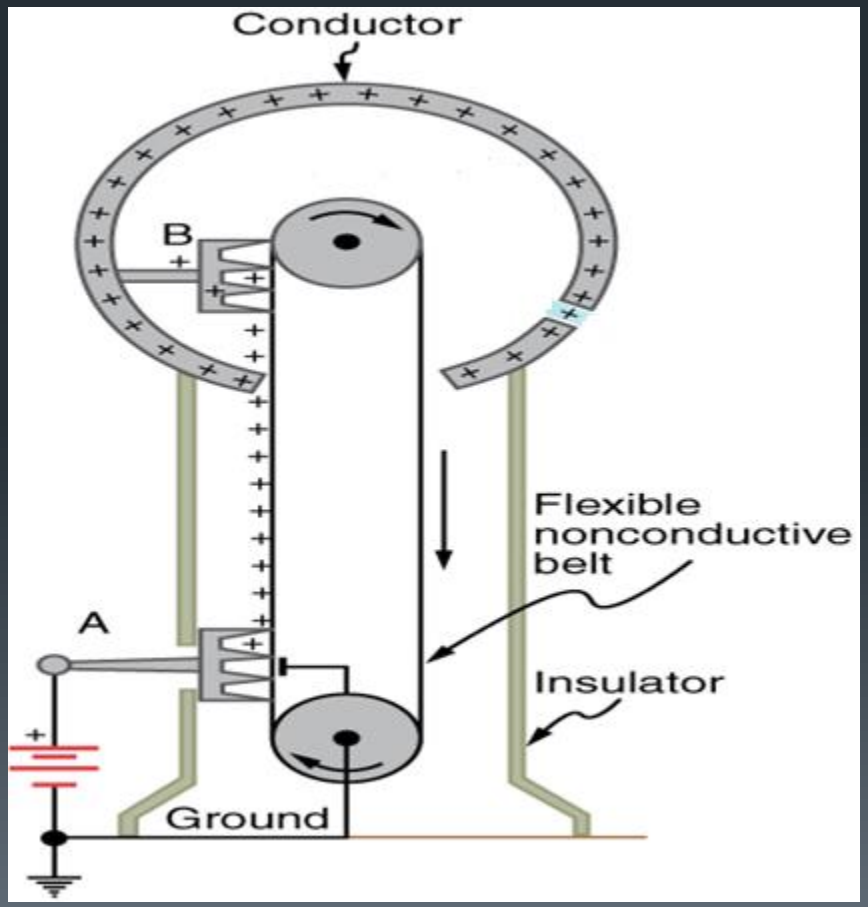




$$U_{tot} = 2nU - \frac{2\pi I}{\omega C}\left(\frac{2}{3}n^3 + \frac{1}{4}n^2 + \frac{1}{12}n\right)$$

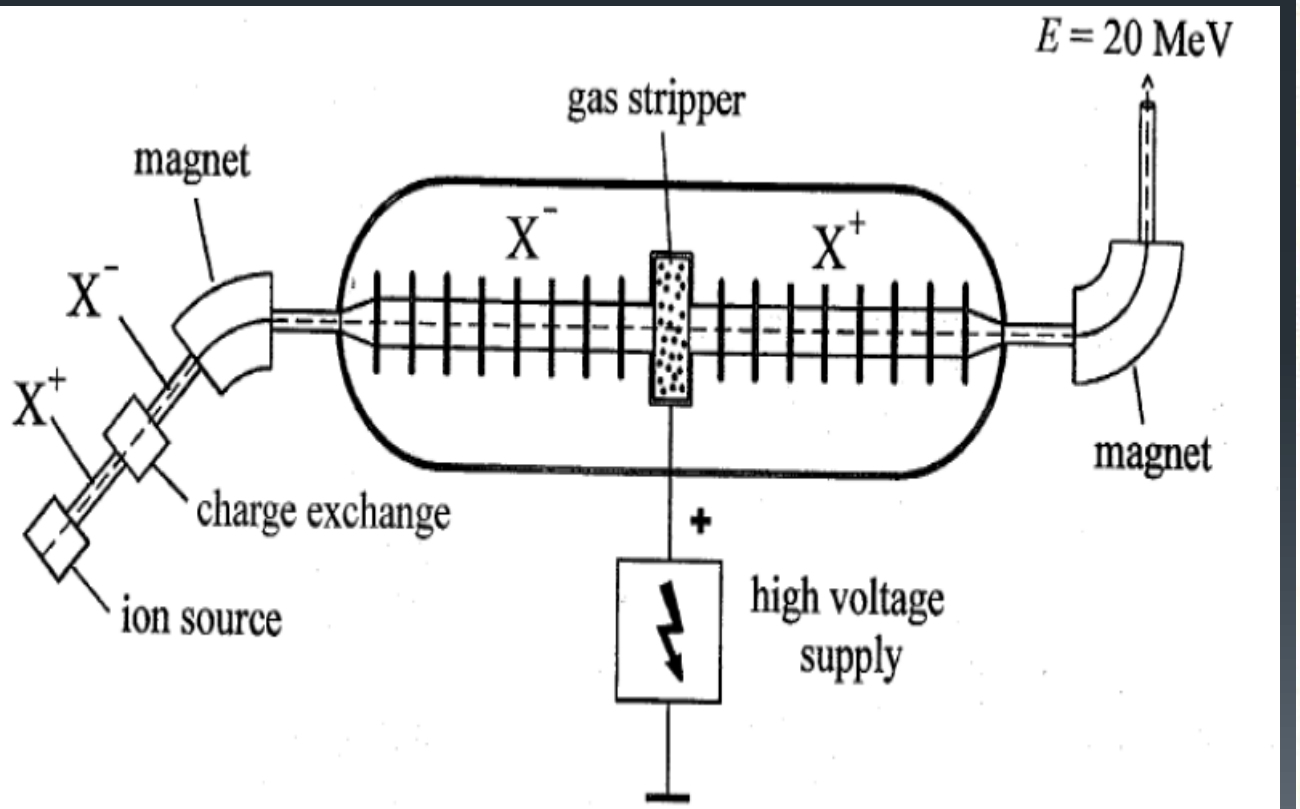
DC accelerators (cont.)

3- Van de Graff generator



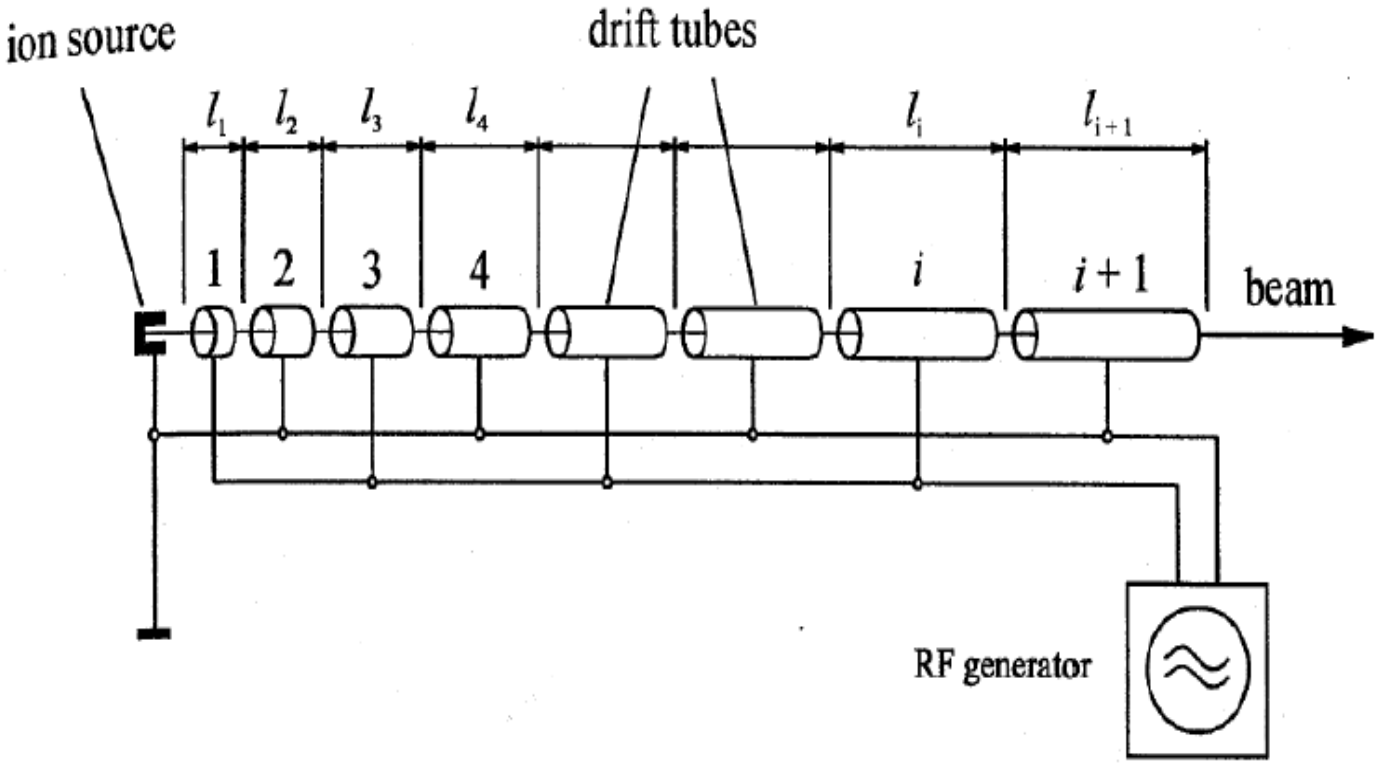
DC accelerators (cont.)

4- Tandem Van de Graff



Linear accelerators

- Wideröe's tube



$$E_i = iqU_{max}\sin\psi_0$$

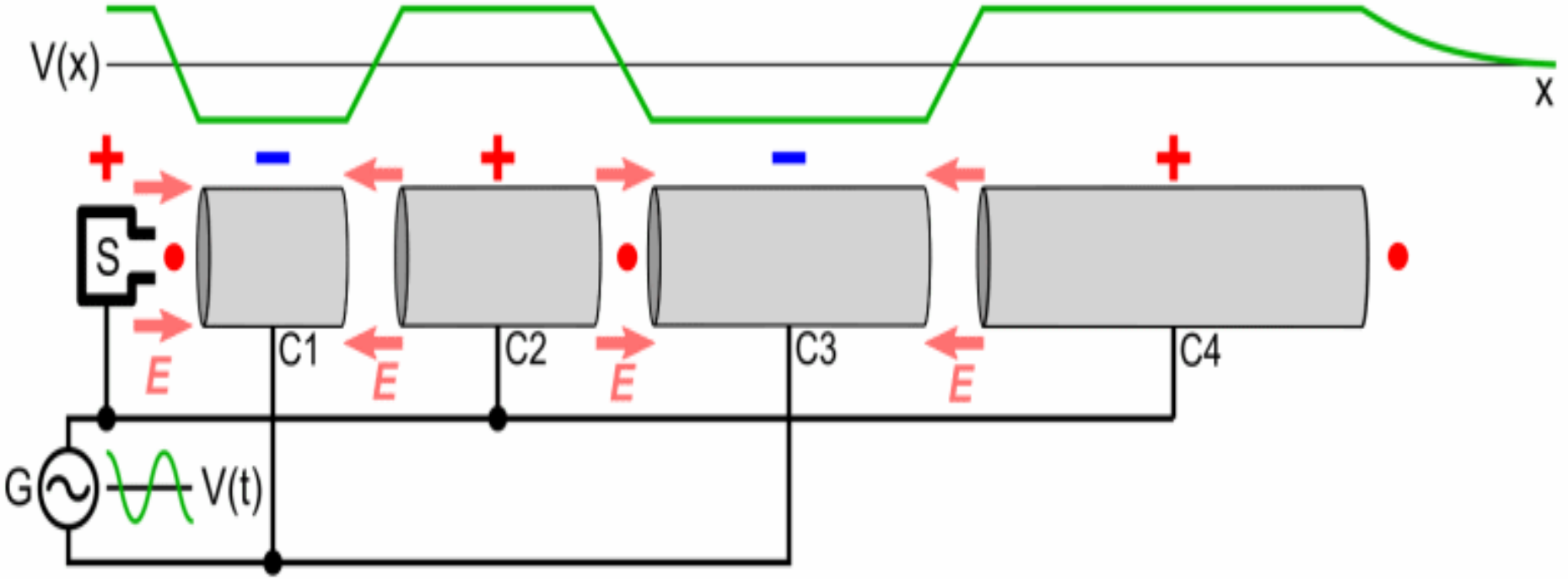
$$E_i = \frac{1}{2}mV_i^2$$

$$L_i = \frac{V_i\tau_{RF}}{2} = \frac{V_i}{2\nu_{RF}}$$

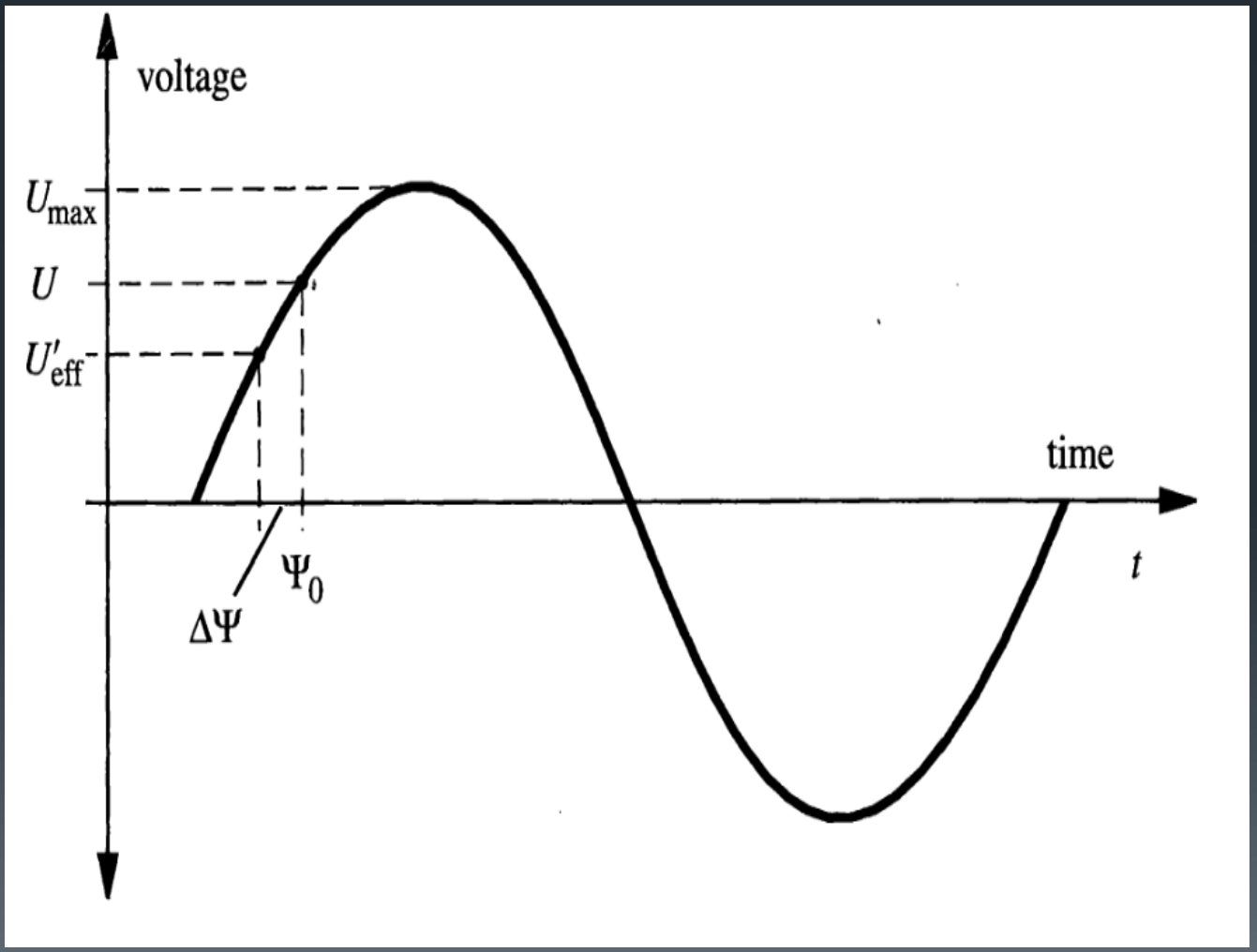
$$L_i = \frac{1}{\nu_{RF}}\sqrt{\frac{iqU_{max}\sin\psi_0}{2m}}$$

Linear accelerators

- Wideröe's tube



Synchronization of the particle motion



$$U(t) = U_{max} \sin \psi_0$$

When $\psi_0 = \pi/2$

The peak voltage is U_{max}

When $\psi_0 < \pi/2$

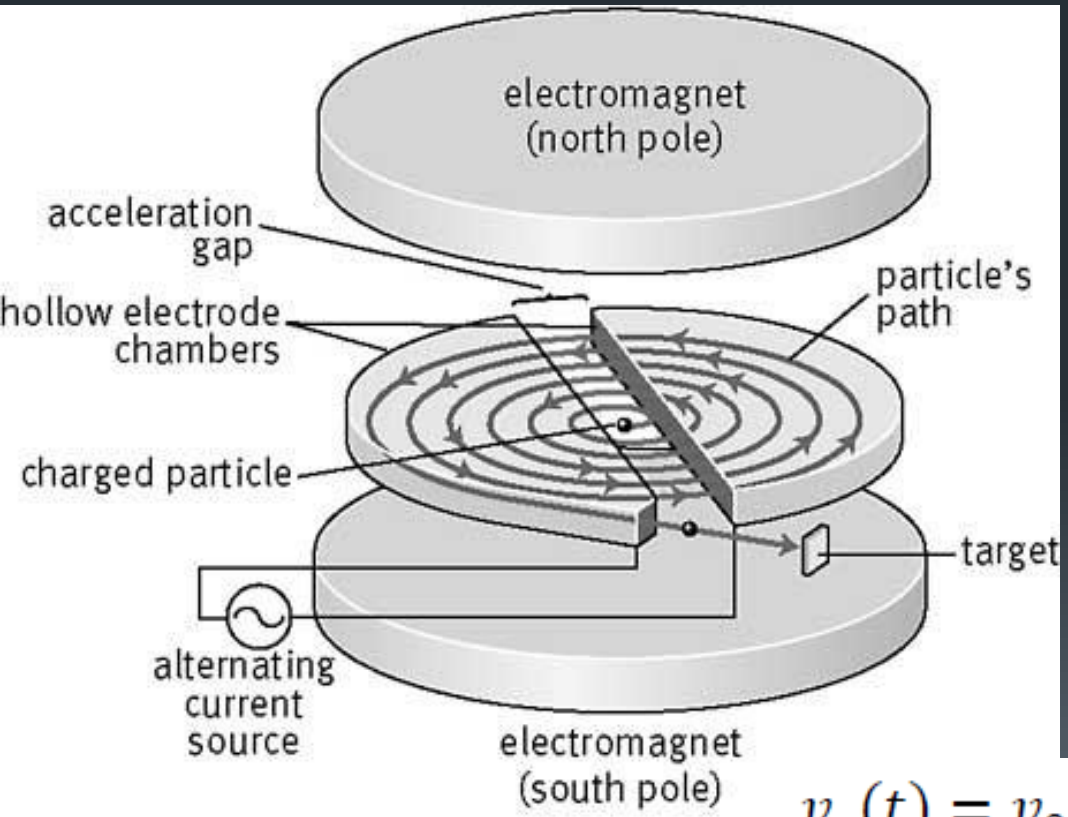
then $U_{eff} < U_{max}$

and

$$U'_{eff} = U_{max} \sin(\psi_0 - \Delta\psi)$$

Circular accelerators

- The cyclotron



$$F = \frac{d}{dt}(mv) = \dot{P} = ev \times B$$

$$\ddot{v_x} + \frac{e^2}{m^2} B_z^2 v_x = 0$$

$$\ddot{v_y} + \frac{e^2}{m^2} B_z^2 v_y = 0$$

$$v_x(t) = v_0 \cos(\omega_z t)$$

$$v_y(t) = v_0 \sin(\omega_z t)$$

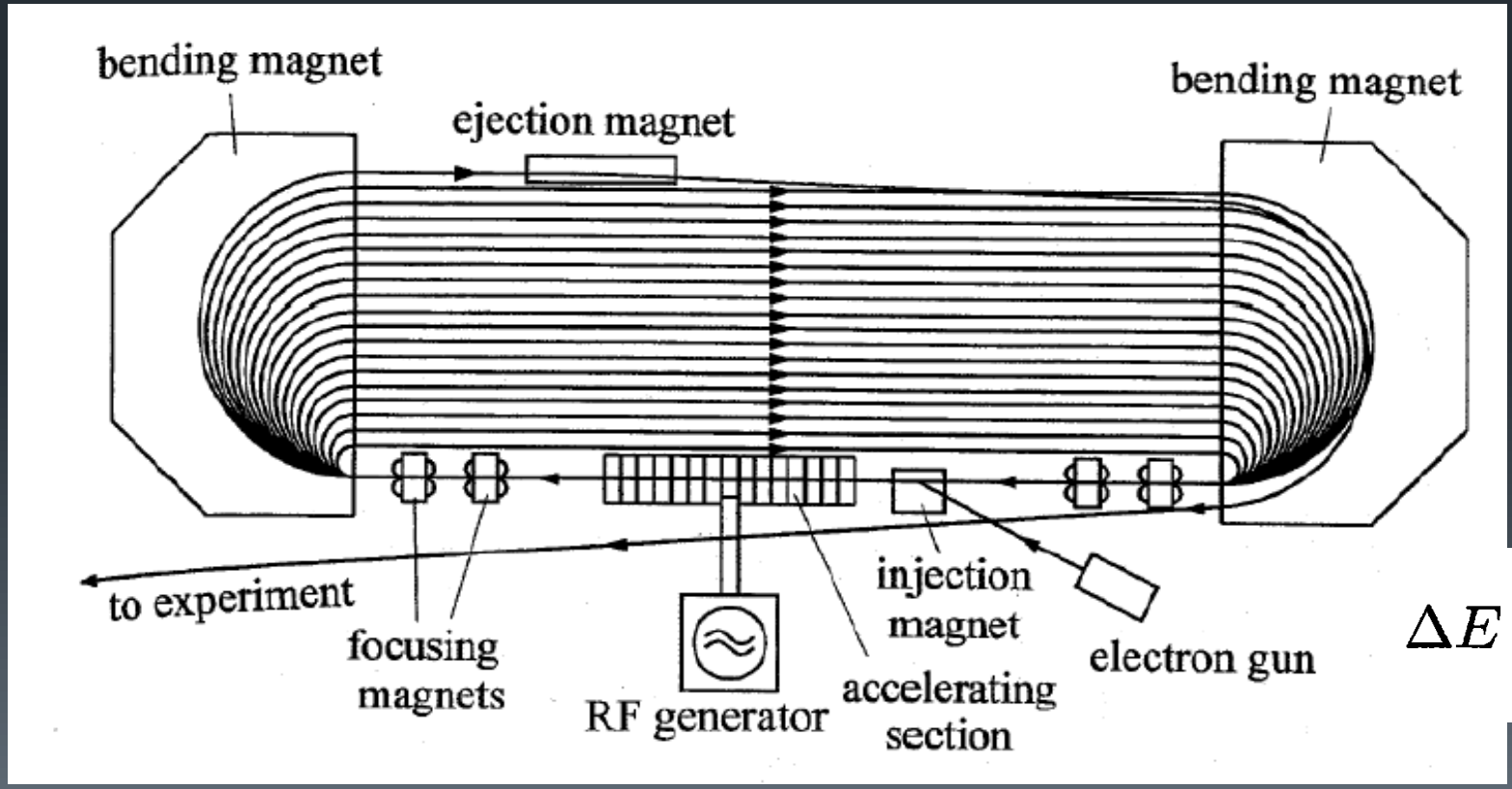
Circular accelerators

- The cyclotron (continue)

Circular accelerators (cont.)

- The race track Microtron

Circumference of the orbit increases by $k\lambda_{RF}$



MAMI is the largest and located in university of Mainz (820 MeV)

$$\Delta E = k\frac{ec^2B}{2\pi\nu_{\mathrm{RF}}}.$$