Lecture 6

Synchrotron Storage Ring RF Systems

November 14, 2002

Why use RF?

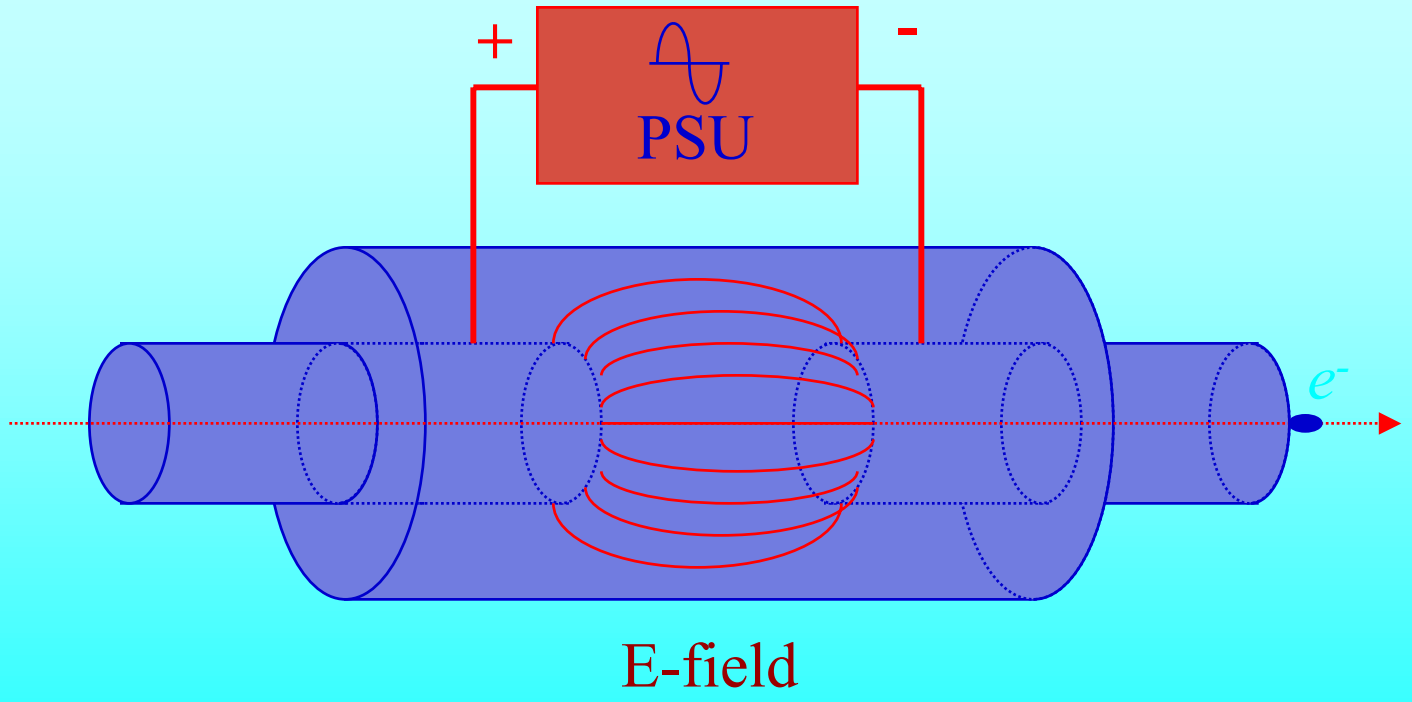
- Charged particles are accelerated in an Accelerator by an Electric Field
- RF system is not always a necessity for accelerating charged particles!
- Consider CRT:
  - has an electron gun ⇒ produces cloud of e^-.
  - high DC potential ⇒ accelerates e^- to the screen.
  - capacitive parallel plates direct e^- onto screen.

Why use RF?

- An RF system is used in accelerators because by using an alternating E-field, the cavities become resonant.
- Cavities will resonate at a specific design frequency.
- Any noise or other higher order modes (HOMs) or frequencies should not resonate.
- Beam should see only the desired frequency and not the HOMs.

RF Cavity

- RF voltage is applied to a Cavity, with an RF gap:



Cavity Design Criteria

- **Frequency**
  - **dictated by the electron accelerator**
- **Light Source Storage Rings**
  - **55MHz - 509MHz**
- **Linear Accelerators (LINAC)**
  - **750MHz - 30GHz**

Cavity Design Criteria

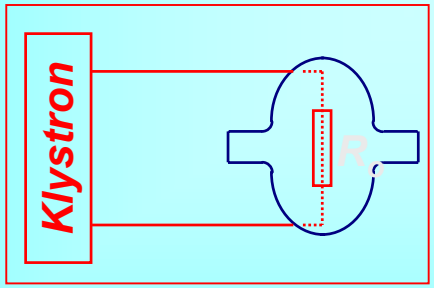
- Q Factor
  - dictates the cavity power consumption:

$$Q_o = 2\pi f \frac{U}{P}$$

  - where:
    - f = mode frequency (Hz)
    - U = Energy stored (eV)
    - P = Power lost per RF cycle (Js^{-1})

Cavity Design Criteria

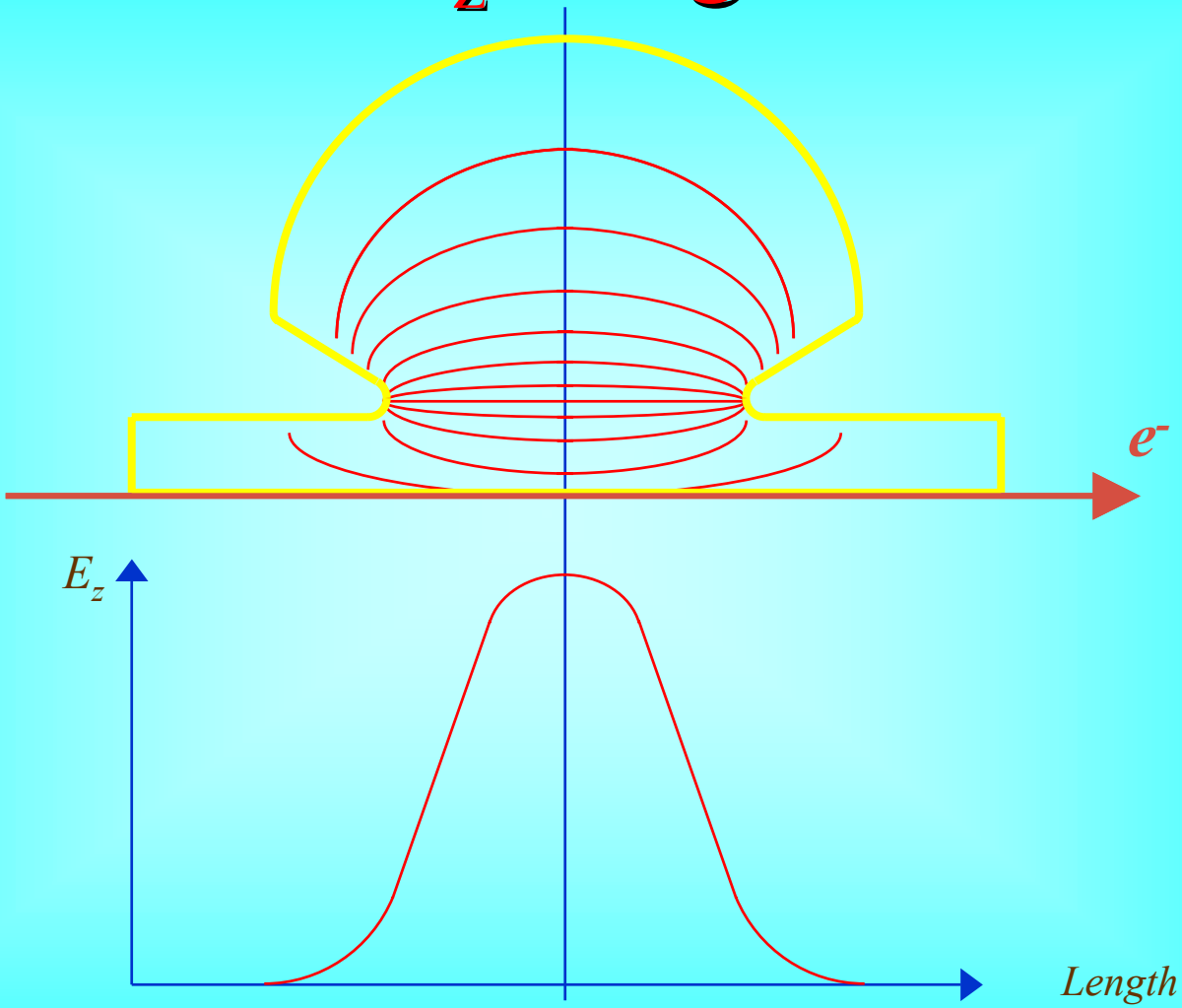
- Shunt Impedance
  - defines the cavity efficiency in transferring RF power into an accelerating voltage for particle accelerators.



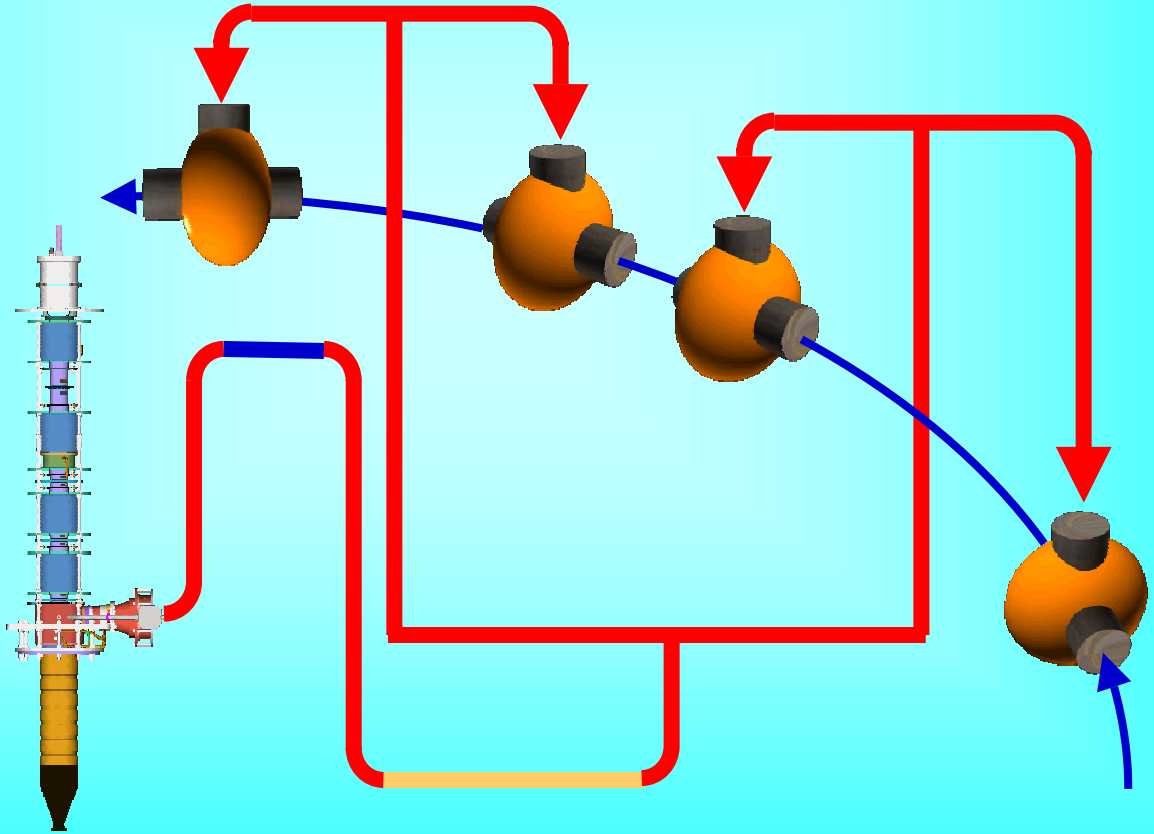
(Engineering definition)

  - $\int E_z$ = E-field on axis through cavity.

E_z Integral



Acceleration



Higher Order Modes

- Circulating beam can excite higher order resonance's in a cavity
- These e-m fields interact back on the beam.
  - Cause the beam to become unstable either longitudinally (beam direction) or transversely.
- Effect of HOMs must be suppressed!

Suppressing HOMs

- Cavity design stage.
- Techniques can be employed once the cavity is operational:
  - cavity temperature control.
  - RF modulation.
  - Beam feedback.
- Combination of all