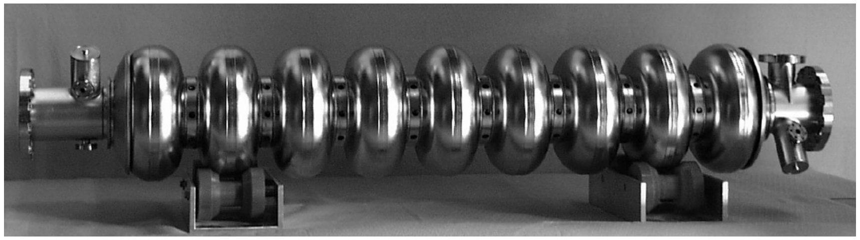
Superconducting Cavities



$Q = 10^{10}$

E = 20MV/m

A bell with this Q would ring for a year.

- Very low wall losses.
- Therefore continuous operation is possible.

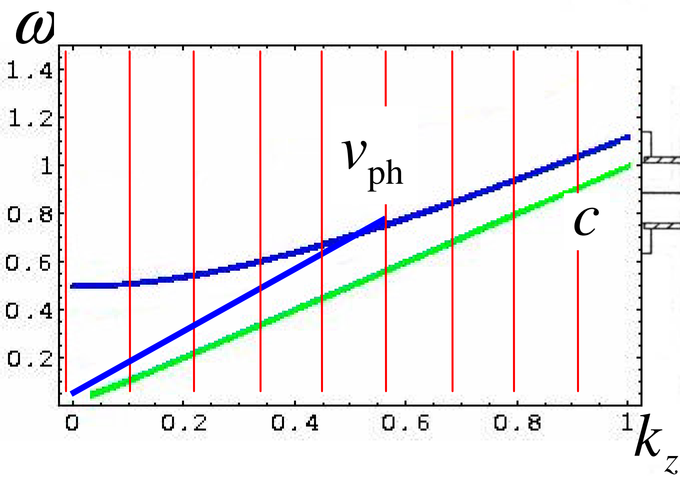
- Energy recovery becomes possible.

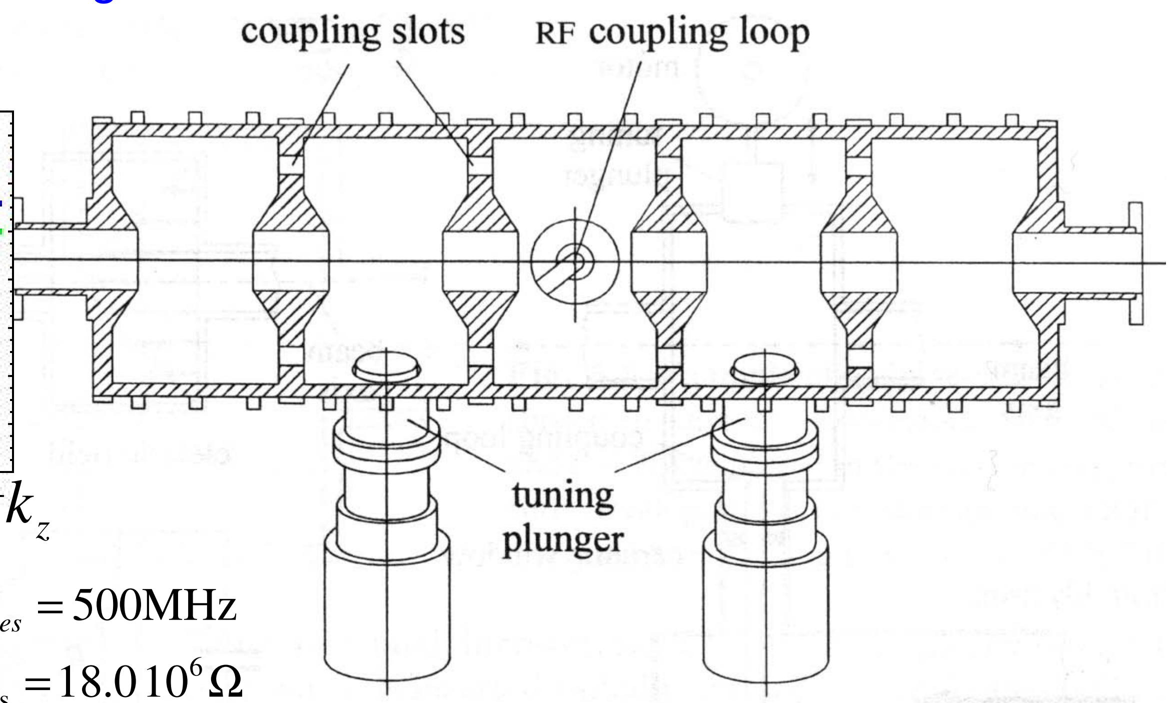
Normal conducting cavities

- Significant wall losses.
- Cannot operate continuously with appreciable fields.
- Energy recovery was therefore not possible.

Multicell standing-wave cavities

The filed in many cells can be excited by a single power source and a single input coupler in order to have the voltage of several cavities available.





Example: PETRA Cavity

$$f_{res} = 500\text{MHz}$$

$$\text{R}_s = 18.0\,10^6\,\Omega$$

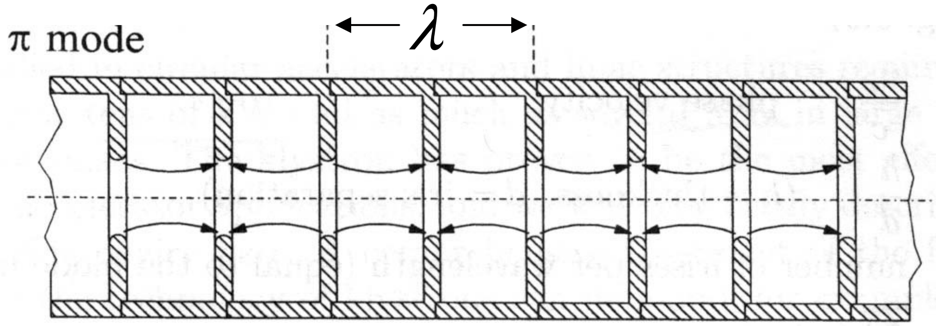
$$125\text{kW} \rightarrow 2.12\text{MV}$$

Without the walls: Long single cavity with too large wave velocity. $v_{\text{ph}} = \dfrac{\omega}{k}$

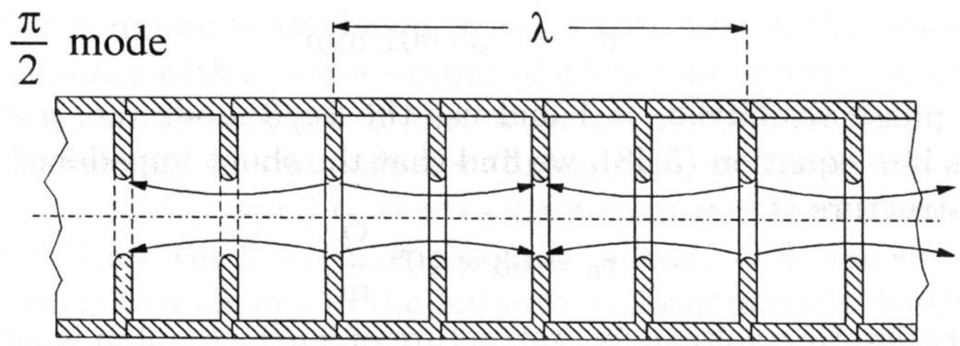
Thick walls: shield the particles from regions with decelerating phase.

Modes in Waveguides

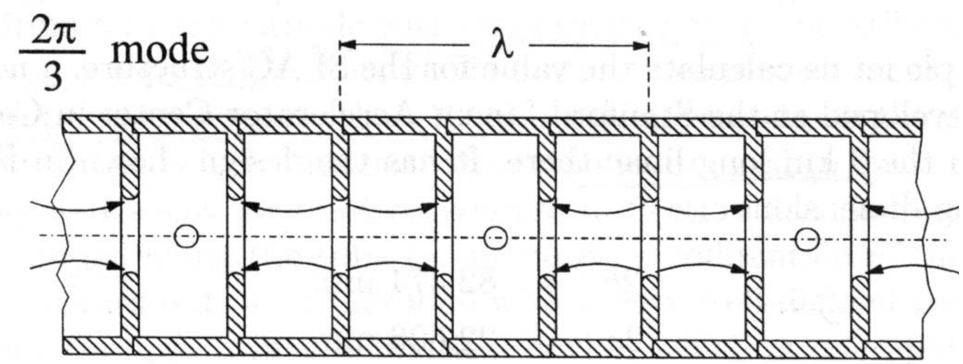
The iris size is chosen to let the phase velocity equal the particle velocity.



Long initial settling or filling time, not good for pulsed operation.



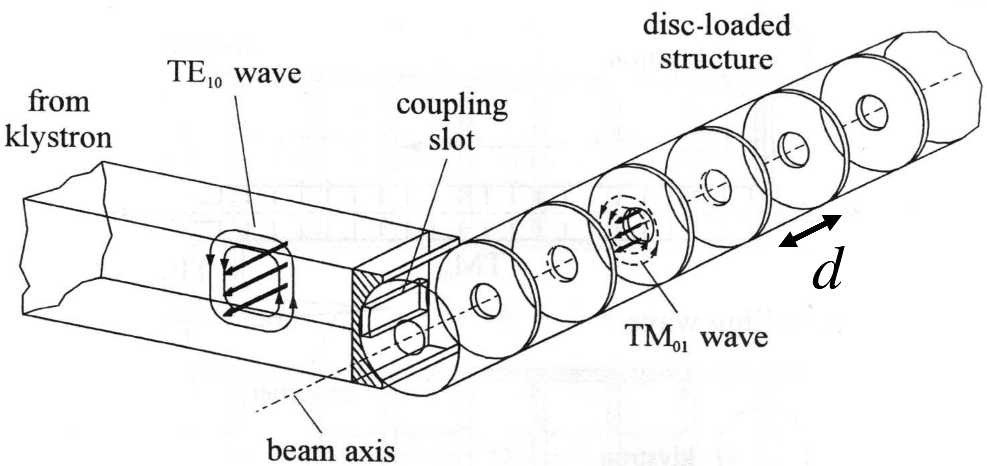
Small shunt impedance per length.

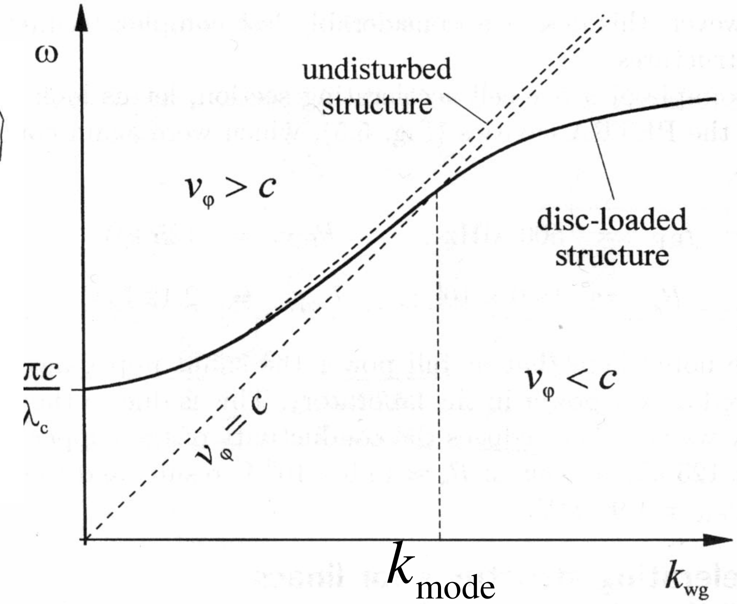


Common compromise.

Disc Loaded Waveguides

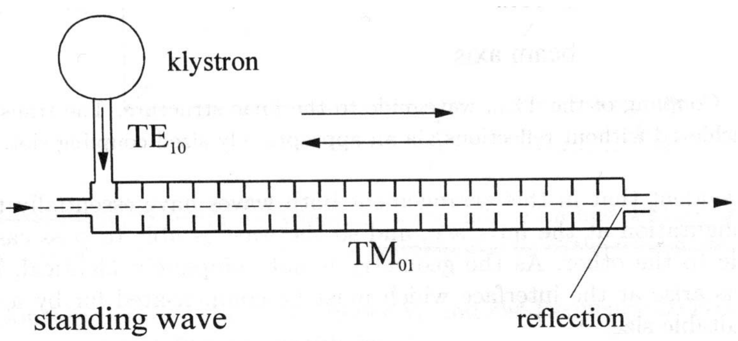
The iris size is chosen to let the phase velocity equal the particle velocity.



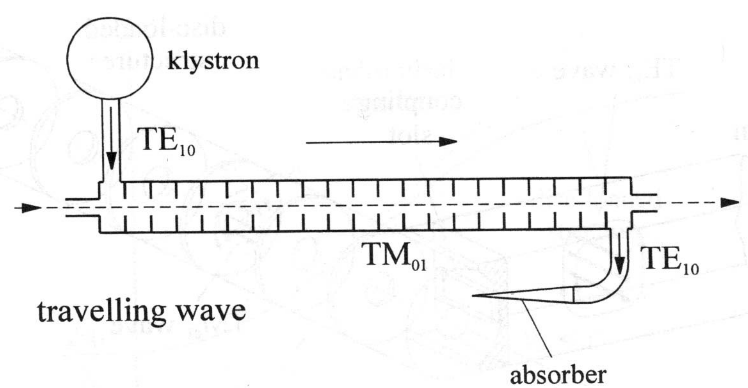


Loss free propagation: $k = \frac{2\pi}{nd}$

Standing wave cavity.



Traveling wave cavity (wave guide).



Transport maps of cavities

(1) Linearization: $E_r(r,z,t) =_1 -\frac{r}{2}\partial_z E_z(0,z,t) \quad \Rightarrow \quad \vec{\nabla}\cdot\vec{E}=0$

$$B_\varphi(r,z,t) =_1 \frac{1}{c^2}\frac{r}{2}\partial_t E_z(0,z,t) \quad \Rightarrow \quad \vec{\nabla}\times\vec{B}=\frac{1}{c^2}\partial_t\vec{E}$$

(2) Equation of motion:

Exact for a traveling wave with $\omega/k = v$ because of: $\frac{d}{dz}\cos(\omega t - kz + \varphi_0)f(z) = \frac{d}{dz}f(z)$

$$a = \frac{p_x}{p_0}$$

$$a' = \frac{1}{p_0 v}(F_x - aF_z) = -\frac{q}{p_0 v}[\frac{r}{2}(\partial_z + \frac{v}{c^2}\partial_t)E_z + aE_z]$$

$$= -\frac{q}{p_0 v}[\frac{r}{2}(\frac{d}{dz} - \frac{1}{v}(1-\frac{v^2}{c^2})\partial_t)E_z + aE_z] \approx -\frac{1}{p_0}[r\frac{1}{2}p_0'' + ap_0']$$

$$u = r\sqrt{p}$$

p denotes p_0 for simplicity

$$u' = a\sqrt{p} + r\sqrt{p}\frac{p'}{2p}$$

Focusing !

$$u'' \approx -\frac{1}{\sqrt{p}}(r\frac{1}{2}p'' + ap') + a\sqrt{p}\frac{p'}{p} + r(\frac{p''}{2\sqrt{p}} - \frac{p'}{4\sqrt{p}^3}) = -u\left(\frac{p'}{2p}\right)^2$$