BEAM LOADING ISSUES

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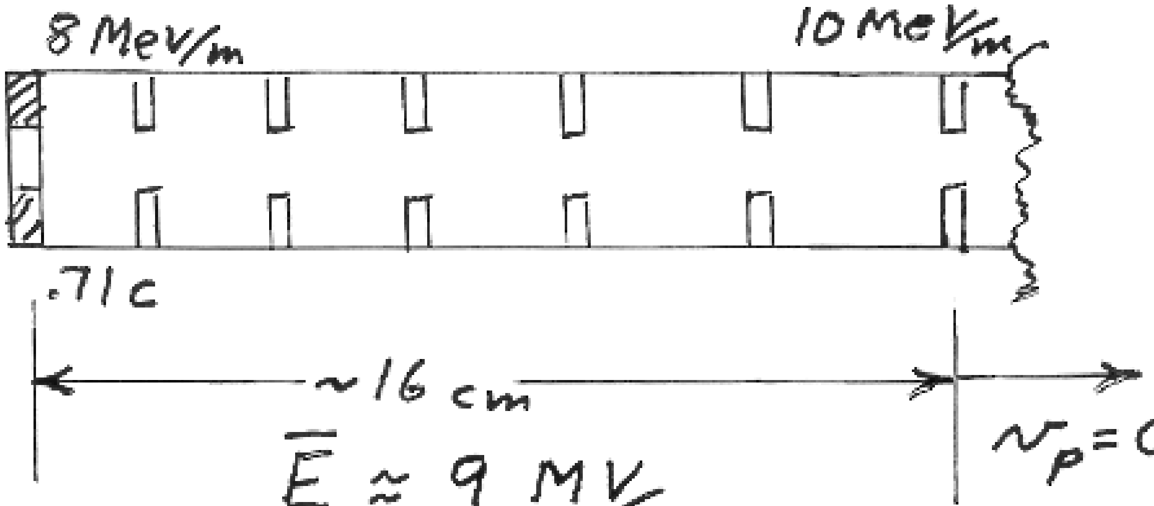
T.W. Buncher Beam Loading



$\bar{E} \approx 9$ MV/m

$\bar{\beta} \approx .85$

My Definition $\frac{R}{Q} \equiv \frac{V^2}{\omega U} \approx 50\ \Omega/\text{cell}$

$$V_{Kly.} = \left(P_{in}\,\omega t_f \frac{R}{Q}\right)^{\frac{1}{2}}$$

$$V_{B.L.} = \frac{1}{4}\, i\, \omega\, t_f \left(\frac{R}{Q}\right)_{Total}$$

$$E_{B.L.}(z=L) = 2\, V_{BL}/L$$

$$\left.\begin{array}{l} P = 35\text{ MW} \\ V = 1.5\text{ MV} \end{array}\right\}\ \omega t_f \left(\frac{R}{Q}\right)_{Total} = 65\text{ k}\Omega$$

$i = 5$A $\quad E_z(z=L) = 1.0$ MeV/m

$i = 7$A $\quad E_z(z=L) = 1.4$ MeV/m.

T.W. Buncher Beam Loading (cont)

Assume Bunch ~ 45° Forward of crest on average.

$i = 5A$ $\Delta E \sim 7\%$

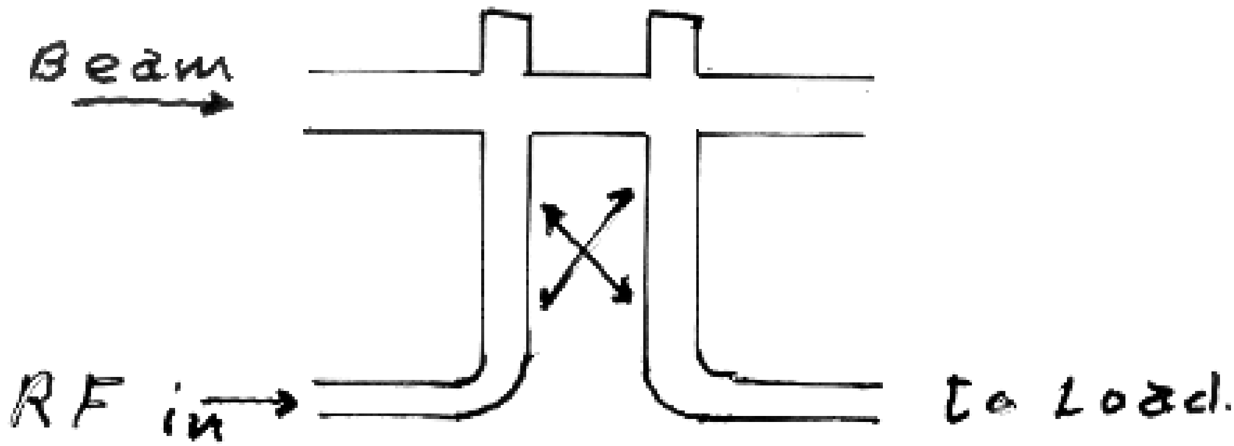
$\Delta \Theta \sim 4°$

$i = 7A$ $\Delta E \sim 10\%$

$\Delta \Theta \sim 6°$

t_s (6 cells) ~ 11 nsec

SHB 2 Beam Loading



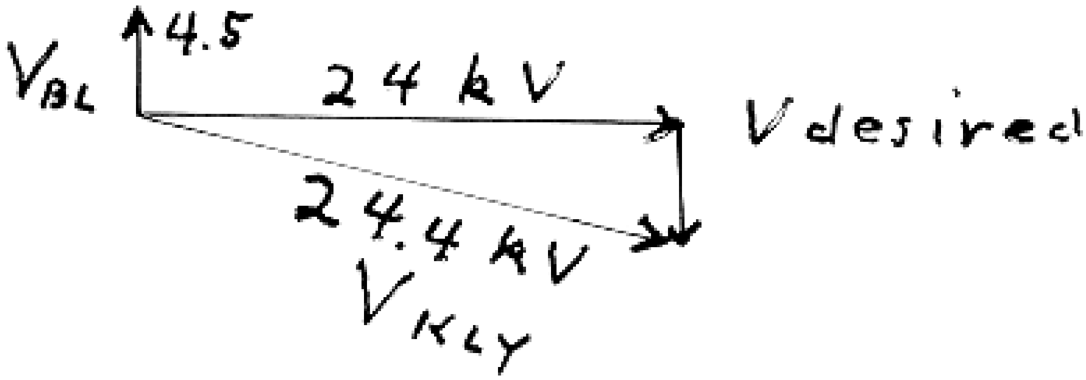
$$80\ \text{kW} \Rightarrow 12\ \text{keV}$$

Define Impedance

$$R \equiv \frac{V^2}{P_{in}} = 1.8\ \text{k}\Omega$$

$$V_{BL} = \frac{I R}{2}$$

5 A: $V_{BL} = 4.5\ \text{kV}$



4.5 GHz Buncher Beam Loading

215 kW $\Rightarrow$ 19 keV

$$R \equiv \frac{V^2}{P_{in}} = 1.7\ k\Omega$$

$$V_{BL} = \frac{I R}{2}$$

$$I \sim \frac{2}{\pi} I_{dc}$$

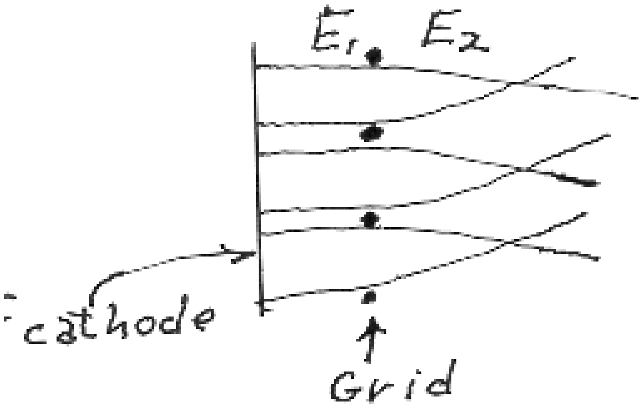
Nominal Case

$V_{BL} \sim 3$ kV

$V_{desired} \sim 7.5$ kV

$V_{KLY} \sim 8$ kV.

Gun Grid Emittance



$$E_r \approx -\frac{r}{2}\frac{\partial E_z}{\partial z}$$

$$\Delta p_r = \int F_r \, dt \approx \frac{1}{\beta c}\int F_r \, dz$$

$$= -\frac{e r}{2\beta c}\int \frac{\partial E_z}{\partial z} dz$$

$$\frac{\Delta p_r}{mc} = -\frac{e r}{2\beta m c^2}(E_2 - E_1)$$

Impulse Approx.

$$\Delta \mathcal{E}_{e,n} \approx \frac{R \Delta p_r}{mc} = -\frac{e R r}{2\beta m c^2}(E_2 - E_1)$$

E_2 calculated with EGUN

E_1 calculated from perveance of planar diode

$$E_1 = \frac{2 V_g}{d} = \frac{2}{d}\left(\frac{I \, d^2}{2\times 10^{-6} A}\right)^{\frac{2}{3}}$$

d = cathode grid spacing

A = cathode area