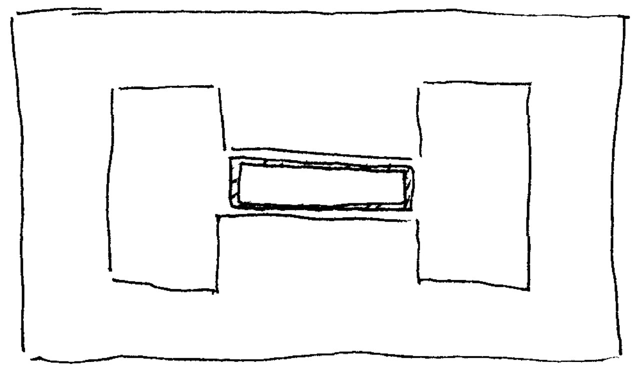
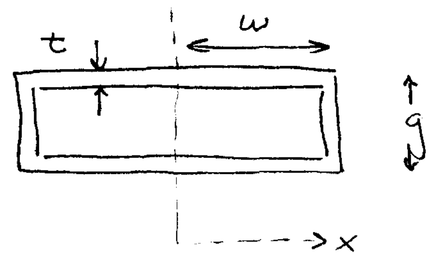
4/10/90

S. Holmes

Eddy Current Effects in the Main Injector Beam Tube



Beam Pipe:



In the presence of $\dot{B}_0$ there is a longitudinal electric field:

$$E_z = \dot{B}_0 x$$

where x is the distance from the pole center line.

$$j = \sigma E = \sigma \dot{B}_0 x$$

The current flowing in the pipe is:

$$\frac{dI}{dx} = j t = \sigma \dot{B}_0 t x$$

I Induced Field

Amperes Law ($\mu = \infty$) $\qquad g B(x) = \mu_0 \int_x^w dI$

③ The induced dipole field is

$$\boxed{B_d = \frac{\mu_0 \sigma \dot{B}_0 t}{g} (w^2 + wg)}$$

For $w = 2''$ $(= .05m)$: $B_d = 12$ Gauss

④ The induced dipole + sextupole are non-negligible at 8.9 GeV.

II Power Dissipation in the Beam Pipe

$$dP/l = 2 \sigma t \dot{B}_0^2 x^2 dx \qquad \text{(top + bottom)}$$

$$P/l = 2\sigma t \dot{B}_0^2 \int_{-w}^{w} x^2 dx$$

$$\boxed{P/l = \sigma t \dot{B}_0^2 \left(\underbrace{\tfrac{4}{3} w^3}_{\text{Top + Bottom}} + \underbrace{2 w^2 g}_{\text{Sides}} \right)}$$

For $\dot{B}_0 = 2.8$ T/sec, $w = 2''$ $(= .05$ m$)$

$$\boxed{P/l = 11 \text{ Watts/m}}$$

For $l = 6$ meters, $P = 66$ Watts @ 2.8 T/sec.

Duty factor should reduce this × 1/2. → Should be no problem.