

Intrabeam Scattering Results for a High Frequency RF System with Tight RF Buckets

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May 25, 1988

Factors Leading To Growth

$$1) \frac{1}{\sigma} \frac{d\sigma}{dt} \approx (Q^2/A)^2$$

2) Distance from "Equilibrium State"

$$\text{Invariant} \rightarrow \sigma_E^2 - \sigma_x^2 = \text{const}, \quad \sigma_E = \chi_p \sigma_p$$

$\chi > \chi_c$, cells only lattice, no coupling

$$t \rightarrow \infty, \quad \sigma_E \sim \sigma_x$$

$$\frac{1}{\sigma_E} \frac{d\sigma_E}{dt} = \left(\frac{\sigma_x}{\sigma_E} \right)^2 \frac{1}{\sigma_x} \frac{d\sigma_x}{dt}$$

If $\sigma_E \ll \sigma_x$ at $t=0$, the σ_E will grow much faster than σ_x until $\sigma_E \sim \sigma_x$.

Protons may show large growth in σ_E , if $\sigma_E \ll \sigma_x$ at $t=0$.

(2)

High Frequency RF System

To get shorter σ_z , suggests $f \sim 200 \text{ MHz}$

Earlier calculations required

large voltage $V \approx 40 \text{ MV}$, and gave large growth in ϵ_x, σ_p , by factor ≈ 2 .

Old Procedure

V held constant. V chosen large enough to contain bunch at $\delta = 100$; $\Delta_B = 2.5 \sigma_p$ at $\delta = 100$ after 10 hours.

New Suggested Procedure

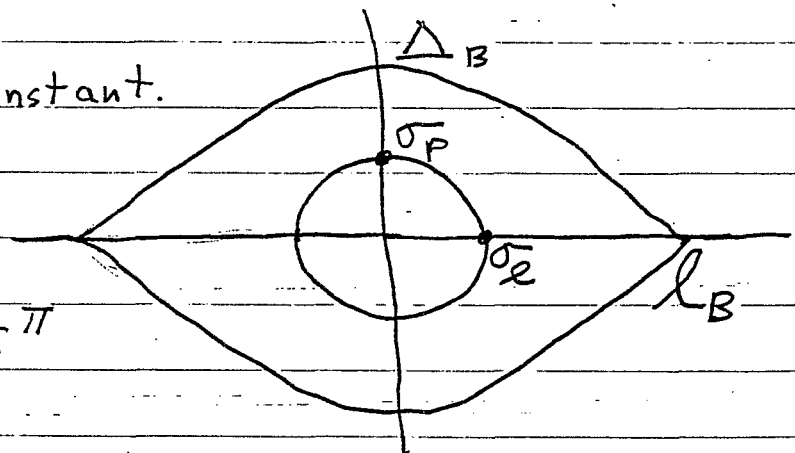
V varied with time so that bucket just contains the bunch, $\Delta_B = 2 \sigma_p$ at all times.

For fixed σ_p / Δ_B , σ_z is constant.

$$\frac{\sigma_p}{\Delta_B} = \sin \phi/2$$

For $\Delta_B = 2 \sigma_p$, $\phi = 60^\circ = \frac{1}{3} \pi$

$$\sigma_z = \frac{1}{3} \ell_B$$



Proposed RF System

$$f = 160 \text{ MHz}, \quad h = 2052$$

$$\sigma_e = 31 \text{ cm}$$

$$A = .3 \text{ eV-rec}$$

$$\Delta_B = 2 \sigma_p$$

- 1) Increasing f will reduce σ_e but will increase ϵ_x , σ_p and V
- 2) Increasing A will increase ϵ_x , σ_p , and V .
- 3) Increasing Δ_B / σ_p will reduce σ_e and improve the safety (reduce the losses from the bucket) but will increase ϵ_x , σ_p and V

Intra-beam Scattering, 10 hrs - G. Parzen, 5/24/88

(4)

	Au, 160 MHz $N_b = 1.1 \times 10^9$, $\Delta B = 2\sigma_p$ $h = 2052$, $A = 3$ ev-sac, $\epsilon_{x_0} = 10$		Au, 214 MHz $N_b = 1.1 \times 10^9$, $\Delta B = 2\sigma_p$ $h = 2736$, $A = 3$, $\epsilon_{x_0} = 10$	
γ	30	100	30	100
σ_{x_0} (cm)	31	31	23.4	23.4
$\sigma_{p_0} / 10^{-3}$.827	.248	1.09	.327
σ_x (cm)	31	31	23.4	23.4
$\sigma_p / 10^{-3}$	1.97	1.14	2.18	1.29
σ_x (mm)	2.69	1.36	2.93	1.46
$\epsilon_x / 10^{-6}$	26	22	31	25
V (MV)	1.74	5.97	2.98	10.1
$\Delta p/p = 2\sigma_p / 10^{-3}$	4.0	2.28	4.36	2.58

	Au, 160 MHz $\Delta B = 2.5\sigma_p$ $h = 2052$, $A = 3$, $\epsilon_{x_0} = 10$		Au, 160 MHz $N_b = 1.1 \times 10^9$, $\Delta B = 2\sigma_p$ $h = 2052$, $A = 1$, $\epsilon_{x_0} = 10$	
γ	30	100	30	100
σ_{x_0}	24.4	24.4	31	31
σ_{p_0}	1.05	.315	2.75	.826
σ_x	24.4	24.4	31	31
σ_p	2.15	1.26	2.90	1.54
σ_x	2.90	1.44	3.05	1.52
ϵ_x	30	25	33	27
V	3.4	11.5	3.96	11.0
$\Delta p/p$	4.30	2.52	5.8	3.08

	Protons, 160 MHz $N_b = 1 \times 10^{10}$, $\Delta B = 2\sigma_p$ $h = 2052$, $A = 3$, $\epsilon_{x_0} = 20$		Protons, 160 MHz $N_b = 1 \times 10^{10}$, $\Delta B = 2\sigma_p$ $h = 2052$, $A = 1$, $\epsilon_{x_0} = 20$	
γ	30	250	30	250
σ_{x_0}	31	31	31	31
σ_{p_0}	.827	.0992	2.75	.330
σ_x	31	31	31	31
σ_p	1.23	.286	2.77	.458
σ_x	2.47	.854	2.50	.869
ϵ_x	21.9	21.9	22.5	22.5
V	.284	.395	1.44	1.01
$\Delta p/p$	2.46	.572	5.54	.916

Protons, 160 MHz
 $N_b = 1 \times 10^{11}$, $\Delta_B = 2.5 \sigma_p$

$h = 2052$, $A_0 = .3$, $E_{x_0} = 20$
 30 250

γ

σ_{L_0} (cm) 24.4 24.4
 $\sigma_p / 10^{-3}$ 1.05 .126

σ_L (cm) 24.4 24.4
 $\sigma_p / 10^{-3}$ 1.40 .331
 σ_L (mm) 2.51 .865
 $E_x / 10^{-6}$ 22.5 22.4

V (MV) .578 .830
 $\Delta p/p = 2 \sigma_p / 10^{-3}$ 2.80 .662

Protons, 160 MHz

$N_b = 1 \times 10^{11}$, $\Delta_B = 2.5 \sigma_p$

$h = 2052$, $A_0 = .3$, $E_{x_0} = 10$
 30 250

24.4 24.4
 1.05 .126

24.4 24.4
 1.48 .410
 2.08 .680
 15 13.8

.641 1.27
 2.96 .820

RF Voltage versus Time

$h = 2052$ $f = 160 \text{ MHz}$

46 1320
V (mV)

$\Delta B = 2 \sigma_P, \epsilon_{x_0} = 20$

$\gamma = 25^\circ$

Protons

$\gamma = 30^\circ$

1 2 3 4 5 6 7 8 9 10
t (hours)

10 X 10 TO 1/2 INCH 1 X 10 INCH
K&E: 100 FELT ESSER CO. MADE IN U.S.A.

V (mV)

$\Delta B = 2 \sigma_P, \epsilon_{x_0} = 10$

$\gamma = 100^\circ$

Al

$\gamma = 30^\circ$

1 2 3 4 5 6 7 8 9 10
t (hours)