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

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Factors Leading To Growth

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

2) Distence from "Equilibrium State"

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

$\gamma > \gamma_t$, cells only lattice, no coupling

$t \to \infty$, $\sigma_E \sim \sigma_x$

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

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 $t=0$.

High Frequency RF System

To get shorter σ_ℓ, suggests $f \sim 200$ MHz

Earlier calculations required large Voltage $V \simeq 40$ MV, and gave large growth in ε_x, σ_p, by factor $\simeq 2$.

Old Procedure

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

New Suggested Procedure

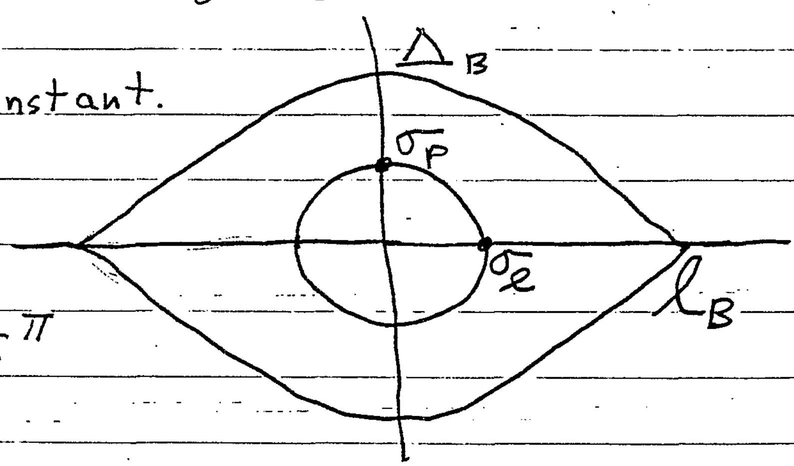
V varied with time so that bucket just contains the bunch, $\Delta_B = 2\,\sigma_p$ at all times.

For fixed σ_p / Δ_B, σ_ℓ is constant.

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

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

$$\sigma_\ell = \frac{1}{3}\, \ell_B$$



Proposed RF System

$f = 160$ MHz , $h = 2052$

$\sigma_\ell = 31$ cm $\quad A = .3$ eV-sec

$\Delta_B = 2\,\sigma_p$

1) Increasing f will reduce σ_ℓ 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_ℓ and improve the safety (reduce the losses from the bucket) but will increase ε_x, σ_p and V

Intrabeam Scattering, 10 hrs — G. Parzen, 5/24/88

	Au, 160 MHz $N_b = 1.1\times10^9$, $\Delta_B = 2\sigma_p$ $h = 2052$, $A = .3$ ev-sec, $\varepsilon_{x_0} = 10$		Au, 214 MHz $N_b = 1.1\times10^9$, $\Delta_B = 2\sigma_p$ $h = 2736$, $A = .3$, $\varepsilon_{x_0} = 10$	
γ	30	100	30	100
σ_{ℓ_0} (cm)	31	31	23.4	23.4
$\sigma_{p_0}/10^{-3}$	.827	.248	1.09	.327
σ_ℓ (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
$\varepsilon_x/10^{-6}$	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 $\Delta_B = 2.5\sigma_p$ $h = 2052$, $A = .3$, $\varepsilon_{x_0} = 10$		Au, 160 MHz $N_b = 1.1\times10^9$, $\Delta_B = 2\sigma_p$ $h = 2052$, $A = 1$, $\varepsilon_{x_0} = 10$	
γ	30	100	30	100
σ_{ℓ_0}	24.4	24.4	31	31
σ_{p_0}	1.05	.315	2.75	.826
σ_ℓ	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 $N_b = 1\times10^{11}$, $\Delta_B = 2\sigma_p$ $h = 2052$, $A = .3$, $\varepsilon_{x_0} = 20$		Protons, 160 MHz $N_b = 1\times10^{11}$, $\Delta_B = 2\sigma_p$ $h = 2052$, $A = 1$, $\varepsilon_{x_0} = 20$	
γ	30	250	30	250
σ_{ℓ_0}	31	31	31	31
σ_{p_0}	.827	.0992	2.75	.330
σ_ℓ	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 $N_b = 1\times10^{11}$, $\Delta_B = 2.5\sigma_p$ $h=2052$, $A_0=.3$, $\epsilon_{x,0}=20$		Protons, 160 MHz $N_b = 1\times10^{11}$, $\Delta_B = 2.5\sigma_p$ $h=2052$, $A_0=.3$, $\epsilon_{x,0}=10$	
γ	30	250	30	250
σ_{ℓ_0} (cm)	24.4	24.4	24.4	24.4
$\sigma_{p_0}/10^{-3}$	1.05	.126	1.05	.126
σ_ℓ (cm)	24.4	24.4	24.4	24.4
$\sigma_p/10^{-3}$	1.40	.331	1.48	.410
σ_x (mm)	2.51	.865	2.08	.680
$\epsilon_x/10^{-6}$	22.5	22.4	15	13.8
V (MV)	.578	.830	.641	1.27
$\Delta p/p = 2\sigma_p/10^{-3}$	2.80	.662	2.96	.820

RF Voltage versus Time

$h = 2052 \quad f = 160\ MHz$