

Short Bunches Performance With Intrabeam Scattering

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SHORT BUNCHES PERFORMANCE
WITH INTRABEAM SCATTERING

A.G. Ruggiero

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Short Bundles

$$L = \frac{N_c^2 B f_{\text{rev}}}{2\pi \alpha \sigma_e \sigma_v}$$

$\sigma_e = 10 \text{ cm}$

$f_{\text{rev}} = 78.1975 \text{ kHz}$

$\sigma_v = 0.0037 \text{ cm}$

$\alpha = 4 \text{ mrad}$

$N_c = 6.24 \times 10^8$

$B = 57$

$L = 1.9 \times 10^{27} \text{ cm}^{-2} \text{ s}^{-1}$

Filling sequence :

- one AGS pulse is made of 3 bundles
- 19 AGS pulses stacked in a box-car fashion

Filling Time : about 1 minute -

Longitudinal Stability of short bunches

$$\left| \frac{Z}{n} \right| = \frac{E/m}{eI_p} \left(2 \frac{\sigma_E}{E} \right)^2 \frac{A}{Z^2}$$

I_p , peak current = $N_c e \beta c / (\sigma_z \sqrt{2\pi})$

N_c , no. of particles / bunch = ~~6.24~~ 6.24×10^8

σ_z , rms bunch length = 10 cm ($\sigma_z = 0.33$ nsec)

$I_p = 0.12$ Amp - particle ($\beta \approx 1$)

For Gold (Au) $A = 197$ and $Z = 79$

Assume a coupling impedance of $|Z/n| = 10$ ohms

E , energy per nucleon ~ 100 GeV/A

$\eta = \gamma^{-2} - \gamma_T^{-2}$, γ_T = transition energy / rest energy

σ_E/E , rms energy spread at stability

$B = 6\pi \sigma_E \cdot \sigma_z$, bunch area

The following table explores the dependence on γ_T of the threshold energy spread $\hat{\sigma}_E/E$ and the corresponding bunch area -

(3)

δ_T	$ z $	σ_e/E threshold @ 100 GeV/A	B eV/A - sec
10	.0099	0.98×10^{-4}	0.061
20	.0024	1.99×10^{-4}	0.124
30	1.011×10^{-3}	3.07×10^{-4}	0.191
50	3×10^{-4}	5.63×10^{-4}	0.350
80	5.625×10^{-5}	13.00×10^{-4}	0.809

Intra beam scattering diffusion rates @ 100 GeV/A

$$E_N = 4.0 \pi \text{ mm.mrad}$$

σ_e/E	t_E	t_β
$1. \times 10^{-4}$	0.13 hours	0.32 hours
$2. \times 10^{-4}$	0.68	0.43
$4. \times 10^{-4}$	4.4	0.7

At injection (12 GeV/A) we keep the same σ_E/E but lengthen the bunch by a factor $100/12 = 8.333$ then the peak current at injection is

$$I_p = 0.014 \text{ Amp-particle } (\beta \sim 1)$$

Intra-beam Scattering Diffusion Rates @ 12 GeV/A

$$E_N = 4.0 \pi \text{ mm-mrad}$$

σ_E/E	t_E	t_β
$1. \times 10^{-4}$	0.057 hours	5.5 hours
2.	0.37	8.8
4.	4.0	24.
8.	350.	700.