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Short Bunches Performance With Intrabeam Scattering

A. G. Ruggiero

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Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

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Short Bunches

$$\mathcal{L} = \frac{N_c^2 B f_{rev}}{2\pi \alpha \sigma_\ell \sigma_v}$$

$\sigma_\ell = 10$ cm

$\sigma_v = 0.0037$ cm

$\alpha = 4$ mrad

$B = 57$

$f_{rev} = 78.1975$ KHz

$N_c = 6.24 \times 10^8$

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

Filling sequence :

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

Filling Time : about 1 minute -

Longitudinal Stability of short Bunches

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

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

N_c, no. of particles / bunch $=$ 6.24×10^8
σ_ℓ, rms bunch length $=$ 10 cm $(\sigma_\tau = 0.33$ nsec$)$

$$I_p = 0.12 \text{ Amp - particle} \quad (\beta \simeq 1)$$

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

$B = 6\pi\, \sigma_E \cdot \sigma_\tau$, bunch area

The following table explores the dependence on γ_T of the threshold energy spread σ_E/E and the corresponding bunch area.

γ_T	$\lvert\eta\rvert$	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

Intrabeam scattering diffusion rates @ 100 GeV/A

$\varepsilon_N = 4.0\ \pi$ 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

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

Intrabeam Scattering Diffusion Rates @ 12 GeV/A

$\varepsilon_N = 4.0\ \pi$ 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.