

## Short Bunches Performance With Intrabeam Scattering

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SHORT BUNCHES PERFORMANCE  
WITH INTRABEAM SCATTERING

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## Short Bundles

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

$$\sigma_e = 10 \text{ cm}$$

$$\sigma_v = 0.0037 \text{ cm}$$

$$\alpha = 4 \text{ mrad}$$

$$B = 57$$

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

$$N_c = 6.24 \times 10^8$$

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

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

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

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

$$N_c, \text{ no. of particles / bunch} = 6.24 \times 10^8$$

$$\sigma_z, \text{ rms bunch length} = 10 \text{ cm} \quad (\sigma_z = 0.33 \text{ nsec})$$

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

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

Assume a coupling impedance of  $|Z/n| = 10 \text{ ohms}$

$E$ , energy per nucleon  $\sim 100 \text{ GeV/A}$

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

$\sigma_E/E$ , rms energy spread at stability

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

The following table explores the dependence on  $\gamma_T$  of the threshold energy spread  $\sigma_E/E$  and the corresponding bunch area -

(3)

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

Intra beam scattering diffusion rates @ 100 GeV/A

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

$\sigma_E/E$	$t_E$	$t_\beta$
$1. \times 10^{-4}$	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  $\sigma_E/E$  but lengthen the bunch by a factor  $100/12 = 8.333$  then the peak current at injection is

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

Intra-beam Scattering Diffusion Rates @ 12 GeV/A

$\epsilon_N = 4.0 \pi$  mm-mrad

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