

## Short Bunches Performance With Intrabeam Scattering

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November 1983

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**U.S. Department of Energy**

USDOE Office of Science (SC)

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SHORT BUNCHES PERFORMANCE  
WITH INTRABEAM SCATTERING

A.G. Ruggiero

(BNL, November 17, 1983)

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~~  $6.24 \times 10^8$

$\sigma_z$ , 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  $\sim 100$  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  $\hat{\sigma}_E/E$  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

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

### Intra-beam Scattering Diffusion Rates @ 12 GeV/A

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

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