

## Short Bunches Performance With Intrabeam Scattering

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SHORT BUNCHES PERFORMANCE  
WITH INTRABEAM SCATTERING

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## Short Bundles

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

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

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

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

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

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

$$B = 57$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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 $                  | $\sigma_e/E$<br>threshold<br>@ 100 GeV/A | B<br>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.      |