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Intrabeam Scattering In RHIC

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(BNL, December 9, 1983)

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IBS:

$$\frac{1}{\tau} = \frac{3}{4} L \frac{\left(Z^2 r_p/A\right)^2 mc^2 N}{\gamma \epsilon_x \epsilon_y S} H(\lambda) \qquad \text{(Bjorken)}$$

$\epsilon_x = \gamma \sigma_x^2/\beta$ ($\frac{1}{6}$ of conventional definition)

S = long. phase space per mass unit ($eV-sec$)

$= 6\pi \sigma_s \sigma_p/A$

$$L = \ln \frac{b_{max}}{b_{min}} \approx \ln \frac{10^{-1}\ mm}{A^{2/3} \times 1.5 \times 10^{-12}\ mm} \approx 20$$

H is a complicated integral.

At high energies, "smooth" machine ($\gamma_x = \gamma_y = \gamma_t$; $\epsilon_x = \epsilon_y$):

$$H \approx \pi \left(\frac{\gamma^2}{\gamma_t^2} + \frac{\epsilon_x \gamma \gamma_t}{R(\delta p/p)^2} \right)^{1/2} \quad \text{provided this} >> 1.$$

Strategy: Make ϵ and S as large as possible.

Transition energy:

$$\text{Max } \frac{\Delta f}{f} \sim \frac{h^{1/3}}{\gamma_t^{1/3}} \left(\frac{eV \omega_s^2 \varphi_s}{m \varphi_s}\right)^{1/6} \left(\frac{\beta}{R}\right)^{1/2}$$

Max allowable $\frac{\Delta p}{p} \sim \gamma_t^2 \, a/R$ $\quad a$ = machine aperture

Therefore: Large γ_t permits larger S

Hence better IBS lifetime!

Transition space charge effect turns out to be OK (Sørensen – see CERN Spring Study, 1972)

GeOLD; $\gamma = 100$

I/e	2.14 mA	3.59 mA	1.55
N	1.74×10^{11}	2.87×10^{11}	1.24×10^{11}
ϵ	10×10^{-6}	10×10^{-6}	1.67×10^{-6}
No. of bunches	3	57	57
γ_{tr}	35	35	25
S/M (eV)	50	263	5
V (kV)	250	250	250
Lum	10^{27}	10^{27}	5×10^{26}
τ_{IBS}	1.78 h	0.78	0.26

H I 12/9/83

e=79
N=197
I/e=2.18E-3
GAM=100.00
EX=10.00
EY=10.00
BX=30.00
BY=2.00
ε=2.00E-3
R=610.00
GTR=35.00
H=3
Nb=3
N=1.74E11
P/b=5.00E10
A/M=50.00
V=250.00

SIGX=1.73E-3
SIGY=4.47E-4
NU-S=1.91E-5
SIGZ=13.92
dP/P=6.09E-4
AT TRS
dP/P=3.69E-3
SIGZ=7.59

LUM=1.00E27
DQX=1.71E-4
DQY=1.88E-3
L/b=4.26E21
IBS 1.78 HRS

e=79
N=197
I/e=3.59E-3
GAM=100.00
EX=10.00
EY=10.00
BX=30.00
BY=2.00
ε=2.00E-3
R=610.00
GTR=35.00
H=285
Nb=57
N=2.87E11
P/b=5.04E9
A/M=2.63
V=250.00

SIGX=1.73E-3
SIGY=4.47E-4
NU-S=1.86E-4
SIGZ=1.02
dP/P=4.36E-4
AT TRS
dP/P=3.86E-3
SIGZ=0.38

LUM=1.00E27
DQX=3.75E-4
DQY=9.86E-4
L/b=2.24E20
IBS 0.78 HRS

I/e=1.55E-3
GAM=100.00
EX=1.67
EY=1.67
BX=30.00
BY=2.00
ε=2.00E-3
R=610.00
GTR=25.00
H=285
Nb=57
N=1.24E11
P/b=2.18E9
A/M=5.00
V=250.00

SIGX=7.07E-4
SIGY=1.83E-4
NU-S=2.70E-4
SIGZ=1.70
dP/P=5.00E-4
AT TRS
dP/P=5.95E-3
SIGZ=6.58E-1

LUM=5.00E26
DQX=1.05E-4
DQY=1.06E-3
L/b=1.12E20
IBS 0.26 HRS