

RF Parameters And Beam Dimensions At Transition

A. G. Ruggiero

February 1984

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

RF PARAMETERS
AND
BEAM DIMENSIONS AT TRANSITION

A. G. Ruggiero

(BNL, February 24, 1984)

Luminosity Head-on Initial

$$L_0 = \frac{N^2 B f_{rev}}{4\pi \sigma_H^* \sigma_V^*}$$

initial values

$$N = 1.1 \times 10^9$$

$$\beta_H^* = 17.7 \text{ m}$$

$$E_N = 10 \pi \text{ mm} \cdot \text{mrad}$$

$$B = 57 \text{ bunches}$$

$$\beta_V^* = 3.0 \text{ m}$$

$$\sigma_L = 40 \text{ cm}$$

$$f_{rev} = 78.2 \text{ kHz}$$

$$\gamma = 108.4$$

$$\sigma_E/E = 0.4 \times 10^{-3}$$

$$\sigma_{Int.} = 20 \text{ cm}$$

$$L_0 = 0.4 \times 10^{27} \text{ cm}^{-2} \text{ s}^{-1}$$

Crossing at angle α

$$\alpha \quad 2 \text{ mrad}$$

$$10 \text{ mrad}$$

$$L/L_0 \quad 0.79$$

$$0.25$$

$$\sigma_I \quad 15. \text{ cm}$$

$$7 \text{ cm}$$

Beam-Beam Tune Shift (head-on, initial)

$$\Delta\nu_0 = \frac{3 N r_0 Z^2}{\pi E_N A} \frac{1}{1 + \frac{\sigma_{V,H}}{\sigma_{H,V}}} = \begin{cases} 0.0036 & (H) \\ 0.0015 & (V) \end{cases}$$

Harmonic No., h	$6 \times 57 = 342$		$12 \times 57 = 684$	
RF Frequency ($\beta=1$)	26.743 MHz		53.486 MHz	
RF Voltage, MV	1.42	2.85	1.42	2.85
Bucket Area, eV/A-s	13.38	18.92	4.73	6.69
Height, ΔE_B	280. MeV/A	400. MeV/A	200. MeV/A	280. MeV/A
$\Delta E_B/E$	0.283 %	0.40 %	0.20 %	0.283 %
σ_E/E } aspect σ_L } ratio	0.1 %	0.1 %	0.1 %	0.1 %
	128 cm	90 cm	90 cm	64 cm
S, eV/A-sec (95%)	7.96	5.66	5.66	3.98
σ_E/E max } σ_L max } S min }	0.116 %	0.163 %	0.082 %	0.116 %
	148 cm	148 cm	74 cm	74 cm
	10.71	15.04	3.80	5.36
Voltage / cavity	200 kV	200 kV	200 kV	200 kV
Length of Cavity	2.5 m	2.5 m	1.3 m	1.3 m
no. of Cavities	7	14	7	14
Total Length	17.5 m	35. m	9.1 m	18.2 m
R_{sh} / cavity	0.84 M Ω	0.54 M Ω	1.29 M Ω	1.29 M Ω
Power / cavity	24 kW	24 kW	16 kW	16 kW
Power Cost	4.5 \$/W		4.5 \$/W	
Total Cost / Ring (w/ 50% trans. eff.)	1.5 M\$	3.0 M\$	1.0 M\$	2.0 M\$

Harmonic No., h	$6 \times 57 = 342$		$12 \times 57 = 684$	
Voltage, MV	1.42	2.85	1.42	2.85
Stationary Bucket Injection: Area, eV/A-s $\Delta E_B/E$	2.36 $\pm 0.43\%$	3.34 $\pm 0.60\%$	0.84 $\pm 0.30\%$	1.18 $\pm 0.43\%$
Acceleration Period No. of Revolutions Total Energy Gain Energy Gain/Turn $\sqrt{s} \sin \phi_s$			30 sec 2.346×10^6 89.3 GeV/A 38 KeV/A 95 KJ	
$\sin \phi_s$ ϕ_s v Y	0.0069 3.836° 0.86 1.34	0.03345 1.917° 0.92 1.38	0.0669 3.836° 0.86 1.34	0.03345 1.917° 0.92 1.38
Transition Energy Crossing $S = 1. \text{eV/A-s}$				
T \pm msec $\Delta p/p$ \pm % L \pm nsec	21.2 1.15 1.30	16.8 1.45 1.03	16.8 1.45 1.03	13.3 1.83 0.82

Beam Dimensions @ Transition

Phase Advance / Cell	98°	120°
γ_T	26.42	30.64
β_{max}	51.6 m	62.6 m
η_{max}	1.4 m	1.1 m
ϵ @ $\gamma = \gamma_T$	0.3785 π mm-mrad	0.3264 π mm-mrad
σ_V (max, rms)	1.8042 mm	1.8453 mm
δ (rms)		
$\frac{1 \text{ MV}}{h = 12 \times 57 \text{ (6} \times 57\text{)}} \times 1 \text{ eV/A-sec}$	0.53 % (0.42)	0.50 %
σ_H (max, rms)	7.64 mm (6.15)	5.80 mm
$\sqrt{6} \sigma_H$ (95%)	18.7 (15.1)	14.2 mm
For $h = 12 \times 57$ Voltage requirement at top energy	1.4 MV	1.0 MV