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Vacuum Pipe Heating in RHIC

A. G. Ruggiero

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Collider Accelerator Department Brookhaven National Laboratory

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AD/RHIC-AP-48

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Vacuum Pipe Heating

Assume Mequally spaced bunches of the same shape and population with gaussian longitudinal distribution

(1

N, number of particles per bunch Oz , rms bunch length

P, total power dissipated

 $P = \frac{1}{2} \sum_{n=1}^{\infty} R_n I_{nM}^2$

where

det

Ray wall resistance at a M harmonic InM beam current at nM harmonic



l., free path length 0 = = = 1/p , conductivity is an invariant which depends on the material density 0/6 (1) For those frequencies such that l/s < 1 Normal Skin Depth $R_{nM} = R_{1} n^{\frac{1}{2}}$ $R_{1} = \sqrt{(Z_{o} q R M)/2b^{2}}$ For those frequencies such that (2)e/s = 1 Abnormal Skin Depth $R_{nM} = R_{1} n^{2/3}$ $R_{1} = \begin{cases} \begin{pmatrix} \ell \\ 0 \end{pmatrix} \sqrt{3} & Z_{0} & M^{2} R \\ \hline 0 & 4 \\ \pi & 5^{3} & J \end{cases}$





6) Assuming the Beam Parameters from CDR Z Tave \mathcal{N} 100 × 109 1 71 mA (electric) proton Carbon 6 94 22 6.4 Sulfur 16 73 Copper 29 4.5 93 Indine 53 2.6 98

Gold 79 11 62

with M=57 bunches

As reference Ø-L-40 cn



Power in mWatt

Power Dissipated per 10m Dipole in Watts Reference Case: Gold, Average Current = 62 mA Stainless Steel

М	N		0.40 m	0.20 m
57 114	1.1 1.1	x 10^9	0.085 0.170	0.242 0.484
57 114	2.2 2.2		0.340 0.680	$0.968 \\ 1.936$
57 114	3.3 3.3		0,765 1,530	$2.178 \\ 4.356$

sigma-L

Power Dissipated per 10m Dipole in milli-Watts Reference Case: Gold, Average Current = 62 mA Copper, Normal + Abnormal Skin Depth

			sigma-L		
М	N		0.40 m	0.20 m	
57 114	1.1 1.1	x 10^9	2.7 5.4	7.6 15.2	
57 114	2.2 2.2		10.8 21.5	$\begin{array}{c} 30.4\\ 60.7 \end{array}$	
57 114	3.3 3.3		$24.2 \\ 48.4$	68.3 136.6	

Power Dissipated per 10m Dipole in Watts Reference Case: Protons, Average Current = 71 mA Stainless Steel

		sigma-L			
N	N	0.80 m	0.40 m	0.20 🖿	
57	1 x 10^11	0.039	0.112	0.317	
114	1	0.078	0.224	0.634	
57	3	0.351	1.008	2.853	
114	3	0.702	2.016	5.706	
57	8	2.496	7.168	20.288	
114	8	4.992	14.336	40.576	

Power Dissipated per 10m Dipole in milli-Watts Reference Case: Protons, Average Current = 71 mA Copper, Normal + Abnormal Skin Depth

		sigma-L			
N	N	0.80 m	0.40 m	0.20 m	
57	1 x 10^11	1.3	3.5	10.0	
114	1	2.6	7.1	19.9	
57	3	11.7	31.8	89.6	
114	3	23.4	63.5	179.1	
57	8	83.2	225.9	636.8	
114	8	166.4	451.8	1273.6	