

# HIGHER ORDER BEAM MULTIPACTORING AND SINGLE SIDE BEAM MULTIPACTORING

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## Abstract

High current application of superconducting cavity, some electron energy depositions affect to not only cavity performance but also cryogenic load of refrigerators. The threshold current formula for tow sides beam multipactoring derived by O. Grobner is easily extended to higher order beam multipactoring and single side beam multipactoring. Estimations of the threshold current of positive and negative charge beams in the field free beam tube are given for high current application or small bore beam tube application such as KEKB and TESLA.

## INTRODUCTION

The threshold current formula for tow sides beam multipactoring derived by O. Grobner [1] is easily extended to higher order beam multipactoring and single side beam multipactoring.

For secondary electron yield higher than one,

$$N_b = r_p^2 / r_e * L_b$$

$N_b$ : (threshold) electron number in bunched beam

$r_p$ : Beam pipe radius

$r_e$ : Classical electron radius

$L_b$ : Bunch spacing

## SINGLE SIDE MULTIPACTORING

For secondary electron yield higher than one and finite initial velocity

$$N_b = r_p * |r_p + a| / 2 * r_e * L_b$$

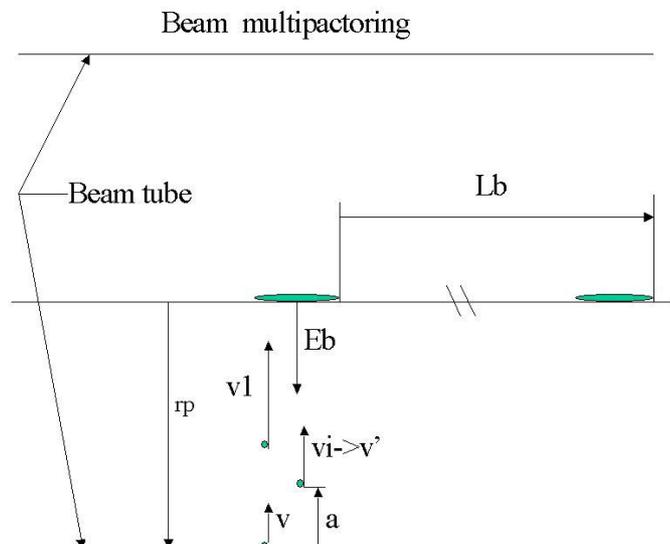
$$a : v_i * L_b / c$$

$v_i$  : initial velocity of secondary electron (~5eV)

+ : positive charge beam

- : negative charge beam

$$a < 2 * r_p$$



## HIGHER ORDER BEAM MULTIPACTORING

For AR high current beam test

500 mA 16 bunch case  $N_b = 2 \times 10^{11}$

$$L_b = 18.8 \text{ m}$$

$$v_i = 1.3 \times 10^6 \text{ m/sec}$$

$$a = 0.081 \text{ m}$$

$$r_p = 0.105$$

$$r_e = 2.85 \times 10^{-15} \text{ m}$$

$$N_b = 2.3 \times 10^{10} < 2 \times 10^{11}$$

additional beam loss observed depend on cavity excitation

For TESLA

$$r_p = 0.035 \text{ m}$$

$$L_b = 101.1 \text{ m}$$

$$v_i = 1.3 \times 10^6 (5 \text{ eV})$$

$$a = 0.438 \text{ m}$$

$a > 2 * r_p$  : So all electron varnish before next bunch arrival except very small energy.

For  $r_p = 0.035 \text{ m}$ , if choosing beam spacing about 8.1 m, some problem possibly arise.

For KEKB superconducting cavity

$$r_p = 0.105 \text{ m}$$

$$L_b = 2.4 \text{ m}$$

$$a = 0.0104 \text{ m}$$

$$r_e = 2.82 \times 10^{-15} \text{ m}$$

$$N_b = 0.105(0.105 - 0.0104)/r_e/2.4/2 = 7.3 \times 10^{11}$$

$$> 5.73 \times 10^{10} (1.1 \text{ A})$$

No single side multipactoring for KEKB SC.

Second order beam multipactoring

$$N_{b2nd} = (1 - 1/2^{0.5}) r_p^2 / r_e / L_b$$

$$\sim 0.292 N_{b1st} \sim 1/3 N_{b1st}$$

For KEKB LER or positron for HER

LER beam pipe and coaxial HOM damper of Crab cavity  
2.5 A ( $N_{bLER} = 1.3 \times 10^{11}$ )

$$r_p = 0.05 \text{ m}$$

$$L_b = 2.4 \text{ m}$$

$$N_{b1st} = 3.6 \times 10^{11} > N_{bLER}$$

$$N_{b2nd} = 1.05 \times 10^{11} < N_{bLER}$$

KEKB HER positron case for SCC (Charge switching)

$$r_p = 0.105$$

$$N_{p2nd} = 4.7 \times 10^{11} > 5.72 \times 10^{10} (1.1 \text{ A})$$

## SUMMARY

- Beam multipactoring effect have possibility to increase thermal loss of cryogenic system. Even small amount of cryogenic loss have possibility about 1000 time larger effect to cryogenic system, compared for normal system.
- Electron beam also have possibility to induce single side beam multipactoring.
- KEKB HER now have no beam multipactoring problem at superconducting cavity. Larger bunch spacing experiment will useful for higher beam current operation, but should be done carefully. More small beam aperture part have smaller threshold current.

## REFERENCES

[1] O. Grobner, 10<sup>th</sup> Int. Conference on High Energy Accelerators, Protovino (1977)