MULTIPACTING ON THE TRAILING EDGE OF PROTON BEAM BUNCHES IN THE PSR AND SNS*

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Abstract

The Proton Storage Ring (PSR) in Los Alamos has a fast intensity-limiting instability, which may result from an electron cloud interaction with the circulating proton beam leading to a transverse mode coupling instability. The most probable mechanism of the electron creation is multipacting. Though the effect depends on many parameters, a model is presented which predicts a large electron creation in the vacuum chamber. A comparison of this effect between the PSR in Los Alamos and the Spallation Neutron Source (SNS) in Oak Ridge is given. In addition, several possibilities to reduce multipactor are discussed.

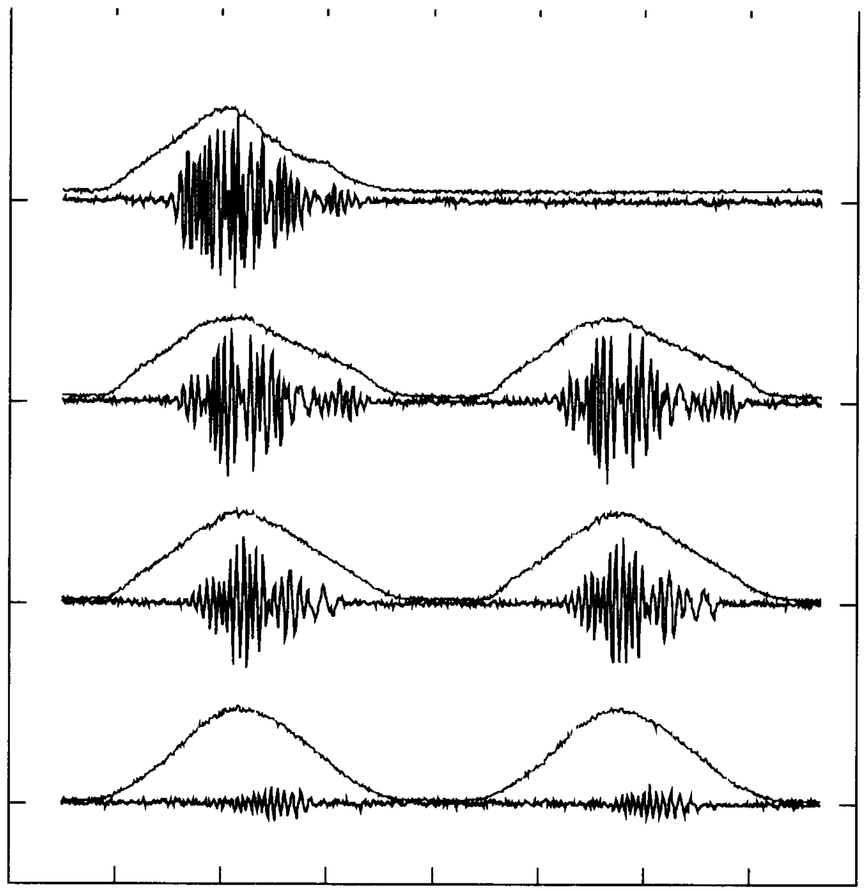

Fig. 1 Vertical oscillations on the tail of the proton bunch at PSR. (Courtesy Mike Plum, January, 1999.)

2 MULTIPACTING ON THE TRAILING EDGE

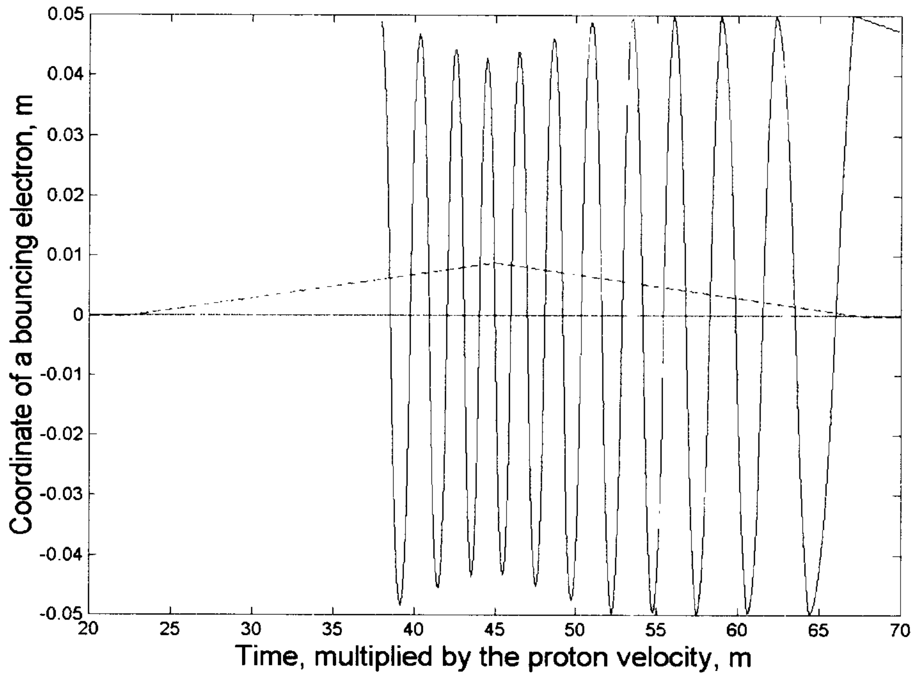

Fig. 2 Coordinate of an electron oscillation in the electric field of proton beam.

The formula for secondary emission yield (y) from Ref. 2, assuming the primary electrons are normal to the surface. That is:

$$y(E) = y_{\max} 1.11 (E/E_m)^{-.35} (1 - e^{-2.3(E/E_m)^{1.35}})$$

where $E_m = 400 eV$, $y_{\max}$ depends on the vacuum chamber material.

It was estimated in Ref. 1 that total number of initial electrons created per proton for one thousand turns due to losses could be from 0.01 up to 1. If we took the upper number, it would give us sufficient amount of electrons to explain the instability without additional processes of electron creation and trapping. In this case for each proton bunch revolution we have a newly created electron density of about 1/1000 of the proton density, namely, 0.1% of the proton density on average in the vacuum chamber. For the PSR we assume that 10% of the vacuum chamber consists of the elements with high secondary emission yield with a maximum of about 3.5. These elements are bellows, holes, the aluminium box near the stripper foil, etc. Also we assume the initial electron population grows 1000-fold, due to multipacting. Additionally, the fraction of the vacuum chamber, where these electrons build up is occurring, is already mentioned 10 % of the vacuum chamber. Thus, the final average compensation of the proton beam by the electron cloud is 0.1*.001*1000*.1=.01 or about 1% and, according to estimations in Ref. 2 that is enough for instability to occur.

3 PSR AND SNS COMPARISON

Table 1 Comparison of the SEM coefficients for the PSR and SNS. Negative coefficients mean that the electron density decreases.

RING	Max SEM yield/ material	Vacuum chamber radius equal to 5 cm	Vacuum chamber radius equal to 10 cm
PSR $3x10^{13}$ protons	3.5/Aluminum 0.3% 3.5/Stainless Steel with holes and slots 10%	10	N/A
SNS $1x10^{14}$ protons	2/Stainless Steel	-17	3.8
SNS $2x10^{14}$ protons	2/Stainless Steel	-15	11

POSSIBLE WAYS TO ELIMINATE MULTIPACTING

1 TiN coating

2 Magnetic field near the vacuum chamber surface

3 Longitudinal density variation

5 CONCLUSION

We find that the multipacting effect is as important for the Spallation Neutron Source as for the Proton Storage Ring with intensities that correspond to the e-p instability. Consequently, special investigations and experiments should be made to determine appropriate methods to rise the e-p instability threshold in the PSR and avoid the e-p instability in the SNS.

REFERENCES

[1] T.-S. Wang, Talk on e-p instability, Los Alamos, January 26, 1998

[2] D. Neufer, et al., Particle Accelerators **23**, 133-148 (1988).