Abstract Submitted
for the DPP15 Meeting of
The American Physical Society

**How Accurate Is Pierce's Theory of Traveling Wave Tube?**[1] D.H. SIMON, U. Michigan, D. CHERNIN, Leidos Corp., P. WONG, P. ZHANG, Y.Y. LAU, C.F. DONG, U. Michigan, B. HOFF, Air Force Research Lab, R.M. GILGENBACH, U. Michigan — This paper provides a rigorous test of the accuracy of Pierce's classical theory of traveling wave tubes (TWTs). The EXACT dispersion relation for a dielectric TWT is derived, from which the spatial amplification rate, ki, is calculated. This ki is compared with that obtained from Pierce's widely used 3-wave theory and his more general 4-wave theory (which includes the reverse propagating circuit mode [1]). We have used various procedures to extract Pierce's gain parameter C and space charge parameter Q from the exact dispersion relation. We find that, in general, the 3-wave theory is a poor representation to the exact dispersion relation if C >0.05. However, the 4-wave theory gives excellent agreement even for C as high as 0.12 and over more than 20 percent bandwidth, if the quantity ($k^2 \times C^3$) is evaluated accurately as a function of frequency, and if Q is expanded to first order in the wavenumber k [2], where Q is the difference between the exact dispersion relation and its 4-wave representation in which Q is set to zero [3]. Similar tests will be performed on the disk-on-rod slow wave TWT, for which the hot tube dispersion relation including all space harmonics has been obtained.

[1] J.R. Pierce, Traveling Wave Tubes, p. 113 (1950).
[2] D. Dialetis, et al, IEEE Trans. ED 54, 888 (2007).
[3] Y. Y. Lau and D. Chernin, Phys. Fl. B4, 3473 (1992).

[1]Supported by AFOSR FA9550-14-1-0309, FA9550-15-1-0097, AFRL FA9451-14-1-0374, and L-3 Communications.

Peng Zhang
Univ of Michigan - Ann Arbor

Date submitted: 24 Jul 2015 Electronic form version 1.4