Modeling Nonlinearity in Traveling Wave Tubes

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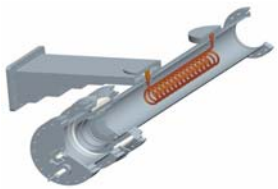
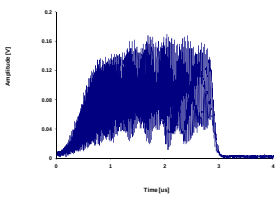
Revolutionary Research . . . Relevant Results

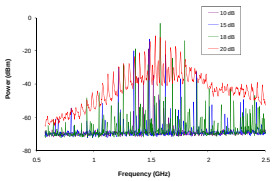


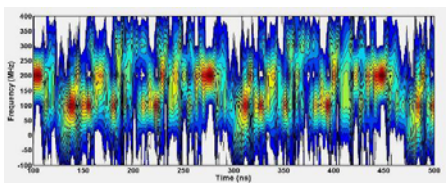
Typical Operating Parameters	
Pout	MW
V_{beam}	40 kV
I_{beam}	30 A
Freq.	800 -1300 MHz
Spectrum	Chaotic chirp/hop
Self focused beam (B_z=0)	

Motivation :
- Traveling wave tubes (TWT) operating in a nonlinear regime are potentially useful wideband sources
- Analytical analysis of TWT's is difficult for TWT's operation in a nonlinear regime
- The goal is to develop accurate numerical simulation models of nonlinear TWT operation using computer software

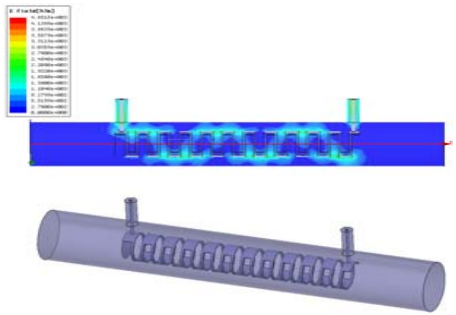
Example of TWT operating in a nonlinear regime





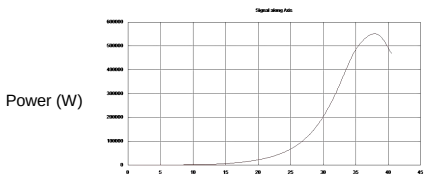


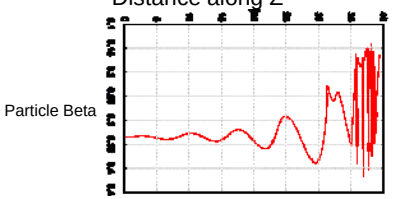
Model Created in Ansoft HFSS software package



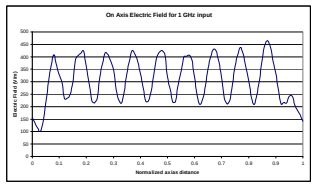
CHRISTINE

- CHRISTINE is a multi-frequency nonlinear parametric computer code developed by Dr. Tom Antonsen
- Using the coupling impedance and dispersion parameters obtained from HFSS, CHRISTINE can be used to calculate the following :
  - Complex gain
  - Nonlinear product frequencies
  - Band Width
  - Efficiency
  - Space Charge Effects

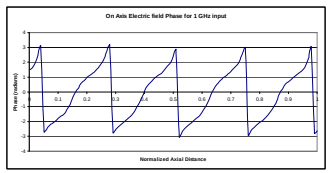




- Ansoft HFSS can be used to model and accurately obtain electromagnetic properties of the structure
- Solving for the fields in within the structure allows for the calculation of the dispersion and coupling impedance
- The coupling impedance and the dispersion can the be used to simulate the nonlinear behavior using CHRISTINE



- The plot above is the axial electric field obtained from the HFSS simulation of the ring bar structure
- The plot below is a phase of the axial electric field



$$K_\omega = \frac{\left|\frac{1}{l}\int_l \overline{E}\bullet\overline{dl}\right|^2}{k_z^2\,\mathrm{Re}\{\int_A \overline{E}\times\overline{H^*}\bullet\overline{dl}\}}$$

Coupling Impedance

$$k = \frac{\Phi}{L}$$

Wave Number