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Study of the Frequency Spectrum, Stability and Harmonics in the PASOTRON

J. Rodgers, A. Shkvarunets, Y. Carmel, D. M. Goebel and G. S. Nusinovich

Institute for Research in Electronics and Applied Physics
University of Maryland
College Park, MD 20742

rodgers@umd.edu

Motivation

- Plasma-based microwave devices are widely considered to be noisy sources with high levels of spurious sidebands and harmonics.
- Questions remain about whether any plasma instabilities in the electron gun cause fluctuating beam currents and unstable RF interaction.
- Issues of basic scientific interest include:
  - Comparison of measurements with linear and nonlinear theory of shot noise which includes 3D particle motion
  - Space charge shielding in high-current beams and plasmas
  - Ion oscillation in the focusing region
  - Relation of harmonics to interaction parameters (efficiency, Q, current, plasma density, etc.)
  - Frequency pulling, axial mode competition and chirping.

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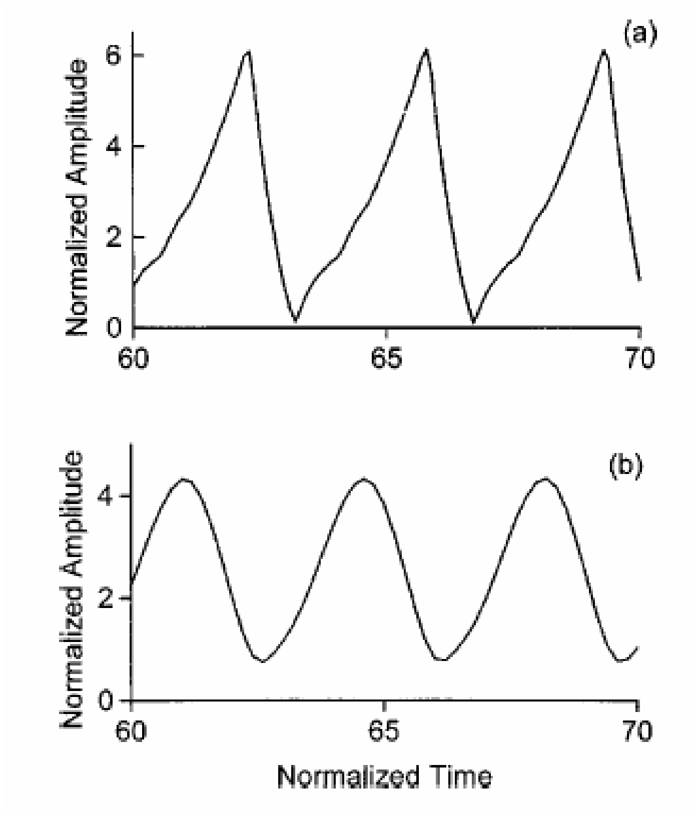
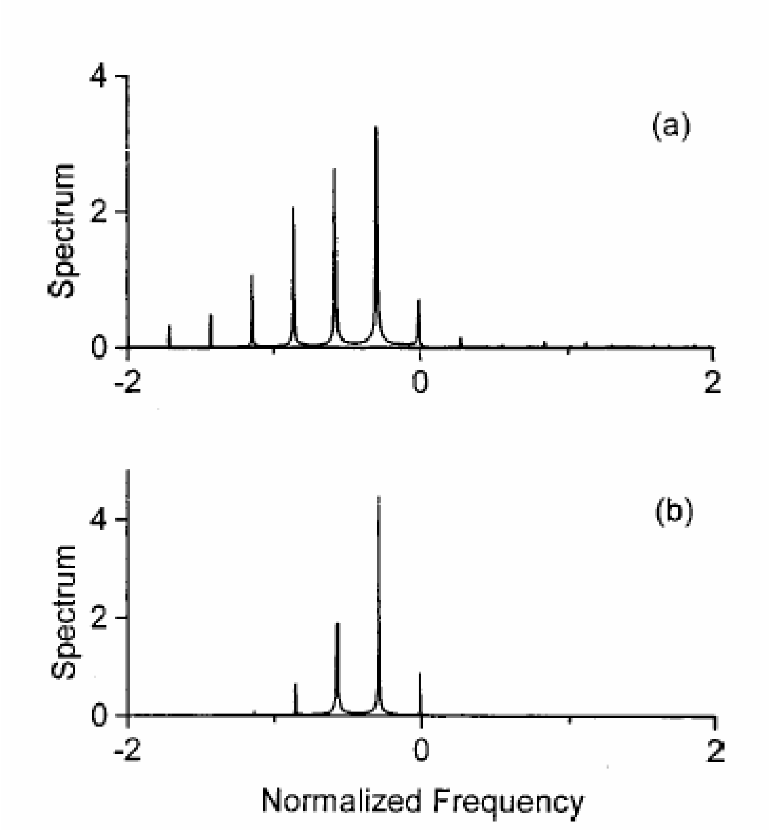
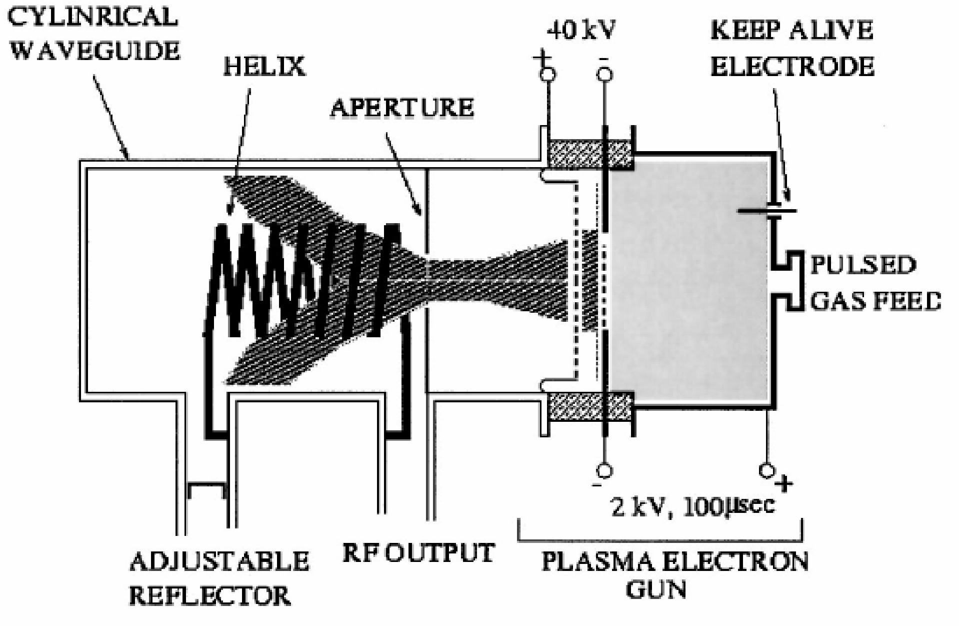
High-power vacuum BWO's also have harmonics (a) and auto-modulation (b) problems.

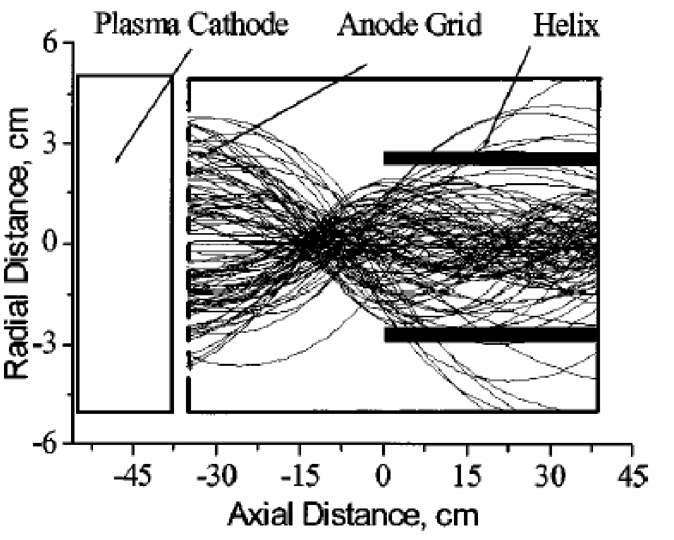




Beam formation and transport in the Pasotron using plasma rather than magnetic fields

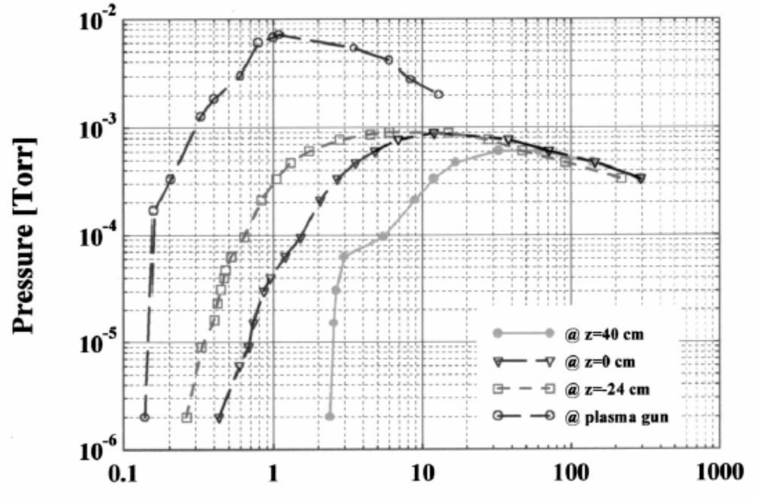


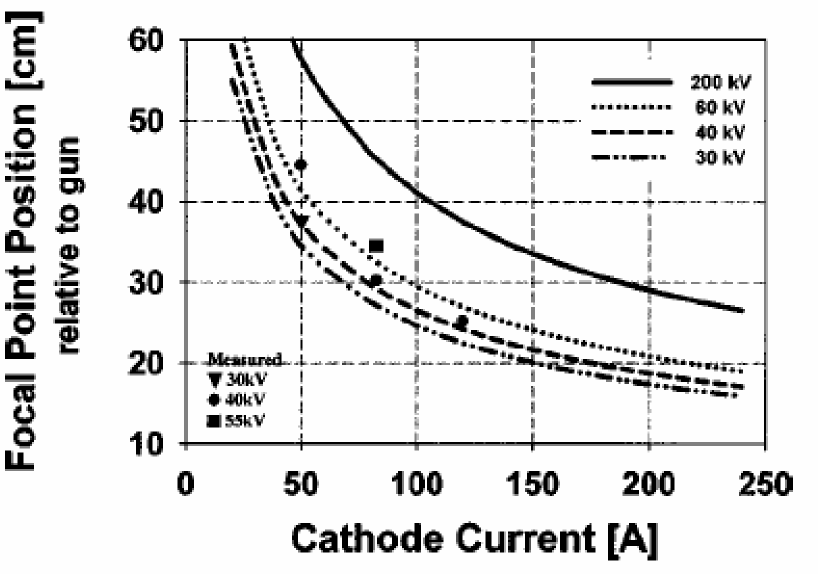
Schematic of PASOTRON



Electron Trajectories in Ion-focused Beam

Axial Profile of Gas and Focusing Characteristics of the Beam



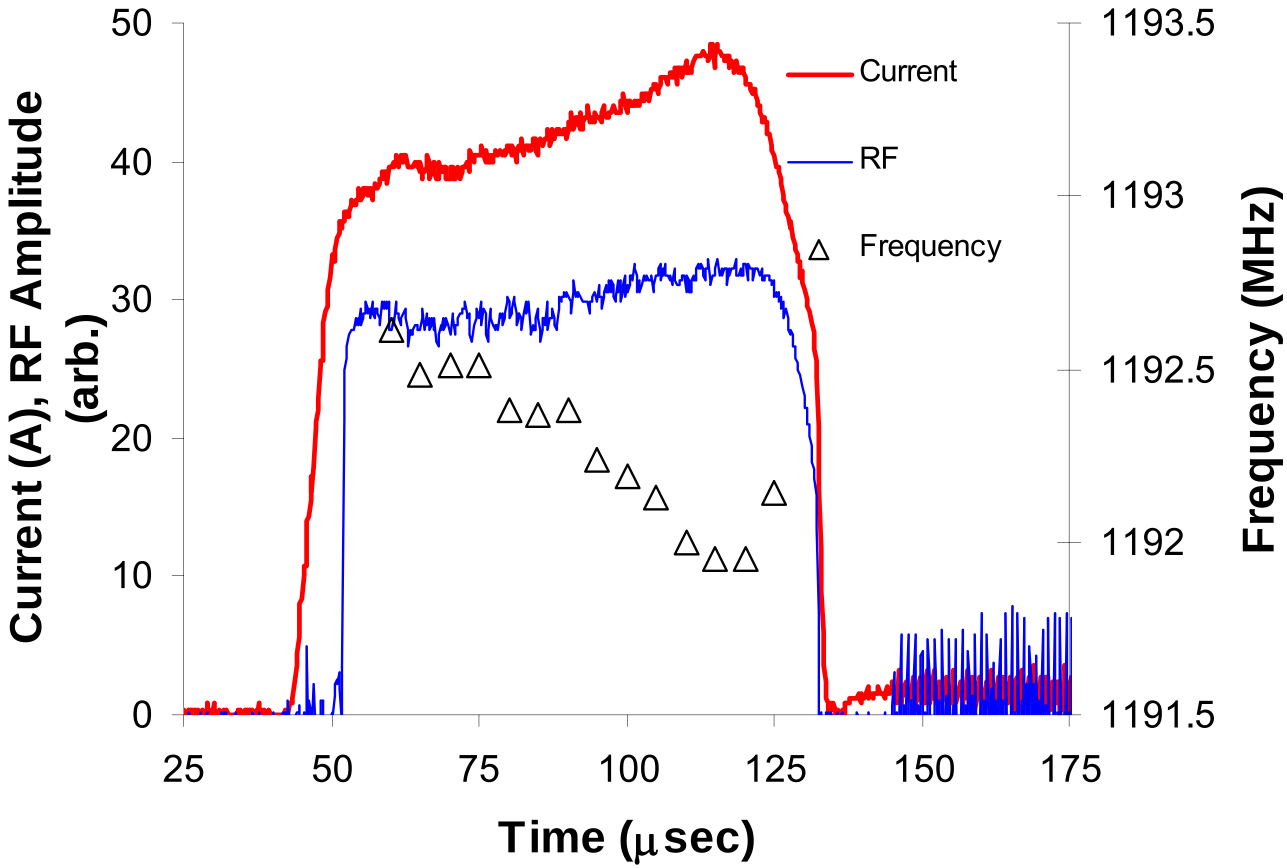


When the gas puff-to-beam delay is < 1 msec, the gun and focusing regions and the interaction circuit.

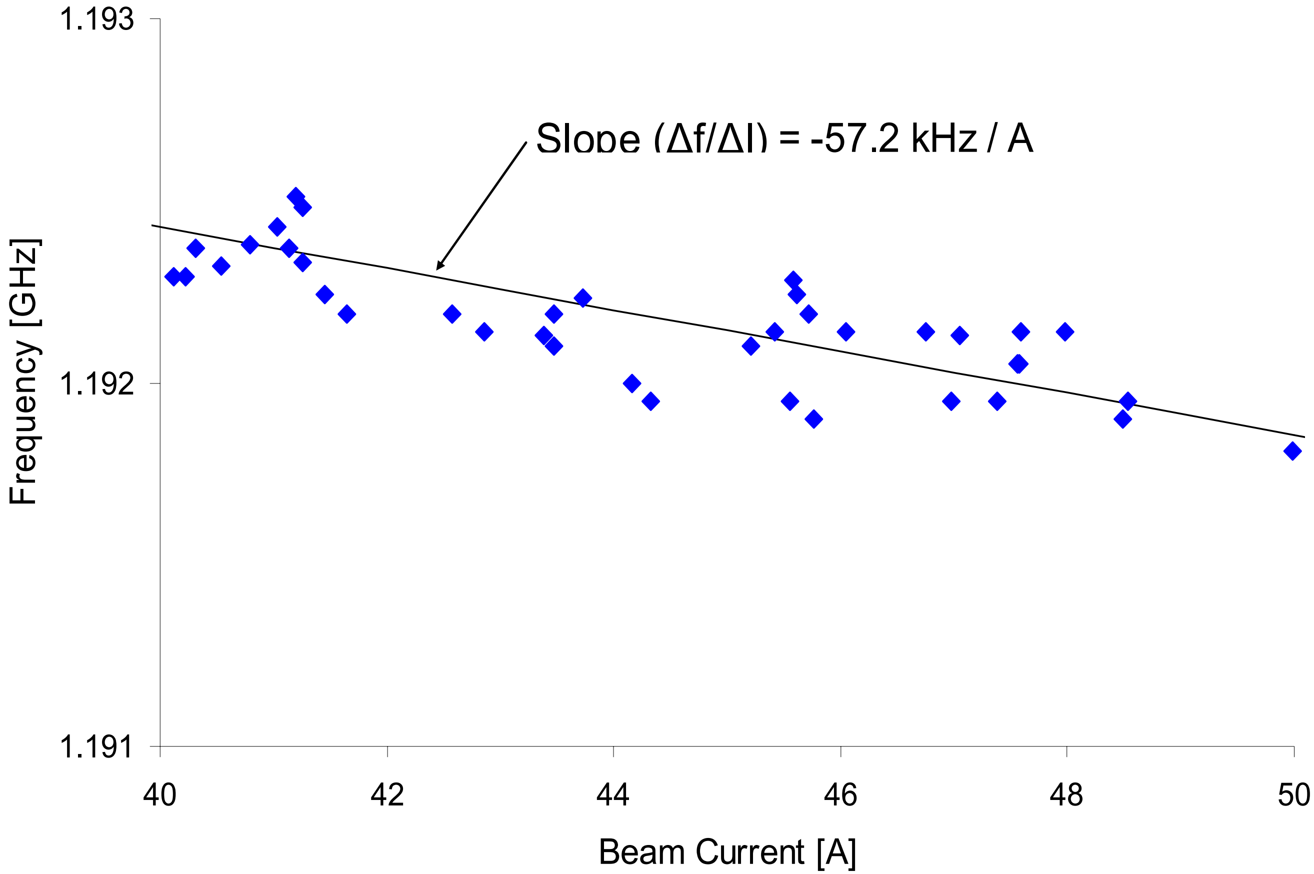
Operating Parameters for Measurement of Pasotron Spectrum

Beam Voltage	55 kV
Beam Current	40-48 A
Helix Parameters	10 turns Cu tubing, dia. = 51 mm, pitch = 22.5 mm
Output Frequency	1.192-1.193 GHz
Output Power	730 kW
Efficiency	33%
Cold Resonance	1.19402 GHz
Cold Quality Factor (Q)	620 (tuned using external reflectors)
Puff Gas	Helium
Puff-Beam Delay Time	700 µsec
RF Pulse Width	80 µsec FWHM
Repetition Frequency	0.1 Hz

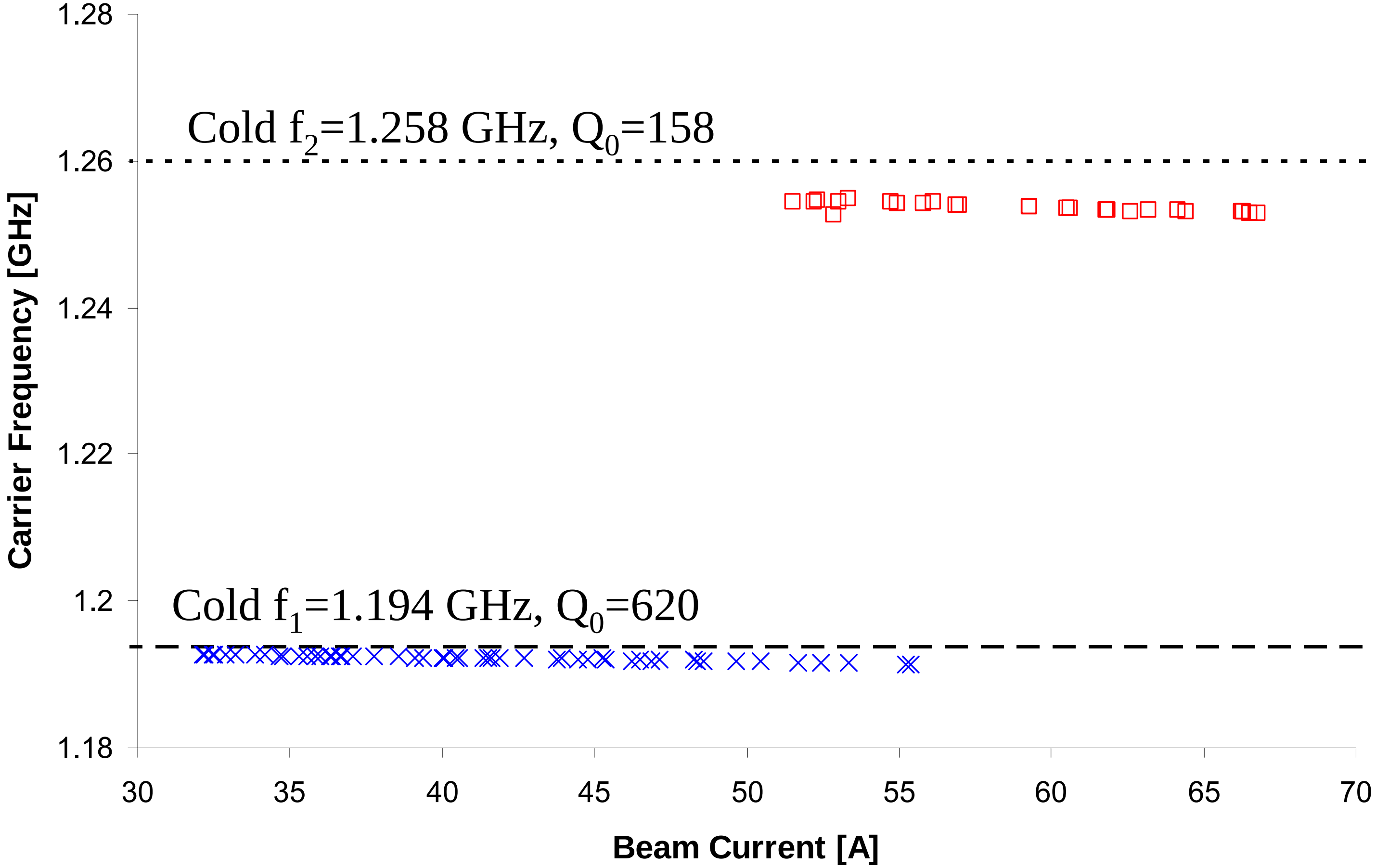
Comparison of Temporal Beam Current, RF Amplitude and Frequency



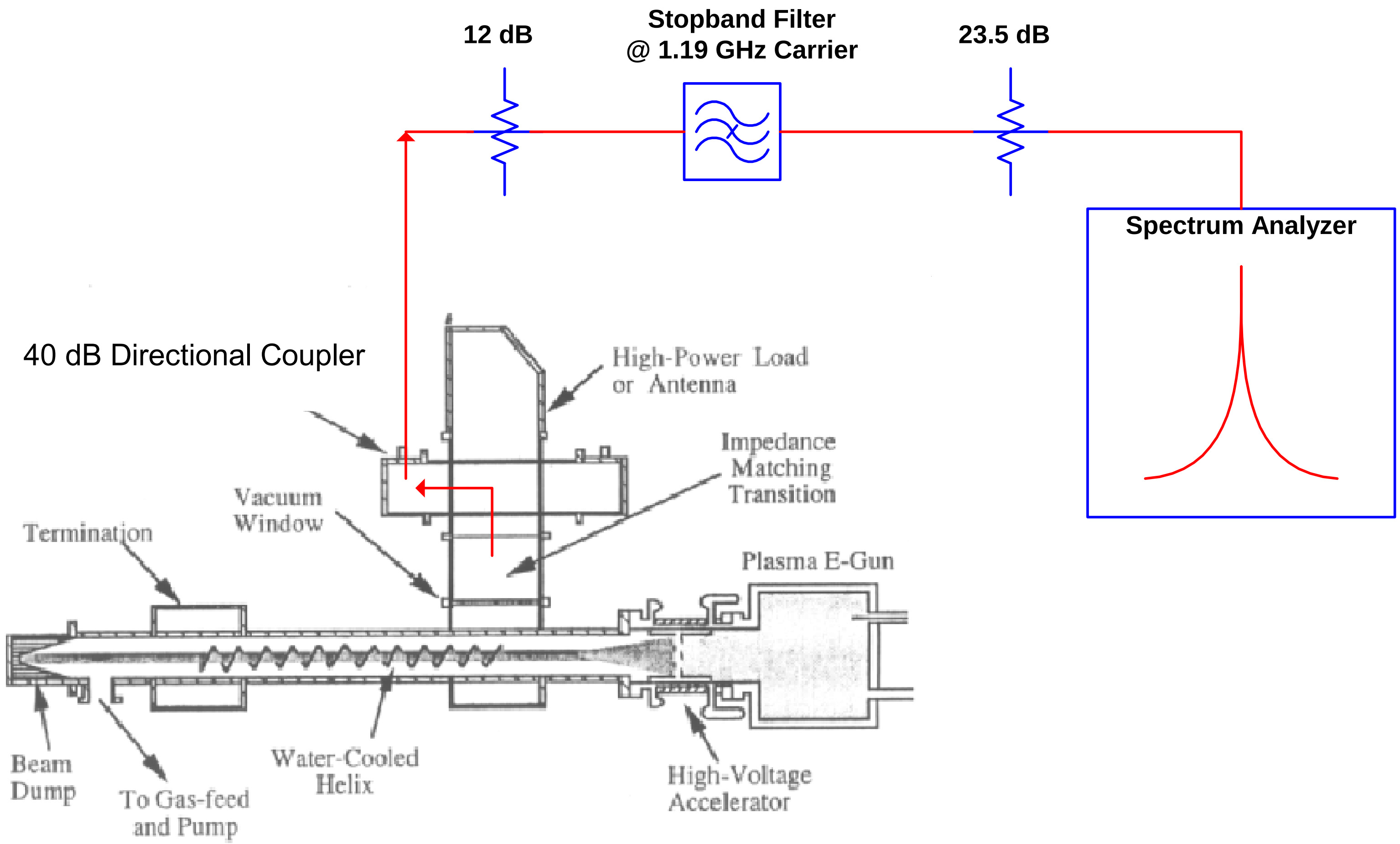
Measurement of Frequency Pulling



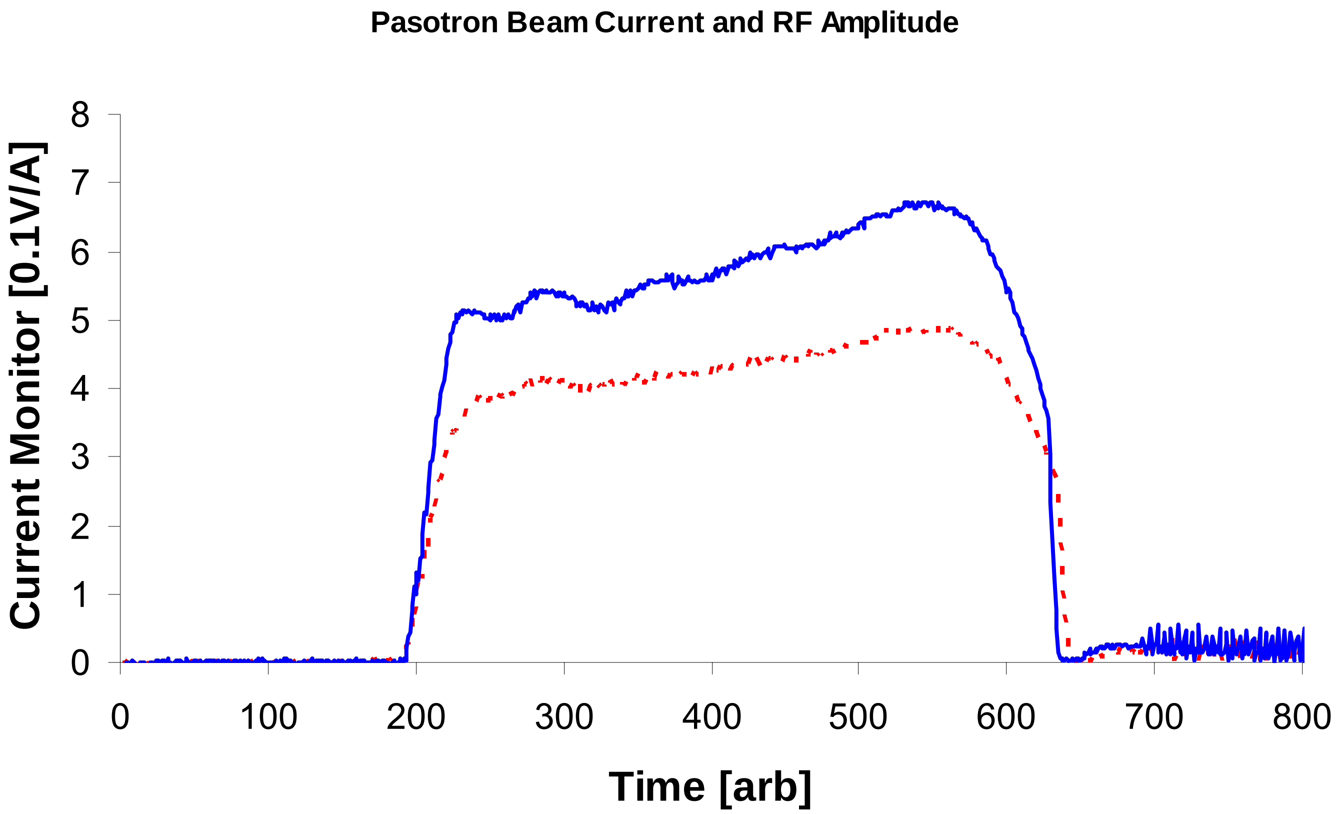
Frequency Hopping and Start Condition for Excitation of Axial Modes



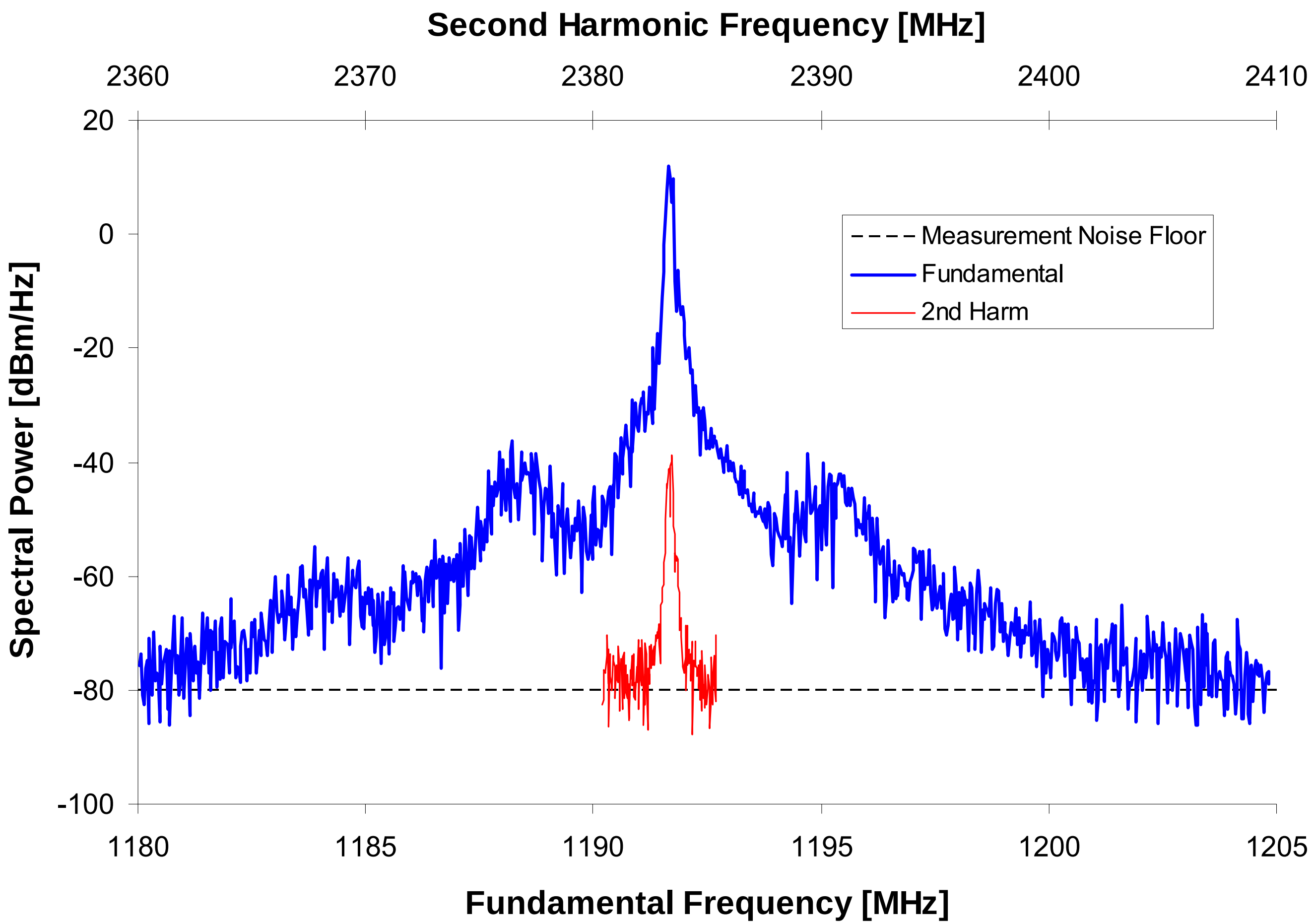
RF System for Measurement of Pasotron Spectrum



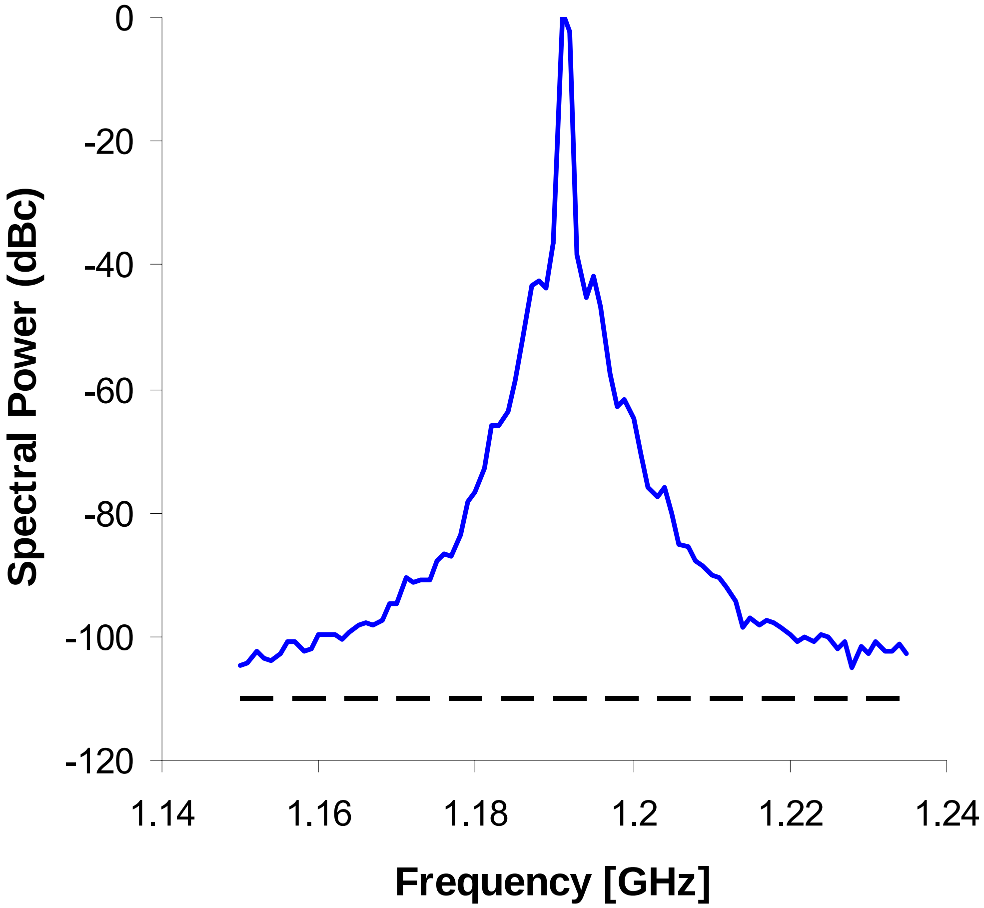
Comparison of Beam Current and RF Envelope vs. Time



Narrowband PASOTRON spectrum showing 1/f noise slope, sidebands (-50 dBc) and a comparison of the fundamental and second harmonic lines (-50 dBc)



Wide spectrum showing that broadband noise is -105 dB below carrier



Future Work: Configure Pasotron as a Wideband, Chaotic Source for RF Effects Applications (vehicle stopping, explosive device clearing, WMD countermeasures)