UNIVERSITY OF MARYLAND

Miniature Plasma Cathode for High-Power Terahertz Cherenkov Sources

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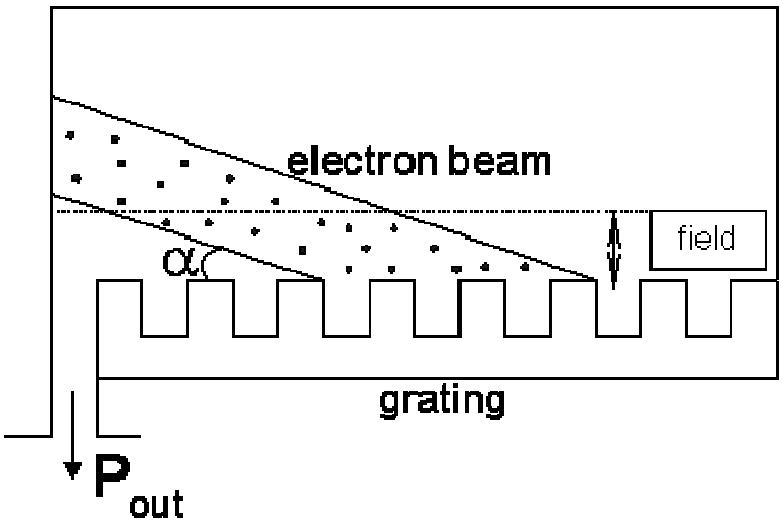
Motivation

- **Increase power**: Need compact (vacuum or solid state) terahertz sources capable of ~ 100 mW for high resolution sensing and imaging.
- **Improved efficiency**: Need to drive a sub-millimeter slow-wave circuit at 2-3 times the starting current (~ 100 mA).
- **High current density:** Thermionic guns would require compression ratios ~10x, which complicates the beam optics and makes alignment challenging.
- **Investigate alternative emitters:** Photo cathodes, plasma cathodes

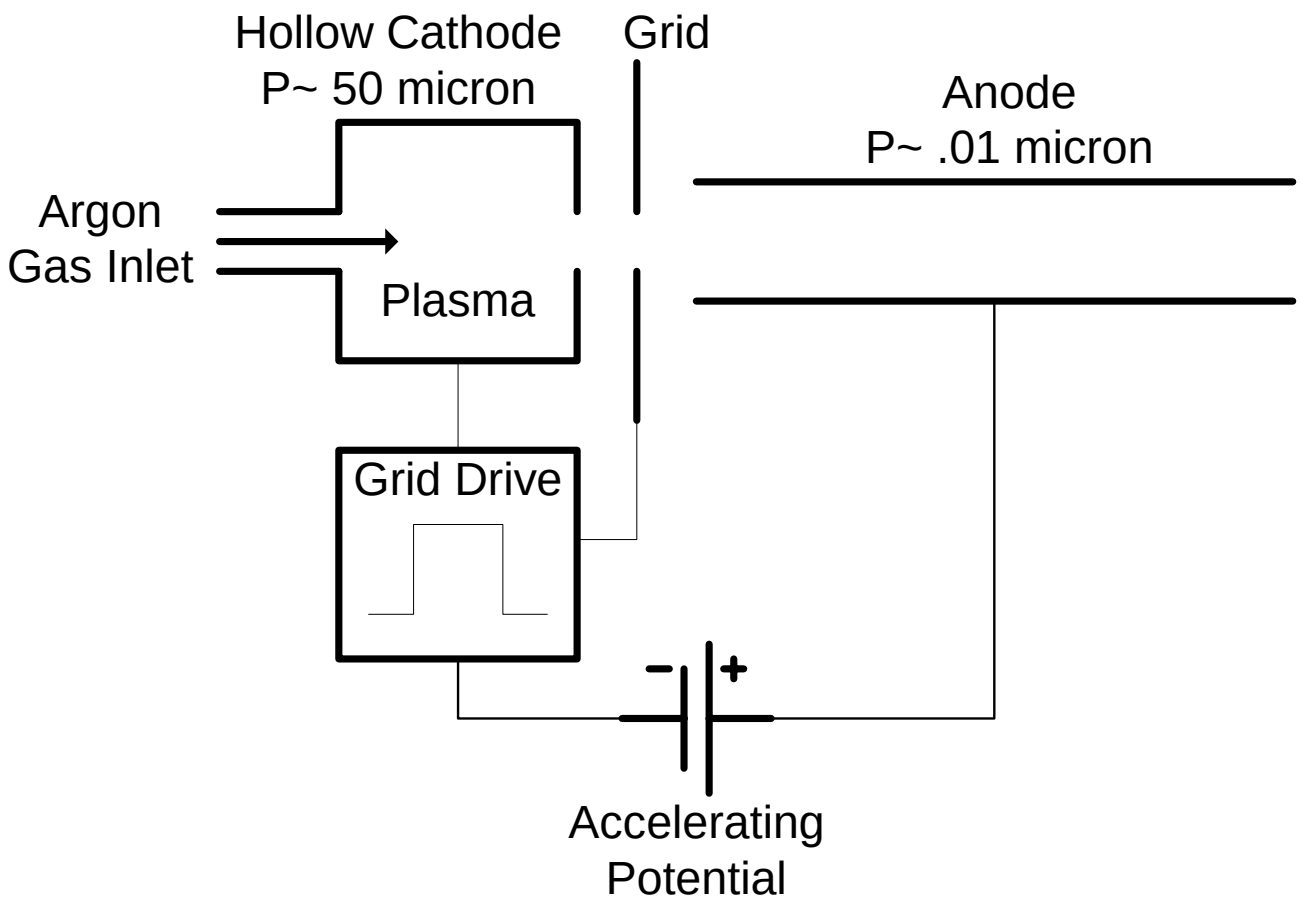
Example: Design Parameters for a 850 GHz Clinotron



Beam Voltage (kV)	5-10
Beam Current (mA)	150-300
Current Density (A/cm^2)	50-100
Grating Period (μm)	50-70
Grating Depth (μm)	84
Slot Width (μm)	
Mirror Separation (mm)	3
Sheet Beam Width (mm)	3
Length of SWS (mm)	55
Angle between the beam and SWS (angular minutes)	7

Schematic figure courtesy of A.Ya. Kirichenko and S.A. Churilova, Institute of Radio Astronomy, Kharkov, Ukraine

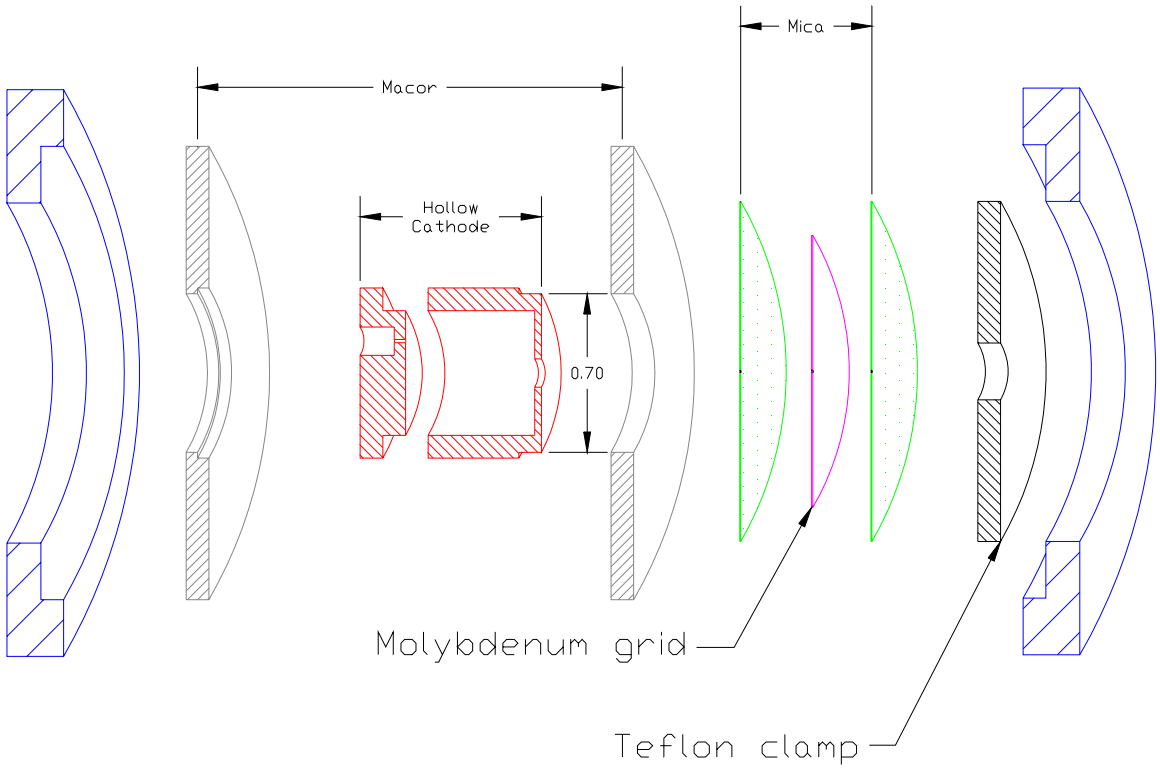
Schematic of Plasma Gun



Experimental Parameters

Beam Voltage	0.5 – 1.1 kV
Beam Current	0 – 0.3 A
Max Current Density	~ 1 kA / cm^2
Plasma Current	0.5 A
Gas (constant source)	N, Ar, Xe
Cathode Pressure	10 - 50 microns
Base Pressure	< 0.01 microns
Pumping	Turbo w/ diff.

Cross-section of Cathode Pieces



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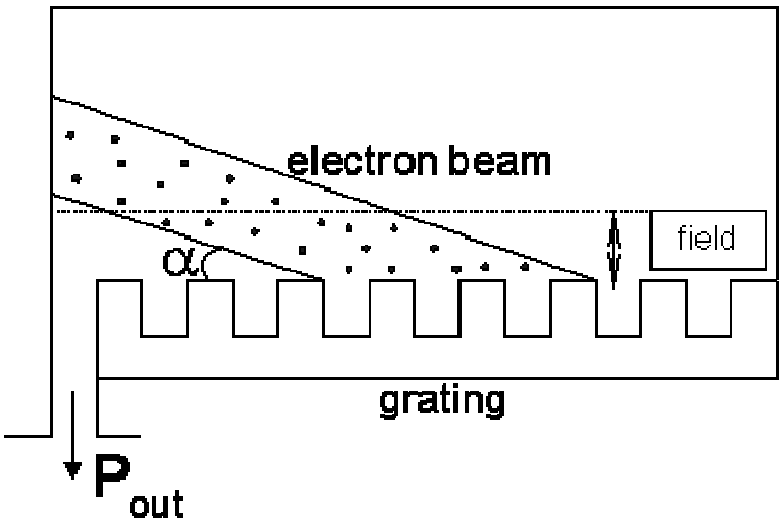

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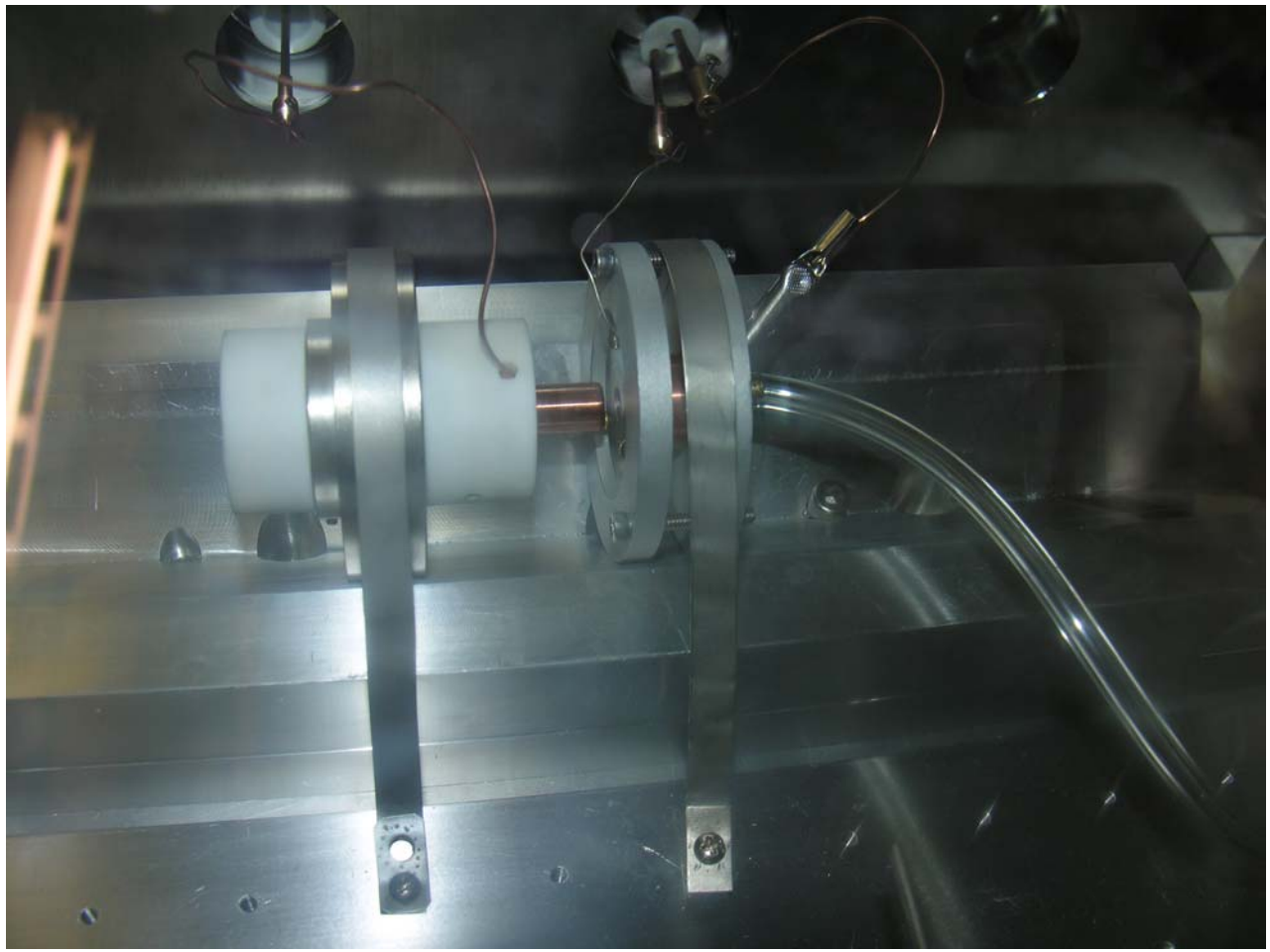
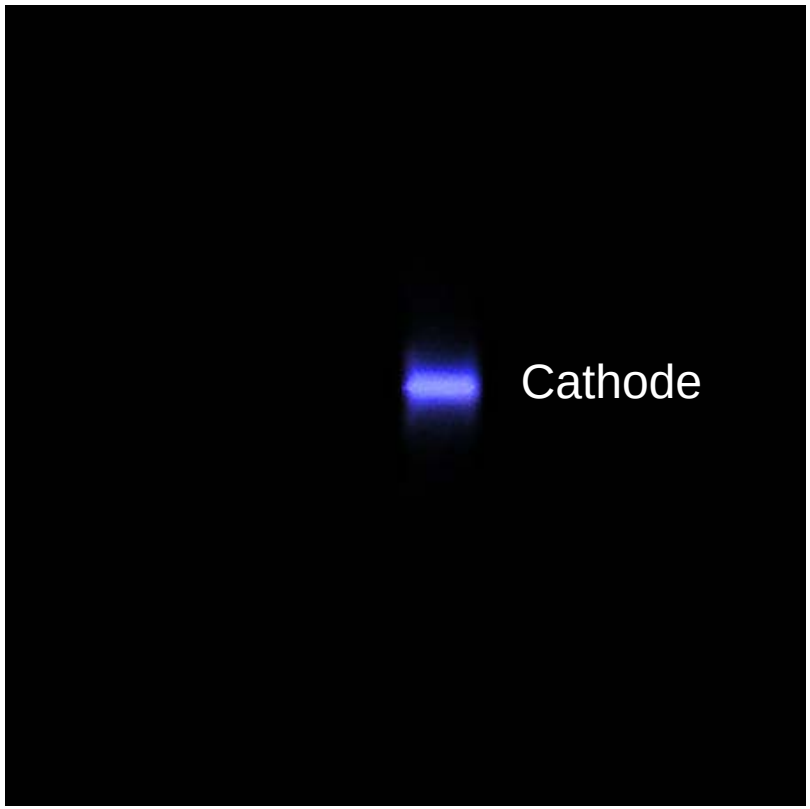
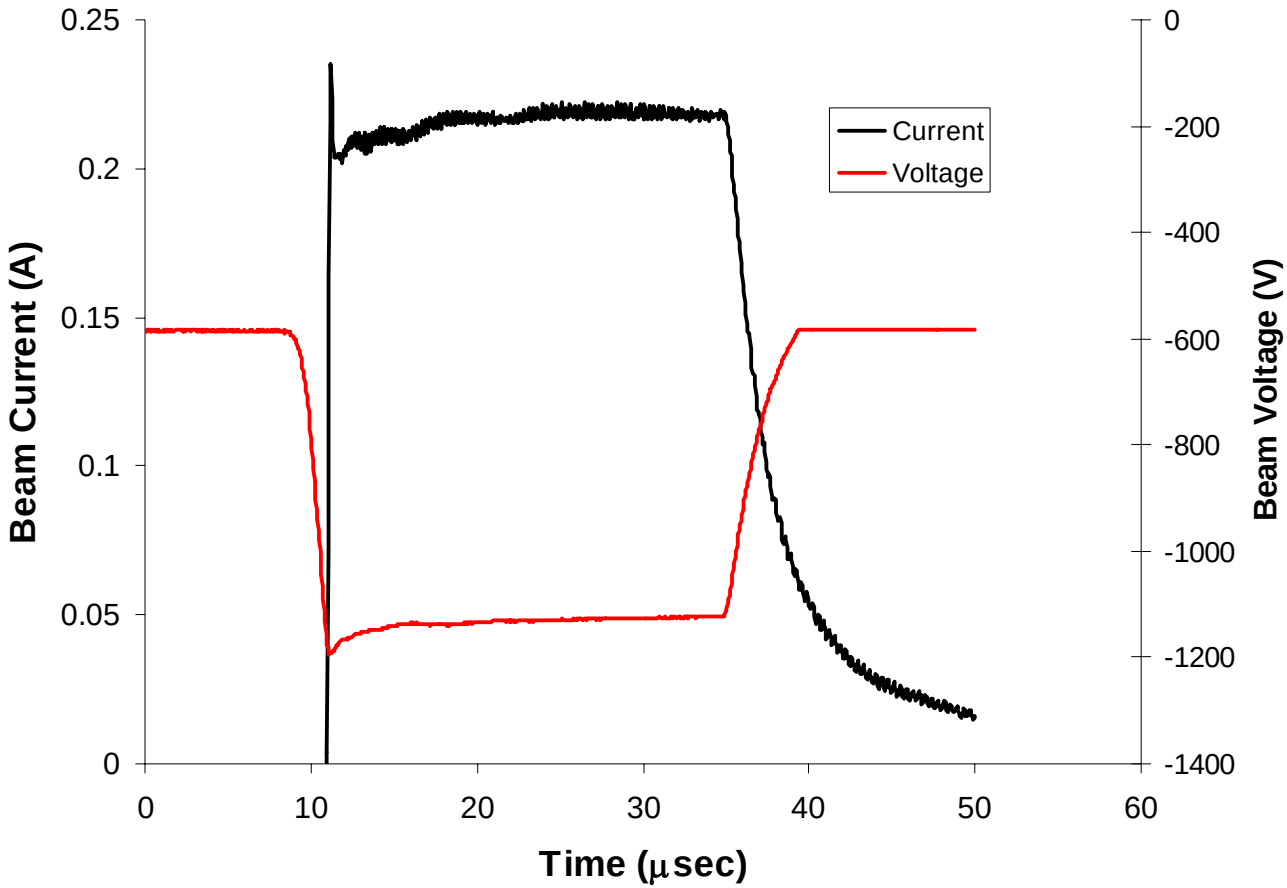
Photo of Gun in Vacuum Test Stand



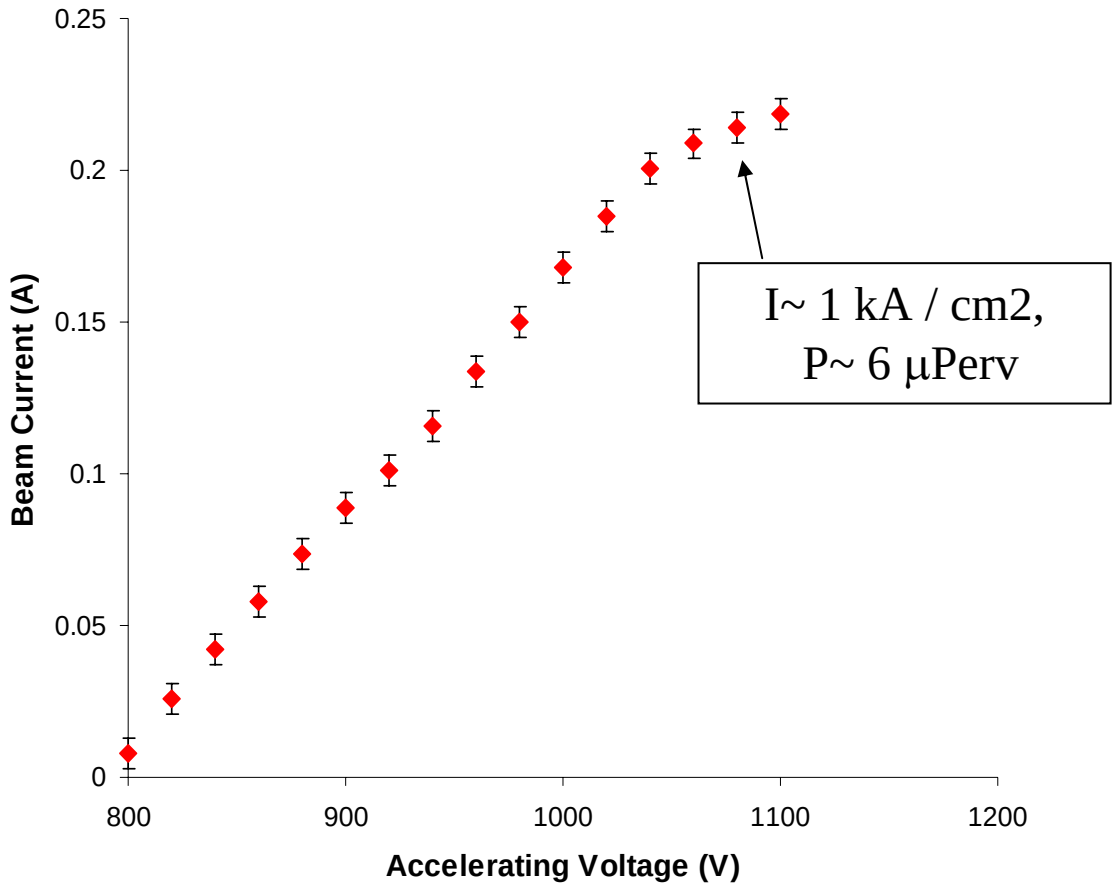
Light Emission from Beam Channel Between Grid and Anode



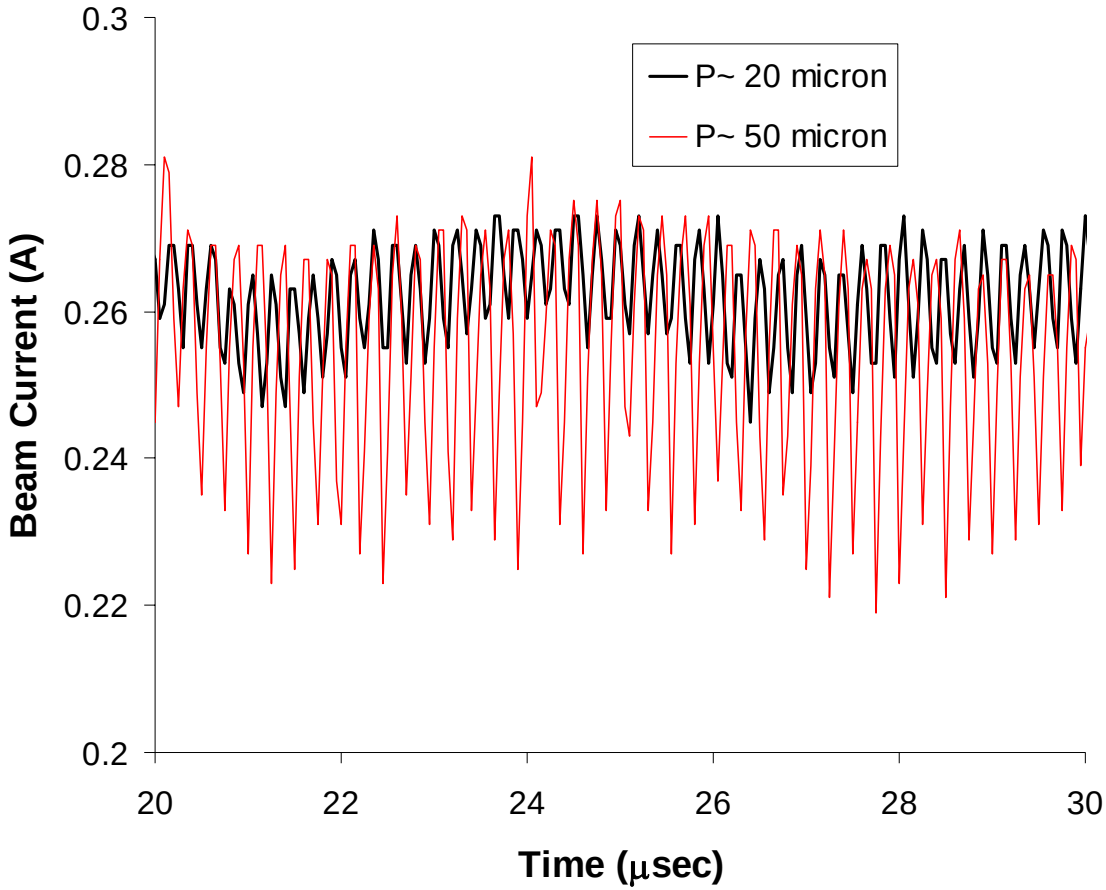
Typical Beam Voltage and Current Waveforms



I-V Characteristics of Plasma Gun



Dependence of Fluctuations in Beam Current on Gas Pressure



Conclusions

- Developed a simple design based on a scaled pasotron gun with no filament or keep-alive current.
- Operation at current densities up to 1 kA/cm^2 in a 100-micron diameter electron beam has been demonstrated.
- The low conductance of the beam aperture facilitates “natural” differential pumping: steady-state gas flow, no puff valve.
- Plasma cathodes may be a viable alternative to thermionic guns for high-power terahertz sources.

Future Work

- Study ion focusing, transport and gas fill
- Measurement of beam profile, emittance
  - Need to develop new micron-scale diagnostics
- Study beam stability
- Develop pulser for V_{beam}> 1.1 kV
- Fabricate and test simple slow-wave structure at submillimeter wavelengths
- Investigate miniature PPM-ion focus structure

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