RESULTS OF A COMPACT REFLEX TRIODE WITH MULTI CAVITY ADJUSTMENT

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1. Background and Motivation
   a. Cathode
   b. Anode
   c. Tube Structure

2. Experimental Setup
   a. Sealed Tube Reflex-Triode Vircator
   b. Pulsed Power Source

3. Experimental Results
   a. Frequency tunability comparison

4. Future Work
OLD TUBE PERFORMANCE

- Only a few main frequencies
- Low power at a large majority
- Limited ability to adjust performance
Bimodal carbon-fiber (CF) cathode
- 2 million CF pyrolytically bonded to a POCO graphite substrate
- Rogowski-profile
- 2.5” diameter

Pyrolitic graphite anode
- Long life time >100,000 shots
- High thermal emissivity
- 70% transparent
- 3.5” diameter

- Electron source → Explosive emission induce plasma
Cathode Conditioning

- Tube Preparation
  - Extreme cleaning of internal components
  - Plasma cleaning of smaller components
  - Bake out at 175°C for 72 hours while connected to a turbo molecular pump

- Procedure
  - >1,000 shots minimum
  - Shots taken at 10Hz, 20 shot burst
  - 50 kV charging voltage
  - 8 mm A-K gap
**Waveguide**

- 4.91”(124.7mm) X 5.58”(141.7mm) W X H
- 1.58”(40mm) Bottom Plate travel
- \( f_c = 1.202 \text{ GHz} \)
  - \( a = 4.91", b = 5.58\", m = 1, n = 0 \)

\[
f_c = \frac{1}{2\pi\sqrt{\mu_0\varepsilon_0}} \sqrt{\left(\frac{m \pi}{a}\right)^2 + \left(\frac{n \pi}{b}\right)^2}
\]
**Tube characteristics**

- Background pressure: \( \approx 10^{-9} \) Torr
  - Backed by a 20 L/s ion pump
- 8” Tube
- Internal liner
- Movable Backwall (BW)
- Movable Bottom Plate (BP)
- Adjustable Anode –Cathode Gap (AK gap)
- Sealed tube

**Diagnostics**

- Capacitive Voltage Divider
- Person Current Monitor
- Wide Band Receiving Antenna
PULSED POWER SOURCE

- 12 stage PFN-based Marx Generator
  - Rayleigh PFN
  - 50 kV charging voltage
  - 600 kV output @ 50 kV charge (open circuit)
  - \( \approx 65 \, \Omega \) output impedance
  - 100 ns FWHM
  - 157 J
• Result settings
  a. Backwall: 0mm – 17.5mm in 2.5mm steps
  b. Bottom plate: 0mm – 32mm in 2mm steps
  c. AK sweep: 5mm – 24.5mm in .5mm steps
E-Field Vs. Frequency @ 3M
Frequency Vs. AK, E-Field > 25KV
Settings Showing Frequency Movement

- Frequency Vs Bottom Plate (BW=2.5)(AK=8mm)
- Frequency Vs Bottom Plate (BW=2.5)(AK=9.5mm)
- Peak E-Field Vs Bottom Plate @ 3m
- Peak E-Field Vs Frequency
Settings showing frequency movement

**Frequency Vs Bottom Plate (BW=7.5)(AK=24.5mm)**

**Frequency Vs Bottom Plate (BW=0.0)(AK=13mm)**

**Peak E-Field Vs Bottom Plate @ 3m**

**Peak E-Field Vs Frequency**
• Total estimated radiated power ≈139MW
• Estimated efficiency ≈ 13.4%
  • Calculated from Marx Energy & pulse width
  • RF was considered rotationally symmetric across beam spot
• Total estimated radiated power $\approx 77$MW
• Estimated efficiency $\approx 7.5\%$
  • Calculated from Marx Energy & pulse width
  • RF was considered rotationally symmetric across beam spot
5.36GHz Mode Pattern
2GHz Mode Pattern
SUMMARY

• Achieved wide tuneability of a sealed Vircator tube.
• Long life time $> 10^6$
• Rep-rate able to 100Hz
• Fully automated system
  – Microprocessor ran system
    • Air valves
    • Tuneability via 4 stepper motors
    • Charging
    • Firing

• Future work
  – Determine mode competition