SUBMILLIMETER BACKWARD-WAVE OSCILLATOR PROGRAM

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SUBMILLIMETER BACKWARD-WAVE OSCILLATORS

OBJECTIVE

TO DEVELOP THE TECHNOLOGY FOR VOLTAGE TUNABLE LOCAL OSCILLATORS IN THE FREQUENCY RANGE 300-2000 GHz TO SUPPORT FUTURE NASA MISSIONS IN ASTROPHYSICS AND RADIO ASTRONOMY

SUBMILLIMETER BWO PROGRAM

PROGRAM STRUCTURE:

- MIT LINCOLN LABORATORY: CIRCUIT ETCHING (NOT FUNDED FY 1990)
- UNIVERSITY OF UTAH: DESIGN AND TESTING (TRANSFERRED TO LeRC FY 1989)
- LeRC: OUTPUT COUPLER, GUN DESIGN

SUBMILLIMETER BACKWARD-WAVE OSCILLATORS

3 PROBLEMS:

1) FABRICATION TECHNIQUE FOR INTERDIGITAL LINE
   - HIGH IMPEDENCE CIRCUIT, HENCE
   - LOWER START CURRENT, AND
   - WIDER BANDWIDTH
   - LOWER BEAM VOLTAGE

2) HEAT TRANSFER PROBLEM
   - DIAMOND TYPE IIA HEAT SINK

3) LIFETIME PROBLEM
   - LONG LIFE CATHODE

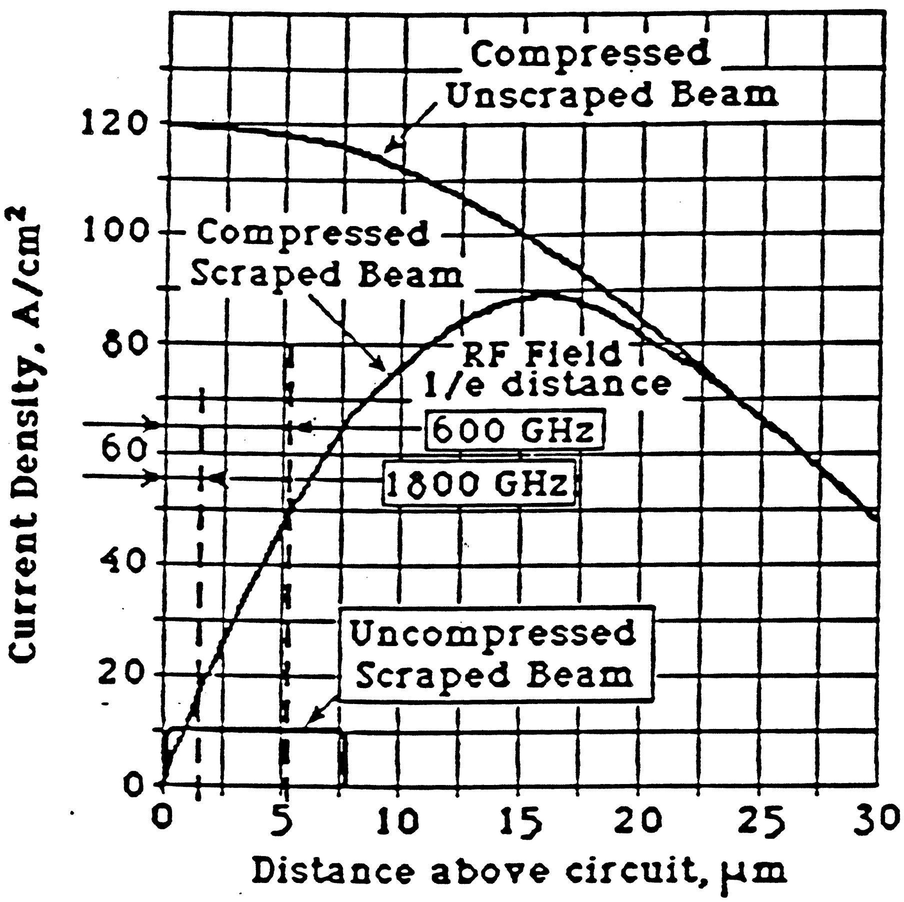


Fig. 2. Calculated beam current densities before and after circuit interception (scraped).

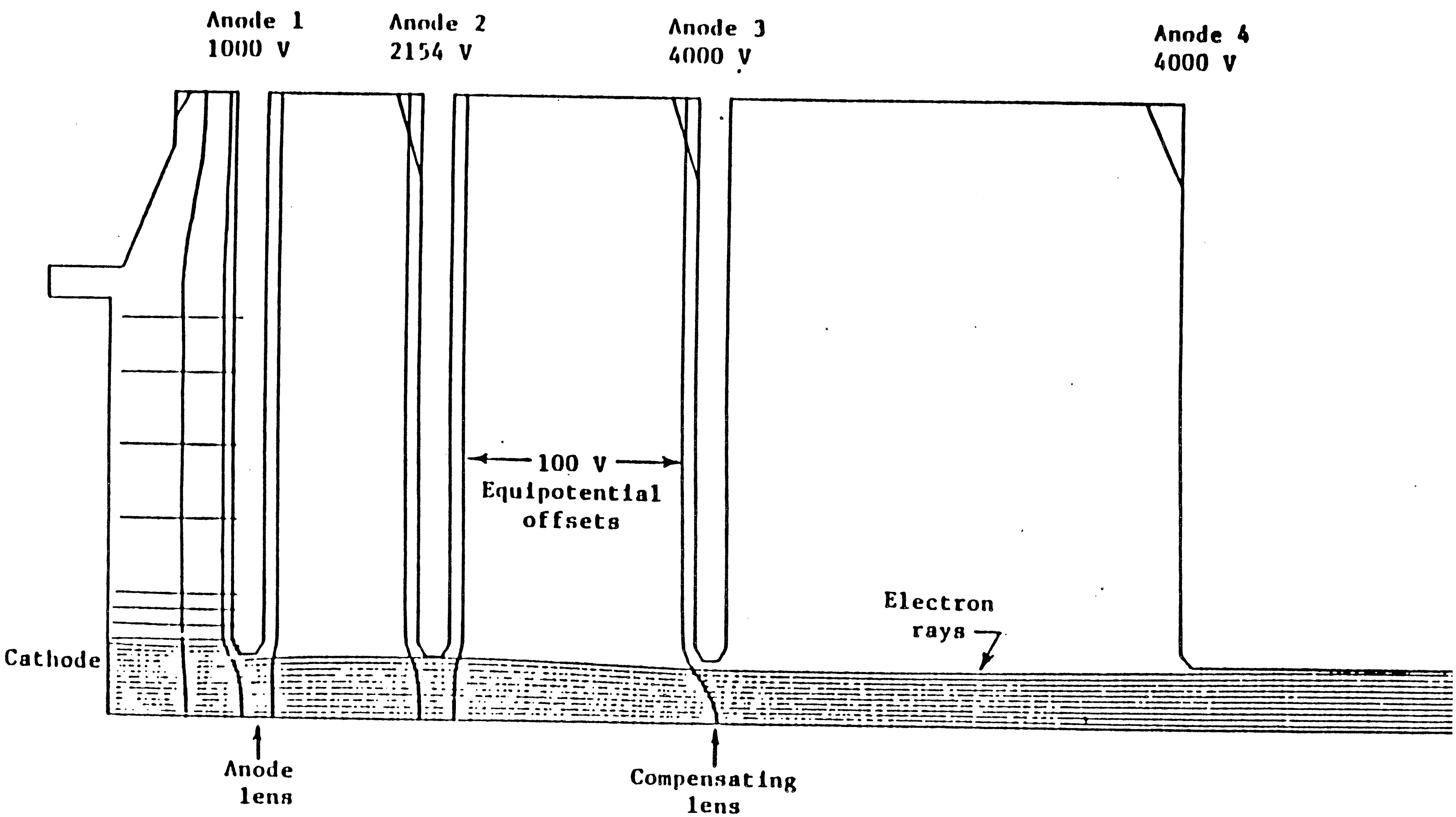


Fig. 7. The multielectrode lens compensated gun for the first experiment with calculated electron trajectories.

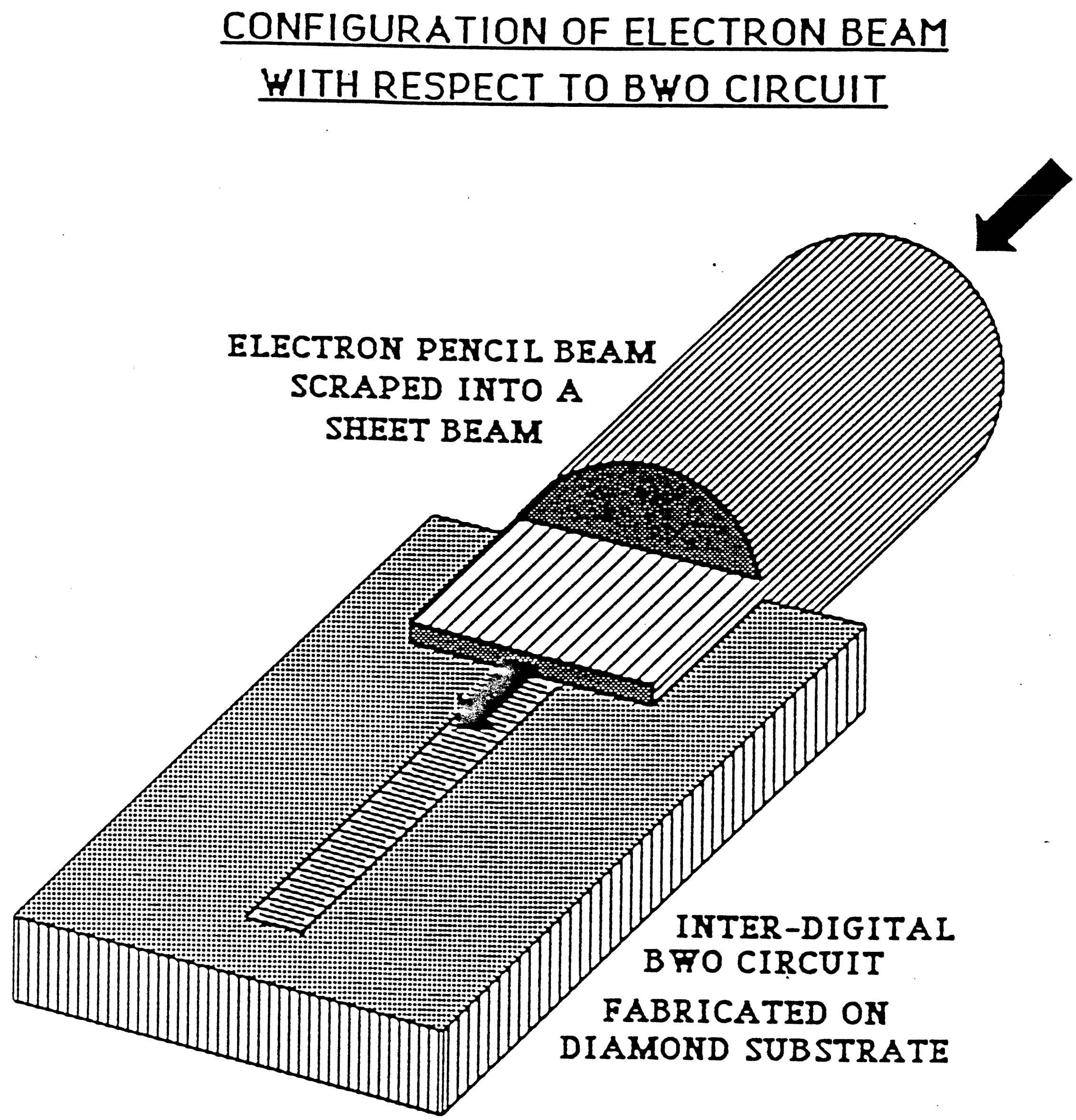


Fig. 1. Configuration of the electron beam with respect to the BWO circuit.

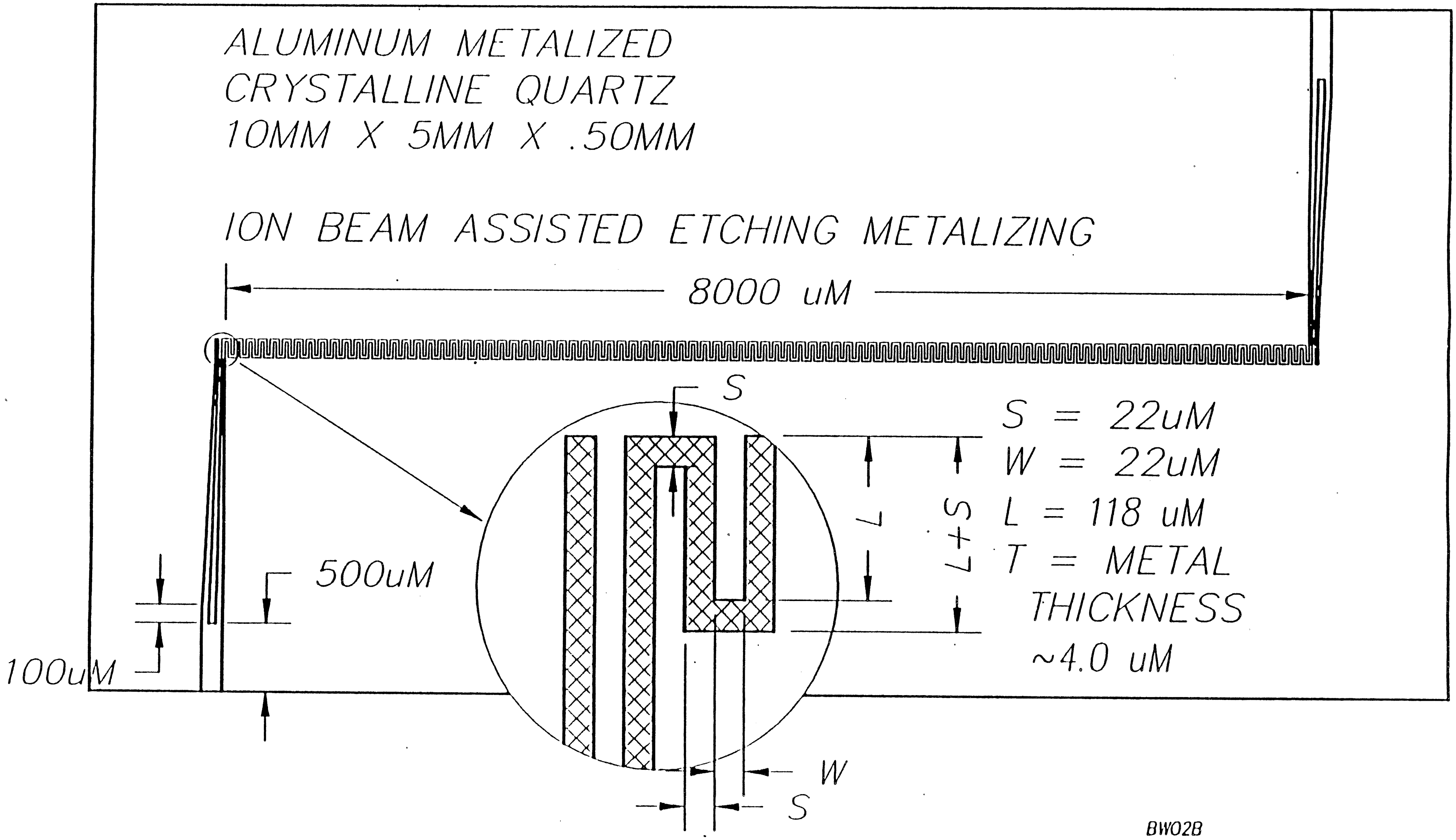


Fig. 14. Drawing of 200-250 GHJz backward-wave oscillator interdigital line as used to make circuits.

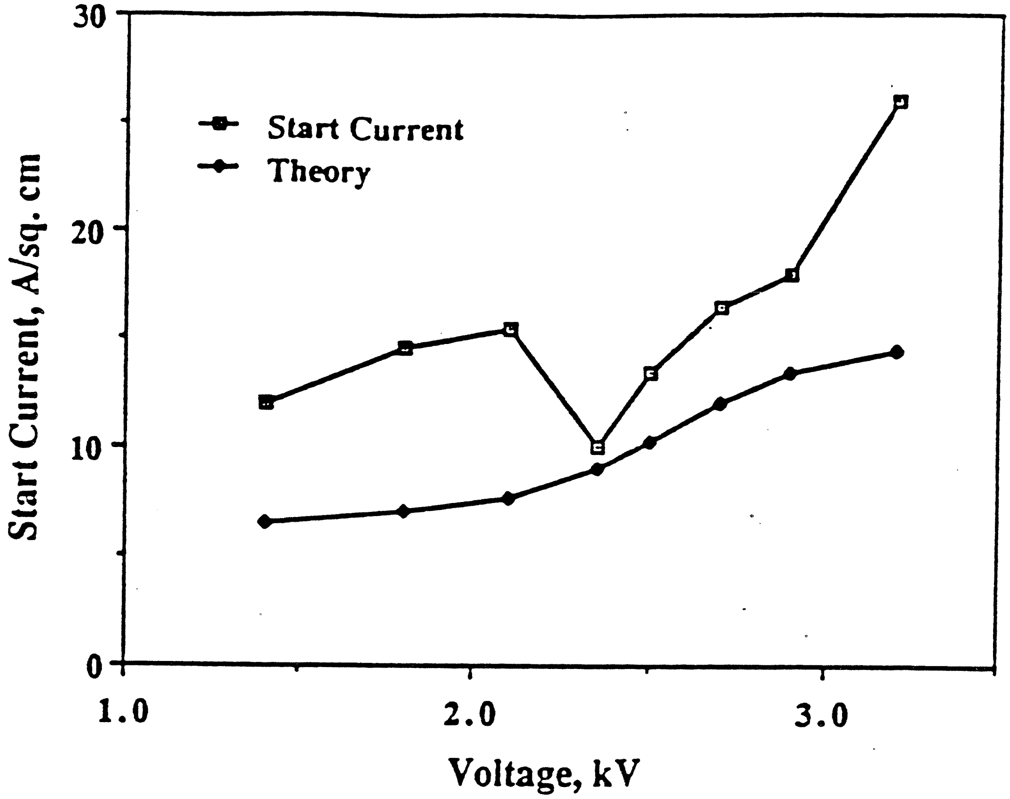


Fig. 19. Theoretical and experimental starting current for the aluminum metalized crystalline quartz circuit shown in Fig. 14.

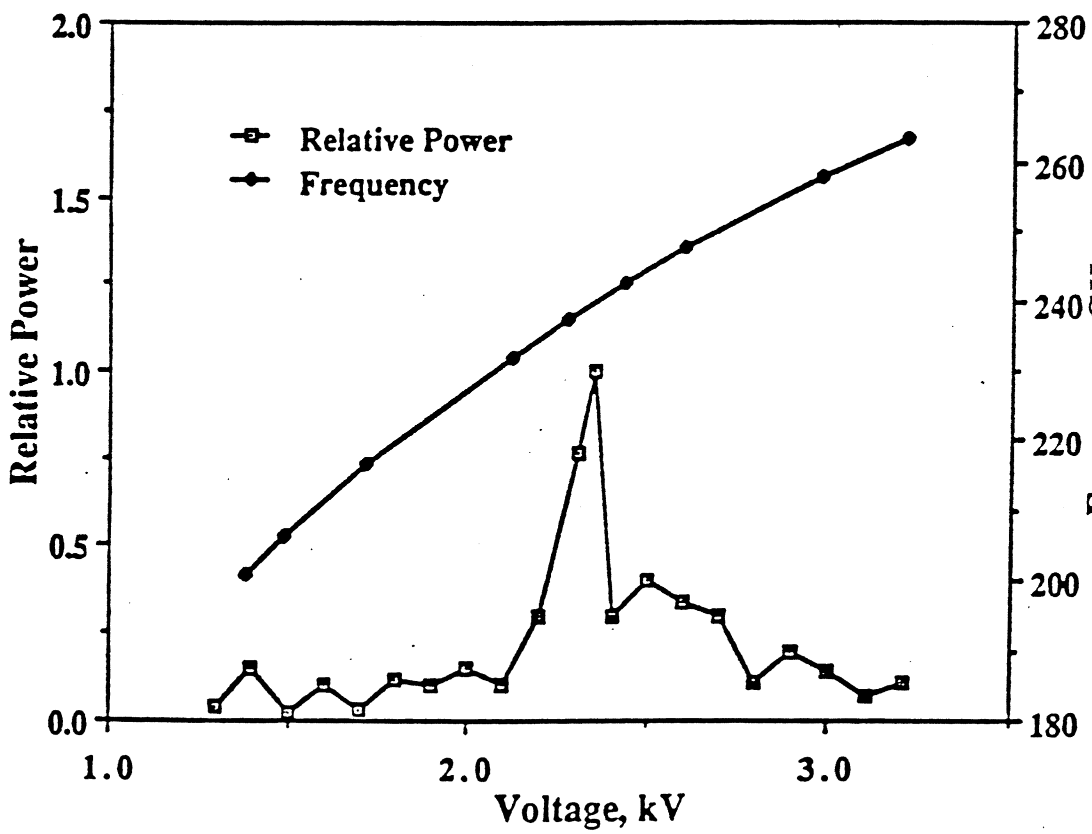


Fig. 20. Tuning curve and power output curve for the aluminum metalized crystalline quartz circuit shown in Fig. 14.

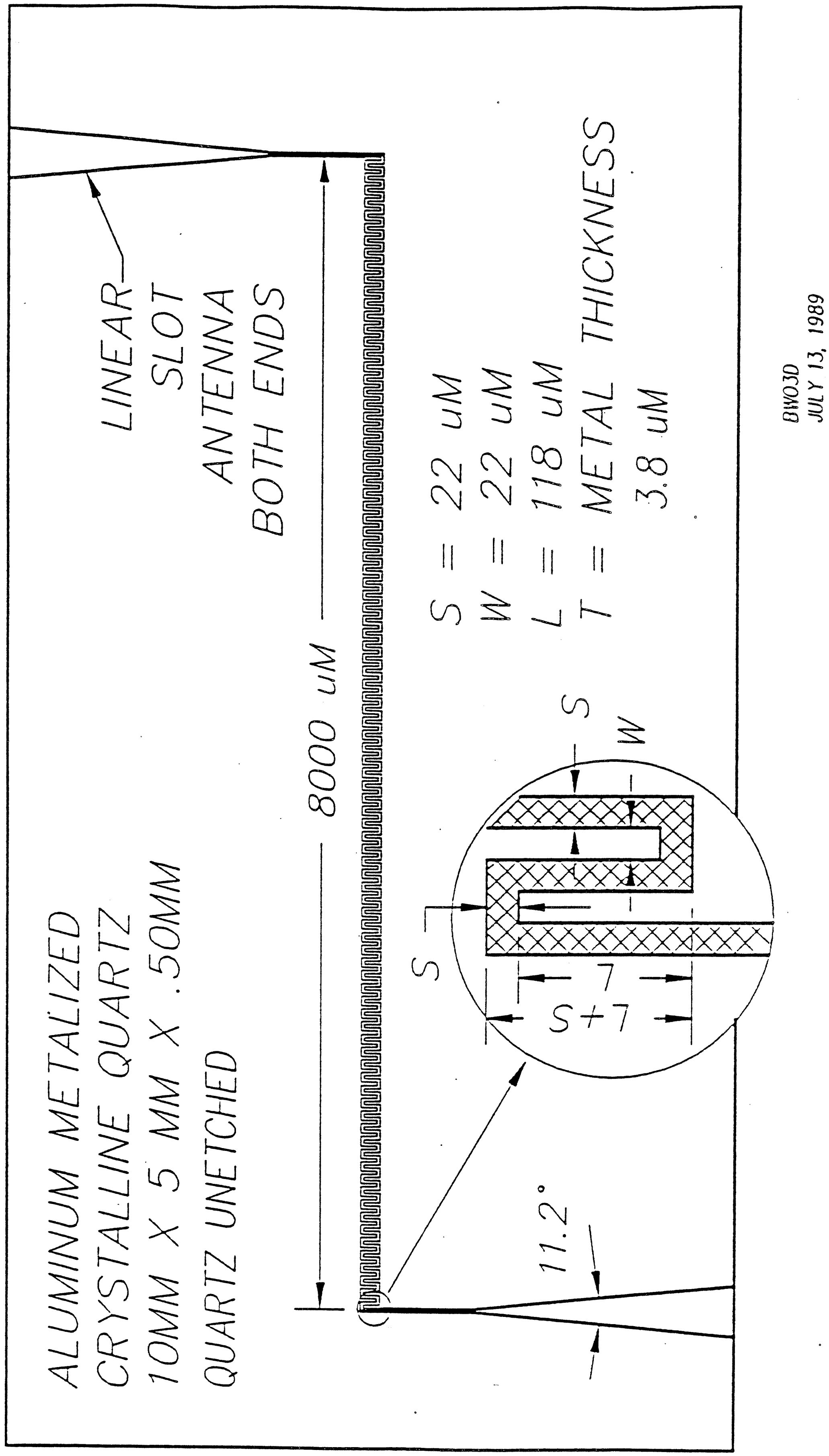


Fig. 23. Drawing of aluminum metalized crystalline quartz circuit with horn antenna for trying optical experiment.

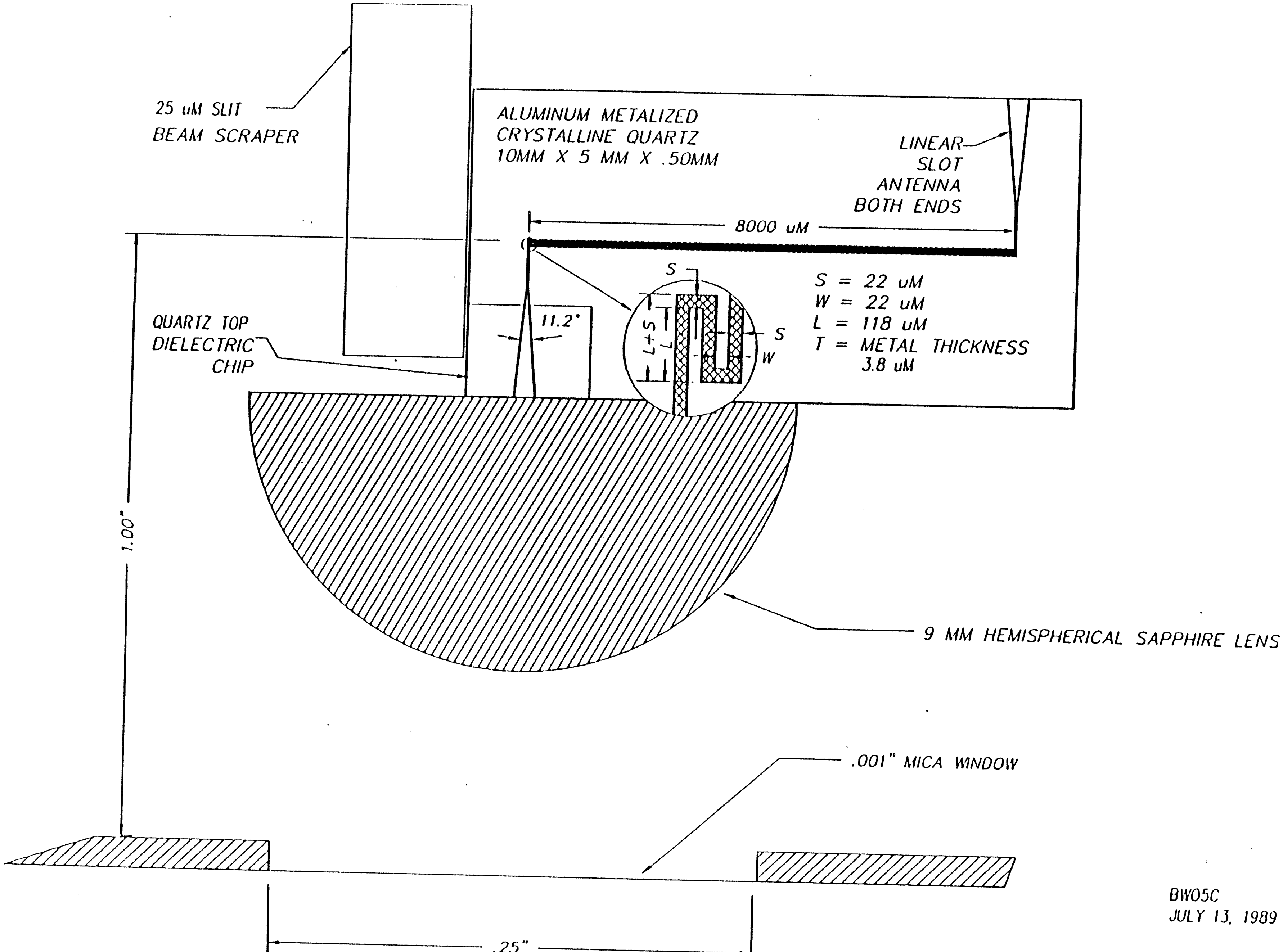


Fig. 24. Schematic diagram of the circuit, lens, and window configuration for the optical experiment.

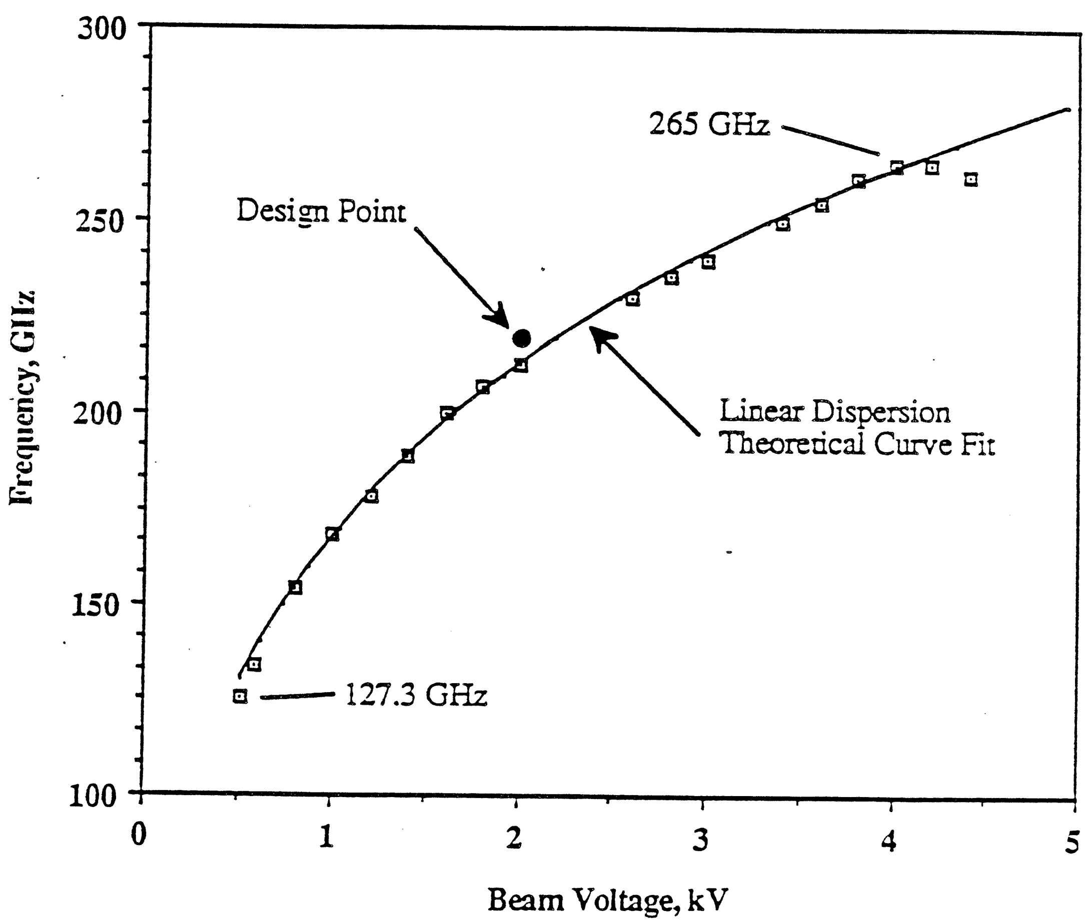


Fig 25. Quartz substrate BWO frequency versus beam voltage.

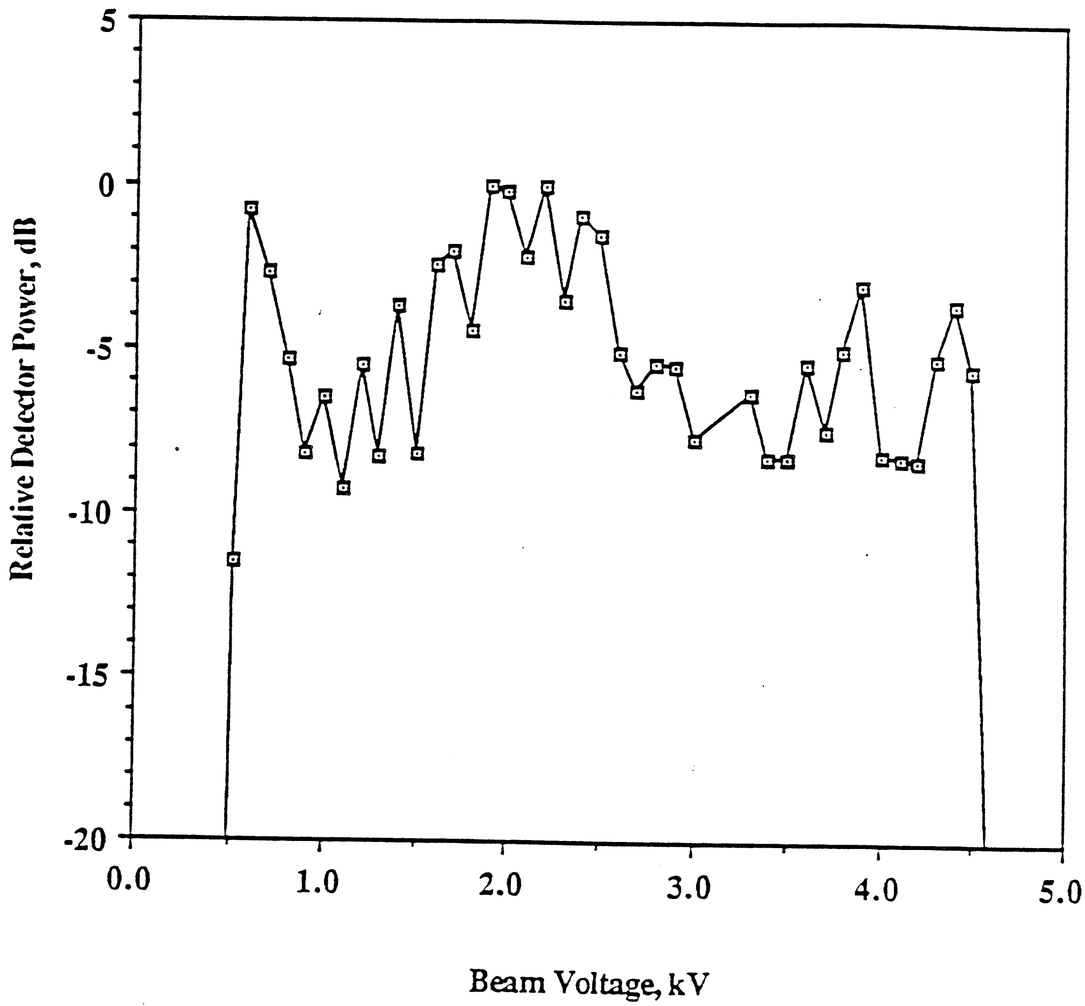


Fig..26. Quartz substrate BWO output.

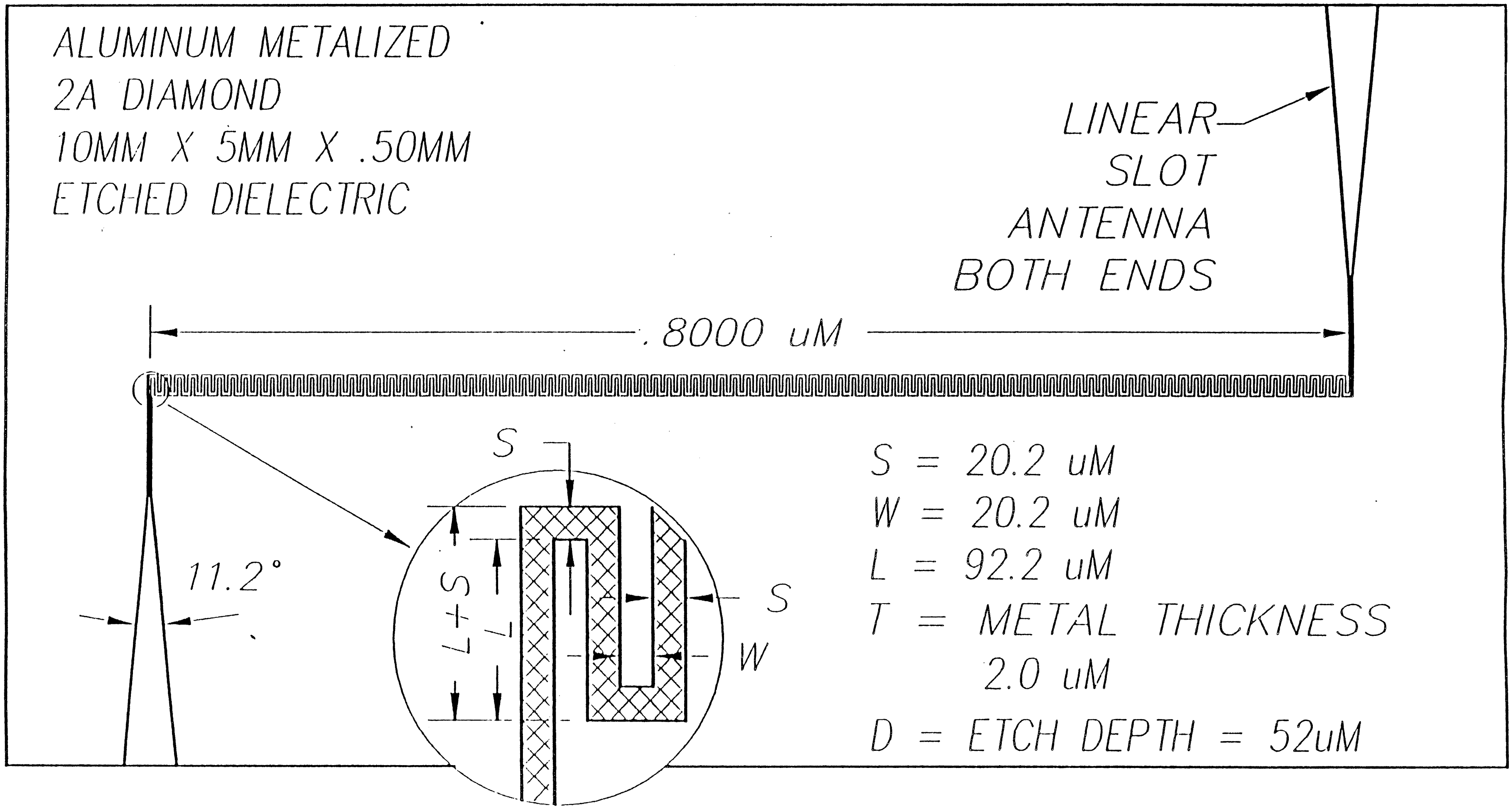


Fig. 27. Drawing of aluminum metalized etched diamond circuit with tapered slot antenna.

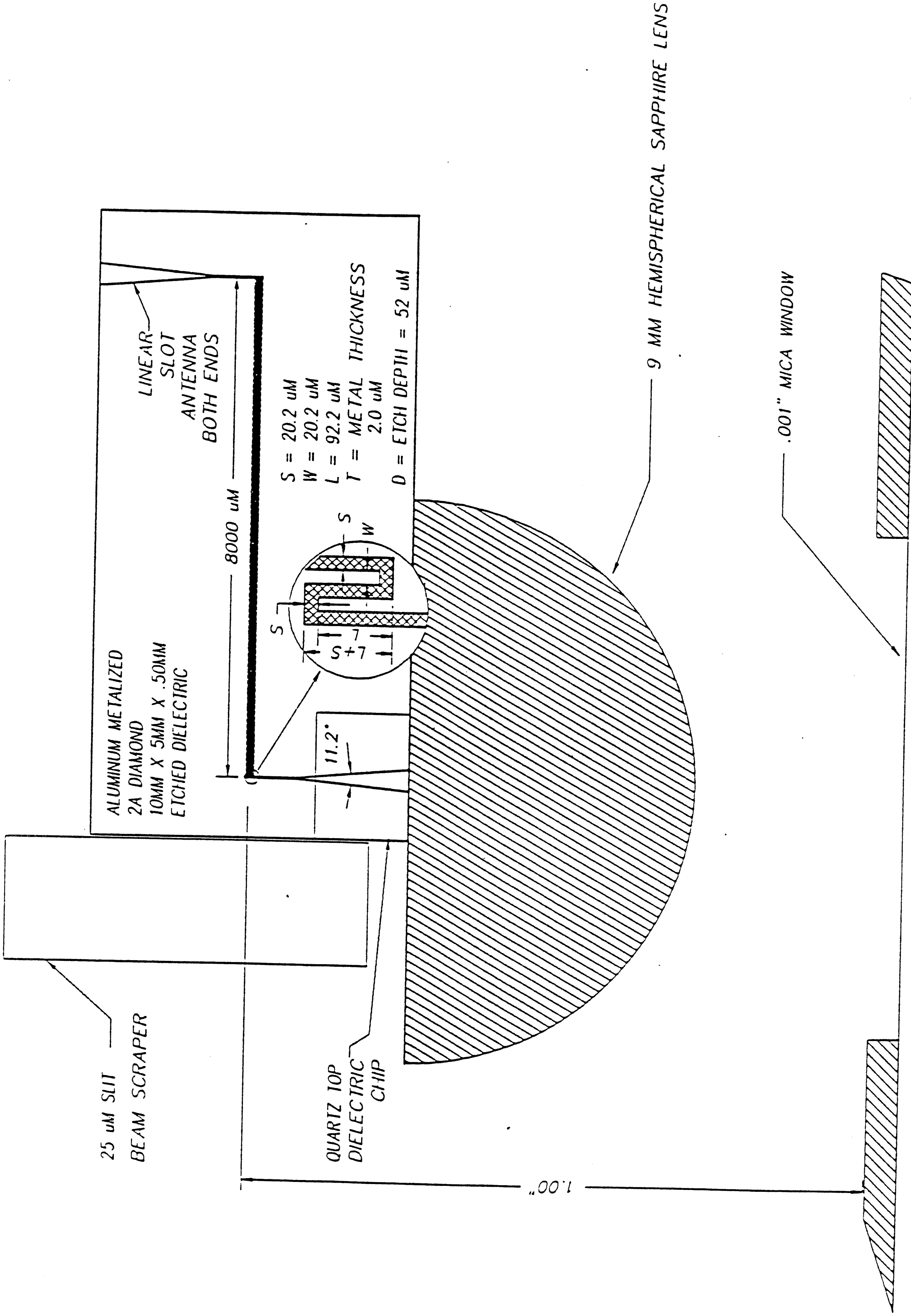


Fig. 28. Schematic diagram of the circuit, lens, and window configuration for the diamond experiment.

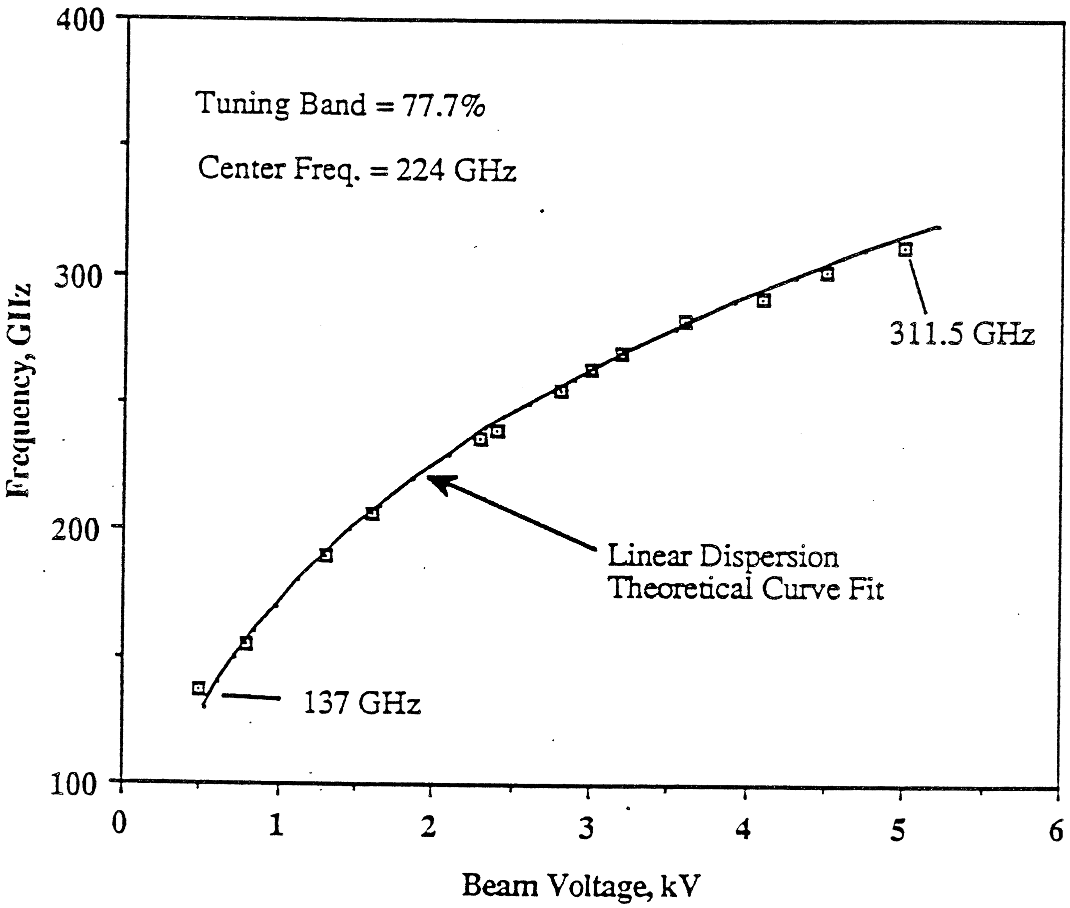


Fig. 29. Diamond substrate BWO tuning. Experimental frequency versus beam voltage.

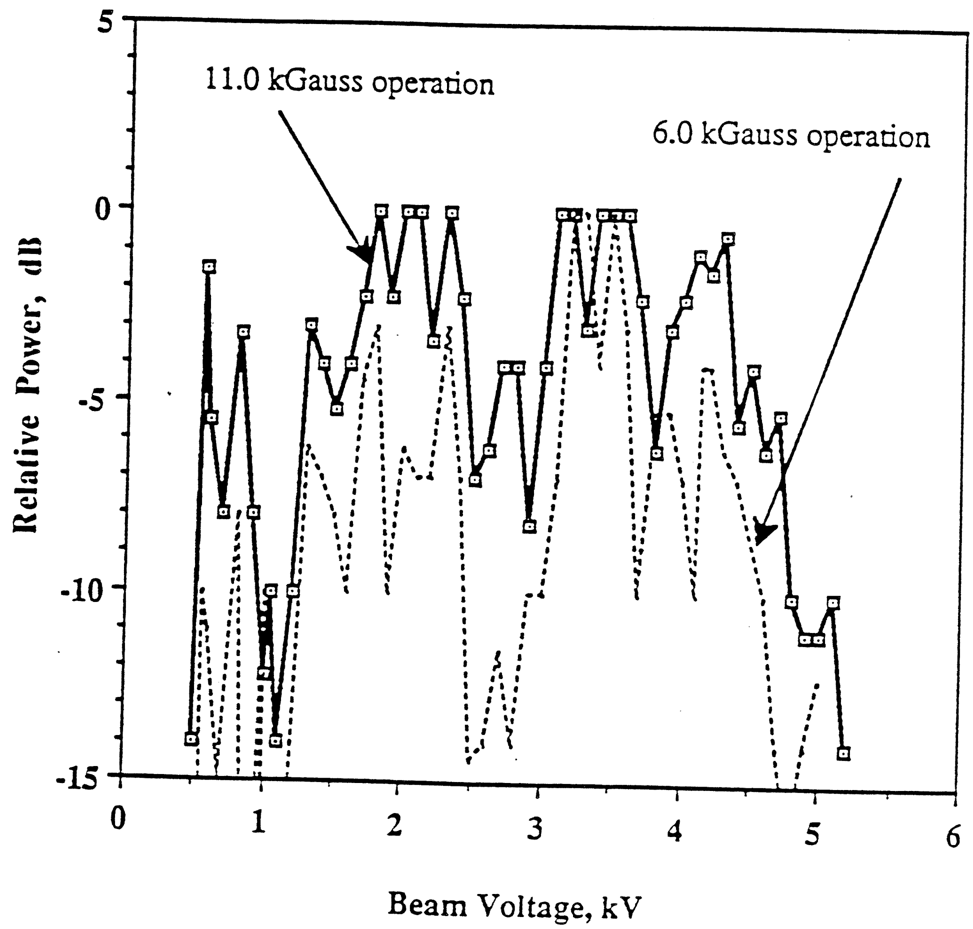


Fig. 30. Diamond substrate BWO. Relative power output versus voltage.

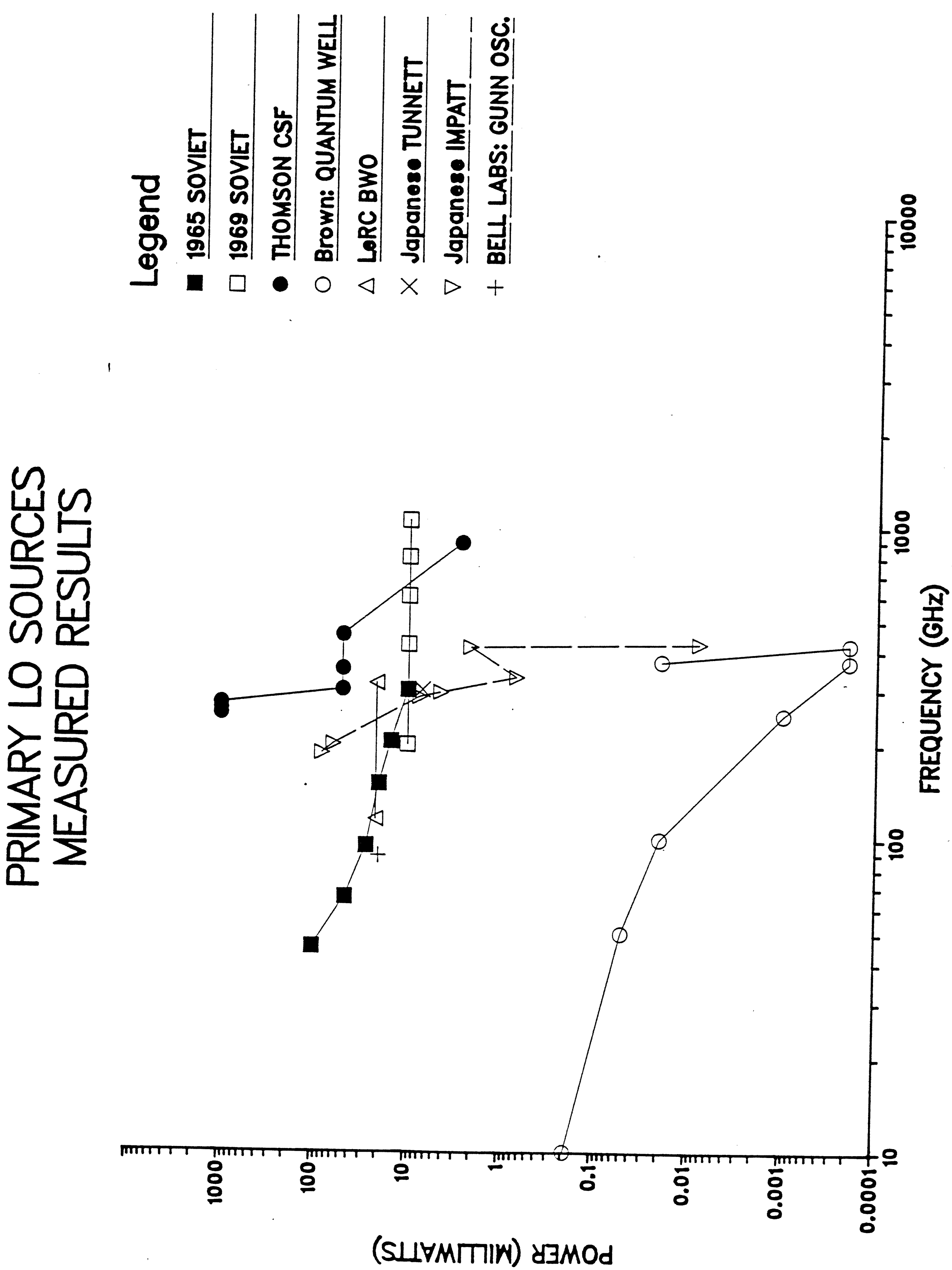
SUBMILLIMETER BWO PROGRAM

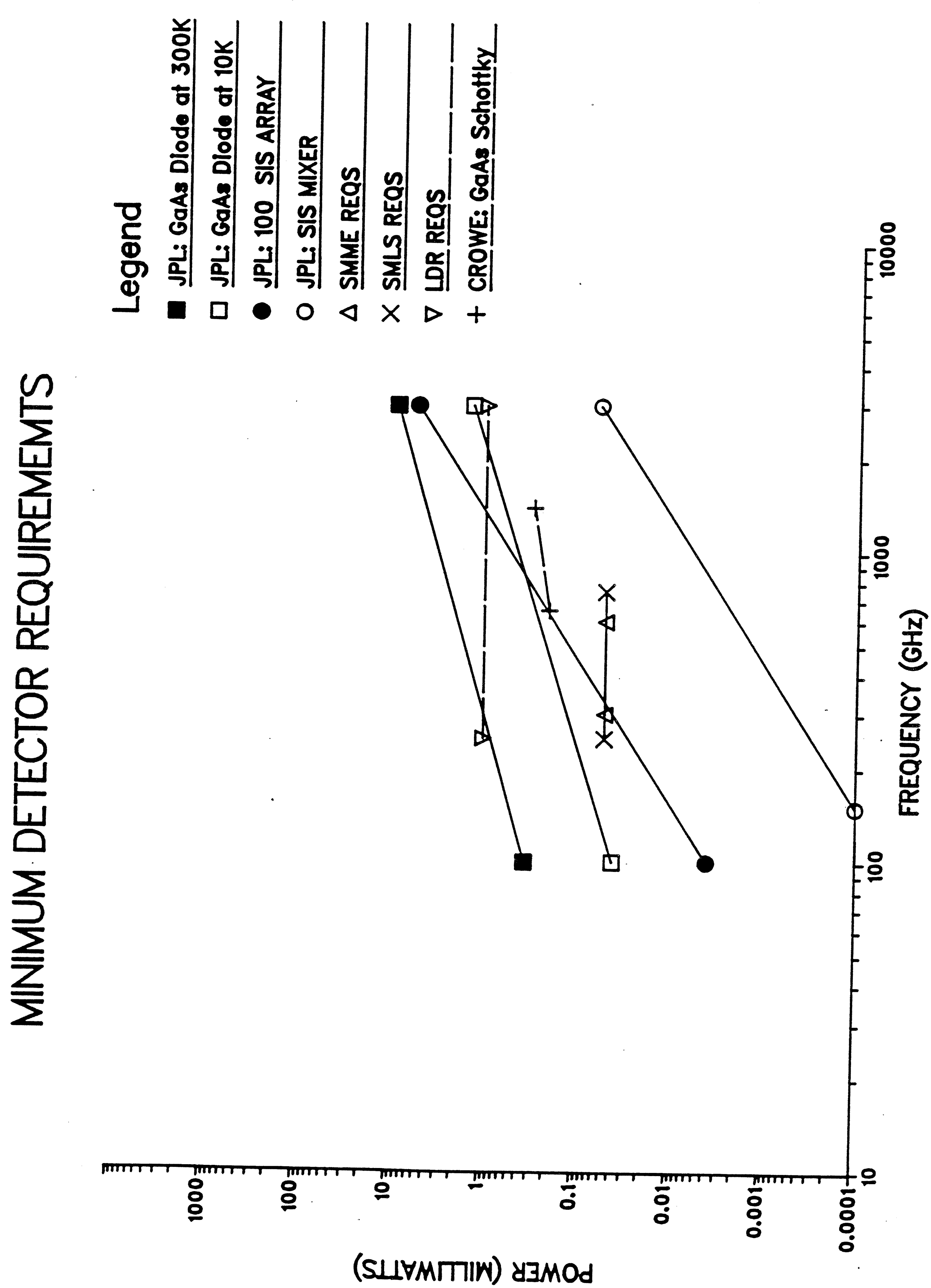
PROOF OF CONCEPTS RESULTS:

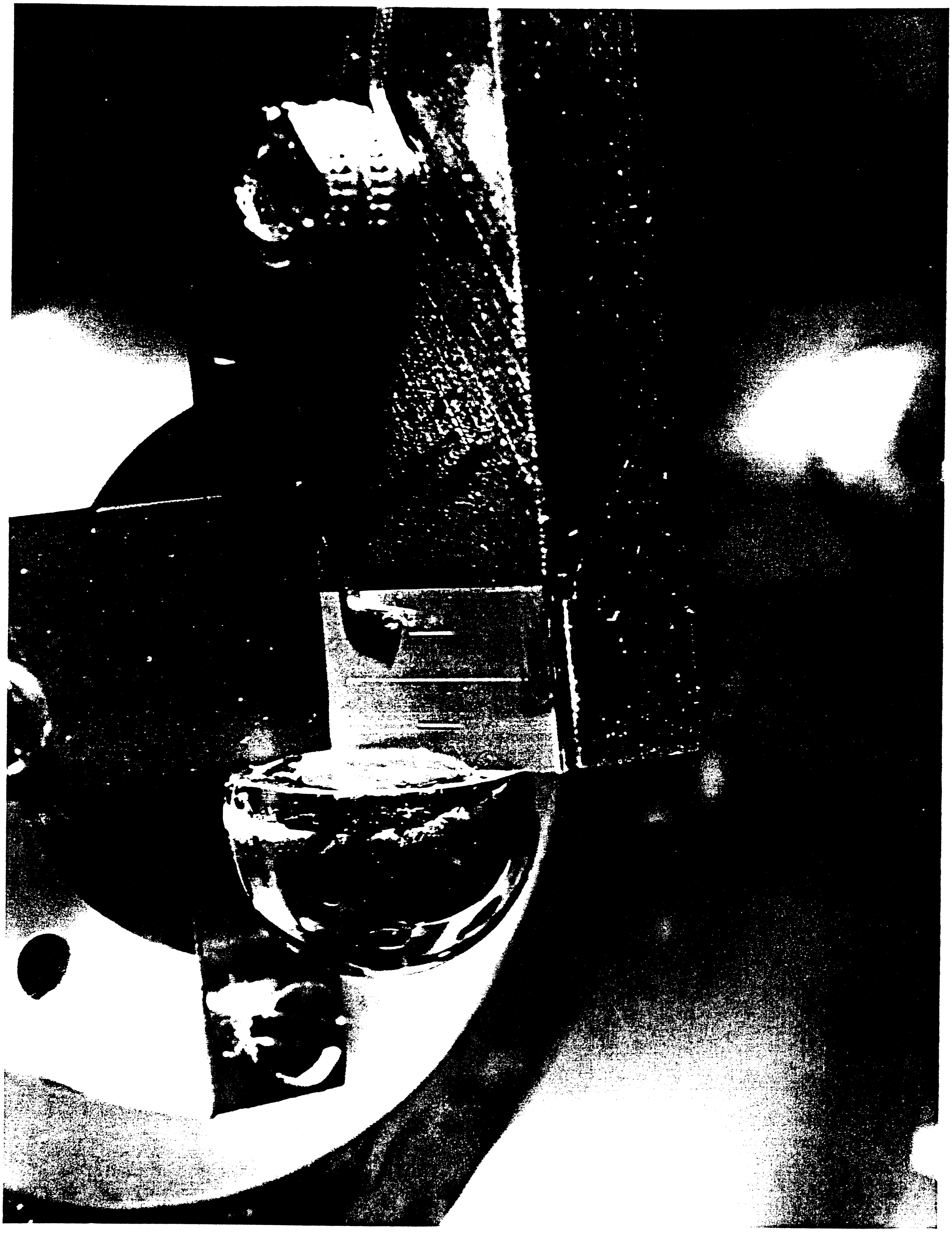
1) Al/QUARTZ SUBSTRATE
   COPLANER WAVEGUIDE/WAVEGUIDE
   200-265 GHz

2) Al/QUARTZ SUBSTRATE
   TAPERED SLOT LINE ANTENNA
   SAPPHIRE LENS
   127-265 GHz

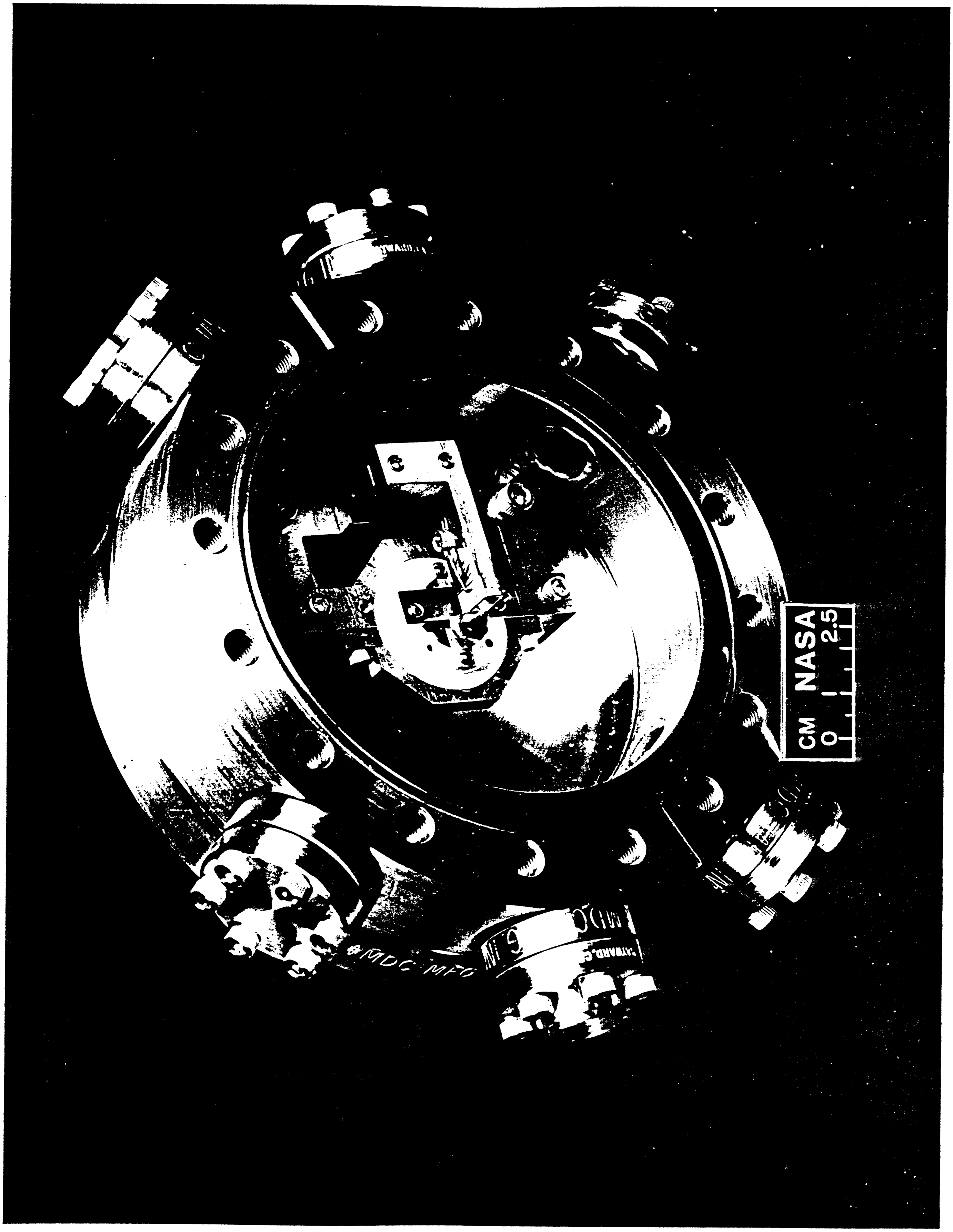
3) Al/ETCHED DIAMOND SUBSTRATE
   137-312 GHz
   ESTIMATED POWER 1-10mW


PRIMARY LO SOURCES
MEASURED RESULTS
Legend
1965 SOVIET
1969 SOVIET
THOMSON CSF
Brown: QUANTUM WELL
LeRC BWO
Japanese TUNNETT
Japanese IMPATT
BELL LABS: GUNN OSC.
POWER (MILLIWATTS)
1000
100
10
1
0.1
0.01
0.001
0.0001
FREQUENCY (GHz)
10
100
1000
10000


MINIMUM DETECTOR REQUIREMEMTS
Legend
JPL: GaAs Diode at 300K
JPL: GaAs Diode at 10K
JPL: 100 SIS ARRAY
JPL: SIS MIXER
SMME REQS
SMLS REQS
LDR REQS
CROWE: GaAs Schottky
POWER (MILLIWATTS)
1000
100
10
1
0.1
0.01
0.001
0.0001
10
100
1000
10000
FREQUENCY (GHz)



NASA
C-90-02787



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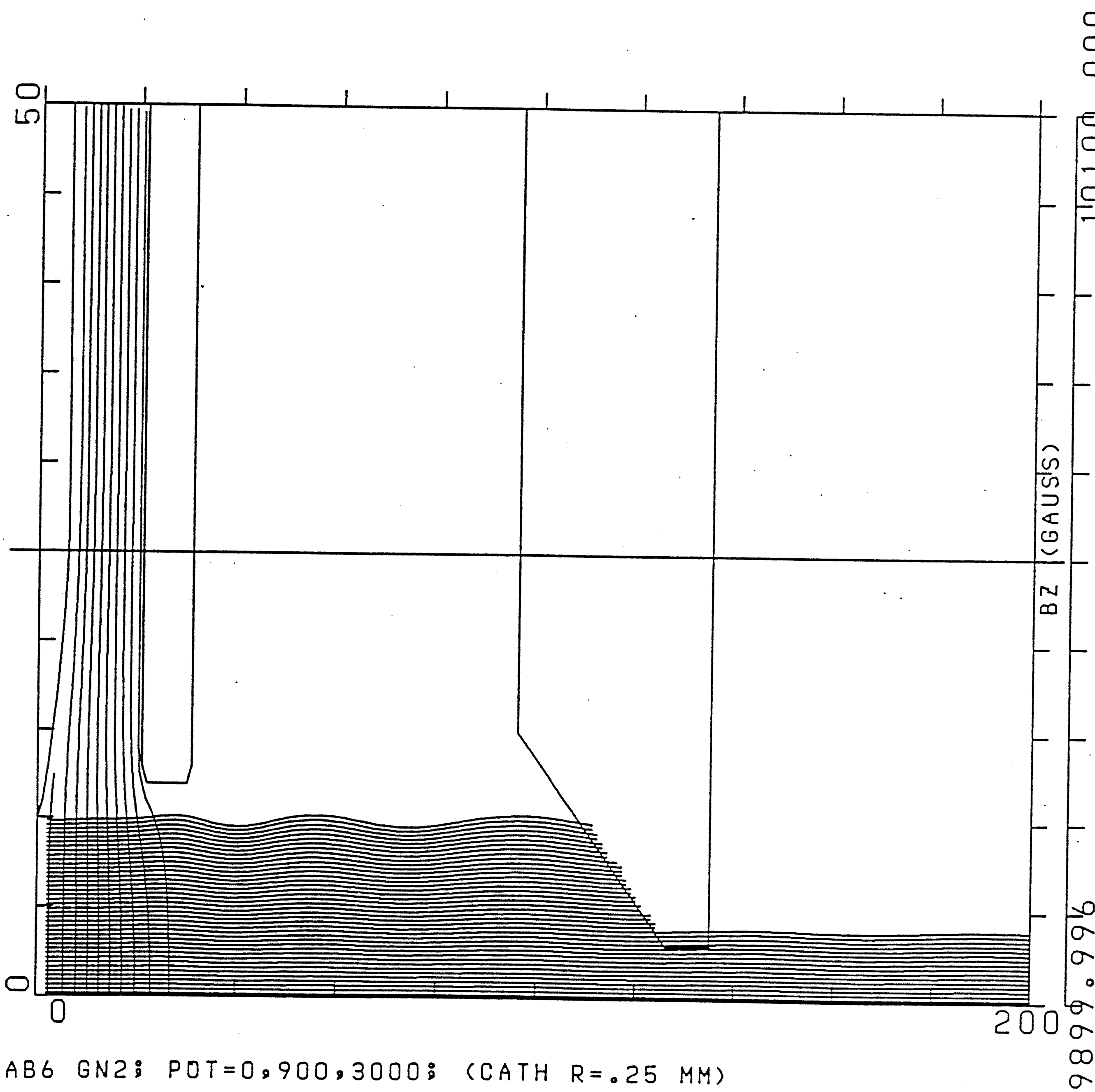
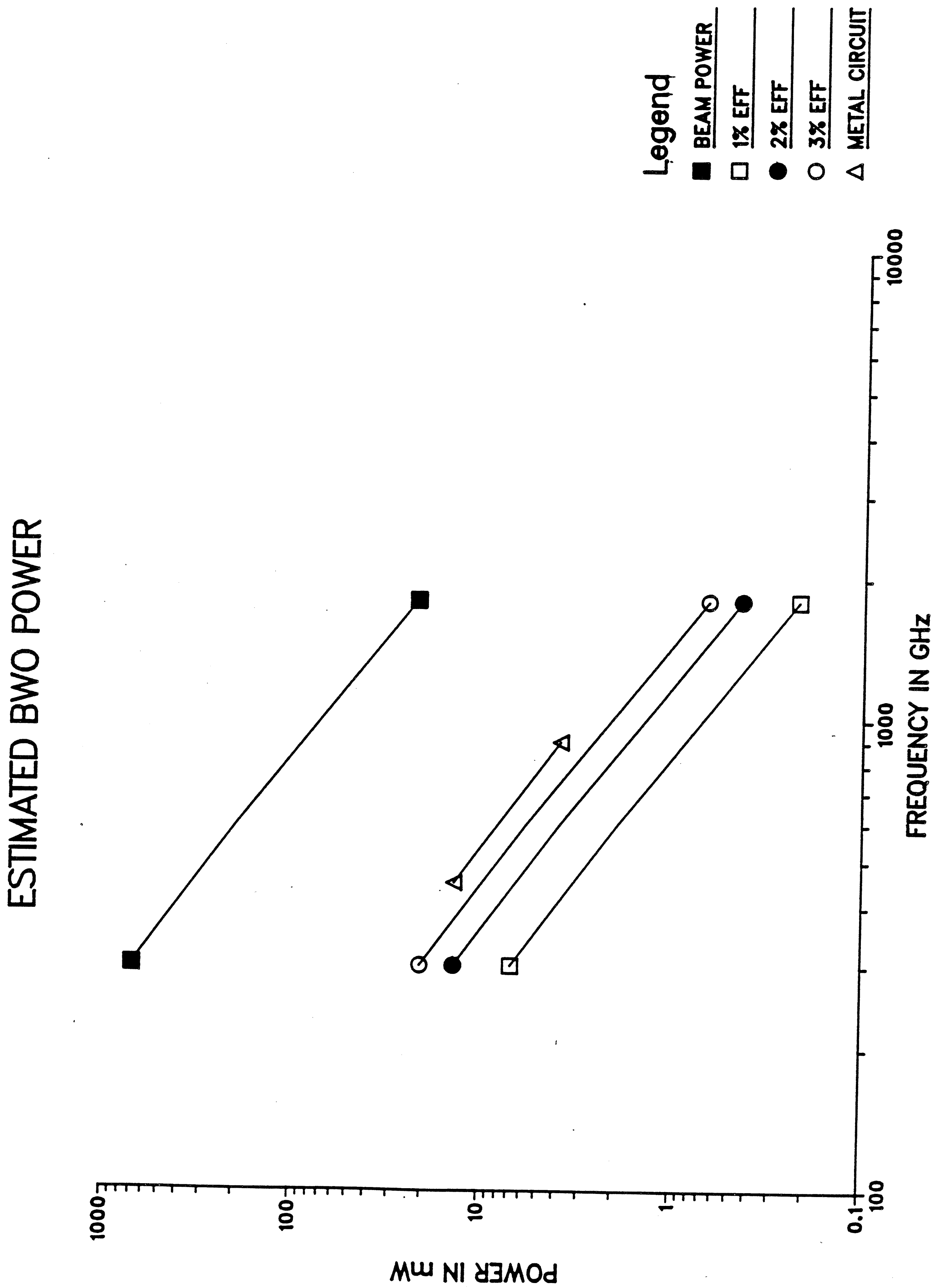


LAB6 GN2; POT=0,900,3000; (CATH R=.25 MM)


ESTIMATED BWO POWER
Legend
BEAM POWER
1% EFF
2% EFF
3% EFF
METAL CIRCUIT
POWER IN mW
1000
100
10
1
0.1
FREQUENCY IN GHz
100
1000
10000

SUBMILLIMETER BWO PROGRAM

BWO ADVANTAGES

- A PRIMARY SOURCE
- VOLTAGE TUNABLE
- STABLE PHASE LOCK CAPABILITY
- RELATIVE HIGH POWER AND EFFICIENCY
- SMALL PACKAGE
- BROAD BANDWIDTH
- MODEST INPUT POWER
- LONG LIFE CATHODE

SUBMILLIMETER BWO PROGRAM

FUTURE PLANS

- o WEDGE LaB_6 CATHODE
  - RIBBON BEAM
- o PARALLEL CIRCUITS
  - HIGHER OUTPUT POWER
  - IMPROVED EFFICIENCY
- o ALL METAL SLOW WAVE STRUCTURE
  - BULK CONDUCTIVITY
  - NO DIELECTRIC LOADING
  - 1 THz
- o MULTIPLE OUTPUT PORTS
  - IMPROVED OUTPUT COUPLERS
- o HIGH DUTY CYCLE OPERATION
  - IMPROVED POWER MEASUREMENTS