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ANALYSIS OF A HIGH HARMONIC RECTANGULAR GYROTRON USING RIBBON BEAMS

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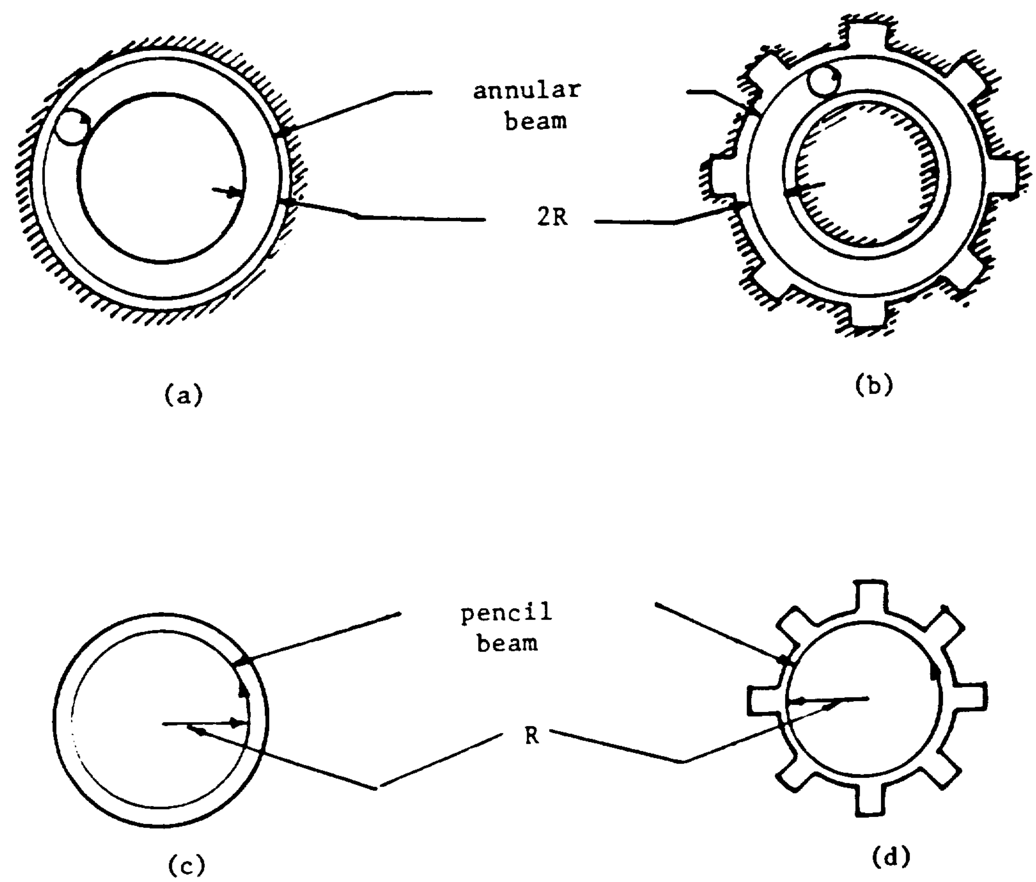

Cylindrical cavity structures and electron orbits in a) conventional, b) grooved coaxial, c) whispering gallery mode gyrotron and d) gyromagnetron.
In b) the electrons see only a single ridge in their complete orbit. In a) and c) the electrons do not see any ridges at all during their complete orbit but generate highly efficient interactions with the electromagnetic fields.

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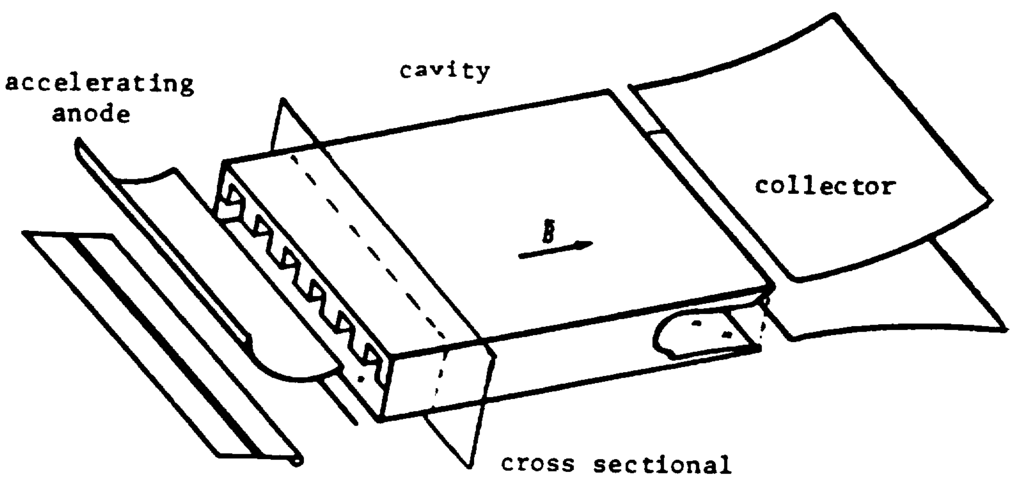
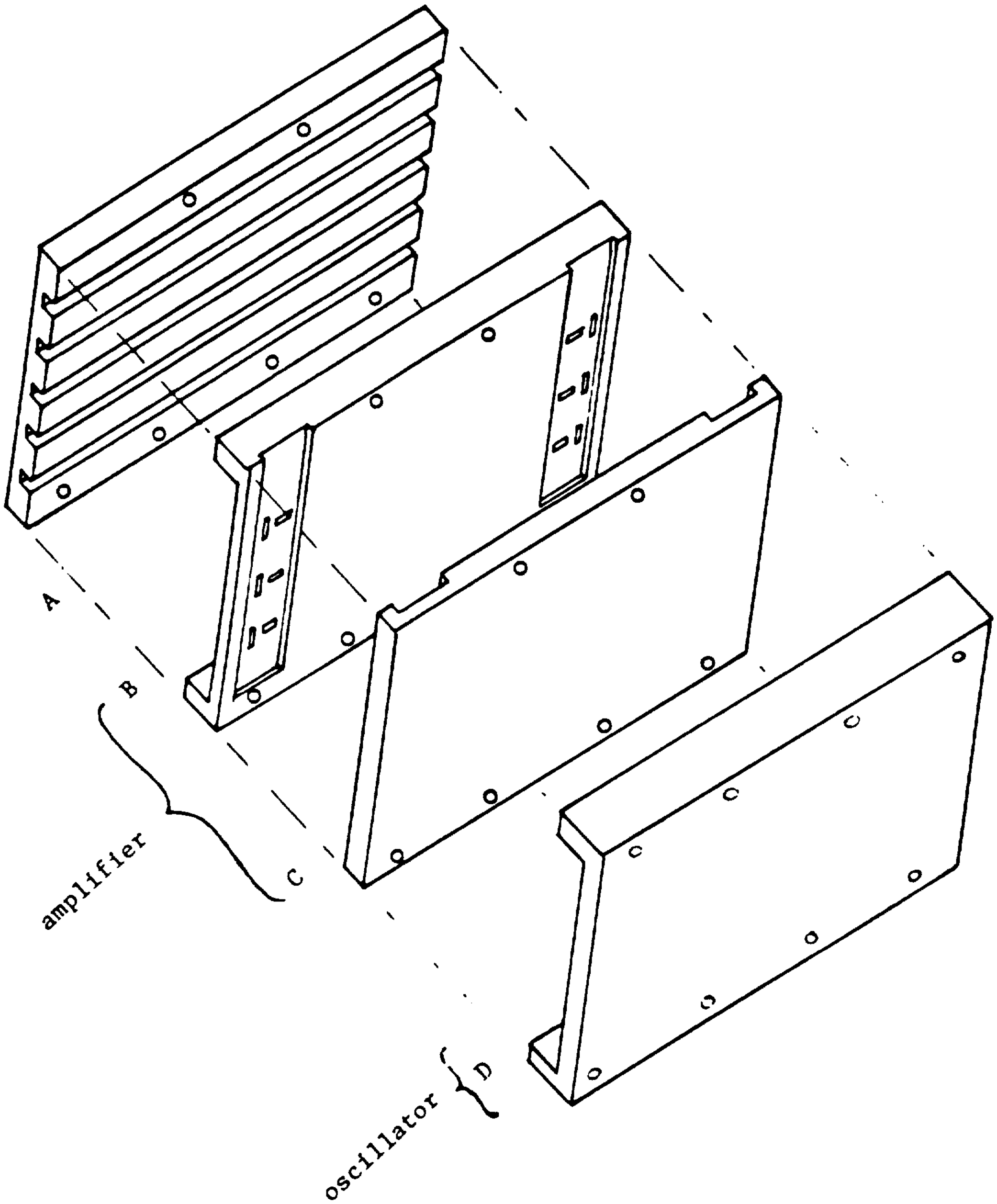
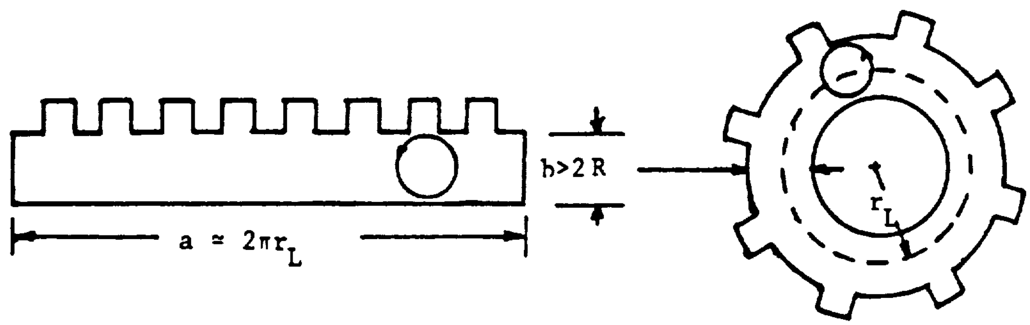


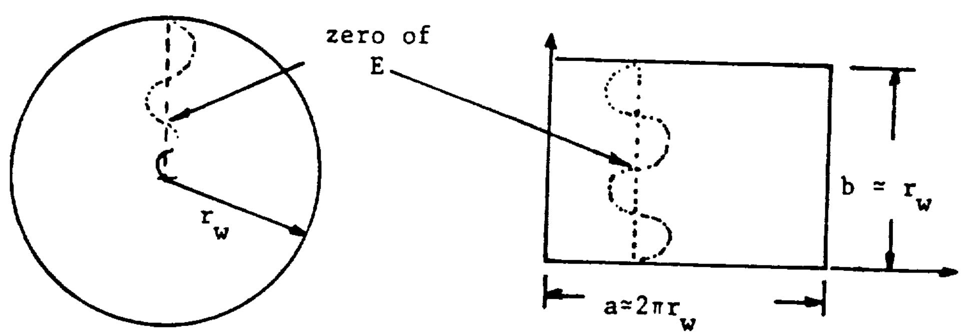
General schematic of an axially grooved gyrotron using a ribbon beam.



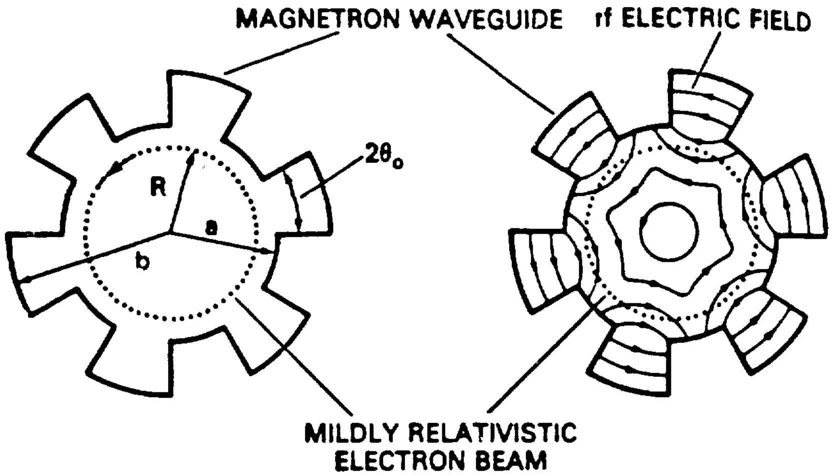
Constructional details. Upper grooved wall A is attached to the B and C for an amplifier or to D for an oscillator. B has coupling holes for input-output.



a - Folding a rectangular waveguide is equivalent to a coaxial waveguide.

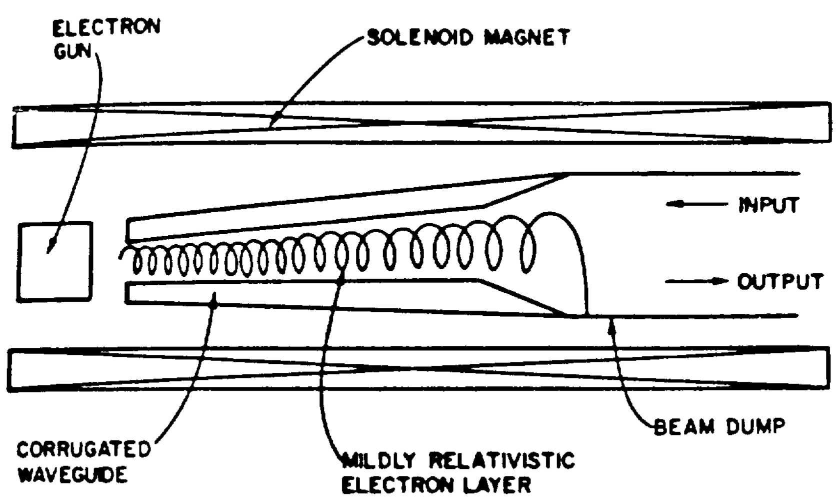


b - For fields to be compatible, only a rectangular waveguide with large dimensions but with small b/a ratio is equivalent to a circular waveguide having a few radial zeros.

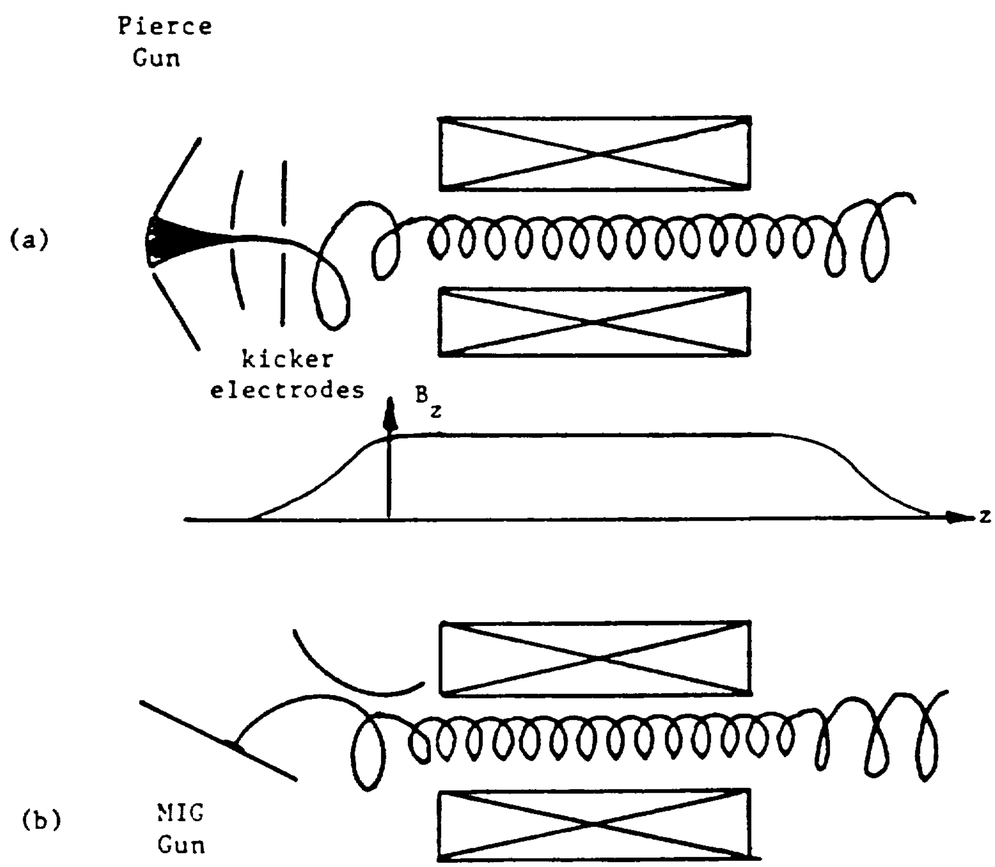


(a) Left. The cross-sectional view of a gyromagnetron with six vanes. (b) Right. Sketch of the rf electric fields of the 2π mode.

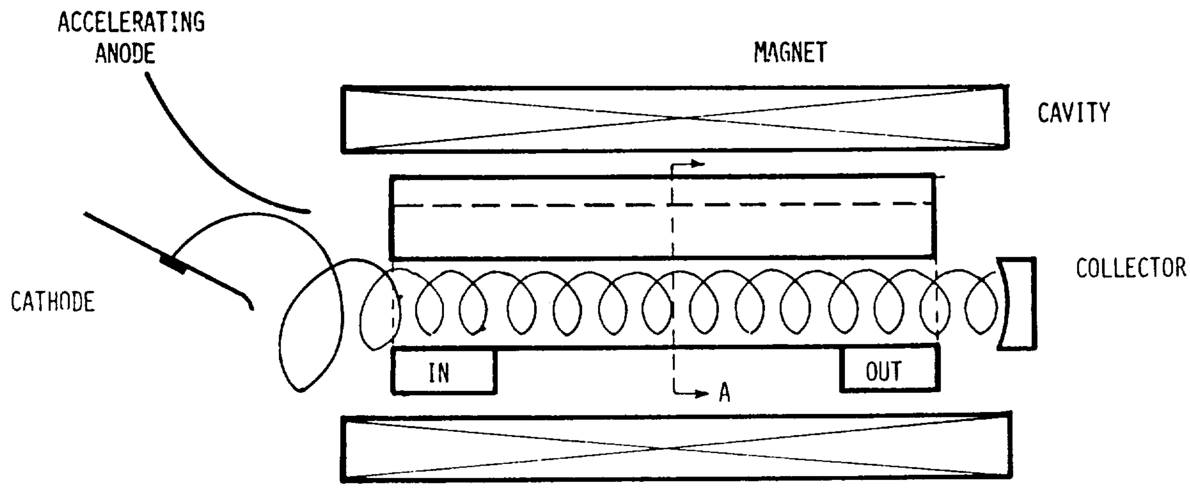
Low Magnetic Field Gyrotron



A schematic drawing of a low magnetic field, broad band, gyromagnetron amplifier



a) Ribbon beam using a conventional Pierce gun and kicker fields. b) Ribbon beam generated by a planar version of the MIG gun.

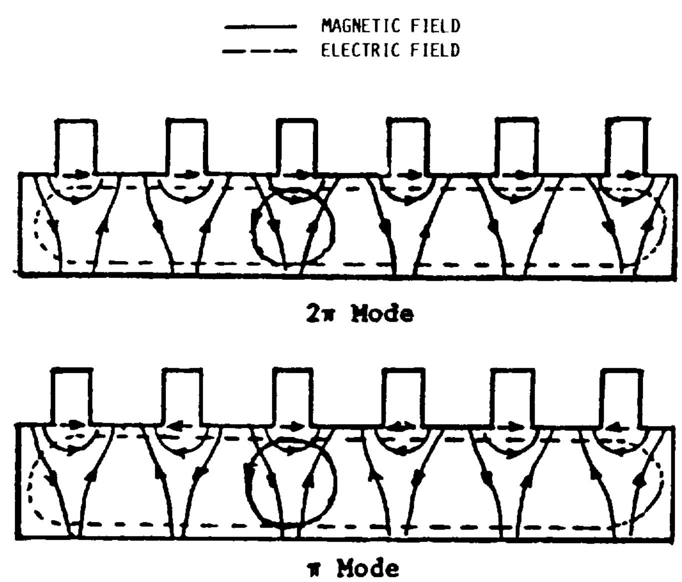


LONGITUDINAL CROSS SECTION OF GYROTRON AMPLIFIER

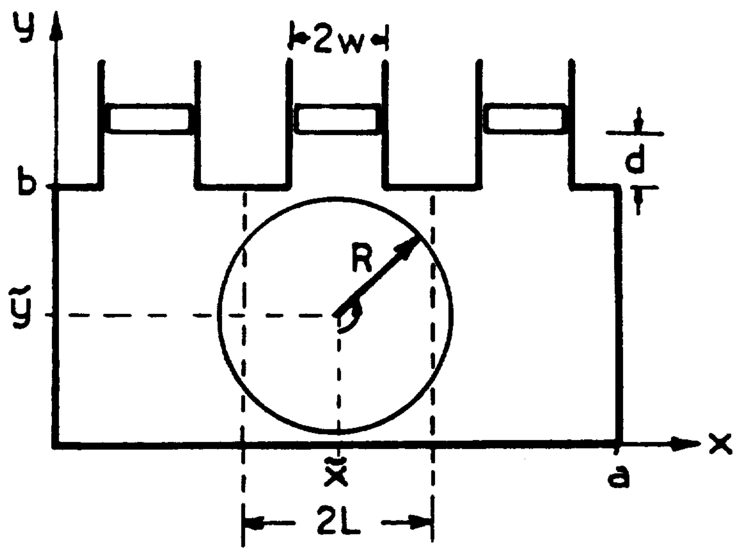
RESULTS

OPERATING FREQUENCY = 90 GH_z
HARMONIC NUMBER S
$V_\perp = 0.4\ C$
$V_z = 0.267C$
$\nu = 2.2 \times 10^{-3}$ (9.5 A)
P_b (BEAM CURRENT) = 670 KW

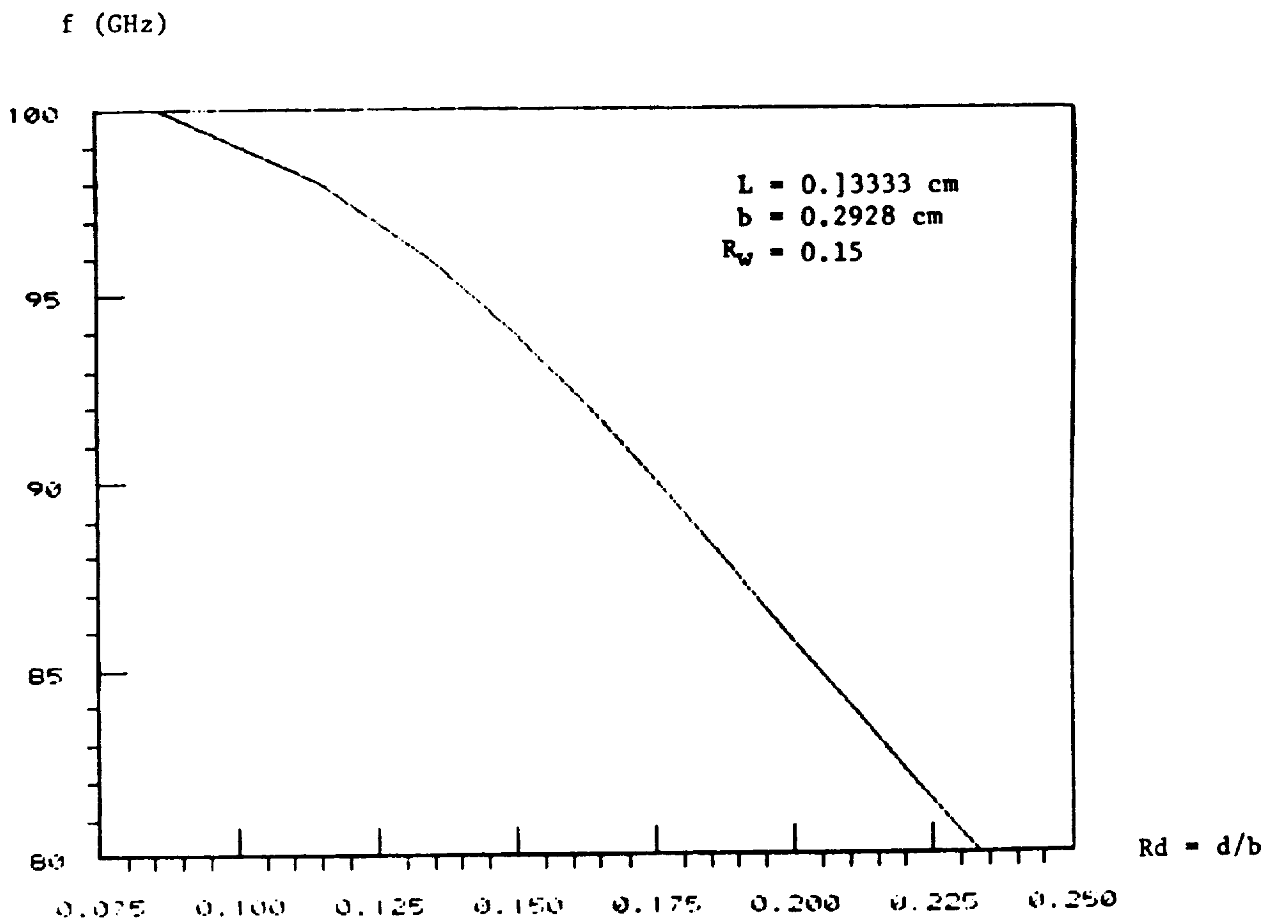
N = 3
$a = 0.64$ cm
$b = 0.2928$ cm
$R_w = 0.15$
$R_d = 0.19$



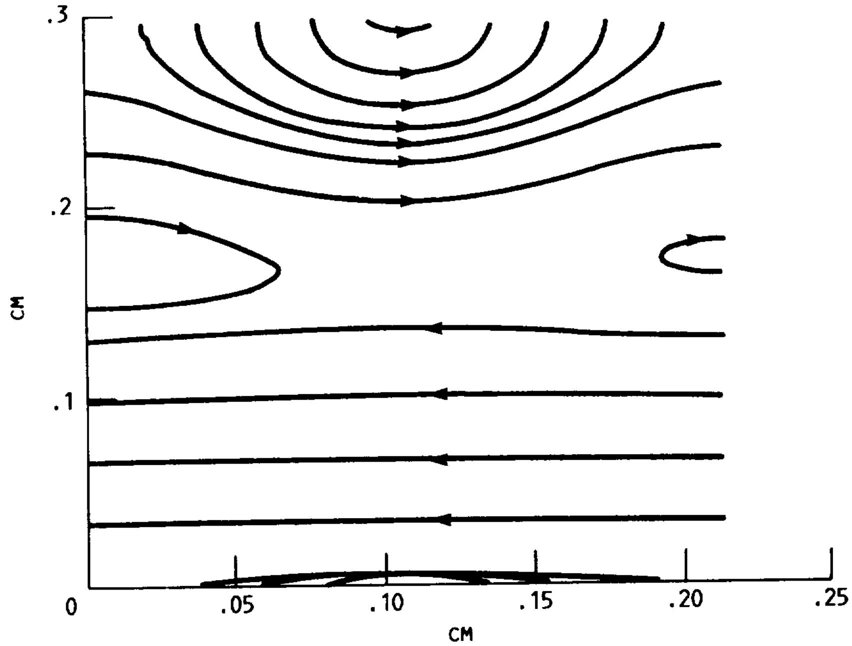
RADIATION PATTERN IN RECTANGULAR GYROTRON



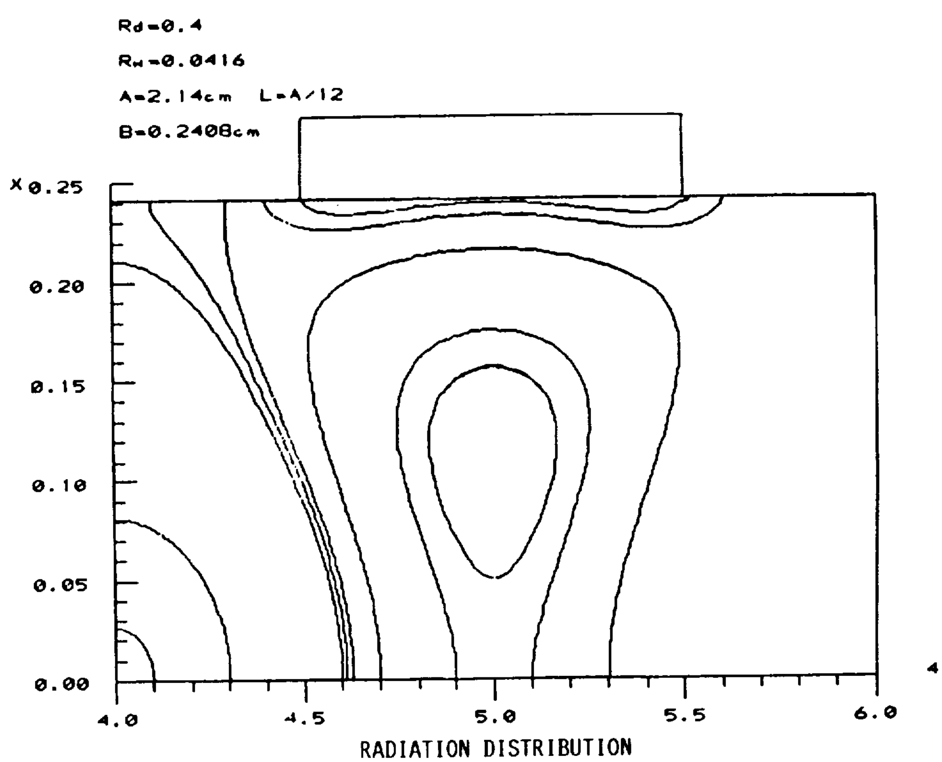
y
2w
d
b
R
ỹ
x
x̃
a
2L



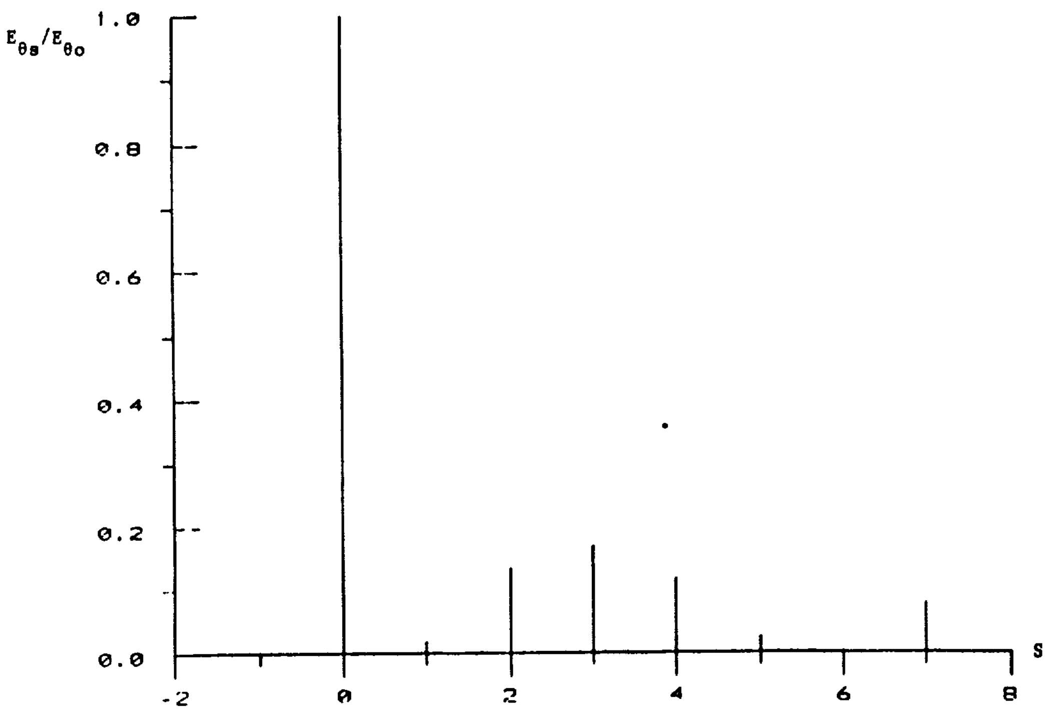
f (GHz)
100
95
90
85
80
L = 0.13333 cm
b = 0.2928 cm
R_w = 0.15
0.075
0.100
0.125
0.150
0.175
0.200
0.225
0.250
Rd = d/b



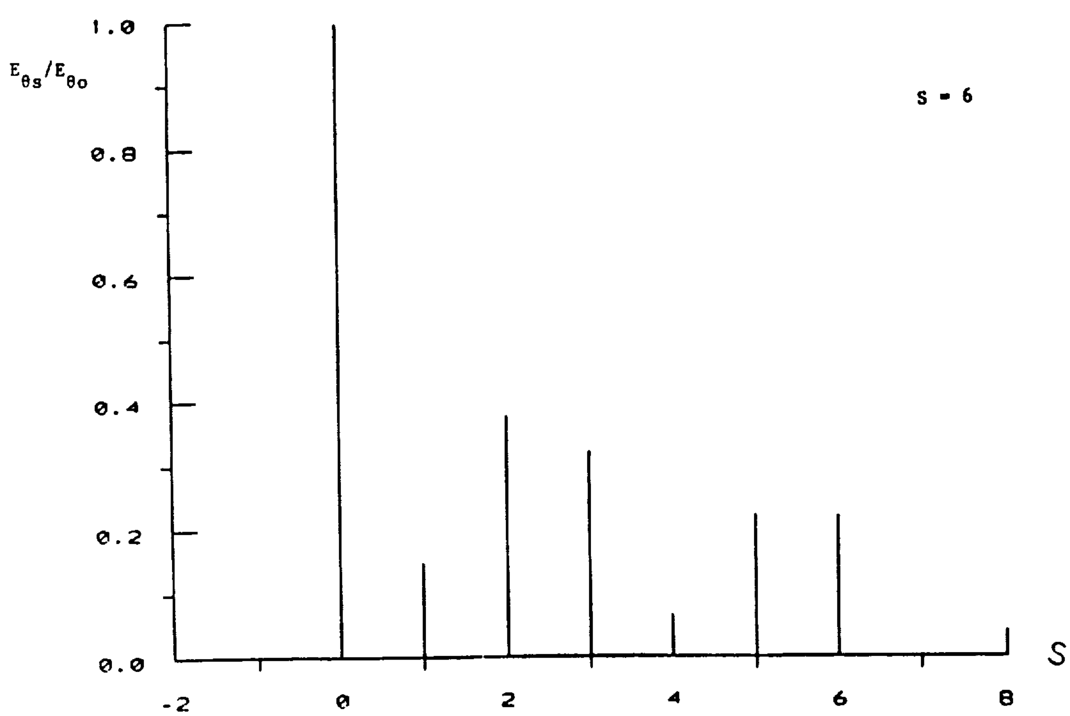
.3
.2
.1
0
.05
.10
.15
.20
.25
CM
CM



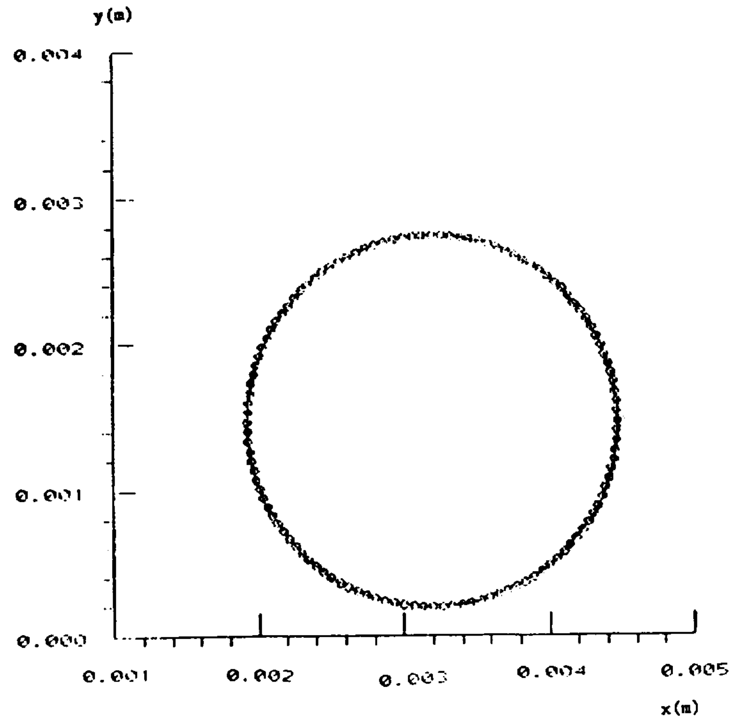
Rd=0.4
Rw=0.0416
A=2.14cm L=A/12
B=0.2408cm
X
0.25
0.20
0.15
0.10
0.05
0.00
4.0
4.5
5.0
5.5
6.0
RADIATION DISTRIBUTION



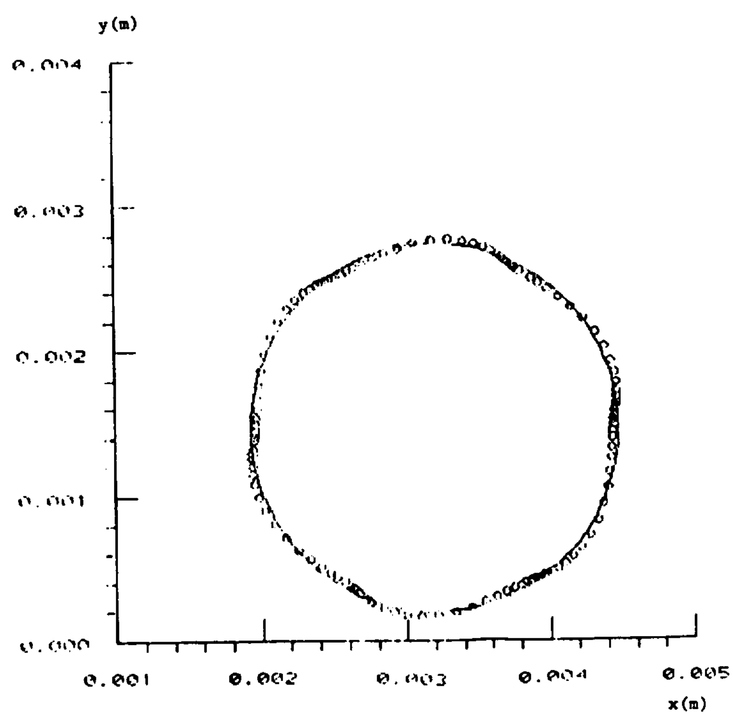
Fourier component spectrum of the tangential electric field



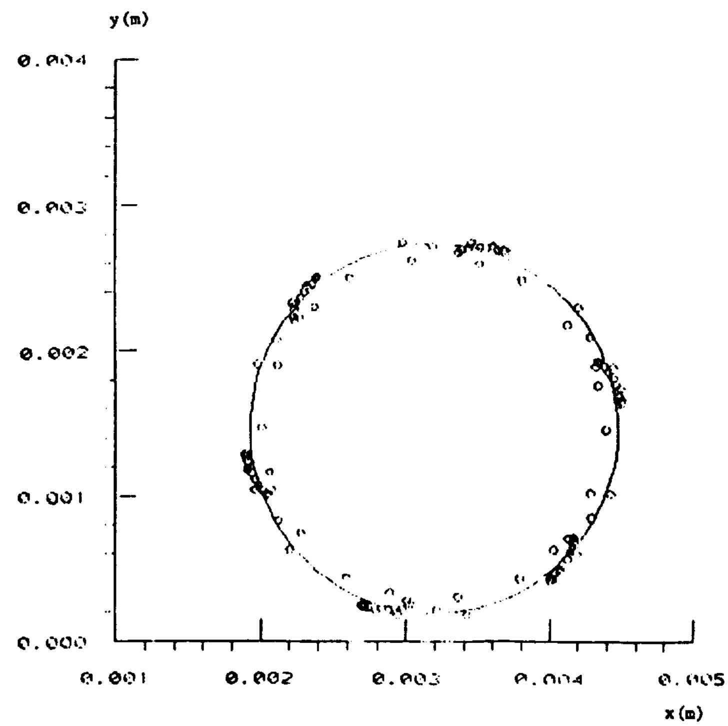
Fourier component spectrum of the tangential electric field



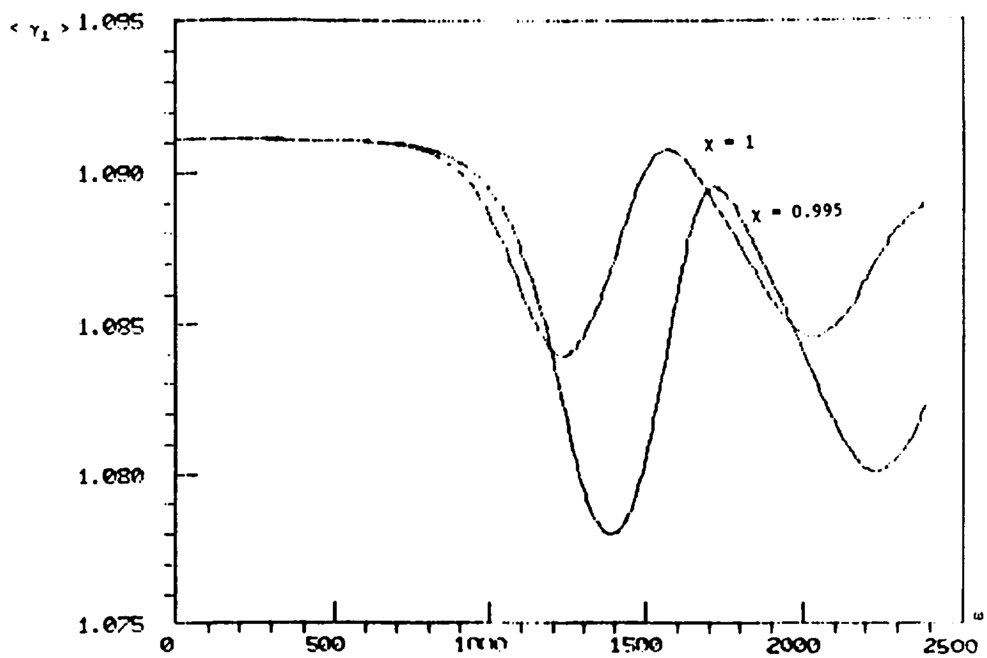
The initial phase distribution of an annular pencil beam which includes 120 electrons.



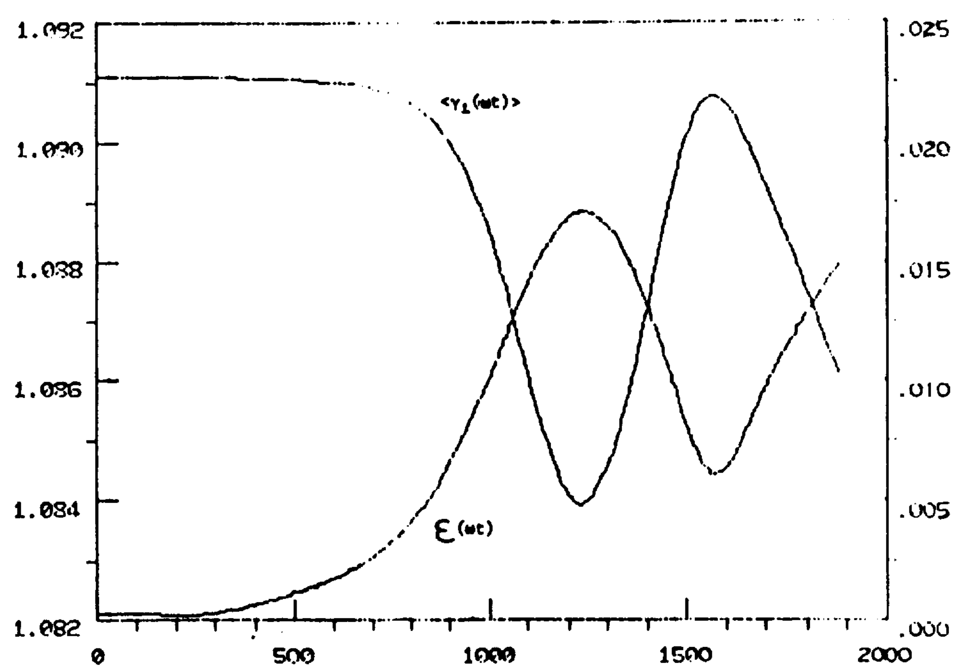
The phase distribution of the ensembled 120 electrons in linear region.



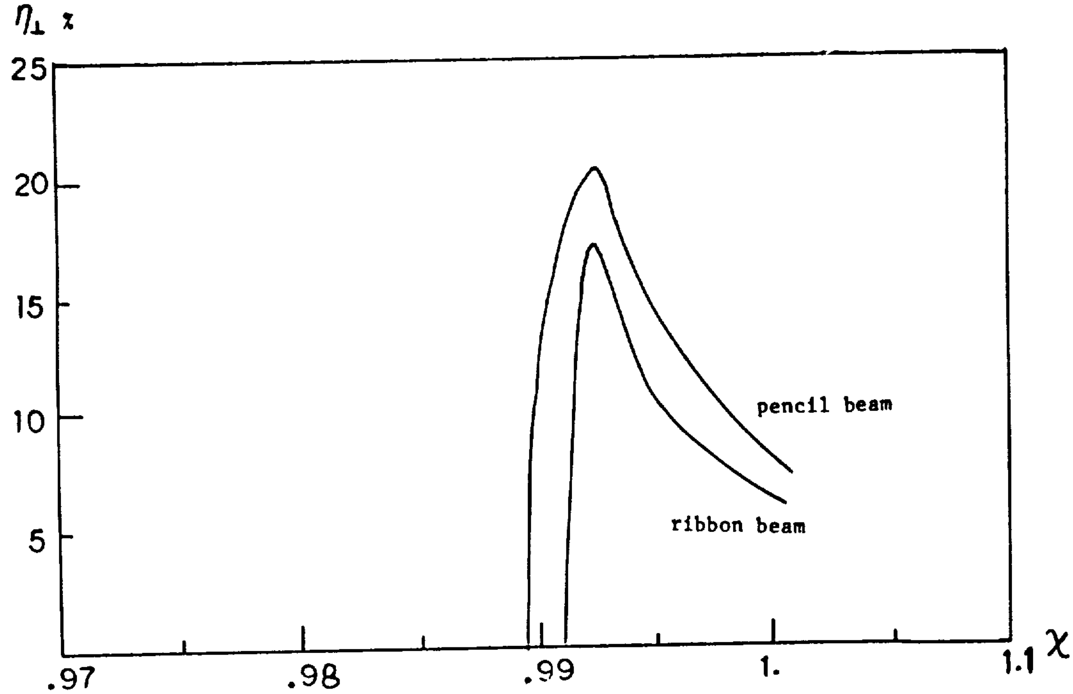
The phase distribution of the ensembled 120 electrons when the electrons regain energy from the field after saturation.



Energy curves with $\chi = 0.995$ and $\chi = 1$ respectively for a pencil beam at s=6.



The field amplitude and average beam γ as a function of ωt for a typical nonlinear simulation.



The energy conversion efficiencies of sixth cyclotron harmonic operation vs. χ for a pencil beam with its guiding center (a/2,b/2) and a ribbon beam at $\underset{\sim}{y}$=b/2.

ADVANTAGES

1 - ELIMINATION OF SUPERCONDUCTING MAGNETS

2 - REDUCED MODE COMPETITION PROBLEMS

3 - HIGHER POWER HANDLING CAPABILITY

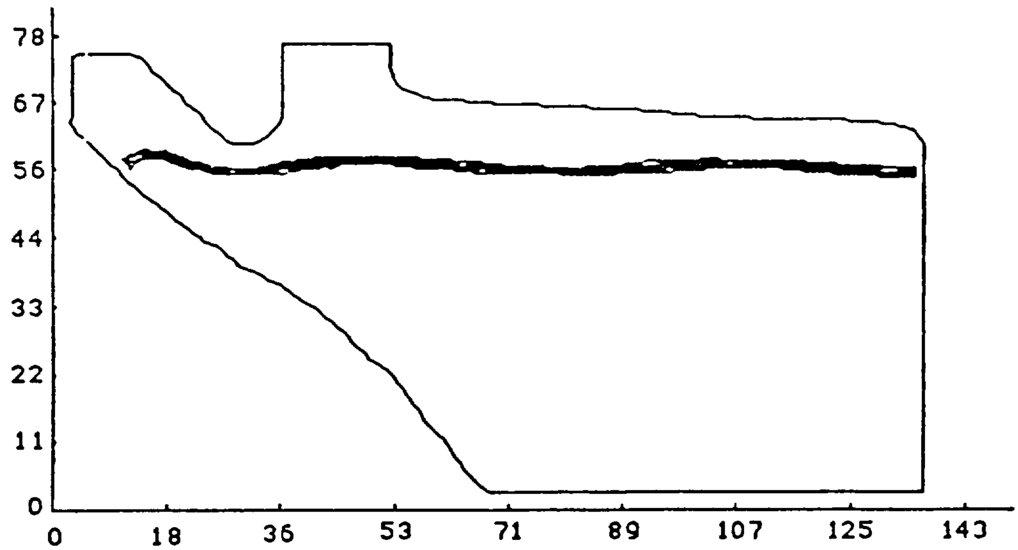
4 - REDUCTION OF SPACE CHARGE FORCES

5 - EASE OF MODIFICATION AS AN AMPLIFIER AND OSCILLATOR

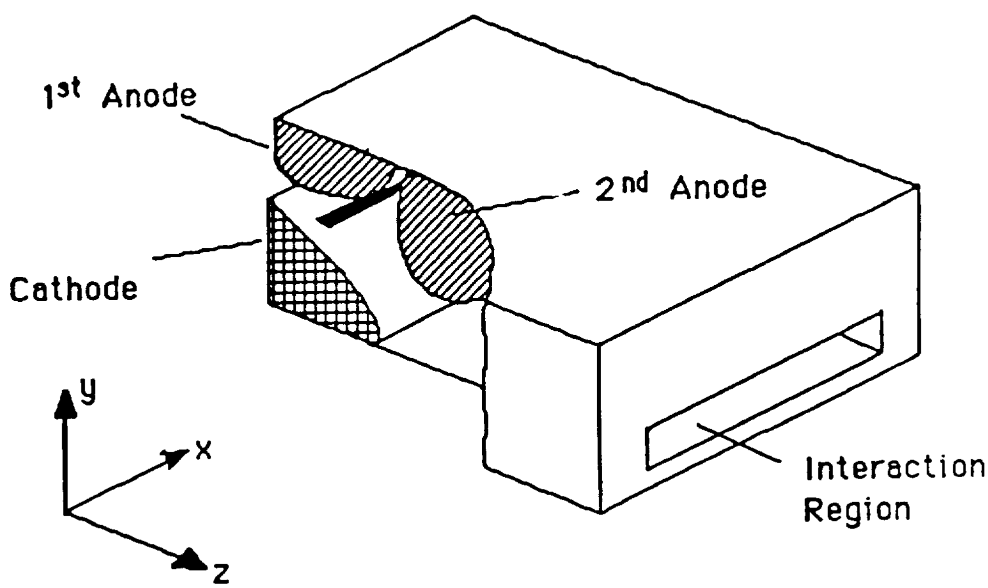
6 - EASE OF MACHINING

7 - SEPARATE INPUT-OUTPUT PORTS FOR AN AMPLIFIER

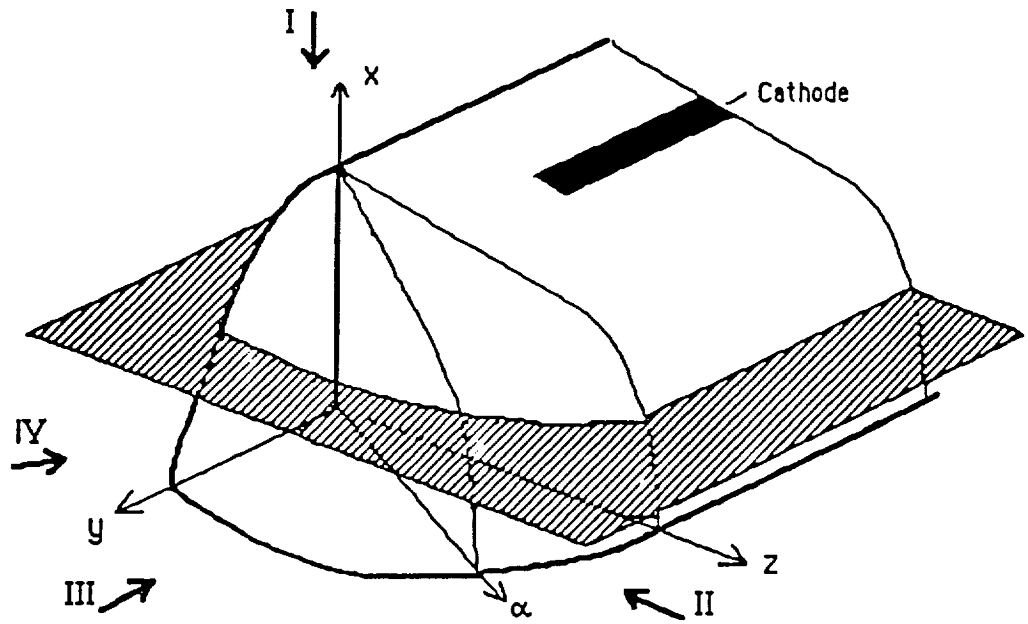
8 - BETTER EFFICIENCY AT HIGHER HARMONICS



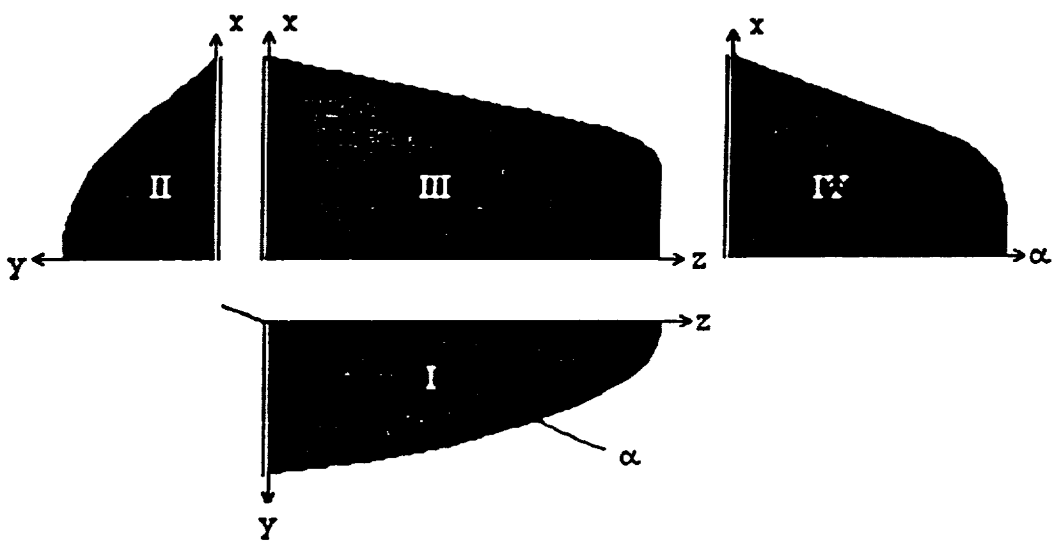
Simulation of the MIG gun whose boundaries are determined by computer bit mapping the boundaries of Fig.6. First anode potential V_1 = 40 kV and the final electrode potential V_2 = 80 KV. B_o = 1 KG in the axial direction.



Boundary identification is made by bit mapping the projections of the different electrodes onto different mutually perpendicular coordinate planes.

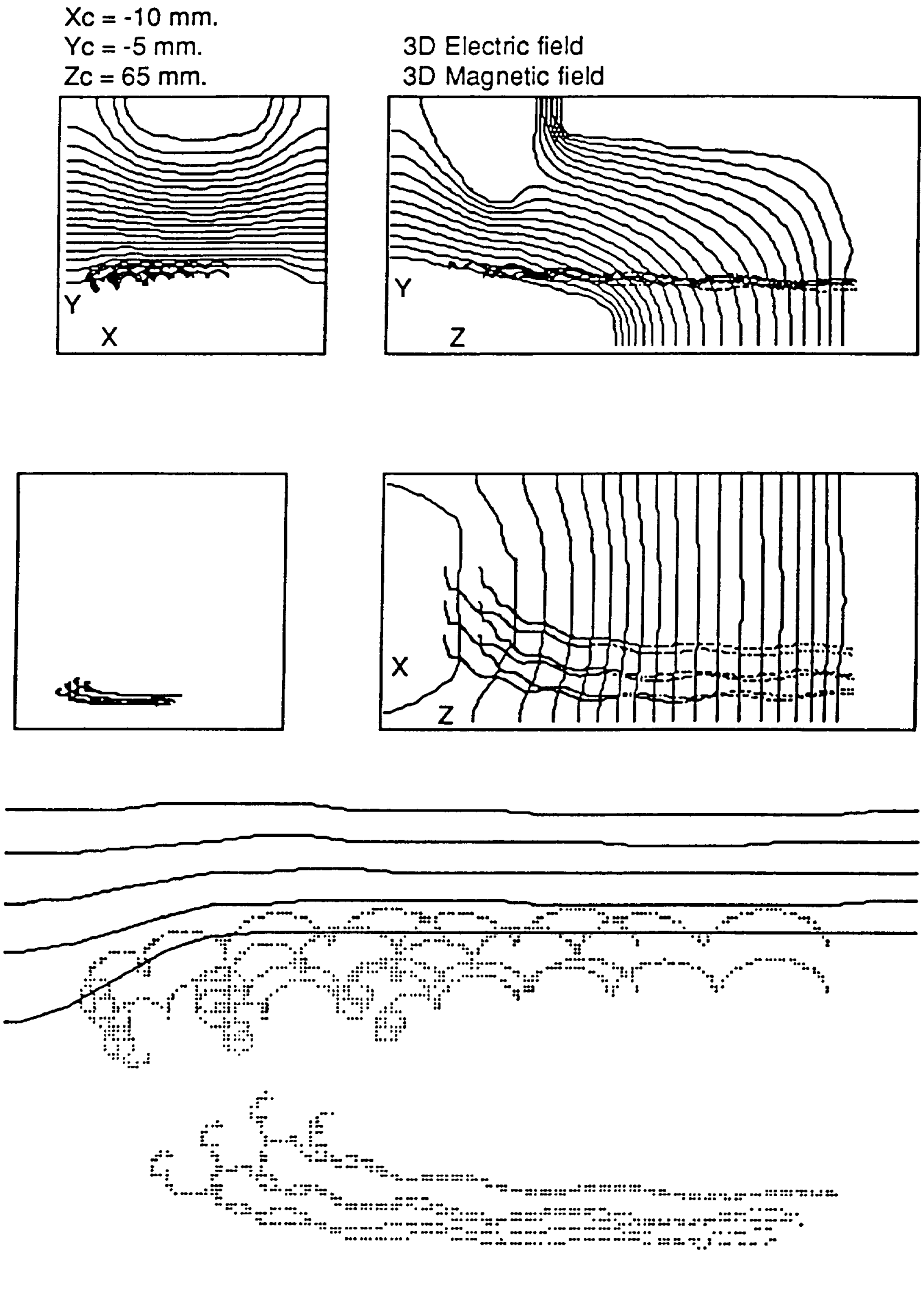


(a)

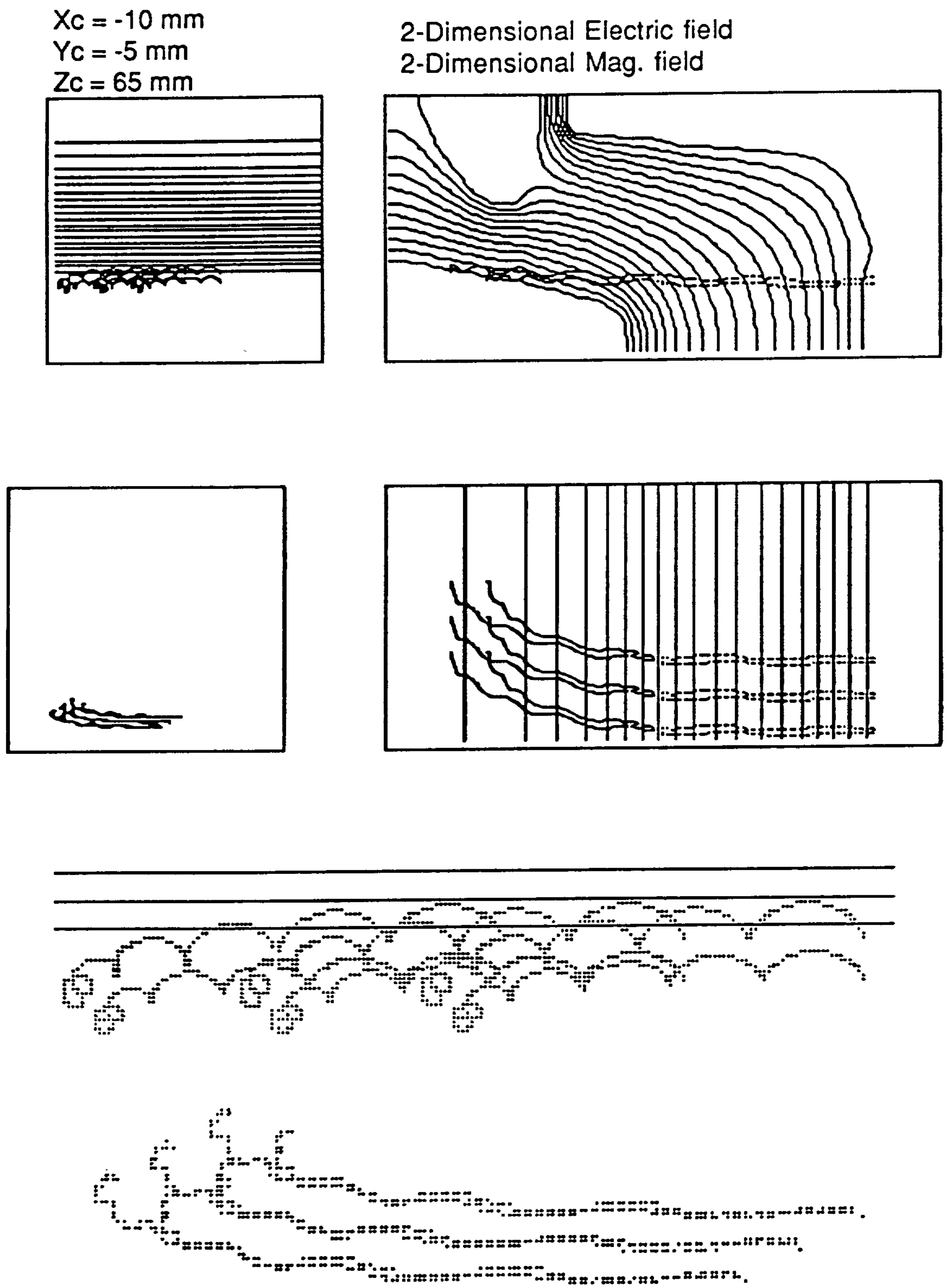


(b)

The projections of the cathode electrode at different planes. Projections I is in (y,z) plane, II is in(x,y) plane, and III is in(x,z) plane and IV is in an intermediate plane perpendicular to the (y,z) plane. Plane I is not necessary for many electrode profiles.



Xc = -10 mm.
Yc = -5 mm.
Zc = 65 mm.
3D Electric field
3D Magnetic field
Y
X
Y
Z
X
Z


Xc = -10 mm
Yc = -5 mm
Zc = 65 mm
2-Dimensional Electric field
2-Dimensional Mag. field