INT 142/88

M O D I D I C A T I O N S T O T H E E L E C T R O N G U N O F T H E 1 1 5 G H Z G Y R O T R O N

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May 88

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CONTENTS

FIGURES

1. Introduction

The first design of the electron gun was done in october 86. To reduce the development cost to a minimum, the gun geometry is identical to that of the 120 GHz gyrotron (INT 116/84). Only the beam duct was modified due to the dimensions of the new coils. During the the conditioning of the 120 GHz gun, arcing between the control electrode and the anode was sometimes observed. Therefore, a new gun with rounded electrodes was studied in march 88 (INT 139 /88). But only machinable modifications to an existing gun were investigated. In the numerous numerical simulations the beam anisotropy always turned out of the order of 1 to 1.2 with a spread of 10 to 15% and it was thought at that time that a better beam quality could be achieved by changing some of the gun parameters.

However the poor user-friendliness of the Herrmannsfeldt program, and the large amount of Cray time required have prevented so far an extensive study of the influence of all geometrical parameters.
It the aim of this study to propose some modifications in order to decrease the velocity spread. The influence of the B field at the cathode is also presented.

2. Gun geometry

The geometrical parameters are described in Fig.1.
In the original design (fig.2) the beam clearance to the control electrode is 1 mm. It has been increased to 3 mm in the new design (fig.3) by reducing the cathode length (z_t) and rounding the control electrode (r_{c3}).

Geometrical Parameters	Design of October 86	Design May 88
CATHODE		
R_k	0.89305 cm	0.9 cm
l_k	0.332	0.3
α_1	30°	30°
α_2	25°	30°
z_{c1}	1.875	1.499
r_{c1}	0.3995	0.5
z_t	2.2745	1.999
R_t	1.4354	1.4427
R_a	0.81005	0.7
z_k	0.93939	0.94

Geometrical Parameters	Design of October 86	New design
CONTROL ELECTRODE		
d_k	0.4105 cm	0.4
r_{c2}	0.37083	0.5
L_e	0.755	0.5584
r_{c3}	0.10083	0.5
d_e	2.37583	2.401
R_{e1}	1.08917	1.201
R_{e2}	2.0	2.0
ANODE AND BEAM DUCT		
d_{an}	2.025 cm	2.0
r_{c4}	0.42917	0.5
R_{b1}	0.85	Unchanged
d_{b1}	5.59917	Unchanged
β_1	2.905°	Unchanged
R_{b2}	0.6	Unchanged
d_{b2}	10.	Unchanged
β_2	1.43°	Unchanged
R_{b3}	0.5	Unchanged
d_{b3}	10.	Unchanged
β_3	0.5729°	Unchanged
R_{b4}	0.5	Unchanged
d_{b4}	16.8	Unchanged
β_4	0.°	Unchanged

Figs. 2 and 3 show the electron trajectories.

3. Comparison of e^- beam characteristics

The first numerical simulations were done with the same B field as in INT 139/88. The results are summarized below:

Beam parameter	Design of October 86	Design May 88
Cathode voltage [kV]	70.	70.
Electrode voltage	30.	26.
Anisotropy α at interaction region	1.120 ± 15.5 %	1.488 ± 13.9 %
Relativistic γ	1.134 ± 0.024 %	1.134 ± 0.033 %
Beam radius R_b [mm]	2.040 ± 6.7 %	2.040 ± 6.7 %
Magnetic field [Teslas]		
at cathode (B_k)	0.225	0.225
at interaction region (B_0)	4.45	4.45

It is seen that α reaches a higher value, but the spread is as large as before. The next table show how the velocity spreads depend on Ve:

Ve [kV]	$v_\perp/c$	$v_\parallel/c$	$= v_\perp/v_\parallel$
25.	0.3763 ± 1.82 %	0.2830 ± 2.38 %	1.332 ± 5.3 % ←
26.	0.3888 ± 3.49 %	0.2644 ± 8.6 %	1.488 ± 13.9 %
27.	0.4132 ± 3.94 %	0.2241 ± 13.4 %	1.885 ± 16.3 %
27.5	0.360 ± 20. %	0.284 ± 28. %	1.44 ± 43. %

At Ve = 25 kV the velocity spread is significantly less than with the former design. However for Ve > 26 kV, the spread is comparable. For Ve > 28 kV mirroring occurs and not all electrons reach the interaction region.

4. Influence of the B field at the cathode

In a quasi-optical gyrotron, the radius of the annular beam (R_b) in the interaction region is usually chosen in such a way as to minimiize the starting current. For a fixed cathode radius (R_k), this determines the compression ratio $\alpha_c = B_o/B_k = (R_k/R_b)^2$. At 115 GHz $B_o = 4.488$ T and $B_k = 0.2506$ (see appendix A).

For both design, the Herrmannsfeldt code was run for 3 values of B_k and 5 values of the B field gradient at the cathode. The beam anisotropy and its spread are shown in the table below:

B_k [Tesla]	Gradient [Tesla/mm]	α Design of October 86 Ve = 30 kV	α Design of May 88 Ve = 26 kV
0.2506	0.0005	0.897 ± 8.7 %	1.164 ± 5.5 %
	0.0010	1.025 ± 12.4 %	1.097 ± 8.0 %
	0.0015	1.120 ± 15.3 %	0.978 ± 9.0 %
	0.0020	1.232 ± 16.5 %	0.867 ± 9.2 %
	0.0025	time limit *	0.793 ± 6.9 %
0.2400	0.0005	0.851 ± 8.7 %	1.109 ± 5.7 %
	0.0010	0.965 ± 7.9 %	1.266 ± 4.8 % ←
	0.0015	1.090 ± 12.0 %	1.219 ± 6.6 %
	0.0020	1.247 ± 15.0 %	1.094 ± 9.2 %
	0.0025	time limit	0.988 ± 9.9 %
0.2300	0.0005	0.924 ± 17.4 %	1.026 ± 8.2 %
	0.0010	0.979 ± 13.6 %	1.213 ± 8.7 %
	0.0015	1.087 ± 13.7 %	1.354 ± 5.7 % ←
	0.0020	1.262 ± 14.2 %	time limit

*) time limit after 600 s, usually symptomatic of mirroring.

5. Conclusions

By modifying slightly the electron gun geometry, it is possible to reduce the spread on α by a factor of 3. It is not claimed that the design studied here is the best one can achieve. It would certainly be interesting to study other geometries, but large amounts of computer time are necessary. However this study motivates further efforts towards the synthesis of guns having low velocity spread.

Appendix A

Magnetic field B (Interaction zone, z=0.)

For V_a = 70 kV and α = 1.5:

$$\gamma_o = 1 + 70./511. = 1.137$$

$$\beta_{//o} = \sqrt{\frac{1 - \gamma_o^{-2}}{1 + \alpha^2}} = 0.264 \quad ; \quad \beta_{\perp o} = \alpha \beta_{//o} = 0.396$$

From the non-linear gyrotron theory (B.G. Danly and R.J.Temkin, MIT) we can compute B_o for the optimum value of Δ , the normalized detuning parameter. Δ has an optimum value of 0.5.

$$B_o = \gamma\omega \frac{m_e}{e}(1 - \frac{\beta_{\perp o}^2}{2}\Delta) = 4.671 \cdot (1 - \frac{\beta_{\perp o}^2}{4}) = 4.488 \text{ Teslas}$$

$$\frac{e}{m_e} = 1.7588 \cdot 10^{11} \; ; \; \omega = 2\pi \cdot 115 \cdot 10^9.$$

Magnetic field B_k (cathode)

B_k is choosen such that the annular electron beam has a radius which maximize the quasi-optical gyrotron efficiency in the linear regime, while keeping the beam voltage depression at an acceptable value.

R_b = electron beam radius at the interaction zone

R_k = radius of the emitting part of the cathode
8.93 mm for the actual ABB electron gun

α_c = compression ratio = B_o/B_k

$R_k = \sqrt{\alpha_c} \cdot R_b$ (adiabatic trajectories)

Ratio of the annular beam efficiency to the pencil beam efficiency:

$$\frac{\eta_{ab}}{\eta_{pb}} = \frac{1}{2}[\, 1 \pm J\ (2kR_b)\ ] \quad \begin{cases} + \text{ if } e^- \text{ beam centred on maximum} \\ - \text{ if } e^- \text{ beam on node} \end{cases}$$

where k is the wavenumber of the RF radiation field inside the quasi-optical resonator.

	n=1	n=2	n=3	n=4
$2kR_b = \nu'_{on}$	3.83170	7.01558	10.17346	13.32369
$J_o(\nu'_{on})$	-0.40275	0.30011	-0.25970	0.21835
beam on	node	max	node	max
η_{ab}/η_{pb}	0.701	0.650	0.625	0.609
$R_b = \frac{\lambda}{4\pi}\nu'_{on}$ [mm]	0.795	1.455	2.110	2.764
$\alpha_c = (R_k/R_b)^2$	126	37.7	17.91	10.44
B_k [T]		0.1190	0.2506	0.4299

(ν'_{on} = extremas of J_o)

Since the magnetic field compression for n=1 or 2 is too high, n=3 has been selected. It is seen that η_{ab}/η_{pb} decreases slowly with R_b so that larger values of R_b could be proposed to alleviate the problems associated with beam depression and large current densities at the cathode.

Appendix B

Current settings in gyrotron coils

Geometry of coils:

	z position [m]	innner and outer radii [m]
1) BC1	Z1(1)=-0.514, Z2(1)=-0.464,	A1(1)=0.070, A2(1)=0.14
2) BC2	Z1(2)=-0.459, Z2(2)=-0.409,	A1(2)=0.070, A2(2)=0.14
3) Supra1	Z1(3)=-0.129, Z2(3)=-0.064,	A1(3)=0.085, A2(3)=0.185
4) Supra2	Z1(4)= 0.064, Z2(4)= 0.129,	A1(4)=0.085, A2(4)=0.185

Cathode position: z_k = -0.4586 m
B field at interaction region B(z=0) = B_o = 4.488 T

B_k [Tesla]	Gradient [Tesla/mm]	I1 [At]	I2 [At]	I3 [At]	I4 [At]
0.2506	0.0005	15285	-13099	909040	911230
	0.0010	8789	-6879	909350	910870
	0.0015	2294	-659	909660	910510
	0.0020	-4201	5561	909960	910150
	0.0025	-10697	11781	910270	909790
0.2400	0.0005	14389	-14155	909020	911300
	0.0010	7984	-7935	909330	910940
	0.0015	1399	-1715	909640	910580
	0.0020	-5096	4504	909950	910220
	0.0025	-11592	10725	910250	909860
0.2300	0.0005	13545	-15151	909000	911370
	0.0010	7050	-8932	909310	911010
	0.0015	554	-2711	909620	910650
	0.0020	-5941	3508	909930	910290
	0.0025	-13436	9728	910240	909930
Current settings of INT 139/88 (B_o = 4.45 T):					
0.2272	0.0016	-1185	-1185	902400	902400

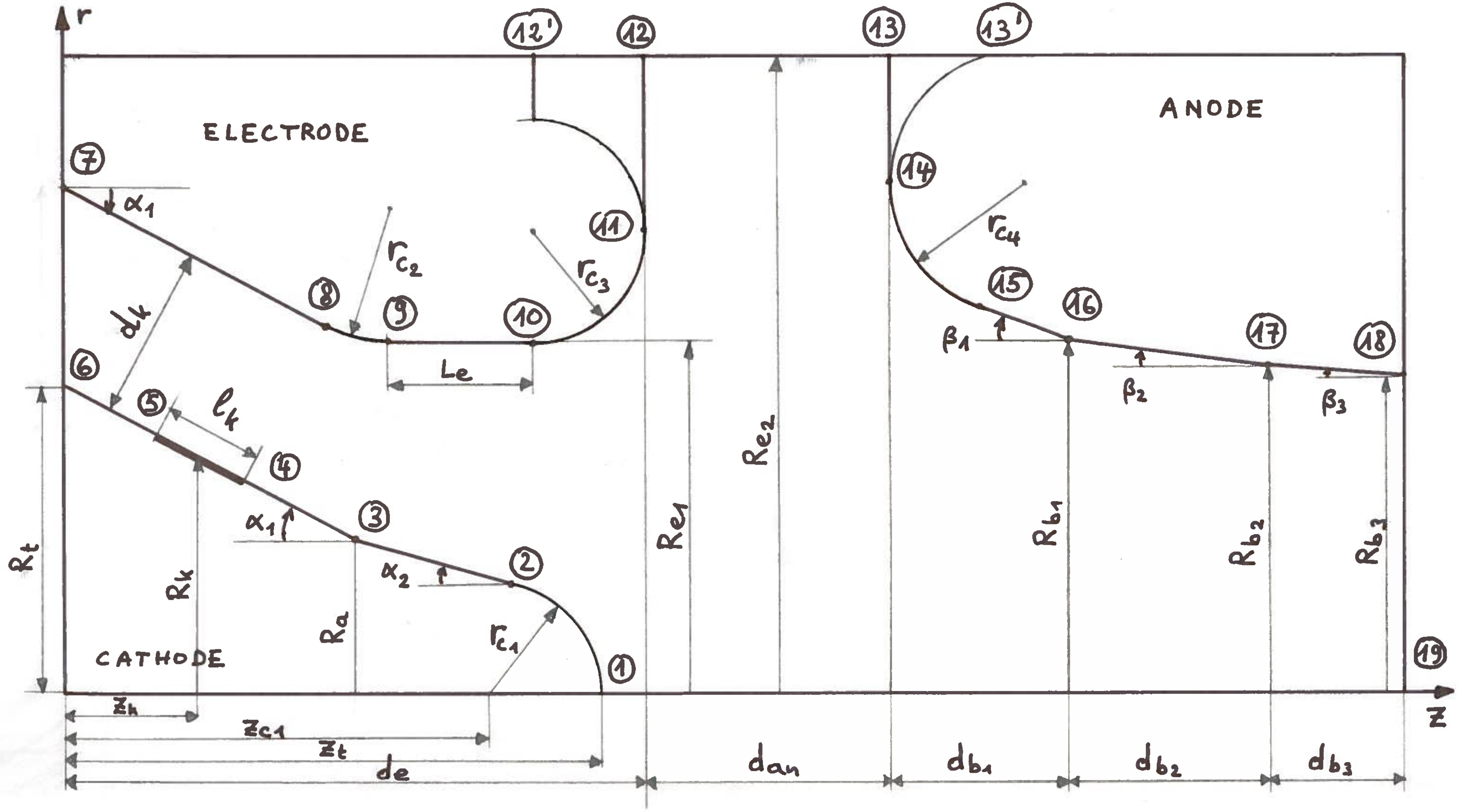


Fig. 1 Definition of the geometrical parameters.

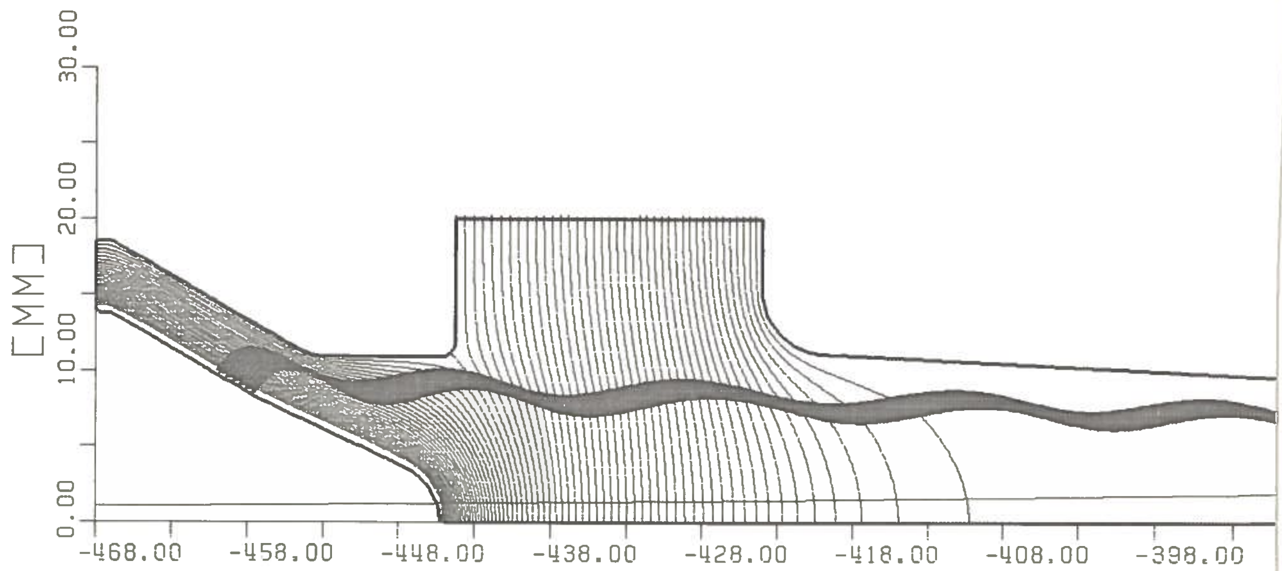


Fig. 2 Electron trajectories. Design of October 86.
V_A = 70 kV, V_E = 30. kV.

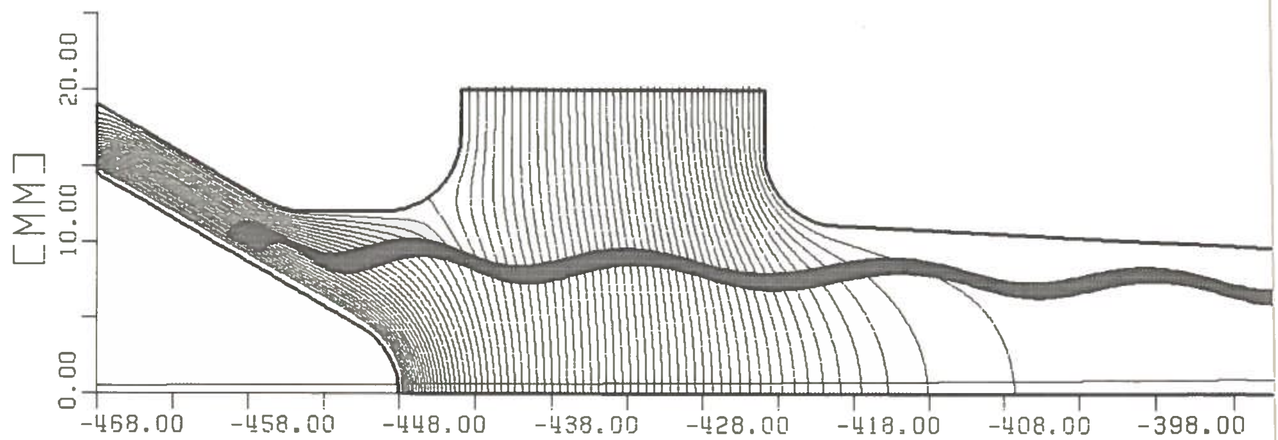


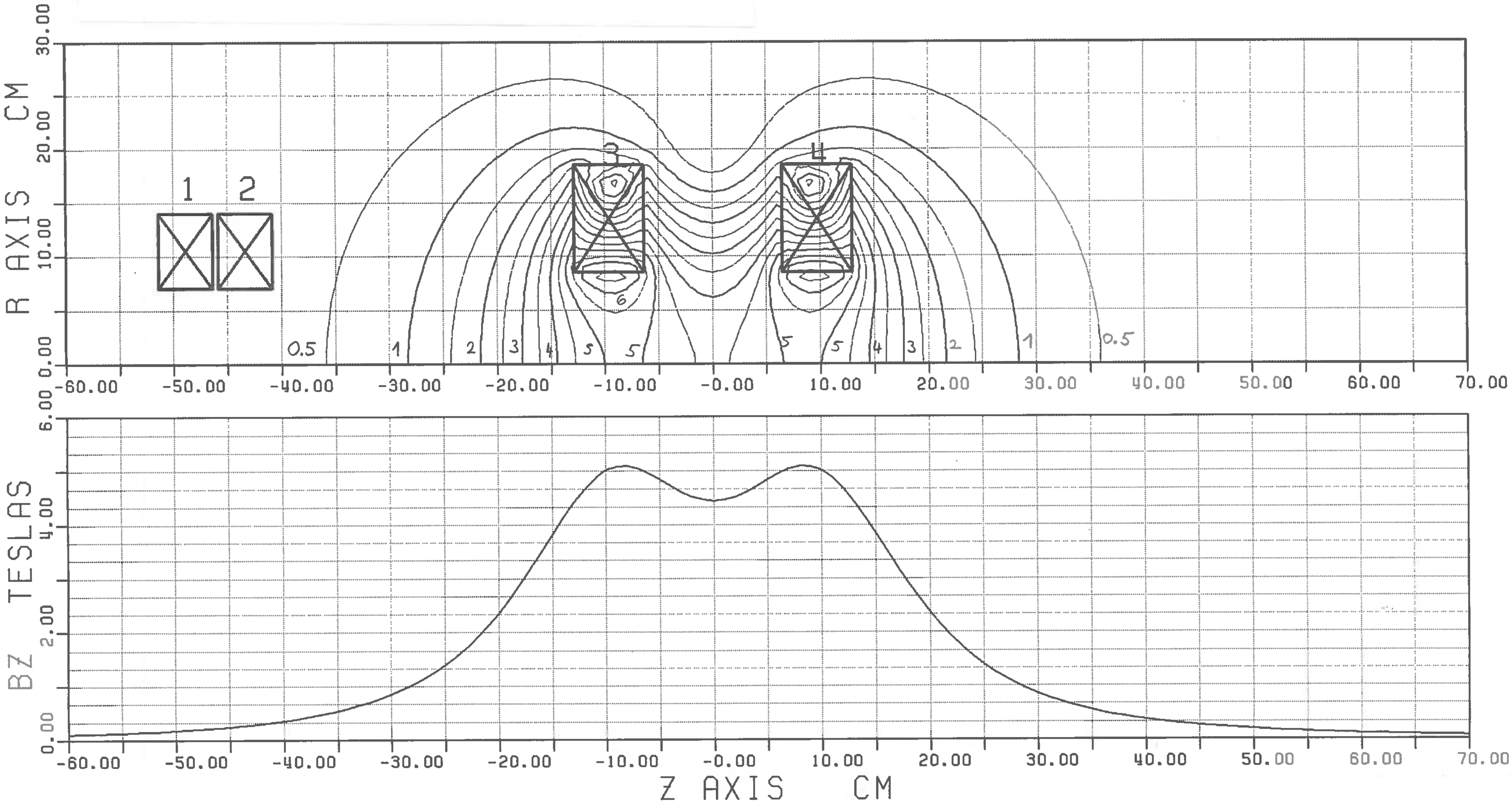
Fig. 3 Electron trajectories. Design of may 88.
V_A = 70 kV, V_E = 26. kV.

CONTOUR PLOT OF STATIC MAGNETIC FIELD
115 GHZ GYROTRON   ALPHAC = 20.

GYROTRON PROJECT
CRPP   88/04/29.   17.09.14.

COIL	CURRENT A*T	CURRENT DENSITY A/CM**2
1	-.11850E+04	-.33857E+02
2	-.11850E+04	-.33857E+02
3	.90240E+06	.13883E+05
4	.90240E+06	.13883E+05

Fig. 4 Coutour of magnetic field profile.



Appendix C

Cray and Cyber input files

Design d'octobre 86, mise en ordre des fichiers mai 88.

Fichier input		fichier output	zmin [cm]	zmax [cm]	rmax [cm]	dz [cm]
RMAG115	Contour du champ B		-60.	70.	30.	1.
JMAG115	B pour EGUN (0+1)	VECT115	-50.	5.	2.5	0.025
JMA1152	B pour EGUN (2)	VEC1152	-1.	51.	3.	0.025
JMA1153	B pour EGUN (3)	VEC1153	20.	122.	3.	0.1
GUN115	EGUN # (0+1)	OGY1151	-46.8	0.	2.	0.025
GUN1150	EGUN (0)	(OGYR115)	-46.8	-26.8	2.	0.025
GUN1151	EGUN (1)	(OGY1151)	-26.8	0.	1.	0.025
GUN1152	EGUN (2)	OGY1152	0.	24.6	2.	0.025
GUN1153	EGUN (3)	OGY1153	24.6	50.	3.	0.1
PLOTG45	Dessin sur le grand Versatec (CYBER)					
GUNTOC	Crée les programmes exécutables sur CRAY					

EGUN: code Herrmannsfeldt

La zone d'intéraction est en z=0 (plan de symétrie des bobines). L'origine de l'axe z a été modifiée; précédement le plan de symétrie était en z = 12.9 cm (voir INT 139/88).

```
JOBST,STLYY.     FILE GUN115:  115 GHZ GYROTRON      SECTIONS 0+1
USER,AP1,.
JOB,JN=GUN115,MFL=720000,T=600.
ACCOUNT,AC=20007,APW=SANDRA,US=AP1,UPW=,NUPW=.
*
*  ELECTRON GUN DESIGN : COMPUTATION ON CRAY, PLOT ON CYBER
*
ACCESS,DN=BOUNDY,OWN=AP1.
ASSIGN,DN=ZOUT,A=FT09.
ASSIGN,DN=TAPE6,A=FT06.
BOUNDY.
REWIND,DN=ZOUT.
COPYD,I=ZOUT,O=$OUT.
*REWIND,DN=TAPE6.
*COPYD,I=TAPE6,O=$OUT.
REWIND,DN=TAPE6.
COPYD,I=TAPE6,O=INSUGUN.
REWIND,DN=INSUGUN.
RELEASE,DN=BOUNDY:TAPE6:ZOUT.
*
REWIND,DN=INSUGUN.
ACCESS,DN=VECTORA,PDN=VECT115.
ASSIGN,DN=ZOUT1,A=FT09.
ACCESS,DN=EGUN,OWN=AP1.
EGUN.
*
* SAVE DATA FOR NEXT SECTION
*
ACCESS,DN=OGY1151,NA,UQ.
DELETE,DN=OGY1151,NA.
RELEASE,DN=OGY1151.
REWIND,DN=OUTGUN1.
SAVE,DN=OUTGUN1,PDN=OGY1151.
*
* SAVE PLOTGUN AND DATPLT ON CYBER (INPUT FILES OF PLTGUN)
*
DISPOSE,DN=PLOTGUN,DC=ST,TEXT='CTASK.ROUTE,PLOTGUN,UJN=TAPE1,DC=WT.',WAIT.
DISPOSE,DN=DATPLT,DC=ST,TEXT='CTASK.ROUTE,DATPLT,UJN=TAPE12,DC=WT.'
'GET,PLOTG45/UN=AP1.GO,PLOTG45.'.
*
REWIND,DN=ZOUT1.
COPYD,I=ZOUT1,O=$OUT.
RELEASE,DN=INSUGUN:NRNZ:EGUN.
*
EXIT.
REWIND,DN=ZOUT1.
COPYD,I=ZOUT1,O=$OUT.
/EOF
```

File GUN115, suite

```
 GUN115     VE = 30. KV  I = 10. A   06/05/88.  CRPP-EPFL  RUN 3
 $INPUT0
  RLIM= 80, ZLIM=1872, POTN=6, INTPA=.TRUE.,
 $END
 $INPUT1
  POT=0., 70000., 0., 0., 0., 30000., MI=3, TYME=100.,
  LSTPOT=0,
 $END
 $INPUTB
  RR0=0., ZZ0= -128. , ZORG=-46.8, ZLENGT=0.0,
 $END
  000
2., 46.8, .025, 0., 2.2745, 4, 0/
'A', 4,                       65., 0., 1.875/
'L', 4, 1.060,  155./
'L', 1, 0.332,  150./
'L', 4, 0.810,  150./
'L', 4, 0.1,    180./
'L', 0, 0.474,   90./
'L', 6, 0.1,      0./
'L', 6, 1.43,   -30./
'A', 6,                       30., 1.46, 1.52/
'L', 6, 0.755,    0./
'A', 6,                       90., 1.19, 2.275/
'L', 6, 0.82,    90./
'L', 0, 2.025,    0./
'L', 2, 0.458,  -90./
'A', 2,                       87.095, 1.542, 4.83/
'L', 2, 5.2,     -2.905/
'L', 2, 10.0031, -1.43/
'L', 2, 10.,     -0.5729/
'L', 2, 16.801,   0./
'L', 0, 0.5002, -90./
'E'/
  888
 $INPUT4
  MAXRAY=40, NMAG=0,
 $END
 $INPUT5
  RC=33.5, ZC=42.0, NS=50, UNIT=.00025, ZEND=1872,
  ZMAG=1878, SPC=1., AV=10, AVR=10., STEP=.2, ERROR=10.,
  DENS=5.83800, MAGORD=4, RMAG=36.0,SX=50.,SY=28.,
  CZ=400., CR=147., CM=243000.,
  IZS=69,
 $END
/EOF
```

```
JOBST,STLYY.     FILE GUN1152:  115 GHZ GYROTRON       SECTION  2
USER,AP1,.
JOB,JN=GUN1152,MFL=720000,T=600.
ACCOUNT,AC=20007,APW=SANDRA,US=AP1,UPW=,NUPW=.
*
*  ELECTRON GUN DESIGN : COMPUTATION ON CRAY, PLOT ON CYBER
*
ACCESS,DN=BOUNDY,OWN=AP1.
ASSIGN,DN=ZOUT,A=FT09.
ASSIGN,DN=TAPE6,A=FT06.
BOUNDY.
REWIND,DN=ZOUT.
COPYD,I=ZOUT,O=$OUT.
RELEASE,DN=BOUNDY:ZOUT.
*REWIND,DN=TAPE6.
*COPYD,I=TAPE6,O=$OUT.
*
REWIND,DN=INSUGUN.
ACCESS,DN=VECTORA,PDN=VEC1152.
ACCESS,DN=OUTGUN1,PDN=OGY1151.
ASSIGN,DN=ZOUT1,A=FT09.
REWIND,DN=TAPE6:OUTGUN1.
COPYR,I=TAPE6,O=INSUGUN,NR.
SKIPF,DN=INSUGUN.
COPYR,I=OUTGUN1,O=INSUGUN,NR.
REWIND,DN=INSUGUN.
RELEASE,DN=OUTGUN1.
ACCESS,DN=EGUN,OWN=AP1.
EGUN.
*
* SAVE DATA FOR NEXT SECTION
*
ACCESS,DN=OGY1152,NA,UQ.
DELETE,DN=OGY1152,NA.
RELEASE,DN=OGY1152.
REWIND,DN=OUTGUN1.
SAVE,DN=OUTGUN1,PDN=OGY1152.
*
* SAVE PLOTGUN AND DATPLT ON CYBER (INPUT FILES OF PLTGUN)
*
DISPOSE,DN=PLOTGUN,DC=ST,TEXT='CTASK.ROUTE,PLOTGUN,UJN=TAPE1,DC=WT.',WAIT.
DISPOSE,DN=DATPLT,DC=ST,TEXT='CTASK.ROUTE,DATPLT,UJN=TAPE12,DC=WT.'
'GET,PLOTG45/UN=AP1.GO,PLOTG45.'.
*
REWIND,DN=ZOUT1.
COPYD,I=ZOUT1,O=$OUT.
RELEASE,DN=INSUGUN:NRNZ:EGUN.
*
EXIT.
REWIND,DN=ZOUT1.
COPYD,I=ZOUT1,O=$OUT.
/EOF
```

File GUN1152, suite

```
 GUN115(2)  VE = 30. KV  I = 10. A   09/05/88.  CRPP-EPFL  RUN 3
 $INPUT0
  RLIM= 80, ZLIM= 984, POTN=6, INTPA=.TRUE.,
 $END
 $INPUT1
  POT=0., 70000., 0., 0., 0., 30000., MI=3, TYME=100.,
  LSTPOT=0,
 $END
 $INPUTB
  RR0=0., ZZ0= -40. , ZORG= 0., ZLENGT=0.0,
 $END
  000
2., 24.6, .025, 0., 0.04999, 0, 0/
'L', 0,  0.04999,180./
'L', 0,  0.9995,  90./
'L', 2, 17.1,      0./
'L', 2,  7.52,     3.0529/
'L', 0,  1.4,    -90./
'E'/
  888
 $INPUT4
  MAXRAY=40, NMAG=0,
 $END
 $INPUT5
  ISTART=3, SKAL=1., ZO=-1870.,
  RC=33.5, ZC=42.0, NS=50, UNIT=.00025, ZEND=984,
  ZMAG=990, SPC=1., AV=10, AVR=10., STEP=.2, ERROR=10.,
  DENS=5.83800, MAGORD=4, RMAG=36.0,SX=26., SY=28.,
  CZ=400., CR=147., CM=243000.,
  IZS=69,
 $END
/EOF
```

```
JOBST,STLYY.     FILE GUN1153:  115 GHZ GYROTRON      SECTION  3
USER,AP1,.
JOB,JN=GUN1153,MFL=720000,T=600.
ACCOUNT,AC=20007,APW=SANDRA,US=AP1,UPW=,NUPW=.
*
*  ELECTRON GUN DESIGN : COMPUTATION ON CRAY, PLOT ON CYBER
*
ACCESS,DN=BOUNDY,OWN=AP1.
ASSIGN,DN=ZOUT,A=FT09.
ASSIGN,DN=TAPE6,A=FT06.
BOUNDY.
REWIND,DN=ZOUT.
COPYD,I=ZOUT,O=$OUT.
RELEASE,DN=BOUNDY:ZOUT.
*REWIND,DN=TAPE6.
*COPYD,I=TAPE6,O=$OUT.
*
REWIND,DN=INSUGUN.
ACCESS,DN=VECTORA,PDN=VEC1153.
ACCESS,DN=OUTGUN1,PDN=OGY1152.
ASSIGN,DN=ZOUT1,A=FT09.
REWIND,DN=TAPE6:OUTGUN1.
COPYR,I=TAPE6,O=INSUGUN,NR.
SKIPF,DN=INSUGUN.
COPYR,I=OUTGUN1,O=INSUGUN,NR.
REWIND,DN=INSUGUN.
RELEASE,DN=OUTGUN1.
ACCESS,DN=EGUN,OWN=AP1.
EGUN.
*
* SAVE PLOTGUN AND DATPLT ON CYBER (INPUT FILES OF PLTGUN)
*
DISPOSE,DN=PLOTGUN,DC=ST,TEXT='CTASK.ROUTE,PLOTGUN,UJN=TAPE1,DC=WT.',WAIT.
DISPOSE,DN=DATPLT,DC=ST,TEXT='CTASK.ROUTE,DATPLT,UJN=TAPE12,DC=WT.'
'GET,PLOTG45/UN=AP1.GO,PLOTG45.'.
*
REWIND,DN=ZOUT1.
COPYD,I=ZOUT1,O=$OUT.
RELEASE,DN=INSUGUN:NRNZ:EGUN.
*
EXIT.
REWIND,DN=ZOUT1.
COPYD,I=ZOUT1,O=$OUT.
/EOF
```

File GUN1153, suite

```
 GUN115(3)  VE = 30. KV  I = 10. A   09/05/88.  CRPP-EPFL  RUN 3
 $INPUT0
  RLIM= 30, ZLIM= 954, POTN=6, INTPA=.TRUE.,
 $END
 $INPUT1
  POT=0., 70000., 0., 0., 0., 30000., MI=3, TYME=100.,
  LSTPOT=0,
 $END
 $INPUTB
  RR0=0., ZZ0=-46.,   ZORG=24.6, ZLENGT=0.0,
 $END
  000
3., 95.4, .10, 0., 0.09999, 0, 0/
'L', 0,  0.09999,180./
'L', 0,  1.3998,  90./
'L', 2, 22.532,    3.0529/
'L', 2, 72.901,    0./
'L', 0,  2.601,  -90./
'E'/
  888
 $INPUT4
  MAXRAY=40, NMAG=0,
 $END
 $INPUT5
  ISTART=3, SKAL=0.25, ZO=-246.,
  RC=33.5, ZC=42.0, NS=50, UNIT=.0010, ZEND=954,
  ZMAG= 960, SPC=1., AV=10, AVR=10., STEP=.2, ERROR=10.,
  DENS=5.83800, MAGORD=4, RMAG=10.0,SX=96., SY=28.,
  CZ=400., CR=147., CM=243000.,
  IZS=69,
 $END
/EOF
```

```
JOBST,STLYY.    FILE JMAG115: CREE LE FICHIER DU CHAMP B POUR EGUN  1ERE SECT
ION
USER,AP1,.                        GYROTRON 115 GHZ  ALPHAC = 20.
JOB,JN=MAG115,MFL=400000,T=400.
ACCOUNT,AC=20007,APW=SANDRA,US=AP1,UPW=,NUPW=.
*
*PRINT THE OUTPUT
*DISPOSE,DN=$OUT,SDN=OUT,DC=ST,TEXT='CTASK.ROUTE,OUT,TC=13.',DEFER.
*
ACCESS,DN=MAGNET,OWN=AP1.
ACCESS,DN=VECT115,NA,UQ.
DELETE,DN=VECT115,NA.
RELEASE,DN=VECT115.
MAGNET.
SAVE,DN=VECTORA,PDN=VECT115,RT=100.
DISPOSE,DN=$OUT,SDN=OUT,DC=ST,TEXT='CTASK.ROUTE,OUT,DC=WT.'
'GET,GUN115/UN=AP1.GO,GUN115.'.
EXIT.
/EOF
 $SELECT
  NCOAX=+1,
  NFORCE=0,
  NPRINC=0,
 $END
 $DATA2
  NBF=1,
  RPI=0.00000,
  DRP=0.00025,
  ZPI=-.500000,
  DZP=0.00025,
  NPTR= 100,
  NPTZ= 2200,
 $END
 $COILS
  NC=4,
  UN=3,
 $END
 $TRAJ
   NT=0,
  R1=0.050,
  IMAX=500,
  Z0=-0.600,
  Z11=0.40,
 $END
 $DATA
  Z1(1)=-0.514,Z2(1)=-0.464,A1(1)=0.070,A2(1)=0.14 ,AT(1)=  -1185.,
  Z1(2)=-0.459,Z2(2)=-0.409,A1(2)=0.070,A2(2)=0.14 ,AT(2)=  -1185.,
  Z1(3)=-0.129,Z2(3)=-0.064,A1(3)=0.085,A2(3)=0.185,AT(3)= 902400.,
  Z1(4)= 0.064,Z2(4)= 0.129,A1(4)=0.085,A2(4)=0.185,AT(4)= 902400.,
  KSWI=2,
 $END
 $LINES
 $END
```

```
JOBST,STLYY.    FILE JMA1152: CREE LE FICHIER DU CHAMP B POUR EGUN  2EME SECT
ION
USER,AP1,.                      GYROTRON 115 GHZ  ALPHAC = 20.
JOB,JN=MAG115,MFL=400000,T=400.
ACCOUNT,AC=20007,APW=SANDRA,US=AP1,UPW=,NUPW=.
*
*PRINT THE OUTPUT
*DISPOSE,DN=$OUT,SDN=OUT,DC=ST,TEXT='CTASK.ROUTE,OUT,TC=13.',DEFER.
*
ACCESS,DN=MAGNET,OWN=AP1.
ACCESS,DN=VEC1152,NA,UQ.
DELETE,DN=VEC1152,NA.
RELEASE,DN=VEC1152.
MAGNET.
SAVE,DN=VECTORA,PDN=VEC1152,RT=100.
DISPOSE,DN=$OUT,SDN=OUT,DC=ST,TEXT='CTASK.ROUTE,OUT,DC=WT.'
'GET,GUN1152/UN=AP1.GO,GUN1152.'.
EXIT.
/EOF
 $SELECT
  NCOAX=+1,
  NFORCE=0,
  NPRINC=0,
 $END
 $DATA2
  NBF=1,
  RPI=0.00000,
  DRP=0.00025,
  ZPI=-.010000,
  DZP=0.00025,
  NPTR= 120,
  NPTZ= 2080,
 $END
 $COILS
  NC=4,
  UN=3,
 $END
 $TRAJ
   NT=0,
  R1=0.050,
  IMAX=500,
  Z0=-0.600,
  Z11=0.40,
 $END
 $DATA
  Z1(1)=-0.514,Z2(1)=-0.464,A1(1)=0.070,A2(1)=0.14 ,AT(1)=  -1185.,
  Z1(2)=-0.459,Z2(2)=-0.409,A1(2)=0.070,A2(2)=0.14 ,AT(2)=  -1185.,
  Z1(3)=-0.129,Z2(3)=-0.064,A1(3)=0.085,A2(3)=0.185,AT(3)= 902400.,
  Z1(4)= 0.064,Z2(4)= 0.129,A1(4)=0.085,A2(4)=0.185,AT(4)= 902400.,
  KSWI=2,
 $END
 $LINES
 $END
```

```
MAGNET.              FILE : RMAG115     CONTOUR PLOT OF MAGNETIC FIELD
USER,AP1,.                              115 GHZ GYROTRON MAGNET
CHARGE,*.
SETTL,*.
PURGE,OM115/NA.
ATTACH,MA.
MA,INPUT,OUTPUT,OM115.
SAVE,OM115.
GET,PLTM115.
FTN5,I=PLTM115,L=0,ANSI=0.
REWIND,OM115.
LGO,OM115,OMAGN2.
RASTER.
ROUTE,GLDX.FC=PC.
GET,PLTM1.
FTN5,I=PLTM1,L=0,ANSI=0,B=PLT.
REWIND,OM115.
GET,CLEANUP.
CLEANUP.
REWIND,OM115.
PLT,OM115,OMAGN2.
RASTER.
ROUTE,GLDX,FC=PC.
(EOR)
CONTOUR PLOT OF STATIC MAGNETIC FIELD
115 GHZ GYROTRON       ALPHAC = 20.
 $SELECT
  NCOAX=1, NFORCE=0, NPRINC=0,
 $END
 $DATA2
  NBF=1,
  NPTR=31, RPI=0., DRP=0.01,
  NPTZ=131 , ZPI=-0.6, DZP=0.01,
 $END
 $COILS
  NC=4, UN=3,
 $END
 $DATA
  Z1(1)=-.5140,Z2(1)=-.4640,A1(1)=0.0700,A2(1)=0.140,AT(1)=-1185.,
  Z1(2)=-.4590,Z2(2)=-.4090,A1(2)=0.0700,A2(2)=0.140,AT(2)=-1185.,
  Z1(3)=-.1290,Z2(3)=-.0640,A1(3)=0.0850,A2(3)=0.185,AT(3)=902400.,
  Z1(4)=0.0640,Z2(4)=0.1290,A1(4)=0.0850,A2(4)=0.185,AT(4)=902400.,
  XWID(3)=1.E-3, XHEI(3)=1.064E-03,
  XWID(4)=1.E-3, XHEI(4)=1.064E-03,
  KSWI=0, KSWIC=0, KSWZ=0,UNIT=1.,
 $END
 $ADJUST
 NP=4,
 ZZ1(1)= 0.032, BZZ(1)=5.91,
 ZZ1(2)=-0.032, BZZ(2)=6.27,
 ZZ1(3)=-0.510, BZZ(3)=0.295,
 ZZ1(4)=-0.500, BZZ(4)=0.305,
 WEIGHT(1)=1., WEIGHT(2)=3.0, WEIGHT(3)=1.0, WEIGHT(4)=2.5,
 $END
```

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File PLOTG45

```
PLOTG45.        A.PERRENOUD CRPP    PLOT GYROTRON GUN
USER,       .
CHARGE,*.
SETTL,*.
ATTACH,PLTGUN.
QGET,UJN=TAPE1.
QGET,UJN=TAPE12.
PLTGUN.
RASTER.
REWIND,GLDX.
*     PAPIER NORMAL
*ROUTE,GLDX.
*     PAPIER NORMAL + ENVOI PAR LA POSTE
ROUTE,GLDX,FC=PC.
*     PAPIER CALQUE
*ROUTE,GLDX,FC=CA.
```

```
JOBST,STLYY.                       FILE: GUNTOC
USER,AP1,.
JOB,JN=EGUNTOC,MFL=720000,T=20.
ACCOUNT,AC=20007,APW=SANDRA,US=AP1,UPW=,NUPW=.
*
********************  FILE GUNTOC  *****************************
*
* PRODUCE AN EXECUTABLE VERSION ON THE CRAY OF:
*
* EGUN     HERRMANNSFELDT CODE
*
* MAGNET   MAGNETIC FIELD COMPUTATION (VECTOR POTENTIAL)
*
* BOUNDY   TRANSLATE GUN GEOMETRY TO BOUNDARY SEGMENTS
*
***************************************************************
ACCESS,DN=MAGNET,NA,UQ.
DELETE,DN=MAGNET,NA.
RELEASE,DN=MAGNET.
FETCH,DN=COMPILE,TEXT='GET,OLDPL=MAGNTL2/UN=AP1.GET,MAGCORN.'
                      'UPDATE,I=MAGCORN,F,L=0.CTASK.'.
CFT,I=COMPILE,B=BIN,L=0.
LDR,DN=BIN,NX,AB=MAGNET.
SAVE,DN=MAGNET,RT=100,PAM=R:E.
RELEASE,DN=COMPILE:BIN:MAGNET.
***************************************************************
ACCESS,DN=BOUNDY,NA,UQ.
DELETE,DN=BOUNDY,NA.
RELEASE,DN=BOUNDY.
FETCH,DN=COMPILE,TEXT='GET,OLDPL=GUNNWPL/UN=AP1.GET,BOUNDYC.'
                      'UPDATE,I=BOUNDYC,Q,L=0.CTASK.'.
CFT,I=COMPILE,B=BIN,L=0.
LDR,DN=BIN,NX,AB=BOUNDY.
SAVE,DN=BOUNDY,RT=100,PAM=R:E.
RELEASE,DN=COMPILE:BIN:BOUNDY.
***************************************************************
ACCESS,DN=EGUN,NA,UQ.
DELETE,DN=EGUN,NA.
RELEASE,DN=EGUN.
FETCH,DN=COMPILE,TEXT='GET,OLDPL=GUNNWPL/UN=AP1.GET,GUNCOR/UN=AP1.'
                      'UPDATE,I=GUNCOR,Q,L=0.CTASK.'.
CFT,I=COMPILE,B=BIN,L=0.
LDR,DN=BIN,NX,AB=EGUN.
SAVE,DN=EGUN,RT=100,PAM=R:E.
RELEASE,DN=COMPILE:BIN:EGUN.
******************************************************************
AUDIT,LO=L:P:A.
******************************************************************
```