EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE

CERN - PS DIVISION

PS/ OP/ Note 94-27 (Info.)

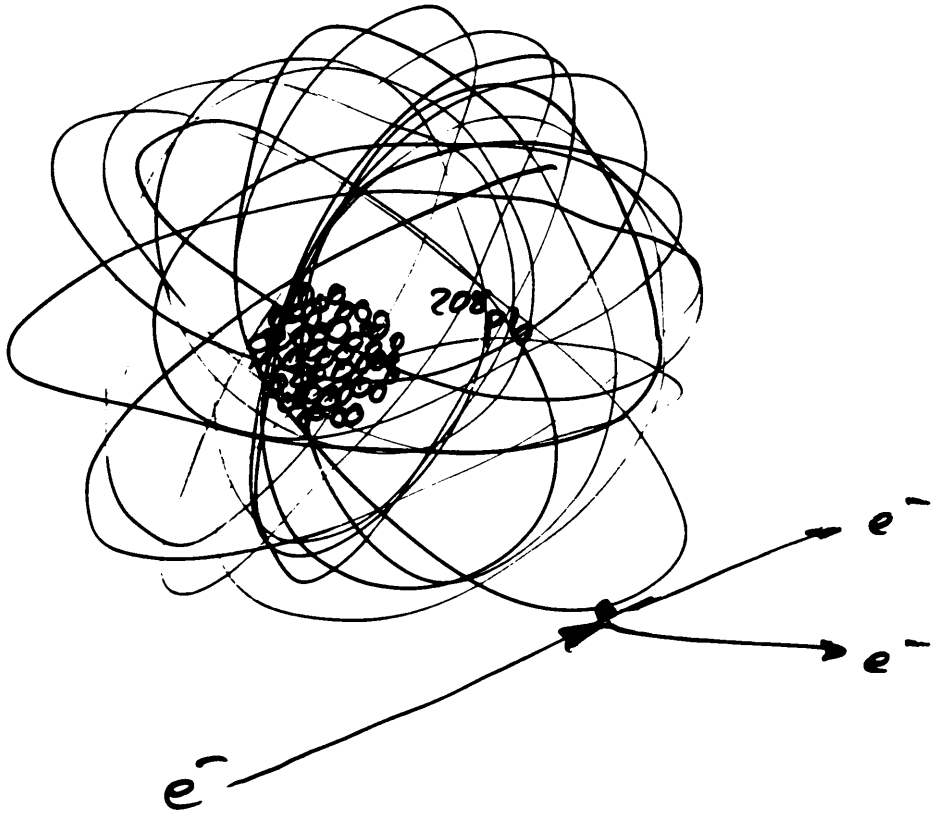
SOURCE D'IONS PLOMB

Cours Donné Aux Techniciens D'opération **PS/LI/PSB**

K. Langbein

Geneva, Switzerland
9 mars 1994

Ionization

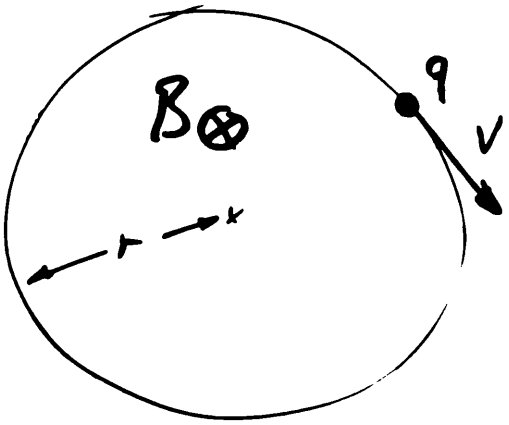


Lead ions are ionized stepwise by impact of energetic electrons.

e.g.

		req. Energy
Pb	$\rightarrow Pb^{+}$	7eV
Pb^{+}	$\rightarrow Pb^{2+}$	15eV
$\vdots$	$\vdots$	
Pb^{25+}	$\rightarrow Pb^{26+}$	1keV
$\vdots$	$\vdots$	
Pb^{81+}	$\rightarrow Pb^{82+}$	$\approx$ 90keV

Cyclotron Resonance



$$\frac{mv^2}{r} = q\,v \times \vec{B}$$

centrifugal force = magnetic force on charge

$$v = \frac{q r B}{m}$$

circumference: $2\pi r$

time req. for one orbit: $t = \frac{2\pi r}{v}$ or $v = \frac{2\pi r}{t}$

i.e.

$$\frac{2\pi r}{t} = \frac{q r B}{m}$$

or

$$t = \frac{2\pi m}{qB}$$

i.e. time for one orbit is indep. of radius or particle energy!

or:

$$\frac{1}{t} = f = \frac{qB}{2\pi m}$$ frequency is const.

Example

$$f = \frac{eB}{2\pi m_e}$$

e = electron charge = 1.6×10^{-19} Cb

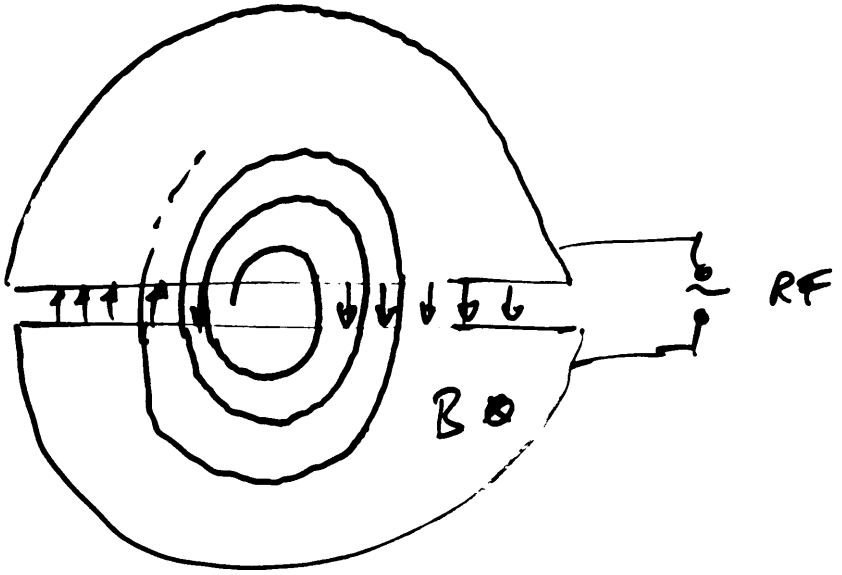
m_e = rest mass of electron = 9.1×10^{-31} kg

B = mag. field = 0.5 Tesla

$$f = \frac{1.6 \times 10^{-19} \times 0.5}{2\pi \times 9.1 \times 10^{-31}}$$

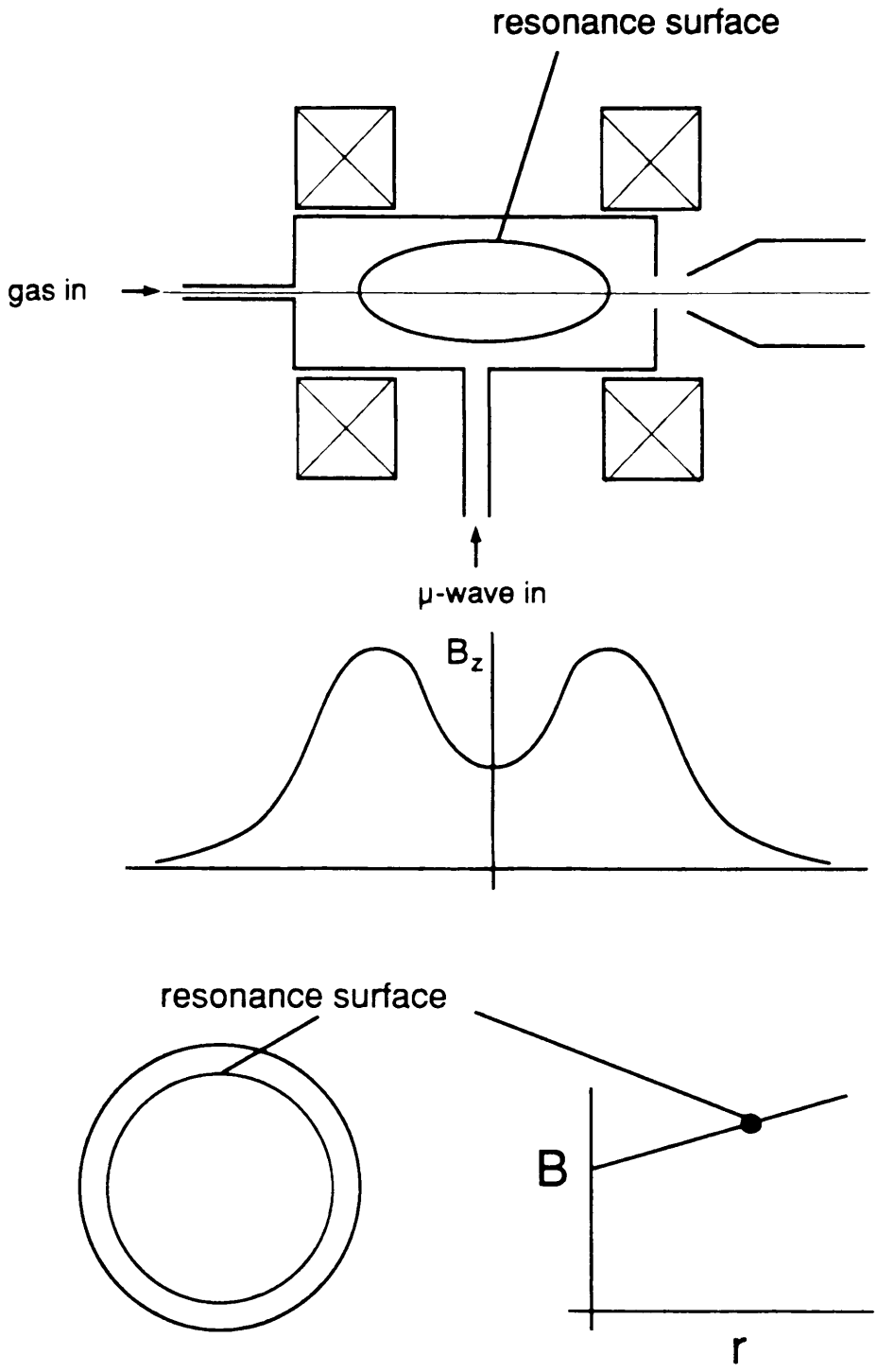
$$f = 14 \text{ GHz}$$

Cyclotron



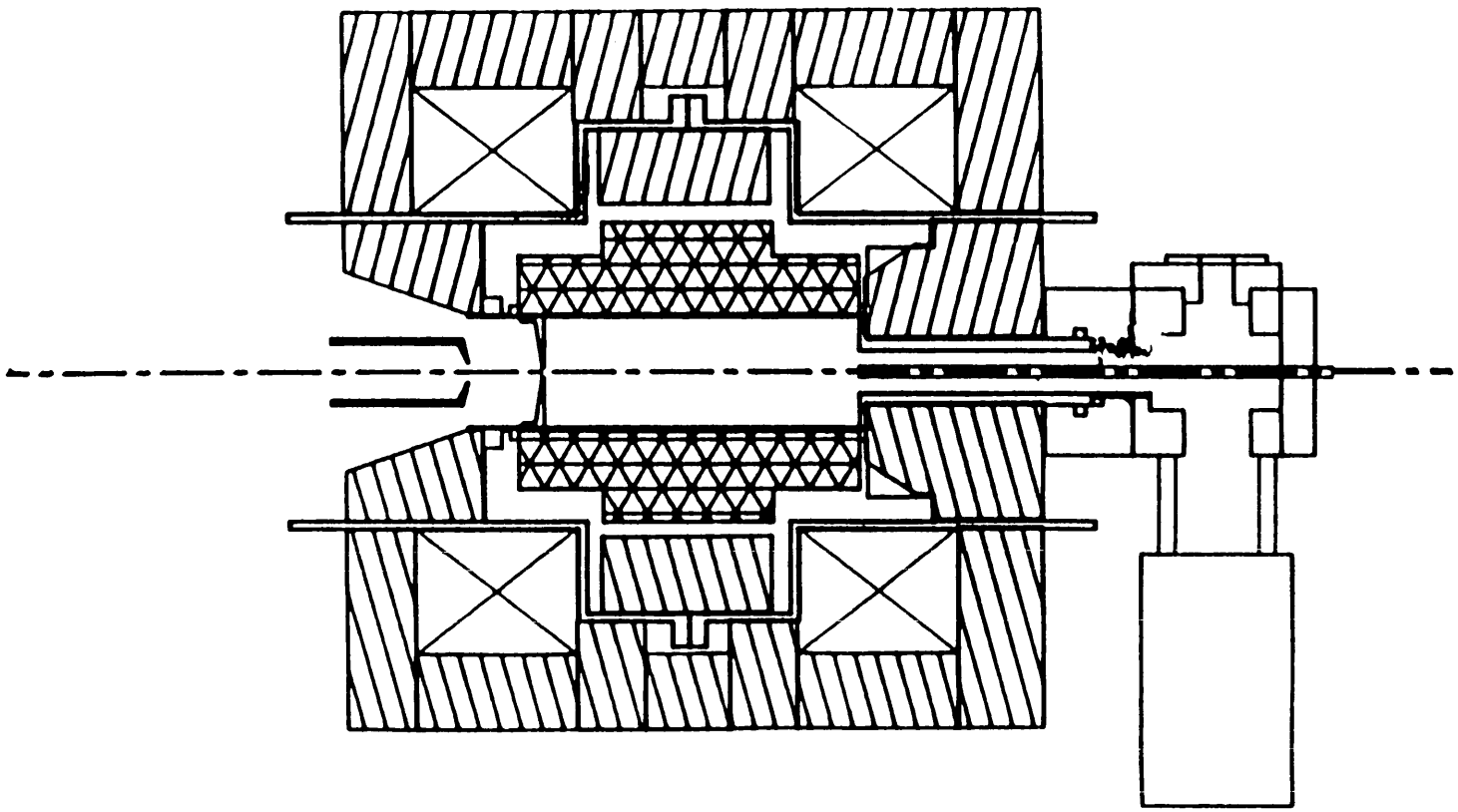
Radius + energy increase, but time for one orbit is constant. Thus exitation of cavity with const freq. is possible.

Electron Cyclotron Resonance Ion Source



If magnetic field increases towards all sides
a closed surface is found on which the resonance
conditions for the given frequency are fullfilled

GANIL source ECR4 14.5 GHz

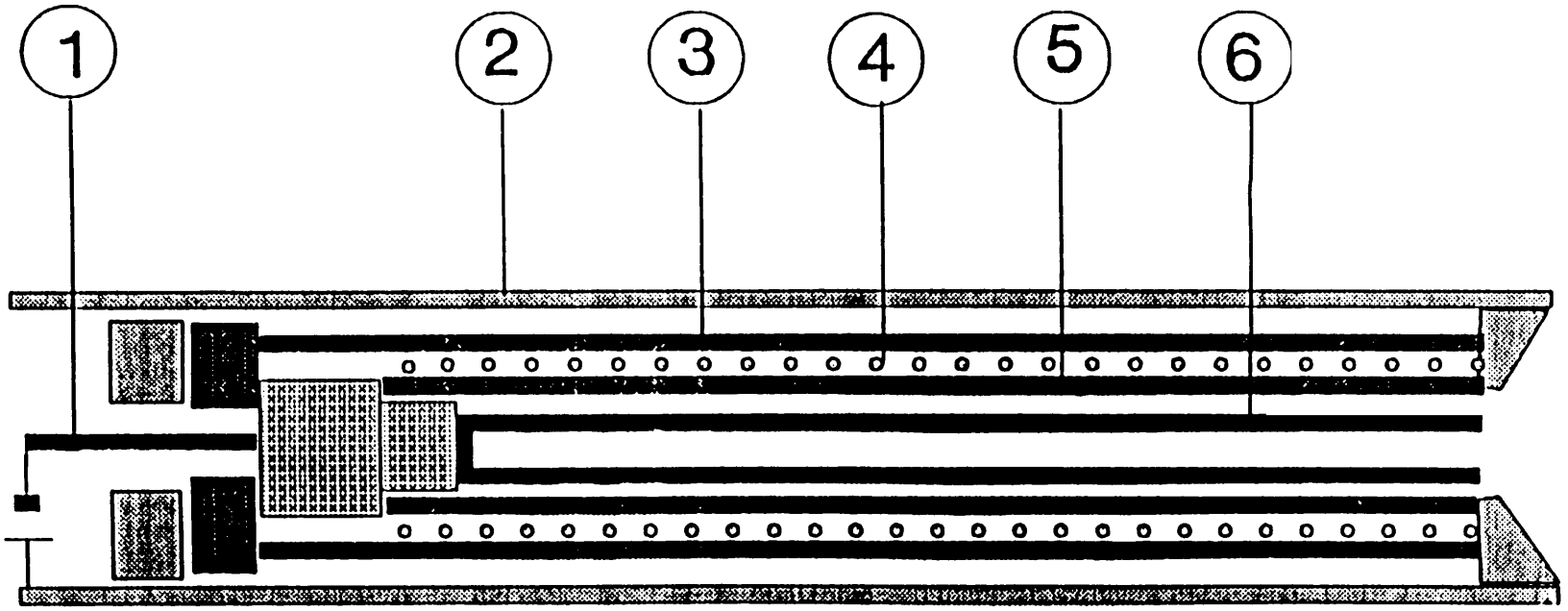


extraction, plasma, uhf, gaz, cooling and pumping system

hexapolar magnetic system

axial magnetic system

MICRO-OVEN

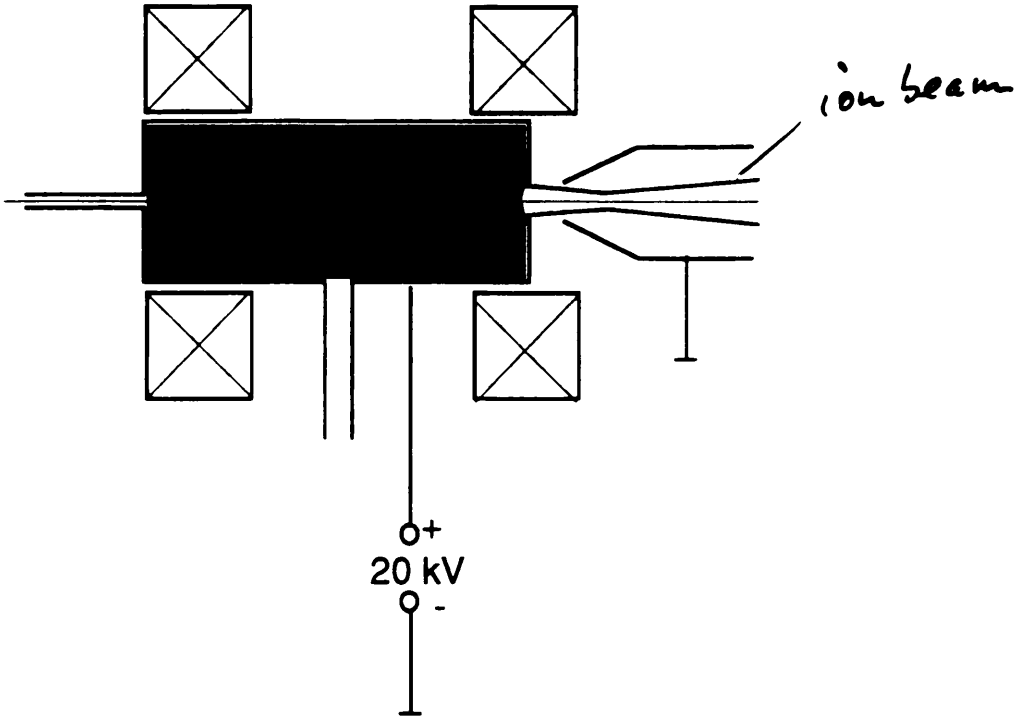


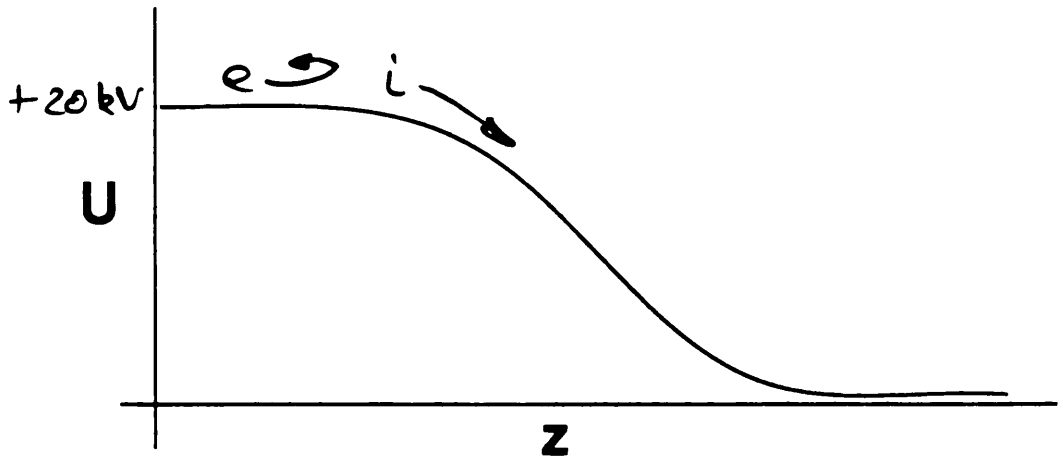
1-Power supply
2-Reflector tube
3-Insulator
4-Heating system
5-Insulator
6-Evaporator tube

SIZES

Φ 5mm Lenght 50mm

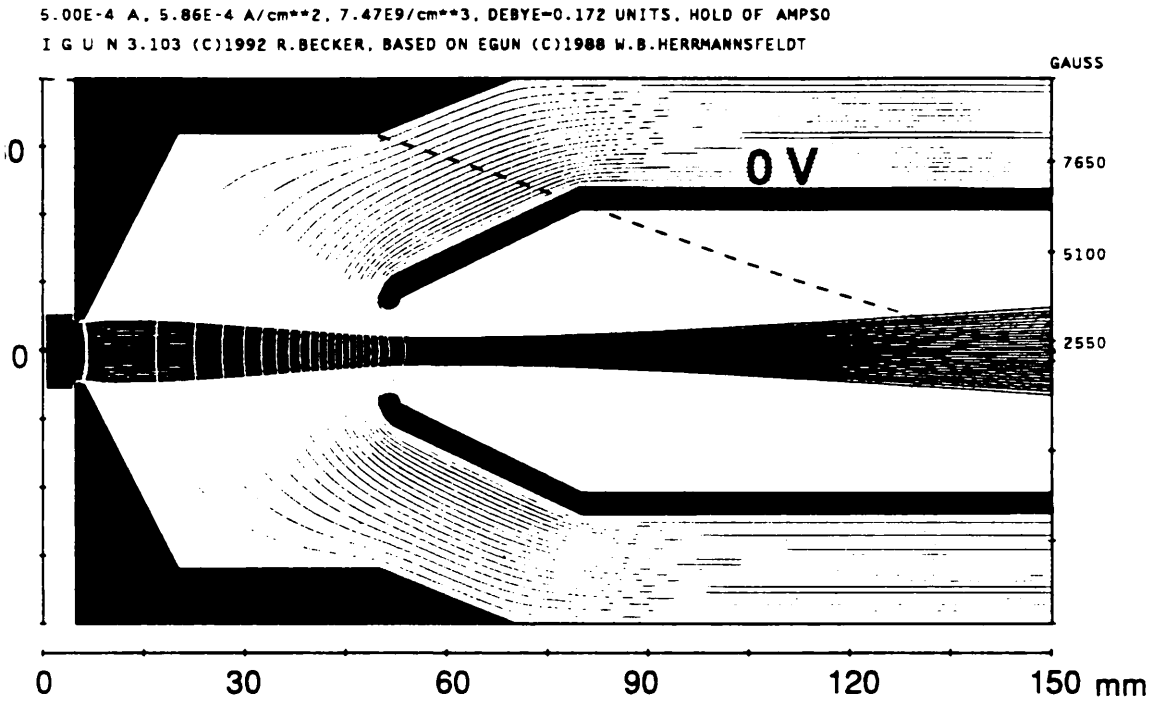
Ion Extraction



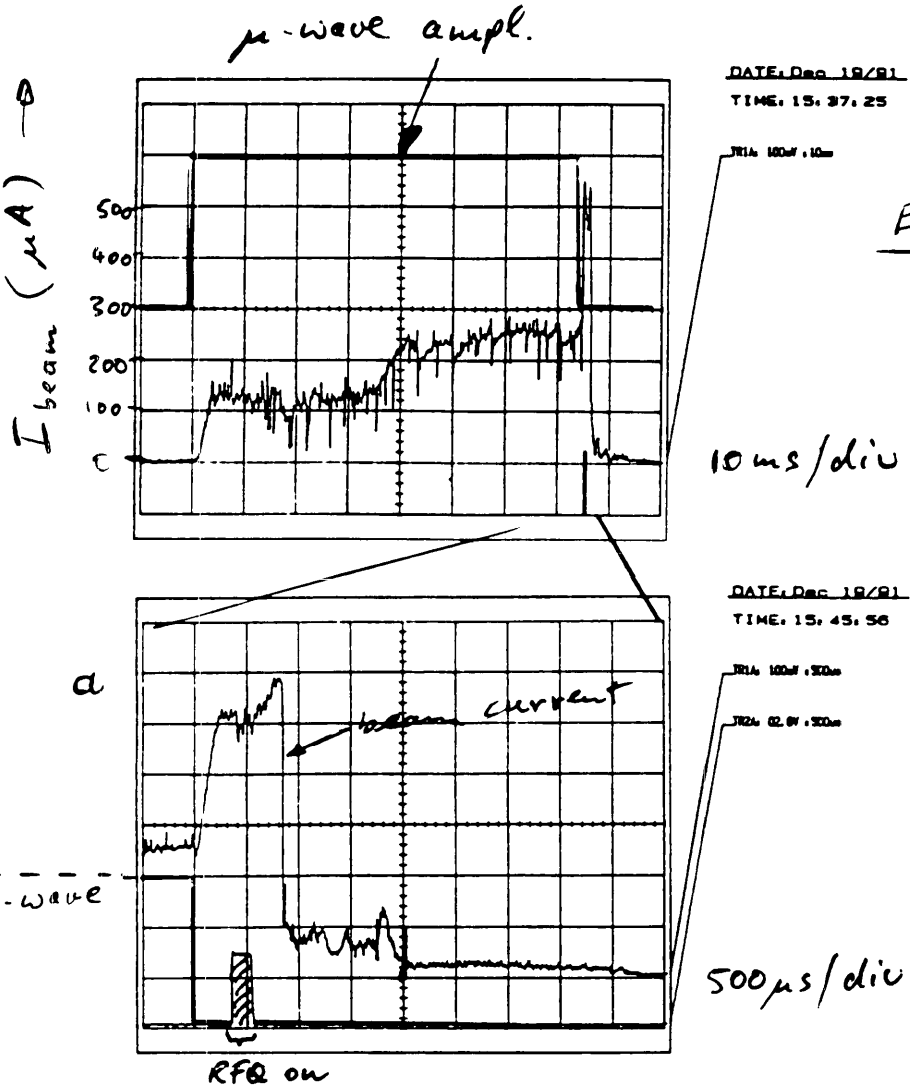


Simulation of the Extraction System of the ECR Ion Source

Parameters: Acceleration voltage=20 kV, total ion current = 0.5 mA, average mass/charge ratio=8, diam. of outlet aperture=10mm



K. Langbein 9.2.94



Examples of "afterglow"

O^{6+} beam current at entrance RFQ

y: 100 μA/div

I_{max} = 500 μA

a, b, c

variation of afterglow from pulse to pulse (no change of source parameters)

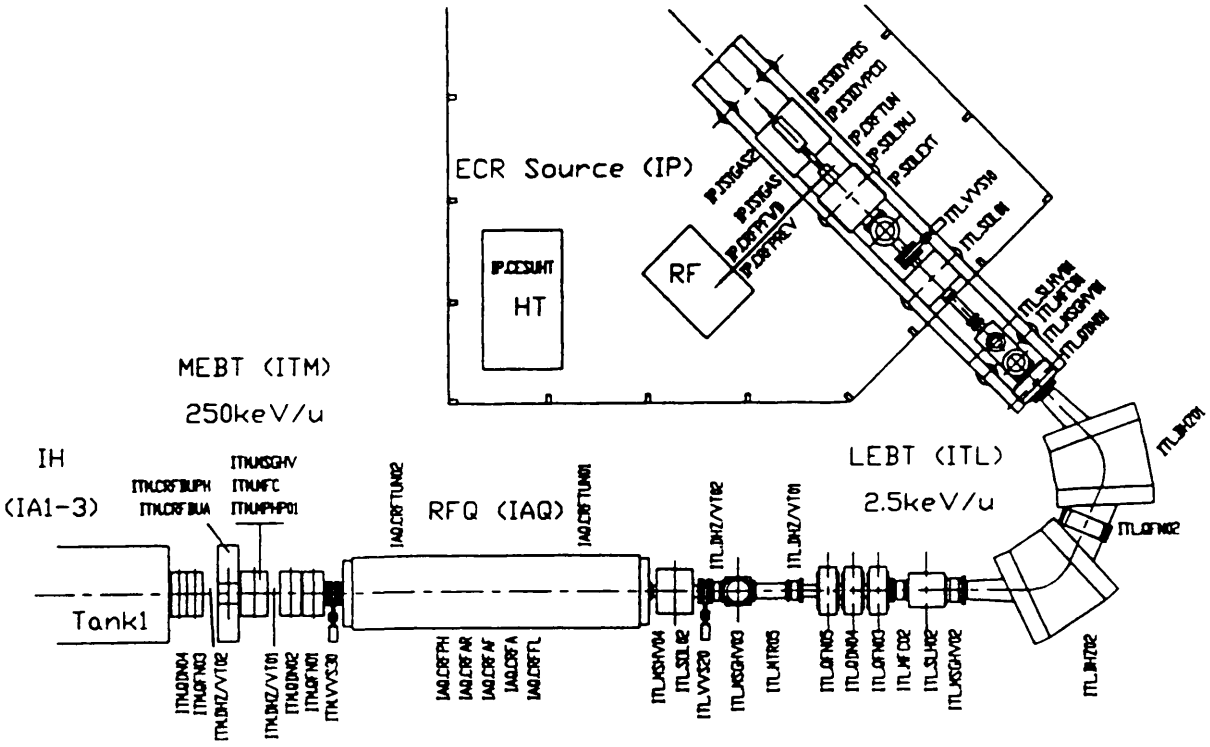


Fig. 2.6 Schematic Layout of LEBT, RFQ and MEBT Region

2.3.3 Waist to High Resolution Waist After 135^{0} Spectrometer

The central part of the LEBT is a compact spectrometer with a resolution of 3/1000. The choice of a bending radius = 0.4 m and a dipole field of 0.15 T is convenient for the engineering of the magnets and it has been selected from different configurations, taking into account the non-linear analysis which includes the magnetic aberrations in the dipole magnet, in order to accommodate a beam with a horizontal extension comparable with the bending radius. The spectrometer design used for the LEBT of the new high charge state injector (HLI) at GSI [24], has been selected. This has two separated 67.5^{0} magnets with the angles of all pole faces inclined by 25^{0}, to provide focusing in the vertical plane. The gap height is 90 mm and the pole width 480 mm (Fig. 2.7).

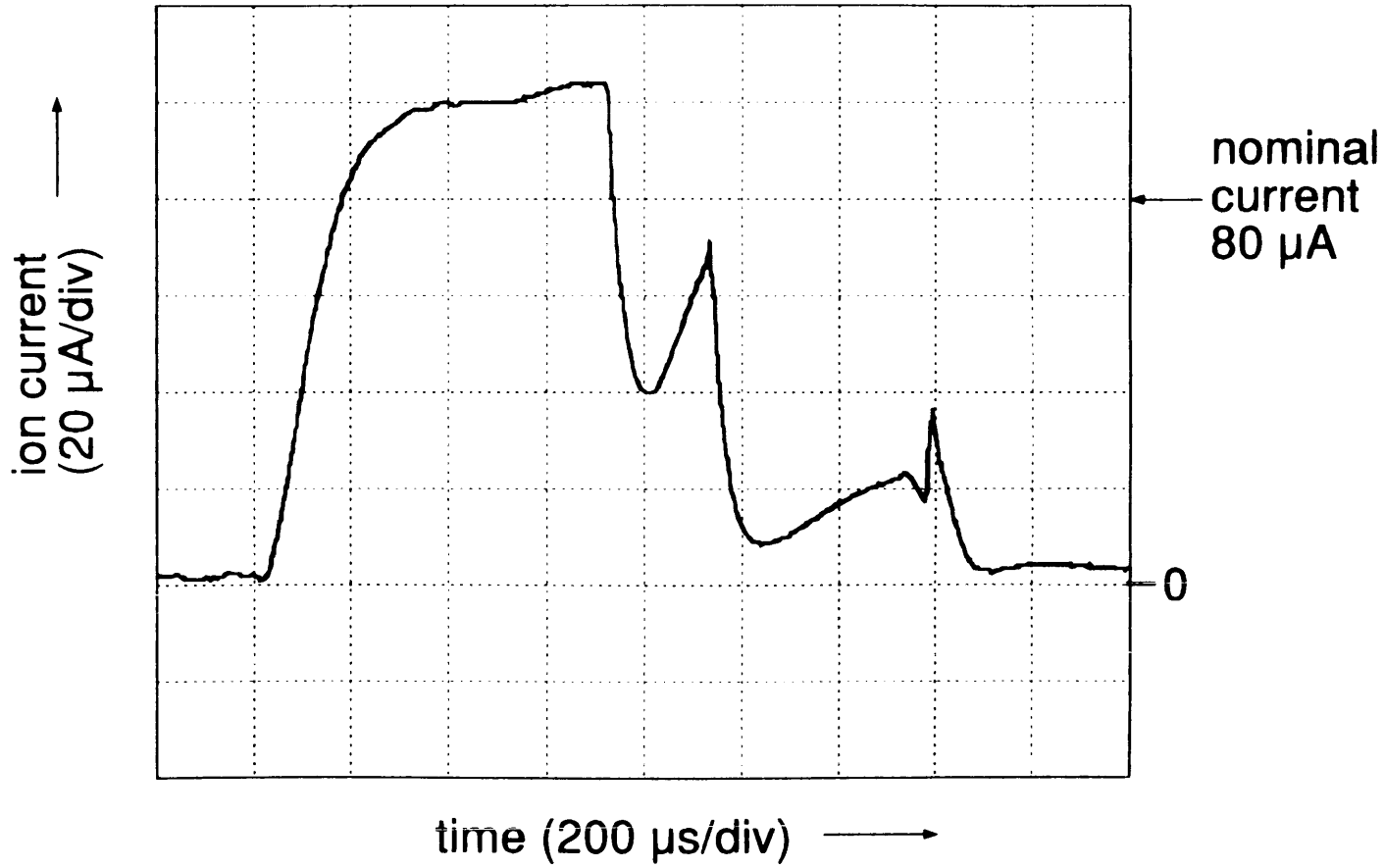
The advantage of this configuration (two magnets) is the possibility of shimming the internal faces of the magnets so as to introduce a sextupole correction; with a curvature of radius 2.7 m of these faces, the second order aberrations of the magnets can be corrected.

2.3.4 Waist to Input of RFQ

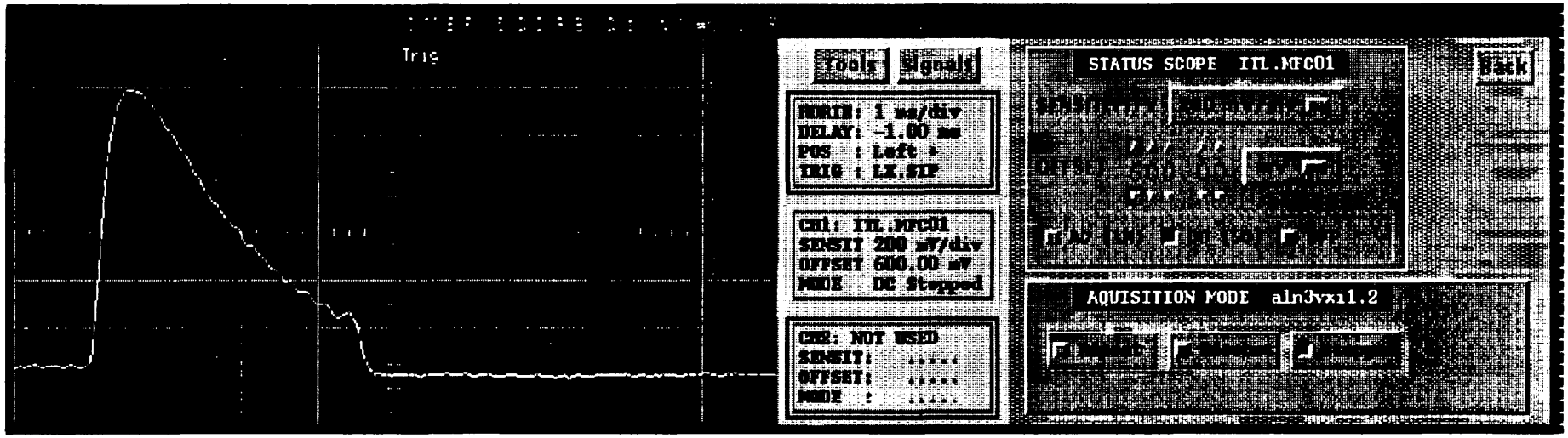
After the spectrometer, a quadrupole triplet restores the cylindrical symmetry of the beam, and the solenoid SOL02 focuses the beam to match the initial RFQ conditions. Two pairs of steering magnets (horizontal, DHZ and vertical, DVT) are located between the triplet and SOL02, to have the possibility of a position and angle correction at the entrance of the RFQ (Fig. 2.6).

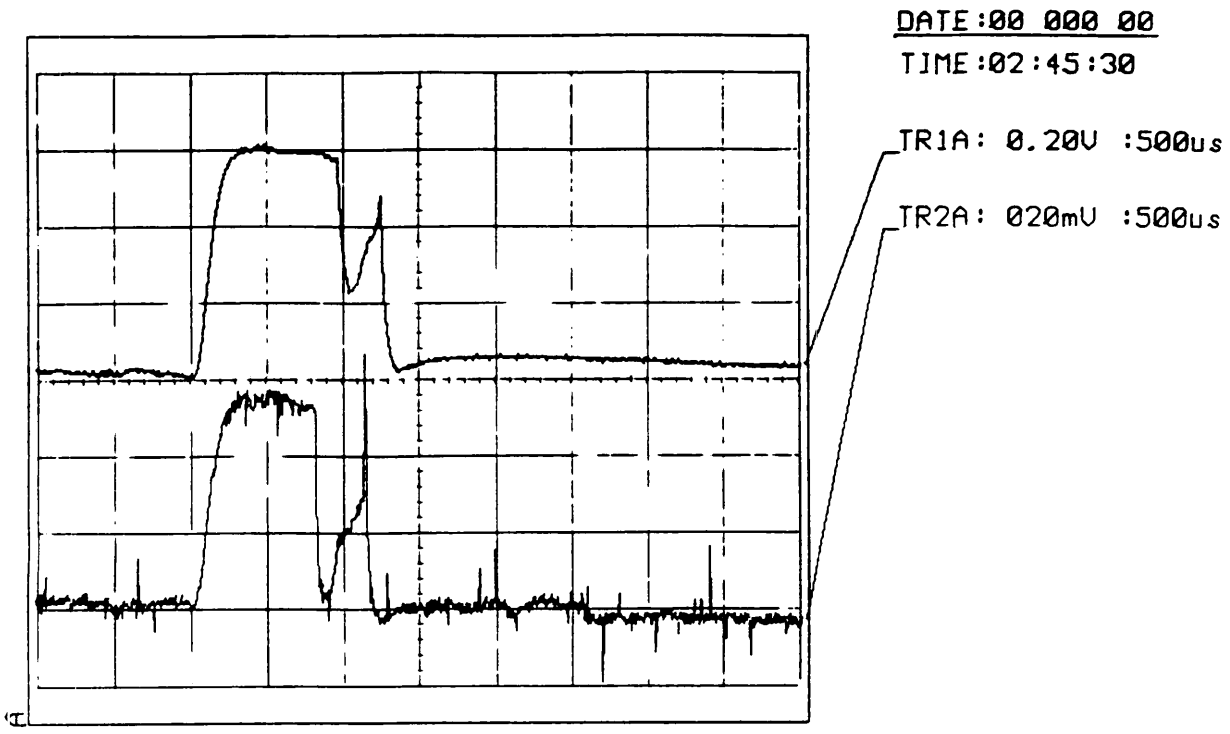
2.3.5 Summary of Beam Dynamics Including Space Charge

In table 2.3.1 are listed the main matrix elements between the object and the image after correction; x_i is the horizontal beam dimension at the image point. For this particular matrix, involving imaging, the term $\partial x_i/\partial x'$ is ideally zero.

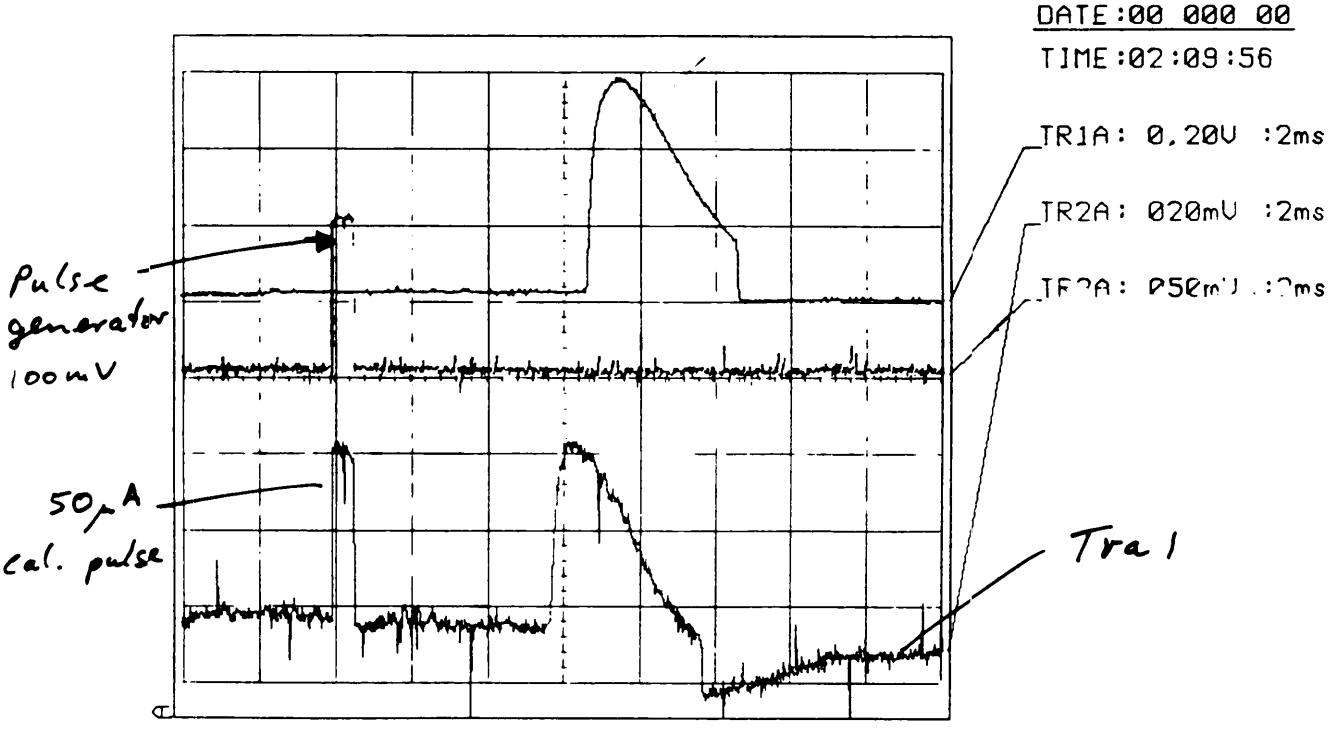


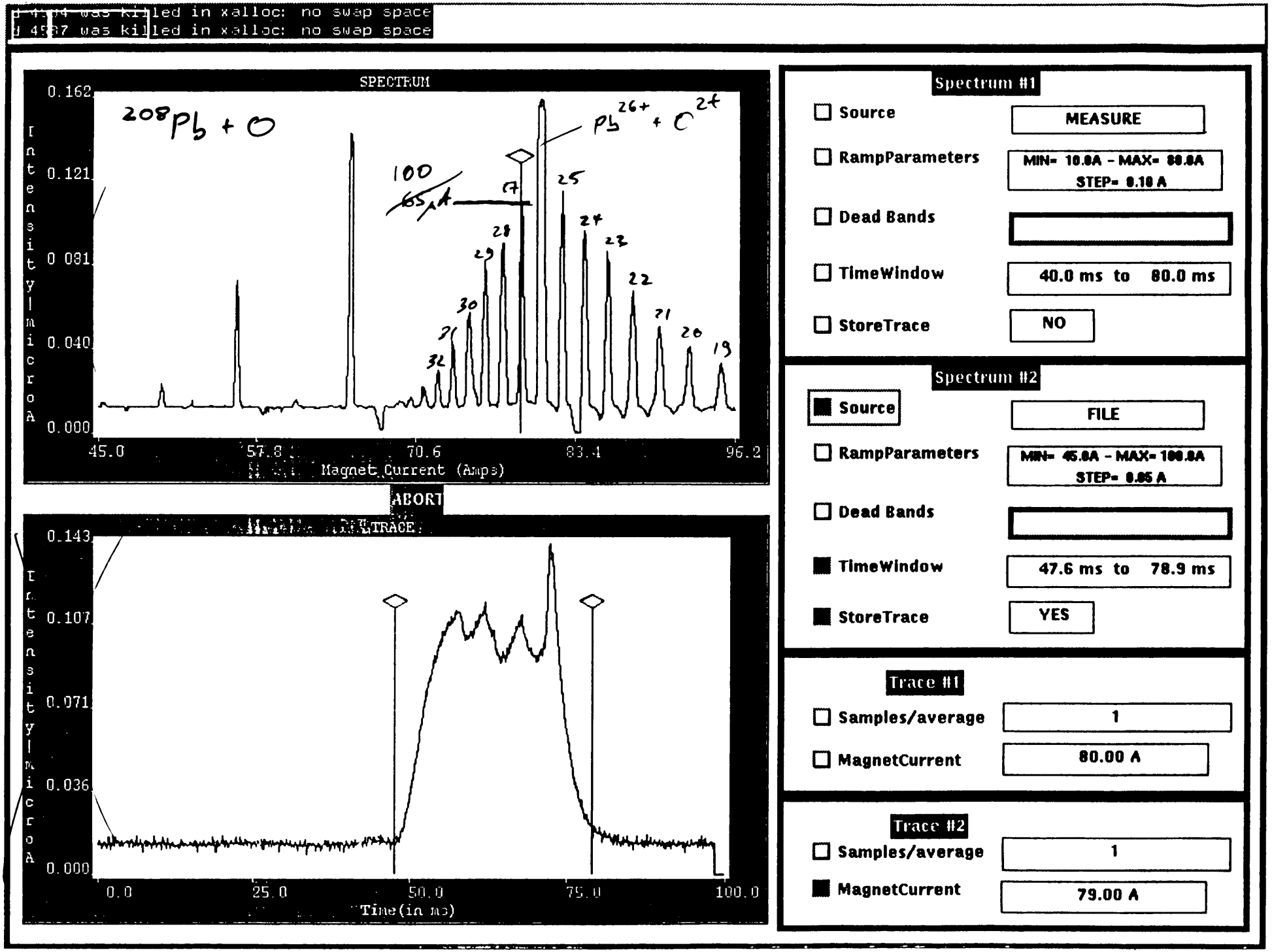
Pb^{27+}-ion current produced by ECR ion source


Trig
Tools
Signals
RUN: 1 ms/div
DELAY: -1.00 ms
POS : Left
TRIG : LX.SIP
CH1: ITL.MFC01
SENSIT 200 mV/div
OFFSET 600.00 mV
MODE DC Stopped
CH2: NOT USED
SENSIT:
OFFSET:
MODE :
STATUS SCOPE ITL.MFC01
Back
AQUISITION MODE


DATE:00 000 00
TIME:02:45:30
TR1A: 0.20V :500us
TR2A: 020mV :500us

FC2

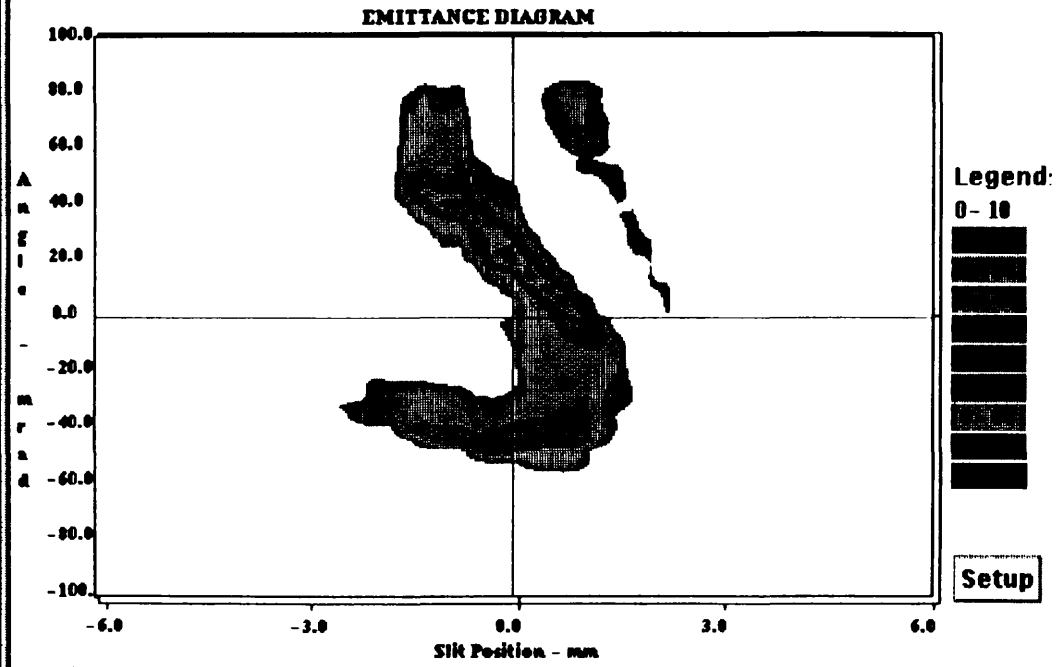

DATE:00 000 00
TIME:02:09:56
TR1A: 0.20V :2ms
TR2A: 020mV :2ms
Pulse generator 100mV
50μA cal. pulse
Tra 1


4144 was killed in xalloc: no swap space
4187 was killed in xalloc: no swap space
SPECTRUM
208Pb + O
Pb26+ + C2+
100
65μA
32
31
30
29
28
27
25
24
23
22
21
20
19
0.162
0.121
0 081
0.040
0.000
Intensity|microA
45.0
57.8
70.6
83.4
96.2
Magnet Current (Amps)
ABORT
TRACE
0.143
0.107
0.071
0.036
0.000
Intensity|microA
0.0
25.0
50.0
75.0
100.0
Time(in ms)
Spectrum #1
Source
MEASURE
RampParameters
MIN= 10.0A - MAX= 80.0A
STEP= 0.10 A
Dead Bands
TimeWindow
40.0 ms to 80.0 ms
StoreTrace
NO
Spectrum #2
Source
FILE
RampParameters
MIN= 45.0A - MAX= 100.0A
STEP= 0.05 A
Dead Bands
TimeWindow
47.6 ms to 78.9 ms
StoreTrace
YES
Trace #1
Samples/average
1
MagnetCurrent
80.00 A
Trace #2
Samples/average
1
MagnetCurrent
79.00 A

File Options Analysis Help

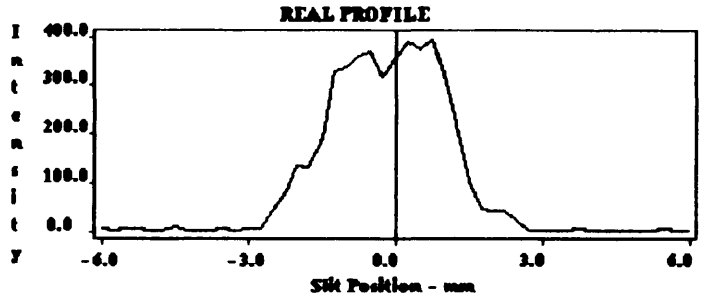
Start New Measure | Stop Measure | ALL *** | [redacted]

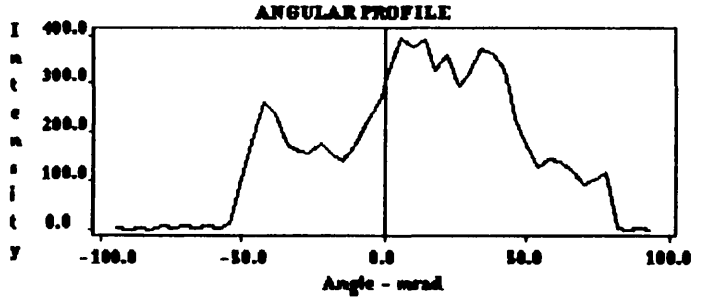
Measurement Dec 1 12:57:56 1993 File emlv_pb27_29119304.dat ---

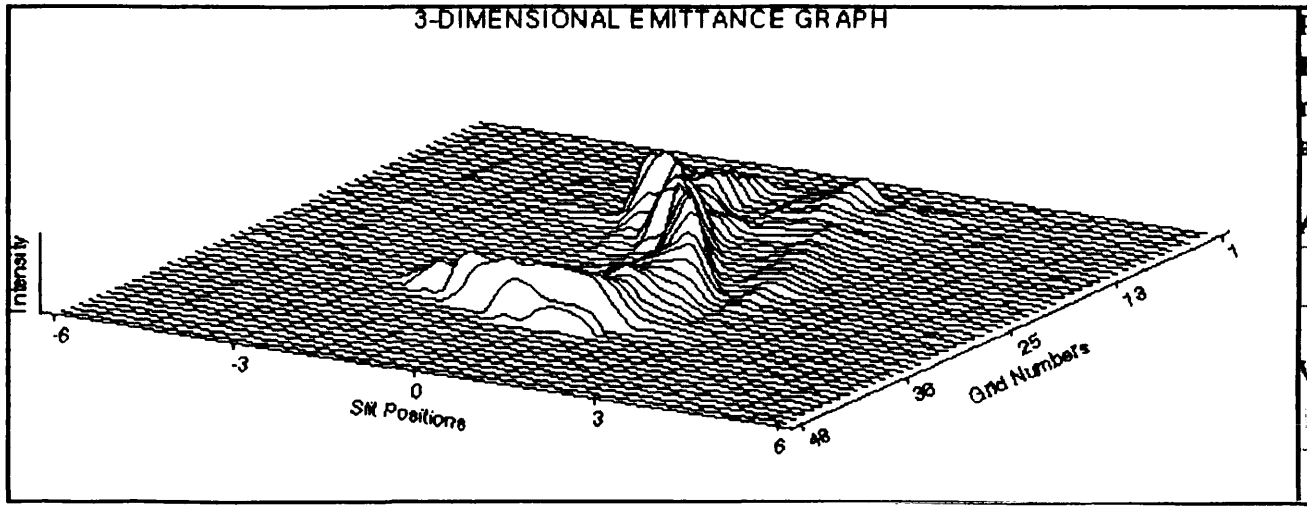


Legend:
0 - 10

Setup







Plane	Horizontal
Emittance	318.31
rms-Emittance	45.68
alpha	0.1177
beta	0.0327
gamma	31
Av. X	0.025
Av. Angle	7.8
THRESHOLD	0

DISPLAY CONTROLS

View -70 Rotation -30

X-Curves X'-Curves

StepSize 0.250000 mm

Max & Min values on Horizontal & Vertical motors read...

Parameters

High Voltage

Microwave power (forward & reflected)

Magnetic field (2 indep. coils)

Gas pressure (gas inlet by thermo valve)

Oven temperature

Vacuum

Vacuum

Pressure inside source: 1*10-5 mbar

Pressure in extraction region : 1*10-7 mbar

Pressure in LEBT 8*10-8 - 2*10-7

In case of high vacuum pressures: Poor performance
Pressures >1* 10-6: interlock trips

Gas inlet

Permanent flow of oxygen into source.

Poss. problems: Thermally controlled valve opens in case of power failure

Pressure regulation fails in case of failure of penning gauge. Incr. of pressure.

High Voltage

Determines beam energy

Energy requ. by RFQ: 2.5 keV/u

19.6 kV for Pb27+
20.0 kV for Pb26+
20.7 kV for PB25+

Possible problems:

Breakdown in extraction system
Breakdown outside (unlikey but poss.)
Voltage stability

Current from HV supply:

Normal 1-2 mA
In case of discharge in extr. system >2mA

Microwave Power

Usual operating range: 1-1.6 kW
Pulse length: 50 ms
Rep. rate 5-10 Hz

Reflected power <100W

Possible problems:

Miocrowave fails due to:

Arc fault in Klystron
Wrong or no filament current in Klystron
No cooling water
Internal interlock problem of transmitter
No magn. field in source (interlock)
Open cage (interlock)
Tuning out of range (interlock)

High X-ray level may be due to high microwave power

Oven for lead evaporation

Usual heating power 1-5 W (2.5W)

Possible problems:

Low or no heater power --> bad performance

heater power too high --> Contamination of source
Poor performance

Possible action in case of failure of microwave:
Turn off oven heating.

Distribution

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B. Frammery
D. Manglunki

/ed

E. Wildner ***

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