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THE NEW ELECTRON BEAM COLLECTOR FOR LEAR

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ABSTRACT

The present electron beam collector is derived from that used at ICE. It suffers from a poor electron recuperation efficiency and of a lack in reliability.
It has been decided to foresee the construction of a new collector which has been entrusted to CAPT at Lipetsk (USSR) under the authority of INP Novosibirsk.
This paper describes the desigh of the new collector taking into account the present environmental constraints and the need to insert a vacuum valve. First results of trajectory calculation are also presented.

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1. INTRODUCTION

Since more than two years CERN has made the effective experience of an electron-cooler inserted in LEAR. The overall project, derived from ICE[1)], has been managed by a KfK. team with the collaboration of some CERN members.

Many reports have been published on the results obtained with this device [2,3,4)], they are promising.

Electron cooling is in itself a complicated process and implies much hardware and software development. To be fully used in LEAR, it cannot suffer from any lack in reliability. Amongst all the "sensitive parts" the collector is the most unreliable. Its sophistication and bad reliability during tests has not yet allowed the LEAR Electron-Cooler to be put into normal operation.

In consequence CERN, has decided to look for another collector. The design, construction and test has been entrusted to CAPT with the collaboration of CERN (essentially on mechanical and vacuum techniques and computer simulations).

2. SPECIFICATIONS FOR THE NEW COLLECTOR

Some specific requirements must be fulfilled for this new collector which has to be installed on the LEAR Electron-Cooler. First of all, the collector must provide an efficient collection of the electron beam on a surface with a potential close to that of the cathode. "Efficient" in this case means that potential difference between cathode and collector is as small as possible and simultaneously that the current loss due to secondary and reflected electrons from the collector do not cause an increase in vacuum pressure inside the storage ring due to the residual gas desorption under bombardment of the chamber walls by electrons.

The high level of losses occurring in the present electron cooling device at LEAR (see Table 1) produces monotonous worsening of the vacuum during the working cycle and it results in the instability of the parameters of the cooled antiproton beam and other undesirable effects. It seems true that the main reason of this high level of current loss is due to the specific arrangement of the electron collector[1,5], where the "reflecting electrostatic needle" is used. The other reason to reconsider the LEAR-Collector scheme is its bad behavior under high voltage, and therefore high current, environment [4,6]. Particularly, it is at present impossible to collect electron beams with an energy higher than 15 keV.

Table 1 - Main parameters of the electron-cooling device

PARAMETER		PRESENT SYSTEM	SYSTEM UNDER DEVELOPMENT
Electron energy	keV	15	35 (40)
Electron beam diameter	cm	5	5
Electron beam current	A	2.4	3.3 (4)
Collector potential	kV	1.5 to 2.5	up to 3.5
Repeller potential	kV	0.8 to 1.5	up to 3
Current losses	mA	7.5	0.3
Average vacuum at collector level	pTorr	50	$\leq$10

3. THE DESIGN

During the elaboration of the new collector design some practical considerations were taken into account. The main difficulty of the new collector construction is that it must be integrated to LEAR which is intensively used for physics experiments. This dictated some additional conditions for the design and construction. They are:

1) The overall time which can be devoted for design, construction and test of the new collector is very short -less than one year-.
2) The collector must be supplied together with a vacuum valve in order to dismount and remount it without any significant influence on LEAR. It is worth remembering that the baking procedure is tedious and risky; it happens no more than once a year.
3) Most of the power supplies of the "old" system should be re-used in order to simplify and reduce the necessary investment and work.
4) The present allowed "volume" is limited.

The first condition excludes any application of a sophisticated collector system like reviewed in Ref. 5 (pp. 37-38). As a result, the simplest collector scheme was chosen. It is similar to the one used for the first electron cooling device at NAP-M storage ring[7]. The water-cooled Faraday cup together with a suppressor (repeller) electrode form the main frame. Magnetic shielding to form magnetic field geometry is sufficient to obtain a homogeneous electron density distribution onto the collector surface.

To fulfill the second condition, and not to distort significantly the main solenoid longitudinal magnetic field, an additional coil is placed near to the collector entrance. It can be powered with the power supply already used for the present collector entrance coil, "BBC", at LEAR.

4. SIMULATIONS

The collector scheme is given in Fig. 1.

The computations have been done using a dedicated software package[8].

In Fig. 2 are presented:

- The electron trajectories. They take into account the effect of the space charge of the primary electron beam. The electron beam input energy is 20 keV.
- The equipotential lines. They show an electrostatic trap inside the collector Faraday cup, near to collector output for the secondary electrons. This should forbid the exit of secondary electrons with initial energy less than 350 eV.
- The corresponding magnetic field distribution on the axis (radius $r = 0$). One can see the existence of a magnetic mirror near to the collector entrance of the primary beam.

The magnetic field lines are plotted in Fig. 3. They take into account steel saturation effects. The magnetic shield is placed outside the vacuum chamber. The used software package named "Poisson" is standard at CERN. The entrance coil is fed by a current of 6.986 kA.

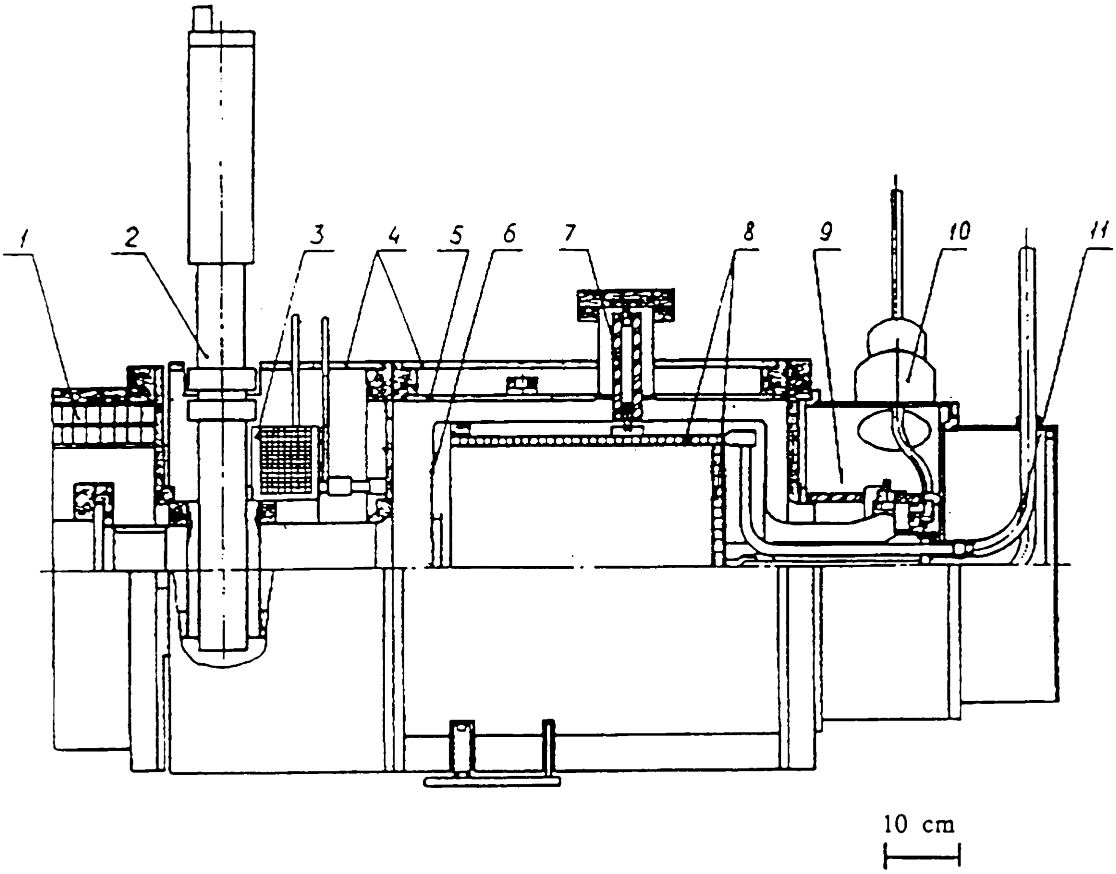
Many other computations have been made (and are underway) with other electrical potentials and magnetic fields.

If possible, one would try to simulate the trajectories of secondary electrons issued from the collector surface with different angles and energies.

A test bench is under construction at CAPT. It will be used later this year to test the performances of this project.

5. REFERENCES

1) Bell, M. et al., "Electron Cooling in ICE at CERN", Nucl. Instr. and Methods, Vol. 190, N2, 237-255 (1981).
2) Poth, H. et al., "First Results from Electron-Cooling Experiments at LEAR, Zeitschrift für Physik.
3) Wolf, A. et al., "Results from Electron Cooling Experiments at LEAR", Proc. of the 1988 EPAC Conference (Rome), Vol.1, 204-206 (1988).
4.) Bosser, J., Ley, R. and Tranquille, G., "Status of Electron Cooling Experiments at LEAR". This Workshop.
5) Poth, H., "Electron Cooling; Theory, Experiment, Application", CERN-EP/90-04, 36-38 and Fig. 22 (1990).
6) Poth, H. et al., "Further Results and Evaluation of Electron Cooling Experiments at LEAR", Nucl. Instr. and Methods, A287, 328-332 (1990).
7) Kudelainen, V., Meshkov, I. and Salimov, R., "The Electron Cooling Device", CERN 77-08, Part B, 63-64 (1977).
8) Herrmannsfeld, B., "Electron Trajectory Program", SLAC-226.UC-28.



1 - solenoid
2 - vacuum valve
3 - compensation coil
4 - magnetic shielding
5 - vacuum chamber
6 - repeller
7 - supporting insulator
8 - collector
9 - vacuum insulator
10 - feed through
11 - water cooling tubes

Figure 1: The new collector scheme

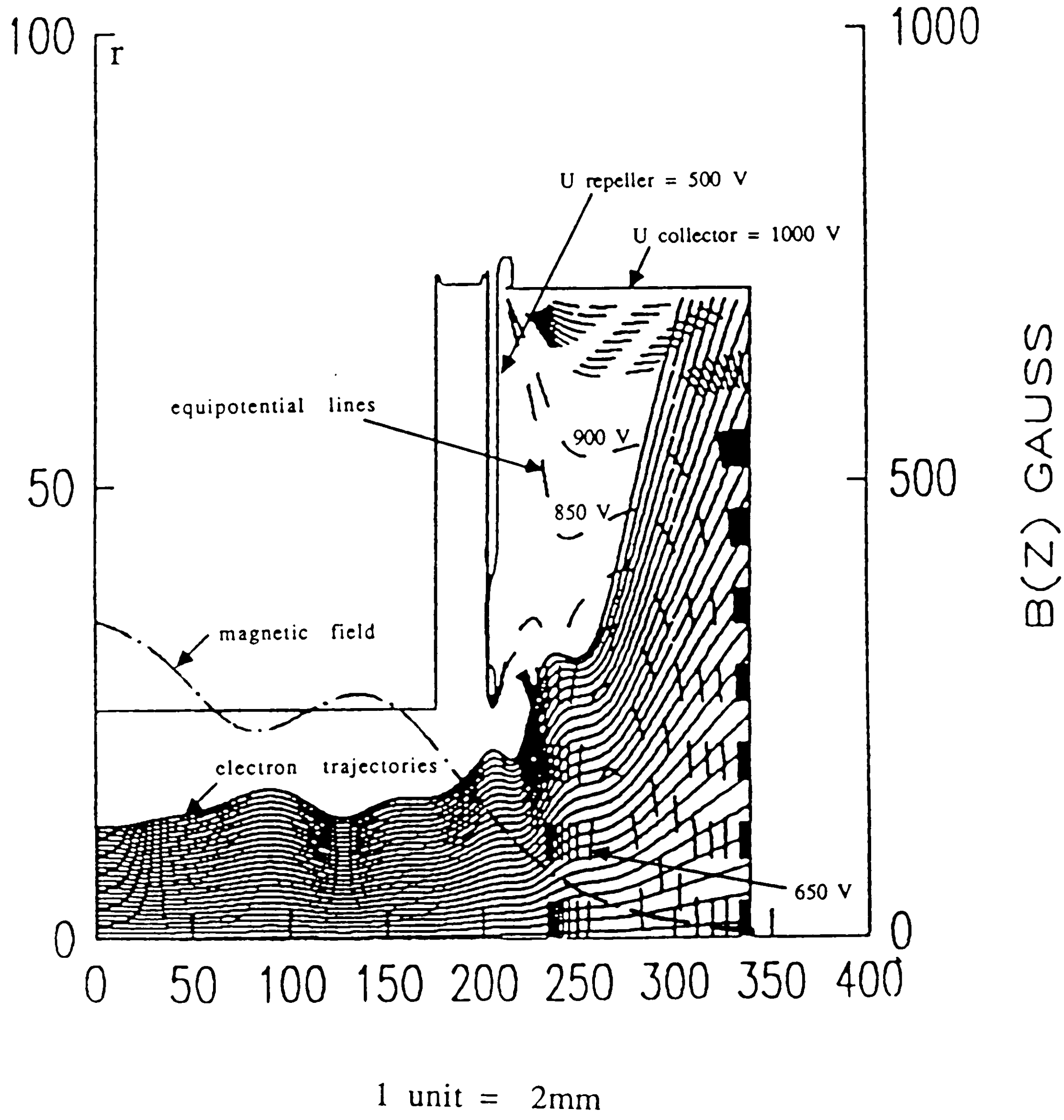


Figure 2: The electron trajectories with the equipotential lines and the corresponding magnetic field on axis (I coil = 1500 A)

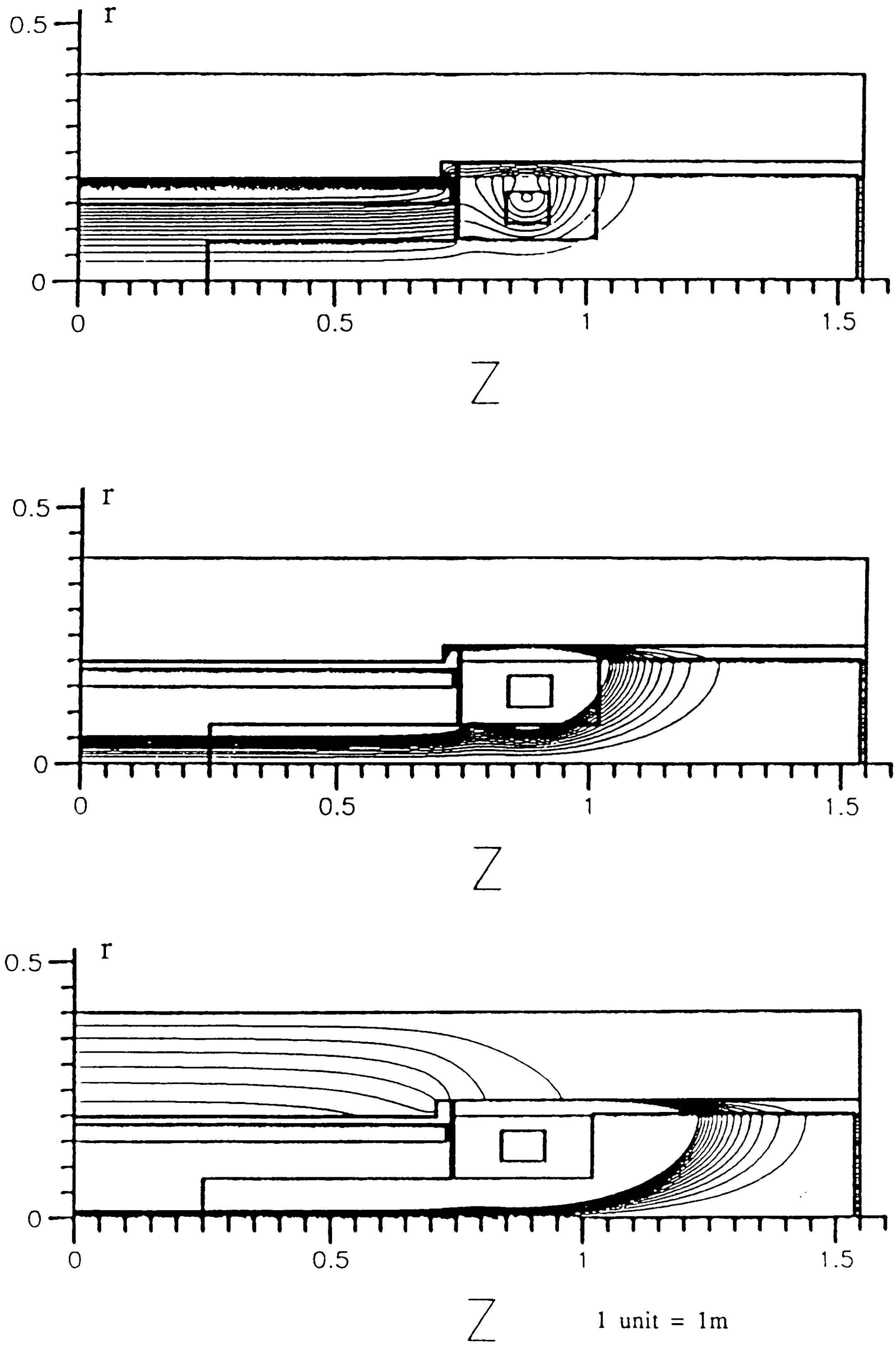


Figure 3: The magnetic field lines as a function of radius