BWA/cg

PS/DI/Note 95-16 (Min.)
15 June 1995

Minutes of PS Technical meeting N° 73
held on 14th June 1995

LEAR ion test results and e- cooling

Présents: *B.W. Allardyce, S. Baird, J. Boillot, J. Bosser, M. Bouthéon, C. Carli, M. Chanel, J.P. Delahaye, R. Garoby, G. Gelato, J. Gruber, H. Haseroth, C Hill, P. Lefèvre, R. Ley, S. Maury, D. Moehl, F. Motsch, H. Mulder, J.P. Riunaud, K. Schindl, C. Serre, D.J. Simon, G. Tranquille,*

C.C: *J. Boucheron, K. Hübner, H. Koziol, D. Manglunki, F. Perriollat,*

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1. D. Moehl noted that PS/AR/Note 95-06 gave extensive results of the December 94 LEAR ion MD's, and reminded us that the LEAR configuration at present only permits partial tests (cooling and lifetime) but excludes multi-turn stacking. The December tests gave an unexpectedly short (2 see) lifetime in the presence of e-cooling and we would really like to gain at least a factor 2. The objective for the June 95 MD were presented, in particular the use of 54^+ and 52^+ charge states in order to investigate the di-electronic resonant recombination effect which might explain the observed lifetime. Copies of D. Moehl's transparencies are attached in annex.

2. P. Lefèvre explained that a problem has arisen for lighter ions than Pb, as shown by C. Hill in PS/HI/Note-95-09. Light ions are not yet officially in the LHC project, but are likely soon to become part of it. The problem is linked to the Q/A values that the source can produce for ions like Kr, and the fact that the proposed scheme requires these ions to pass through the existing loop to get into LEAR, but the magnet cannot reach the required field strength. There is no short-term solution, so lighter ions will not be studied in LEAR this year. For the future there are several possible scenarios to get round this problem.

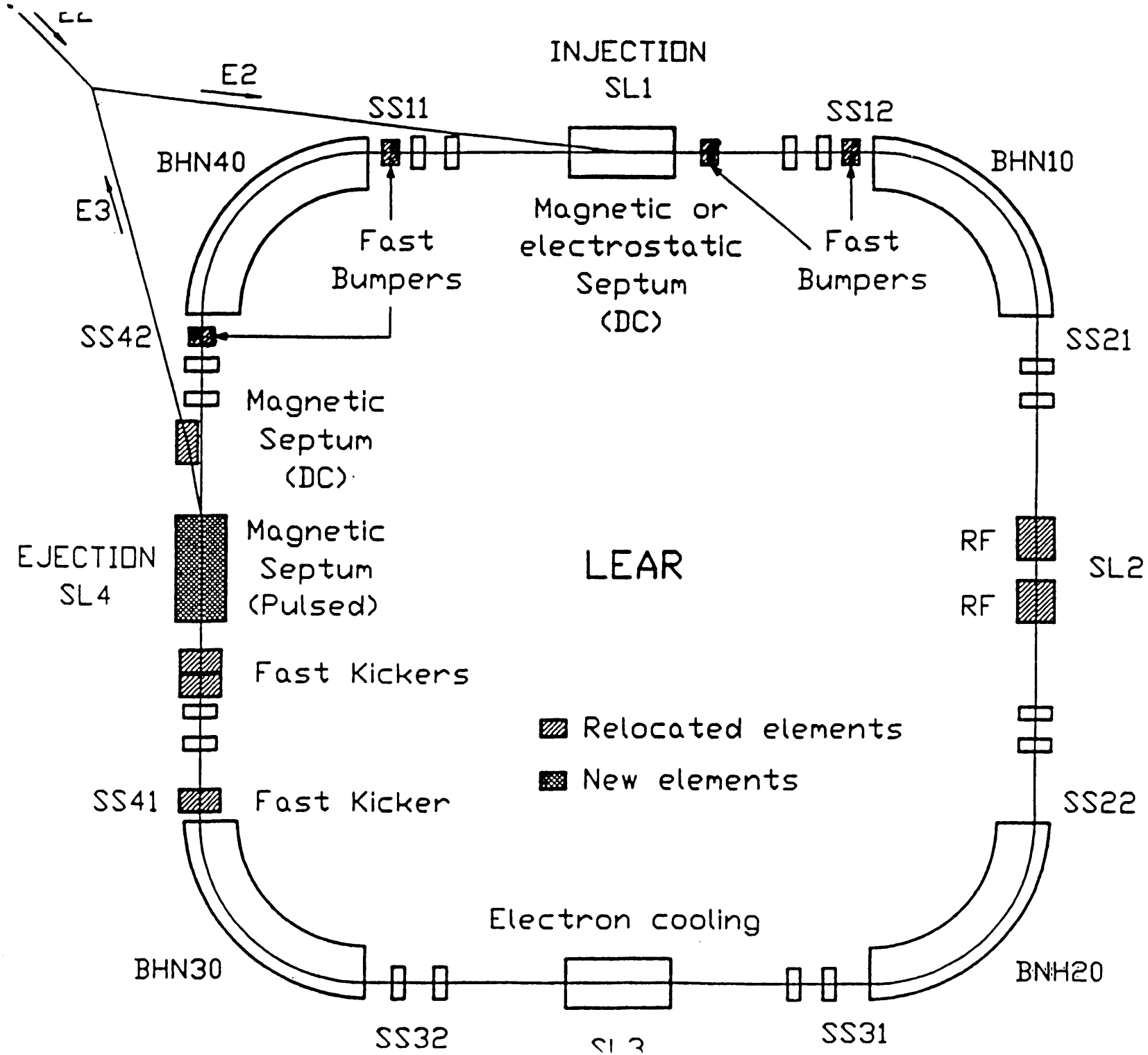
3. J. Bosser explained the status of the e- cooling work (see transparencies attached), in particular that the varying tube diameters means there is a natural neutralisation due to accumulated positive charges, but this is unstable and is

therefore an unsatisfactory situation. This problem will be solved in 1996 by the addition of an electrode in the solenoids. The neutralisation obtained with the existing polarised electrodes has been found to be unstable but the problem has been cured for the moment by using a "shaker" electrode, although this reduces the neutralisation factor which we are trying to increase. The improvements foreseen for 1996 include the installation of polarisation to counteract the effect of the different sized tubes, and the use of X-ray detectors to try to observe the X-rays emitted during the alleged di-electronic recombination effect with Pb^{53+} ions.

4. S. Maury and J. Bosser presented the status of the e- cool neutralisation collaboration with Russia. This has been an extremely well-run collaboration with clear goals having been set by CERN, and specific tasks evaluated before payment, and it may be considered a success. The collaboration continues until the end of 1995 but will then be completed. The PS allocated up to 2 x 50 kCHF over the 2 years of the collaboration. A selection of the transparencies shown is attached in annex.

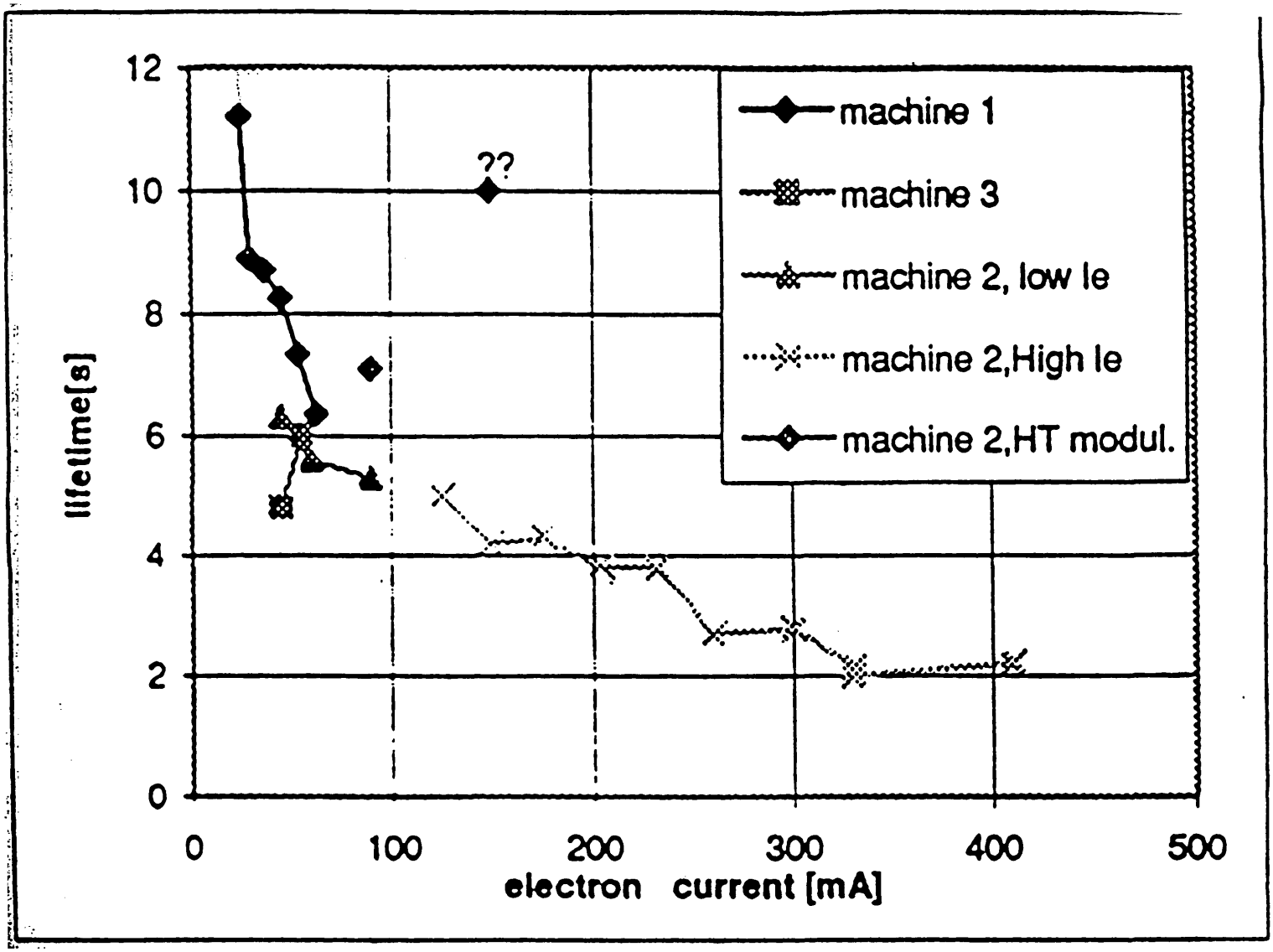
5. J. Bosser then explained that a new collaboration with CRYRING in Stockholm is being set up (see annex) whereby work of interest to LEAR e- cooling can be done on CRYRING with Pb ions as this machine has parameters which are not far removed from those of LEAR. Beam time already in 1995 is under discussion, but the collaboration document has not yet been established.

B.W. Allardyce


E2
INJECTION
SL1
SS11
SS12
BHN40
BHN10
E3
Fast
Bumpers
Magnetic or
electrostatic
Septum
(DC)
Fast
Bumpers
SS42
SS21
Magnetic
Septum
(DC)
EJECTION
SL4
Magnetic
Septum
(Pulsed)
LEAR
RF
RF
SL2
Fast Kickers
Relocated elements
New elements
SS41
Fast Kicker
SS22
Electron cooling
BHN30
BNH20
SS32
SS31

D. Möhl
14/6/95

D. MCHL
14/6/95


12
10
8
6
4
2
0
lifetime[s]
??
machine 1
machine 3
machine 2, low Ie
machine 2,High Ie
machine 2,HT modul.
0
100
200
300
400
500
electron current [mA]

D. MCHL
14/6/95

Notes in preparation of the MD

The aim of the MD is to investigate the Pb53+, Pb54+ and (if possible) Pb52+ beam lifetime in the presence of E-cooling.

Comparative measurements require careful adjustment of E-cooling for each charge state and ample time for "life and cooling data taking" (in all at least 24h/c.state)

Good adjustment of the transfer and injection is desirable but if this turns out time-consuming one can live with non-optimised transfer.

We propose that only the normal LEAR optics is used (except if there is lots of time left at the end).

3 shifts (schematically) a "machine -", an "e-cool- " and a "measurement shift" could alternate to share the time.

Recombination- and cooling-rate (1/e) should be explored as fct. of: alignment, Ie, B|cooler, Temperature of e-beam (excitation), energy displacement, neutralisation, " gun settings".. aperture (scrapers)... vacuum, Lear working-point, ion-intensity...,
with the aim to find a regime where tlife/tcool --> 20 - 50

D. McHL
14/6/95

Subject: MD June

Points to be checked:

SOURCE&LINAC:
- pulse "clipping" ,
- stripping and charge-state selection (BHZ11 -BHZ14) ,
- observation (MSG10 MSG05 ..)
- adjustment linac and line (to entrance E0) (SM on call (!!))

TRANSFER:
- optics of loop(E0) , E2, matching for 53+ 54+ 52+ ,
- nominal pictures on TV and SEM-grids
- instrumentation (SEM-grids, Transfo...)

LEAR :
- calculated settings for 53+ 54+ 52+, (B, Qdrpl., injection....)
- vacuum ,
- orbit, workingpoint, chromaticity...
- standart settings for instrumentation (Schottky long., -trans., BIPM, scapers, transfo(?)), lifetime measurement progrm.

E-cool : parameters to be used and changed ...

J. Bosser (1)

E-COOLING - NEUTRALISATION MD's
(AR - OP teams + visitors)

1) WHAT HAS BEEN PUBLISHED

a) MD November 94 report
PS/AR/Note (MD) 94-28

b) Collection of transparencies from discussion meeting on electron beam neutralisation
PS/AR/Note 94-29 (MDs)

c) Neutralisation:
- EPAC (London 1994)
- PAC (Dallas 1995) 2 papers
- Thesis (French) F. Varenne end 1995

d) lead ions
First Electron Cooling tests with Pb^{53+} ions (Dec 94)
PS/AR/Note 95-06 (MD)

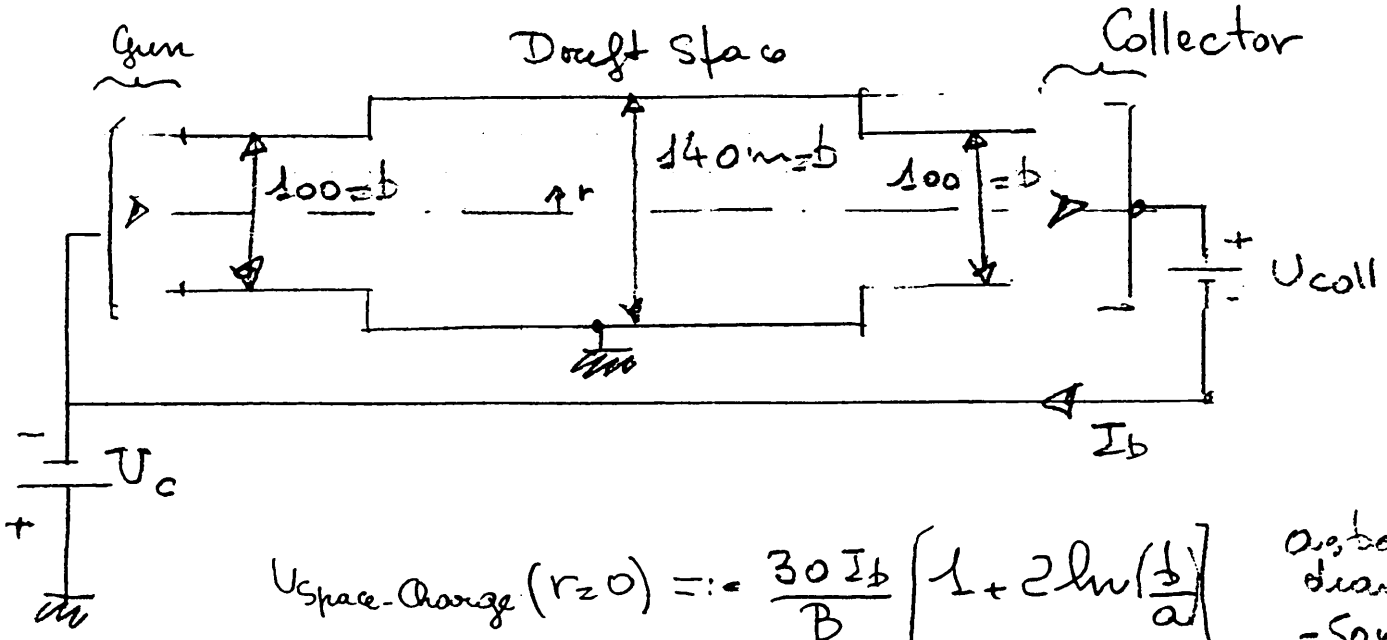
2) MD's BEGINNING 1995

Aimed:

* To understand some processes mainly related to instability (including that induced by natural neutralisation)

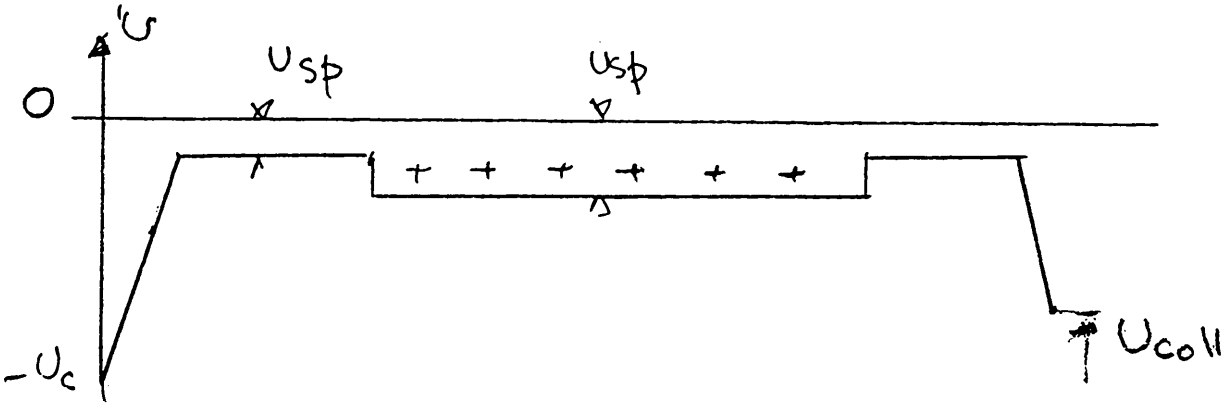
* Try to cure partially the instabilities

Natural neutralisation is due to the differences in tube diameters



$$U_{space\text{-}charge}(r=0) =: \frac{30\, I_b}{\beta}\left[1 + 2\ln\left(\frac{b}{a}\right)\right]$$

a: e-beam diameter = 50 mm



"Some" of our experiments were dealing with

a) Stability. For a given set of parameters the stability $\eta = \frac{\text{density of stored ions}}{\text{density of e-beam}}$,

is unstable. ⇒ Observation of instability Spectrum
Influence of ions (not made)
Reflected and stored e^-

J. Bisset ②

β) Cure of instability

* Feed-back: no success, will be improved
* Shaker ($\simeq$ 200 kHz) $\Rightarrow$ stable but the neutralisation factor is reduced.
* Shaker allow other measurements like BTF, standing waves, velocity distr. electron and ion coherent oscillation frequency

γ) Recombination $\bar{p} \rightarrow H_0$ to determine the e-beam temperature. Not always coherent with theory

δ) Electron beam for Pb^{53+} (4.2 MeV/u)

- 0.5 A with shaker: stable
- 0.9 A with shaker and blower stable for 5-6 seconds

ε) Influence of neutralisation on the transverse cooling time

- Reduction by 2 (Dixit J. Bosser)
- Reduction by 1 - 1.5 (Dixit others)

3) Improvement for beginning 96

- Feedback
- Transverse heating of e-beam. Test end 9
- Modification of the $\phi = 100$ collector tube (Fig

including
- * Polarisation (to avoid natural neutralisation)
- * Shaker + PU
- * Clearing of secondary or reflected e^-

- Improve position PU's (cables --)
- Inversion of collector toroid (expensive !)

Fig 2

X ray

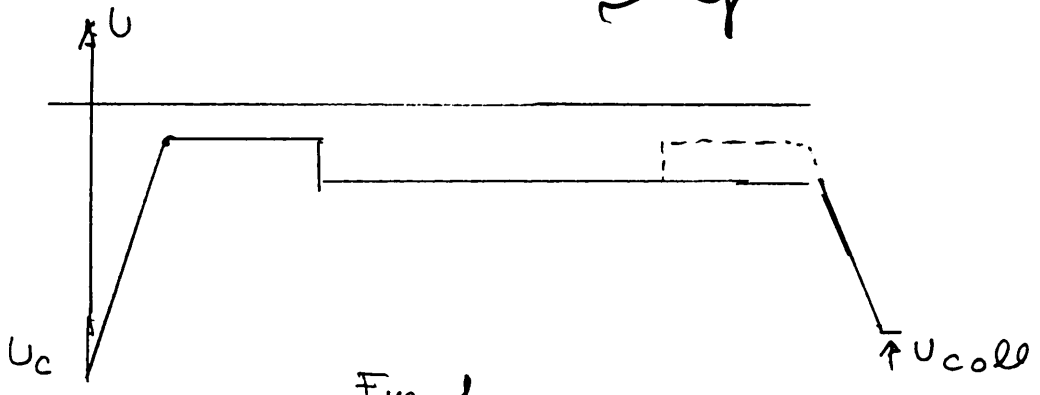


Fig 1

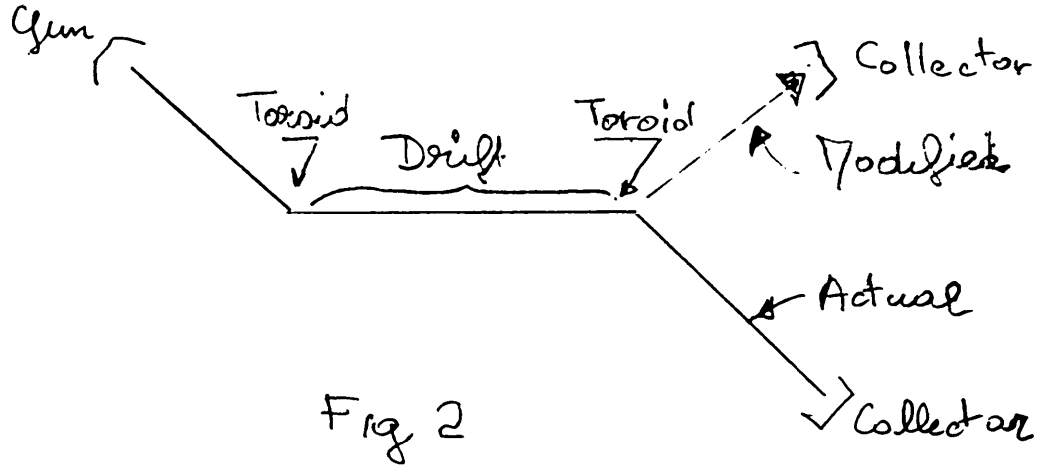
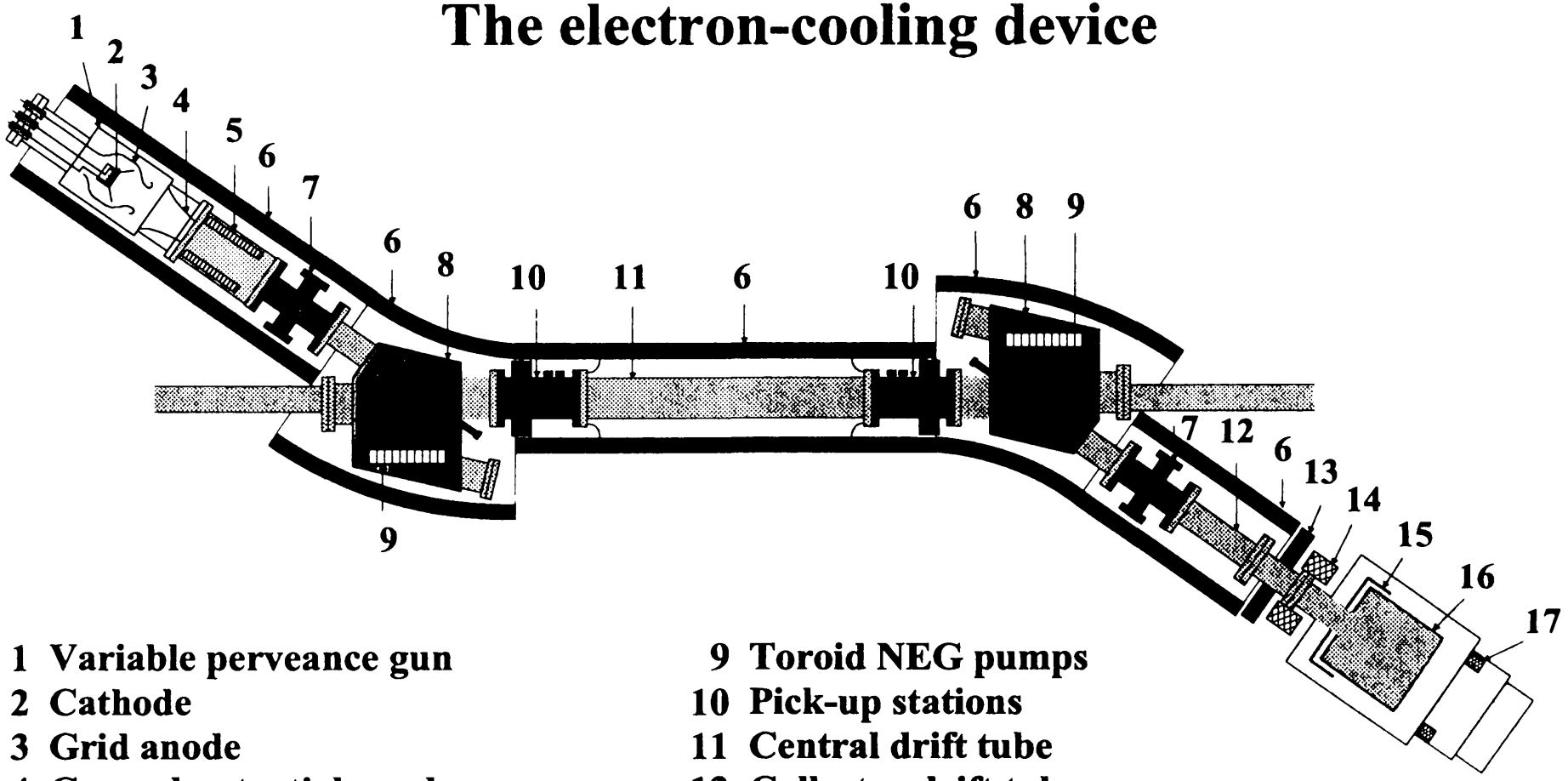


Fig 2

- Studies on Penning traps 2
- X rays ($\Leftrightarrow$) Pb^{53+}

The electron-cooling device



1 Variable perveance gun
2 Cathode
3 Grid anode
4 Ground potential anode
5 NEG pump
6 Solenoid
7 Neutralisation electrodes
8 Toroid chambers with pumps and diagnostic ports
9 Toroid NEG pumps
10 Pick-up stations
11 Central drift tube
12 Collector drift tube
13 Collector vacuum valve
14 Collector entrance coil
15 Repeller
16 Collector
17 Collector end coil

1.0 m

5 MARY
12/6/95

COLLABORATION RUSSIA - CERN

AIMS : Studies on the neutralization of dense electron beams (2 years)

* Official agreement : PS/AR/Note 93-22
* Help to F. Varenne's thesis (November 95

COST :

* PS Budget :

  2 x 50 k SF for 94 and 95

* Visits :

  . Russian experts to CERN

  1994 : 7 man. month
  1995 : 6 "

  . Cern experts to Russia

  1994 : 3 man. month
  1995 : 3 "

S. MAURY
14/6/95

Why this study ?

Cooling time $\tau \sim \frac{1}{I}\left(\frac{A}{Z^2}\right)$

Intensity $\frac{I}{\pi a^2} = e\, n_e\, v_e$

Radial E. field $E_r = \frac{n_e (1-\eta)}{2\pi\varepsilon_0}\,\frac{r}{a^2}$ $r<a$

We need $\tau \searrow \Rightarrow I \nearrow \Rightarrow n_e \nearrow$

$\Rightarrow E_r \nearrow \Rightarrow v_\perp \nearrow$

$\Rightarrow$ Bad cooling

No, if $\eta = \frac{\text{Nb of ions}}{n_e} \nearrow$

S. MAURI
14/6/95

* Studies with subject :

. 7 subjects 1800 SF / Russian expert

. Complement to the official agreement
PS / AR / Note 94-13

Subjects :

1. Asymetric Poisson equation + Trajectories
2. Neutralisation diagnostics
3. Transverse emittances measurements
4. Neutralisation process
5. Theoretical stability studies
6. Influence of secondary electrons
7. Influence of particle species on stability

PREDICTION FOR 1995

Visits from Russian experts :

. E. Syresin : 21/02 - 21/03 (1 month)
. I. Meshkov : 17/03 - 11/04 "
. I. Meshkov : 20/06 - 19/07 "
. E. Syresin : 05/08 - 05/10 (2 months)
. P. Zenkevich : August (?) (1 month)

Visits of CERN experts

. D. Mohl (?)

J. BOSSER
1 14/6/95

PS/AR/JB/ar

PS/AR/Note (Spec)94-27
5 December 1994

STATUS OF THE STUDIES ON THE NEUTRALISATION OF DENSE ELECTRON BEAMS

1) Introduction

This note aims to give the present status of the collaboration, between the CERN/PS and the JINR, Dubna, on neutralisation of dense electron beams.

The terms of the collaborations have been fixed by a protocol PS/AR/Note (Spec) 93-22 and the subjects, to be studied, given in note PS/AR/Note 94-13 (Spec).

It is worth recalling that an annual sum of S0=50KSF has been allocated to this project.

2) Issues of the collaboration in 1994

2.1) Invitation to CERN of Russian experts.

The visits are summarised in Table 1.

Names	Amount
Ter-Akopian	1125
Meshkov	8355
Syresin	9000
Smirnov	4500
Polyakov	4500
Lavrentiev	4500
Zenkevich	3124
Total S1	30604

Table 1

2.2) Expert work.

Five subjects have been proposed to 7 Russian experts (Refer to PS/AR/Note 94-13 (Spec). A stipendium of 1800 SF has been allocated to each of the experts. Our conclusions are summarised in Table 2.

2 J Bosser 14/6/95

Subject No	No of Experts	Percent of Work	Amount
1	1	20	360
2	2	30	1200
3	1	20	360
4	1	30	540
5	2	100	3600
		Total S2	6060

Table 2

Therefore S2=6060 SF will be paid at the end of 1994 and the remaining S3=7 · 1800-9300=6540 SF will be paid in 1995 at the completion of the pending subjects 1 to 4.

2.3) Balance.

The expenses for the 1994 amount to S1+ S2=36664 SF to which we must add S3 which is expected to be paid in 1995. Consequently it may be considered that S1+S2+S3=43204 SF has been spent for the collaboration during 1994.

2.4) Visits by CERN experts.

Three CERN experts have visited Russia for technical and experimental works.

3) Expected collaboration during 1995

3.1) Russian visits.

We expect 6 man months and therefore an expense by CERN of S4=6 · 4500=27000 SF.

3.2) Expert work.

Subjects 1 to 4, and their corresponding Russian experts will receive no additional funds (see also 2.2).

We foresee that the subject 5 has to be continued by the two previous experts. To this we add subjects 6 and 7 (given in annex) to be treated by one expert each. Therefore S5=4 · 1800=7200 SF will correspond to this expert work.

3.3) Hardware supply.

In order to do some special experiments, resulting from the conclusions of the 1994 collaboration, we propose to allow S6=10000 SF for the implementation of experimental apparatus of the JINR electron beam test bench (the moving of the test bench from CAPT Lipetsk to JINR, Dubna is not included in these 10000 SF).

J. Gosser
14/6/95

COLLABORATION WITH CRYRING

CRYRING (K.G. Rensfelt) proposed us:

a) Beam time for measurements on e-cooled Pb^{53+} ions

b) Collaboration for e-cooler improvements (new cooler?) in the frame of the Swedish collaboration to the LHC project.

We asked to postpone b)

We submit a registration form for a)

- 1 week End August - Beginning Sept 95
  +
- 1 week in October 1995
- Wait for 1996
- Cryring user meeting 12 and 13 June 95