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STATUS AND FUTURE POSSIBILITIES OF THE STOCHASTIC COOLING SYSTEM FOR LEAR

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ABSTRACT

The results reached are now : momentum cooling at 609, 309 and 200 MeV/c, vertical cooling at 609 and 309 MeV/c, horizontal cooling at 609 and 309 MeV/c.

Improvements planned in a near future, especially in the horizontal plane, are presented.

Lecture given to the third LEAR Workshop
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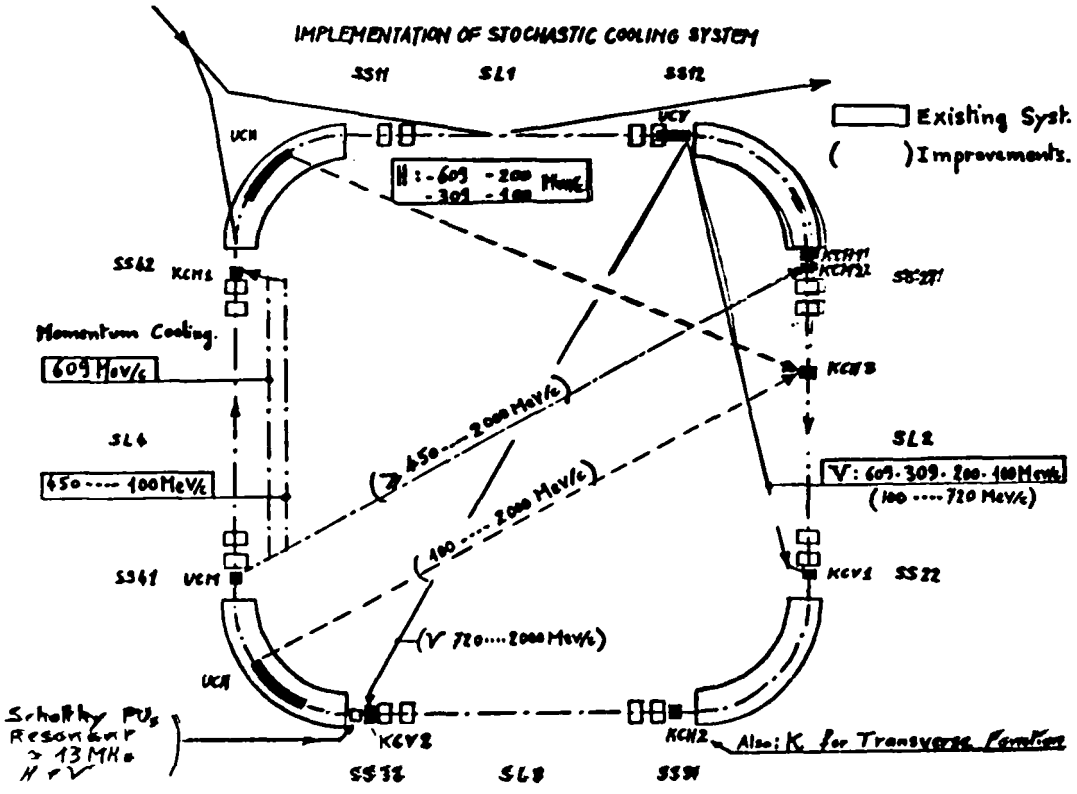

IMPLEMENTATION OF STOCHASTIC COOLING SYSTEM
SS11
SL1
SS12
Existing Syst.
( ) Improvements.
UCH
UCV
H: -609 -200 Mev/c
-309 -100 Mev/c
SS62
KCH1
KCH11
KCH12
SS21
Momentum Cooling.
609 Mev/c
KCH3
SL6
450 ---- 100 MeV/c
SL2
V: 609-309-200-100 Mev/c
(100 ---- 720 MeV/c)
(450 ---- 2000 MeV/c)
(100 ---- 2000 Mev/c)
SS61
UCM
KCV1
SS22
(V 720 ---- 2000 Mev/c)
UCA
Schottky PUs
Resonant
> 13 MHz
H + V
KCV2
KCH2
Also: K for Transverse Feedback
SS32
SL3
SS31

1°) Momentum cooling

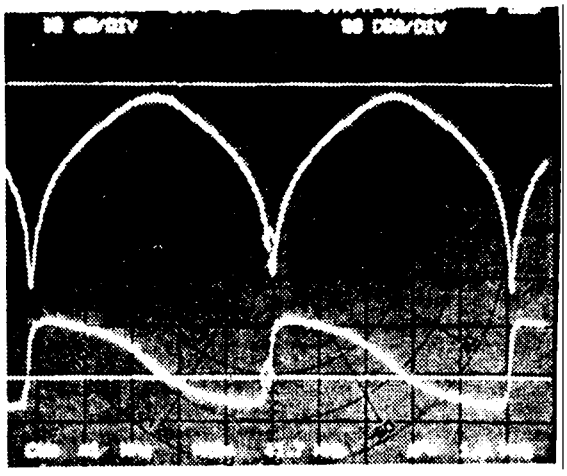
There are two systems, each using the same pick-up: one short fixed system for injection at 609 MeV/c and another synthesized adjustable system for 100 to 450 MeV/c.

The pick-up is built with 24 rings of ferrite in air, around a ceramic chamber:

- 24 low noise amplifiers (2.5 dB noise figure) are combined in a sum network, which are adjusted in electrical length according to the beam velocity;

- two line filters: one fixed in electrical length 2 x 144 m of foam cable for 609 MeV/c; the second variable in electrical length between 70 and 700 m in increments of 2.5 cm per step.

The kickers are built in the same way as the pick-up. The power amplifiers output is 20 W between 20 and 200 MHz.



Amplitude: 10 dB

Phase: 90°

Figure No. 1 : Line filter response

- Results with fixed system at 609 MeV/c

The photographs show the Schottky signal from the pick-up.

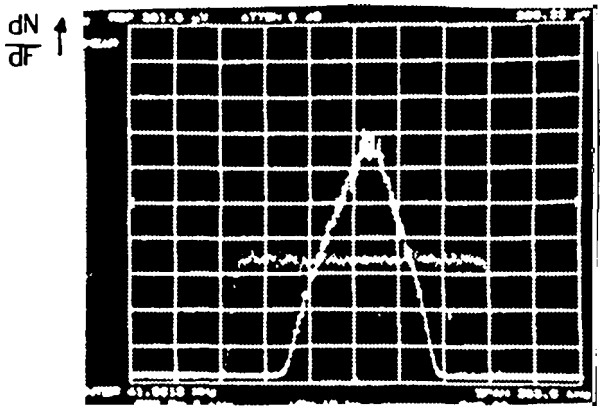


Figure No. 2:
3.15×10^9 protons
The density is increased by a factor of 3.7 in 3 minutes.

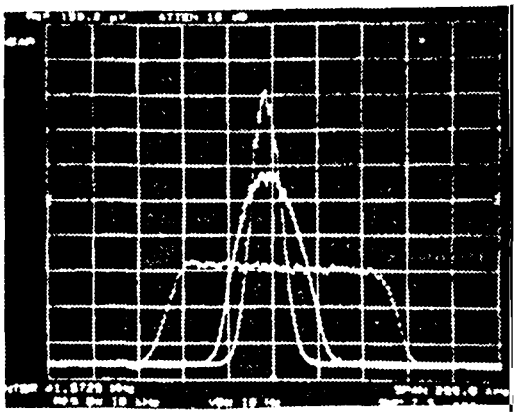


Figure No. 3:
0.65×10^9 protons
3 minutes of cooling between each trace.

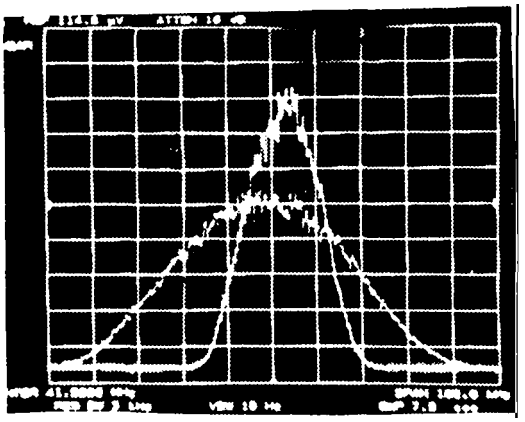


Figure No. 4:
0.5×10^9 antiprotons
The density is increased by a factor of 2.2 in 3 minutes.

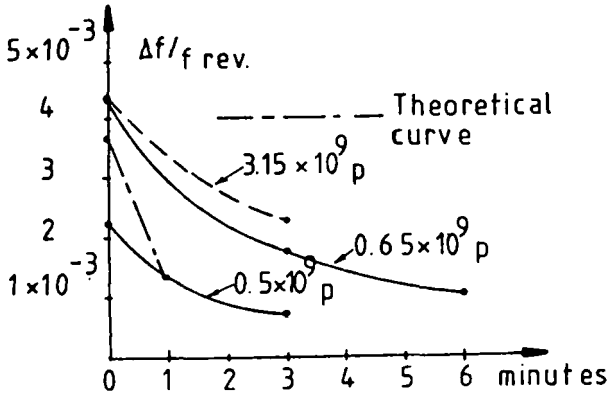


Figure No. 5:
Cooling efficiency with respect to number of particles

- Results with synthesized systems

a) At 309 MeV/c

Frequency range: 15-100 MHz; revolution frequency: 1.192 MHz

Relative velocity of beam (β) = 0.313

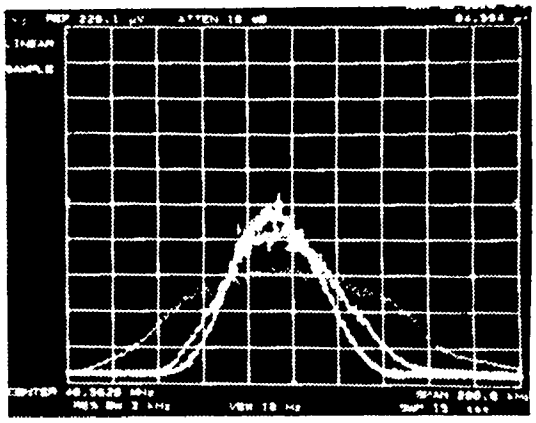


Figure No. 6:

2.7×10^9 protons
3 minutes of cooling between each trace.

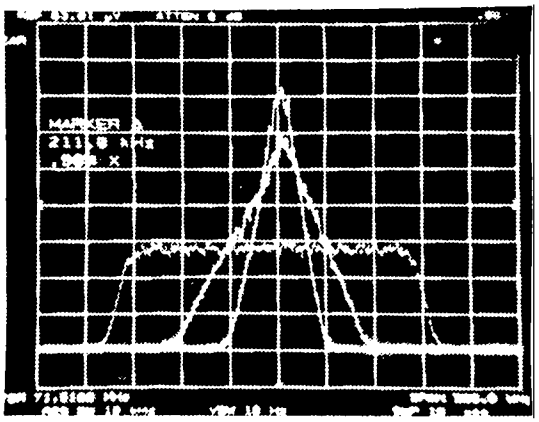


Figure No. 7

0.5×10^9 protons
3 minutes of cooling between each trace.

b) At 200 MeV/c

Frequency range: 15-100 MHz; $f_{rev.}$= 0.7976 MHz

Relative velocity of the beam = 0.213

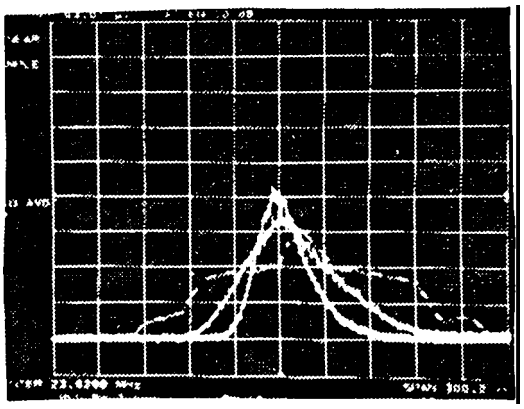


Figure No. 8:

1×10^9 protons initial
0.8×10^9 p after 3 minutes of cooling
0.65×10^9 after another 3 minutes (losses in horizontal plan).

2°) Vertical cooling

The pick-up is built with 8 pairs of loop electrodes. Each side of the electrodes are connected to a low noise amplifier (2 dB noise figure): one output for energies > 300 MeV/c and the other for energies < 300 MeV /c.

The combiner network is adjustable in electrical length, so as to get a synthesized adjustment for all energies in the range of 2000 to 100 MeV/c.

The kicker is built with only one pair of loop electrodes.

- Results

Frequency range : 50-650 MHz
Power : 500 mW

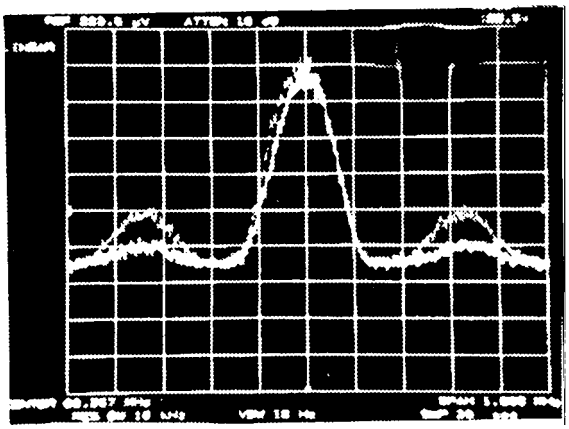


Figure No. 9:
1 x 10^9 proton
309 MeV/c after 3 minutes of cooling

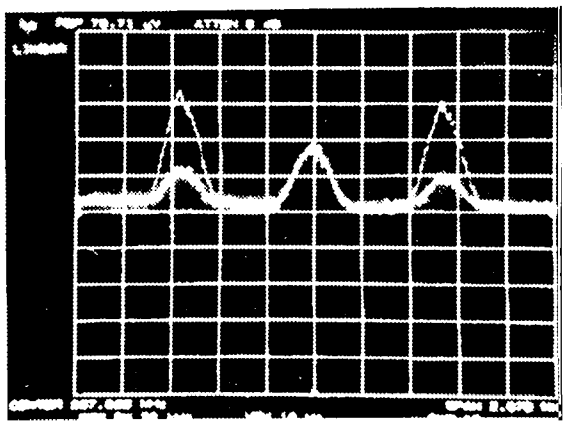


Figure No. 10:
1.4 x 10^9 protons
609 MeV/c after 2 minutes of cooling

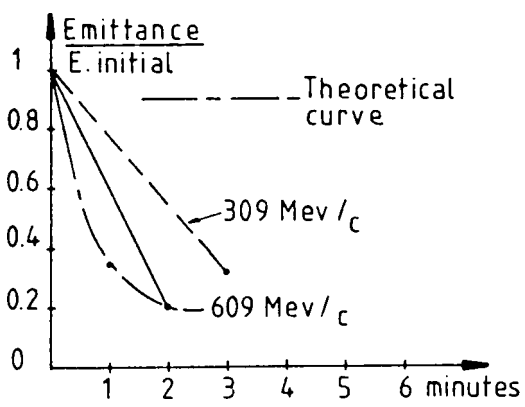


Figure No. 11
Emittance
Comparative values with theoretical curve.

3°) Horizontal cooling

The pick-up is built with 12 pairs of electrodes. The signals are combined in the same way as for the vertical pick-up. The kicker is also built with one pair of loop electrodes.

- Results

Frequency range : 50-650 MHz

Power : 1 Watt

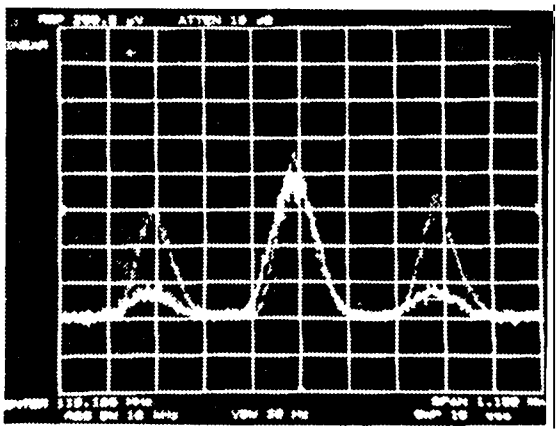


Figure No. 12:
2×10^9 protons
309 MeV/c after 5 minutes of cooling

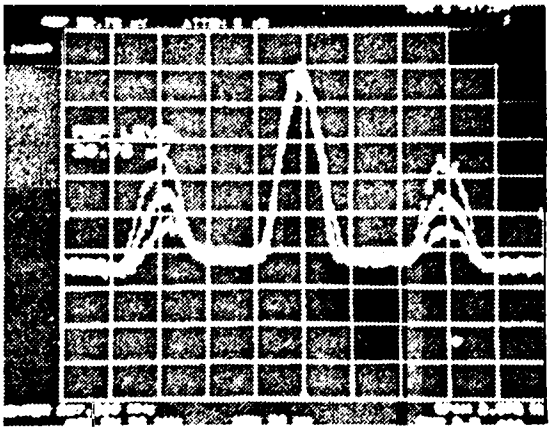


Figure No. 13:
3×10^9 protons
609 MeV/c after 2 and 3 minutes of cooling

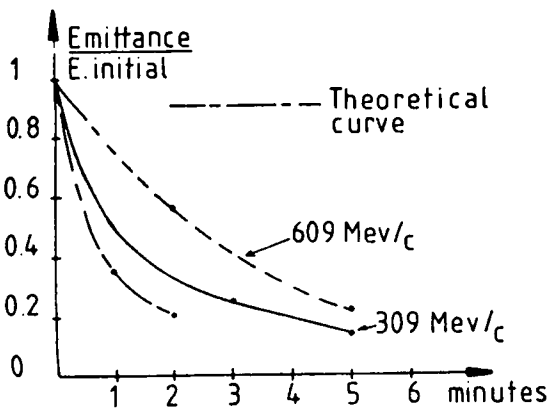


Figure No. 14:
Emittance
Comparative values with theoretical curve.

4°) Improvements

In the momentum plane

- We must optimize the upper frequency pass-band following energy and $\Delta p/p$;
- We must also make a connection with kicker 21 for E > 450 MeV/c.

In the vertical plane

- It is necessary to balance gain between upper and lower electrodes, in order to minimize the revolution frequency signal.
- The summation pick-up system will be modified for synthesized delays in combining network, i.e. all energies.
- We require a kicker s.s. 32 for E > 700 MeV/c.

In the horizontal plane

- We will balance gain between external and internal electrodes in 3 groups of 4 pairs of electrodes.
- Then, we will add the signal from pick-up s.s. 3 to pick-up s.s. 4.
- The pick-up s.s. 4 is fixed at 4 energies, pick-up s.s. 3 is synthesized, but the upper pass-band is limited to 500 MHZ because minimum step increment with electrical length system is 13 cm.
- If we want to increase the upper pass-band in pick-up s.s. 4 to 1000 MHz, we must install a damper for microwaves in the vacuum chamber, between horizontal kicker and vertical pick-up. (The first microwave mode TE11 should appear at the frequency:

$$\frac{1}{2} \cdot \frac{c}{\text{width}} = \frac{1}{2} \quad \frac{3 \times 10^8}{.2} = 750 \text{ MHz}).$$

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