STOCHASTIC COOLING TESTS IN ICE

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ICE (for Initial Cooling Experiment) is a storage ring, built for testing both stochastic and electron cooling of proton beams in view of future application in a scheme for collecting antiprotons.

The ring, shown in Figure 1 is the transformed g-2 muon storage ring. Its main parameters are:

Proton momentum	1.73 GeV/c
Average radius	11.8 m
Working point	$Q_H = 1.35$, $Q_V = 1.55$
Number of circulating protons	10^7 - 10^{10}
Average vacuum pressure	3×10^{-9} Torr
Beam lifetime (no cooling)	40 mins.

We have recently made stochastic cooling tests which confirm the existing theory at cooling rates several orders of magnitude higher than those previously obtained in the CERN Intersecting Storage Rings (ISR)[1].

Three cooling systems are installed. Two of these reduce the horizontal and vertical betatron oscillations; they are similar to the systems used before in the ISR. The third system reduces the momentum spread using for the first time the so-called filter method[2].

Momentum spread and oscillation amplitudes were determined by means of Schottky scans, i.e. frequency analysis of the noise voltage induced by the particles in longitudinal or transverse pick-up electrodes[3].

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This noise is caused by statistical fluctuations in the density of the proton beam, due to the finite number of protons; a similar noise signal, over a larger bandwidth (100 - 180 MHz) is fed back into the beam via kicker electrodes and so provides stochastic cooling. In addition to the Schottky scans, a beam profile detector was used to observe the reduction of the horizontal beam width.

Figure 2 shows a typical longitudinal Schottky scan. The flat, wide initial momentum distribution is changed into the peaked curve by momentum cooling for 204 seconds. This particular result was obtained with a beam of 3.4×10^8 particules. At lower intensities, the cooling is faster. With 7×10^7 protons, the width of the momentum distribution was reduced by a factor e in 15 seconds.

Betatron cooling was slower, mainly because of a lower signal-to-noise ratio for the transverse channels. As an example, with 3.9×10^8 particles, horizontal and vertical cooling times of about 4 minutes were observed.

Simultaneous cooling in the three degrees of freedom resulted in beam lifetimes of about 20 hours, a value consistent with losses due to single scattering on the rest gas.

These results confirm the theoretical predictions[4), 5)], and the scan of Figure 2, when scaled by the relevant parameters (ring size, bandwidth, quality factor of the filter, number of particles, frequency spread) agrees with the performance required for fast precooling in the proposed antiproton accumulator[6)].

It is a pleasure to acknowledge the assistance of the many people at CERN who contributed to the building of the ICE ring.

Figure 1. General view of the ICE storage ring.

Figure 2 Longitudinal Schottky scan. The horizontal scale is the frequency around the 17th harmonic of the revolution frequency. It corresponds to momentum spread ($\Delta p/p = 5 \times 10^{-4}$ per division). The vertical scale corresponds to the square root of the particle density.

References

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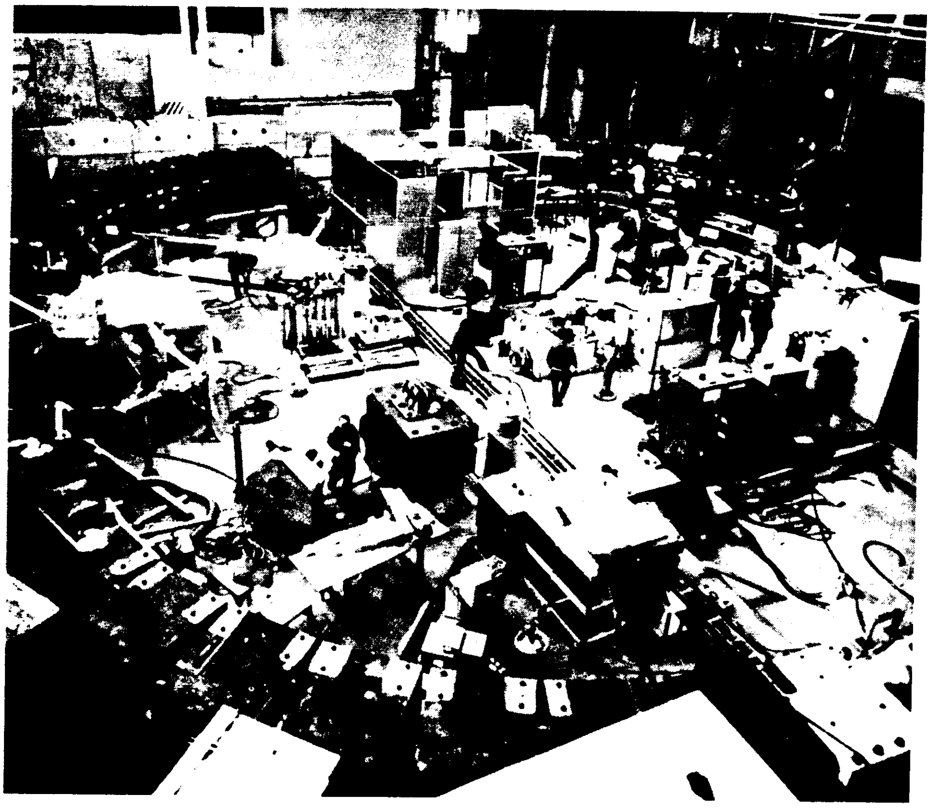

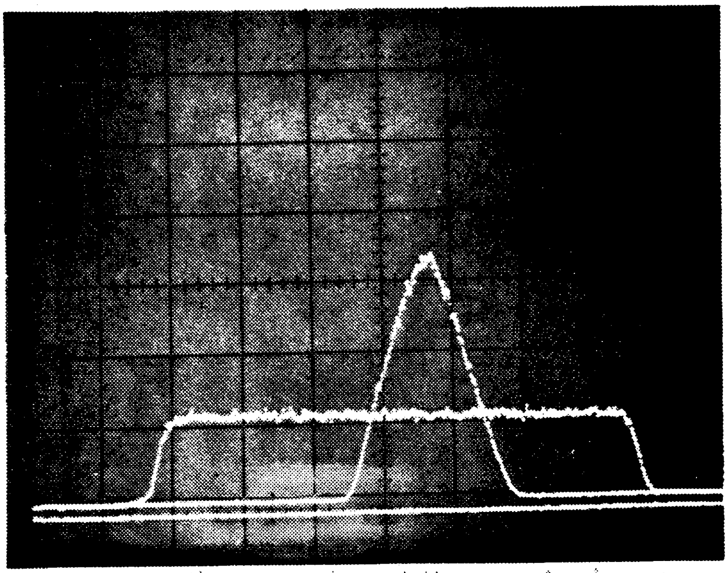

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