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LEAR MD Report: Oxygen ions storage tests (05-10/05/92)

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Aim of the MD:
- Stacking of oxygen ions (O^{8+} and O^{6+}) to the maximum density
- Measurement of cooling times for the two species.
- Measurement of lifetimes for the two species.
- Search for instabilities

Stacking:
Method:The now standard stacking scheme used at LEAR [1,2] has been simplified as follows: RF gymnastics have been reduced to a minimum. The coasting beam is bunched on harmonic one, and the incoming beam is injected on the unstable phase. The RF voltage is then ramped down in 10 milliseconds. Electron cooling is applied continuously during the whole process.
Intensities: injection took place once per supercycle, i.e. every 14.4 seconds. Each injected pulse contained between 2 and 5.10^8 charges. Up to $6.4.10^{10}$ charges of O^{8+} and $4.8.10^{10}$ charges of O^{6+} (i.e. 8.10^9 ions in both cases) could be accumulated in the machine this way [Fig 1].

Electron cooling:
Longitudinal cooling times were measured with two different methods: "Receiver mode" and "Snapshot".
In the "receiver mode", method, the beam is first shaped with a constant RF noise of suitable power and bandwidth until its density is grossly squared [Fig 2]. A spectrum analyser looks at one longitudinal Schottky band, with a null frequency span, thus giving as output the time evolution of the central density. The cooling time is deduced from this curve [Fig 3]. In the snapshot method, the spectum analyser's frequency span covers the whole band, and the experiment is repeated several times, with a measurement trigger which is every time delayed, yielding a "movie" of the cooling process.
The equilibrium transverse emittances were measured with the scrapers.
The result of the measurements are summarised in table 1.

	O^{8+}	O^{6+}
Number of charges for this measurement[10^{10}]	5.0	3.0
$\tau_{EC//}$ [seconds]	0.4	3.0
ε_H [π.mm.mrad]	7.0	6.1
ε_V [π.mm.mrad]	12.0	8.2

Table 1: Cooling times and transverse emittances for both charge states.

Lifetimes:

The measured lifetime was 90 minutes for the O^{8+} beam under electron cooling, and 4.3 minutes for the O^{6+} beam. The difference is explained by the stripping of the O^{6+} ions by the electrons and by the residual gas..

Instabilities:

The fact that no stacking was possible without the transverse damper showed evidence of transverse instabilities. Transverse instabilities were observed on Schottky pick-ups [Fig 4].

During the stacking process, we normally debunch the beam in 10 milliseconds. However, at large intensities, we could observe a coherent signal for about 300 milliseconds after the RF voltage had ramped down to zero [Fig 5]. A density modulation signal was observed on the electrostatic pick-ups [Fig 6].

References:

[1] S.Baird et al."Stochastic cooling and storage tests with oxygen ions in LEAR". Proc 1989 Particle Accelerator Conference, Chicago (USA), March 20-27, 1989

[2] S.Baird et al. "Oxygen ions in LEAR". Proc EPAC90, European Particle Accelerator Conference, Nice (France), June 12-16, 1990.

[3] J.Bosser et al. "Electron beam cooling and beam instability studies at LEAR". CERN/PS 92-45 (AR)

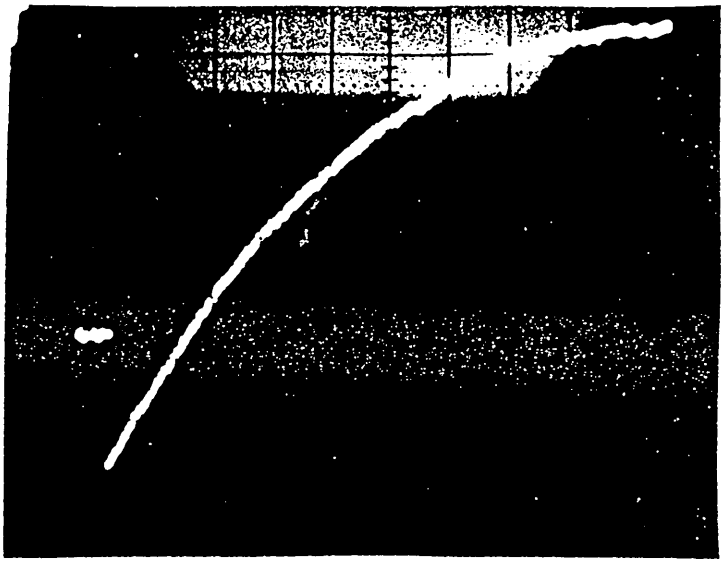


Fig 1. Accumulation of O^{6+}
Timescale: 100 s/cm
Intensity scale: $5\ 10^9$ charges/cm

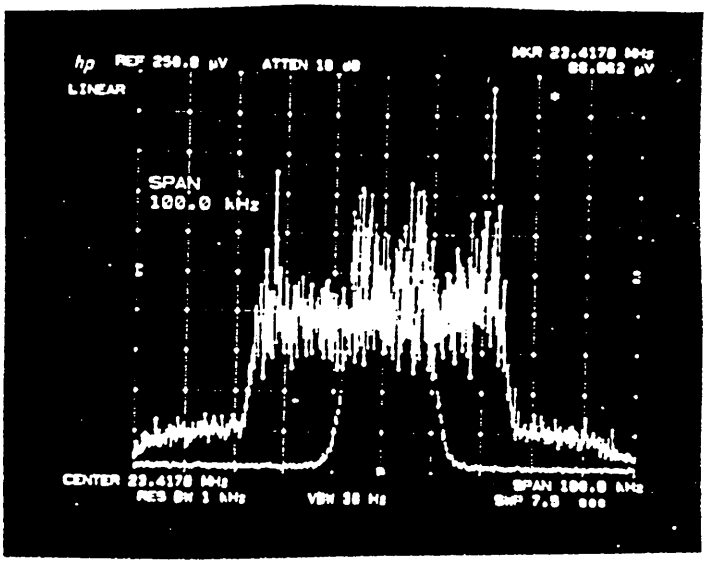


Fig 2. Shaping of the beam for longitudinal cooling time measurements.

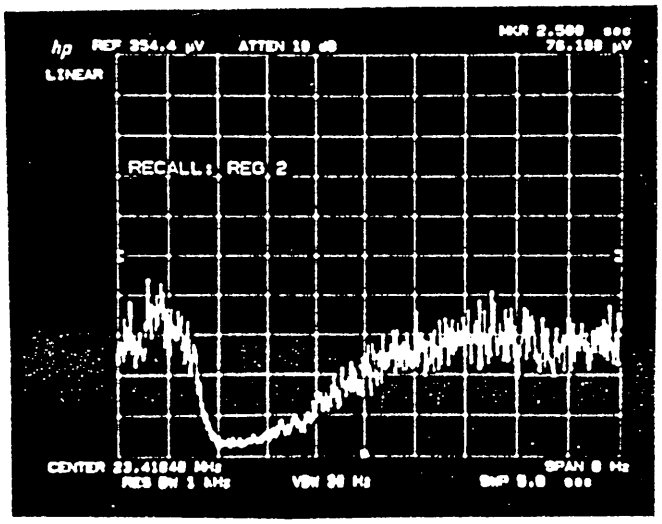
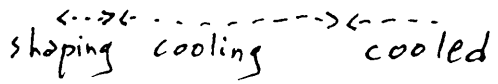


Fig 3. Evolution of the central density
time scale: 0.5 s/cm



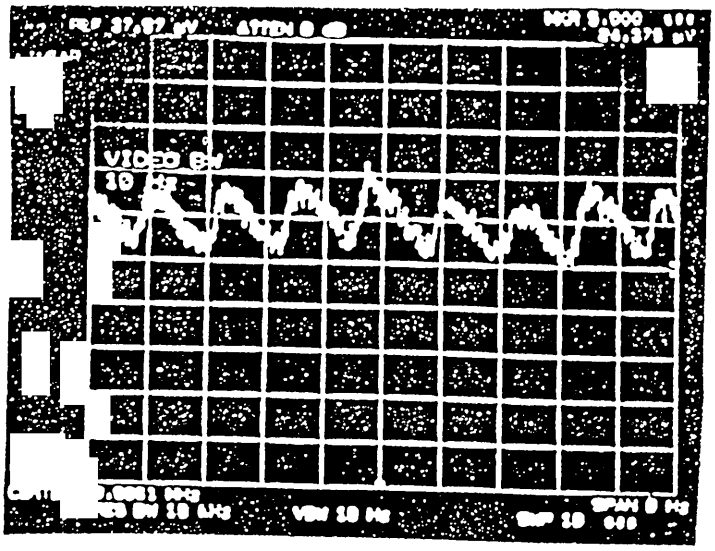


Fig 4. Vertical instabilities.
A sideband is observed in "receiver mode" (span 0 Hz).
The beam is cooled, then blows up every second
Time scale 1s/cm

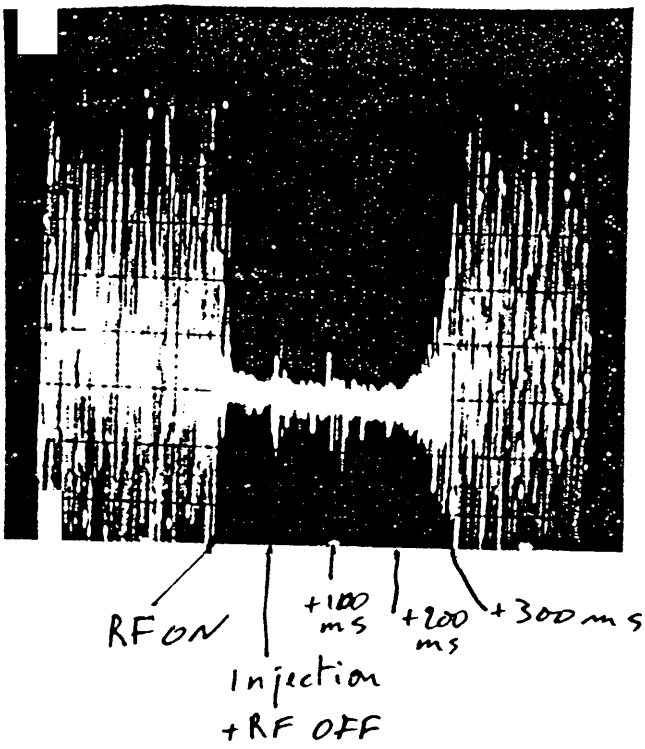


Fig 5. Longitudinal instability
A coherent signal can be detected on a pick up several hundreds of milliseconds after the RF is turned OFF
Time scale 100 ms/cm

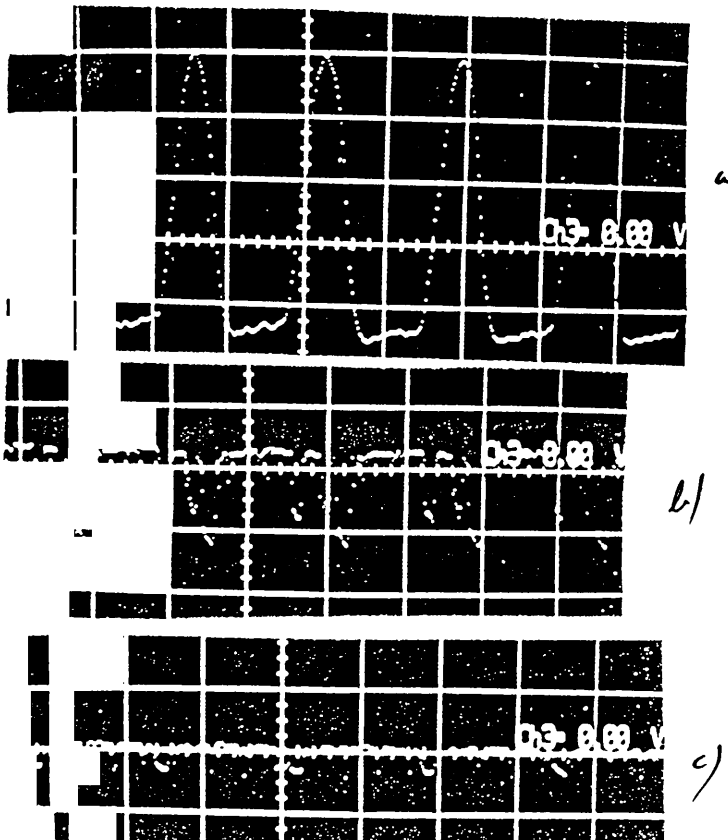


Fig 6. Longitudinal instability (Fine structure)
Beam structure a) at injection (RF on) b) 100 ms after injection and c) 200 ms after injection.
Time scale 1 μs/cm

Distribution

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