Performance Update of the LEIR Electron Cooler

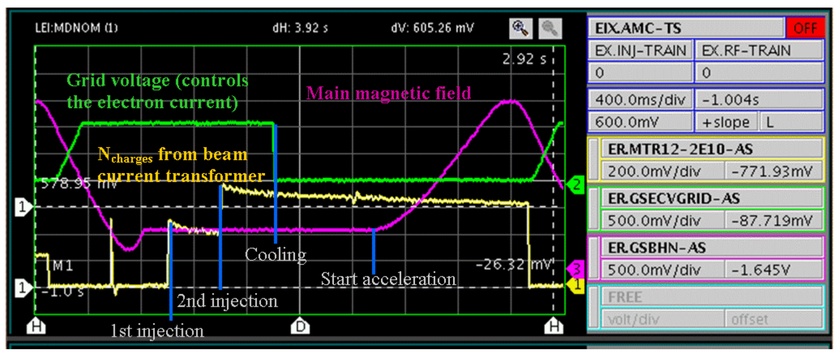
Lars Joergensen, Gérard Tranquille
CERN, Switzerland

WEPPO15

COOL'13
10th - 14th June 2013
Mürren, Switzerland

ABSTRACT

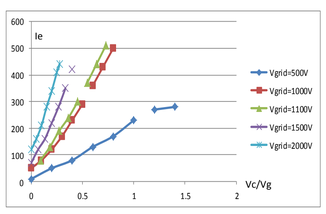
The LEIR electron cooler was successfully commissioned in 2006 and is used to routinely cool and accumulate high brightness beams of Pb54+ ions for the LHC. Some initial measurements on the performance of the device were reported in 2007 but did not fully study the influence of the electron beam current and density distribution on beam cooling. We present a compilation of measurements performed over the last years during dedicated machine study sessions which aim to shed some light as to the effectiveness of electron cooling with hollow beams.



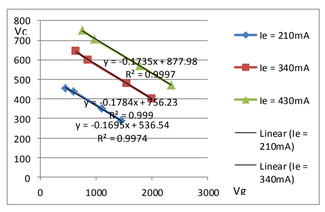
Pb accumulation on the LEIR EARLY cycle

A clone of the EARLY cycle was created (named MDEC) such that we were able to perform our measurements without disturbing the ion accumulation for the LHC or the experiments in the North Area.

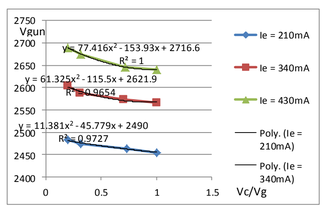
By varying the control and grid voltages we are able to modify the electron beam current and distribution.



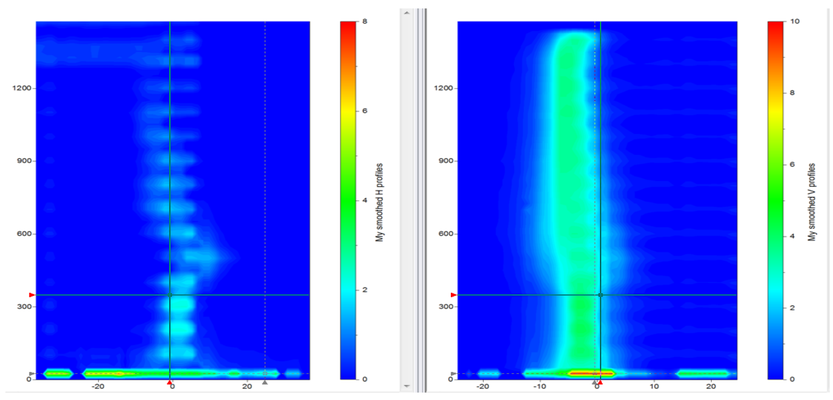
Electron current as a function of the ratio of control to grid electrode voltages (for varying grid voltage)



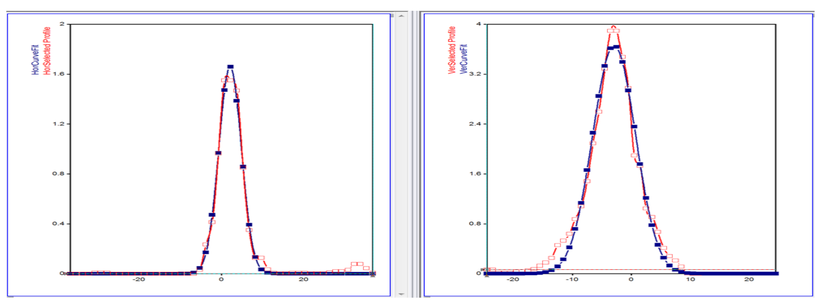
Relationship between control and grid electrode voltages for a constant current



Cathode voltage required to centre the cooled beam as a function of the control and grid electrode voltage ratio



Signals from the horizontal (left) & vertical (right) ionisation profile monitors

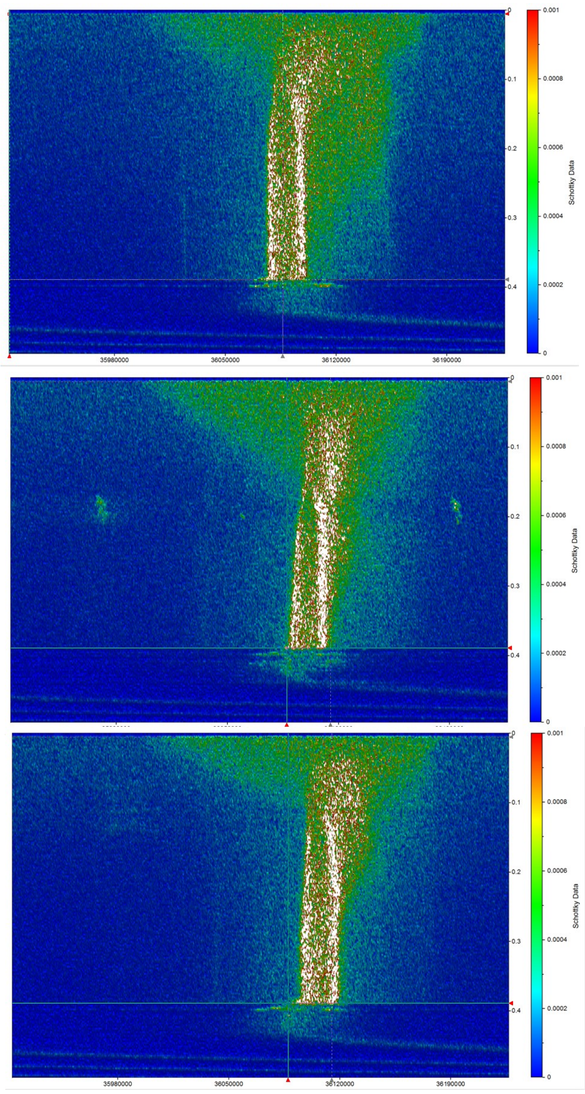


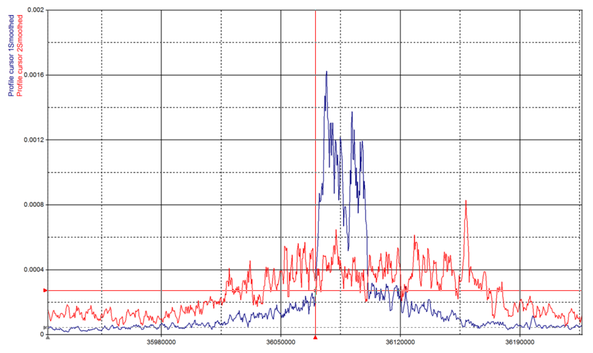
Horizontal (left) & vertical (right) cooled beam profiles

Transverse cooling has not been properly analysed.

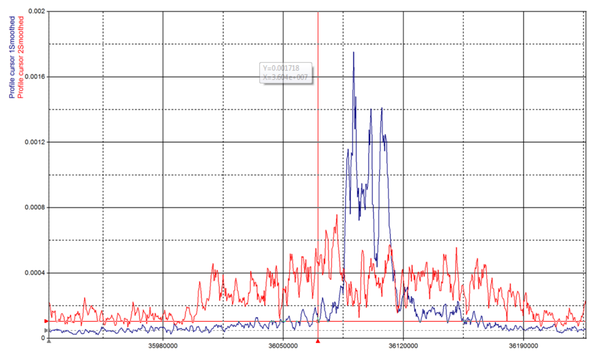
First indications point to a degradation in the cooled beam size for a hollow electron beam distribution.

Extensive measurements have to be made with Ar ions in 2014 and again with Pb ions in 2015.

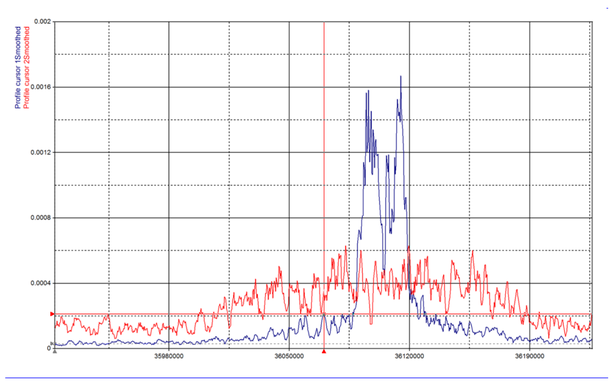




Ie = 210 mA
Vc = 290 V
Vg = 1450 V
Vc/Vg = 0.2

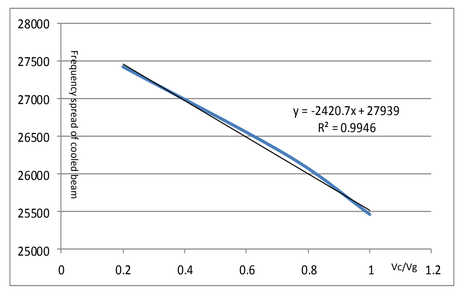


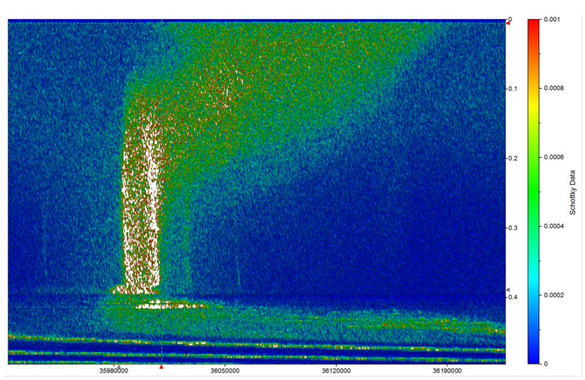
Ie = 210 mA
Vc = 440 V
Vg = 600 V
Vc/Vg = 0.733



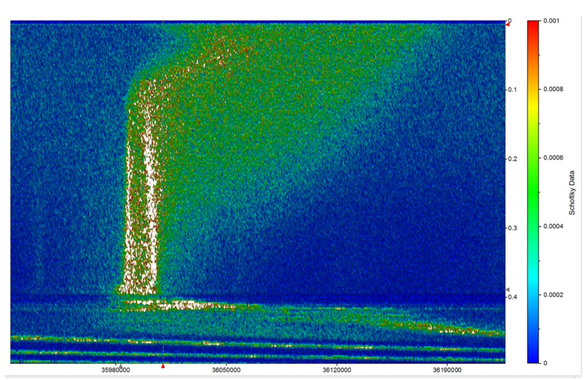
Ie = 210 mA
Vc = 455 V
Vg = 455 V
Vc/Vg = 1.0

Longitudinal cooling of Pb ions with a constant electron current and varying density profile. On the right one sees the Pb ion beam distribution at injection (red trace) and after 400 ms of cooling (blue trace)

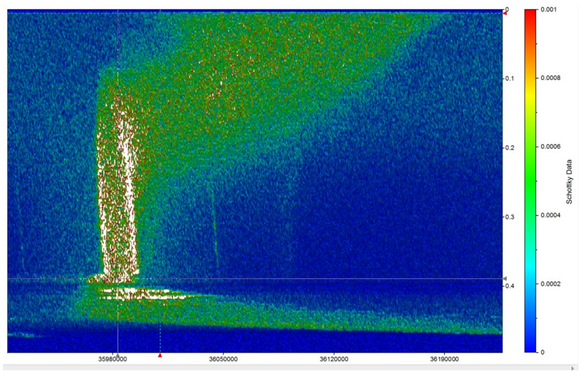




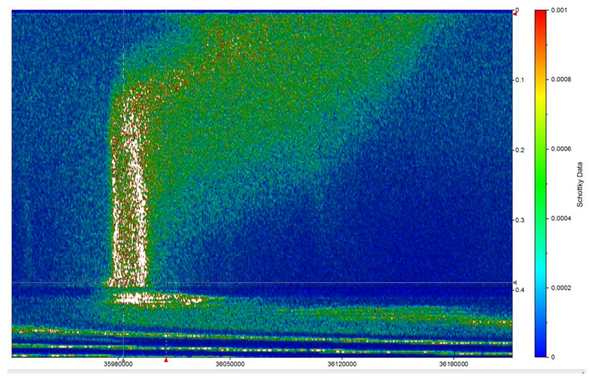
Ie = 340 mA, Vc/Vg = 0.31



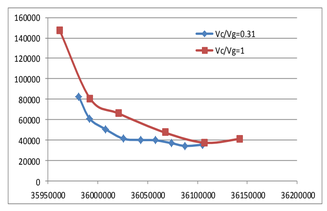
Ie = 340 mA, Vc/Vg = 1.0

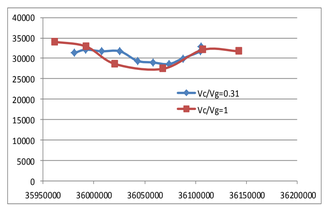


Ie = 430 mA, Vc/Vg = 0.31

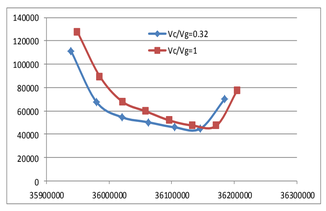


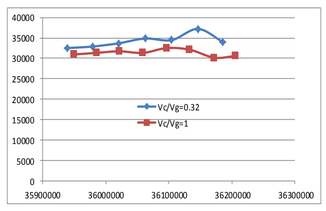
Ie = 430 mA, Vc/Vg = 1.0



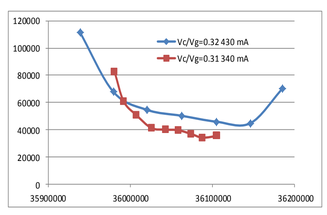


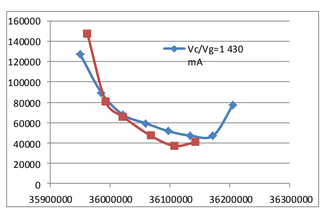
Frequency spread after 200 ms and 400 ms for Ie = 340 mA and varying Vc/Vg





Frequency spread after 200 ms and 400 ms for Ie = 430 mA and varying Vc/Vg





Frequency spread after 400 ms for constant Vc/Vg (0.3 on the left, 1.0 on the right) and varying electron current (340 & 430 mA)

A hollow electron beam distribution results in a cooler ion beam at equilibrium.

However longitudinal cooling is faster with a flat electron beam distribution.

Increasing the electron current does not give faster cooling for the same distribution.