



Cooling Results from LEIR

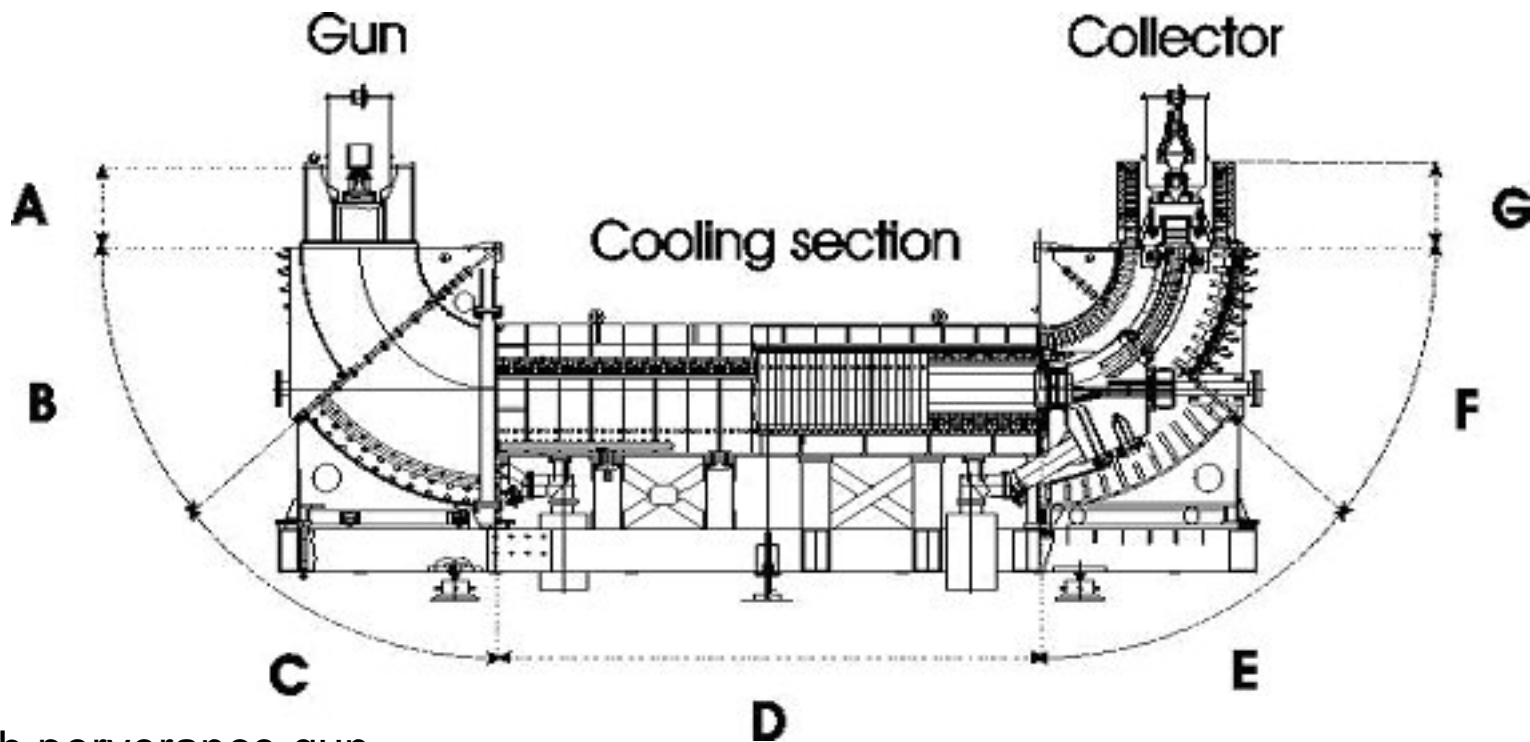
Gerard Tranquille
AB department
CERN

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Cooler parameters



High perverance gun
Beam expansion
Electrostatic bend
Pancake structure of magnets

E_e up to 6.5 keV
 $I_e = 600$ mA
 $k = 3$, $r = 14$ to 25mm

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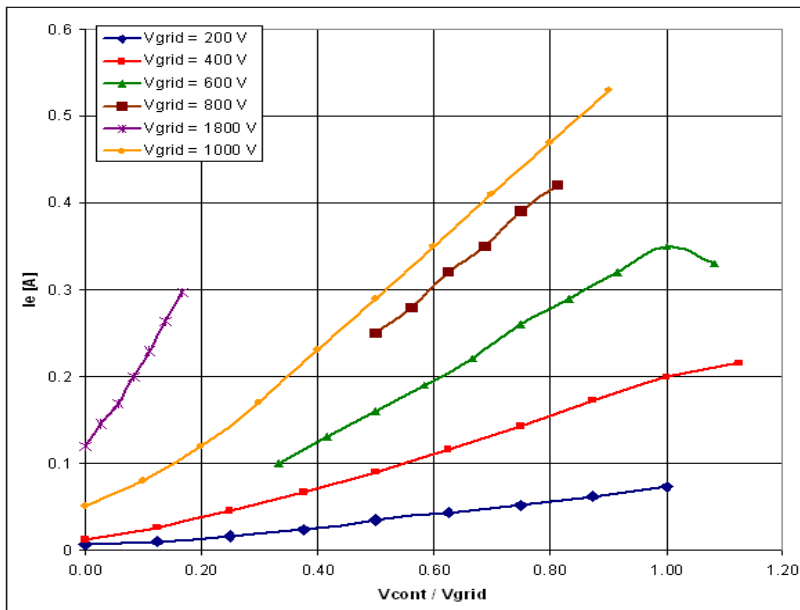
Hardware commissioning



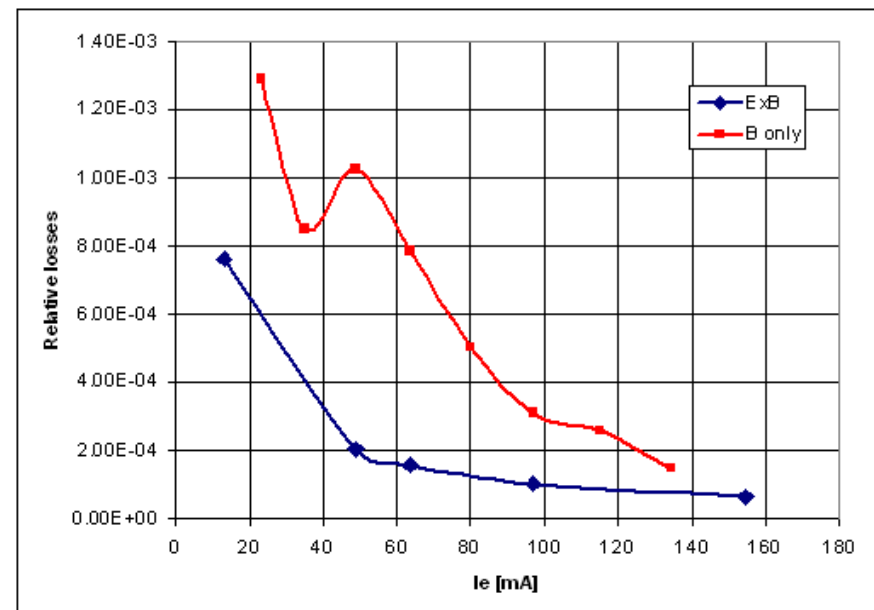
- Vacuum compatibility with the LEIR ring, $P < 10^{-11}$ torr.
- Gun operation:
 - control of intensity and density distribution
 - function generator (GFA) operation
 - electron beam intensity limit
- Test of electrostatic bend.
- Implementation of beam position measurement.

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Electron current vs. V_{cont} / V_{grid}
("hollowness")



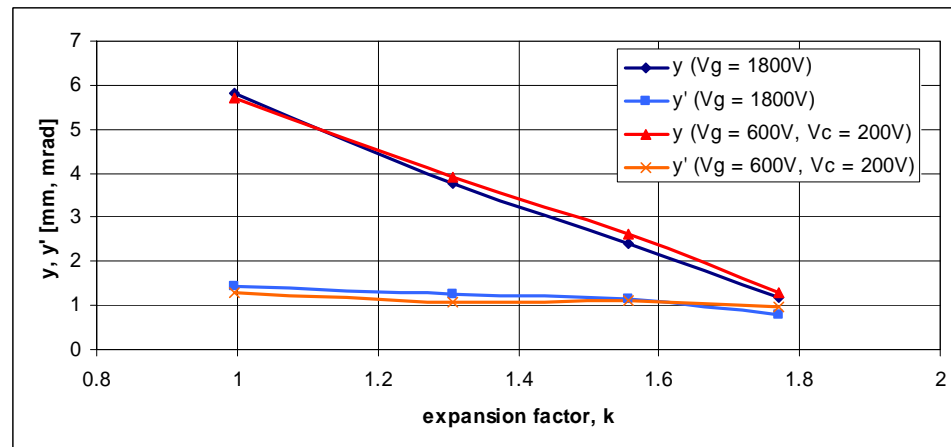
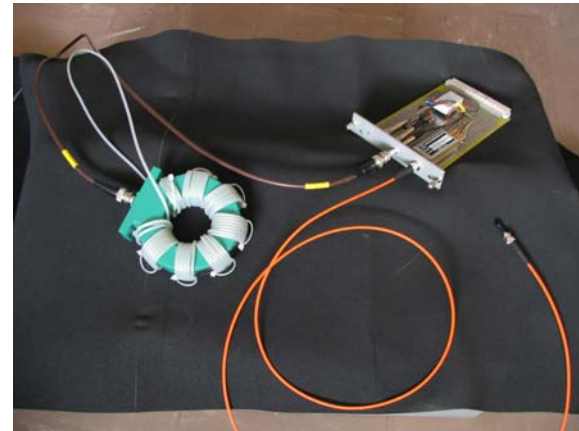
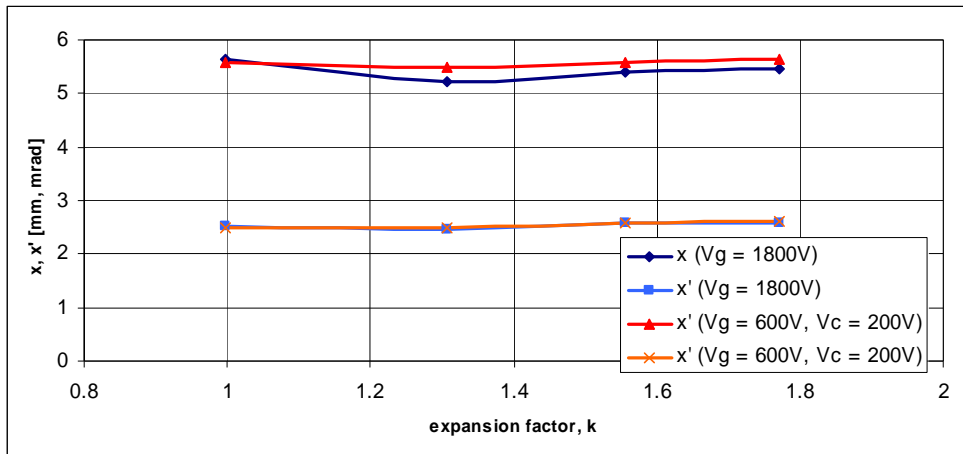
Losses vs. I_e , demonstrating the effectiveness of the electrostatic bend.

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Electron beam position



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LEIR commissioning



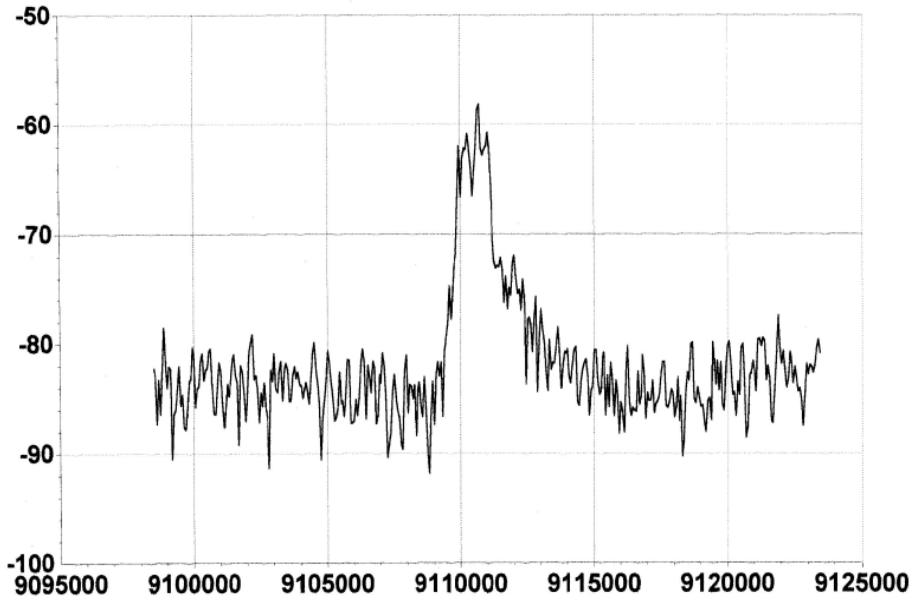
- 3 commissioning runs:
 - October 2005, O^{4+} , reproduce 1998 results
 - February 2006, Pb^{54+} , stacking, acceleration and ejection to PS
 - September 2006, Pb^{54+} , PS beam studies with “early” beam, initial tests with “nominal” beam.

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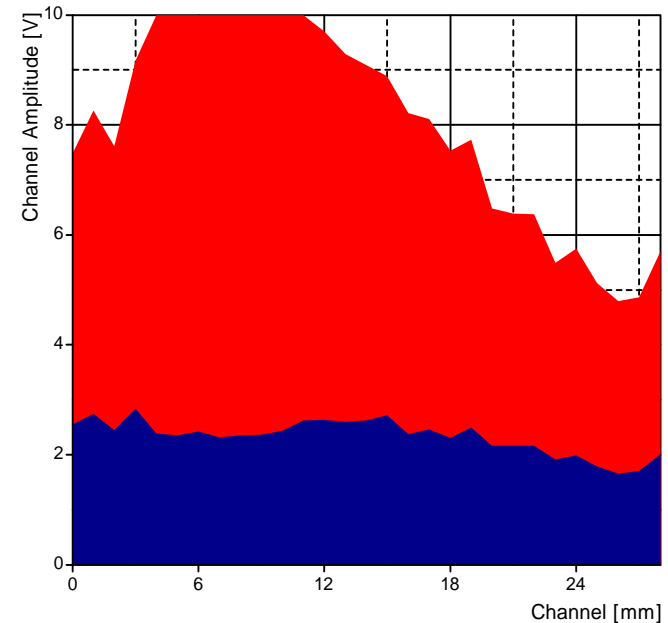
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First cooling of O^{4+} ions



Longitudinal Schottky signal of Cooled O^{4+} ions



Horizontal beam profile measured with an ionisation profile monitor. The blue trace shows the profile at injection and the red profile is after 300 ms of cooling.

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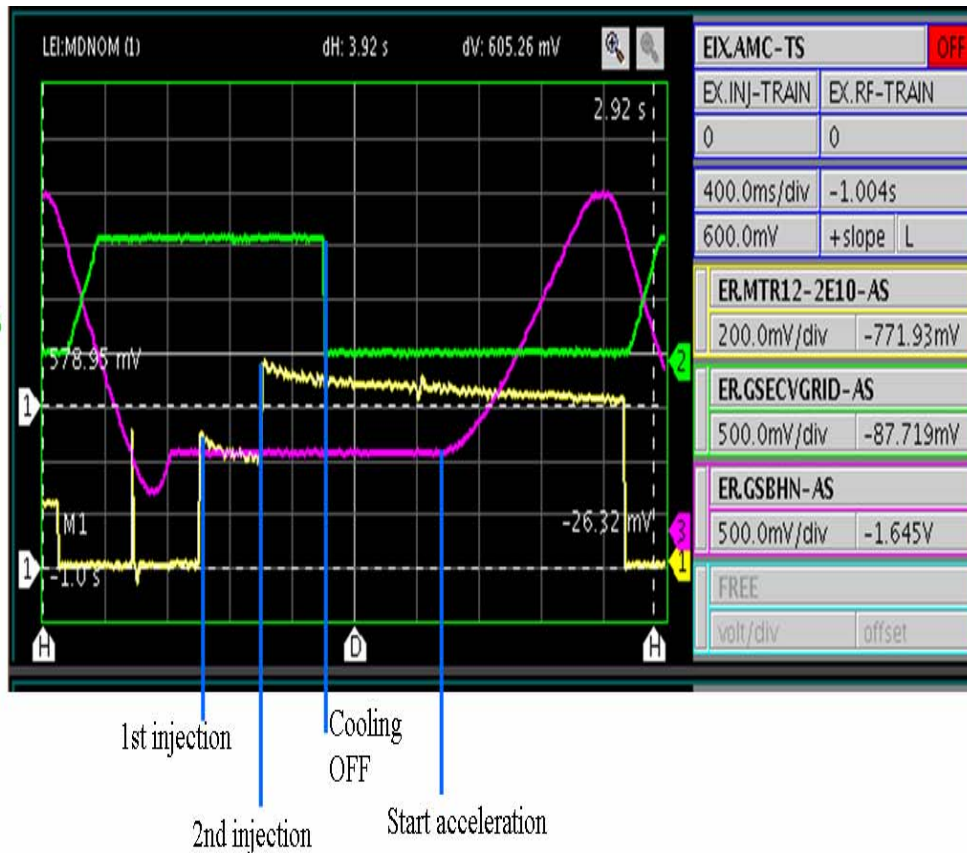
The “early” Pb beam for LHC



Main magnetic field

Grid voltage (controls the electron current)

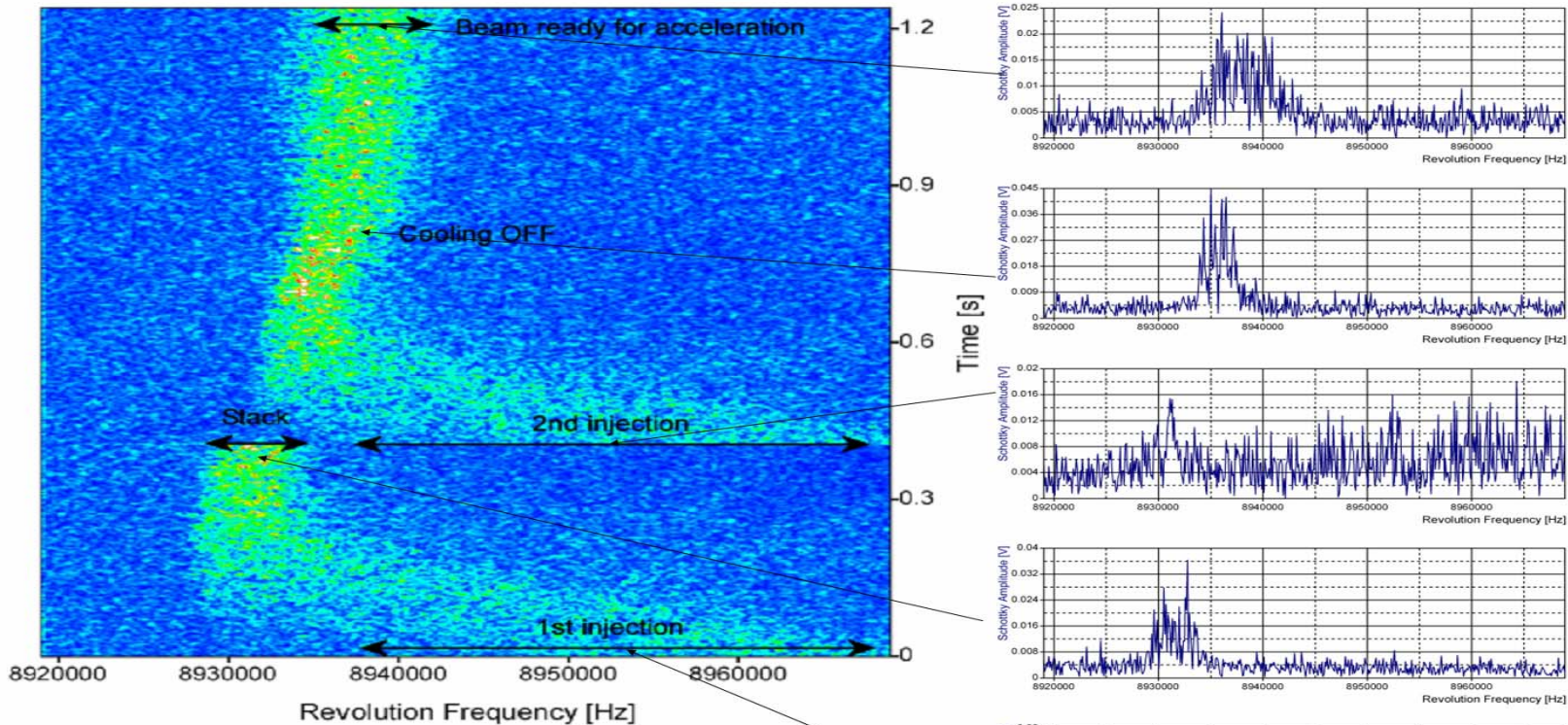
N_{charges} from beam current transformer



A standard 3.6s LEIR cycle during which 2 LINAC pulses are cooled-stacked in 800ms at an energy of 4.2 MeV/n. After bunching the Pb ions are accelerated to 72 MeV/n for extraction and transfer to the PS.

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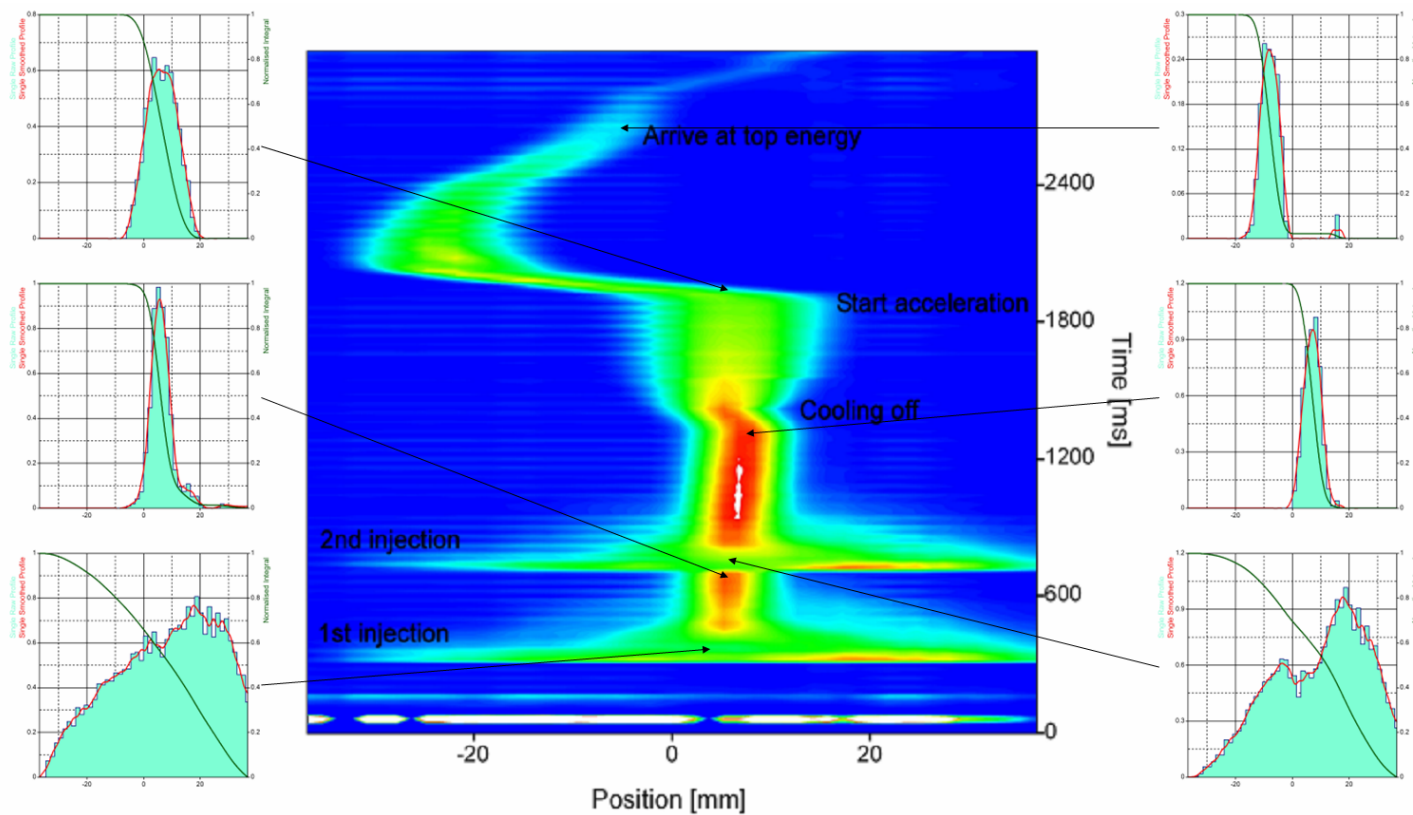
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Longitudinal Schottky spectrum evolution on the LEIR injection plateau. The injected pulses are dragged and cooled at the stack momentum, 2% lower than the nominal momentum. After the second pulse, the electron beam energy is stepped up to bring the cold stack to the nominal momentum before bunching and acceleration.

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Horizontal beam profile evolution during a complete LEIR cycle measured on the ionisation profile monitor. Two LINAC pulses are cooled-stacked at 4.2 MeV/n in 800 ms, then the beam is bunched and accelerated to 72 MeV/n for transfer to the next machine in the chain, the PS. The measured emittance at extraction is typically 0.4 μm .

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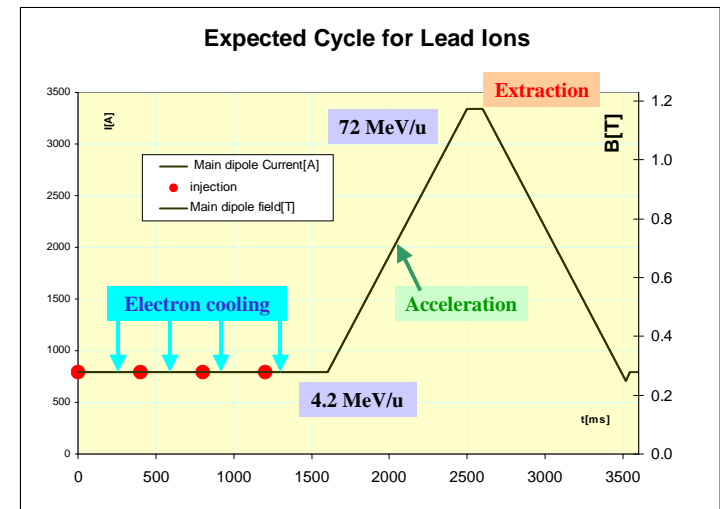
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Cooling measurements



- All measurements made in parallel with the LEIR commissioning => short 2.4 or 3.6 cycles, long cycles rarely possible.
- Beam width and $\Delta P/P$ at 400 ms used as measurement parameter.
- Longitudinal Schottky signal.
 - Down-mixed signal
- Ionisation profile monitors.
 - Prototypes only
 - Vertical plane did not work

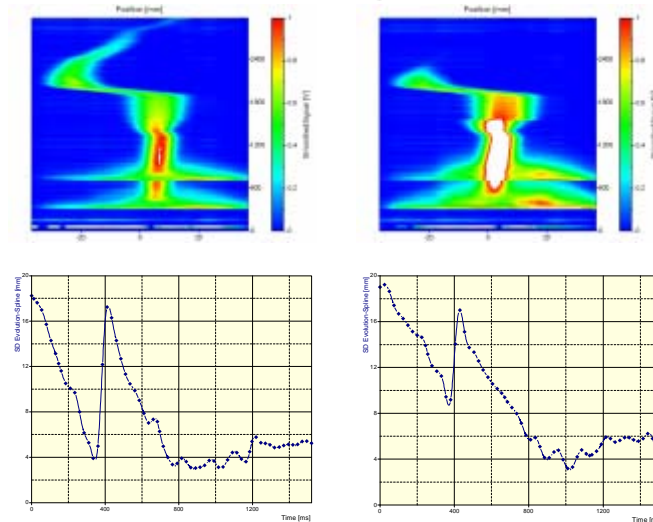
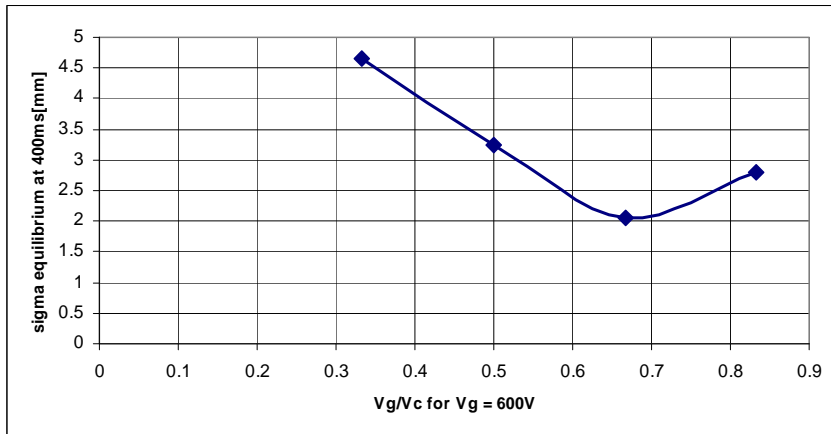
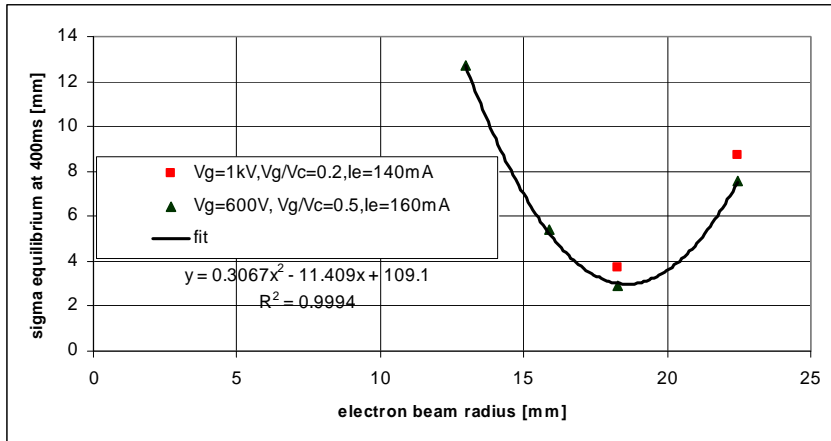


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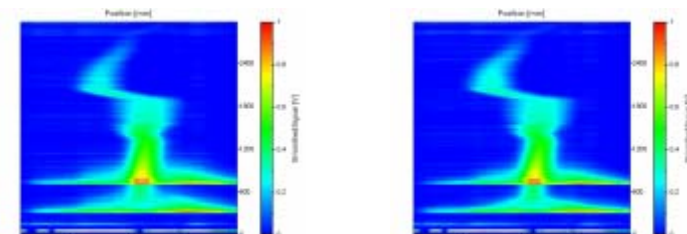


Transverse cooling



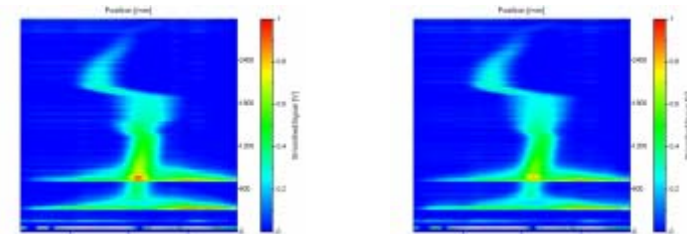
$r = 18.3\text{ mm}$

$r = 22.4\text{ mm}$



$V_g/V_c = 0.33$

$V_g/V_c = 0.5$



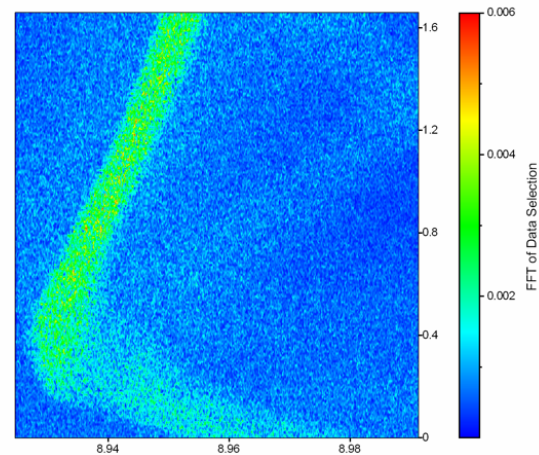
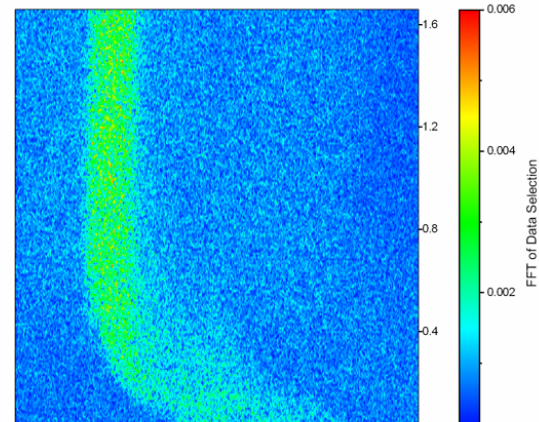
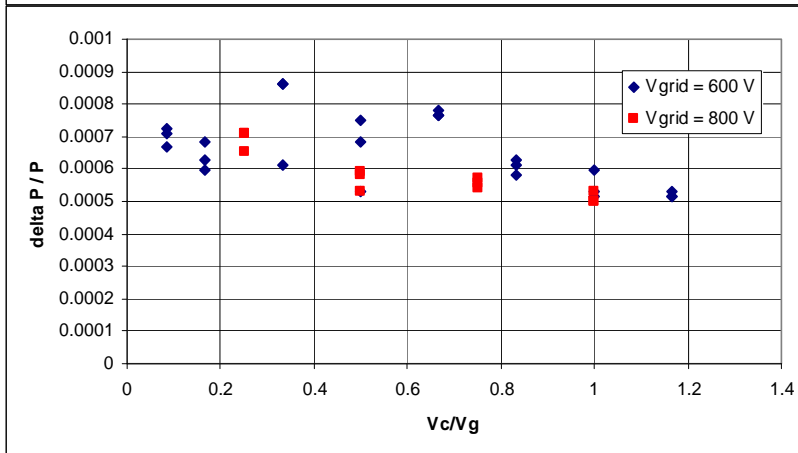
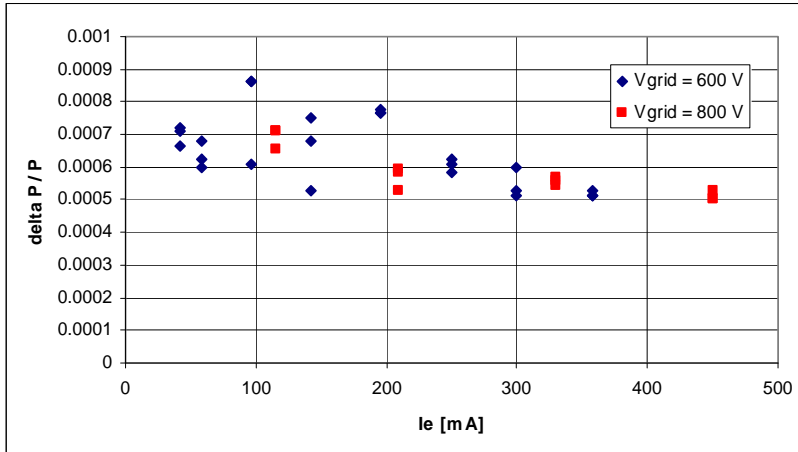
$V_g/V_c = 0.66$

$V_g/V_c = 0.87$

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Longitudinal cooling



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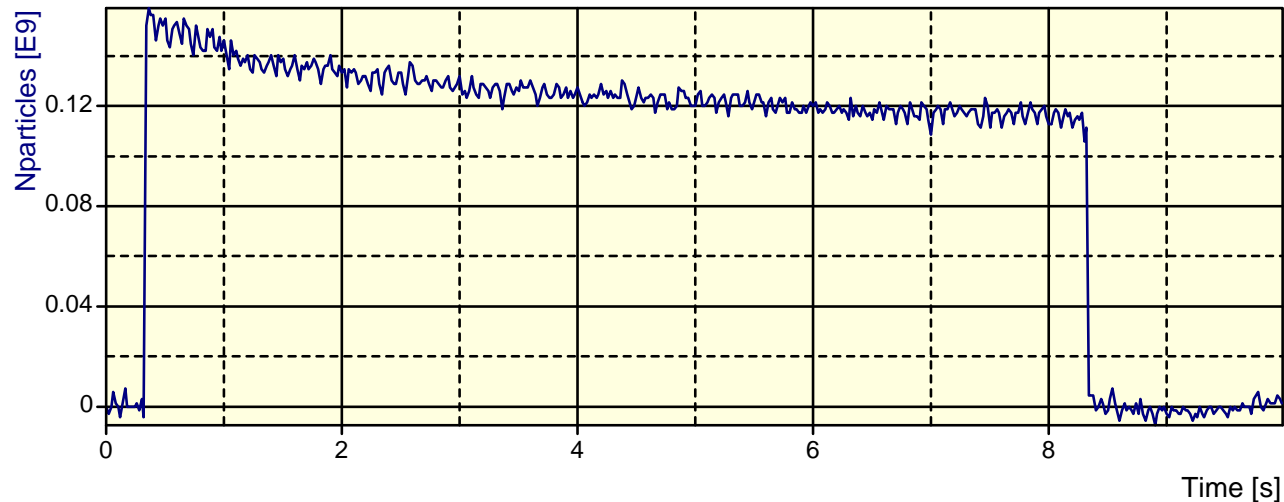
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Lifetime measurements

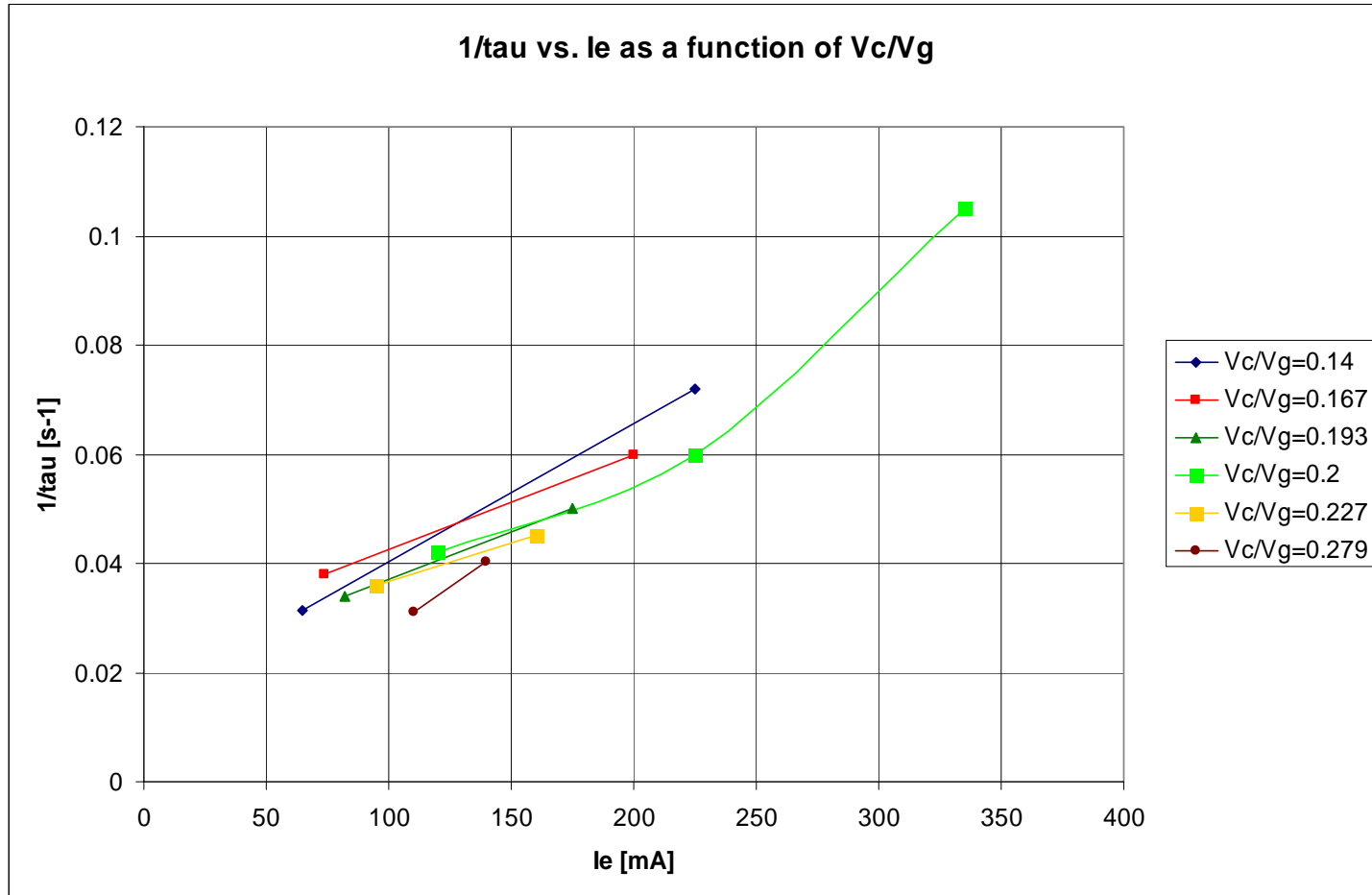


- Dedicated “long” ($n \times 1.2$ s) cycle.
- “early” beam
- BCT signal (sometimes very noisy)



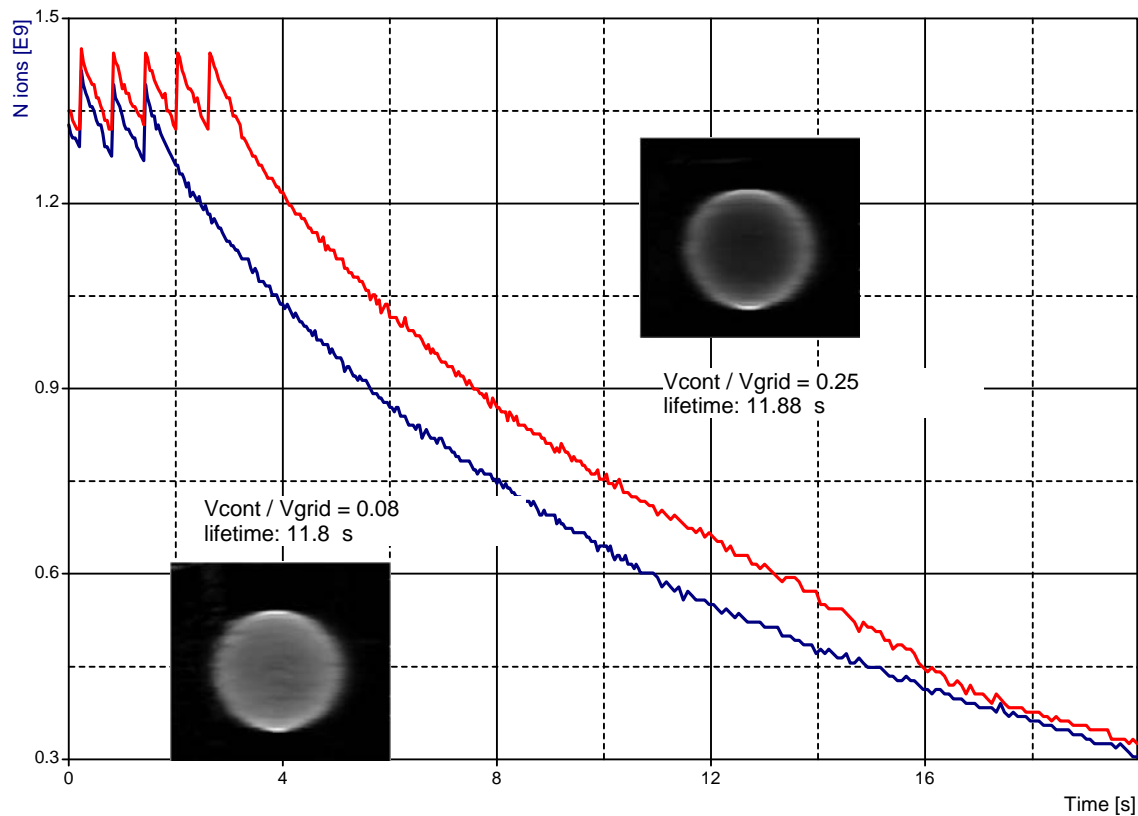
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“Nominal” ion beam lifetime measured for different electron density distributions.

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Future



- New ionisation profile monitors are now operational (horizontal AND vertical planes).
- New high performance spectrum analysers for longitudinal Schottky.
- Present run is the last Pb run until 2009 (for LHC).
 - Dedicated to SPS studies with “early” ion beam.
 - Continue to make measurements whenever possible.
- May be possible to make studies with other ions (In, S and C) in 2008.

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