# Operation of a small pulsed Mevva in ECR ion source environment

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*Abstract*

The insertion of a small mevva ion source inside an ECR source is a promising way to inject metal atoms inside the ECR source, and to study plasma nonstationary regimes. The status of Nanomevva 1 and 2 is reported, giving performance of Nanomevva 1 with aluminium and lead cathodes. Insertion of Nanomevva 2 and 1 into the ECR source Alice is described. First measurement of the Nanomevva output transmitted to the ECR Faraday cups and of the metal ion yield of ECR Alice during and after the Nanomevva operation are reported.

## 1 INTRODUCTION

The insertion of a NanoMevva inside an ECR ion source was proposed and is beginning to be tested in this laboratories, as an exotic method to inject metal ion into an ECR ion source, for practical production of beams and to study the physics of two largely opposite ion sources.

It should be noted that ECR is an universal source [3], and can ionize any element; the only advantage of combining it with other techniques may be an increase in current, be it in continuous or in a pulsed mode (or other practical advantages, like switching metal without opening the source). Still there are considerable researches on metal feeding techniques for ECR in many labs, ranging (for example) from traditional oven [2] to laser ablation [1], considering the vast need of different beams in nuclear and atomic physics.

For effectively ionizing the element $X$, it is well known that $X$ should be a minority ion of the plasma, whose majority ion $Y$ is usually lighter than $X$ . This implies a limited flow of atom of element $X$ inside the plasma $F_X = 1\times 10^{13} - 1\times 10^{14}$ atoms/s; assuming the usual linear relation between the integrated anode current $I_a$ and the emitted material, we get

$$I_a \tau \nu < F_X / k \qquad (1)$$

with $\nu$ the repetition rate of the Mevva, $\tau$ the pulse length and the ablation coefficient $k = 2\times 10^{17}$ atom/s. From the other side, repetition period $1/\nu$ must be equal or shorter than ionization time, which implies $\nu > 10 - 20$ Hz. It should be noted that low current, short arcs are much more difficult to produce reliably, since it exists a minimum hot spot current $I_h(X)$ for self regenerating arc ($I_h = 30 - 50$ A for aluminium) We tried to develop a mevva driver approaching condition (1) , with $I_A = 30$ A , $\tau \cong 20\ \mu$s, providing a large stabilizing inductance, with very limited success (see later). Some preliminary observation of cathode consumption showed possibility lower consumption coefficient $k$ for short pulses, that lead us to increase $I_A = 60$ A.

While is clear that a pulse of ion from Mevva will alter the ECR equilibria besides feeding metal, the effect of this perturbation can be assessed only experimentally. Just for recalling main possibility the pulse can alter the ECR plasma confinement leading to similar to afterglow effect, or induce extreme turbulence inside the ECR plasma, leading to much depressed charge state distribution. Notwidstanding some difficulties with electronics, we installed a manually controlled Mevva power supply at the ECR source potential, inside the lead box which shield the ECR X-rays, and we begin experiments, whose very preliminary results are here reported.

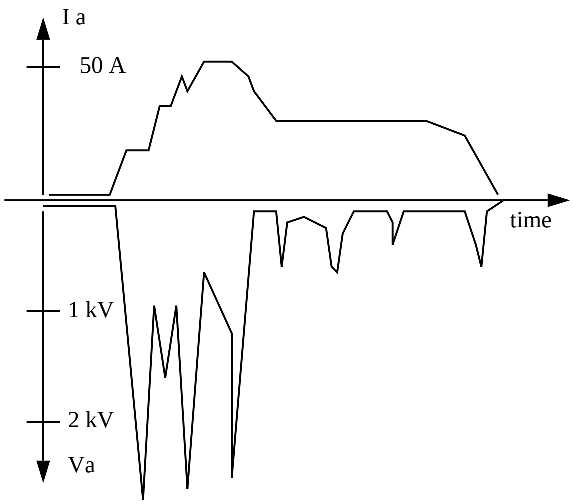


Figure 1: The total arc current $I_a$ and the arc voltage $V_a$ for support current of about 30 A; time in $\mu$s

## 2 EXPERIMENT WITHOUT ECR SOURCE

The construction of the power supply was described elsewhere, as well as extensive tests of the nanomevva with a cathode of Aluminum in a test stand separated from the ion source Alice. We noted that not all of the pulse from Mevva were stable, but some lasted less than $\tau$ . Arc current and voltage measured confirmed the explanation of arc instability for premature end of the pulse, and in some event (see fig 1) show quite dramatic feedback from the power onto the arc in order to sustain it: voltage may vary from a quiescent level (100 V) to few kV in one microsecond.

Several perturbations of the experimental condition were tried, in order to increase the repeatability of the arc. The only satisfying method was previous exposure of cathode to air, but this guarantees working for some hours. Exposure to one mbar hydrogen atmosphere also gave some temporary improvements.

After installing a lead cathode, we noted complete repeatability of the main arc (since $I_h \cong 5$ A for lead); but trigger gap metallization proved to be a problem; typically after 100-1000 god shots, the arc disappeared completely. Condition may be ripristinated by evaporating the metal film with a proper pulse ( with $\int I^2 \, dt > 0.02$ A$^2$ s )

## 3 EXPERIMENT WITH THE ECR ION SOURCE

We decided to increase the mevva driver maximum current to $60$ A and to return to Al cathode for the run of Mevva inside Alice.

Experience with Mevva operation inside the ECR ion source is still limited by experimental contingencies, since in the first run (called run A) the ECR water cooling system (called RPC) developed a leak that forced us to empty the circuit, to seal it with plastic plugs, and to run with a very low klystron power (40 W) and relatively high pressure $5 - 10 \times 10^{-6}$ mbar. ECR plasma had consequently a very low average charge state, and large current of $N_2^{1+}$were detected. On the contrary the new nanomevva 2 worked with no problems, and we obtained 100 % repeatability both at $I_A = 35$ A and $I_A = 60$ A.

In the second run (called run B) a well-proven RPC was used, together with the nanomevva 1, where the lead cathode was substituted back with an Al cathode. ECR worked as usual. The track of lead remaining on the trigger insulator causes still the problem of metallization, which now is more practically vexing than before: we have indeed to stop the ECR and dismount a shield to apply the proper cleaning pulse. We hope that the source will self clean with time.

## 4 RESULTS

Before listing the result of run A, let us explain what kind of signal we can measure. Since the ECR is running in continuous mode, we can simply adjust the analyzing dipole field $B_{dip}$ so that an ion species is selected by the faraday cup, measuring a current $I_q(t)$ for charge state $q$; synchronizing the scope with the Mevva shots we can observe the perturbation caused by the Mevva on $I_q$ . We can not directly search for every ion emitted from the Mevva; we can search for the ion which are identified previously by the ECR (with present setup). We can also directly measure the arc current $I_A$ by a current transformer designed for 20 kV insulation at most (it works smoothly with 9 kV ). We can read the total current emitted from the source $I_s$ digitally and current emitted from the puller with a galvanometer.

All our result come from run A. Repetition rate was 1 Hz. We was unable to identify safely any aluminium peak. Therefore we stay on peaks of several ion species, including O, $N_2$, $OH$ , $H_20$ and we measured fluctuation of $I_q$; see Fig. 2. Note that current swing is large, but ion current is not completely destroyed. That is a first indication of impact of the Mevva. Swings of $I_q$ and arc current $I_A$ start synchronously, and typical swing times (2 ms) are in the order of ionization times. The galvanometer needle moved with 1 Hz frequency.

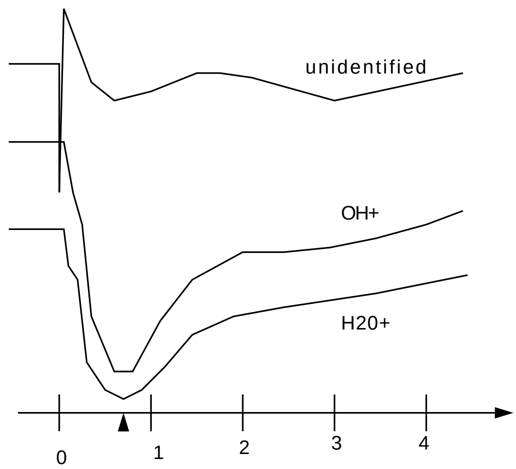


Figure 2: The ECR emitted current , after a Mevva shot at $t = 0$ ; time are in ms. The unidentified ion has $A/q$ cong 3.3 . Current are largely different: for upper, medium and lower track we have respectively $0.060$ , $3.3$ and $11.11$ $\mu$A before $t = 0$ and $0.038$, $2.48$ and $8.27$ $\mu$A at the minimum near $t_1$ . 99 pulses was averaged.

As a second result, we note that at least in some condition ECR discharge actually helps in stabilizing marginally stable Mevva arc, from the observation of 100 % repeatability mentioned before.

A third consideration is that the ECR ion is not saturated with Al ions, so that can increase repetition rate and arc current beyond limit given by (1). Clearly much more systematic observation are required.

## 5 ACKNOWLEDGEMENTS


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