EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN/PS/2002-058 (PP)

NEW BEAM FOR THE CERN FIXED TARGET HEAVY ION PROGRAMME

C.E. Hill, D. Küchler., M. O'Neil

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The physicists of the CERN heavy ion community (SPS fixed target physics) have requested lighter ions than the traditional lead ions, to scale their results and to check their theories. Studies have been carried out to investigate the behaviour of the ECR4 for the production of an indium beam. Stability problems and the low melting point of indium required some modifications to the oven power control system which will also benefit normal lead ion production. Present results of the source behaviour and the ion beam characteristics will be presented.

Paper presented 15th International Workshop on ECR Ion Sources, ECRIS'02
June 12 - 14, 2002, University of Jyväskylä, Finland

Geneva, Switzerland
27 August 2002

New beam for the CERN Fixed Target Heavy Ion Programme

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Abstract

The physicists of the CERN heavy ion community (SPS fixed target physics) have requested lighter ions than the traditional lead ions, to scale their results and to check their theories. Studies have been carried out to investigate the behaviour of the ECR4 for the production of an indium beam. Stability problems and the low melting point of indium required some modifications to the oven power control system which will also benefit normal lead ion production. Present results of the source behaviour and the ion beam characteristics will be presented.

1 INTRODUCTION

This year is the 9th year that the SPS fixed target physics uses a lead ion beam. Large quantities of data have been collected and several theories concerning the inner structure of matter were developed. To scale the data to lower energies, and to distinguish between the different theories, an ion run using indium instead of lead is scheduled for 2003 for the NA60 experiment[1].

The behaviour of the ECR4 source with indium had to be studied, and the stability and the lifetime checked. Some hardware developments for the oven control were needed.

2 INDIUM OPERATION

First tests to study the behaviour with indium were made in 2001[2]. The necessary beam intensity could already be delivered last year (Figure 1). From the source we had ∼80 eμA of In^{21+} at 2.5 keV/u.

This year's tests had the source long-term stability as the main target. Two propositions were thought to be applicable for this purpose [2].

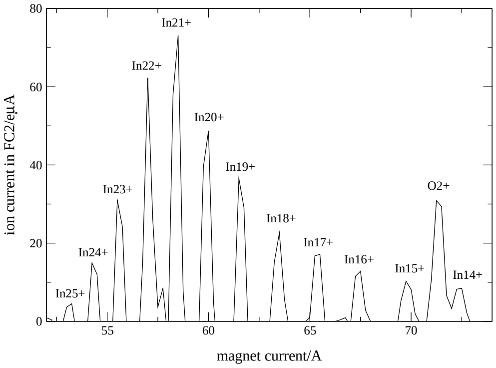

Figure 1: Indium charge state distribution (2.5 keV/u).

The first idea was to use indium(III)oxide (In_2O_3) instead of metallic indium. In the oven the indium(III)oxide can be reduced to indium(I)oxide (In_2O) and then sublimated [3] into the plasma. We could get a stable indium beam with this method. Oxygen was used as carrier gas as usual. This gave no problems for the indium(III)oxide reduction, but the sample was exhausted in 24 hours. This was too short for this method to be an option.

The next idea was to modify the oven power control in such a way that the oven power was the control value instead of the oven voltage (see section 3). During the first test run we monitored the current in the Faraday cup FC3 behind the RFQ[4] (Figure 2).

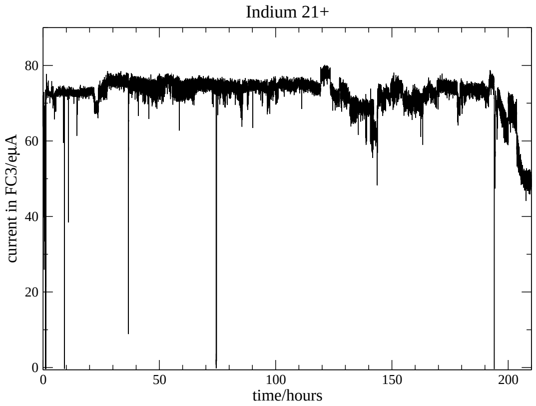

Figure 2: Indium current in Faraday cup FC3 (first run).

This gave ∼200 hours of stable beam. At around 75 h there was an external timing problem stopping the source for a quarter of an hour, and at 120 h there was the first short circuit in the oven (due to the molten indium). The oven power control followed the current changes very well, but due to the changed distribution of indium in the oven, the variations of the ion beam current increased. The shot-to-shot stability was around 10%, which is worse than for lead (∼5%) but still acceptable.

The source had to be readjusted approximately once per day in contrast to several times per day in last year's experiment. At the end of the 200 hours, the oven power reached 6.75 W, more than double the value for lead operation. This is one of the reasons for the shorter lifetime compared to lead (3–4 weeks).

The consumption of indium could not be measured because the sample was not completely empty and the molten indium glues all the oven parts together. Assuming the sample is totally consumed one gets ∼16 mg/day compared to lead of 4–8 mg/day.

For physicists, the down time is also an important point. A scheduled down time will be the change of the oven and

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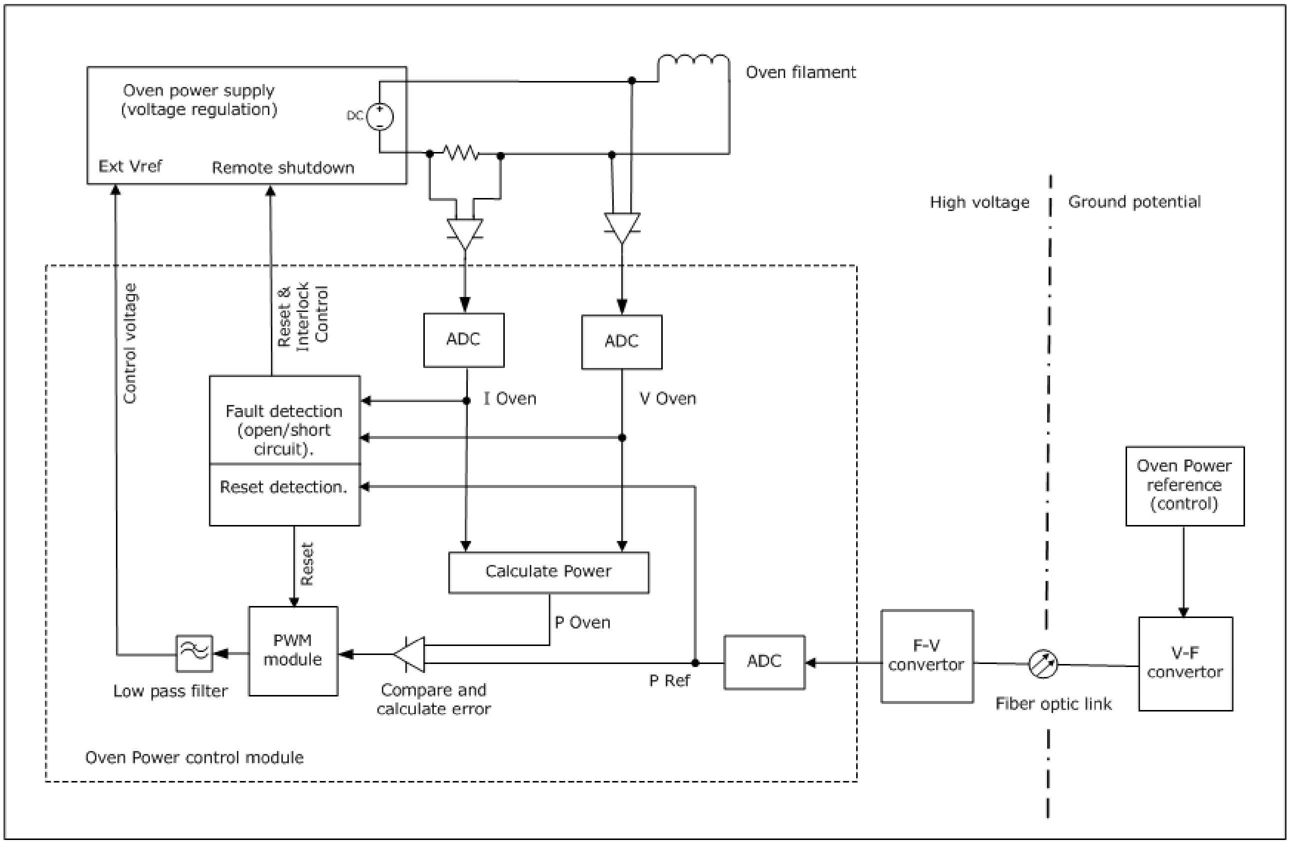

Figure 5: Schematic view of the oven power controller.

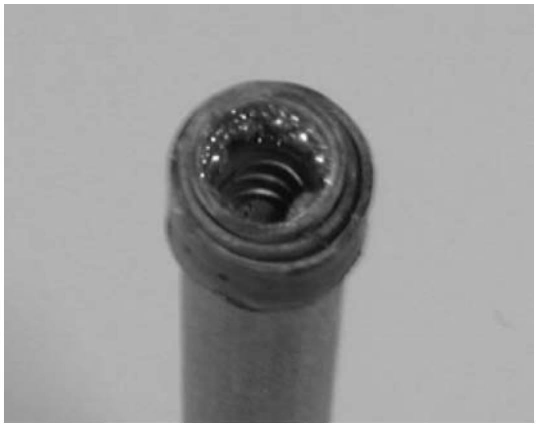

Figure 3: Tip of the micro-oven, showing droplets of indium.

the sample and the reestablishment of the full stable beam. It could be done in 8 hours, but due to earlier experience we know, especially for indium, it can also take up to 24 hours.

The second test run was more successful. The source delivered an indium beam for 17 days (only interrupted for 12 hours due to a power failure). The time was also used to check the acceleration in Linac3 (up to 4.2 MeV/u, stripped to In^{37+}, 28 eμA) and in the PS Booster (up to 224.0 MeV/u). Due to the higher revolution frequency of indium in the Booster, a new acceleration scheme had to be used[5]. All the acceleration tests were successful.

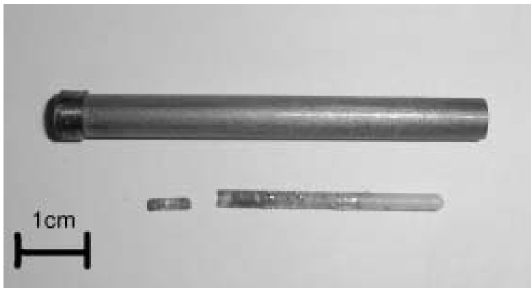

Figure 4: The oven and the alumina sample tube. The small piece is a molybdenum plug to close the sample tube partially.

The inspection of the oven after the removal from the source gave some interesting hints. The sample seemed to be a little bit deeper inside the oven. The sample tube is not mechanically fixed. During the installation of the oven into the source it can move a little. At the tip of the oven one could see indium droplets (figure 3). This means that the tip was colder during the operation of the oven than the inner part. It is not clear if this is related to the longer lifetime. Further investigations have to be done during the next runs.

In Figure 4 one can see the oven and the alumina sample tube used for the indium run. The tube was partially closed by a plug of molybdenum to prevent, as much as possible, molten indium leaking out; but it could not prevent all leakage, especially as the molten metal "wets" alumina ceramics. The sample tube is covered with droplets of indium.

3 THE OVEN POWER CONTROL

The ECR oven filament is heated with a DC current from a voltage regulated power supply. The previous control system supplied a reference voltage to the power supply's external voltage reference input. This kept the voltage to the oven constant, allowing the current to vary depending on the resistance of the filament. Problems arose during the first indium tests when molten indium caused partial short circuits of the filament. When the overall resistance of the filament decreased, the power supply voltage remained constant, with an increase in current. The result was that the power also increased into a smaller filament leading to a shorter than usual lifetime of the oven, an unstable ion current from the ECR source, as well as increased evaporation and hence consumption of indium.

The new oven controller (Figure 5) attempts to improve this situation by regulating the power to the filament. The same voltage regulated power supply is used but the actual voltage and current seen by the oven are measured. From these the power is calculated and compared to the external reference power. The error between desired and measured power is used to alter the duty cycle of a pulse width modulator, which is then filtered by a low pass filter and fed to the external voltage reference of the power supply. The power supply is thus automatically adjusted to maintain the desired power, regardless of changes in the load caused by molten indium. Intermittent short circuits or open circuits of the filament are detected and the power supply is temporarily shut down and slowly ramped up again. Permanent filament faults will cause a complete shutdown of the power supply. The result is a longer oven lifetime and reduced indium consumption leading to longer time periods between oven interventions and a more stable ion beam from the source.

The oven power controller is implemented with a single PIC16F876 micro-controller with built-in ADC and PWM modules.

4 REFERENCES

[1] http://na60.web.cern.ch/NA60/

[2] C.E. Hill, D. Küchler, R. Scrivens, F. Wenander, Studies on ECR4 for the CERN ion program, Rev. Sci. Instr., 73 (2002) 564-566.

[3] GMELIN Handbook of Inorganic and Organometallic Chemistry, Springer-Verlag, Heidelberg.

[4] N. Angert et al., CERN Heavy-Ion Facility Design Report, CERN 93-01 (1993).

[5] M. Benedikt, A. Blas, G. Cyvoct, J-P. Terrier, Test of a new acceleration scheme for indium ions in the PS-Booster, CERN PS/RF/Note 2001-015(MD) (2001).