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ON THE PRODUCTION OF A ^{48}Ca BEAM AND OTHER ION BEAMS OF RARE ISOTOPES FOR TANDEM ACCELERATORS

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Résumé. — Des faisceaux de $^{48}\text{CaH}_n^-$ (~ 250 nA $n = 1$ et 3) et de $^{76}\text{Ge}^-$ (400 nA) ont été produits à partir de matériaux enrichis utilisant le processus du *sputtering* par faisceau de Caesium. Des faisceaux de ^{48}Ca de 10 p n A pour les états de charge les plus probables ($6^+ - 10^+$) ont été analysés après accélération dans le tandem de Munich à 10 MV. On décrit un procédé qui permet de récupérer 80 % du calcium.

Abstract. — Beams of $^{48}\text{CaH}_n^-$ (~ 250 nA, $n = 1$ and 3) and $^{76}\text{Ge}^-$ (400 nA) have been produced from isotopically enriched material using the cesium-beam sputter process. ^{48}Ca -beam currents of around 10 p n A for the most probable charge states ($6^+ - 10^+$) have been analysed after acceleration in the Munich MP tandem at 10 MV. A procedure to recover 80 % of the calcium material is described.

1. Introduction. — The following quantities govern the production of a negative ion beam of a rare isotope suitable for acceleration in a tandem.

1. Negative ion yield of the element.
2. Isotopic abundance.
3. Mass separation from the main isotope.
4. Mass resolution of the injector system.
5. Cost of enriched material.

If 1. to 3. is high we usually have no problems. For example to produce a ^{34}S beam of reasonable intensity from natural material is quite trivial, since S^- currents of ≥ 10 μA can be obtained from a caesium-beam sputter source, the isotopic abundance of ^{34}S is 4.2 % and most of the existing injector magnets can separate ^{34}S from the main isotope ^{32}S . However, to pick out ^{33}S before the injection is already quite difficult, due to the lower abundance (0.75 %) and the lower mass. Although a separation of ^{33}S from ^{32}S is always possible with the 90° -magnet on the high energy side of the tandem, it is desirable not to inject the whole elemental beam because of tube loading and stripper lifetime problems. In addition, it might become a very difficult task to identify uniquely a specific beam component if a more complex negative ion beam is injected (e.g. molecular ions, several unresolved isotopes of a heavy mass element) and a second stripper is used in the tandem. Therefore, an injecting system with a high mass resolution is necessary if a more involved isotopic beam production is performed.

2. The negative-ion testinjector. — In Munich we have built a negative-ion test injector [1] right after the original HVEC injector. Figure 1 shows a schematic view of the injector region with the new test-facility sitting on a separate platform (II). Platform III carries

SCHEMATIC OF INJECTOR REGION

FIG. 1. — Schematic lay-out of the negative-ion source facilities at the Munich MP-Tandem.

the Lambshift source for polarized H^- and D^- . Each of the platforms can be coupled or decoupled from each other in order to run them either on ground or pre-acceleration potential. Figure 2 gives a more detailed view of the test-injector. Main component is a double-focussing 90° -magnet with a mass-energy product of $ME/Z^2 = 8.5$ MeV amu and a mass resolution

FIG. 2. — The negative-ion test injector.

FIG. 3. — Negative-ion mass spectra from the ^{48}Ca sputter target shown on the top of the figure. The upper spectrum (from a HICONEX 810 with Cs-lens) have been measured on the testinjector, the lower one (from a HICONEX 834) on the original HVEC-Injector.

of $\Delta M/M \approx 1/100$. The improvement in resolution obtained with this device is shown in figure 3. It shows a comparison of negative ion mass spectra in the ^{48}Ca experiment analysed on the teststand (upper spectrum) and on the original HVEC injector (lower spectrum). The difference in detailed information is quite evident.

3. ^{48}Ca -beam. — Our main effort on the isotopic beam production was concentrated on producing a ^{48}Ca beam suitable for acceleration in the tandem [2]. Since the elemental yield of Ca^- is low and the abundance of ^{48}Ca is only 0.19 % one has to use enriched material. This demands a beam production method with a low consumption of material. Naturally, the caesium-beam sputter process was used. Our investigations were concentrated on minimizing the sputter target and trying to fill the material with hydrogen in order to produce negative Ca-hydride ions. During these trials R. Middleton found a nice method to produce Ca-hydrides using an ammonia-spray [3]. Finally, we combined our own method with Middleton's NH_3 -spray and this target arrangement is shown in the uppermost part of figure 3. An essential part in preparing the target was the production of a metal ^{48}Ca -pill from the original $^{48}\text{CaCO}_3$ material (69 % ^{48}Ca). This was achieved by H. J. Maier through a special reduction-distillation technique [4]. The output on ^{48}Ca -hydrides was in the range of 200-300 nA on both injectors. Running a HICONEX 834 sputter source [5] with the shown target on the HVEC injector, we obtained the following beam conditions :

Injected ion : $^{48}\text{CaH}^-$.
L.E.-Cup : 200 nA.
H.E.-Cup : 800 nA.

Analysed ^{48}Ca beam at 10 MV tandem voltage and C-foil stripping (electrical currents) : 6^+ (65 nA), 7^+ (120), 8^+ (150), 9^+ (130), 10^+ (80), 11^+ (13), 12^+ (1.5). Continuous running time : 23 hours.

4. Recovery of the calcium material. — If an expensive enriched material is used for an isotopic beam production it seems worthwhile to consider a recovery of the sputtered material. From the ratio of the Cs^+ -beam current to the total negative Ca-hydride current, which is roughly $1 \text{ mA} : 1 \mu\text{A} = 1000 : 1$ it is clear that the negative ion efficiency is very low and most of the sputtered Ca is deposited in the source. In order to trace this deposit and to measure the recovery efficiency we used ^{47}Ca which has a half-life of $T_{1/2} = 4.5 \text{ d}$. The following procedure was performed :

i) PREPARATION OF THE SPUTTER TARGET. — A mixture of $^{40}\text{CaCO}_3$ (50 mg ^{40}Ca , 99 % enriched) $^{46}\text{CaCO}_3$ (0.7 mg ^{46}Ca , 27 % enriched) was reduced to a metallic calcium pill. This pill was filled in the usual way [2] with hydrogen and irradiated for 4 hours in the FRM-Reactor Garching with a neutron

flux of 10^{13} n/cm 2 s. In this way a reasonable ^{47}Ca activity was produced through the reaction $^{46}\text{Ca}(n, \gamma)^{47}\text{Ca}$. A sputter target similar to the one shown in figure 3 was then prepared from this material and put in a carefully cleaned HICONEX 834 sputter source.

ii) SOURCE OPERATION. — The source was running for 50h on the teststand with an average output of $^{40}\text{CaH}^-$ around 200 nA.

iii) COLLECTION OF THE SPUTTERED MATERIAL. — After the 50h running time the sputtered material was collected by scrapping it from the most active regions in the source (negative extraction electrode, surrounding of the sputter cone on the target assembly). A 90 % collection efficiency was obtained. This material consists of caesium, copper (from the carrier cone) and calcium.

iv) CHEMICAL SEPARATION OF THE CALCIUM. — The collected material was dissolved in diluted hydrochloric acid (HCl) and filtered to get rid of the copper. Then some oxalic acid ($\text{HO}_2\text{CCO}_2\text{H}$) was added to the solution and the calcium was precipitated with the help of an ultra centrifuge as calcium oxalate (CaC_2O_4). The precipitate contained 90 % of the activity scrapped off from the source. Therefore, an 80 % recovery of the calcium material could be obtained. The calcium oxalate should be well suited to produce a metallic calcium pill for the sputter target.

5. ^{76}Ge -beam. — A germanium beam is of some interest in our laboratory, since we have got a post-accelerator [6], which is capable to accelerate germanium to energies above the Coulomb barrier of the system $^{76}\text{Ge} + ^{76}\text{Ge}$ ($E_{\text{coul}}(\text{Lab}) = 240$ MeV). Figure 4 shows a comparison of the negative ion spectra from natural germanium and from an enriched material measured on the teststand. Clearly all 5 isotopes of germanium are resolved. The sputter geometry for the enriched material was chosen according to the method described by K. Brand [7]. This method is especially suited for isotopic targets since the preparation is much easier than in the case of a central target with a hole and in addition less material is needed. However, this method seems not to work for every material, e.g. we were unsuccessful in getting good intensities for ^{48}Ca and ^{64}Ni . In a first testrun with the ^{76}Ge target the source was running for several hours with an average output of 400 nA $^{76}\text{Ge}^-$.

6. Conclusion. — Using caesium-beam sputter sources and isotopically enriched material it is possible to produce negative ion beams of reasonable intensities to be used in a tandem accelerator. The consumption of the enriched material is in the order of 1 mg/h. As has been described in the case of ^{48}Ca a recovery of most of the sputtered material deposited in the ion source can be obtained.

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FIG. 4. — Negative-ion mass spectra from natural germanium (HICONEX 834) and from an enriched ^{76}Ge sputter target (HICONEX 810 with Cs-lens) measured on the test injector.

References

- [1] BRAUN-ELWERT G., HUBER J., KORSCHINEK G., KUTSCHERA W., GOLDSTEIN W. and HERSHBERGER R. L., Int. Conf. on the Physics of the Tandem, Trieste, Italy, 1976, to be published in *Nucl. Instrum. Methods*.
 - [2] KORSCHINEK G. and KUTSCHERA W., *Nucl. Instrum. Methods*, in print.
 - [3] MIDDLETON R., *Nucl. Instrum. Methods* **141** (1977) 373.
 - [4] MAIER H. J., Universität München, private communication and to be published.
 - [5] Manufactured by the General Ionex Corp., Ipswich, Mass., U.S.A.
 - [6] NOLTE E., GESCHONKE G., BERDERMANN K., OBERSCHMID R., ZIERL R., FEIL M., JAHNKE A., MORINAGA H., *IEEE* (1977) particle accelerator conference, Chicago, U.S.A.
 - [7] BRAND K., *Nucl. Instrum. Methods* **141** (1977) 519 and contribution to this conference.
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