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PERFORMANCE OF AN INVERTED SPUTTER SOURCE

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Résumé. — Pour la production d'ions lourds, nous avons construit et installé sur l'accélérateur TANDEM de NRC Demokritos, une source *sputtering* renversée. Avec cette source les ions négatifs qui, dans les sources *sputtering* normales, vont vers l'ioniseur sont utilisés comme faisceau. La source produit un nombre d'ions lourds en quantité suffisante sans érosion significative de l'ioniseur.

Pour comparer la qualité du faisceau, on a transmis un faisceau d'oxygène produit par la source renversée et la source diode. Le même pourcentage de transmission à travers l'accélérateur a été observé, indiquant une qualité de faisceau similaire pour les deux sources.

Abstract. — An inverted sputter source manufactured locally was installed on the Demokritos Tandem for heavy ion production. The source is utilizing as an extracted beam the negative ions that are found to be back streaming towards the ionizer in a regular sputter source. The source produces in sufficient quantities a number of ion species with rather few signs of ionizer erosion. Concerning the quality of the beam, direct comparison of the transmission through the accelerator of an oxygen beam produced by the sputter source and a diode source indicates the same percentage of transmission.

The need to produce a number of heavy ion species reliably and in large quantities led to the decision of installing a sputter source on the Demokritos Tandem. The choice of the inverted sputter source from among the available sputter sources was due to the favorable comments on its performance by our physicist colleagues at Florida State University and the availability of its drawings for local manufacturing. The inverted sputter source [1] utilizes as an extracted beam, the negative ions that are found to be back streaming towards the ionizer in a regular sputter source. As shown in figure 1, in the inverted sputter source developed by K. Chapman the positive cae-

sium beam is accelerated towards the cone and the negative ions sputtered from the cone pass through the center hole of the ionizer forming the extracted beam. The positive caesium beam with its space charge helps to focus the negative sputtered beam, preventing it from hitting and eroding the ionizer.

The source was manufactured at our Tandem machine shop, from drawings kindly provided by K. Chapman. Its construction required approximately 1 000 man hours. Since there is only one pre-accelerator tube available on the Tandem, the source was manufactured so that we could interchange between the inverted sputter source and the diode source utilized for large proton current production. The addition of two supplies was necessary and the change over from the one source to the other is performed during a regular maintenance period.

Several features of the source make it easy to operate, namely the ease of changing or installing new cones through the loading port without disassembling the source, and the incorporation of the caesium boiler, Pierce electrode and ionizer onto one assembly easy to remove and service apart from the remaining of the source.

Table I shows various ion species extracted from the inverted sputter source. Due to the limited terminal voltage of the Tandem (5.5 MV) there is no demand of developing beams heavier than $A = 20$ at this time. The maxima of the beam intensities seem to occur at about 9.5 kV extractor voltage independent of the oven temperature. Also, this voltage is lower than the 13 kV expected from the beam quality mea-

FIG. 1. — INVERTED SPUTTER SOURCE.

TABLE I. — *Parameters for ion species extracted from the inverted sputter source.*

Ion	Heater (°C)	Extractor Voltage (kV)	Extractor Current (ma)	Ionizer Heater (A)	Gas Pressure (Torr)	Inflector Current	L.E. Current (μA)	Type of cone
¹² C	270	9.5	1	26.8	—	19.72	14	C
⁷ Li	260	9.5	1	26.8	—	14.8	0.3	Li
¹ H	270	9.5	2	26.8	1.8×10 ⁻⁵	5.5	3.6	Ca
¹⁰ B	270	9.5	1	26.8	—	17.6	0.42	B
¹⁶ O	270	9.5	1.2	26.8	6×10 ⁻⁶	22.5	20	Ti

surements performed on the source by G. Doucas *et al.* [2].

Examination of the ionizer has shown small signs of erosion after 400 hours of operation, indicating that

the beam is well focussed as it passes through the 3 mm ionizer hole.

Actual emittance measurements of the beam performed at Oxford [2] indicate the emittance of 30 % of the beam is 6 mm.mrad. MeV^{1/2} We could not perform any similar tests at our laboratory but we could make a direct comparison between the diode source and the inverted sputter source. For an oxygen beam produced from either source and for a terminal voltage of 4 MV, the transmission through the accelerator was found to be the same, producing the same analyzed current of a given charged state.

We find the overall performance of the inverted sputter source satisfactory and with the automated heating and cooling cycles installed on it, easy to operate in a reliable manner.

References

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[2] DOUCAS G., HYDER H. R. M., KNOX A. B., Nucl. Phys. Lab. University of Oxford, Report, june 1975.