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ION-SOURCE DEVELOPMENT AT ARGONNE

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To do effective ion source development work, it is necessary, among other things, to have a good test facility. The test stand which we have built in the last two years is shown in Fig. 1. It uses a 90° double-focussing magnet with a mass energy product of about 10 and a Δ m/m of about 1/130. The test stand should accomodate different sources. The negative ion beam from the ion source is focussed and accelerated with a NEC general purpose acceleration tube with a built-in einzellens and changeable extraction electrodes. We have variable slits at the focal points of the magnet. A NEC movable Faraday cup is located ahead of the slits. This cup is used to measure the total beam from the source. In addition, there is a NEC beam profile monitor in the 0° beam line. After the magnetic analysis, we have another NEC movable Faraday cup and a version of the Wisconsin beam emittance measurement device.[1)]

The ratio of the beams on the two cups gives one indication of the origin of the negative ion beam. Of course, the magnet provides only mass analysis. For example, mass 43 should not be construed to be CaH_3^- unless there is substantial other evidence, such as the appropriate amount of mass 47, that it is in fact CaH_3^-. The test stand can be used to plot mass spectra with the intensities either on a log or linear scale. While the linear scale looks cleaner, the log scale is very useful for identifying small beams in the presence of large ones; e.g. to verify that the isotopic composition of the spectrum is approximately correct. This helps to avoid confusion between molecular beams of uncertain composition and the negative ion beam of interest.

We have three usable sources: a copy of SNICS[2)], an ANIS[3)] source which was purchased from NEC, and the inverted sputter source. Our development work in the last year has been concentrated on the inverted sputter source.

The Chapman inverted sputter source[4)], with a split extraction potential[5)], has been used for several years as the ion source for the Argonne Tandem Superconducting Linac Booster System. It is quite a reliable source and it is quite easy to change the sputter target loading in it. However, the source does not give the beam intensities which one would expect from a cesium sputter source, and its emittance is not very good. The problem appeared to us to be the focussing of the Cs beam. It is possible to redesign the electrode configuration to achieve focussing of the Cs beam on the sputter target and focussing of the negative ion beam in the area of the hole in the ionizer[6)]. If one wants good emittance, it is important to make the Cs beam spot on the sputter target small. The electrode configuration which we have used to achieve this is similar to that described by White[7)], and is shown in Fig. 2. In this

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configuration, the Cs beam spot has a diameter of about 1 mm. With the electrode diameters which we use at the present time, the measured emittance of the beam is the one shown in Fig. 3. The emittance and beam intensities are quite sensitive to the electrode aperture diameter. When we changed the source from a single sputter target arrangement to a multiple target wheel arrangement the sputter target was moved back slightly from its original position. To restore the beam we increased the diameter of the negative extraction electrode by 5%. A change of a few percent in the Cs electrode aperture changes the emittance by 30% and the total beam by about the same amount.

Typical beam currents for a number of ion species are shown in Table I.

A significant difference between the inverted sputter source and SNICS is the possibility to use gas in the former. A slight flow of oxygen improves the Li^-, Al^- and Fe^- beam substantially. However, the behavior of the new source with H_2 and ammonia is somewhat puzzling. The production of CaH^- beams with ammonia with the new source is not substantially better than the one obtained from the Chapman design. We can obtain rather good TiH^- beams from hydrogenated Ti metal, however the flow of hydrogen or ammonia over the hydrogenated Ti surface results in a loss of beam intensity. In general it appears advisable to avoid using ammonia as much as possible.

In the new configuration, much more of the beam measured at the first cup comes from the sputter target itself. The ratios of analyzed beams to total beams for $^{12}C^-$ and $^{28}Si^-$ are typically of the order of 0.55. The remainder can be accounted for by clusters of atoms and other isotopes of the target materials.

The disadvantage of the sputter source compared to SNICS or ANIS is that it is not always possible to optimize the Cs layer cover on the target material. As one increases the flux, one decreases the Cs coverage. When one increases the Cs current, the temperature at the surface of the sputter target increases. The Cs then evaporates and deposits on colder surfaces. This results in an increase in the work function and decreases the probability that an atom sputtered from the surface will collide with a Cs atom and produce a negative ion. This probably accounts for the dependence of negative ion-intensity on boiler temperature as shown in Fig. 4. In some cases therefore, to achieve maximum beam intensity one may have to use the ANIS or SNICS sources unless one can find a way to improve the Cs coverage of the target in the sputter source.

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REFERENCES

1. J. H. Billen, Rev. Sci. Instrum. 46 (1975) 1295.
2. J. H. Billen and H. T. Richards, SNEAP (1978), 137.
3. H. H. Andersen and P. Tykesson, IEEE NS-22 (1975) 1632.
4. K. R. Chapman, IEEE Trans. Nucl. Sci. NS-23 (1976) 1098.
5. P. J. Billquist and J. L. Yntema, Nucl. Inst. Meth. 178 (1980) 9.
6. V. K. Zworykin et al. Electron Optics and the Electron Microscope, John Wiley & Sons, Inc., New York, N.Y. (1945) 455.
7. N. White, Ph.D. Thesis, Oxford University, 1981, (unpublished). Proc. Symp. on Accelerator Mass Spectroscopy, ANL, 1981, 373.

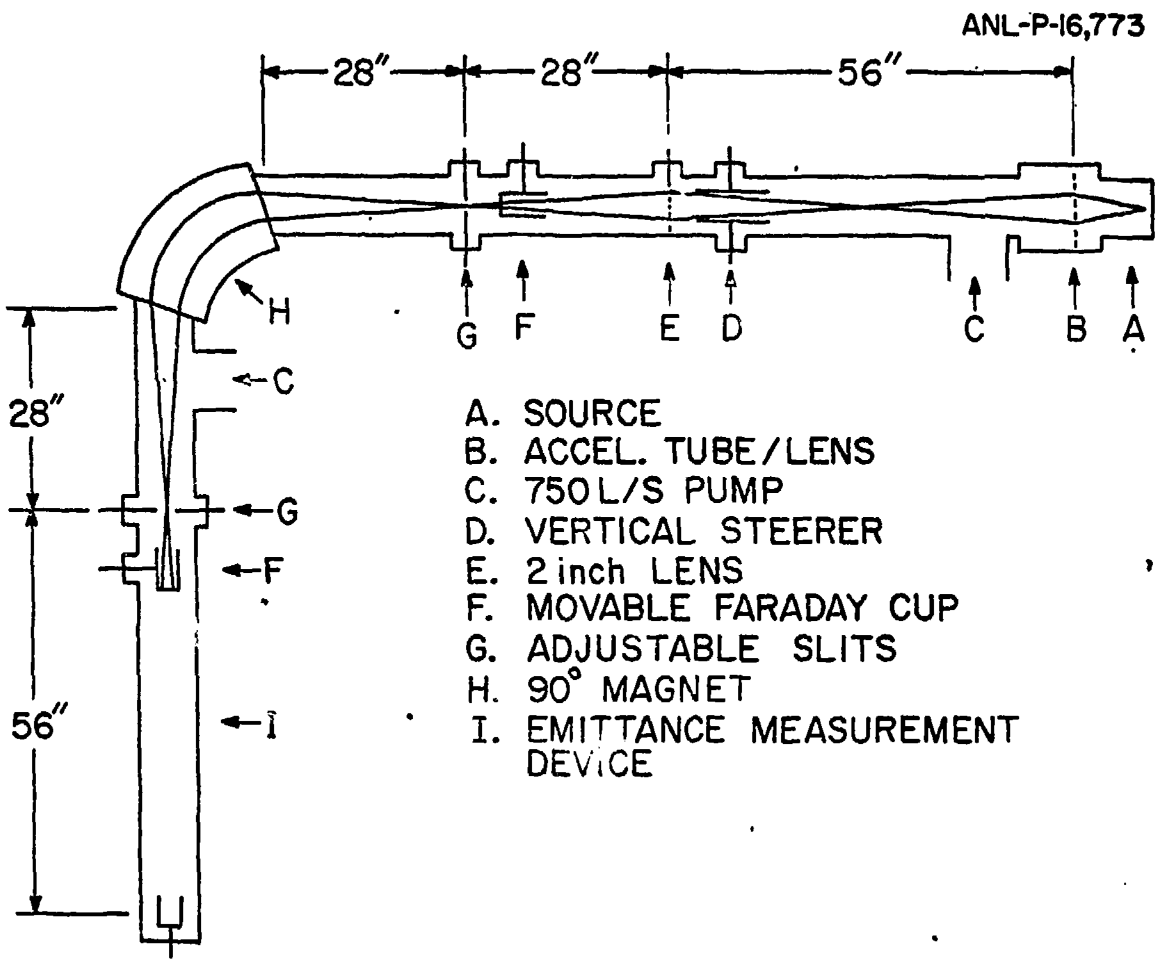
TABLE I

Ion	Current μa
i^- $(+0_2)$	1.170
B^- (powder)	.300
$^{11}B^-$ (fused)*	1.620
$^{12}C^-$	80.
$^{16}O^-$	50.
$^{27}Al^-$ $(+0_2)$	0.150/0.300
$^{28}Si^-$	30.00
TiH^- (mass 49)	1.50
CaH^-	0.090/0.300
$^{56}Fe^-$ $(+0_2)$	0.200/0.460
$^{58}Ni^-$	11.7

*isotopically enriched.

FIGURE CAPTIONS

FIGURE 1 Schematic layout of test stand.
FIGURE 2 Modified inverted sputter source.
FIGURE 3 Emittance of modified inverted source.
FIGURE 4 Al^- beam intensity as a function of Cs boiler temperature.



ANL-P-16,773
28"
28"
56"
H
G
F
E
D
C
B
A
28"
C
G
F
56"
I
A. SOURCE
B. ACCEL. TUBE/LENS
C. 750 L/S PUMP
D. VERTICAL STEERER
E. 2 inch LENS
F. MOVABLE FARADAY CUP
G. ADJUSTABLE SLITS
H. 90° MAGNET
I. EMITTANCE MEASUREMENT DEVICE

Fig. 1

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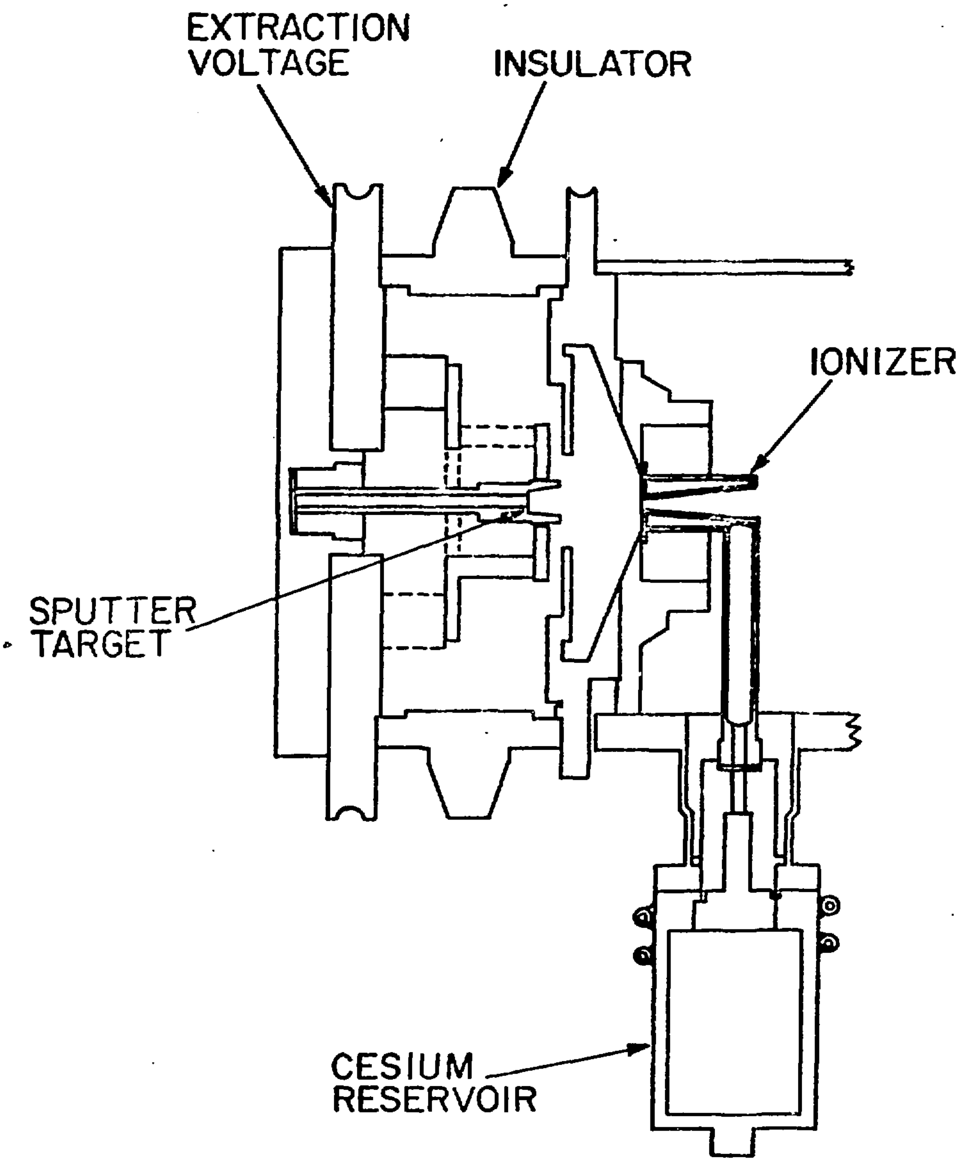

Fig. 2

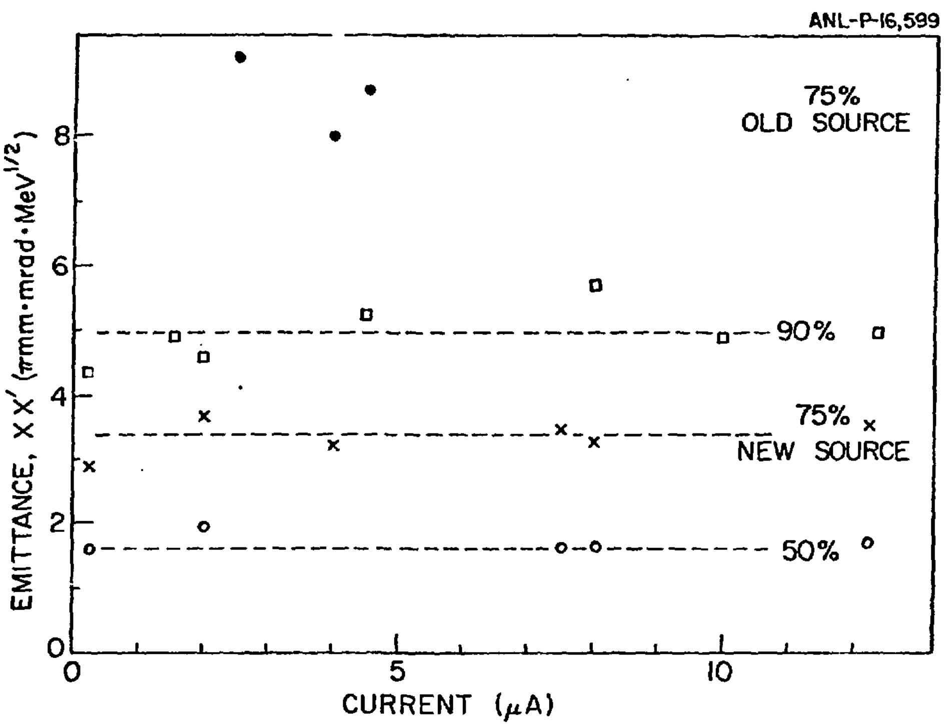
ANL-P-16,599
75%
OLD SOURCE
90%
75%
NEW SOURCE
50%
EMITTANCE, XX' (πmm·mrad·MeV^1/2)
CURRENT (μA)
0
2
4
6
8
0
5
10

Fig. 3

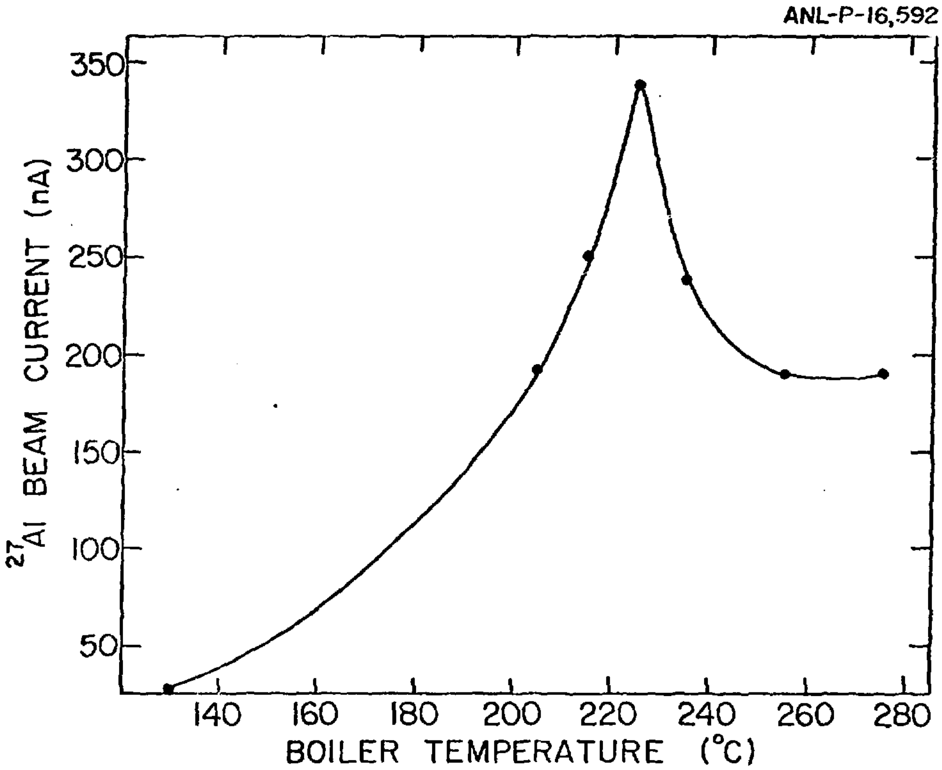

Fig. 4

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