ISR-VA/KZ/sm 19th July 1974

ISR PERFORMANCE REPORT

Run 492, 15 GeV, FP line

Ionisation of sodium by 15 GeV/c protons

Previous measurements (Run 354) of the total ionisation cross section of sodium by protons of 26 GeV/c have yielded a specific primary ionisation of 0.56 ($torr^{-1}$ m^{-1}), which seemed to us to be very low. Therefore we repeated the measurements using a different experimental set-up.

Experimental arrangement :

The electrons, which are ejected from the sodium curtain in the beam profile monitor, are allowed to flow in the potential well of the proton beam towards the clearing electrode situated at intersection 5 (see fig. 1). There the electron current I_e was measured as a function of the extraction voltage V_e. The results are plotted in figures 2, 3, 4. The density n of the sodium curtain at the intersection with the protons is determined by measuring the temperature of the evaporating sodium in the boiler. The density n is proportional to the density in the boiler, which is related to the measured sodium temperature. The error of the temperature measurement was at most $\pm$ 2^{o}C which corresponds to $\pm$ 5% error in the determination of the pressure.

During the experiment with 5.92 Ampères and 2.88 Ampères of protons respectively, circulating in ring 2, the density of the sodium curtain was 6.8×10^9 atoms/cm^3 which is equivalent to a pressure of 4.3×10^{-7} torr. Knowing that the proton beam traverses 1 mm of the sodium curtain, the primary ionisation has been calculated. The measurements yielded 3 values : 0.86, 1.06 and 0.67.

Discussion

We notice that the measured current I_e in Figure 2 increases with an increasing extraction voltage up to 200 V. This behaviour can be explained in the following way : when the extraction electrode has the same potential as the vacuum pipe, the proton beam is neutralised and only few electrons are spilled out toward the extraction electrode. If the potential V_e is increased the clearing electrode attracts the electrons of low initial energy, whereas the higher energetic ones still reach the vacuum pipe. Finally, at an extraction potential of 200 V all electrons are collected by the clearing electrode. Examining figures 3 and 4, we notice a peak situated at a potential of about 50 V. We cannot explain this phenomenon. Further experiments would be helpful in order to get a better understanding of the influence of ions and secondary electrons upon our measurements.

We also observed that the electron current was rather unstable when the sodium curtain was turned off but became stable as soon as the electron current was increased by the adding of electrons from the sodium. It would be very interesting to check whether these electron current fluctuations have something to do with the p-e instability.
This instability very much influenced the precision of our measurements and it partly explains the scatter of the 3 primary ionisation values so far measured.

Conclusion :

The specific primary ionisation of sodium has been determined to be about 0.8 ($torr^{-1}$ m^{-1}) which is almost the same as that for molecular hydrogen (0.733 at 15 GeV/c). If the electron current measurements could still be improved, a precice absolute value of the ionisation cross-section of sodium by high energetic protons could be obtained. This would be a valuable contribution in checking experimentally Bom's approximation of the calculation of the ionisation cross section of an atom with one electron on its outer shell and two filled shells.

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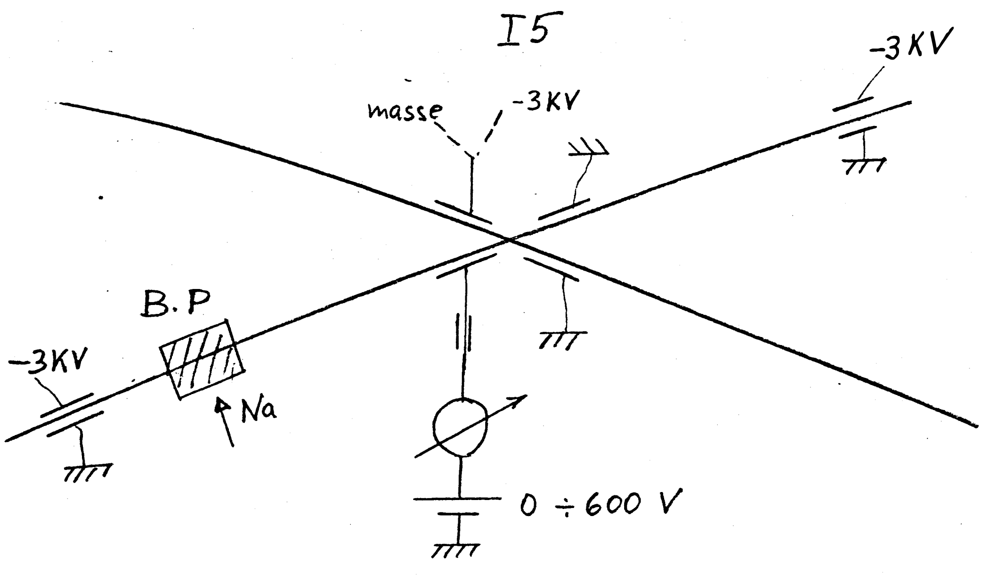
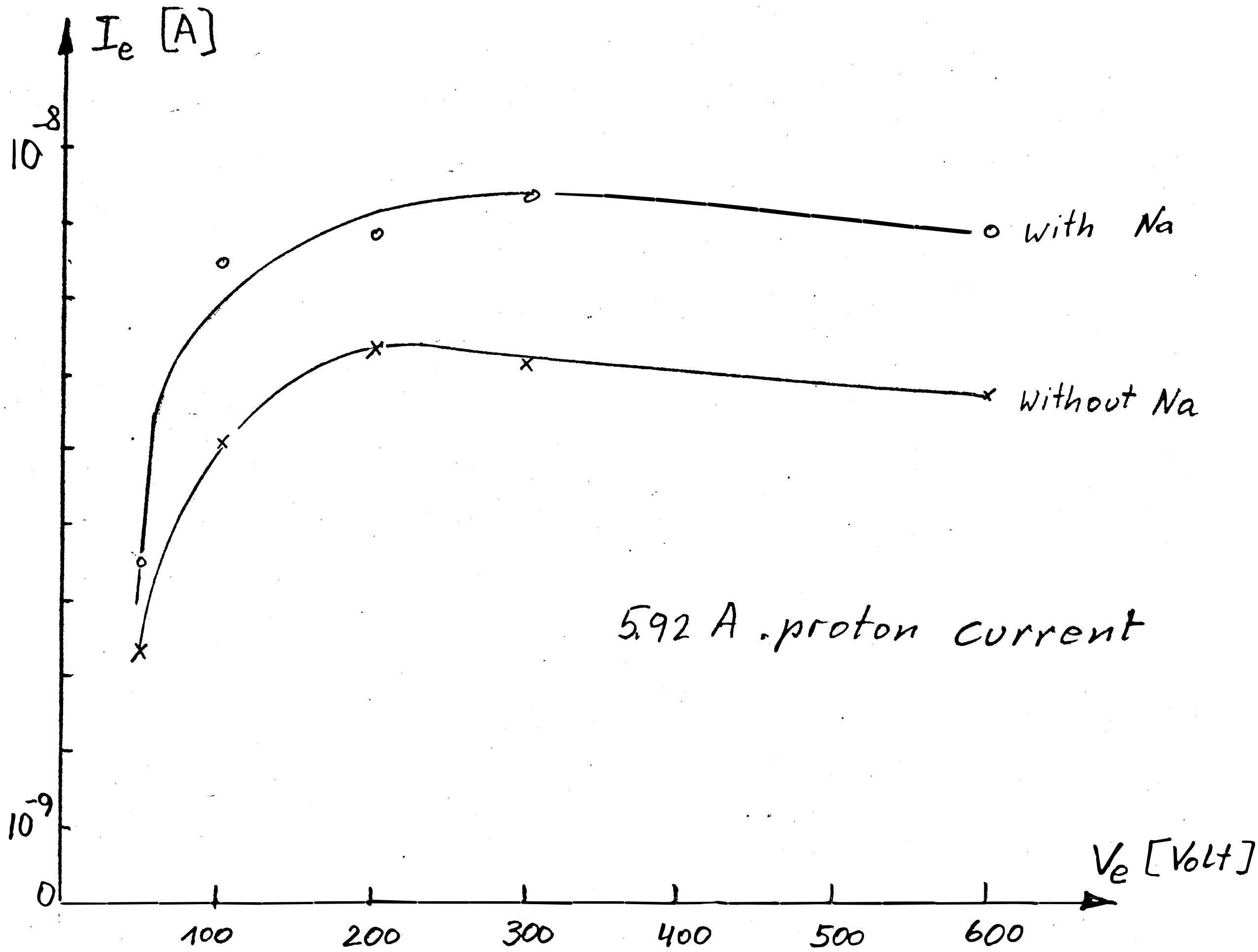


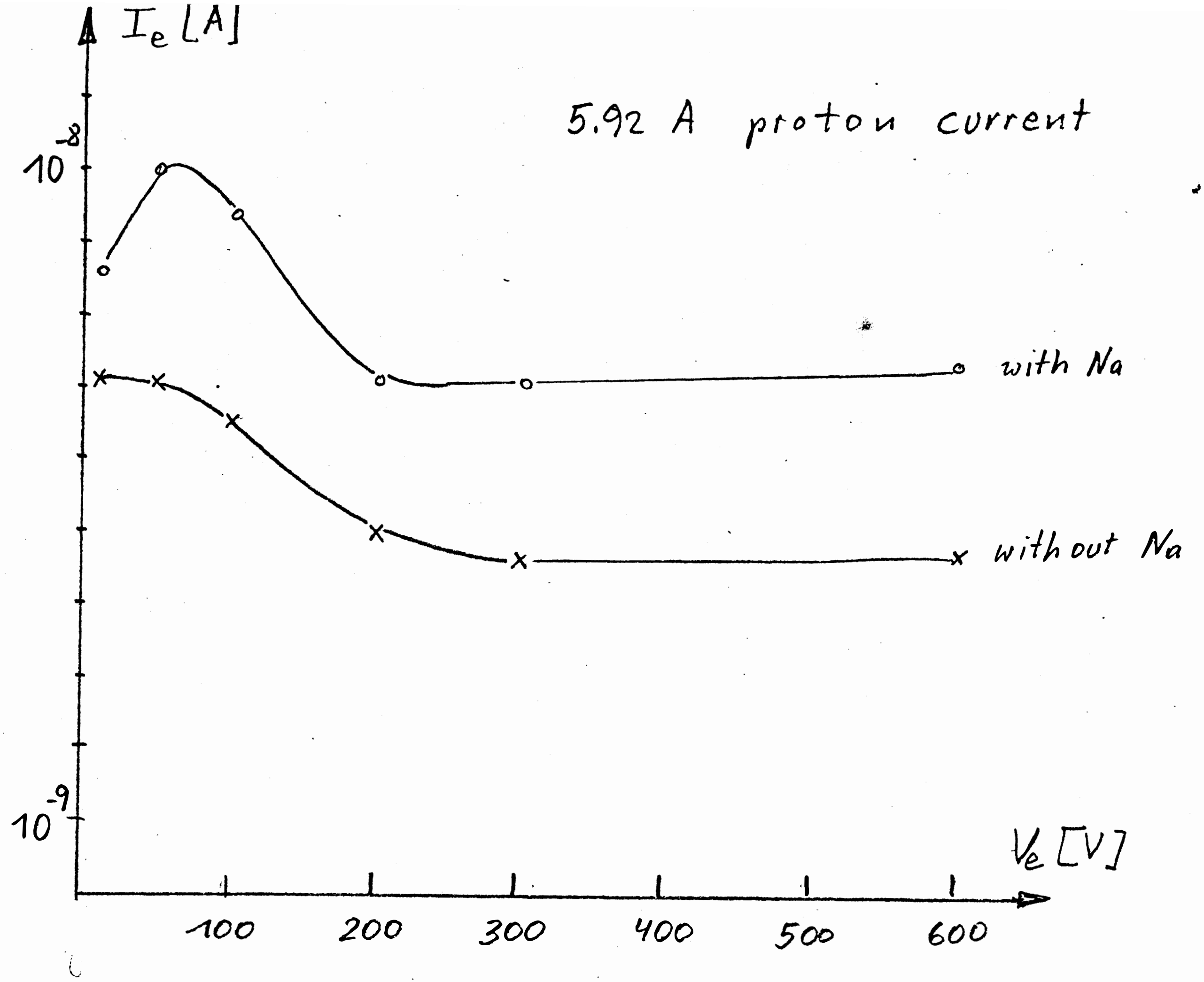
I5
-3KV
masse
-3KV
B.P
-3KV
Na
0 ÷ 600 V

fig 1



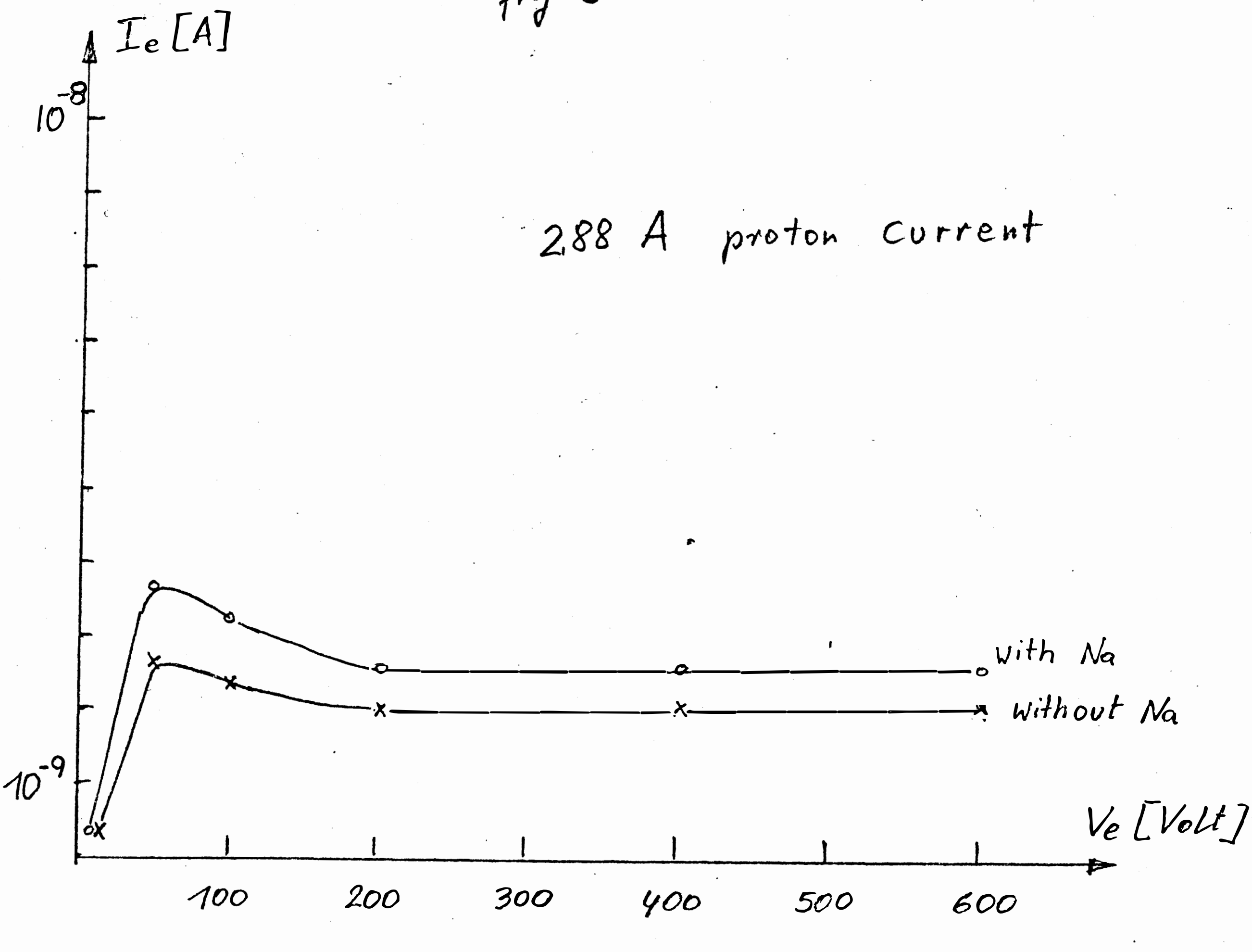
Ie [A]
10-8
10-9
0
with Na
without Na
5.92 A .proton current
Ve [Volt]
100
200
300
400
500
600

fig 2



I_e [A]
10^{-8}
5.92 A proton current
with Na
without Na
10^{-9}
V_e [V]
100
200
300
400
500
600

fig 3



I_e [A]
10^{-8}
2.88 A proton current
with Na
without Na
10^{-9}
Ve [Volt]
100
200
300
400
500
600

fig 4