

Accelerator Mass Spectrometry Programme at Mumbai Pelletron Accelerator Facility

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Abstract. The Accelerator Mass Spectrometry (AMS) programme and the related developments based on the Mumbai Pelletron accelerator are described. The initial results of the measurement of the ratio, $^{36}\text{Cl}/\text{Cl}$ in water samples are presented.

1. Introduction

The AMS technique is widely used in multidisciplinary programmes [1-3]. The AMS programme at the Mumbai pelletron (14 UD NEC) accelerator has been initiated with major emphasis on the determination of ^{36}Cl concentration in environment in general and water samples in particular. The blank and the standard samples obtained from Prime Lab, Purdue University, USA have been used to assess the beam transmission efficiency through the accelerator and for initial quantitative measurement of $^{35}\text{Cl}/^{37}\text{Cl}$ and $^{36}\text{Cl}/\text{Cl}$ ratios. For old ground water samples measurements were done using this technique.

2. AMS system

The layout of the accelerator and the AMS beam line is shown in *FIG.1*. For the measurements reported here, a single cathode SNICS was employed. To augment this programme, a multi cathode ion source is being indigenously built and it is at an advanced stage of completion. Typical intensities of Cl^- ions used for this work were limited to 10 μA , even though during trials we could extract currents as high as a few tens of μA . As it is not possible to inject the high intensity Cl^- ions into the machine due to machine loading problems, a beam chopper has been employed to allow only 1/20th of the total intensity to be put through the machine. The negative ions accelerated up to 150 keV are made to pass through the chopper located just after the injector magnet (*FIG.1*). To assess the transmission efficiency of the AMS system, ^{35}Cl and ^{37}Cl beams from the AgCl sample were transported through the machine up to the Faraday Cup just before the detector system and the various quadrupoles and dipoles were properly adjusted to ensure that the ratio measured was consistent with the natural abundance value. The magnetic field of the analyzing magnet was set at 4623.15 Gauss and the terminal voltage at $\sim 7\text{MV}$ to get 56 MeV of ^{36}Cl and ^{36}S beams of charge state 7^+ . For the other isotopes of Cl, the analysing magnet field was kept the same but the terminal voltages were suitably scaled as follows: for ^{35}Cl and ^{37}Cl , the terminal values were 7.180 and 6.790 MV respectively.

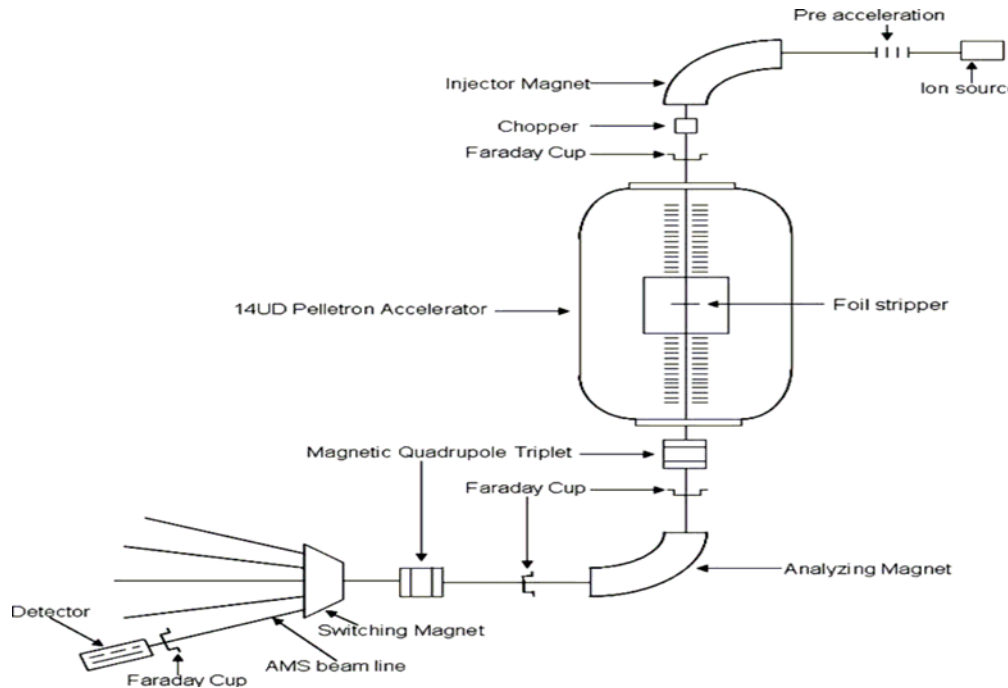


FIG. 1 The layout of the AMS system. The accelerator and the AMS beam line are shown.

3. Detection system

In order to separate the low intensity ^{36}Cl from the interfering high intensity isobar viz. ^{36}S (impurity from the ion source), a hybrid split anode gas detector plus silicon surface

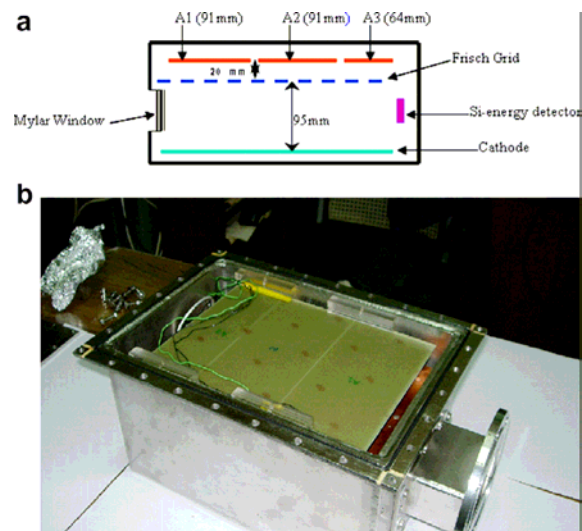


FIG. 2 a. A schematic of the hybrid detector. b. Segmented gas detector

barrier detector set up has been employed [4-5]. A 3.5 micron thick mylar foil was used as the window and the detector was operated at a pressure of about 54 mbar (P-10 gas). While the entrance window was of dimension 30 mm x 25 mm, the silicon detector kept at the end of the hybrid detector was of diameter 15 to 20 mm to collect the ions passing through the gas medium of the detector (FIG.2). The detector was calibrated using very low intensities of ^{35}Cl and ^{37}Cl (we ensured that the resultant count rate in the detector set up was limited to 1 kHz by keeping ion source filament current very low) from the blank sample provided by Prime lab. Filament current was increased and Mass 36 was selected by injector magnet and transported through the machine up to the detector. Back ground ^{36}S (coming from the ion source as an impurity or memory effect) was identified in the detector. The detection limit for ^{36}Cl due to back ground was estimated in terms of the ratio $^{36}\text{Cl}/\text{Cl}$ to be of the order of 7×10^{-14} .

4. Measurements and results

The standard Cl sample (containing known value of $^{36}\text{Cl}/\text{Cl}$) from Purdue was mounted and Cl beam was tuned through the whole accelerator system. Mass 36 was selected by the injector magnet. The 2D spectrum, anode A2 vs silicon detector measured with this sample is shown in FIG.3.

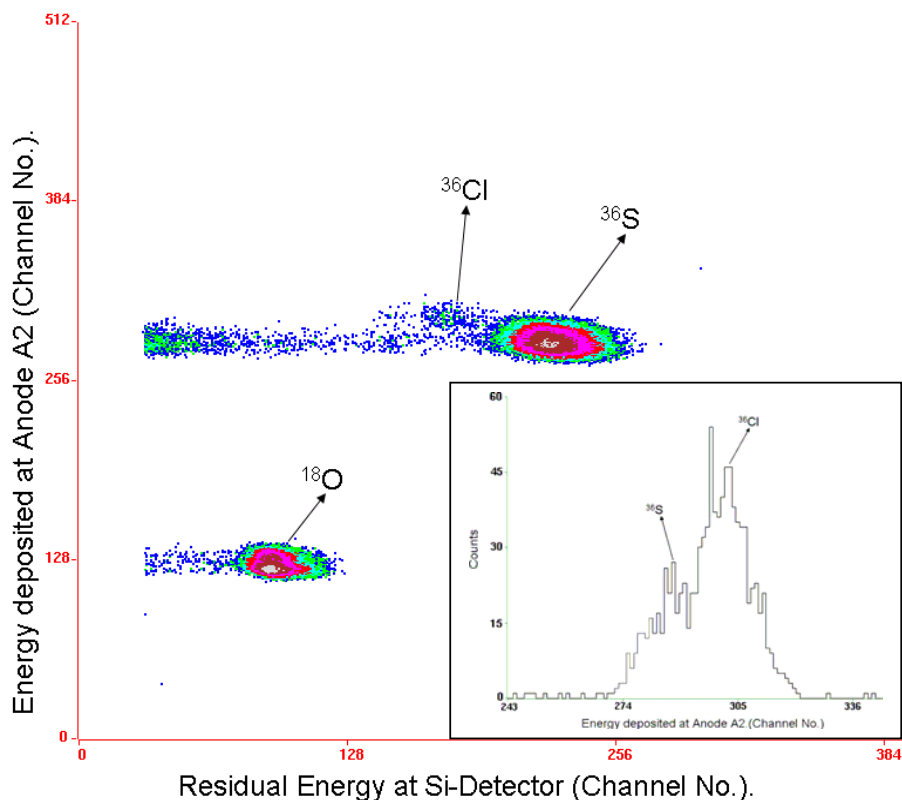


FIG. 3 Plot of A2 vs Si detector signals.

The strong peak due to ^{36}S is seen in the figure. The ^{36}Cl intensity though low is clearly identified. It has been possible to achieve a good degree of rejection of ^{36}S while detecting ^{36}Cl by following this procedure. In the inset of *FIG.3*, we have shown the signal from A2 gated by the ^{36}Cl group selected from the 2D plot of A2 vs. Si detector. By this method, we have been able to reduce the interference of ^{36}S in the detection of ^{36}Cl . There is also a peak corresponding to ^{18}O coming from the fragmentation of $^{18}\text{O}_2$ molecule present in ion source sample perhaps due to moisture. By measuring the yield of ^{36}Cl in the detector (from two peak fit of ^{36}S , ^{36}Cl) and the ($^{35}\text{Cl}+^{37}\text{Cl}$) beam intensity in the Faraday cup located in front of the detector, the value of the ratio $^{36}\text{Cl}/\text{Cl}$ in the sample was estimated. The measured value was very close to the Purdue estimate, implying that the beam transmission through the AMS system was nearly the same for different Cl isotopes of varying energies. Following a similar procedure, measurements were carried out with ground water samples (in the form of AgCl). The final results are given in table I. These ratios were normalized to Purdue standard. Some initial results from this programme have been reported elsewhere [6-7].

Table I. Results of AMS measurement for the various water samples along with the background and the Purdue standard values

Sample	Ratio $^{36}\text{Cl}/\text{Cl}$	Sample	Ratio $^{36}\text{Cl}/\text{Cl}$
Blank sample	$\sim 7 \times 10^{-14}$	Ground Water-2	$4.28 \pm 0.27 \times 10^{-12}$
Standard Sample	4.16×10^{-11}	Ground Water-3	$5.00 \pm 0.50 \times 10^{-12}$
Ground Water-1	$3.83 \pm 0.40 \times 10^{-12}$	Ground Water-4	$2.80 \pm 0.27 \times 10^{-12}$

5. Conclusion

The AMS facility at Mumbai pelletron is now ready for regular $^{36}\text{Cl} / \text{Cl}$ ratio measurements in samples. This programme will get a boost with the installation of a multicathode ion source which is expected soon. The ^{14}C content in these water samples is estimated to be of the order of 1 to 4 pMC. The samples analysed here are expected to have

half lives more than 35,000 years and hence age estimates based on ^{14}C dating method will not be accurate for them. Hence the $^{36}\text{Cl}/\text{Cl}$ ratio determination was carried out. However, some more controlled experiments are planned in future to obtain reliable estimates of the age of these water samples.

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