THE CHANDIGARH VARIABLE ENERGY CYCLOTRON AND ITS APPLICATION FOR TRACE ELEMENT ANALYSIS USING PIXE TECHNIQUES.

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Abstract

The paper describes the details of the Chandigarh Variable Energy Cyclotron and its application to trace element analysis using PIXE Technique. The various samples of water and Air of Chandigarh and nearby regions have been analyzed using 2-4 MeV Proton beam from this Cyclotron. The importance of the analysis of a few Biological and Archeological samples has also been discussed. The application of this technique is also being exploited for identification of forged ancient coins.

I. INTODUCTION

The Variable Energy Cyclotron at Chandigarh [1] has now been functioning with resolved beams of protons, deuterons, alphas and He-3. The beams of protons of energy from 1 to 5 MeV, deuterons of 4 MeV, alphas from 7 to 8 MeV and He-3 upto 11 MeV have been obtained at the target. This paper describes the various features of the cyclotron and the characteristics of the accelerated particles. The recent use of this machine for trace element analysis using Proton Induced X-ray Technique has also been discussed.

II. MAIN FEATURES OF THE CYCLOTRON

The machine at Chandigarh is adapted and built out of the components of the variable energy cyclotron at the University of Rochester, Rochester, New York, USA. It is single Dee classical cyclotron with arrangement for variable frequencies from 10 to 20 MHz, and a main magnetic field upto a maximum of 14 K Gauss. This permits the variability of the energy of the various accelerated ions. The layout plan of the whole set-up is shown in figure 1. Figure 2 shows the variation of the typical beam currents of the various ions at different radii from the center of the cyclotron. Figure 3 and 4 shows the gamma-ray and charged Particle spectra taken with protons on the specpure Al target. The γ-ray spectra were taken at 90° to the beam direction with the help of 50 cc Ge(Li) detector to avoid broadening of the peaks due to Doppler shift and charged particle spectra were taken with 300 um thick silicon surface barrier detector.

III. EXPERIMENTS WITH MACHINE

At present three types of experiments are being done with this machine which are described below.

(A) *In-beam spectroscopy using proton and He^4 induced reactions.*

In these experiments, we have studied the angular distribution of resulting γ-rays from the excited nuclei formed by (p,p'γ),(p,nγ),(p,$\alpha\gamma$) reactions and similarly with alphas by (α,pγ),(α,nγ) and (α,α',γ) reactions. The angular momentum and lifetimes of various excited states are measured using the computer code CINDY and DSAM technique[2-4].

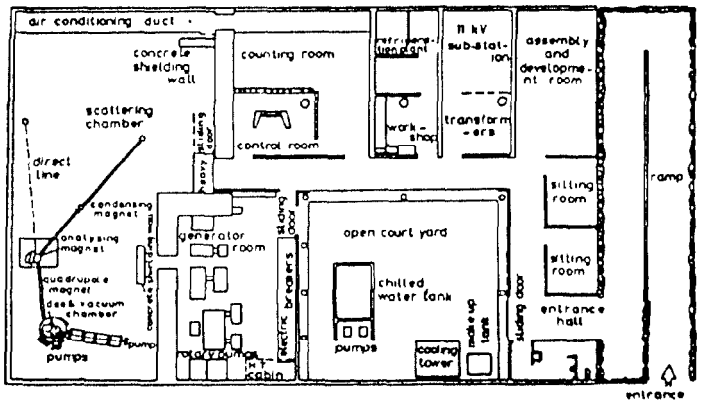

Figure 1. General layout plan of the cyclotron laboratory.

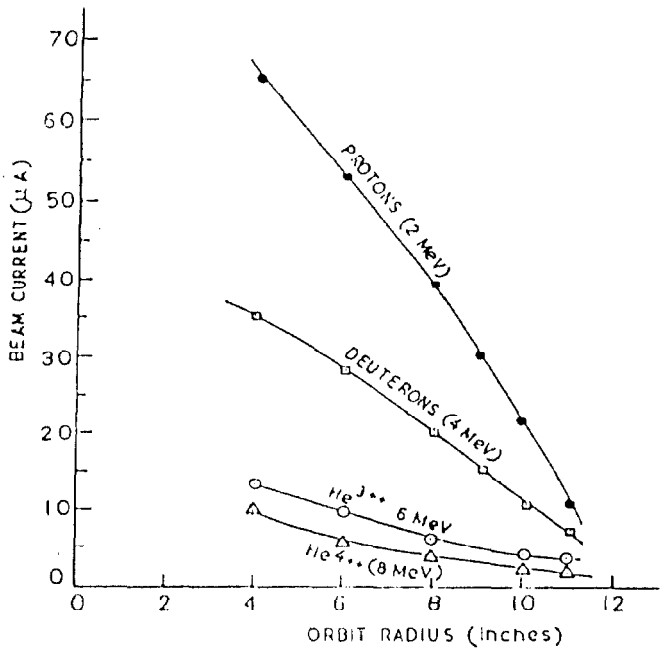

Fig. 2 VARIATION OF INTERNAL BEAM CURRENTS INSIDE THE CHAMBERS

(B) Coulomb Excitation

The phenomena of Coulomb excitation takes place when protons or α-particles interact with the target nucleus with the energy lower than the Coulomb barrier. Many cases of Coulomb excitation have been studied and reported in literature[5-6] using protons as projectiles.

(C) Proton Induced X-ray Emission Technique

In this technique, the interaction between target material and the incident beam of Protons or Alphas results in the emission of X-rays. These X-rays are then detected by a Si(Li) detector at Liquid Nitrogen temperature. The energies and intensities of the characteristic X-rays gives the information about the presence and the concentration of the trace element in the target material.

Figure 5 shows the PIXE spectrum of NBS standard Spinach sample. The analysis of spinach standard shows the presence of Al, Cl, K, Ca and Fe. Out of these K has maximum relative percentage of 63.48% followed by Ca (30.65%), Cl (3.83%), Fe (1.38%) and Al (0.66%). These results are in agreement with the standard data and hence allows the confidence in our results.

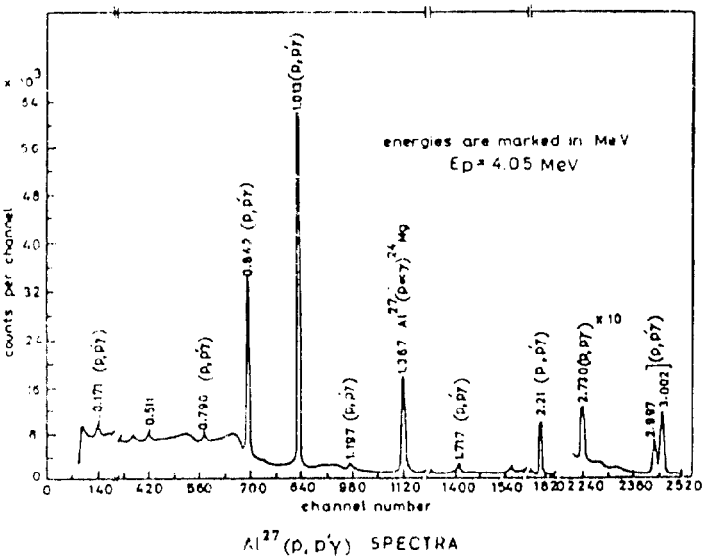

Figure 3 Typical gamma rays spectra due to ^{27}Al $(p, p'\gamma)$ at $E_p = 4.05$ MeV.

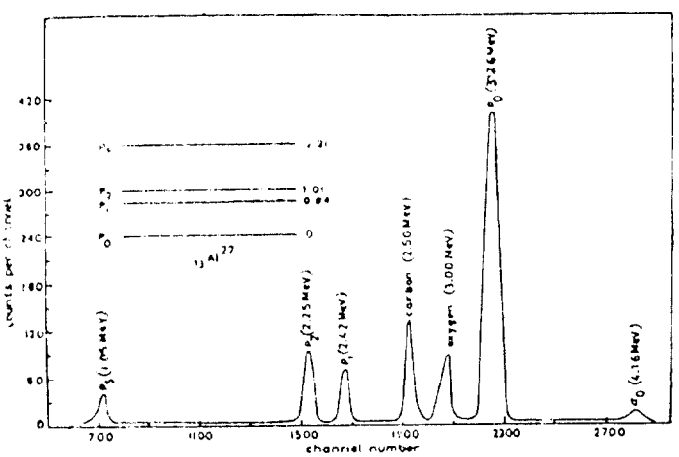

Figure 4 Proton spectrum from ^{27}Al $(p, p'\gamma)$.

SPECTRUM OF SPINACH

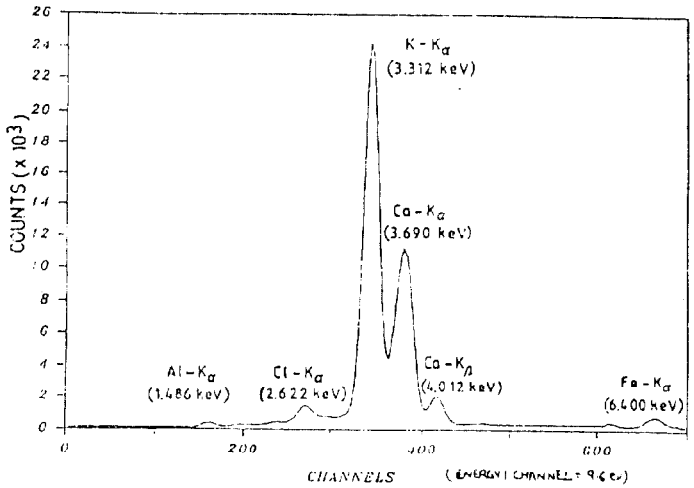

Fig. 5

WATER 1

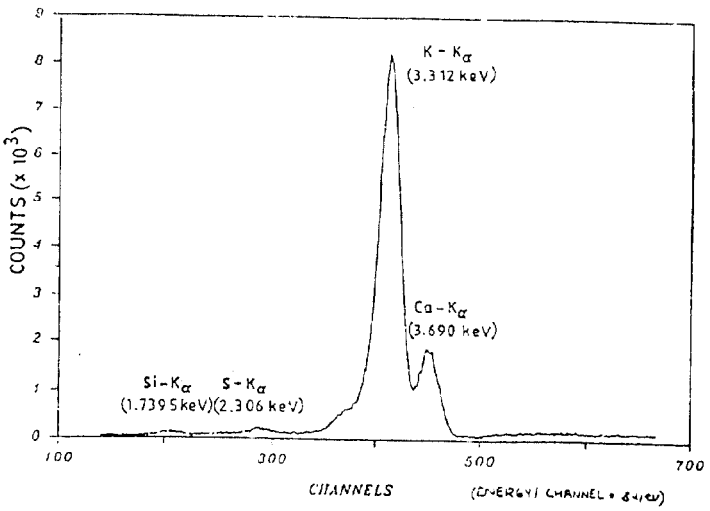

Fig.6

As a first case, this technique was used to study the water pollution of the different places in Patiala District in India[7]. The PIXE spectrum of typical two water samples are shown in Figure 6-7. The Table 1 shows various polluents and their relative percentage in there two samples In all the samples, the common polluents are found to be K, Ca, S with the relative percentage of K as maximum. Element K, Ca, S, Cr, Fe are essential for man, defficiency disease is known for each but may not always result from an inadequate diet. Co is physiological active only in the form of vitamin B_{12}. In addition to these Mn, V, Ni, Si have been shown by highly artificial isolator system to be essential for animals. Human defficiency disease is not known for many of these minor trace elements. Therefore, trace element analysis of water samples using PIXE technique is quite useful in the diagnosis of various types of diseases in animals and human beings.

W A T E R 2

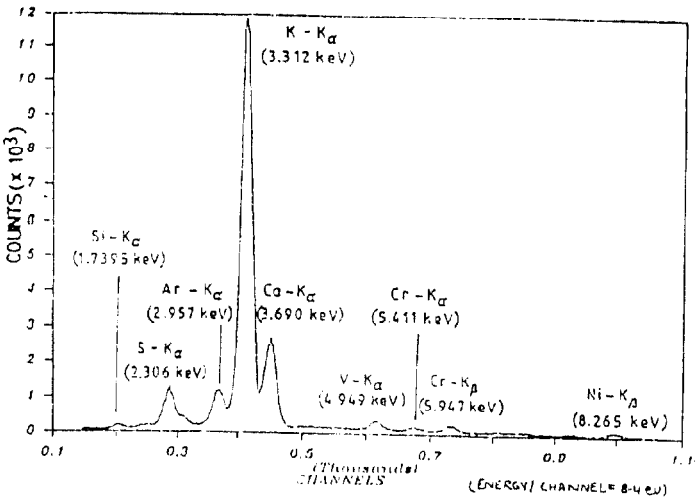

Fig.7

This technique is also being used for the study of Ancient coins, pottery and other artifacts of Archaeological importance with a special emphasis on the identification of forged Indian coins.

RELATIVE PERCENTAGE OF METALLIC POLLUENTS PRESENT IN WATER SAMPLES

Water Sample	Metaliic polluents present	A(mass per unit area of polluents in ngm/cm^{2}x10^6)	Relative % of polluents
1. (Kila Chonk)	Si	0.0021	.80
	S	0.0035	1.33
	K	0.2347	89.34
	Ca	0.2224	8.53
2. (Ragho Mazra)	Si	0.0013	0.61
	S	0.0087	4.11
	Ar	0.0103	4.87
	K	0.1455	68.76
	Ca	0.0286	13.52
	V	0.0023	1.09
	Cr	0.0098	4.63
	Ni	0.0051	2.41

IV. REFERENCES

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