ACCELERATOR MASS SPECTROMETRY PROGRAMME AT MUMBAI PELLETRON ACCELERATOR FACILITY

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AMS Programme based on ^{36}Cl
- Environment and water samples

INTRODUCTION

AMS

STABLE ISOTOPES OF VERY LOW ABUNDANCE

AND

LONG LIVED RADIOACTIVE ATOMS IN LOW CONCENTRATIONS

FROM 1977 **NEARLY 60 AMS FACILITIES**

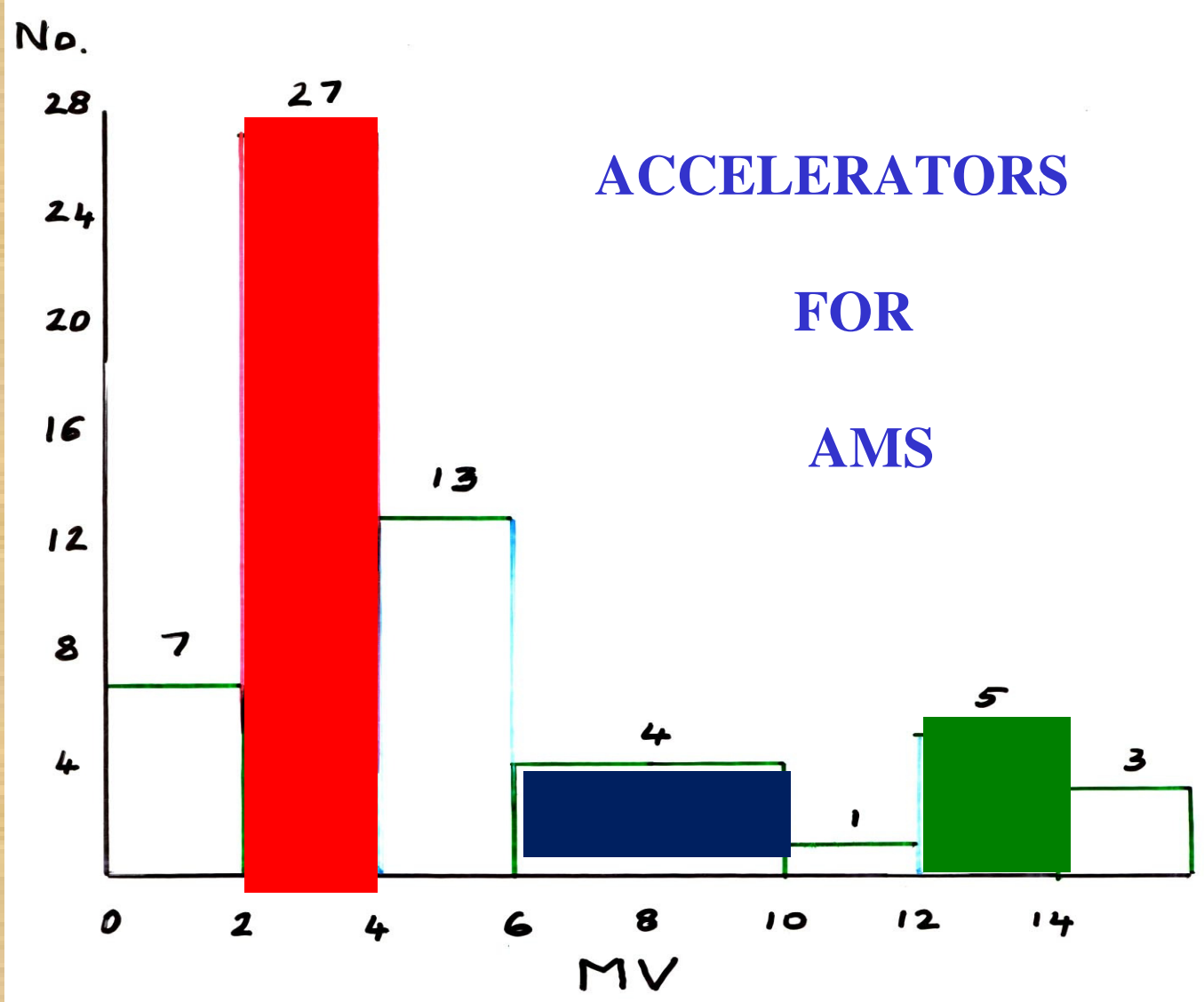
WHY AMS : Conventional MS

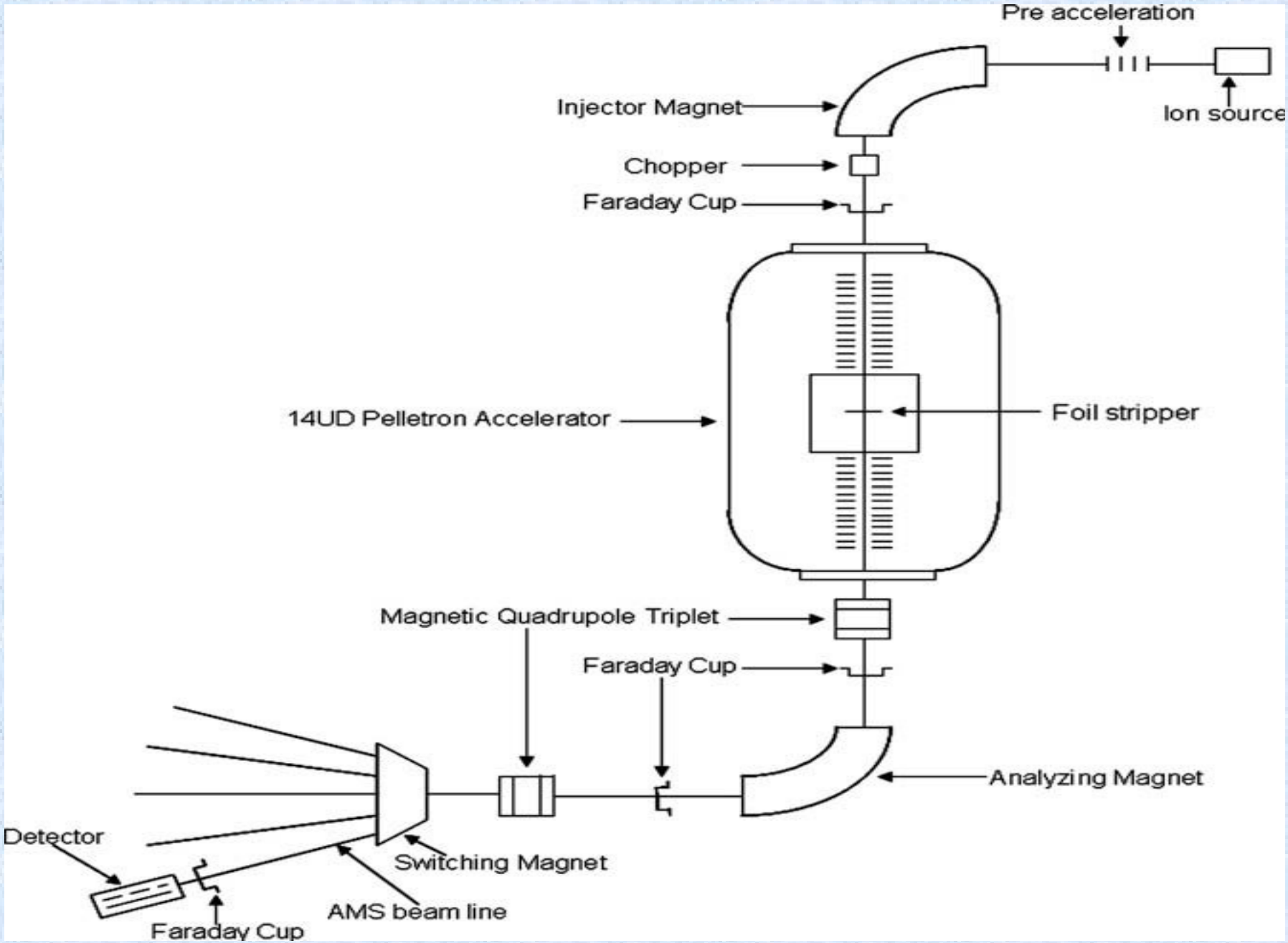
Interference from molecular ions, isobars

Radioactive decay counting

Too long a counting time for small sample

ACCELERATORS FOR AMS




Pre acceleration
Injector Magnet
Ion source
Chopper
Faraday Cup
14UD Pelletron Accelerator
Foil stripper
Magnetic Quadrupole Triplet
Faraday Cup
Analyzing Magnet
Detector
Switching Magnet
AMS beam line
Faraday Cup

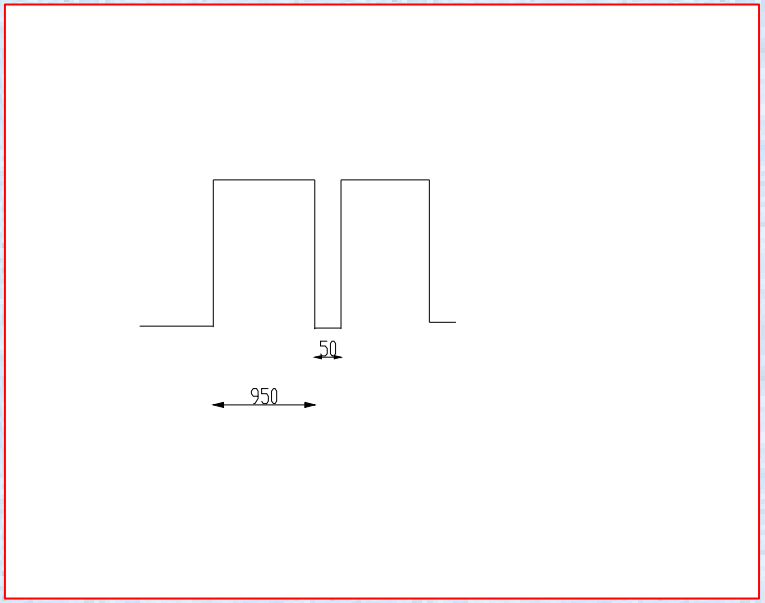
BEAM CHOPPER

- A Chopper is designed to reduce beam current by a factor of 20 while transporting ^{35} Cl and ^{37} Cl.
- Chopper will be off for ^{36}Cl.

- Duty Cycle = 1/20

- Beam on time = 50 µS

- Beam off time = 950 µS



MULTI CATHODE ION SOURCE

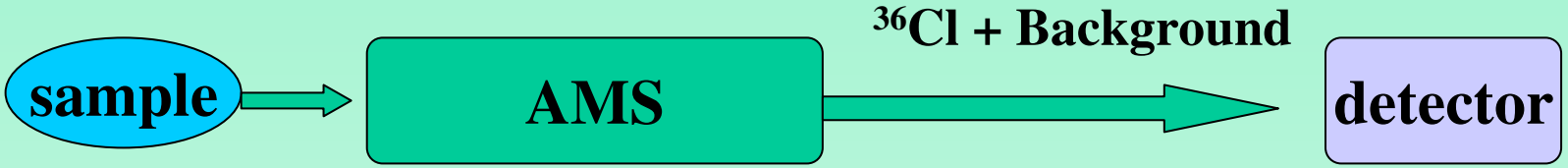
- A multi cathode sputter ion source
- 30 samples mounting cathode wheel undergoing testing at our ion source test bench set up.
- The design and development of this source is fully indigenous in all respects.
- Initial test results are encouraging. It is at an advanced stage of completion

Important Applications of ^{36}Cl

- measure the ages of ground water
- measure terrestrial ages of meteorites
- trace the movement of ground water
- trace the leakage of nuclear waste
- calibrate the cosmic ray flux using ice
- cores
- measure the neutron flux from the
- nuclear bombs
- dating of exposure ages of rocks

Detection Of ^{36}Cl

$T_{1/2}$ = 301000years

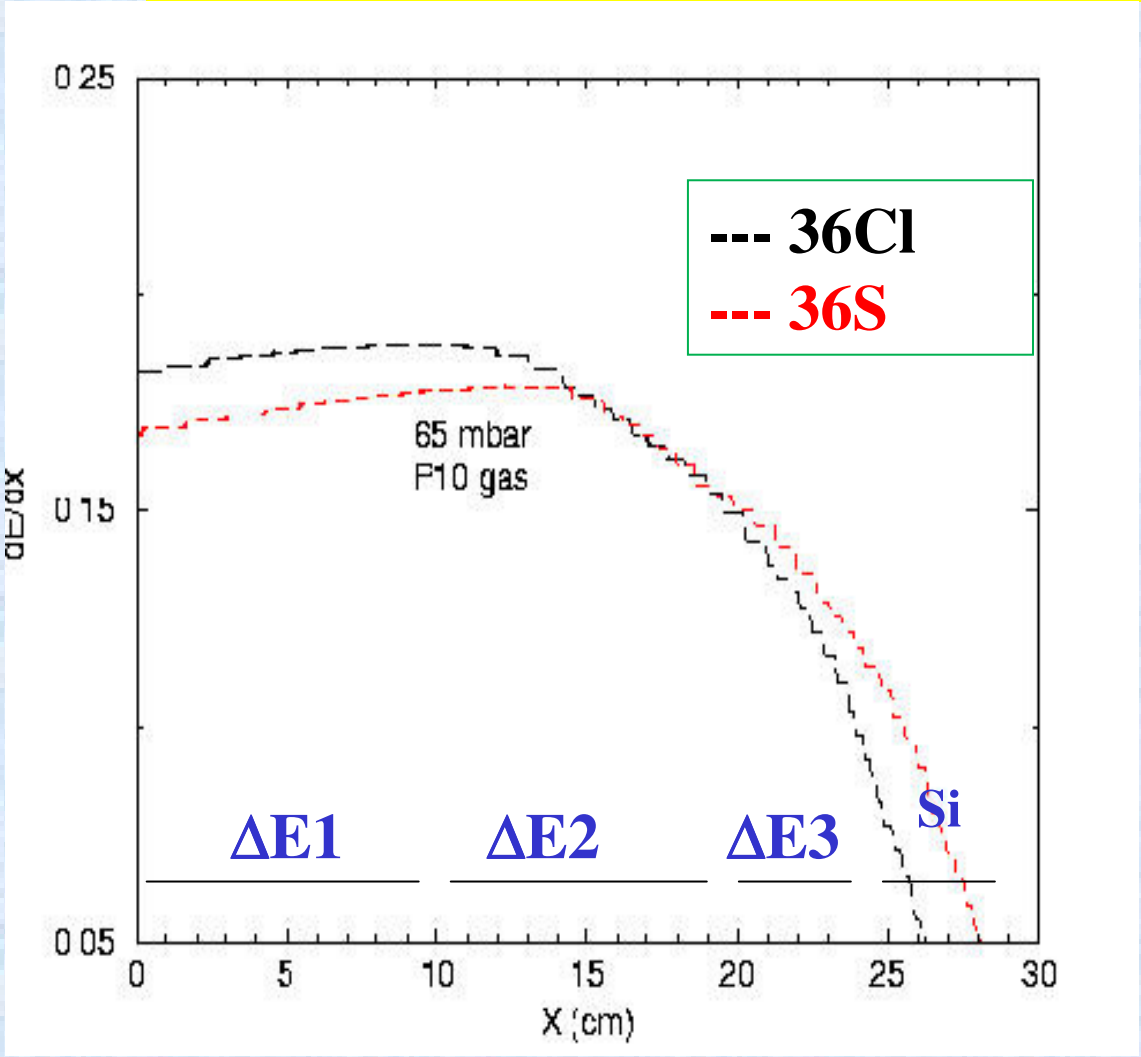


Accelerator based Mass Spectrometry (AMS) : ultra-sensitive means of counting individual atoms of long half life.

Background : Stable isotope of sulfur – ^{36}S

Detector : Multi-anode gas detector.
Length of ΔE anodes, matched according to the energy loss curves of ^{36}Cl and ^{36}S

Energy Loss Curves ^{36}Cl, ^{36}S

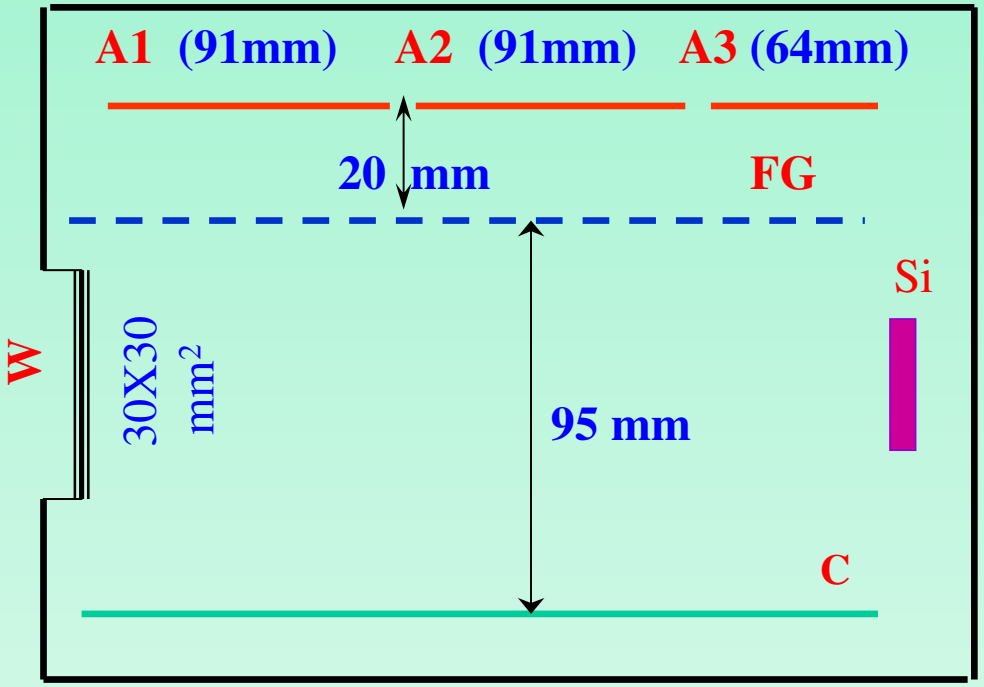


In ΔE1 & ΔE2, signal height of $^{36}Cl > {}^{36}S$

In ΔE3, Eres, signal height of $^{36}S > {}^{36}Cl$

^{36}S background can be reduced by Factor 10^4

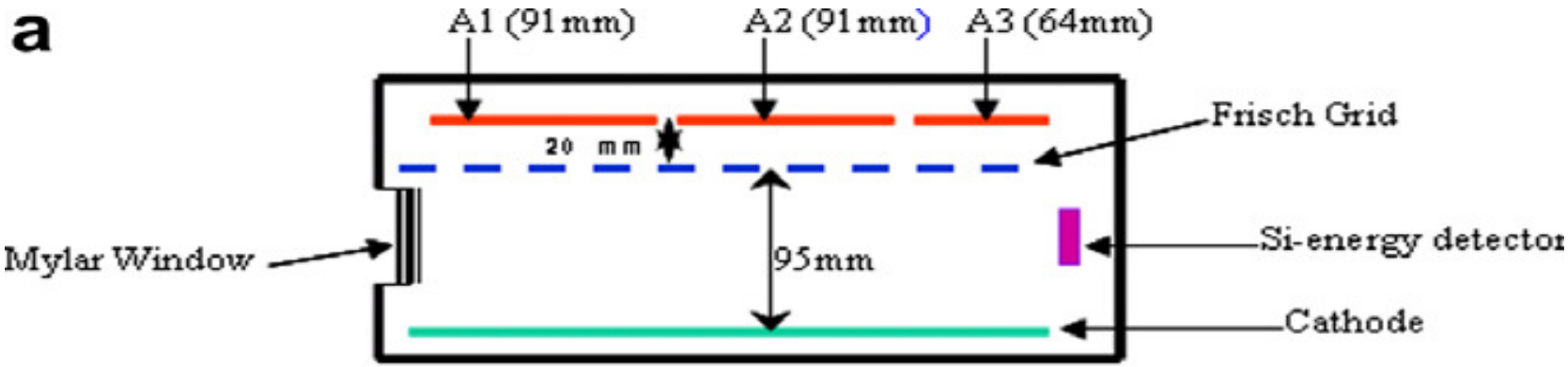
Hybrid Ionisation Chamber



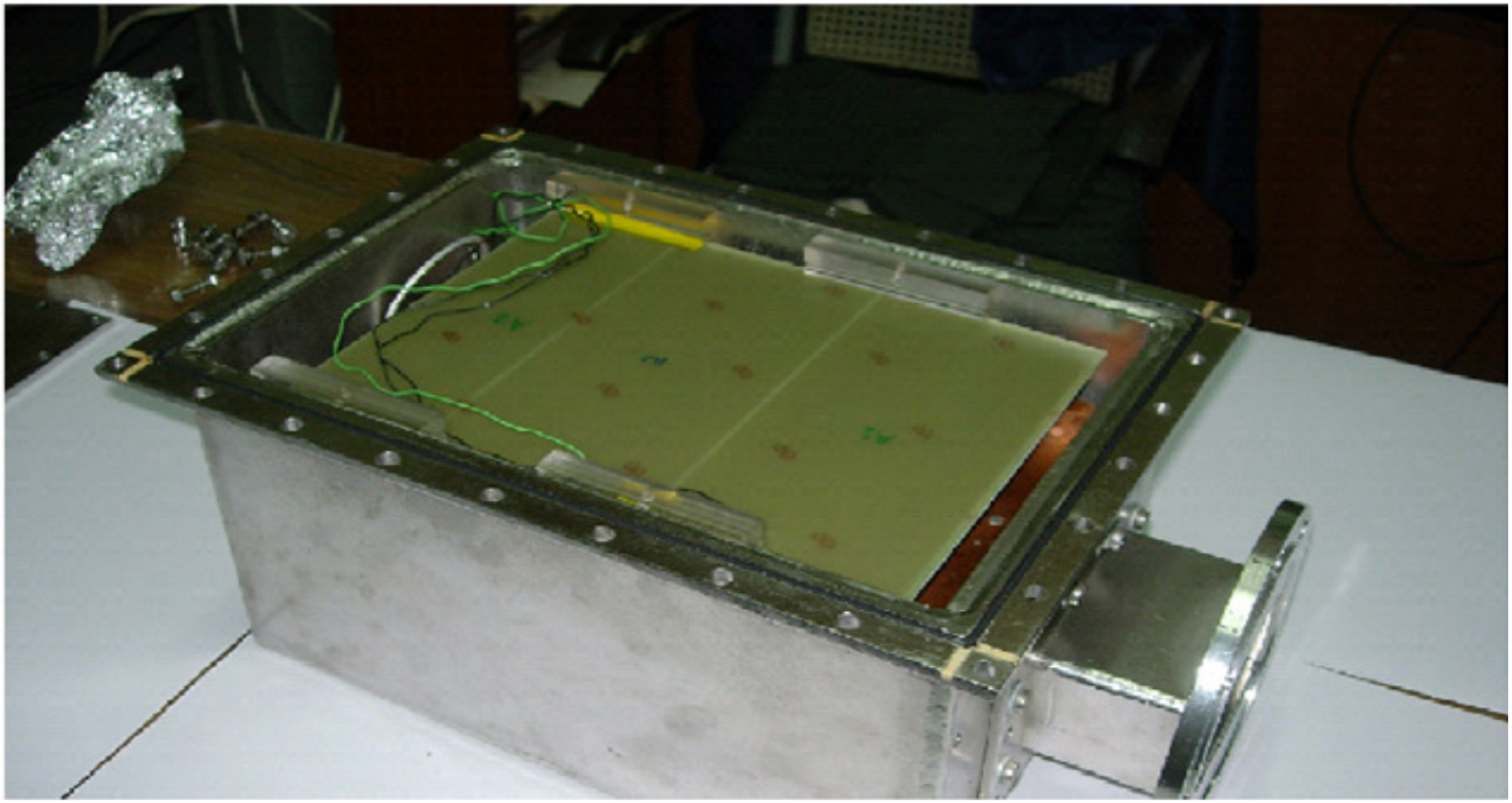
V_{anode} = +150 V
V_{grid} = +63 V
$V_{cathode}$ = -150 V
Gas : P10 (52 torr flow mode)
Window : Mylar (3.5µm)
Si –Detector : 300µm

Fig. 1

a


A1 (91 mm)
A2 (91 mm)
A3 (64mm)
Frisch Grid
20 mm
95mm
Mylar Window
Si-energy detector
Cathode

b



Experiment

To test and calibrate the hybrid Detector

^{32}S, ^{34}S, ^{36}S, ^{35}Cl, ^{37}Cl,^{36}Cl ions from 14UD Pelletron in low intensity, 10^3 pps were detected directly in the hybrid-gas detector

Procedure Followed

Tune beam – Maximise current in FC in front of detector
Ensure that ^{35}Cl / ^{37}Cl ratio is as per natural abundance
Optimise with chopper on and chopper off

Adjust IM – select isotopes of interest
Keep AM field , quadrupoles …all magnetic elements fixed
Terminal voltage scaled As per mass - constant ME/q^2

Calibrate detector with different ions - directly into the detector - Reduce filament current to do this

Detector optimised – signals from segmented detector
$^{32,34,36}S$ and ^{35,37} Cl ions used

First measurement with BLANK. Later with STANDARD
Finally unknown samples

Table: Energy loss at different stages

ion	VT MV	Ebeam MeV	Eres(after Mylar)MeV	A1 MeV	A2 MeV	A3 MeV
^{32}S	7.873	62.99	55.6	15.3±0.5	17.0±0.8	9.7±0.4
^{34}S	7.410	59.28	51.7	15.8±0.6	17.7±0.7	9.3±0.4
^{36}S	6.999	55.99	48.0	16.5±0.6	17.8±0.7	7.9±0.4
^{35}Cl	7.198	57.59	48.3	17.2±0.6	18.5±0.6	7.7±0.4
^{36}Cl	6.998	55.99	47.5	17.4±0.8	18.4±0.7	7.1±0.4
^{37}Cl	6.810	54.48	45.8	17.7±0.7	18.2±0.5	6.2±0.3

Energy loss curves for $^{32,34,36}S$ and $^{35,36,37}Cl$

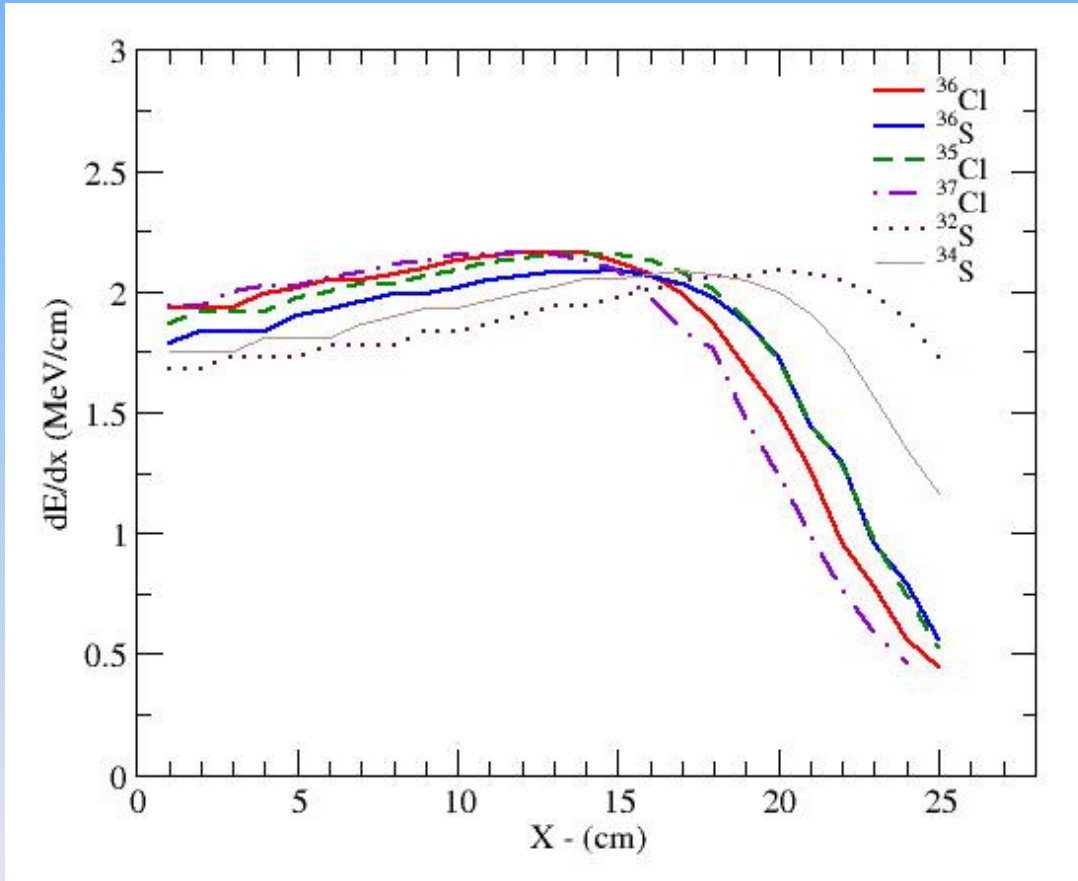
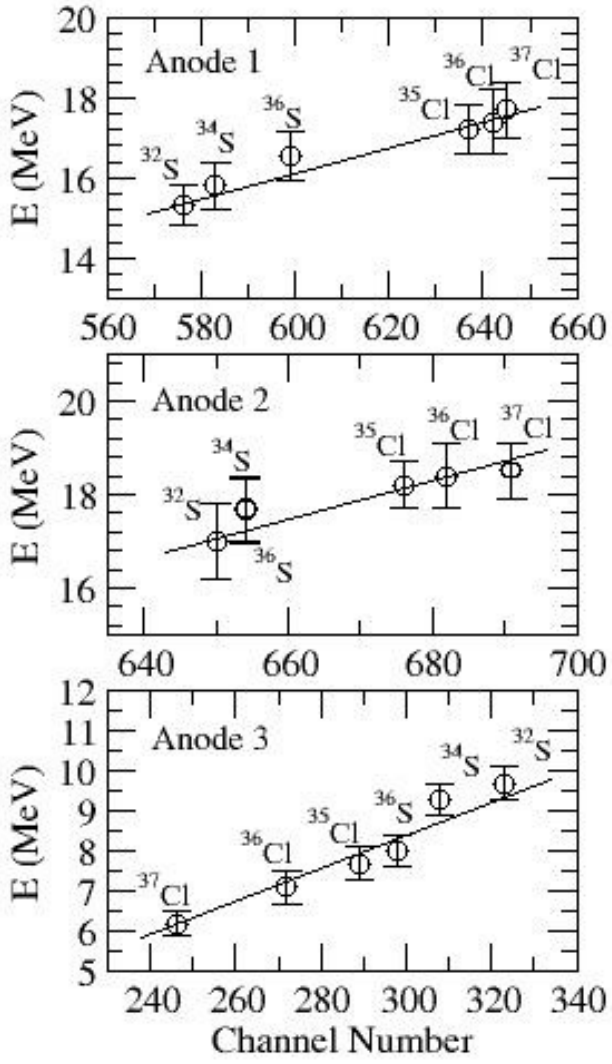
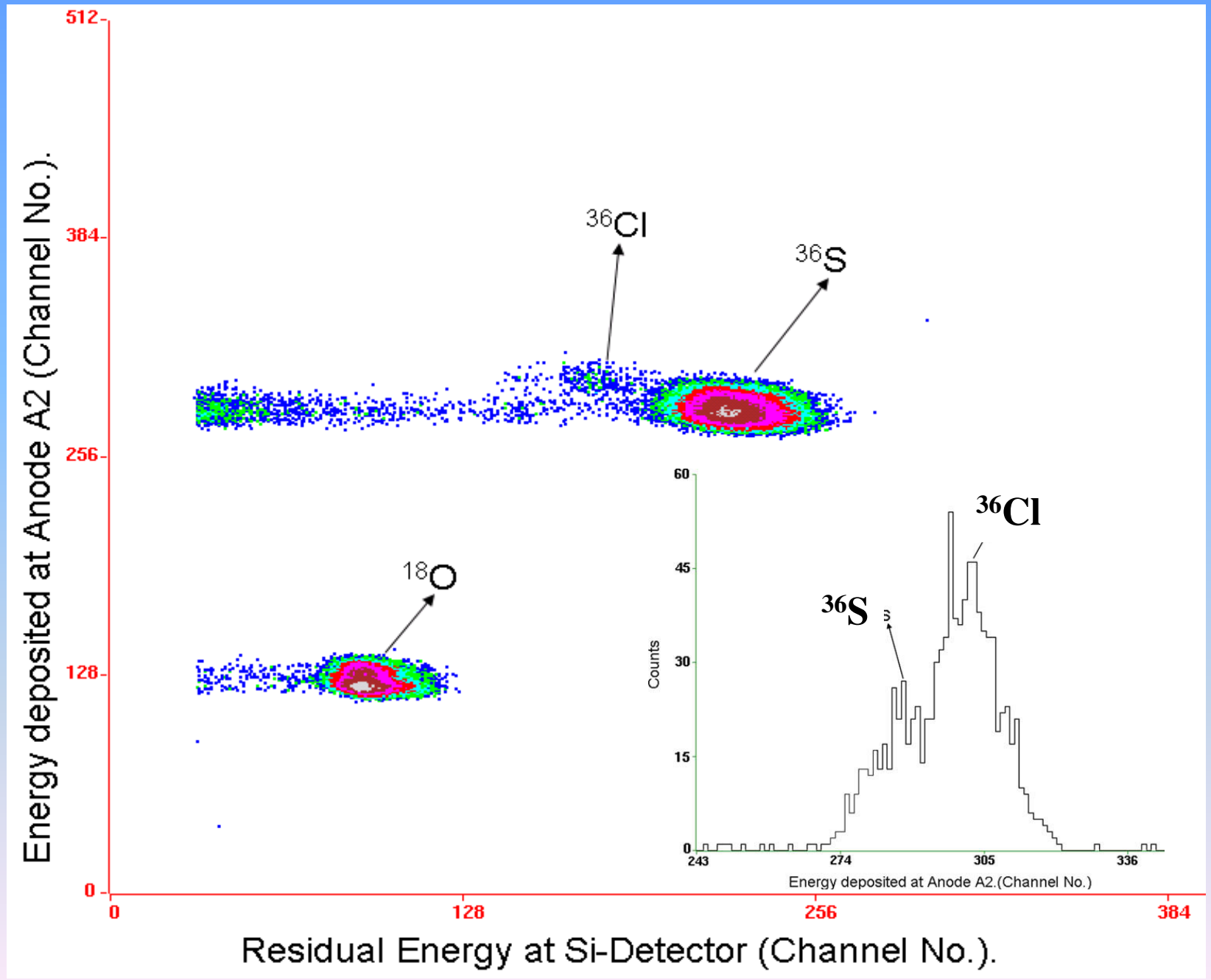


Fig. 2

Results


Anode 1
Anode 2
Anode 3
E (MeV)
Channel Number
32S
34S
36S
35Cl
36Cl
37Cl


512
384
256
128
0
Energy deposited at Anode A2 (Channel No.).
0
128
256
384
Residual Energy at Si-Detector (Channel No.).
36Cl
36S
18O
60
45
30
15
0
Counts
243
274
305
336
Energy deposited at Anode A2.(Channel No.)
36Cl
36S

RESULTS
Old Water Samples

Sample	Ratio $^{36}Cl/Cl$	Sample	Ratio $^{36}Cl/Cl$
Blank sample	~ 7×10^{-14}	Ground Water-2	$4.28\pm0.27\times10^{-12}$
Standard Sample	4.16×10^{-11}	Ground Water-3	$5.00\pm0.50\times10^{-12}$
Ground Water-1	$3.83\pm0.40\times10^{-12}$	Ground Water-4	$2.80\pm0.27\times10^{-12}$

CONCLUSION

AMS facility is ready for regular $^{36}Cl/ Cl$ ratio measurements

$^{36}Cl / Cl$ ratio of water samples range between 2 to 5 x 10^{-12}

Controlled experiments planned to get the age of these Water samples (expected to be over 35,000 years – 1- 4 pMC)

^{129}I is planned for future

^{14}C at IOP

^{10}Be at IUAC