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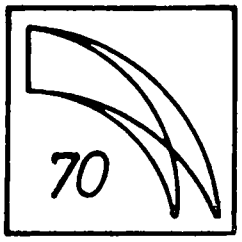
Kernforschung

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON ELECTROMAGNETIC ISOTOPE SEPARATORS AND THE TECHNIQUES OF THEIR APPLICATIONS

Marburg, Sept. 7 to Sept. 10, 1970



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Dezember 1970

ON LINE SEPARATION OF SHORT-LIVED IODINE ISOTOPES

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The Buenos Aires ISOL set-up was designed primarily to study short lived fission products, if possible without being restricted to gases, i.e. Kr and Xe, but having also a reasonable chance to detect non-gaseous but volatile elements, such as Br and I. To this end the following design was adopted:

a) a fission-product generating system coupled through a short (50 cm) transport line to

b) an electromagnetic mass separator of high resolving power and efficiency, with double focussing, which delivers the mass to be studied to

c) the collecting device with its detection system, which includes a moving-tape collector and Ge(Li) and Si(Li) detectors.

a) Generation of fission products

The fission products are produced in the fission of ^{235}U placed in a thermal neutron flux of approximately 10^{8} n.cm^{-2}.s^{-1}. The neutrons are generated in the $^{7}Li(d,n)^{8}Be$ reaction by bombarding a natural Li target with a deuteron beam of 1-2 mA, accelerated up to about

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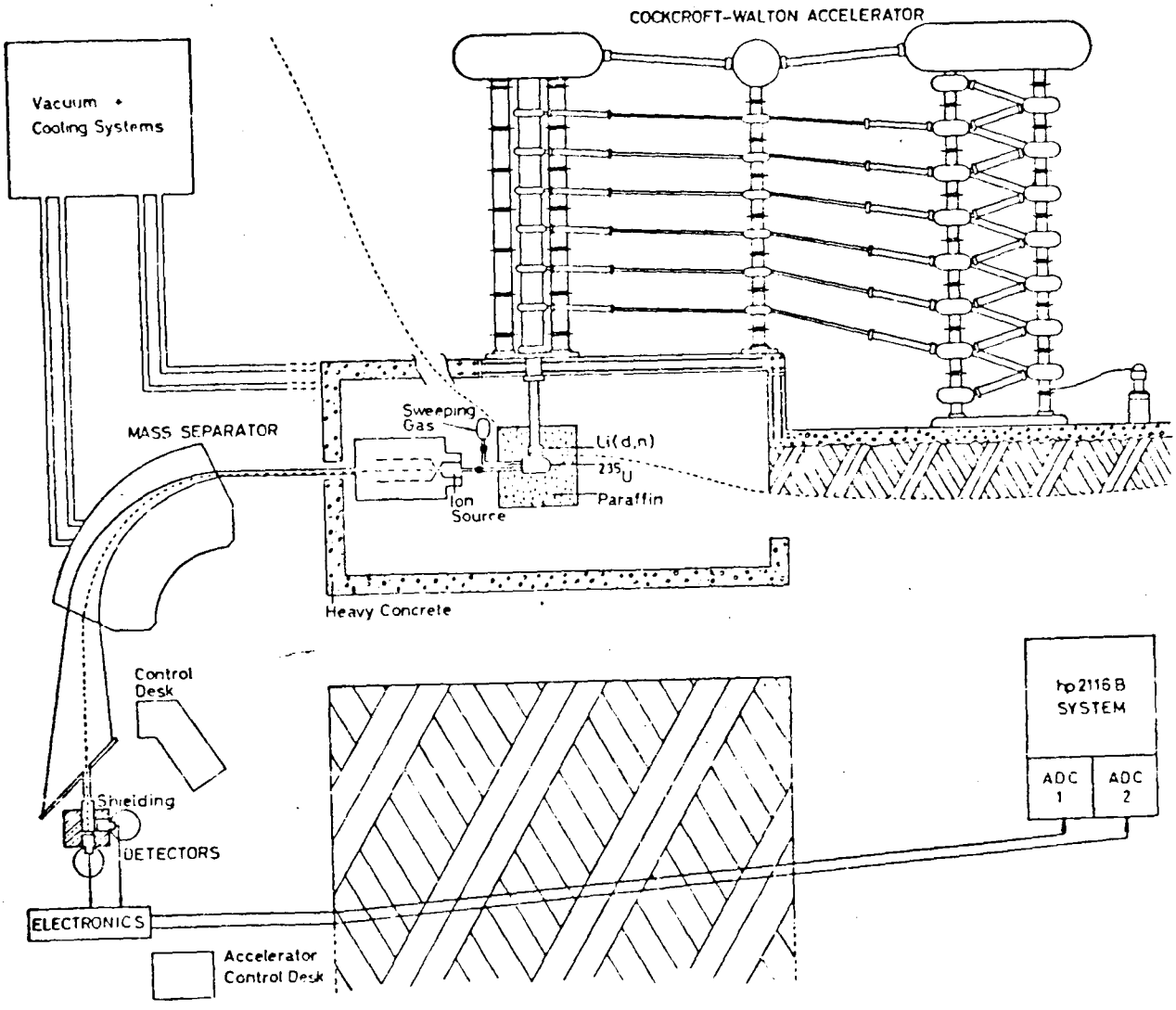
x) Member of the Scientific Research Career of the Consejo Nacional de Investigaciones Científicas y Técnicas



BUENOS AIRES ISOL SET-UP

900 keV in a Cockcroft-Walton machine. The neutrons are thermalized in a paraffin cube of 0.7 m^3 with the Li target at its center. The ^{235}U is contained in a sample of about 20 g of uranyl stearate, enriched to 90 %, placed in a stainless steel container near the target. This container is connected to the ion source of the mass separator by a 50 cm long stainless steel pipe of 10 mm diameter. The fission products are swept into the separator by a controlled flux of gas which enters the uranium sample container through another line of 1 mm diameter. The sweeping gas, besides helping in the transport of the fission products, has two other important functions. First, by mantaining a controllable gas pressure within the ion source it permits a stable operation; this restricts the allowable range of pressures which may be used to sweep the fission chamber. Second, the stable isotopes in the sweeping gas, in our case Kr or Xe, serve to identify the mass number being accumulated, by means of current measurements on the collected beam and/or by the observation of the spots which can be seen on a fluorescent screen provided for image observation.

b) Mass separator

This machine was designed and built at our laboratory specifically for the ISOL set-up. The ion source has a cylindrical graphite discharge chamber and a 0.8 mm tungsten filament. After axial extraction the ion beam is accelerated by a potential of 60-80 kV and focused by a system of electrostatic lenses. The magnet is of 90° deflection and the entrance and exit planes make an angle $\Phi = 63.5°$ with the direction of the central trajectory. This provides for

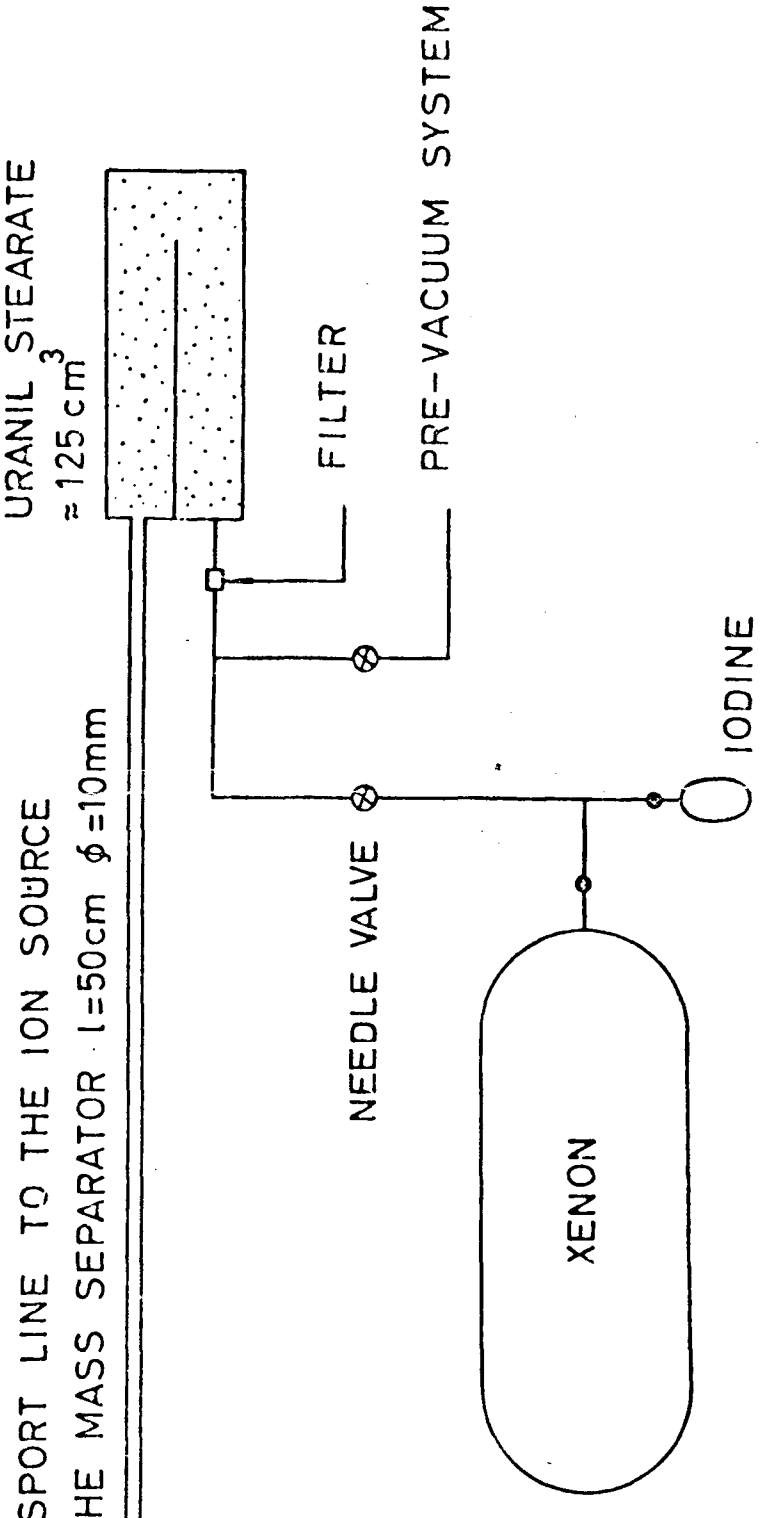


Fig. 2: Schematic arrangement of the ^{235}U sample and the sweeping gas

double focussing and a greater dispersion for a given magnification than would be the case in the more usual configuration with $\varphi = 90°$. The radius of curvature is 150 cm and the air gap is 10 cm. The maximum field that can be achieved is 4300 Gauss. The vacuum system is conventional; the normal working pressure in the separator is $2-3 \times 10^{-6}$ Torr.

The current source for the magnet coils is stabilized to 1:5000. Fine adjustments in the beam position are made by means of a system of electrostatic deflection plates which can be controlled either by hand monitoring the beam current at the collector, or automatically by a feedback mechanism which senses beam deviations through two feeler electrodes.

With this machine we have achieved stable operation with an efficiency of the order of 10 % for rare gases and a separation of about 15-17 mm for adjacent masses in Xe, with an image diameter of some 4-5 mm.

c) Collection of separated activity

Two main configurations were used so far in our experiments for collection of the ion beam of interest. The first consisted of a moving-tape collector coupled to the exit of the separator by a short piece of brass pipe. The tape was threaded through several guides so that it came as near as possible to the front end of the cryostat assembly which housed the Ge(Li) detector. In this configuration there is only the thickness of the magnetic tape and 0.5 mm Lucite from the housing of the collector interposed between the activity collected and the detector assembly.

The second configuration was used with the Si(Li) detector. In this case the housing of the detector was

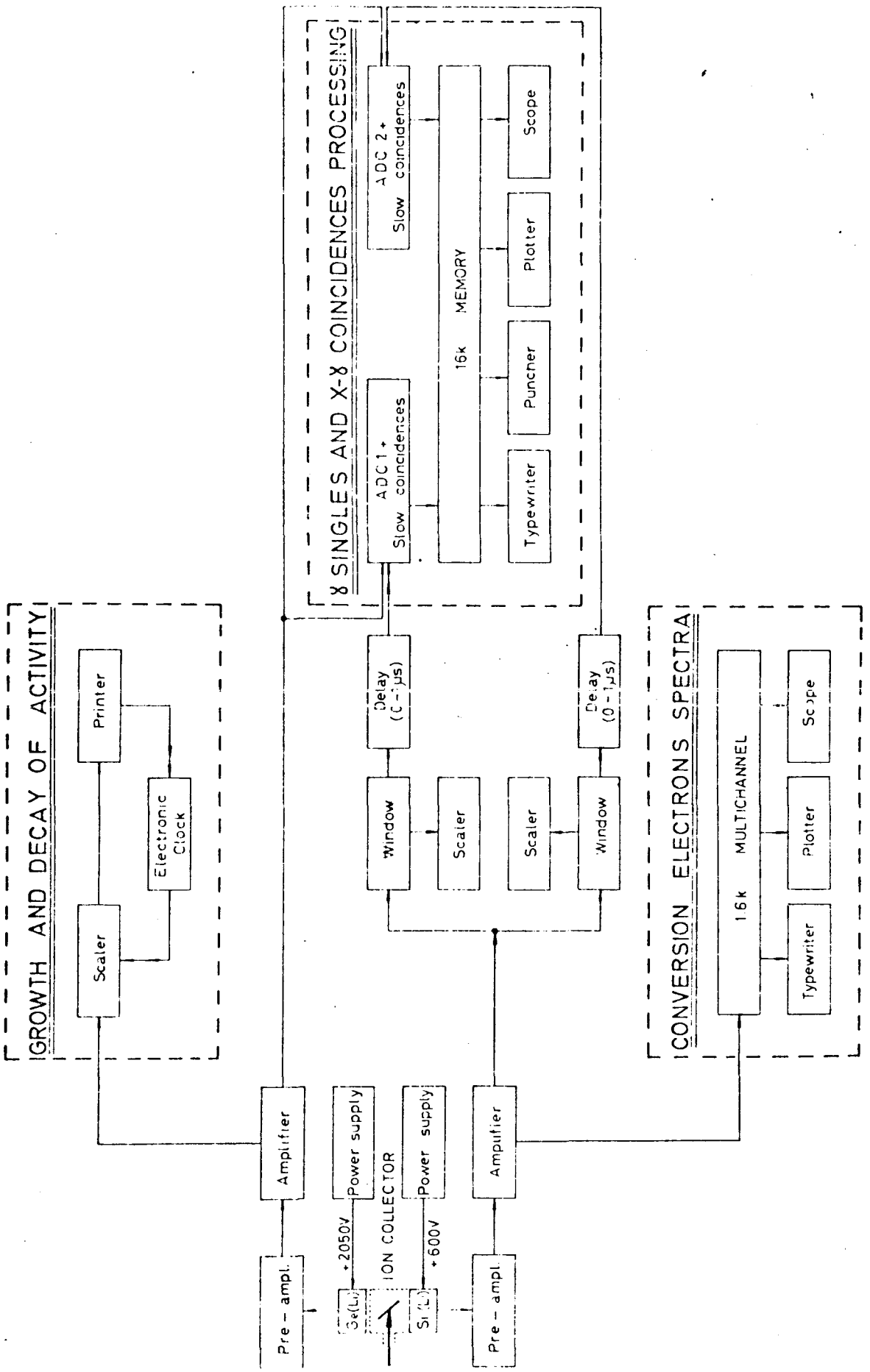


Fig. 3: Detection set-up used in the mass 134 measurements

coupled directly to the output of the separator, so that the required vacuum was provided by the main pumps in the mass separator. For off-line experiments the vacuum could be mantained by a set of cryogenic pumps. The detector was mounted with its face parallel to the beam direction and positioned so that the fission fragments could not reach it directly. The beam was stopped by a small piece of aluminum of 5 mg/cm^2, set at 45° with respect both to the beam direction and to the face of the detector.

In both these configurations it was possible to install a second detector, usually a Ge(Li), so that we could make gamma-gamma and electron-gamma coincidence measurements. The rest of our instrumentation for detection is fairly conventional. The detectors are Nuclear Diodes Ge(Li) diodes of 35 and 45 cm^3 of good resolution and a Simtec Si(Li) detector of 1 cm^2 area and 3 mm depth; they are coupled to the analyzing system through Nuclear Diodes preamplifiers and Tennelec amplifiers. The detector signals are fed to a computerized multichannel analyzer system fitted with two 4096 channel ADC's, oscilloscope, teleprinter, tape reader and puncher, magnetic tape and a Calcomp digital plotter. Part of this equipment has only recently become operative and has not been used to a significant degree in our reported work.

Experimental results

With the set-up described above we have been able to observe reasonable activites from I isotopes of mass numbers 133, 134, 135 and 136, as well as Xe isotopes in the range 133 to 140, and Br and Kr isotopes with mass numbers 86 to 91. We assume that our relatively good iodine yields are due

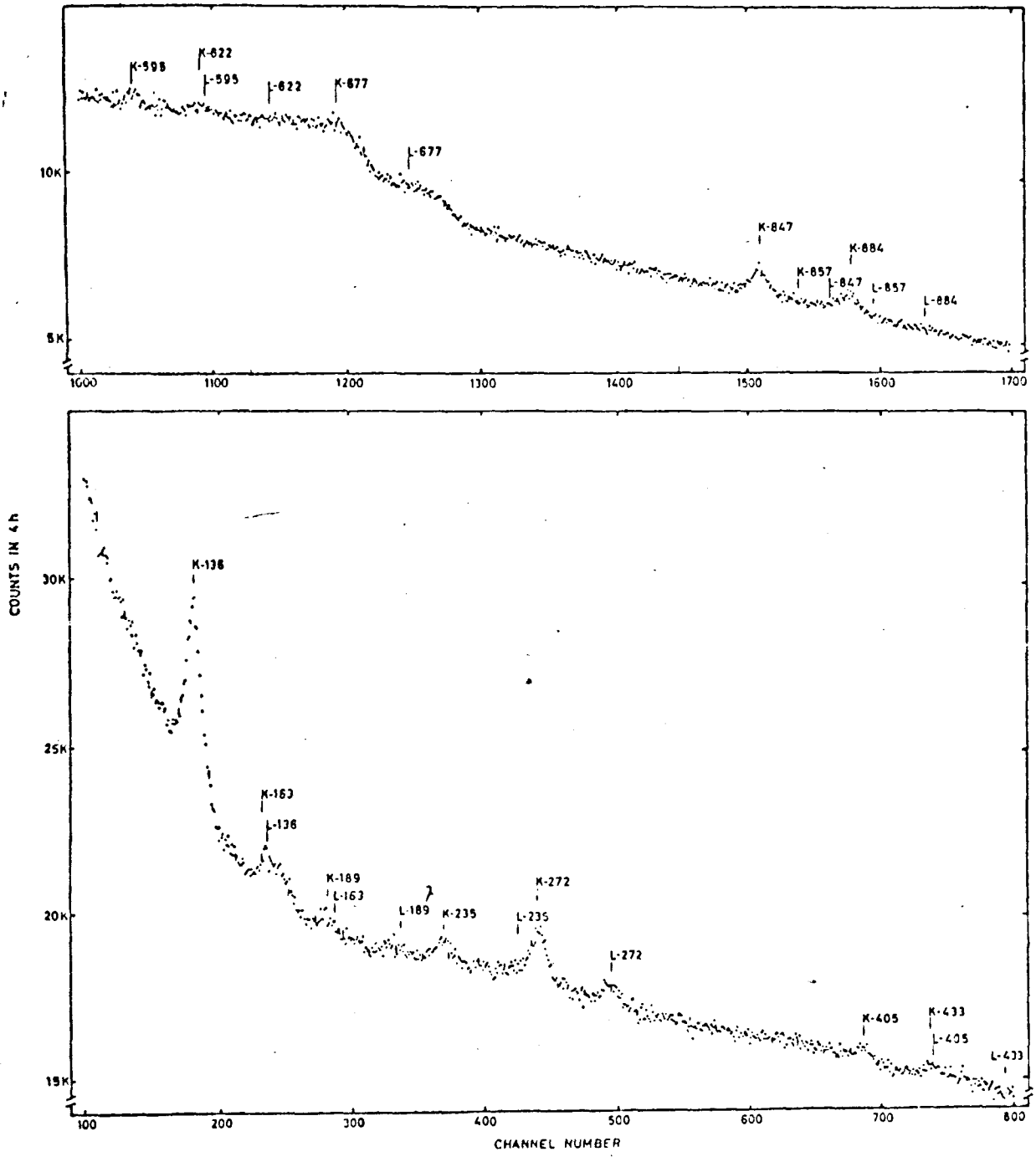


Fig. 4 : On-line electron spectrum of ^{134}I

Table 3

Properties of low-energy transitions following decay of ^{139}Xe

E_γ(keV)	I_γ	$\alpha_K \times 10^3$	K/L+...	OL
104	6 ± 1	800 ± 100	0.7 ± 0.1	E2
175	372 ± 10	120 ± 10	1.9 ± 0.1	E2
219	1100 ± 30	63 ± 5	4.2 ± 0.1	E2
290	198 ± 6	28 ± 5	3.4 ± 0.5	E2(+M1)
297	424 ± 10	31 ± 5	4.5 ± 0.5	E2(+M1)
339	13 ± 1	6 ± 1	3.2 ± 1	E3
357	11 ± 1	75 ± 10	2.2 ± 1	E3
394	156 ± 5	10 ± 3	3.3 ± 0.5	E2-M1

mainly to the three following reasons:

1) the chemical composition of the uranium,compound. We had markedly lower yields using either uranyl nitrate or uranium oxide;

2) we have a short transport line from the fission container to the ion source of the separator, reducing trapping of the fission fragments;

3) we use a sweeping gas mixture of Xe and I whose composition has been optimized at roughly about 1:1.

In these circunstances we have obtained gamma and electron spectra for I and Xe isotopes and have been able to measure energies and intensities of a considerable number of gamma-rays and conversion electron lines. Our results for iodine isotopes have been presented in detail at the recent Leysin Conference and include among other data a number of internal conversion coefficients, and in the case of ^{134}I, a study of the 3.5 min isomeric level. For illustrative purposes we include here Table 3 of that communication which gives the energies and intensities of the low energy transitions of the ^{139}Xe decay.