ISTITUTO NAZIONALE DI FISICA NUCLEARE

Sezione di Milano

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A TIME OF FLIGHT SYSTEM BASED ON LOW-PRESSURE MULTIWIRE PROPORTIONAL COUNTERS FOR ACCELERATOR MASS SPECTROMETRY

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1. - INTRODUCTION

This report describes a time of flight (TOF) system based on Multi Wire Proportional Counters (MWPC) which we have recently built and tested in order to complete the final detector system of our accelerator mass spectrometry (AMS) apparatus. This apparatus, which uses the analytic properties of the 16 MV XTU Tandem of the Laboratori Nazionali di Legnaro, has been fully described in previous papers [1] , together with our first measurements on Be-10 and Cl-36. In the case of these cosmogenic radioisotopes, the separation form the interfering isobars (Be-10 and S-36 respectively) and isotopes (Be-9 and Cl-35, Cl-37 respectively), could be easily performed by means of ionization chambers, either of the multianode [1] or of the Bragg type [2]. On the other hand, in the case of I-129, the next radioisotope included in the Italian AMS program we will be studying, the problem is somewhat different. No interfering isobar will reach the final detector system, since the only one, Xe-129, does not form negative ions in the source. However, interference is expected from the stable, abundant isotope I-127, not completely suppressed by the low energy injection magnet and passing through the high energy analyzing magnet with the same rigidity (ME/q^2) as I-129, due to charge exchange processes with the residual gas present in the accelerating tubes. This "abundant" isotope differes only 1.5% in energy from the "rare" I-129 isotope, a value not significantly higher than the energy resolution of our gas detectors [1,2]. We therefore decided to build a TOF system to measure also the

2. - WHAT IS A LPMWPC ?

A LPMWPC (Low Pressure Multi-Wire Proportional Counter) is a gas detector utilizing the double amplification process as discovered by Breskin [3]. These detectors operating in the 0.3-5 Torr range have shown to have very good timing characteristics in comparison with the traditional MWPCs operating at atmospheric pressure. What is typical of a LPMWPC is the high reduced electric field. The electrons released in the sensitive volume start indeed an amplification process already in the constant field region, relatively far apart from the anode (the wires), where fields of the order of several V/(cm.Torr) are reached. The slow migration of electrons towards the anode before any amplification starts, a phenomenon which is typical of the traditional MWPCs, is thus avoided in these LPMWPCs. In these counters indeed all electrons instantaneously can start an avalanche process. A second amplification subsequently occurs in proximity (about 0.3 mm) of the wires, where the electric field (behaving as 1/r) is about 2 orders of magnitude higher. This combined mechanism allows to obtain very high gains (from 5 to 2000 times higher than a parallel plate counter operating in similar conditions), thus giving an acceptable signal/noise ratio even in presence of low ionizing particles such as alpha particles.

We have mounted various anodes using wires of different diameters in order to study their effect on amplification factor. Each cathode consists of 0.5 μm stretched polypropylene foil, glued with epoxy-resin on 4 mm thick plexiglass frames, in which a hole O 30 mm was made. The electrical conducibility was obtained by evaporating a 50 $\mu g/cm^2$ thick gold layer. The total detector thickness was about 240 $\mu g/cm^2$.
The electrical contact between the cathodes and the cables soldered to the H.V. connector was made with a conductive silver paint. The gap between cathodes and anode could be varied between 3.2 and 1.6 mm by interposition of precision teflon spacers. The filling gas was chosen to be isobutane, which allows to obtain amplification factors about 1 order of magnitude higher than the other commonly used gases, even though it is not the fastest one [4]. The gas is continuosly replaced to avoid contamination due to leaks or outdegasing by a two-valve flux system. The START detector is mounted in a stainless vacuum vessel, the STOP detector in a aluminum one placed in front of a Bragg ionization chamber for energy and atomic number identification [2]. The second cathode of this detector therefore acts only as an electrode and not as a window.

4. - EXPERIMENTAL SET-UP

5. - TIME RESOLUTION TESTS

The first tests have been made in our laboratory, using a 0.1 μCi Am-241 alpha source. The time resolution of each detector was measured versus a 300 μm solid state silicon detector placed just behind the LPMWPC. The best conditions were the following: H.V. 620 V, p= 1 torr, cathode-anode gap 3.2 mm, anode wires 10 μm.

A typical time spectrum obtained in these conditions is shown in Fig. 6. The peak on the right has been obtained by introducing a delay of 2 ns. The intrinsic resolution obtained, after subtraction of the electronic resolution (100 ps) and the silicon detector resolution (150 ps) is 450 ps. This value compares favourably with the result of Breskin [3], and was also confirmed by measuring the resolution with both LPMWPC as Start and Stop detectors. An overall resolution of 690 ps, again corresponding to an intrinsic resolution of about 450 ps for each detector, was measured in this case (see Fig. 7 for the corresponding time spectrum).

The final tests were made with heavy-ion beams at the XTU Tandem of Laboratori Nazionali di Legnaro. The TOF system was placed on the sliding-seal scattering chamber, mounted on the -20 deg. beam line, and a 80 MeV S-32 beam, elastically scattered by a 150 $\mu gr/cm^2$ Au target, was used.

The angle was 20 deg.

even after including the effect of straggling of Iodine in the 2 cathodes of the Start detector (150 ps at 80 MeV)[5]. On the other hand, the time resolution measured, about 200 ps, allows to consider these LPMWPC as excellent devices in any TOF apparatus and compares favourably with other, more expensive and delicate, time detectors.

ACKNOWLEDGEMENTS

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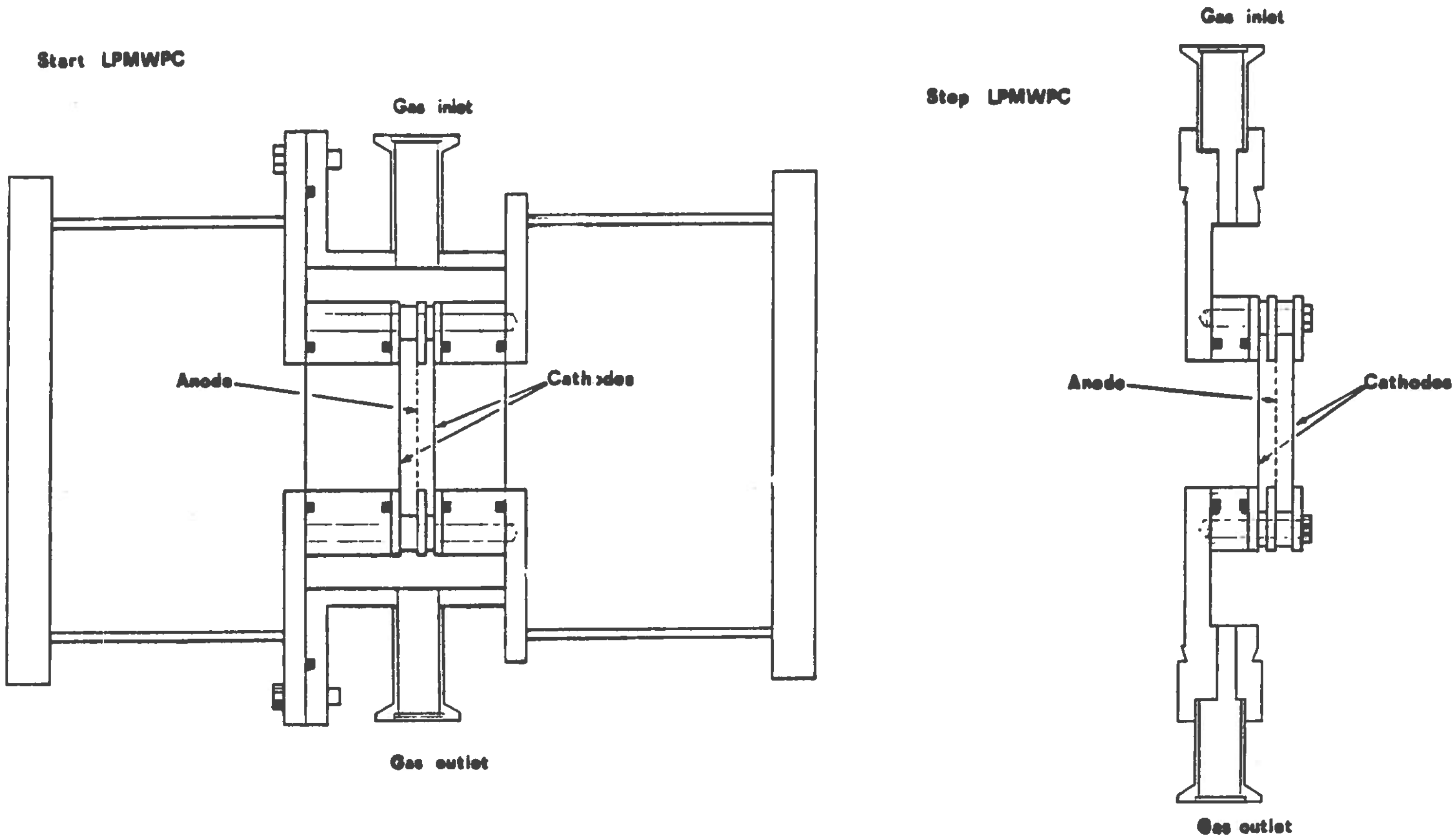


FIG. 1 - Cross sectional view of the Start and Stop detectors.

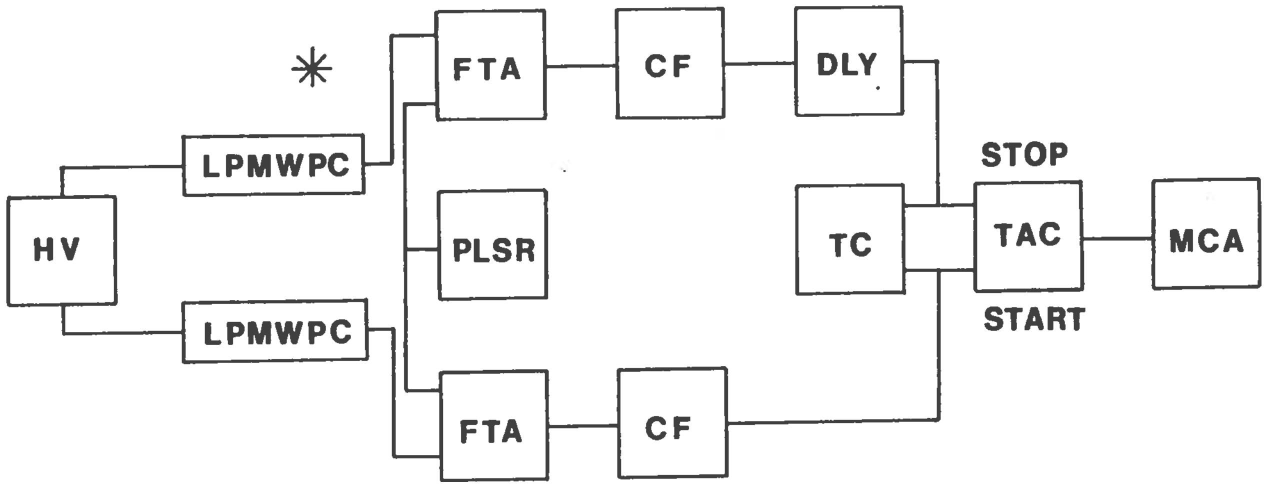
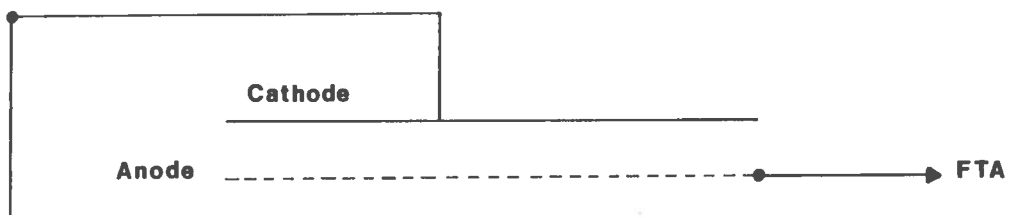


FIG. 3 - The electronic chain used for resolution tests.
FTA : Fast Timing Amplifier
CF : Constant Fraction Discriminator
TAC : Time to Amplitude Converter
DLY : nanosecond delay
PLSR: Pulser
TC : Time Calibrator



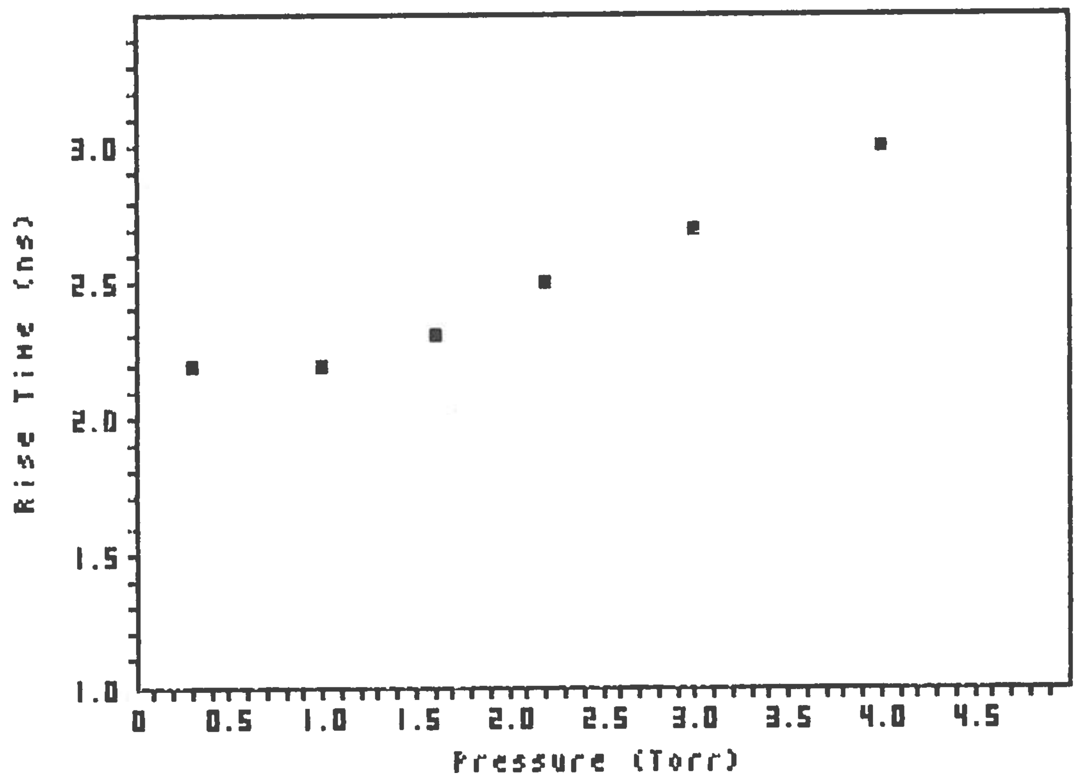
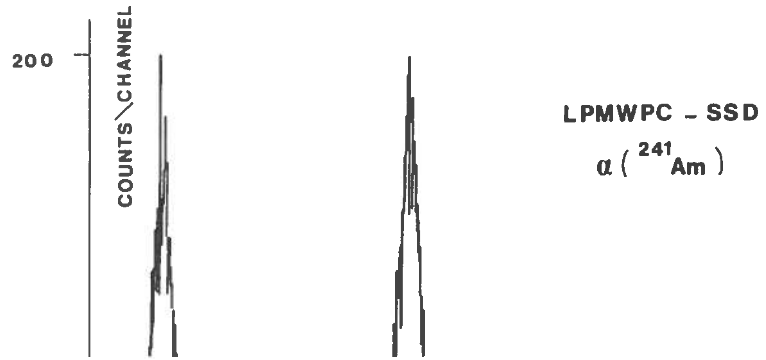


FIG. 5 - Rise - Time of the FTA output signals versus isobutane pressure.



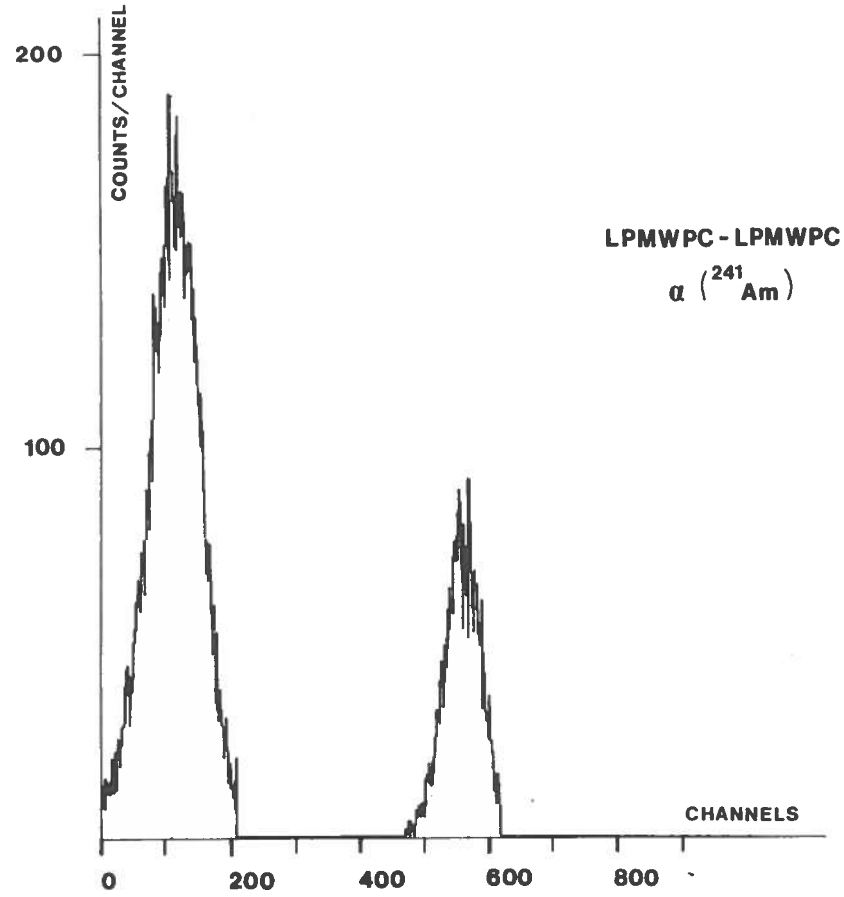
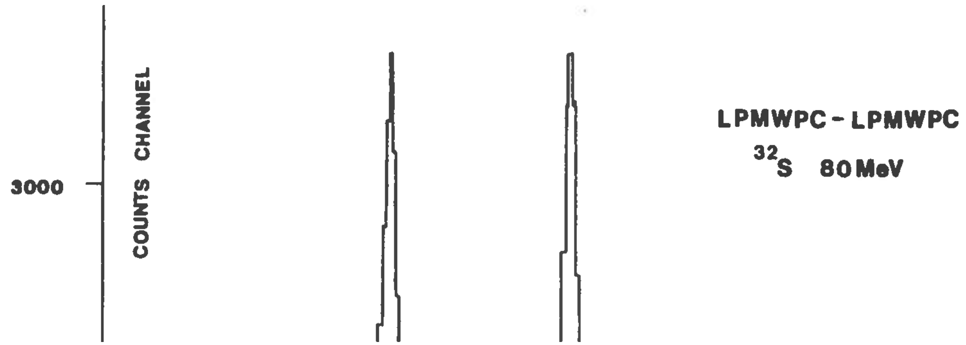


FIG. 7 - Time distribution of α particle pulses obtained by coincidence of 2 LPMWPC detectors. The two peaks are separated by 2 ns.



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