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M. Albicocco, G.P. Capitani, E. De Sanctis, P. Di Giacomo, C. Guaraldo, V. Lucherini, E. Polli and A.R. Reolon: A MULTIWIRE CHAMBER FOR POSITRON AND PHOTON BEAM SCANNING

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A MULTIWIRE CHAMBER FOR POSITRON AND PHOTON BEAM SCANNING

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ABSTRACT

A sensitive profile and position monitor for low intensity positron ($\sim 10^{-9}$ A) and photon ($\sim 10^{8}$ γ/s) beams is described. It consist of a multiwire chamber with two sensitive planes and additional electronics circuits. The display of the beam profiles, which appears on a standard oscilloscope, is live and quantitative; the effect of adjustments of the beam transport is immediately and continuosly visible.

1. - INTRODUCTION

Positron annihilation in flight has been widely used in recent years to obtain quasi-monochromatic photon beams[1]. As it is known, the annihilation peak is associated with an unwelcome continuous bremsstrahlung spectrum. In order to improve the annihilation to bremsstrahlung ratio one increases the collection angle of the photon beam respect to the positron one.

In the Frascati LEALE facility[2] this purpose is achieved by changing the positron incidence angle on the annihilation target through two bending magnets (B_5 and B_6 in Fig. 1), which give two vertical deflections of opposite sign (see Ref. 3 for details). Therefore, in order to determine the photon collection angle, it suffices to measure the positron beam displacements on the annihilation target.

In this paper we describe the "easy to use" beam scanner we have built to monitor beam profile and position. The scanner consists of a multiwire chamber, with two sensitive planes and additional electronics circuits, which allow to display both vertical and horizontal beam profiles on an oscilloscope.

In the next sections we describe the mechanical details of the chambers, the readout system and the operation modes.

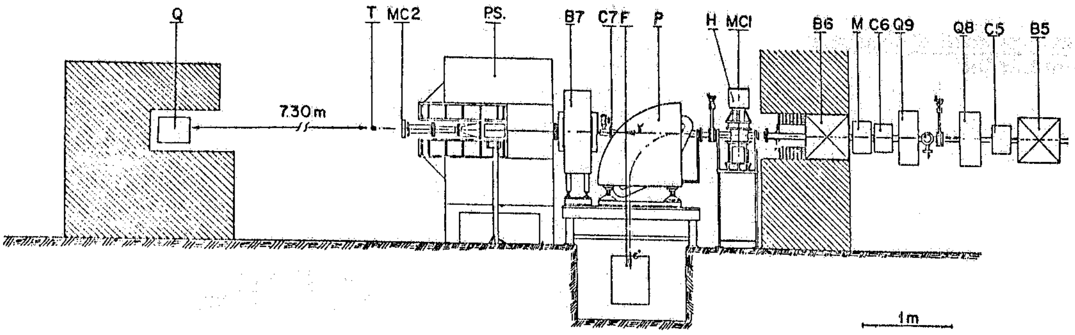

FIG. 1 -Layout of the positron-photon beam end-station: B5, B6 magnets; removable C5, C6 copper collimators (diameter: 7 mm and 6 mm, respectively), Q8, Q9 quadrupols, M ferrite toroid monitor; MC1, MC2 beam profile monitors; H hydrogen target; P dumping magnet; F Faraday cup; C7 five lead collimators (diameter: 9 mm, 10 mm, 10.5 mm, 11.5 mm, 12.2 mm, respectively) 10 cm long each; B7 sweeping magnet, PS pair spectrometer, T photoreaction target, Q quantameter.

2. - MECHANICAL COSTRUCTION

Two different chambers, MC1 and MC2 (useful area 5.6 x 5.6 cm^2 and 11.6 x 11.6 cm^2, respectively), are used to monitor positron and photon beams, respectively in the two positions shown in Fig. 1. That means MC1 is put at the position of the hydrogen target (in fact three configurations can be allowed in the target position (accuracy setting 0.5 mm): 1) hydrogen cell on; 2) hydrogen cell off, for alignement operation; 3) MC1 beam scanner on and MC2 ~ 50 cm before the photoreaction target. Due to the very small room available for MC1 (3.8 x 12.3 x 31.0 cm^2 box), the design of two ad-hoc printed cards for the sensitive wires of this chamber has been required (see Fig. 2).

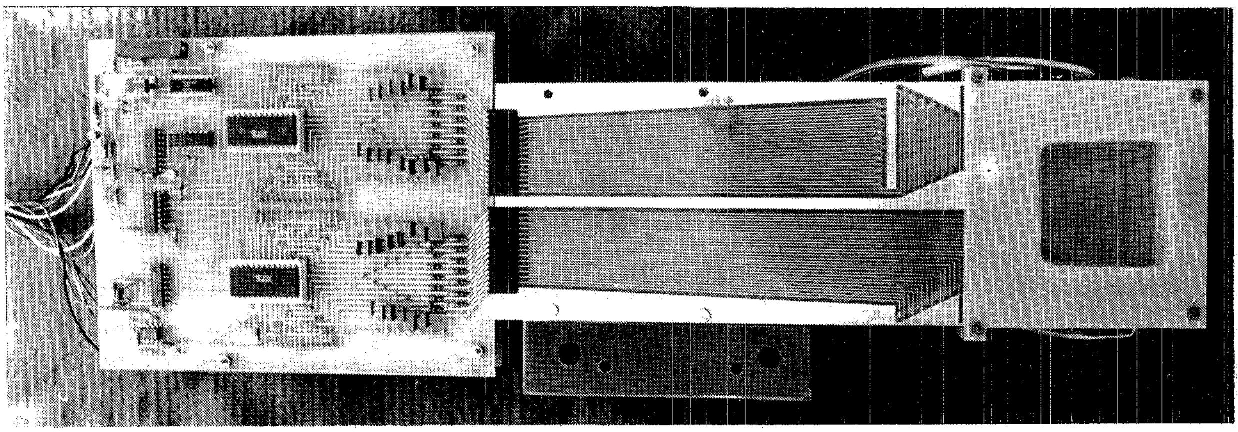

FIG. 2 - MC1 monitor photograph.

The chambers have been constructed following standard wire chamber techniques. Both wire chambers consist of 11 vetronite frames of different thicknesses, carrying on wires or foils as shown in Fig. 3. There are 3

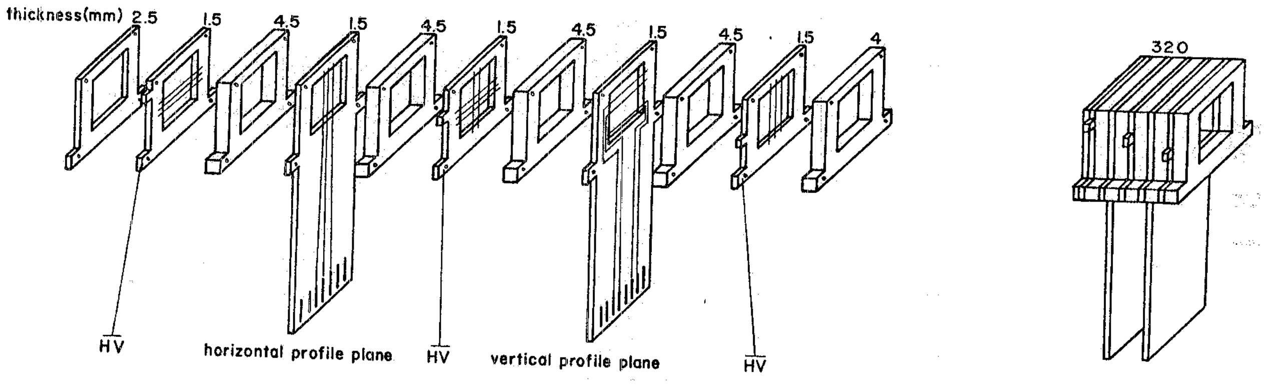

FIG. 3 - Schematic diagram of the mechanical construction of MC1 chamber: HV, H, V are high voltage, horizontal profile and vertical profile planes, respectively. Vetronite frame external sizes: 11x11 cm^2, internal aperture: 6x6 cm^2. (The MC2 chamber frames are 20x20 cm^2 external size with a 12x12 cm^2 aperture).

high voltage and 2 sensitive planes separated by 0.6 cm each from the other. Each sensitive plane of MC1 (MC2) carries on 30 (60) gold plated tungsten wires, 20 μm diameter, 2 mm spaced. This provides an active area of 56 x 56 mm^2 for MC1, and 116 x 116 mm^2 for MC2. The outermost wires are copper-berillium, 100 μm diameter, in order to avoid too high field strengths at the end of the planes. The two external high voltage frames carry gold plated molybdenum 50 μm diameter, spaced 1 mm and wound in a direction perpendicular to that of the nearest sensitive plane. On the central frame the wires are wound to form a mesh of 1 mm side, in order to keep uniform the electrical field in the two gaps.

The wires are pneumatically stretched to 0.4 N. The chamber is sealed with two mylar sheets (100 μm thick), glued on the external frames, and o-ring between frames. The Charpak magic gas mixture[4)] (0.5% freon 13-B1, 4% methylal, 23.5% isobutane, 72% argon) is used.

A negative high voltage is applied to the high voltage planes; the sensitive wires are virtually at ground potential.

3. - READOUT SYSTEM

In Fig. 4 a detailed electronic scheme is given. Each wire in the chamber is connected to a capacitor (0.1 μF), which integrates the charge originating from traversing ionizing particles. A 10 MΩ resistance is used to protect the high voltage power supply and the electronics from spikes in the chamber.

The capacitors are scanned one by one by a set of multiplexers (CMOS 4067), each containing 16 switches and having high input impedance ($\simeq 10^{11}\Omega$), in order to make negligible the decay of the signal during the scanning time. The multiplexers are controlled by a decoding circuit, consisting of an oscillator (CMOS-555), whose frequency can be continuously adjusted from 50 Hz up to 6 KHz, connected to a decimal counter with a 10-output decoder (CMOS-4017). The 10th decoder output (B in Fig. 4) drives a 4-bit binary counter which selects the wire to be sent to the amplifier. The 9th output (C in Fig. 4) triggers the discharging of the capacitor of the last wire selected by means of the discharge switch which is common to all outputs. The 16-th binary counter output drives a second decimal counter (CMOS 4017) which, in turns, selects the multiplexer.

During a scan a particular "switched on" capacitor has its voltage switched through to the input of an operational amplifier (TTL-3140) which is given a high input inpedence and a gain that can be varied from 10 up to 1000. By scanning the two sets of wires in series and by connecting the amplifier outputs to an oscilloscope,

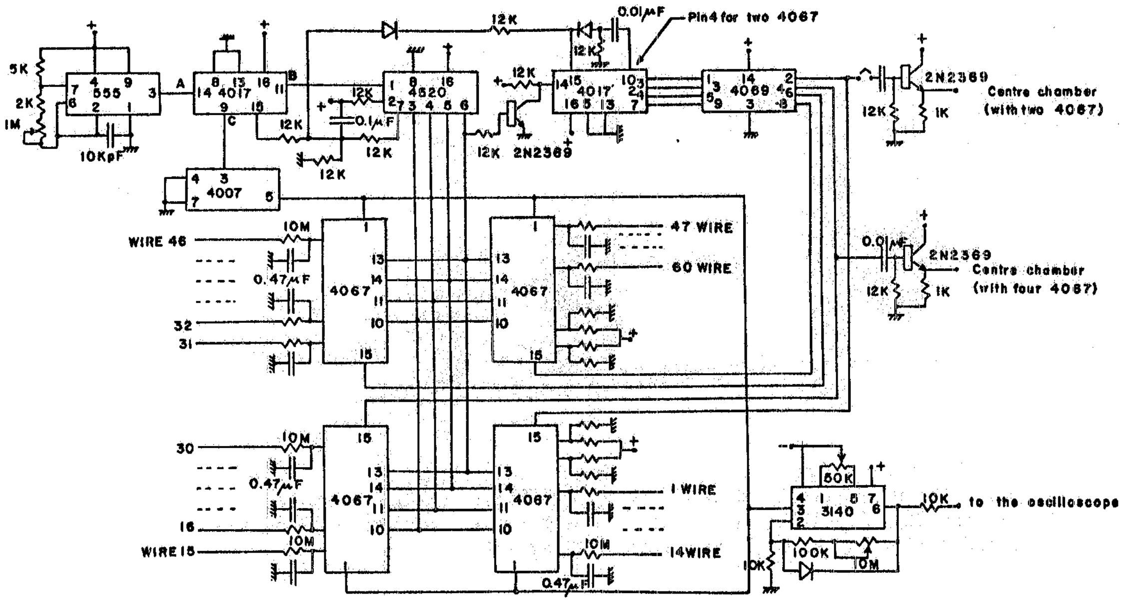

FIG. 4 - Scheme of the electronics associated with the chamber.

triggered by the rising edge of the "end wire" signal, one can see both X and Y histograms of the beam profile.

In both chambers the first and the last wires are tide up to +5 V in order to have a visual reference about the chamber bounds on the oscilloscope screen. For the same reason a centre chamber signal is also available.

In Fig. 5 the timing diagram is given. The circuit design takes into account the macroscopic temporal structure of the positron beam, which consits of pulses 4 μs in length repeated 150 times per second (the

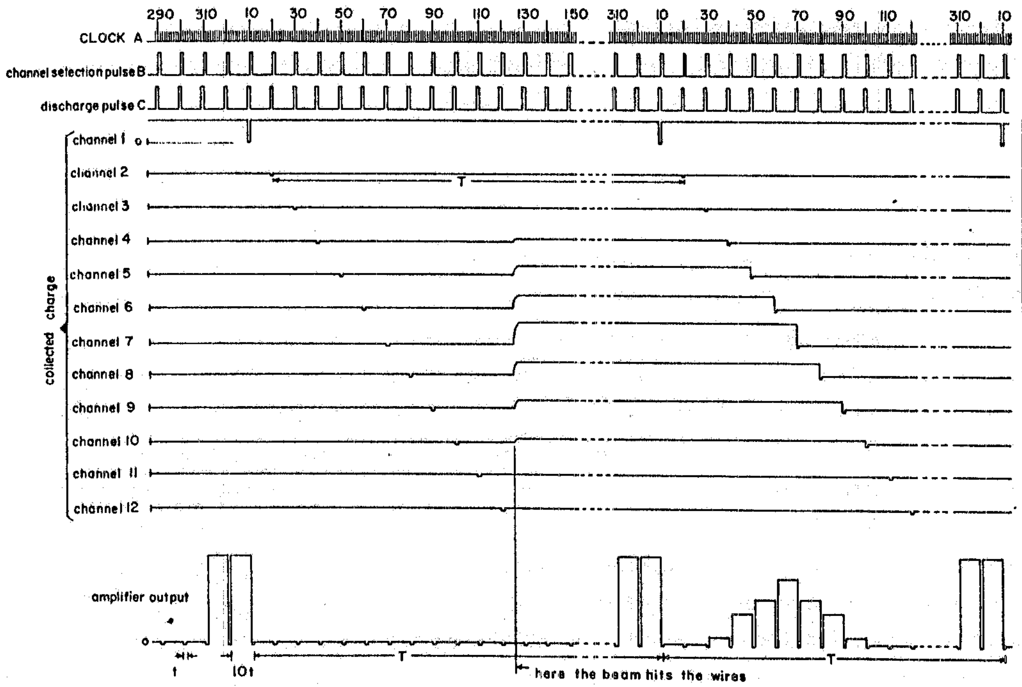

FIG. 5 - Timing diagram.

repetition rate can also be varied at the values of 5, 50 or 100 Hz). The operative scanning rate of the beam monitor is 1 ms per channel. The charge time of each capacitor is T=(10 n-1) t, where 1/t is the working frequency of the oscillator and n is the number of channels (respectively 32 and 64 for each sensitivity plane, for MC1 and MC2). The discharge switch for each capacitor is closed for a time t.

One printed card contains all the required elements for the display of each wire plane. The electronics is plugged into the wire chamber through two 15 pin connectors. The chamber is driven by a remote control box through a cable which is 60 m long.

4. - RESULTS

A collimated ^{50}Sr source was used to test the chambers. The source intensity was low (about 2000 electrons/s), so that the chambers had to be operated at their maximum sensitivity (high voltage around 5500 V) and at slow repetition rate for the oscillator. We obtained a fairly uniform gain (within 2÷3%) over the whole sensitive area of the chambers. The position resolution resulted to be within half a wire spacing, as expected.

Finally, the chambers have been tested at their sites along the LEALE positron-photon beam handling, as given in Fig. 1. Fig. 6 shows typical X-Y positrons beam profiles as seen on oscilloscope screen. The linac working

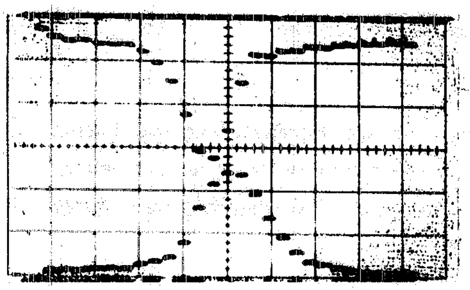

FIG. 6 - Vertical (up) and horizontal (down) positron beam profiles as seen on the oscilloscope.

conditions were: positron energy 180 MeV, peak current 50 μA, repetition rate 50 Hz.

Fig. 7 shows the effect of the operating voltage: as expected, the FWHM of the beam profile is relatively independent of the impressed voltage.

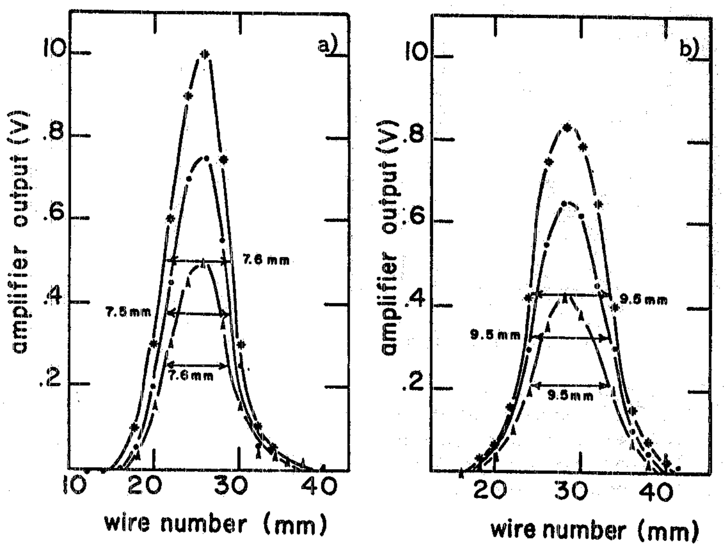

FIG. 7 - Vertical (a) and horizontal (b) positron beam profiles at three operating voltages: ▲ 1000 V; ● 1500 V; ✱ 2000 V. Same linac working conditions as in Fig. 6.

Fig. 8 shows typical photon beam profiles obtained with the MC2 chamber in the position given in Fig. 1. The linac working conditions were: positron energy 150 MeV, peak current 35 μA, repetition rate 150 Hz. The ending kapton window (123 μm thick) of the pair spectrometer vacuum chamber and the incoming mylar sheet (100 μm thick) of the MC2 chamber, are thick enough in order to create an ionizing cascade, registred by the beam scanner. The chamber was operated at 4000 V.

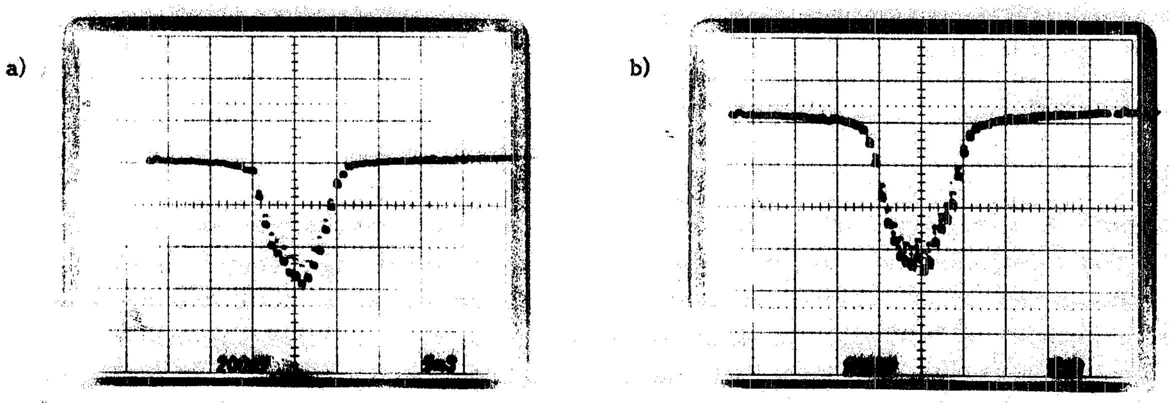

FIG. 8 - Vertical (a) and horizontal (b) photon beam profiles as seen on the oscilloscope.

In Fig. 9 an independent measurement of the photon beam profiles, obtained by analyzing the fission fragments distribution in a glass sandwich detector, with an uranium target at the centre, exposed to the photon beam at the same position of MC2[5], is compared to the MC2 response. As can be seen the agreement is fairly good.

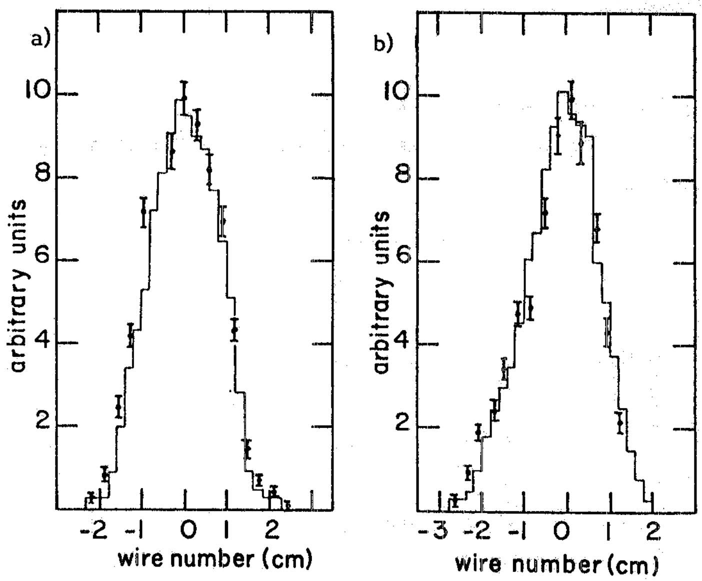

FIG. 9 - Horizontal (a) and vertical (b) photon beam profiles: the hystrogram is the CM2 monitor response; ⫯ are values obtained by glass sandwich detectors in photofission measurements. Positron energy 200 MeV; repetition rate 100 Hz; positron peak current 40 μA, MC2 high voltage 4000 V.

In conclusion the described beam scanner is easy to operate and it gives instantaneous reliable responses to beam manipulations. This feature results very useful both during the alignement operations of the positron beam along the optical axis of the channel and when one has to vary the impinging positron angle on the annihilation target.

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REFERENCES

1) A. Veyssière, H. Beil, R. Bergère, P. Carlos, J. Fagot, A. Leprêtre, J. Ahrens, Nuclear Instr. & Meth. 165, 417 (1979), and references therein.

2) G.P. Capitani, E. De Sanctis, C. Guaraldo, G. Ricco, M. Sanzone, R. Scrimaglio and A. Zucchiatti, Frascati Report LNF-45 (1977), and Proc. Few Body System and Electromagnetic Interactions. Eds. C. Ciofi degli Atti and E. De Sanctis, Lecture Notes in Physics, Vol. 86 (Springer, Berlin 1977) 127; G.P. Capitani, E. De Sanctis, P. Di Giacomo, C. Guaraldo, S. Gentile, V. Lucherini, E. Polli and R. Scrimaglio, Nuclear Instr. & Meth. 178, 61 (1980).

3) P. Di Giacomo e V. Lucherini, Frascati Report LNF-78/8 (1978).

4) G. Charpak, H.G. Fisher, C.R. Gruhn, A. Minten, F. Sauli, G. Pech and G. Flügge, Nuclear Instr. & Meth. 99, 279 (1972).

5) V. Bellini, E. De Sanctis, P. Di Giacomo, V. Emma, S. Gentile, C. Guaraldo, S. Lo Nigro, V. Lucherini, C. Milone, G.S. Pappalardo and A.R. Reolon, Frascati Report LNF-79/7 (1979).