OPTO-ELECTRONIC DELAY TUBES(*)

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ABSTRACT

This paper describes a scale model prototype of an opto-electronic pipeline for the read-out of a scintillating fibre tracker. It also presents preliminary results on the capability of this device to delay optical images and select them by external trigger signals.

1. INTRODUCTION

Within the framework of the LAA Project [1], we have designed an optoelectronic delay line for the read-out of a scintillating fibre tracker [2–4]. The principle of this delay device has been discussed in detail in previous papers [5–6]. It represents an electromagnetically focused image intensifier with sufficient drift space for low-energy photo-electrons, in order to provide an image delay of ~ 1 μs. The functions of delay, selection and amplification of optical images are ensured by adequately applying electric fields in the different tube sections separated by high-transparency grids (fig. 1).

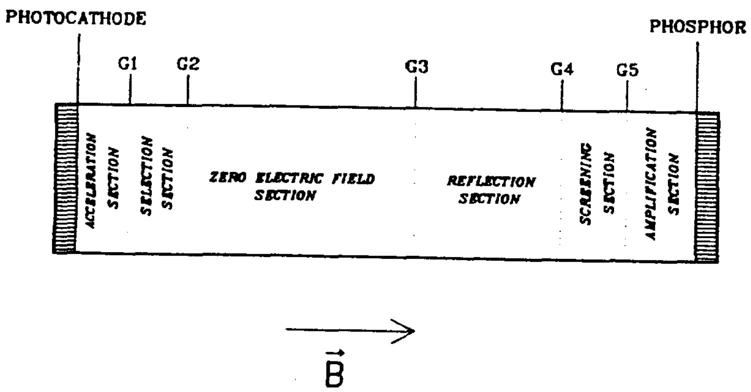


Fig. 1 Basic scheme of the delay tube

(*) The work reported here is part of the LAA Project

The choice of this solution for an analog pipeline has the following advantages:

- it is an imaging device by itself, and thus simplifies the overall data analysis;
- it preserves both excellent time resolution (within the bunch crossing period) and space resolution (within the microfibre diameter);
- it can perform parallel processing of up to 1 million channels (1 channel = 1 microfibre). As a consequence, it yields a low cost per channel;
- it has a low power consumption (of the order of 1 W per tube) and thus minimizes heat production;
- it represents only a few percent of a radiation length;
- it is expected to be radiation hard.

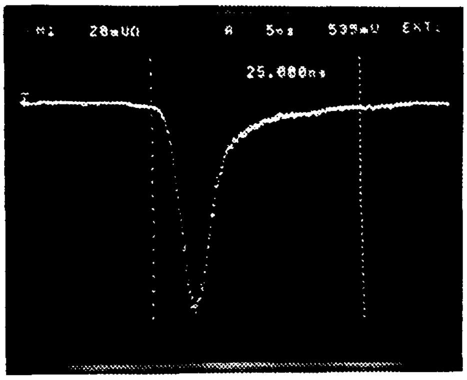
With a first simplified prototype built by EEV Ltd (England), we have already demonstrated our ability to delay optical images for some hundreds of nanoseconds with an excellent space resolution (25 μm) in a moderate magnetic induction (0.7 T) [6]. This device, however, was not equipped to perform the selection of an image.

2. THE SCALE MODEL PROTOTYPE AND THE IMAGE SELECTION

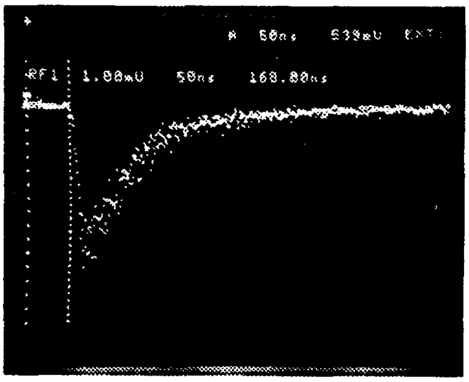
A 300 mm long prototype (scale 2:1) has been manufactured by DEP B.V. (The Netherlands) and delivered at CERN in July 1990. It includes all the elements schematically depicted in fig. 1. With this device, optical signals have been delayed by up to 500 ns, selected by appropriate grid pulsing, and amplified by a phosphor screen.

The selection performances of the tube are illustrated in fig. 2. For timing measurements, the tube can work in a magnetic induction limited to 0.03 T. It is fed by a short light-pulse from a blue LED (fig. 2(a)). Figure 2(b) displays the output signal obtained by supplying all the tube grids at +7.5 V DC, the cathode being at ground, and the phosphor at +6 kV. In this mode where all photo-electrons drift through the tube without being reflected in the reflection section, a delay of only 170 ns is obtained and no image selection is possible.

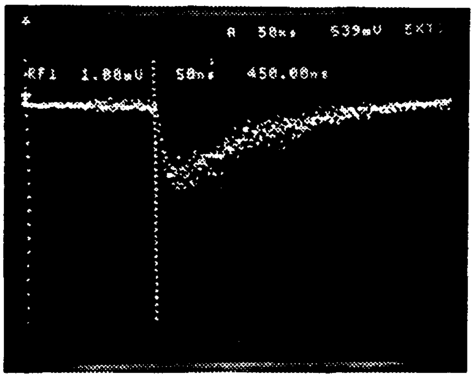
If the tube works in the image elimination mode [5,6], grids Gl, G2, G3 and G5 are at +7.5 V and grid G4 at –1 V so that every image is now reflected and delayed by 400 ns. The selection of an image is realized by pulsing G1 with a short negative pulse (triangular shape −200 V in amplitude, 3 ns fall time, 5 ns rise time). The resulting phosphor signal is displayed in fig. 2(c).



(a) Averaged blue LED light-pulse feeding the tube photocathode (time base: 5 ns/div., cursor separation: 25 ns).



(b) Averaged phosphor-light signal obtained when the tube grids are at the same potential of +7.5 V. The rise time of the signal is given by the decay time constant τ of the phosphor screen (we use a P47 screen so that $\tau \sim 60$ ns (time base: 50 ns/div., right cursor position: 168 ns)).



(c) Averaged phosphor-light signal obtained when the tube is working in image elimination mode while a negative pulse is applied on grid G1 in order to select an image (time base: 50 ns/div., right cursor position: 450 ns).

Fig. 2

3. CONCLUSIONS

We tested a prototype of an opto-electronic delay line. Preliminary results show encouraging performances in terms of signal delay, selection and amplification capabilities.

We are currently investigating in detail the time resolution of the device. In the next future, we envisage to test the selection of a wanted image out of several consecutive images separated by 15 ns. We intend also to study the noise performance of the tube.

Acknowledgements

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