# DTBX: A DRIFT TUBES, SYSTEM FOR THE CMS BARREL MUON DETECTOR

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DTBX (Drift Tubes providing Bunch crossing identification) has been proposed by the Padova and Bologna INFN groups as a possible design for the CMS barrel muon detector.

The basic unit of DTBX is a drift cell made of a plastic tube, whose useful cross section is 38 x 10 $mm^2$. Three electrodes are used to shape the drift field: the central wire (+ HV), two C shaped electrodes painted on the shorter sides of the tube cross section (- HV), and a ground plane outside the plastic walls. The maximum drift time is 400 ns.

A barrel chamber consists of 12 layers of tubes; its mechanical structure is shown in Fig. 1. The chamber dimensions range from 3 x 2.5 $m^2$ to 3 x 3.5 $m^2$. Two groups of 6 layers are symmetrically supported by a central 12 cm thick aluminum honeycomb plate: each group has 4 layers with wires parallel to the beam line in order to measure the coordinate in the bending plane, and 2 layers with wires perpendicular to the beam line to measure the position in the longitudinal plane. The honeycomb gives the required rigidity and stiffness to the chamber and houses, along its 4 sides, electronics and services. This design has proven itself in much larger chambers, up to 4 x 10$m^2$, built in Padova to equip the ZEUS muon barrel and rear detector [1]. The CMS chambers are supported by two wheels on either sides of the chamber and slided inside the iron yoke by means of guidance rails fixed to the yoke. Once the wheels are blocked this arrangement should allow a stable positioning of the chamber necessary for the required precision. The final design of the chamber arrangement in the yoke including the fixations of fiducials required for alignment purposes is being studied.

The performance of the drift tubes was measured on a small prototype in the RD5 test beam (H2 North area beam) at CERN in August and November 1992. First results about space and time resolution, effects of δ-rays and radiative interactions of muons between 100 and 300 GeV/c were published in March 1993 [2] and are summarized in Table 1 and 2. The prototype had 20 µm wires and gas mixtures of Ar/Ethane and Ar/Isobutane were used. The basic results may be summarized in a 160 - 180 µm position resolution and in a 3 - 4 ns time resolution in the identification of the time of the event. The last result was obtained with a Mean Timing operation on a system of 3 layers of tubes staggered by half a tube. We plan to use this technique to generate fast timed pulses from each chamber for triggering purposes.

**TABLE 1**

Performance of the DTBXs in the RD5 test beam

| Test period | Gas/wires | Space resolution per layer | Mean timer resolut. for 3 layers | Mean timing efficiency |
|---|---|---|---|---|
| Aug. 1992 | Ar/Ethane 20 µm | ≈ 170 µm | ≈ 3 ns | 80 % for 3 layers incl. showers and δ-rays |
| Nov. 1992 | Ar/Ethane 20 µm | ≈ 170 µm up to $20^0$ | ≈ 3.4 ns up to $20^0$ | 80 % for 3 layers incl. showers and δ-rays |
| Mar. 1993 | Ar/Ethane 20 µm | ≈ 170 µm up to $20^0$ | ≈ 3.4 ns up to $20^0$ | 94 % for 4 layers on insolated tracks |
| Sep. 1993 | $Ar/CO_2$ 50 µm | ≈ 200 µm | ≈ 3 ns | 94 % for 4 layers on insolated tracks |

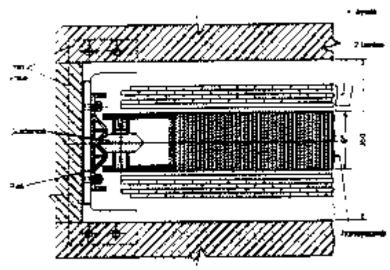

Fig. 1: DTBX chamber in the iron yoke with two quartets in the bend plane and two doublets orthogonal to them

Since then further important information was obtained from a more refined analysis of the data from the 1992 runs and from two short runs in May and in September 1993. The uniformity of the efficiency and resolution inside the drift cell is shown in Figs. 2 and 3 for the data taken in 1992.

We also obtained that the probability of a δ-ray spoiling space and time resolution is about 5% per layer and that 78% of such δ-rays are confined inside only one layer and these figures is constant in the range 100 to 300 GeV/c (see Table 2).

**TABLE 2**

Fraction of background events in a 3 layer system

| p (GeV/c) | δ-rays | bremstrahlung | total |
|---|---|---|---|
| 100 | 17.0 ± 0.7 % | 3.9 ± 0.3 % | 20.9 ± 0.8 ±0.5 % |
| 200 | 16.4 ± 0.6 % | 5.4 ± 0.4 % | 21.9 ± 0.8 ± 0.5 % |
| 300 | 17.6 ± 0.6 % | 6.4 ± 0.3 % | 24.0 ± 0.8 ± 0.5 % |

The result was obtained looking at the time correlation between the two mean timing operation on three consecutive layers of tubes that are possible in a four layer system (Fig. 4). The effect of a δ-ray confined in the first or in the fourth layer will affect only one of the mean timing operation. A δ confined in the second or in the third layer affects both operations in a correlated way. If the δ affects more than one layer the corresponding point in the plane (MT1, MT2) will be randomly scattered.

The two results on the δ-rays effect indicate that the requirement [3] to obtain a muon vector with 100 μm precision in position and 1 mrad in direction can be achieved in one muon station formed by 8 layers.

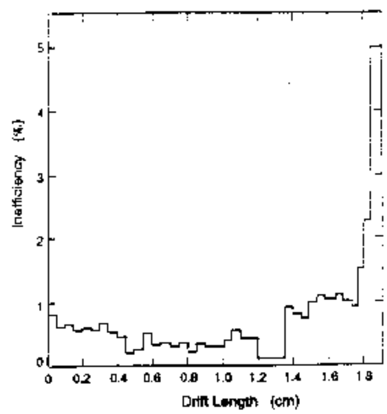


Fig. 2: Uniformity of efficiency over the drift cell

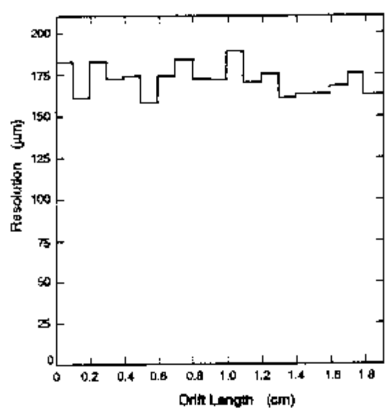


Fig. 3: Uniformity of resolution over the drift cell

A fully simulated Mean Timing circuit that looks at the same time at a four layer system was used to process real events. Its efficiency of identification of the parent bunch crossing on isolated muons is 94%. The circuit gives also prompt information on the position and angle of the track in the 4 layer system with a resolution useful to perform $p_t$ cuts at the trigger level [4]. Each chamber is able to give 4 independent time and position measurements, from the 2 groups of 4 and the 2 groups of 2 layers. A simulation study of the correlation between the signals generated by the 3 or 4 chambers crossed by a muon shows that the related bunch-crossing can be identified by a simple majority logic with very high efficiency also in presence of the background coming from radiative processes in the iron of the return yoke [4].

An important step has been performed in the september 1993 run in the RD5 experiment. Twelve planes of tubes have been arranged to simulate a CMS chamber, with a 12 cm thick honeycomb plate interleaved and with a 20 cm thick iron slab in front. The tubes had 50 µm wires and have been operated with different $Ar/CO_2$ mixtures with variable ratios between 82/18 and 88/12. Very stable operating conditions have been achieved and very preliminary results indicate a resolution of 200 µm per plane.

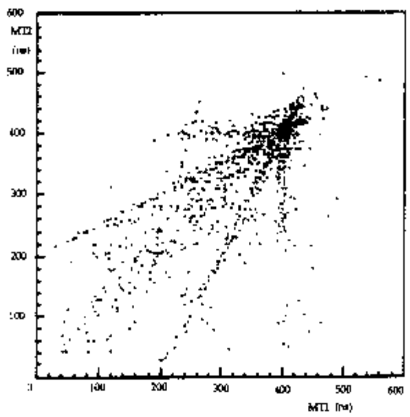


Figure 4: Correlation between $MT1 = \frac{t_1 + t_2}{2} + \frac{t_2 + t_3}{2}$ and $MT2 = \frac{t_2 + t_3}{2} + \frac{t_3 + t_4}{2}$ in a four layer system.

**References**

[1] G. Abbiendi et al., Nucl. Instr. and Methods in Phys. Res. A333 (1993) 342.

[2] M. Andlinger et al., *Bunch Crossing Identification at LHC using a Mean-Timer Technique*, Preprint DFPD 93/EP/16, Università degli Studi di Padova, to be published in Nucl. Instr. and Meth. in Phys. Res. A

[3] CMS Letter of intent, CERN/LHCC 92-3, LHCC/I 1, 1 October 1992.

[4] P. L. Zotto, presented at the 5th Topical Seminar on Experimental Apparatus for High Energy Particle Physics and Astrophysics, San Miniato, 26- 30 April, 1993