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The test of the prototype 0.3 of the KLOE chamber in magnetic field. The measurements at the X7 beam of the CERN West Area.

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Introduction

The central tracking detector of the KLOE experiment will be a large cylindrical drift chamber, 4 m in diameter and 3.3 m in length, with almost square cells arranged in circular layers of alternate stereo angles. It has been fully described in the Addendum to the KLOE Technical Proposal [1]. Some prototypes of this large chamber were studied in the past.

The first prototype (prototype 0) was a cylindrical chamber with 42 quasi hexagonal cells about 4 m long. Results are reported in [2].

In 1993 two small prototypes were tested at P.S.I. (Zurich). They had 25 cells instrumented out of 49. The almost square cells (2 x 2 cm^2) were realized with a different structure: 3 field wires for each sense wire in prototype 0.1 (R_{fs}=3:1), 2 field wires for each sense wire in prototype 0.2 (R_{fs}=2:1). The results from these two prototypes have been already reported in the Addendum (Chap. 7 of Ref. [1]), in KLOE Notes [3] (also appendices of the Addendum), and have been published in [4].

While a new full scale prototype (prototype 1) was in preparation in Lecce [Chap. 8 of Ref. [1] and after the suggestion of a larger cell (3 x 3 cm^2) with R_{fs}=3:1 in the Addendum of the KLOE tracking chamber, we decided to prepare and to test a new small prototype similar to prototype 0.1 but for the dimensions of the cells. The main aim of this test was to study the cells of the KLOE drift chamber in a 0.6 Tesla magnetic field as in the real detector.

In this note we describe this small prototype (named prototype 0.3), the electronics used, the very accurate tracking system and the data taking at CERN in September 1994.

Preliminary results from this test have already been reported in [5]; more extensive studies will be described in following notes. Results on the tracking devices have been presented at the 1995 Vienna Wire Chamber Conference [6] and more extensively in [7] and [8].

Prototype 0.3

The prototype would represent a small part of the KLOE chamber at a radial distance r ≈ 36 cm from the beam and at the center along the beam direction.

The 49 almost square cells (3 x 3 cm^2 with R_{fs}=3:1) are disposed in seven layers of seven cells (Fig. 1) following the same configuration already used in prototype 0.1.

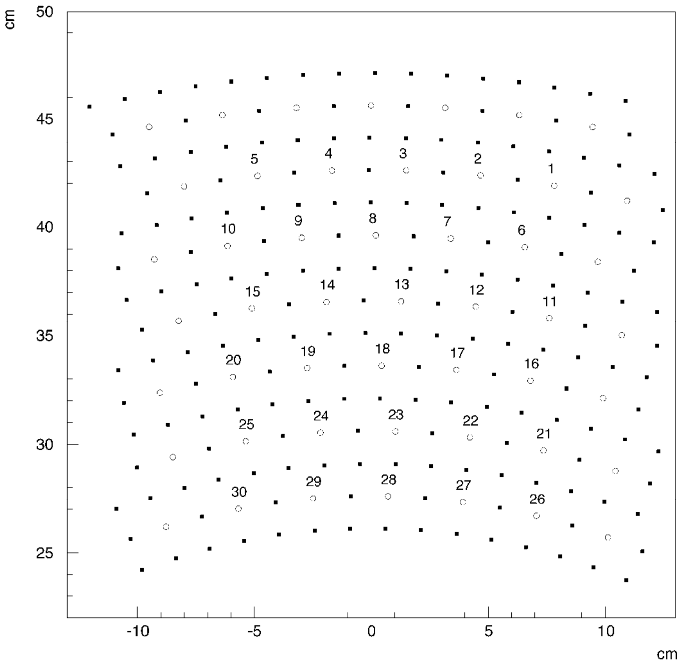

Fig. 1

All the sense wires were at high voltage to correctly shape the electric field over the innermost 25 cells that we decided to study. Anyway, since 30 read-out channels were available, five more wires were read out (numbered 26-30 in Fig. 1).All the wires (60 cm long) are parallel: that is the small stereo angles (50÷120 mrad with alternate sign), foreseen in the KLOE chamber, have been neglected. The sense wires were of tungsten with a 25 μm diameter and the field wires of aluminium with an 80 μm diameter.

The structure of this small chamber (Fig. 2) is in aluminium and was machined with an accuracy of about 30 μm. Nominal position of the sense wires on the end plates have an error < 20 μm.

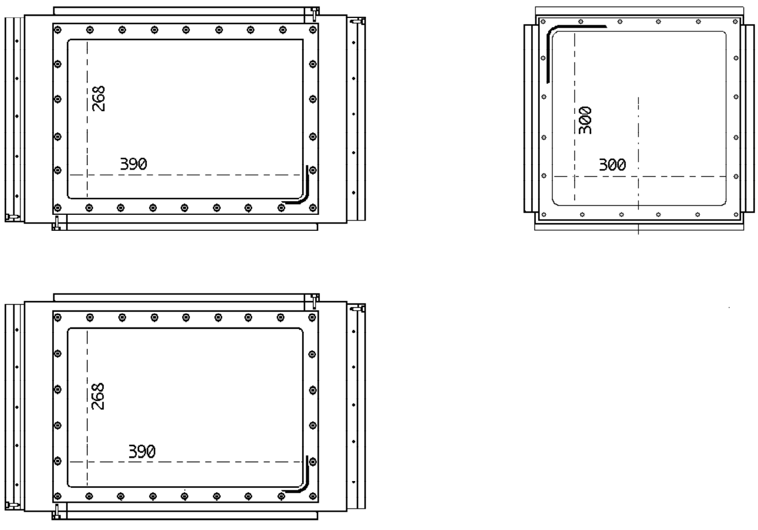

Fig. 2

High voltage was supplied with seven printed boards at one end of the chamber and three cards, with ten preamplifiers each, were mounted at the other end of the chamber.

The gas mixture used was 90% He - 10% iC_4H_{10} as in the KLOE chamber. The two gases were supplied by mass flowmeters at a total rate of about 10 l /h.

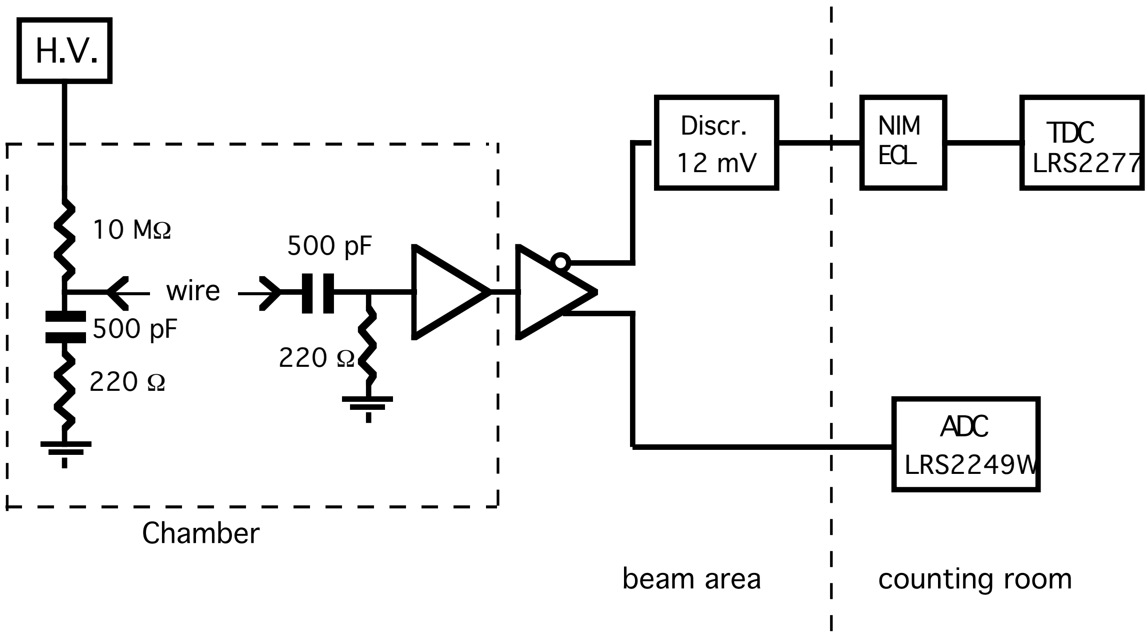

Fig 3

A scheme of the read-out electronics is shown in Fig. 3. At the time of this test only the preamplifier card out of the final front-end electronics [see Chap. 6 in Ref. 1 and references therein] was available. The VTX preamplifier chip, mounted in this card, provides a gain equal to 1 mV /1 fC (50Ω load). This was followed by an amplifier (gain factor 3) with two outputs. One of these was fed into a low threshold CAEN N417 discriminator with the threshold set at 12 mV, and after a NIM to ECL adapter (LRS 4416), to a CAMAC LRS2277 TDC unit (12 bits, 1 ns LSB). The other was sent to a LRS2249W ADC with a 2 μs gate.

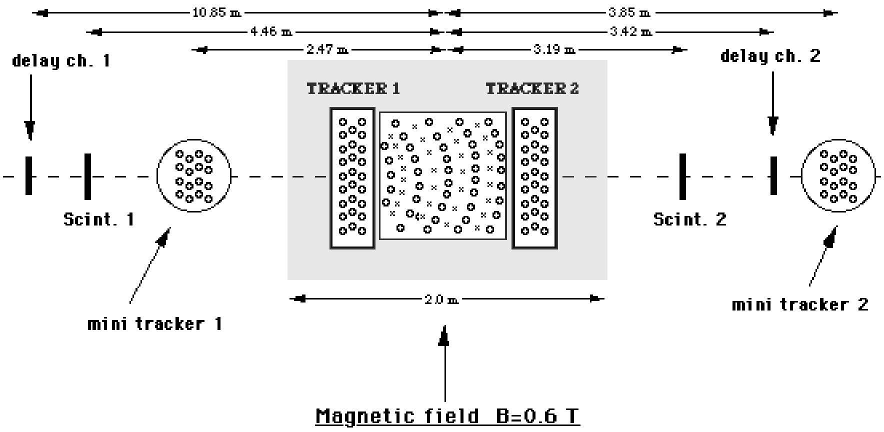

Fig. 4

Mini-trackers

Two identical mini-trackers were attached on the two long opposite sides of the prototype (Fig. 4). These detectors, extensively described in [6,7], have been foreseen to precisely track beam particles through the prototype. Each minitracker consists of 26 Al tubes (3.0 cm diameter, 500 μm thickness) in three layers (9+8+9 tubes) with the central layer offset by one tube radius. The distance between two layers is 4 cm.

A 100 μm thick Cu-Be wire was used. The tubes were operated in limited streamer mode with a gas mixture 40% Ar - 60% iC_4H_{10} at 5.7 kV.
The frames supporting the tubes and the feedthroughs of the wires have been machined with an accuracy at the level of ≤ 30 μm. The large signals (> 200 mV), shaped by CAEN N224 discriminators with a threshold set at 15 mV, were read out by CAEN C414 TDC (12 bits, 125 ps LSB).

The chamber and the two minitrackers were solidly attached together to provide the stability of the relative positioning of the wires .

Experimental layout and data acquisition

A magnet large enough to include our small prototype, was found at the X7 beam in the CERN West Area. This magnet (MN101) has a useful aperture 80 x 62 cm^2

transverse to the beam (80 cm along the B field), and is 3.72 m long in the direction of the beam. Our prototype and the minitrackers were positioned in its middle, where the field is very uniform, with the wires normal to the beam and parallel to the B field (as in the KLOE detector).

Additional tracking devices were present upstream and downstream of the magnet (see Fig. 4). Two trackers, each composed by four staggered layers of four high pressure streamer tubes, provided a precise measurement outside the magnet.
The sixteen tubes of each tracker were housed inside a cilindrical vessel with an Ar-Ethane (70%-30%) gas mixture at a pressure of 3.5 absolute bar.
The tubes were identical to the ones used for the minitracker except for the length (32 cm) and the wire (80 μm Al). The tubes were operated at 6.4 kV and the signals were fed into discriminators (with a 35 mV threshold) and then into a LRS2277 TDC.
Two MWPC's (10 x 10 cm^2) with delay line read-out [9] were used to monitor the beam and to provide a measurement of the position of beam particles in both vertical and horizontal directions. Their resolution is about 300 μm.

The coincidence of two fast scintillation counters (10 x 10 cm^2) was used to trigger the acquisition.

The data acquisition system used an embedded OS9 system based on a VME 68030 CPU (CES FIC8232) and a VAX Station both connected through Ethernet.
Data were acquired by the VME CPU from a single CAMAC crate via a CAMAC branch driver and stored into a circular buffer controlled by SPIDER, a complete DAQ program developed at CERN [10]. The OS9 system sent the data to an Exabyte driver for tape recording. A fraction of the total events was sent by an event producer process from the CPU to the workstation. A data spying process running on the workstation generated the histograms required for monitoring and event displays.
The average acquisition rate was approximately 180 events per burst.

Measurements

The data were collected with a 50 GeV/c π^+ beam. Since the beam profile had a width of σ = 1.5 cm, to get an average uniform illumination of all the cells of our prototype, the beam spot at the chamber was moved vertically by a trim magnet at each change of DAQ run.

Before starting data taking, the efficiency of the prototype versus the high voltage was studied by measuring the coincidence of the two scintillation counters with signals in the cells. Data for cells 3, 8 and 11 (with a 10 mV threshold) are reported in Fig. 5 and clearly show a plateau extending from 1750 V up to 1900 V. Afterwards, a more accurate analysis of the data recorded at different voltages between 1750 and 1950 V, confirmed this preliminary measurement.

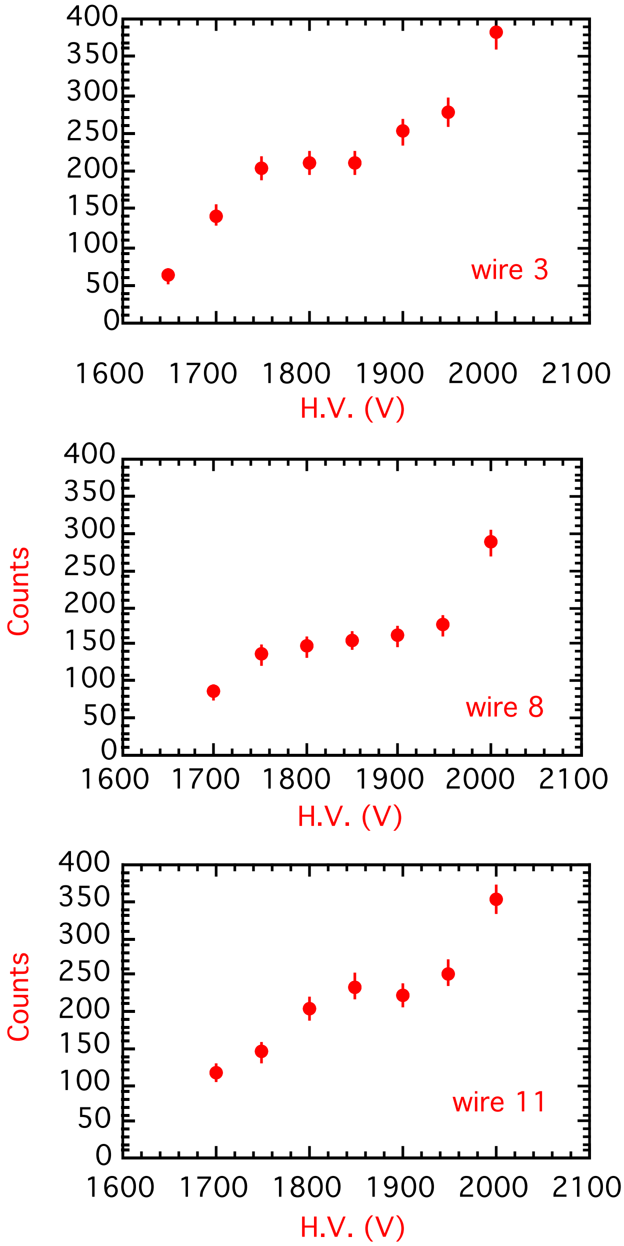

Fig. 5

After the amplifier the average height of the signal from the first cluster was 26.0 mV at a high voltage of 1850 V and 34.7 mV at 1900 V corresponding to an amplification at the wire equal to 2.4 x 10^5 and 3.2 x 10^5 respectively after correction for electron multiplicity in the cluster [11].

Data taking started on the 18th of September and ended in the morning of the 26th of September. Unfortunately in this period, apart the time scheduled for usual shutdown, few days went lost owing to a general power failure over the CERN area

A total of 2.5 millions of events were recorded with high voltage at 1850 and 1900 V without magnetic field and with a 0.6 Tesla magnetic field. A detailed list of these data is given in Tab. I.

At the end of our test beam period 100 K events at B=0.9 Tesla and 25 K events at B=0.3 Tesla were recorded with a high voltage of 1900 V.

During this beam period the temperature was varying very slowly in the range 19.1 ÷ 20.9 ^{0}C while the pressure was between 950 and 972 mbar. Stability of gas mixtures was insured by mass flow meters.

Table I

	B=0. Tesla	B=0.6 Tesla	B=0.3 Tesla	B=0.9 Tesla
HV=1850 V	900 K events	800 K events		
HV=1900 V	400 K events	400 K events	25 K events	100 K events

Acknowledgements

It is a pleasure for us to mention here the kind and enthusiastic help of Giles Barr, SPS Coordinator, in organizing this test at CERN. We also are very grateful to F. Cataneo for suggestions in finding the magnet, to Lau Gatignon for assistance during our test, to J. Spangaard for making available the delay chambers, to R. Dillon for his help, once more, in preparing the gas system.

We also want to remind the courtesy of our friends of Delphi Collaboration who agreed in sharing with us the beam area.

Of course we have to acknowledge all people who contributed to the preparation of the detectors and the electronics. In particular M. Iannone, F. Pellegrino, G. Capradossi. and M. Siteni for preparing the chamber, A. Di Virgilio, L. Iannotti for the minitrackers, S. Di Marco, F. Pulcinella and A. Rossi, for the electronics.

We have to thank the help of G.Bencivenni, U.Denni and E.Rosso for their help in the construction of the chamber.

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Figure Captions

Fig. 1: Geometry of the cells in the prototype.
Fig. 2: Structure of the prototype.
Fig. 3: Scheme of the read-out electronics of the prototype.
Fig. 4: Layout of the beam area with the detectors.
Fig. 5: Efficiencies of the cells 3, 8 and 11 measured by coincidence with beam scintillation counters.