IL NUOVO CIMENTO Vol. 33 C, N. 6 Novembre-Dicembre 2010
DOI 10.1393/ncc/i2011-10795-y

Colloquia: IFAE 2010

An innovative tracker for precision measurements at KLOE-2

G. Morello for the KLOE-2 Collaboration
Università della Calabria and INFN, Gruppo collegato di Cosenza - Cosenza, Italy

(ricevuto l'8 Ottobre 2010; pubblicato online l'8 Febbraio 2011)

Summary. — A new Inner Tracker is going to be realized for the KLOE-2 experiment at DAΦNE. The tracker is based on GEM technology in order to improve vertices resolution near the interaction point, thanks to the low material budget and consequently a low effect of multiple scattering. Here there follows a description of the detector and some measurements performed.

PACS 29.40.Cs – Gas-filled counters: ionization chambers, proportional and avalanche counters.
PACS 29.40.Gx – Tracking and position-sensitive detectors.

1. – The KLOE experiment

The KLOE experiment [1] collected an integrated luminosity $\int \mathcal{L}\mathrm{d}t \sim 2.5\,\mathrm{fb}^{-1}$ at the Frascati ϕ-factory DAΦNE, an e^+e^- collider, at a center-of-mass energy of 1020 MeV. The experiment achieved several precision results both in kaon and hadron physics: the measurements of all branching ratios of K_S, K_L and $K^\pm$, the study of scalar and pseudoscalar mesons and $e^+e^- \to \pi^+\pi^-$ cross section, giving the low-energy hadronic contribution to the muon anomaly. A detailed description of the experiment can be found in [1].

2. – KLOE-2

At KLOE-2 the interest will be focused on physics coming from the IR: K_S decays, K_S-K_L interference, η, η' and $K^\pm$ decays, multi-leptons events. Such a research requires an additional tracker detector (Inner Tracker) [2, 3] between the beam pipe and the inner wall of the central tracking chamber. It will: 1) reduce the track extrapolation length and improve the decay vertex reconstruction capability; 2) increase the geometrical acceptance for low momentum tracks; 3) improve track momentum resolution (fig. 1).

The Inner Tracker must satisfy the following requests: $\sigma_{r\phi} \sim 200\,\mu\mathrm{m}$ and $\sigma_Z \sim 500\,\mu\mathrm{m}$, $< 2\% X_0$ material budget, $5\,\mathrm{kHz/cm}^2$ rate capability.

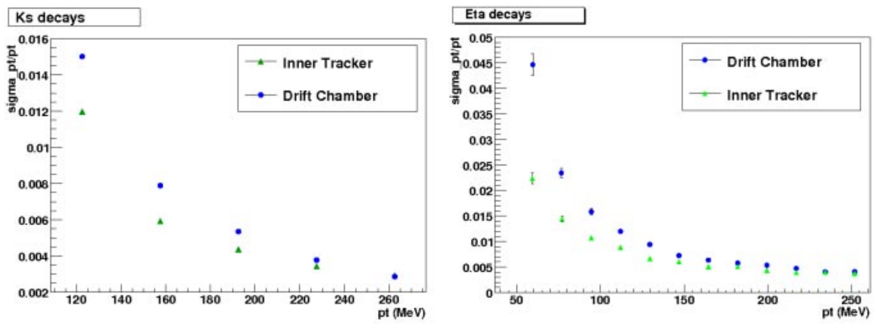

Fig. 1. – Simulated resolution σ_{p_t}/p_t on the transverse momentum measurement as a function of p_T for $K_S \to \pi^+\pi^-$ (left) and $\eta \to \pi^+\pi^-e^+e^-$ (right) with DC only (circles) and with the addition of the IT information (triangles).

3. – The Inner Tracker

The proposed solution is based on GEM technology: four layers of cylindrical triple-GEM with radii between 13 cm and 23 cm, 70 cm active length, XV strips readout with a stereo angle of 40° and a total radiation length of $1.5\% X_0$. A full-scale CGEM prototype was built, with 15 cm radius and 35 cm active length. The construction process is described in [2]. The anode was patterned with 650 μm pitch longitudinal strips. The chamber was tested with X-rays and, once equipped with 16-channels prototype GASTONE ASIC chip, tested at CERN with 10 GeV pion beam. The detector was flushed with Ar : CO_2 70 : 30 gas mixture and operated with the fields $E = 1.5/2.5/2.5/4$ kV/cm and with the GEM voltages 390/380/370 V, corresponding to a gas gain of 2×10^4. The tracks reconstructed by two external tracker stations were compared to those reconstructed by the prototype [4]. The reconstruction efficiency is about 99.6% while the CGEM spatial resolution is $\sim 200\,\mu$m, in good agreement with what expected from a digital readout of the strips. Since the IT will be equipped with XV patterned strips and it will operate in magnetic field, a dedicated test to address these issues was performed at CERN with 150 GeV pion beam line. Five $10 \times 10\,\text{cm}^2$ planar triple-GEM detectors were assembled with 650 μm pitch strips. Four of them were equipped with standard XY readout [5], while the fifth with the XV geometry. All the chambers were placed in magnetic field adjustable up to 1.5 T. The magnetic field affects the drift motion of electrons making a displacement between the track and the area where signals are induced and increasing the electron spread over the readout, as shown by GARFIELD simulations (fig. 2 (left)). The gas mixture was Ar : CO_2 70 : 30, with the fields 1.5/3/3/5 kV/cm and the voltages 390/380/370 V applied on GEM foils. In order to measure the displacement dx, the four XY chambers were likewise oriented, while the XV chamber was reversed. The distance between the reconstructed track and the point of the XV chamber is twice the displacement of the electrons in a chamber. The dx was measured for different magnetic fields (fig. 2 (right)). The spatial resolution was measured as a function of the gain of the GEM and of the magnetic field (fig. 3 (right)). As shown in fig. 3 (left), the efficiency drops as the magnetic field increases. This effect can be reduced working at higher gain which consequently involves a worse spatial resolution.

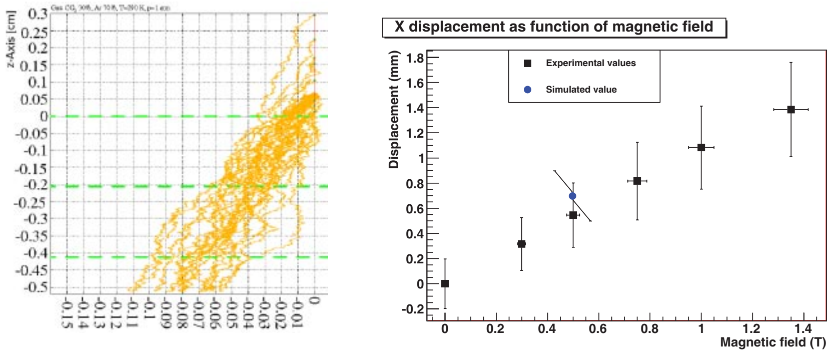

Fig. 2. – GARFIELD simulation (left) and measurements of electron displacement as a function of the magnetic field (right).

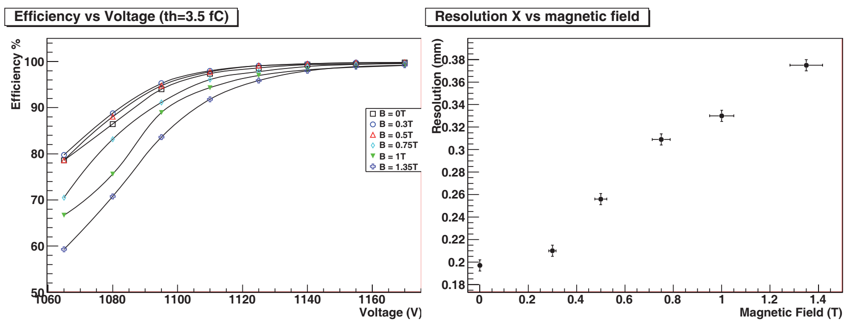

Fig. 3. – Efficiency as a function of voltage and magnetic field (left) and x resolution as a function of the magnetic field (right).

4. – Conclusions

The beam tests performed on the KLOE-2 Inner Tracker prototype have demonstrated the feasibility of this detector. The readout geometry was validated and the test in magnetic field was successful in terms of achieved spatial resolution. The R&D phase is concluded and the construction of the Inner Tracker has started.

REFERENCES

[1] Bossi F. *et al.* and KLOE Collaboration, *Riv. Nuovo Cimento*, **31** (2008) 531.
[2] KLOE-2 Collaboration, *Technical Design Report of the Inner Tracker for the KLOE-*2 *experiment*, ArXiv 1002.2572v1 and LNF-10/3(P) INFN-LNF Frascati (2010).
[3] Di Domenico A. and KLOE-2 Collaboration, *J. Phys.: Conf. Ser.*, **171** (2009) 012008.
[4] Domenici D. *et al.*, in *2009 IEEE Nuclear Science Symposium. Conference Records.*
[5] Balla A. *et al.*, *Nucl. Instrum. Methods A*, **604** (2009) 23.