A New Cylindrical-GEM Inner Tracker For The Upgrade of The KLOE Experiment

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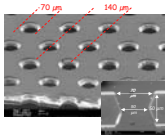
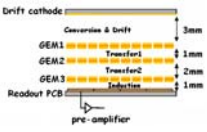
Abstract

A new data taking campaign with an upgraded KLOE detector, **KLOE-2**, at an **improved DAFNE machine** will start by mid of 2010. The detector will be upgraded with the insertion of an Inner Tracker (IT) between the beam pipe and the Drift Chamber (DC) inner wall, composed by 4 concentric detection layers at radii from 13 cm to 23 cm from the beam line and with an active length of 70cm, based on the innovative idea of the **Cylindrical GEM detector (C-GEM) technology**. The program is planned to be accomplished and ready for the installation by the **end of autumn 2011**.



The GEM detector:principle of operation

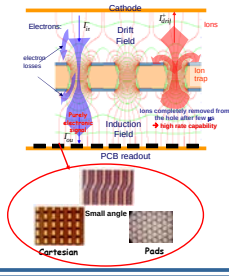


The GEM (Gas Electron Multiplier) [1] is a thin (50 mm) metal coated kapton foil, perforated by a high density of holes (70 mm diameter, pitch of 140 mm)
→ standard photolithographic technology.

By applying 400-500 V between the two copper sides, an electric field as high as ~100 kV/cm is produced into the holes which act as multiplication channels for electrons produced in the gas by a ionizing particle.

Gains up to 1000 can be easily reached with a single GEM foil. Higher gains (and/or safer working conditions) are usually obtained by cascading two or three GEM foils.

A Triple-GEM detector is built by inserting three GEM foils between two planar electrodes, which act as the cathode and the anode.[2]



GEM Detectors advantages:

high counting rate, radiation hardness, low material budget, high space and time resolution, flexible detector geometry and freedom in read-out design choice,detecting different ray by using various convertors and so on, the prospect applying of them have many ways → they could easily meet the need of KLOE-IT.

The KLOE-2 Inner Tracker group

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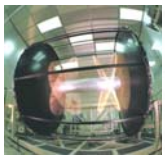
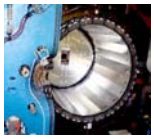
INFN Roma, Roma, Italy: A. Di Domenico, M. Capodiferro, A. Pelosi

KLOE at the DAFNE Φ-Factory





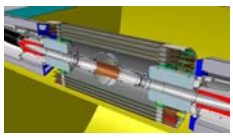
- Huge, transparent Drift Chamber in 5.2 kGauss field of a SC coil
- 2 m radius, 4 m long, He/C_2 gas mixture
- Carbon fiber walls, 12582/52140 sense/total stereo wires
- Momentum resolution: $\sigma(p_T)/p_T \sim 0.4\%$
- Vertex resolution $\sigma_V \sim 3$ mm
- Pb-Scintillating Fiber Calorimeter with excellent timing performance
- 4 m long, 88 modules (barrel + end-caps) for 98% solid angle coverage
- 4880 PMTs for a two-side readout
- Time resolution: $\sigma_T = 54$ ps / $\sqrt{E(GeV)} \oplus 50$ ps
- Energy resolution: $\sigma_E/E = 5.7\%$ / $\sqrt{E(GeV)}$

KLOE-2 upgrade: Inner Tracker[3]

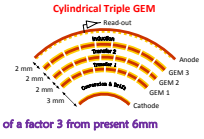
For fine vertex reconstruction of K_S, η and η' rare decays and K_S- K_L interference measurements :

- $\sigma_{r\phi} \sim 200$ μm and $\sigma_z \sim 500$μm
- low material budget: $<2\%X_0$
- 5 kHz/cm² rate capability

Cylindrical GEM technology

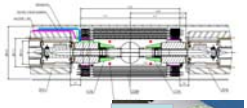


- **4 CGEM** layers with radii from **13** to **23** cm from IP and before DC Inner Wall
- **700 mm** active length
- **XV strips-pads readout (40° stereo angle)**
- **1.5% X_0** total radiation length in the active region with Carbon Fiber supports



$K_S \rightarrow \pi\pi$ vertex resolution will improve of a factor 3 from present 6mm

The KLOE-2 IT project

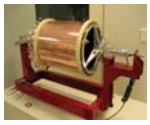


Technical Design Report of the Inner Tracker for the KLOE-2 experiment [arXiv:1002.2572]

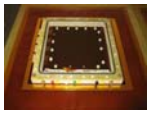
KLOE-2 beam pipe with the IT installed

R&D step by step[4]

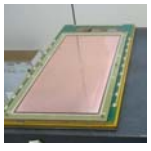
1. 2008. C-GEM prototype using 3 (354x330 mm²) GEM foils spliced together with simplified readout. No final readout, No final GEM



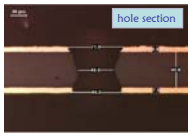
2. 2009. 100x100 mm² planar chambers with XV readout pattern for study in magnetic field. Final readout, No final GEM



3. 2010. Two large (300x700 mm²) planar chambers with the new single-mask GEM foils and XV readout. Final readout and final GEM



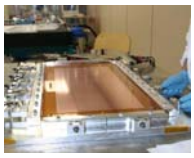
Large area GEM and planar prototype



- GEM foils as large as 350x700 mm² are needed for the IT (3 are spliced together for 1 electrode)
- A change in the GEM manufacturing technique has been driven by request of large foils
- After a 1 year effort by CERN TS/DEM and PH/GDD groups and all the RD51 Collaboration we have the first large GEM

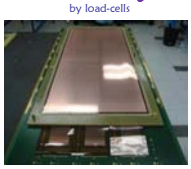
Very large GEM: 0.21 m²

Two planar prototypes have been built to validate the new GEM foils



GEM are stretched on a custom-made machine with a tension of **~1kg/cm** measured by load-cells

- One large prototype is assembled with the final KLOE-2 readout: XV strips-pads with 650 μm pitch (~220k vias)



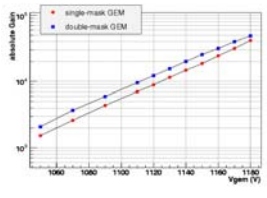
FR4 frame is glued on the GEM in a vacuum-bag
The result is a planar foil (20 μm sag) with no need of frames inside the active area

The other detector has been flushed with **Ar/CO_2 (70/30)** and tested in current-mode with a **^{137}Cs source** (660 keV photons)

A 10x10 cm² chamber with double-mask foils has been used for reference and normalization of performance.

Gain

- The different shape of the hole affects the gain of the GEM
- Gain ~25% lower in single-mask GEM
- Only ~20 V increase in the operating voltage of a Triple-GEM to reach same gain
- NO discharge observed up to 40000 gain



Very stable operation

Conclusions and next steps

- **KLOE-2** and the **Cylindrical-GEM** project are approaching steadily the finalization.
- A mandatory step is the validation of the new single-mask GEM technology.
- Two planar prototypes with **300x700 mm2 foils** (same dimensions for the cylindrical Inner Tracker) have been built .One is assembled with the final XV readout, equipped with the 64 channels GASTONE and will be tested on the PS beam in October; and the other was tested in current mode showing **good stability, uniformity and a gain ~25% lower than double-mask GEM.**
- **The first Layer of the KLOE-2 Inner Tracker has been funded and will be realized by the end of this year.**

References

[1]. (F.Sauli, NIM A386 (1997) 531).

[2]. G.Bencivenni, The activity of the LNF Detector Development Group, Jun 30,2006.

[3]. Technical Design Report of the Inner Tracker for the KLOE-2 experiment.

[4]. D.Domenici'report,12th Topical Seminar on Innovative Particle and Radiation Detectors Siena, 8 June, 2010.