Status of Cylindrical-GEM project for the KLOE-2 Inner Tracker

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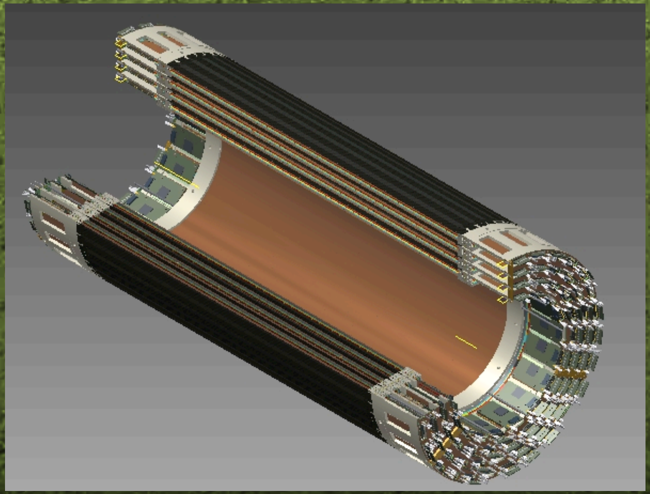
and possible Cylindrical-GEM in BESIII

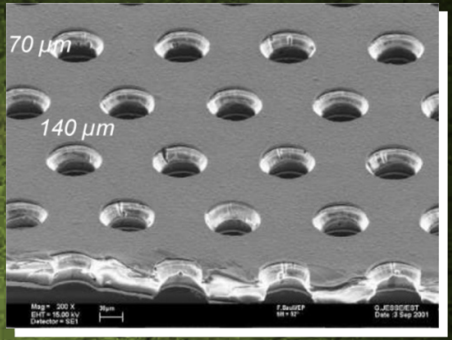
BESIII Italian Collaboration

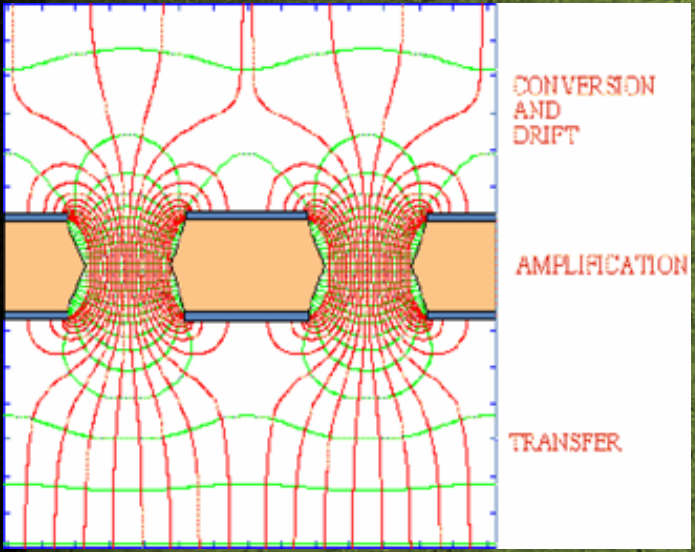


8 – 13 June 2012, BESIII Collaboration 2012 Spring Meeting, Suzhou (China)

GEM: principle of operation

The GEM (Gas Electron Multiplier) [F.Sauli, NIM A386 (1997) 531] is a thin (50 μm) metal coated by a kapton foil perforated by a high density of holes (70 μm diameter, pitch of 140 μm) → standard photo-lithographic technology.

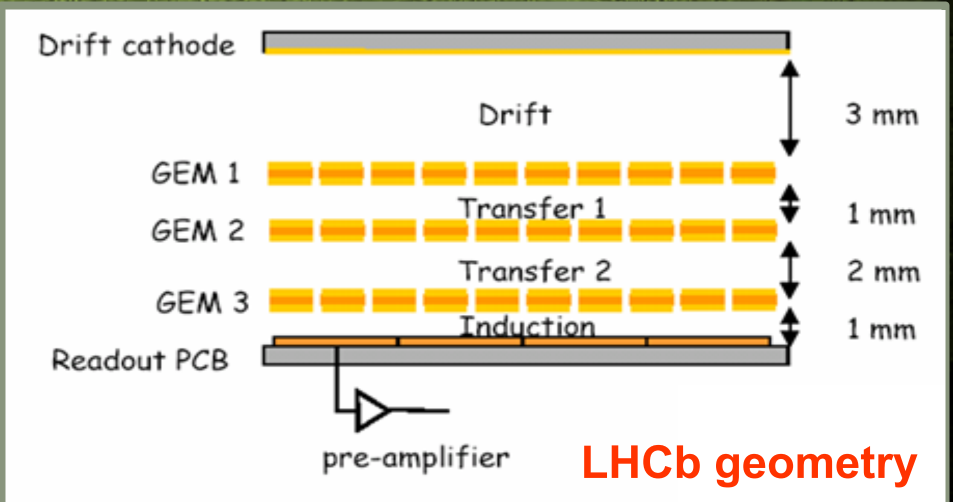




By applying 400-500 V between the two copper sides, an electric field as high as ~100 kV/cm is produced into the holes which act as multiplication channels for electrons produced in the gas by a ionizing particle.

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.



GEM detector features

- **flexible geometry** → arbitrary shape: rectangular, cylindrical …
- **ultra-light structure** → very low material budget: <0.5% X0/chamber
- **gas multiplication separated from readout stage** → arbitrary readout pattern: pad, strips (XY, UV), mixed …
- **high rate capability:** >50 MHz/cm2
- **high safe gains:** > 10^4
- **high reliability:** low discharge, $P_d < 10^{-12}$ per incoming particle
- **rad hard:** up to 2.2 C/cm^2 integrated over the whole active area without permanent damages (corresponding to 10 years of operation at LHCb1)
- **high spatial resolution:** down to 60μm (COMPASS with analog readout Nucl.Phys.Proc.Suppl. 125 (2003) 368-373)
- **good time resolution:** down to 3 ns (with CF_4)

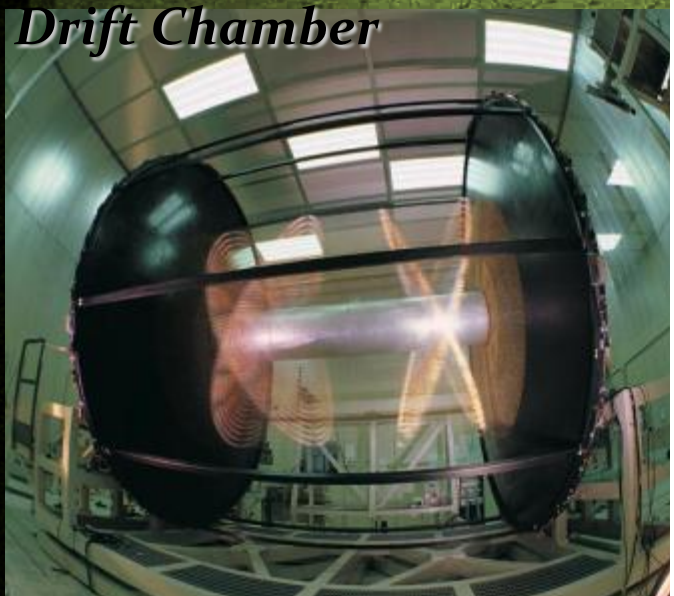
KLOE at upgraded DAFNE f-factory (1020 MeV)

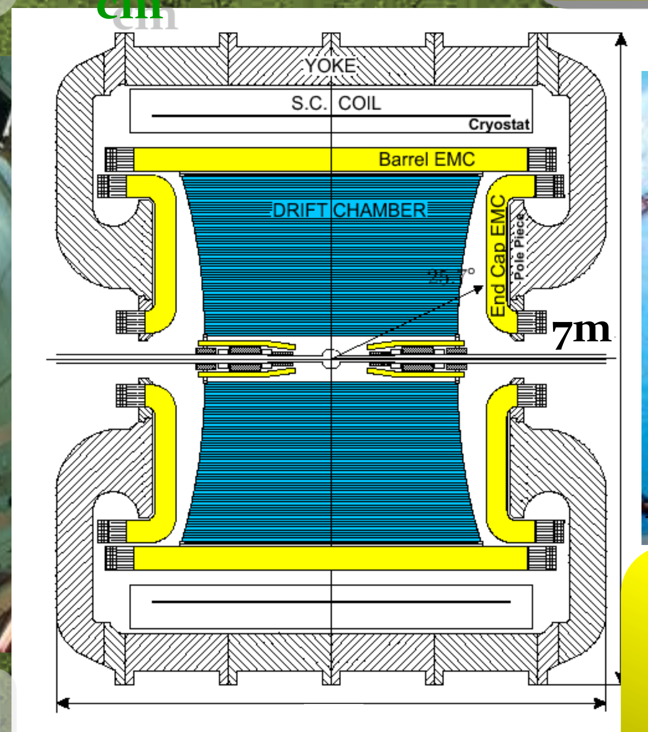
- 4 m diameter × 3.3 m length
- 90% helium, 10% isobutane
- 12582/52140 sense/tot wires
- All-stereo geometry

$_{KS}$ = 0.6 cm $_{KL}$ = 340 cm $_{K}$ = 95 cm

- Lead/scintillating fiber
- 98% coverage of solid angle
- 88 modules (barrel + end-caps)
- 4880 PMTs (two side read-out)

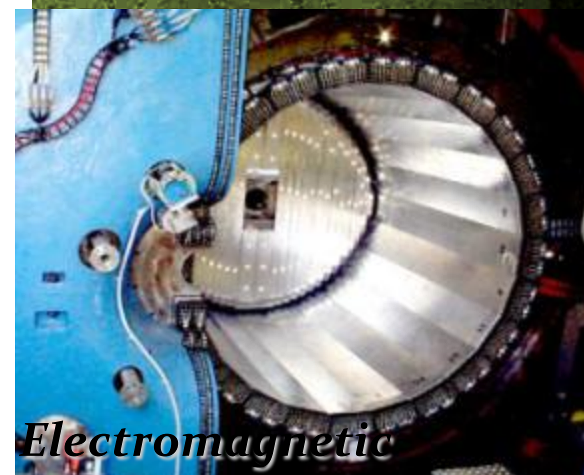
Drift Chamber





6 m

B = 0.52 T



Electromagnetic

s_{rf} = 150 mm s_z = 2 mm
s_V = 3 mm s_p/p = 0.4 %

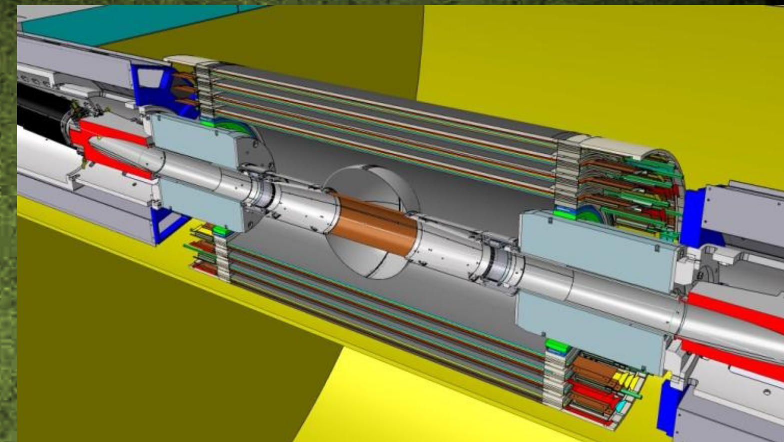
s_E/E = 5.4%/$\sqrt{E(GeV)}$

s_t = 54 ps/$\sqrt{E(GeV)}$

Å 100 ps(calib)

KLOE-2 Inner Tracker

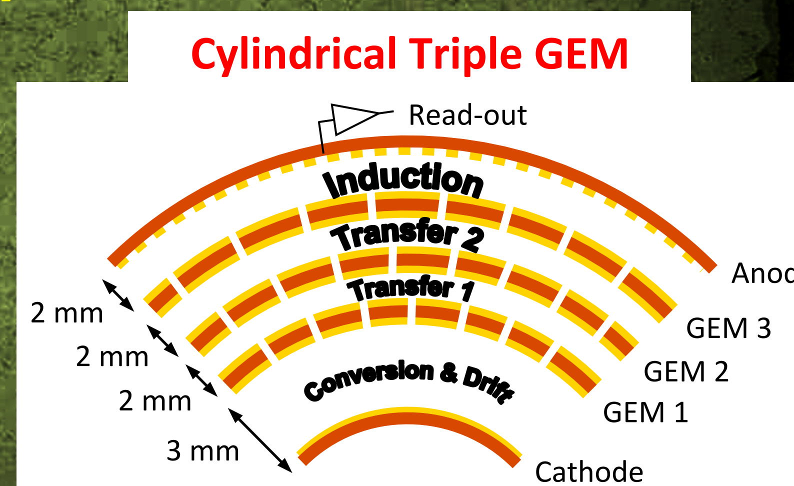
To improve vertex reconstruction of **K_s , η and η'** and **K_s- K_L interference measurements:**



1. **⊠$_{r\varphi}$ ⊠ 200 μm and ⊠$_z$ ⊠ 350μm**
2. **low material budget**: < 2% X_0

Cylindrical GEM detector is the adopted solution

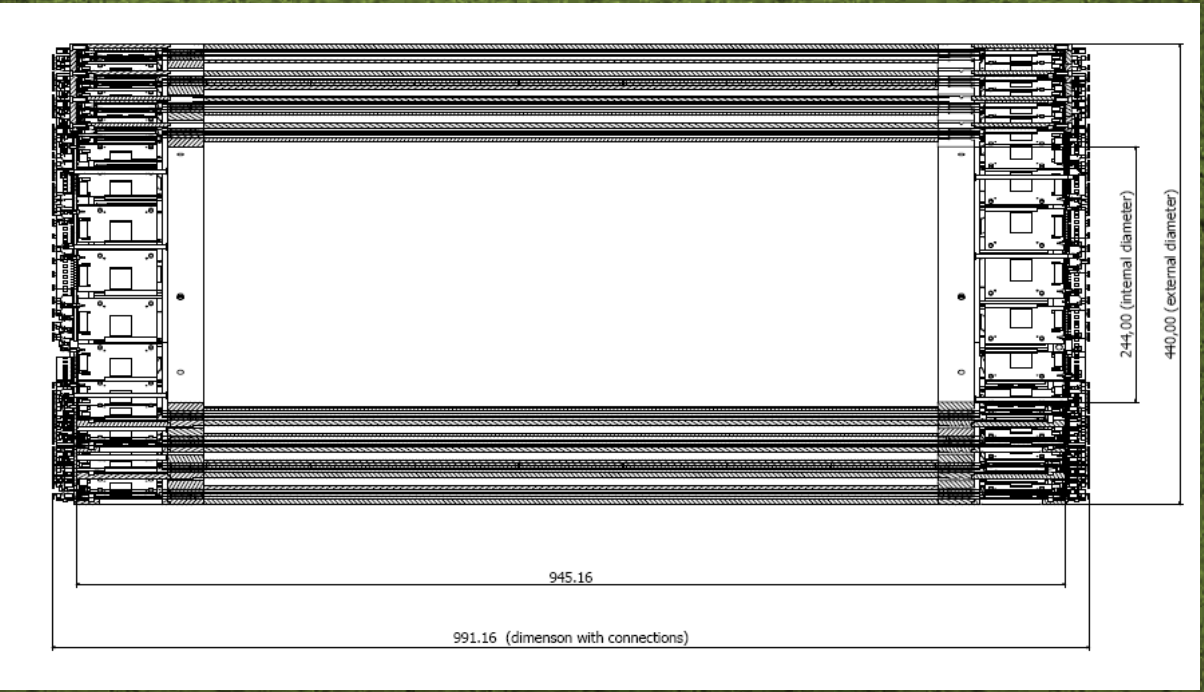
- **4 CGEM** layers :from IP to DC Inner wall
- **700 mm** active length
- **XV strips-pads readout (~40^o stereo angle)**
- **2%X_0** total radiation length in the active region



K_S → p^+p^- vertex resolution **will improve of about a factor 3** from present **6mm**

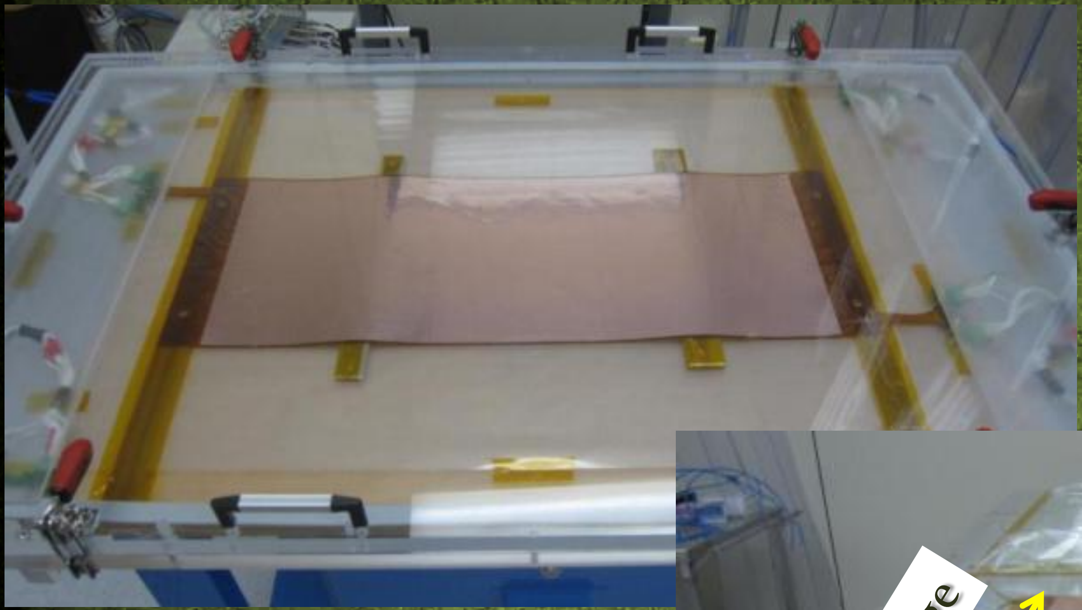
KLOE - IT dimensions

	Ext diam (mm)	Int diam (mm)
Layer 1	290	244
Layer2	340	294
Layer3	390	344
Layer4	440	394

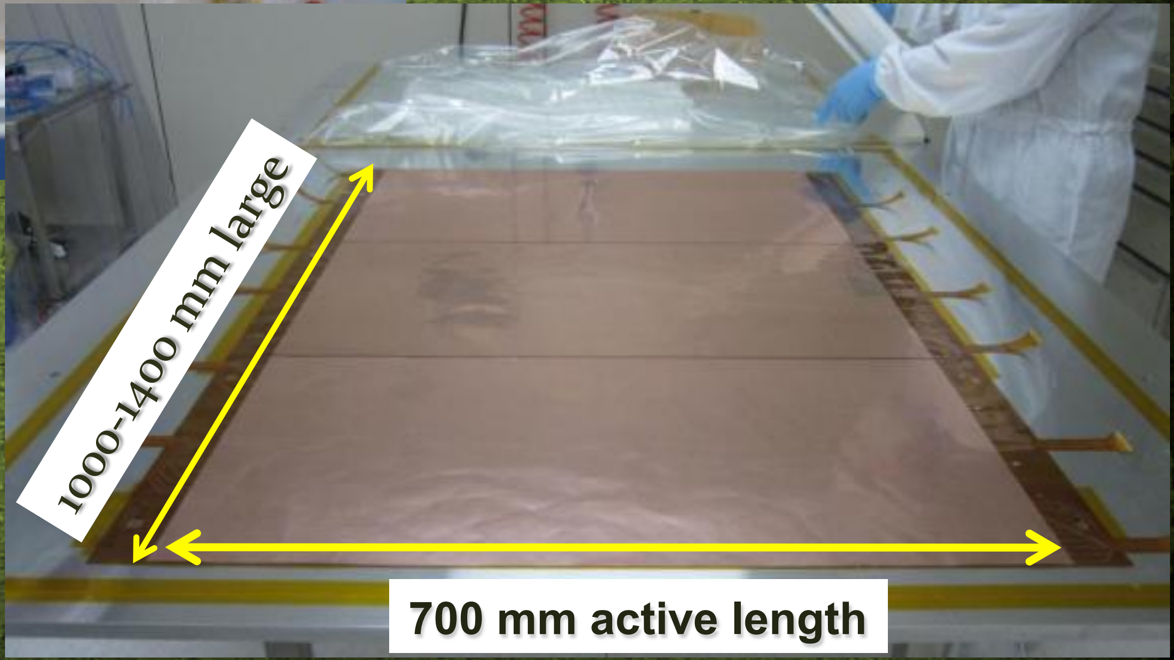


Total lenght 945,16 mm + connectors ~ 991,16 mm

The Large GEM Foils



Before gluing each GEM foil, it is tested with HV (up to 600V) in a N_2 flushed plexiglass box, to reduce RH below 10%



3 GEM foils spliced and envelopped in a vacuum bag

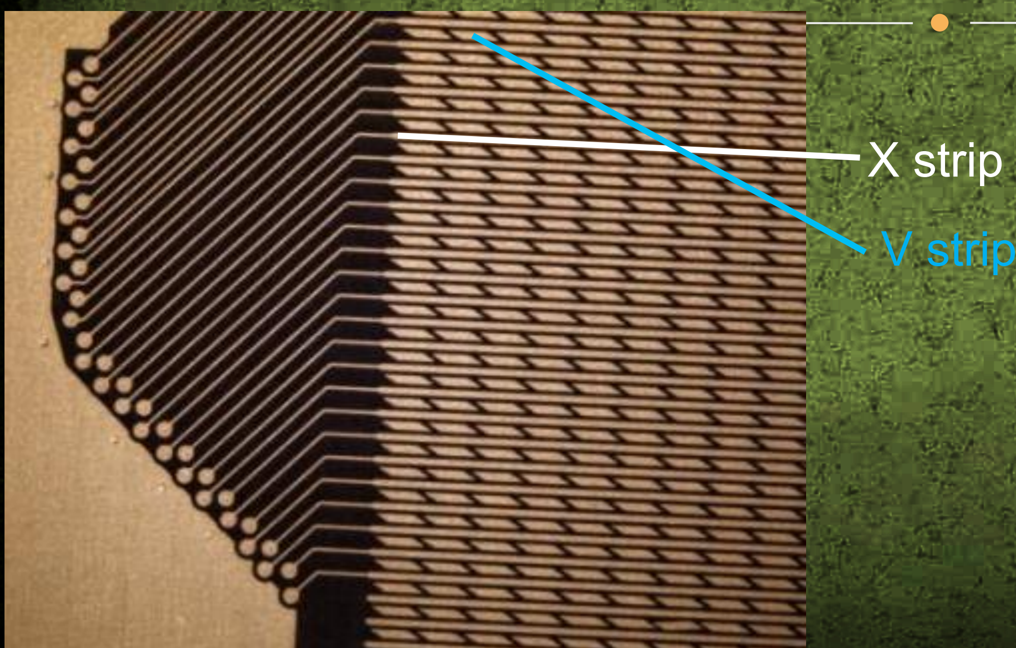
Anode Readout

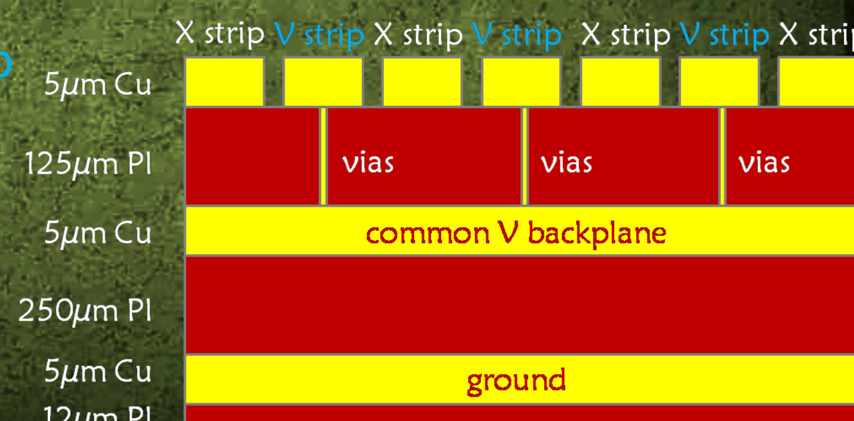
2-D readout with XV strips on the same plane

X pitch 650µm ⊠ X res 190µm

V pitch 650µm ⊠ Y res 350µm

Multilayer Kapton circuit realized at CERN



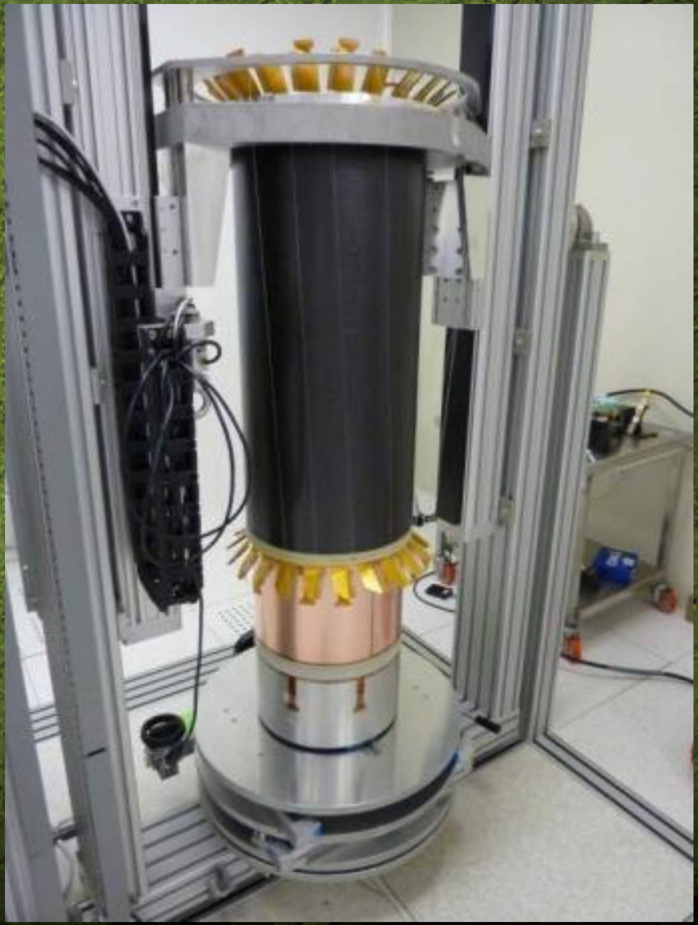


Costruction toolings (I)

Special molds for cylindrical electrodes (cathode, GEMs, anode readout) constructions.
N.5 molds per layer (total 20 molds)

Costruction toolings (II)

Vertical Insertion System for the cylindrical electrodes insertion and final detector assembly



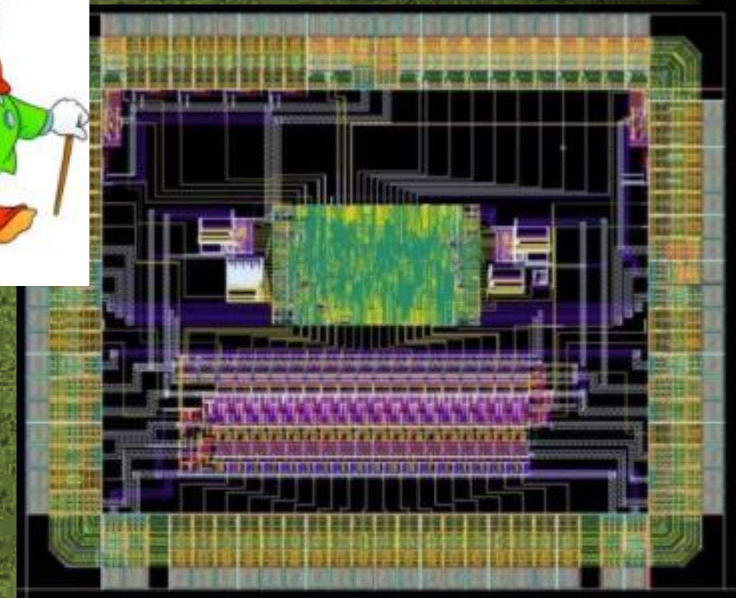
Layer 1 & Layer2

Up to now, the first two layers have been made, and will be tested with cosmics.

The manufacture of the other two layers should be completed in October 2012. The installation in KLOE is foreseen by the end of 2012

GASTONE: the IT dedicated FEE chip

Sensitivity (pF)	20 mV/fC
Z_{IN}	400 Ω (low frequency)
C_{DET}	1 – 50 pF
Peaking time	90 – 200 ns (1-50 pF)
Noise (erms)	800 e^- + 40 e^-/pF
Channels/chip	64*
Readout	LVDS/Serial
Power consum.	≈ 0.6 mA/ch

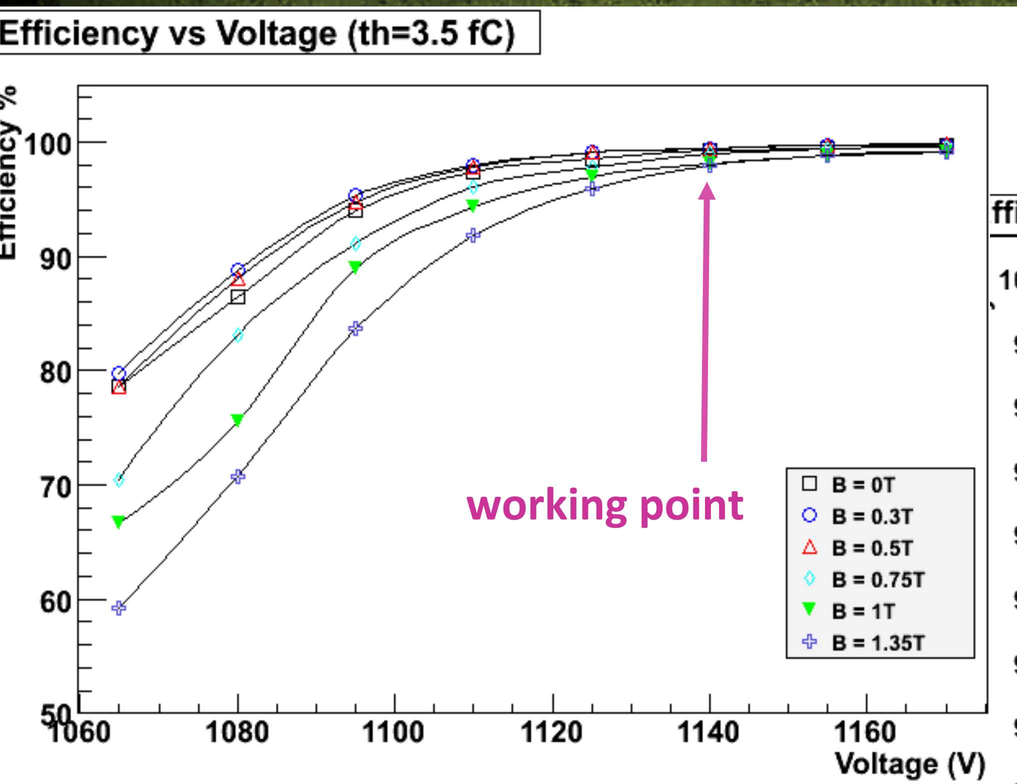


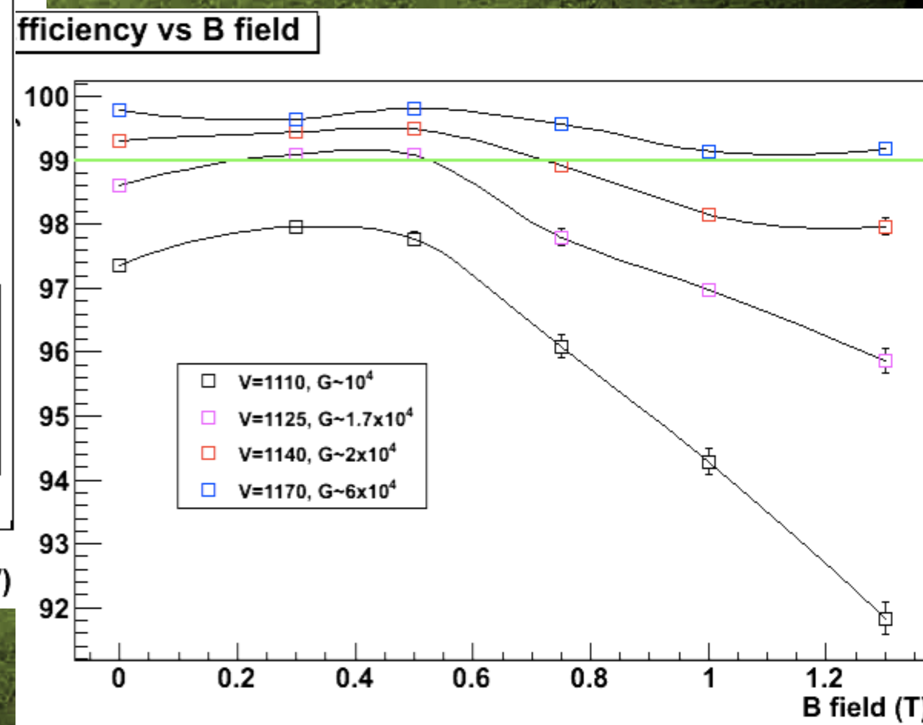
- **Mixed analog-digital circuit** (KLOE-2 dedicated);
- **Low input equivalent noise, low power consumption** and **high integrated chip;**
- 4 blocks:
  - **charge sensitive preamplifier**
  - **shaper**
  - **leading-edge discriminator** (prog. thr.)
  - **monostable** (stretch digital signal to match the trigger timing of the experiment)

0.35 CMOS technology- no Rad-Hard

Efficiency vs B field and Gain

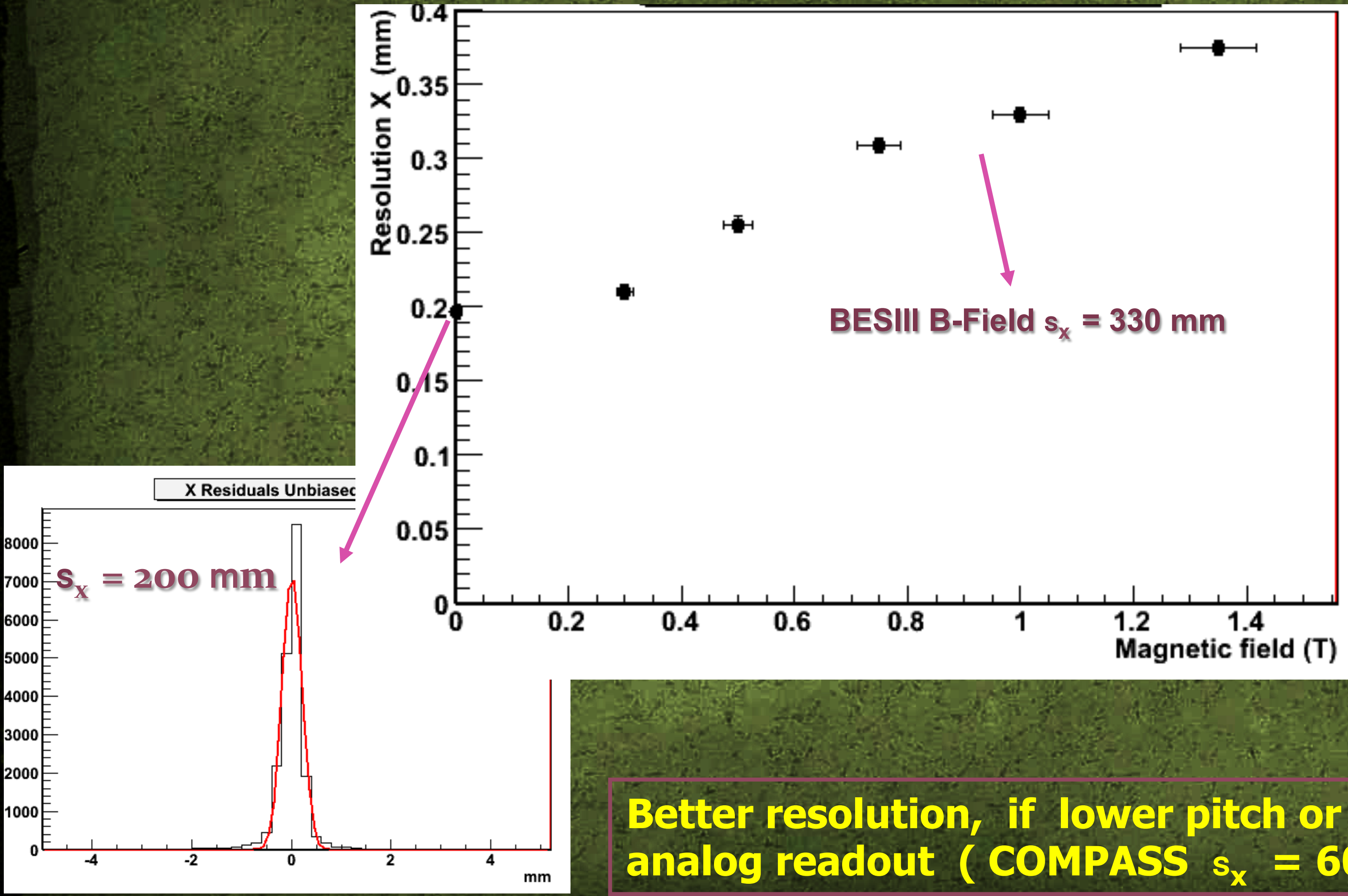
At working point, V_G = 1140 Volt, $G \sim 2 \times 10^4$, **efficiency drop is negligible for B < 0.5 T**





The **increase of the magnetic field,** increasing the spread of the charge over the readout strips (less charge is collected by each single pre-amp channel) results in an efficiency drop, thus **requiring for higher gain to efficiently operate the detector.**

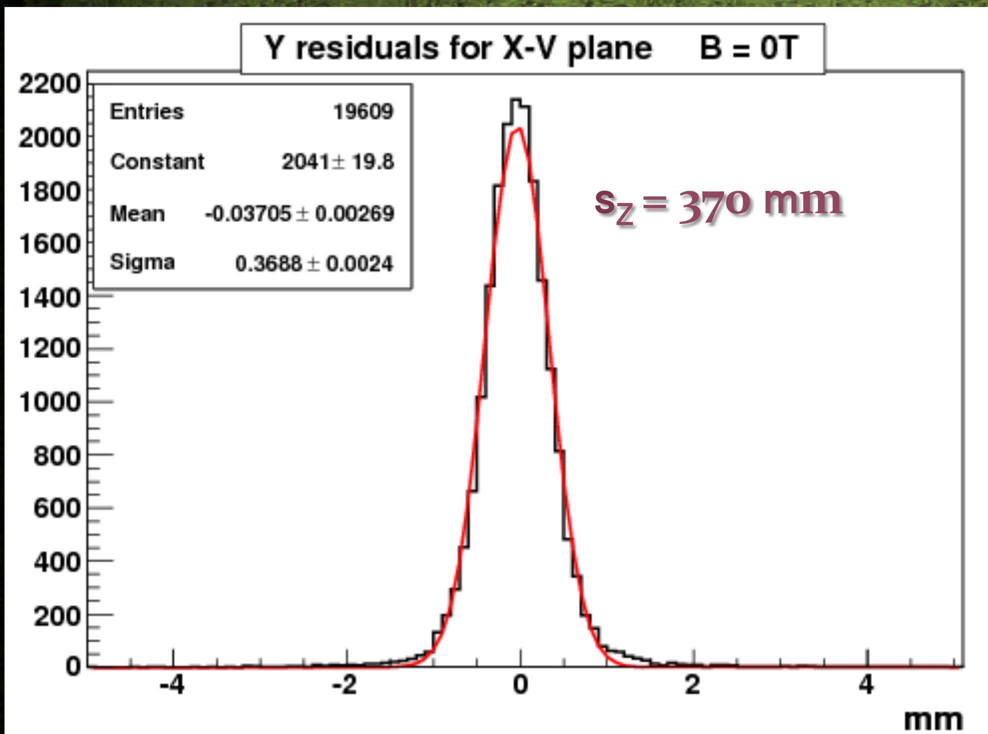
Spatial resolution: X-view (r-φ)

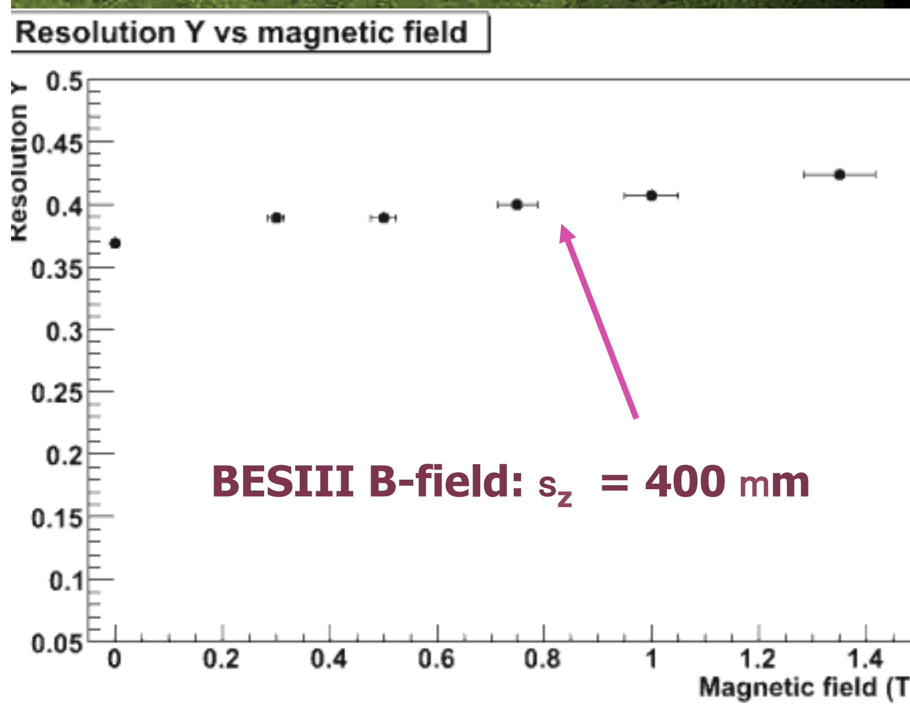


Better resolution, if lower pitch or analog readout (COMPASS s_x = 60 mm)

Spatial resolution : Z-coordinate

The Z coordinate is determined from the crossing of X (r-φ) and V views
(Better z resolution， if lower pitch or analog readout)





In BESIII: Ö($s_x^2 + s_z^2$) ~ 500 mm
(if analog readout ~ 150 mm)

A Cylindrical_GEM at BESIII
in case a new inner chamber is needed ?

- The manifacture of a Cylindrical_GEM, which fulfills many BESIII needs, is on going at LNF and will be installed in KLOE-2 by the end of this year

- BESIII inner chamber is a bit smaller:
  - makes a Cylindrical_GEM easier to be built,
  - enough space to allocate 4 triple-GEM,
  - equivalent to the present 8 layers,
  - however, new tools (molds) are needed

BESIII GEM
possible geometrical parameters

Layer	Int.diam (mm)	Ext.diam (mm)	Length (mm)	Foils
1	120	166	789+46	1
2	176	222	813+46	1
3	232	278	837+46	2
4	288	334	861+46	2

BESIII GEM vs KLOE2 possible improvements

- Expertise from KLOE2 and CERN
- Faster construction, if better molds technique
- Lower high voltage, if higher readout gain
- Better spatial res, if reduced pitch or analog readout (COMPASS analog readout s_x = 60 mm)
- Less material budget

Thanks for

谢谢

your attention