Трековый детектор на основе цилиндрических тонких GEMов

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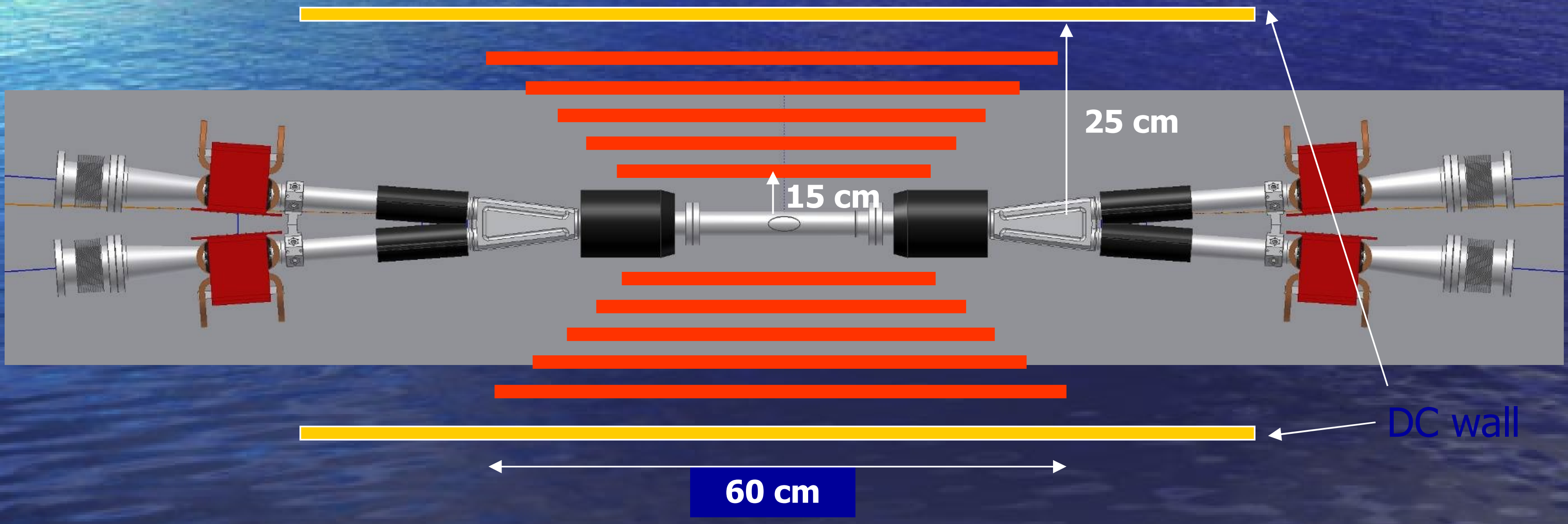
KLOE-2 Inner Tracker

Detector Requirements:

- $\sigma_{r\phi} \times \sigma_z \approx$ 200x500μm single layer spatial resolution for fine vertex reconstruction of **K_s** and **η rare decays** and **interferometry** measurements
- 5 tracking layers with low material budget (< 1.5% X_0): each is a triple-GEM detector
- $R \geq 20\tau_s$ to preserve $K_L K_s$ interference
- Rate capability 30 ÷ 40 hits/plane/μs (< 50 kHz/cm²)



Cylindrical GEM for KLOE-2 Inner Tracker

THE IDEA:

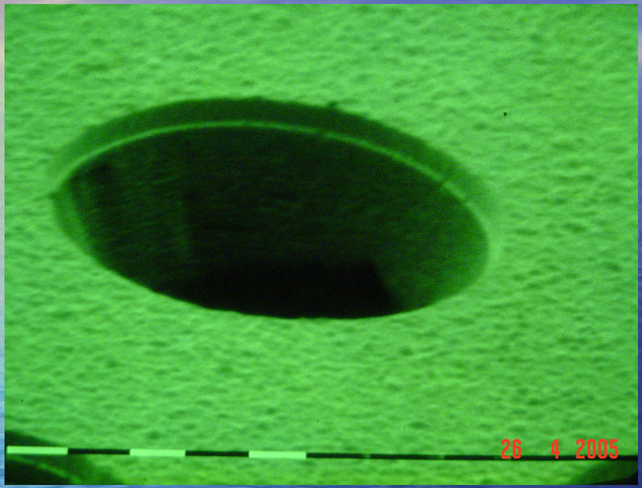
- We propose a **low-mass**, **fully cylindrical** and **dead-zone-free** GEM detector as Inner Tracker for the KLOE-2 experiment.
- The IT is composed by five concentric layers of cylindrical triple-GEM detectors (**C-GEM**).
- Each **C-GEM** is realized inserting one into the other the required five cylindrical structures made of very thin polyimide foils: the cathode, the three GEMs and the readout anode.
- Very light detector: only **0.3% of X_0 per layer** inside the active area.

HOW to do that?

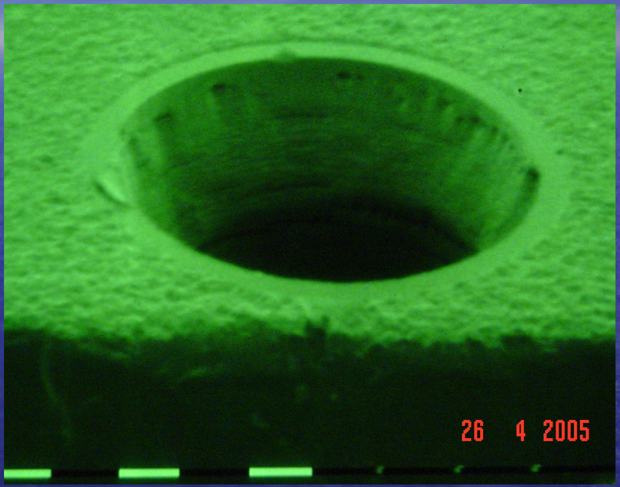
A cylindrical GEM electrode is obtained exploiting the **vacuum bag technique, rolling the polyimide foil up on machined PTFE** cylindrical mould.

Detector element (material)	Rad.length, cm	x/X0
Si 300µm	9.4	$3.2*10^{-3}$
Copper 5µm	1.44	$3.5*10^{-4}$
Kapton 50 µm	28.57	$1.8*10^{-4}$
Argon 1cm	11762	$0.85*10^{-4}$
Triple-GEM detector (5 layers of kapton 50 µm, 7 layers of copper 5 µm, 7mm of Ar)		$3.4*10^{-3}$
Light Triple-GEM detector (5 layers of kapton 50 µm, 7 layers of copper 1 µm, 7mm of Ar)		$1.5*10^{-3}$

Table 1. Comparison of several materials and GEM assemblies in terms of radiation length.
The second colomn is radiation length of pure material, the third colomn is the ratio of thickness to the radiation length.



Обычный GEM



Тонкий GEM

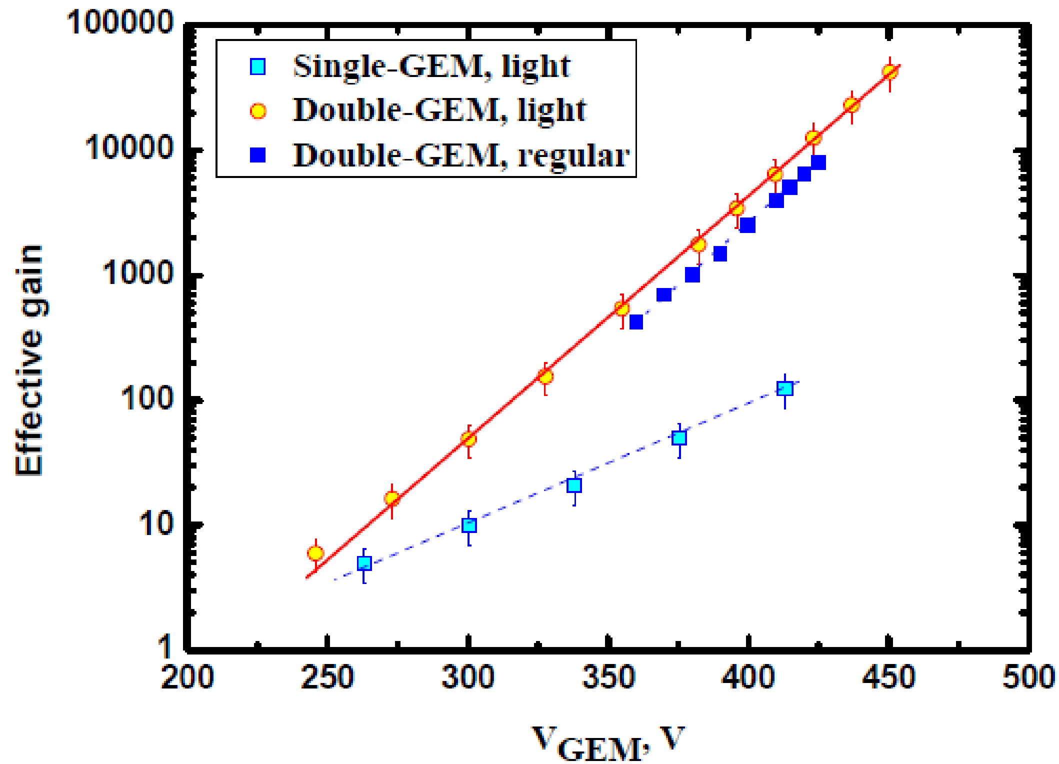
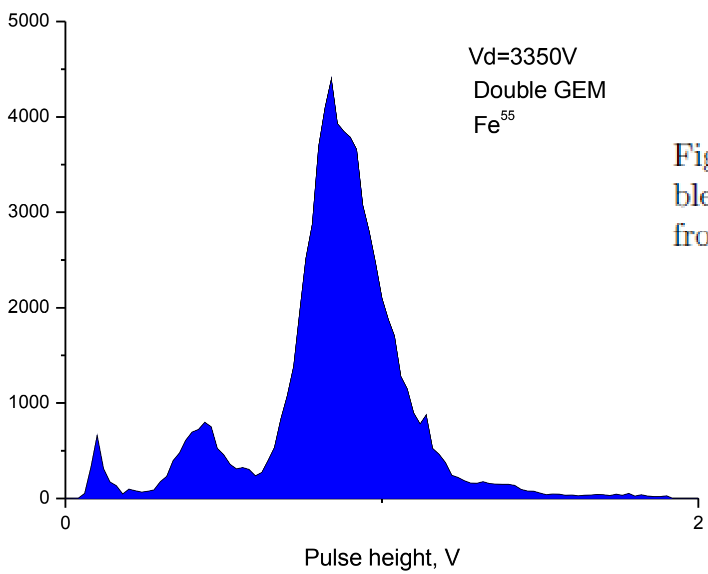


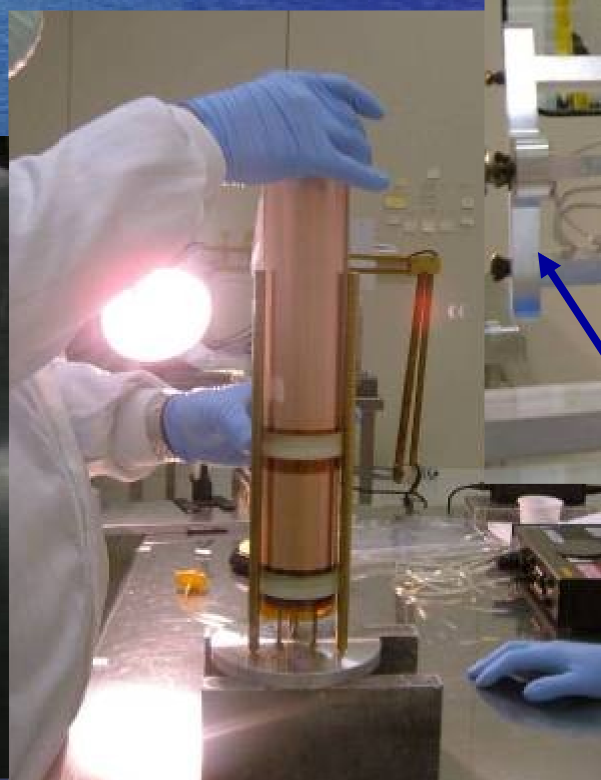
Fig. 2. Effective gain as a function of single GEM voltage for Single- and Double-GEM set-up. For comparison the data for regular Double-GEM are shown, taken from [4].

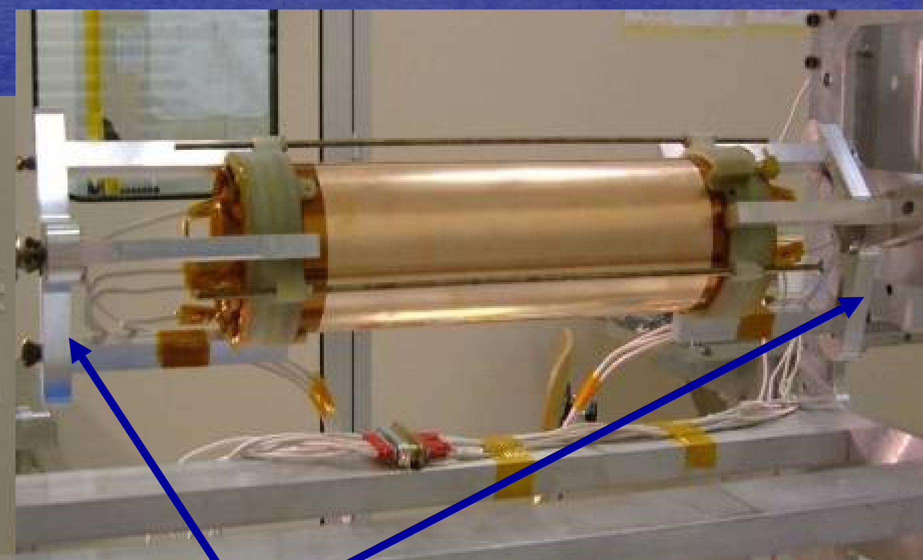


Construction of a small size C-GEM

We built a small size (∅ ~ 90mm, L ~ 250 mm) C-GEM prototype using GEM foils from LHCb, while the anode and cathode electrodes were realized with 50 μm kapton foil with a mono-layer of 5 μm of Cu deposition (Sheldhal G2300).

Standard drift/transfer1/transfer2/induction configuration has been used: 3/2/2/2 mm

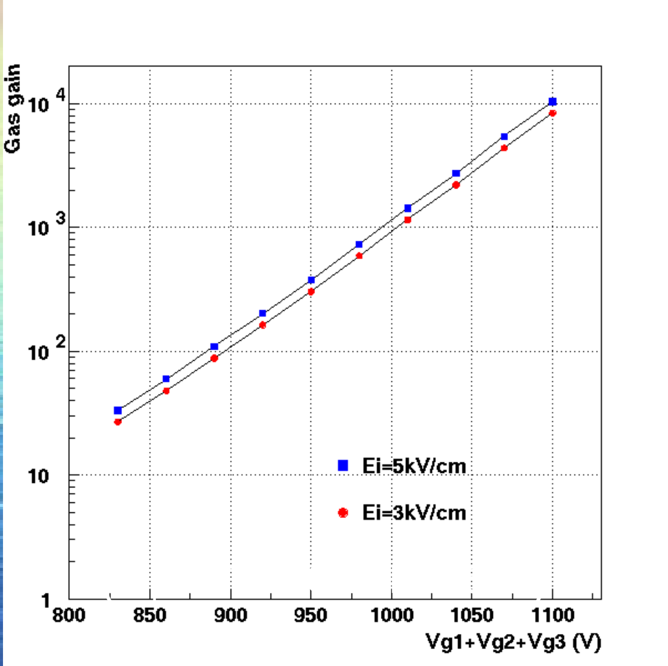




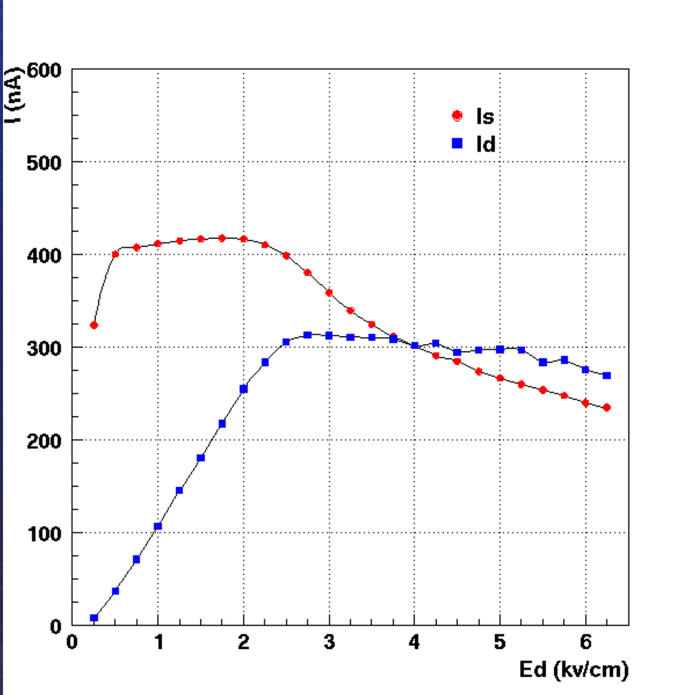
Stretching system with gauge meter to monitor mechanical tension

Test of the small size C-GEM prototype

The C-GEM prototype, operated with Ar/CO_2 = 70/30 gas mixture, has been fully characterized with an X-ray gun (~6 KeV) in current mode (no FEE).



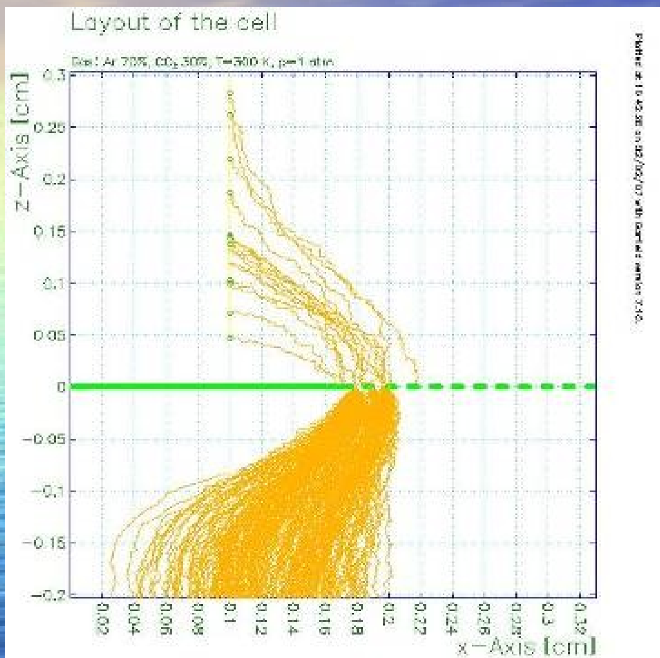
Excellent stability (no dark current, no sparks) is observed up to a gas gain of 10^4, for a wide range of stretching tension (2 ÷12 kg/cylindrical electrode)



… and typical electron transparency curves of the standard planar triple GEM detector are reproduced

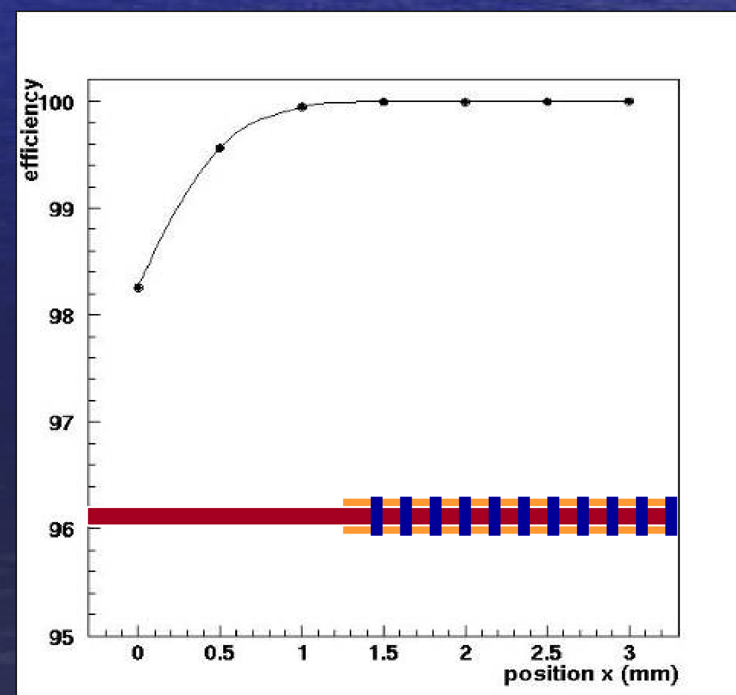
Preliminary simulation of the junction line

The construction procedure implies the presence of a singularity along the gluing junction line made of bare Kapton (neither copper nor holes).



The distorsion of the field lines still efficiently drives the electrons to the multiplication holes

A slight drop to 98% efficiency is only observed in the case of a track crossing perpendicularly the middle of the junction line.



More detailed simulation studies and
the measurements on the next prototype in construction
will give us relevant hints on this issue.

Construction of the full size proto

- Diameter: ~ 300 mm (KLOE-IT Layer 1)
- Active length: ~ 352 mm

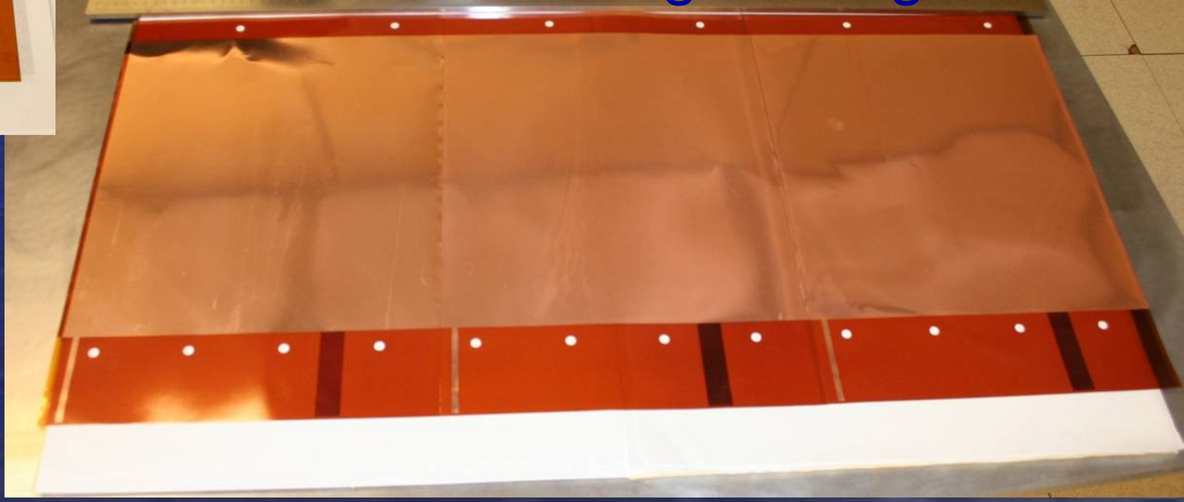
→ ~1000 x 350 mm^2 GEM active area patch of n.3 333x350 mm^2

- Number of strips: 1538 (only 1D rφ view for simplicity)
- Readout channels: 384 (money limitation)

Cylindrical Electrodes status

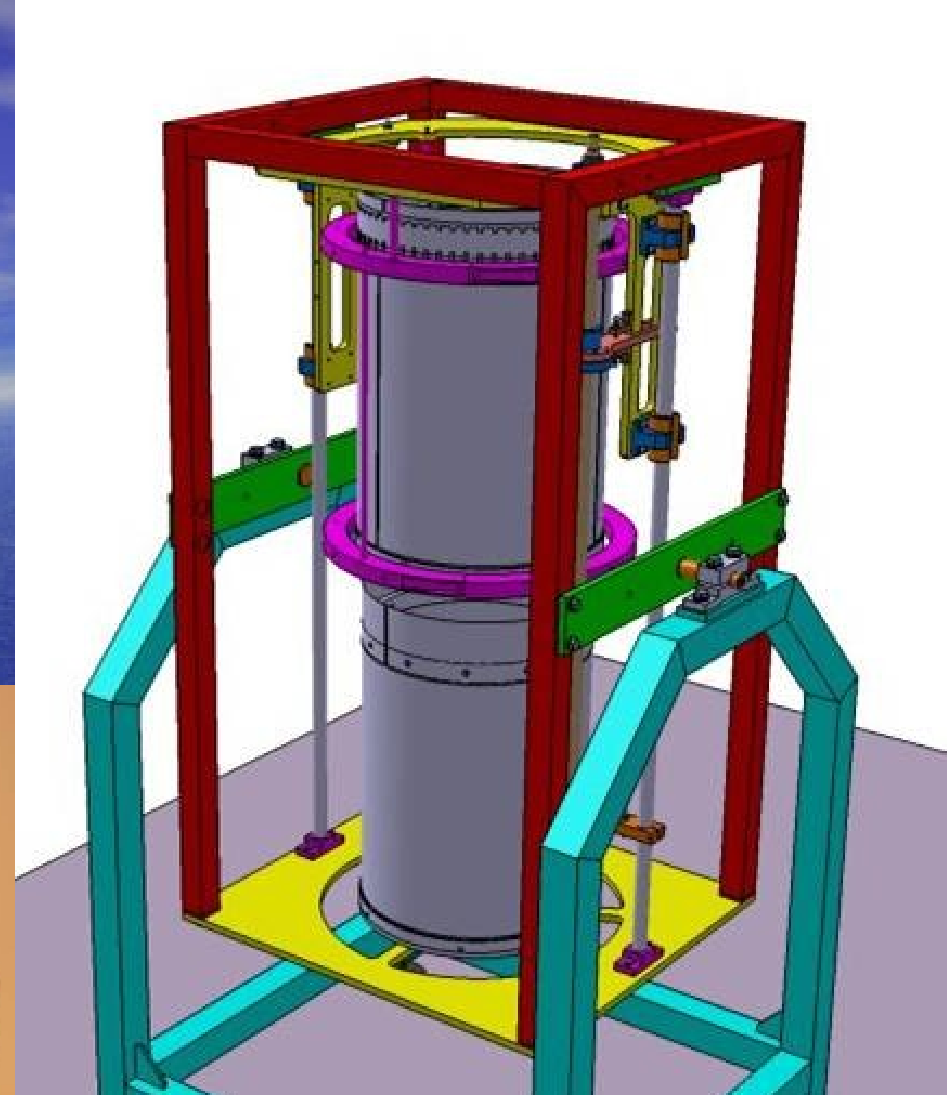
The GEM foils are ready:
333x350 mm^2 active area,
divided in 20 sectors

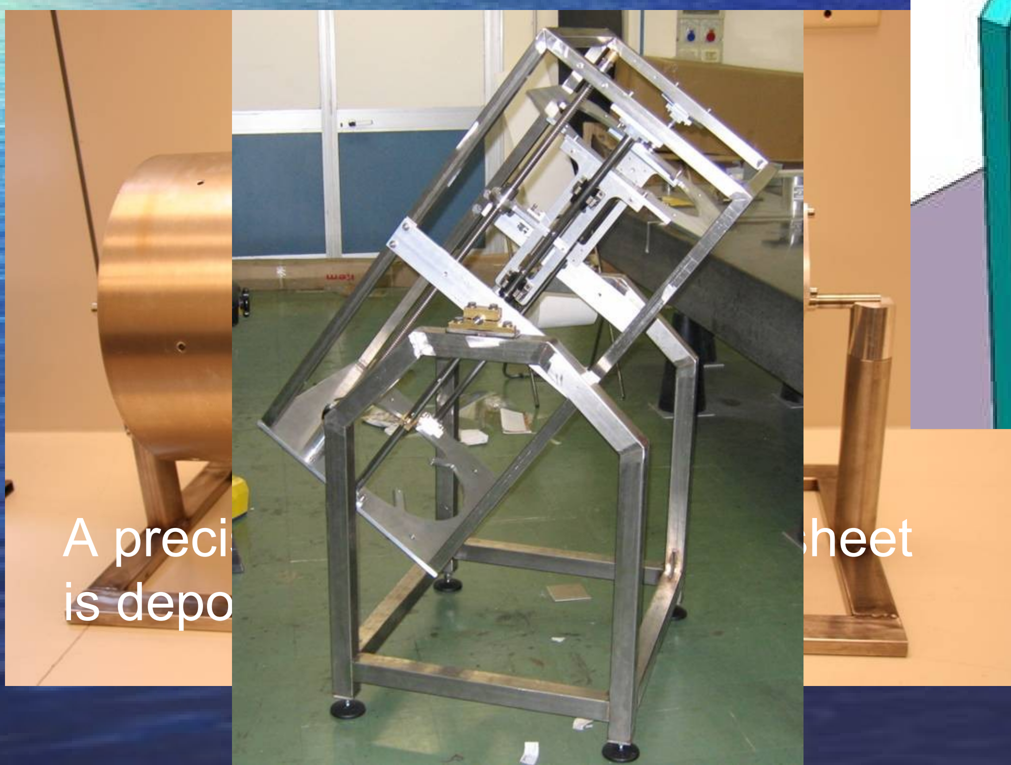
The three foils composing the cathode has been glued together



Mechanics is ready

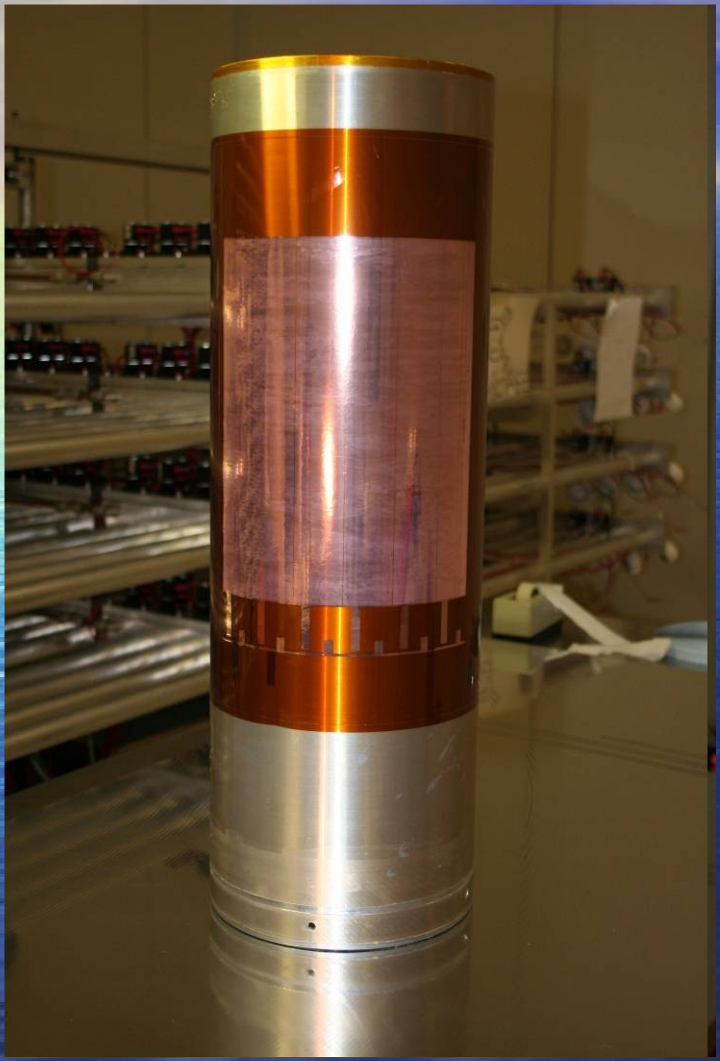
- fiberglass cylindrical frames
- cylindrical moulds
- vertical insertion tool



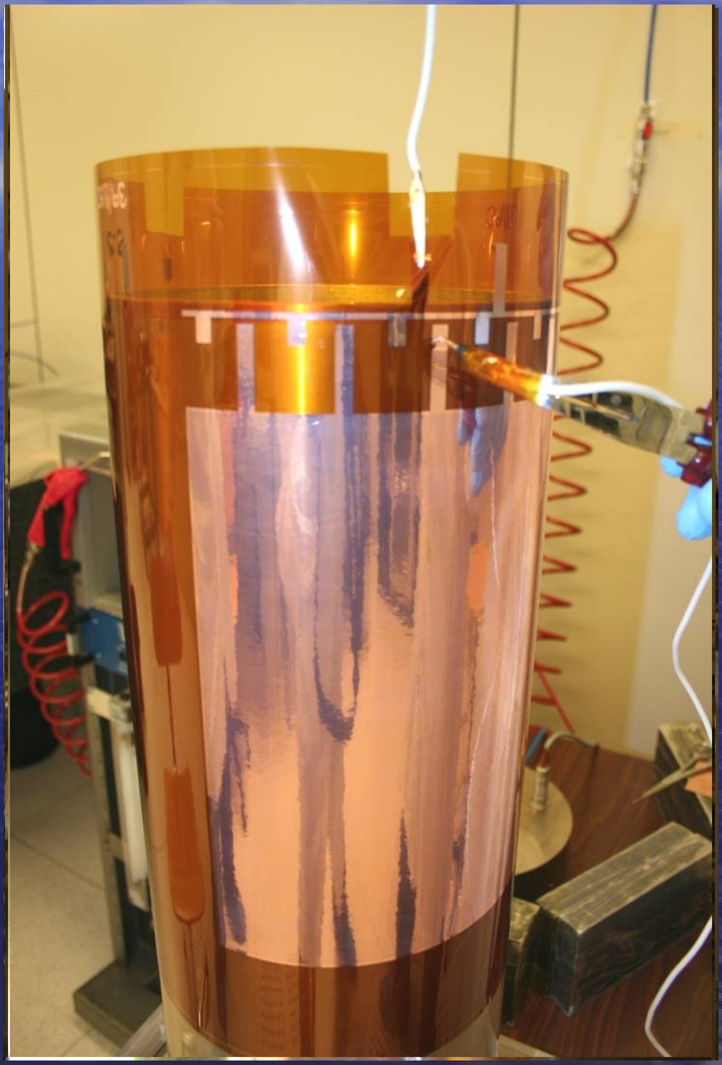


The vertical insertion system requires for very precise mechanics and linear bearing equipments.

Preliminary tests of large foils extraction



200 mm diameter C-GEM



Successfully tested at 500 V

Prototype schedule

❑ Readout anode foil delivery	11 september
❑ Detector assembling	15 october
❑ Preliminary cosmic ray test	25 october
❑ Beam tests	december

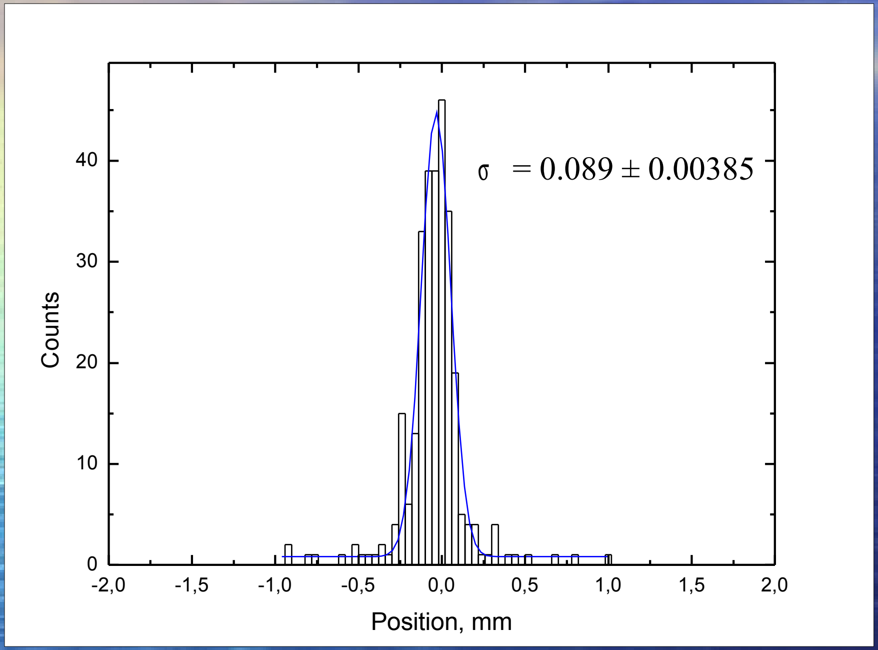
General schedule

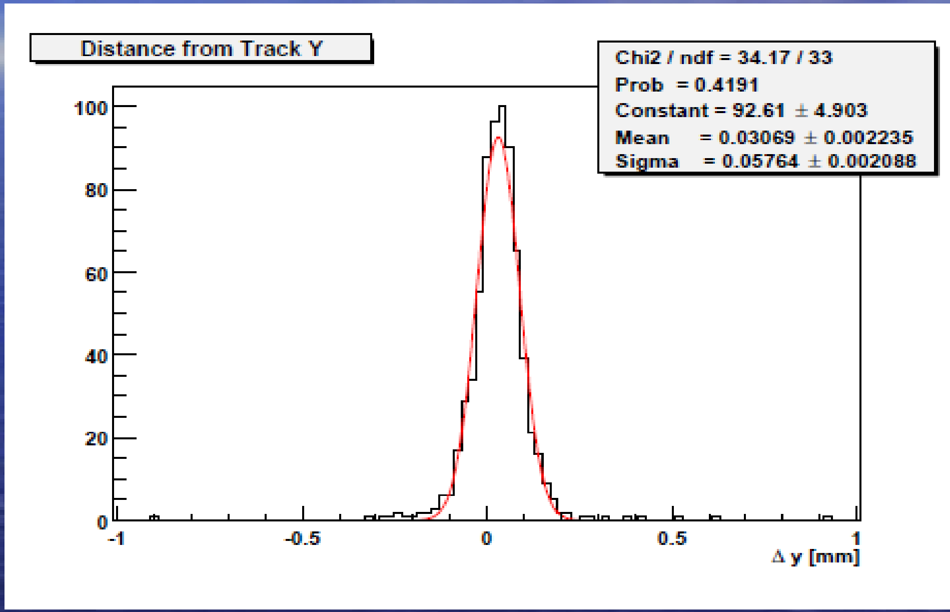
❑ Final Inner Tracker Design	July 2008
❑ Start construction	Spring 2009
❑ Commissioning in KLOE-2	end of 2009

SPATIAL RESOLUTION

GEM-TS, KEDR

GEM, COMPASS

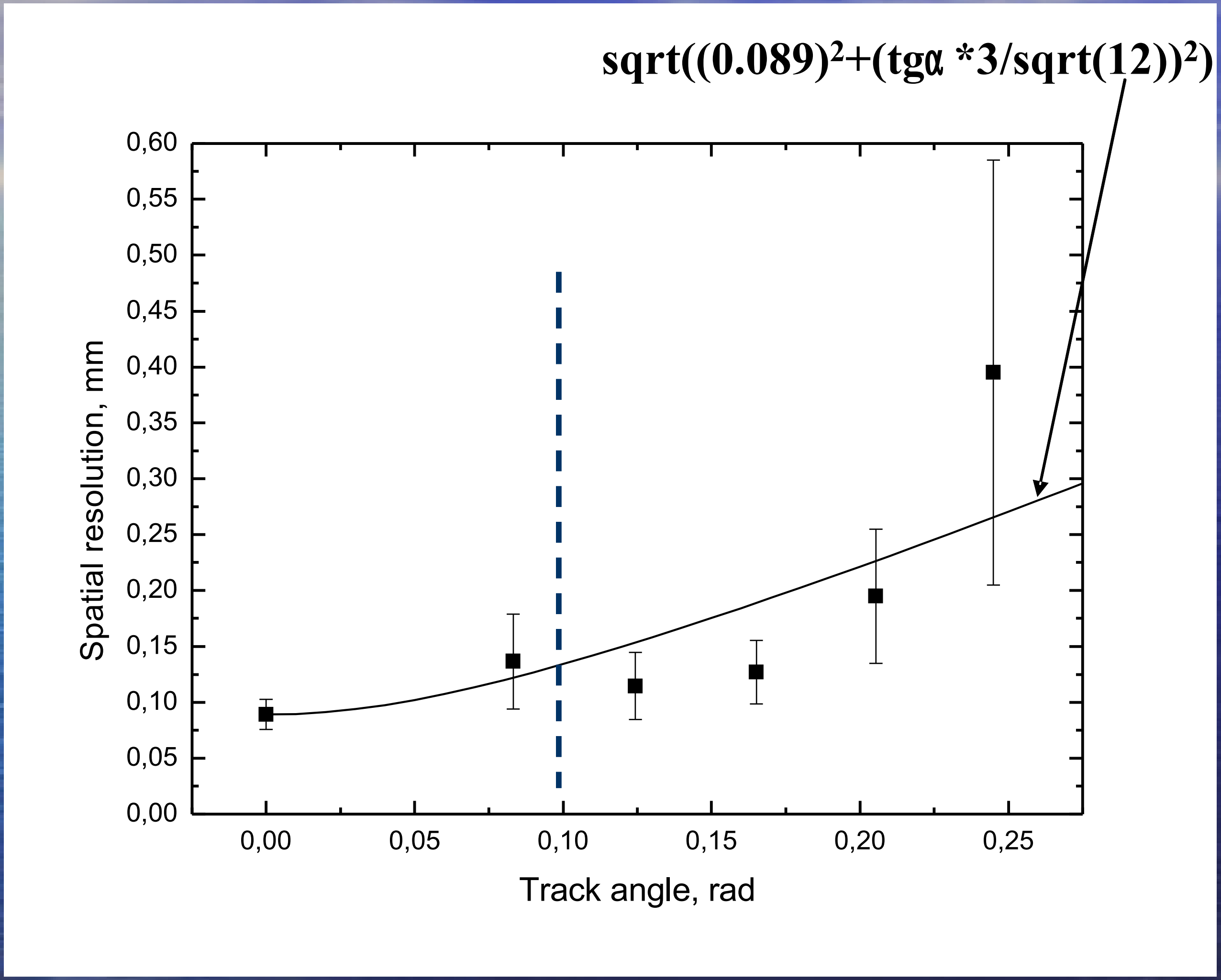




pitch=0.5mm, σ_{det} = 0.073 mm

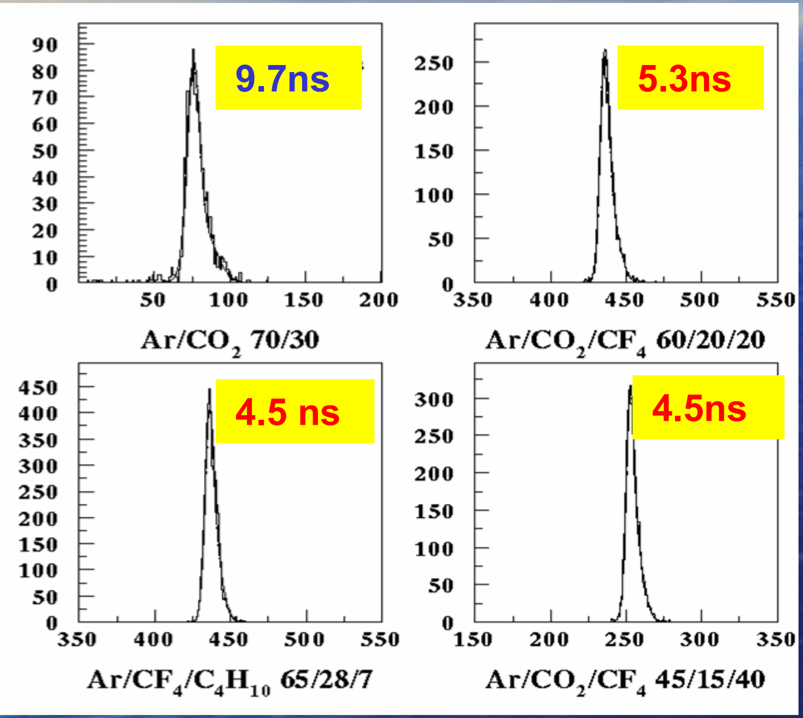
pitch=0.4mm, σ_{det} = 0.046 mm

Spatial resolution as a function of track angle:

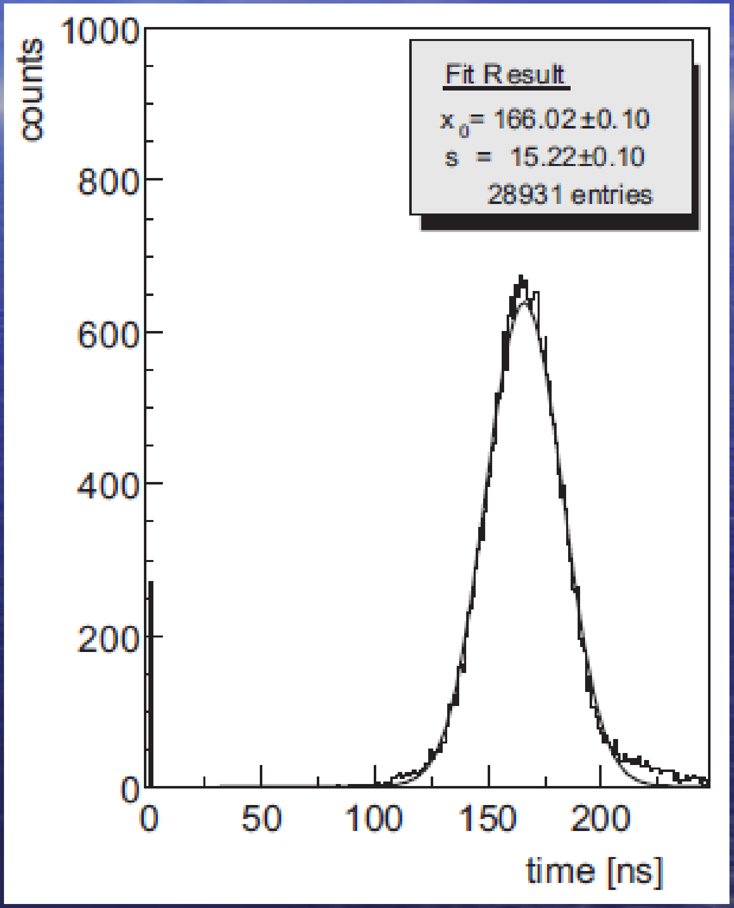


Временное разрешение

LHCb



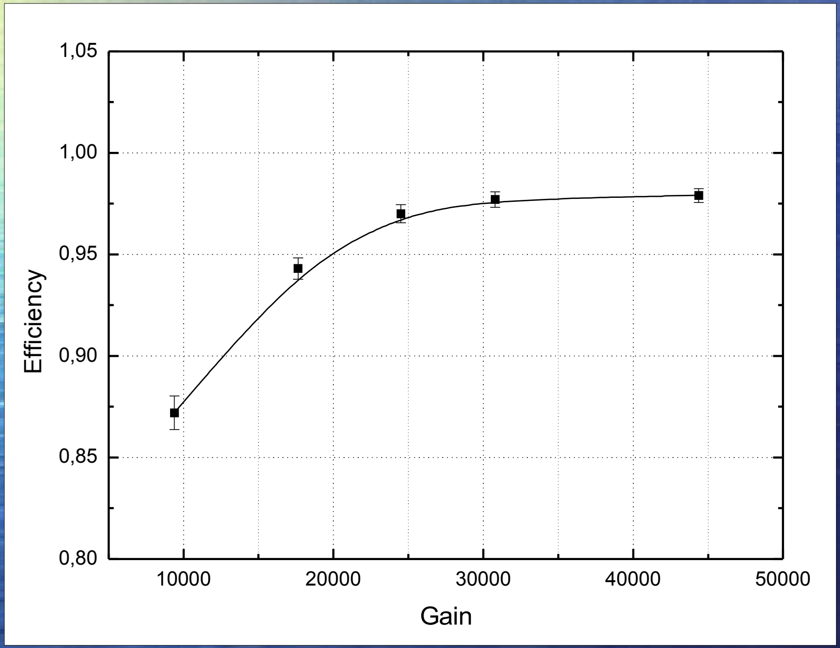
COMPASS

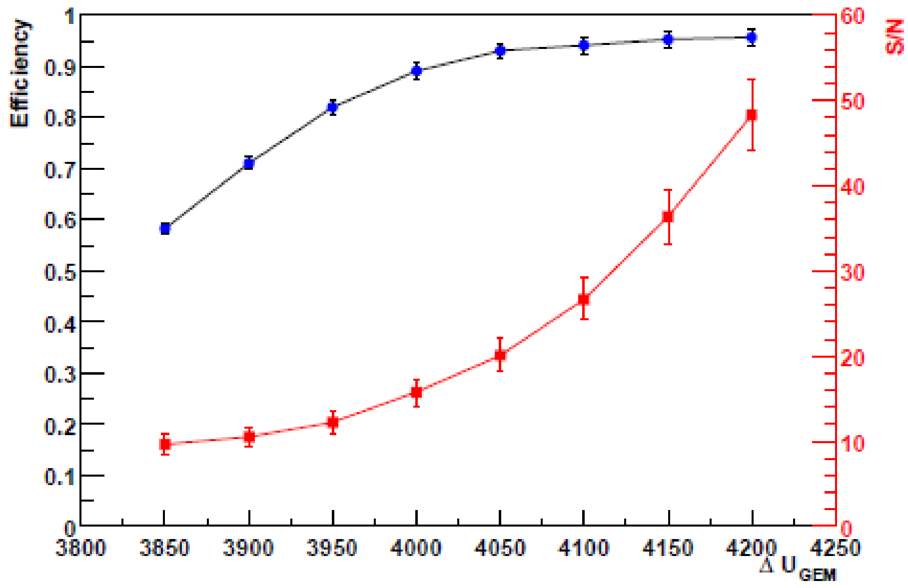


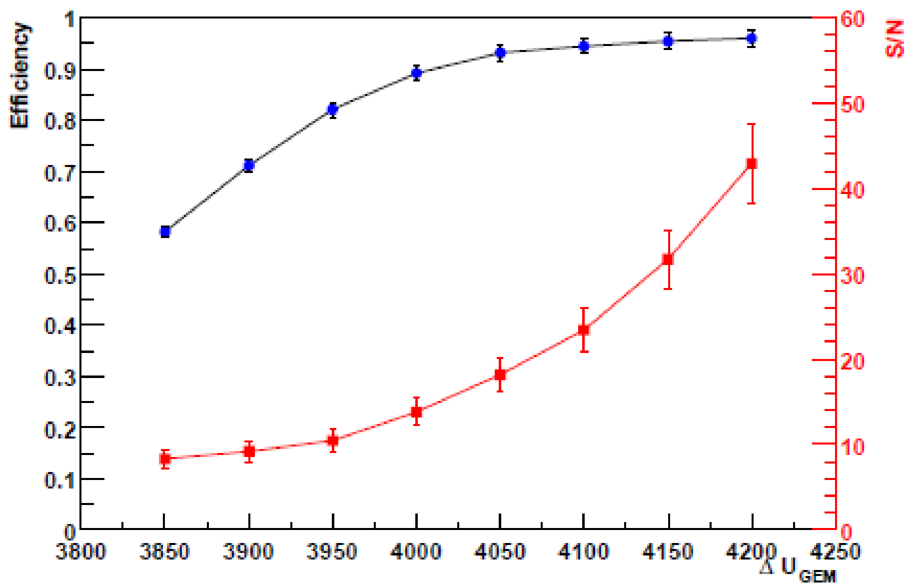
EFFICIENCY

COMPASS

GEM-TS, KEDR







Преимущества

Очень легкий >1%X0
Хорошее пространственное разрешение
Хорошее временное разрешение
Есть опыт разработки-изготовления-запуска-эксплуатации

Недостатки

Пространственное разрешение сильно ухудшается с углом (проблема для сильно искривленных треков)

Требует очень чистого помещения для изготовления