Preliminary study with CGEM inner detector at BESIII

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Outline

- Introduction
- Preliminary simulation
- Preliminary reconstruction
- Conclusion

Introduction

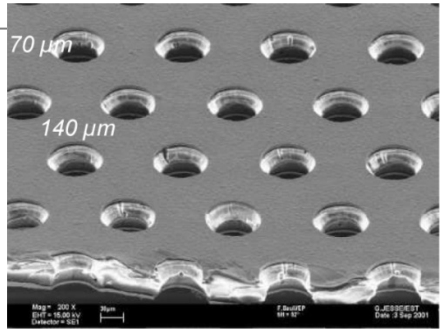
- BESIII MDC inner detector
  - Beam related background
  - Aging problem
- Possible inner detector candidate:

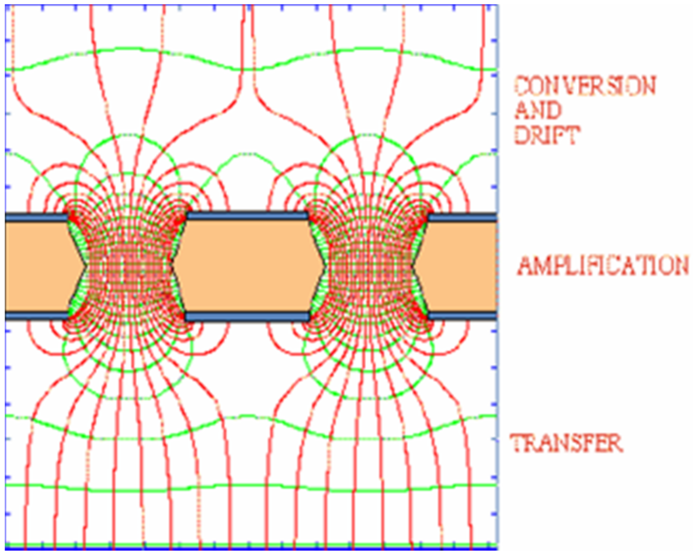
  CGEM(Cylindrical Gas Electron Multiplier)
  - rad hard: up to 2.2 C/cm^2
  - Expertise from KLOE2 and CERN
  - Faster construction

  … (for details, please see Adriano's talk)

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.



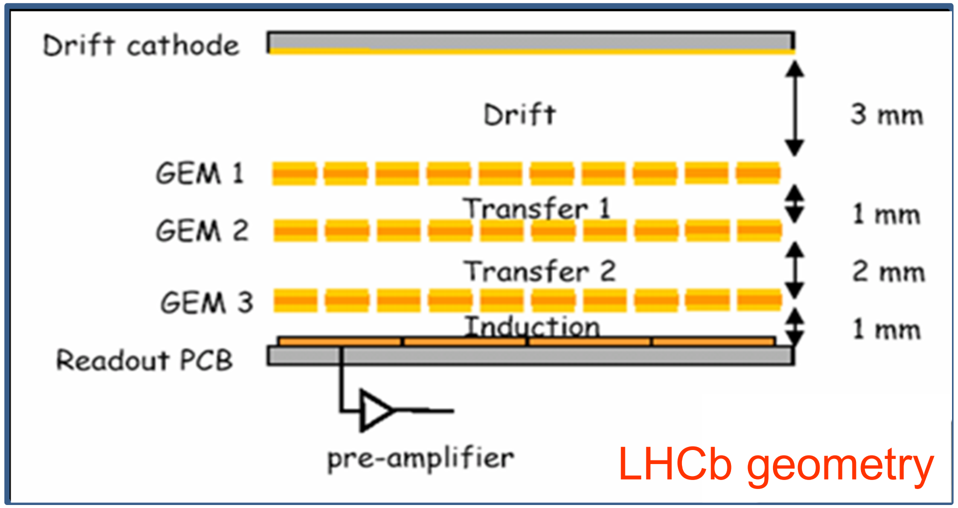


By applying 400-500 V between the two copper sides, an electric field as high as ~100 kV/cm is produced into the holes which act as multiplication channels for electrons produced in the gas by a ionizing particle.

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.

(This slice from Italian group)

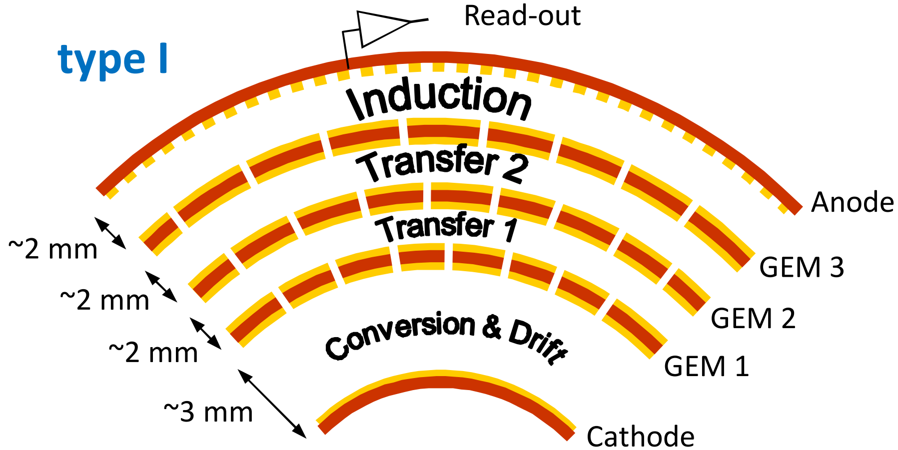


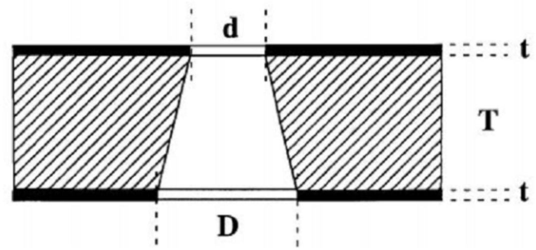
Preliminary simulation

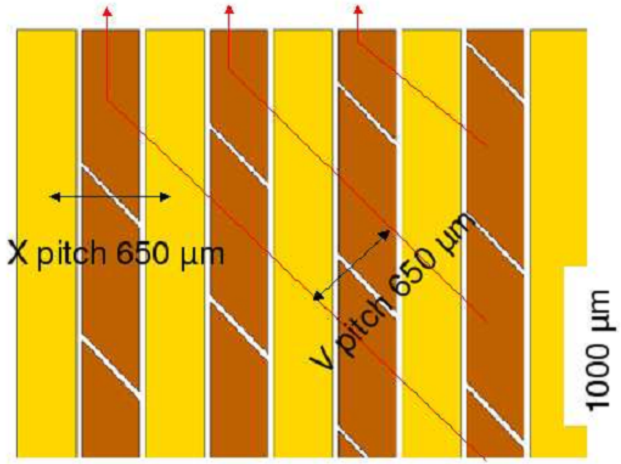
One layer of
CGEM detector

From KLOE-2 inner tracker upgrade Scheme

type I







A triple–GEM detector

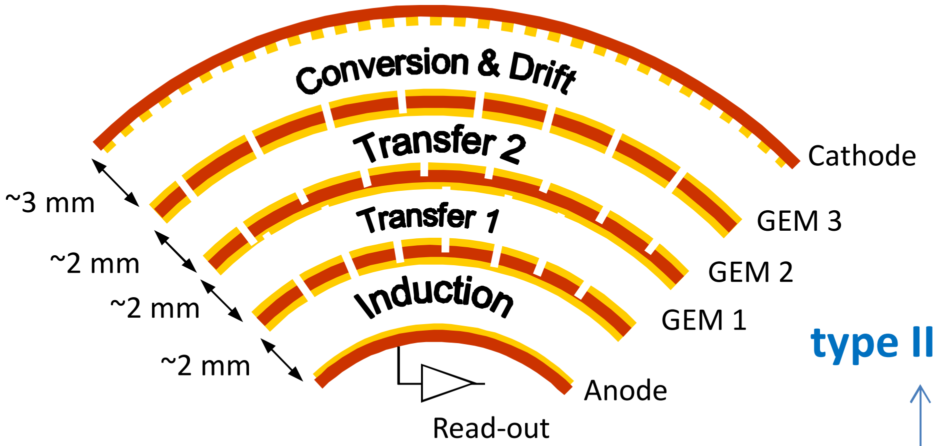
- cathode
- three GEM foils
- anode readout

650 µm pitch XV strips
(stereo angle ~40°):

Preliminary simulation

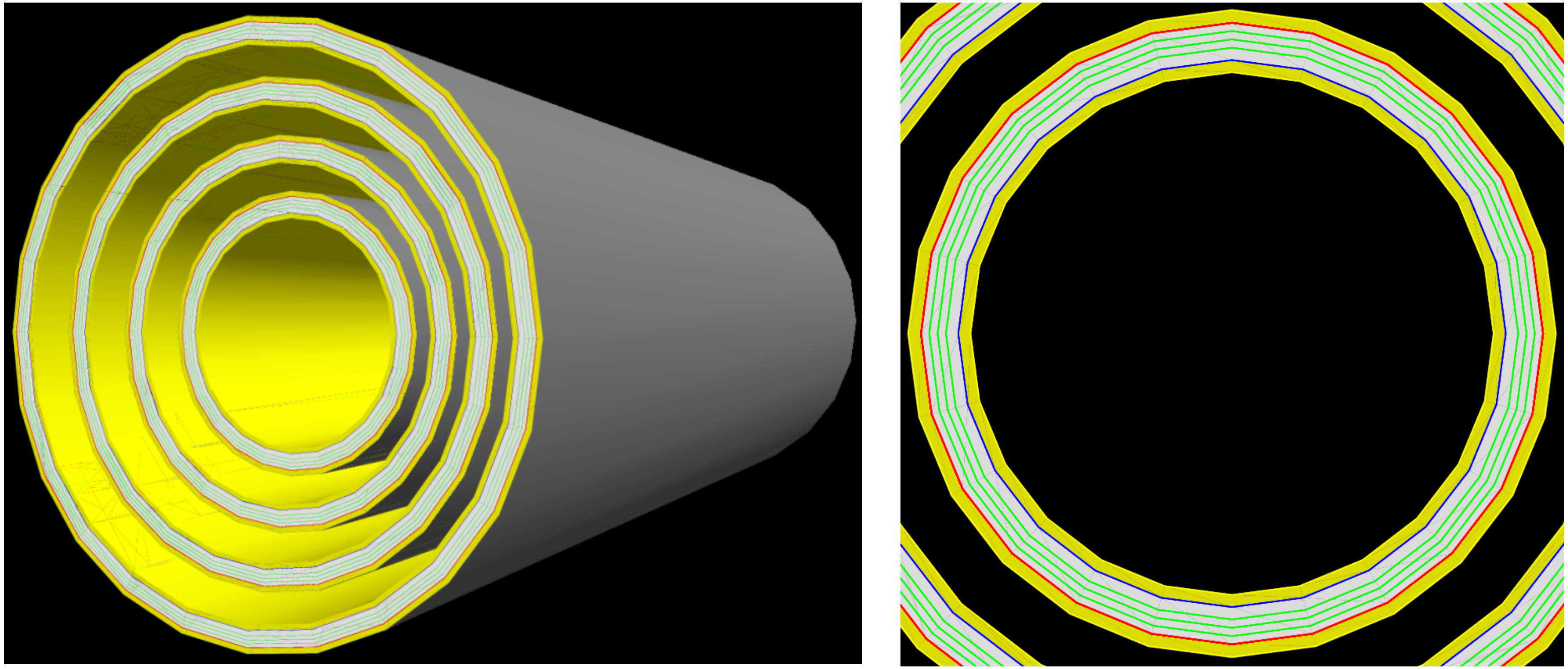
CGEM parameters

- ❑Number of CGEM layers = 3 or 4
- ❑ Each layer thickness ~ 1.56cm
- ❑ Space between two layers
  - ~ 1.26cm for 4 layers (type I)
  - ~ 2.69cm for 3 layers (type I)
  - ~ 2.07cm/3.3cm for 3 layers (type II)
- ❑Operation gas: Ar/CO2 (70/30)



	4 layers (type I)	3 layers (type I)	3 layers (type II)
R_{inner}(Layer 0)	7.77cm		
R_{inner}(Layer 1)	10.6cm	12.02cm	12.64cm (type II)
R_{inner}(Layer 2)	13.44cm	-	
R_{inner}(Layer outmost)	16.27cm		
Material budget (X_0)	1.56%	1.17%	1.17%

Geant4 Model of CGEM



Yellow: Honeycomb Support (Nomex)

Blue: Cathode (Cu, Kapton)

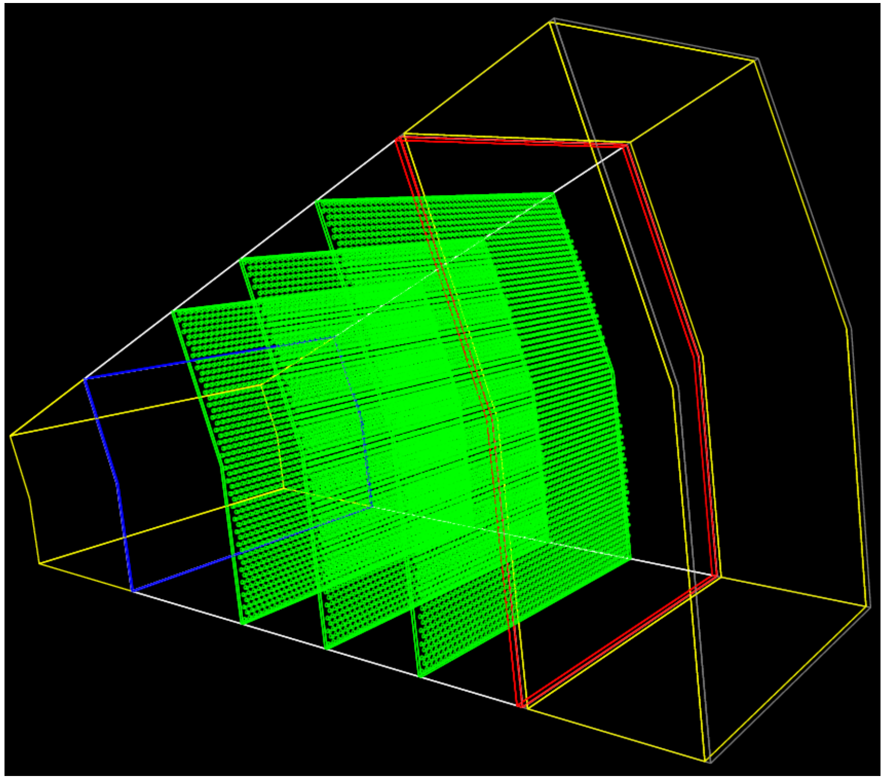
White: Work Gas of Gem ($Ar:CO_2$=70:30)

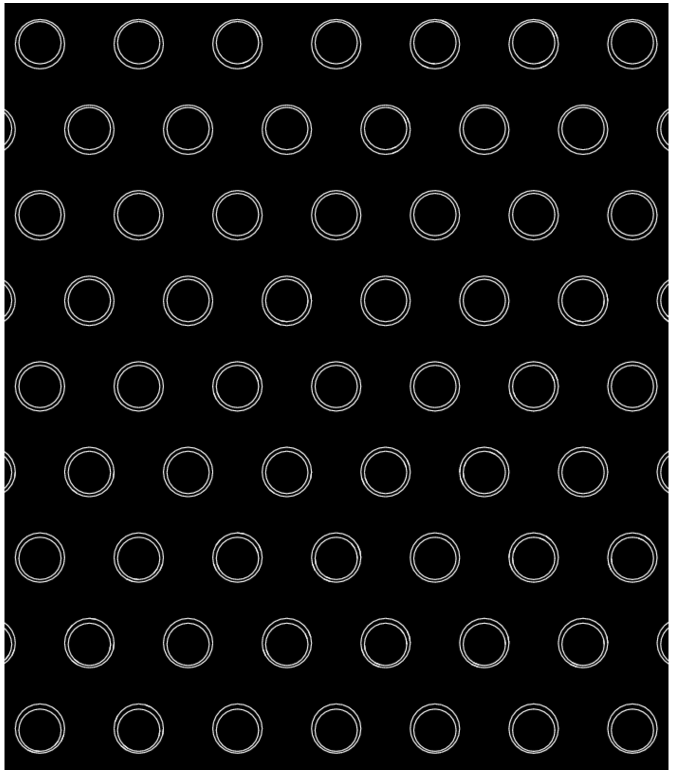
Green: Gem Foil (Cu, Kapton)

Red: Readout Anode (Cu, Kapton, Al Shielding)

Grey: Carbon Fiber Support

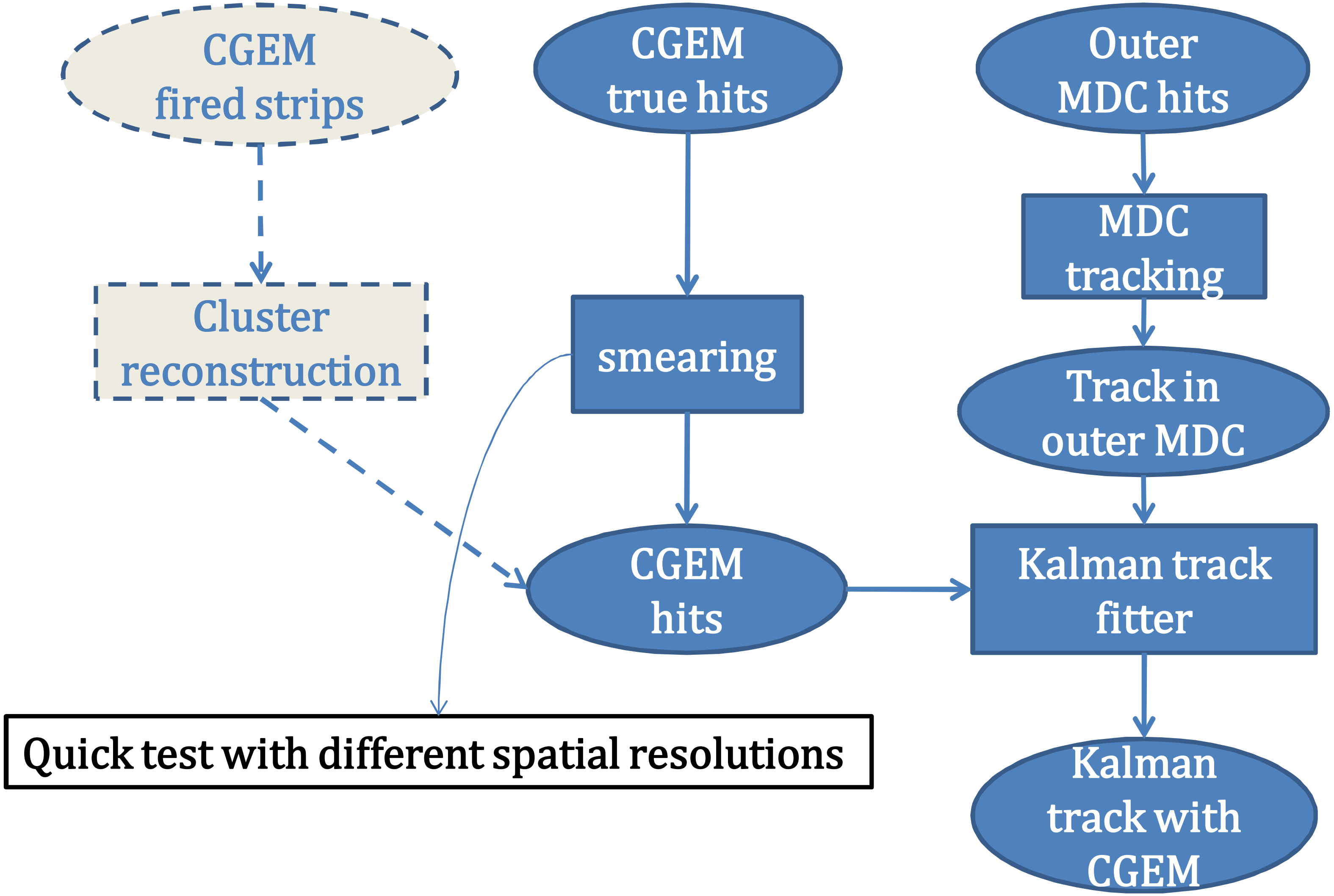
Detail Structure of CGEM Layer



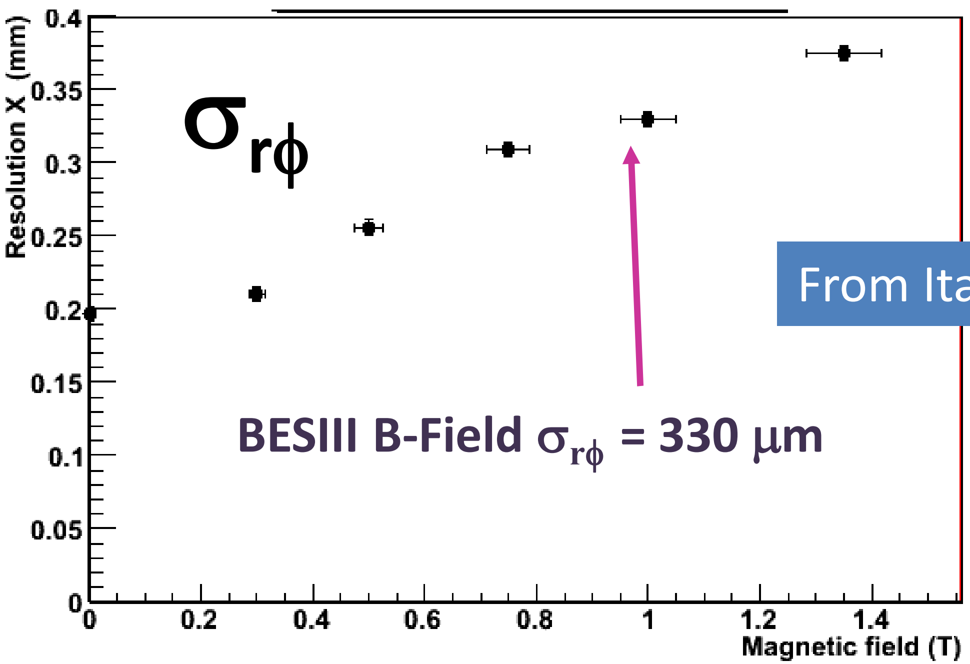


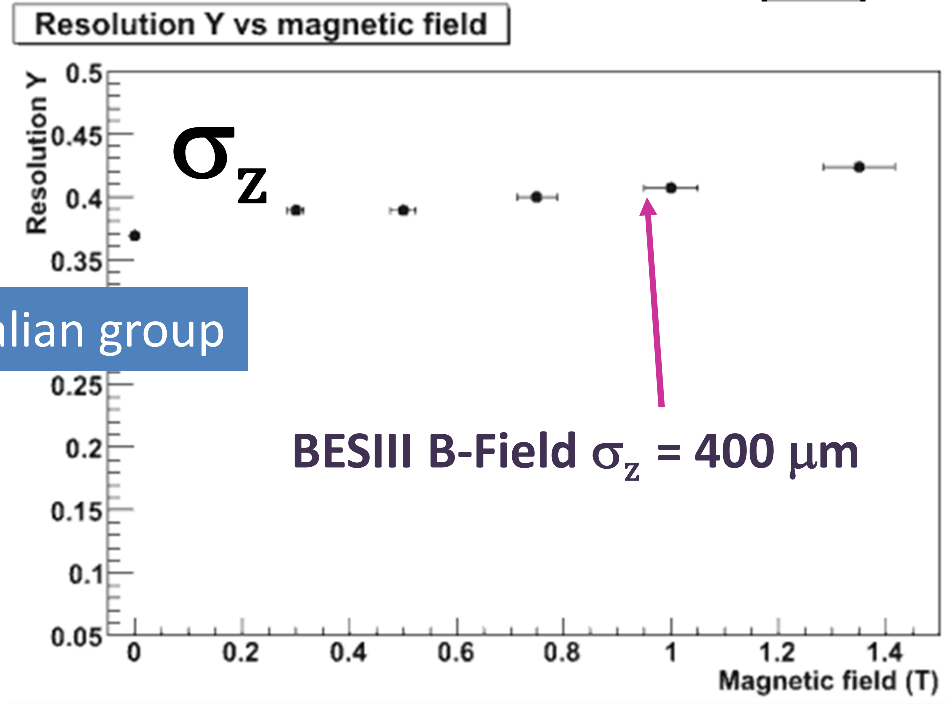
Single Mask Gem Foil, Single conical hole structure
Hole diameter: 70-60 um
The larger section of the holes facing the cathode.
Hole Pitch: 140um

Preliminary reconstruction with CGEM inner detector



Expected spatial resolution





From Italian group

Readout	$\sigma_{r\phi}$ (μm)	σ_z (μm)
Digital readout (Beam test @2009)	330	400
Analog readout (magnetic field effect avoided)*	80	150

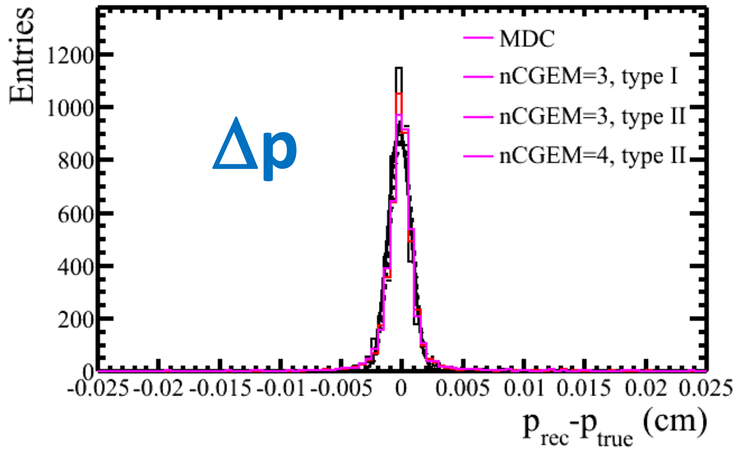
* Taken as expected spatial resolution

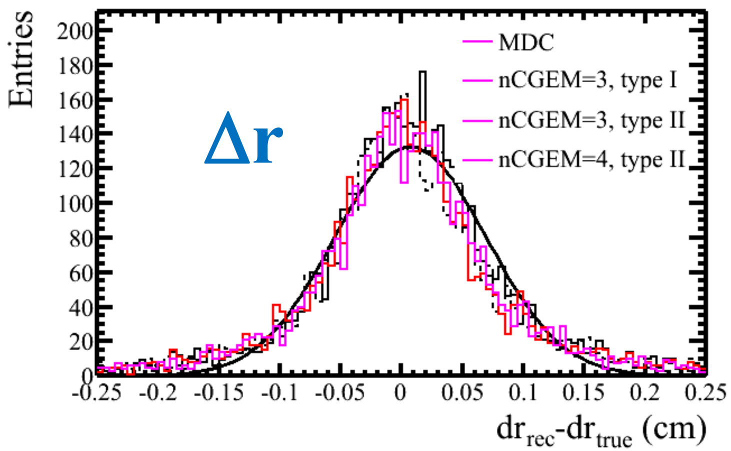
MC sample and Residual distribution

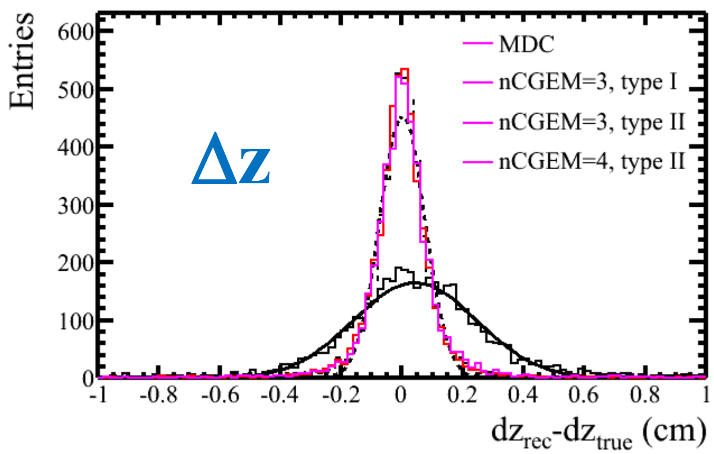
Single particle MC sample (no background mixed):

π^{-} |cosθ|<0.8, p_{tot}: ~0.2GeV/c, ~0.6GeV/c, ~1.0GeV/c

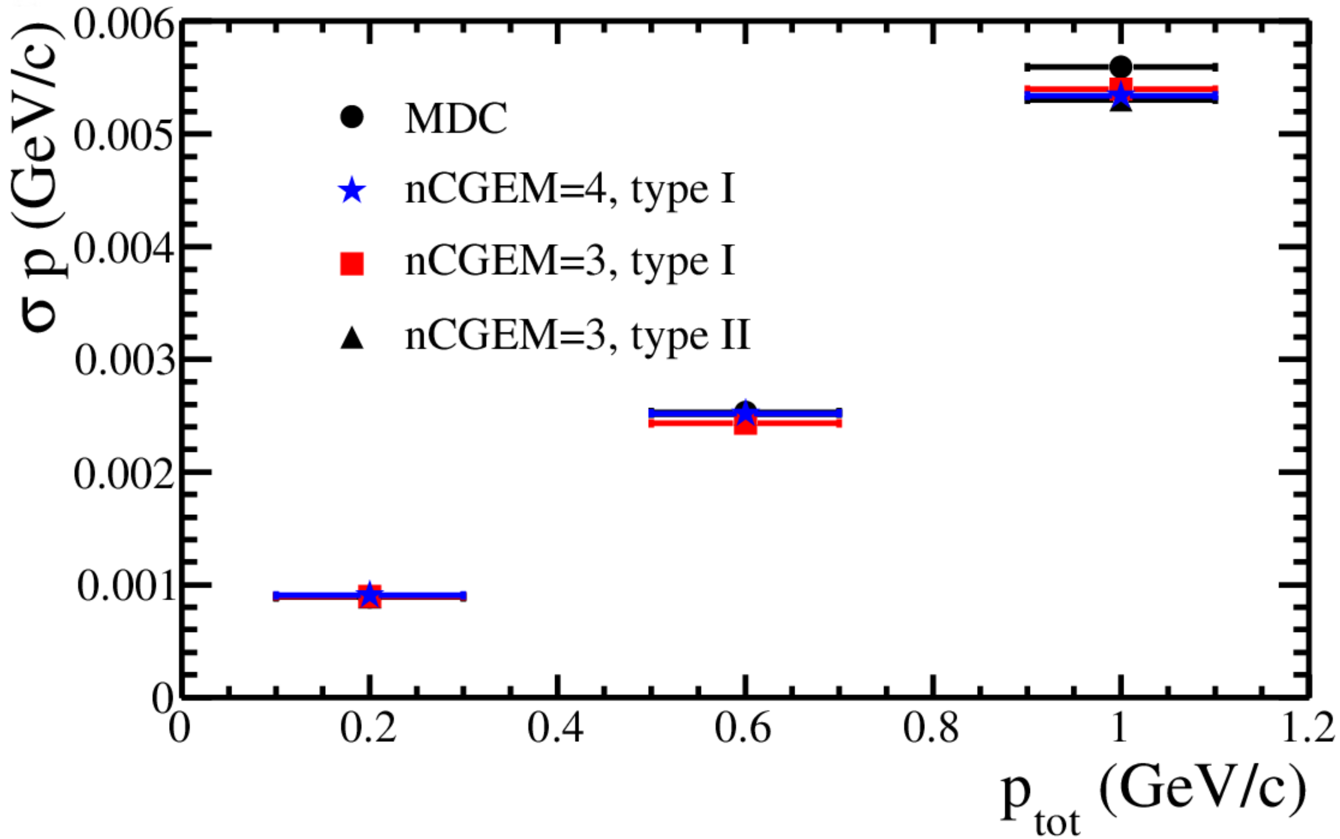
e.g. ~0.2GeV





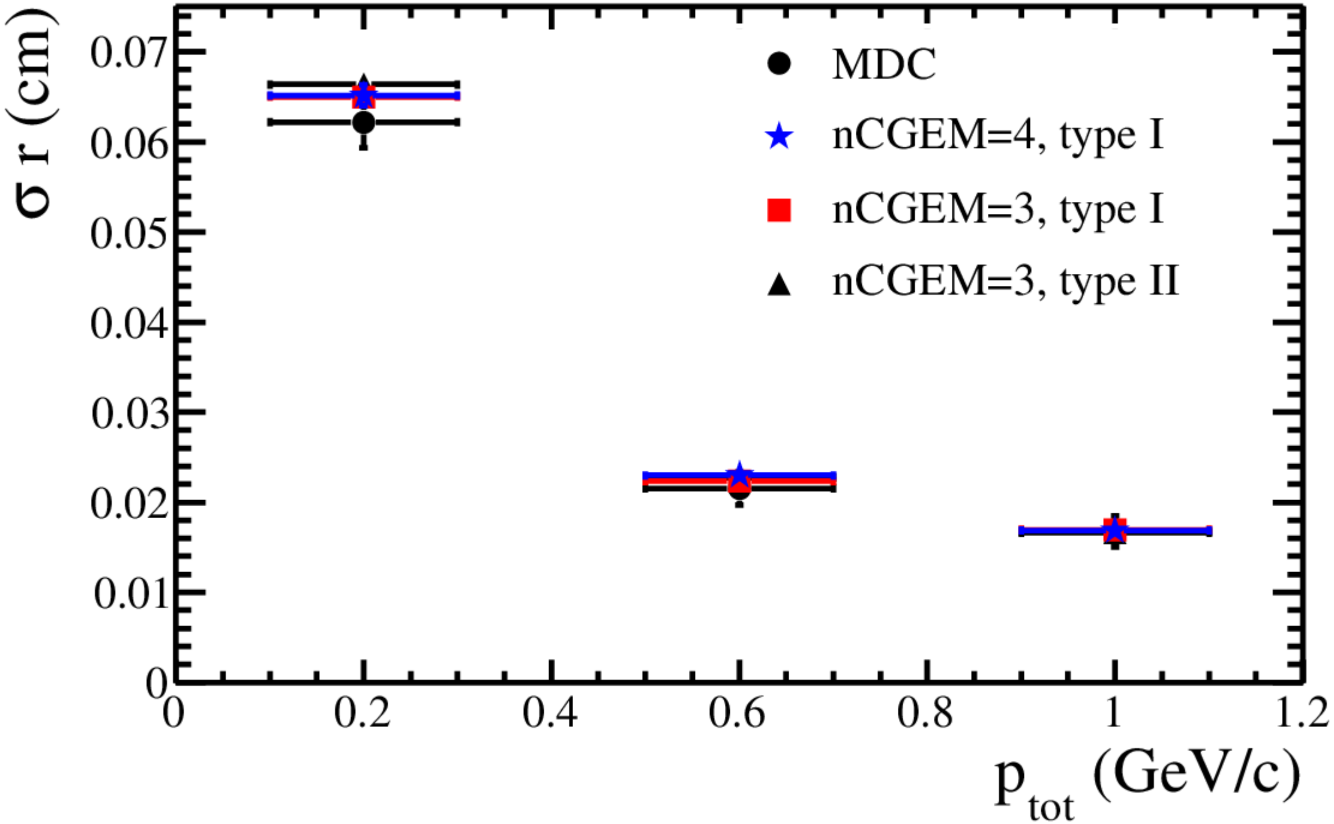


Momentum resolution σ_p



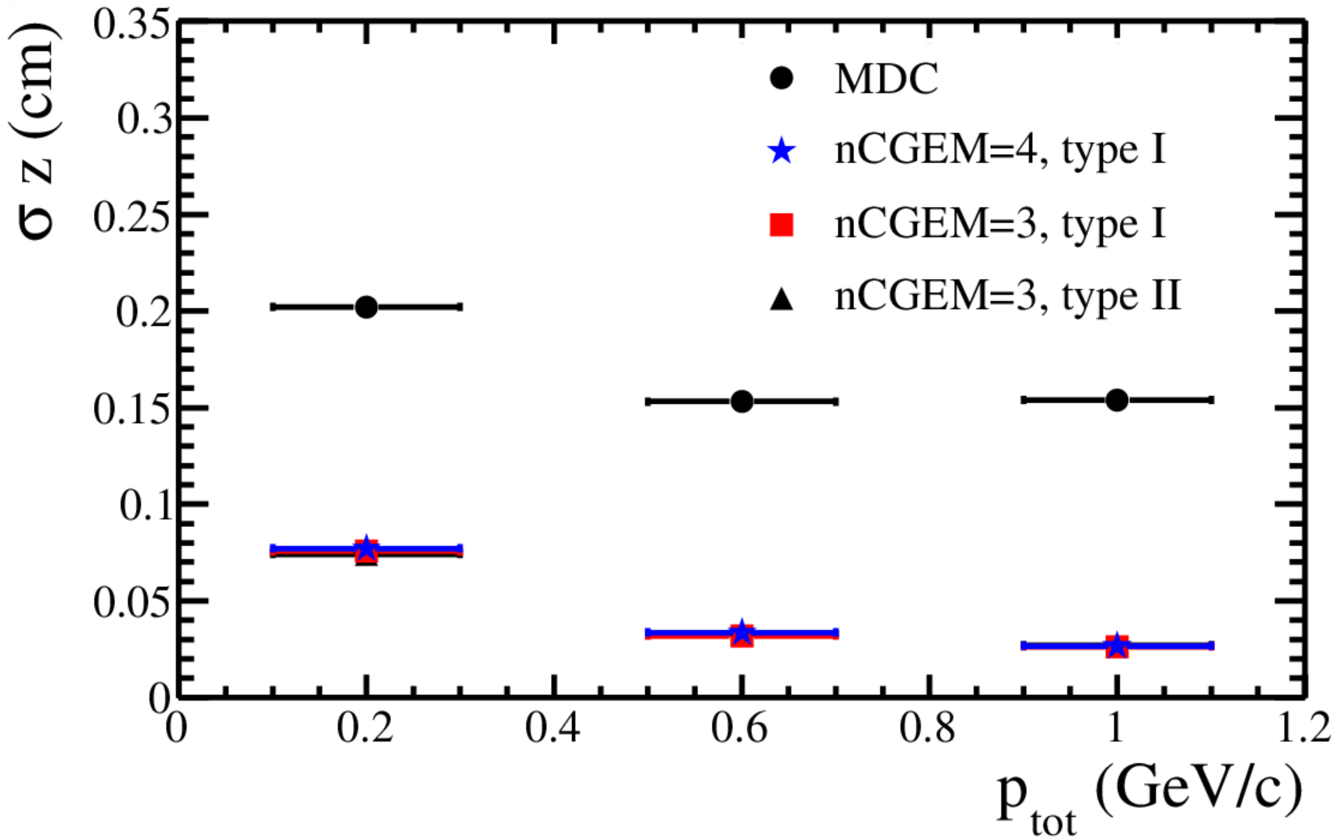
P_{tot}(GeV/c)	0.2	0.6	1.0
σ_p(MDC) (MeV)	**0.89** (100%)	**2.53** (100%)	**5.59** (100%)
σ_p(CGEM 4 layers, type I)	**0.91**(+2.2%)	**2.52** (-0.4%)	**5.34**(-4.5%)
σ_p(CGEM 3 layers, type I)	**0.89**(+0%)	**2.43** (-3.9%)	**5.40**(-3.4%)
σ_p(CGEM 3 layers, type II)	**0.89**(+0%)	**2.51** (-0.8%)	**5.30**(-5.2%)

Vertex resolution in r (σ_r)



P_{tot}(GeV/c)	0.2	0.6	1.0
σ_r(MDC) (μm)	**622** (100%)	**215**(100%)	**168**(100%)
σ_r(CGEM 4 layers, type I)	**652**(+4.8%)	**230**(+7.0%)	**169**(+0.6%)
σ_r(CGEM 3 layers, type I)	**650**(+4.5%)	**224**(+4.2%)	**170**(+1.2%)
σ_r(CGEM 3 layers, type II)	**664**(+6.7%)	**228**(+6.0%)	**166**(-1.2%)

Vertex resolution in z (σ_z)



P_{tot}(GeV/c)	0.2	0.6	1.0
σ_z(MDC) (μm)	**2020** (100%)	**1531**(100%)	**1539**(100%)
σ_z(CGEM 4 layers, type I)	**772**(-61.8%)	**336**(-78.1%)	**266**(-82.7%)
σ_z(CGEM 3 layers, type I)	**757**(-62.5%)	**319**(-79.2%)	**263**(-82.9%)
σ_z(CGEM 3 layers, type II)	**742**(-63.3%)	**327**(-78.6%)	**270**(-82.5%)

Conclusion

CGEM inner detector (**VS** MDC inner detector)

- **Improves dz resolution significantly** (by a factor of 2.6~6)
- **Comparable dr resolution**
  (~5% poorer for low momentum tracks)
- **Comparable momentum resolution**
  (~5% better for high momentum tracks)

Backups

Mismatch of material budgets between simulation and reconstruction!

P_{tot}(GeV/c)	0.2	0.4	1.0
σ_p(MDC) (MeV)	0.89 (100%)	2.53 (100%)	5.59 (100%)
σ_p(CGEM 4 layers, type I) (In last talk)	1.72(+93%)	2.62 (+3.6%)	5.58(-0.18%)
σ_p(CGEM 4 layers, type I)	0.91(+2.2%)	2.52 (-0.4%)	5.34(-4.5%)
σ_p(CGEM 3 layers, type I)	0.89(+0%)	2.43 (-3.9%)	5.40(-3.4%)
σ_p(CGEM 3 layers, type II)	0.89(+0%)	2.51 (-0.8%)	5.30(-5.2%)

P_{tot}(GeV/c)	0.2	0.6	1.0
σ_r(MDC) (μm)	622 (100%)	215(100%)	168(100%)
σ_r(CGEM 4 layers, type I) (In last talk)	729(+17%)	262(+22%)	177(+5.4%)
σ_r(CGEM 4 layers, type I)	652(+4.8%)	230(+7.0%)	169(+0.6%)
σ_r(CGEM 3 layers, type I)	650(+4.5%)	224(+4.2%)	170(+1.2%)
σ_r(CGEM 3 layers, type II)	664(+6.7%)	228(+6.0%)	166(-1.2%)