A Cylindrical GEM Inner Tracker for the BESIII experiment at IHEP

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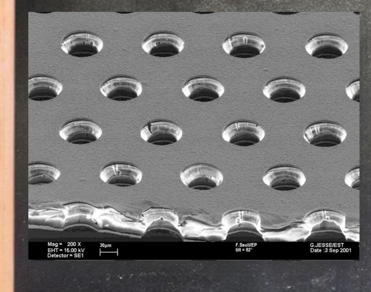
University of Turin, Department of Physics and INFN, Section of Turin

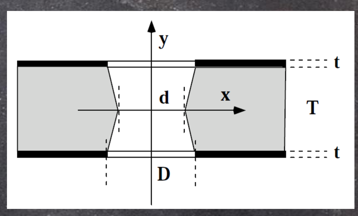
BESIIICGEM HORIZON 2020

The GEM technology

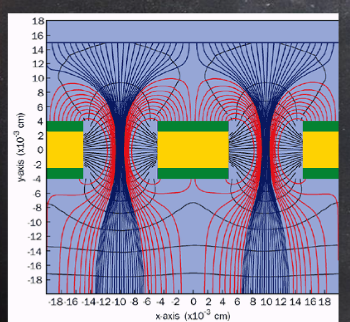
Gaseous Electron Multiplier gas tracker of charged particles



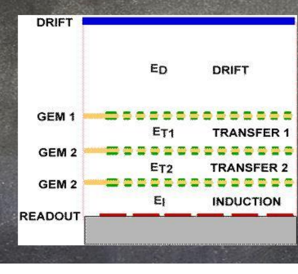
Concept: a thin polymer foil (kapton, 50 µm) copper-coated on both sides (3/5 µm)



A voltage gradient of few hundreds V creates an electric field of some tens of kV/cm in the holes → avalanche multiplication

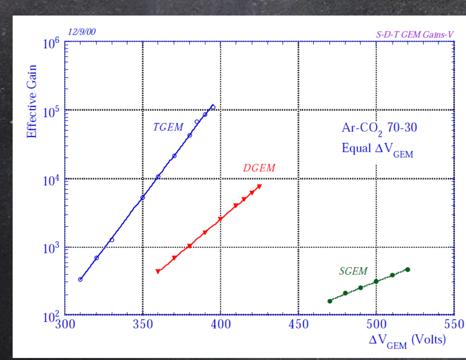


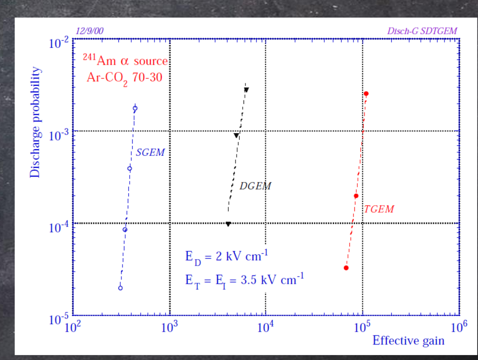
Why a triple GEM?



Problem: possible discharges

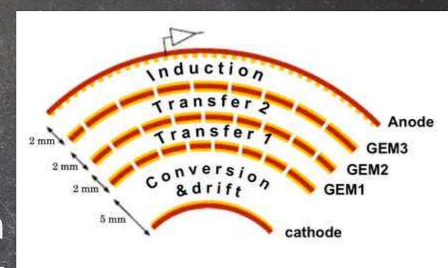
Solution: three GEM foils require lower individual voltage gradient



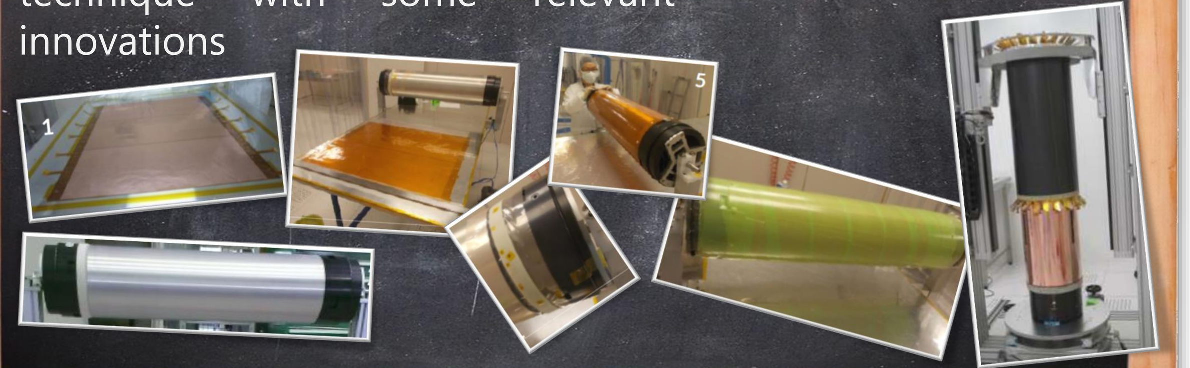


How to craft a Cylindrical GEM

Some history: the first triple cylindrical GEM has been built for KLOE-2 (Frascati)

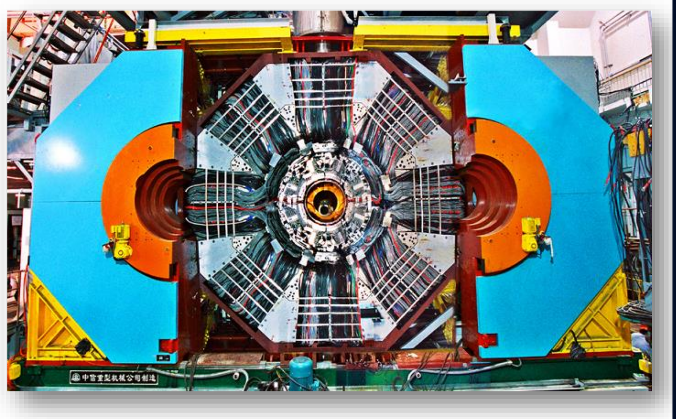


BESIII inherits the same construction technique with some relevant innovations



CGEM-IT will be installed inside BESIII Spectrometer on July 2018...

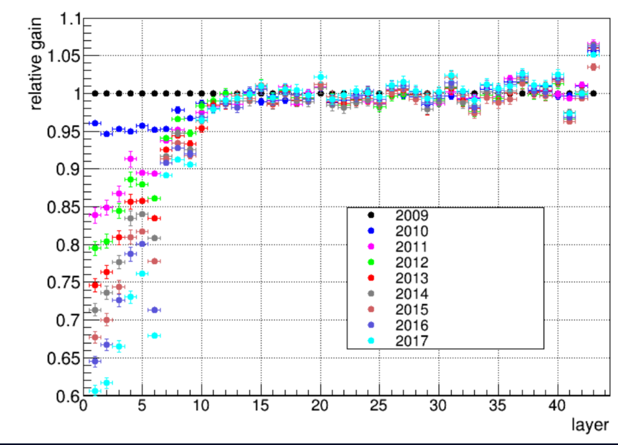
Beijing, China | **BEPCII (e+e- collider)** | **BESIII Spectrometer**



"Design and construction of the BESIII detector", M. Ablikim et al., Nucl. Instrum. Methods Phys. Res., Sect. A 614, 345 (2010)

...to take the place of the aging Inner Drift Chamber

MDC gain loss

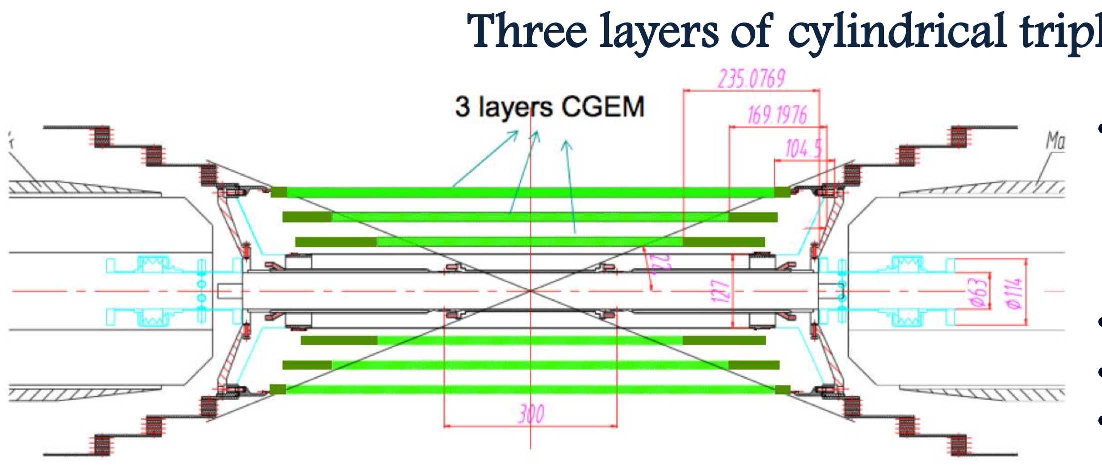


Benefits
- restore efficiency (present gain loss on innermost layers: ~4%/y)
- improve spatial resolution along z coordinate
- more precise determination of secondary vertices (→ short living particles)
- lower aging effect and higher radiation resistance

Requirements
- maintain transverse spatial resolution
- maintain momentum resolution
- low material budget

BESIII CGEM-IT design

Three layers of cylindrical triple-GEM



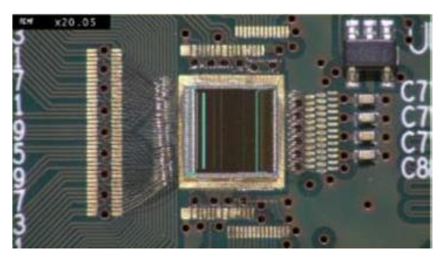
- **Resolution**
  - momentum = 0.5% @ 1GeV/c
  - spatial r–ϕ = 130 µm
  - azimuthal coordinate = 1mm
- acceptance = 93% of 4π
- $X_0 < 1.5\%$
- rate capability ~ 10^4 Hz/cm^2

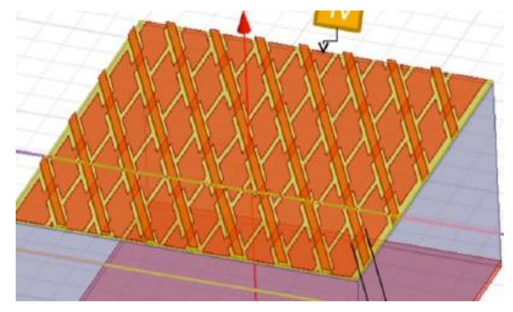
BESIII CGEM-IT innovations

- ROHACELL as new support for anode and cathode
- permaglass rings outside active zone

→ low material budget

Dedicated ASIC: TIGER (Torino Integrated GEM Electronics for Readout) TDC, ADC and ToT charge and time information

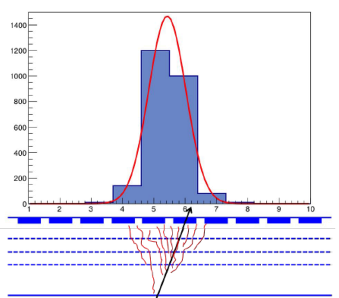




Anode plane with *jagged* strips to reduce of around 30% inter-strip capacitance (MAXWELL simulations)

Spatial resolution

Analog readout in (sizeable) magnetic field



Exploitable variables:
- firing strip position
- collected charge
- time information

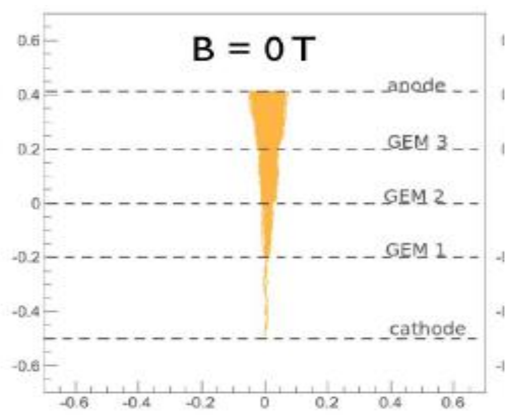
Charge centroid

Perpendicular tracks and *no magnetic field*

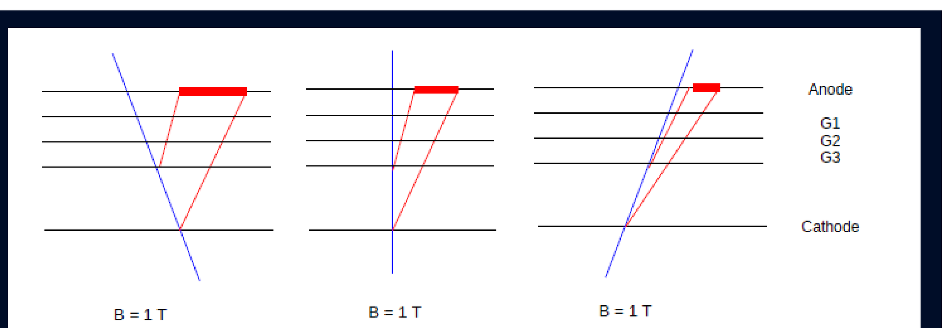
⇩

Weighted average of strip positions by collected charge

$$< x > = \frac{\sum_i x_i q_i}{\sum_i q_i}$$



incident angle ≠ 0
+
Lorentz angle (B ≠ 0)



The combined action creates a focusing or de-focusing effect depending on whether the incident and Lorentz angles have same or opposite signs

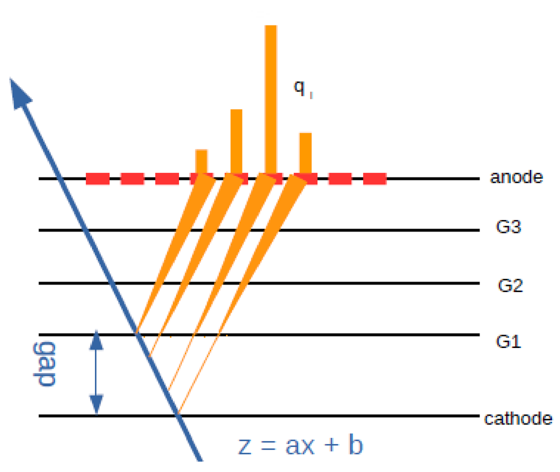
µ-TPC readout

Non-perpendicular tracks and/or *magnetic field*

⇩

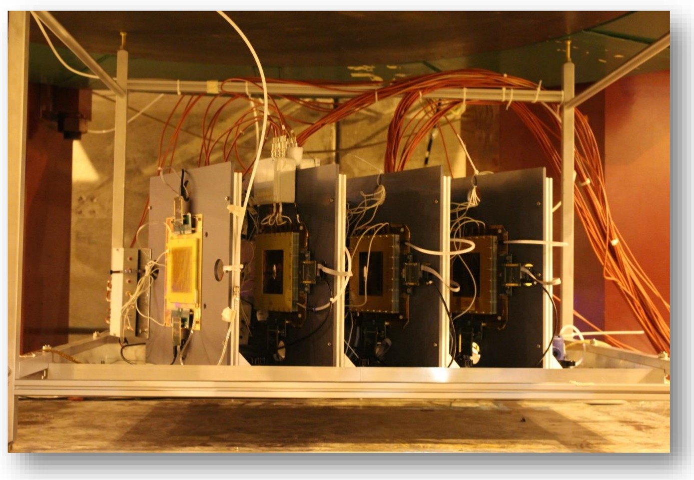
Drift Gap acts as a "micro time projection chamber". The position of each primary ionization is reconstructed exploiting the drift velocity (evaluated with Garfield)

$$x = \frac{\frac{gap}{2} - b}{a}$$



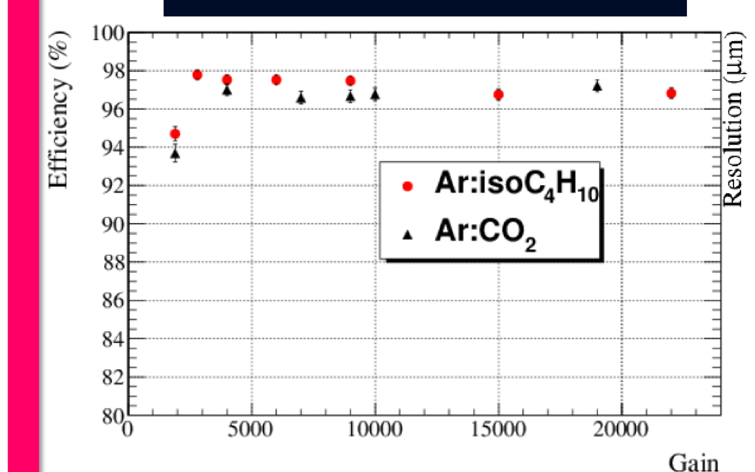
Results of the CGEM test beams

Test conditions
- H4 beam line – SPS, North Area @ CERN
- dipole magnetic field [−1.5, 1.5] T
- 150 GeV/c muons/pions
- 2k events/spill

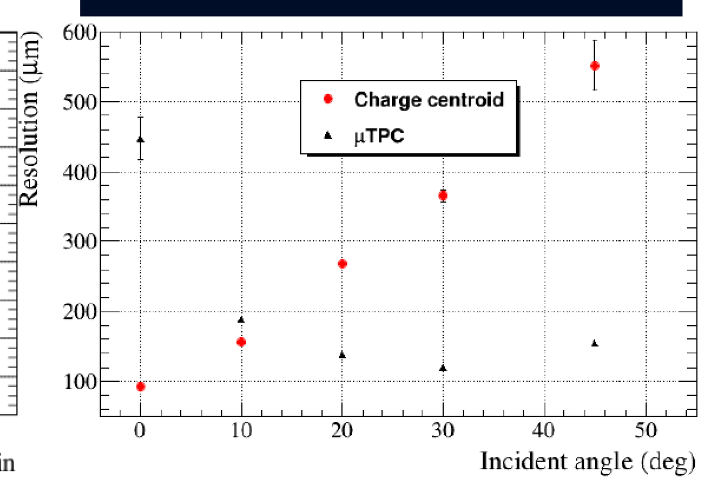


Planar chambers
- 10 × 10 cm^2
- x/y views
- strip pitch 650 µm
- gas mixtures:
  - Ar/CO_2 (70/30%)
  - Ar/Iso (90/10%)
- ASIC: APV 25

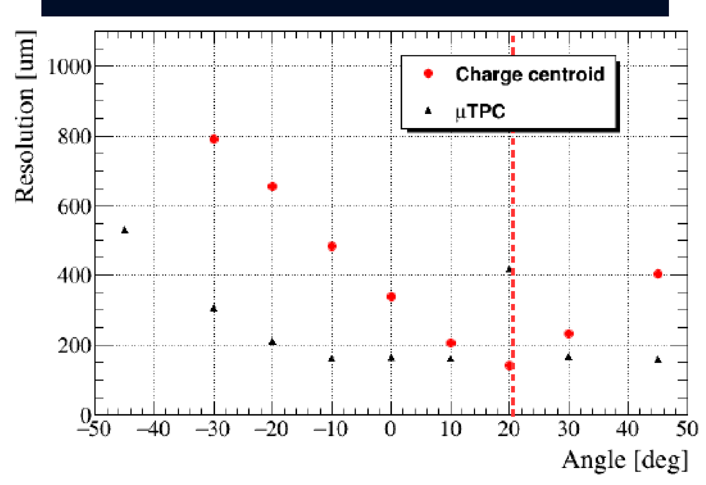
EFFICIENCY ~ 96/98%



B=0 / INCLINED TRACKS

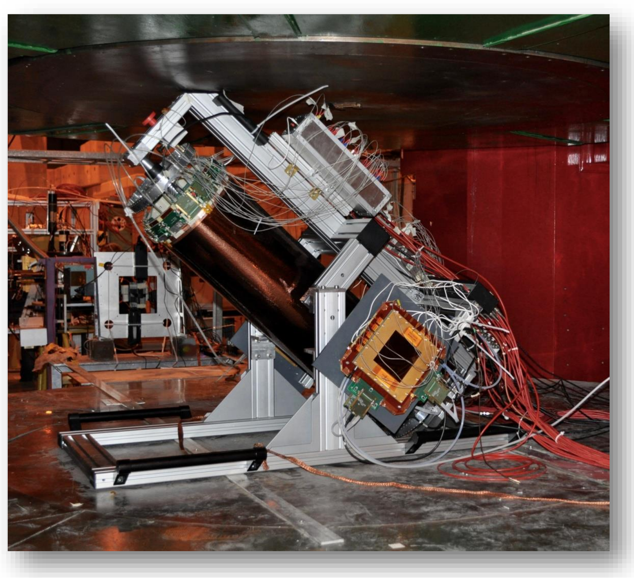


B≠0 / INCLINED TRACKS



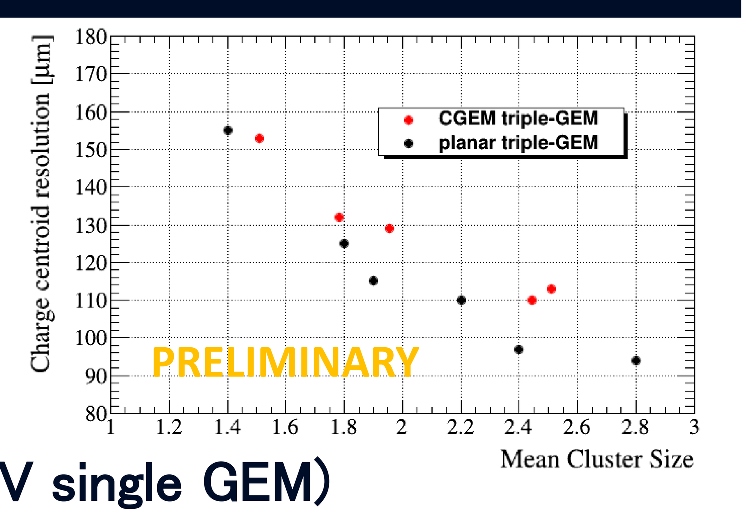
97% (design) achieved at different gains

a 130 µm (design) spatial resolution can be achieved combining both charge centroid and µ-TPC methods



Cylindrical chambers
- October 2016: first beam test of the layer2 prototype
- gas mixture: Ar/CO_2 (70/30%)
- x/v views
- Drift Gap = 3 mm

B=0 / PERPENDICULAR TRACKS



Excellent stability:
- **up to gains ~ 10^5 (HV = 400 V single GEM)**
- **exposed to high intensity π beams: some tens of kHz/cm^2**

CC resolutions show CGEM performances in agreement with planar GEM

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International Workshop on e^+e^- collisions from Phi to Psi 2017
Mainz – June, 26th - 29th 2017