A Cylindrical GEM Detector with Analog Readout for the BESIII Experiment

THE BESIII GEM GROUP


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Beijing Electron Positron Collider @ IHEP

- Storage Ring circumference of about 237 m
- Center of mass energy [2-4.6] GeV
- Peak luminosity ~ 10^34 cm^-2 s^-1

The BESIII Detector

- Drift Chamber (MDC)
- Muon identifier
- EMC: p/E (1 GeV) ~ 2.5% position resolution ~ 0.6 cm

MDC aging issue

- The Inner Drift Chamber gain and efficiency are decreasing due to Malter effect
- Aging speed up due to increasing of the luminosity
- Significant effect in the eight innermost layers

CGEM BASED INNER TRACKER FOR BESIII

GAS ELECTRON MULTIPLIER

A thin polymer foil, metal-coated on both sides, is chemically pierced by a high density of holes.

On application of a voltage gradient, electrons released on the top side drift into the hole, multiply in avalanche and transfer to the other side.

A Cylindrical GEM (CGEM)

- Three active layers
- Active area: L1 length: 532 mm, L2 length: 690 mm, L3 length: 847 mm
- Inner radius: 78 mm, Outer radius: 178 mm
- Proportional gains above 10^7 are obtained in most common gases.
- Cascaded GEMs permit to obtain larger gains
- Spatial resolution determined by chamber and readout electrode geometries

REQUIREMENTS AND INNOVATIONS

Detector Requirements

- Rate capability: ~100 Hz/cm²
- Spatial resolution: σ_μ = ~120 μm; σ_V = ~1 mm
- Momentum resolution: c/pt/Pt = ~0.5% @ 1 GeV
- Efficiency = ~98%
- Material budget ≤ 1.5% of X0 for all layers
- Coverage: 93% 4π
- Operation duration ~ 5 years

Significant improvement in the secondary vertex resolution expected

Anode plane with jagged strips to limit the parasitic capacitance

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PROJECT STATUS, PLANS AND CONCLUSIONS

- Cathode and three GEM layers of the first cylindrical prototype have been assembled.
- Final assembly detector expected by September 2015.
- Final Inner Tracker design will be finalized by 2015.
- Frontend electronics design ongoing.
- Full detector production, assembly and test by 2016.

Design, construction and test of a CGEM prototype and readout electronics funded by the Foreign Affairs Ministry agreement of scientific cooperation for a Joint laboratory “INFN-IHEP”.

The BESIII/GEM project has been recently selected as one of the project funded by the European Commission within the call H2020-MSCA-RISE-2014.

More information @ http://www.lnf.infn.it/experiment/bes3/

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PROTOTYPE BEAM TEST

- Gas mixture (Ar/isobutane - 90:10), APV25 readout electronics.
- 2-dimensional efficiency ~97%.
- Efficiency plateau starts at ~6000.

Spatial resolution vs Gain

- Spatial resolution evaluated as the a of the residual distribution w.r.t. the fitted track.
- Spatial resolution ~90 μm in the plateau region, including tracking error.

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