Study of TGEMs and RETGEMs for the possible ALICE upgrade

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Motivation

These studies are part of the ALICE RICH upgrade program aiming to extend particle identification capability for hadrons to 30 GeV/c

For this several new modules (with gaseous radiator instead of liquid) will be built and installed in the ALICE detector. They are called <u>VHMPID</u>.



Possible position of VHMPID modules

The VHMPID should be able to identify, on a track-by- track basis, protons enabling to study the leading particles composition in jets (correlated with the $\pi 0$ and /or γ energies deposited in the electromagnetic calorimeter).

A schematic design of the individual VHMPID module



Alice upgrade

- <u>Option#1</u>:MWPC with CsI Photon convertor and Pad readout (current HMPID technology).
- <u>Option#2</u>:New approach- Thick GEMs or Resistive (RETGEMs) with CsI photon convertor.
- Spark protected: dissipation of energy produced by discharges on the resistive layer.
- High gain of the order of 10⁵.
- Compact
- They can work <u>with any gas</u> (the MWPC works with pure methane <u>only</u> which can pose a safety issue).

Basic construction of TGEMs and RETGEMs

- TGEMs: They are produced from thin G-10 (Polyamide) sheets using industrial PCB processing of precise drilling and etching. The electrodes are made up of either Copper or gold.
- RETGEMs: They are produced from thin G-10 (polyamide) sheets followed by a mesh of Cu electrode and finally with a coating of resistive paste Encre MINICO and then holes are drilled.

Pictures of TGEMs and RETGEMs



Photo of RETGEM



Photo of TGEM with gold electrode

Active area = 10 * 10 cm2 Thickness = 0.45 mm Hole diameter = 0.4 mm Pitch = 0.8 mm



Photo of TGEM with copper electrode

Prototypes of RICH detectors:

- <u>Prototype 5</u>: Dedicated to the study of RICH detector based on cascade of RETGEMs (Triple RETGEM).
- <u>Prototype 4</u>: Dedicated to the study of RICH detector based on TGEMs with Copper and Gold electrodes (6 stacks of Triple GEMs)

Pictures of the prototypes





Prototype 5

Prototype 4

Study on TGEMs and RETGEMs

- The study was performed in the following manner:
- 1. Performance of the TGEMs (Cu and Au electrodes) and RETGEMs: maximum achievable gain, stability, energy resolution and etc.
- 2. Improving RETGEM quality, installation in the prototype 5.
- Optimization of parameters (voltage settings, gaps and etc) for the simultaneous detection of charge particles (produced by ⁵⁵Fe and ⁹⁰Sr) and UV photons produced by Hg lamp.

Gas chamber and set up for testing <u>individual</u> TGEMs and RETGEMs



Testing chamber for TGEMs and RETGEMs



The entire set up for testing the performance

Typical gas gains previously achieved with Kapton RETGEM and screen-printed RETGEM (resistive paste)



Fig. 6. Gain vs. voltage measured in Ar (blue symbols) and Ar+20%CO2

B. Clark et al, ArXiv0782344





R. Oliveira et al., ArXiv0701154

Performance of RETGEMs



(In a good agreement with previous works, see B. Clark et al, ArXiv0782344)

Our Contribution: after discussion with R. Oliveira we applied to these detectors a sand blust cleaning technique and distilled water celannin afterwirds



After this treatment for the first time with screen printed RETGEMs gas gains <u>as high as Kapton</u> RETGEMs were achieved After observing such a strong effect of cleaning we applied distilled water cleaning to the rest of the detector to TGEMs

Performance of TGEMs



Performance of TGEMs after cleaning (copper electrode)







Overall performance of TGEMs after cleaning





Comments

- TGEMs performance: it was observed that after cleaning the gain of TGEMs increased tremendously for both with TGEMs made of copper electrode (Amax = 5000) and TGEMs made of gold electrodes (Amax = 10⁴) as compared to the earlier Amax = 10³.
- RETGEMs performance: it was observed that after cleaning the gain of the RETGEMs increased manifold, Amax = 10⁴. This was interesting as this high gain was never seen before for this type of construction (can be attributed to the sand blasting technique used for cleaning).
- Maximum achievable gain for TGEMs made of gold electrodes was found to be more that those made of copper electrodes.



Study of cascade detector made of RETGEMs on prototype – 5 in <u>laboratory</u>



Ne/CH₄ 90/10

Experimental set up for discharge studies on triple GEM

| V _D (volts) | V _{T1} (volts) | V _{B1} (volts) | V _{T2} (volts) | V _{B2} (volts) | V _{T3} (volts) | V _{B3} (volts | A _{max} (UV |
|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|------------------------|----------------------|
| | | | | | |) | photons) |
| 2640 | 2840 | 2000 | 1760 | 1050 | 738 | 100 | 10 ⁵ |

Comments

- In order to detect simultaneously the charge particles (either from ⁵⁵Fe or ⁹⁰Sr) and UV photons application of zero drift field was utilized, this was found to be a efficient way to respect the Raether limit (Amax*No =10⁷- 10⁸).
- Successful simultaneous detection of charge particles and UV photons was observed in the laboratory and the operating points were noted down and utilised in the beam test. Also a very high stability was observed with respect to the discharge.
- By studying systematically all the stages of the Triple GEM (RETGEMs), it was found that we need an operating voltage of around 600 V across the detector and 200 V between the detector. With the help of these operating points a voltage divider was designed.

Beam test preparation of prototype- 5 with triple RETGEM









Beam test result



Triple RETGEMs works very stable at overall gain 10⁵ both mixture no single discharge was observed with reverse drift.

Beam test data are under analysis now.

Beam test was performed in Ne + 10% CH4 and Ne + 10 % CF_4 (inflammable gas mixture)



Comments

- In calcium Fluoride radiator, most of the Cherenkov light is trapped inside the crystal due to the internal reflection (so we can extract the data about the quantum efficiency only from simulations and compare them with experimental data; this was already successfully done for the previous beam test -see back up slides)
- In order to make <u>easier data extraction and direct</u> <u>comparison with the MWPC option</u> we are preparing now next beam test with (liquid C₄ F₁₀) as radiator in which the light will not be trapped and thus we can directly measure no. of Cherenkov photons

The top view of the Proto-4



Proto-4 (schematic side view)



Prototype 4



Prototype 4 preparation





Voltage divider networks for prototype 4



Future studies during our stay at CERN

- Testing of all the six stacks of Triple GEM of prototype 4 with regards to simultaneous detection of both UV photons and charge particles.
- Finding out the operating point for the simultaneous detection for all the six stacks using the concept of reverse drift field.
- Testing the entire prototype 4 in the laboratory and make it ready for the beam test in September.

Back up slides

Monte Carlo simulations well reproduce the experimental data



Preliminary analysis of the beam test data shows that for the given geometrical layout the <u>QE of TGEM</u> (after geometrical corrections) is <u>compatible</u> to one of the <u>HMPID</u>



Alice VHMPID detector

- It will consist of two main parts:
- 1. Gas radiator

2. Planar photon detector

• RICH detector:

Based on Cherenkov effect

Cherenkov radiation produced by the suitable radiator is detected on a position sensitive planar photon detector.

The position sensitivity allows reconstructing a rind or a disc, the radius of which is a measure of the Cherenkov angle.

Particle identification:

m = (p.
$$(n^2 \cos^2 \vartheta_c - 1)^{-1/2})/c$$