Thick-GEM Based Trigger Detector Development

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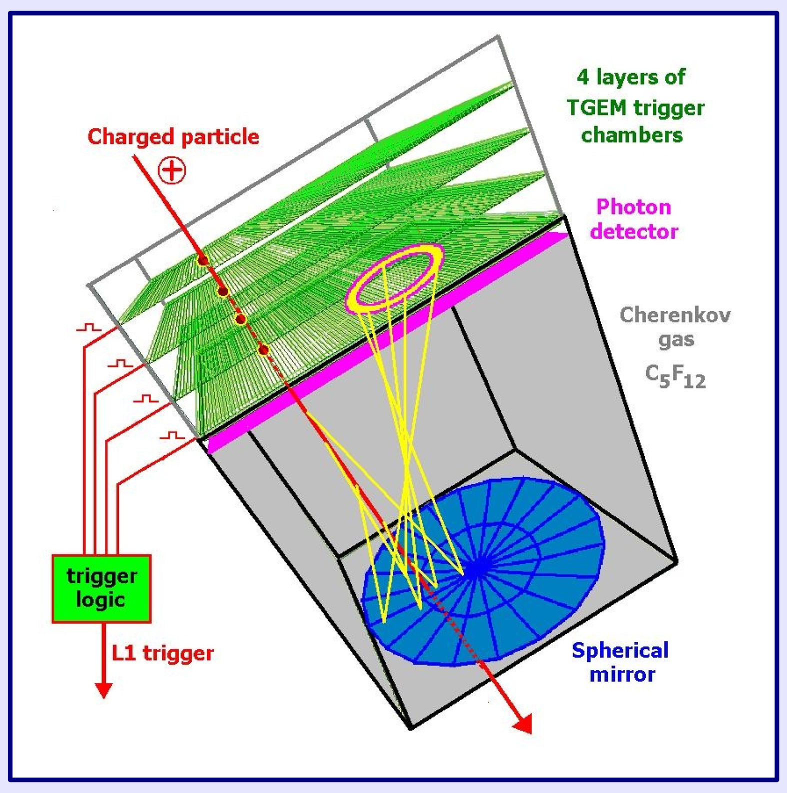
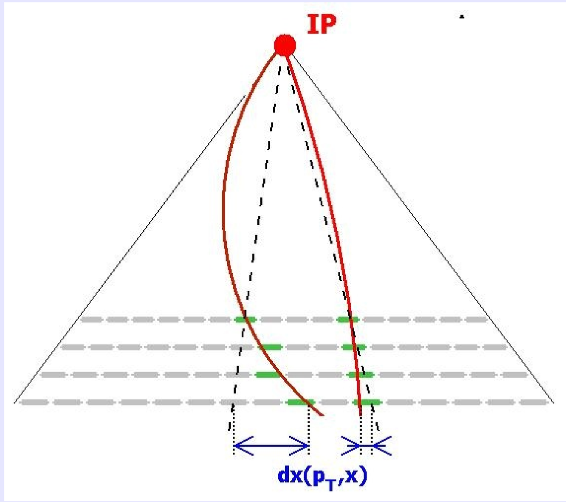


1. Motivation

1.1 VHMPID

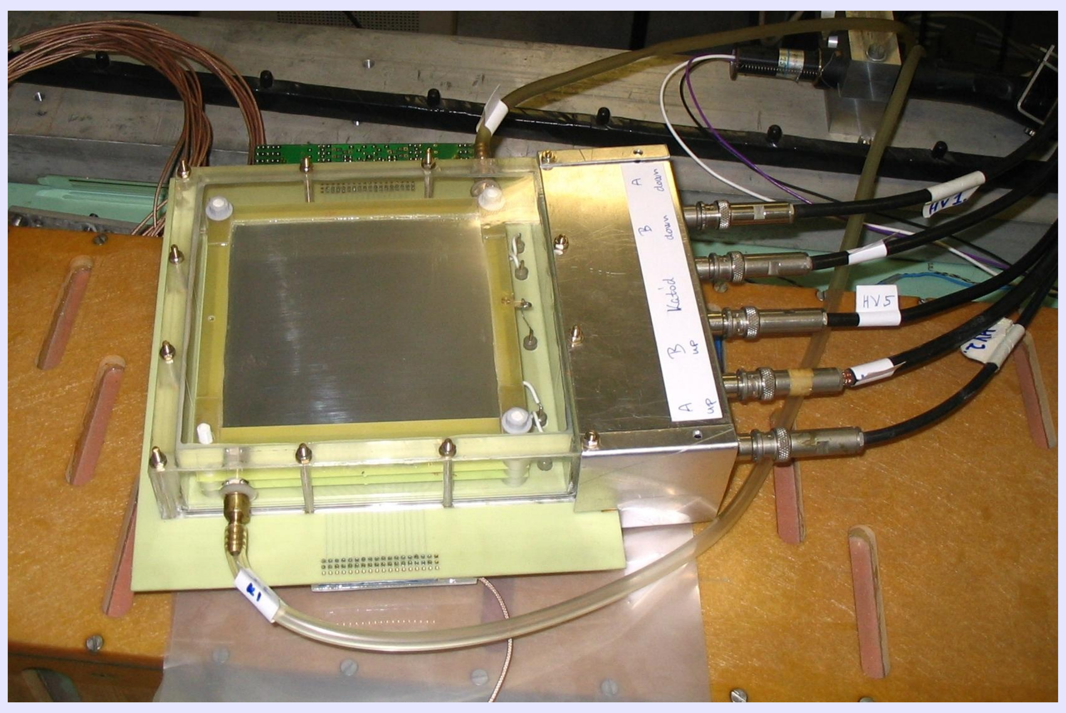
Many theoretical models are trying to describe the nature of particle production in heavy ion collisions where the quarks and gluons may be forming the plasma (QGP). Interesting anomalies have been measured at RHIC in the at the 5 GeV/c < pT < 10 Gev/c region, especially at the baryon-meson, proton-pion ratios. This motivates Particle Identification (PID) to much higher momenta than originally planned at LHC ALICE. Solving this problem VHMPID (Very High Momentum Particle Identification Detector) have been designed: gas filled Ring Imaging Cherenkov detector which will be able to track-by-track distinguish pions, kaons and protons in the 5 GeV/c < pT < 25 Gev/c region. Low event rate at this high transverse momentum requires a dedicated trigger.



1.2. HPTD (High PT Trigger Detector)

Main idea of the triggering: measure the inclination of tracks far from the interaction point (5 meters), tracks which are bent by the ALICE magnetic field (0.5 T). High momentum means small bending -- or smaller inclination. The HPTD contains 4 layers of TGEM based detector, with fair spacial resolution in the direction of the azimuthal direction and reduced resolution in the direction of the field.

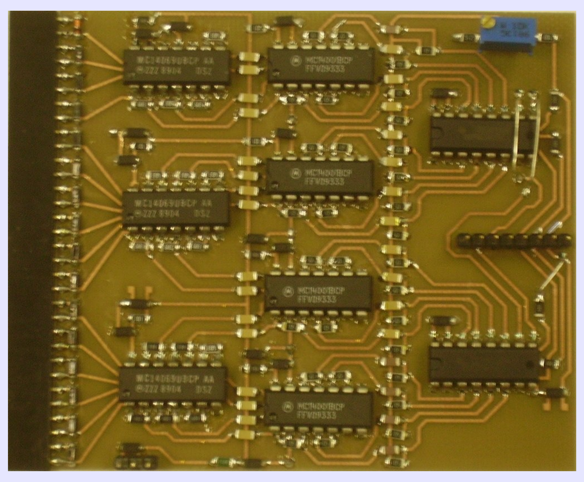
Such a trigger detector needs high granularity (pads < 2 cm^2) and high multi-track resolution. No need of amplitude measurement; track inclination measured via "pattern recognition" using fast digital logic (e.g. FPGA based).

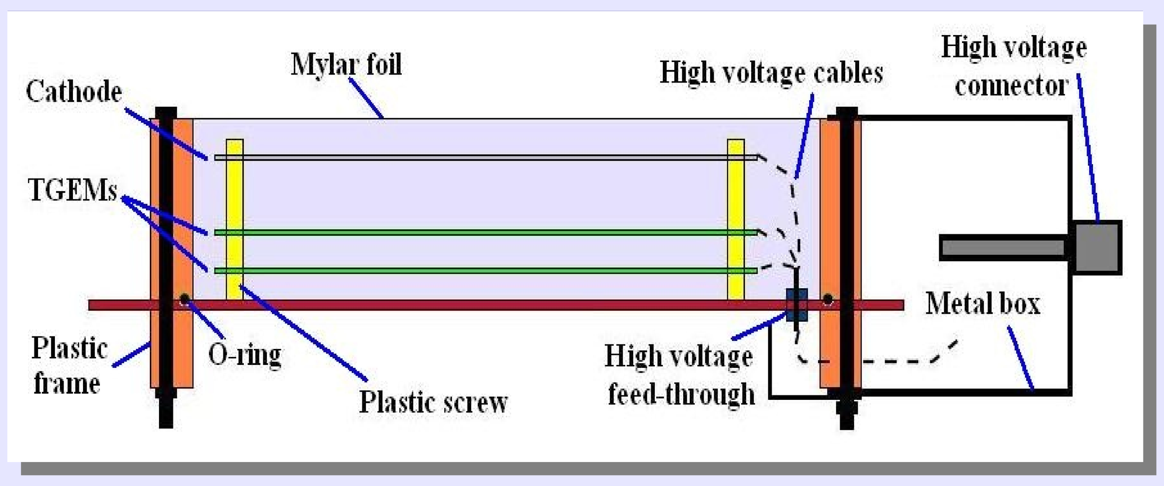


2. Chamber

2.1 Test Chamber

Small test chambers have been build with 10cmx10cm active area. Double thick GEMs have been used: thickness 400 µm, hole diameter 300 µm, 600 µm pitch. For the pad readout we used 5mmx50mm (and in the second chamber 2.5mmx50mm) size pads according to the requirements of the HPTD. Spacers: 3mm between TGEMs, 3mm between the lower TGEM and the pads, 10mm drift space. Cathode and TGEM voltages were set by a resistor chain, in order with 20(drift):30(TGEM):20(transfer):30(TGEM):40(extractor) MOhms.





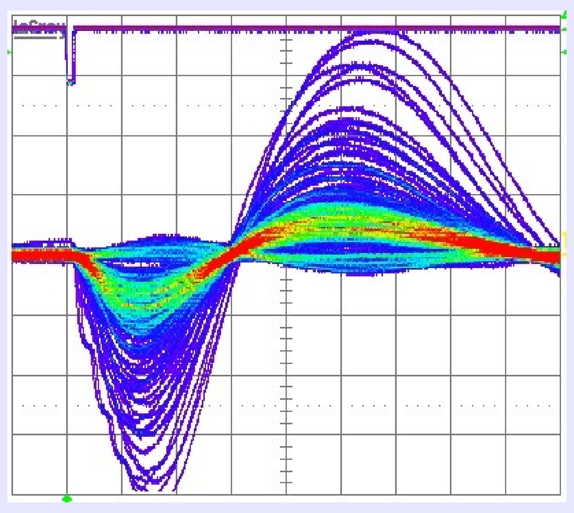
2.2 Electronics

The custom designed electronic readout prototype handles with 16 channels. After the preamplification and amplification one can read out the analog signals. Final design will not need any amplitude resolution, after discrimination a shift register permits the multiplexed readout. Each channel has a 20 pF input capacity from the pads and needs a 600 ns integration time. Total noise is smaller than 10^4 electrons per channel.

2.3 Test beam setup

Recent results have been measured at CERN PS test beam in 2008. Beam contained positive charged particles (mostly pions) with momentum 6 GeV/c. We used scintillator coincidence for triggering.

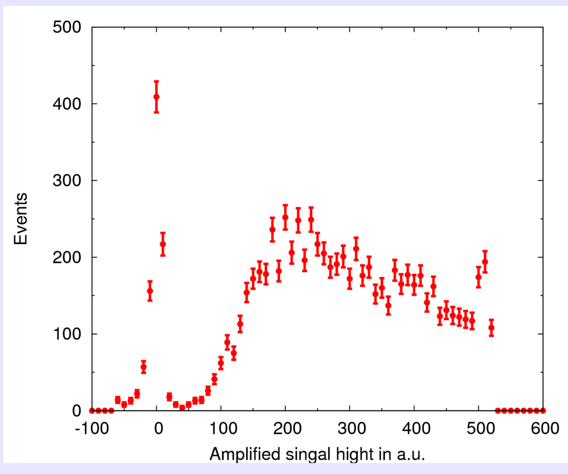
3. Analog measurements



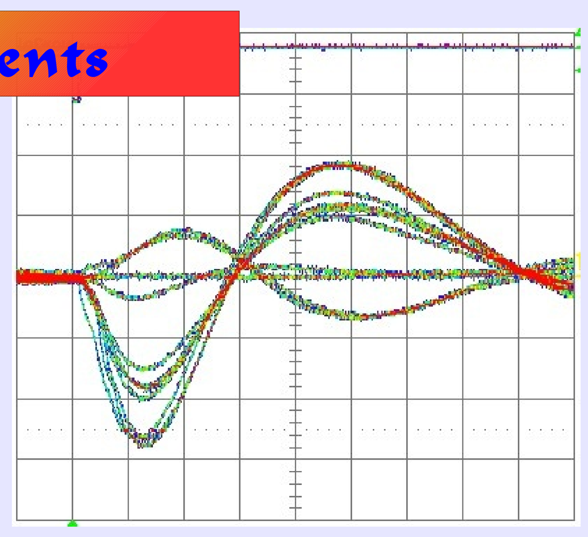
3.1 Signal shape

Both on the oscilloscope screenshot and on the ADC plot one can clearly see the amplified signal and distinguish it from the noise.

Analog signal area were measured with a Camac ADC.



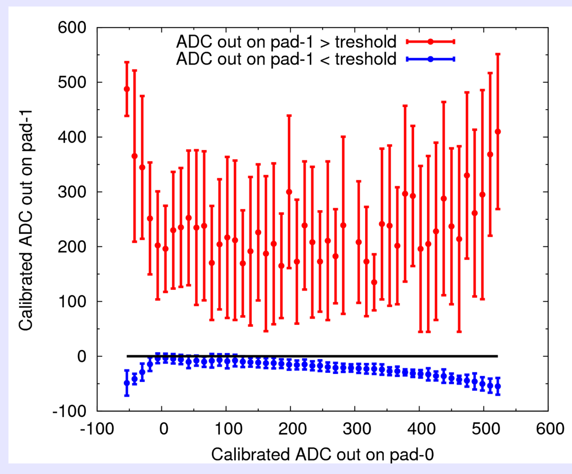
The distortion at the tail of the Landau distribution is made by the electronics which does not need high dynamic range at the final design.



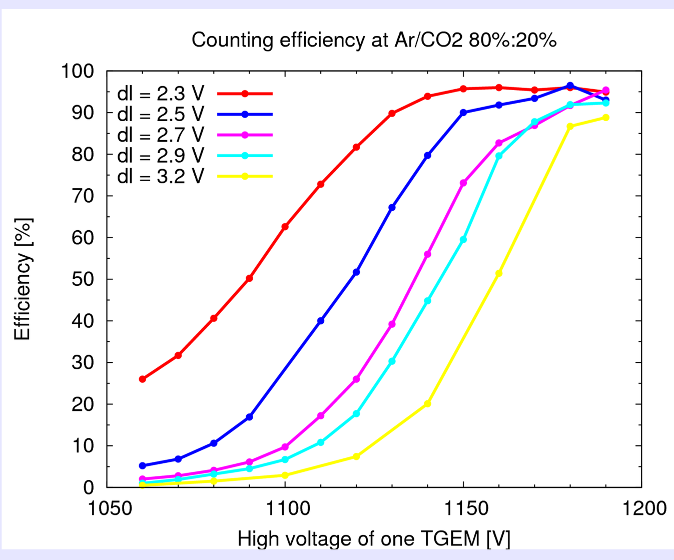
3.2 Correlations

The multiplied electron cloud could spread onto more than one pad issuing positive correlations. Great charge deposit issues negative correlations due to the capacitive connection of the pads. Both effects can be seen on the scope screenshots.

Dividing the correlated signal into categories: below or above threshold, these effect become measurable. Negative correlations shows the expected tendence, positive correlations have huge error-bars due to the big fluctuations in the tail of the Landau distribution, however slightly increase can be observed.



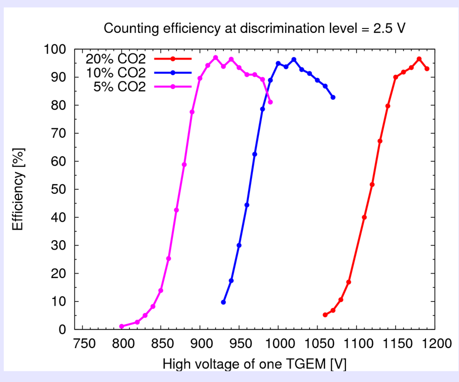
4. Digital measurements



4.1 Efficiency

Further measurements will be with 1 bit digitalized multiplexed readout. We measured the chamber's efficiency versus the applied high voltage at different discrimination levels. Full efficiency can reached around gain 2x10^3. Discrimination level were optimized to cut down the noise and get the maximal efficiency.

After a certain high voltage (gain) the chamber starts to spark and the efficiency drops.



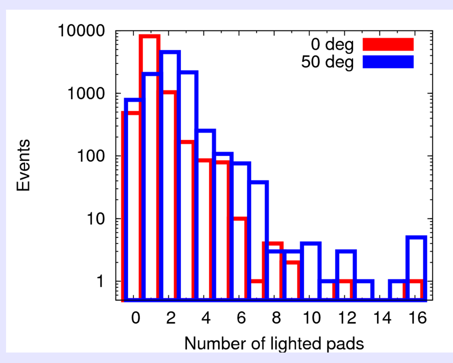
Efficiency curves are similar for all the tested gas mixtures : Ar/CO2 : 80%/20%, 90%/10%, %95/5%.

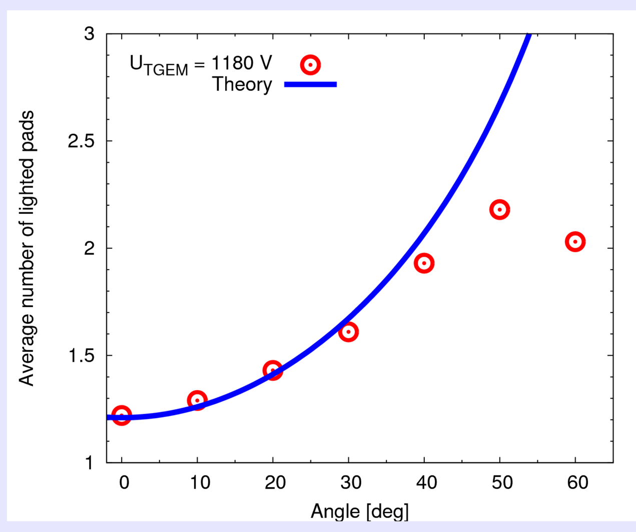
4.2 Angular smearing

The crates where the chambers had been mounted could be rotated from 0 to 60 degrees. For HPTD angular smearing can be important. Calculated smearing for small angles is:

$$\langle n\rangle_\alpha^2 = \langle n\rangle_0^2 + (2*\tan\alpha)^2$$

At large angles the charged particles travel less above one pad so the effective efficiency drops therefore the average number of lighted pads will be less than the expected.

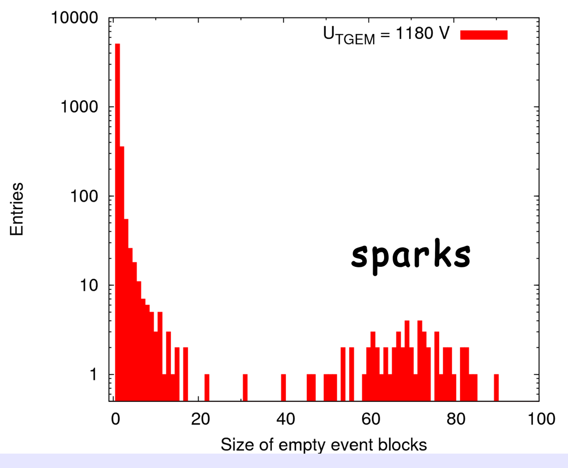


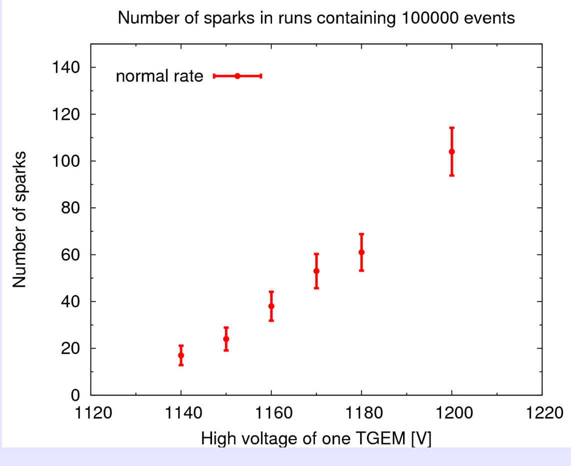


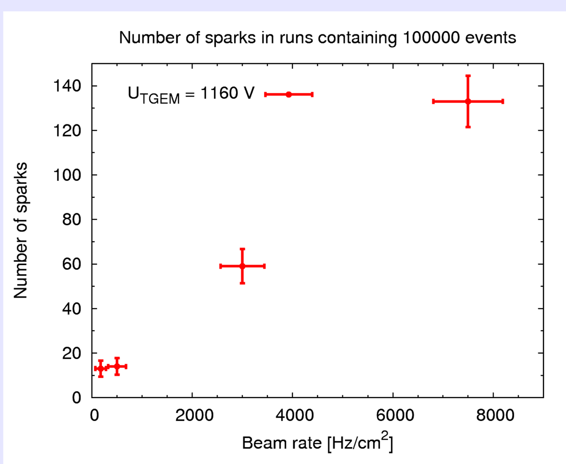
5. Spark study

5.1 - Spark detection

We used a special offline method to detect the sparks. In the case of sparking the high voltage drops and the chamber will be "blind" for a long time. Plotting the multiplicity of the empty event sequences one can see the statistically allowed region of normal behavior and a number of entries far away from the former which are connected to the sparks. Our measurements shows that the higher the TGEM voltages are the higher the sparking probability is. However it is not an exponentially growing as one expects naively, so not linearly connected to the gain.





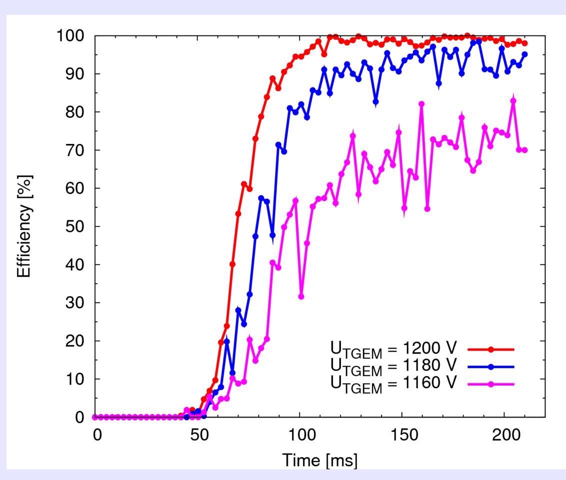


5.3 - Recovery

Sparing makes chamber silent for about 50 ms. After a spark the chamber slowly (50-80 ms) recovers to its normal behavior region. The ~100 ms total recovery time suits with the ~10 ms timescale of the chamber's structure (resistors ~10MOhm, TGEM's capacitance ~1nF).

5.2 - Rate

For a give gain the sparking probability is linear with the beam rate till 8000Hz/cm2 (our measurable limit).



6. Summary

The new physical questions motivated VHMPID needs a trigger. Our measurement confirmed the applicability of TGEM technology for this task. The 98% efficiency can be reached and the angular smearing is close to the expected. With offline spark detection we could analyse sparking probability at different TGEM high voltages and beam rates, and recovery time became measurable (~100 ms) too.

7. Acknowledgment

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