Minutes of RD51/WG2 meeting

CERN, 23rd of February 2010

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During the meeting, a special emphasis was put on gas discharges in MPGDs. Four presentations were devoted to that subject (G. Croci, S. Wu, D. Neyret, S. Procureur) showing results of beam test of Micromegas and triple-GEM detectors as well as GEANT4 simulation. Other topics were discussed like gas gain fluctuations (P. Colas), new detectors with resistive meshes (V. Peskov) and characterisation of a TPC for dark matter search (F. Resnati). A report on a gas filling system for GOSSIP detectors was given by F. Hartjes. A brief summary of each presentation is given below.

An important issue addressed during the discussions is that of the definition of a spark which is essential to compare spark probability or spark rate with different detectors. In the work reported during the meeting, a spark is defined as a fast variation of the current or voltage measured on one electrode larger than a certain threshold (S. Wu, G. Croci). This definition is not suitable as in the case of detectors with resistive elements, the time development of a spark is modified and the spark current is attenuated. A more suited quantity should account for the current and the dead time. This point should still be debated.

Important questions on the shape of the single electron gas gain distribution (quantified by the *theta* parameter) and the power law behaviour of the spark probability with gas gain were also raised.
Recent measurements with an InGrid-TimePix detector clearly favor a value of theta close to 1 (Polya-like gain fluctuations). Simulation studies presented during the WG4 meeting indicate that this value is rather insensitive to the gas composition, still is it not understood why a value of *theta* of 1 is favored.
The power law behaviour of the spark rate with gain was measured in 2001 with Micromegas detectors. Recent simulation work presented in the meeting shows trends compatible with these measurements and will be useful to answer this question.

<u>Progress on a double phase liquid argon LEM-TPC, F. Resnati</u>

A 10x10x20 cm^3 double phase TPC with Large Electron Multiplier (LEM) is functioning at CERN. This prototype is equipped with PM tubes on the bottom plane in the liquid phase and charge readout electrodes on the top plane in the gaseous phase. To allow for a two coordinate measurement of the ionisation position in the readout plane, the LEM bottom electrode and the anode plane are segmented into strips and the foil is operated in a semi-transparent mode: electrons produced in the LEM being equally shared between each planes.

Measurements on strips of the charge distribution from cosmic muons as a function of time were reported. This measurement gives an indication of the oxygen contamination level in the TPC and was used to assess the performance of the gas purification system which can lower the contamination down to 2 ppb. Anode plane of 10x10 cm^2 with double strip array (“2 views anode”) have been produced to use LEM foils with unsegmented electrodes. This, together with the fabrication of thicker LEM electrodes with smaller rims should improve the spark proofness and the gain stability of the detector. Tests of foils of different thicknesses were carried out in air (HV test) and in argon at various pressure.

First test of a triple GEM detector in a high flux neutron beam, G. Croci

The aim of the test was to measure the spark rate of a triple GEM in a neutron beam and to investigate the activation of the detector copper electrodes. The detector was made of standard 10x10 cm^2 foils with a small drift gap of 3 mm. 5.5 MeV neutrons were delivered at fluxes between 10^4-10^5 Hz/cm^2.

The anode charge spectrum is a continuous distribution corresponding to neutron conversions in the gas into Ar, C or O ions and to photon (from material activation) interactions. Sparks between GEM foils were identified as a drop of the anode current during irradiation. During 1 hour of irradiation, three spark candidates were spoted while raising the gas gain from 3000 to 30000.
After 2 hours of irradiation, the beam was stop to study the activation of the chamber materials. The count rate measured on the anode decreases exponentially with time. The measured time constant is for the moment not understood.

Results of a beam test of Micromegas chambers with various resistive coatings, S. Wu

In the framework of the MAMMA collaboration for the ATLAS muon spectrometer upgrade, a set of two standard Bulk, six Micromegas with different resistive elements (strips, pads, layers) and one detector with a segmented mesh were tested in a high intensity hadron beam at CERN. Results on spark rate, efficiency and spatial resolution were presented. The detectors, filled with T2K gas, are readout by GASSIPLEX chips and placed in a 120 GeV/c pion beam with an intensity between 5 to 40 kHz/cm^2.

A sparks is identified when the mesh voltage drops by more than 50 mV. The measured spark rates lie between 10^{-3} and 10^{-5}. The detector with 400 kOhm/square resistive strips shows the lowest spark rate, the spark current and voltage drop are very small with respect to the values measured with standard Bulk. The comparison between different Micromegas, however, remains difficult as the quality of the resistive coatings of some detectors is questionable. In the best case, the drop of efficiency with rate is rather limited (97 % to 94 % when increasing the rate from 5 to 40 kHz/cm^2).
The spark current measured on the segmented mesh detector assumes 8 values which corresponds to the discharge of several mesh sectors at the same time.

The spatial resolution was measured as the residuals of the cluster position measured in the tested chambers to the extrapolated track position (using telescope chambers). With 1 mm pitch resistive strips, an intrinsic point resolution of 91.4 +/- 2.2 um is obtained when correcting for the extrapolation procedure and the multiple scattering.

Recent measurements of gain fluctuations with an InGrid-TimePix detector, P. Colas

There is a renewed interest for electron avalanche fluctuations as they impact on the performance of MPGDs (e.g. spatial resolution of TPC, single electron efficiency of GridPix detectors...). Thanks to the low noise at the input of each pixel, a TimePix equipped with an InGrid can measure directly the single electron response (SER). An indirect measurement is also possible by counting a almost fixed number of primary electrons released in the gas as a function of gas gain.
It was stressed during the discussions that the measurement of basic gas physics quantity (such as mean energy per ion pair W and Fano factor F) with this detector would provide very important inputs to predict the performance of gaseous detectors for dark matter searches as well as to understand in more detail the mechanisms of primary ionisation (Penning ionisation, photo-ionisation ...). The latter point

is also very interesting for the simulation of MPGD performance with Garfield, Heed and Magboltz.

Measurement of the number of detected electrons from ^{55}Fe conversions in an Ar/isobutane 95/5 gas mixture as a function of mesh voltage strongly favors Polya-like fluctuations with a parameter *theta* close to 1. At high gains, the number of counted electrons indicates a W value of 24 eV in the mixture. This value is lower than that in pure argon and could be a sign of some inter-molecular interactions during the ionisation process (e.g. Penning transfer). Direct measurements of the charge distribution on the single pixels show larger values of *theta* but are certainly affected by large systematics errors. This measurement will be repeated with a more detailed calibration of the pixel matrix.

First results from tests of gaseous detectors assembled from resistive meshes, V. Peskov

Resistive Mesh Detectors (RMD) are Micromegas detectors with a mesh made from a few MOhm.cm kapton foil with holes defined either by laser etching or mechanical drilling. They are interesting for GridPix detectors which need a protection against discharges at the level of the mesh rather than at the chip. In the latter configuration, the induced charge spreads over some pixels which lowers the detection efficiency and the spatial resolution of the detector.

Several foils stretched on 10x10 cm^2 frames could be tested in different detector configurations (RPC, Micromegas, GEM and GEM+Micromegas). Measurements in the RPC configuration (1 to 3 mm amplification gap with a drift region) showed gas gains between 1000 and 10000 with ^{55}Fe X-rays depending on the gas mixture and the amplification gap thickness. The maximum gain is thought to be limited by some imperfections of the mesh as the measured value is lower than what is expected from the Raether's limit. At smaller gaps (100 um, Micromegas configuration) the imperfections play an even more important role and the maximum gain is lower than 1000. When operated in cascade mode (GEM+Micromegas), no discharge propagations were observed in RMDs.

Preliminary results of beam test at CERN of Micromegas for CLAS12 and COMPASS, D. Neyret

COMPASS and CLAS12 are two experiments where Micromegas are used (or are foreseen to be used) in high particle fluxes (~ 10kHz/mm^2 and 5 MHz/detector respectively). In COMPASS, important efforts have been devoted to lower the spark probability by using a light gas mixture (Ne-based) and the gas gain by using low noise electronics. To lower the rate even further, Micromegas with non resistive or resistive electrodes or with a GEM pre-amplification stage have been tested at the CERN SPS inside the GOLIATH magnet (1.4 T) in an argon/isobutane 95/5 mixture with ^{55}Fe quanta and 150 GeV/c muon (resolution study) and pion beams (spark study). Because resistive detectors showed gain instability, all reported results were recorded with non-resistive detectors. Resistive detectors should be tested again in beam in 2010.

The gas gain, measured by means of an ^{55}Fe X-ray source, is similar for the tested detectors (the ones with non resistive electrodes), with variations possibly caused by slightly different detector geometries. The spark rate, defined as the number of spark per trigger, shows a power law behaviour, rising from 10^{-8} to 10^{4} for gas gain from 100 to 10000. This trend is observed for all detectors, though the rate is lowered by a factor 10 when using GEM pre-amplification. An effect of the magnetic field on the spark rate could be expected as due to the Lorentz angle, the charge density at the mesh is lower than that without field. No effect, however, was observed certainly because at the high electric fields used the Lorentz angle is less than 20°. Measurements in a muon beam indicate that there is no dependence of

the spatial resolution on the type of mesh used.
As a conclusion, there are essentially no difference in performance and sparking rate between standard and Bulk Micromegas.

Simulation of the spark rate in a Micromegas detector with GEANT4, S. Procureur

Particles traversing a detector interact with the materials or the gas and produce secondary particles. Some of these can be heavily ionising. A GEANT4 simulation of the spark rate can therefore be useful to better understand the origin of the sparks, and eventually to optimize the design of detector.

GEANT4 was used to predict the spectrum of secondary particles resulting from the interaction of 15 GeV/c pions with the material (Ar/iso 89/11 gas mixture, 7 um Cu readout strips, 4 um Ni mesh and drift electrode). The simulation parameters are taken from previous measurements of spark rate published in 2001. The simulation shows that there is a small (but potentially important at high fluxes) probability to produce highly ionising particles such as protons, alphas, deuteron, tritium ions... with low momenta. 42 % of these are produced at the cathode while 22 % originate from the gas.

When converting primary charge into spark probability, the simulated probability shows the right order of magnitude and the same variations with gas gain as the measurements. Also the increase of spark rate with the atomic number of the gas molecules is compatible with the published data. There is no significant effect of the mesh thickness on the spark rate as the secondaries need to escape from the mesh bulk.

NewGas, the NIKHEF gas filling system, F. Hartjes

With very small detector volumes, GOSSIP detectors (typically 0.2 ml each) requires flow rates as low as 0.1 to 1 l/h. Small JSP gas bottles (12.3 l, 20 bar) are hence sufficient to provide gas during 10 to 100 days, depending on the flow. This is very attractive as these bottles are easily transportable and could possibly be placed in test beam areas thanks to the low dead volumes (short and thin pipes). Due to the long delivery times and expensive price of pre-mixed gases proposed by commercial vendors, a gas filling system was built at NIKHEF. The mixing is controlled by a computer through a LabView program by monitoring the pressure monitoring with accurate electronic pressure sensors (+/- 35 mbar). Up to three components can be mixed.

Typical mixtures are P10, CO_2/DME 50/50 and Ar/iso 80/20. In all mixtures, the H_2 mass inside a JSP bottle is smaller than 30 g which is classified as Risk class 1 according to CERN safety regulations on the use of flammable gases (< 400 g). It was emphasize that the system is developed in contact with the CERN safety department so that eventually, a JSP bottle could be brought inside a test beam area.