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GEM operation in Nitrogen based gas mixtures: opening new applications for X-Rays, UV-light and neutron detection with the use of environmental-friendly mixtures

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GEM based detectors have been historically operated using gas mixtures containing mainly Ar, CO2 and CF4. CO2 being a polyatomic gas is used as quenching gas to stop the release of secondary electrons following the primary multiplication. Quenching gases are usually heavy, organic molecules or diatomic molecule gases. In this contribution we explored the possibility of operating GEM devices with gas mixture containing Ar and/or N2 by performing a series of performance measurements with some GEM based detectors. Removing CO2 allows the use of environmental-friendly gases that is a major development for next generation of gaseous detectors. N2 offers a series of advantages: it can be used in recirculating systems of sealed detectors since most of purifying systems are not sensitive to it; it has a sufficiently high thermal neutron cross section (due to the reaction n+14N -> p + 14C, that shows a cross section of about 10 b for thermal neutron energies, i.e. 25 meV) and it scintillates mainly emitting photons with wavelength higher than 250 nm. These three N2 features pave the way to the development of sealed X-Rays GEM based detectors, low mass neutron beam monitors and of GEM photon amplifiers. In Milano, two N2-based detectors have been developed: one Triple GEM detector operated with Ar/N2 gas mixtures in proportion 90%/10%, 80%/20% and 70%/30% equipped with a padded anode featuring 256 pads with an area of 6x6 mm2 and a single GEM completely operated in N2 and read-out by a Photo-Multiplier Tube (PMT). The Triple GEM detector was read-out using GEMINI front-end electronics and was first tested using 4.5 keV fluorescence X-Rays emitted by a Ti-Target irradiated by Bremsstrahlung X-rays emitted by a 40 kV X-Rays generator. The counting rates, gain and energy resolution as a function of the sum of the potential difference over the GEM foils have been measured and compared to the standard values obtained with the reference gas mixture Ar/CO2 70%/30%. The gas mixture Ar/N2 90%/10% showed similar results to the reference mixture, since we measured the same gain (a value of about 2000) and a similar energy resolution (about 25% at 4.5 keV). This proves that N2 can also be used as quenching gas and that this gas mixture can be a potential candidate to develop sealed X-Rays detectors. The same detector was then tested as neutron beam monitor at the Triga Mark 2 reactor of the L.E.N.A laboratory in Pavia: it was proven that the efficiency and therefore the counting rate reduces as the amount of N2 is reduced (keeping the same neutron flux) and that the detector is able to online reconstruct the 2D thermal neutron beam profile with all above cited Ar/N2 mixtures. Finally, the scintillation properties of N2 can open a new development towards the realization of gaseous photon multipliers. This study was performed by realizing an experimental setup made of a vacuum chamber hosting a cathode mesh, a single GEM and an anodic mesh, filled with pure N2. The vacuum chamber was closed on one side by a window that allows the transmission of photons with wavelength higher than 200 nm. The window is then coupled with a Hamamatsu R9420-100-10-mod PMT whose spectral response ranges from 300 to 650 nm. An 241Am source emitting 5 MeV alpha particles was placed in the N2-filled chamber just outside the cathode mesh (which is placed at 12 mm from the GEM foil) and in order to register signals on the PMT potential differences from 400 V to 500 V must be applied to the single GEM foil; the time duration of the signals registered by the PMT was also varied by changing the drift field and since it was possible to reconstruct the electron drift velocity in N2, this confirms that the registered signals come from primary electron scintillation in the GEM holes. If the GEM foil would be covered with

UV converter photocathodes (like CsI) whose quantum efficiency decreases above 200 nm, this achievement opens the way to the development of N2-based wavelength shifting gas photon multipliers.

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