The Frontier of Gas Detectors: the micro-RESISTIVE WELL

The Particle Detectives:
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The Detectives Group:
The Detector Development Group (DDG LAB Frascati INFN), has long been involved (since 1985) in the R&D, design and manufacturing of classical gaseous detectors, such as wire tubes operated in proportional or streamer mode (1983–1990), RPC with glass electrodes (1991–1994), large drift chamber (1995–1997) and Micro-Pattern-Gaseous-Detector (MPGDs – since 2000) for high large energy physics experiments.

Muon Apparatus in LHCb

Cylindrical GEM in KLOE

Future Upgrade of the Muon Apparatus at LHCb

Sketch of the SHIP Experiment

The Portfolio:
The R&D activity on MPGDs focused on GEMs and other innovative architectures in the framework of the LHCb experiment (CERN) with the development of planar GEM detectors (2005–2006), and the pioneering construction of the first Cylindrical-GEM (2006–2013) for KLOE experiment (Frascati).
The last DDG artefact is an innovative gas detector, named micro-Resistive-WELL (µ-RWELL - 2014) a compact MPGD with a single-amplification stage based on the "well" concept intrinsically protected against the sparks.
The µ-RWELL had been recently proposed for the upgrade of the Muon stations of the apparatus of the LHCb experiment as well as Target Tracker of the SHIP experiment at CERN.

The µ-RWELL Architecture

The µ-RWELL consists of two elements: the µ-RWELL_PCB and the cathode

The µ-RWELL_PCB, the core of the detector, is realized by coupling:
1. WELL patterned kapton foil or amplification stage
2. resistive layer for discharge suppression & current evacuation:
   i. Single resistive layer < 100 kHz/cm²: single resistive layer ê surface resistivity ~ 100 MΩ/cm (LHCb-Muon Upgrade & SHIP experiment)
   ii. Double resistive layer > 1 MHz/cm²: more sophisticated resistive scheme must be implemented suitable for LHCb-Muon upgrade & future experiment at future collider (ICC/ee/hh & CepC)
3. a standard readout PCB

The µ-RWELL Step by Step

CAD Detector Design

MonteCarlo simulation

µ-RWELL_PCB construction at ELTOS

Quality Control & Detector Assembly

Detector test with muon/hadron beams

Detector Performance

Applications Beyond High Energy Physics (HEP)

Gain Measurement

Particle Track Fitting

Reconstruction of inclined-muon particle obtained with the µ-TPC mode

Time Resolution

Feasibility study of µ-RWELL for high energy physics applications at LHCb

Neutron detection
Thermal neutrons can be also exploited for radiography they are mostly stopped by light elements being then suitable for inspections within metallic shields.
A µ-RWELL represents a break-through in neutron imaging technology. Neutrons are converted in alpha particles on the boron doped cathode.
The layout of the readout should then be very similar to the one proposed for X-rays detection, in order to perform a 3D reconstruction of the charged particle path.

Setup for X-ray test and X-ray recording of a crash-test dummy seated in a Smart Radiation Portal Monitor for homeland security

Monte Carlo evaluation of the neutron backflow towards the cathode for neutron detection

Gamma & X-ray
The µ-RWELL represents a suitable solution due to its compactness, construction simplicity and operational stability for non-HEP applications.

For the gamma detection, the detector must be equipped with a proper converter, just a fraction of photons interacting with the detector extracts a Compton electron; if this is emitted in the active gas volume then is detected with high efficiency (X-HEP).
The compactness helps for the realization of a stack of detectors.

For X-ray detection in the keV energy region, the photons are converted in the gas volume of the device. A proper segmentation of the readout (pixels) bound to an on-board front-end electronics, would allow the use of µ-RWELL for fine X-ray imaging, exploitable for medical, industrial, material science and archeology diagnostics.

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