A small current measurement system for gaseous micropattern detectors suitable for operation at high voltages

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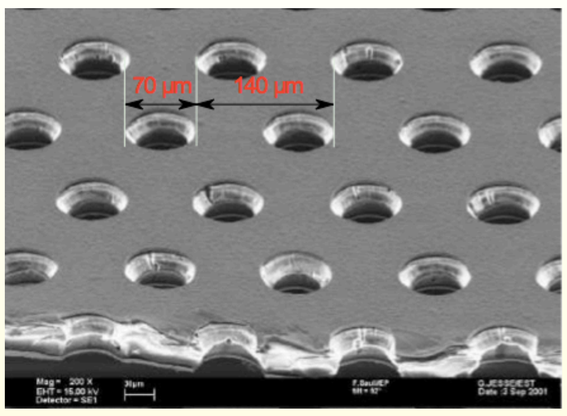
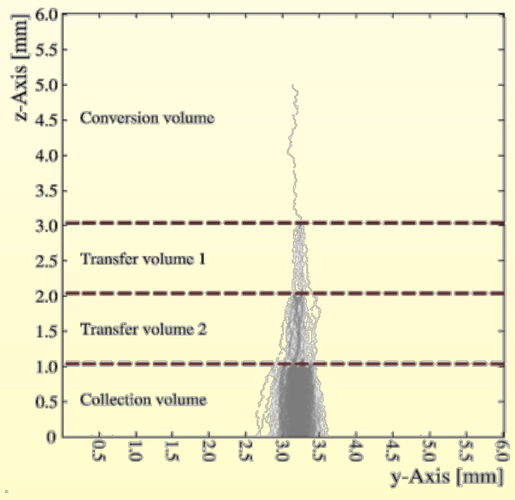
Future upgrades of several large particle detectors intend to employ gaseous micropattern detectors. This class of detectors, which include Gas Electron Multipliers (GEMs), Micro-MEsh Gaseous Structure detectors (MicroMegas) and similar, usually require the measurement of small currents (pA) at high potentials (kV) with respect to ground. While only this in itself presents an obstacle, the measurements very often need to satisfy other strict requirements, such as small current resolution, low power consumption, high readout frequencies (1 kHz) or simultaneous readouts of multiple channels.

Gaseous micropattern detectors

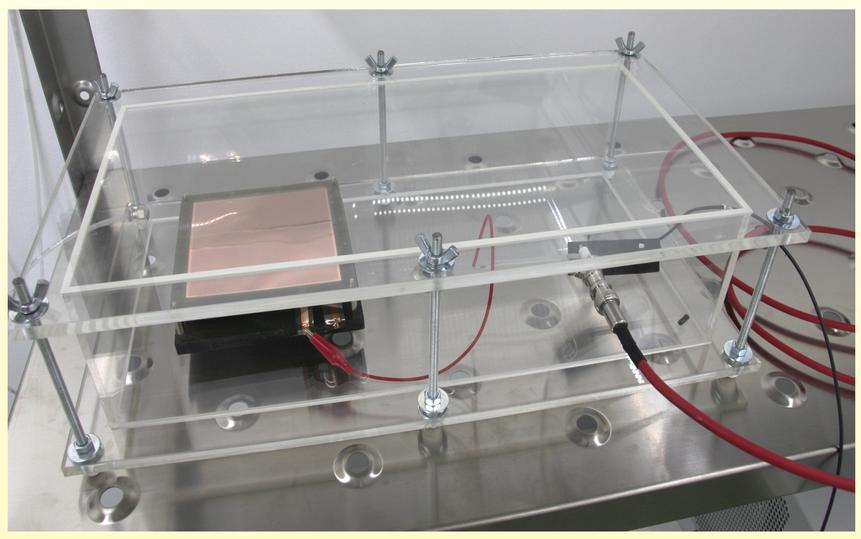
- A new generation of detectors used in various aspects [1-4]
- Systems that typically consist of one or several perforated thin metal sheets immersed in a gaseous environment and placed at high potentials [5]
- Electrons created by incoming radiation drift into the holes, multiply and transfer to a collection pad [6]

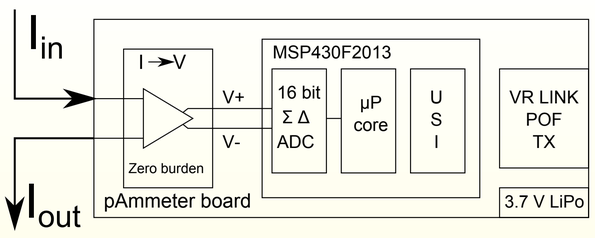


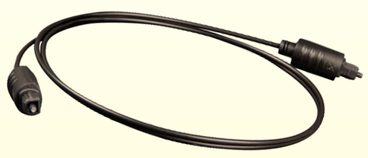


Device requirements

- Very small currents (nA) at high potentials (kV) in early multiplication stages create a readout problem
- Measure small currents with good resolution (100pA) at high bias voltages (5kV)
- Multi-channel high-frequency (1kHz) digital readout
- Cost-effective, low-powered compact device
- Concept tested on a laboratory GEM setup



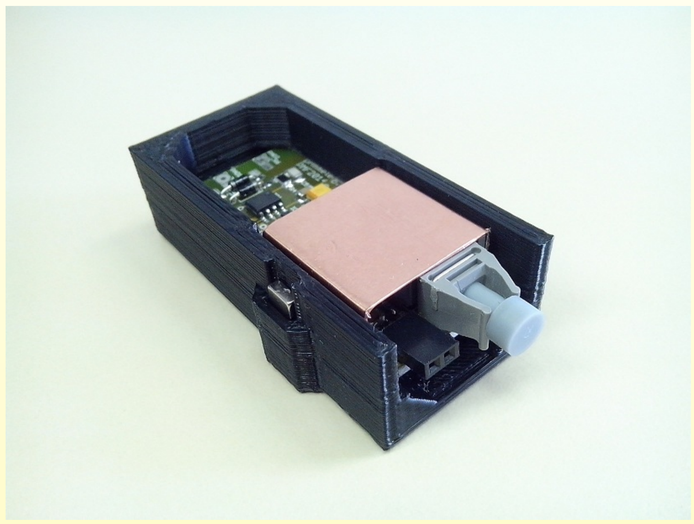


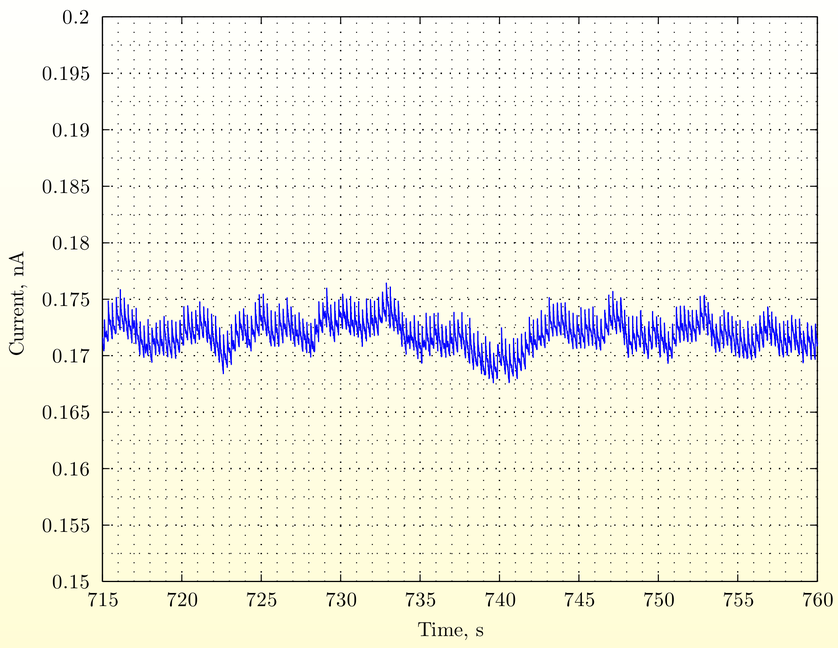


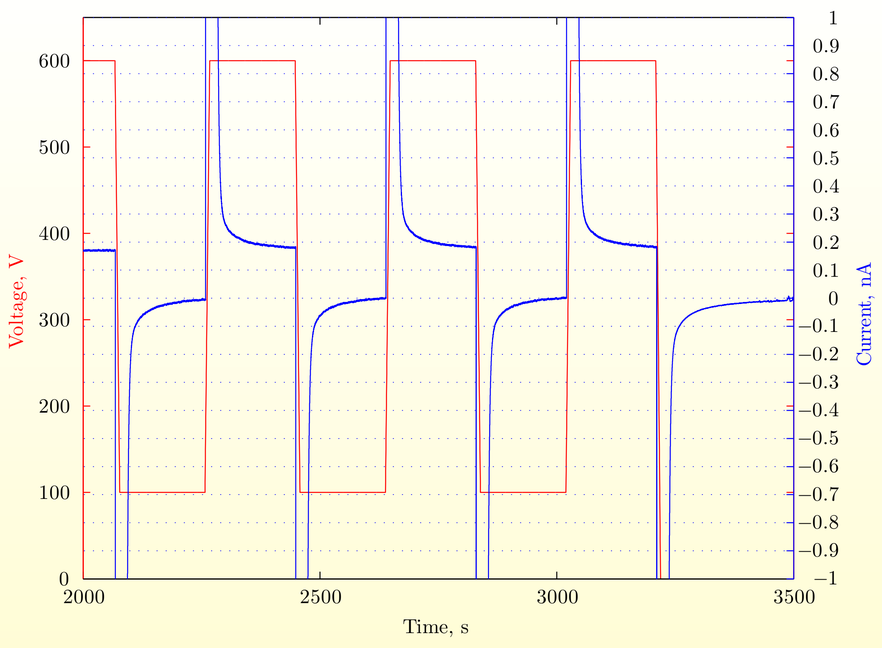
Concept and design

- Custom-made signal conditioning board with a **low power preamp** and a **Σ-Δ opamp** [7,8]
- 14 data bits sent through **an optical link** to minimize leakage currents (**500kbps rate at 1kHz sampling rate**)
- Data is collected by an **FPGA board** [9] from up to **32 channels** and sent to a LabView PC module via a USB interface
- The final product is placed in a **custom printed plastic housing** measuring 6 x 3 x 2 cm^3 and is powered by a **LED charging system** [10]

This solution improves vastly on previously encountered difficulties (**number of readout channels, readout frequency and power consumption**, among others)







A stability test is performed first (left), after which a GEM current measurement is performed in several phases (right). The ammeters show **exceptional stability** and a **current resolution of <7pA FWHM at 1kHz readout rates at the readout range of ±125 nA**

[1] doi:10.1016/j.nima.2004.07. 146.
[2] doi:10.1016/j.nima.2009.07.006.
[3] doi:10.1016/j.nima.2012.10.058
[4] H. Appelshaeuser et al., Technical design report of the ALICE TPC upgrade, 2013.
[5] http://ts-dep-dem.web.cern.ch/ts-dep-dem/products/gem/
[6] doi:10.1016/j.nima.2013.04.020
[7] http://www.ti.com/product/lmc6442
[8] http://www.ti.com/product/msp430f2013
[9] http://www.avagotech.com/docs/av02-0730en
[10] 10.1016/j.nima.2015.08.021

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