Temperature and pressure monitoring for the AstroBox2 detector

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Gas gain, especially in the exponential regime of a Micromegas, can be very sensitive to various changes in the detection medium such as gas impurity levels and gas density changes due to either pressure or temperature fluctuations. We have implemented multiple independent ways to track possible gain drift and to monitor the stability of the detector: (1) an α-source on an active side pad of the detector, (2) a separate chamber for a ~1 cm^2 Micromegas detector using ^{55}Fe X-ray source at the gas exhaust, (3) a pulser in the AstroBox electronics, and (4) possible strong decay branches of the species under study and devised methods for correcting these fluctuations [1].

Temperature related fluctuations are very evident in laboratory spaces without proper environmental controls such as in the high-bay area. Inside the experimental caves which are closed for the beam time, the temperature stabilizes relatively quickly during beam tuning and the remaining fluctuations are monitored during data taking. In the past these fluctuations during the beam time have washed out into the intrinsic detector resolution. However, during the latest runs in 2017 and 2019 we have observed quite strong fluctuations in the signal amplitudes of the sources used for monitoring as well as in the real data, all correlated with daily outside temperature variations. This is likely due to fact that there was an upgrade into the building air conditioning in general improving the cooling also inside the caves. On the other hand, some of the external cooling water circuit connected to the cave air handler heat exchanger are likely not well insulated outside the building enhancing the coupling to the outside air temperature.

Thus far we can only show the correlation between the daily weather data and that the signals track the changes outside the building but we have lacked actual temperature measurement other than a household thermometer and the temperature logging of the gas controller. However, the controller is heated by manufacturer's design to ensure steady mass flow through the controller but the gas lines and the detector are in the ambient room temperature.

To improve understanding of the origin of the drifting of the signals beyond just qualitative level and perhaps even to quantify the connection between actual gas temperature inside the detector setup we have designed and built a simple readout circuit to measure temperature with high precision thermistors (Omega instruments 44004, R = 2252 Ohm at 25C) and record the temperature event-by-event basis into the data stream. Fig. 1. shows the schematic of the circuit which is a very basic resistance readout powered with +6V NIM voltage from a preamplifier power supply. The thermistors are mounted into end of shielded 50 Ohm coaxial cables while the auxiliary resistors are housed inside a metal box. The box receives external NIM power via shielded cable and connects the ADC readout cables for each thermistor. The configuration in Fig. 1. allows recording of temperature from -10C to +100C, covering most of usable range of a 44004 thermistor as well as all realistic temperatures in the lab and in the setup. In addition, an old MKS 122 baratron was added into the detector setup for testing purposes to measure the actual pressure inside the detection volume (the MKS piPC99 gas controller pressure measurement is inside the unit itself). The output of the MKS 122 at 10V corresponds to 1000 torr pressure, allowing direct recording of pressure with an ADC capable of reading DC voltages (e.g. mesytec MADC32 as in this case).

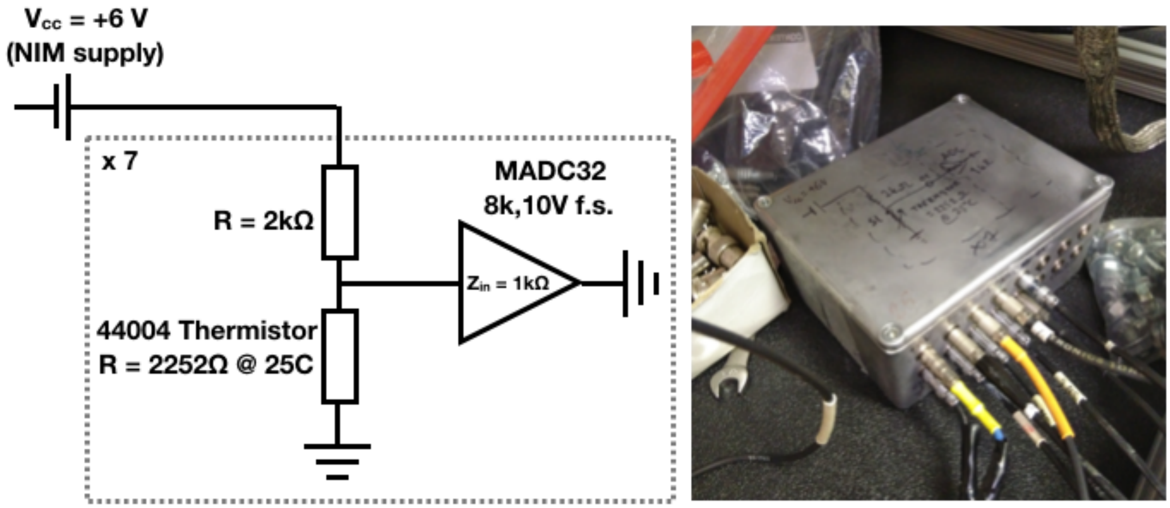

Fig. 1. Left: Schematic of a simple temperature measurement circuit to read thermistors resistances (therefore temperatures) from all over the detector setup and to record the values into the data stream event-by-event basis. Right: a photo of the metal box housing the readout circuit and connectors to connect external NIM power, thermistors and the cables to ADC. See text for details.

Fig. 2. shows an example of alpha source data and temperature reading from inside AstroBox2 detector collected of about two days test period in the high-bay lab. It is evident that the signals from a mixed ^{239}Pu, ^{241}Am, ^{244}Cm source do track the fluctuations in the gas temperature. In addition to the thermistor inside gas volume, pressure from the detector as well as temperature data from various parts of the setup and the room were recorded. In offline analysis these readings can be correlated roughly (to about few seconds) with the MKS piPC99 gas controller logs by using the controller timestamps and the

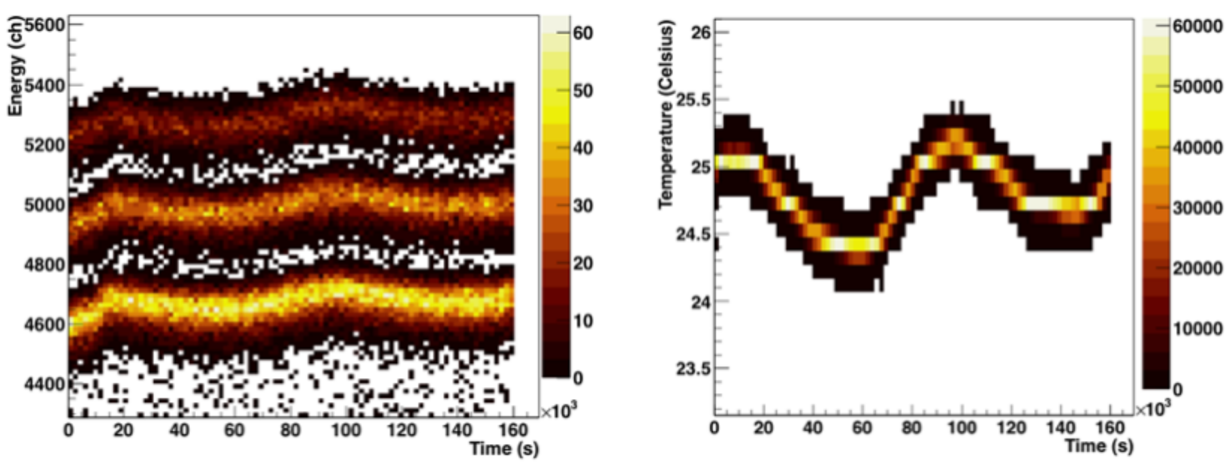

Fig. 2. Left: Signals from mixed ^{239}Pu, ^{241}Am, ^{244}Cm source versus setup timestamp since beginning of data collection (not real-time clock). Right: Calibrated Omega instruments 44004 thermistor reading from inside AstroBox2 chamber during the same time period as source data on left.

event real-time timestamps (reconstructed from the datafile opening unix timestamps and the clock time stamping each event in the data stream). Further testing and analysis of these environmental data and influence on the detector performance will resume once the situation with the ongoing pandemic allows.

[1] A. Saastamoinen *et al.*, Nucl. Instrum. Methods Phys. Res. **B463**, 251 (2020).