Development of electronics to allow vertex determination in the KISS MSPGC

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The goal for the KEK Isotope Separation System (KISS)[1)] is to provide precise nuclear data of neutron-rich nuclei near $N = 126$. Such nuclei, which play an important role in the r-process, are difficult to produce by traditional means (*e.g.* in-flight fission/fragmentation, fusion, ISOL) and therefore KISS uses multi-nucleon transfer reactions to produce them. The rates of interesting nuclei are typically less than 1 s^{-1}.

For understanding the nature of the $N = 126$ bottleneck presumed to be responsible for the 3^{rd} peak of the r-process requires precise atomic masses and decay half-lives. In order to provide the nuclear astrophysics community with the necessary precise half-life data, a multi-segmented proportional gas counter (MSPGC)[2)] was developed for KISS. The system as initially envisioned utilized two concentric rings of proportional gas counter (PGC) tubes (16 in each ring), thereby allowing the use of "hit pattern" analysis to discriminate background events such as *e.g.* cosmic rays. This proved to be a successful strategy which allowed meaningfully precise half-life determination from species delivered with rates down to 0.1 s^{-1}.

In order to push the half-life measurements to $N = 126$, however, will require use of the MSPGC with rates an order of magnitude lower. To accomplish this, the PGC tubes have been upgraded to utilize a resistive wire. By detecting the charge deposited on each end of the wire, it is possible to extract the position of the decay detection along the length of the detector. The 3D decay vertex made possible be this added information should allow half-life determination from yields on the order of 0.01 s^{-1}.

This requires a charge-sensitive pre-amplifier, shaping amplifier, and trigger generator for both ends of each PGC tube −64 sets in total. Noise considerations require the pre-amplifier to be located as close to the PGC as possible, while space constraints make it infeasible to pack everything into the area near the MSPGC. A small circuit board with power conditioners, a Cremat CR-110 charge-sensitive amplifier (CSA) ($g = 1.6$ V/pC), and an AD8138 differential line driver is installed close to each end of every PGC tube. The differential signals are immune to environmental noise.

An array of receivers, as well as power supplies, is installed within a 3U 19" crate installed in a rack ≈ 3 m from the MSPGC. The power for the CSA circuit boards is supplied via a long ribbon cable. The differential line drivers following the CSA allow the signal from each detector to be sent to the receiver crate via the long flat ribbon cable as well. The receiver boards use a pair of AD8130 differential receiver amplifiers to provide a decoupled pair of signals, one to be processed by a CR-200 shaping amplifier and the the other to trigger the 14-bit Hoshin C008 analog-to-digital converter (ADC) used to measure the pulse-height of the CR-200 output and determine the detection position along the PGC. Details are given in Fig. 1.

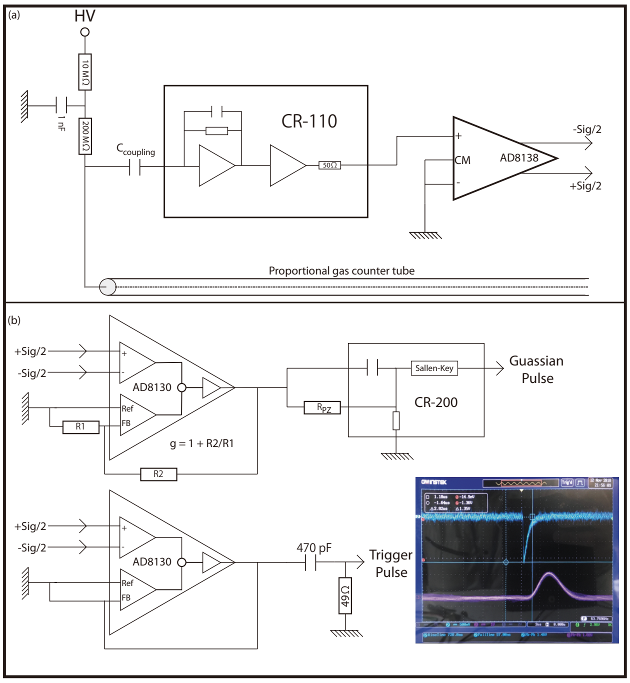

Fig. 1. Sketch of circuitry installed (a) near to and (b) at a distance from the MSPGC. The signal from the CSA is converted to a differential signal to allow noise-free transmission, via long ribbon cable, prior to application of a shaping amplifier. In the inset the trigger pulse is light blue and the Gaussian pulse is purple. The ADC is triggered by the falling edge of the trigger pulse, 2.5 μs prior to the peak of the Gaussian pulse.

In the initial testing with $C_{\text{coupling}} = 1$ nF, large ∼100 kHz oscillations were observed in the CSA output. After consultation with Cremat, it was determined that the each CSA saw the coupling capacitor on the opposite end of the PGC as a heavy load. Reducing C_{coupling} to 100 pF gave clean, stable signals. Development is ongoing.

References
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