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Development of a high-rate Scalable Readout System for gaseous detectors

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The RD51 collaboration pursues research activities on Micro-Pattern Gaseous Detectors. One of its achievements is the development of a common multi-purpose readout system, the RD51 Scalable Readout System (SRS). Successfully established within the community, the SRS was enhanced by integrating the ATLAS/BNL VMM3a front-end ASIC. The outcome is a self-triggered continuous readout system for any kind of gaseous detector. It allows to record particles with MHz interaction rate, measuring their energy, space and time in small R&D set-ups (0.2k channels) to mid-sized experiments with multiple detectors (2.5k to 5k channels).

Summary (500 words)

Readout platforms in particle physics, including the readout ASICs, are usually exactly tailored to the detector parameters. In case of the RD51 collaboration, which focuses on the R&D of Micro-Pattern Gaseous Detectors (MPGDs), a large variety of detector technologies exist, being combined with very different applications. To cope with this, to join development efforts and profit from synergies, RD51 developed the Scalable Readout System (SRS) [JINST 8 (2013) C03015]. Its goal is to provide a flexible and multi-purpose readout system, which allows to read out small R&D set-ups (order of 10^2 channels) up to mid-sized experiments (several 10^3 channels). To read different experimental sizes, the SRS implements a tree-like structure. To read different detector technologies, various front-end ASICs have been implemented (APV25, Timepix and VMM3a as the most prominent examples).

From these ASICs, the VMM3a is the latest integration, from a few years ago [NIM A 903 (2018) 91-98]. The ATLAS/BNL VMM3a is an analogue and digital 64-channel readout ASIC, developed within the ATLAS New Small Wheel upgrade, specifically to read out gaseous detectors. With its integration, the SRS'capability of being a multi-purpose readout system was enhanced with features, which were previously not accessible. One of its main advantages are acquisition rates in the MHz regime, due to the continuous self-triggered readout [NIM A 1031 (2022) 166548]. The compatibility with an even larger range of detector technologies is achieved due to a large dynamic range (adjustable electronics gain of the charge sensitive amplifier; 0.5 to 16 mV/fC in 8 discrete steps), the resulting capability of handling input capacitances over a wide range (from some pF to 1-2 nF), as well as adjustable peaking times (25 to 200 ns in four discrete steps). With the VMM3a providing a multi-channel readout for charge information (10-bit ADC) and time information (12+8-bit; ˜1 ns resolution), its SRS integration becomes a highly advanced system which can be adapted from small laboratory set-ups to multi-detector systems or large area, high channel count tracking or imaging detectors.

In this presentation, the structure of the system, its capabilities and the installation in mid-sized set-ups are shown. This includes the commissioning (e.g. clock, power and ground distribution) of VMM3a/SRS for the successful read-out of a GEM-based beam telescope (multiple detectors with 10x10 cm^2 active area) and a large area (50x50 cm^2) neutron detector. Also, a review of the firmware and hardware for the system is given. With the successful improvements of VMM3a/SRS in terms of scalability and reliability since its integration, due to large community efforts within RD51, the system is now used for a large variety of applications (detector R&D, neutron and material science, HEP, muon tomography, neutrino physics, medical imaging) and detector technologies (e.g. GEMs, MicroMegas, Straw Tubes, TPCs, Scintillators/PMTs). In addition, ongoing studies to even further characterise the system and investigate future improvements are presented.

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