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# Multiple Use SiPM Integrated Circuit (MUSIC) for SiPM Anode Readout

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This paper presents an 8 channel ASIC for SiPM anode readout. The Multiple Use SiPM Integrated Circuit (MUSIC) is based on a low input impedance current conveyor (patented). It provides a differential channel summation and individual SE (analog or ToT) channel readout. MUSIC is designed using AMS 0.35um SiGe technology. Full die simulation yields these specifications: 500MHz bandwidth for channel sum and 150MHz for individuals channels, output pulse width at half maximum (FWHM) between 5-10ns and with a power consumption of 30mW/ch plus 200mW for 8 ch sum. Encapsulated samples will be tested in spring of 2016.

## Summary

Many radiation detectors in astrophysics, particle physics, medical imaging and other fields utilize multi-anode PMTs (Photo Multiplier Tubes) or PMT with large photo-cathode area (1 inch or more). Recently, Silicon Photomultipliers (SiPMs) sensors have become candidates to substitute PMTs due to their high gain, fast response, high quantum efficiency and low-amplitude after-pulses.

This paper presents MUSIC (Multiple Use SiPM Integrated Circuit), an 8 channel ASIC for SiPM anode readout. It is devised to fulfill several purposes, including the readout of SiPM arrays in cameras for Gamma-Imaging Atmospheric Cherenkov Telescopes (IACTs), either in summation or in individual channel mode (analog or Time-over-Threshold).

A novel low impedance input stage based on bipolar current mirrors with double feedback loop is used for SiPM anode readout (patented). The low frequency feedback loop controls the DC voltage at the input node, whereas the high frequency feedback path keeps low input impedance over high signal bandwidth. This kind of input stage allows for summing the currents delivered by SiPMs without adding together their capacitances, so that the timing behavior of the SiPM is not affected. The input current from the sensors is copied and scaled at the readout stage in order to implement different functionalities, as detailed next:

- The summation of any combination of readout channels is provided as a dual-gain output in differential mode.
- 8 individual single ended analog outputs.
- 8 individual binary outputs encoding the amount of charge in the width of the output pulse, using the technique called time-over-threshold.

Note that for each individual channel the user must select either the analog or binary output, since both signals share the same output pad. As additional features, MUSIC includes: (1) a trigger pulse obtained by performing a fast OR between any selection of digital signals and (2) 8 output currents for an external slow integrator. Moreover, the circuit can make use of a tunable pole zero cancellation (PZ) of the SiPM recovery time constant (up to 100 ns) to deal with sensors from different manufacturers (it can be bypassed in any operational mode). Each main functionality (sum or A/D) has a selectable dual-gain mode. Lastly, any block and channel can be disabled (power down mode) with a specific control signal.

MUSIC is designed using AMS 0.35$\mu$m SiGe technology. Full die simulation yields the following specifications: (1) Total die size of 9 mm$^2$; (2) 64-QFN 9x9mm package; (3) bandwidth of 500 MHz for the differential channel sum output and bandwidth of 150 MHz for single ended A/D channel outputs; (4) low input impedance ($\approx$

32Ω);
(5) single photon output pulse width at half the maximum (FWHM) between
5 and 10 ns; (6) power consumption of 30mW/ch for individual channels and 200mW for the 8 channel sum;
(7) 15 bits dynamic range for summation and 10 bits for individual analog readout. Encapsulated samples will be tested in spring of 2016.

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