ANDESPix: A Digital SiPM for Muon Detectors

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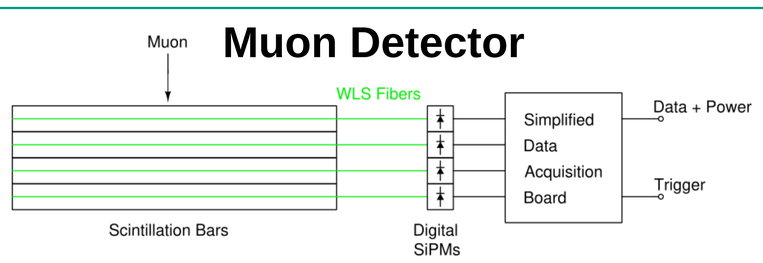
Muon Detector

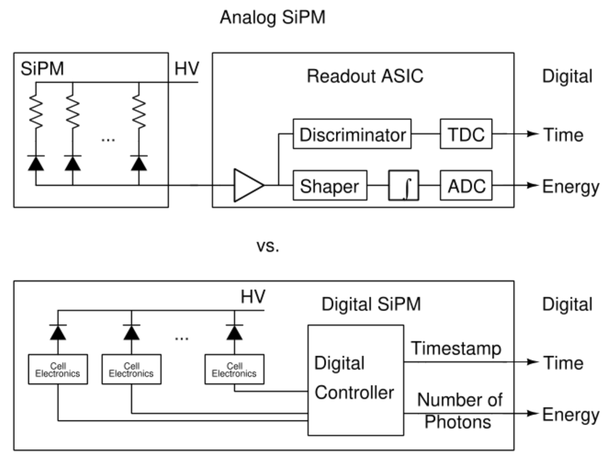


Schematic of proposed Muon Scintillator Detector in ANDES [1-3]

- Muon generates photons (410 nm/blue) in scintillator
- Photons are absorbed (+re-emitted at 485 nm (green)) by wavelength shifting (WLS) fiber and detected by SiPM
- Improve detector with better time resolution of SiPM
  - Detect **position** of impinging muon by measuring the arrival time of each single photon individually
  - Time-of-flight measurements by double-sided fiber readout

Digital SiPM

- Each SPAD has it own digital cell electronics

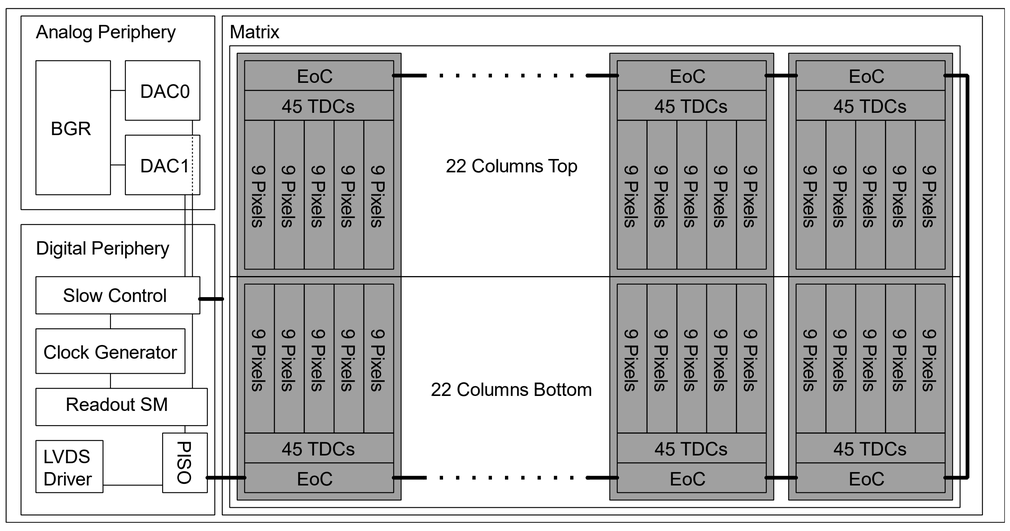


Analog vs. Digital SiPM [4]

- Noisy SPADs can be masked
- Photon hit position information available with specific readout

ANDESPix

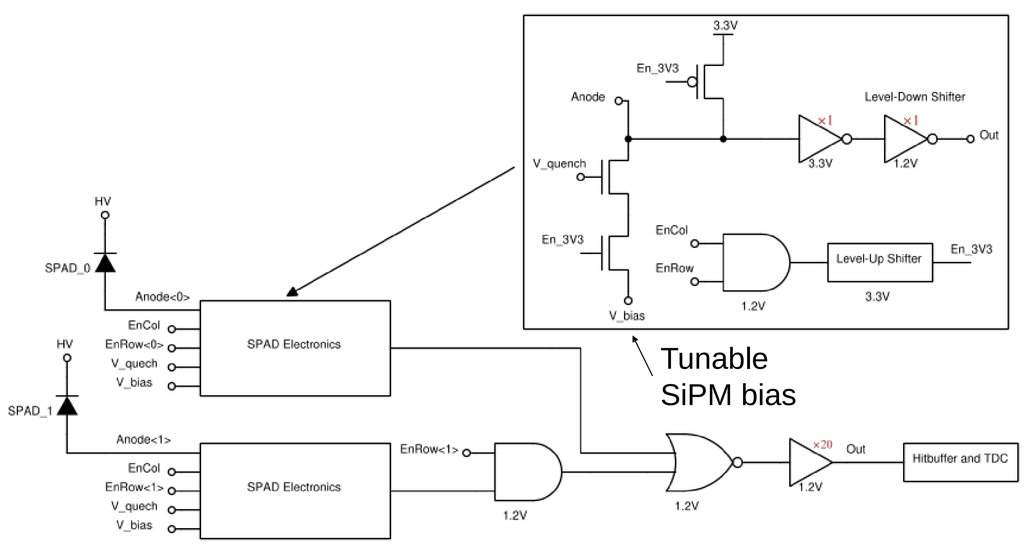
- Digital SiPM with one time-to-digital converter (TDC) per microcell
- Technology: LFoundry 110 nm incl. SPAD addon by FBK



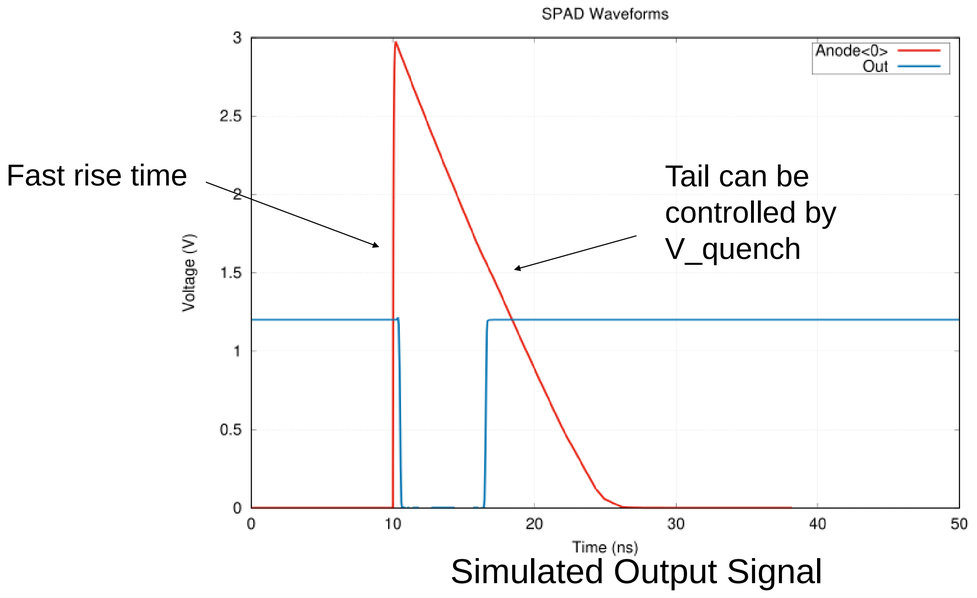
Overview of ANDESPix

- Goal: 100 ps time resolution and high photon-detection efficiency (PDE)
- Pixel matrix can host two scintillating fibers, each producing <50 photons/muon
- DACs to control SPAD bias and quenching time
- Zero-suppressed priority logic readout with hitbuffers and end of column (EoC) buffers
- Different readout modes possible
  - Asynchronous mode: read all hits all the time
  - Synchronous mode: read a certain amount of hits in a certain time frame, discard remaining
  - Self-triggered mode: only read data if internal threshold number of columns with hits is passed

Microcell Electronics



Schematic of Electronics of one Microcell



Simulated Output Signal

References

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[2] A. Aab et al., “Design, upgrade and characterization of the silicon photomultiplier front-end for the AMIGA detector at the Pierre Auger Observatory,” J. Inst., vol. 16, no. 01, pp. P01026–P01026, Jan. 2021, doi: 10.1088/1748-0221/16/01/P01026.
[3] A. Aab et al., “Muon counting using silicon photomultipliers in the AMIGA detector of the Pierre Auger observatory,” J. Inst., vol. 12, no.03, pp. P03002–P03002, Mar. 2017, doi: 10.1088/1748-0221/12/03/P03002.
[4] T. Frach, G. Prescher, C. Degenhardt, R. de Gruyter, A. Schmitz, and R. Ballizany, “The digital silicon photomultiplier — Principle of operation and intrinsic detector performance,” in 2009 IEEE Nuclear Science Symposium Conference Record (NSS/MIC), Oct. 2009, pp. 1959–1965. doi: 10.1109/NSSMIC.2009.5402143.

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