CPAD 2021 - **Fast Electronics for Timing Detectors**

Fast Timing Circuits at SLAC

A. Dragone, B. Markovic on behalf of the SLAC team
dragone@slac.stanford.edu

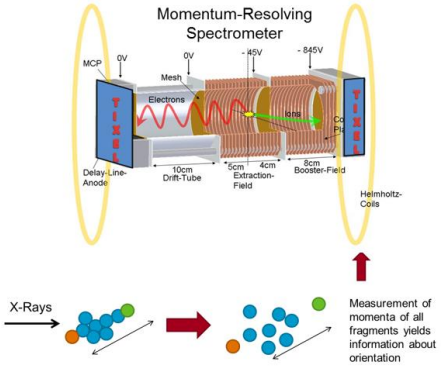
U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

Timing ASICs @ SLAC

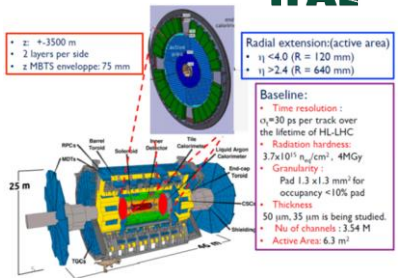
Tixel (SparkPix family)

- Application: **Photon Science**
- Detector Type: Hybrid **PAD**
- Sensor: Thin **Si**
- ASIC Technology: 0.13µm
- Resolution: **100ps**
- Pixel: **100x100µm²**
- TDC area: **85x45µm²**
- TDC DR: **16bits (4 + 4 + 8) - 1µs**
- TDC Power: **16µW**



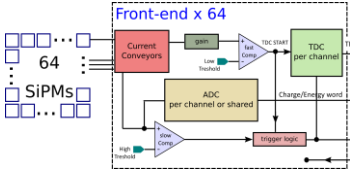
HGTD (Altiroc)

- Application: **HEP**
- Detector Type: Hybrid **PAD**
- Sensor: **LGAD**
- ASIC Technology: 0.13µm
- Resolution: **20ps**
- Pixel: **1.3x1.3mm²**
- TDC area: **210x430µm²**
- TDC DR: **7bits (5 + 2) – 2.56ns**
- TDC Power: **460µW (10% occupancy)**



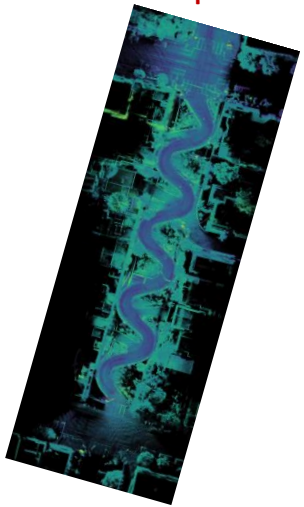
SiPM ToF PET

- Application: **Nuclear Medicine**
- Detector Type: Hybrid
- Sensor: **SiPM**
- ASIC Technology: 0.13µm
- Resolution: **10ps**
- Channel width: **250µm (64 channels)**
- TDC area: **450x430µm²**
- TDC DR: **11bits (5+2+4) – 20ns**
- TDC Power: **650µW (10% occupancy)**



ToF LiDAR (CRADA)

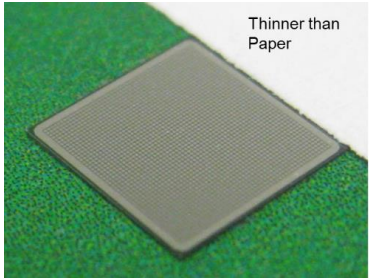
- Application: **Automotive**
- Detector Type: Monolithic
- Sensor: **SPAD**
- ASIC Technology: 0.13µm HV
- Resolution: **1ns**
- Channel width: **400µm (80 channels)**
- TCSPC area: **200x140 µm²**
- TDC DR: **10bits**
- TCSPC Power: **1000µW**



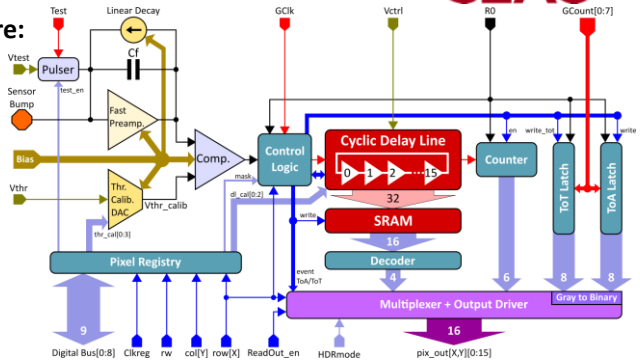
Timing ASICs @ SLAC - Tixel

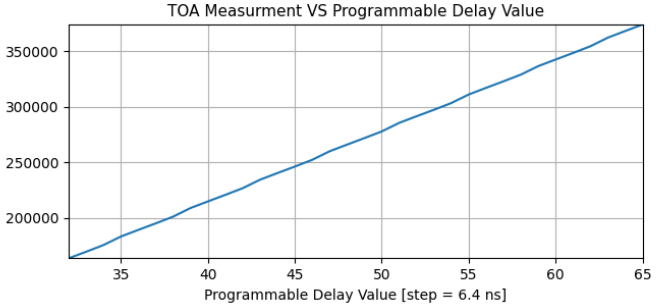
TID-AIR

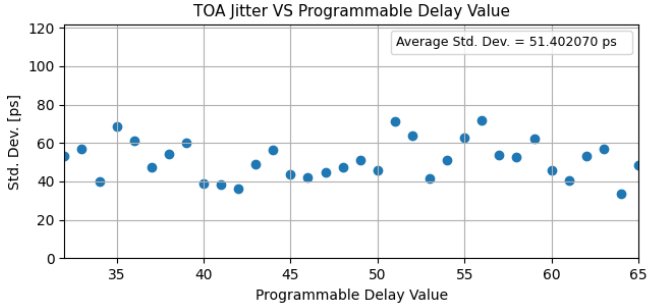
	Tixel
Mode of Operation	Time of Arrival (+ ToT)
Timing resolution	100ps
Technology	130nm
Pixel size	100x100 µm²
Array	(176x192) x 4 tileable
Range	1keV-10keV
Max Hit rate / area	49Mhit/s/cm²
Gating	min 5ns
Pixel dead time	200ns

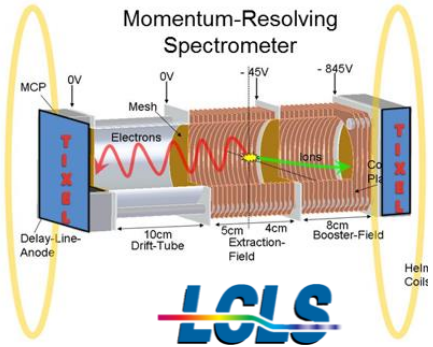


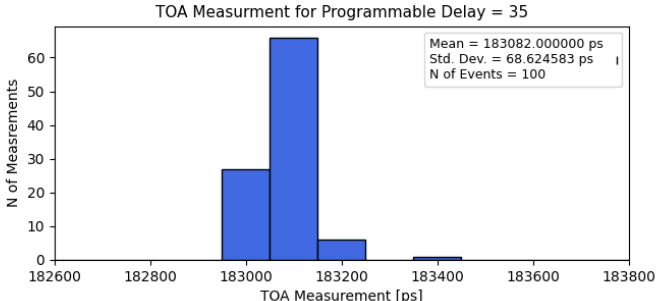
Pixel Architecture:

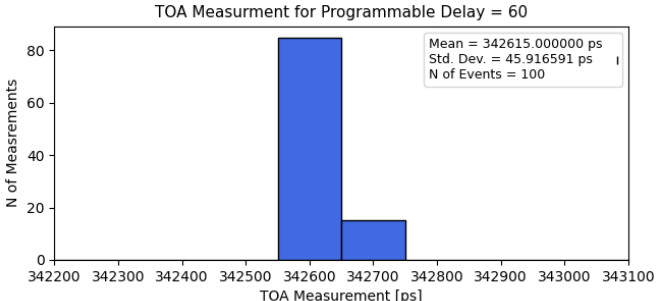








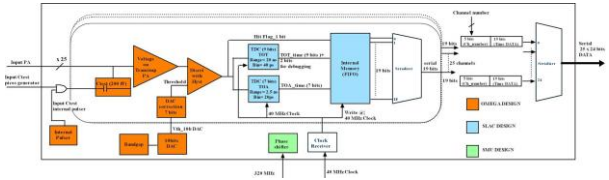




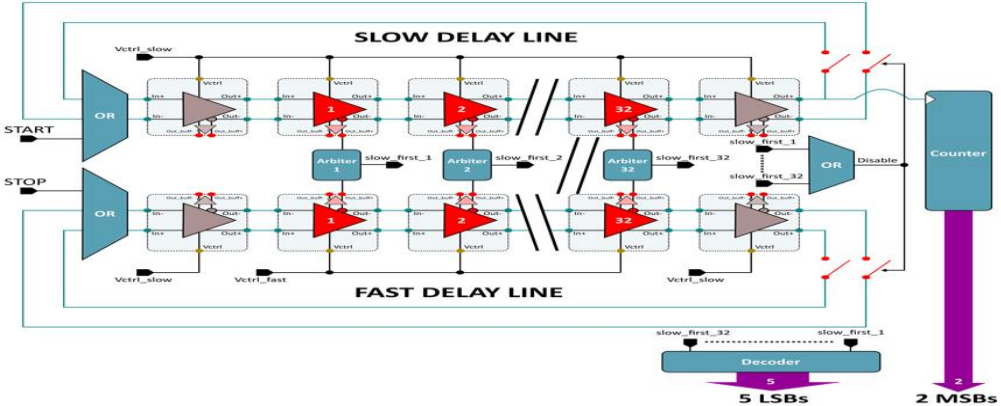
Timing ASICs @ SLAC – HGTD (Altiroc ASIC)

TID-AIR SLAC

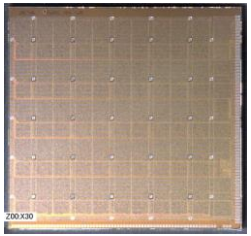
Pixel Architecture:

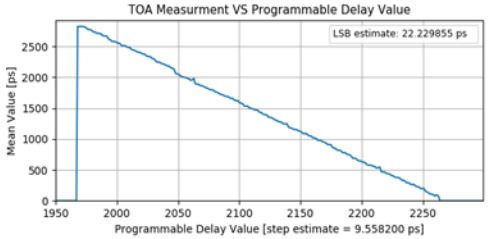


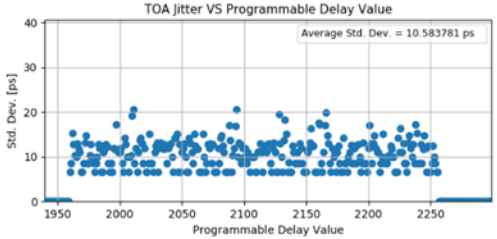
TDC Architecture:

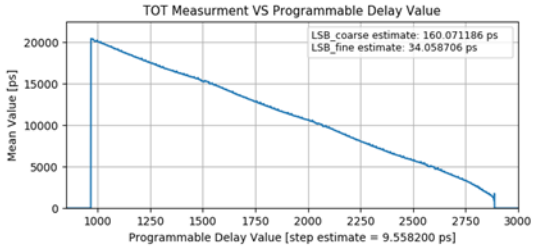


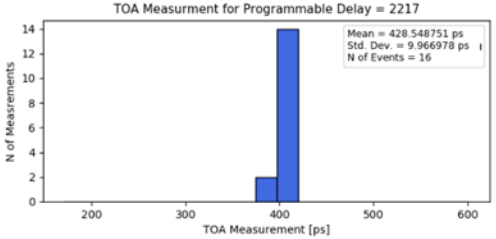
ALTIROC1:

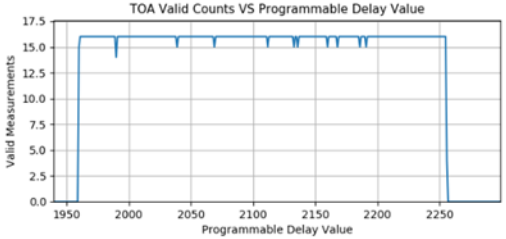


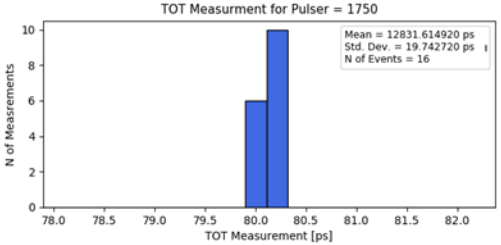








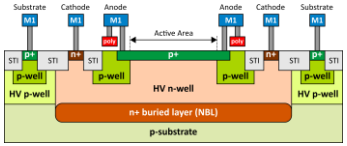


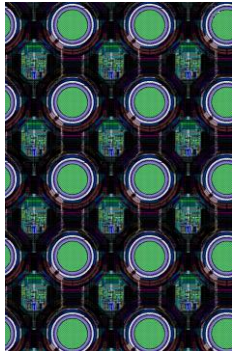


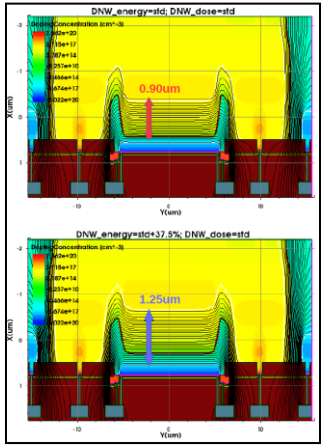
Timing ASICs @ SLAC –ToF LiDAR (CRADA)

TID-AIR SLAC

SPAD Array Design @ SLAC:

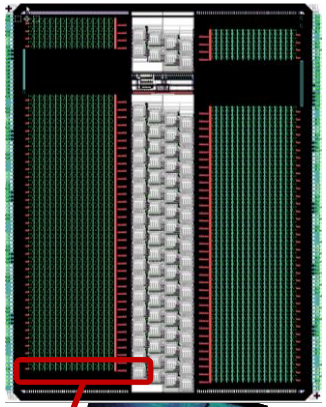


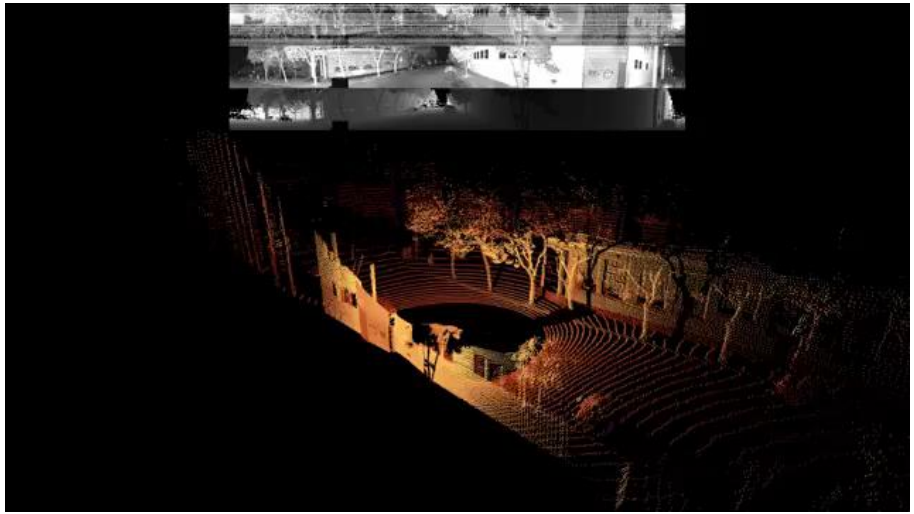


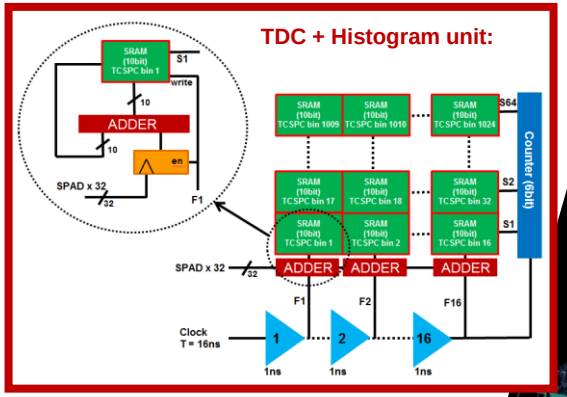


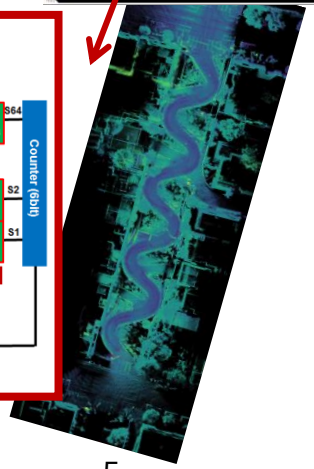
ToF real-time histogramming ASIC with monolithic SPAD array

- 80 macro-pixels with 32 SPADs each
- Photon Counting: 20bit counter for each SPAD
- Photon Timing: 10bit, 1ns resolution TDC and in-chip 1024 bin, 10bit depth Histogram unit per macro-pixel









Next steps: Toward 4D trackers and calorimeters

- Participating in the CERN 28nm Forum
- Started exploring designs in 28nm HPC+
- Focus on TDCs order 10ps, trade-off
  - Power
  - Area
  - DR
- Interested in collaborating with other groups