TIIMM-1 Design Report

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STRONG 2020

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STRONG – TIIMM: strategy & requirements

The TIIMM

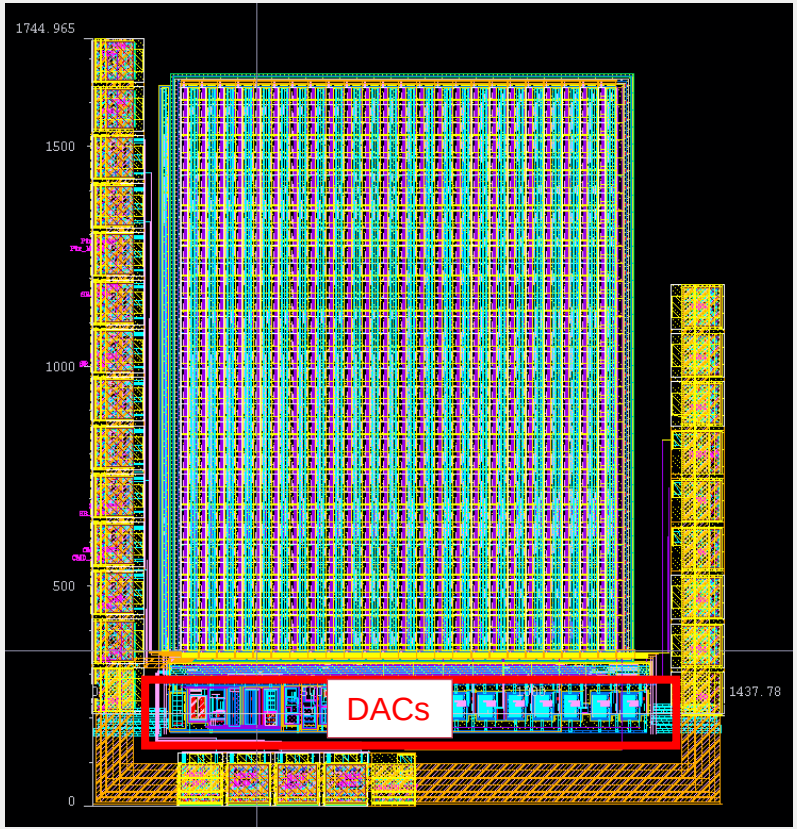
The TIIMM (Tracking and Ions Identifications with Minimal Material budget) project in STRONG aims to create a new class of instrument combining precision tracking and energy loss measurement in conditions where minimizing the crossed material is mandatory.

TIIMM-prototype expectations

-TIIMM-prototypes target to establish a pixel architecture allowing to digitize in-pixel the charge collected.

- Prominent difficulty is the dynamic range: signal equivalent charge from 500 e- to 500 ke- (possibly reduced to 100-200 ke- by charge sharing among pixels
- Pixel pitch should be as small as possible, at least smaller that current hybrid-pixel sensors (50 µm pitch).
- 2 to 3 prototypes should help optimize the resolution on the collected charge and the dynamic range
- Prototypes do not investigate the sensor read-out architecture.

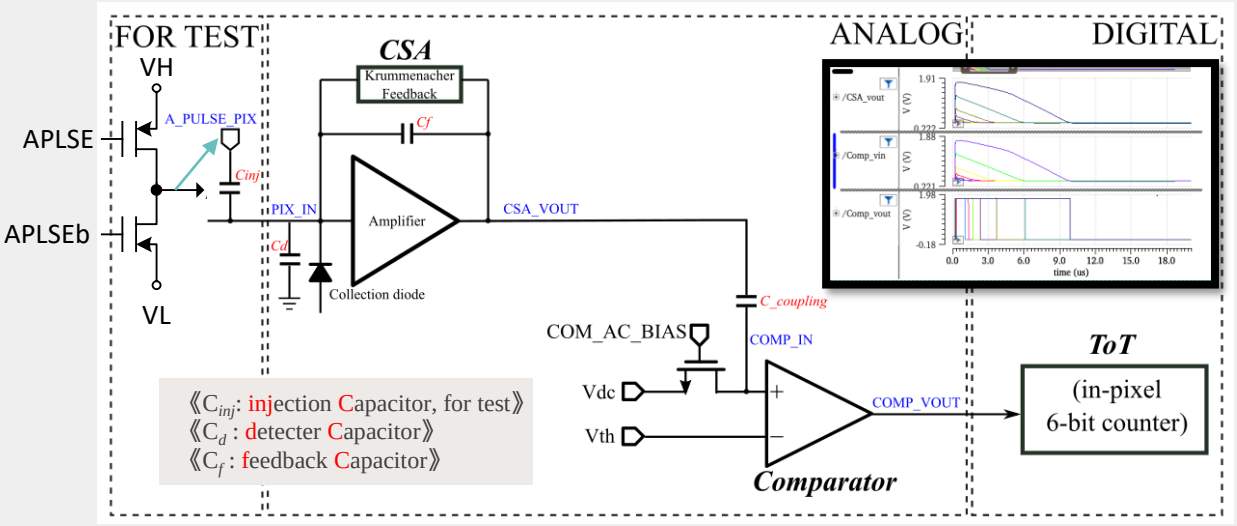
TIIMM1 layout



- Matrix: 32 (rows) * 24 (columns)
- Pixel analog: new analog pixel is used for TIIMM1.
- Pixel digital: the TIIMM1 digital part is the same as in TIIMM0 but with the TrimDAC functionality removed.
- DACs inside the chip.

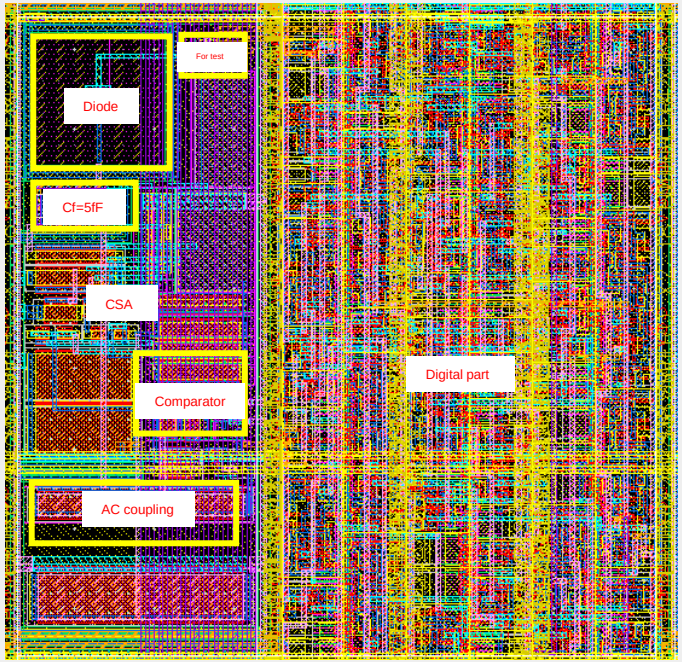
TIIMM1

- CMOS Monolithic Active Pixel Sensor
- Design in TowerJazz 180 nm process
- Matrix: 32 (rows) * 16 (columns)
- Pixel pitch: ≤ 40 μm
- Analog part in pixel: optimization for better performance
- Digital part in pixel: use the same readout structure in TIIMM-0
- The charge is digitized over 6 bits (ToT).

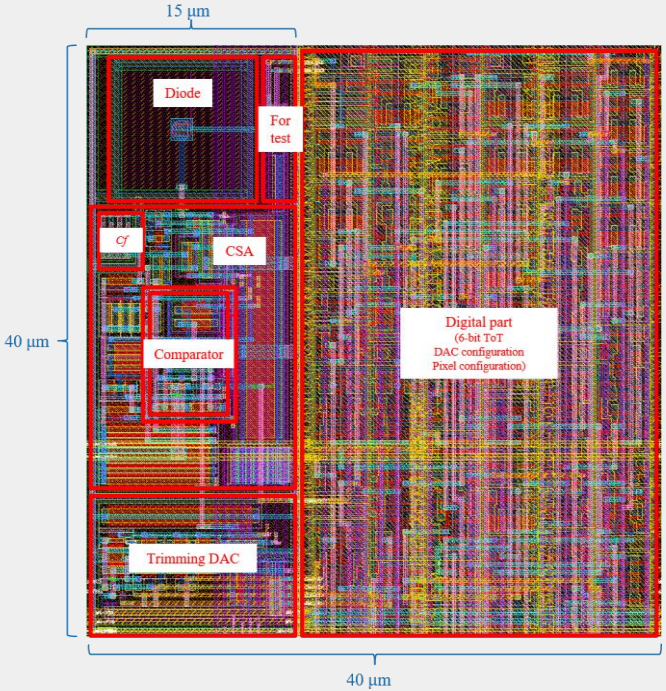


1. AC coupling structure (C_coupling).
2. Optimization of the CSA.
3. Keep the digital readout structure.
4. Remove the 4-bit trimming DAC and the DAC configuration part.

TIIMM1: Pixel layout



TIIMM1 layout 40 µm×41.2 µm
(Pixel analog: 40 µm×15.44 µm)



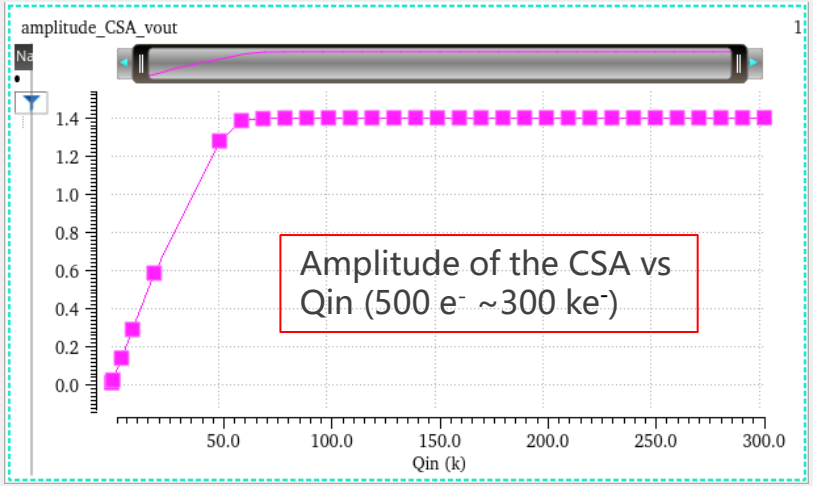
TIIMM0 layout 40 µm×40 µm
(Pixel analog: 40 µm×14.235 µm)

TIIMM1: Pixel analog layout

(Layout sim) **Comp_vin=420mV, Qin=1000 e^-**	**NOM 27℃**	**FAST 0℃**	**SLOW 85℃**
CSA Power [nA]	-	-	-
ENC [e^-]	73.26	63.87	87.51
Amplitude of the CSA output [mV]	26.93	23.92	25.61
Pulse width of the CSA output [nS]	451.1	510	328.9
Baseline of the CSA output [mV]	400	400	400

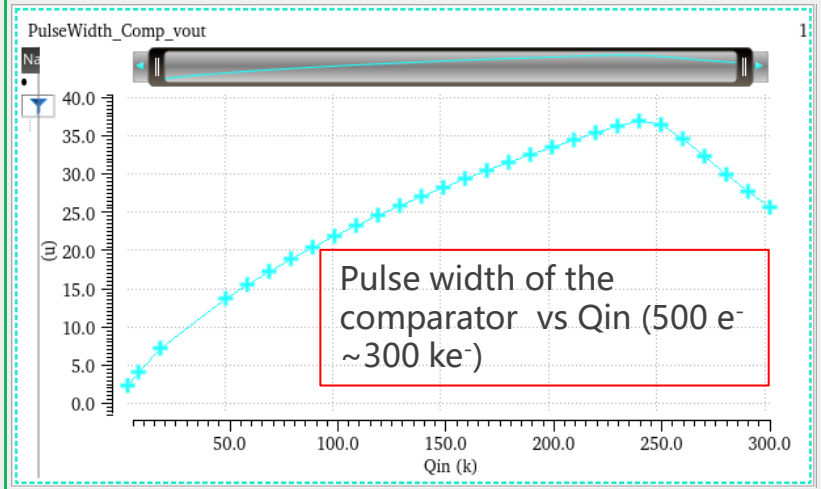
TIIMM1: Pixel analog layout

Amplitude of the csa_vout (V)



Qin (ke-)

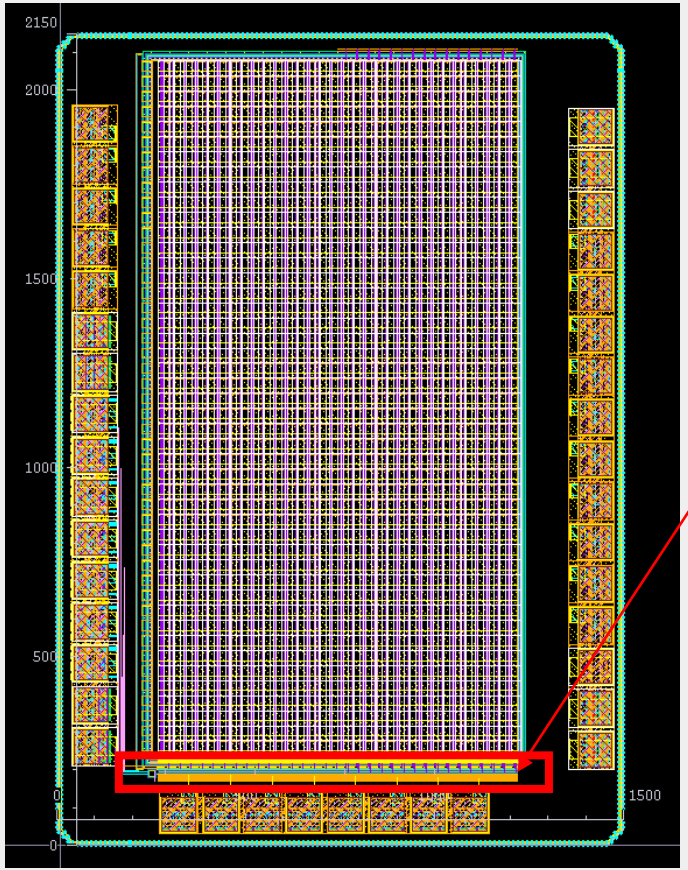
Pulse width of the comparator (µS)



Qin (ke-)

- After Qin >240 ke-, the pulse width decreases with the Qin. The linear range for ToT is 0~240 ke-.

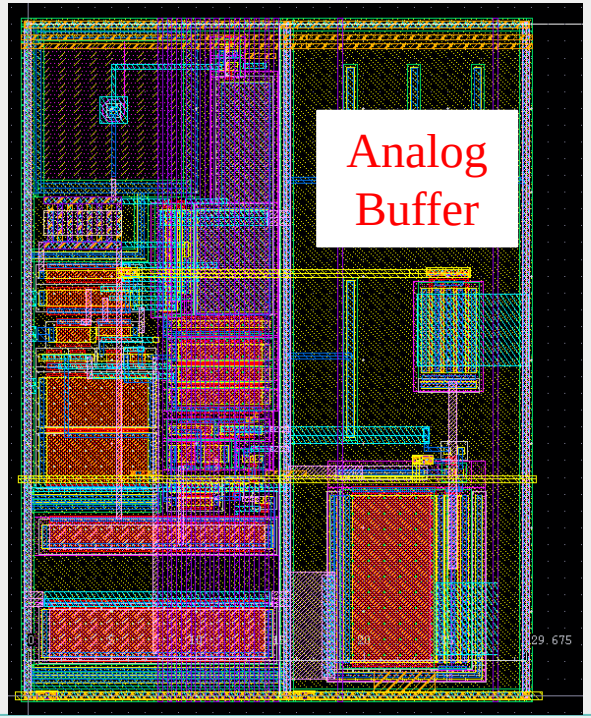
TIIMM1A layout



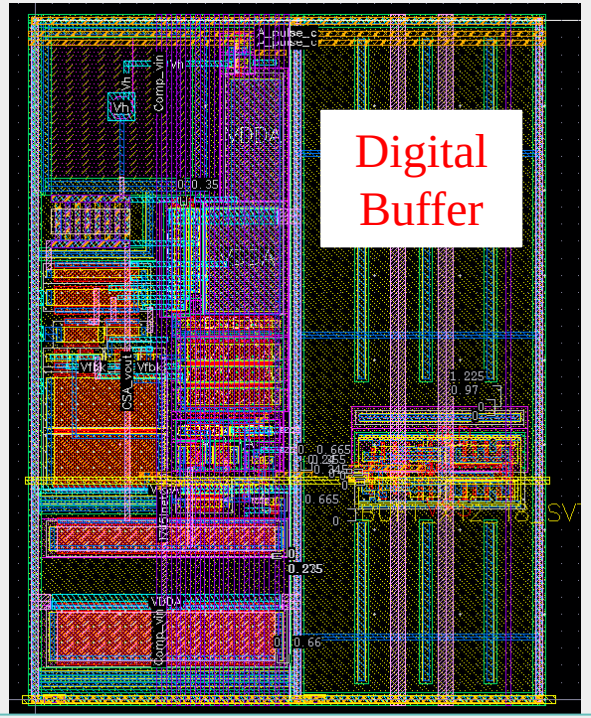
- Matrix: 46 (rows) * 32 (columns)
- 4 submatrixs:
  - A) 8 columns of CSA with DC coupled output (Analog ouput)
  - B) 8 columns of CSA with AC coupled output (Analog ouput)
  - C) 8 columns of the discriminator with the inputs from PADs (Digital ouput)
  - D) 8 columns of CSA with the discriminator (Digital ouput)

- A 2-bit address is used to select the desired submatrix (TIIMM1A_output_selector).
- No DACs inside the chip, all the biases should be provided from the outside of the chip.

TIIMM1A: Pixel layout



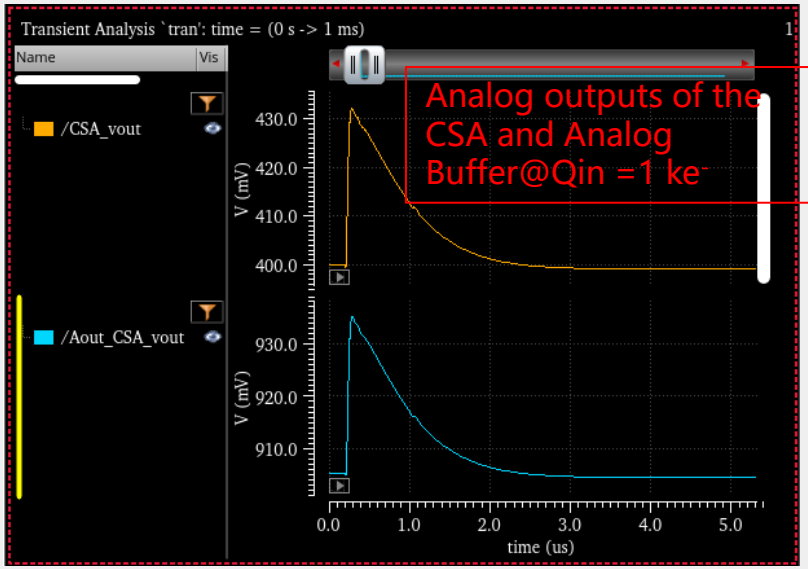
TIIMM1A pixel layout (with analog ouput): 40 µm×29.675 µm)
(Pixel analog: 40 µm×15.44 µm)



TIIMM1A pixel layout (with digital output): 40 µm×29.675 µm)
(Pixel analog: 40 µm×15.44 µm)

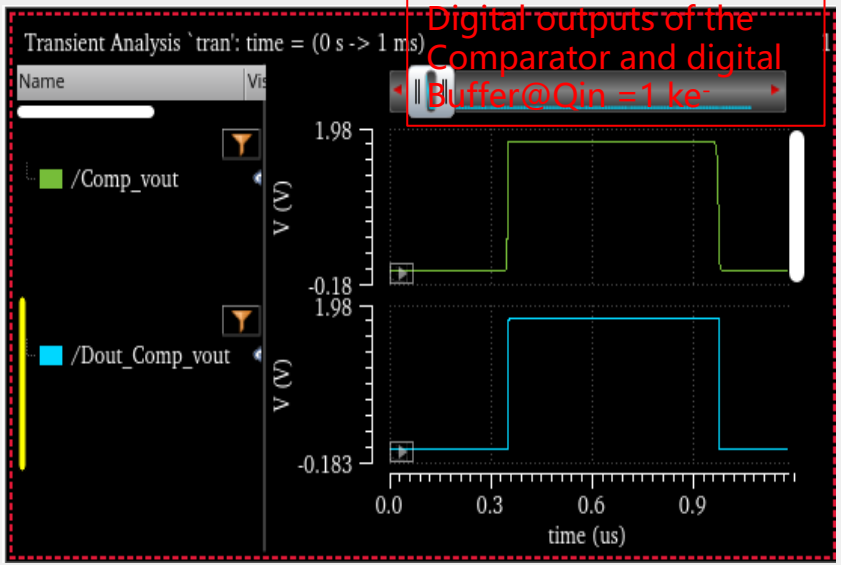
TIIMM1A: Pixel simulation

Analog output (V)



Time(us)

Digital outputs (V)



Time(us)

THANKS!