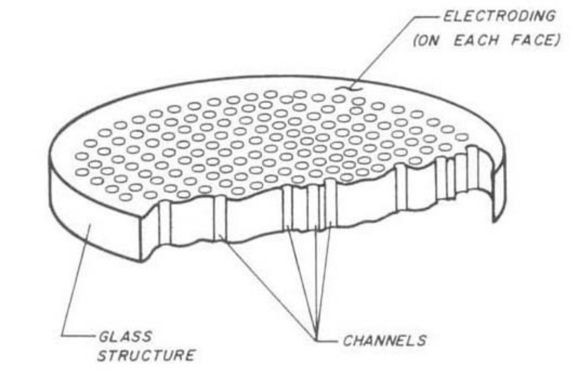
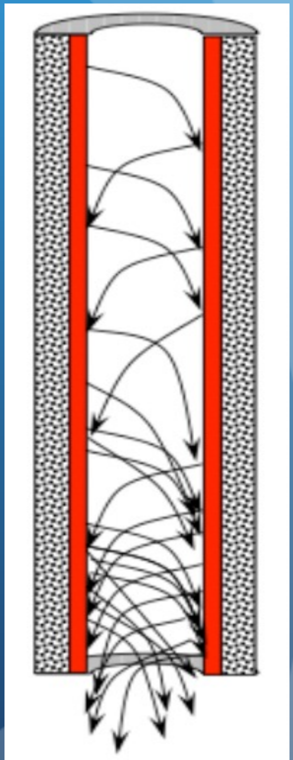
PICMIC status

I.Laktineh
on behalf or the PICMIC groups
IP2I, IPHC,IJCLAB,CPP

Micro Channel Plate (MCP)



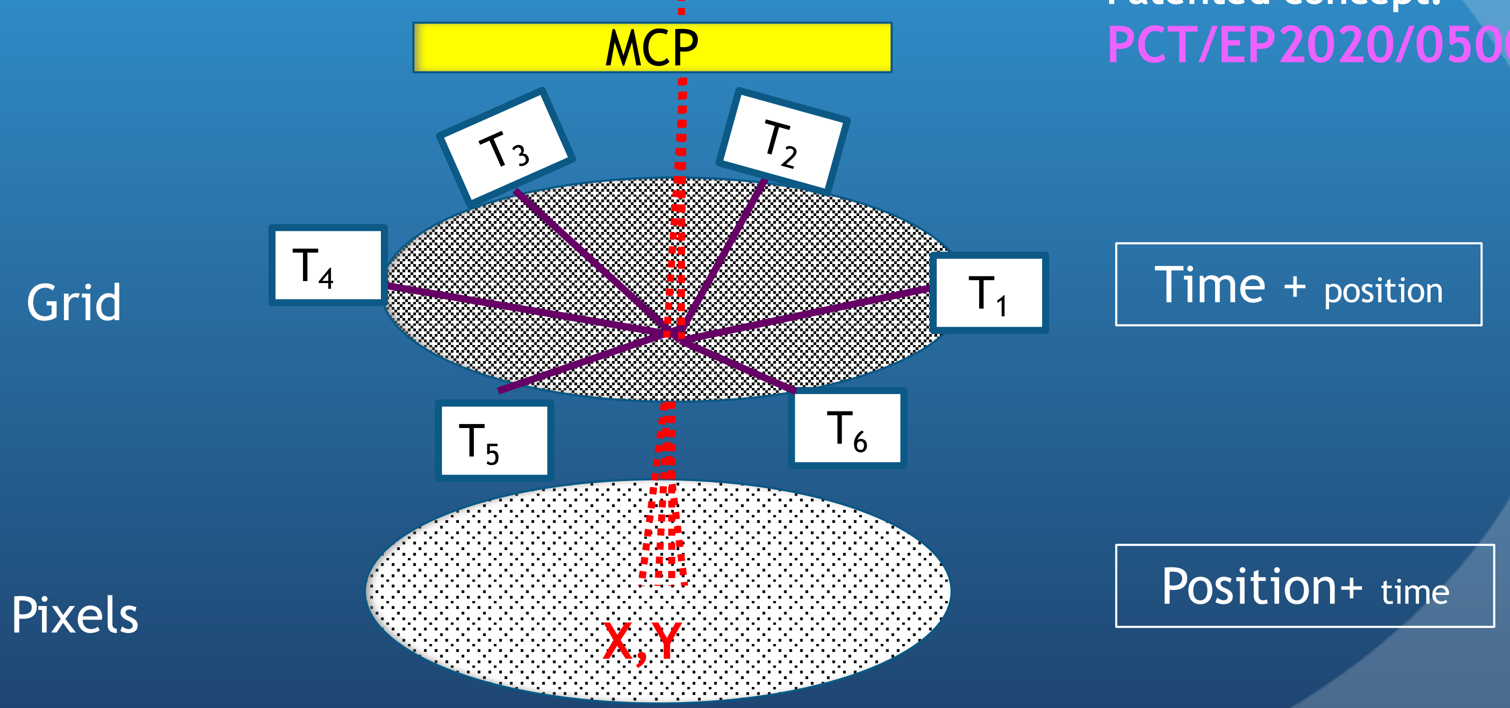
- MCP is considered as the best timing device with a few picoseconds of time resolution.
- Most often there are two plates with the channels oriented in a slightly tilted way (chevrons) to increase the gain and at the same time reduce the ion return impact.
- MCP has an excellent intrinsic spatial resolution since the avalanche produced by the incoming particle is constrained to one of the glass tube whose diameter can ba as small as 2 μm
- MCP are often used for their timing while their spatial resolution is not appropriately exploited.



To fully exploit MCP we propose the following scheme:

- A transparent grid placed downstream and read out by sensors with excellent time resolution
- A detection matrix with micrometric pixels to measure with great precision the position of the avalanche while requiring limited number of electronics channels.

Patented concept:
PCT/EP2020/050058



Confidential

Concept description

- ❑The avalanche crosses a transparent grid connected on its periphery to a few timing sensors
- ❑ The avalanche is then collected by pixels

1- Measure X,Y, from the fired woven strips by

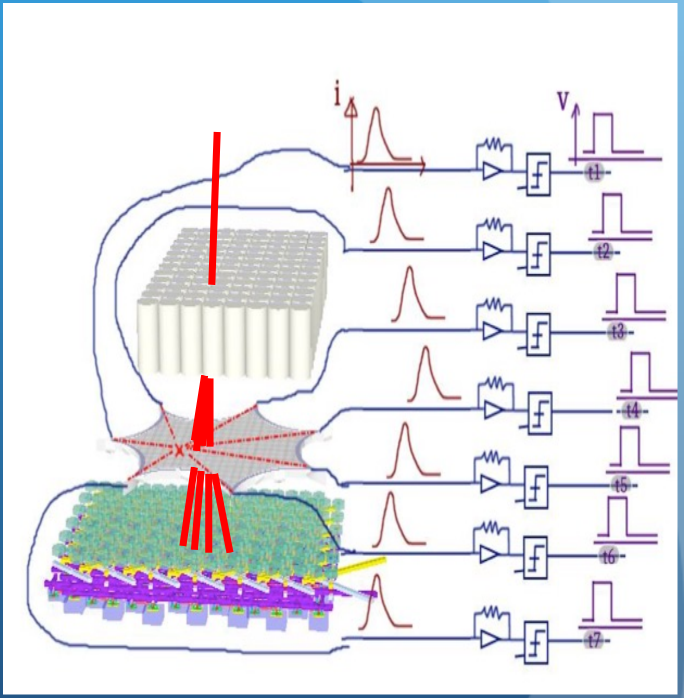
crossing them geometrically

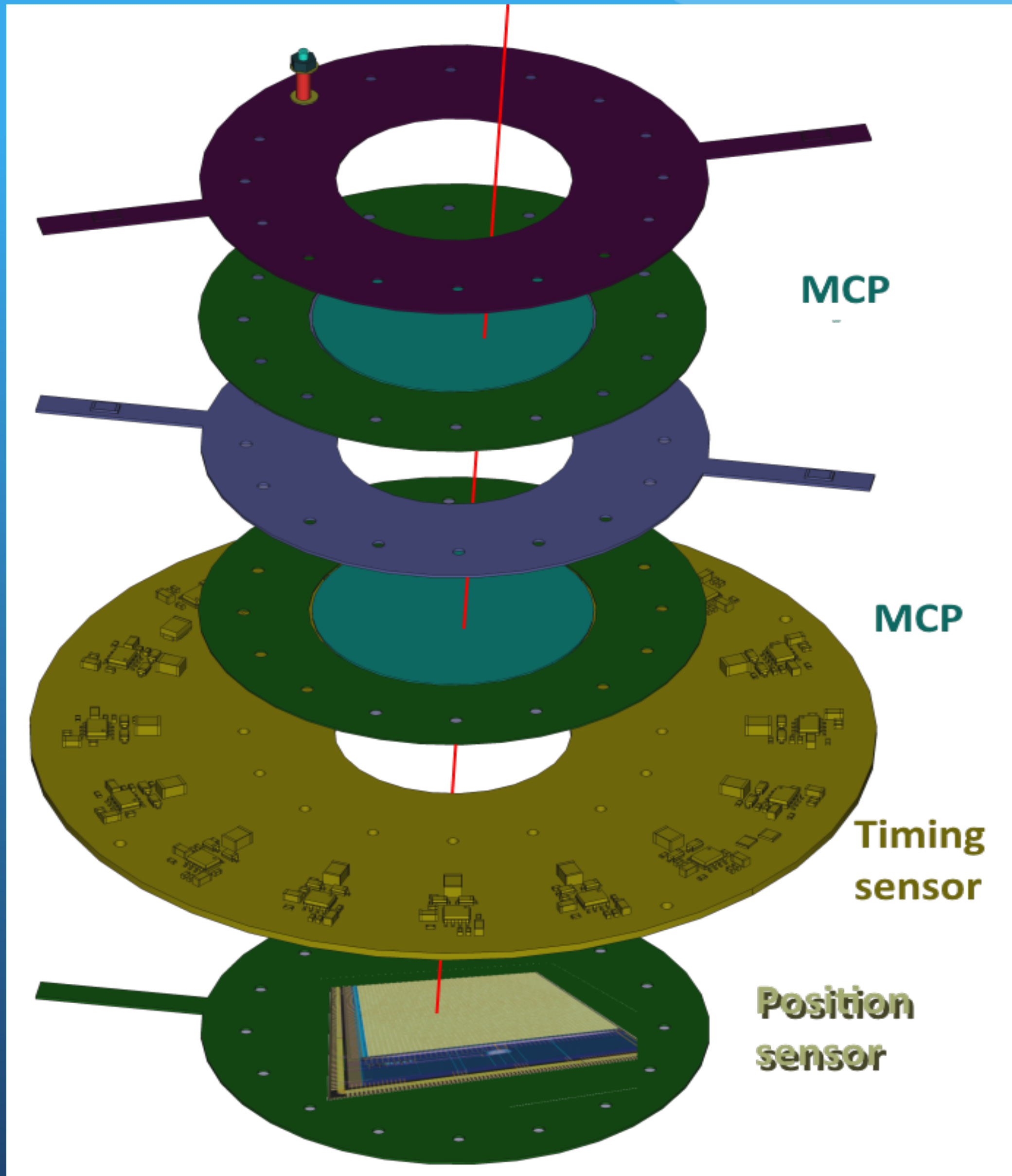
2- Measure T_i (from time sensors)

3-Substract time propagation using speed propagation and X-Y)

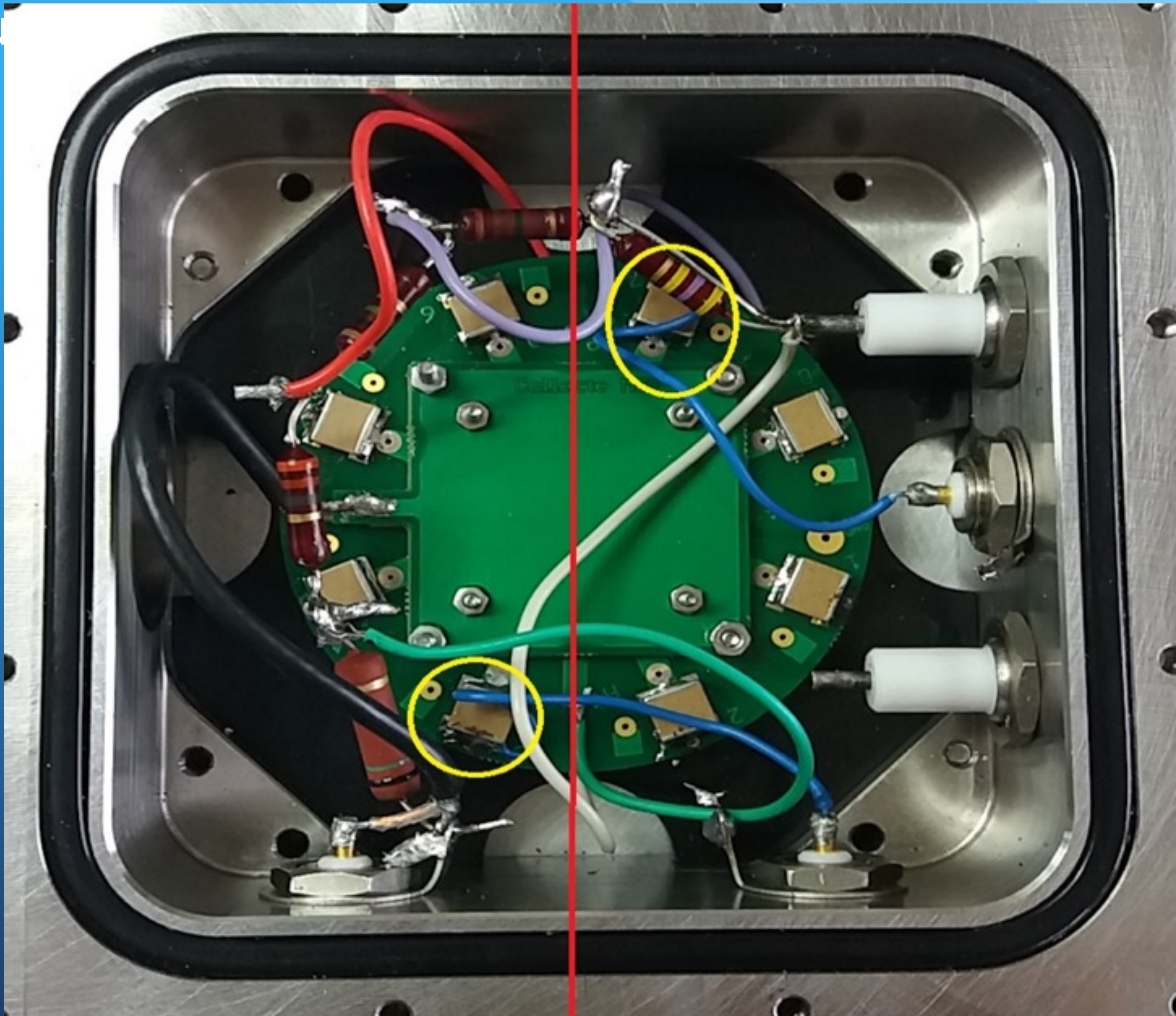
4- average on the (T_i-T_i(propag))

$$T_{abs} = \frac{\sum_0^N T_i - T_{i-propag}}{N}$$



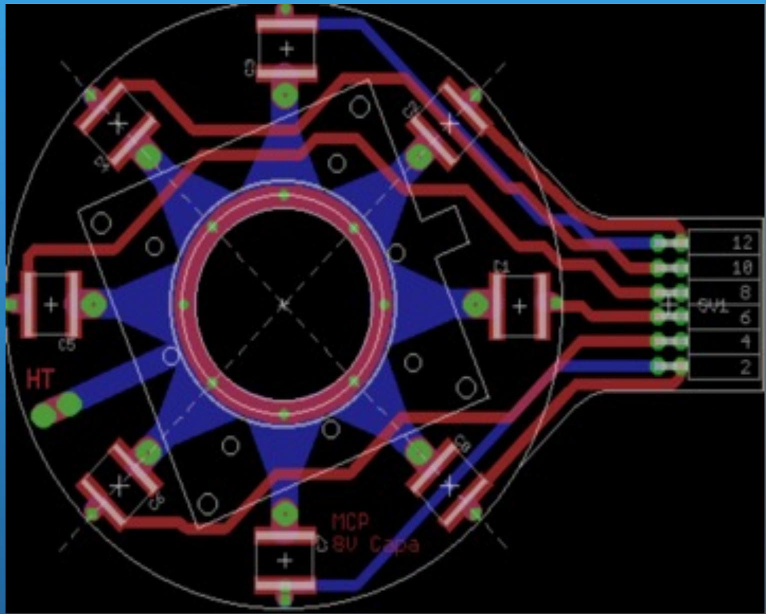

MCP
MCP
Timing sensor
Position sensor

Cu



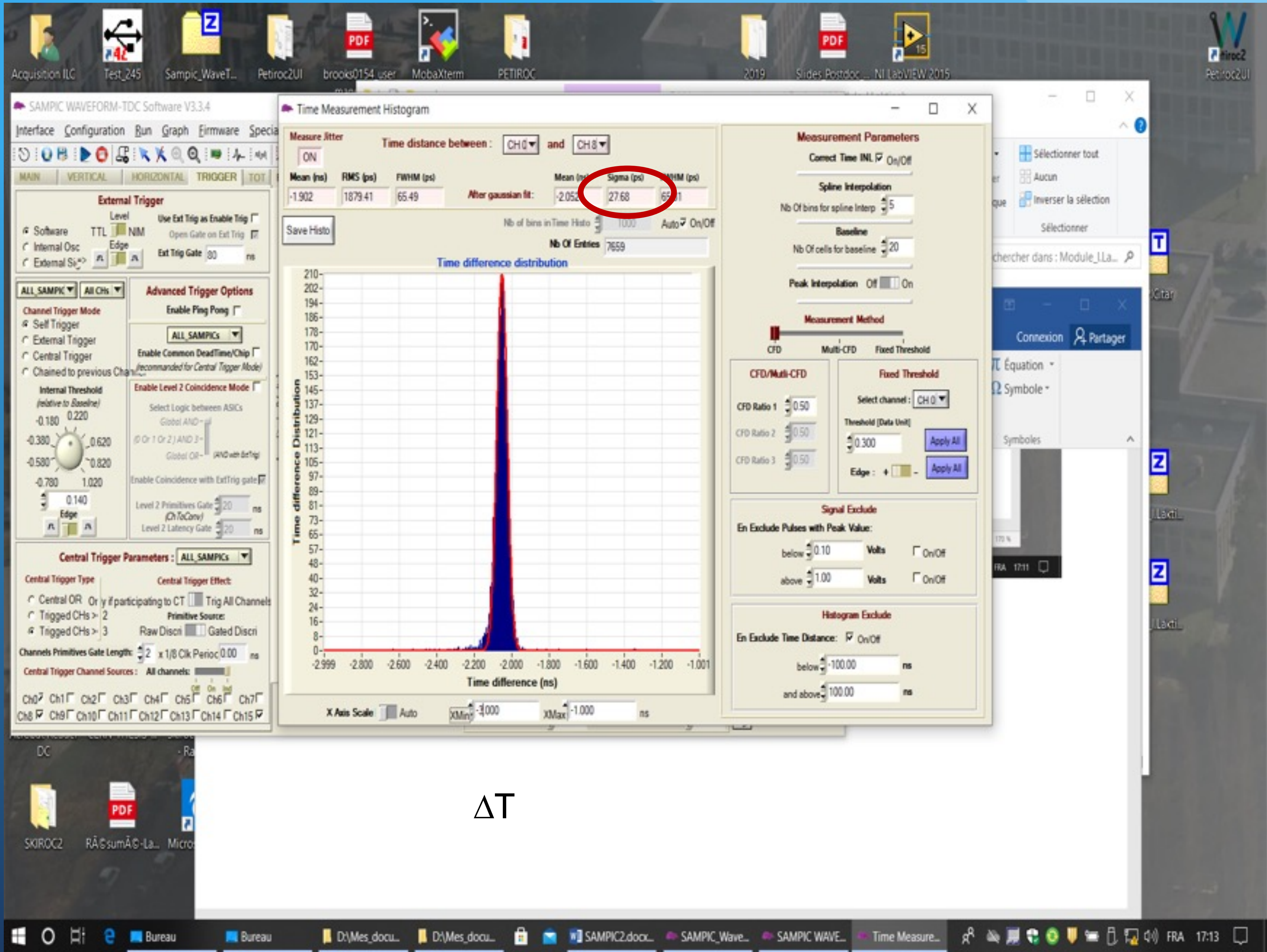
Time Measurement

Principle components for this measurement already exist.



8-point PCB for the time measurement.
PCB to be in contact with the grid (already produced and tested)

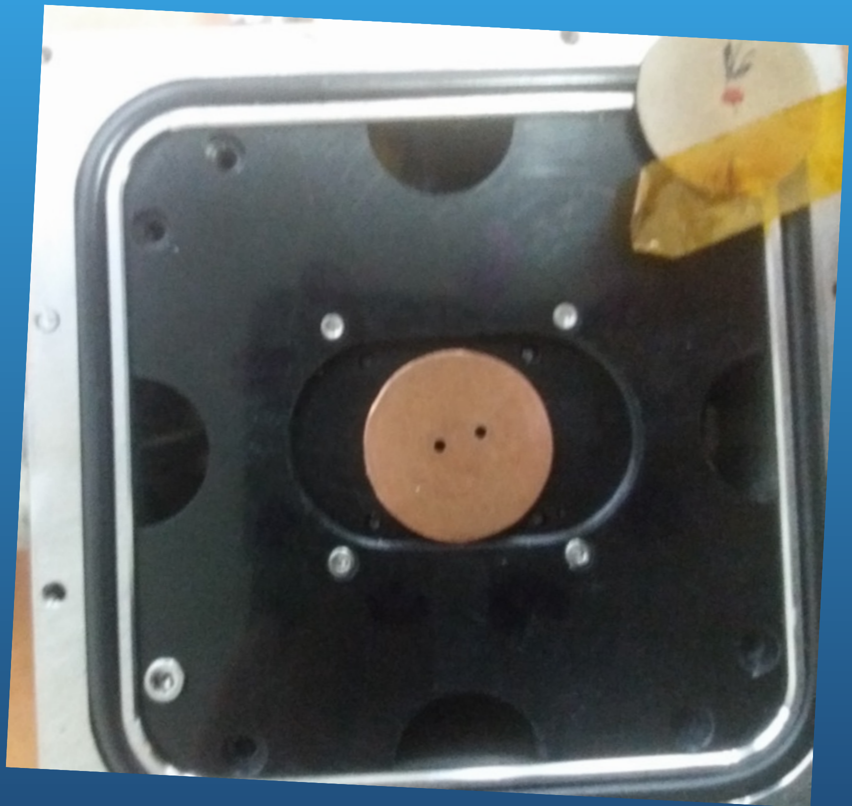
SAMPIC: TDC ASIC allowing to reach 3 ps time resolution

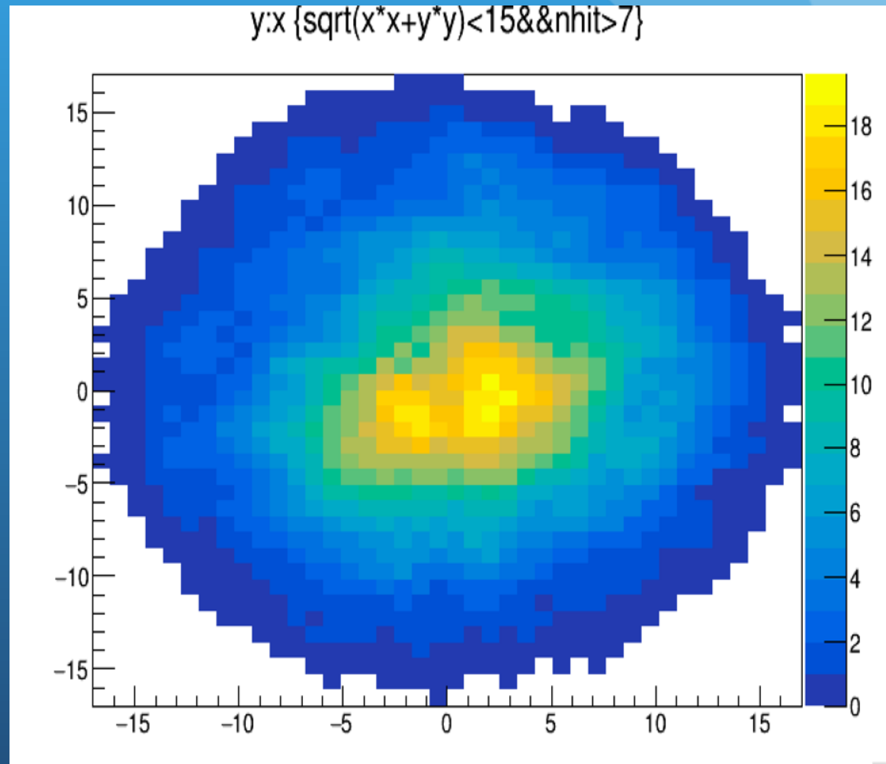


Time Measurement Histogram
SAMPIC WAVEFORM-TDC Software V3.3.4
Measure Jitter
Time distance between : CH0 and CH8
Mean (ns) RMS (ps) FWHM (ps)
-1.902 1879.41 65.49
After gaussian fit:
Sigma (ps)
27.68
Nb Of Entries 7659
Save Histo
Time difference distribution
Time difference Distribution
Time difference (ns)
Measurement Parameters
Correct Time INL On/Off
Spline Interpolation
Baseline
Peak Interpolation
Measurement Method
CFD Multi-CFD Fixed Threshold
Signal Exclude
Histogram Exclude
External Trigger
Advanced Trigger Options
Central Trigger Parameters

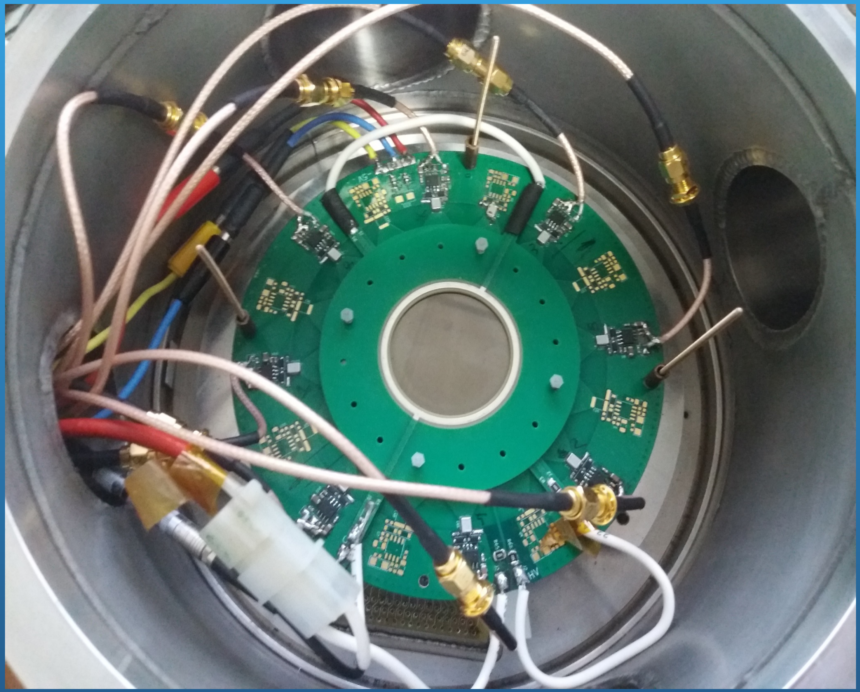
ΔT

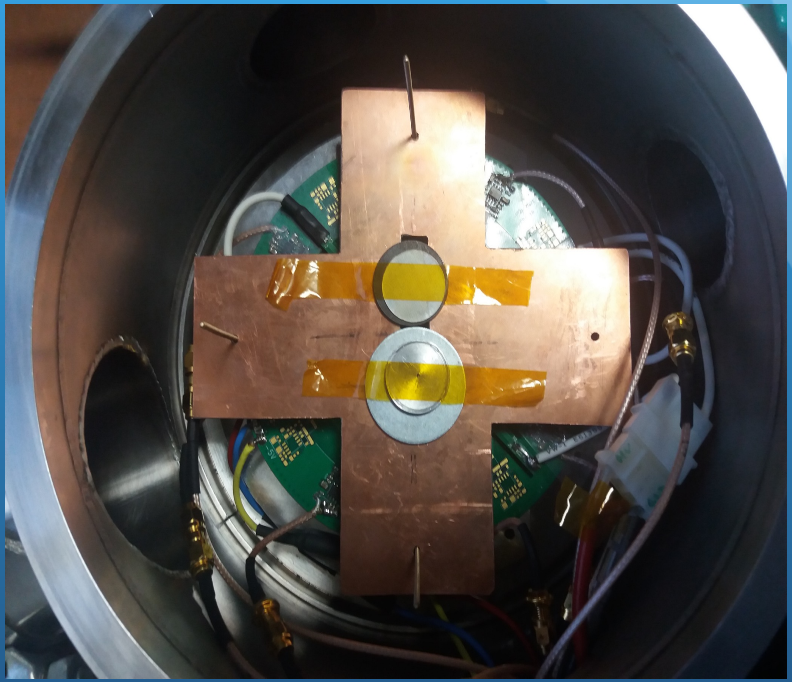
Waiting to have the pixel matrix, two algorithms using the difference of time arrival among the different channels were developed to obtain the position of the hitting particle → a new concept: delay plane





- A new timing PCB equipped with 16 channels was conceived and produced
- A new setup thanks to R. Barbier is used to host this large PCB

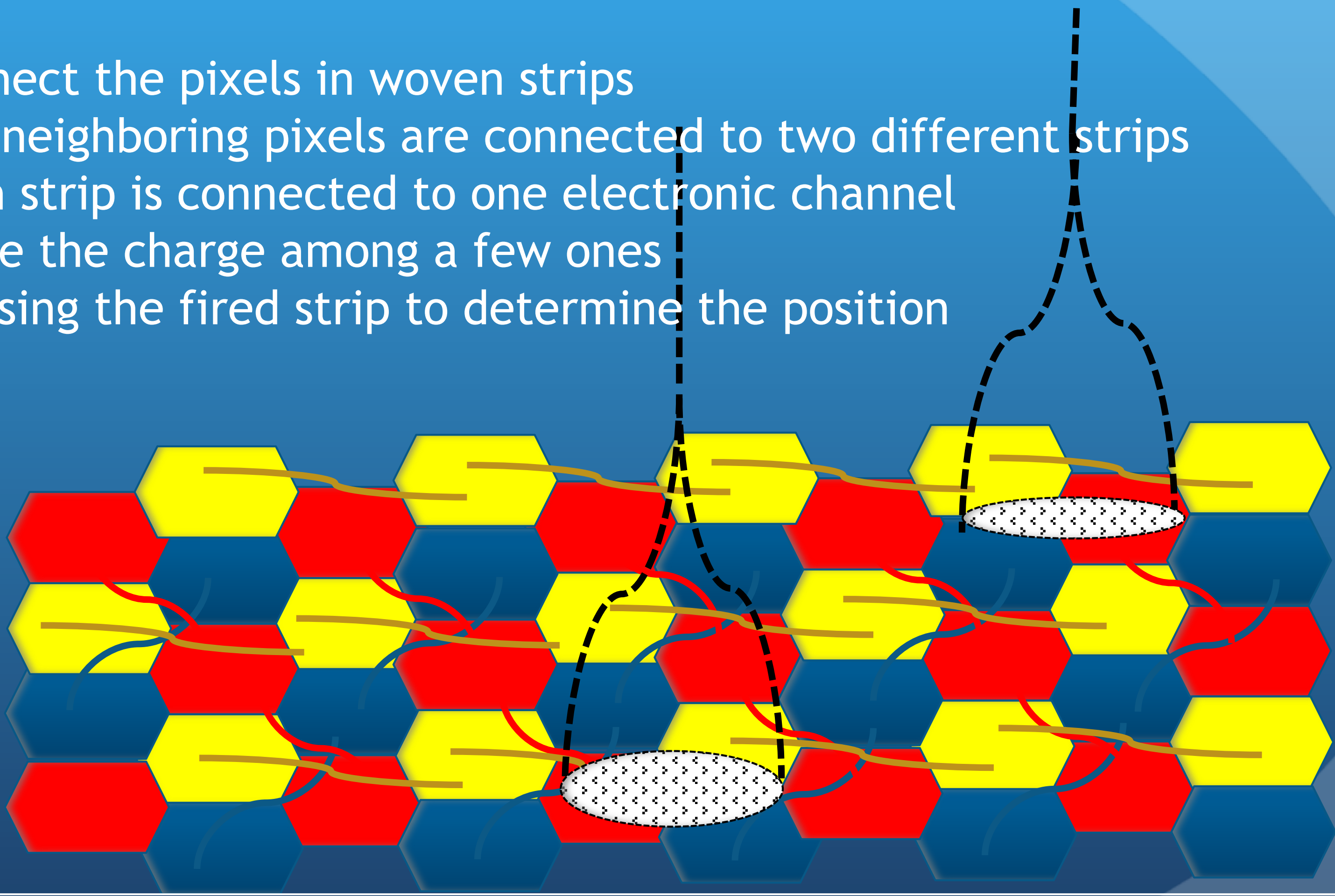




Position measurement

To reach few microns resolution with a limited number of electronic channels, a genuine concept was developed, successfully **tested** and **patented**.

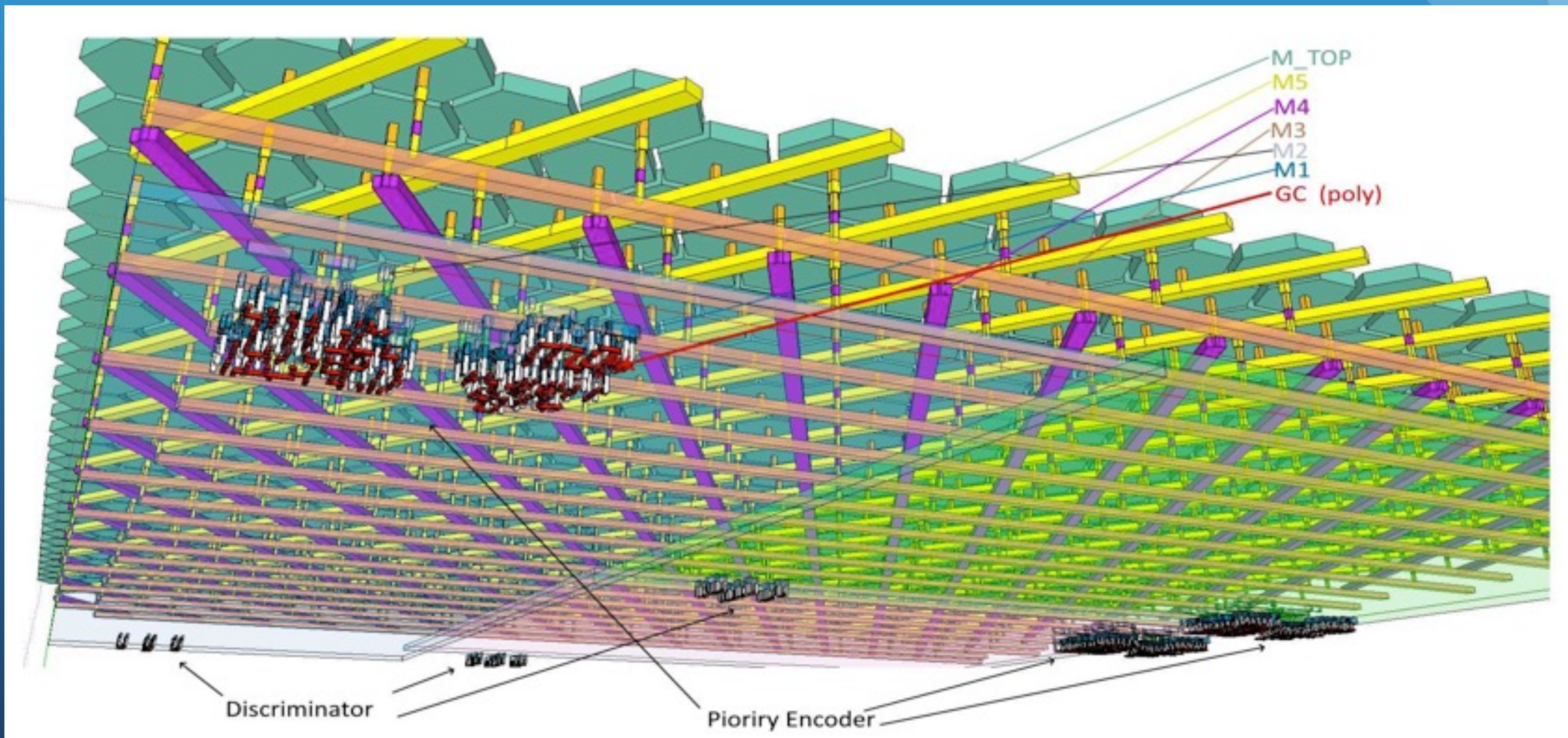
- ❑ Connect the pixels in woven strips
- ❑ Two neighboring pixels are connected to two different strips
- ❑ Each strip is connected to one electronic channel
- ❑ Share the charge among a few ones
- ❑ Crossing the fired strip to determine the position



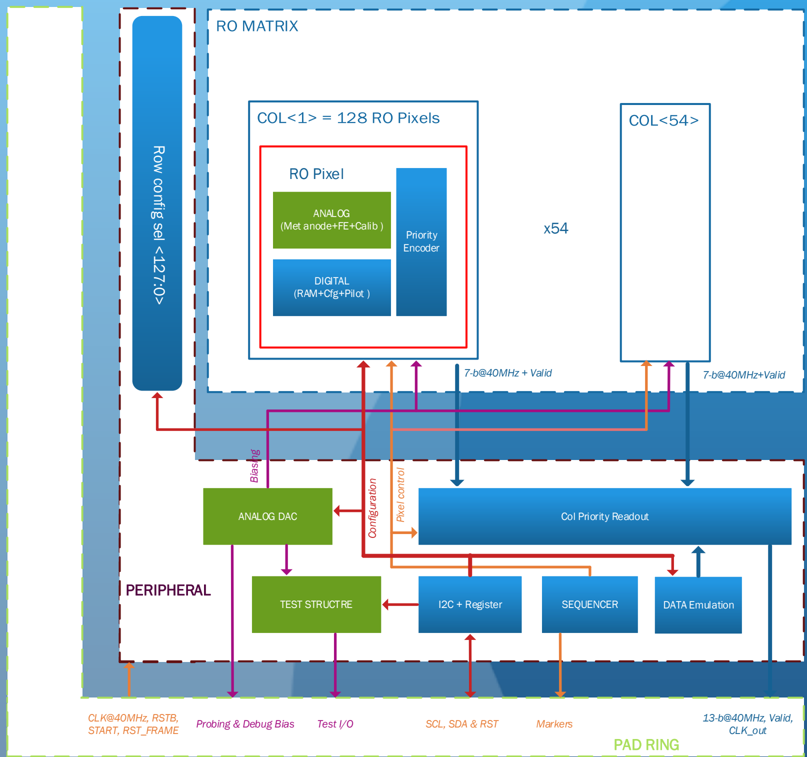
NXN → 3N : Reduction of electronic channels, power consumption and occupancy

Position Measurement

Exploiting the expertise IN2P3 in μelectronics, we propose to read out the connected pixels by CMOS discriminators in TJ 180 nm (6 metal layers) technology.



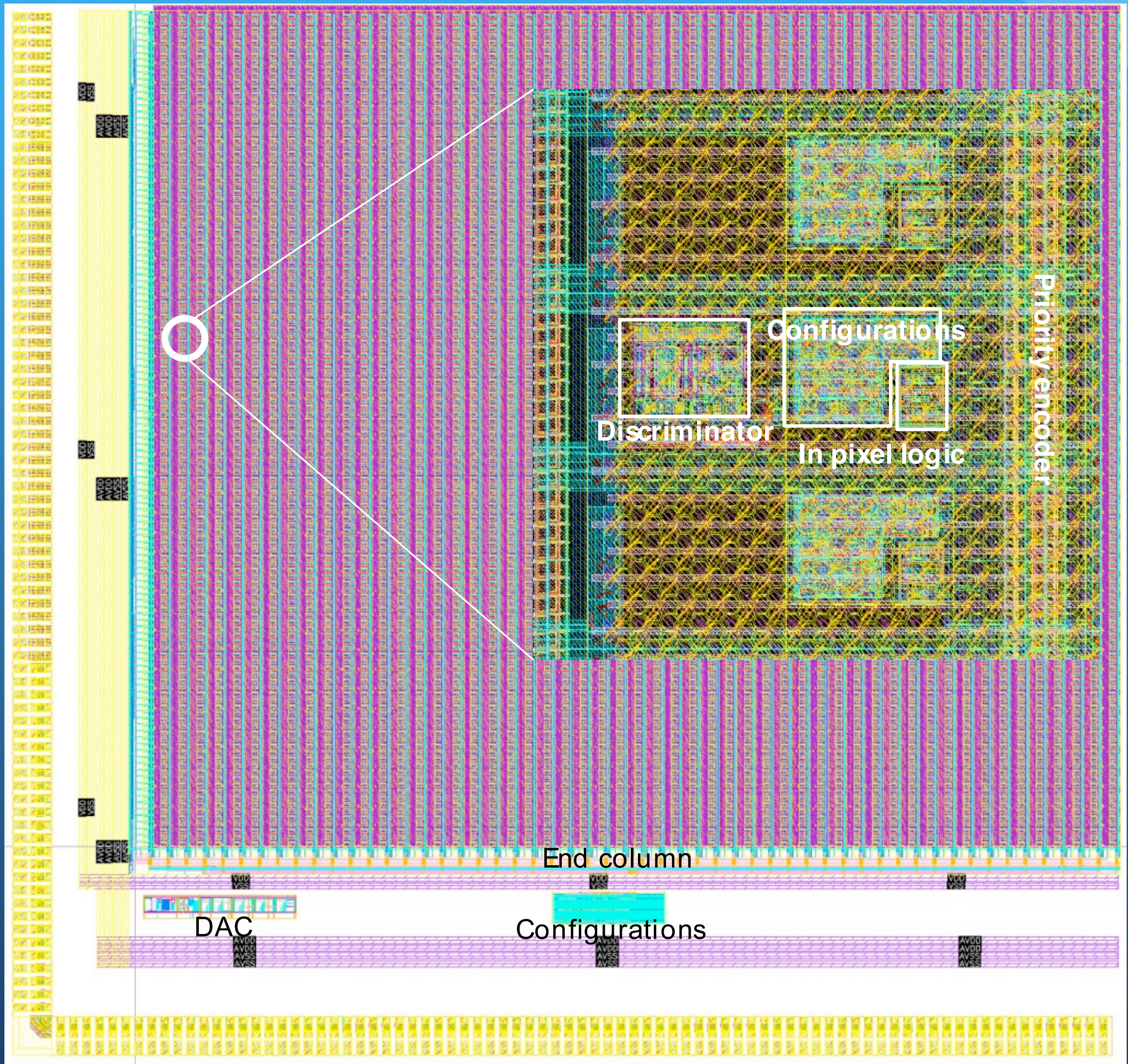
PICMIC Architecture



Priority Encoder

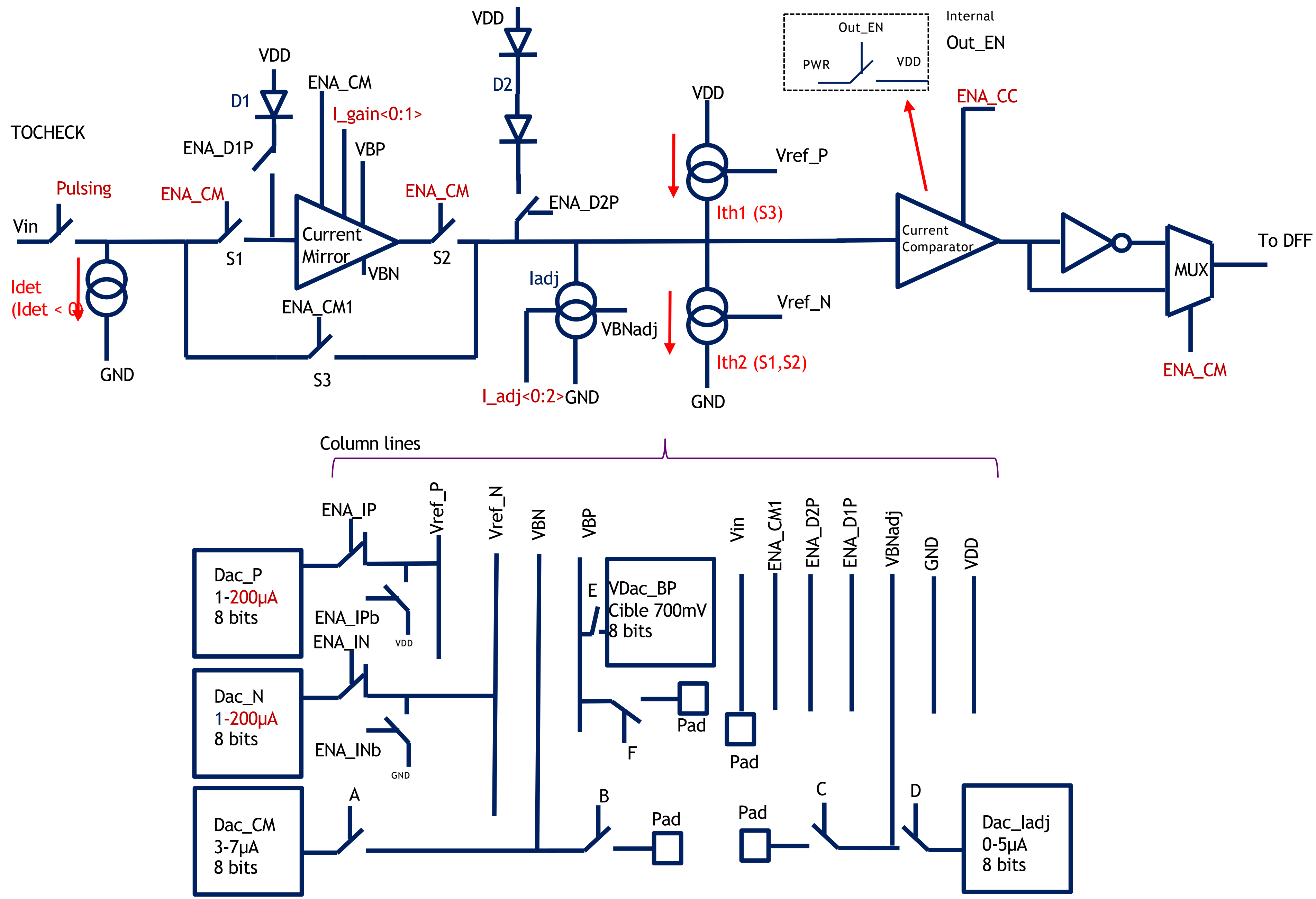
Parameters	Value
Design Flow	Cadence DoT flow
Technology	TJ CIS 180nm
Power supplies	1.8V
Power density	>172mW/cm² (only analog static current)
Die dimension	~7.5x7.5 mm² (6.5x7.5mm² active)
Anode dimension	~22µ²(5µm hexagonal pitch)
Readout pixel dimension	50µmx140µm
Readout matrix	128x54 cells (only 2556 active)
Input clock	40MHz
Read-out port	13-bit parallel, 1 sync clock out, 1 marker (programmable 1clk cycle resolution)
I/O Pad	CMOS
Slow control	I2C
Max data rate (1Mhz hit rate)	390Mbps

PICMIC Layout

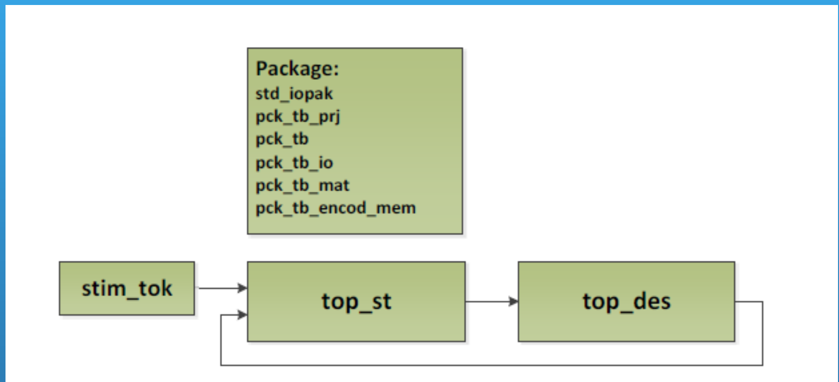


- Only **2556** RO cells are active among the 6912
- The active RO cells are placed in a way to improve heating dissipation
- The 2556 RO cells allow reading out the 2 216 000 pixels

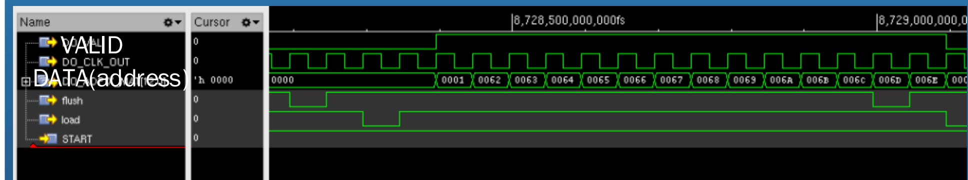
Front End lock



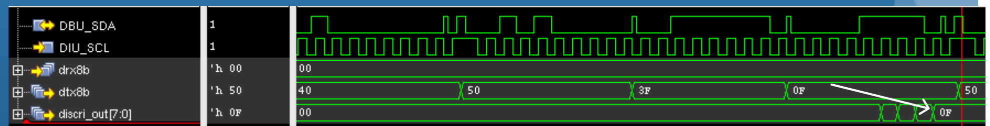
PICMIC Simulation (Digital Matrix + Peripheral)



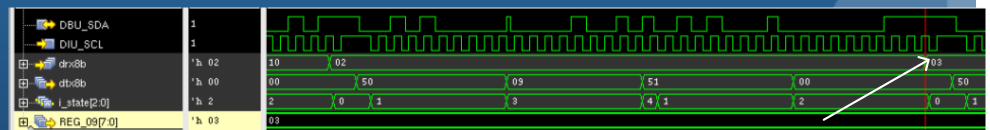
- The simulation validates:
  - I2C Register R & W
  - Analog matrix output by different hit patterns
  - Output data stream with CTS



Output data stream

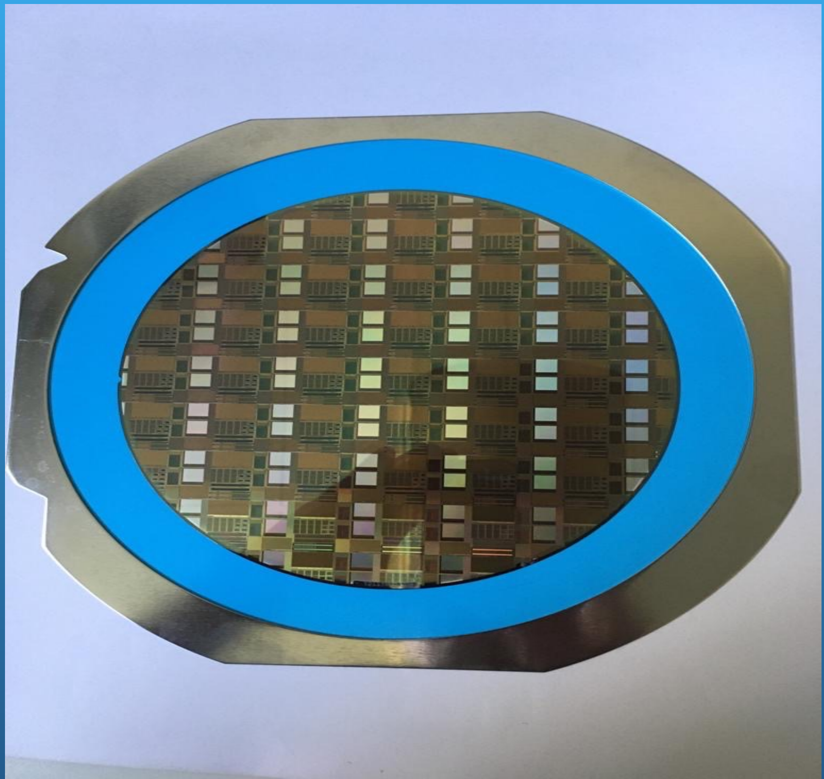


Write Configuration Registers



Read Configuration Registers

The chip was submitted in November 2021 (TowerJazz) and received on July 2022



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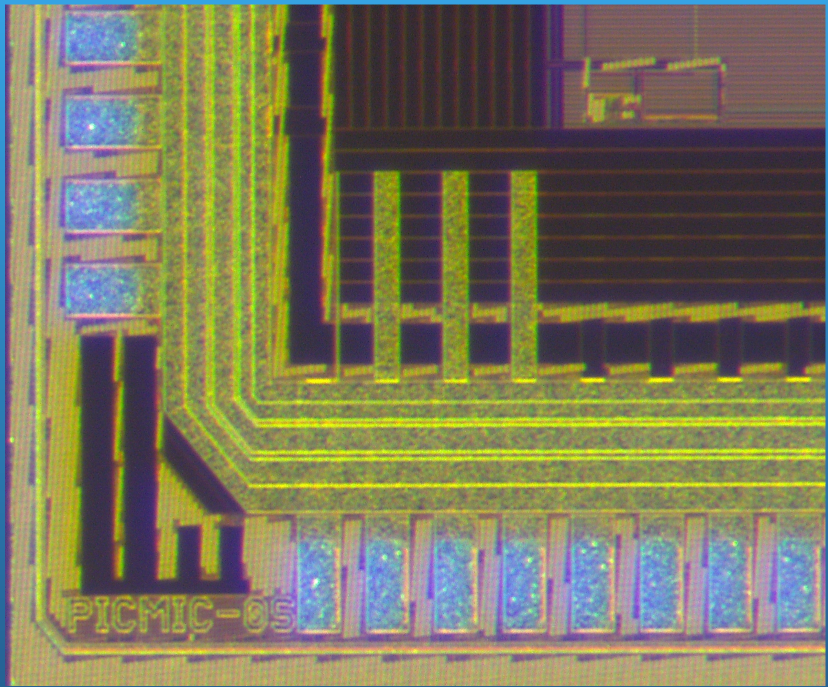
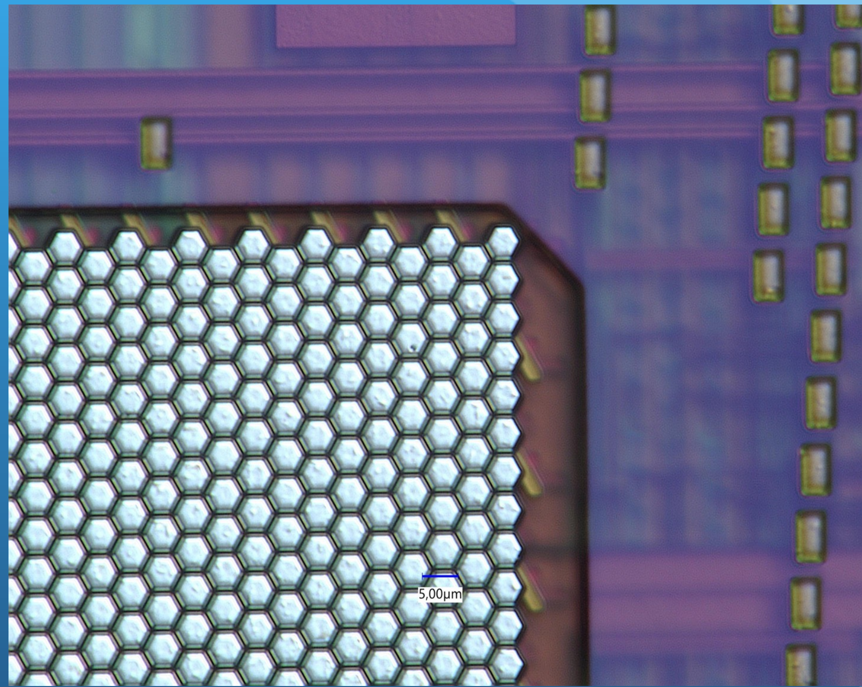
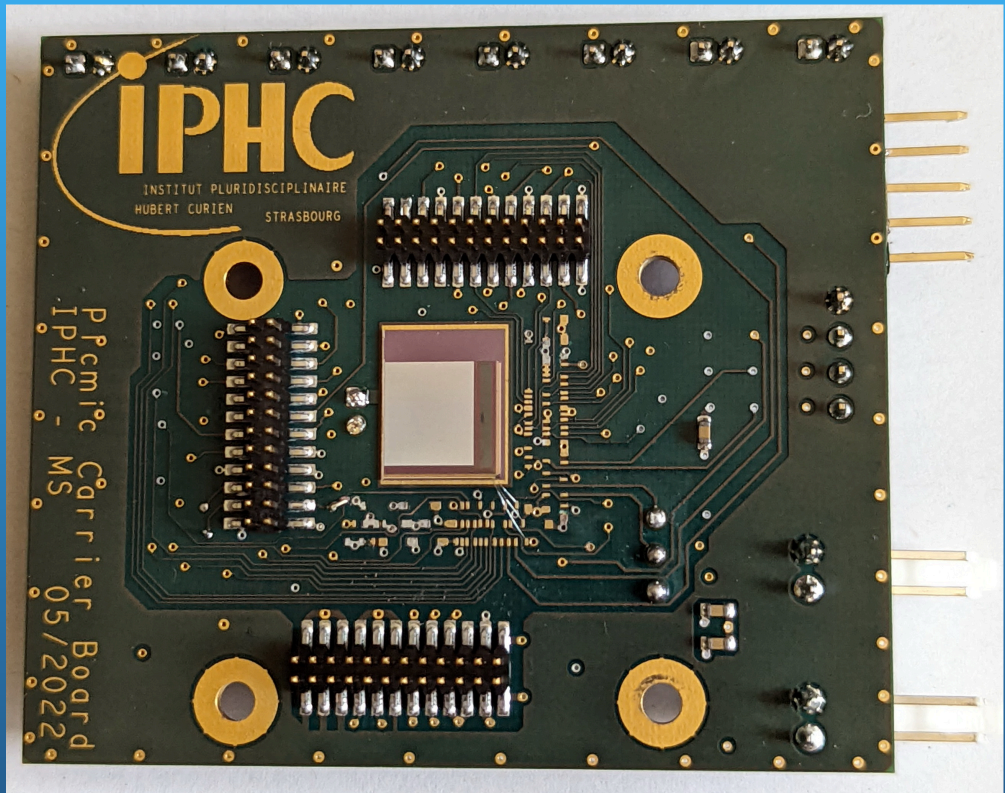
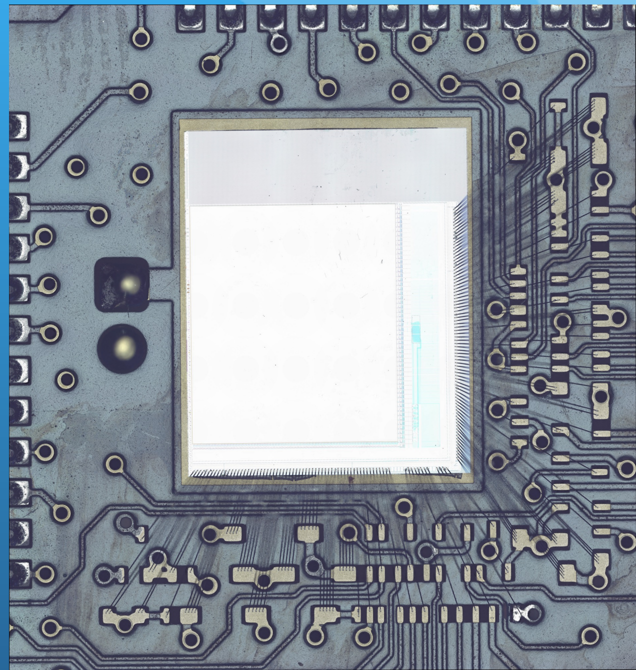




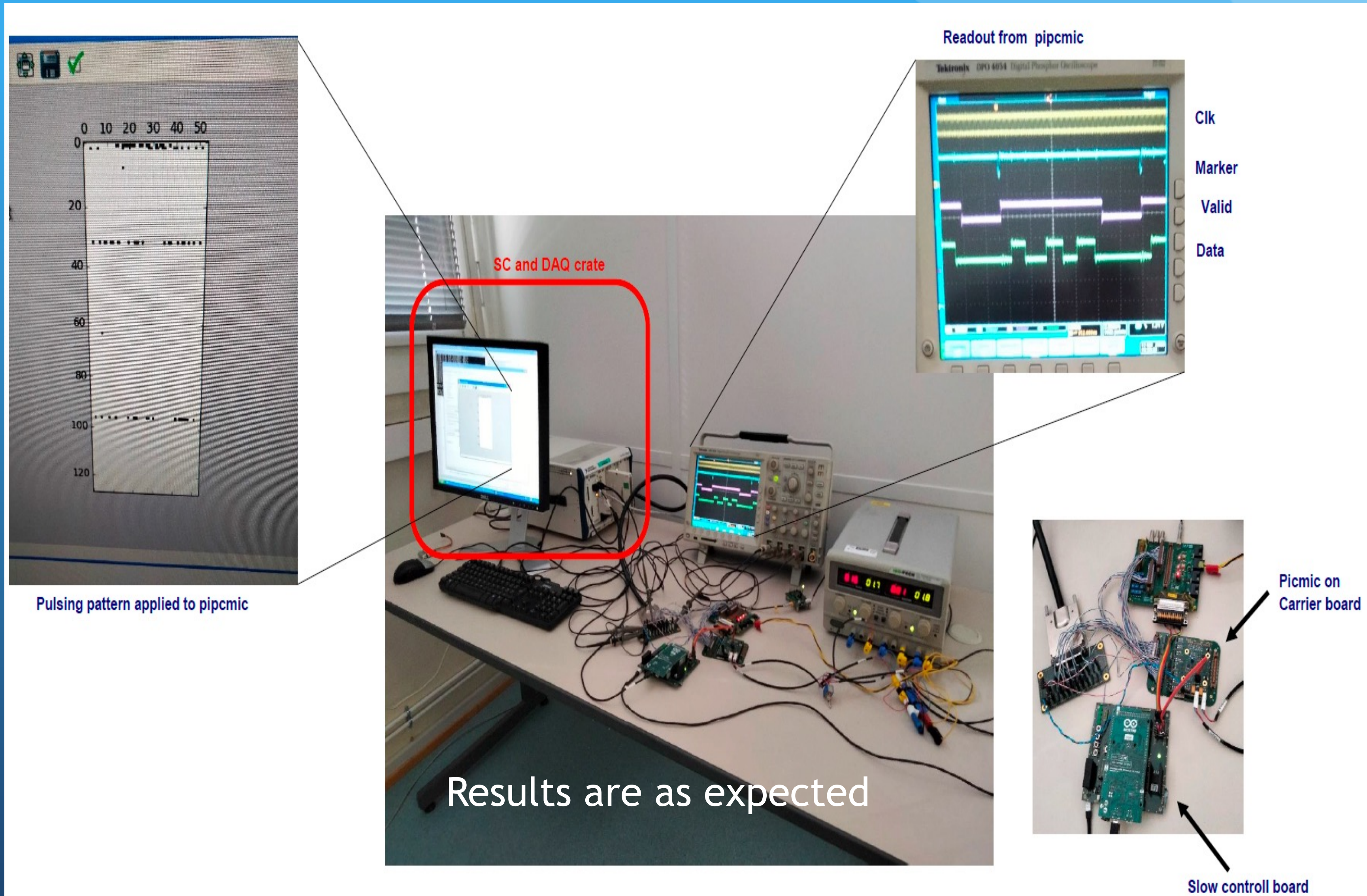
Tests were carefully prepared by IPHC electronics team.



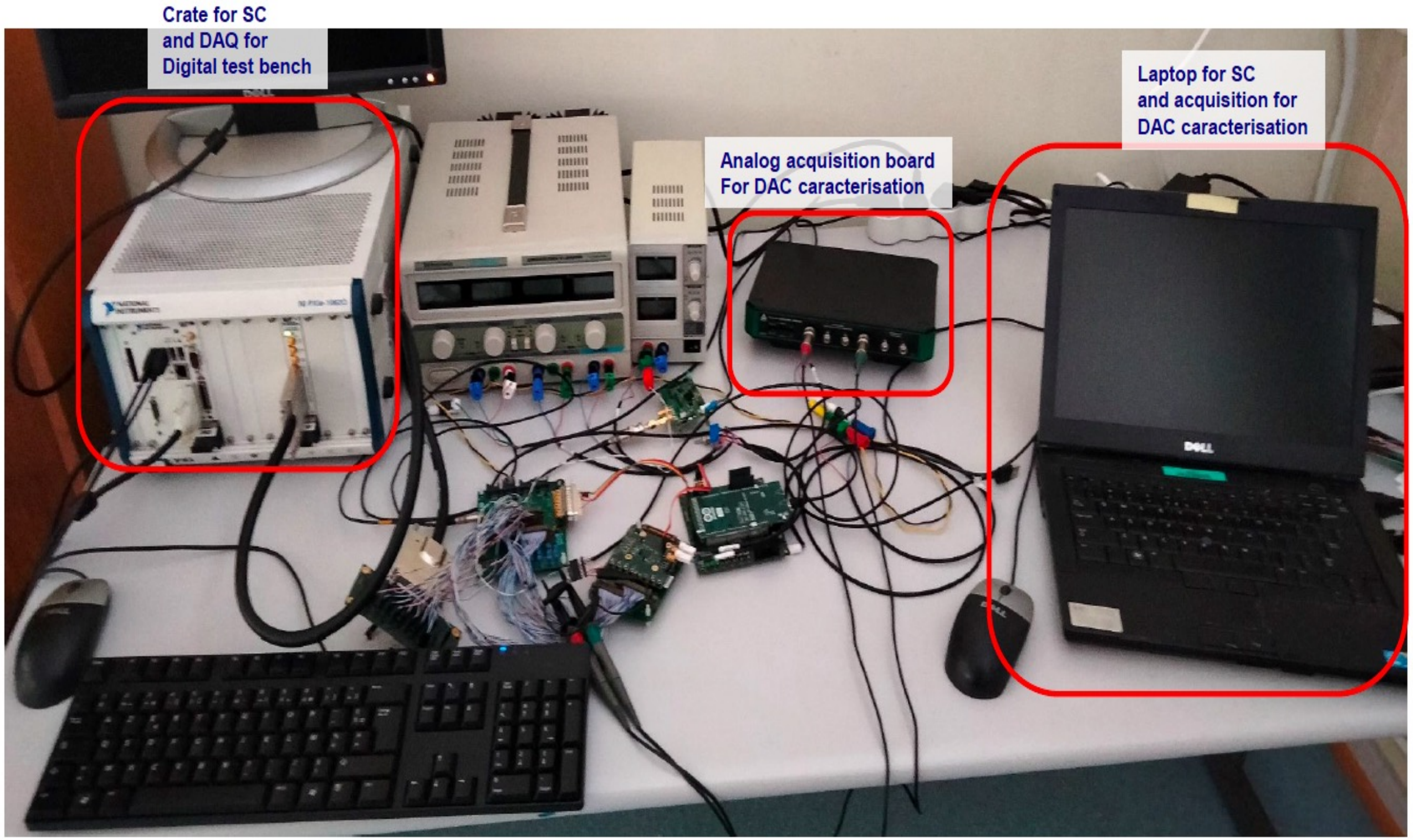


A system used for other application was adapted to test PICMIC chip

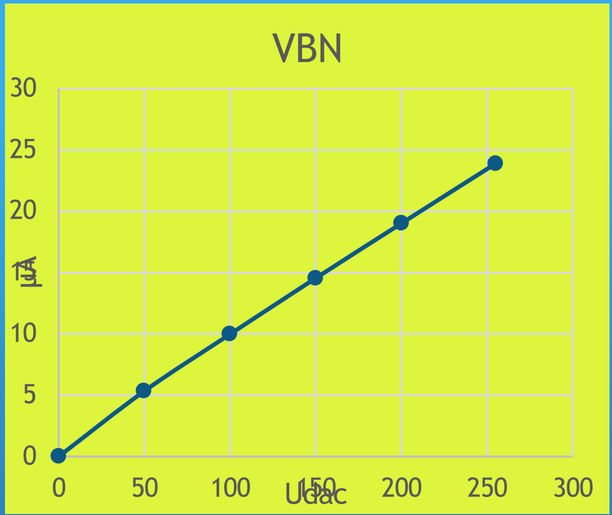
Digital test bench

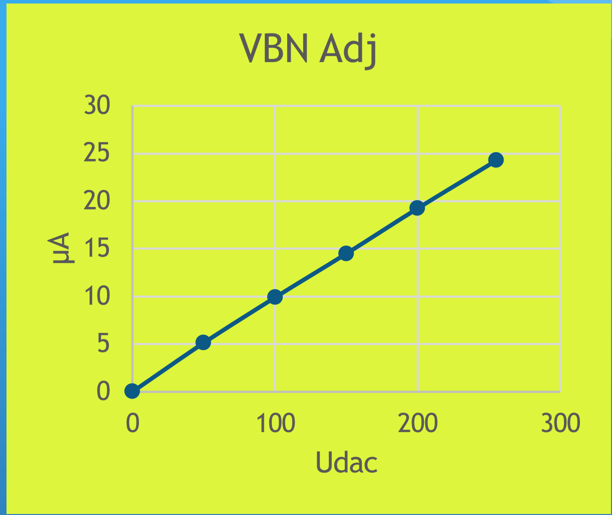


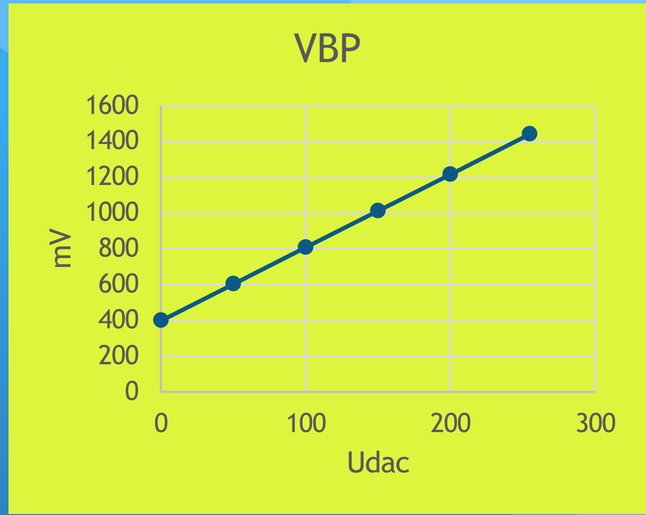
Digital and DAC characterization test bench

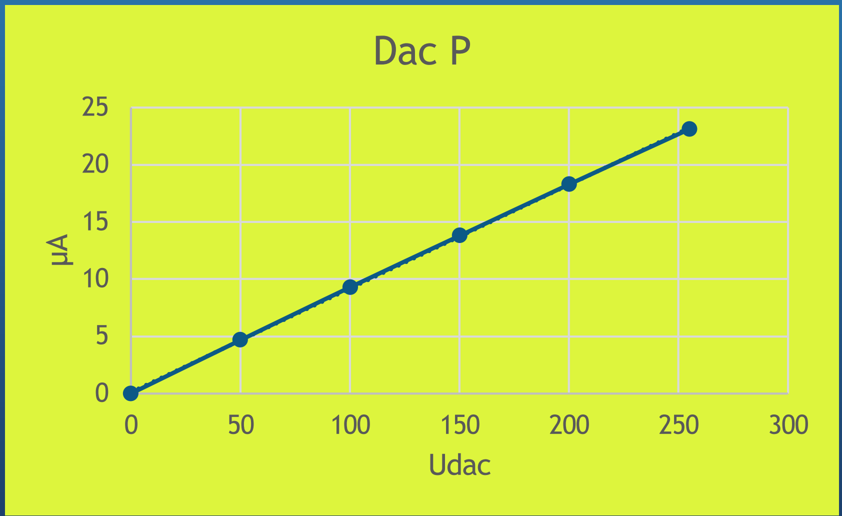


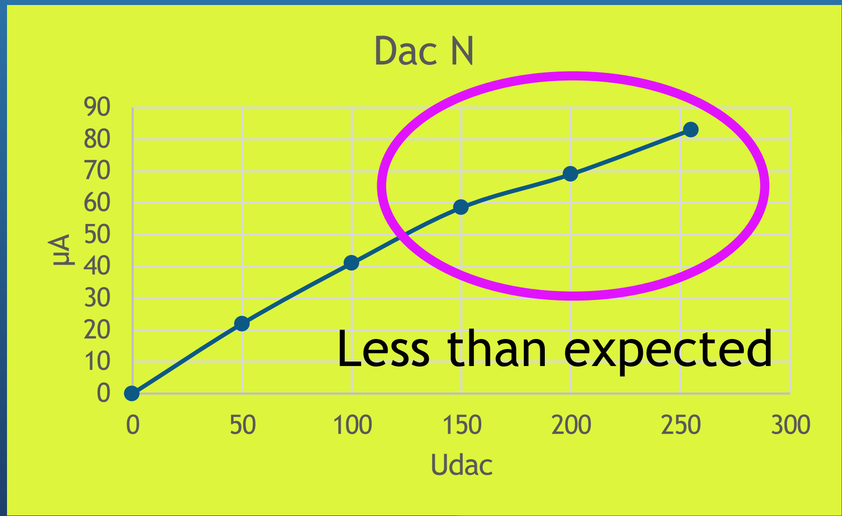
DAC measurements



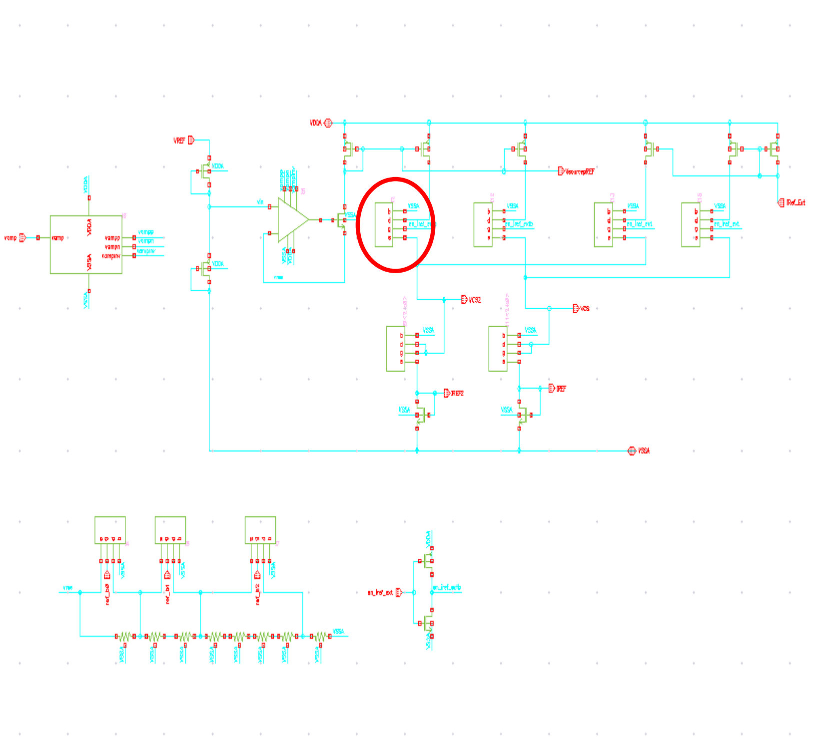


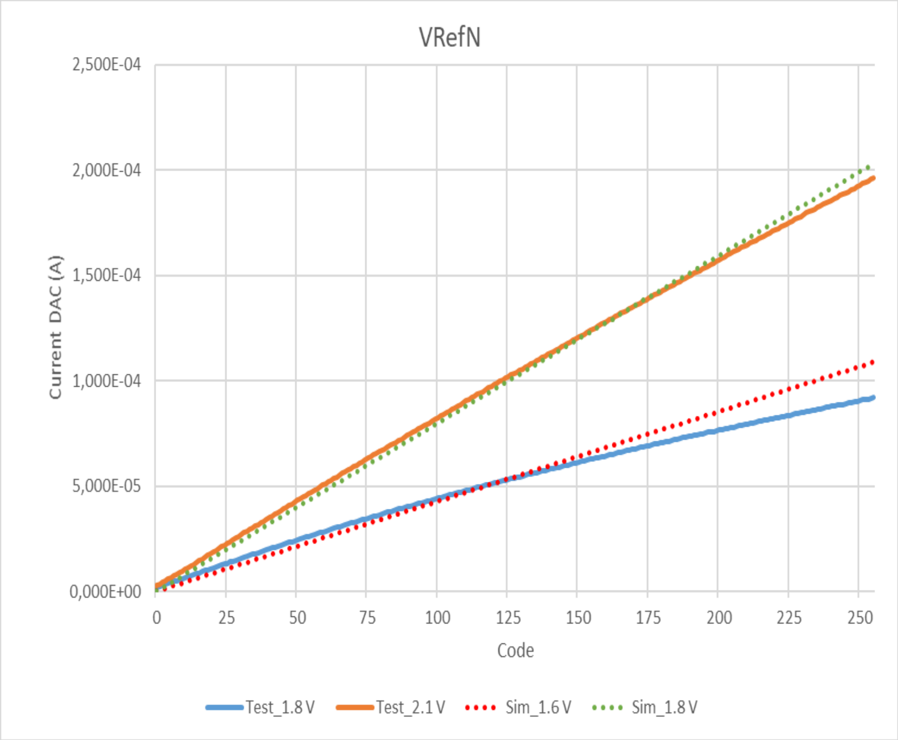






Problem understood and a solution found



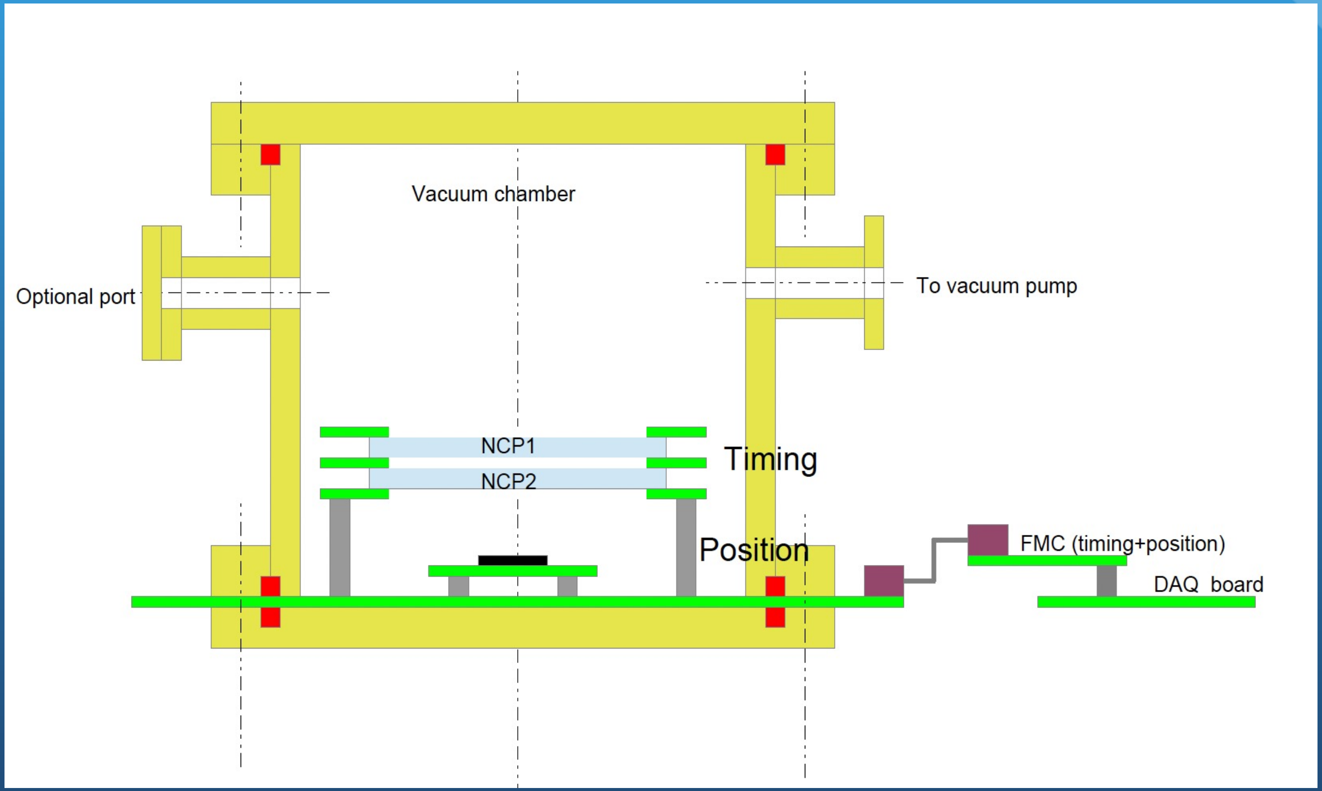


Either increase the VDD from 1.6 to 2 V or use an external DAQ

Next step is to test the sensor using charge injection

Towards the first PICMIC demonstrator

The position sensors are being validated, we envisage to build our first prototype



Towards the first PICMIC demonstrator

The position sensors are being validated, a new board to host the sensor is being designed by IP2I. The design and realization of the first prototype has started.

The first version will use SAMPIC module to

1) Measure the time information from the 8 (16) sensors as in the present scheme.

2) To distribute the same clock (40 MHz) to both the timing and position chips
3) To collect data from both and associate them.

The two last will need a card that be developed
By IJCLAB colleagues and placed
within the SAMPIC module.

The protocol has been agreed upon
among IJCLAB, IPHC and IP2I and the design will start soon

Next step

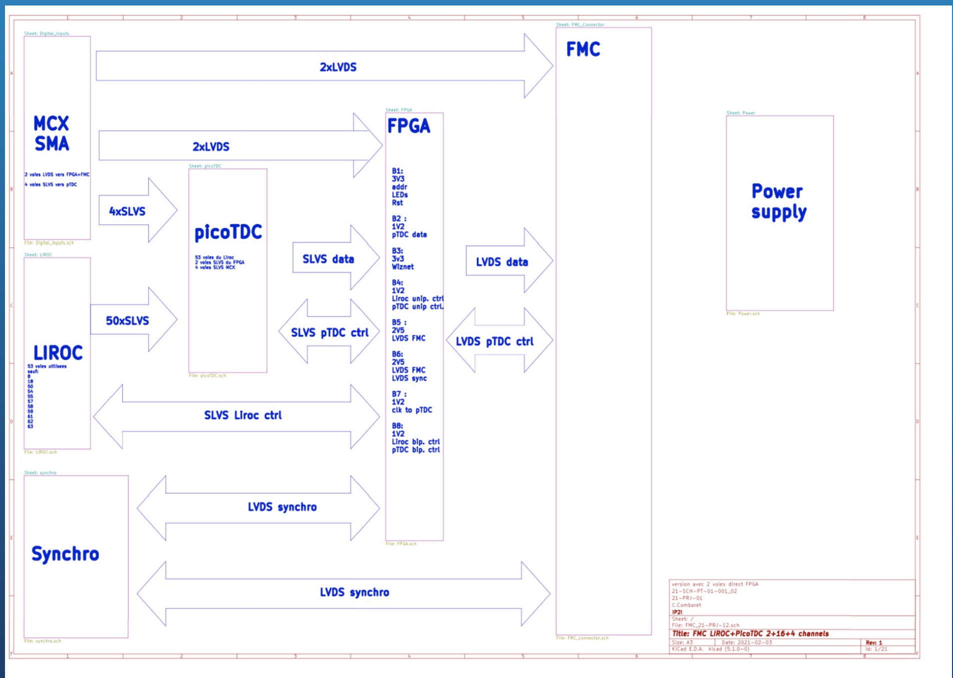
SAMPIC is an excellent toot but has dead time of about 1 μs.

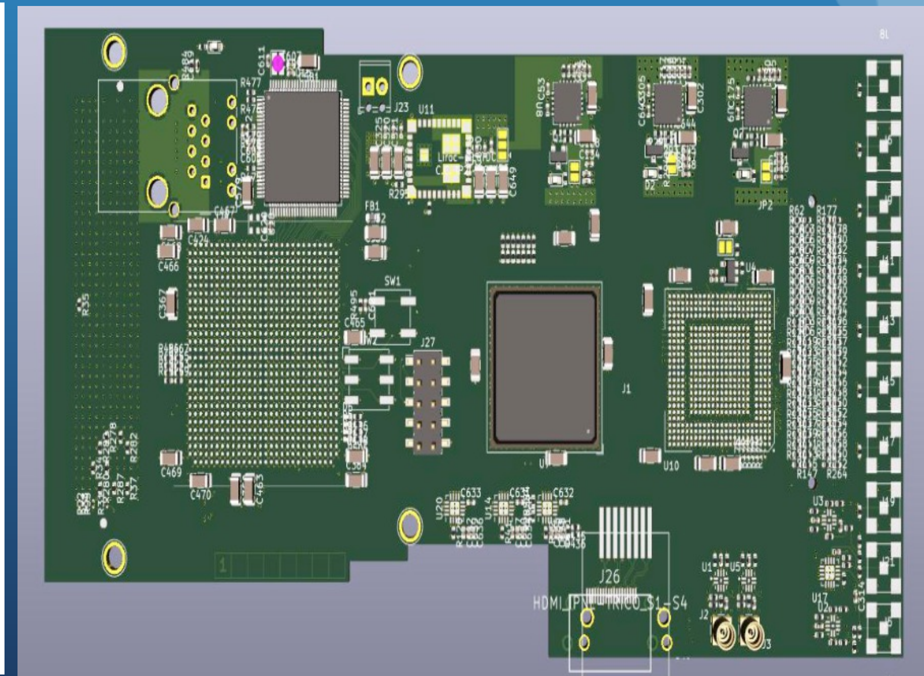
We envisage to use another TDC with negligible dead time to use PICMIC with higher rate

Next step: Time Measurement

A board integrating a low-jitter timing preamplifier and discriminator (LIROC-OMEGA) as well as a precise TDC (picoTDC-CERN) was conceived.
The board will use the GBTX developed by the CERN to communicate with
The DAQ system.

The timing board will soon be finalized (all components are available)





Next step: Acquisition

IDROGEN board that was developed within the DAQGEN of the IN2P3 will be used.

To be able to exploit the IDROGEN board we need:

- ❑ **develop appropriate interface/mezzanine boards** between the IDROGEN and the timing and position boards.
- ❑ develop **an appropriate firmware**

This workis now in advanced stage thanks to A. Back and D. charlet from IJCLAB.

Summary

- Principle of very precise time measurement is ok
- Principle of very position measurement is being validated
- A first demonstrator using SAMPIC for time measurement and combining both time and position measurements based on SAMPIC DAQ will allow to have the first demonstrator.
- In parallel a new DAQ system using IDROGEN and exploiting the Liroc of OMEGA group and the CERN picoTDC chips are being developed and will be ready early next year.