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ON HIGH ENERGY PHYSICS

**VIRTUAL
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ALPIDE pixel detector for tracking in space

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Agenzia Spaziale Italiana

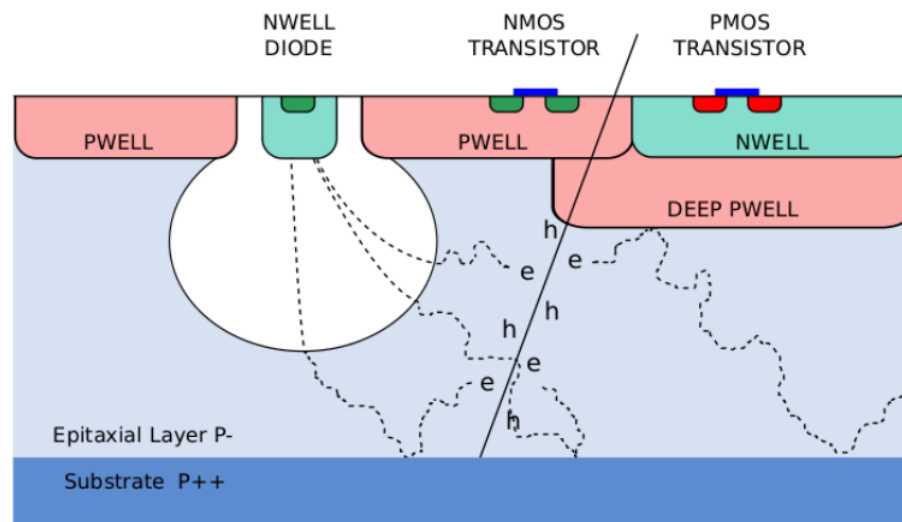
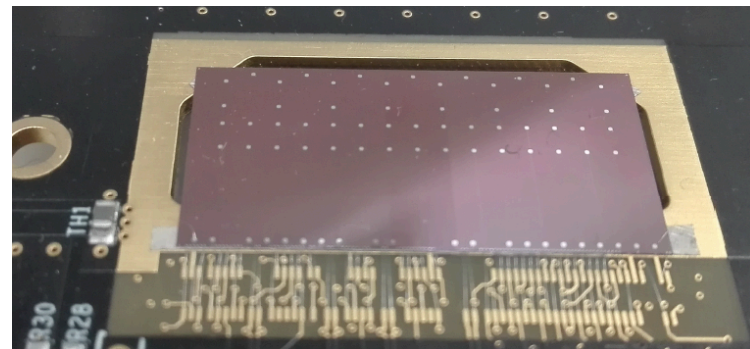


Istituto Nazionale di Fisica Nucleare
Sezione di Torino



The ALPIDE silicon sensor

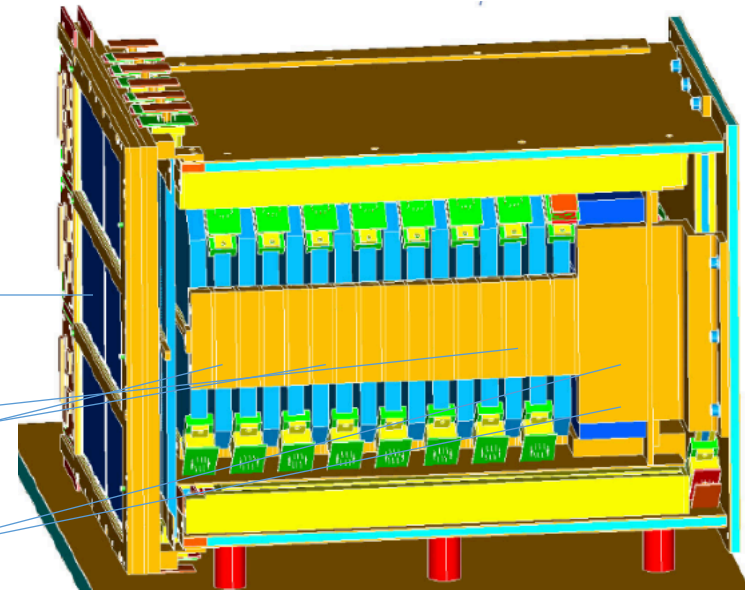
- Designed by ALICE collaboration for their Inner Tracker Upgrade;
- Implemented using CMOS technology;
- 512x1024 pixel in 1.5x3 cm²;
- 100 (50) μm thick;
- Deep p-well allow p-MOS transistor implantation on chip without reducing collection efficiency.
- Charge collection by diffusion;



Use ALPIDE in Space

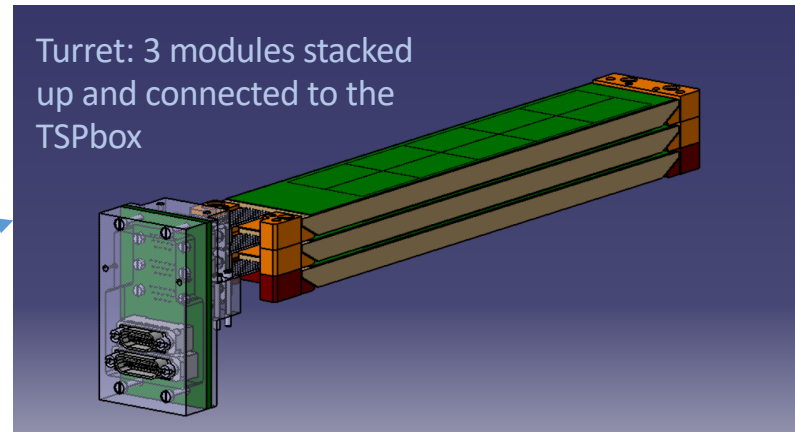
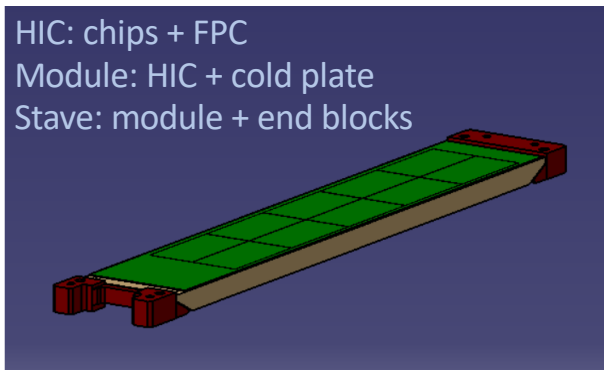
- Sun-synchronous polar orbit
- Measure fluxes of proton and electron trapped in the Earth Magnetosphere
- Energy ranges:
 - 5 MeV - 100 MeV electrons
 - 30 MeV - 300 MeV protons,

- Silicon tracker
- Trigger planes
- Plastic scintillator planes
- LYSO cubes
- Veto counters



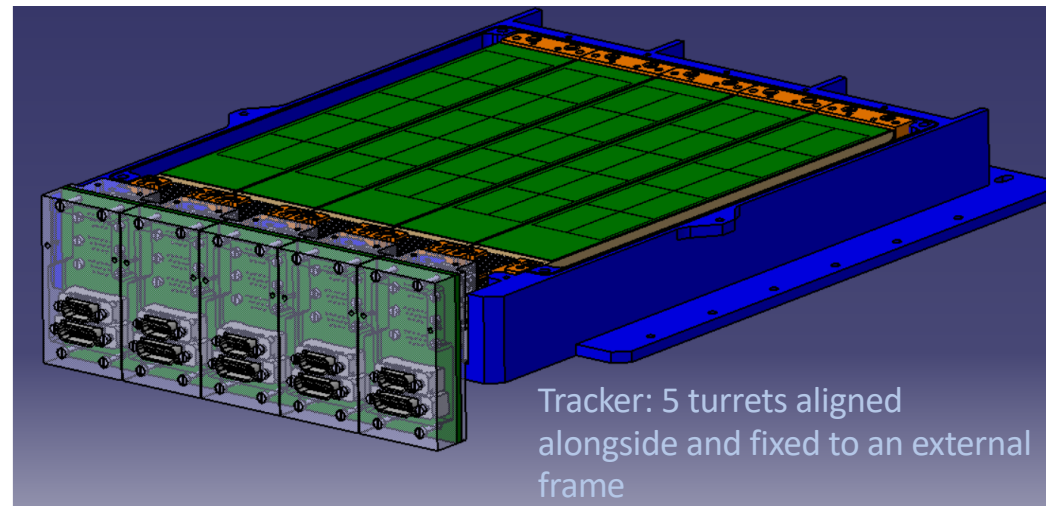
- The ALPIDE has been designed to fit ALICE requirements, and it has been characterized mainly with MIPs
- There is an interest from different collaborations to use the same device in different conditions
- In particular Limadou collaboration, that already designed the High Energy Particle Detector for the Chinese CSES satellite, is designing a new tracker based on ALPIDE

Tracker structure and elements



Single components status:

- HIC: Chips + **FPC (Flex Printed Circuit)**
 - FPC design completed
 - **READY for PRODUCTION**
- Module: HIC + **Cold Plate (CP)**
 - Cold plate stratigraphy defined
 - Thermal simulation available
 - Ready for production
- Stave: module + **End Blocks (Design completed)**
- Turret: 3 staves + TSPbox
- Tracker: 5 turrets + external frame



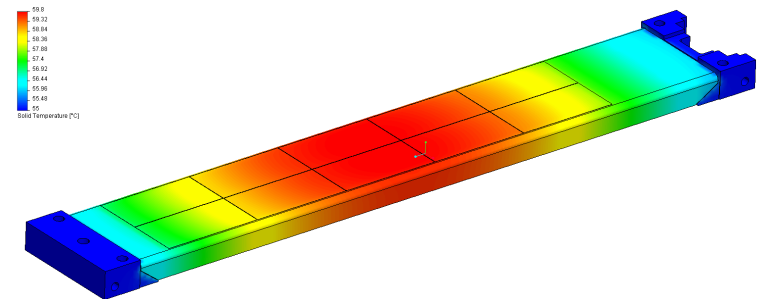
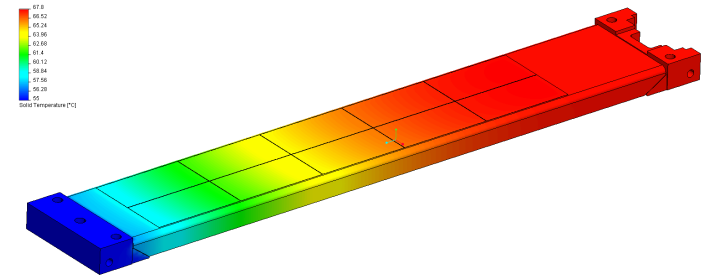
Challenges for use in Space

- Light support (no multiple scattering)
- Support must withstand launch acceleration and vibration
- Heat dissipation in vacuum
- Material outgassing in vacuum
- Limited power budget

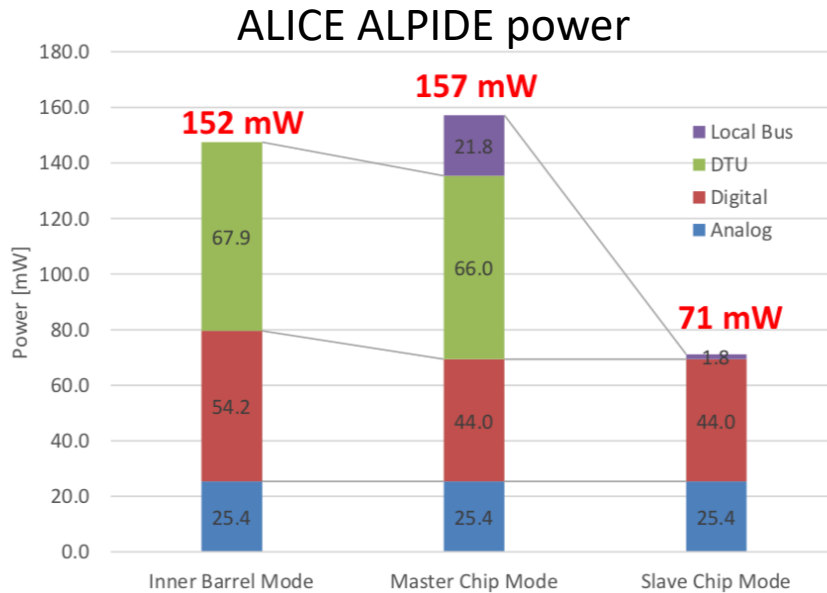
Example of study of the heat dissipation

LOAD CASE: conservative approach. Better results expected if conductivity is higher. Waiting for results of tests on prototypes

- Single Thermal Interface;
- Laminate with Standard Conductivity (HC) CF:
 $K = 200/200/0.5\text{W}/(\text{mK})$
- End-Block Joints with Silver-Epoxy Adhesive.

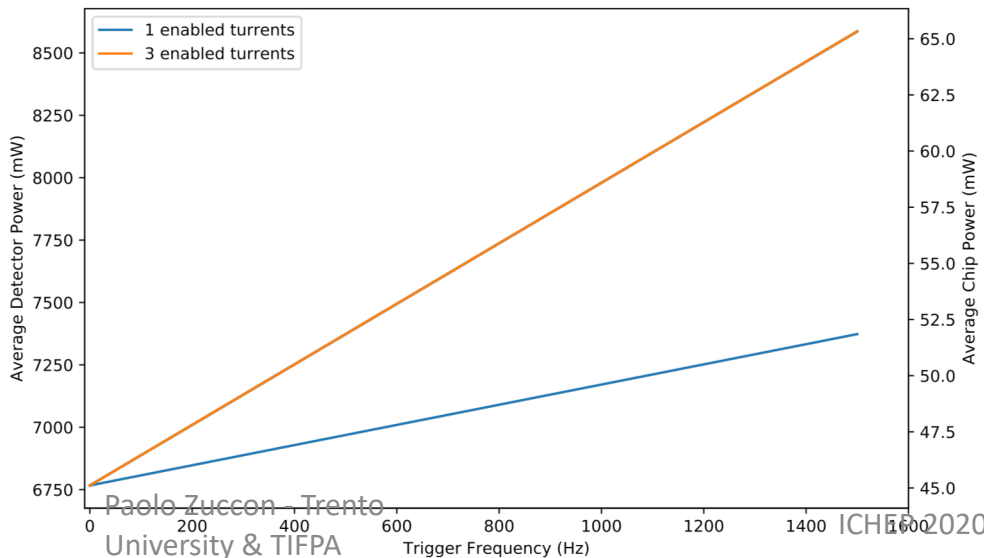


Power consumption mitigation



- Use Master Slave architecture
- Switch off the Data Transmission Unit and read the data through the Control Line

- **Clock – ON** **17 mW/cm²**
- **Clock – OFF** **7 mW/cm²**



Clock GATING

Default Clock is OFF

On Trigger:

- Clock ON
- Wait for signal digitization
- Read Data,
- Clock OFF

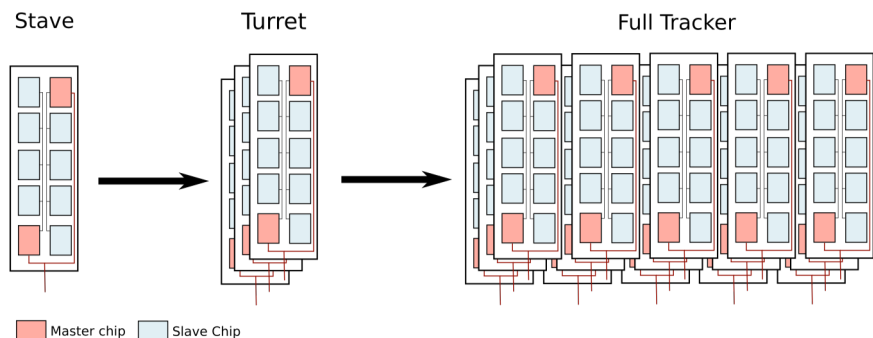
New DAQ for ALPIDE detector

- Low power
- Handles the full ALPIDE control and DAQ through the DCTRL serial line
- modular and redundant.

Implementation on a custom board equipped with

- Xilinx ARTIX low power
- HDL - implements DAQ and control
- Soft processor (Microblaze) implements Calibration and service procedures
- Soft processor is switched off most of the time during normal operations.

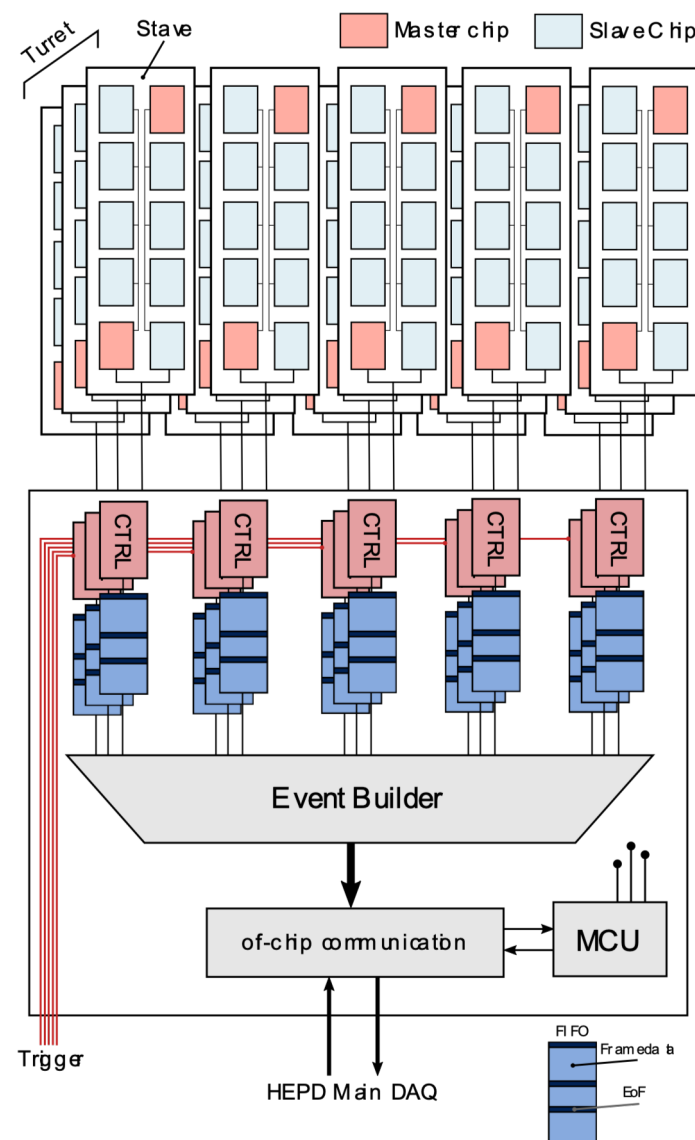
Firmware Layout



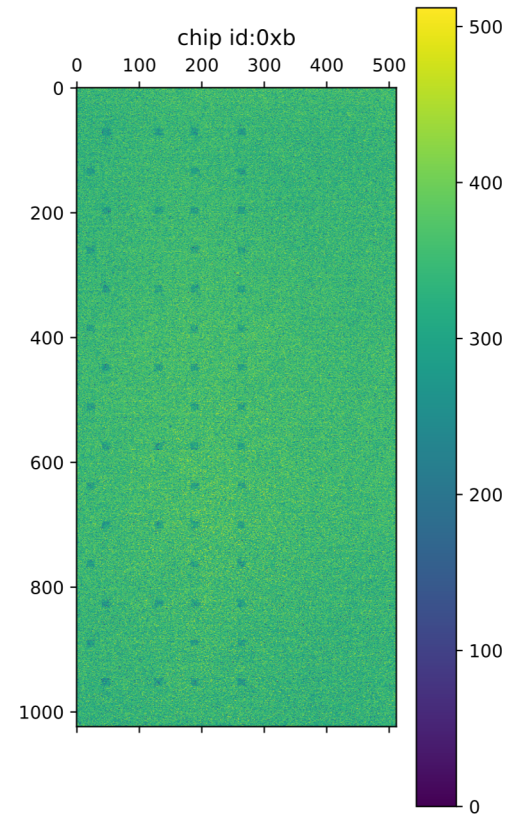
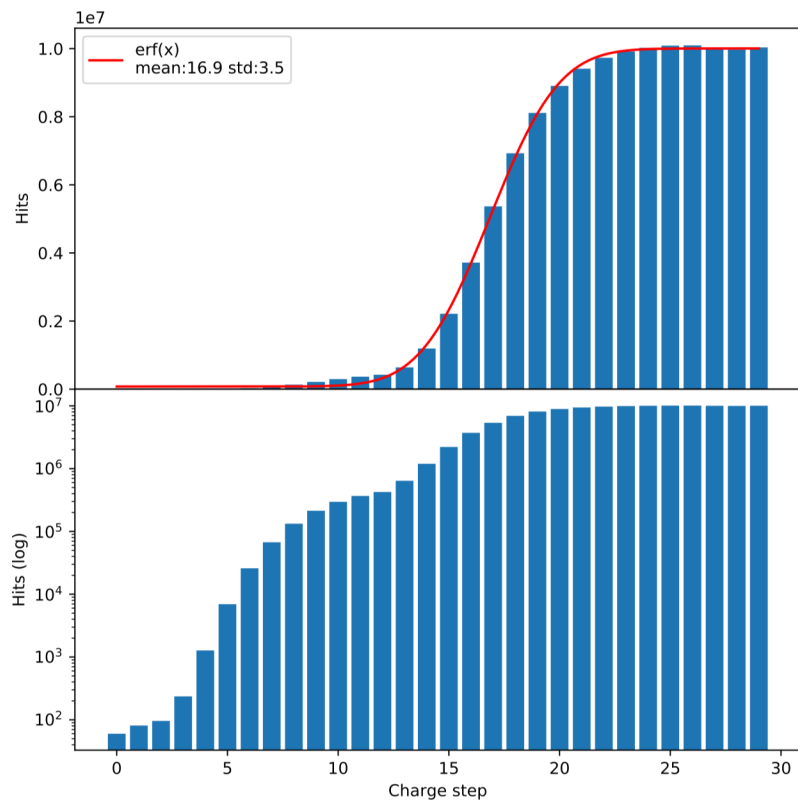
Firmware is designed in VHDL

- 15 stave control modules
- Event builder
- Microblaze soft - processor

**FULLY
IMPLEMENTED**

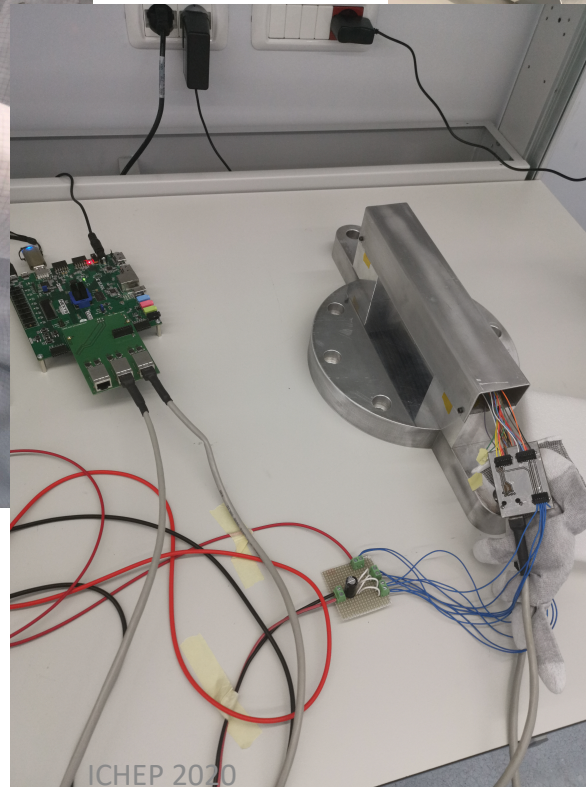
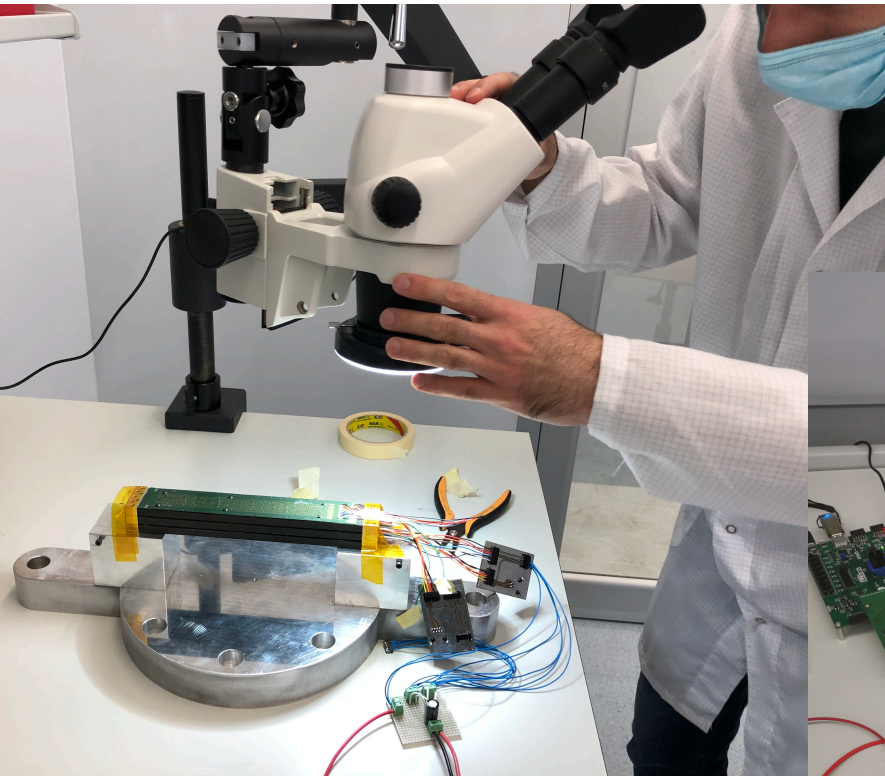


Calibration Procedure



First turret has been produced

Assembled at INFN Torino

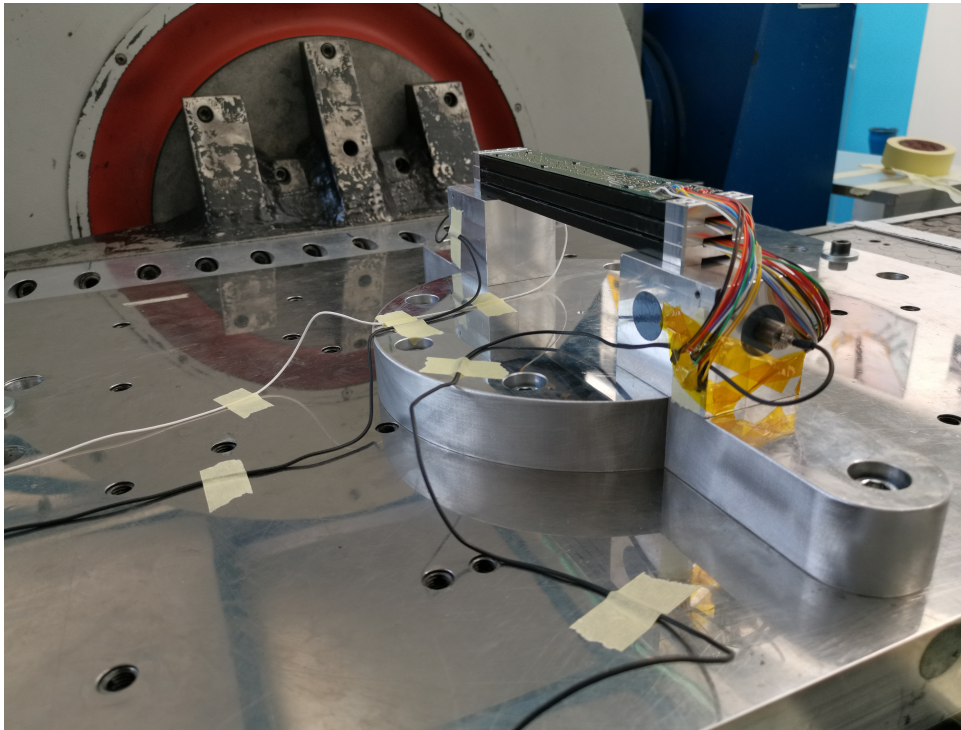


Under test and review at
INFN TIFPA - Trento

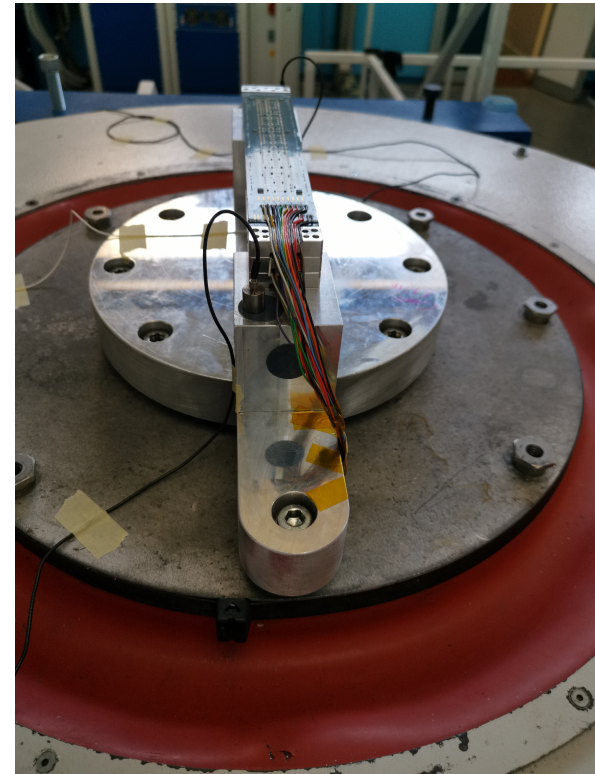
Paolo Zucon - Trento
University & TIFPA

And tested at SERMS in Terni

Vibration test

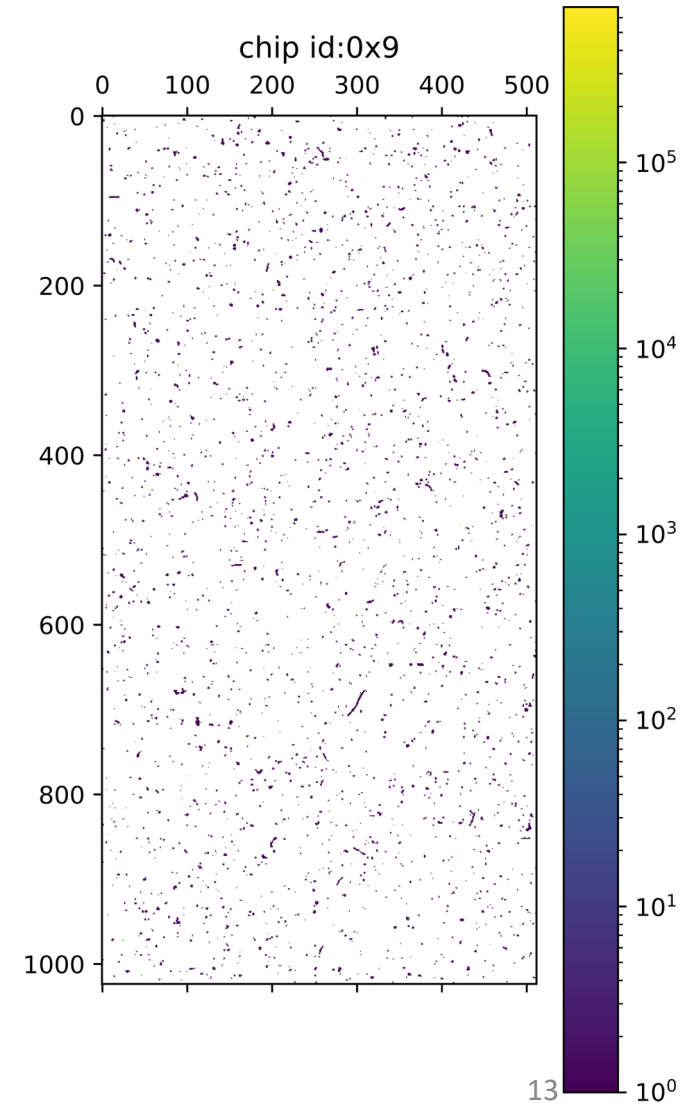
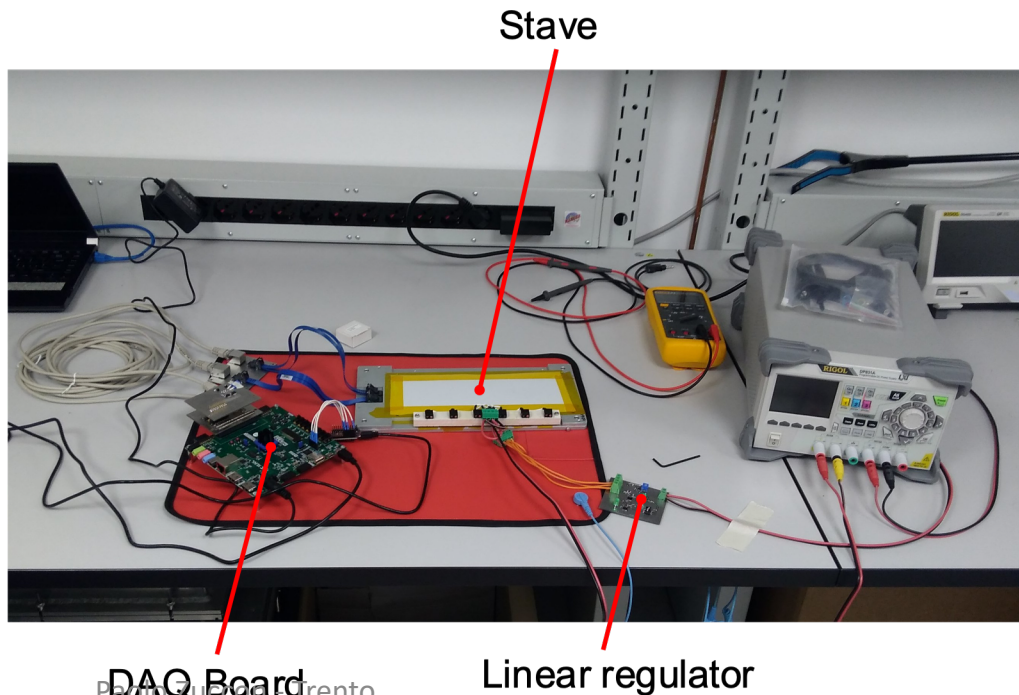


Y – axis

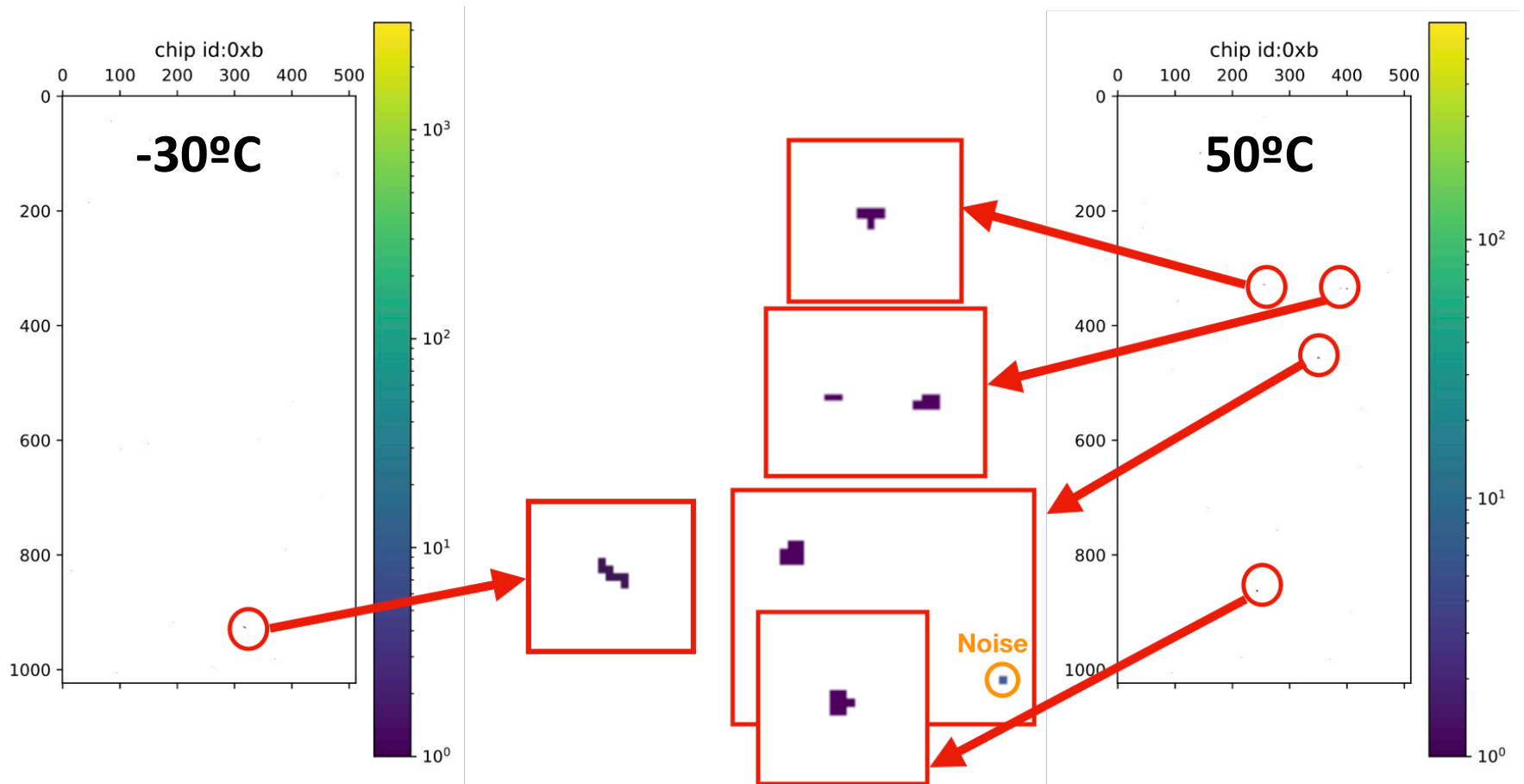


Z – axis

Test data acquisition



Muon test in TVT chamber



Conclusions

- ALPIDE silicon tracker in space is proceeding
- Design has been finalized
- Mechanical support has been designed and prototype has been produced
- Low power DAQ EM has been produced and tested
- A FULL Tracker Turret successfully passed the vibration test.
- All points to a fruitful implementation of MAPS pixel technology in space