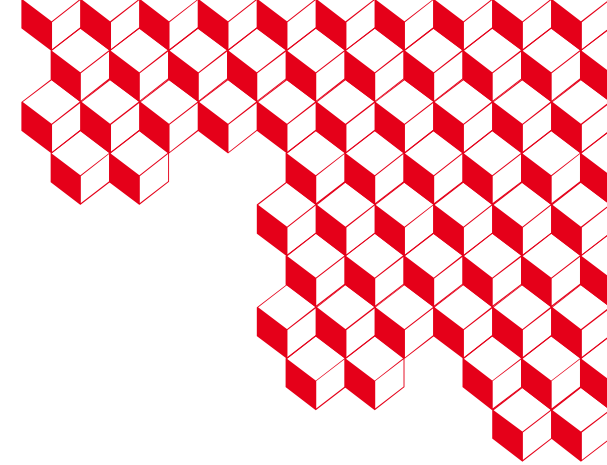# Delatcheur: a generic tool for latch up measurement during irradiation campaign

## Journées des Métiers de l'Electronique de l'IN2P3 et de l'IRFU @LPC Caen

**Amala DEMONTI** [1]**,** *Ilham BAJNATI* [1]*, Thomas BEY* [1]*, Florent BOUYJOU* [1]*, Olivier GEVIN* [1]*, Aude GRABAS* [1]*, Jean–Pierre MEYER* [2]*, Philippe SCHWEMLING* [2]

[1] CEA-DRF-IRFU-DEDIP *(The Electronics, Detectors and Computing Division)*

[2] CEA-DRF-IRFU-DPhP *(The Particle Physics Division)*

Commissariat à l'énergie atomique et aux énergies alternatives – www.cea.fr
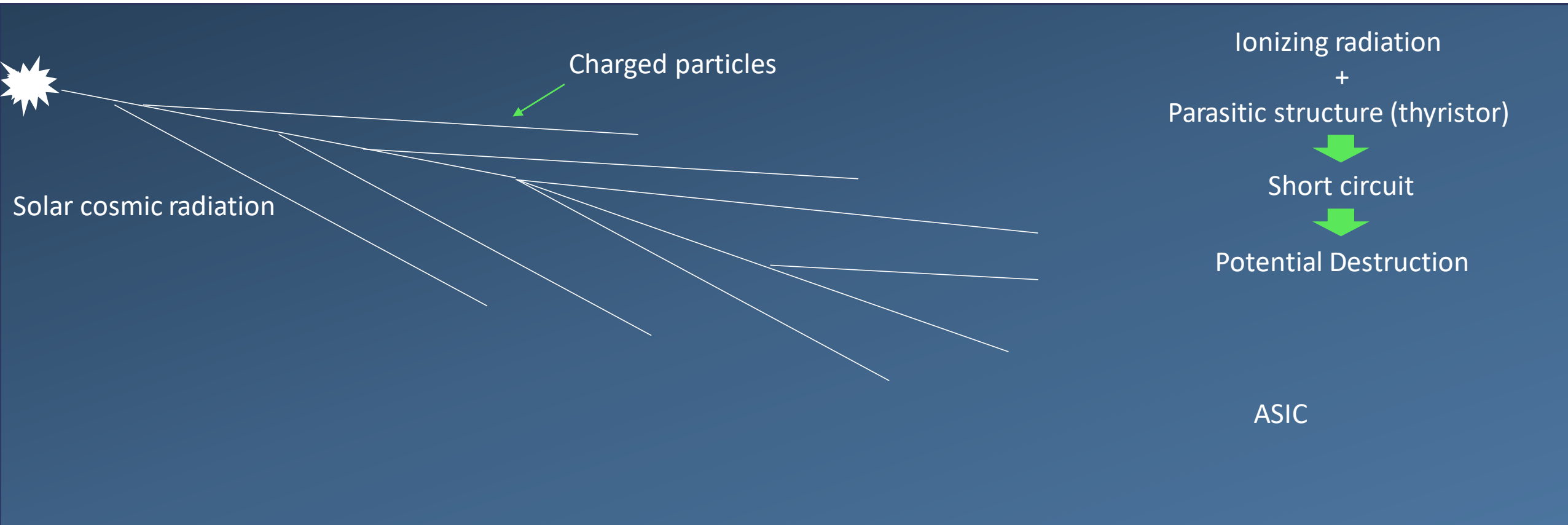
*Tuesday* **13** *[rd] June 2023*

# Delatcheur: a generic tool for latch up measurement during irradiation campaign

1. Context of Delatcheur: latch up measurement

2. Design of *Latchupuce* PCB

3. Futur plans for Delatcheur

4. Conclusion

# Context of Delatcheur: latch-up measurement

➢ Generic tool used for ASIC qualification in latch-up event

➢ What is a « latch-up event » ?

Charged particles

Ionizing radiation
+
Parasitic structure (thyristor)

Short circuit

Potential Destruction

Solar cosmic radiation

ASIC

*Latch-up event in space application*

# Context of Delatcheur



Particle accelerator

Picture from https://home.cern/fr

Particle beam

ASIC 1

ASIC *n*

...

Supply voltage (220-230V)

USB port connected to Arduino

Computer

Delatcheur
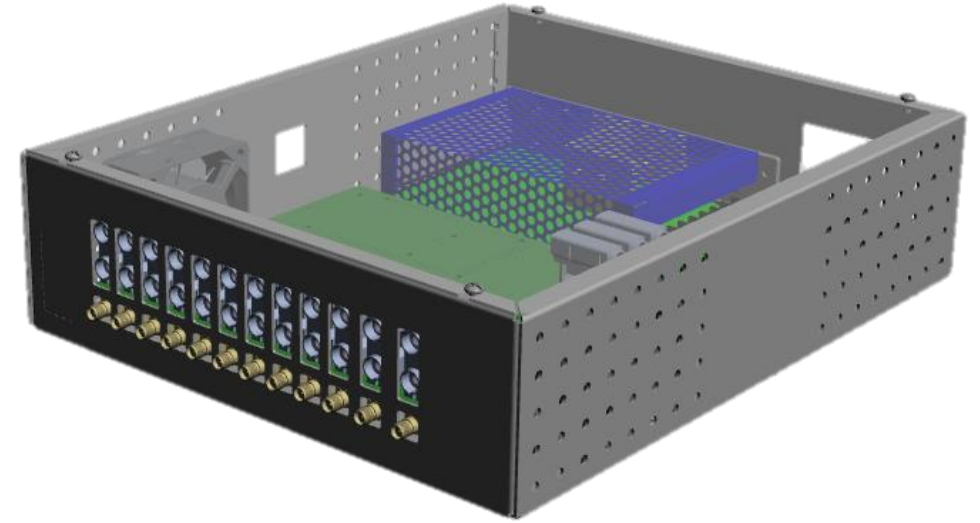
Power supply in each channel

*Typical setup with the Delatcheur*

# Goal of Delatcheur

➢ Generic tool used for ASIC qualification in latch-up event

➢ In general, the goal of delatcheur is:
  - Providing power supply
  - Measuring power consumption
  - Shuting the power down, if overcurrent
  - Counting latch-up events



*Delatcheur box*

# Design of Latchupuce PCB

Presentation of Latchupuce PCB

- PCB thickness: 1,6 mm

- PCB FR4 180°C

- Halogen Free

- 1200 vias, 4 500 nets

- Size of PCB: 155 mm x 173 mm

- Stackup: 8 layers

- Number of component: 1 000

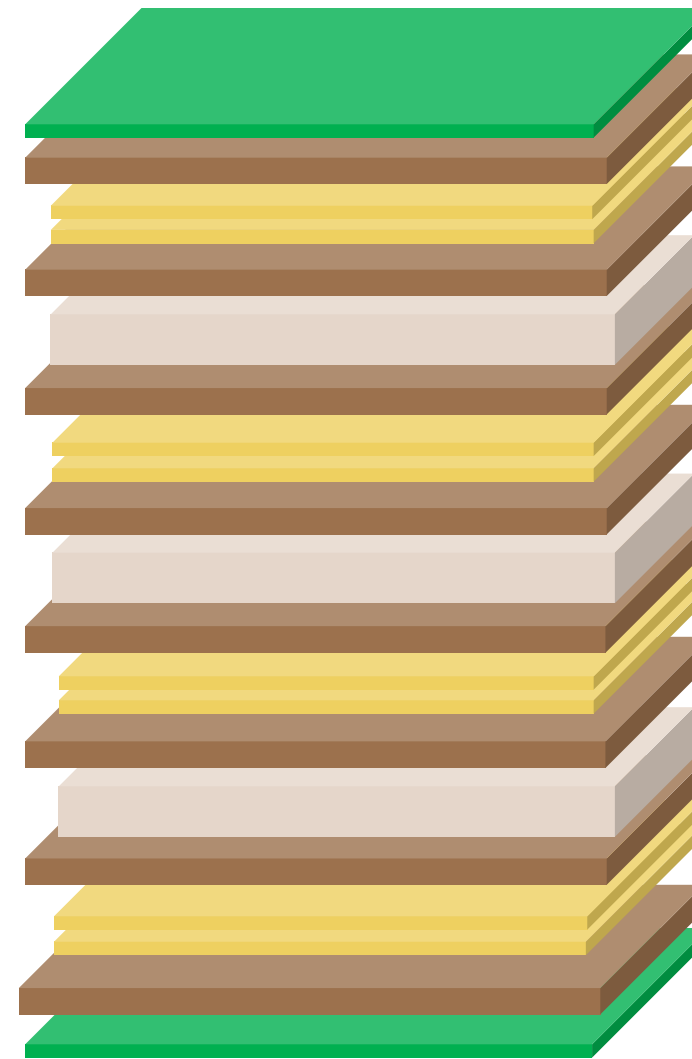- Different type of package (TDFN, QFN, SOIC, 0402…)

Top: 10 µm

Prepreg: 140 µm

L1: 35 µm

Core: 254 µm

L2: 35 µm

Prepreg: 140 µm

L3: 35 µm

Core: 254 µm

L4: 35 µm

Prepreg: 140 µm

L5: 35 µm

Core: 254 µm

L6: 35 µm

Prepreg: 140 µm

L7: 35 µm

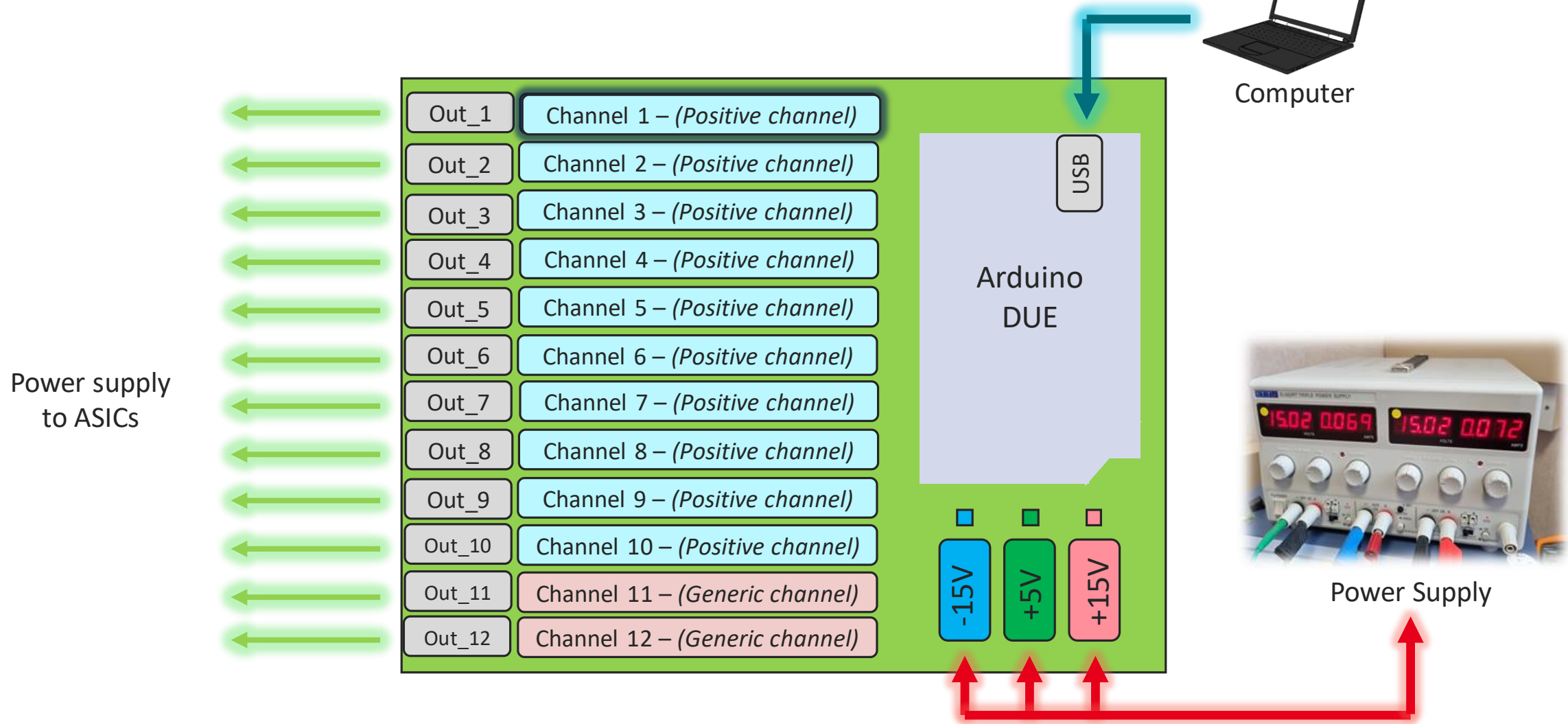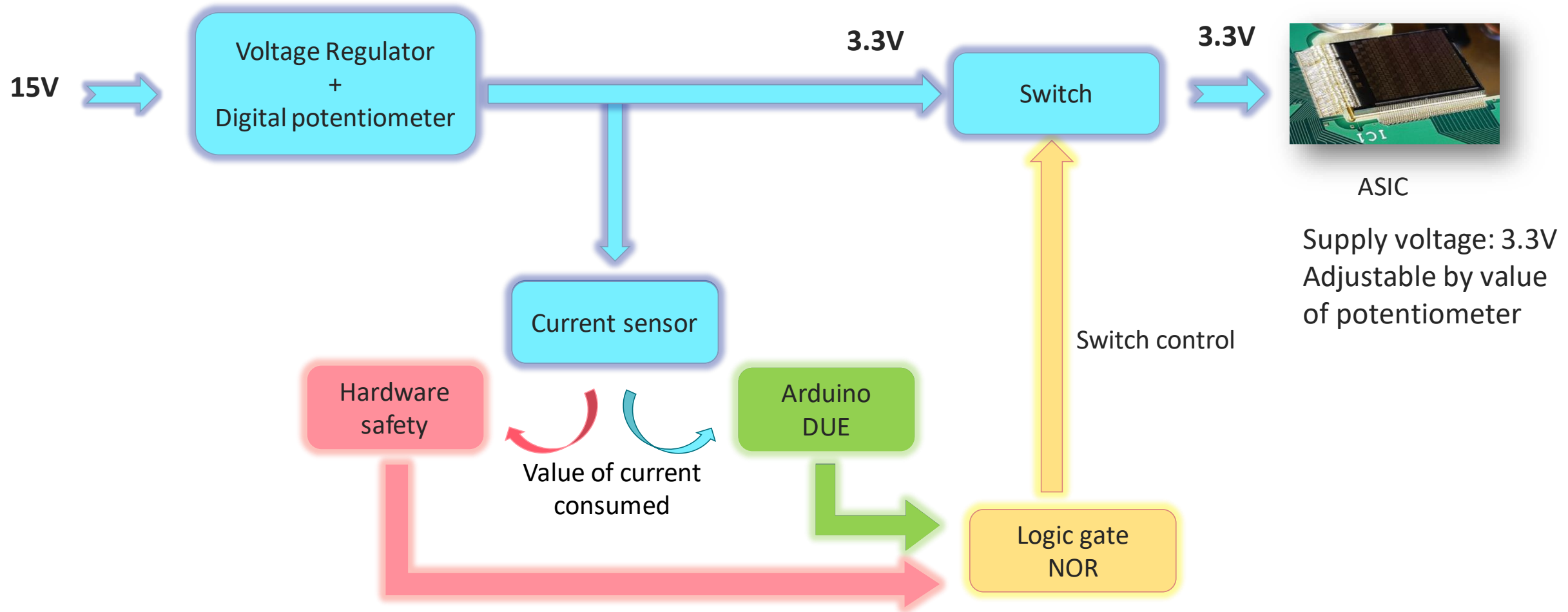Bottom: 10 µm

L8: 35 µm

*Stack up of Latchupuce PCB*

# Design of Latchupuce PCB



Block diagram of Latchupuce PCB

# Bloc diagram of one positive channel



**15V** → **Voltage Regulator + Digital potentiometer** → **3.3V** → **Switch** → **3.3V** → ASIC

Current sensor

Value of current consumed

Hardware safety

Arduino DUE

Logic gate NOR

Switch control

Supply voltage: 3.3V
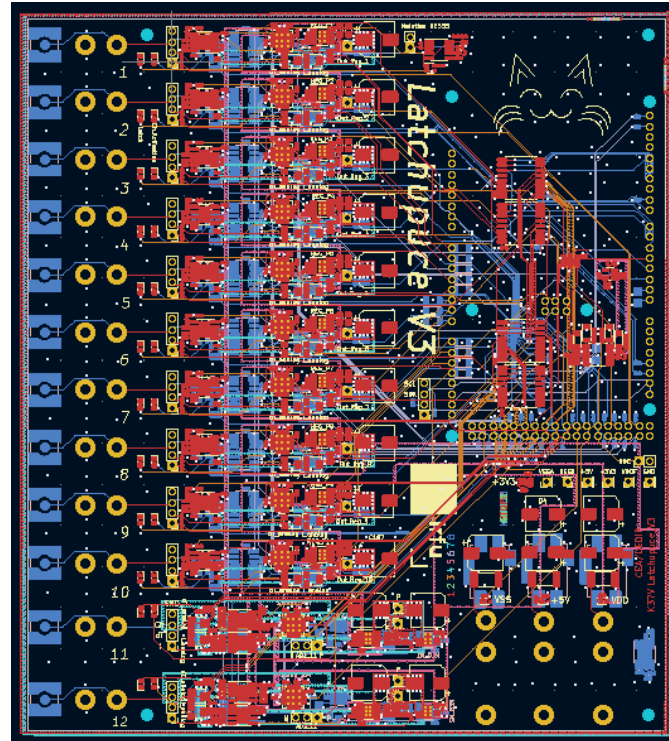Adjustable by value of potentiometer

*Block diagram of Latchupuce PCB*

# Design of Latchupuce PCB

➢ Simulation with LTSPICE (Linear Technology)
- Positive and negative regulator
- Adaptation of voltage reference
- Input and Output of external ADC
- Analog positive channel
- Analog negative channel

➢ Design with Kicad (Version 6.0)
- Schematic with hierarchical blocks
- Routing with hierarchical blocks

➢ Technical performance:
- 12 channels (10 positive and 2 generic)
- Positive voltage range: From 500mV to 15V
- Negative voltage range: From -15V to -500mV
- Current range: From 0A to 500mA
- Fast throughput rate of ADC: 188 kSPs
- Low noise component



*Layout of Latchupuce PCB*



*Latchupuce PCB*

# Latch-up detection

- ➤ dT to enable
- ➤ dT to shutdown
- ➤ dT off

All these parameters can be modified by user

- ➤ The goal of the Arduino program is:
  - ❖ Channel settings:
    - ▪ Used channel or not
    - ▪ Supply voltage
    - ▪ Current threshold
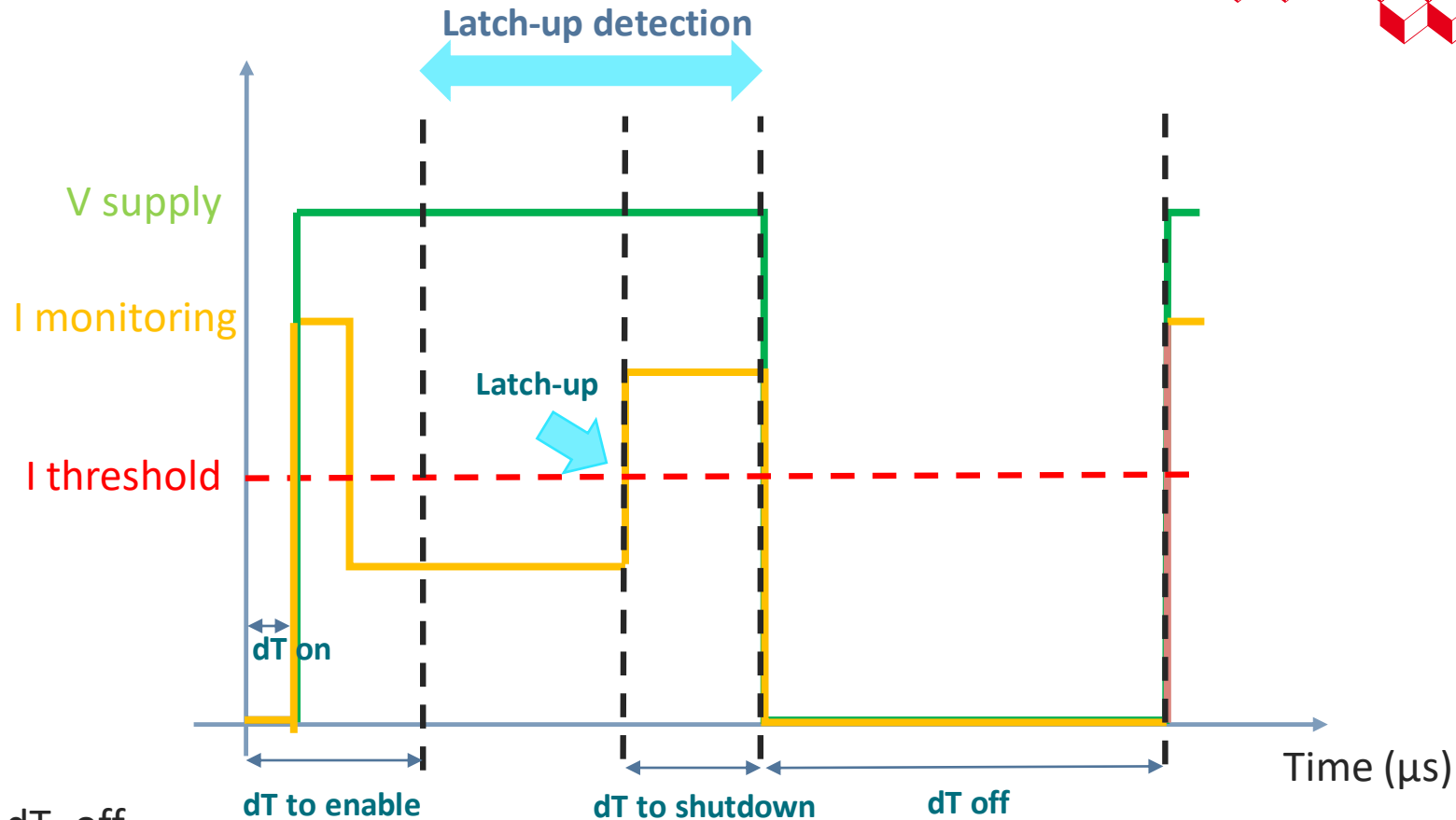    - ▪ dT to enable, dT to shutdown, dT_off
  - ❖ Reading value of current consumption
  - ❖ Reading value of power supply
  - ❖ Make comparison between current consumption and current threshold
  - ❖ Put shutdown circuit, if overcurrent
  - ❖ Send data to PC (Counting latch-up events and current measurement)



**Latch-up detection**

V supply

I monitoring

Latch-up

I threshold

dT on

dT to enable

dT to shutdown

dT off

Time (µs)

*Latchupuce chronogram*

# Testbench for Latchupuce PCB



Raspberry PI4
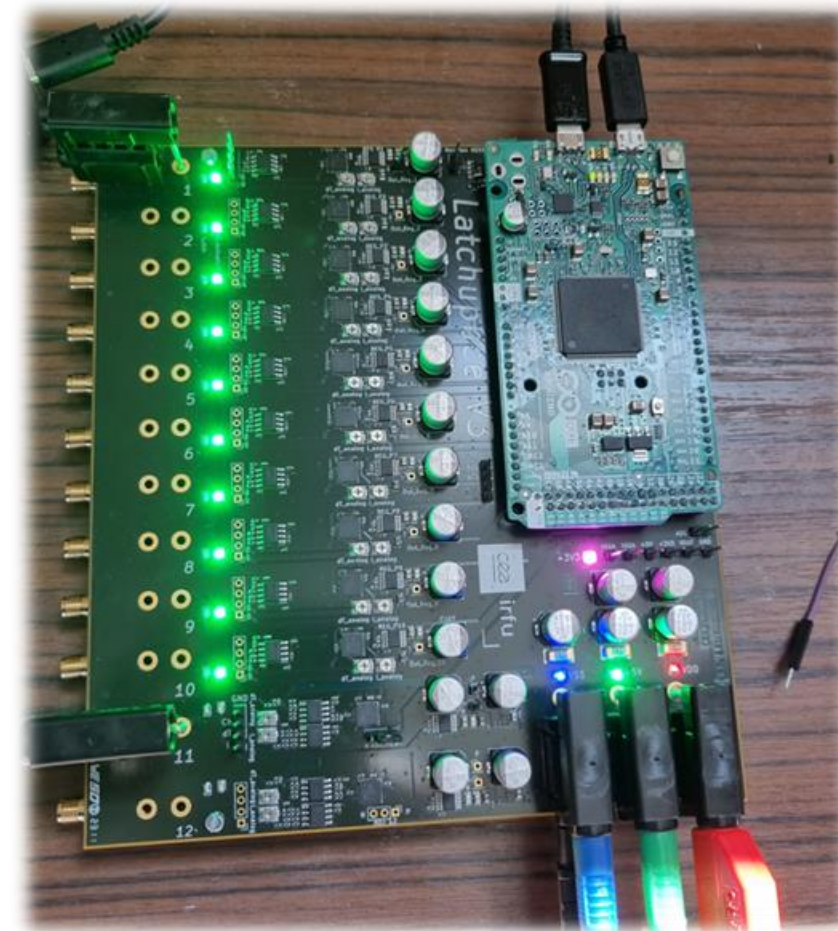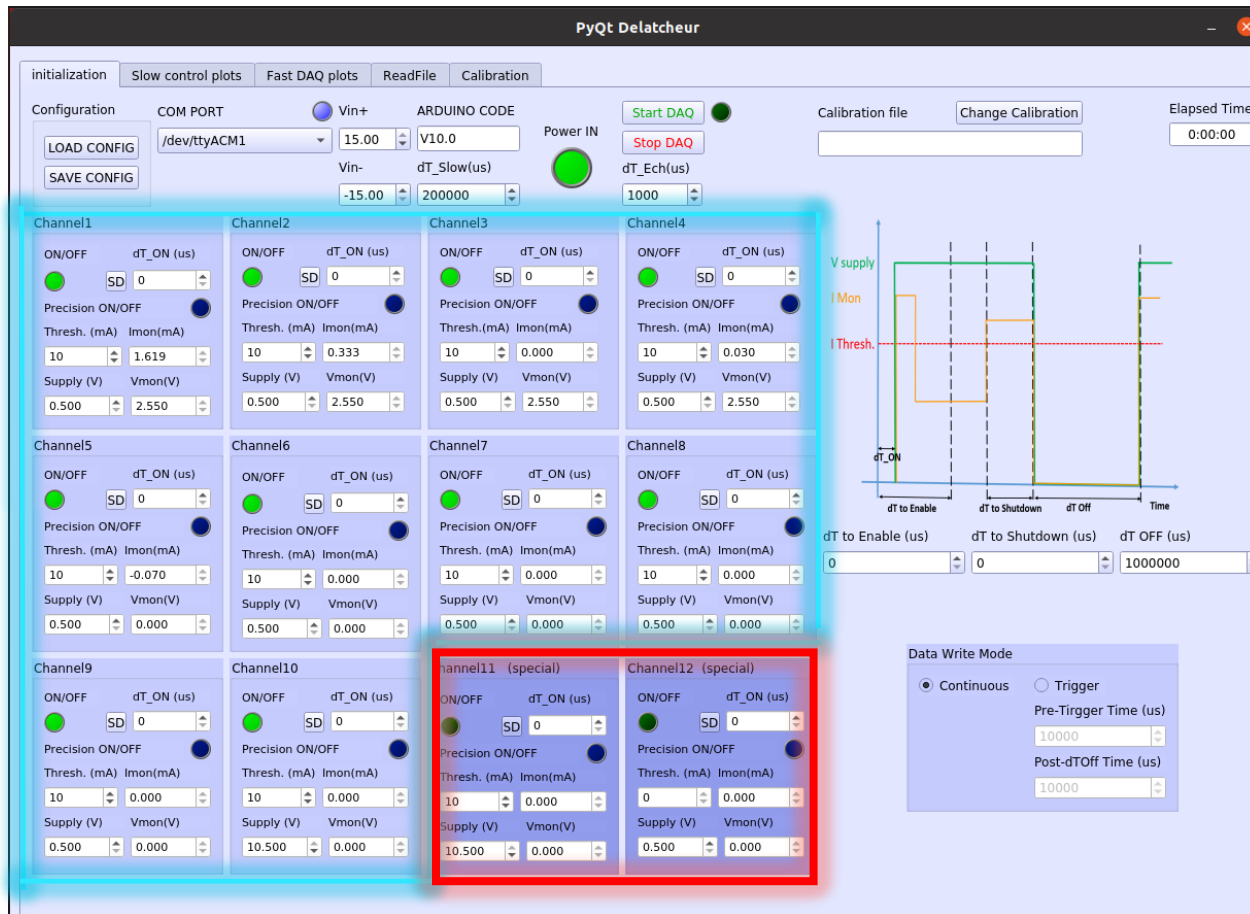
User interface in Python

Load with 100 Ω resistor

Latchupuce PCB

Power Supply

*Testbench for Latchupuce PCB*

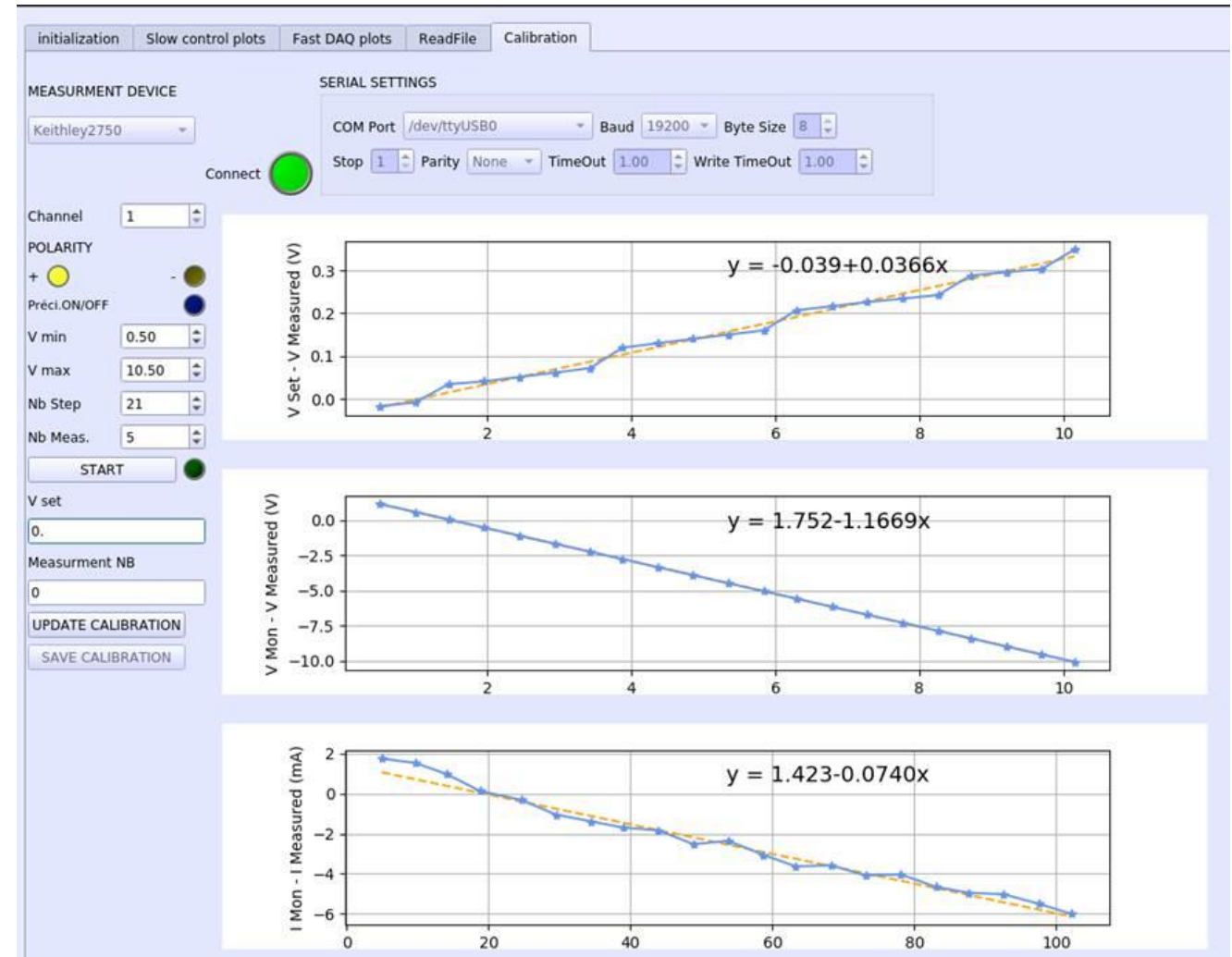# Latch-up monitoring: testing





➢ Each channel can be configured independently

*All positive channels activated*

# Latch-up testing: calibration on going

➢ Calibration of Vset and Imonitoring => ok

➢ Calibration of Vmonitoring: on going (without calibration, we have range from 500mV to 10V)
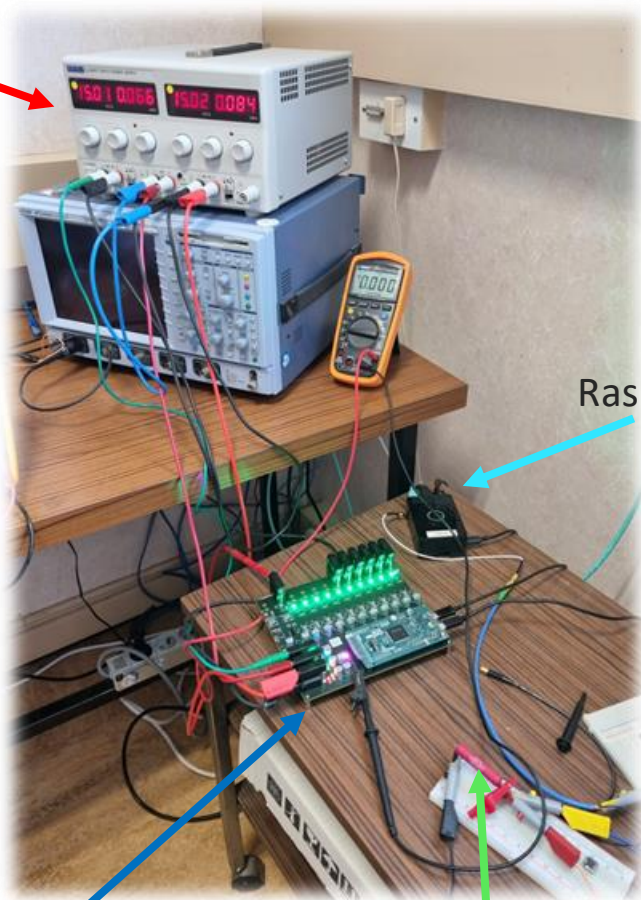


*Calibration for positive channel*

# Latch-up testing: on going
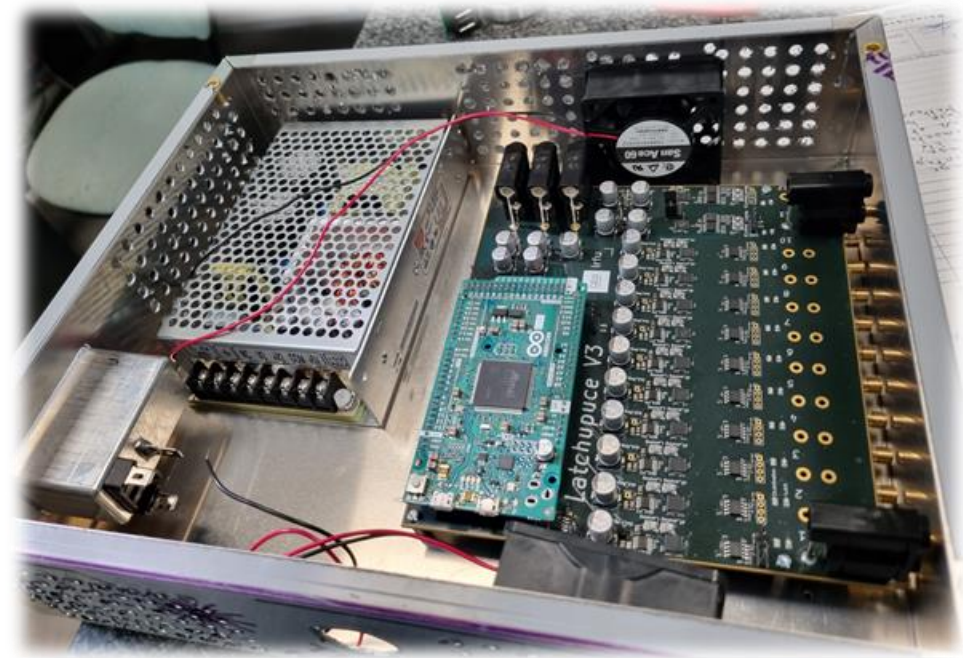


Power Supply

Raspberry PI4

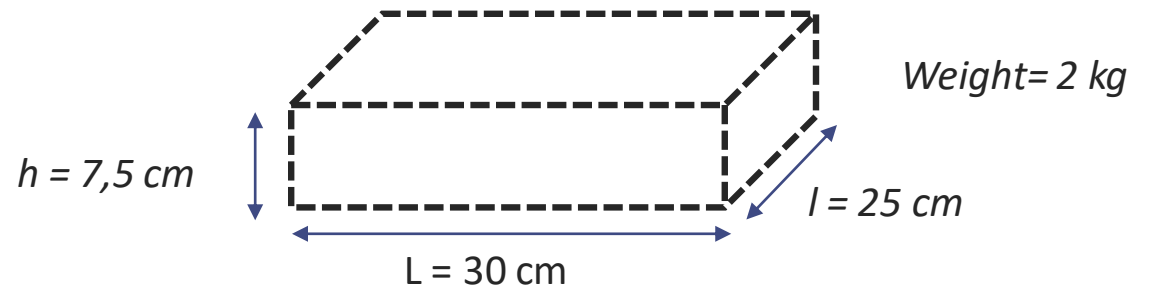Latchupuce

Load (resistor 100 Ω)

*Calibration for positive channel*

# Next step and use of Delatcheur

- **Test on going:** Complete functional and performance testing of Latchupuce PCB

- **Mechanical status:** Mechanical part will be done by end of June 2023.

- **For irradiation campaign test at GANIL on 06/07 July 2023:** Use the delatcheur in order to be able to supply voltage ASICs in beam test

- **For ATLAS Experiment:** Monitoring 12 channels for irradiation of opamps for LSB board (ATLAS Liquid Argon)
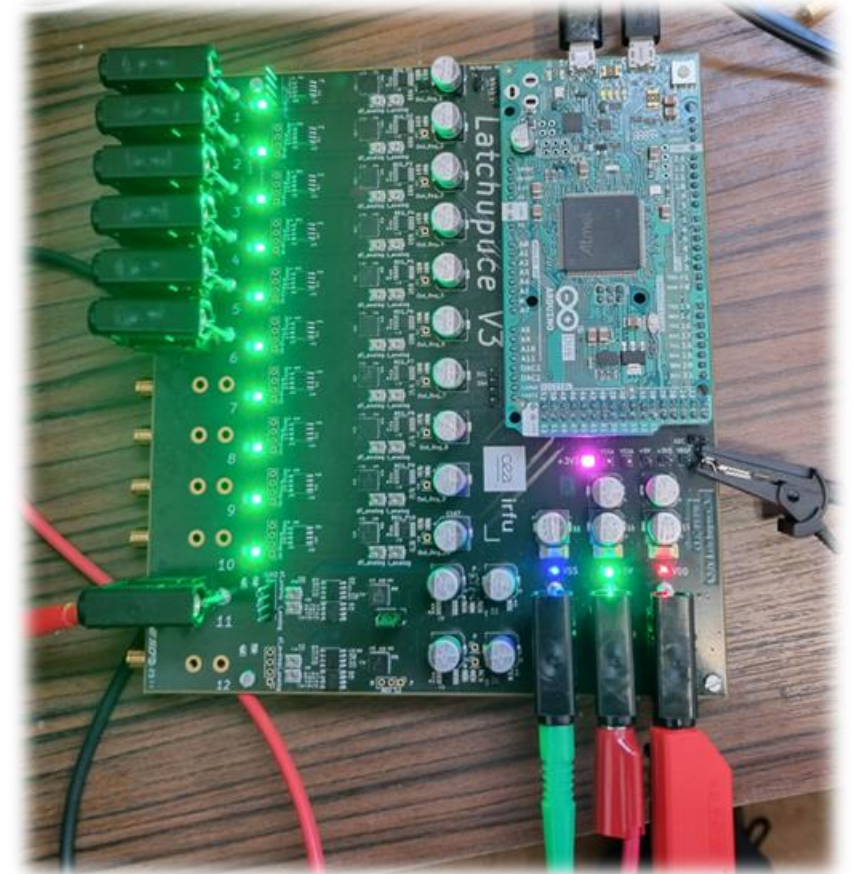


*Latchupuce PCB in mechanical box*

*Weight= 2 kg*

$h = 7,5$ cm

$l = 25$ cm

$L = 30$ cm

# Conclusion

➤ Design and developpement of Latchupuce PCB

➤ Functional and performance testing on going

➤ Material status:
  ▪ One Delacheur available with test on going
  ▪ Four additionals Delatcheurs ready to be produced (including components)

➤ Test beam scheduled next month at GANIL.



*Latchupuce PCB*

**Thank you for your attention, any questions ?**