

Silicon Photomultiplier characterization on board a satellite in Low Earth Orbit

Federico Izraelevitch
UNSAM, CNEA, CONICET

**SiPM workshop: from fundamental research to
industrial applications**

Bari

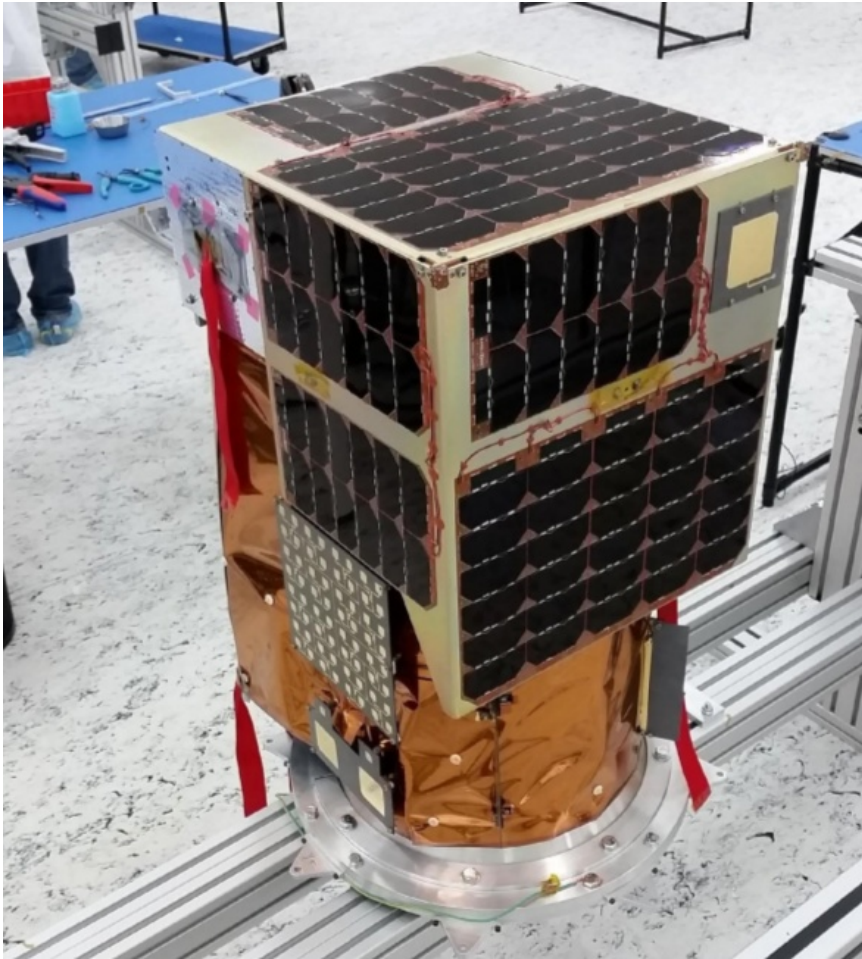
Oct-2019



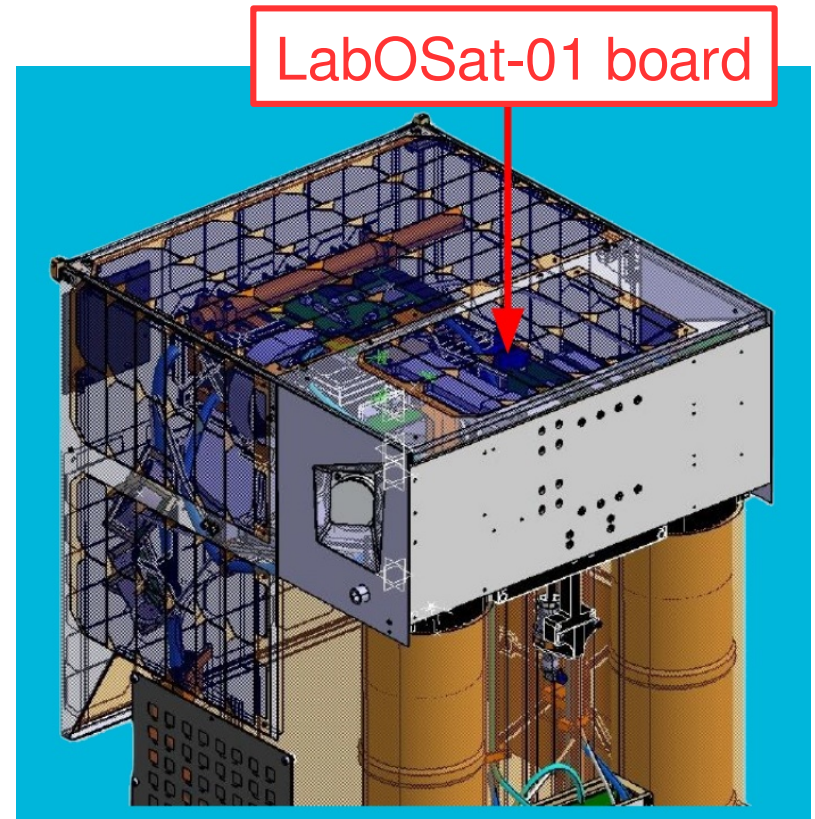
The LabOSat Project

- Objective: novel electronic components and devices
→ Space applications.
- Electronic board to perform experiments on board of satellites.
- Increase the Technology Readiness Level (TRL).
→ Enable usage in future missions.
- Strong partnership with industry: Satellogic.

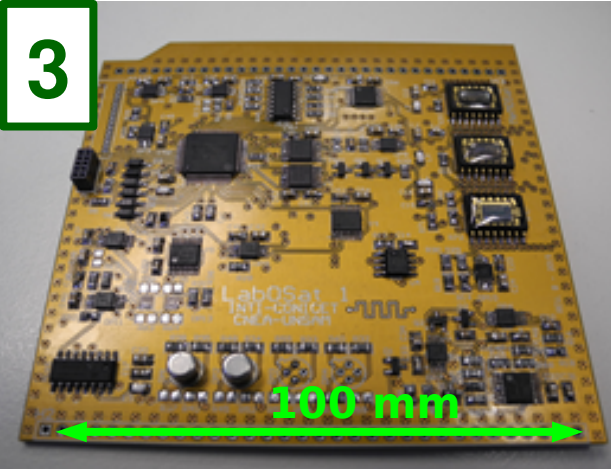
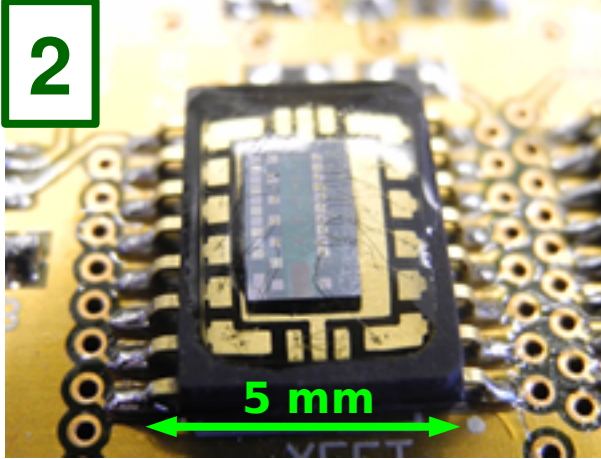
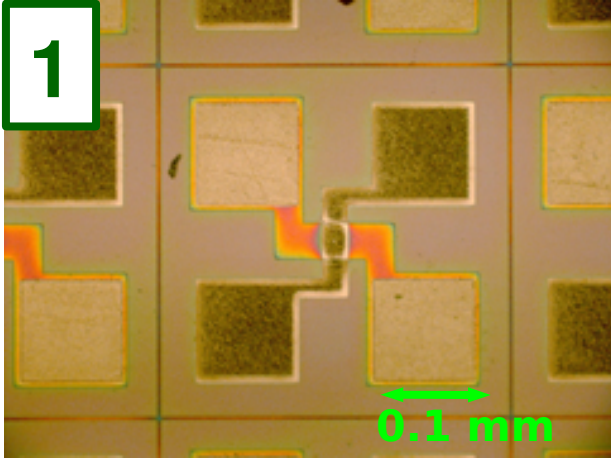
Sattellogic spacecraft: Ñu Satellites



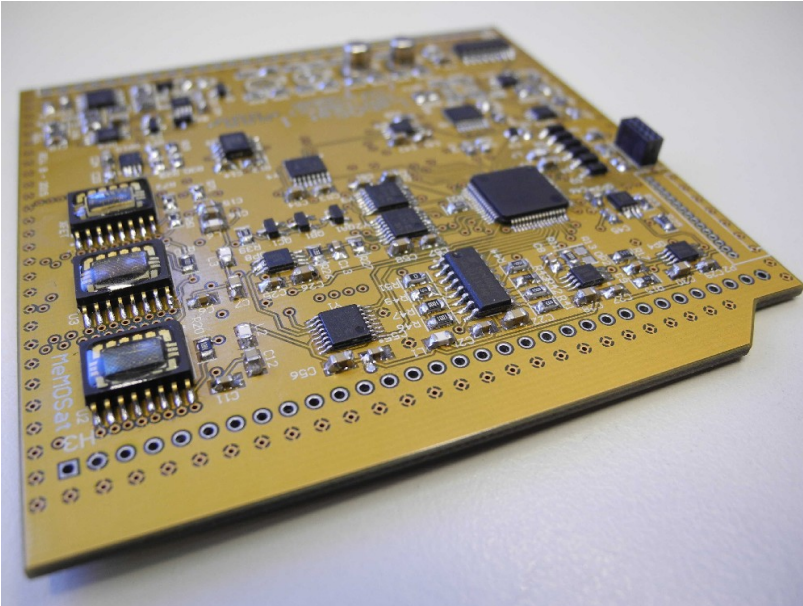
- 40 kg
- 80 cm x 45 cm x 50 cm



The LabOSat Project



LabOSat-01 board



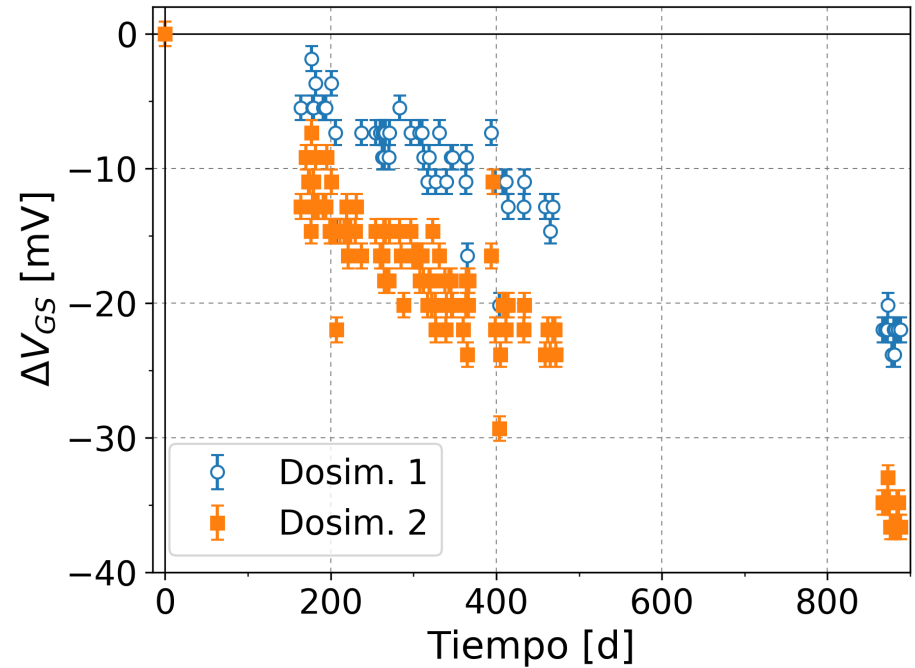
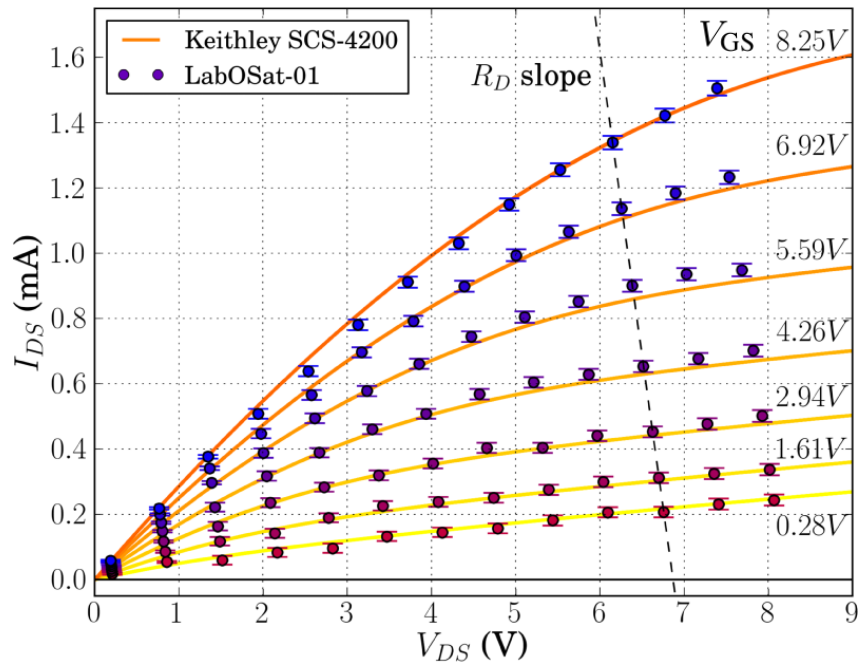
- Source Measuring Unit (SMU), single channel, multiplexed.
- Dimensions = 10 cm x 10 cm x 1 cm
- Weight = 38 g
- Power cons. < 1 W
- Comm. with host = SPI at 200 kHz
- Space qualification:
 - Thermal under vac:
 - Cycling = +/- 40°C
 - Steady at 100°C for 7 days
 - Survival shock at +150°C
 - Shaker test
 - Irradiation
 - 10-MeV protons (TandAr)
 - Thermal neutrons (RA-6)

• Successful operation in six satellite missions

The LabOSat Project

- At the moment:
 - Seven boards in orbit performing experiments.
- Components and devices:
 - Transistors.
 - Resistive switching memories (ReRAM).
 - Sensors.
- Own components, commercial ones, and from collaborators:
 - External groups in Argentina
 - U. Turku (Finland)
 - Nanogune (Spain)
 - INL (Portugal)

MOSFET: Characterization and dosimetry



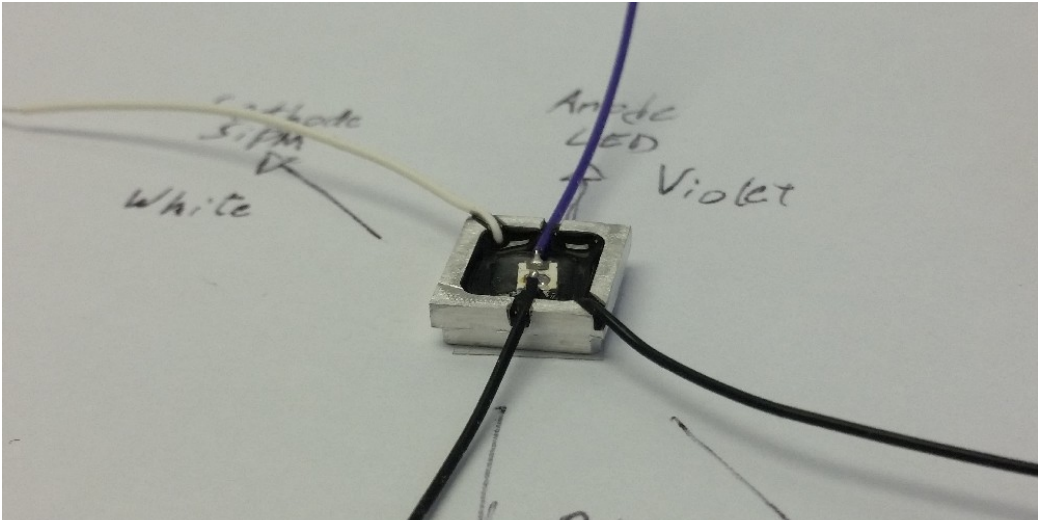
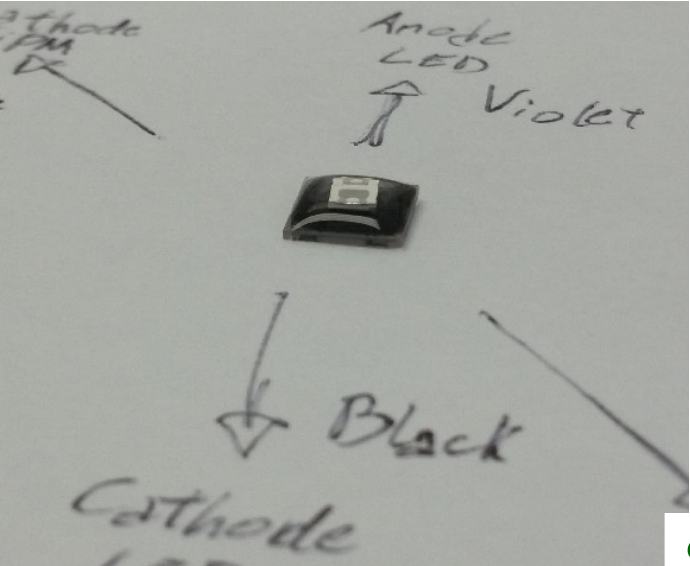
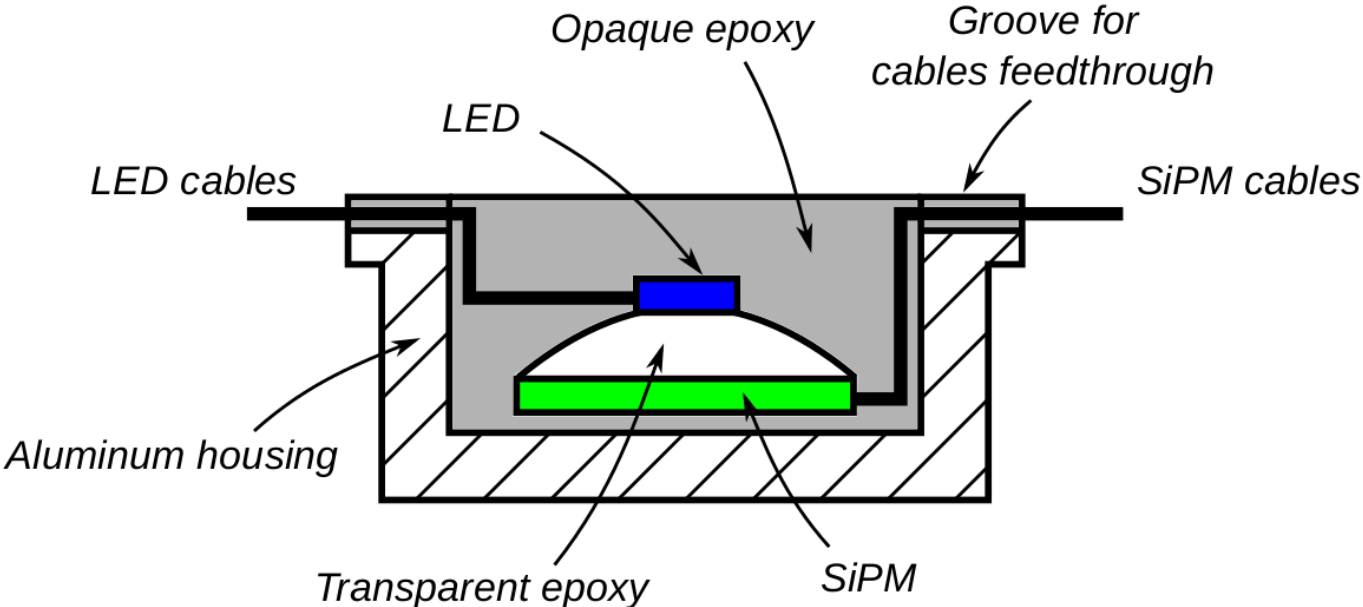
The LabOSat group (CNEA, CONICET, INTI, UBA, UNSAM)



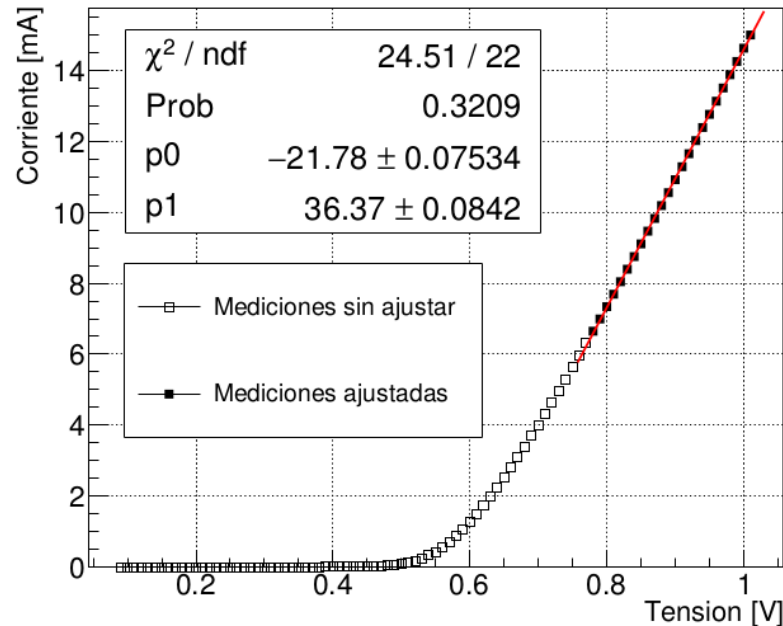
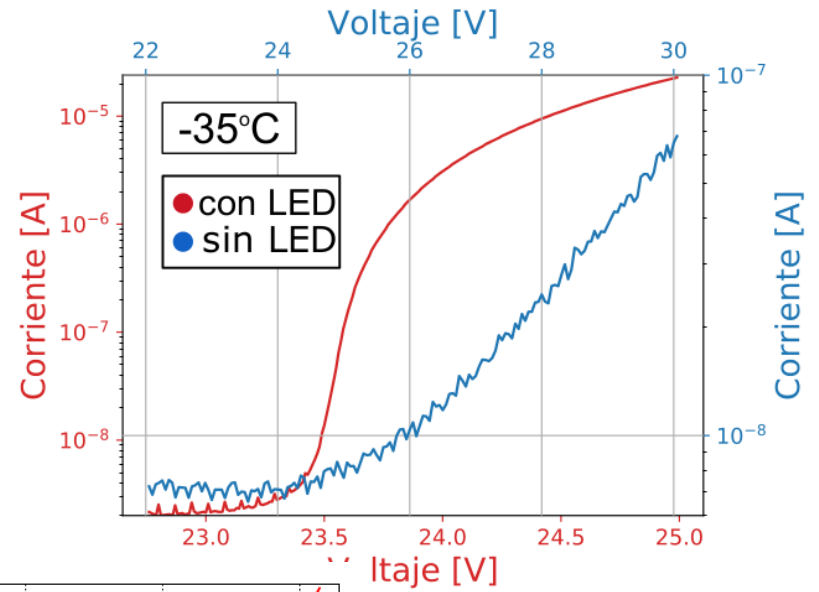
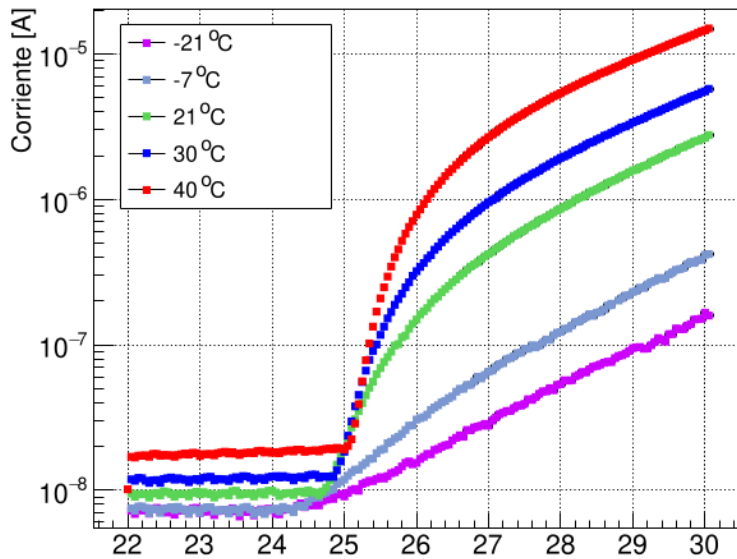
SiPM characterization in DC current mode

- Early 2018: launch opportunity within a year
 - Use the proven LabOSat-01 board
- Objective:
 - Validate (learn about) a DC-DC (COTS from LT) for biasing SiPMs
 - Bias voltage in Open loop (no temp. correction)
 - Measure the DC response of SiPMs at fixed V_{bias}
 - Dark current
 - Under faint DC illumination

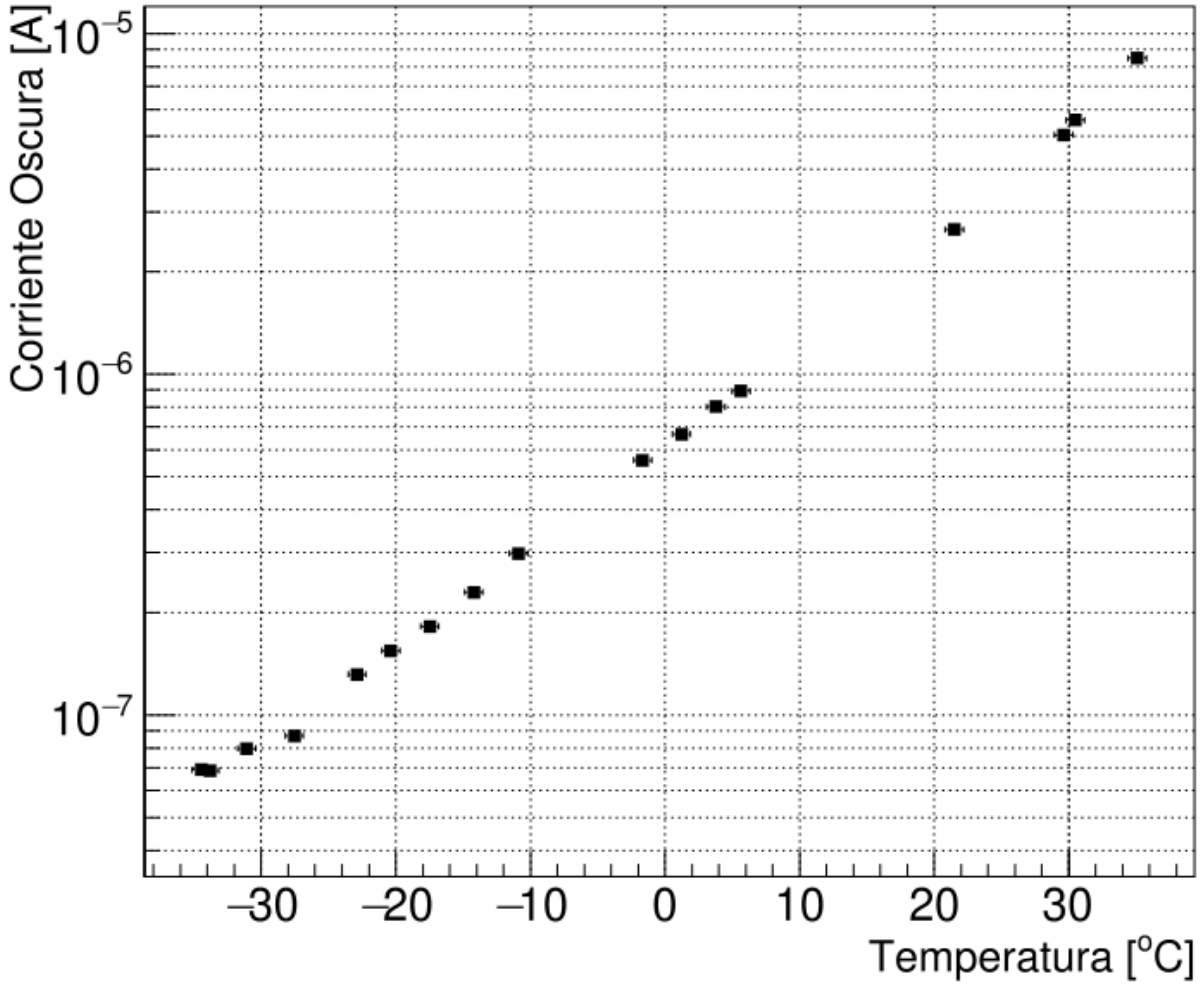
SiPM characterization in DC current mode



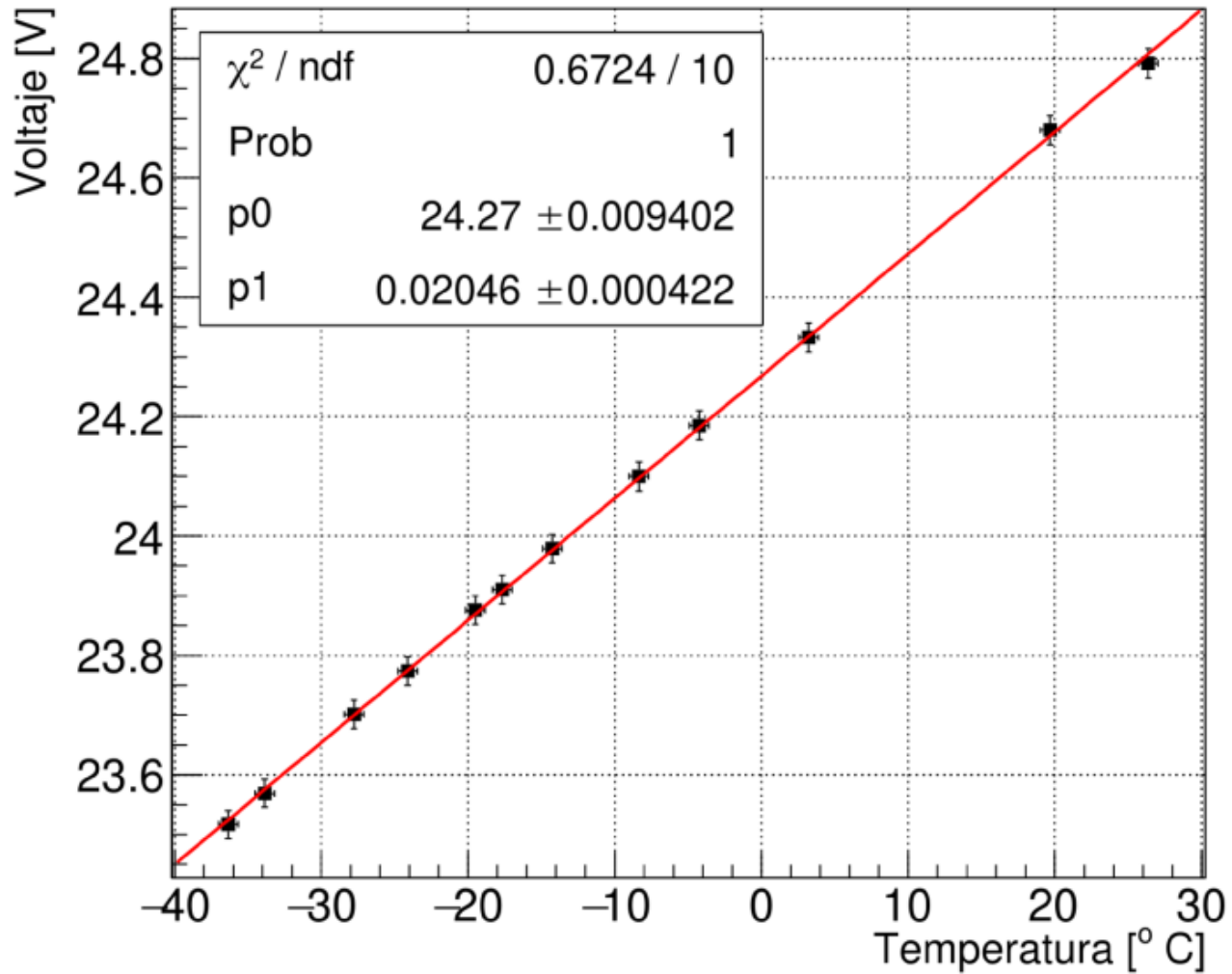
Current-Voltage characterization with benchtop instruments



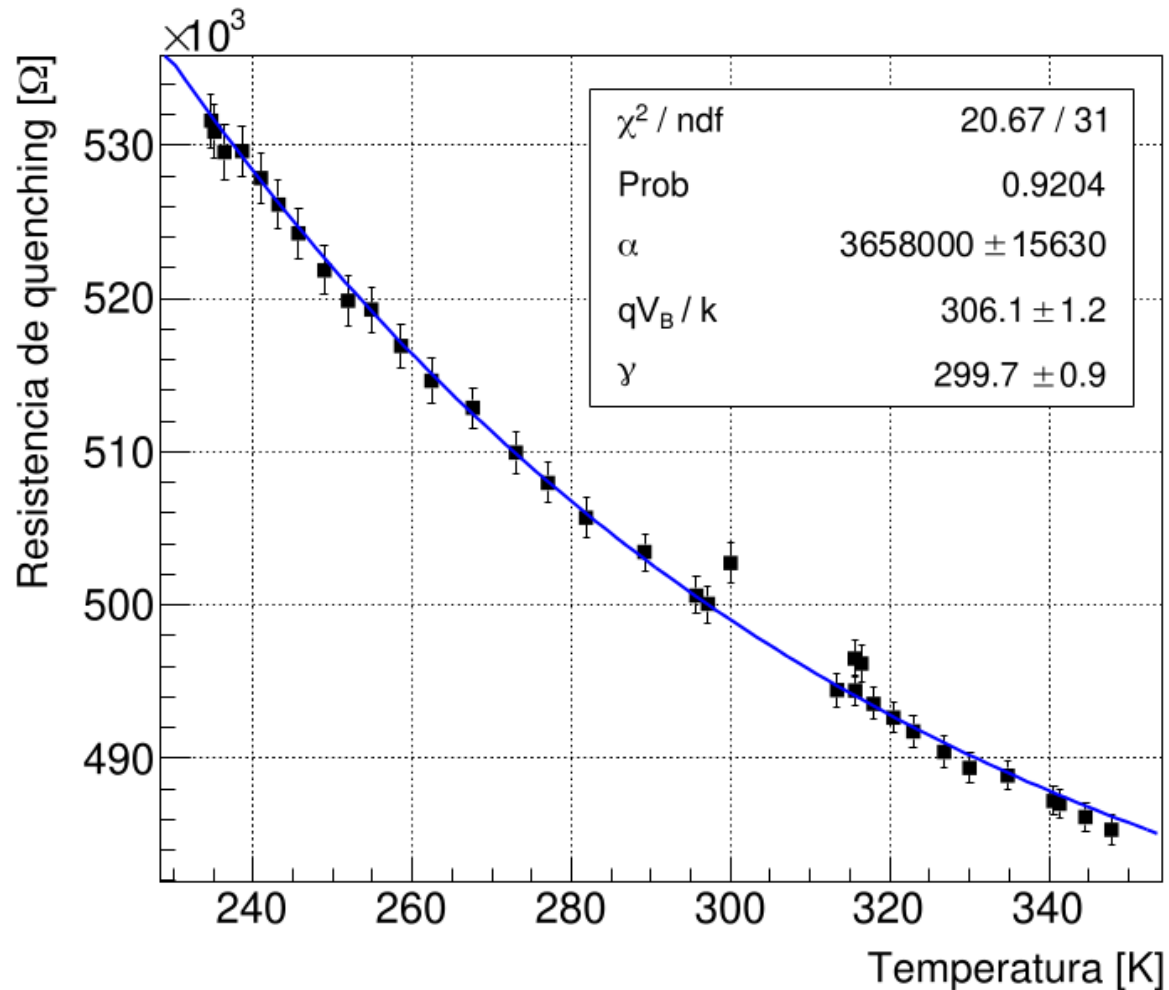
Dark current vs. Temperature



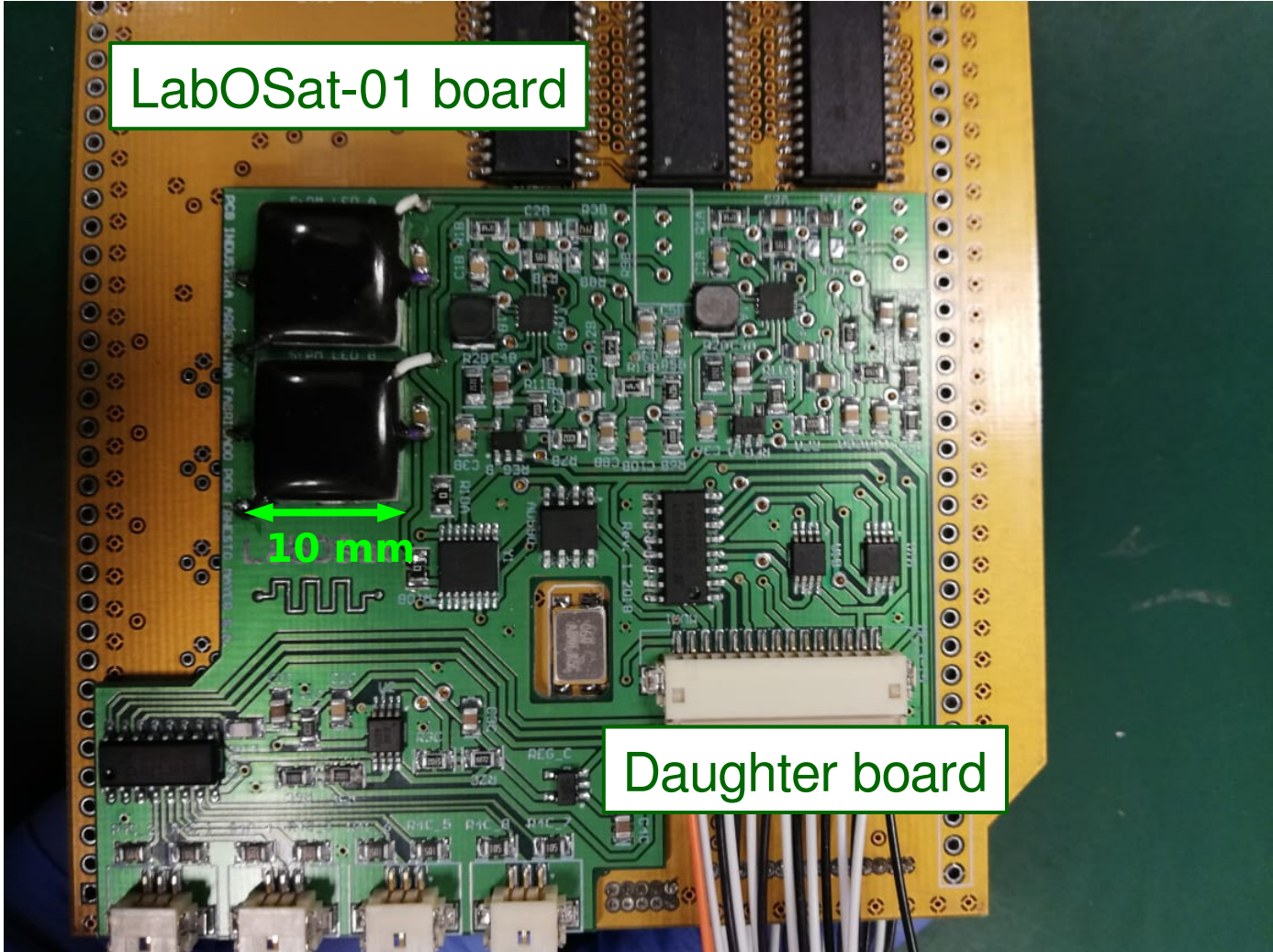
Breakdown voltage vs. Temperature



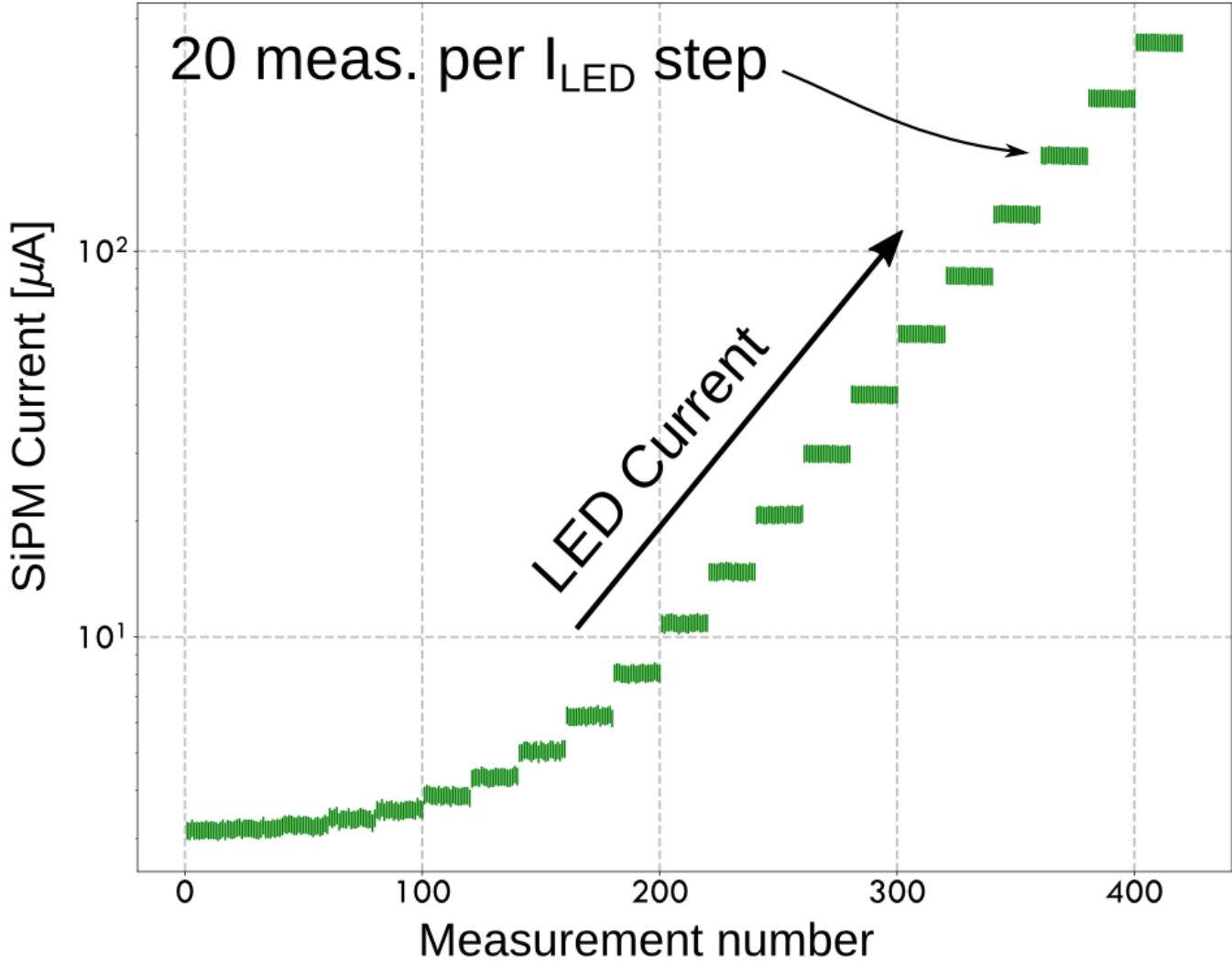
Quenching resistor vs. Temperature



Two SiPM-LED packages in a daughter board

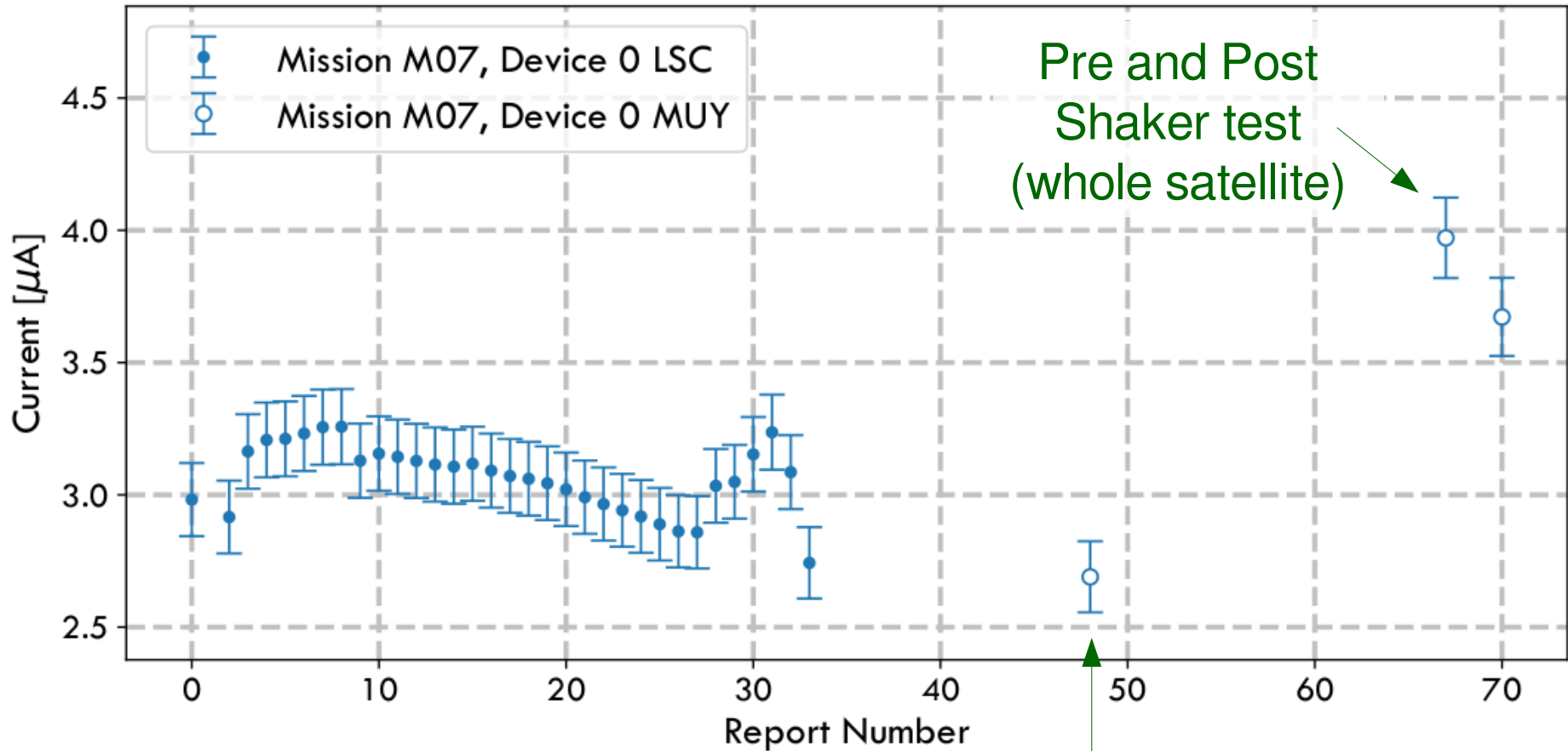


Experiment concept



Dark current vs. Report number

Current vs Report Number for M07, Device 0

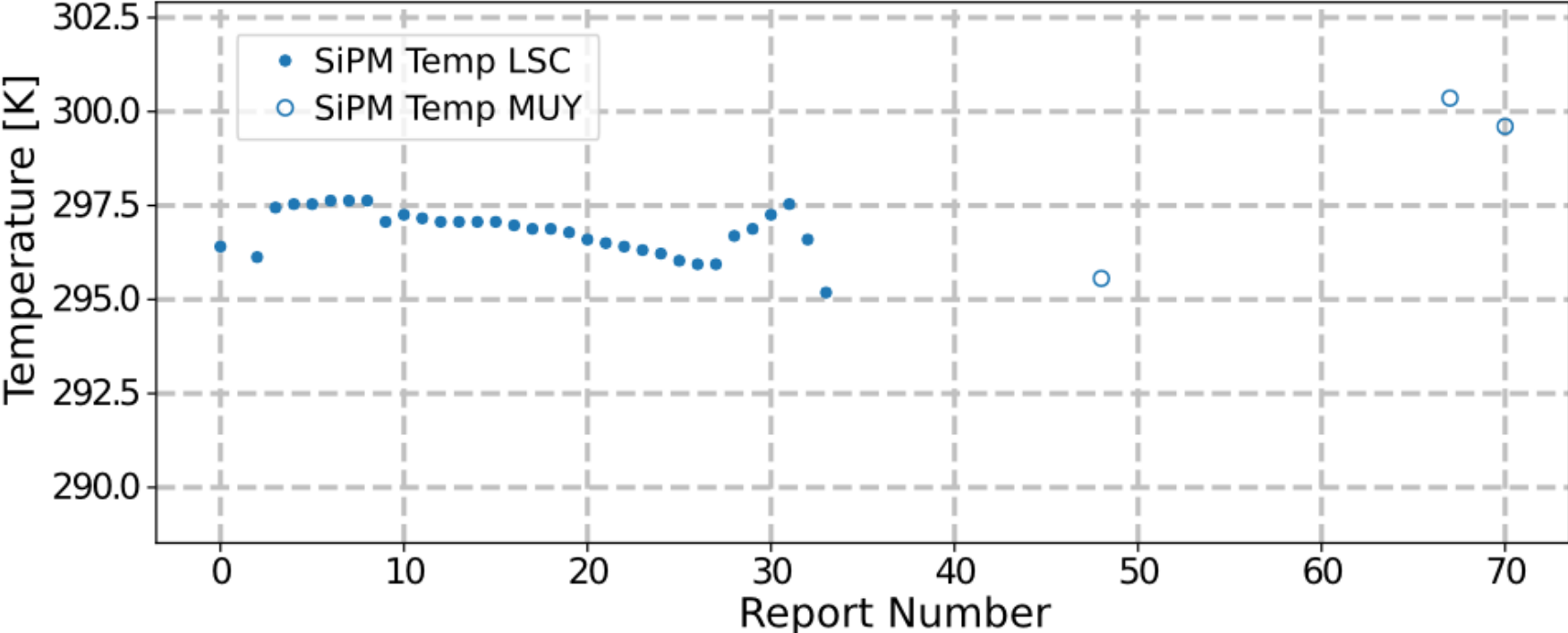


Start-up at the laboratory

Integration with the host satellite

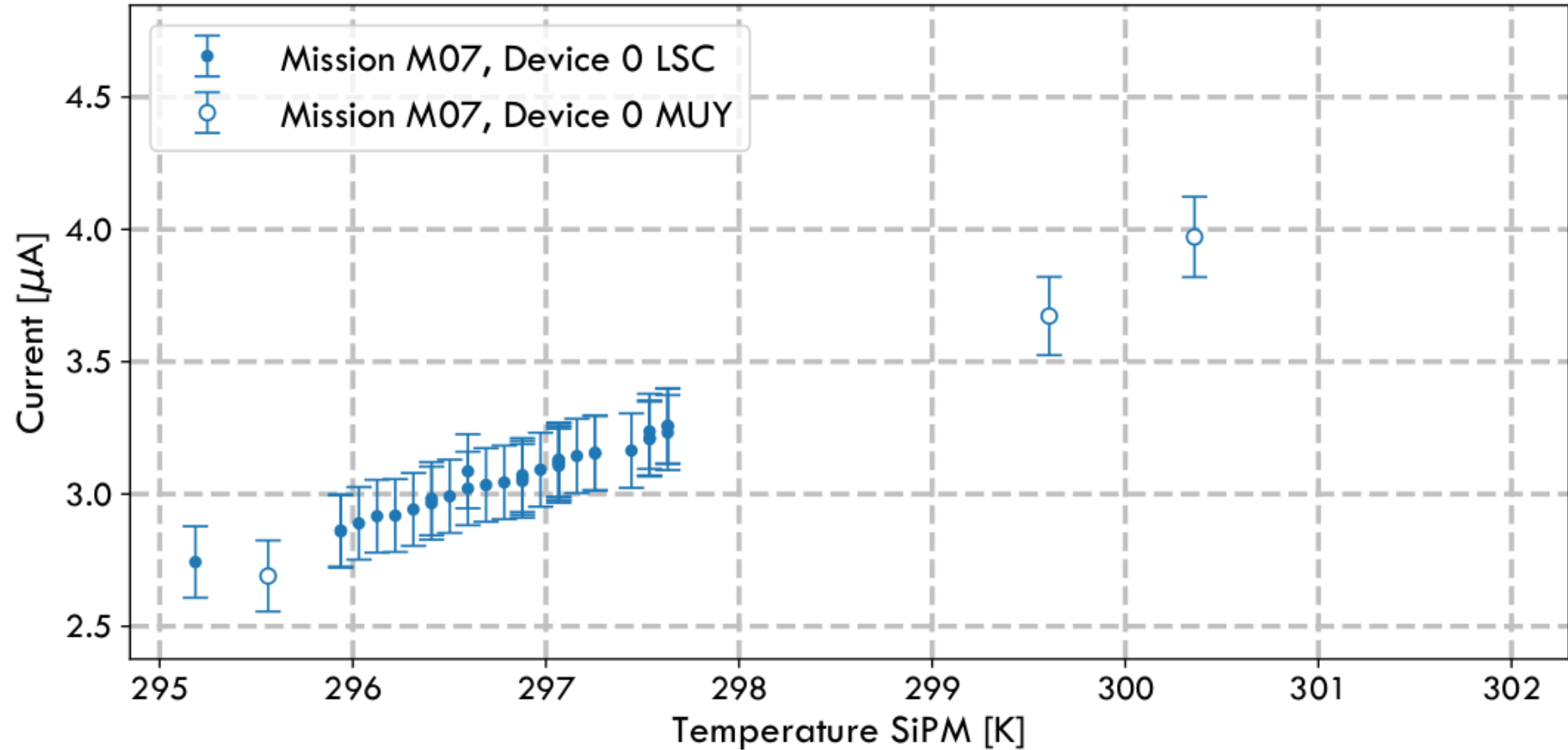
Temperature vs. Report number

Temperature Vs. Report Number for Mission M07, Device 0



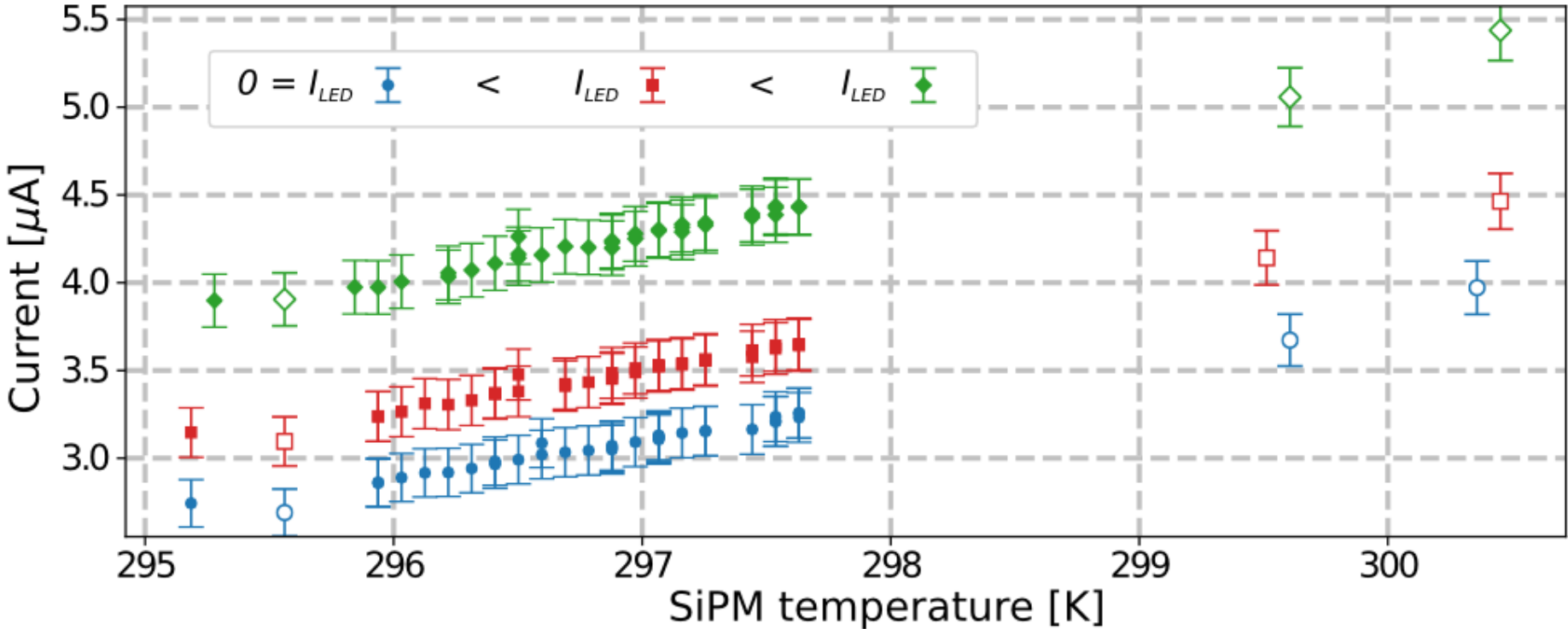
Dark current vs. Temperature

Current vs SiPM Temperature for M07, Device 0



SiPM current for different LED illuminations vs. Temperature

SiPM Current Vs. SiPM Temperature, M07, Dev0



Current mission status

- Launch was expected on Q3 2019
→ Delayed until Nov-2019
- All the data analysis pipeline done
→ Plots update automatically with new Reports from LEO

LabOSat Project: outlook

- Access to a Secondary Payload Bay
 - Vol ~ 2 liter
 - Mass ~ 1 kg
 - Nadir FoV
- Currently under development:
 - On-board Computer on PC/104
 - Instrument based on 1 or 2 SiPMs in photon counting mode
 - Objective: measure photon flux from different sources

