Inner Tracking Detector Upgrade

ABC130 Chip Irradiation and SEU Testing

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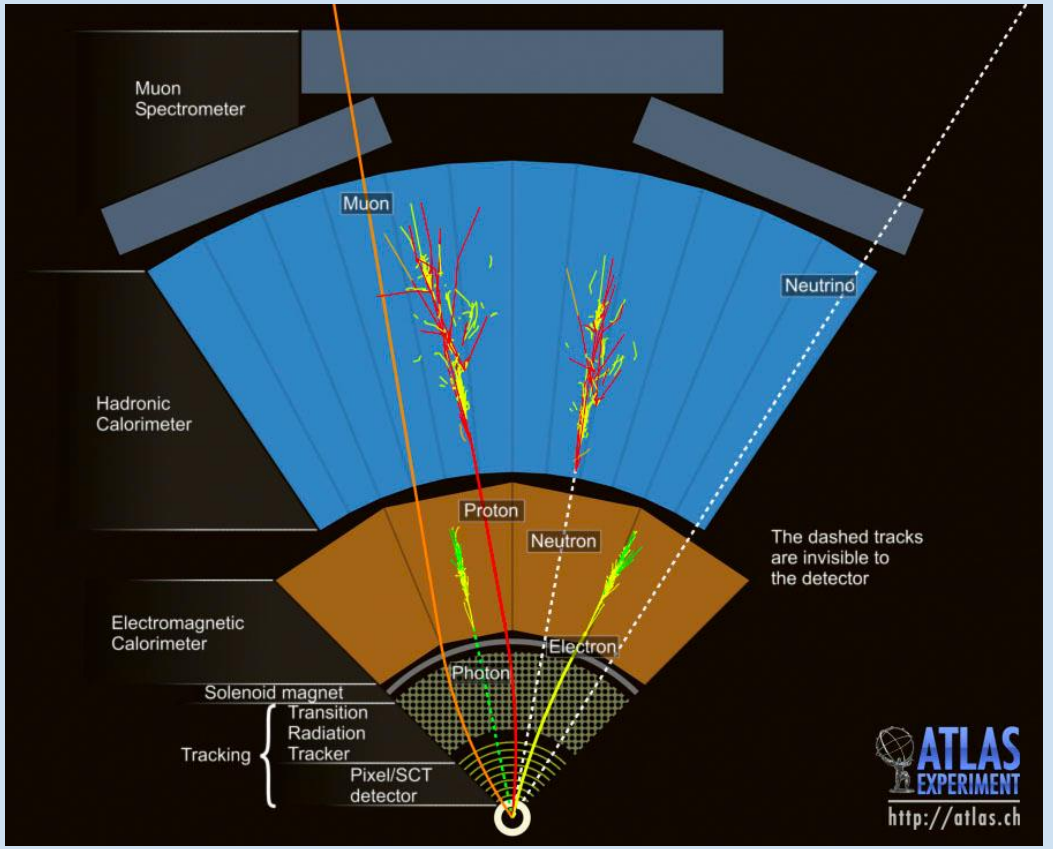
Overview

- Introduction
- ABC130 Chips
  - Post Irradiation Measurements
  - Pre-and-during Irradiation Measurements
  - Re-irradiation
- TFileMerger
- Future Work

Background

The ATLAS detector

- The detector is divided into a number of subdetectors which can be grouped as follows
  - Tracker
    - This is the area just outside of the beam pipe, it does not destroy any particles, but it can track charged particles
  - Calorimeters (Electromagnetic and Hadronic)
    - Identification to get Energy of particles
  - Spectrometer
    - Finds muons



The Inner Detector

The Inner detector is made of three components: the pixel detector, the transition radiation tracker and the Semi-Conductor Tracker.

Pixel Detector (55-150 mm)

- Silicon pixels –each is 50 x 400 microns (1x8 human hairs)
- 1750 modules (~50, 000 pixels/module + 16 readout boards)
- Total: ~80 million channels of readout

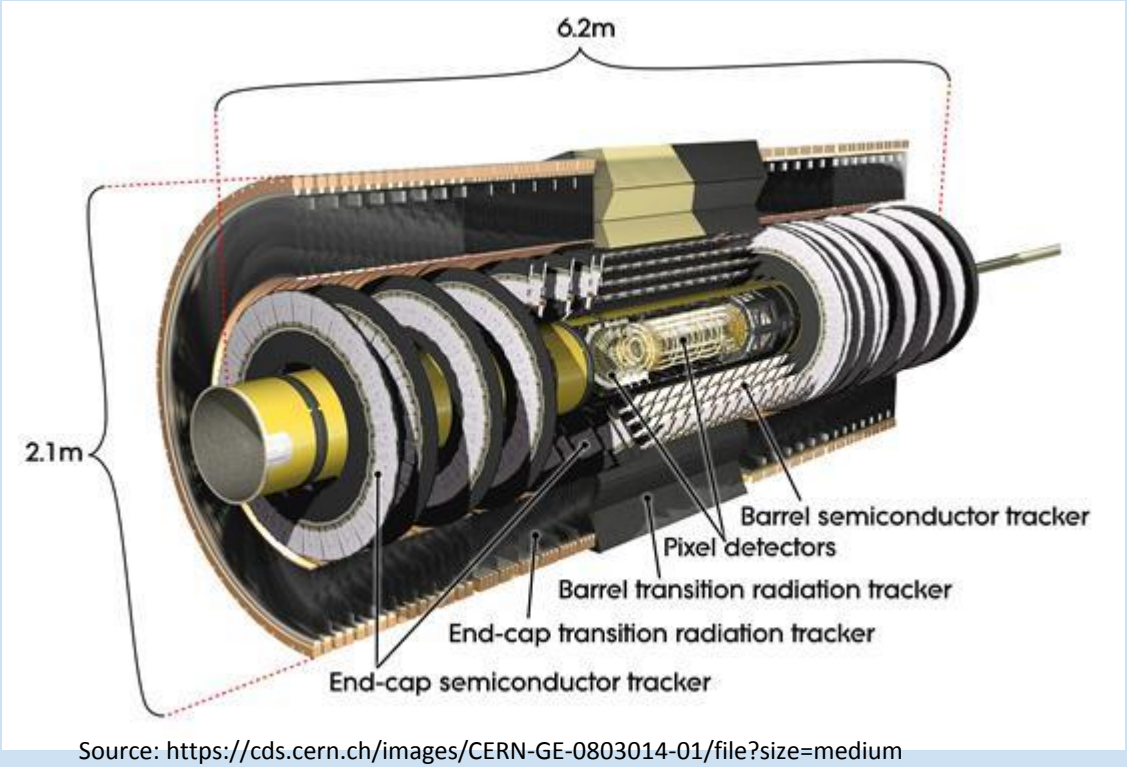
Semi-Conductor Tracker (299-506 mm)

- SiPM micro-strip detector made of two sections
  - Barrel—Long staves—2112 modules total
  - End Cap—Composed of Petals each containing slices of Rings of detectors—2 endcaps with 988 modules each
- ~6 million channels of readout
- Gives 8 measurements per particle for spatial positioning

Both of these work by detection of charged particles, measuring the small ionization caused by the particles passing through the strip

Transition Radiation Tracker (563-1066 mm)

- Drift Tube + Radiatiors in 1 barrel & 2 endcaps
  - Barrel—3 layers of 32 modiules
  - Endcaps- 1 per side 18 modules total
- Particles ionize gas which then drift towards the wire for 30 position points



Source: https://cds.cern.ch/images/CERN-GE-0803014-01/file?size=medium

ITK Design

- The ITK will be the all silicon detector replacing the whole Inner Detector for High Luminosity LHC
- Similar system to current SCT
- This “strip” detector will be replacing the pixel detector to increase pile up efficiency and jet identification

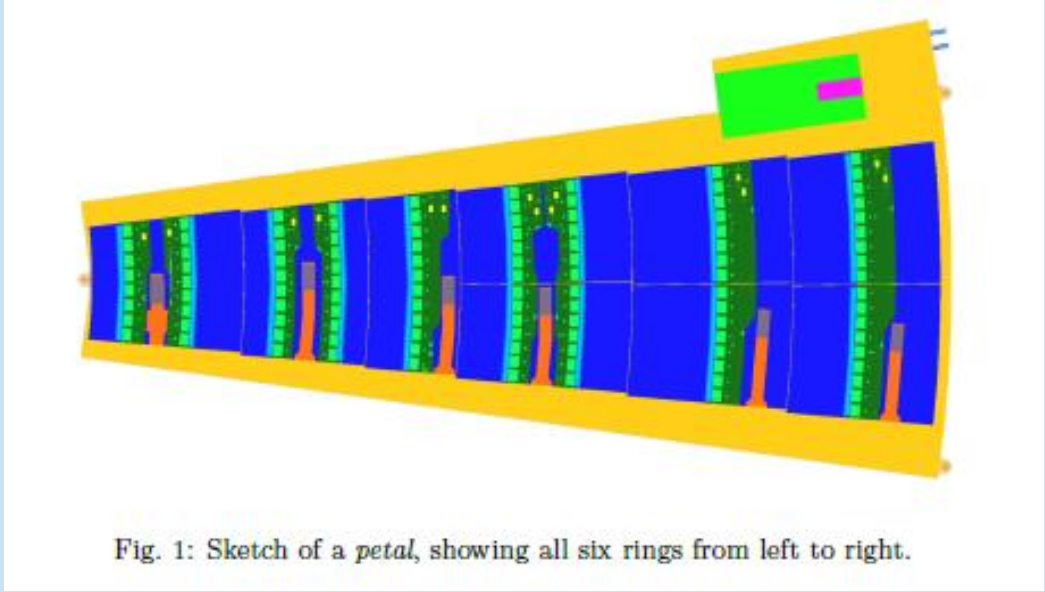
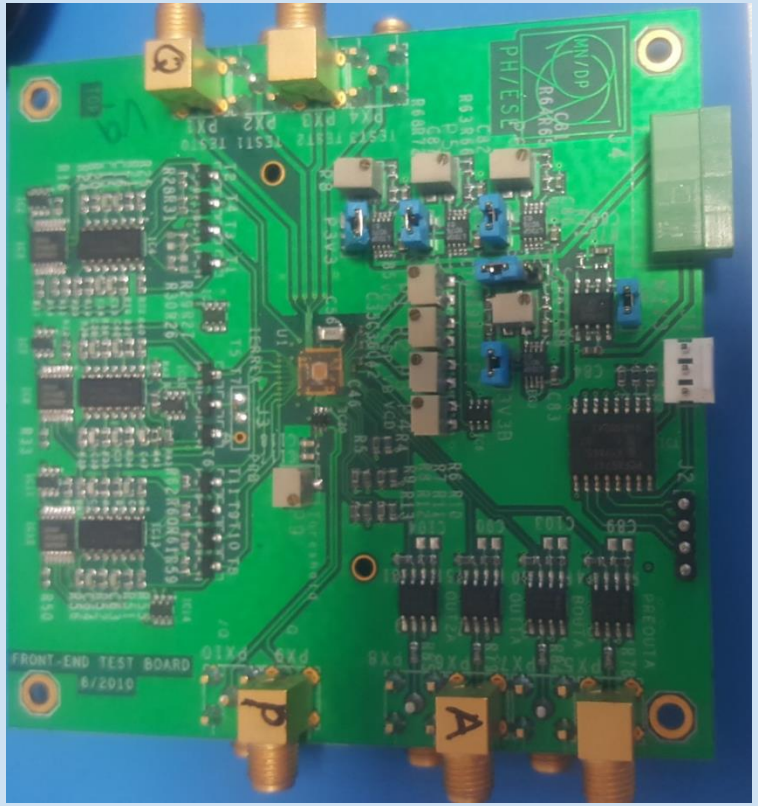


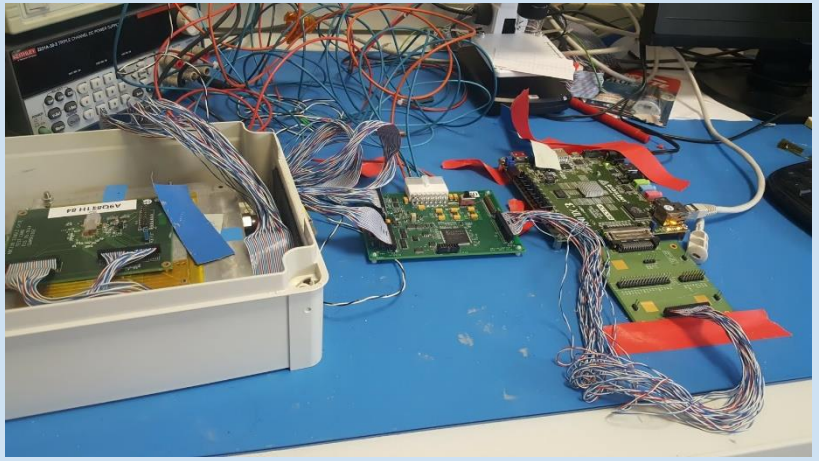
Fig. 1: Sketch of a *petal*, showing all six rings from left to right.

ABC130 Chip

ITK operations

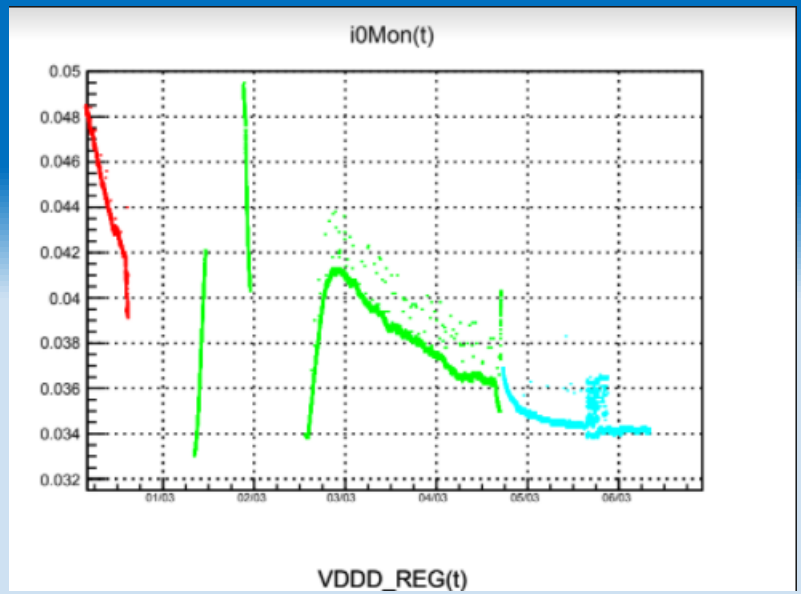
- driver board (FPGA)
- Hybrid Controller
- Readout chip
- DC-DC converter
  - Regulates Voltage down to 1.5 V

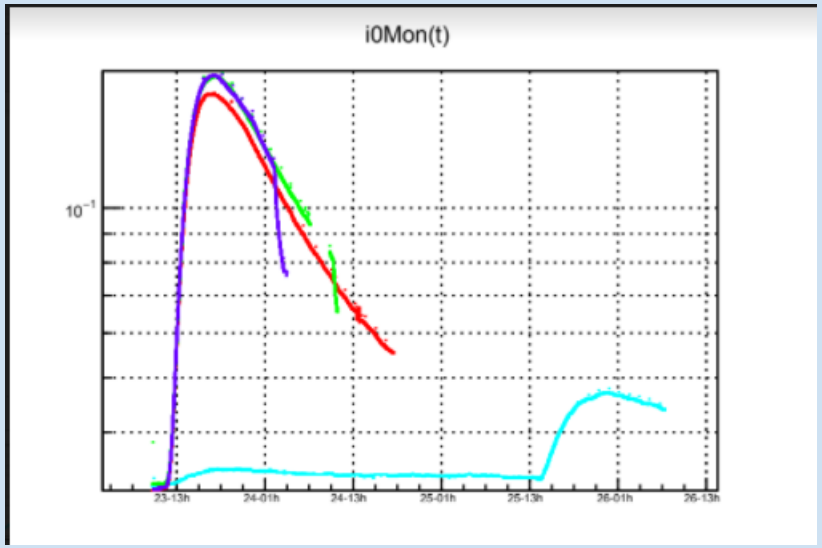




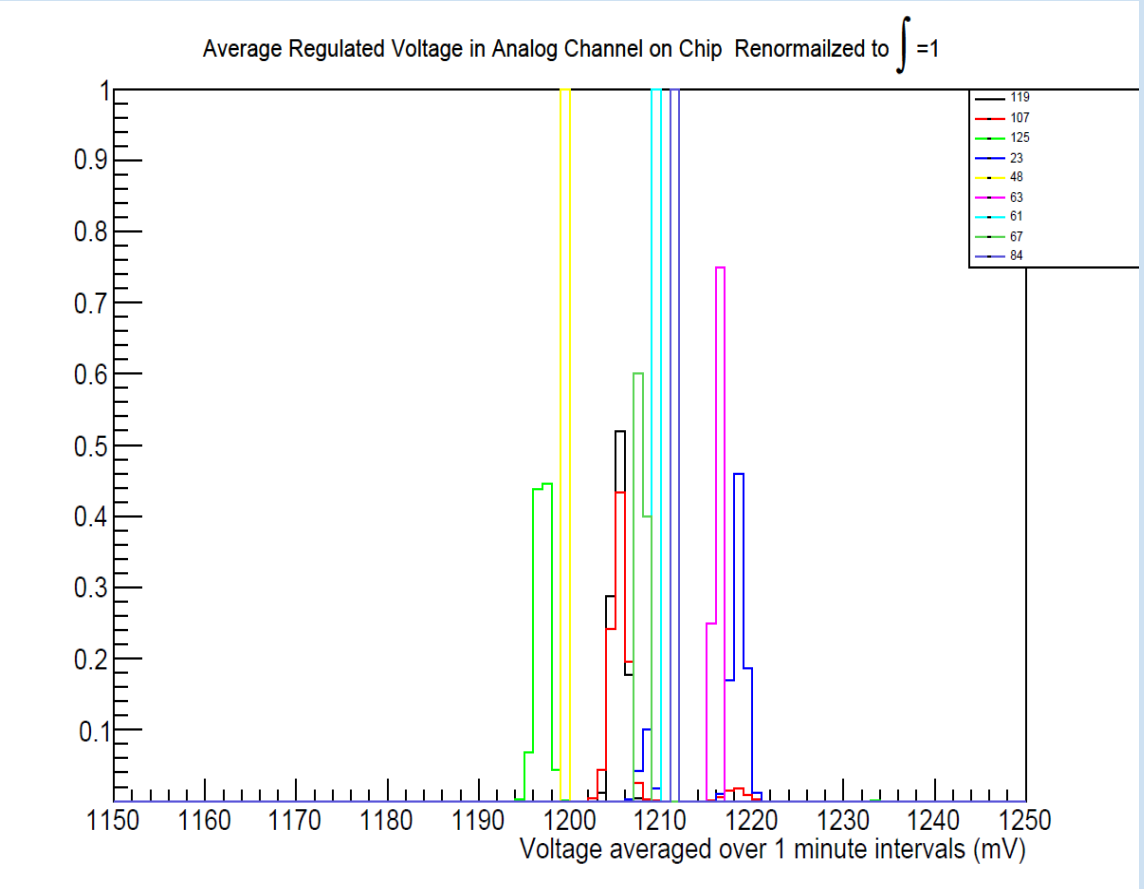
Total Ionizing Dose Bump and Annealing

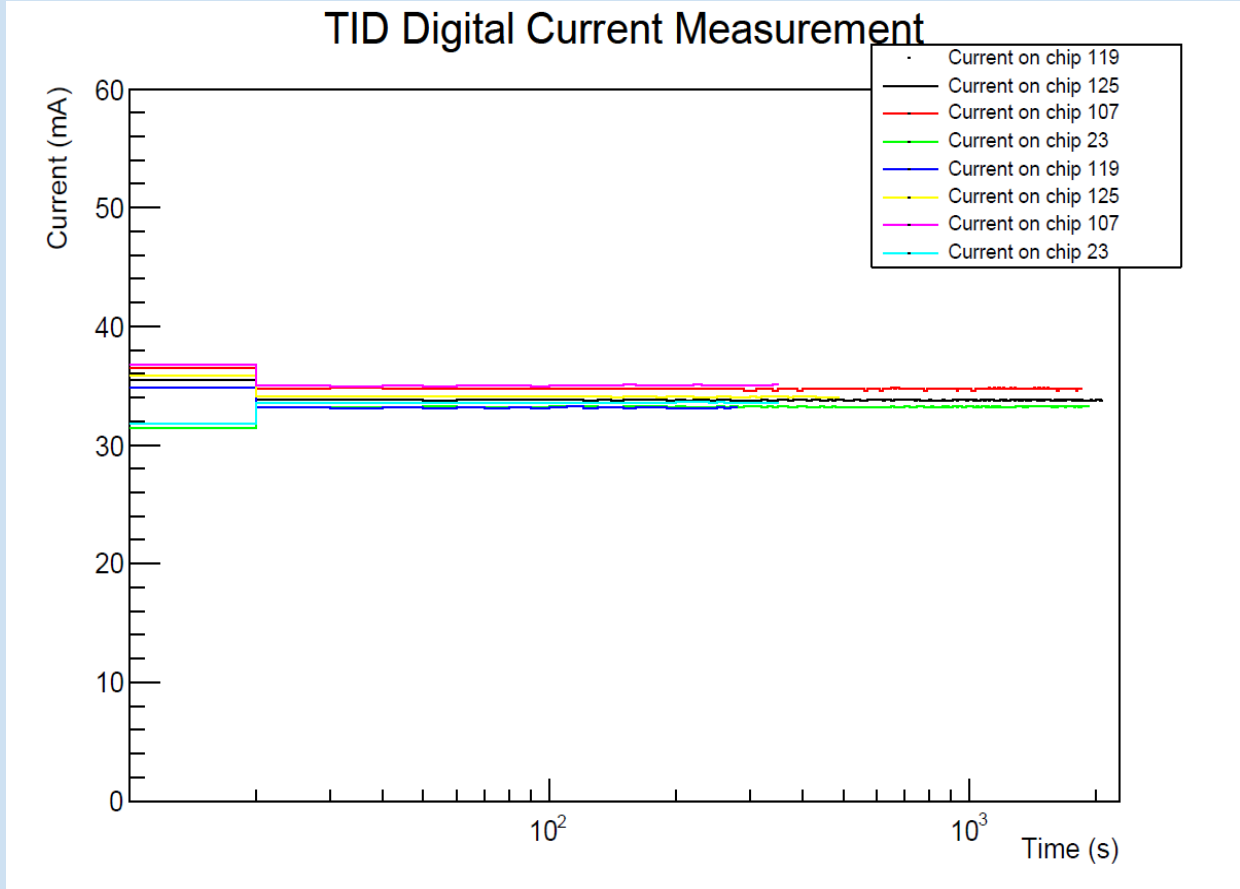
- There is an increase in current consumption when the chip is exposed to ionizing radiation
- This effect is thought to be caused by damages to the chip
- These damages cause leakage current and significant temperature increases (few °C per chip)



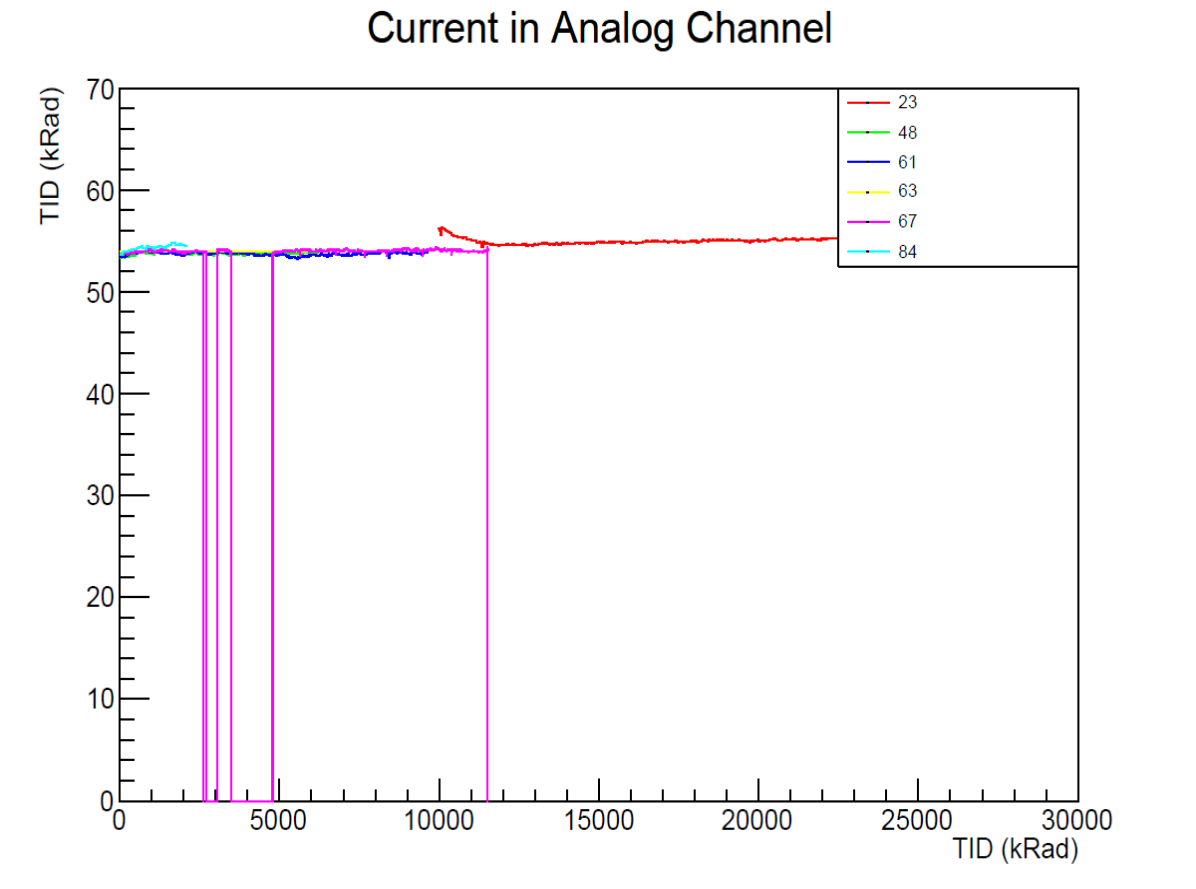


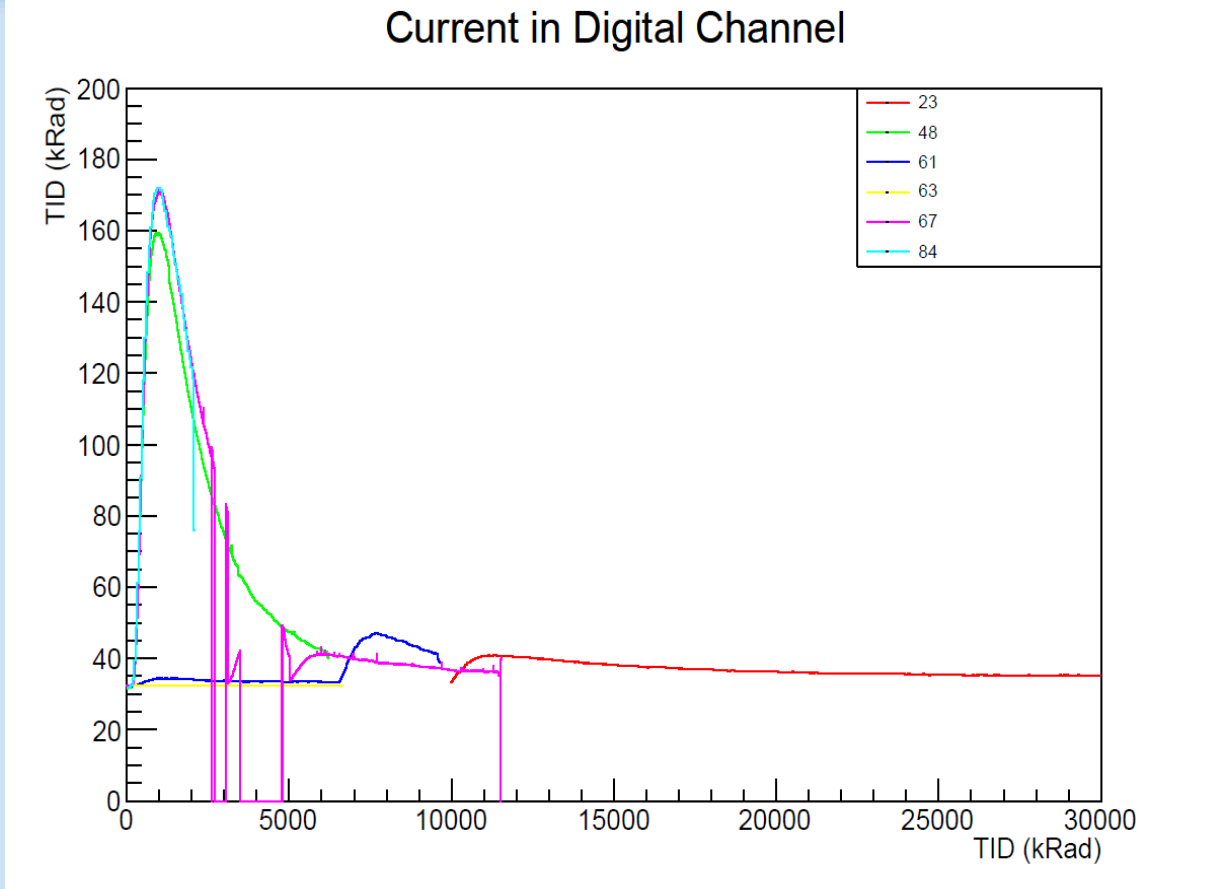
Post-Irradiation (Batch 2) & Pre-Irradiation (Batch 3)



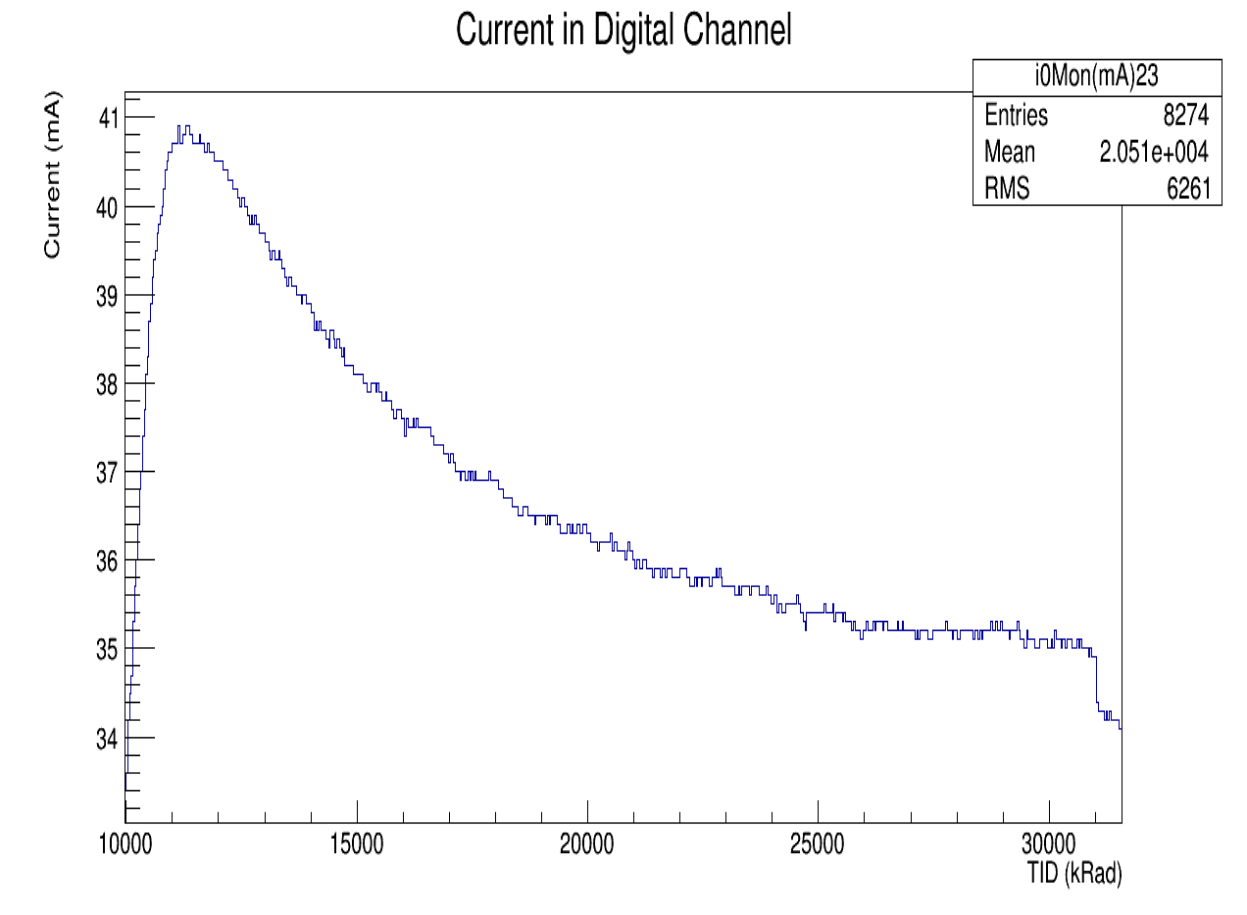


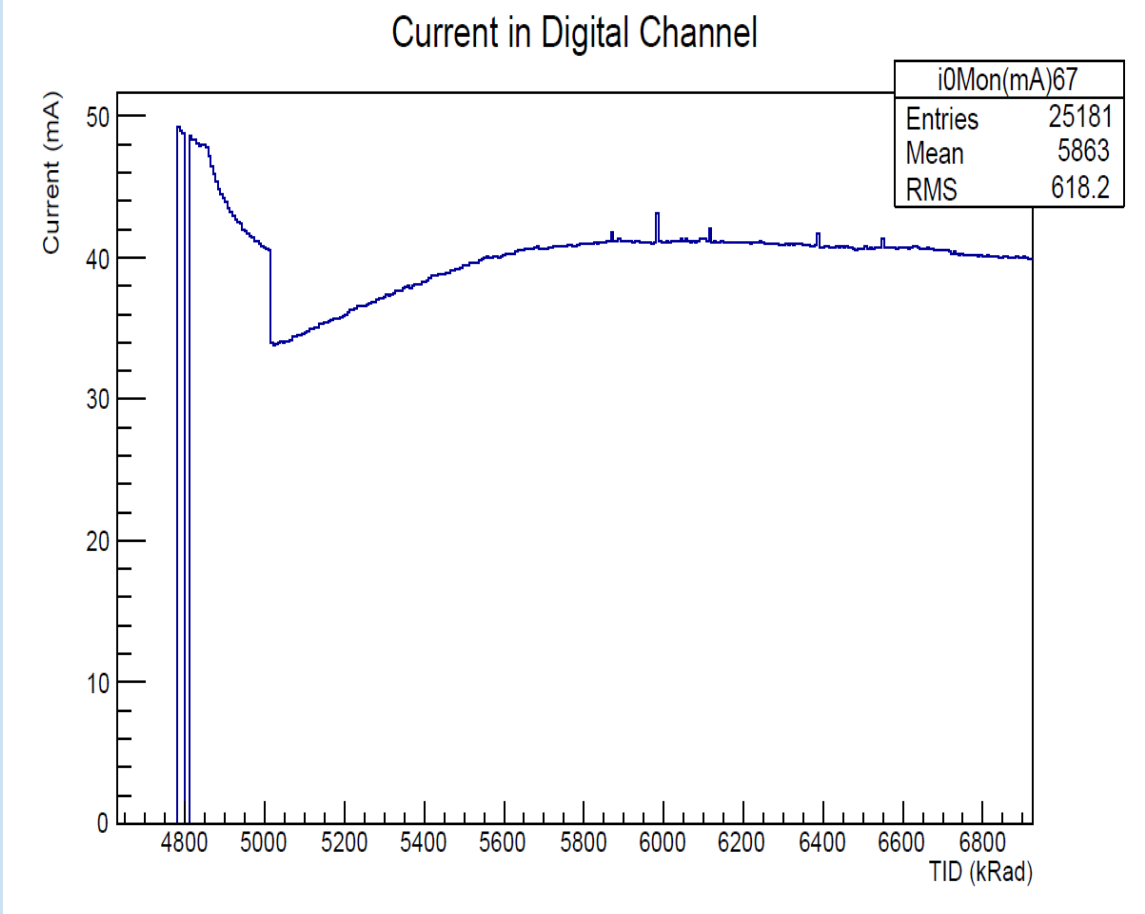
During Irradiation



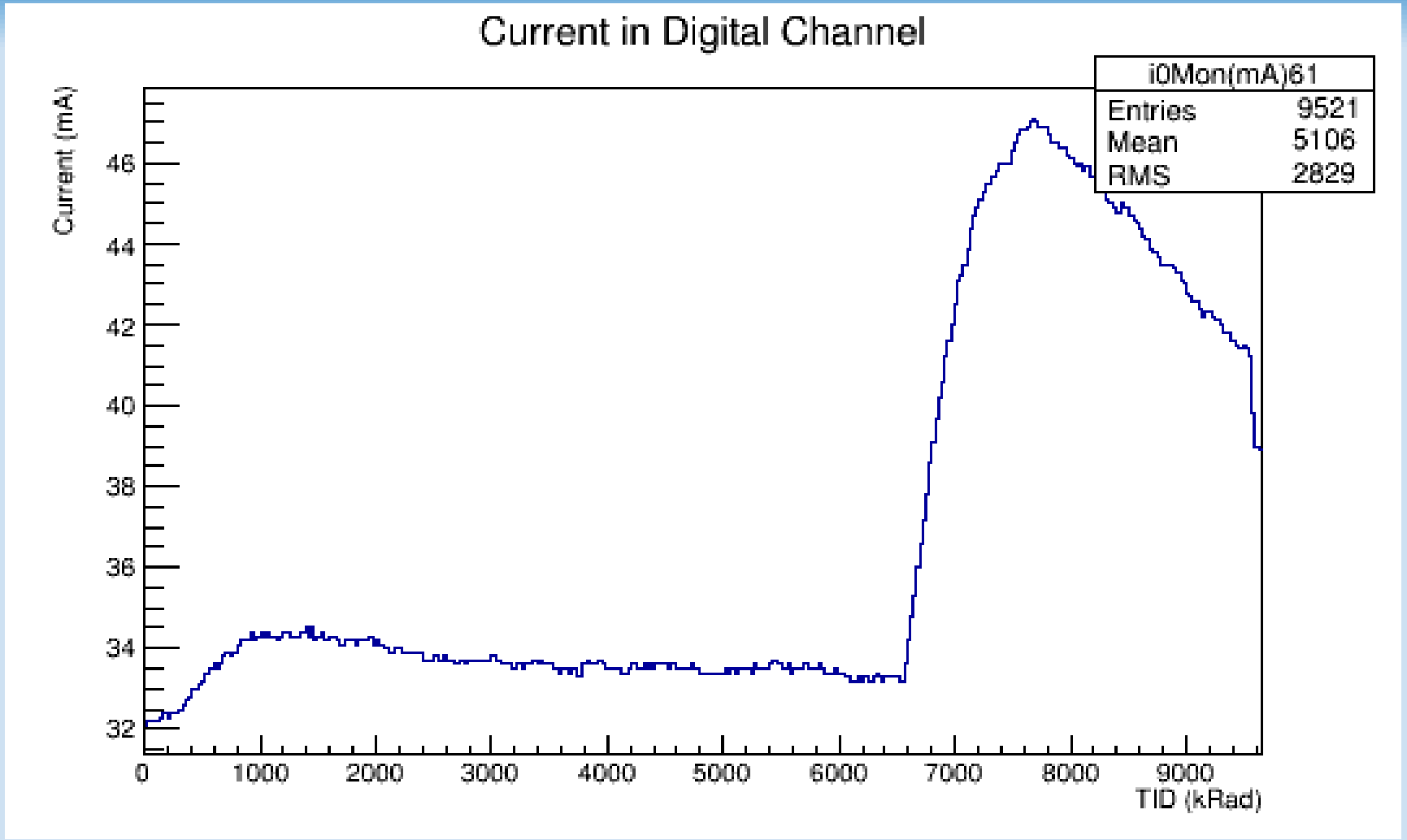


Re-Irradiation

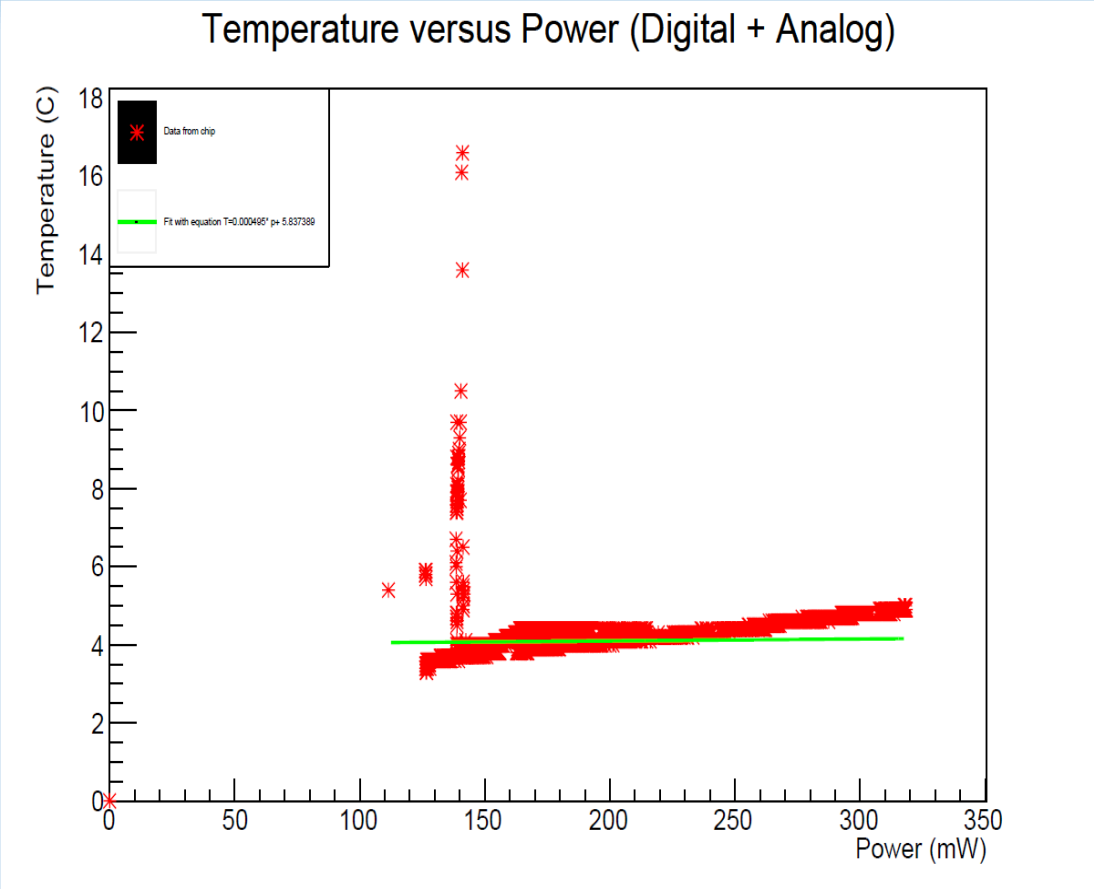


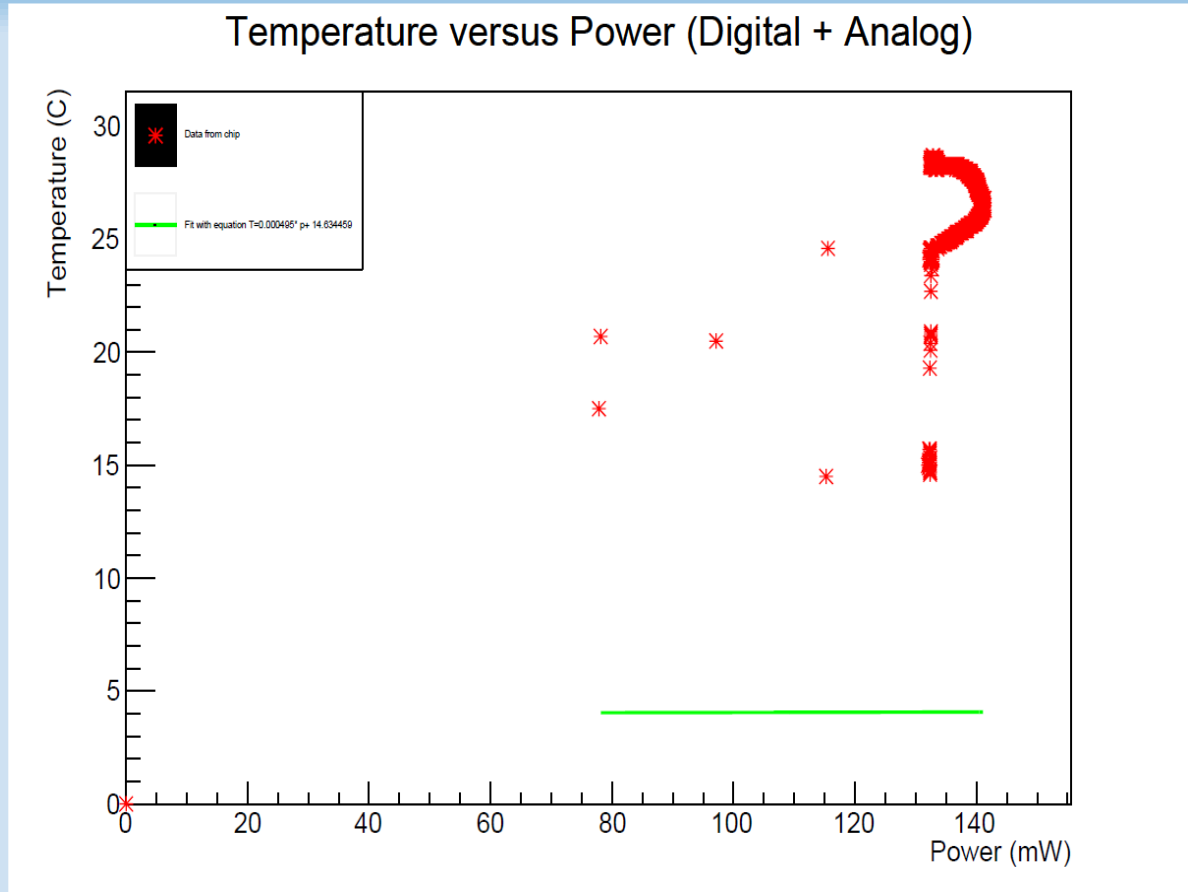


Power Off Irradiation

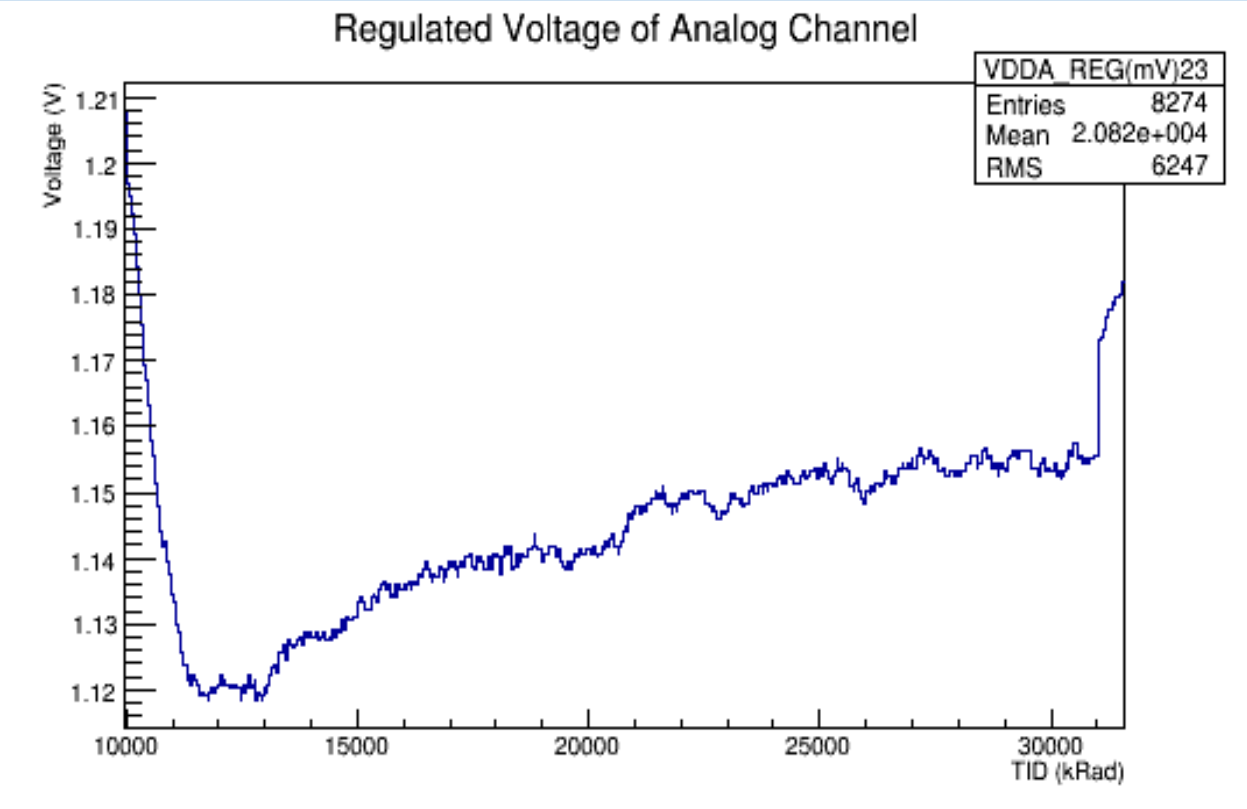


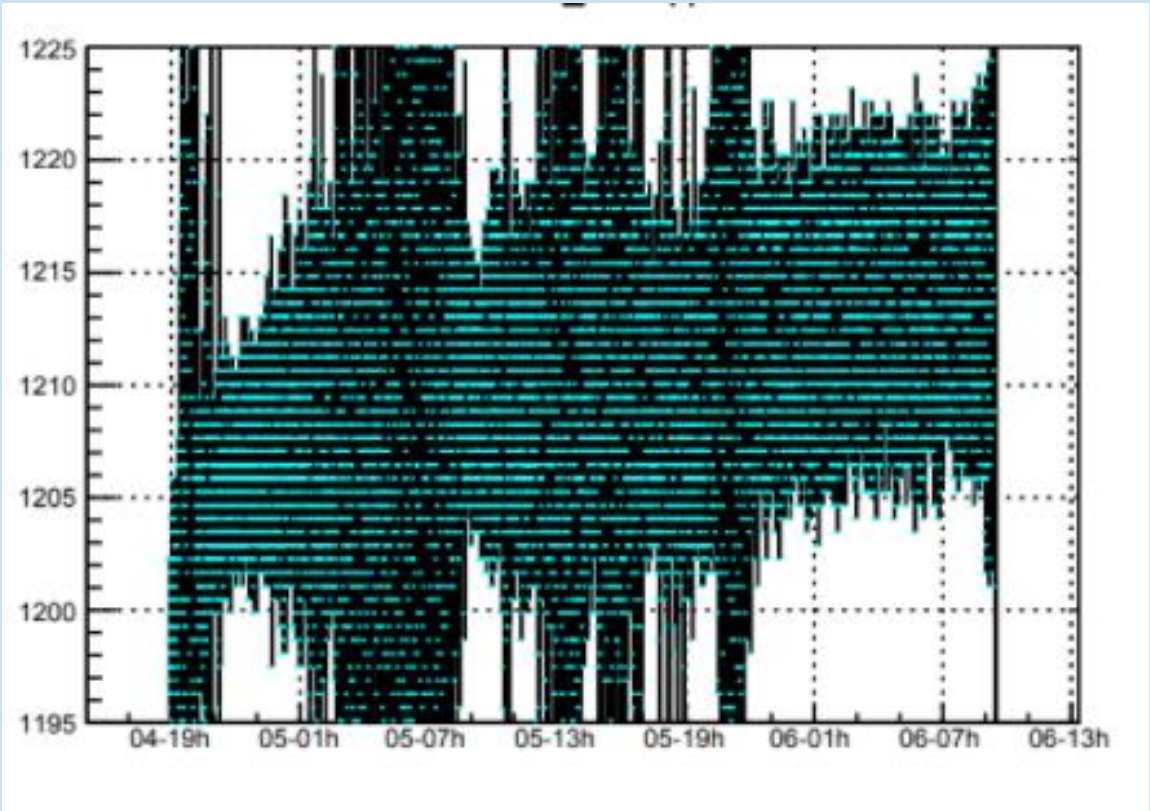
Temperature Rise



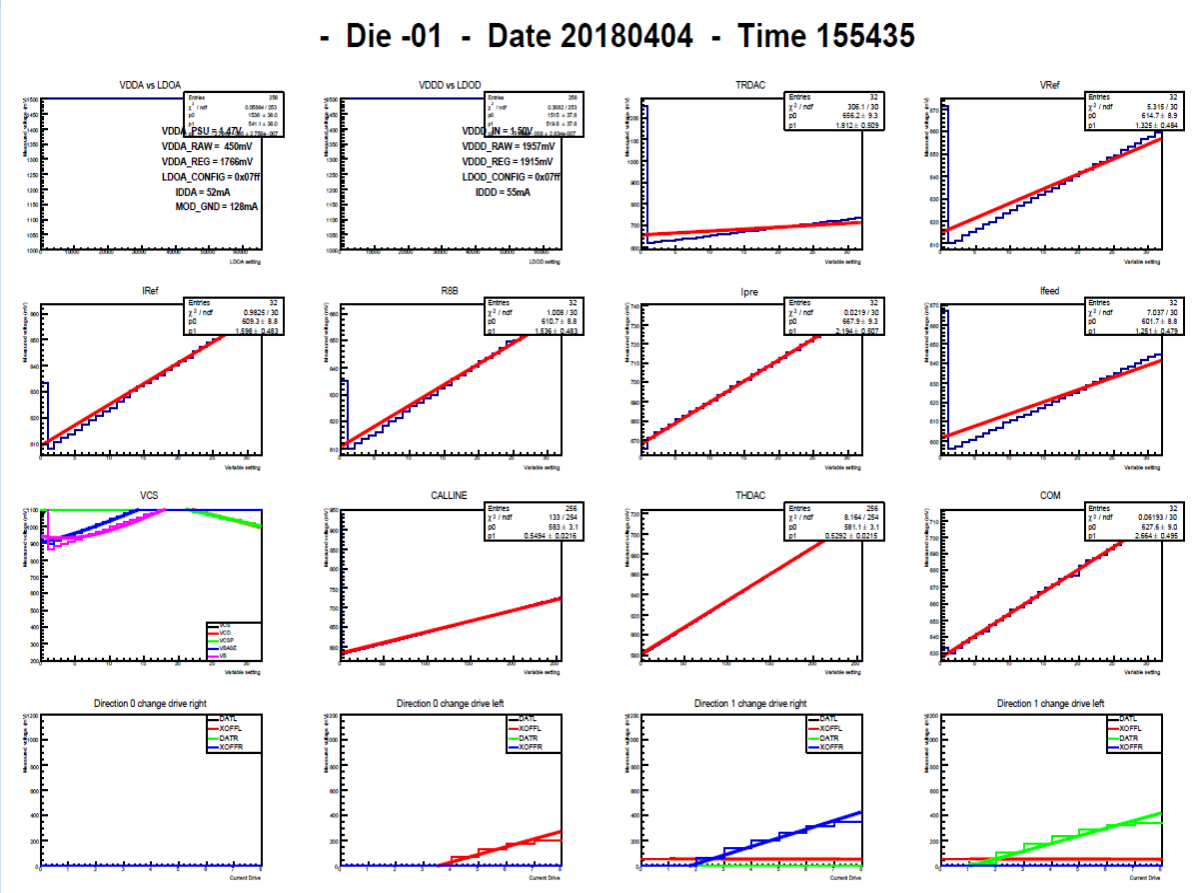


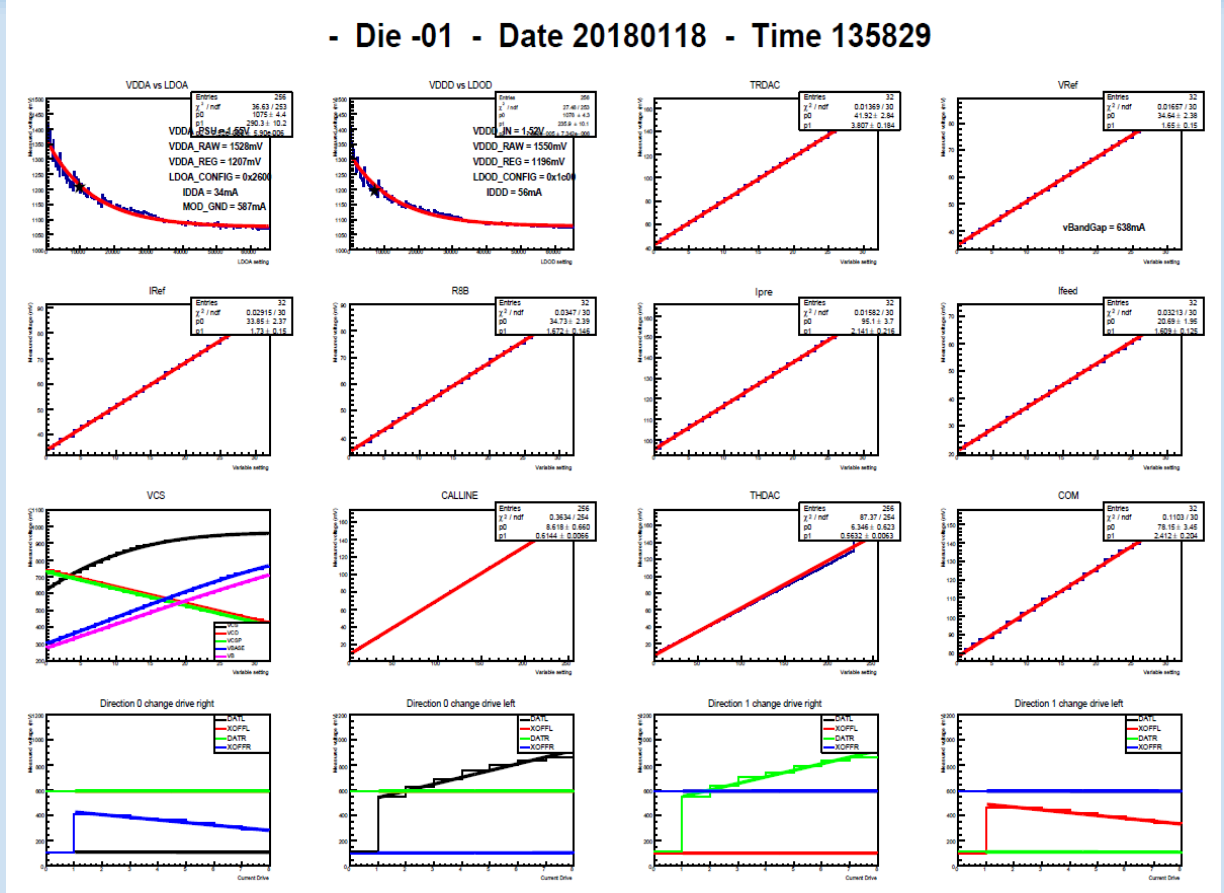
Regulated Voltage Failures





Batch 3 Chip Issues





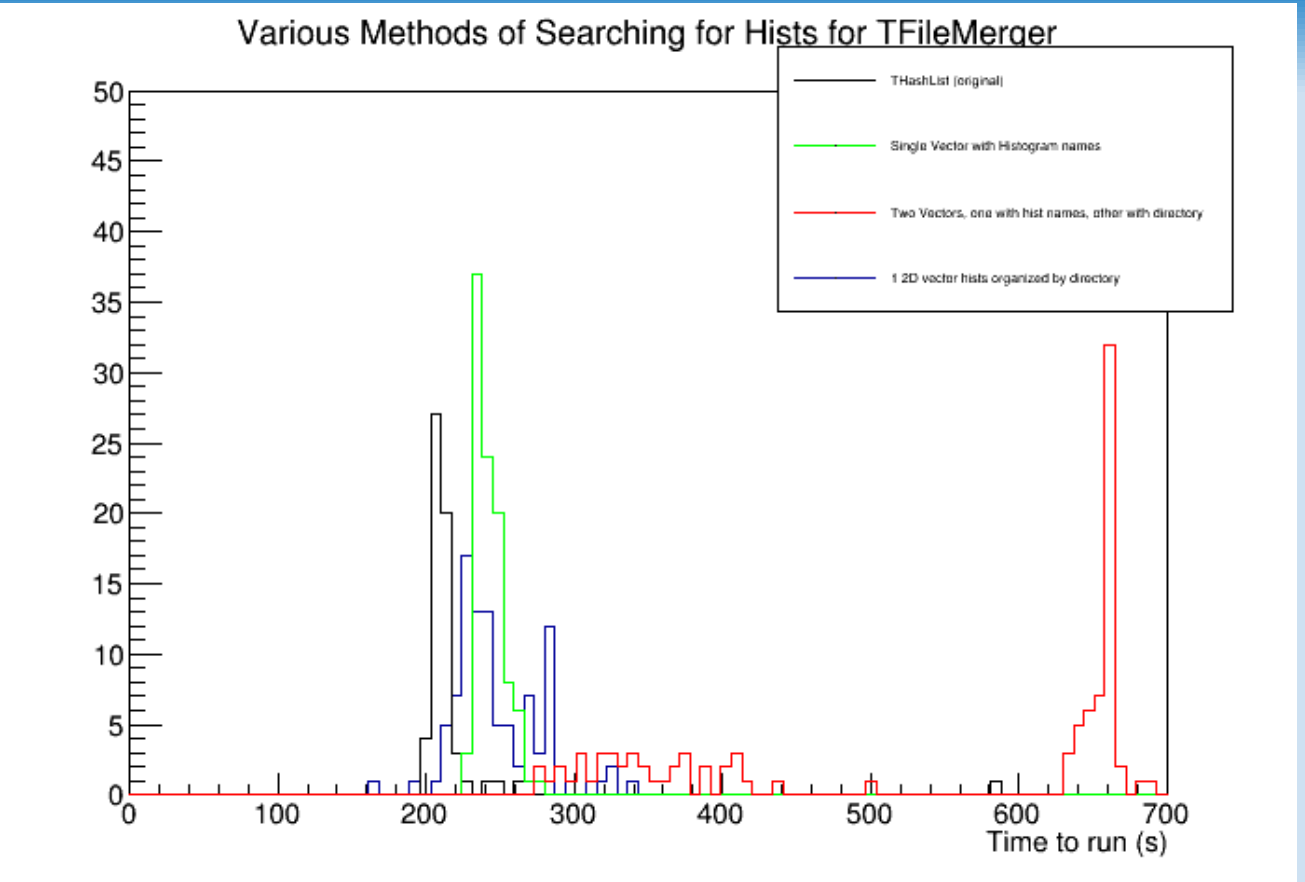
Other Work

TFileMerger and SEU

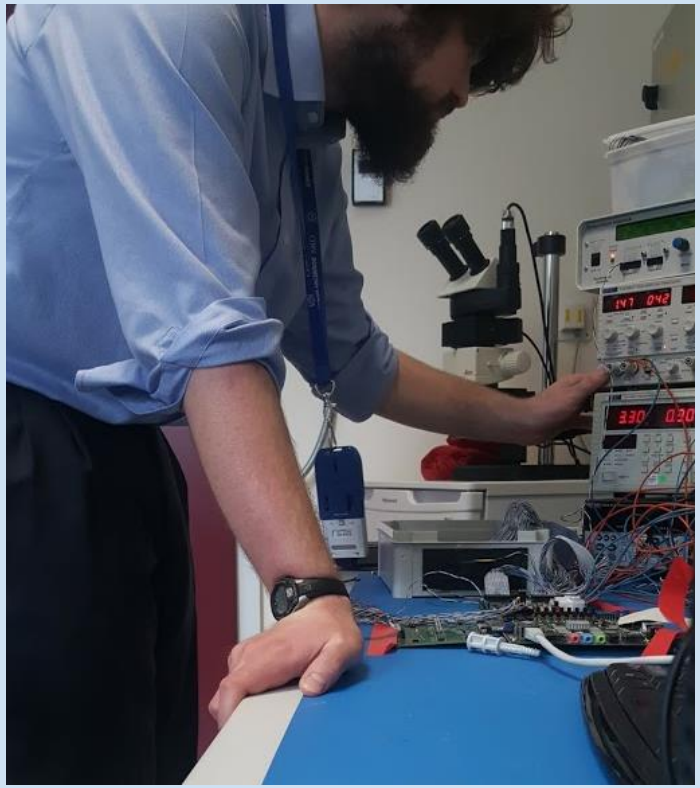
SEU package: Identifies Single Event Upsets—ionization caused readout errors—wrote a README file for proper use

TFileMerger: main macro of “hadd” in ROOT.

new Verison was running slowly/incorrectly, so I tried to implement a few potential fixes



Miscellaneous



Acknowledgements

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