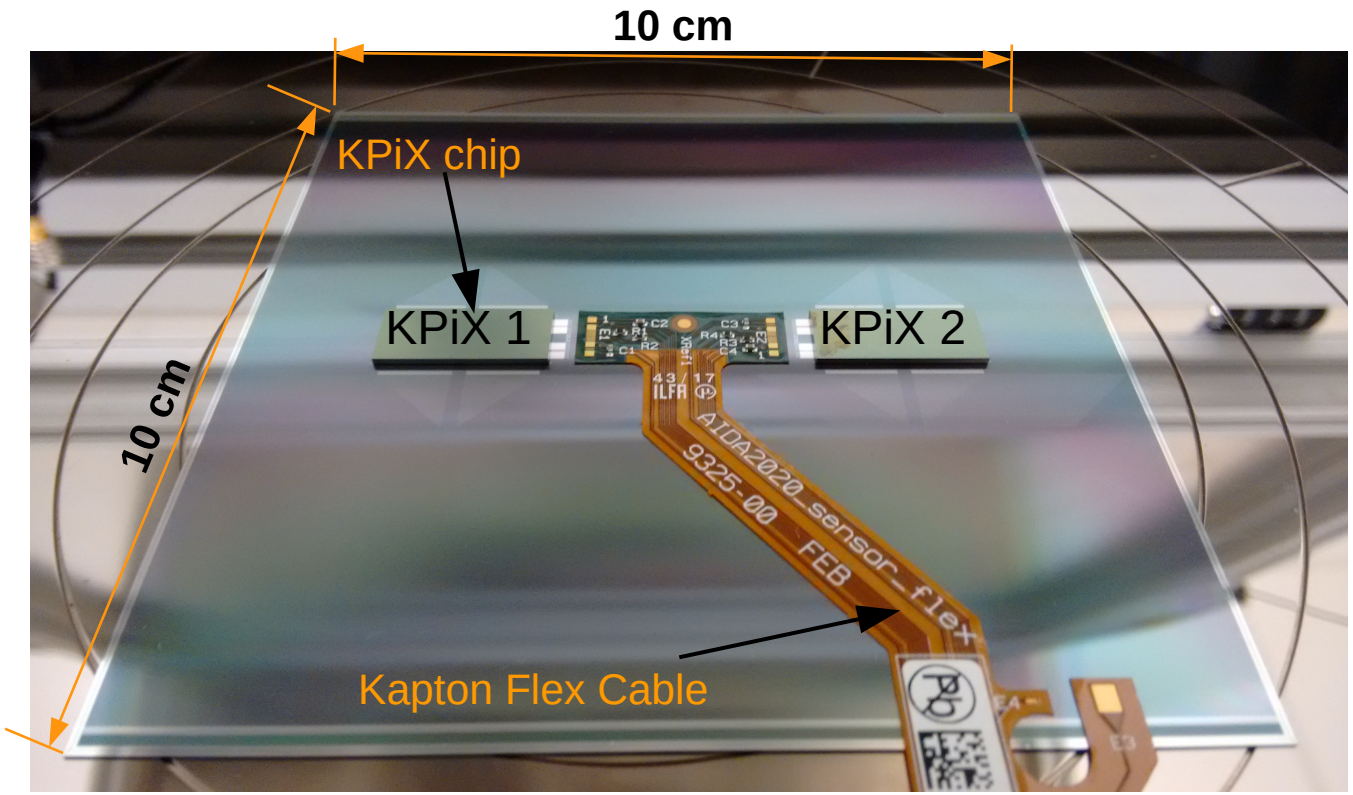
The SiD Silicon Strip Sensor

Hybrid-Less silicon strip sensor designed by SLAC NATIONAL ACCELERATOR LABORATORY for the ILC :

- A strip pitch of 25 µm
- Alternate strips will be read out
- ~7 micron tracking resolution
- Thickness of 320 µm
- Material budget of 0.3% X_0
- An integrated pitch adapter and digital readout (KPiX)

  → Directly bump bonded to sensor surface

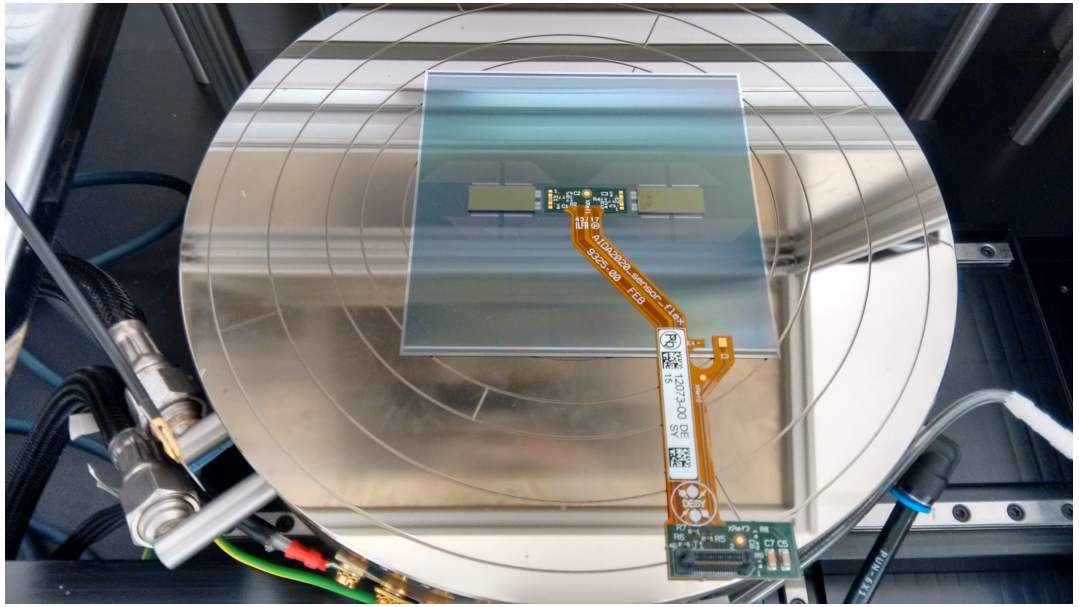
  → Signal routing through double metalization layer



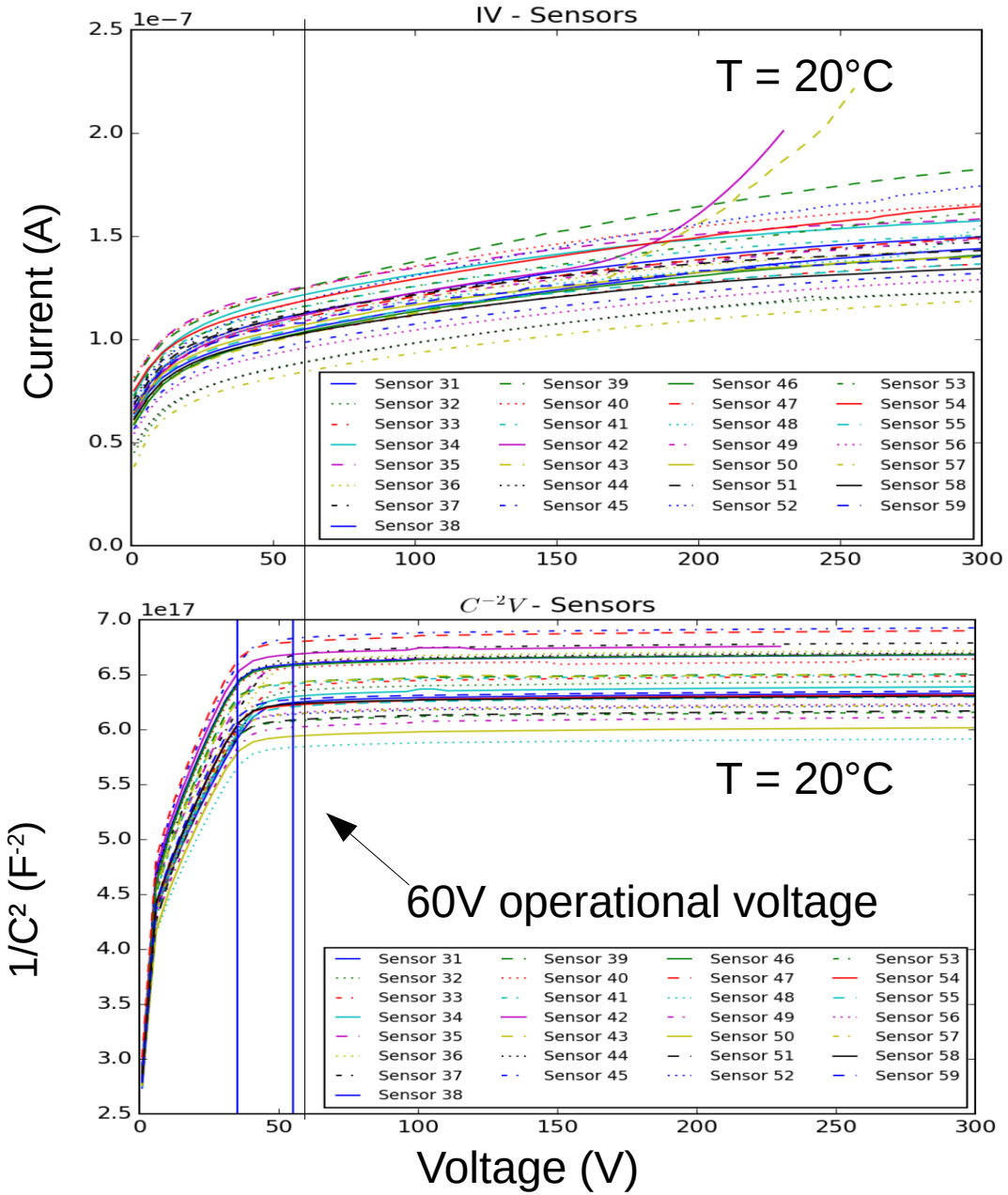
IV/CV measurements

- Good behaviour:
  - ~ 100 nA currents, stable up to 300 V
  - Depletion voltage for all sensors at ~50 V
- Two sensors show breakdown beginning at 280 V

  → irrelevant for 60 V operational voltage.



Bump Bonded Sensor with flex cable on the probe station



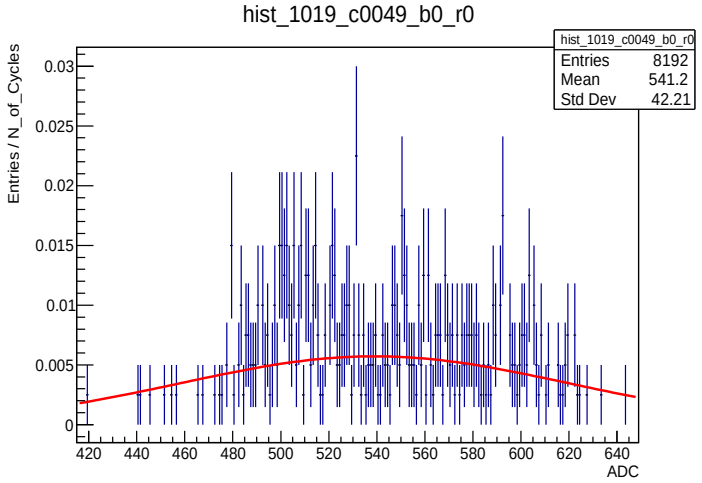
Sensor performance

- For tests of the sensor performance the three distinct running modes of the Chip need to be understood:
  1. Calibration
     - Test of KPiX Chip performance
     - Only capacitive influence from the sensor
     - Charge to ADC calibration
  2. Self triggering
     - Triggering based on a charge threshold set by the user
  3. External triggering
     - Triggering based on an external logic signal fed into the DAQ board

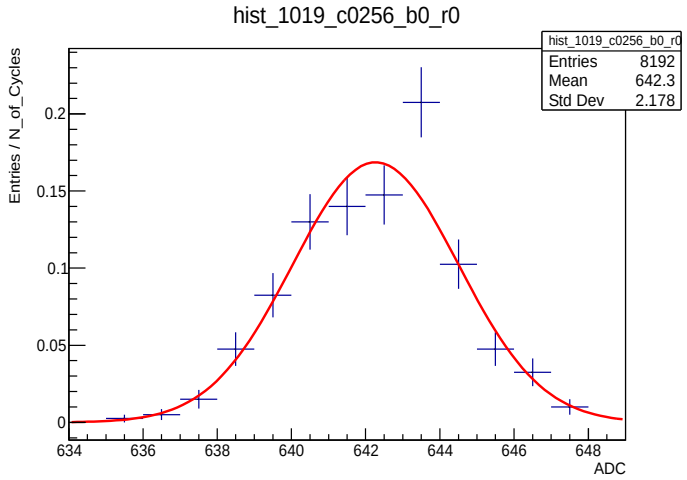
- The performance of the sensor needs to be tested for each KPiX separately, problems need to be identified and solutions found.

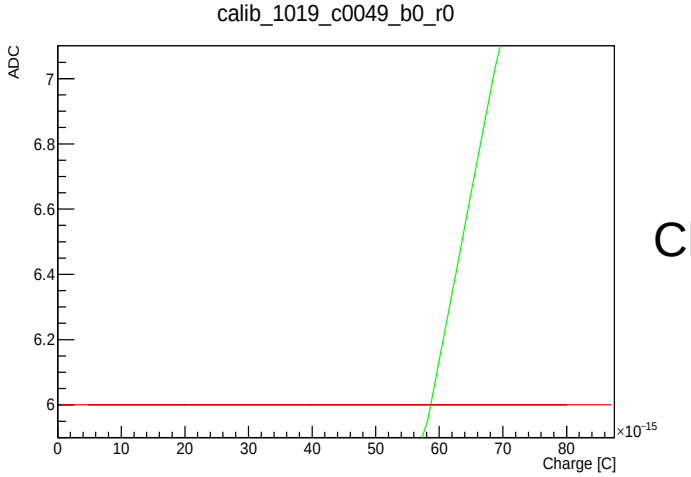
Calibration results (Module 1 KPiX 1)

- Width in the calibration pedestal gives an estimate of the noise of the chip
- Charge to ADC slope (red fit) shows whether the channel is functional or not

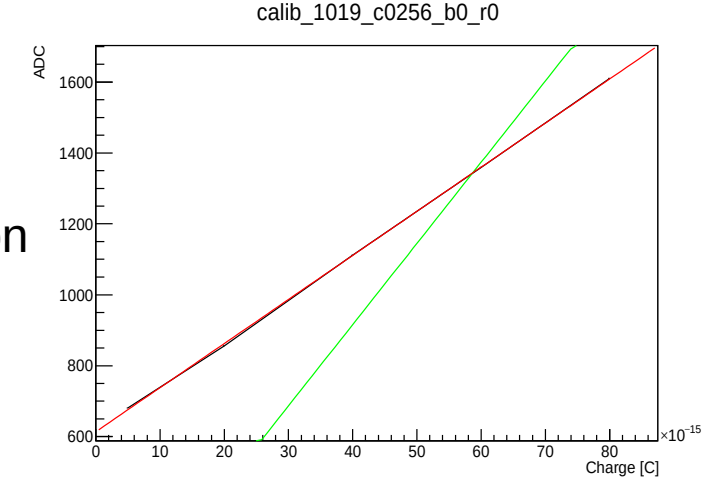


Calibration pedestal





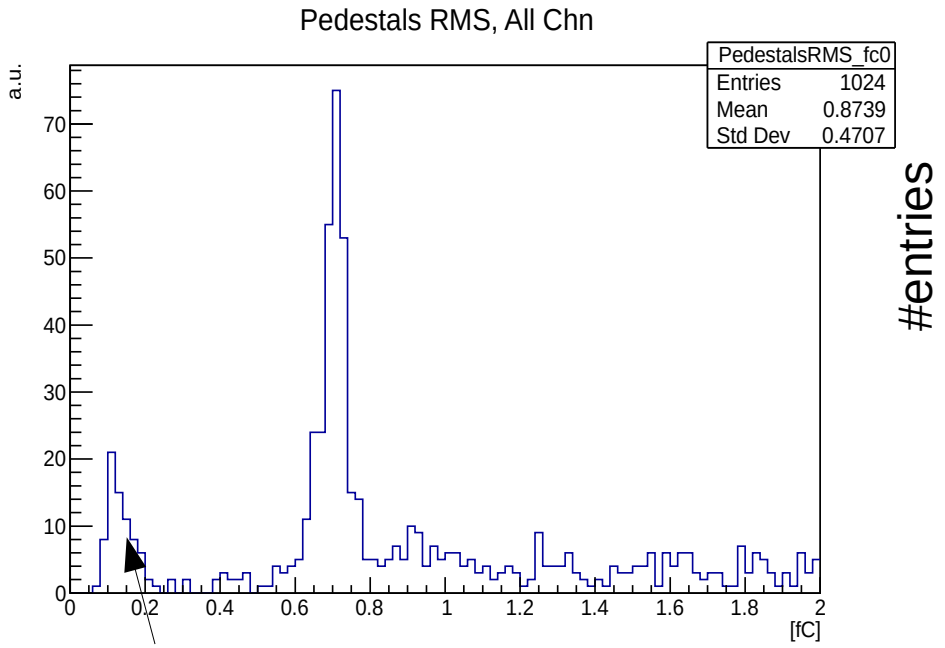
Charge to ADC calibration



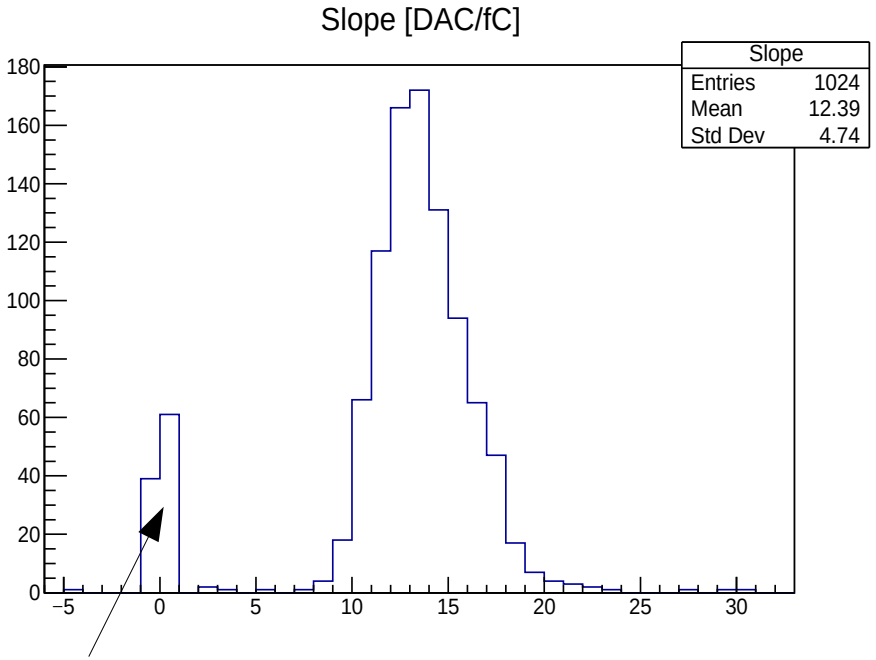
Calibration results (Module 1 KPiX 1)

- ~100 non functioning channels (0 Slope) found on the KPiX → Unclear if problem comes from the KPiX or was introduced during assembly.
- ~80 channels with extremely low noise, lower than should be possible → ripped bump bonds

- Behavior not present in all KPiX, some show no disconnected channels and no slope of 0
  <u>→ No systemic problem but reason needs to be investigated further</u>



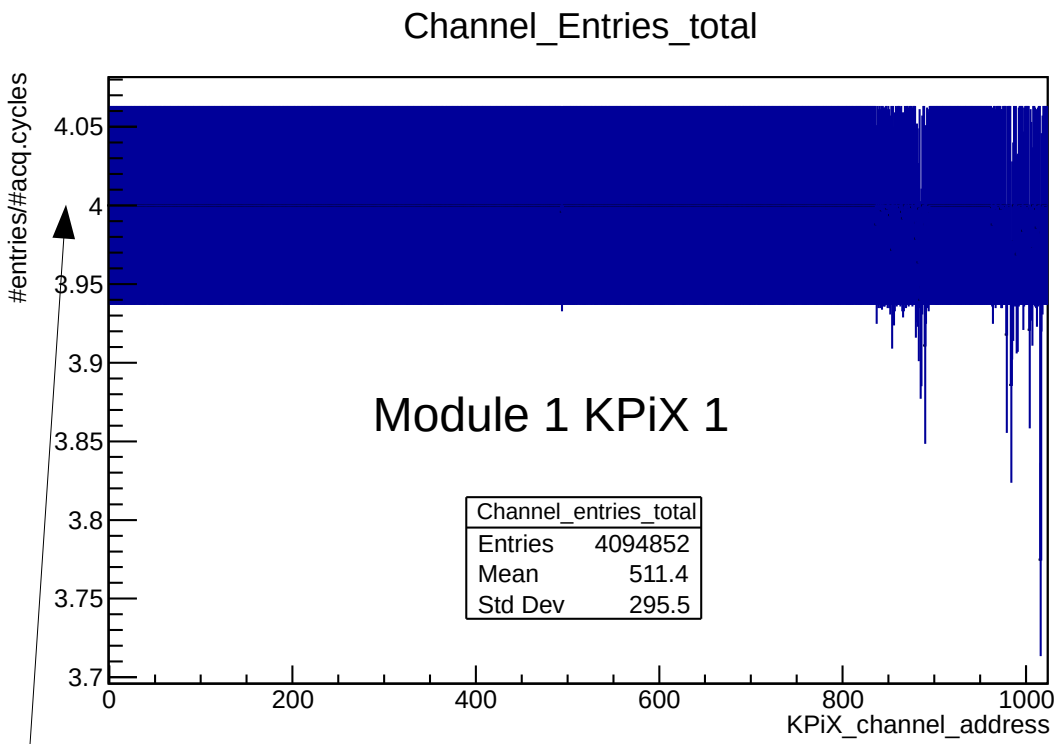
Disconnected channels



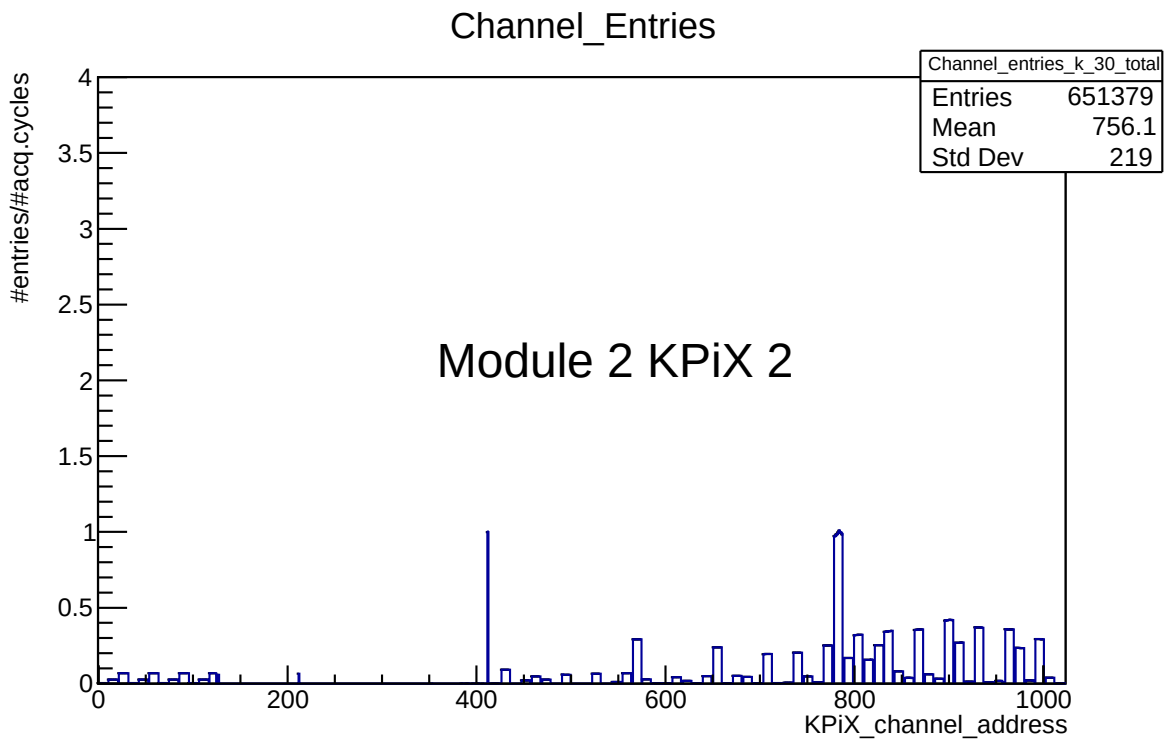
Broken channels

Self triggering results

- KPiX can at most record four events per channel per data taking cycle
- Two KPiX show a very high amount of triggers even at large thresholds, a third KPiX is much more reasonable
  → Third KPiX feasible for testing with a radioactive source



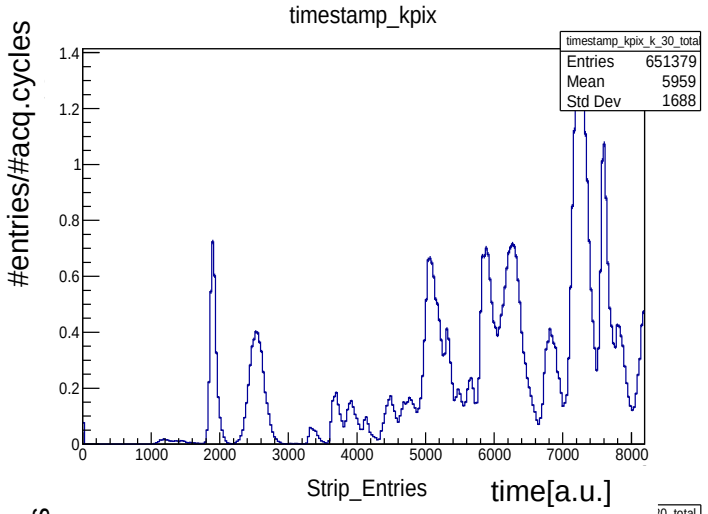
Maximum possible amount of triggers

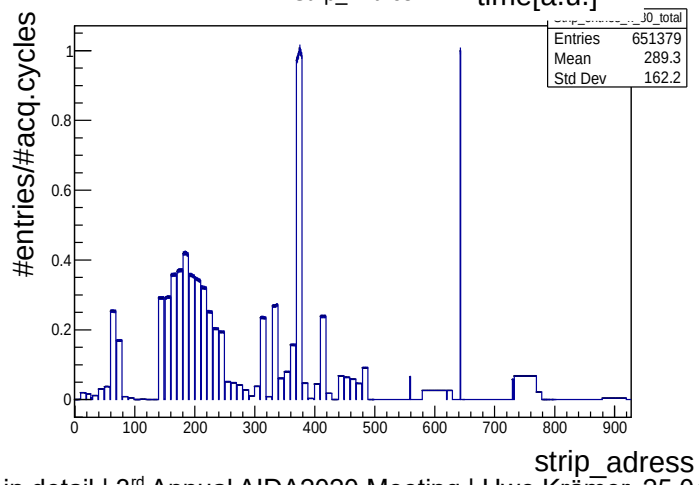


Self triggering results

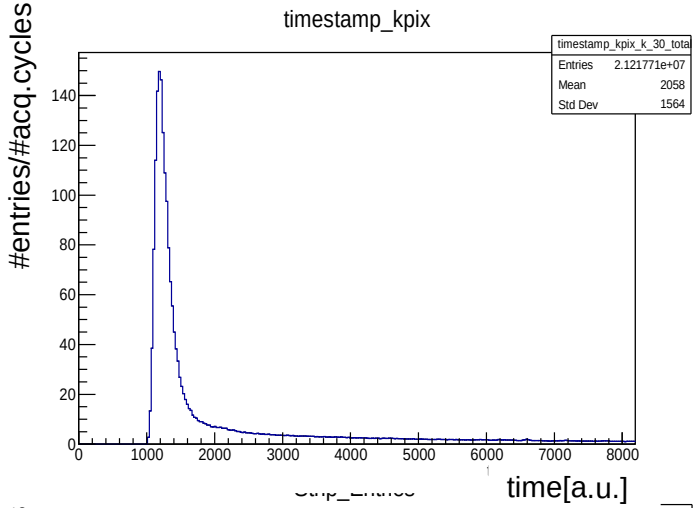
- Time structured noise indicates system induced noise. Possibly pickup over long cables of current setup
- Able to measure radioactive source with sensors.

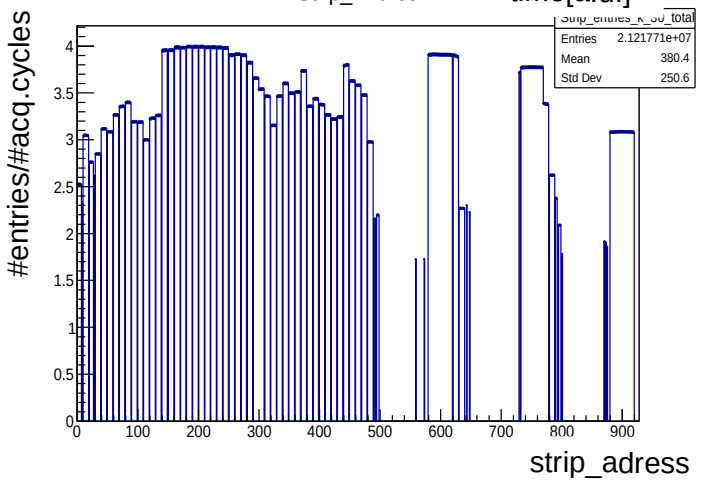
Without Sr90 source





With Sr90 source



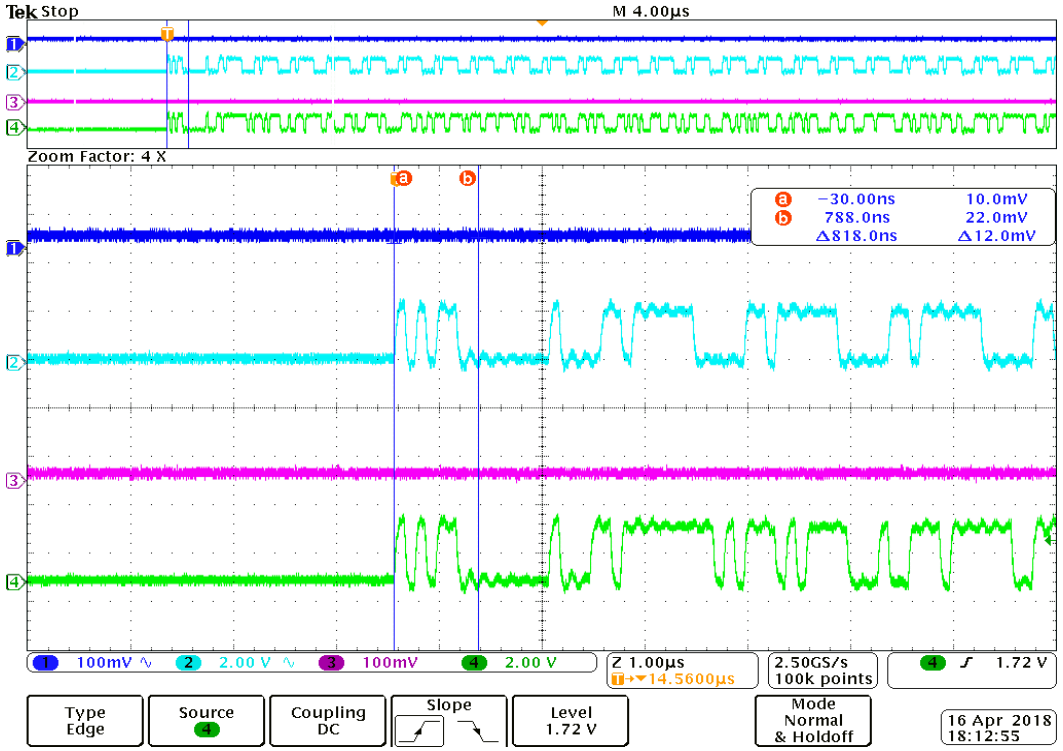


Parallel data taking

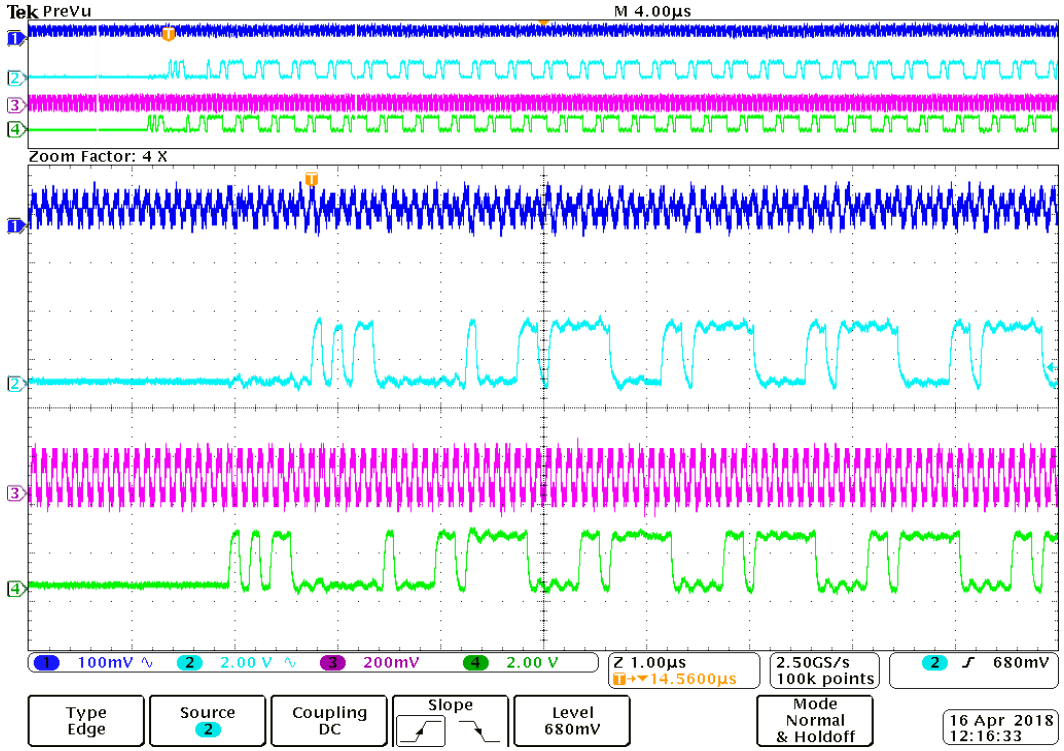
- In general no problem running multiple KPiX in parallel, one KPiX for some reason cannot be synchronized

  → Not systemic.

- Currently being investigated and checking for a potential firmware solution as a backup



Runs well



Does not run

Conclusion

- The first two sensors showed unexpected problems, sensor behavior, noise, open channels…
  → **<u>We know every component works</u>**

- Main suspect is the current assembly procedure:
  - Investigating the glue
  - Assembly tool

- Also currently suspecting some signal transfer problems → New electronics being designed

- **<u>Strategy:</u> Understand assembly issues and identify solutions before producing further modules**

Thank you for your attention

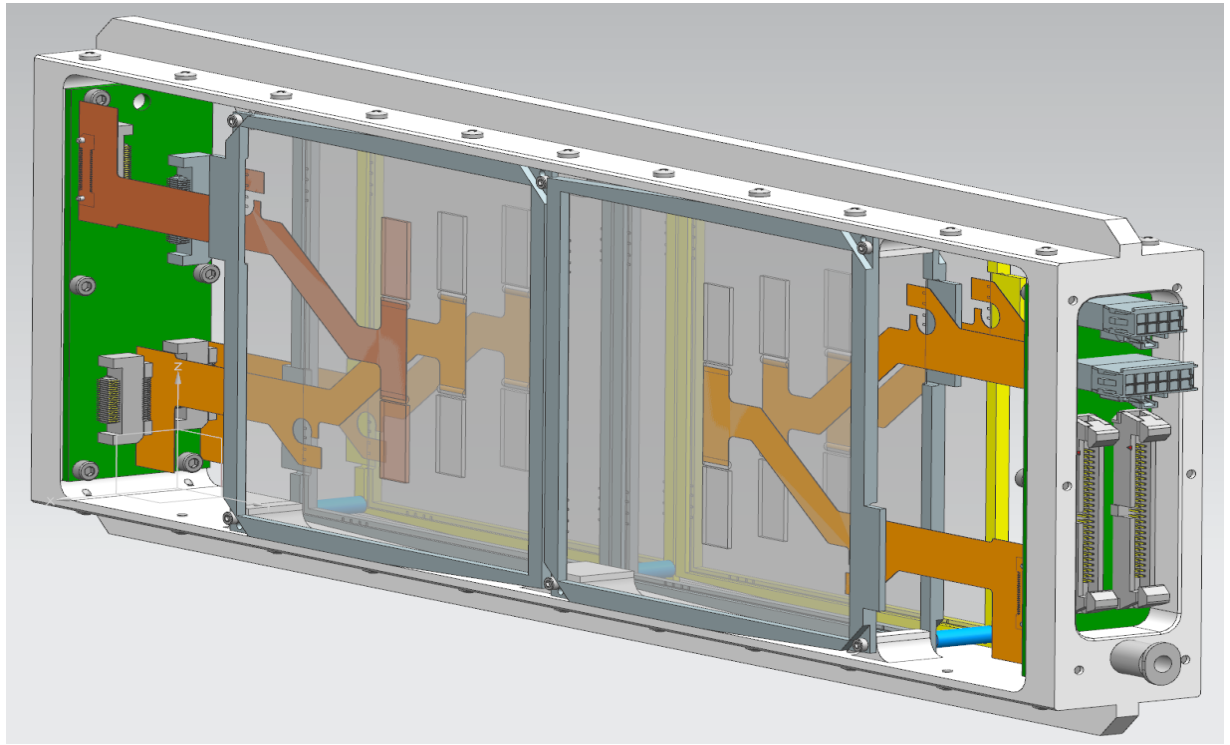


Fig.: Lycoris Tēlescopium

Fig.: Lycoris Radiata

Sensor overview

- First two sensors assembled (#59 and #58)
  - Module 1 (Sensor #59):
    - ▶ Depletes well, showing low 350 nA currents at 60 V bias.
    - Can talk to both KPiX separately → 1 KPiX on this sensor appears to show a different startup
    - ▶ Extremely high amount of triggers

  - Module 2 (Sensor #58):
    - ▶ No longer depletes, shows resistor behavior → Not visible directly after gluing appeared over time.
    - ▶ Can only talk to one of the two KPiX
    - ▶ Much lower amount of triggers at more reasonable thresholds

  - ▶ Able to run multiple tracker KPiX together.
  - ▶ Capable of seeing a radioactive source using the sensor as well as the impact form different levels of ambient light.

  - Module 3 (Sensor #52)
    - Finished assembly last week, currently in testing

The tracker system test setup