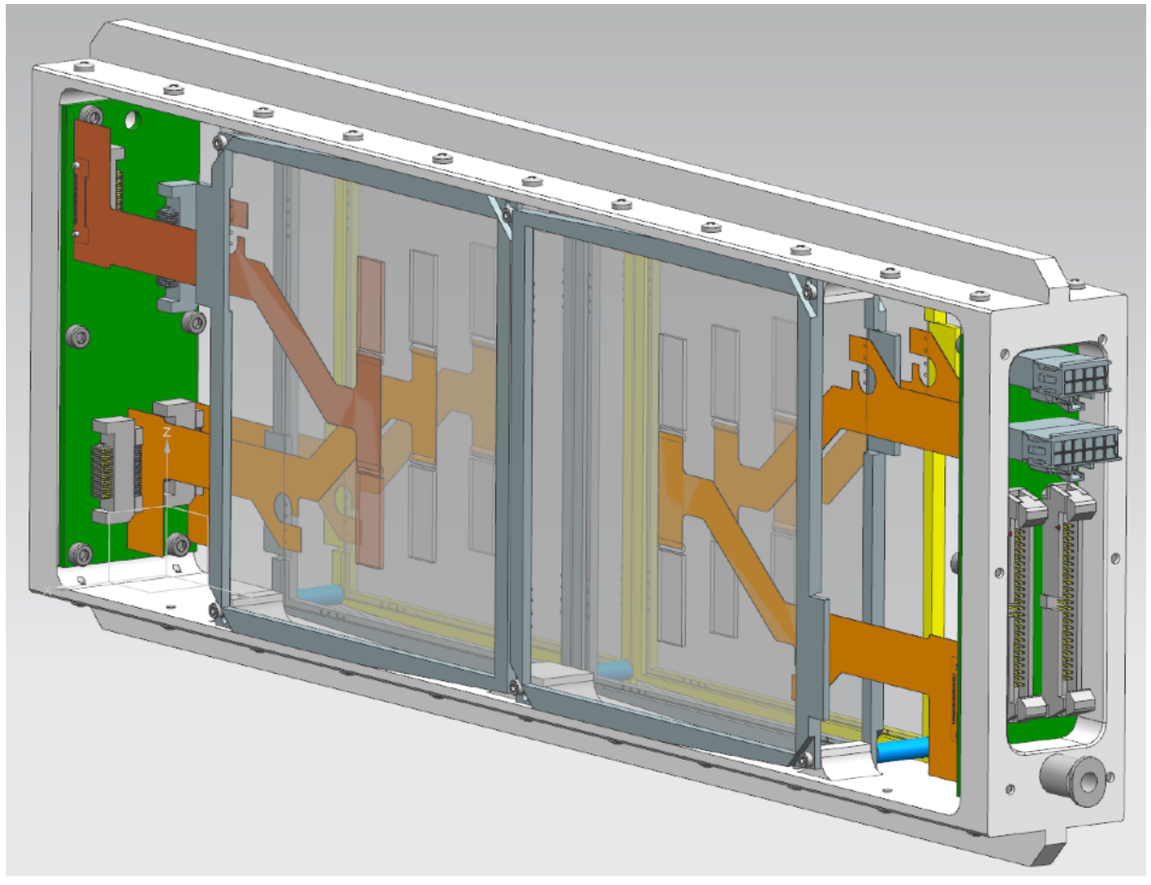
Development of a large area strip telescope for the DESY II Testbeam Facility.

Large Area X-Y Coverage Readout Integrated Strip (LYCORIS) Telescope



Uwe Krämer
Mengqing Wu
Marcel Stanitziki

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6th Beam Telescope and Test Beams Workshop

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Telescopes at DESY

Mimosa telescopes at DESY: (see Jan's talk)

- 6 layers of pixel planes, 1*2 cm^2, 18 µm pitch;
- Based on Mimosa26;
- Trigger rates up to ~2 kHz;
- 3 microns tracking resolution;
- Provideds full tracking and analysis packages;
- Very high demand! (see Ralf's talk)
- requested by **70-80%** test beam users in 2017;
- In use of **EUDAQ** and EUDET/**AIDA mini-TLU**.

Mimosa is **definately awesome**!
But still user cases **not covered due to**:

- small active area
- support structure demands a lot of space
- high amount of channels → large power consumption → dedicated water cooling
- relatively slow readout with an integration time of ~100 µs

Leading to a **new telescope**

Introduction: the LYCORIS strip telescope

With the **AIDA2020** project :

A new large area strip telescope within the solenoid in DESY-II beam area 24

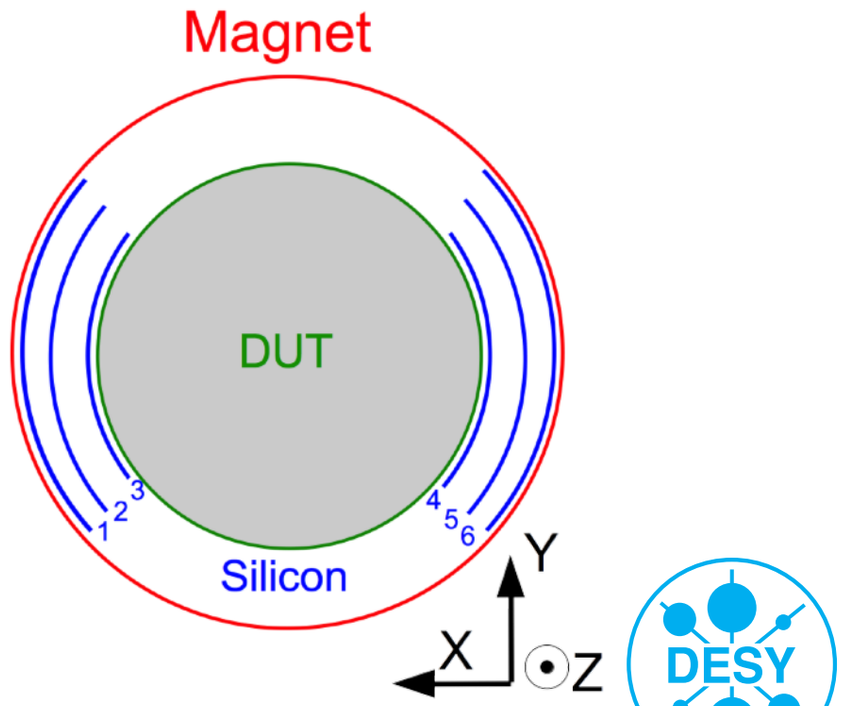
The T24/1 solenoid has:

- ~75 cm usable inner diameter;
- A wall with a radiation length of 0.2 X_0;
- Is mounted on a stage that can be moved/rotated around 3 axes;
- A magnetic field up to 1T.

Telescope demands defined by use case:

- A large coverage area (~10x10 cm^2)
- Minimal needed space to allow large DUT inside the magnet (e.g. a TPC)
- Spatial resolution better than σ_y= ~10 μm along bending direction of particles in the magnet
- Resolution along field axis of the magnet less important σ_z= ~1 mm

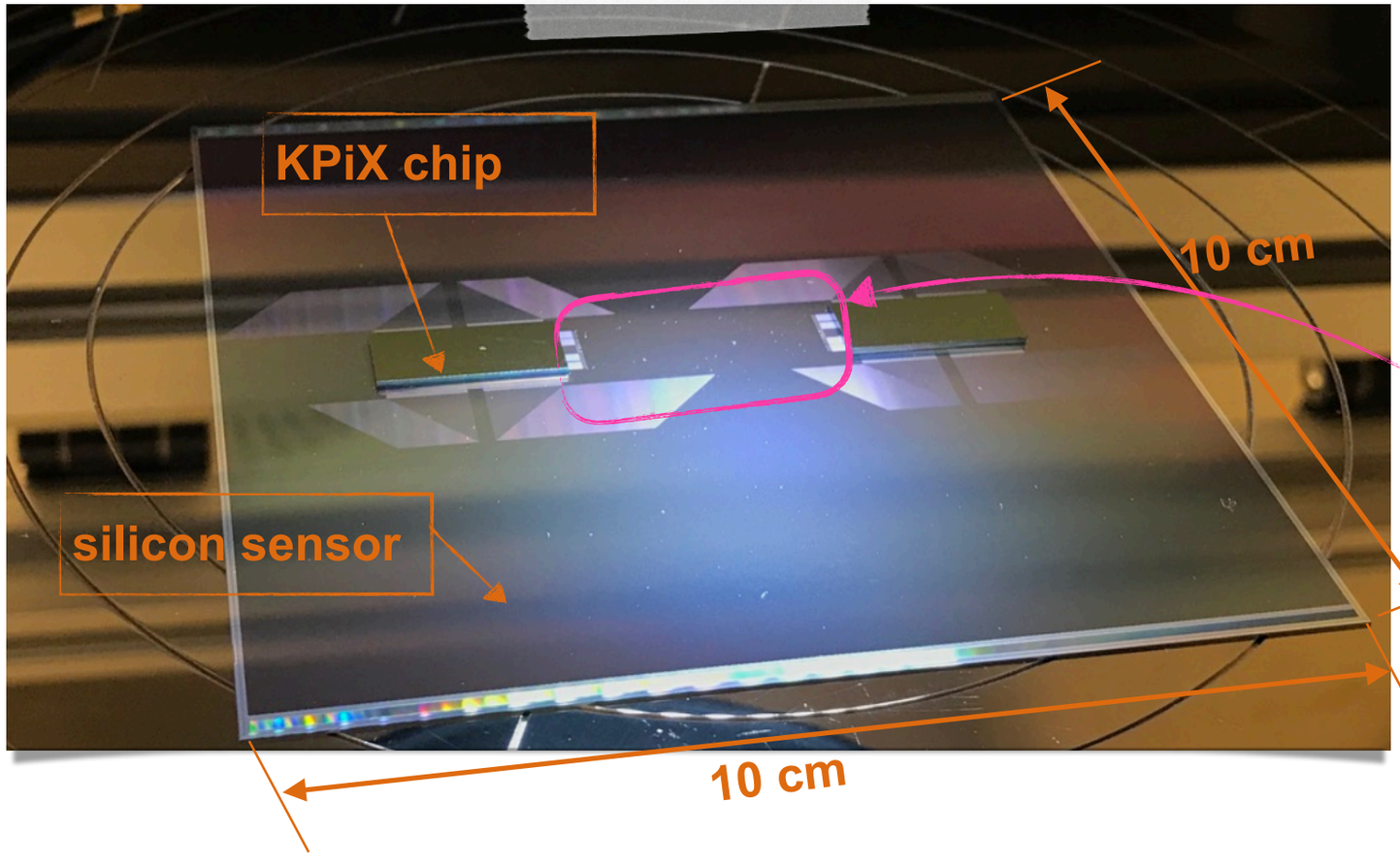

Solenoid in the DESY-II beam area 24/1

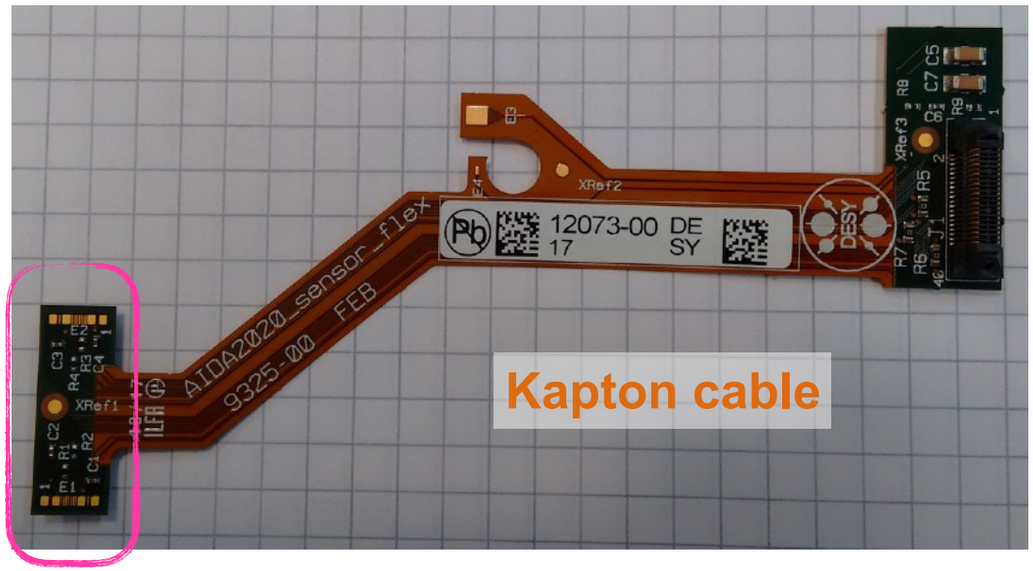


The SiD strip sensor

Designed by SLAC for an ILC environment:

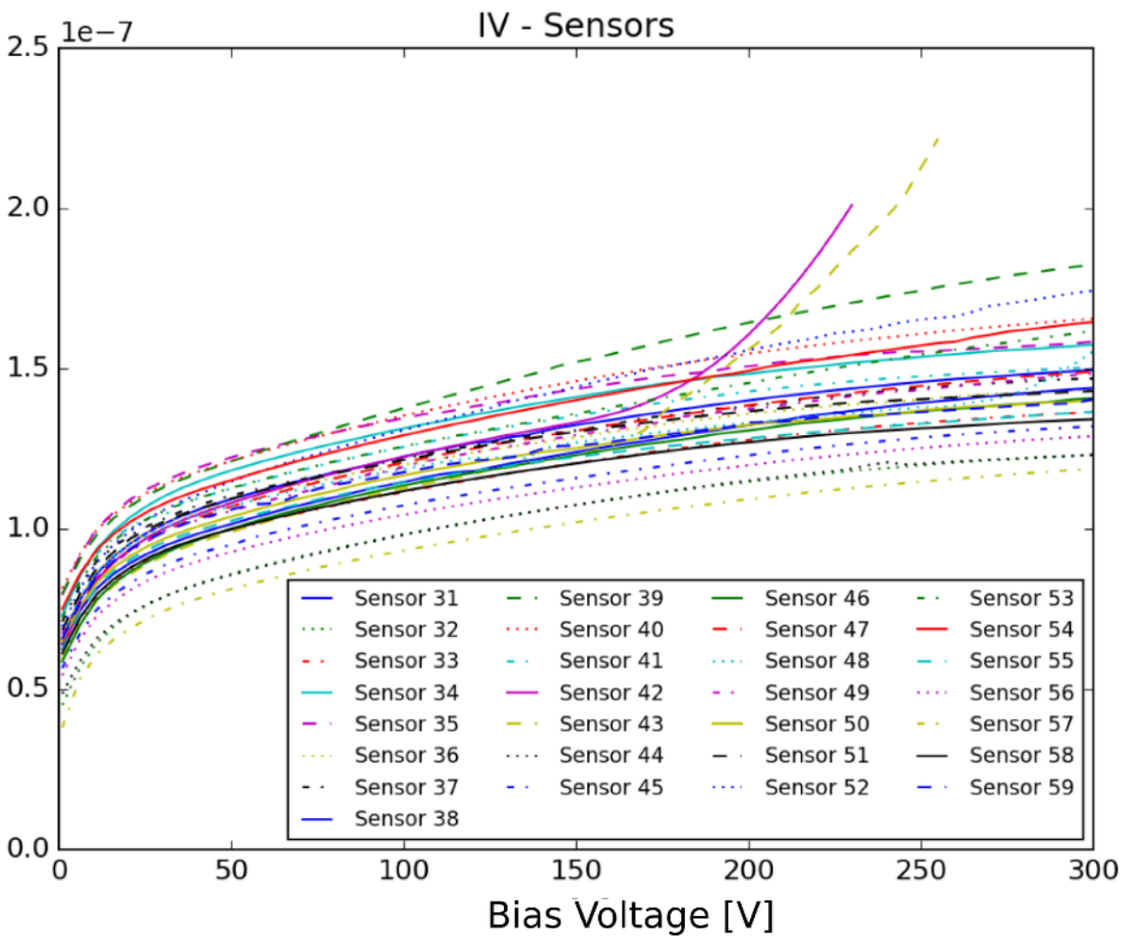
- A strip pitch of 25 μm
- Alternate strips will be read out
- Thickness of 320 μm
- Material budget of 0.3% X_0
- An integrated pitch adapter and digital readout (KPiX)

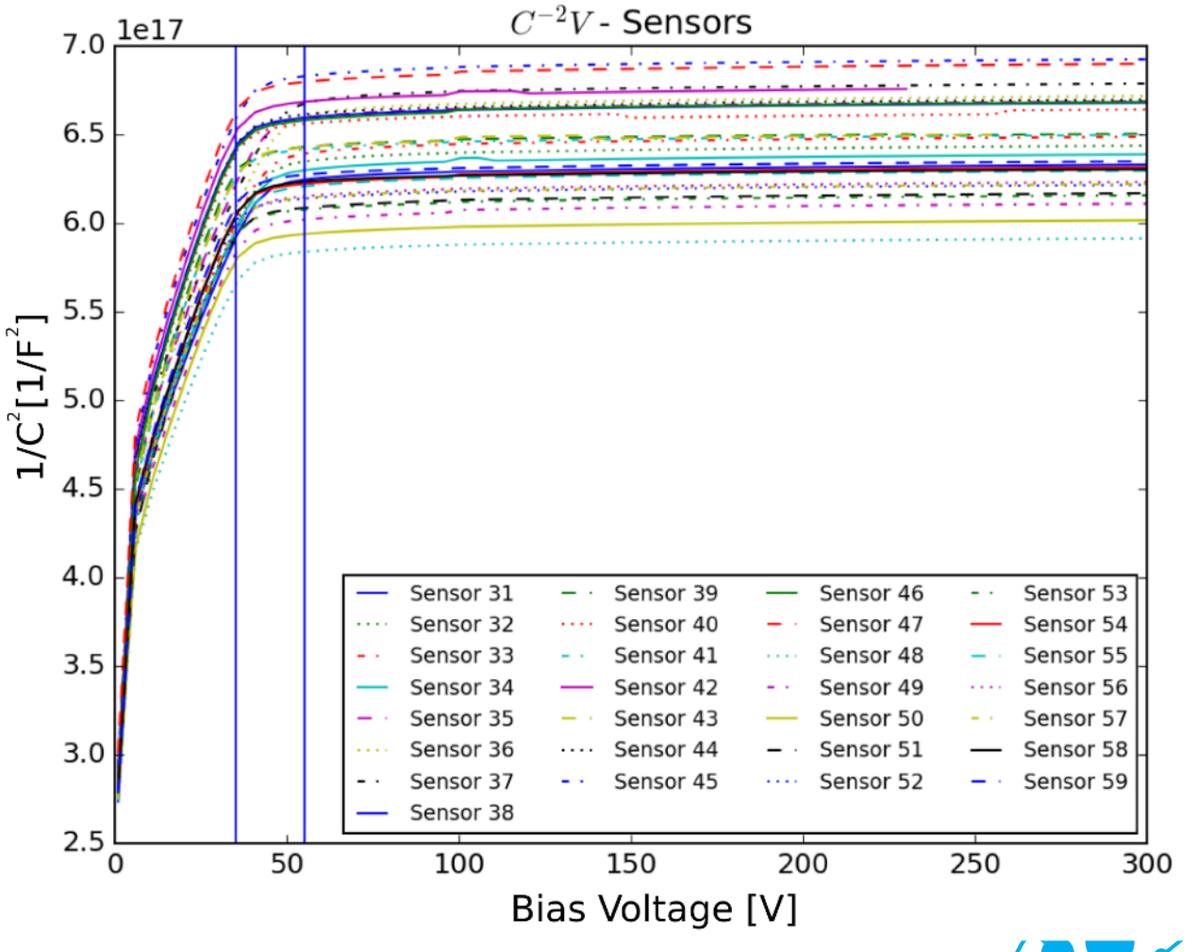




The SiD strip sensor: IV measurements

- **Good behaviour**:
  - ~100 nA currents and stable up to 300V;
  - Two sensors show the beginning of a breakdown around 280V.
- **Depletion** voltage for all sensors around **50V**;
- **Expected** behaviour **after bump bonding**: still **good IV**-behaviour with **same depletion** voltage.

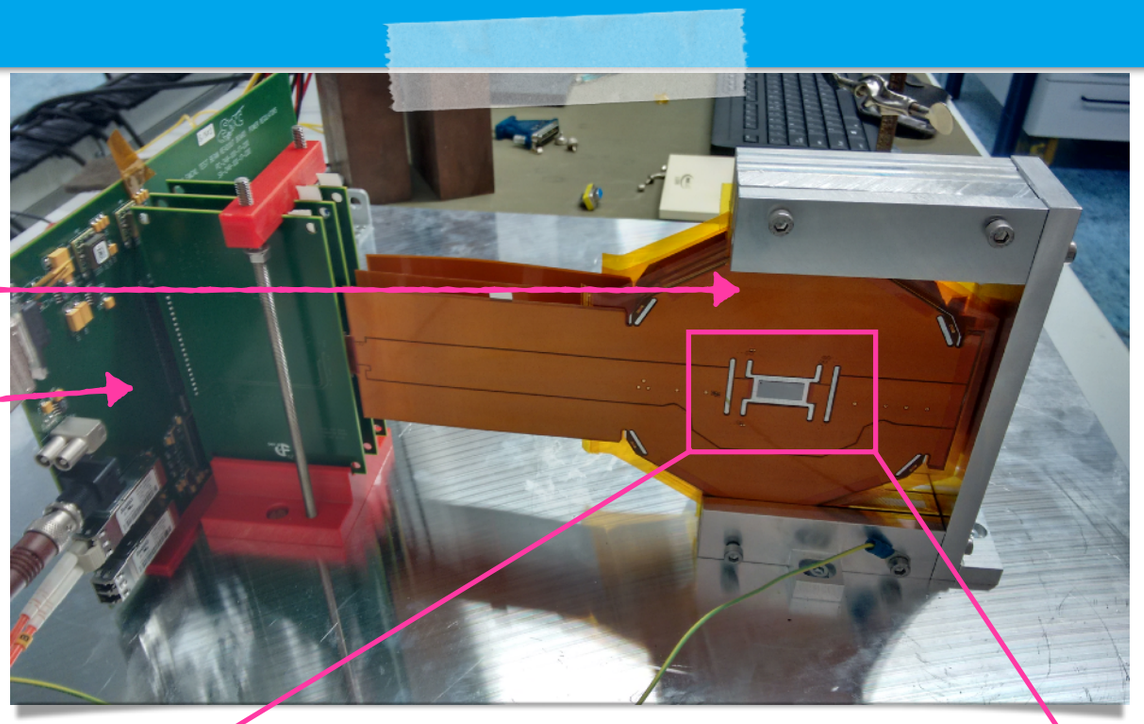




Test the KPiX readout system

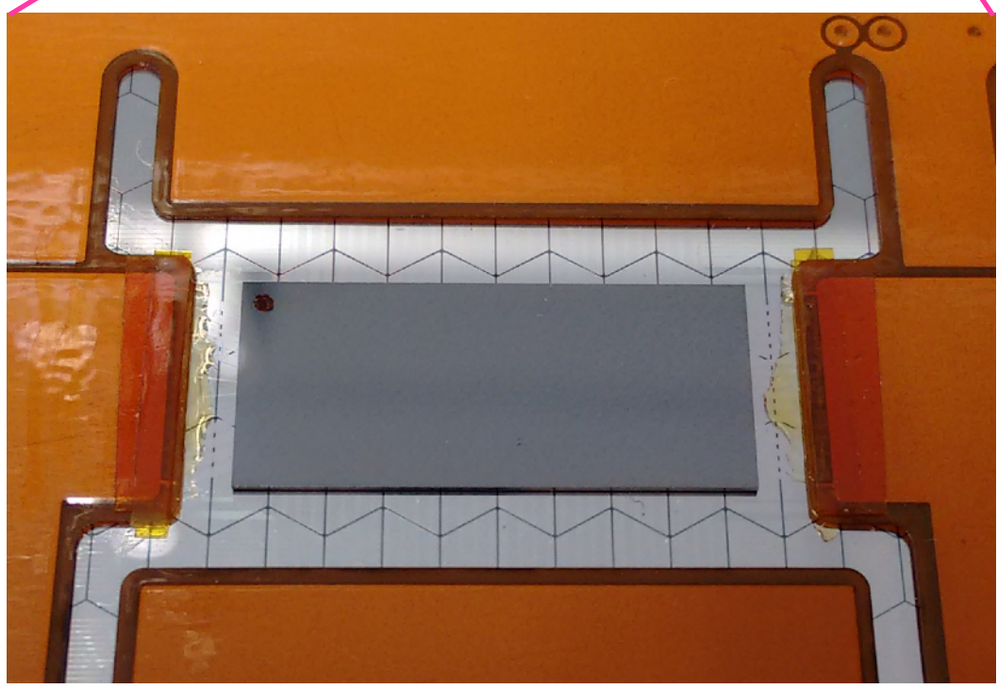
The test setup at DESY…

- 3 Pixel sensors with large pixel size and bump bonded KPiX
- Readout FPGA board
- Dark box cover to reduce light induced noise



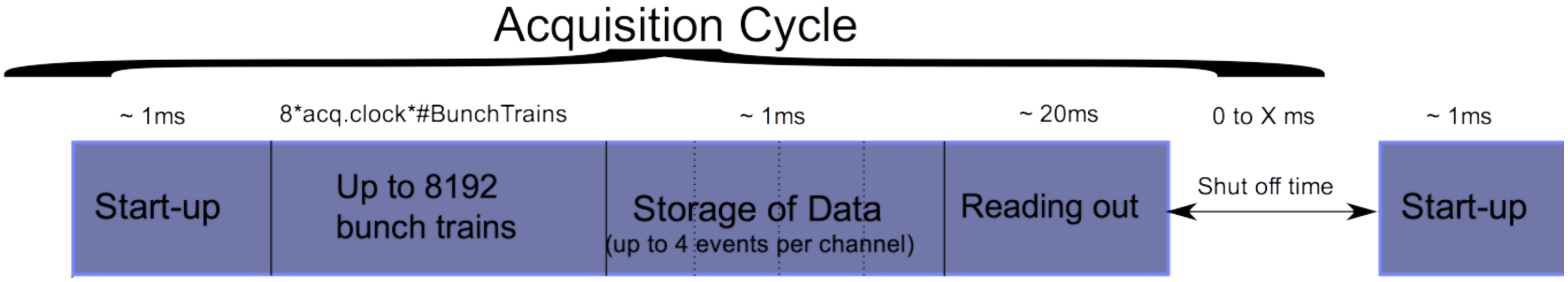
Performance and functionality tests conducted…

- Measurement of heat generation of readout chip
- Test of the chip with pedestals and calibration
- Measurements with a radioactive source
- Testbeam measurements with DAQ synchronisation



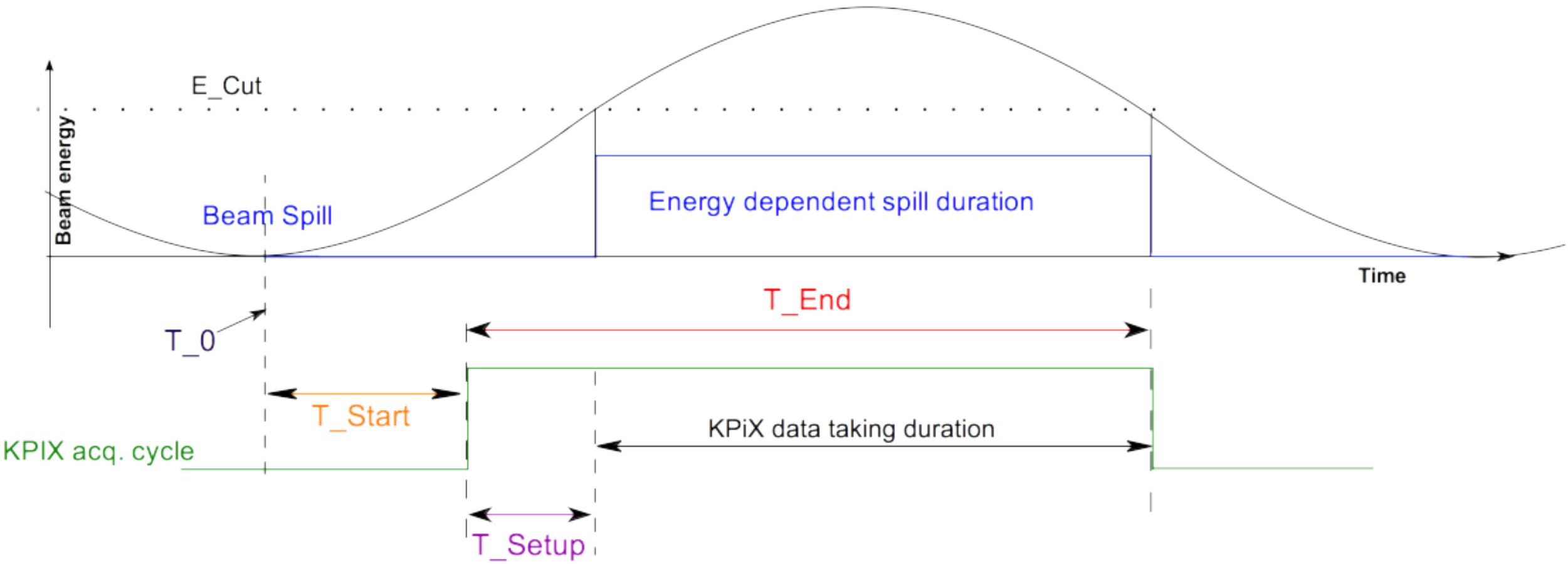
The KPiX readout chip

- Fully digital readout with 13 bit resolution (8192 ADC)
- 100 MHz clock → 10 ns flexible acq. Clock
- Can work in **2** trigger modes:
  - Self trigger = 4 events *per* channel *per* cycle stored
  - External trigger = 4 events *per* cycle stored
- Capable of power pulsing
- Length of the opening period depends on timing resolution



- Only open for a maximum time of 8192*8*acq.clock
  → For example with a 320 ns acq.clock = 20.97 ms

KPiX synchronisation with Beam



- As a result of the power pulsing KPiX needs to be synchronised to beam spill of the accelerator and the different devices.
  - This will be accomplished via a new AIDA2020 TLU (see David's talk).

T_0: Accelerator signal for synchronisation with beam spill.

T_Start: User adjustable delay between T_0 and the KPiX switch on.

T_Setup: Setup time of KPiX. At the end of which KPiX can start the data taking.

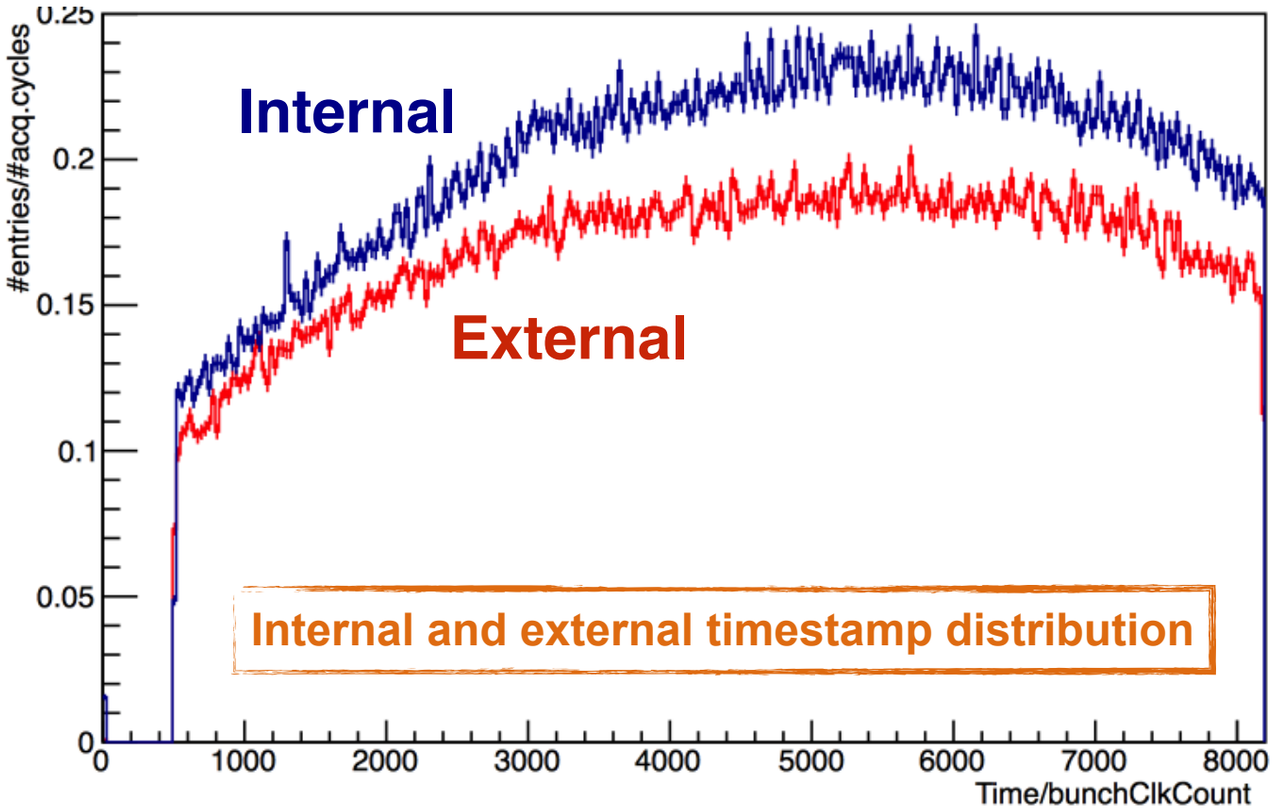
T_End: User Adjustable signal telling all devices that KPiX has stopped data taking.

KPiX readout system: test beam results

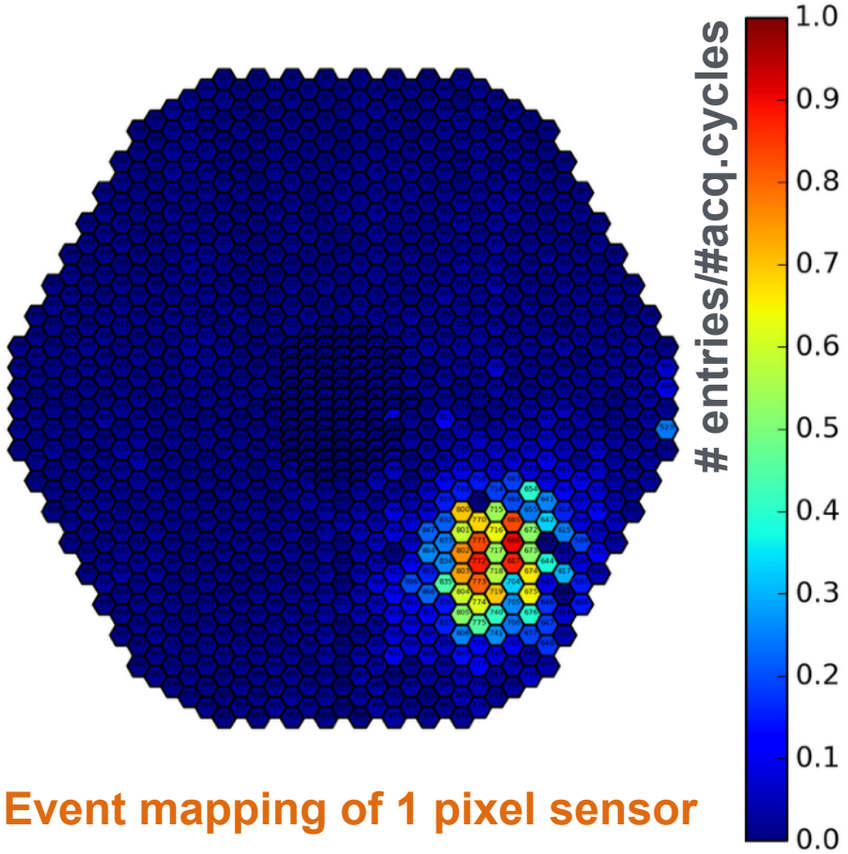
Tests resulted in a good understanding of data taking with KPiX in all aspects:

- Time analysis of events and matching with based on timing with external timestamps
- ADC response of channels and calibration
- Mapping of events onto the testing pixel sensor

→ Well prepared for the final strip sensors!



Internal and external timestamp distribution

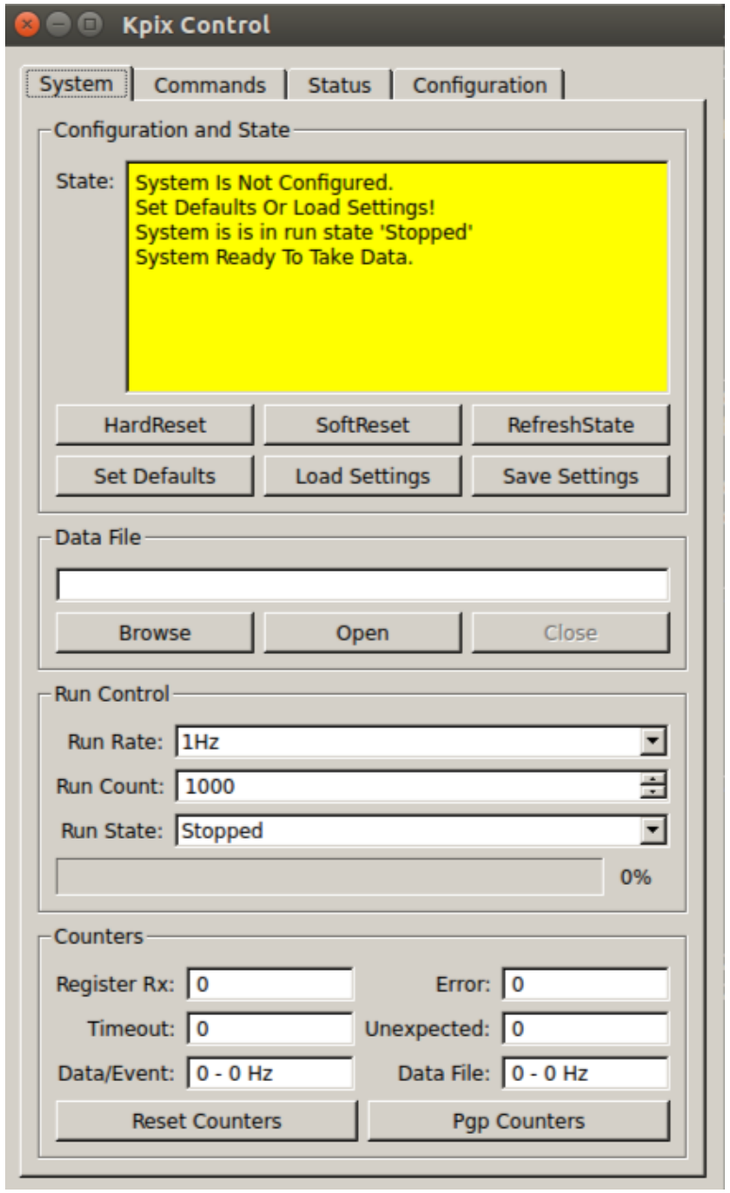


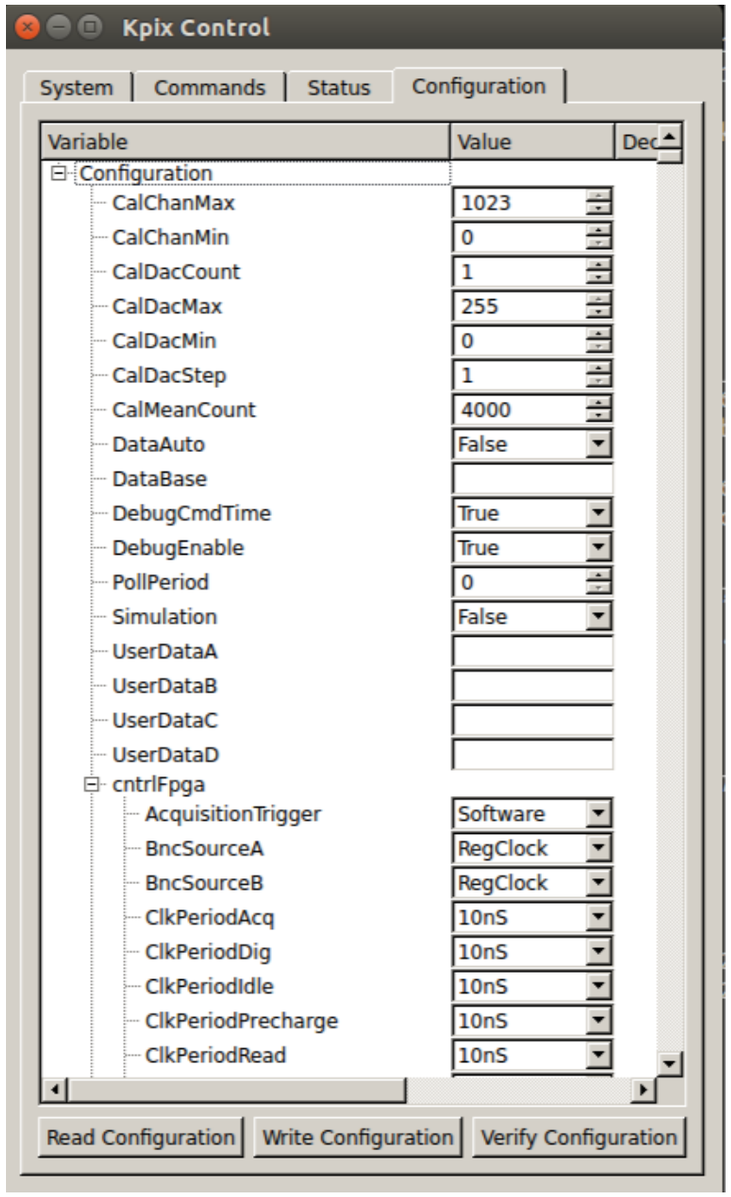
Event mapping of 1 pixel sensor

Integrating to a common DAQ

The KPiX has its own DAQ system developed by SLAC:

- The **Control GUI** is very **powerful** to **control/monitor** the chip
- Output data only in binary files, with its own analysis package





However, as a telescope

- Too many functions and print-out → longer training peirod to users + higher possibility for mis-operation;
- Unique output data with special analysis package → difficulty to integrate with other facility.

Result in an integration to ➜

EUDAQ

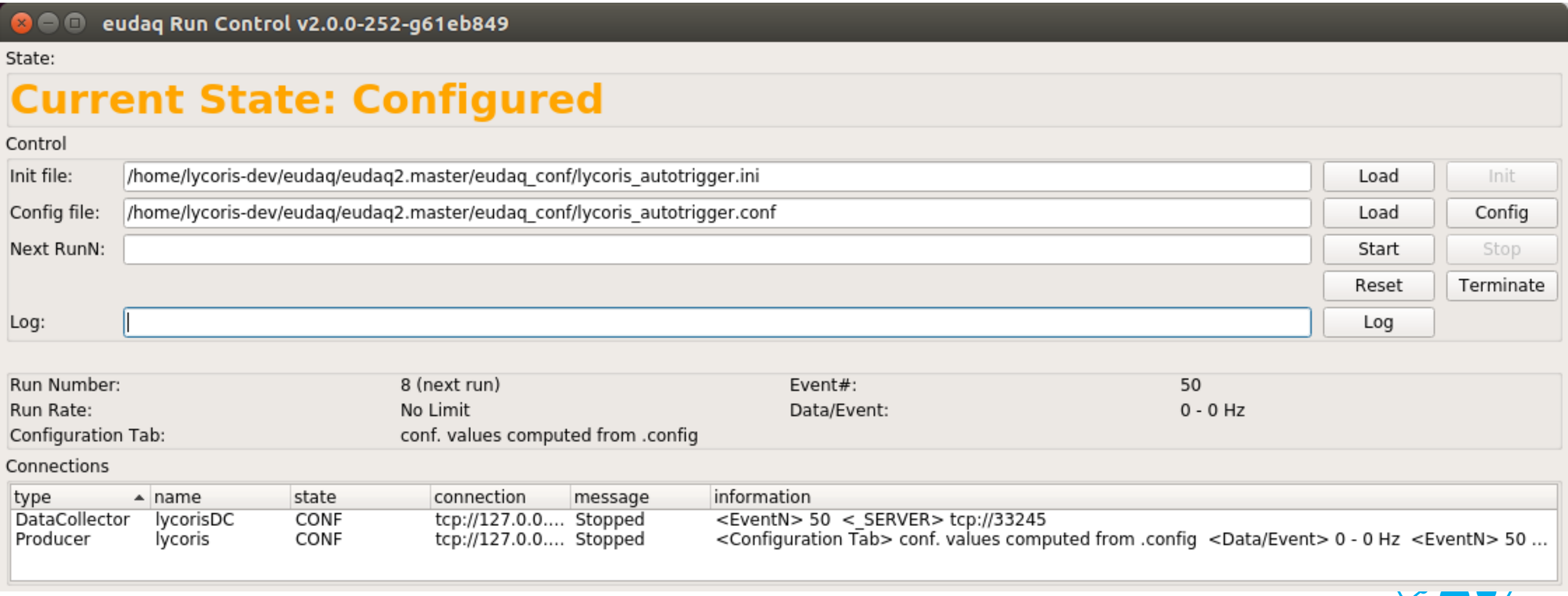
SLAC NATIONAL ACCELERATOR LABORATORY

DESY

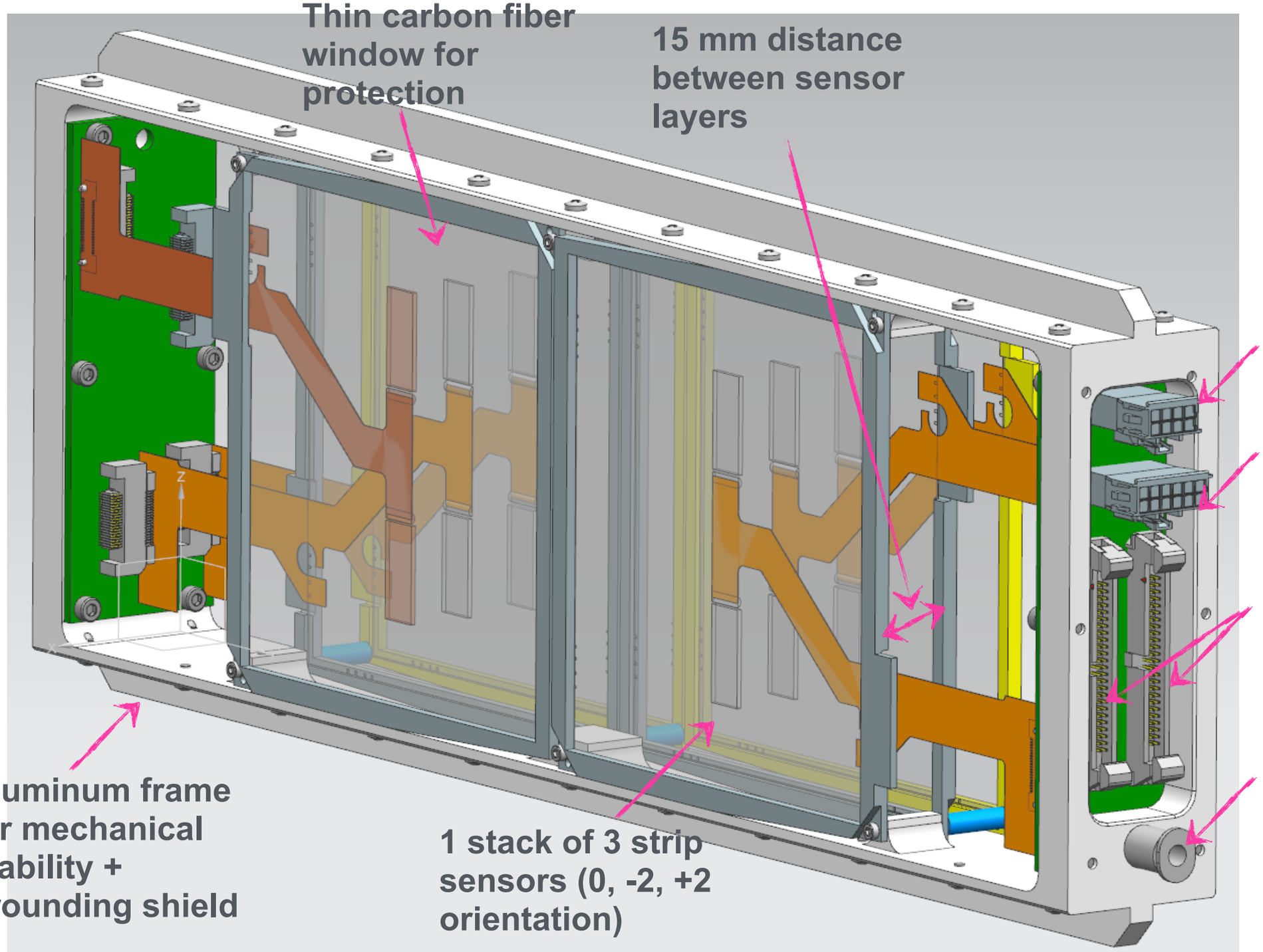
EUDAQ integration

Dedicated Github repository: https://github.com/Lycoris2017/EUDAQ-Lycoris

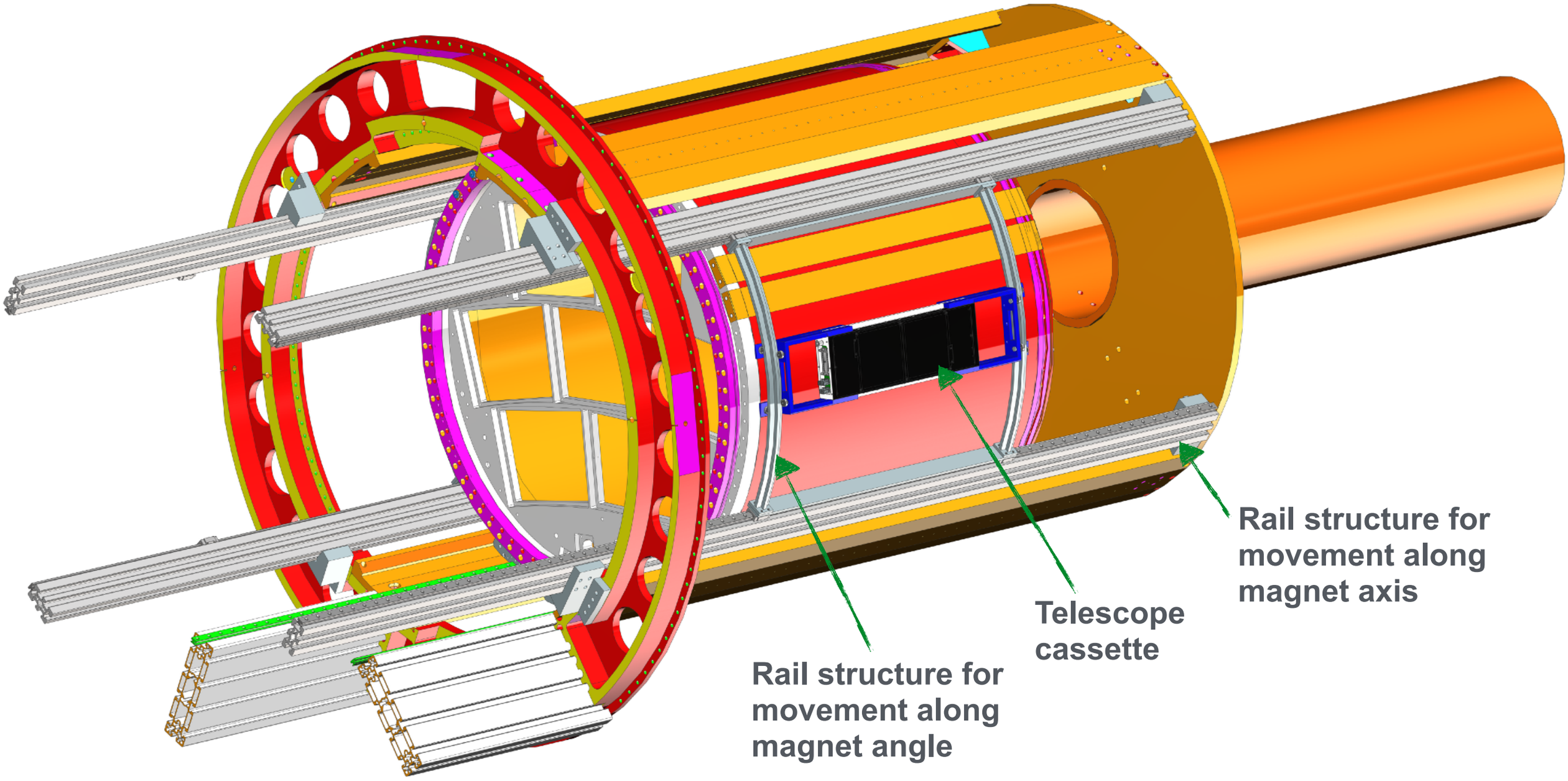
- Base on the central AIDA2020 common DAQ (EUDAQ2),
- with Many modules customized, incl. the RunControl GUI;
- KPiX readout data stored **at the same time** (=> capable for validation)
  - from EUDAQ side: in both formats, KPiX and EUDAQ;
  - from KPiX DAQ side.
- Succeeded in validating EUDAQ output data from lab tests!



The sensor cassette



Magnet telescope structure



Final active area is 10x20 cm²

Conclusion and Outlook

action ongoing

Mission complete

- Construction of a large area strip telescope ongoing;
- Multiple tests with KPiX readout system completed;
- Delivery of <Mechanical structure for installation> and <Electronics> expected middle of 02/2018;
- Integration to EUDAQ2 framework for usesrs:
  Run Control, Data Collector and Data Converter —> common data format with relevant offline event building/analysis package provided.

Full assembly of the first sensor expected this week!

- Thanks to the cooperation with SLAC NATIONAL ACCELERATOR LABORATORY !
  this project profits from expertise and manpower of both DESY and SLAC.
- Fruitful cooperation with University of BRISTOL and the AIDA2020-WP5 team!
  To **sync** LYCORIS telescope with DUT and the Accelerators

AIDA2020 deliverable due is 04/2018,

the project is currently well on track to fulfill this goal!

AIDA 2020

DESY

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LYCORIS will see you soon in 3 months!

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谢谢观赏！

Many thanks for your attention!

Danke schön!

Merci beaucoup!

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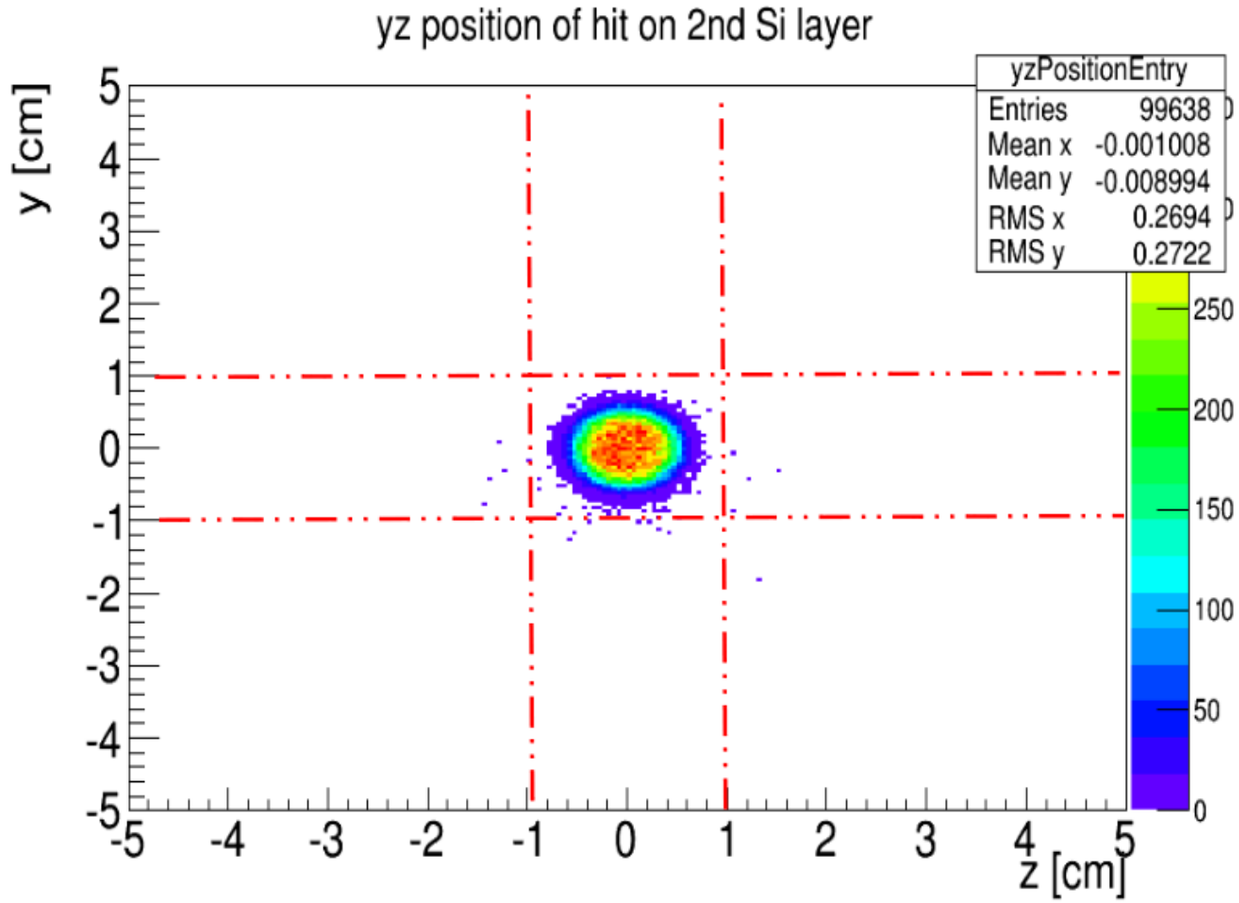
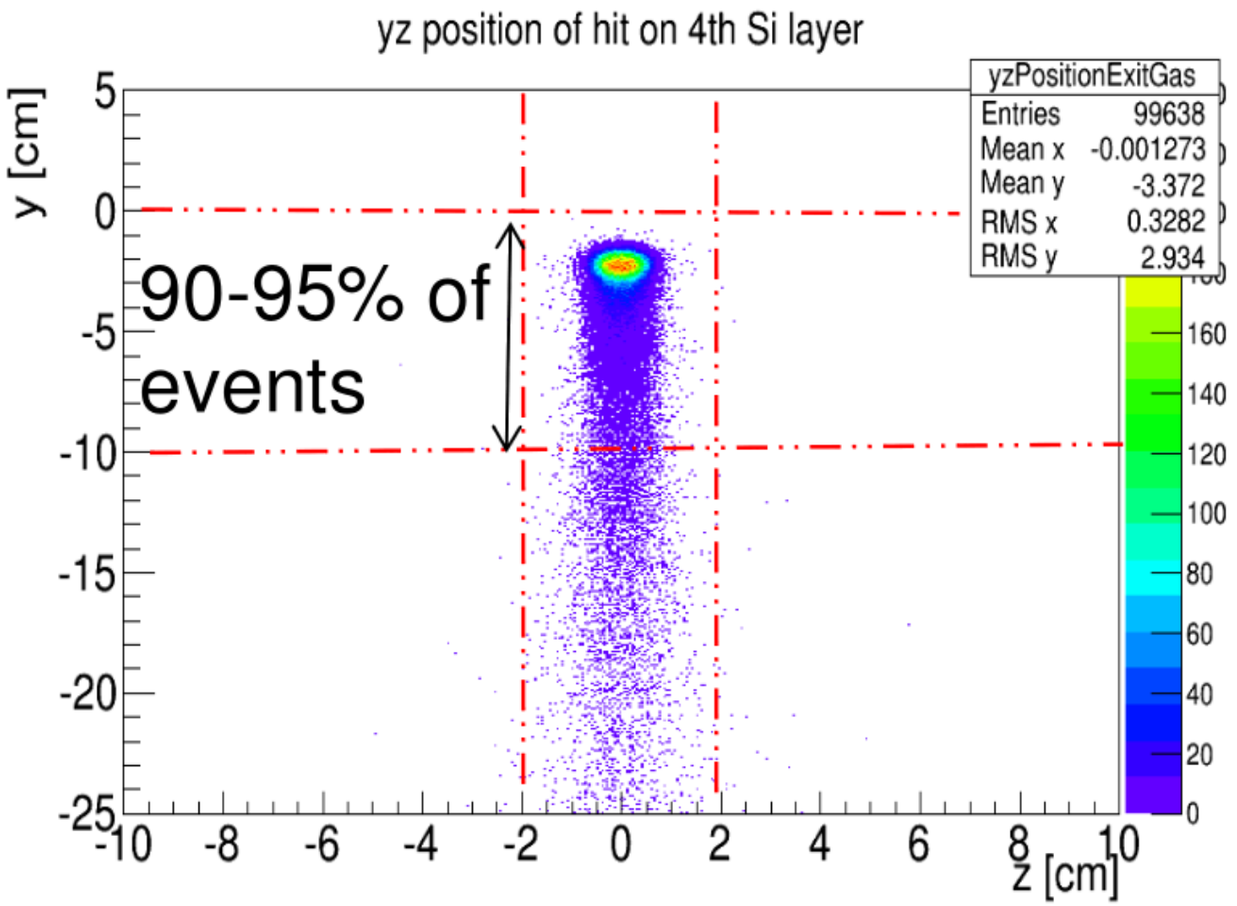
Everyone needs back up :)

Demand for Coverage Area

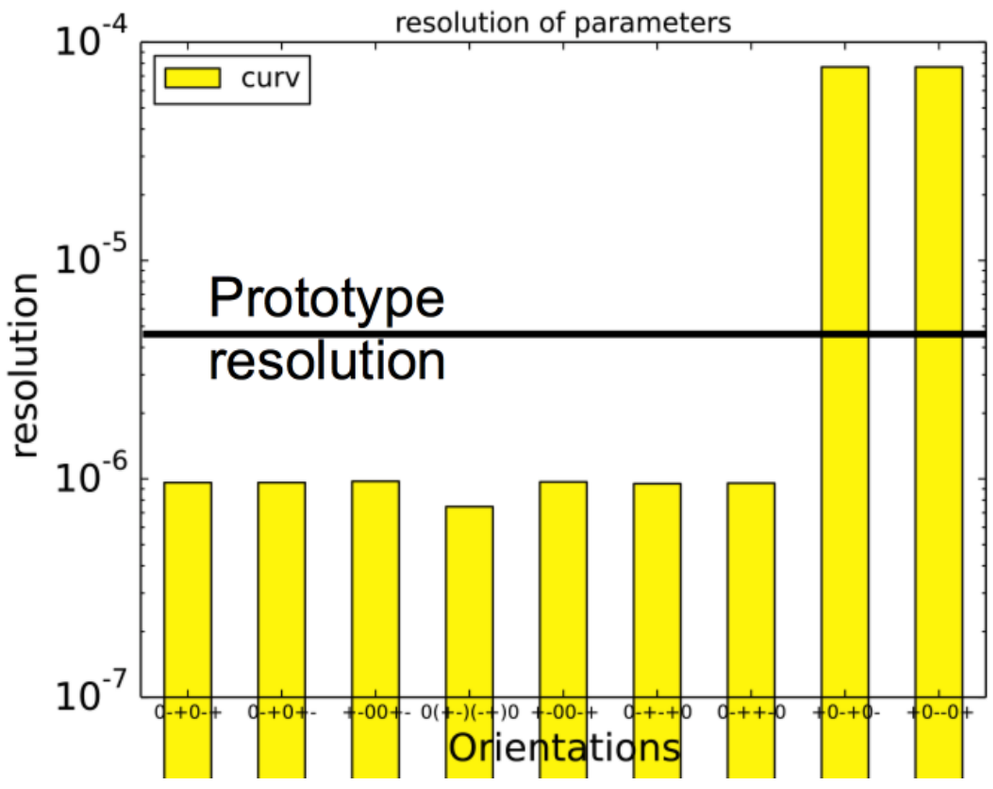


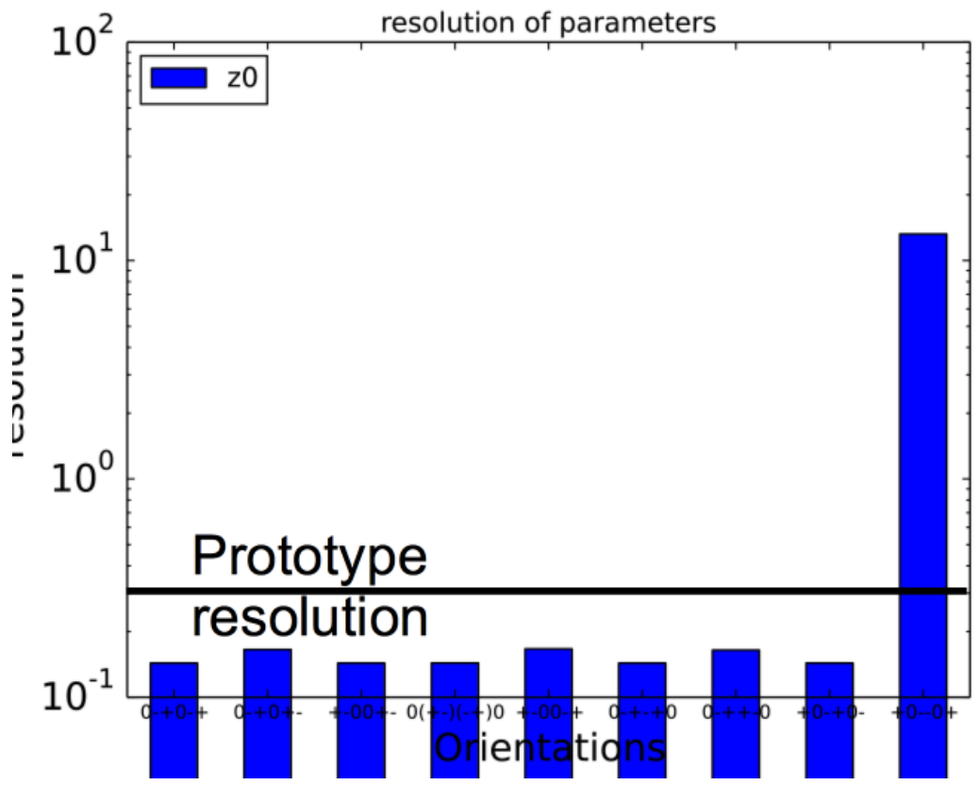


- For lower energy beams, the hit distribution on the back sensors is more spread and shifted to lower y values
- Larger coverage area is beneficial (e.g. less moving and alignment of the system)

Study on Sensor Orientation

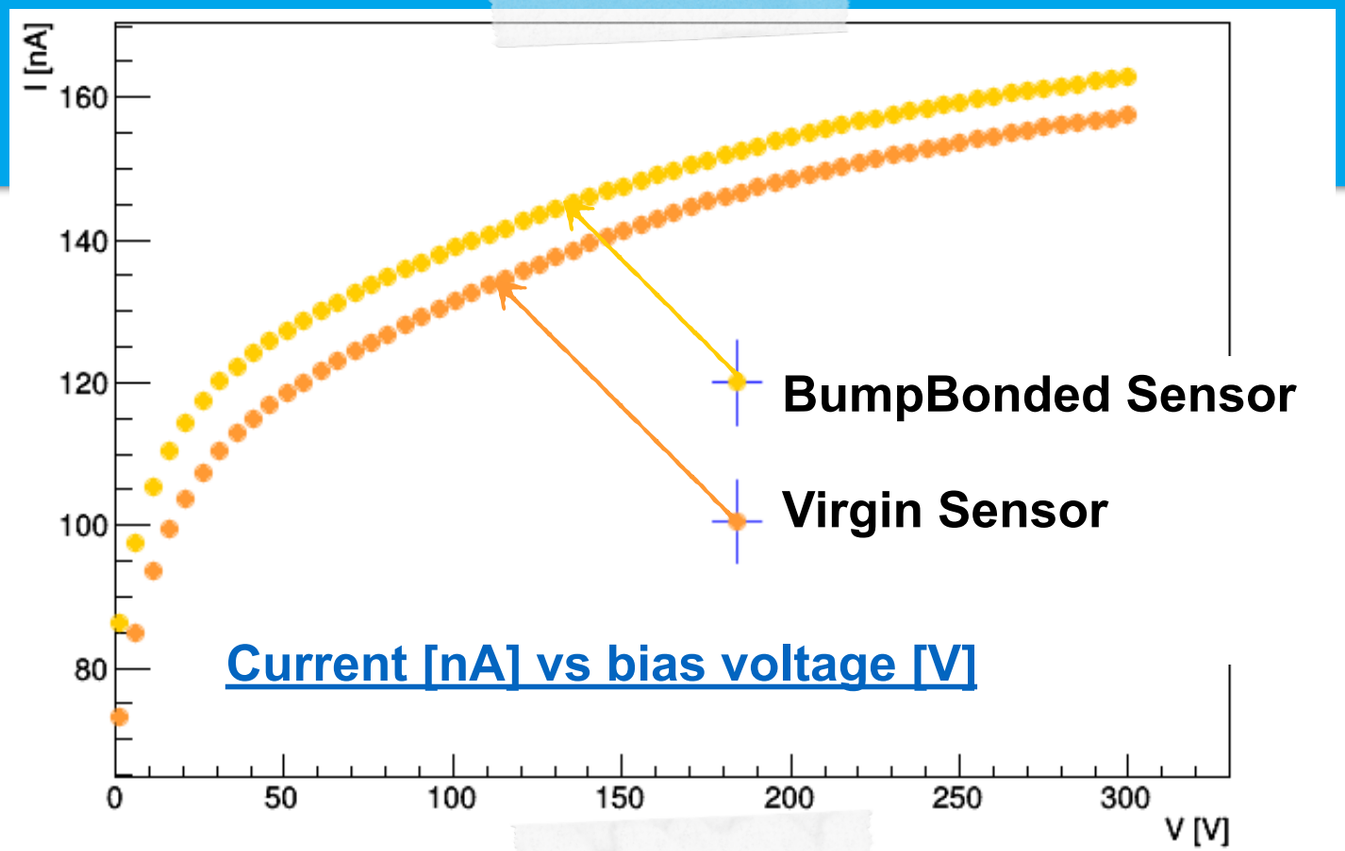
- Analytical calculations using GeneralBrokenLines (GBL) by Claus Kleinwort with a 25 µm pitch strip sensor;
- Depending on the orientations, correlations between planes severely limit the resolution;
- The right orientation means the Telescope can easily achieve the curvature resolution needed for the LP TPC.

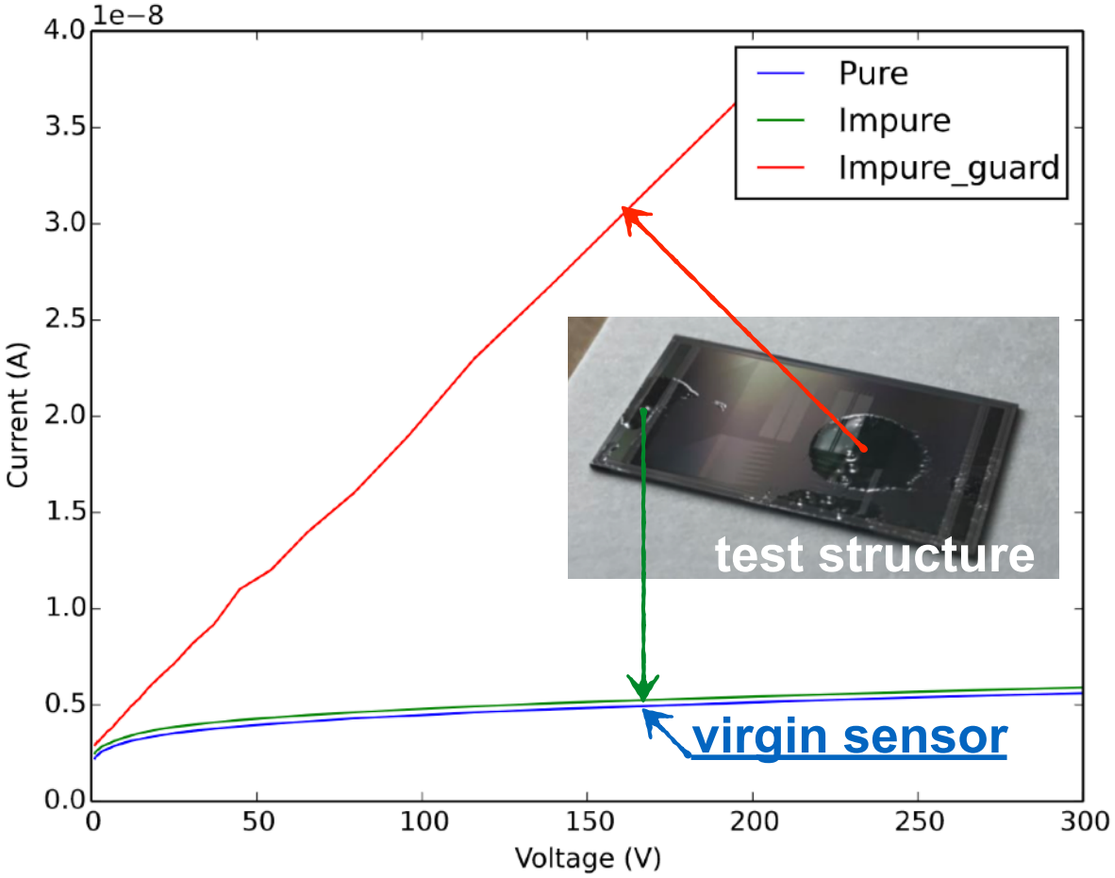


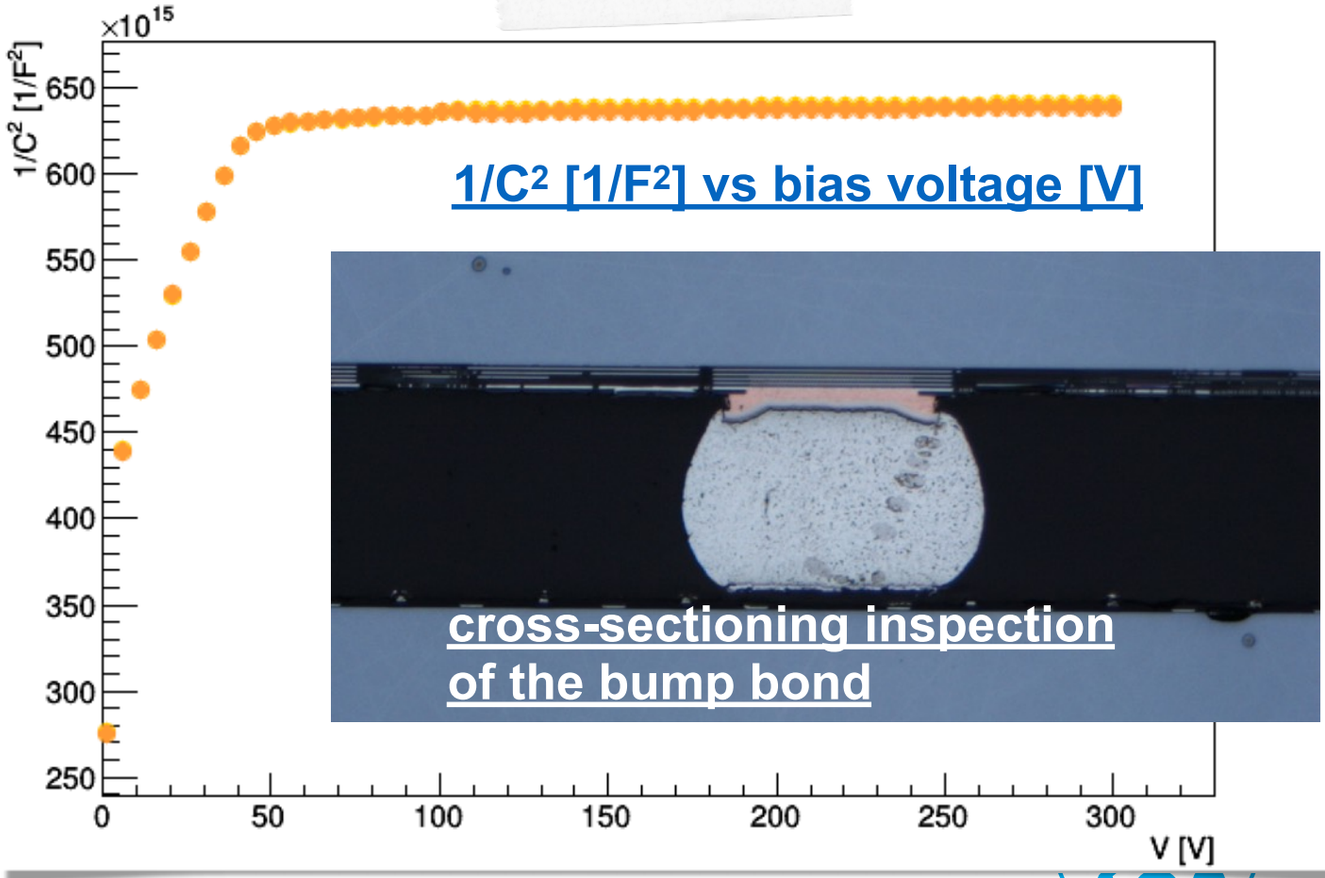


Strip Sensor inspections

- Comparing IV/CV curves from bump-bonded sensors to virgin sensors: example shown right side with the cross-section inspection of a bump bond;
- Further inspection before glue the kapton cable to sensor:
  - IV measurements at different steps of putting glue on a test structure.
    ➜ **<u>avoid glue on outter rings</u>**.

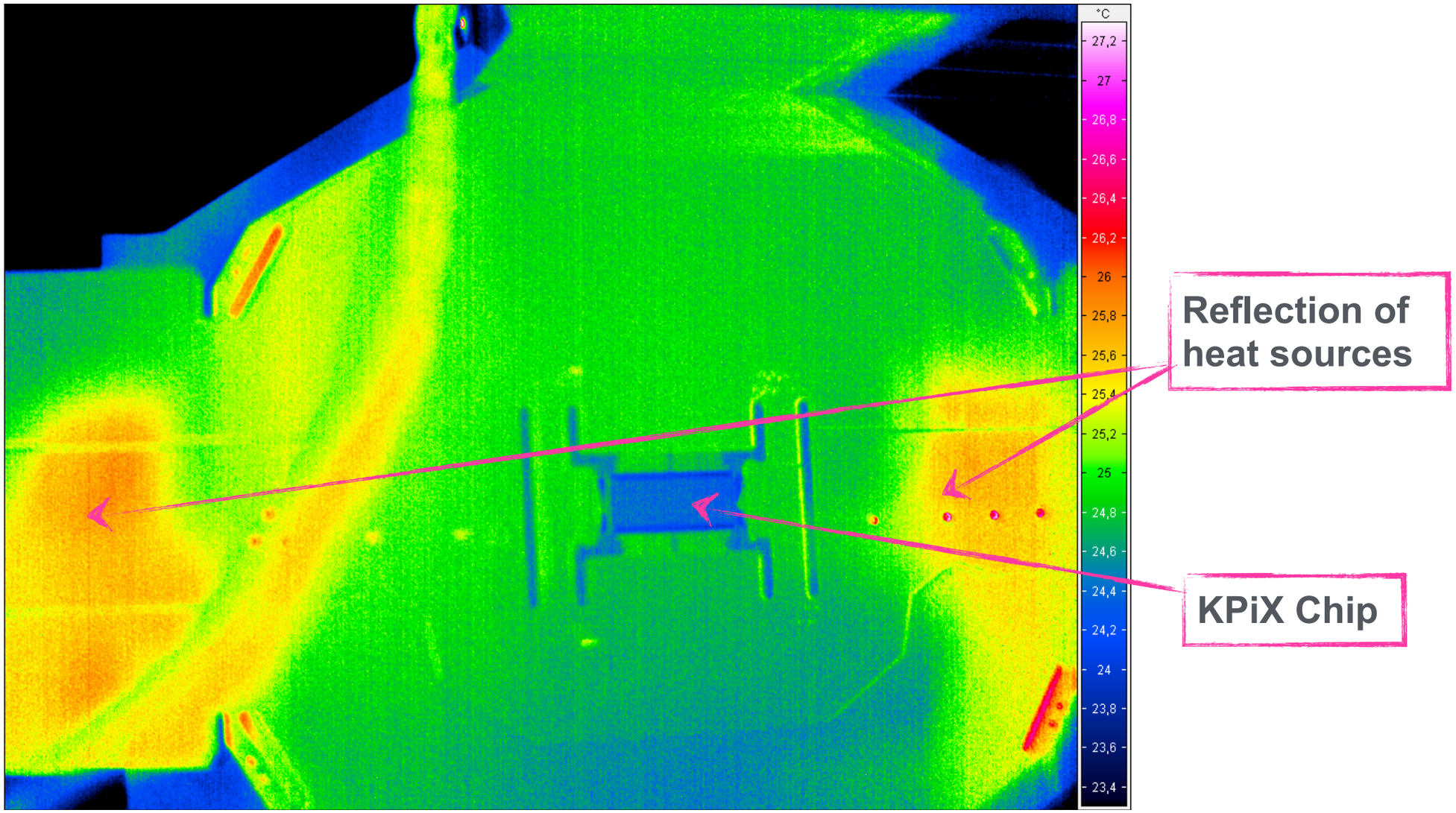






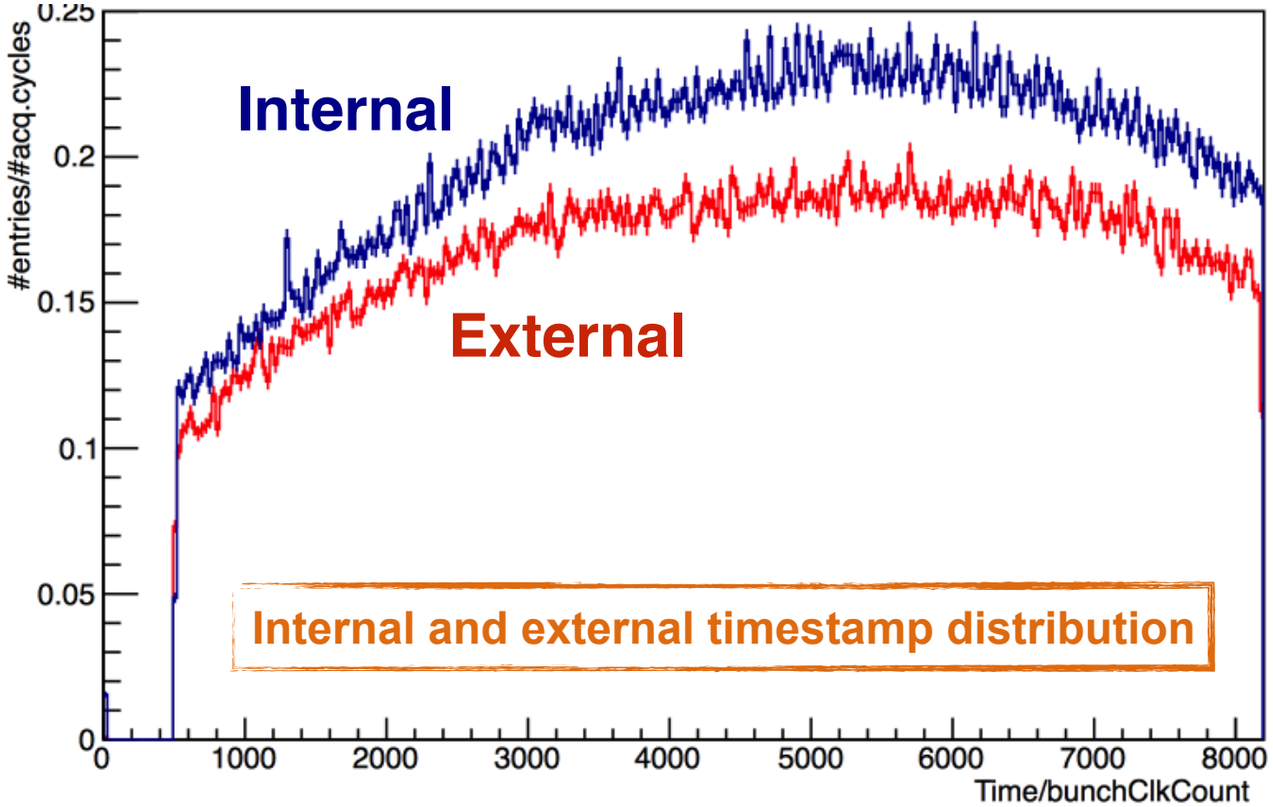
KPiX studies: do we need cooling?

- As a result of power pulsing and only 1024 readout channels
  → a low Power Consumption is expected (40 mW in total)
- Measurement of heat production done via infrared camera
- Overall power consumption and heat generation is negligible
  → No active cooling needed

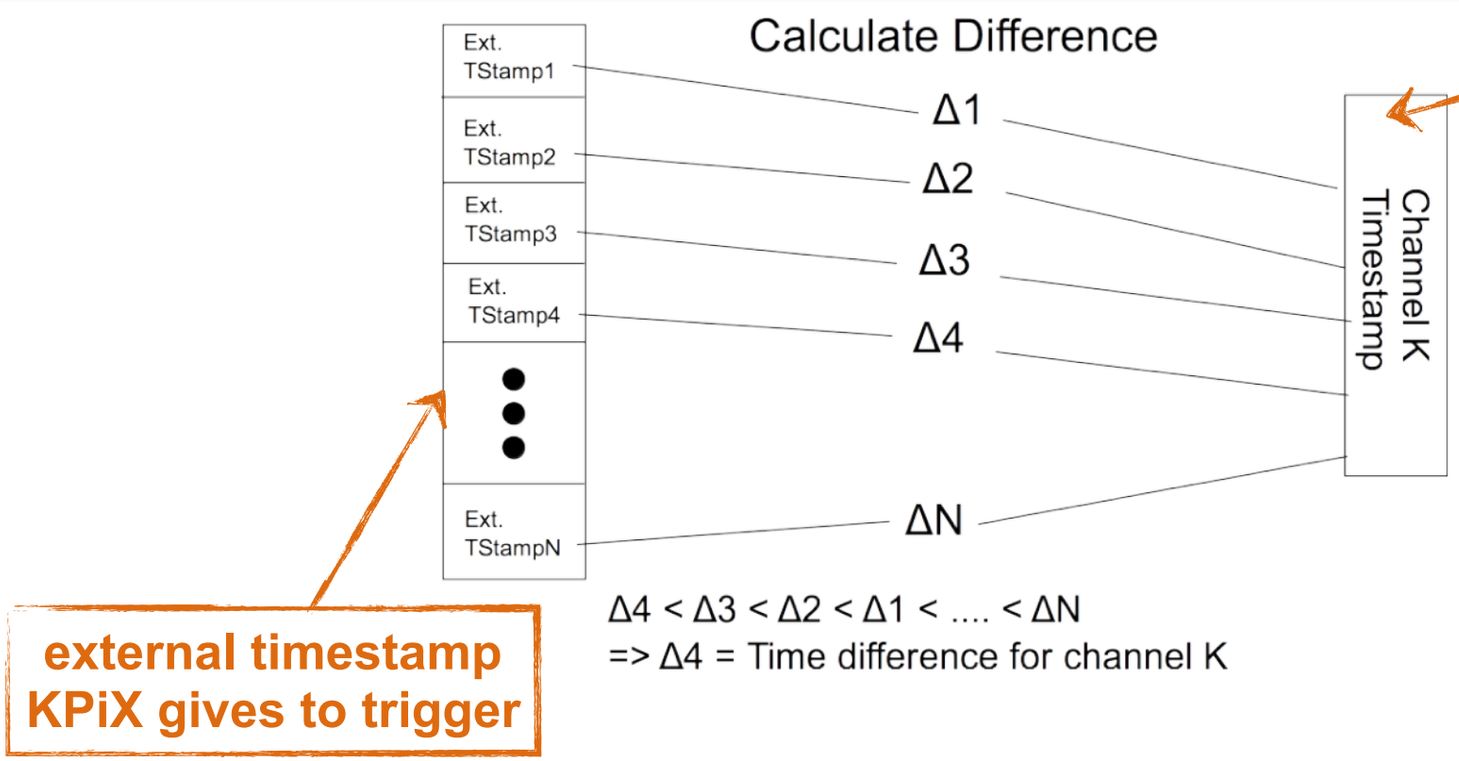


KPiX Timing Studies: diff from internal to external

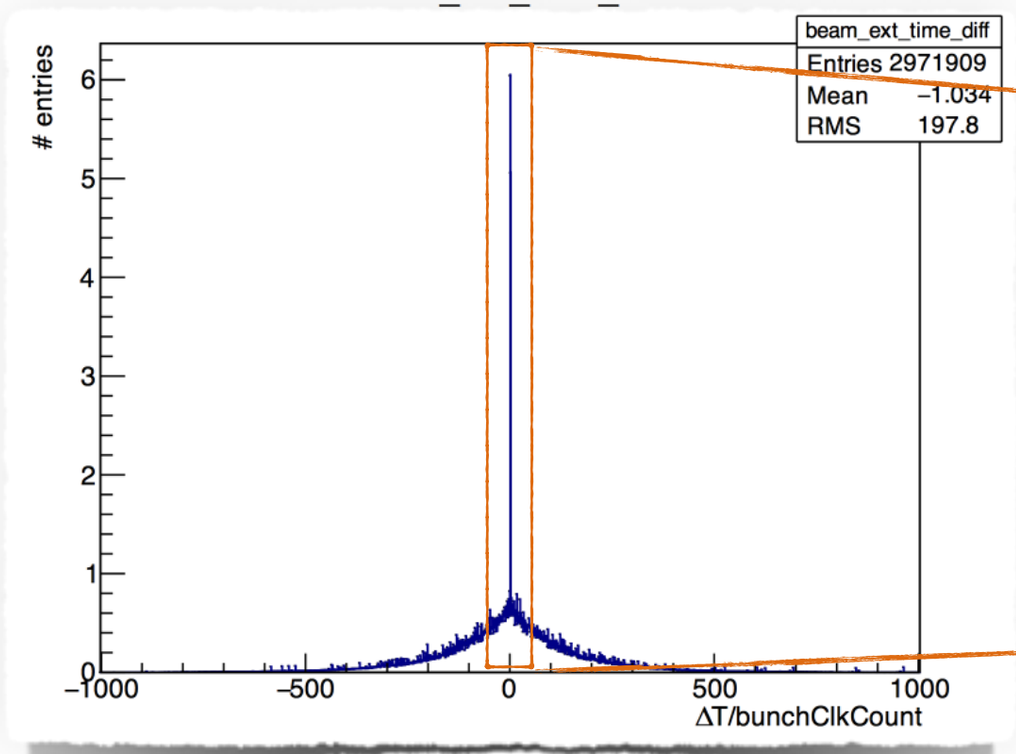
- KPiX allows for storage of external trigger timestamp and internal timestamp of Data.
- Fed in either via a NIM or CMOS signal on current DAQ board
- Data is stored in multiples of the BunchClockCount = 8*Acq.Clock
- For the testbeam Acq.Clock = 320 ns → BunchClockCount 2.5 µs
- Time data is then used to reduce noise levels and match between sensor layers

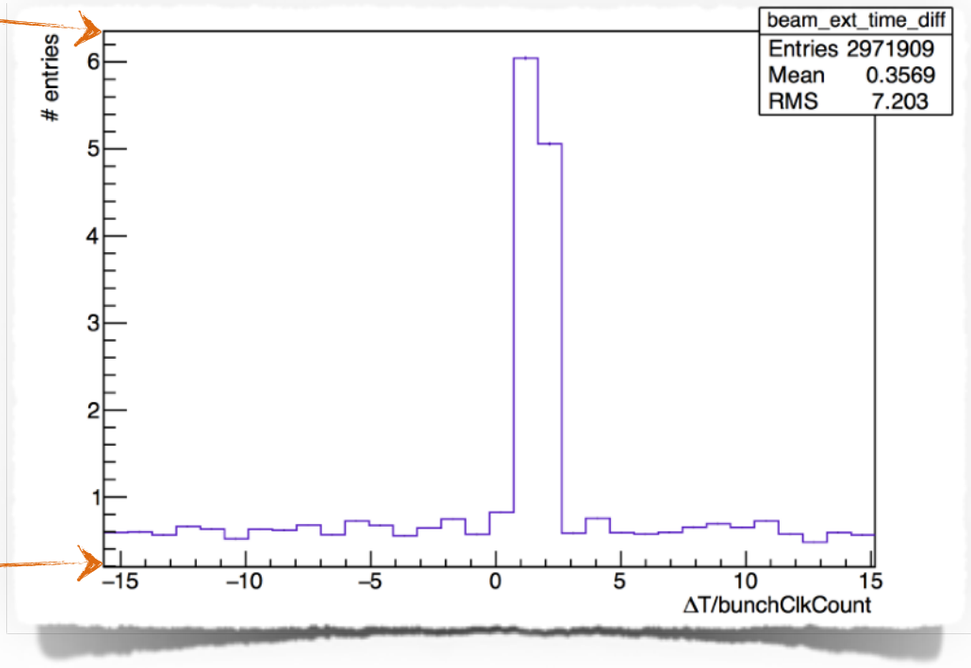


KPiX Timing Studies: diff from internal to external



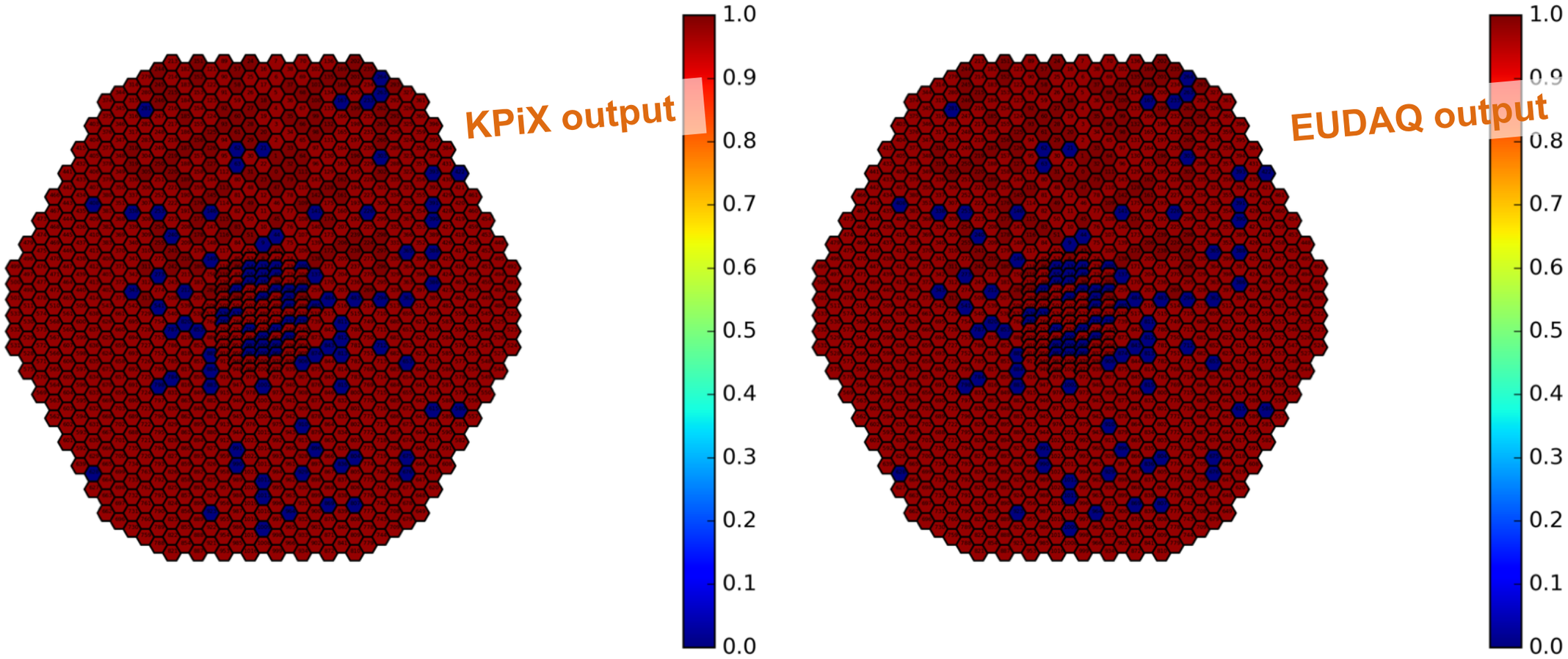
- Matching between external timestamps and internal timestamps shows a small delay between signals.
- Event selection will be done using this information





Software status update: lab test succeeded

- Same analysis and event mapping code
- Exact same results from EUDAQ to KPiX for same data-taking



* event mapping on the ECal sensor for KPiX tests at DESY
* same sensor, same bucket