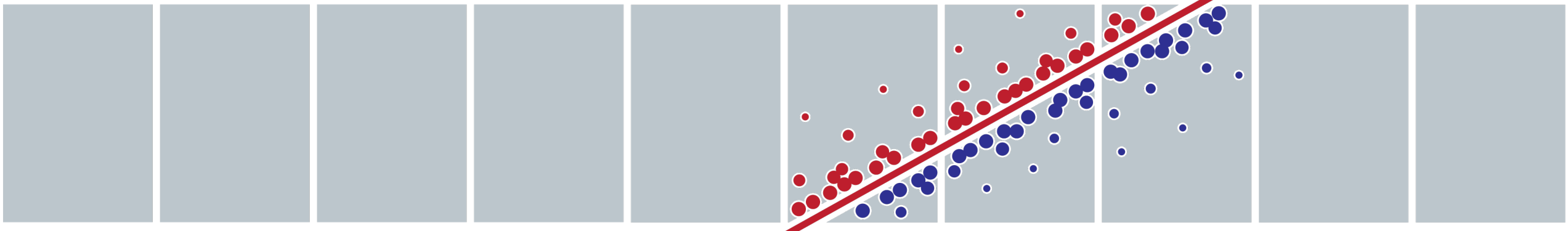
HV-CMOS Characterisation for Mighty Tracker

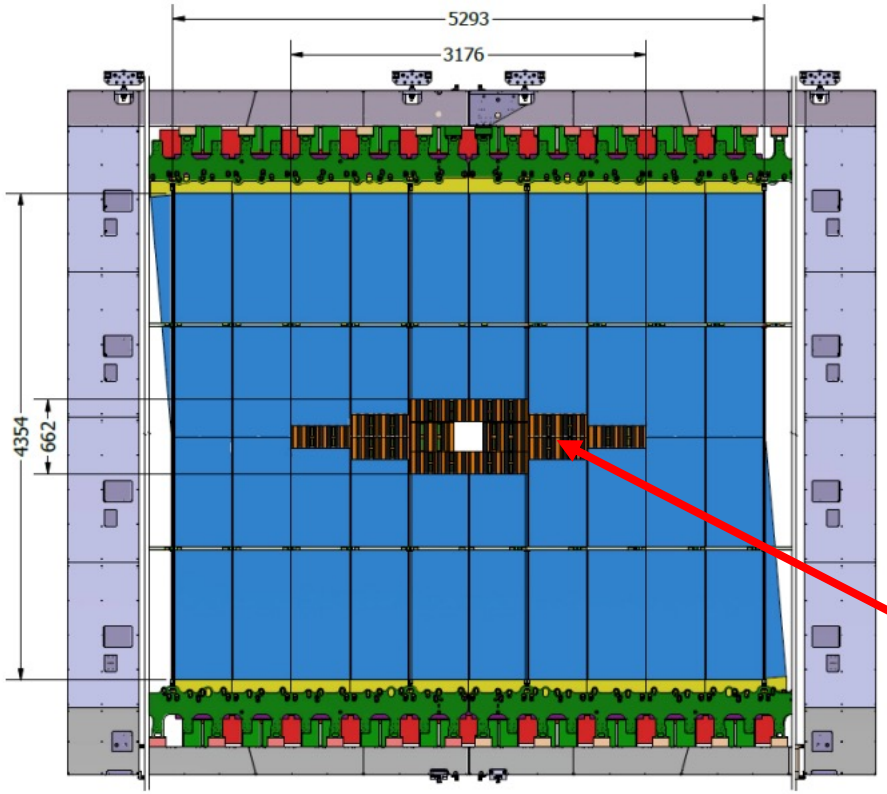
Hussain Al Saleh, **Miles Armour**, Daniel Foulds-Holt, Giovanni 'T Lam

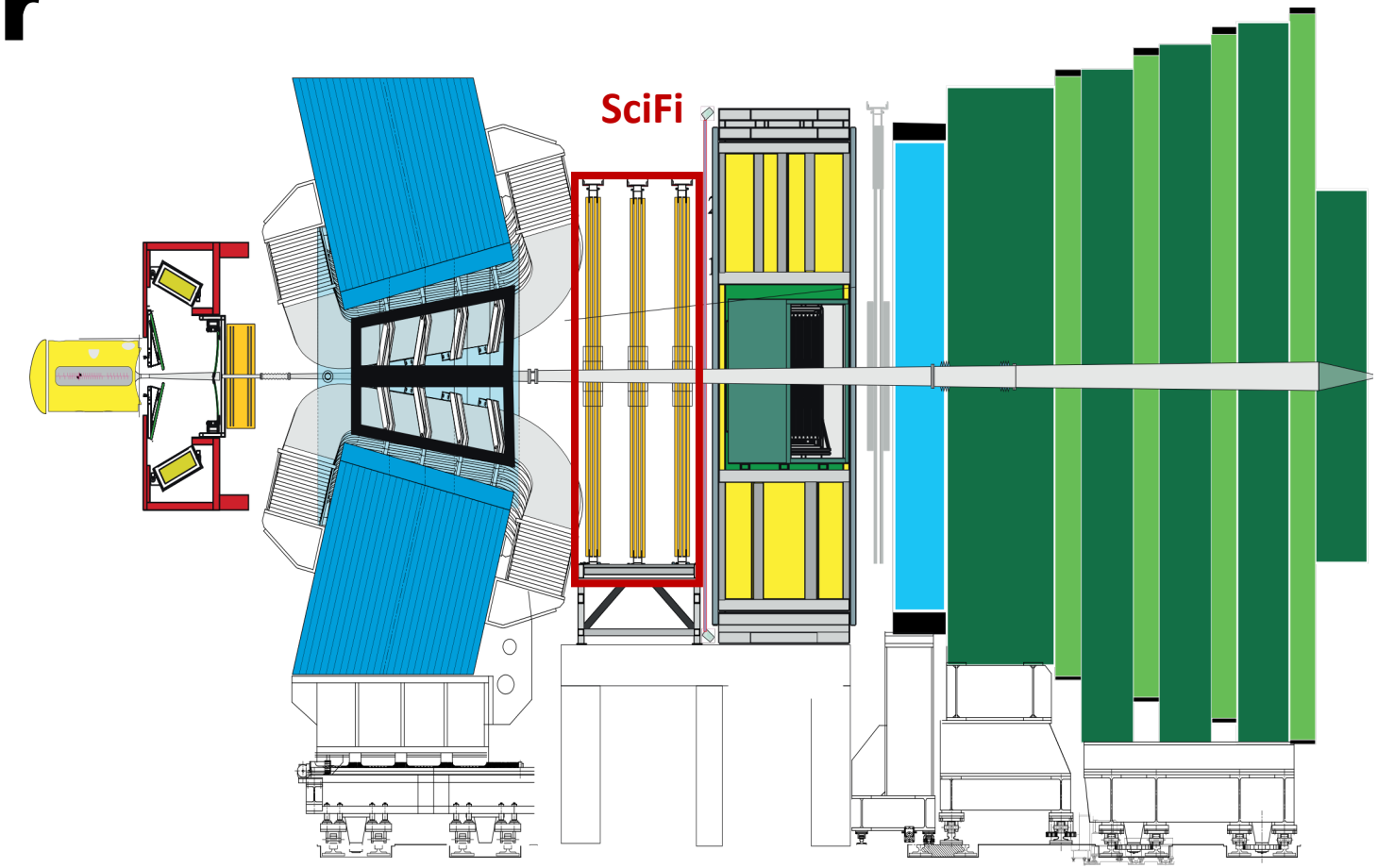
Detector Informal Meeting PPE
29th October 2026



LHCb Mighty Tracker

The **Mighty Tracker** is the proposed upgrade to the existing **Scintillating Fibre (SciFi)** detector. It will cope with the harsher conditions of the **high luminosity** LHC.





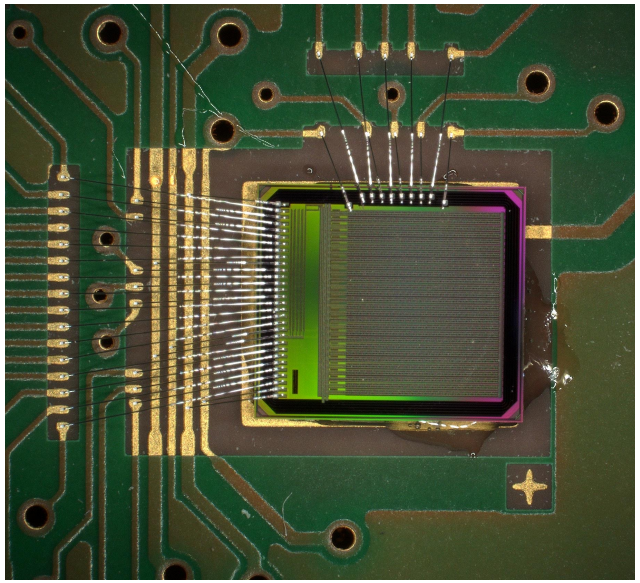
Mighty tracker will enhance the SciFi tracker with the innermost region closest to the beam pipe instrumented with **silicon pixel sensors.**

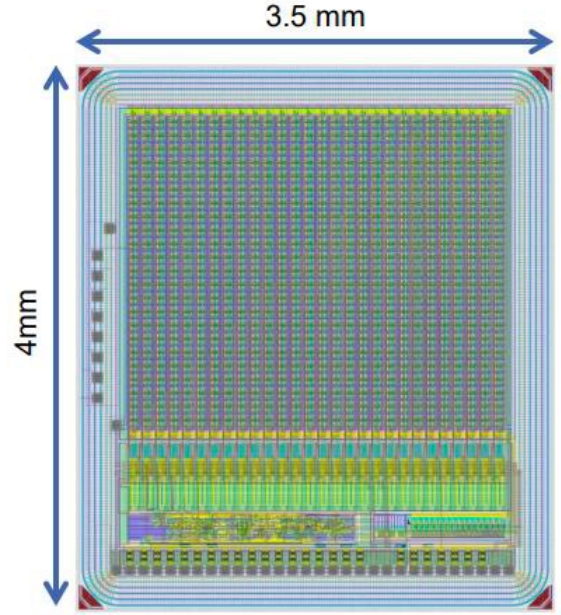
By **segmenting** in **y** alongside **x**, **pile-up** is **reduced** which results in the improved performance.

MightyPix sensor

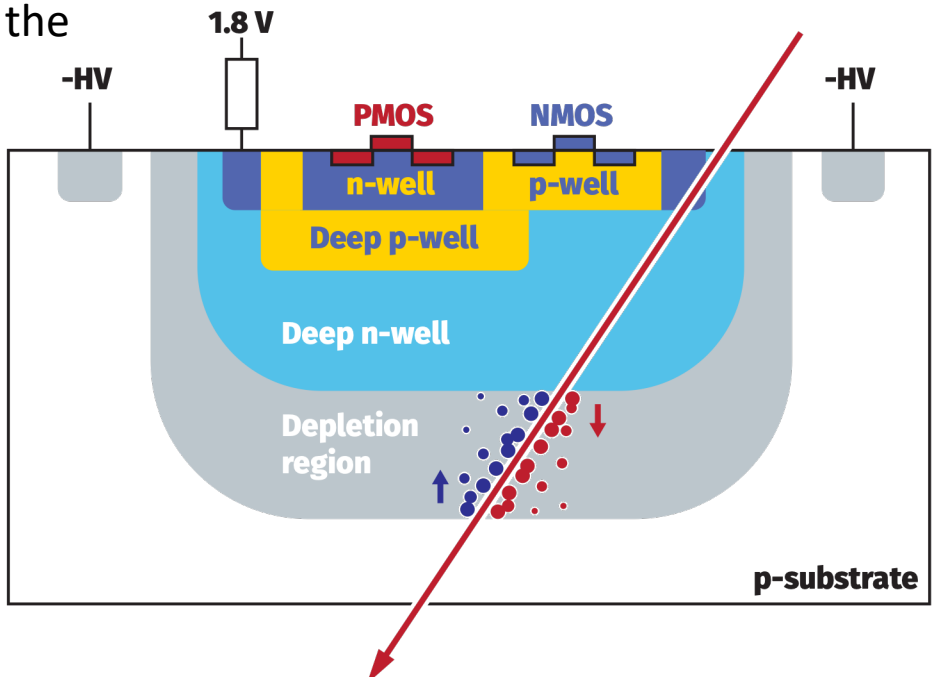
The MightyPix Sensors are a series of High-Voltage Complementary Metal-Oxide Semiconductors (**HV-CMOS**) developed to fill the needs of the Mighty Tracker.

HV-CMOS sensors integrate sensor and readout electronics in a single process. With **fast charge collection**, **low power consumption** and no external readout electronics (**less material budget**) they are the favoured technology.





Parameter	LF-MightyPix
Process	150 nm CMOS
Dimensions	3 mm x 4 mm
Number of pixels	28 x 23
Pixel pitch (X & Y)	100 um



Default foundry is AMS (180nm CMOS). The backup is LF (150nm, constructed LF-MightyPix).

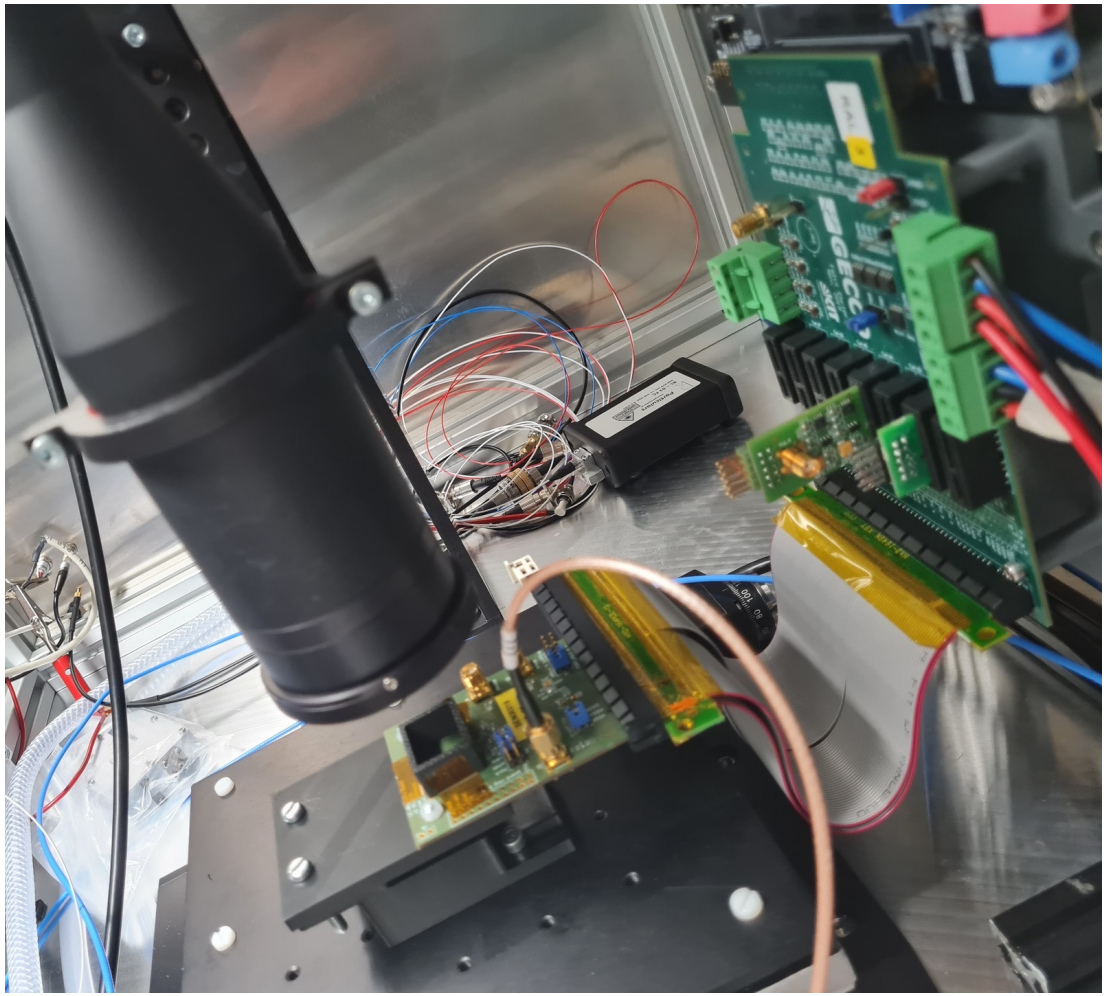
The most recent chip is LF-MightyPix however, future chips are being manufactured.

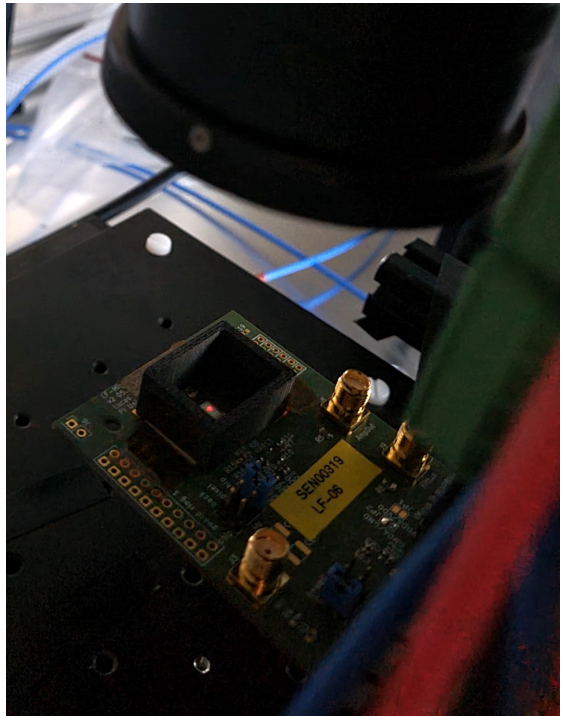
Laser setup

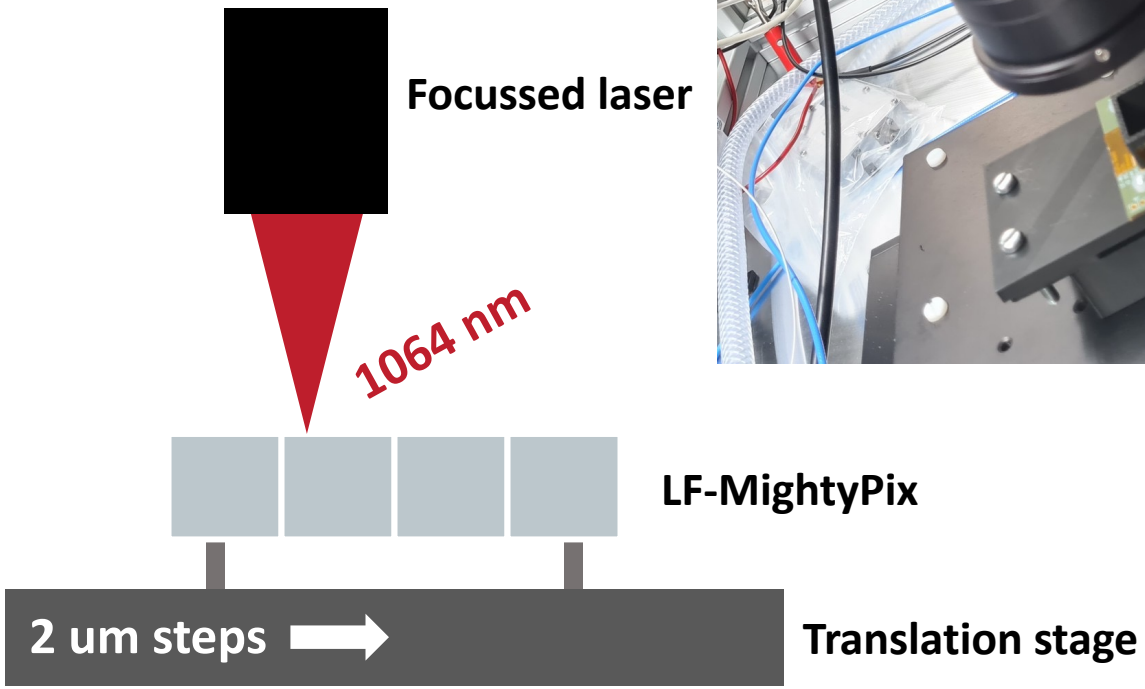
The LF-MightyPix chip was characterized using the transient current technique (**TCT**) equipment in the Edinburgh clean room.

The laser height and sensor position can be changed using translation stages.

ECROC was used as the control software in this experiment.

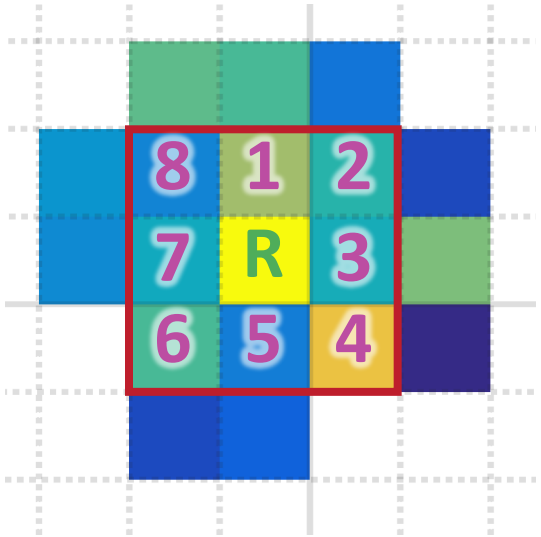


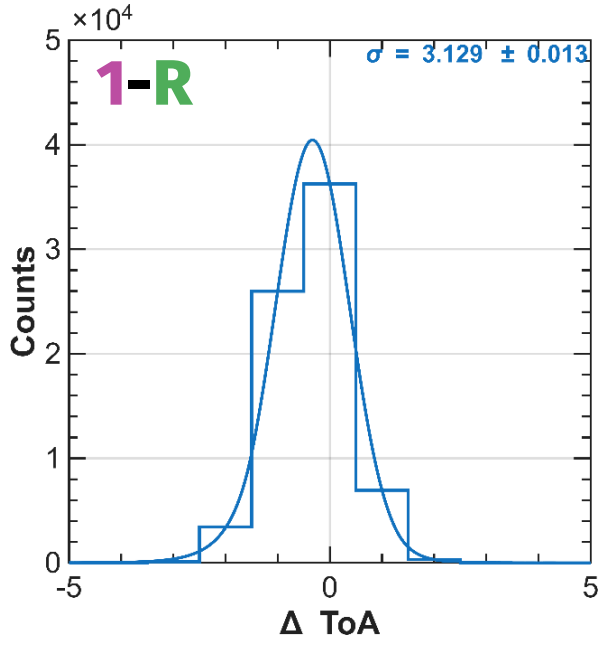


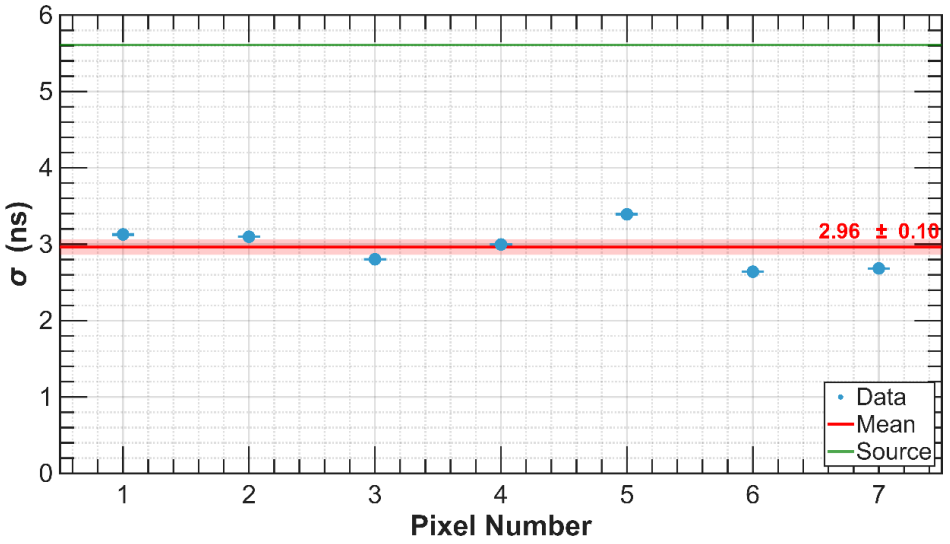


Timing measurement results

Earlier this year, Giovanni performed timing measurements using a defocused laser spot. By taking the difference in time of arrival (**ToA**) between adjacent pixels, a measurement of the time resolution can be made.







$$\sigma_{ToA} = 2.96 \pm 0.10\,ns$$

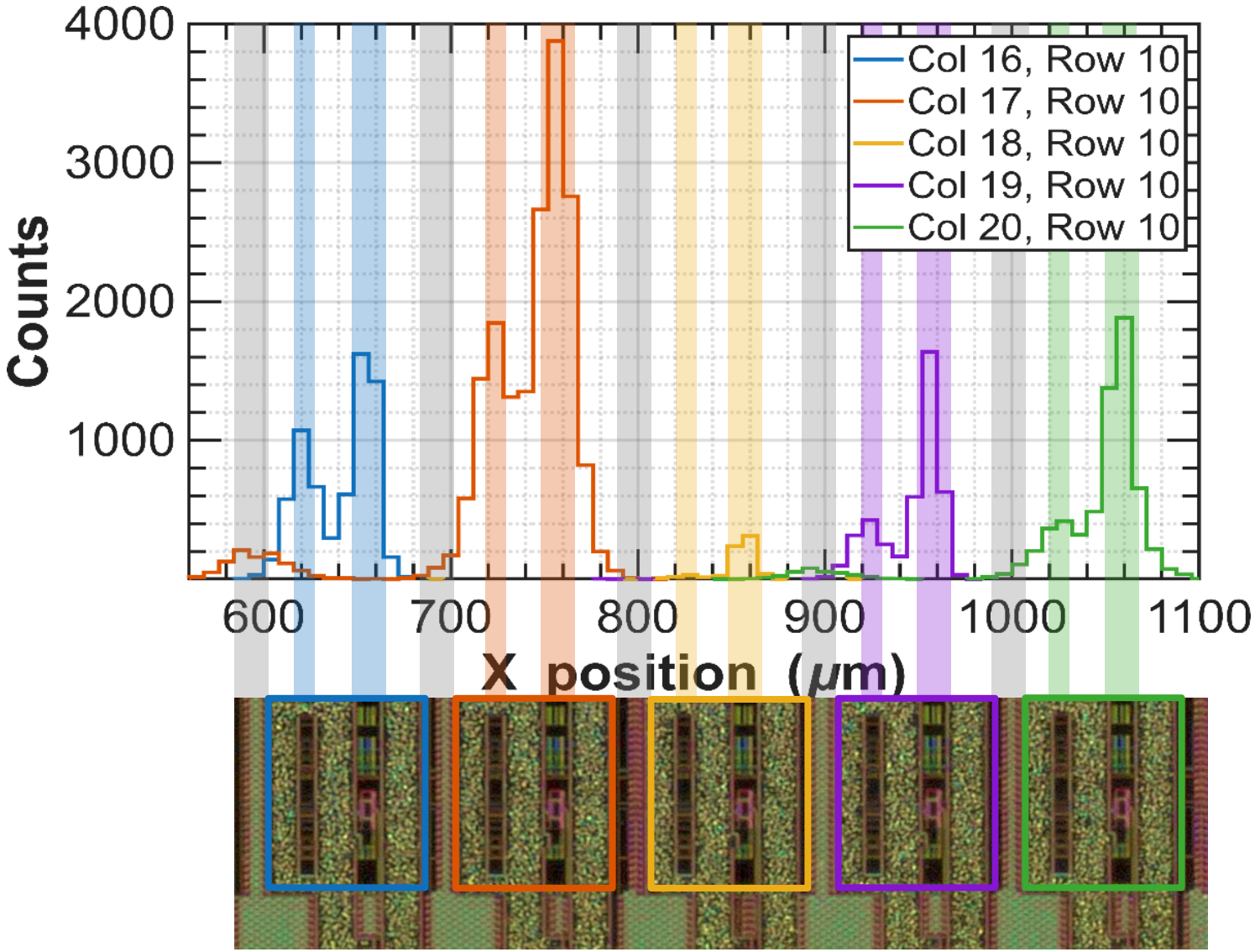
Cross-talk measurements

Giovanni, also using the TCT, performed a scan across a single row of the chip.

Instances of **cross-talk** were observed where hits were registered in pixels not illuminated by the laser. The cause of the displaced peaks of cross-talk, are, as-of-yet, unknown.

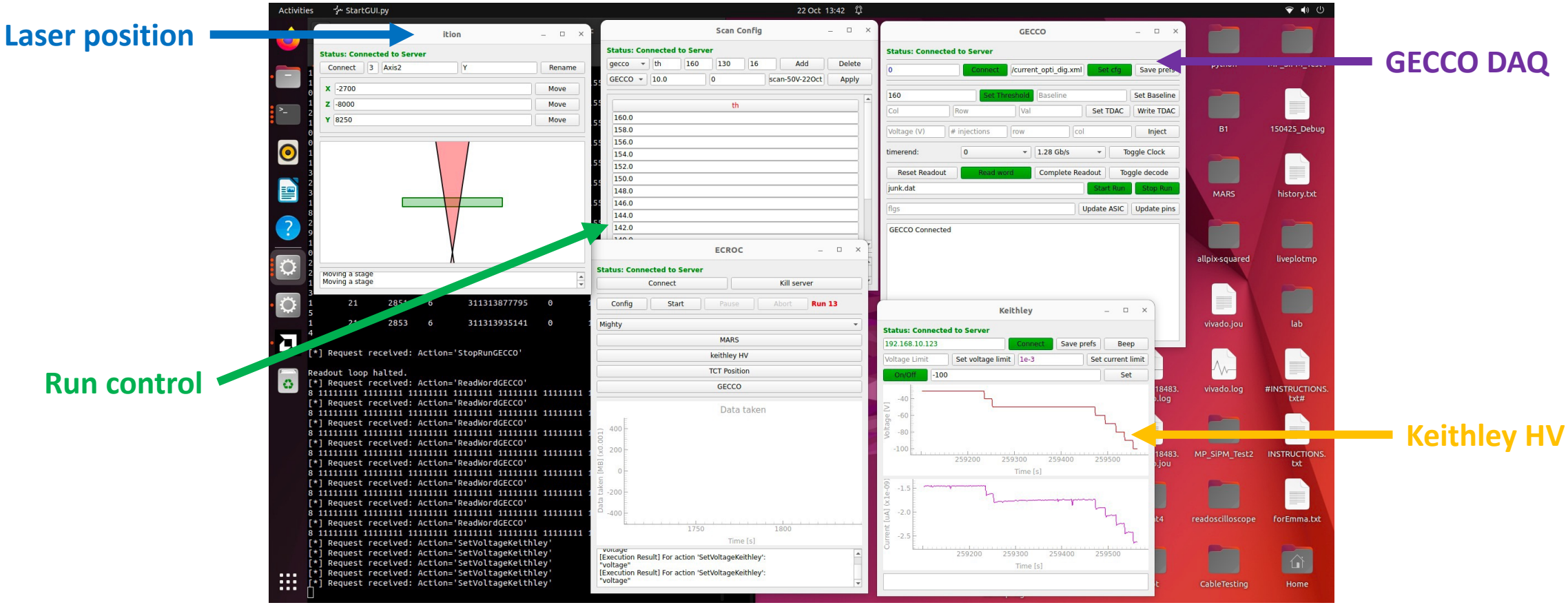
The aluminum transmission lines on the surface of the chip, reflect light appearing as gaps in the sensor response.

Pixel-to-pixel response differs as the chip is not equalised i.e. per-pixel thresholds have not been calibrated.

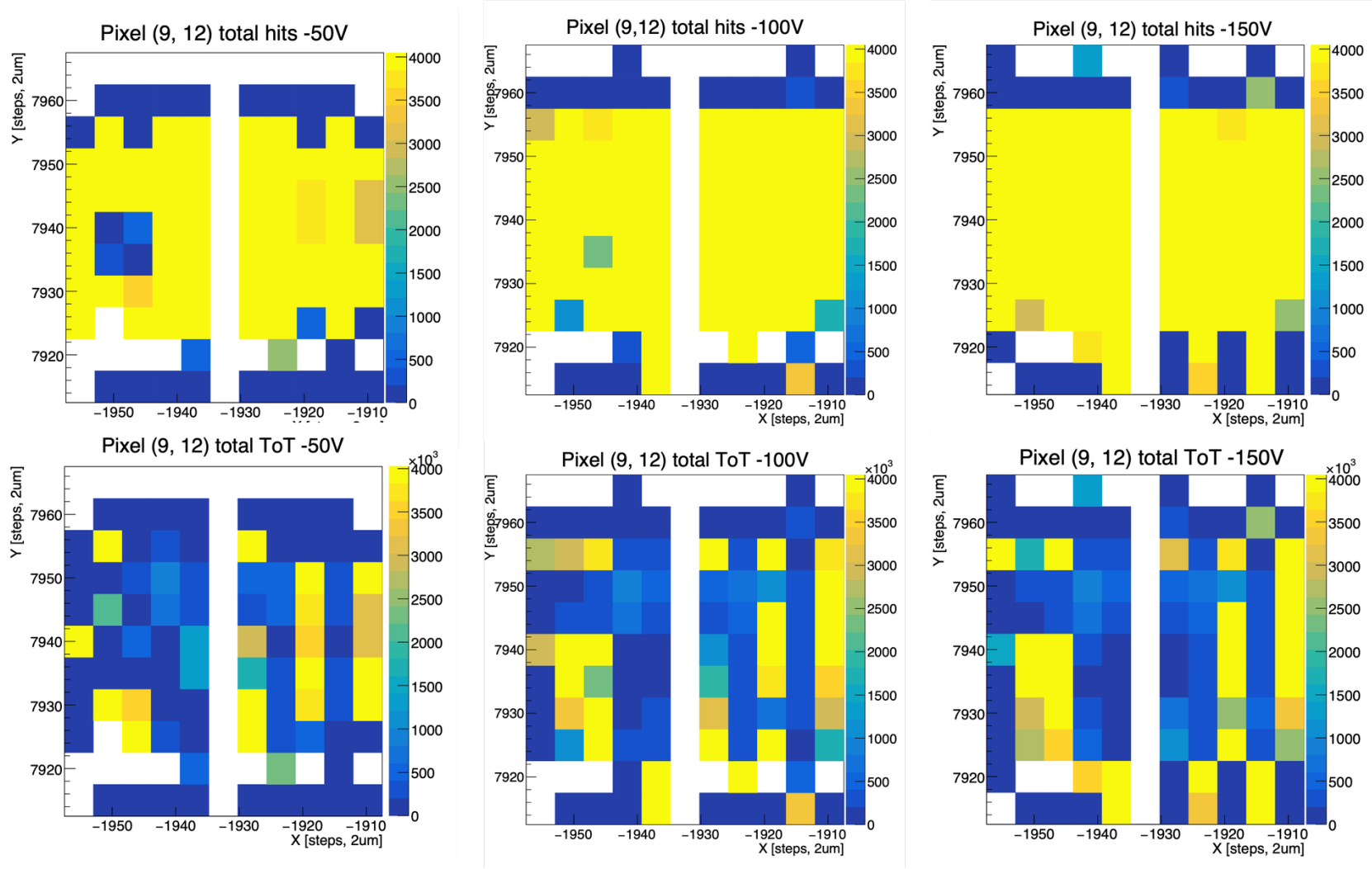


ECROC integration

Over the past week we extended the scans to 2D surface scans using a focused laser spot. To do this required integration with ECROC. The **laser position**, **HV**, and **data acquisition** are all controlled by ECROC.



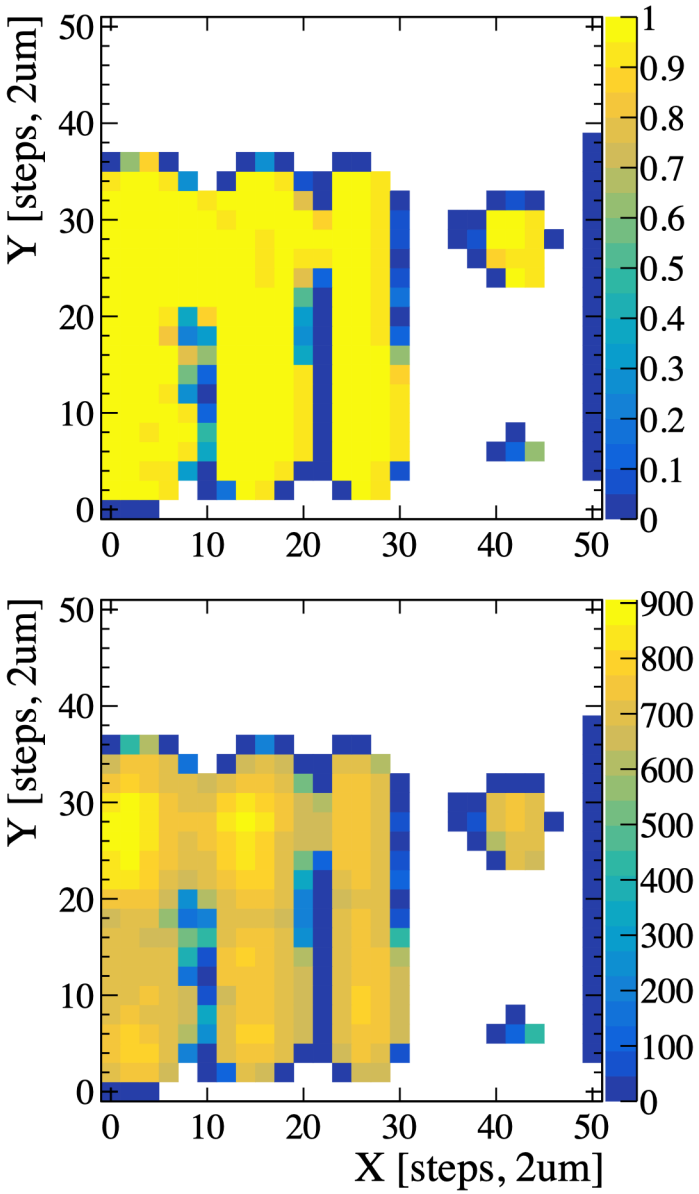
Coarse position scan results



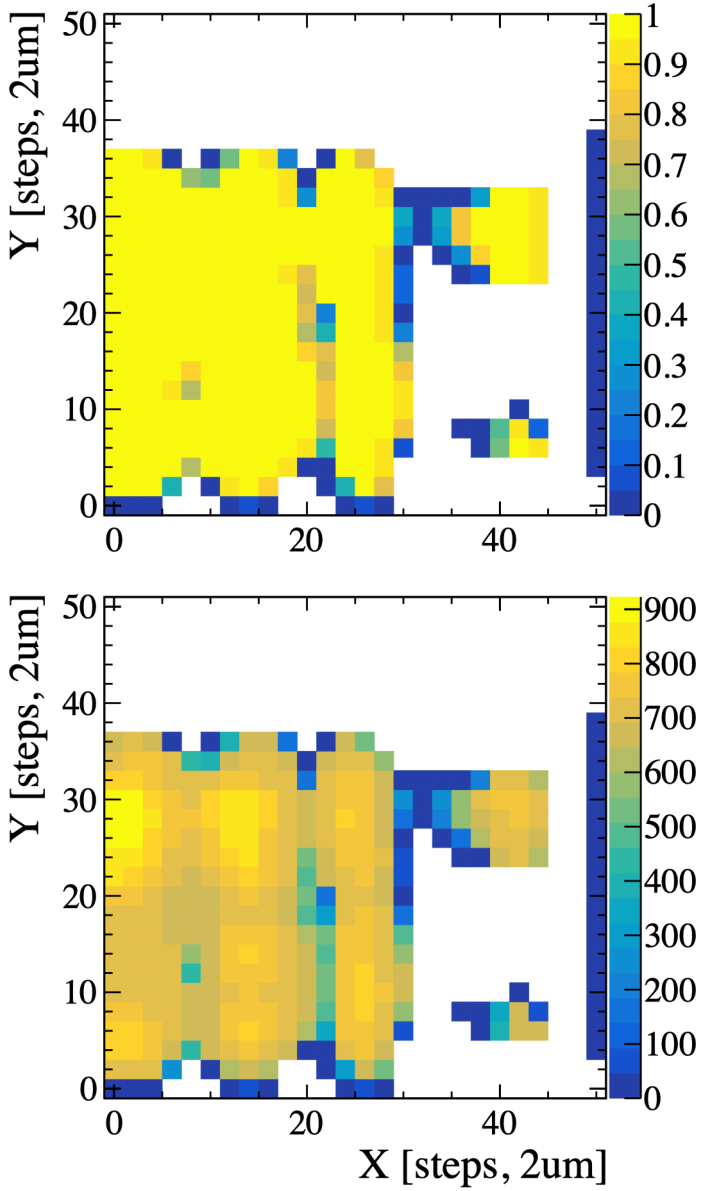
Initial coarse scans of a single pixel, where total hits indicates efficiency and average ToT indicates the charge collected.

Fine scan results

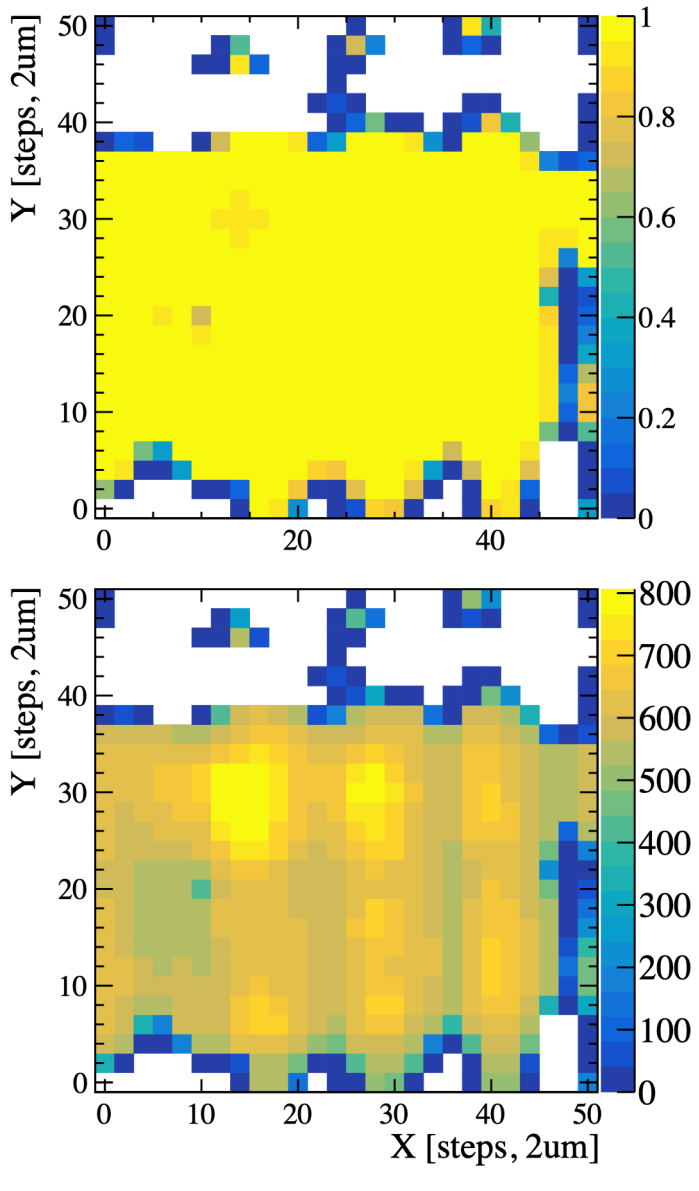
25V



50V

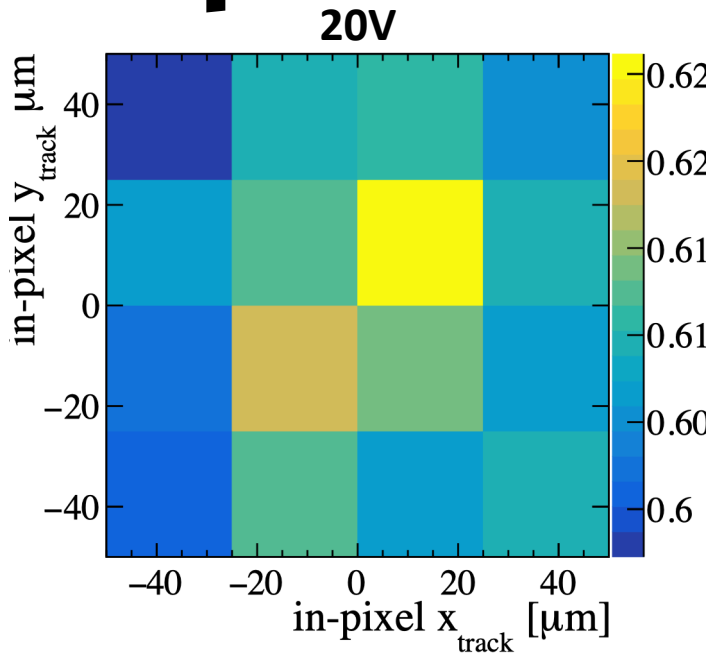


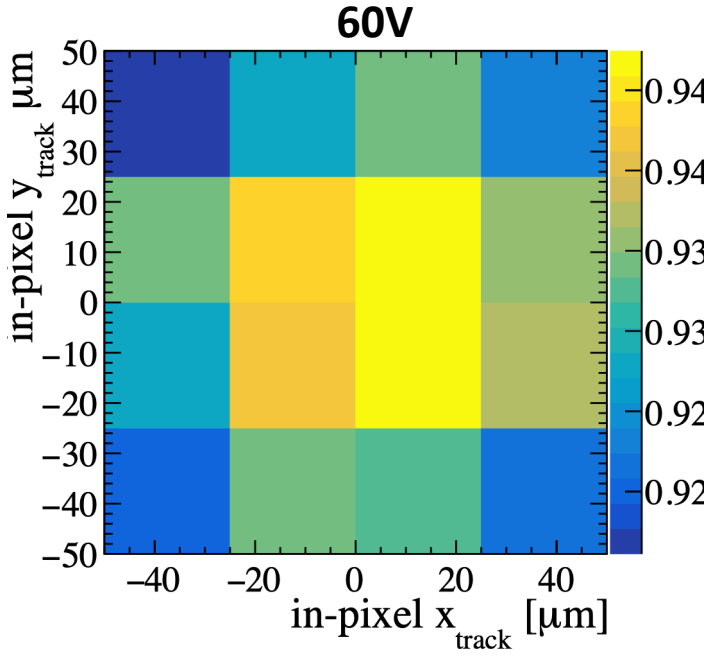
150V after intervention

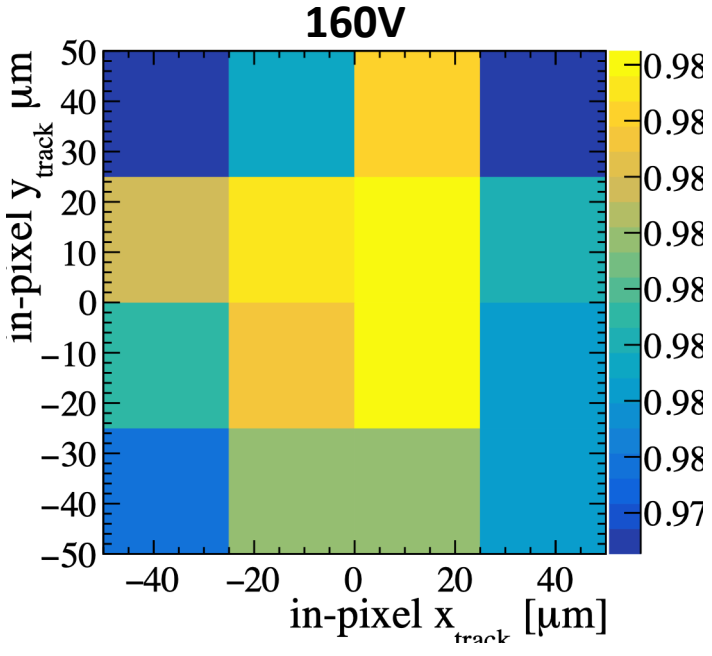


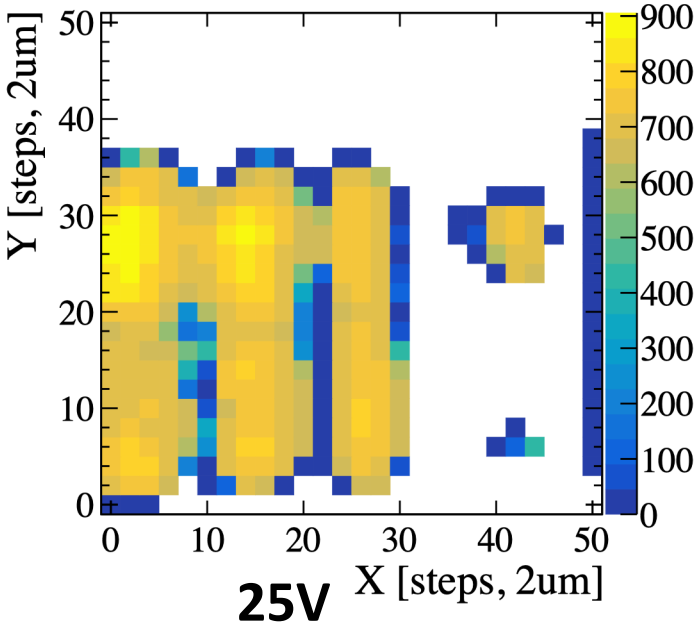
Comparison to test beam results

Beam test plots provided by Emma

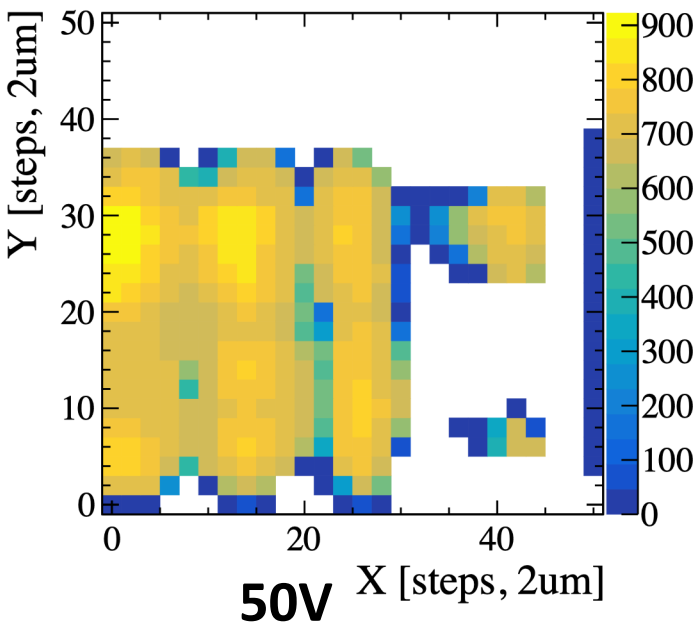




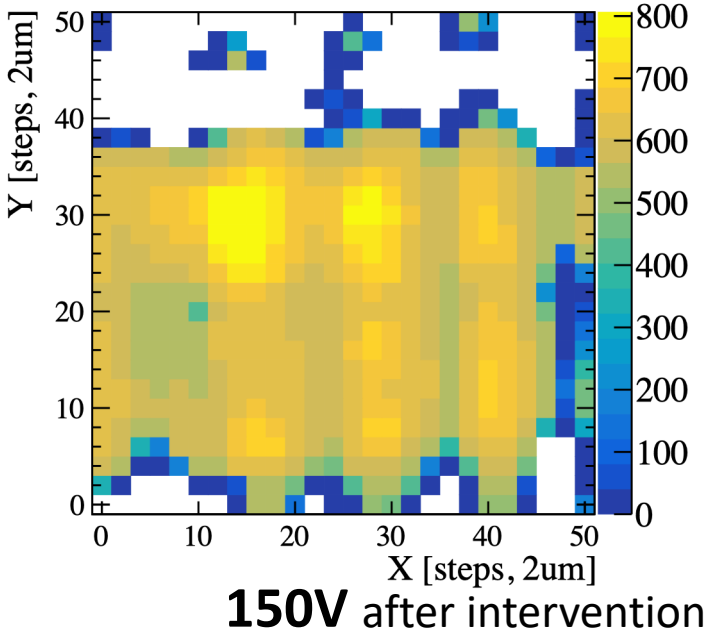




25V



50V

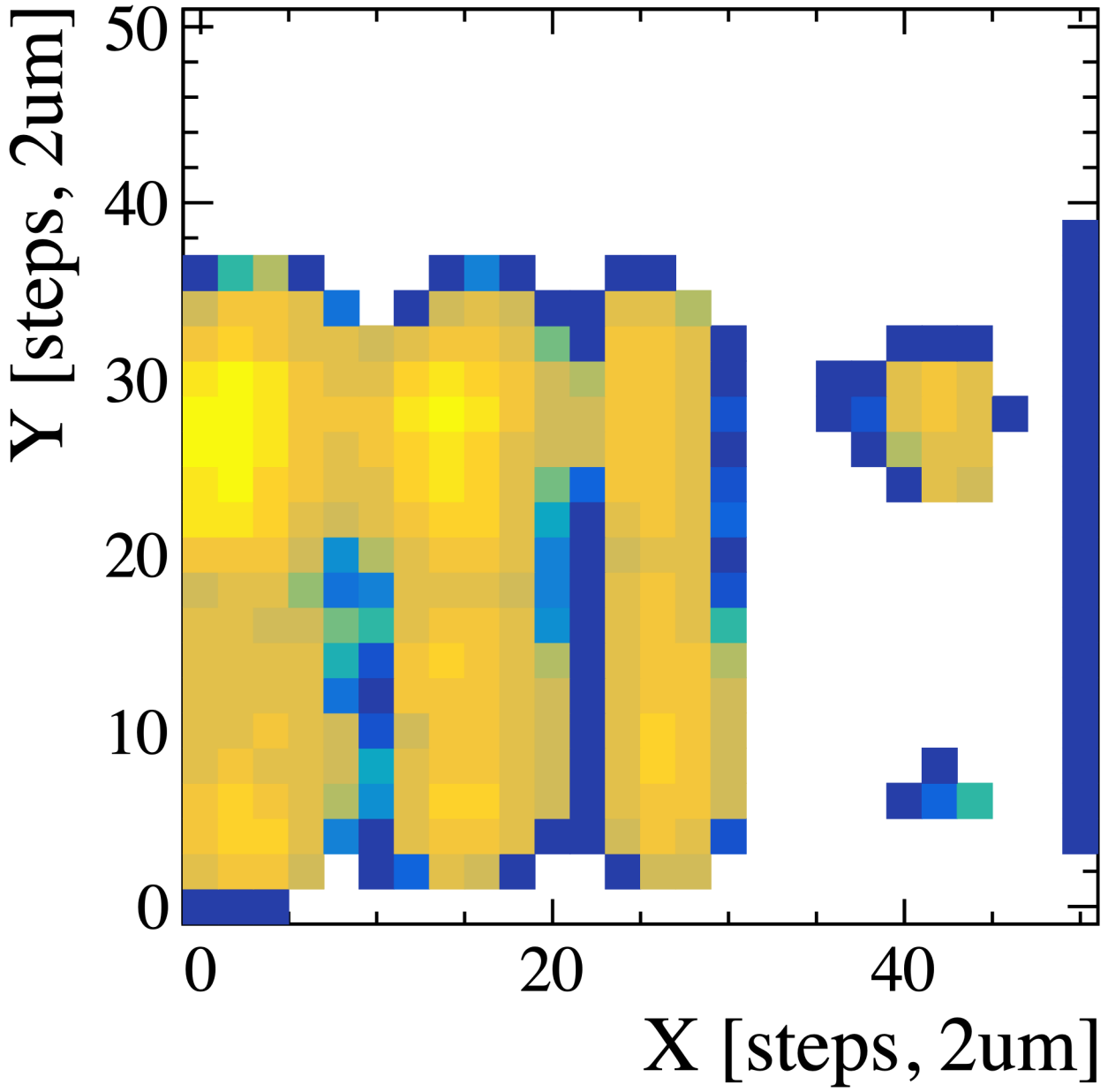


150V after intervention

Multi-pixel response

With a -25V bias, we can see the effects of cross-talk and charge-sharing between pixels by plotting multiple pixels on the same plot using different colour palettes.



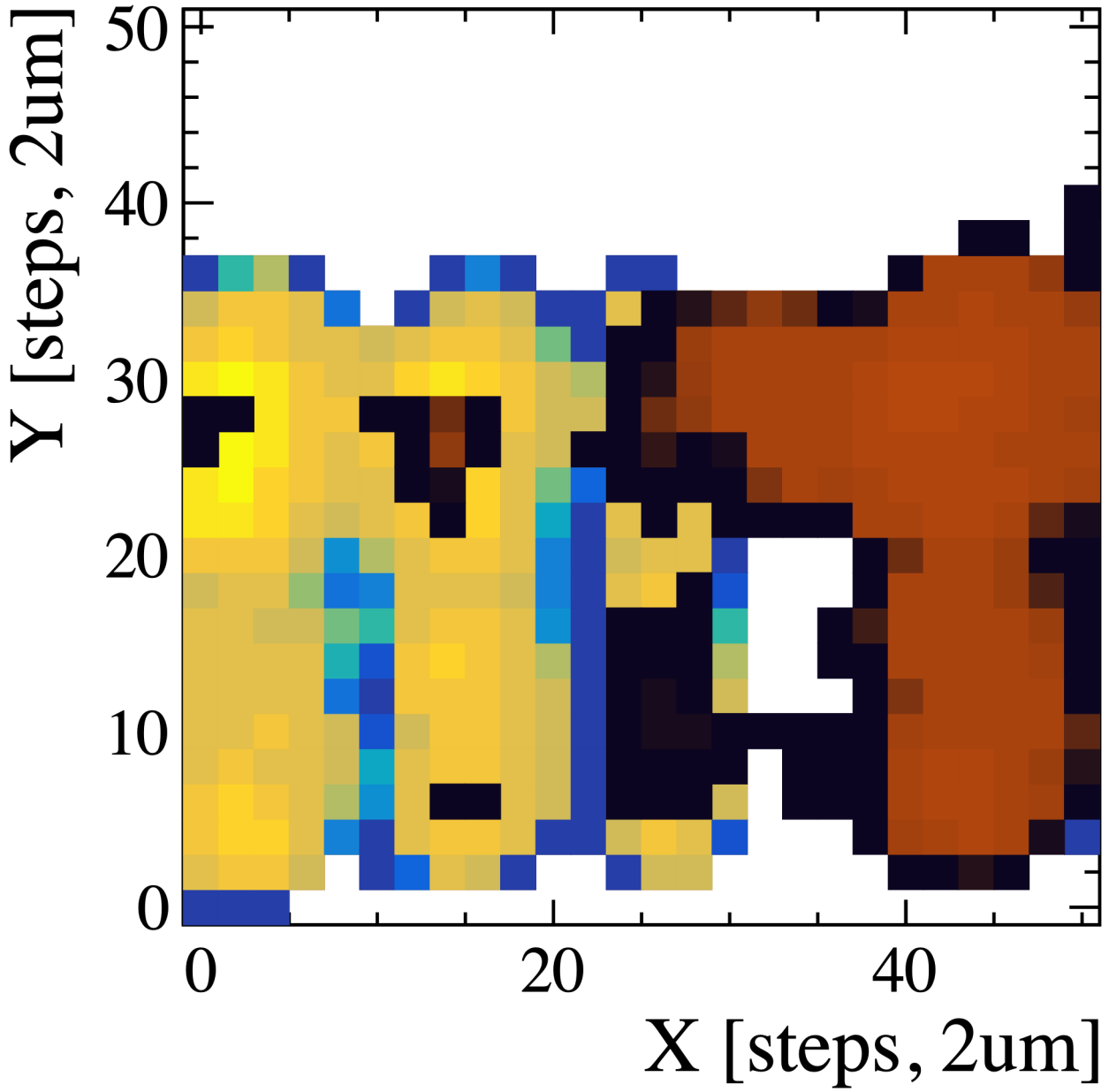


Multi-pixel response

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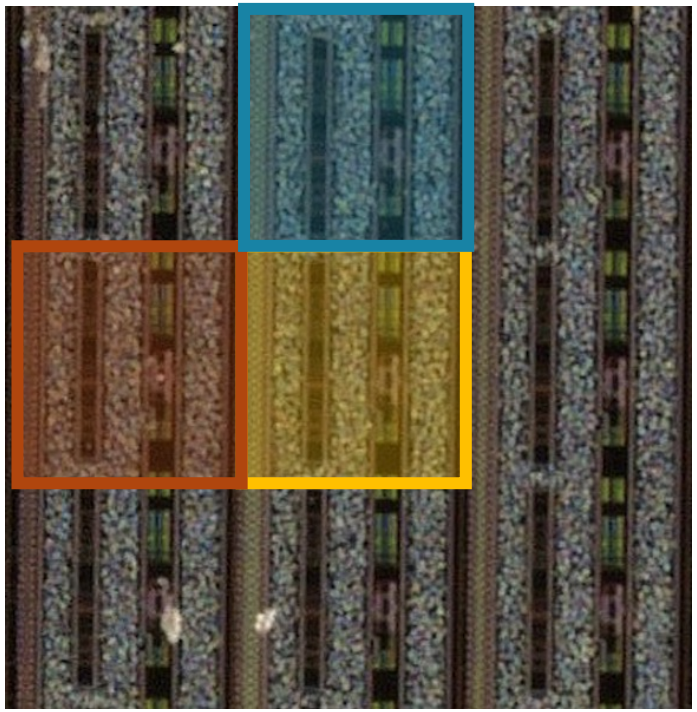


***x axis inverted in the plot**

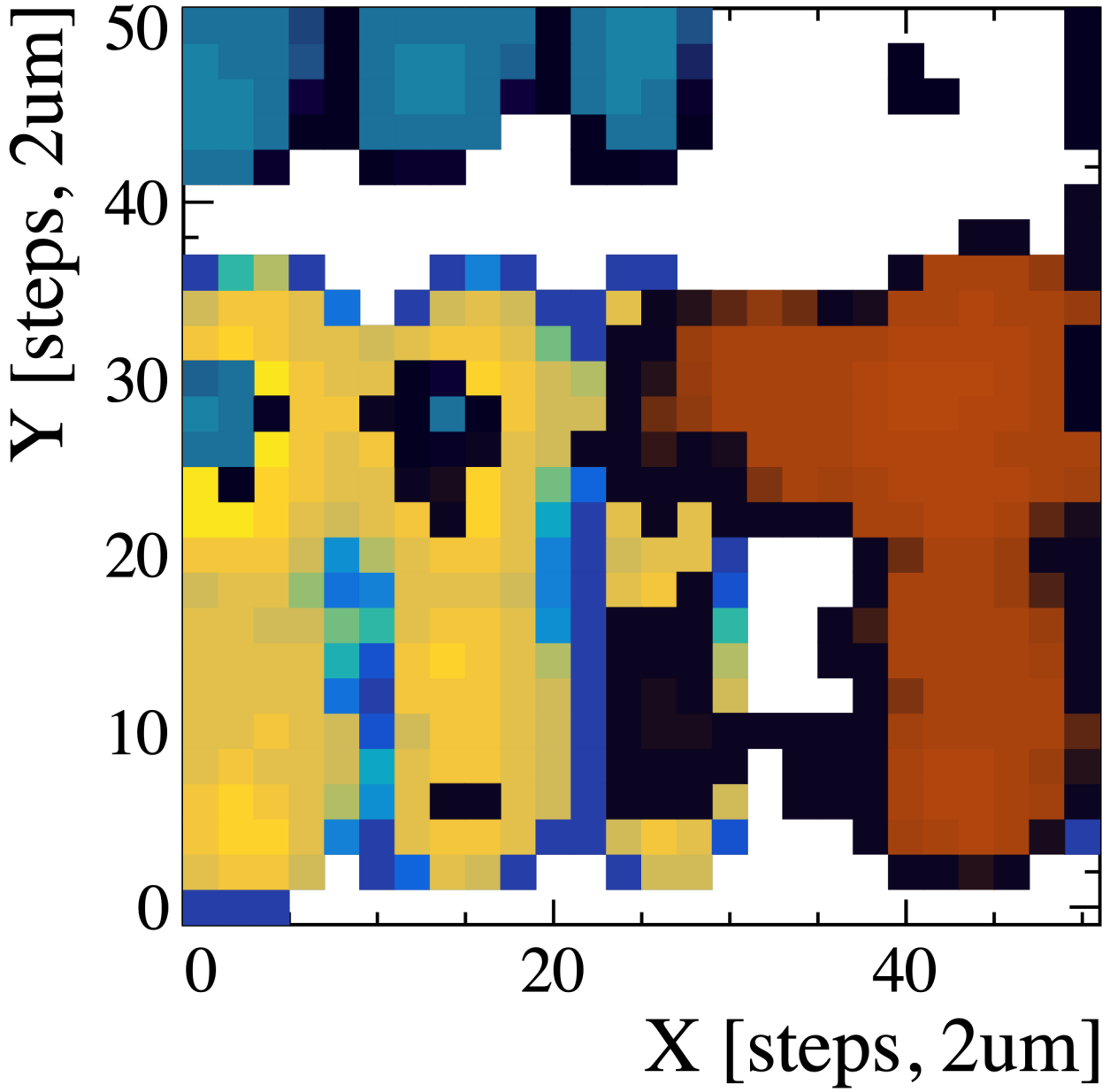


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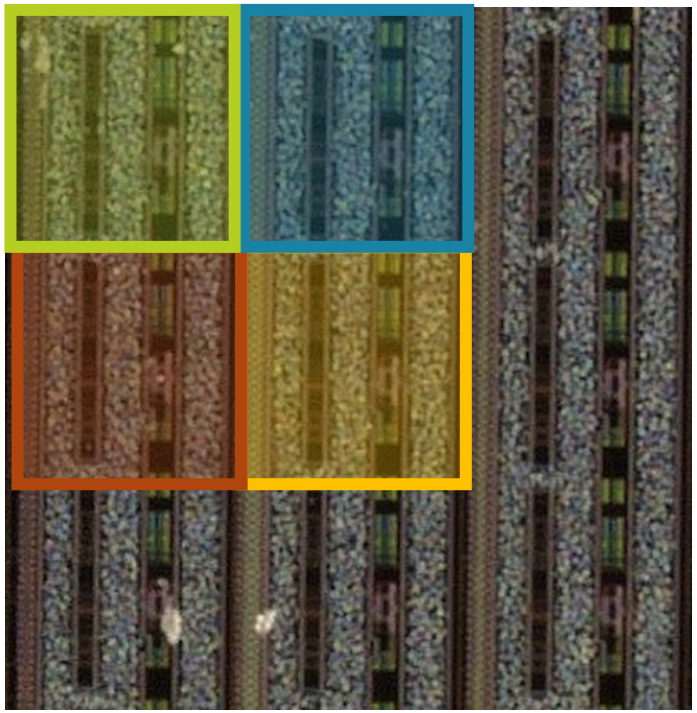


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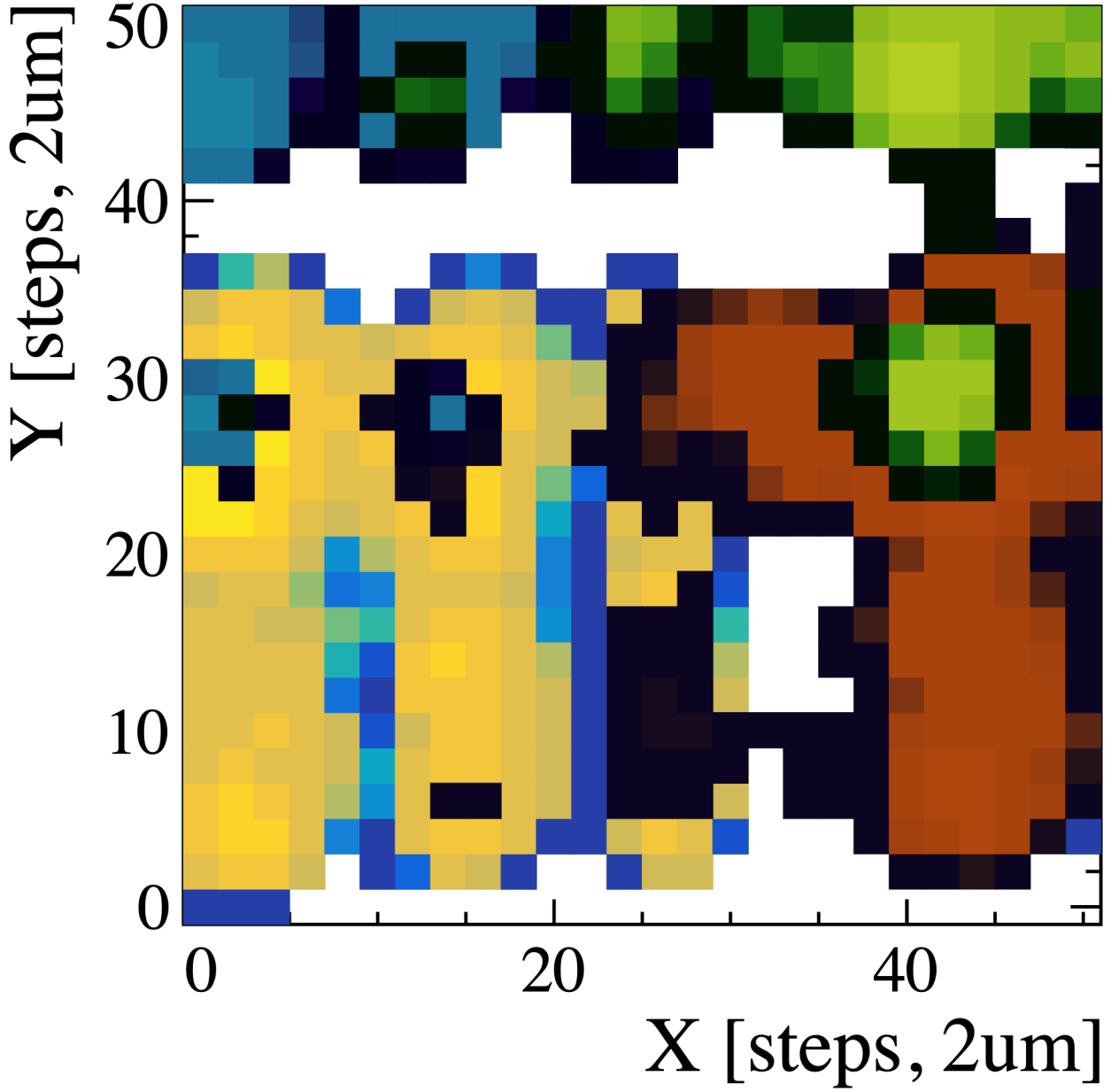


Multi-pixel response

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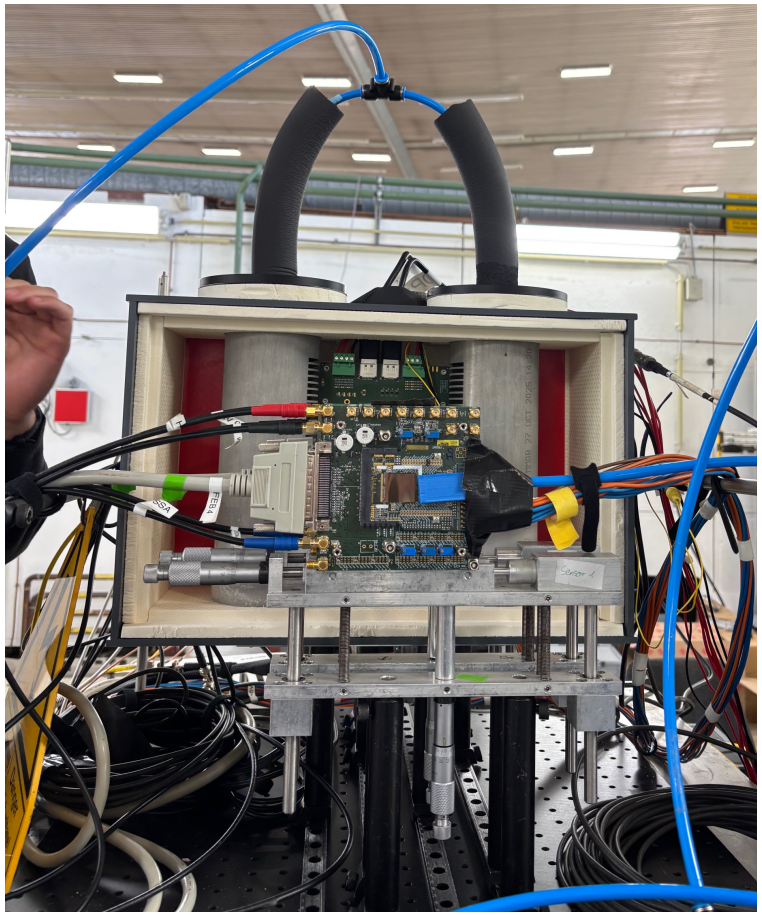


***x axis inverted in the plot**

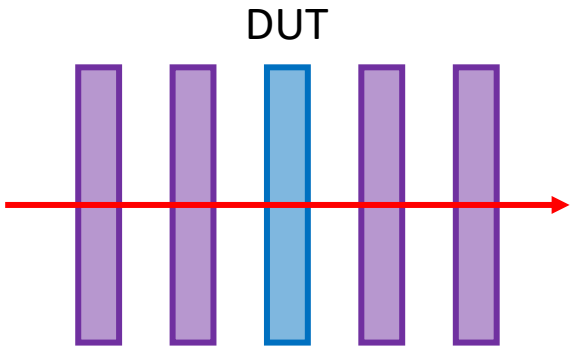


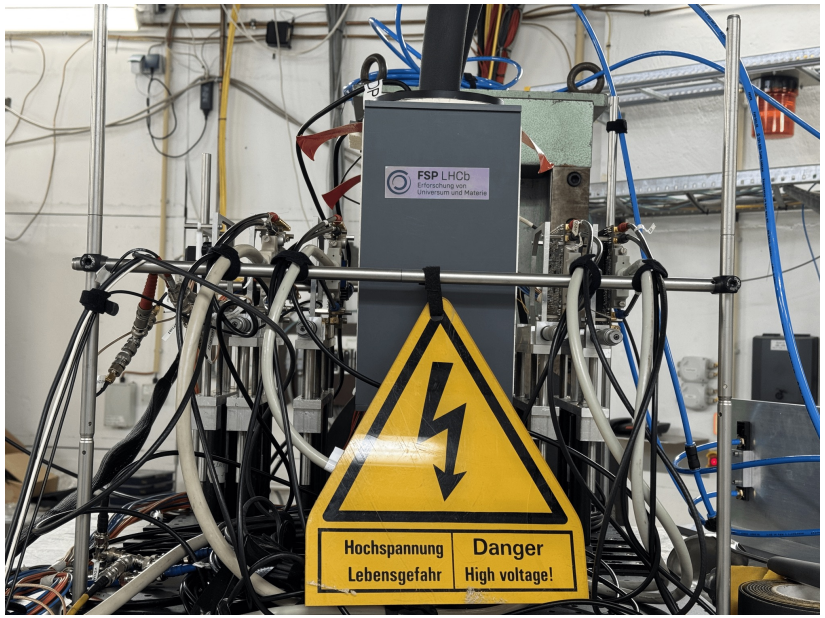
LF MightyPix test beam

Test beams have been carried out be the Heidelburg group, with participation from Edinburgh, to characterise the LF-MightyPix.

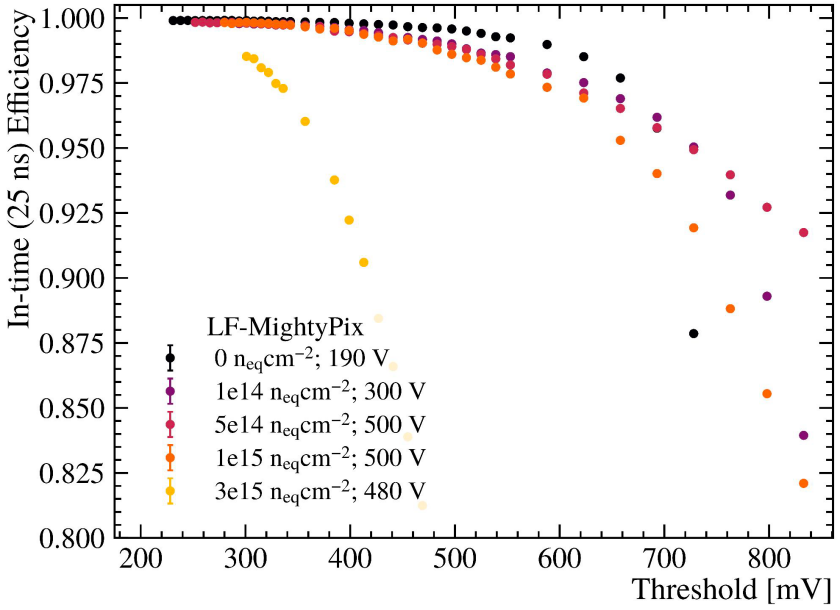


Characterisation studies were conducted for a non-irradiated LF-MightyPix and for 4 irradiated chips to evaluate their performance up to their end-of-life neutron fluence.





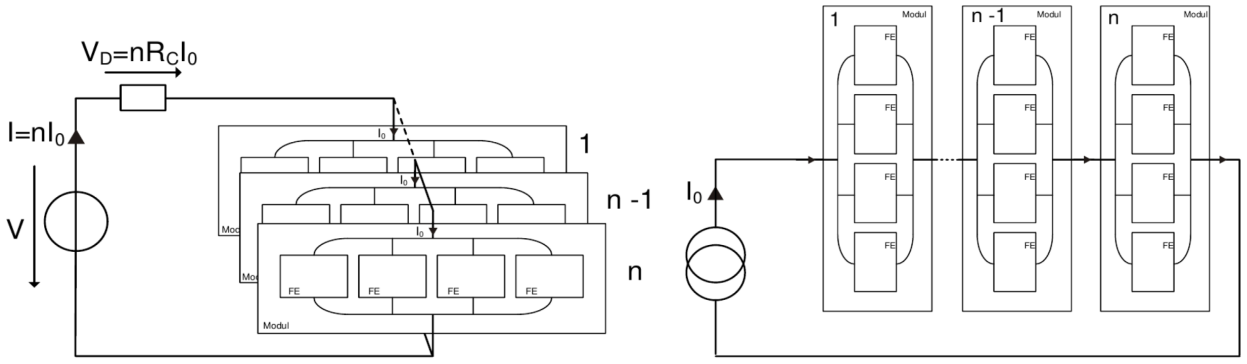
Results shown at PIXEL 2026

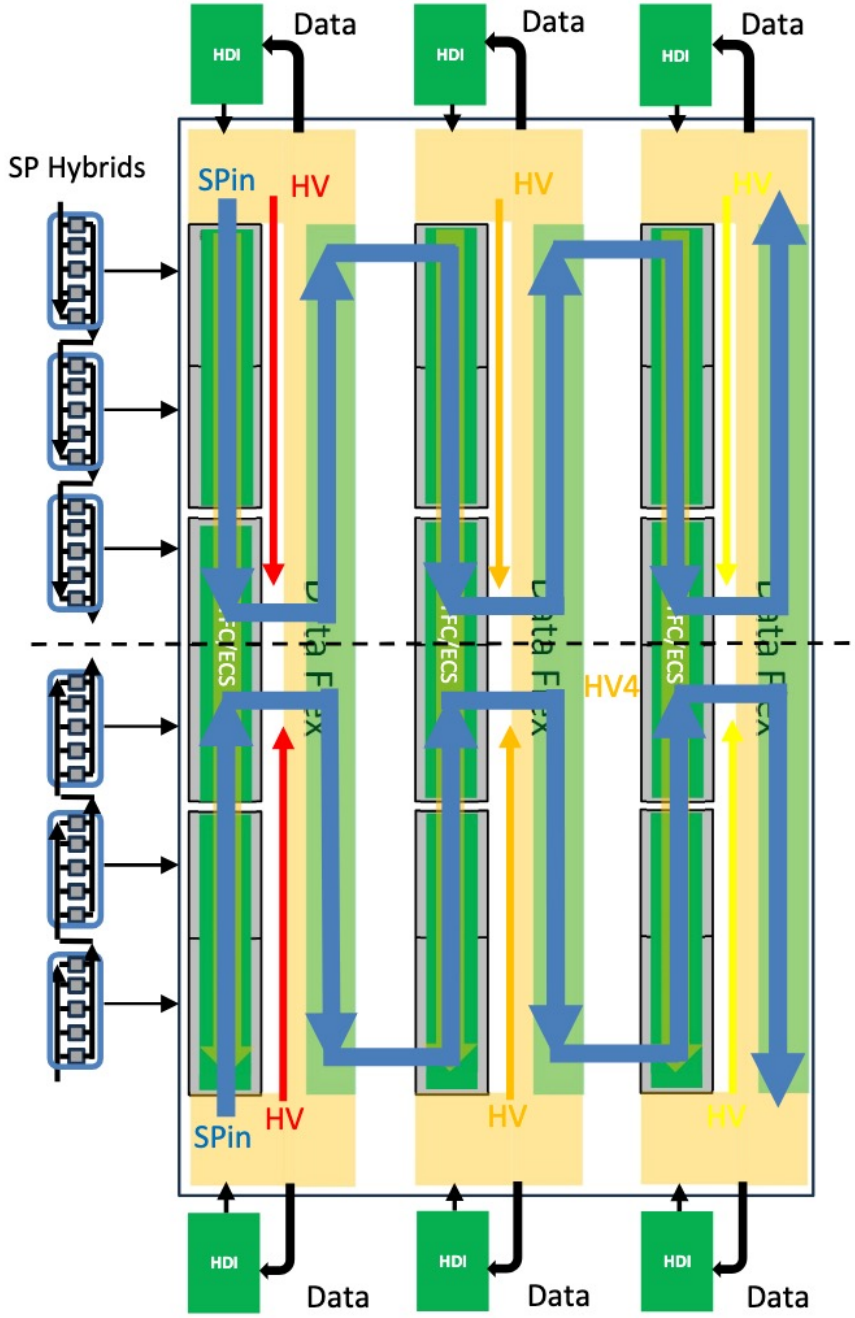


Serial powering

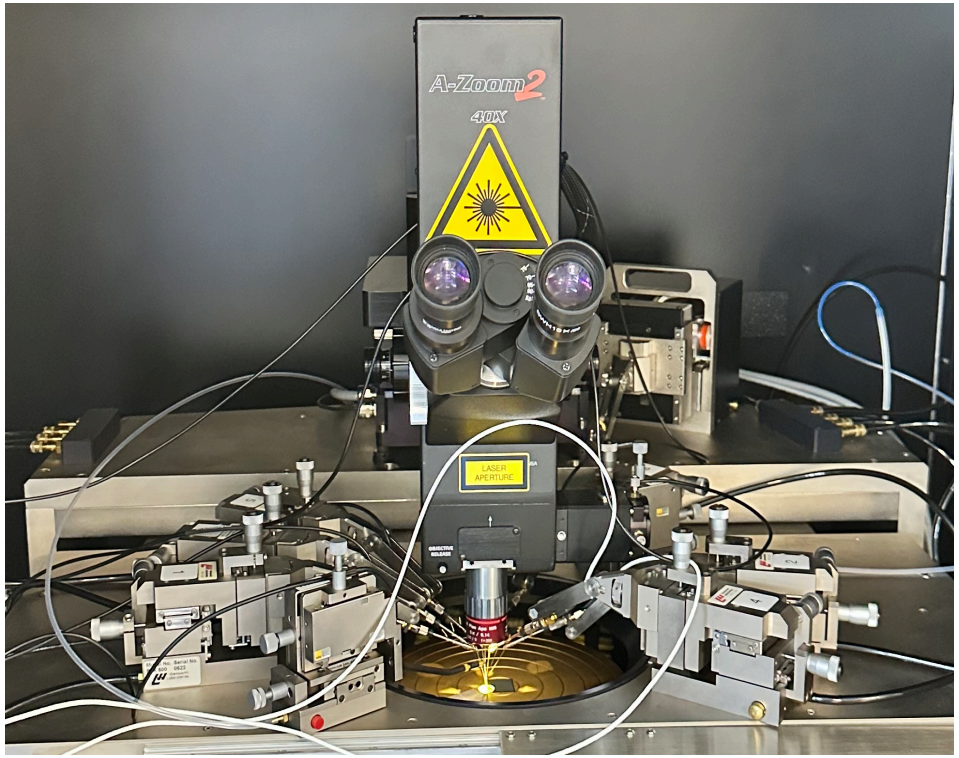
Serial powering will be implemented in the Mighty Tracker to reduce cabling, and hence the material budget that would otherwise be needed in a parallel powered configuration.

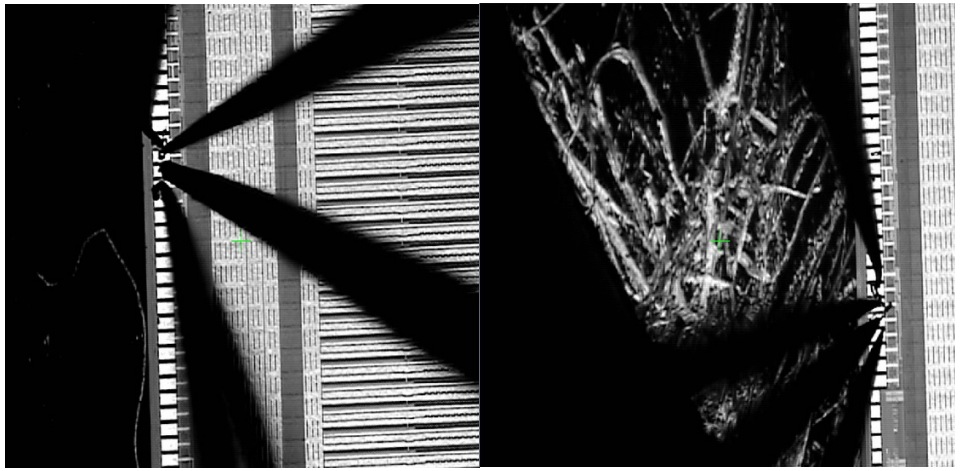
On chip shunt low-dropout (**SLDO**) regulators convert the single constant current source to the low voltages required for the analog and digital domains of the chip.



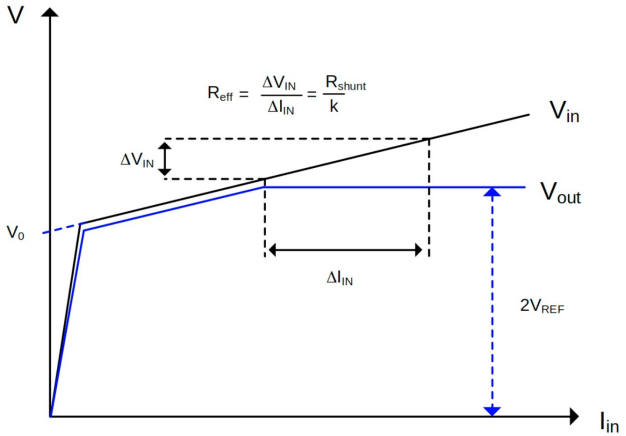


Wafer probing



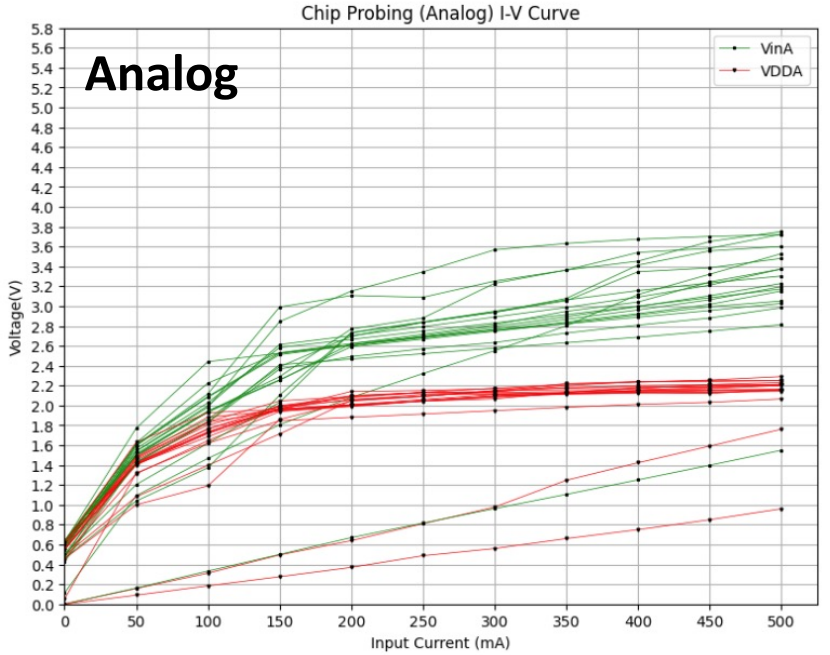


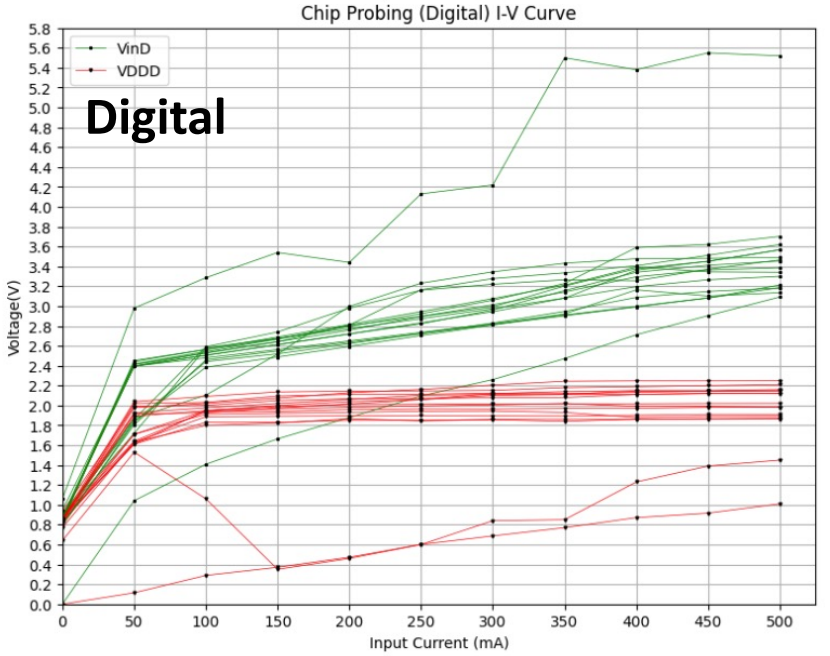
The wafer probing set-up in Edinburgh was used to measure IV curves for the two ATLASPix3.1 SLDOs, supplying the analog and digital domains.



The pass rate of the all chips (50um thinned) is:
15/18 = ~83% and 8/9 = ~89%
150um.

Due to chips breaking after handling, 21 validated chips are available for assembly.





Summary

Recap:

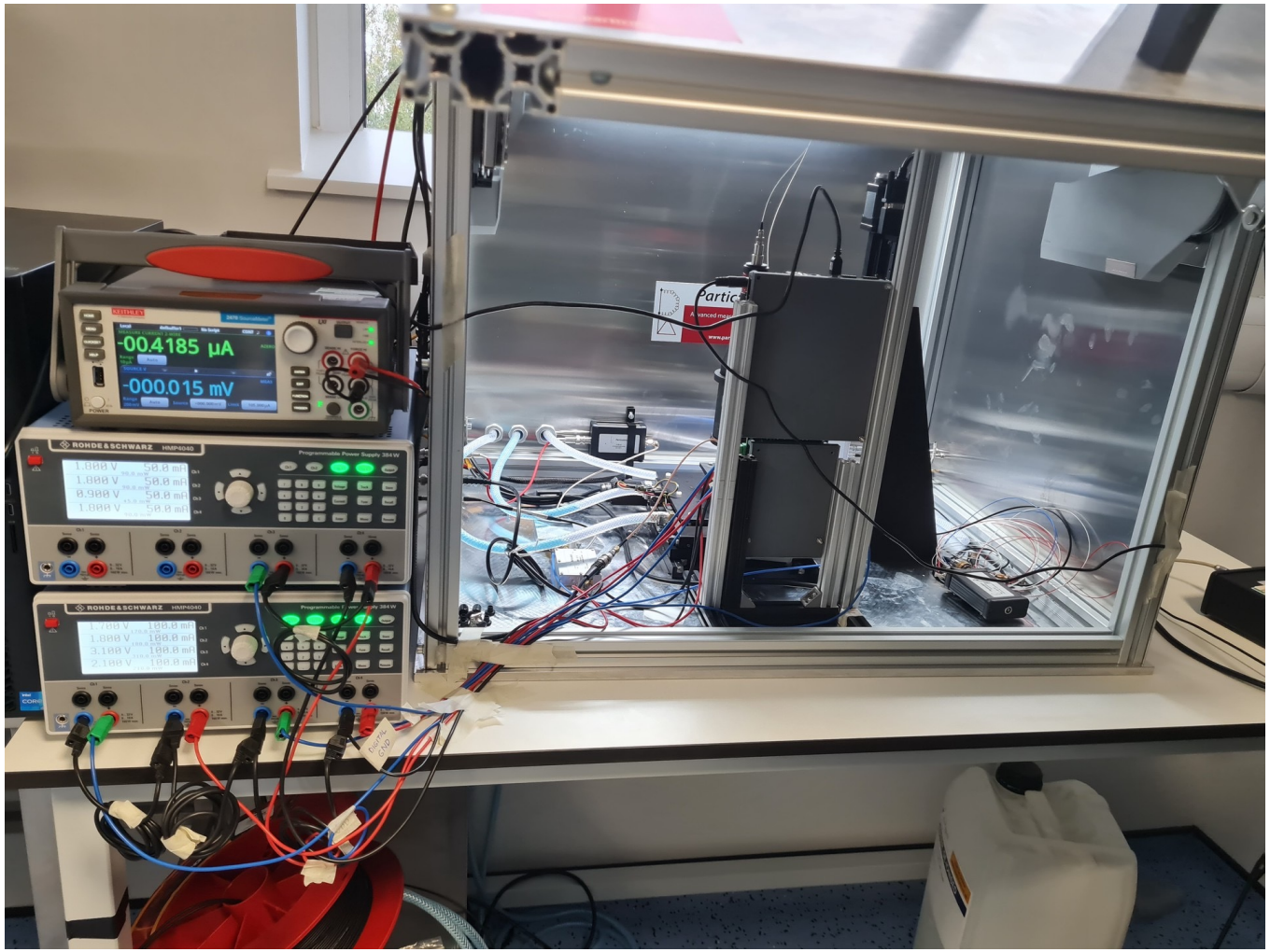
- Laser studies in lab
- Mightypix test beam
- Wafer probing

We want to do:

- Equalise the chip
- Do further laser studies (larger scans, more operating conditions)
- Continue developing the chip characeterisation procedures

Backup slide





Backup slide

