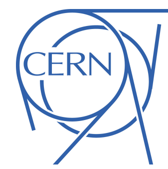
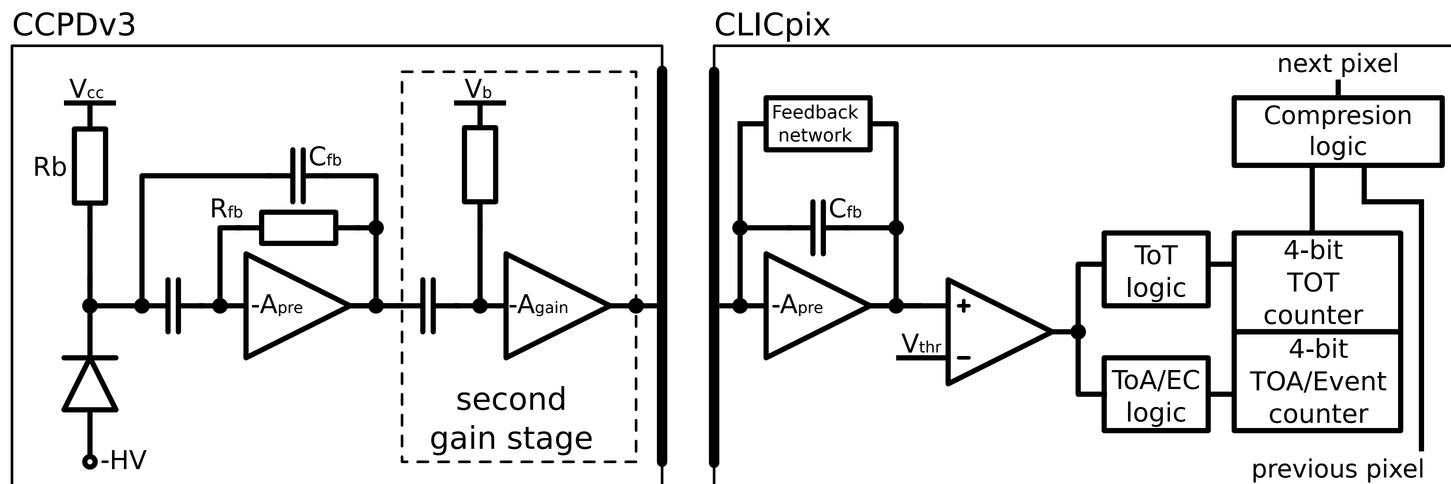


Preliminary results with capacitively coupled pixel detectors for CLIC - the sequel

Daniel Hynds
(on behalf of many people)

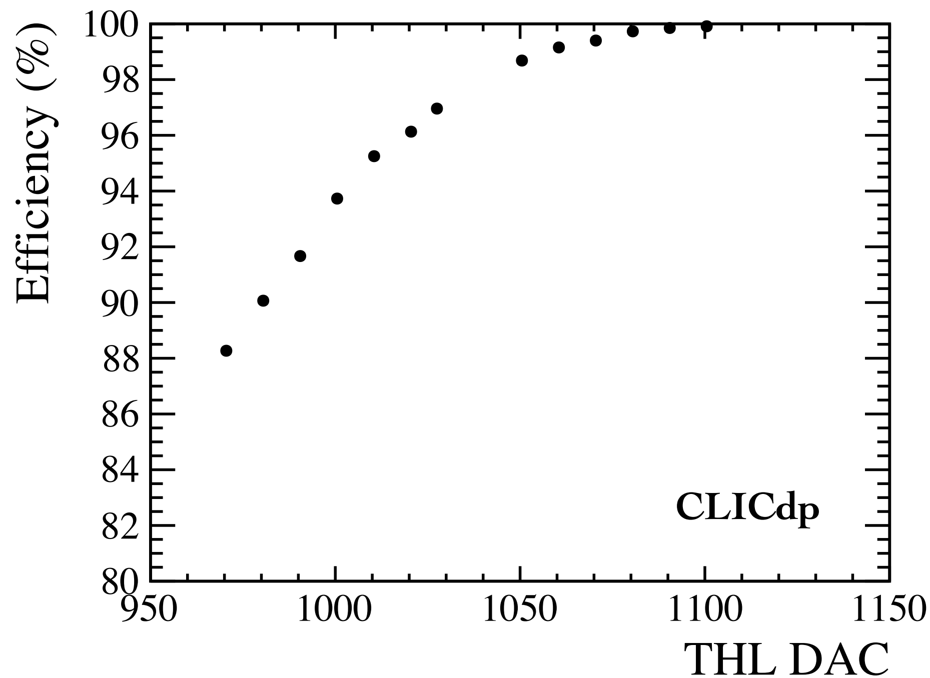
Quick reminder

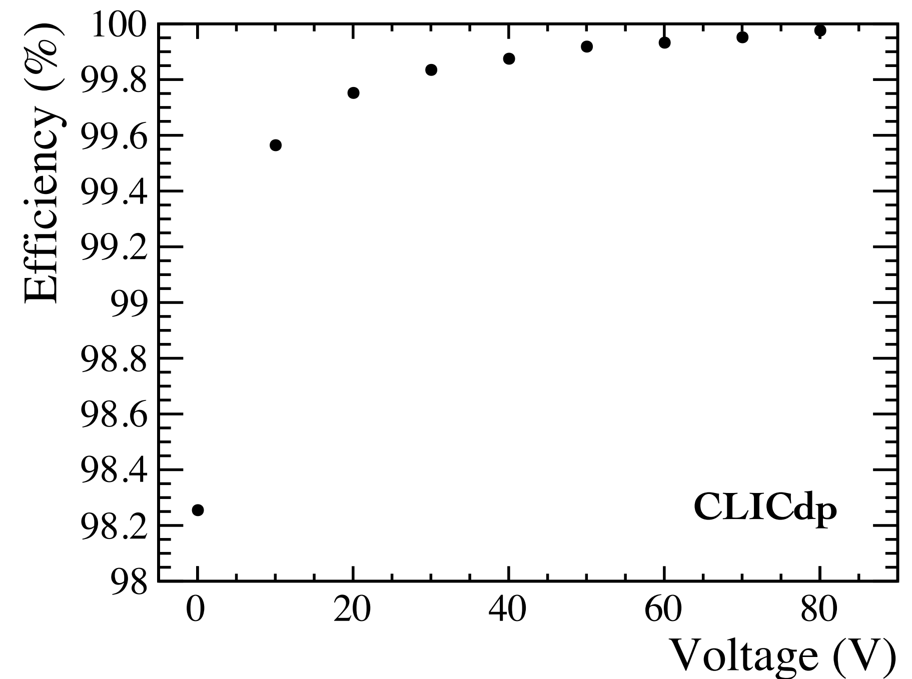
- Last collaboration meeting in Jan. presented results of then-recent november beam period
  - First CLIC measurements with capacitively coupled pixel detectors
  - Custom "active sensor" fabricated in 180 nm AMS High-Voltage CMOS technology
  - 2-stage amplification on the HV-CMOS
  - Precision glued to CLICpix readout chip, signal propagation by capacitive coupling



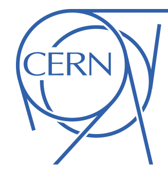
Proof of concept

- Results presented showed high efficiency with modest bias voltage
  - Full efficiency with ~1200 electron threshold and 50+ V
  - Promising devices for further investigation
  - Collaboration comments receieved on paper - to be updated before publication
  - Current draft at https://cds.cern.ch/record/2010263 - results presented at Trento 2015



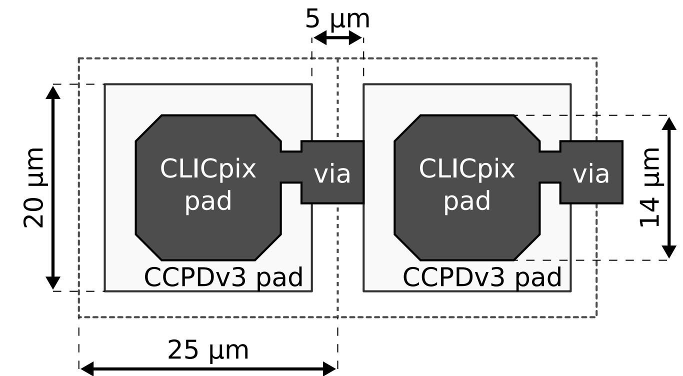


Recent progress

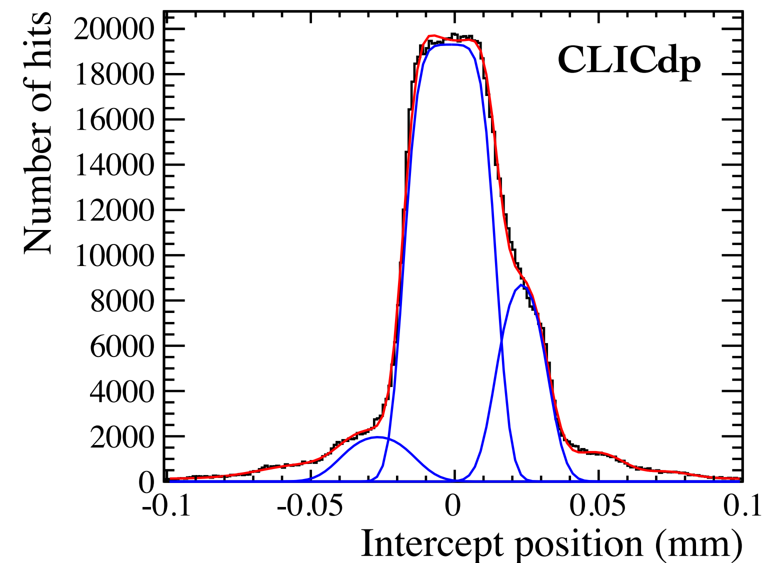


Fabrication

- Before the production of different ASICs (see following talks) can still probe the requirements on device fabrication
  - Previously observed asymmetry in pixel response - assumed to be coupling to CLICpix ***via***
  - Sensitivity of parameters such as glue thickness and pad alignment not known



Assembly embeded in epoxy

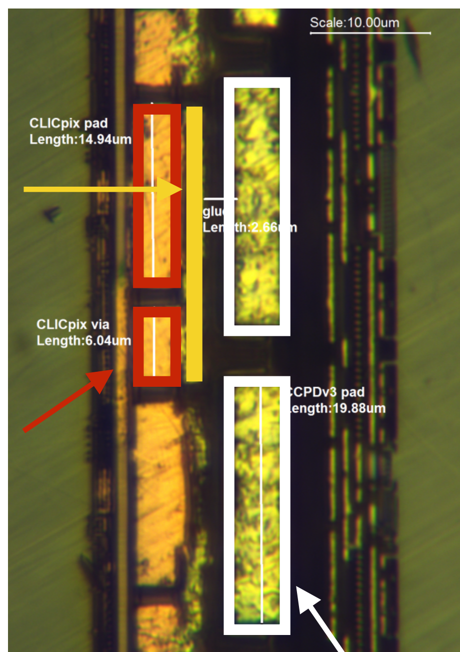


Pad alignment and glue thickness

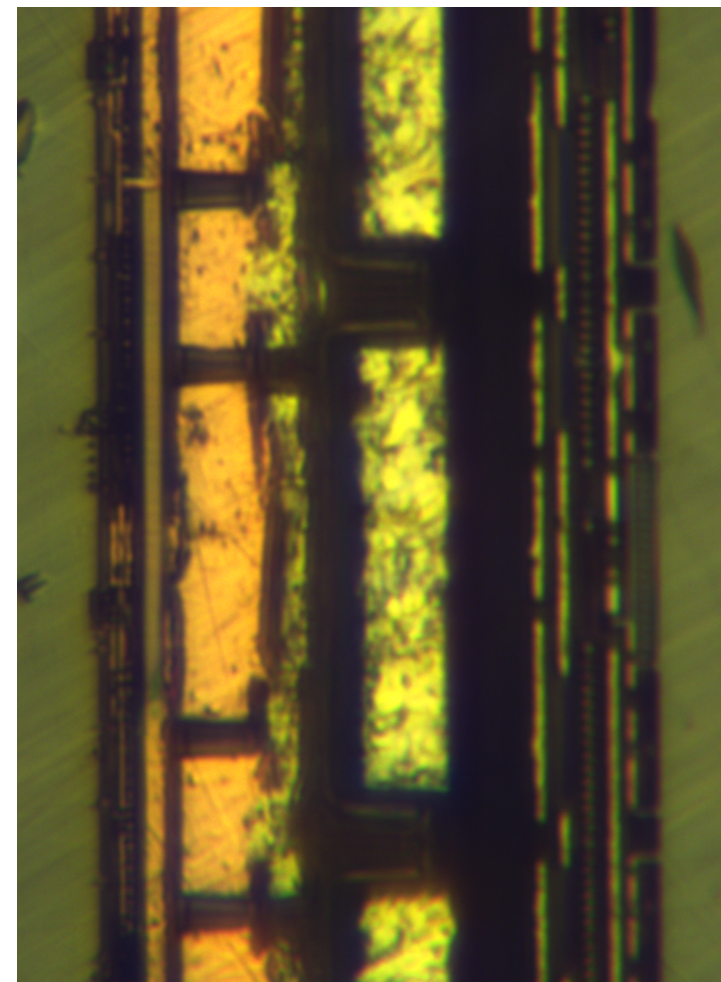
- Several samples produced at SET with the same pad alignment and with varying force to produce different glue thicknesses. Overall results:
  - Precision of ~ 1-1.5 μm obtained
  - Glue thickness for all samples was ~ 2 μm regardless of force applied

CLICpix pad + via

CLICpix shielding



HV-CMOS pad



PH-DT Composite Lab

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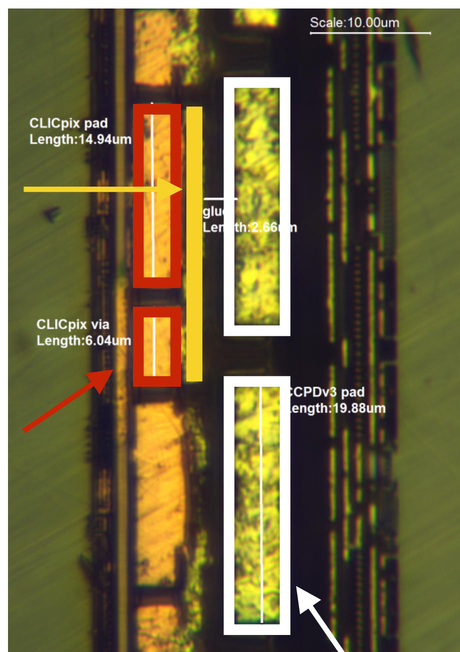
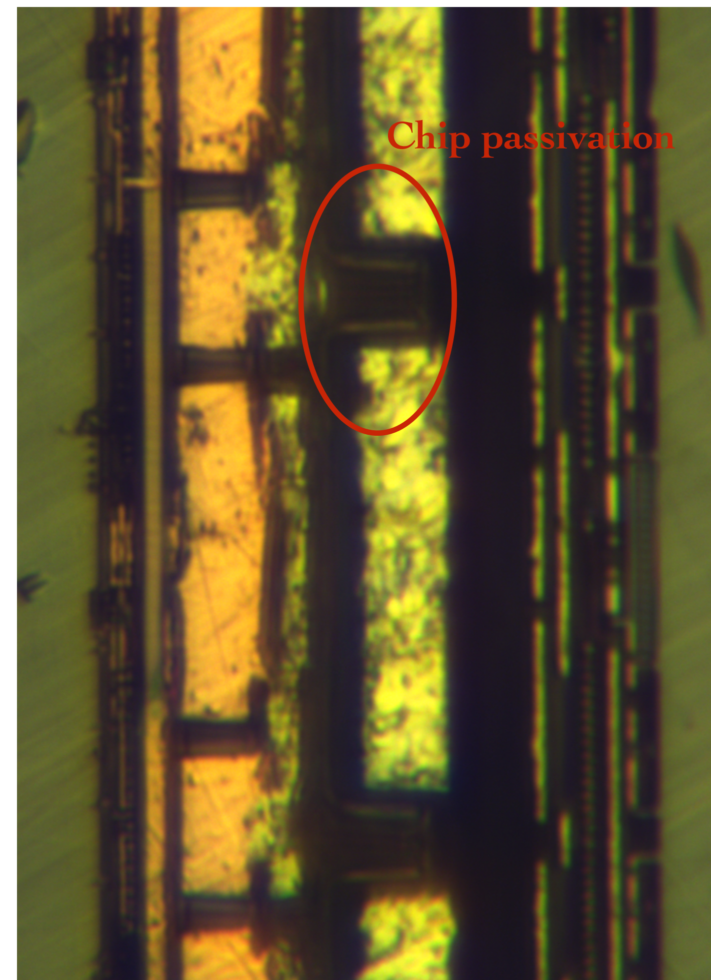


HV-CMOS pad

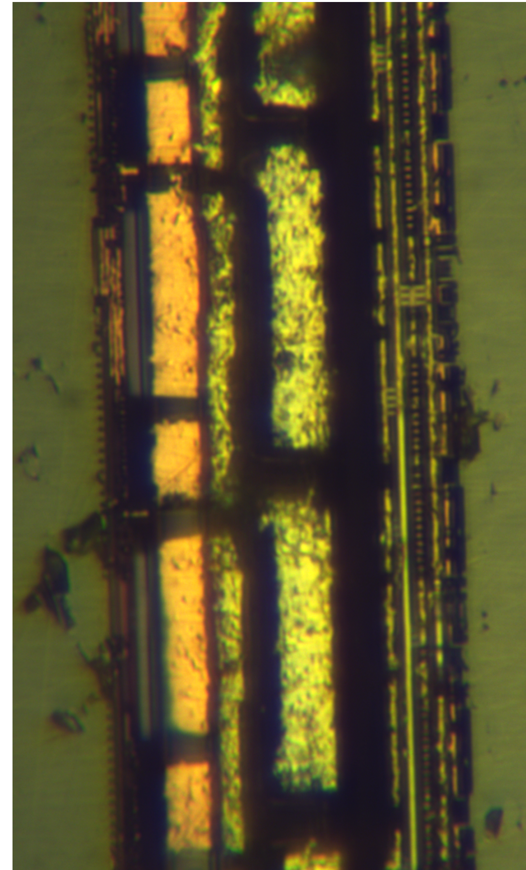


PH-DT Composite Lab

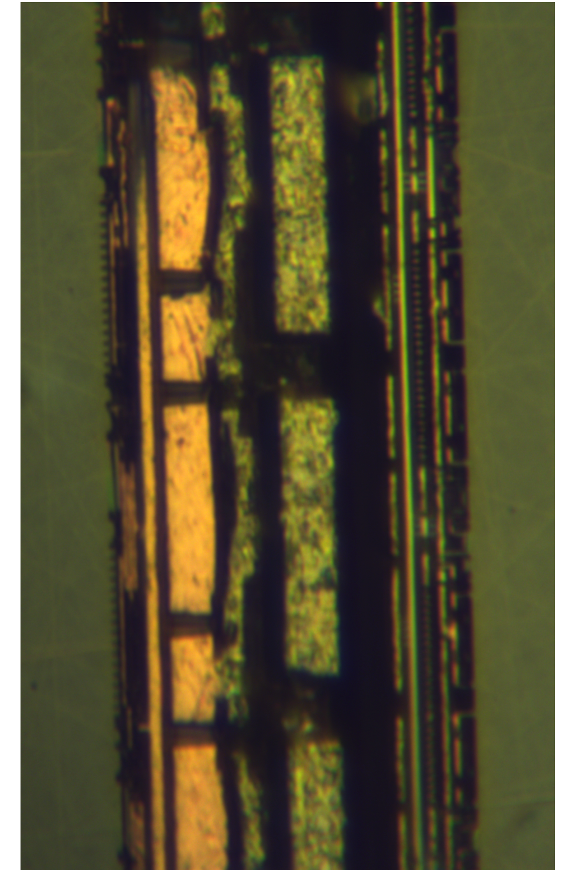
Pad deformation

- For samples glued with high force (~ 2 kg over 1.6×1.6 mm^2) a noticeable deformation of the CLICpix pads appears to take place

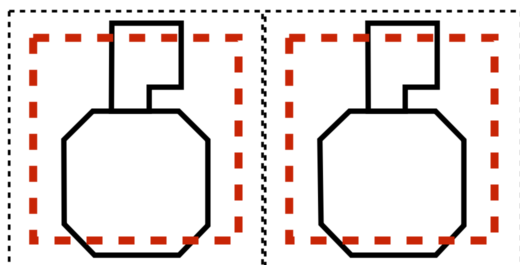
Bond force 500 g

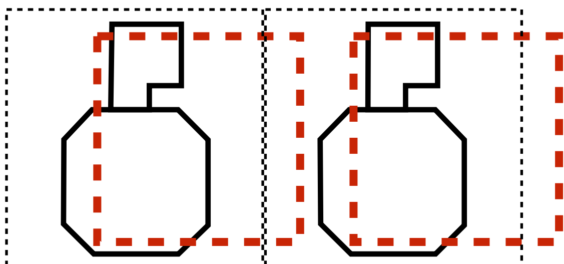


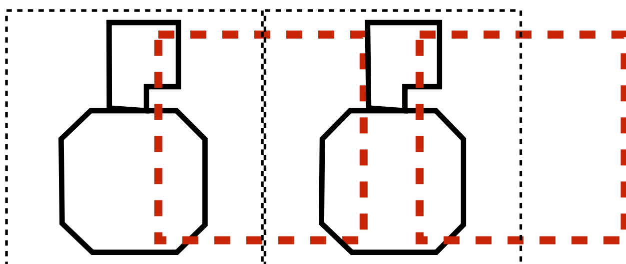
Bond force 2 kg



Samples for beam tests







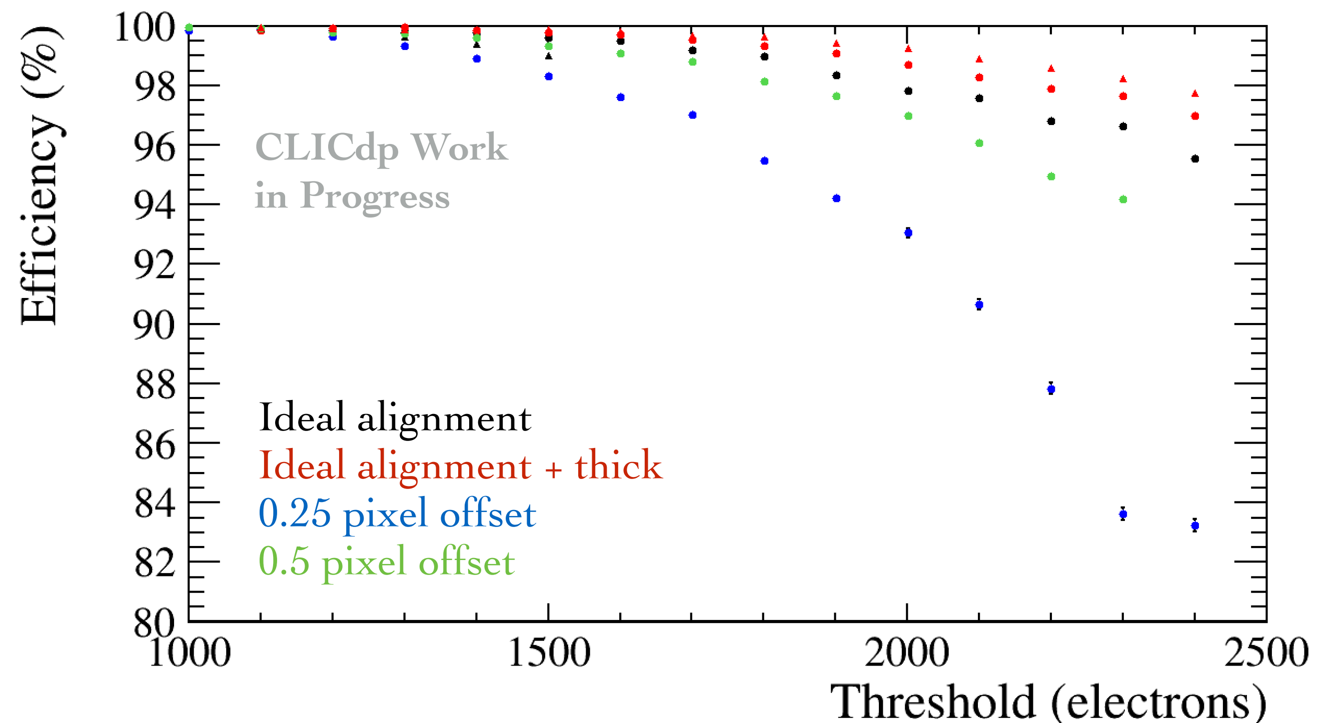
CLICpix pad + via **HV-CMOS pad**

- After cross-section measured for mechanical samples, several samples produced for measurement in beam tests
  - Asymmetry along the columns addressed by adjusting pad alignment to include the CLICpix ***via***
  - Deliberate offsets in the lateral alignment added to determine the impact on device performance
  - Shifts of 0.25 pixels (6.25 µm) and 0.5 pixels (12.5 µm)
  - Samples with "thicker" glue (lower bonding pressure - 50 g) nb. unsure if these are really thicker!

Initial results

- Promising start => all samples show high efficiency at ~1200 electron threshold (60 V bias)

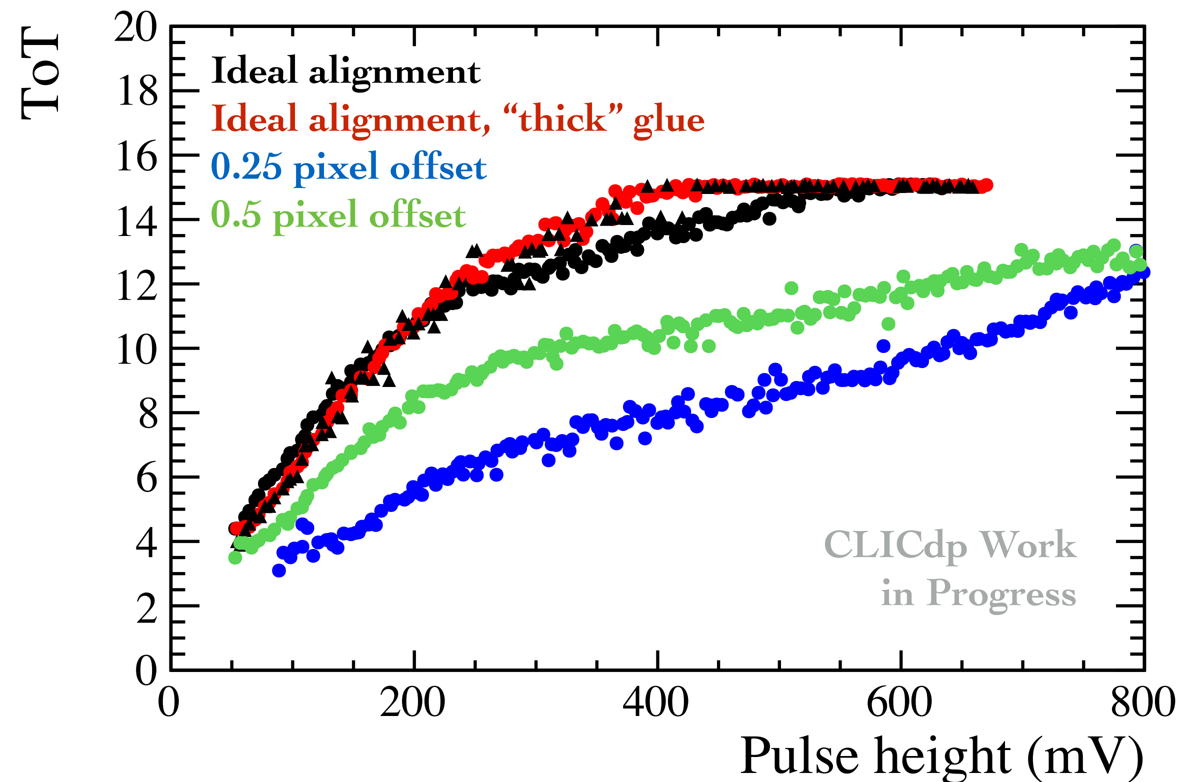
- Many puzzling questions - analysis only just starting in detail
  - Higher efficiency observed for 0.5 pixel offset than for 0.25?
  - Better performance for samples with “thick” layer of glue
  - Variation between devices for nominally identical fabrication



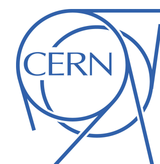
Sample calibration

- Long chain of steps involved in final gain from deposited charge to measured ToT
  - Gain of HV-CMOS amplifier
  - Coupling capacitance
  - Injected current pulse shape
  - CLICpix gain

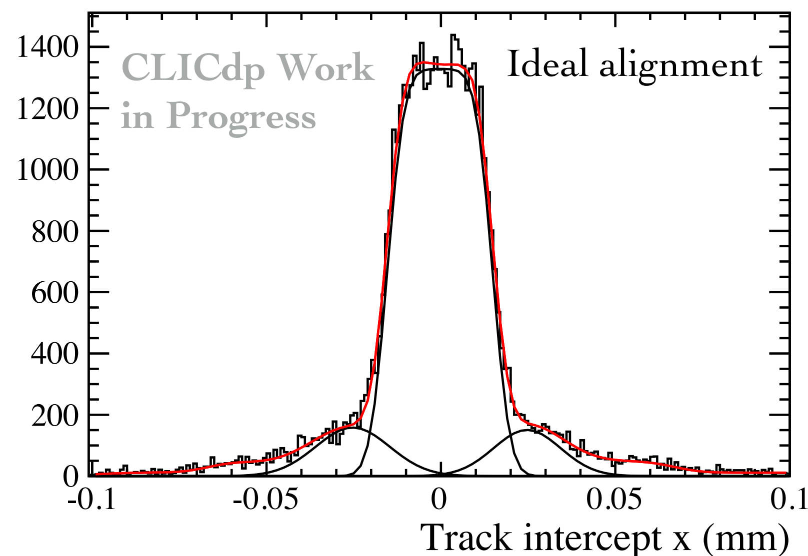
- Initial rough calibrations from HV-CMOS pulse to CLICpix ToT confirm the testbeam results
  - Work on HV-CMOS calibration ongoing

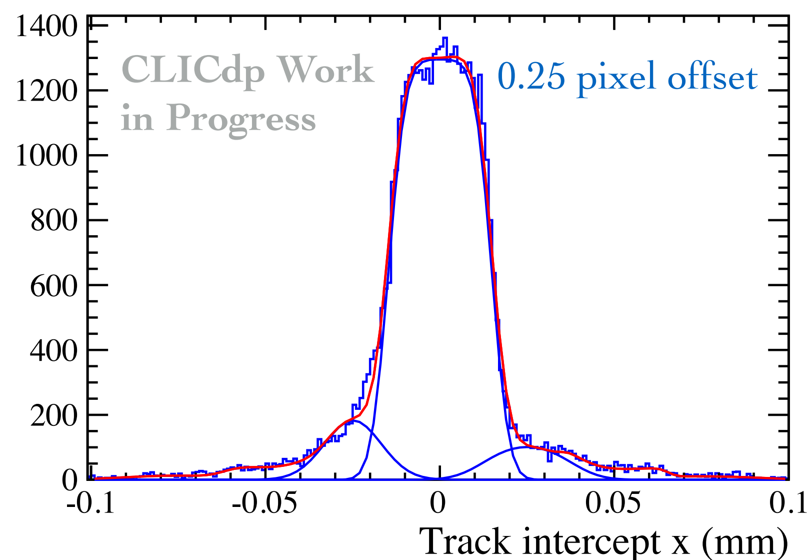


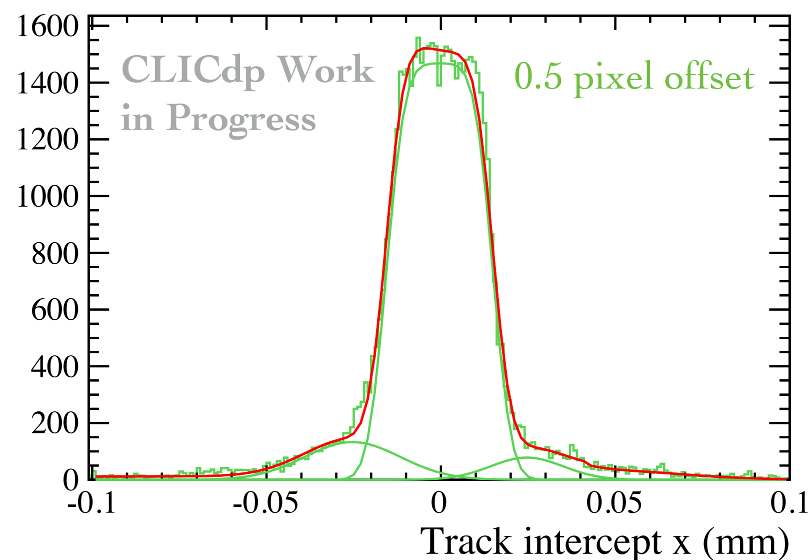
Cross coupling



- Alignment of the CLICpix ***via*** along the column removed the asymmetric contribution
- Deliberate offsets between columns starts to give asymmetric contributions and lower overall coupling

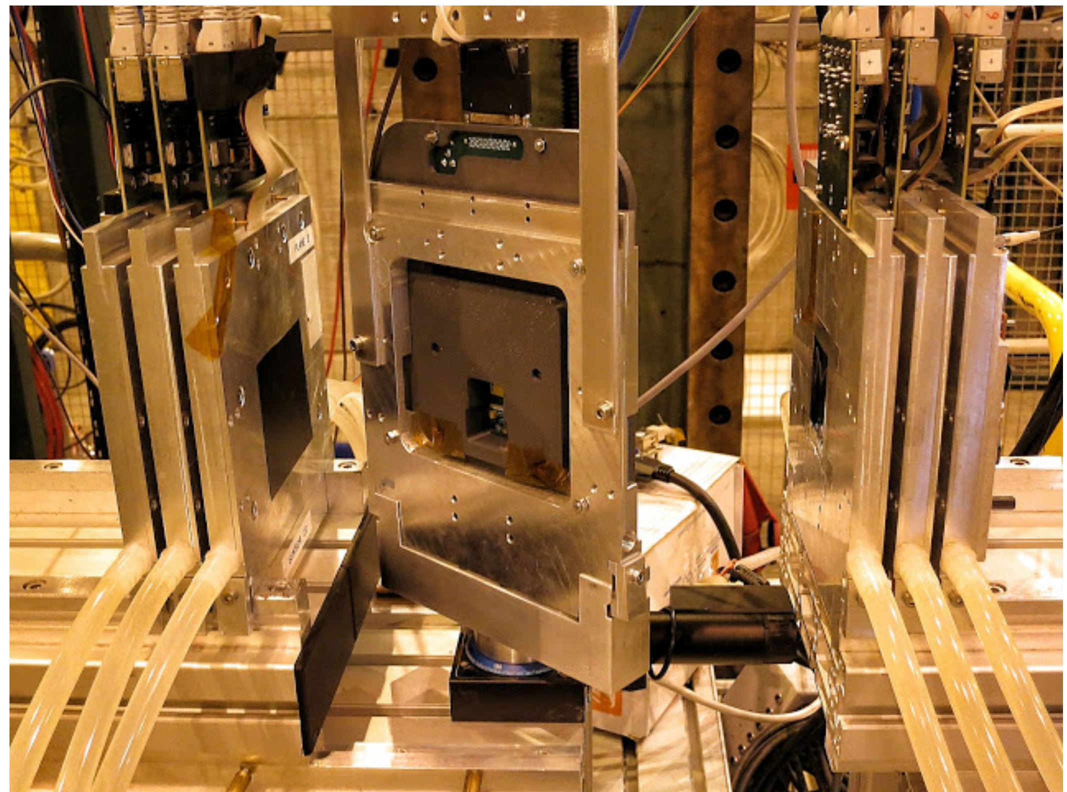




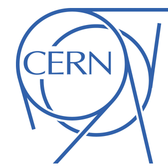


Angled track data

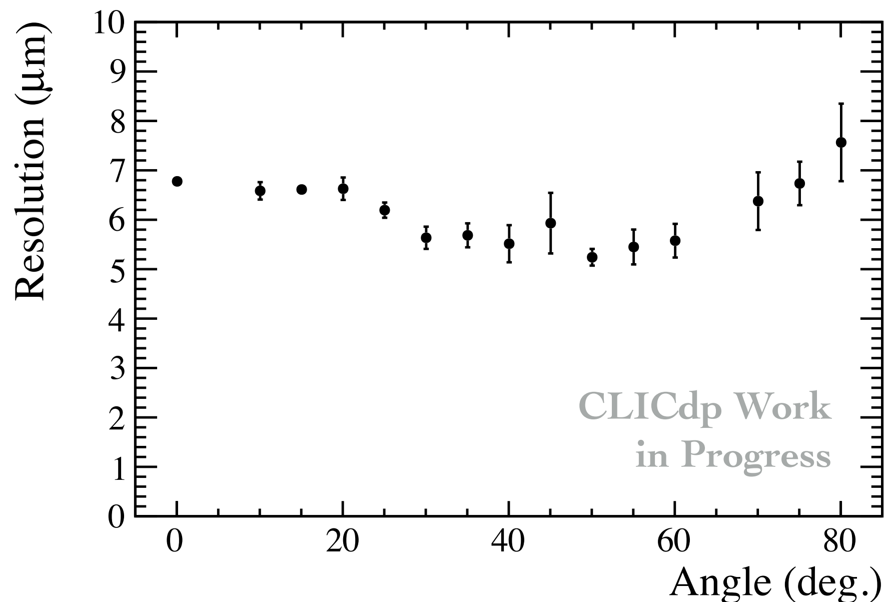
- Two beam periods were granted in May due to change in SPS schedule
  - 1 week beam time, followed by 1 week down time and another 4.5 days beam
- Unexpectedly took data for all samples during first beam period
  - ~ 24 hour cycle of device change + measurement program
- Improvised the second beam period and took detailed angle scan on "ideal" sample

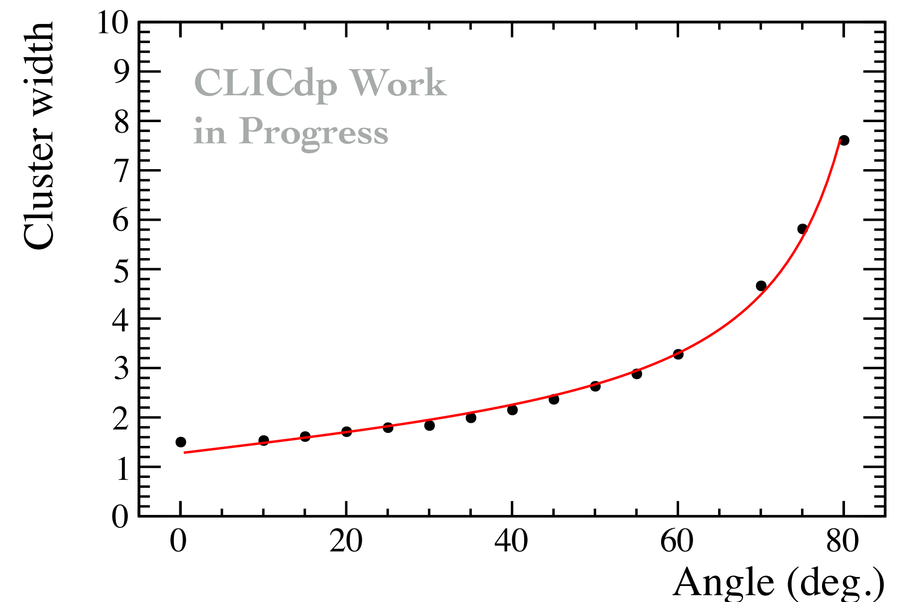


(Very) Preliminary results



- Initial results considering two aspects: change in tracking performance as a function of angle, and determination of the active depth (complimentary to edge TCT)
  - Resolution (sigma of a gaussian fit) remains ~ constant over the full range
  - No change in clustering - simple ToT-weighted (no head-to-tail etc. as yet)
  - Fit to cluster width in rotation direction gives estimate of active depth of order ~ 30 μm





Studies and further measurements

- Many studies now possible with the testbeam data set
  - Detailed studies of coupling dependence for misaligned samples, comparison with FE simulation
  - Study of signal propagation through devices, tuning of time constants
  - Tracking performance and variation between devices
  - Studies of charge collection as a function of depth
  - Optimisation for next iterations of HV-CMOS and CLICpix ASICs
- Lab studies required - calibrations, IR laser tests, beam time requested at Diamond Light Source
- Reproducability of producing assemblies shown, along with some useful observations on pad design and bonding parameters
  - Next steps: new CLICpix and HV-CMOS ASICs towards the end of the year