ITkPixv1.1 – Threshold vs. BCID dependence study

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Weekly instrumentation meeting

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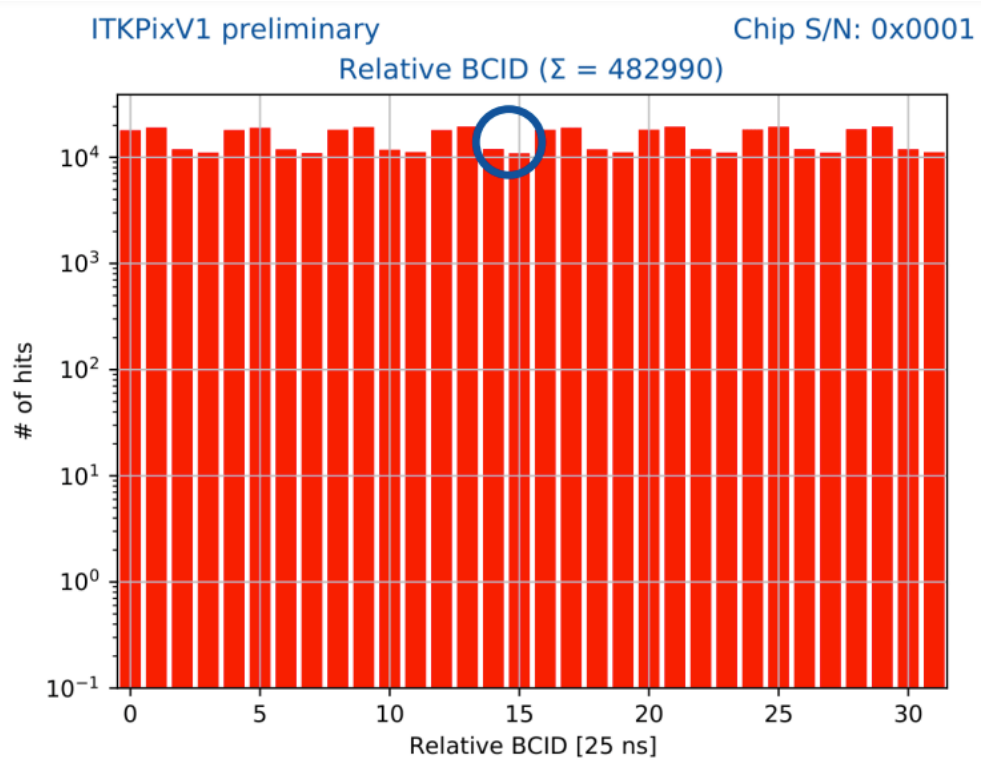
BERKELEY LAB

Context

- Testing ITkPixv1.1 – preproduction chip
- A dependence of the threshold on the BCID has been observed:



- First noticed periodic behavior in noise scan
- Also observed in RD53A

Mark Standke

- Testing ITkPixv1.1 – preproduction chip
- A dependence of the threshold on the BCID has been observed:

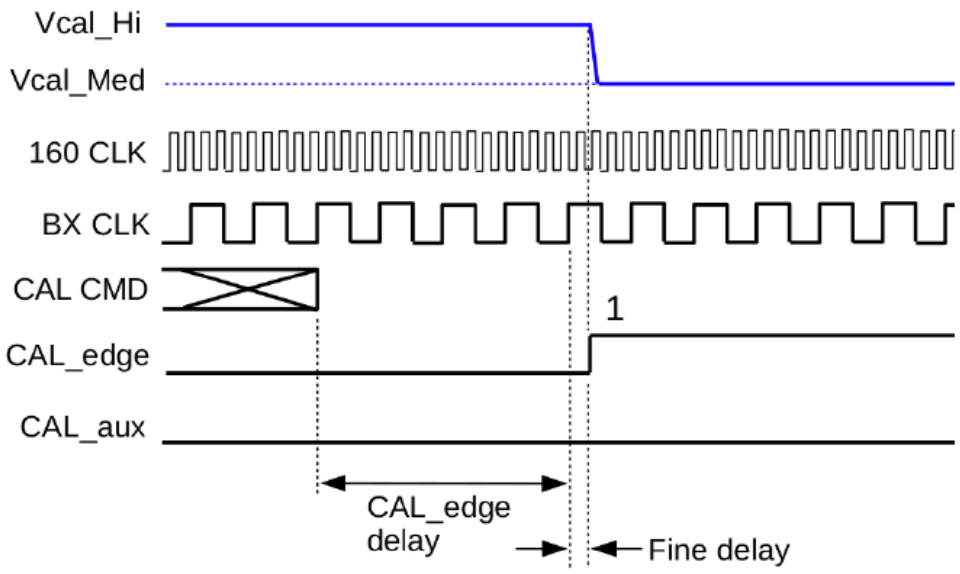
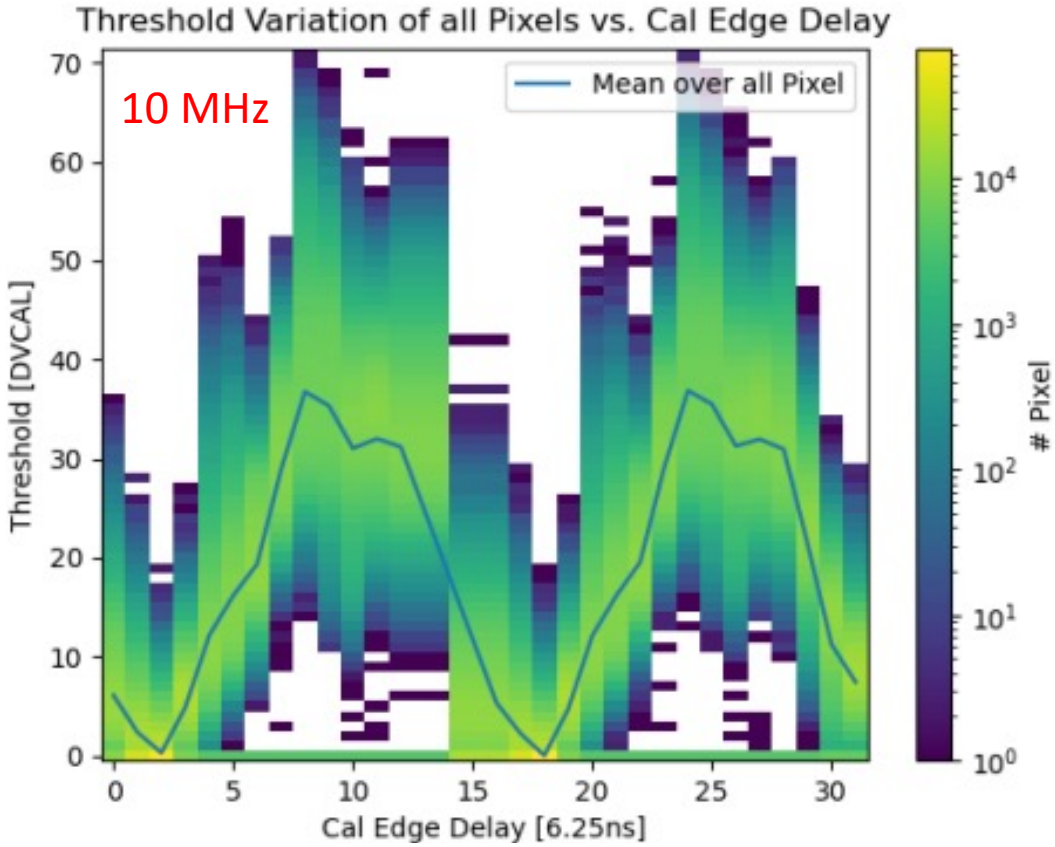


Figure 34: Timing diagram illustrating standard calibration injection.



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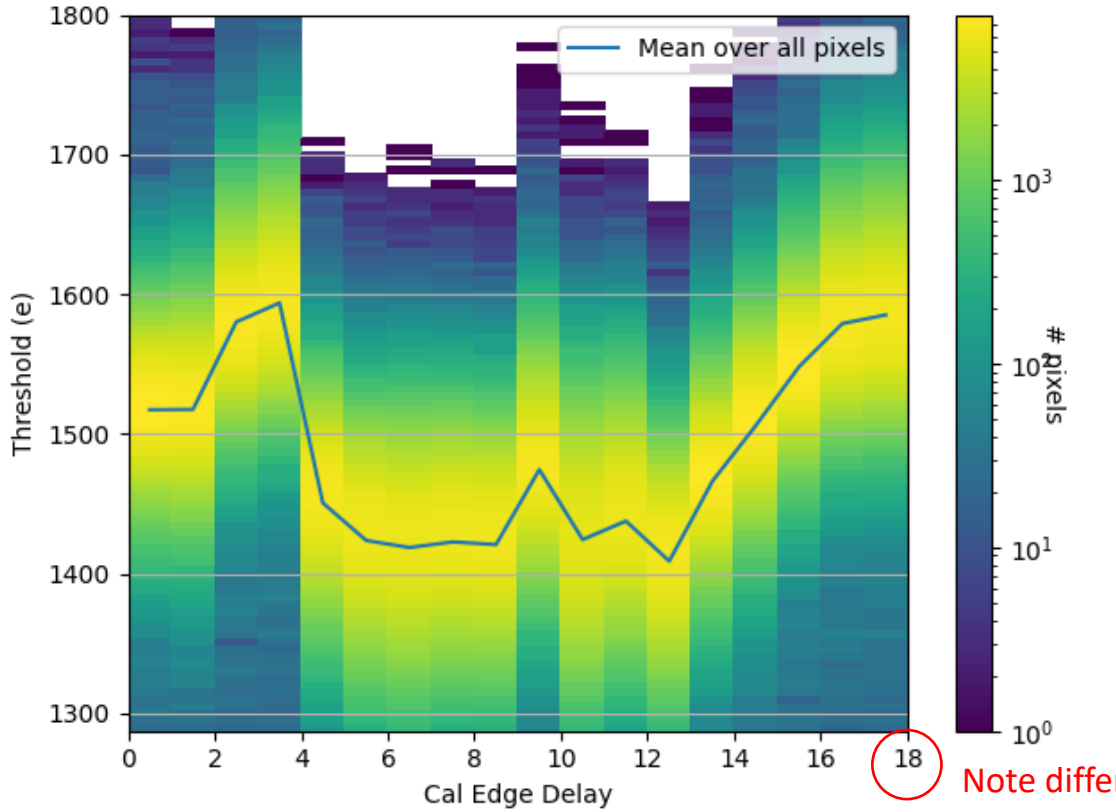
160 MHz clock → 1 BCID = 4 Cal Edge Delays

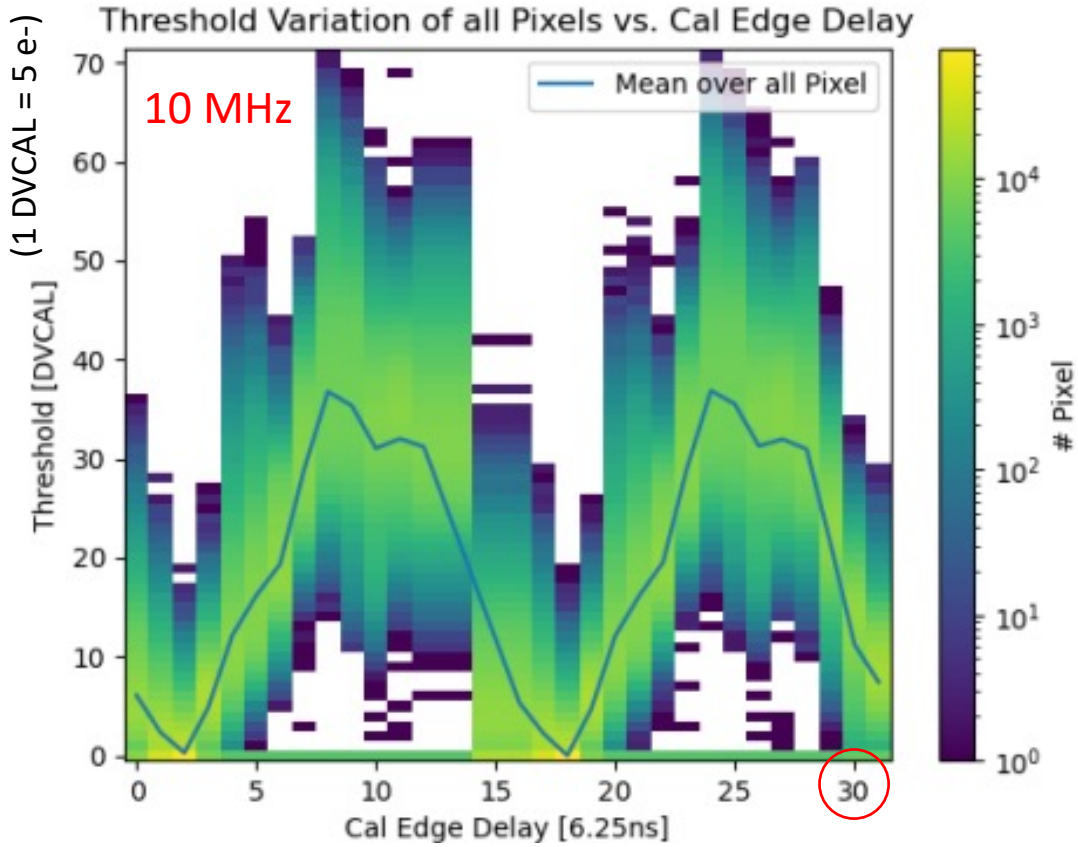
Reproducing this behavior

- We confirm that we see a similar behavior, and it has also been observed on CMS chip (CROC)

Our results (SCC with unbiased 3D sensor, single isolation)



Note different x-axis range



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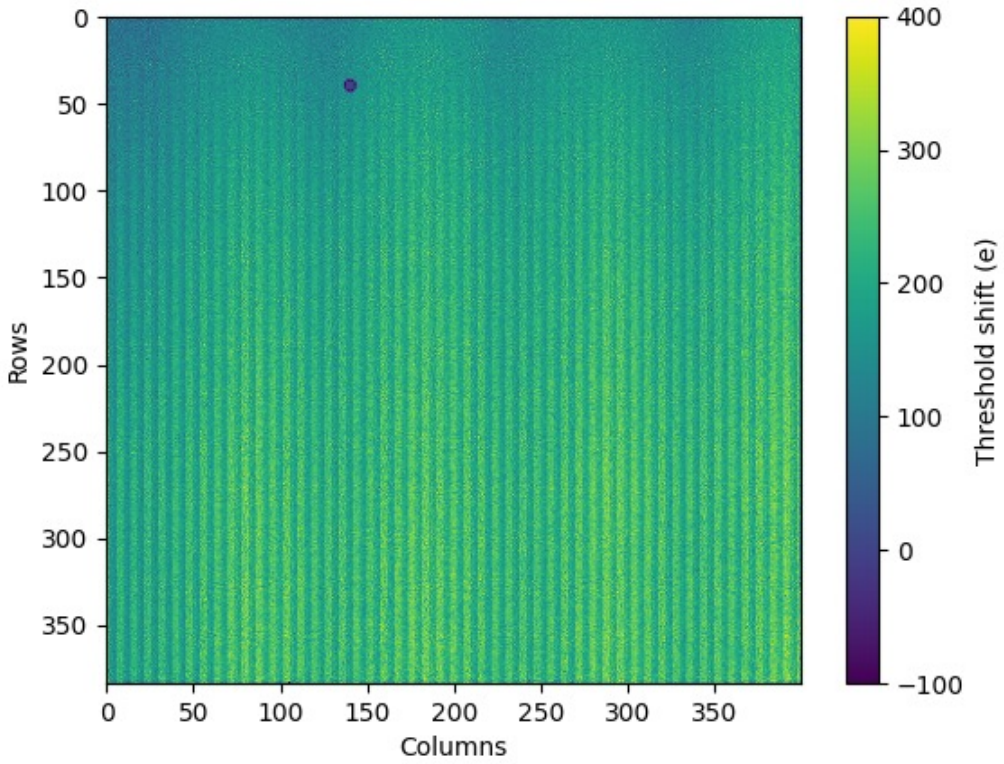
- Amplitude and frequency are similar but phase-shifted (different trigger setup)

More interesting features

- Pixel-by-pixel threshold shift depends on location and core column

Threshold shift vs. CAL delay Min: 10, Max: 17



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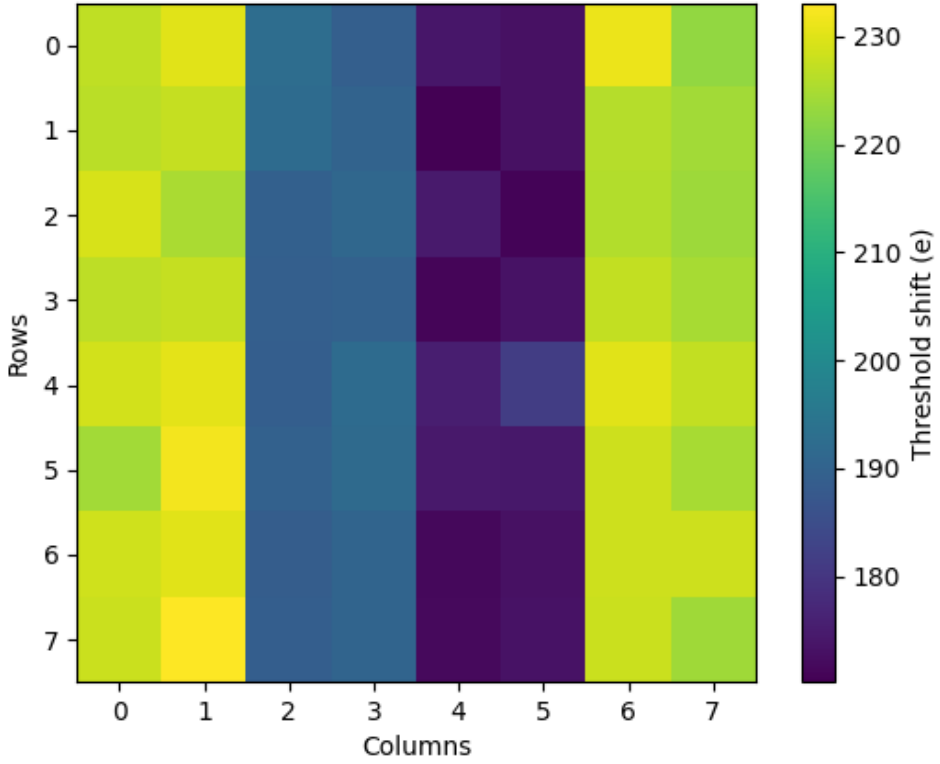


- Pixels closest to GNDA pads have lowest threshold shift

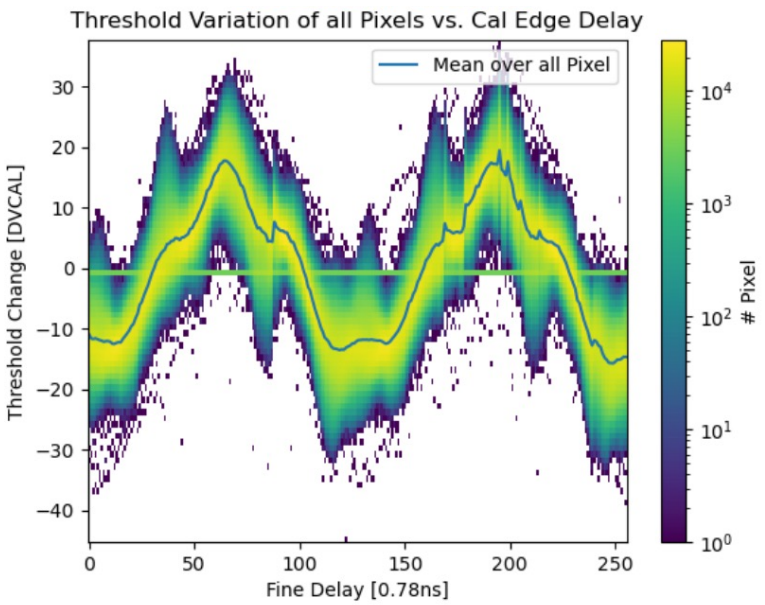
Difference between chips with single and double isolation

Double isolation: both analog and digital circuits embedded in deep N-wells

Single isolation: only digital circuit in deep N-well

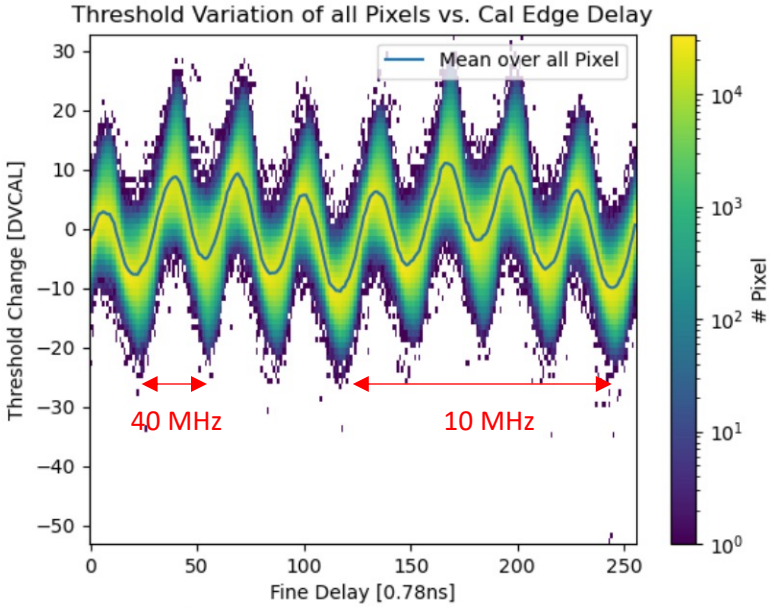
- We want to compare threshold vs. BCID with **single and double isolation** chips
- This comparison was already performed with **ITkPixv1.1** chips:

Single isolation (with sensor)



10MHz Frequency Dominant

Double isolation (without sensor)



40MHz Frequency Dominant

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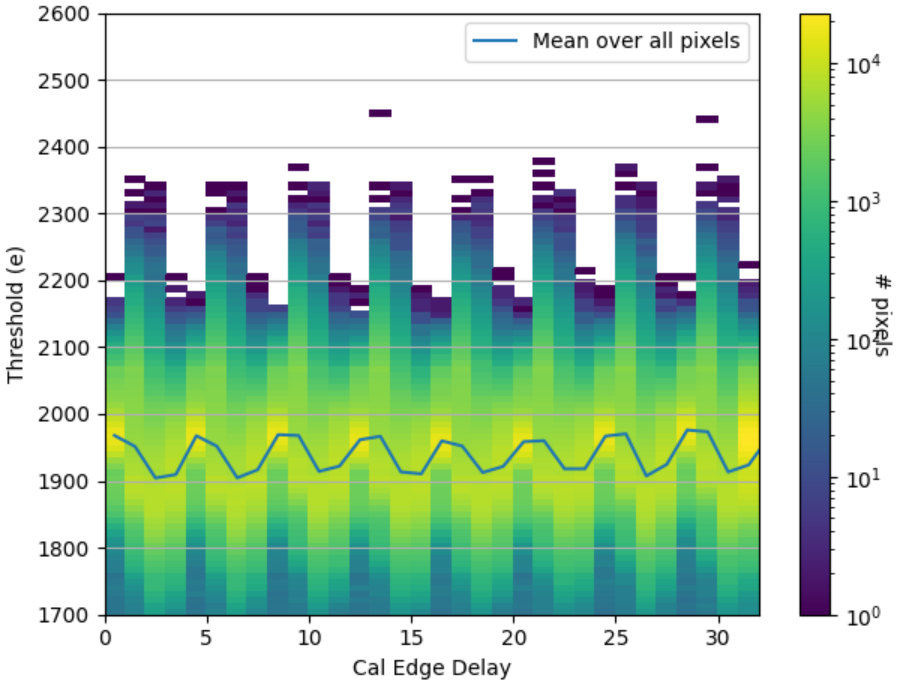
- We will make this comparison with **ITkPixv1.0** chips, where both single and double isolation chips are available **without sensor**

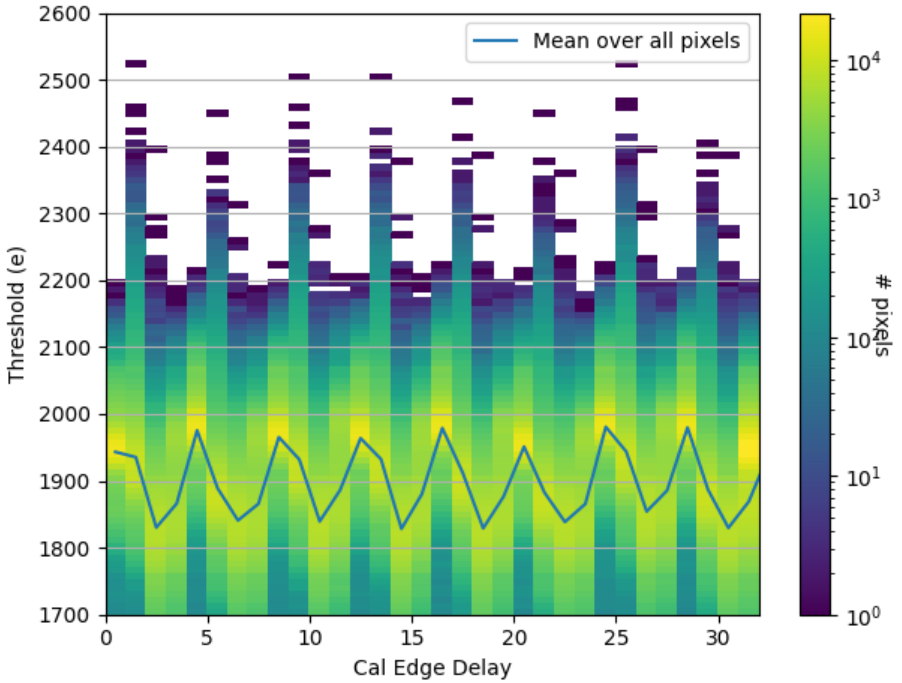
Difference between chips with single and double isolation

- Results comparing single and double isolation of ITkPixv1.0 chips (without sensors, -20 C)

Single isolation



Double isolation



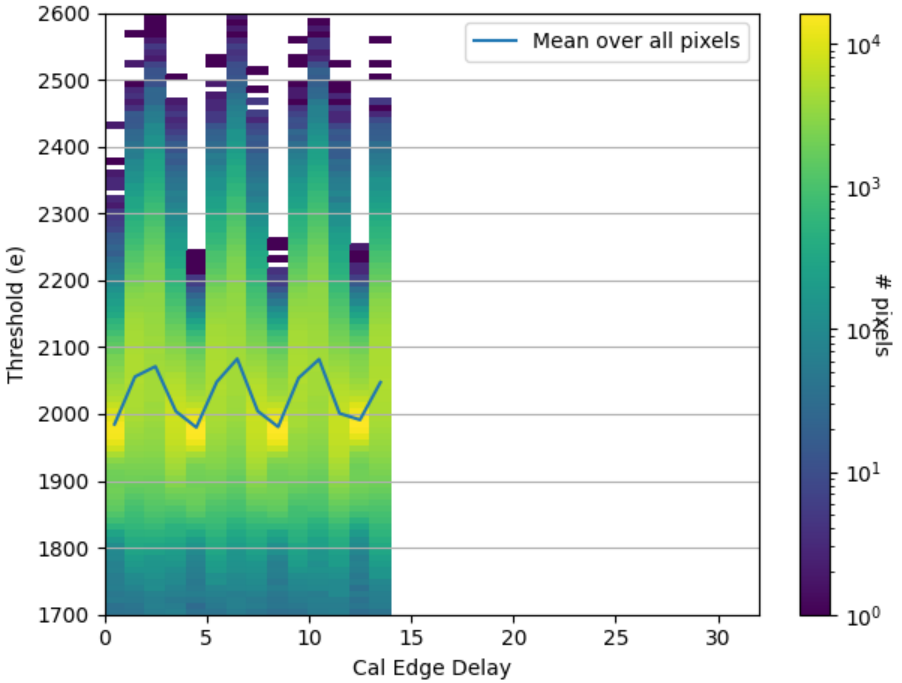
- Only 40 MHz component is visible → connection between sensor and 10 MHz component?
- Oscillation amplitude is smaller than previous plots → temperature dependent?
- Oscillation is slightly higher for double isolation → effect could be due to unstable GND?

Difference between chips with single and double isolation

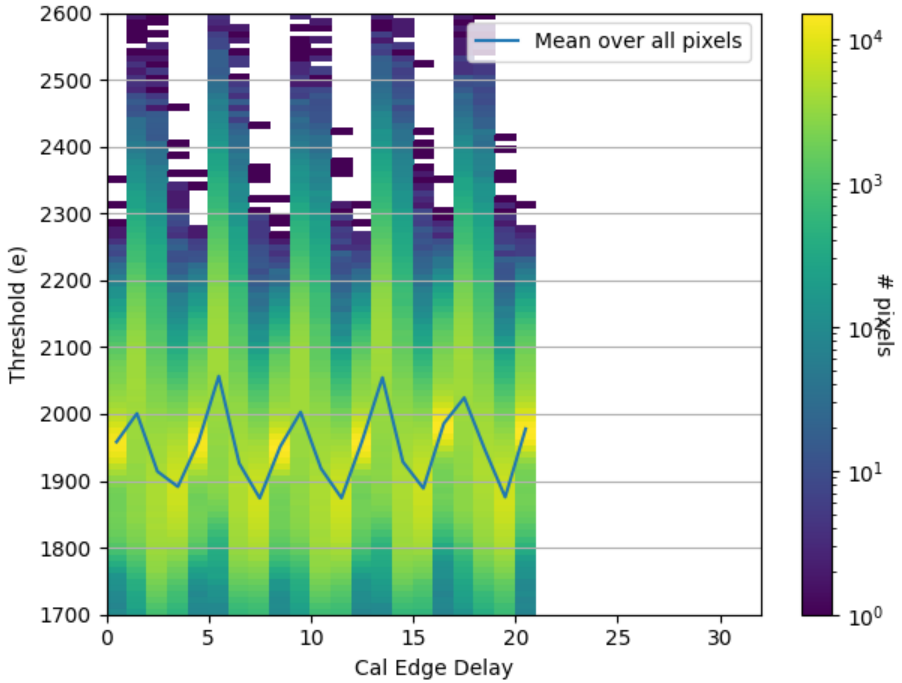
- In these plots we have changed DiffComp: 500 → 1000 (comparator total current bias) + chips retuned

Very preliminary

Single isolation



Double isolation



- No decrease in amplitude
- Phase is shifted

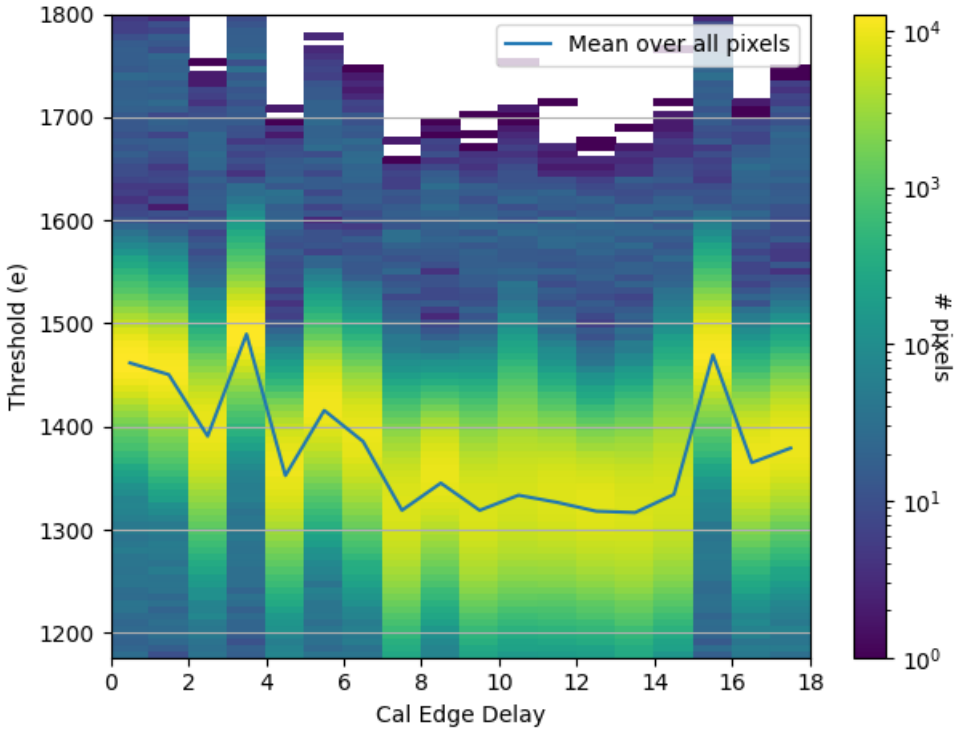
Summary & next steps

- We are actively investigating the threshold dependence on BCID of ITkPixv1.1 chips – still many open questions
- Next steps:
  - Understand dependence of this effect on temperature
  - Better analysis:
    - Analyze at pixel-by-pixel threshold changes instead of average threshold shift
    - Look at how collected charge distribution changes using ptot
    - Compare tag distribution between peaks and valleys
  - Impact on tracking?

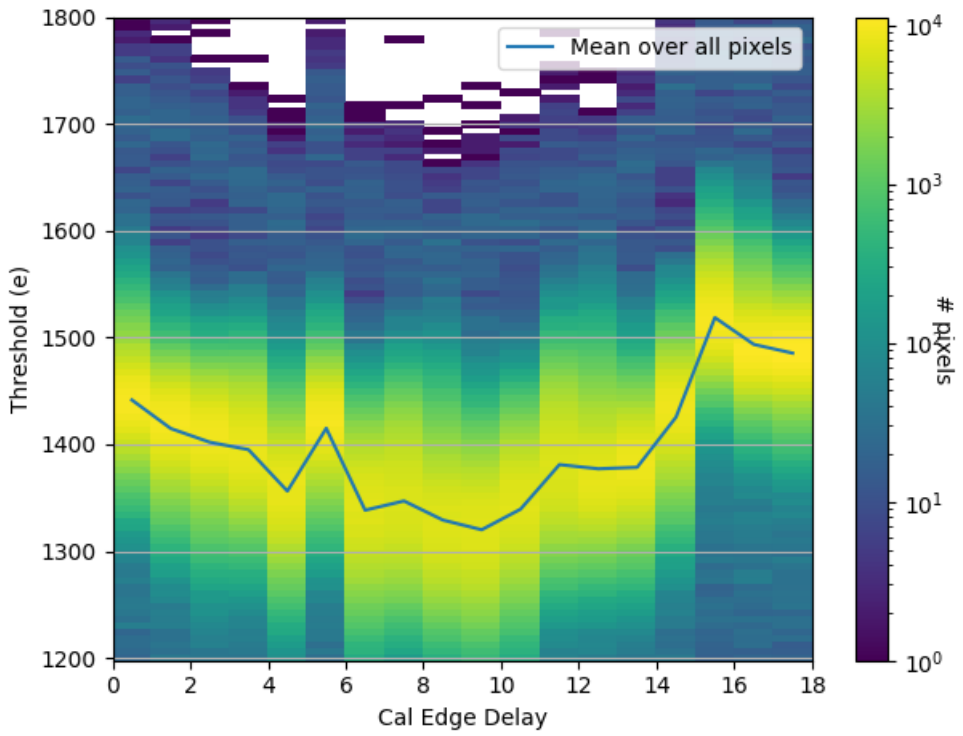
Backup: std vs. ptot threshold scans

- To use ITkPixv1.0 chips in this study, we first need to confirm if the threshold vs. BCID dependence is observed using ptot-threshold scans instead of std-threshold scans
- The following comparison was made with ITkPixv1.1 chip (with unbiased 3D sensor)

std_threshold scans:



ptot_threshold scans:

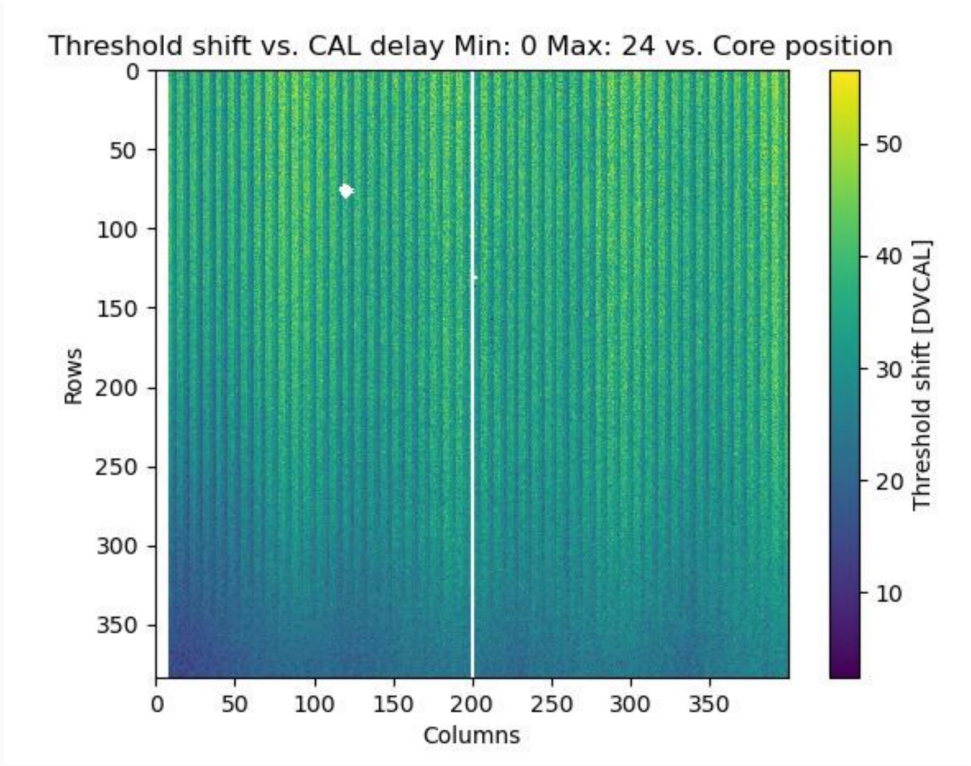


✓ Threshold vs. BCID behavior is also present when using ptot threshold scans

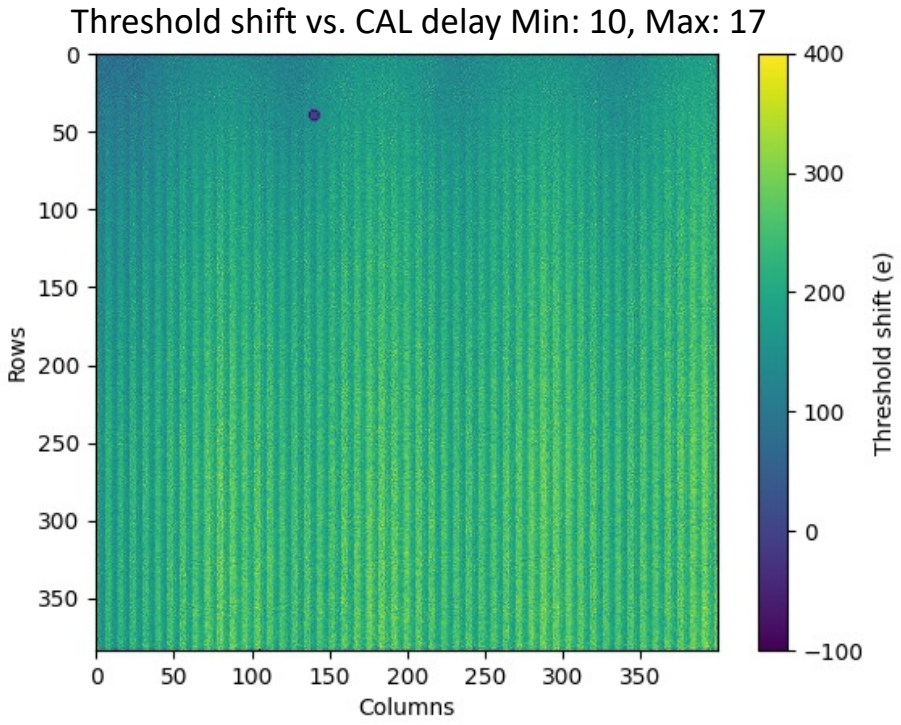
Backup: location dependence

- Amplitude of oscillation depends on pixel location and column
- These plots compare pixel-by-pixel threshold shift between peak and valley

Plot from Mark



Our results



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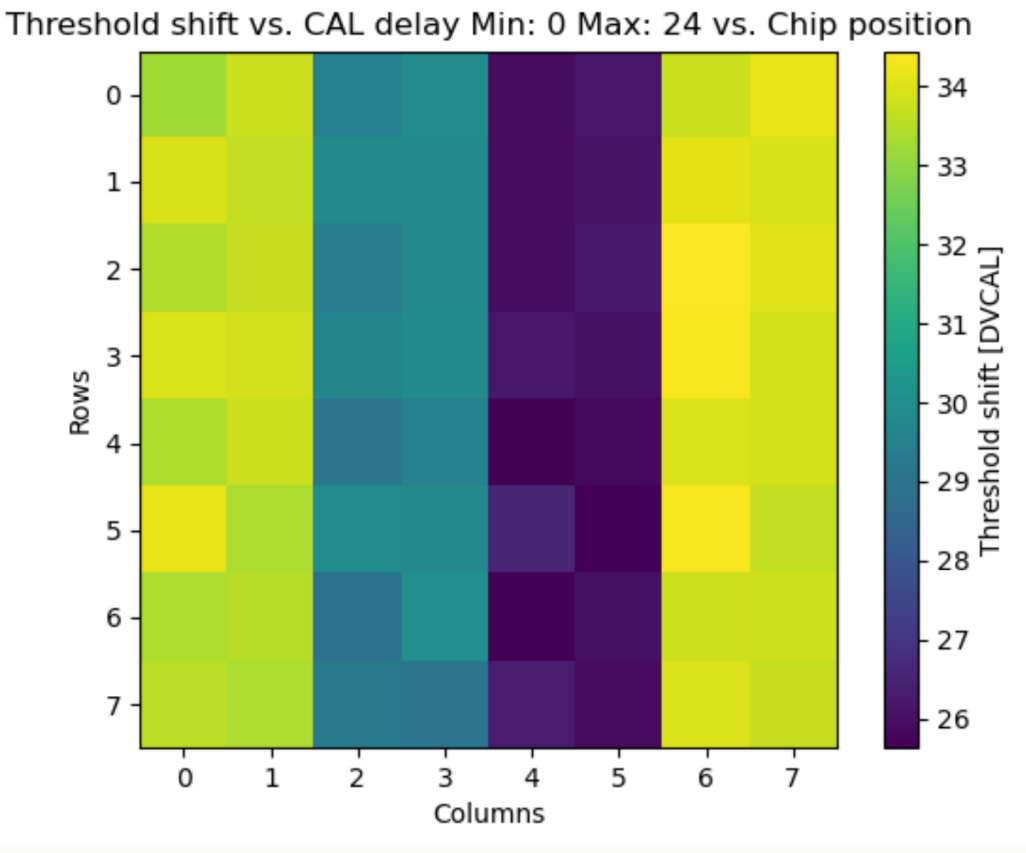

Our results