ITkPixv1.1 – Threshold vs. BCID dependence study

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Pixel roundtable

Nov 1, 2022

BERKELEY LAB

Summary

- I have studied threshold oscillation on a variety of Itkpix chips:

1. v1.1 SCC with unbiased 3D sensor
   - 10 MHz dominant

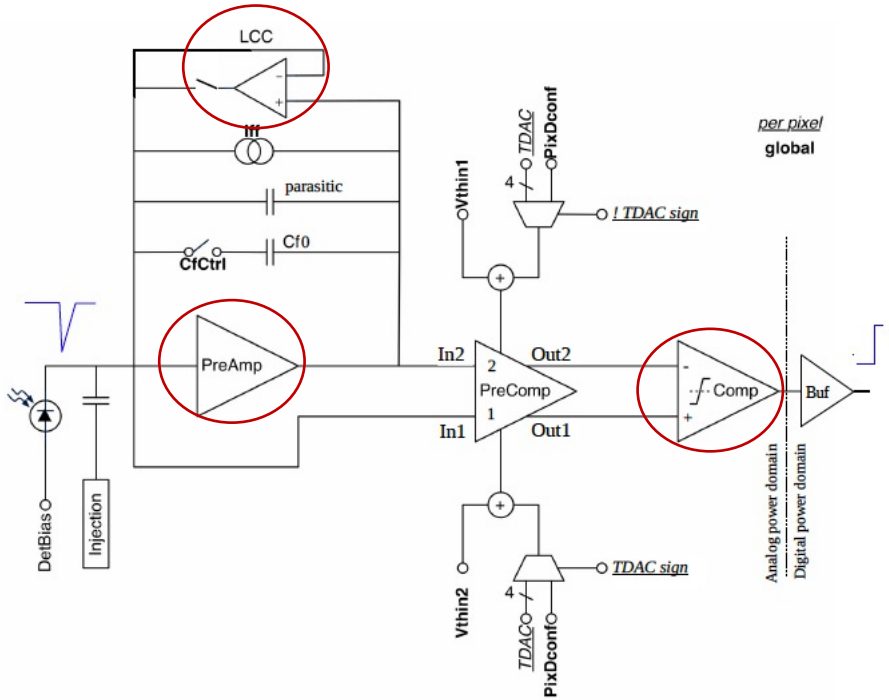
2. v1.1 quad module with HPK planar sensor, biased at 100 V
   - 10 MHz & 40 MHz visible

(with sensor)

(without sensor)

3. v1.0 SCC's without sensors (single and double isolation)
   - 40 MHz dominant

4. v1.1 quad module without sensors
   - 40 MHz dominant



+ temperature
+ single vs. double isolation

Summary

- I have studied threshold oscillation on a variety of Itkpix chips:

1. v1.1 SCC with unbiased 3D sensor
   - 10 MHz dominant
   - No **DiffPreamp** dependence (though perhaps retuning is needed): Slide 6-7
   - No **temperature** dependence: Slide 8-9
   - No change with **LCC** enabled: Slide 10-11

2. v1.1 quad module with HPK planar sensor, biased at 100 V
   - 10 MHz & 40 MHz visible
   - With smaller **DiffPreamp**: 40 MHz amplitude decreases, 10 MHz amplitude stays the same: Slide 14-21
   - Small changes with **DiffComp**: Slide 22-29

(with sensor)

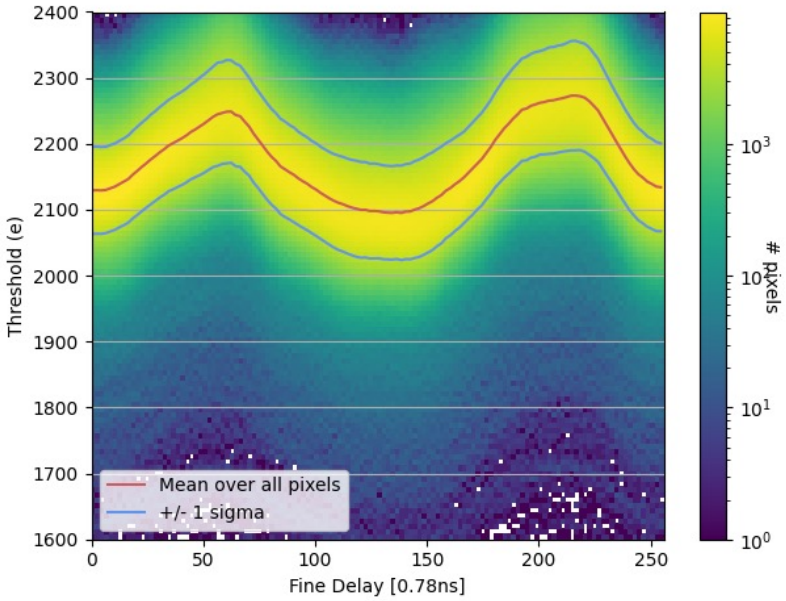
(without sensor)

3. v1.0 SCC's without sensors (single and double isolation)
   - 40 MHz dominant
   - No significant difference between **single and double isolation**
   - With larger **DiffComp**: dispersion of oscillation increases significantly, amplitude increases slightly

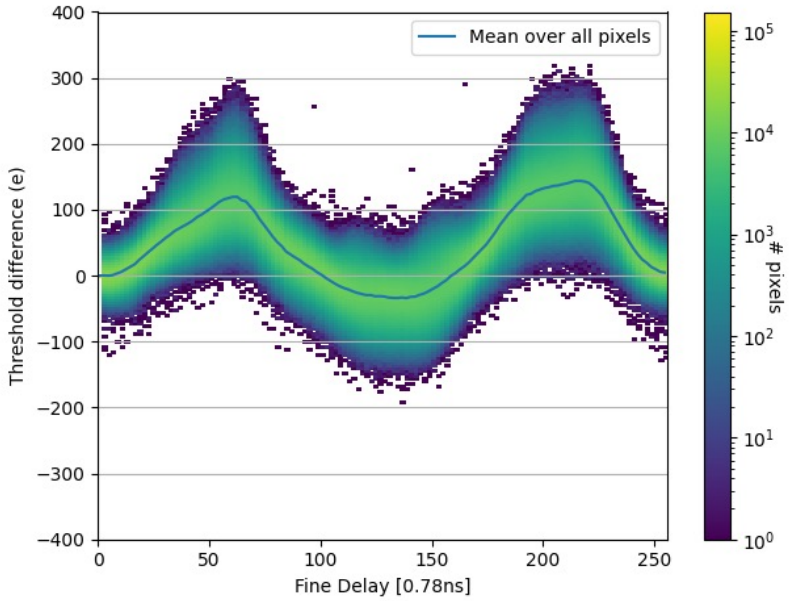
4. v1.1 quad module without sensors
   - 40 MHz dominant

Plot styles

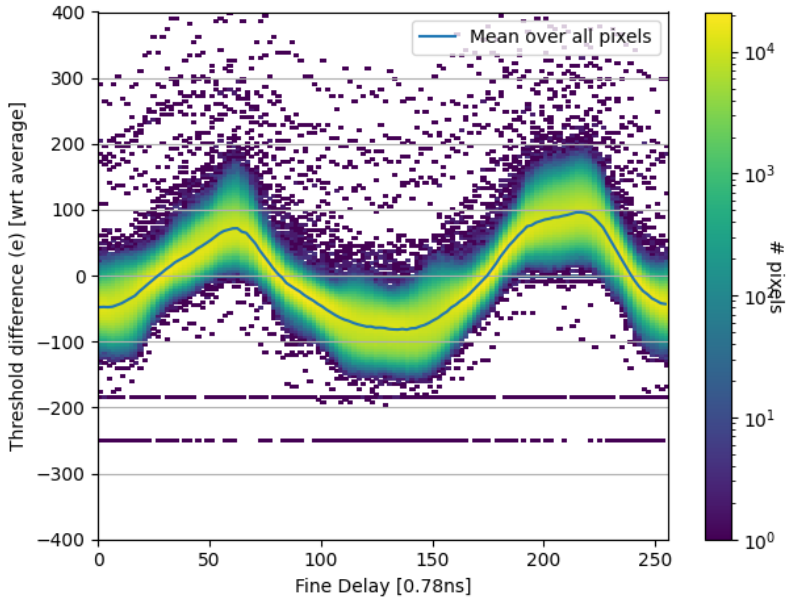
Plot threshold of each pixel:



Plot Δthr of each pixel, with respect to fine delay = 0 scan



Plot Δthr of each pixel, with respect to average threshold of that pixel over entire fine delay range



(all plots in this style in backup)

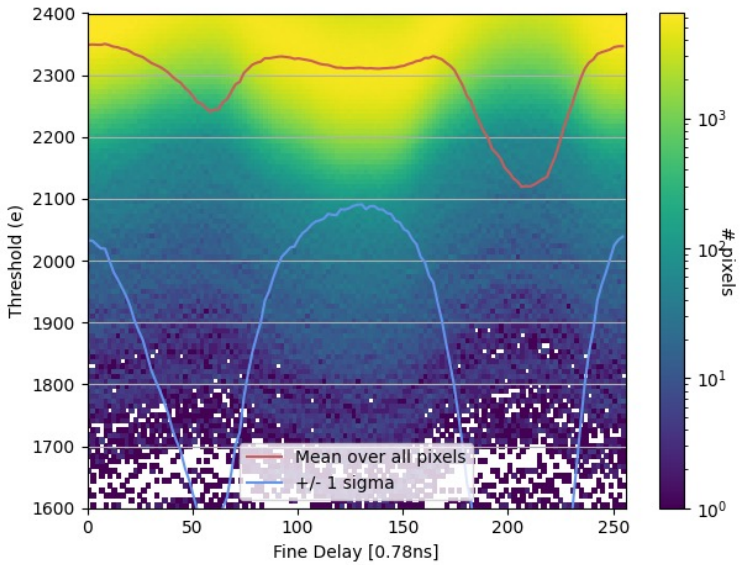
1. v1.1 SCC with unbiased 3D sensor
    - 10 MHz dominant
    - No DiffPreamp dependence (though perhaps retuning is needed)
    - No temperature dependence
    - No change with LCC enabled

DiffPreamp dependence

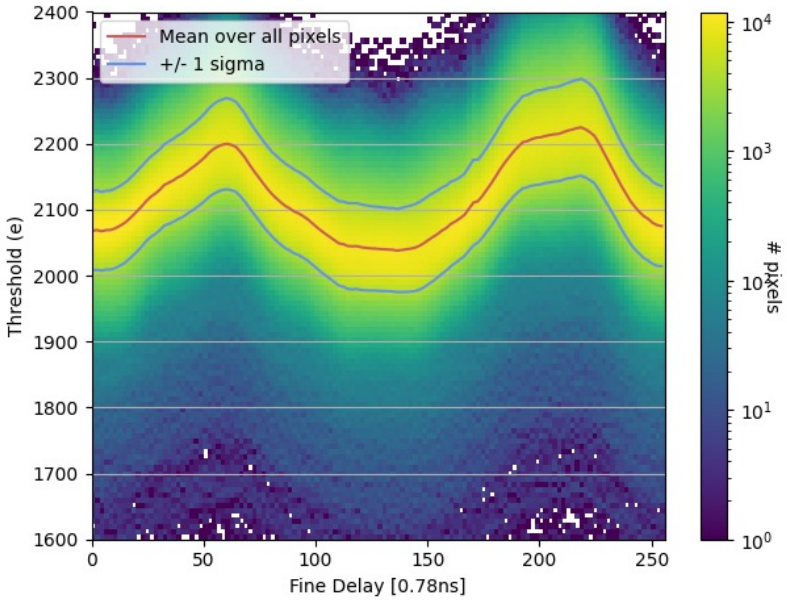
v1.1, with unbiased 3D sensor

- No re-tuning in between DiffPreamp scans

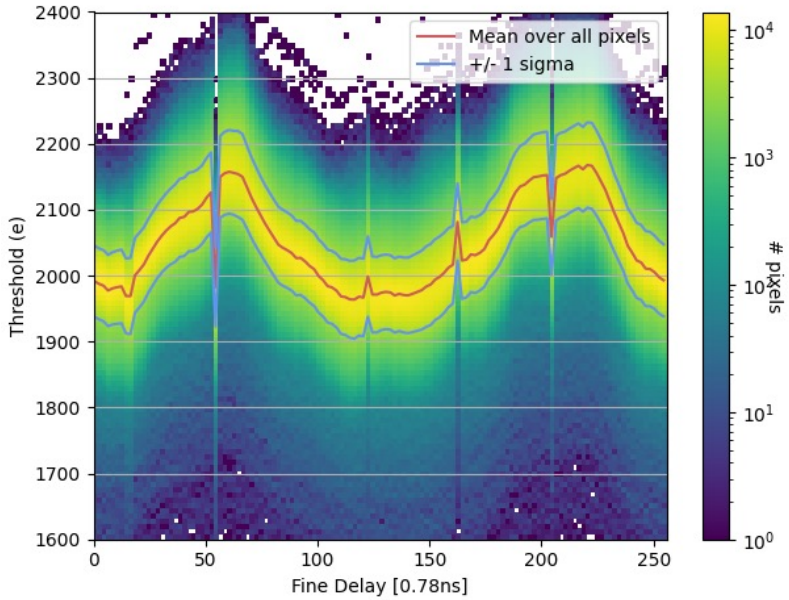
DiffPreamp = 300



DiffPreamp = 600



DiffPreamp = 900



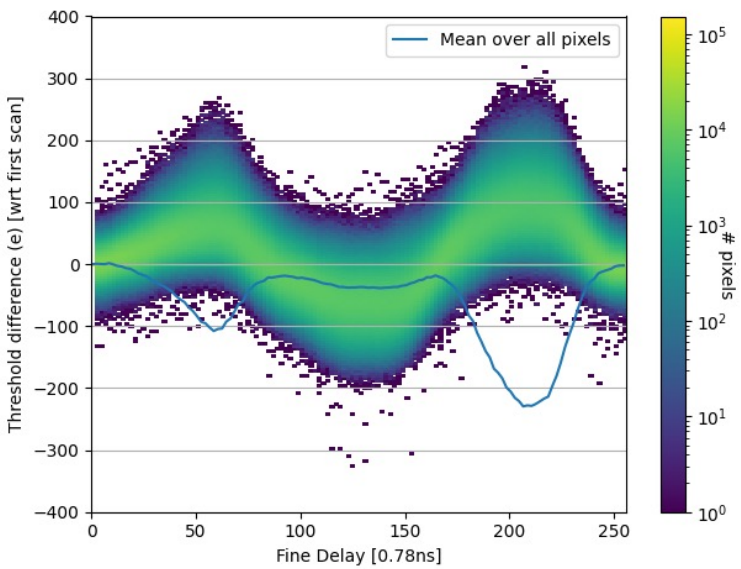
Note that there were many failed fits with this run! Because threshold increased with smaller DiffPreamp, and thr scan wasn't capturing full s-curve.

DiffPreamp dependence

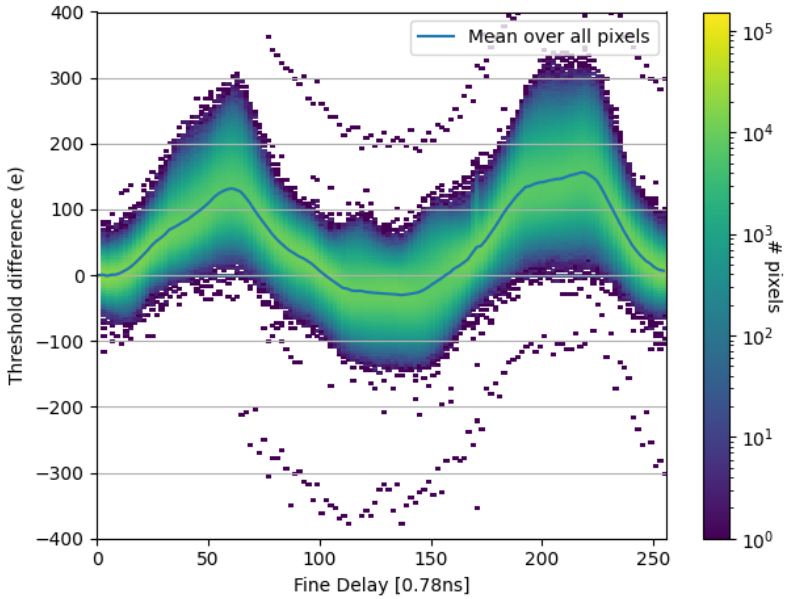
v1.1, with unbiased 3D sensor

- No re-tuning in between DiffPreamp scans

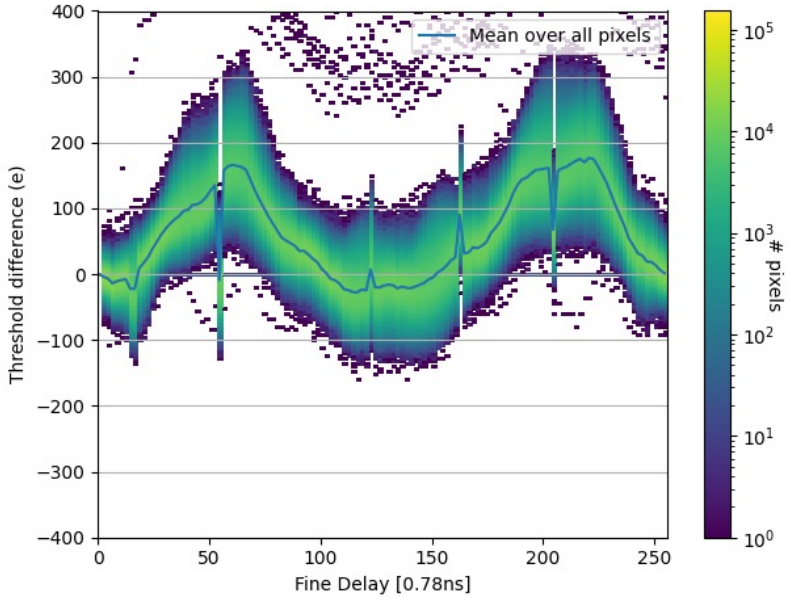
DiffPreamp = 300



DiffPreamp = 600



DiffPreamp = 900



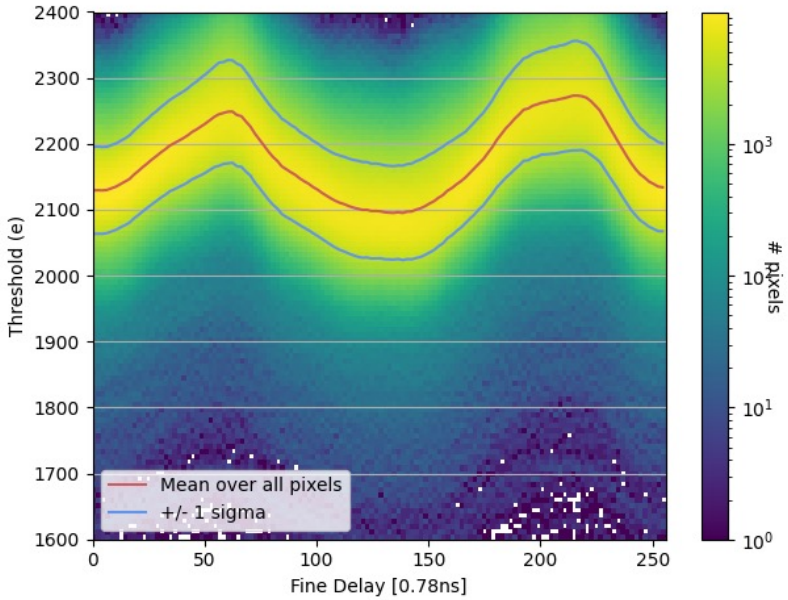
Note that there were many failed fits with this run! Because threshold increased with smaller DiffPreamp, and thr scan wasn't capturing full s-curve.

Temperature dependence

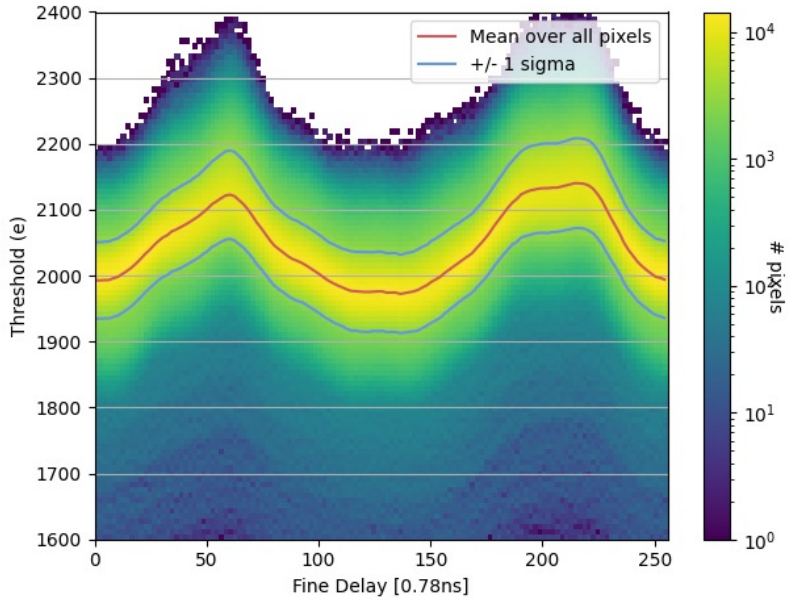
v1.1, with unbiased 3D sensor

Chiller temp:

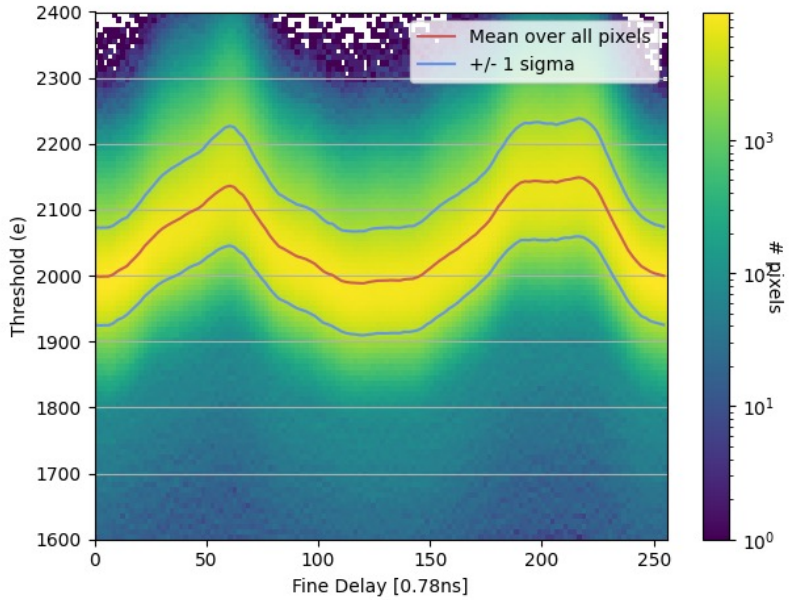
23 C



0 C



-20 C

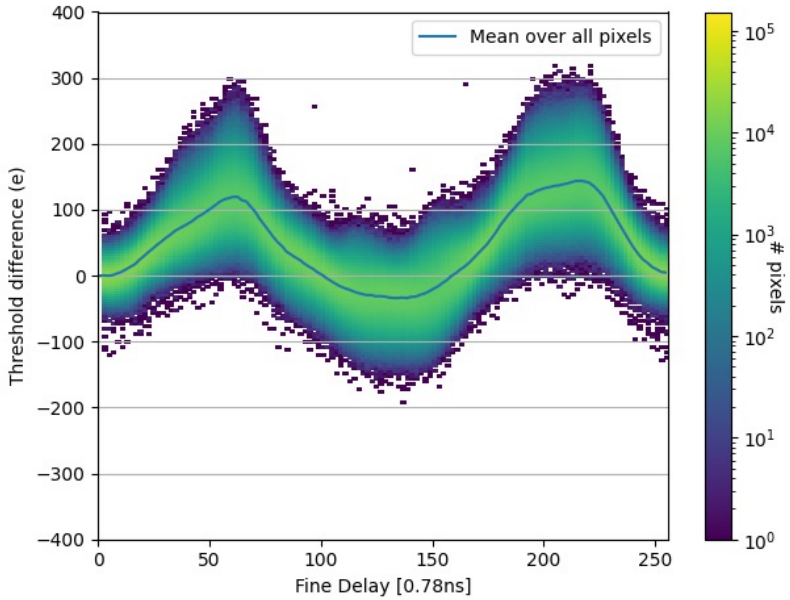


Temperature dependence

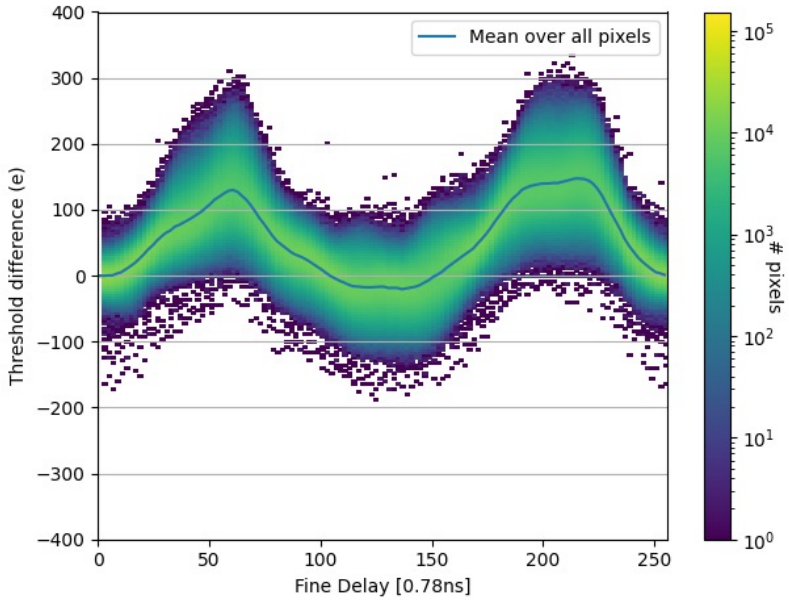
v1.1, with unbiased 3D sensor

Chiller temp:

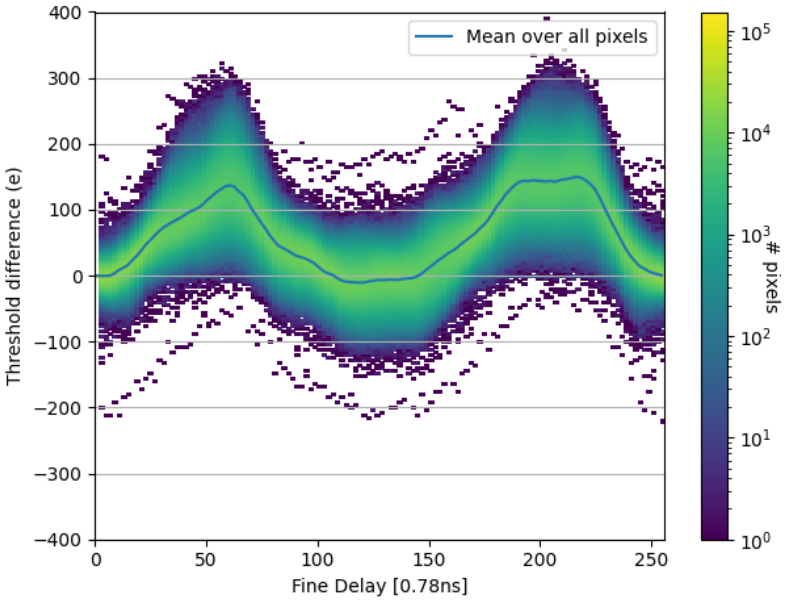
23 C



0 C



-20 C

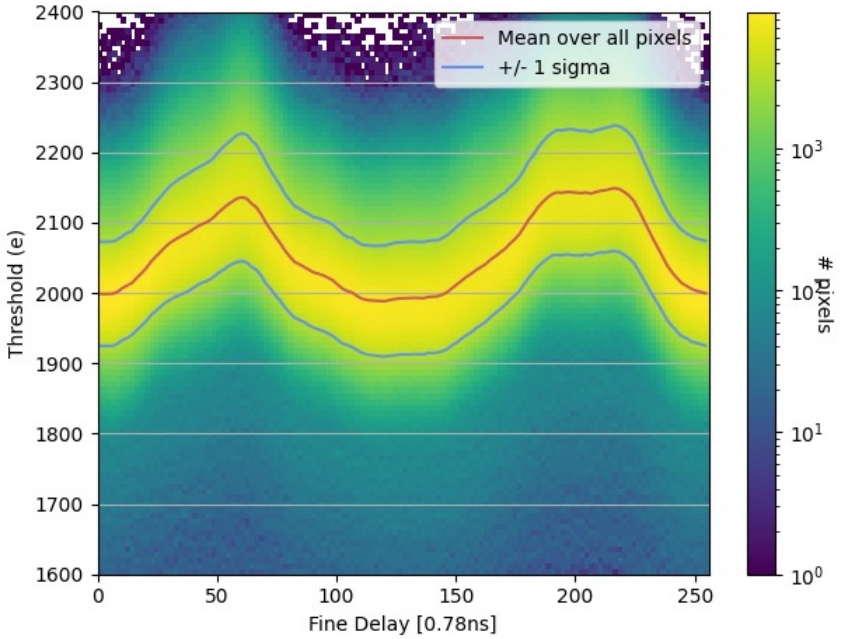


LCC results

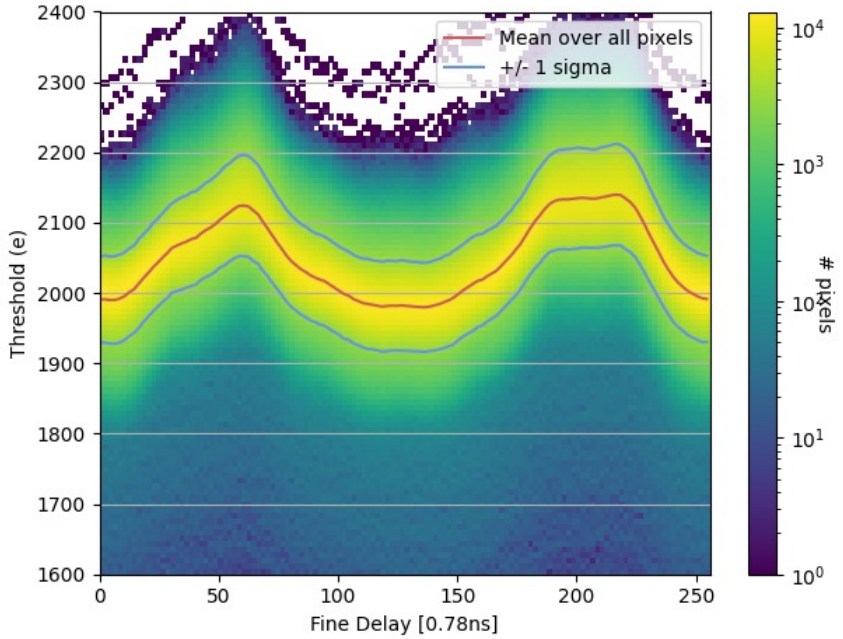
v1.1, with unbiased 3D sensor

Temperature: -20C

With LCC off



With LCC enabled at 500



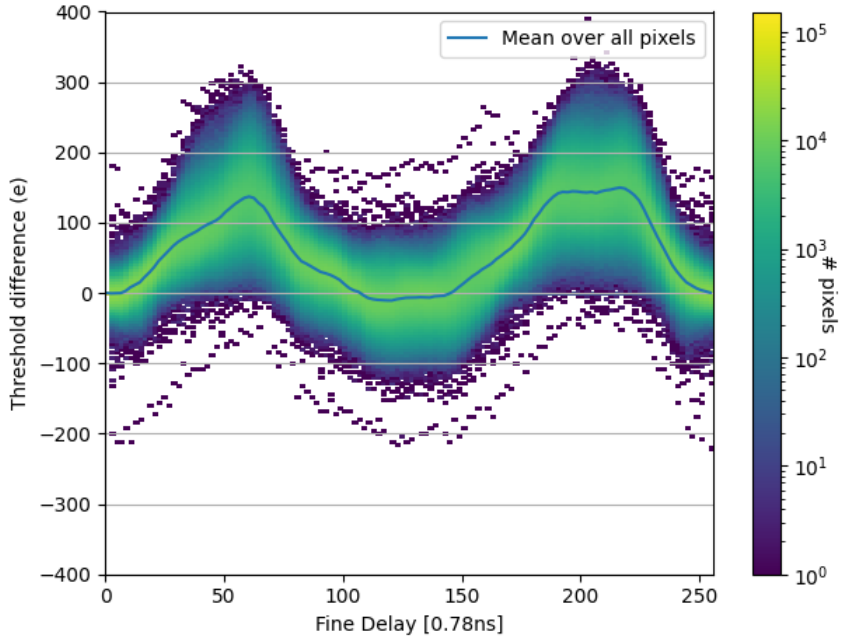
(with retuning to 2000e)

LCC results

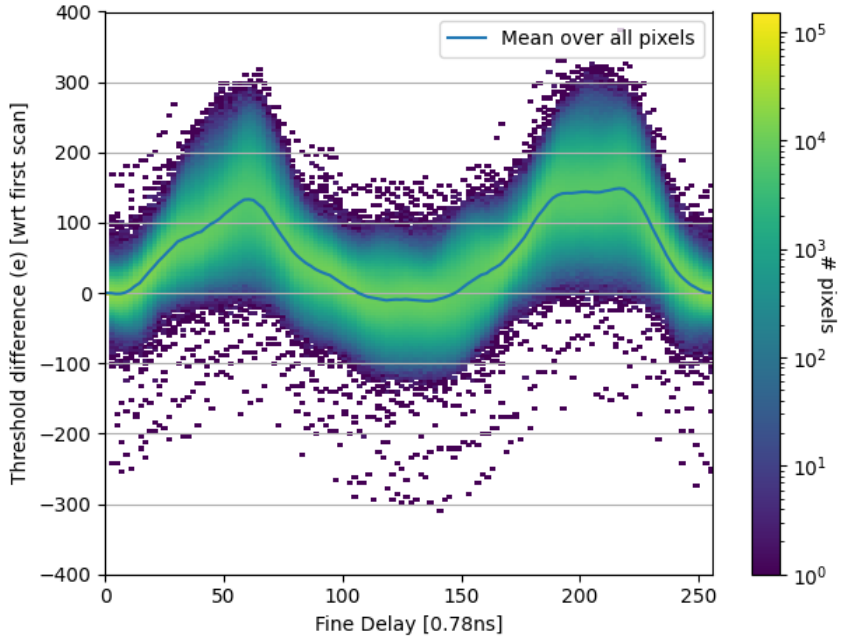
v1.1, with unbiased 3D sensor

Temperature: -20C

With LCC off



With LCC enabled at 500



(with retuning to 2000e)

Temperature dependence

- ITkPix v1.1 quad module
- HPK planar sensor, biased @ 100V
- 15 C

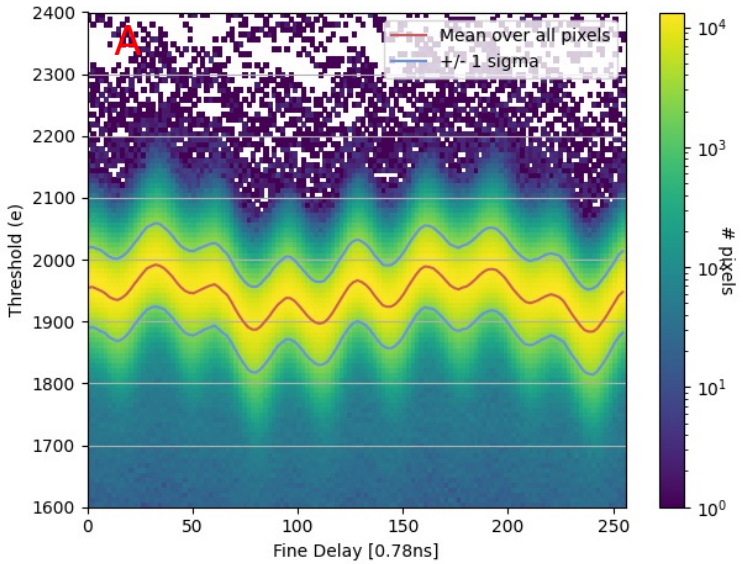
Quad results

v1.1, with biased HPK planar sensor

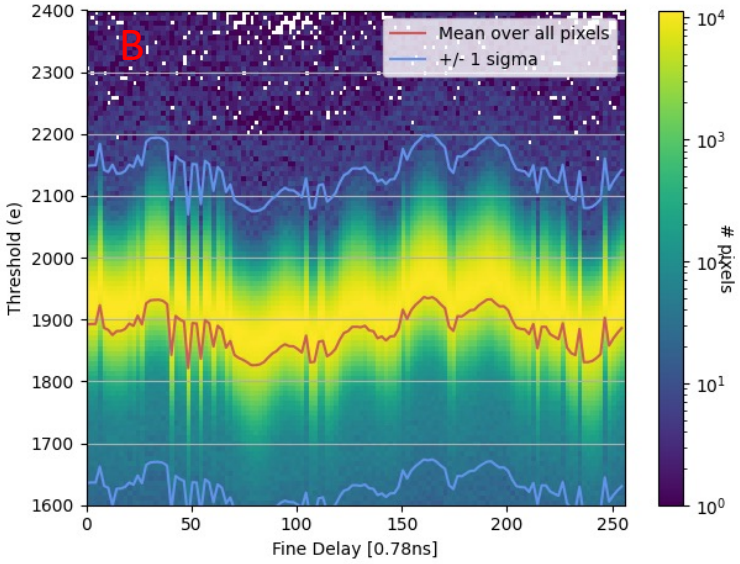
For all chips:

DiffPreamp: 500
DiffComp: 500

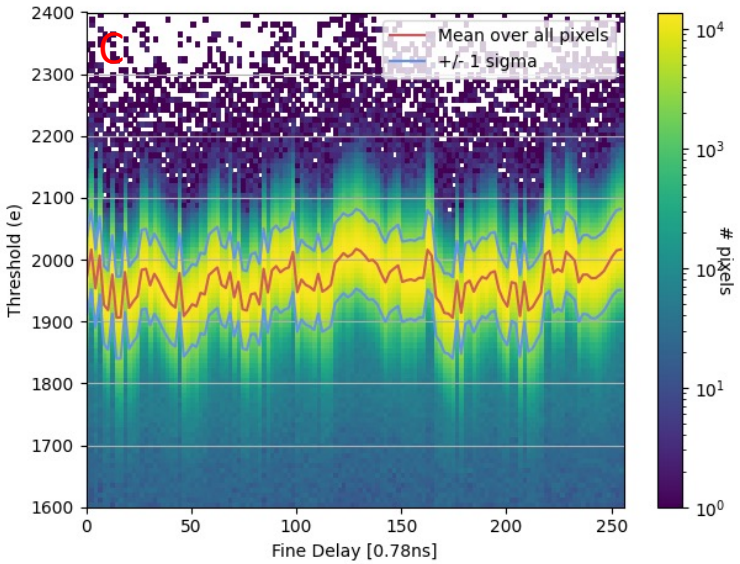
0x130bc



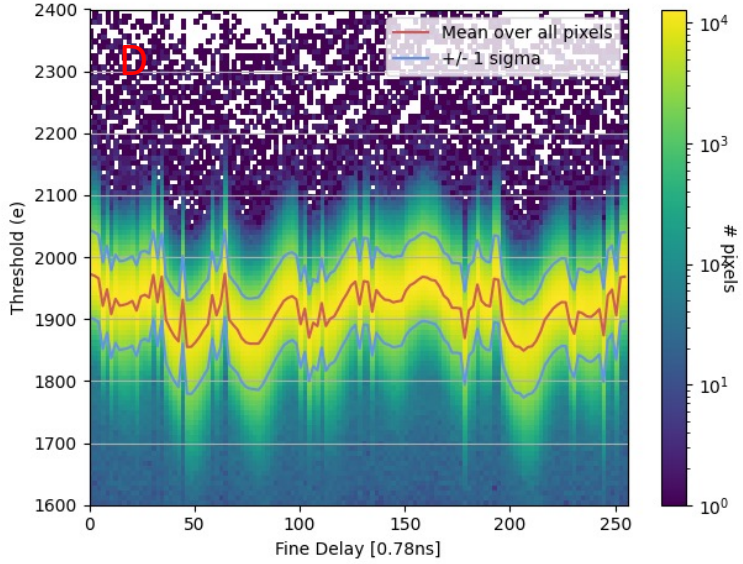
0x130c9



0x130d8



0x138b6

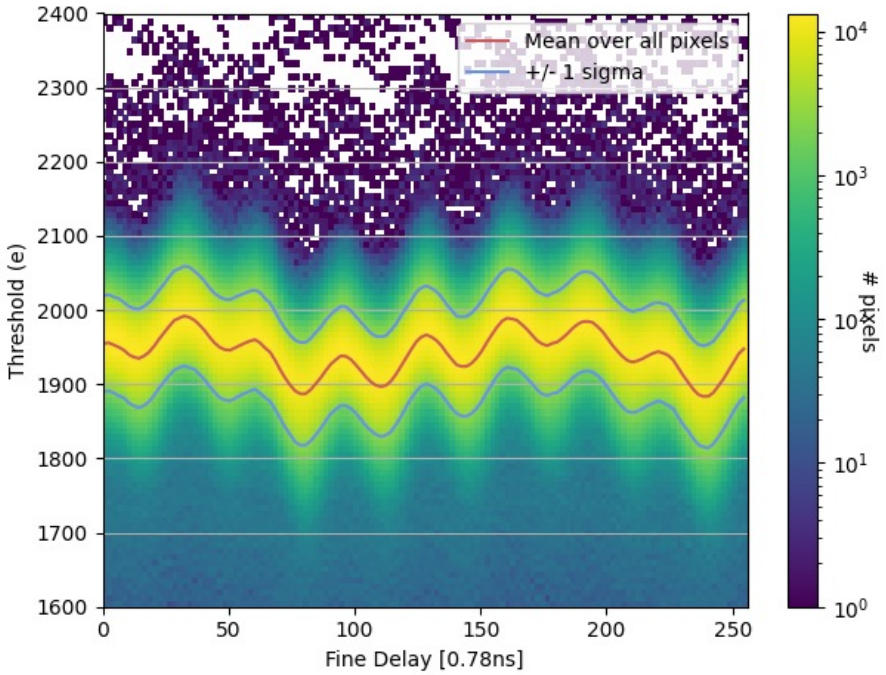


Quad results

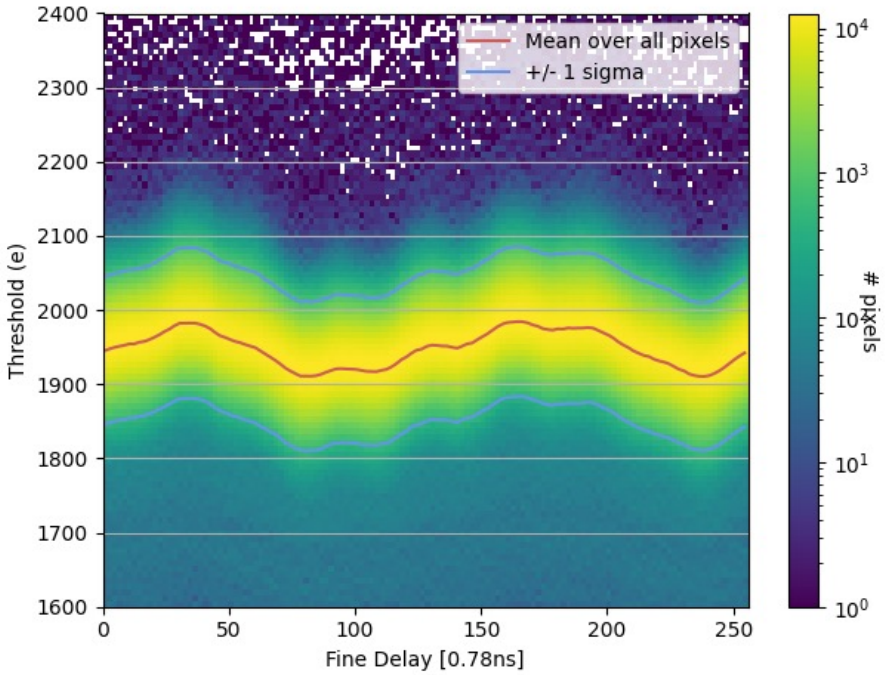
v1.1, with biased HPK planar sensor

0x130bc (chip A)

DiffPreamp: 500



DiffPreamp: 300



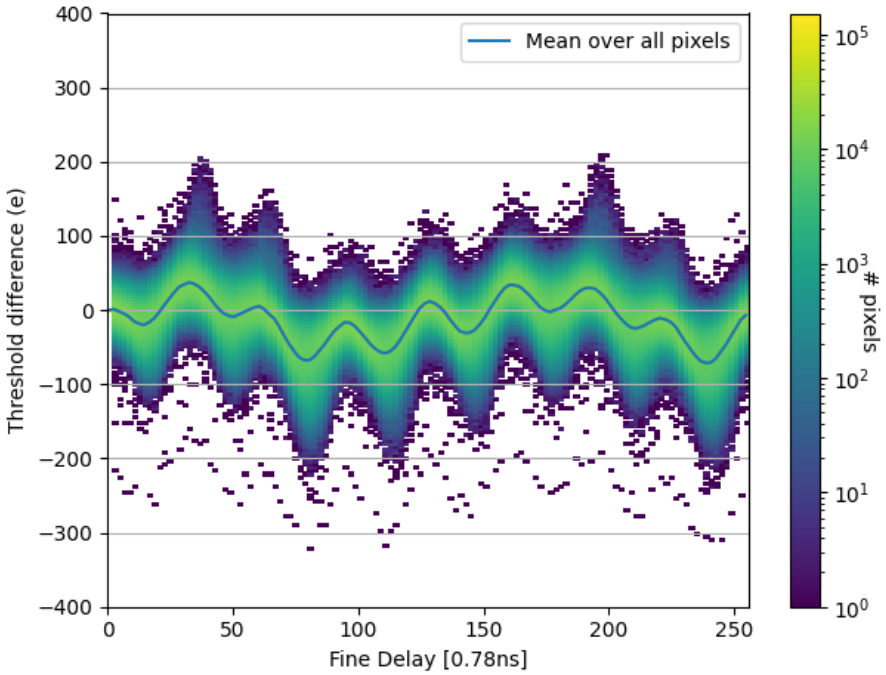
(with retuning to 2000 e)

Quad results

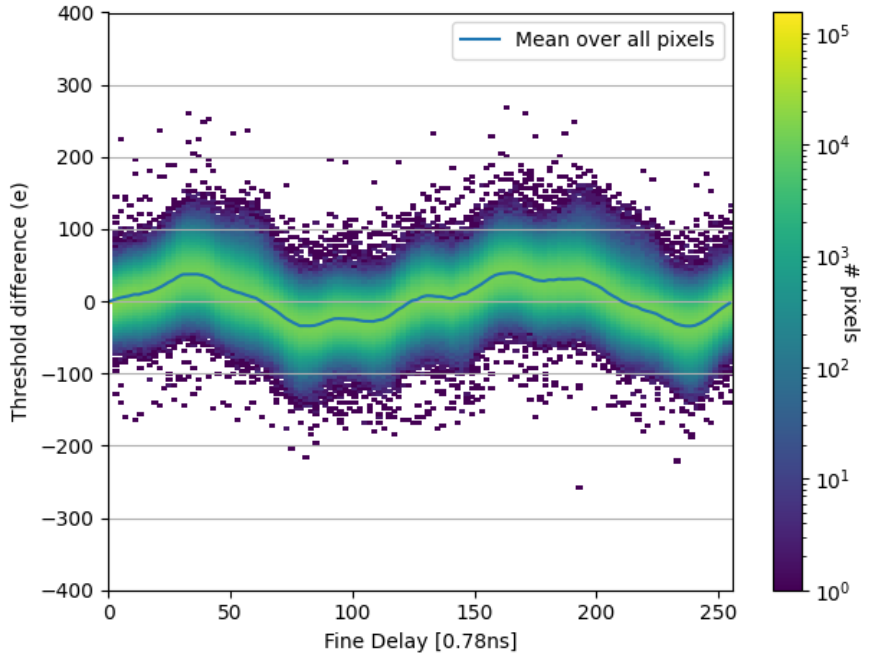
v1.1, with biased HPK planar sensor

0x130bc (chip A)

DiffPreamp: 500



DiffPreamp: 300



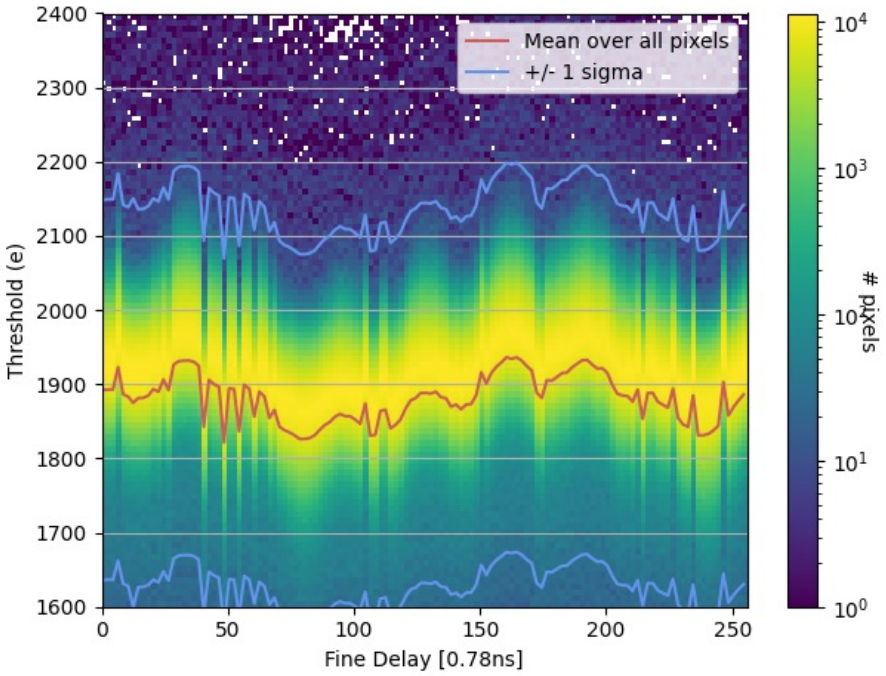
(with retuning to 2000 e)

Quad results

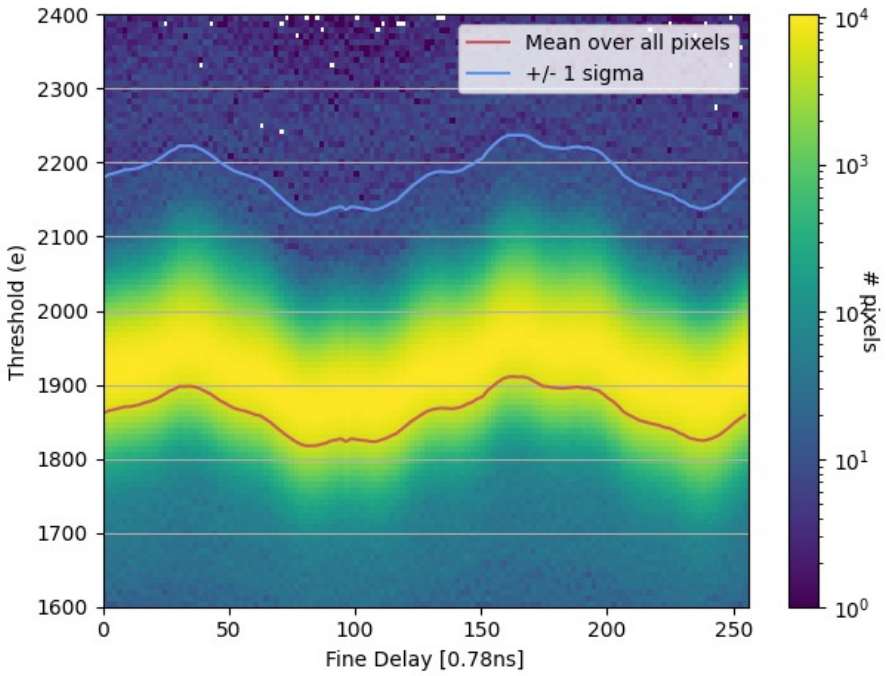
v1.1, with biased HPK planar sensor

0x130c9 (chip B)

DiffPreamp: 500



DiffPreamp: 300



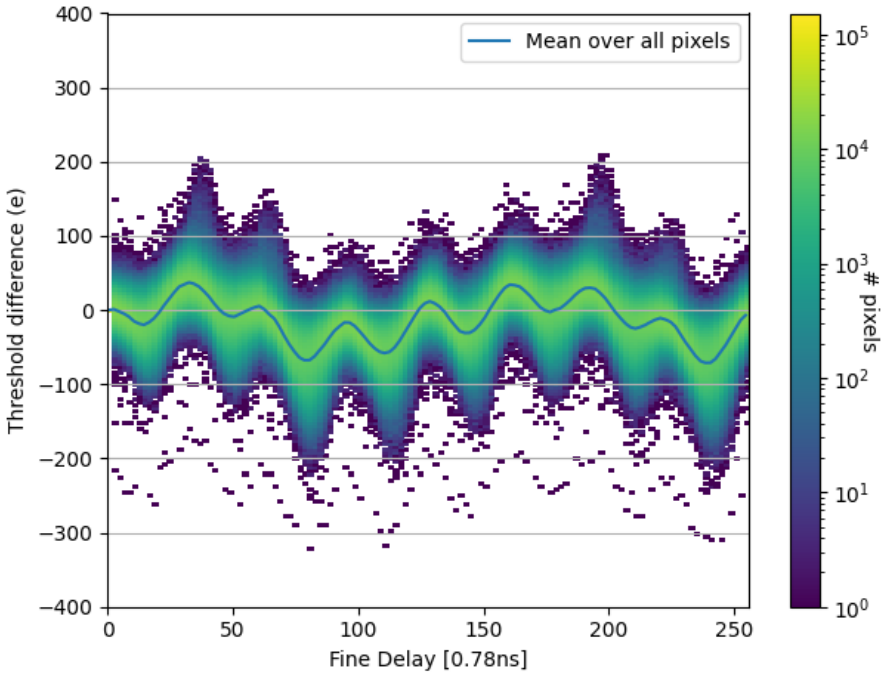
(with retuning to 2000 e)

Quad results

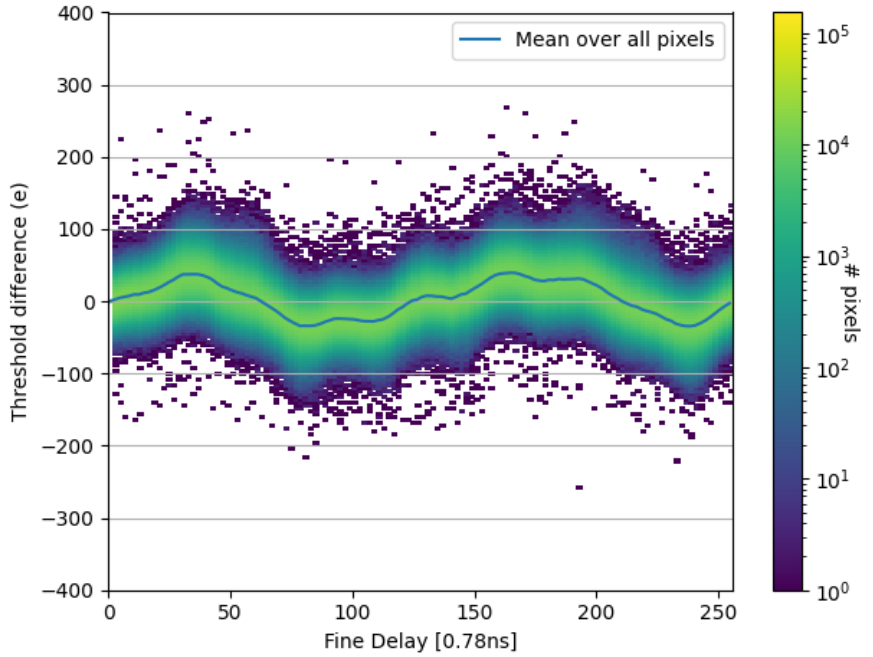
v1.1, with biased HPK planar sensor

0x130c9 (chip B)

DiffPreamp: 500



DiffPreamp: 300



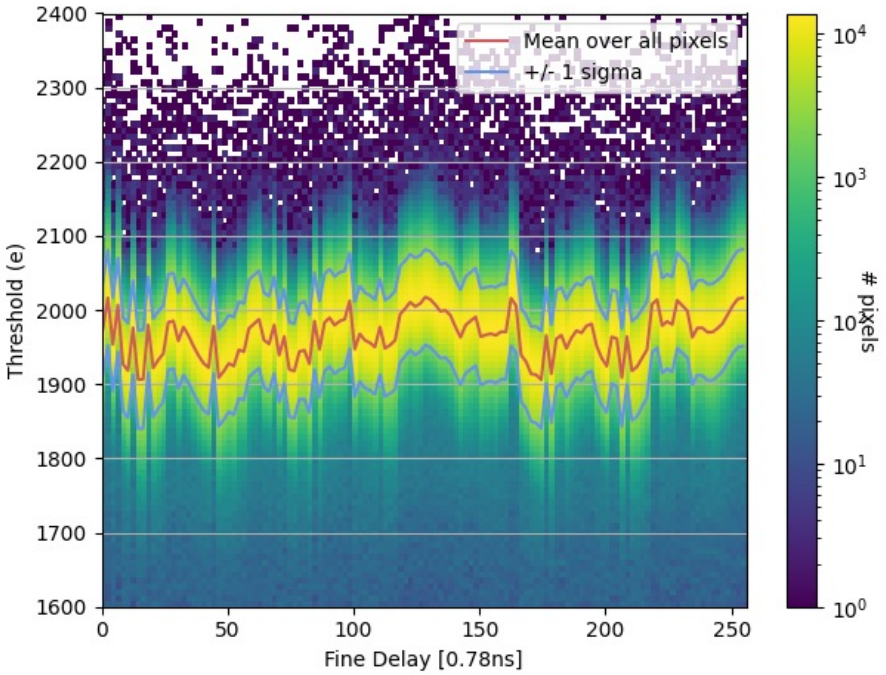
(with retuning to 2000 e)

Quad results

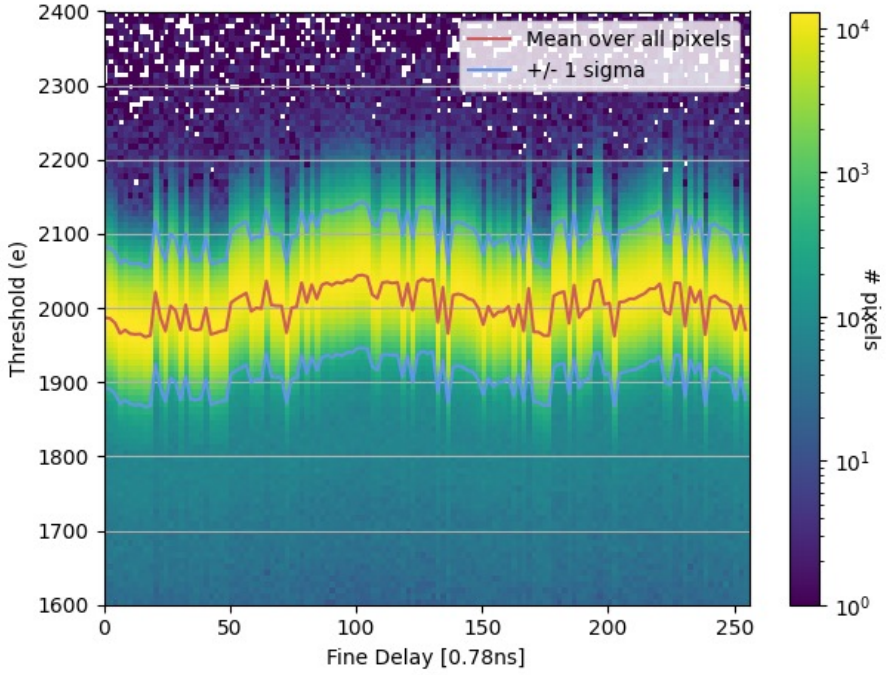
v1.1, with biased HPK planar sensor

0x130d8 (chip C)

DiffPreamp: 500



DiffPreamp: 300



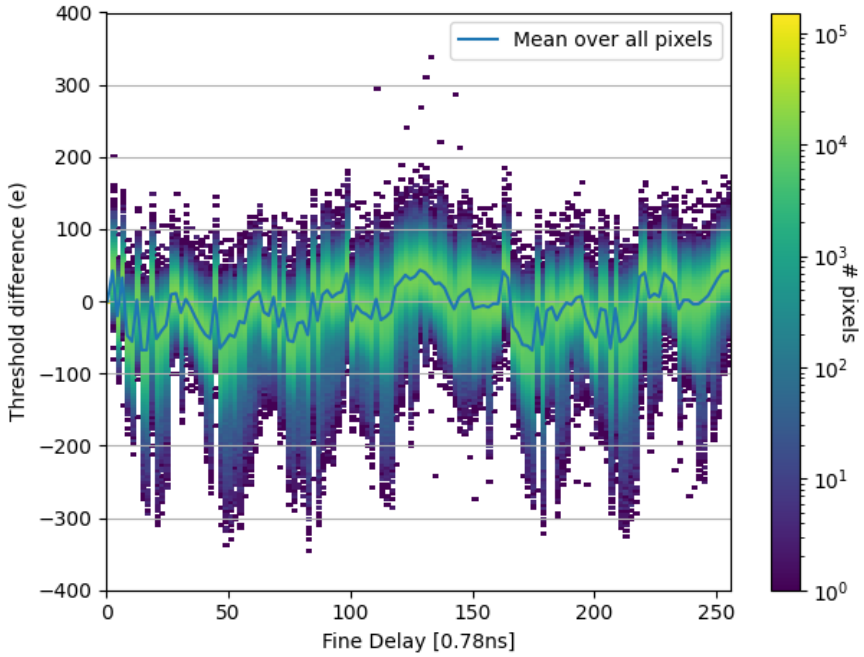
(with retuning to 2000 e)

Quad results

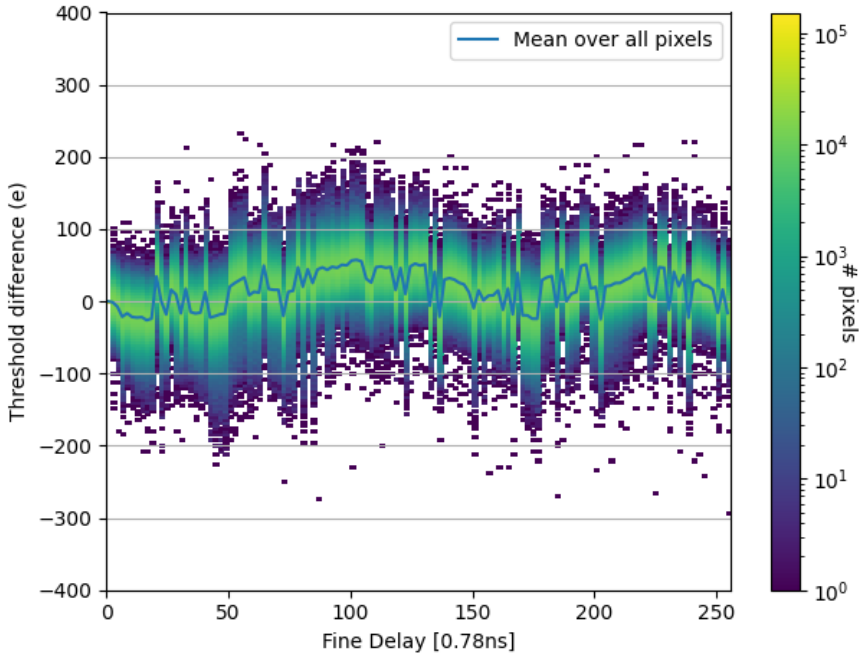
v1.1, with biased HPK planar sensor

0x130d8 (chip C)

DiffPreamp: 500



DiffPreamp: 300



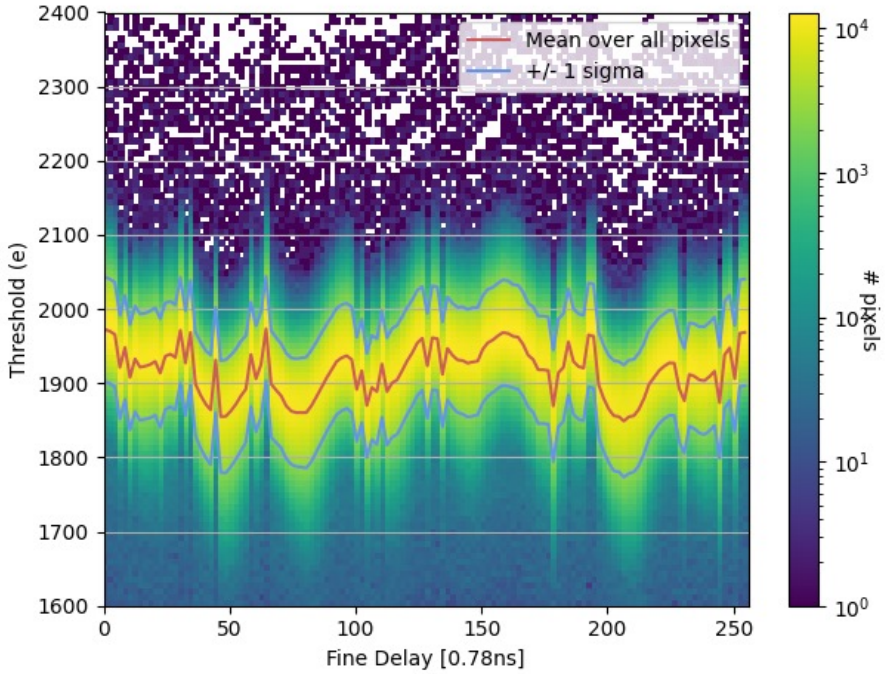
(with retuning to 2000 e)

Quad results

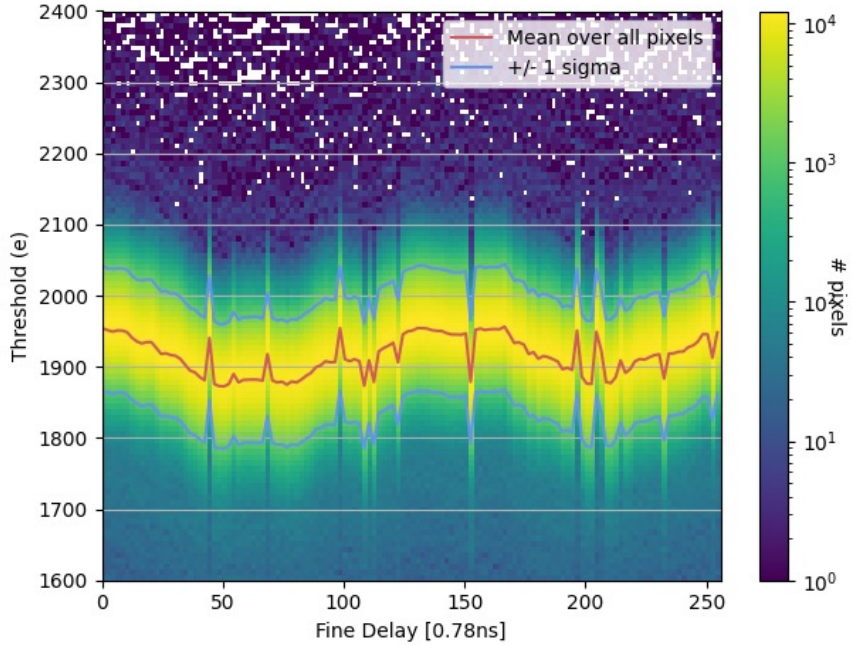
v1.1, with biased HPK planar sensor

0x138b6 (chip D)

DiffPreamp: 500



DiffPreamp: 300



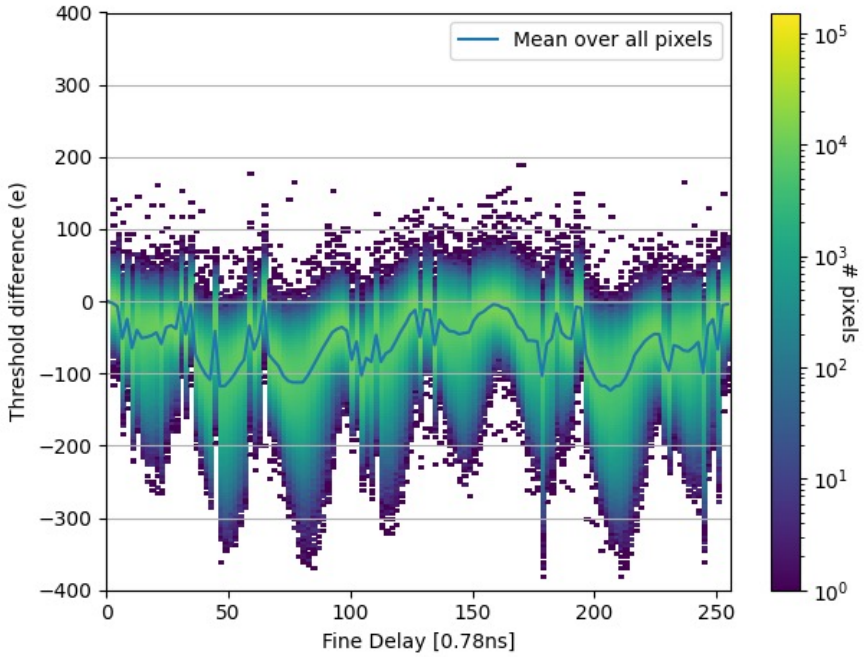
(with retuning to 2000 e)

Quad results

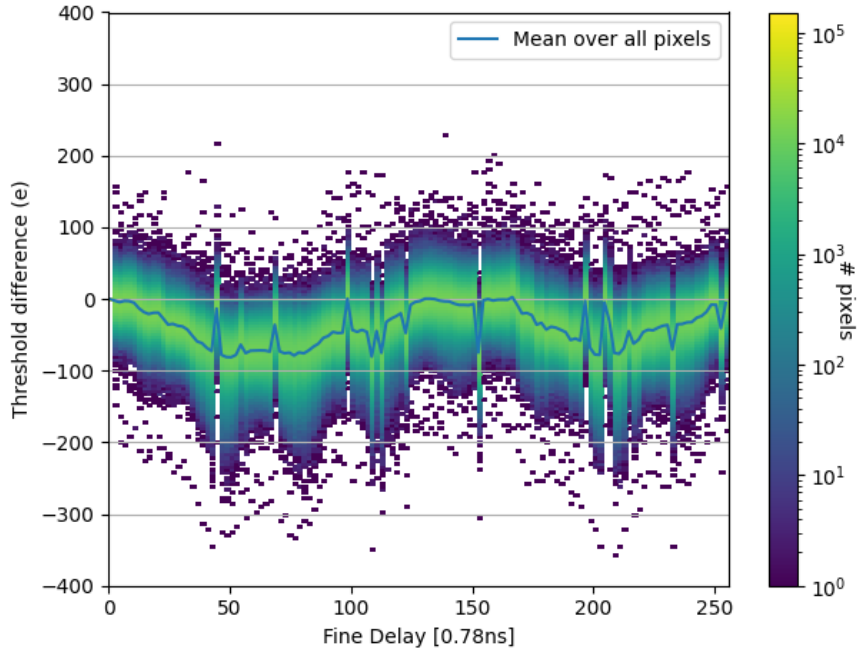
v1.1, with biased HPK planar sensor

0x138b6 (chip D)

DiffPreamp: 500



DiffPreamp: 300



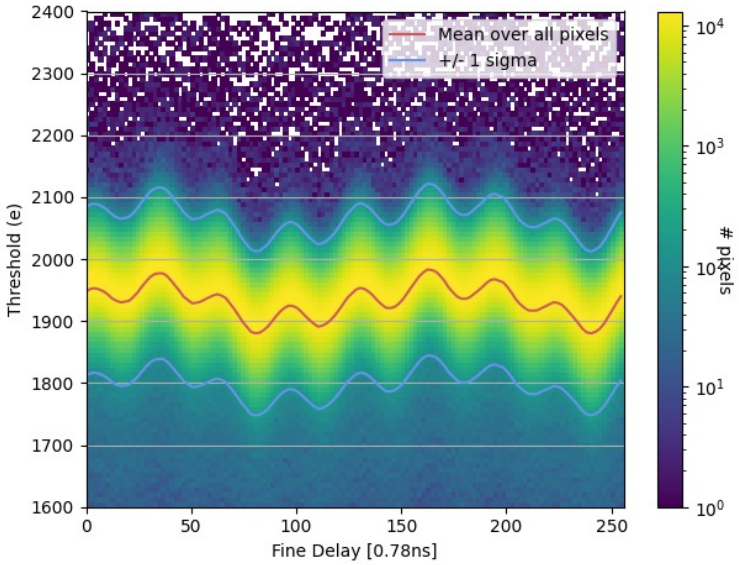
(with retuning to 2000 e)

Quad results

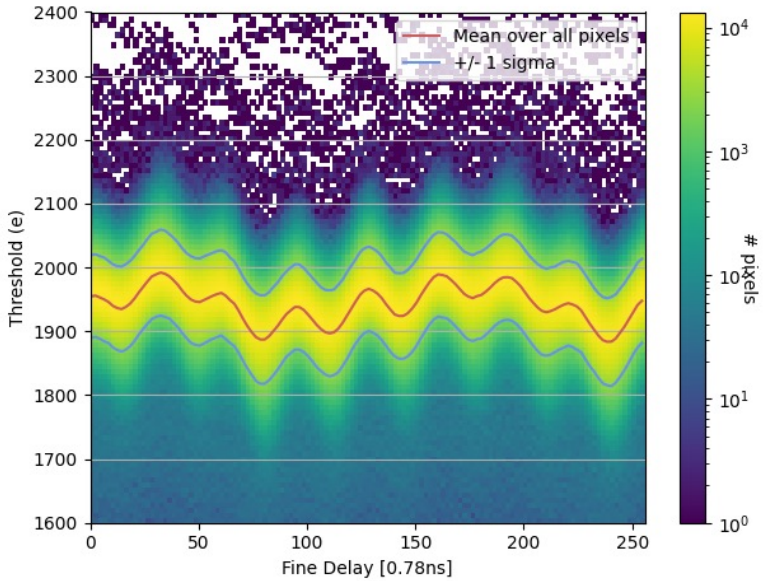
v1.1, with biased HPK planar sensor

0x130bc (chip A)

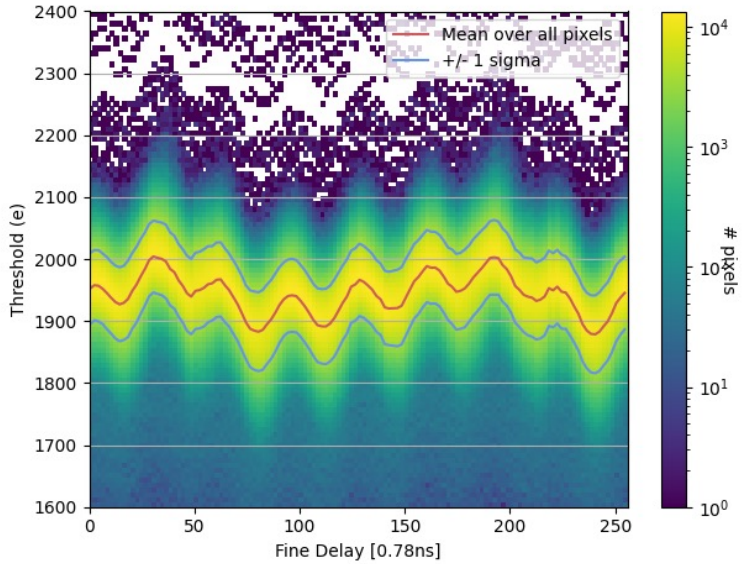
DiffComp: 300



DiffComp: 500



DiffComp: 1000



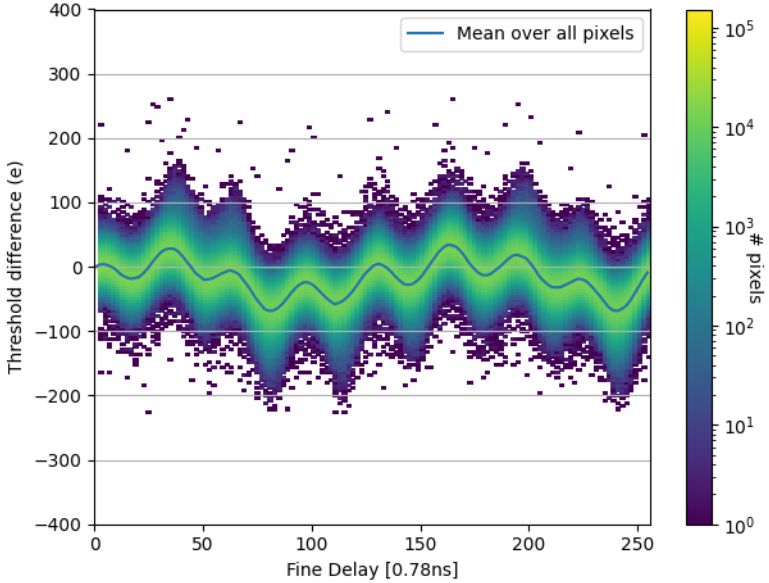
(with retuning to 2000 e)

Quad results

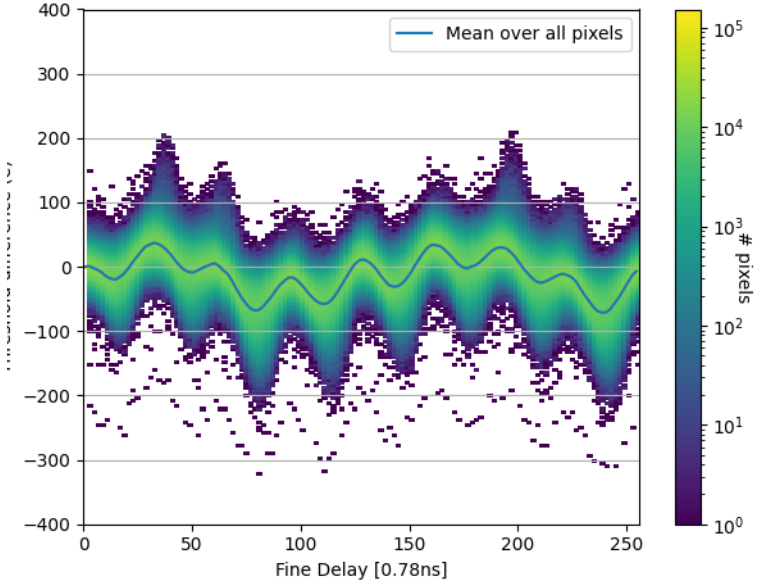
v1.1, with biased HPK planar sensor

0x130bc (chip A)

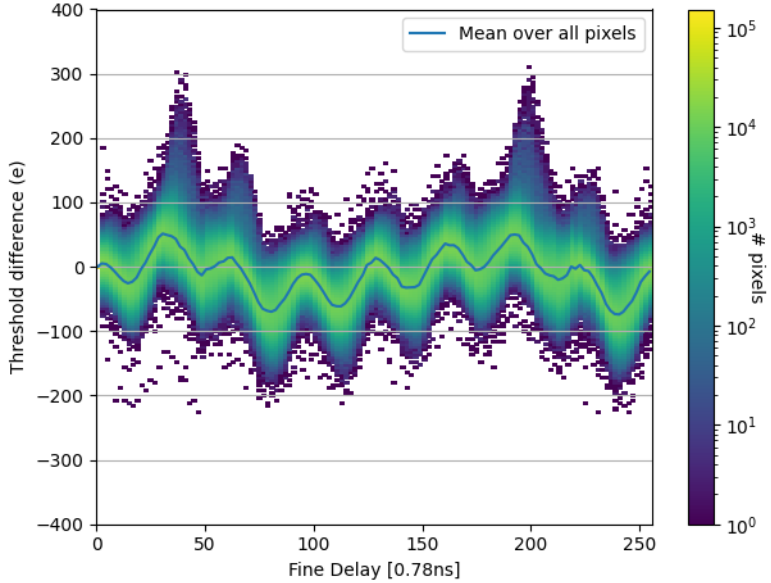
DiffComp: 300



DiffComp: 500



DiffComp: 1000



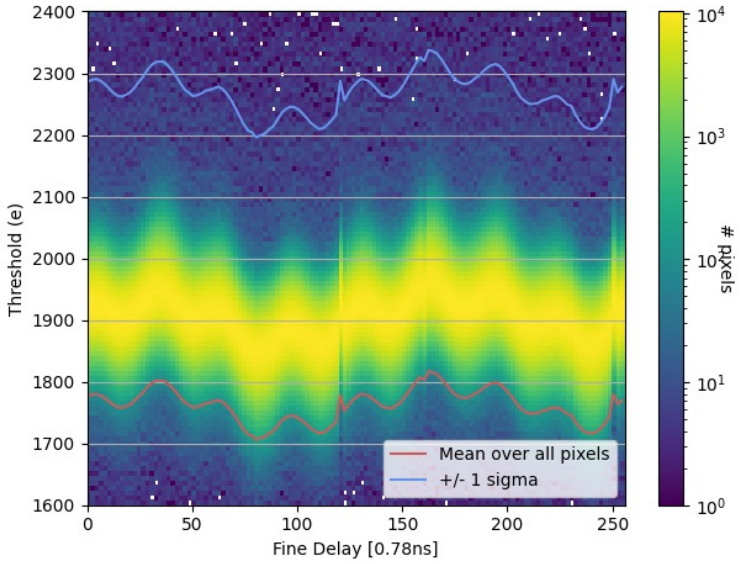
(with retuning to 2000 e)

Quad results

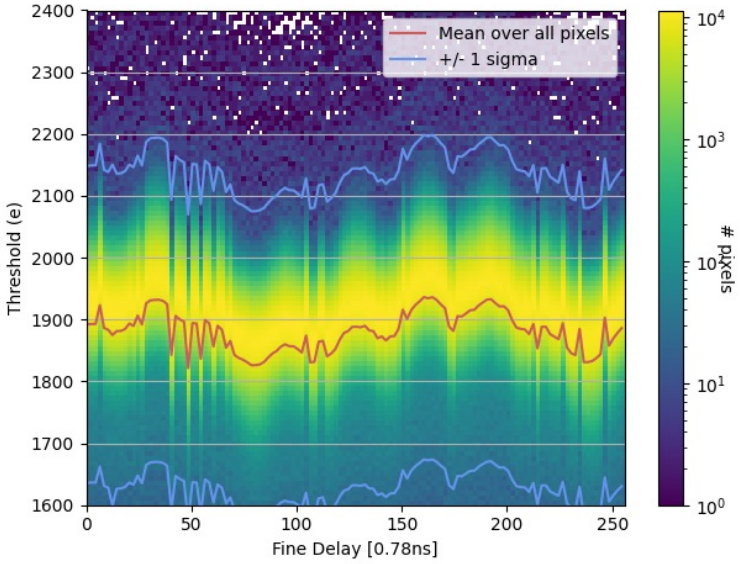
v1.1, with biased HPK planar sensor

0x130c9 (chip B)

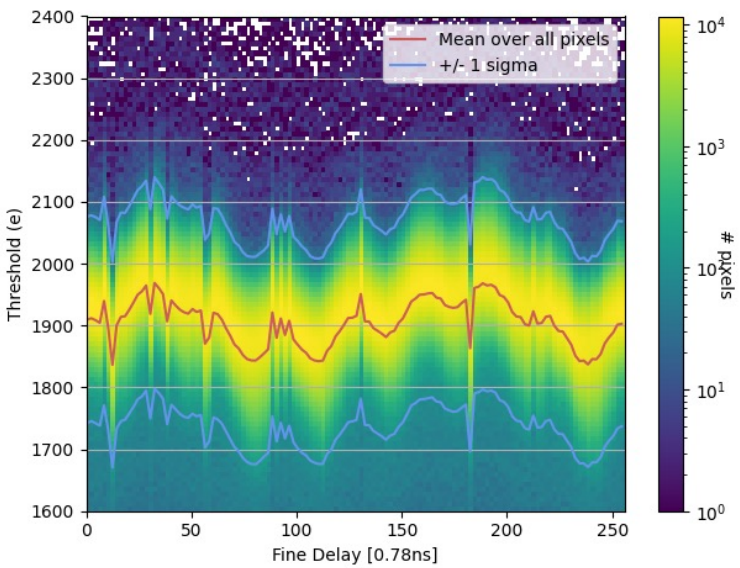
DiffComp: 300



DiffComp: 500



DiffComp: 1000



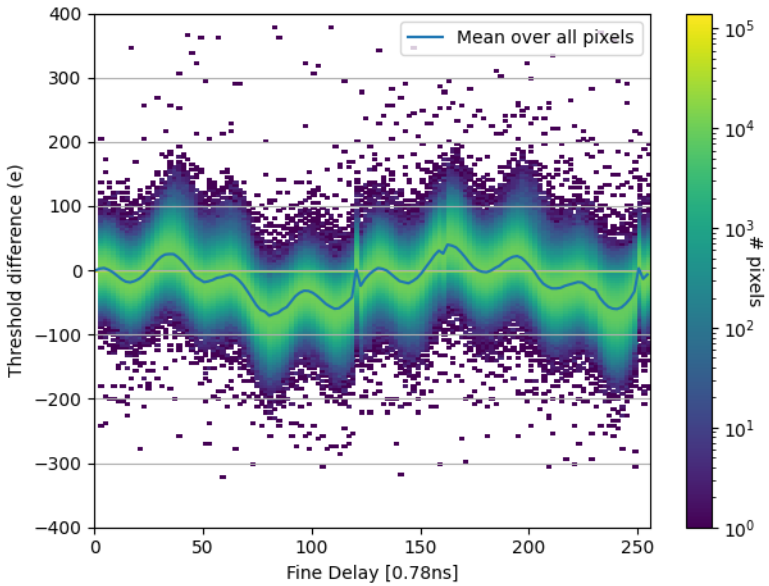
(with retuning to 2000 e)

Quad results

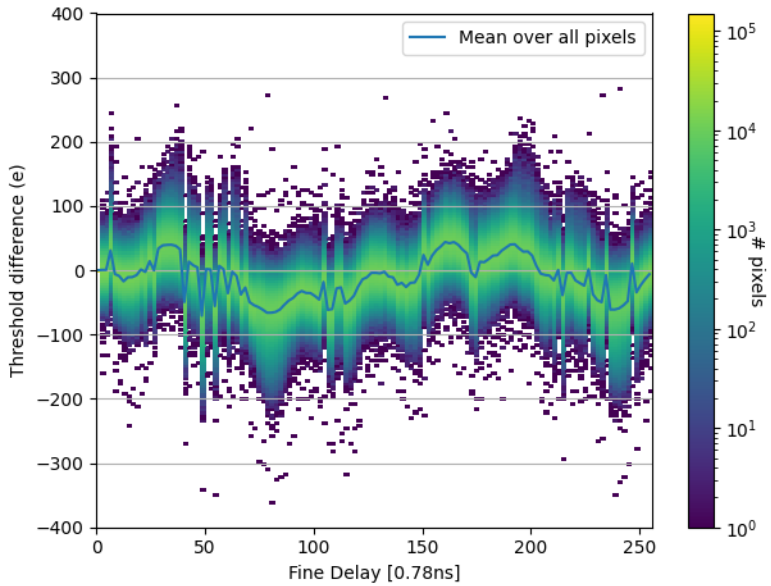
v1.1, with biased HPK planar sensor

0x130c9 (chip B)

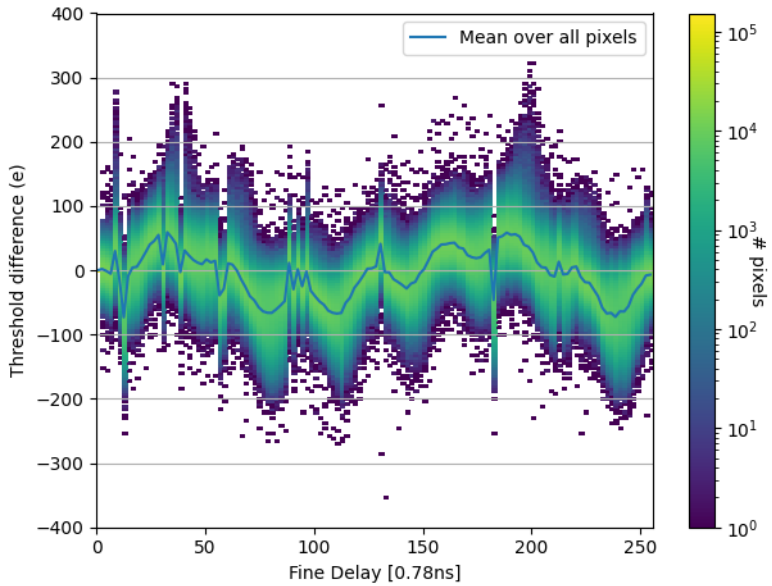
DiffComp: 300



DiffComp: 500



DiffComp: 1000



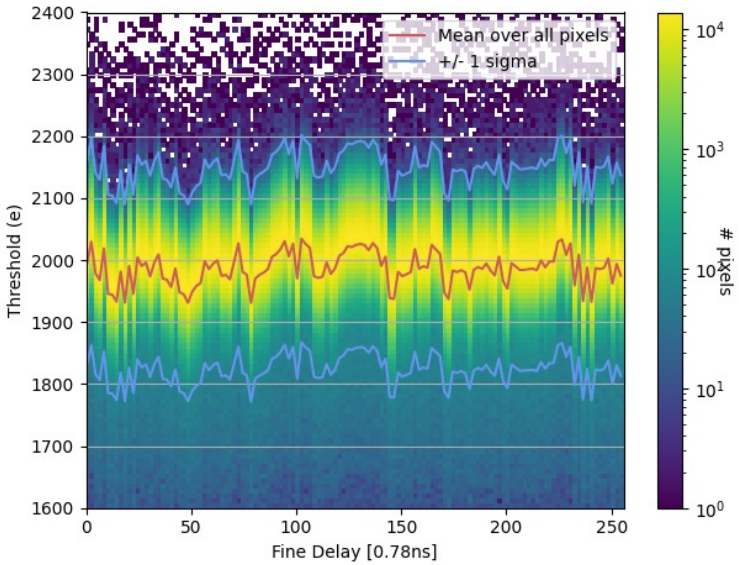
(with retuning to 2000 e)

Quad results

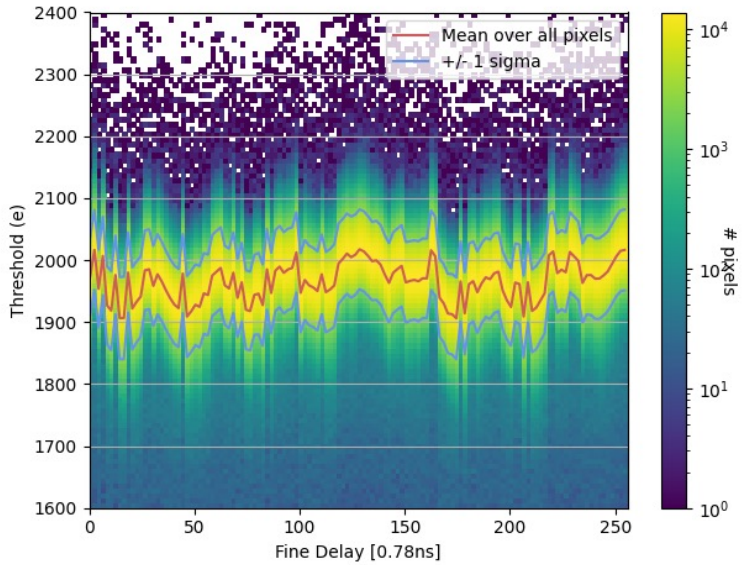
v1.1, with biased HPK planar sensor

0x130d8 (chip C)

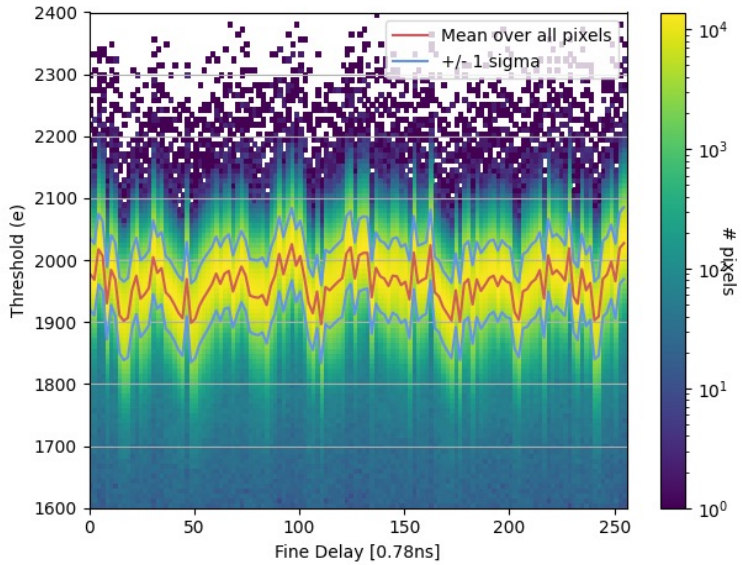
DiffComp: 300



DiffComp: 500



DiffComp: 1000



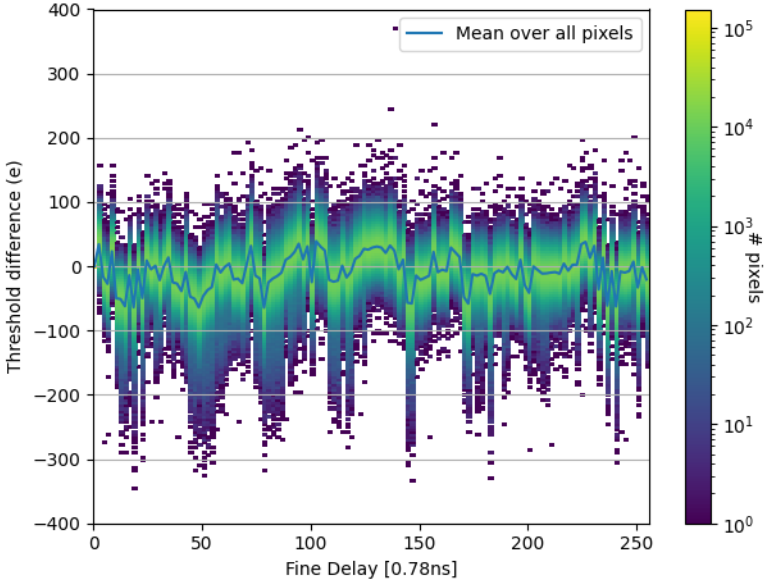
(with retuning to 2000 e)

Quad results

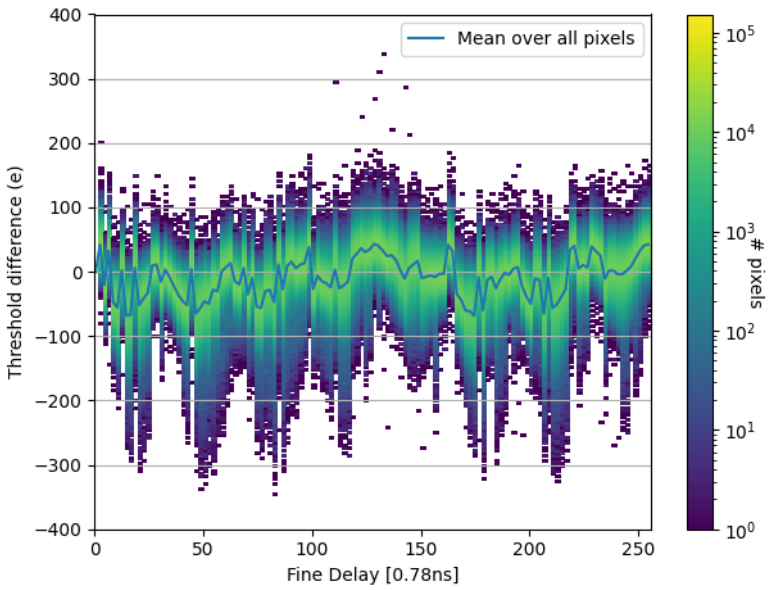
v1.1, with biased HPK planar sensor

0x130d8 (chip C)

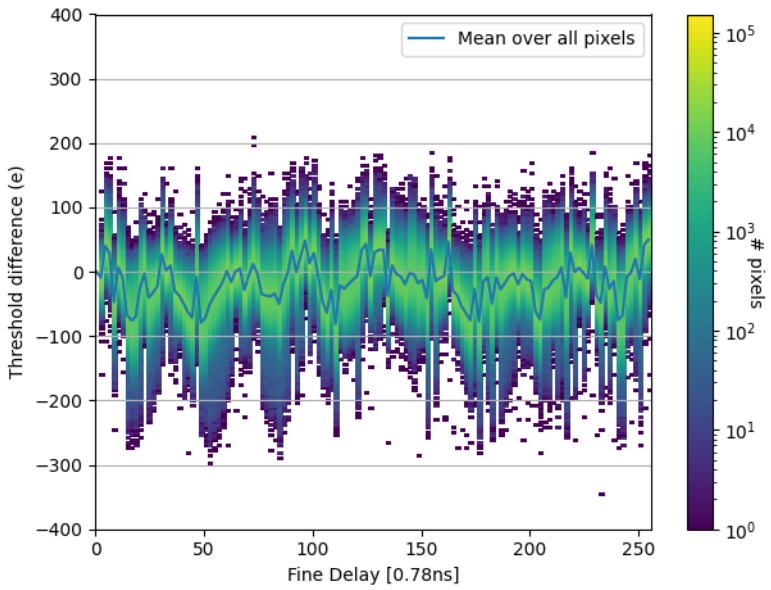
DiffComp: 300



DiffComp: 500



DiffComp: 1000



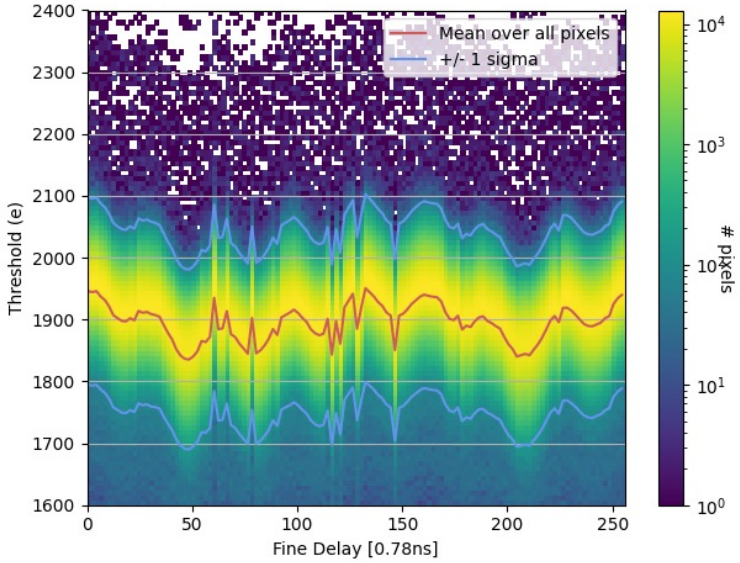
(with retuning to 2000 e)

Quad results

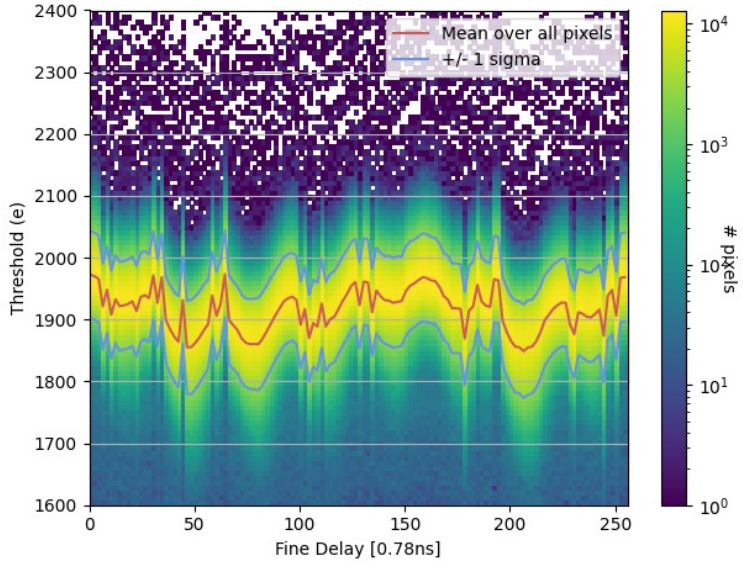
v1.1, with biased HPK planar sensor

0x138b6 (chip D)

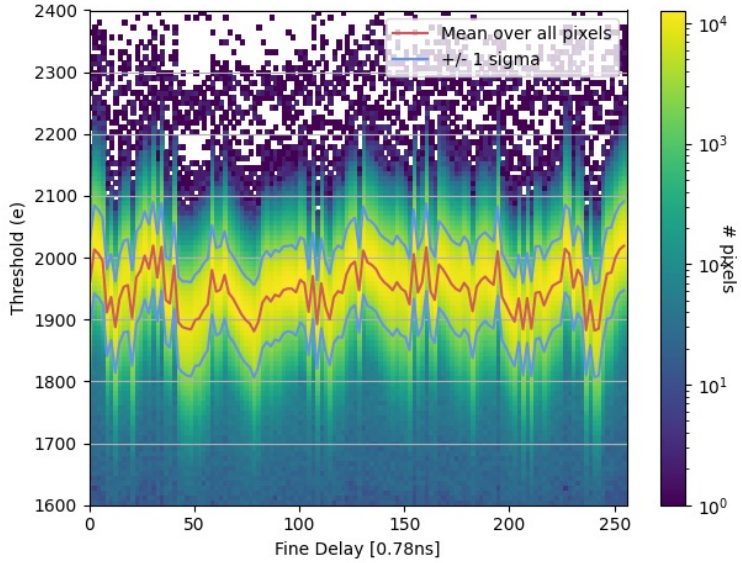
DiffComp: 300



DiffComp: 500



DiffComp: 1000



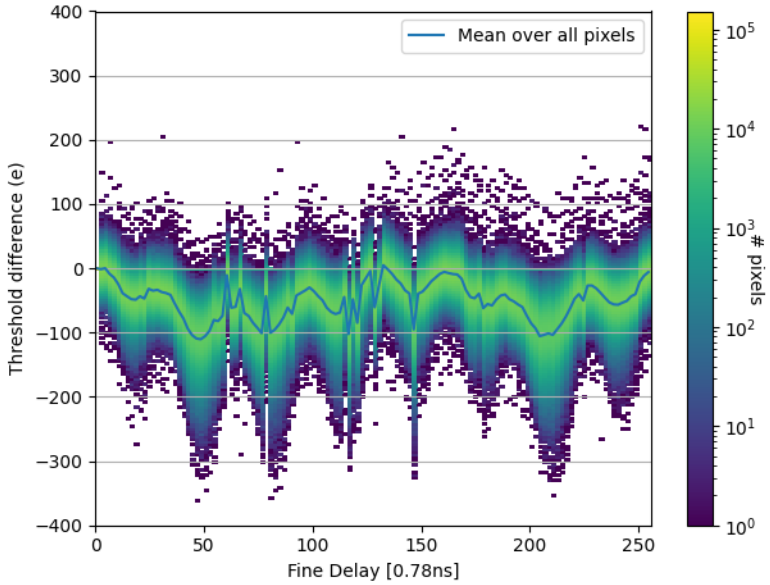
(with retuning to 2000 e)

Quad results

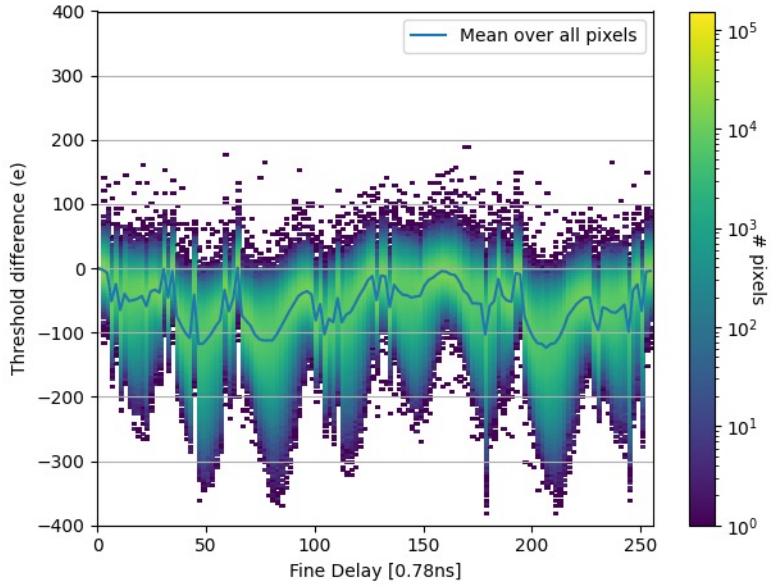
v1.1, with biased HPK planar sensor

0x138b6 (chip D)

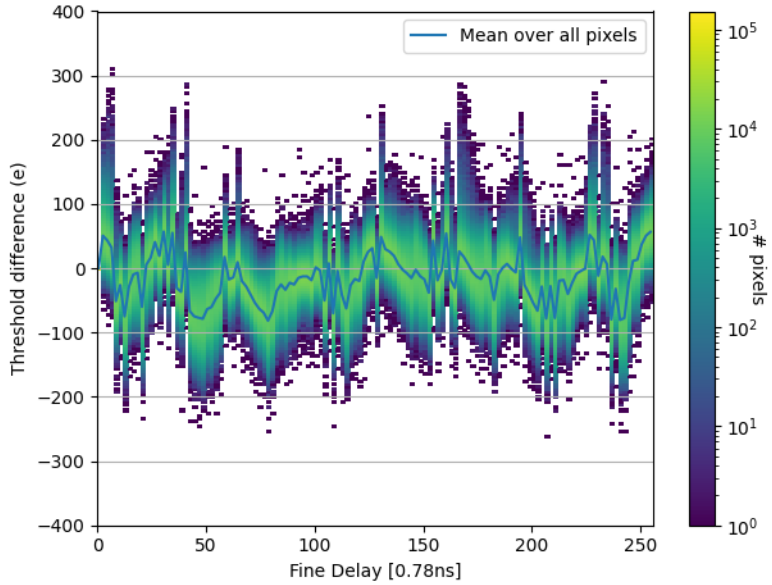
DiffComp: 300



DiffComp: 500



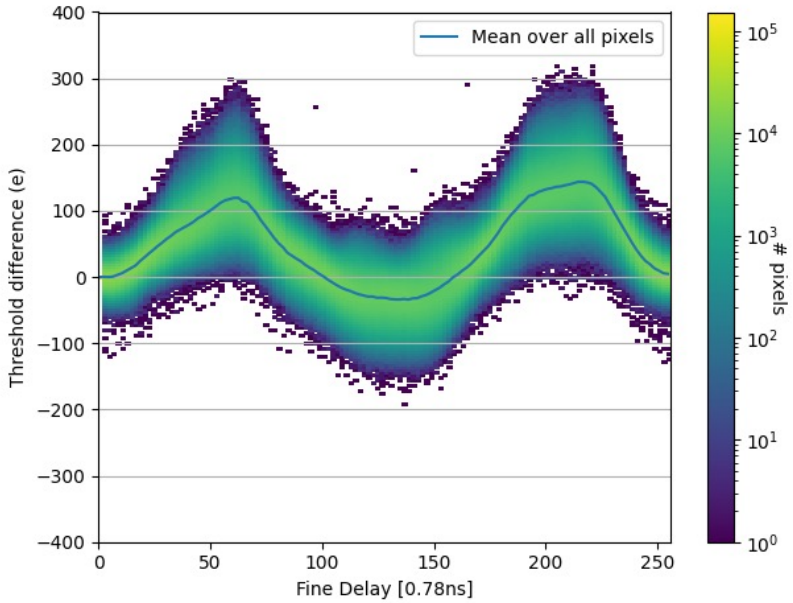
DiffComp: 1000



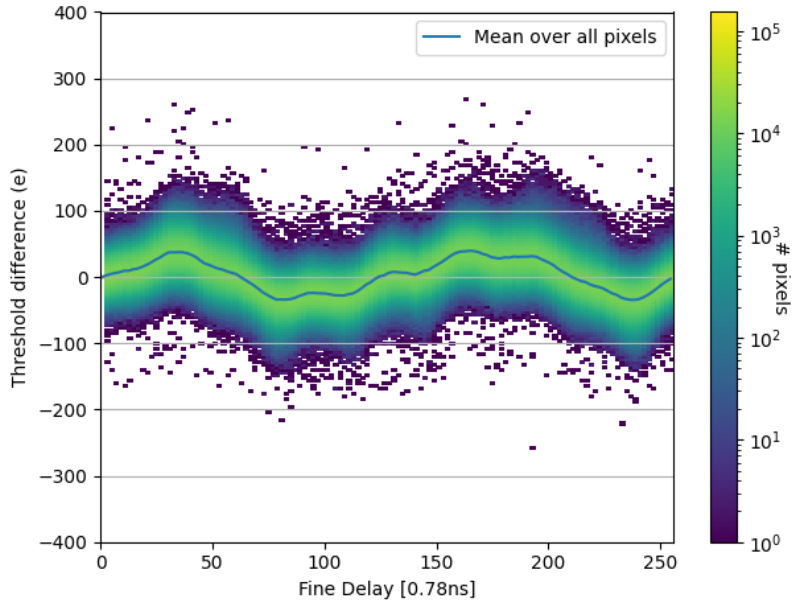
(with retuning to 2000 e)

Focus of next studies

3D sensor, default config, room temp



HPK planar sensor,
DiffPreamp = 300



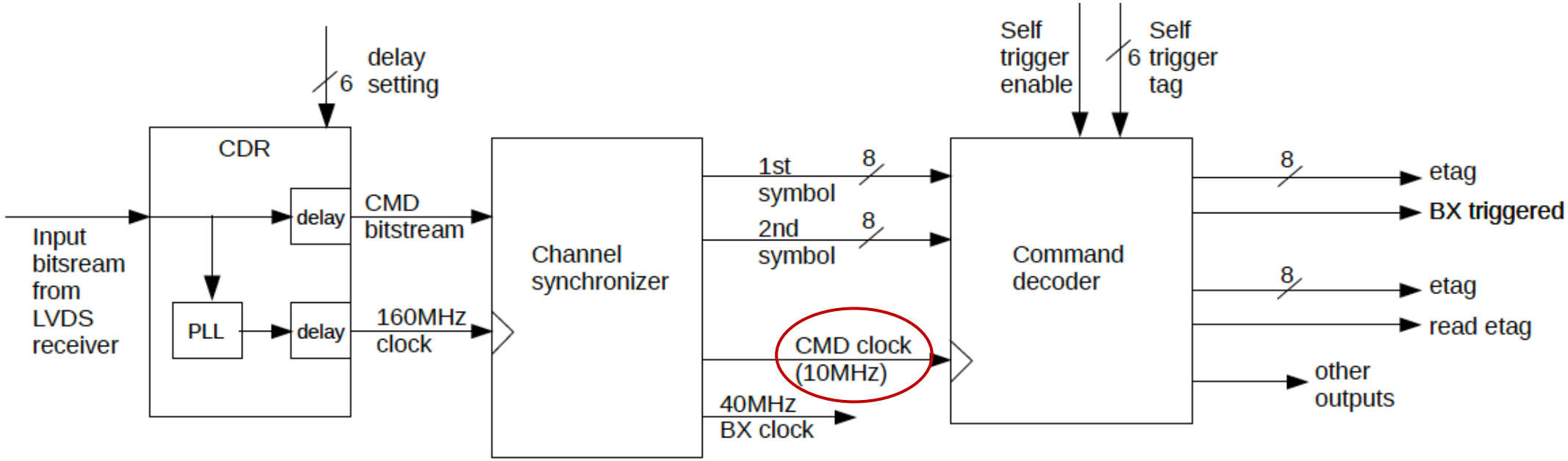
1. Amplitude of 10 MHz oscillation is smaller in HPK planar sensor – why?
2. 40 MHz not clearly visible in 3D sensor – why?

- LCC is different, but no change when turning on LCC in 3D sensor
- Differences in electrical connections between quad and SCC
- Powering is different (LDO in SCC vs. SLDO in quad)

Next steps:

1. Test two more SCC's with 3D sensor
2. Power SCC's in SLDO
3. Power PLL separately

CMD clock


6
delay
setting
CDR
delay
CMD
bitstream
Input
bitsream
from
LVDS
receiver
PLL
delay
160MHz
clock
Channel
synchronizer
1st
symbol
8
2nd
symbol
8
CMD clock
(10MHz)
40MHz
BX clock
Self
trigger
enable
6
Self
trigger
tag
Command
decoder
8
etag
BX triggered
8
etag
read etag
other
outputs

Context

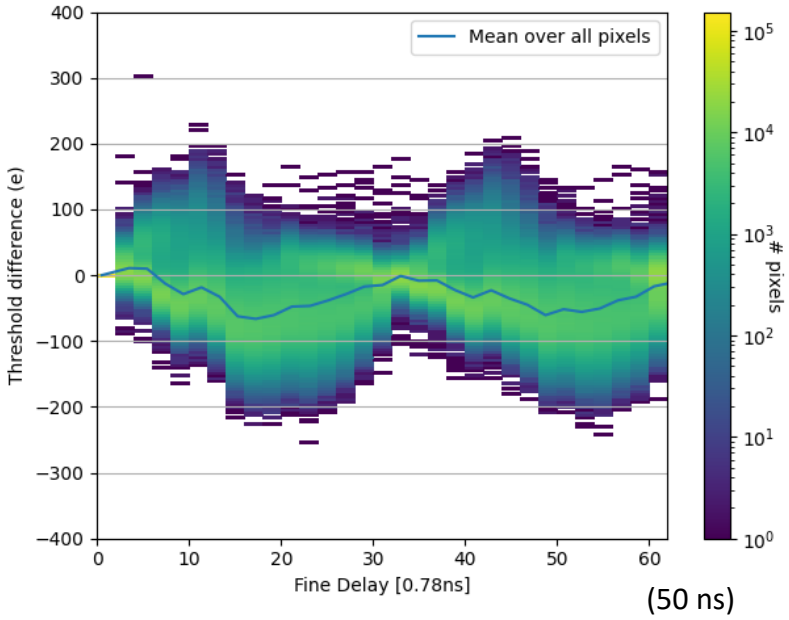
- ITkPix v1.0 SCC's
- No sensor
- Single and double isolation
- Kept in freezer at -20 C

DiffComp studies

v1.0, no sensor, single iso

- Chip is retuned to 2000e after changing DiffComp
- Scanning fine delay (0.78125 ns each, but in steps of 2) with cal edge delay = 0

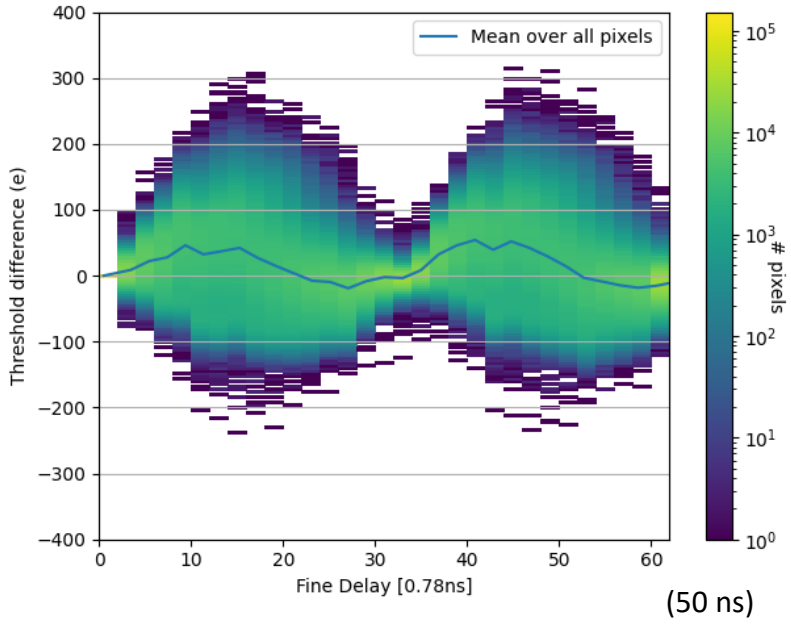
DiffComp = 300



(50 ns)

DiffTH1L/M/R: 200/206/200

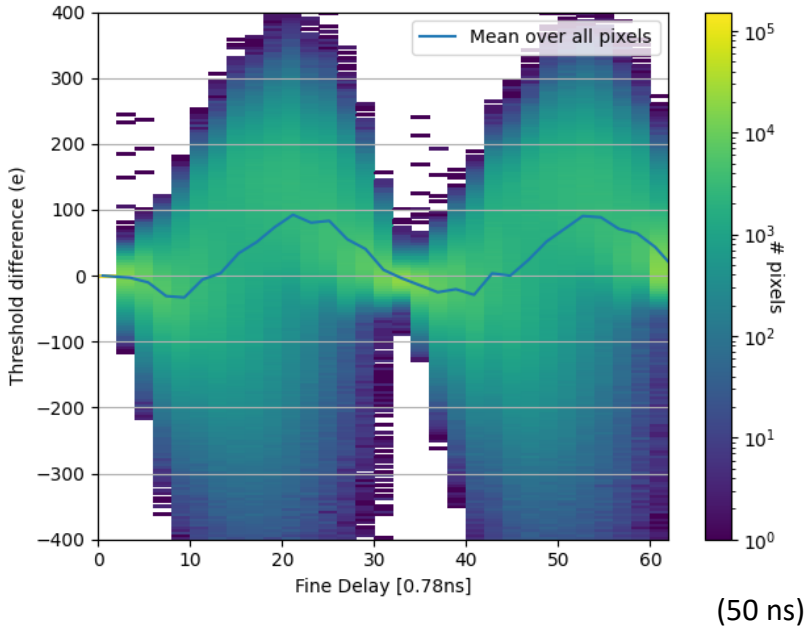
DiffComp = 500 (default)



(50 ns)

DiffTH1L/M/R: 200/246/200

DiffComp = 1000



(50 ns)

DiffTH1L/M/R: 200/286/200

- We see 40 MHz oscillation
- Amplitude changes slightly, dispersion increases with higher DiffComp

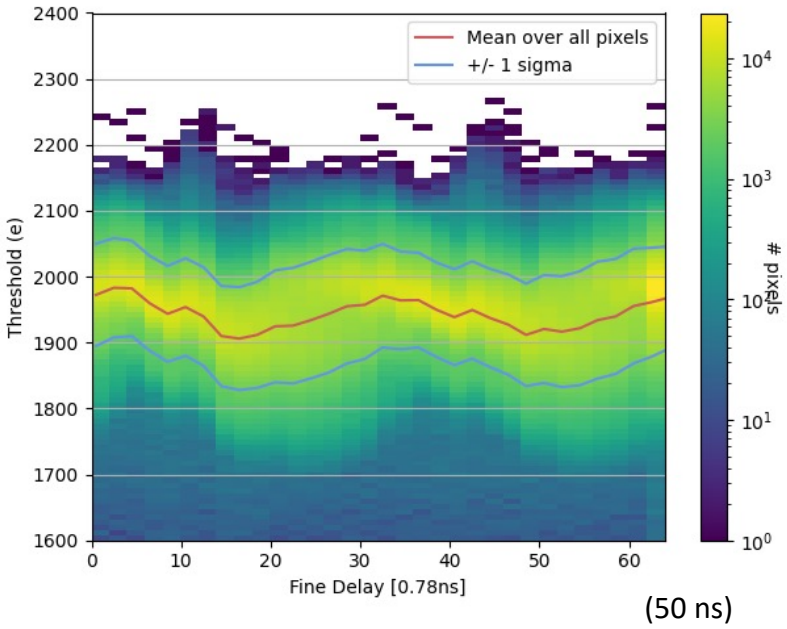
(Note x-axis range difference)

DiffComp studies

v1.0, no sensor, single iso

- Chip is retuned to 2000e after changing DiffComp
- Scanning fine delay (0.78125 ns each, but in steps of 2) with cal edge delay = 0

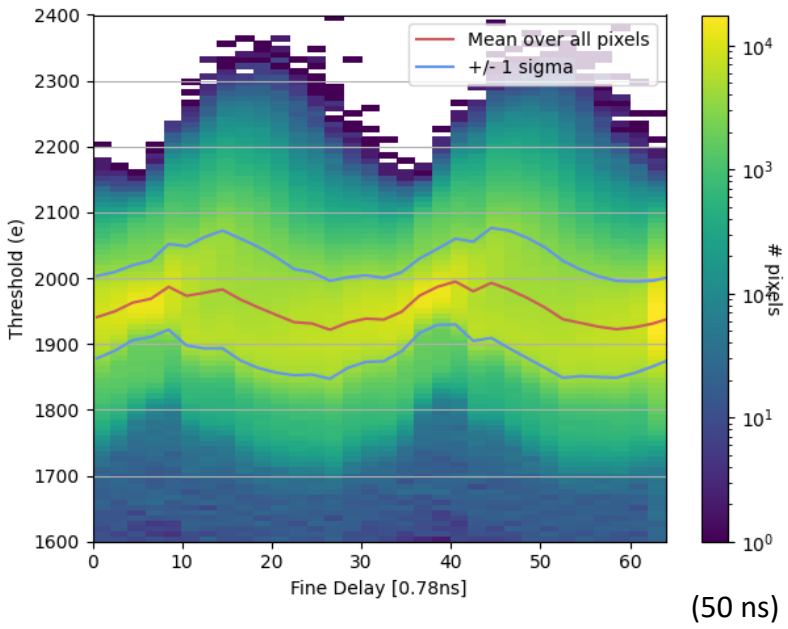
DiffComp = 300



(50 ns)

DiffTH1L/M/R: 200/206/200

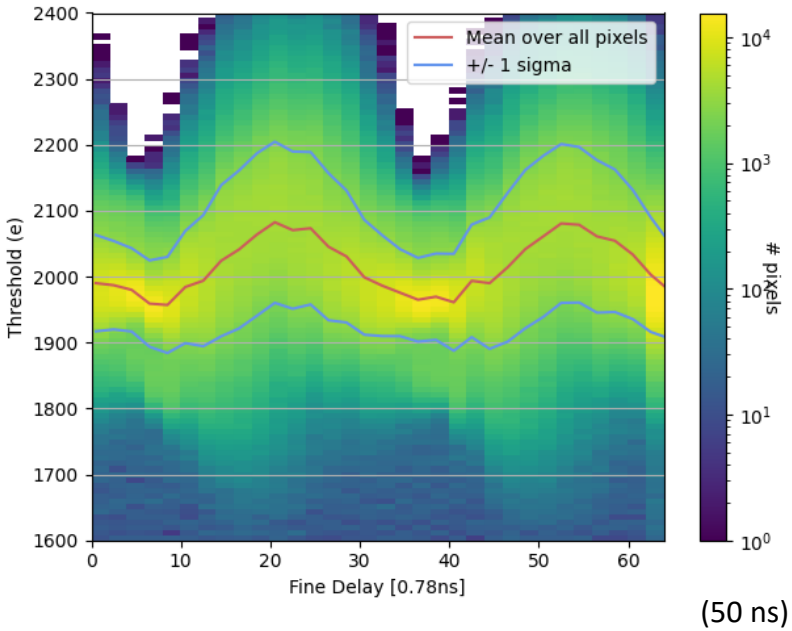
DiffComp = 500 (default)



(50 ns)

DiffTH1L/M/R: 200/246/200

DiffComp = 1000



(50 ns)

DiffTH1L/M/R: 200/286/200

- We see 40 MHz oscillation
- Amplitude changes slightly, dispersion increases with higher DiffComp

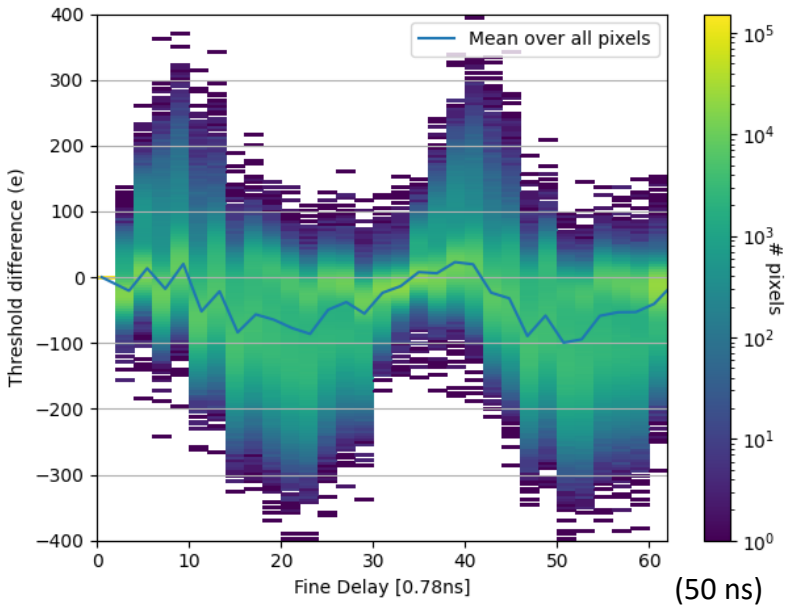
(Note x-axis range difference)

DiffComp studies

v1.0, no sensor, double iso

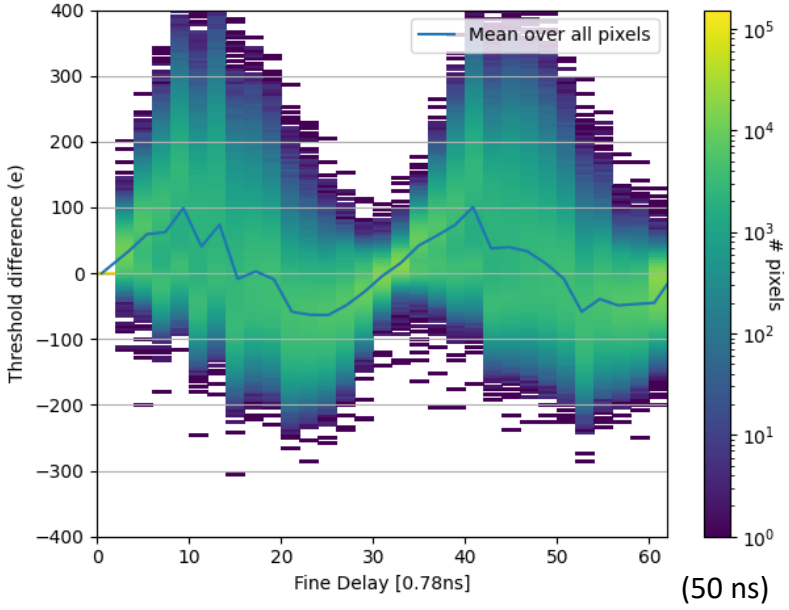
- Chip is retuned to 2000e after changing DiffComp
- Scanning fine delay (0.78 ns each, but in steps of 2) with cal edge delay = 0

DiffComp = 300



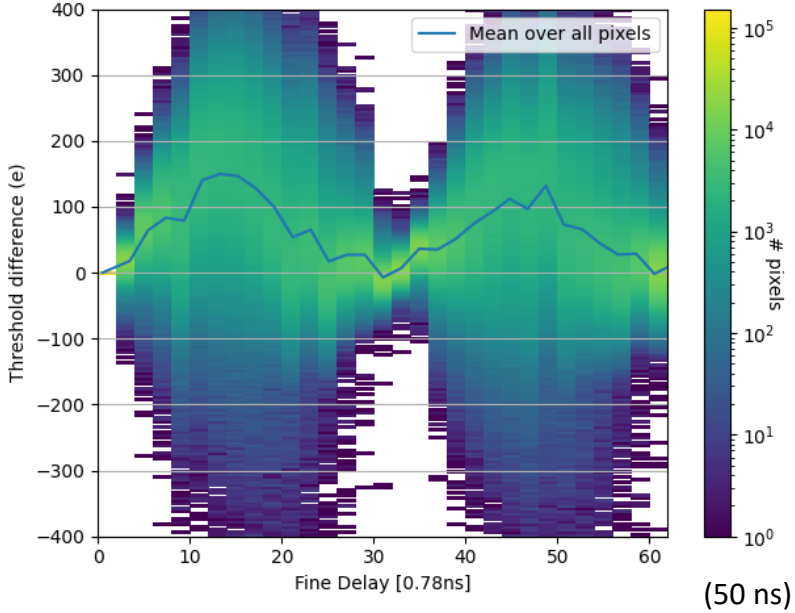
DiffTH1L/M/R: 200/238/200

DiffComp = 500 (default)



DiffTH1L/M/R: 200/270/200

DiffComp = 1000



DiffTH1L/M/R: 200/302/200

- We see 40 MHz oscillation
- Amplitude changes slightly, dispersion increases with higher DiffComp

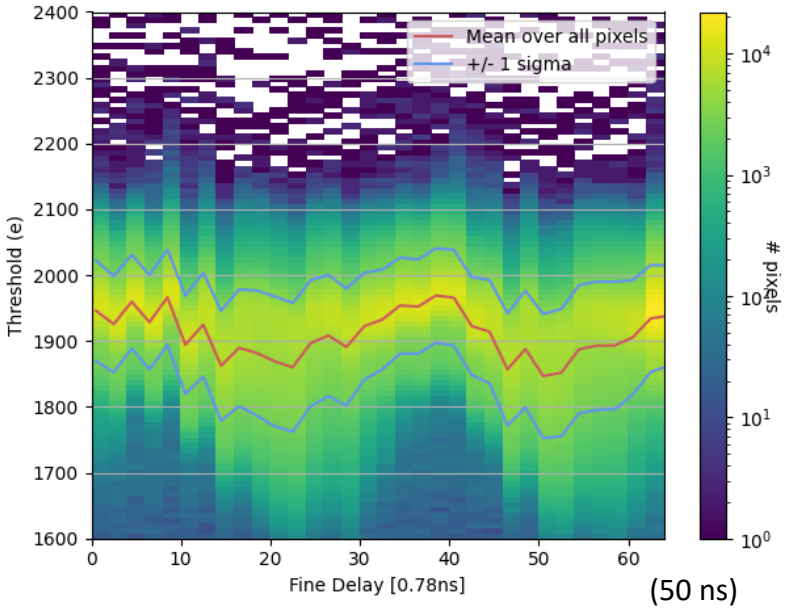
(Note x-axis range difference)

DiffComp studies

v1.0, no sensor, double iso

- Chip is retuned to 2000e after changing DiffComp
- Scanning fine delay (0.78 ns each, but in steps of 2) with cal edge delay = 0

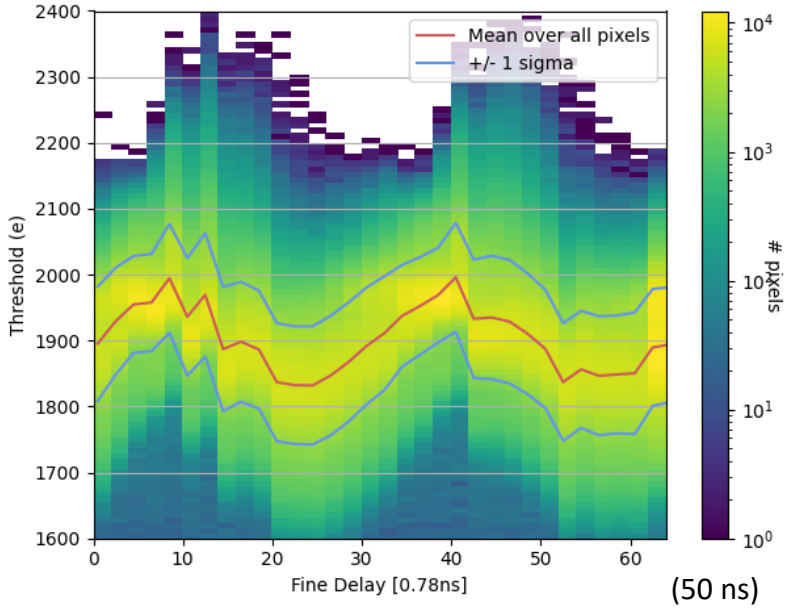
DiffComp = 300



(50 ns)

DiffTH1L/M/R: 200/238/200

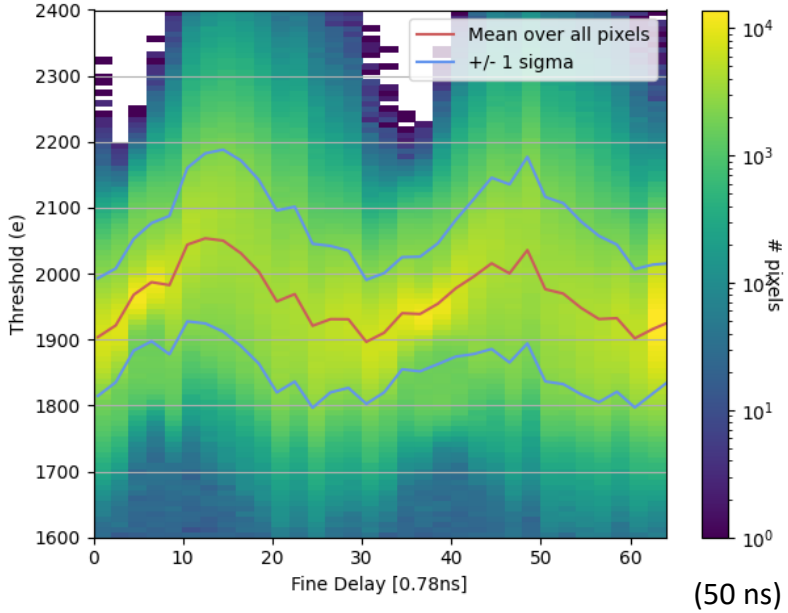
DiffComp = 500 (default)



(50 ns)

DiffTH1L/M/R: 200/270/200

DiffComp = 1000



(50 ns)

DiffTH1L/M/R: 200/302/200

- We see 40 MHz oscillation
- Amplitude changes slightly, dispersion increases with higher DiffComp

(Note x-axis range difference)

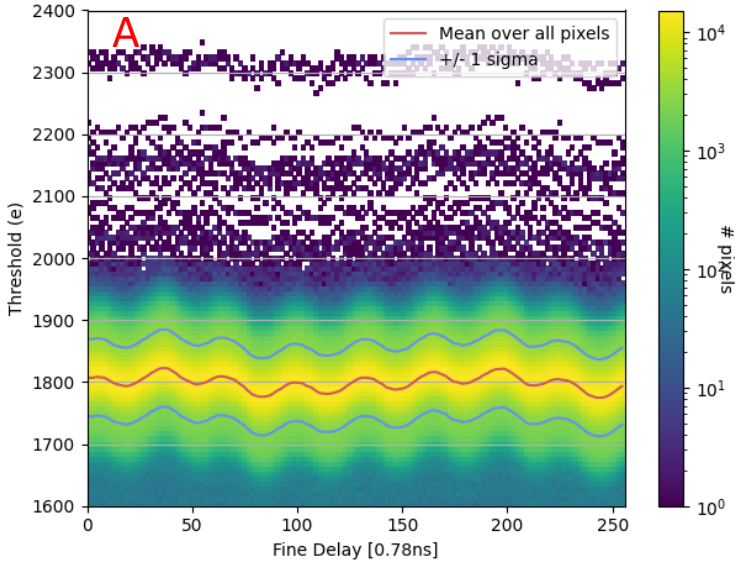
- ITkPix v1.1 quad module
- No sensor
- Room temperature

Quad module with bare chip (no sensor)

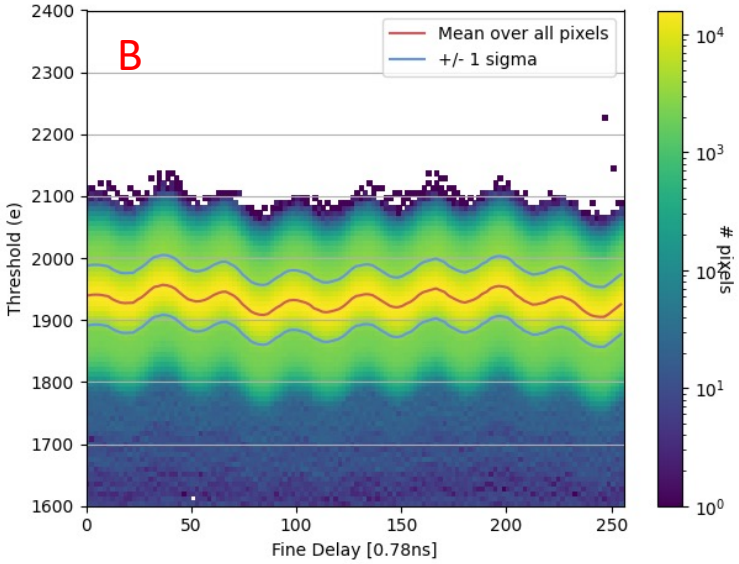
v1.1 quad, no sensor

- No sensor → 40 MHz dominant

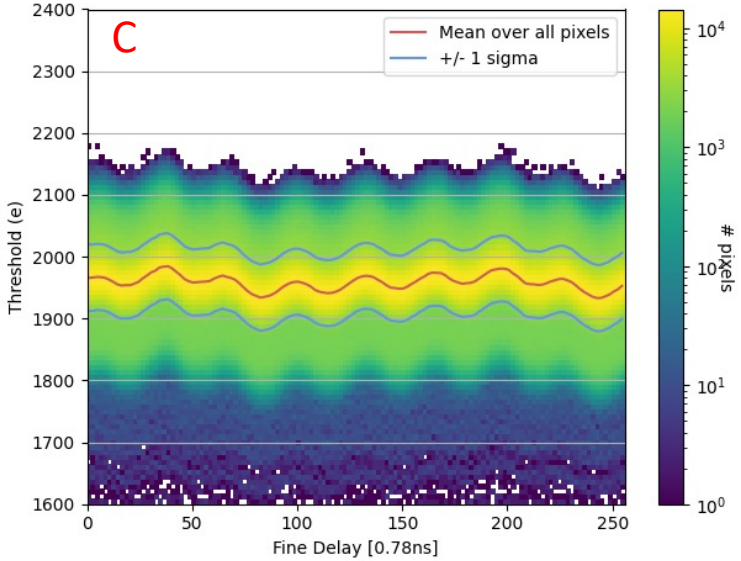
0x14118



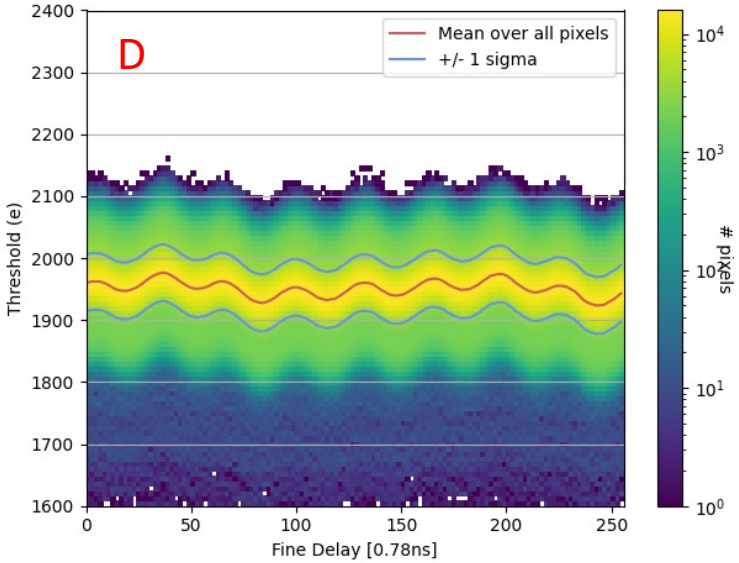
0x14119



0x14128



0x14129

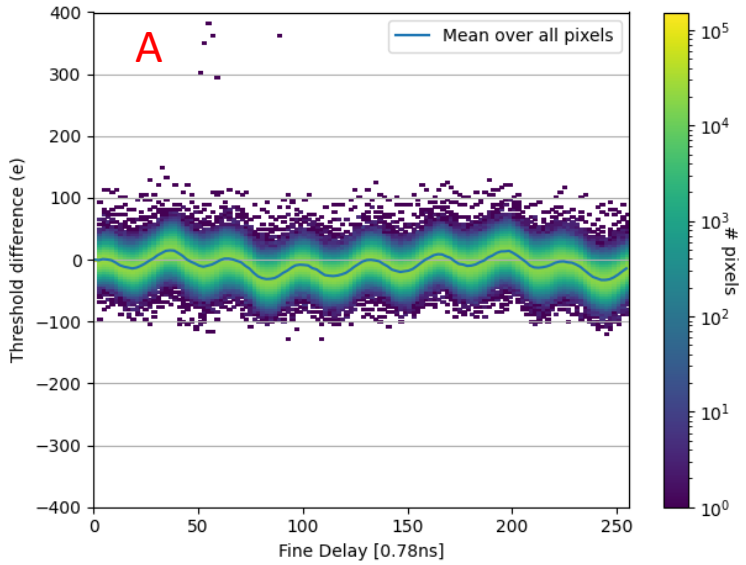


Quad module with bare chip (no sensor)

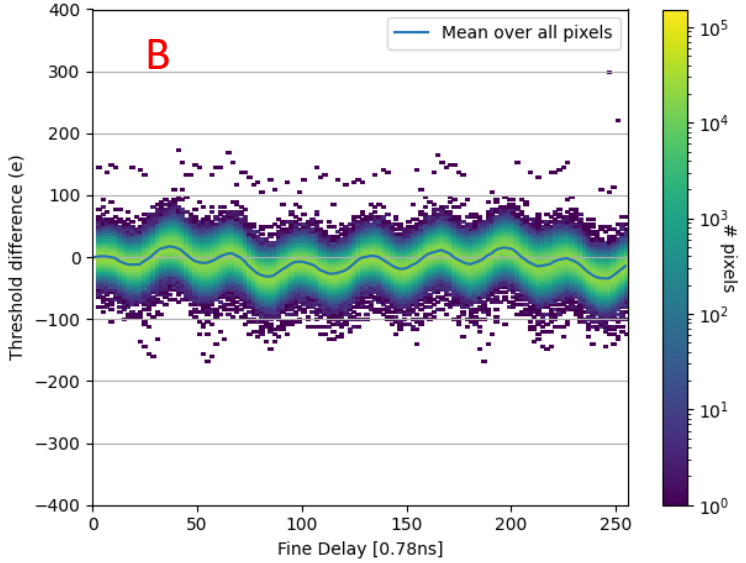
v1.1 quad, no sensor

- No sensor → 40 MHz dominant

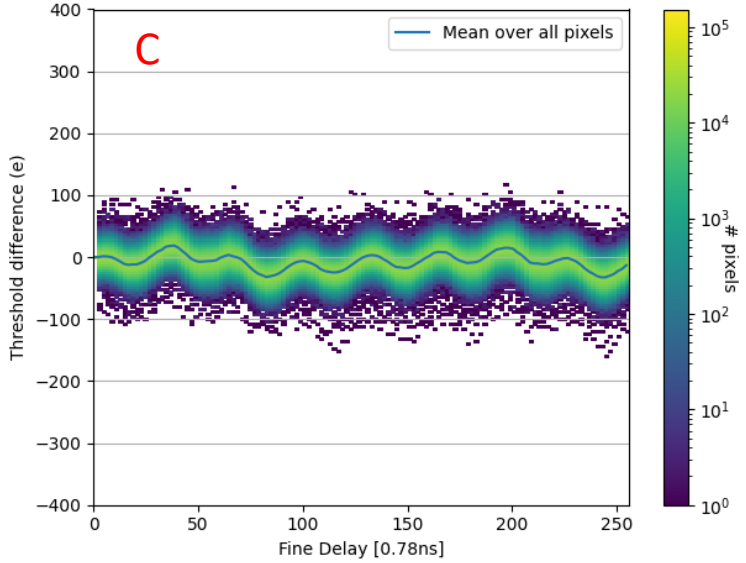
0x14118



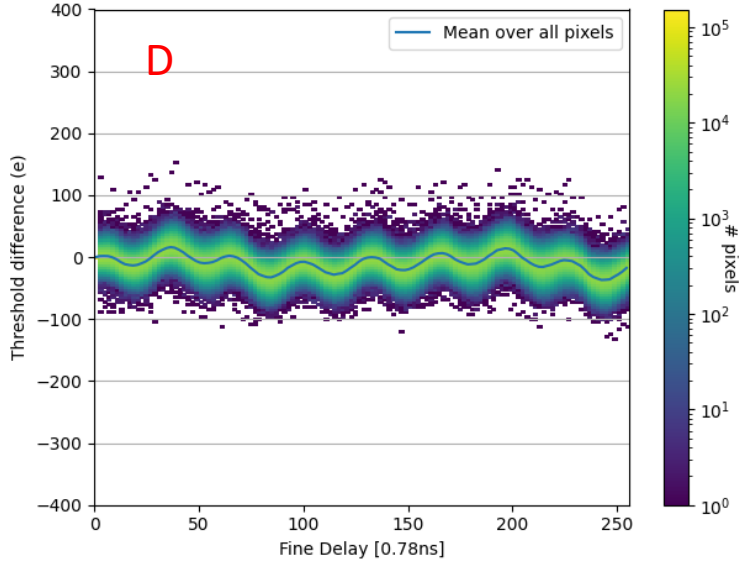
0x14119



0x14128



0x14129

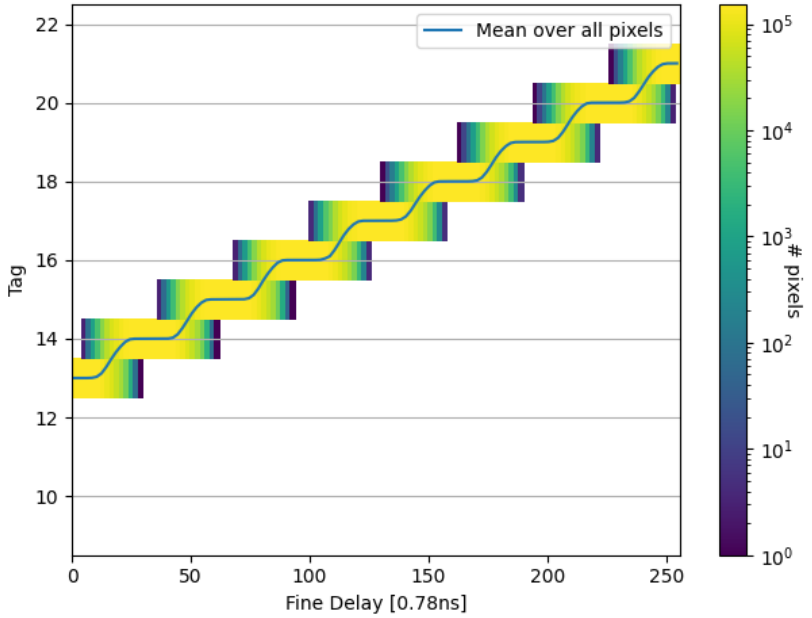


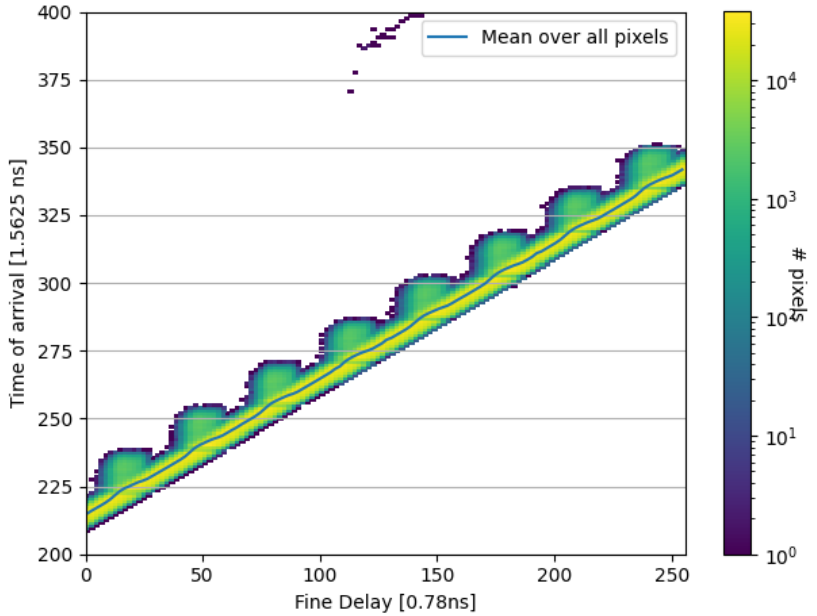
Backup

Backup: tag and toa distributions

v1.1, with unbiased 3D sensor

This slide is a sanity check that we are really scanning the full 200 ns of delay





Backup: alternative plot style

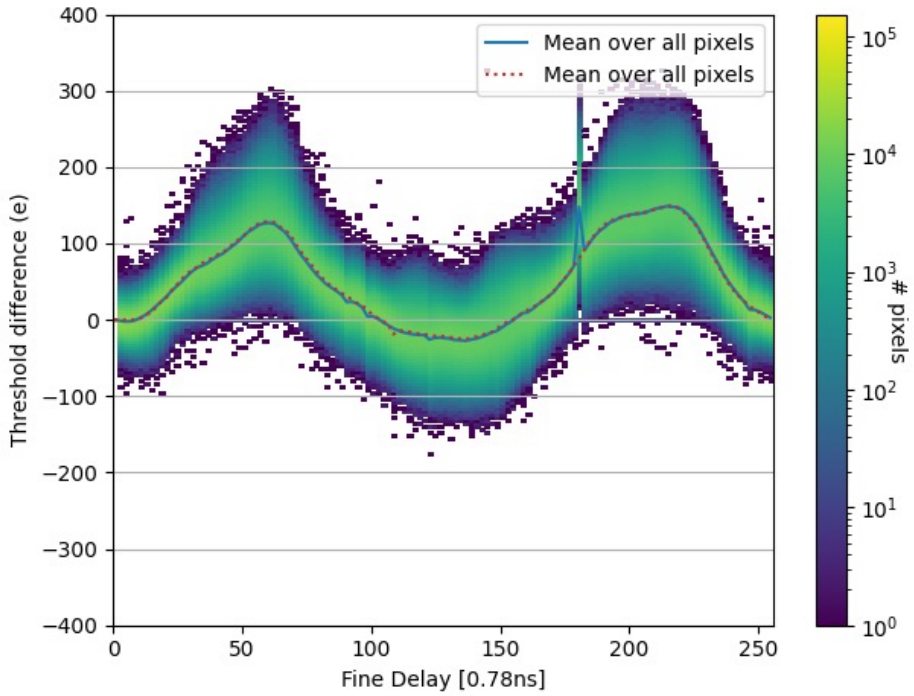
The following slides show the exact same results already presented, however in a different plotting style (showing Δthr of each pixel with respect to average)

Backup: Stability of results

v1.1, with unbiased 3D sensor

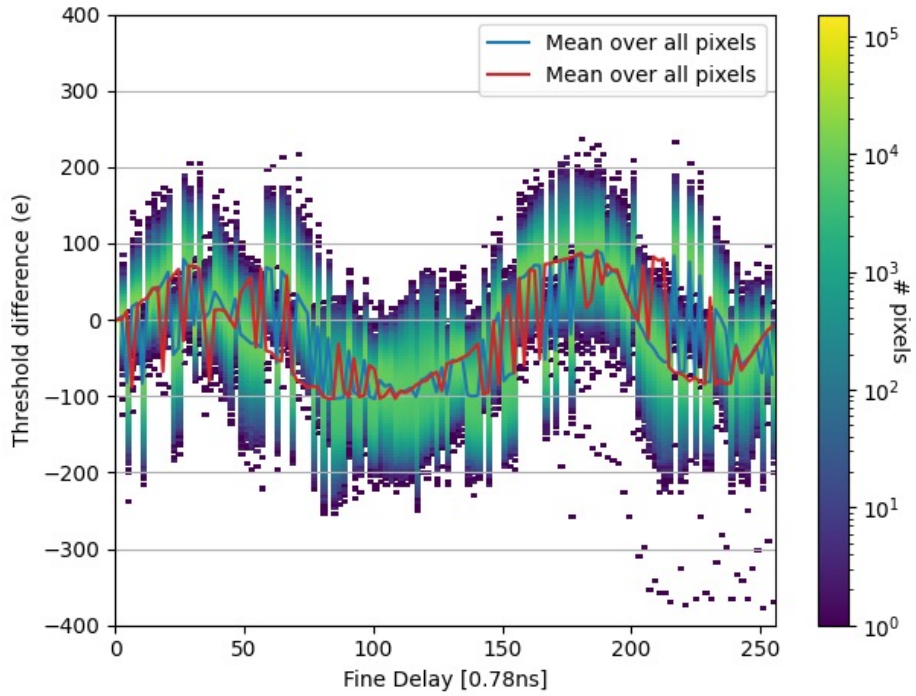
How stable are the threshold results? Do we see large variations when we run the exact same scan multiple times?

DiffPre: 500 (10 C):



Results are very stable (w/in a few electrons)

DiffPre: 600 (10 C):



Fluctuations seem to be random

1. v1.1 SCC with unbiased 3D sensor
    - 10 MHz dominant
    - No DiffPreamp dependence (though perhaps retuning is needed)
    - No temperature dependence
    - No change with LCC enabled

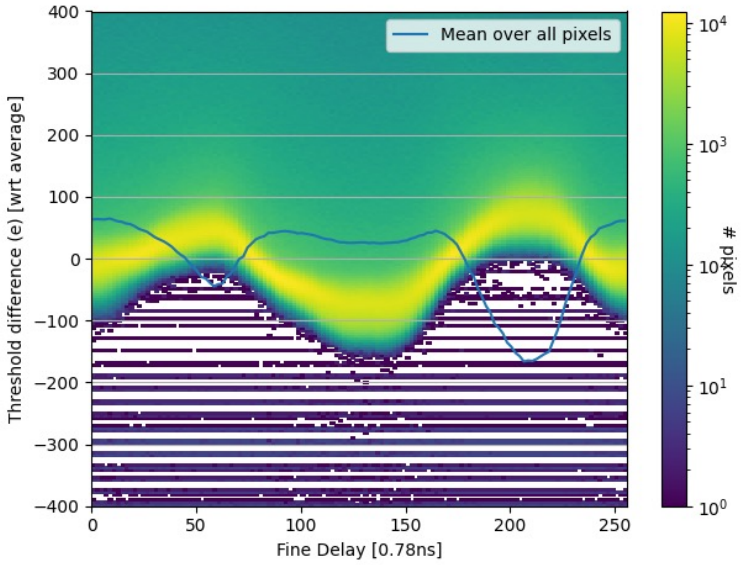
(room temperature)

DiffPreamp dependence

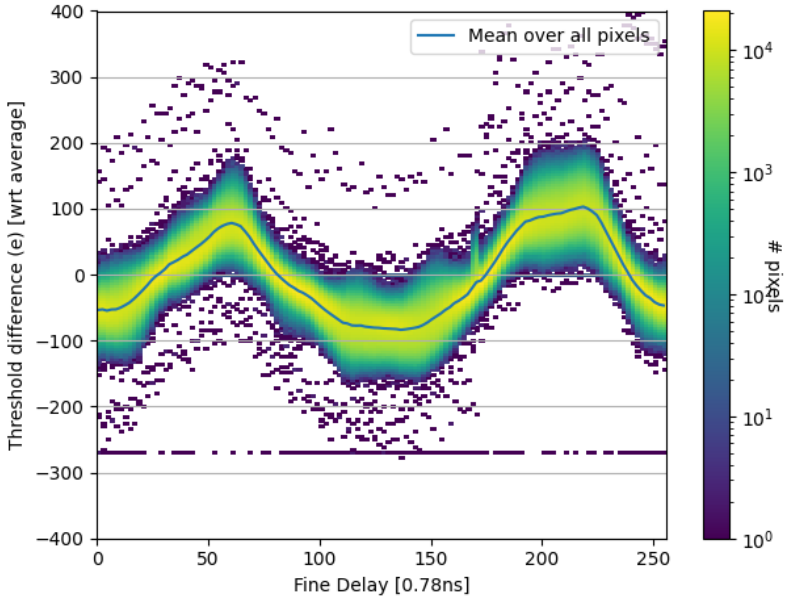
v1.1, with unbiased 3D sensor

- No re-tuning in between DiffPreamp scans

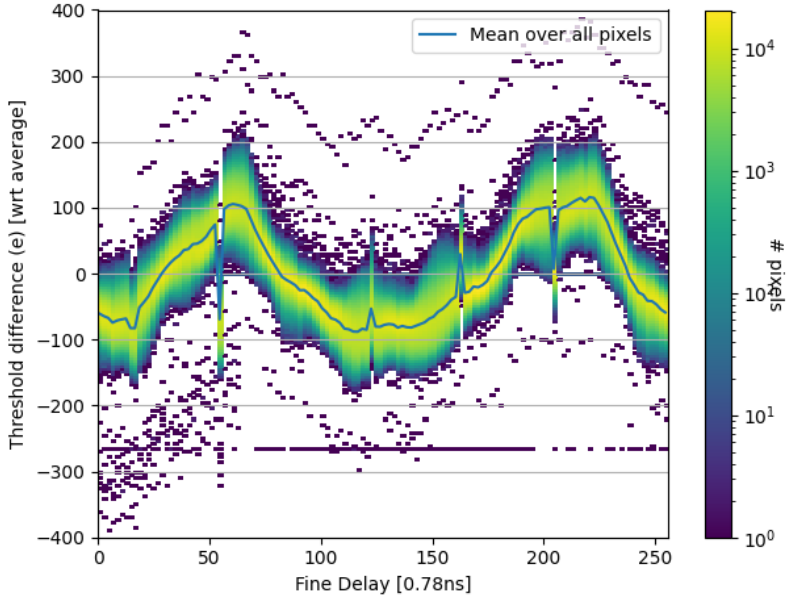
DiffPreamp = 300



DiffPreamp = 600



DiffPreamp = 900



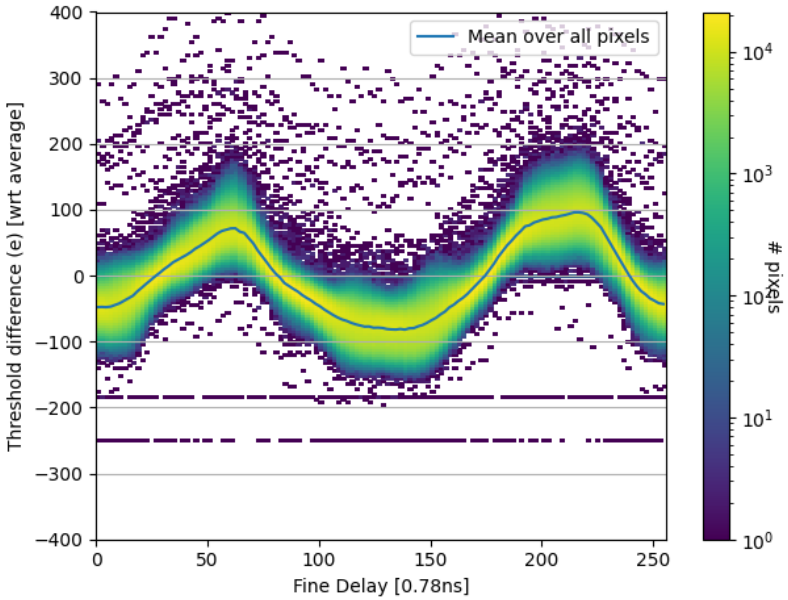
Note that there were many failed fits with this run! Because threshold increased with smaller DiffPreamp, and I wasn't capturing full s-curve. 2500 at delay = 0, and 20,000 at delay=214

Temperature dependence

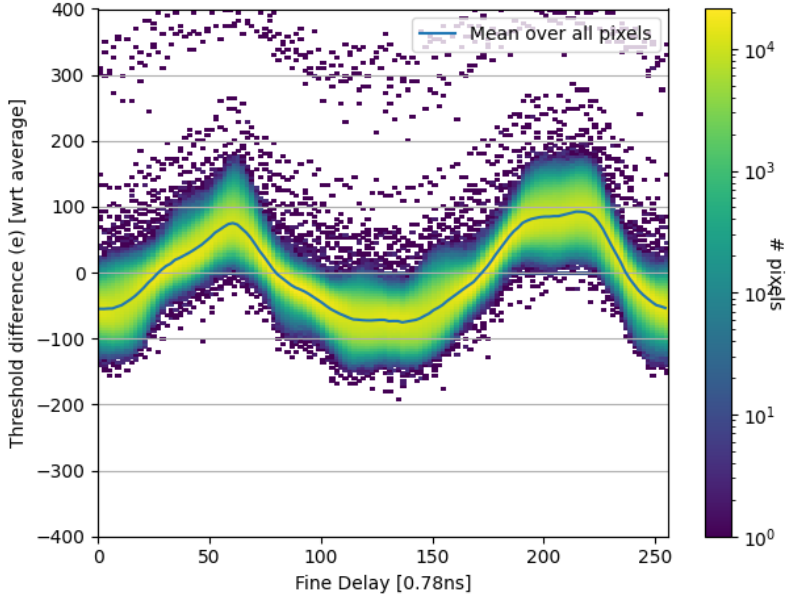
v1.1, with unbiased 3D sensor

Chiller temp:

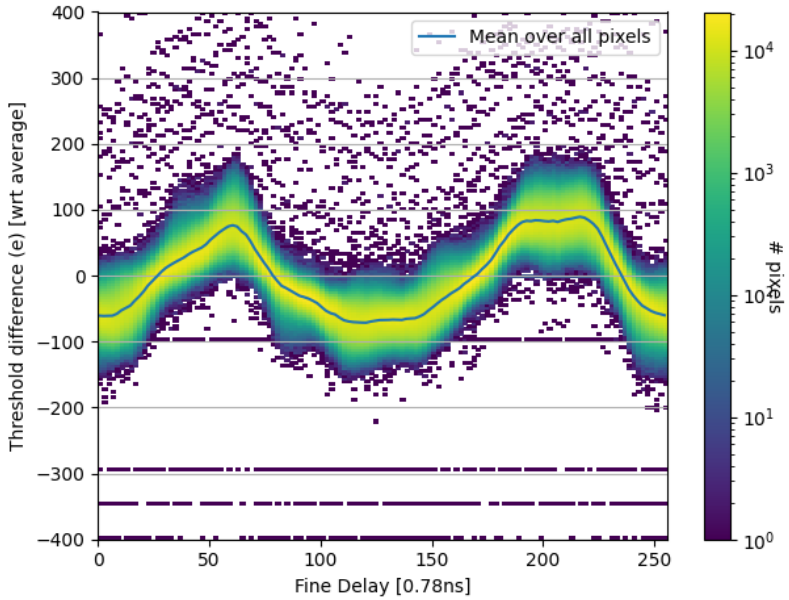
23 C



0 C



-20 C

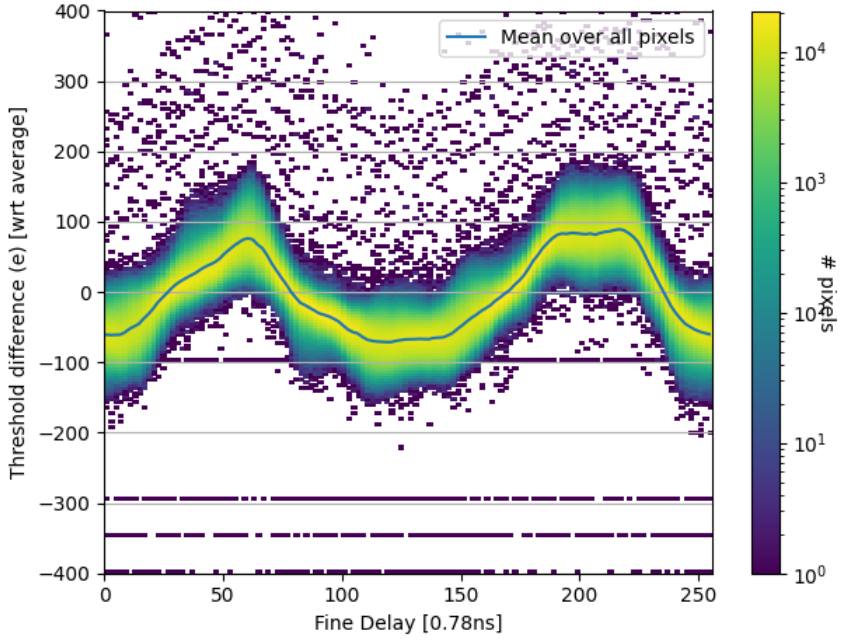


LCC results

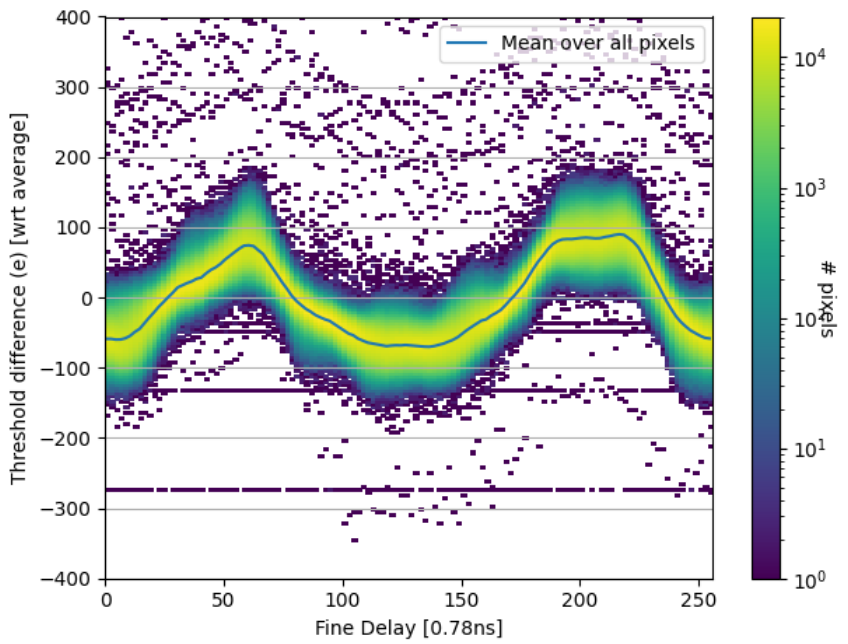
v1.1, with unbiased 3D sensor

Temperature: -20C

With LCC off



With LCC enabled at 500



(with retuning to 2000e)

Temperature dependence

- ITkPix v1.1 quad module
- HPK planar sensor, biased @ 100V
- 15 C

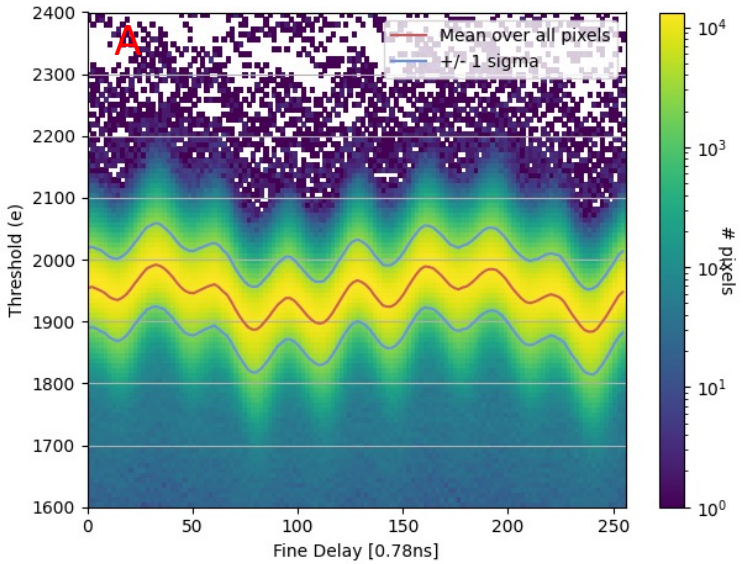
Quad results

v1.1, with biased HPK planar sensor

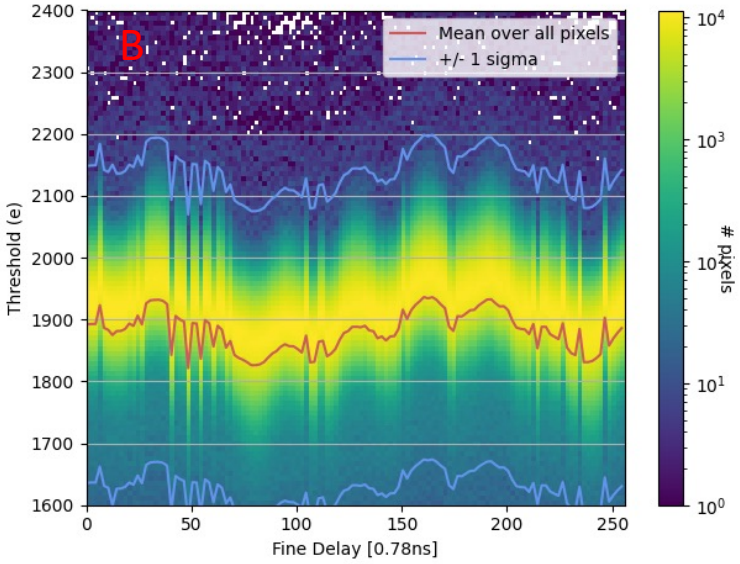
For all chips:

DiffPreComp: 350
DiffPreamp: 500
DiffComp: 500

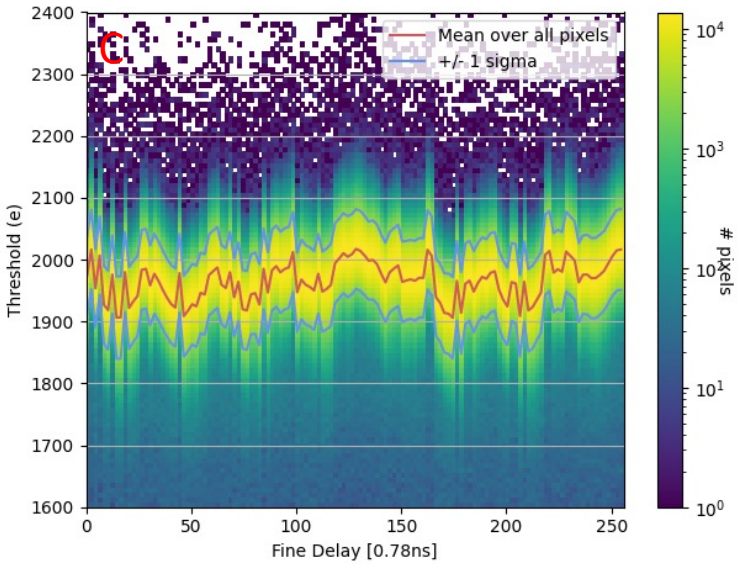
0x130bc



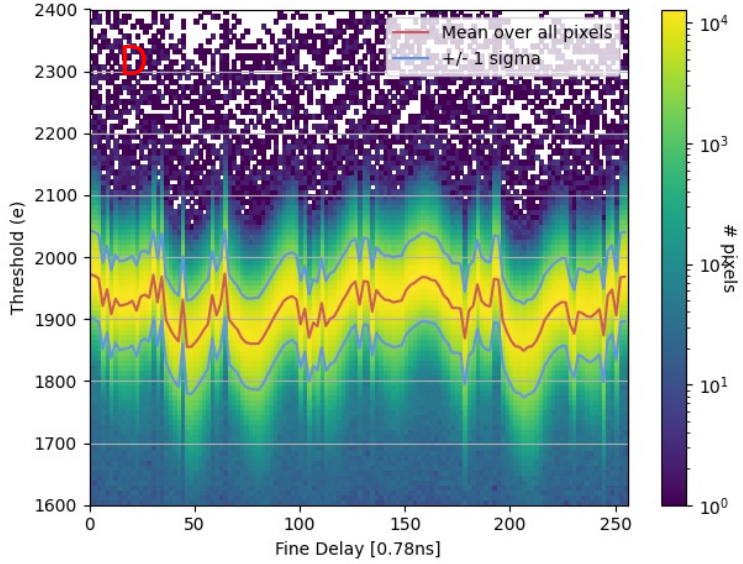
0x130c9



0x130d8



0x138b6

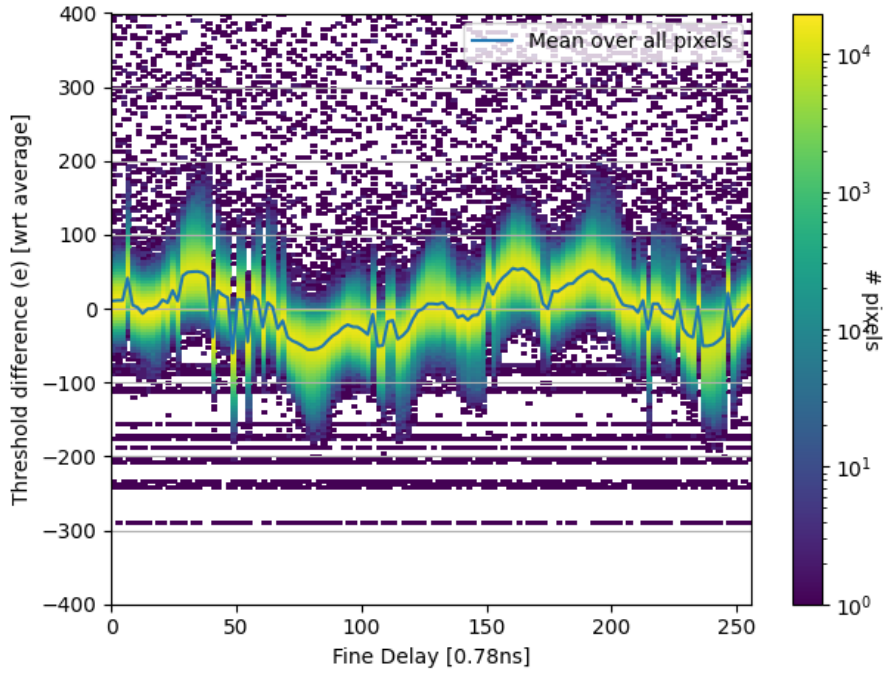


Quad results

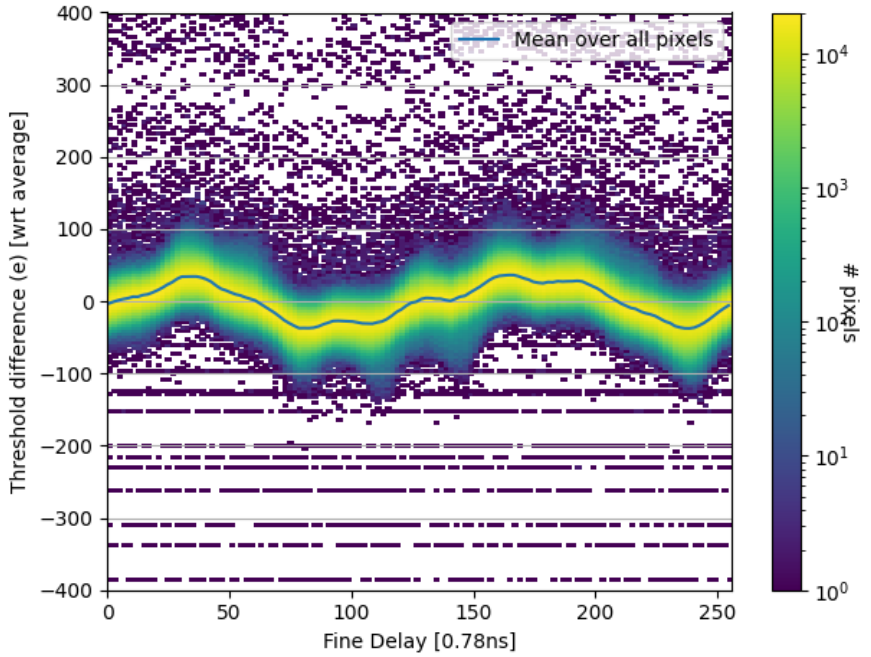
v1.1, with biased HPK planar sensor

0x130bc (chip A)

DiffPreamp: 500



DiffPreamp: 300



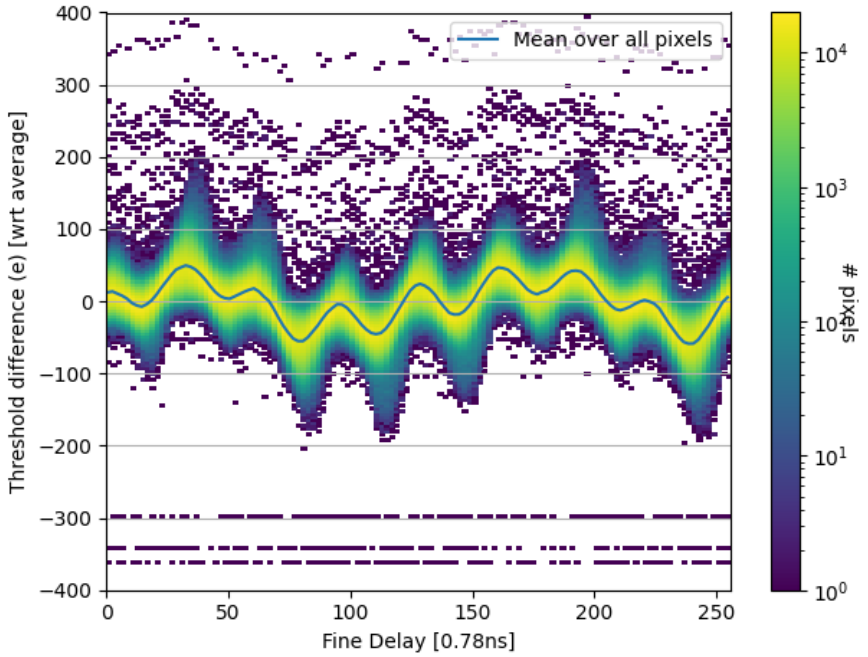
(with retuning to 2000 e)

Quad results

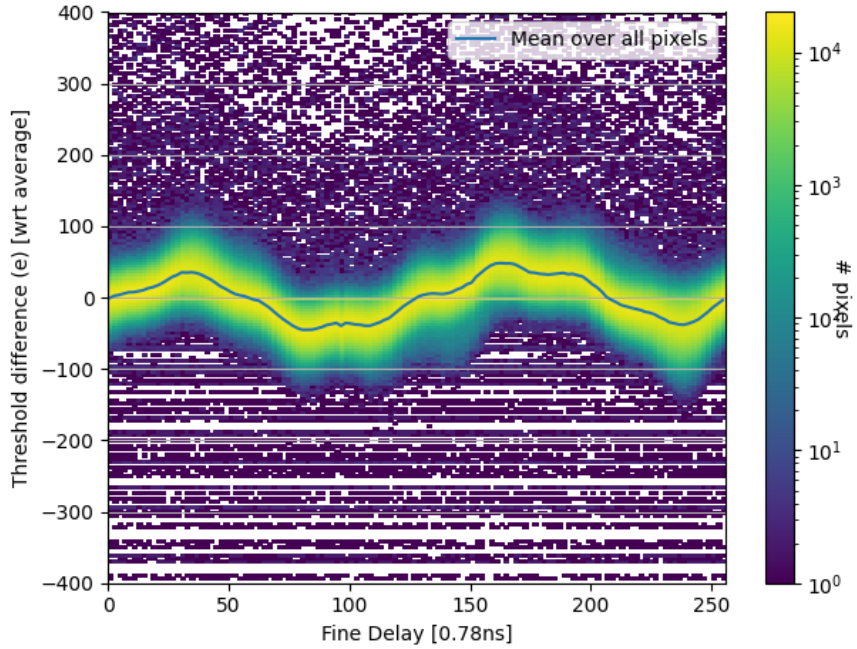
v1.1, with biased HPK planar sensor

0x130c9 (chip B)

DiffPreamp: 500



DiffPreamp: 300



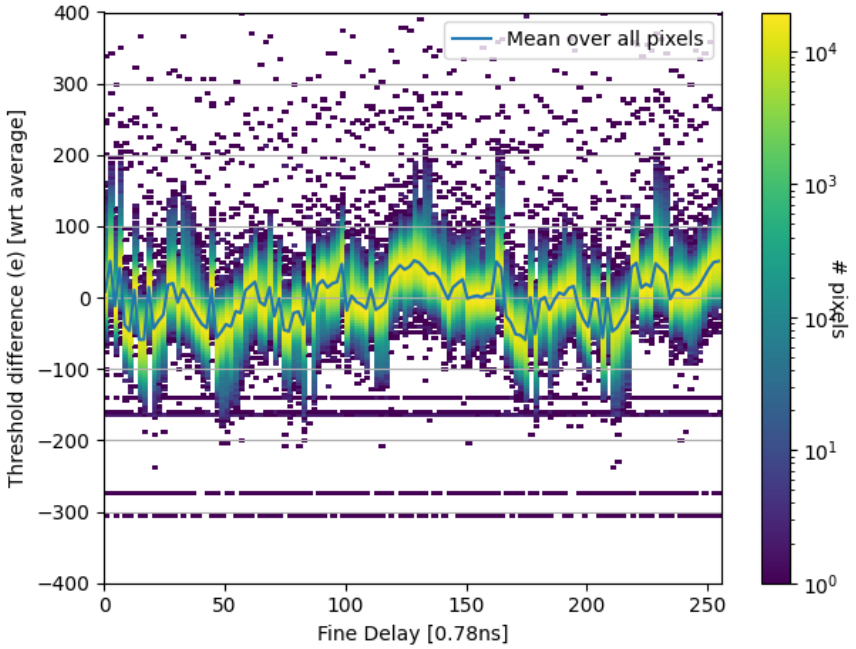
(with retuning to 2000 e)

Quad results

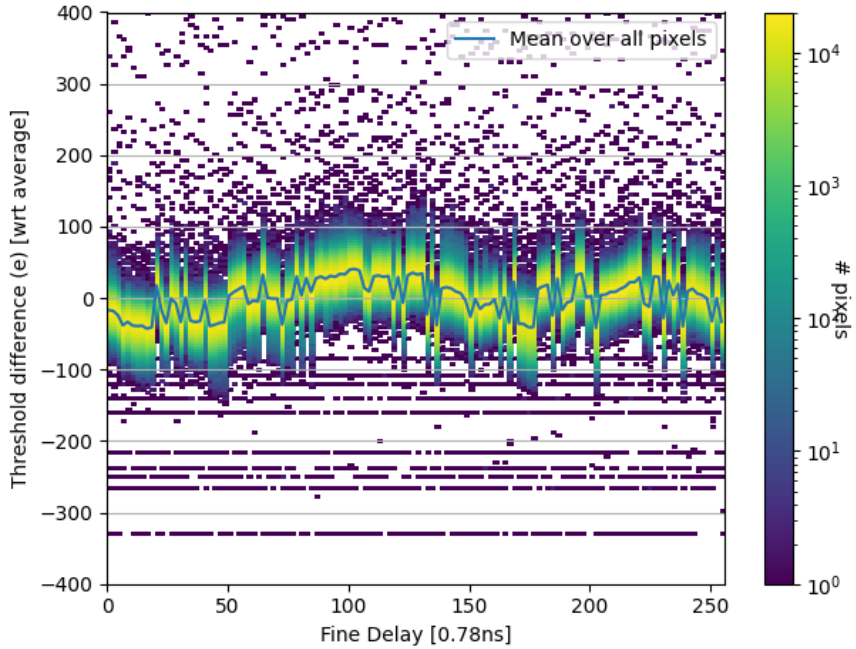
v1.1, with biased HPK planar sensor

0x130d8 (chip C)

DiffPreamp: 500



DiffPreamp: 300



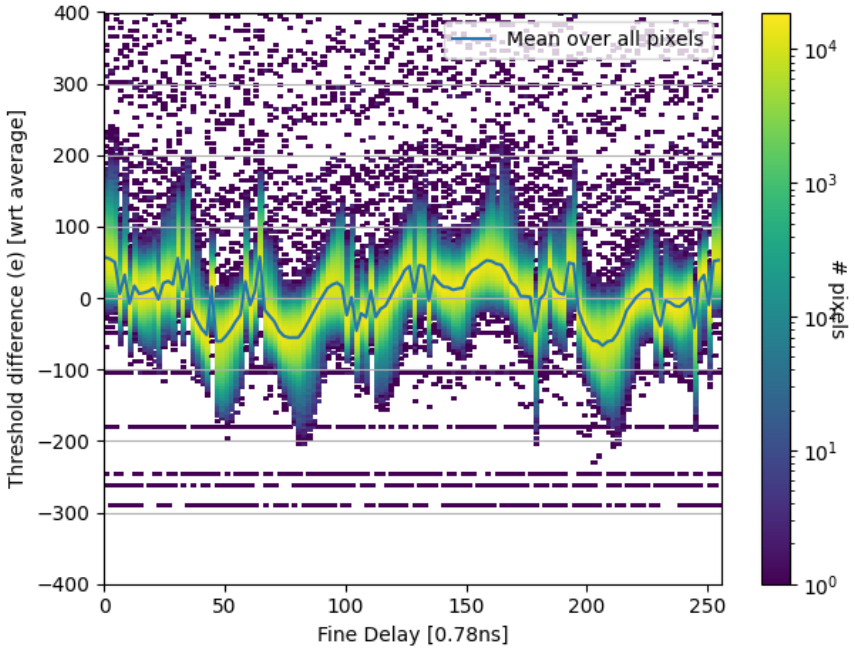
(with retuning to 2000 e)

Quad results

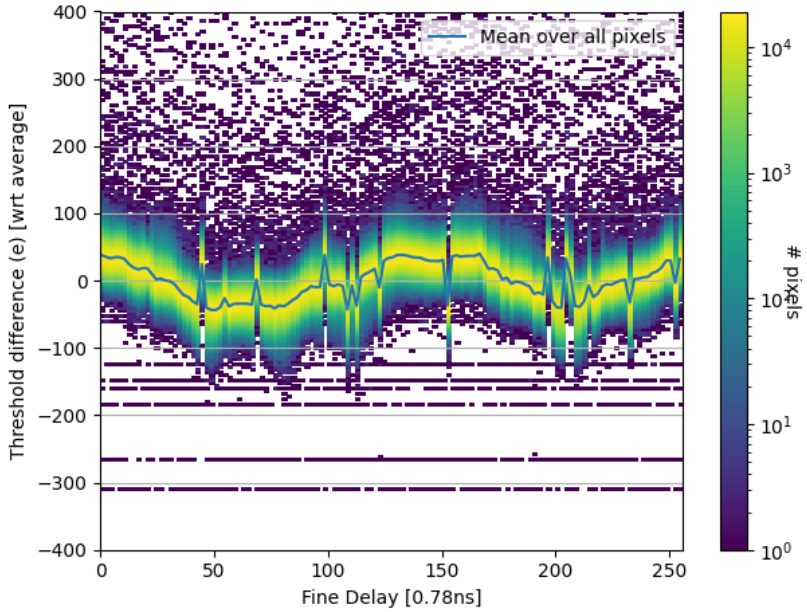
v1.1, with biased HPK planar sensor

0x138b6 (chip D)

DiffPreamp: 500



DiffPreamp: 300



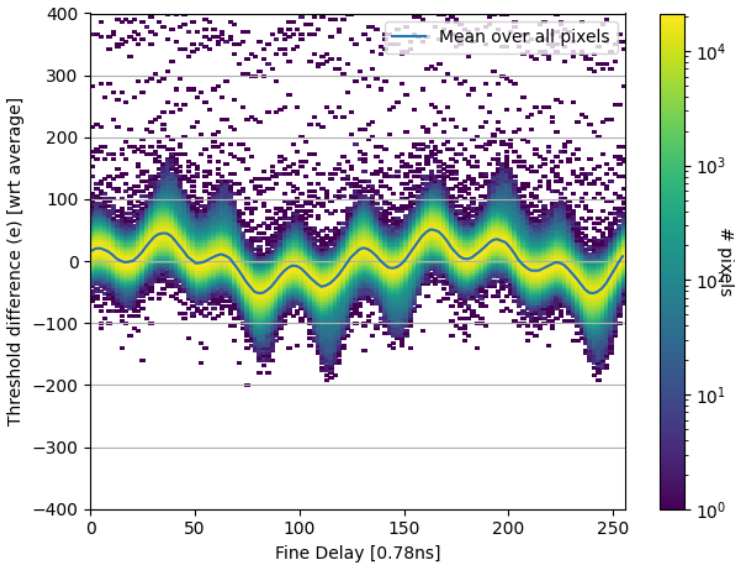
(with retuning to 2000 e)

Quad results

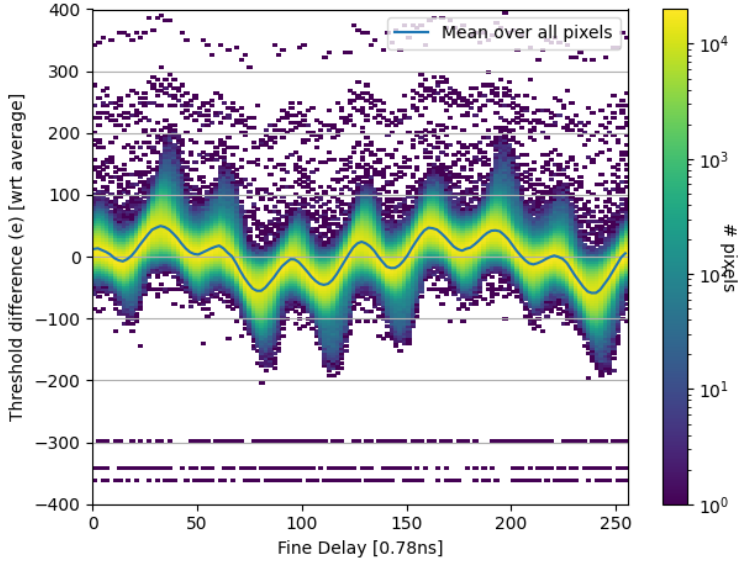
v1.1, with biased HPK planar sensor

0x130bc (chip A)

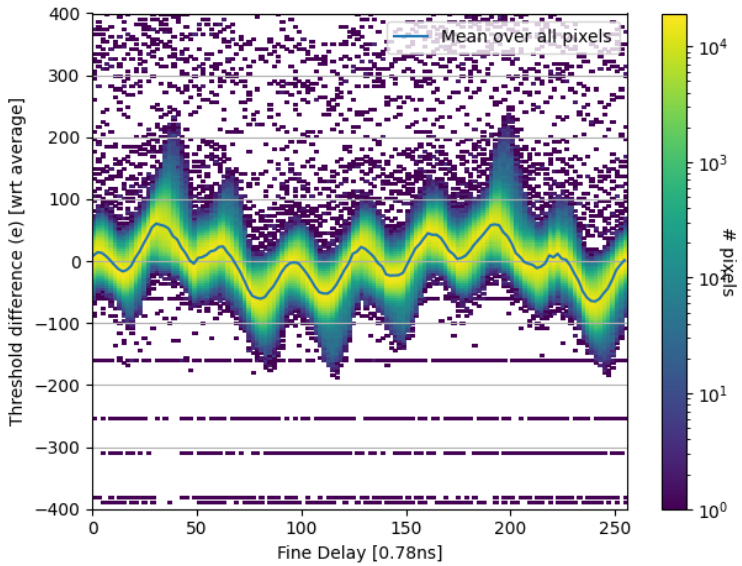
DiffComp: 300



DiffComp: 500



DiffComp: 1000



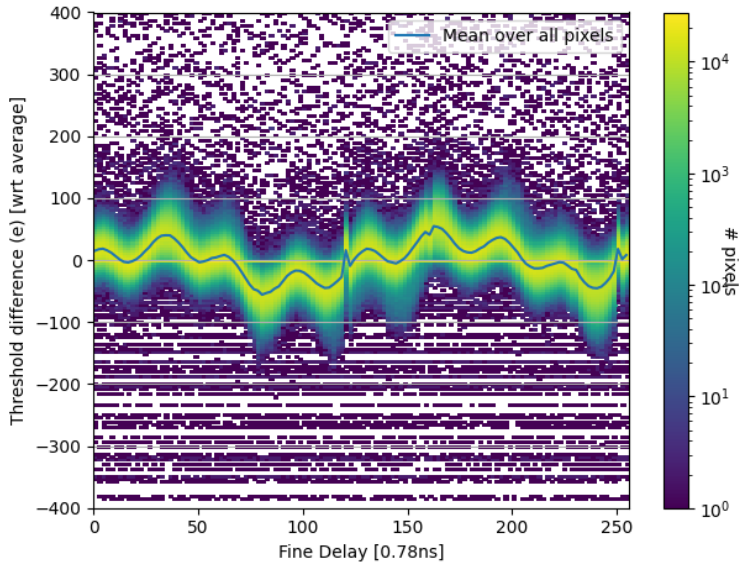
(with retuning to 2000 e)

Quad results

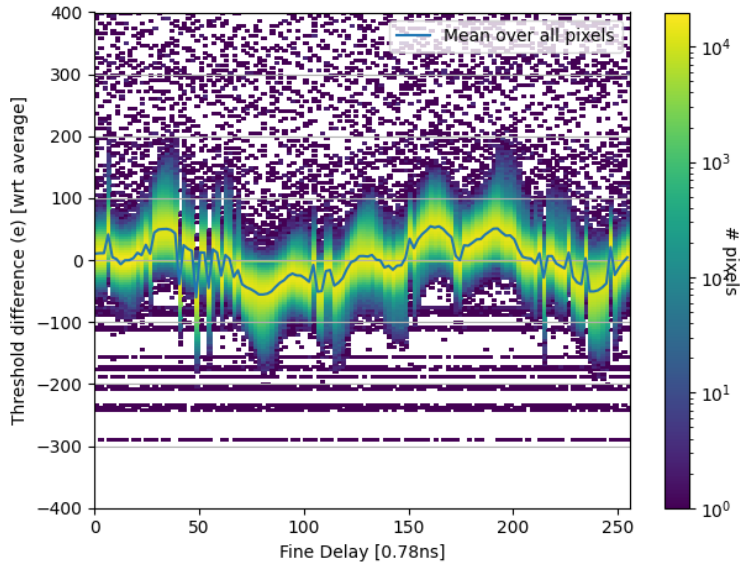
v1.1, with biased HPK planar sensor

0x130c9 (chip B)

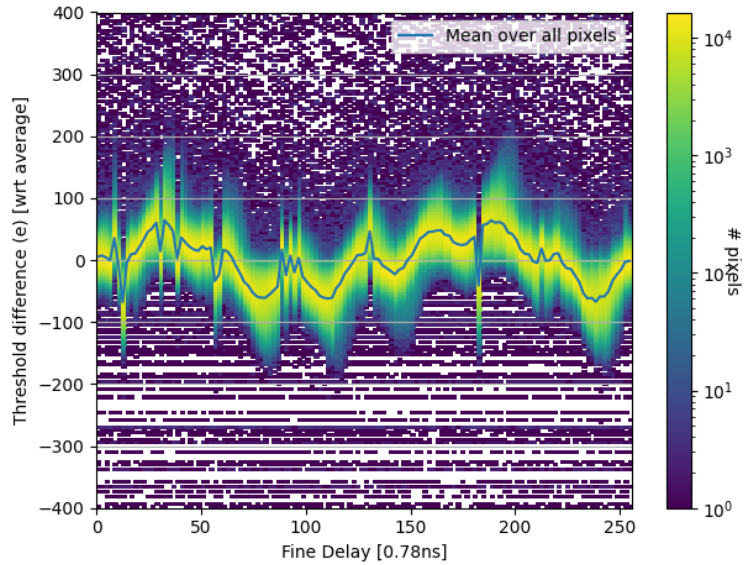
DiffComp: 300



DiffComp: 500



DiffComp: 1000



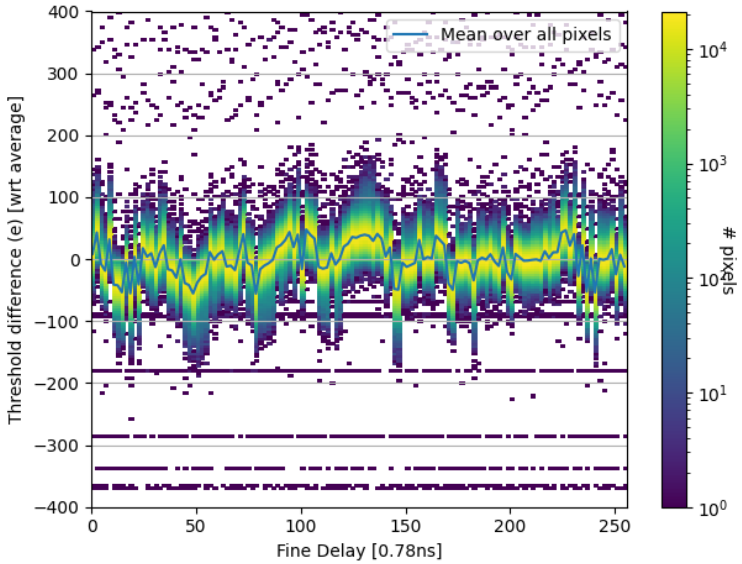
(with retuning to 2000 e)

Quad results

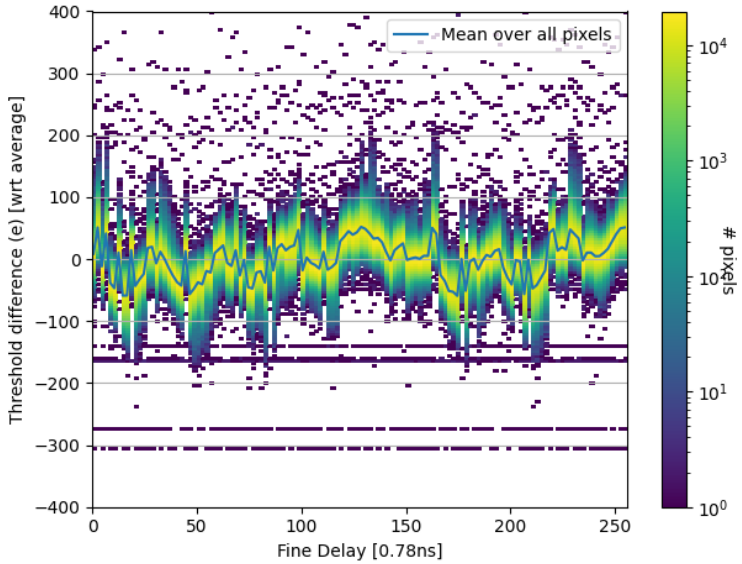
v1.1, with biased HPK planar sensor

0x130d8 (chip C)

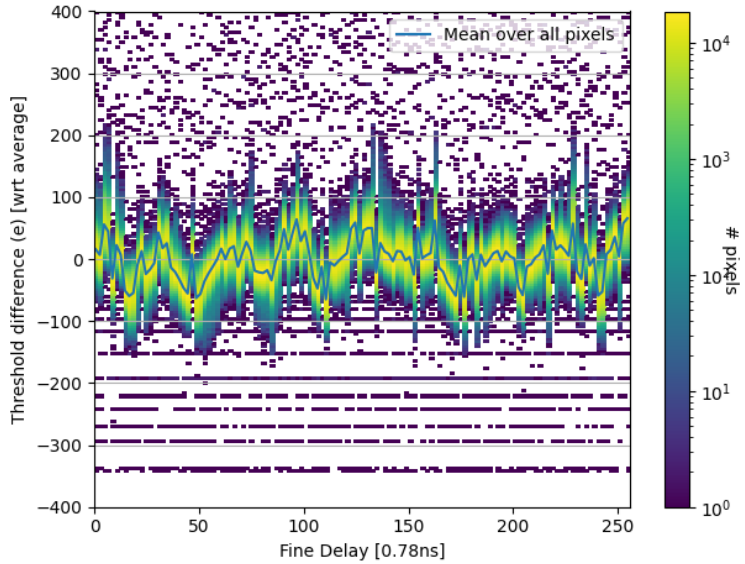
DiffComp: 300



DiffComp: 500



DiffComp: 1000



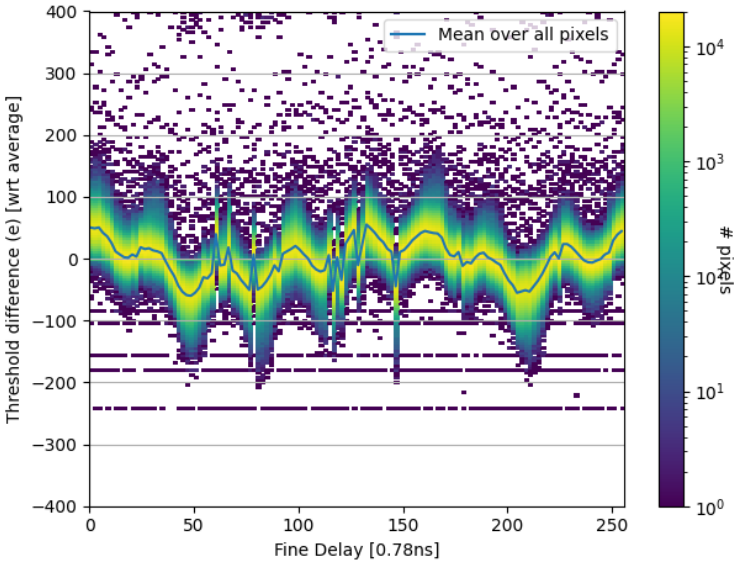
(with retuning to 2000 e)

Quad results

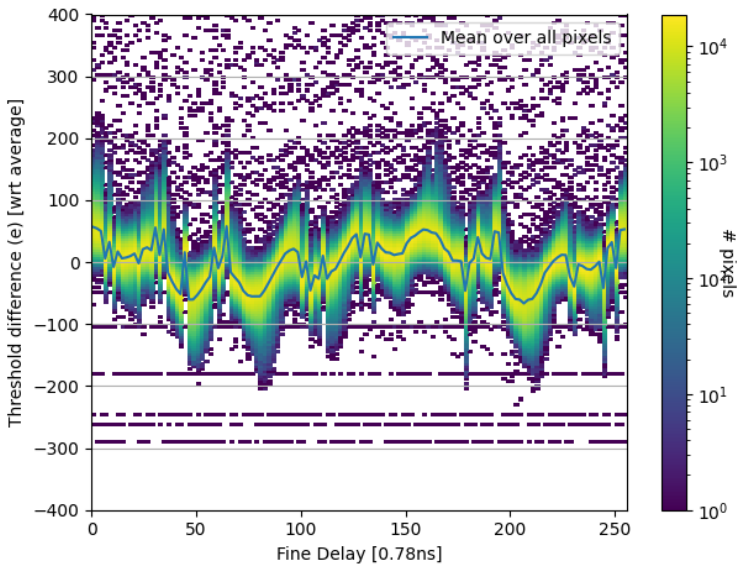
v1.1, with biased HPK planar sensor

0x138b6 (chip D)

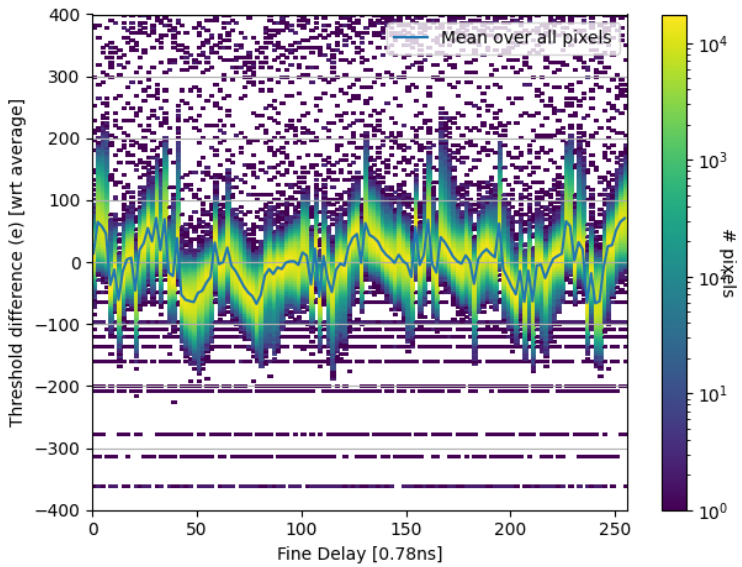
DiffComp: 300



DiffComp: 500



DiffComp: 1000



(with retuning to 2000 e)

Context

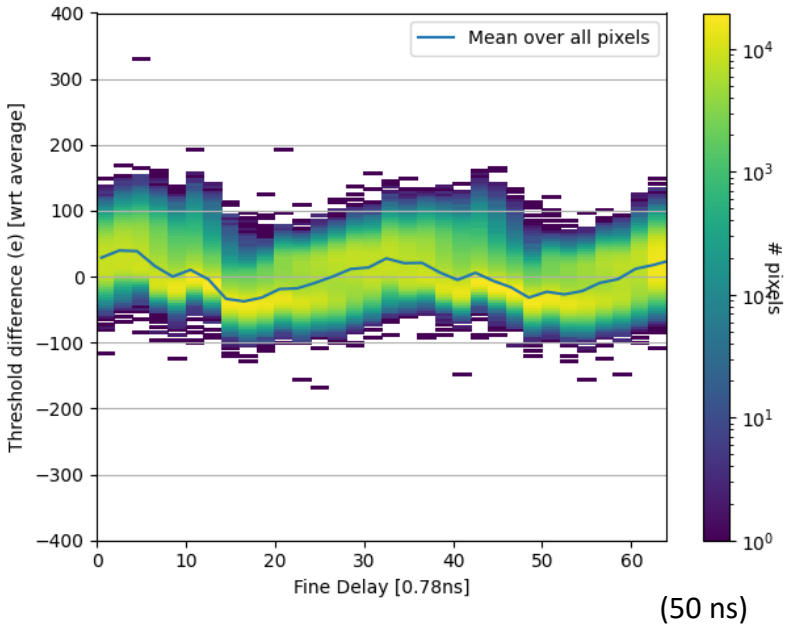
- ITkPix v1.0 SCC’s
- No sensor
- Single and double isolation
- Kept in freezer at -20 C

DiffComp studies

v1.0, no sensor, single iso

- Chip is retuned to 2000e after changing DiffComp
- Scanning fine delay (0.78125 ns each, but in steps of 2) with cal edge delay = 0

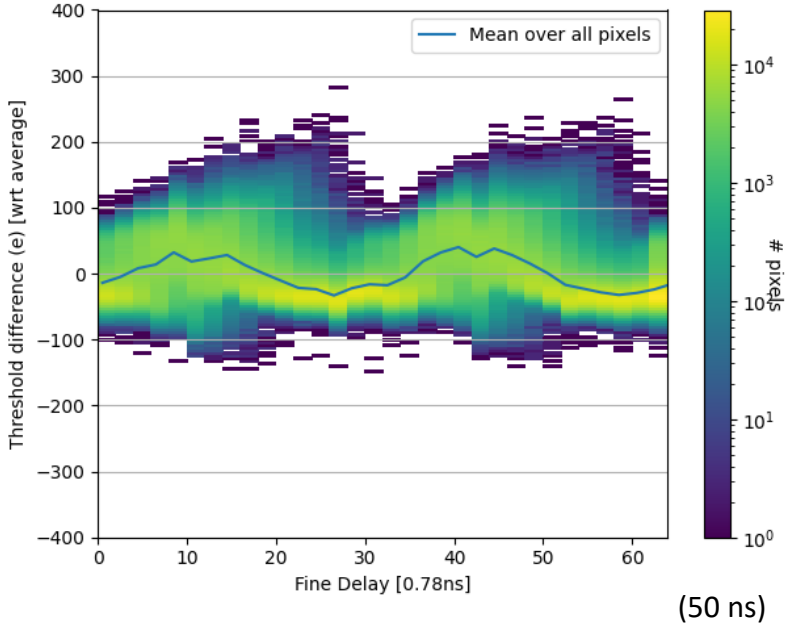
DiffComp = 300



(50 ns)

DiffTH1L/M/R: 200/206/200

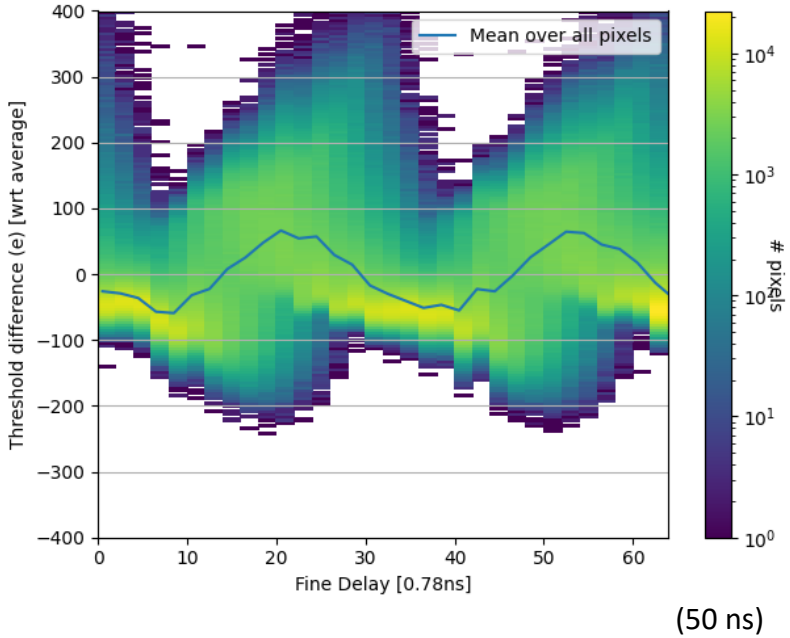
DiffComp = 500 (default)



(50 ns)

DiffTH1L/M/R: 200/246/200

DiffComp = 1000



(50 ns)

DiffTH1L/M/R: 200/286/200

- We see 40 MHz oscillation
- Amplitude changes slightly, dispersion increases with higher DiffComp

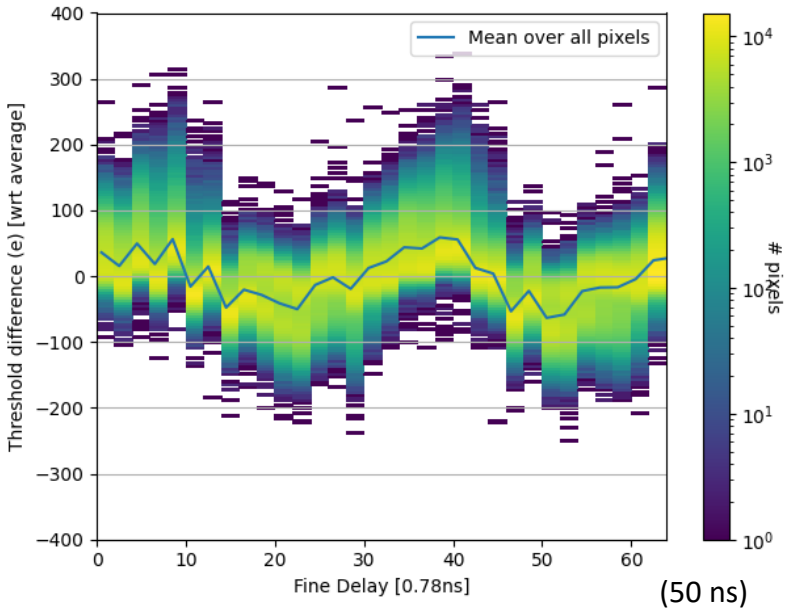
(Note x-axis range difference)

DiffComp studies

v1.0, no sensor, double iso

- Chip is retuned to 2000e after changing DiffComp
- Scanning fine delay (0.78 ns each, but in steps of 2) with cal edge delay = 0

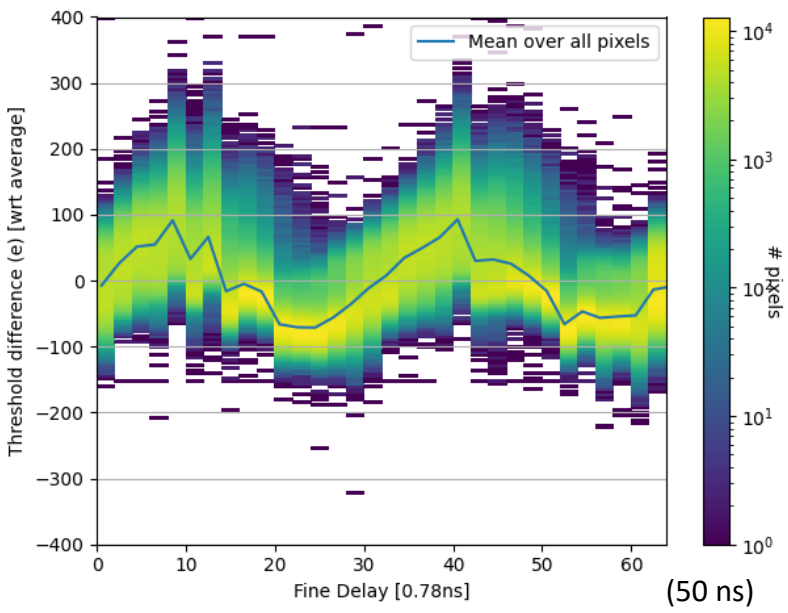
DiffComp = 300



(50 ns)

DiffTH1L/M/R: 200/238/200

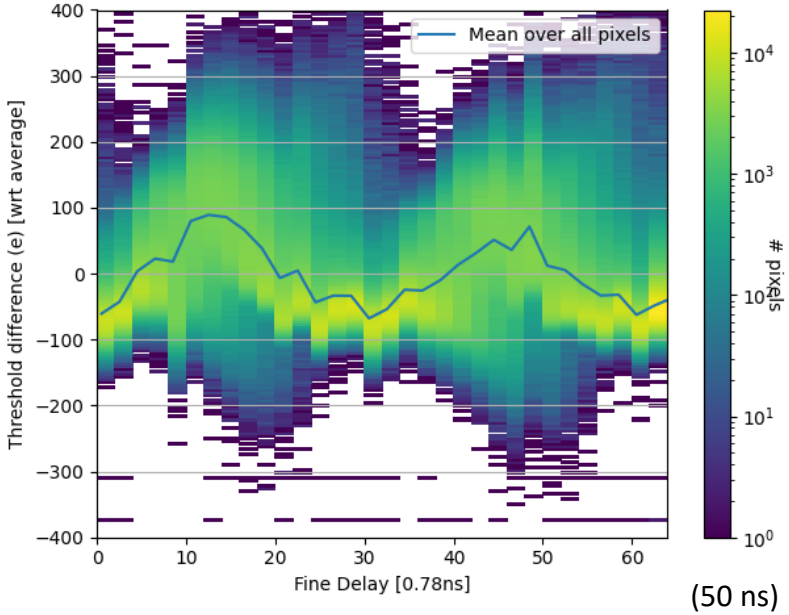
DiffComp = 500 (default)



(50 ns)

DiffTH1L/M/R: 200/270/200

DiffComp = 1000



(50 ns)

DiffTH1L/M/R: 200/302/200

- We see 40 MHz oscillation
- Amplitude changes slightly, dispersion increases with higher DiffComp

(Note x-axis range difference)

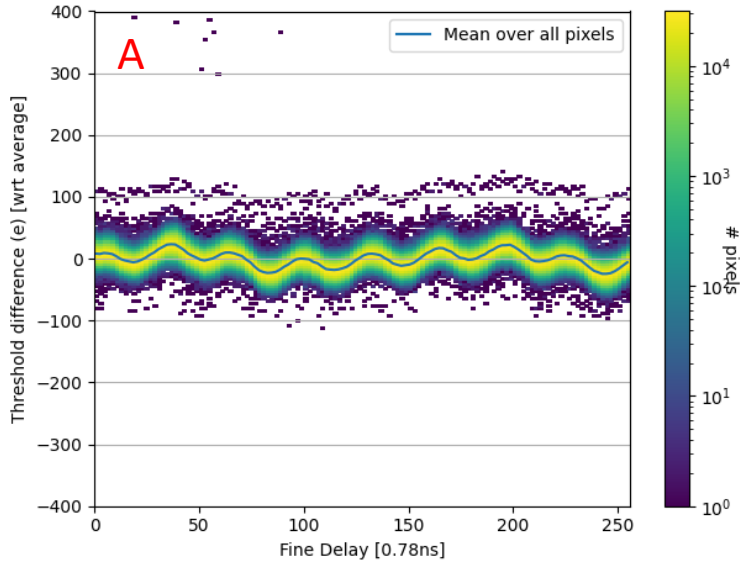
- ITkPix v1.1 quad module
- No sensor
- Room temperature

Quad module with bare chip (no sensor)

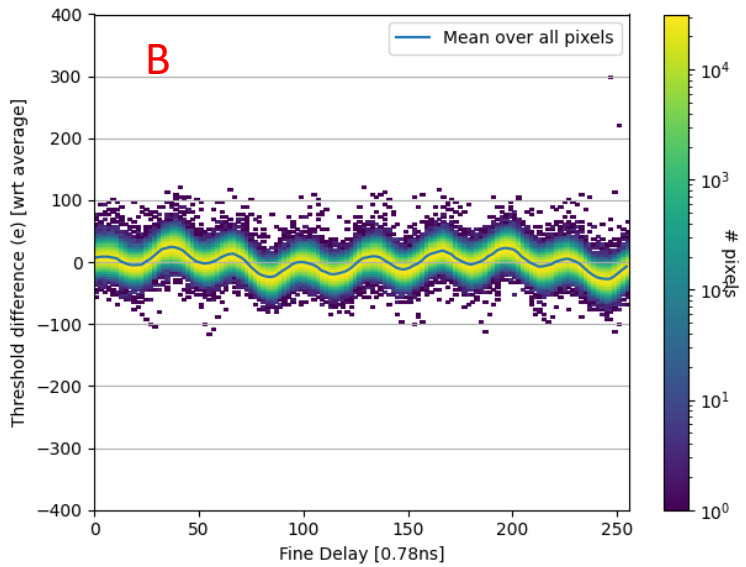
v1.1 quad, no sensor

- No sensor → 40 MHz dominant

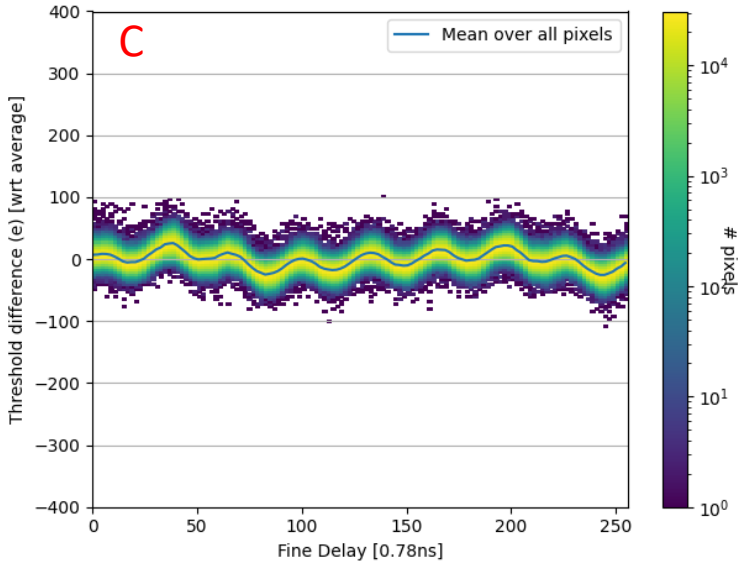
0x14118



0x14119



0x14128



0x14129