# ITkPixv1.1 – Threshold vs. BCID dependence study

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Pixel roundtable

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BERKELEY LAB

# Context

- We are investigating threshold vs. BCID dependence if ITkPix chips
- Shown last week: Results with different DiffComp values, incomplete temperature dependence studies
  - Fixed issue with scanning InjFineDelay above 50 ns
- We are currently focusing on:

  1. Understanding **DiffComp / DiffPreamp** dependence of threshold oscillation
  2. Understand **temperature** dependence of threshold oscillation

- We are using the following chips:

Freezer, -20 C

1. v1.0 without sensor, double isolation (101)
2. v1.0 without sensor, single isolation (122)

Climate chamber #2:

1. Quad with HPK planar sensor, biased @ 100V

Climate chamber #1:

1. v1.1 with 3D sensor, unbiased, single isolation (?)
2. v1.0 with questionable sensor, unbiased (?)
3. v1.0 without sensor, single isolation (122)
4. v1.0 without sensor, double isolation (10A)

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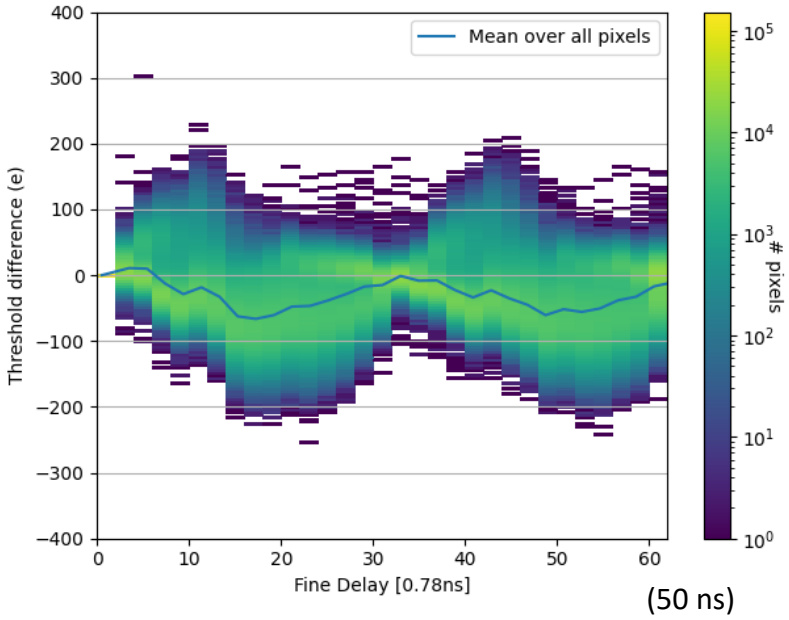
# DiffComp studies

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

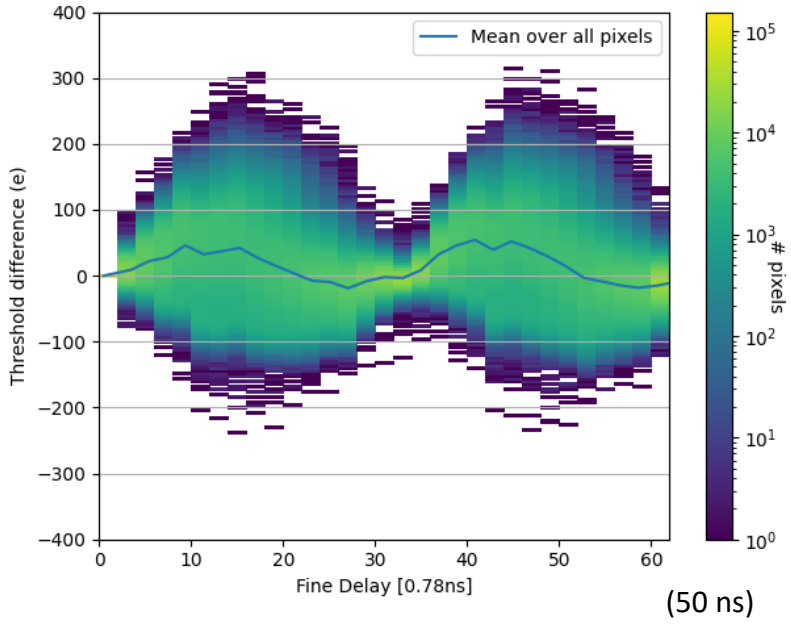
DiffComp = 300




(50 ns)

DiffTH1L/M/R: 200/206/200

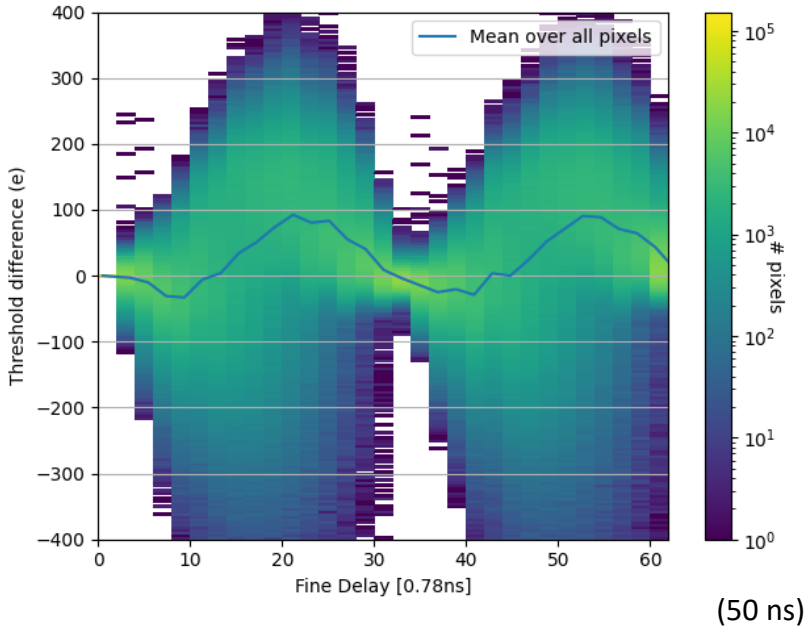
DiffComp = 500 (default)




(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

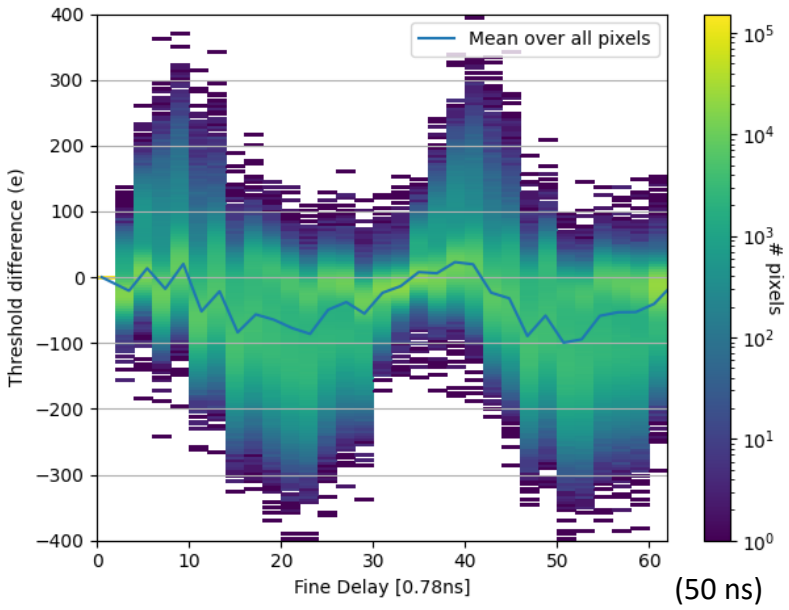
(Note x-axis range difference)

# DiffComp studies

v1.0, no sensor, double iso

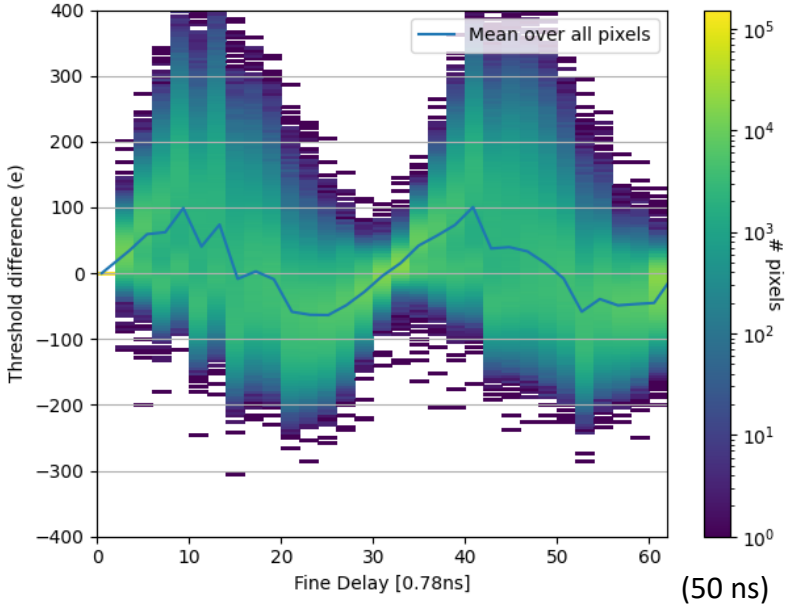
- Chip is retuned to 2000e after changing DiffComp
- Scanning fine delay (0.78 ns each, but in steps of 2) with cal edge delay = 0

DiffComp = 300



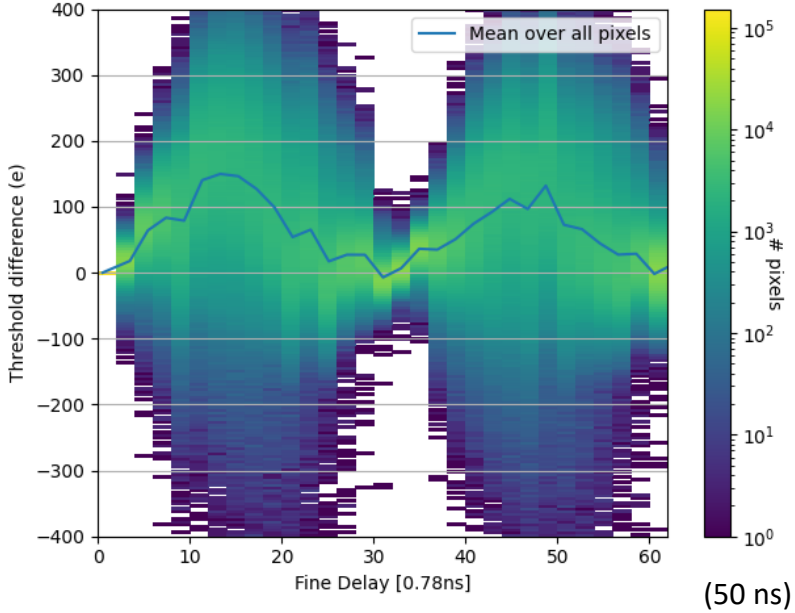

DiffTH1L/M/R: 200/238/200

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)

# DiffPreamp studies

What happens if we change the DiffPreComp and DiffPreamp settings?

Use v1.1 chip (with sensor) instead of v1.0 chips (without sensor) to speed up scans.

Freezer, -20 C

1. v1.0 without sensor, double isolation (101)
2. v1.0 without sensor, single isolation (122)

→

Climate chamber #1:

1. **v1.1 with 3D sensor, unbiased, single isolation (?)**
2. v1.0 with questionable sensor, unbiased (?)
3. v1.0 without sensor, single isolation (122)
4. v1.0 without sensor, double isolation (10A)

# DiffPreamp studies

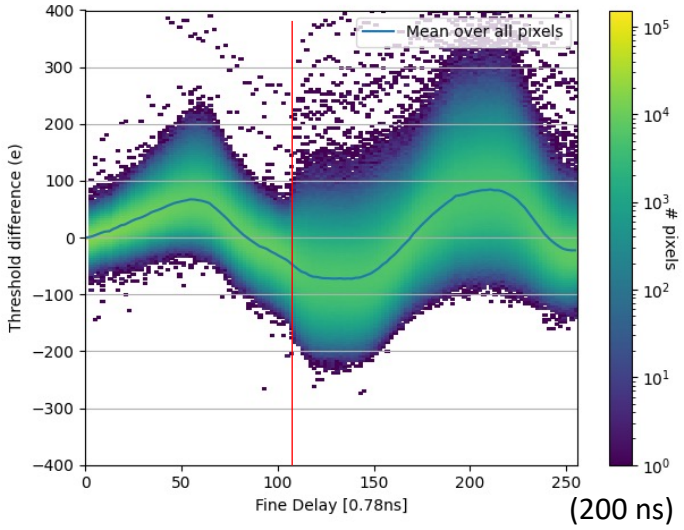
v1.1, with unbiased 3D sensor

- DiffPreamp studies

Default:
DiffPreComp: 350,
DiffPreampL: 800,
DiffPreampM: 800,
DiffPreampR: 800,
DiffPreampT: 800,
DiffPreampTL: 800,
DiffPreampTR: 800,

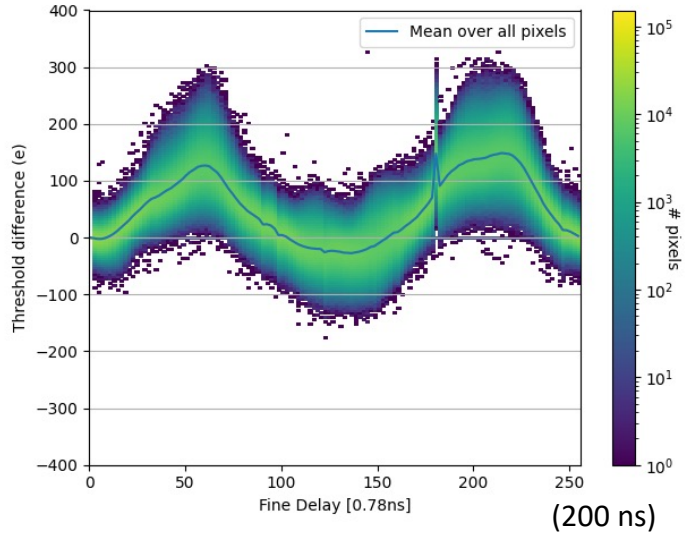
We see 10 MHz oscillation

DiffPre: 300 (23 C →10 C)



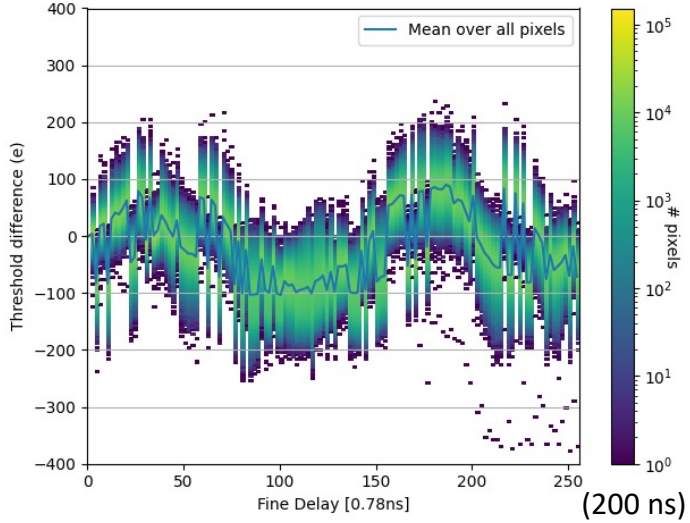
(200 ns)

DiffPre: 500 (10 C)



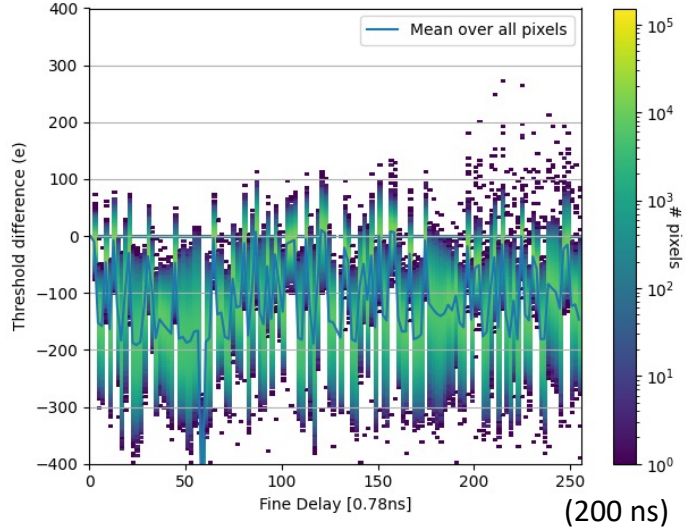
(200 ns)

DiffPre: 600 (10 C)



(200 ns)

DiffPre: 900 (23 C)



(200 ns)

# DiffPreamp studies

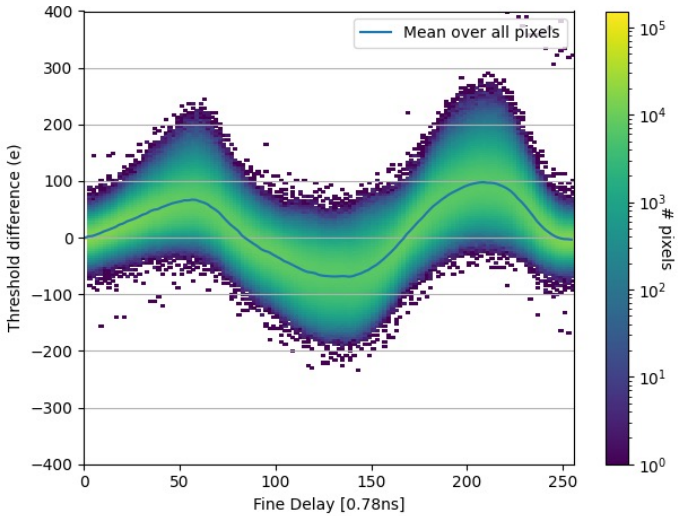
v1.1, with unbiased 3D sensor

- DiffPreamp studies

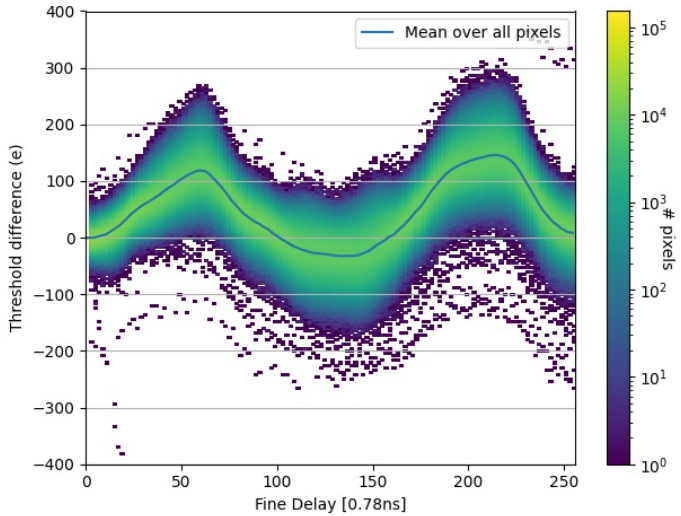
Default:
~~DiffPreComp: 350,~~
DiffPreampL: 800,
DiffPreampM: 800,
DiffPreampR: 800,
DiffPreampT: 800,
DiffPreampTL: 800,
DiffPreampTR: 800,

We see 10 MHz oscillation

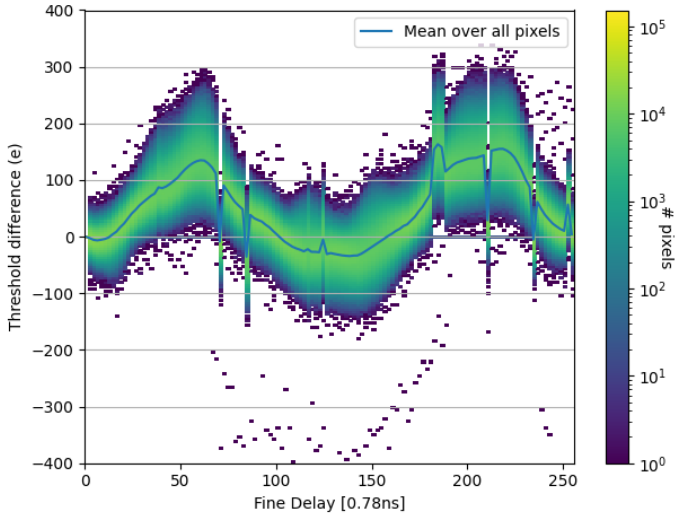
DiffPre: 300 (room temp)



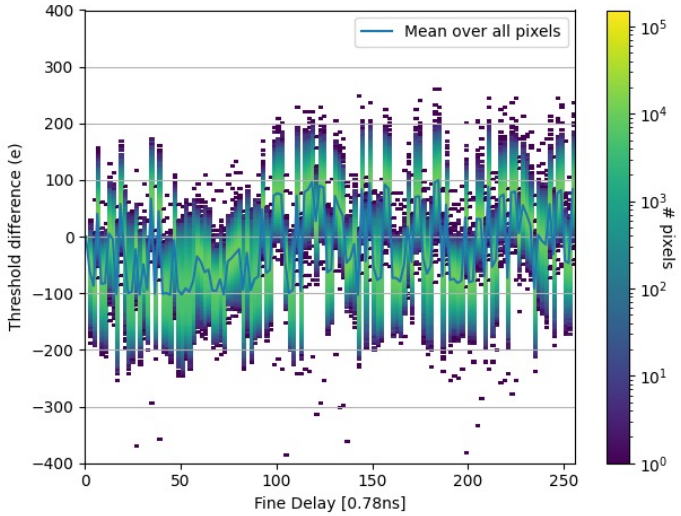

DiffPre: 500 (room temp)




DiffPre: 700 (room temp)



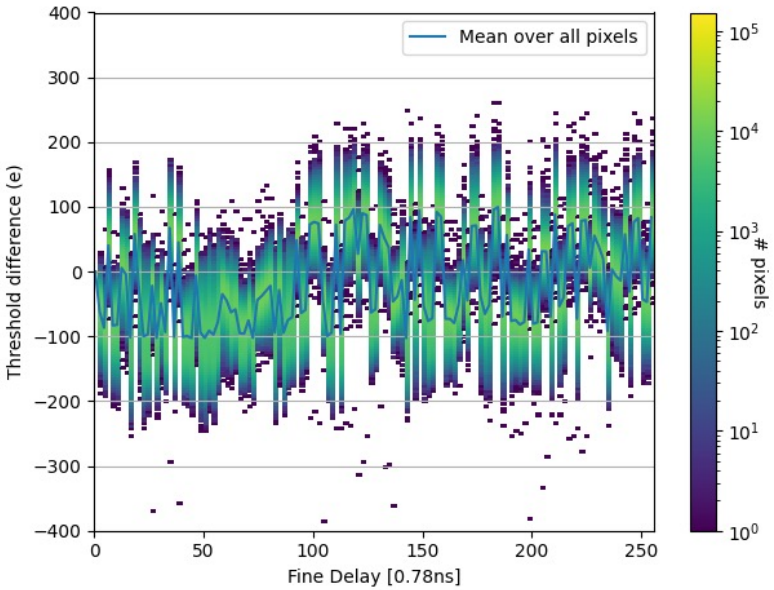

DiffPre: 900 (room temp)



# DiffPreamp studies

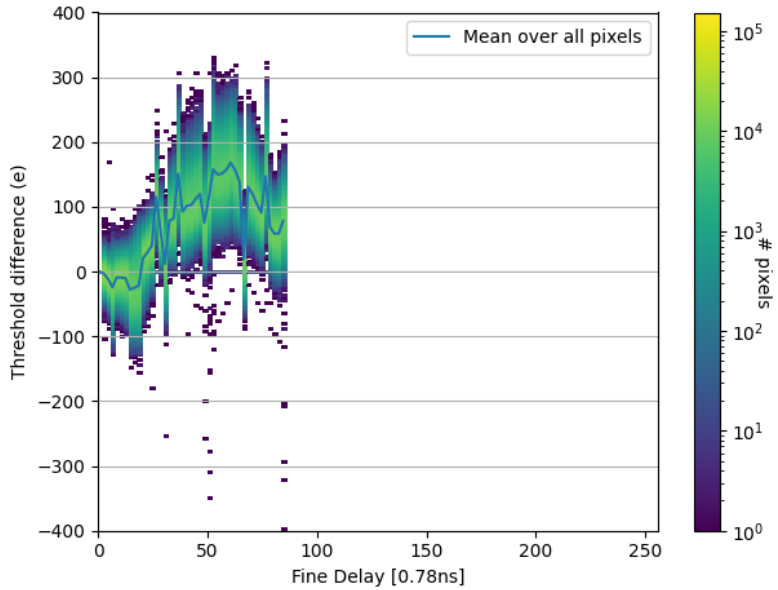
Wait 5 ms after changing preamp

DiffPre: 900 (room temp)



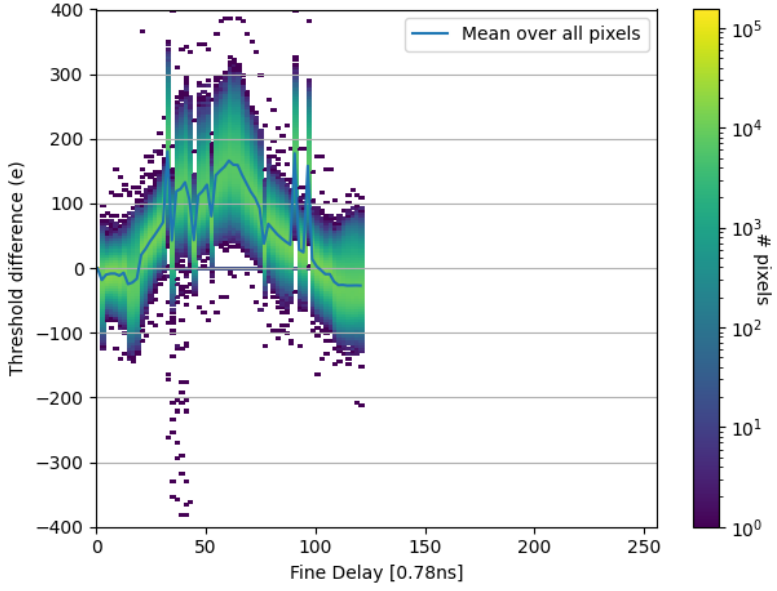

Wait 20 ms after changing preamp

DiffPre: 900




Wait 100 ms after changing preamp

DiffPre: 900

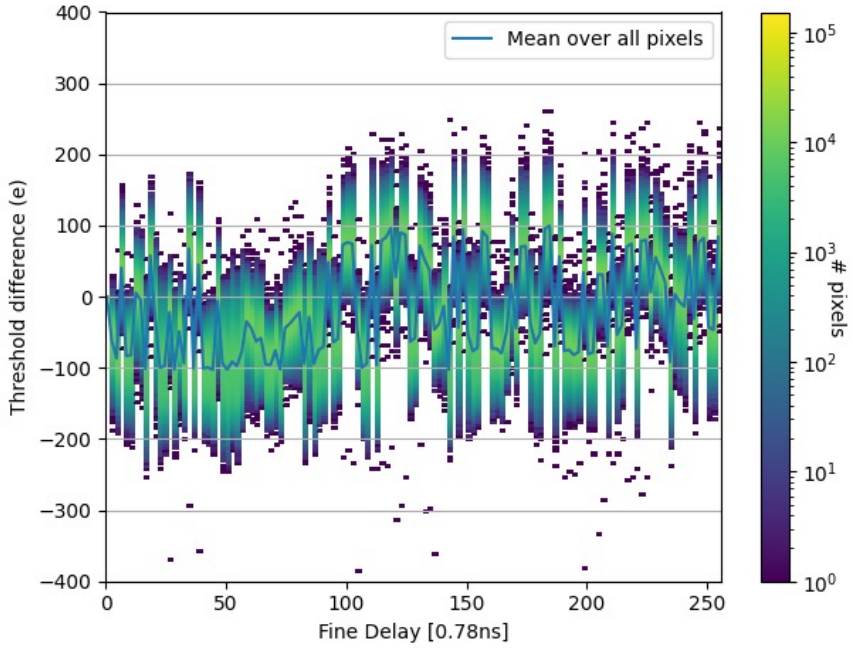



Going back to original 5 ms wait time, I couldn't reproduce these results! Even after using exactly the same chip configuration.

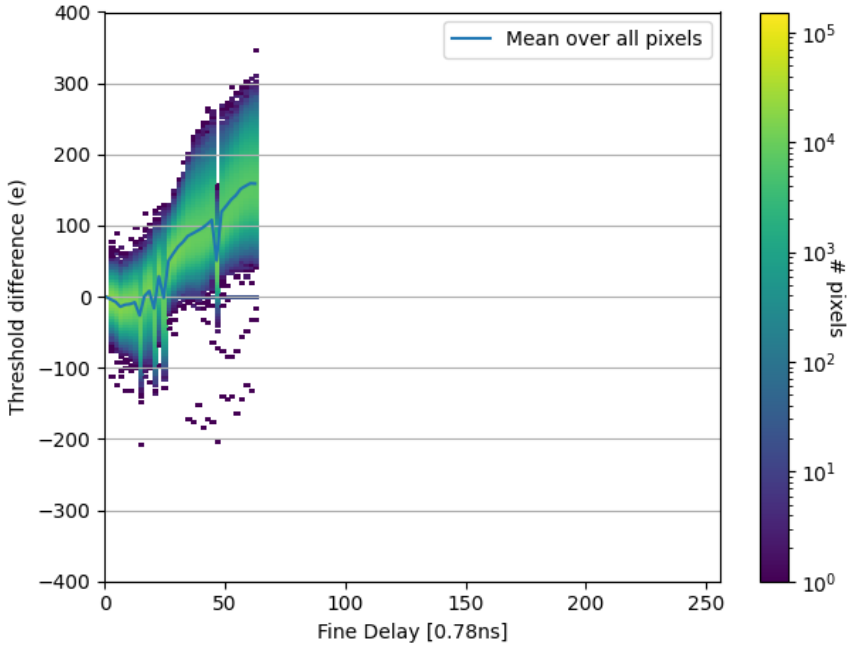
# DiffPreamp studies

These have the exact same chip configuration file!!

Original scan (run Oct 19)




Repeat scan (run Oct 24)



# DiffPreamp studies

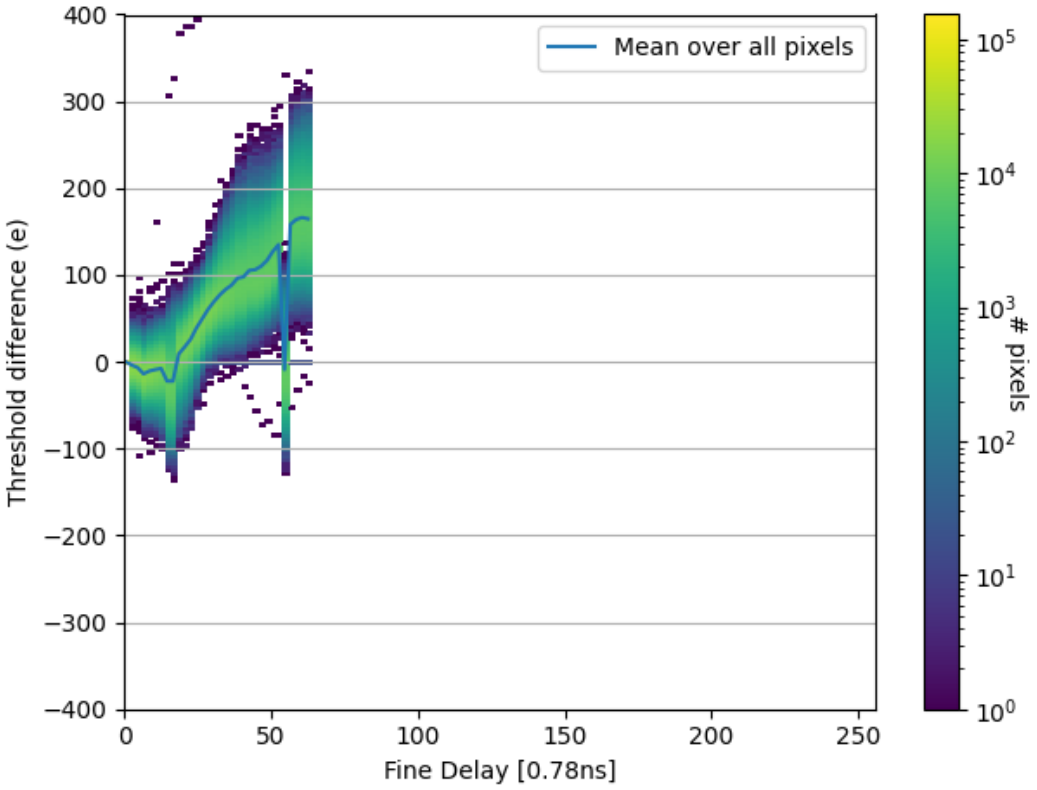
Try different preamp values WITHOUT retuning chip in between. This ensure that the chip configuration stays the same. And don’t run analog scan either.

EXACT procedure:

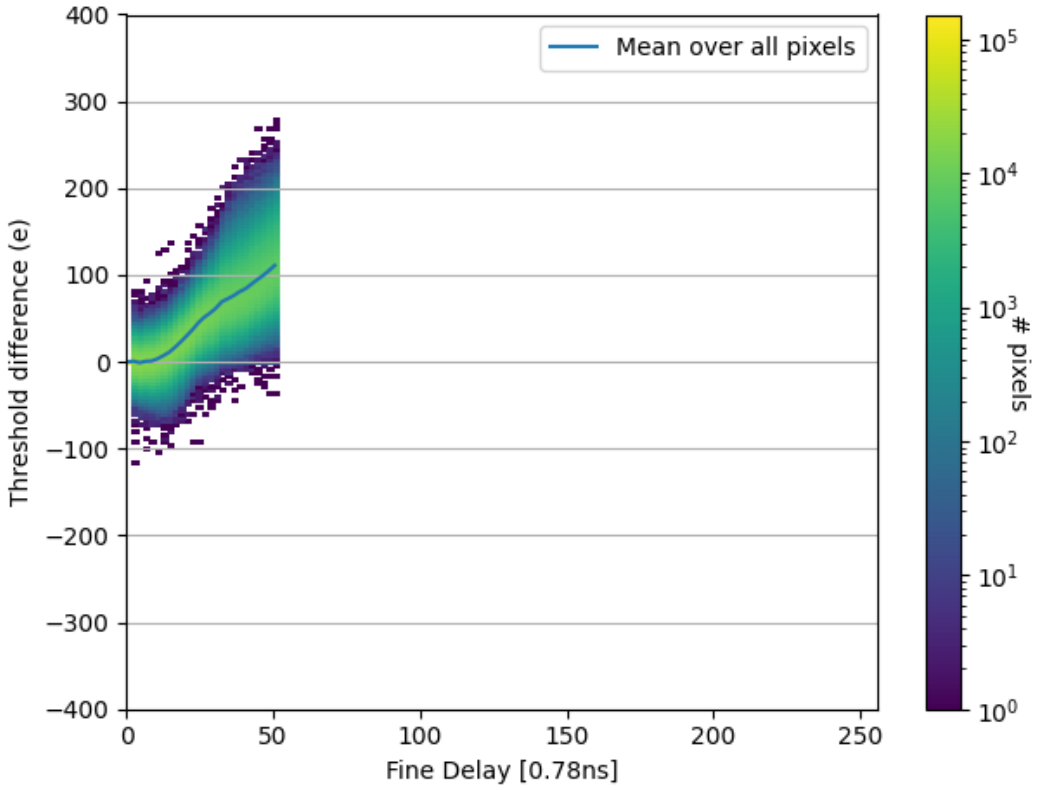
- Checkout latest changes of YARR from devel branch; recompile YARR.
- Set DiffPreamps = 900. Keep DiffPreComp at 350. Tune chip to 2000 e.
- Run series of threshold scans at different fine delay.
- Change DiffPreamps = 600. Do NOT retune chip.
- Run series of threshold scans at different fine delay.
- Repeat for different preamps.

# DiffPreamp studies

DiffPreamp = 900




DiffPreamp = 600



# DiffPreamp studies

v1.1, with unbiased 3D sensor

- DiffPreamp studies

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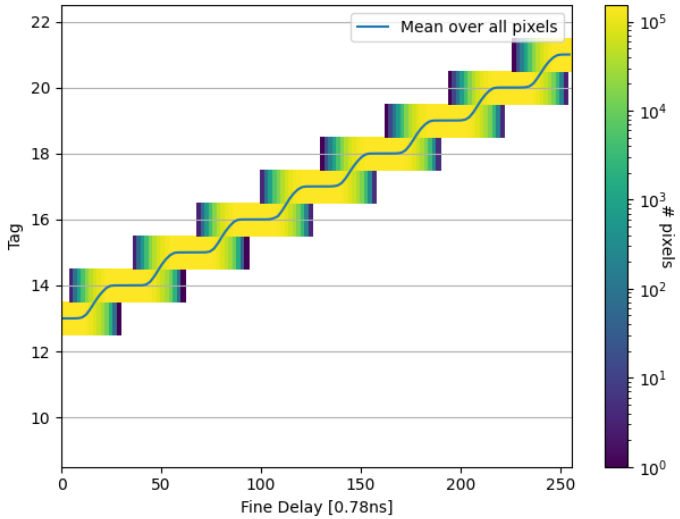
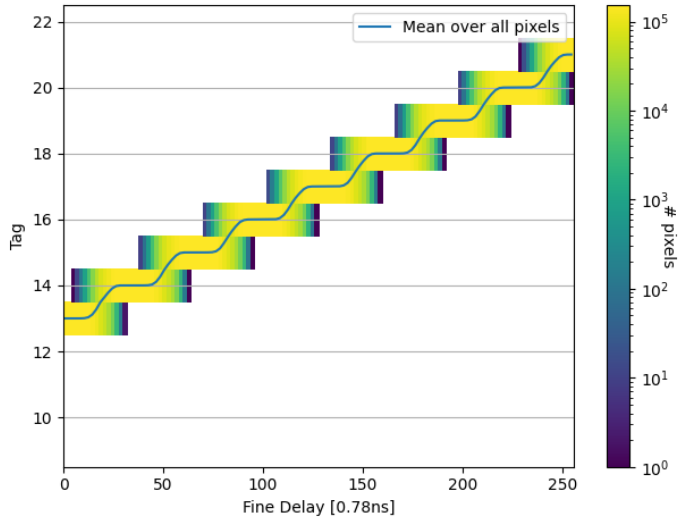
DiffPreampTL: 800,
DiffPreampTR: 800,

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

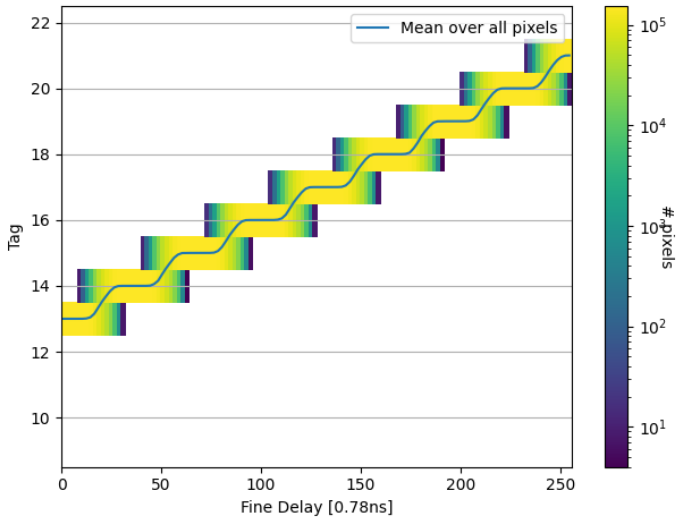
DiffPre: 300 (23 C →10 C)



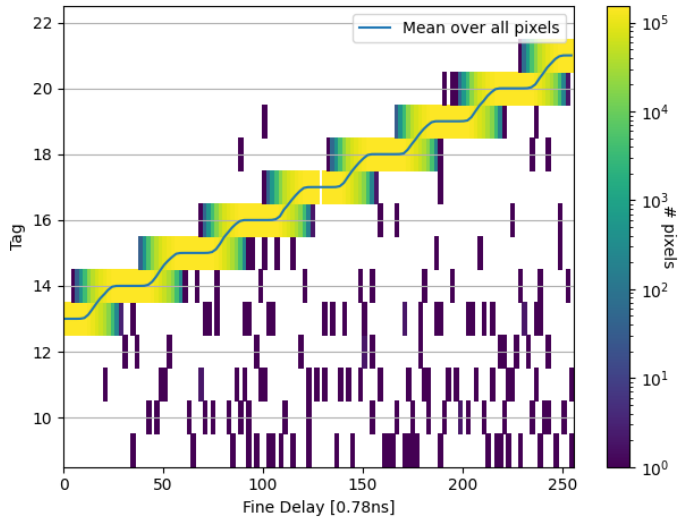

DiffPre: 500 (10 C)




DiffPre: 600 (10 C)




DiffPre: 900 (23 C)



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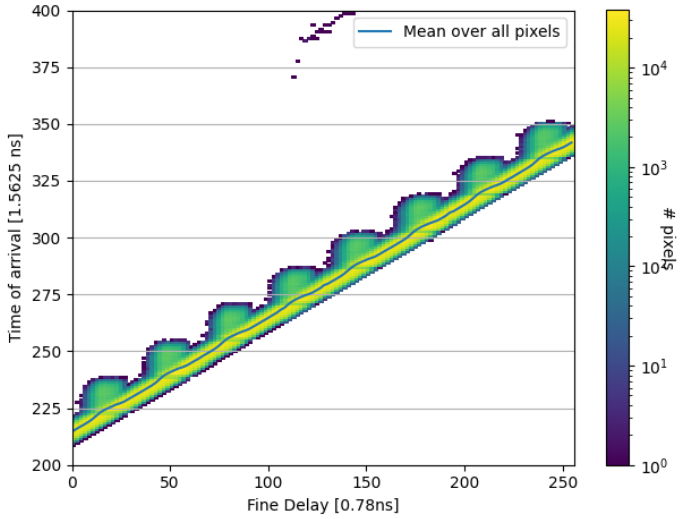
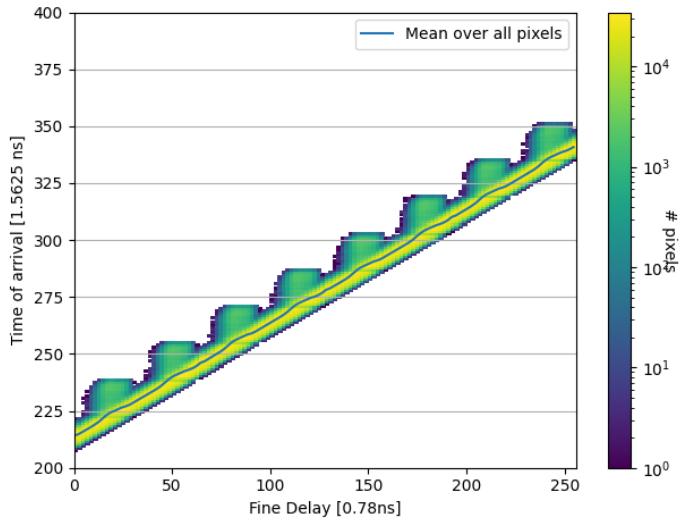



DiffPre: 500 (10 C)

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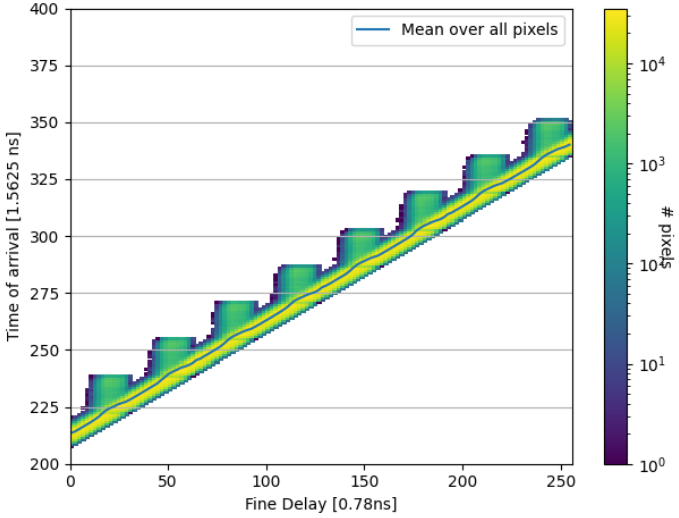
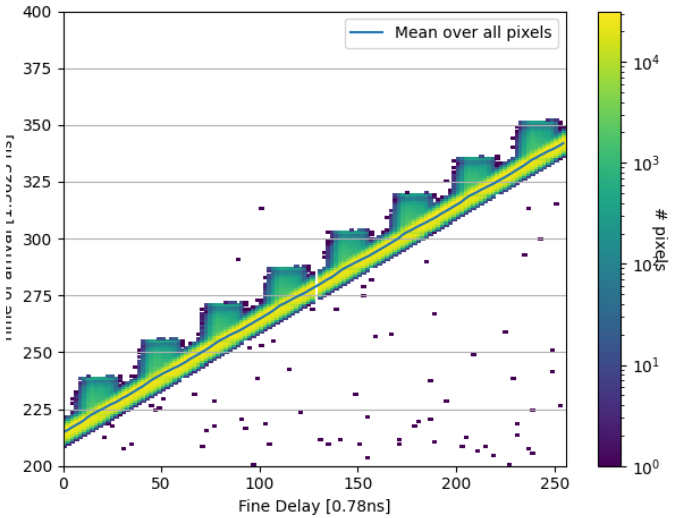



DiffPre: 900 (23 C)

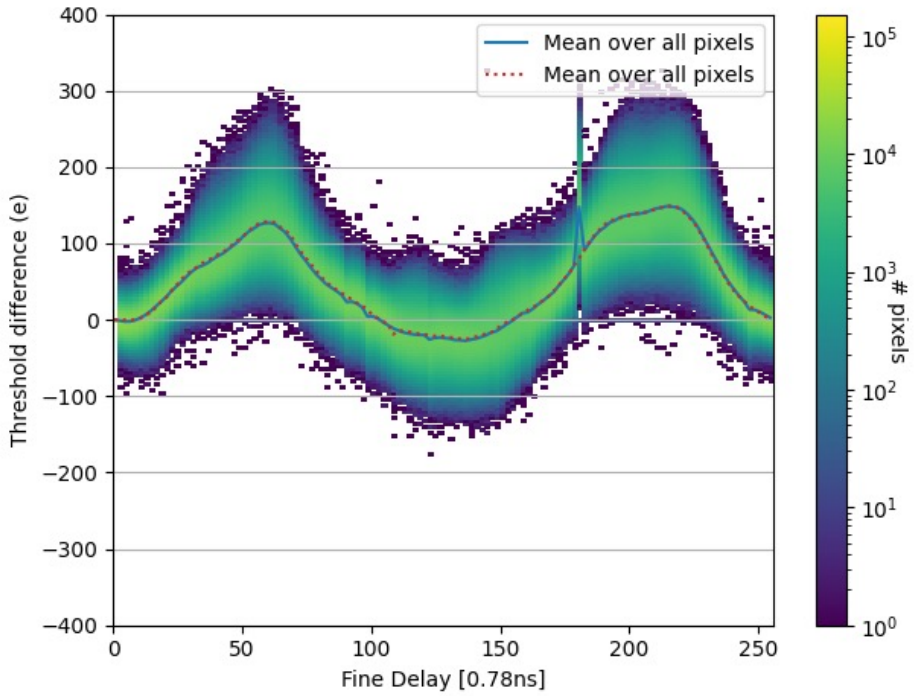


# Stability of results

v1.1, with unbiased 3D sensor

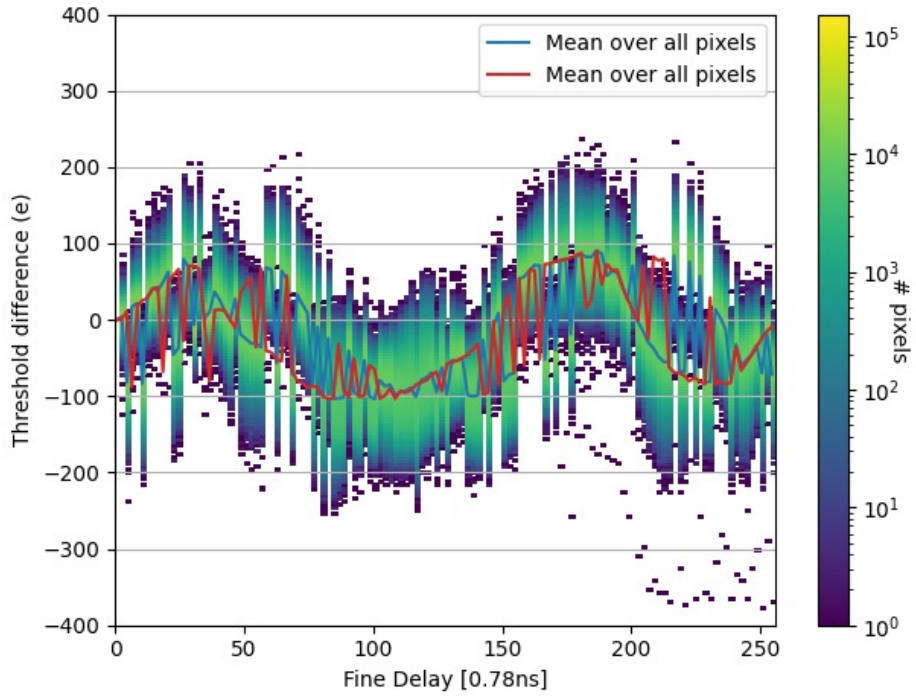
How stable are the threshold results? Do we see large variations when we run the exact same scan multiple times?

DiffPre: 500 (10 C):




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

DiffPre: 600 (10 C):




Fluctuations seem to be random

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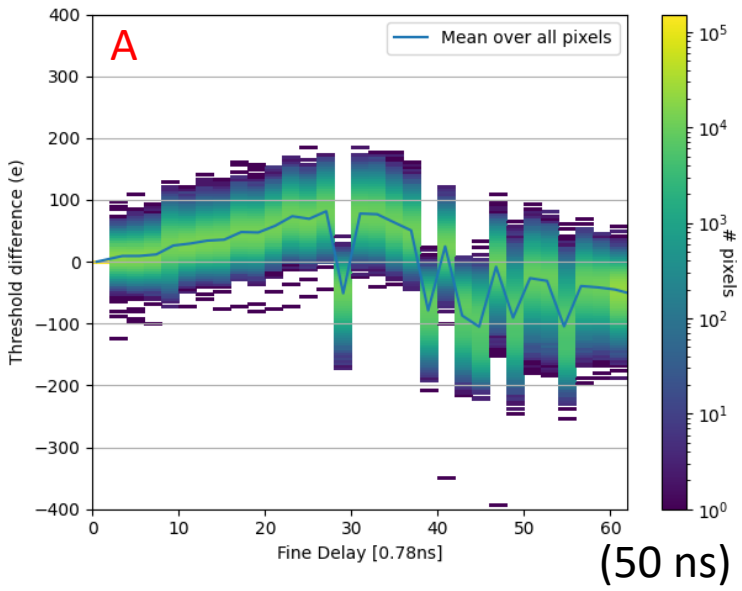
# Threshold oscillation dependence on temperature

Results @ room temperature:

We see mostly 10 MHz oscillation in A and mostly 40 MHz component in B-D

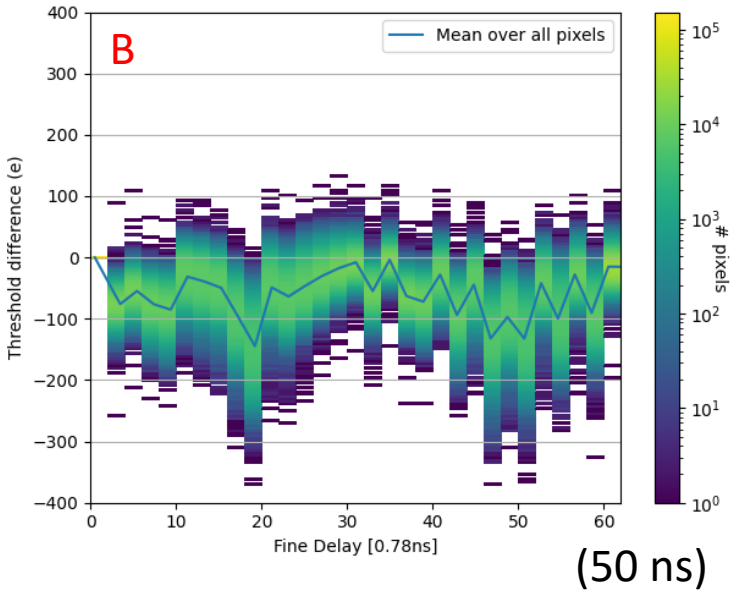
(Planning to run these with lower DiffPre values to get cleaner curves)

v1.1 with 3D sensor, unbiased, single iso



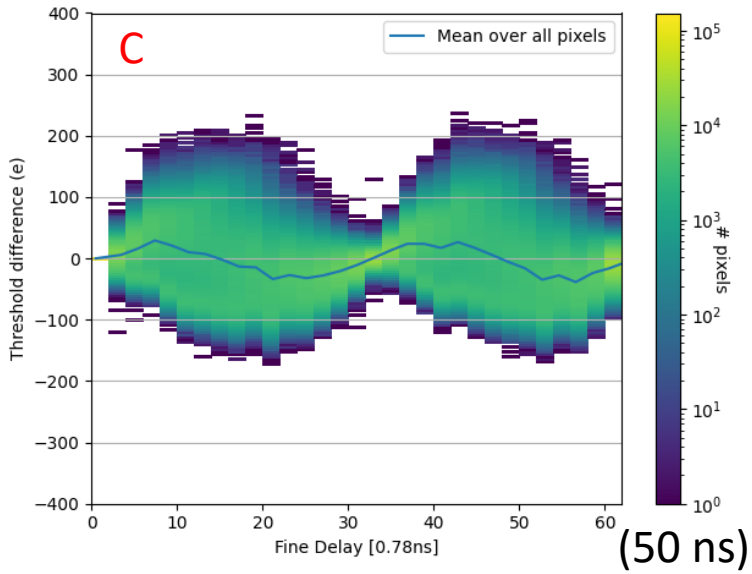

(50 ns)

v1.0 with questionable sensor, unbiased



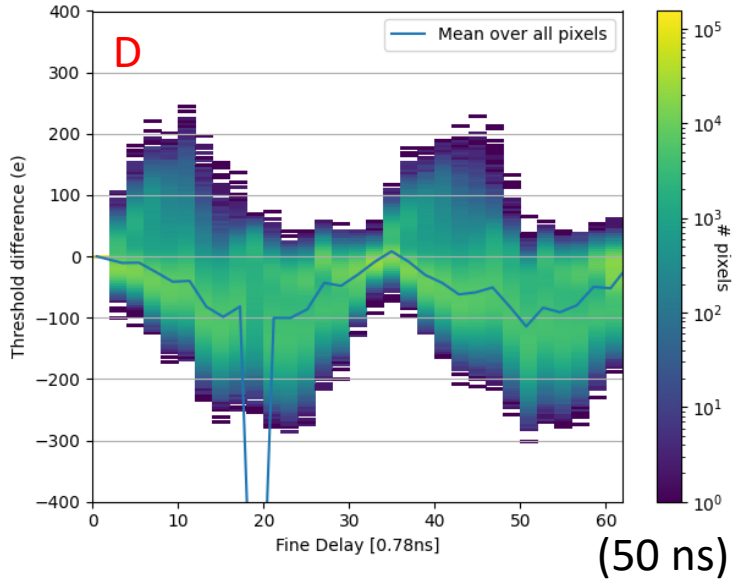

(50 ns)

v1.0 without sensor, single isolation (122)




(50 ns)

v1.0 without sensor, double isolation (10A)




(50 ns)

# Threshold oscillation dependence on temperature

Results @ room temperature:

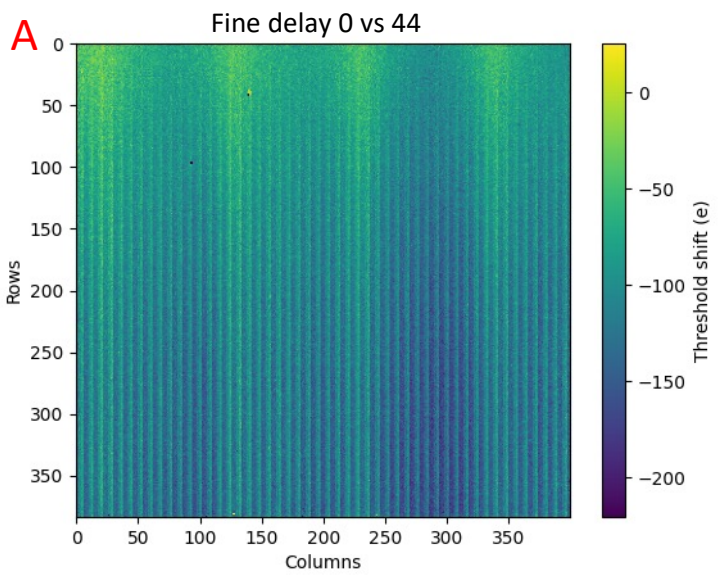
We see mostly 10 MHz oscillation in A and mostly 40 MHz component in B-D

These plots compare only two threshold scans from the previous slide*

* Better analysis needed

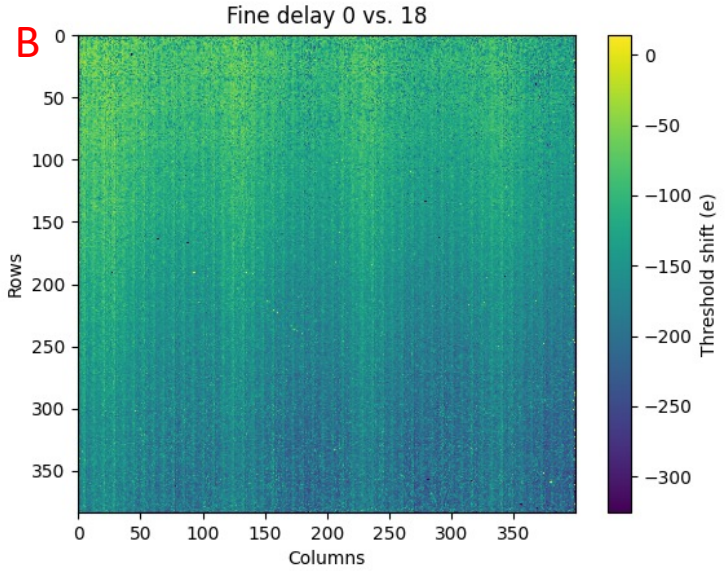
v1.1 with 3D sensor, unbiased, single iso

A



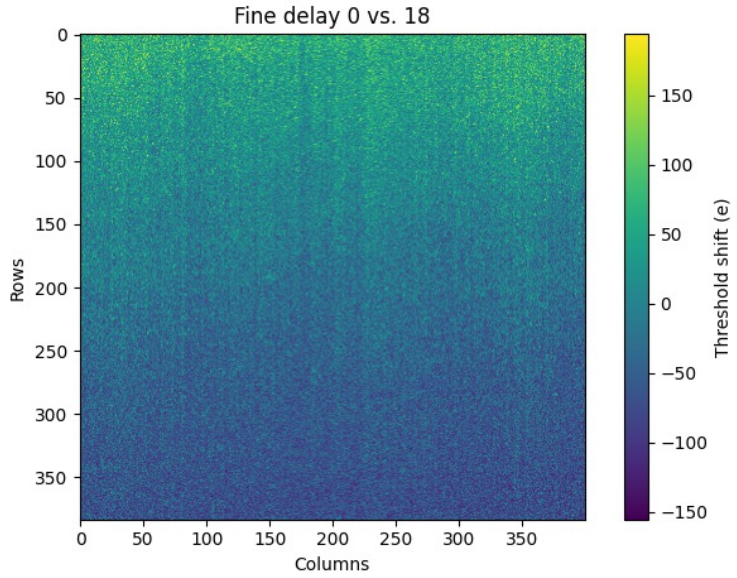

v1.0 with questionable sensor, unbiased

B



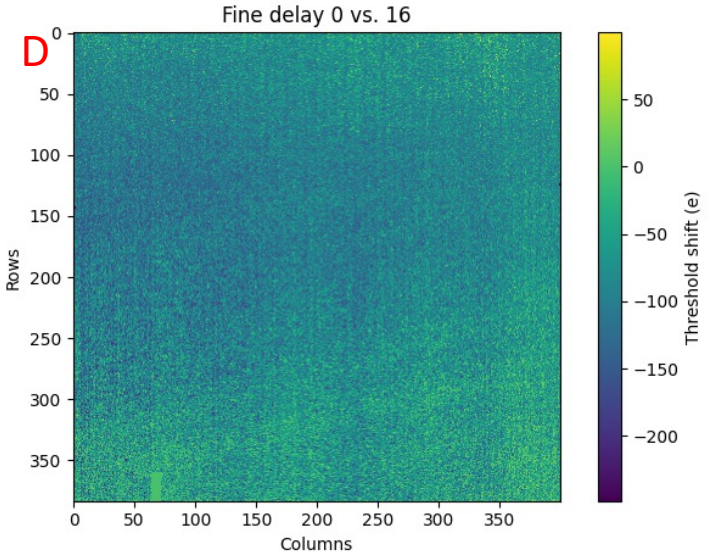

v1.0 without sensor, single isolation (122)

C




v1.0 without sensor, double isolation (10A)

D



# Threshold oscillation dependence on temperature

Results @ room temperature:

We see mostly 10 MHz oscillation in A and mostly 40 MHz component in B-D

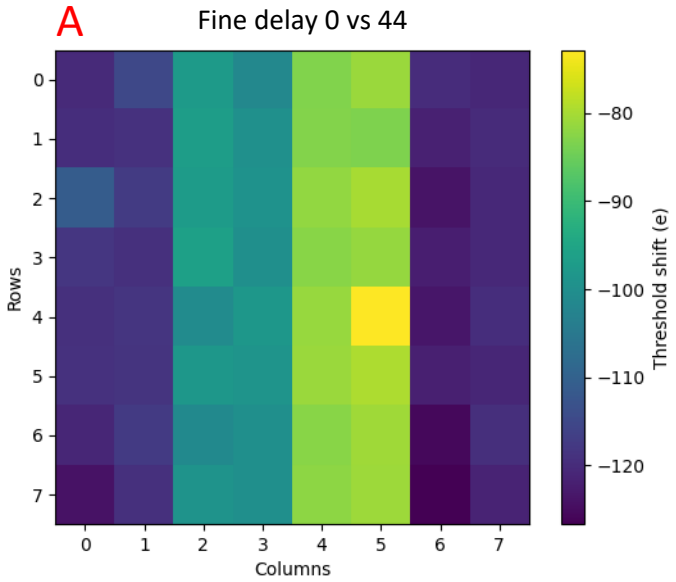
These plots compare only two threshold scans from the previous slide*

We see mostly column structure in A, mostly checkerboard pattern in C-D, and a mixture of both (?) in B

* Better analysis needed

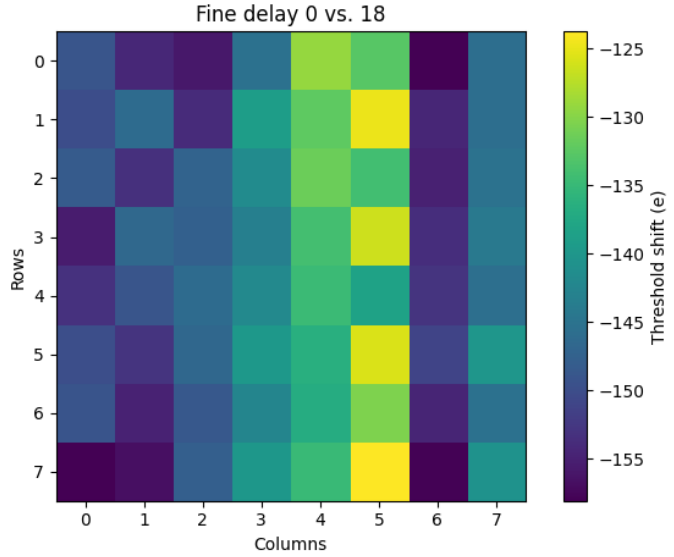
v1.1 with 3D sensor, unbiased, single iso

A



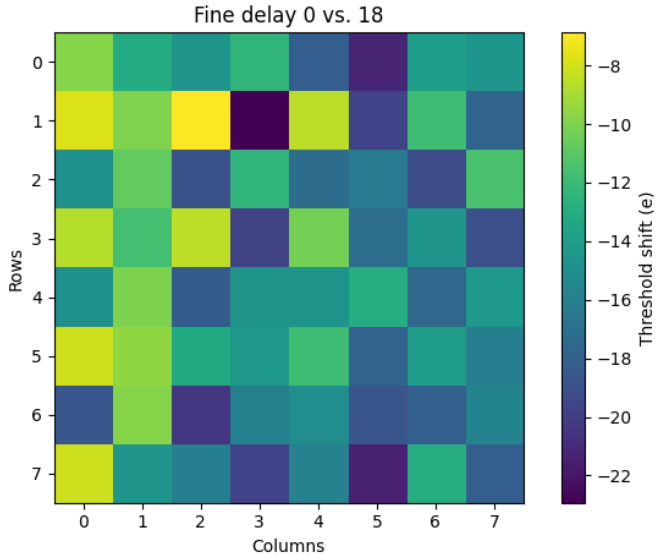

v1.0 with questionable sensor, unbiased

B



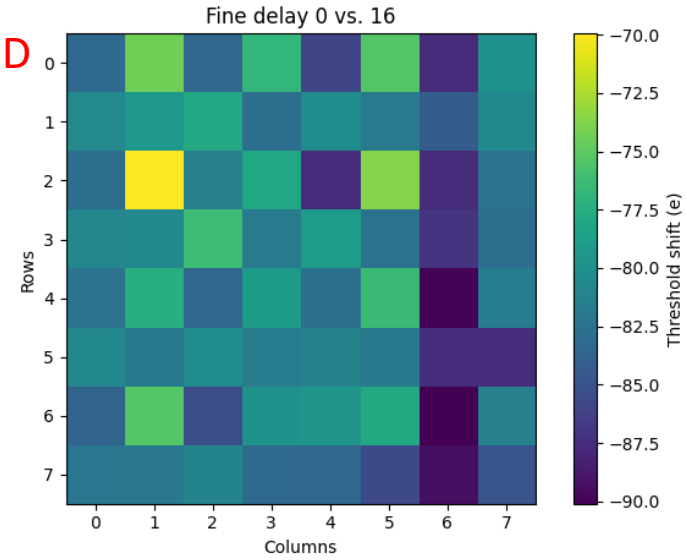

v1.0 without sensor, single isolation (122)

C




v1.0 without sensor, double isolation (10A)

D



# Summary so far

Freezer, -20 C

1. v1.0 without sensor, double isolation (101)
2. v1.0 without sensor, single isolation (122)

- 40 MHz frequency dominant
- No big difference between single / double isolation

Climate chamber #1:

1. v1.1 with 3D sensor, unbiased, single isolation (?)
2. v1.0 with questionable sensor, unbiased (?)
3. v1.0 without sensor, single isolation (122)
4. v1.0 without sensor, double isolation (10A)

- 10 MHz frequency dominant in #1
- 40 MHz frequency dominant in #3-4
- Difficult to tell in #2
- No big difference between single / double isolation

**Hypothesis: 40 MHz is dominant in chips with a sensor.**

Check this hypothesis with quad module:

Climate chamber #2:

1. Quad with HPK planar sensor, biased @ 100V

# Quad results

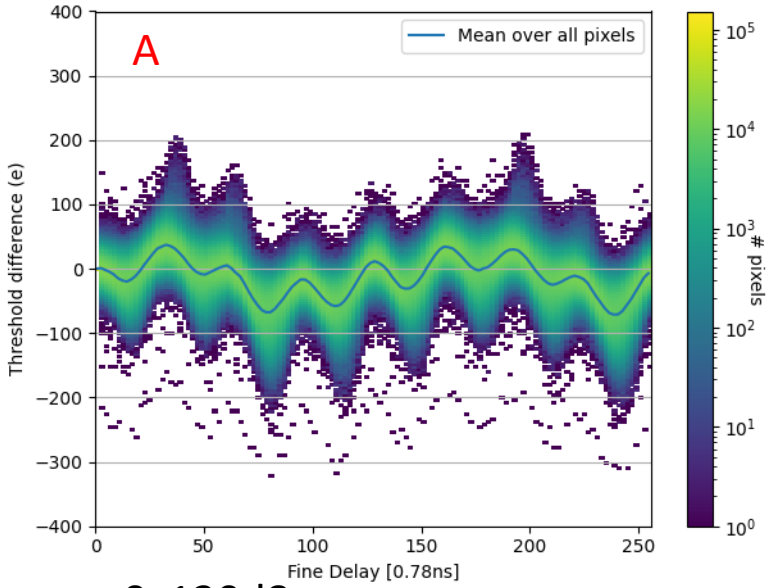
v1.1, with biased HPK planar sensor

Results @ 15 C:

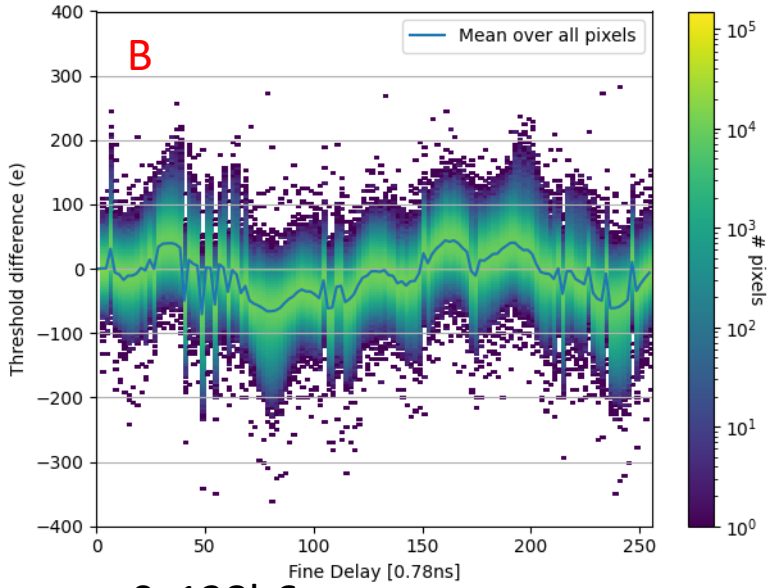
For all chips:

DiffPreComp: 350
DiffPreamp: 500
DiffComp: 500

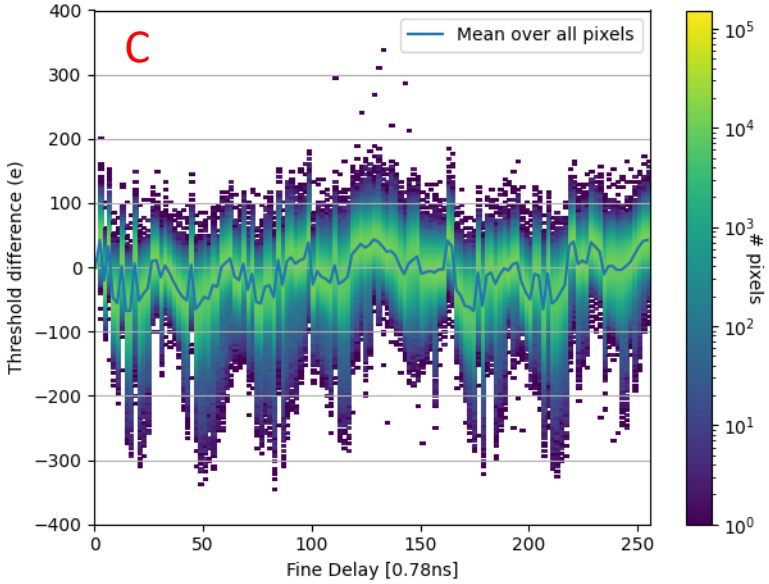
0x130bc



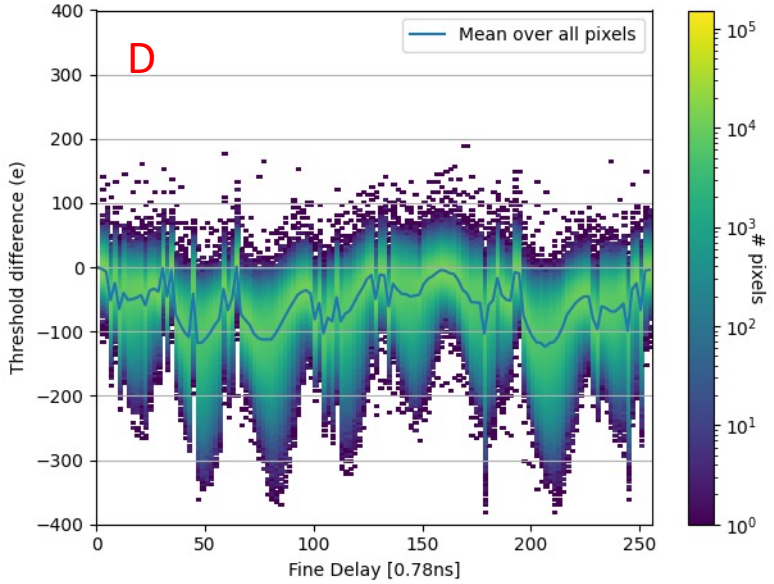

0x130c9




0x130d8




0x138b6



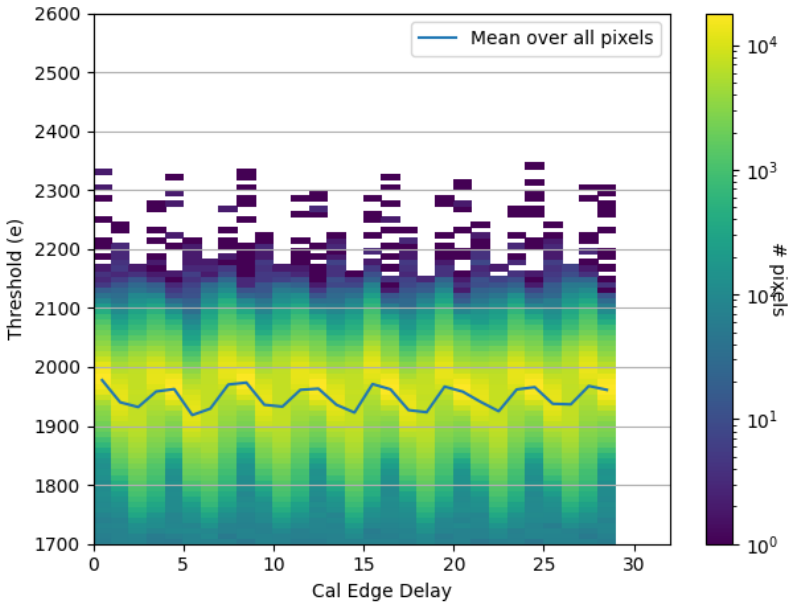
# Backup

# DiffComp studies

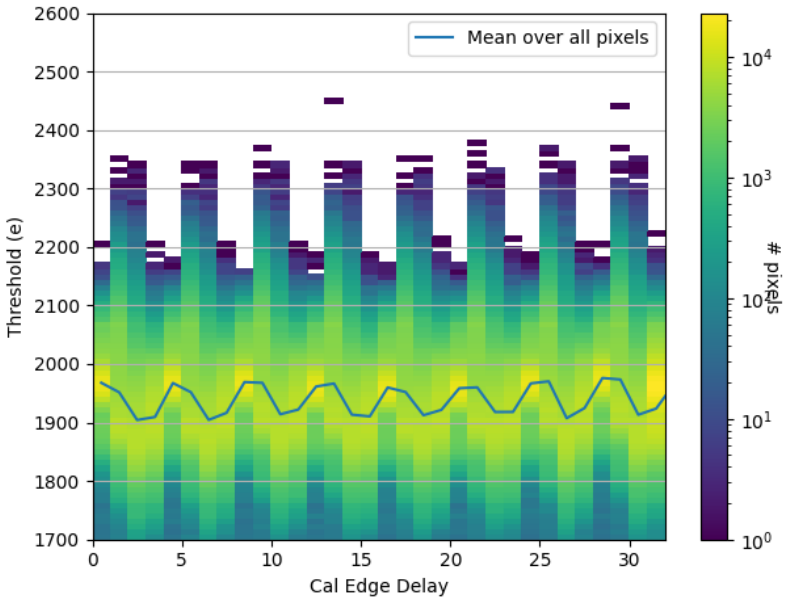
v1.0, no sensor, single iso

- Using v1.0 chip, **single isolation**, chip is retuned to 2000e after changing DiffComp
- Scanning the cal edge delay (6.25 ns) with fine delay = 5

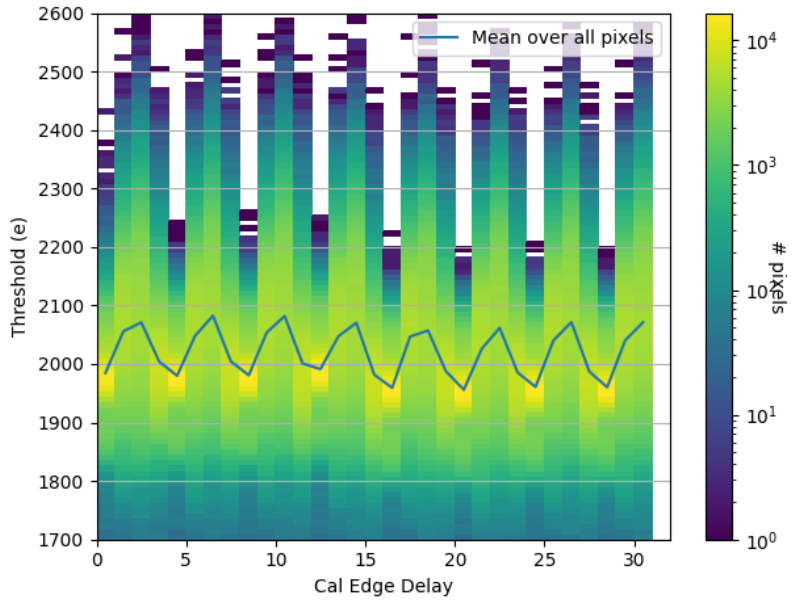
DiffComp = 300




DiffComp = 500 (default)




DiffComp = 1000



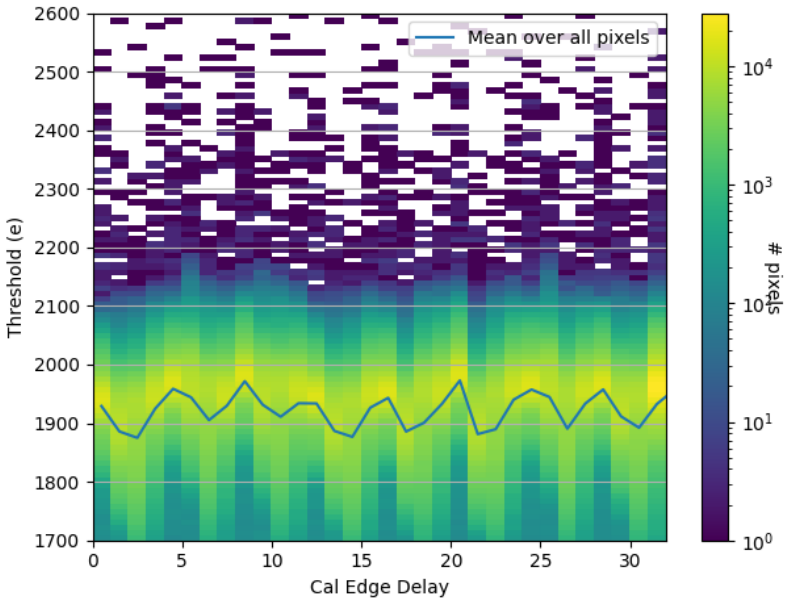

- We see 40 MHz oscillation
- Cal Edge Delay might be too coarse to determine if amplitude of oscillation is changing

# DiffComp studies

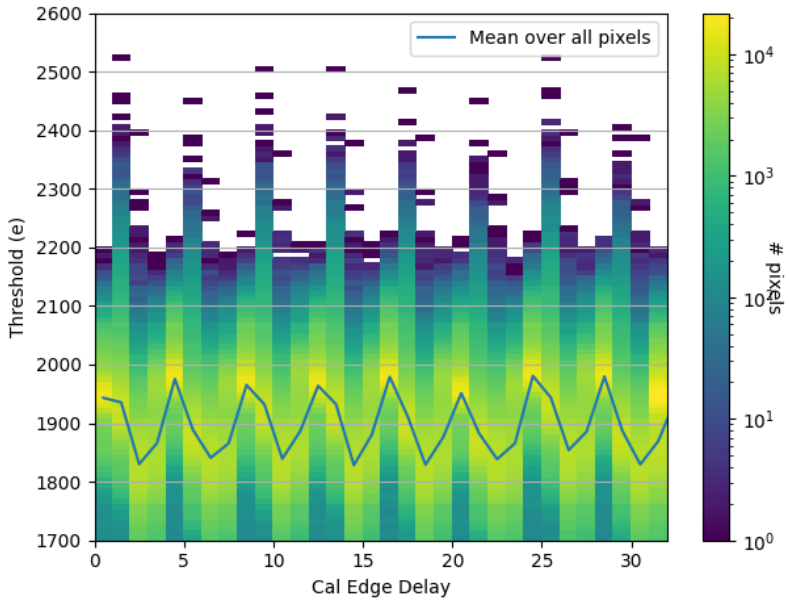
v1.0, no sensor, single iso

- Using v1.0 chip, **double isolation**, chip is retuned to 2000e after changing DiffComp
- Scanning the cal edge delay (6.25 ns) with fine delay = 5

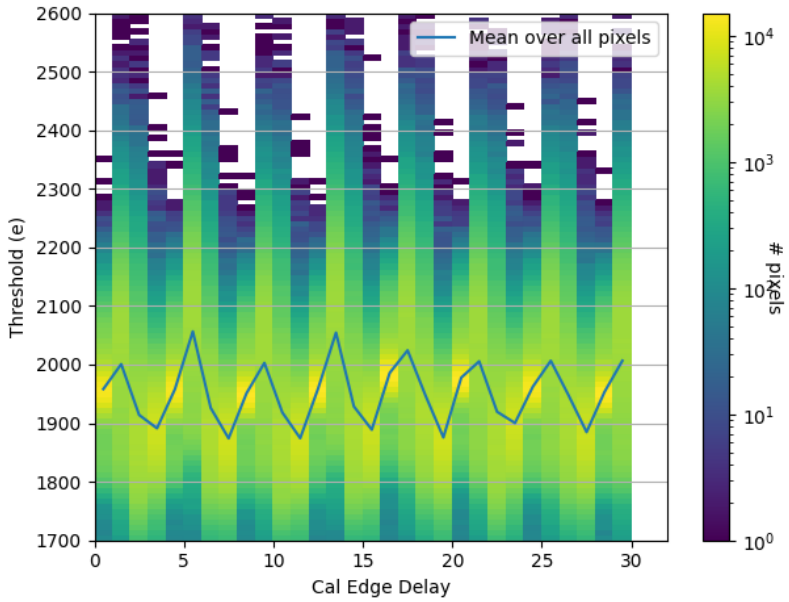
DiffComp = 300




DiffComp = 500 (default)




DiffComp = 1000



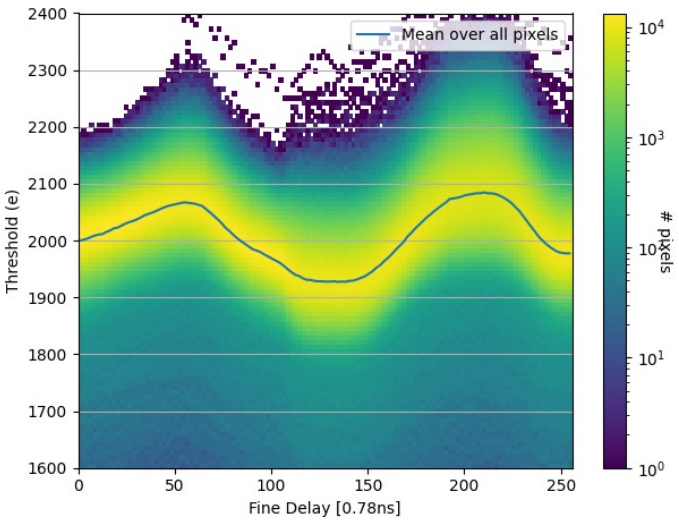

- We see 40 MHz oscillation
- Cal Edge Delay might be too coarse to determine if amplitude of oscillation is changing

# DiffPreamp studies

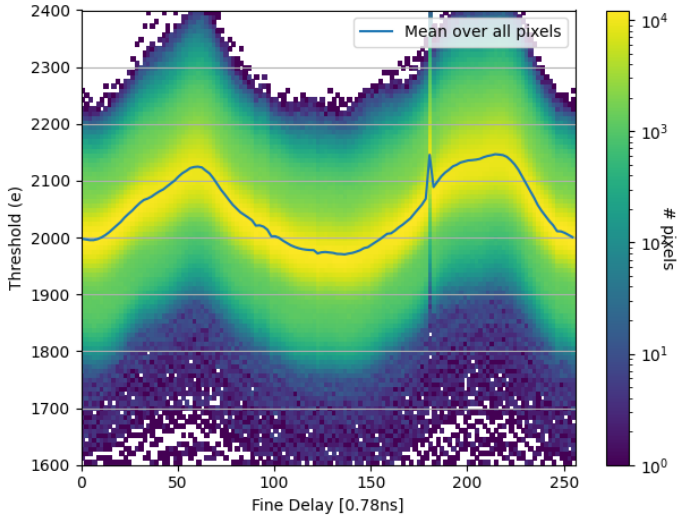
v1.1, with unbiased 3D sensor

- DiffPreamp studies

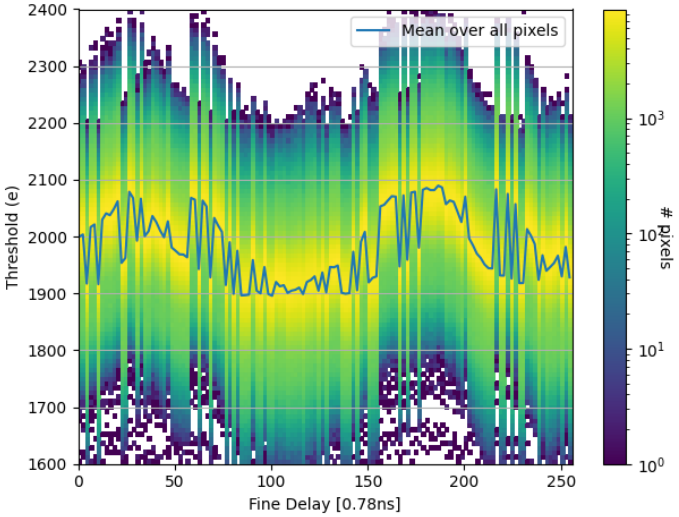
DiffPre: 300 (23 →10 C)



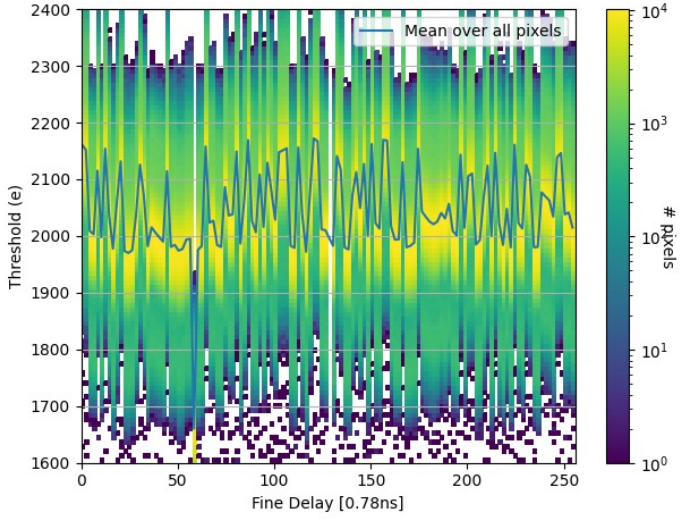

DiffPre: 500 (10 C)




DiffPre: 600 (10 C)




DiffPre: 900 (23 C)

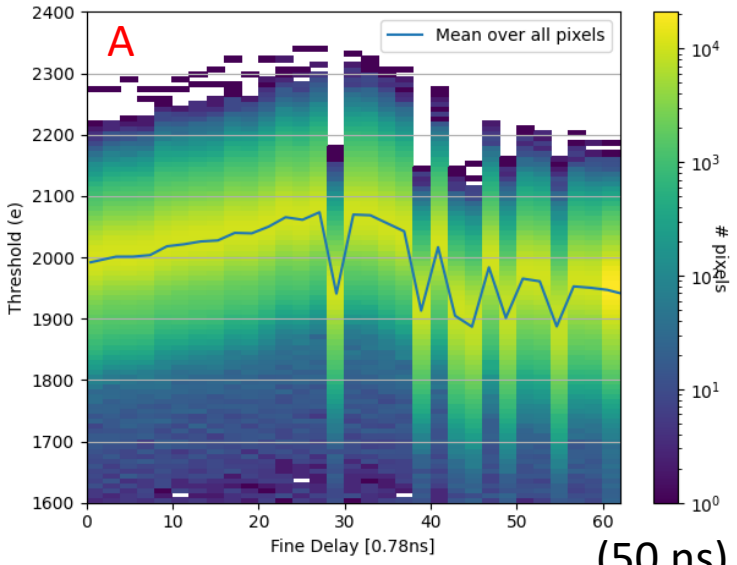


# Threshold oscillation dependence on temperature

Results @ room temperature:

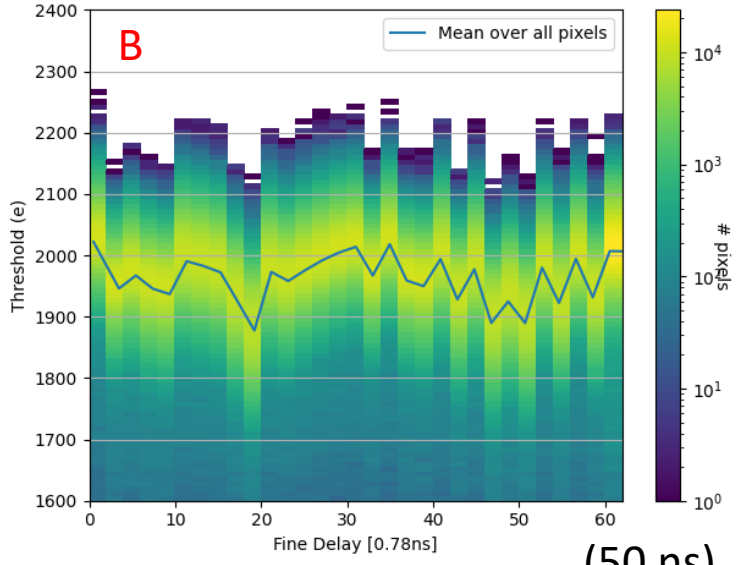
We see mostly 10 MHz oscillation in A and mostly 40 MHz component in B-D

v1.1 with 3D sensor, unbiased, single iso



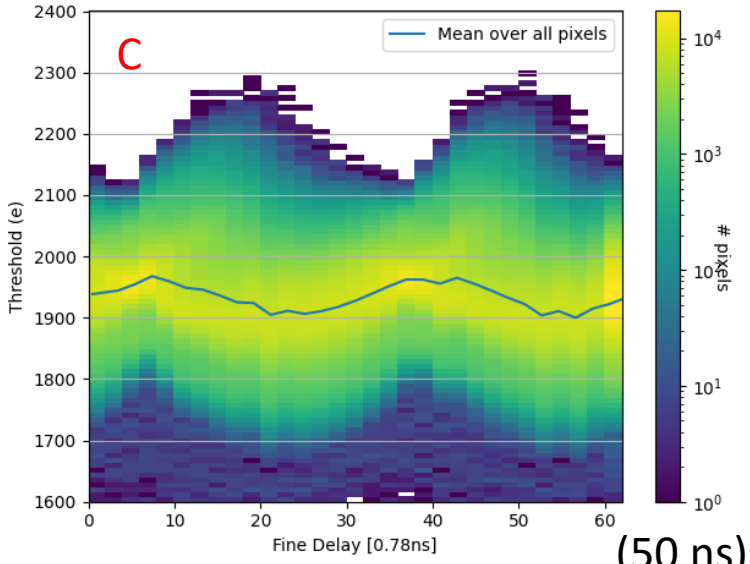

(50 ns)

v1.0 with questionable sensor, unbiased



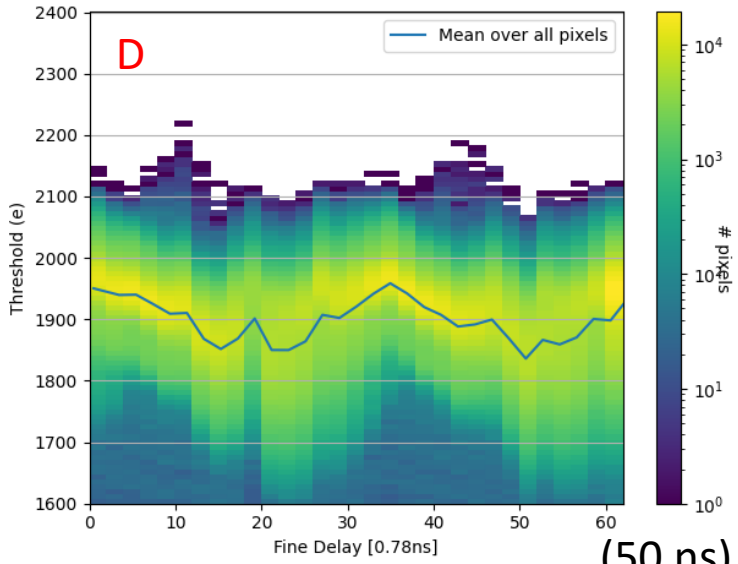

(50 ns)

v1.0 without sensor, single isolation (122)




(50 ns)

v1.0 without sensor, double isolation (10A)



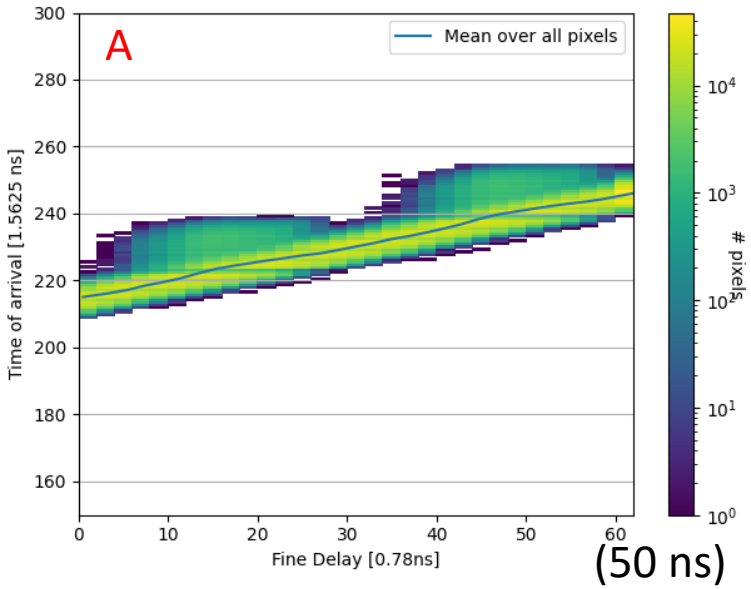

(50 ns)

# Threshold oscillation dependence on temperature

Results @ room temperature:

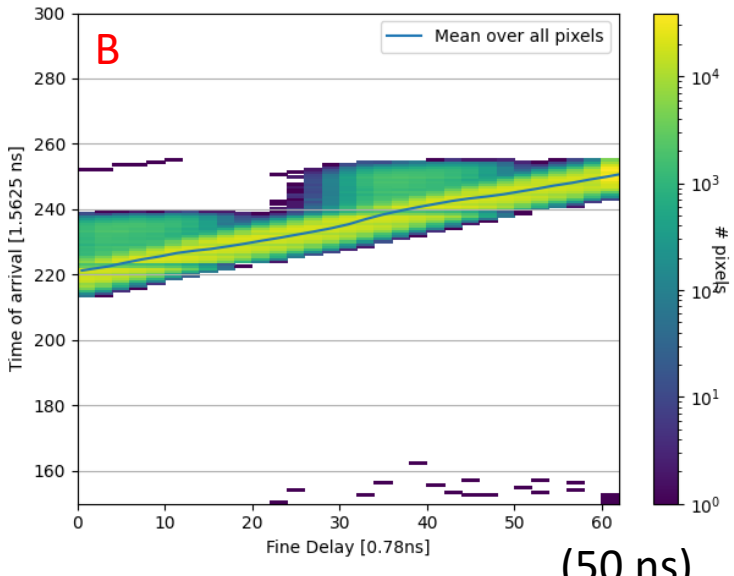
We see mostly 10 MHz oscillation in A and mostly 40 MHz component in B-D

v1.1 with 3D sensor, unbiased, single iso



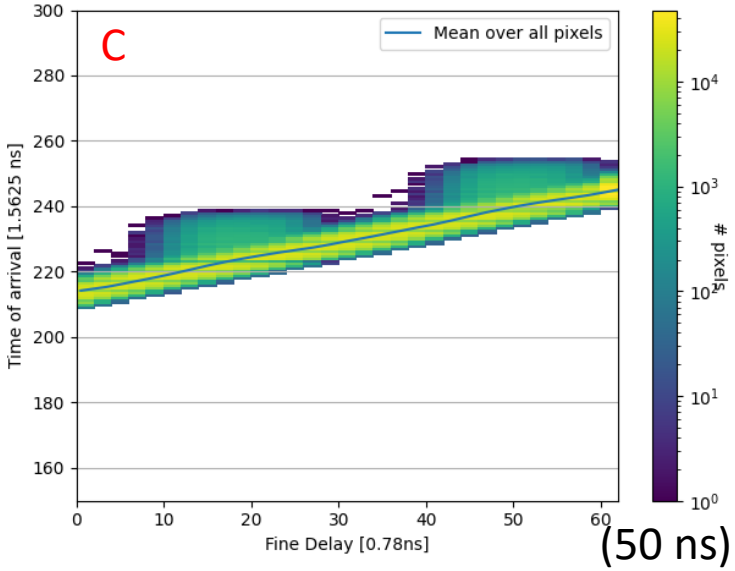

(50 ns)

v1.0 with questionable sensor, unbiased



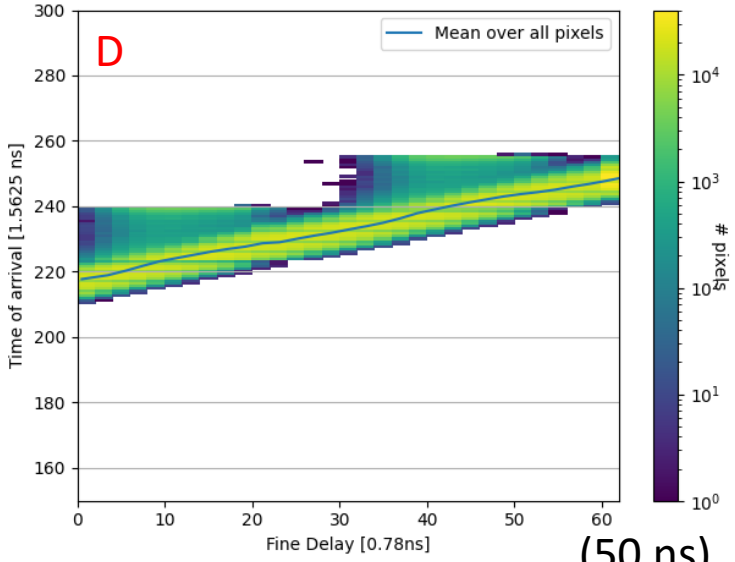

(50 ns)

v1.0 without sensor, single isolation (122)




(50 ns)

v1.0 without sensor, double isolation (10A)



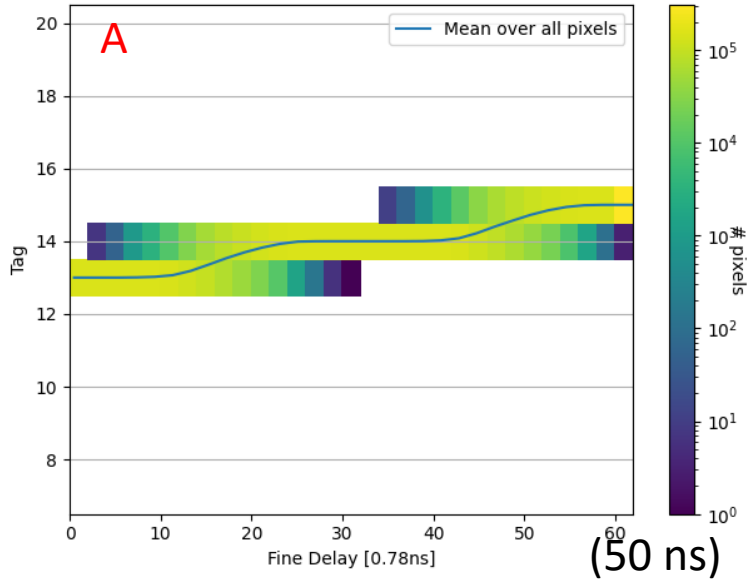

(50 ns)

# Threshold oscillation dependence on temperature

Results @ room temperature:

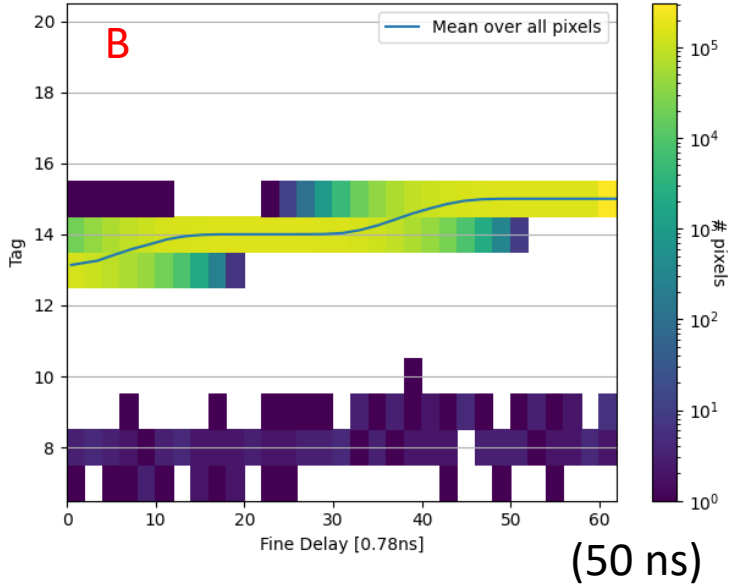
We see mostly 10 MHz oscillation in A and mostly 40 MHz component in B-D

v1.1 with 3D sensor, unbiased, single iso



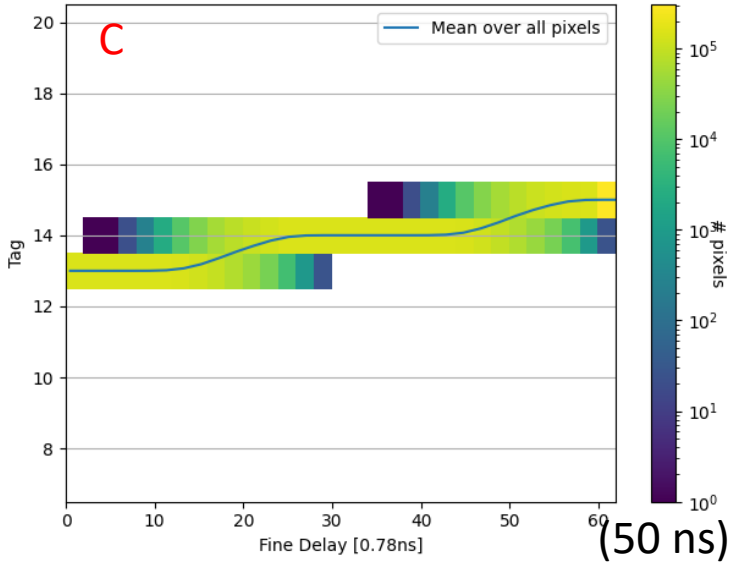

(50 ns)

v1.0 with questionable sensor, unbiased



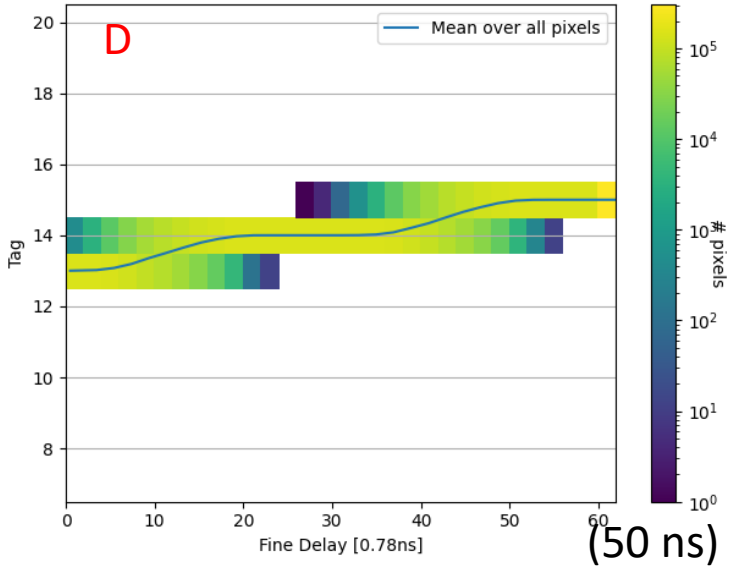

(50 ns)

v1.0 without sensor, single isolation (122)




(50 ns)

v1.0 without sensor, double isolation (10A)

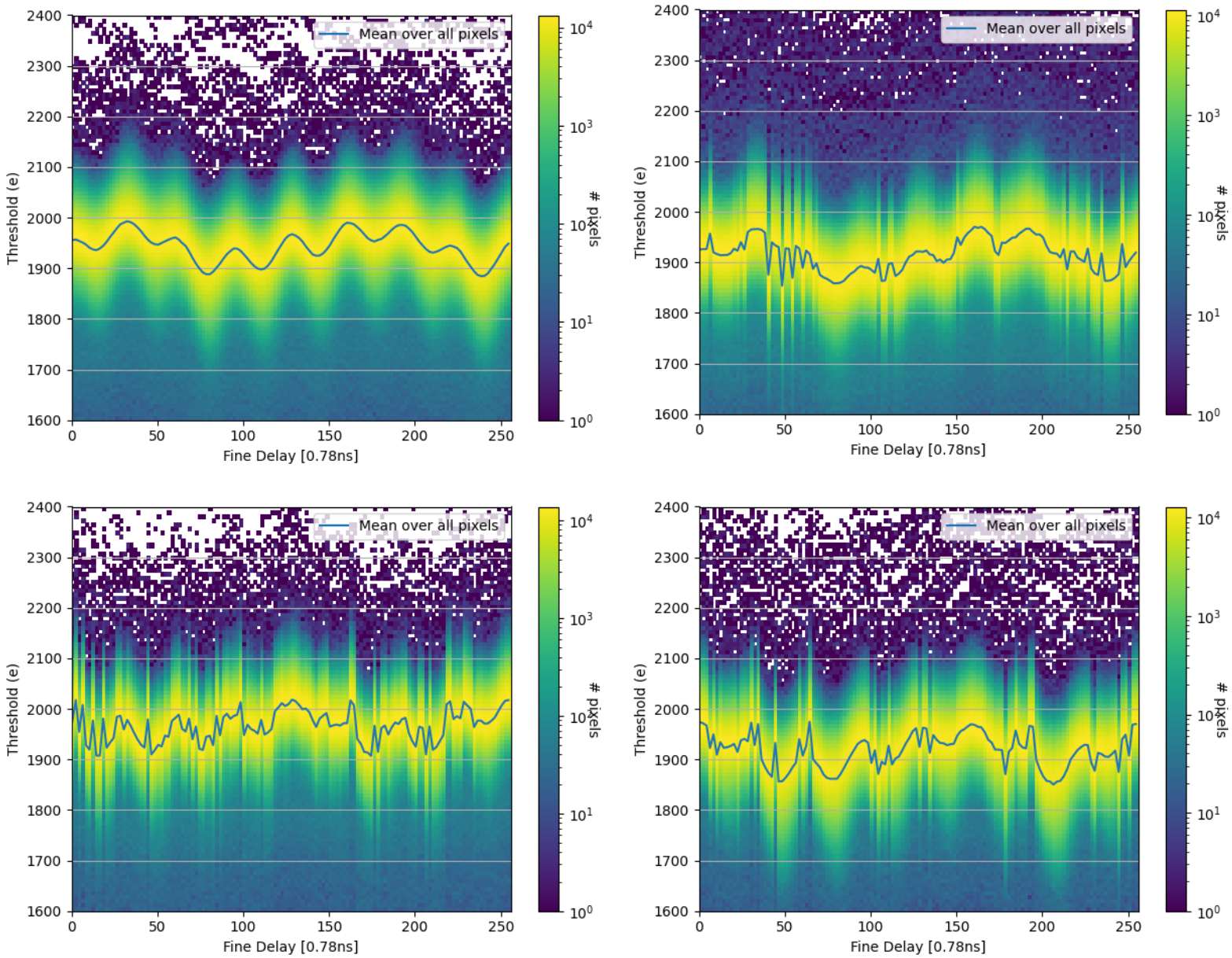



(50 ns)

# Quad results

v1.1, with biased HPK planar sensor

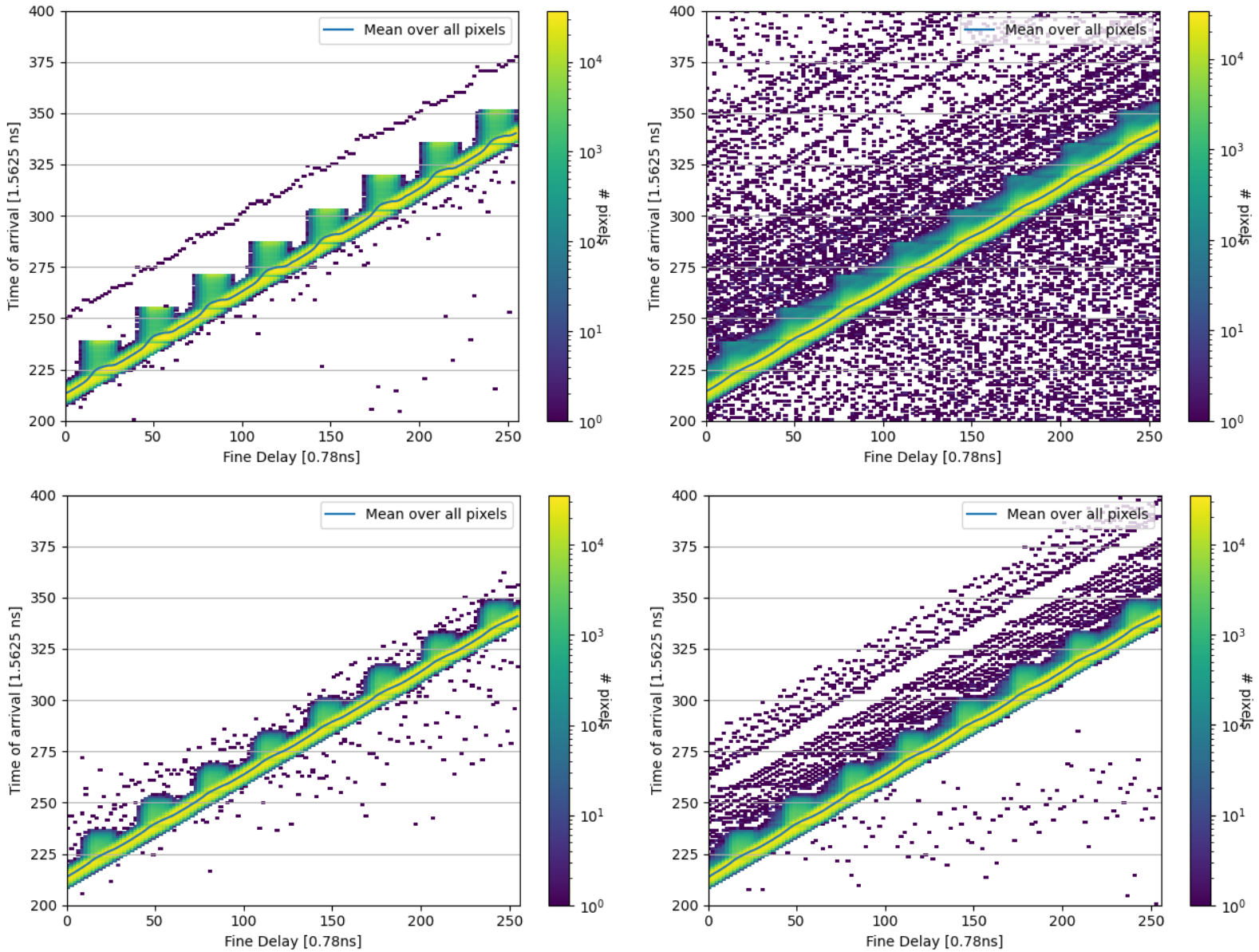
DiffPreComp: 350
DiffPreamp: 500
DiffComp: 500



# Quad results

v1.1, with biased HPK planar sensor

DiffPreComp: 350
DiffPreamp: 500
DiffComp: 500



# Quad results

v1.1, with biased HPK planar sensor

DiffPreComp: 350
DiffPreamp: 500
DiffComp: 500