Update on DPTS Time-over-Threshold (ToT) studies

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Data collected

Setting used

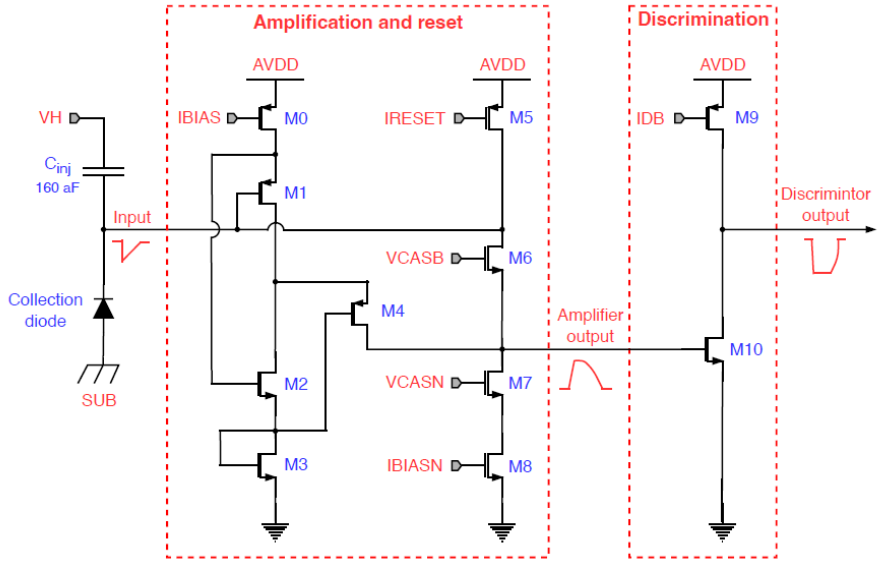
Nominal	
VCASB = 150 mV	VCASN = 200 mV
VCASB = 200 mV	VCASN = 400 mV
VCASB = 225 mV	VCASN = 500 mV
VCASB = 250 mV	VCASN = 600 mV
VCASB = 275 mV	IDB = 50 nA
VCASB = 350 mV	IDB = 200 nA
IRESET = 5 pA	IDB = 300 nA
IRESET = 15 pA	IDB = 400 nA
IRESET = 25 pA	IDB = 500 nA
IRESET = 40 pA	IBIAS = 50 nA
IRESET = 60 pA	IBIAS = 200 nA
	IBIAS = 300 nA
	IBIAS = 400 nA
	IBIAS = 500 nA

Nominal settings

I_{reset} = 10 pA
I_{bias} = 100 nA
I_{biasn} = 10 nA
I_{db} = 100 nA
V_{casn} = 300 mV
V_{casb} = 300 mV
$V_{pwell} = V_{sub}$ = -1.2 V

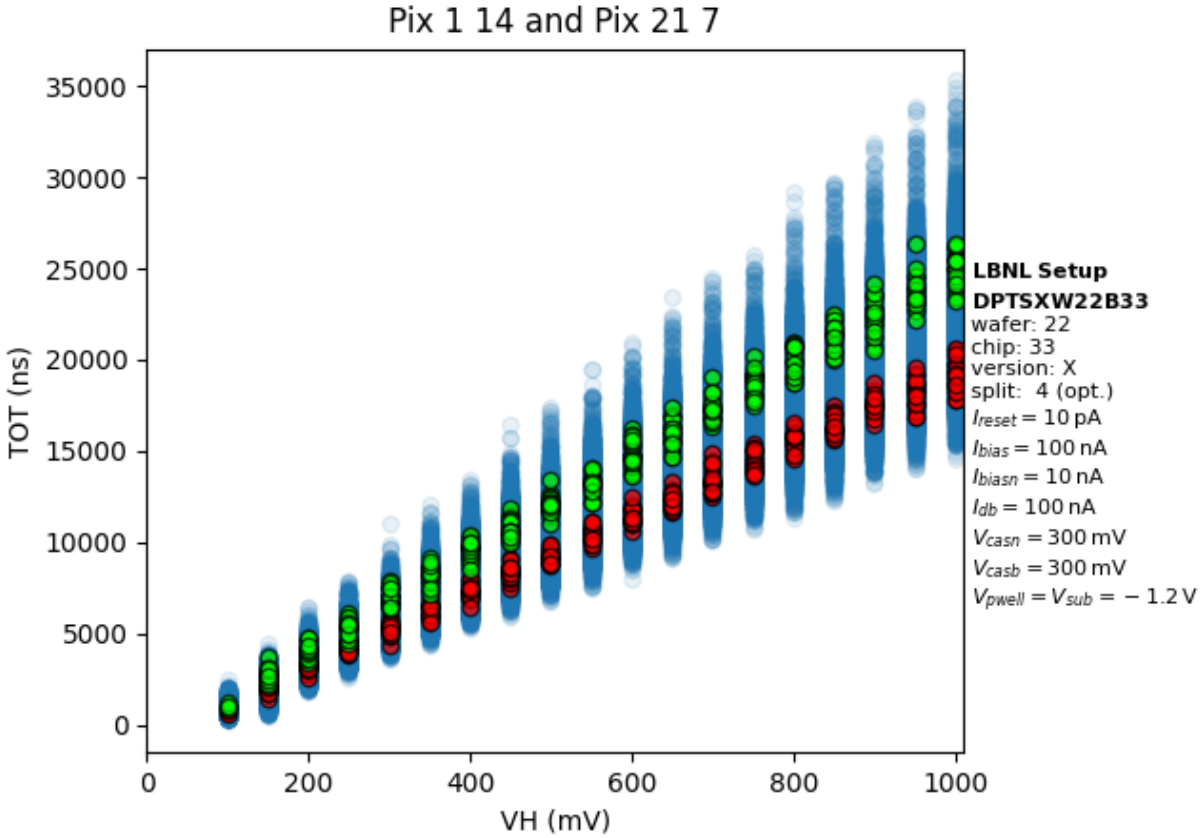
We did not change
$V_{pwell} = V_{sub}$ from -1.2 V

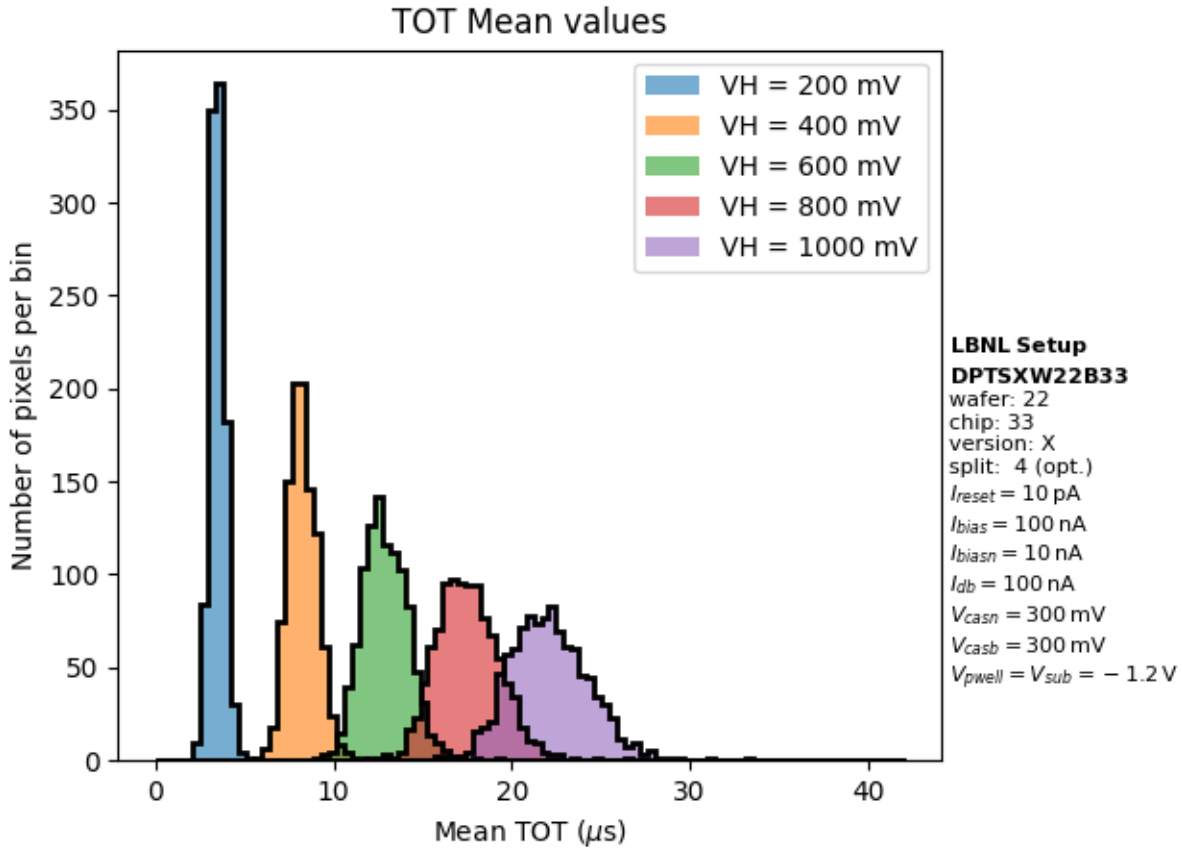
We always set
IBIASN = IBIAS/10



We study the ToT as we inject charge in the range VH = 50-1000 mV with 50 mV steps. We have 25 injections per VH value.

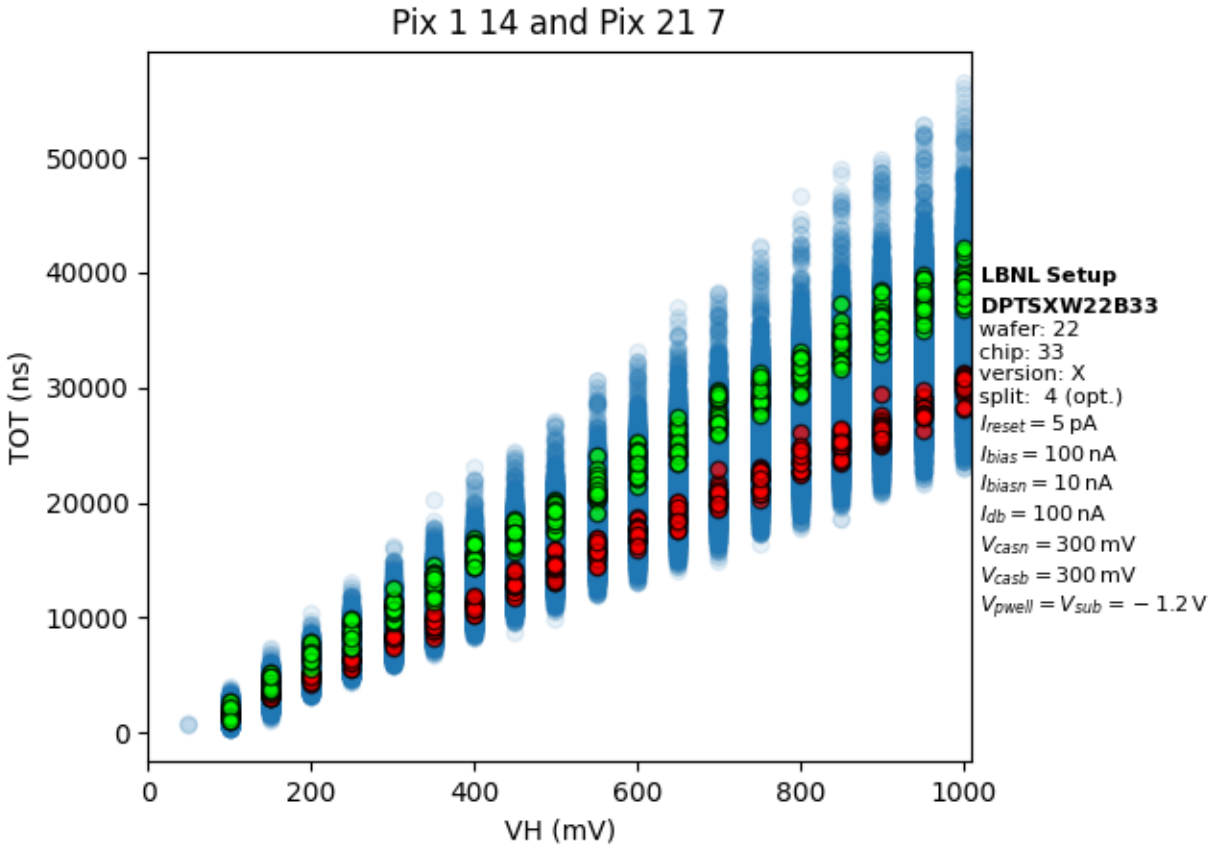
ToT results at nominal settings



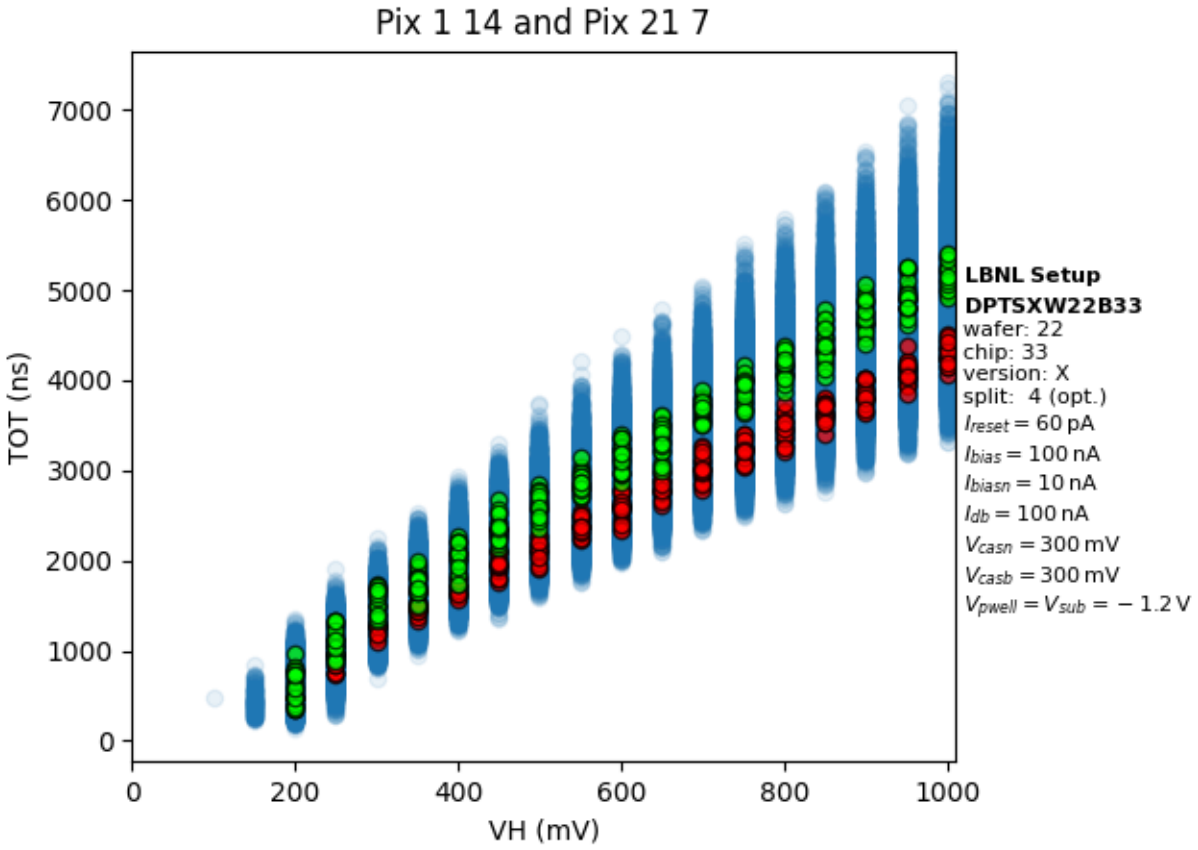


ToT results with varying IRESET – lowest and highest value

IRESET = 5 pA

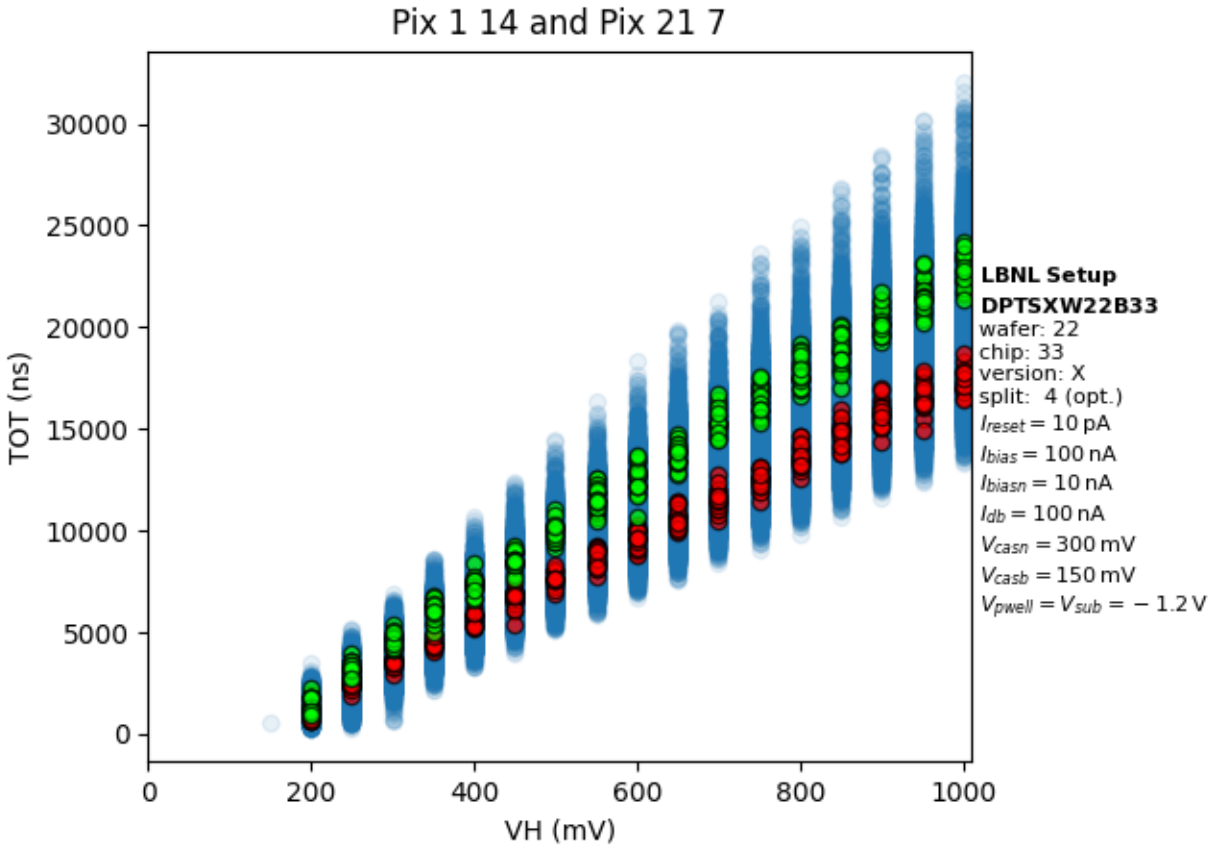


IRESET = 60 pA

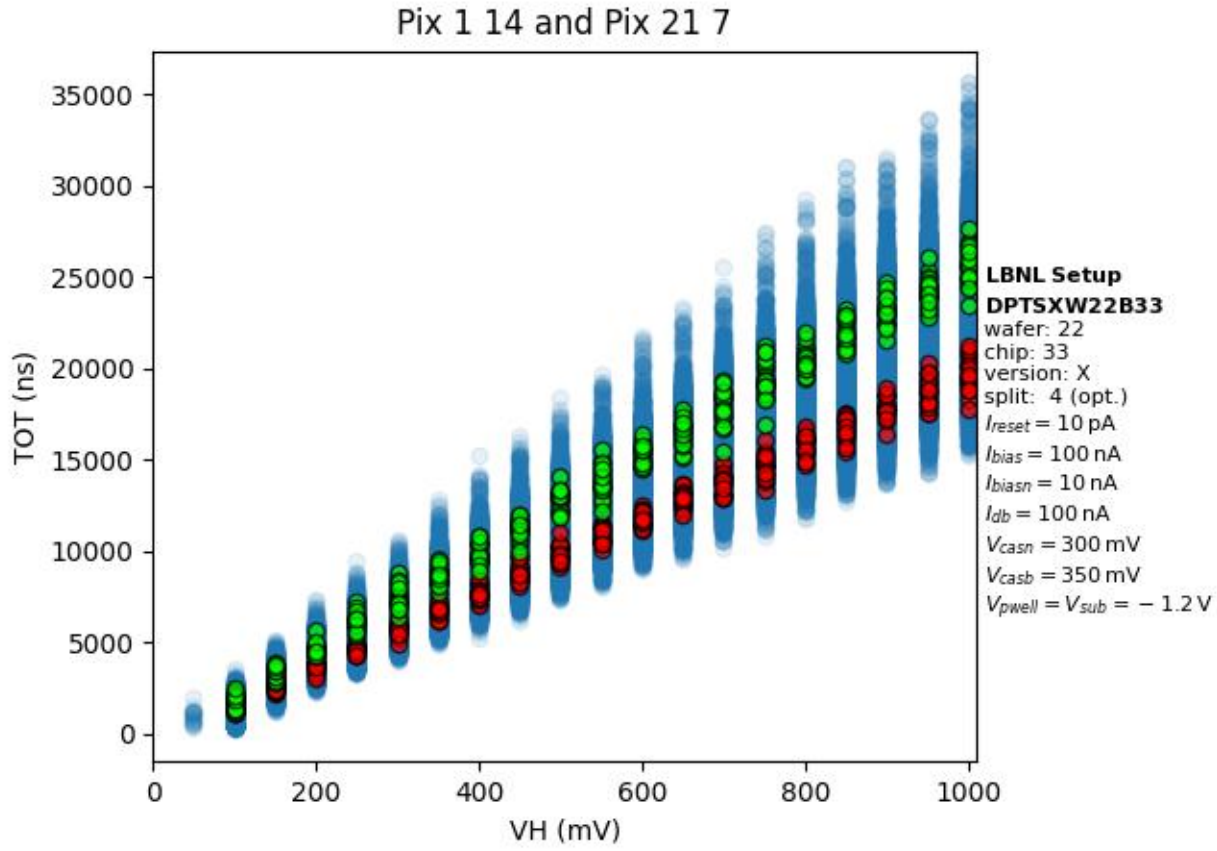


ToT results with varying VCASB – lowest and highest value

VCASB = 150 mV

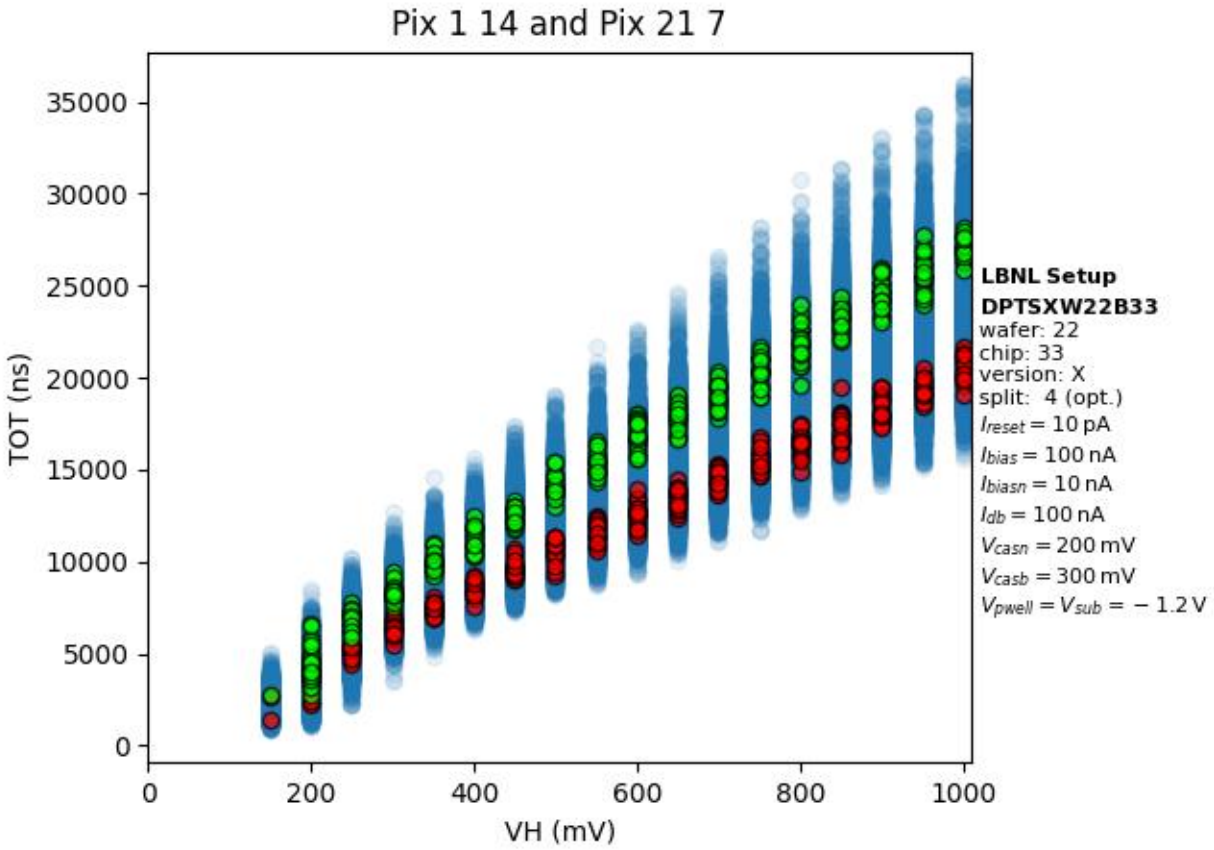


VCASB = 350 mV

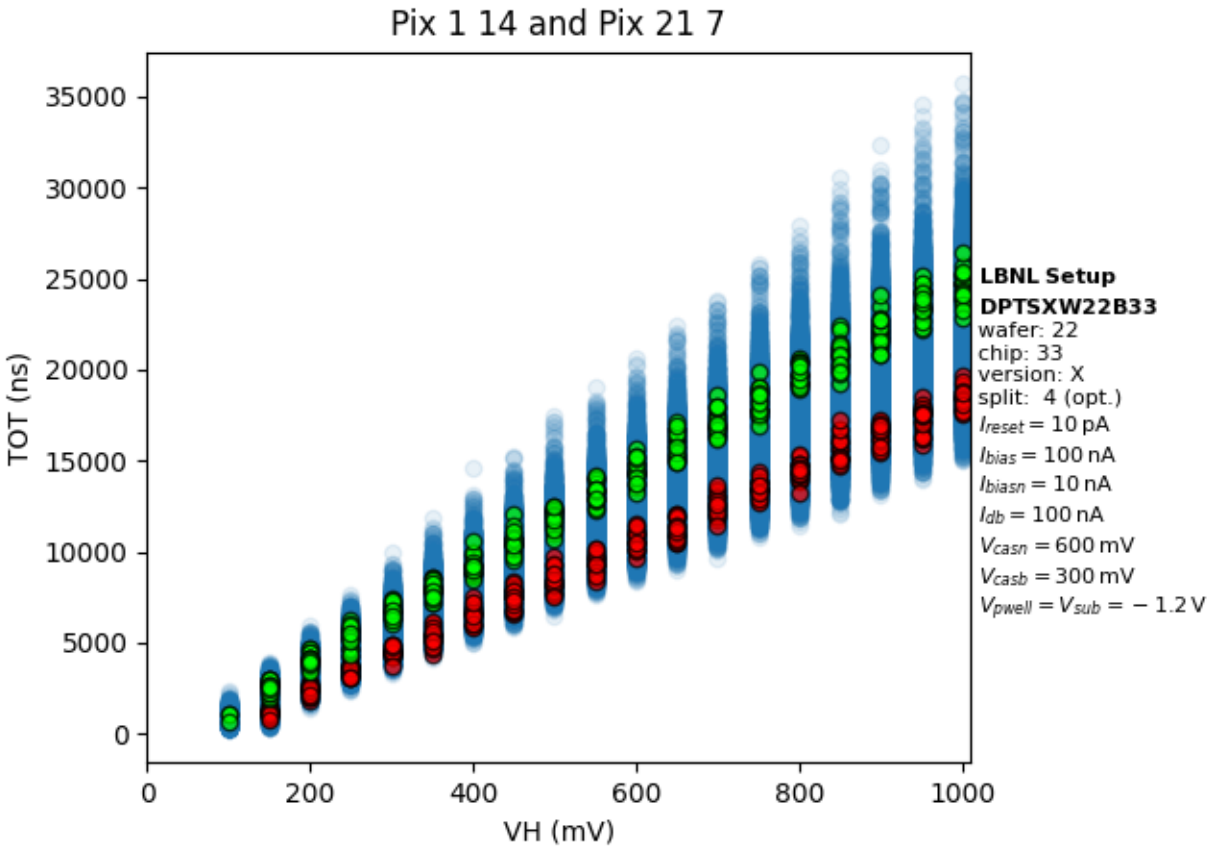


ToT results with varying VCASN – lowest and highest value

VCASN = 200 mV

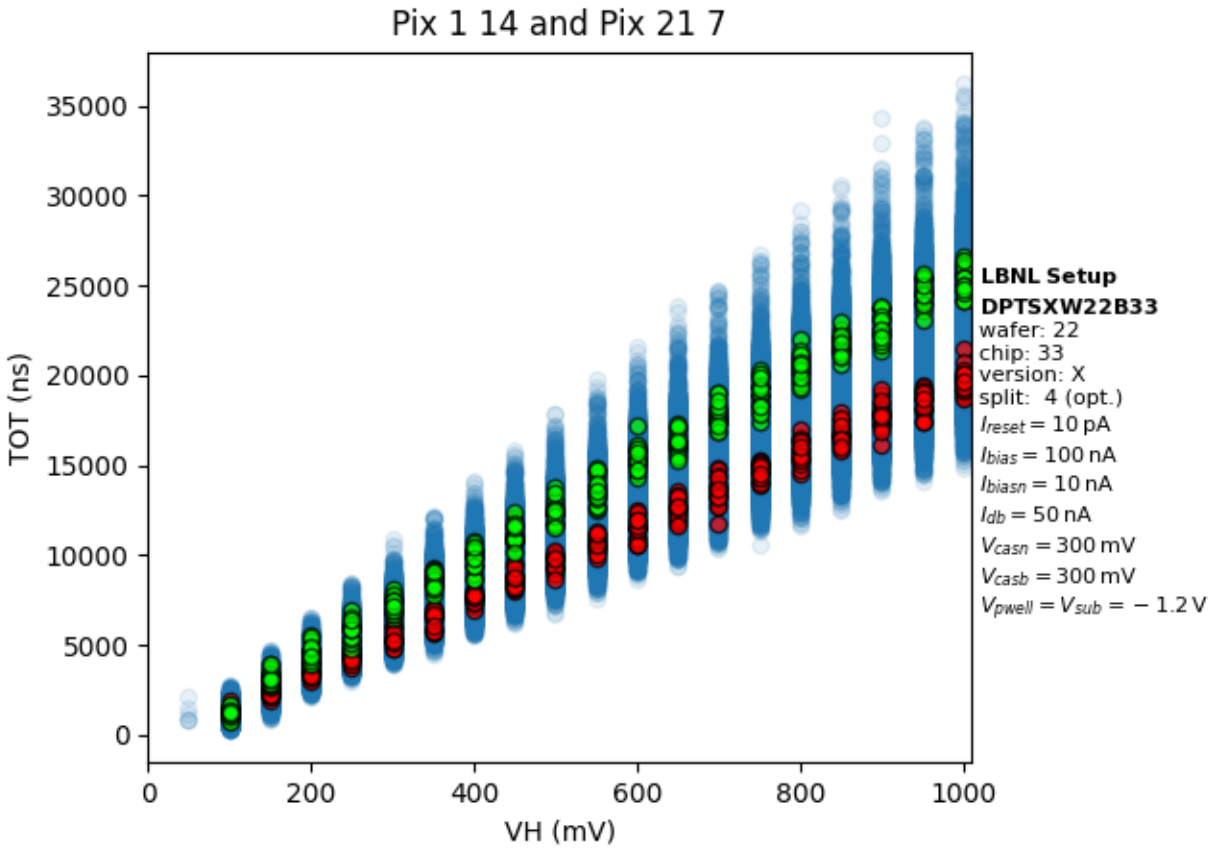


VCASN = 600 mV

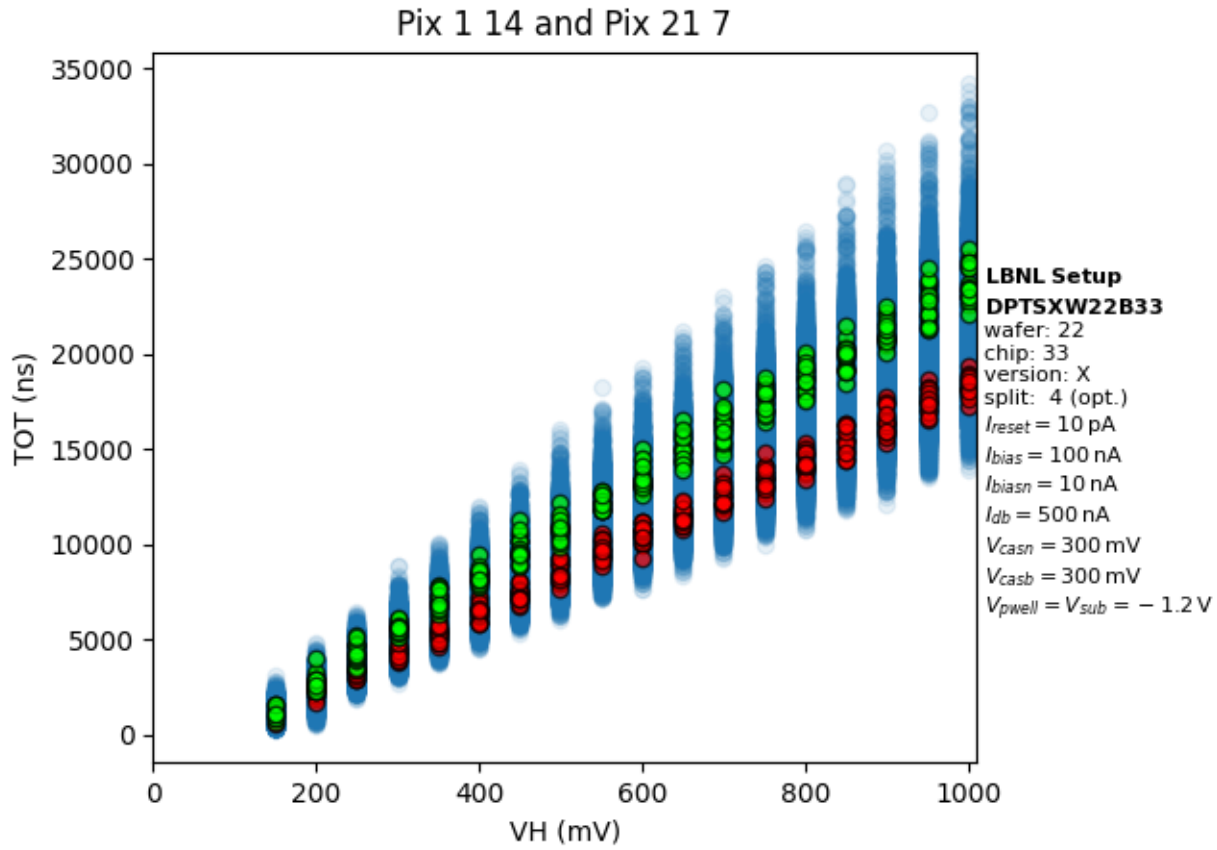


ToT results with varying IDB – lowest and highest value

IDB = 50 nA

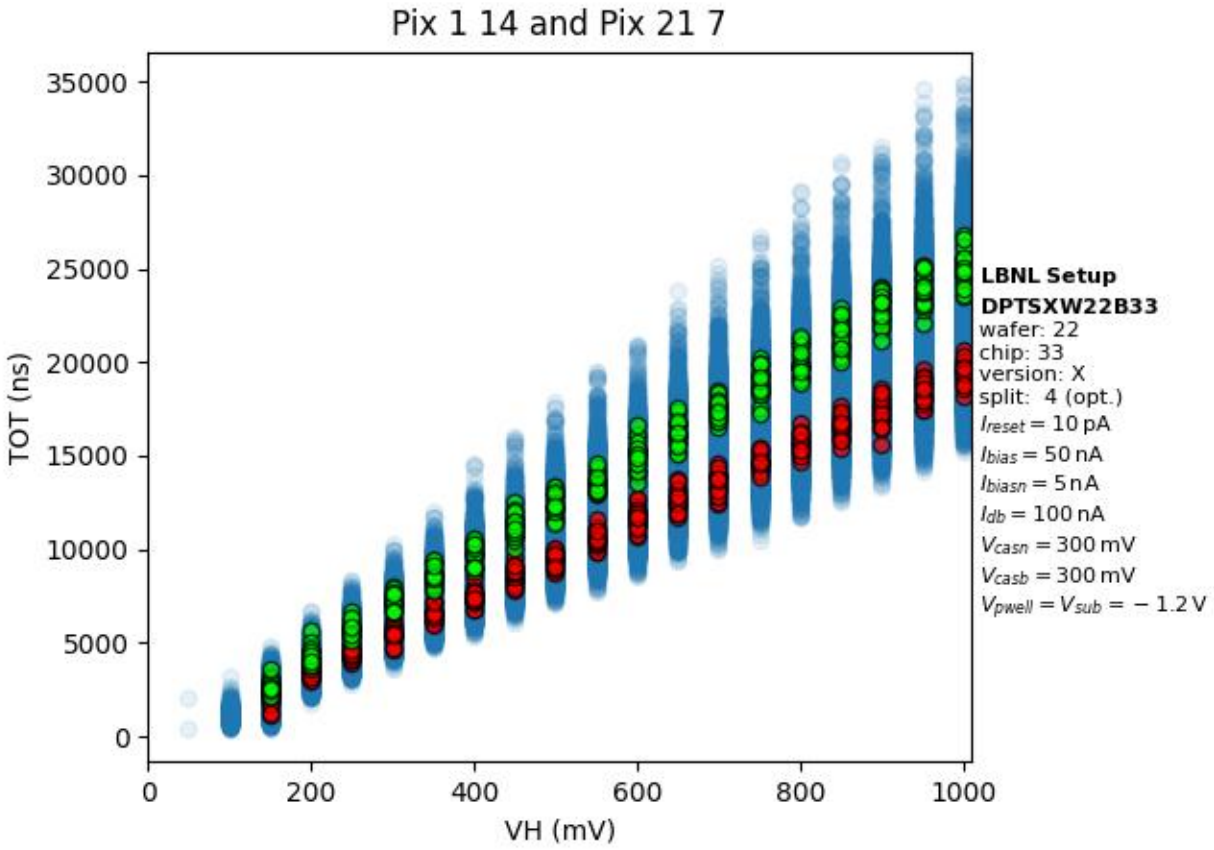


IDB = 500 nA

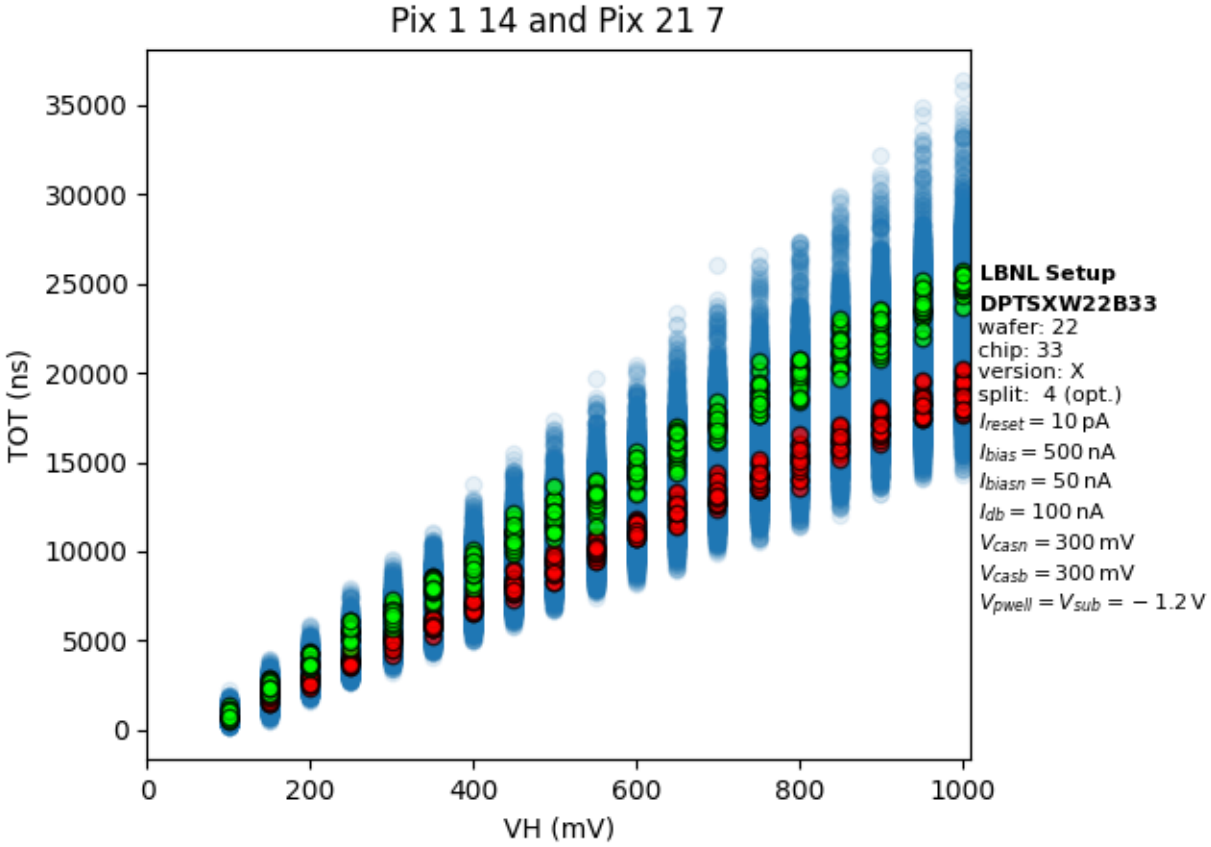


ToT results with varying IBIAS – lowest and highest value

IBIAS = 50 nA

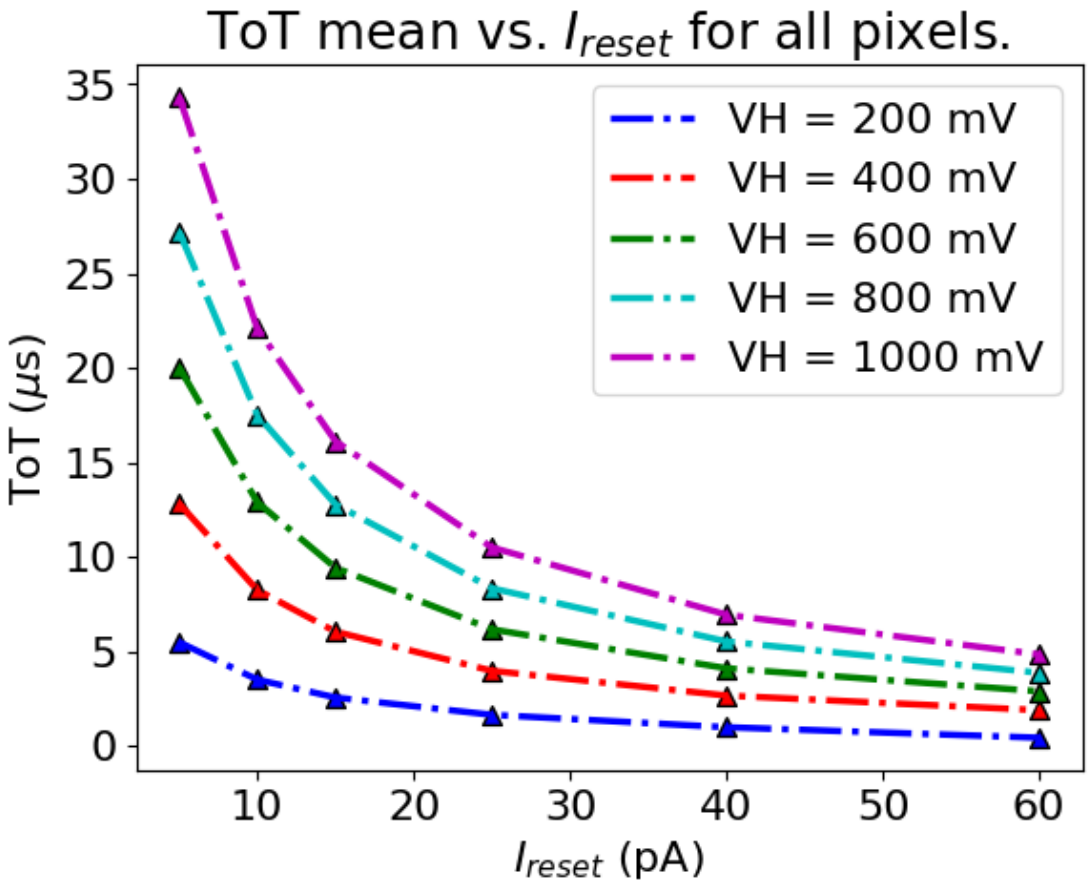


IBIAS = 500 nA



ToT average over all injections – IRESET

Our results



DPTS paper: arXiv:2212.08621

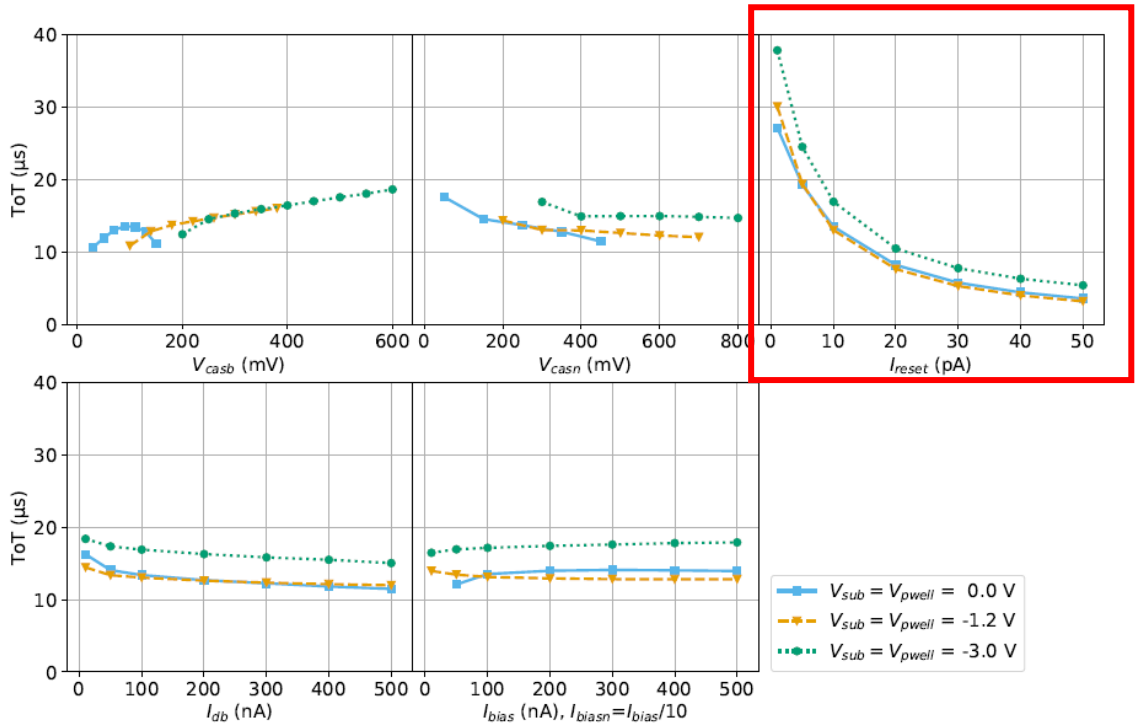
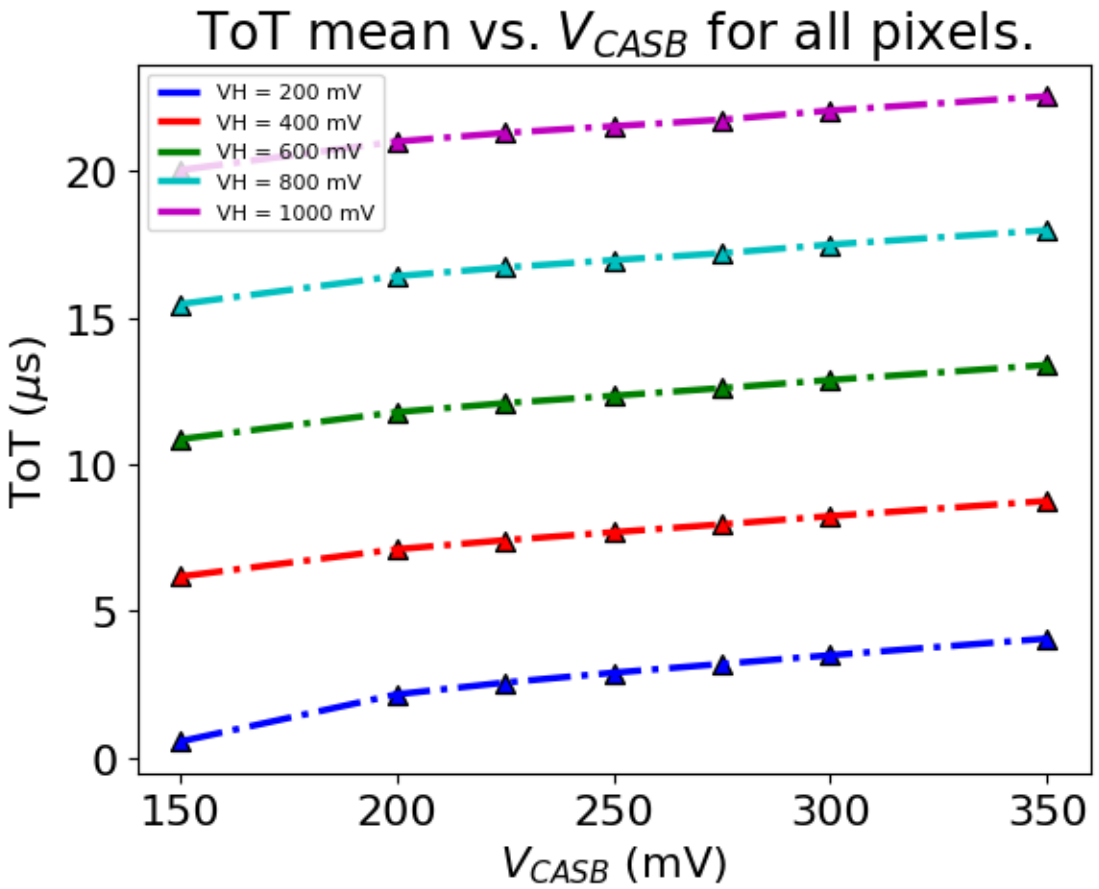


Figure 10: Time-over-threshold (ToT) as a function of different chip biases at a fixed charged injection of 725 e^-. Non-varied parameters are at nominal values (cf. Sec. 3.1).

ToT average over all injections – VCASB

Our results



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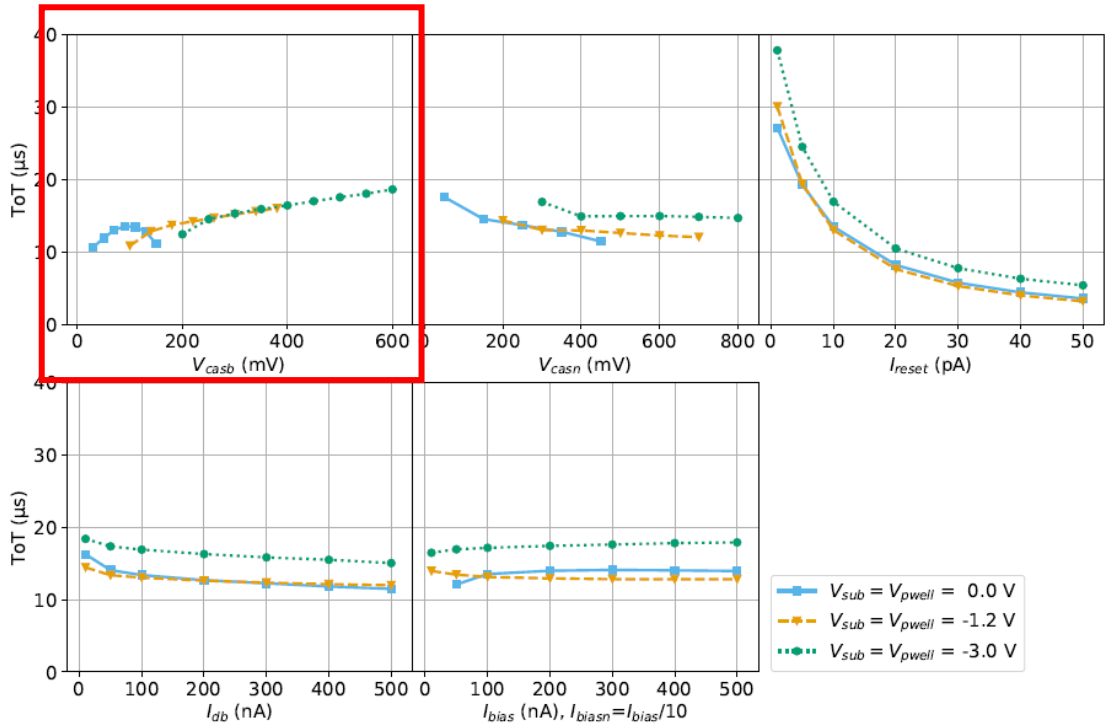
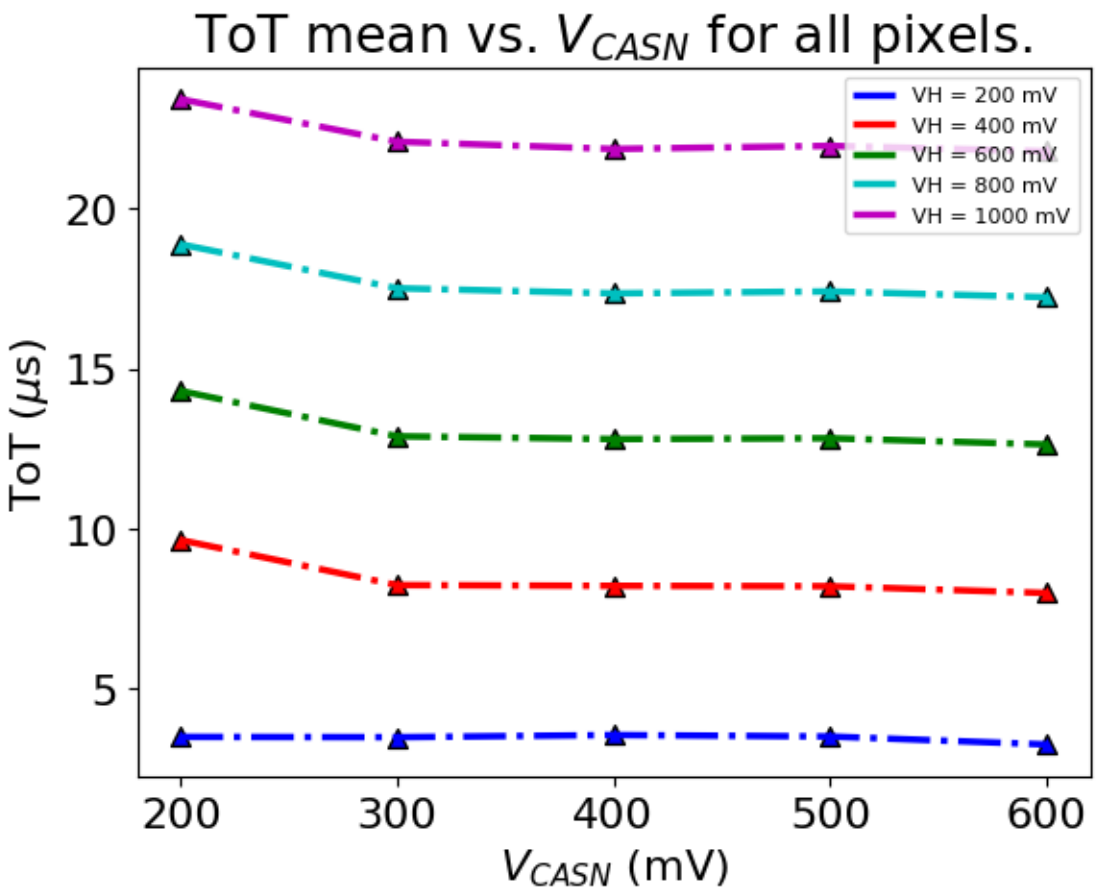


Figure 10: Time-over-threshold (ToT) as a function of different chip biases at a fixed charged injection of 725 e^-. Non-varied parameters are at nominal values (cf. Sec. 3.1).

ToT average over all injections – VCASN

Our results



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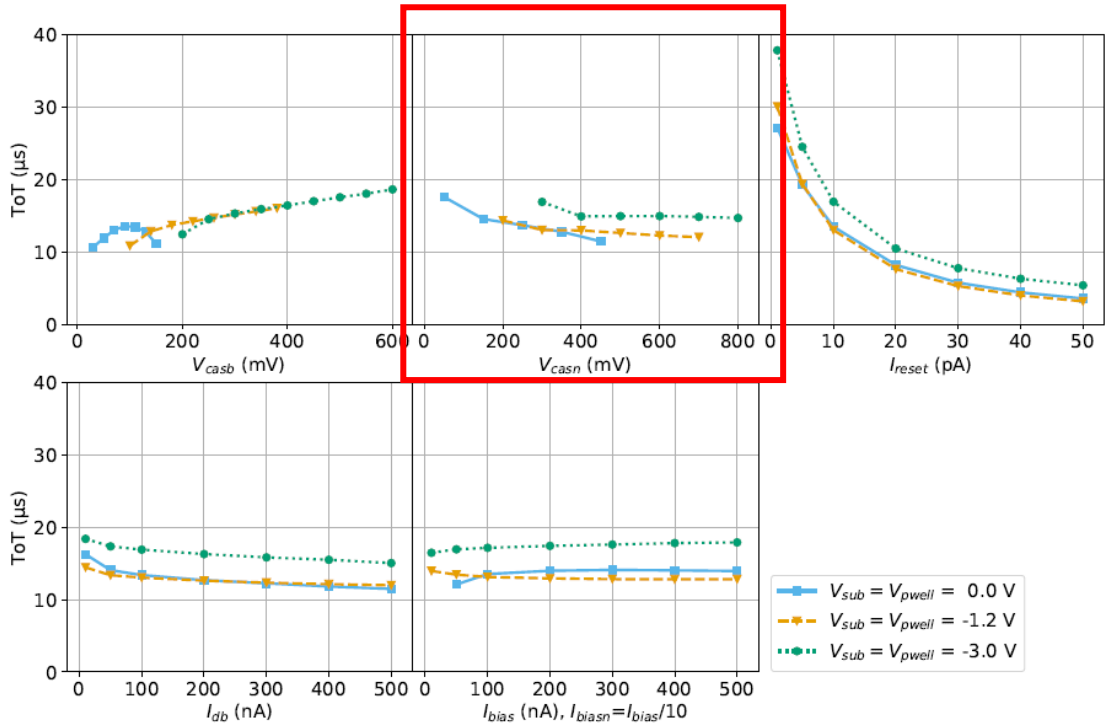
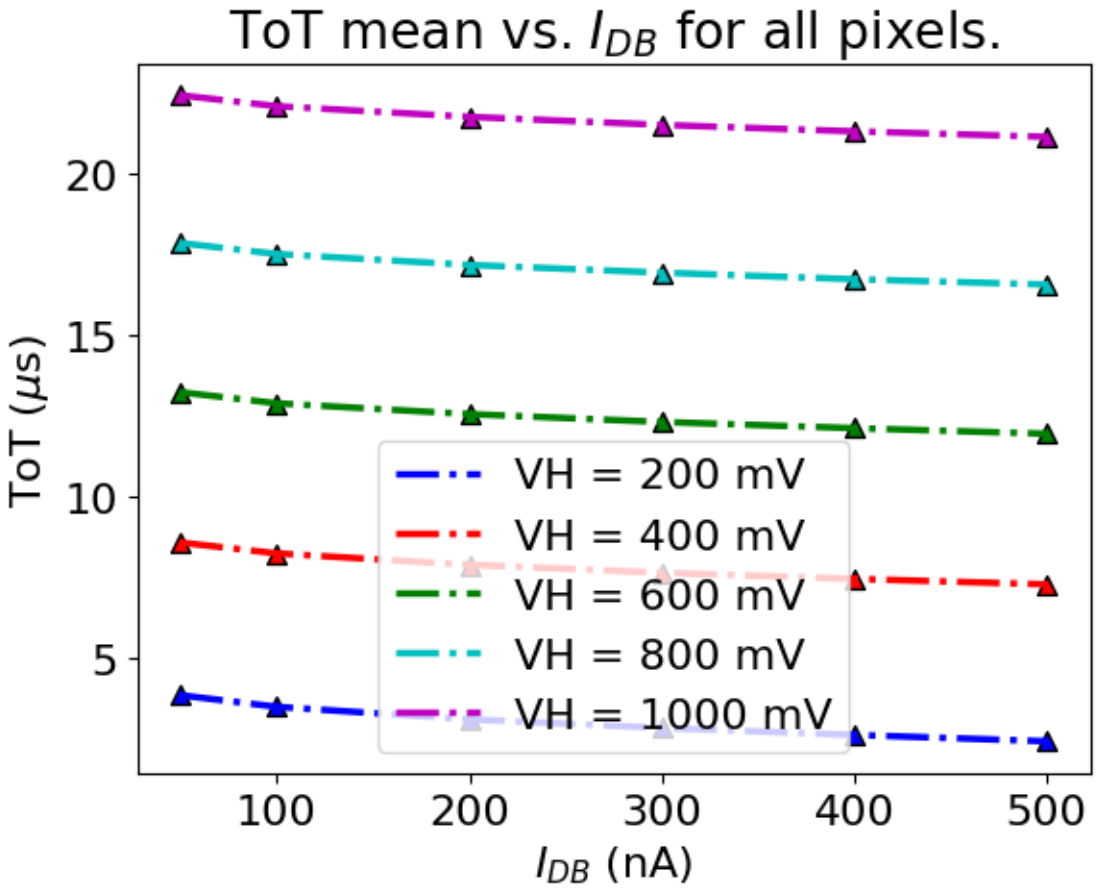


Figure 10: Time-over-threshold (ToT) as a function of different chip biases at a fixed charged injection of 725 e^-. Non-varied parameters are at nominal values (cf. Sec. 3.1).

ToT average over all injections – IDB

Our results



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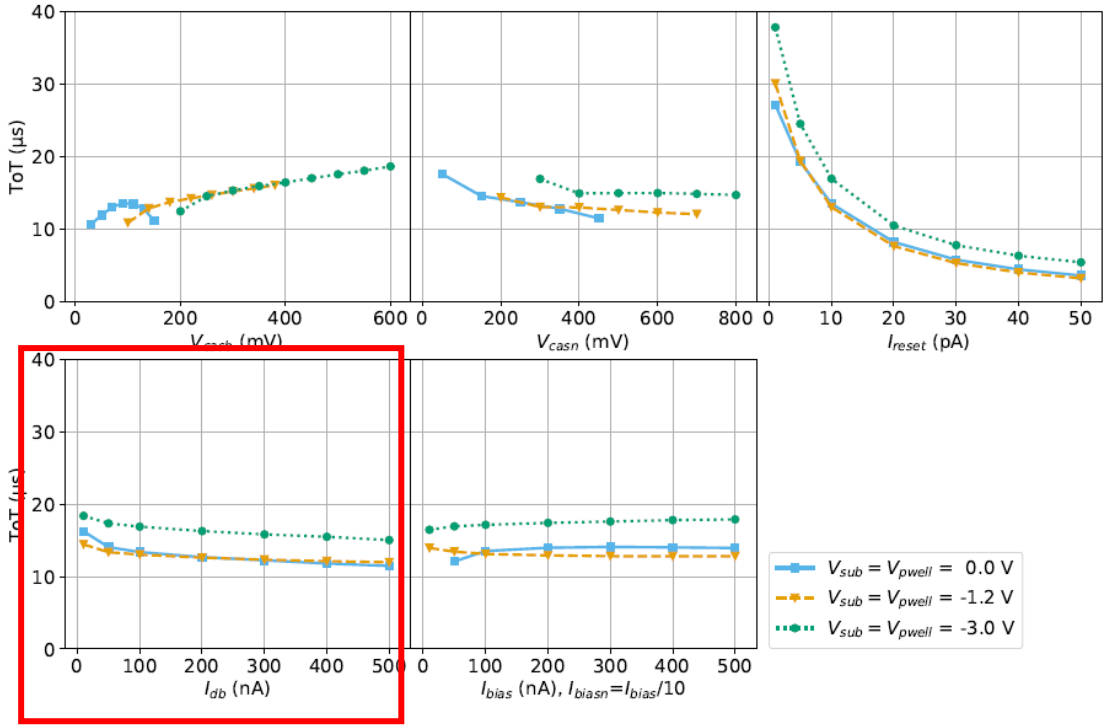
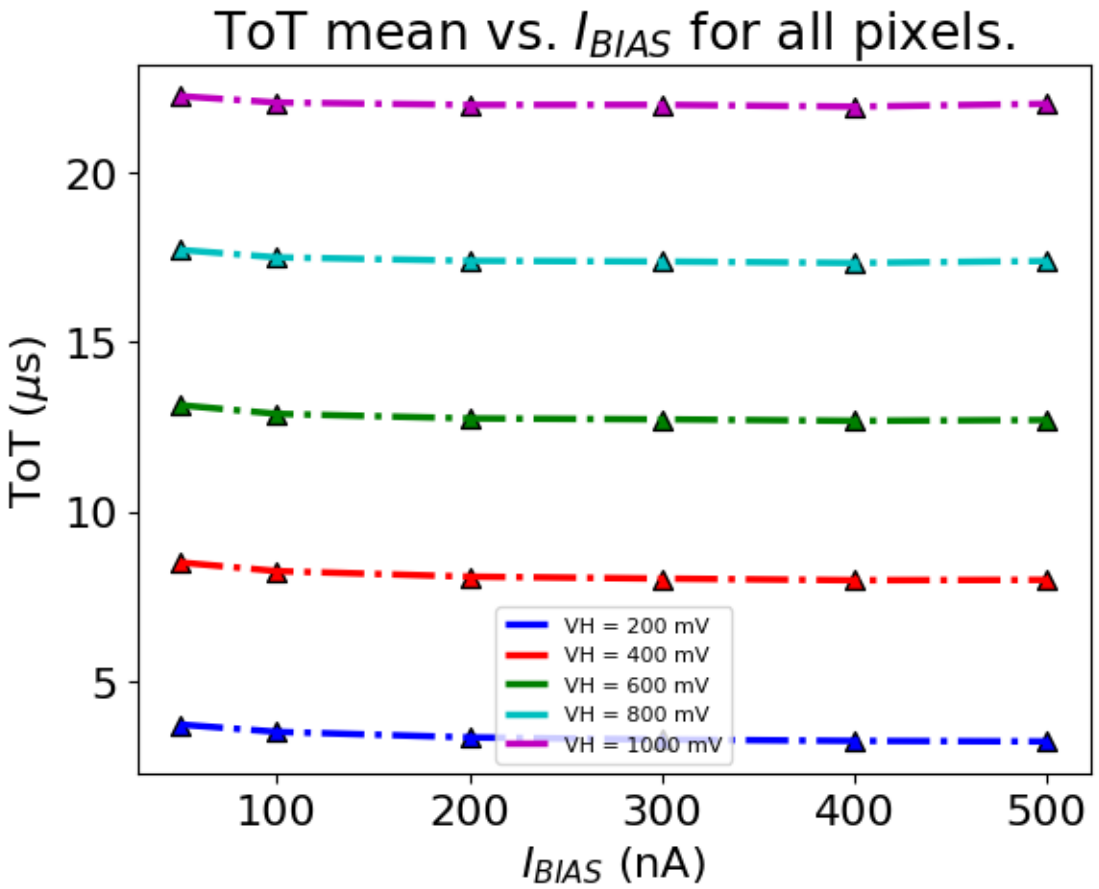


Figure 10: Time-over-threshold (ToT) as a function of different chip biases at a fixed charged injection of 725 e^-. Non-varied parameters are at nominal values (cf. Sec. 3.1).

ToT average over all injections – IBIAS

Our results



DPTS paper: arXiv:2212.08621

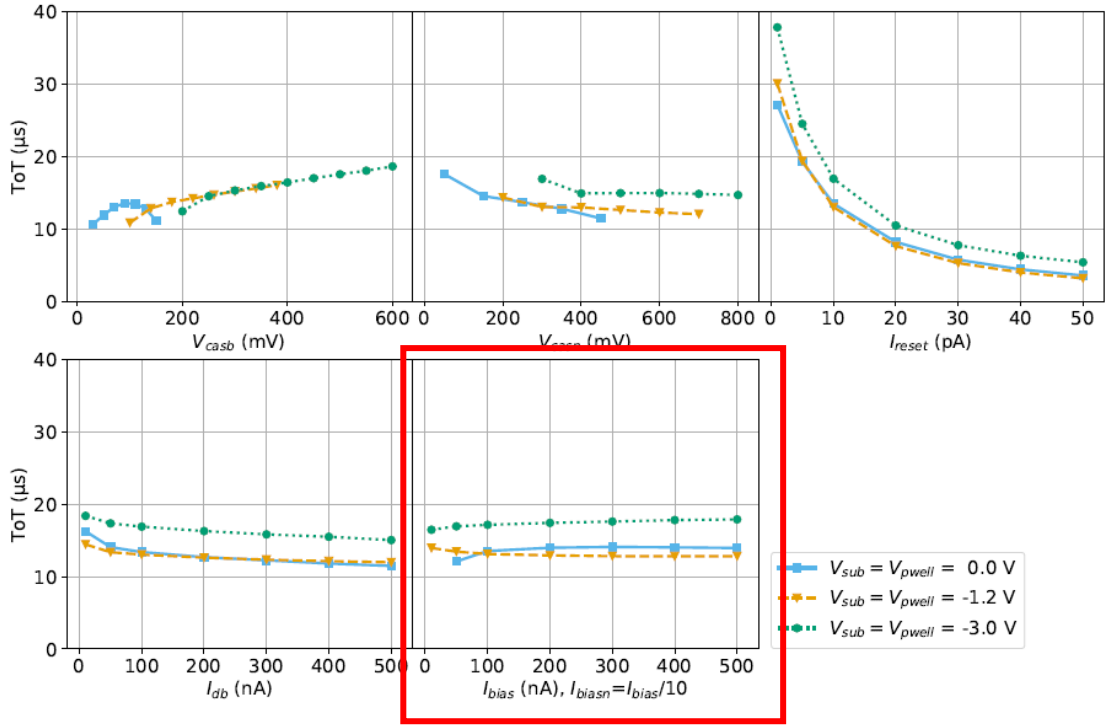
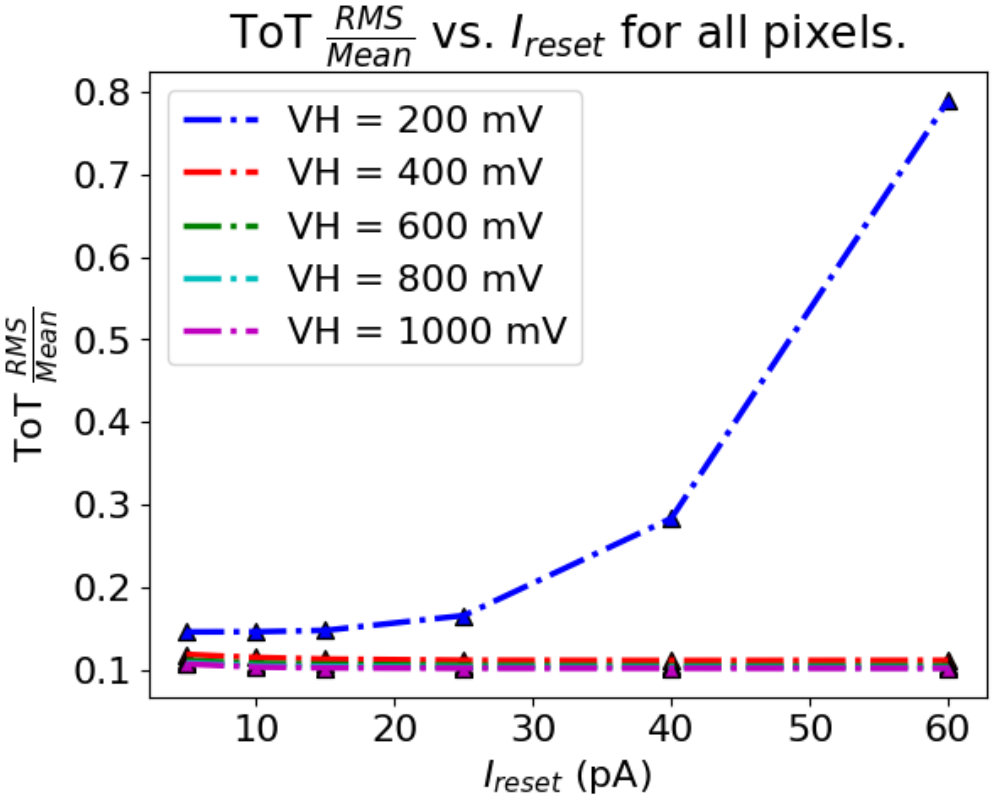
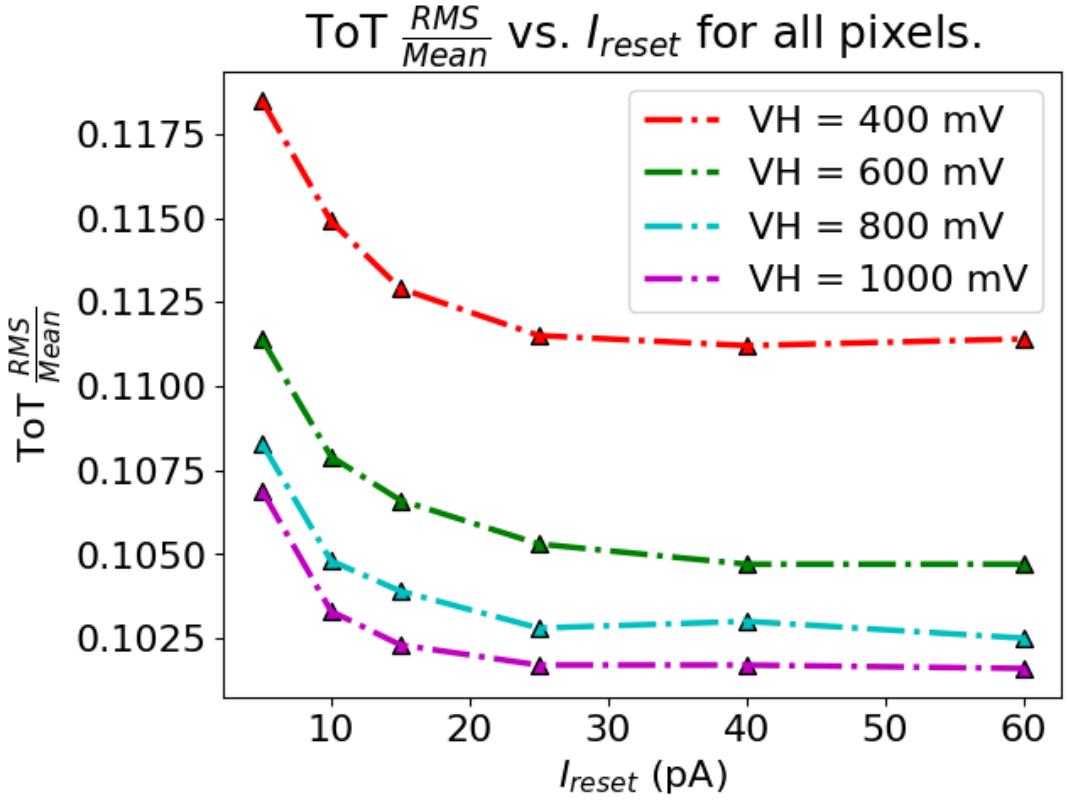


Figure 10: Time-over-threshold (ToT) as a function of different chip biases at a fixed charged injection of 725 e^-. Non-varied parameters are at nominal values (cf. Sec. 3.1).

ToT relative RMS over all injections – IRESET



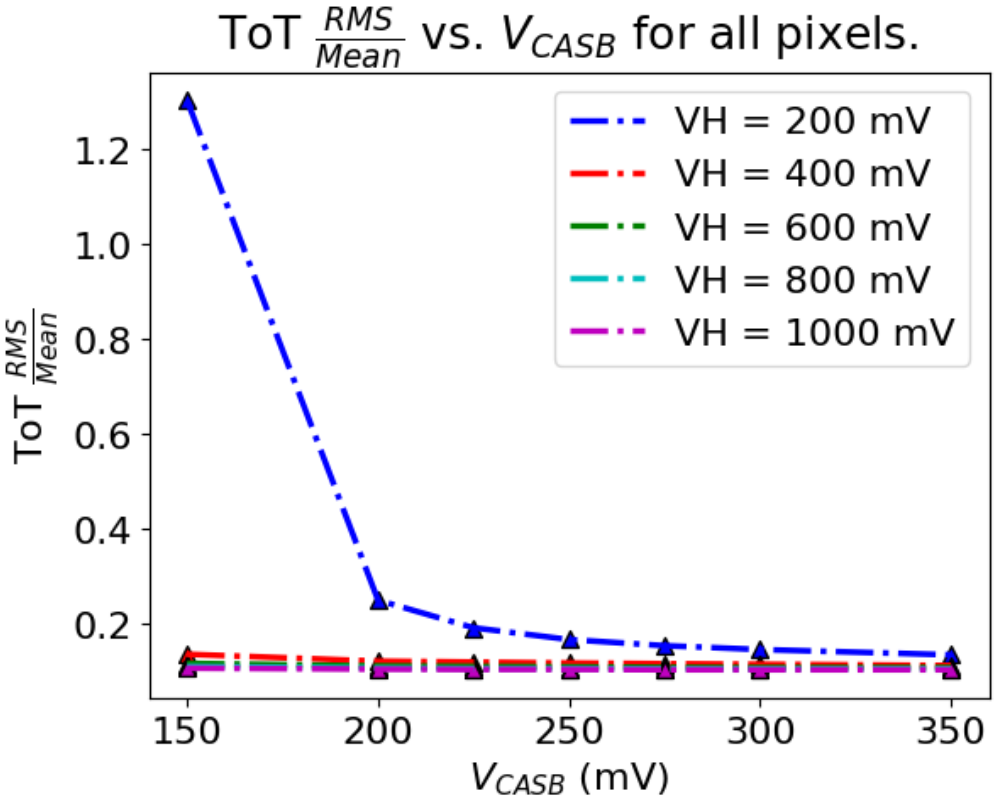
Focusing on 400-1000 mV VH range



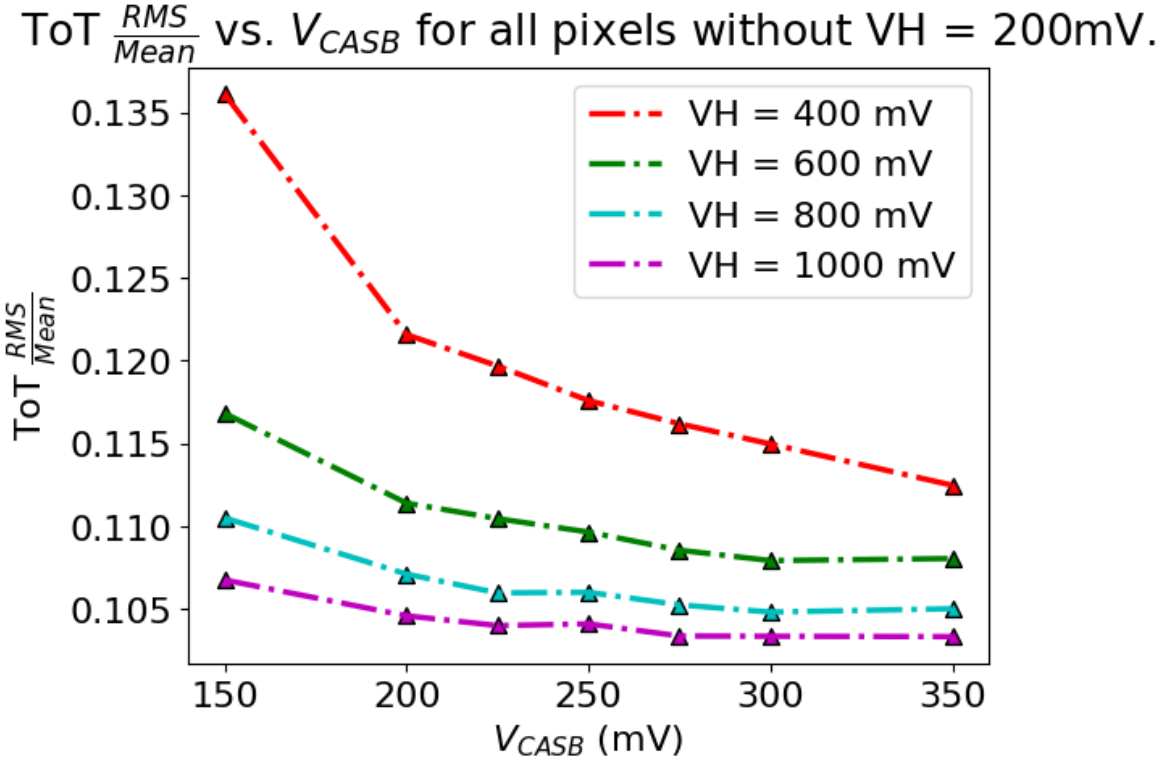
VH = 200 mV is near threshold for higher I_{Reset} currents

We see a ~5% effect from low to high I_{Reset}

ToT relative RMS over all injections – VCASB



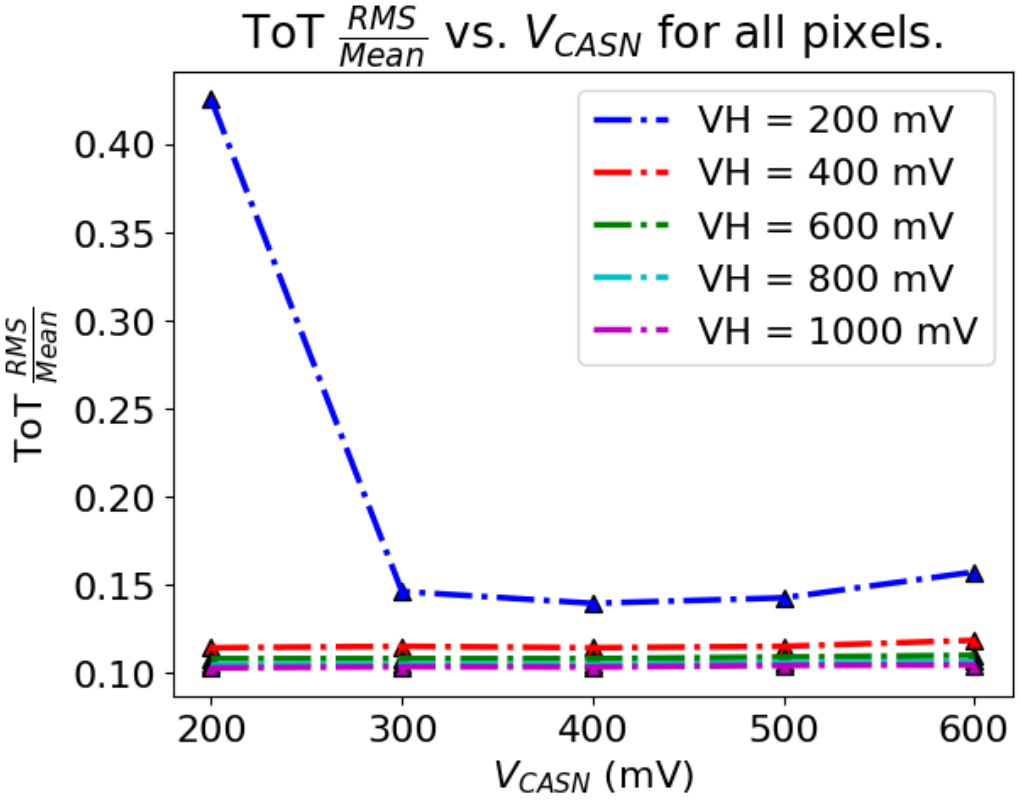
Focusing on 400-1000 mV VH range



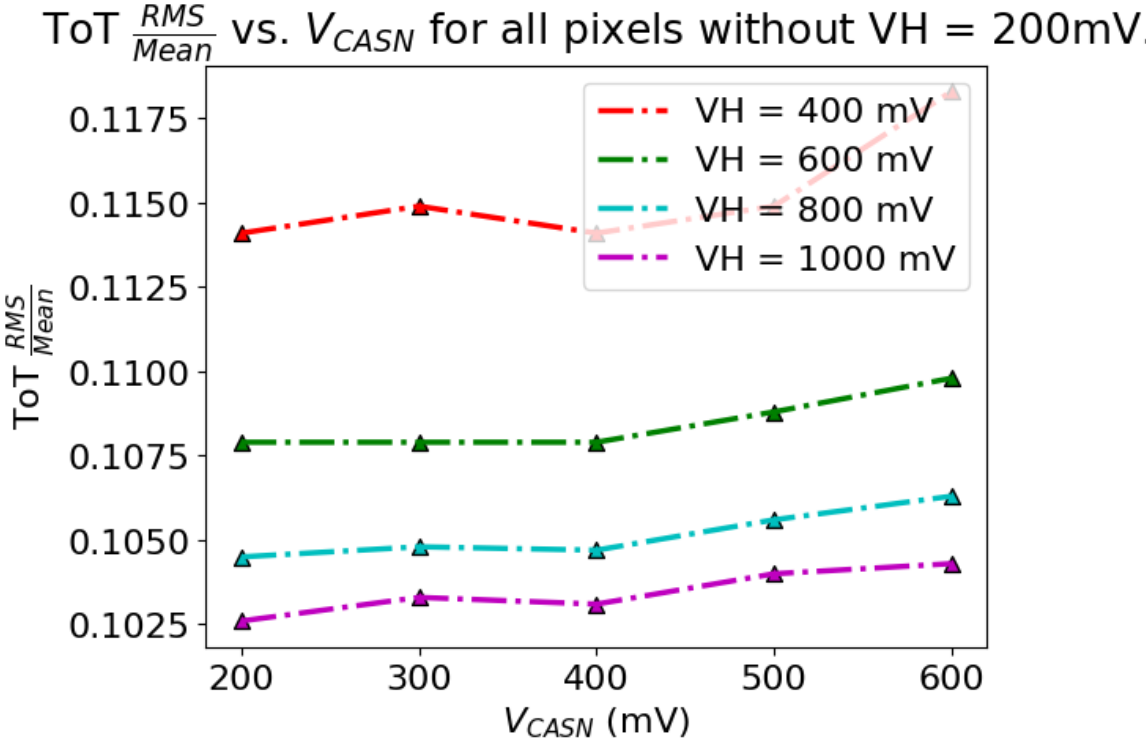
VH = 200 mV is near threshold for lowest V_{CASB} voltages

We see a ~5-10% effect from low to high V_{CASB}

ToT relative RMS over all injections – VCASN

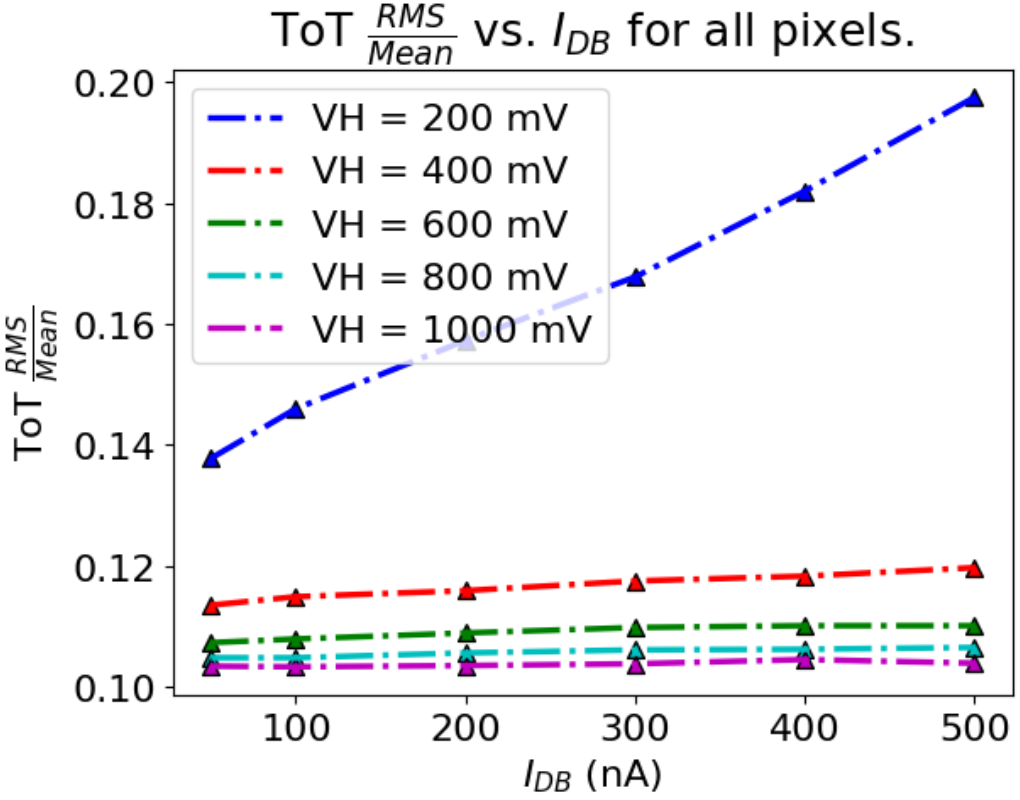


Focusing on 400-1000 mV VH range

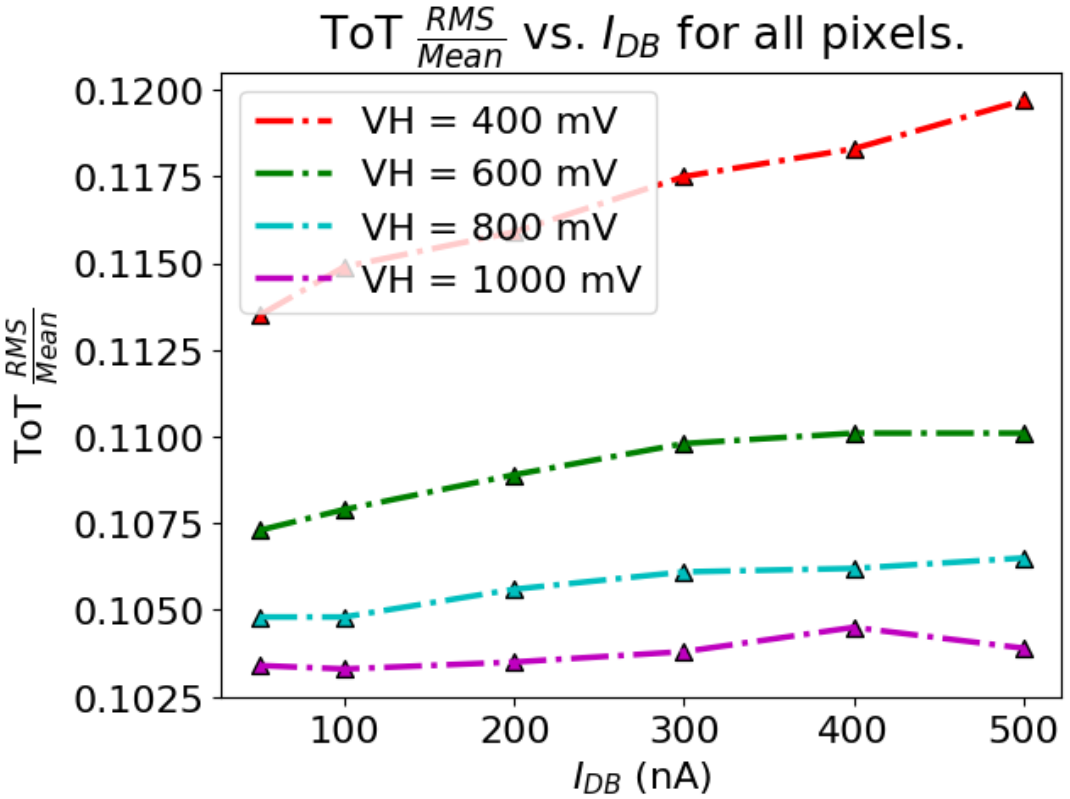


We see a few percent effect from low to high V_{CASN}

ToT relative RMS over all injections – IDB

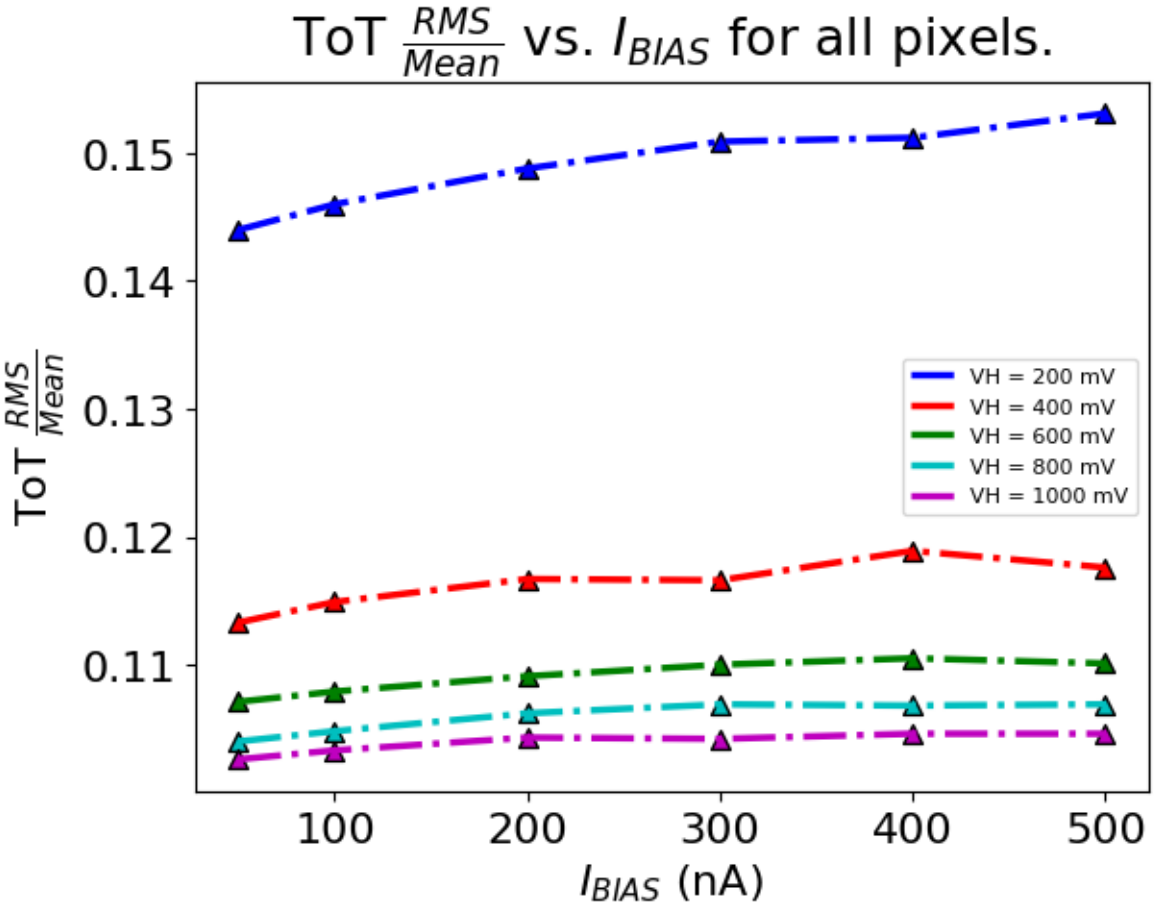


Focusing on 400-1000 mV VH range



We see a few percent effect from low to high I_{DB}

ToT relative RMS over all injections – IBIAS

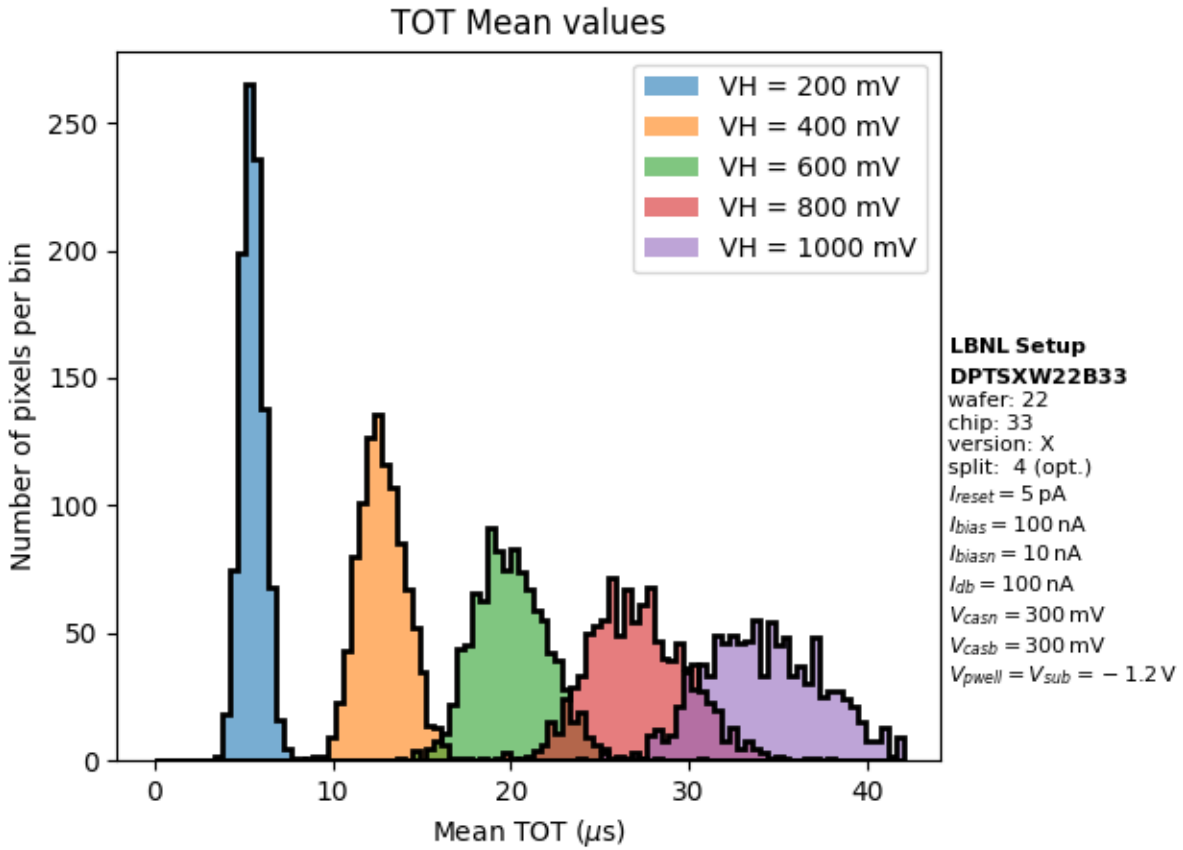


Similar behavior for VH = 200mV and other VH values.

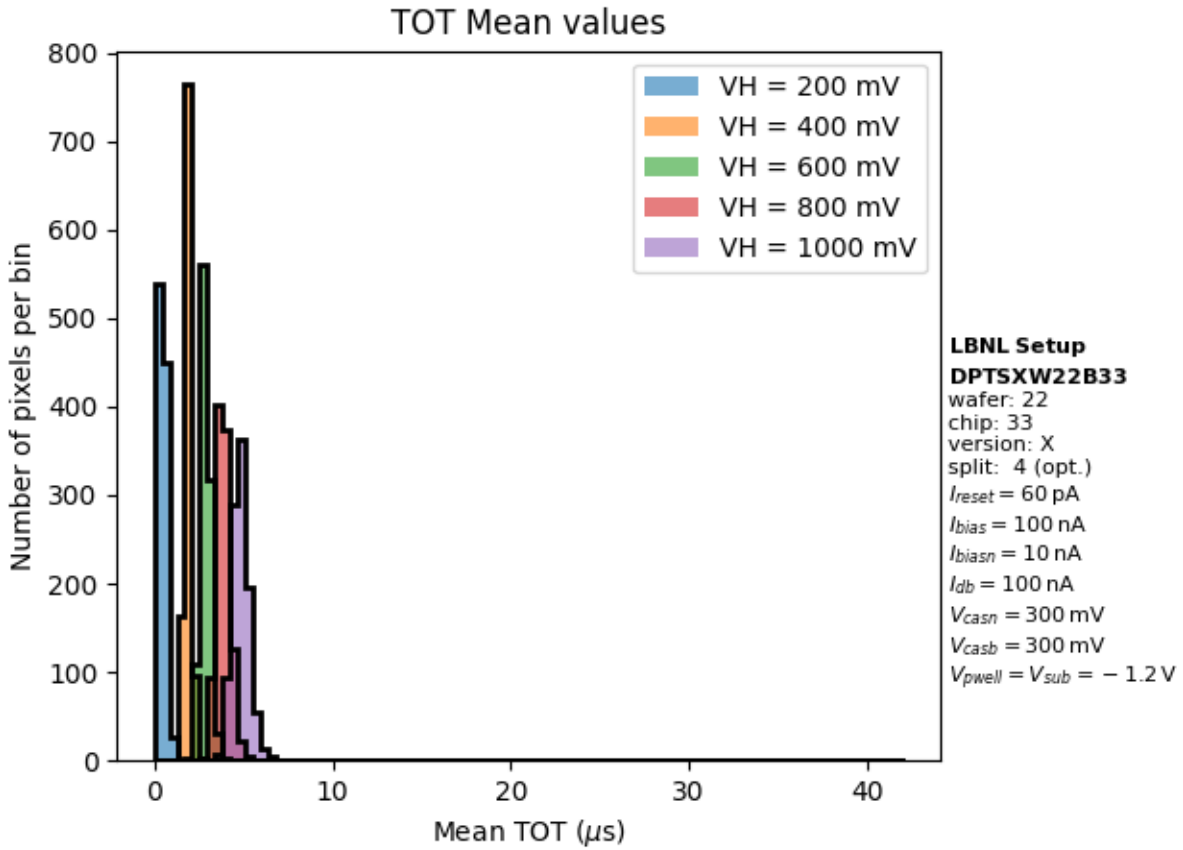
We see a few percent effect from low to high I_{BIAS}.

Individual pixel means over the 25 injections – IRESET

IRESET = 5 pA



IRESET = 60 pA

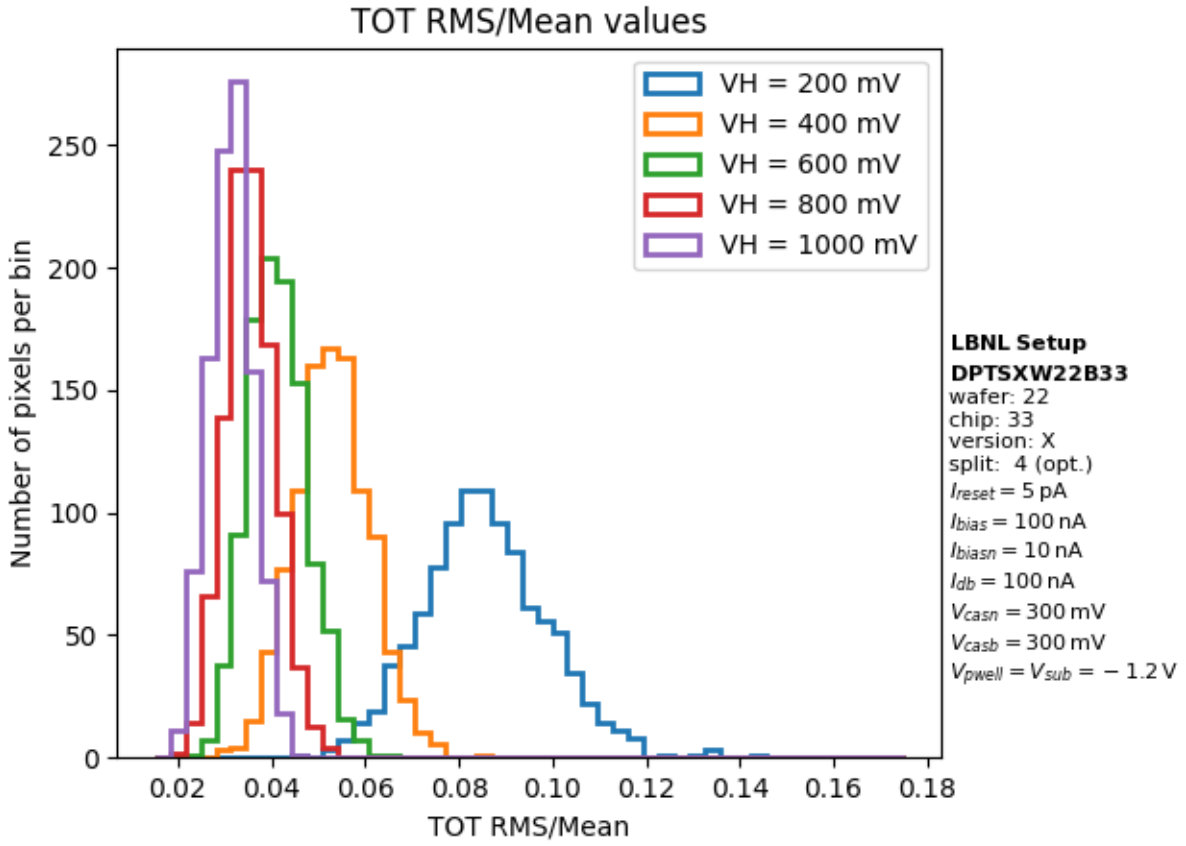


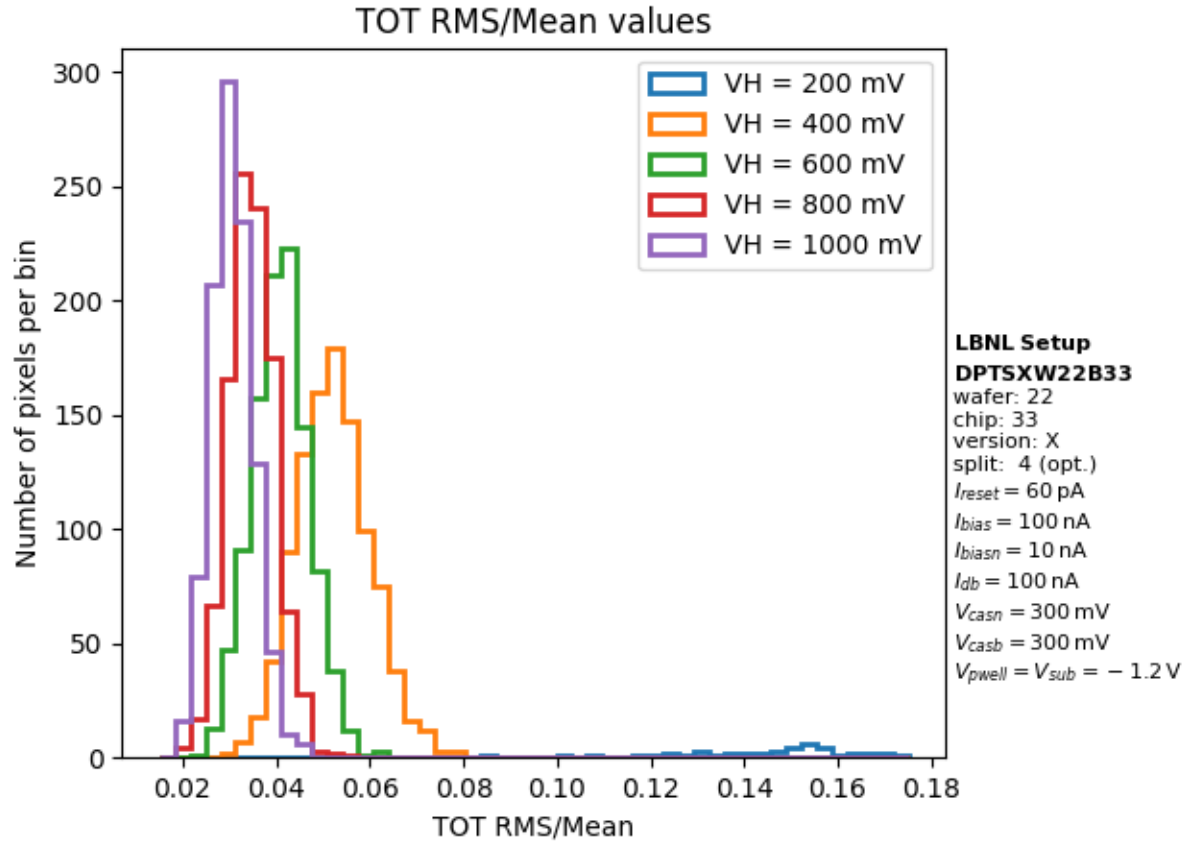
Individual pixel relative RMS values over the 25 injections – IRESET

IRESET = 5 pA

For the individual pixels, the relative RMS over the injections at a fixed VH depends very weakly on I_{Reset}.

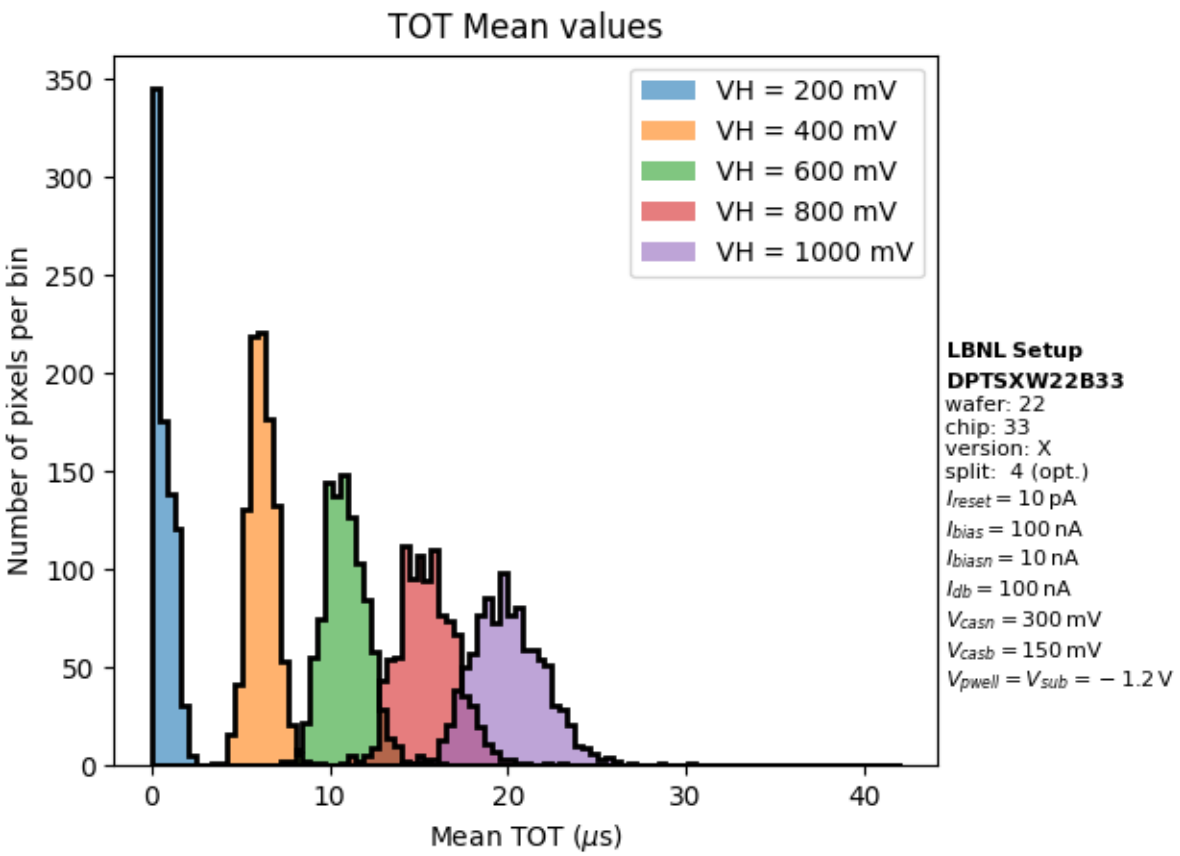
IRESET = 60 pA



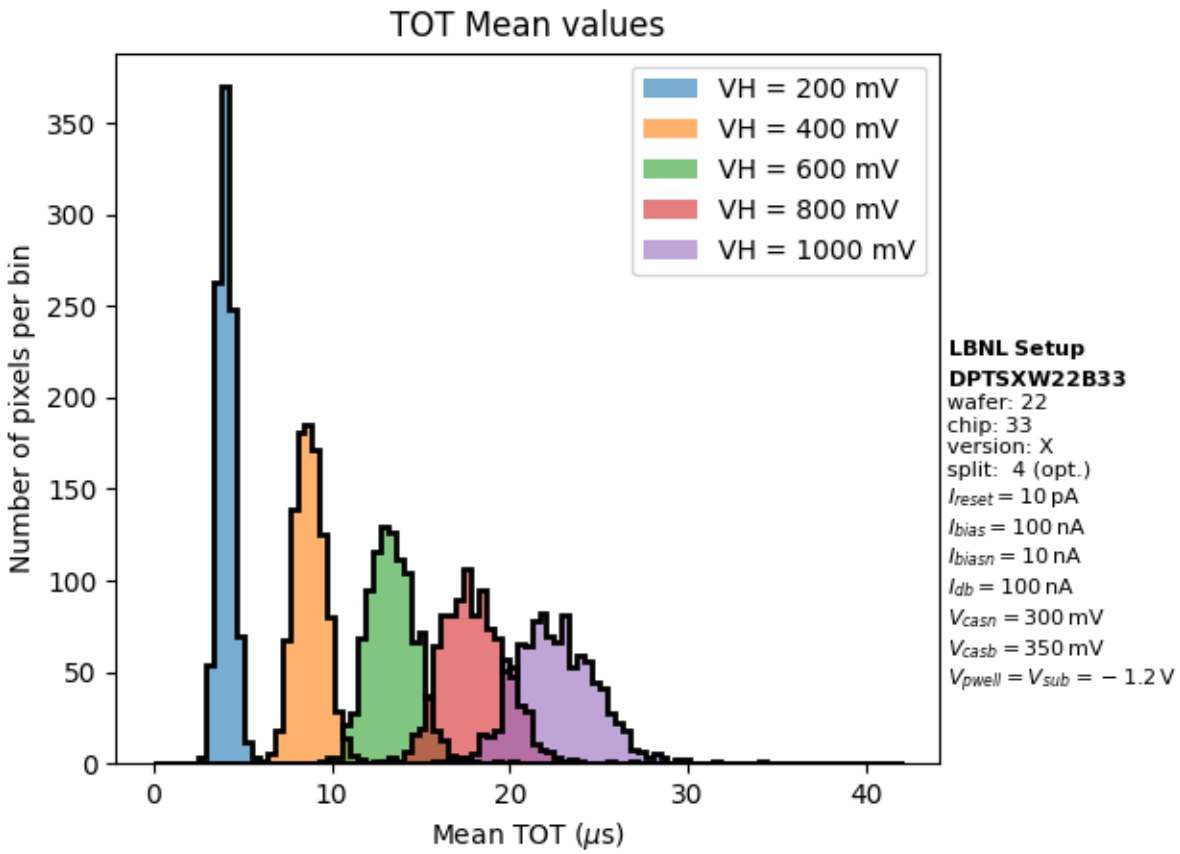


Individual pixel means over the 25 injections – VCASB

VCASB = 150 mV



VCASB = 350 mV

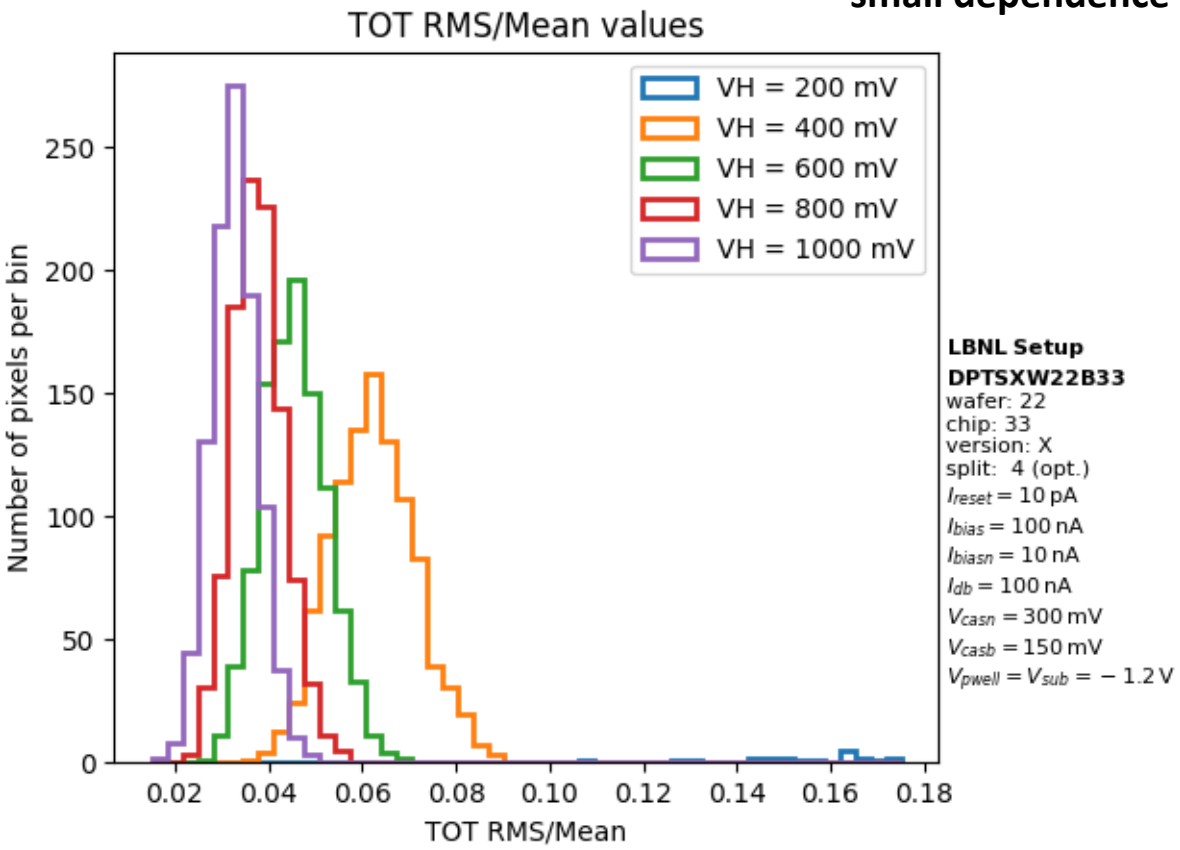


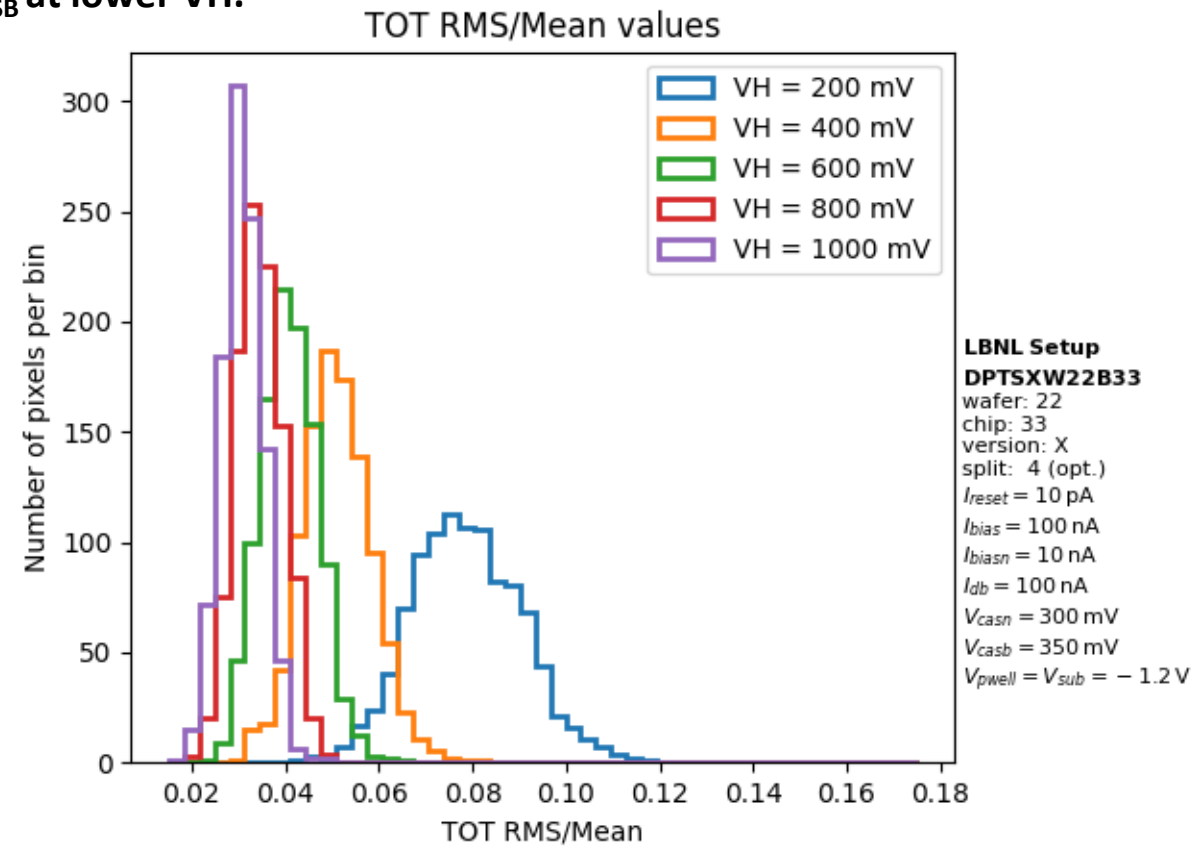
Individual pixel relative RMS values over the 25 injections – VCASB

VCASB = 150 mV

For the individual pixels, the relative RMS over the injections at a fixed VH shows a small dependence on V_{CASB} at lower VH.

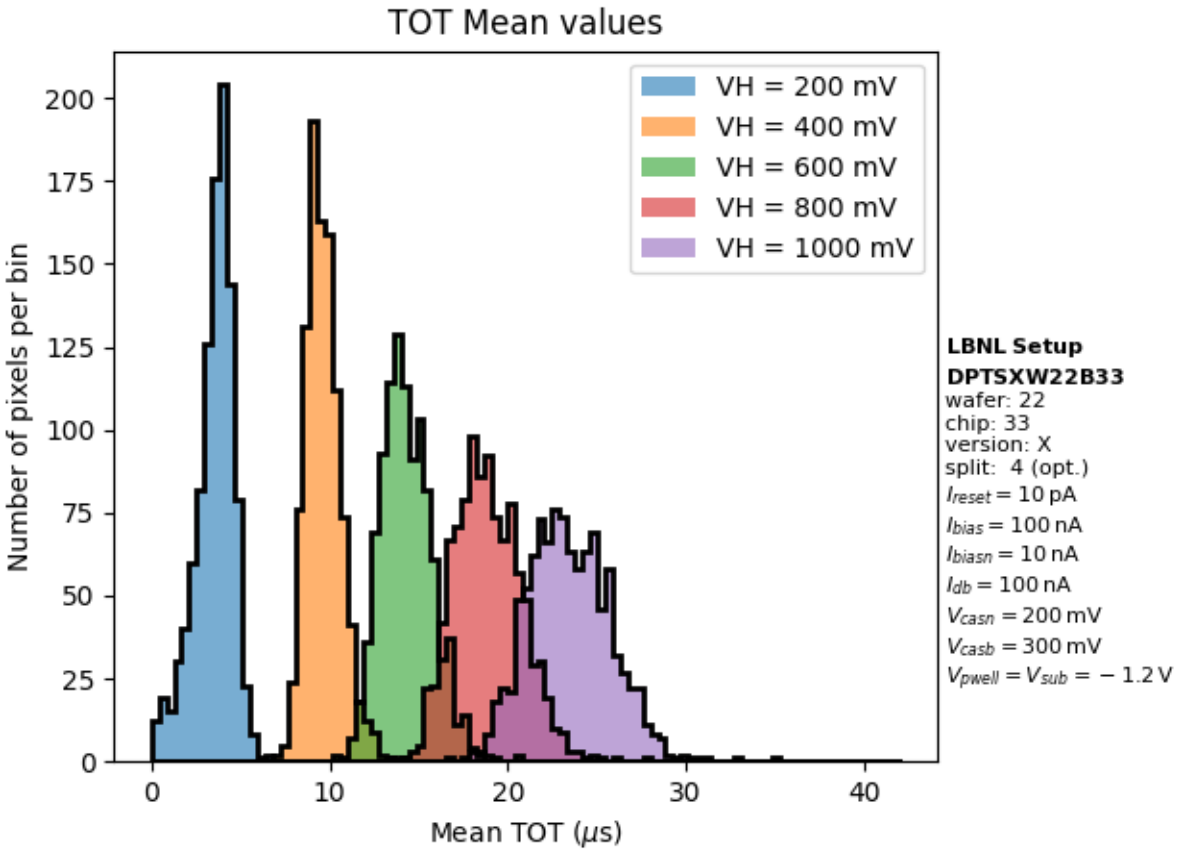
VCASB = 350 mV



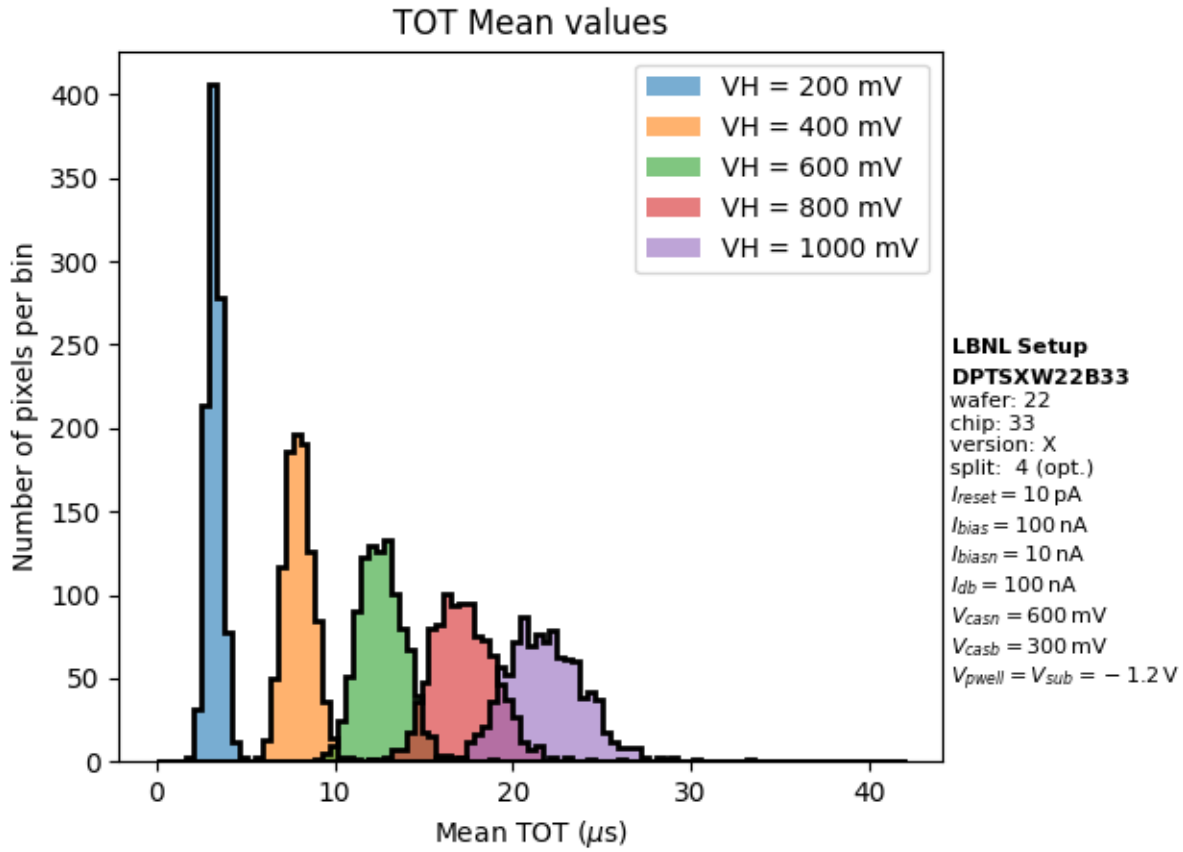


Individual pixel means over the 25 injections – VCASN

VCASN = 200 mV



VCASN = 600 mV

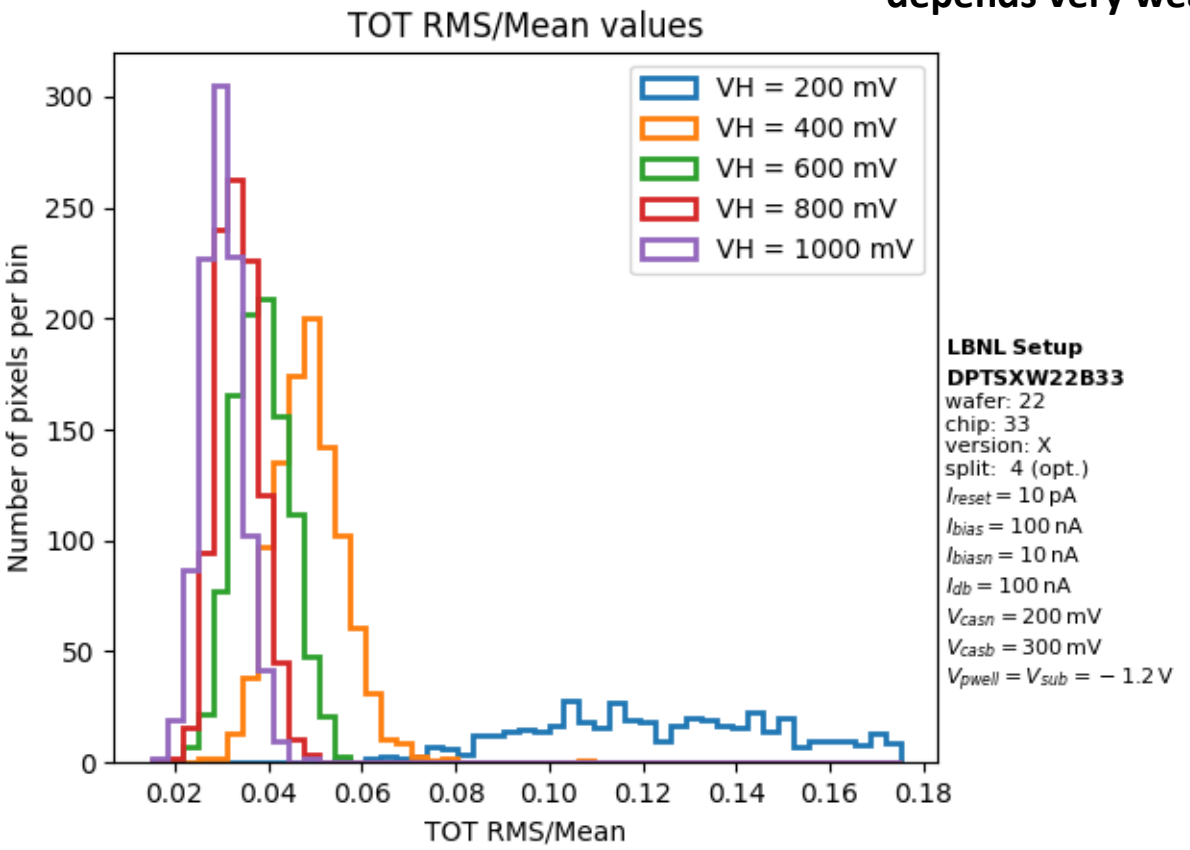


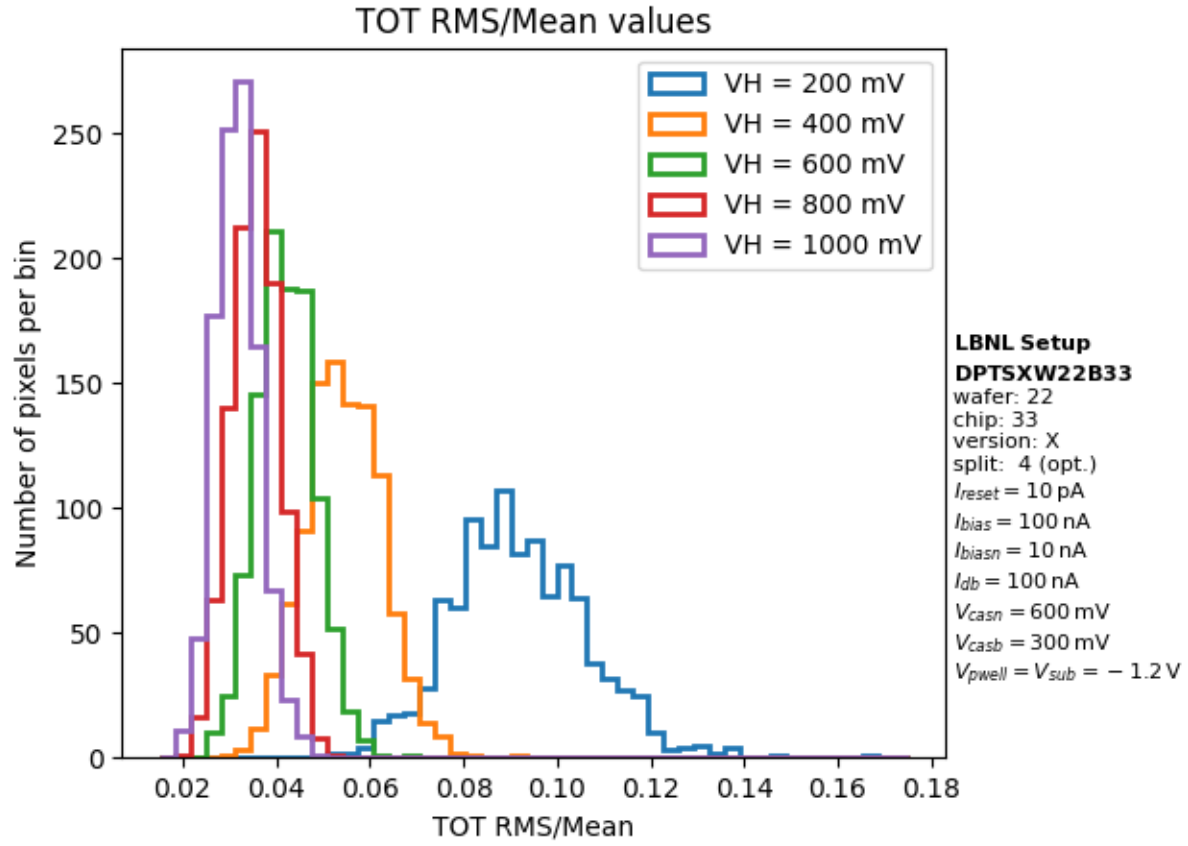
Individual pixel relative RMS values over the 25 injections – VCASN

VCASN = 200 mV

For the individual pixels, the relative RMS over the injections at a fixed VH depends very weakly on V_{CASN}.

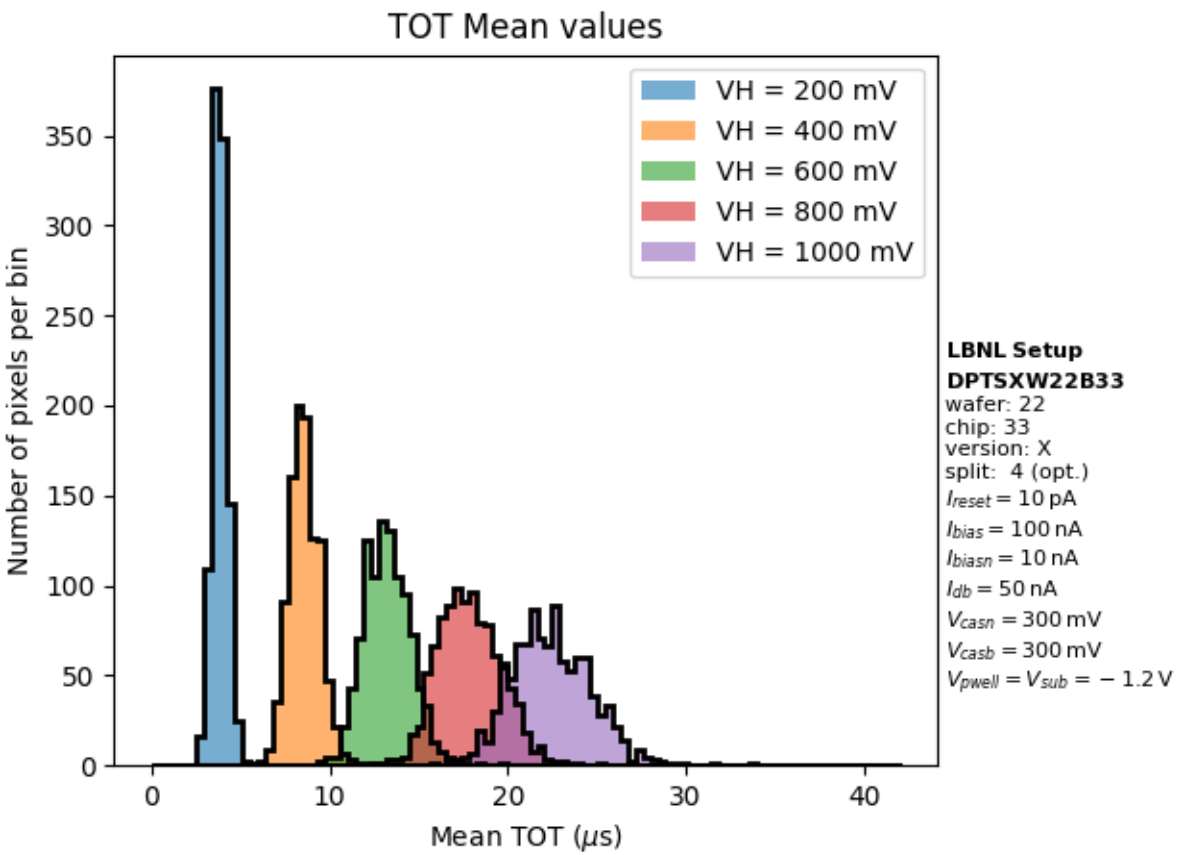
VCASN = 600 mV



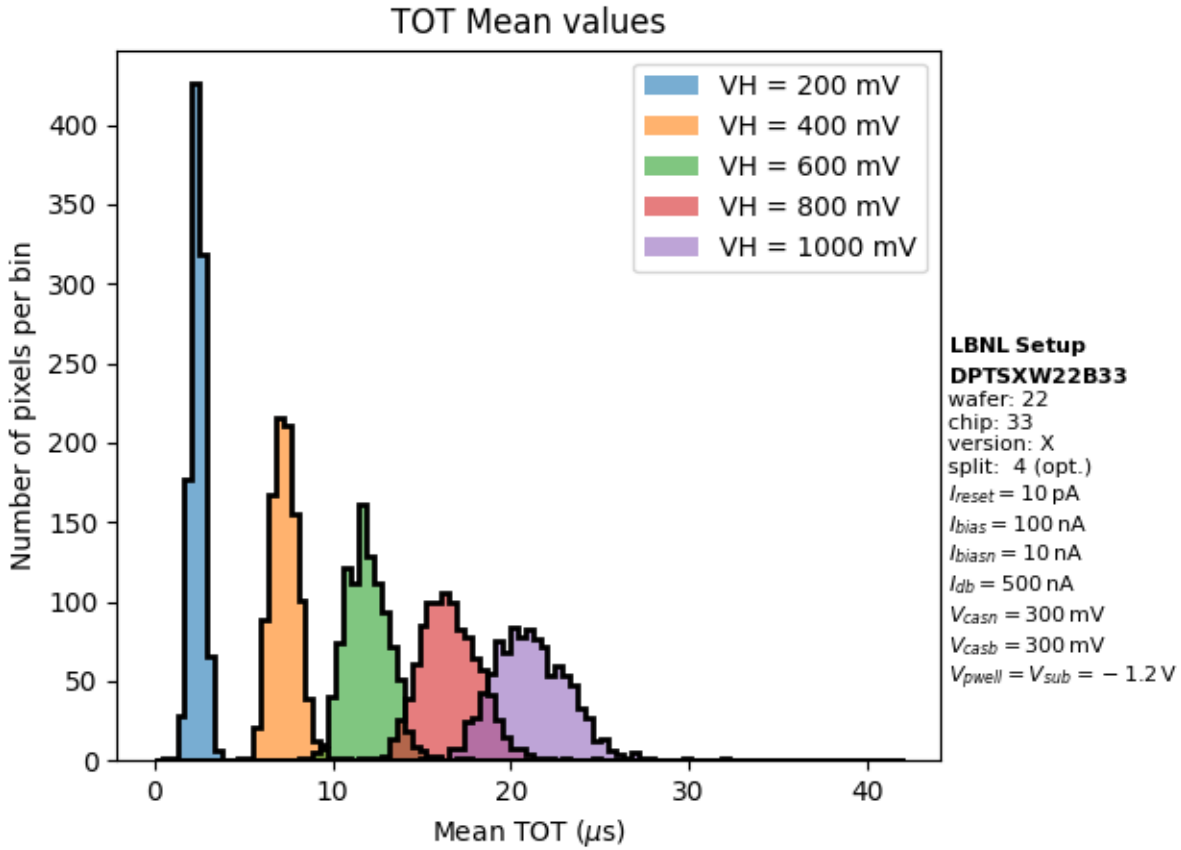


Individual pixel means over the 25 injections – IDB

IDB = 50 nA



IDB = 500 nA

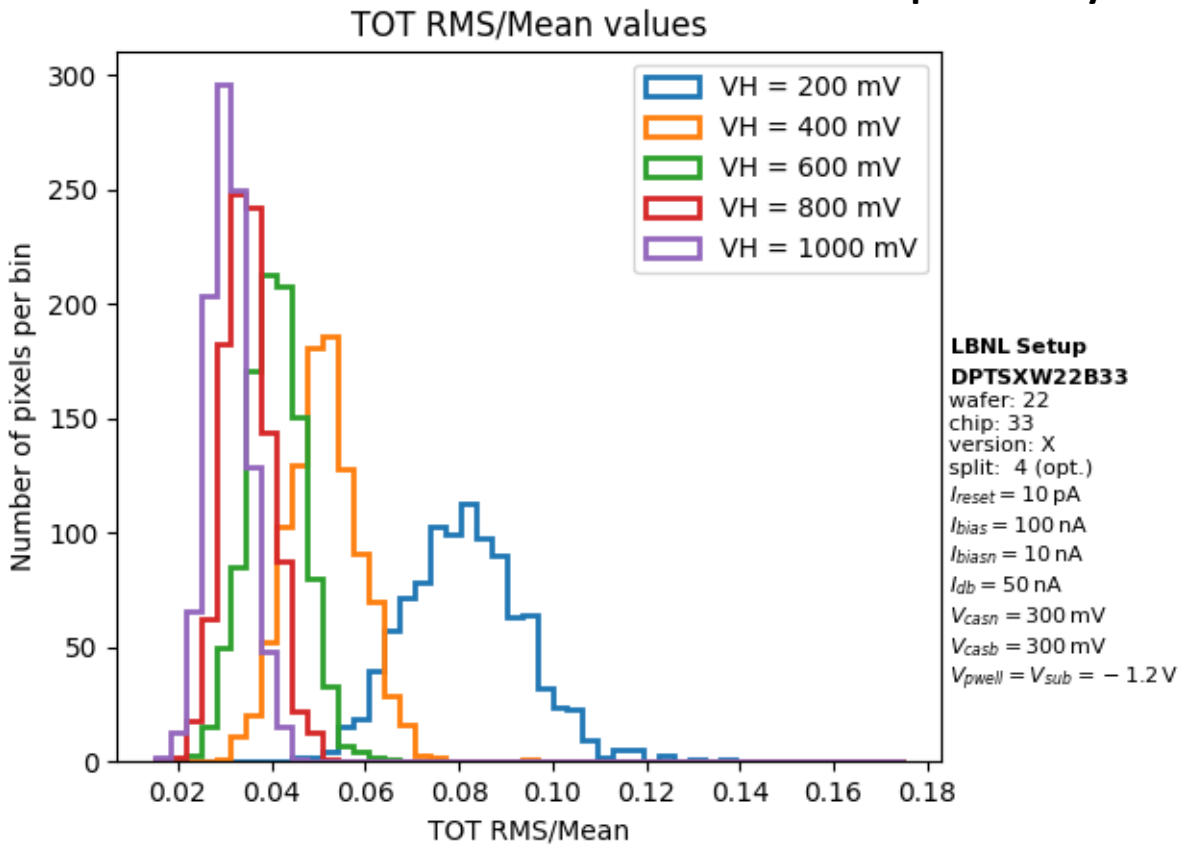


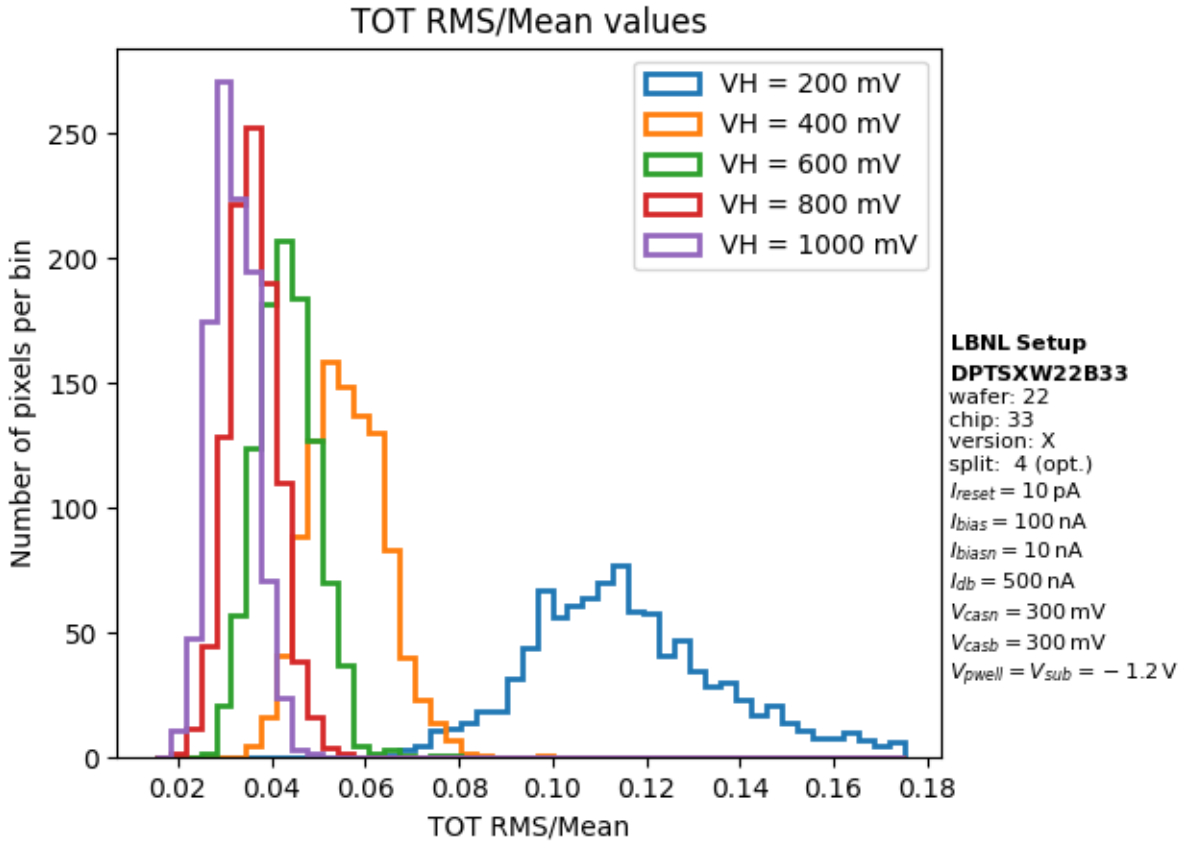
Individual pixel relative RMS values over the 25 injections – IDB

IDB = 50 nA

For the individual pixels, the relative RMS over the injections at a fixed VH depends very weakly on I_{DB}.

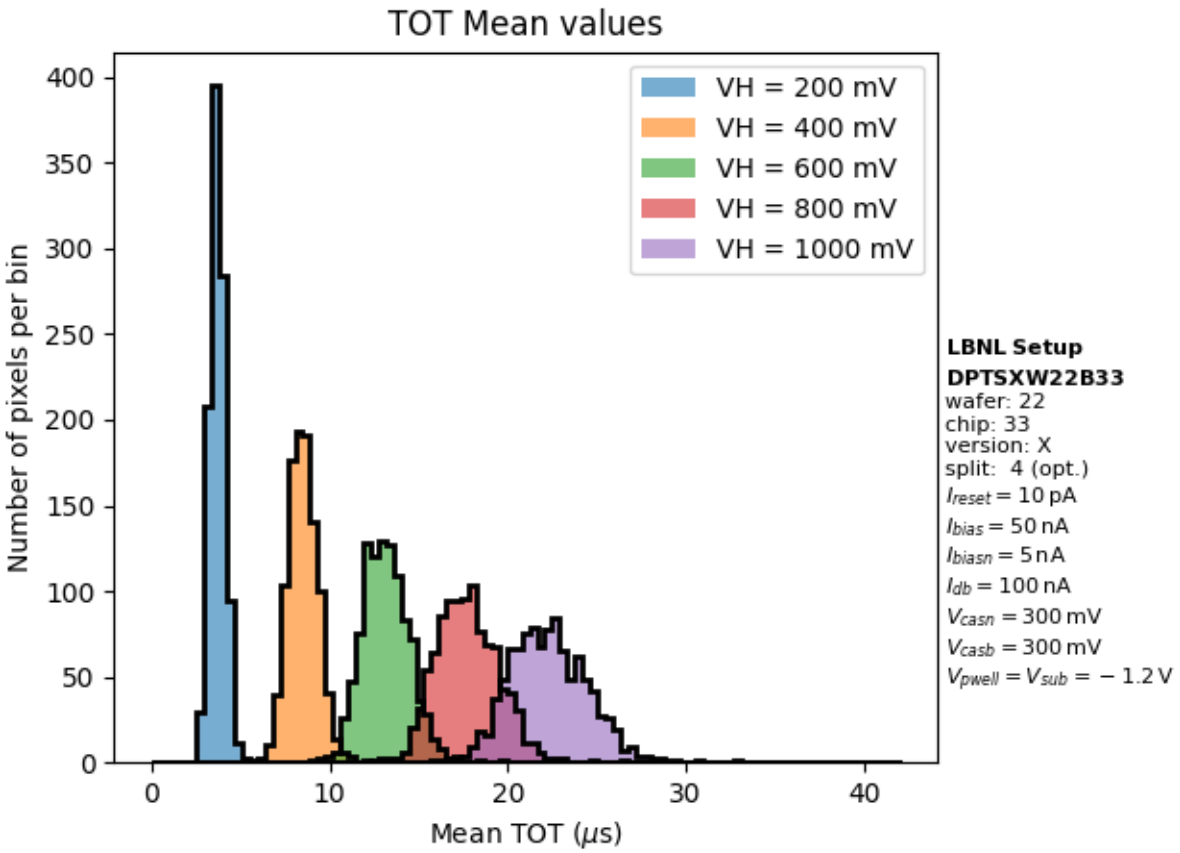
IDB = 500 nA



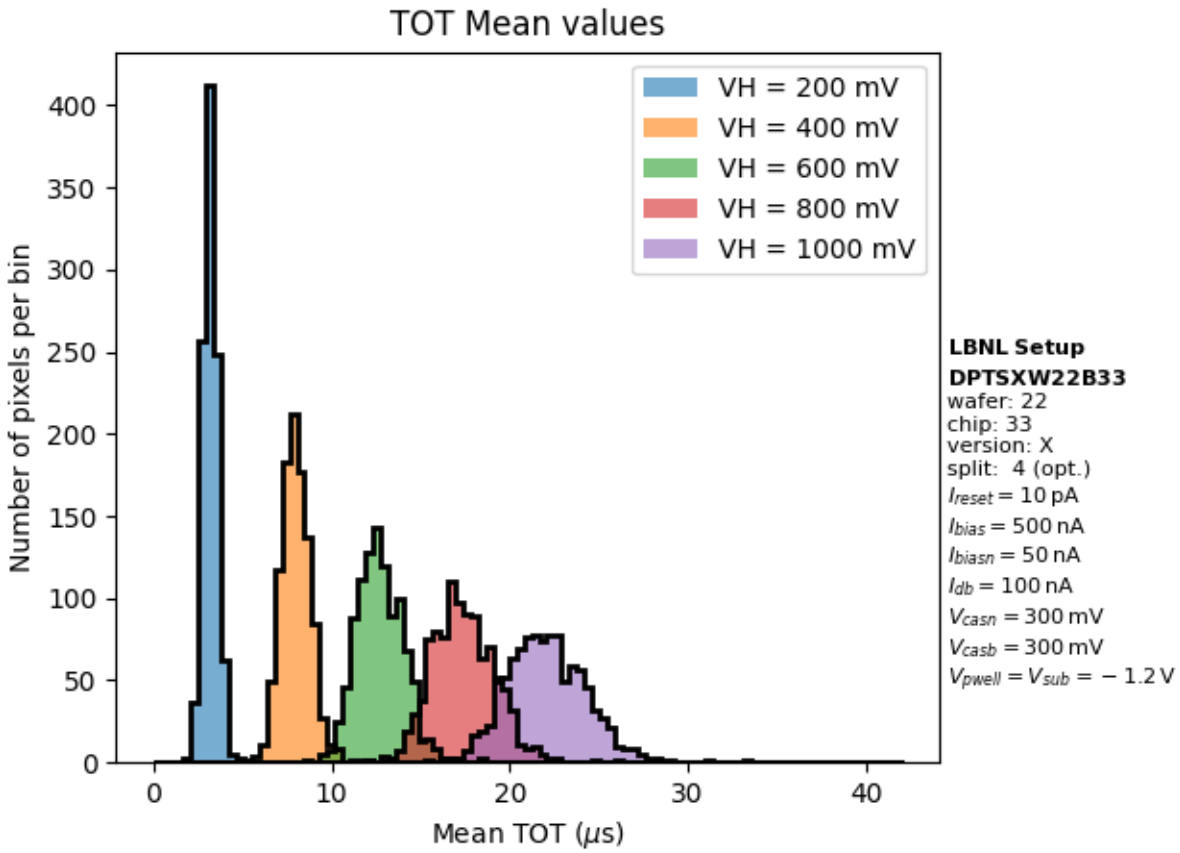


Individual pixel means over the 25 injections – IBIAS

IBIAS = 50 nA



IBIAS = 500 nA

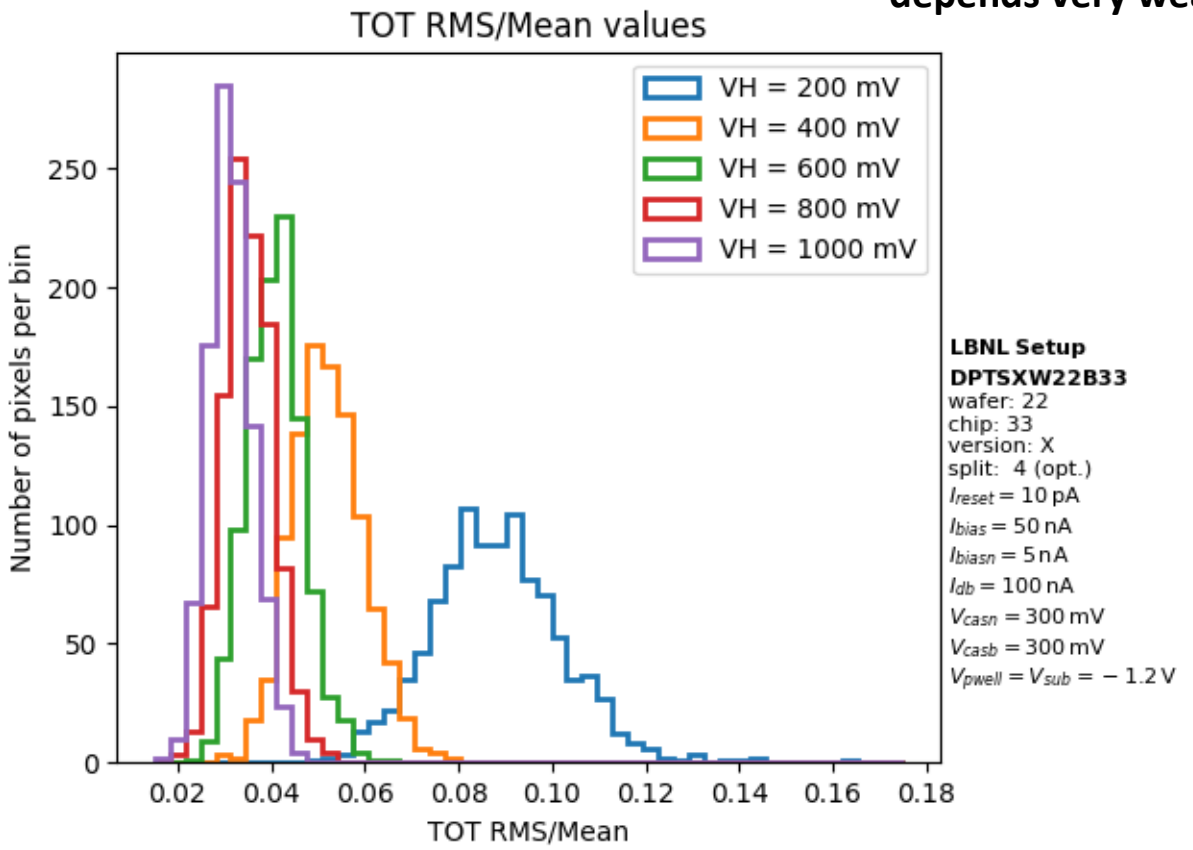


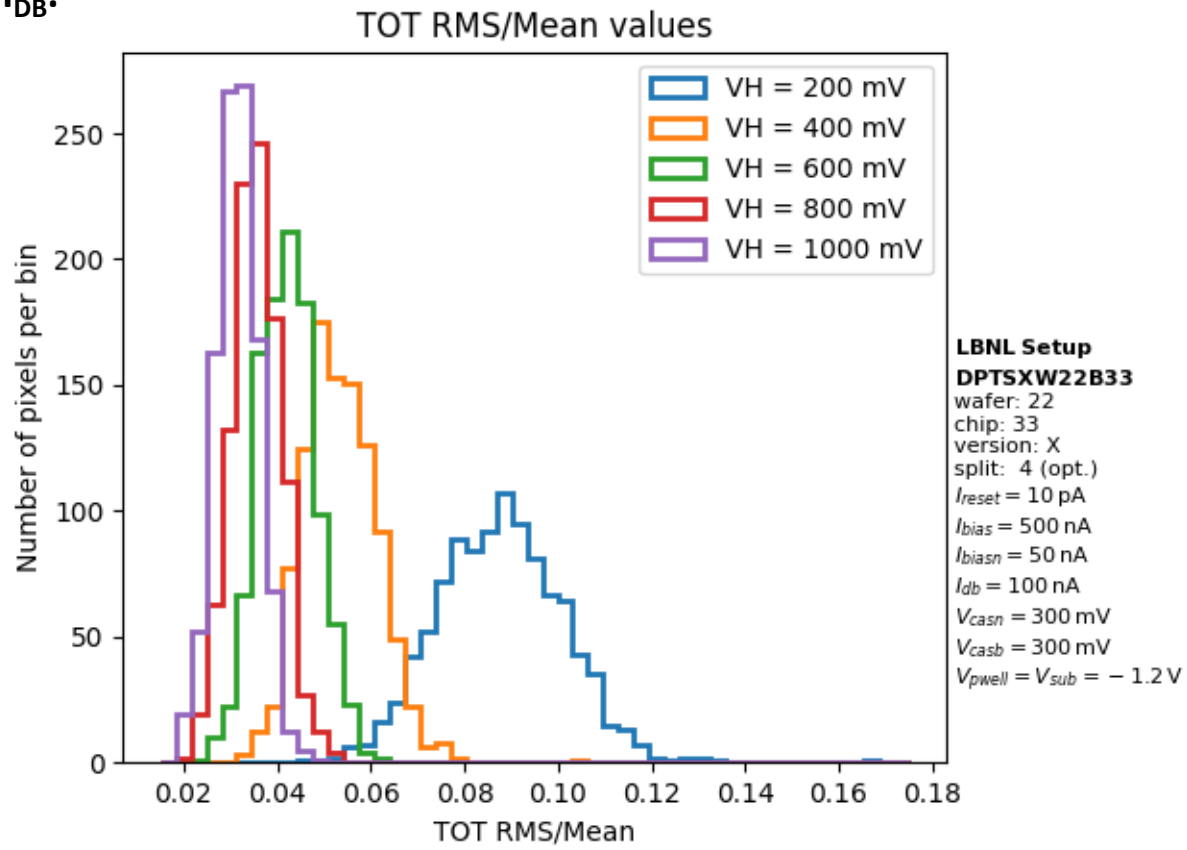
Individual pixel relative RMS values over the 25 injections – IBIAS

IBIAS = 50 nA

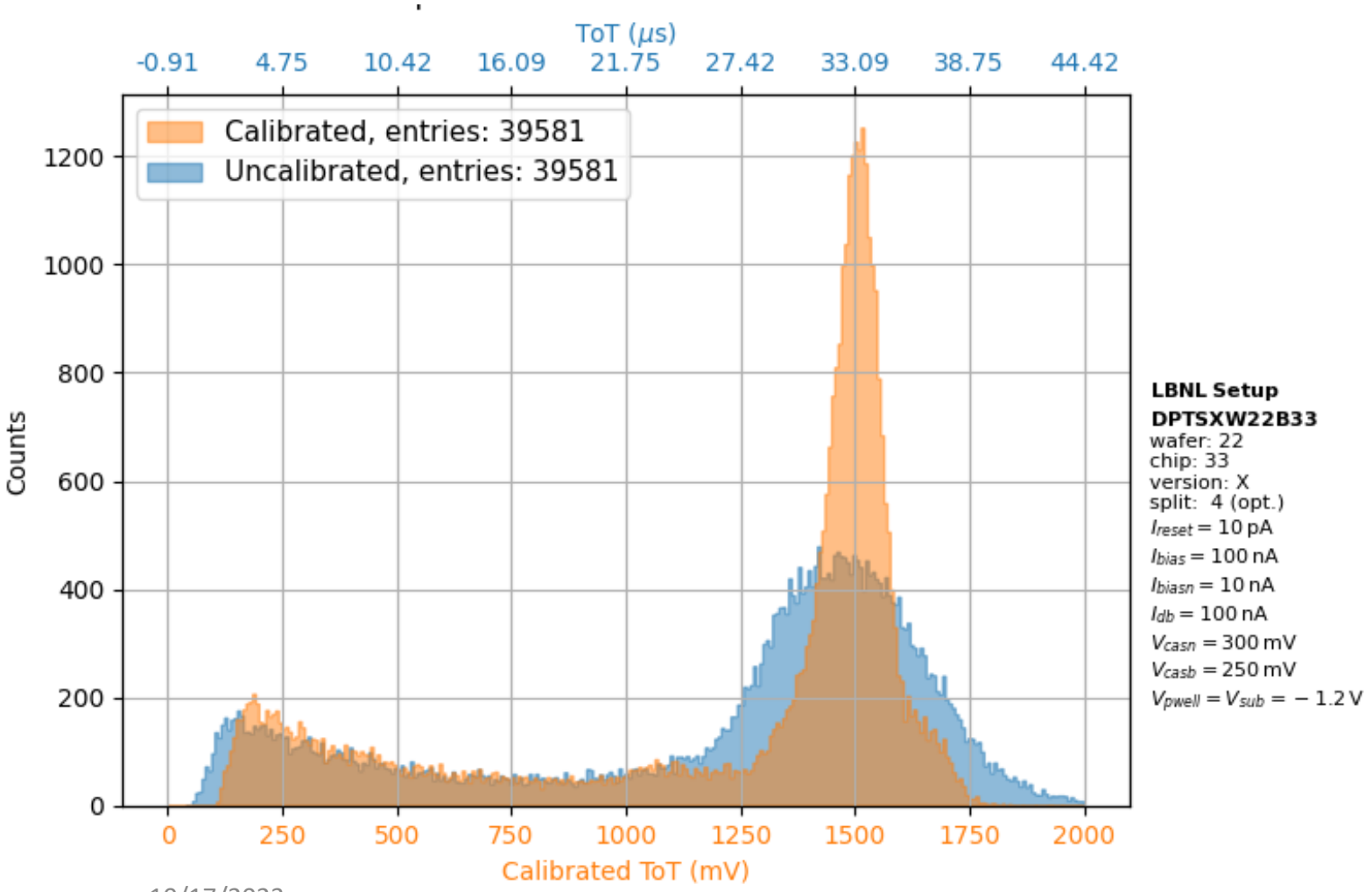
For the individual pixels, the relative RMS over the injections at a fixed VH depends very weakly on I_{DB}.

IBIAS = 500 nA





^{55}Fe source data



Collected 100k triggers with a ^{55}Fe source. After requiring events with a single pixel and applying some other cuts, about 40k events remain.

The main peak should be the K-alpha X-ray at 5.9 keV. Since it takes 3.6 eV to create an electron-hole pair in silicon, we would expect this peak to be at 1640 electrons. However, we see the peak at ~1510 electrons. This means on average,

$$C_{inj} \approx \left(\frac{1640}{1510}\right) \times 160\ aF = 173.8\ aF$$

We are working to take more data to do this correction pixel-by-pixel.

Conclusions

- We have studied the ToT sensitivity to the voltages and currents that power/control the DPTS chip. We observe the following:
  1. Combining all pixels, we see the average ToT at fixed VH depends strongly on I_{RESET} only. This is consistent with the published results.
  2. Combining all pixels, we see the relative spread (RMS/Mean) of the ToT at fixed VH depends weakly – up to 5% – on all the parameters when safely above the threshold.
  3. For individual pixels, the relative spread of the ToT at fixed VH also depends weakly on the parameters.
  4. The difference in the mean ToT for individual pixels relative to the average ToT for all pixels also seems to depend weakly on all the parameters.
- We are working on taking high-statistics data with the Fe55 source to perform the energy calibration pixel-by-pixel.