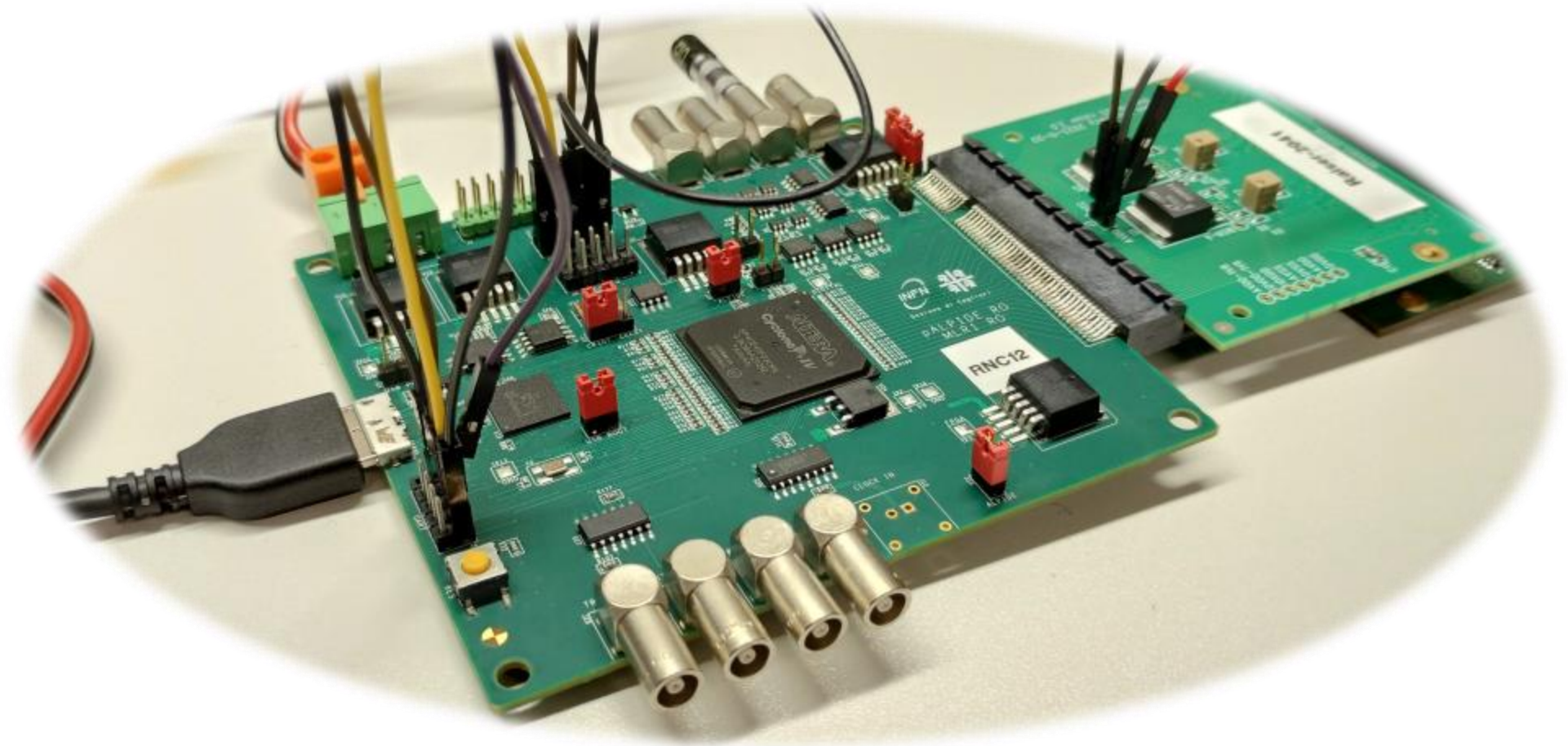
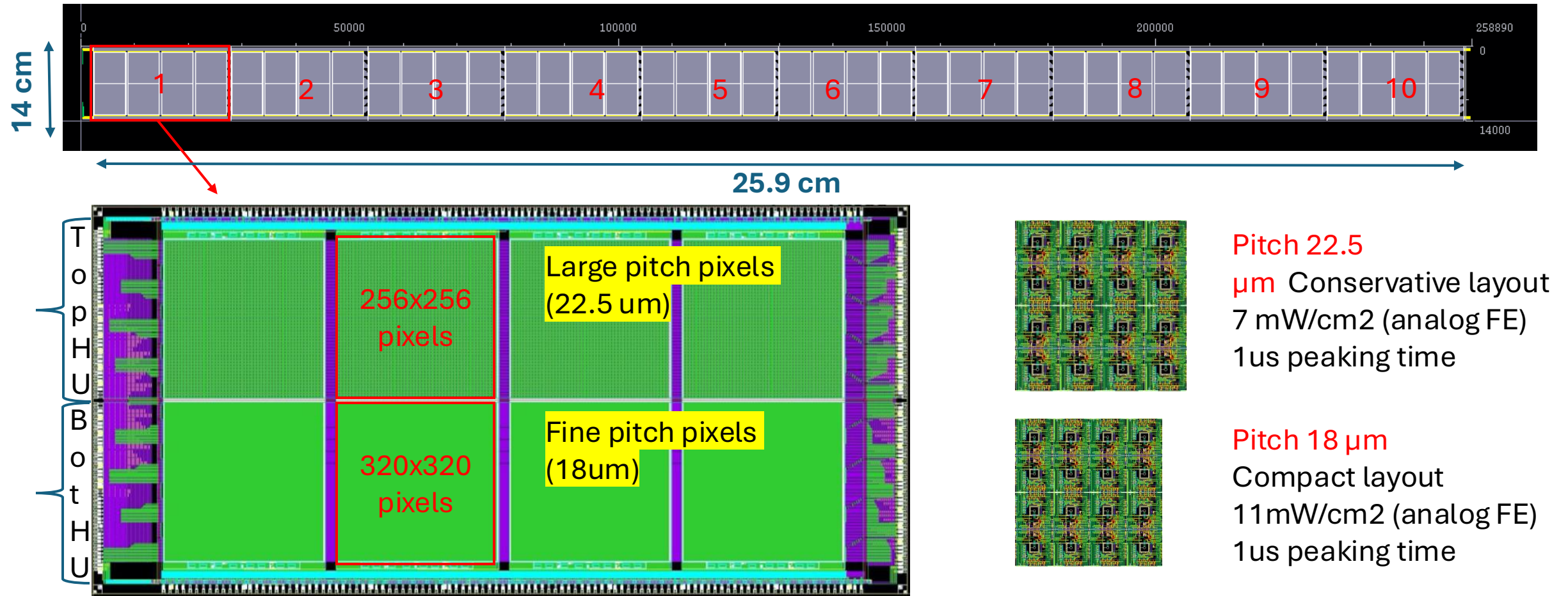


babyMOSS Test Set-up and Scans at Bari



29.01.2025

babyMOSS Prototype summary



- MOnolithic Stched Sensor (MOSS) is made of ten **repeated sensor units (RSUs)**. **babyMOSS** is equivalent to pixel matrix of the One RSU.
- Each RSU is composed of two **half-units (HUs)**, labeled **top** and **bottom**. Each half-unit contains four **matrices**, also referred to as **regions**.

babyMOSS Prototype summary

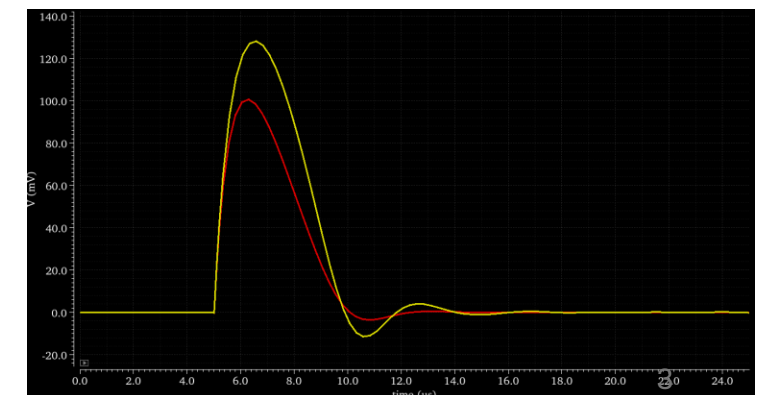
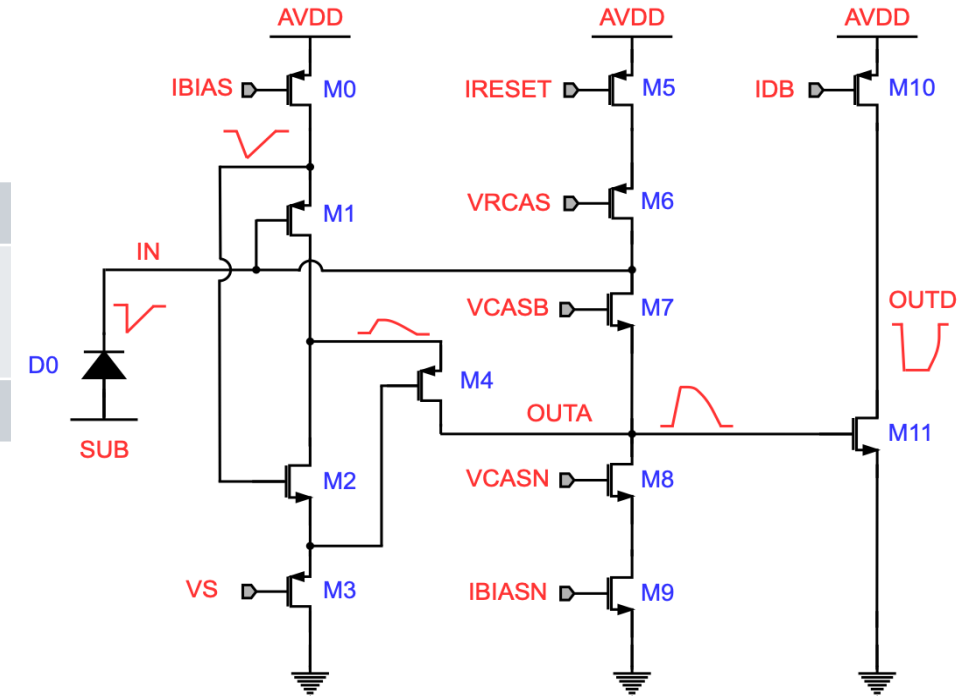
- There are different front-end variants within a HU:

	Region 0	Region 1	Region 2	Region 3
TOP	Standard	Larger input transistor (M1)	Larger discriminator input transistor (M11)	Larger common-source transistor (M2)
BOTTOM	Standard	Standard	Standard	Slightly different layout

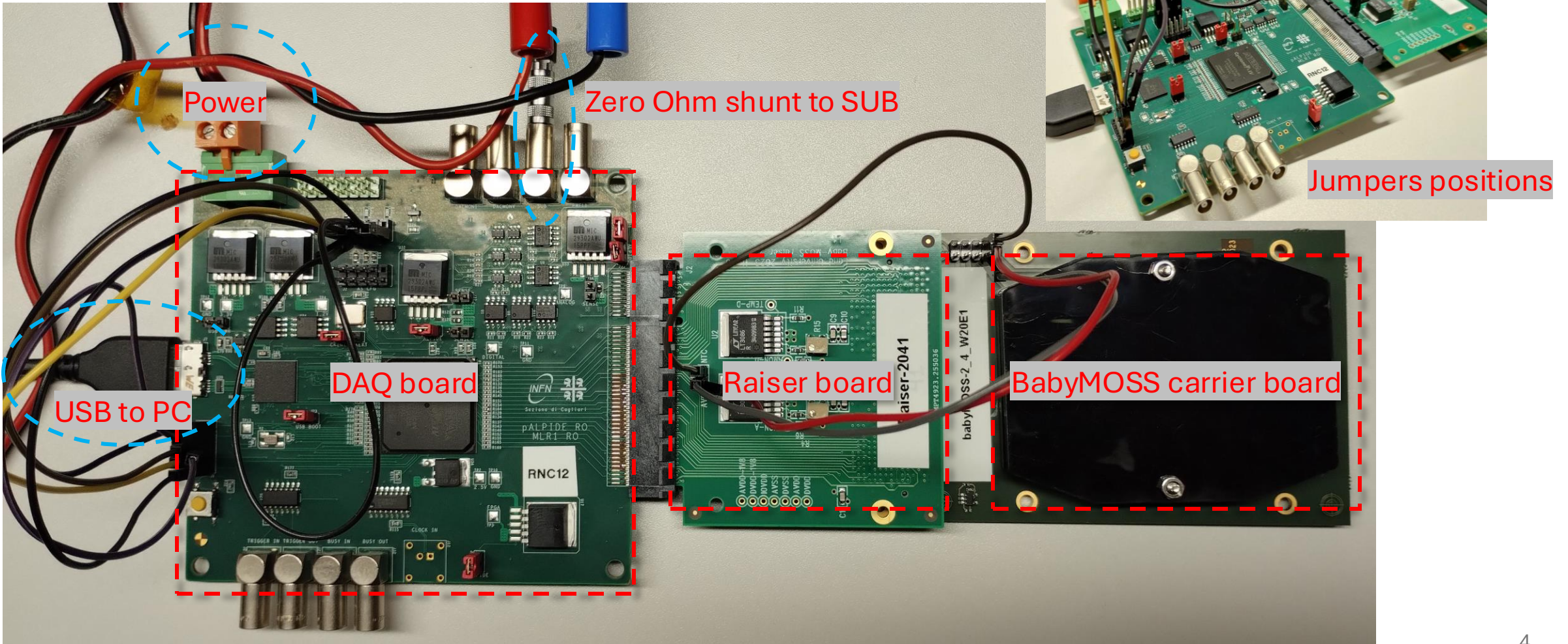
- For nominal settings with p_{well}/p_{sub} at 0V and $C_{in} = 5$ fF, simulated thresholds are:

Thresholds	Region 0	Region 1	Region 2	Region 3
TOP	104 e	108 e	130 e	106 e
BOTTOM	104 e	104 e	104 e	85 e

- In "**standard layout**" a parasitic capacitance added to improves the stability of the circuit. This capacitance, however, also reduces the front-end gain (**red curve**).
- In "**slightly different layout**" parasitic capacitance was slightly reduced, so front-end gain increases (**yellow curve**).

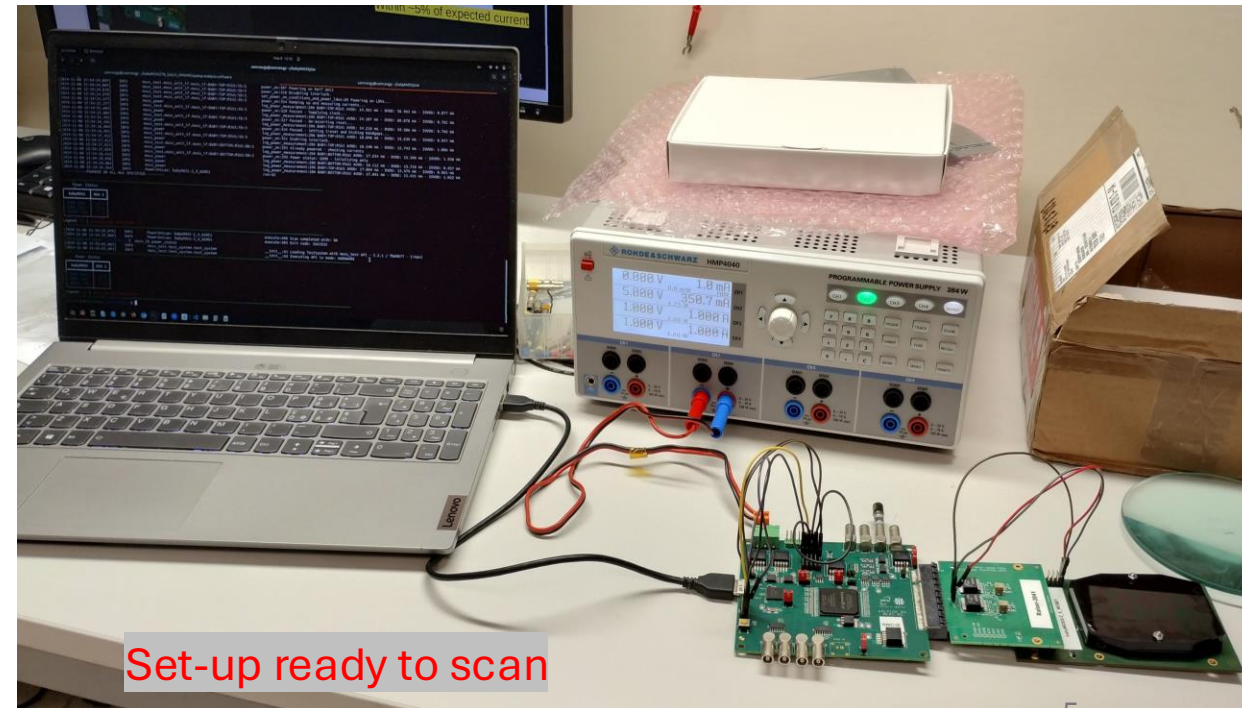


babyMOSS components and connections



Set-up configuration

- DAQ board ID: DAQ-0009012905D1273D, Raiser board ID: Raiser-2041, Chip ID: babyMOSS-2_4_W20E1
- Zero-ohm shunt resistor in SUB at VBB = 0 V
- No Temperature control



Software installation and scans

- The software can be installed in any linux PC.
- The steps to install the software are summarised in wiki page [babyMOSS Lab test setup](#)
- The scan history can be found in the [logbook](#).

Configuration files

ts_config_raiser.json

```
1 {
2   "moss_chip_id": "babyMOSS-2_4_W20E1",
3   "fw_hash": "0x6e00d1dd",
4   "mode": "hardware",
5   "power_config": "config/power_config_raiser.json5",
6   "power_off_when_done": false,
7   "disable_power_interlock": false,
8   "boards": [
9     {
10      "location": "baby",
11      "usb": {
12        "idVendor": 5462,
13        "product": "ALPIDE-DAQ",
14        "manufacturer": "CERN/INFN-CA",
15        "serial_number": "DAQ-0009012905D1273D"
16      }
17    }
18  ]
19 }
```

scan_config_raiser.json

```
1 {
2   "ts_config": "config/ts_config_raiser.json5",
3   // For baby-moss use "tby" (top) and "bby" (bottom)
4   "enabled_units": ["tby", "bby"],
5   // "enabled_units": ["bby"],
6   "region_readout_enable_masks": {
7     "bb": 0xD,
8   },
9   "seed": "random",
10  "moss_dac_settings": {
11    "*": {
12      // "IRESET": 30,
13      "VCASB": [
14        25,
15        25,
16        25,
17        25
18      ]
19    }
20  }
21 }
```

Different scans to be performed

- Functional testing:
 - power on scan
 - register scan
 - shift register scan
 - DAC scan
- Readout and pixel matrix testing:
 - digital scan
 - analogue scan
 - FHR scan
 - threshold scan

Functional scans

- Power on scan: If the scan is OK then end with `Exit` code: `SUCCESS`
- Same for register scan.
- Dac scan: performances of different dac parameters `VCASB`, `VCASN`, `VPULSEH`, `VSHIFT`, `IBIAS`, `IBIASN`, `IDB`, `IRESET`

```
[2025-01-17 11:49:12,720] INFO      moss_test.moss_uart1_tx.moss_tx.BABY:BOTTOM:RSU1:BB:1 power_on:293 Power Status: GOOD - tntcattzu
g_only
[2025-01-17 11:49:13,236] INFO      moss_power log_power_measurement:206 BABY:BOTTOM:RSU1 A
VDD: 16.995 mA - DVDD: 14.282 mA - IOVDD: 0.957 mA
[2025-01-17 11:49:13,744] INFO      moss_power log_power_measurement:206 BABY:TOP:RSU1 AVDD
: 16.651 mA - DVDD: 14.609 mA - IOVDD: 1.038 mA
[2025-01-17 11:49:14,259] INFO      moss_power log_power_measurement:206 BABY:BOTTOM:RSU1 A
VDD: 16.820 mA - DVDD: 14.705 mA - IOVDD: 0.981 mA
[2025-01-17 11:49:14,260] INFO      PowerOnScan: babyMOSS-2_4_W20E1 run:62
-----POWERED ON ALL HUS SPECIFIED-----
```

Power Status

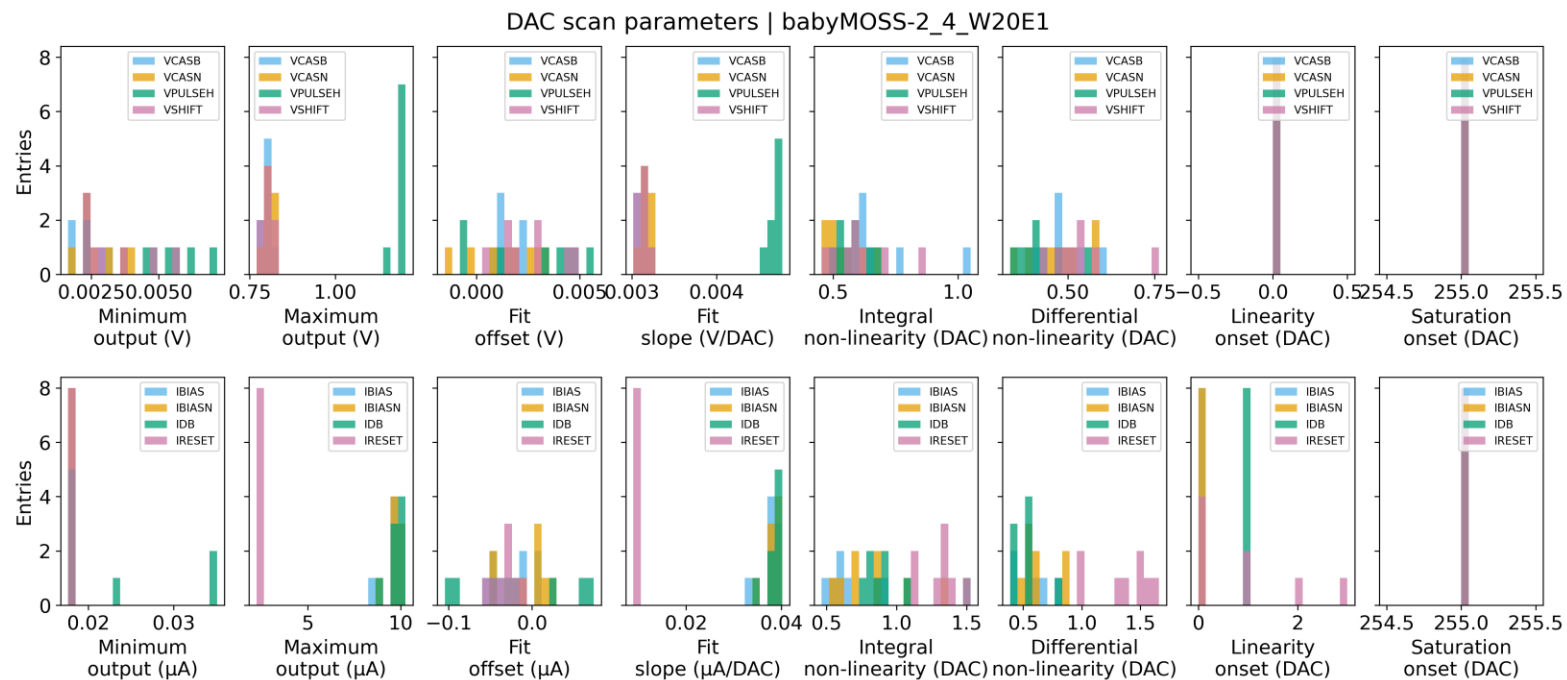
babyMOSS	RSU 1
AVDD (mA)	16.5
DVDD (mA)	14.8
IOVDD (mA)	1.0

Legend: OK | above/below threshold

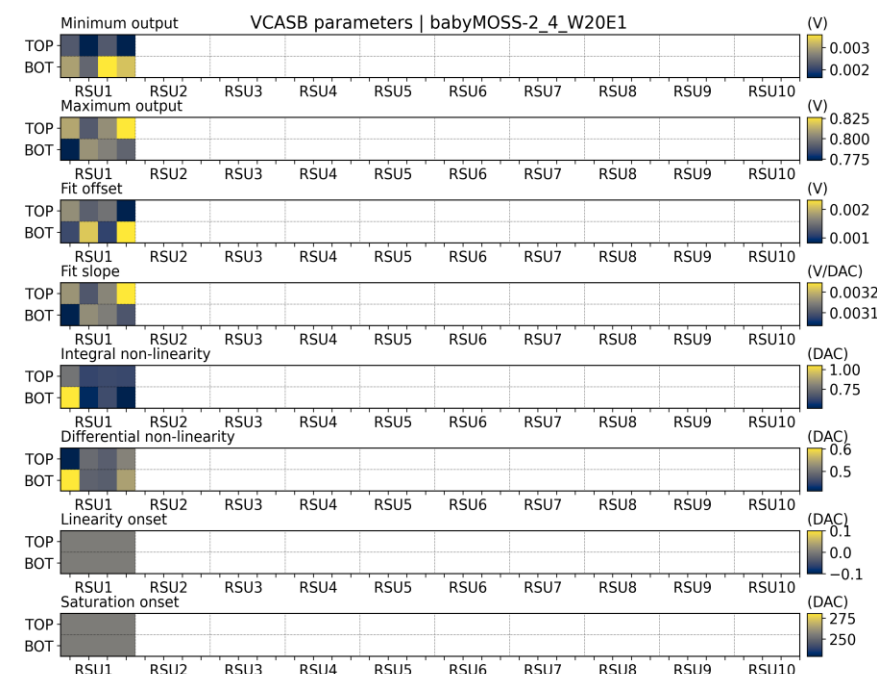
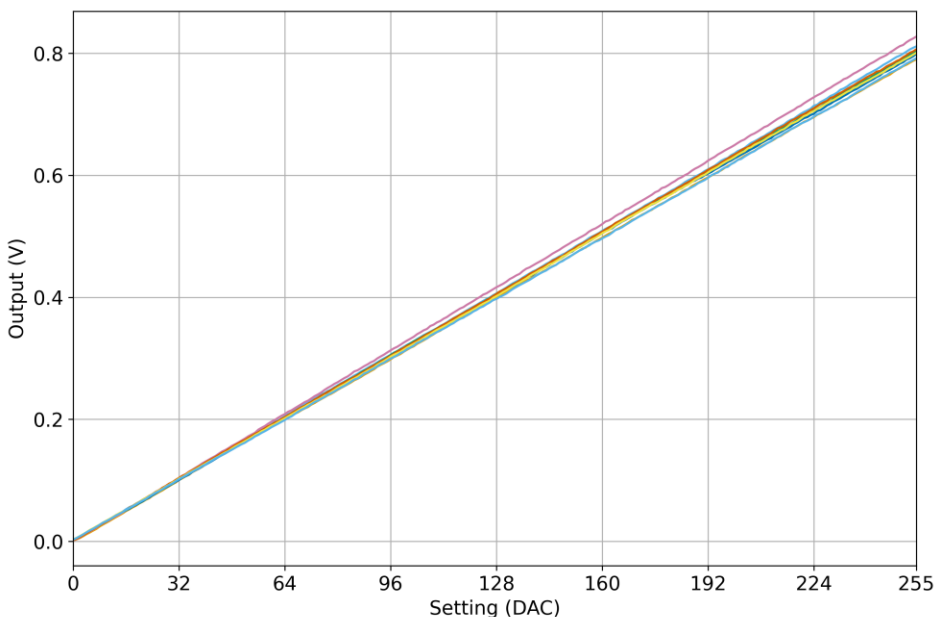
```
[2025-01-17 11:49:14,767] INFO      PowerOnScan: babyMOSS-2_4_W20E1 execute:498 Scan completed with: OK
[2025-01-17 11:49:14,767] INFO      PowerOnScan: babyMOSS-2_4_W20E1 execute:505 Exit code: SUCCESS
```


DAC scans

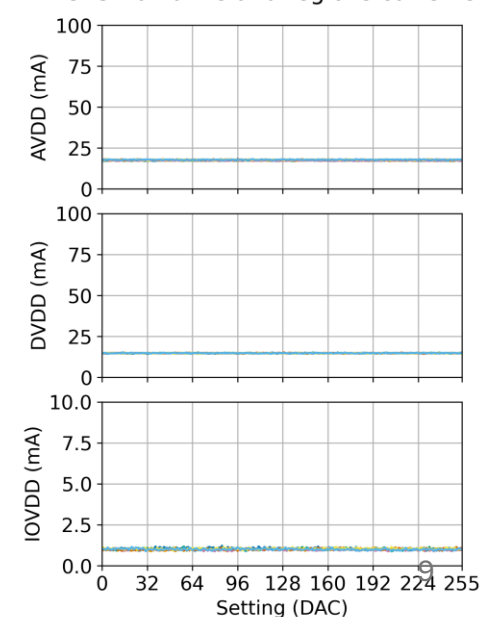
- Each parameter is scanned with changing DAC values 0 - 255
- DAC Scan produces 20 plots of different combination of the dac parameters
- Few of the DAC scan results are shown



babyMOSS-2_4_W20E1 | VCASB all units and regions | DacAnalysis

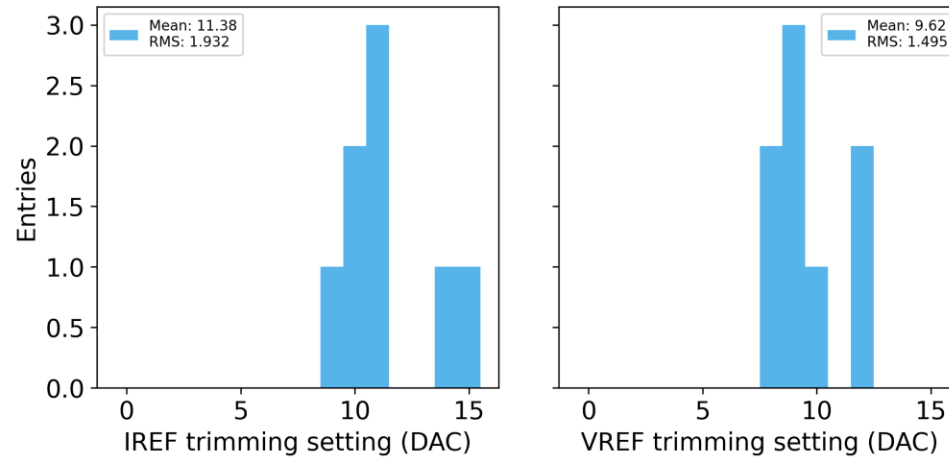


babyMOSS-2_4_W20E1 | DacAnalysis VCASN all units and regions currents

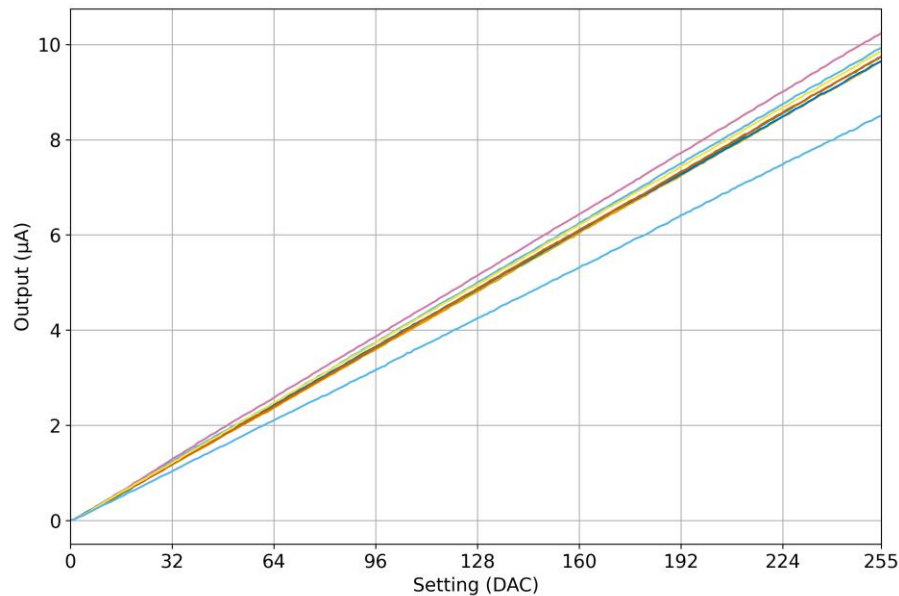


DAC Scan

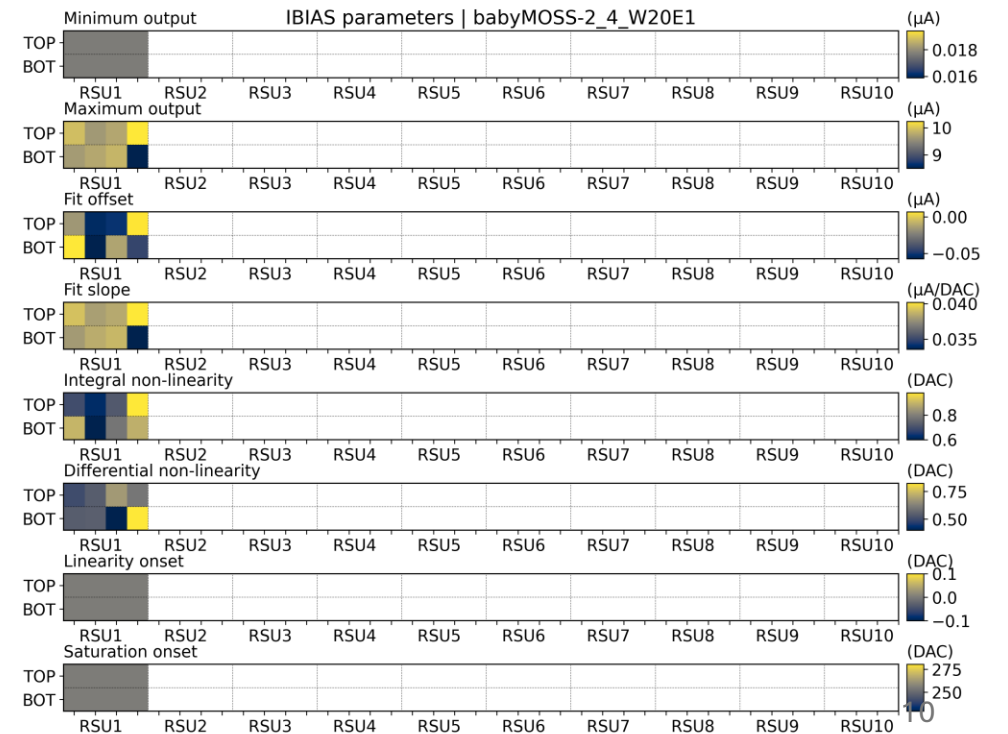
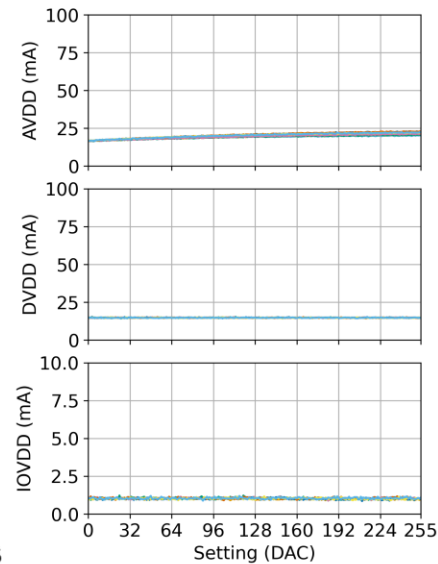
Bandgap trimming settings | babyMOSS-2_4_W20E1



babyMOSS-2_4_W20E1 | IBIAS all units and regions | DacAnalysis

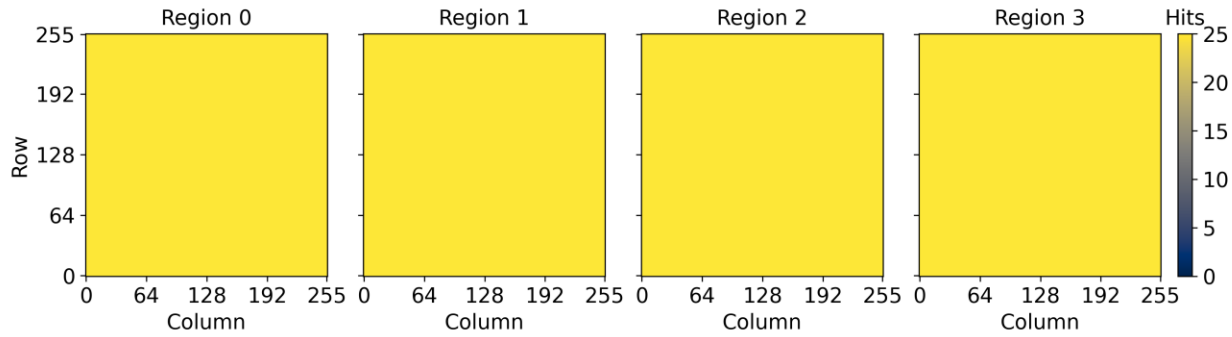


babyMOSS-2_4_W20E1 | DacAnalysis IBIAS all units and regions currents

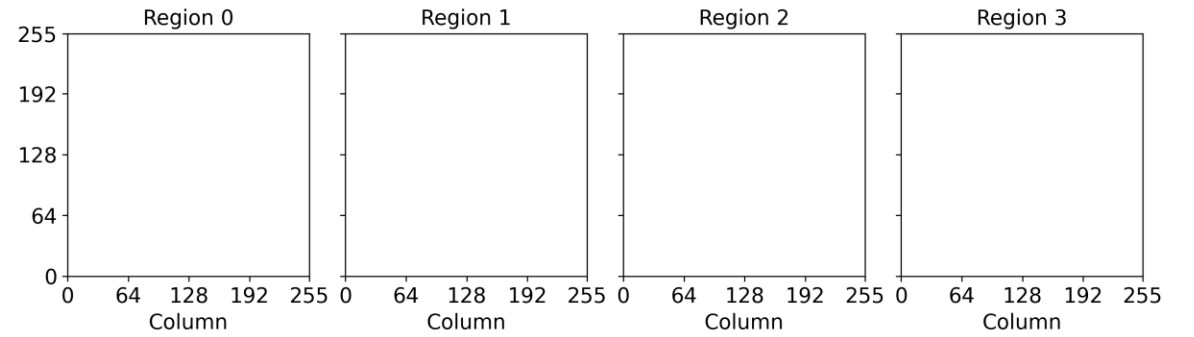


Digital scan: tb

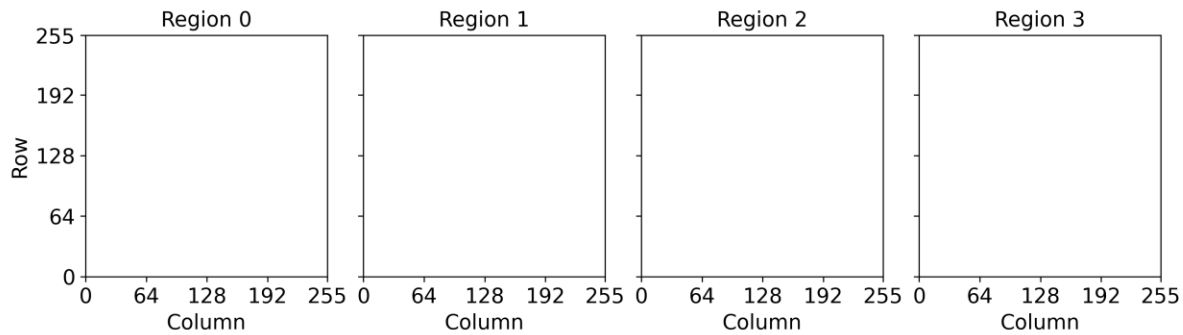
babyMOSS-2_4_W20E1 | tb hitmap | DigitalAnalogScanAnalysis



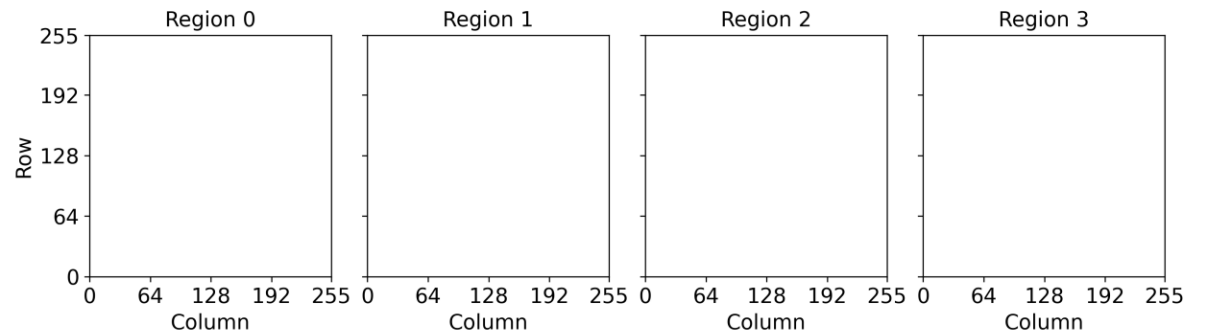
babyMOSS-2_4_W20E1 | tb inefficient pixels | DigitalAnalogScanAnalysis



babyMOSS-2_4_W20E1 | tb noisy pixels | DigitalAnalogScanAnalysis

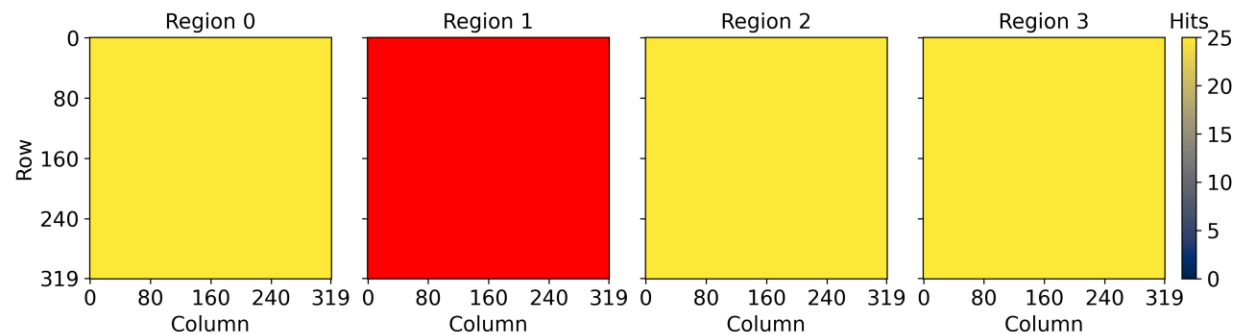


babyMOSS-2_4_W20E1 | tb dead pixels | DigitalAnalogScanAnalysis

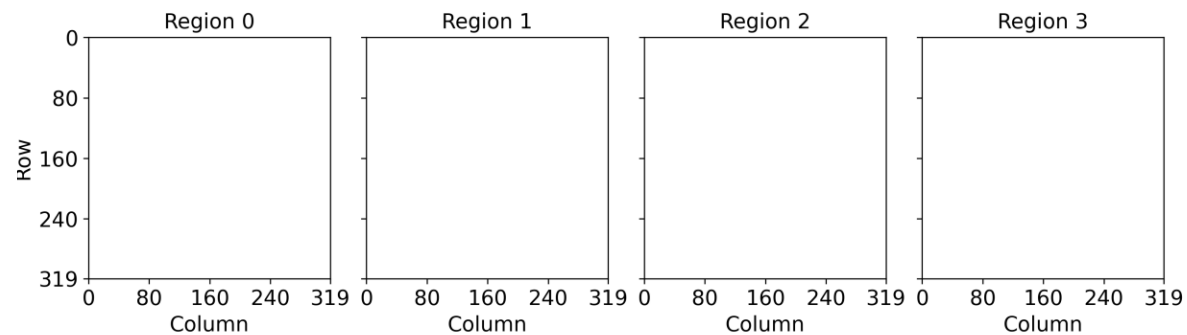


Digital scan: bb

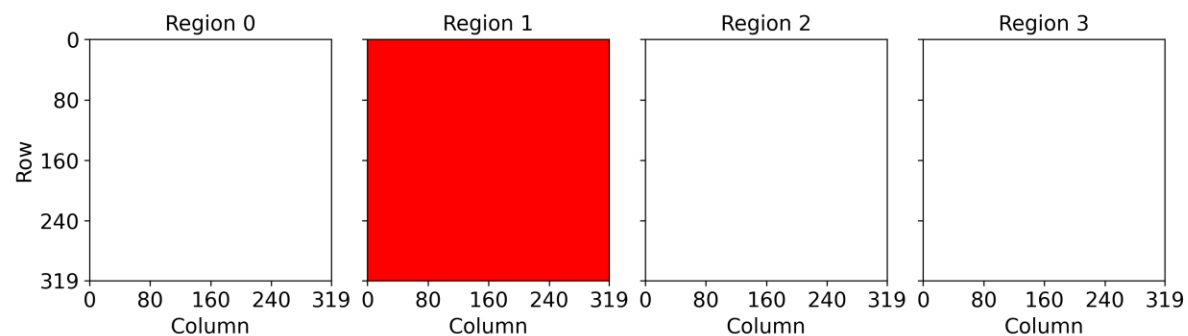
babyMOSS-2_4_W20E1 | bb hitmap | DigitalAnalogScanAnalysis



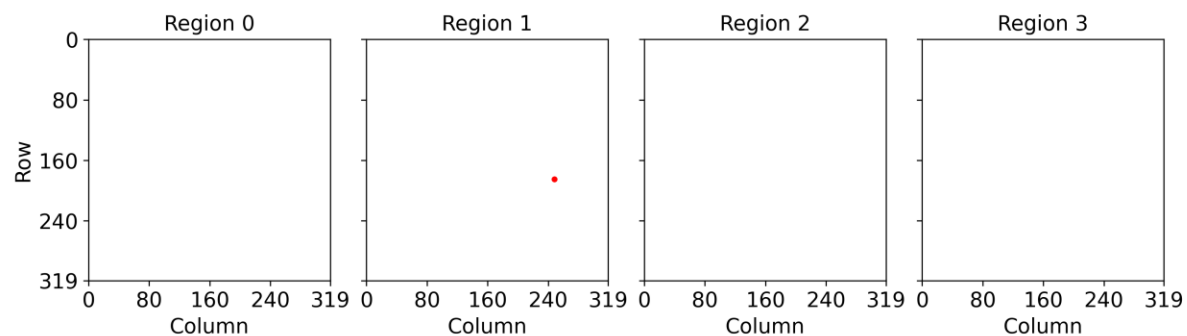
babyMOSS-2_4_W20E1 | bb inefficient pixels | DigitalAnalogScanAnalysis



babyMOSS-2_4_W20E1 | bb noisy pixels | DigitalAnalogScanAnalysis



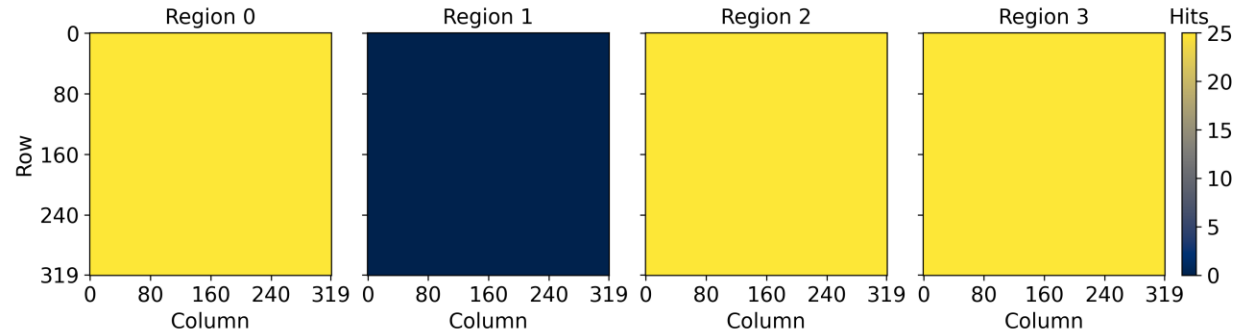
babyMOSS-2_4_W20E1 | bb dead pixels | DigitalAnalogScanAnalysis



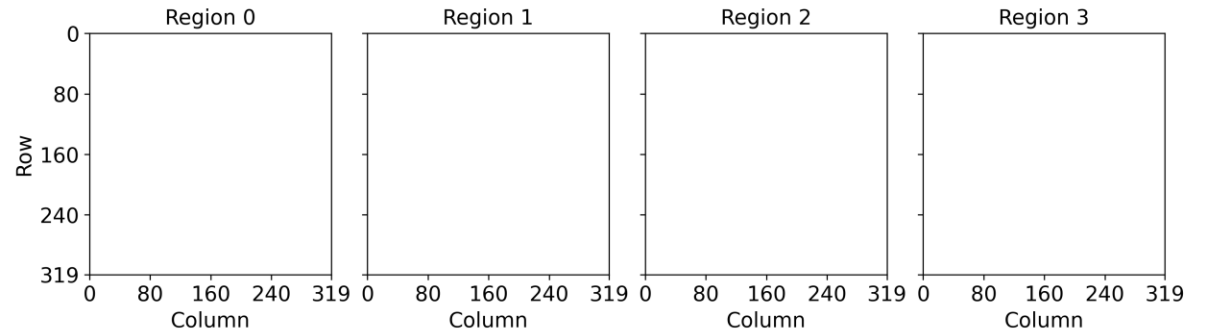
- Bb region 1 is noisy.

Digital scan: bb

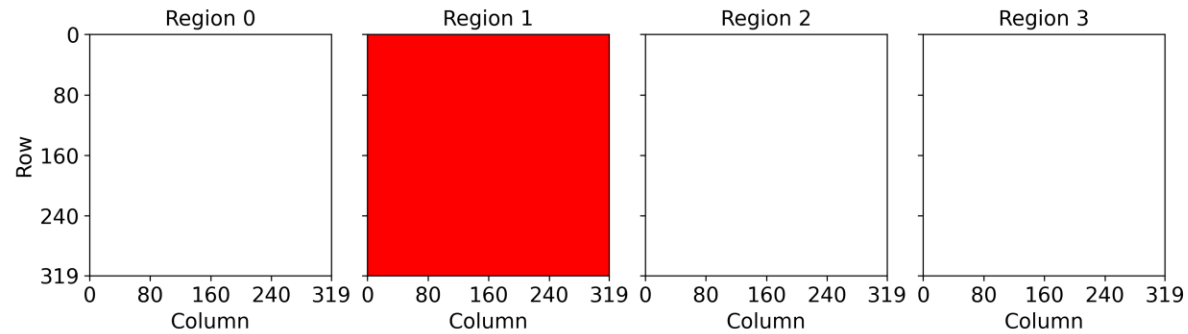
babyMOSS-2_4_W20E1 | bb hitmap | DigitalAnalogScanAnalysis



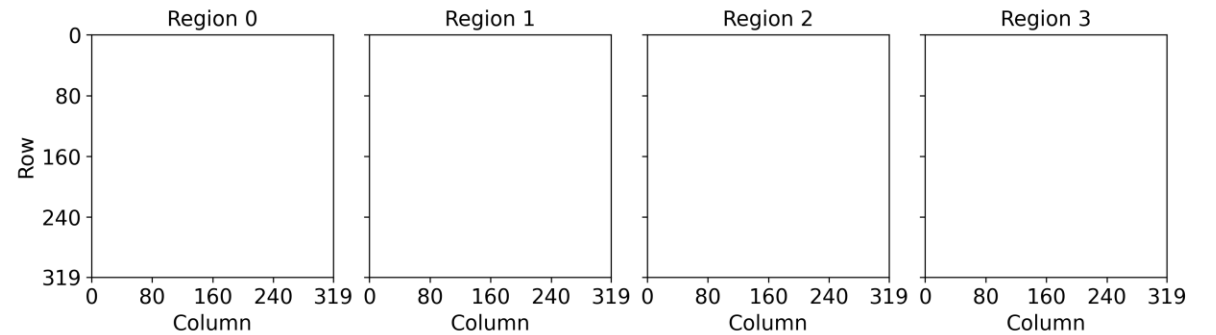
babyMOSS-2_4_W20E1 | bb noisy pixels | DigitalAnalogScanAnalysis



babyMOSS-2_4_W20E1 | bb dead pixels | DigitalAnalogScanAnalysis



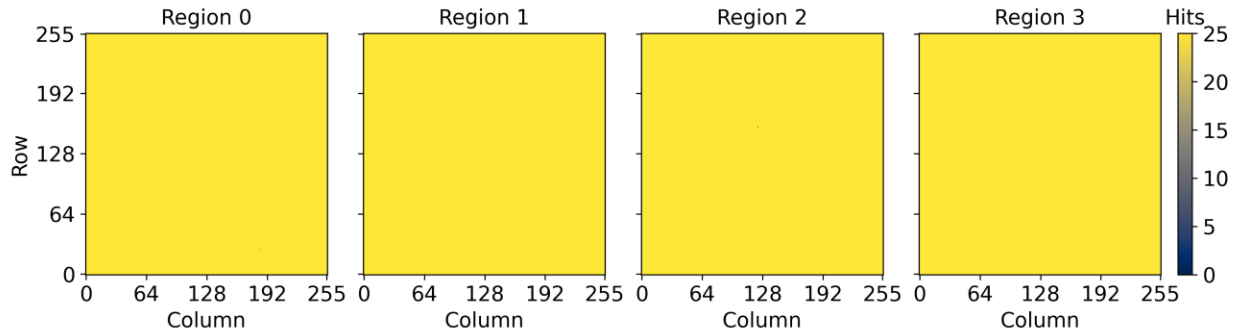
babyMOSS-2_4_W20E1 | bb inefficient pixels | DigitalAnalogScanAnalysis



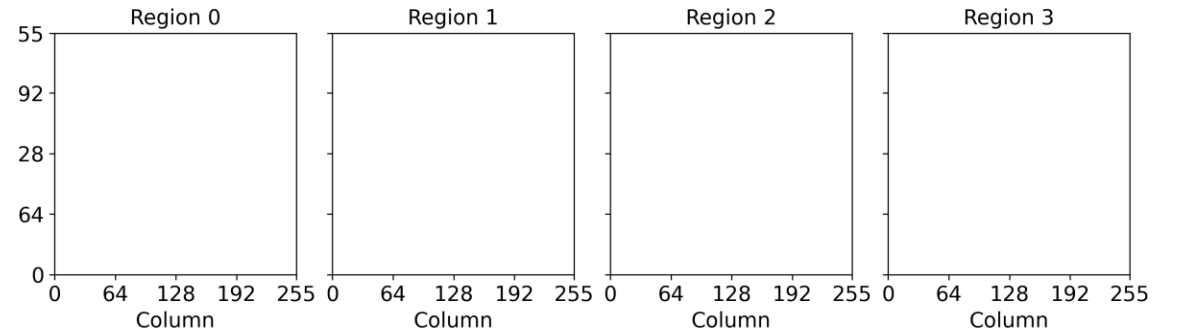
- Digital Scan test performed after masking the noisy region.

Analogue scan: tb

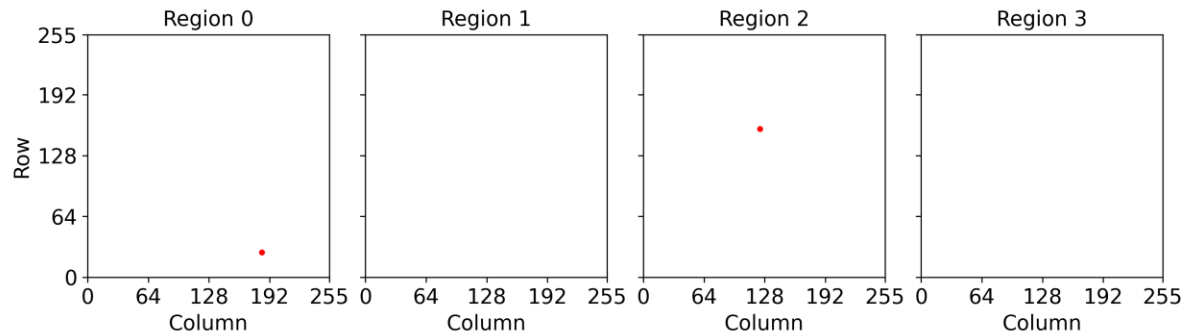
babyMOSS-2_4_W20E1 | tb hitmap | DigitalAnalogScanAnalysis



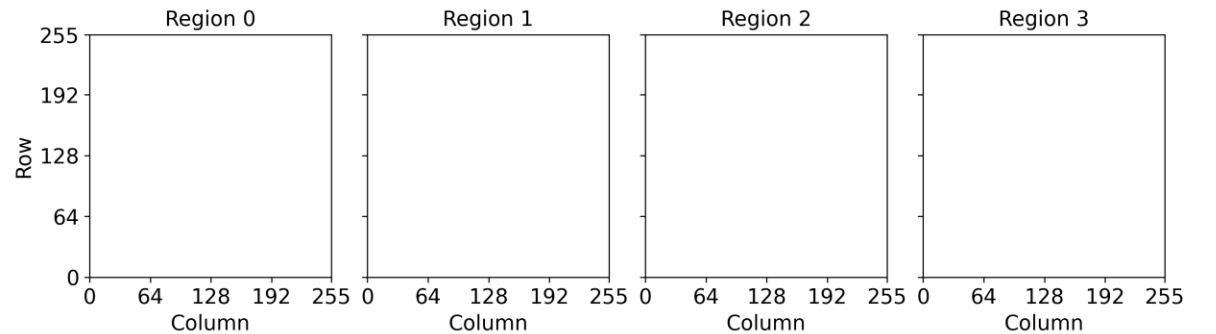
babyMOSS-2_4_W20E1 | tb inefficient pixels | DigitalAnalogScanAnalysis



babyMOSS-2_4_W20E1 | tb noisy pixels | DigitalAnalogScanAnalysis

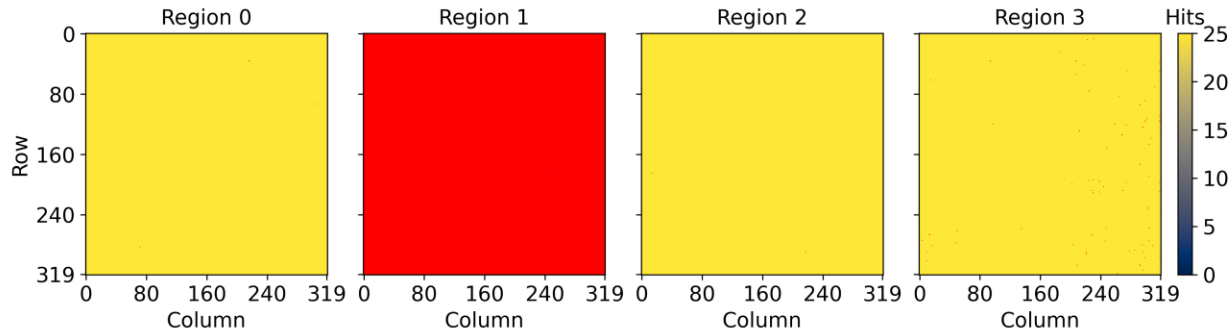


babyMOSS-2_4_W20E1 | tb dead pixels | DigitalAnalogScanAnalysis

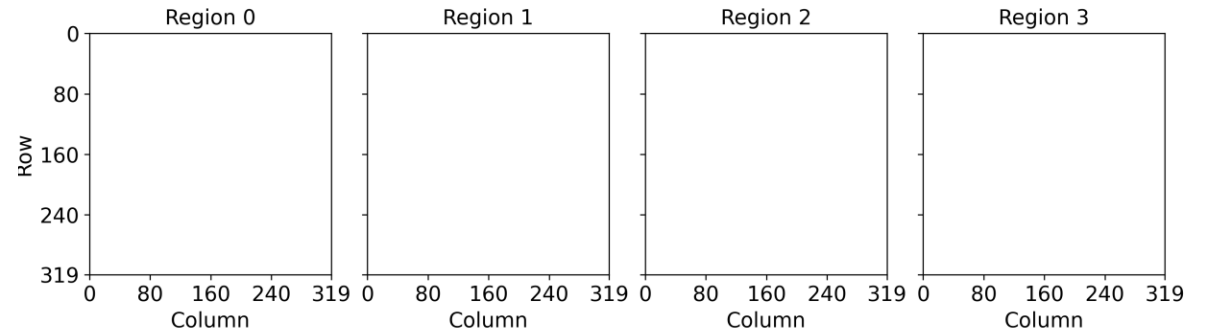


Analogue scan: bb

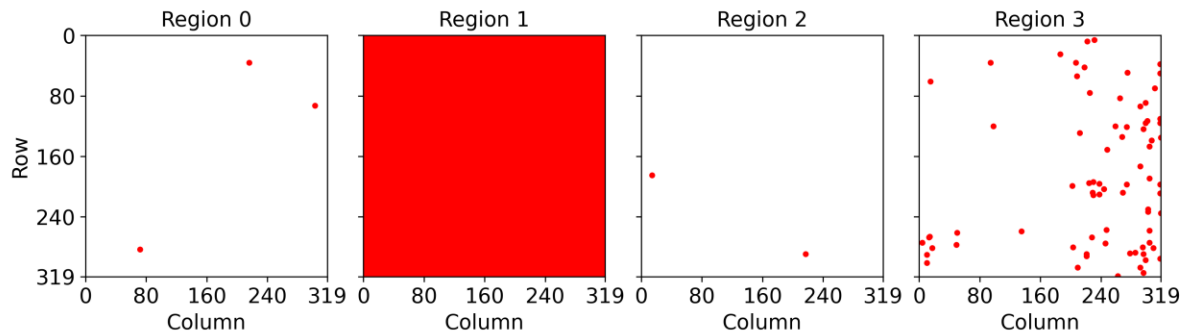
babyMOSS-2_4_W20E1 | bb hitmap | DigitalAnalogScanAnalysis



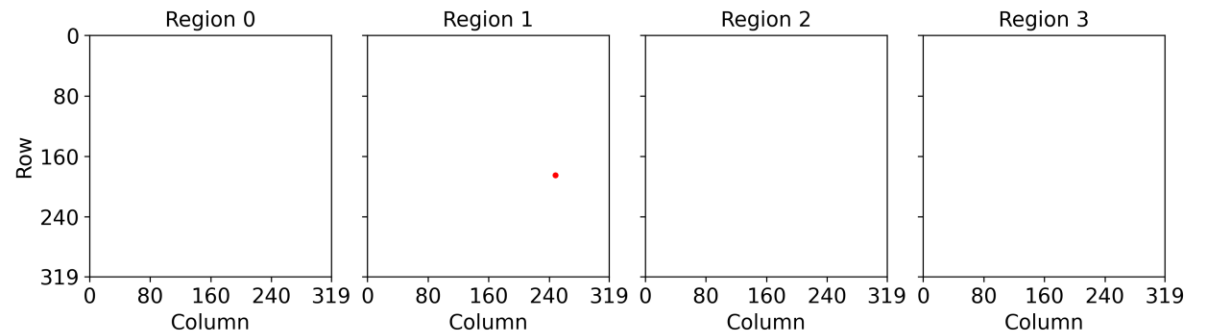
babyMOSS-2_4_W20E1 | bb inefficient pixels | DigitalAnalogScanAnalysis



babyMOSS-2_4_W20E1 | bb noisy pixels | DigitalAnalogScanAnalysis



babyMOSS-2_4_W20E1 | bb dead pixels | DigitalAnalogScanAnalysis

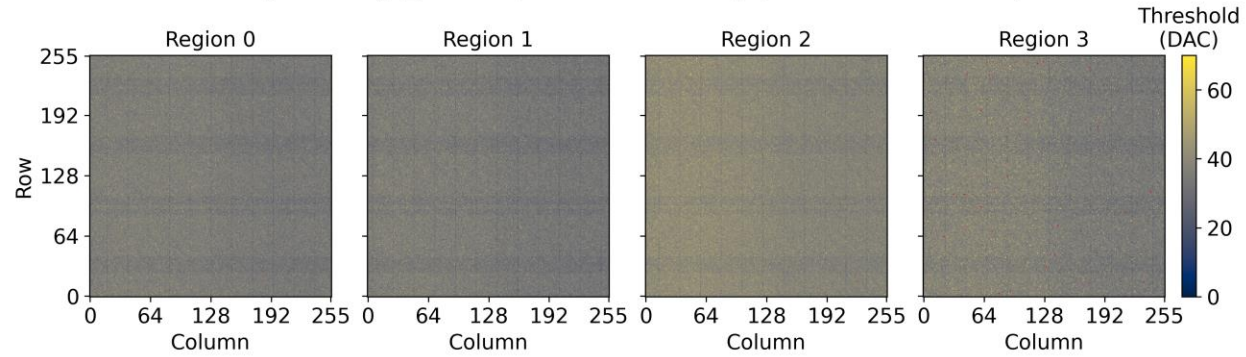


- BB region 1 is noisy

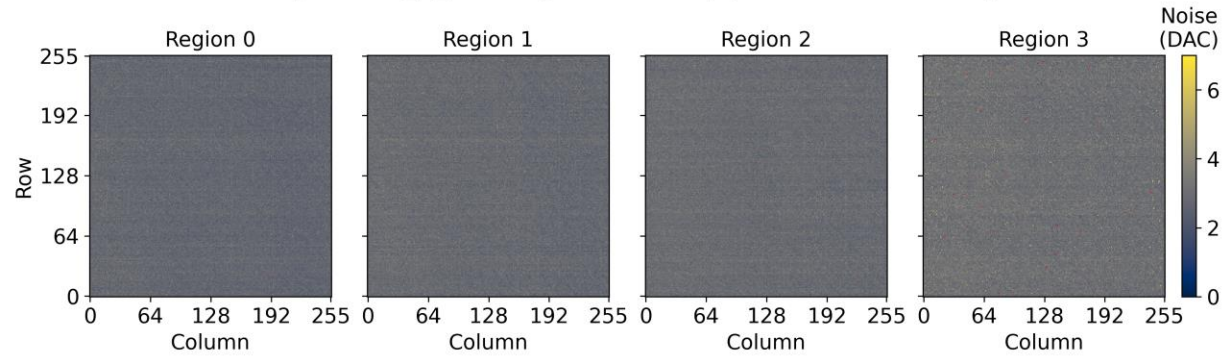
Threshold scan: tb

VCASB = 15

babyMOSS-2_4_W20E1 | tb Threshold map | ThresholdScanAnalysis

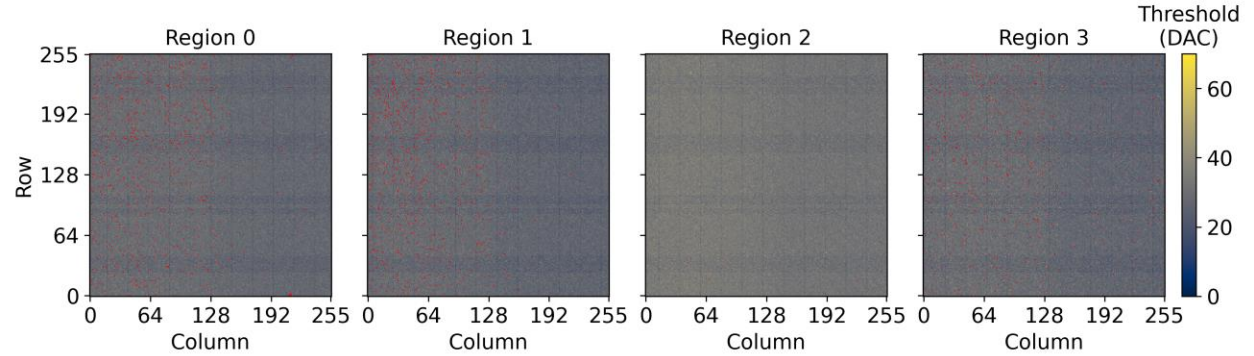


babyMOSS-2_4_W20E1 | tb Noise map | ThresholdScanAnalysis

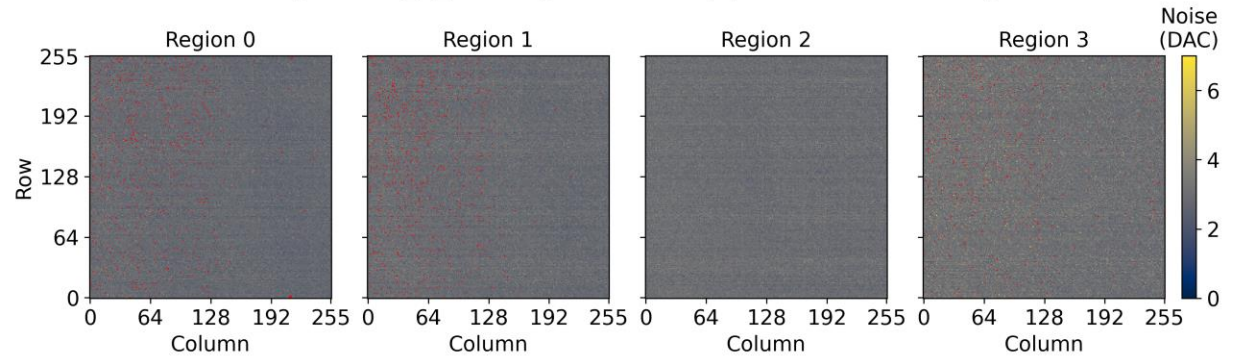


VCASB = 25

babyMOSS-2_4_W20E1 | tb Threshold map | ThresholdScanAnalysis



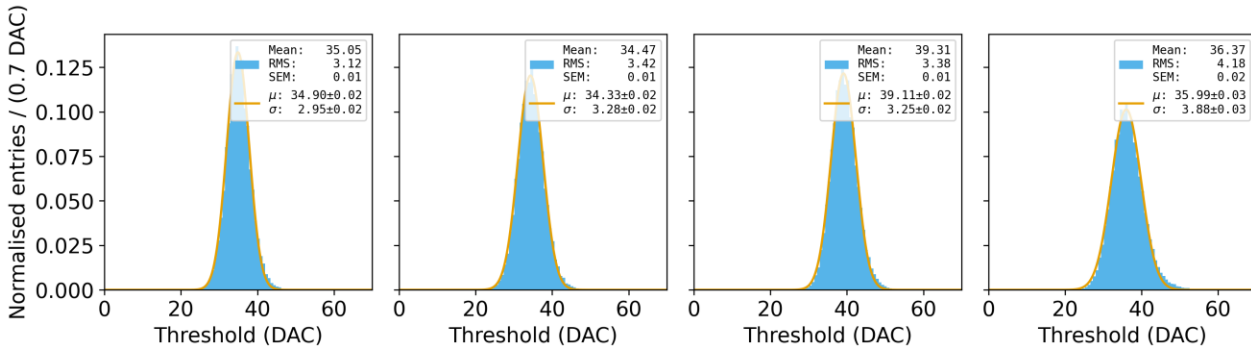
babyMOSS-2_4_W20E1 | tb Noise map | ThresholdScanAnalysis



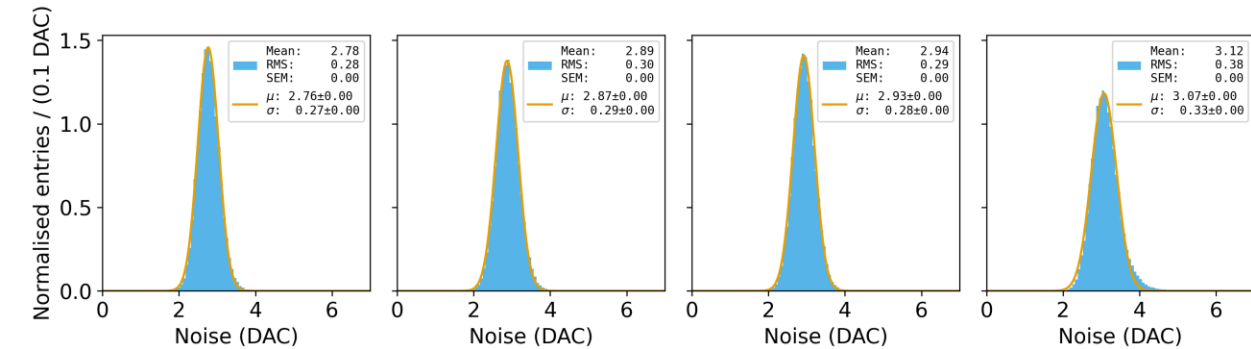
Threshold scan: tb

VCASB = 15

babyMOSS-2_4_W20E1 | tb Threshold distributions | ThresholdScanAnalysis

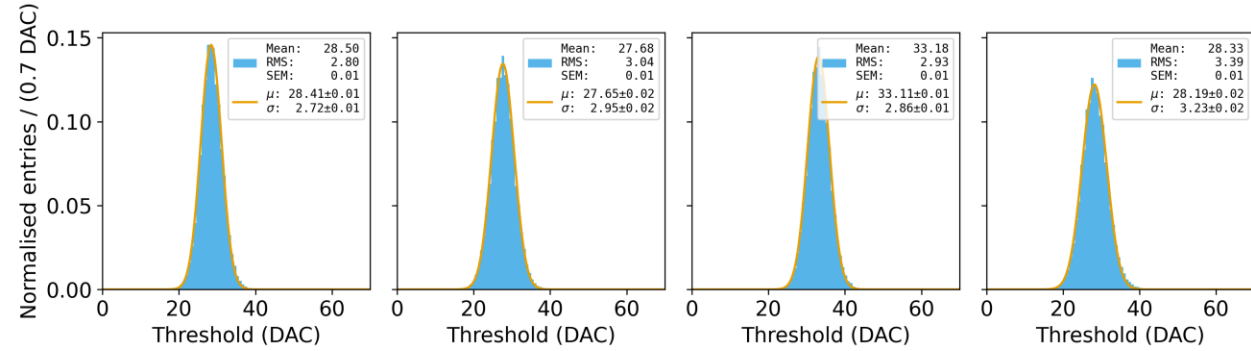


babyMOSS-2_4_W20E1 | tb Noise distributions | ThresholdScanAnalysis

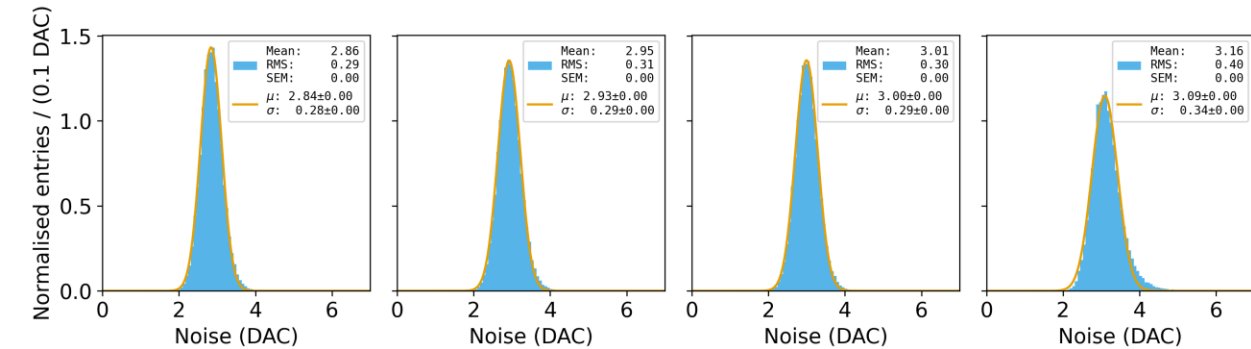


VCASB = 25

babyMOSS-2_4_W20E1 | tb Threshold distributions | ThresholdScanAnalysis



babyMOSS-2_4_W20E1 | tb Noise distributions | ThresholdScanAnalysis

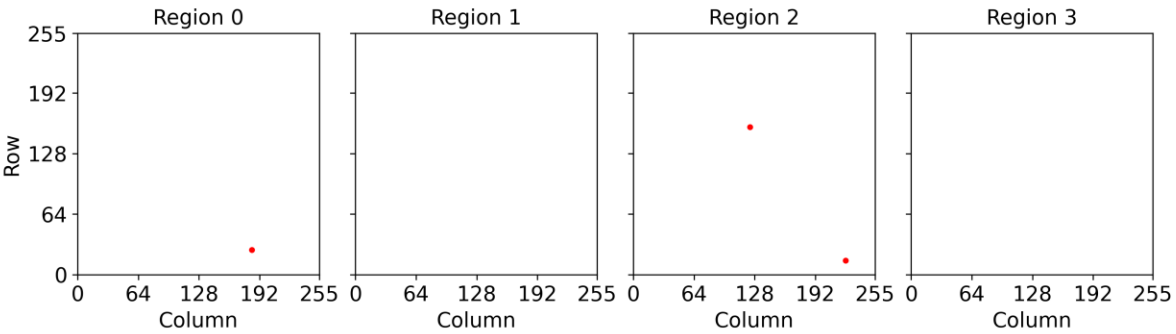


With increasing VCASB threshold value decreases.

Threshold scan: tb

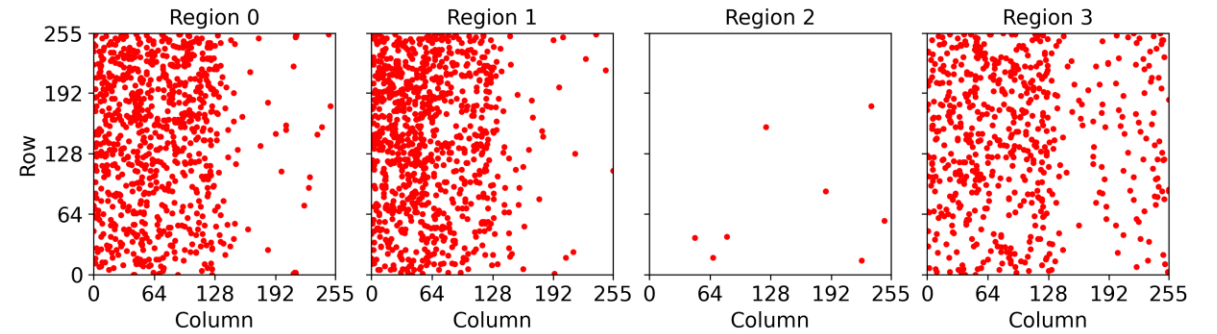
VCASB = 15

babyMOSS-2_4_W20E1 | tb noisy pixels | ThresholdScanAnalysis

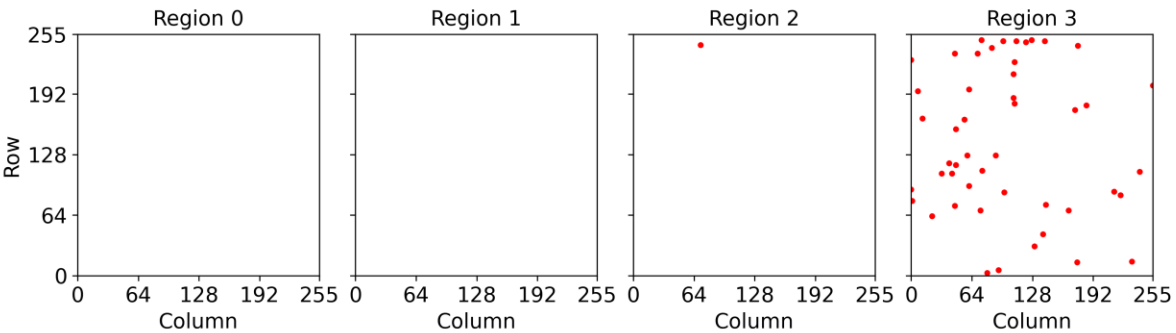


VCASB = 25

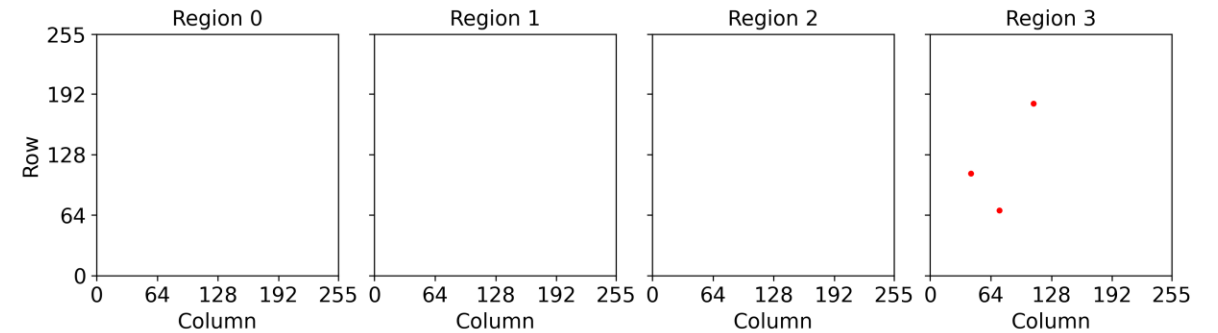
babyMOSS-2_4_W20E1 | tb noisy pixels | ThresholdScanAnalysis



babyMOSS-2_4_W20E1 | tb bad pixels | ThresholdScanAnalysis



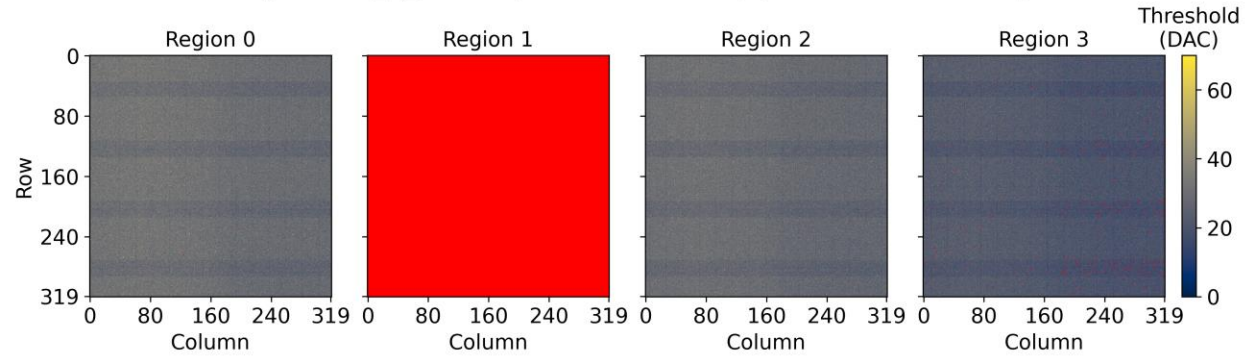
babyMOSS-2_4_W20E1 | tb bad pixels | ThresholdScanAnalysis



Threshold scan: bb

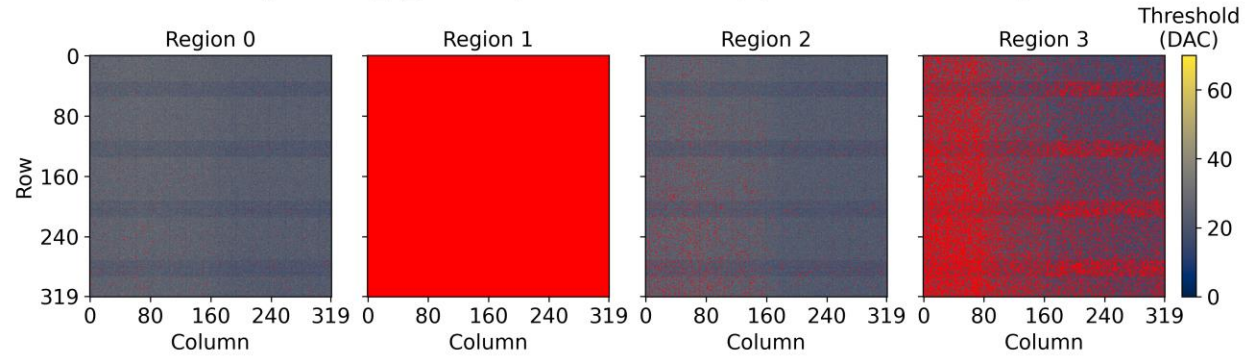
VCASB = 15

babyMOSS-2_4_W20E1 | bb Threshold map | ThresholdScanAnalysis

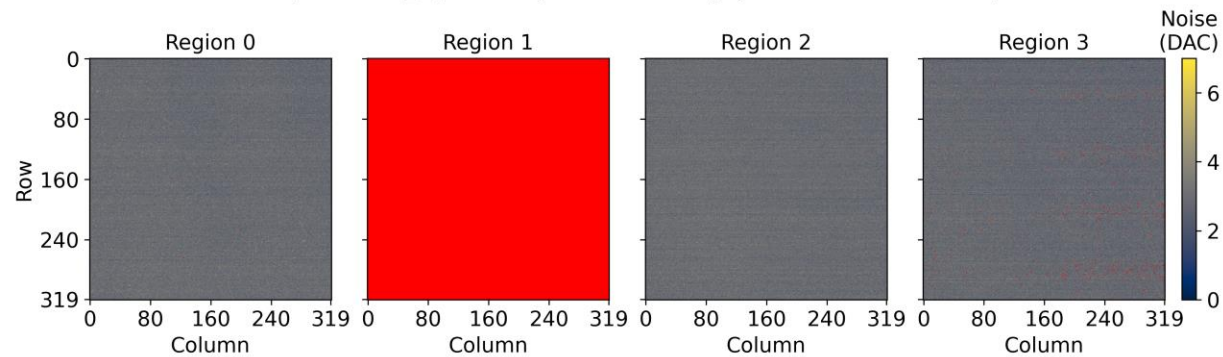


VCASB = 25

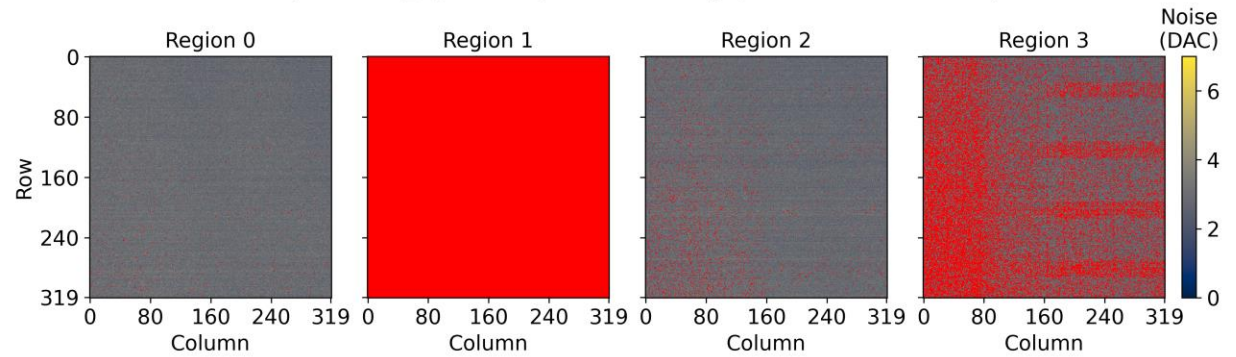
babyMOSS-2_4_W20E1 | bb Threshold map | ThresholdScanAnalysis



babyMOSS-2_4_W20E1 | bb Noise map | ThresholdScanAnalysis



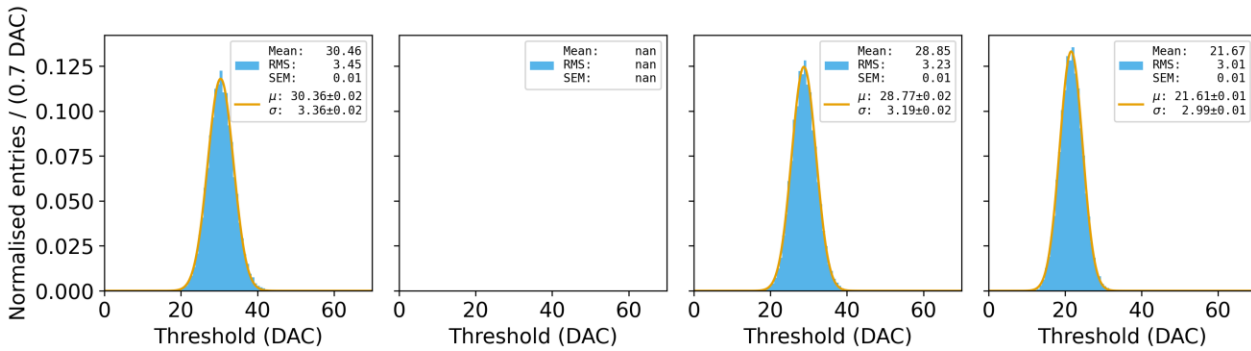
babyMOSS-2_4_W20E1 | bb Noise map | ThresholdScanAnalysis



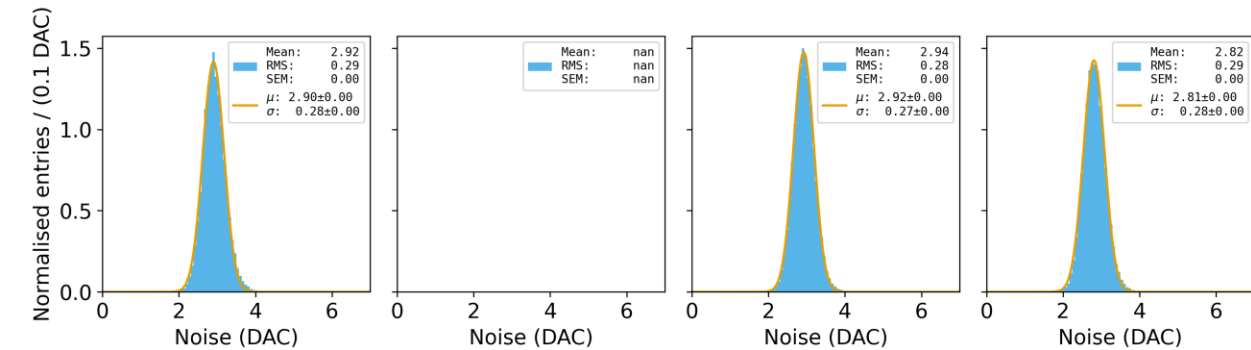
Threshold scan: bb

VCASB = 15

babyMOSS-2_4_W20E1 | bb Threshold distributions | ThresholdScanAnalysis

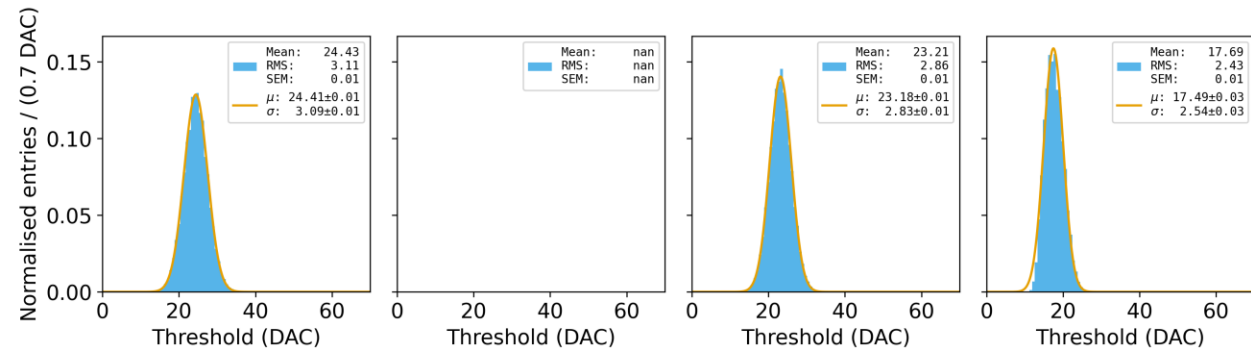


babyMOSS-2_4_W20E1 | bb Noise distributions | ThresholdScanAnalysis

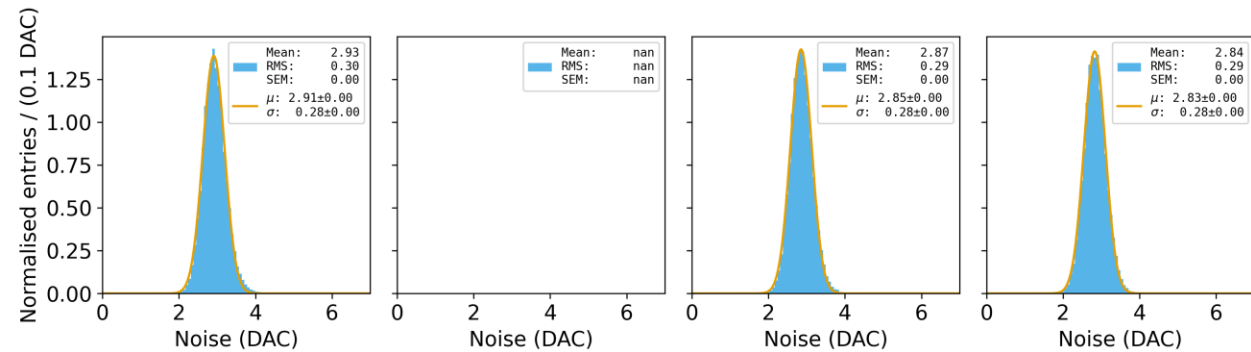


VCASB = 25

babyMOSS-2_4_W20E1 | bb Threshold distributions | ThresholdScanAnalysis



babyMOSS-2_4_W20E1 | bb Noise distributions | ThresholdScanAnalysis

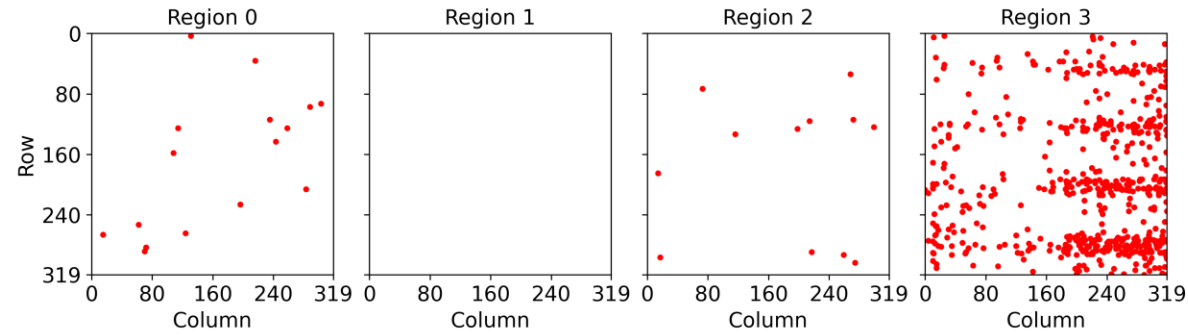


With increasing VCASB threshold value decreases.

Threshold scan: bb

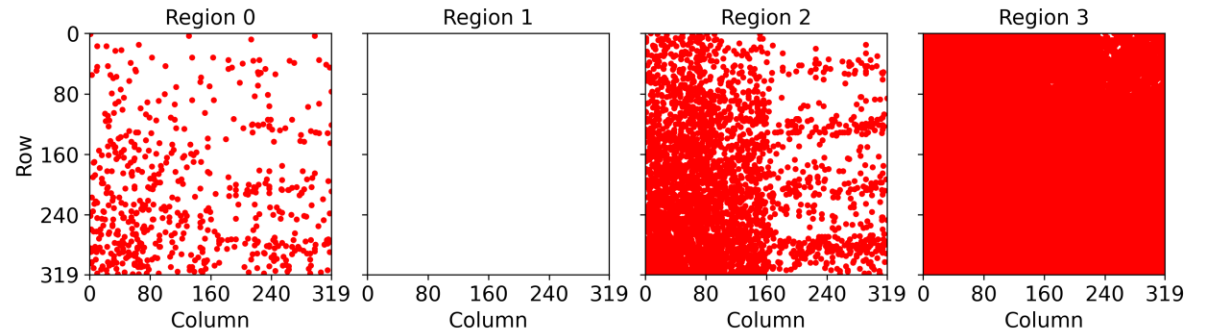
VCASB = 15

babyMOSS-2_4_W20E1 | bb noisy pixels | ThresholdScanAnalysis

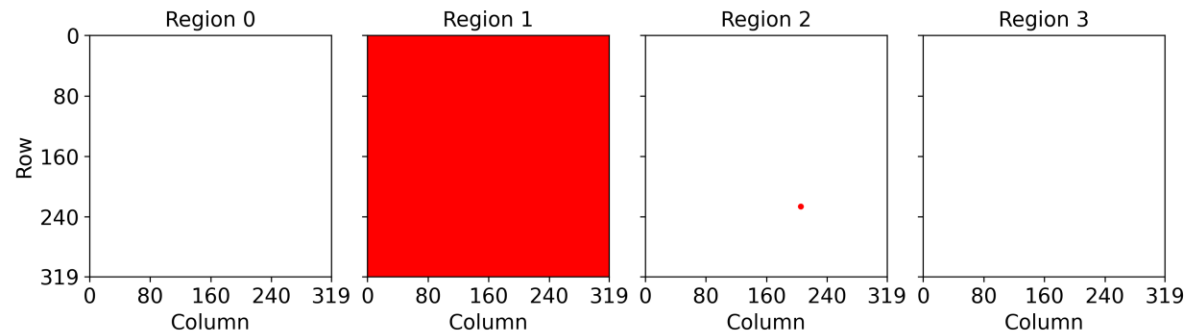


VCASB = 25

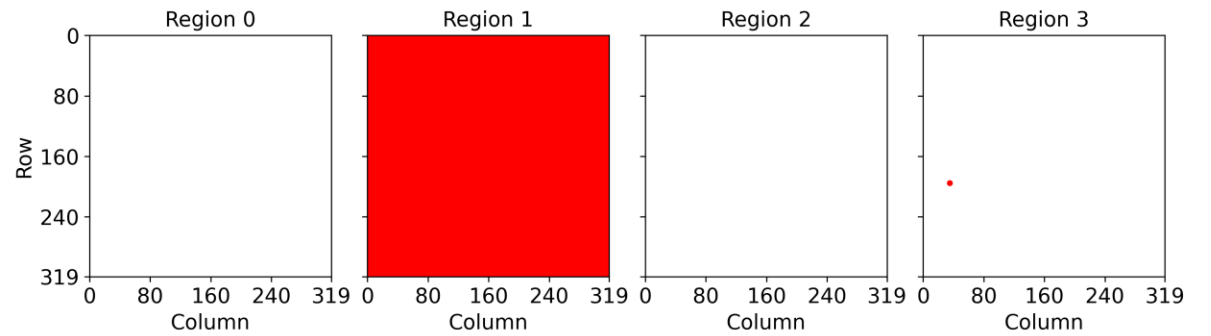
babyMOSS-2_4_W20E1 | bb noisy pixels | ThresholdScanAnalysis



babyMOSS-2_4_W20E1 | bb bad pixels | ThresholdScanAnalysis



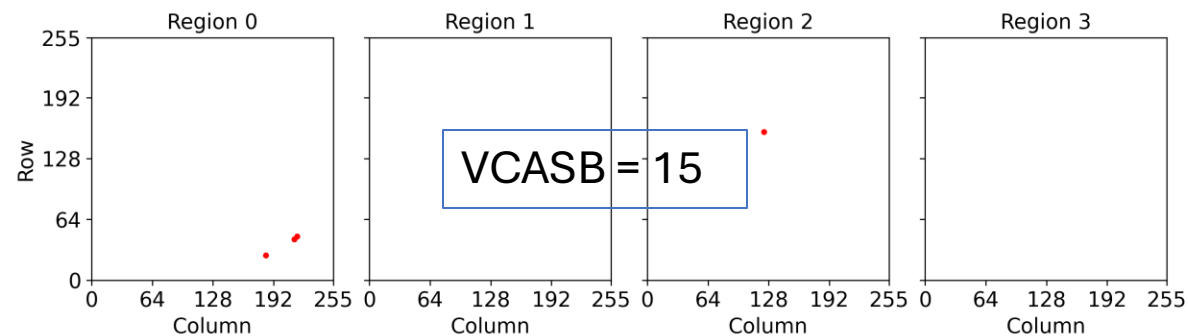
babyMOSS-2_4_W20E1 | bb bad pixels | ThresholdScanAnalysis



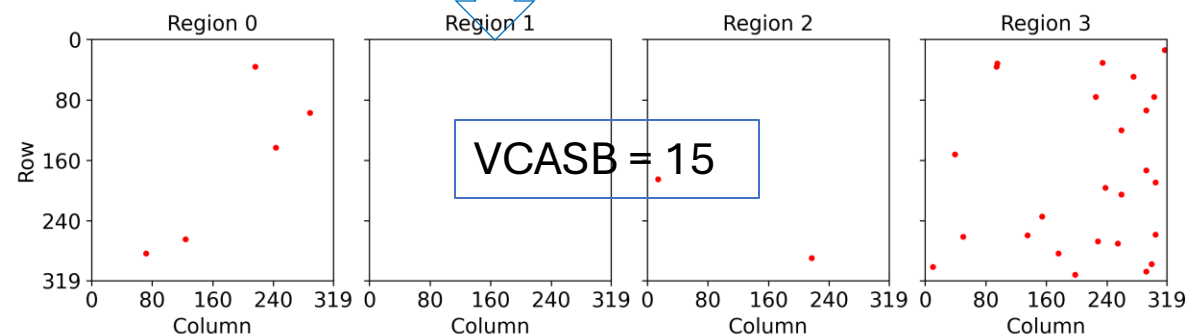
Noise along the rows are probably due to the medallic lines on chips

Fake Hit Rate scan

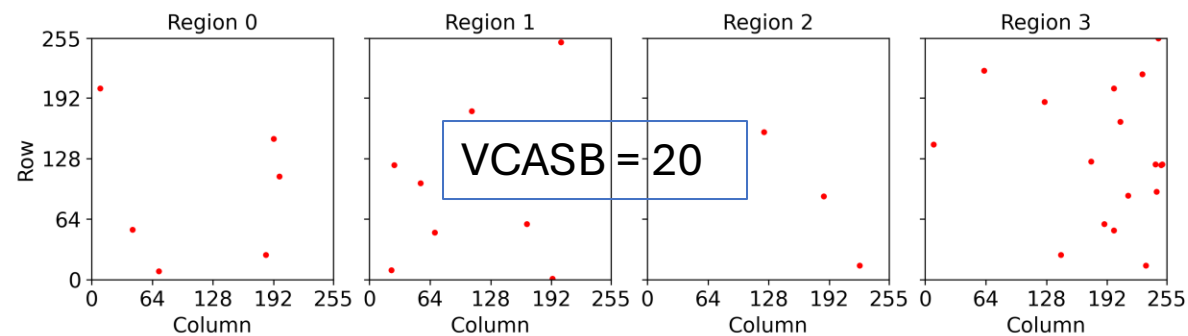
babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis



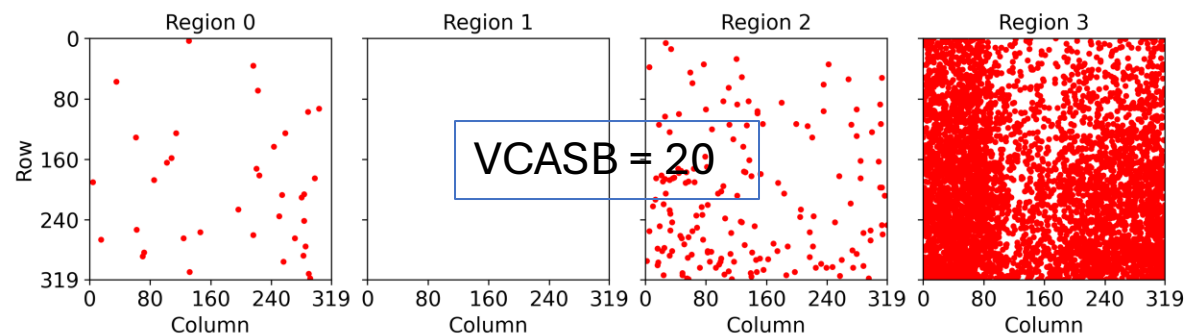
Bb region 1 masked
babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis



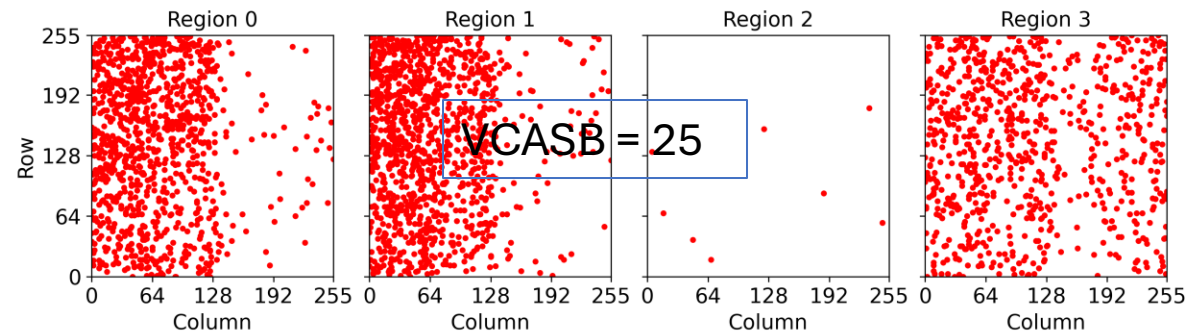
babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis



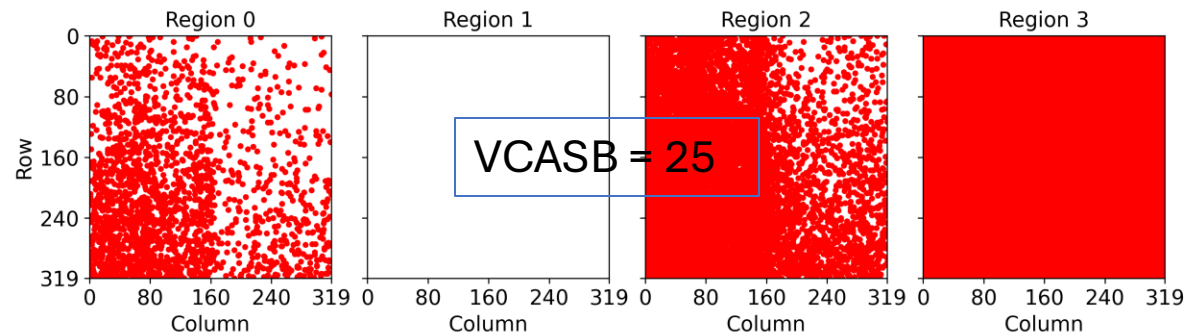
babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis



babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis



babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis



- With increasing VCASB the Fake Hit Rates increases
- FHR is high for the first half of the columns

THR Scan: Different combinations of VCASB

	TB 0	TB 1	TB 2	TB 3	BB 0	BB 1	BB 2	BB3	Commet
VCASB	15	15	15	15	15	15	15	15	
THR	35.48	35.03	39.77	36.92	30.85		29.16	21.89	22.01.25, start
THR	35.24	34.78	39.66	36.66	32.33		29.03	21.81	22.01.25, end
THR	35.05	34.47	39.31	36.37	30.46		28.85	21.67	21.01.25
THR	34.91	34.44	39.22	36.29	30.35		28.76	21.59	15.01.25
VCASB	25	15	15	15	25	15	15	15	
THR	27.38	34.91	39.6	36.75	23.05		29.19	21.93	22.01.25
VCASB	25	10	10	10	25	10	10	10	
THR	27.24	39.67	44.8	45.56	22.69		33.3	25.41	22.01.25
VCASB	25	25	25	25	25	25	25	25	
THR	27.44	26.62	32.12	27.12	23.53		22.37	17.44	22.01.25
THR	28.5	27.68	33.08	28.33	24.43		23.21	17.69	17.01.25

- Noise distribution in range 2.75 - 3.1

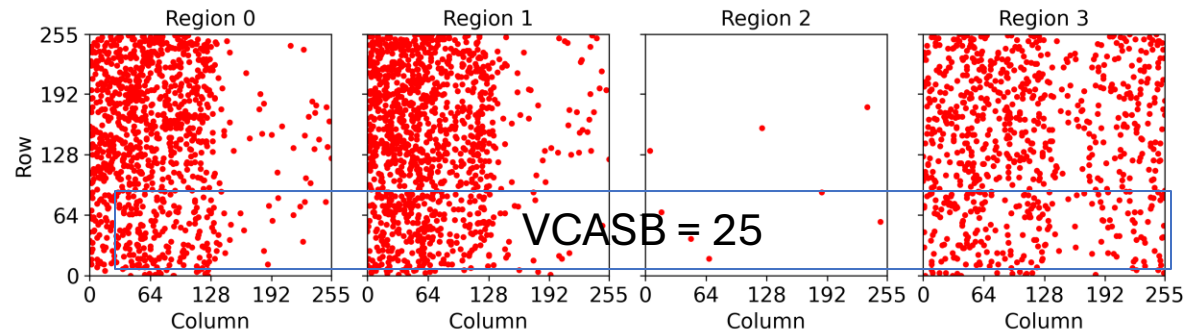
THR Scan: Different combinations of VCASB

	TB 0	TB 1	TB 2	TB 3	BB 0	BB 1	BB 2	BB3	Commet
VCASB	15	15	15	15 ¹	15	15	15	15	
THR	35.48	35.03	39.77	36.92	30.85		29.16	21.89	22.01.25, start
THR	35.24	34.78	39.66	36.66	32.33		29.03	21.81	22.01.25, end
THR	35.05	34.47	39.31	36.37	30.46		28.85	21.67	21.01.25
THR	34.91	34.44	39.22	36.29	30.35		28.76	21.59	15.01.25
VCASB	25	15	15	15	25	15 ²	15	15	
THR	27.38 ³	34.91	39.6	36.75	23.05		29.19	21.93	22.01.25
VCASB	25	10	10	10	25	10	10	10	
THR	27.24	39.67	44.8	45.56	22.69		33.3	25.41	22.01.25
VCASB	25	25	25	25	25	25	25	25	
THR	27.44	26.62	32.12	27.12	23.53		22.37	17.44	22.01.25
THR	28.5	27.68	33.08	28.33	24.43		23.21	17.69	17.01.25

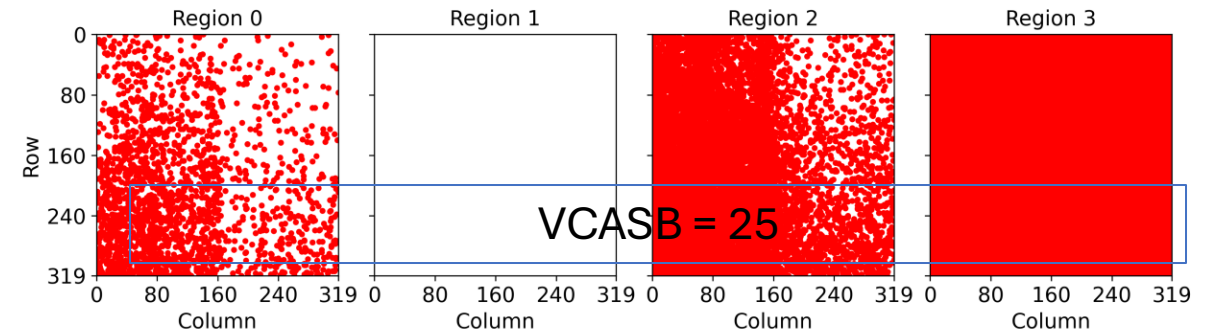
- Noise distribution in range 2.75 - 3.1
- THR is almost same for multiple scans with same VCASB
 - THR decreases with higher VCASB
 - THR depends on VCASB of the region and independent of the neighbouring regions VCASB

FHR Scan: Different combinations of VCASB

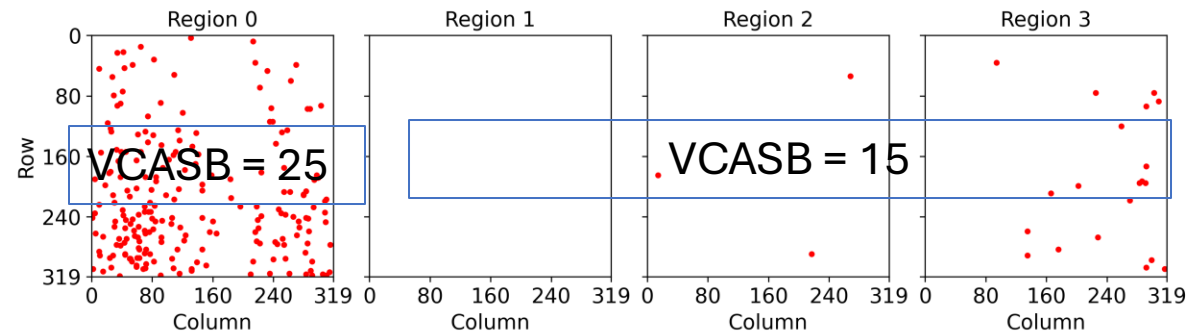
babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis



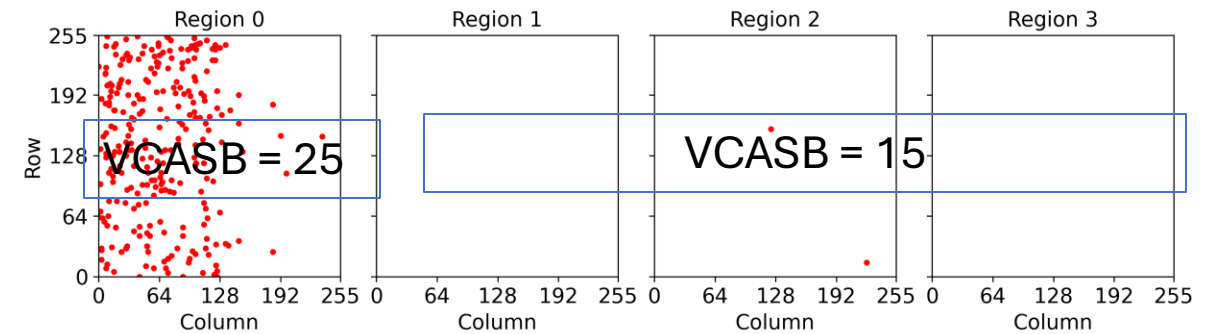
babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis



babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis



babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis

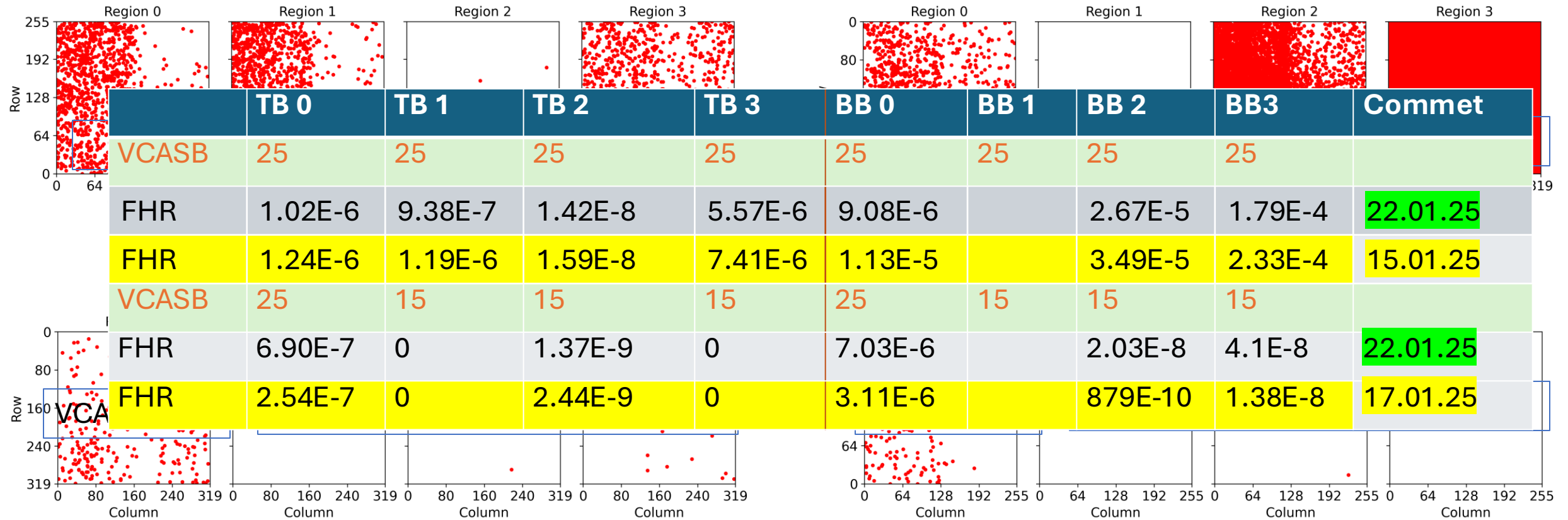


From first try, it seems that lower VCASB at neighbouring regions reduces the FHR compare to VCASB = 25 to all regions

FHR Scan: Different combinations of VCASB

babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis

babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis



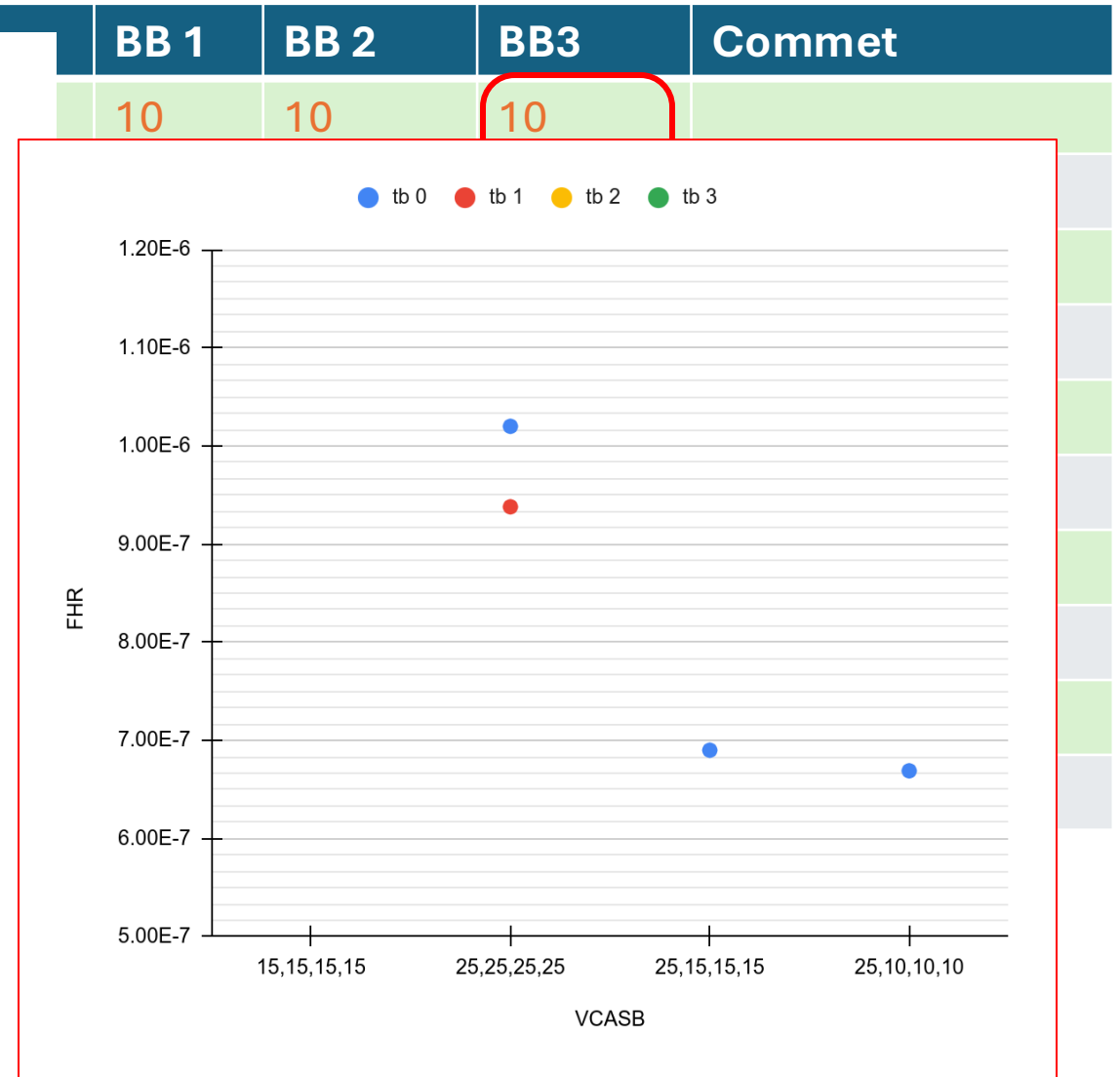
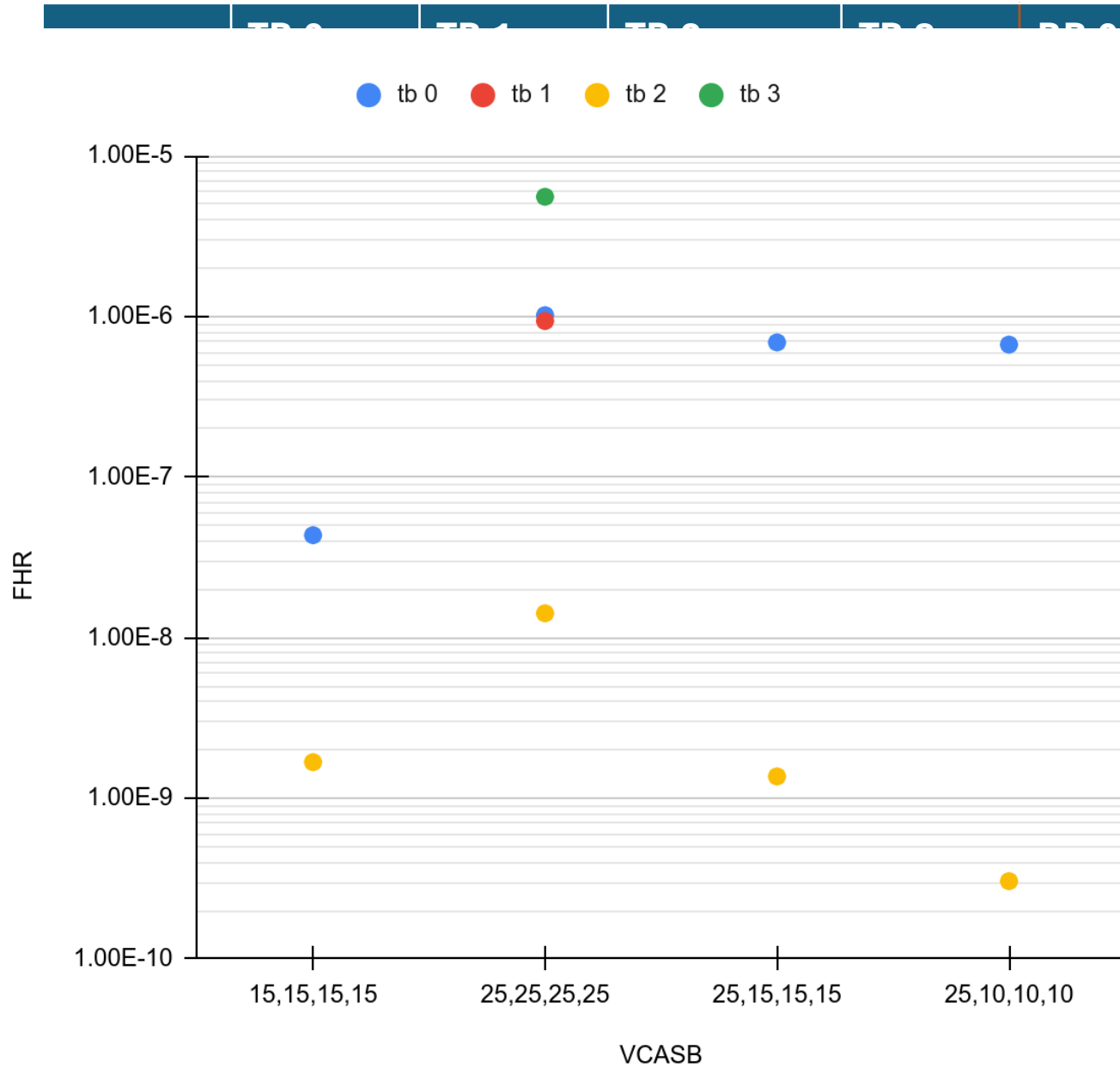
- However, comparing data, it seems that FHR of 17.01.25 shows lower compared to 22.01.25
- Further study performed to investigate the VCASB of neighbouring regions.

FHR Scan: Different combinations of VCASB on 22.01.2025

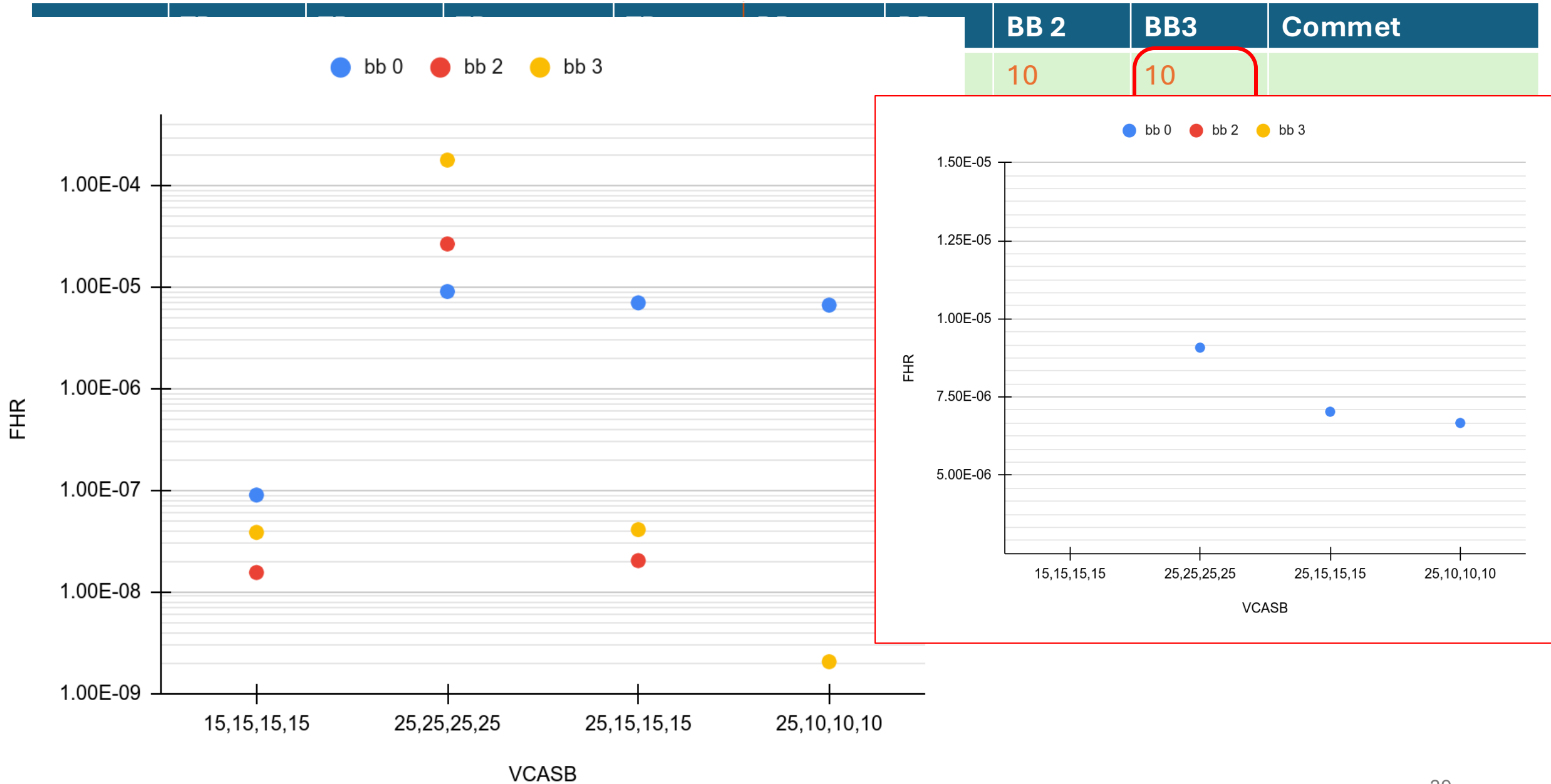
	TB 0	TB 1	TB 2	TB 3	BB 0	BB 1	BB 2	BB3	Commet
VCASB	25	10	10	10	25	10	10	10	
FHR	6.69E-7	0	3.05E-10	0	6.67E-6		0	2.05E-9	22.01.25
VCASB	25	15	15	15	25	15	15	15	
FHR	6.90E-7	0	1.37E-9	0	7.03E-6		2.03E-8	4.1E-8	22.01.25
VCASB	25	15	15	15	15	15	15	15	
FHR	6.43E-7	0	9.16E-10	0	9.78E-8		1.58E-8	4.1E-8	22.01.25
VCASB	25	25	25	25	25	25	25	25	
FHR	1.02E-6	9.38E-7	1.42E-8	5.57E-6	9.08E-6		2.67E-5	1.79E-4	22.01.25
VCASB	15	15	15	15	15	15	15	15	
FHR	4.35E-8	0	1.68E-9	0	8.99E-8		1.55E-8	3.85E-8	22.01.25

1. FHR also depends on VCASB of neighbouring regions
2. FHR increases with higher VCASB

FHR Scan: Different combinations of VCASB

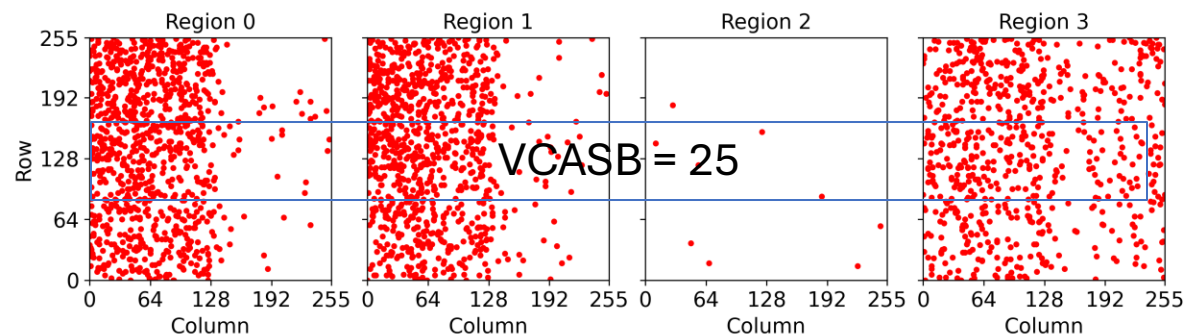


FHR Scan: Different combinations of VCASB

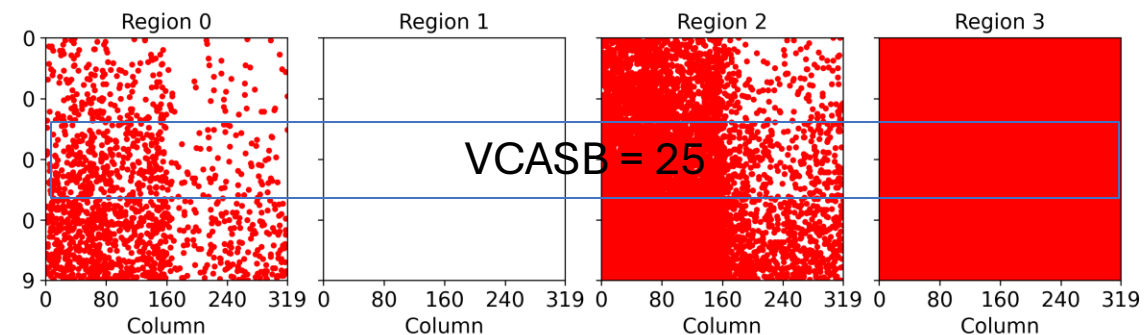


Fake Hit Rate scan

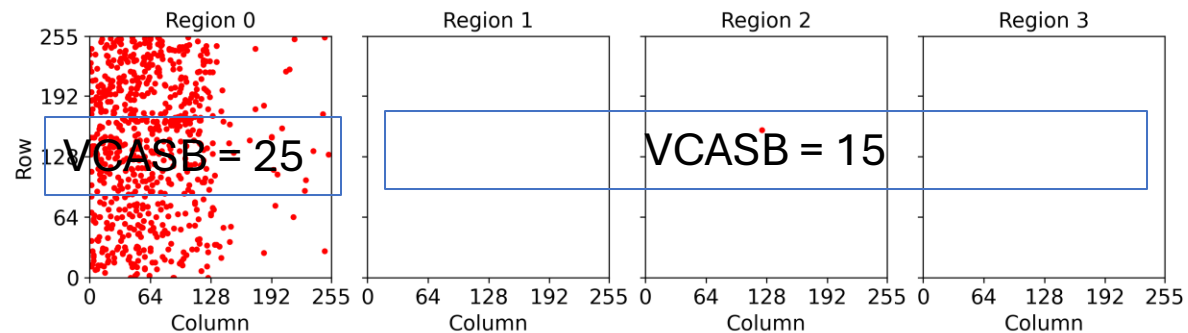
babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis



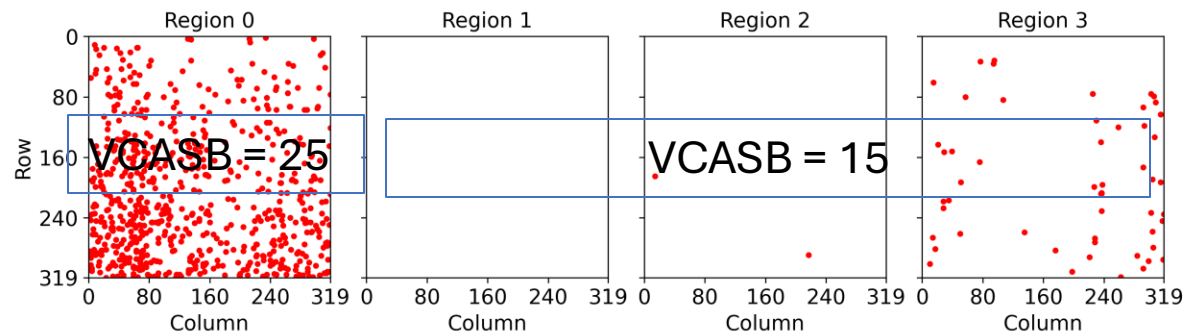
babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis



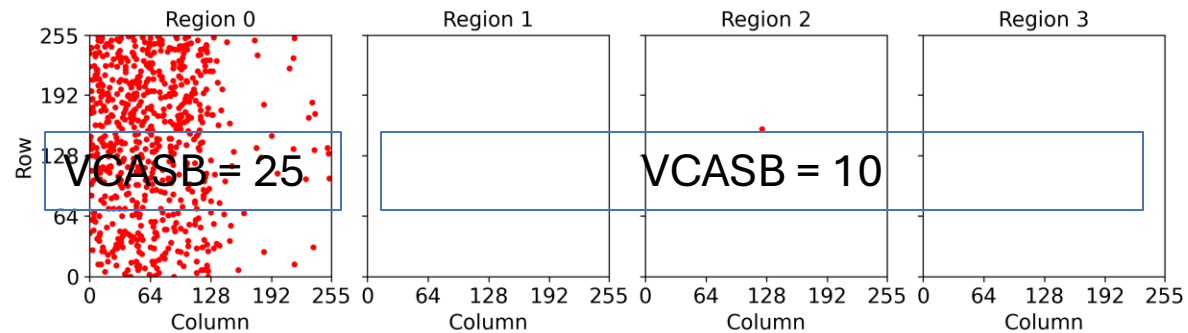
babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis



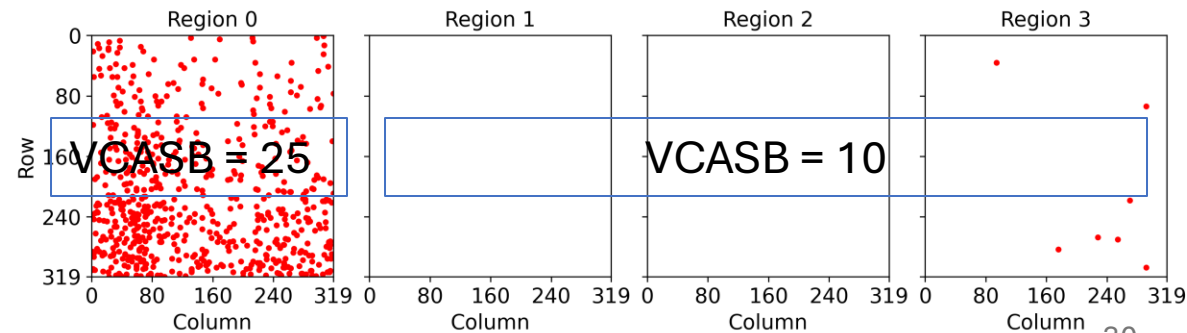
babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis



babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis



babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis



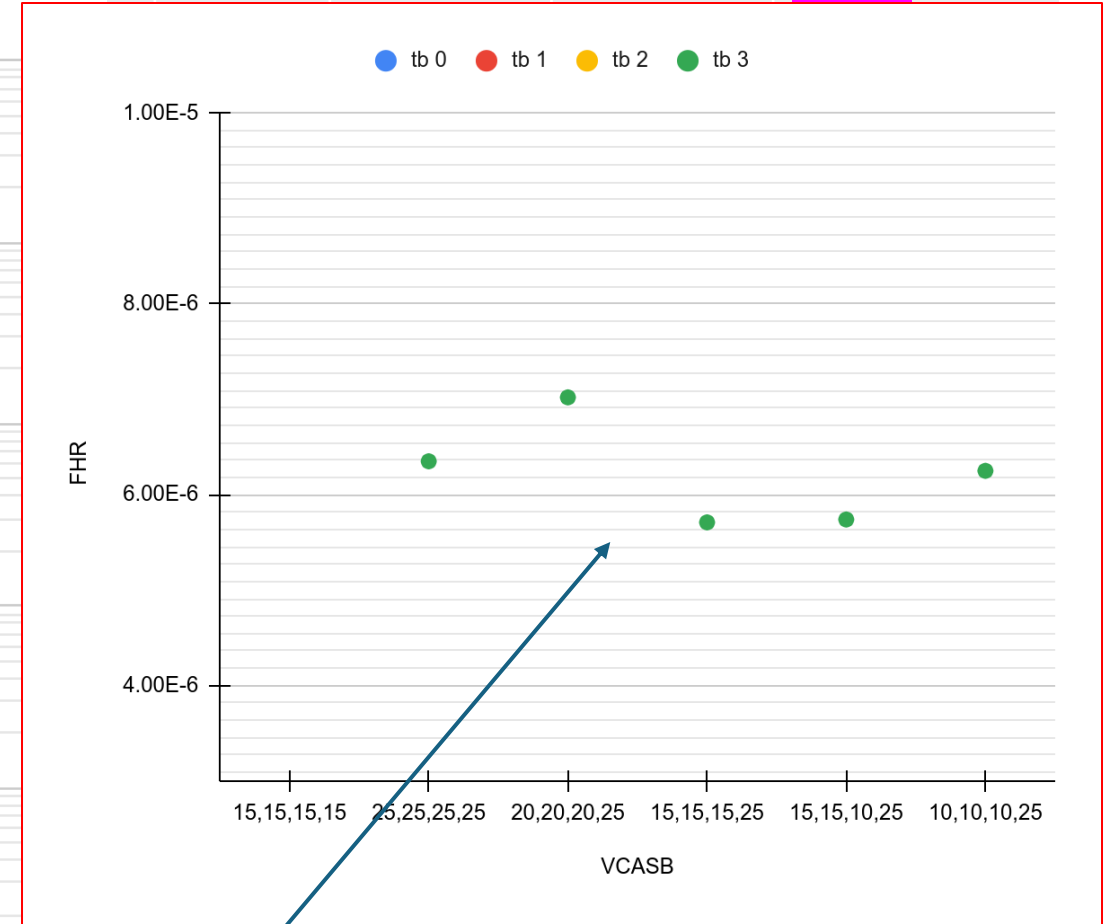
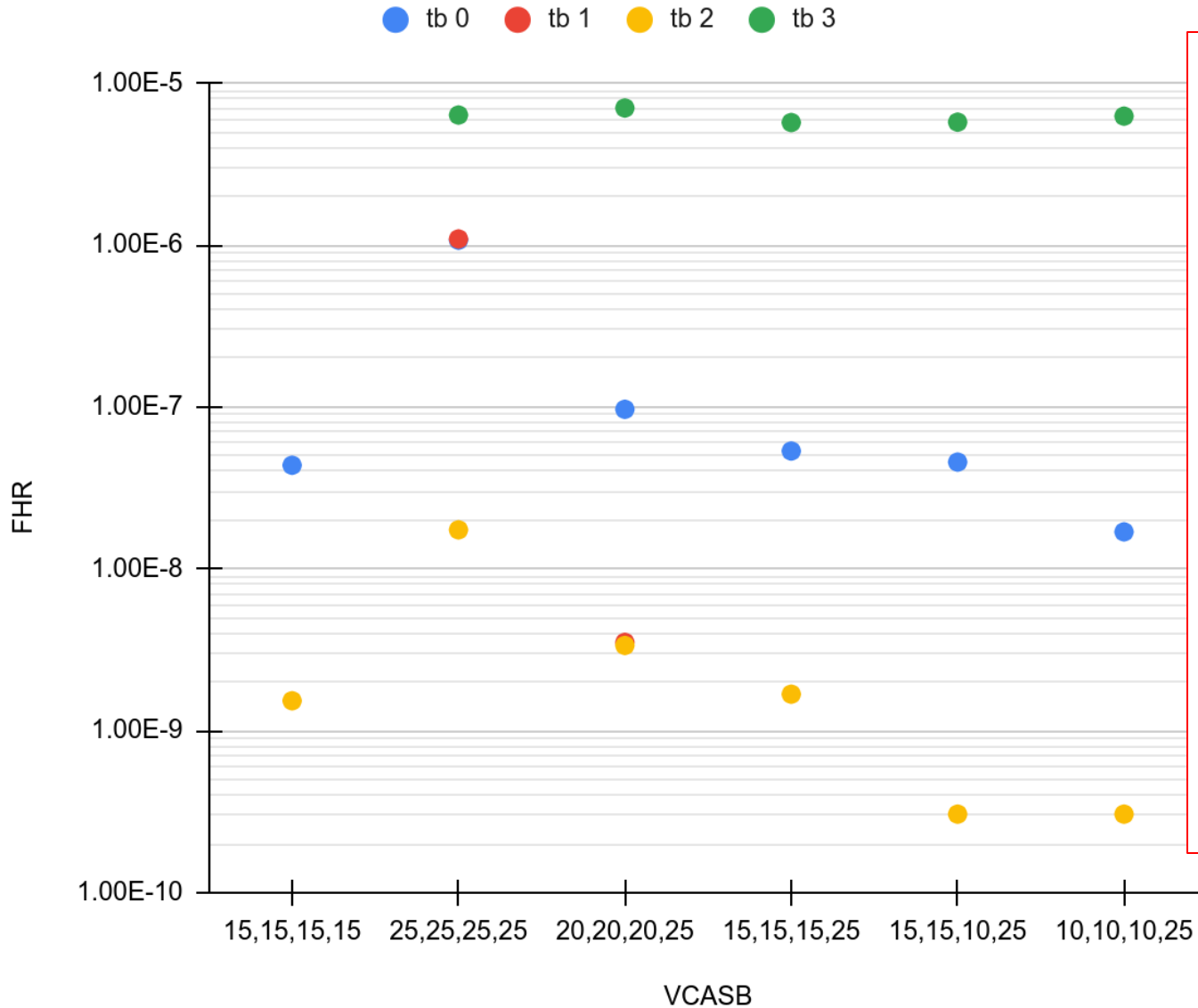
FHR Scan: Different combinations of VCASB on 24.01.2025

	TB 0	TB 1	TB 2	TB 3	BB 0	BB 1	BB 2	BB3	Commet
VCASB	10	10	10	25	10	10	10	25	
FHR	1.69E-08	0	3.05E-10	6.25E-06	1.56E-08		9.77E-11	0.000126481	24.01.25
VCASB	15	15	10	25	15	15	10	25	
FHR	4.56E-08	0	3.05E-10	5.74E-06	3.27E-08		0	0.000121594	24.01.25
VCASB	15	15	15	15	15	15	15	25	
FHR	4.91E-08	0	1.98E-09	0	3.66E-6		3.41E-8	0.000134969	24.01.25
VCASB	15	15	15	25	15	15	15	25	
FHR	5.34E-08	0	1.68E-09	5.71E-06	3.80E-08		3.01E-08	0.000128104	24.01.25
VCASB	20	20	20	25	20	20	20	25	
FHR	9.66E-08	3.51E-09	3.36E-09	7.02E-06	5.61E-07		2.15E-06	1.70E-04	24.01.25
VCASB	25	25	25	25	25	25	25	25	
FHR	1.07E-6	1.09E-6	1.74E-8	6.35E-6	1.00E-5		3.07E-5	0.000203257	24.01.25
FHR	1.02E-6	9.38E-7	1.42E-8	5.57E-6	9.08E-6		2.67E-5	1.79E-4	22.01.25
VCASB	15	15	15	15	15	15	15	15	
FHR	4.36E-8	0	1.53E-9	0	3.54E-8		1.46E-8	3.23E-8	24.01.25
FHR	4.35E-8	0	1.68E-9	0	8.99E-8		1.55E-8	3.85E-8	22.01.25

Unexpectedly FHR is different

FHR Scan: Different combinations of VCASB

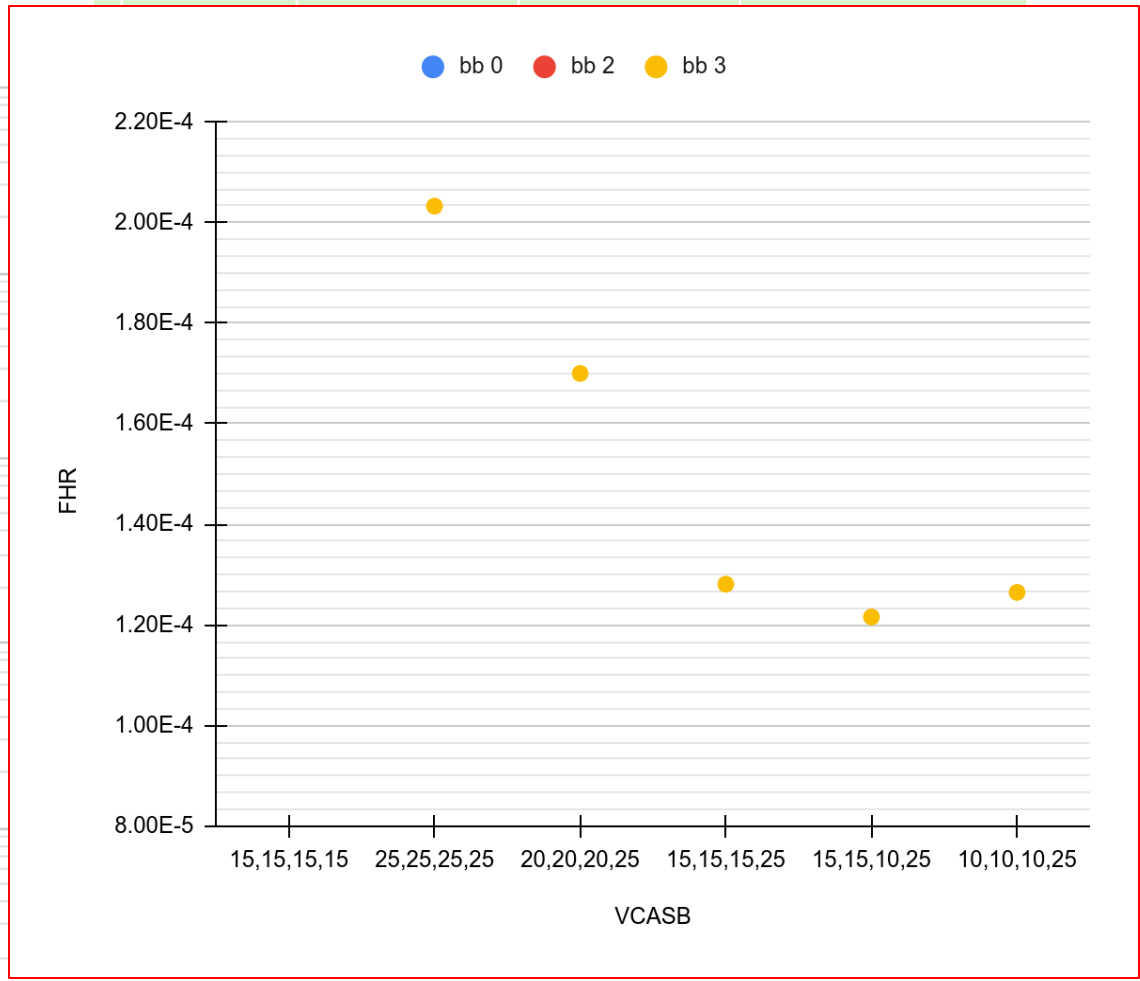
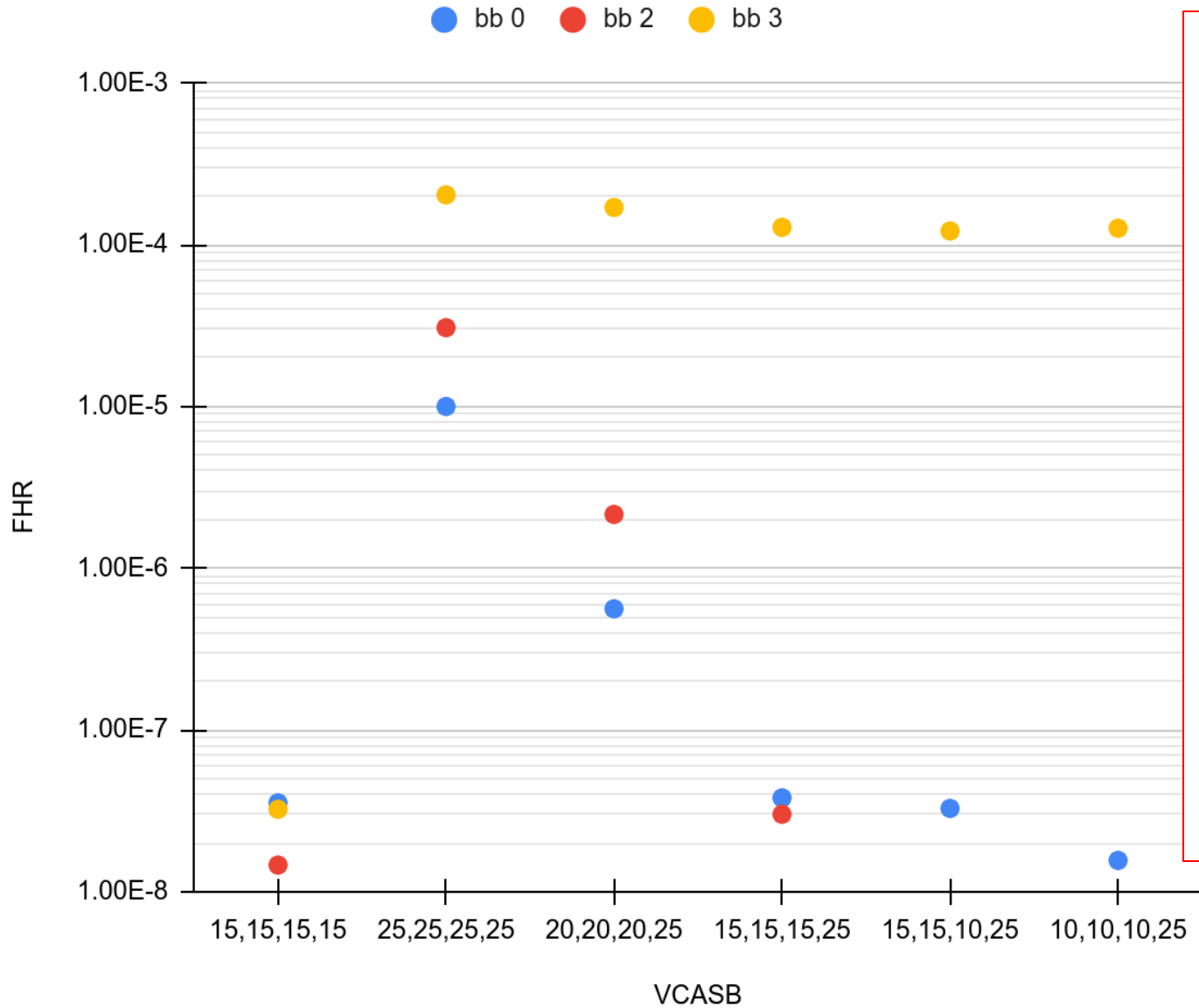
TB 0	TB 1	TB 2	TB 3	BB 0	BB 1	BB 2	BB 3	Commet
					10	10	25	



There is not much variation at tb region 3 of FHR for different VCASB setting among regions

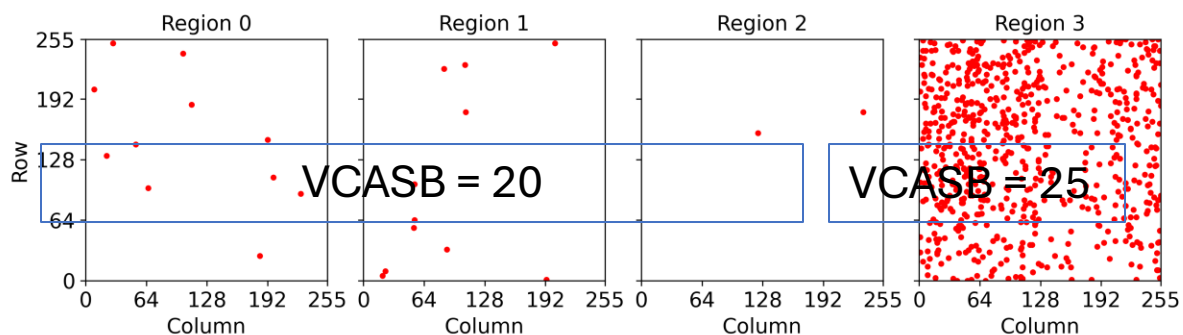
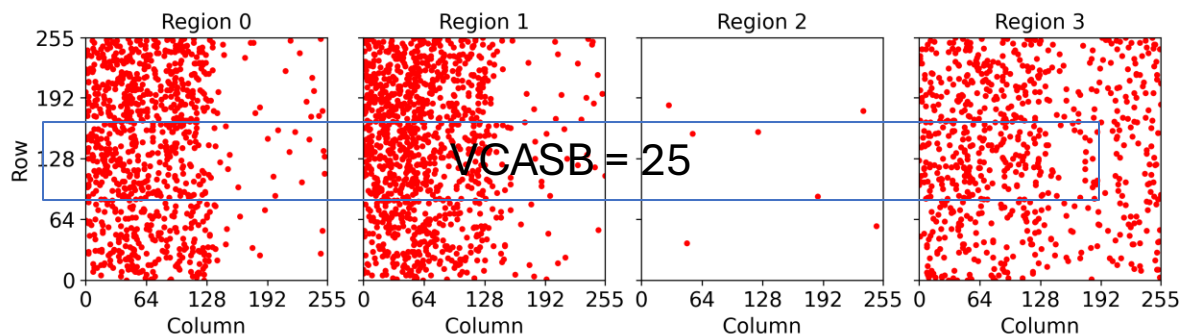
FHR Scan: Different combinations of VCASB

TB 0	TB 1	TB 2	TB 3	BB 0	BB 1	BB 2	BB 3	Commet
					10	10	25	

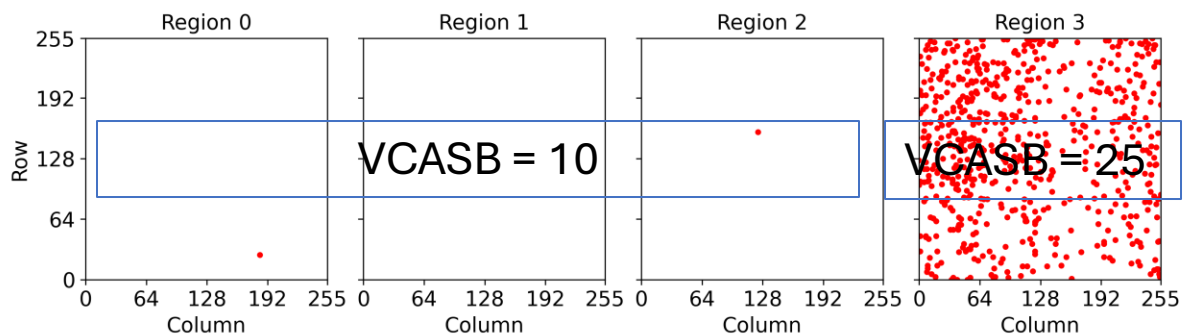


Fake Hit Rate scan

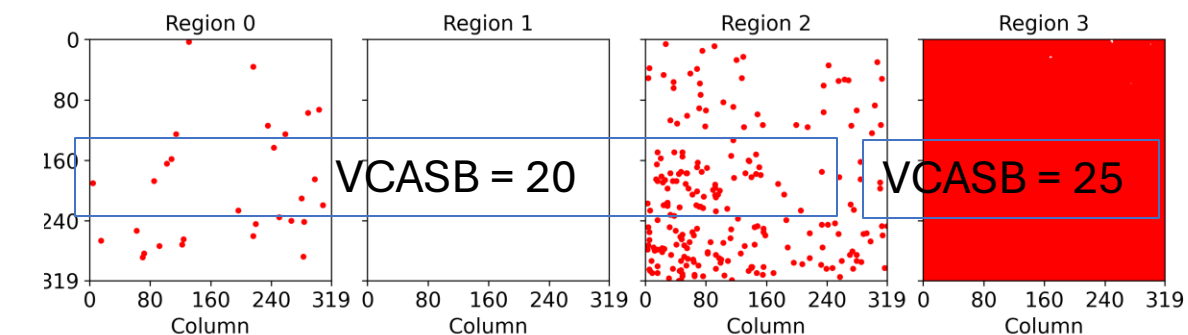
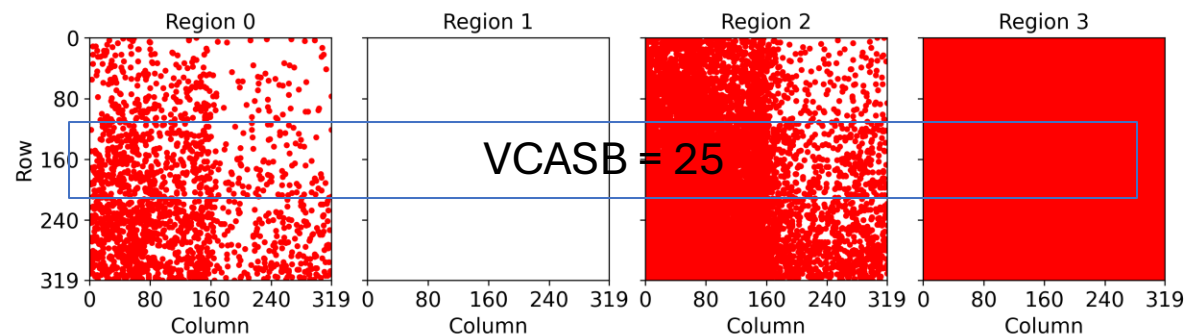
babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis



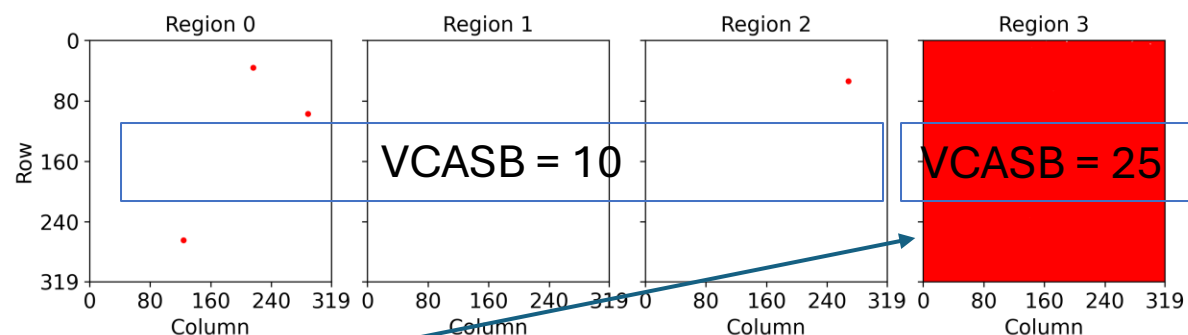
babyMOSS-2_4_W20E1 | TB scatter plot | FakeHitRateAnalysis



babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis

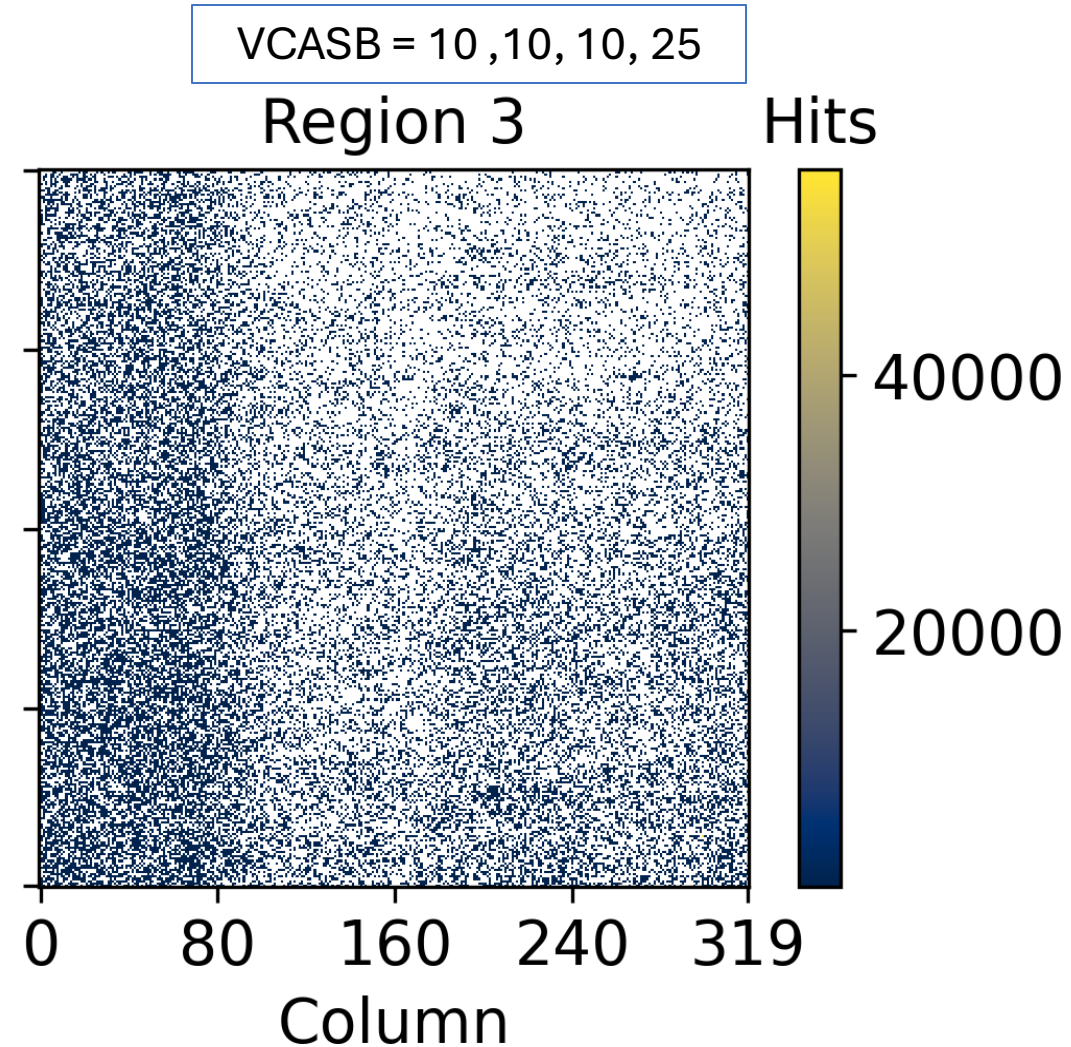
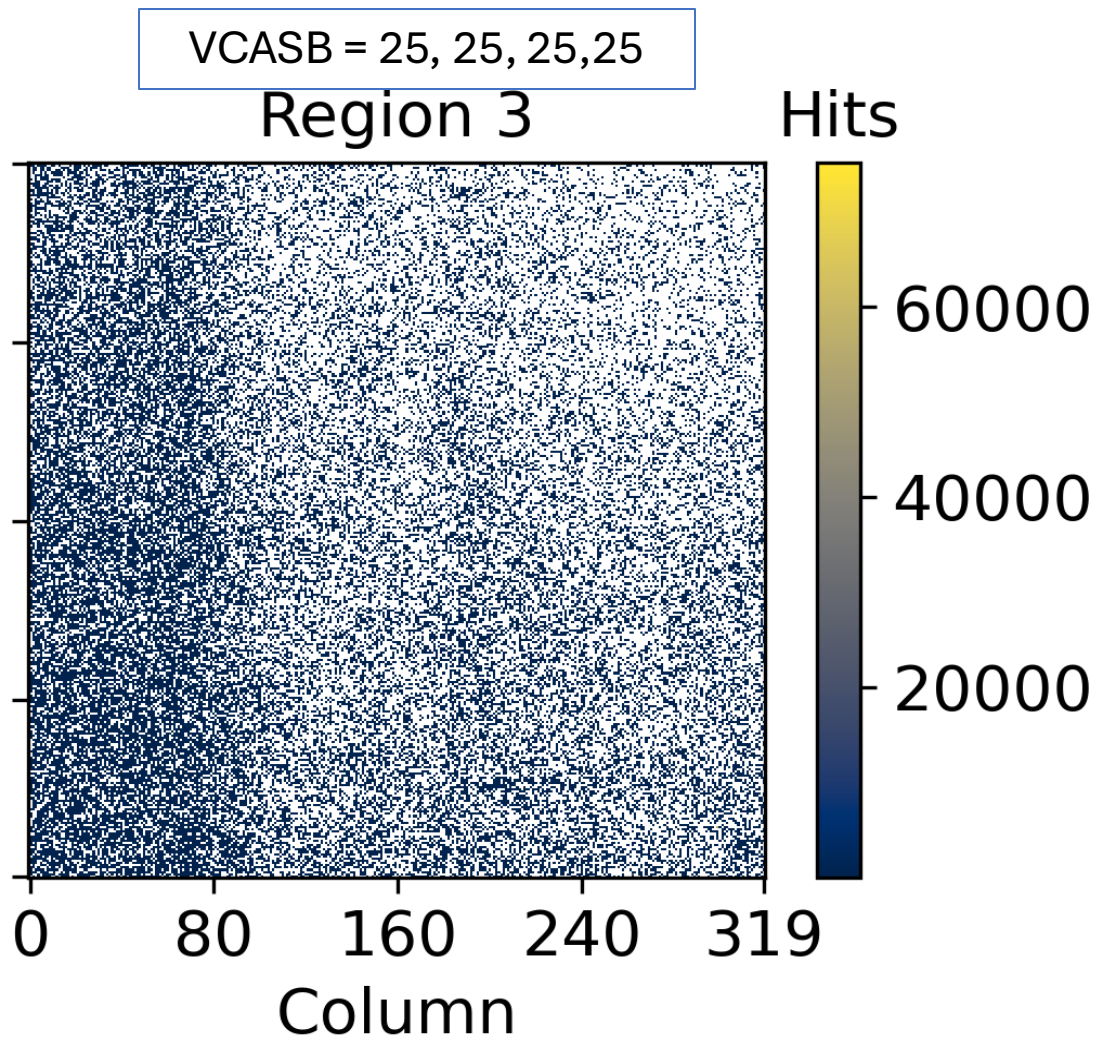


babyMOSS-2_4_W20E1 | BB scatter plot | FakeHitRateAnalysis



From the scattered plot, it is impossible to see the changes of FHR with various VCASB setting in bb region 3³⁴

Fake Hit Rate scan, BB



From the hit map, it can be seen that FHR reduced in bb region 3 at VCASB = [10, 10, 10, 25] compared to VCASB = [25, 25, 25, 25]

Summary

- BabyMOSS test set-up has assembled in Bari and first QA scans are performed at $V_{SUB} = 0\text{ V}$
- The chip passed all functional tests and readout and pixel matrix scans except bottom region 1, which is a noisy one
- Threshold scan, FHR scan are studied at different V_{CASB} at $V_{SUB} = 0\text{ V}$
- Their might have neighbouring regions influence in FHR