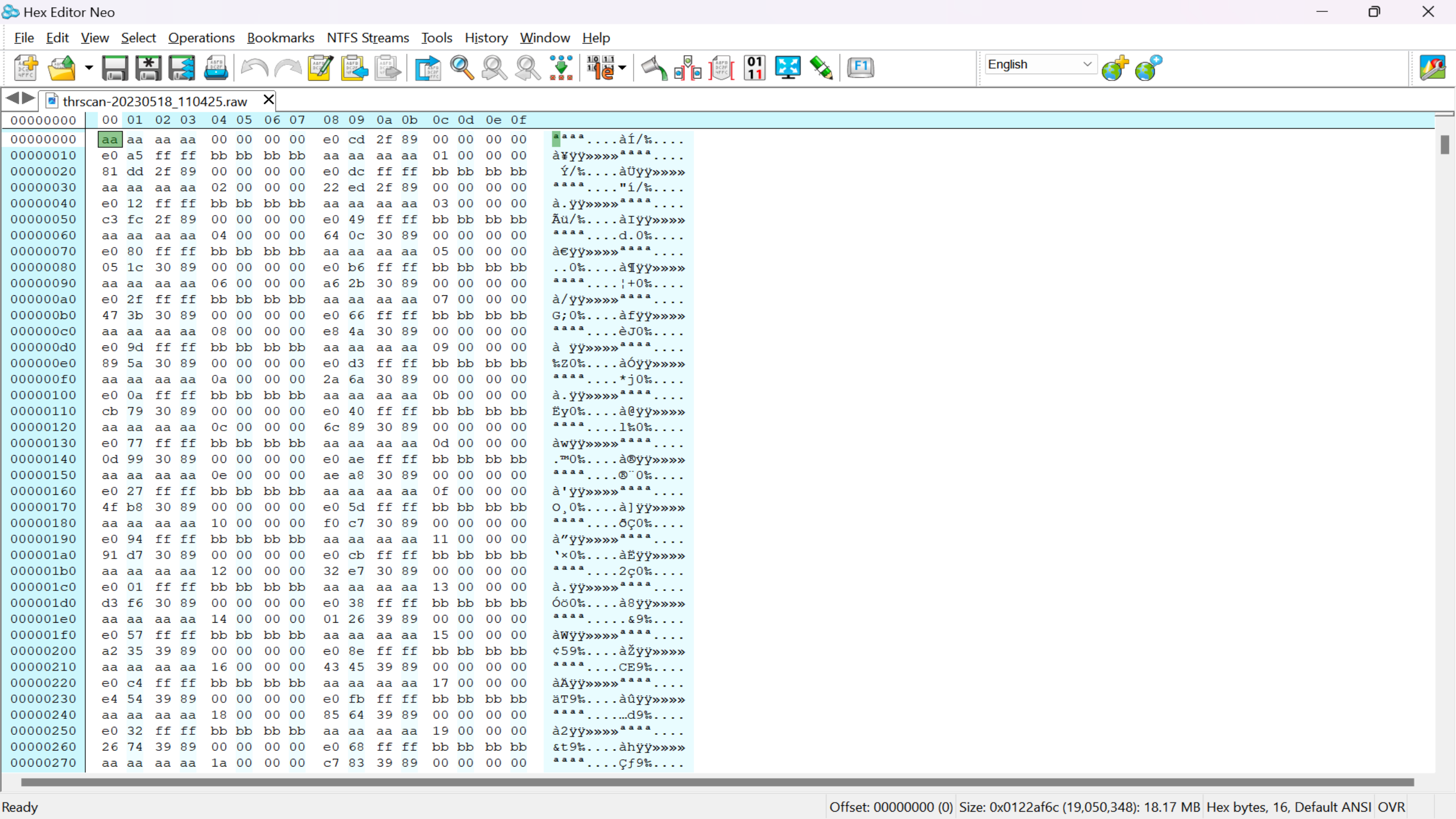
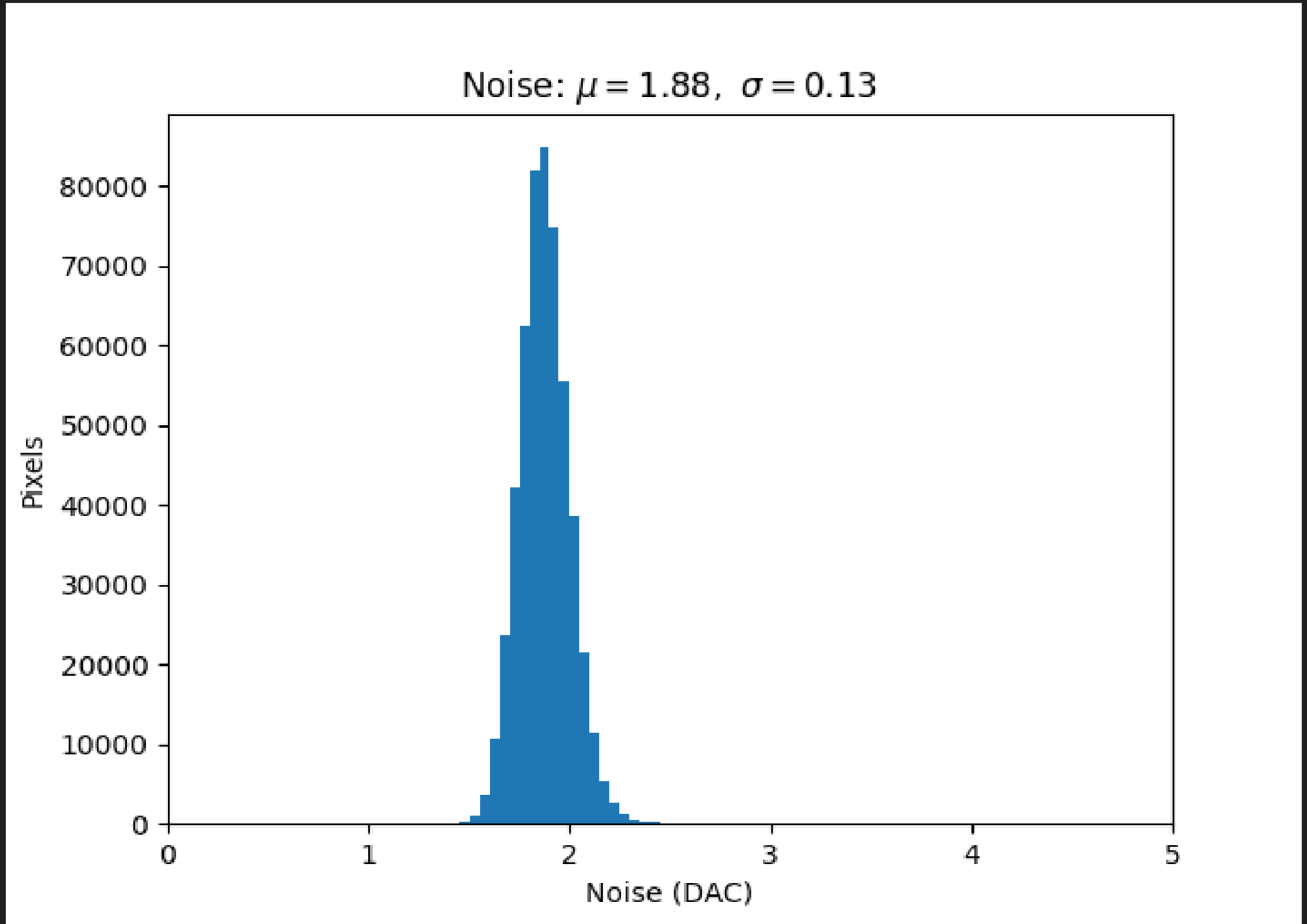
JINR DAQ board at SPbU, latest firmware

```
IAA = 15.71 mA
IDD = 64.37 mA
LDOs: ON
100%|████████████████████████████████████████████████████████████████████████████████| 512/512 [10:36<00:00,  1.24s/it]
TRGMON: Triggers sent: 793600
TRGMON: avg rdo time: 3.1 us
ALPIDE: Triggers: 7168
ALPIDE: Strobes: 7168
ALPIDE: Matrix readouts: 7168
ALPIDE: Frames: 7168
work@LAPTOP-GL7LQ75D:~/alpide-daq-software-master/test_data$ ls
thrscan-20230518_110414.json  thrscan-20230518_110425.json  thrscan-20230518_110425.raw
work@LAPTOP-GL7LQ75D:~/alpide-daq-software-master/test_data$ ./../analyses/thrscanana.py thrscan-20230518_110425.raw thrscan-20230518_110425.json

Namespace(debug_plots=False, fit=False, output='thresholds.npy', params='thrscan-20230518_110425.json', path='.', quiet=False, rawdata='thrscan-2
0230518_110425.raw')
100%|████████████████████████████████████████████████████████████████████████████| 19050348/19050348 [00:04<00:00, 4606212.80it/s]
./../analyses/thrscanana.py:115: RuntimeWarning: Mean of empty slice
  print('Threshold: %.2f +/- %.2f DAC (based on %d pixels)'%(np.nanmean(thresholds),np.nanstd(thresholds),int(np.sum(~np.isnan(thresholds)))))
/usr/lib/python3/dist-packages/numpy/lib/nanfunctions.py:1665: RuntimeWarning: Degrees of freedom <= 0 for slice.
  var = nanvar(a, axis=axis, dtype=dtype, out=out, ddof=ddof,
Threshold: nan +/- nan DAC (based on 0 pixels)
/usr/lib/python3/dist-packages/numpy/lib/histograms.py:839: RuntimeWarning: invalid value encountered in greater_equal
  keep = (tmp_a >= first_edge)
/usr/lib/python3/dist-packages/numpy/lib/histograms.py:840: RuntimeWarning: invalid value encountered in less_equal
  keep &= (tmp_a <= last_edge)
./../analyses/thrscanana.py:119: RuntimeWarning: Mean of empty slice
  plt.title('Threshold: $\mu=%.2f,\ \sigma=%.2f$'%(np.nanmean(thresholds),np.nanstd(thresholds)))
./../analyses/thrscanana.py:126: RuntimeWarning: Mean of empty slice
  print('Noise: %.2f +/- %.2f DAC (based on %d pixels)'%(np.nanmean(noise),np.nanstd(noise),int(np.sum(~np.isnan(noise)))))
Noise: nan +/- nan DAC (based on 0 pixels)
./../analyses/thrscanana.py:130: RuntimeWarning: Mean of empty slice
  plt.title('Noise: $\mu=%.2f,\ \sigma=%.2f$'%(np.nanmean(noise),np.nanstd(noise)))
Found 524288 bad pixels (with <50 hits)
  of which 524206 dead (with 0 hits).
work@LAPTOP-GL7LQ75D:~/alpide-daq-software-master/test_data$ ls
thresholds.npy                thrscan-20230518_110425-noise.png      thrscan-20230518_110425-thresholdmap.png  thrscan-20230518_110425.raw
thrscan-20230518_110414.json  thrscan-20230518_110425-threshold.png  thrscan-20230518_110425.json
work@LAPTOP-GL7LQ75D:~/alpide-daq-software-master/test_data$
```


Hex Editor Neo
File Edit View Select Operations Bookmarks NTFS Streams Tools History Window Help
English
thrscan-20230518_110425.raw
00000000 00 01 02 03 04 05 06 07 08 09 0a 0b 0c 0d 0e 0f
00000000 aa aa aa aa 00 00 00 00 e0 cd 2f 89 00 00 00 00
00000010 e0 a5 ff ff bb bb bb bb aa aa aa aa 01 00 00 00
00000020 81 dd 2f 89 00 00 00 00 e0 dc ff ff bb bb bb bb
00000030 aa aa aa aa 02 00 00 00 22 ed 2f 89 00 00 00 00
00000040 e0 12 ff ff bb bb bb bb aa aa aa aa 03 00 00 00
00000050 c3 fc 2f 89 00 00 00 00 e0 49 ff ff bb bb bb bb
00000060 aa aa aa aa 04 00 00 00 64 0c 30 89 00 00 00 00
00000070 e0 80 ff ff bb bb bb bb aa aa aa aa 05 00 00 00
00000080 05 1c 30 89 00 00 00 00 e0 b6 ff ff bb bb bb bb
00000090 aa aa aa aa 06 00 00 00 a6 2b 30 89 00 00 00 00
000000a0 e0 2f ff ff bb bb bb bb aa aa aa aa 07 00 00 00
000000b0 47 3b 30 89 00 00 00 00 e0 66 ff ff bb bb bb bb
000000c0 aa aa aa aa 08 00 00 00 e8 4a 30 89 00 00 00 00
000000d0 e0 9d ff ff bb bb bb bb aa aa aa aa 09 00 00 00
000000e0 89 5a 30 89 00 00 00 00 e0 d3 ff ff bb bb bb bb
000000f0 aa aa aa aa 0a 00 00 00 2a 6a 30 89 00 00 00 00
00000100 e0 0a ff ff bb bb bb bb aa aa aa aa 0b 00 00 00
00000110 cb 79 30 89 00 00 00 00 e0 40 ff ff bb bb bb bb
00000120 aa aa aa aa 0c 00 00 00 6c 89 30 89 00 00 00 00
00000130 e0 77 ff ff bb bb bb bb aa aa aa aa 0d 00 00 00
00000140 0d 99 30 89 00 00 00 00 e0 ae ff ff bb bb bb bb
00000150 aa aa aa aa 0e 00 00 00 ae a8 30 89 00 00 00 00
00000160 e0 27 ff ff bb bb bb bb aa aa aa aa 0f 00 00 00
00000170 4f b8 30 89 00 00 00 00 e0 5d ff ff bb bb bb bb
00000180 aa aa aa aa 10 00 00 00 f0 c7 30 89 00 00 00 00
00000190 e0 94 ff ff bb bb bb bb aa aa aa aa 11 00 00 00
000001a0 91 d7 30 89 00 00 00 00 e0 cb ff ff bb bb bb bb
000001b0 aa aa aa aa 12 00 00 00 32 e7 30 89 00 00 00 00
000001c0 e0 01 ff ff bb bb bb bb aa aa aa aa 13 00 00 00
000001d0 d3 f6 30 89 00 00 00 00 e0 38 ff ff bb bb bb bb
000001e0 aa aa aa aa 14 00 00 00 01 26 39 89 00 00 00 00
000001f0 e0 57 ff ff bb bb bb bb aa aa aa aa 15 00 00 00
00000200 a2 35 39 89 00 00 00 00 e0 8e ff ff bb bb bb bb
00000210 aa aa aa aa 16 00 00 00 43 45 39 89 00 00 00 00
00000220 e0 c4 ff ff bb bb bb bb aa aa aa aa 17 00 00 00
00000230 e4 54 39 89 00 00 00 00 e0 fb ff ff bb bb bb bb
00000240 aa aa aa aa 18 00 00 00 85 64 39 89 00 00 00 00
00000250 e0 32 ff ff bb bb bb bb aa aa aa aa 19 00 00 00
00000260 26 74 39 89 00 00 00 00 e0 68 ff ff bb bb bb bb
00000270 aa aa aa aa 1a 00 00 00 c7 83 39 89 00 00 00 00
Ready
Offset: 00000000 (0) Size: 0x0122af6c (19,050,348): 18.17 MB Hex bytes, 16, Default ANSI OVR

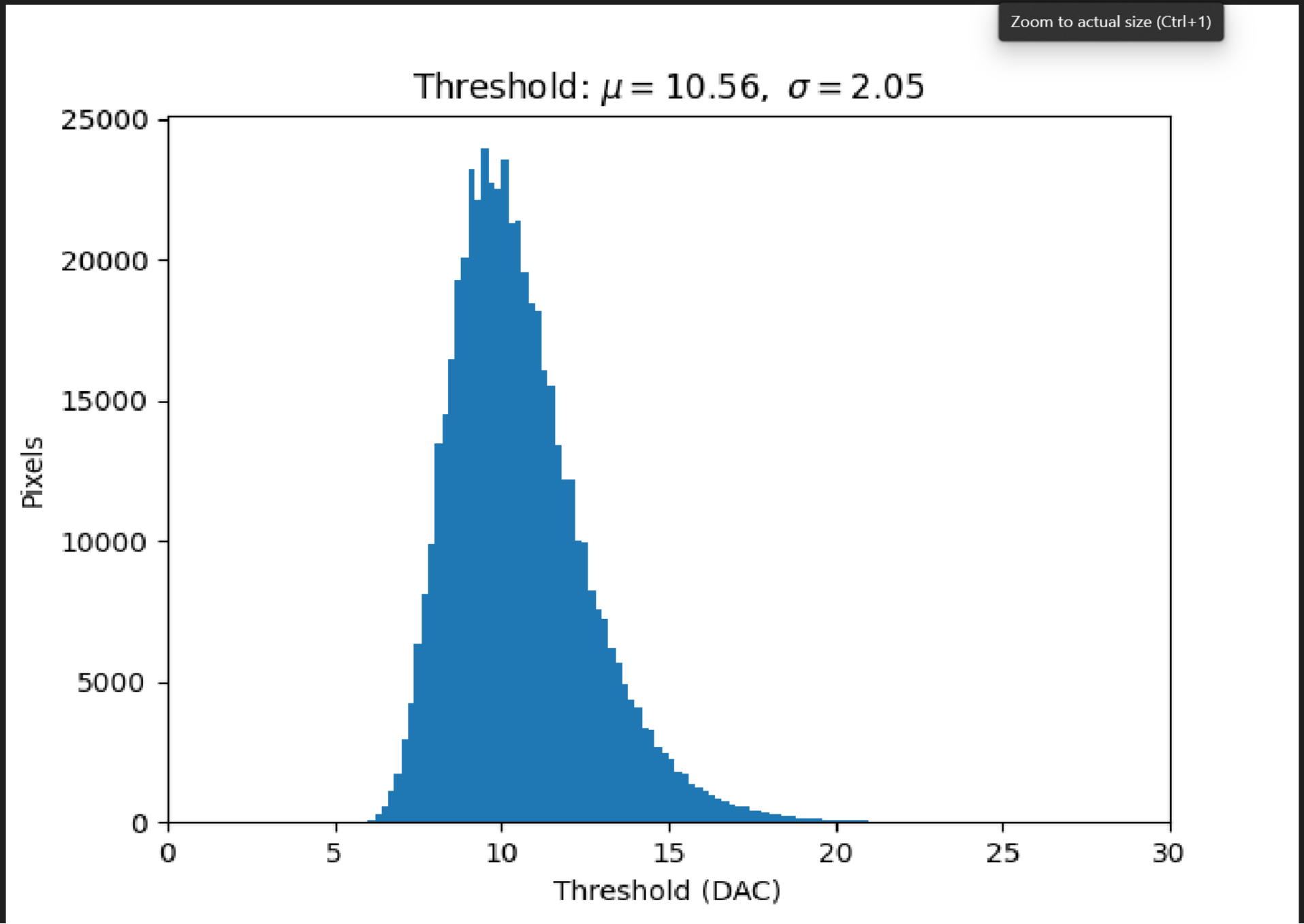
JINR DAQ board at CERN, latest firmware

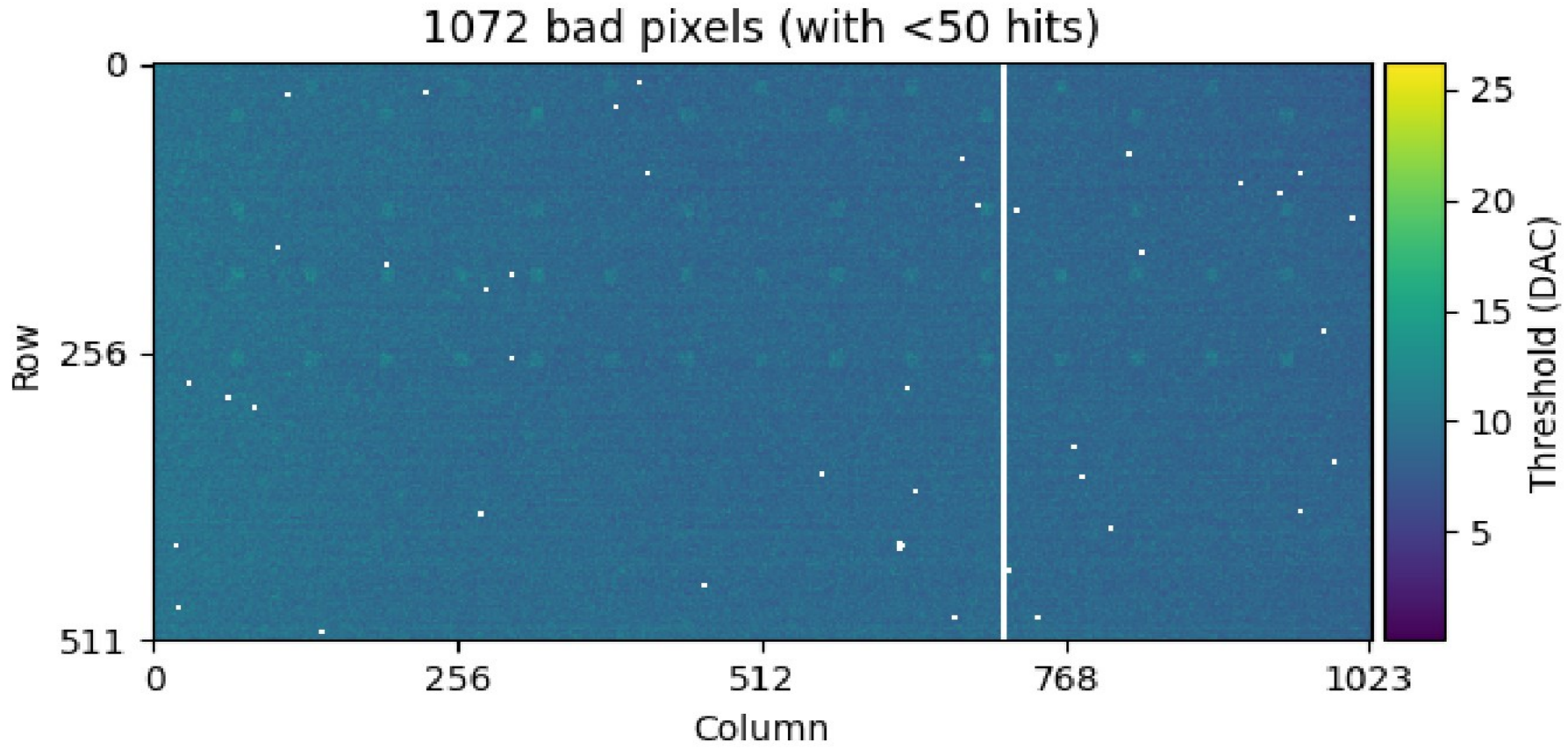

Noise: $\mu = 1.88,\ \sigma = 0.13$
Pixels
80000
70000
60000
50000
40000
30000
20000
10000
0
0
1
2
3
4
5
Noise (DAC)

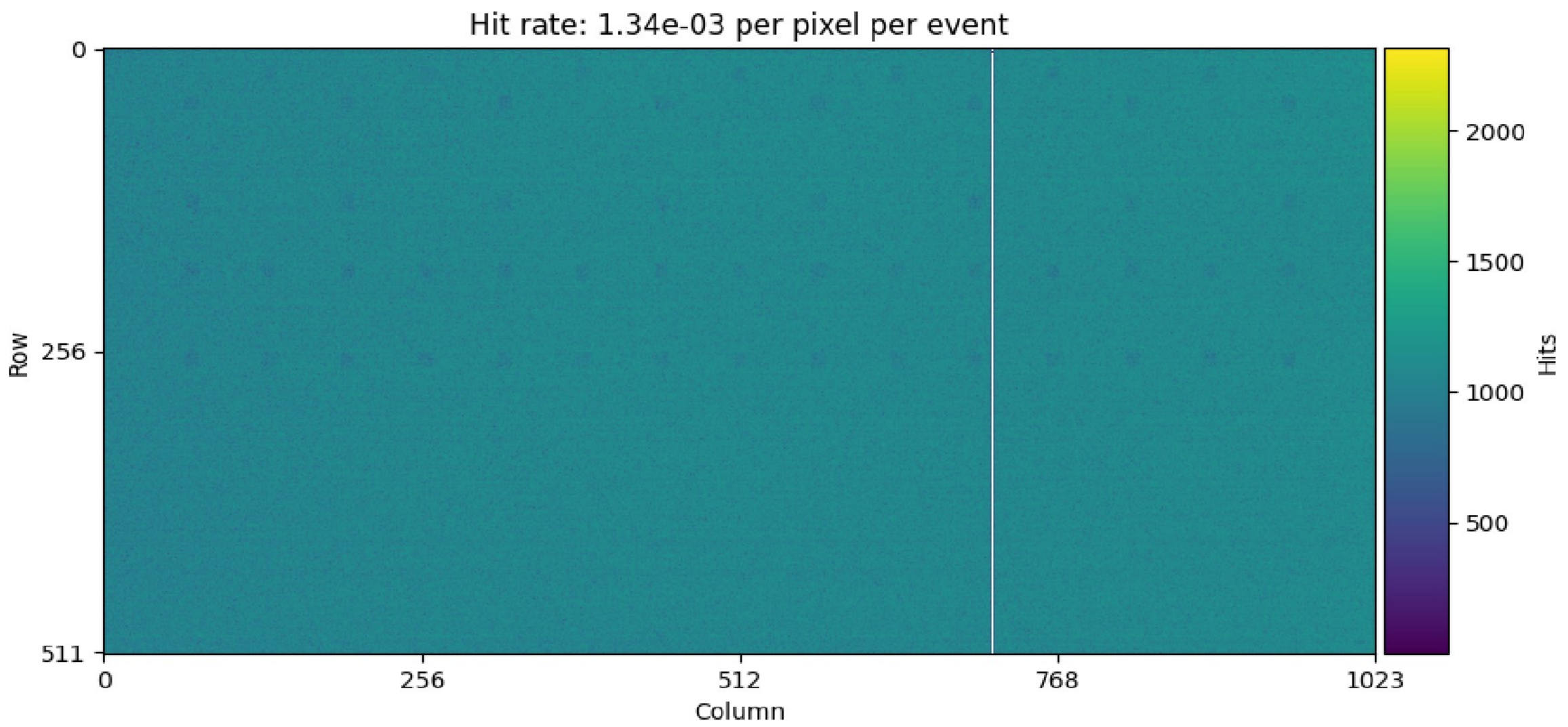
thrscan-20230518_094718-threshold.png

Zoom to actual size (Ctrl+1)

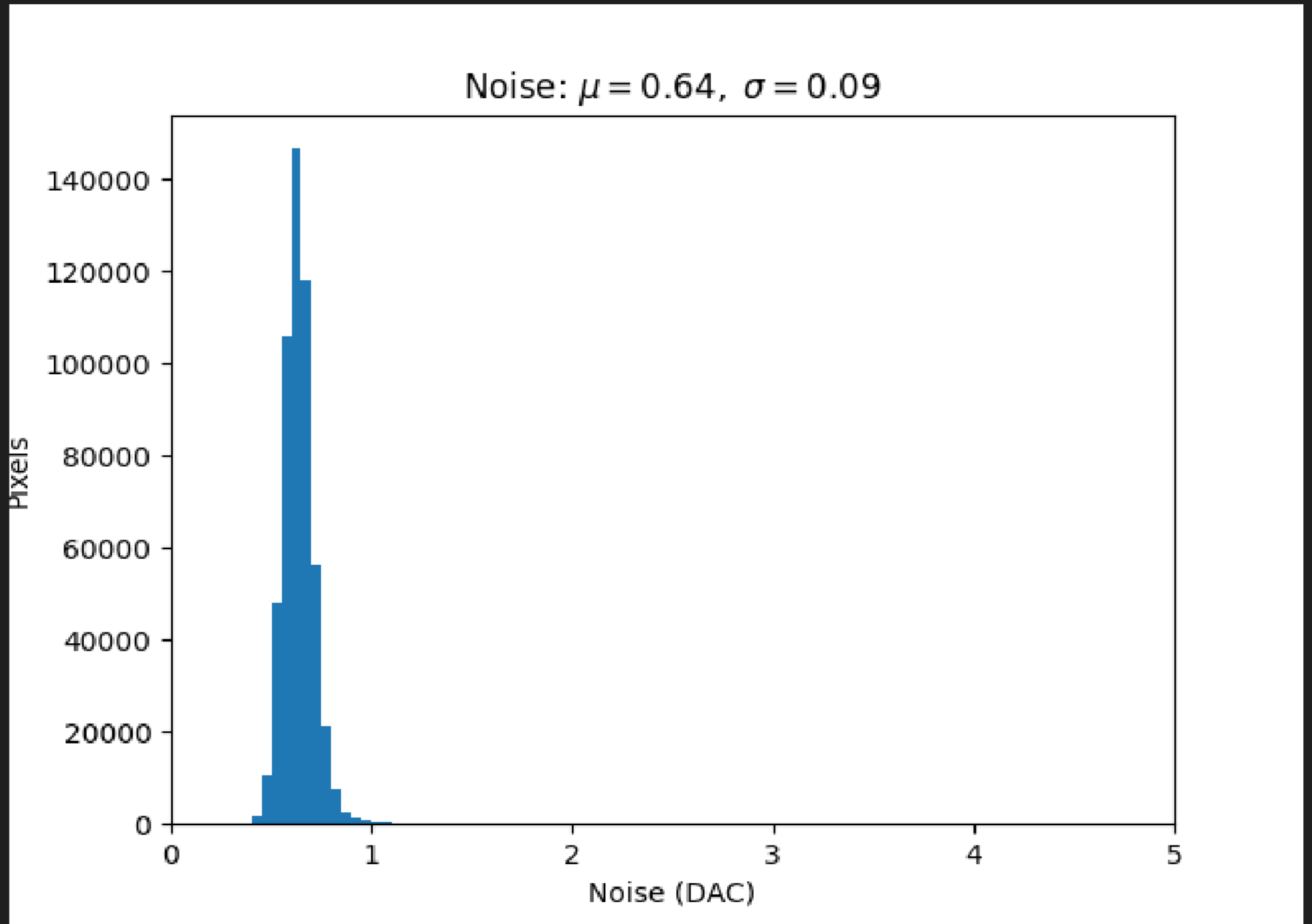
222%

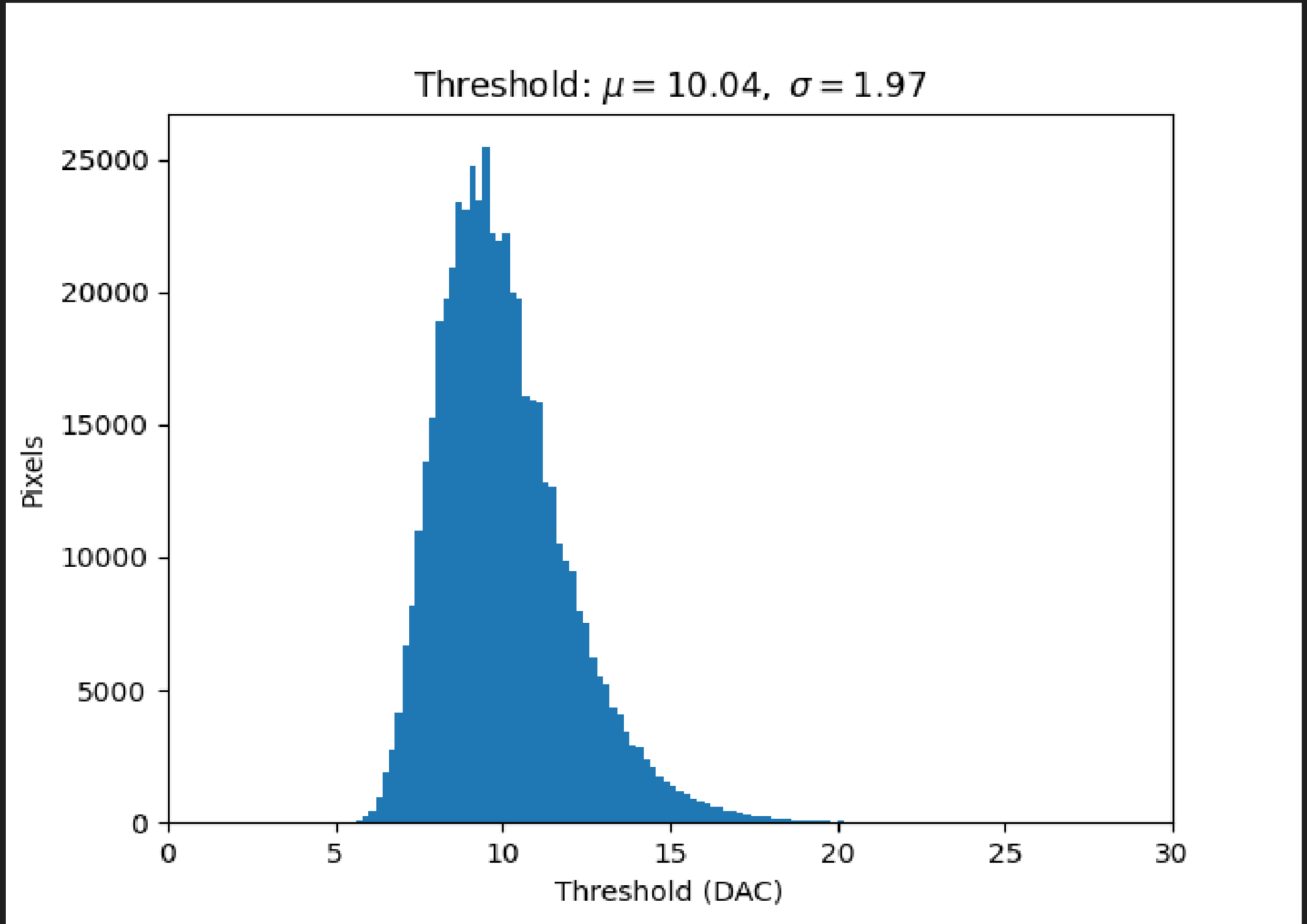


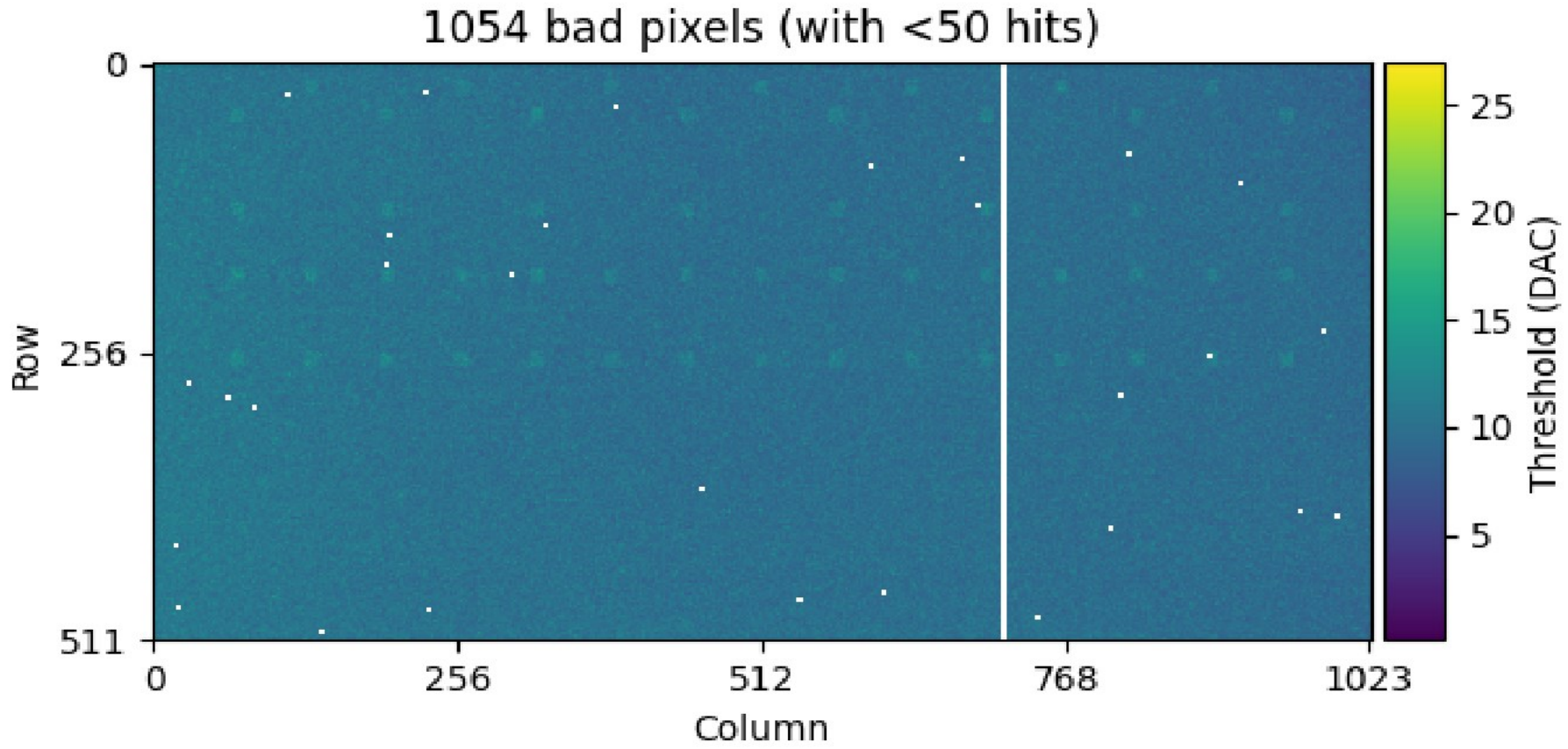

1072 bad pixels (with <50 hits)
Row
0
256
511
0
256
512
768
1023
Column
Threshold (DAC)
25
20
15
10
5

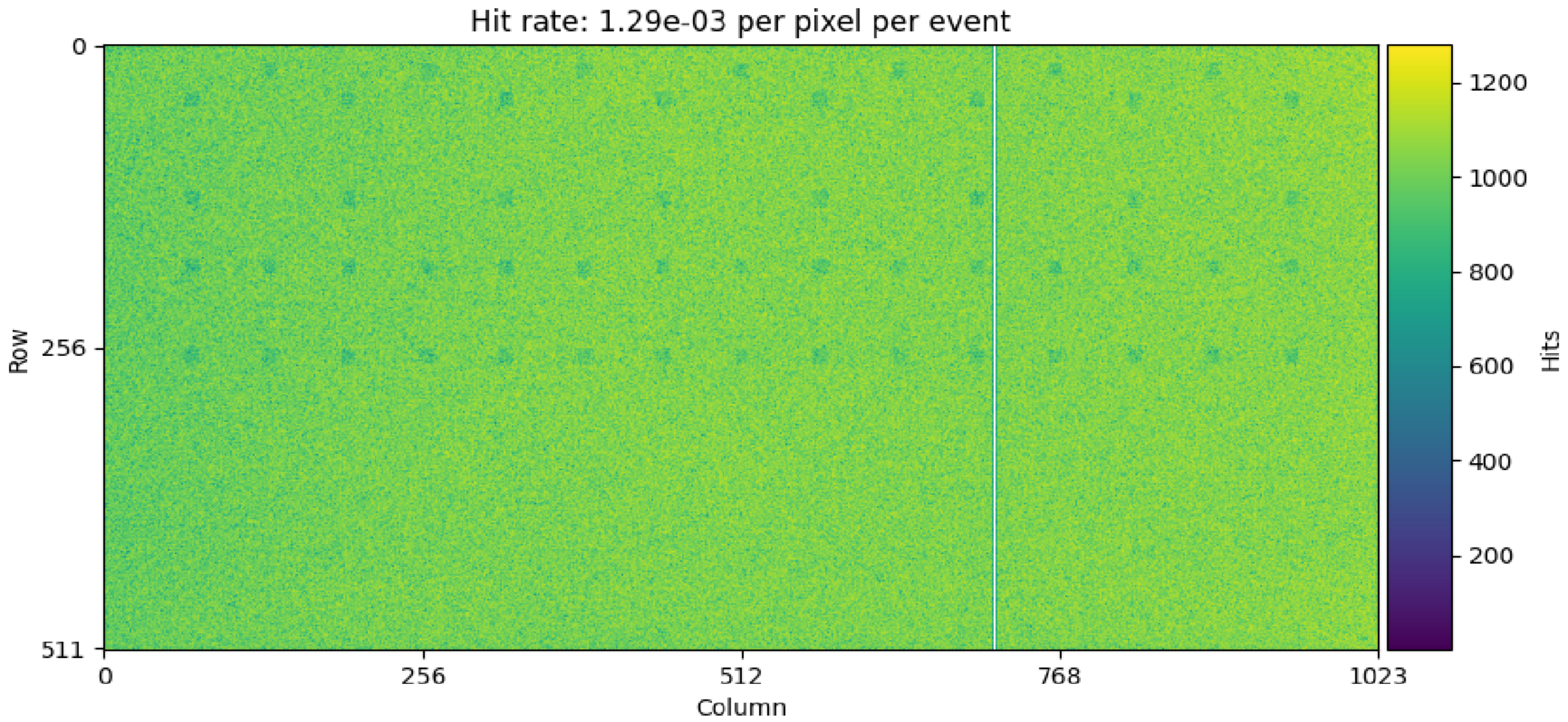


CERN DAQ board, latest official firmware


Noise: $\mu = 0.64$, $\sigma = 0.09$
Pixels
140000
120000
100000
80000
60000
40000
20000
0
0
1
2
3
4
5
Noise (DAC)


Threshold: $\mu = 10.04,\ \sigma = 1.97$
Pixels
25000
20000
15000
10000
5000
0
0
5
10
15
20
25
30
Threshold (DAC)

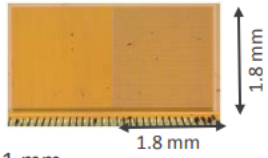

1054 bad pixels (with <50 hits)
Row
0
256
511
0
256
512
768
1023
Column
Threshold (DAC)
25
20
15
10
5



Development Roadmap

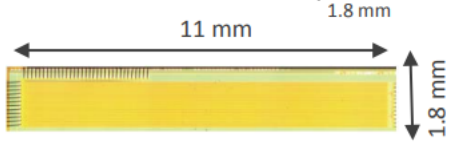
2012 — Explorer

20µm x 20µm and 30µm x 30µm pixels (analogue readout)
pixel geometry, starting material, sensitivity to radiation



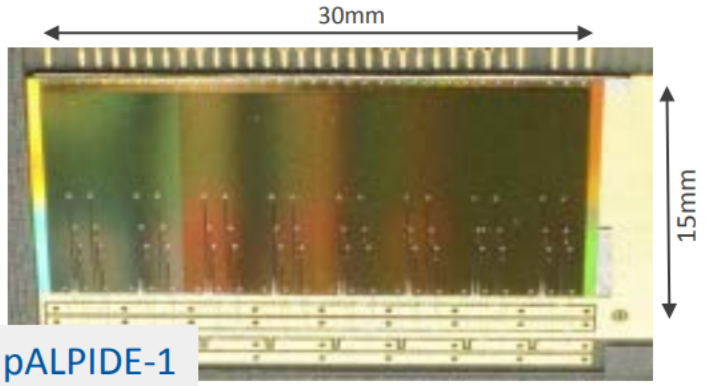
2013 — pALPIDEss-0

Matrix with 64 columns x 512 rows
22 µm x 22 µm pixels
In-pixel discrimination and buffering
Zero suppression within pixel matrix



2014 — pALPIDE-1

First full-scale prototype
Pixel pitch: 28 µm x 28 µm
4 sectors with pixel variants
1 register/pixel, no final interface



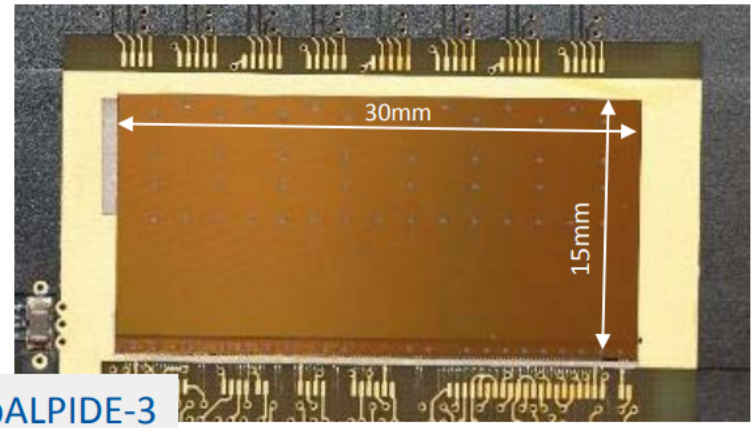
pALPIDE-1

Apr 2015 — pALPIDE-2

4 sectors with pixel variants
Optimization of circuits
Allowing integration in ITS modules
No high-speed serial output

Oct 2015 — pALPIDE-3

8 sectors with pixels variant
All Communication Features
(no ADC, no Temp Sens)



pALPIDE-3

Aug 2016 — ALPIDE

Single pixel variant
All features and optimization

From pALPIDE-3 to ALPIDE, main design changes

1. Select and integrate **final pixel sensing diode and**

2. Improve routing of **pixels configuration control wires** under Pads Over Active Circuits

   Solve weakness of wiring (row select lines in M5) under pads over circuits identified in pALPIDE-3

3. Optimize distribution of **global signals** from periphery ← EDR recommendation

   STROBE, MEMSEL, FLUSH, PULSE

   Option to phase shift global pulses in time: mitigate risk of noise, optimize supply current time profile

   Automatic rotation of PULSE: support **acceleration of pixel tests** with analog scans and charge injection

4. Improve management of **pixel configuration signals** from periphery ← EDR recommendation

   Enable **fast reload of pixels mask** even during readout. Support active forcing of the mask bits from periphery

   Mitigate potential impact of SEUs in pixel mask registers

From pALPIDE-3 to ALPIDE, main design changes (2/2)

5. Optimize CMOS IO drivers ← EDR recommendation

   Improve series termination. Increase timing margins on OB Module Local Bus. Verify adequate on-chip decoupling with more detailed analog sims.

6. Separation of on-chip PLL power distribution network

   Mitigation of excess jitter induced by noise on power supply

7. Full triplication of global asynchronous RESET signals in Digital Periphery, DTU-PLL, DTU-Serializer ← EDR recommendation

   Improve resilience to SEUs and SETs

8. Clock gating of digital periphery modules

   Optimization of digital power consumption

9. Add **new ADC module, Temperature Senseor** and related digital features for analog monitoring