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# Procedure of aligning baselines in the PASTTREC based on measurement of noise


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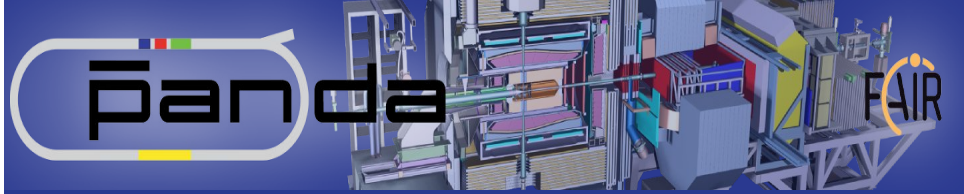
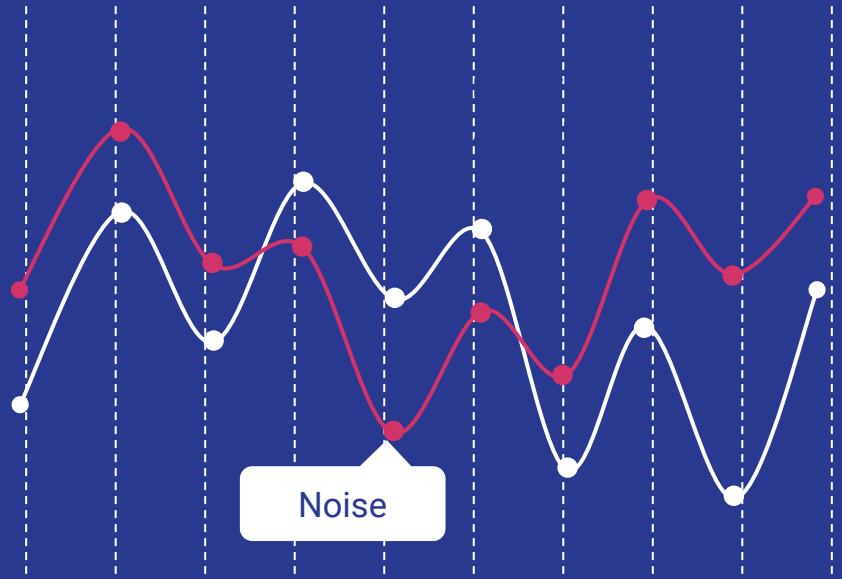


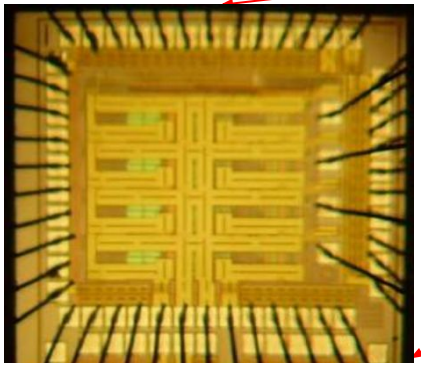

GSI

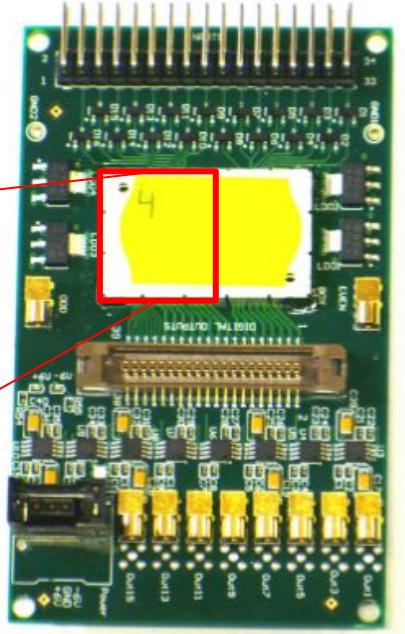
# ------- Outline ----------

- -- Frontend electronic card
- -- Internal parameters of Pasttrec chip
- -- Baseline alignment based on Time-over-Threshold Technique
- -- Baseline alignment based on Technique of Noise
  - -- Procedure
  - -- Results
- -- Advantages of new Technique
- -- Search of best settings of Threshold value in Front-end electronic card
- -- Conclusion
- -- Test results....

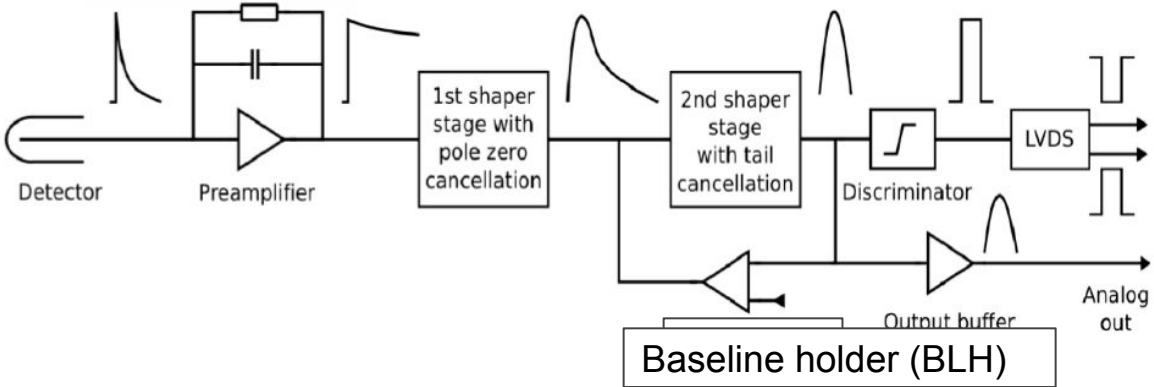
# Frontend electronic card

➔ The FEE card contains two 8-channel PASTTREC chips (developed by M. Idzik et. al. at AGH). One channel comprises often amplifier, shaper and discriminator stage.





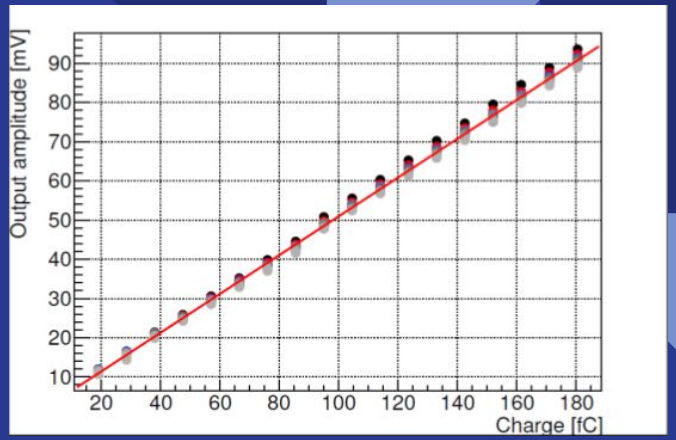
Front-end Board



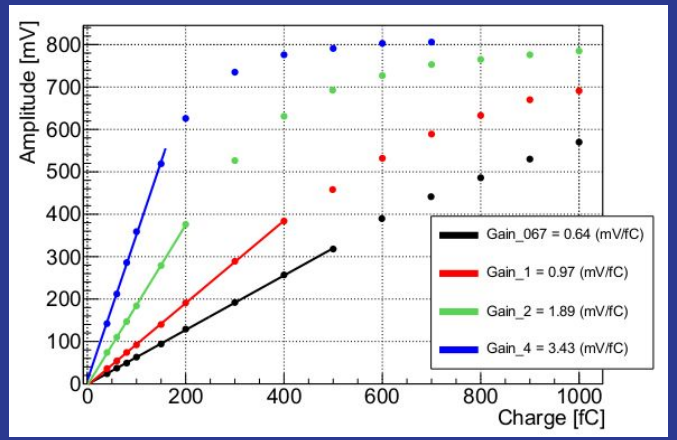

Schematic representation of the front end electronics functions with a concepts of signal shaping with analog circuitry.

# ➢ Main parameters of the PASTTREC

- ➔ Technology = 0.35 µm CMOS
- ➔ Number of channels = 8
- ➔ Equivalent (delta)input range = 0 - 200 fC
- ➔ Variable gain ~ 1.8-10.5 mV/fC
- ➔ Variable peaking time (for delta) = 10-35 ns
- ➔ Noise ENC = < 1 fC
- ➔ Baseline tuning = -32 - +32 mV
- ➔ Output standard = LVDS and analog
- ➔ Power consumption ~ 35 mW/channel




Amplitudes of 16 output signals versus input charge for the same ASIC configuration.




Gain measurements for delta pulses for four settings of preamplifier gain parameter (K).

# Configurable Settings for the Pasttrec Chip

-- 1 Pasttrec chip has 8 channels with adjustable baseline

-- One common threshold for 8 channels

-- Threshold - 0 to 254 mV ( step of 2 mV )

-- Gain - 0.67, 2, 3, 4 mV / fC

-- Peaking time - 10, 15, 20, 35 ns

-- Baseline level : - 31 to + 31 mV ( step of 2 mV )

-- Shaping parameters :

-- TC1C - 6, 7.5, 9, 10.5, 12, 13.5, 15, 16.5 pF

-- TC2C - 0.6, 0.75, 0.9, 1.05, 1.2, 1.35, 1.5, 1.65 pF

-- TC1R - 3, 7, 11, 15, 19, 23, 27, 31 kΩ

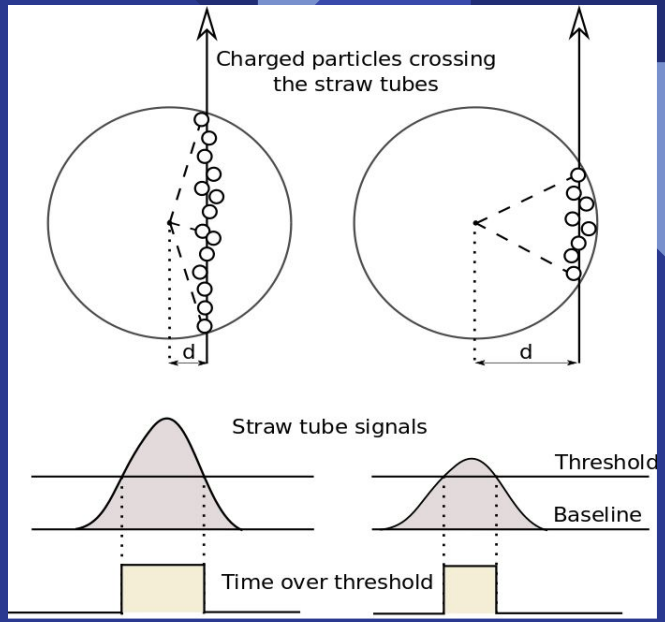
-- TC2R - 5, 8, 11, 14, 17, 20, 23, 26 kΩ


The snapshot of the currently used graphical user interface for the FEE setup. The GUI is integrated with the TRBv3 system.

# Using TOT for tuning of Baseline

The baseline level differs among the PASTTRECv1 channels but it can be fine tuned thanks to the internal DAC circuits.

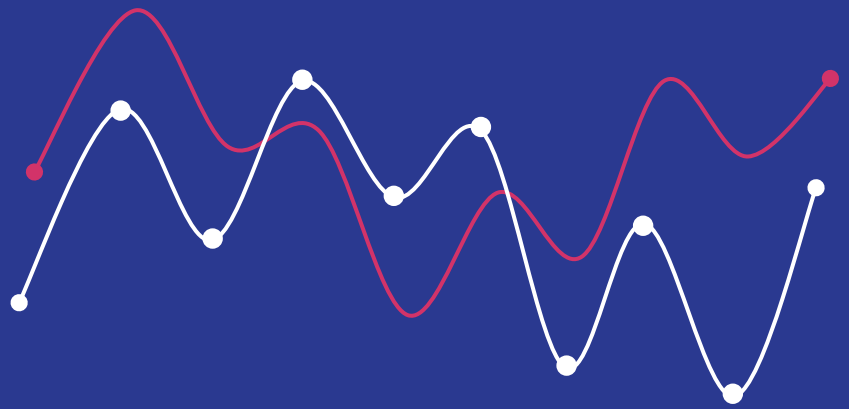
- ➔ The first step of the procedure implies collection of the TOT spectrum of the $^{55}Fe$ source for all the system channels.
- ➔ The median of the position of the TOT peaks is established.
- ➔ The baseline levels are shifted for the channels which have different TOT peak position than the calculated median value.
- ➔ If the peak is below the median then the baseline is augmented by 2 mV else it is reduced by the same value or left untouched if its position is close to the median.
- ➔ After completion of all the mentioned steps next iteration of the procedure starts.
- ➔ Once the baseline configuration has been found it remains stable over the time.




**Generation of the signal inside the straw. Particle crossing the straw close to the anode wire (left) leaves more charge than the one crossing close to the wall (right).**

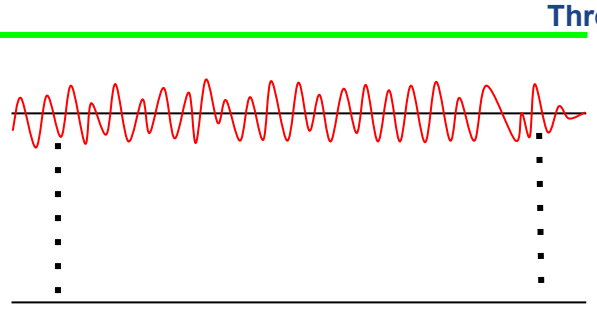
# New method for Baseline tuning

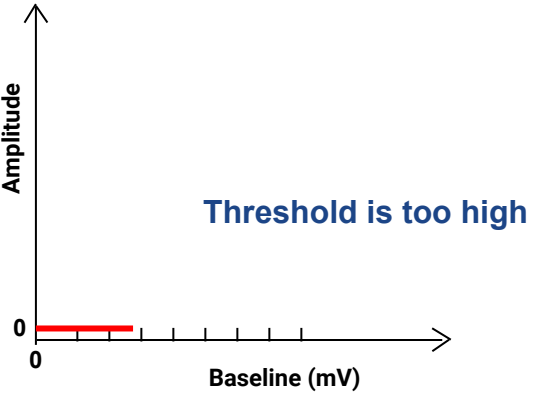
## **Noise Accurate Baseline Alignment (NASA)**



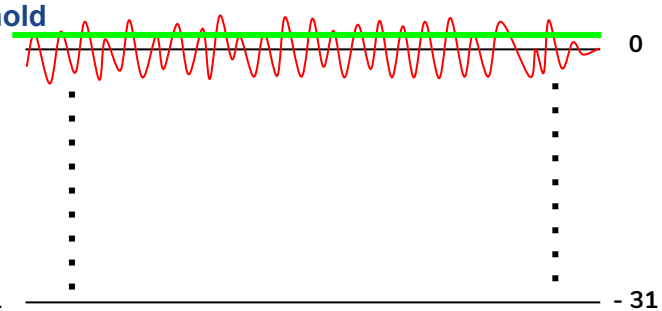
1 LSB = 2 mV
3 - 5 Bins

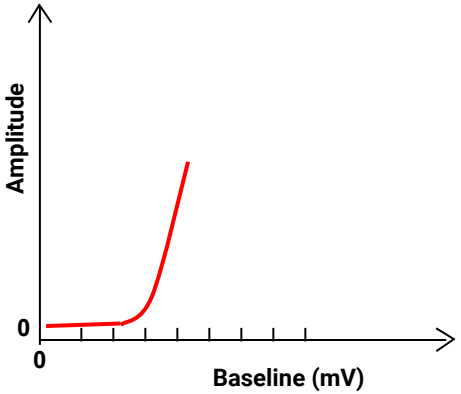
Max level Baseline = + 31 mV
Low level Baseline = - 31 mV



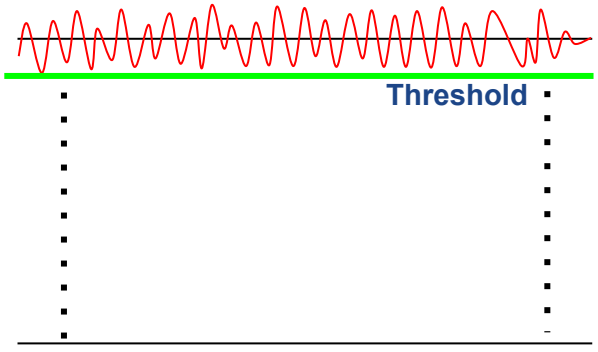



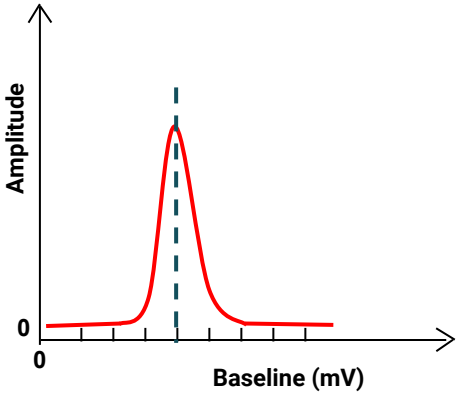

Baseline level << Threshold level



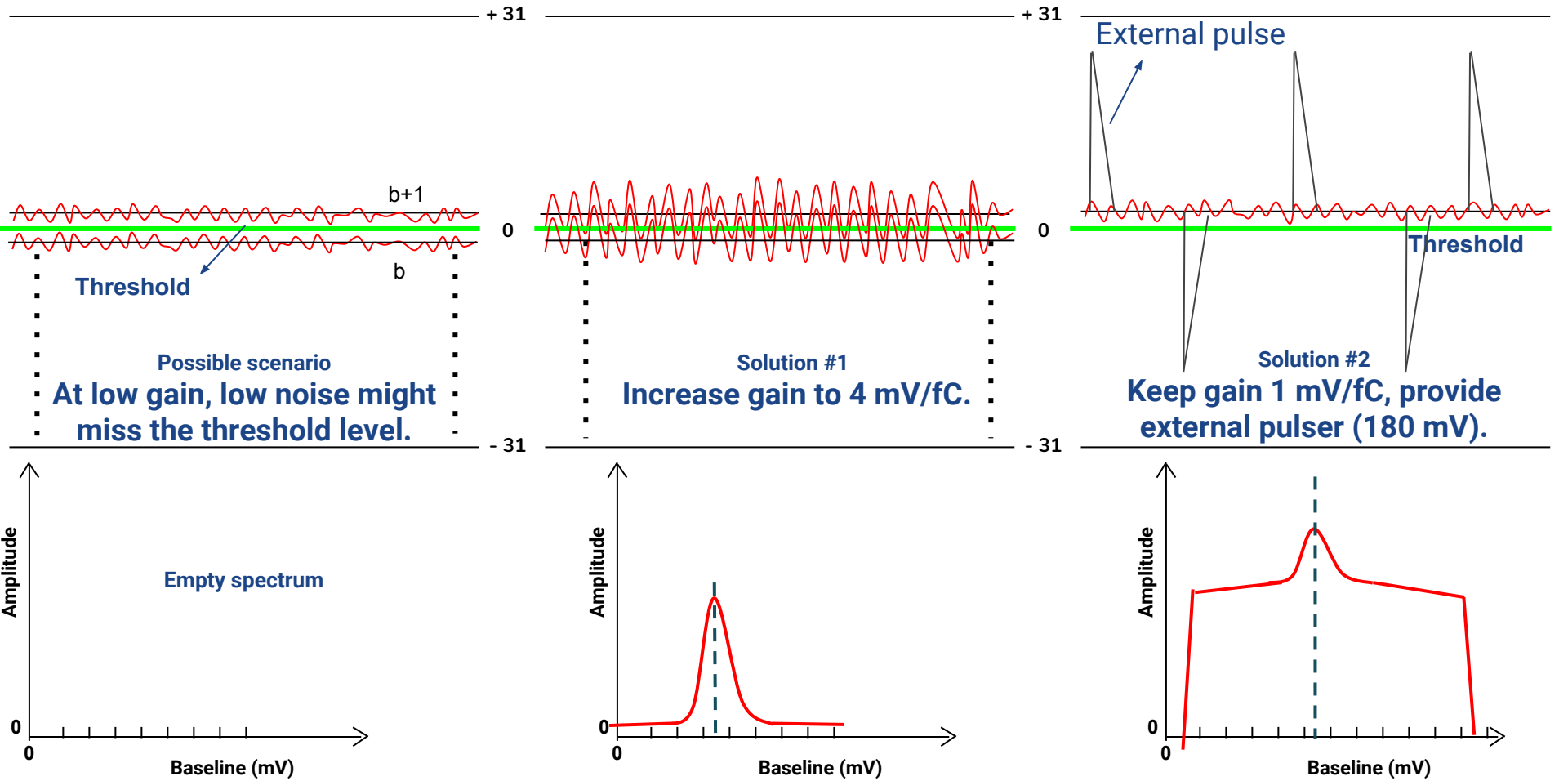




Baseline level at threshold



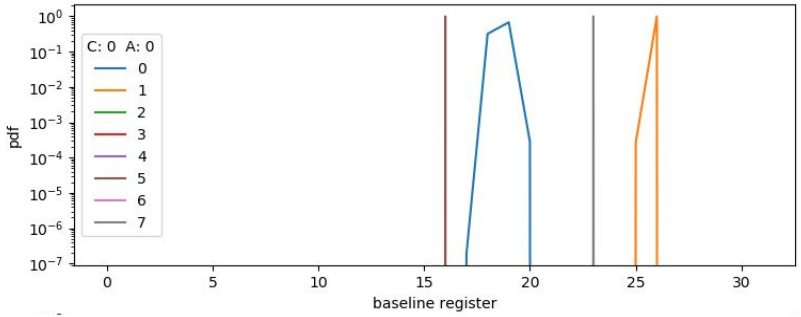

Baseline level > Threshold level

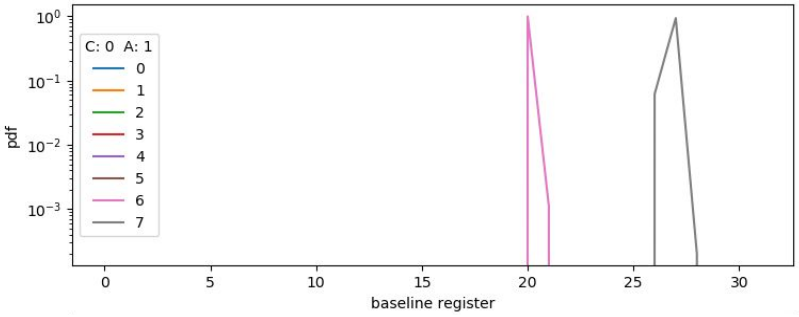



1 LSB = 2 mV

Max level Baseline = + 31 mV
Low level Baseline = - 31 mV

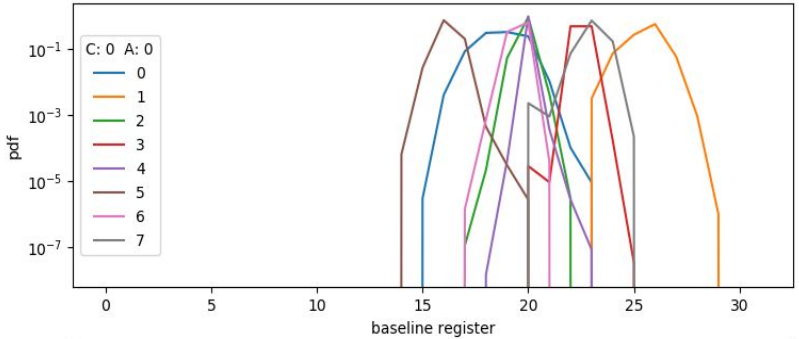
## Scenario with gain = 1 mV/fC

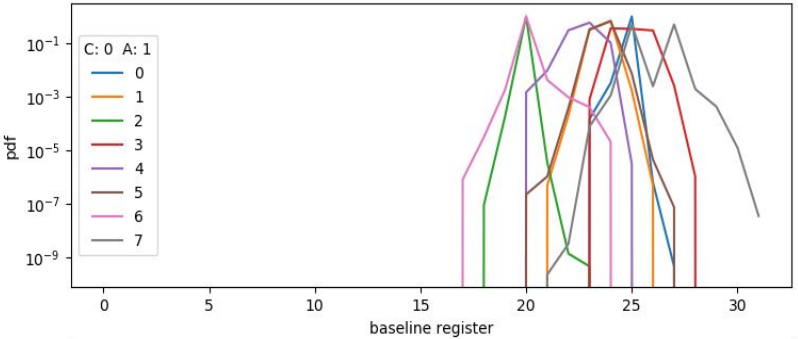



Due to low noise levels in the chip, it is impossible to determine all baseline levels.

## Scenario with gain = 4 mV/fC




Due to appropriate noise levels in the chip, alignment is possible.

# Alignment procedure

1. Set HV OFF (dark current and background radiation will bias the alignment).
2. Load the analog stage configuration (peaking time, shaping parameters, gain).

   Baseline scan has Gain : e.g. 1 mV/fC, Peaking Time : 20 ns

   Shaping parameters -- tc1c : 10.5 pF, tc1r : 27 kΩ, tc2c : 0.9 pF, tc2r : 20 kΩ, bl : [0, 0, 0, 0, 0, 0, 0, 0]
3. Set threshold to 0.
4. Scan all baseline values, read scalers for each value in desired time period, e.g. 1 s
5. If any channel is not responding, alignment will not be possible for that channel.
6. Re-run the procedure for higher gain, e.g. 4 mV/fC or with external pulser.
7. Extract the mean noise position from the baseline scan.
8. Prepare configuration with proper baselines and reconfigure ASICs.

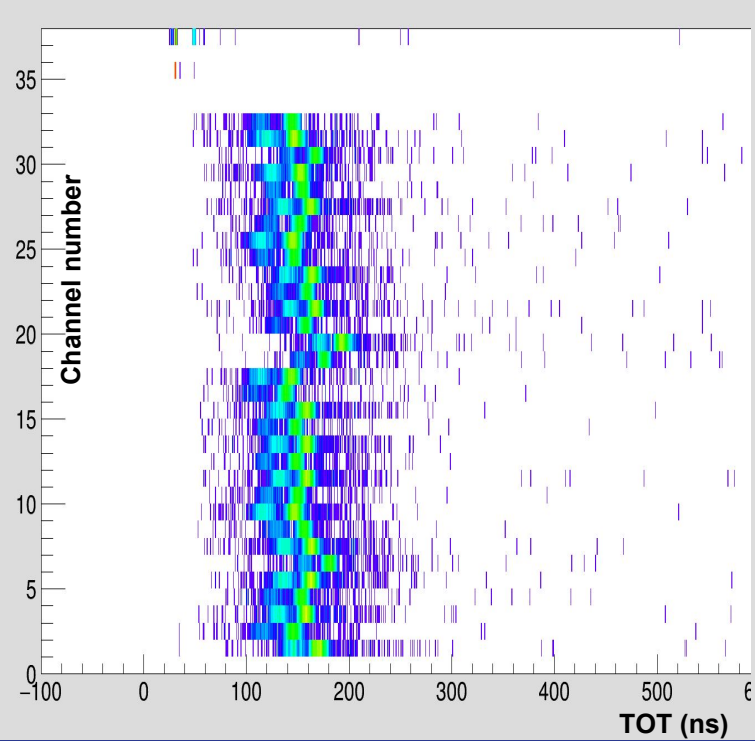
Steps 2-4, 7-8 are performed automatically using scan_baselines.py and calc_baselines.py scripts.

<u>It was shown that alignment with higher gain stays valid for the lower gain configuration.</u>

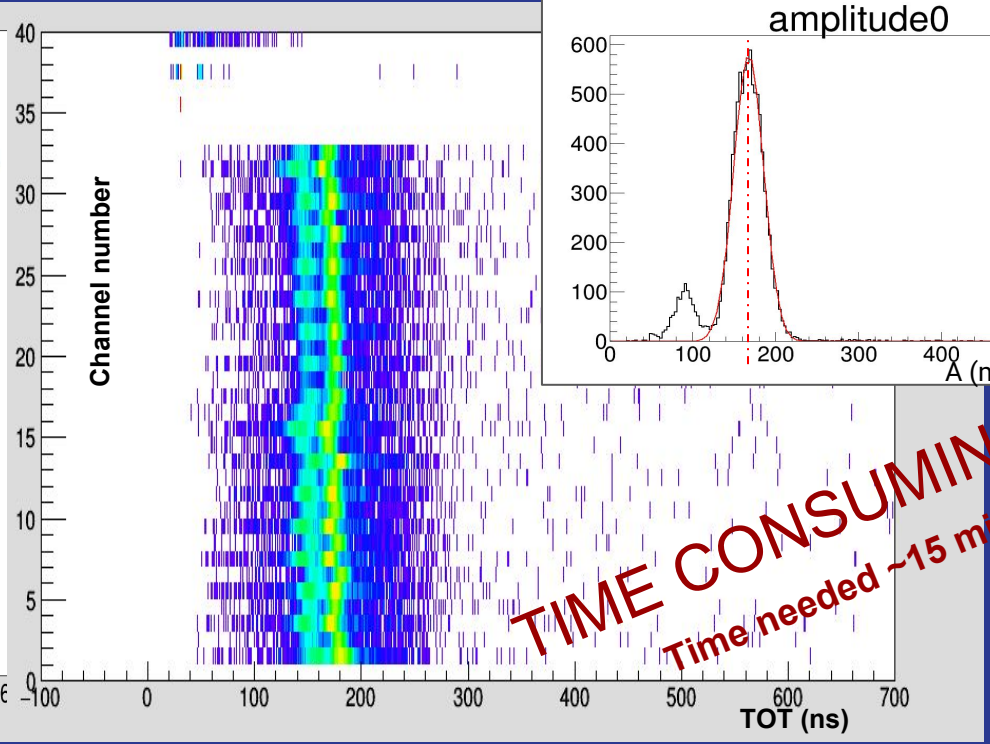
Alignment is ASIC specific and time-independent - once done, valid in future.

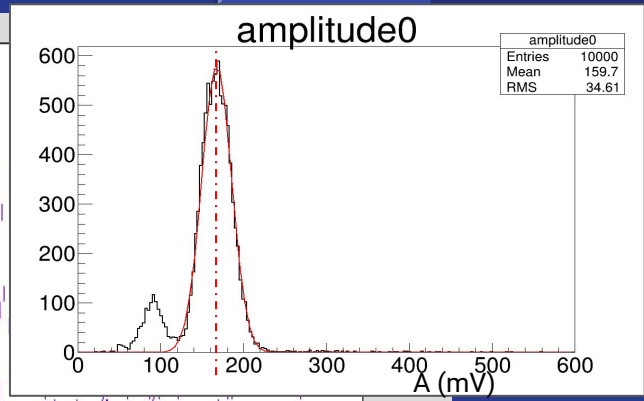
# Alignment using $^{55}Fe$ source and adjusting the TOT
# ( Old Technique )

**Before**




**After**




TIME CONSUMING

Time needed ~15 min

**All Baseline set to same value**

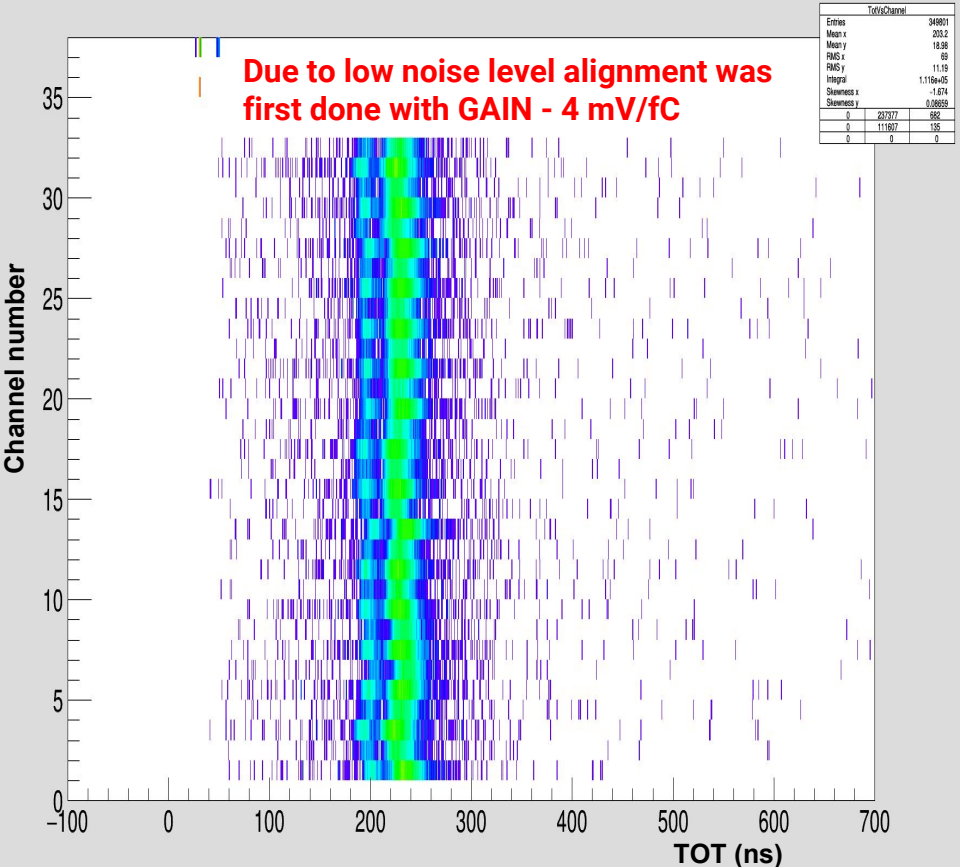
**After providing correct baseline values**

**Gain: 1 mV/fC, Peaking Time : 20, Threshold : 20 mV, Shaping parameters -- tc1c : 10.5 , tc1r : 27 , tc2c : 0.9 , tc2r : 20.**

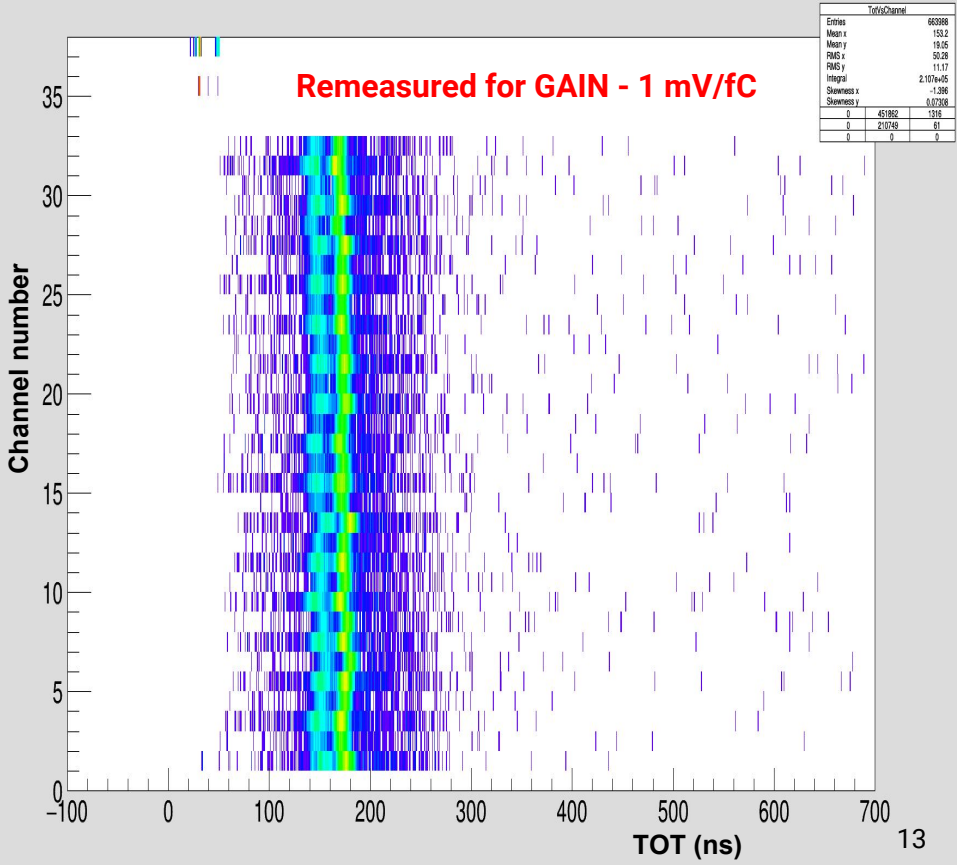
# Baseline alignment by NASA

**Peaking Time : 20, Threshold : 20 mV, Shaping parameters -- tc1c : 10.5 pF, tc1r : 27 kΩ, tc2c : 0.9 pF, tc2r : 20 kΩ.**

**Gain: 4 mV/fC**




**Gain: 1 mV/fC**

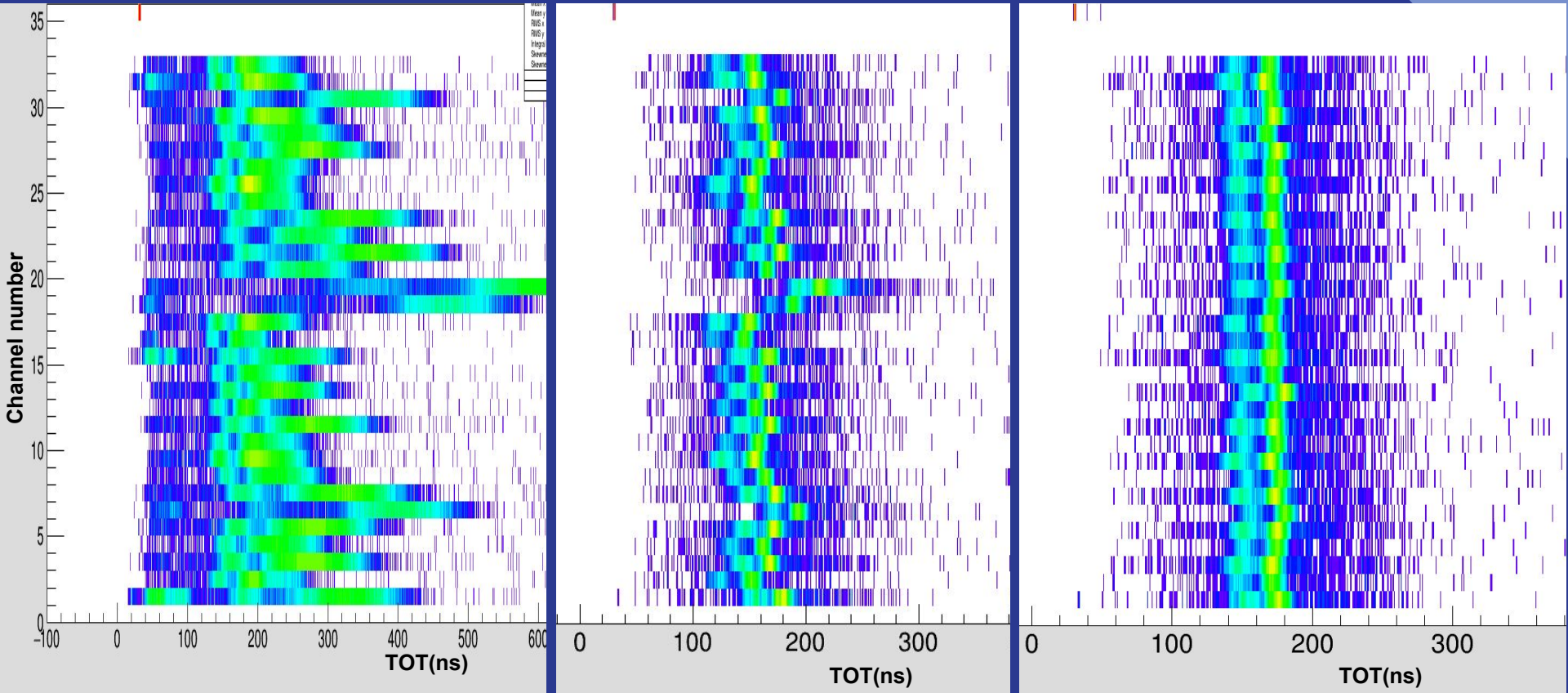


# How good is alignment

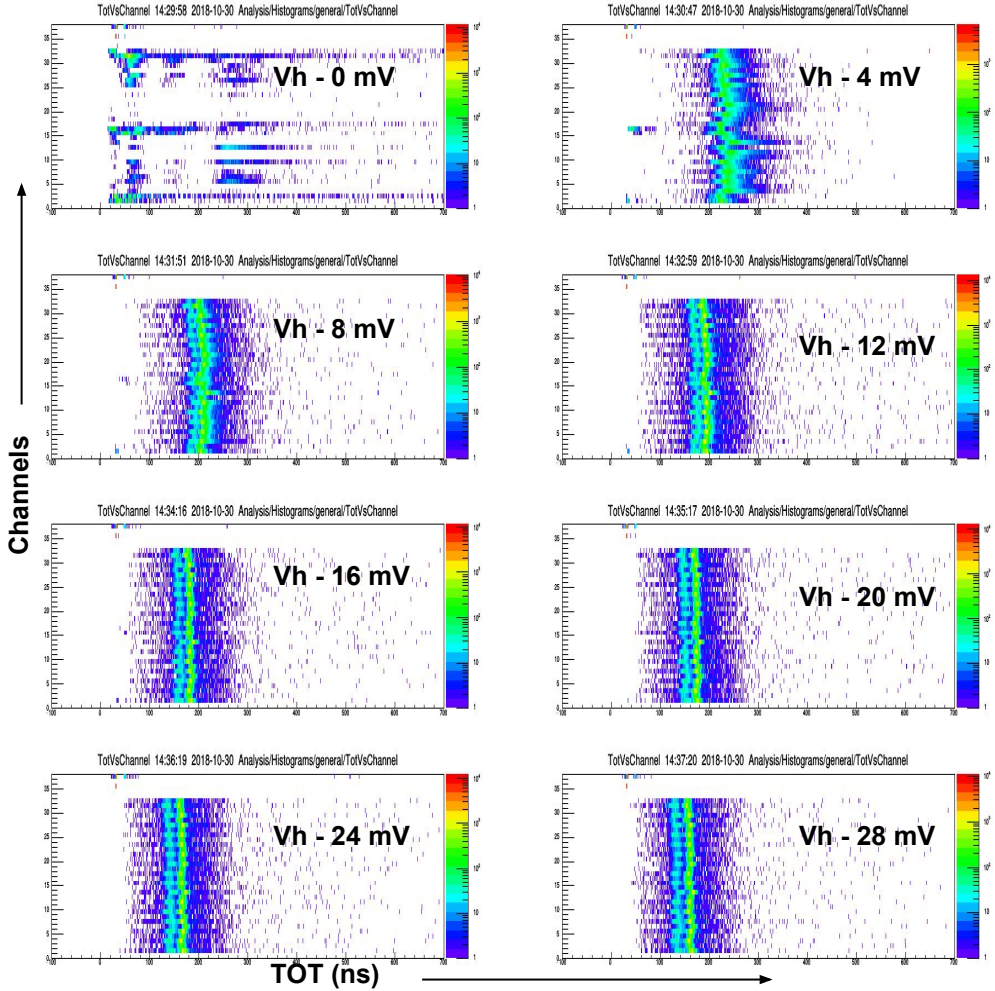
Gain -1 mV/fC, Peaking Time : 20, Threshold : 20 mV, Shaping parameters -- tc1c : 10.5 pF, tc1r : 27 kΩ, tc2c : 0.9 pF, tc2r : 20 kΩ.

Without configuration

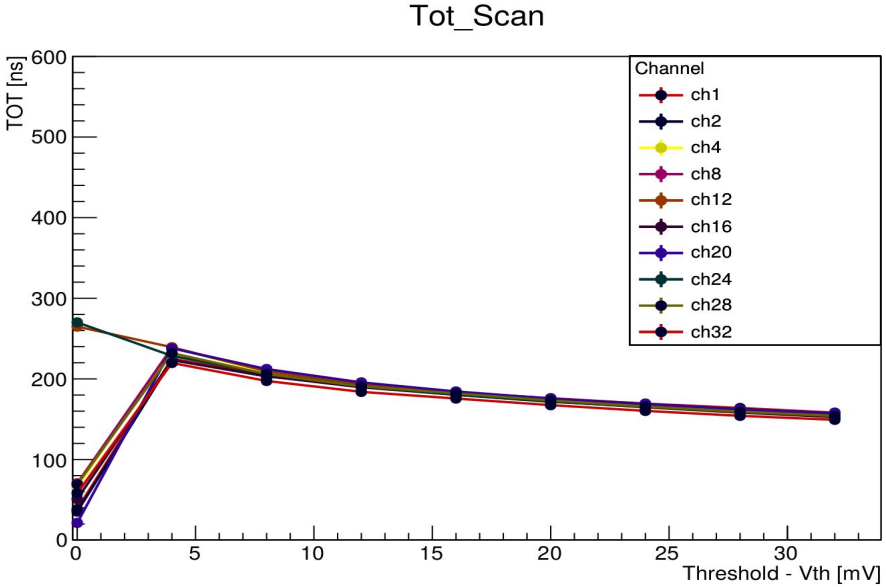
All baseline are set to +7 mV



# TOT's at different threshold, Baselines are aligned




# Max value of TOT's vs channel number



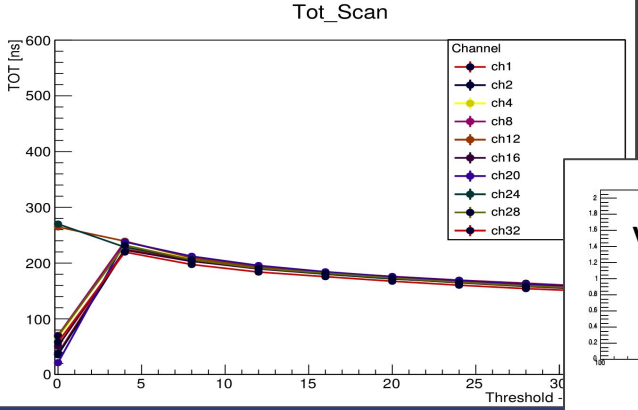

-- Center value of TOT is plotted with their corresponding channels.

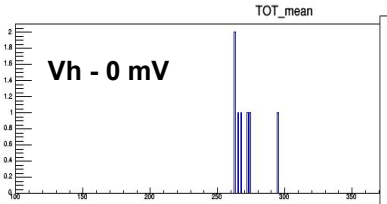
-- At very low thresholds baseline has high range of fluctuation.

-- Threshold value 16 and higher has very narrow spread in TOT's which further can be considered as a better settings.

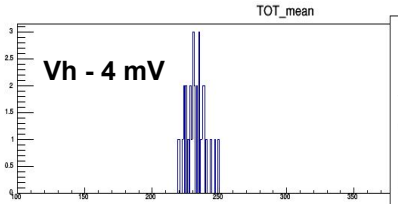
# Distribution of spread TOT at different Thresholds

## Minimum spread will provide better resolution

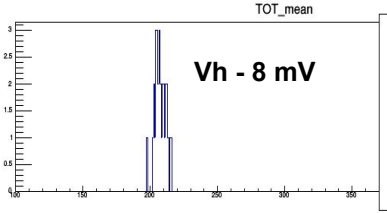


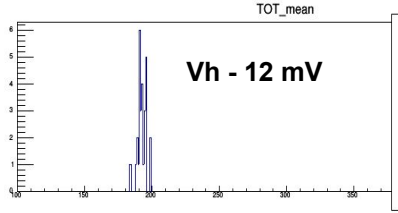

| | |
|---|---|
| Entries | 32 |
| Mean | 271.3 |
| RMS | 10.39 |



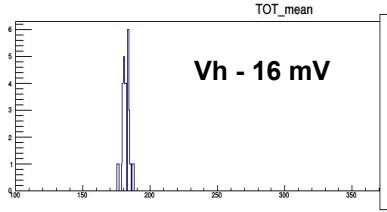

| | |
|---|---|
| Entries | 32 |
| Mean | 232.3 |
| RMS | 7.164 |



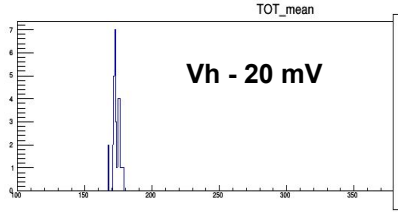

| | |
|---|---|
| Entries | 32 |
| Mean | 207.2 |
| RMS | 4.232 |



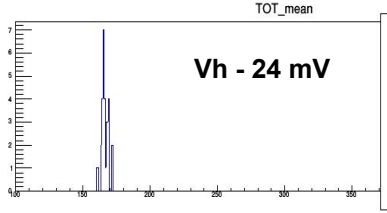

| | |
|---|---|
| Entries | 32 |
| Mean | 192.2 |
| RMS | 3.348 |



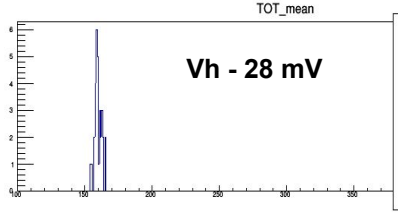

| | |
|---|---|
| Entries | 32 |
| Mean | 181.8 |
| RMS | 2.533 |




| | |
|---|---|
| Entries | 32 |
| Mean | 173.3 |
| RMS | 2.501 |




| | |
|---|---|
| Entries | 32 |
| Mean | 166.3 |
| RMS | 2.562 |

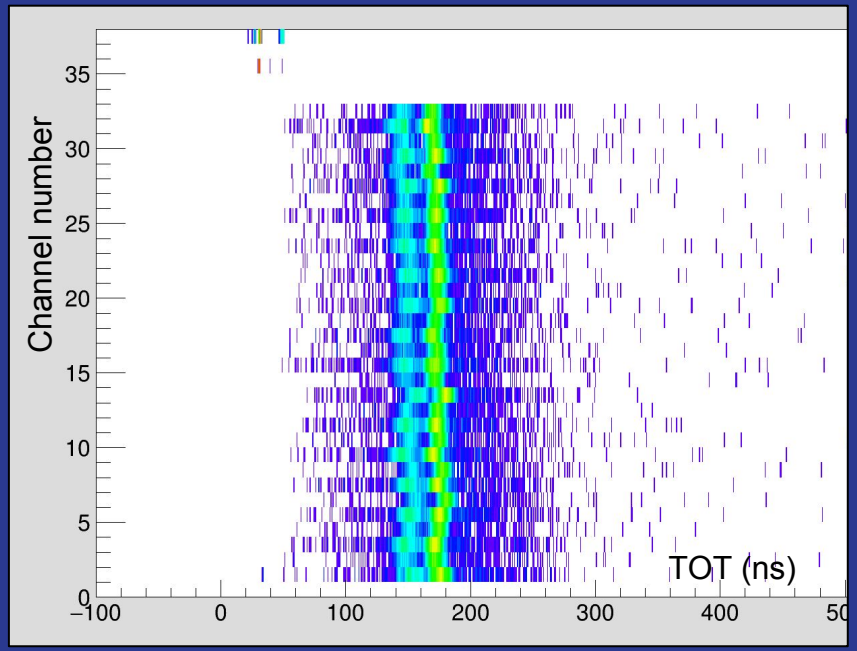


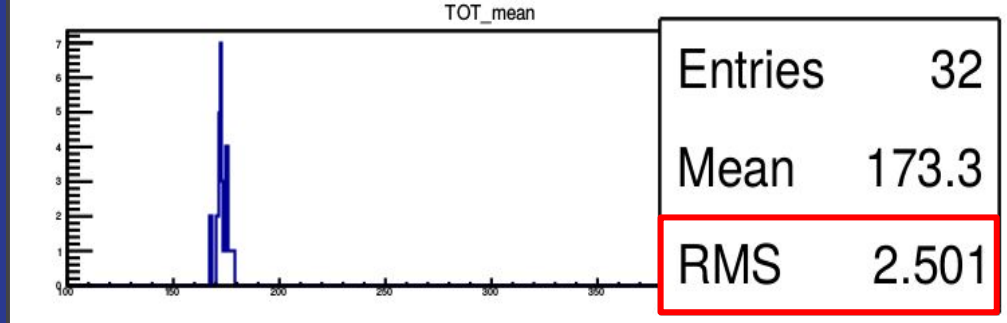

| | |
|---|---|
| Entries | 32 |
| Mean | 160 |
| RMS | 2.588 |

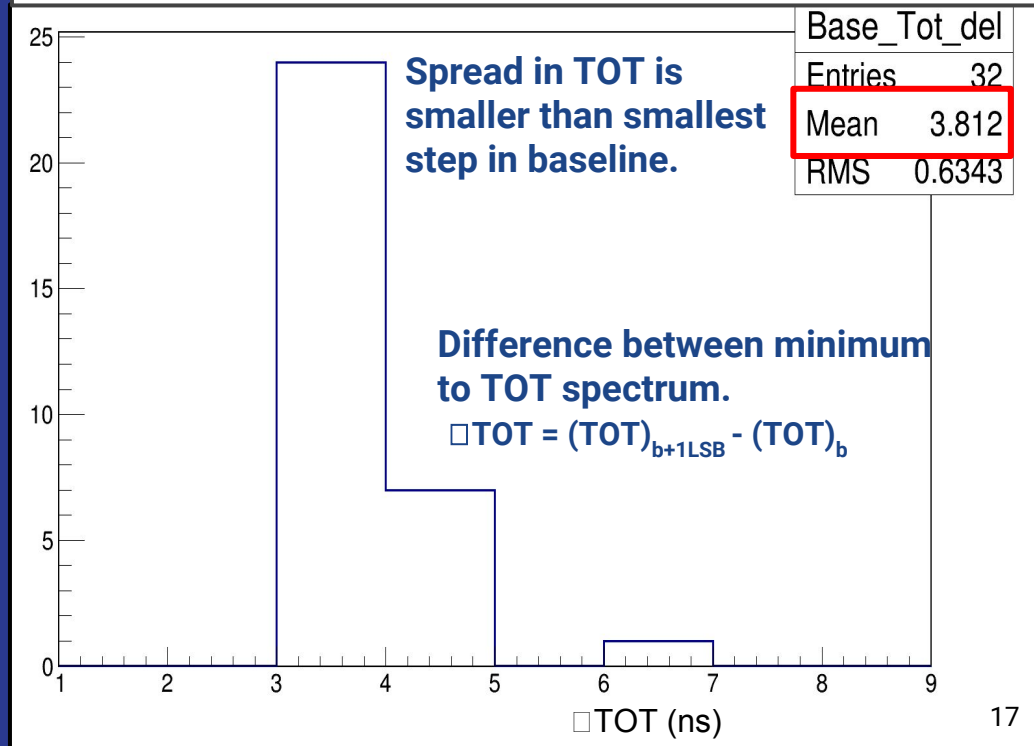
**Low threshold provide high fluctuation in the noise level but threshold value above 12 mV can provide better resolution.**

Smaller Sigma (spread) = Better Uniformity.

# Time-over-Threshold spread




Peaking Time : 20 ns, Threshold : 20 mV
Shaping parameters -- tc1c : 10.5 pF, tc1r : 27 kΩ,
tc2c : 0.9 pF, tc2r : 20 kΩ.

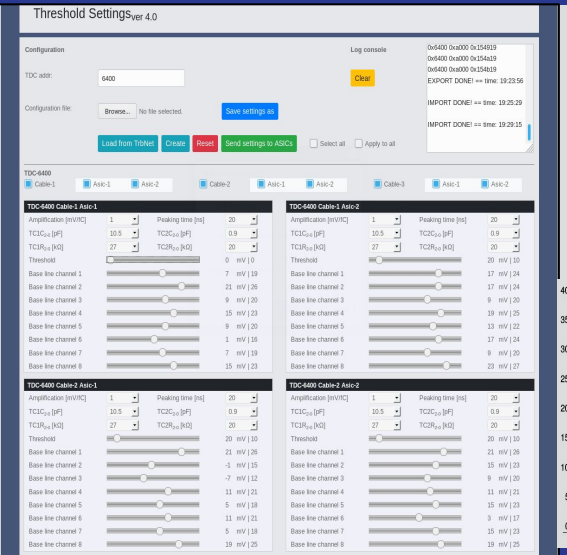
Gain: 1 mV/fc

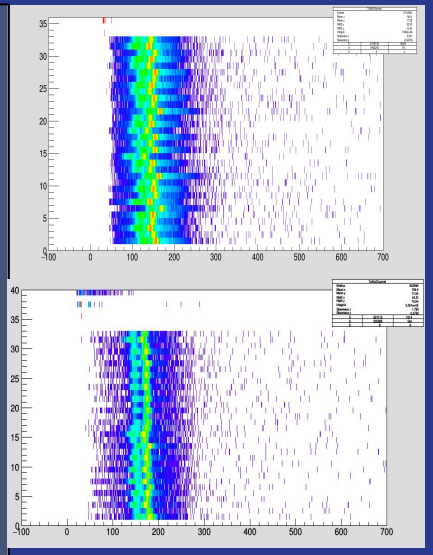
Aligned baselines are shifted by +1 LSB (2 mV)
Calculate difference in TOT value

# Conclusion

## Fe55 source alignment

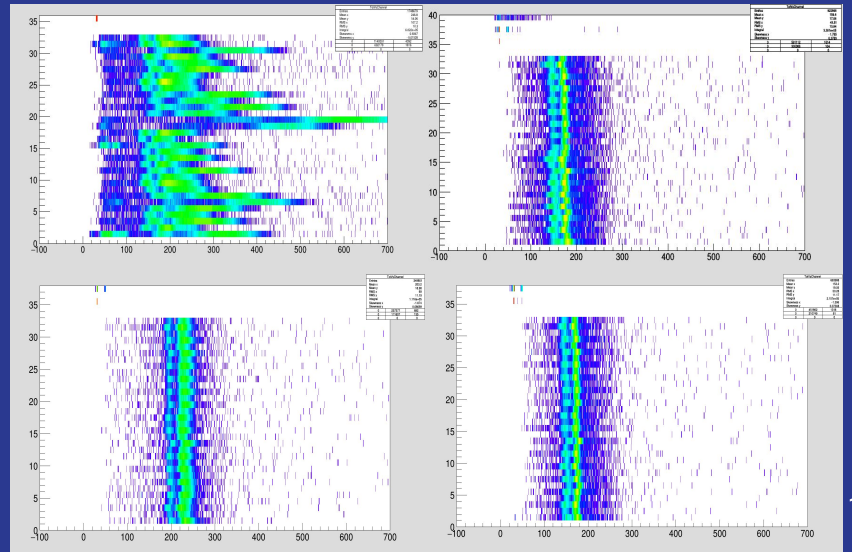
-- Detector must be operational (HV, gas).
-- Impossible to illuminate all straws with source (specially with detector in place).
  -- Only single card alignment at a time.
-- Manually plays with each channel.
-- Too time consuming.



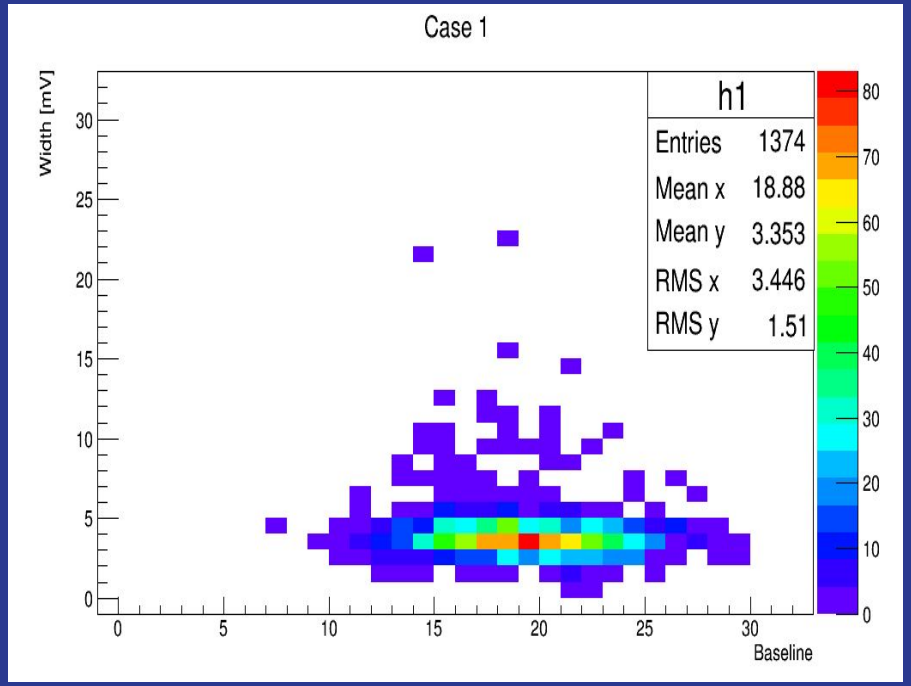
## NASA alignment

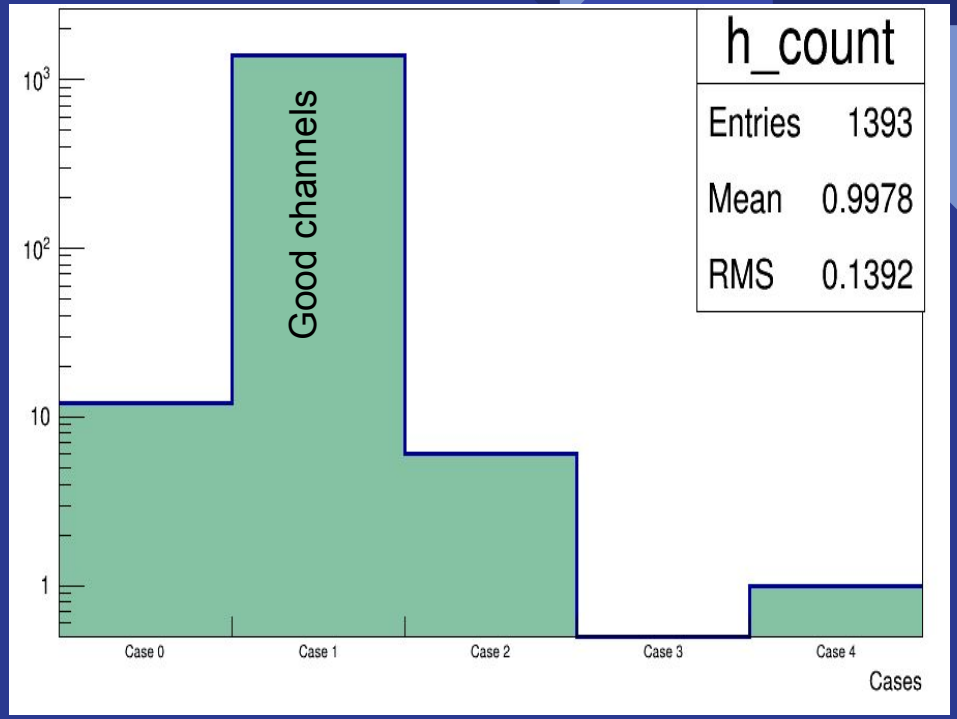
-- Detector is used only to provide input capacitance for ASIC (and card holder for tests - power, signal, etc).
-- Easy to test many cards at the same time!
-- Fully automatic, quick and reliable technique!



# Statistical analysis of results from 87 cards

**87 cards x 16 channel = 1392 channels**



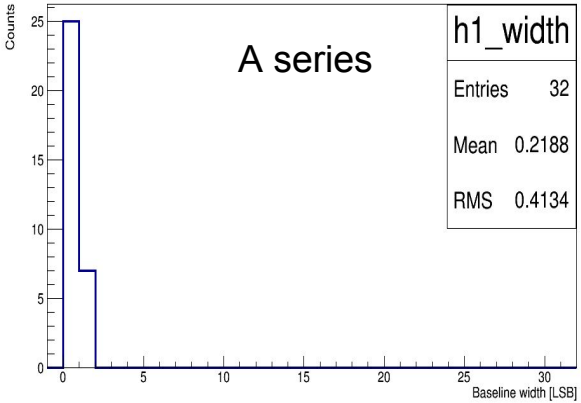

**Averaged obtained Baseline ~ 19 mV**

**98.7% channels work good**

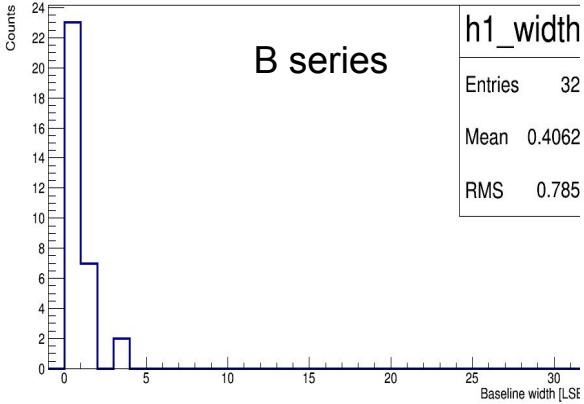
# Distribution of Noise for different front-end electronic cards



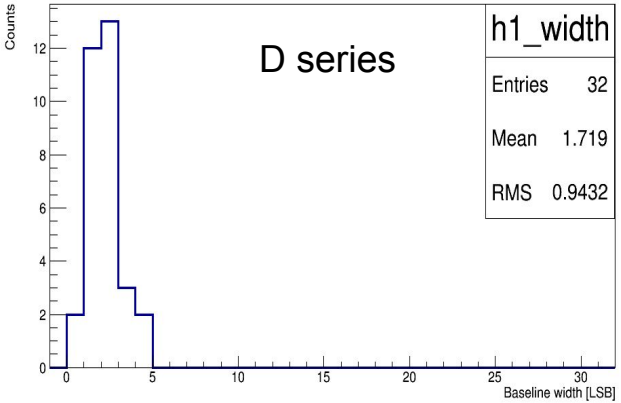

Baseline_scan




Baseline_scan




Baseline_scan



# Software for NASA :-)

Software:

- written in Python 3
- Uses TRBnet interface to Communicate with ASICs

Download it from:
https://github.com/HADES-Cracovia/pasttrectools

Contact : **Dr. Rafal Lalik** for details or questions:
**Rafal.Lalik@uj.edu.pl**

```
( ✓      (1)      pandastraws@pandastraws      16:03:28
|~/tests_20181002> ./TDC0x6400_quick_skan_K0.sh
Slow Control set to sodanetTrb1
  address   channel   bl 0                              31
                      |-------------------------------|
  0xfe4f    all        ##############################  done
Namespace(Dump='20181026_161018_cfg.sh', dump=None, gain=2, json_file='20181026_161018_scan.json', offset=0, output='20181026_161018_bl.json', threshold=10, verbose=0)
{'bg_int': 1, 'gain': 0, 'peaking': 3, 'tc1c': 3, 'tc1r': 2, 'tc2c': 6, 'tc2r': 5, 'vth': 0, 'bl': [0, 0, 0, 0, 0, 0, 0, 0]}
Scanning 0x6400  CARD: 0  ASIC: 0
0  bl:  18  (0x12)   +5 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2, 0, 1, 1136, 378140, 2156484971, 10207743, 1612330, 6449, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,  ]
1  bl:  26  (0x1a)  +21 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 2, 1, 1, 1, 1990, 936656, 4405400, 127323, 56, 2, 0, 0,  ]
2  bl:  20  (0x14)   +9 mV   [  2, 1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 1, 0, 1, 1, 1, 11282, 385544, 75, 28, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1,  ]
3  bl:  23  (0x17)  +15 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 1, 1, 1, 1, 0, 1, 1, 0, 3, 24, 29910, 301568, 92, 0, 1, 1, 1, 1, 0, 1,  ]
4  bl:  20  (0x14)   +9 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2, 0, 1, 0, 2, 1, 458, 242400, 19416, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,  ]
5  bl:  16  (0x10)   +1 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2, 0, 0, 925, 403372, 17800, 2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,  ]
6  bl:  19  (0x13)   +7 mV   [  0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 2, 3, 2, 3, 2, 6, 15, 99624, 3250, 4, 3, 2, 3, 3, 3, 2, 2, 2, 3, 2,  ]
7  bl:  23  (0x17)  +15 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 19684, 839346, 4602, 2, 1, 3, 0, 1, 0, 0,  ]
Scanning 0x6400  CARD: 0  ASIC: 1
0  bl:  24  (0x18)  +17 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 4, 102304, 23274, 2, 3, 1, 2, 1, 0,  ]
1  bl:  24  (0x18)  +17 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 3816, 33419, 11, 0, 2, 0, 0, 0, 0,  ]
2  bl:  20  (0x14)   +9 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 2, 0, 10822, 189842, 2, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0,  ]
3  bl:  26  (0x1a)  +21 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 49, 51275, 105552, 113, 0, 1, 0, 0,  ]
4  bl:  22  (0x16)  +13 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 51, 85812, 14085, 9, 0, 0, 1, 0, 1, 0, 0,  ]
5  bl:  24  (0x18)  +17 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 13825, 202292, 202, 0, 1, 0, 1, 0, 0,  ]
6  bl:  20  (0x14)   +9 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 2, 0, 0, 0, 6, 275, 344814, 9691312, 2900412, 45205, 18, 1, 0, 0, 1, 0, 1, 0, 0,  ]
7  bl:  27  (0x1b)  +23 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 2491, 567861, 6864202, 2159059689, 3053219, 37591, 16, 0,  ]
Scanning 0x6400  CARD: 1  ASIC: 0
0  bl:  26  (0x1a)  +21 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 5, 10, 19, 29, 34, 86, 144038, 18387, 42, 26, 13, 12,  ]
1  bl:  15  (0x0f)   -1 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 2, 23, 28040, 74320, 51, 7, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,  ]
2  bl:  12  (0x0c)   -7 mV   [  0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 9, 23, 11715, 3249, 13, 3, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0,  ]
3  bl:  21  (0x15)  +11 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 932, 14844, 2, 0, 0, 0, 0, 0, 0, 1, 0, 0,  ]
4  bl:  18  (0x12)   +5 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 6, 28444, 71, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,  ]
5  bl:  21  (0x15)  +11 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 107, 115613, 180, 0, 0, 0, 0, 0, 0, 1, 0, 0,  ]
6  bl:  18  (0x12)   +5 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 6526, 3908, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,  ]
7  bl:  25  (0x19)  +19 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 33279, 3794, 1, 0, 1, 0, 0,  ]
Scanning 0x6400  CARD: 1  ASIC: 1
0  bl:  26  (0x1a)  +21 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 9, 23346, 630, 0, 2, 0, 0,  ]
1  bl:  23  (0x17)  +15 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 5, 185190, 14670, 4, 0, 1, 0, 1, 0, 0,  ]
2  bl:  20  (0x14)   +9 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1, 0, 187, 390400, 916, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0,  ]
3  bl:  21  (0x15)  +11 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 9042, 16841, 1, 1, 0, 0, 0, 0, 0, 1, 0, 0,  ]
4  bl:  23  (0x17)  +15 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 6, 89148, 163, 0, 0, 1, 0, 1, 0, 0,  ]
5  bl:  17  (0x11)   +3 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2, 0, 0, 1225, 657774, 3146, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,  ]
6  bl:  23  (0x17)  +15 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 18068, 3782530, 332380, 44746, 5, 1, 0, 1, 0, 0,  ]
7  bl:  25  (0x19)  +19 mV   [  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 951, 428813, 5625855, 343089, 4527, 0, 1, 0, 0,  ]
```

# Thank you!

**YES ! We do Rocket Science……..**