



Status of Calibration:

First Module Calibration of AGIPD

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Deutsches Elektronen-Synchrotron (DESY)

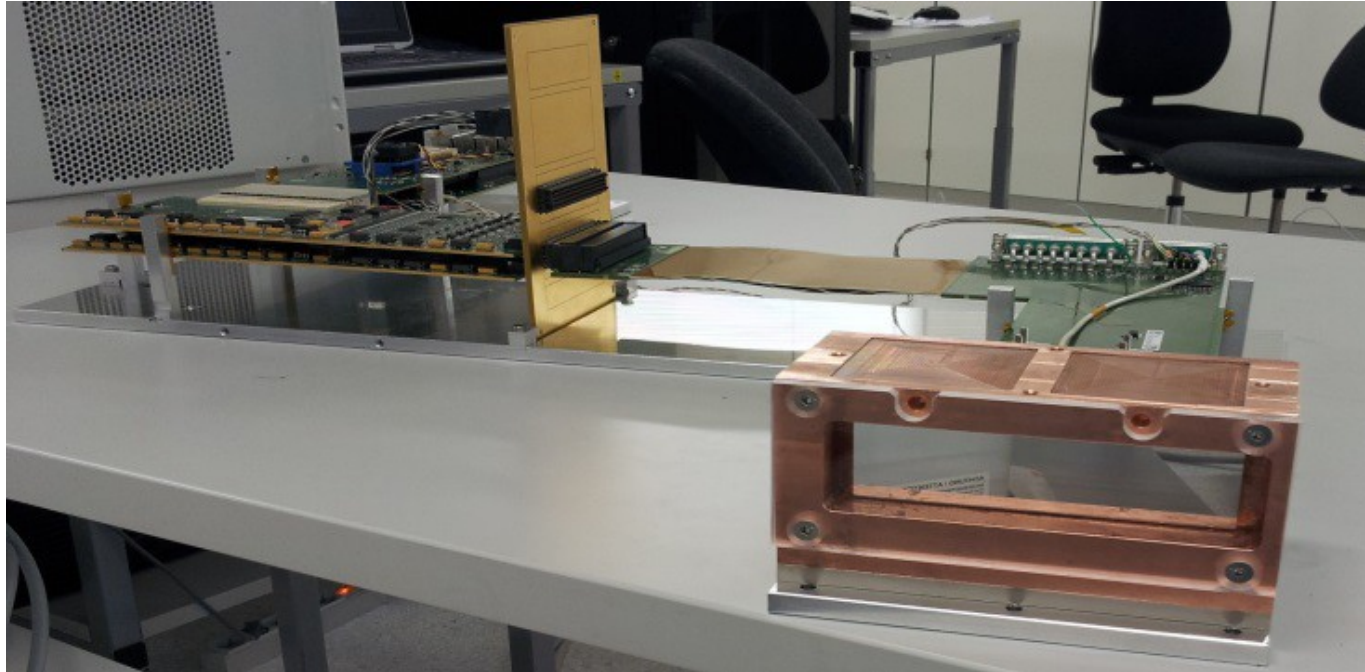


- **Calibration infrastructure**
- **Methods and procedures for individual measurements**
- **Results from the 1st module**
- **Calibration “framework”**
- **Summary and future plan**

Calibration infrastructure



- Single module system with water cooling



- Quadrant + multi-purpose vacuum chamber + multi-module system + 10 G + DAQ

Timing and bias



- XFEL timing: 22 clocks + 100 MHz → 220 ns per cycle

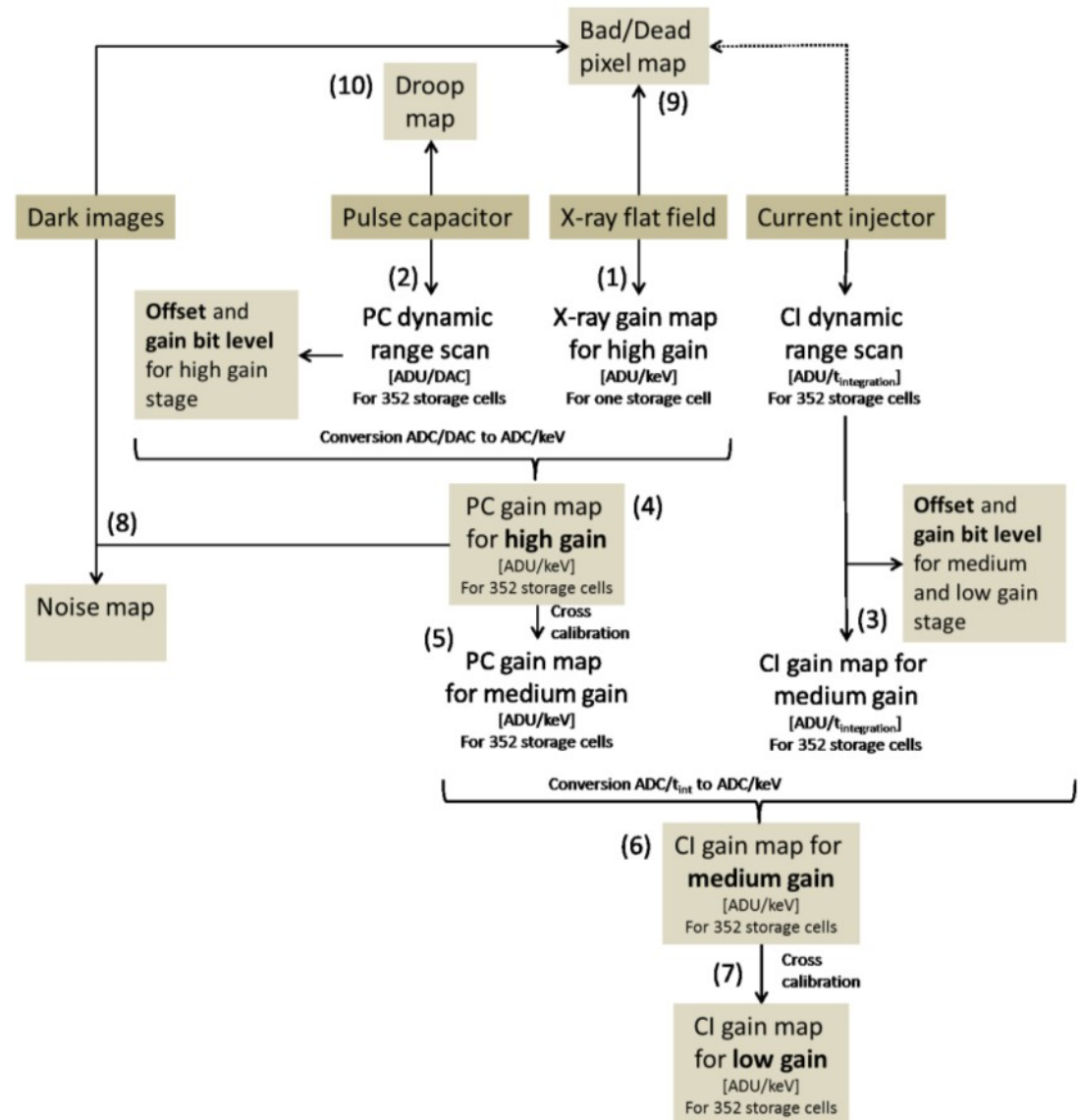
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		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22				
PRE Reset (min 60ns)																								RSTDLY	6	RSTGAT	14
CDS Reset																								DS1DLY	7	DS1GAT	12
Row Prech																								RPDLYW	0	RPGATW	19
Col Sel																								CSDLYW	0	CSGATW	19
Row Sel																								RSDLYW	0	RSGATW	18
En_ext_Gain																								EGSDLY	6	EGSGAT	14
Gain1ext																								G1SDLY	4	G1SGAT	16
Gain2ext																								G2SDLY	5	G2SGAT	15
TEST_Pulsed_C																								TSTDLY	9	TSTGAT	11
TEST_Current																								TSTDLY	9	TSTGAT	1
READ																											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22				
RESET_PXB																								PXBDLY	6		
Row Prech																								RPDLYR	8		
Col Sel																								CSDLYR	2		
Row Sel																								RSDLYR	9		

- Bias of ASICs (optimized): $V_{RFCDS} = 700\text{ mV}$ (140),
 $V_{RFPXB} = 850\text{ mV}$ (166) for analog, 650 mV (130) for digital
- Sensor bias: 120 V and module cooled at 15 C

Methods



- To be calibrated:
 - Gain (H, M, L)
 - Offset (H, M, L)
 - Gain bit (H, M, L)
 - Noise
 - Dead pixel
 - Droop

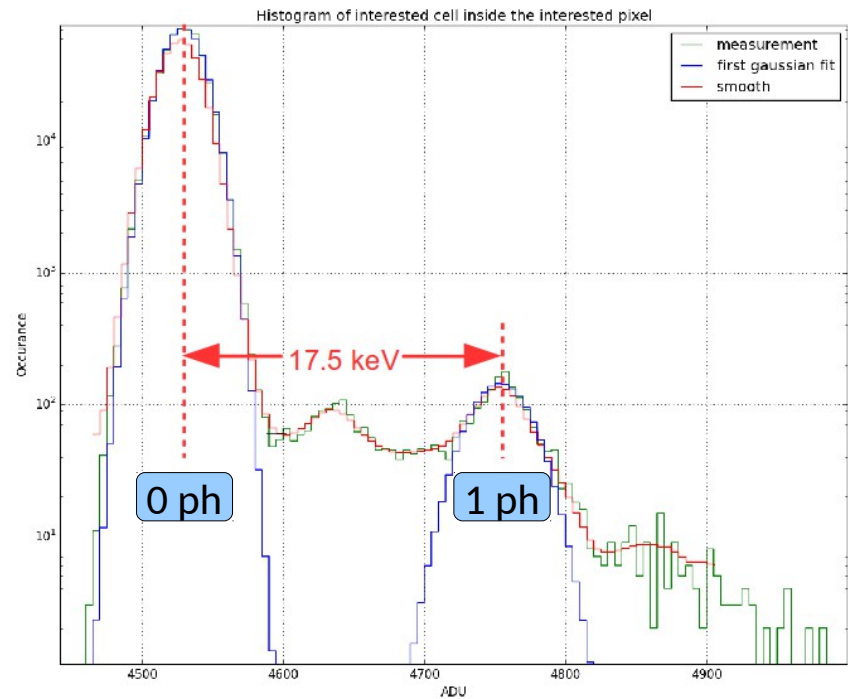
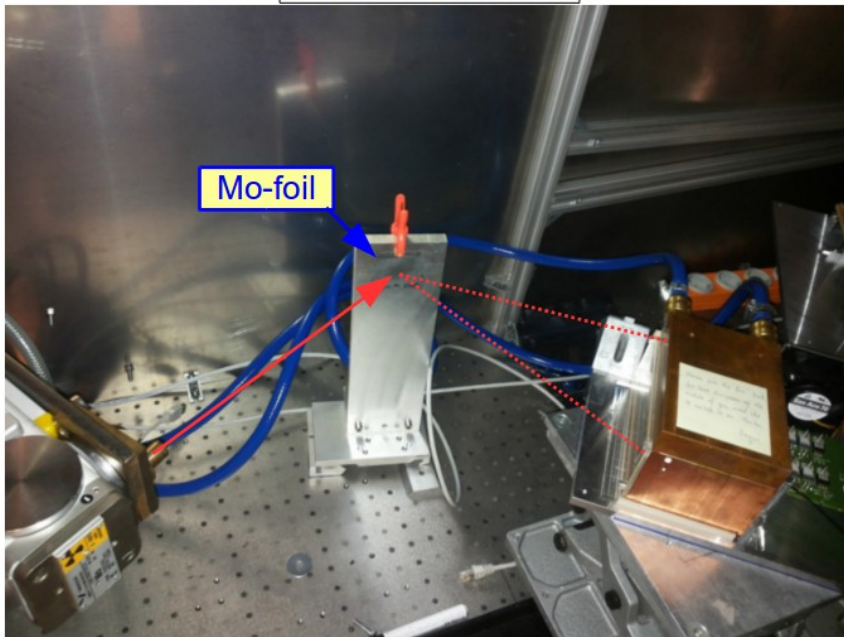


Gain calibration



- High gain extraction with X-ray photons for a single memory cell (cell-175)

Measurement set-up

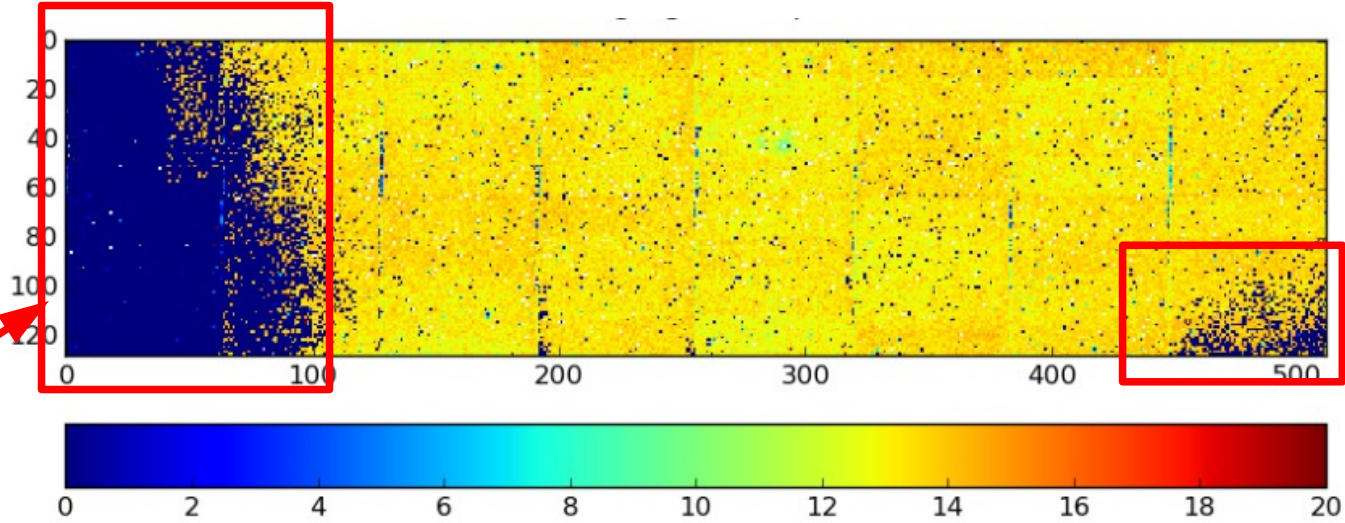


$$\text{Gain(high)} = \Delta\text{ADU}/17.5 \text{ (ADU/keV)}$$

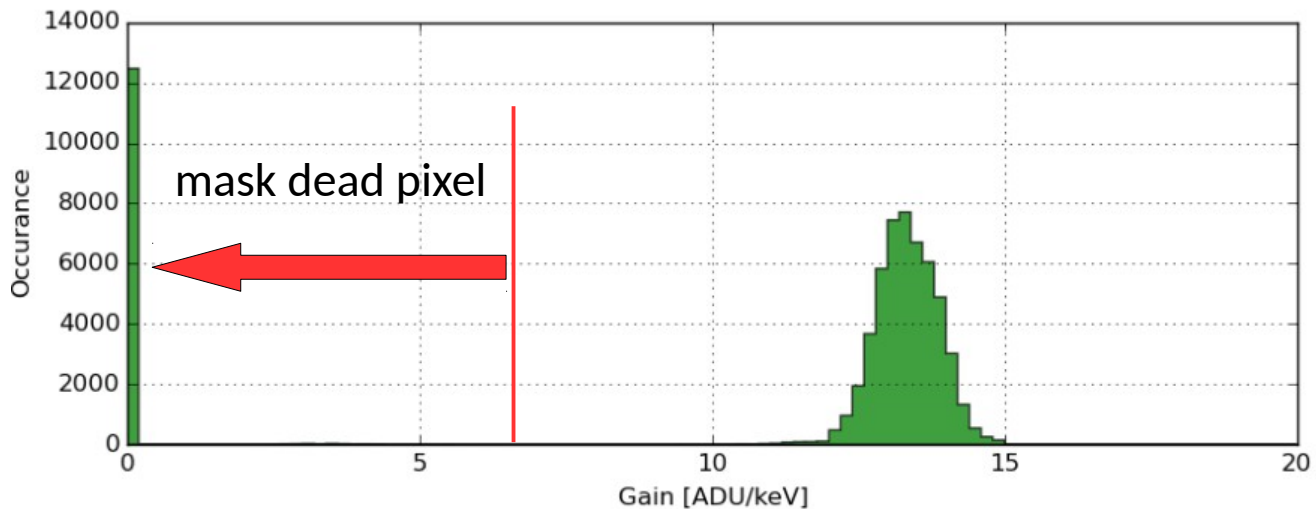
Gain map from photons



- High gain extraction with X-ray photons for a single memory cell (cell-175)



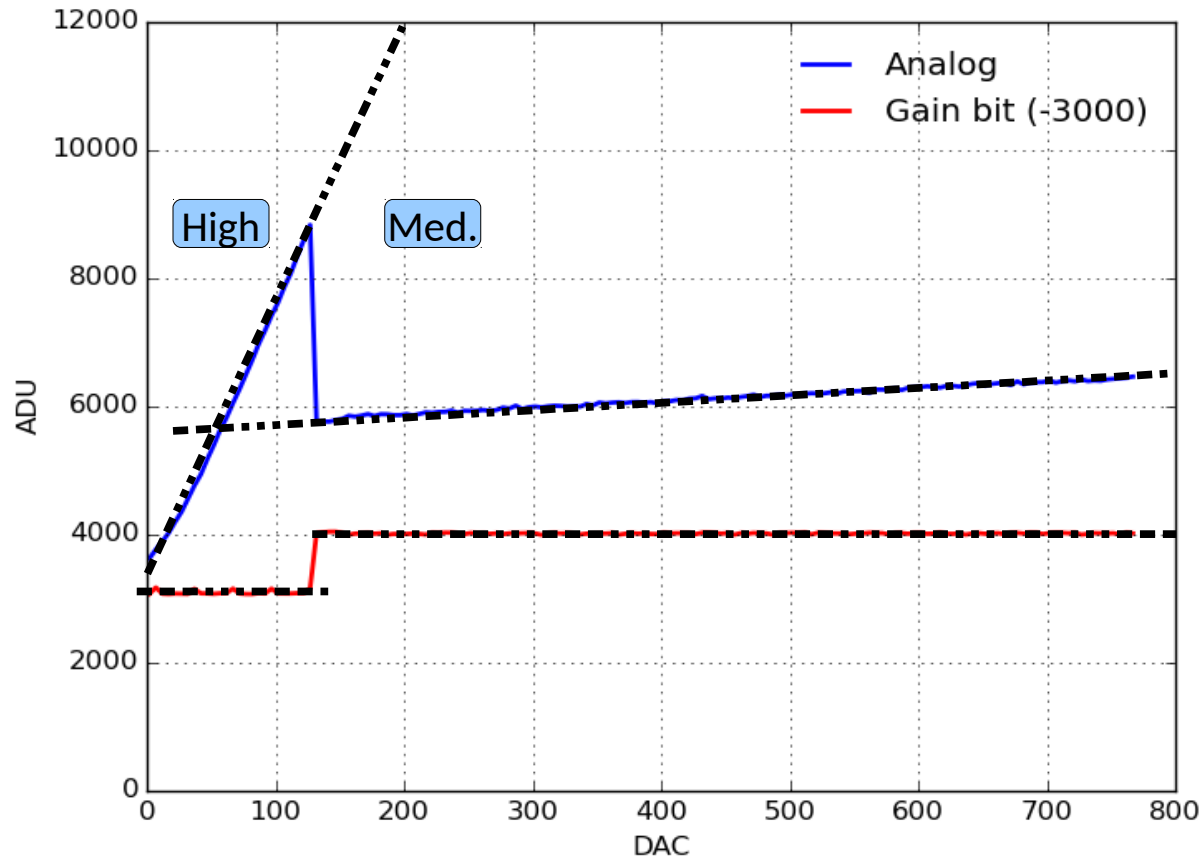
delamination



DR scan with PC



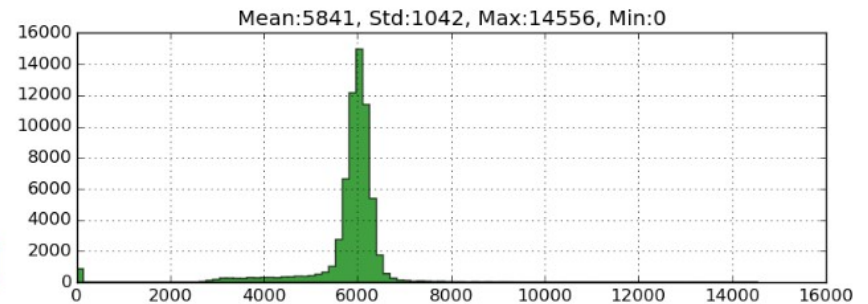
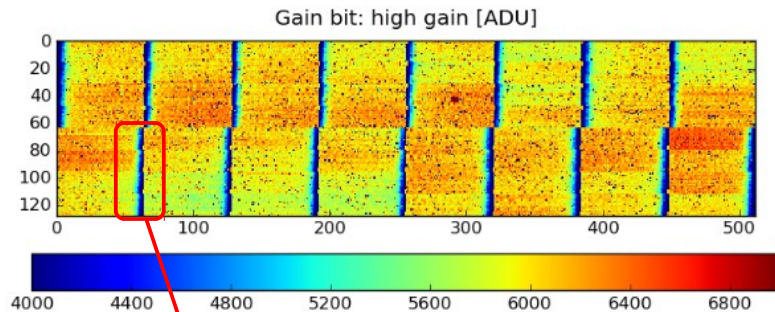
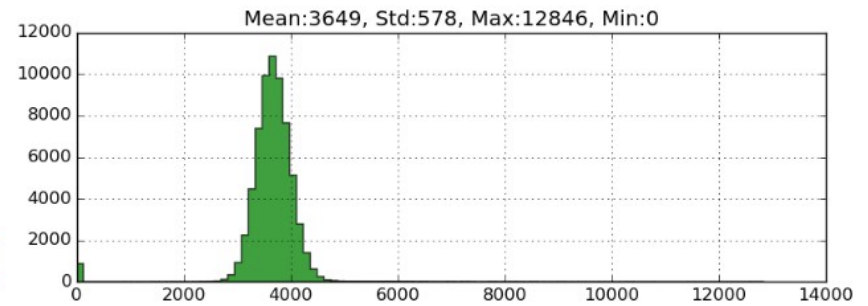
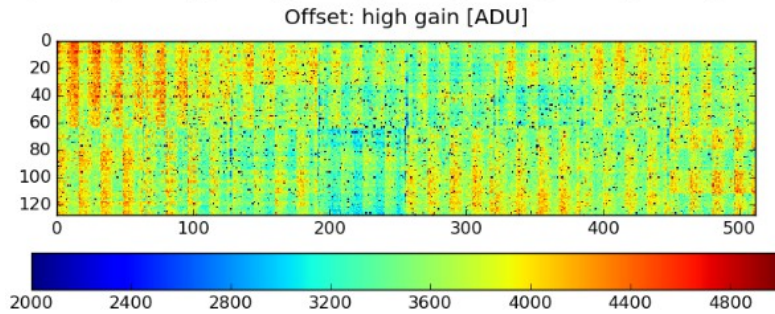
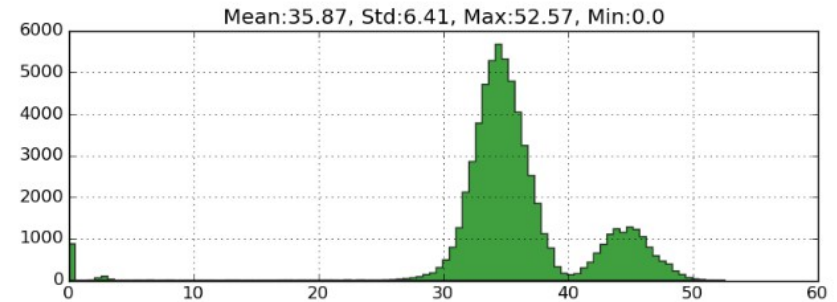
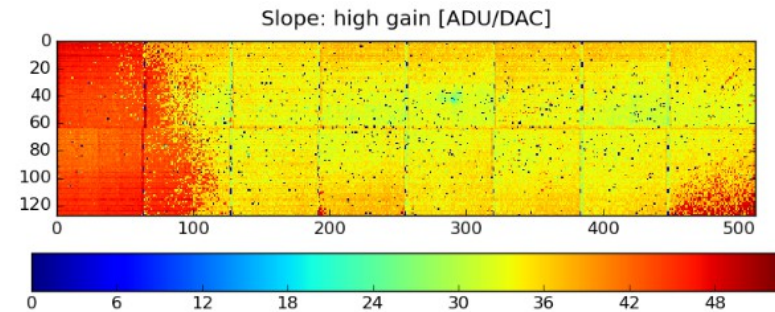
- Extraction of slope (H & M), offset (H & M) and gain bit (H & M)



DR scan with PC



- Results of high gain stage (pixel map for cell-175)

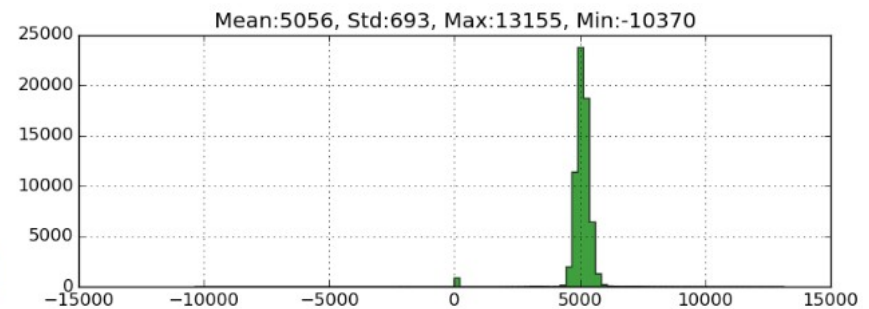
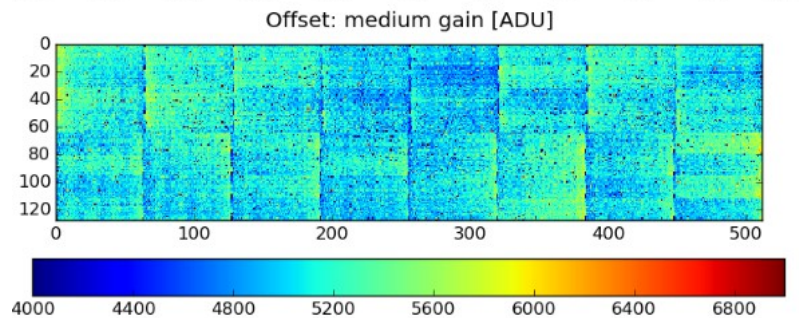
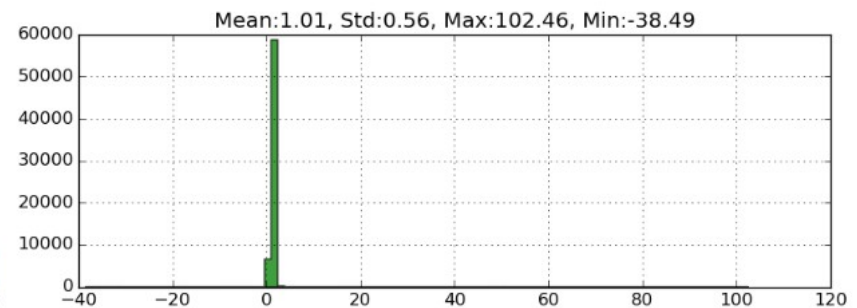
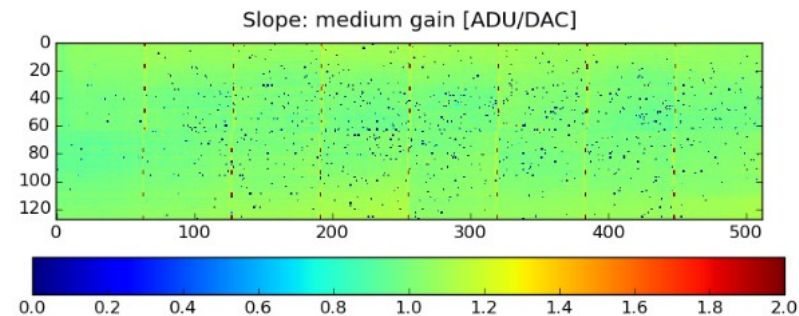


Not enough settling time for VRFPXB → can be improved by increasing settling time!

DR scan with PC



- Results of medium gain stage (pixel map for cell-175)



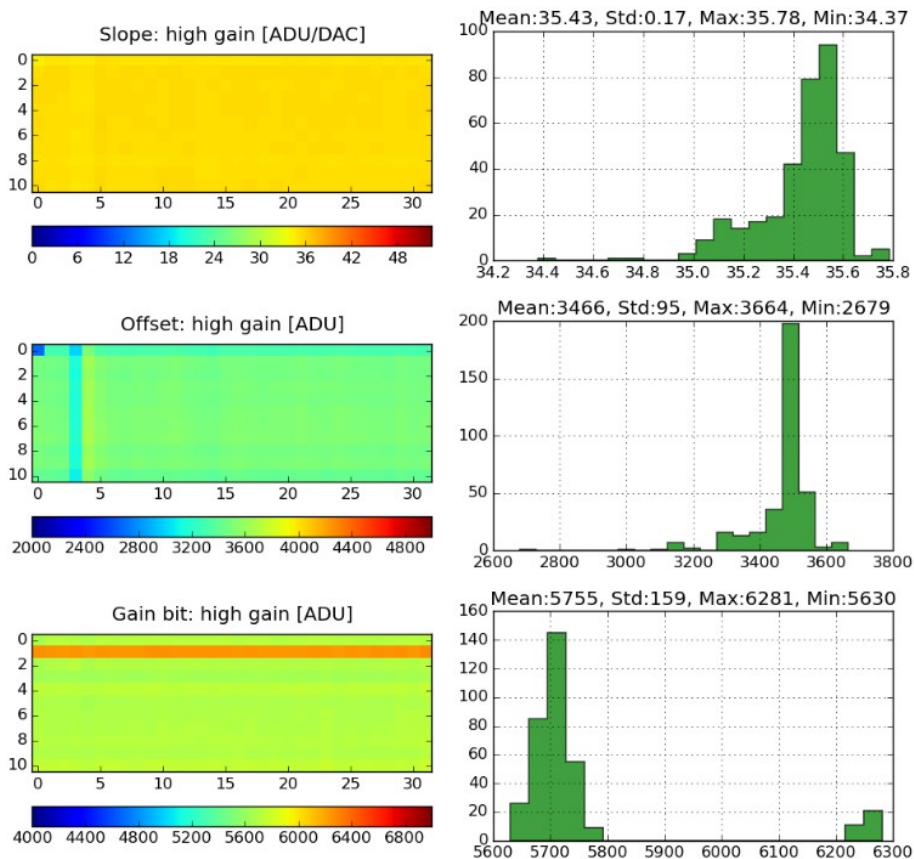
- Delaminated pixels influence the high-gain slope from PC (maskable)
- Uniform high and medium gain slopes over all pixels
- Gradient gain bit level over ASICs → improvable by increasing settling time

DR scan with PC

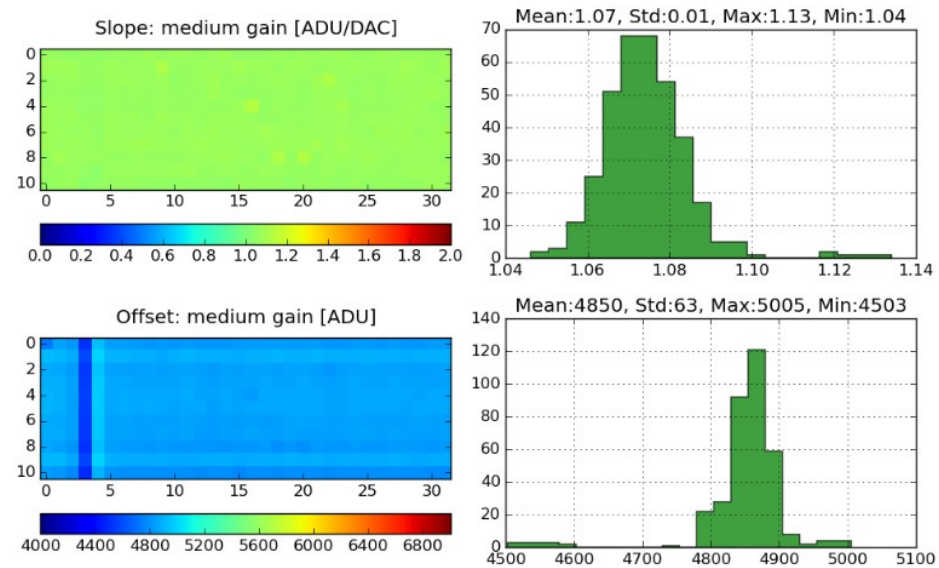


- Cell map of high & medium gain stage (pixel-[20,200])

High gain stage



Medium gain stage

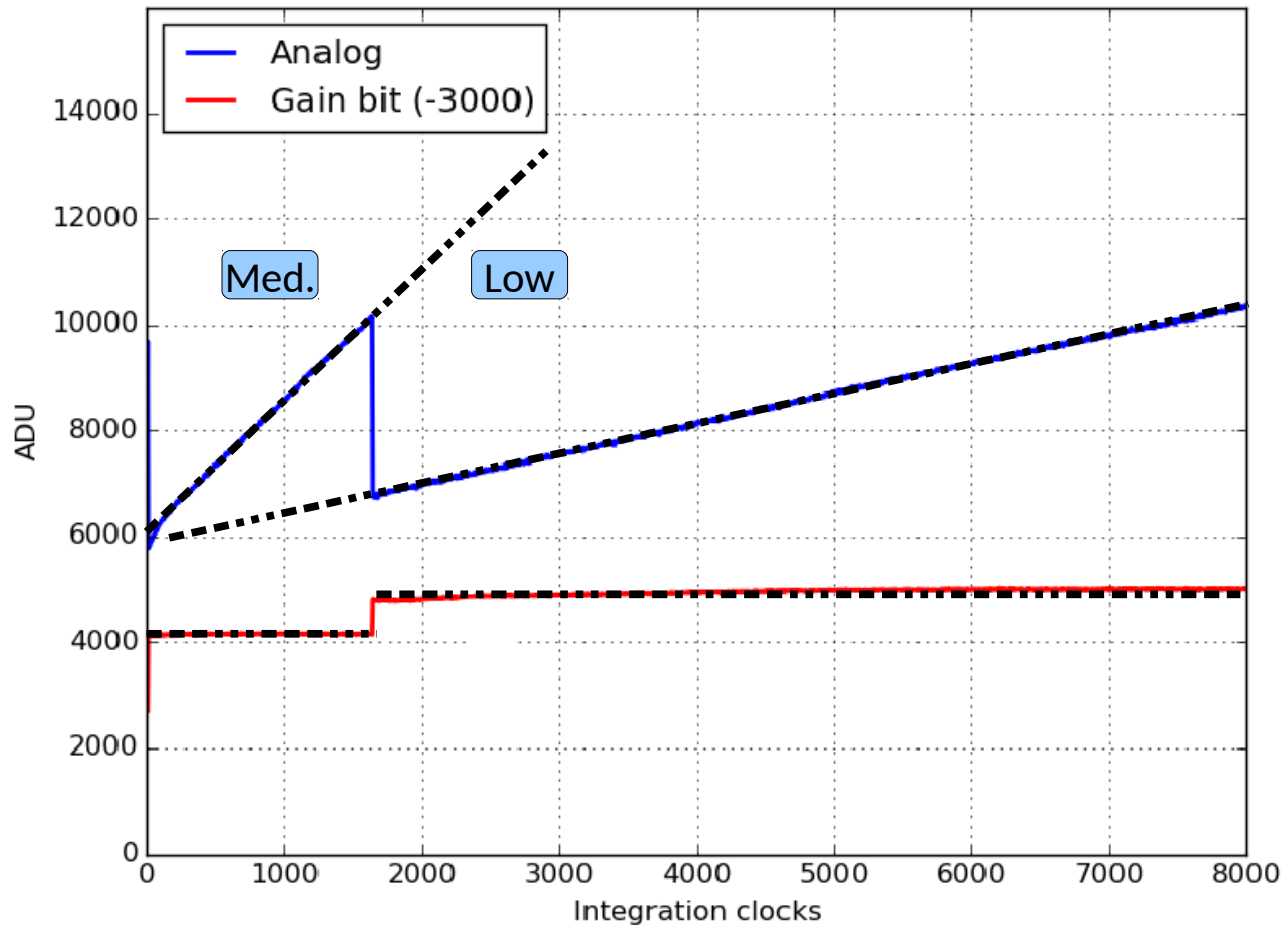


- Consistent results (slope) in high and medium gain stages for all memory cells

DR scan with CS



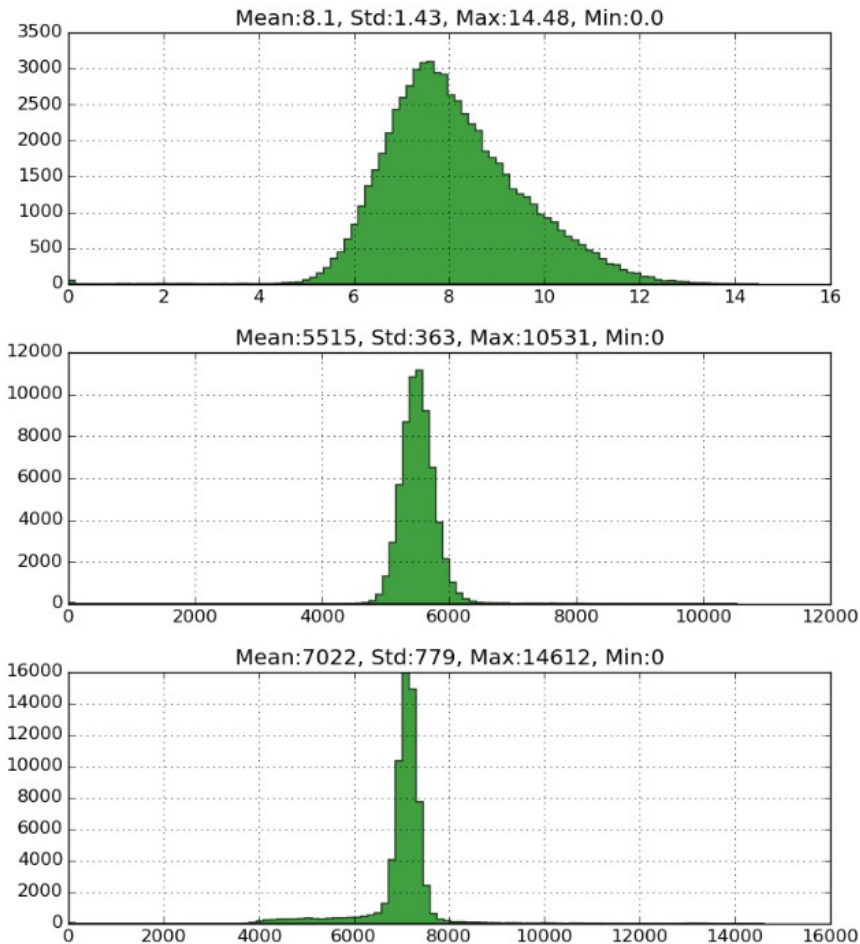
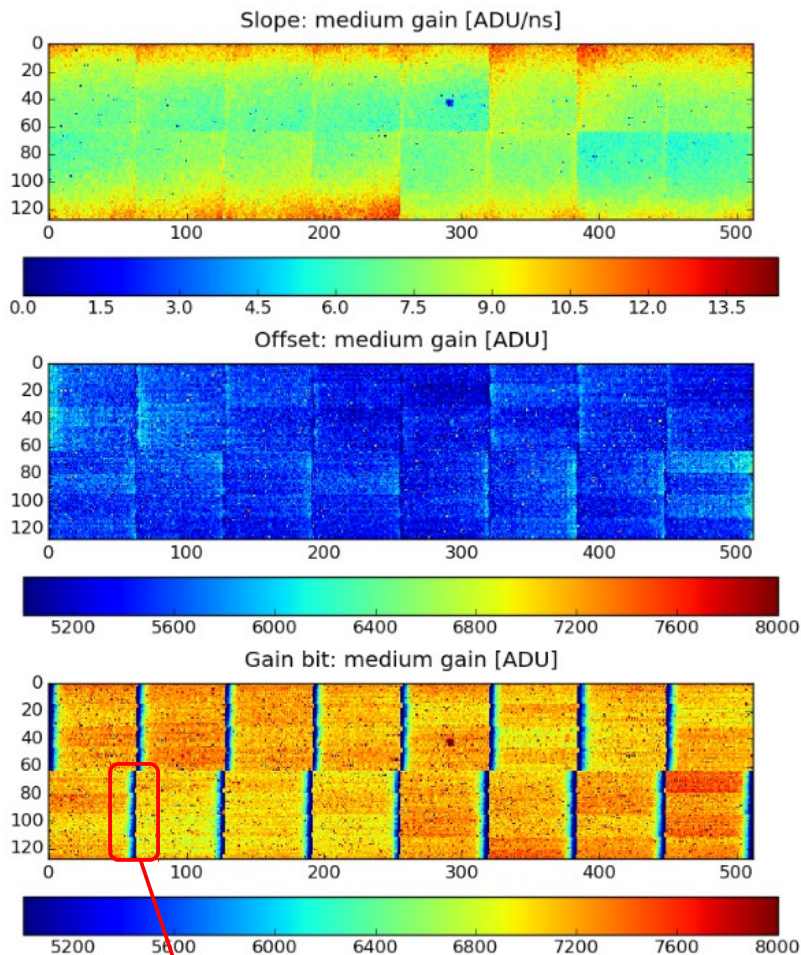
- Extraction of slope (M & L), offset (M & L) and gain bit (M & L)



DR scan with CS



- Medium gain stage (pixel map for cell-175)

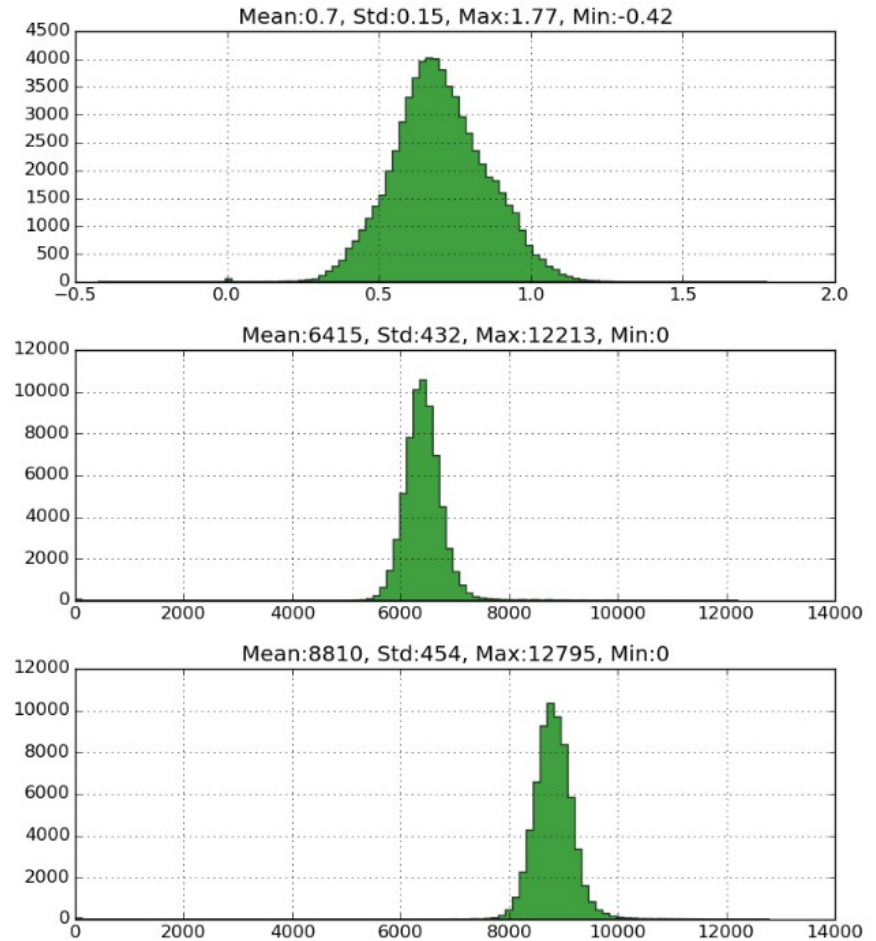
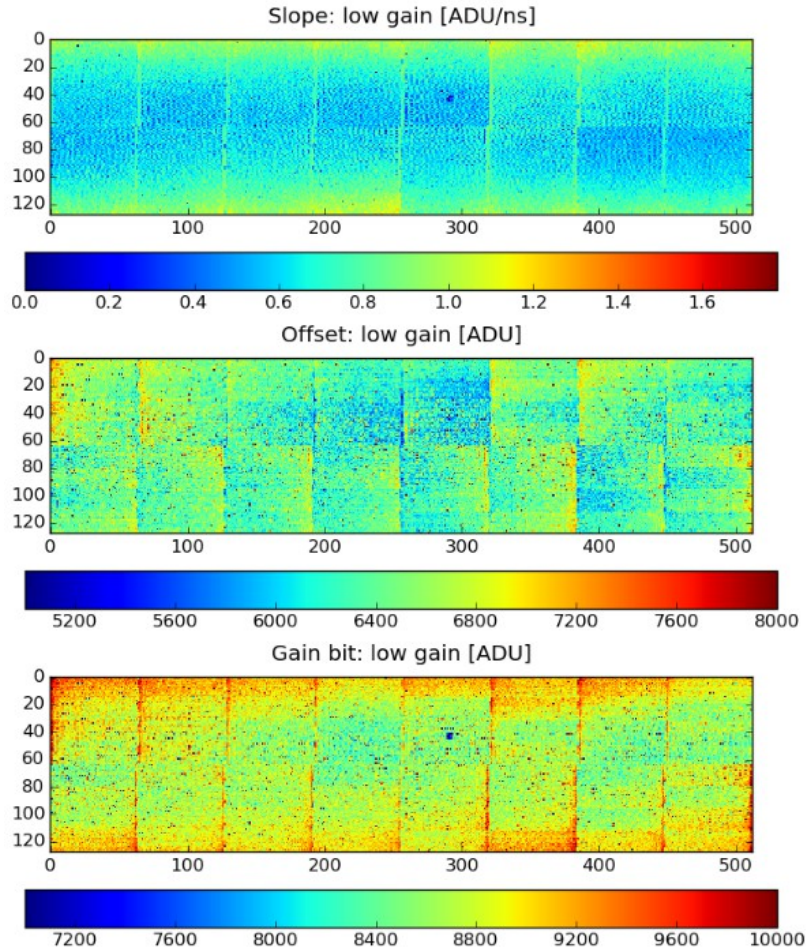


Not enough settling time for VRFPXB → can be improved by increasing settling time!

DR scan with CS



- Low gain stage (pixel map for cell-175)

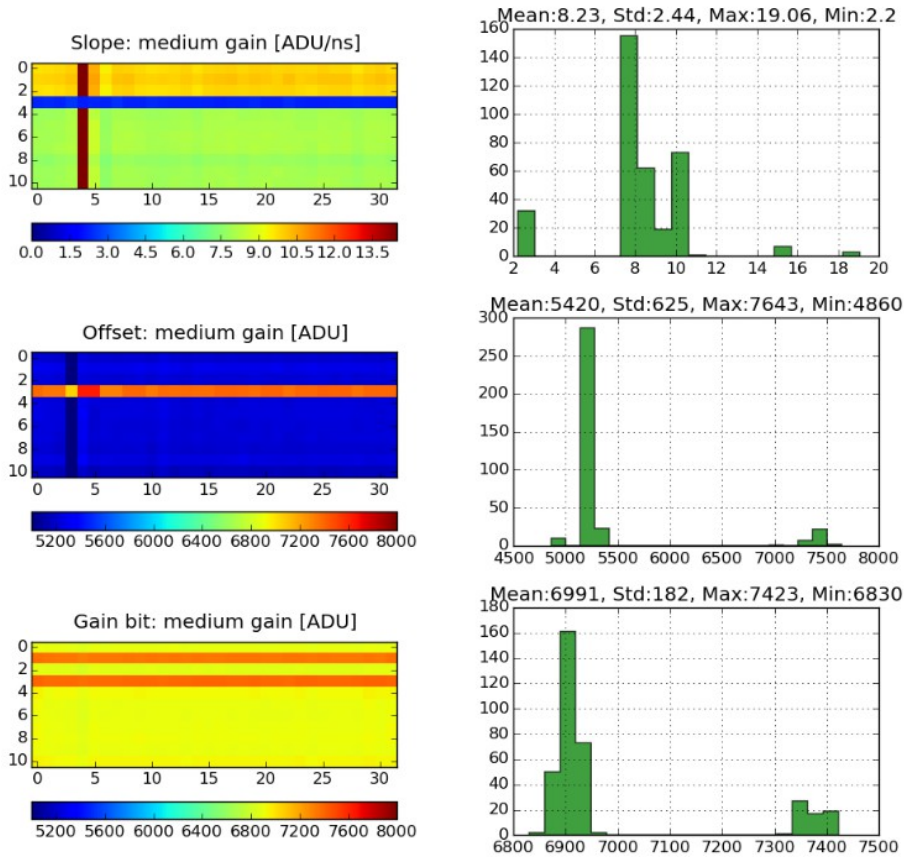


DR scan with CS

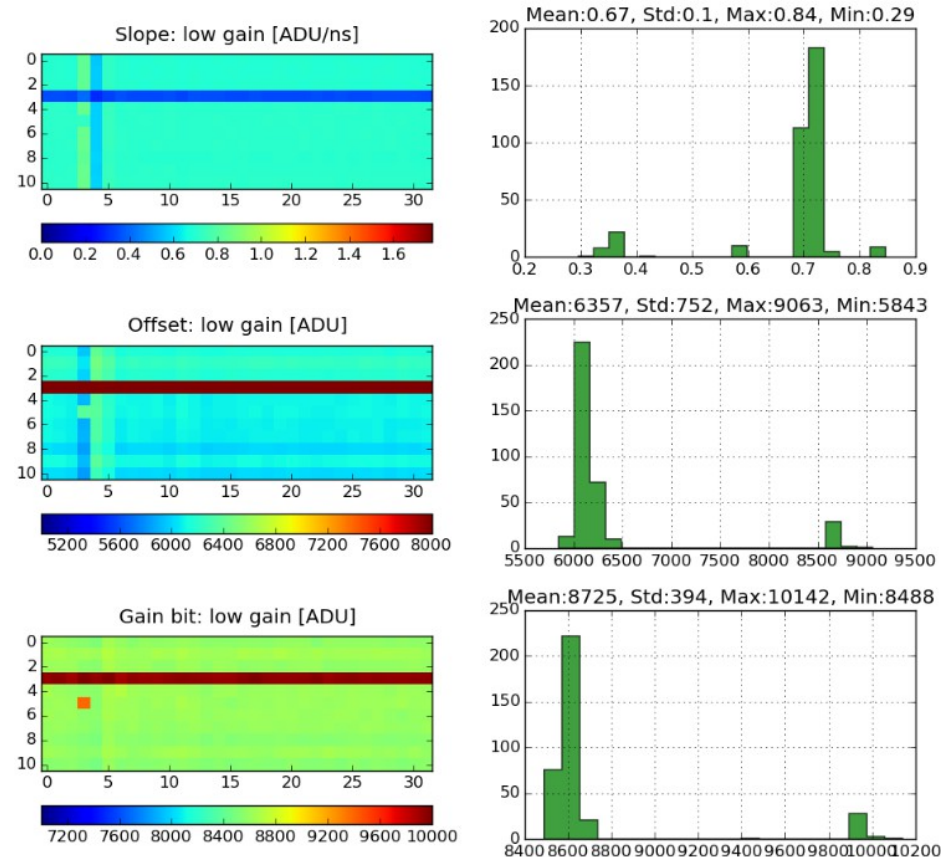


- Cell map of high & medium gain stage (pixel-[20,200])

Medium gain stage



low gain stage

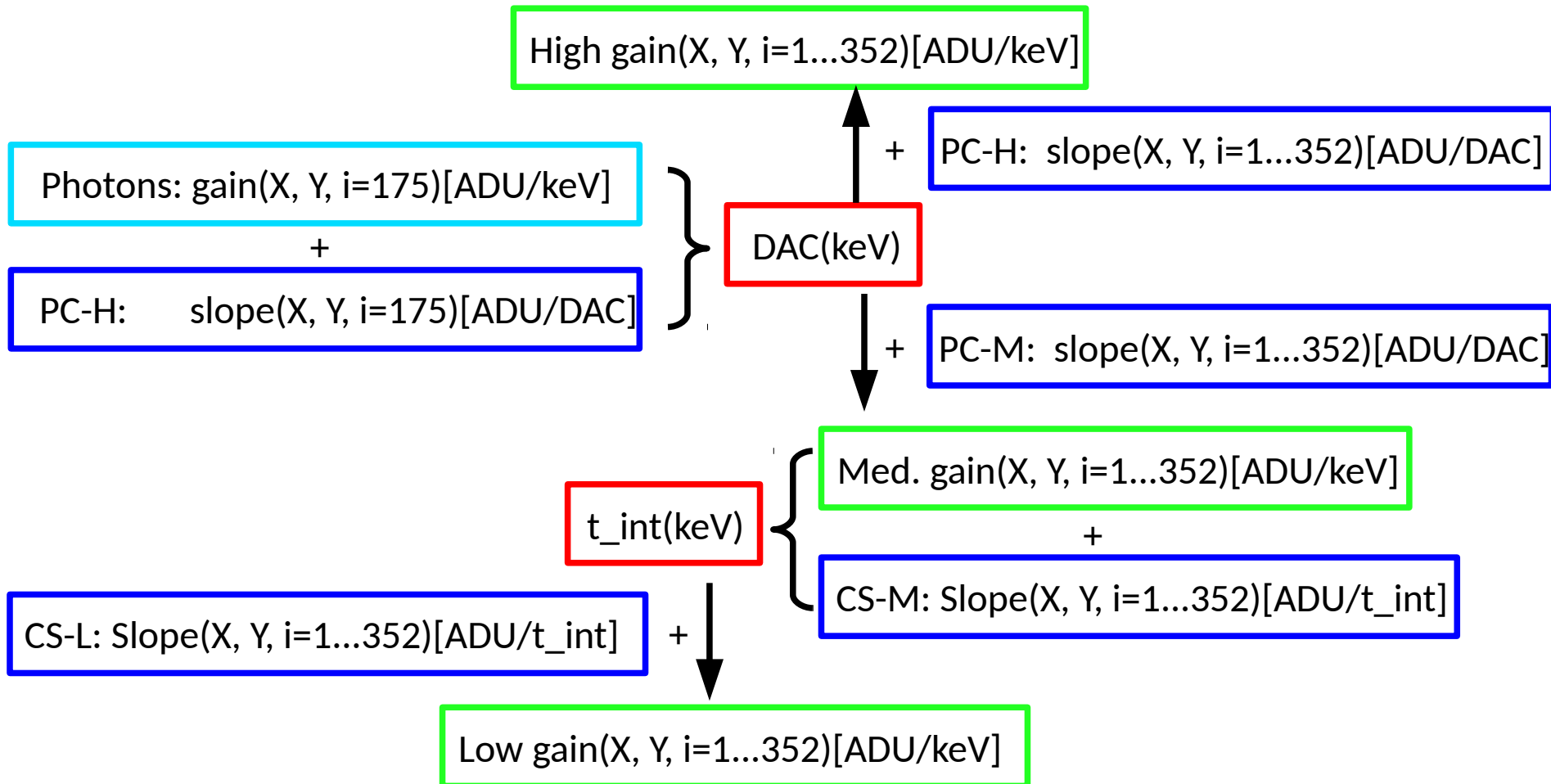


– Memory cell row & column dependent ← cross talk

Gain conversion



- DAC-to-keV and t_{int} -to-keV conversion:

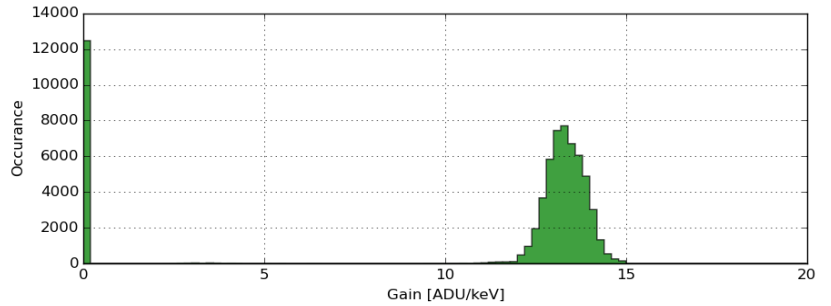
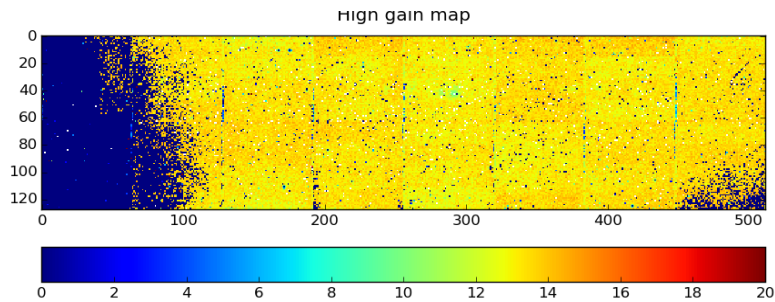


Gain map

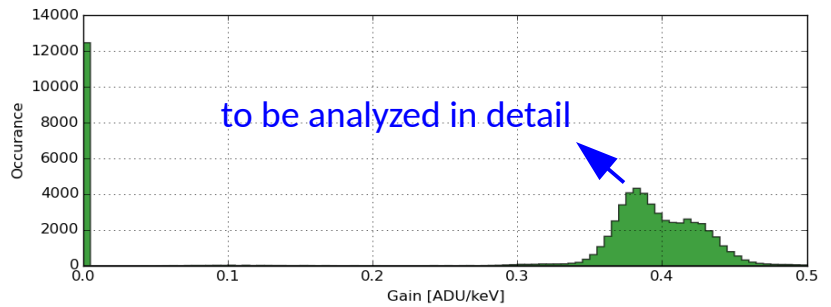
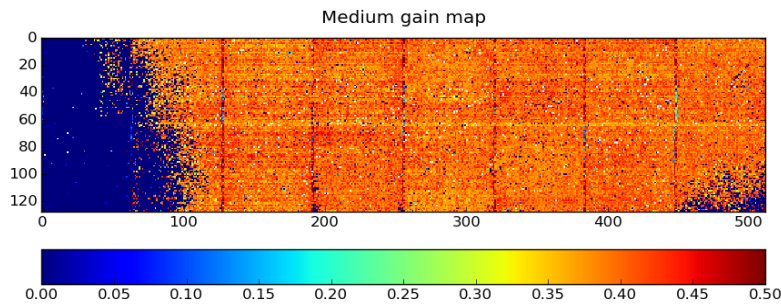


- Gain map (pixel map for cell-175)

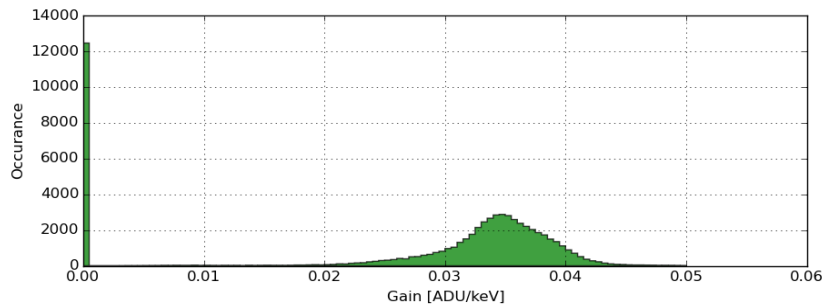
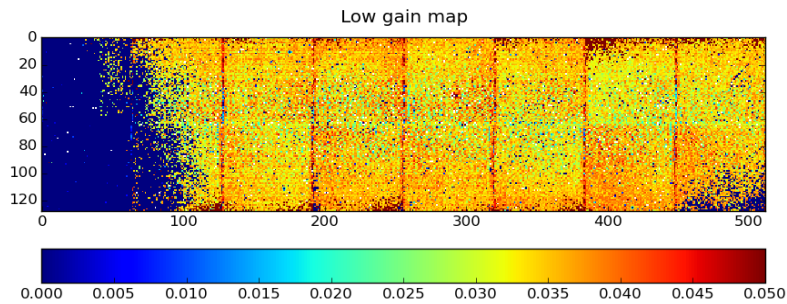
High



Med.



Low

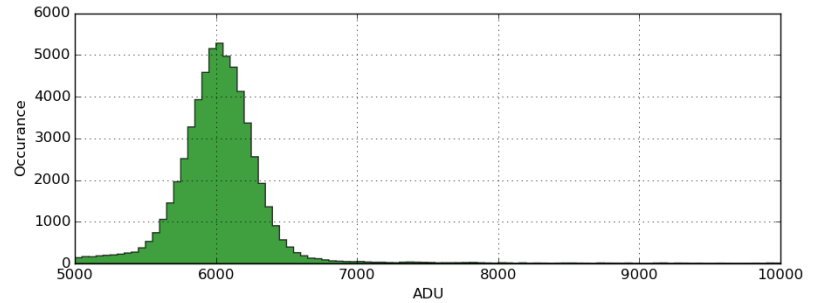
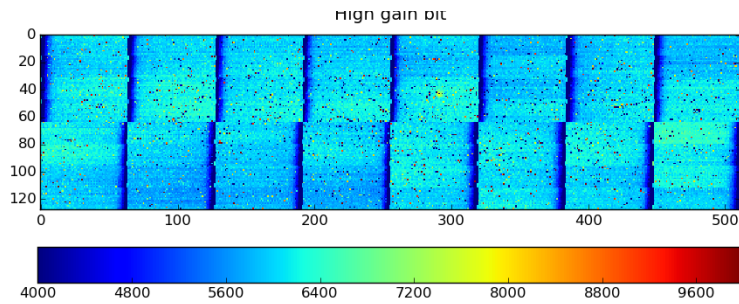


Gain bit map

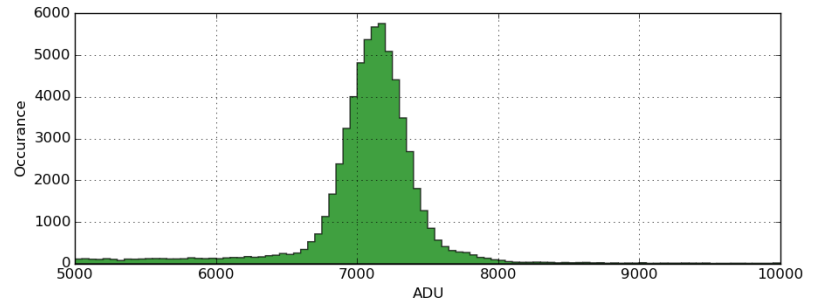
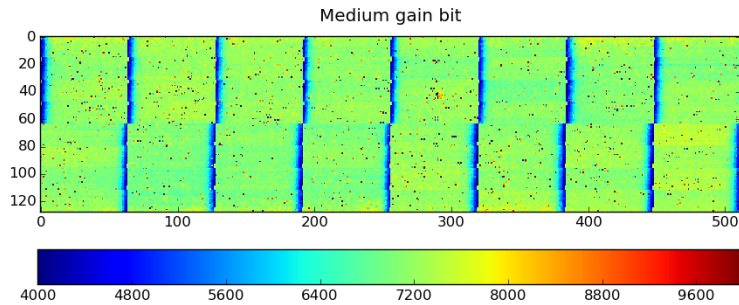


- Gain bit map (pixel map for cell-175)

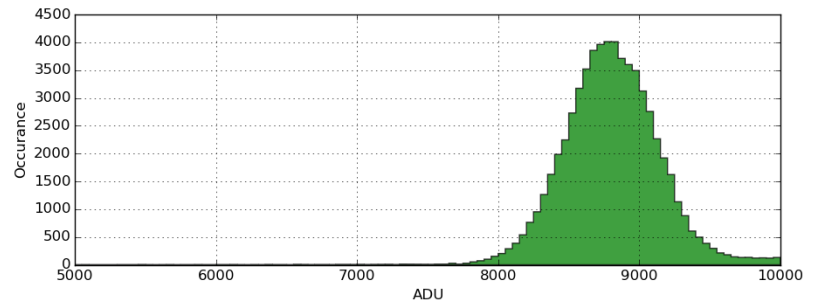
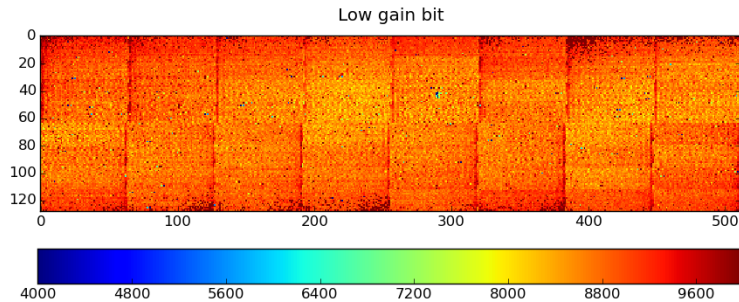
High



Med.



Low



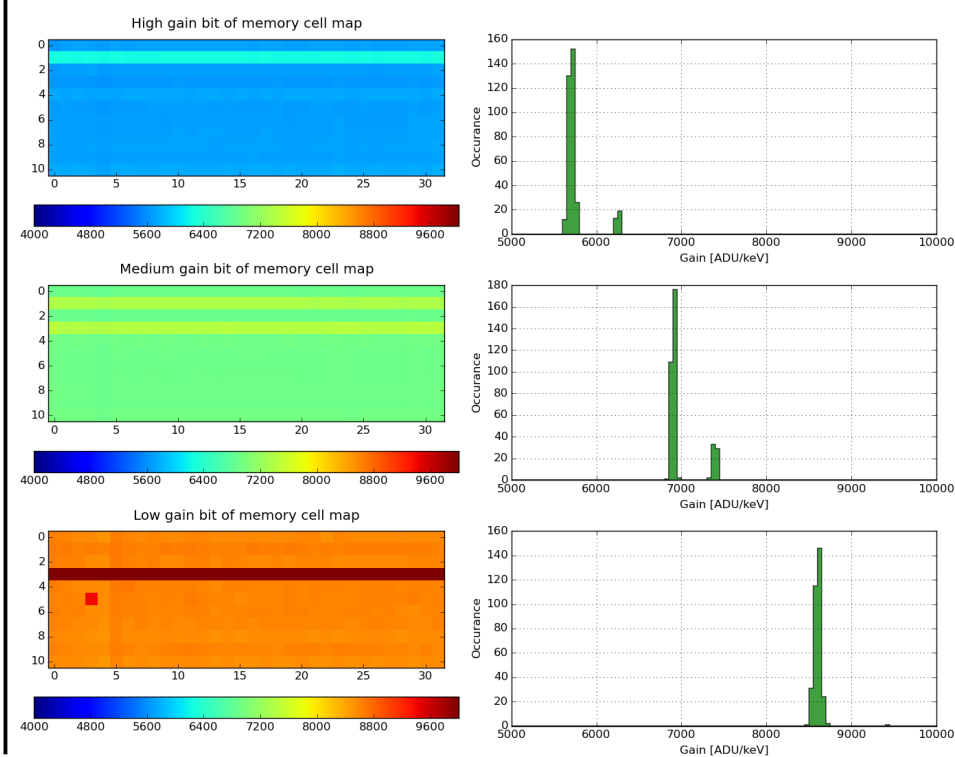
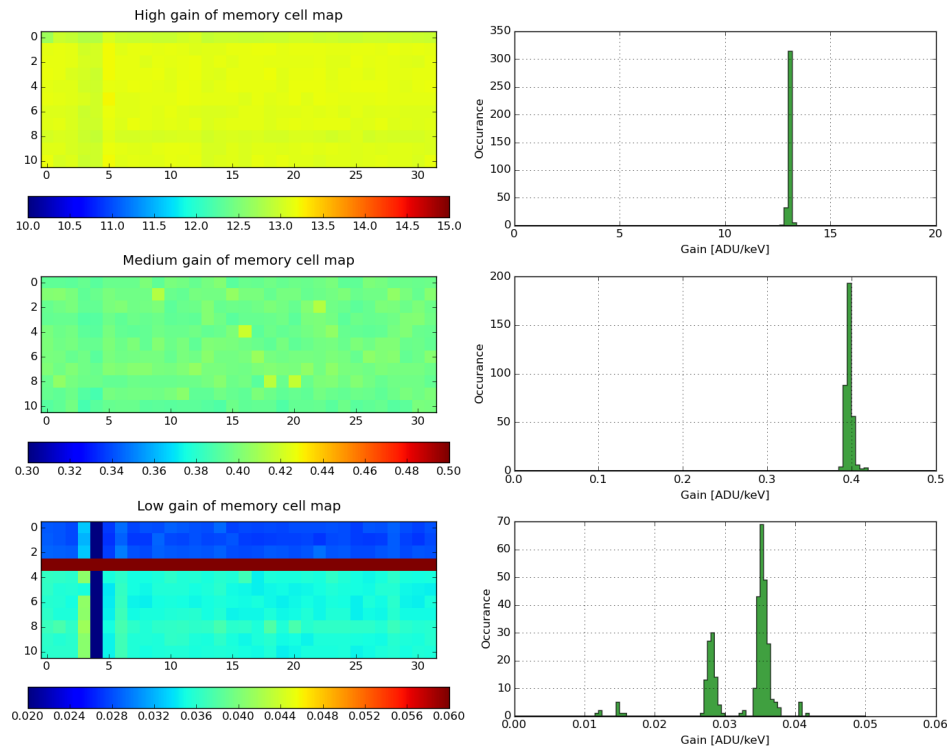
Gain and gain bit map



- Gain and gain bit map (cell map for pixel-[20,200])

Gain cell-map

Gain bit cell-map

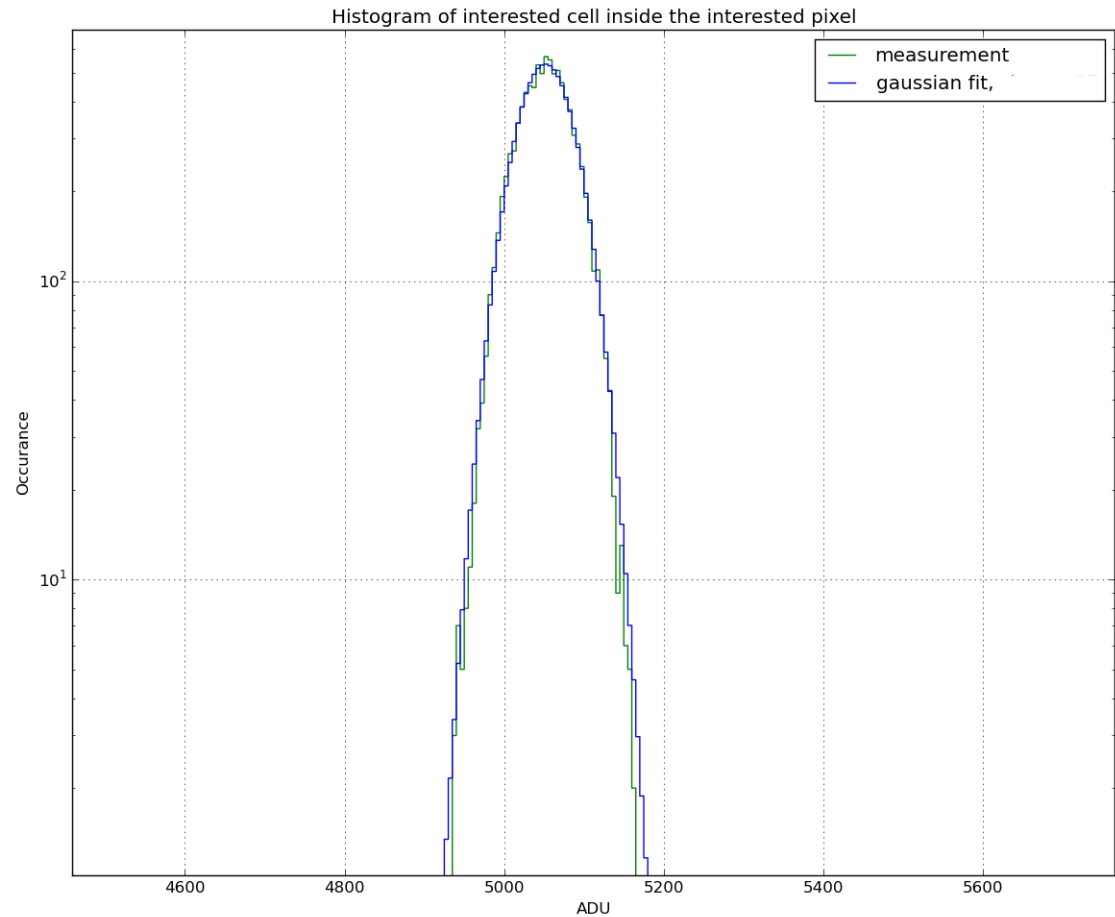


- Consistent gain for all memory cell unit (H & M)
- Cell dependent gain bit level → calibratable on the cell basis

Noise



- Dark measurements in light shielded environment
 - 352 memory cells
 - 10 us integration time
 - Gaussian fitting
 - Sigma extracted

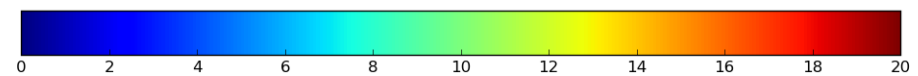
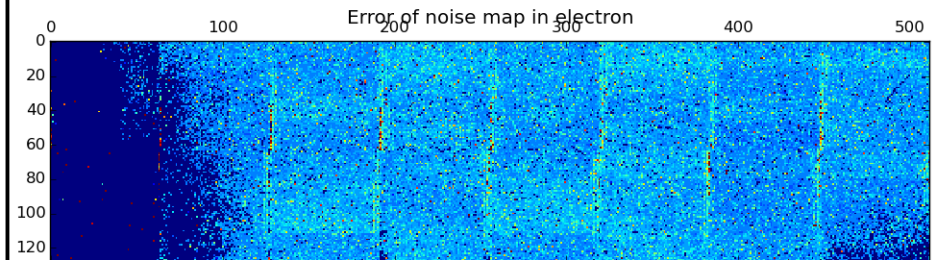
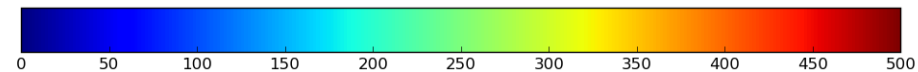
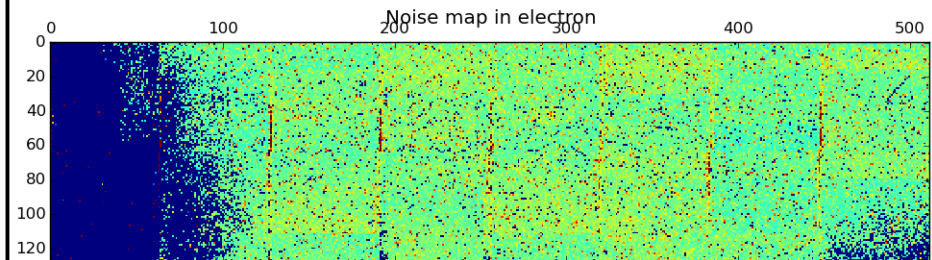
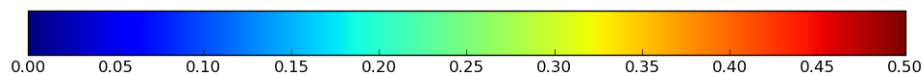
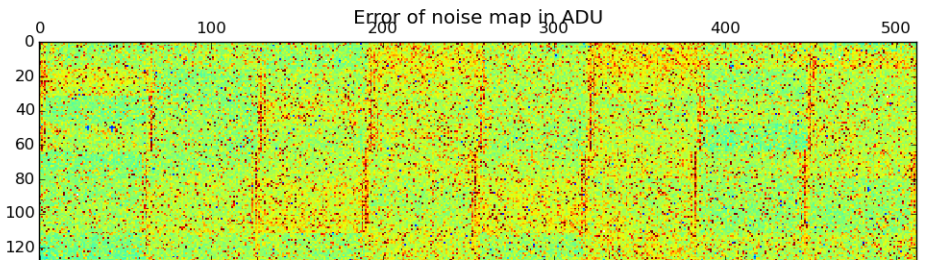
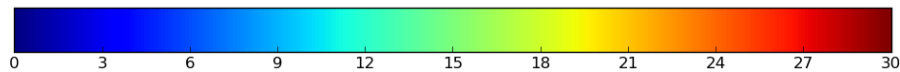
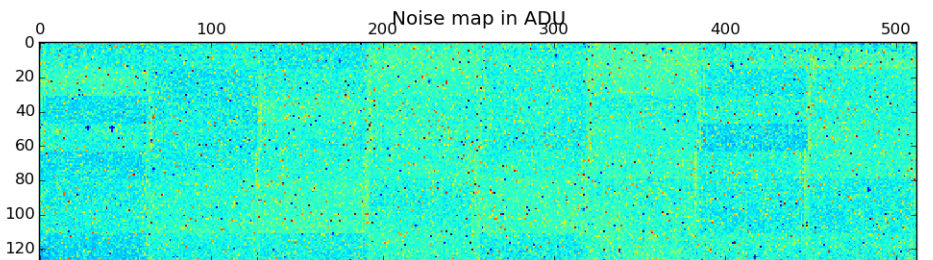


Noise map



- Noise pixel-map (cell-175)

Noise in ADU + high gain map → Noise in electrons



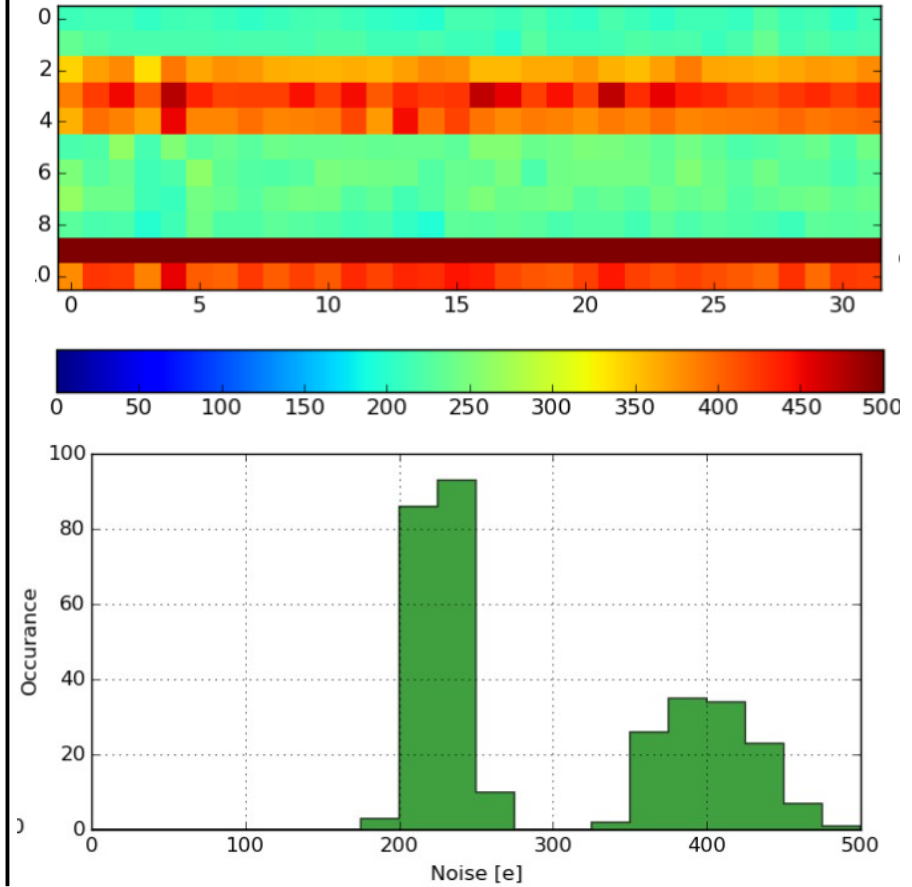
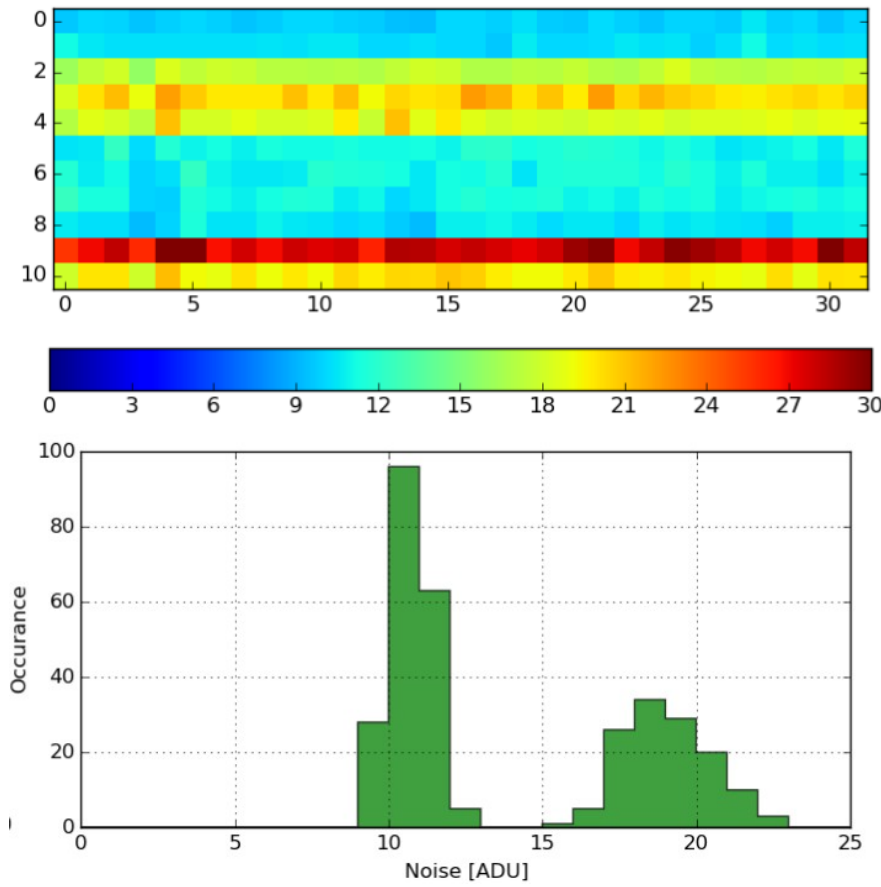
– 220 e⁻ for most of pixels (@ 15 degree C) → can be improved at low temperature

Noise map



- Noise cell-map (pixel-[20,200])

Noise in ADU + high gain map → Noise in electrons

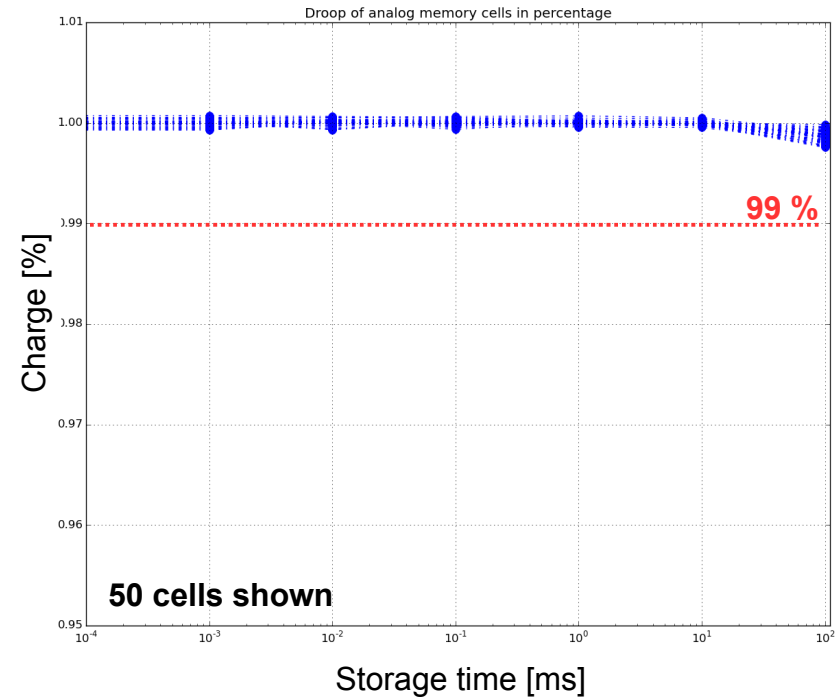
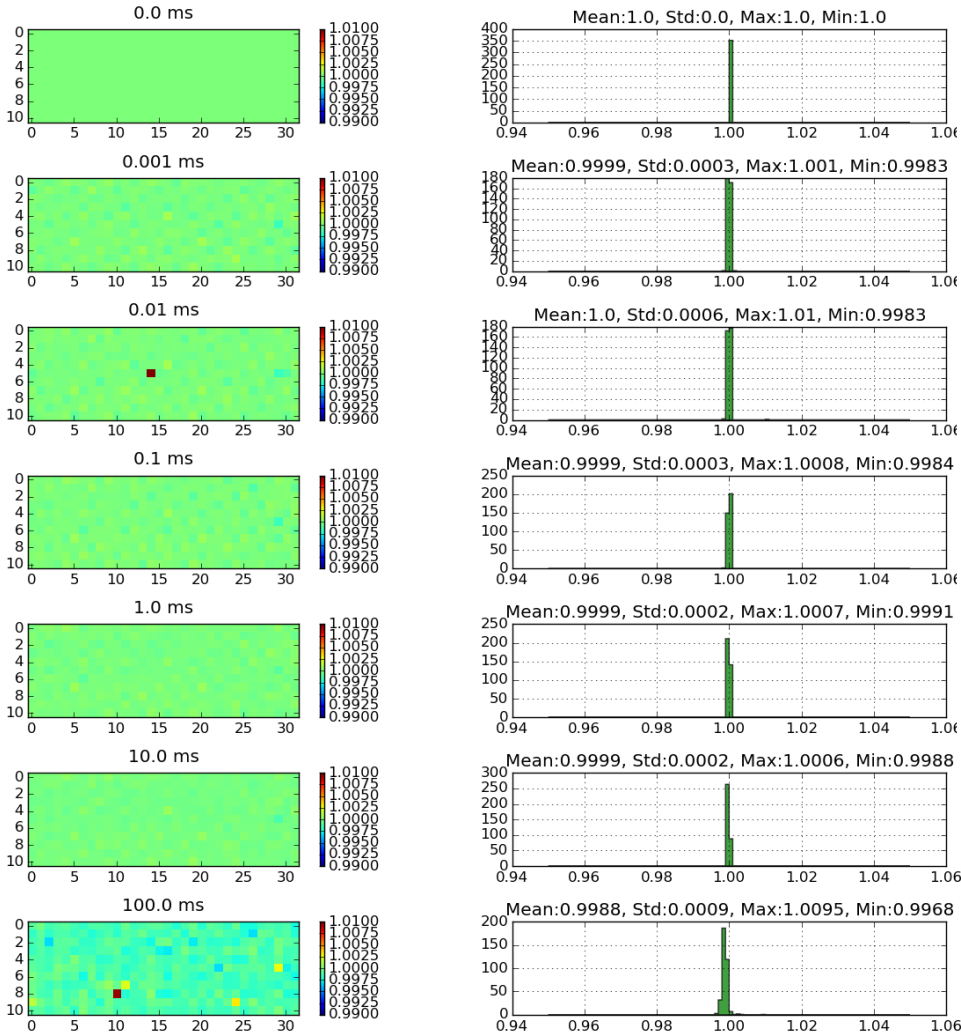


More investigations and compare to different methods → has to be confirmed/understood!

Droop



- Droop as function of storage time: 0 (direct write & read), 10, 100 us, 1, 10, 100 ms

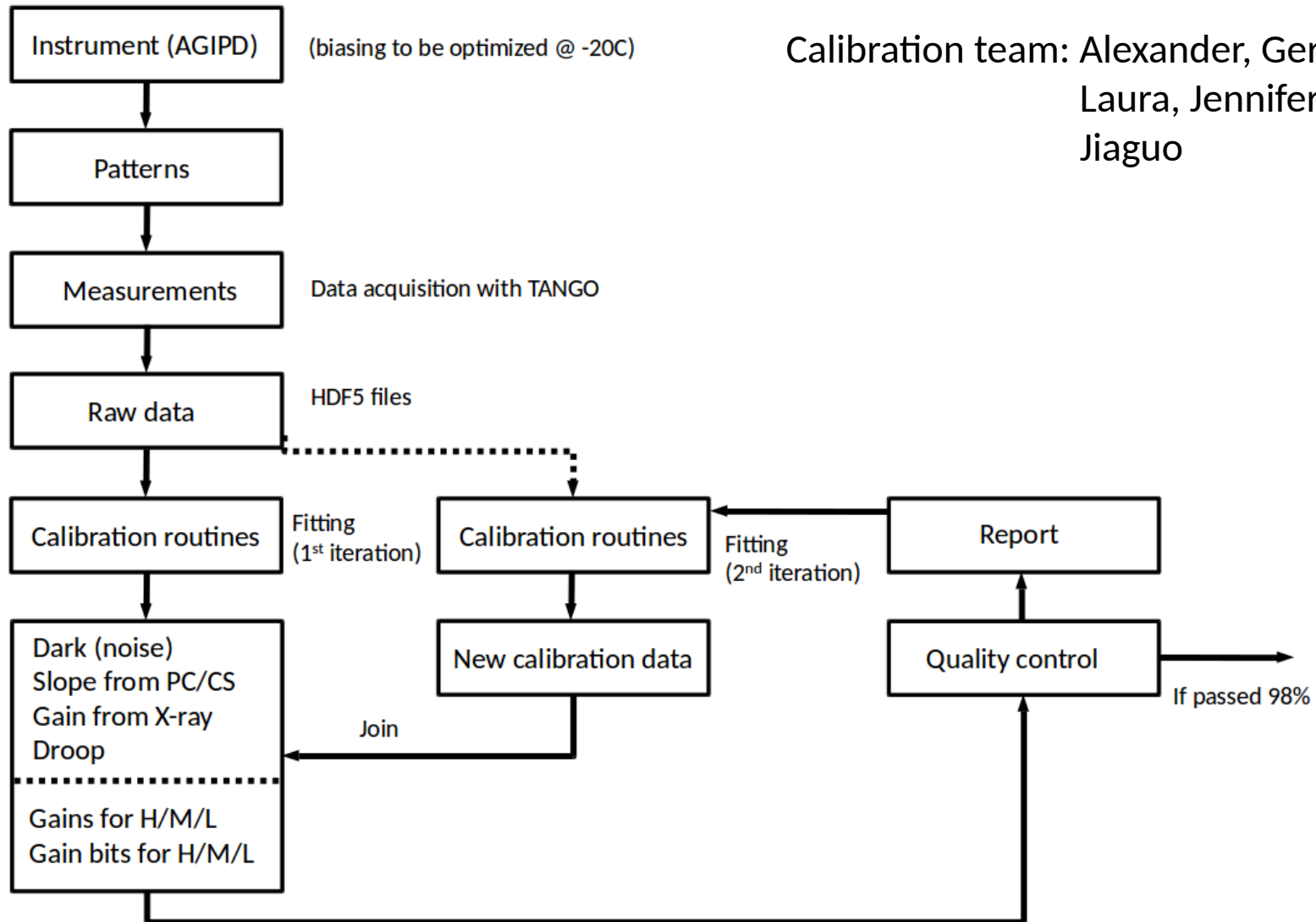


- Without irradiation: droop < 1%
- After irradiation & droop due to switching are under investigation

Calibration “framework”



Calibration team: Alexander, Gerard, Laura, Jennifer and Jiaguo

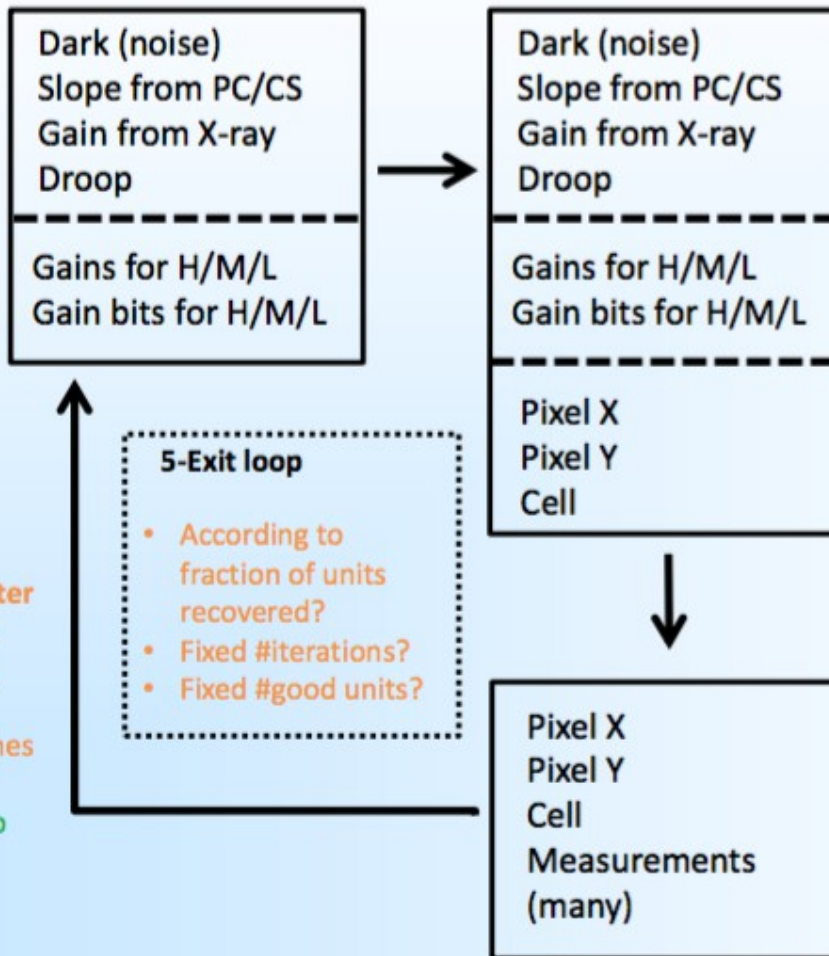


Quality control



1-Processed data

- **3D matrix**
 - D1: Pixel X
 - D2: Pixel Y
 - D3: Cell
- **5 groups of data**
- **Final gain and gain bits for H/M/L** evaluated according to the information in the 5 groups of data



4-Reprocess data

- **Fit again to obtain better values of:** noise, slope from PC/CS, gain x-ray, droop
- **Define better approaches to the fittings**
- **Reinstert new data into old one**

2-N-tuple

- **Event structure**
- Each module has 512 (pixel Y) x 128 (pixel X) x 352 (cells/pixel) = **23068672 memory units (=events)**.
- **Extra magnitudes are evaluated** (i.e. ratio between high gain and medium gain of pulse capacitor).
- **Representation of PIXEL/CELL MAP:** scatter plot of memory units for a particular pixel/cell that fulfill a certain condition (i.e. high gain > 30).
- **Define criterion of quality:**
 - Which magnitudes to evaluate?
 - Which threshold?

3-Report

- **2D matrix** (1 event per row).
- Measurements (m) expressed as the distance from the mean in sigma units $m=(x-\text{mean})/\text{sigma}$, x:value this m.u., mean and sigma of the distribution of all m.u.
- **Include extra processed information:** electronically dead? disconnected?



- **Calibration procedure and “framework” established**
- **QC (→ Gerard) and re-fitting procedures (→ Jennifer) under development**
- **First module calibrated**
 - Gains, offsets, gain bits, noise and droop
 - Delivered to XFEL in Sept.
 - Gain bit uniformity improvable with more settling time
- **What is missing and to be understood:**
 - Fitting error and error propagation to “final” results
 - Reliable droop measurement procedure (burst droop) @ different T and irradiations
 - ASIC bias optimization at -20 C
 - DAQ software for 10 G implemented multi-module system
 - All routines adapted to HDF data format compatible

