UNIVERSIDADE FEDERAL DE JUIZ DE FORA

PPEE Programa de Pós-Graduação em Engenharia Elétrica UFJF

sCMOS Pedestal Studies

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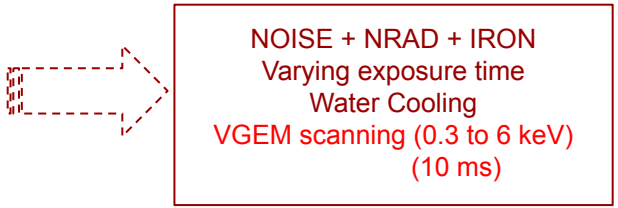
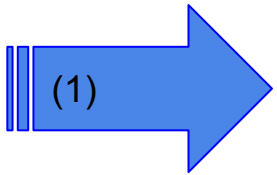
Introduction

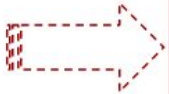
Three setups have been used:

- (1)
  - Orca Flash
  - Orca Fusion
  - Teledyne BSI (HDR and CMS modes)
- (2)
  - Orca Fusion
- (3)
  - Thorit
  - Orca Fusion BT
  - Orca Quest





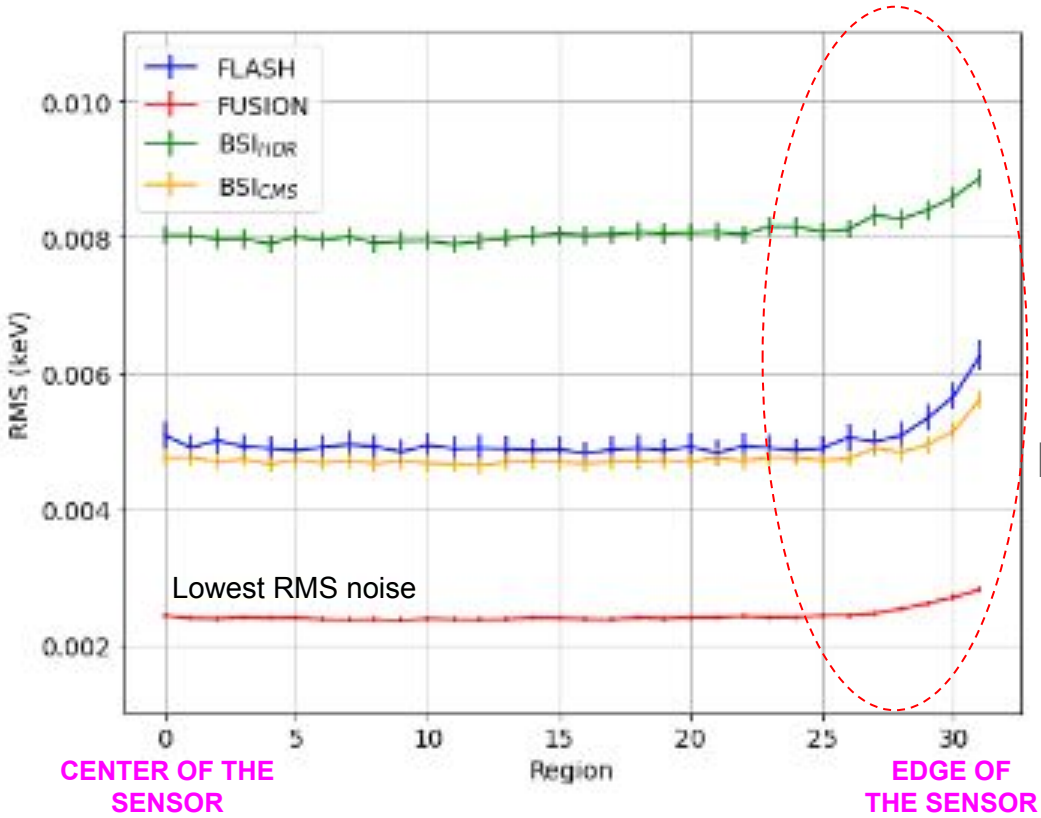
- (1)
  - Orca Flash
  - Orca Fusion
  - Teledyne BSI (HDR and CMS modes)

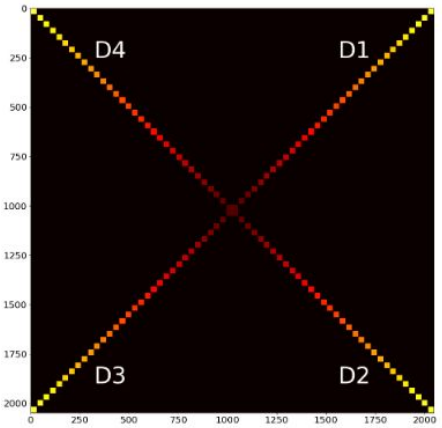


NOISE + IRON
30 ms exposure time
Air Cooling

Measurements - RMS noise

30 ms exposure time

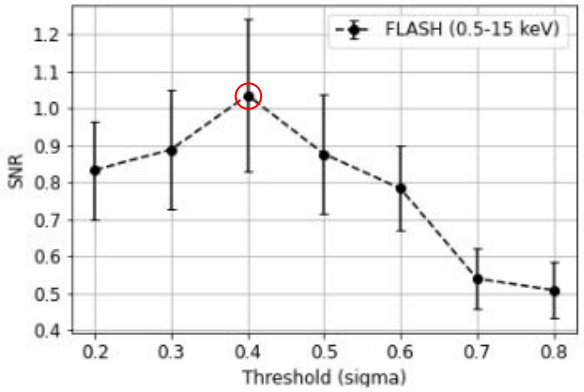


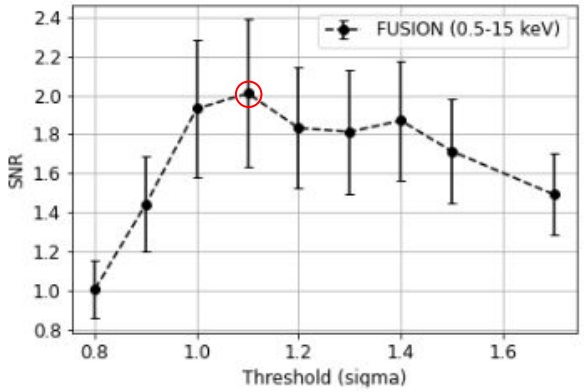


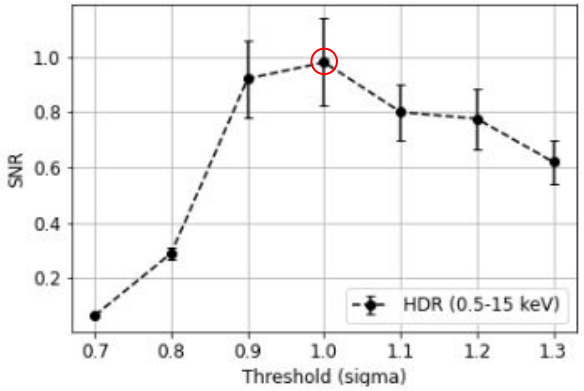
Border effect

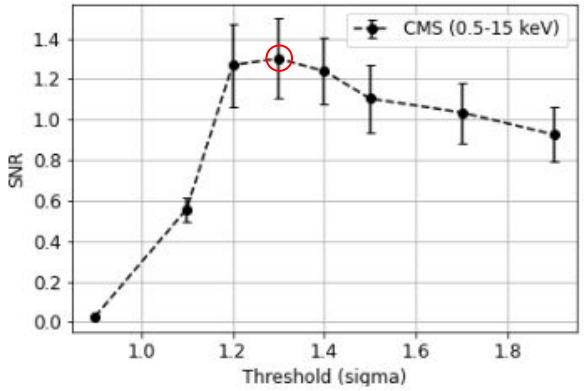
Measurements - Fake clusters

30 ms exposure time





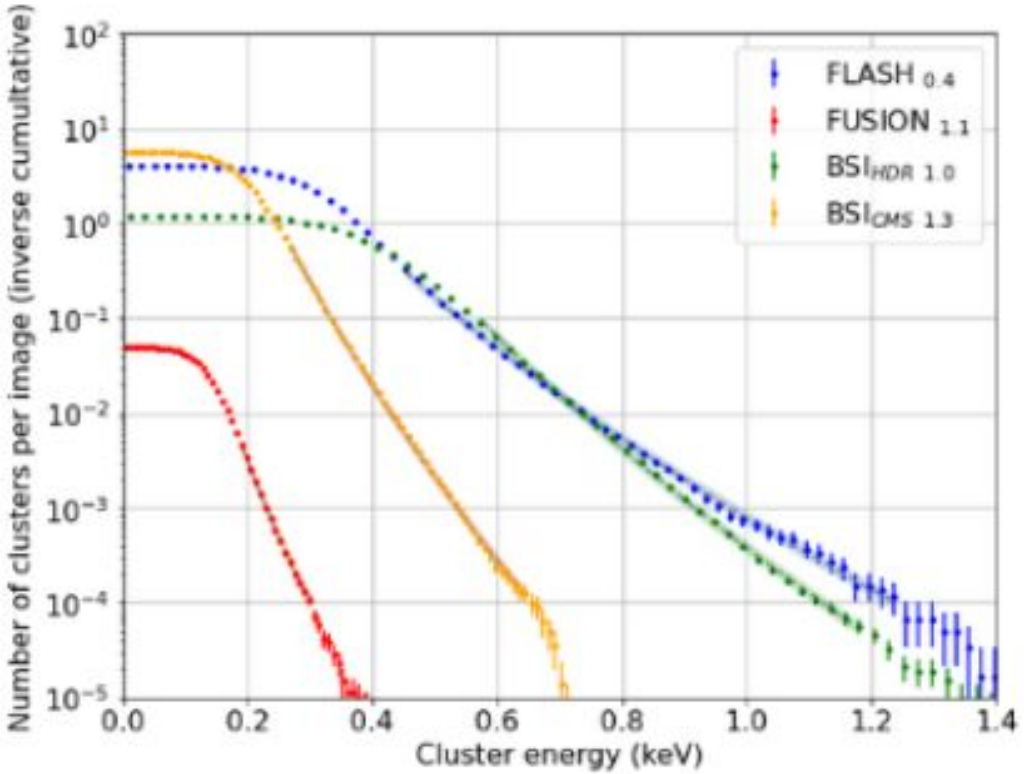




Threshold scanning to select a threshold value per sensor → best SNR

Measurements - Fake clusters

30 ms exposure time



Measurements - Fake clusters

30 ms exposure time

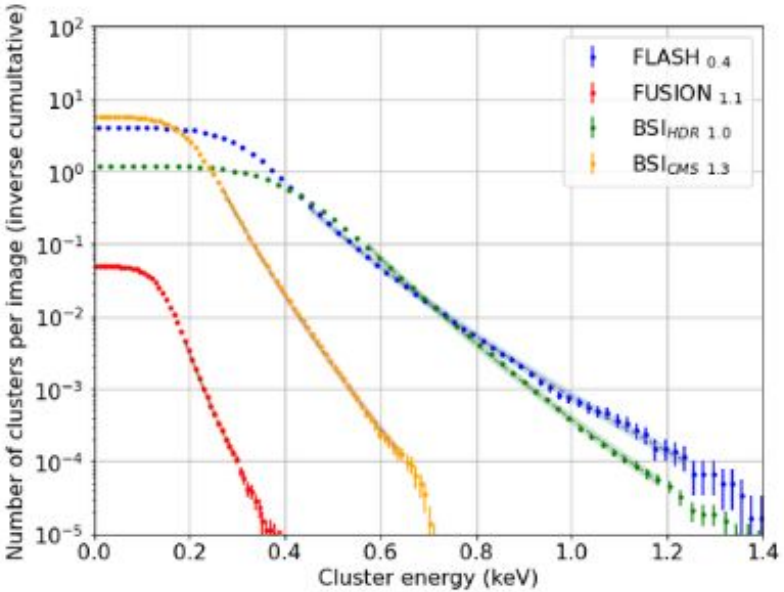
Table 4. Expected rate per image of fake clusters with energies higher than 0.5, 1, 2 and 3 keV.

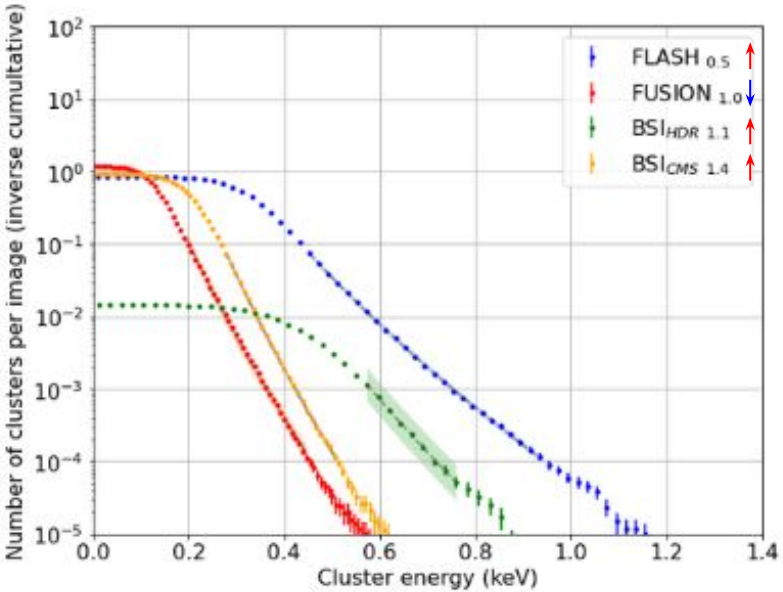
Energy (keV)	*Flash* 0.4	*Fusion* 1.1	BSI_{HDR} 1.0	BSI_{CMS} 1.3
> 0.5	$(1.7 \pm 0.3) \times 10^{-1}$	$(3.9 \pm 1.3) \times 10^{-7}$	$(3.0 \pm 0.5) \times 10^{-1}$	$(2.0 \pm 0.3) \times 10^{-3}$
> 1.0	$(7.9 \pm 1.5) \times 10^{-4}$	$(1.6 \pm 0.7) \times 10^{-11}$	$(3.8 \pm 0.7) \times 10^{-4}$	$(3.1 \pm 0.6) \times 10^{-7}$
> 2.0	$(4.1 \pm 1.0) \times 10^{-8}$	$(9.8 \pm 5.4) \times 10^{-18}$	$(3.1 \pm 0.7) \times 10^{-8}$	$(1.2 \pm 0.3) \times 10^{-12}$
> 3.0	$(1.2 \pm 0.3) \times 10^{-9}$	$(1.7 \pm 1.1) \times 10^{-22}$	$(2.3 \pm 0.6) \times 10^{-11}$	$(8.8 \pm 2.8) \times 10^{-17}$

Measurements - Fake clusters

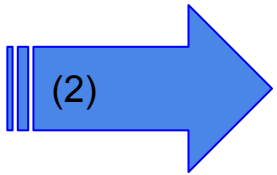
30 ms exposure time

Changing threshold
→ Fusion and CMS get closer





- ***Fake cluster rate can vary a lot for small changes on threshold***
- ***However, energy distribution is less sensitive to threshold***



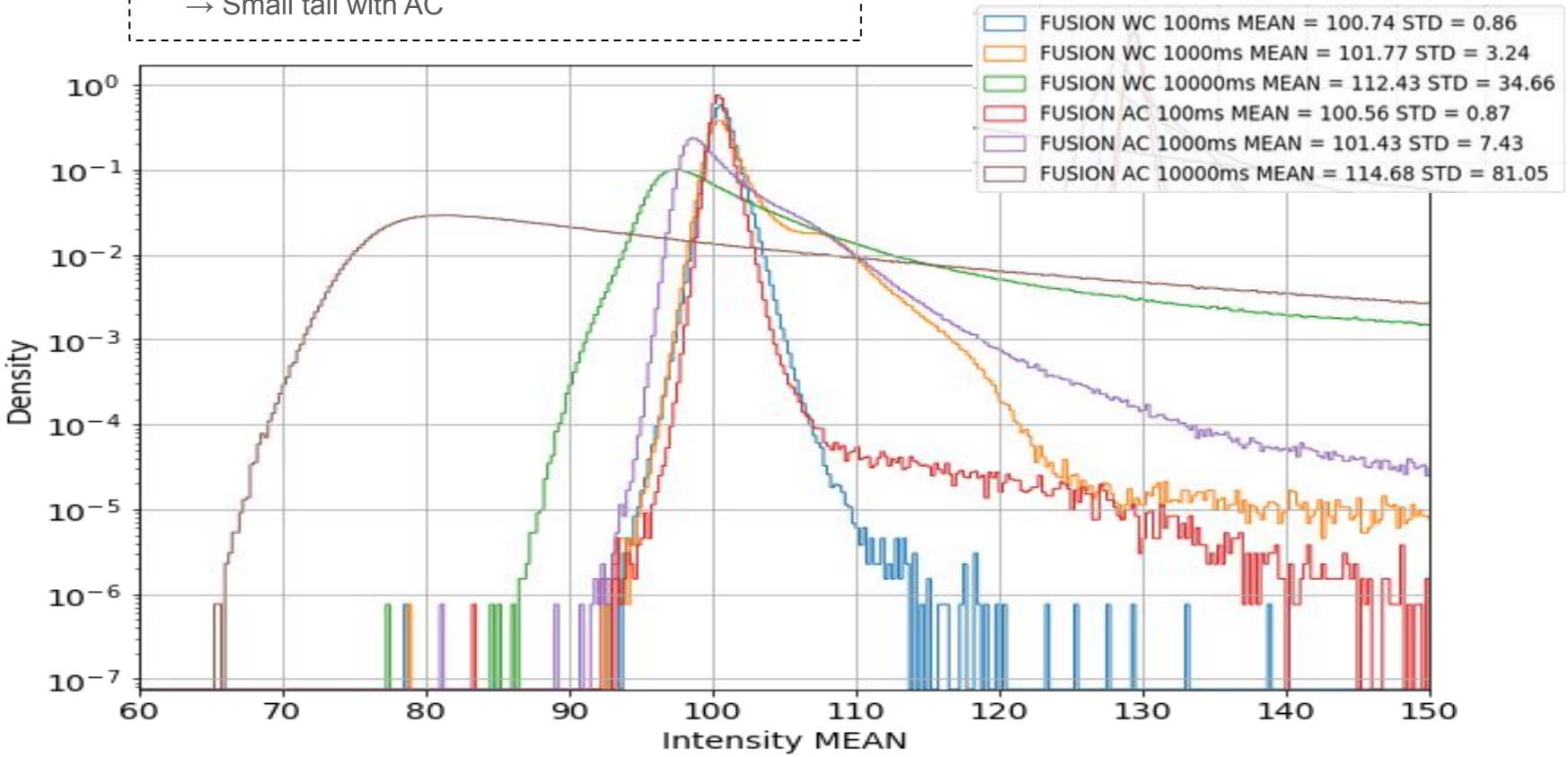
- (2)
  - Orca Fusion

NOISE
Varying exposure time
Air Cooling x Water Cooling

Exposure times→100, 1k, 10k ms

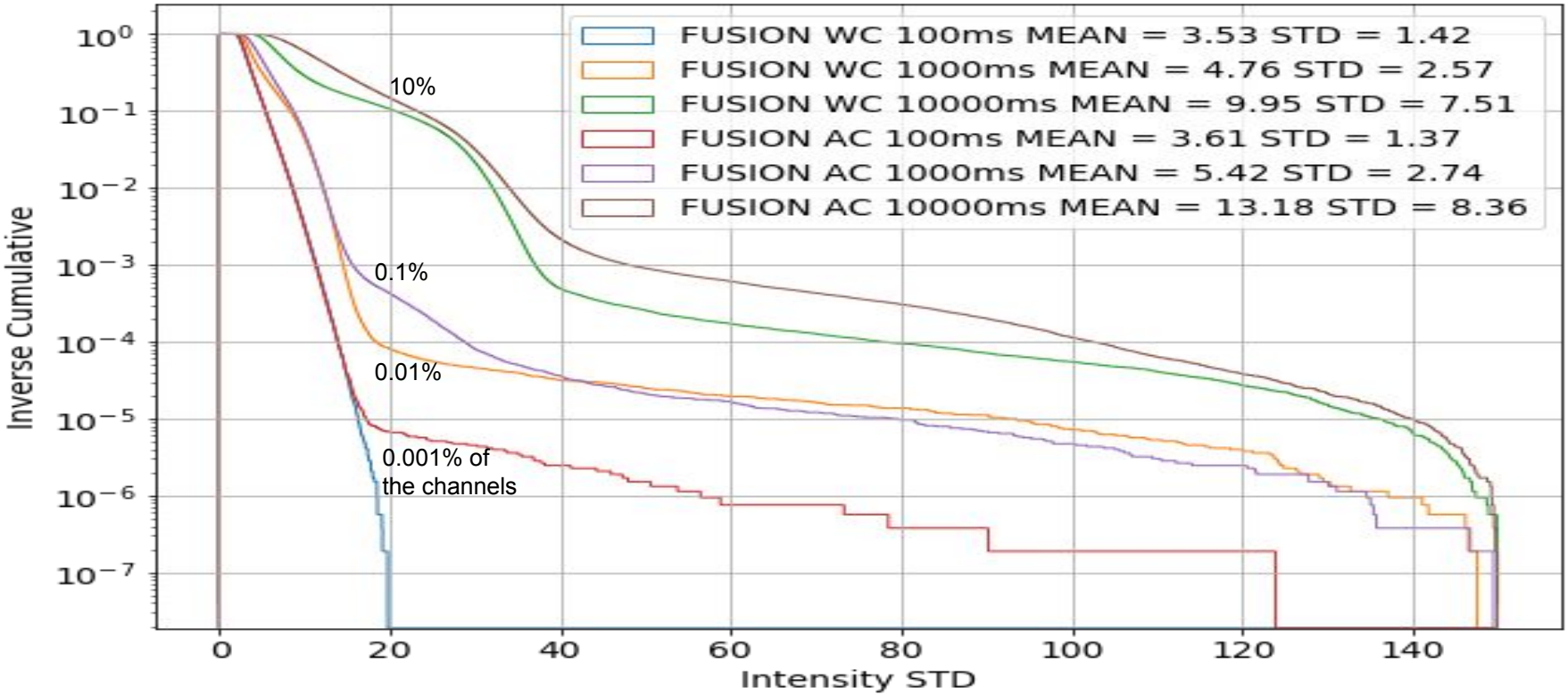
MEAN comparison (WC → -17 °C)

→ No tail for MEAN @ 100 ms with WC
→ Small tail with AC



RMS comparison (WC → -17 ºC)

- high level of dark noise (related to exposure time)
- WC slightly mitigates the problem

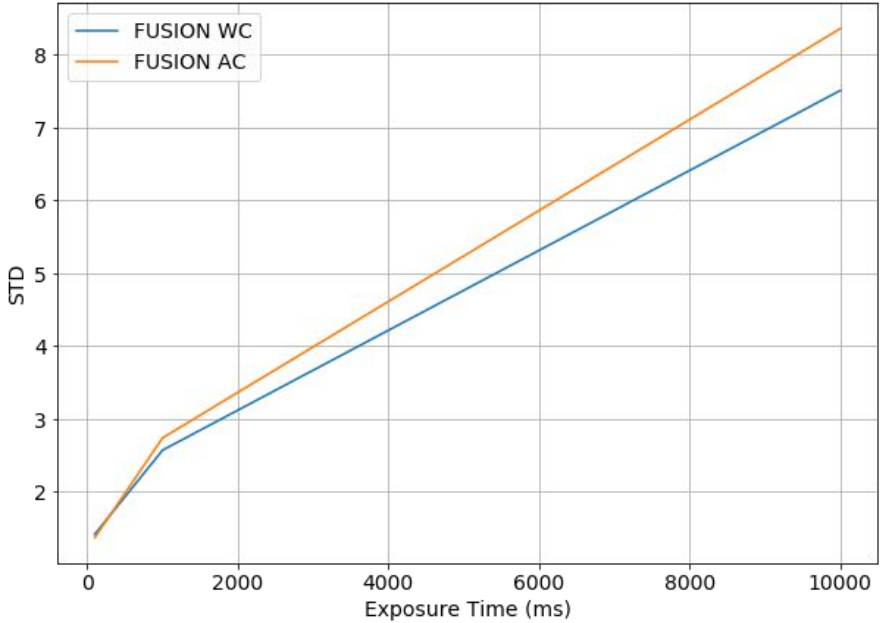


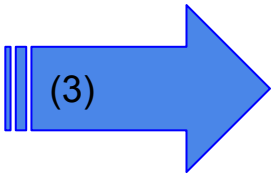
RMS comparison (WC → -17 ºC)

RMS noise SUMMARY

mean of the RMS HISTOGRAMS

EXP. TIME	FUSION **WC**	FUSION **AC**
100 ms	3.53	3.61
1000 ms	4.76	5.52
10000 ms	9.95	13.18





- (3)
  - Thorit
  - Orca Fusion BT
  - Orca Quest

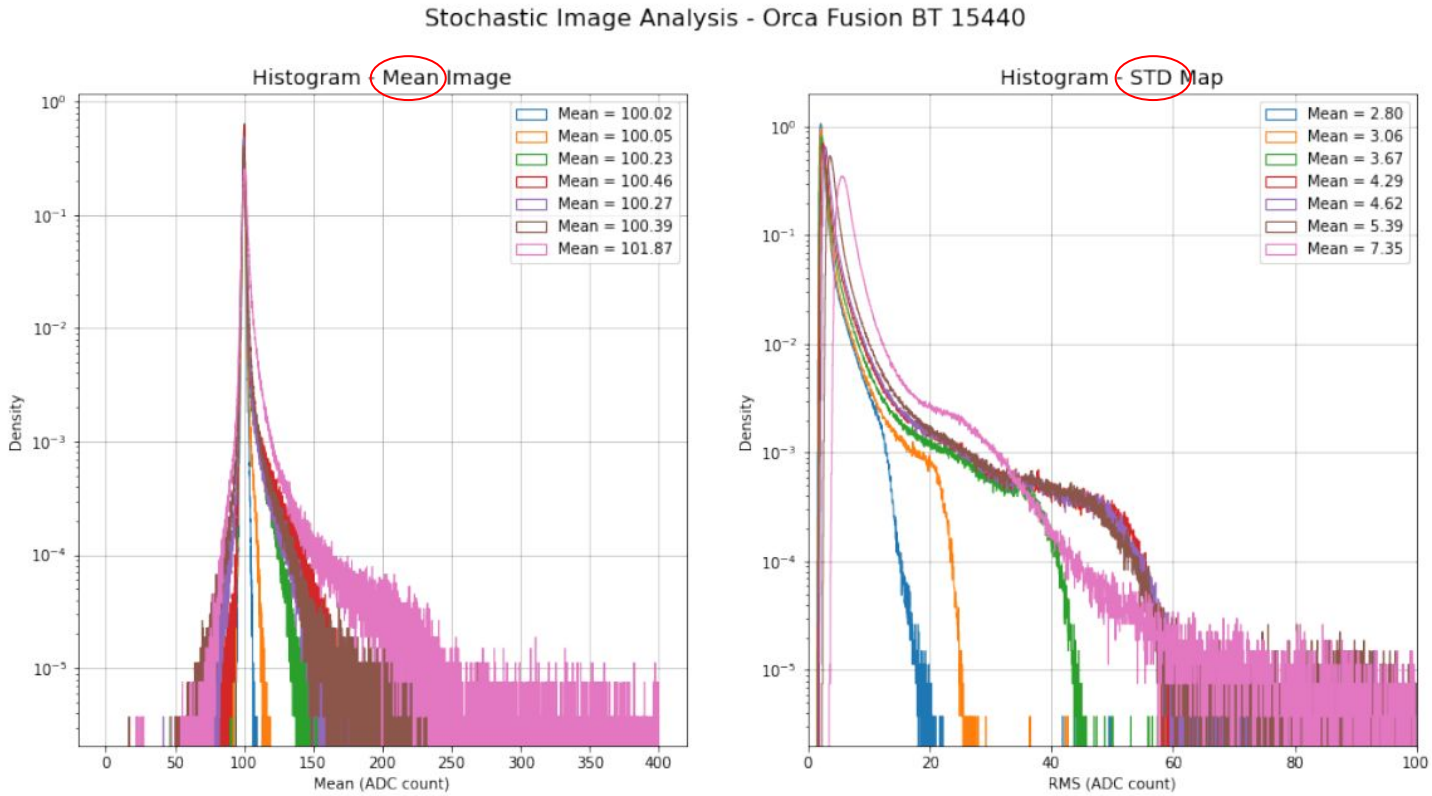
NOISE + NRAD + IRON
Varying exposure time
Water Cooling
VGEM scanning (0.3 to 6 keV)

Measurements

- Thorit
- Orca Fusion BT
- Orca Quest

- Pedestal for different exposure times (10, 30, 100, 300, 1k, 3k, 10k ms)
- Detection efficiency (VGEM scanning → 0.3 keV to 6 keV)
  - Quest sensor under analysis

Pedestal Mean and RMS - **FUSION BT**

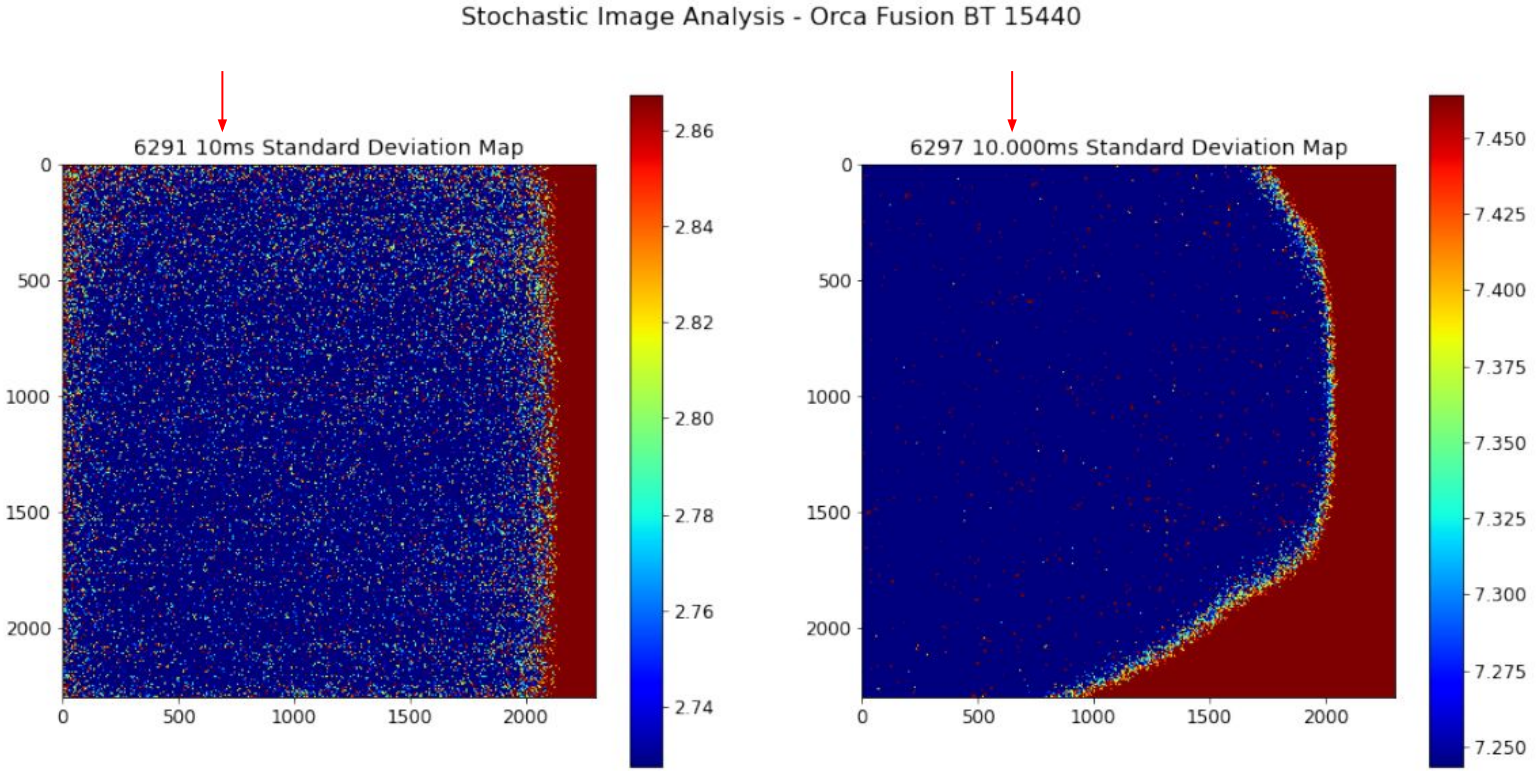


Exposure Times:
10, 30, 100, 300, 1k, 3k, 10k ms

The STD almost doubled(5.39) in 3k ms

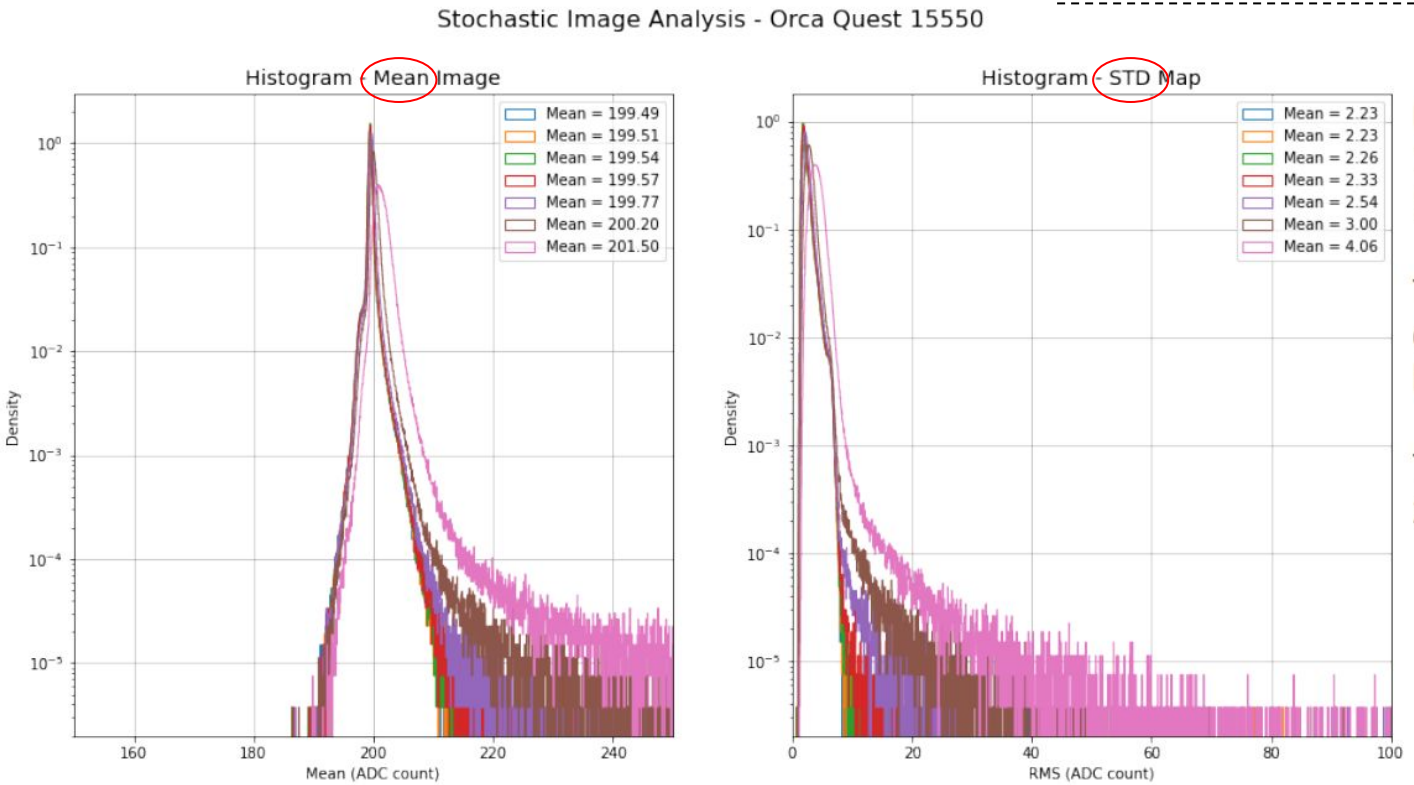
The Mean still around 100 ADC.

Pedestal RMS - **FUSION BT**



Pedestal Mean and RMS - **QUEST**

sensor less sensitive to exposure time



Exposure Times:
10, 30, 100, 300, 1k, 3k, 10k ms

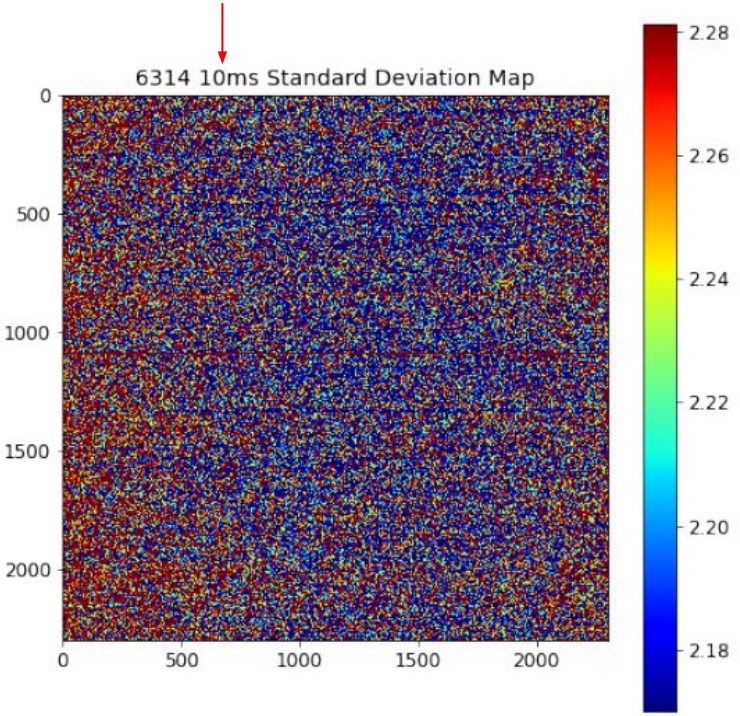
The STD does not double even in the highest exposure time

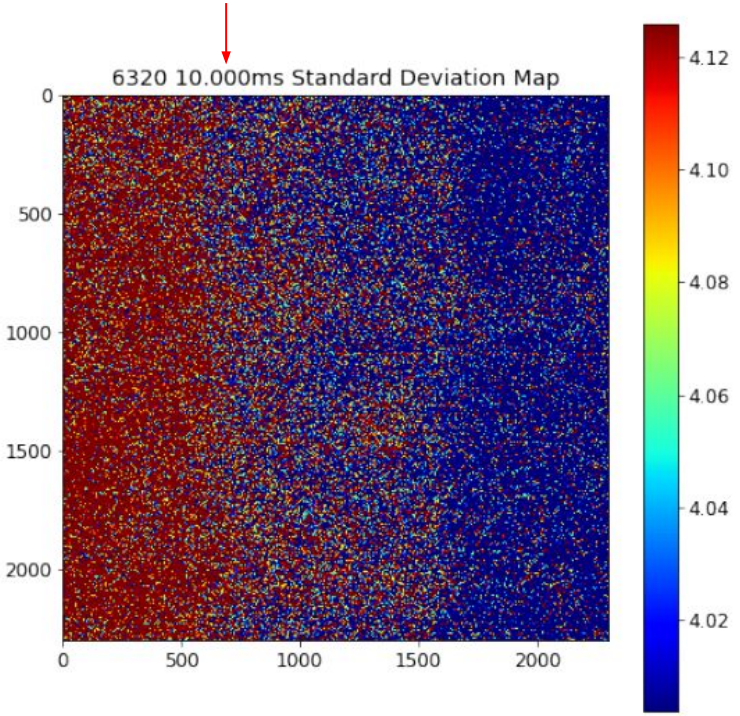
The Mean still around 200 ADC.

Pedestal RMS - **QUEST**

edges less affected

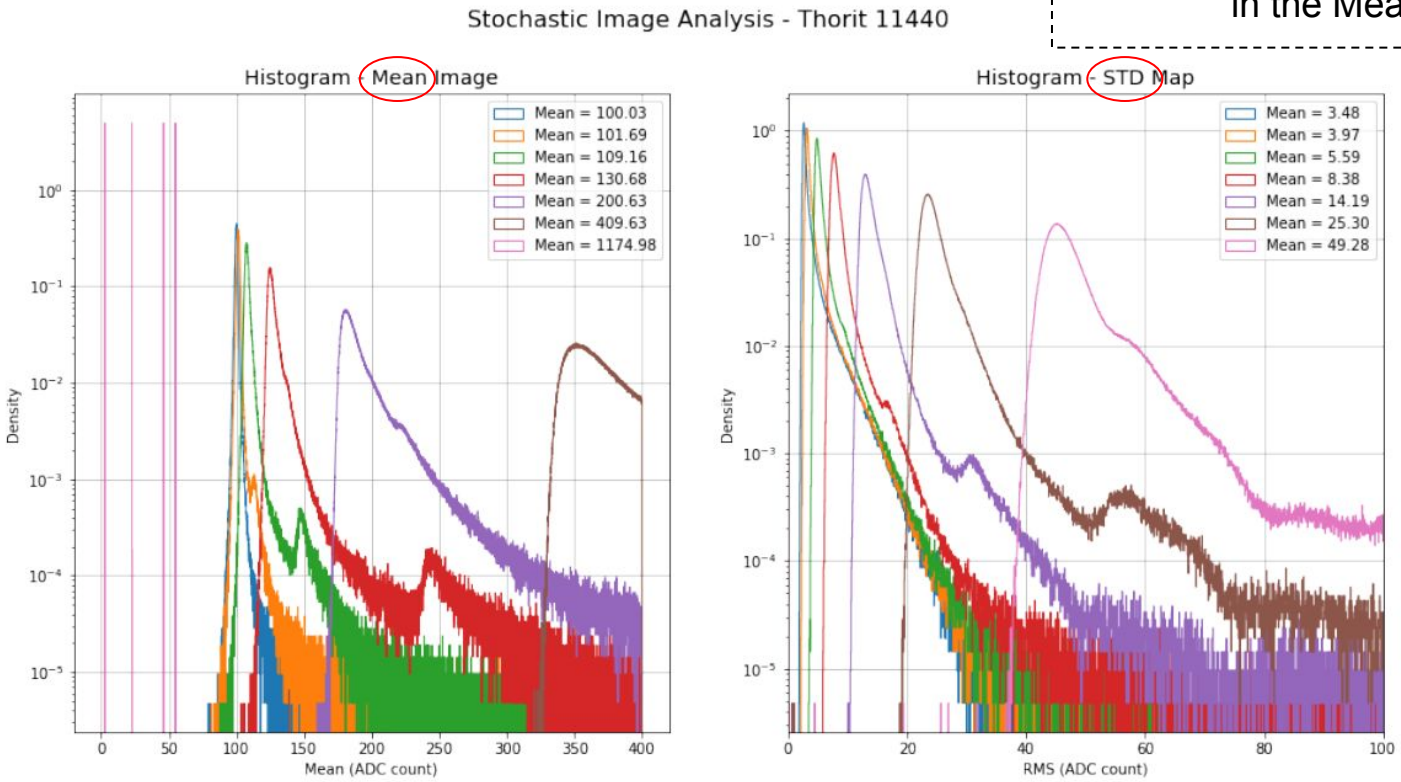
Stochastic Image Analysis - Orca Quest 15550





Pedestal Mean and RMS - **THORIT**

sensor very sensitive to exposure time in the Mean and RMS

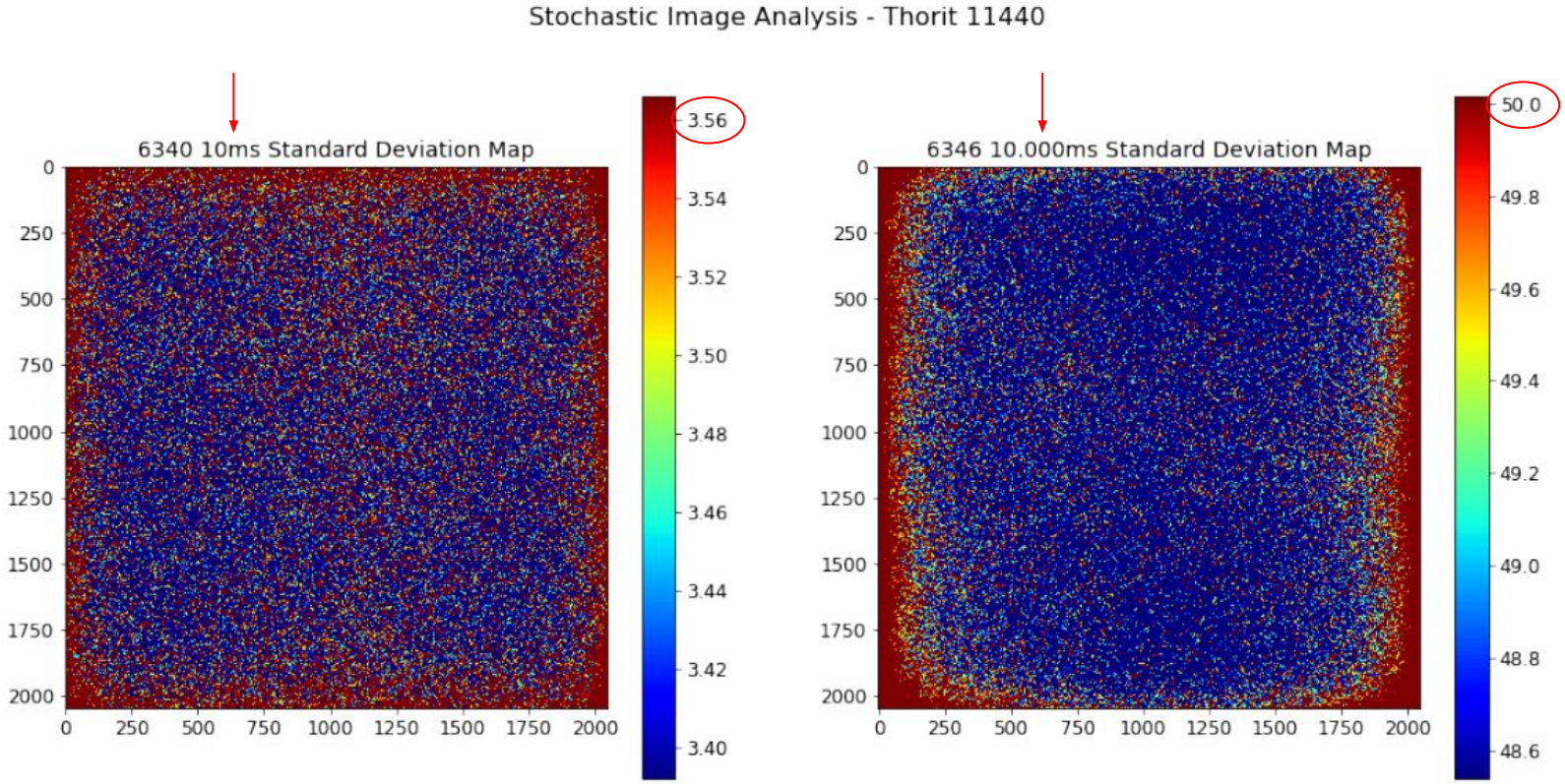


Exposure Times:
10, 30, 100, 300, 1k, 3k , 10k ms

The STD more than doubled in 300ms and reaching more than 14x in the maximum exposure time.

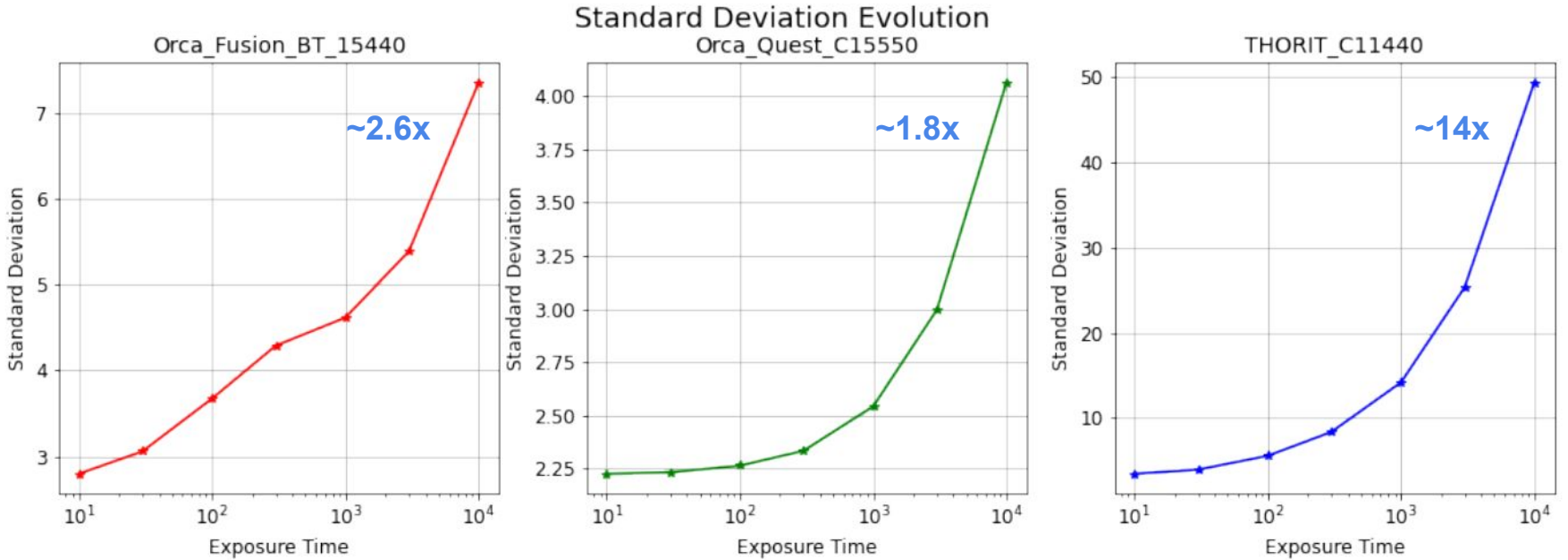
The Mean continued to increase along the exposure time, reaching 10x the initial value for the minimum exposure time.

Pedestal RMS - **THORIT**



Pedestal RMS - **Summary**

THORIT RMS noise changes greatly



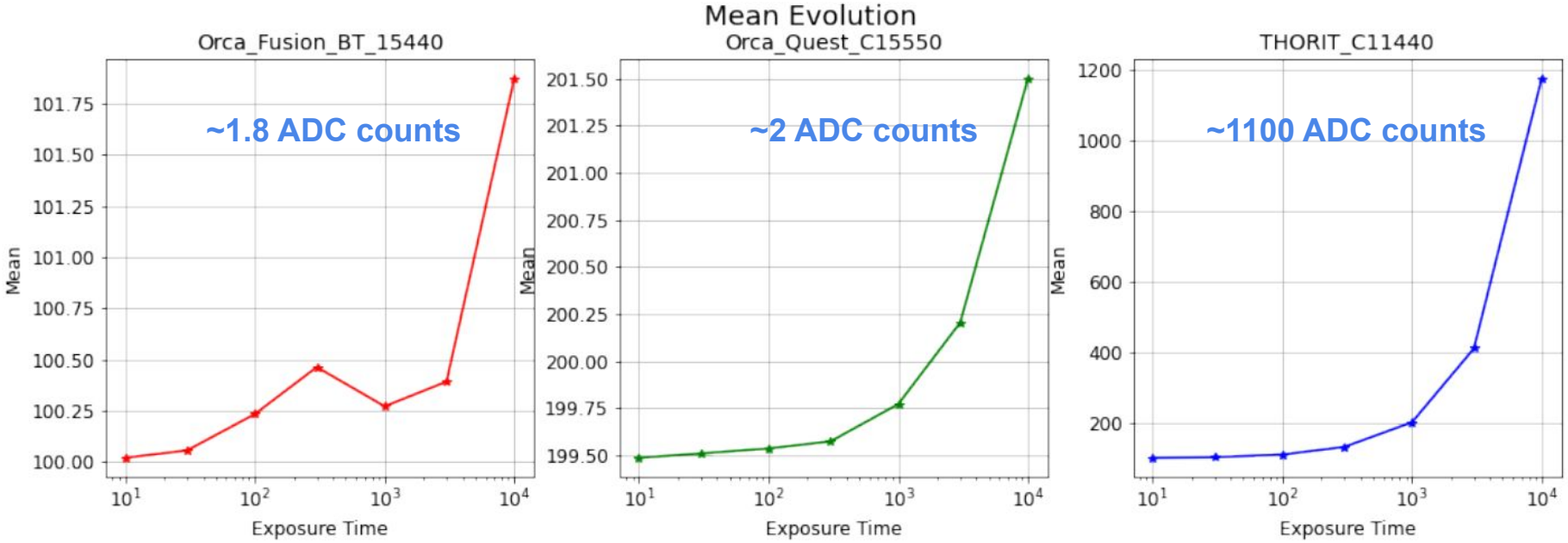
Min 2.80 | Max 7.35

Min 2.36 | Max 4.09

Min 3.48 | Max 49.28

Pedestal Mean - **Summary**

THORIT mean changes greatly

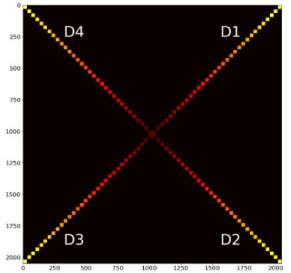


Min 100.02 | Max 101.87

Min 199.49 | Max 201.50

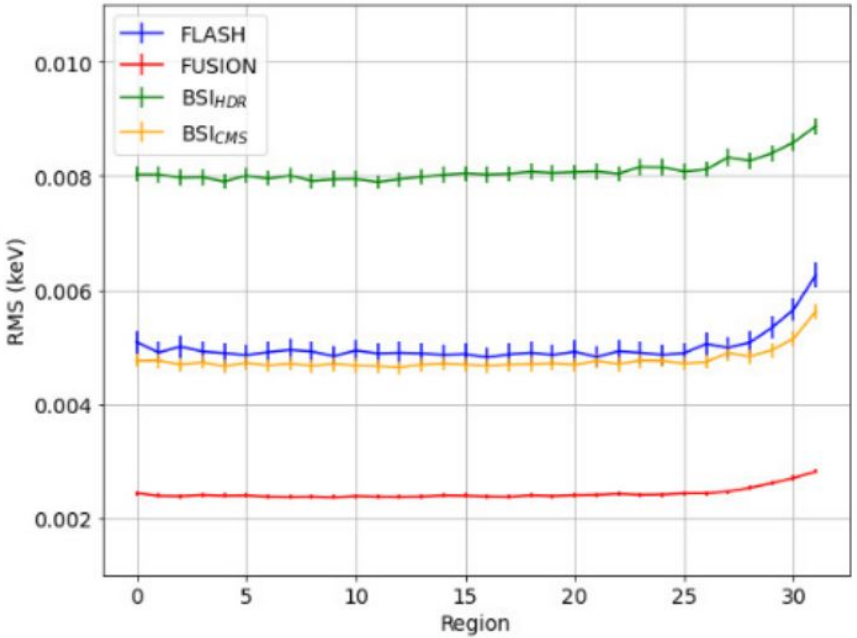
Min 100.30 | Max 1174.98

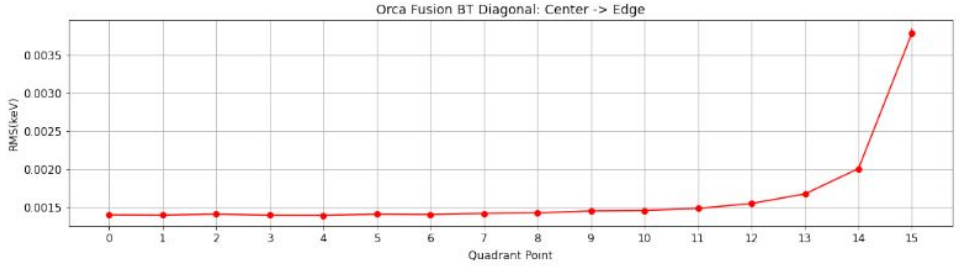
Pedestal RMS - **Summary** (KeV units)

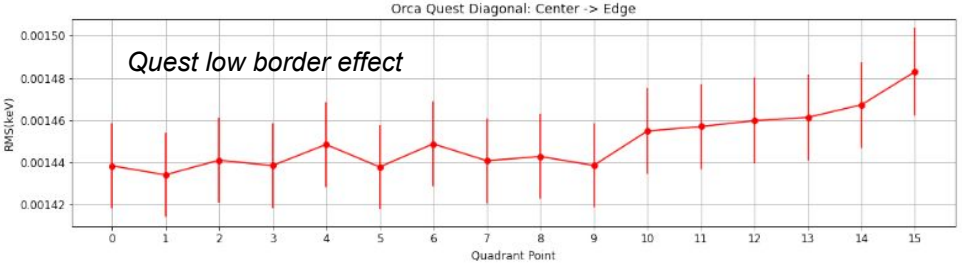


Comparing to setup (1)

Fusion BT and Quest have lower RMS noise compared to Fusion







LIME Detection Efficiency Study

- Thorit
- Orca Fusion BT
- Orca Quest

Measurement of efficiency for different VGEM values → 0.3 to 6 keV

- Datasets:
  - NRAD
  - IRON SOURCE
- Two approaches *(cross-checking)*:
  - Based on cuts over different features and subtraction IRON - NRAD
  - Based on fits applied on NRAD and IRON datasets

Cut based **Efficiency** - Cut parameters

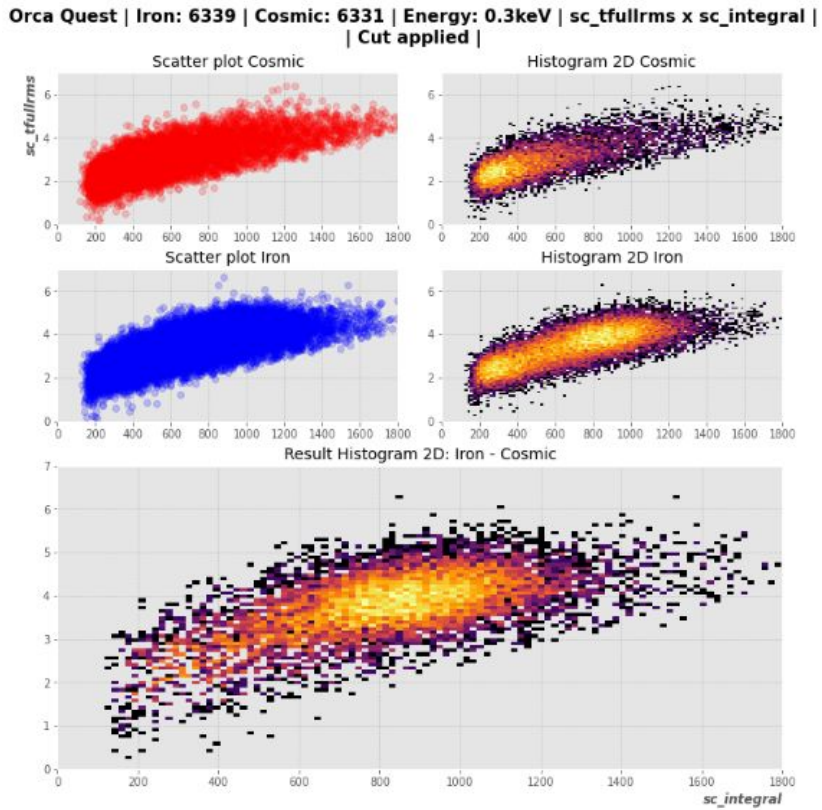
QUEST

all these features have been selected and used to improve SNR *(different cuts for different energies)*

Orca Quest										
Energy	**Slimness**	**sc_nhits >**	**sc_nhits <**	**sc_rms >**	**sc_rms <**	**sc_size >**	**sc_size <**	**sc_tgaussamp >**	**sc_tgaussamp <**	**sc_lgaussamp >**
6 keV	0.4	200	800	7	20	500	1500	500	1800	500
5 keV	0.38	200	800	7	20	500	1500	500	1800	500
4 keV	0.4	200	700	7	20	400	1400	400	1600	500
3 keV	0.45	200	700	6	16	400	1300	400	1600	400
2 keV	0.55	150	600	6	15	400	1200	300	1200	300
1 keV	0.8	100	500	5	12	300	1000	200	800	200
0.5 keV	0.5	50	300	4	10	200	800	50	500	100
0.3 keV	0.25	25	200	4	9	100	500	50	300	50

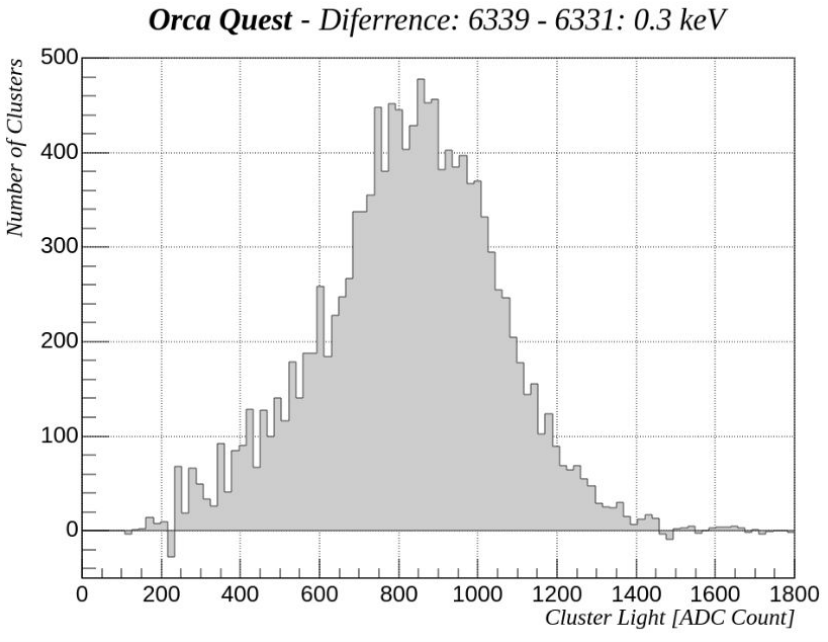
Cut based **Efficiency** - Energy distribution

QUEST



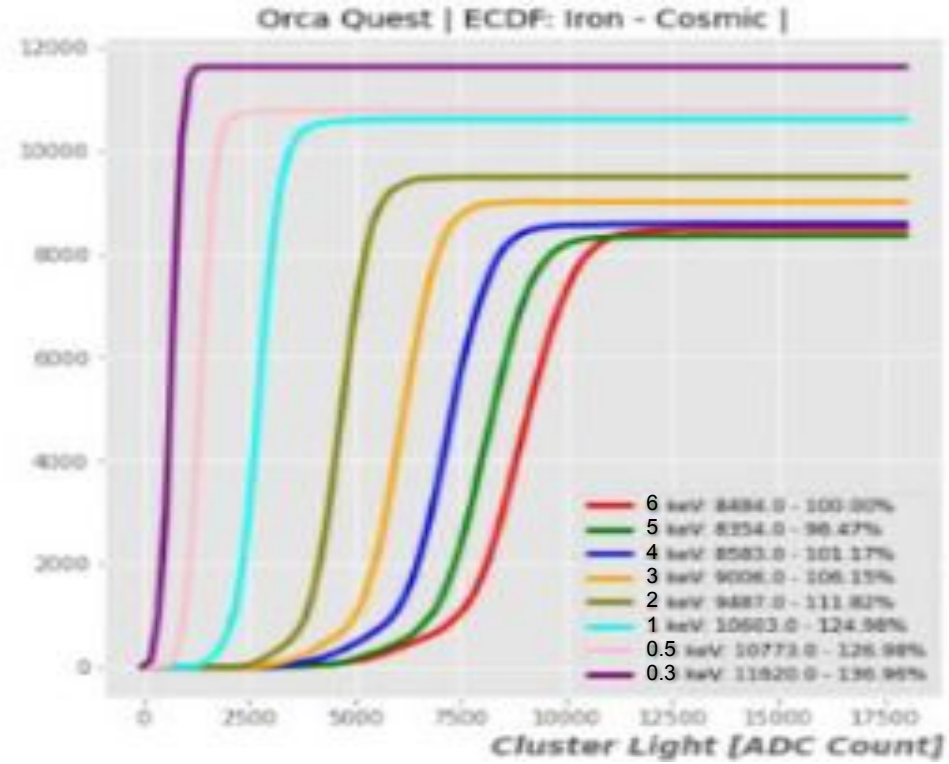
FINAL HISTOGRAM → 0.3 keV example

Cuts + Subtraction (IRON - NRAD)



Cut based Efficiency - # of clusters

QUEST



The lower the energy the greater the # of iron spots

???????????

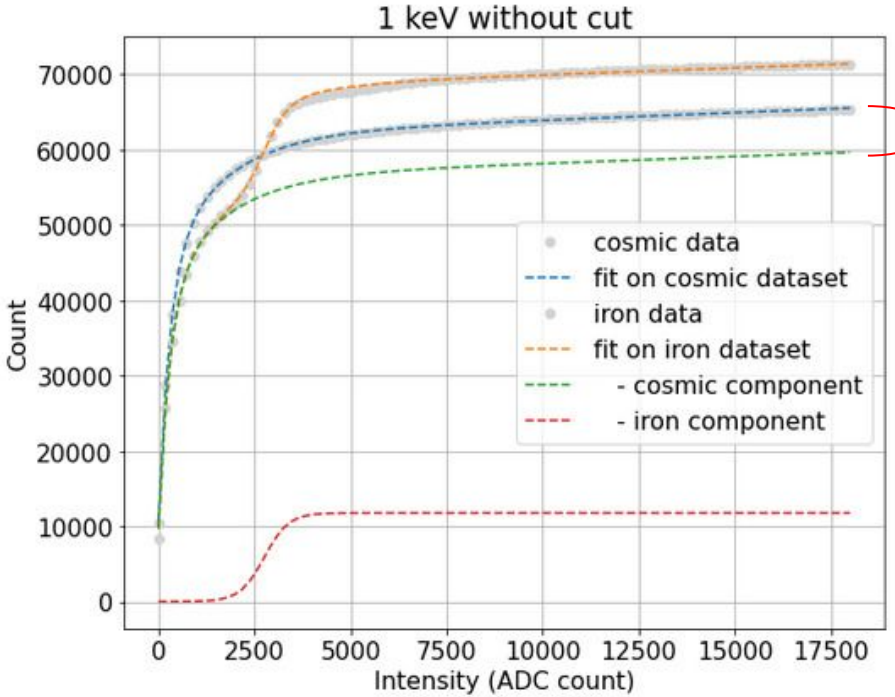
Number of background clusters varies from an acquisition to another **??** (...in average)

And about the number of iron spots **??**

Fit based Efficiency

QUEST

Doing the same measurement but using a different method



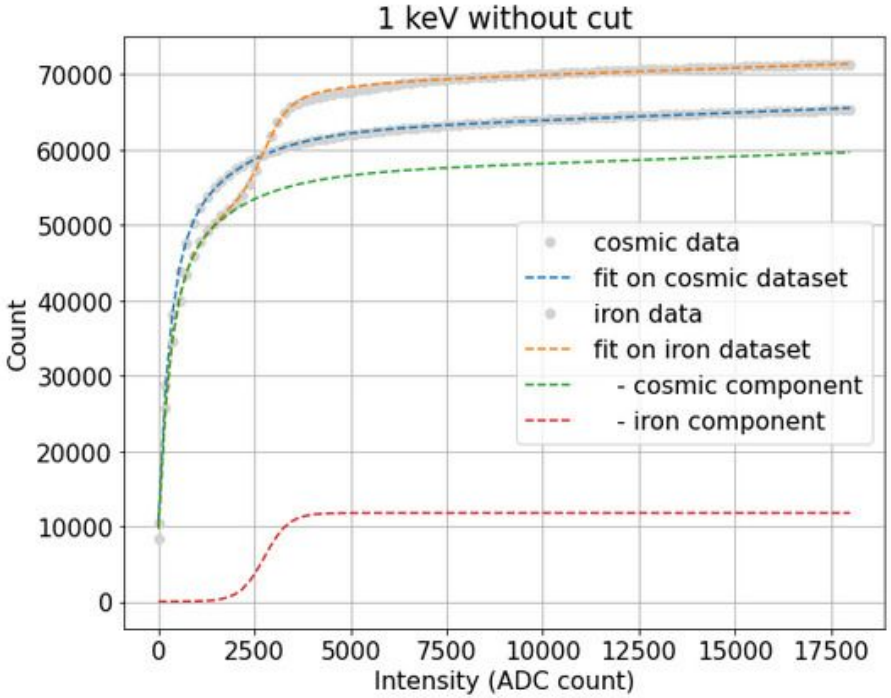
Difference between background components

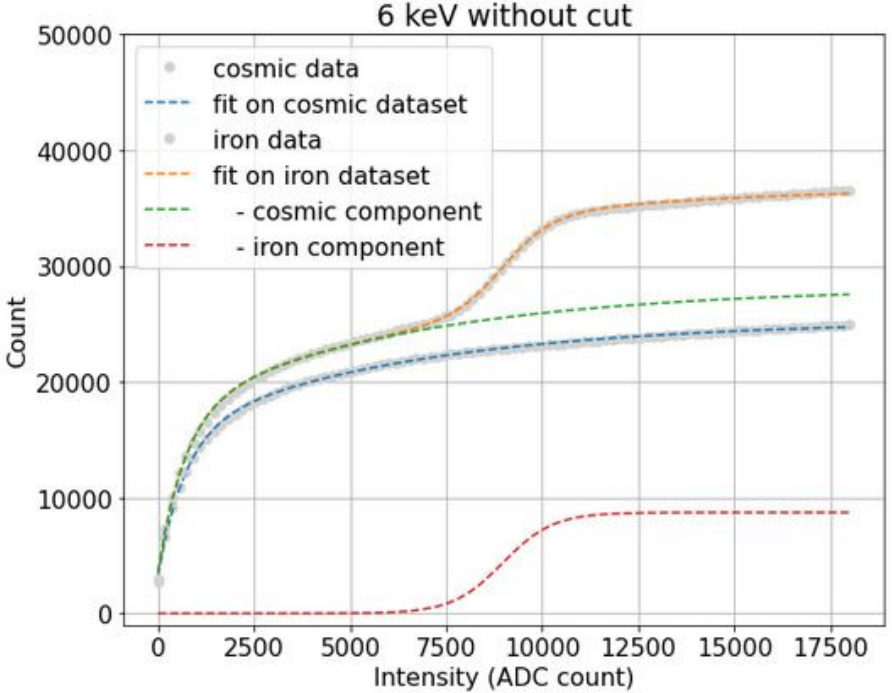
We have checked that this difference becomes negligible after the cuts

Fit based Efficiency

QUEST

just another example - 6 keV

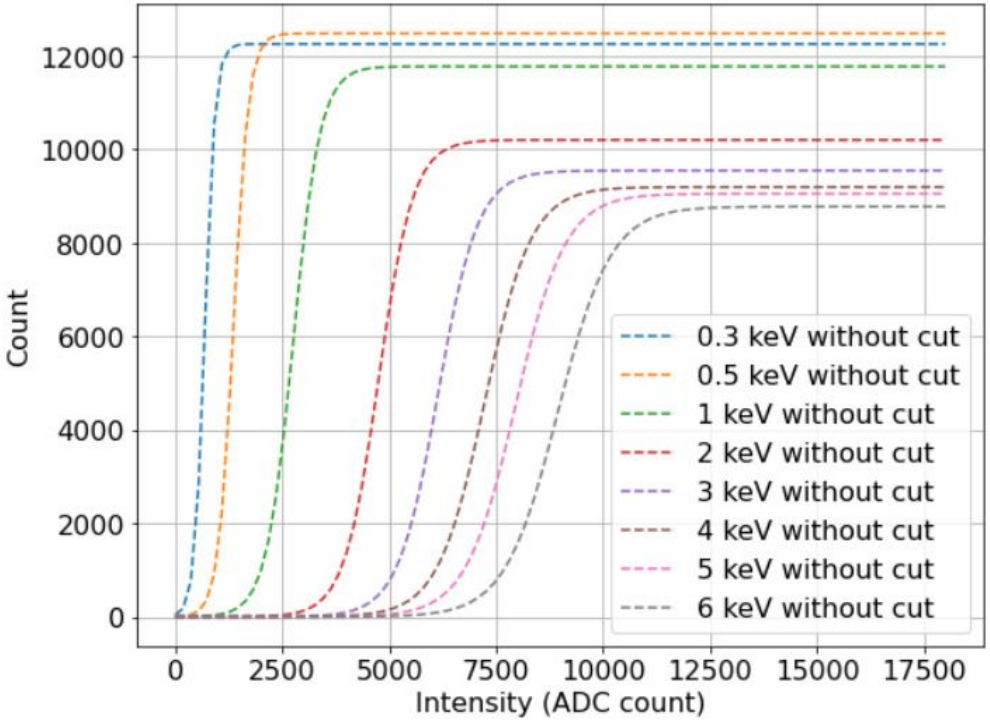


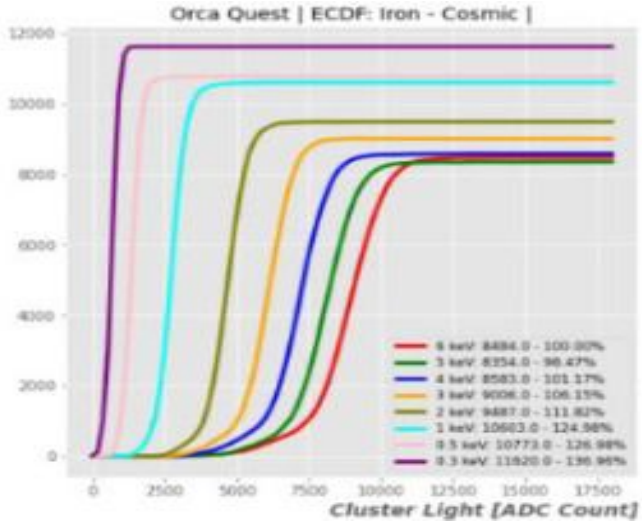


Fit based Efficiency - # of clusters

QUEST

similar results





?????????? remains

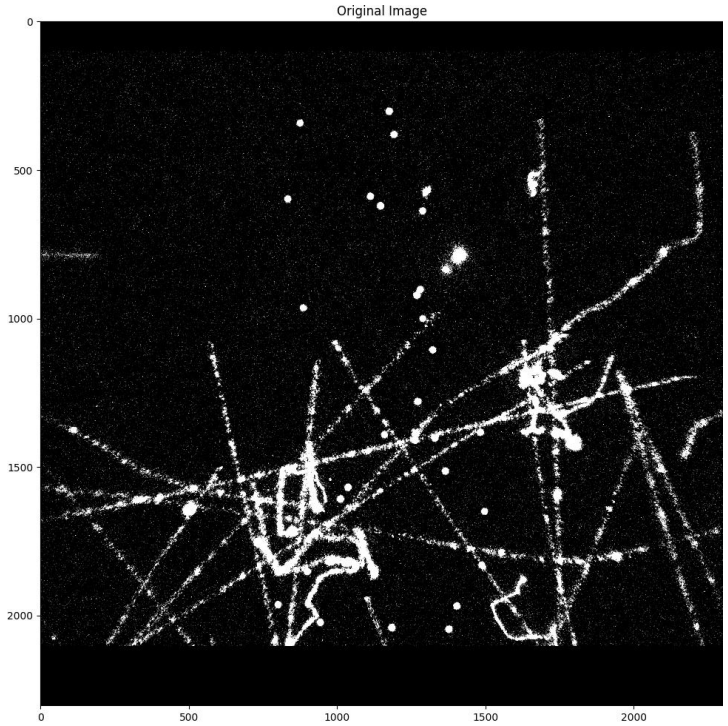
Number of background clusters varies from an acquisition to another?? (...in average)
Yes, but it does not seem to be the problem

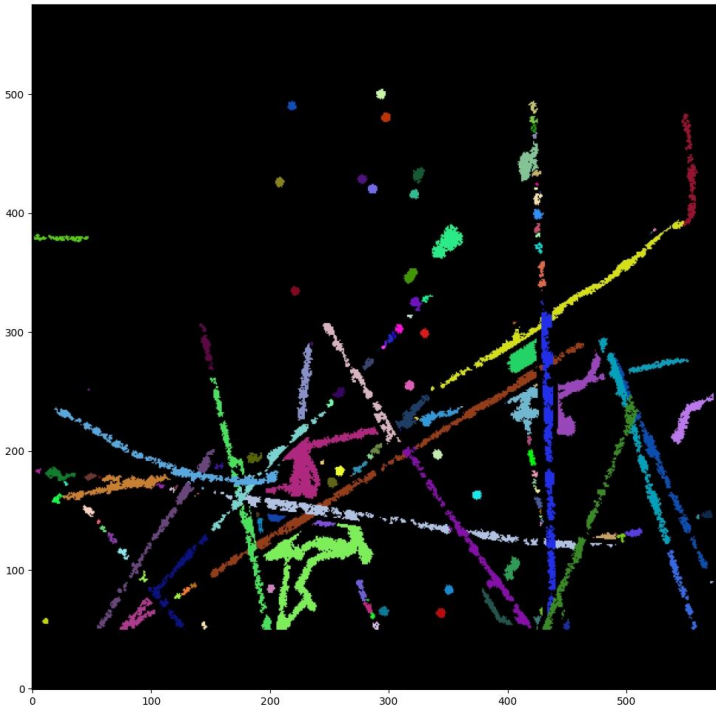
And about the number of iron spots??

Efficiency Measurement - Iron losses 6 keV

QUEST

NRAD tracks affect iron spot clustering



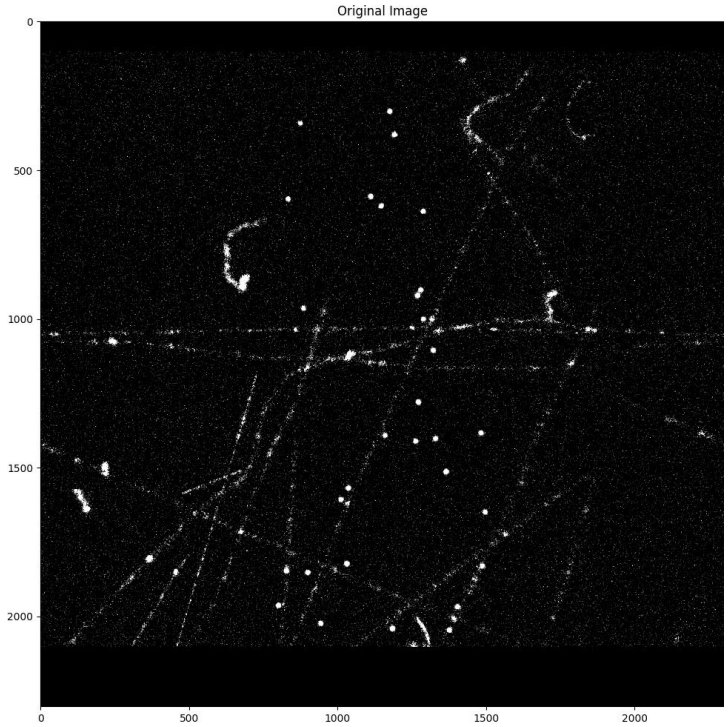


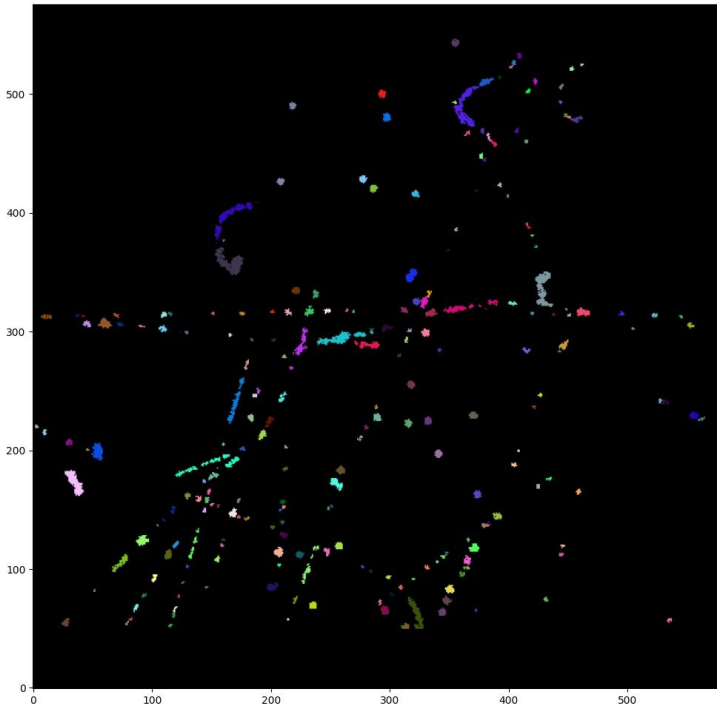
simulated iron spots added to a real NRAD image

Efficiency Measurement - Iron losses 1 keV

QUEST

NRAD tracks become weaker, affecting less iron spot clustering





simulated iron spots added to a real NRAD image

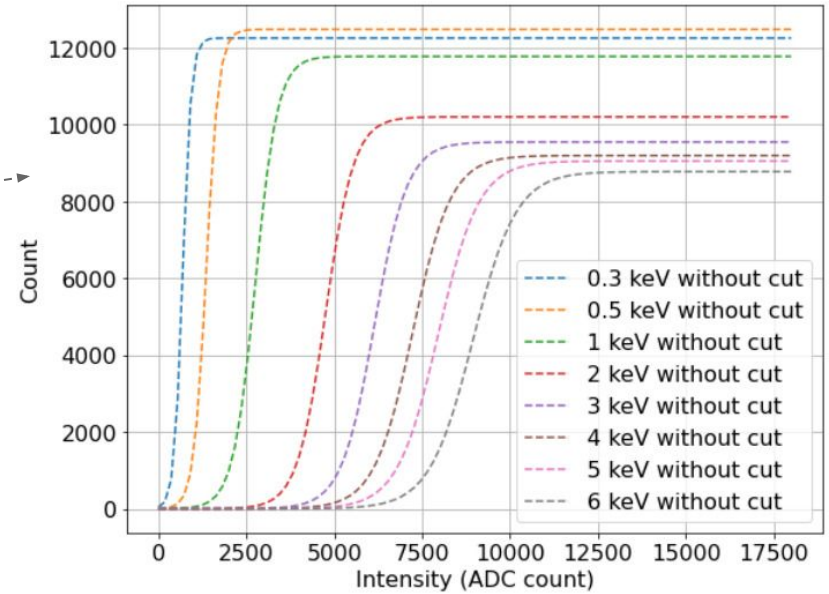
Efficiency Measurement - Iron correction proposal

QUEST

The idea is to estimate the percentage of iron loss by including simulated iron spots in NRAD images to correct those curves…

- for each VGEM
  - include iron spots in NRAD images
  - run reconstruction
  - measure iron loss
  - replicate this analysis

TO BE CONTINUED…



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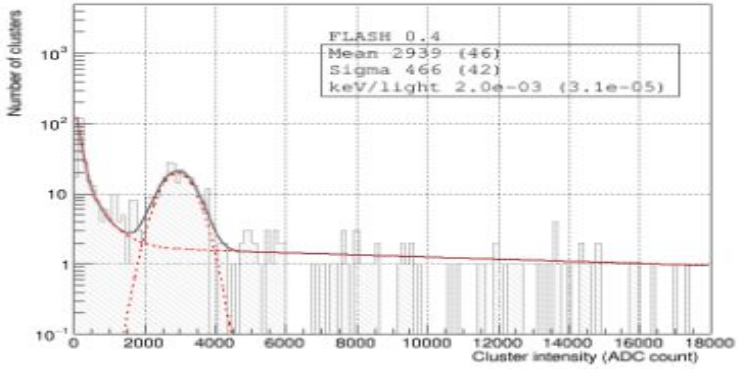
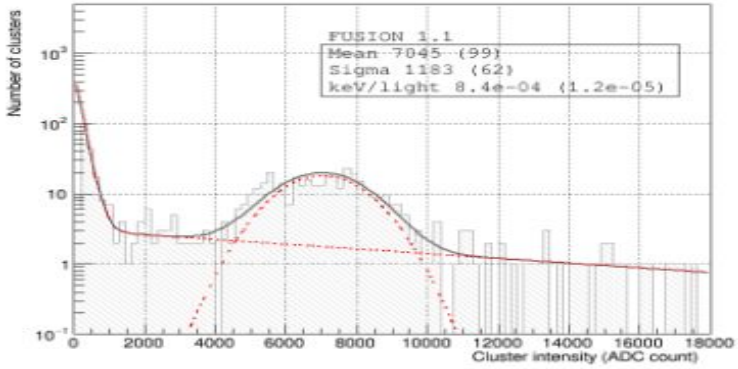
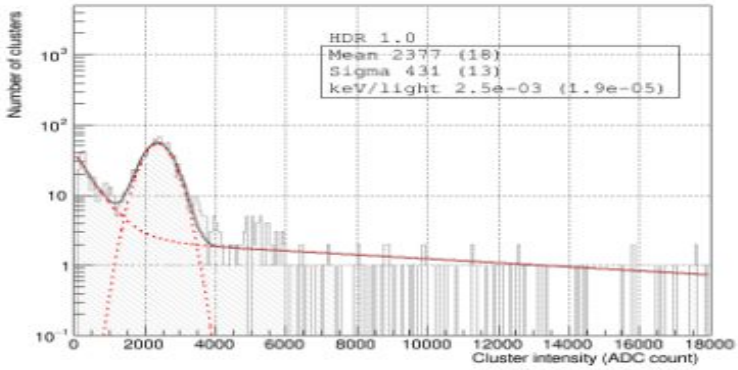
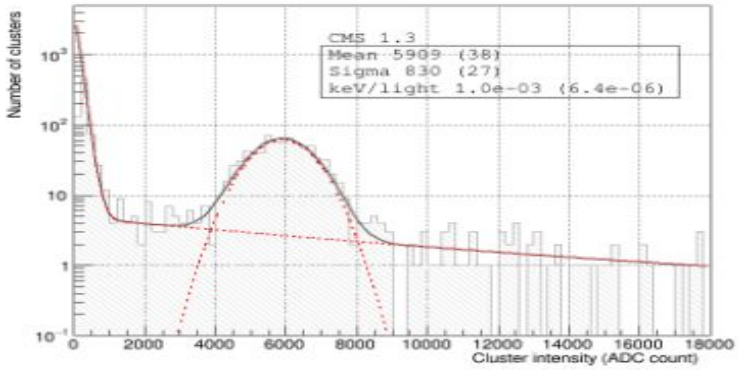
Measurements - Iron calibration (LEMON)



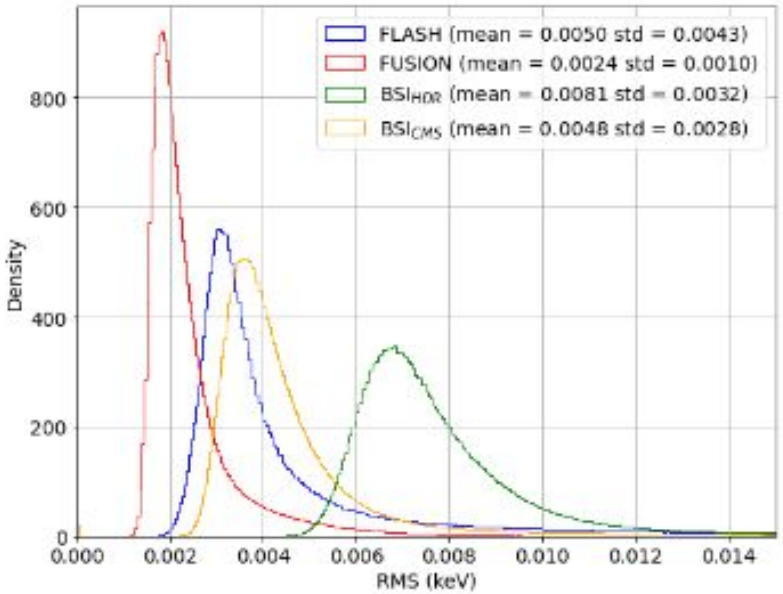


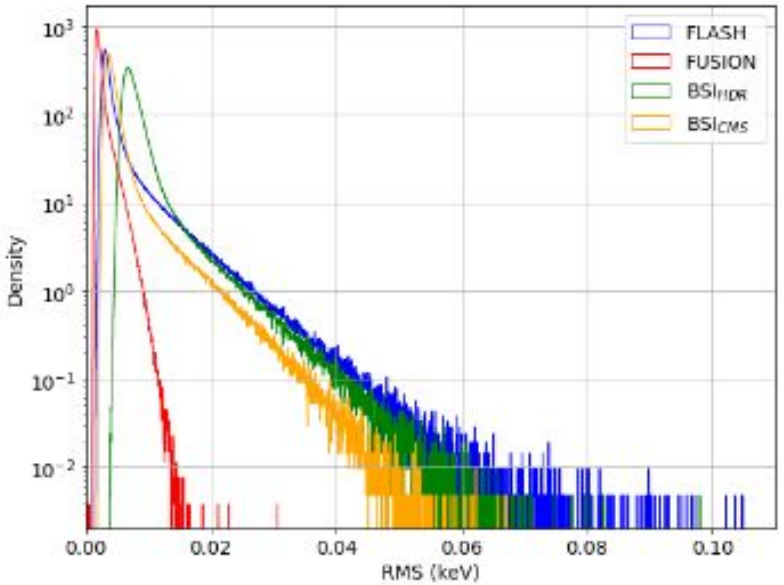




Measurements - RMS noise

Fusion has the smallest RMS noise and tail

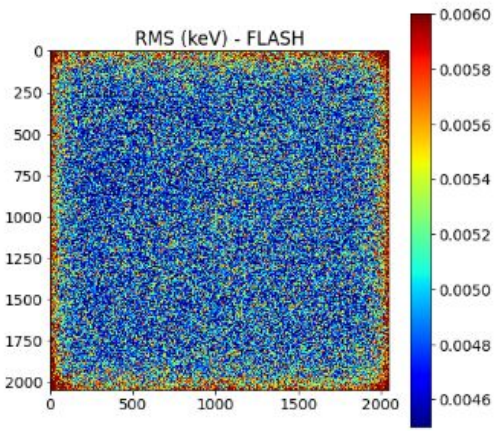


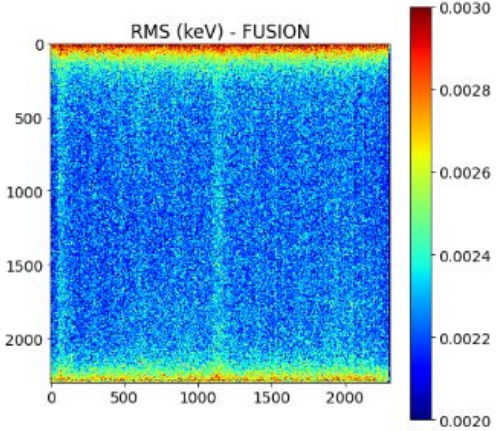


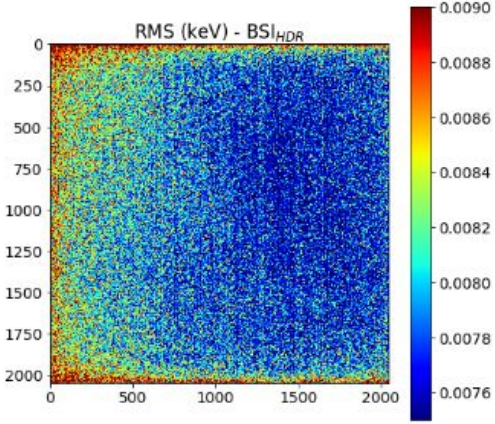
Measurements - RMS noise

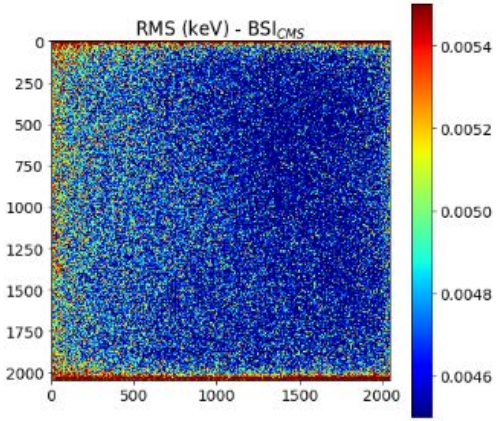
Border effect

- Flash → 4 borders
- Fusion → 2 borders
- BSI → asymmetric





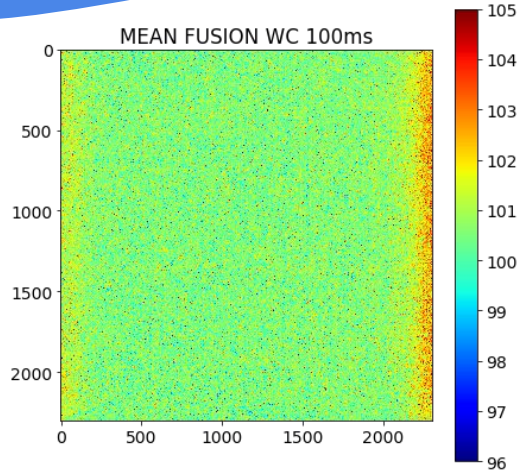


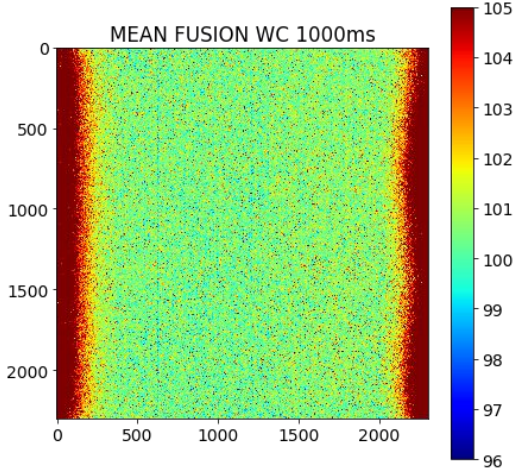


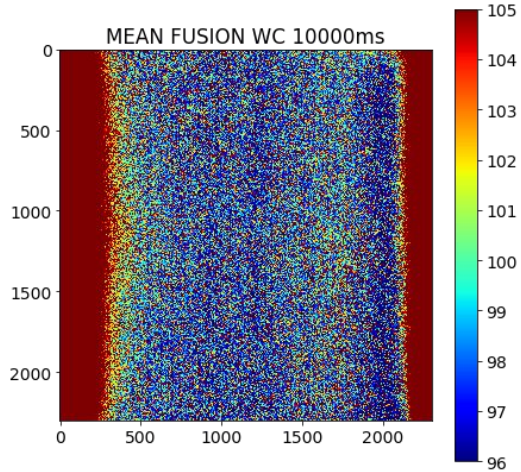
MEAN comparison

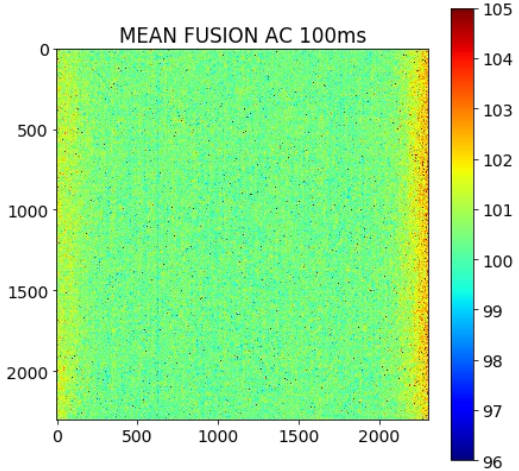
All pixels are affected, but more strongly at the edges

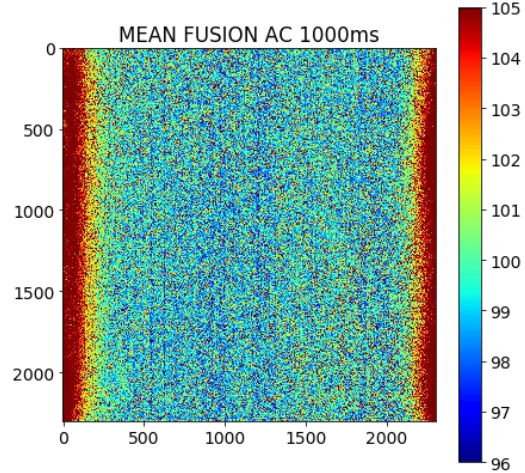
WATER Vs. AIR COOLING

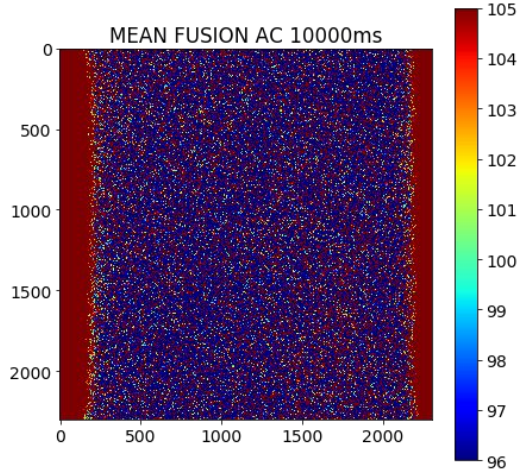












RMS comparison

All pixels are affected, but more strongly at the edges

WATER Vs. AIR COOLING