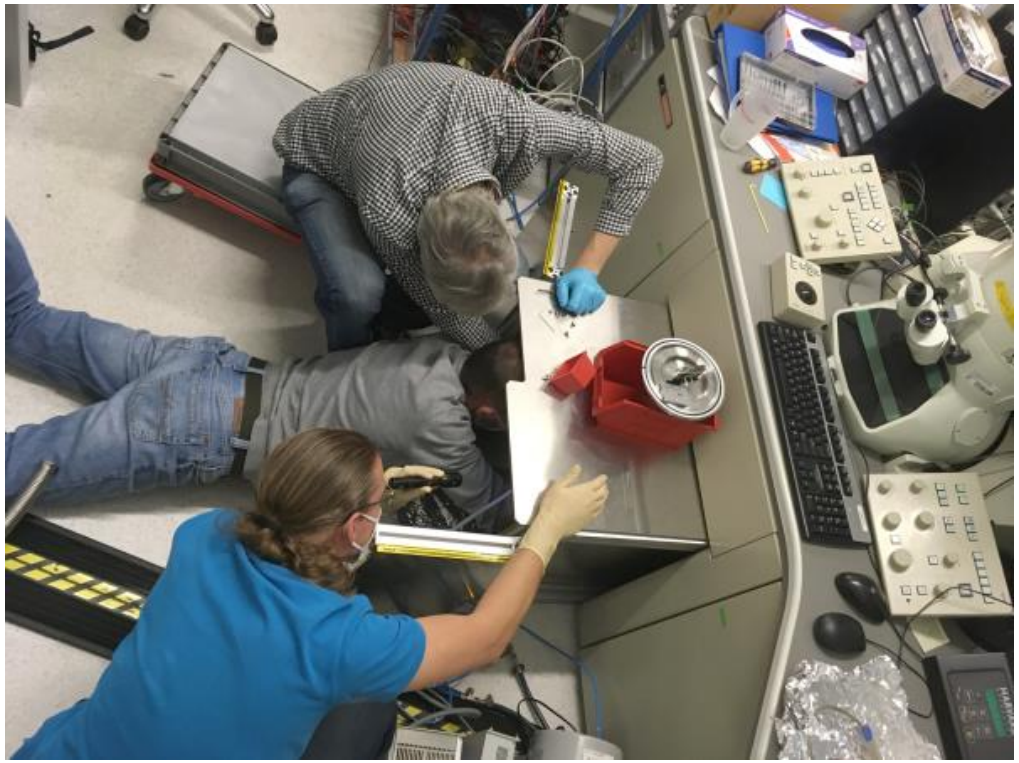
MAX PLANCK SEMICONDUCTOR LABORATORY

More lessons learned from test campaigns



MPG HLL

mpsd

MAX PLANCK SEMICONDUCTOR LABORATORY

I. Software/Hardware improvements
II. Mechanical improvements
III. Radiation measurements issues November 2021
IV. May radiation campaign remotely from Munich

SOFTWARE/HARDWARE IMPROVEMENTS

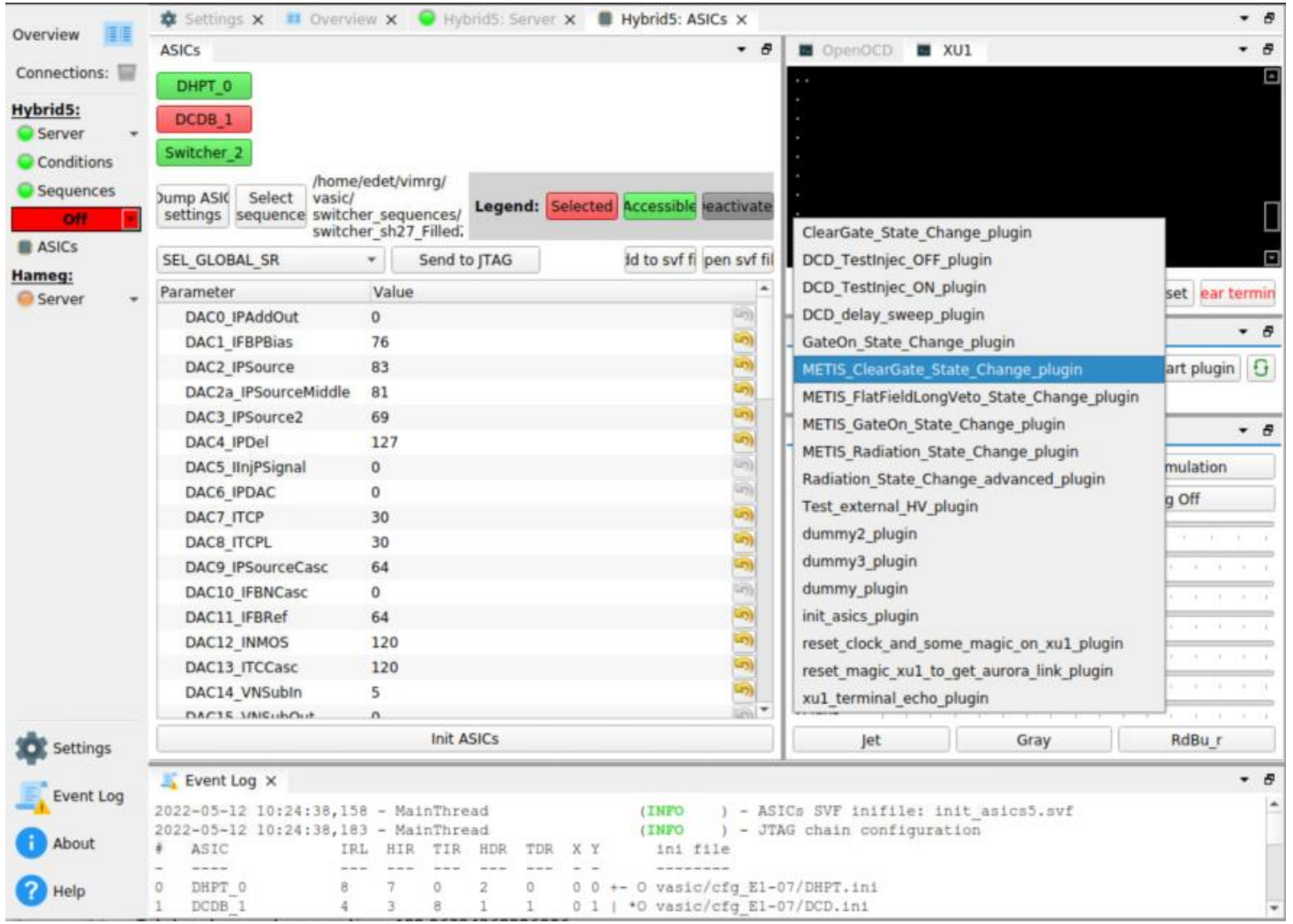
(PLUGINS)

Plugins provide a wide range of possibilities:

- Change single bits like on/off test pattern
- Save time to start/restart aurora link
- Fast change from radiation to flat field measurements (sequence, DCD settings…)

-> Automatization via external python scripts possible. Saves a lot of time.

```
command = (
    "cd /root/OpenOCD/xu1_cfg_sh\n"
    "sh cfg.sh auclk\n"
    "sh cfg.sh si5338\n"
    "sh cfg.sh au\n"
    "sh cfg.sh xg\n"
    "sh cfg.sh au\n"
    "sh cfg.sh auchr 7\n"
    "sh cfg.sh dhpt_reset\n"
)
```

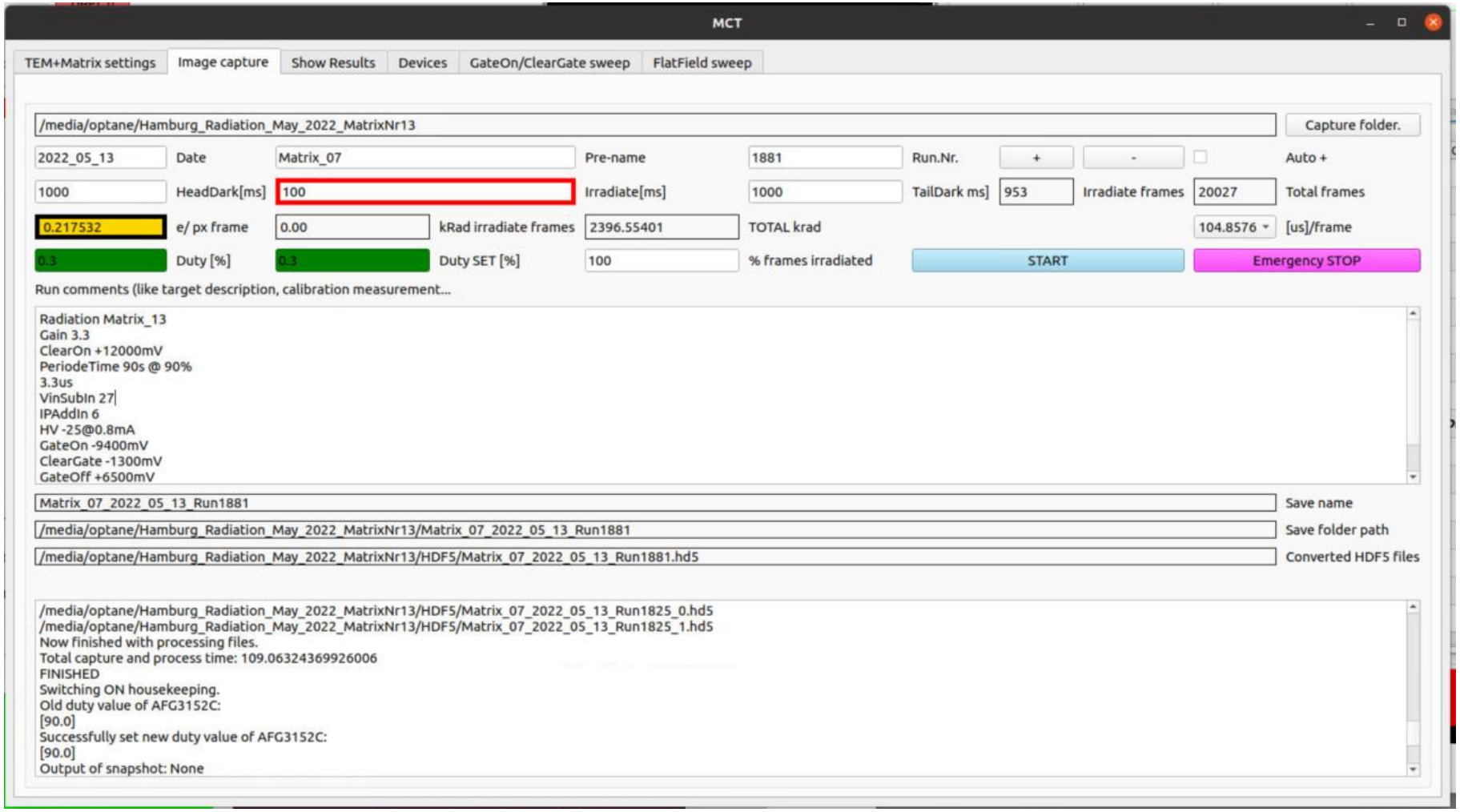


SOFTWARE/HARDWARE IMPROVEMENTS

(AUTOMATIZATION)

Automatization:

- FlatField sweeps
- GateOn sweeps
- ClearGate sweeps



SOFTWARE/HARDWARE IMPROVEMENTS

(ERRORS/CRASHES/FAILURES)

No system is without errors like our software or firmware from used devices. But a failure in the wrong situation without a safety software crash interception can lead to unwanted irradiation of the detector. Some examples:

- The trigger for the signal generator is switched ON/OFF due the XU1 board through software on the operating computer. We had a crash of the software before the XU1 get the trigger off signal -> continuous irradiation
- Changing period time of the used signal generator from “us” to “s” started irradiation -> Needs more investigations
- If the power supplies of the blanker fails the beam hits the matrix.

Between our detector and the TEM is a mechanical shutter. This shutter can currently only manually closed/opened. Also the shutter needs some hundreds of ms to close.

SOFTWARE/HARDWARE IMPROVEMENTS

(ERRORS/CRASHES/FAILURES)

Further issues during the campaigns:

- Storage shortage! One FlatField measurement takes 8GB. One second of irradiation around 21MB. We irradiated 21100s. This takes around 450GB disk space with additional dark frames. For data integrity we are storing the measurements at least on two different computers.
- Third party programs like “n2disk”. This is used to save the data stream from the DHPT. But sometimes it will not save the data (e.q. if disk space is less than 15GB). Or there are write permission issues of the folder due changed user/group name during saving → Wrapper for n2disk needed to show the reasons.
- Better documentation of our software.
- Unknown kernel software update needed recompiling of third party program v4L2loopback (really make sure to switch of all auto updates)

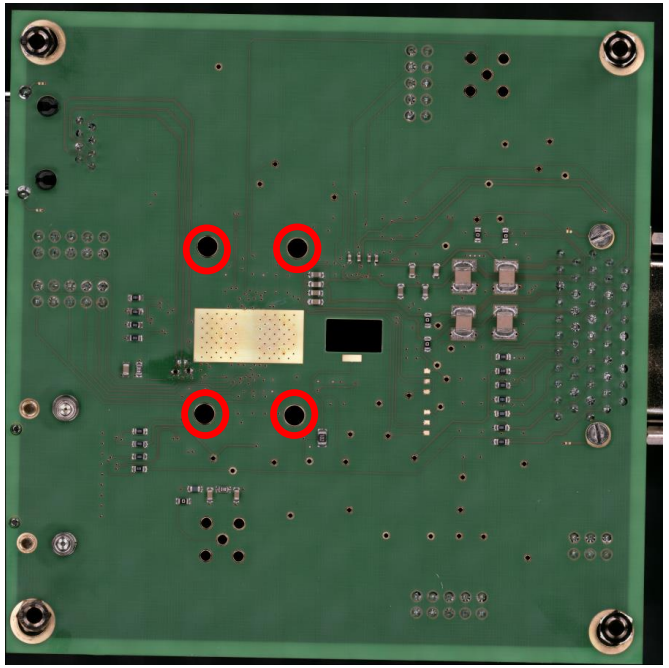
MECHANICAL IMPROVEMENTS - AGAIN

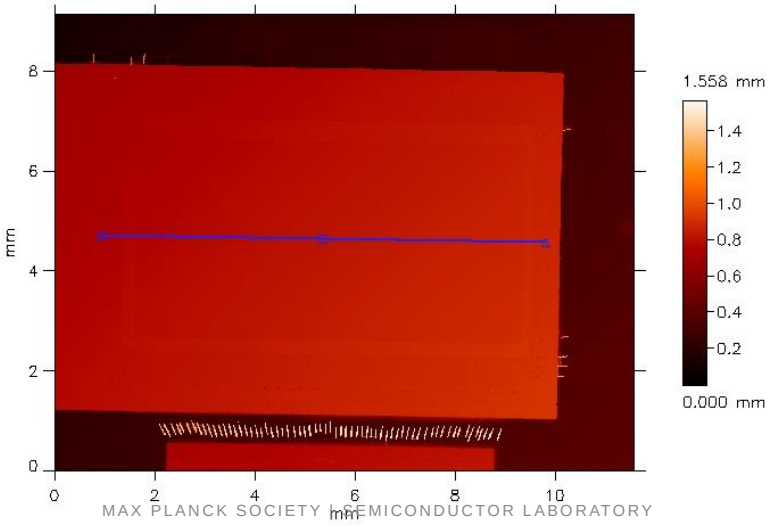
(ASSEMBLY COOLING BLOCK)

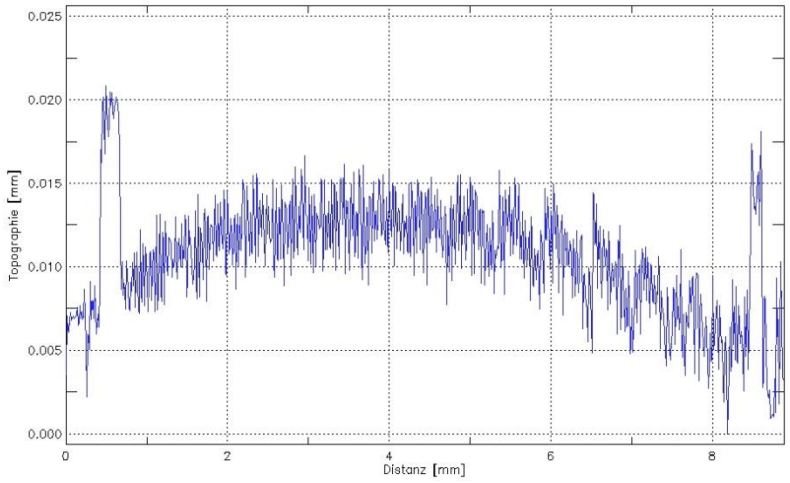
Headache: Hybrid PCB is thin so it will bend with too tighten screws. This resulted in one broken matrix during the November 2020 campaign.

-> Middle 2021 we made some topography measurements before and after assembly the cooling block adapter with different torques and defined in this way the lowest but necessary torque.

Result: No broken matrix in the 2021 June campaign.





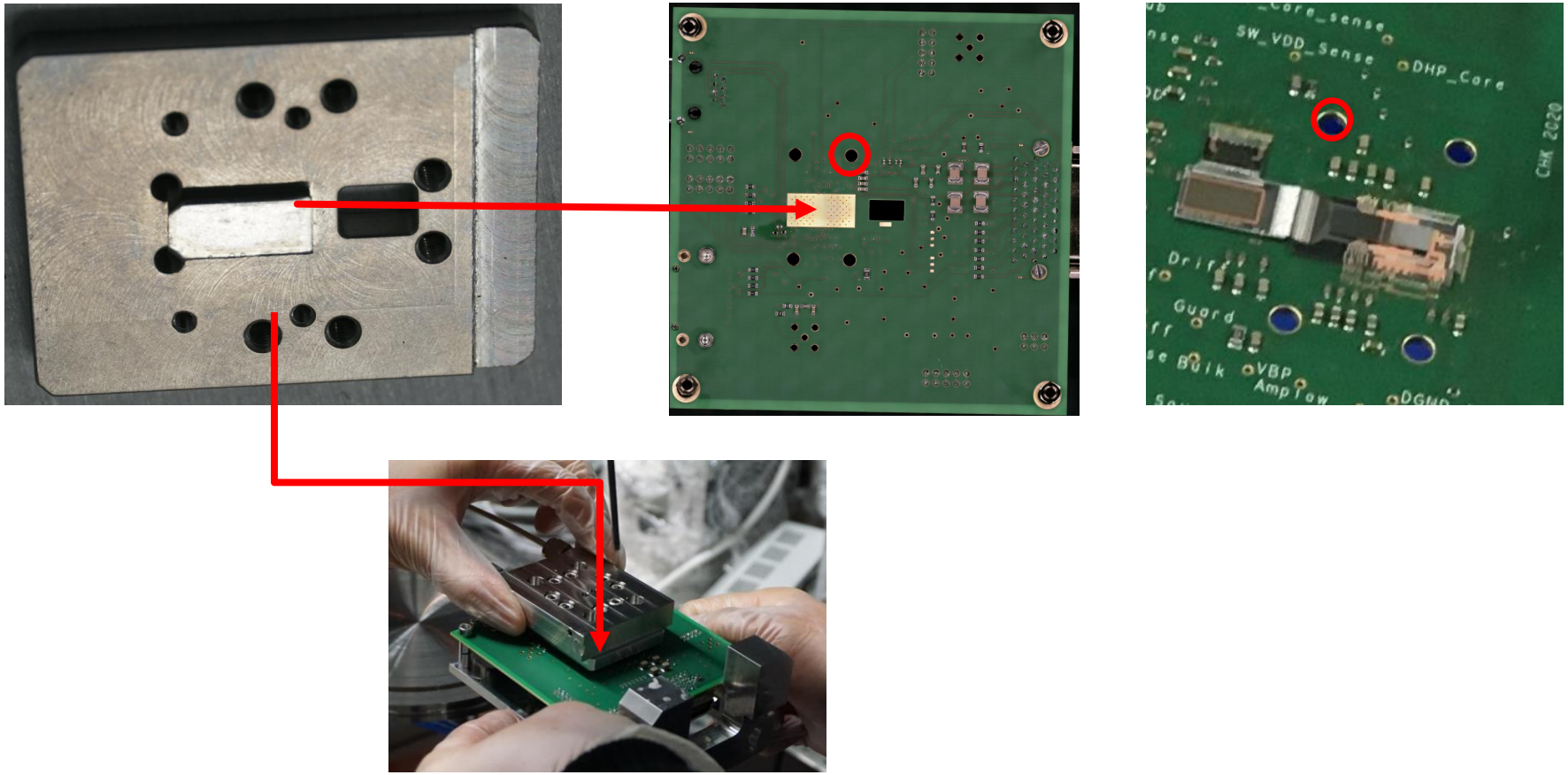


topography of thin matrix before assembly

MECHANICAL IMPROVEMENTS - AGAIN

(ASSEMBLY COOLING BLOCK)

Assembly of cooling block an hybrid board and than to the main cooling block in the vacuum tank.



MECHANICAL IMPROVEMENTS - AGAIN

(ASSEMBLY COOLING BLOCK)

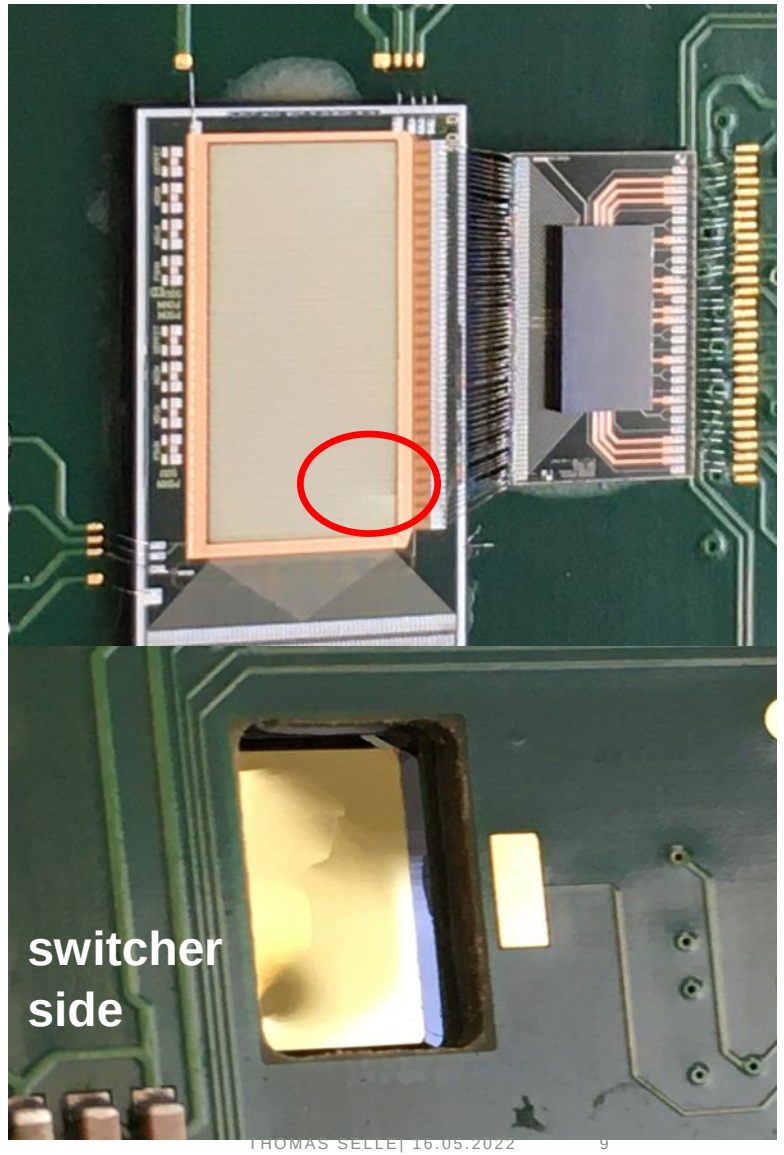
BUT… in the November 2021 campaign again one matrix broke!

This matrix had a second switcher glued on top of the first one perhaps this changed the bending degrees of freedom of the hybrid board in this area?

The torque is already very low so less would lead that the screws are not tighten enough and could unscrew after assembling the second cooling block.

<u>Solution:</u>

We decied to use a 100um Indium foil as a spacer. This worked good for the second hybrid board and also the third didnt‘ broke but… the third had a ground short of one ASIC voltage resulting in damaging the switcher.



MECHANICAL IMPROVEMENTS - AGAIN

(ASSEMBLY COOLING BLOCK)

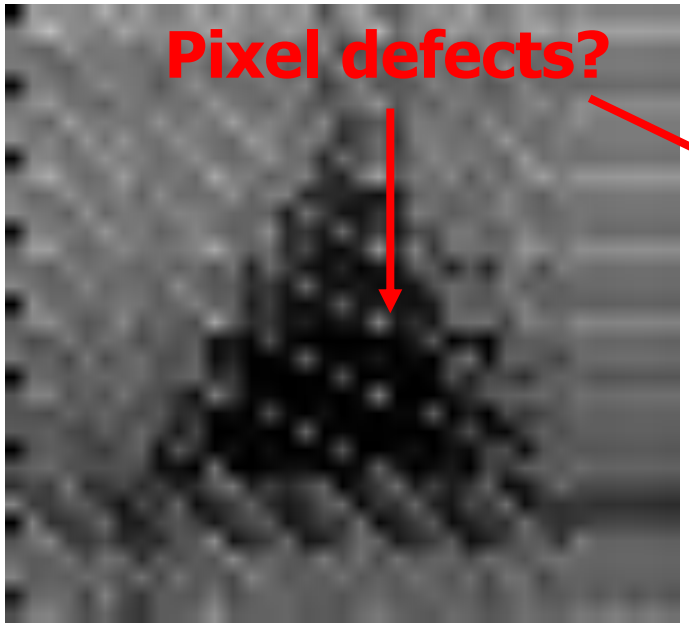
The reason was that some vias are located under the thermal contact surface and not in all hybrid boards the solder resist was perfect covering these vias.

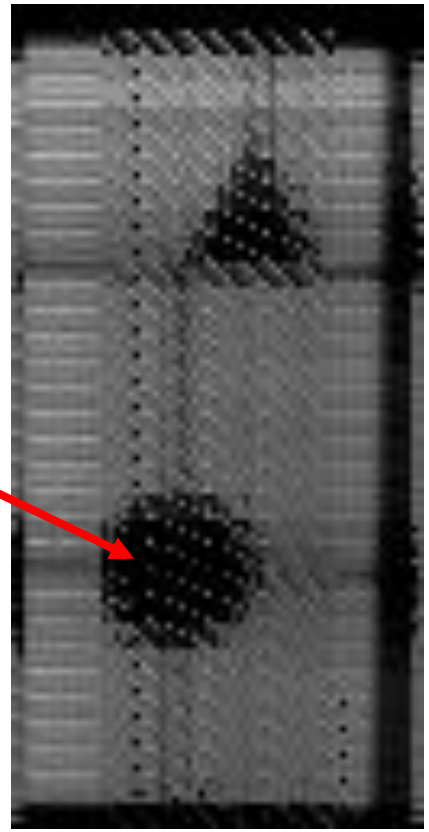
We reduced the size of the cooling block contact area to spare the vias.

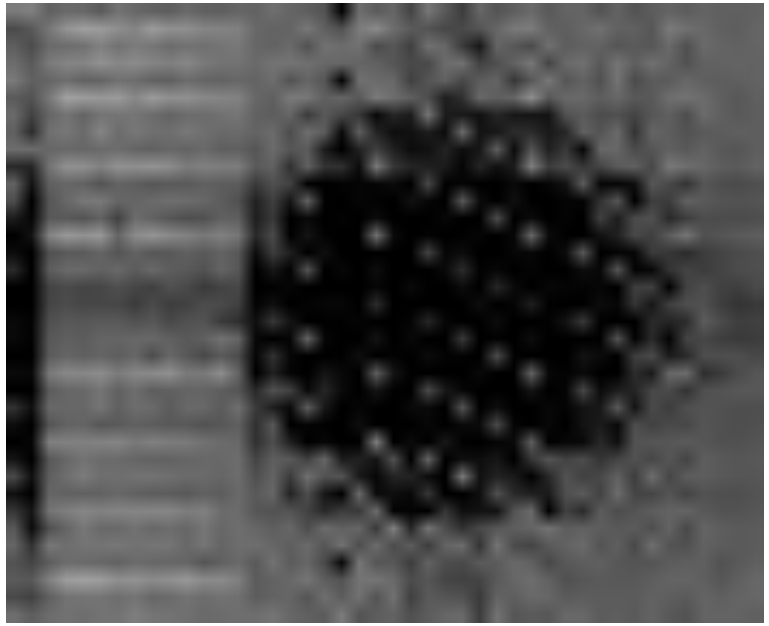
With this approach two more hybrid boards could be mounted with the cooling block without any break.

RADIATION MEASUREMENTS ISSUES NOVEMBER 2021

(HYBRID BOARD #9 450UM W11_C06 PXD10-1 L05)





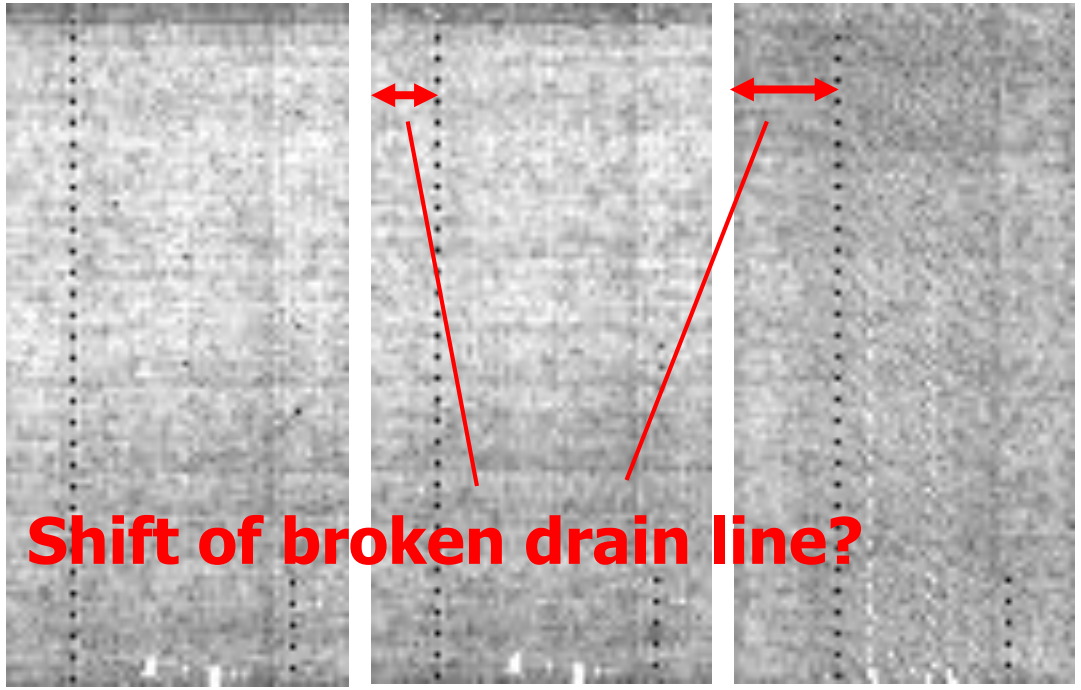


Mask used on hybrid board #9 after ~ 10Mrad radiation

RADIATION MEASUREMENTS ISSUES NOVEMBER 2021

(HYBRID BOARD #9 450UM W11_C06 PXD10-1 L05)

Raw images after irradiation (Vmax@150ADU always the same):



	~ 2Krad	~ 20Krad	~ 200Krad
GateOn	-1900 [mV]	-2400	-3160
ClearGate	-2170 [mV]	-2600	-4220
ISource	26.8 [mA]	26.4	26.6
GateOff	5000 [mV]	5000	5000

RADIATION MEASUREMENTS ISSUES NOVEMBER 2021

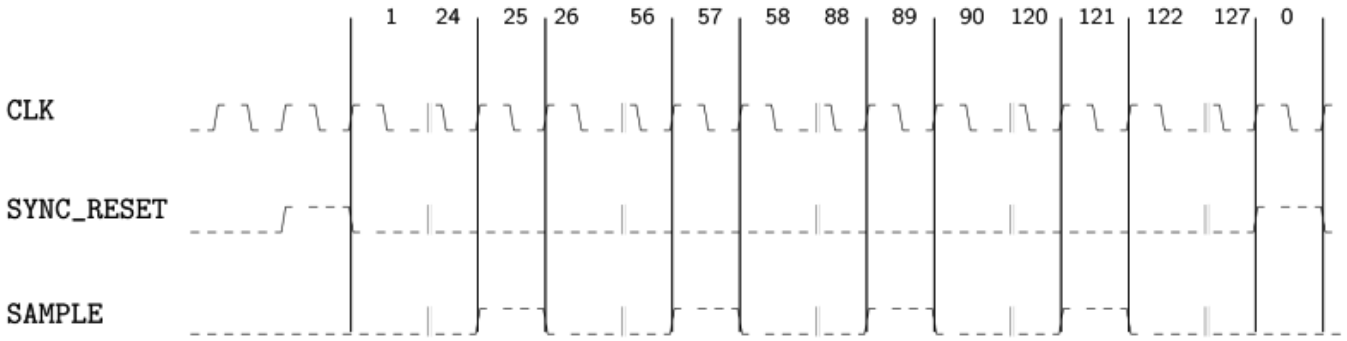
(HYBRID BOARD #9 450UM)

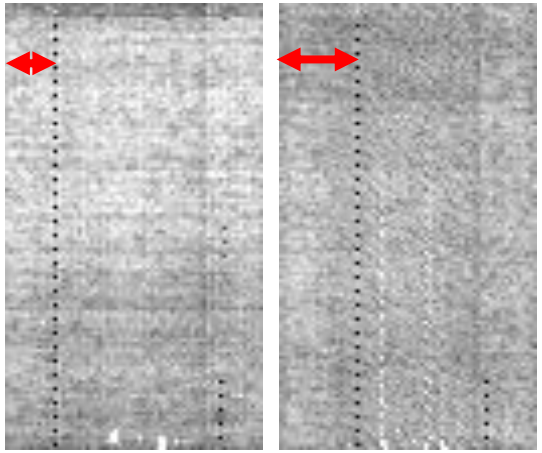
Of course not the physical location of the broken drain lines changed but rather there was a shift in the recording of the data.

Our small 128x64 matrix is read out in rolling shutter mode with 4 rows a‘ 64 pixels in parallel = 256 drain lines connected to the 256 DCD ADC channels.

For the read out the switcher, DCD and DHPT have to work synchronic. A master clock comes from the XU1 board to the DHPT and the DHPT is controlling the DCD and switcher.

After complete configuration of the DCD the data processing is controlled by only two signals: CLK and SYNC_RESET. At first the clock (CLK) must be activated while holding SYNC_RESET high. Then, the DCD starts data processing as soon as SYNC_RESET is released.



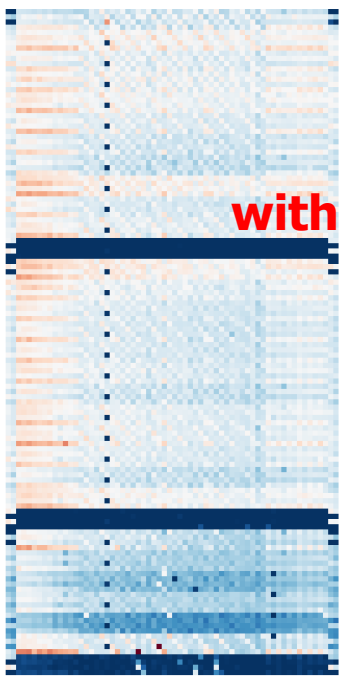


The SYNC_RESET delay can be changed via two settings in the DHPT.

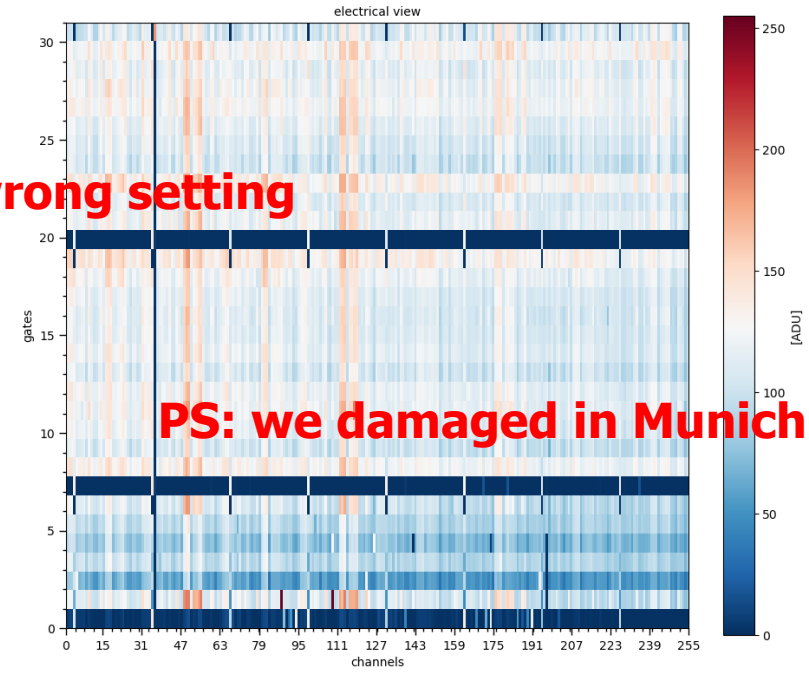
RADIATION MEASUREMENTS HAMBURG NOVEMBER 2021

(HYBRID BOARD #9 450UM)

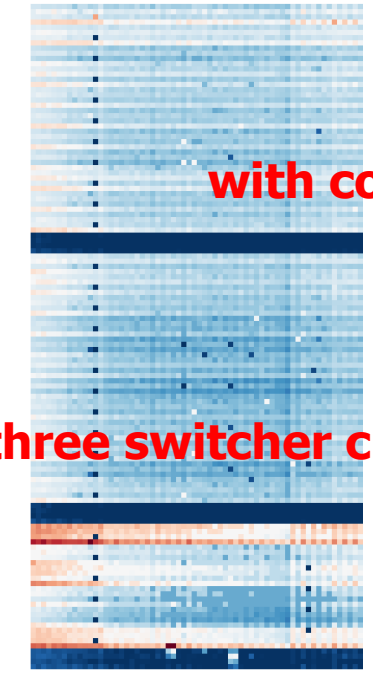
The two settings to change the SYNC_RESET delay in the DHPT are „ROW2_SYNC_DCD_CLK_DLY“ (7bit) and „DCD_ROW_SYNC_DLY“ (4bit) and these results in the same wrong mapping (left image).



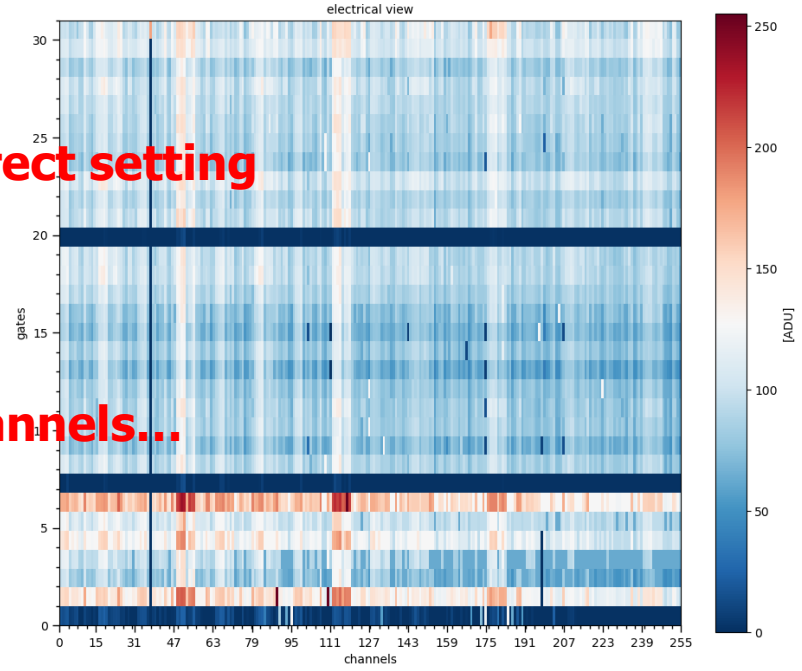
with wrong setting



PS: we damaged in Munich three switcher channels…



with correct setting



RADIATION MEASUREMENTS ISSUES NOVEMBER 2021

(HYBRID BOARD #9 450UM)

DHPT setting	value set in the campaign	value to get the shift
ROW2_SYNC_DCD_CLK_DLY	3 (0000011)	4 (0000100)
DCD_ROW_SYNC_DLY	0 (0000)	8 (1000)

A closer look in the settings and in the corresponding bit values shows that for DCD_ROW_SYNC_DLY only one bit flip would lead to this change.

We also made during the campaign a dump of the DHPT settings send from the GUI to the DHPT and there is no change of one of these settings → We didin‘t changed by accident this value.

An assumption would be that somehow this bit flip happended and because of we didn‘t reconfigured the DHPT during these measurements this setting stayed till the end. Sadly this wrong setting not only leads to this drain line shift but also gives us a little higher offset in the pixels due the wrong sampling time.

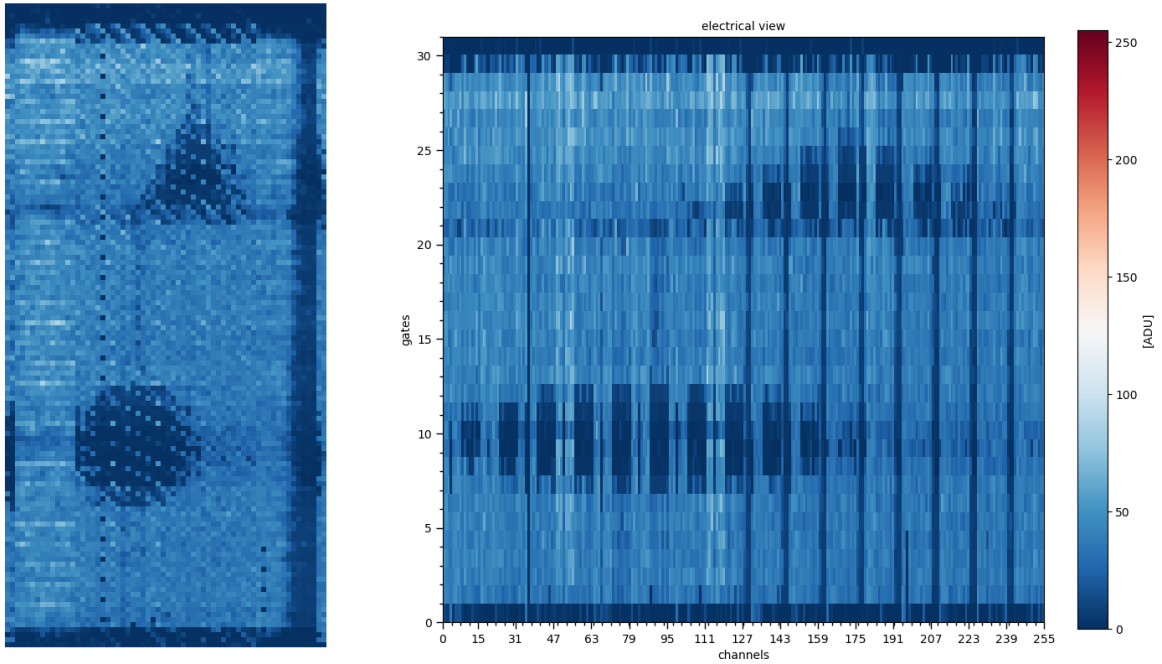
→ For the next campaigns we will more often reconfigure the ASICs

RADIATION MEASUREMENTS ISSUES NOVEMBER 2021

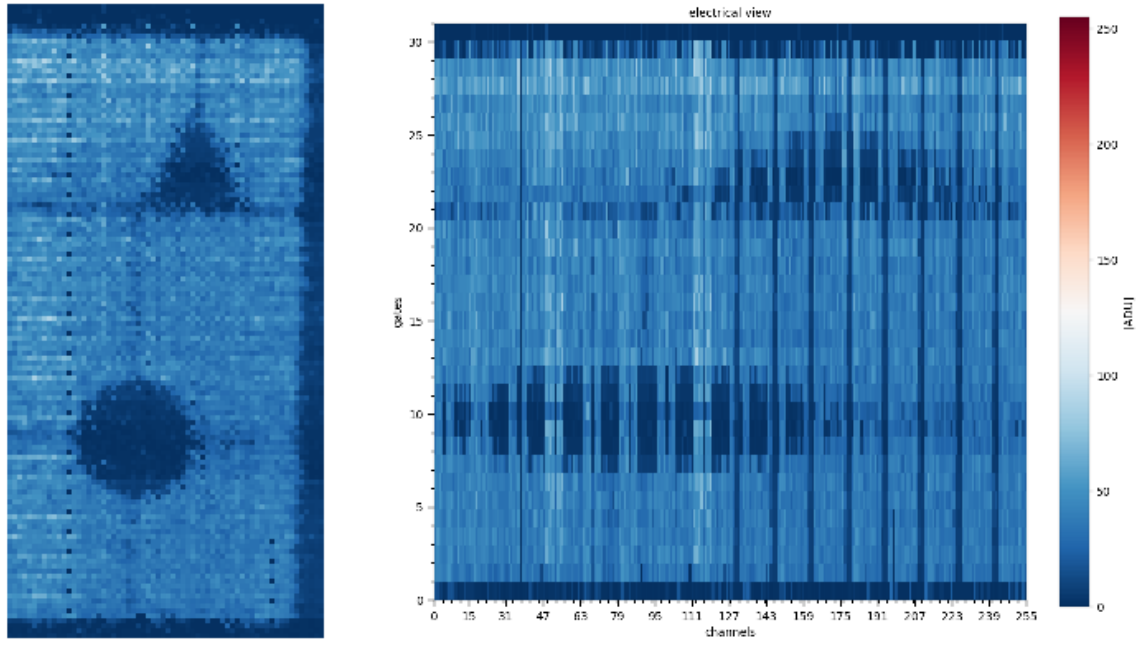
(HYBRID BOARD #9 450UM)

The shift can be adjusted and with this correction the mask after ~10MRad on this 450um matrix looks still nice:

Offset corrected image with wrong mapping



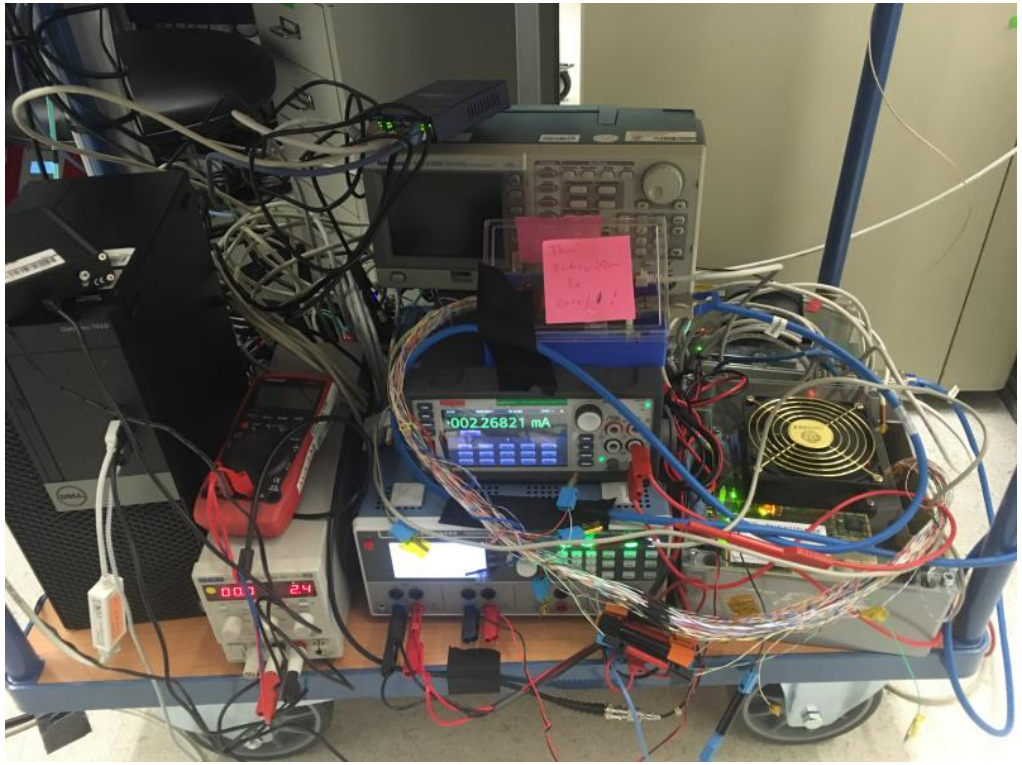
Offset corrected image after remapping



MAY RADIATION CAMPAIGN REMOTELY FROM MUNICH

(PXD10-2: HYBRID BOARD #13 50UM W15_B06)

- Due vacuum problems in March 2022 we set up the system in a state to control it remotely from Munich.
- Only MPSD components (TEM, shutter) had to be controlled by in place operators.



MAY RADIATION CAMPAIGN REMOTELY FROM MUNICH

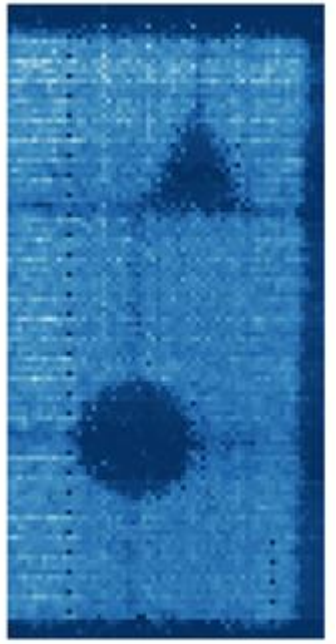
(PXD10-2: HYBRID BOARD #13 50UM W15_B06)

- Radiation campaign started from 3.May till 13.May.
- Totally 7 days spent for irradiation.
- Changed dose between sweeps from a few krad to 4 Mrad in the last irradiation.
- The remote control worked nicely but we had some problems with the used signal generator and unintended irradiated the matrix for some seconds a few times. This issue would have recognized earlier if we would have been in the TEM lab.
- Spontaneously annealing needs time for relaxation. During the begin of the campaign we could start the sweeps directly after irradiation. In the last days with hundreds of krad irradiation the source current needs around 30 minutes to stabilizing.

MAY RADIATION CAMPAIGN REMOTELY FROM MUNICH

(OPEN MEASUREMENTS WITH BUILD IN HYBRID #13)

- Some measurements with edge mask and shape mask.
- Radiate with 1 Mrad and measure overnight annealing with switched ON/OFF system.

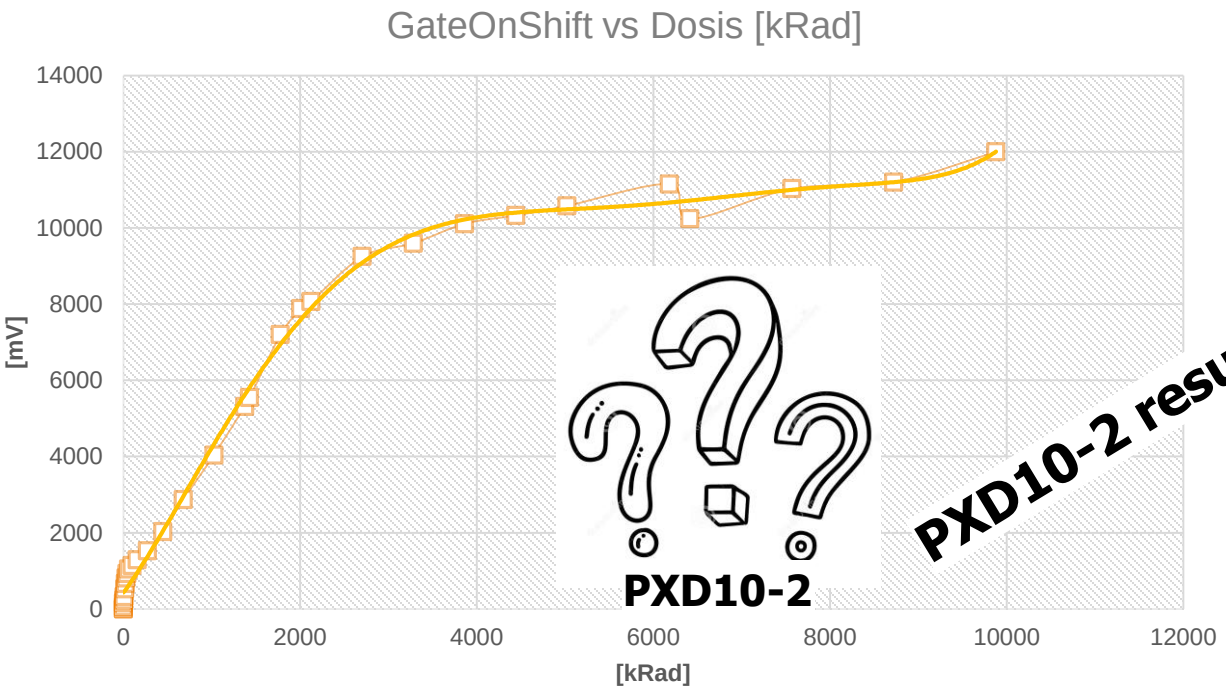


- Future irradiation plans:
  - Irradiate a thin PXD10-1 matrix.
  - Repeat PXD10-2 irradiation measurements but with imaging between the steps.

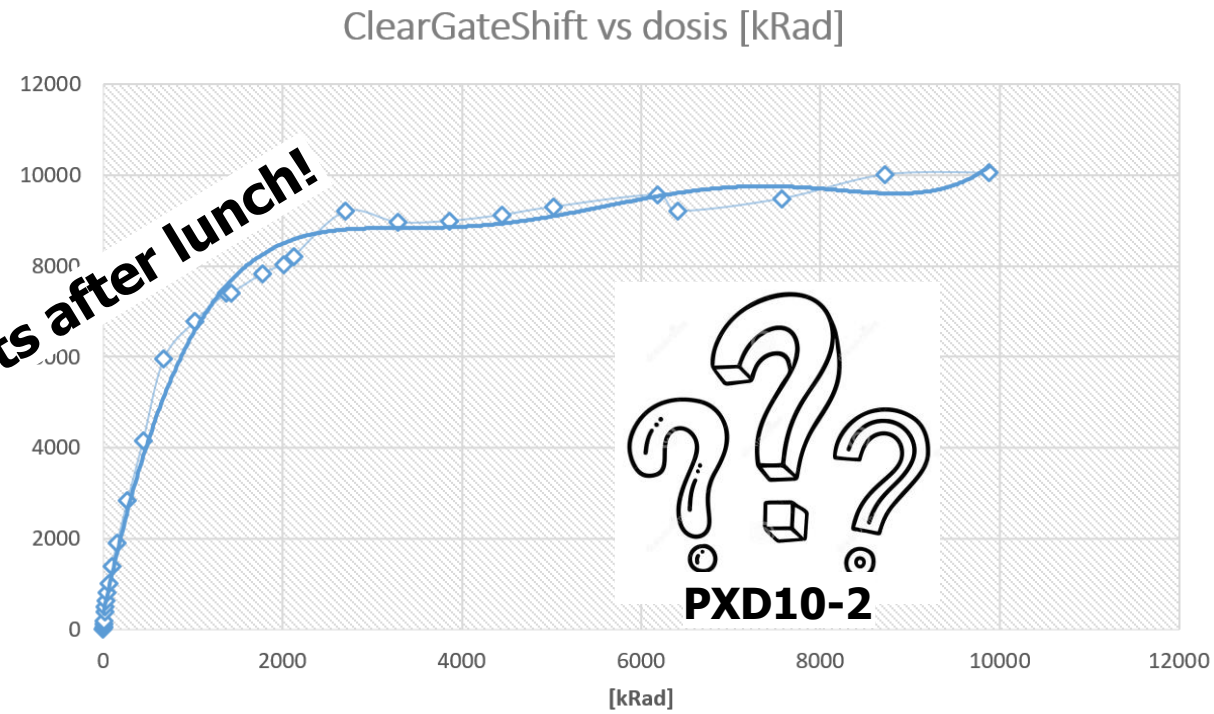
RADIATION RESULTS PXD10-1

(PXD10-1: HYBRID BOARD #9 450UM W11_C06)

Dose ~ 10Mrad



PXD10-2 results after lunch!



GateOnShift ~ -12 V

ClearGateShift ~ -10 V

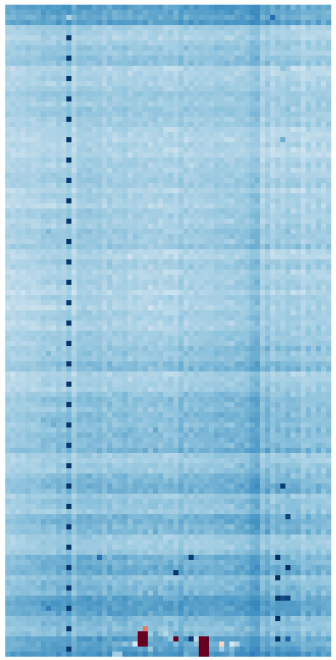
RADIATION MEASUREMENTS ISSUES NOVEMBER 2021

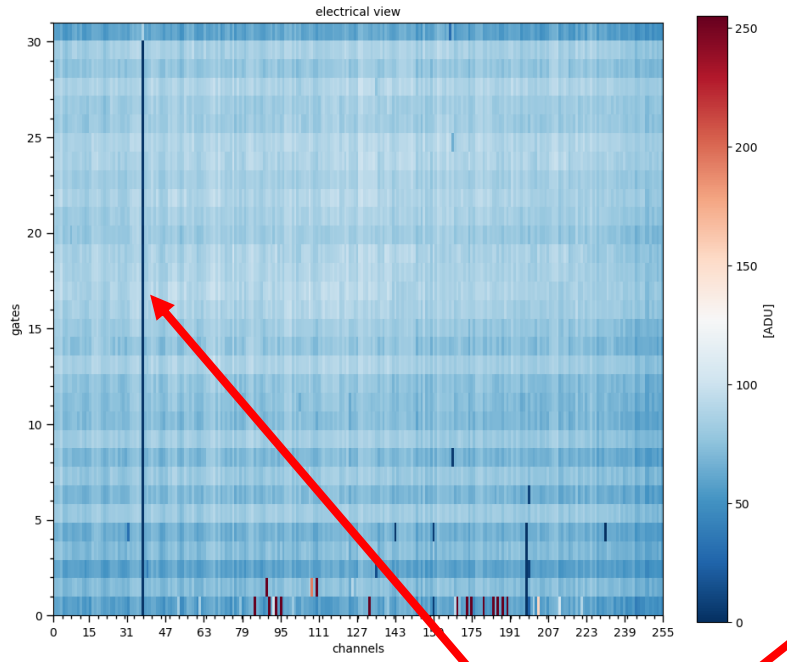
(HYBRID BOARD #9 450UM)

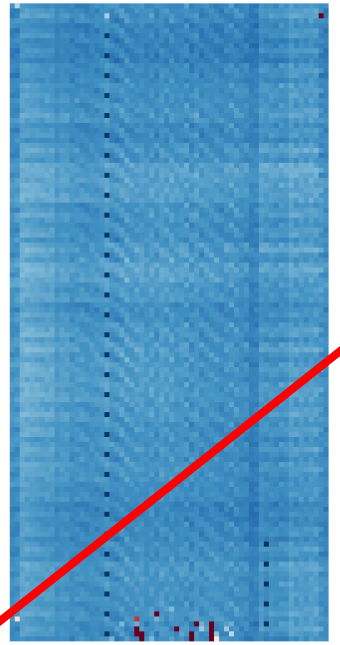
This change happened between run029 to run030 of 128 radiation measurements over 2.5 days. Because of we didn't used any mask or were aware this could happen we just continued with the radiation measurements.

But were comes this changes and has this some effect on the data?

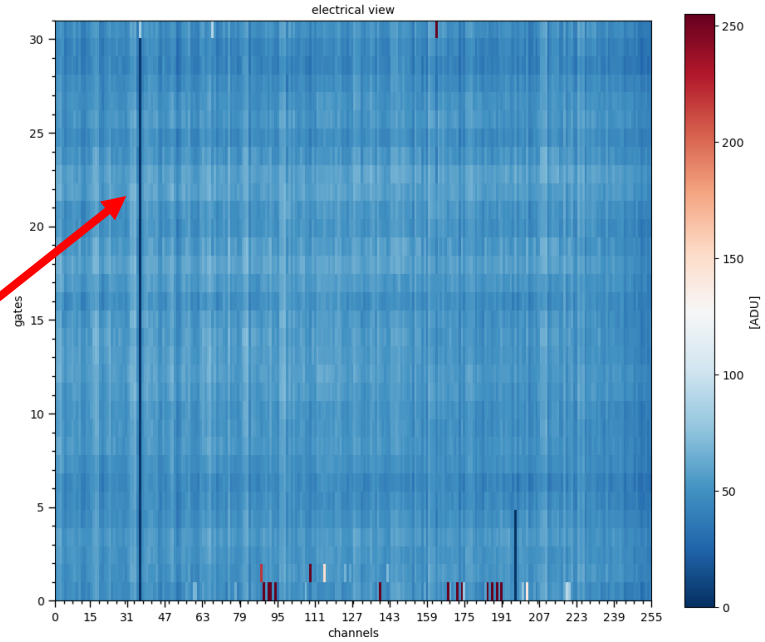
Run029







Run030



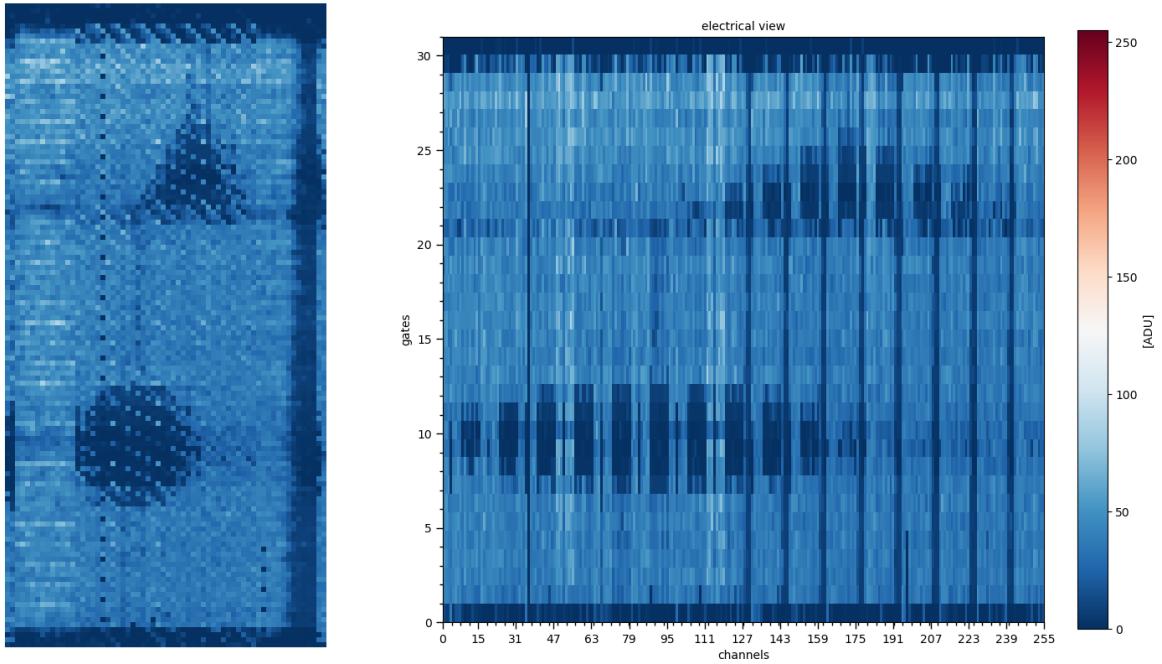
The pysical broken drain line shifted one DCD drainline.

RADIATION MEASUREMENTS ISSUES NOVEMBER 2021

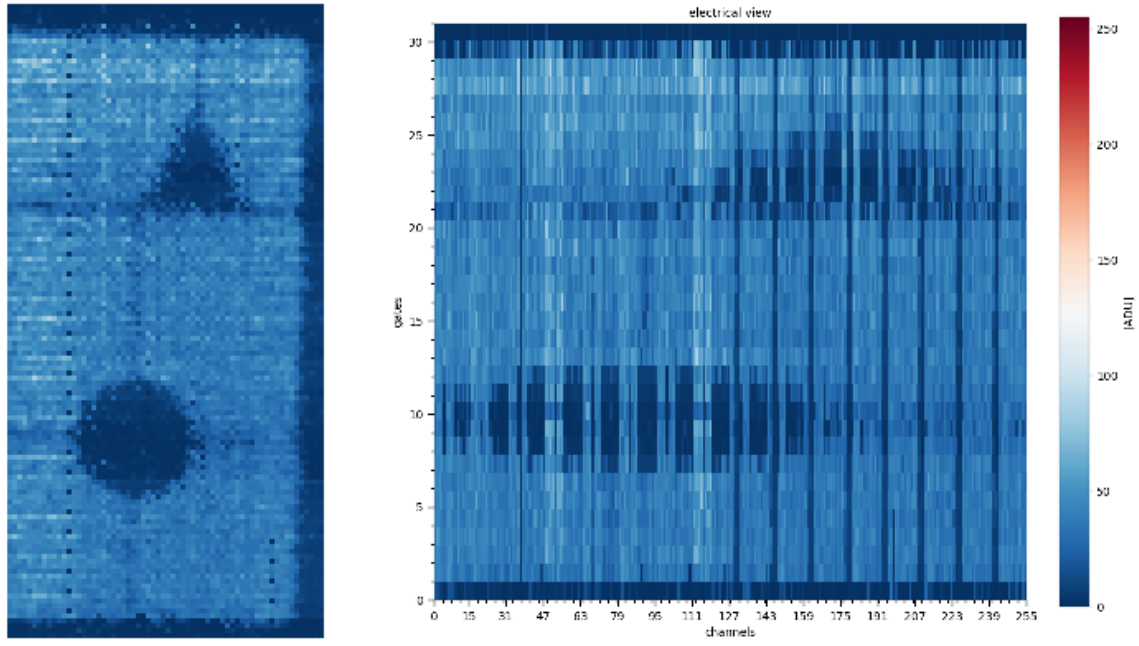
(HYBRID BOARD #9 450UM)

The shift can be adjusted and with this correction the mask after ~10MRad on this 450um matrix looks still nice:

Offset corrected image with wrong mapping



Offset corrected image after remapping



RADIATION MEASUREMENTS ISSUES NOVEMBER 2021

(HYBRID BOARD #9 450UM)

The question is what happened and how?

After some radiation we always did a GateOn and ClearGate sweep to find the best voltages. We did this after run 11,12,13,15,17,21,24,27 and 29. During these sweeps we also recording some frames. Here the data was still correct.

The first frame of run030 already showed the shift.

Back in Munich the matrix showed the broken drain line in the correct position. But if one would change the SYNC_RESET delay in the DHPT settings…