SiPM 2022

irradiation, annealing and characterisation

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Terminate 2021 annealing plans

- **FBK SiPM carrier boards have been reworked**
  - solder paste used originally did not sustain T > 125 C
  - sensors unmounted and remounted on boards with high-T solder paste
- **FBK SiPM carrier boards to anneal like Hamamatsu**
  - we stopped at T = 125 C for FBK annealing
  - we stopped at T = 150 C for Hamamatsu annealing
  - we should align them for a fair comparison
  - discussed with Ferrara, annealing of FBK will be carried out there
- **annealing at higher temperatures**
  - originally we foresaw to reach up to T = 175 C for annealing
  - need to discuss whether and when to do that on FBK and Hamamatsu boards
  - we are not in a hurry for that and Bologna is looking at response with light (see next slides)
  - good idea from Ferrara to first “cook in the oven” the silicone windows and check
  - to be decided before May if T = 175 C is part of the 2022 annealing protocol (see next slide)

2022 irradiation plan

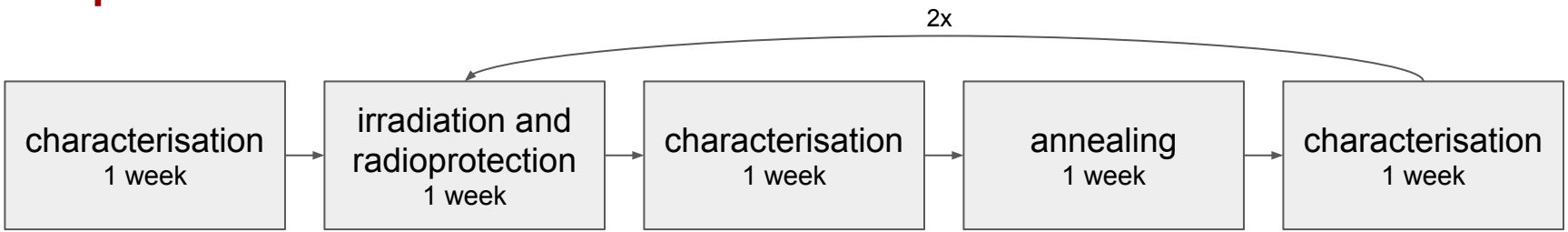
test SiPM performance and annealing with increasing integrated NIEL

simulate a more realistic experimental situation

irradiate full SiPM carrier boards with flat proton field

no collimators, his will make life much easier and very efficient use of beam

- **3 short accesses at TN protontherapy centre (TIFPA) in spring**
  - ideally 4 hours on Saturdays, should be sufficient time to setup and fire the beam
  - tentative dates: 23 April, 28 May and 2 July
  - one access every 4-6 weeks: allow time for radioprotection, characterisation and annealing
  - small NIEL integration steps, perhaps: 1 10^9 , 2 10^9 , 4 10^9
- **plus 1 more access in fall**

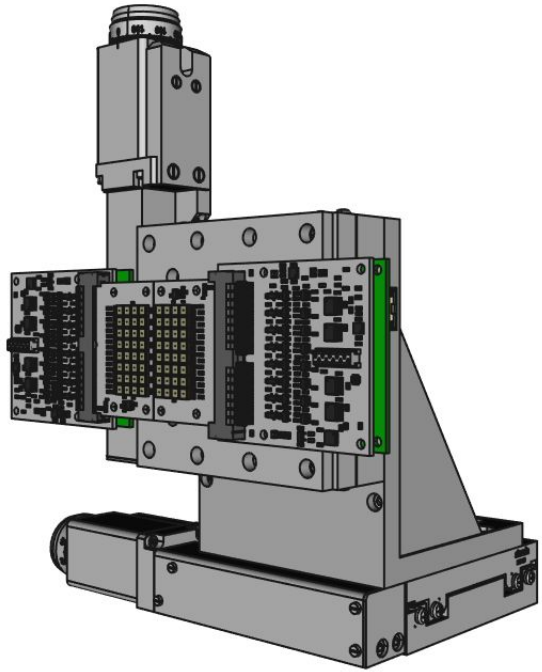


2022 irradiation / annealing / characterisation

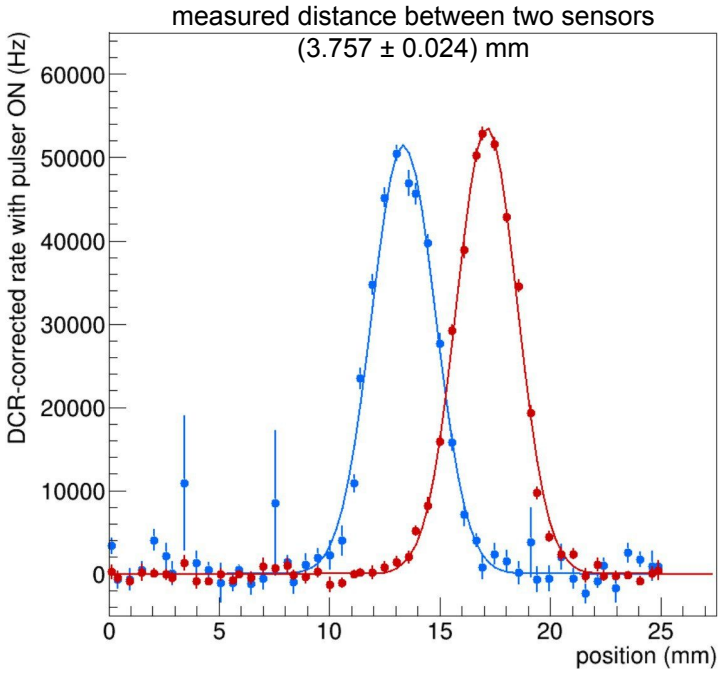
- **irradiation**
  - experience from last year
  - simplified approach for this year proposed
- **electrical characterisation**
  - I-V curves and the like
  - $V_{breakdown}$ vs. T
  - signals and rates on the oscilloscope
- **operation with readout system (ALCOR)**
  - threshold scans
  - dark rates
  - response to pulsed LED / laser light
- **annealing**
  - experience form last year
  - simplified approach for this year
  - one shot at target T for 5 days
  - target T to be defined (150 C or 175 C)

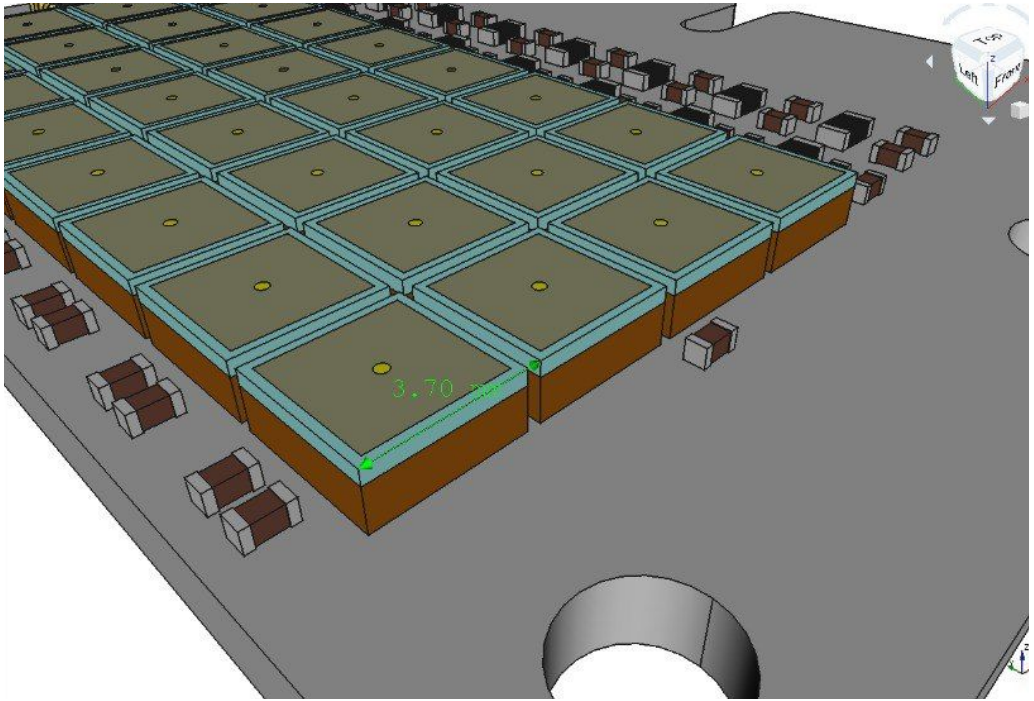
SiPM + ALCOR response with light

- **use the complete electronics built in 2021 for laboratory tests**
  - SiPM carrier + adapter + ALCOR + readout
  - mount everything in the climatic chamber
  - with an LED / laser in front of the sensor
  - plus movimentation to inspect all sensors
- **study response of SiPM to pulsed light**
  - pulsed LED / laser
  - measure increase of rates
  - measure time coincidences
  - compare sensors with different NIEL
- **system is being setup in Bologna**
  - the goal is to have it as a permanent test bench
  - to be used to test SiPM response for 2022 irradiation plan
  - to be used to get ready for test beam (in case we want to)



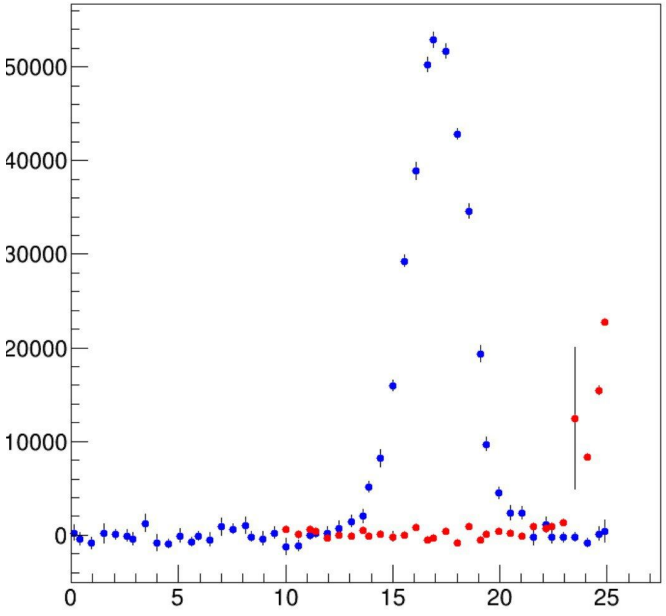
Test of motorised stage (one axis)



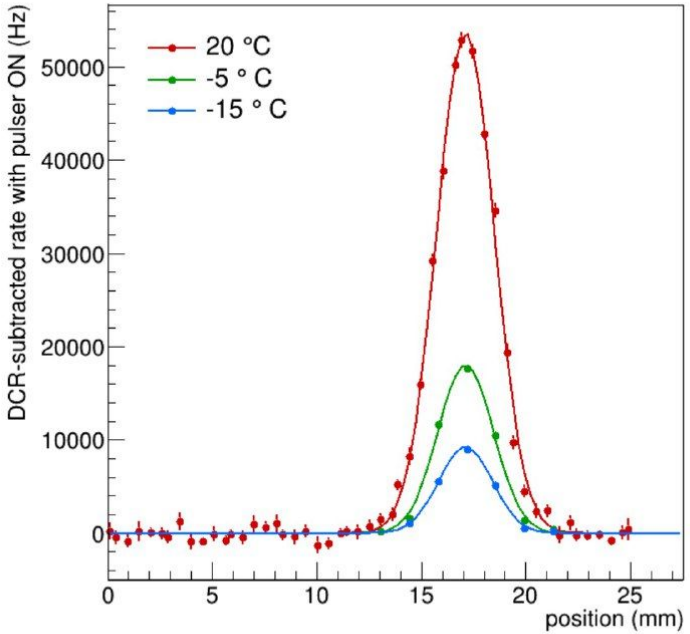


Problems with motor stages at low temperature

with the motorised stages we have we do not have reliable positioning already at T = 5 C
must buy new motor stages

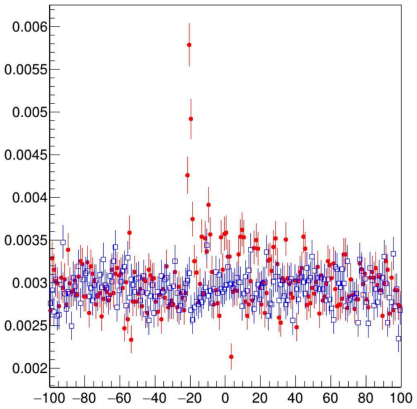


we can anyway do some measurements at low temperature: need to move temperature up and down for movimentation and measurement
very slow process, needs 2 hour for each point



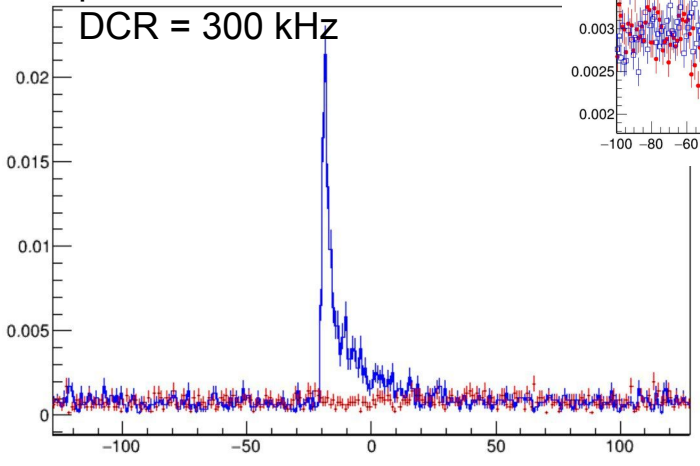
The rest is still very preliminary, but looks promising

sensor at 10^{11}

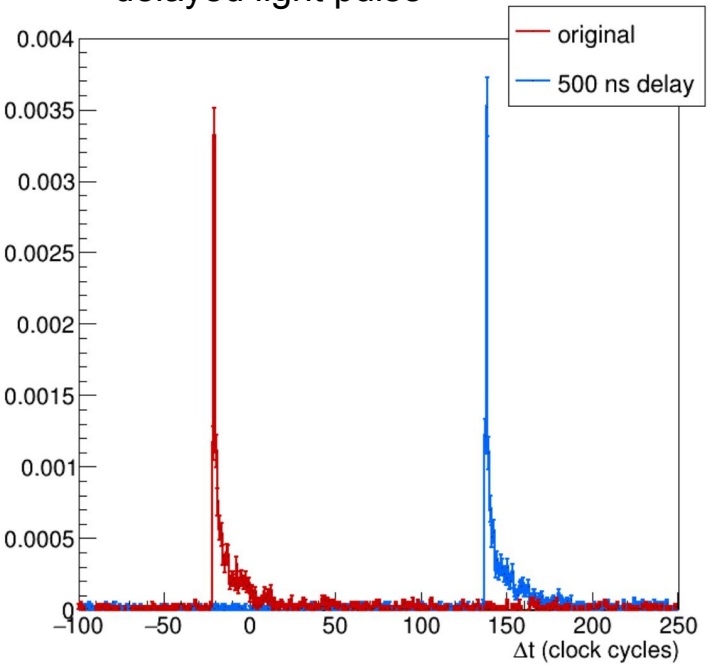


pulser ON / OFF at T = 20 C

DCR = 300 kHz

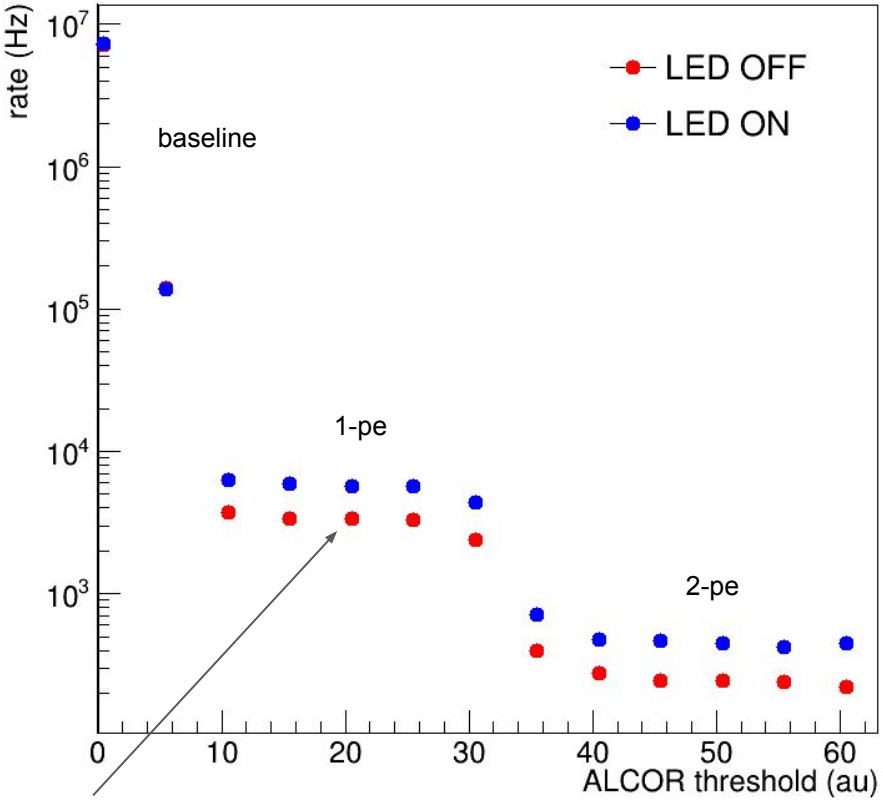


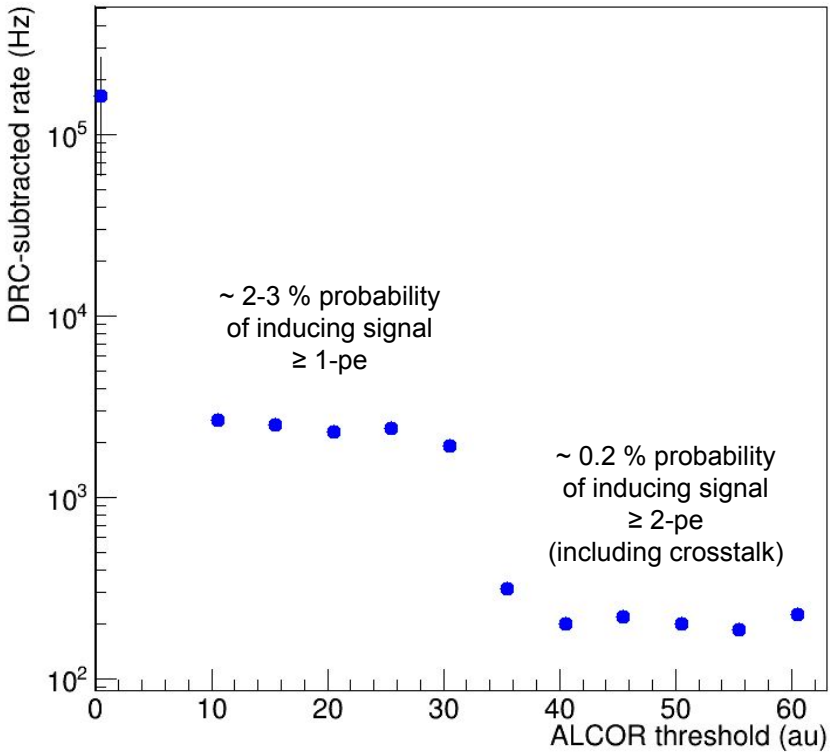
delayed light pulse



pulsed LED at 100 kHz frequency

most of the time (~97%) there is no signal from SiPM
⇒ LED light emission is low





this is the DCR

pulser ON - OFF

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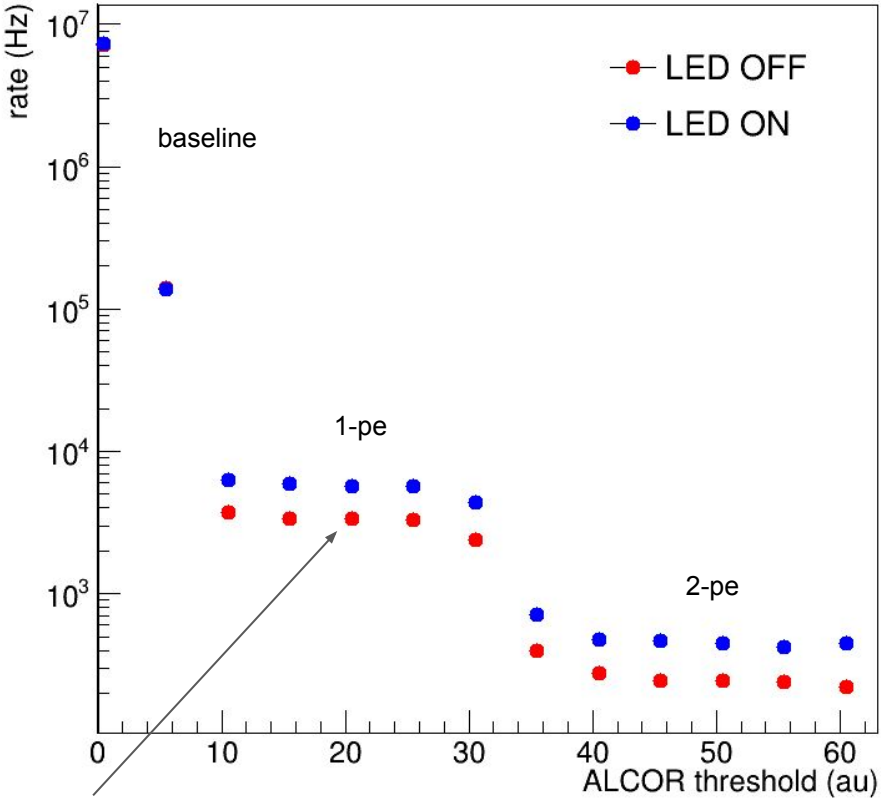
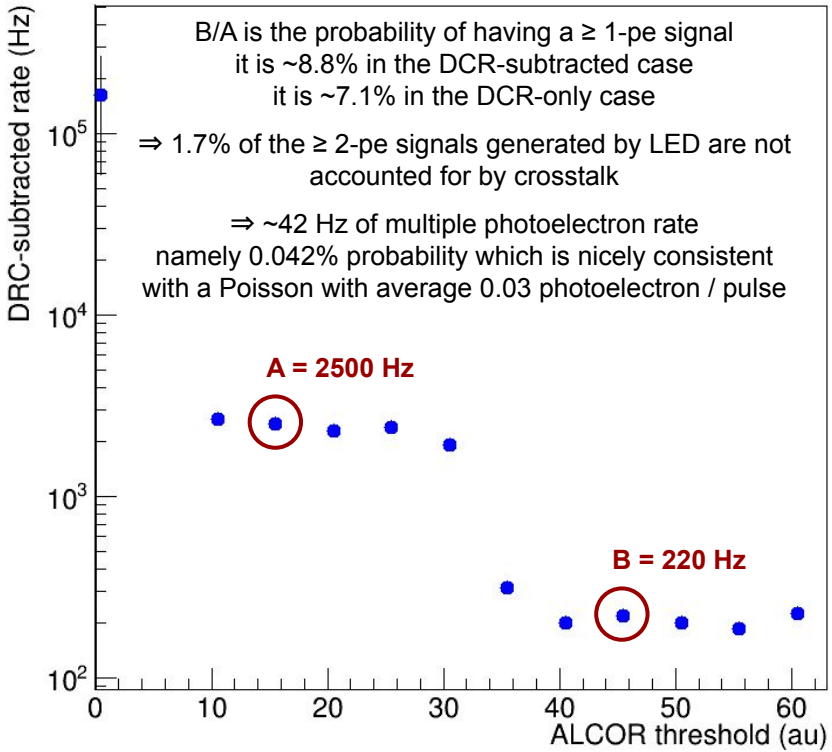


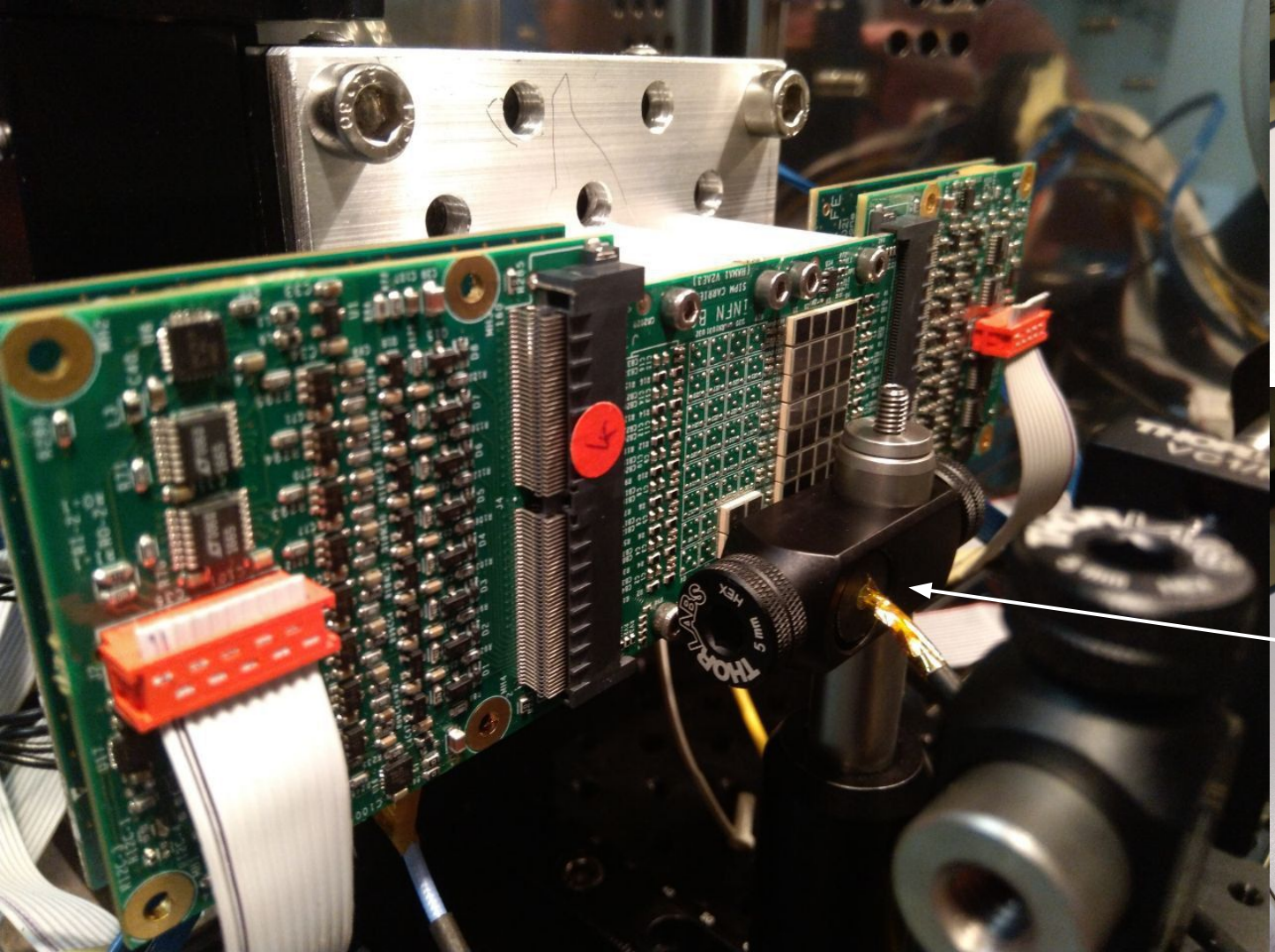


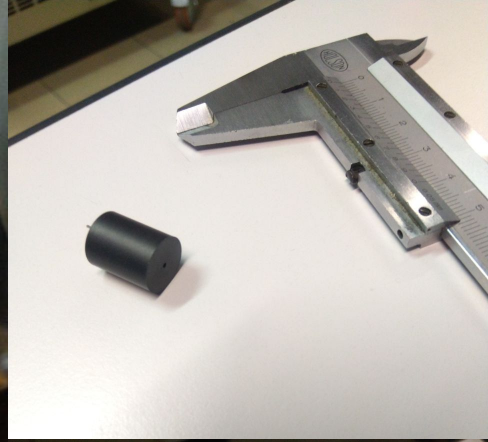
this is the DCR

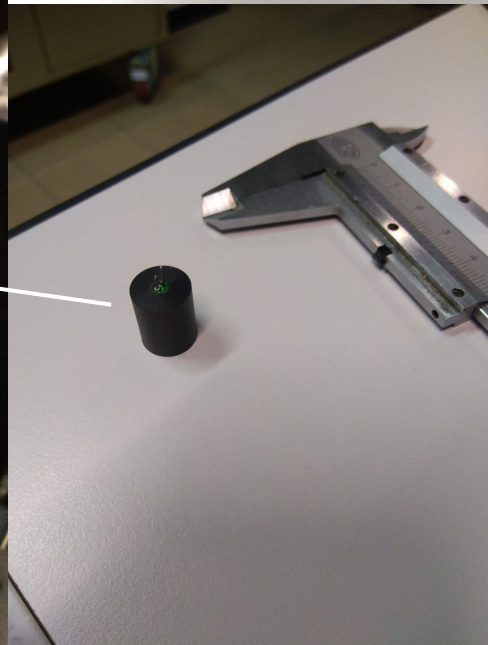
pulser ON - OFF

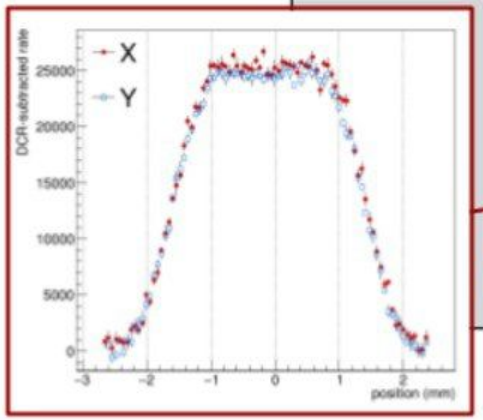
Bologna readout test bench

- **want it to be a permanent setup for SiPM characterisation**
  - and for preparation to beam tests
  - will extend the setup with a Peltier-equipped branch
- **still several work to be done to complete the setup**
  - mount 2nd motor stage and finalise optical bench
  - better collimator for LED
  - will need motor stages that work at low temperature
- **still work to be done to have a complete and proper ALCOR readout**
  - need to better learn how to calibrate fine timing
  - reach better time resolution
  - test pulses and inhibit features for ALCOR discriminator
- **first measurements supposed to be performed end of February**
  - might not be very high precision
  - but hope is to have something to give already an indication


THOR LABS
5 mm
HEX

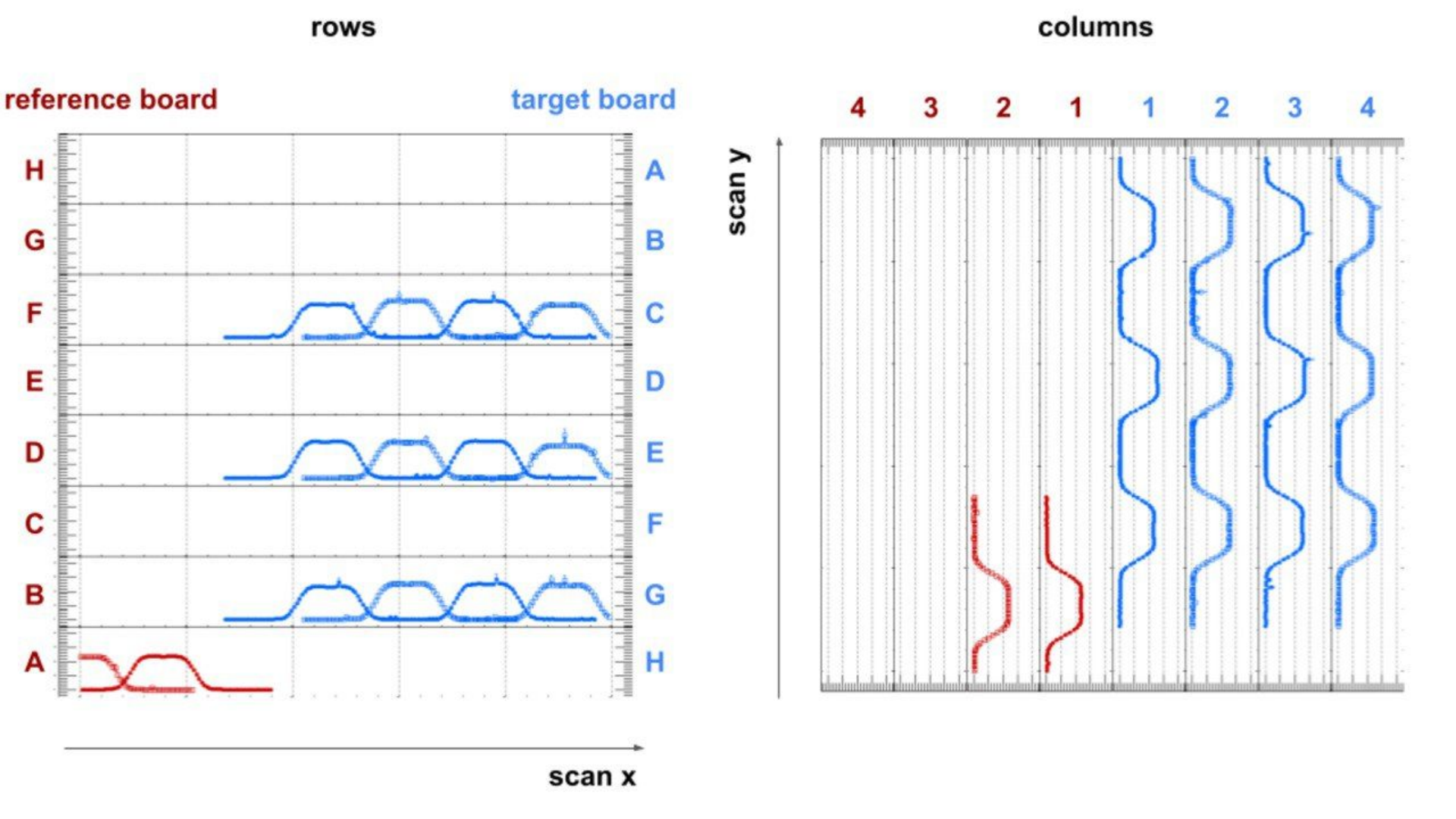


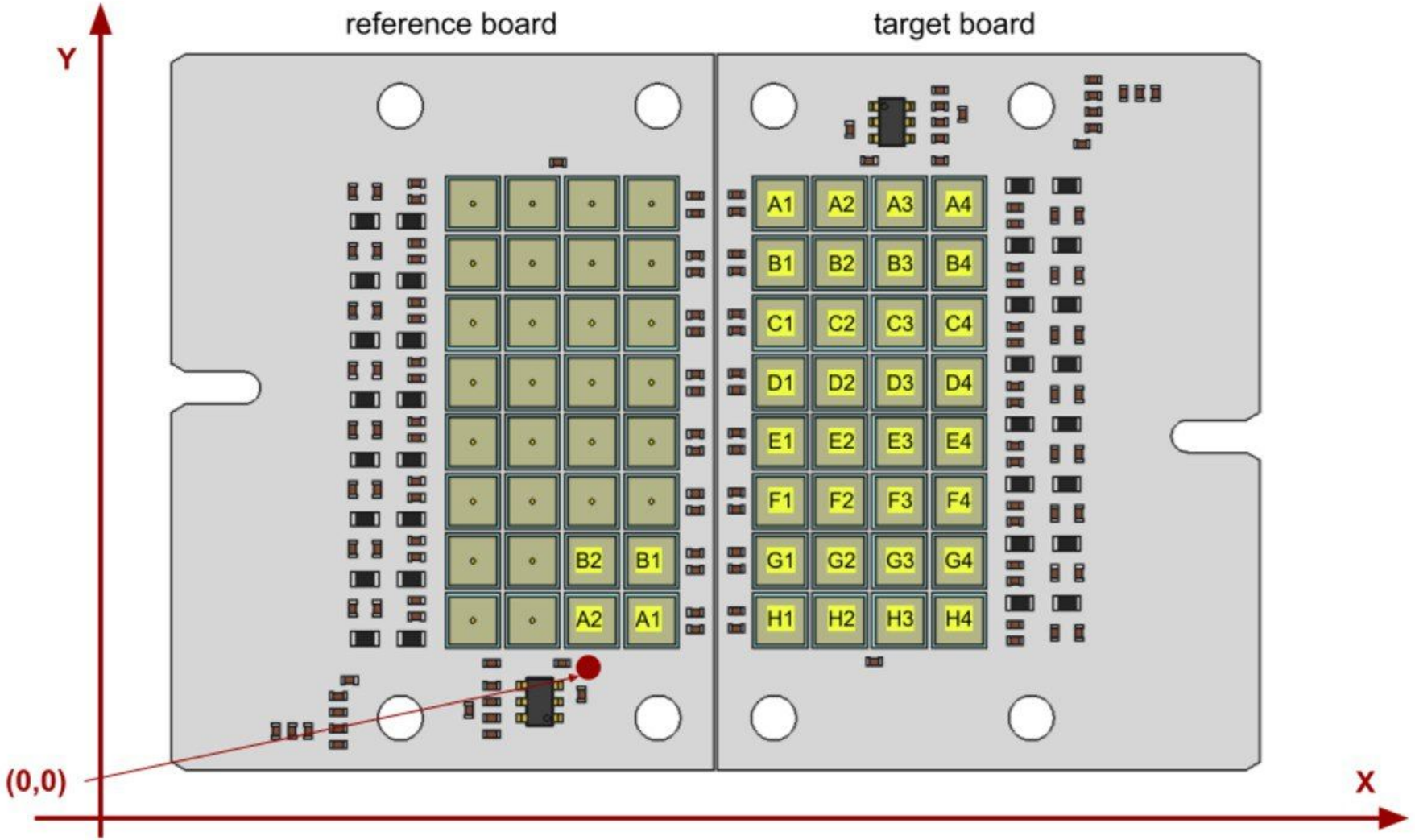


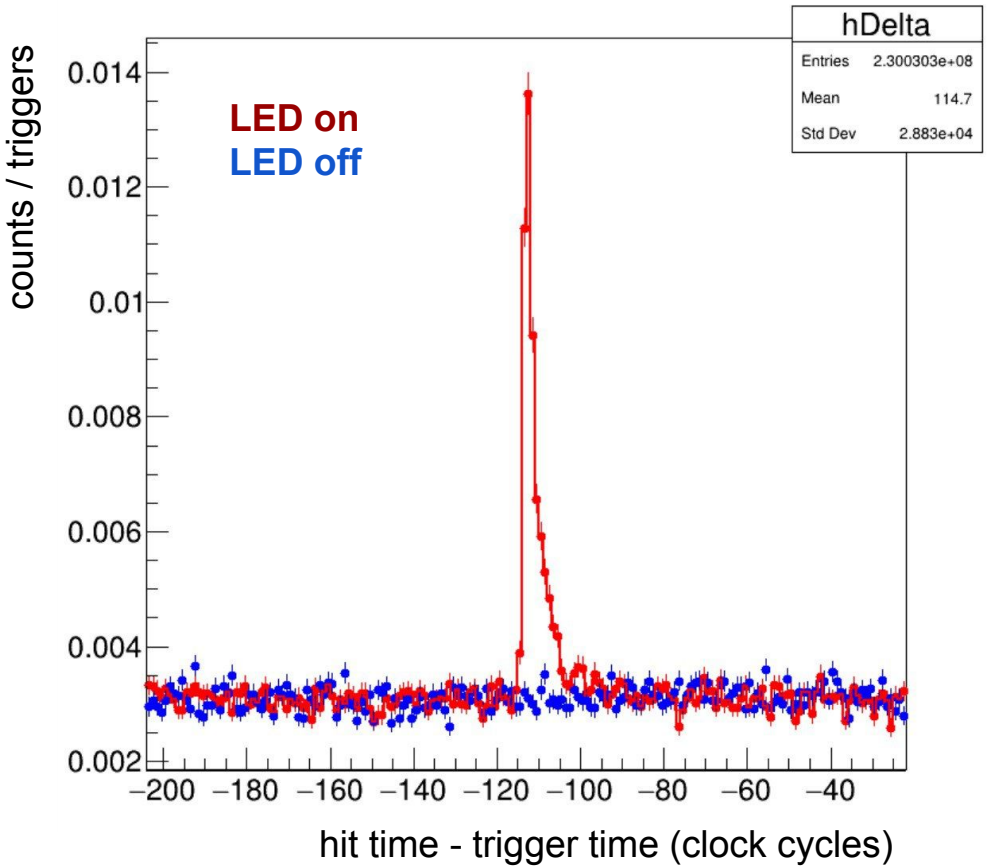


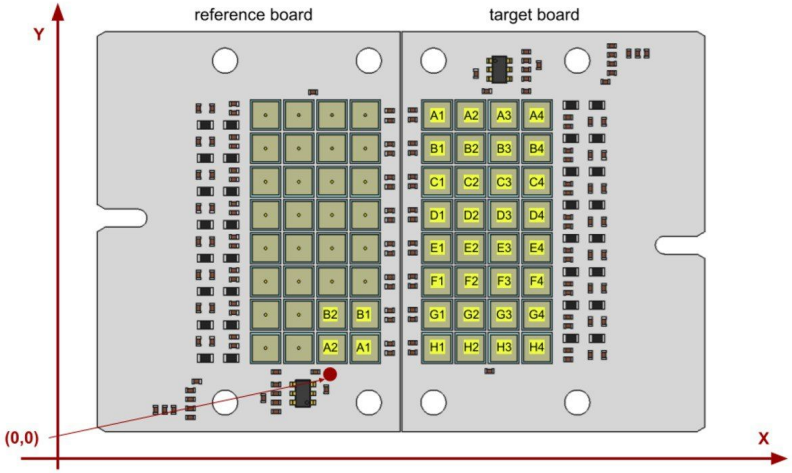
18.95 mm

19.1 mm


rows
columns
reference board
target board
H
G
F
E
D
C
B
A
A
B
C
D
E
F
G
H
scan x
scan y
4
3
2
1
1
2
3
4


reference board
target board
Y
X
(0,0)
A1
A2
A3
A4
B1
B2
B3
B4
C1
C2
C3
C4
D1
D2
D3
D4
E1
E2
E3
E4
F1
F2
F3
F4
G1
G2
G3
G4
H1
H2
H3
H4
B2
B1
A2
A1





this is sensor C4
of the Hama1 irradiated board
which received NIEL = 10^{11}
and annealing at T = 150 C

measured at T = -30 C
with Vbias = 51.3 V
and threshold for 1-pe detection