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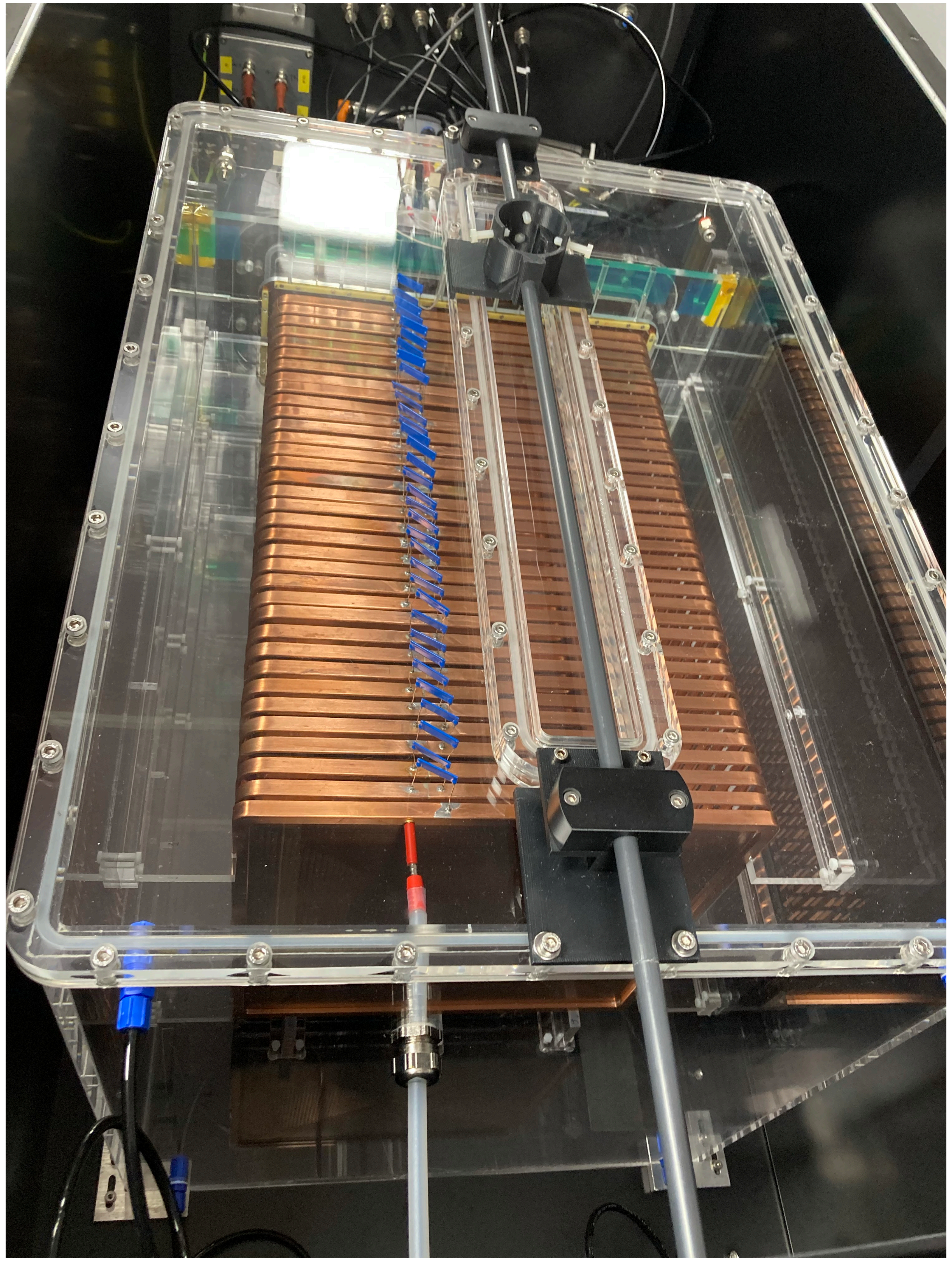
LIME operation

Stefano Piacentini



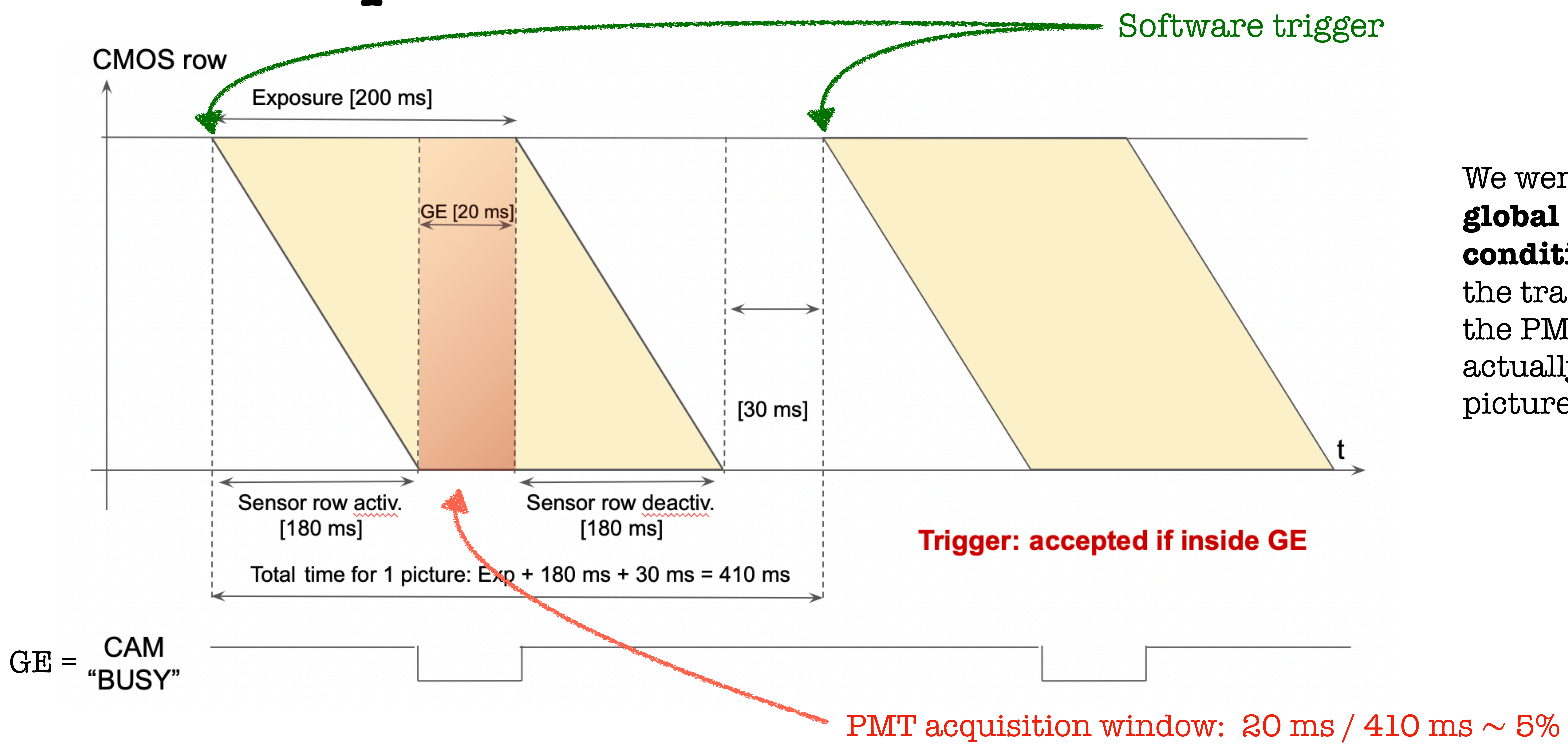
CYGNO Collaboration Meeting **Roma, 19/12/2022**

Introduction

- In this contribution we present the evolution of the **LIME underground operation** in the last couple of months.
- We made a lot of small **improvements** to the **acquisition system**.
- We collected a lot of data in **different readout configurations**, and for the first time we were able to acquire a **large amount of data including the PMTs**.
- We experienced different **issues**, some of them solved, some of them will be (hopefully) solved by the next data acquisition campaign with the new shielding.
- **Next data taking** campaign with a **4 cm copper** shielding at the **beginning of next year**.

Improvements of the acquisition rate and dead time reduction

The "old" acquisition scheme

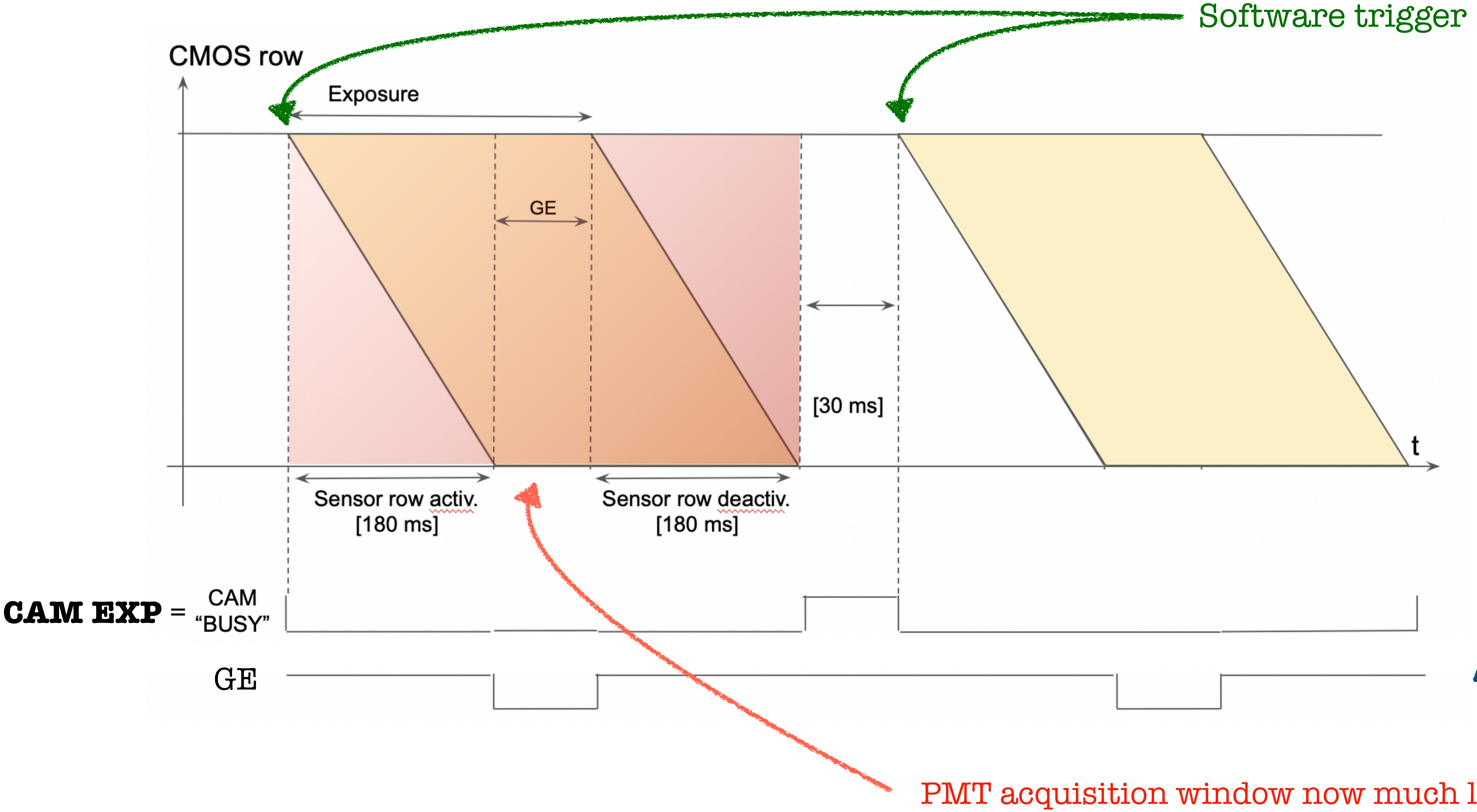


We were imposing the **global exposure (GE) condition** to be sure that the track responsible of the PMT signal was actually inside the picture!

But we use the PMT to trigger the data acquisition!!!

Improvements of the acquisition rate and dead time reduction

The new acquisition scheme



Solution:
program another camera output signal, use the **CAM EXP** signal for the acquisition and **acquire the GE with the DGTZ**

GE sent to DGTZ for the acquisition

Improvements of the acquisition rate and dead time reduction

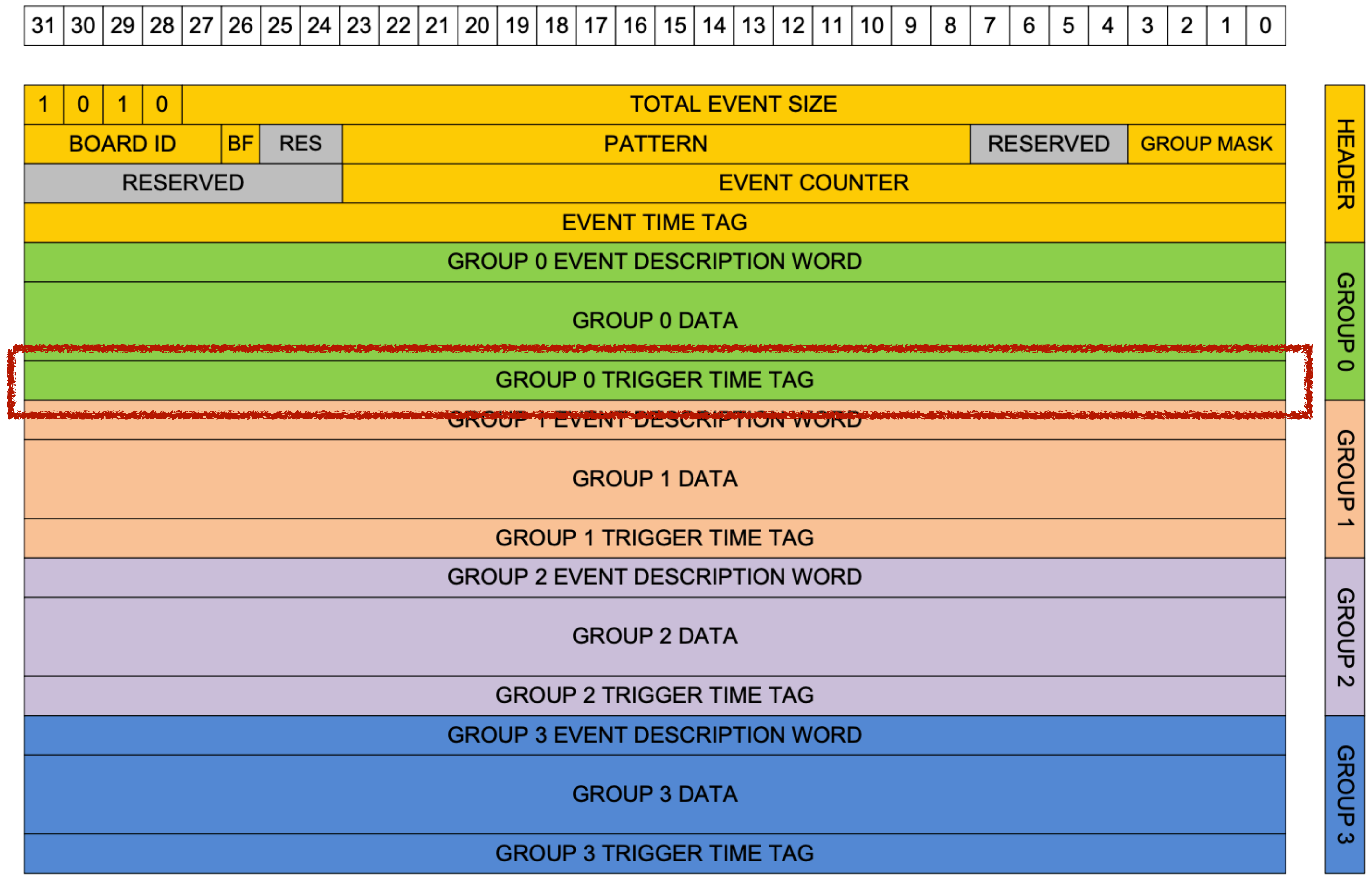
The new acquisition scheme: a small addition

- We decided that with this new scheme it could be useful to **acquire the event timestamp from DGTZ**.

- We added, for each picture, the **trigger time tag (TTT) of each saved waveform (WF)** in the **"DGHO"** data bank in the Midas file.

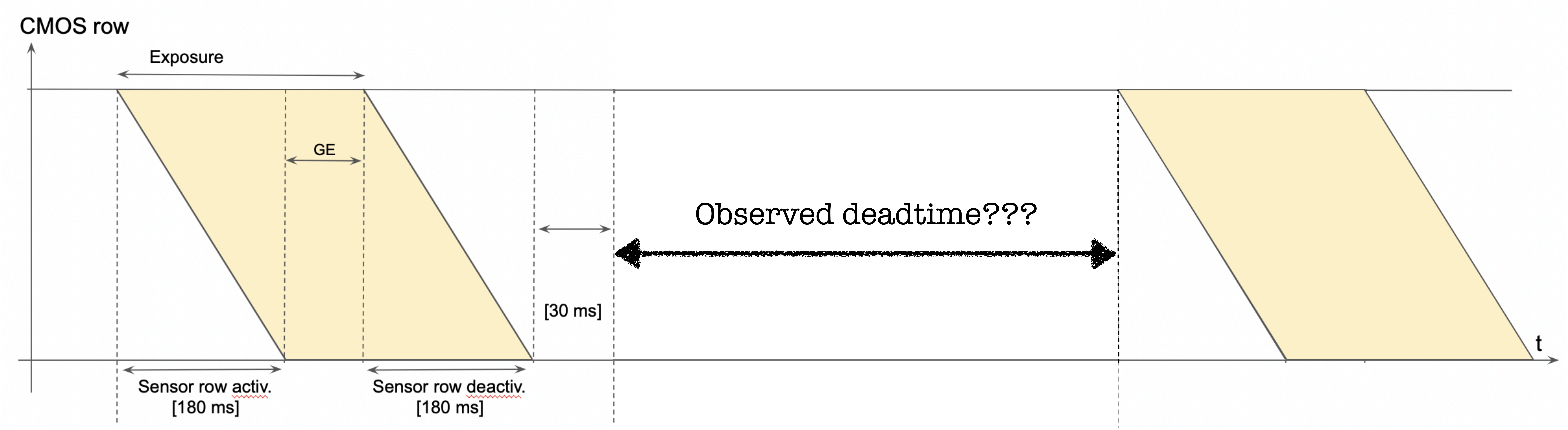
- We used the **CAM EXP signal to sync the TTT of the V1742 (fast) DGTZ.**

v1742 data buffer structure:



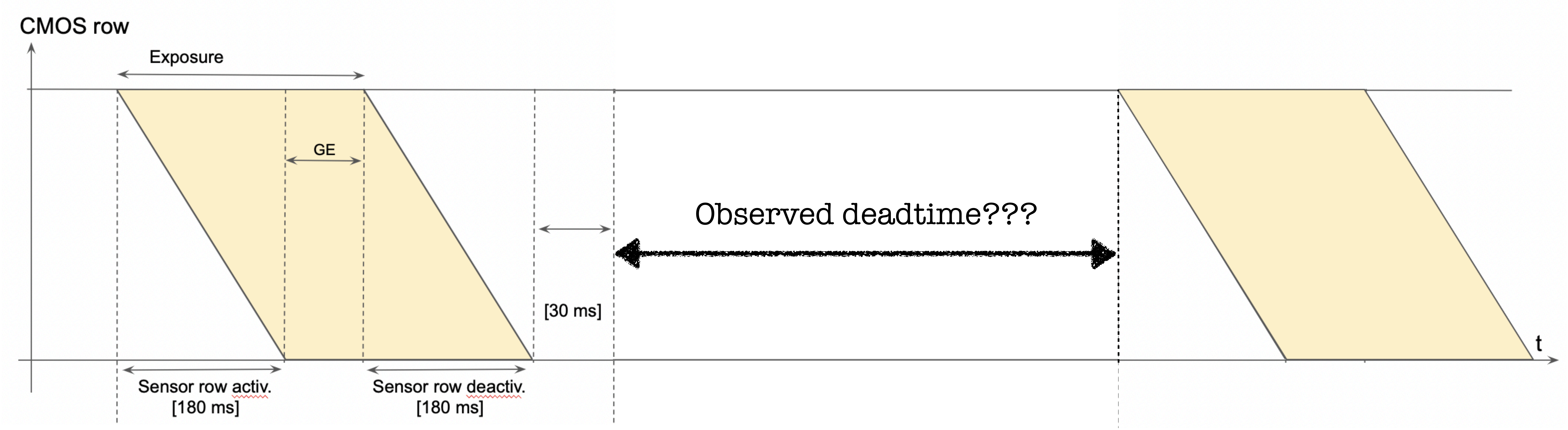
Improvements of the acquisition rate and dead time reduction

The new acquisition scheme: the reality



Improvements of the acquisition rate and dead time reduction

The new acquisition scheme: the reality



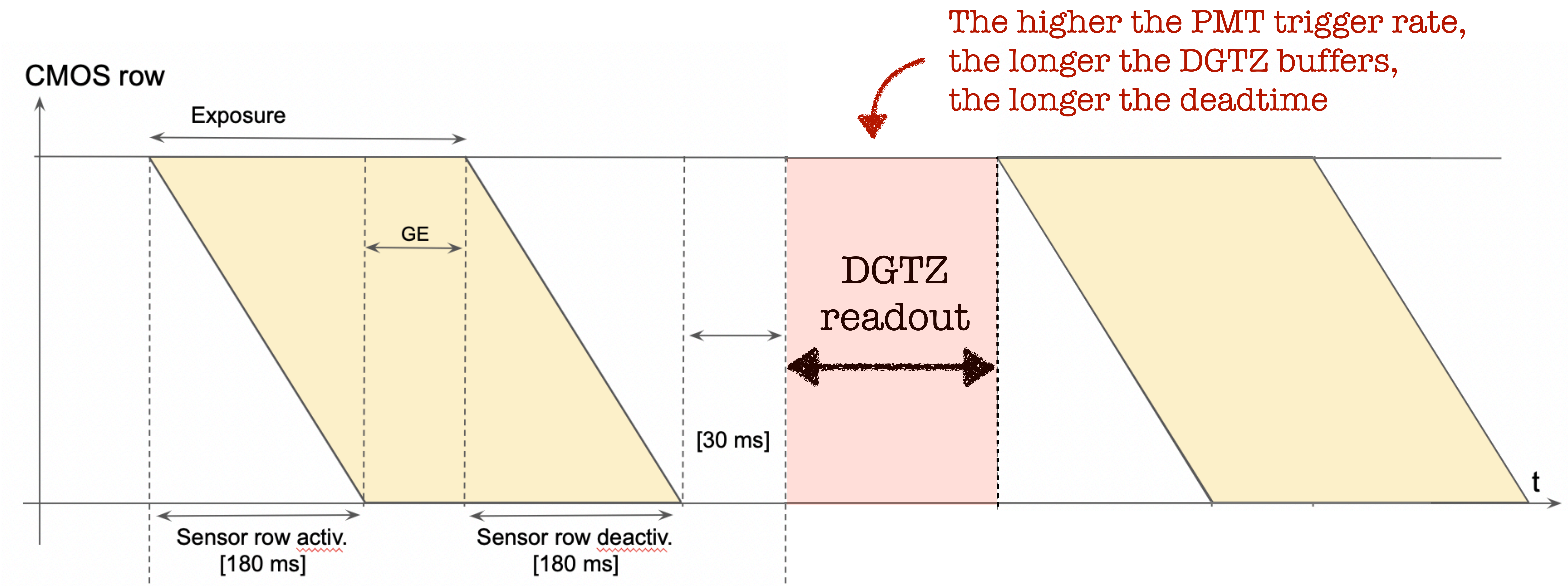
This time was lost:

1. mostly to the **Midas online compression**
2. partially to read the DGTZ buffers (unavoidable)

Compression now performed by the midas2cloud script with a great reduction of DT!

Improvements of the acquisition rate and dead time reduction

The new acquisition scheme: the situation now

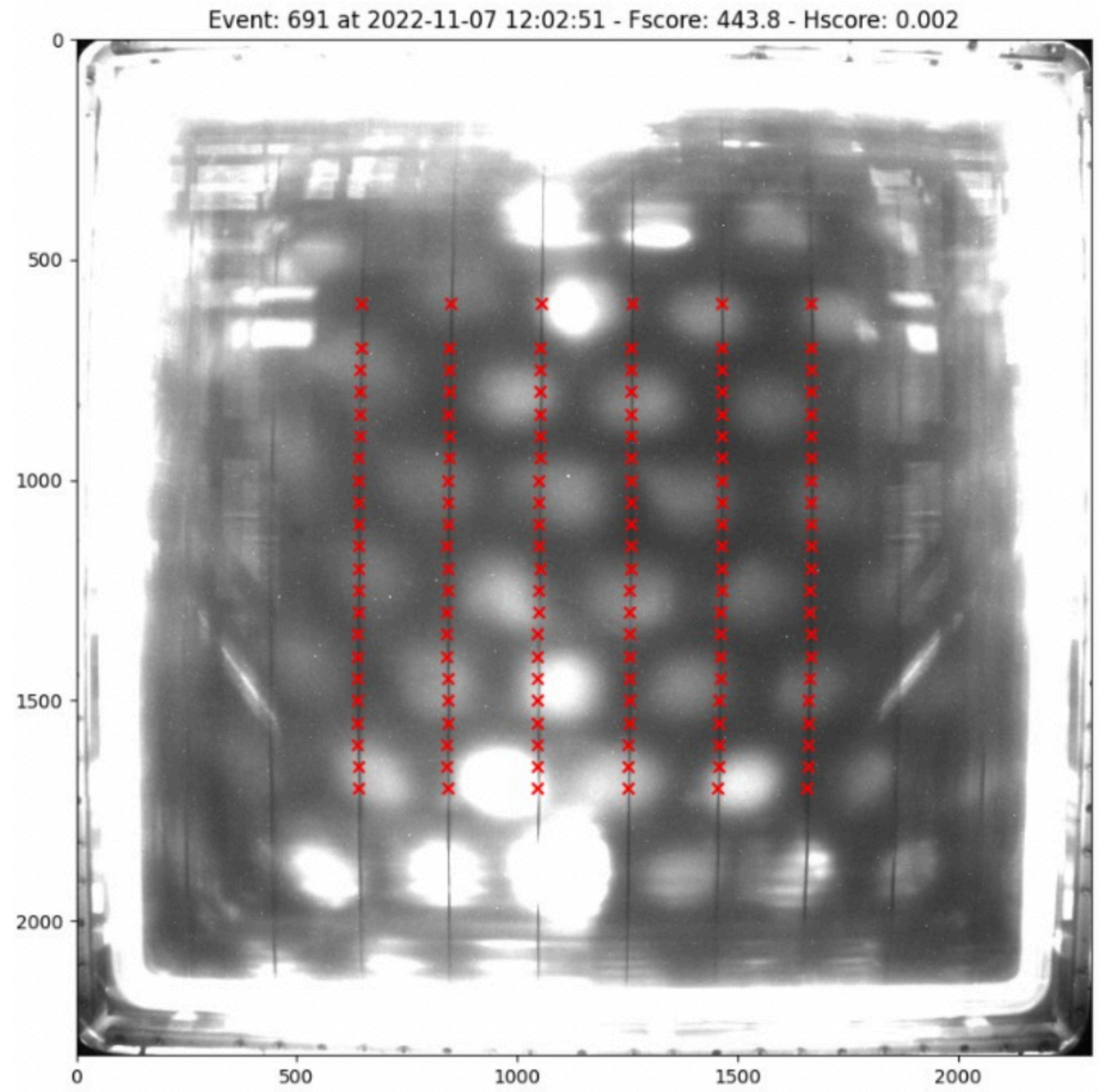


Observed framerates @ 300 ms exposure:

- Freerun (no PMTs): 1.9 Hz (full speed @ 300 ms in the current camera acquisition scheme)
- With PMTs: 1.4 Hz

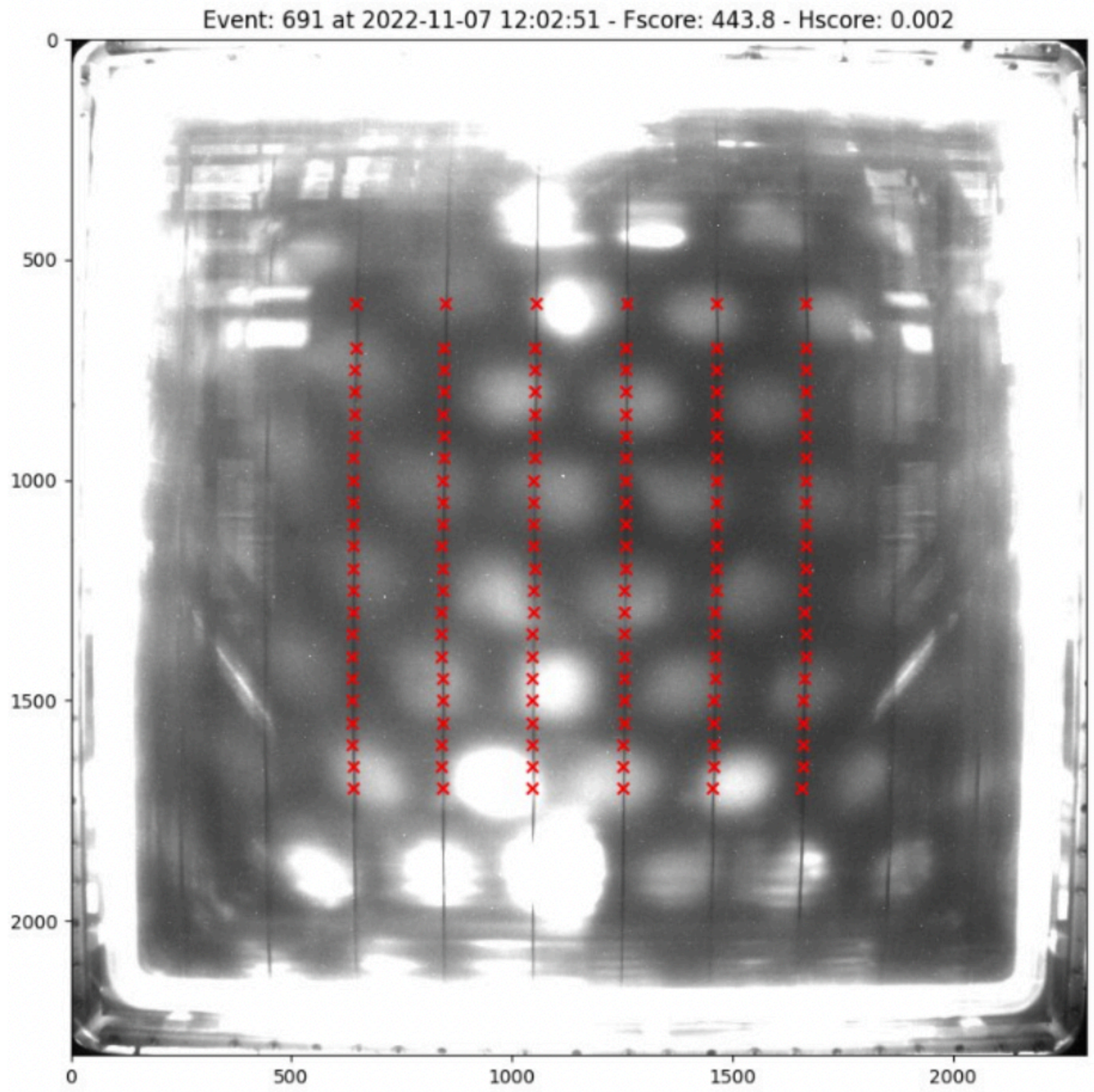
Camera alignment using the GEM sectors

- We developed an **online** code to **assess the goodness of the camera alignment** analyzing the GEM sectors:
  - Focus ∝ line “depth”
  - horizontal alignment ∝ line “barycenter”
  - vertical alignment ∝ line “inclination”
- Very simple but **rough algorithm**: it works, but at the same time it could be surely improved (any volunteer is welcome).



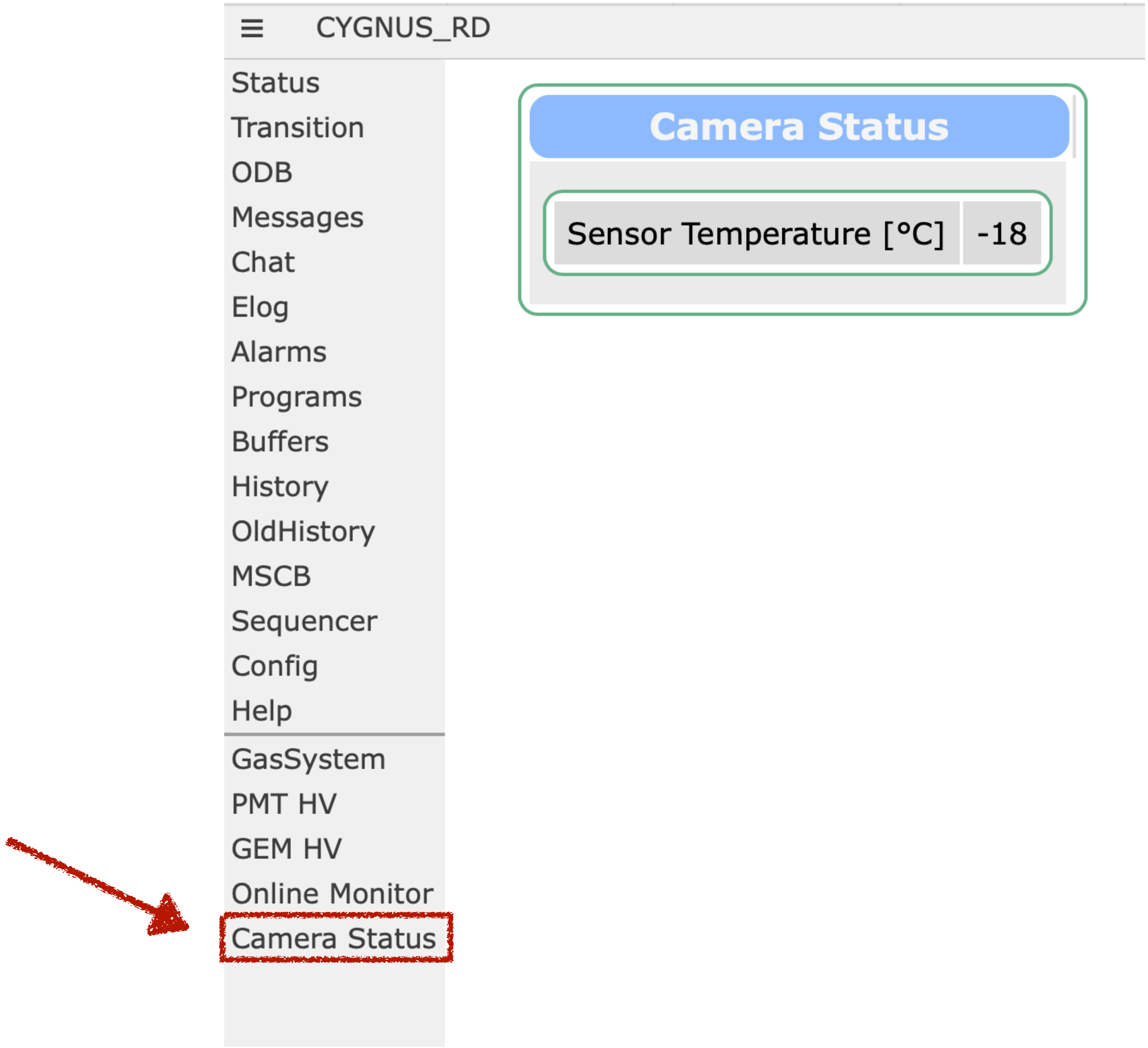
Camera alignment using the GEM sectors

- We collected **data** of the illuminated GEMs with **different alignment configurations** (runs [2361-2431])
- We **verified** that the “best alignment” condition is reasonably close to the “best by-eye alignment”
- We checked the **stability** of the alignment during the 2 months of data taking.



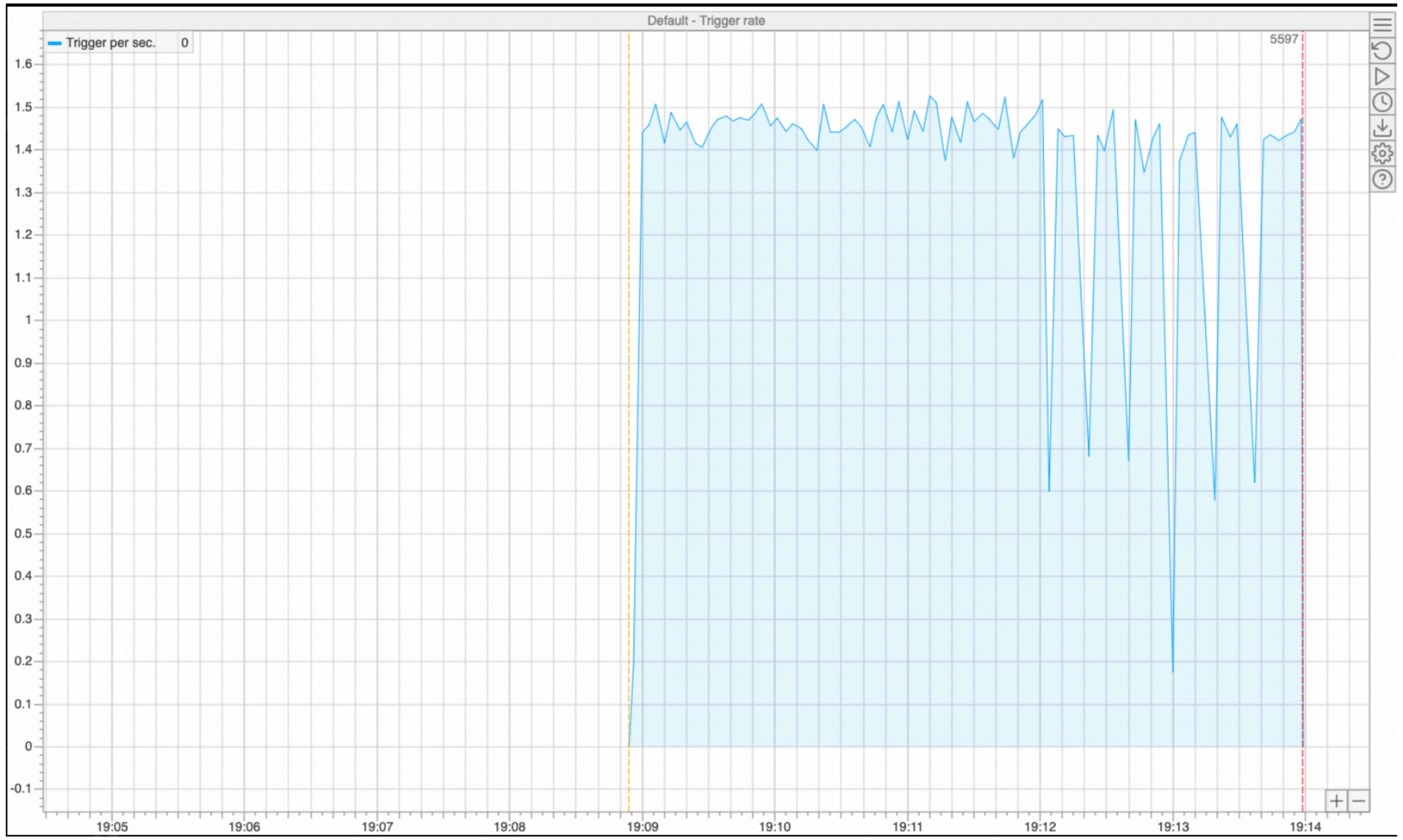
Camera temperature readout now on SC

- We implemented the **readout of the temperature** of the **camera** sensor water-cooled **sensor** in the frontend:
    - new “**TCAM**” data bank in the Midas file with a readout every 10 seconds
    - **online monitoring** via a custom html page in the Midas web server interface



Middleware communication problem: fixed

- We experienced a **drop of the acquisition rate** when the middleware and the other **clients connected to** the Midas **event buffer** were running
- The reason was related to the **priority** that **those clients** had with respect to the way they were accessing that buffer
- <u>**Solved**</u> by giving **priority to the Midas event producer**



Parameters:

buffer_handle	buffer handle obtained via bm_open_buffer()
event_id	event ID for requested events. Use EVENTID_ALL to receive events with any ID.
trigger_mask	trigger mask for requested events. The requested events must have at least one bit in its trigger mask common with the requested trigger mask. Use TRIGGER_ALL to receive events with any trigger mask.
sampling_type	specifies how many events to receive. A value of GET_ALL receives all events which match the specified event ID and trigger mask. If the events are consumed slower than produced, the producer is automatically slowed down. A value of GET_SOME receives as much events as possible without slowing down the producer. GET_ALL is typically used by the logger, while GET_SOME is typically used by analyzers.
request_id	request ID returned by the function. This ID is passed to the callback routine and must be used in the bm_delete_request() routine.
func	allback routine which gets called when an event of the specified type is received.

Collected data

- Data collected from Oct 8, 2022 to Dec 6, 2022
- Summary of the data taking campaign **here**:

Numbers	Description	PMT	Source
3000-3003	Scan HV PMT	Yes	None
3009-3116	stability while flushing gas (Z=5cm)	Yes	55Fe
3125-3160	stability while flushing gas (Z=25cm)	Yes	55Fe
3161-3201	BKG: first study, crashed after 40 runs	Yes	None
3358-3551	BKG	Yes	None
3554-3568	BKG: first study, crashed after 18 runs	Yes	None
3569-4128	BKG	No	None
4141-4143	scan HVGEM All	Yes	55Fe
4145-4201	scan Z, scan VGEM1	Yes	55Fe
4257-4266	scan Z, scan VGEM1	Yes	55Fe
4271-4302	scan Z, scan VGEM1	Yes	55Fe
4202-4256	stability (Z=25cm)	Yes	55Fe
4314-4365	stability (Z=25cm)	Yes	55Fe
4366-4381	Test Trigger	Yes	55Fe
4391-4468	stability (Z=25cm), thr 15 mV	Yes	55Fe
4469-4475	stability (Z=25cm), thr 5 mV	Yes	55Fe
4475-4492	BKG: 5 mV	Yes	None
4493-4512	stability (Z=25cm), thr 5 mV	Yes	55Fe
4513-4780	55Fe: stability (Z=25cm), thr 5 mV, flux 3l/h	Yes	55Fe

4782-4935	BKG: stability (Z=25cm), thr 5 mV, flux 3l/h	Yes	None
4936-4947	55Fe: 100 ms exposure, thr 5 mV, flux 3l/h	Yes	55Fe
4949-4963	55Fe: (Z = 5 cm) thr 5 mV, flux 3l/h, test equalization	Yes	55Fe
4964-4972	55Fe: (Z = 25 cm) thr 100 mV, flux 3l/h	Yes	55Fe
4973-4977	55Fe: (Z = 25 cm) thr 75 mV, flux 3l/h	Yes	55Fe
4978-4982	55Fe: (Z = 25 cm) thr 50 mV, flux 3l/h	Yes	55Fe
4983-4987	55Fe: (Z = 25 cm) thr 200 mV, flux 3l/h	Yes	55Fe
4988-4992	55Fe: (Z = 25 cm) thr 255 mV, flux 3l/h	Yes	55Fe
4993-5000	55Fe: (Z = 25 cm) thr 5 mV, flux 3l/h, scan drift field	Yes	55Fe
5001-5106	BKG: 5 mV, thr 5 mV, flux 3l/h	Yes	None
	55Fe: (Z = 25 cm) thr 5 mV, flux 20l/h, after operations on gas	Yes	55Fe
5163-5174	55Fe: (Z = 25 cm) thr 5 mV, flux 1l/h, after operations on gas s	Yes	55Fe
5175-5178	WARNING: the sequencer was on while the cap was removed,	Yes	55Fe
5179-5366	55Fe: (Z = 25 cm) thr 5 mV, flux 1l/h	Yes	55Fe
5377-5491	55Fe: (Z = 25 cm) thr 5 mV, flux 1l/h - new PMT HV (part 1)	Yes	55Fe
5507-5650	55Fe: (Z = 25 cm) thr 5 mV, flux 1l/h - new PMT HV (part 2)	Yes	55Fe
5652-5692	55Fe: (Z = 25 cm) thr 5 mV, flux 10 l/h - new PMT HV - to study	Yes	55Fe
5694-5730	55Fe: (Z = 25 cm) thr 5 mV, flux 10 l/h - new PMT HV - stable	Yes	55Fe
5732-5740	55Fe: (Z = 25 cm) thr 2 mV, flux 10 l/h - new PMT HV - Drift Fie	Yes	55Fe
5741-5908	BKG: thr 2 mV, flux 10 l/h - new PMT HV - (part 1)	Yes	None
5910-5921	55Fe: (Z = 25 cm) thr 2 mV, flux 10 l/h - new PMT HV - PMT H	Yes	55Fe
5922-6287	BKG: thr 2 mV, flux 10 l/h - new PMT HV - (part 2)	Yes	None
6288 - 6744	BKG: thr 2 mV, flux 10 l/h - new PMT HV - (part 2) - no DGTZ	Yes	None

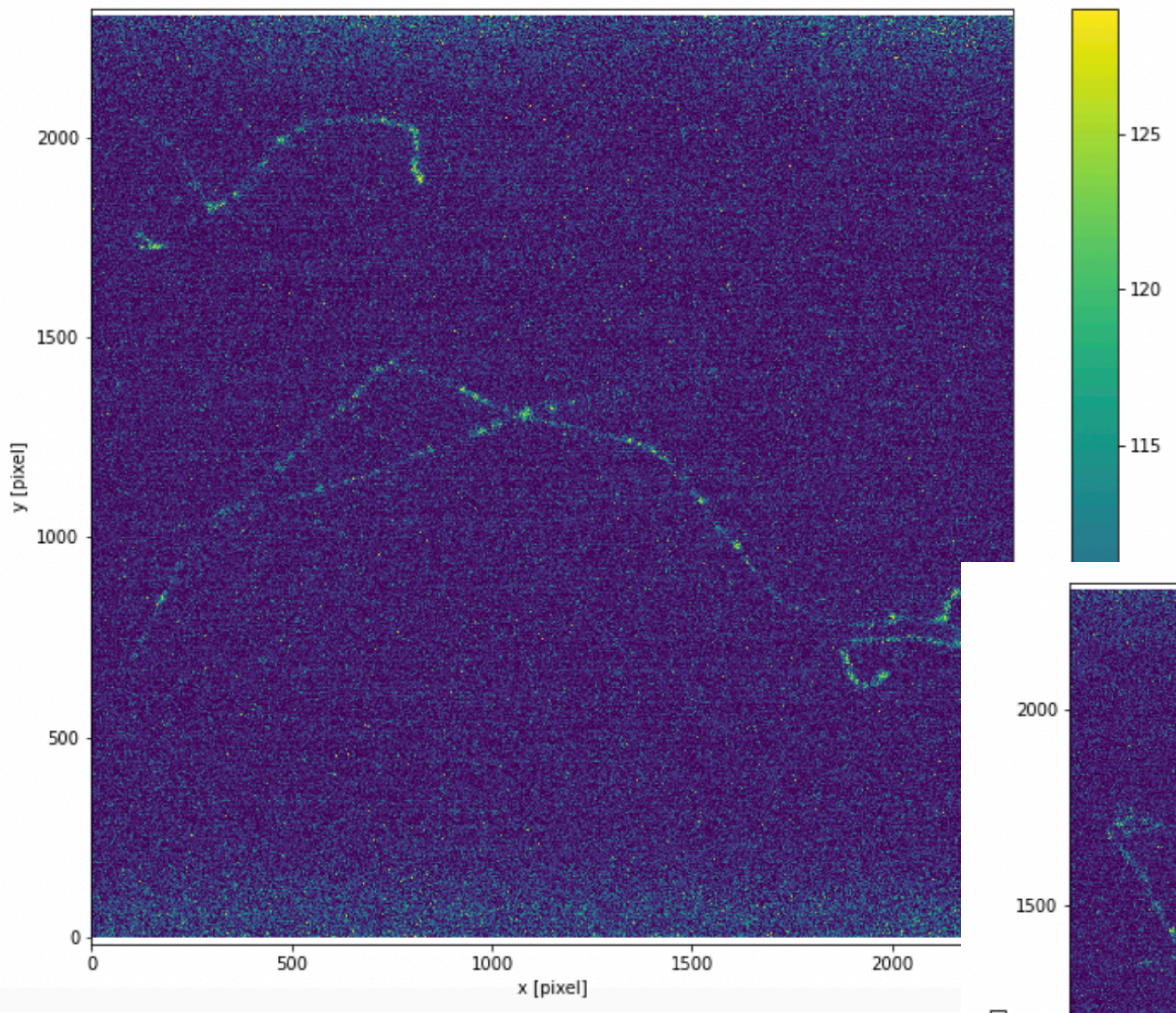
- Complete logbook **here**

Collected data

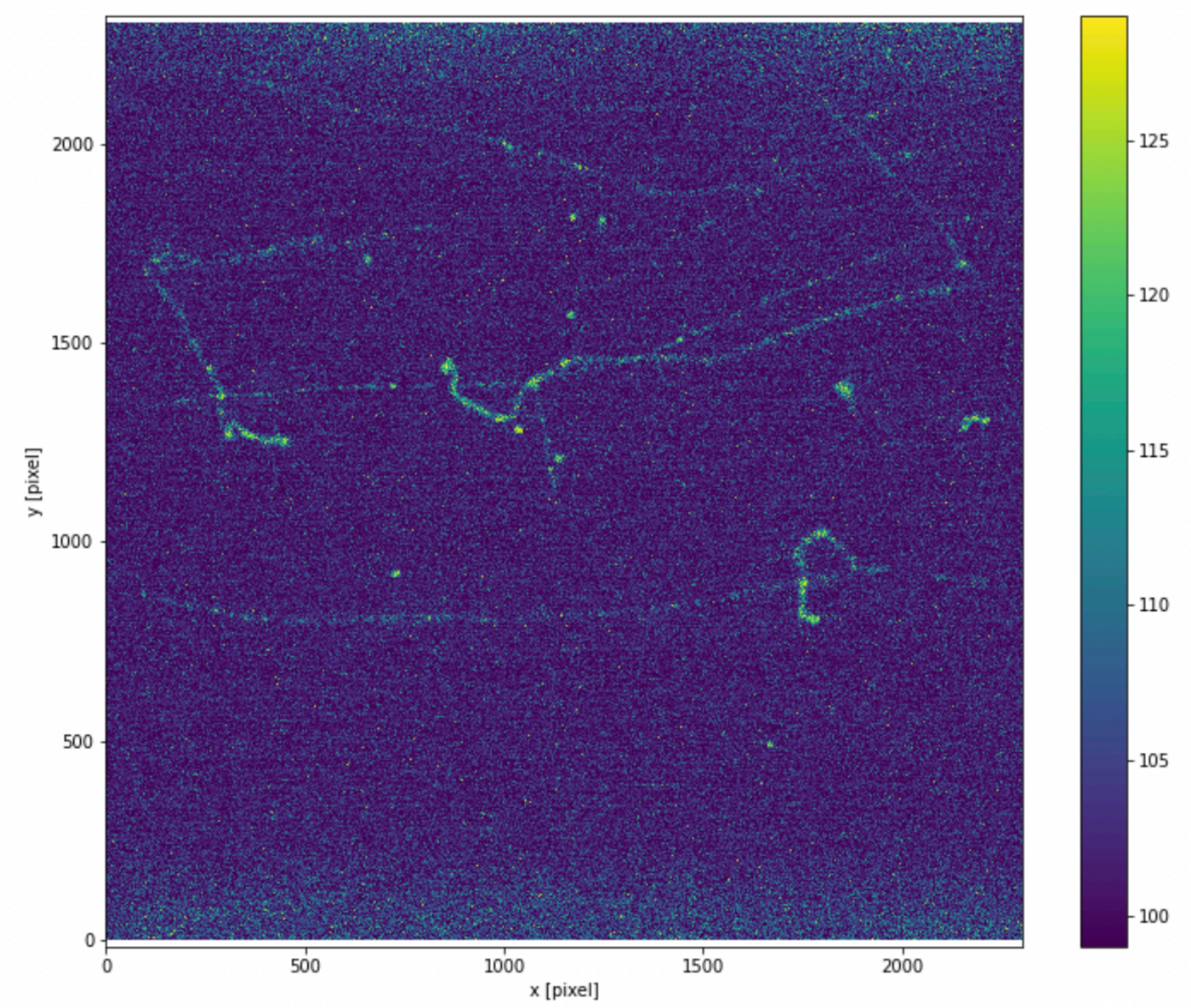
- Data collected **from Oct 8, 2022 to Dec 6, 2022**
- Some numbers:
  - Integral number of **BKG pictures**: $\sim 4 \times 10^5$
  - Integral number of ^{55}**Fe pictures**: $\sim 3 \times 10^5$
  - Estimated integral number of ^{55}**Fe spots** inside the pictures: $\sim 7 \times 10^5$
  - Background/signal **observed event rate**:

	Trigger rate WITH the Fe source		
	Rate (Hz) @ 2 mV	Rate (Hz) @ 3 mV	Rate (Hz) @ 5 mV
TR LVL 2	42,36 ± 0,65	36,74 ± 0,61	34,10 ± 0,58
CH1	471,5 ± 2,2	363,3 ± 1,9	254,8 ± 1,6
CH2	379,3 ± 1,9	290,9 ± 1,7	228,0 ± 1,5
CH3	374,0 ± 1,9	310,9 ± 1,8	260,6 ± 1,6
	Trigger rate WITHOUT the Fe source		
	Rate (Hz) @ 2 mV	**Rate (Hz) @ 3 mV**	**Rate (Hz) @ 5 mV**
TR LVL 2	33,88 ± 0,58	27,10 ± 0,52	26,22 ± 0,51
CH1	442,0 ± 2,1	333,8 ± 1,8	243,5 ± 1,6
CH2	361,4 ± 1,9	269,0 ± 1,6	210,2 ± 1,4
CH3	354,0 ± 1,9	287,4 ± 1,7	246,4 ± 1,6

No source:



With the ^{55}Fe source



Spurious events @ 2 mV

	DF off [Hz]	ALL off [Hz]
TR LVL 2	8,54 ± 0,29	0,110 ± 0,033
CH1	49,32 ± 0,70	0,260 ± 0,051
CH2	22,19 ± 0,47	0,200 ± 0,045
CH3	32,36 ± 0,57	0,170 ± 0,041

Next data data taking campaigns

- **Assumptions**:
  - 300 ms exposure camera (intrinsic DT: (210 ms) / (300 ms + 210 ms) = 41%)
  - Event rates by Flaminia's simulations
  - Different DGTZ DT hypothesis for the "not freerun" configuration

	Bkg rate from sim [Hz]	Events/ Picture [300 ms pics]	Effective time for 1e5 evts [days] [freerun]	Effective time for 1e5 evts [days] [not freerun] [max PMT DT]	Effective time for 1e5 evts [days] [not freerun] [PMT DT = 50 ms]
none	3,7E+01	1,1E+01	0,093	0,11	//
4 cm copper	1,1E+00	3,3E-01	3,1	5,1	3,4
6 cm copper	5,6E-01	1,7E-01	6,1	10	6,8
10 cm copper	3,2E-01	9,5E-02	11	18	12
10+40	2,7E-01	8,1E-02	13	21	14

External neutrons with 10 cm copper: ~ 32 evts/month

↓

We should improve the DAQ by at least a factor of 2-3 to get O(500) neutrons in 6 months!!

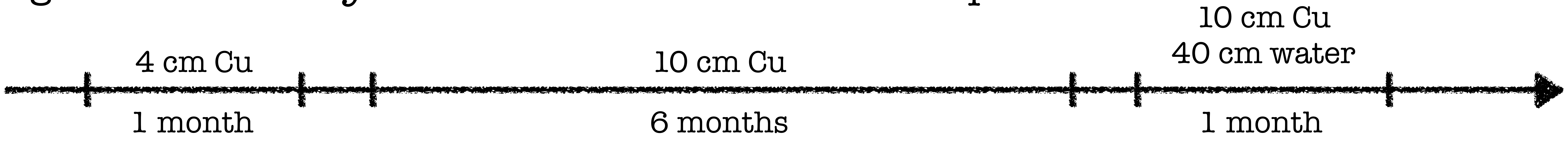
Next data data taking campaigns

	Bkg rate from sim [Hz]	Events/ Picture [300 ms pics]	Effective time for 1e5 evts [days] [freerun]	Effective time for 1e5 evts [days] [not freerun] [max PMT DT]	Effective time for 1e5 evts [days] [not freerun] [PMT DT = 50 ms]
none	3,7E+01	1,1E+01	0,093	0,11	//
4 cm copper	1,1E+00	3,3E-01	3,1	5,1	3,4
6 cm copper	5,6E-01	1,7E-01	6,1	10	6,8
10 cm copper	3,2E-01	9,5E-02	11	18	12
10+40	2,7E-01	8,1E-02	13	21	14

- With the current DAQ system the **time needed to collect 10^5 events** is:

  ~ 3 h [no shielding] ~ 3,5 d [4 cm copper] ~ 12 d [10 cm copper]

- We foresee to **collect data with an AmBe neutron source** in the 4cm copper configuration to study the nuclear recoil detector response



Conclusions

- In this contribution we presented the evolution of the **LIME underground operation** in the last couple of months.
- We made a lot of small **improvements to the acquisition system**.
- We collected a lot of data in different **readout configurations**, and for the first time we were able to acquire a **large amount of data including the PMTs**.
- The **DAQ system will be improved** during the next months to better account for the lower expected event rate.
- **Next data taking campaign** with a **4 cm copper shielding** at the **beginning of next year**.

Many thanks to all the shifters

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