Founded from ERC in Horizon 2020 program (grant agreement 818744)

LIME DAQ dead time and observed rate

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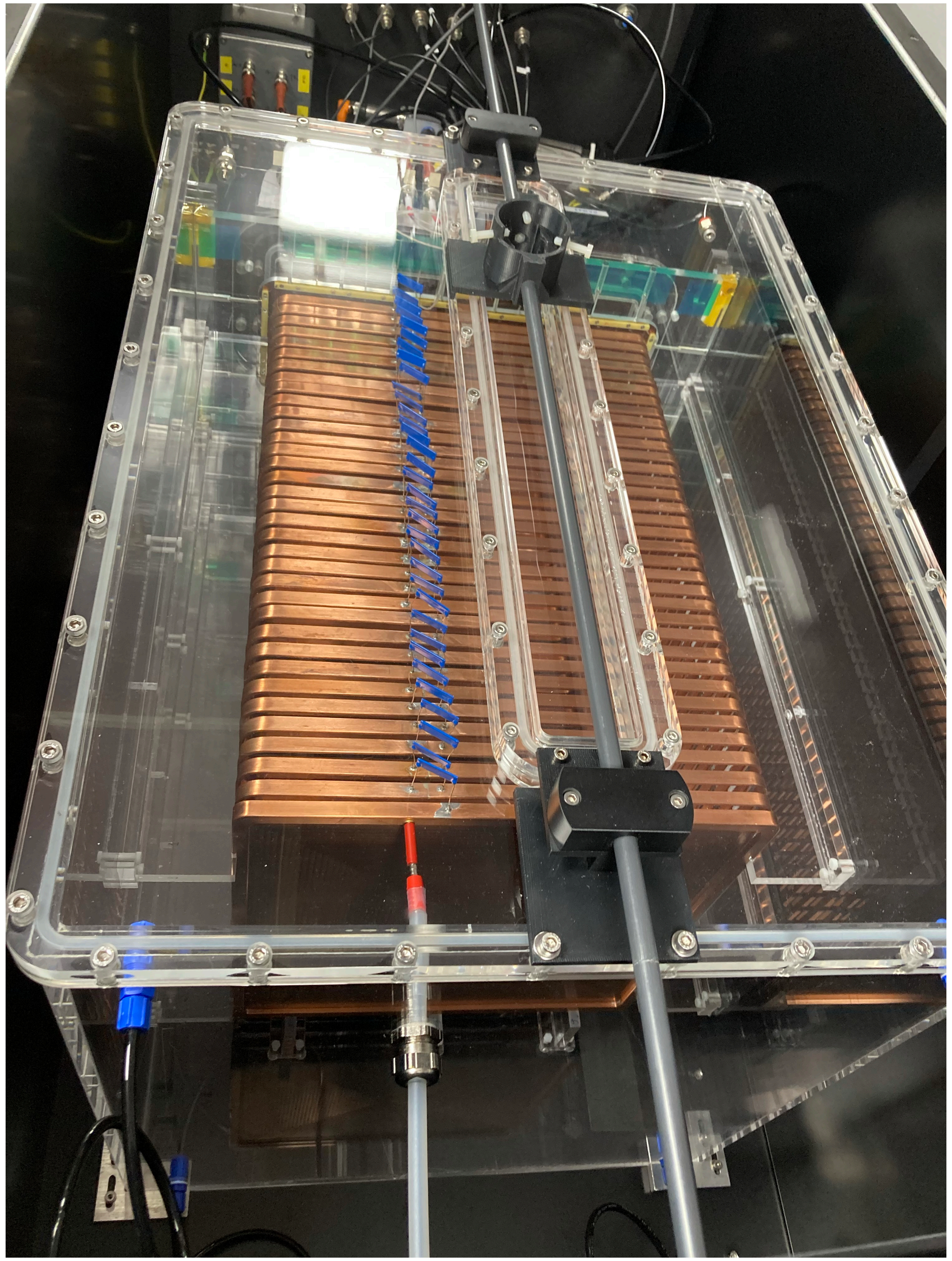


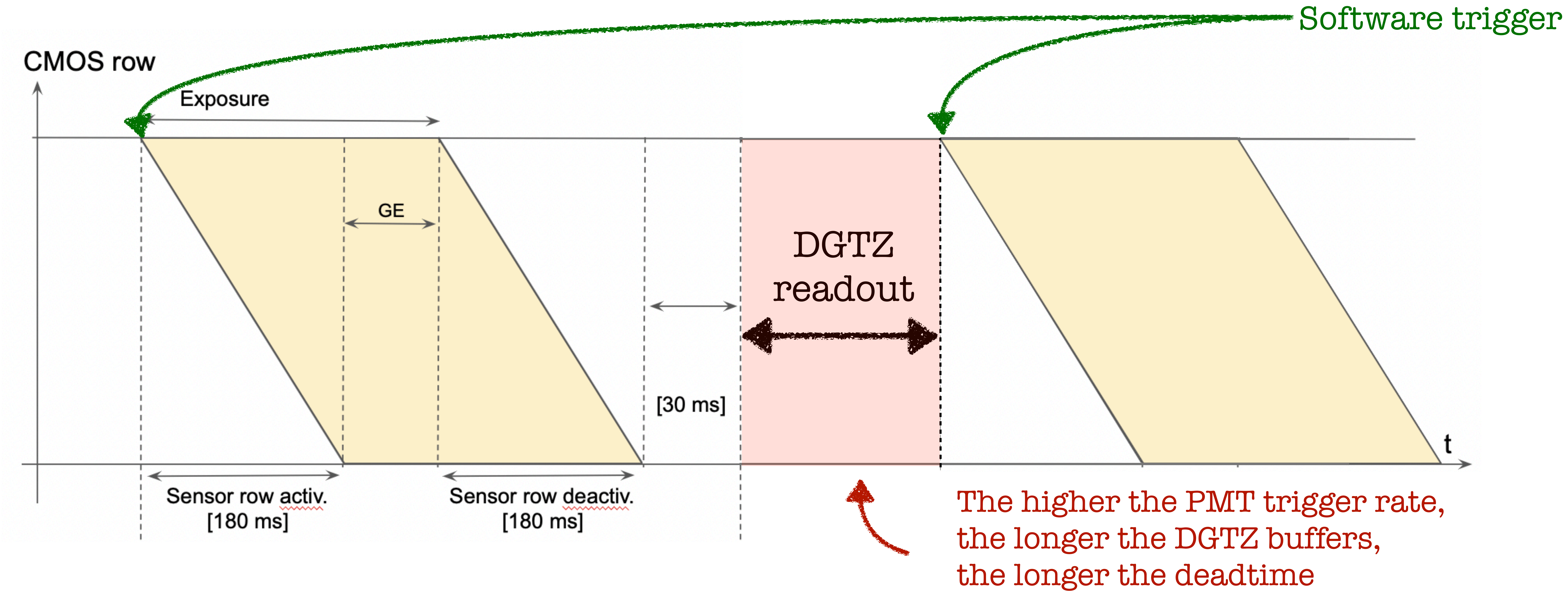
Coimbra Analysis Meeting

Coimbra, 07/06/2023

Introduction

- In this contribution we present the study of the **dead time of the current DAQ scheme**
- This **configuration** is the one **used** for **RUN2** and **RUN3**.
- We show a simple **simulation of the DAQ scheme**, that gives us the possibility to assess the real dead time
- We **compare** the simulation **with the RUN2 data**, finding **consistent** result
- We **compare** the **observed event rate** in the **PMTs** and the **camera**
- Finally, we investigate possible **improvements** of the current scheme.

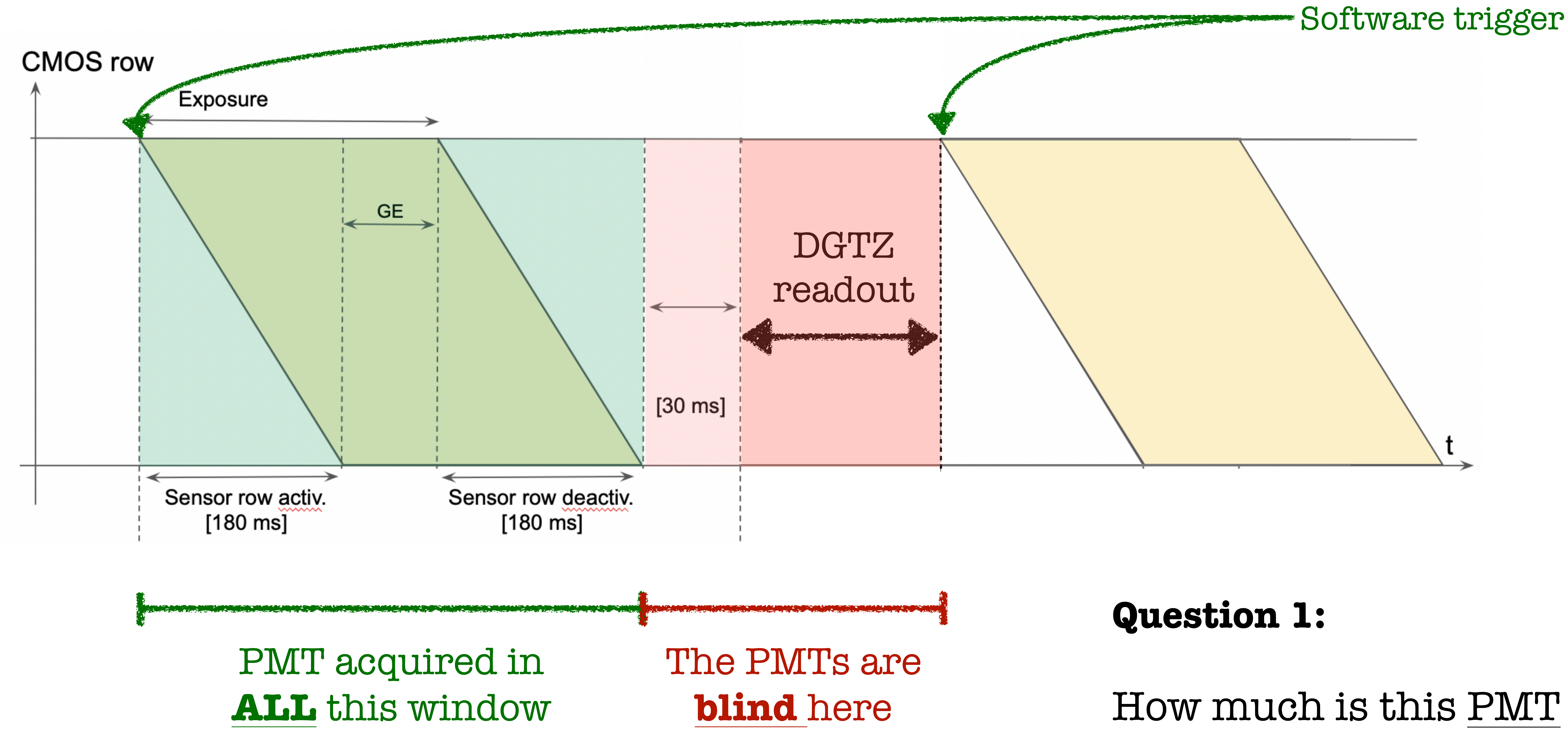
LIME DAQ acquisition scheme



Observed framerates @ 300 ms exposure:

- Freerun (no PMTs): 1.9 Hz
- With PMTs: 1.7 Hz with 10 cm Cu shielding and Fe source

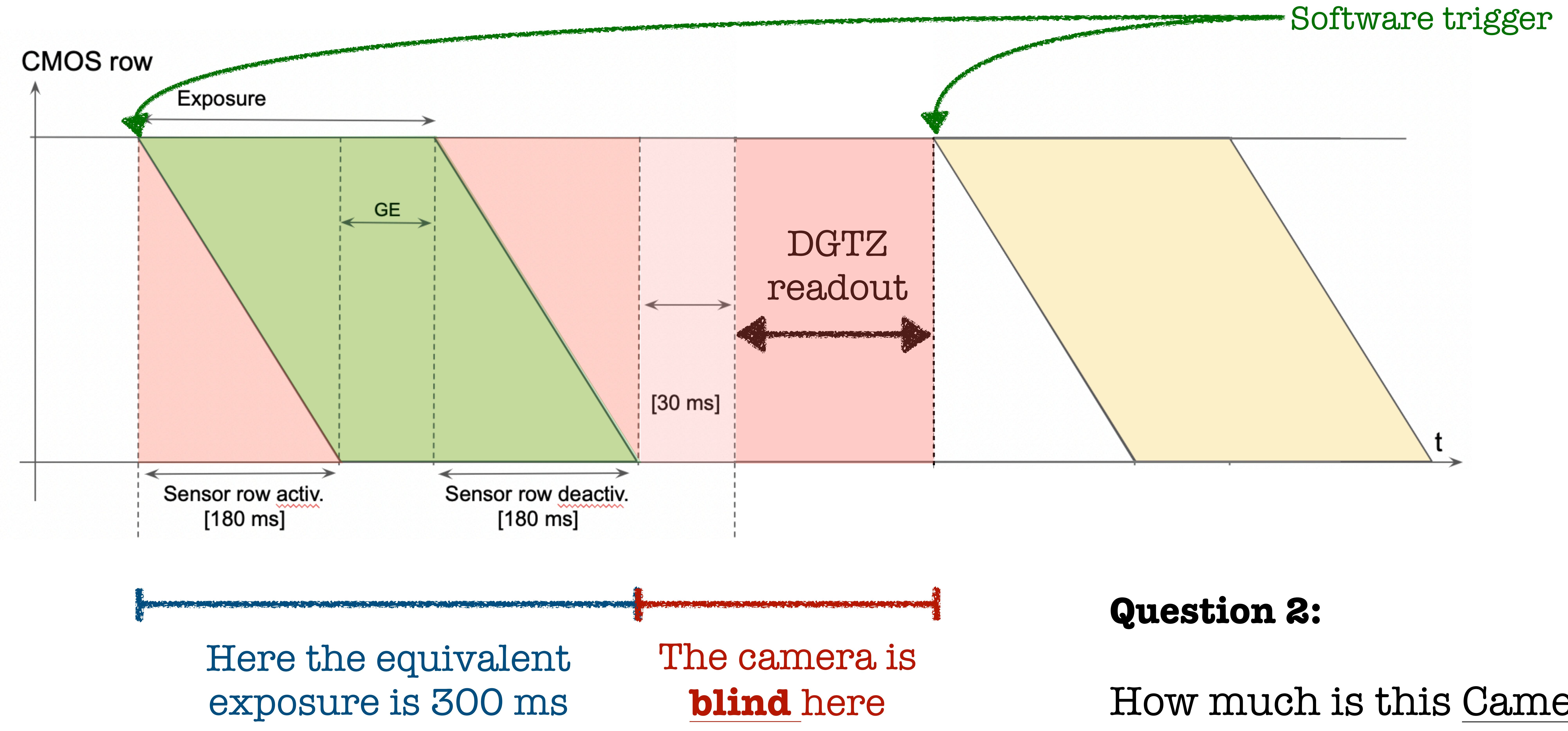
PMT dead time



Question 1:

How much is this PMT dead time?

Camera dead time



Question 2:

How much is this Camera dead time?

Towards a DAQ simulation

- To answer these two questions, we need to understand **how many time we lose for the readout of the boards**

- I developed a small **simulation of the DAQ** behaviour, with the following assumptions:

  1. **always 30 ms** lost **for the** readout of the **camera**

  2. the time lost to readout the boards **scales linearly with the number of waveforms**

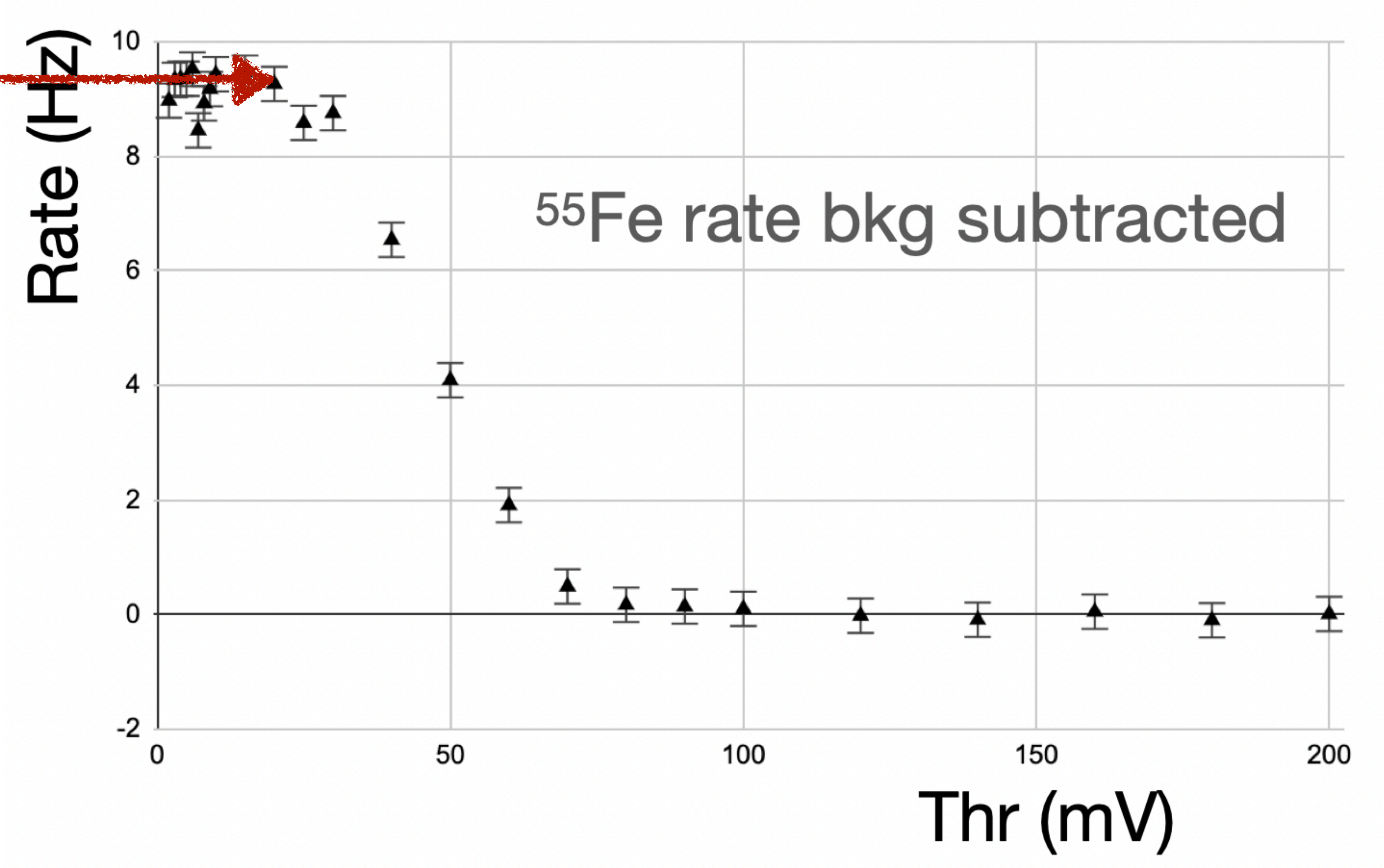
  3. After every waveform, there is a **time veto of 100 us (13 us)** for Run2 (Run3) data

Board readout dead time per trigger signal

- To run the simulation we need to find out **what is the readout time per waveform**

- **Idea**: use 55Fe data (~ no "empty" pictures*) and study the acquisition rate:

r_{Fe} = 9.5 Hz



Assuming no "empty" pics* in this high-rate configuration:

$$r_{Fe}^{DAQ} = 1.7 \text{ Hz}$$

$$T_{lost} = 1/r_{Fe}^{DAQ} - 480 \text{ ms} - 30 \text{ ms} \sim 78 \text{ ms}$$

$$t_{lost}^{1wf} = \frac{T_{lost}}{r_{Fe} \times 480 \text{ ms}} \sim 17 \text{ ms}$$

*pictures not acquired because no PMT coincidence in the window

The DAQ simulation

1. For every run:
    1. For every picture:
        1. **Generate** the events happening in the 480 ms time window according to a Poisson distribution with a given rate
        2. If an event is closer than Δt_{veto} to the previous one, **discard** it
        3. **Add** $\Delta t_{veto} \times n_{wfs}$ to the total time lost
        4. **Add** 30 ms to the total time lost
        5. **Add** $n_{wfs} \times t_{lost}^{1wf}$ to the total time lost

The DAQ simulation: results

- **<u>Not</u>** taking into account time lost between runs and pedestals:

No Fe [$r_{noFe} = 1.3$ Hz]

```
Avg wfs per pic = 0.6
Veto = 100.00 us
79 triggers vetoed over a total of 623100 triggers.
It happend 79 times over a total of 1000000 pictures.
Accumulated DT: 62.30 s
```

```
========   noFe   ========
Average duration of a run: 7.50 min
========    PMT   ========
Total Time        = 520690.44 s
Total   DT        = 40752.75 s
Total Active Time = 479937.69 s
Dead Time         = 7.83 %
========  CAMERA  ========
Total Time        = 520690.44 s
Total   DT        = 220690.44 s
Total Active Time = 300000.00 s
Dead Time         = 42.38 %
```

No Fe [$r_{noFe} = 9.5$ Hz]

```
Avg wfs per pic = 4.6
Veto = 100.00 us
4307 triggers vetoed over a total of 4560046 triggers.
It happend 4289 times over a total of 1000000 pictures.
Accumulated DT: 455.57 s
```

```
========    Fe    ========
Average duration of a run: 3.97 min
========    PMT   ========
Total Time        = 588236.08 s
Total   DT        = 108692.09 s
Total Active Time = 479544.00 s
Dead Time         = 18.48 %
========  CAMERA  ========
Total Time        = 588236.08 s
Total   DT        = 288236.08 s
Total Active Time = 300000.00 s
Dead Time         = 49.00 %
```

The DAQ simulation: results

- **Taking** into account time lost between runs and pedestals (30 s between regular runs, ~150 ms for a full pedestal run):

No Fe [$r_{noFe} = 1.3$ Hz]

```
Avg wfs per pic = 0.6
Veto = 100.00 us
70 triggers vetoed over a total of 625075 triggers.
It happend 70 times over a total of 1000000 pictures.
Accumulated DT: 62.50 s
```

```
========   noFe   ========
Average duration of a run: 7.49 min
========    PMT   ========
Total Time        = 577064.33 s
Total   DT        = 97126.83 s
Total Active Time = 479937.49 s
Dead Time         = 16.83 %
========  CAMERA  ========
Total Time        = 577064.33 s
Total   DT        = 277064.33 s
Total Active Time = 300000.00 s
Dead Time         = 48.01 %
```

No Fe [$r_{noFe} = 9.5$ Hz]

```
Avg wfs per pic = 4.6
Veto = 100.00 us
4274 triggers vetoed over a total of 4559837 triggers.
It happend 4259 times over a total of 1000000 pictures.
Accumulated DT: 455.56 s
```

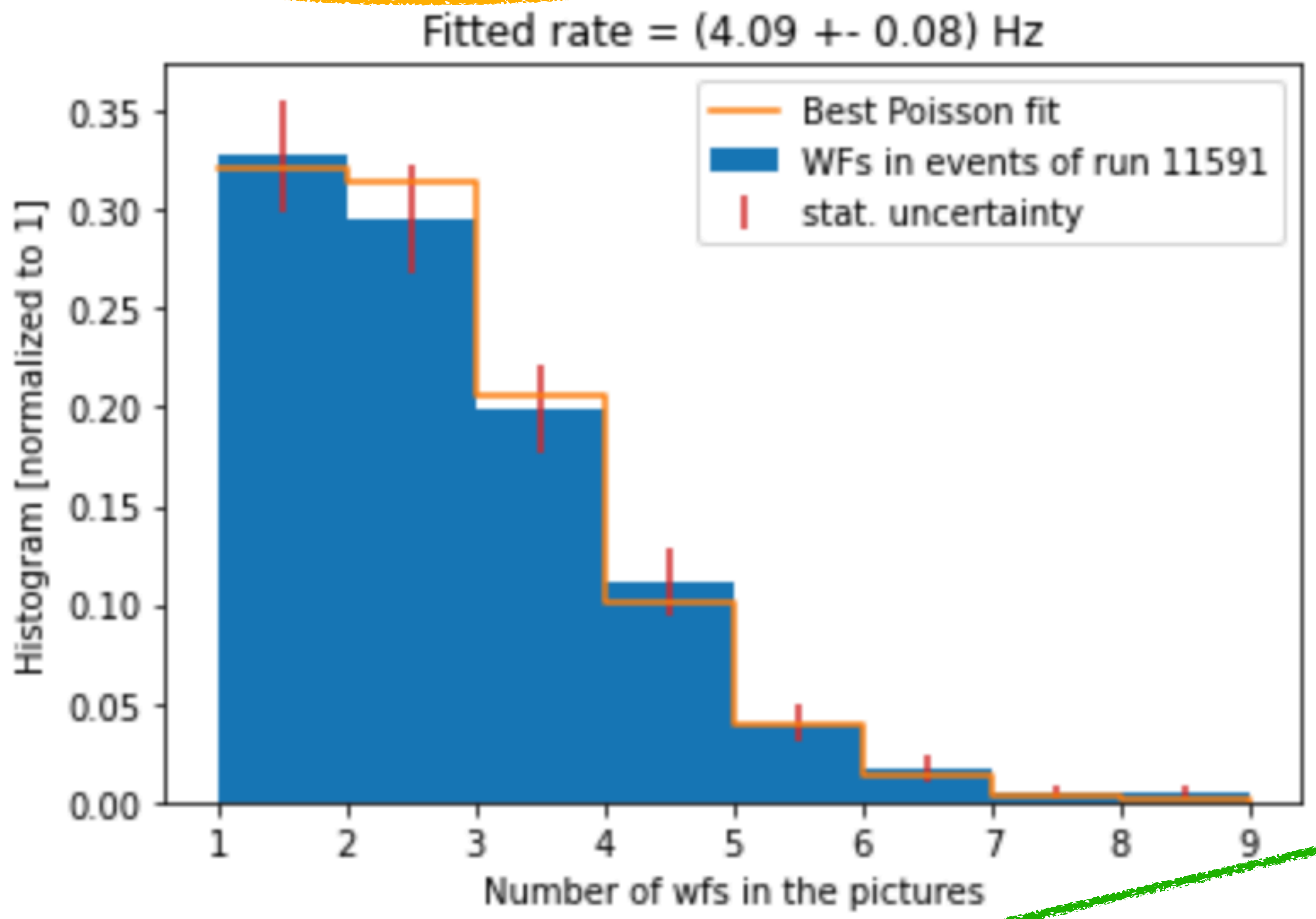
```
========    Fe    ========
Average duration of a run: 3.97 min
========    PMT   ========
Total Time        = 708442.50 s
Total   DT        = 228898.48 s
Total Active Time = 479544.02 s
Dead Time         = 32.31 %
========  CAMERA  ========
Total Time        = 708442.50 s
Total   DT        = 408442.50 s
Total Active Time = 300000.00 s
Dead Time         = 57.65 %
```

Looking at the PMT data [RUN2]

- Run2 DT ~ 11% from the simulation

```
Run 11591 lasted 257 s
```

Simulation average duration: 255.157




```
Naive rate:
(3.71 +- 0.12) Hz
```

Rate computed "naively" as N_{tot}^{wfs}/T_{tot}

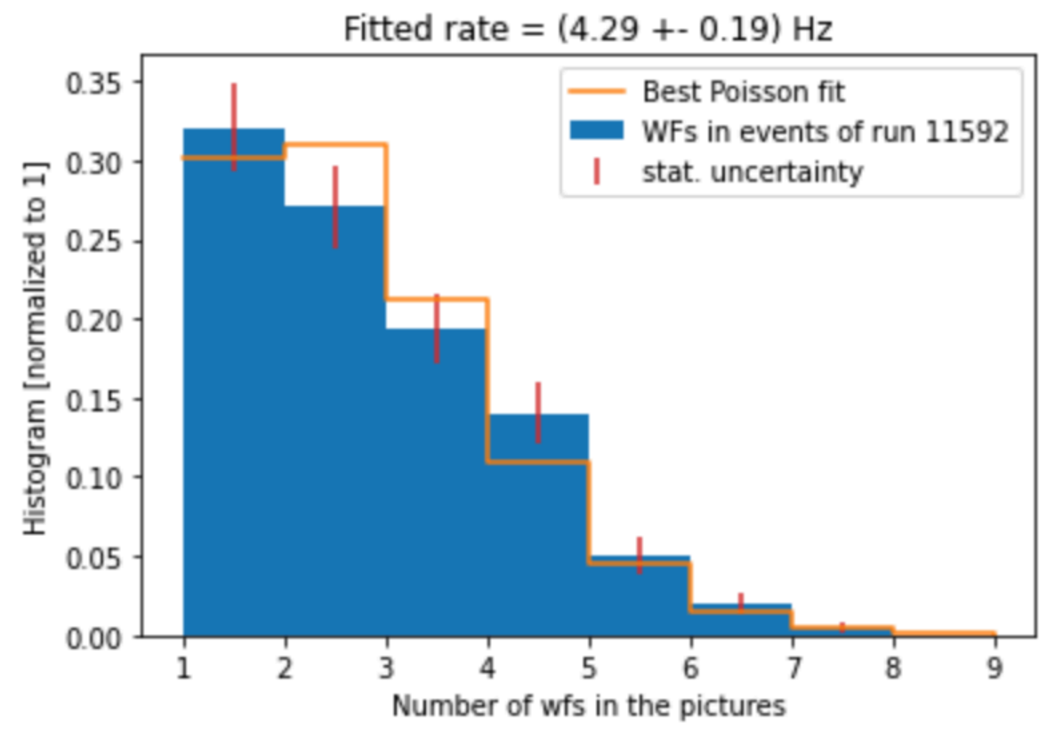
```
DT-corrected rate:
(4.12 +- 0.13) Hz
```

Rate corrected by DT as 1.11 x N_{tot}^{wfs}/T_{tot}

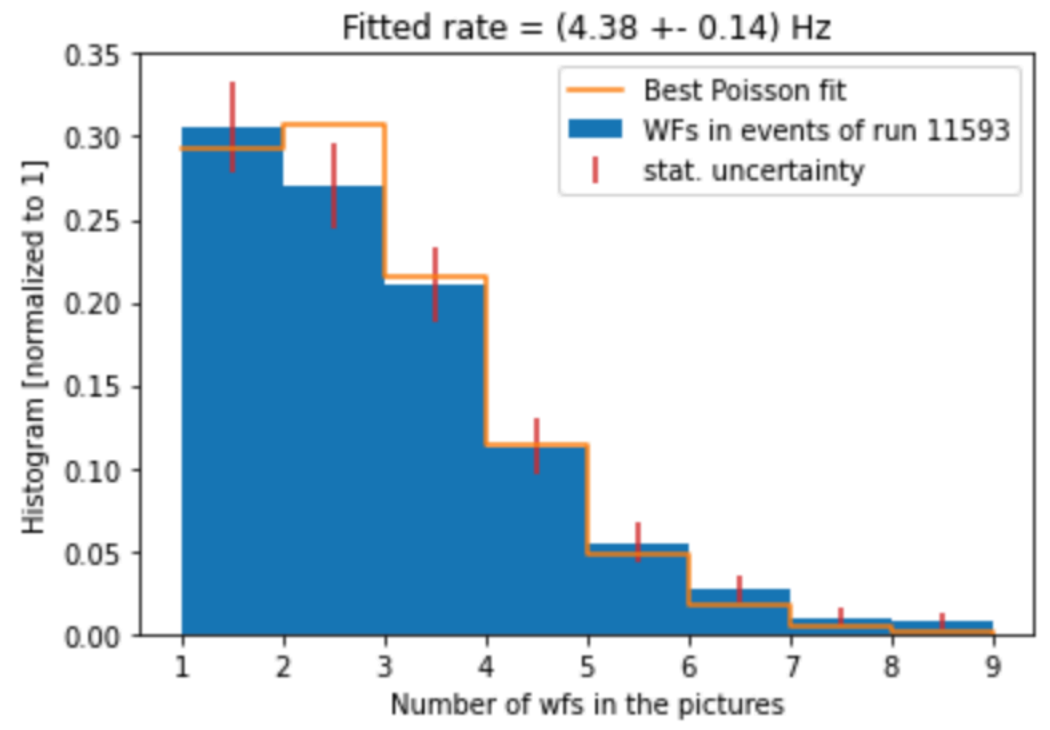
```
csi = -0.180
```

$$\xi = \frac{\mu_{fit} - \mu_{corr}}{\sqrt{\sigma_{fit}^2 + \sigma_{corr}^2}}$$

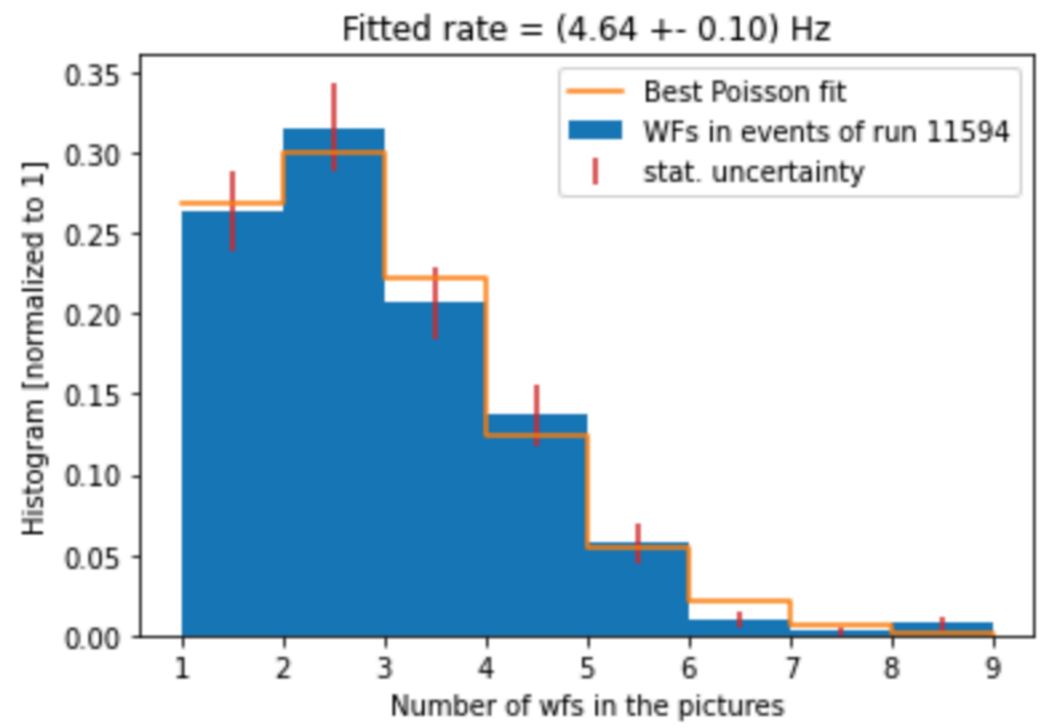
More runs [RUN2]



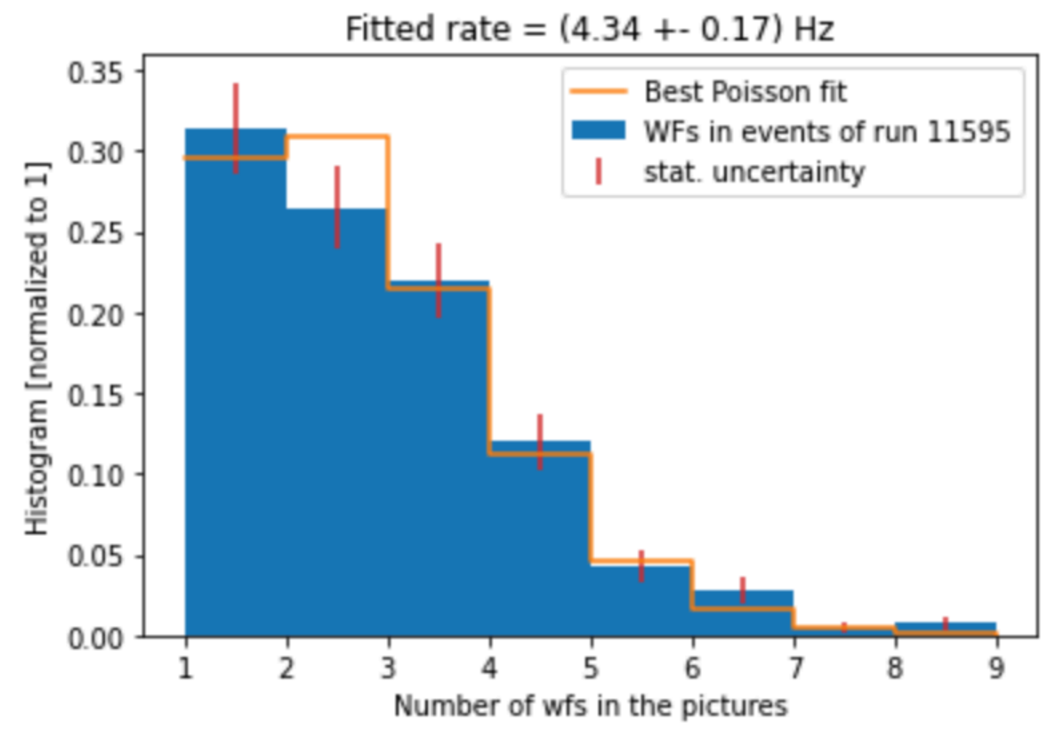

```
Naive rate:
(3.79 +- 0.12) Hz

DT-corrected rate:
(4.20 +- 0.13) Hz

csi = 0.380
```



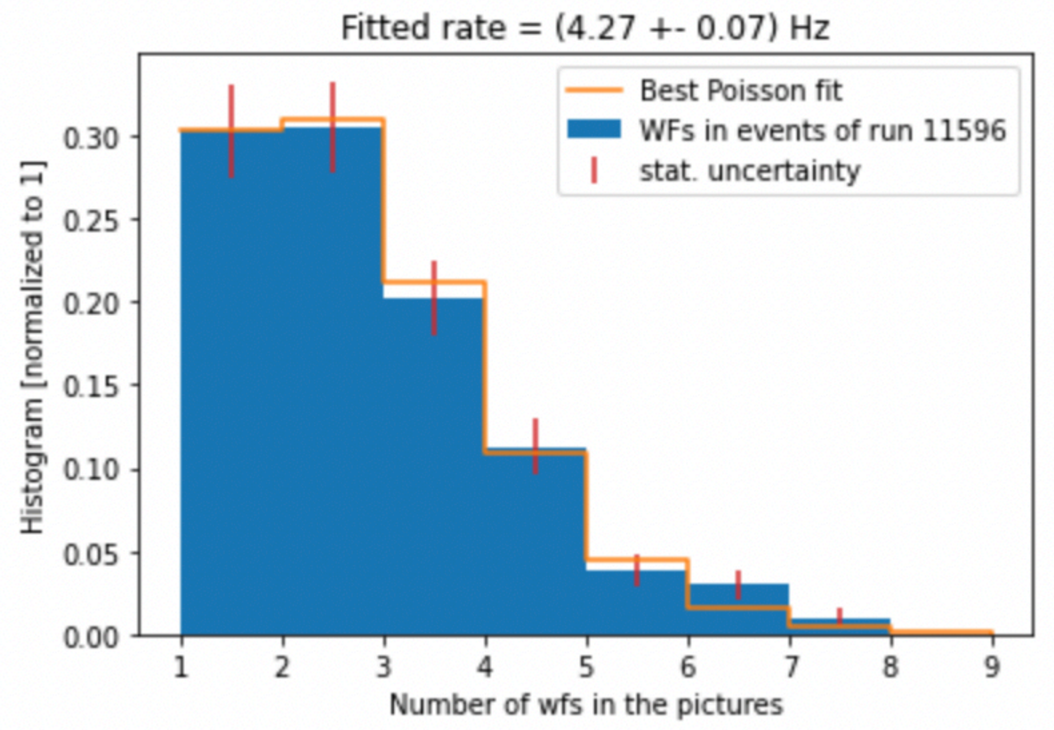

```
Naive rate:
(4.05 +- 0.13) Hz

DT-corrected rate:
(4.50 +- 0.14) Hz

csi = -0.600
```



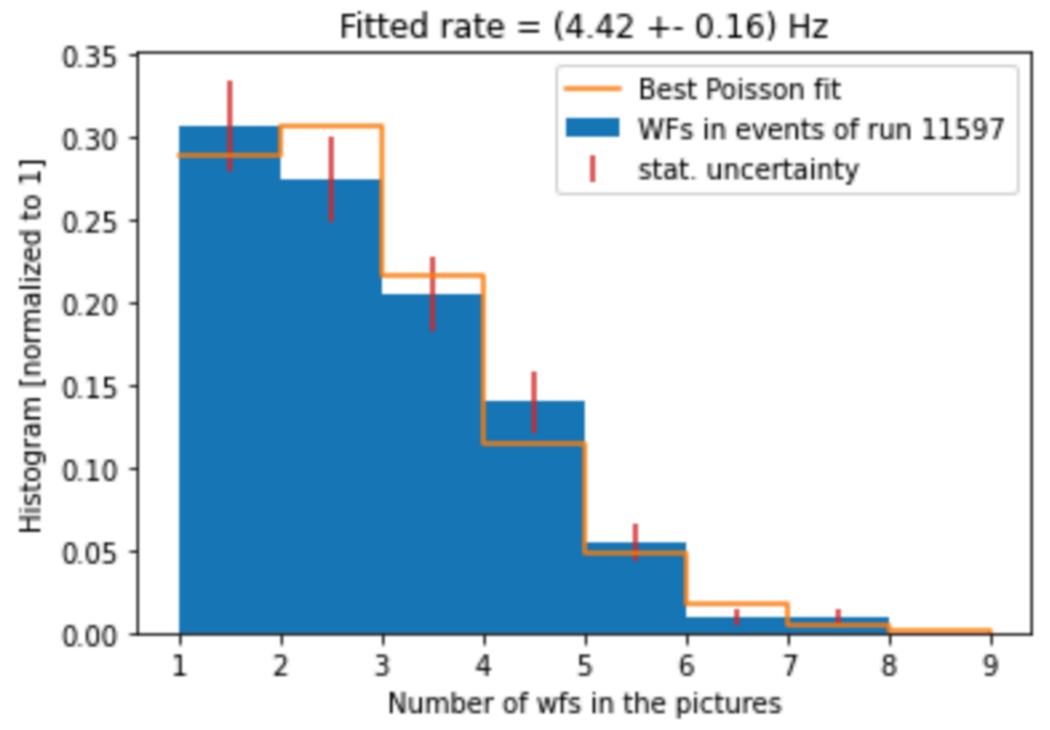

```
Naive rate:
(3.85 +- 0.12) Hz

DT-corrected rate:
(4.27 +- 0.14) Hz

csi = 2.174
```



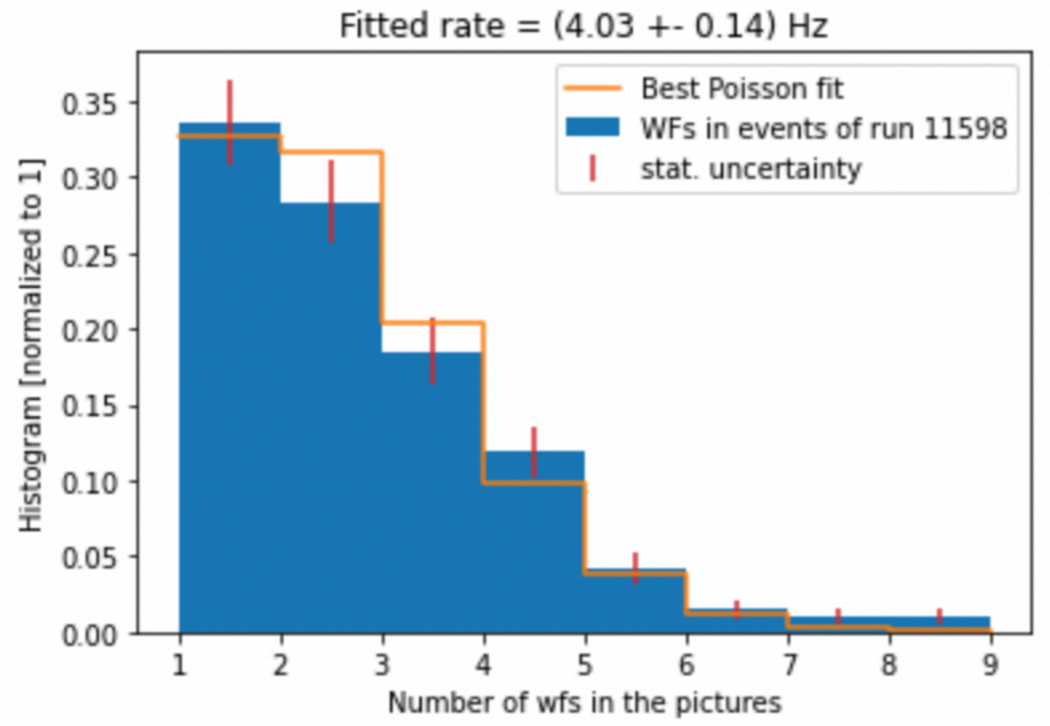

```
Naive rate:
(3.93 +- 0.12) Hz

DT-corrected rate:
(4.36 +- 0.14) Hz

csi = -0.069
```



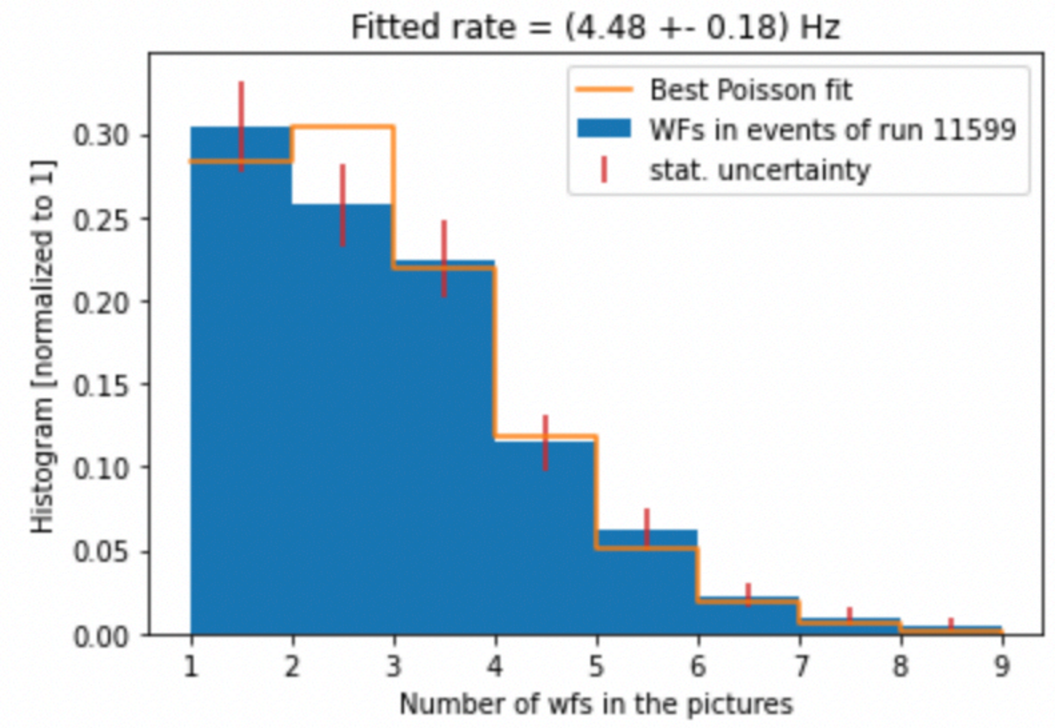

```
Naive rate:
(3.83 +- 0.12) Hz

DT-corrected rate:
(4.25 +- 0.14) Hz

csi = 0.166
```




```
Naive rate:
(3.86 +- 0.12) Hz

DT-corrected rate:
(4.29 +- 0.14) Hz

csi = 0.644
```




```
Naive rate:
(3.80 +- 0.12) Hz

DT-corrected rate:
(4.21 +- 0.13) Hz

csi = -0.932
```

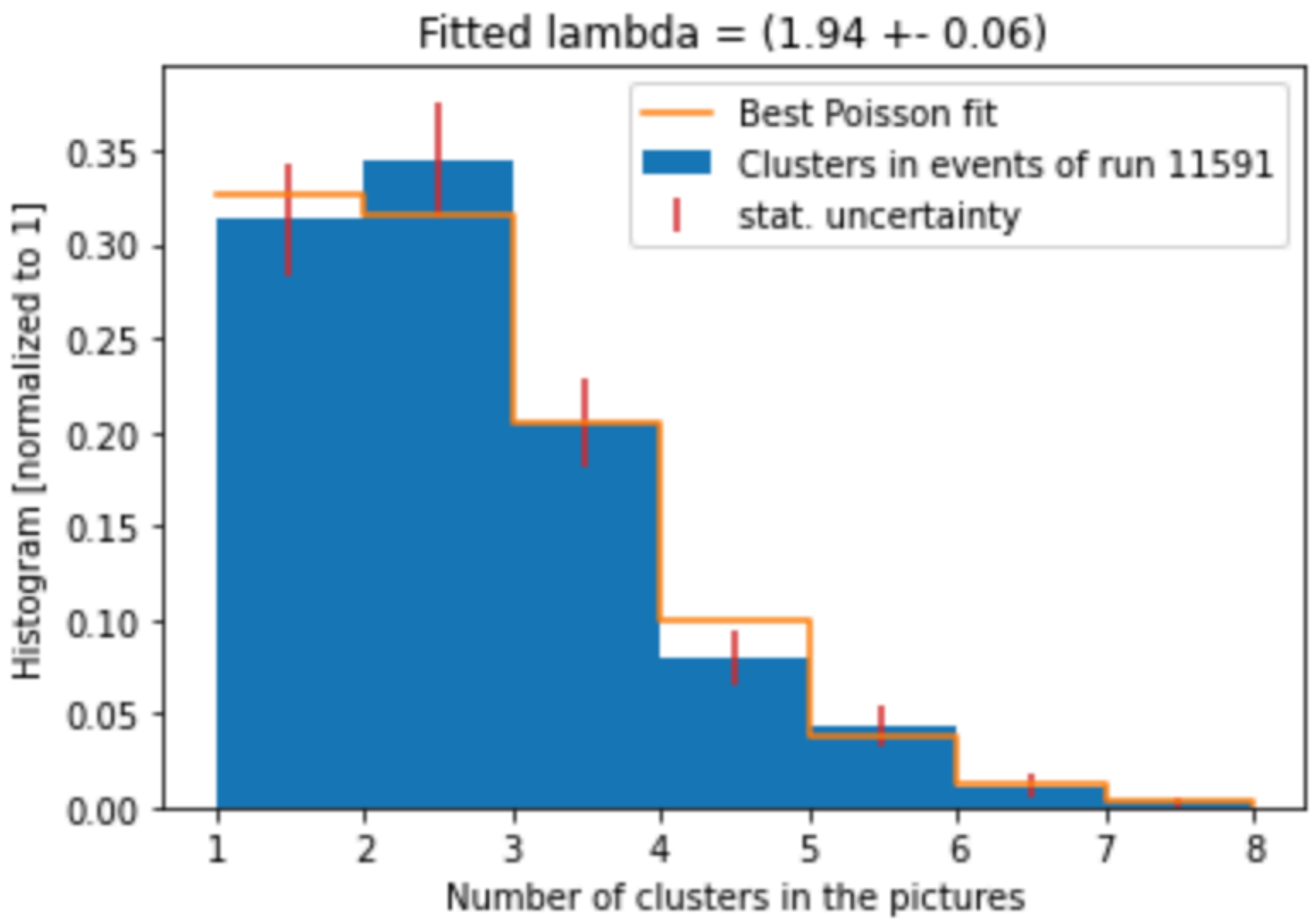



```
Naive rate:
(3.91 +- 0.12) Hz

DT-corrected rate:
(4.34 +- 0.14) Hz

csi = 0.614
```

Looking at the Camera data [RUN2]

- Selection to reduce the fake clusters:
  1. `sc_tgausssigma` > 0.3 / 0.152
  2. `sc_rms` > 6

- Distribution of number of clusters in the images



Fiducialization due to the reconstruction "dead" bands*

$F \sim 1/(1 - 11\%) \sim 1.124$

From **previous study** on the performance of the camera:

$\lambda_{fake} = 0.667 \pm 0.040$

$$r^0_{CAM} = F \frac{\lambda - \lambda_{fake}}{300 \text{ ms}} \sim (4.76 \pm 0.27) \text{ Hz}$$

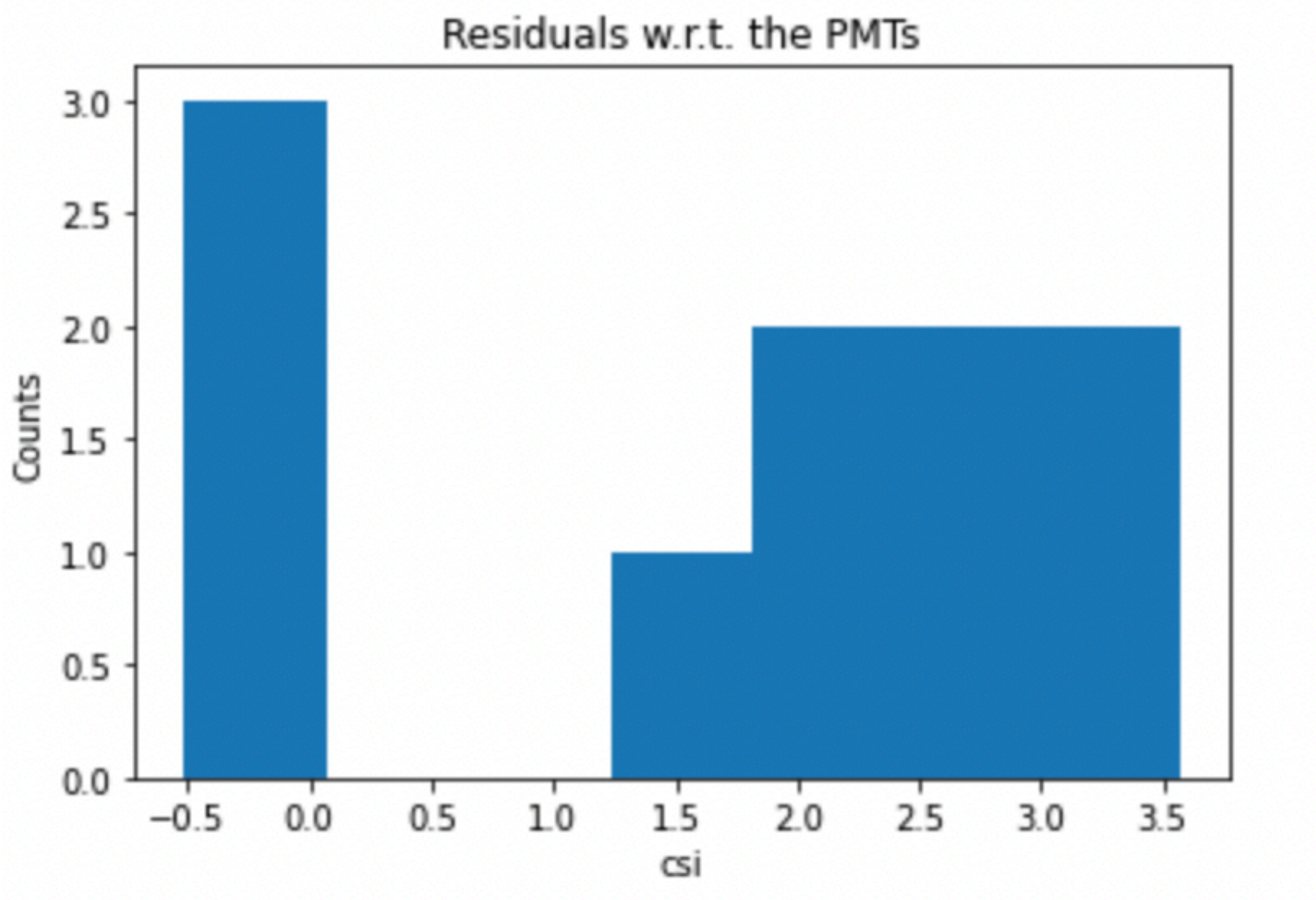
Greater than what is seen by with PMTs!

$$r^0_{PMT} = (4.05 \pm 0.08) \text{ Hz}$$

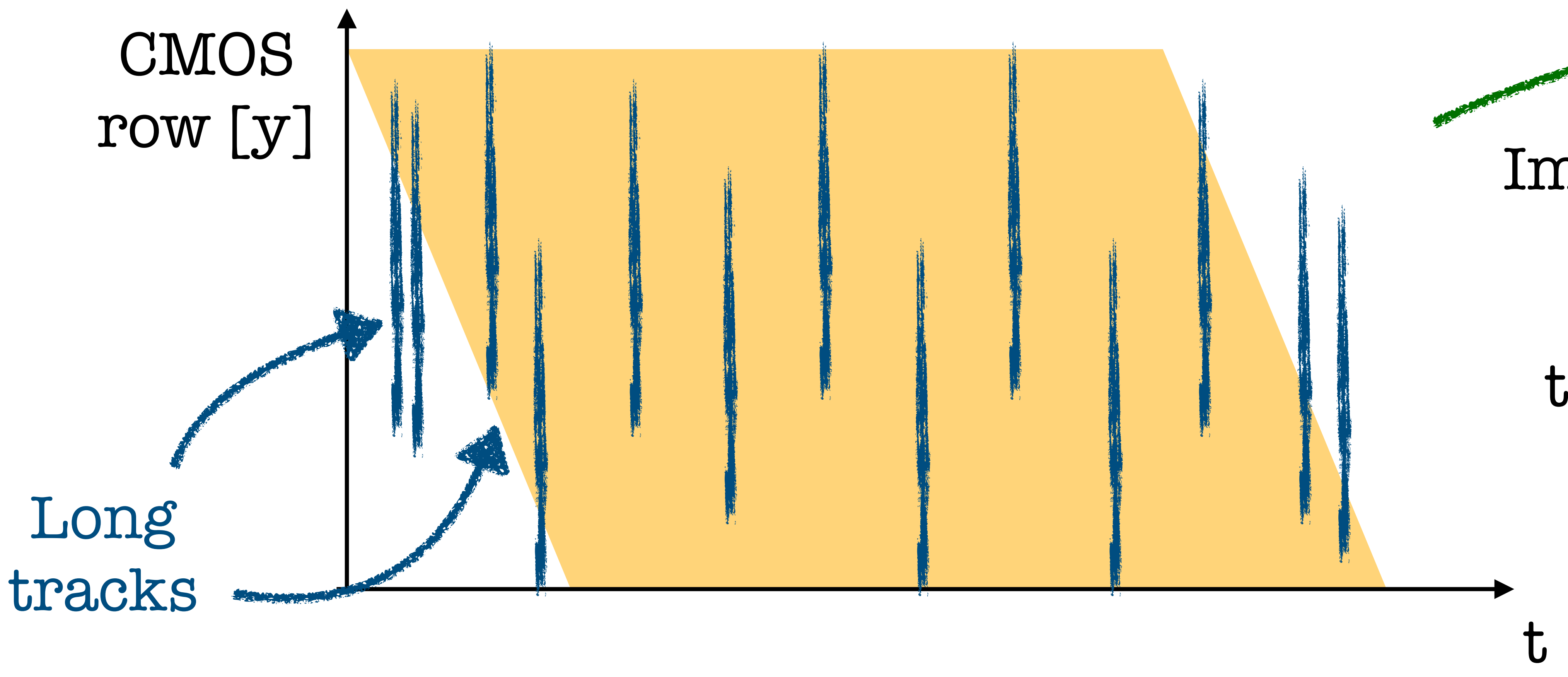
*assuming GEM active area of 1970x1970 px centered with the camera

Looking at the Camera data [RUN2]

- Looking to other runs the situation is the same:

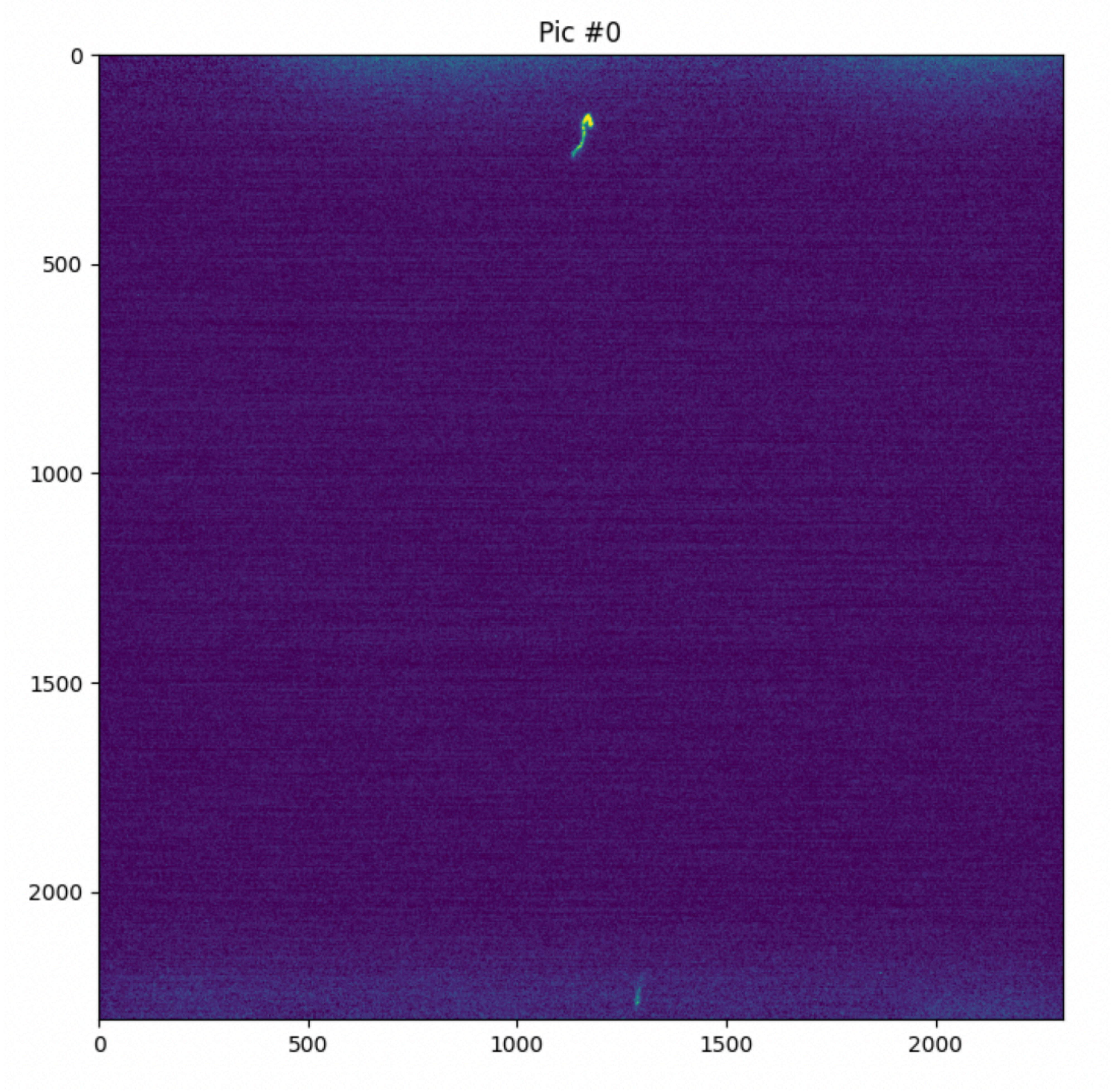


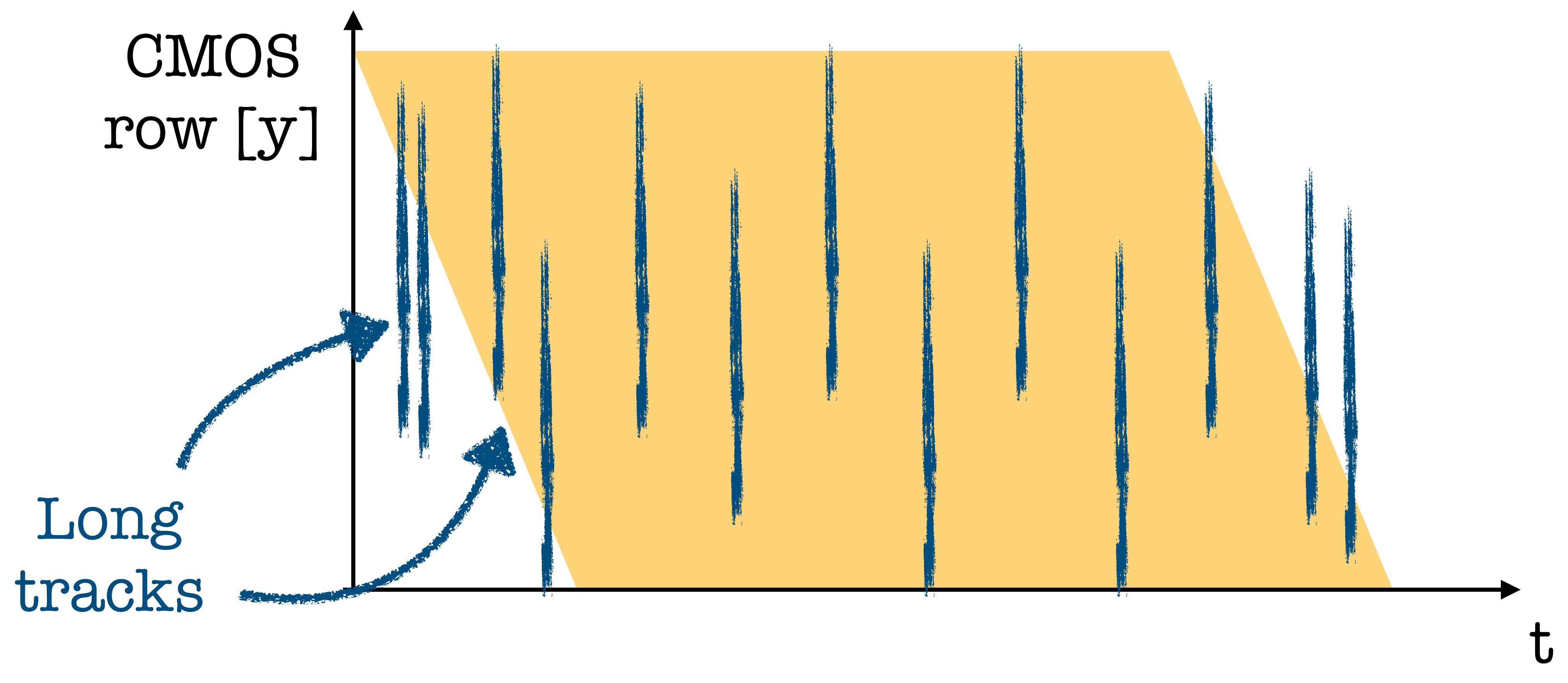
- A possible explanation is that the camera exposure to longer tracks is more than 300 ms!



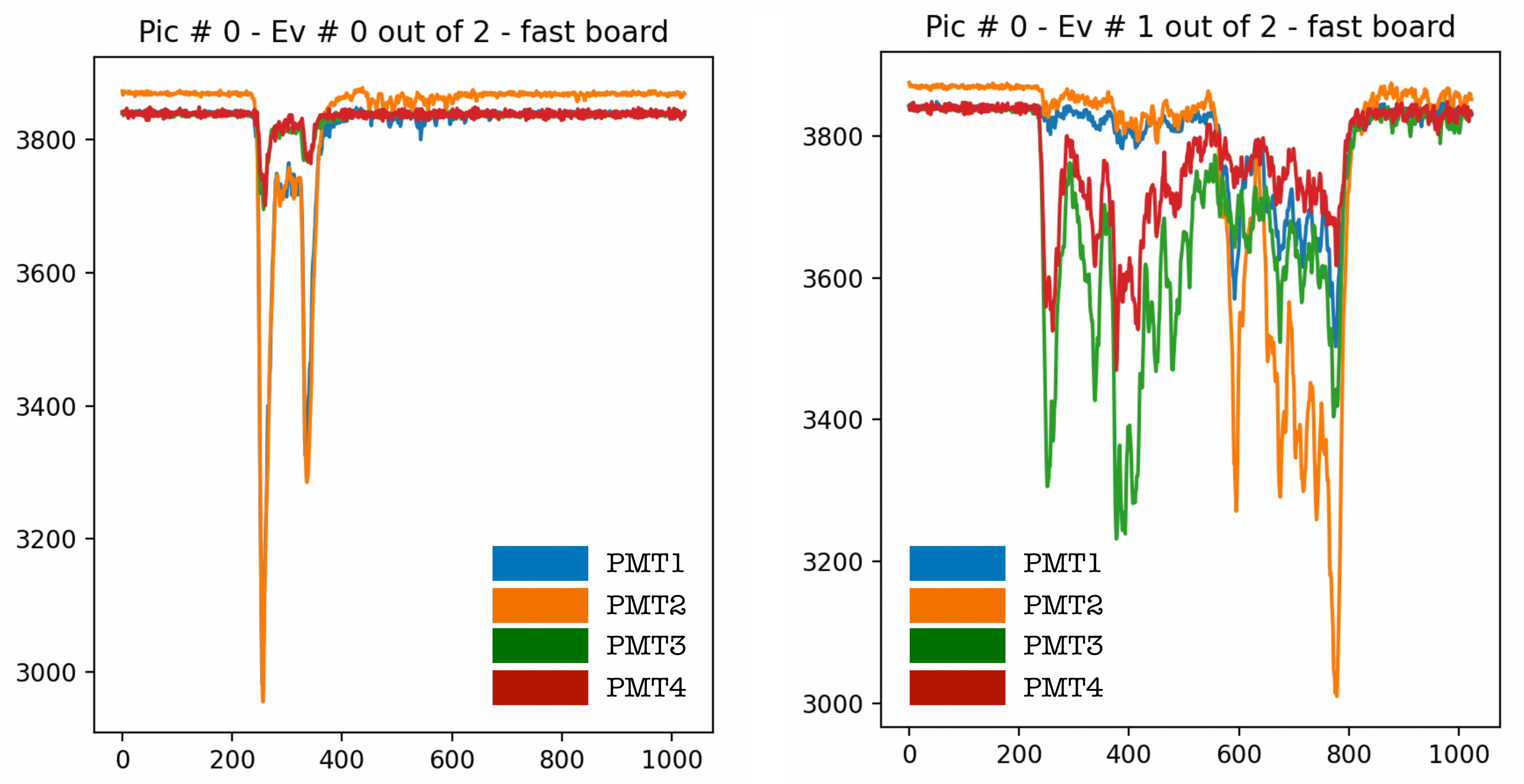
Improving to 340 ms the effective exposure is enough
to produce symmetric residuals!

Cutting long wfs

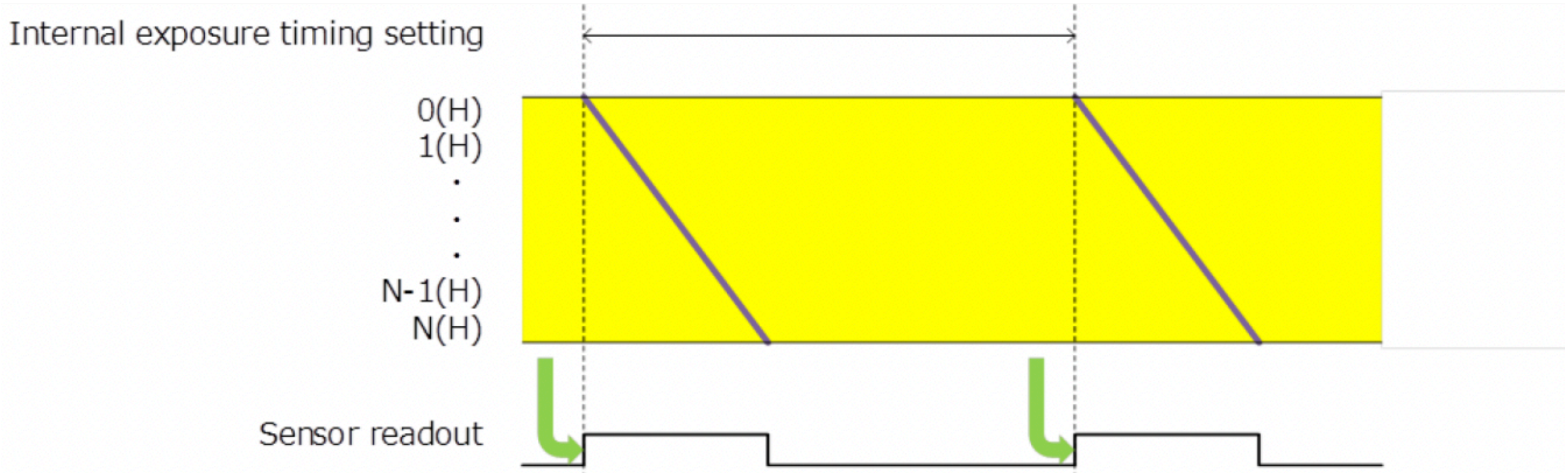




TTTs: [49.849576 473.840541] ms



How can we improve these results



1. Acquire in “Normal” mode
2. Not so easy:
   1. synchronism between pics and boards?
   2. what should be the “event” from the Midas perspective?
3. Possible solution:
   1. acquire ~ 10 subsequent pics
   2. acquire all PMT signal in the FULL window
   3. close the Midas event ⇒ 1 event would be a stream of 10 pics + all the PMT signals happened during it
   4. synchronism thanks to TTT (however it is a 8.5 ns resolution 30-bit [~ 9 s] counter, extendable to 60-bit [310 yr])
   5. Limited by the board buffer size (~ 128 events)

Conclusions

- In this contribution we presented the study of the **dead time of the current DAQ scheme**
- This **configuration** is the one **used** for **RUN2** and **RUN3**.
- We showed a simple **simulation of the DAQ scheme**, that gives us the possibility to assess the real dead time
- We **compared** the simulation **with the RUN2 data**, finding **consistent** result
- We **compared** the **observed event rate** in the **PMTs** and the **camera**
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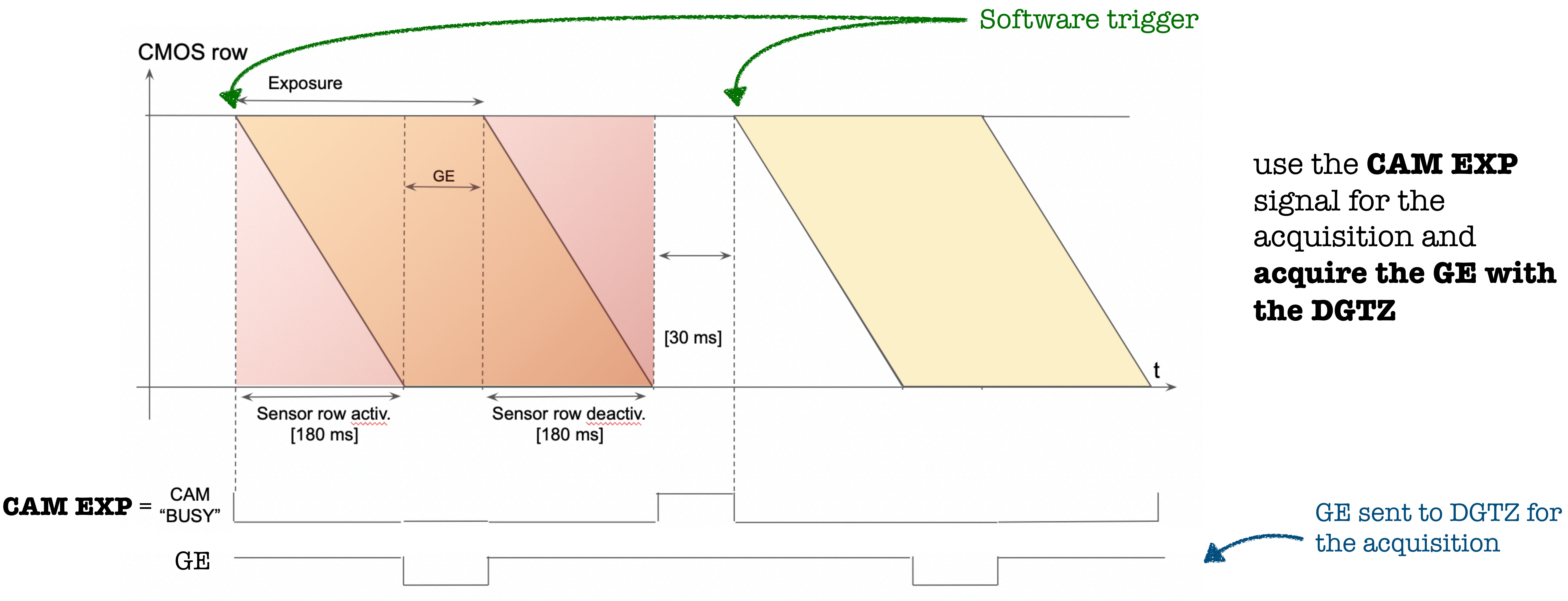
Thanks for the attention

DAQ trigger scheme



use the **CAM EXP** signal for the acquisition and **acquire the GE with the DGTZ**