



MEG II 実験液体キセノン γ 線検出器の安定性のモニ ~~タ~~及び検出器内のMPPCのPDE減少に関する報告

Research on monitoring the stability and PDE decrease of MPPC of MEG II
liquid Xenon photon detector .

17aA572-10

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17th March 2021

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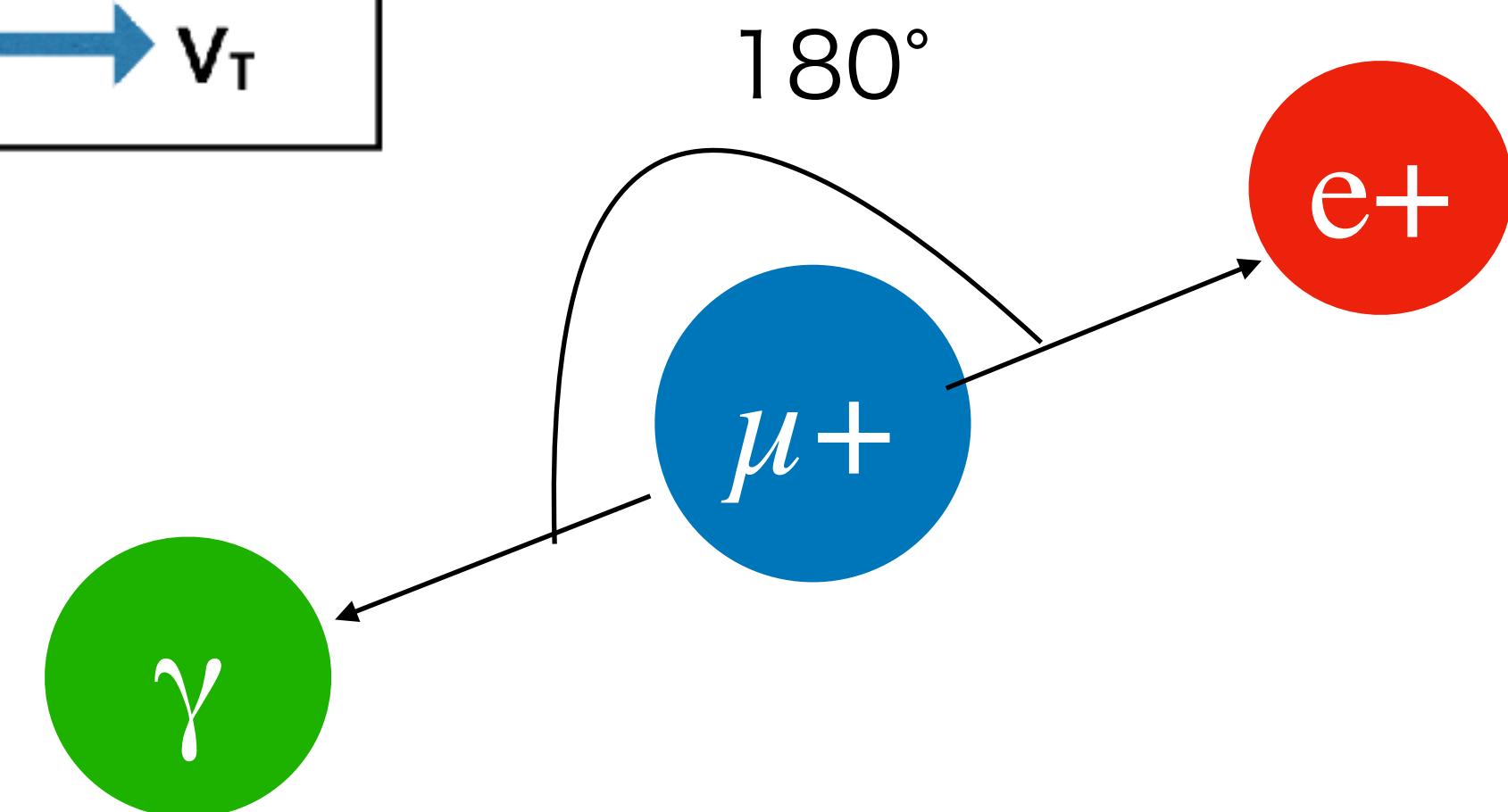
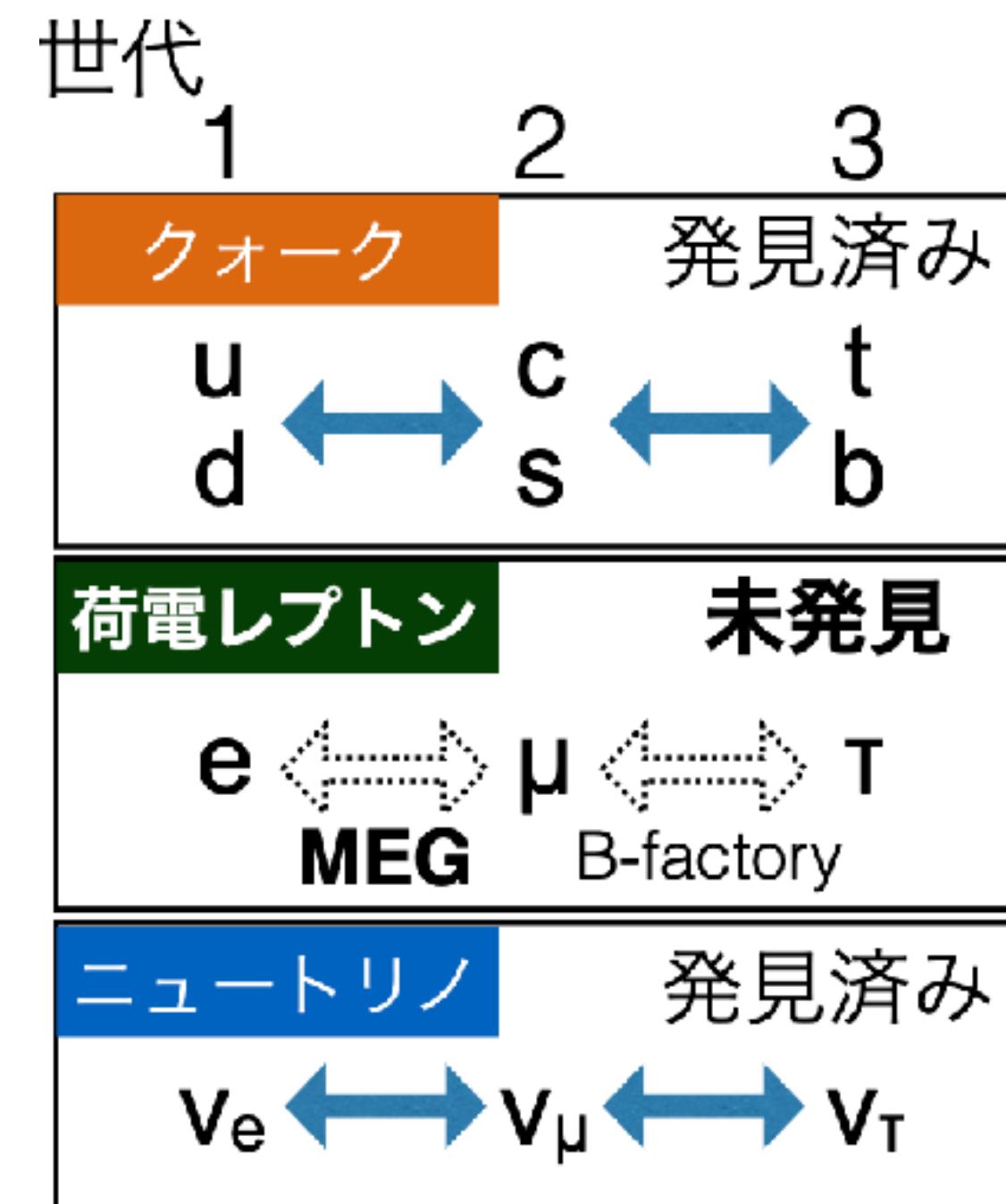
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Introduction

$\mu \rightarrow e\gamma$ search

- $\mu \rightarrow e\gamma$ decay, charged lepton flavour violation (CLFV), is almost forbidden in Standard Model.
- It is, however, predicted to occur in some theories ($\text{Br}(\mu \rightarrow e\gamma) : 10^{-11} - 10^{-14}$).
- MEG experiment gives the current upper limit.

$$\text{Br}(\mu \rightarrow e\gamma) < 4.2 \times 10^{-13} \text{ (90% C.L.)}$$



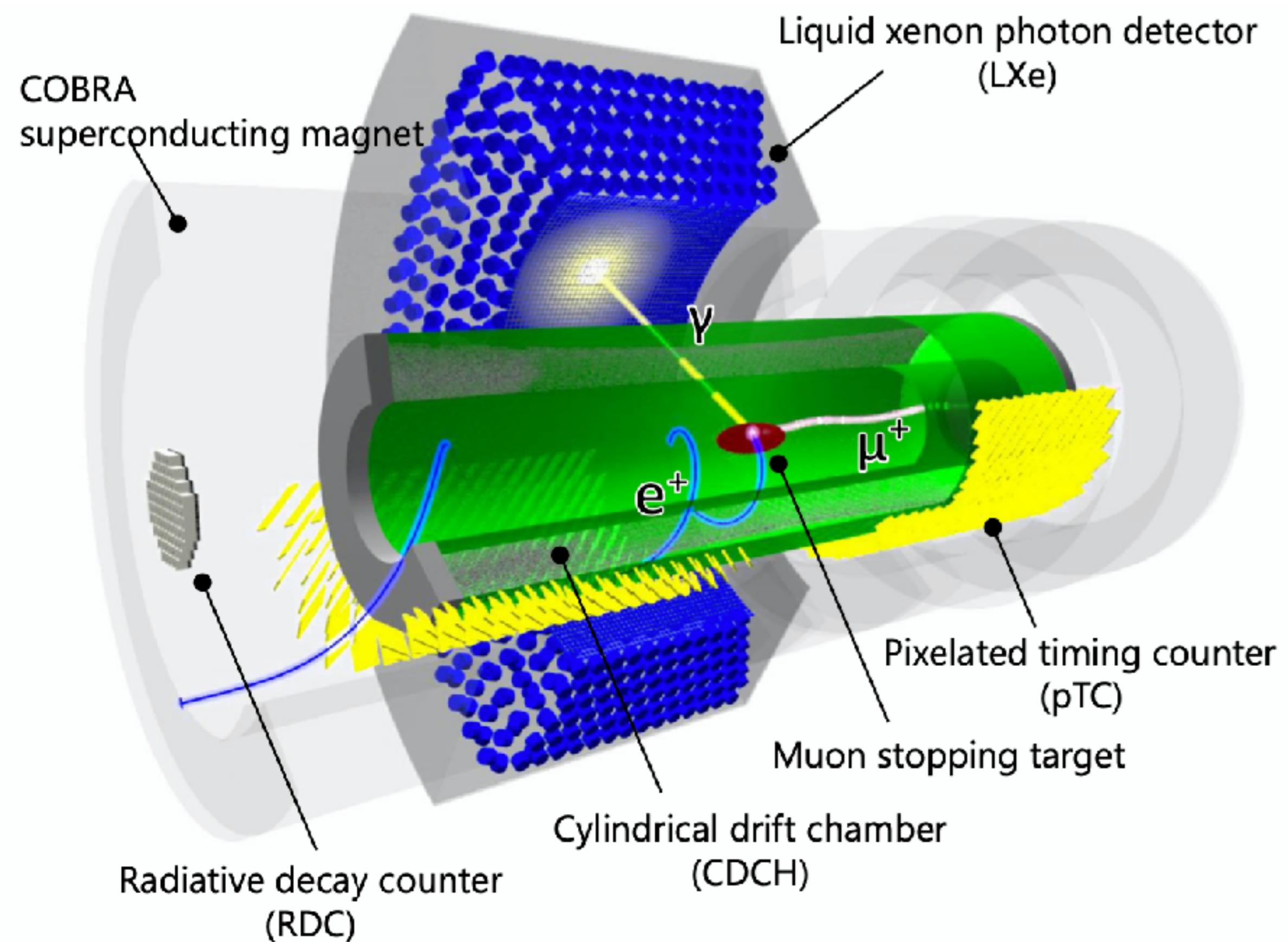
$\mu \rightarrow e\gamma$ decay is

1. Simultaneously emitted
2. Back to back (180°)
3. e^+ and γ are emitted at same energy (52.8MeV)

MEG II experiment

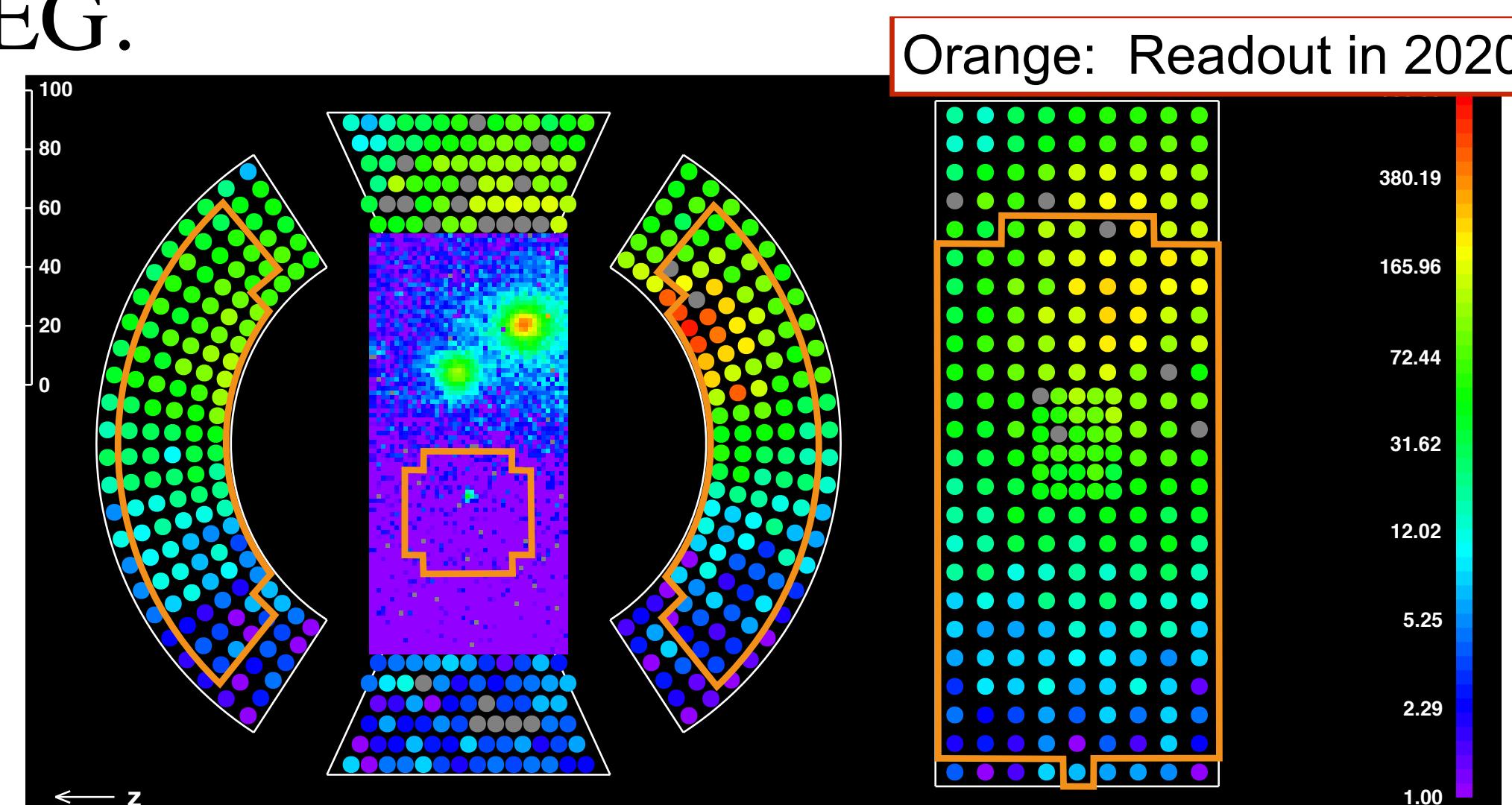
at PSI (Switzerland)

- MEG II aims to detect $\mu \rightarrow e \gamma$.
- Upgraded detectors comparing to that of MEG.
- Using continuous μ^+ beam (up to $7 \times 10^7/s$), MEG II will reach $\text{Br}(\mu \rightarrow e \gamma) \sim 6 \times 10^{-14}$.
- All detectors except RDC at upstream side (15aA573-7,8) were installed and all channel were used in 2021 run (15aA562-4,5,6).

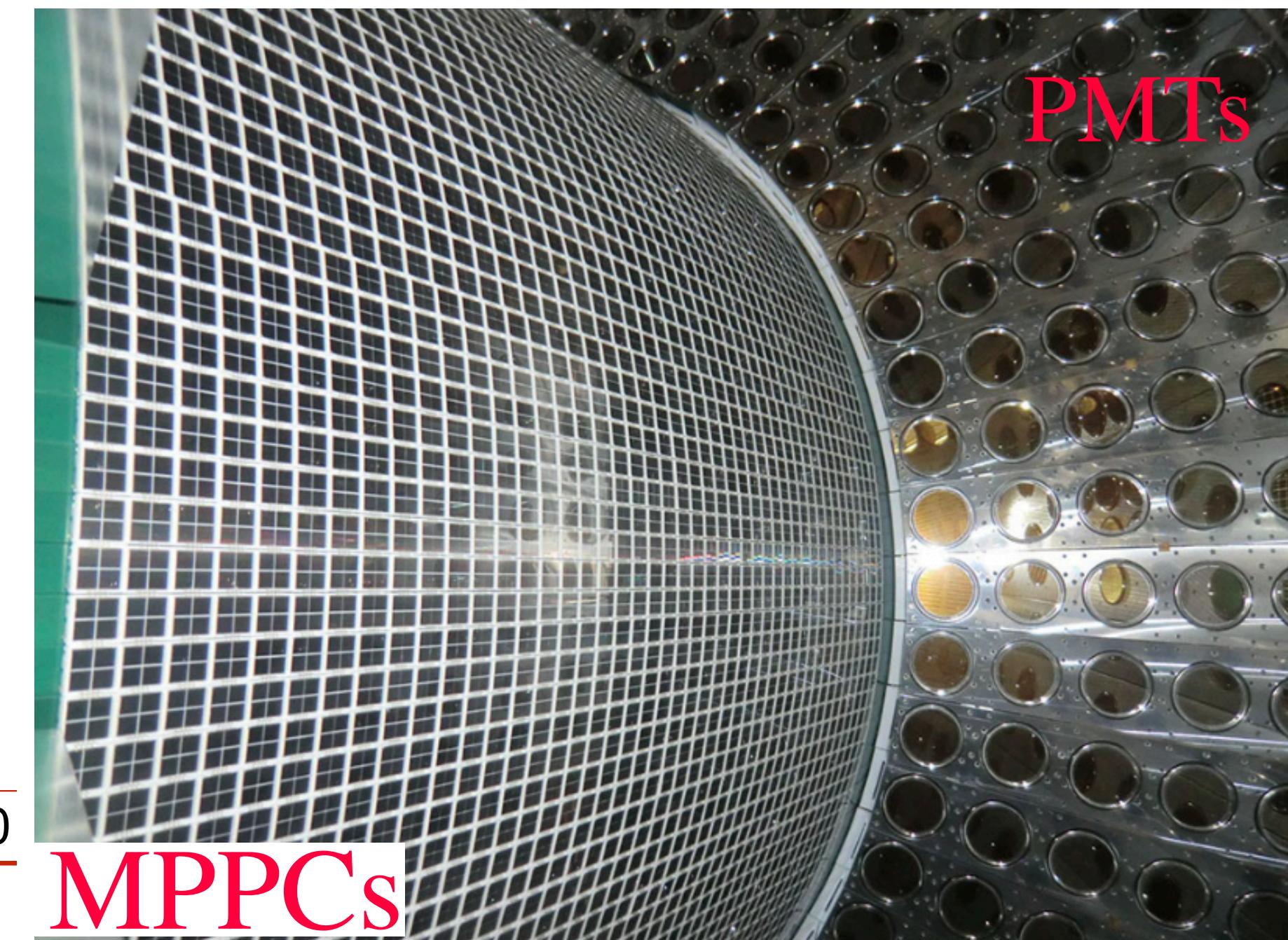


Liquid xenon photon detector (LXe)

- Energy, position and timing of γ are measured.
- Detect the scintillation light (~ 175 nm).
- Use 4092 VUV-sensitive MPPCs (newly installed for MEG II) and 668 PMTs.
- Energy and position resolution will be improved compared to MEG.



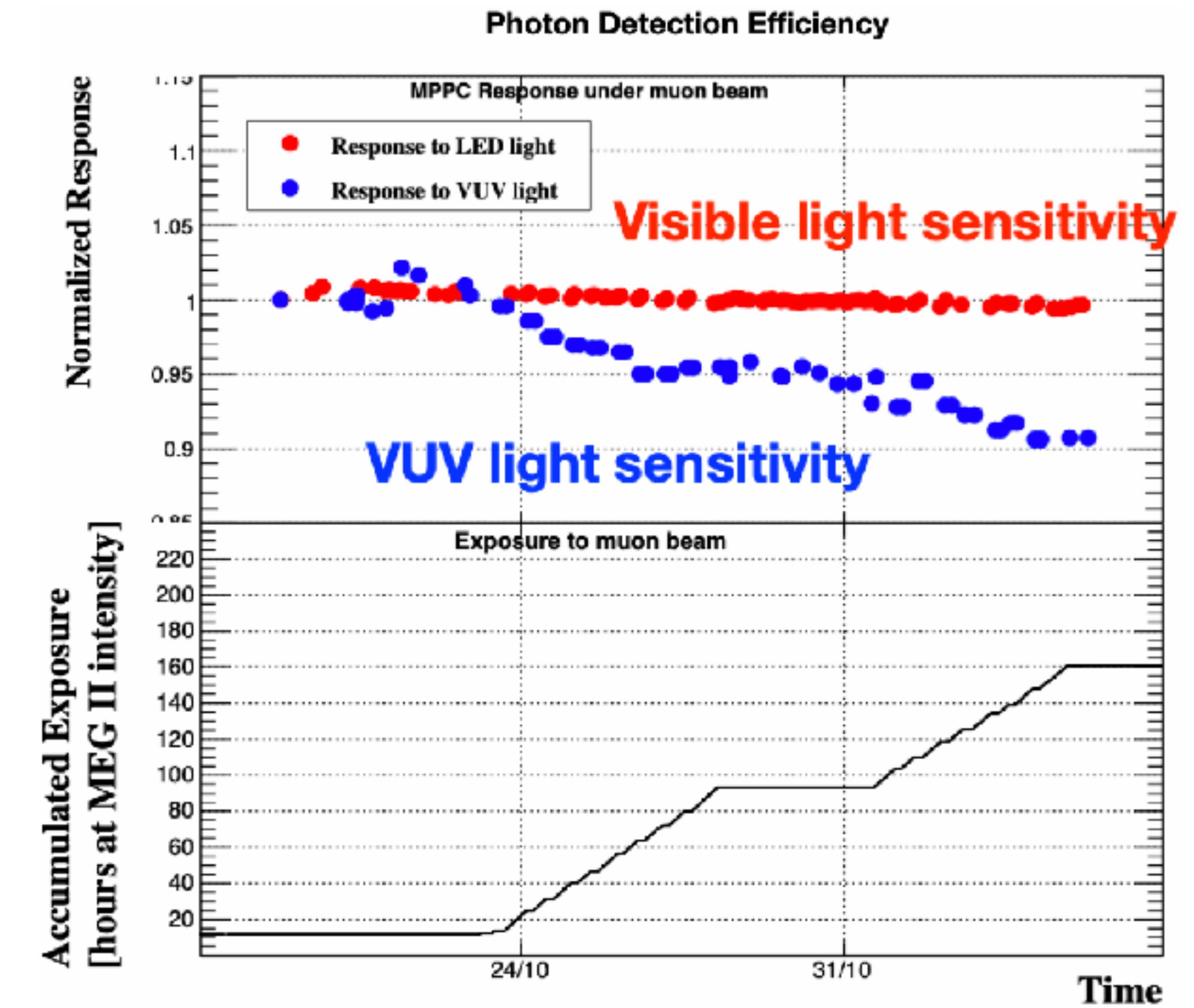
液体キセノン検出器全チャンネルでの読み出し。灰色
のセンターはdead channelである。



PDE decrease

Introduction of PDE decrease

- PDE decrease of VUV-MPPC was observed.
- The decrease is quite fast ($\sim 0.06\%/\text{h}$ in MEG II beam intensity).
- MEG II DAQ time: 120 days/year
=> crucial problem
- Annealing (heating) is effective to recover the decrease (17aA572-8), but the cause is unknown.

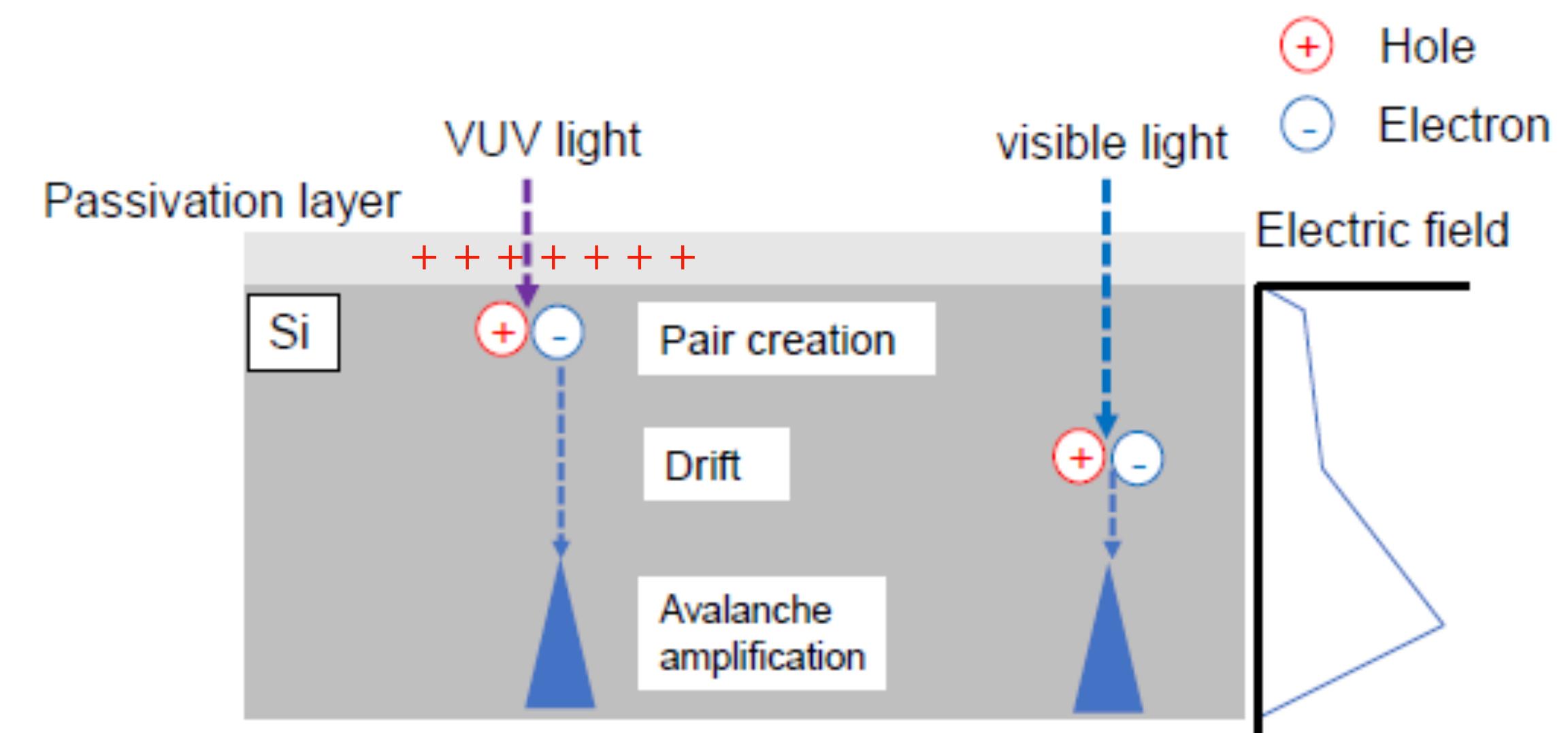


PDE history in 2019

Experiments we did until now

Suspected VUV and γ

- Irradiated condition of MPPCs : VUV, γ , neutron, liquid xenon
- We suspect surface damage by VUV or γ as cause of the decrease.
- Effectiveness of annealing can be explained in case of this damage.



- some VUV stopped in passivation layer
- make electron-hole pairs and holes are trapped.
- The electric field around Si-passivation boundary will be reduced.
- Annealing is effective to recover PDE (may remove holes).

Experiments we did until now

- As for experiments of VUV and γ at low temperature, PDE were measured at room temperature.
- As for γ experiment at low temperature, MPPC was not dipped in Liquid xenon.

=> We should do experiments with different setups.

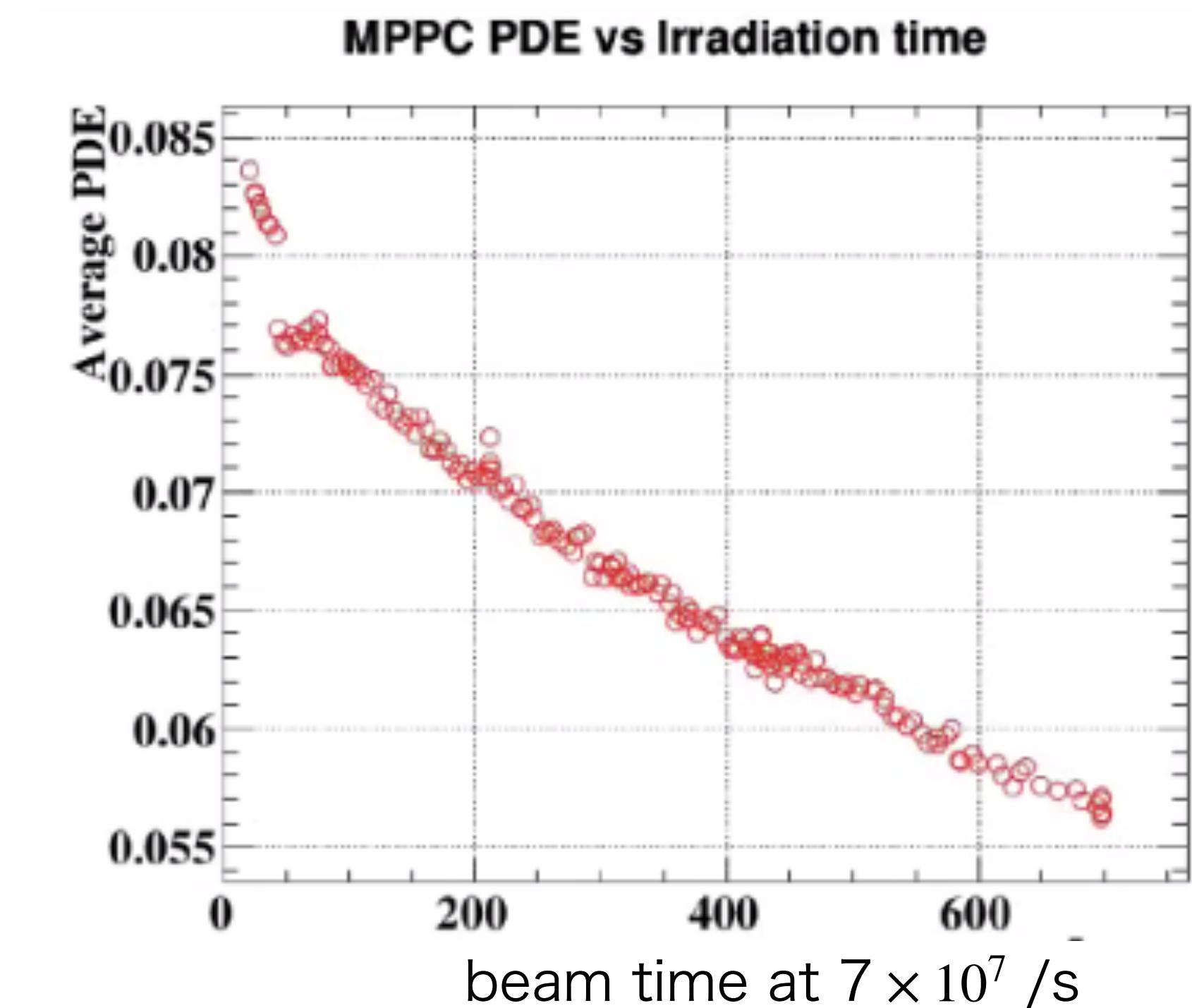
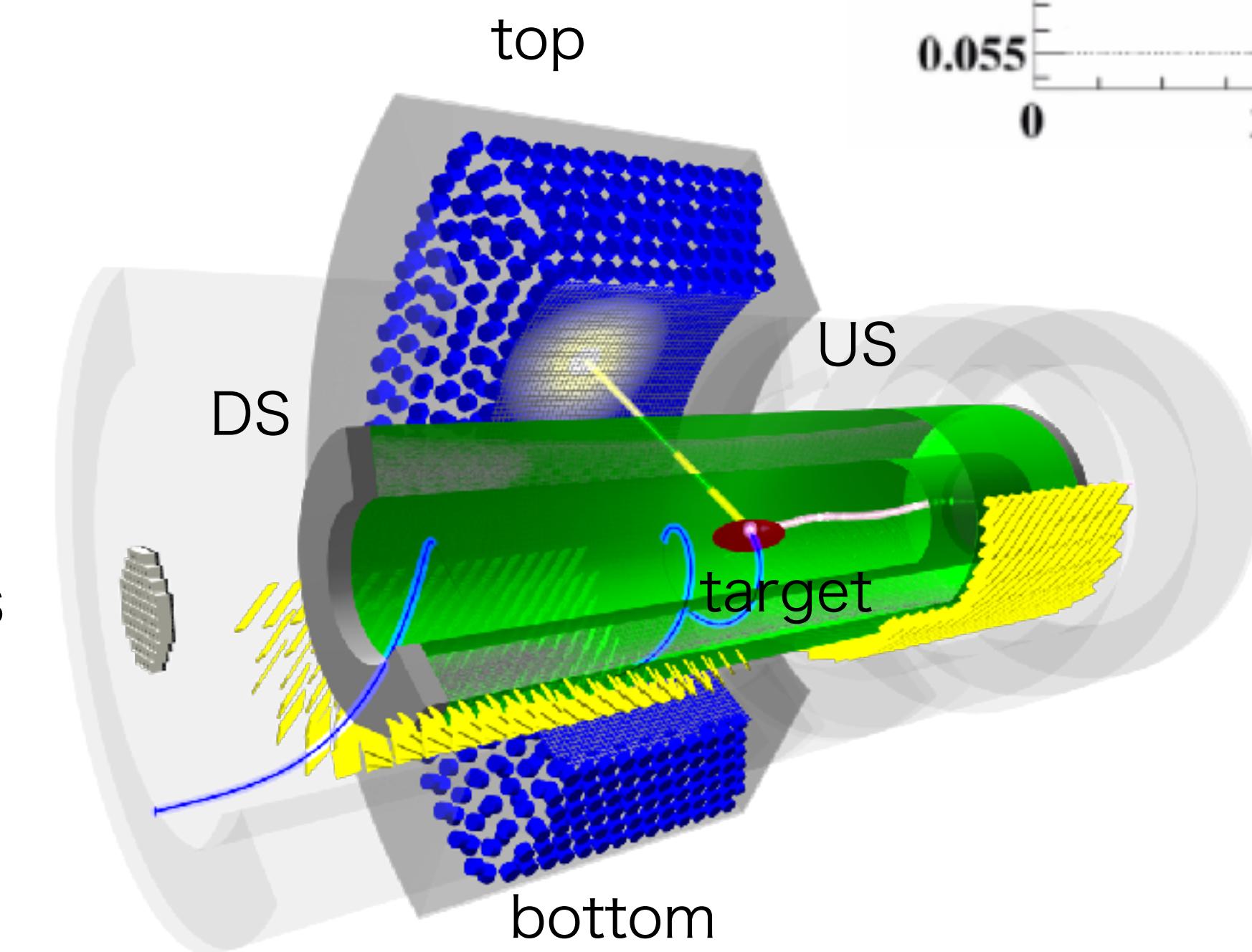
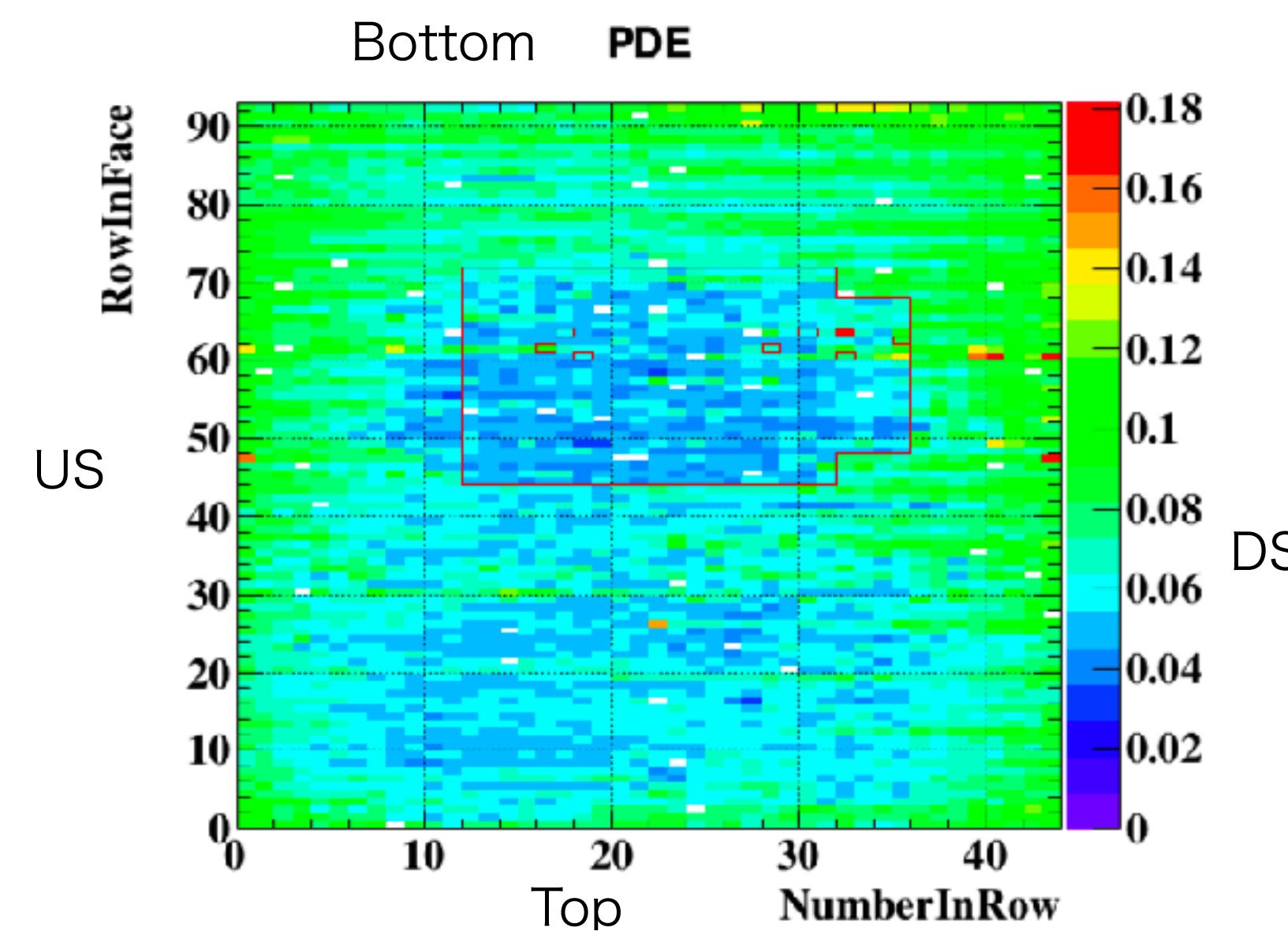
Irradiated sample	Irradiated condition	Result
VUV	at room temperature	observed but too slow
	at low temperature (165K)	not observed
γ ray	at room temperature	not observed
	at low temperature (165K)	not observed

Details is in backups

Characteristics of PDE decrease in 2021 run

PDE decrease in 2021 run

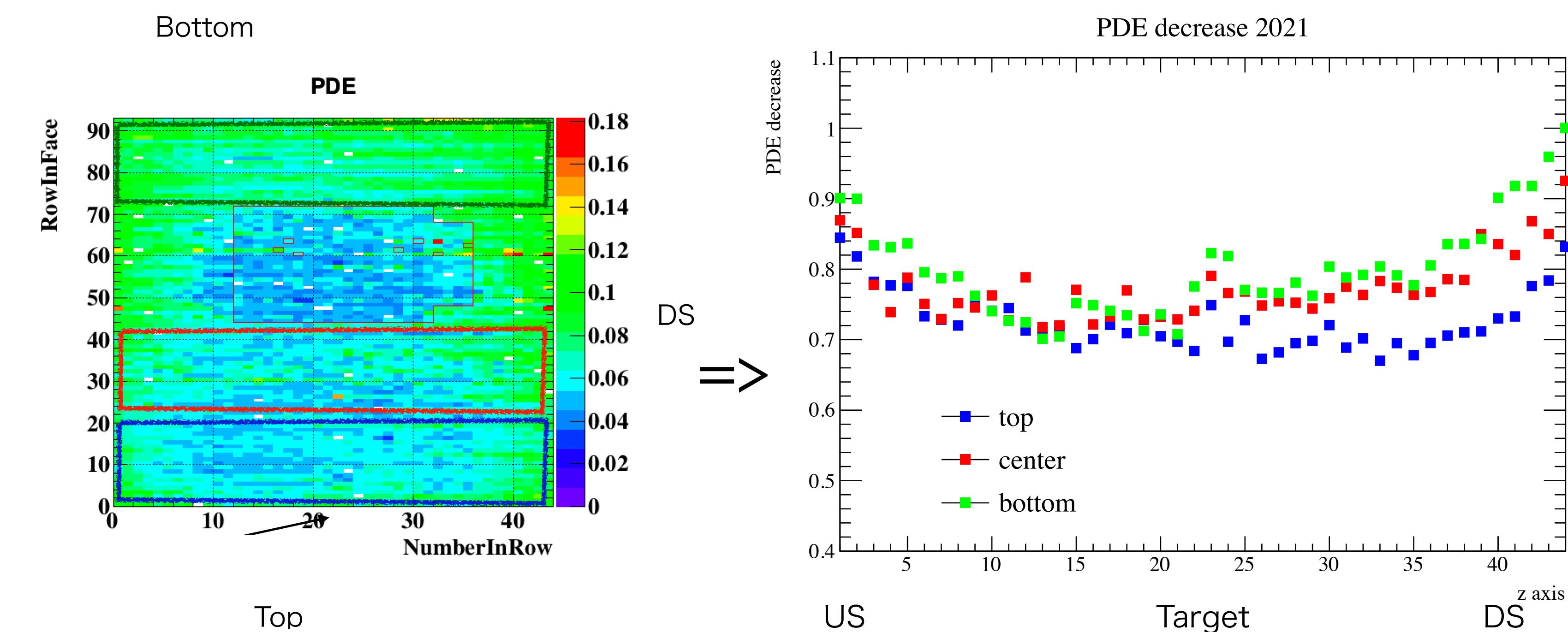
- We calculate PDE of 4092ch mean as monitoring of PDE decrease.
- In this time, Compared PDE of individual MPPC and researched characteristics of PDE decrease by data of 2021 run.



PDE decrease in 2021 run

Compared by position for MPPC from 2021

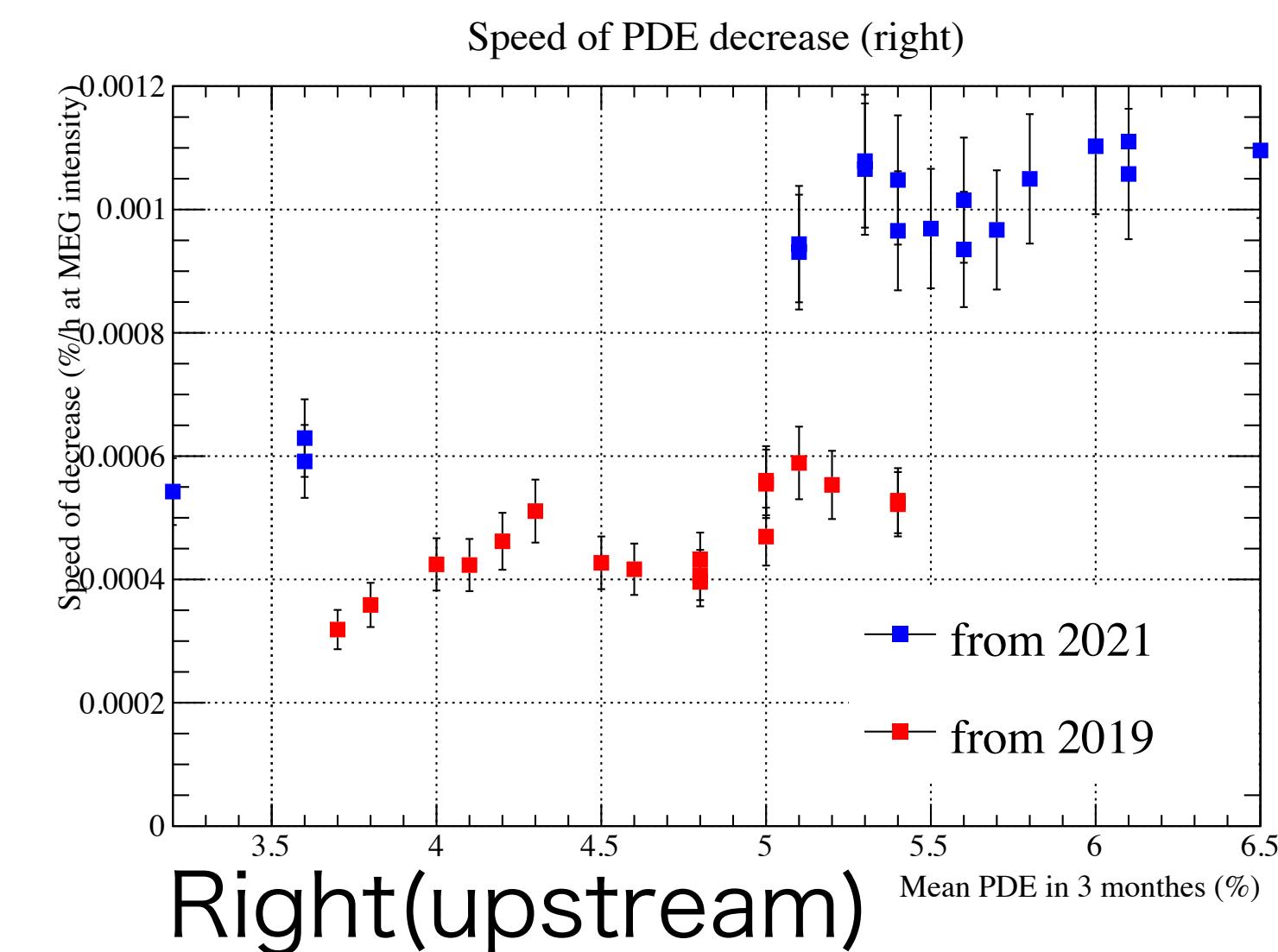
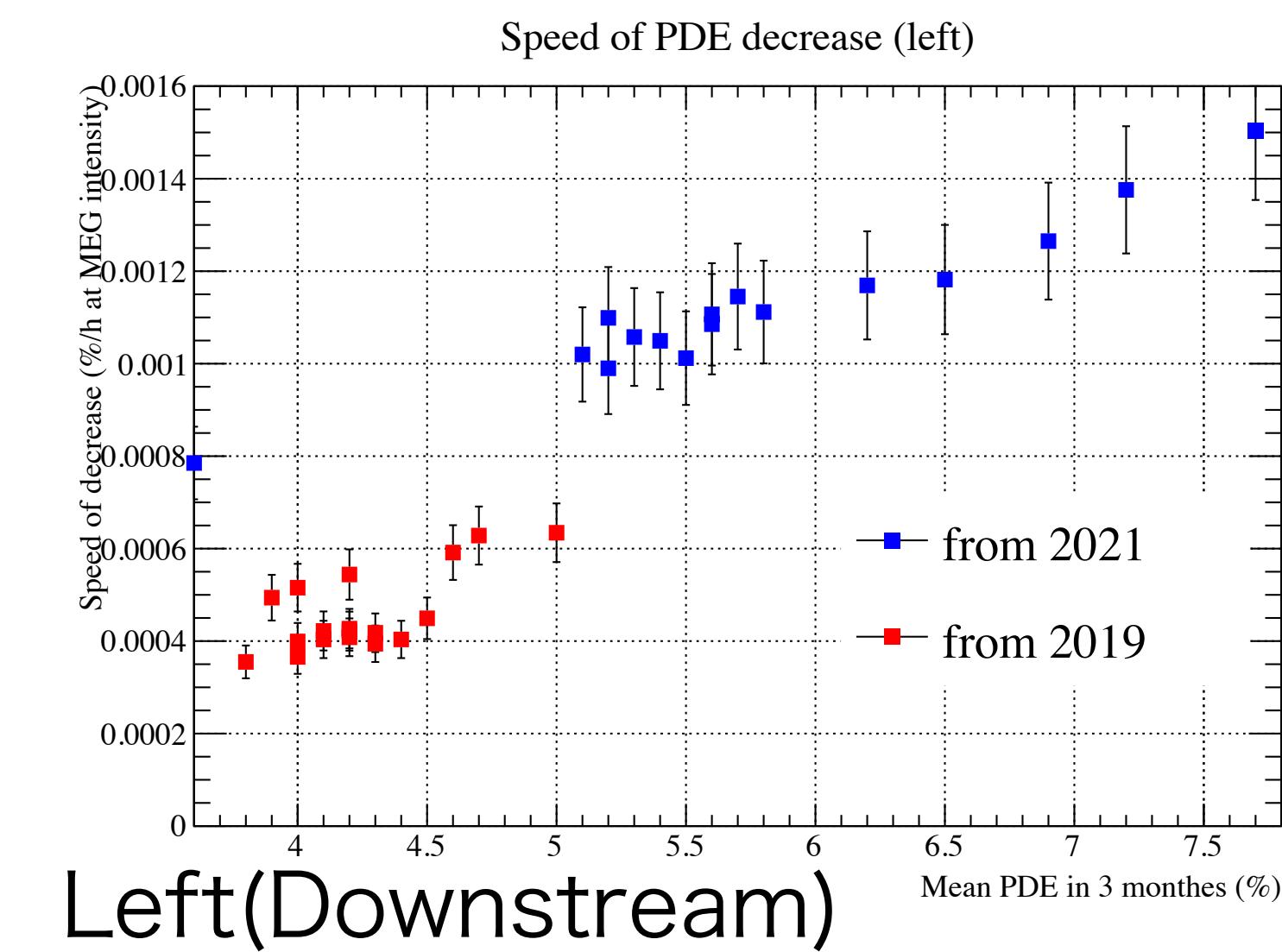
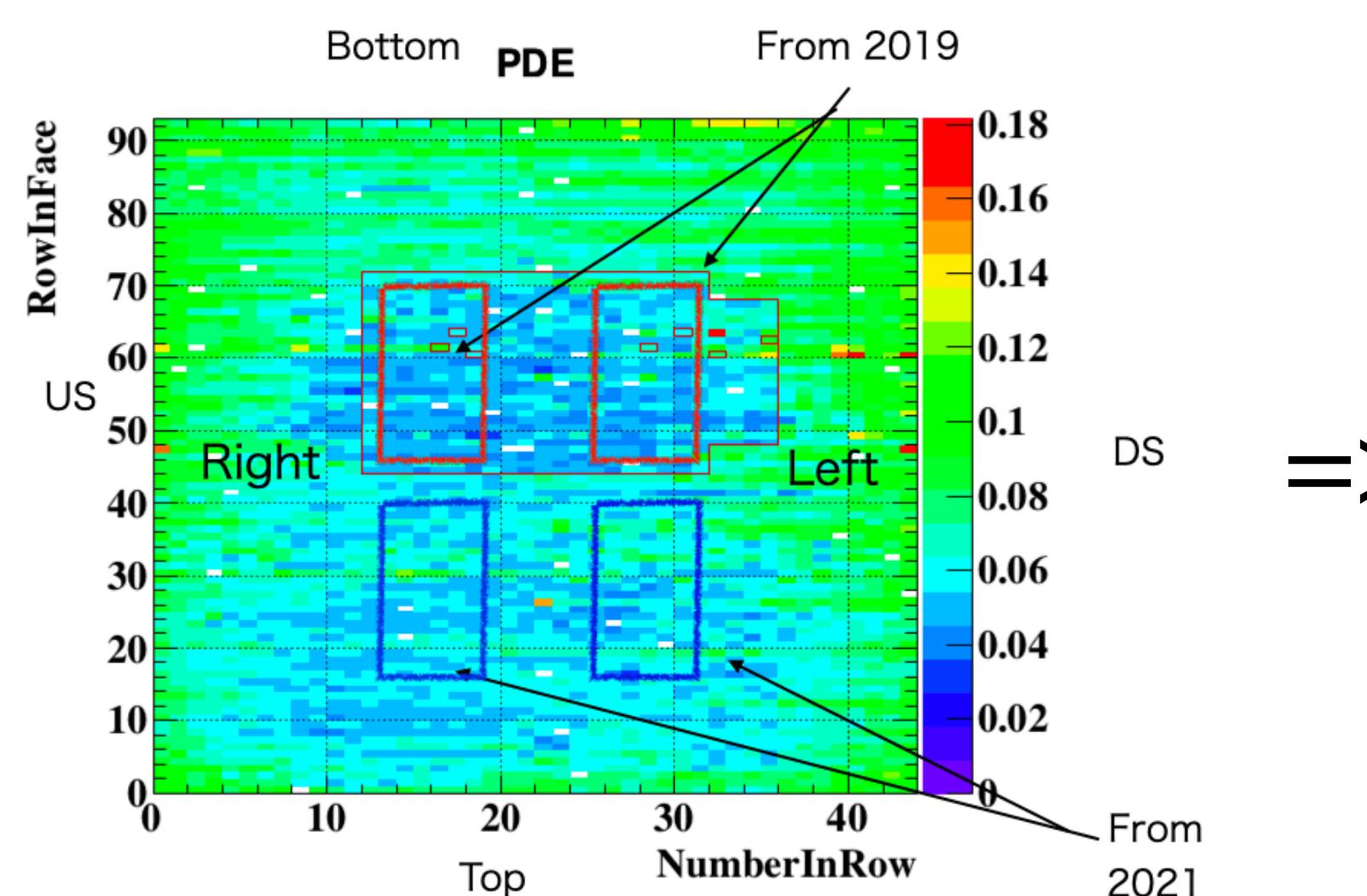
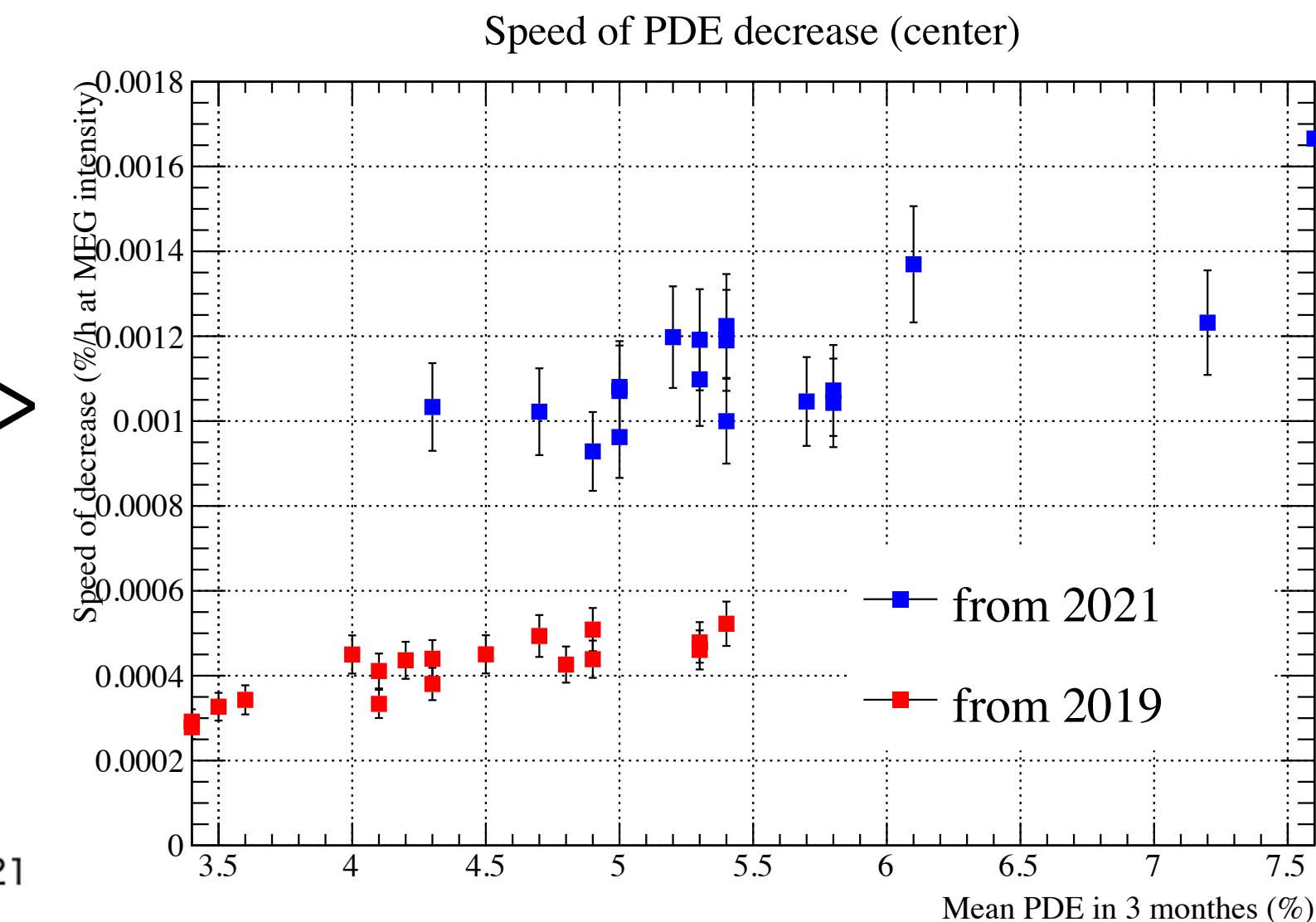
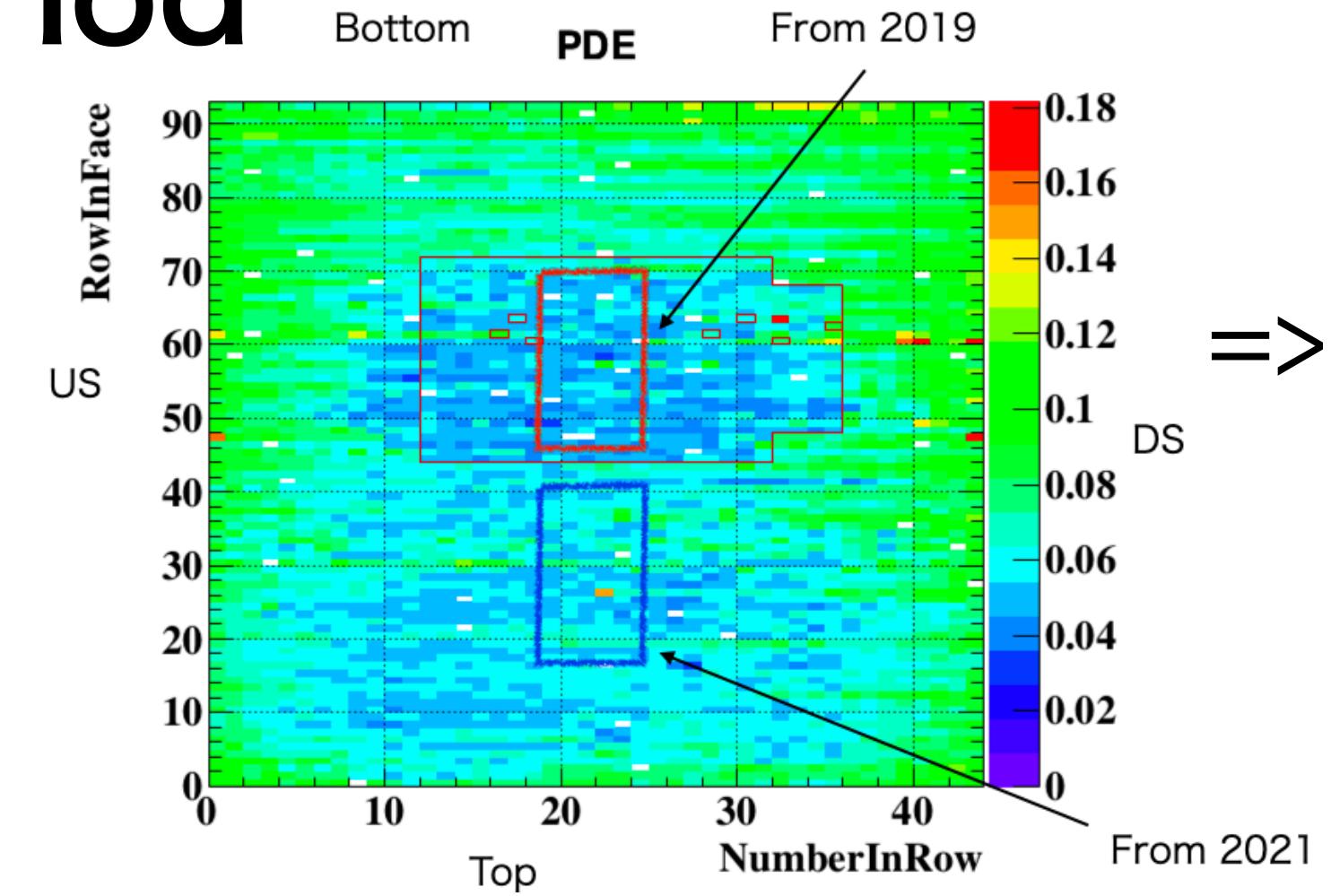
- Compared by top, centre and bottom of MPPC (from 2021)
- The nearer MPPC is to target, the larger PDE decreases.
- It seems that PDE of MPPCs in top decrease larger.



PDE decrease in 2021 run

Compared by used period

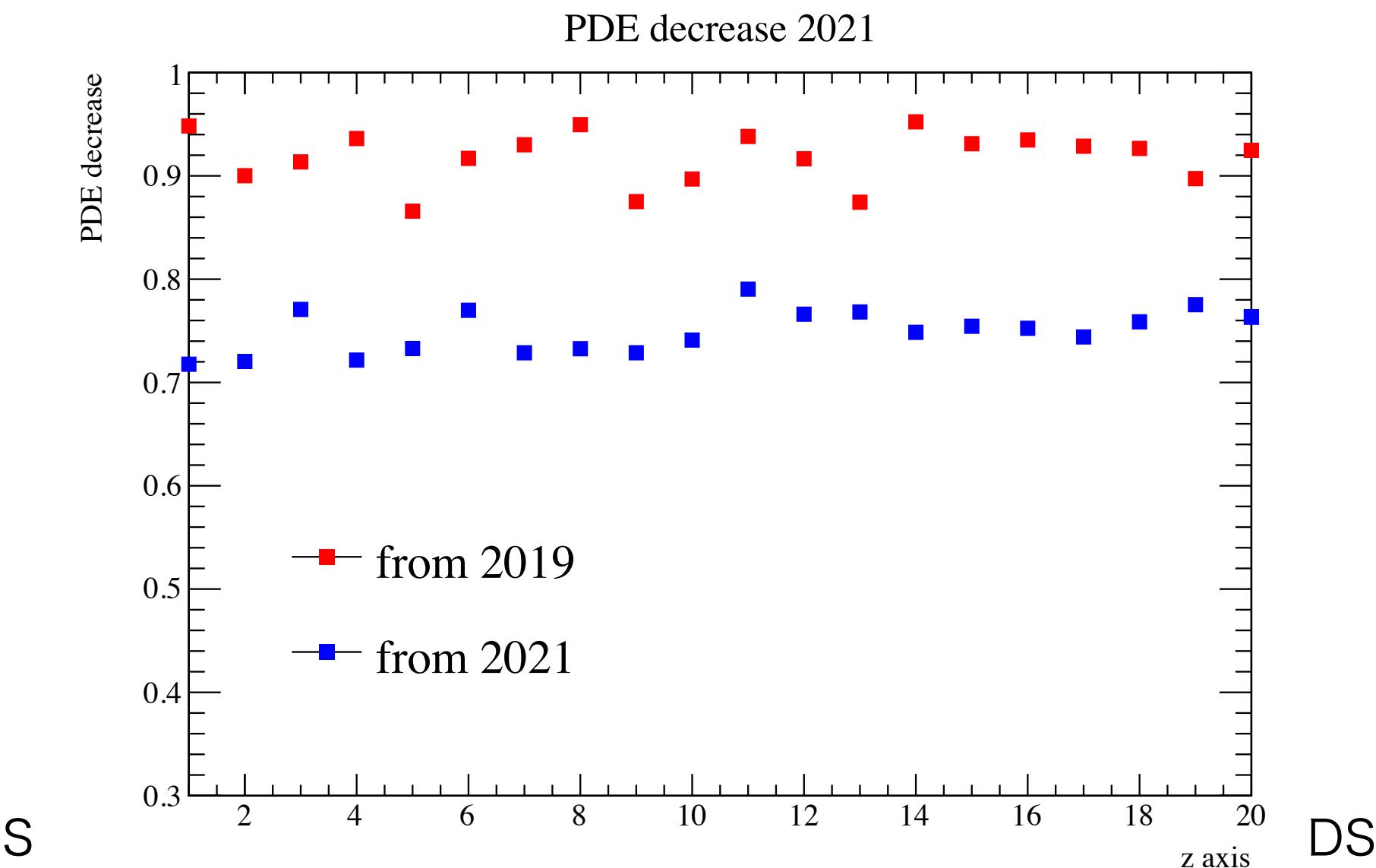
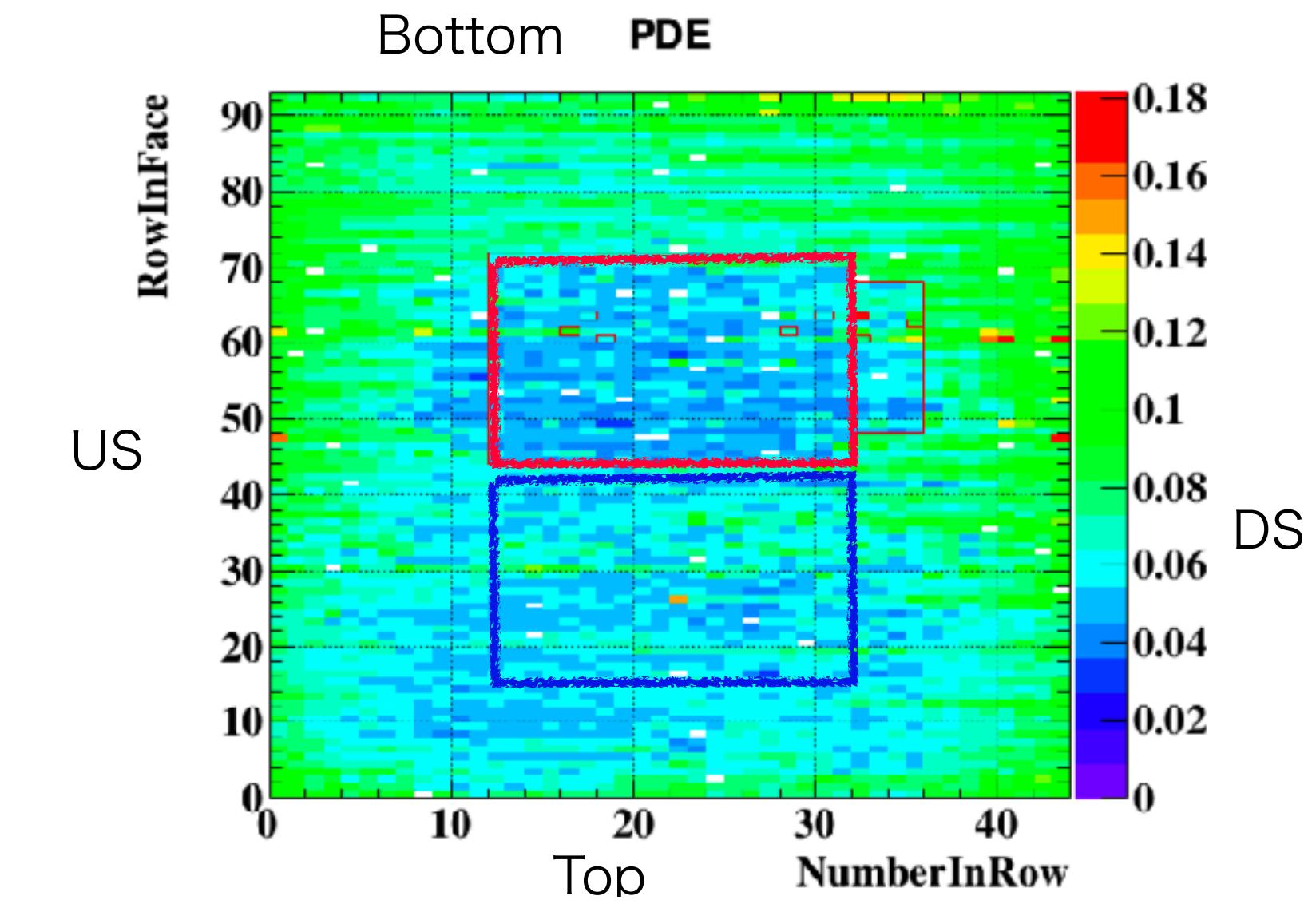
- Some MPPC was used from 2019 and others was from 2021.
- Beam intensity : 3×10^7 (3 months)
- PDE decreases faster in MPPC from 2021.



PDE decrease in 2021 run

Compared by used period

- Compared quantity of the decrease in 2021 run.
- PDE decreased larger in MPPC from 2021.



PDE decrease speed in 2021 run

Compared by beam intensity

- We used different beam intensity in 2021 run.
- The larger intensity is used, the faster PDE decrease is observed.

Beam intensity (/s)	Decrease speed(%/h)	error
3×10^7	0.011	0.00004
4×10^7	0.023	0.006
7×10^7 (2019)	0.06	

PDE decrease speed in 2021 run

Results

- The nearer MPPC is to target, the larger PDE decrease is observed.
- MPPC used from 2021 has larger PDE decrease than that from 2019.
- The stronger beam intensity we used, the faster PDE decrease is observed.
- We should investigate PDE decrease in more detail.

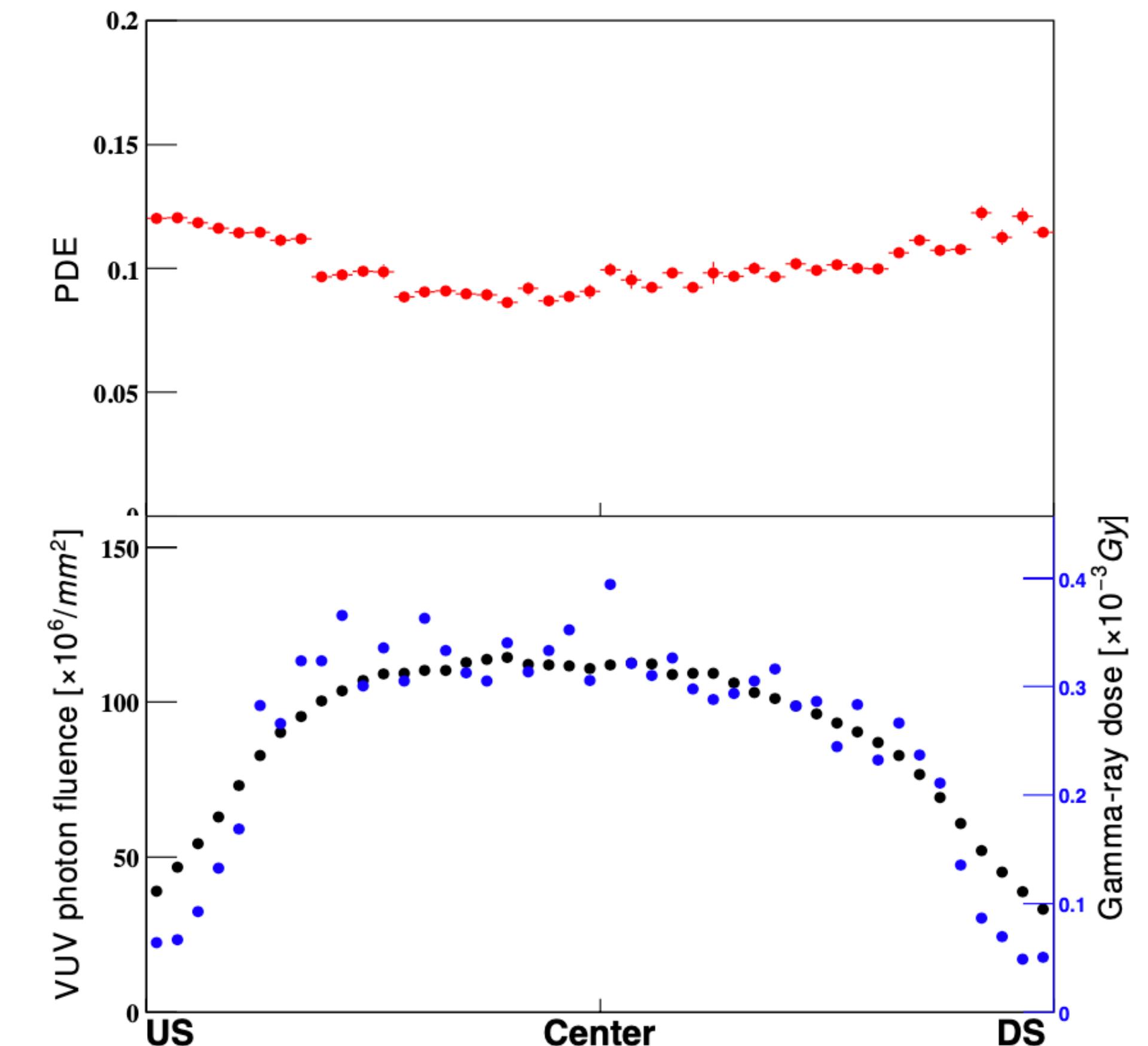
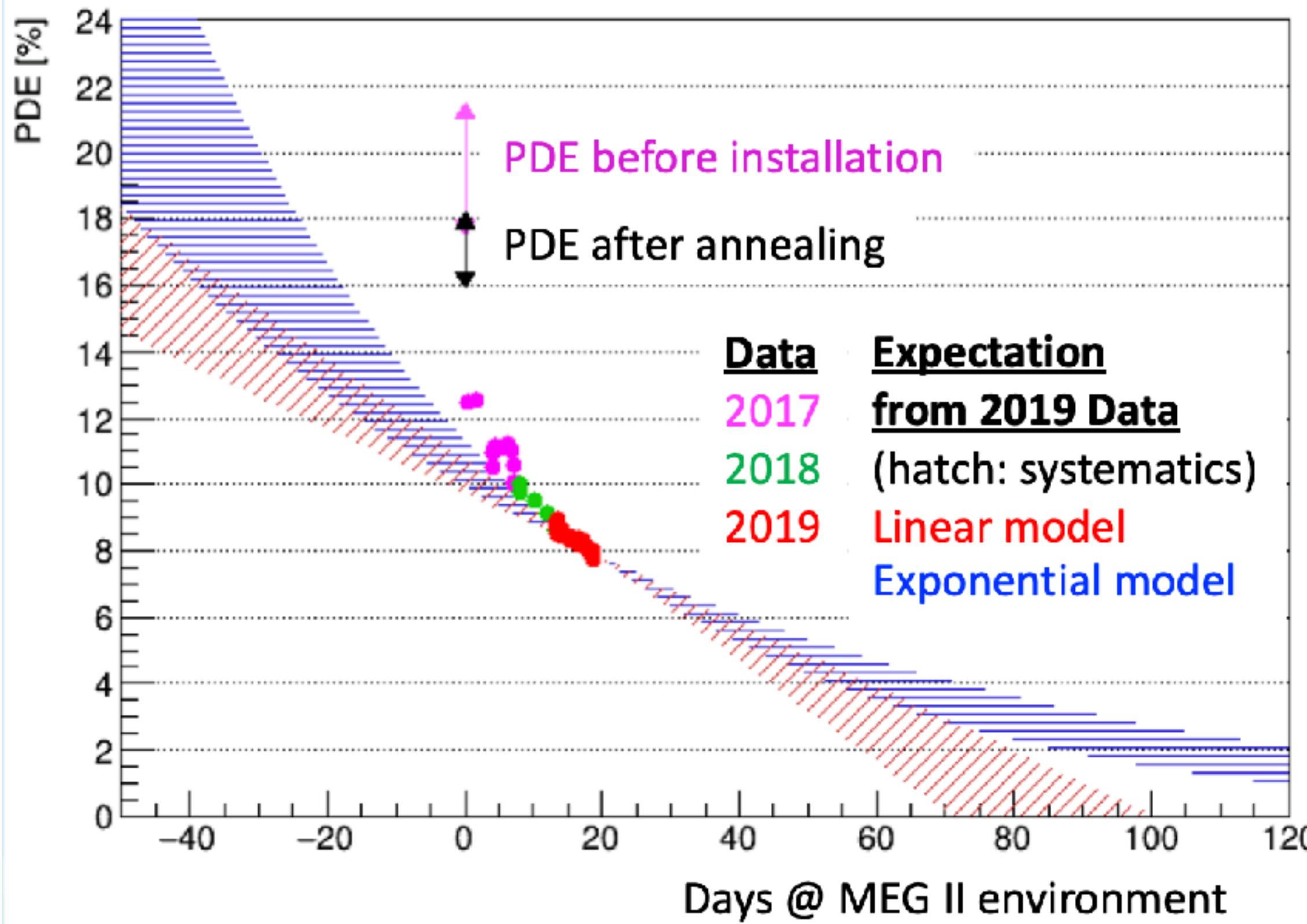
Summary

- MEG II experiment aims to detect $\mu \rightarrow e \gamma$, and started to use all channels from 2021 run.
- PDE decrease of VUV-MPPC is crucial problem for MEG II experiment.
- We researched cause if the decrease in Laboratory but could not specify it.
- Using PDE data in 2021 run, we researched characteristics of PDE decrease and got some results.
- We should continue to specify the cause by experiment in Laboratory and data of MPPC in LXe.

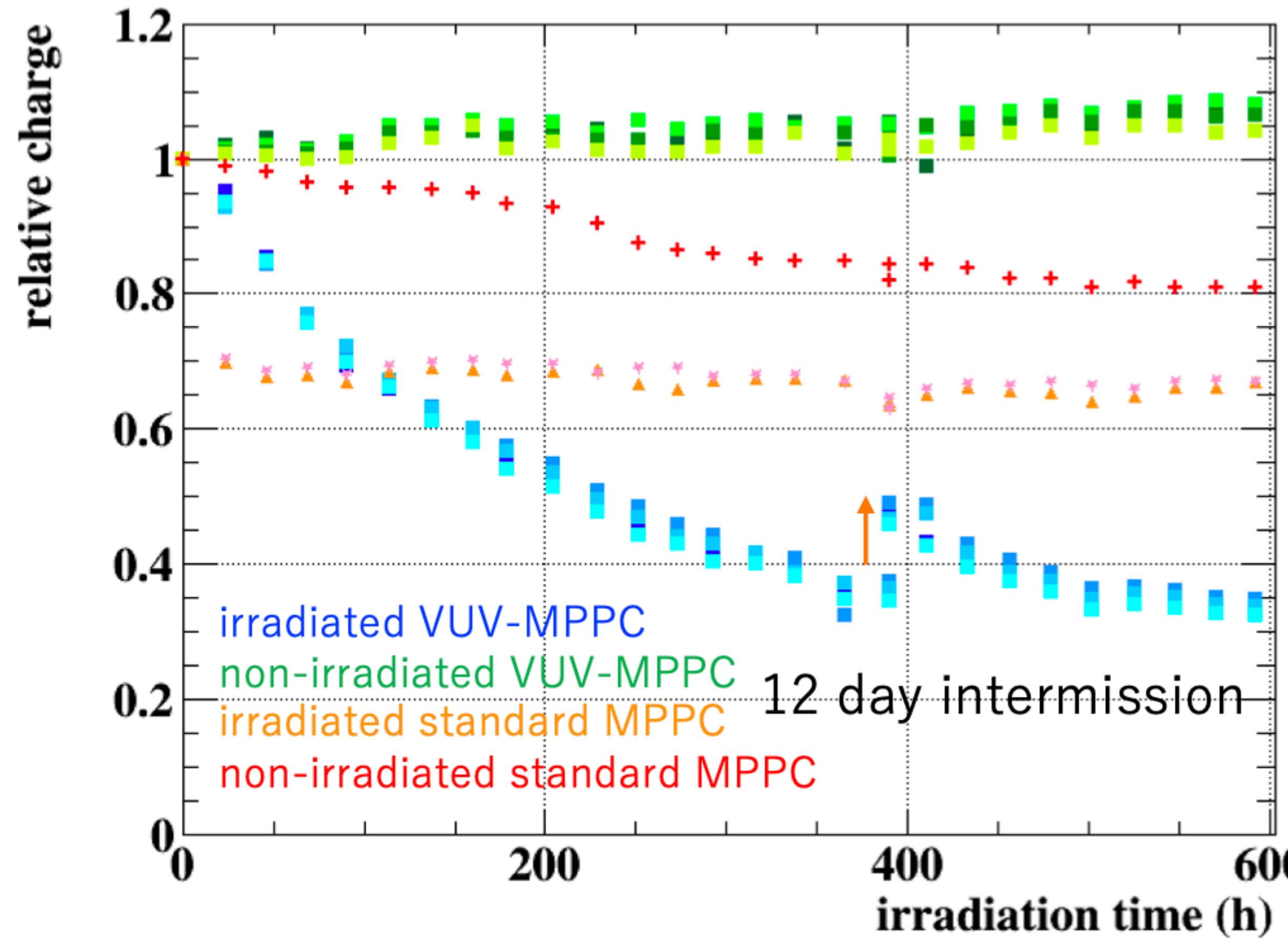
Backups

History of MPPC VUV PDE

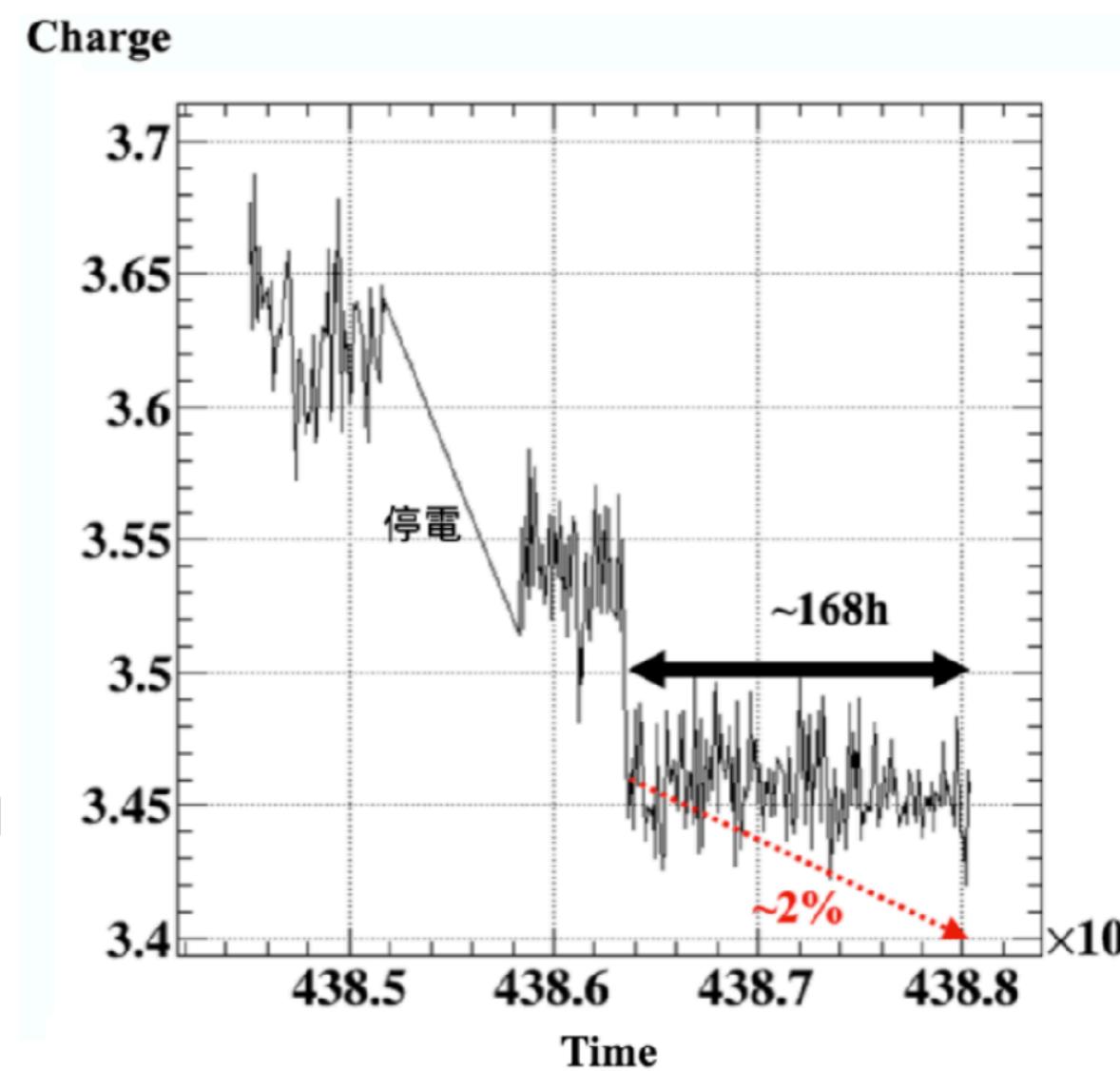
(Measured data & expectation in the future)



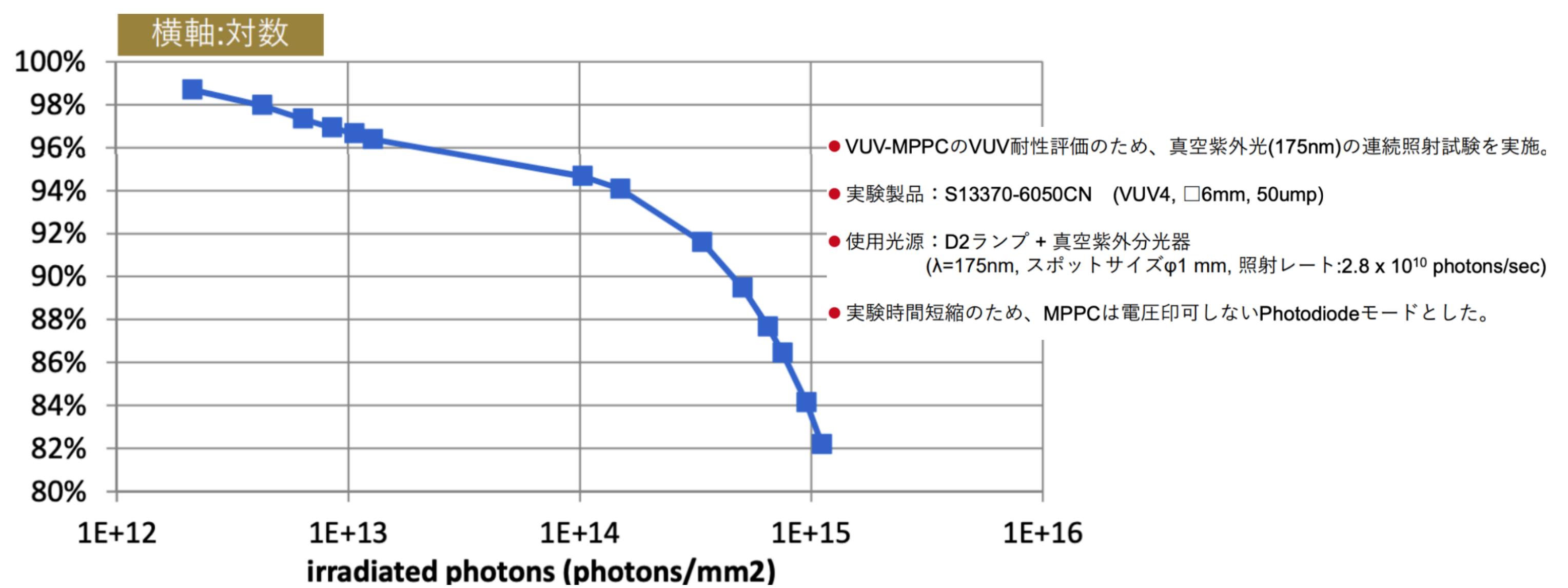
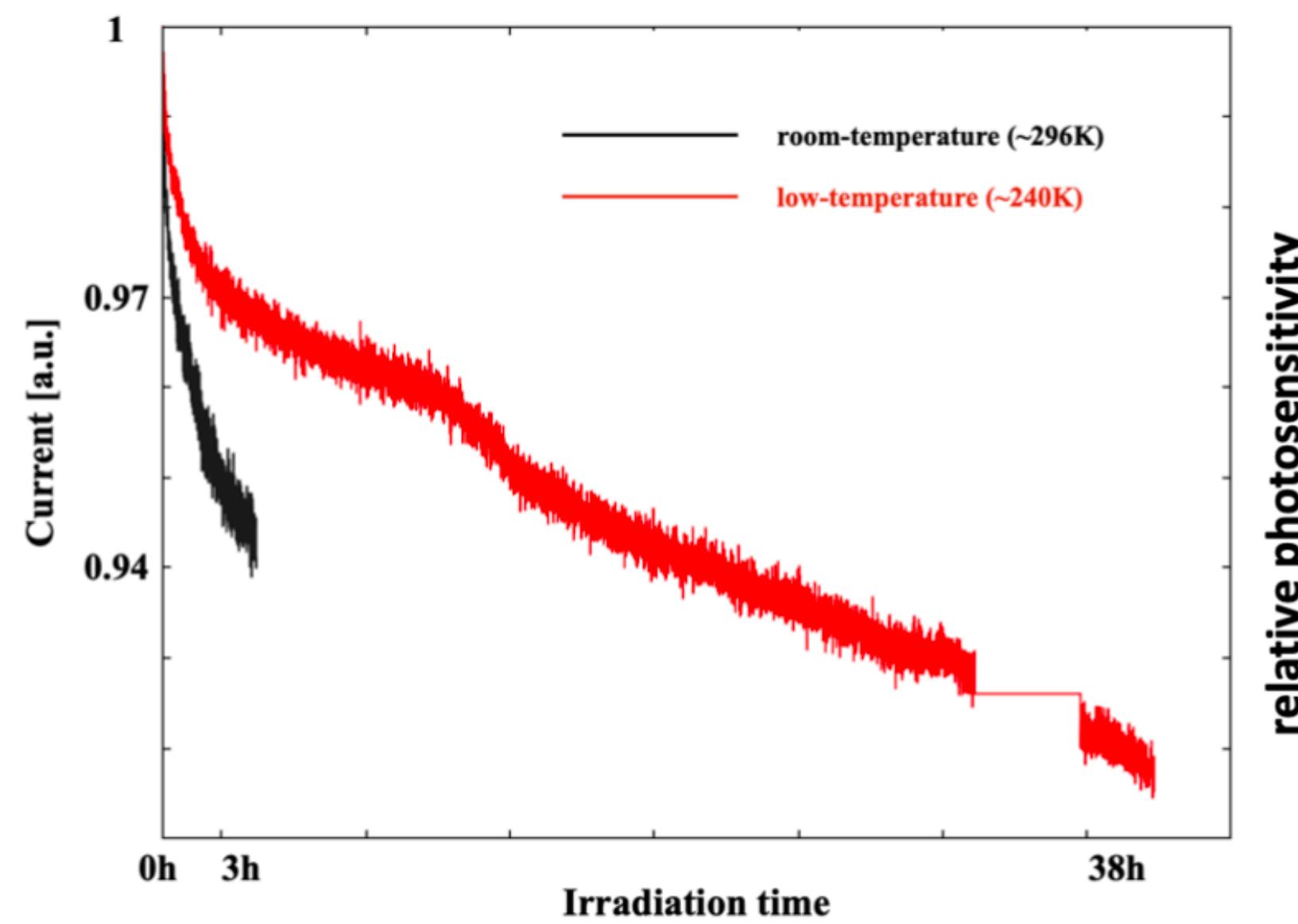
Relative Charge during Irradiation

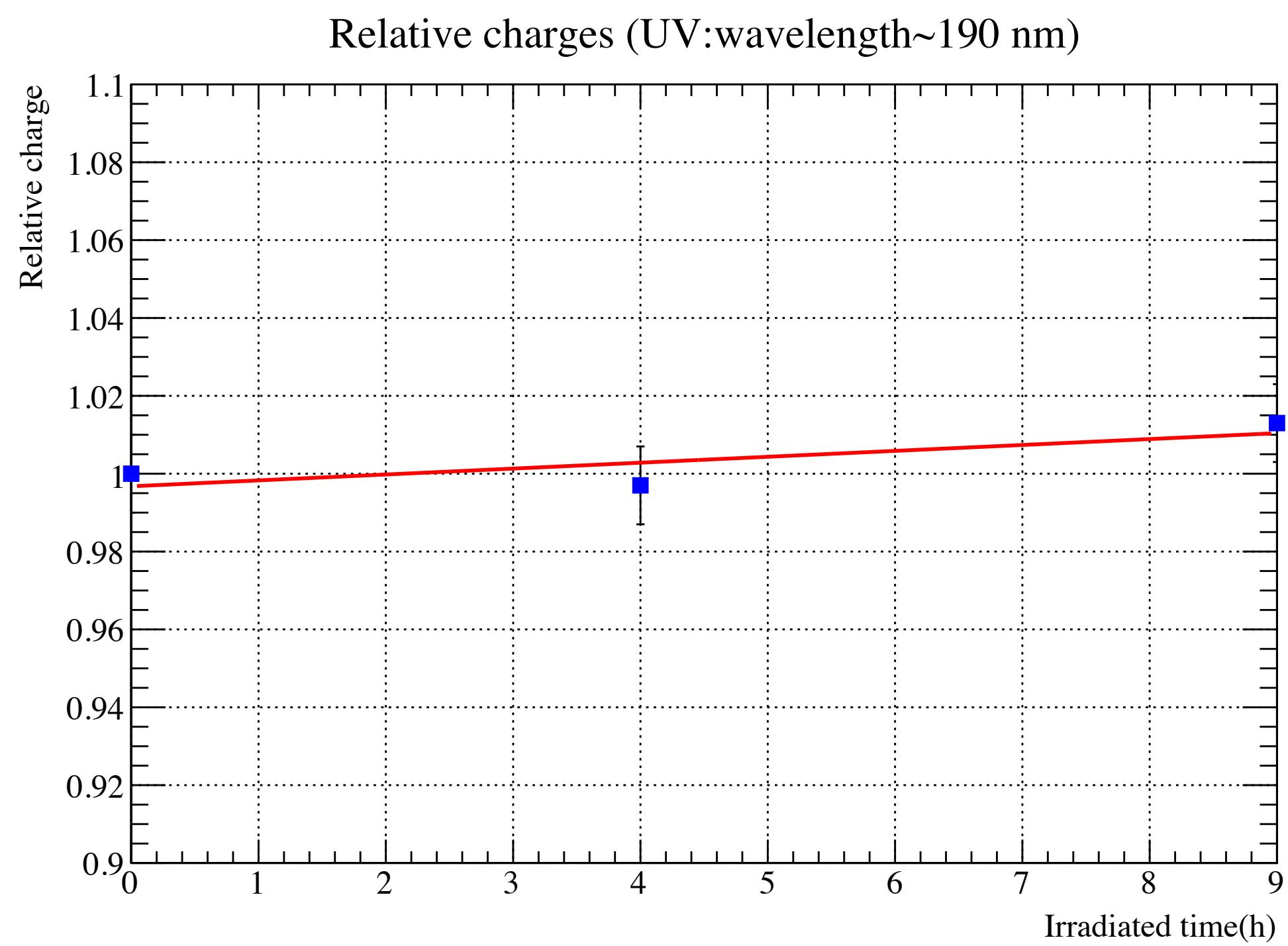
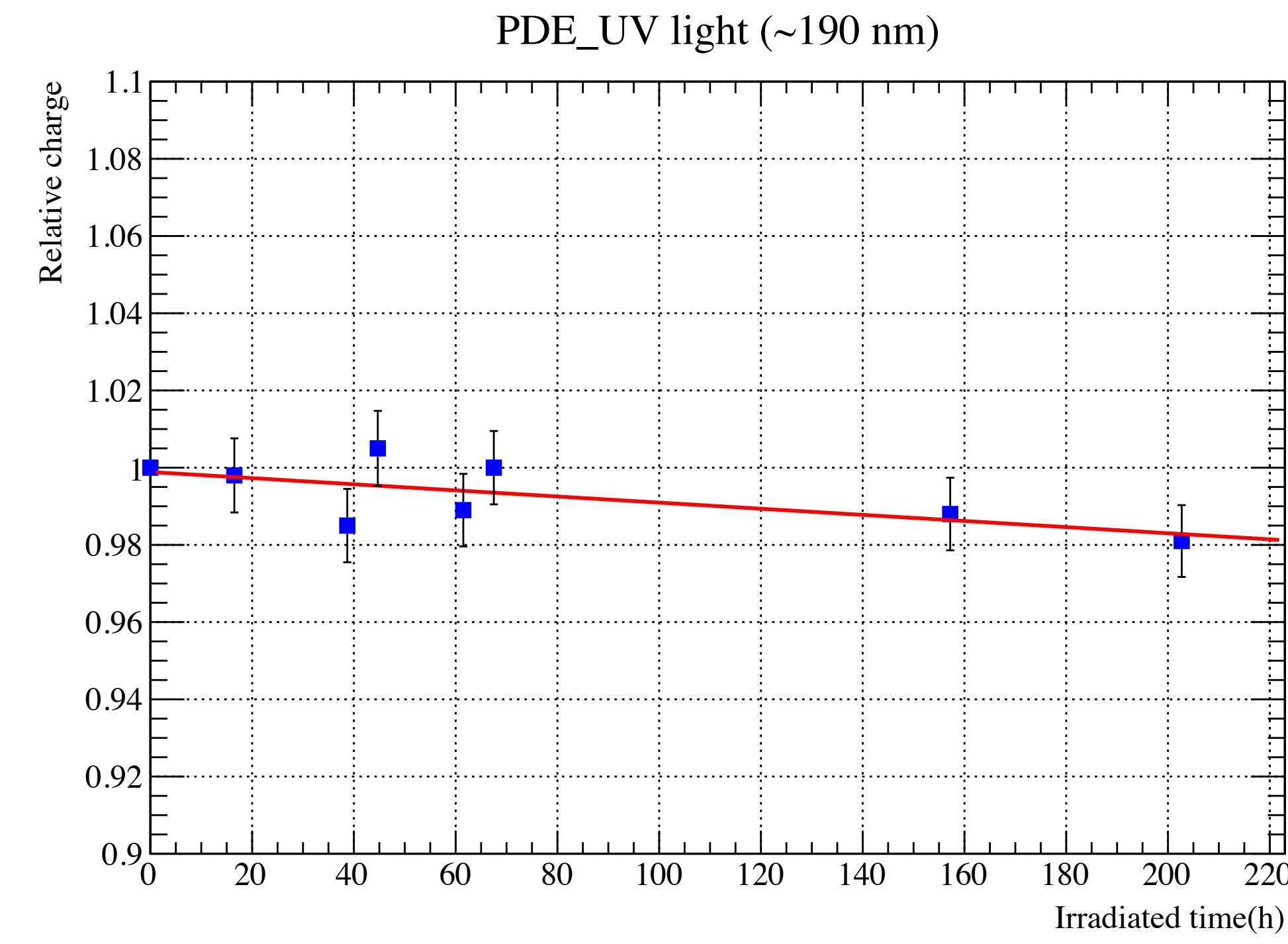


- The data in last 168 h was stable
- Signal charge for LED was not changed
- Dose level (in 168 h) : $\lambda = 175 \text{ nm}$
 - $N_{VUV} = 1.6 \times 10^{10} \text{ photon/mm}^2$
 - $= N_{2019,VUV} \times 0.31$
- In all chips, VUV-PDE decrease was not observed



Result (HV=0V)





history of PDE (no-annealed)

