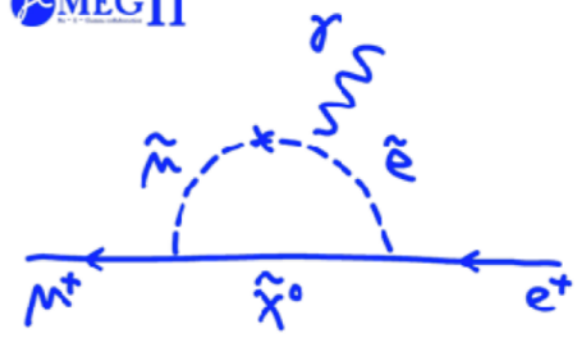




東京大学
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International Center for Elementary Particle Physics
The University of Tokyo

MEG II



MEG II実験：

液体キセノン検出器の2023年ランの運転状況

Sei Ban (ICEPP), for the MEG II collaboration
17th Sep. 2023, JPS 第78回年次大会 @東北大学

Introduction

Annealing result for 2023 run

LXe detector status and stability in 2023 run

Summary and prospects

Introduction

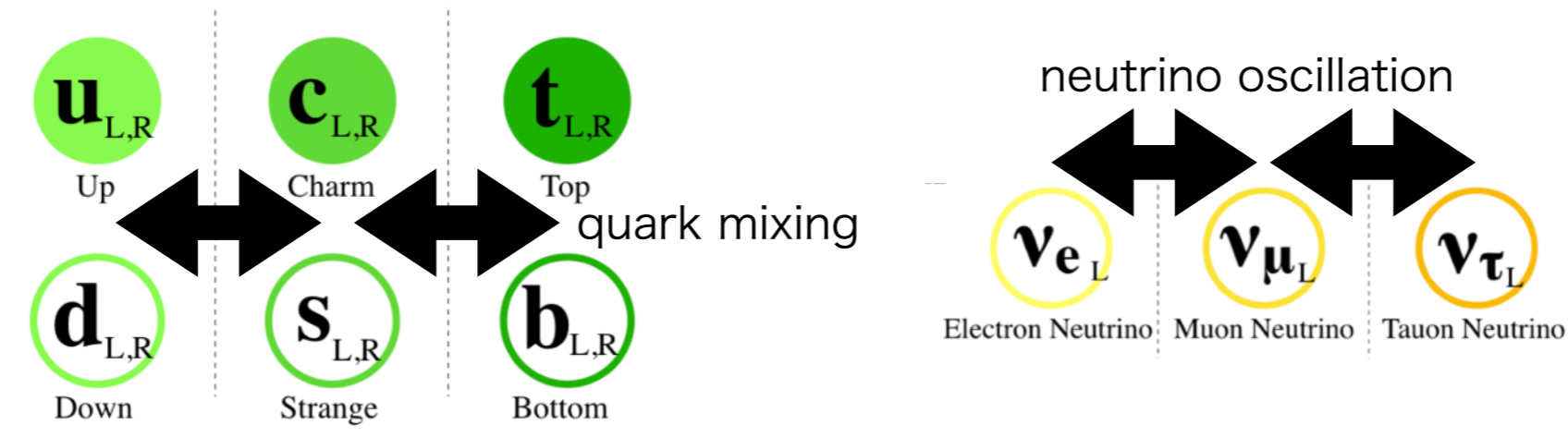
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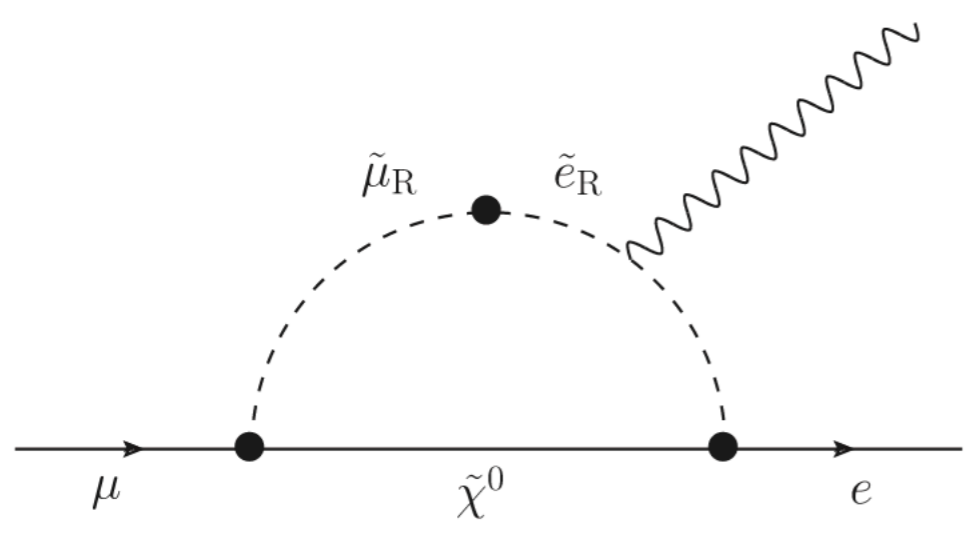
Charged Lepton Flavor Violation

- In quark and neutrino (neutral lepton) sector, the flavor violates in SM

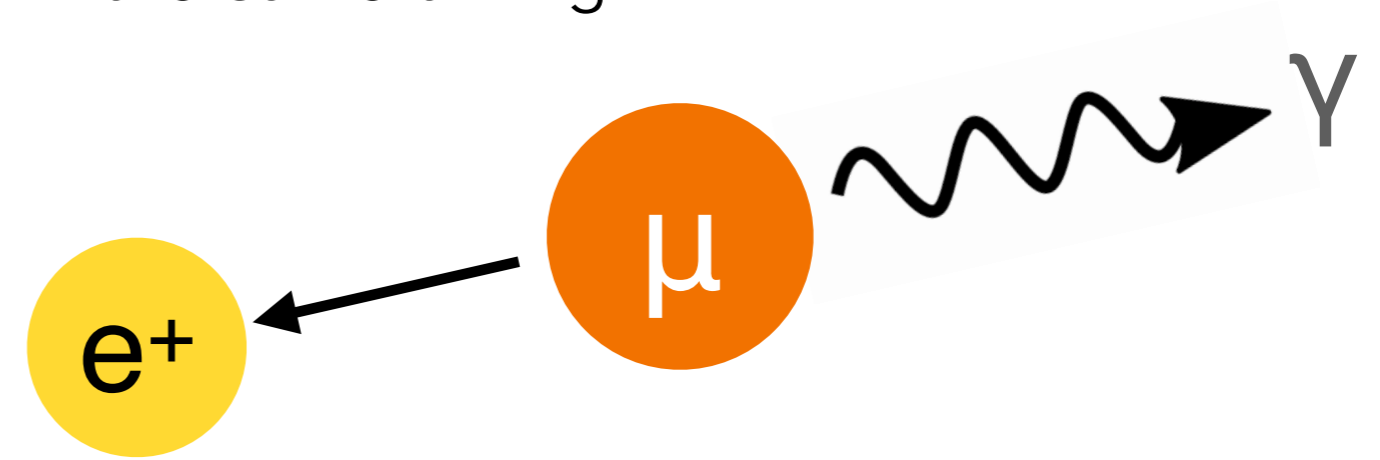


- Some theories BSM predict flavor violation in the charged lepton sector
 - In the Standard Model, it is practically prohibited : $Br(\mu \rightarrow e\gamma) = 10^{-54}$
 - In BSM, $Br(\mu \rightarrow e\gamma) \sim O(10^{-14})$ is predicted : large enough to search

- Signal : Gamma-ray and positron with 52.8 MeV ($=m_\mu/2$)
back-to-back
the same timing

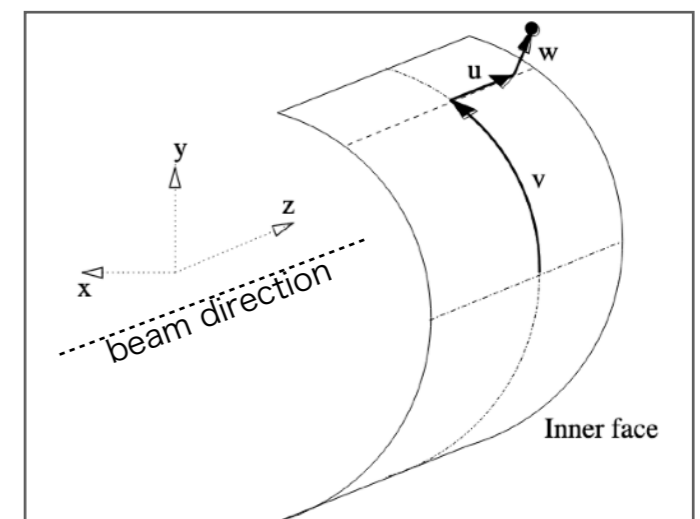
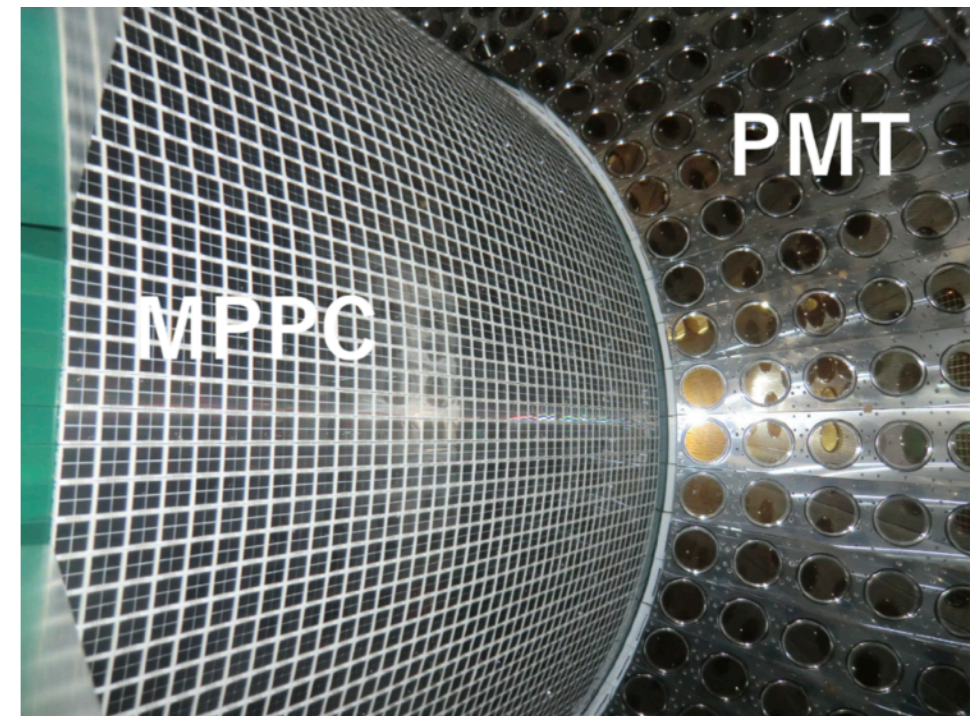
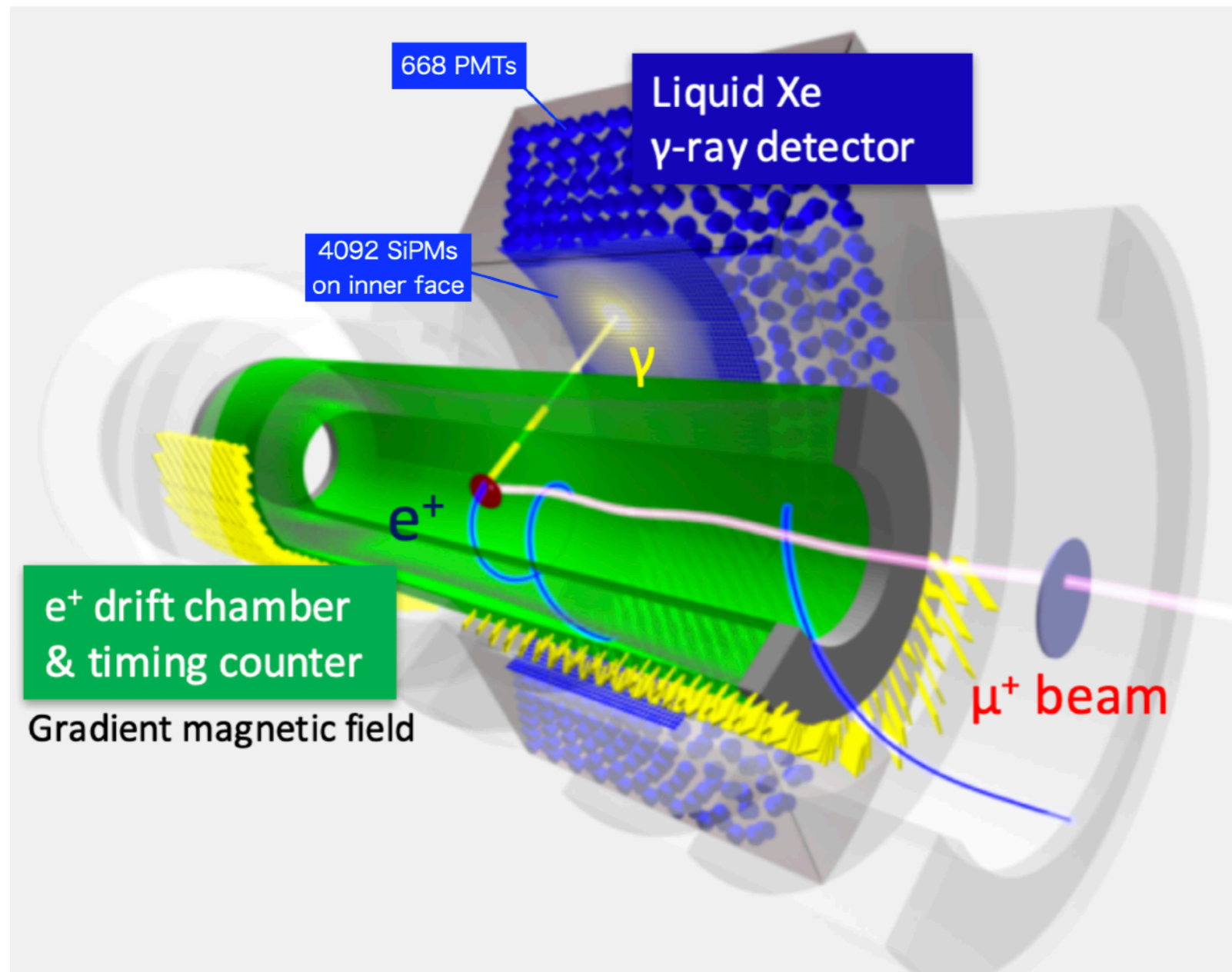


Possible diagram in SUSY-GUT senario



MEG II experiment, LXe detector

- MEG II experiment aims to search for charged lepton flavor violation : $\mu^+ \rightarrow e^+ \gamma$
 - with higher sensitivity by one order of magnitude compared to the MEG
- Consists of LXe detector for γ -ray, drift chamber & timing counter for e^+
 - LXe detector consists of 4092 MPPCs and 668 PMTs (both VUV-sensitive)
- Physics run started in 2021 (pilot run) -> full physics run in 2022, 2023



Introduction

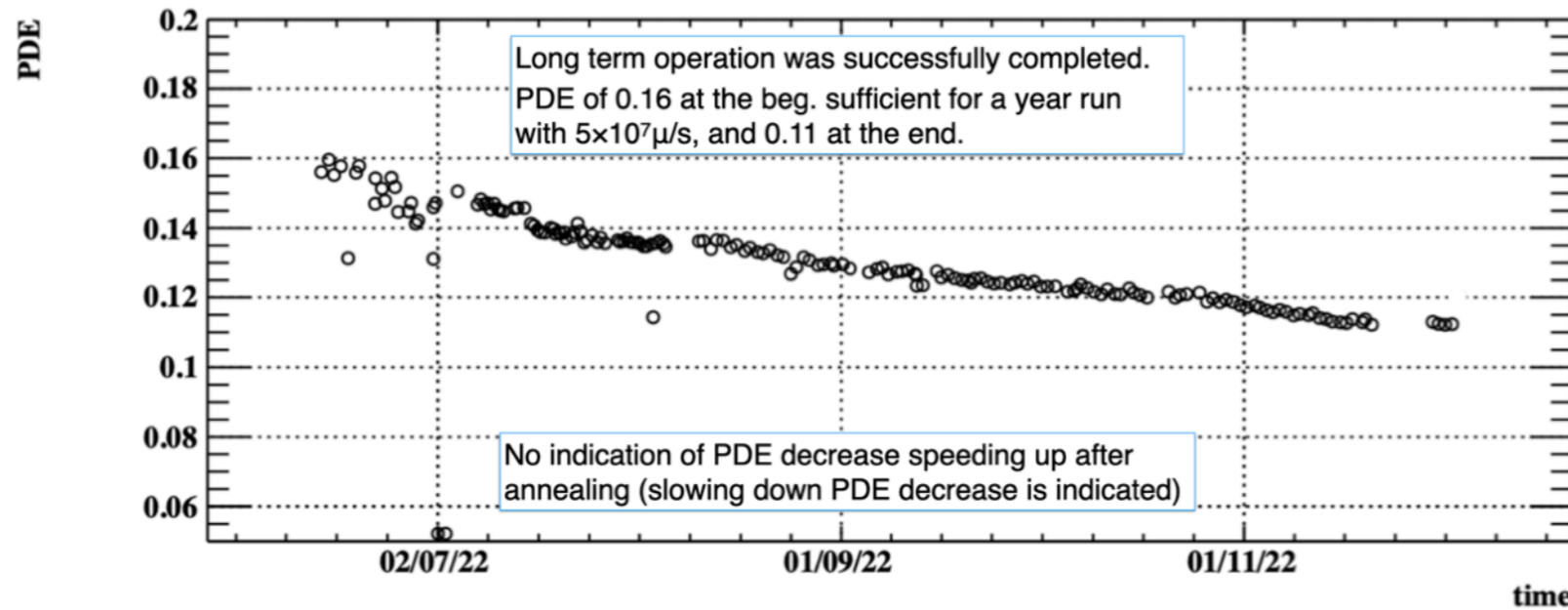
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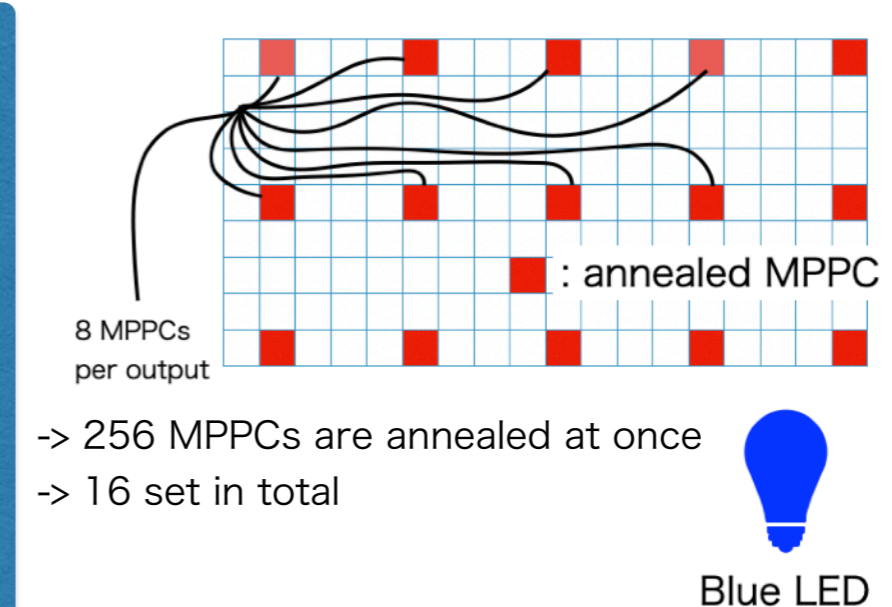
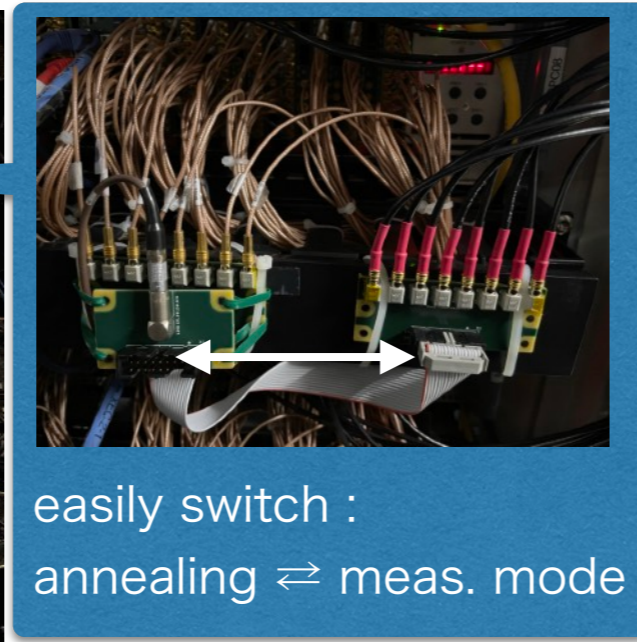
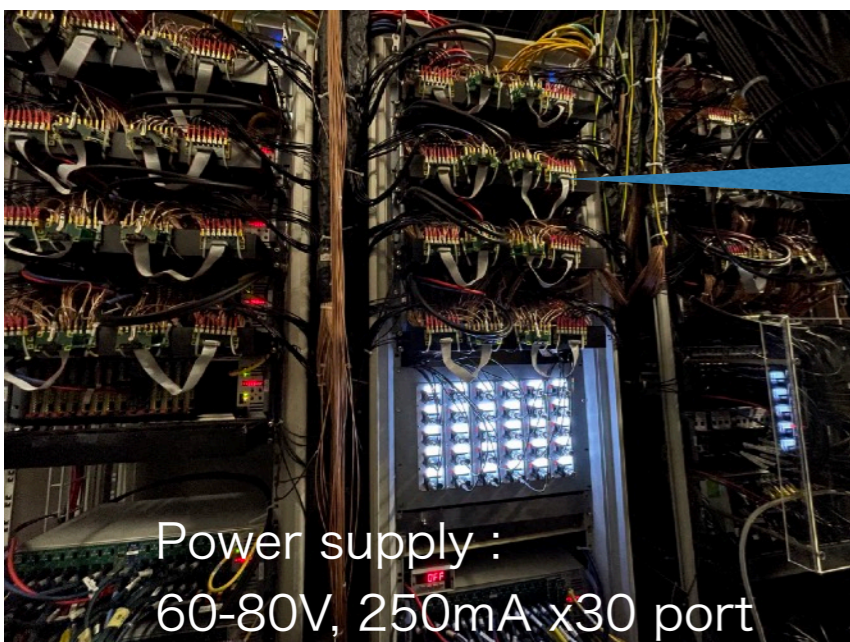
PDE decrease in 2022 run and Annealing 2023

- Averaged Photon Detection Efficiency (PDE) monitoring during 2022 run
 - It decreased gradually because of radiation damage (known problem)



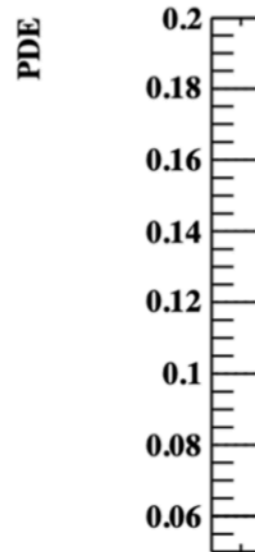
Rough calibration during run time (precise calib. is on going)

- Annealing of MPPCs by Joule heating to recover the PDE
 - $\sim 70V \times \sim 25mA = \sim 1.75W$ /MPPC \rightarrow 30h/MPPC annealing was done (Jan.-Mar.)
 - Monitoring by LED in intervals of annealing in a set : to see degree of recover



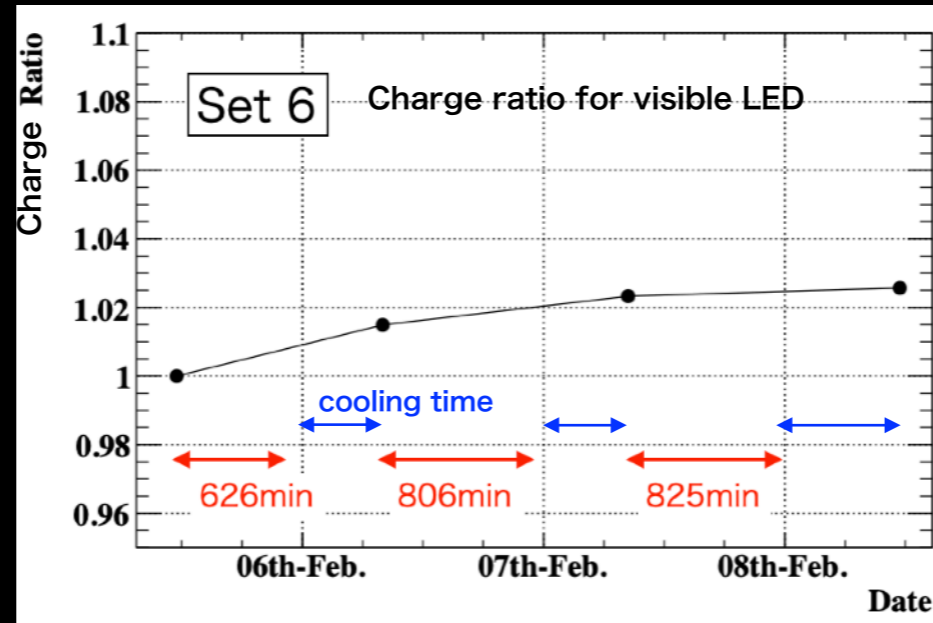
PDE decrease in 2022 run and Annealing 2023

- Averaged Photon Det
- It decreased gradu



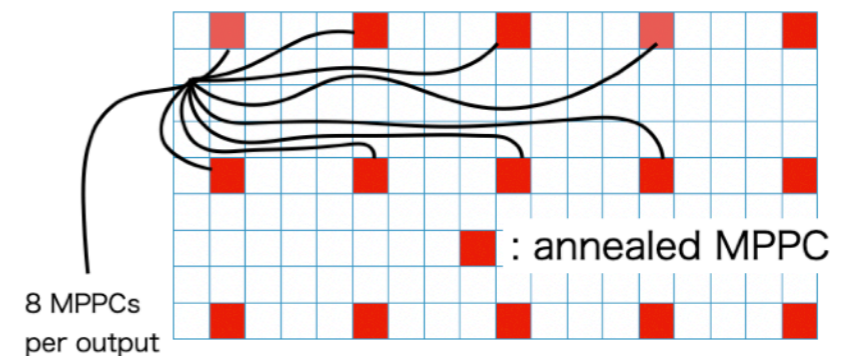
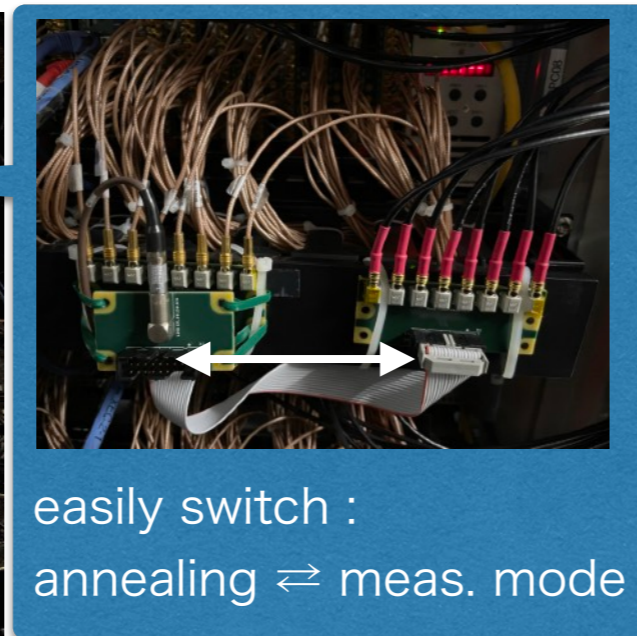
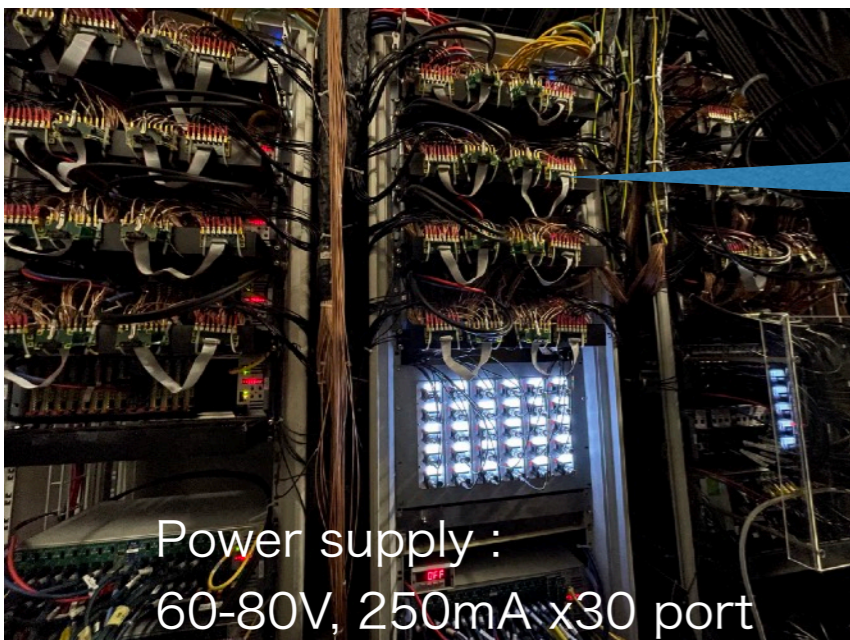
- Empirical relation :

- [Recovery ratio for VUV] = 10 * [Recovery ratio for visible]
- e.g. : (relatively) 5% recovery for visible light -> relatively 50% recovery for VUV



- Annealing of MPPCs

- ~70V x ~25mA = ~1.75W /MPPC -> 30h/MPPC annealing was done (Jan.-Mar.)
- Monitoring by LED in intervals of annealing in a set : to see degree of recover

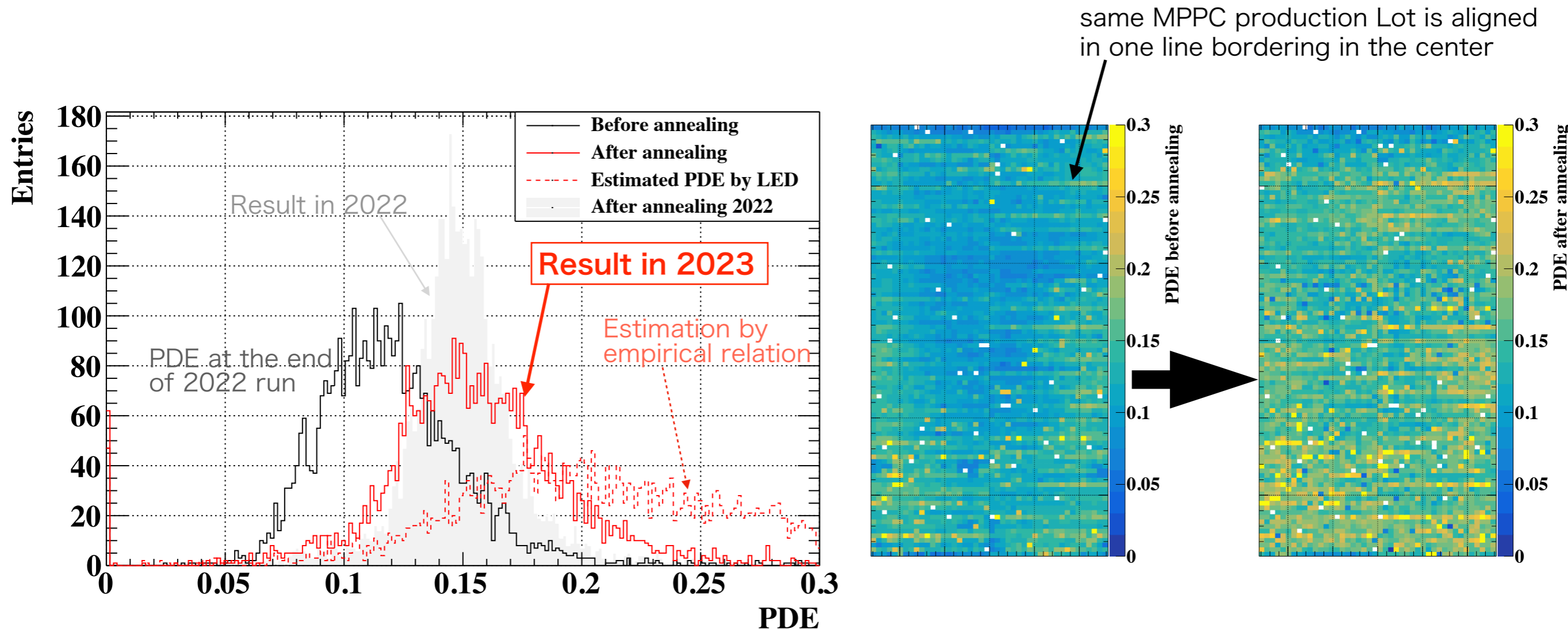


-> 256 MPPCs are annealed at once
-> 16 set in total



Annealing result at the beginning of 2023

- Annealing recovered MPPC PDE from ~11% (in avg.) to ~15% (in avg.)
 - Spread of PDE distribution became wider than 2022
 - Large discrepancy between result and estimation by visible LED
 - Causes are under investigation
 - PDE decrease and recovery seem to depend on production Lot strongly
 - At the top region, not significance recovery is observed
 - should be improved for the next annealing in 2024



Introduction

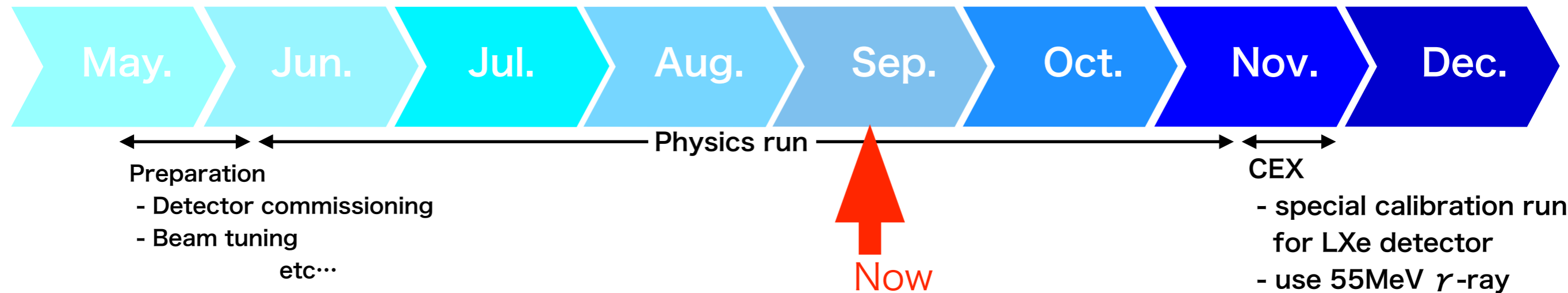
Annealing result for 2023 run

LXe detector status and stability in 2023 run

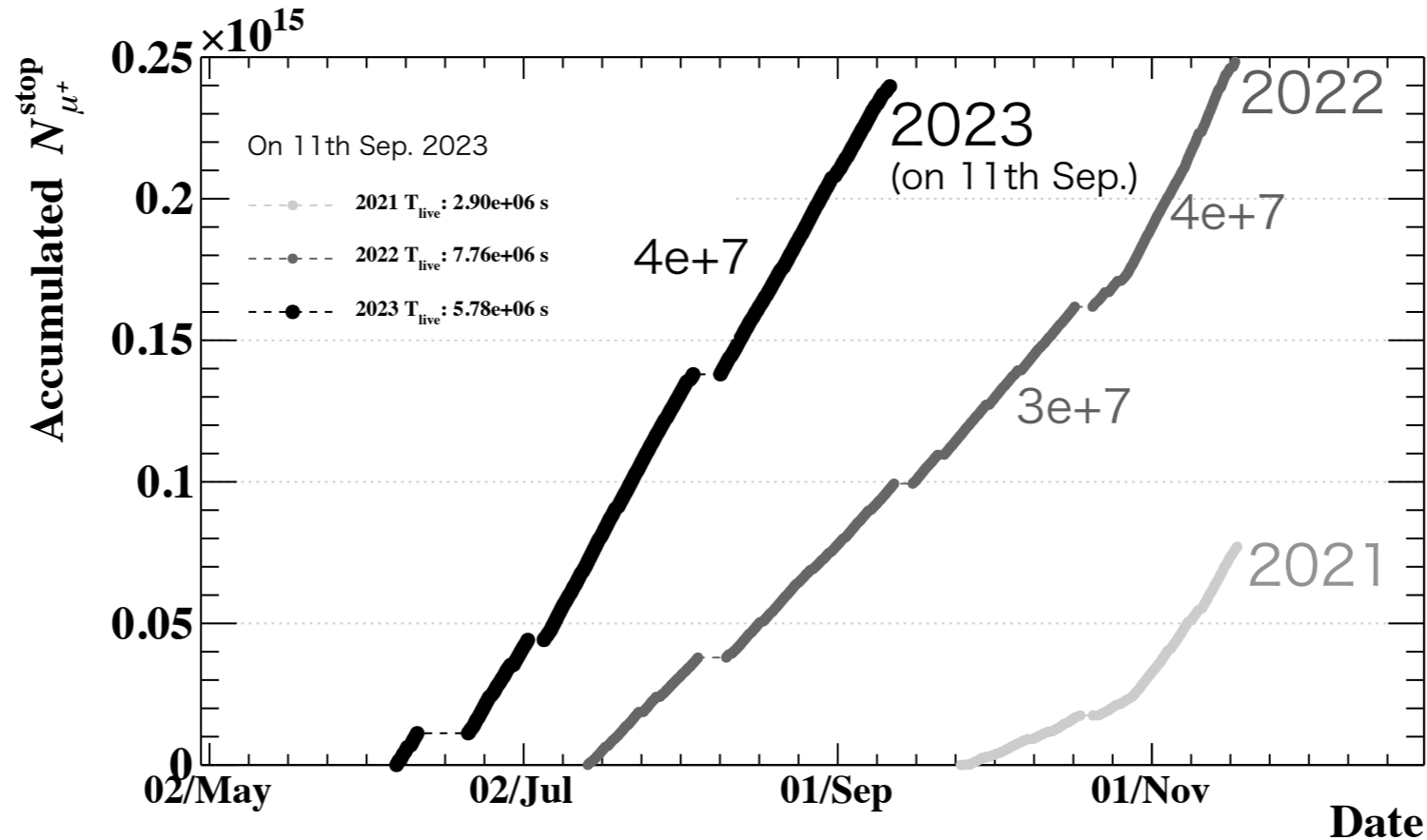
Summary and prospects

MEG II beam time in 2023

Assigned beam time : Middle of May. - End of Nov.

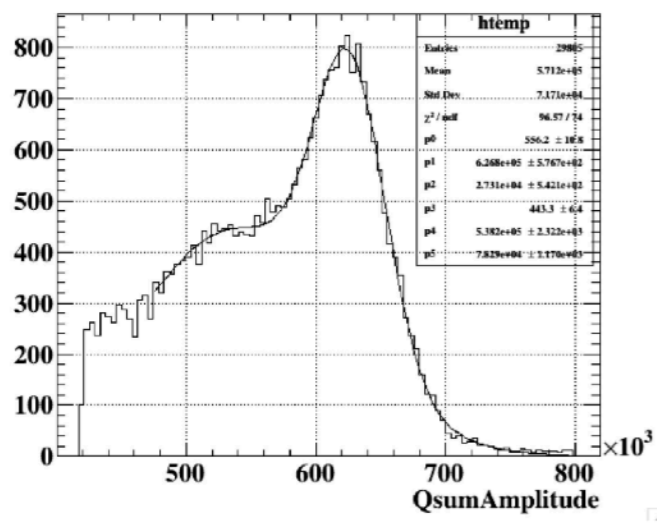


- Physics run started on 7th Jun. in 2023 with intensity of $\sim 4 \times 10^7 \mu/s$
- Almost reach same statistics with 2022 run -> further statistics is expected

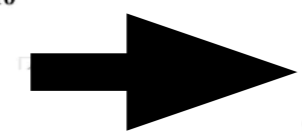
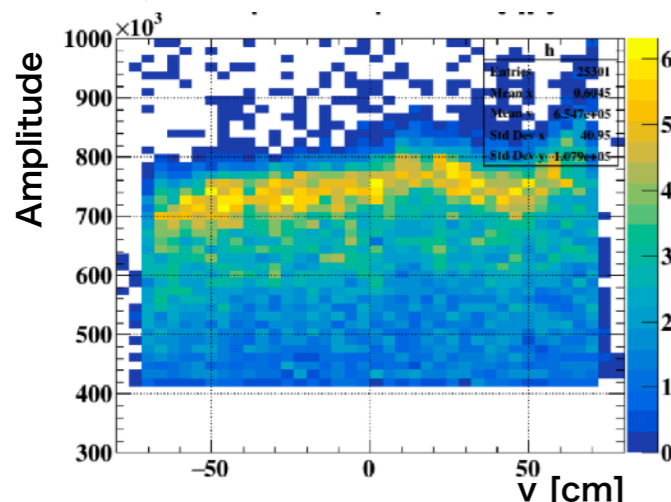
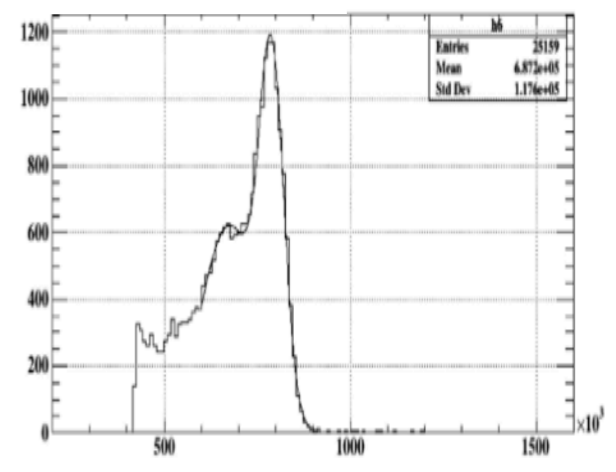
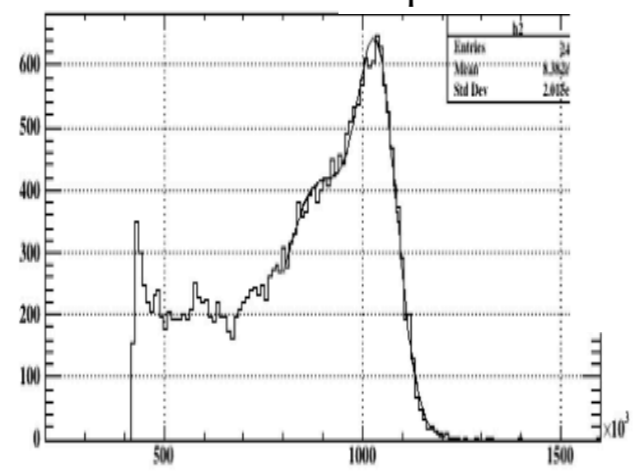


- Trigger rate was suppressed due to non-uniformity of LXe detector in 2022
 - threshold cannot be higher enough to reject BG without dropping signal
 - **Optimization of trigger weight sensor by sensor** is adopted to improve uniformity (since 2021)
 - crosstalk and after pulse of MPPC are also considered on trigger side since 2023 -> uniformity of online charge is much improved

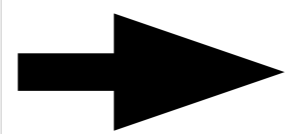
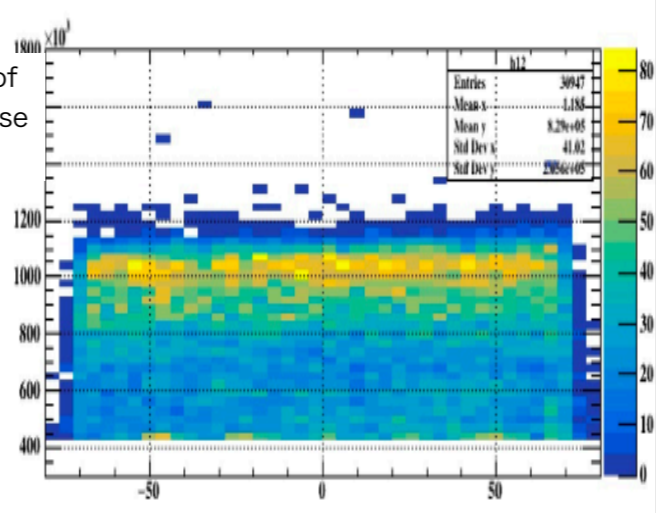
previous method



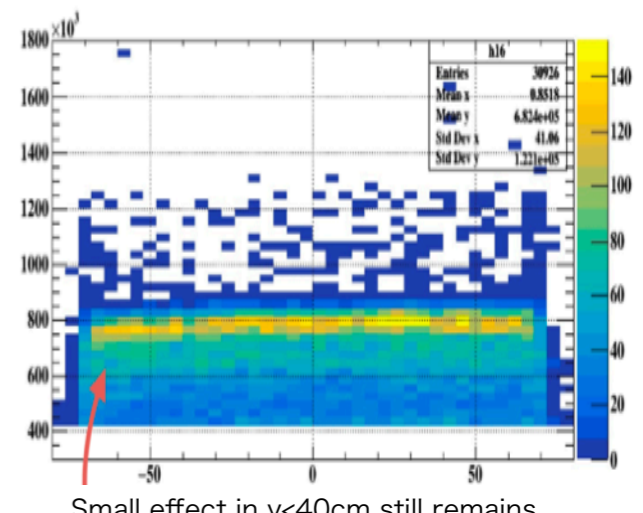
Improved method in 2023 run



Introduce the effect of Crosstalk & After pulse on online charge



Further tuning

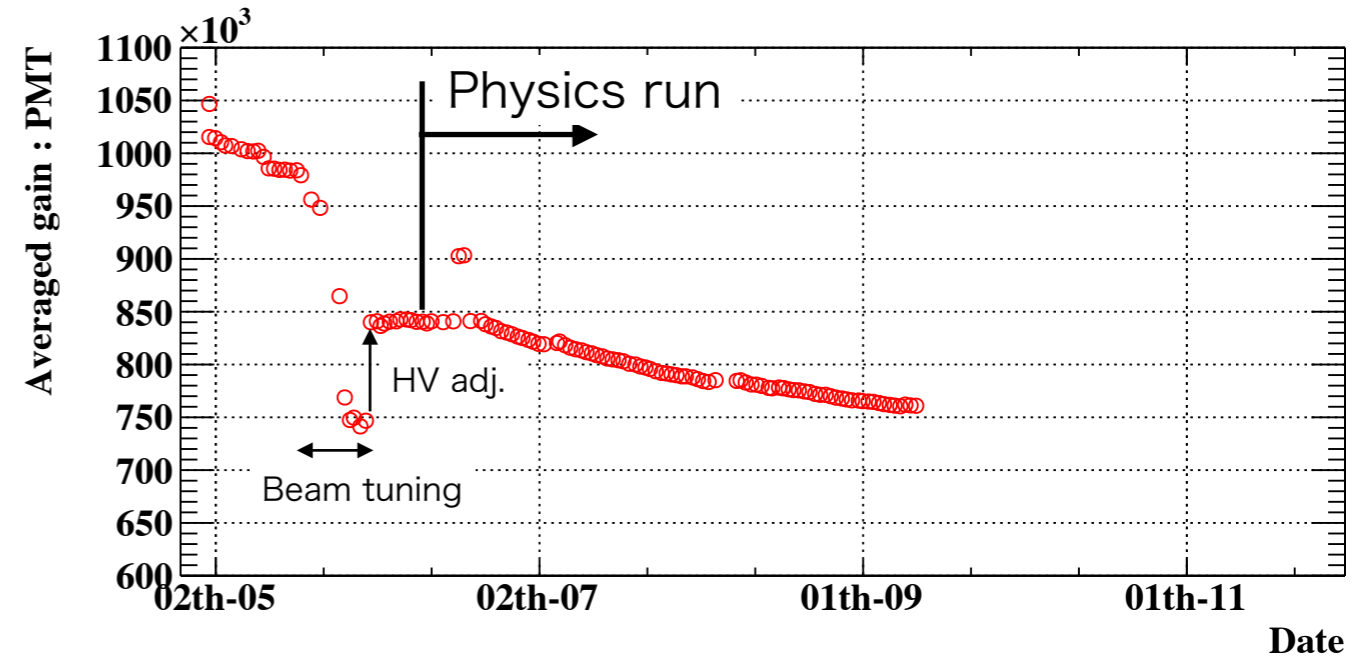


Small effect in v < 40cm still remains

- Sensor calibration (Gain, QE, PDE) for monitoring the LXe detector during run

- For PMT gain

- It decreases by irradiating beam
 - in particular at the beginning of beam time
 - In current situation, it will keep gain > 0.5M until the end of beam time
 - If gain < 0.5M, timing resolution will get worse

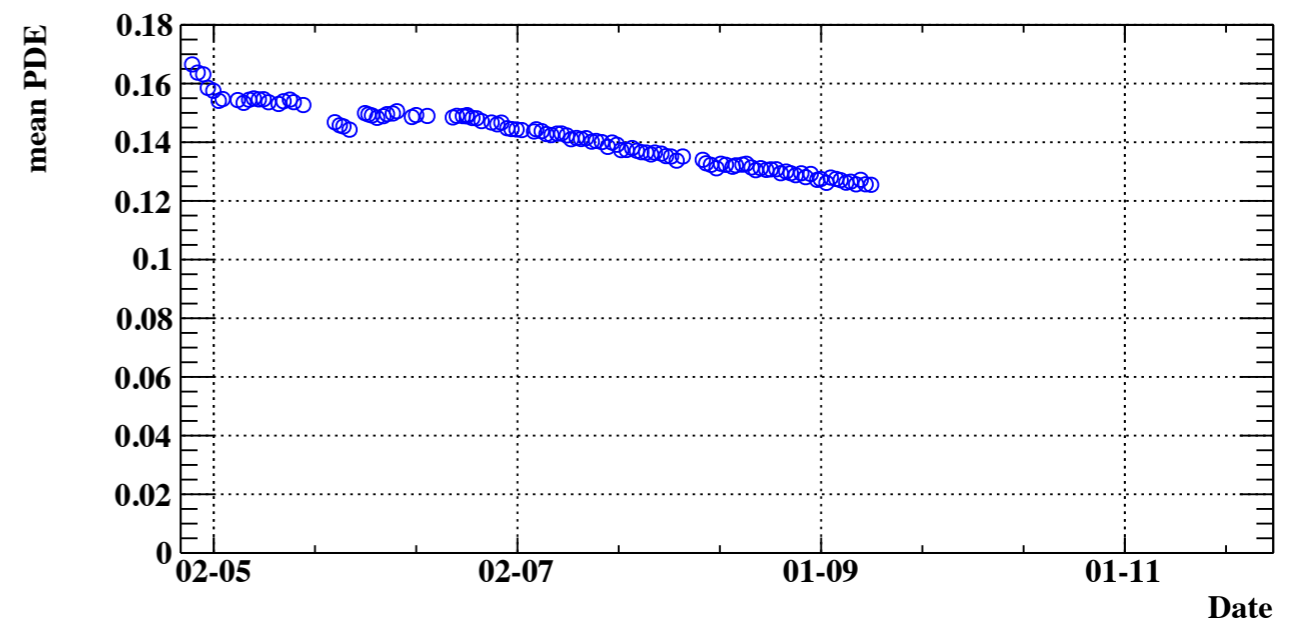
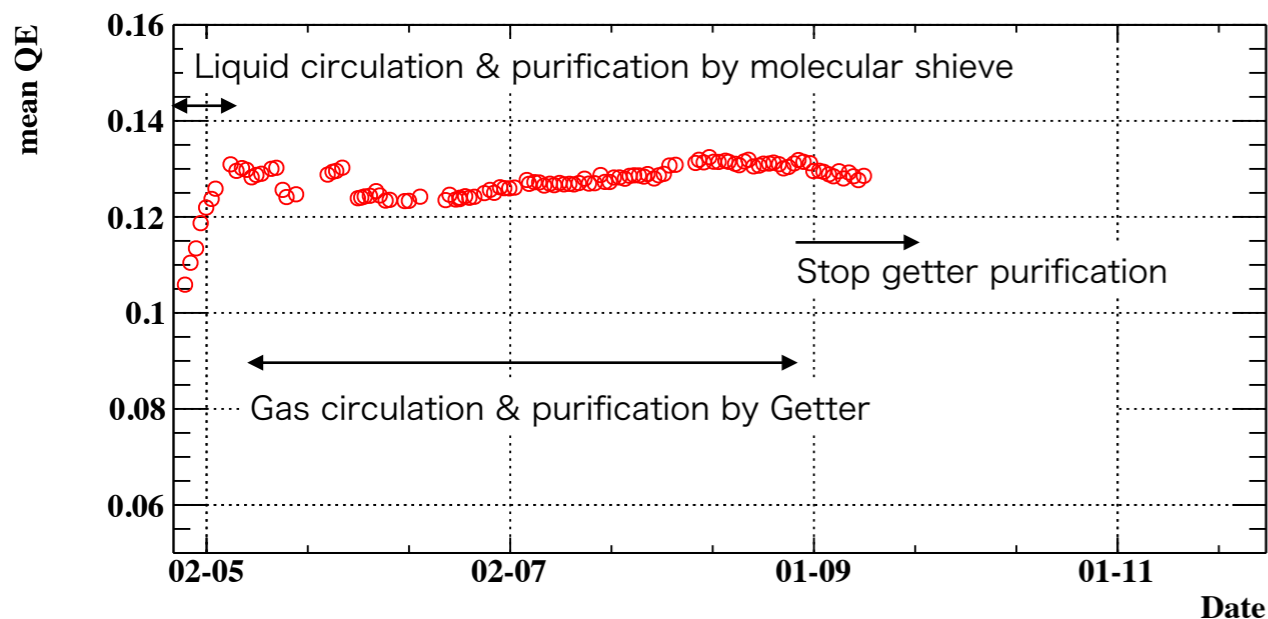


- For PMT Quantum Efficiency (QE)

- The calculation of QE is largely affected by purity of the LXe
 - PMT QE itself is expected to be constant
 - -> can be used as purity monitor of the LXe

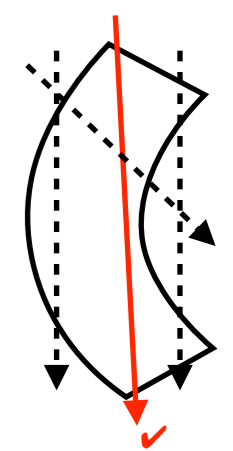
- For MPPC PDE

- The effect of purity variation is included
- It decreases by radiation damage
 - PDE > 4% is expected at the end of beam time
 - performance gets worse when PDE < 4%

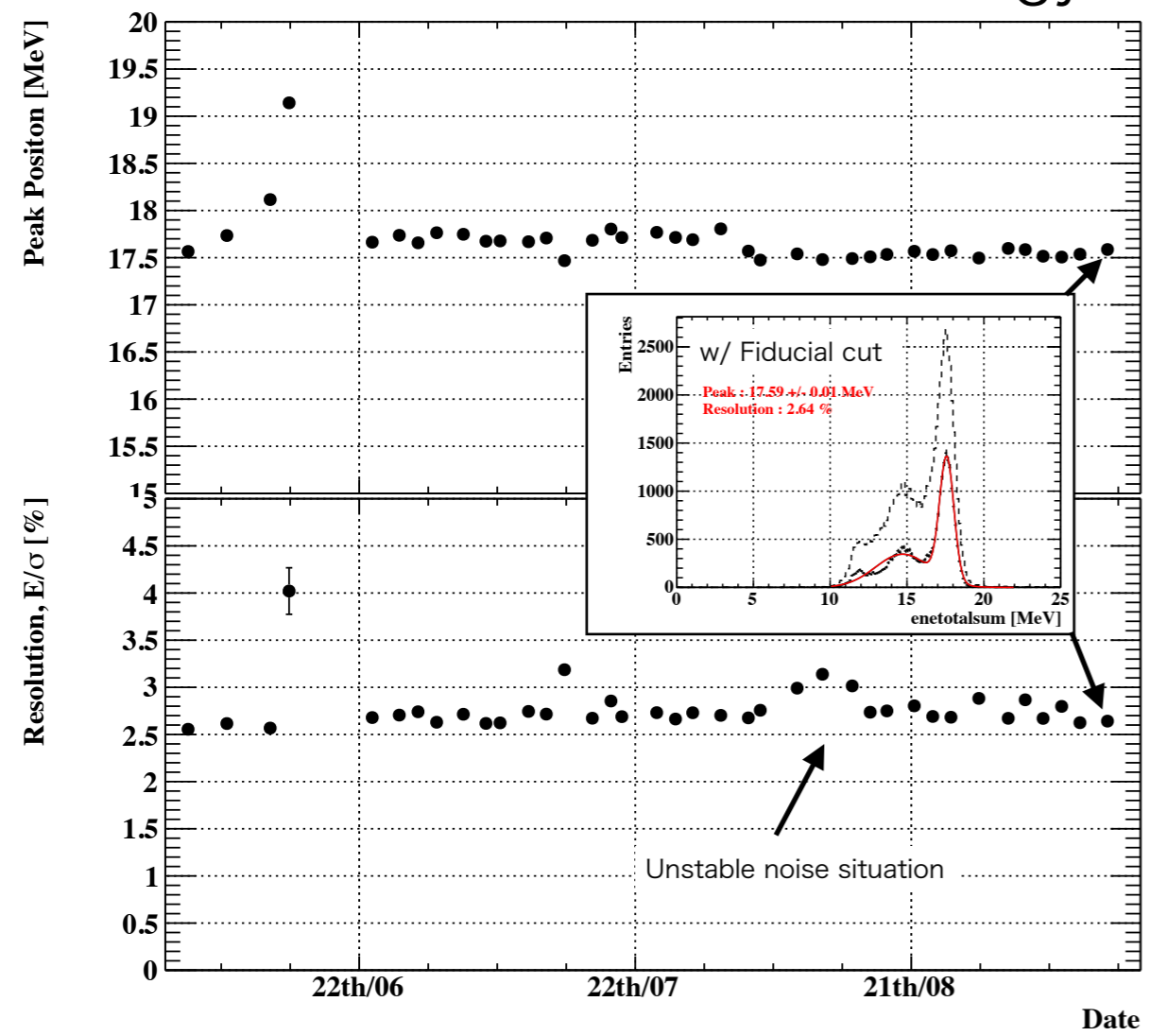


LXe detector status in 2023 run : Energy scale stability

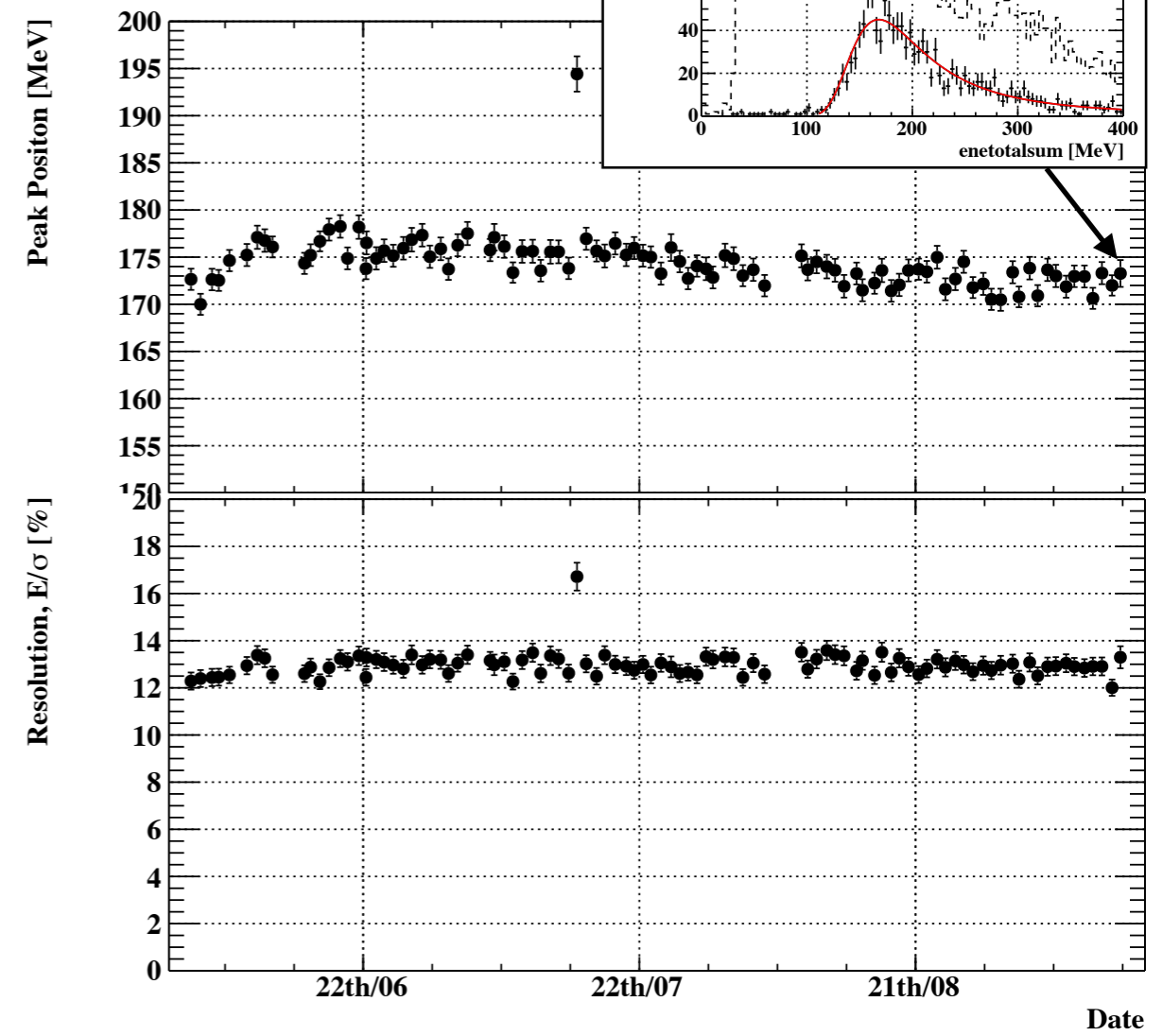
- Energy scale stability is monitored by some calibration source
 - Mono-energy gamma-ray (17.6 MeV, 9 MeV) : 3 times/week
 - Cosmic-ray : everyday
- Energy scale stability : ~1.7% for 17.6 MeV, ~5% for cosmic



- Li(p,γ)Be reaction : 17.6 MeV gamma-ray
 - used as standard of the energy scale



- Cosmic-ray



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Summary and prospects

- MEG II experiment searches for charged lepton flavor violation : $\mu^+ \rightarrow e^+ \gamma$
 - Physics run started since 2021
- Photon detection efficiency (PDE) recovery of MPPCs in the LXe detector by annealing was conducted in the beginning of 2023
 - Averaged PDE : ~10% -> ~15% after the annealing
- Detector status and stability in 2023 run
 - Trigger optimization to earn better uniformity
 - Sensor calibrations using LED and alpha-ray source
 - Energy scale and resolution stability
 - monitored by 17.6 MeV gamma-ray and cosmic-ray
 - The statistics (of physics run) almost reaches that in 2022 and further statistics can be expected by the end of this year's run time