$\mu^+ \to e^+\gamma$探索実験 MEG II Run 2022のまとめと今後の展望

Summary of Run 2022 of $\mu^+ \to e^+\gamma$ experiment MEG II and the prospects

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on behalf of MEG II collaboration

日本物理学会2023年春季大会

令和5年3月23日

23pT1-3

東京大学 THE UNIVERSITY OF TOKYO

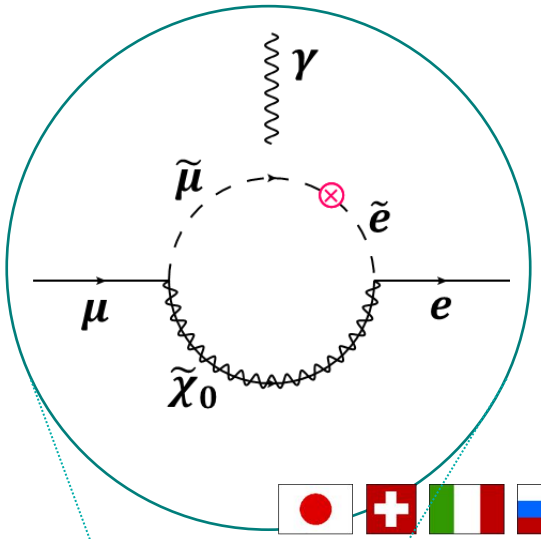
ICEPP The University of Tokyo

研究拠点形成事業 Core-to-Core Program

MEG II has started!

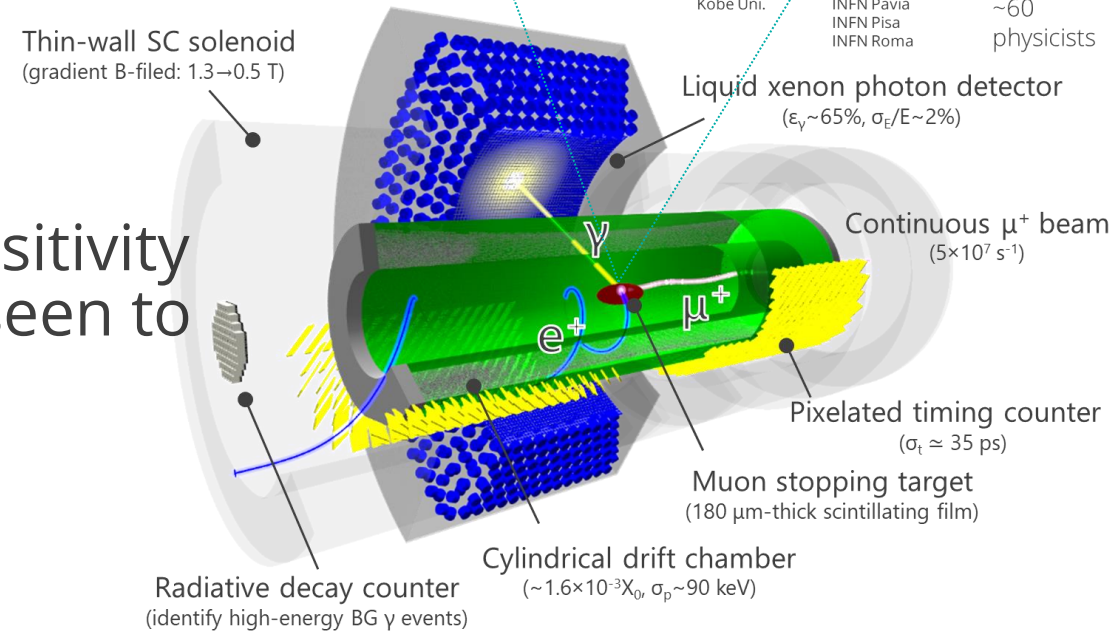
The pilot run in 2021demonstrated:

- Detector operates stably with sufficient resolutions,
- Electronics, trigger, and DAQ system work,
- Reconstruction algorithms are ready,
- Physics analysis ongoing.



UTokyo, KEK, Kobe Uni. | PSI, ETHZ | INFN Genoa, INFN Lecce, INFN Pavia, INFN Pisa, INFN Roma | BINP, JINR | UC Irvine

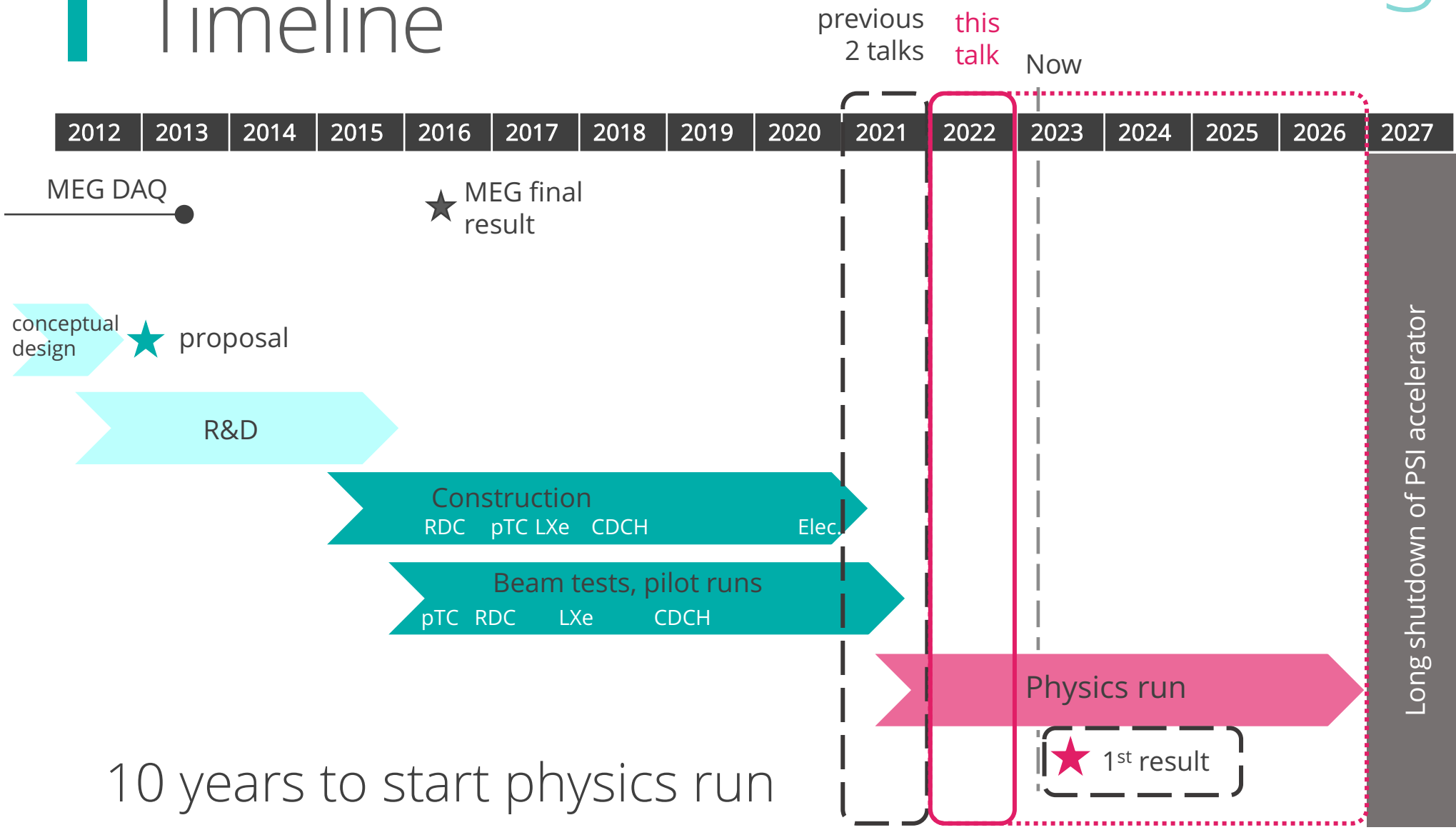
~60 physicists



First physics result with sensitivity comparable to MEG is foreseen to be published this summer

with <10% of data aimed

Timeline

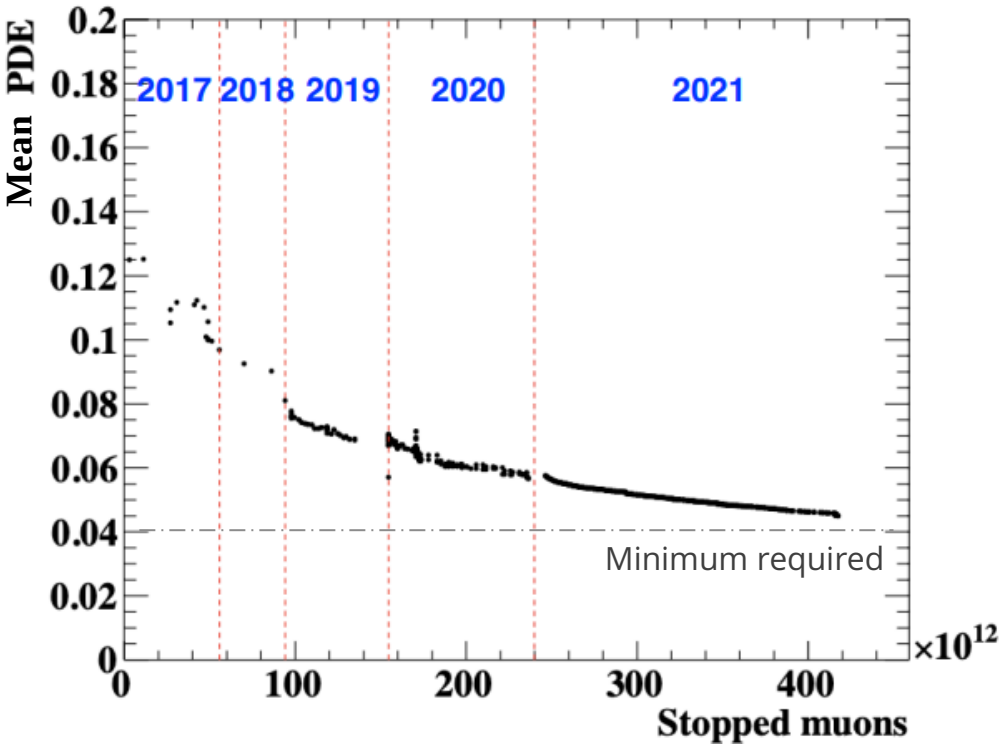


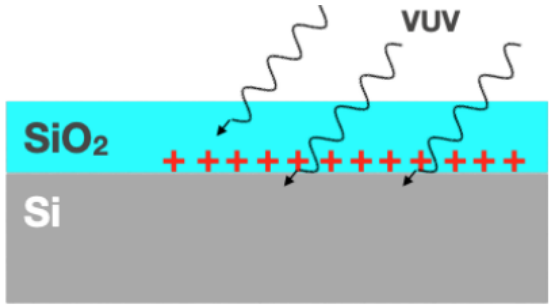
10 years to start physics run

What we need next

- Improve resolutions 23aT3-2,6,7
- Improve reconstruction efficiencies
- Reduce backgrounds 23pT2-5,6,7
- Reduce systematic uncertainties
- **Collect data as much as possible**

For long stable run: LXe detector





Surface damage
(hole buildup)

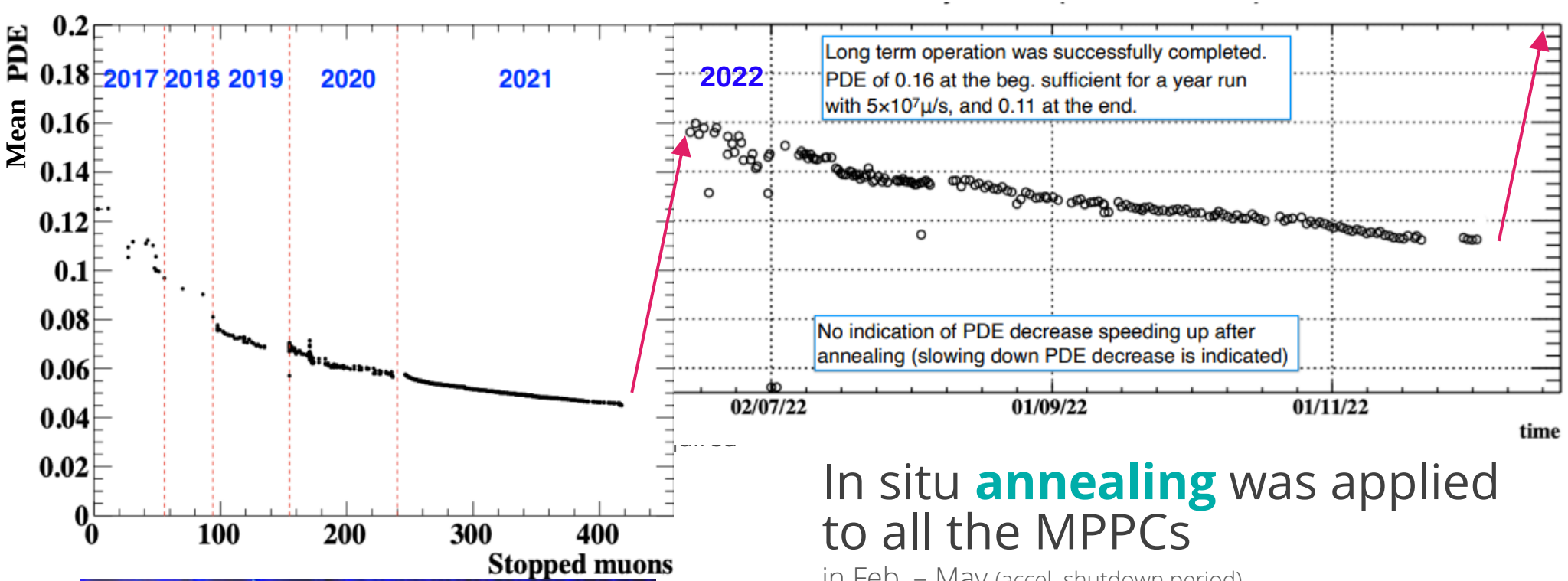
MPPC PDE for VUV light decreases with beam use

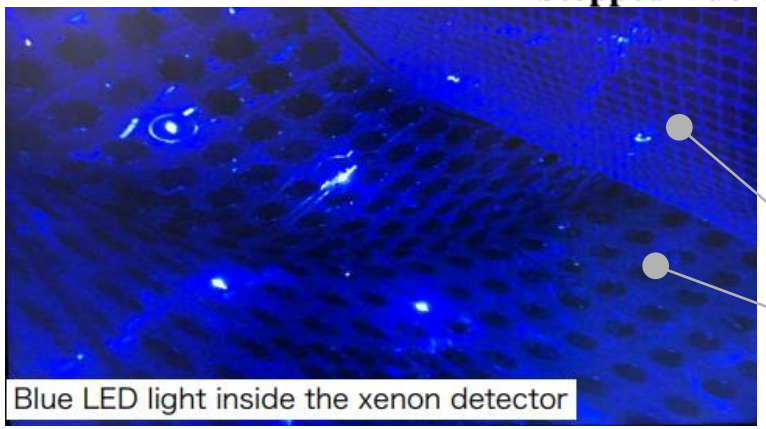
Critical problem

Must recover to >12%

to start 2022 run and to run for ~6 months

For long stable run: LXe detector





In situ **annealing** was applied to all the MPPCs

in Feb. – May (accel. shutdown period)
using Joule heat induced by MPPC current
S. Ban *et al.*, JPS 2022 autumn 7aA441-3

Safe and effective method was established.

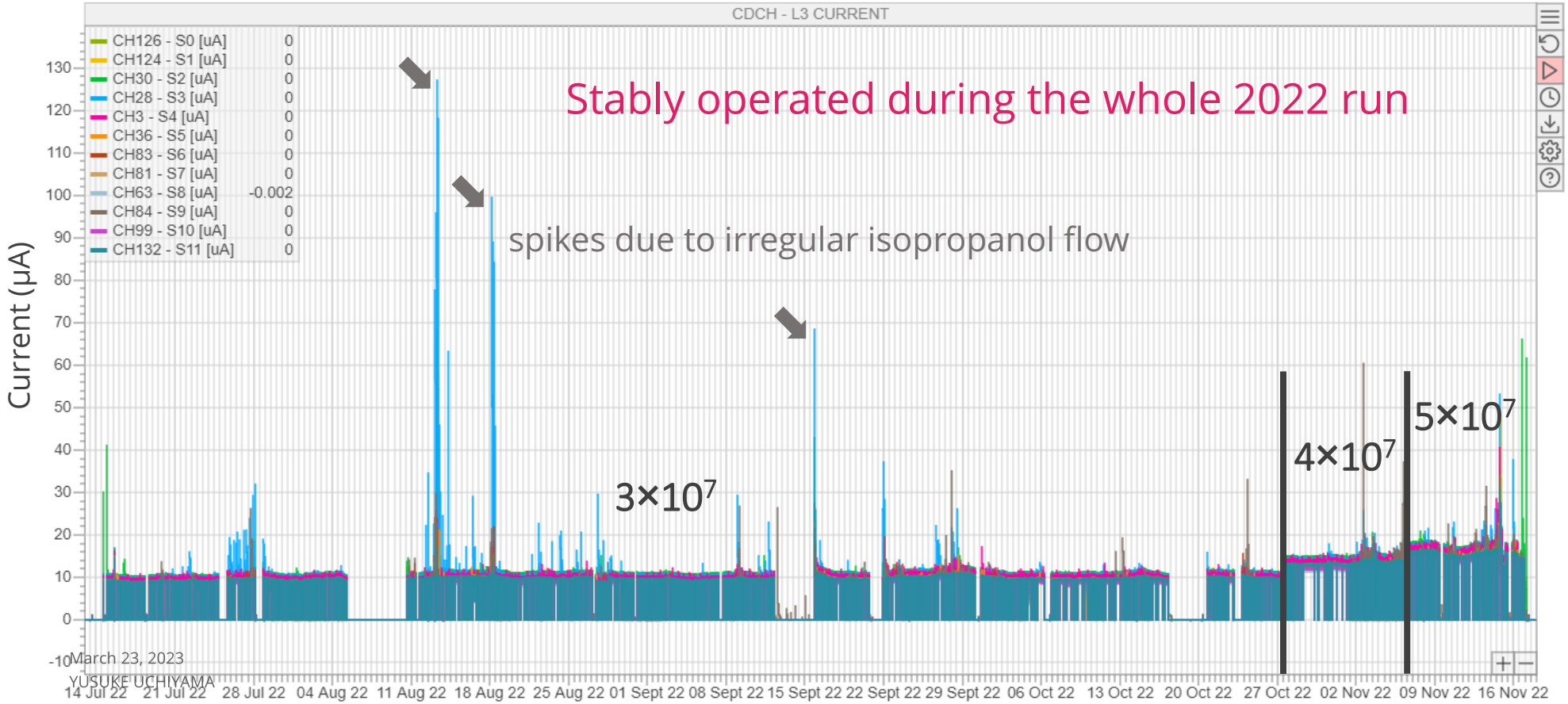
Annealing towards 2023 was already completed in more efficient way (Feb. – Mar.).

See 23aT3-7

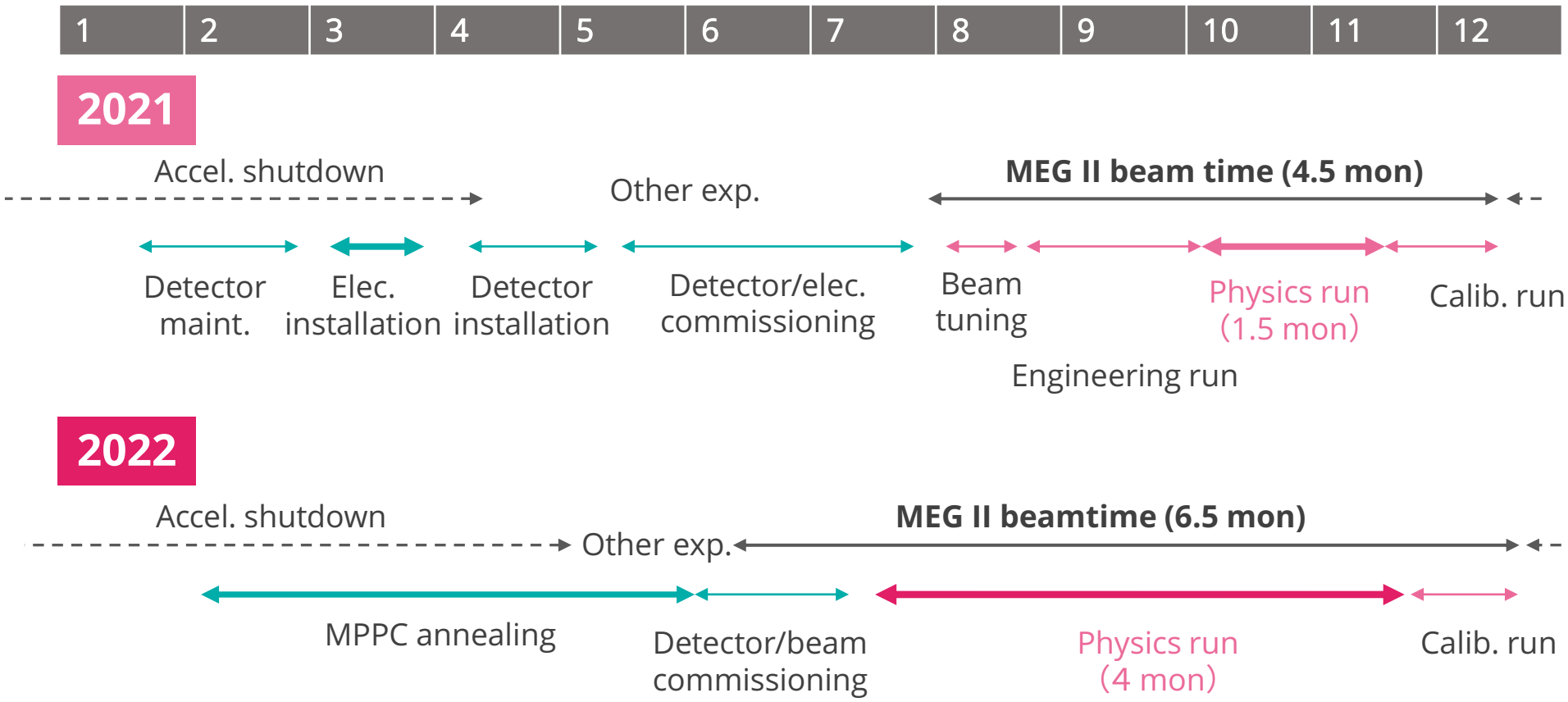
For long stable run: e^+ spectrometer

Minimum maintenance to start 2022 run smoothly

- No wire has broken since 2020. → Did not open chamber.
- Did not extract detectors from beamline. Also, for this year.
- No need of conditioning with optimized gas mixture (He:IsoB (90:10) + 1.5% isopropanol + 0.5% O_2)



Beam time



First long production run

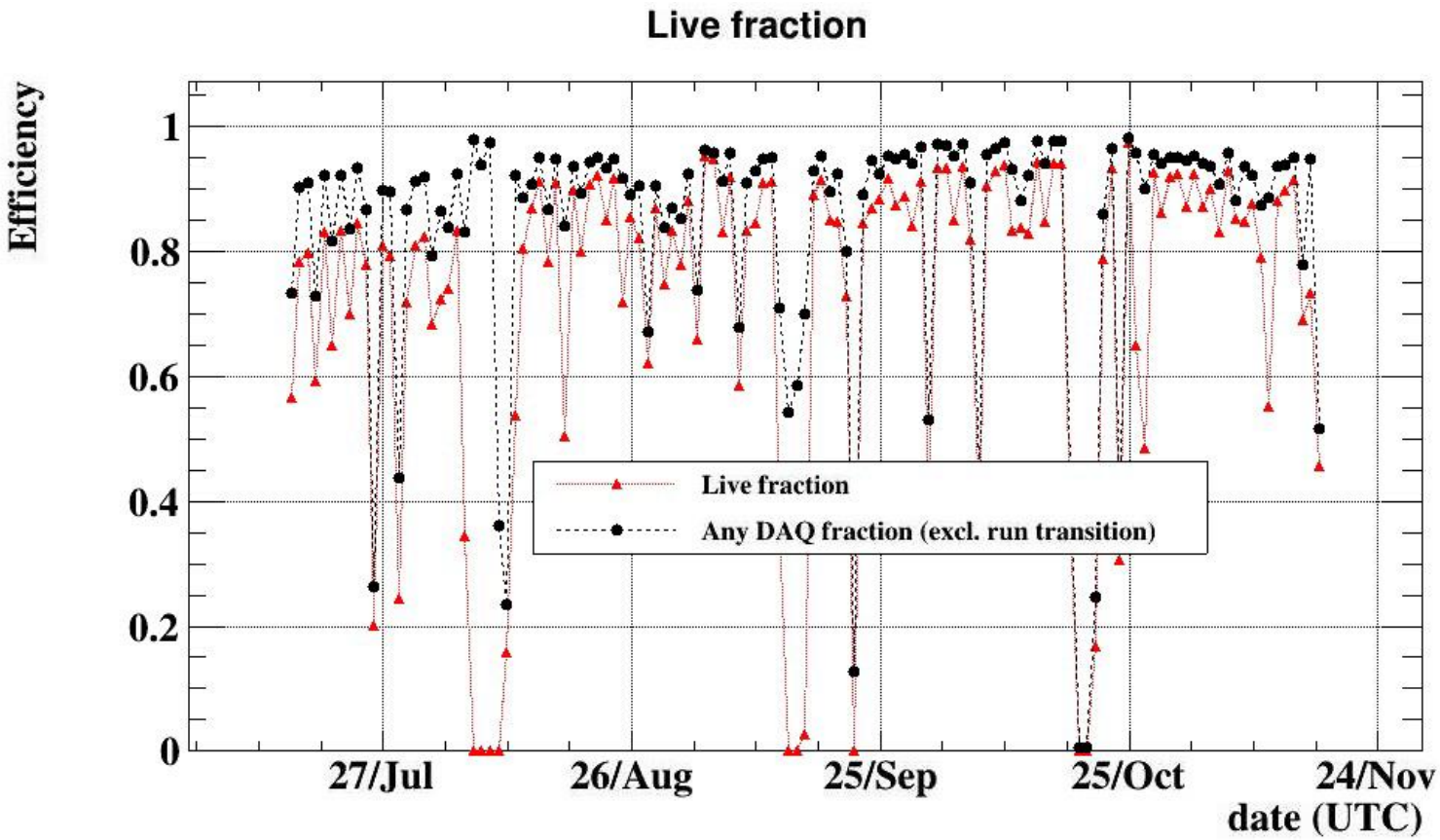
Essential to collect as much data as possible

Improving run efficiency

Optimizing run scheme Physics run vs. calib. run

Periodical calibration is indispensable for long run.
At the beg. dead time due to LXe calib was ~10%.
At the end, it is <5%, by reducing length and frequency of calibrations

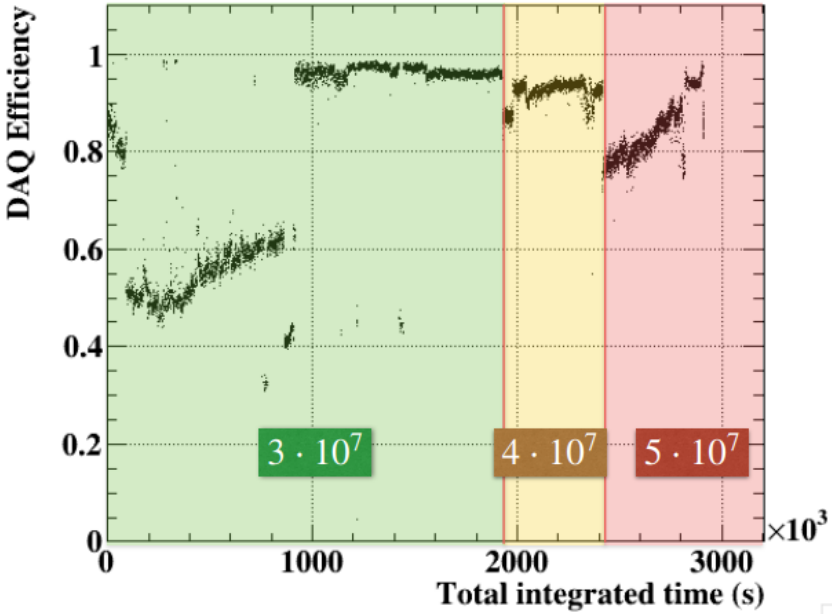
Other dead time (~5%)
- Beam down
- Human error
- Run transition



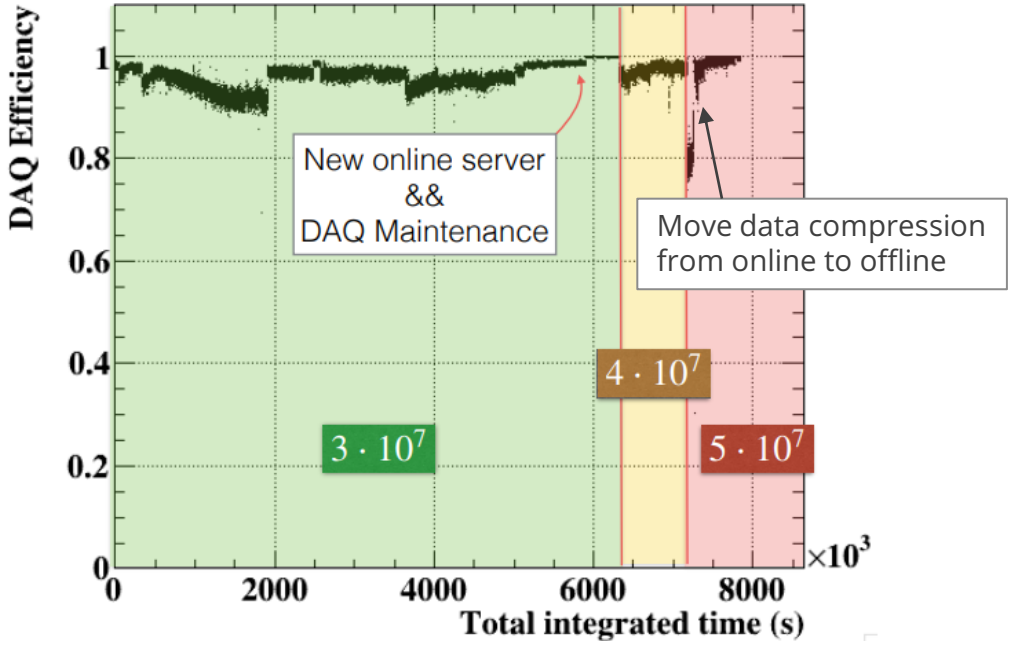
Improving DAQ efficiency

DAQ efficiency: $\epsilon_{DAQ} = \frac{N_{events}}{N_{Triggers}}$

Run 2021



Run 2022



DAQ capability improved from 65 MB/s to 180 MB/s

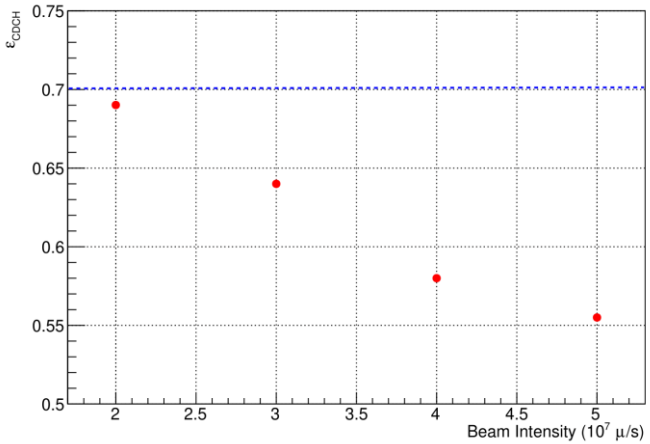
- New DAQ machine & tuning of DAQ system
- Still too high trigger rate causes inefficiency in DAQ. Trigger rate $\propto$ (beam intensity)^2.
- More effort on trigger logic is necessary for higher beam,
  limited in 2022 by LXe energy scale non-uniformity (online calibration).

Beam intensity

Must be chosen to optimize sensitivity considering many factors:

- Capability & ageing of detectors
- Trigger rate & data size
- Reconstruction efficiency with pileup
- Background level $\propto (R_\mu)^2$
- Statistics

e^+ tracking efficiency



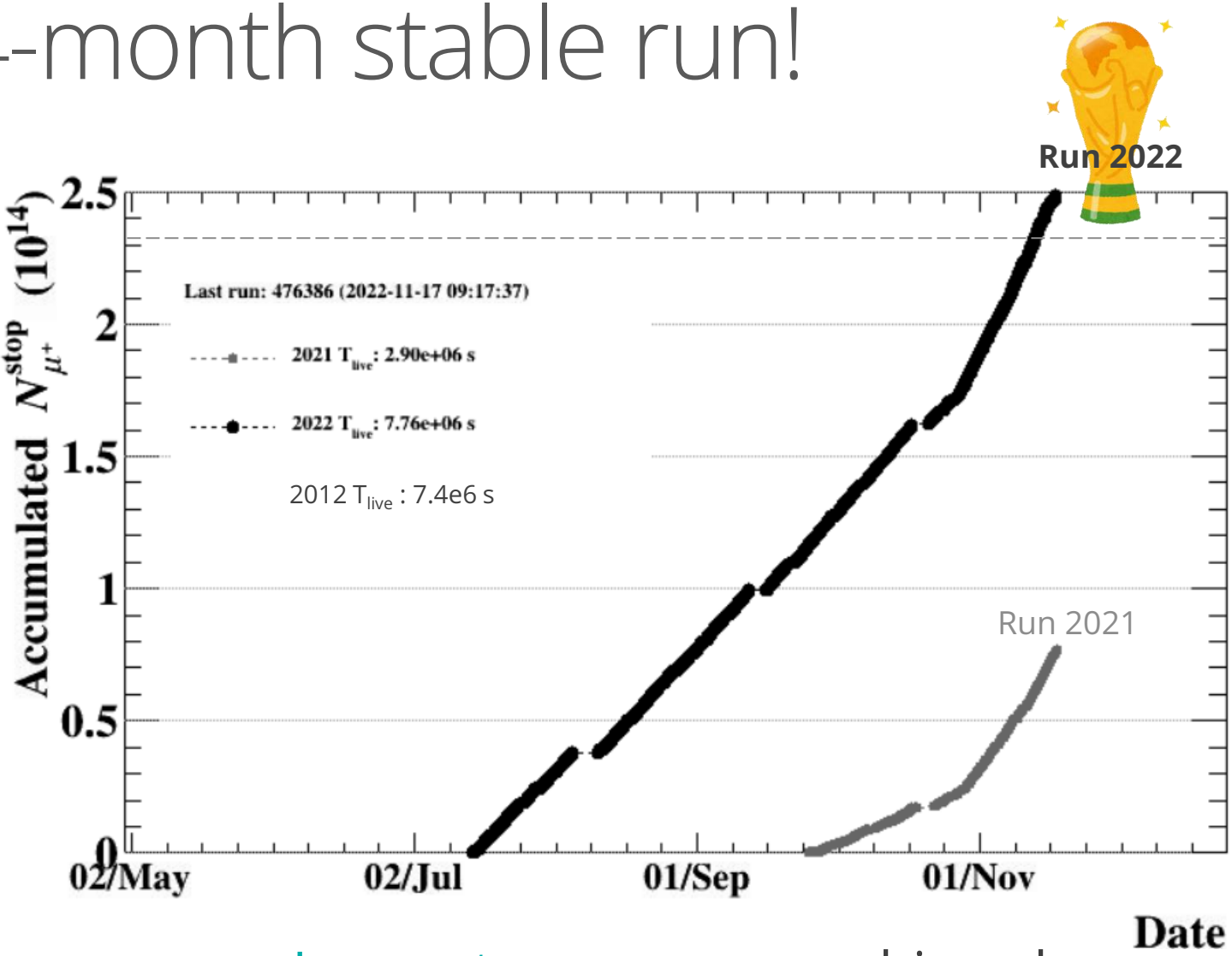
Started with 3×10^7 s^{-1}

- we were not sure MPPC PDE can sustain until the end
- DAQ rate exceeded the capability

Increased to 4×10^7 and 5×10^7 s^{-1}.

Analyze these data to optimize it in next runs.

4-month stable run!



Longest run we ever achieved,
×3.5 statistics of 2021

Sensitivity estimate

"Sensitivity": median 90% CL UL for BG-only hypothesis

$S_{2021} = 8.2\times10^{-13}$ previous talk 23pT1-2

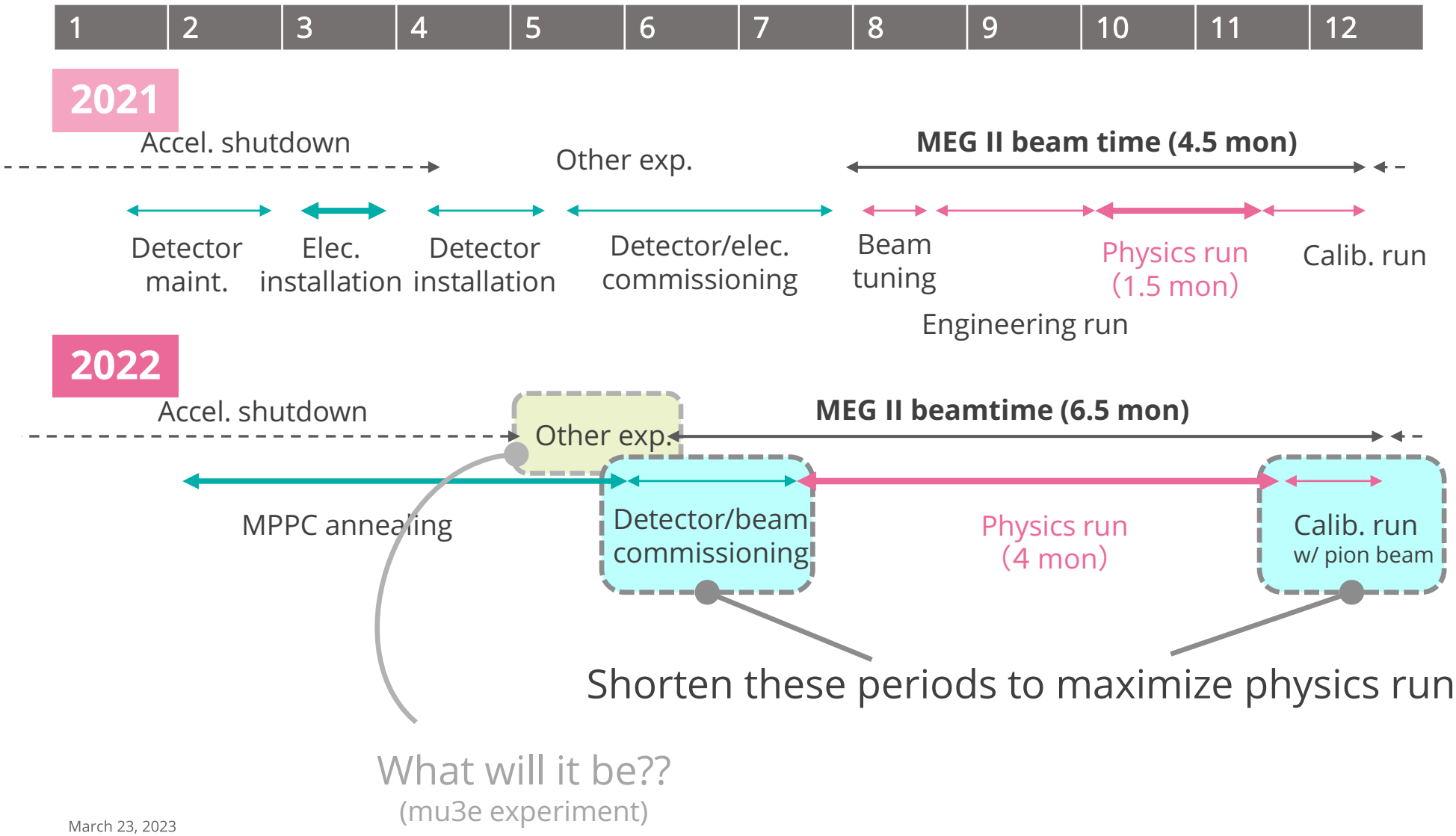
$S_{2021+2022} = (2.0 – 2.4)\times10^{-13}$

- × 2.5 better than MEG
- Still statistical limited
- Assuming same detector performance as 2021

Aim to finalize analysis with further improvement and publish new result by the end of this year

A new limit (or maybe evidence) for μ→eγ foreseen with this dataset

Next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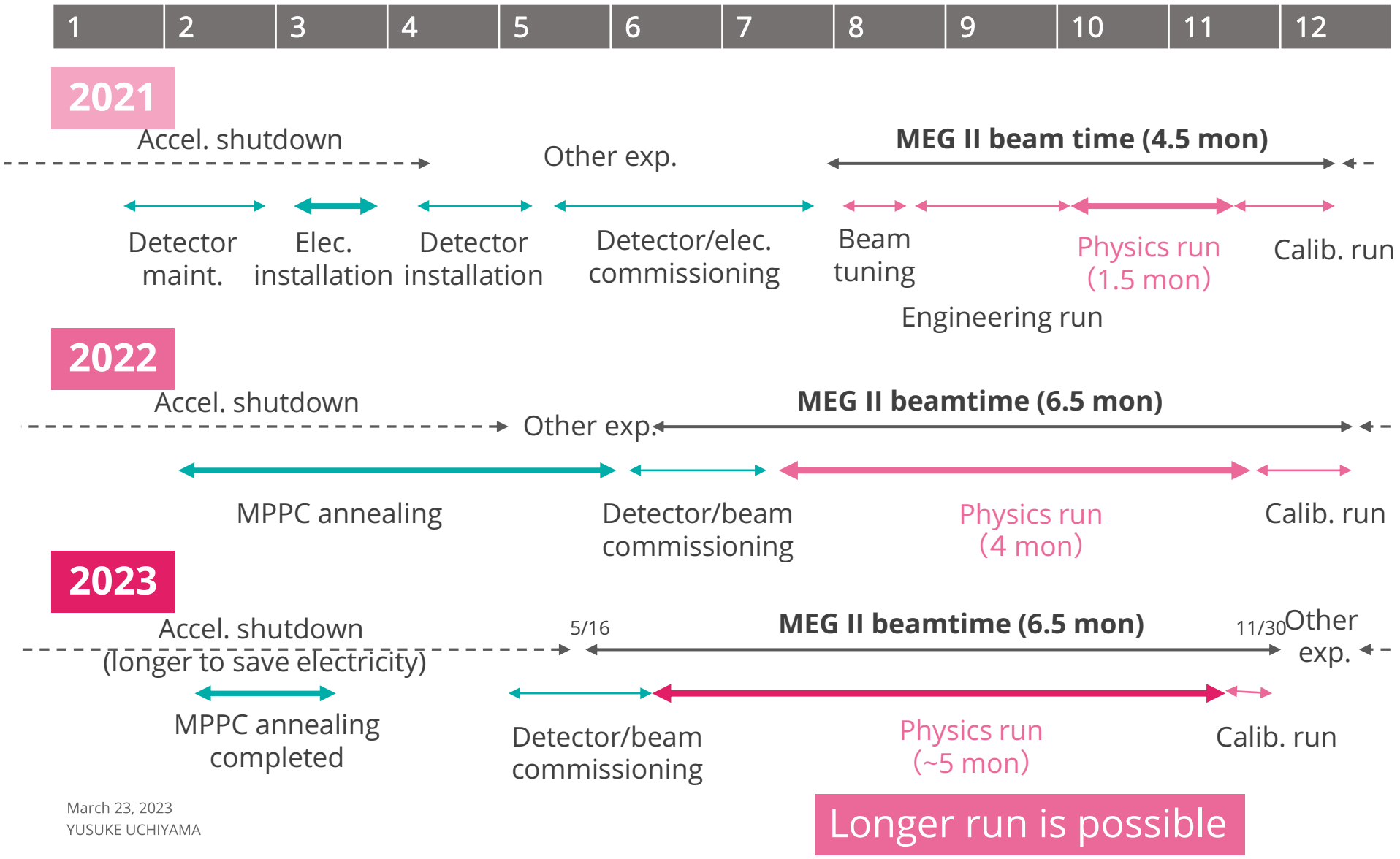
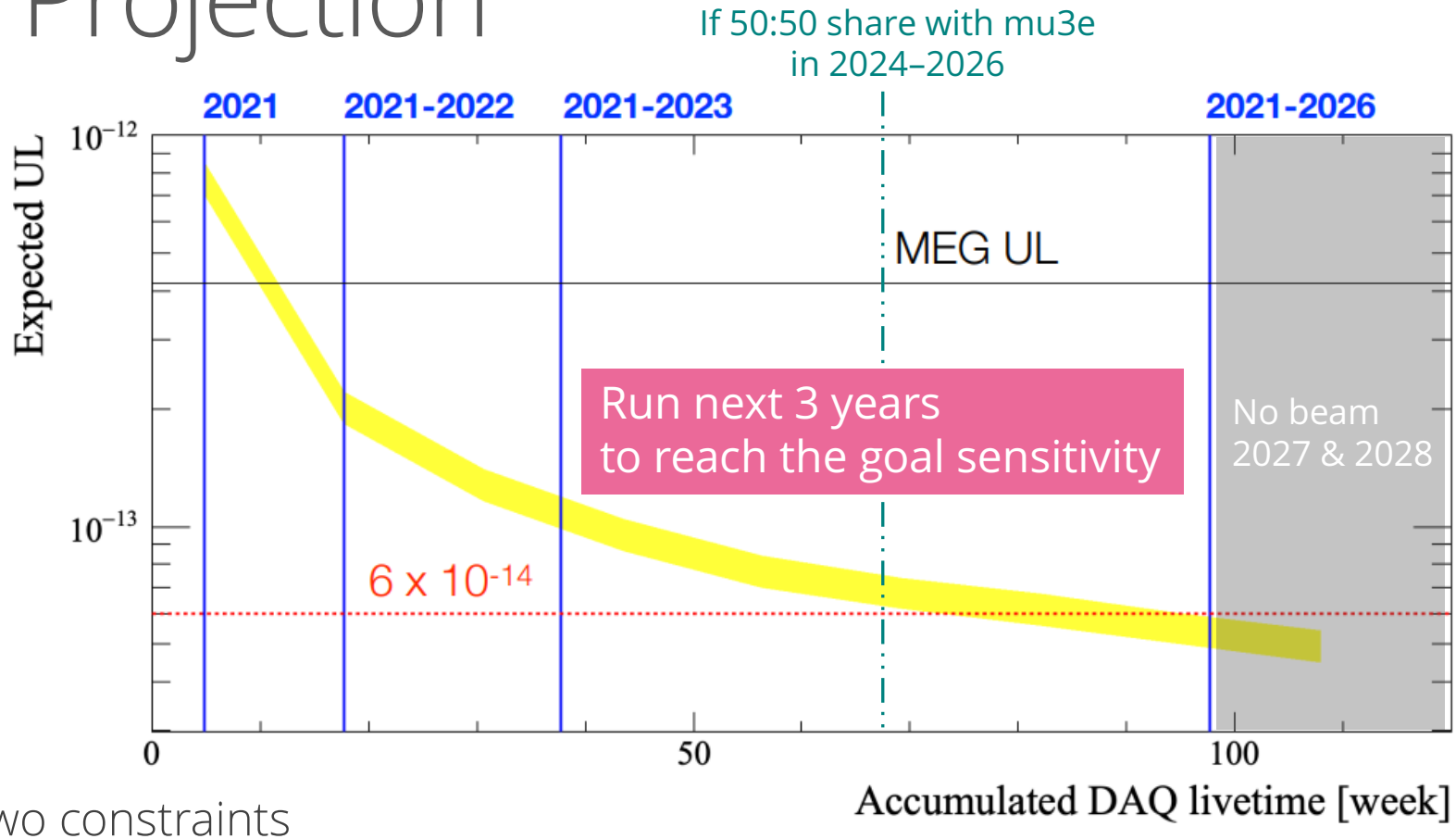
2021
Accel. shutdown
Other exp.
MEG II beam time (4.5 mon)
Detector maint.
Elec. installation
Detector installation
Detector/elec. commissioning
Beam tuning
Physics run (1.5 mon)
Calib. run
Engineering run
2022
Accel. shutdown
Other exp.
MEG II beamtime (6.5 mon)
MPPC annealing
Detector/beam commissioning
Physics run (4 mon)
Calib. run w/ pion beam
Shorten these periods to maximize physics run
What will it be??
(mu3e experiment)

2023 beamtime



Projection



Two constraints

1. Long shutdown in 2027–2028 planned
   to build a new high-intensity muon beamline
2. Share πE5 beamline with mu3e
   once they get ready. They also conduct phase I experiment before the shutdown...

Conclusions

Run 2022 was the 1st long production run of MEG II

The dataset will give us a new limit or evidence for μ→eγ

Look forward to 2021 result first (summer), and then 2021+2022 one later in this year.

To reach the goal sensitivity, we'll run at the end of 2026

This will be the best input to new physics from CLFV experiments in 2020s.
Important to collect as much data as possible.