MEG II 実験の準備状況と今後の展望

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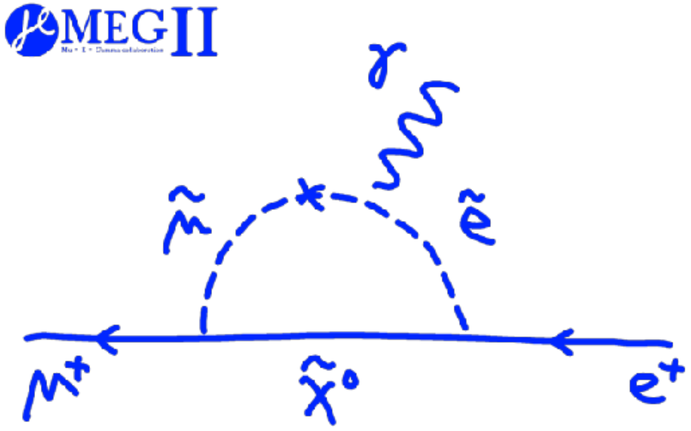
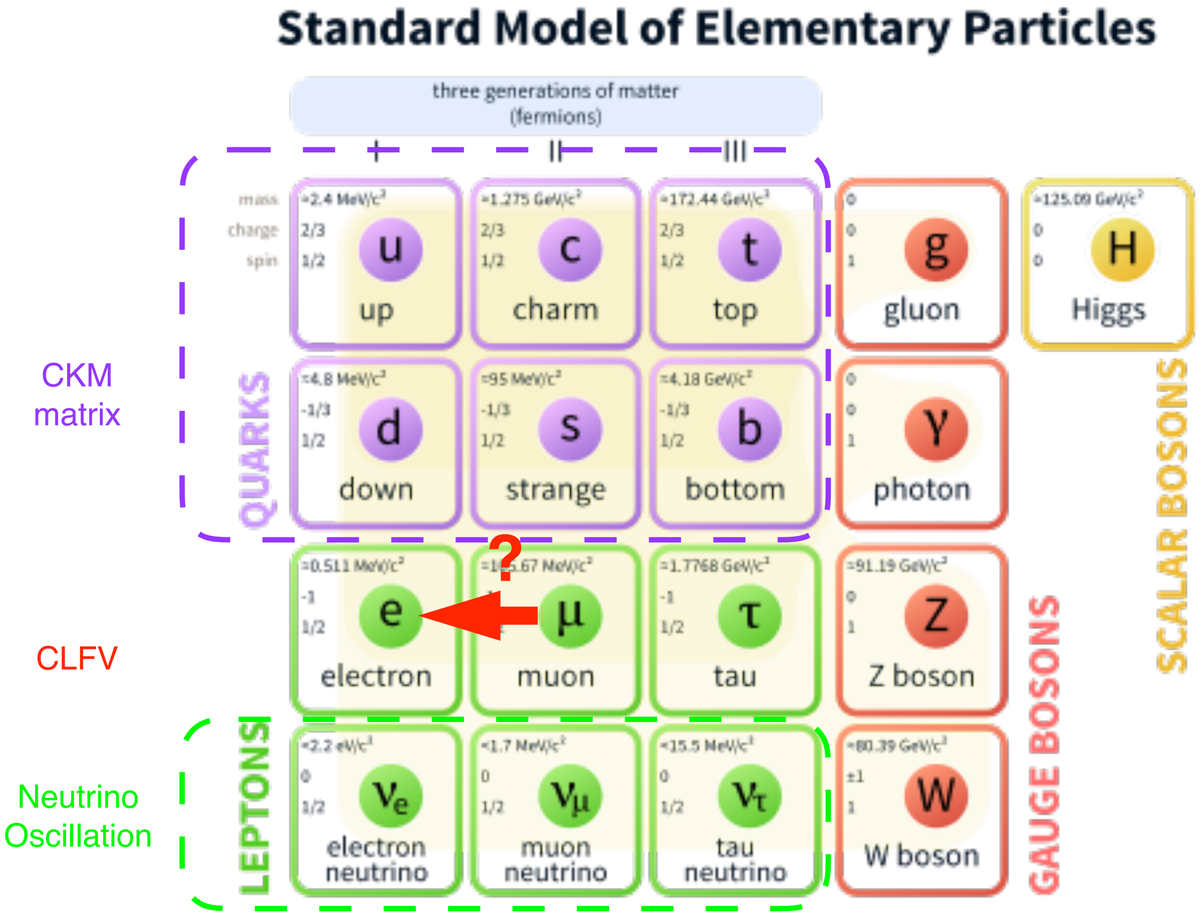
日本物理学会2018年秋季大会@信州大学



JSPS Core-to-Core Program

Introduction

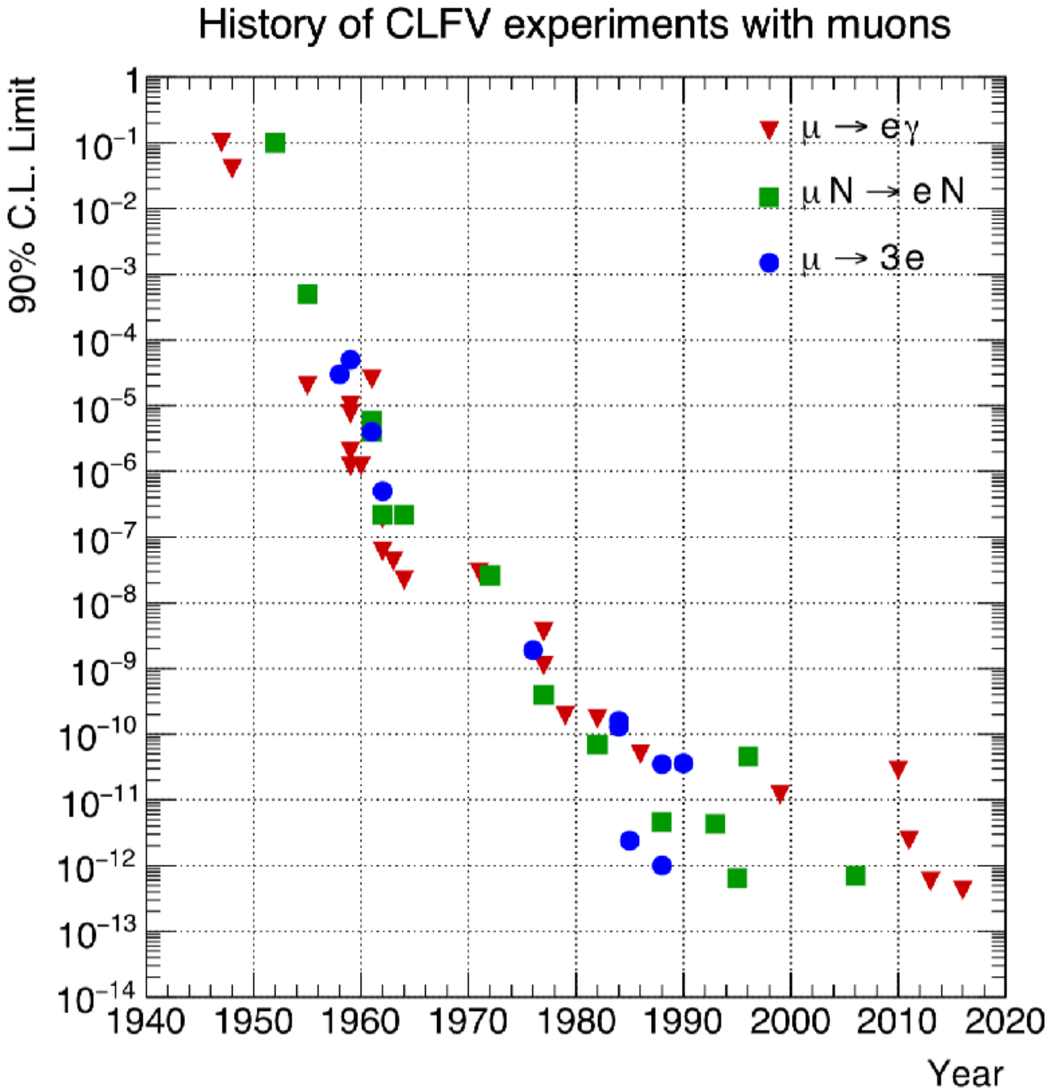
- Flavor physics
  - Why do we have three generations in the SM?
- charged Lepton Flavor Violation
  - FV happens in quark, neutral lepton sector
  - Why not in charged lepton sector?
- μ→eγ
  - Long search history since the muon has been discovered.
  - Negative results contribute to the SM formation
  - In SM + neutrino oscillation, Br(μ→eγ)~10^{-50}
  - Many new physics scenarios predict large Br(μ→eγ)



From Wikipedia

MEG II Experiment

- MEG/MEG II experiment
  - MEG/MEG II are designed to search for such regions where new physics like SUSY-GUT, SUSY-seesaw predict
  - Real chance to discover new physics
- Start new physics search next year
  - Target sensitivity : 6×10^{-14}
  - 10 times better sensitivity with three years data taking than MEG
    - MEG sensitivity : 5.3×10^{-13}
    - MEG final results : 4.2×10^{-13} @90%CL (Eur. Phys. J. C 76(8),434(2016))
- New μ-e conversion, μ→3e experiments will follow soon



Eur. Phys. J. C (2018)78:380

MEG II Experiment

x2 resolution everywhere

Liquid Xenon γ Detector

Better uniformity
w/ VUV-sensitive
12x12mm² SiPM

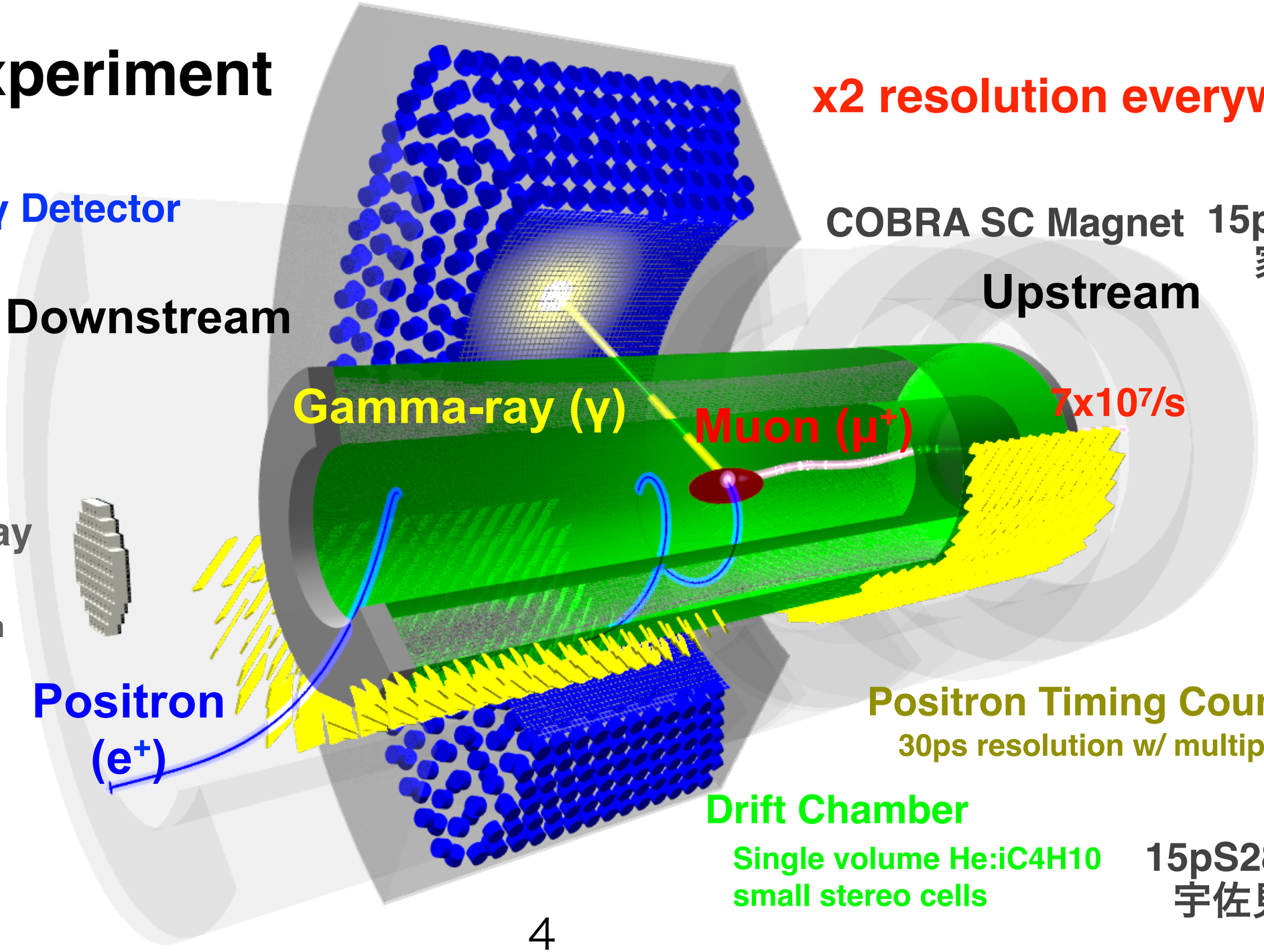
16aS41-7, 8
小林, 小川

COBRA SC Magnet

15pS28-5
家城

Upstream

Downstream



Radiative Decay Counter

Further reduction
of radiative BG

16aS41-5
恩田

Positron Timing Counter

30ps resolution w/ multiple hits

Drift Chamber

Single volume He:iC4H10
small stereo cells

15pS28-4
宇佐見

Current status

Yusuke@Last JPS meeting

- **All the detectors** except for CDCH are constructed.
- Installation and commissioning in 2017.
- **Pilot run** with partial electronics was successfully carried out in Nov.–Dec.

- Struggle with the **wire braking issue** on CDCH.
- Struggle with the **noise issue** on the readout electronics.

⇒ **>2 years delay** from the original (2013) schedule.

- This year all the detectors will get ready.
- Full electronics will be ready toward the end of the year.

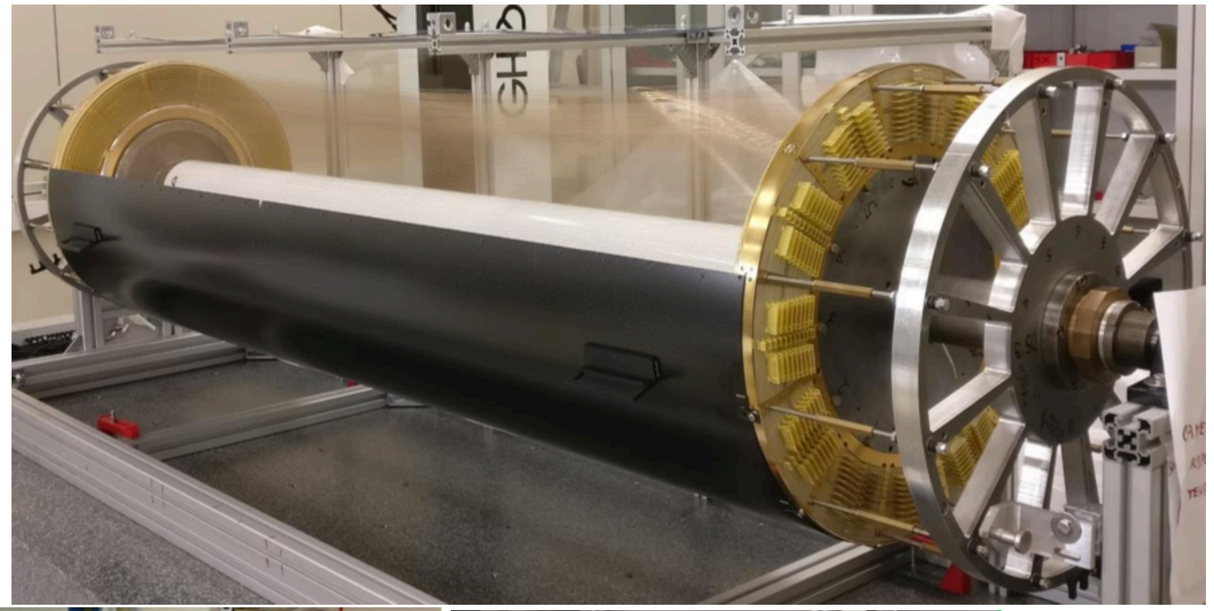
⇒ Carry out **full engineering run**,
but not physics run this year.

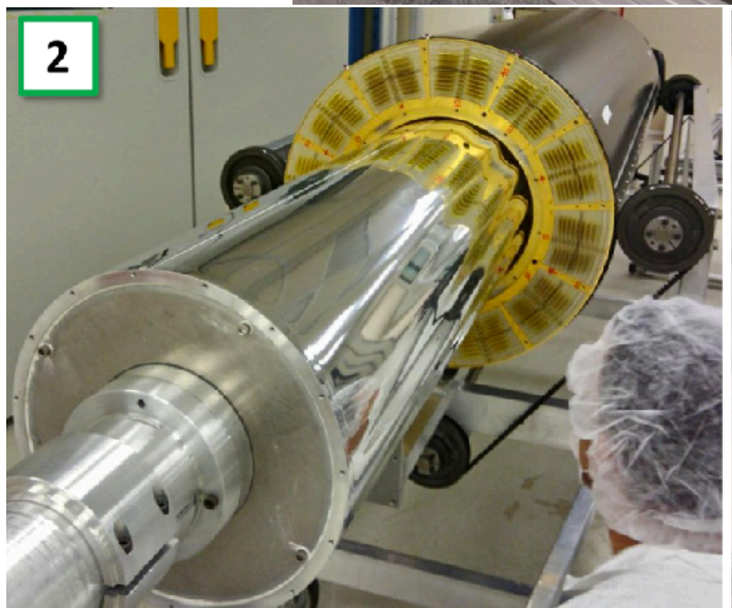
Current status (update from 2018 spring)

- CDCH
  - Wire breaking issue seems to be solved by humidity control, and the assembly is finished.
  - CDCH finally sent to PSI
- WaveDREAM
  - Still struggling with the noise issue, and the mass production has not started yet
  - This year we can not start engineering run due to this problem
- LXe detector
  - Light yield was saturated at the half of the maximum level
- Schedule
  - Now Mu3e beam time at the upstream side of the experimental site
  - In October, integration of all the detectors into the experimental site
  - In November - December, MEG II muon beam time is planned

CDCH

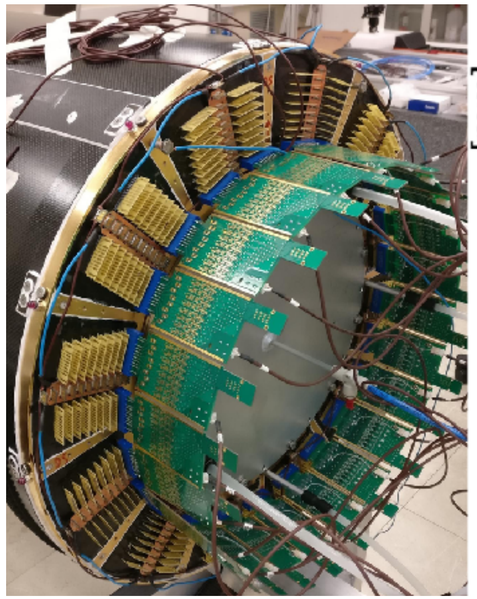
- Chamber construction work finished
  - The problem of broken wires seems to be solved by careful control of humidity
- HV supply test
  - performed before bringing the CDCH from PISA to PSI
- However, we found another problem
  - current instability of many channels observed before reaching the nominal HV
  - three most inner layers are critical
    - Drift cell at center
      5.8mm (inner layer)
      -7.4 mm (outer layer)

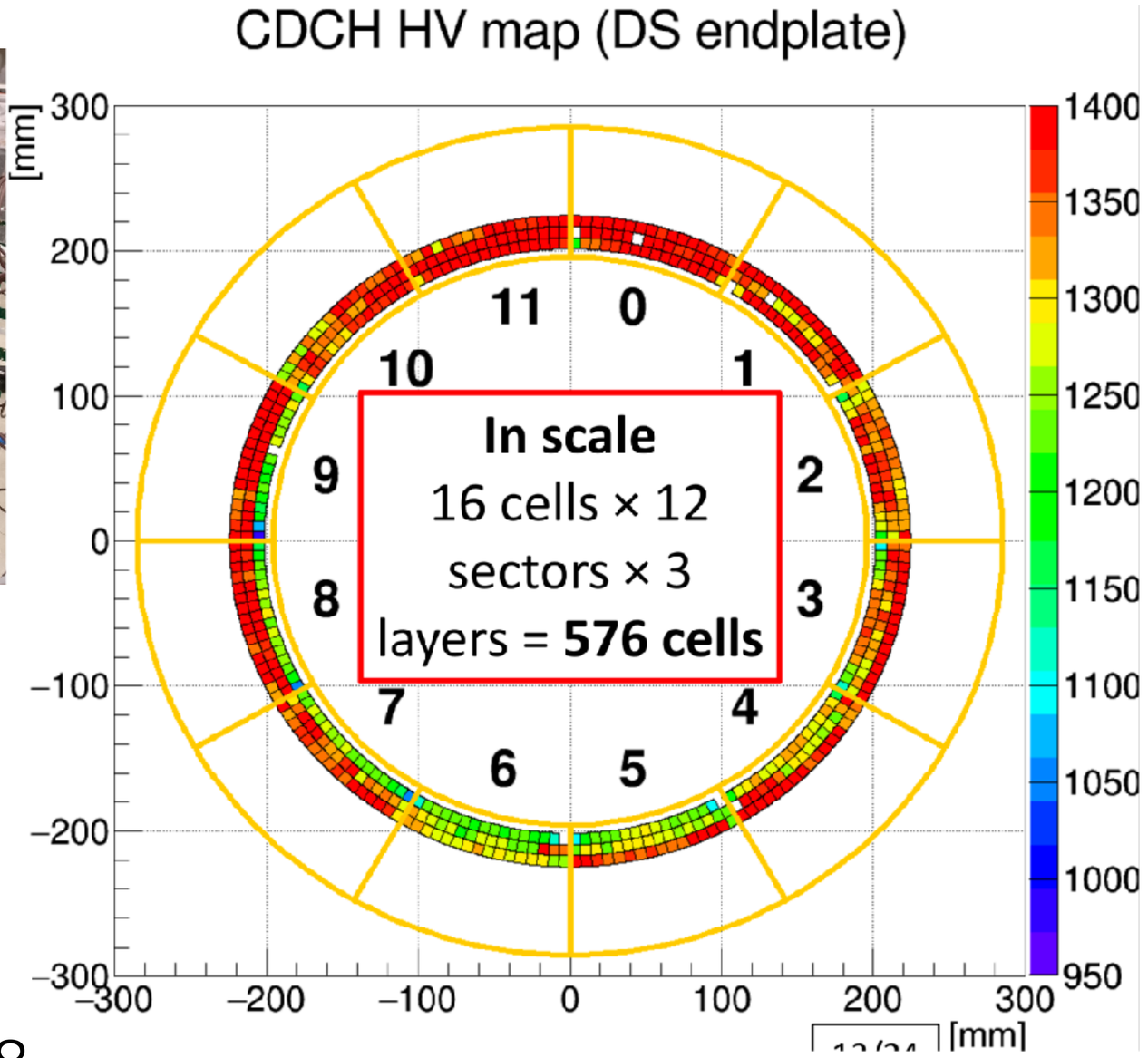




CDCH

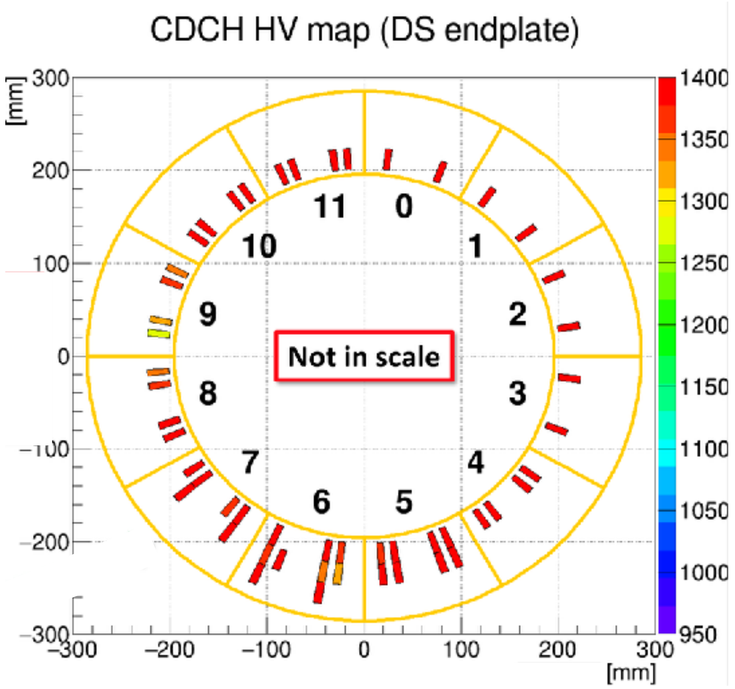
- Limited # electronics channels, and HV are supplied locally.
  - drift cell instabilities have position dependence
  - Worse parallelism of end plate? ~350μm
- Inner three layers had a worse situation
  - smaller drift cells, lack of wire tension?
  - Wire length checked again, and 1mm longer than what was measured before
- Decide to re-open the chamber and correct the wire tension and the parallelism of the end plate

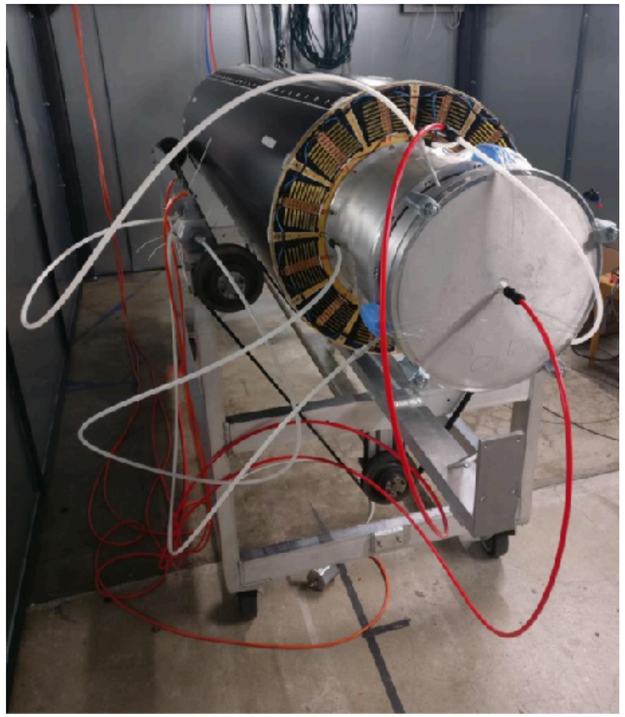




CDCH

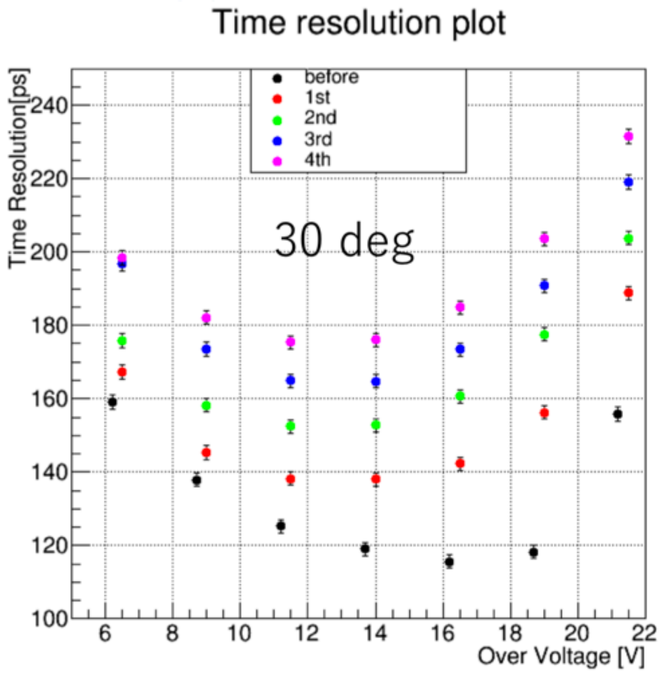
- Making CDCH longer by 0.6mm
  - no short circuit observed
- Both endplate parallelized better
  - uniformity recovered (sector 0, 11 relative to 5, 6)
- Assembly work done again
- Shipped to PSI on 31st/July
  - He: Isobutane = 85 : 15 are supplied at PSI for the first time
  - All the HV cards became available at Mid. Aug.
- Now HV conditioning in progress outside the detector hut
  - Up to now, ~1000V are achieved (working condition will be ~1500V)
- Beg. October installation into the MEG II experimental site if everything is ok

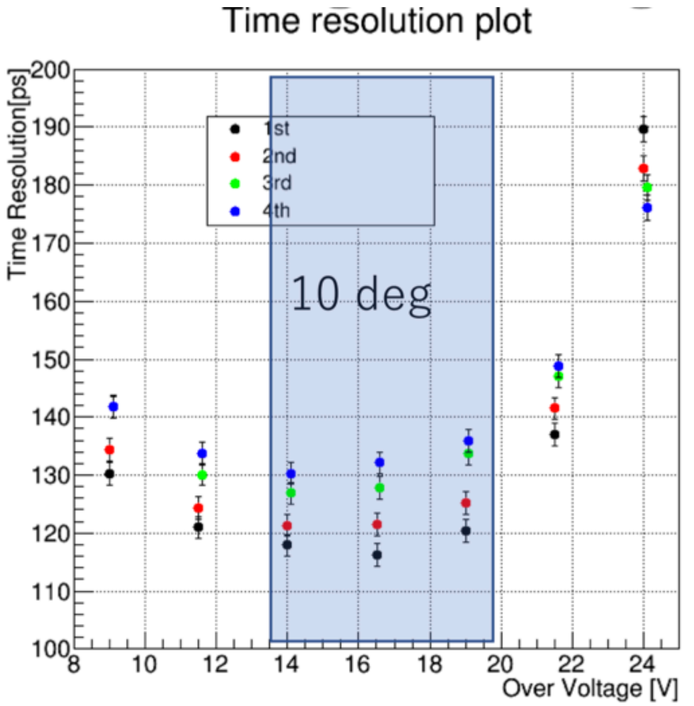


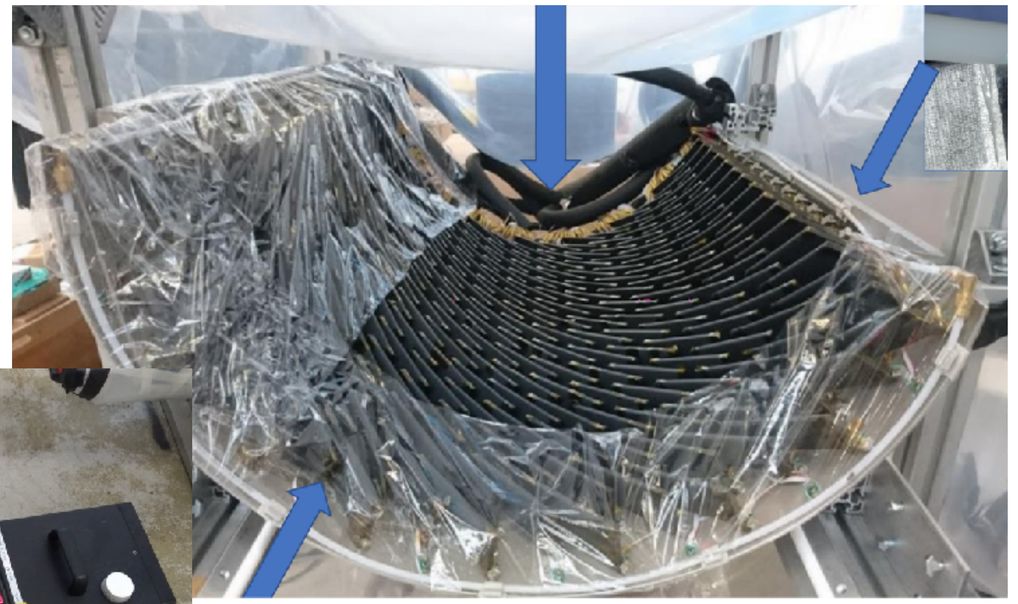


TC

- Full counters were tested under muon beam, and expected performance was confirmed (~30ps)
- Radiation damage can be mitigated by low temperature operation
  - 30% time resolution deterioration at 100μA at 30°C becomes 5% at 10°C
- Cooling test performed at open space
  - 20°C was already achieved
  - Water chiller system plus cooled dry air
  - Cool down test down to 10°C will be done in the detector hut with air conditioning system

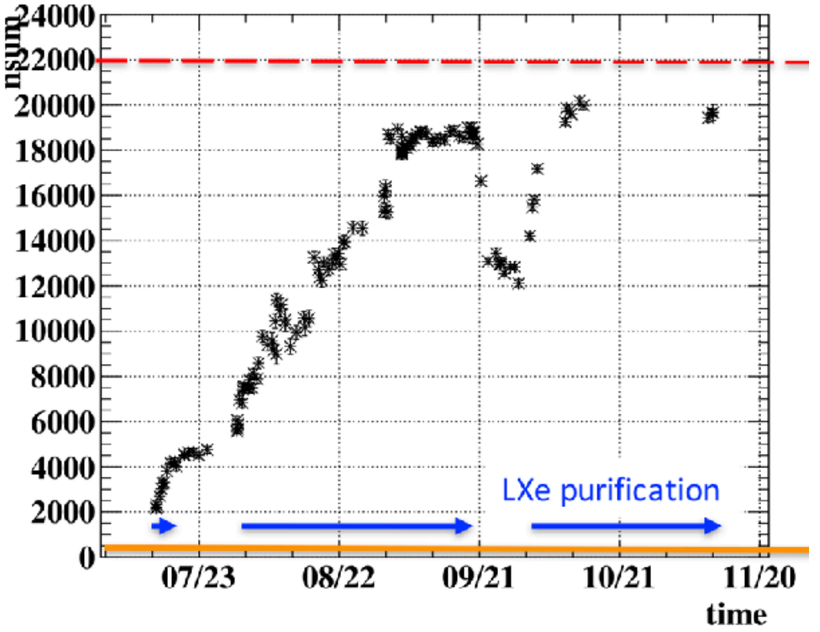


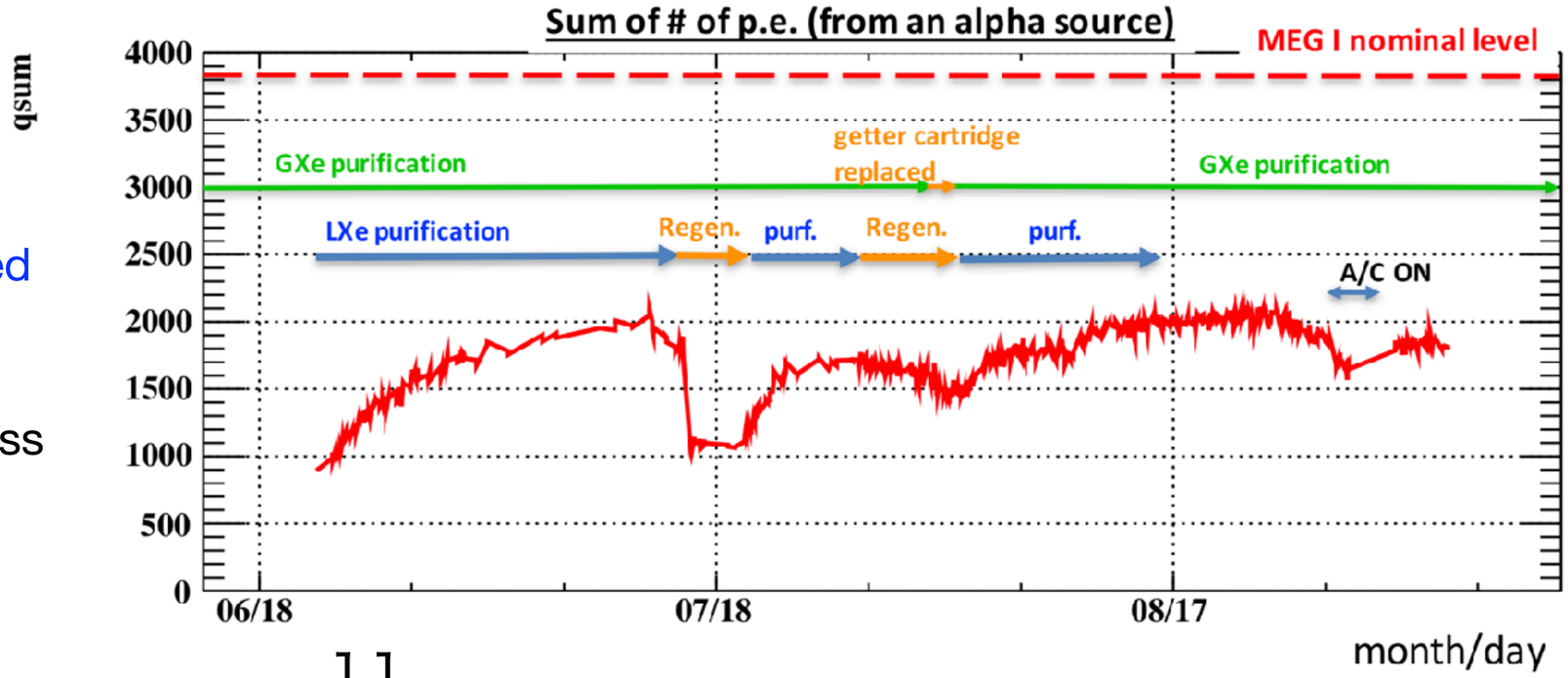




LXe detector

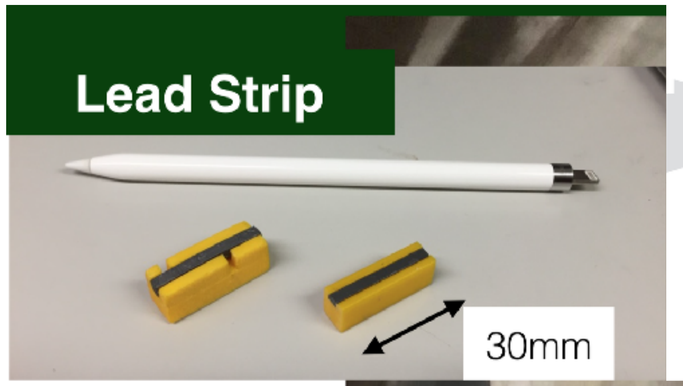
- Last year
  - light yield reached 90% of expected by gaseous/liquid purification
  - After some readout PMTs are modified, it changed to 70% of expected
- This year
  - Started detector operation in June
  - unexpectedly the light yield is saturated at 50% of expected
  - Molecular sieves have some problem? Replacement work in progress

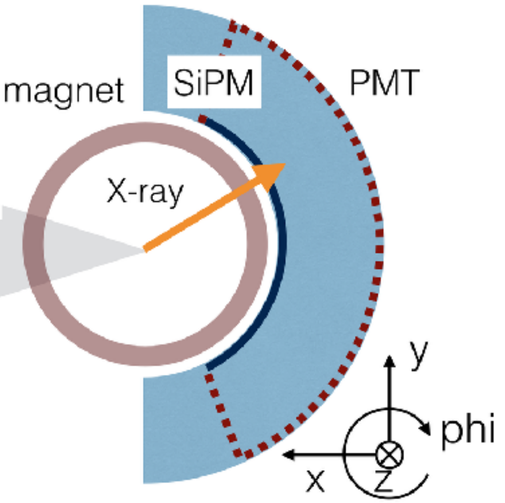


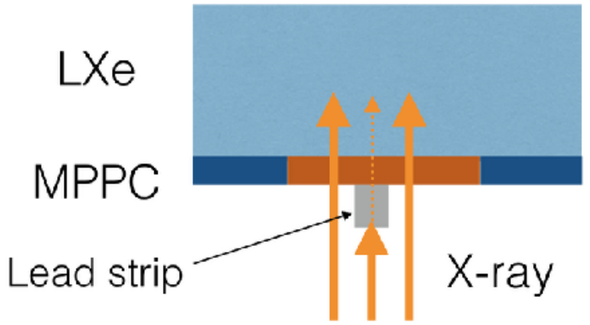


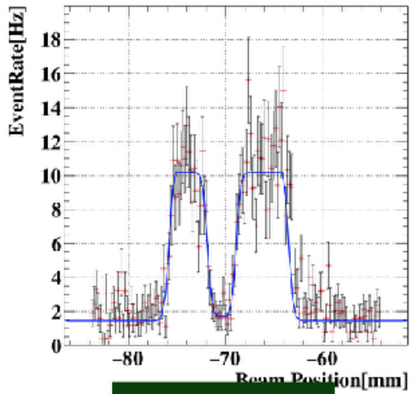
MPPC position survey

- X-ray measurement again this year
  - Measure MPPC positions in LXe directly
  - Absolute MPPC position comparison with more lead strips
    - last year, ~1mm discrepancy was observed
  - Stability of MPPC position after thermal cycle
- Waveform data are taken
  - last year only event rate (scaler) was used.
  - Online trigger can veto cosmic ray events
    - S/N improved from 1 to 5
- Results
  - No significant displacement from the thermal cycle
  - Again, the laser survey and the lead strip data show discrepancy. Careful checks are in progress.

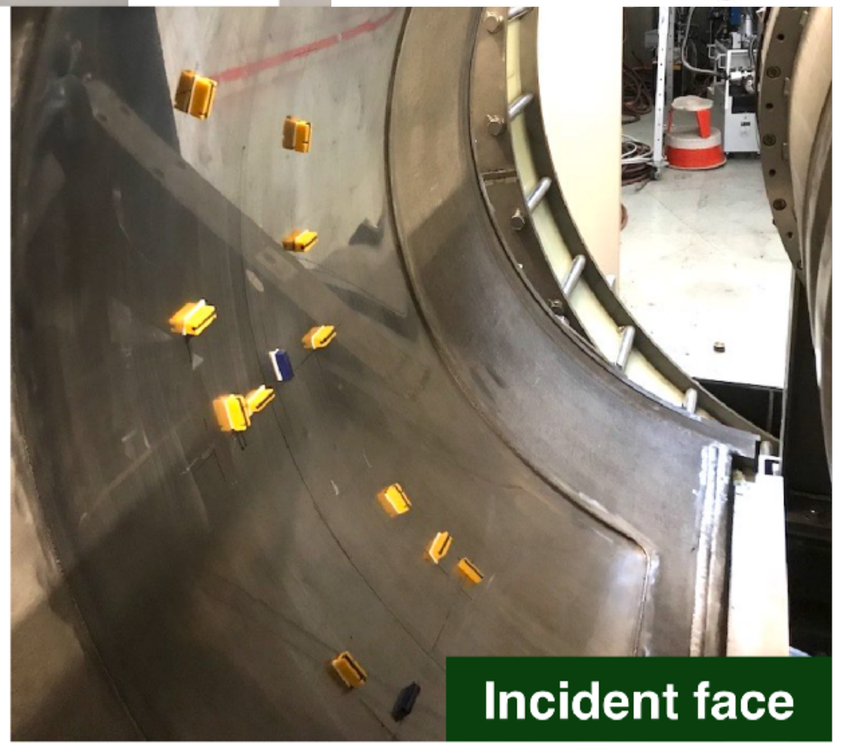






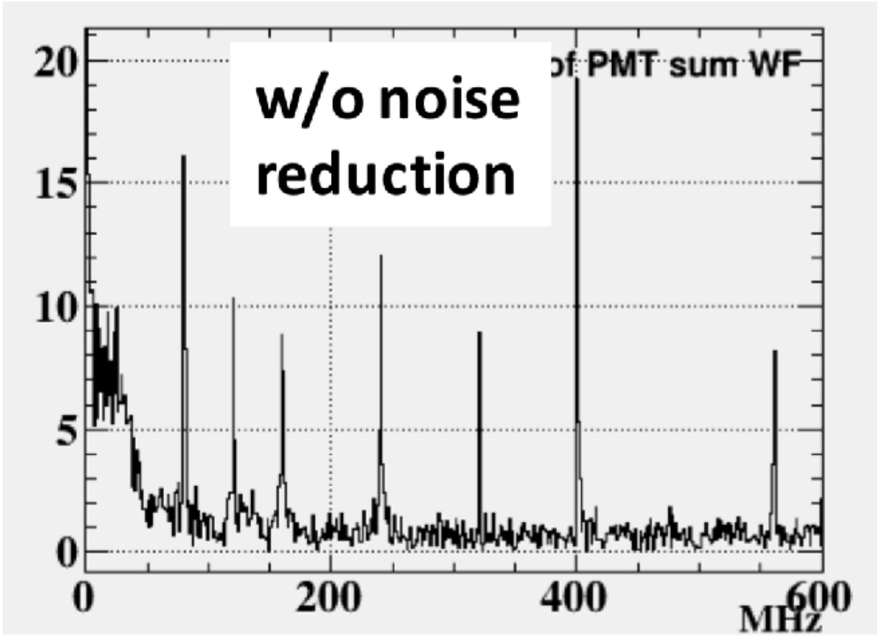


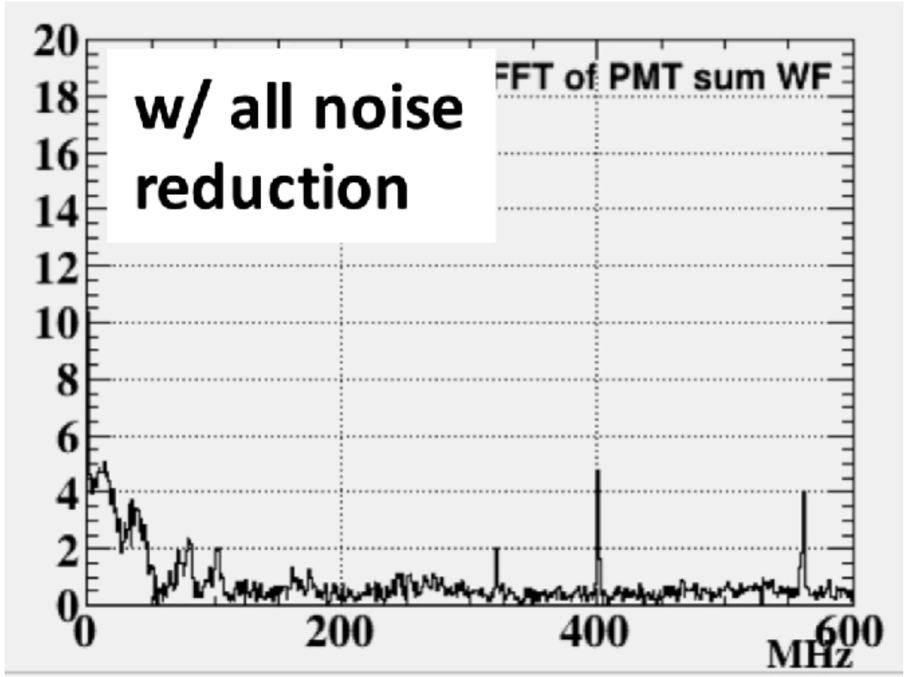
X-ray Signal



Noise

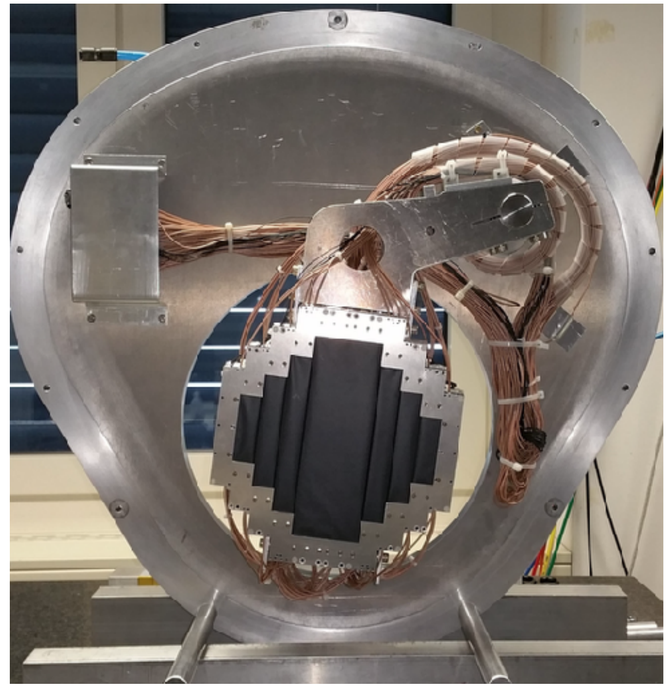
- High/low frequency coherent noises are observed for both PMT and MPPC
- High frequency noise
  - mainly coming from waveform digitizer
  - Related to 80MHz system clock
  - Try to remove the high frequency noise by offline analysis
- Low frequency noise
  - dominant source for charge estimation
  - Still limited number of channels, but already 1% contribution to charge RMS
- Energy resolution will be checked by CW Li 17.6MeV γ monochromatic calibration



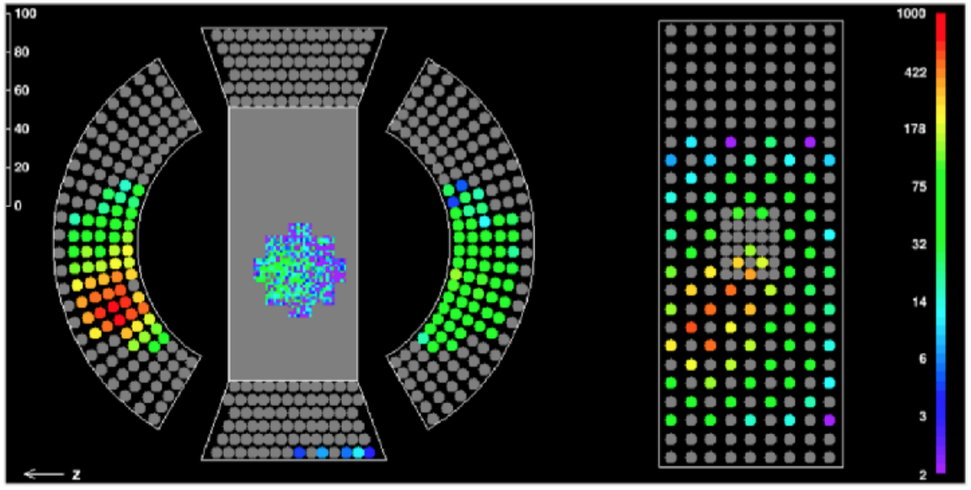


RDC

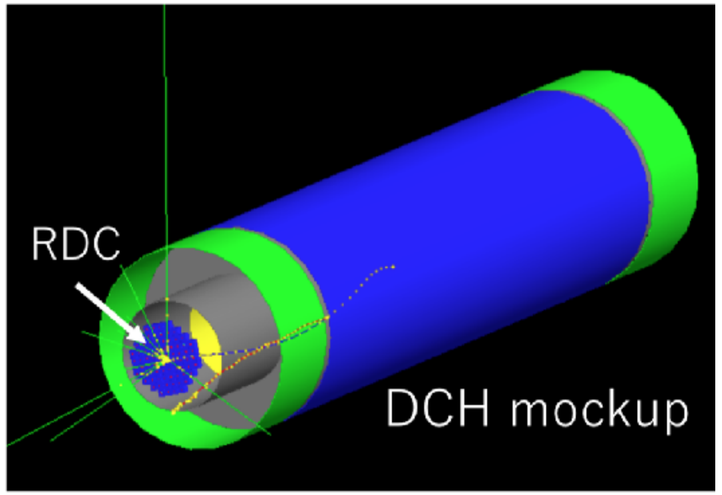
- Downstream RDC
  - In 2017 RDC + LXe data taking was performed, and radiative muon decay events are successfully observed
  - Data analysis and the comparison with MC in progress
- Upstream RDC
  - Considering the possibilities to use silicon sensor, RPC etc.



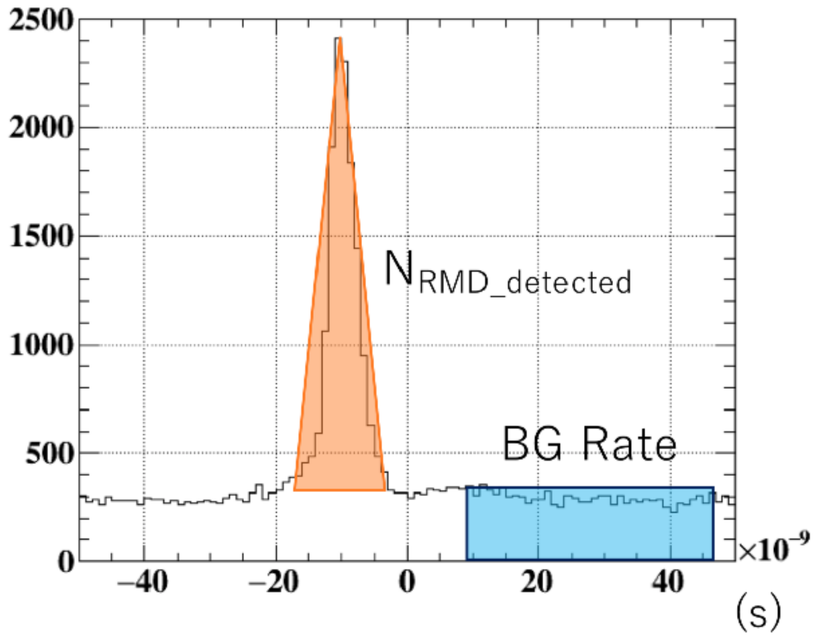
LXe Event Display



DCH mockup

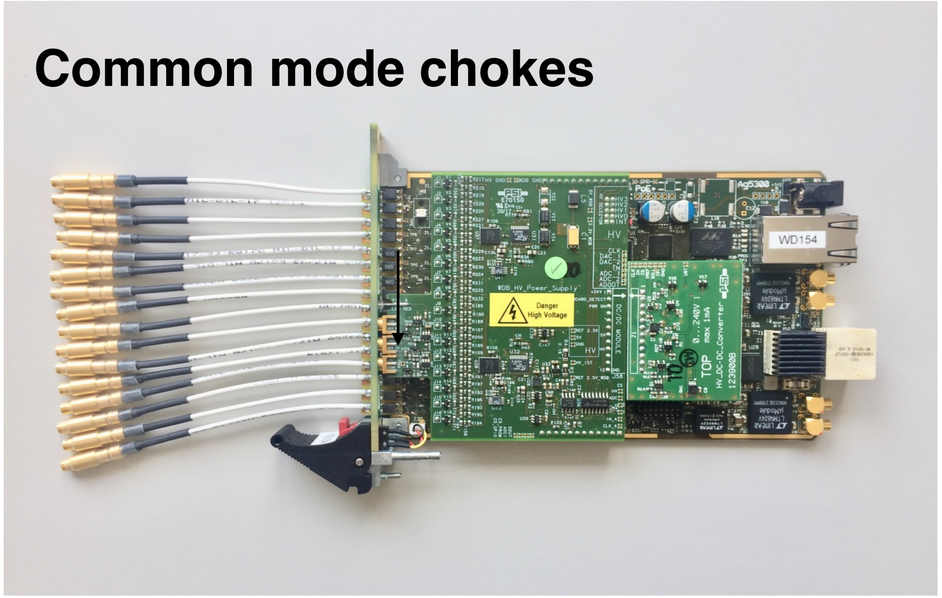


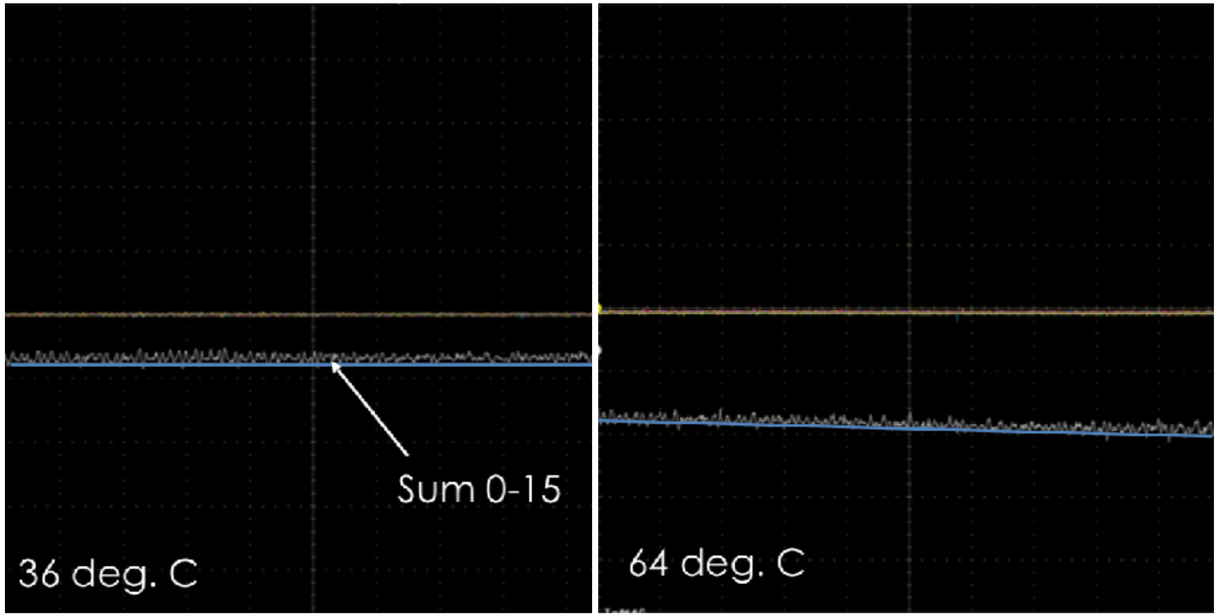
$T_{RDC} - T_{LXe}$ (data)



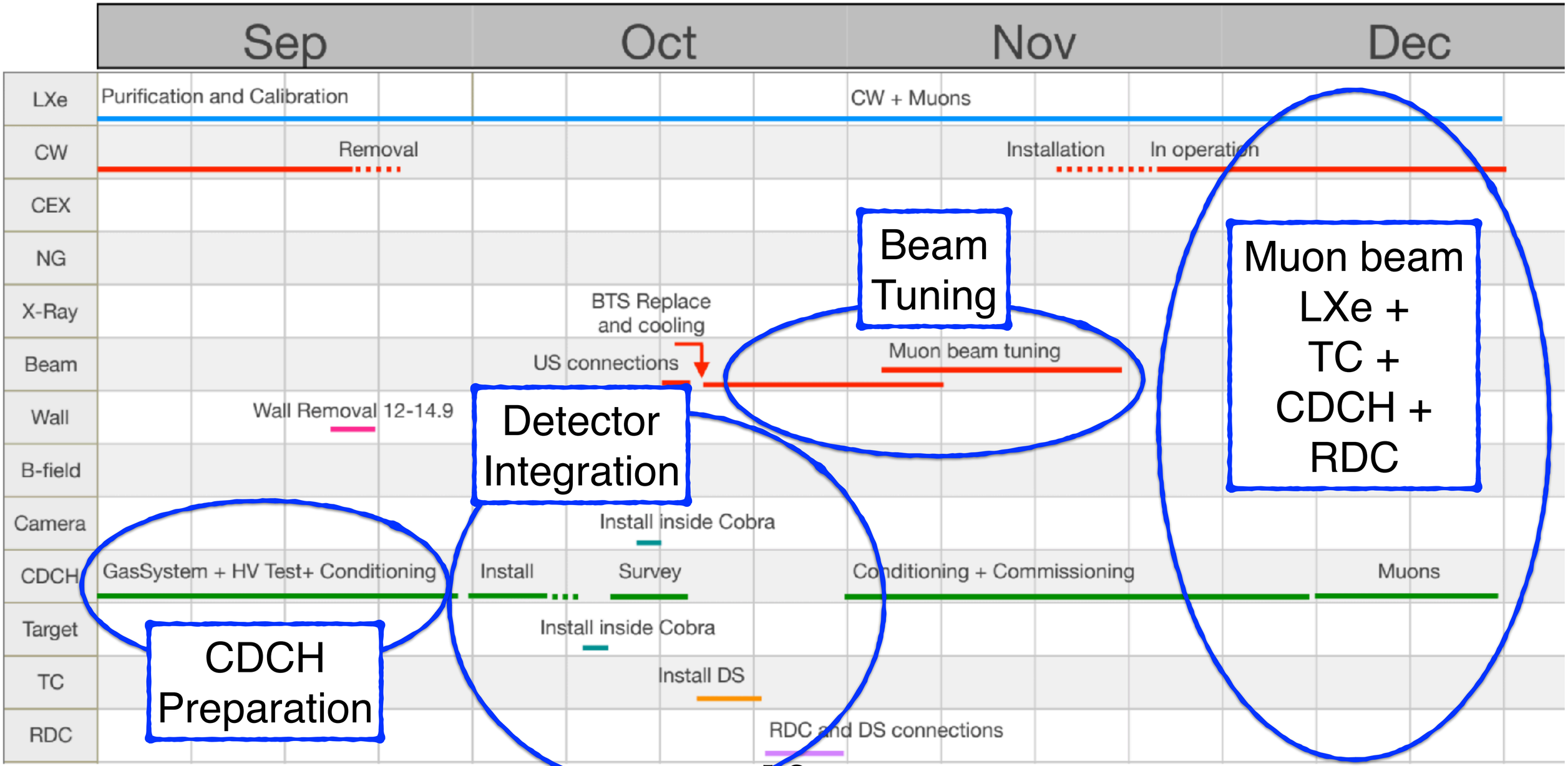
WaveDAQ

- New DAQ/Trigger system
  - Waveform digitizer, amplifier, SiPM voltage supply, trigger are integrated in a card
  - 6 crates (=1500ch.) are now available for test
- Noise study from hardware point of view
  - Test of common mode choke : mainly to remove high frequency noise
- Baseline slope
  - Drop caused by temperature dependent leakage current in DRS
  - Cells at right are read out later → more time for leakage →slope
  - Need to keep the temperature constant
- Next year mass production for all ch.





Prospects 2018

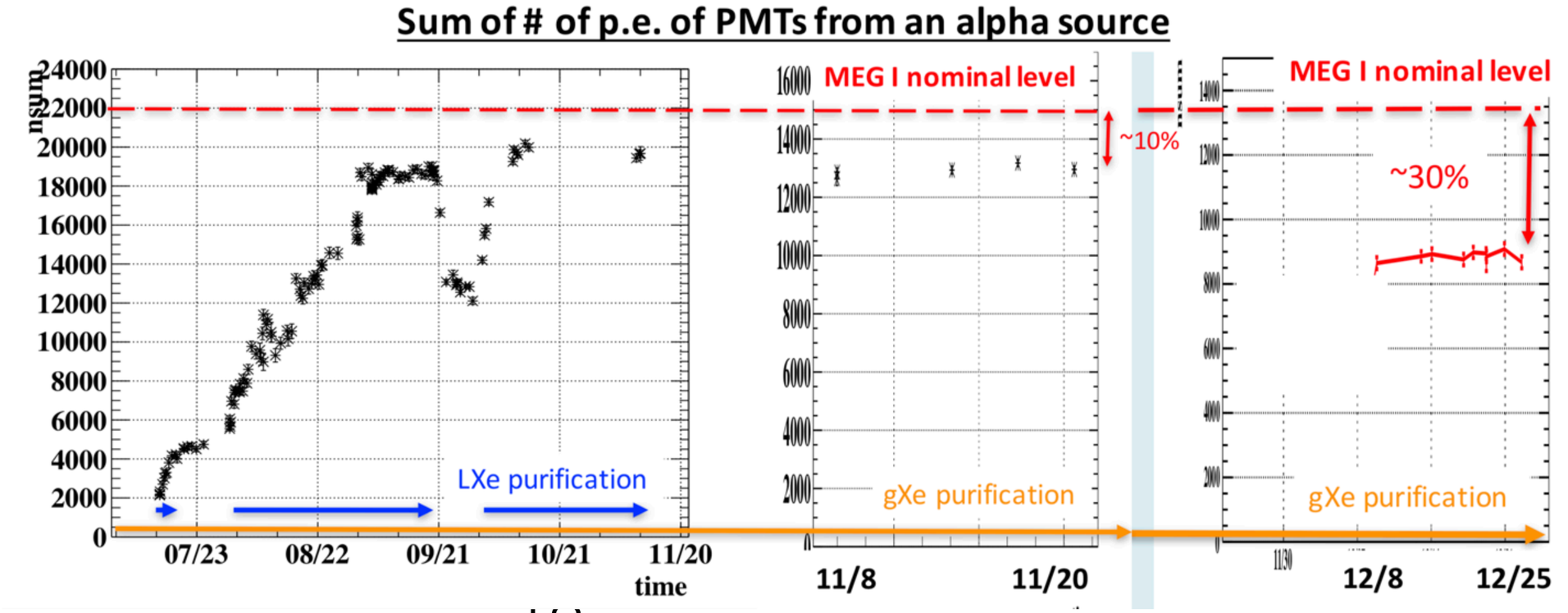


Summary

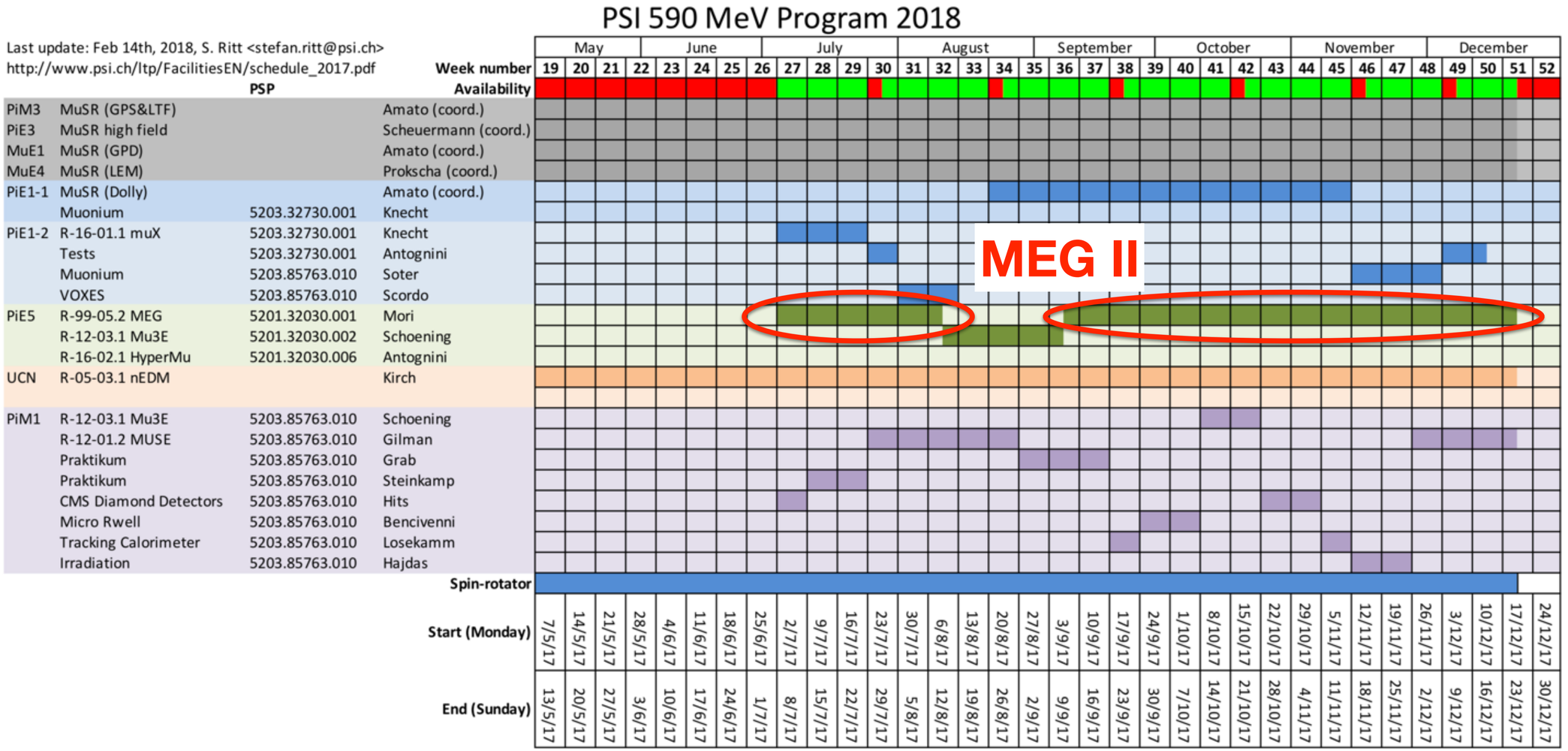
- All the MEG II detectors are finally at PSI, and will be installed into the experimental site in October.

- Muon beam time is scheduled with all the detectors and limited number of readout electronics in November-December.

- Next year after the mass production of the readout electronics, engineering run and physics run will be started.


Sum of # of p.e. of PMTs from an alpha source
nsum
time
07/23
08/22
09/21
10/21
11/20
LXe purification
MEG I nominal level
~10%
gXe purification
11/8
11/20
MEG I nominal level
~30%
gXe purification
12/8
12/25

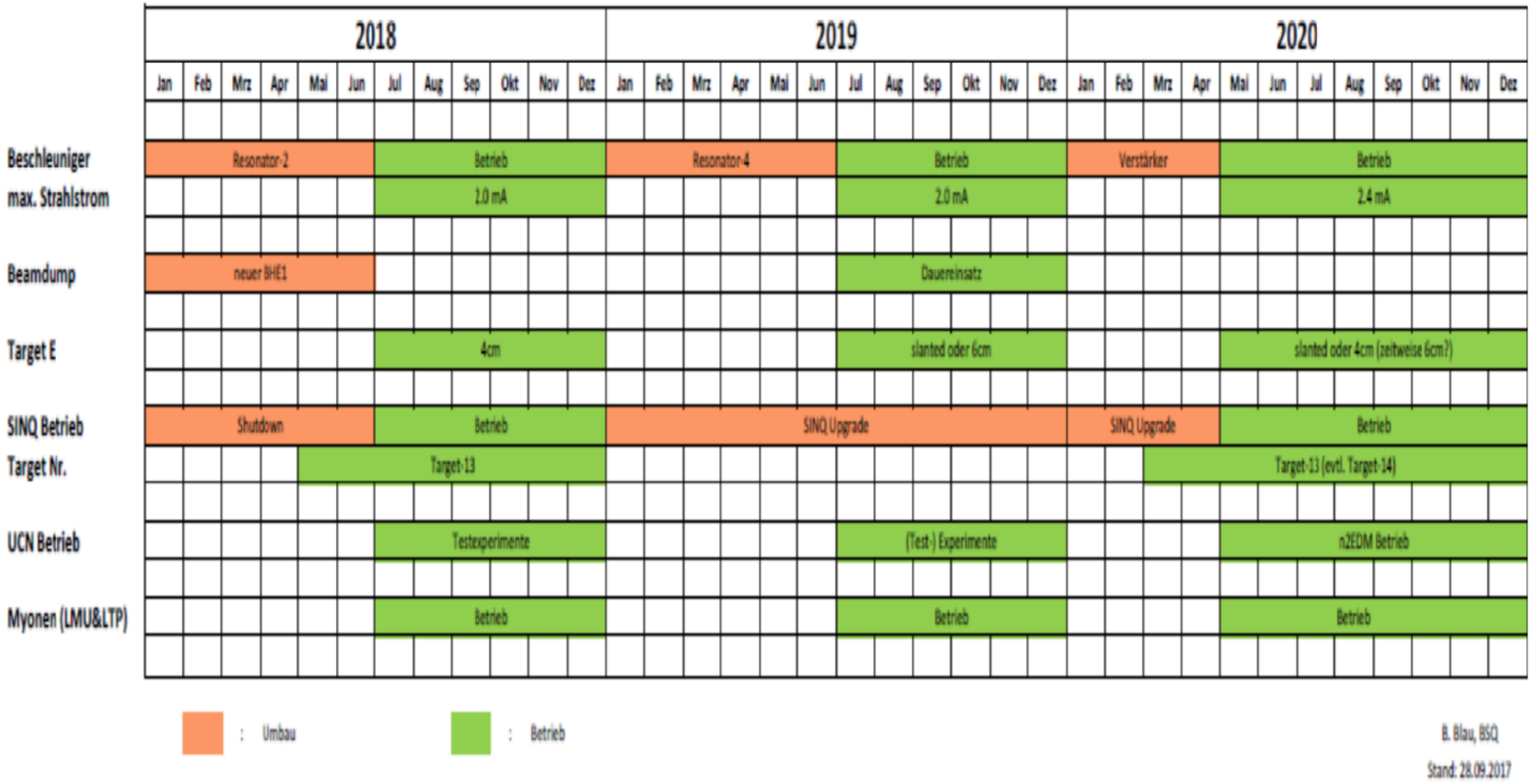
Beam time in 2018



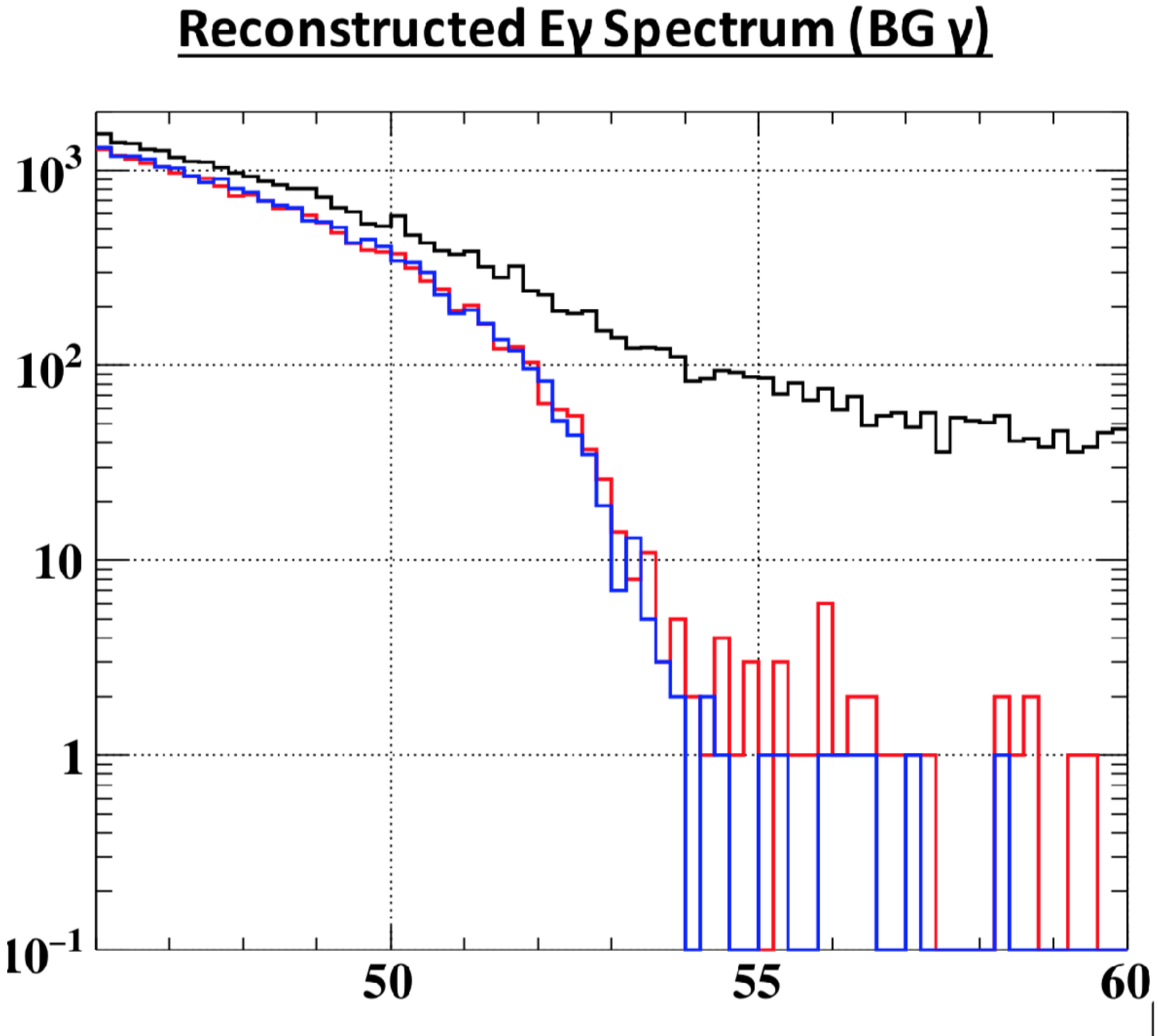
- Beam time in 2018 for MEG II is allocated as requested (by Stefan)

HIPA operation

Betrieb Protonen-Anlagen 2018-2020



Pileup analysis



Positron analysis

Target preparation