Detector Commissioning and Status

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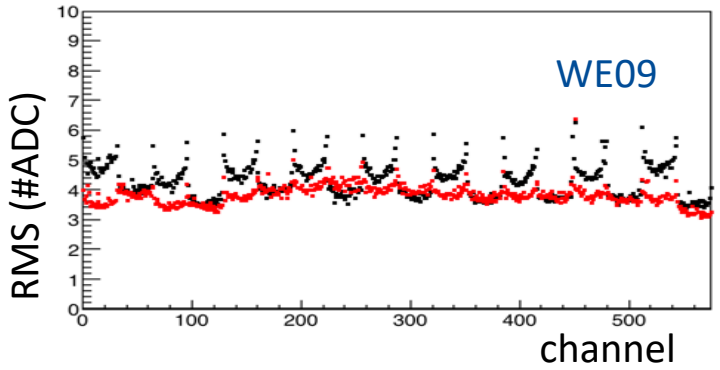
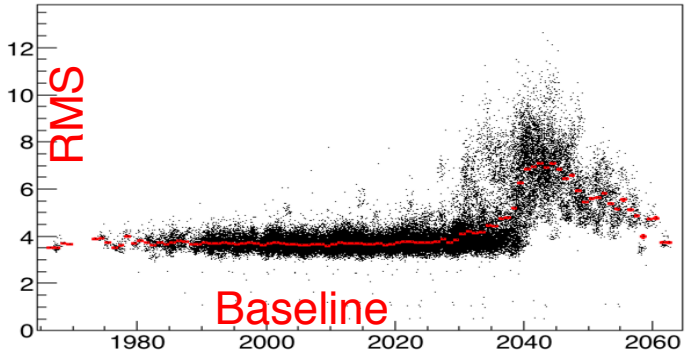
Updates on TPC Noise Mitigation – WEST Module

- ✓ Main results of the Dec 2020 noise mitigation campaign on West cryostat:
  - ✓ Improvement in 9 (of 36) readout units with installation of 2 x 100 Ohm resistors on readout boards.
  - ✓ Improvement in 1 readout unit with connection of a missing ground strap.
  - ✓ Identification of some interference with ancillary cryogenic instrumentation.



- ✓ After deep studies of results, understood that when baseline is 2048 and when this DAC offset value is exactly matched, the ADC crosses a conversion value (2048) where all the bits are flipped. This is the cause of the observed noise.



- ✓ Same effect reproduced in the lab but one order of magnitude smaller (< fraction of bit).
- ✓ Systematic survey to be continued but hard with pandemic. Effort to reproduce the situation in a test stand in Padova (Italy).

DAQ Updates

- ✓ Thanks to help from SLAM, SIS (Scientifics Server Infrastructure), Networking, and the artdaq team, fixed a major issue in system configuration that was making non-optimal use of networking.
  Since then, DAQ and online systems much better/cleaner operation.

- ✓ Now fully using the artdaq configuration database and an upgraded online software suite (more robust for handling larger CRT rates and exploiting time synchronization with the trigger for event building).

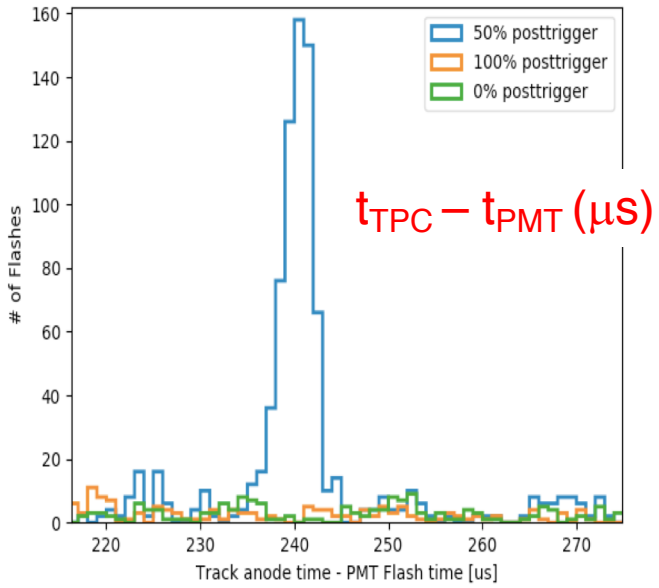
- ✓ DAQ and trigger groups have been commissioning the trigger and supporting studies for readout of beam spills and verifying neutrino timing.
  These studies have already fixed some event synchronization issues and will help finalize commissioning of DAQ pieces.

- ✓ Updated online monitoring suite includes live measurements of the electron lifetime in the detector as part of running. Initial studies show operation is stable, processing ~100 tracks in the detector every 15-20 minutes.

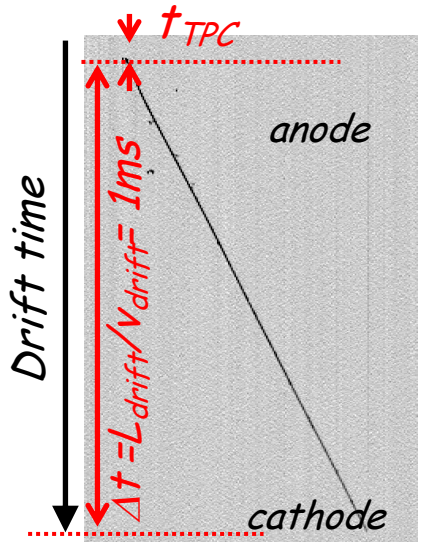
Initial Trigger System Activation

- ✓ Data collected by triggering on the BNB extraction signal (gated-BES) in East cryostat used to check the timing/read-out of both TPC and PMTs signals and the PMT timing w.r.t. the gated-BES signal, a prerequisite for the trigger deployment.
- ✓ Anode-to-cathode cosmic μ tracks with unambiguously measured crossing time in the TPC image t_{TPC} have been found to match the corresponding time of PMT light signal t_{PMT}.

Clear ~2 μs peak in $t_{TPC} - t_{PMT}$ confirming the correct relative TPC - PMT timing.

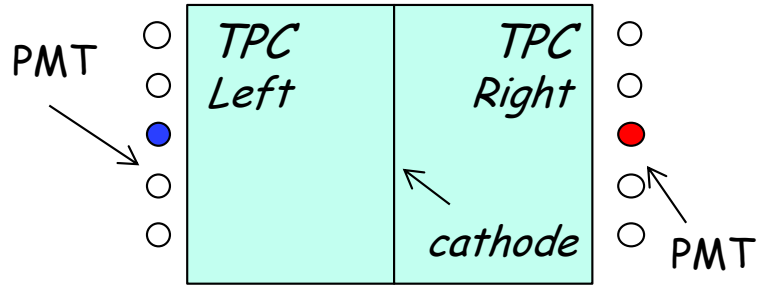


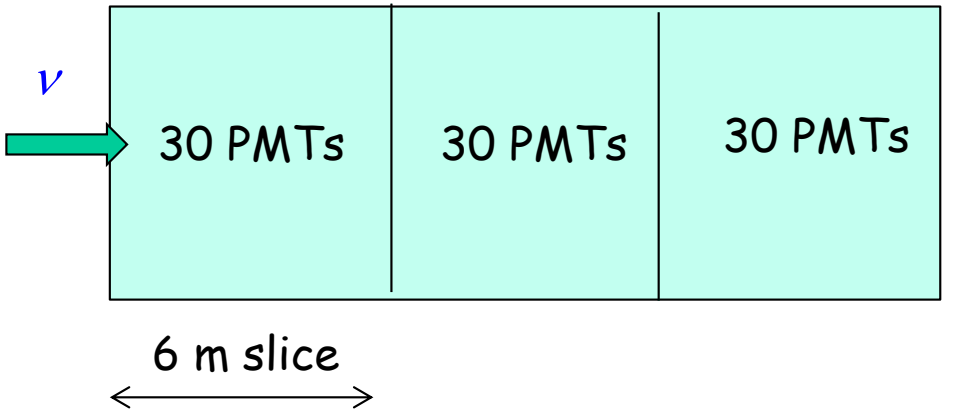
Anode to cathode μ track



Present Trigger System Status and Next Steps

- ✓ After completing the commissioning of timing/read-out of both TPC and PMTs signals w.r.t. the beam spill, a trigger logic based on a fired PMT majority in coincidence with the BNB extraction will be implemented in the East cryostat:
  - ✓ Measurement of multiplicity/rate for 30 PMTs in 6 m detector slice in one TPC wall as a function of PMT threshold.
  - ✓ Production of a trigger signal by PMT majority inside one 6 m slice in coincidence with BNB beam spill.
  - ✓ Extension of the PMT majority logic to 2 others 6 m detector slices of East cryostat and then similarly for the WEST cryostat.

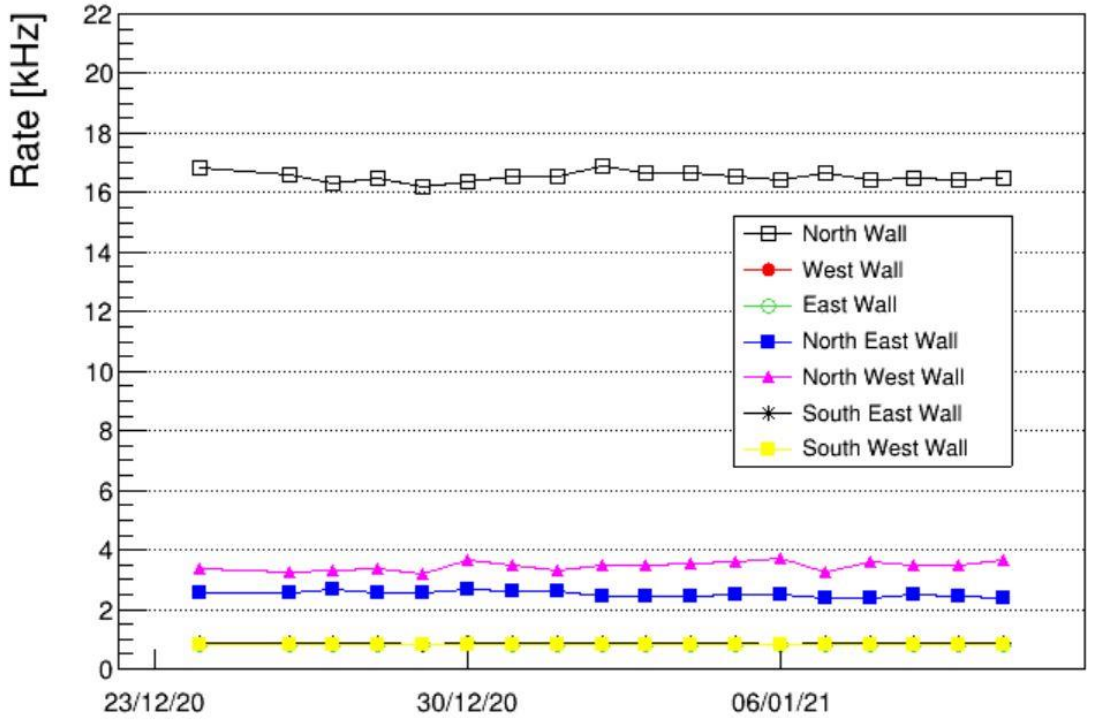




- ✓ This procedure would allow also recognizing first neutrino interactions in ICARUS with just few hours data taking with the EAST T300 module.

Additional Commissioning Updates

- ✓ **PMT** commissioning.
  - ✓ Recording of counting rates for different threshold and logic combination of PMT digital signal, for trigger application.
  - ✓ Data taking with several configurations of the PMT acquisition window, for studying synchronization with the TPC.
  - ✓ Data taking with laser to improve timing equalization.
  - ✓ Upgrades of the PMT slow control system.
- ✓ **CRT** commissioning.
  - ✓ Available CRT walls included in standard data taking.
  - ✓ North wall higher noise under investigation, probably related to cryogenic equipment.



CRT rate with cosmic rays

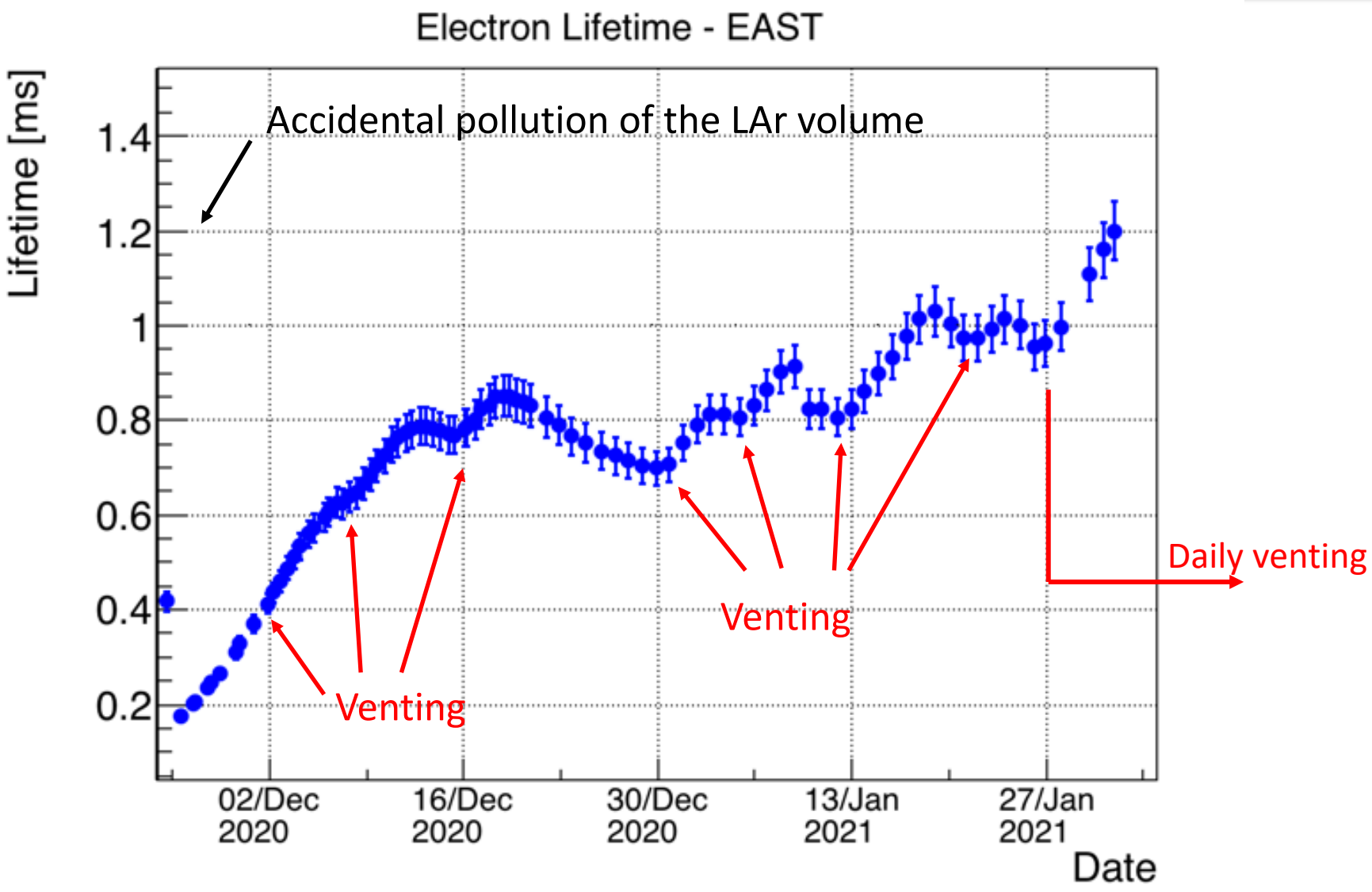
Cryogenics and Purification: Present Status

- ✓ The cryogenic and purification systems remain stable with a free electrons lifetime in both modules ≈ 1 ms.
- ✓ An accidental pollution of the East module occurred on November 23, resulting in a decrease of the free electrons lifetime to about 200 µs. The lifetime was restored, thanks to the recirculation systems, and is presently back to ≈ 1 ms.
- ✓ The two gas recirculation filters of the West module were regenerated during the month of November 2020.
  - ✓ No significant improvement of the lifetime was observed after the regeneration of the filters.
- ✓ There was an attempt to increase the gas recirculation rate by increasing the LN2 temperature in the cold shields. However, due to the non-functionality of the South-East gas recirculation unit, we had to stop such an attempt. The gas recirculation rate, in both modules, has been slowly decreasing in the past 2 months.
- ✓ The purity was maintained stable by venting the two modules every 3 or 4 days for 30 minutes. Since last week venting is being performed daily, for a reduced amount of time (10 minutes). As a result, the lifetime is presently increasing.
- ✓ To achieve functionality, the South-East gas recirculation unit has been modified. The filter has been activated and re-installed. The unit is presently under vacuum pumping and it will be put into operation next week.
  - ✓ Once the South-East recirculation unit will be in steady operation, also the filter of the North-East unit will be regenerated.

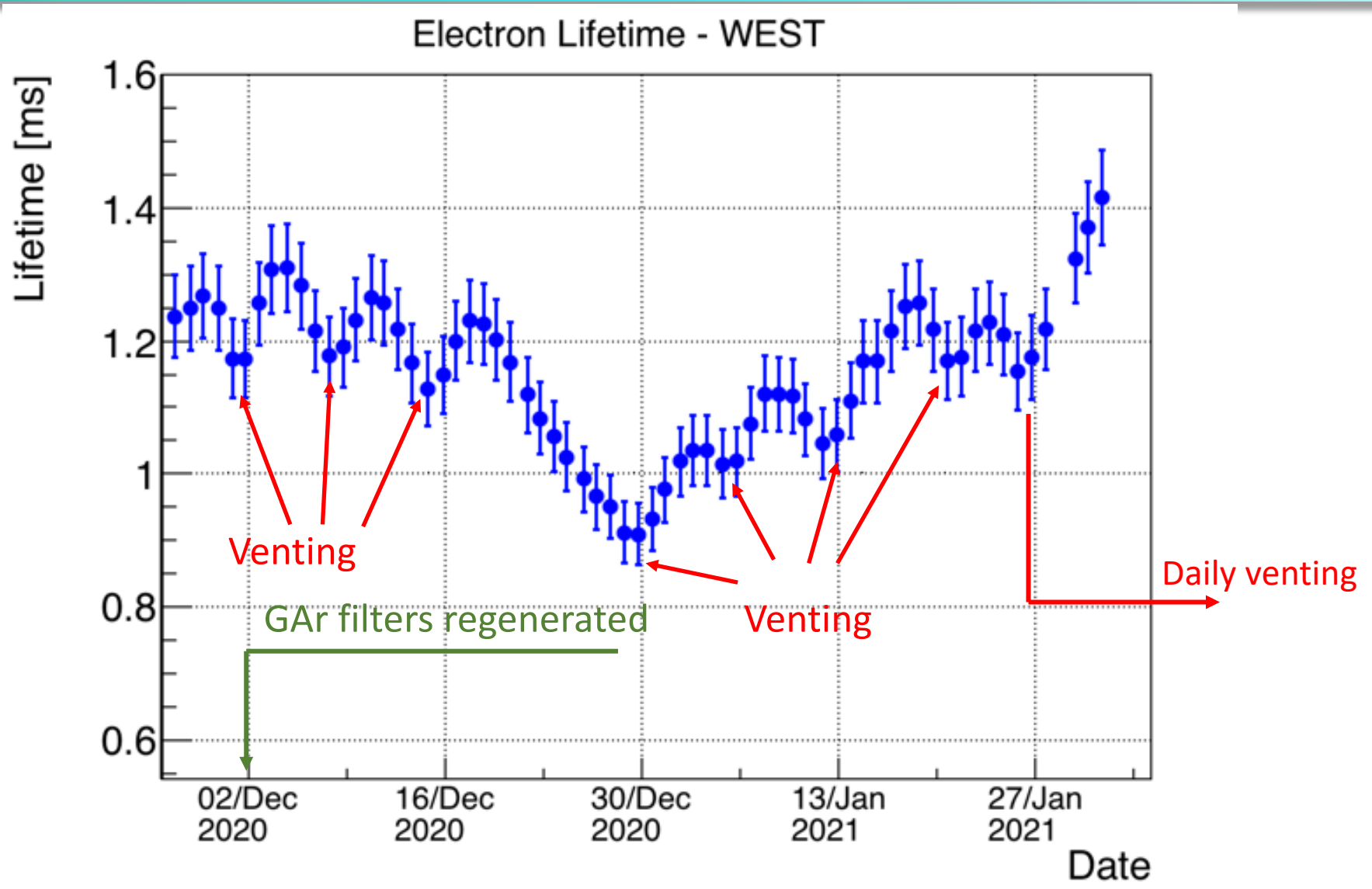
Cryogenics and Purification: Present Status and Next Steps

- ✓ New filters, to be added to the gas recirculation units to increase the filtering capacity, have been designed. Drawings have been transmitted to the Cern group for production. Components are under procurement. The cartridges should be ready for delivery at FNAL around the end of the month. In parallel the modification of the GAr collectors piping will be designed and planned.
- ✓ The East module's liquid recirculation pump has been maintained. It will be put back in operation later, today.
- ✓ As soon as the North-East GAr recirculation unit will be put back into operation, after regeneration of the filter, the cryogenic system will be stabilized.
- ✓ Re-fill of the two modules is planned to top the liquid level after the losses due to the periodic venting (between 1 and 2 cm of liquid (0.25% to 0.5%) has been lost in 4 months, due to periodic venting).
- ✓ A test will be performed with a continuous venting for at least 2 days to verify that the purity can be taken above the minimum design value of 3 ms (simulate an increased GAr recirculation rate).
- ✓ If the above step will be successful, the temperature of the cold shields will be progressively increased to maximize the GAr recirculation rate.

Purity in the East Module

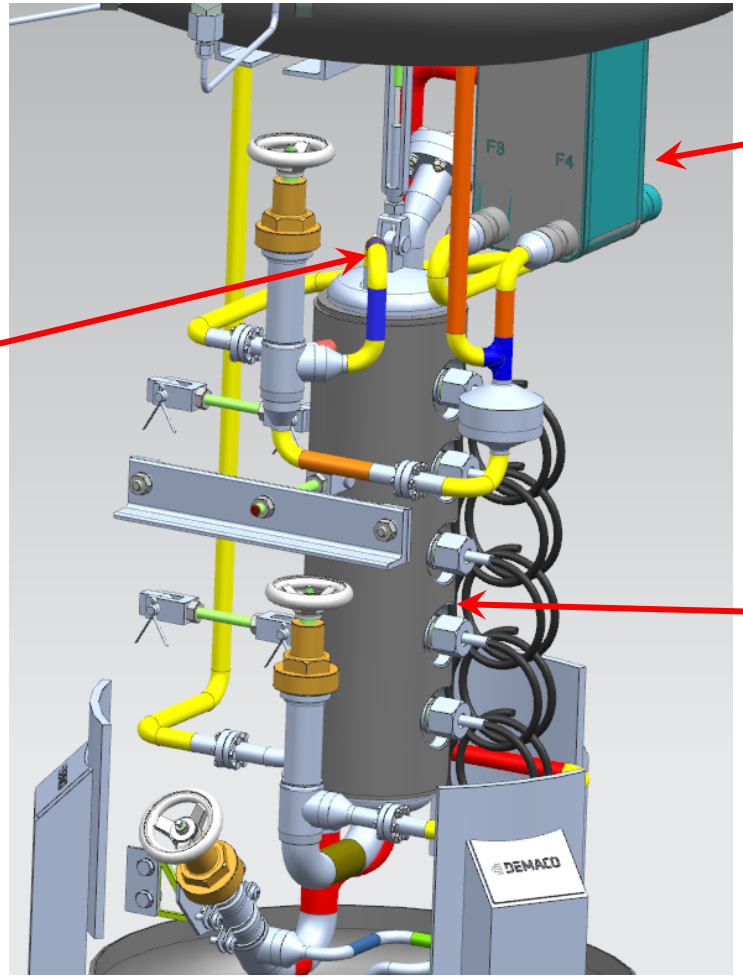


Purity in the West Module



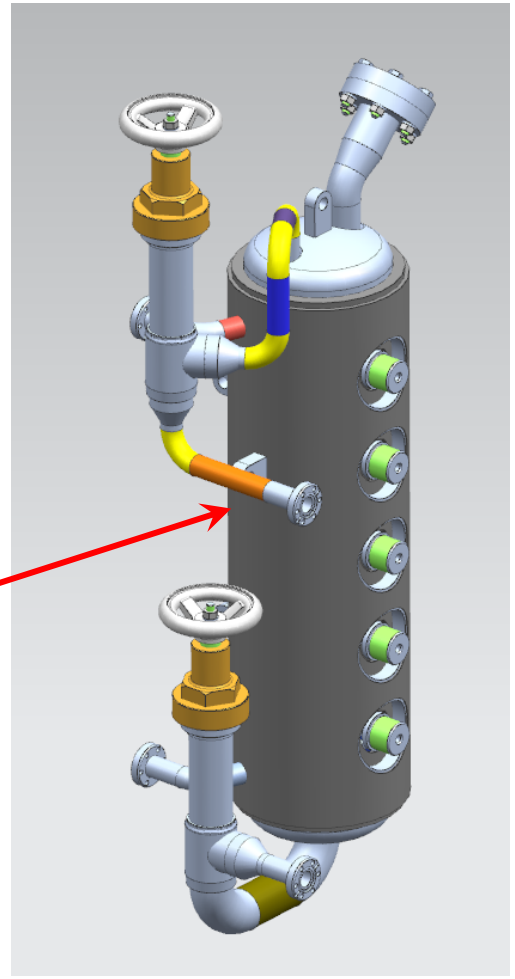
Modification of the South-East GAr recirculation unit

Gooseneck (gas lock preventing recirculation)



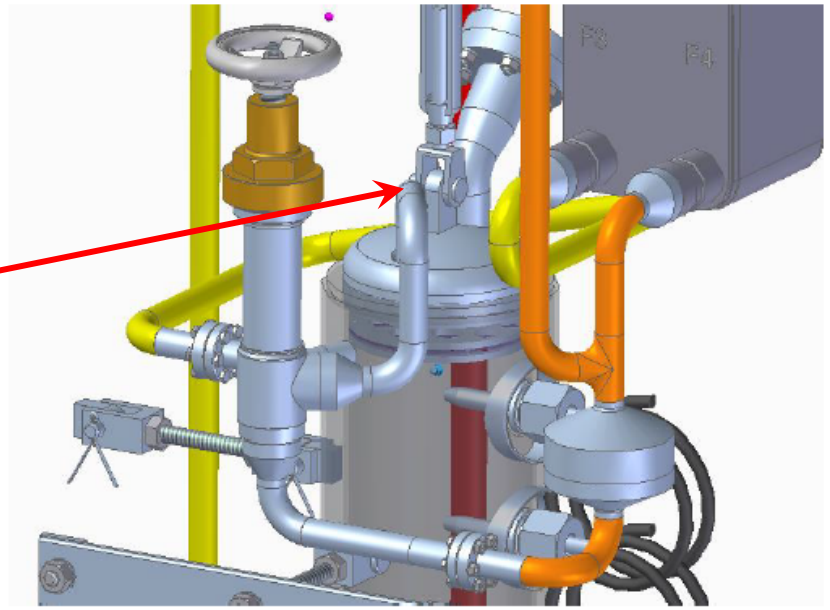
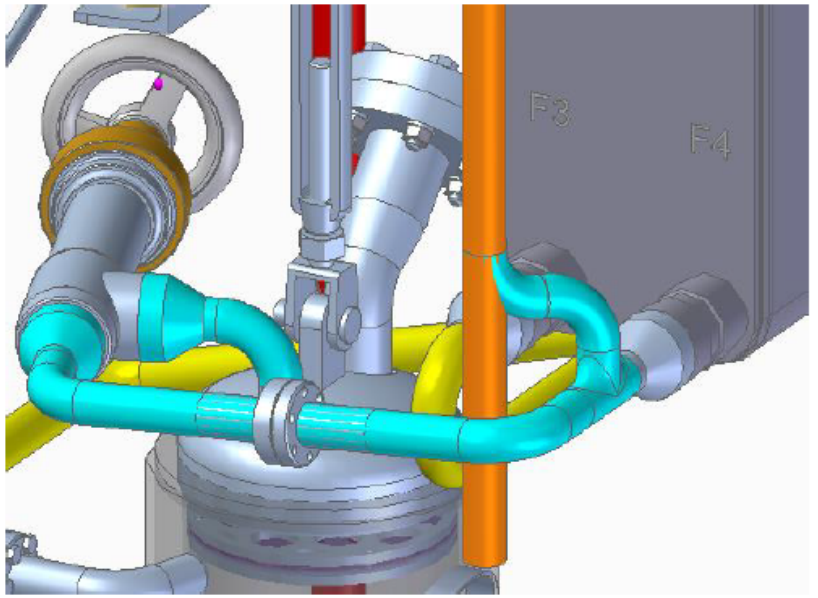
Heat exchanger (LAr re-condenser)

Filter cartridge



Modification of the South-East GAr recirculation unit

Gooseneck (gas lock preventing recirculation)

Present design	Modified design (modification ongoing)
	
Orange piping represents the original (and built) piping routing from the Heat Exchanger F4 Interface to the Argon Filter Vessel.	*Cyan piping shows the modified design of the piping routing connecting the Heat Exchanger F4 Interface to the Argon Filter Vessel. This design will be implemented in the NP-01-50-CB Valve Box after validation.*