

Power over fiber in 50L cryostat

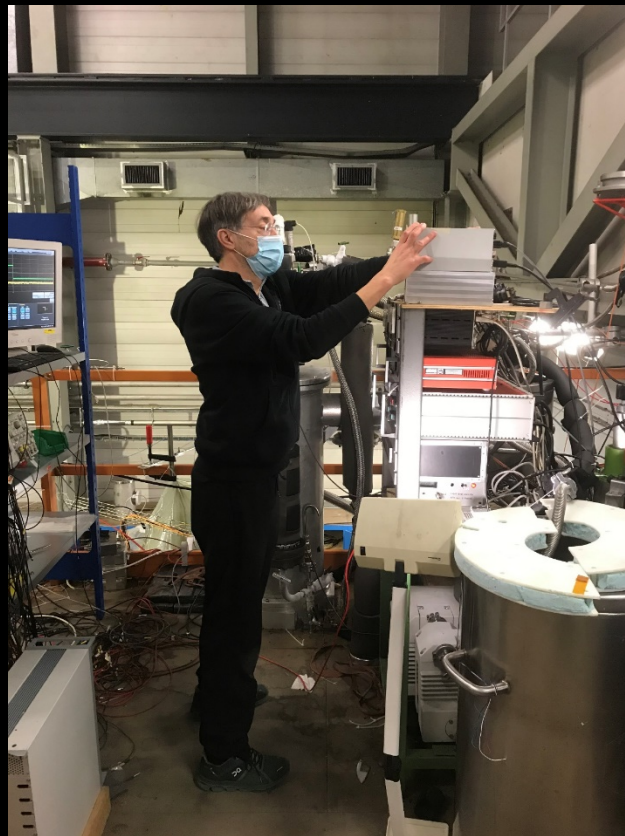
21-22 December 2020

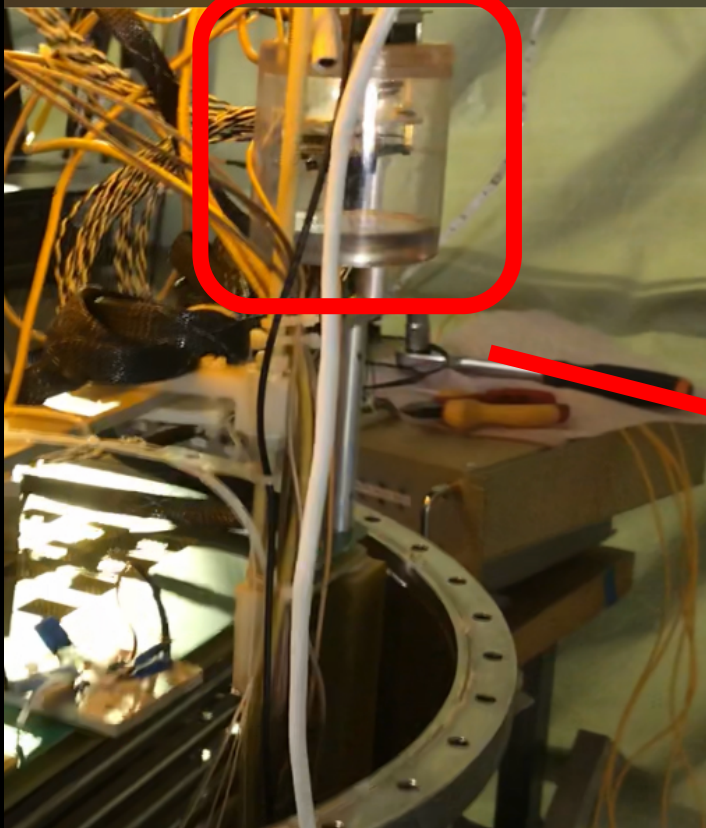
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What is done:

- **December 16 – 18: Cryostat prepared for the test and vacuum started (see previous slides circulated on Friday, December 18)**
- **December 21:**
 - **cooling started around 11:00**
 - **Filling cryostat with liquid argon started around 12:00**
 - **Checking the noise on TPC charge readout**
 - **Checking PoF units**
- **December 22:**
 - **More tests with PoF units**
 - **Noise study with TPC**
 - **Stop the test**
- **December 23:**
 - **Open the cryostat for further investigations**

Cooling and filling the 50L-cryostat





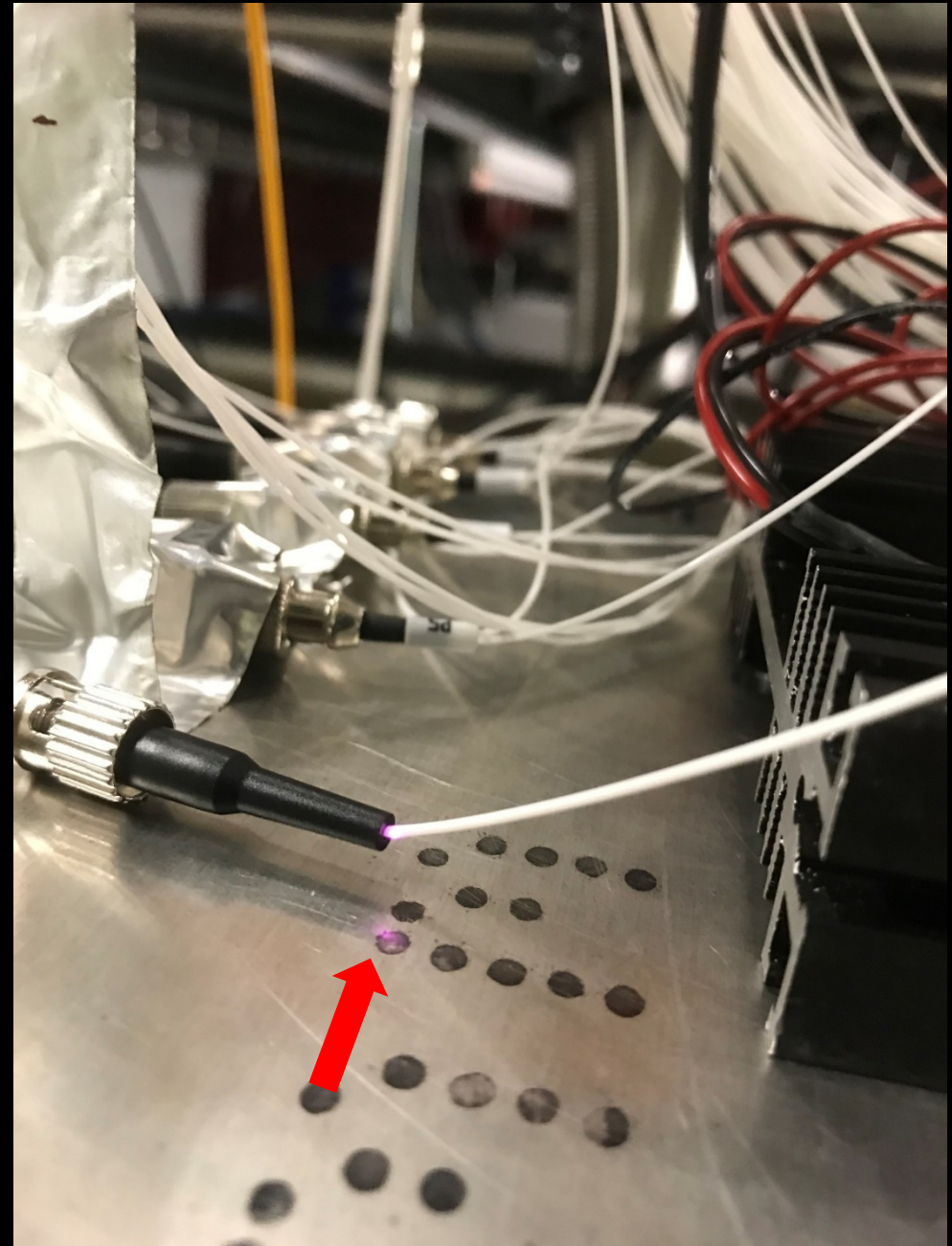
- During cooling stage, some noise comes from the cryostat as if an object was moving and hitting hard to the cryostat wall.



- We found that plastic cover of the internal camera fell down and stuck at the top part of the field cage.

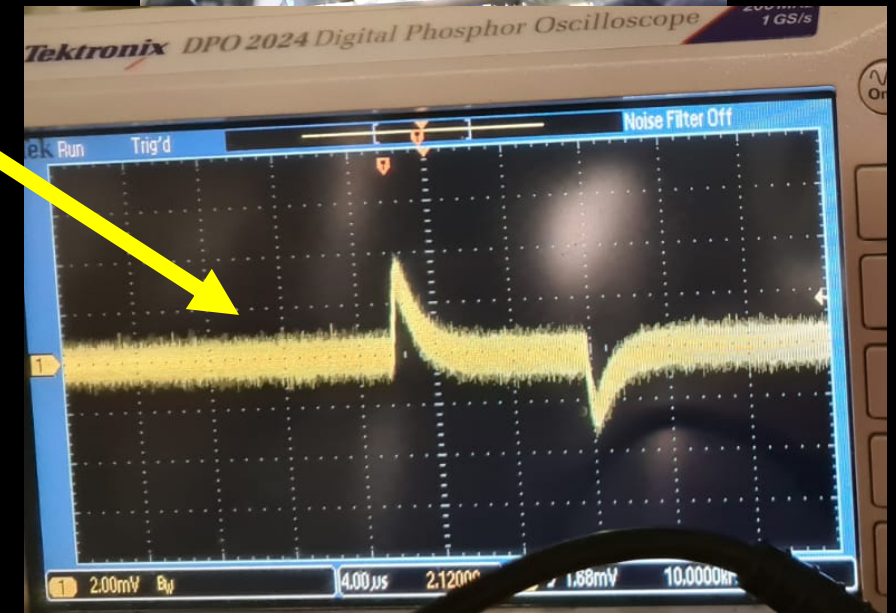
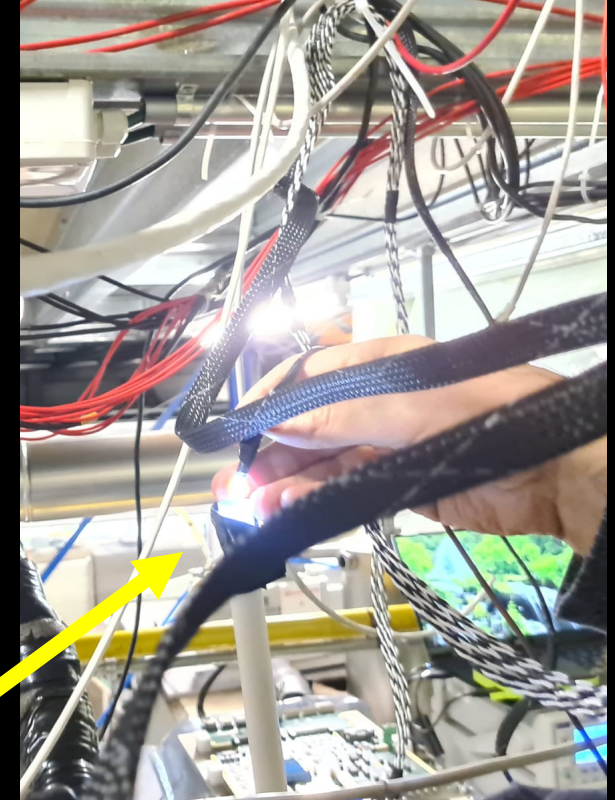
Checking the PoF units 1:

- We found the fiber of the 5W-laser diode got broken! (Friday was working without any problem)
- Replaced with spare one (thanks Xavier and CERN Fireman people)
- This laser diode is used together with 5V-DC-DC circuit. We read out ≥ 48 Volts from feedback cable.
- One VUV type SiPM array is used in SiPM board. We could not get any signals from the SiPM. We found that the signal cable malfunctioned (to be investigated once we open the dewar).



Checking the PoF units 2:

- Fermilab PoF units, **4-PPC in series** with **360 Ohm setting resistance**, we read out **48 Volts** from **feedback cable**.
- SiPM board has three VUV type SiPM arrays. We do not see any signal from SiPM both using self and external trigger (**coincidence of two scintillator slabs located on the left/right side of cryostat, they also move to the top of the cryostat to check with vertical muons**).
- We try to inject pulsed LED light via fiber installed on the cryostat. With high intensity we start to see signal from SiPM array!
- **Why do not we see argon scintillation light? (we will discuss this question in coming slides)**
 - VUV-SiPM has photon detection efficiency of **15% to LAr** and **23% to LXe** and **~40% to visible light**

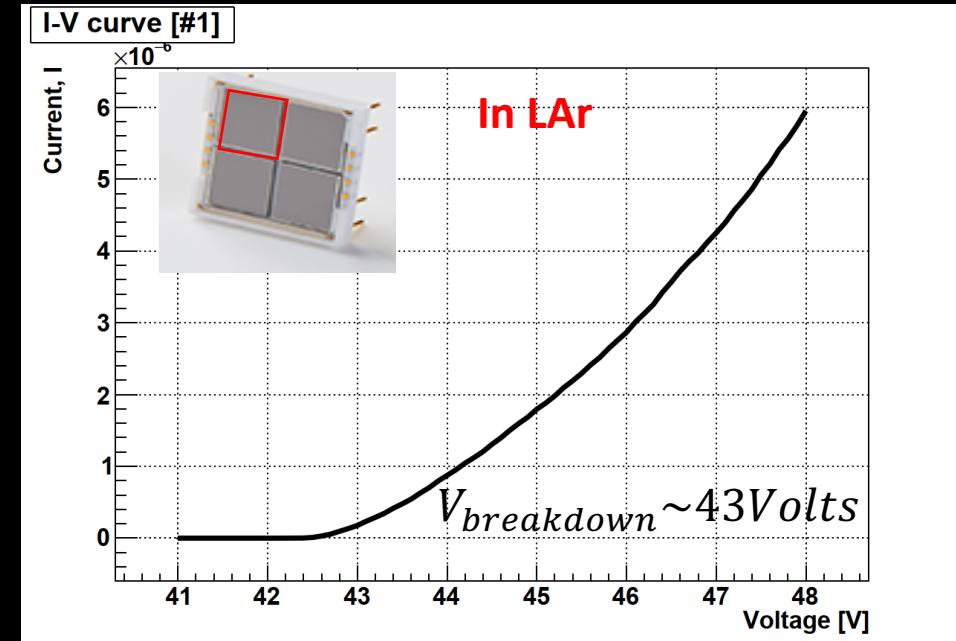
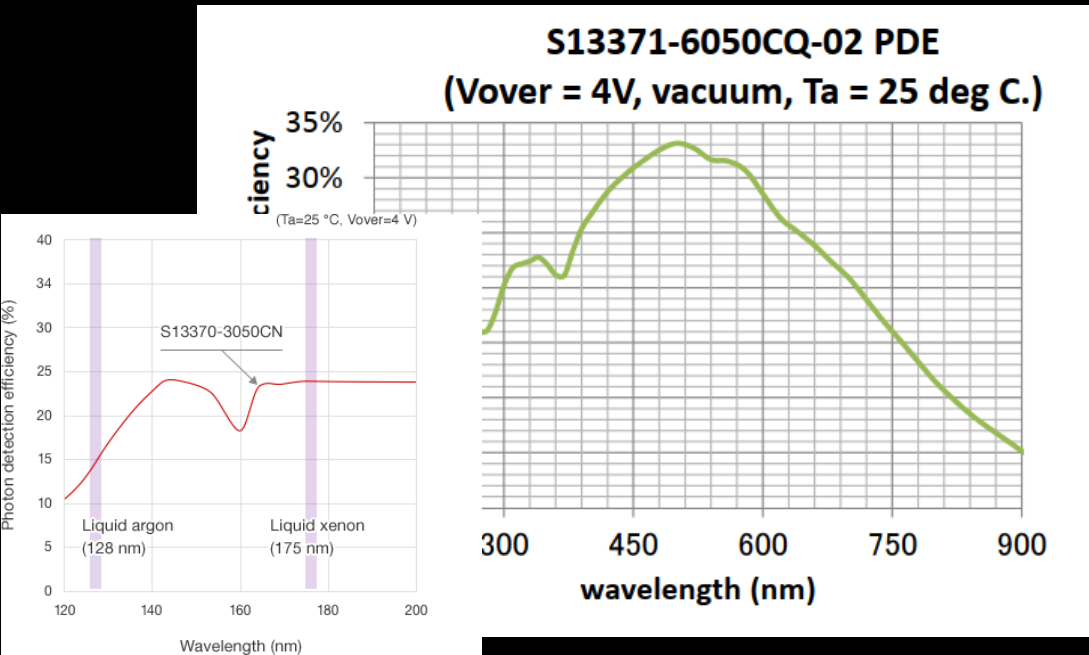


Checking the PoF units 3:

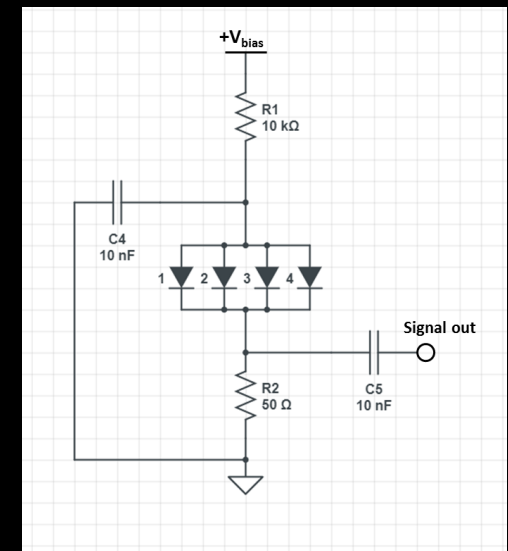
- 1-PPC from Fermilab PoF units connected to 12V-DC-DC circuit.
- **12V-DC-DC** converters requires input current of **15 mA with no load** → **~48 Volts output voltage** and **10mA output current**
- When we have tested the full system in open air dewar, using **1.2k Ω** setting resistors and **PPC#5** from Fermilab PoF units, we could get **~47 Volts** of output voltage from **12V-DC-DC circuit**. We had **11.6 Volts** from PPC#5 as an input to 12V-DC-DC circuit. And in all test, the DC-DC circuit was floating in terms of grounding.
- From test in 50L, using the same settings, we could get maximum **output voltage of 11.4 Volts from PPC#5** and **38 Volts from 12V-DC-DC converter!**
- **Are we loosing some power inside the cryostat? (we will discuss this question in coming slides)**

Reminder on SiPM arrays:

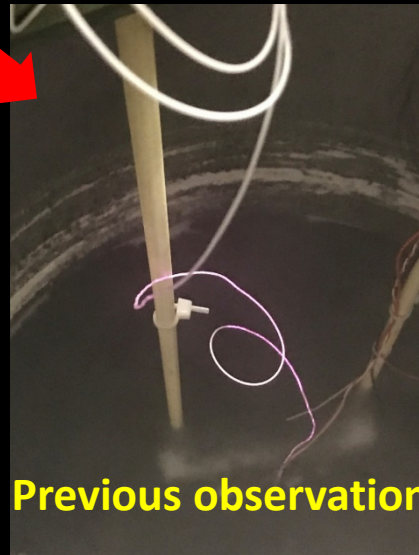
Photon detection efficiency



- We use LAr and LXe sensitive VUV4-SiPM arrays in the tests
- We have measured **break down voltage of ~ 43 Volts** in liquid argon
- We need to get an output voltage of 46 to 48 Volts from power over fiber units to bias the SiPM arrays $V_{operating} = V_{breakdown} + 5V \sim 48 \text{ Volts}$
- SiPM circuit board: signal pulse readout with 10nF capacitor
 - Grounded to the cryostat

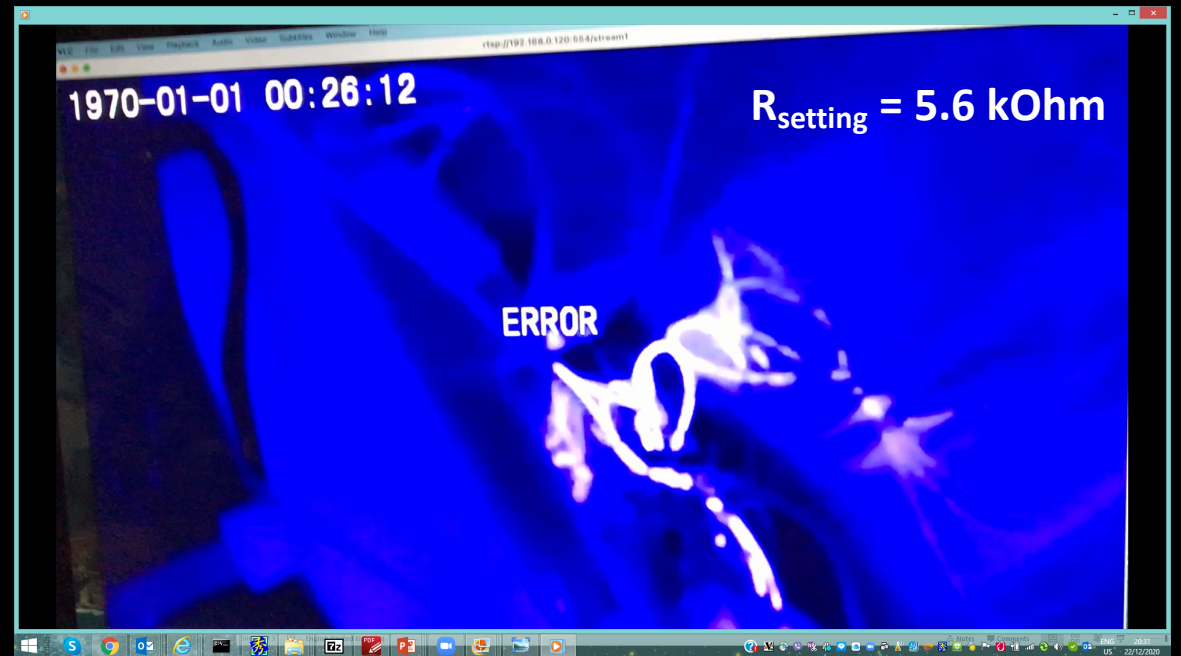


- Thanks to the presence of internal camera and its functionality at absence of its cover, we found that the **light is diffusing out along the surface of the extension fibers** (thin white fibers).
- Changing the setting resistors, the brightness of the light increased.
- Such a diffusion of the light along the fiber has been seen with 2.5W laser diode used w/ DC-DC circuit in LAr. It had a major impact on powering 5V-DC-DC converter which needs 20mA input currents.



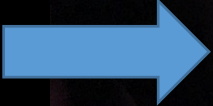
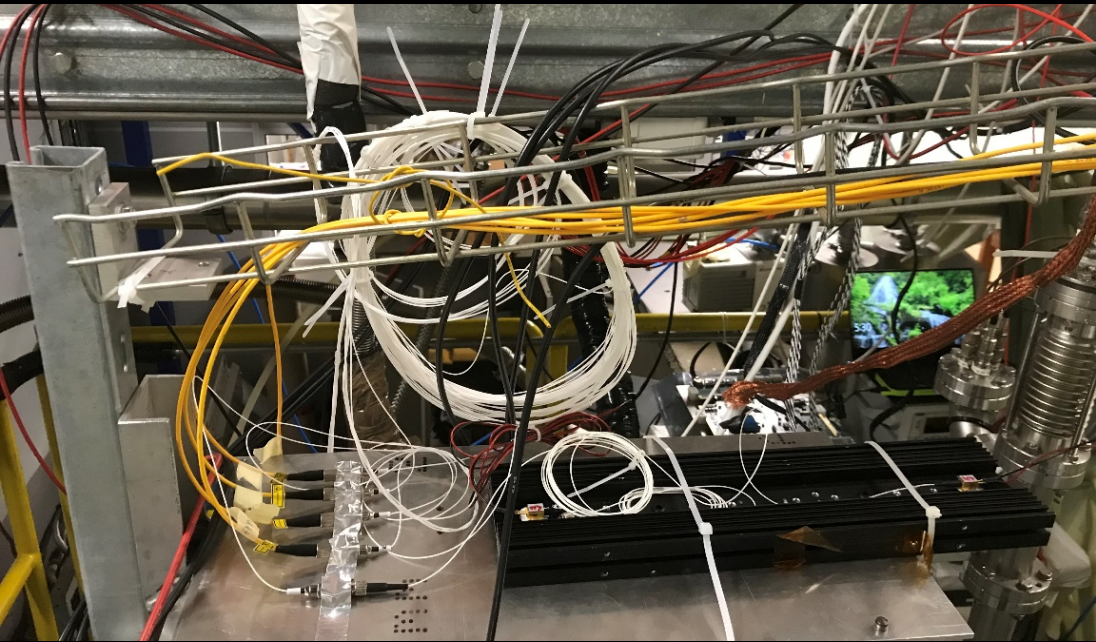
- We had the same test with extension fibers in open air dewar. It was only check by eye so no diffused light we have seen.





See more photos and movies in: <https://cernbox.cern.ch/index.php/s/Cy7jqtf082q0LuH>

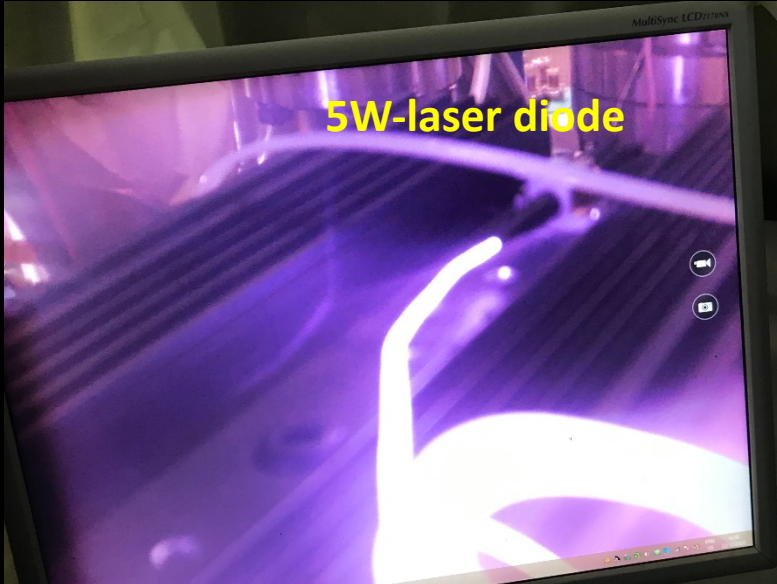
Looking with infrared camera to the fibers



Fermilab PoF



5W-laser diode



Summary on PoF units and SiPM signals:

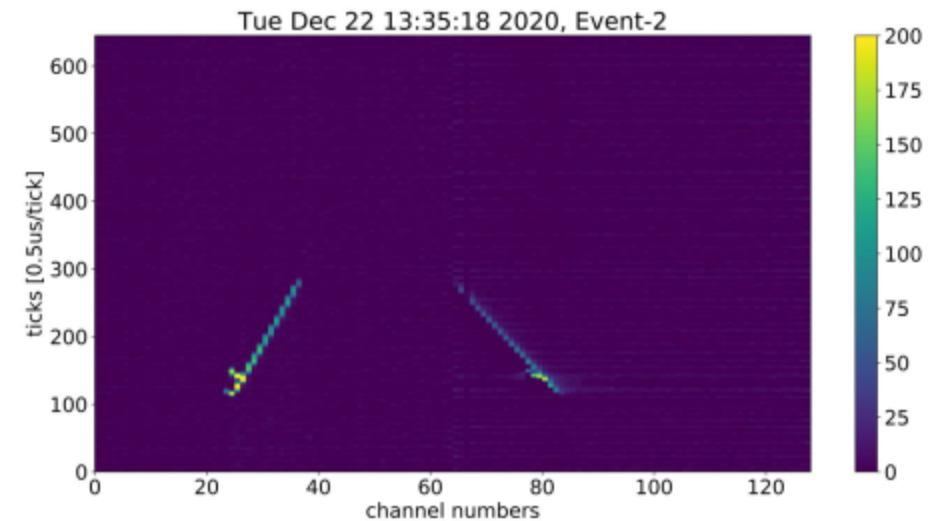
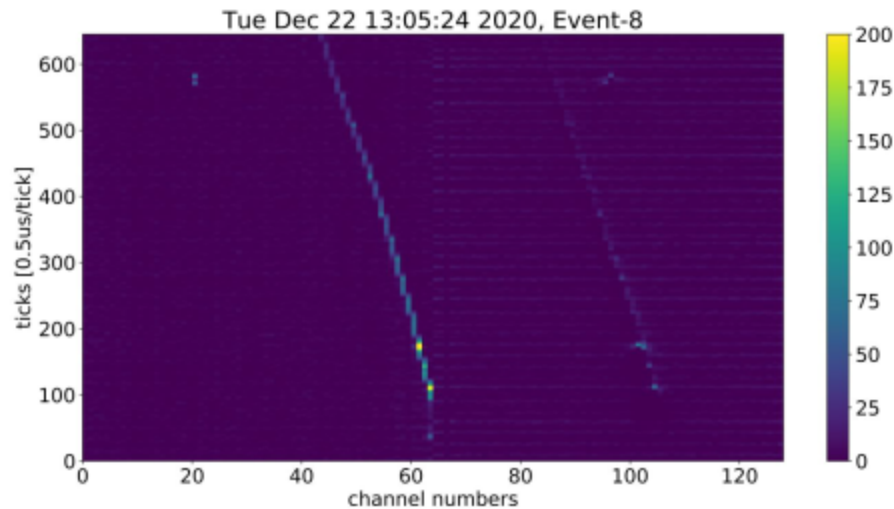
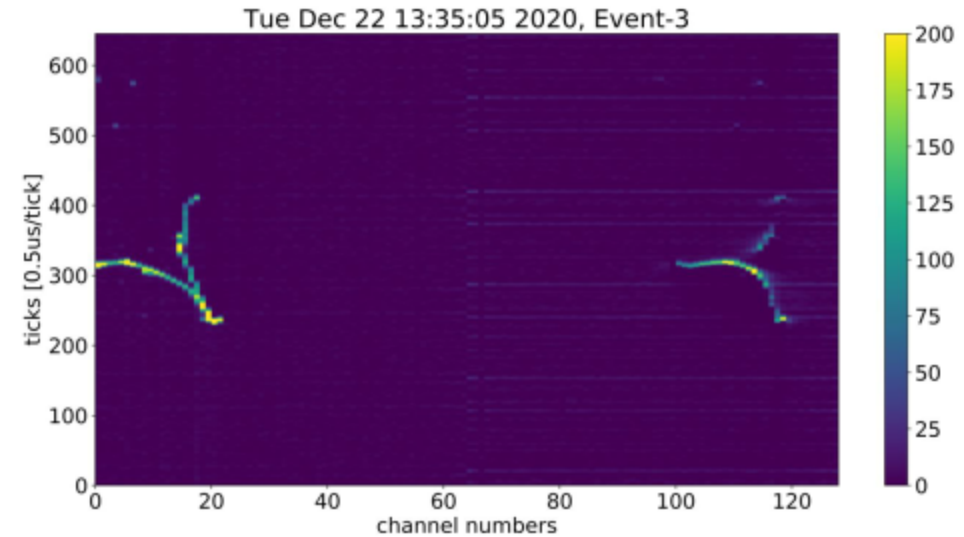
- We have installed three different options:
 - [1] Fermilab PoF unit with 4-PPC in series + SiPM board
 - [2] Fermilab PoF unit with 1-PPC + 12V-DC-DC circuits + SiPM board
 - [3] 5W-laser diode with 5V-DC-DC circuits + SiPM board
- We get the right voltage output from options [1] and [3], while we do not have enough power for [2]. Observing light diffusing out along the fibers could explain why we could not get right voltage output on [2].
- We could not see argon scintillation light on any SiPM arrays. We saw only on option [1] when we inject high intensity LED pulse. That could be due to continues current on the SiPM arrays due to diffused light from the fibers. (reminder: We have used yellow fibers for all the tests performed before 50L tests)
- Keep in mind that we do not have amplifier unit to amplify the signal. Most probably the signal is too small and could not see it. Some more study will be performed once the cryostat opened.
- On option [2] signals from SiPM not seen due to malfunction of signal cable (to be investigated)
- We do not see any issue on injecting noise from PoF to the charge readout (**see next slides for details**)

TPC noise study

- TPC worked w/ electric field of 500V/cm
- PCB with full transparency (setting induction to 0 V and collection to 2 kV)

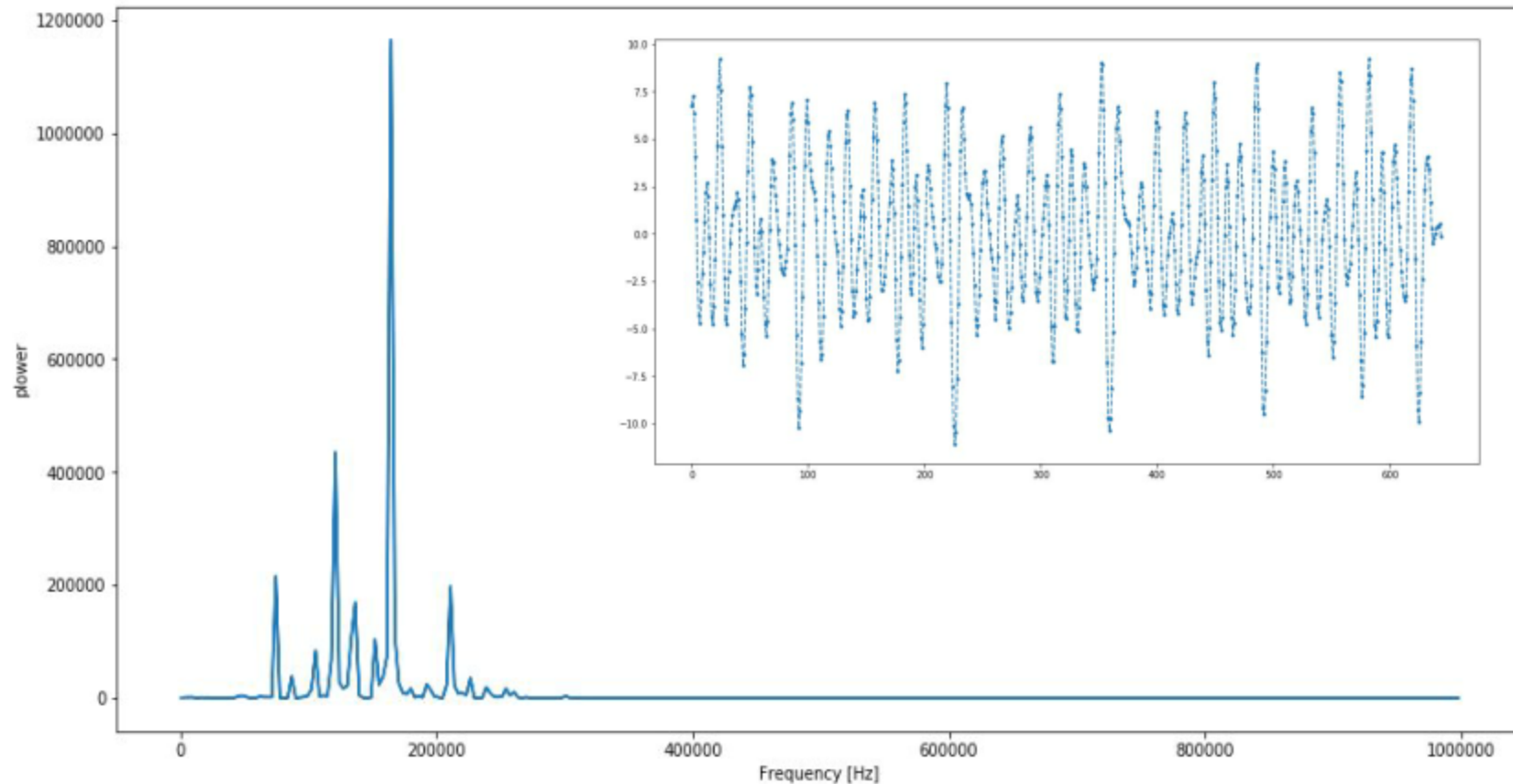
Overall summary on TPC

- Charge readout is working as expected
 - Took data with internal calibration pulse
 - Took data with external trigger using 2 scintillator pads coincidence
- Lower purity wrt previous data taking with 50L
- Higher noise levels wrt previous data taking
 - More visible on the induction plane

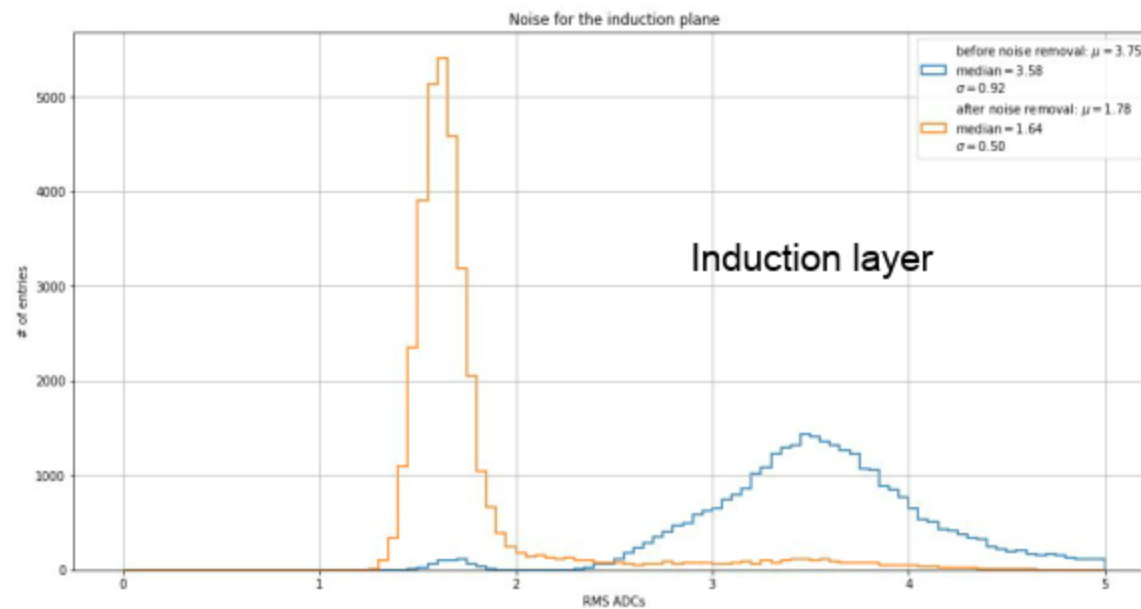
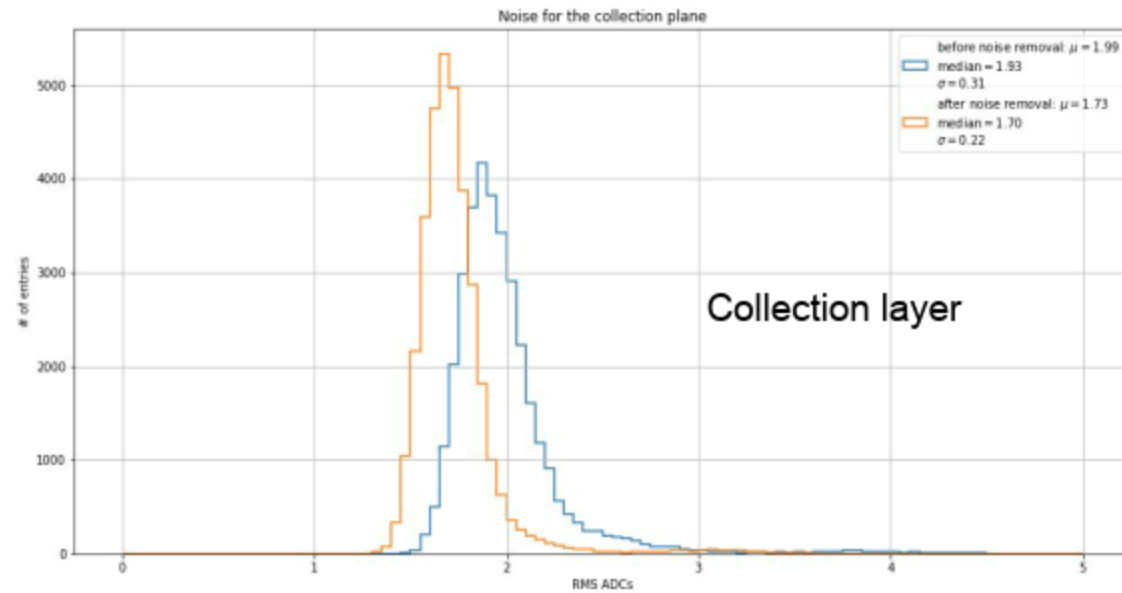


Noise levels

- Very quick and rough noise analysis..
 - Collection layer ~370e ENC
 - Induction layer ~700e ENC
- Most dominant noise at 17-18kHz

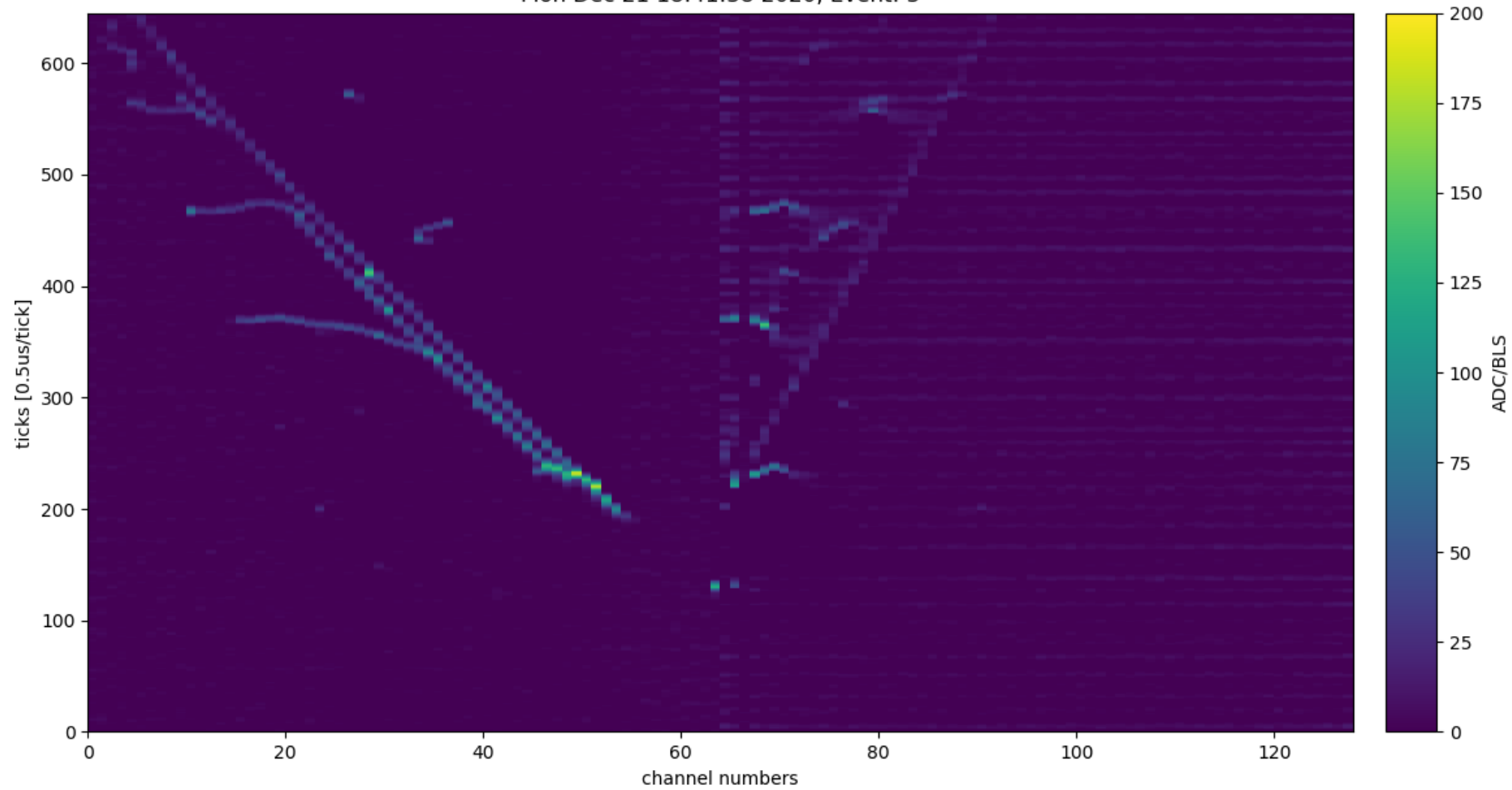


Coherent noise removal

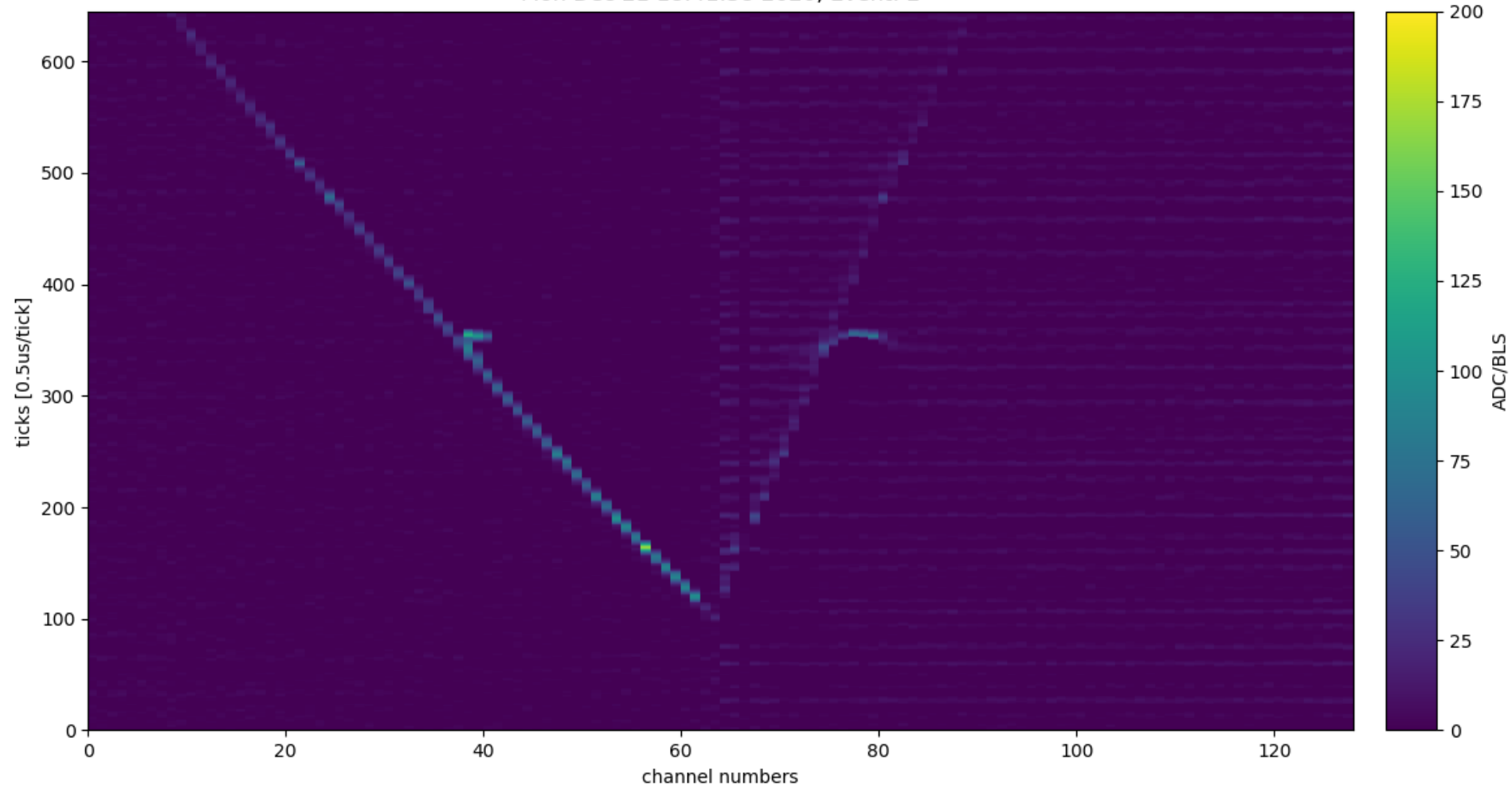


- Most of the noise can be removed by coherent noise removal
- After noise removal
 - 320-330e ENC on collection and induction layers
 - Similar to the ones we measured in the previous runs

Mon Dec 21 18:41:38 2020, Event: 3



Mon Dec 21 18:41:38 2020, Event: 2



Test stopped and cryostat moved into open space (22 December 2020)



Open the cryostat for further investigation of the found problems (23 December 2020)

