

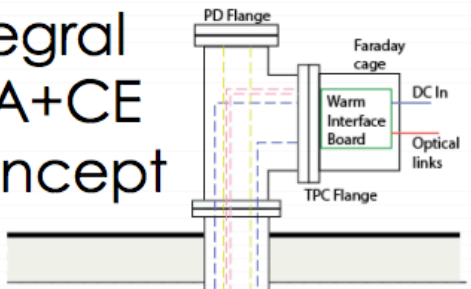
Cold Box TPC Readout Preliminary Results

Matthew Worcester (BNL)

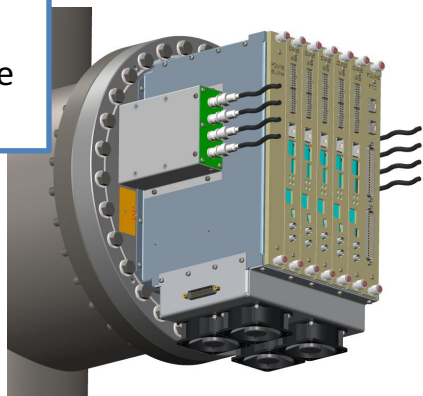
DUNE Collaboration Phone Call
December 8, 2017

protoDUNE-SP LArTPC Readout

Integral
APA+CE
Concept

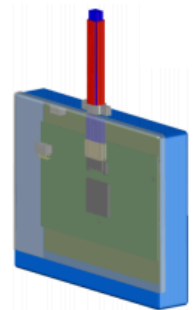
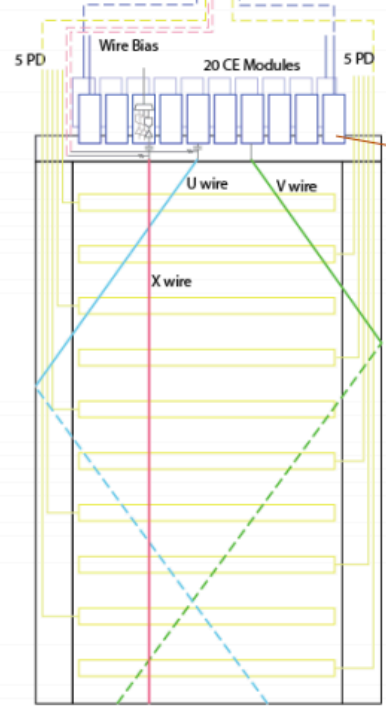


Warm Interface
Electronics Crate
(WIEC)

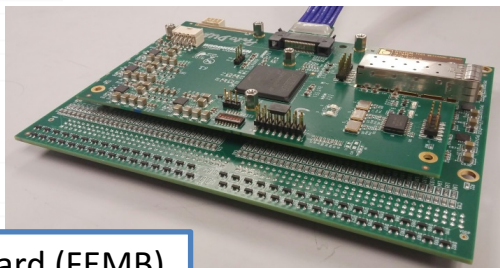


Each APA is isolated inside the cryostat and only connected to the detector ground through the CE at its own CE flange. Warm interface electronics provides real-time diagnostic readout.

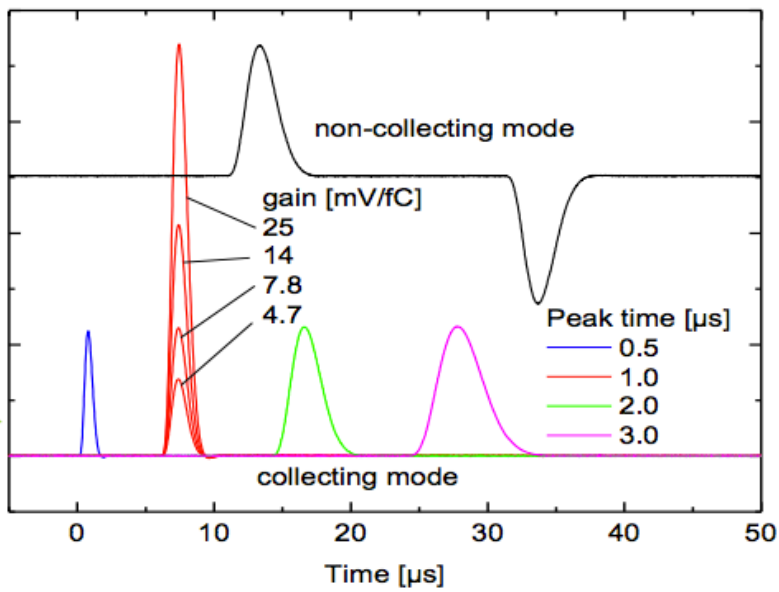
ProtoDUNE-SP



Amplitude [a.u.]



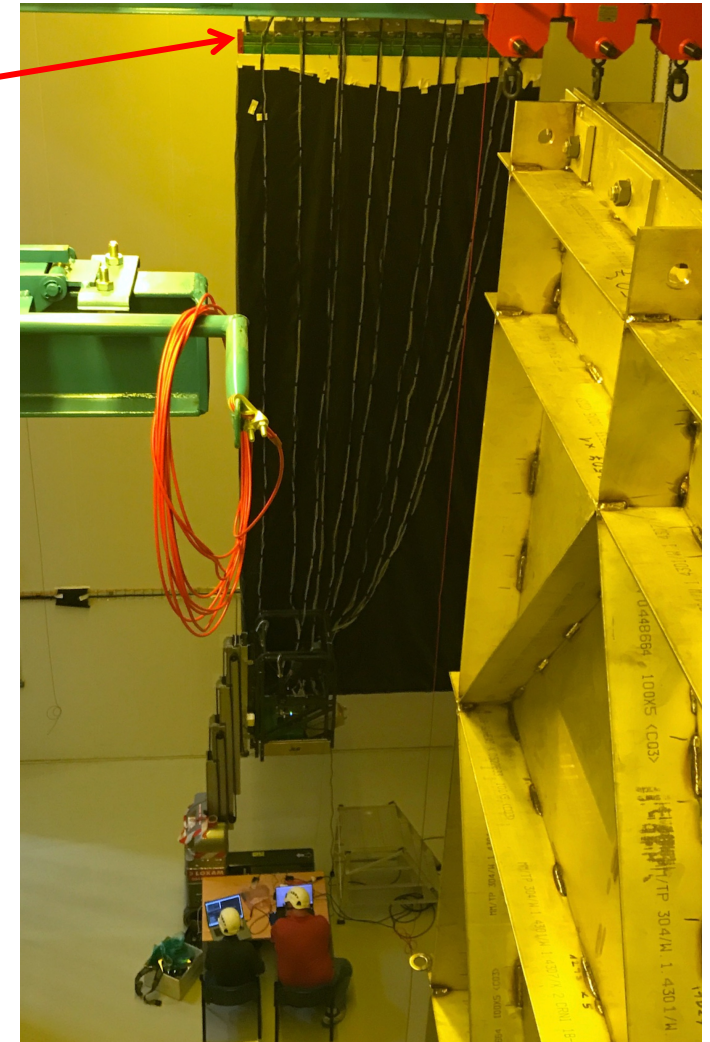
Front End Motherboard (FEMB)



Cold FE ASIC: 4 gains, 4 peaking times

protoDUNE-SP CE Installation

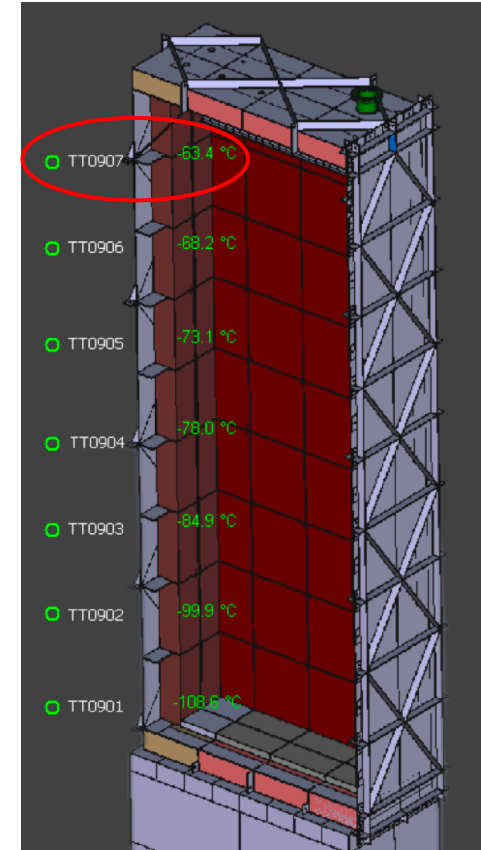
- 20 FEMB inside CE Box assemblies installed on the first APA @ CERN
- Check out test was done on all FEMBs in the week of September 4
 - Built-in electronics calibration circuit was used to characterize the readout electronics system
- **All 2,560 front end channels were confirmed to be 100% functioning well**
 - Only one front-end channel was not connected to APA properly from upstream of cold electronics



Manhong Zhao and Ken Sexton installing CE Box assemblies

Shanshan Gao and Jack Fried: check out tests

protoDUNE-SP Cold Box Test



APA1 moved into Cold Box on 10/13

12/8/17

Matthew Worcester (BNL)

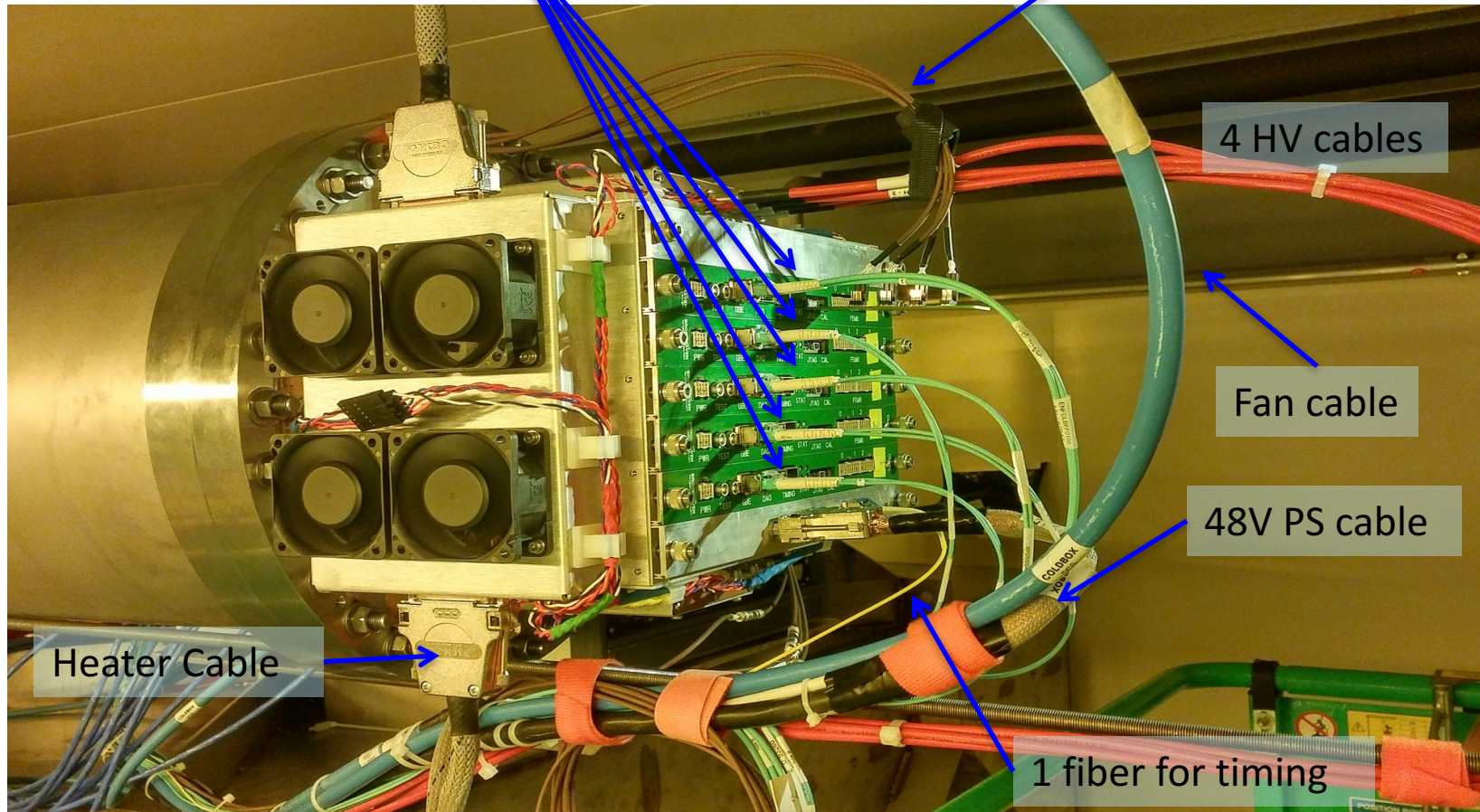
Temperature monitoring

- TT0907 sensor at top of cold box
- Internal FE ASIC temperature sensor is readout through a scope

WIEC

5 fibers for local diagnostic and slow control

4 FE temperature monitor cables

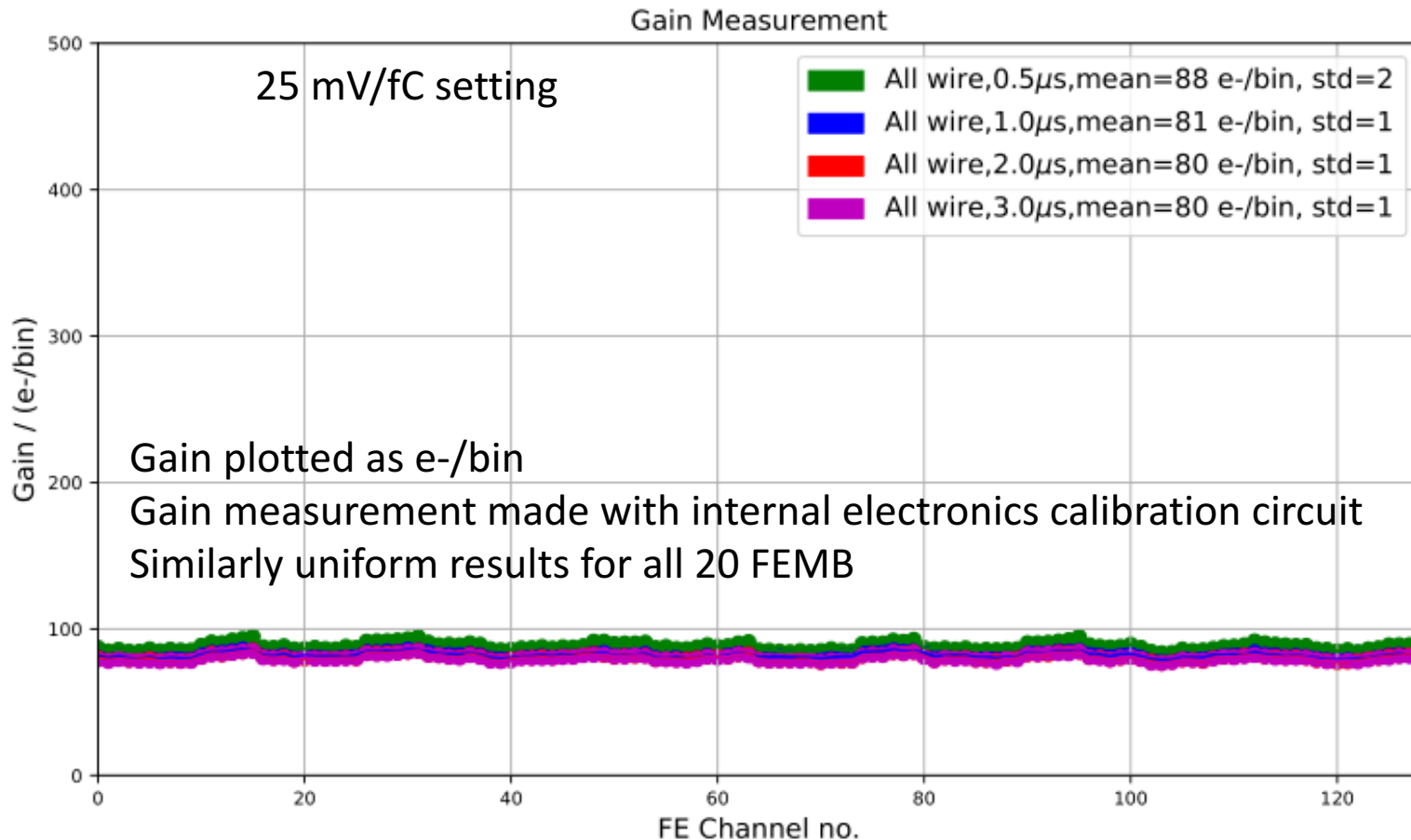


FEMB readout through optical links from **WIB** on top of the signal feed-through
Including real-time diagnostic readout:
Critical for understanding the performance of the Cold Box system

Gain in Cold Box at RT

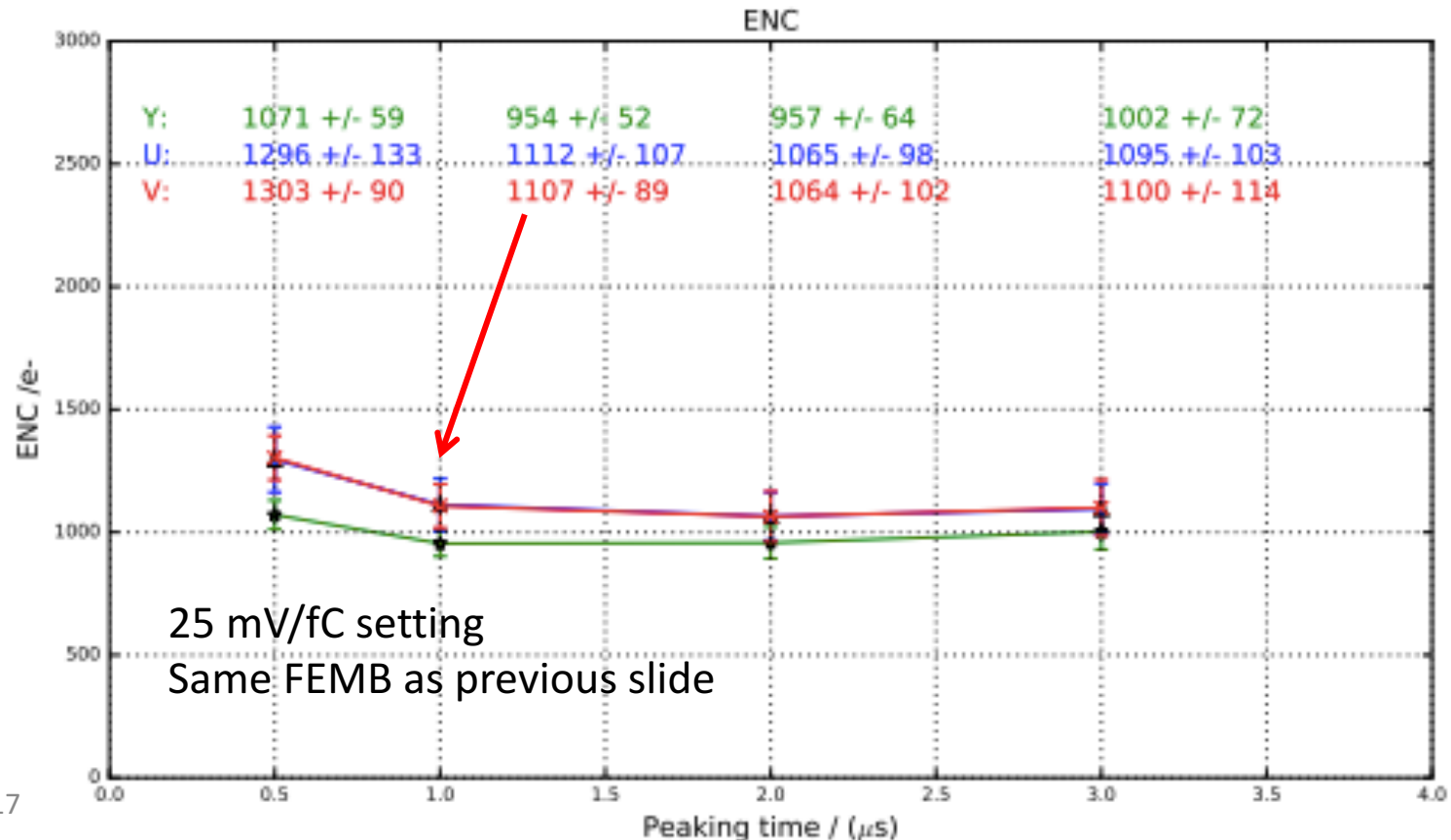
- FEMB + CE Box on APA B side

APA A side	11	12	13	14	15	16	17	18	19	20
APA B side	10	9	8	7	6	5	4	3	2	1

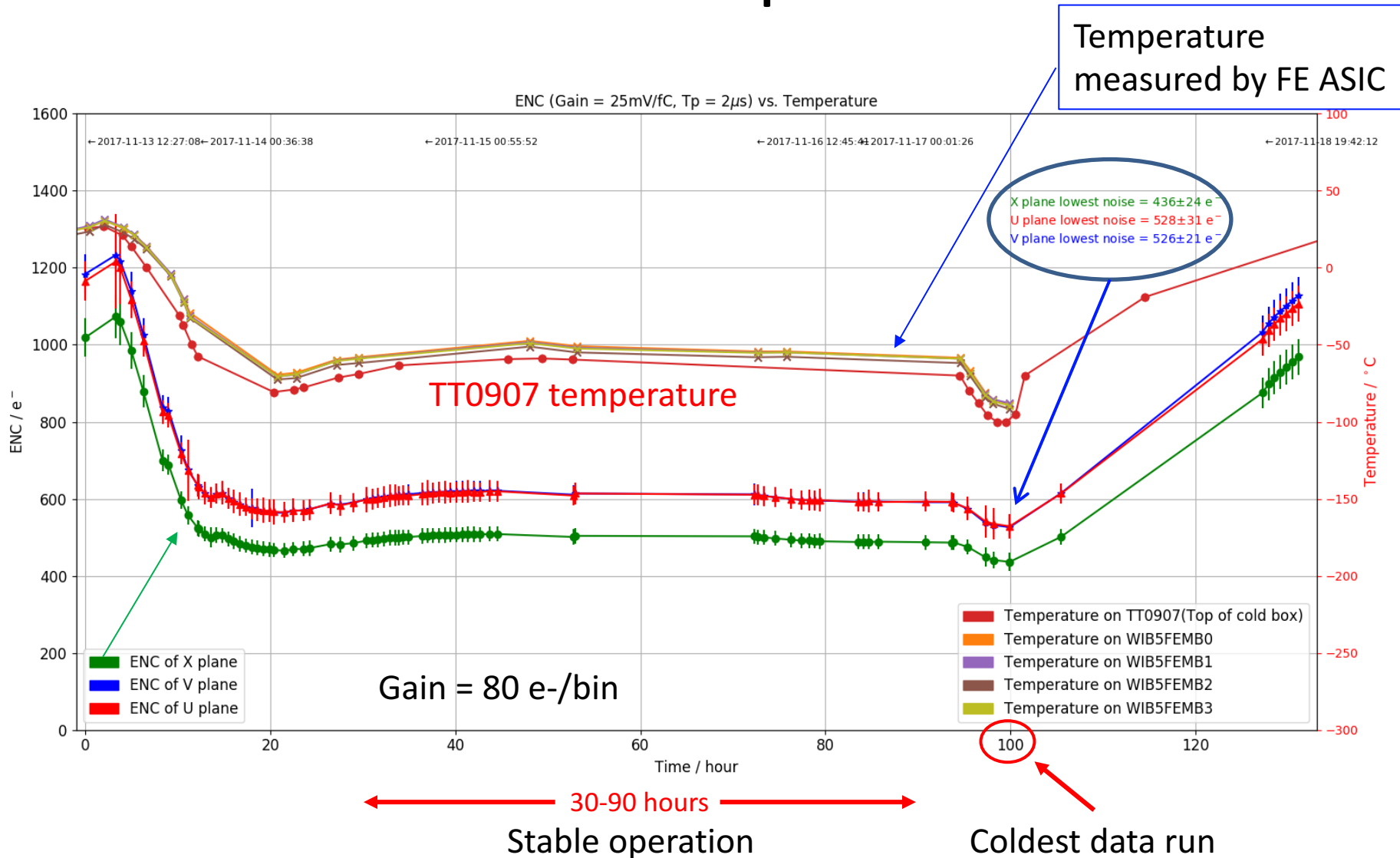


ENC in Cold Box at RT

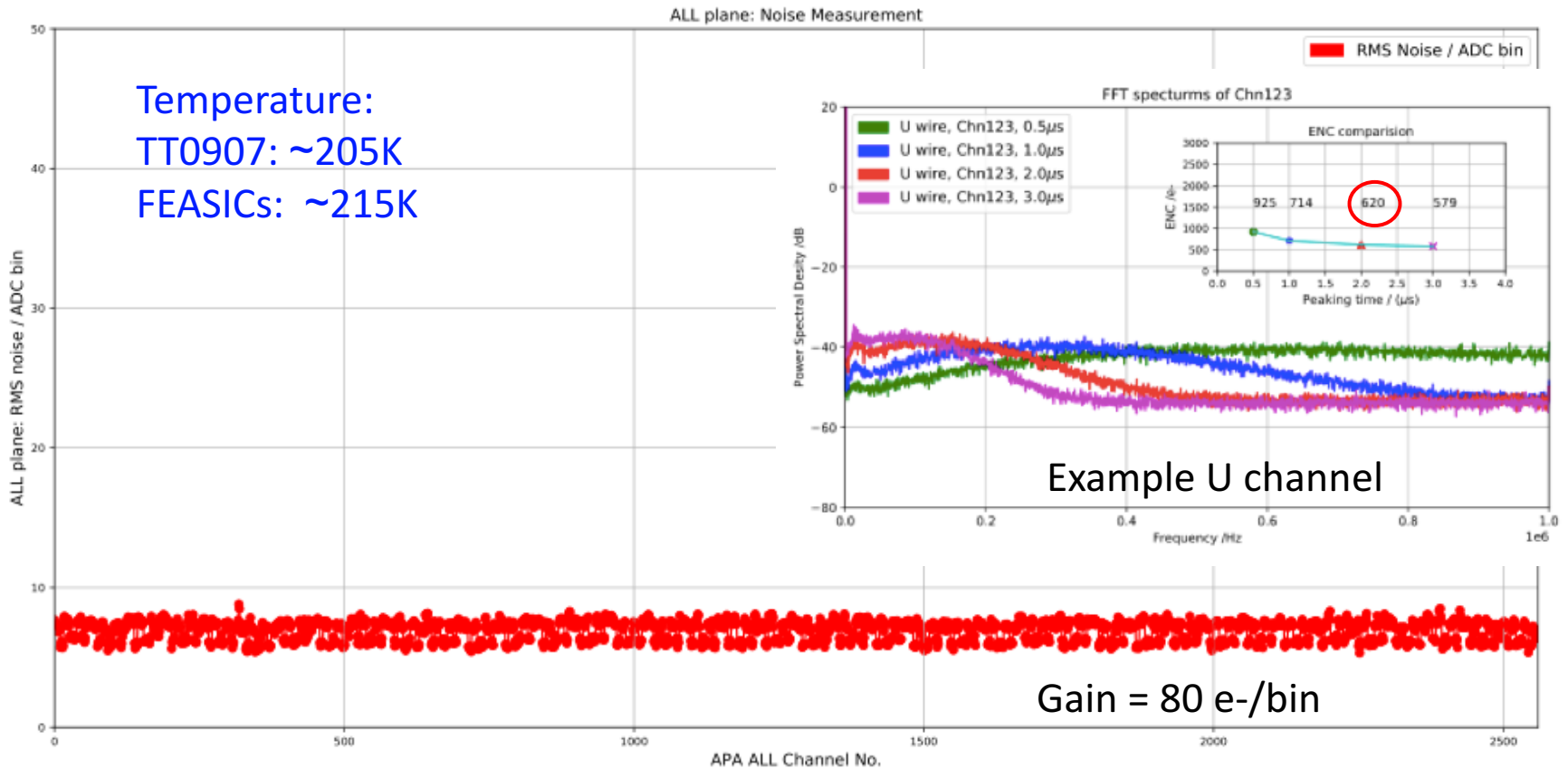
- ENC (Equivalent Noise Charge) is charge (in e-) injected across the detector capacitance which produces at the output of the shaping amplifier a signal whose amplitude equals the output RMS noise
- At 1 usec peaking time, the ENC on induction wires is measured at ~ 1100 e-, for comparison, the smallest charge on a DUNE wire from a MIP is $\sim 11,000$ e-



ENC and Temperature

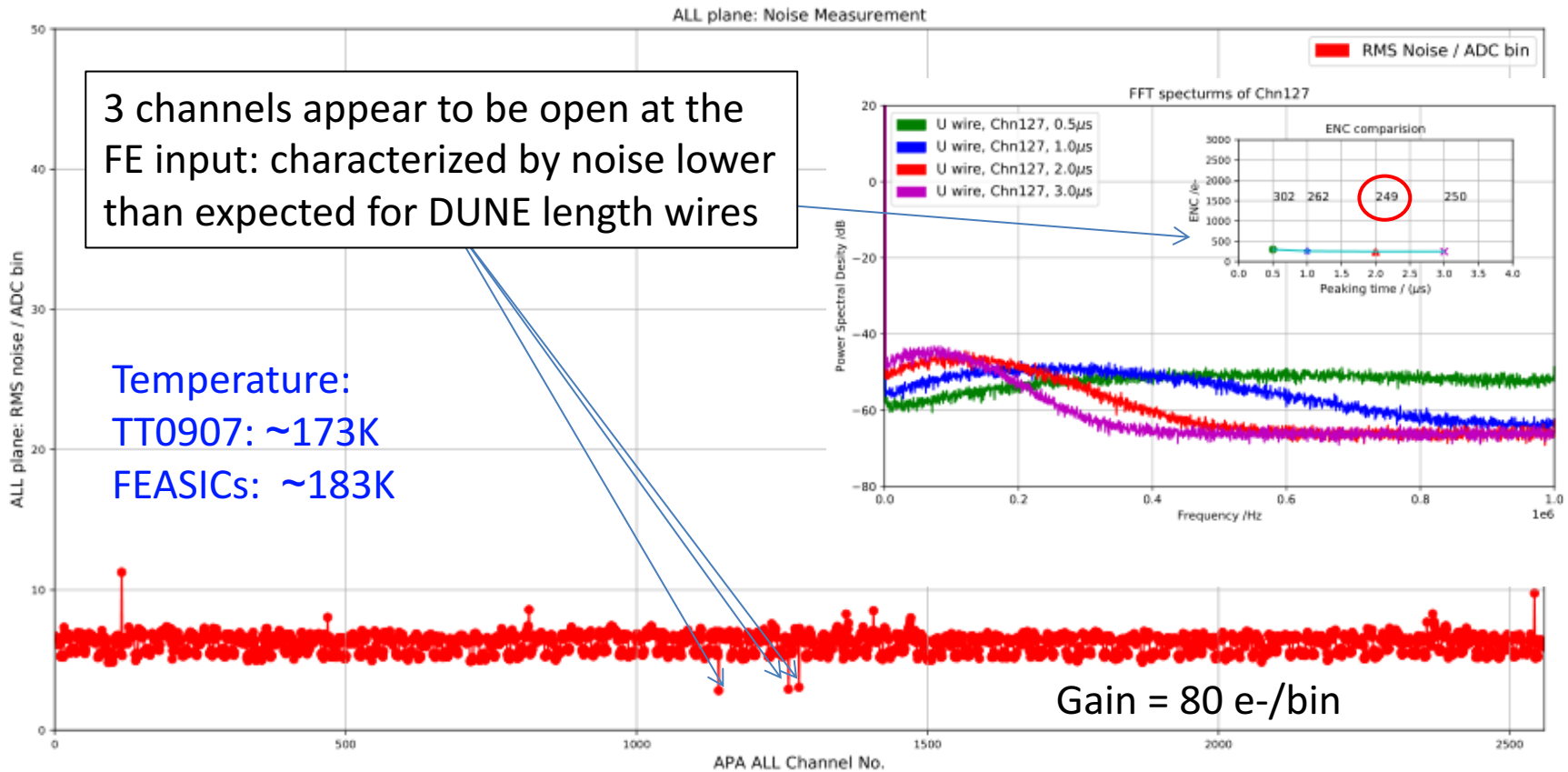


Noise at 215K (30-90 Hours)



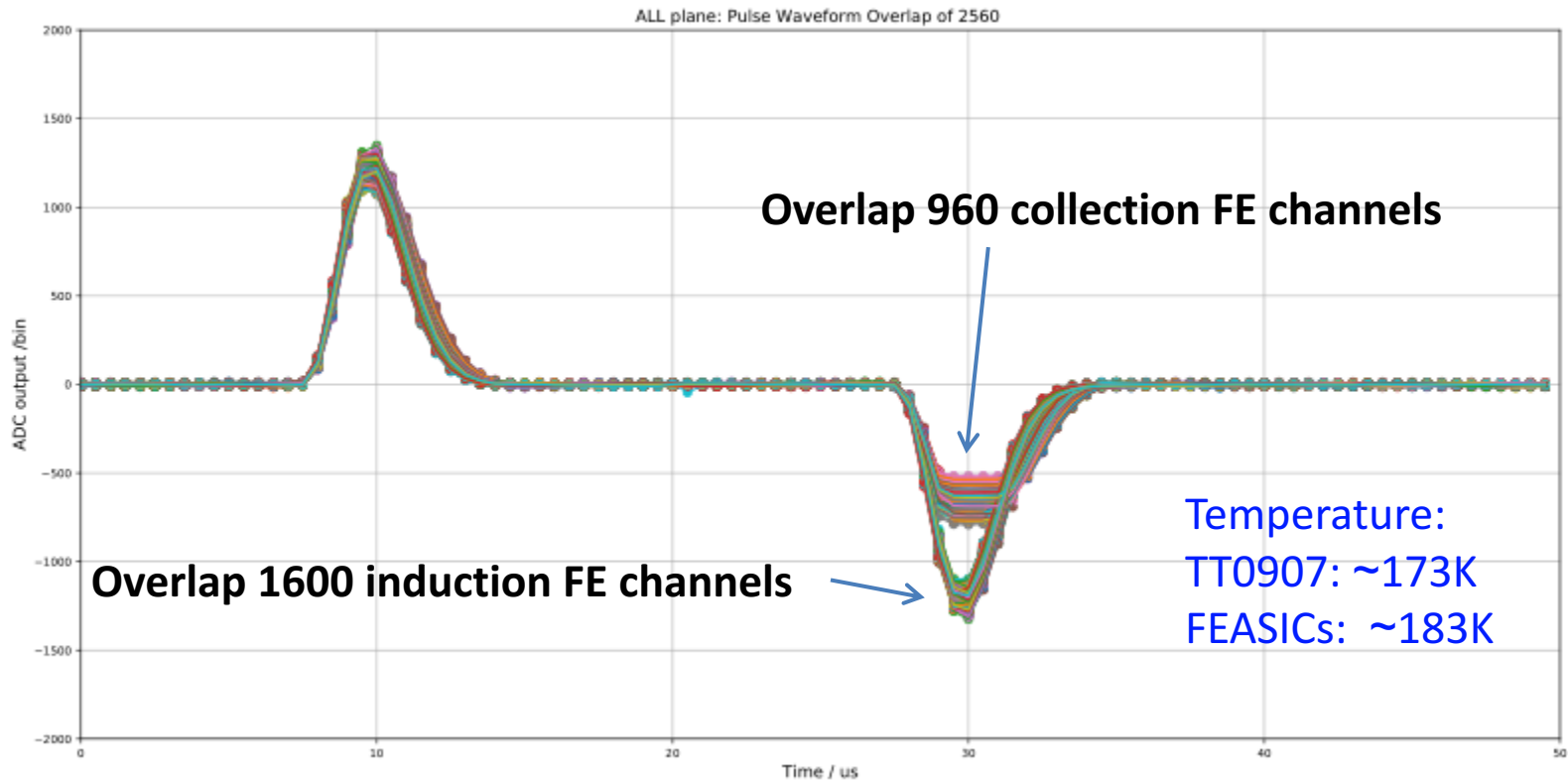
All 2,560 wires (channels) are functioning well
 Several levels of RMS noise due to wrapped (U/V) vs straight (X) wires

Noise at 183K (100 Hours)



All CE Box assemblies including FEMB and cold cables were validated at 78K (LN2) before installation

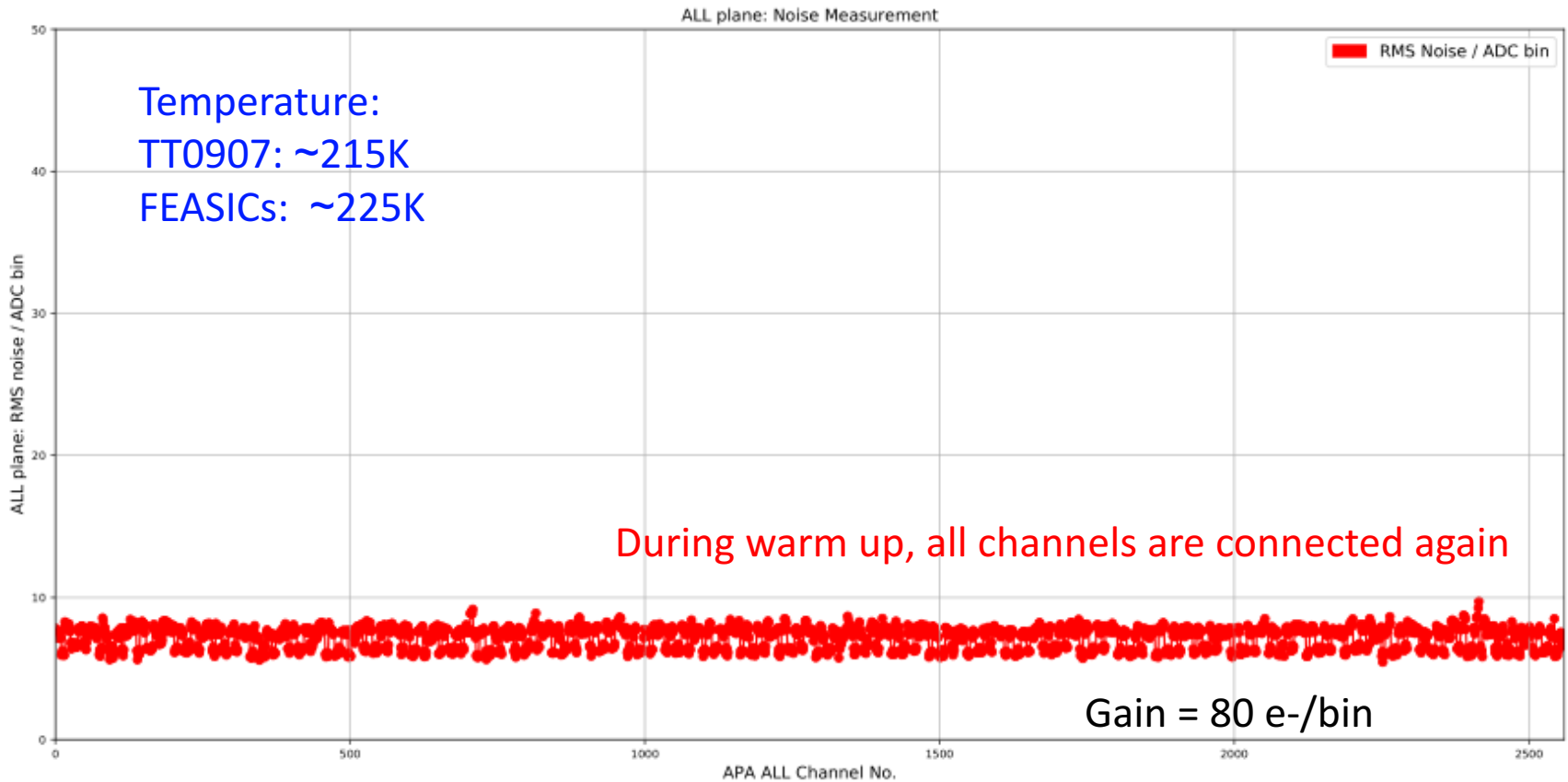
Electronics Checkout at 183K



Inject bipolar pulses from electronics calibration circuit built in to FE ASIC

All front end channels are confirmed to be **100%** functioning well with lowest temperature in the Cold Box

Noise at 225K (106 Hours)



All channels continued working well once Cold Box returned to RT

Conclusions

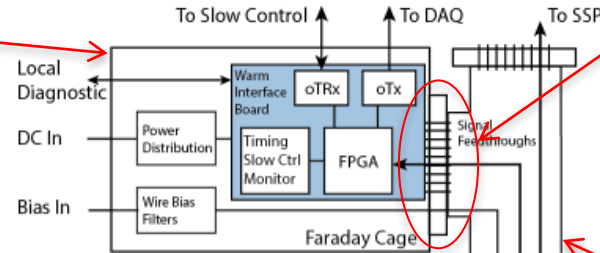
- The APA+cold readout+Faraday Cage/Feedthrough with Warm Interface and Local Diagnostics should be treated as an integrated whole and installed as such
 - Coordinated Cold Box testing between CE, PD, APA, CERN teams is working well
- Preliminary measurement of TPC readout on APA1 in Cold Box is promising
 - All TPC electronics channels (2,560) have been functional from RT to the lowest temperature reached in the Cold Box
 - 3 sense wires appear to have temperature dependent intermittent connection to the FE ASICs
 - Team at CERN investigating these channels
- Data analysis is still ongoing

Backup Slides

protoDUNE-SP Cold Electronics

Warm electronics

- Warm Interface Electronics Crate (6)
- Warm Interface Board (30)
- Power and Timing Card (6)
- Power and Timing Backplane (6)



CE flange

Flange assembly with cable strain relief and flange PCB for cable/WIB connection (6)

Signal feed-through

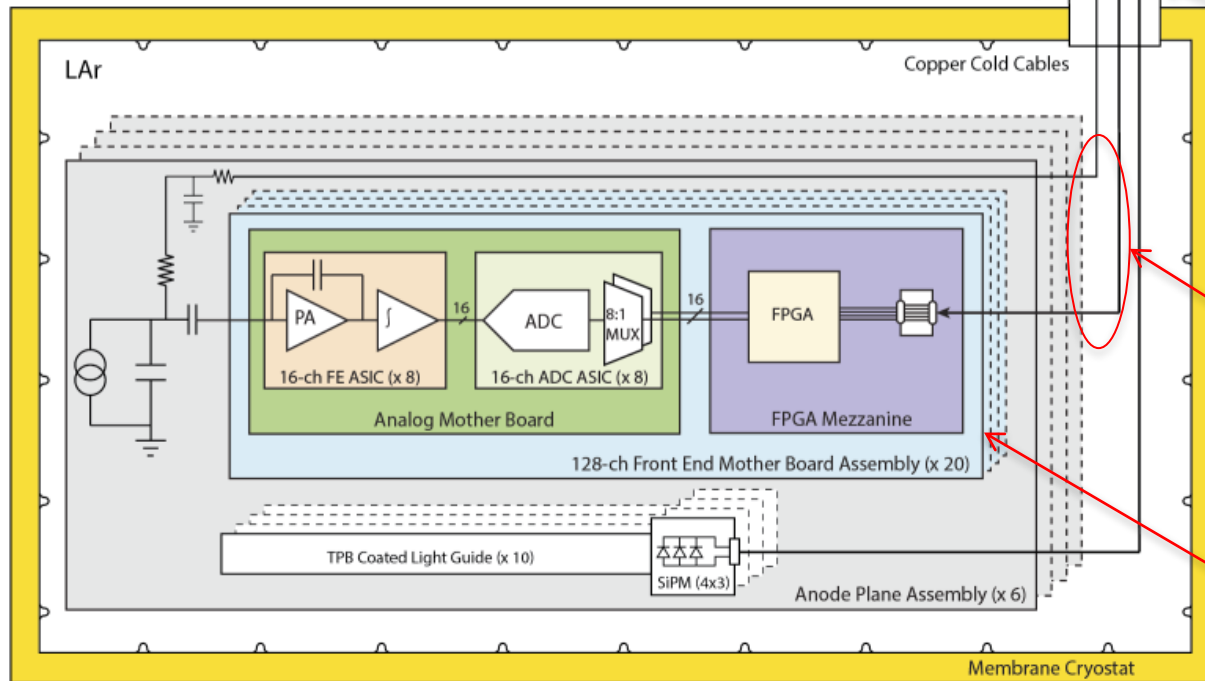
Tee pipe with 14" Conflat flanges and crossing tube cable (CTC) support (6)

Cold cable

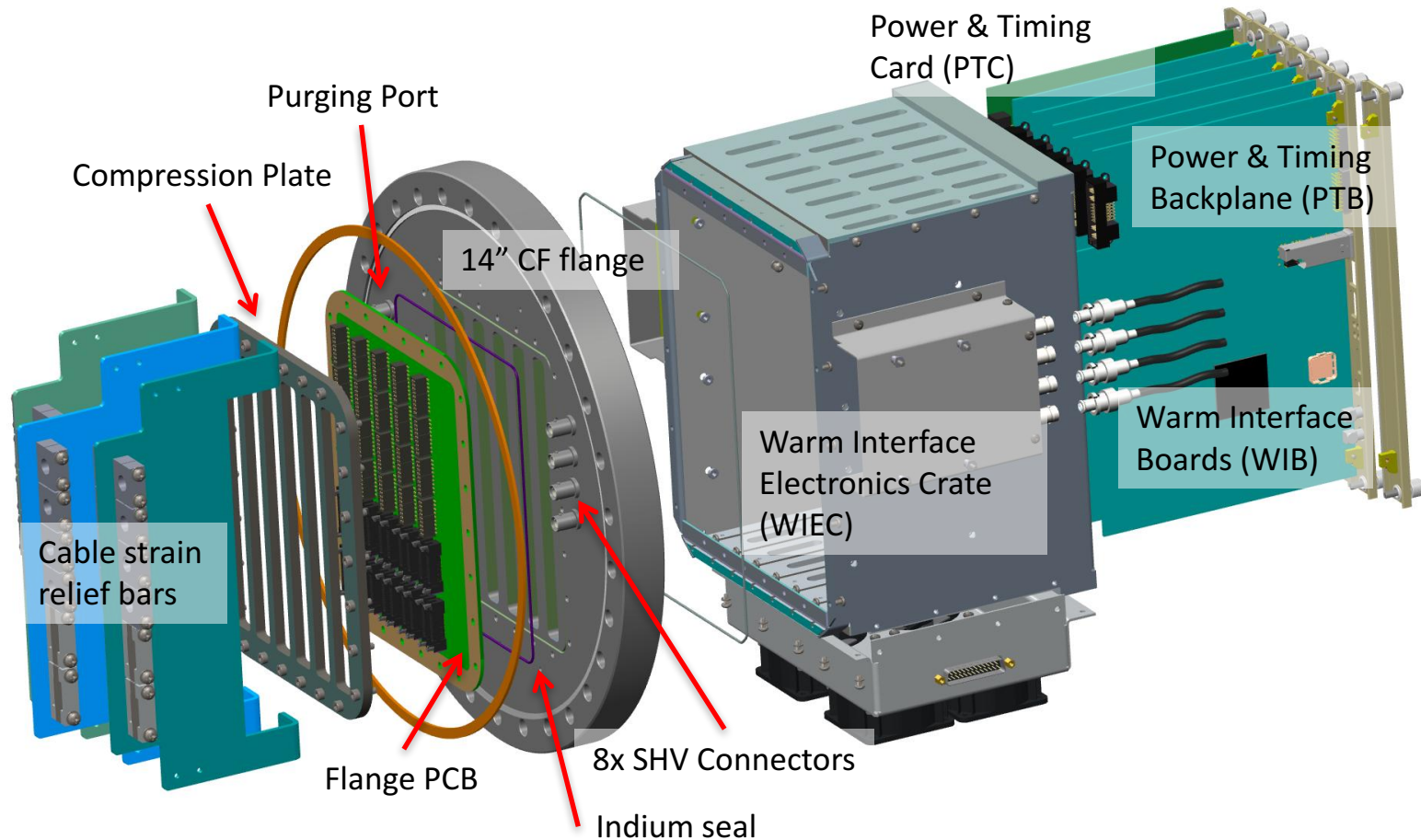
LV and data cable (120+120) to FEMB and APA wire-bias SHV cable (48)

Front End Motherboard

(FEMB) 128 channels of digitized wire readout enclosed in CE Box (120)



CE Warm Components



EHN1

Clean Room (cold box inside)

Cryostat (Red)

Grounding Status Monitor

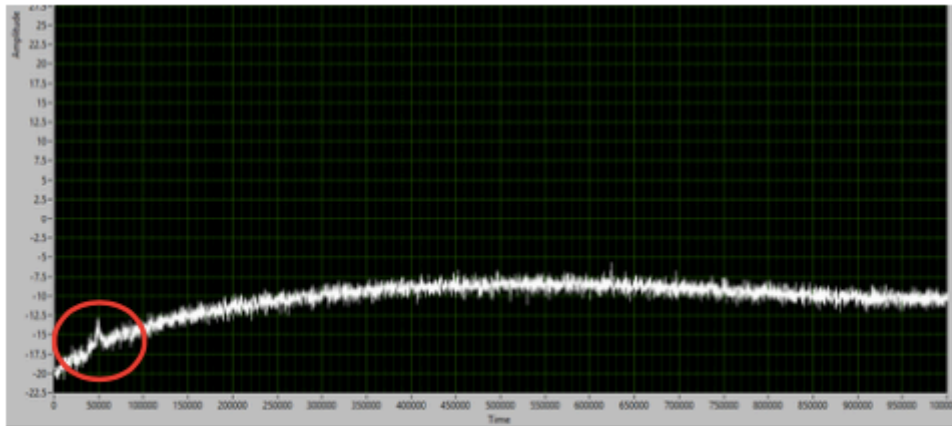


Cooling System

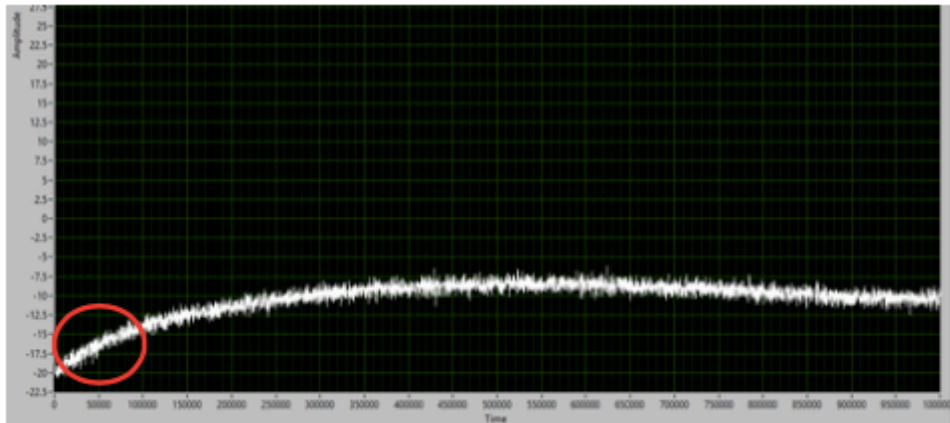
DCS Room

Noise Tests in Cold Box

CE, PD, and CERN teams working to find noise sources in warm Cold Box



- immediate response
- tests full CE readout path
- independent of DAQ



Switched from 24V DCS
to BNL 18V floating
supply for fans

WIB 4 – FEMB 0 – Chip 0 – Chan 0 (Wrapped Wire – U Plane)
0.5 us – 25 mV/fC