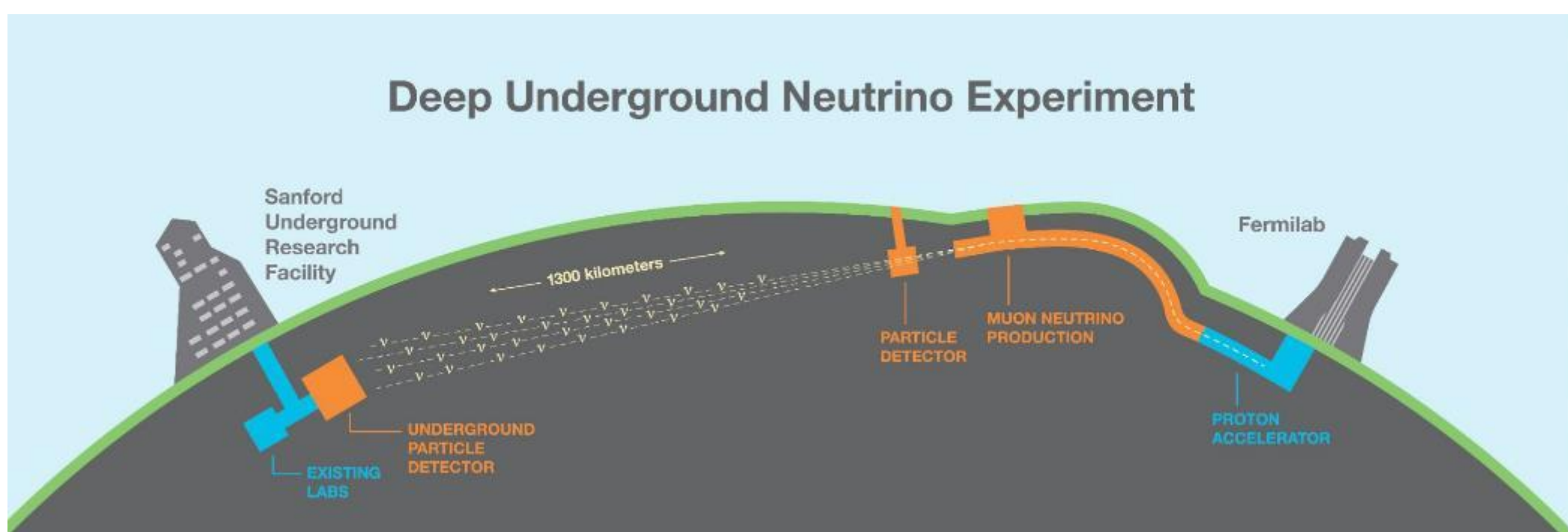
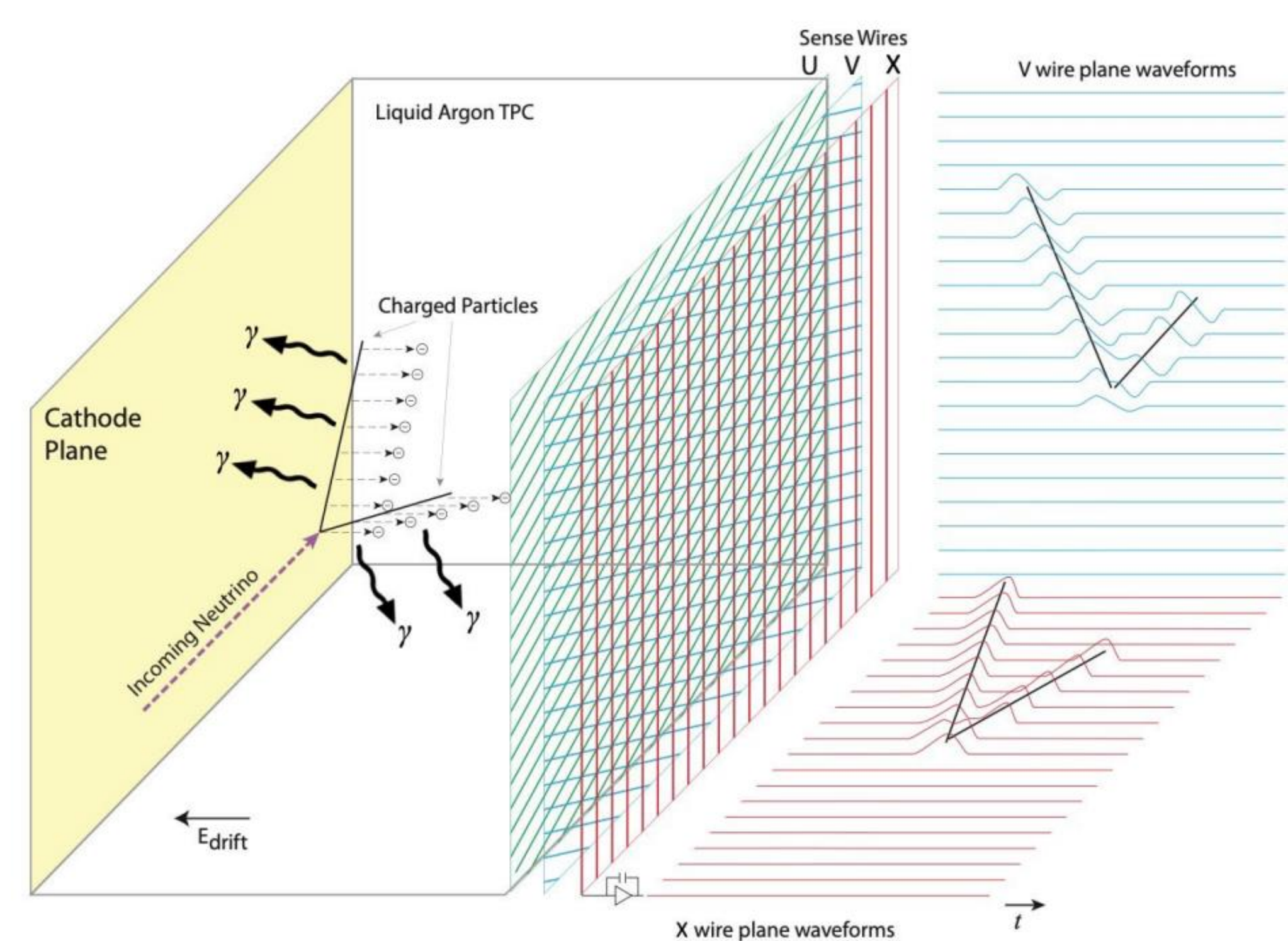


## What are DUNE and ProtoDUNE?

DUNE (Deep Underground Neutrino Experiment) is a long baseline neutrino oscillation experiment under construction in the USA that aims to measure the neutrino mass hierarchy and  $\delta_{CP}$  in the neutrino sector



DUNE far detectors are **liquid argon time projection chambers (LARTPCs)**, allowing for 3D imaging of charged particle interactions



The **ProtoDUNE-II** program consists of two 800-ton LARTPCs at CERN's Neutrino Platform, serving as the final large-scale prototypes of the first 2 DUNE far detector designs

- **ProtoDUNE-II-HD** now taking beam data, testing the horizontal drift far detector design
- **ProtoDUNE-II-VD** taking beam data in 2025, testing the vertical drift detector design

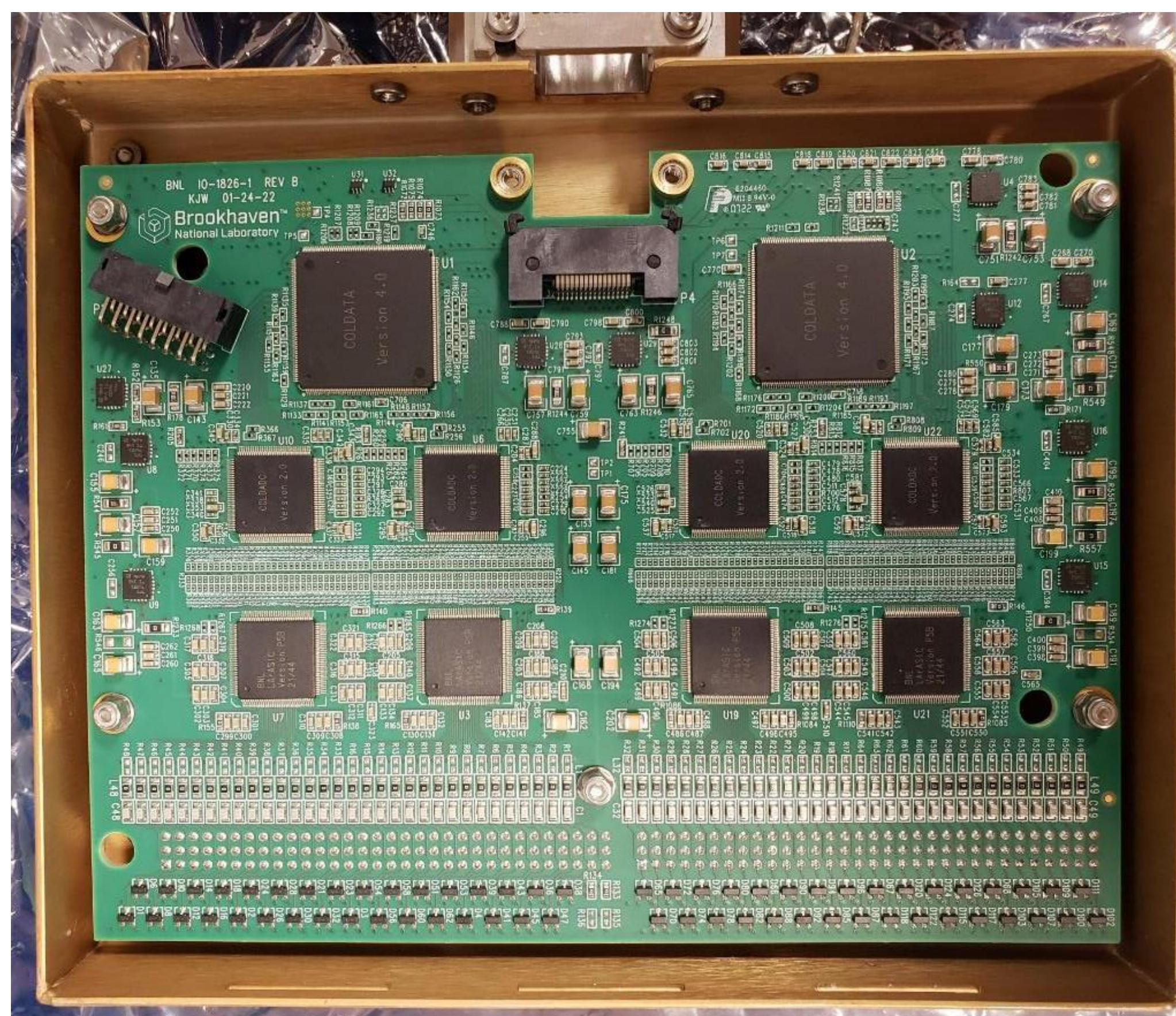
These are sequels to the ProtoDUNE-SP and ProtoDUNE-DP prototypes, and include a **new cryogenic charge readout electronics chain**



## Design of the Cryogenic Charge Readout Electronics for the DUNE Far Detectors

DUNE far detectors use a chain of 3 different ASICs operating in liquid argon (~87 K) for charge readout of the wires/strips:

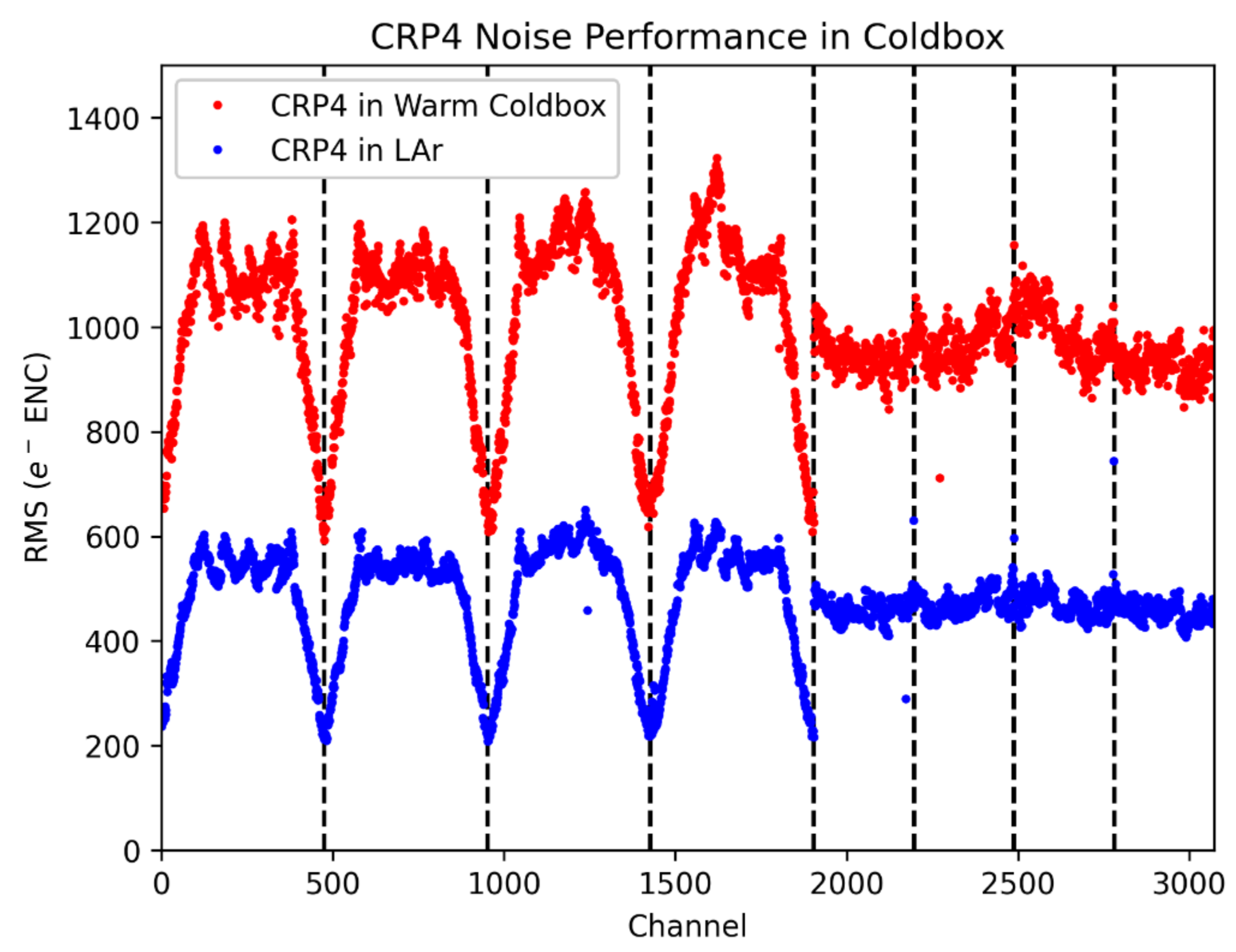
- **LArASIC** for analog signal amplification and shaping (configurable), with internal pulser controlled by 6-bit DAC for calibration
- **ColdADC** for digitization to 14-bit signals at ~1.95 MHz
- **COLDATA** for control of and communication with LArASICs and ColdADCs, and data serialization for transmission to warm electronics



From bottom up: 4 LArASICs, 4 ColdADCs, 2 COLDATA  
(Board contains another 4 LArASIC and 4 ColdADC on other side)

## Expected Electronics Performance in ProtoDUNE-II-VD

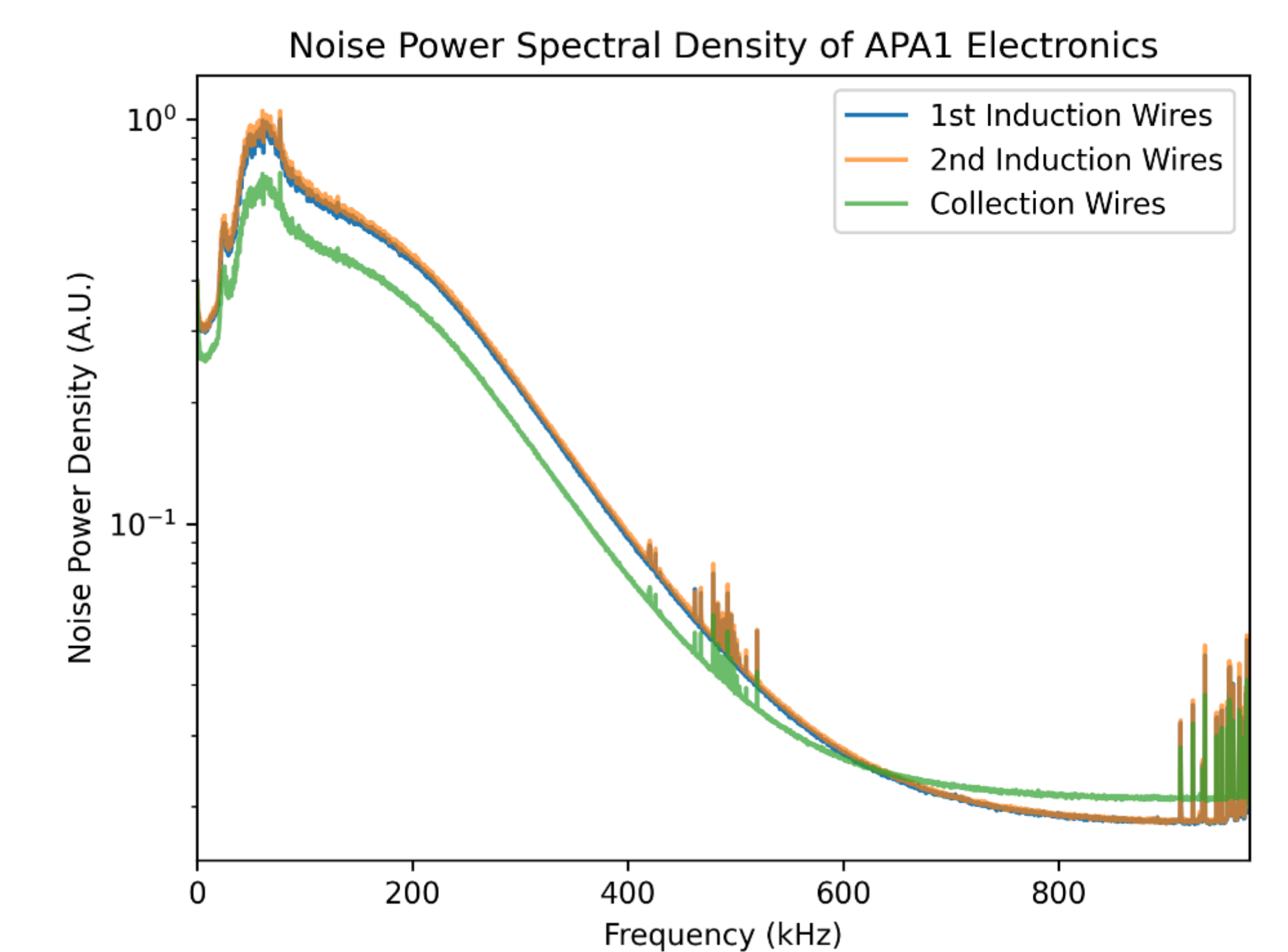
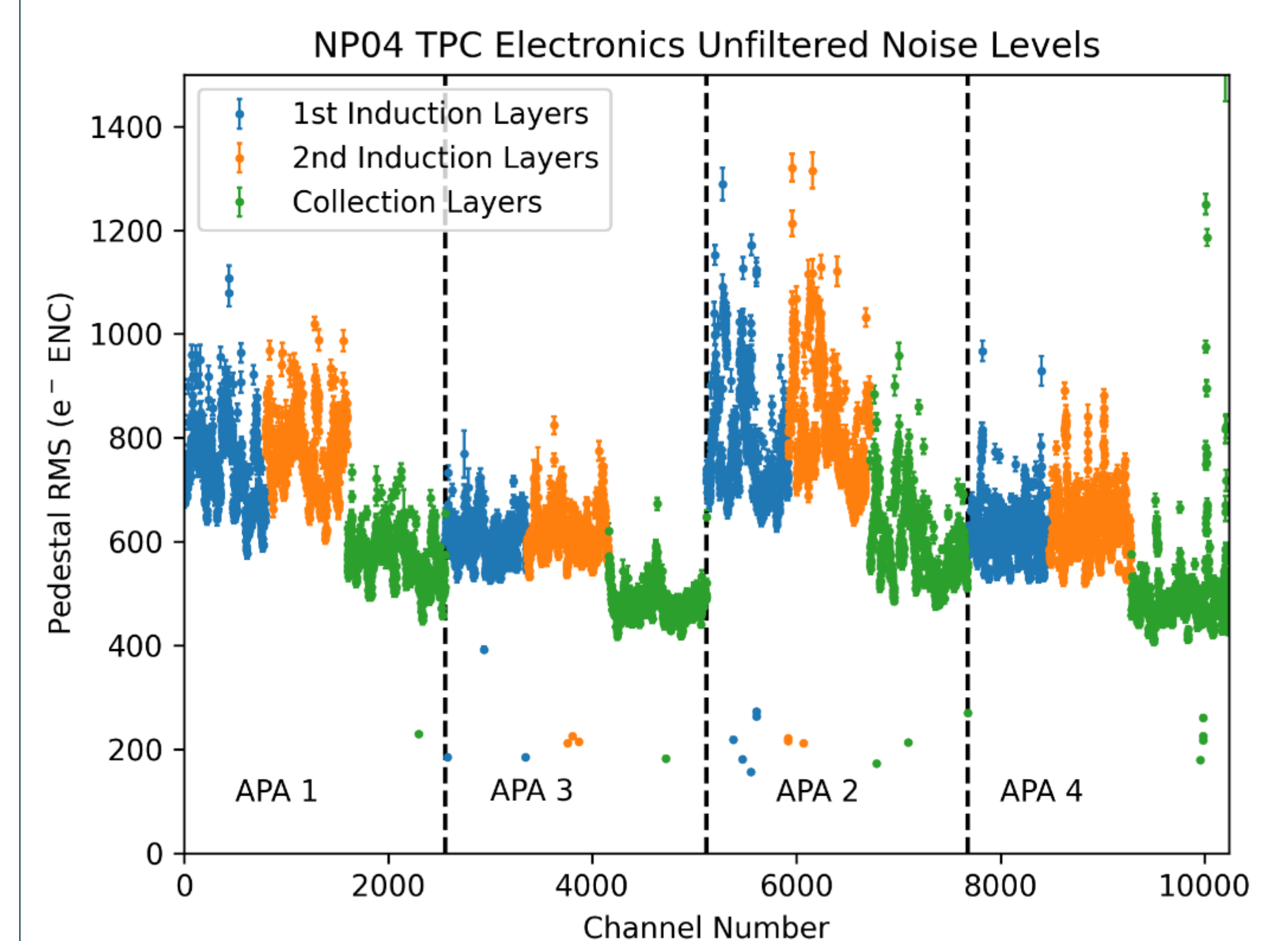
ProtoDUNE-II-VD has not taken data yet, but expected noise levels for its electronics come from "coldbox" tests of its individual modules



## Charge Readout Electronics Performance in ProtoDUNE-II-HD

Electronics noise measured by pedestal RMS in units of number of **electrons equivalent noise charge (e- ENC)**

- Calibrated by LArASIC internal pulser
- DUNE target is **< 1000 e- ENC** on collection channels
- Minimum ionizing particle produces ~24k electrons per ~5 mm wire spacing



ProtoDUNE-II is the first experimental program to use the ColdADC and COLDATA, and has confirmed no digital issues with LAr operation

