Data Quality Monitoring

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VII International Conference on Information Technology and Nanotechnology

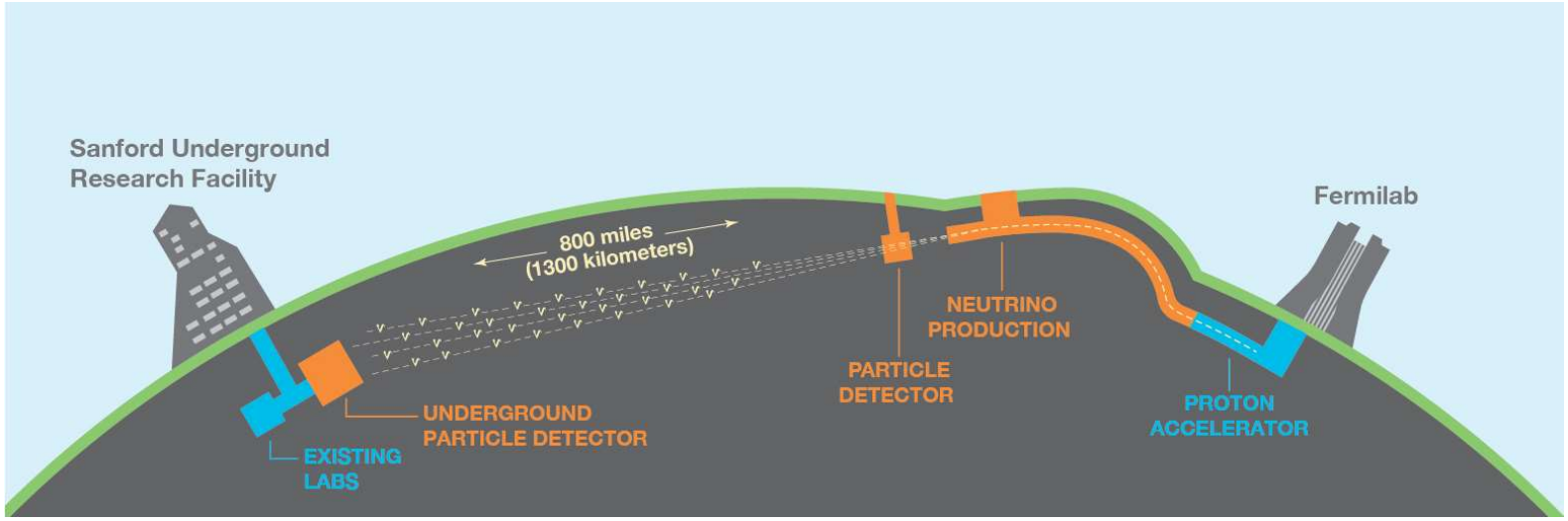
22.9.2021

Content

- Introduction
  - DUNE
  - Neutrinos, why and how?
  - CERN’s role
  - DAQ
- DQM
  - Architecture
  - Metrics
  - Current state

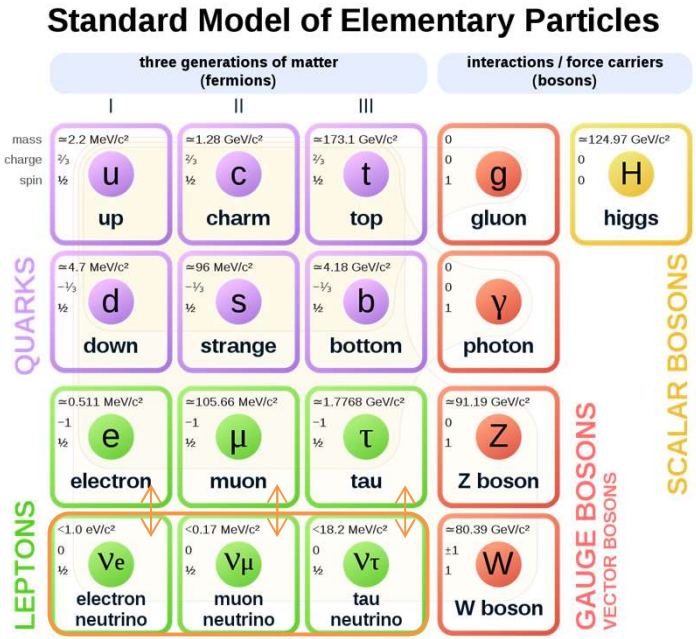
Introduction

DEEP UNDERGROUND NEUTRINO EXPERIMENT



Why study neutrinos?

- Neutrinos are neutral, extremely light particles
- Neutrinos are the 2nd most abundant particle in the universe
- They exist in three flavours



Quark-antiquark asymmetry

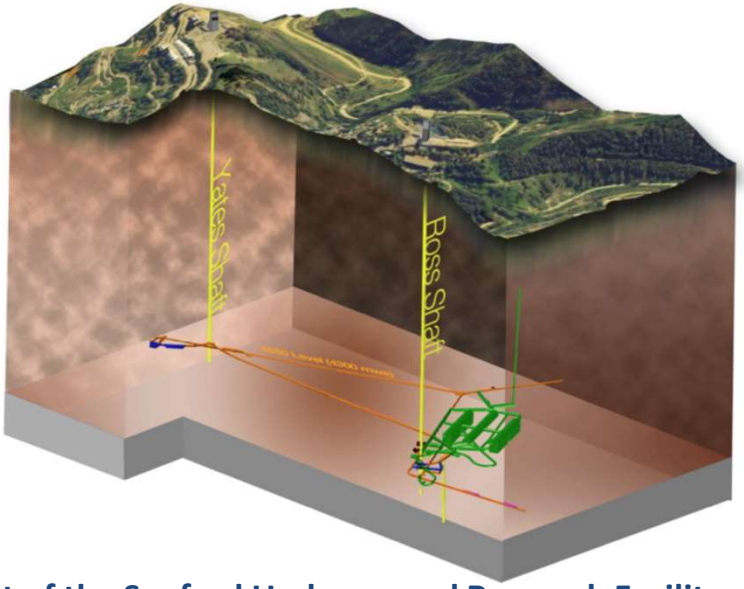
$$\frac{n_q - n_{\bar{q}}}{n_q} \sim 10^{-9}$$

- The universe currently has almost no antimatter
- This corresponds to an early tiny quark-antiquark asymmetry

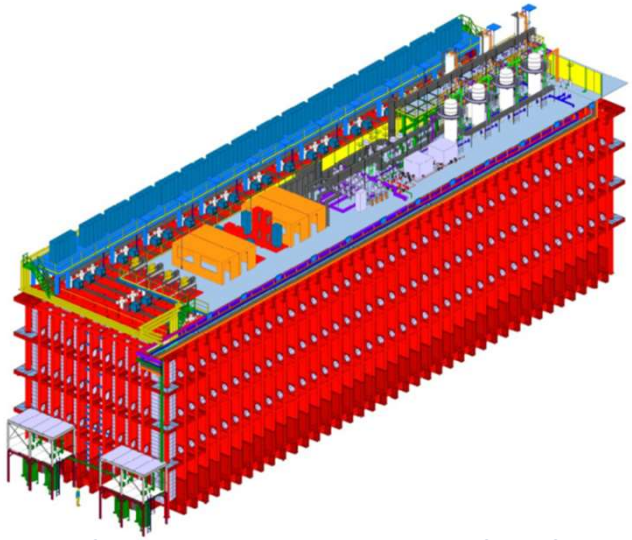
Neutrinos, their oscillations (CP Violation) could explain the matter-antimatter asymmetry

DUNE far detector

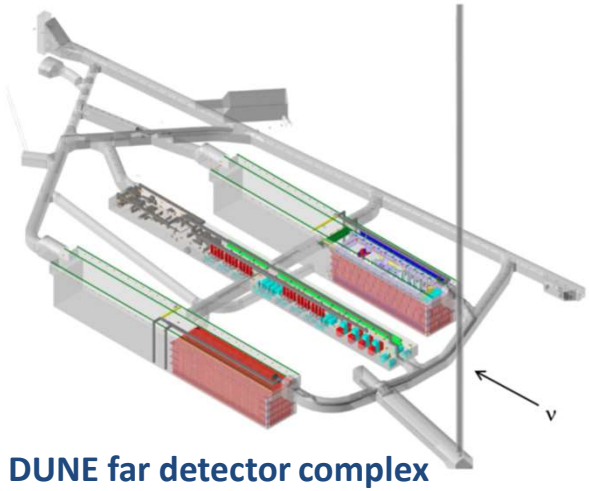
- Sanford, South Dakota, USA
- 1.5 km under the surface
- Four 66x19x18m Liquid Argon Time Projection Chambers (LArTPC)



Cut of the Sanford Underground Research Facility
(Image: DUNE collaboration)



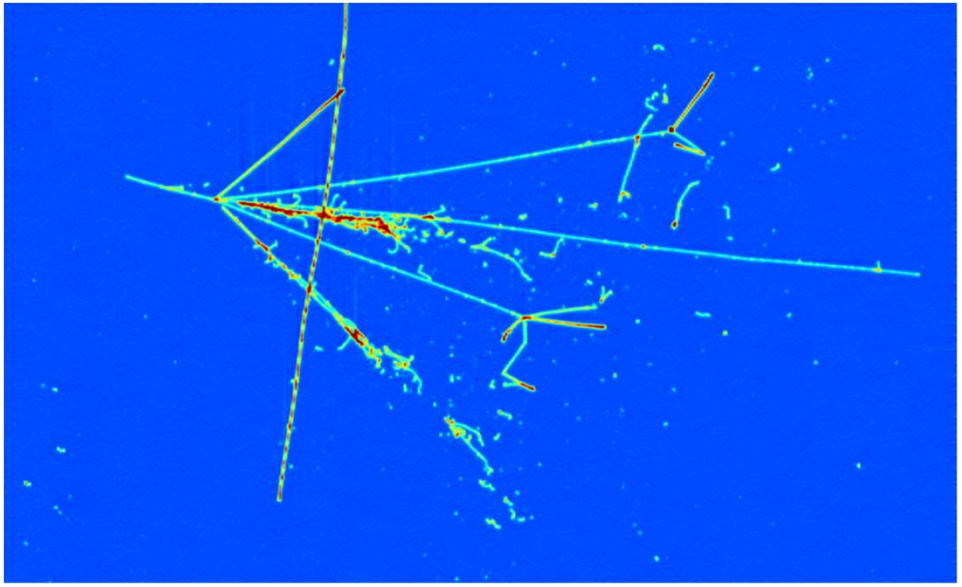
Liquid Argon Time Projection Chamber
(Image: DUNE collaboration)



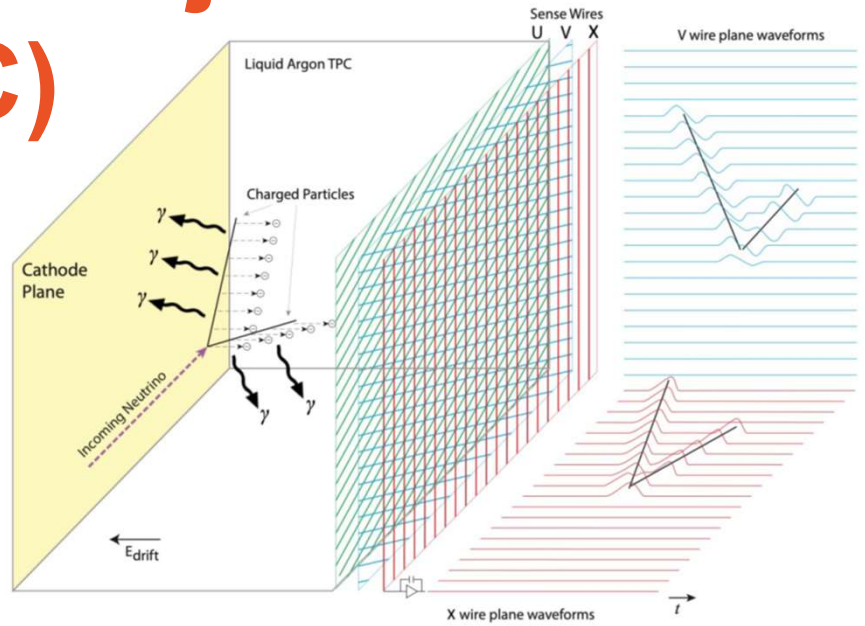
DUNE far detector complex
(Image: DUNE collaboration)

Liquid Argon Time Projection Chambers (LArTPC)

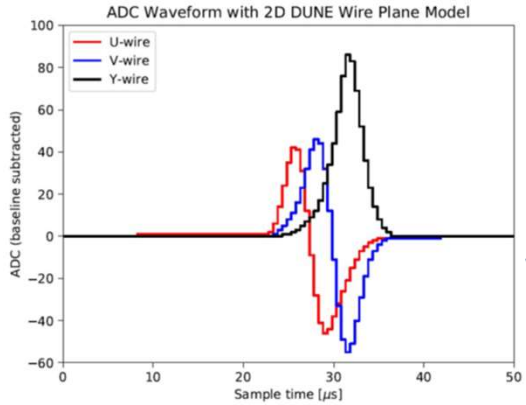
- Interactions provokes ionization
- Liquid Argon
  - Perfect candidate but!
- Electric drift field
  - Field running through the modules
  - Pushes Ionized particles to the readout
- The readout: wires planes and photon detector



Neutrino interaction in LArTPC (Image: DUNE collaboration)



LArTPC architecture in DUNE
(Image: DUNE collaboration)

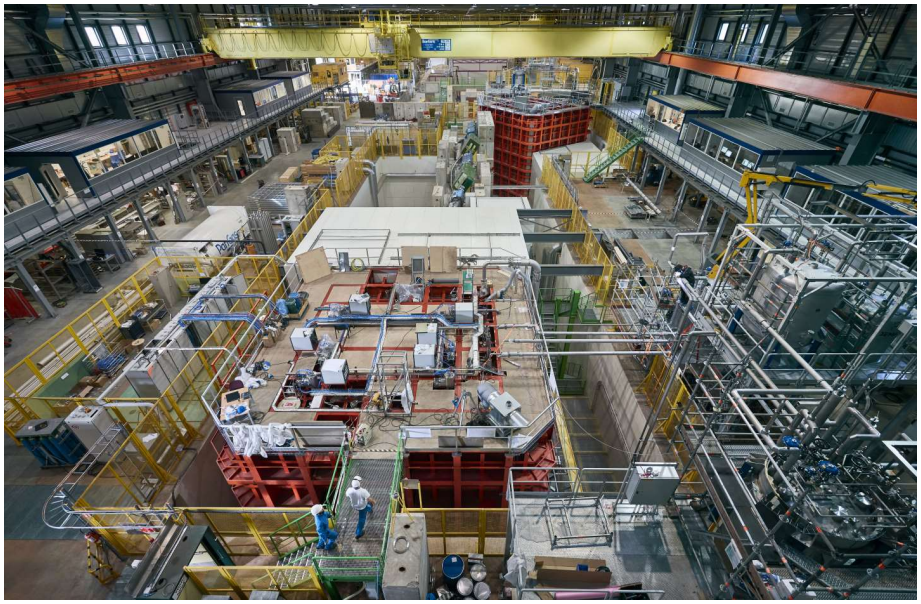


Interaction ADC waveform
(Image: DUNE collaboration)

And CERN?

- Build far detectors prototypes (ProtoDUNEs)
- Testing two variations of a detection technique
- Developing a data acquisition system (DAQ)

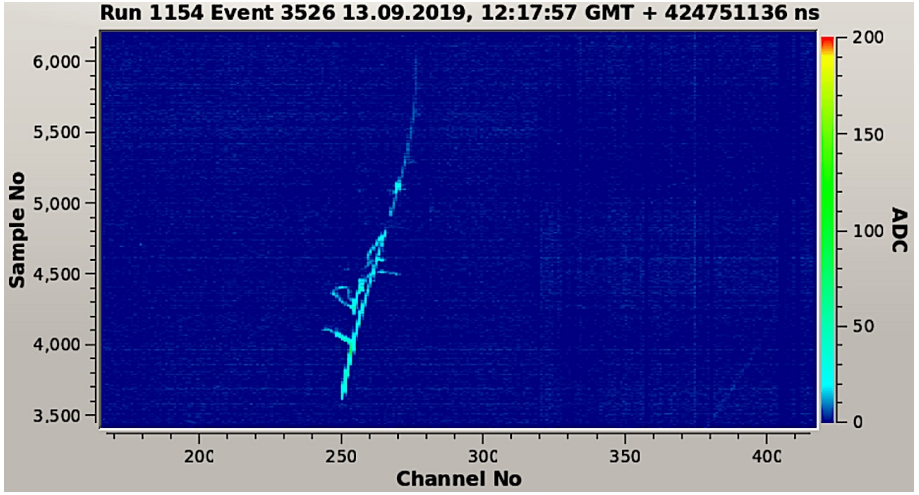
Inside one of the protoDUNE detectors (Image: CERN)



ProtoDUNEs in CERN North Area (Image: CERN)

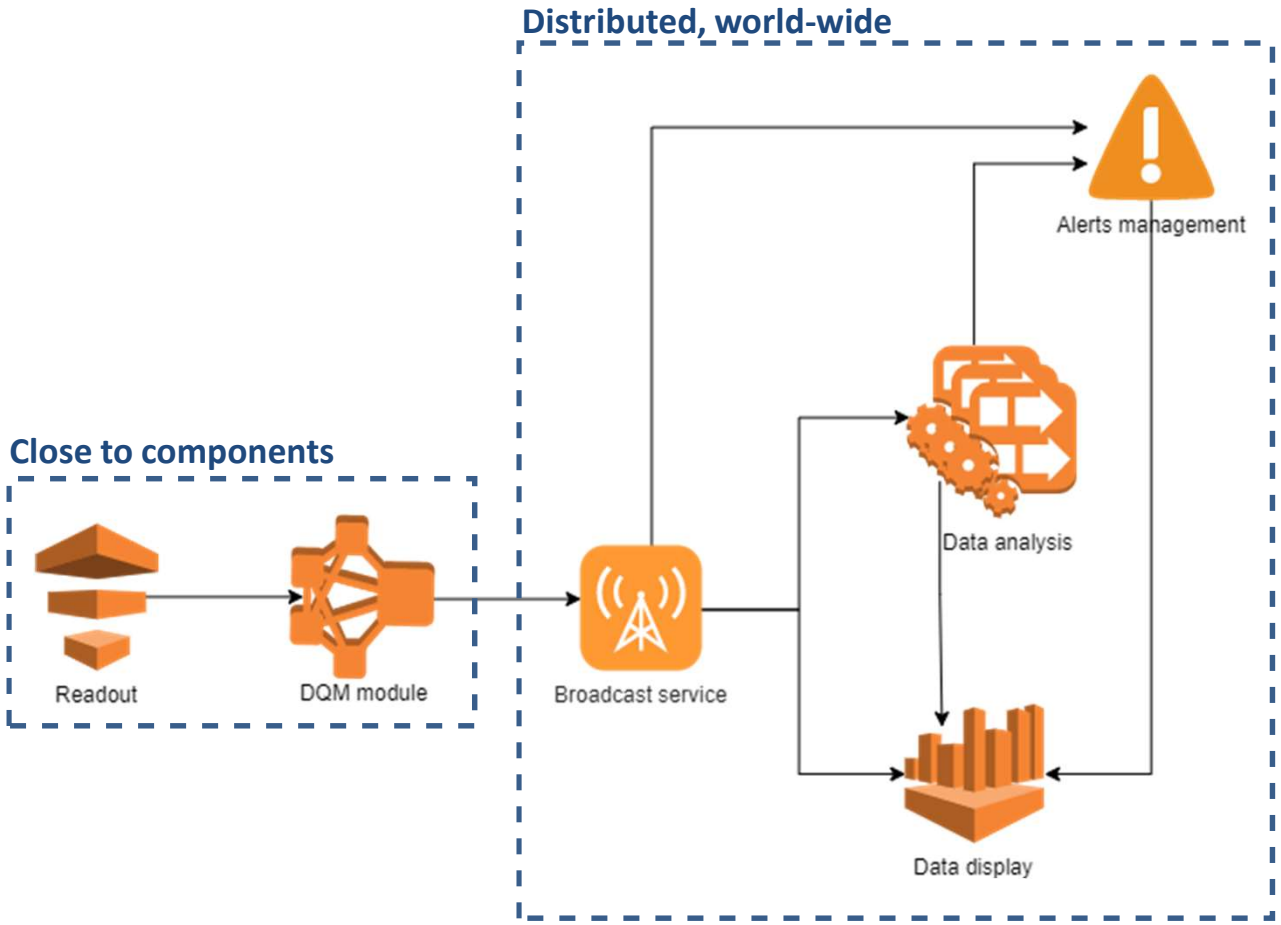
Data Acquisition (DAQ)

- Interaction with the liquid argon creates Ionization tracks
- Ionization tracks are collected by wires
- Electronics amplify and digitize the signal and transmit these waveforms to the DAQ system
- No external triggers, trigger-candidates and trigger-primitives
- A total of 1.5 TBps
- Samples are taken by the Data Qualiy Monitoring (DQM)



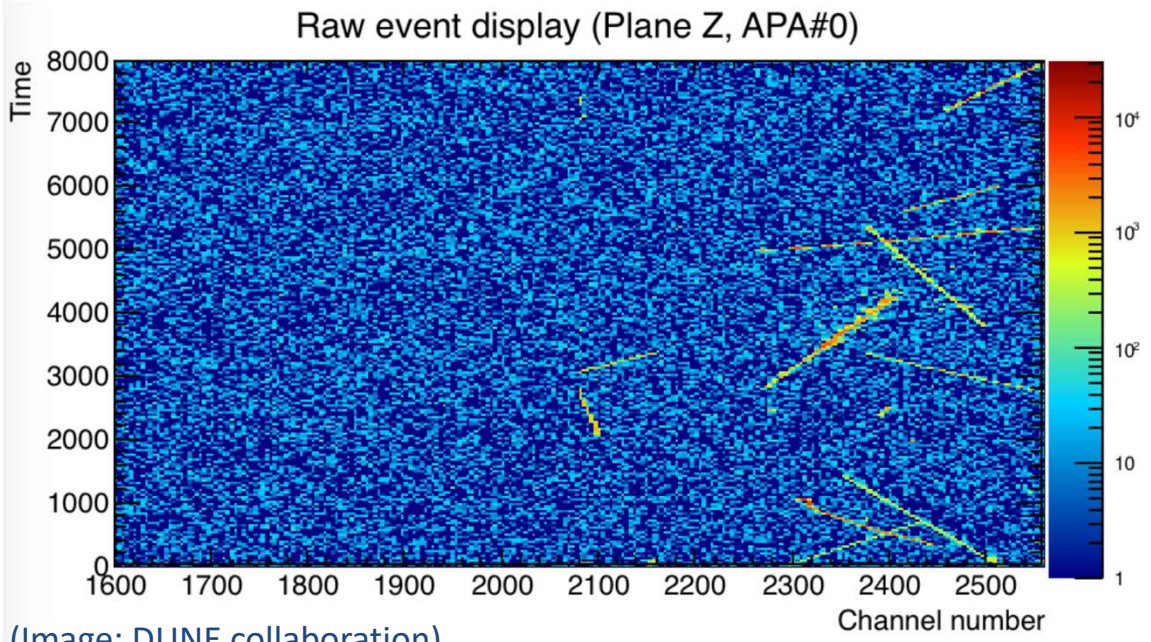
A track made by a cosmic-ray muon, observed in the dual-phase ProtoDUNE detector. (Image: ProtoDUNE)

Data Quality Monitoring (DQM)



Key Quality monitoring data: Raw event display

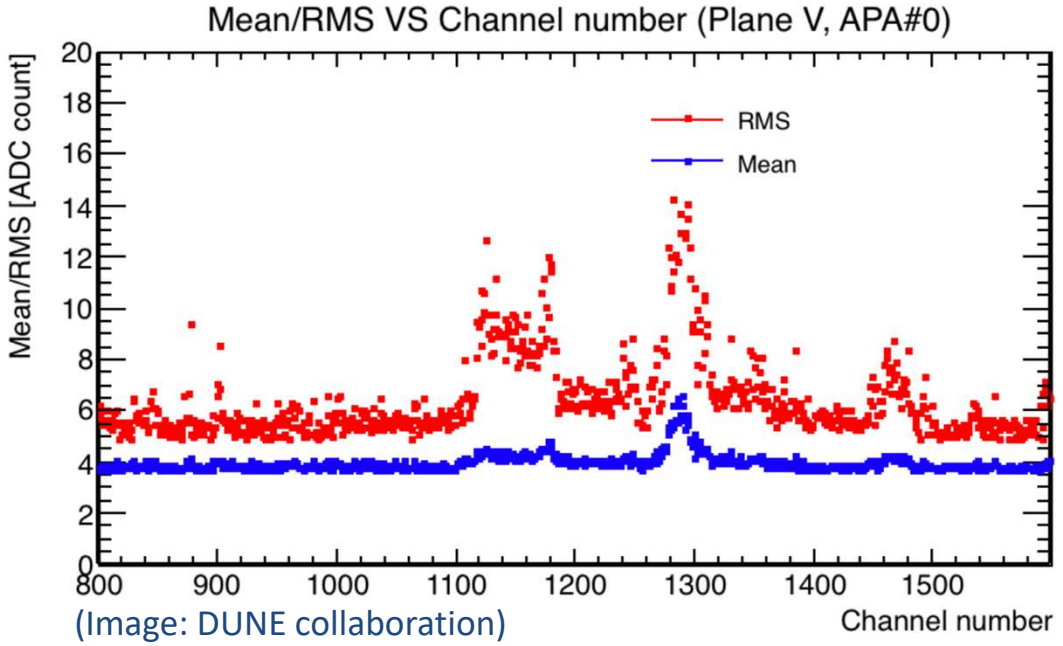
- Represent the raw events, for the human eyes
- See quantity, position, strength of the signal
- Get machine learning powered information



(Image: DUNE collaboration)

Key Quality monitoring data: Mean and RMS

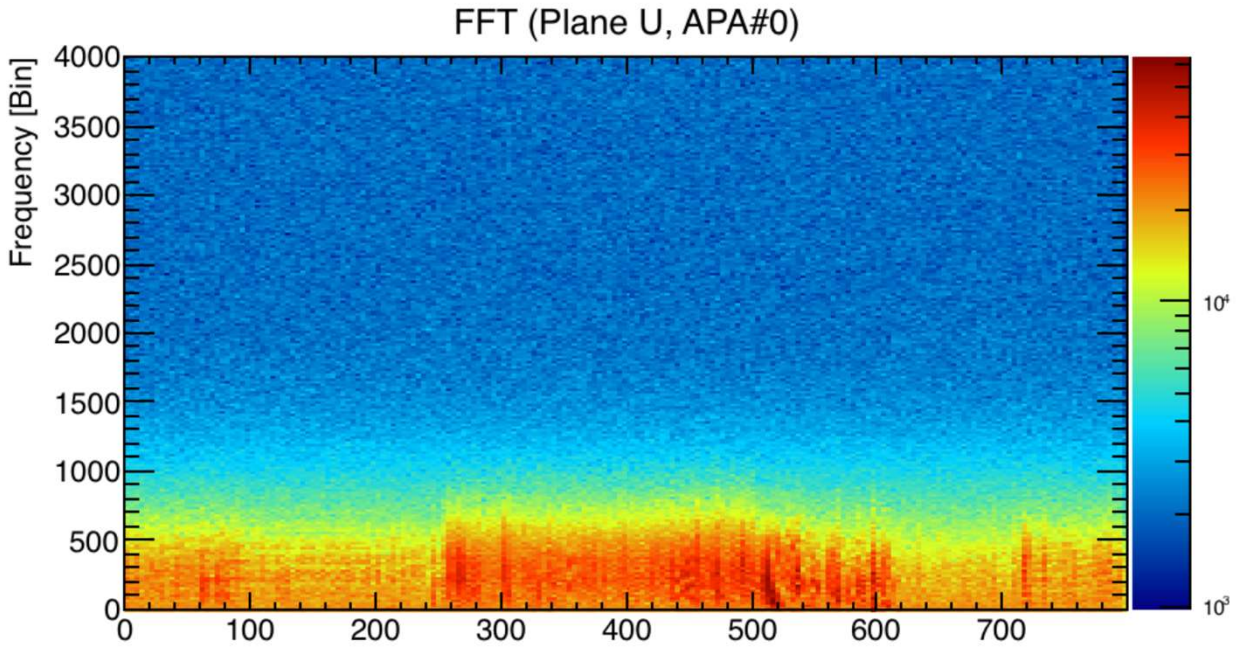
- Hundreds of thousands channels (individual wires)
- The interactions and noise over time
- Measure health of wires and planes
- Spot dead wires



(Image: DUNE collaboration)

Key Quality monitoring data: Fourrier Transform

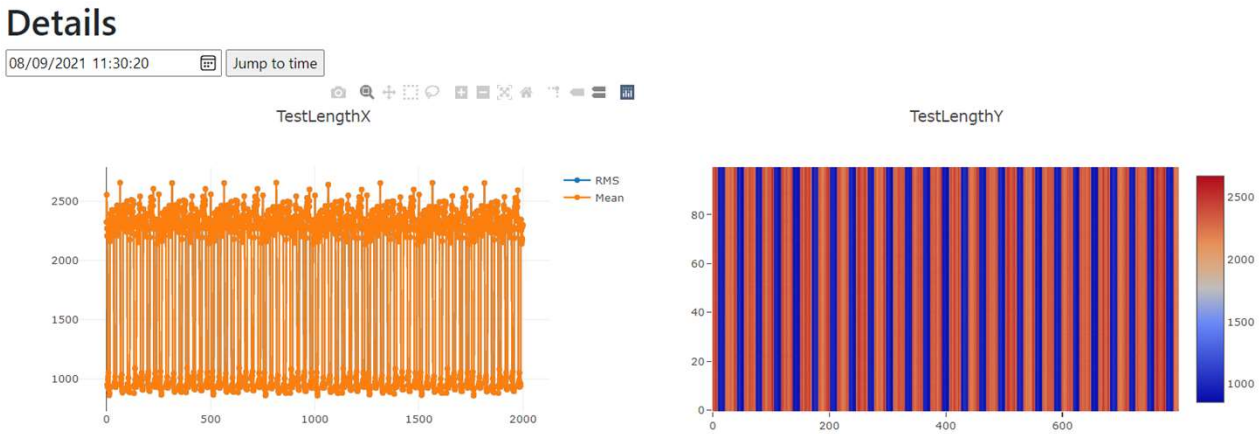
- Fast Fourrier Transform
- Tendency over time



(Image: DUNE collaboration)

Current state

- The infrastructure is available
- Available in docker
- Data transformation
- Processing speed
  - File read time
  - Data transfer
  - Plotting



Display example on the web interface (Image: DUNE DQM team)

Questions ?