

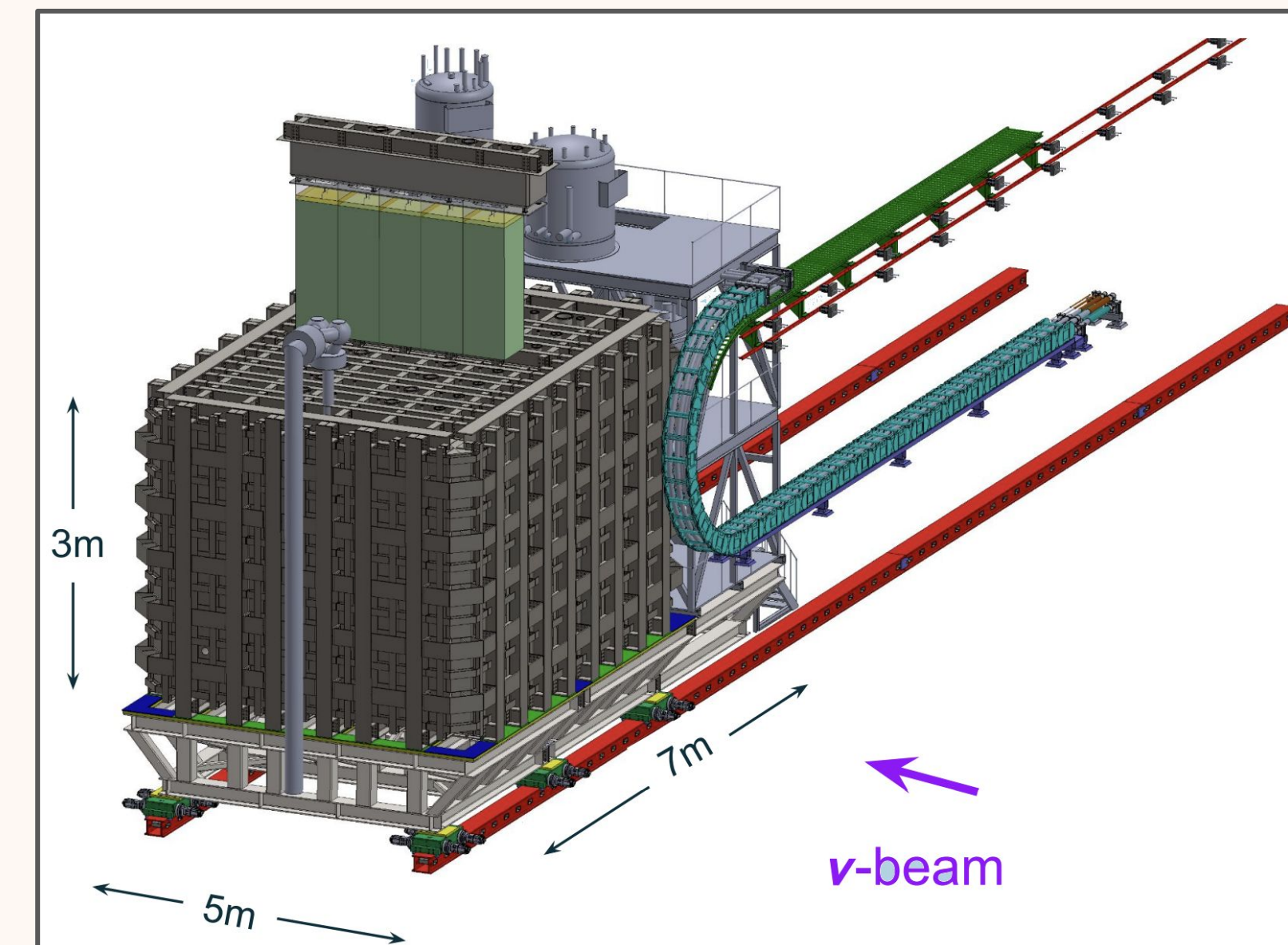
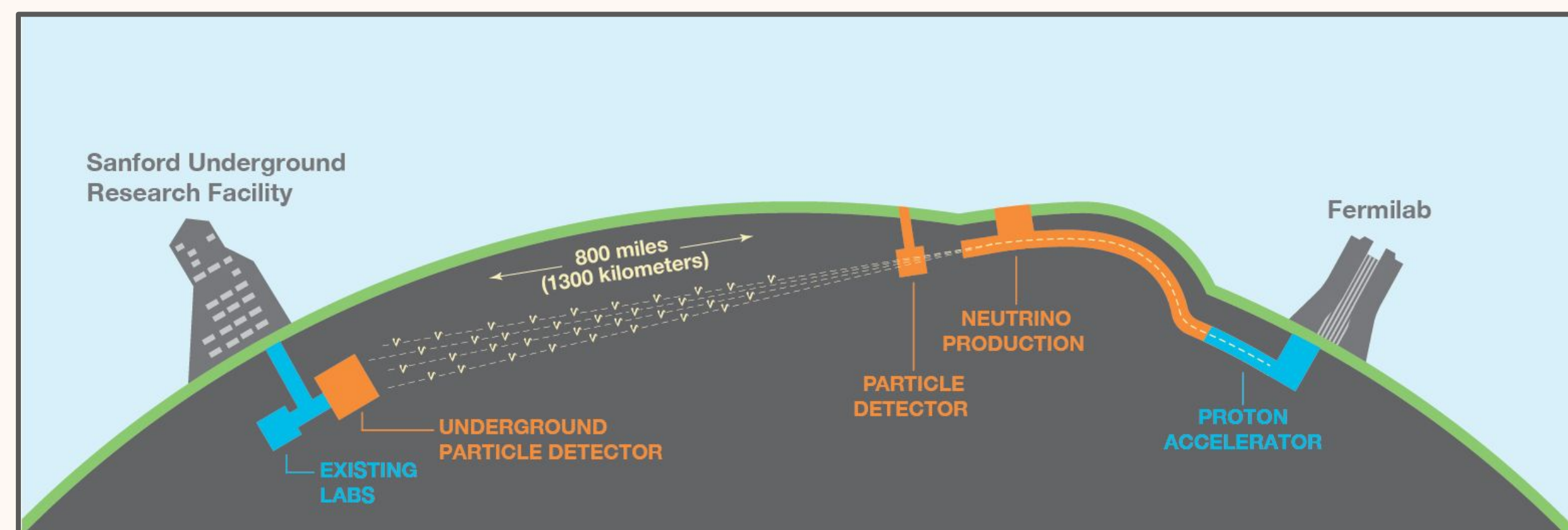
MIP dQ/dx Calibration in DUNE ND-LAr Prototypes with Pixelated Charge Readout

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Introduction

The Deep Underground Neutrino Experiment (**DUNE**) has the goal to measure the neutrino oscillation parameters to an unprecedented precision, determine the neutrino mass ordering and measure δ_{CP} . To achieve this, a high-performing near detector is crucial.

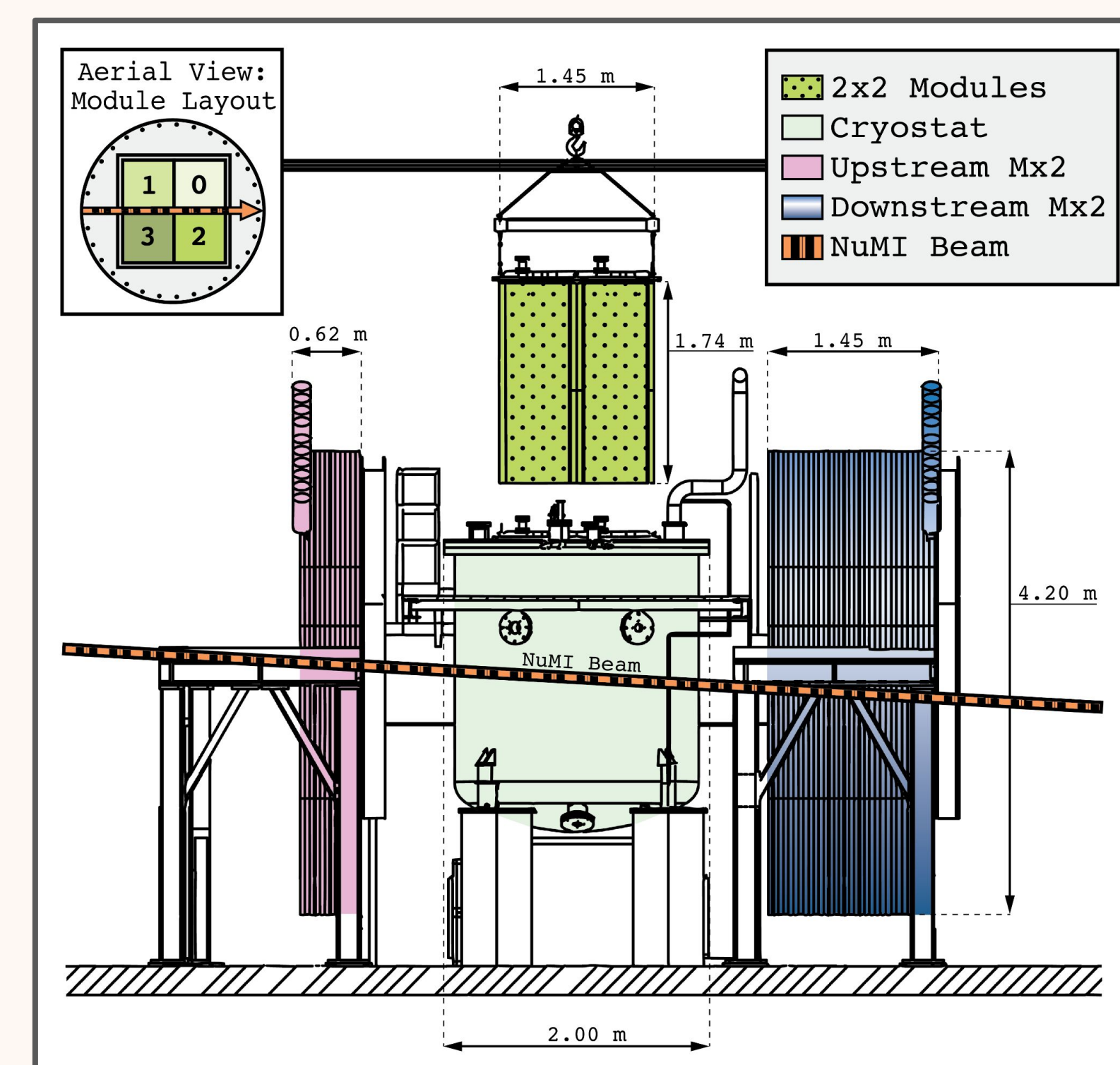
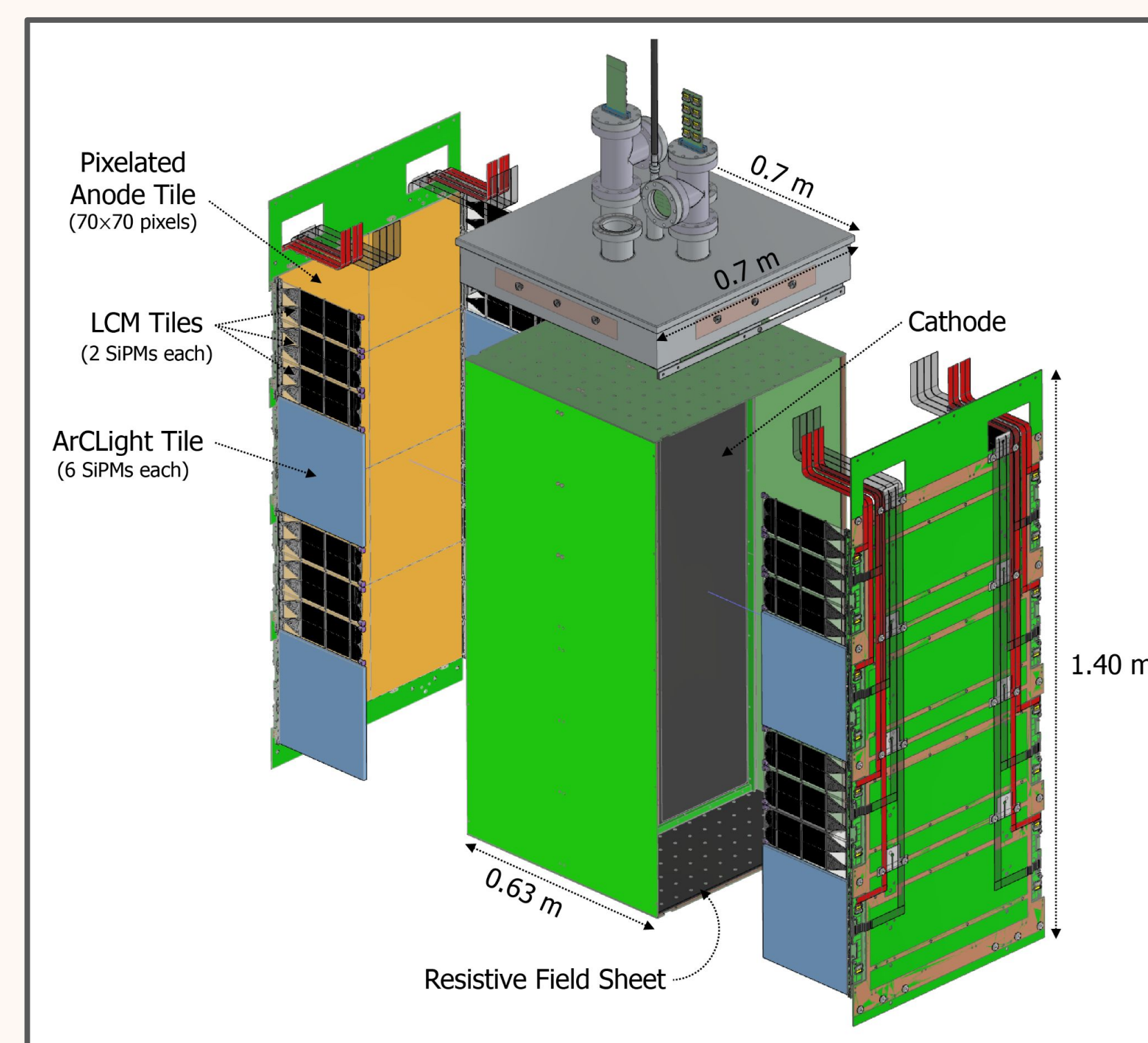


DUNE ND-LAr design consists of 35 modules, each one consisting of two liquid argon time projection chambers (TPC) with a **pixel-based**, true 3D charge readout [1].

DUNE ND-LAr 2x2 Demonstrator

A ND-LAr Prototype

- Consisting of 4 scaled down modules on a 2x2 array.
- Placed on-axis at the **NuMI neutrino beam**, 100 m underground, at Fermi National Accelerator Laboratory.
- Which took 4.5 days of beam data on 2023 [2], more to come this year! (2026).



For the 2x2 modules, the charge readout pixel pitch is **4.4 mm** for 3 of the modules, and **3.8 mm** for module 2. There are **337,600 pixel** in the 2x2 Demonstrator.

Track Reconstruction

Minimum-ionizing particles (**MIP**) present a standard candle for energy deposition. For our sample, **muons** coming from the interaction of beam particles with the rock upstream from the detector are selected.

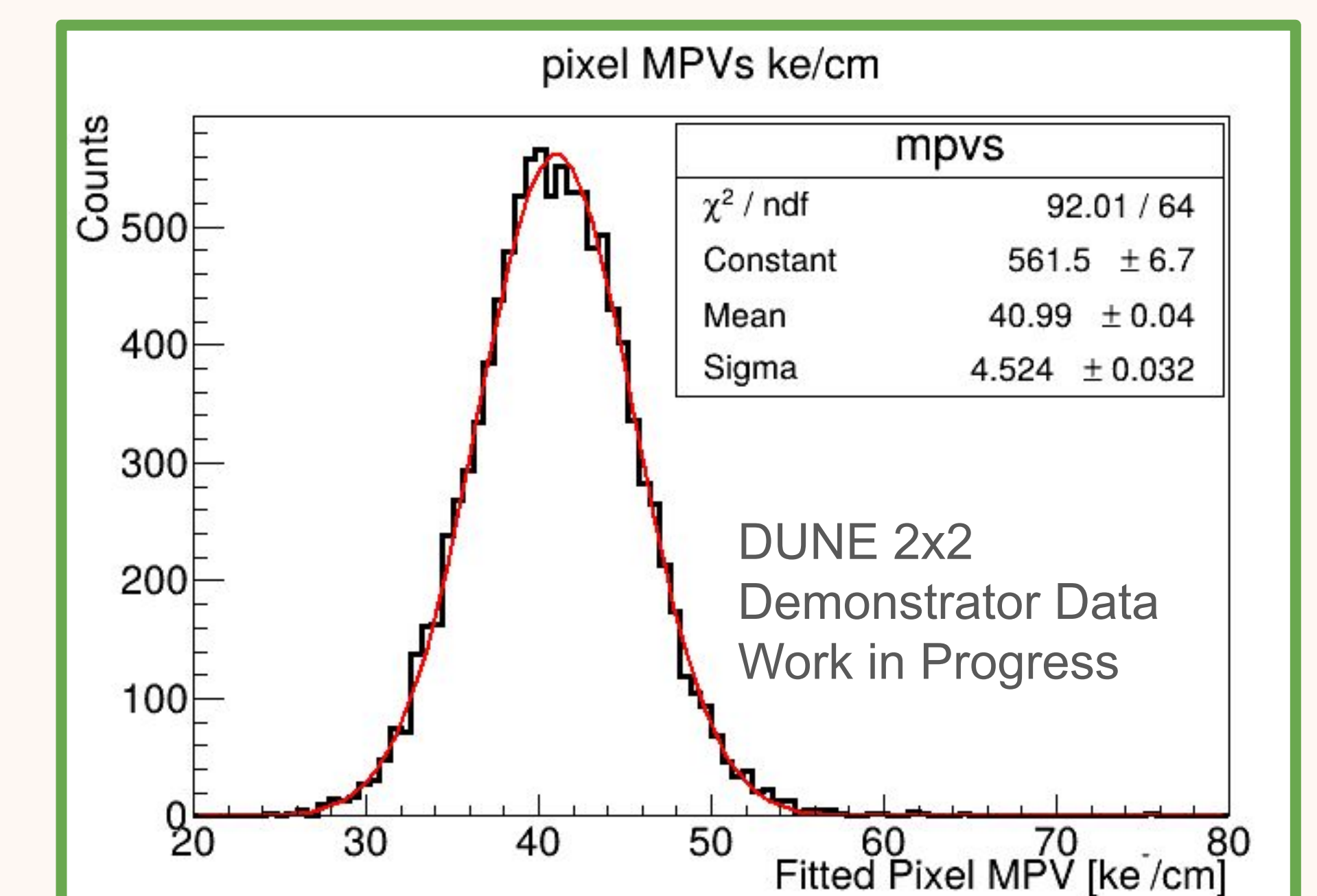
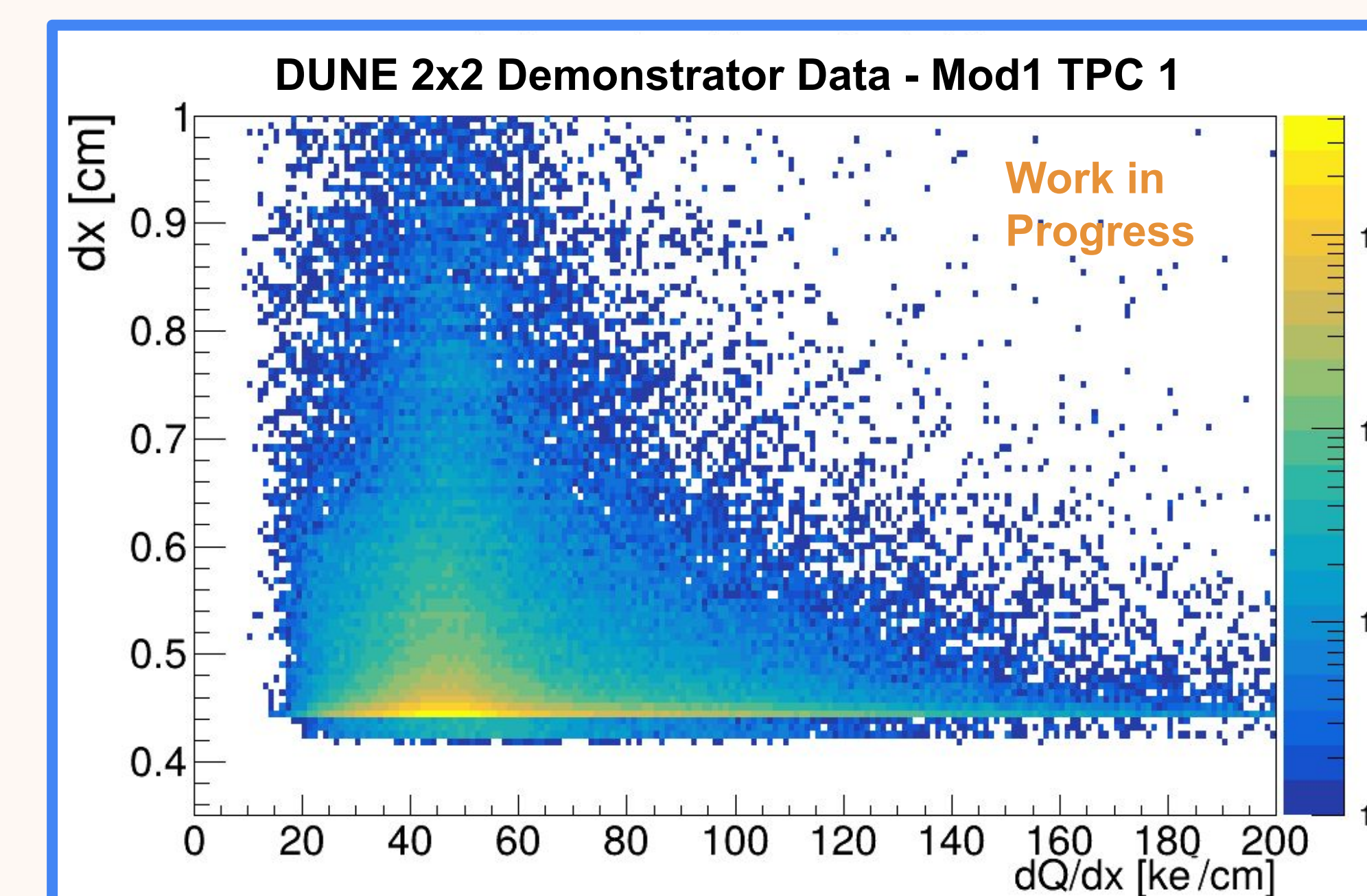
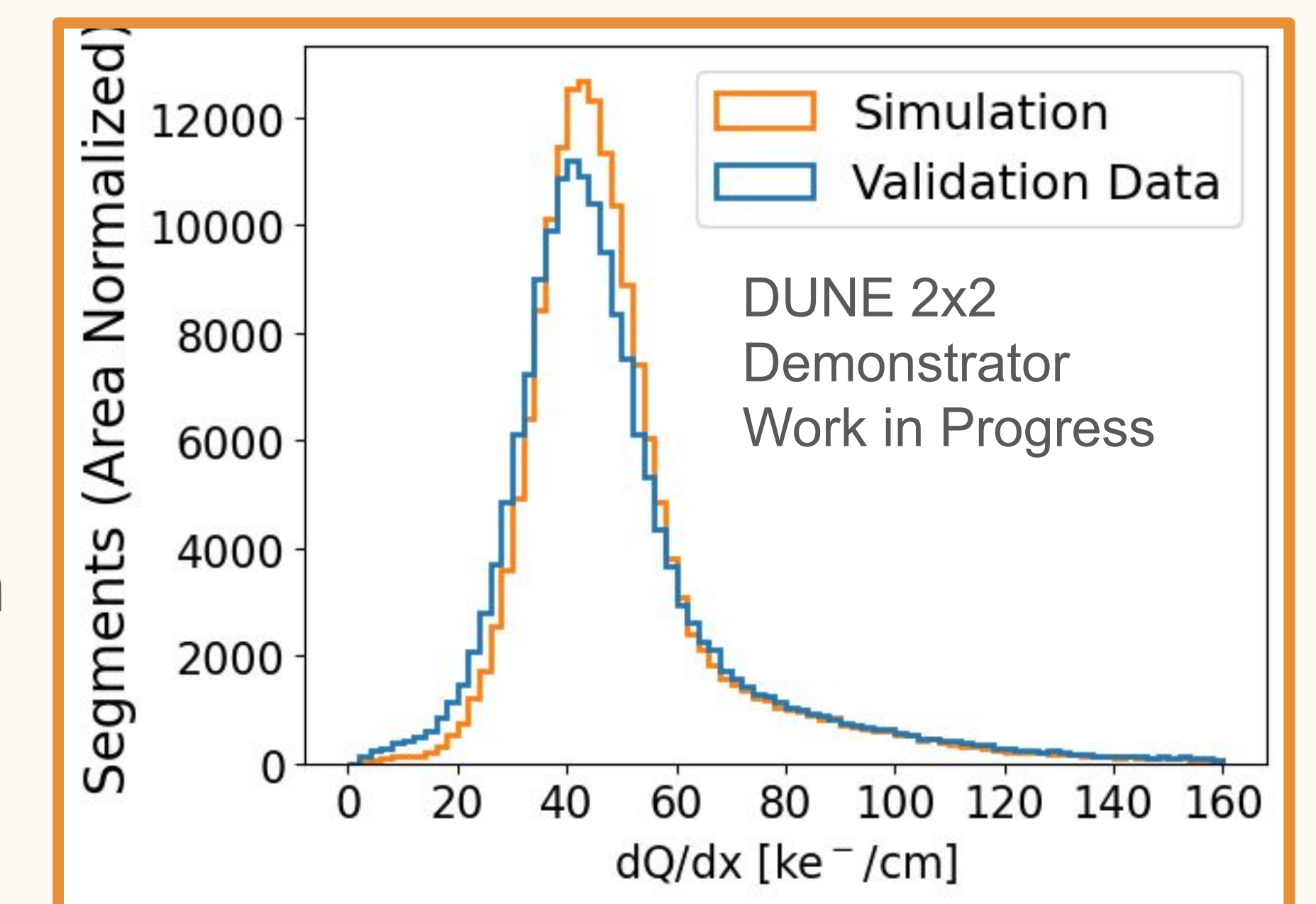
Charge hits in-time with the beam window are clustered and fit to a line to make a track, which is required to cross the detector side to side.

Tracks are divided in **2 cm segments**, the charge of hits in a segment is added to get dQ/dx

Preliminary Results

2 cm segment sample shows good agreement between data and simulation. The main driver of the discrepancy comes from module 2, which has a different charge readout version.

A **single pixel analysis** is also performed with the goal of calibrate individual pixels: **dx** is estimated by projecting the pixel edges to the fitted track and calculating the 3D distance between the intersecting point.



dQ/dx is reconstructed for each pixel and fit to a Landau distribution to extract the **most probable value (MPV)**.

Looking forward, the single pixel analysis provides a promising continuous in-situ calibration of individual pixel gains, and will also provide valuable input for future detector simulation improvements.

References

- [1] D.A. Dwyer et al 2018 JINST 13 P10007
- [2] Instruments 2026, 10(1), 18;

