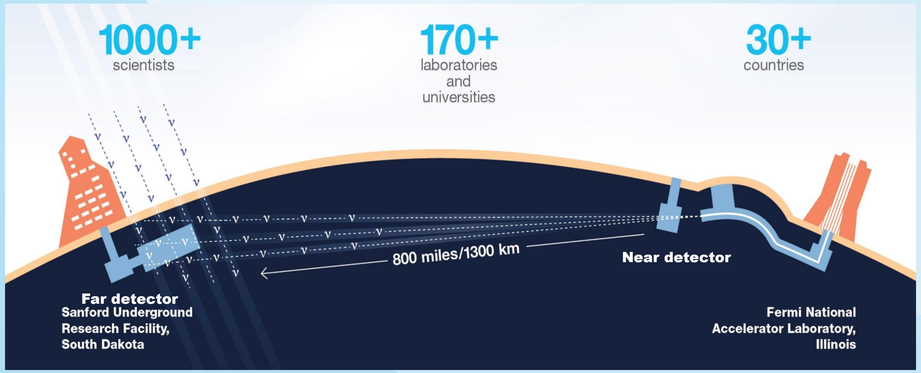
DUNE DEEP UNDERGROUND NEUTRINO EXPERIMENT

Wright Laboratory

Yale University



DUNE consists of two state-of-the-art particle detectors:

- A fine-grained near detector complex at FermiLab, enabling unprecedented studies of neutrino interactions;
- A far detector that will be the **largest of its type ever built**, and will **use 70,000 tons of liquid** argon and advanced technology to record neutrino interactions with **unprecedented precision**. The far detector will be located at **S**anford **U**nderground **R**esearch **F**acility (**SURF**) **1.5 km underground** (> 4000 m.w.e). With a **1300 km baseline**, 1st (2nd) oscillation maximum at about 2.4 (0.8) GeV will be observable.

Long **B**aseline **N**eutrino **F**acility (**LBNF**) will provide a powerful **1.2 MW**, (upgradable to 2.4 MW) neutrino beamline and the infrastructure that will support the DUNE detectors.

Origin of Matter

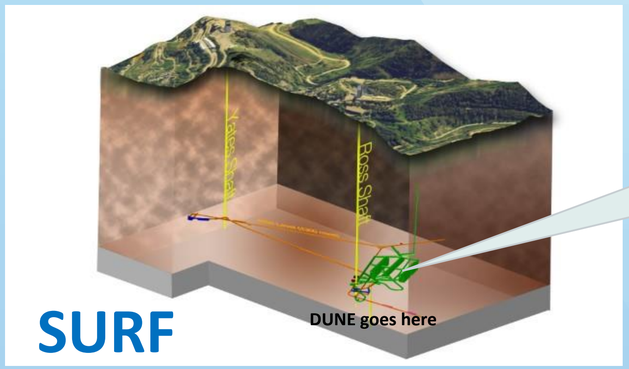
Could neutrinos be the reason that the universe is made of matter rather than antimatter? By exploring the phenomenon of neutrino oscillations, **DUNE seeks to revolutionize our understanding of neutrinos** and their role in the universe.

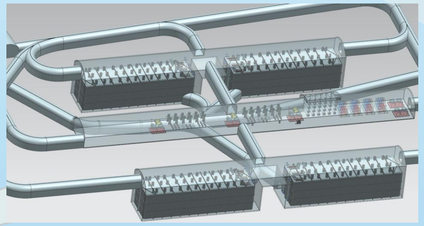
Unification of Forces

With the **world's largest cryogenic particle detector** located deep underground, DUNE can search for signs of proton decay. This could reveal a relation between the stability of matter and the Grand Unification of forces, moving us closer to realizing Einstein's dream.

Black Hole Formation

DUNE's observation of thousands of neutrinos from a core-collapse supernova in the Milky Way would allow us to peer inside a newly-formed neutron star and potentially **witness the birth of a black hole**.





Dune far detector will consist in four 4 identical cryostats 62m (l) x 14m (w) x 15m (h) each instrumented with a **10kt fiducial volume Liquid Argon TPCs**. Each DUNE 10-kt LArTPC module is O(50x) scale-up w.r.t. largest LArTPC to date (ICARUS). The first 10kt module will begin data taking in 2026

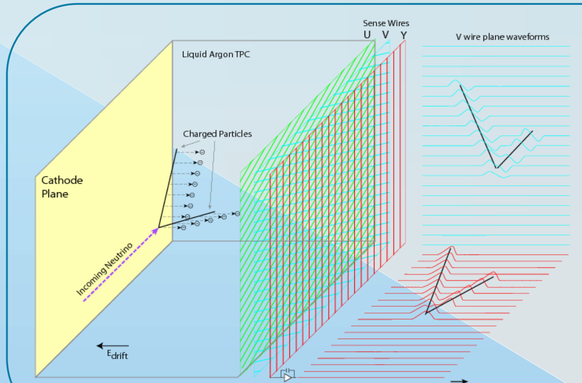
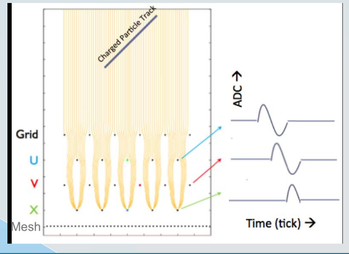
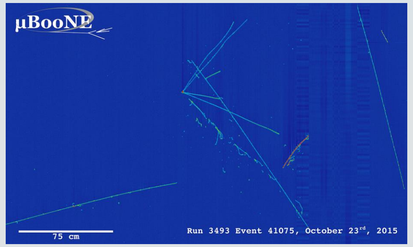
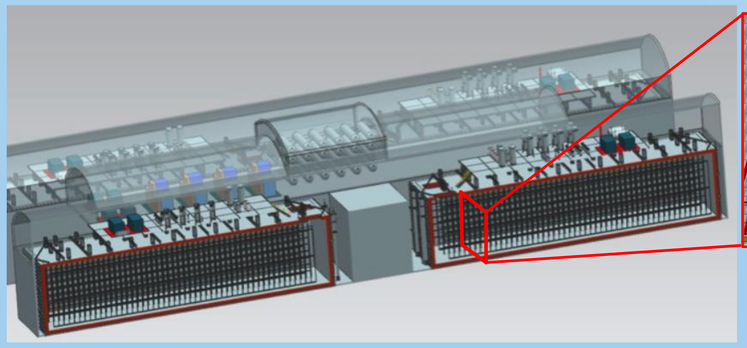


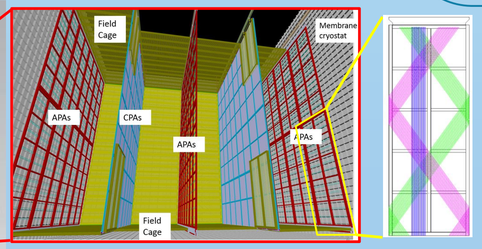
Figure by Bo Yu, BNL

LArTPC technology: In the ν-Ar interaction the charged particles produced ionize the argon as they move through the volume. A field cage provide a uniform E-field and the electrons produced during ionization drift along the field to wire planes where they are collected. What one reads off of wires is the amount of charge and the drift time of the ionization "projected" back into the volume of liquid argon. Hence the name Time Projection Chamber.









Dune LAr-TPC is segmented in units of suspend Anode/Cathode Plane Assemblies (APAs/CPAs) with 3.6 m maximum drift distance and a field of 0.5 kV/cm. Each APA reads out drifted ionization charge from a volume of liquid argon on either side of a sensor wire array. Data is recorded in the form of **high-resolution 2D-projected views** of charged particle trajectories in the liquid argon.

The two planes of induction wires wrap in a helical fashion around the long edges and over both sides of the APA with 37.7° w.r.t the vertical collection planes. The angle was chosen to ensure that each induction wire only crosses a given collection wire once, reducing the ambiguities.

For more information
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DUNE@YALE's Wright Lab: For the 4 TPCs, a total of 300 APAs will be built using winder robots (side picture). Instrumenting an APA is a high precision task. Thousands of Be-Cu wires/APA will be carefully stretched on the APA frame. Tension (5N) and pitch need to be performed and controlled with high accuracy. Electronic board connections have to be tested for electric continuity for every single wire. **Dune's Wright Laboratory group** (D. Franco, T. Langford, B. Fleming, K. Heeger) will play a critical role in the collaboration going to be **one of the four worldwide APA production sites**.

APA design parameters

Parameter	Value
Active Height	5.984 m
Active Width	2.300 m
Wire Pitch (U, V)	4.669 mm
Wire Pitch (X, G)	4.790 mm
Wire Pitch Tolerance	±0.5 mm
Wire Plane Spacing	4.75 mm
Wire Plane Spacing Tolerance	±0.5 mm
Wire Angle (w.r.t. vertical) (U, V)	35.7°
Wire Angle (w.r.t. vertical) (X, G)	0°
Number Wires / APA	960 (X), 960 (G), 800 (U), 800 (V)
Number Electronic Channels / APA	2560
Wire Material	Beryllium Copper
Wire Diameter	150 μm