Calibrating the world's largest LArTPC detector

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on behalf of the DUNE Collaboration

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DUNE

The Deep Underground Neutrino Experiment

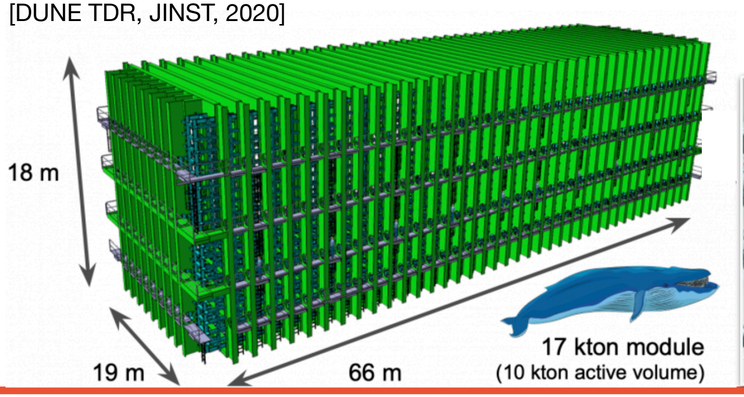
The next generation long-baseline experiment for neutrino physics

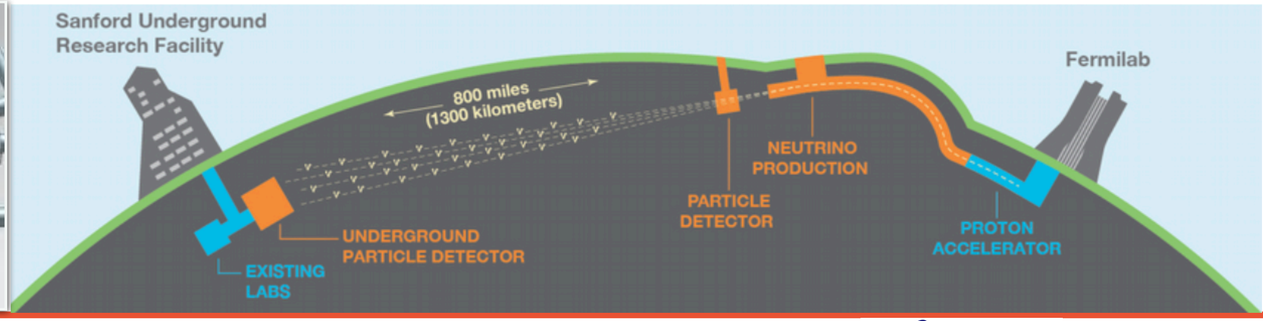
- An ambitious scientific programme:
  - Measure δ_{CP} (probe matter-antimatter asymmetry)
  - Neutrino mass hierarchy
  - Supernovae and solar physics
  - Nucleon decay
  - BSM searches

The two ProtoDUNE detectors (800 tons each) are the largest LAr-TPCs ever built

A single DUNE-FD module will be 20 times larger than one ProtoDUNE detector

[DUNE TDR, JINST, 2020]

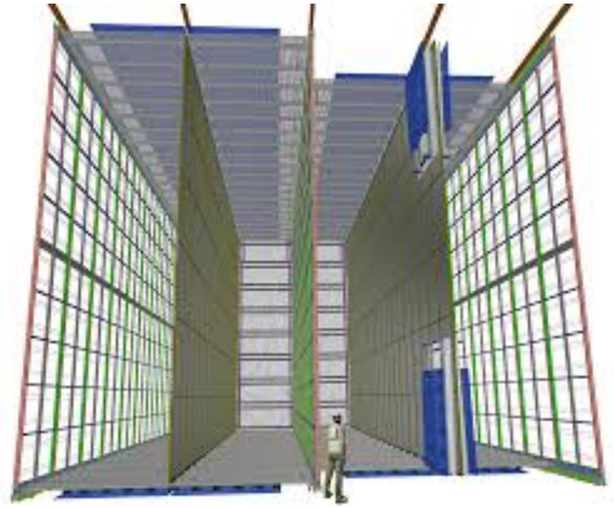




Calibrating DUNE

Getting outstanding performances from a huge-size detector for ambitious physics goals

- Top-level calibration requirements for the physics goals:
  - GeV-scale oscillation physics: energy scale uncertainty < 2% for leptons and 5% for hadrons
  - MeV-scale low-energy physics e.g. supernovae, solar: energy resolution ~20-30%
- Calibration challenges for DUNE
  - Stringent physics requirements
  - Deep underground location, low stats for cosmic rays
  - Challenge due to huge size
  - Highly segmented detector: 4 drift volumes, hundreds of cathode/anode planes, etc

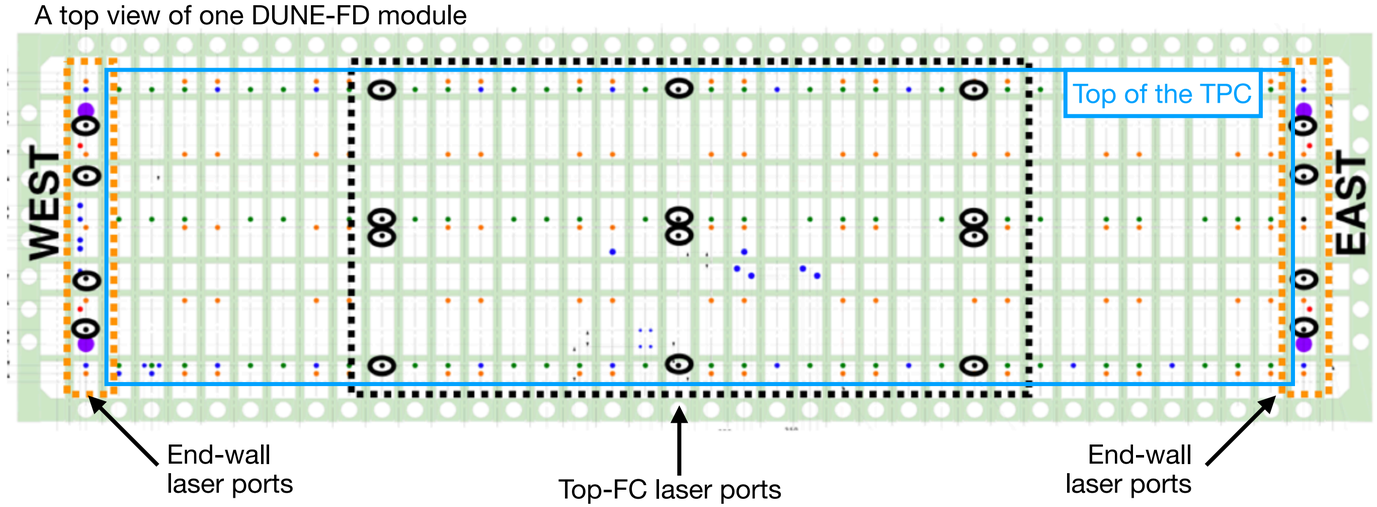


Dedicated calibration systems are needed

External calibration systems for DUNE Far Detector

Introducing the DUNE Ionisation Laser System

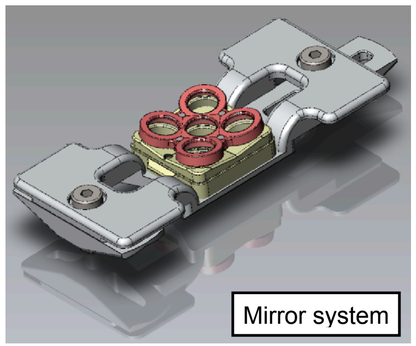
- Radioactive sources
  - Provide in-situ source of 9 MeV gamma rays
- Pulsed Neutron Source
  - Neutron capture on argon resulting in 6 MeV gammas
    (see talks of **Y. Bezawada** and **J. Huang**)
- Ionisation Laser System
  - Multi-purpose calibration system
  - Provides an independent fine-grained measurement of detector parameters
    e.g. drift velocity, electric field
  - Diagnose the detector e.g. tilts/shifts of anode and cathode, high voltage issues
  - Planning for multiple laser systems on DUNE with ~15 m spacing
  - Two designs planned to avoid shadowing effects from detector components e.g. field cage profiles, I-beams, resistor plates etc.
  - For the central ports, field cage penetration is planned for improved coverage

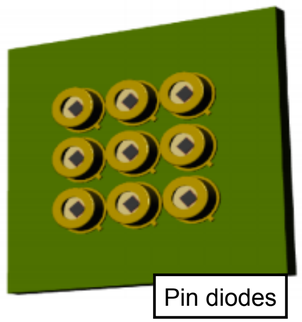


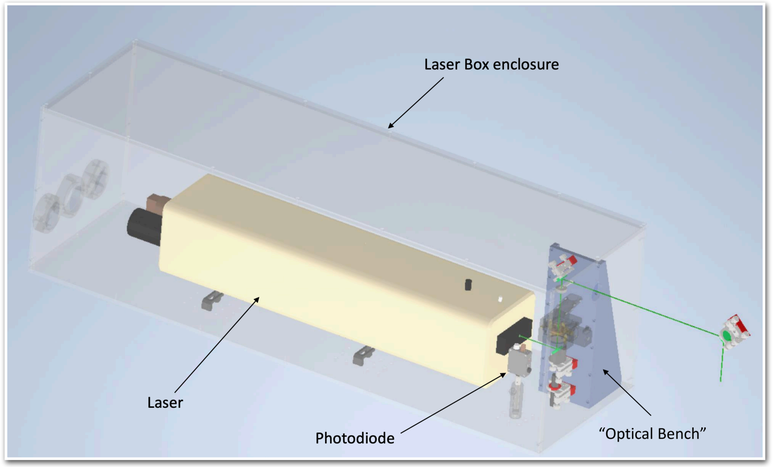
DUNE-IoLS - The DUNE Ionisation Laser System

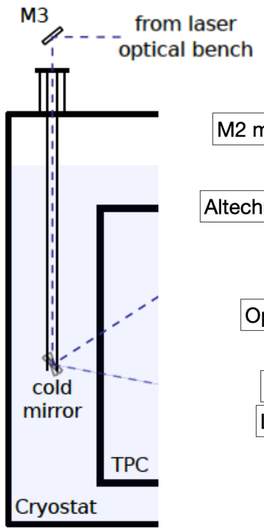
An overview of the hardware design

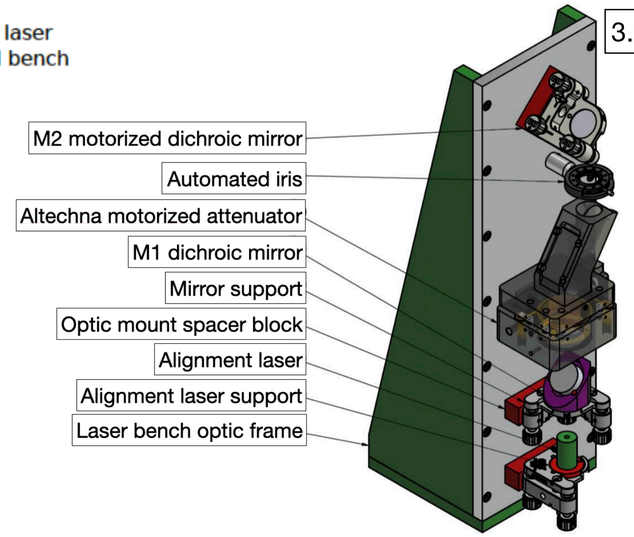
- The system is composed of:
  - One laser system, with a laser (Nd:YAG, 266 nm) and a laser box, including an optical bench
  - One optical feedthrough and periscope system, required to drive the laser light inside the liquid argon volume
- A laser beam location system will independently verify the beam position uncertainty requirement of 5 mm over 10 m distance requirement for precision

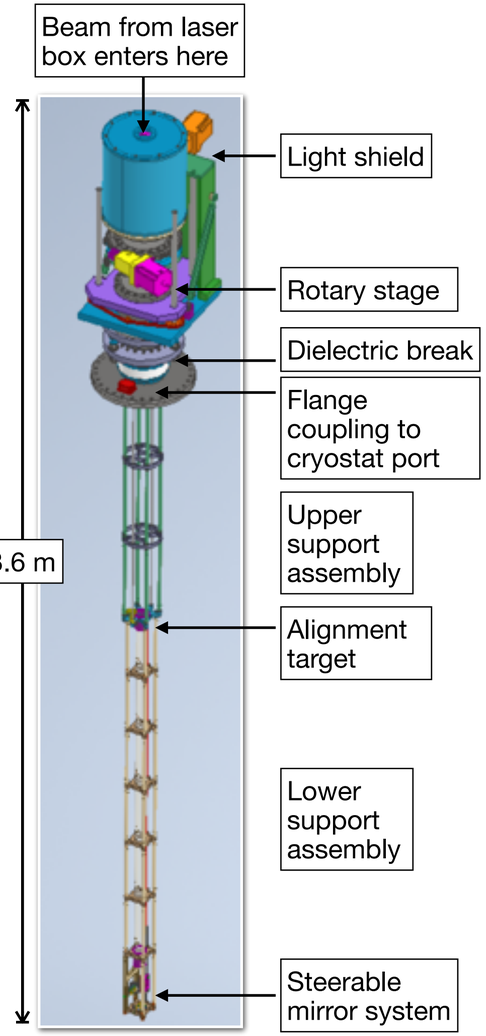












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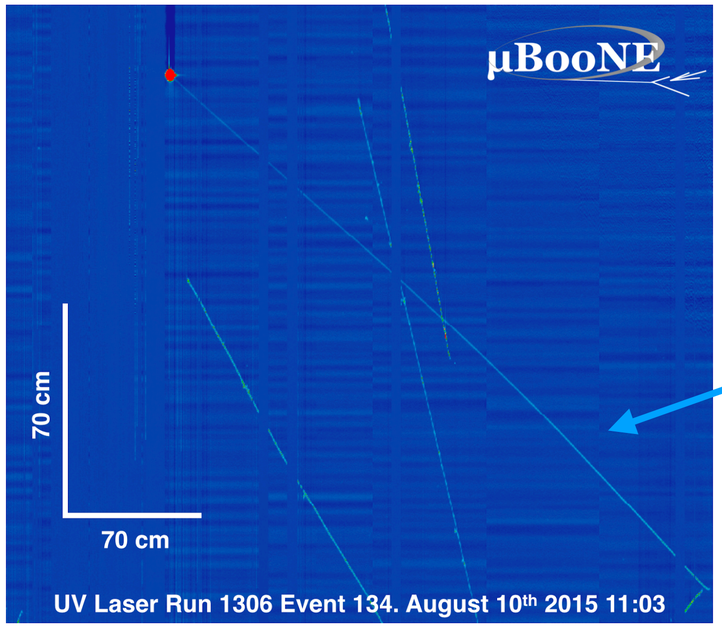
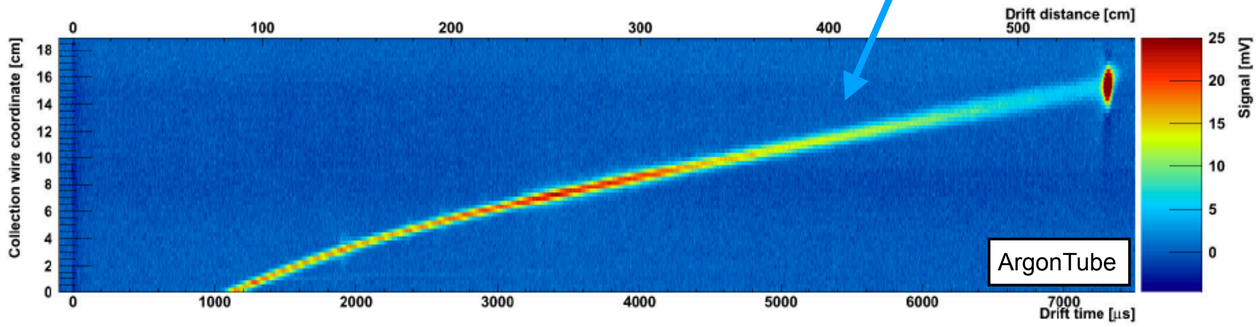
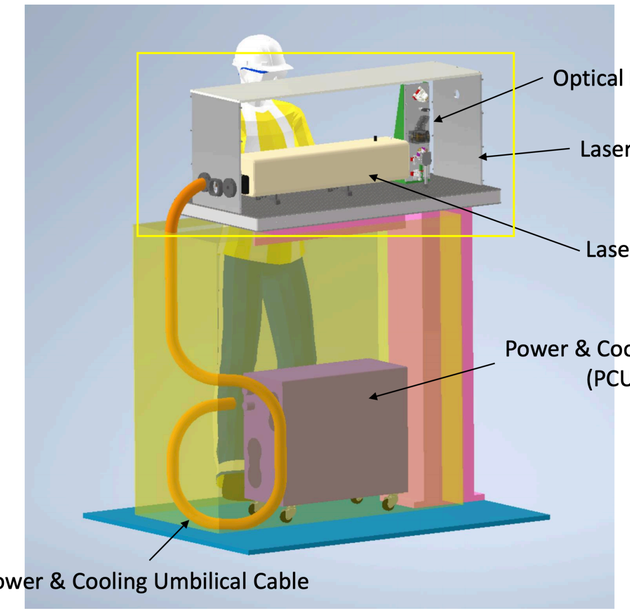
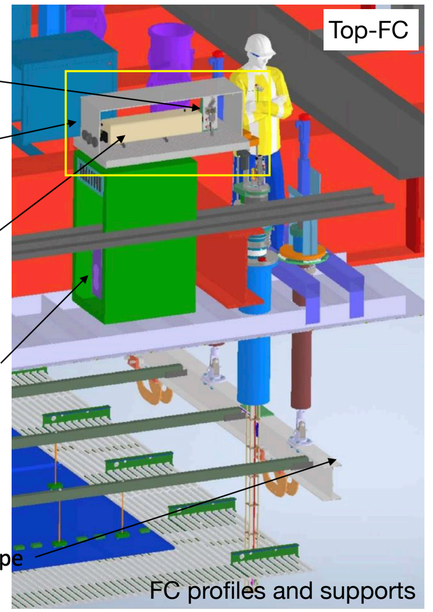


Straight laser tracks detected as curved because of non-uniform electric field





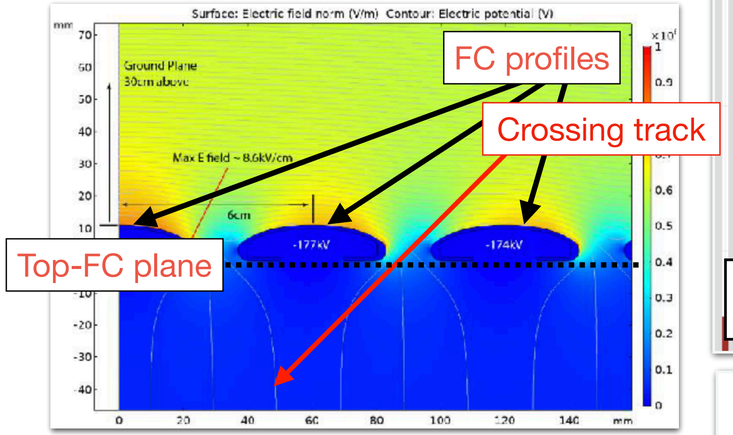


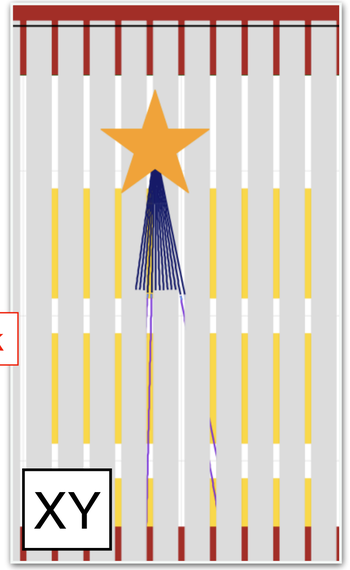
- Plan to install two prototype systems in ProtoDUNE in 2022

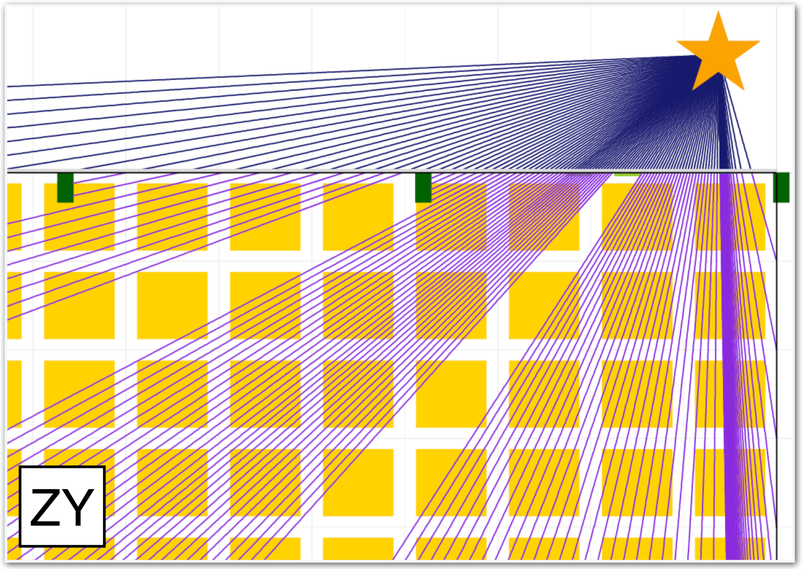
Laser coverage of DUNE

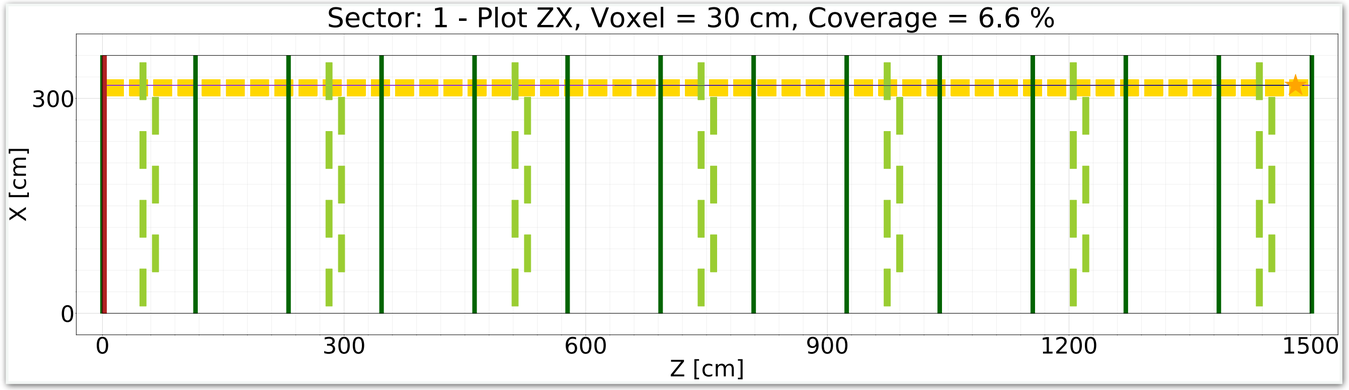
A versatile laser coverage simulation framework

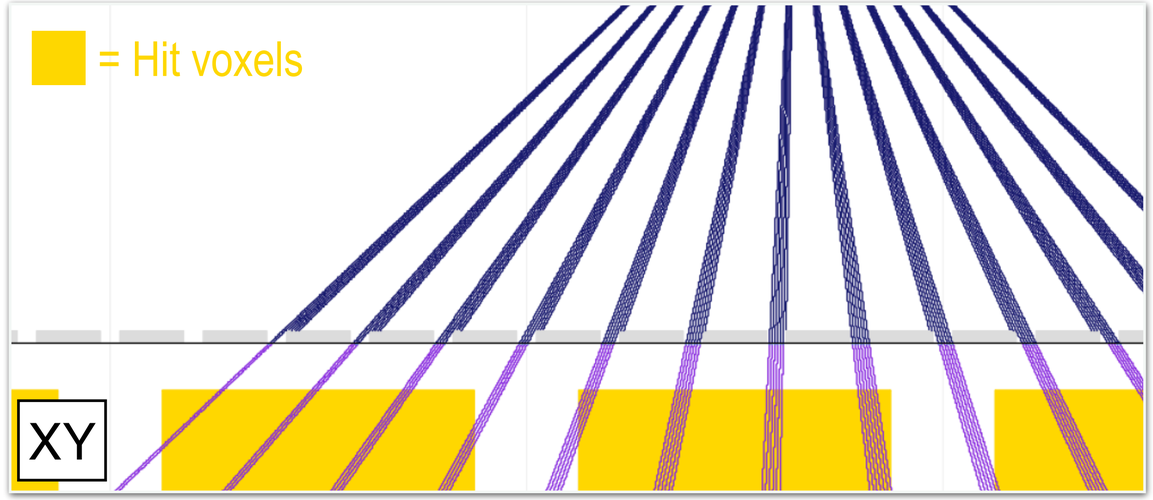
- Laser coverage simulations are actively ongoing to optimise the laser system design and distribution of lasers on top of DUNE considering most realistic scenarios











Thank you for your attention