Design and test of the lens based optical detector for SAND in the DUNE experiment

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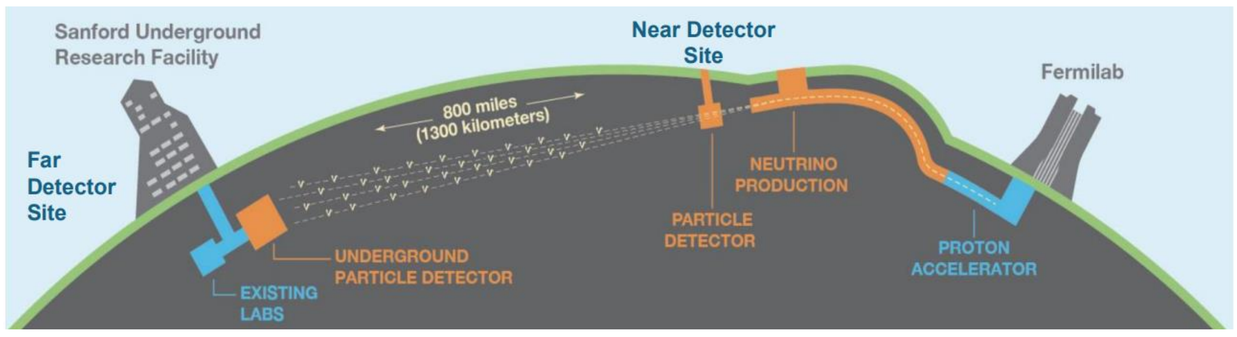
The Deep Underground Neutrino Experiment and the Far Detector



Main physics goals:

- ❖High precision measurements of the neutrino oscillation parameters
- ❖Study of CP violation
- ❖Supernova and solar neutrinos detection
- ❖BSM searches

Far Detector:

- 1300 km far away (South Dakota) and 1.5 km deep underground
- **Phase I**: two Liquid Argon (LAr) TPC modules
- **Phase II**: four LAr TPC modules, with a total mass of 70 kt of LAr

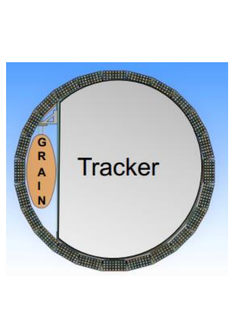
GRAIN (GRanular Argon for Interactions of Neutrinos) detector

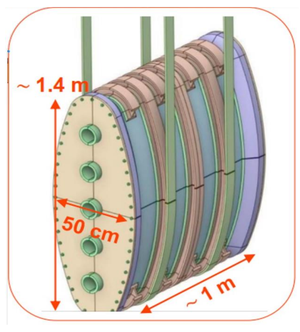
It is a **passive target:**

- **1-ton LAr** in a magnetized volume
- To study for ν-Ar interactions with downstream tracker/calorimeter

It is an **active target,** instrumented with sensors:

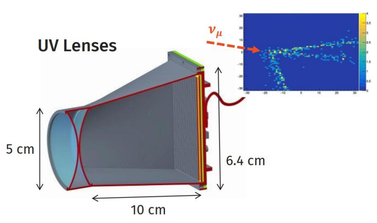
- For collecting UV scintillation light with arrays of SiPMs
- For performing imaging of the event





Lens based optical system

- **2 mm side** SiPM 32x32 matrices
- A **unique ASIC** specifically designed for **GRAIN**



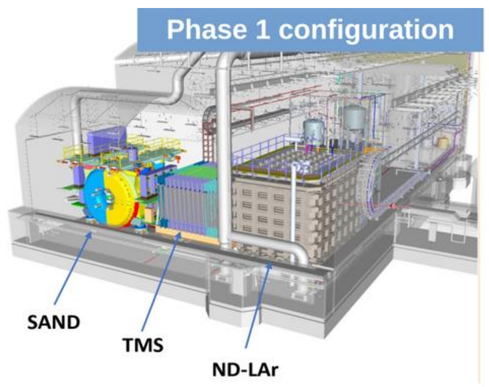
Challenges to be addressed:

1. The VUV light emitted by the LAr scintillation is very short (127 nm)
2. The refractive index of LAr is not precisely known, but it's close to the RI of common lens materials

Near Detector

During the **Phase I**, the Near Detector will be composed of three sub-detectors:

- **ND-LAr**, featuring a LAr TPC
- **TMS** – Temporary Muon Spectrometer
- **SAND** – System for On-Axis Neutrino Detection



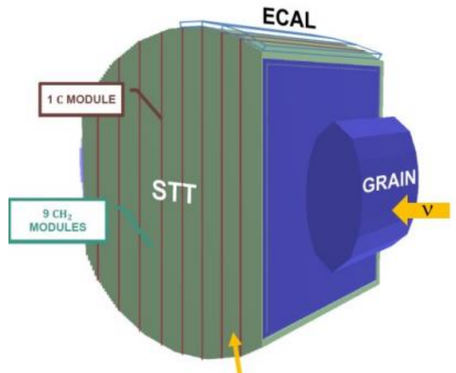
SAND detector

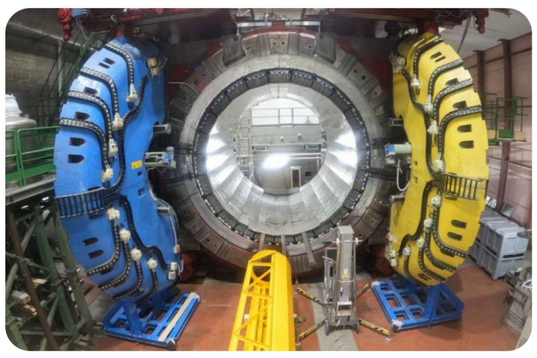
It's a **multipurpose** detector for:

- ➢ Monitoring the on-axis $\nu/\bar{\nu}$ spectra to detect beam variations on a weekly basis
- ➢ ν_μ, ν_e on-axis flux measurements
- ➢ Performing neutrino cross-section studies on different nuclear targets

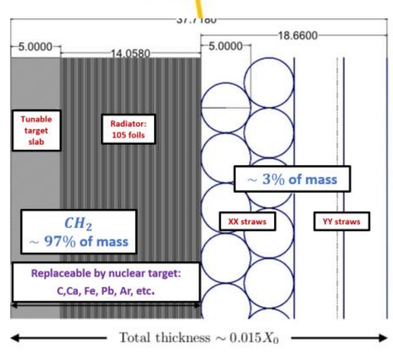
It is composed of:

- ❑ Superconducting magnet (0.6 T)
- ❑ Electromagnetic calorimeter
- ❑ Straw Tube Tracker
- ❑ **GRAIN**: one ton LAr active target



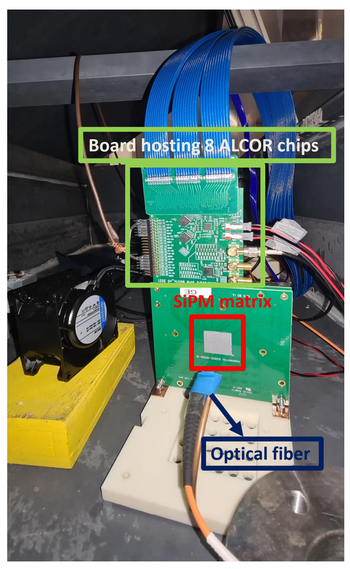


SC magnet and em calorimeter from KLOE experiment

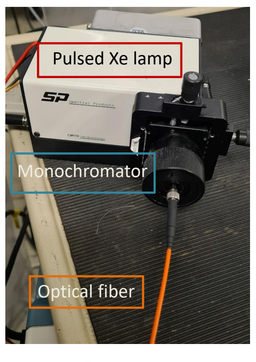


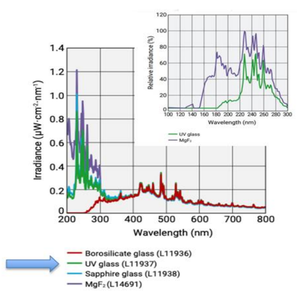
Tests of the acquisition board with an artificial light source

1. Setup

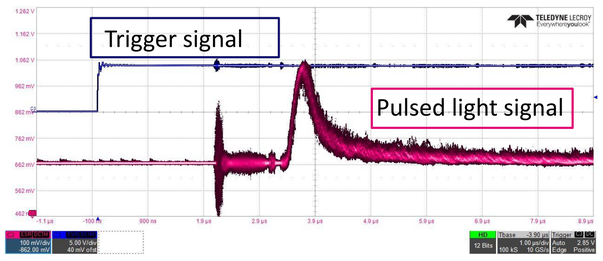


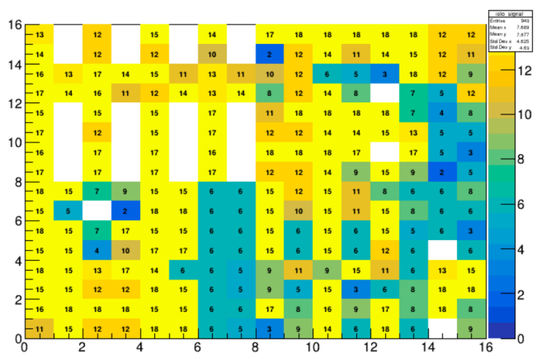
2. Light source





3. Preliminary results





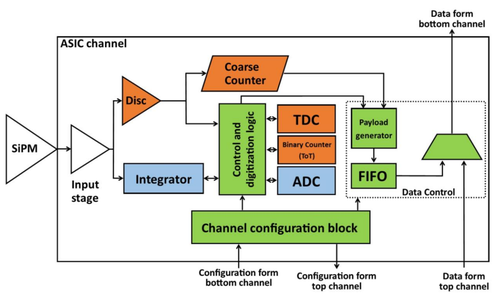
- 18 counts are expected for each channel
- Thresholds have to be optimized for some channels
- Light is detected on the whole matrix

4. Future perspectives

- Optimization of threshold and gain for each channel
- Tests with SiPM of 3 mm side matrix
- Tests with lens prototypes

Readout electronics design: requirements and proposed architecture

1. Proposed architecture



GRAIN ASIC

- **1024** channels
- Integration windows with:

❑ rising edge (TR of 100 ps)
❑ falling edge (TR of few ns)
❑ charge integrator

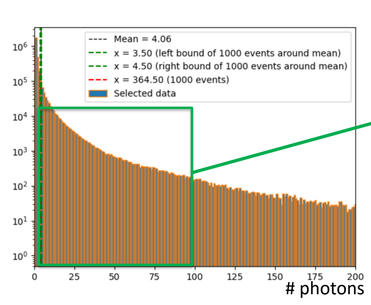
- Power consumption < **5 mW/ch**

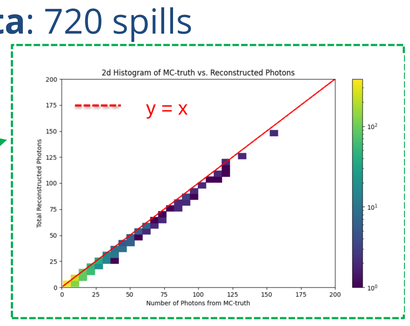
2. ASIC requirements

1) Capability to accurately detect 0-10 photons per channel
2) Saturation over 80/100 photons for each integration window

3. Preliminary studies

Simulated data: 720 spills





Left: distribution of the number of photons per integration window
Right: reconstructed photons vs Monte Carlo – truth photons
Selected sample: integration windows with 2 < # photons < 100
The number of photons is well reconstructed up to ≈200 photons

4. Conclusions

The preliminary ASIC design works as expected

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