A 20 ton double phase LAr TPC for LBNO

Sebastien Murphy on behalf of the WA105 collaboration

ETH Zürich, Institute for Particle Physics.

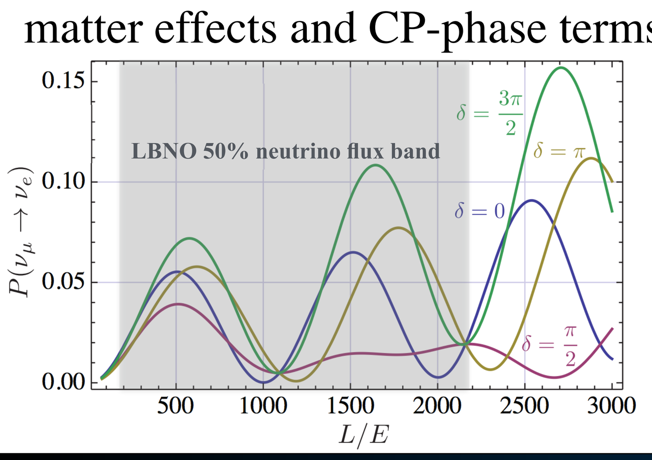
The future: mass hierarchy and CP phase discovery with LBNO

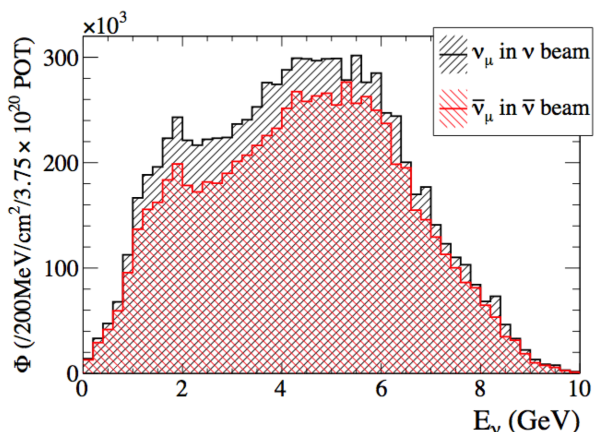
From CERN…to Finland

✴**phase 1.** SPS 700 kW + 20 kt LAr + 35 kt MIND Mass hierarchy 5σ in 5 years. CP 60% coverage at 90% C.L.)

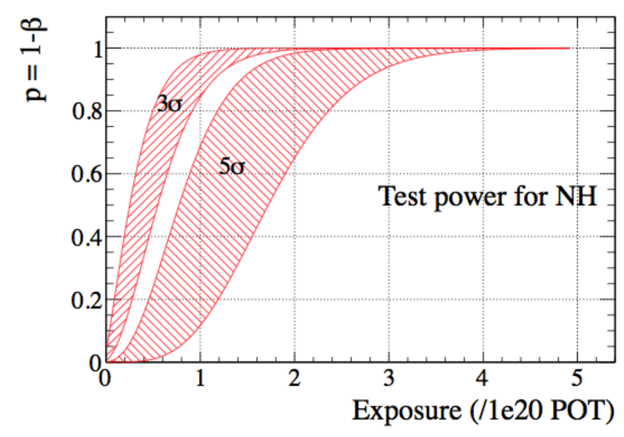
✴**phase 2.** Add 50 kt: 70 kt LAr and/or 2 MW from HP-PS: full CP discovery (5σ)

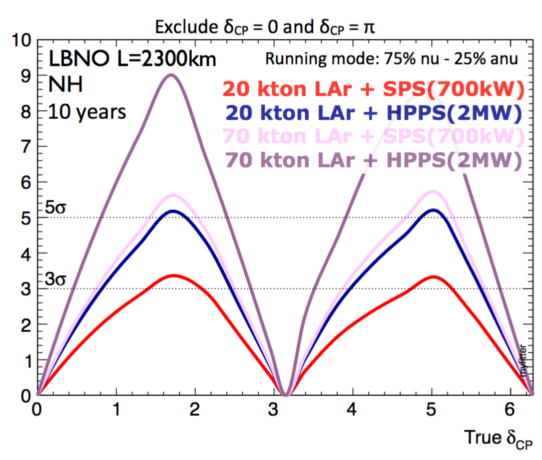
Thanks to the long baseline we can study the **1st and 2nd oscillation maxima**. Reconstruct the L/E feature of the oscillated spectra induced by matter effects and CP-phase terms.





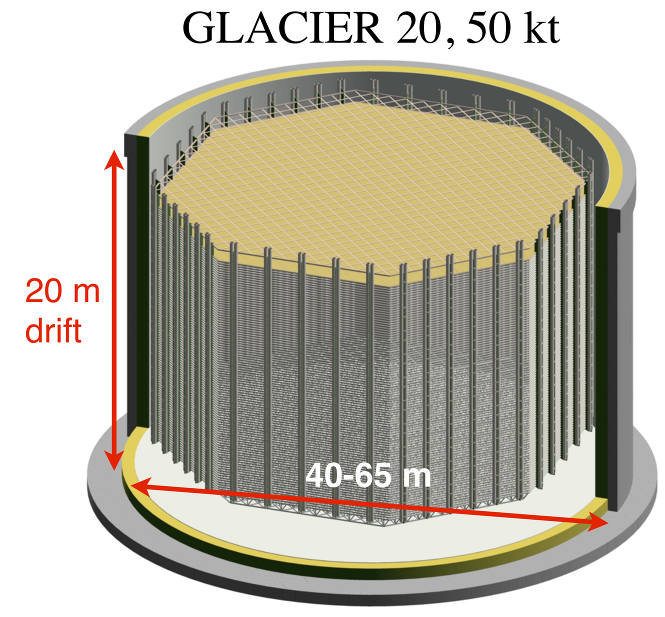
A wide band beam, a long baseline and a far detector with high energy resolution





LBNO strategy relies on precisely measuring the shape of the oscillated spectra in the energy range 1-10 GeV. This requires a far detector with Large mass, low energy detection threshold excellent energy resolution and tracking performance over a wide energy range.

GLACIER 20, 50 kt



requires intensive R&D!

Some of the components that have to be tested and extrapolated to large areas:

✴Charge readout

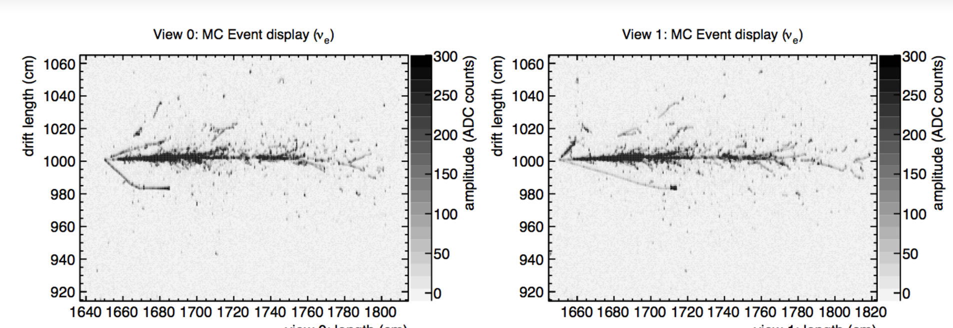
✴Long distance drift (up to 20m) + diffusion

✴HV up to the MV scale

✴purity in non evacuated membrane tank

✴cost effective cold front-end electronics and DAQ

The Double phase liquid argon TPC

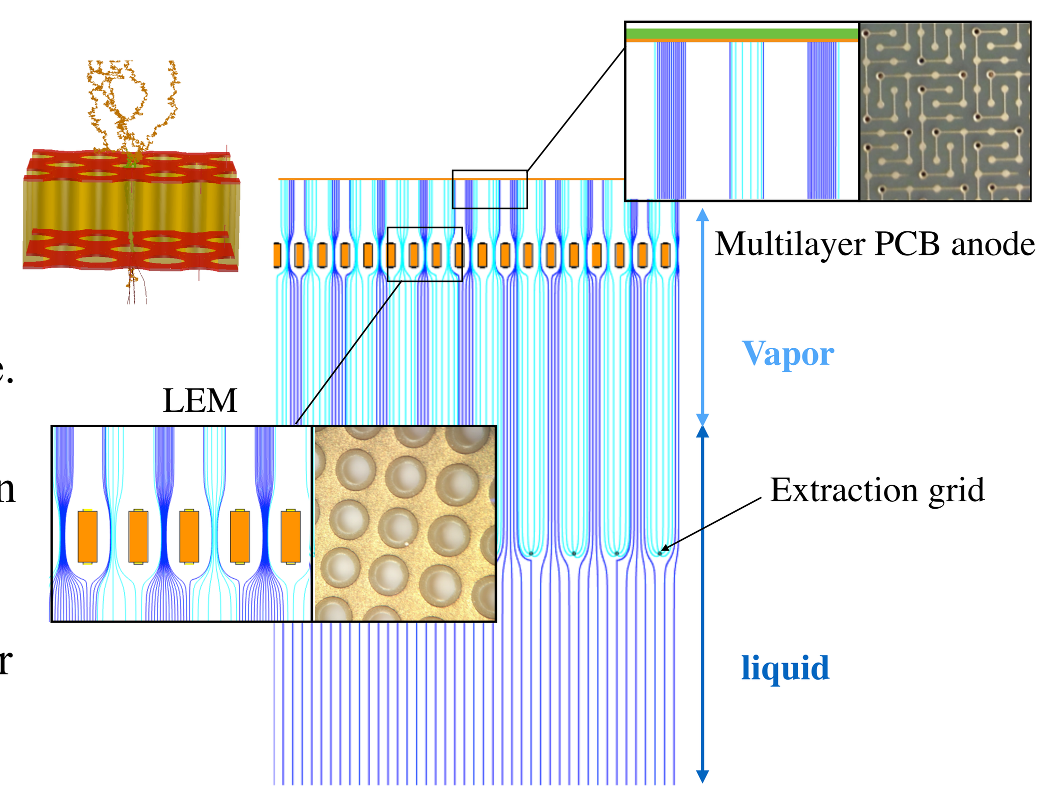


✓**Excellent** energy resolution and tracking performance. **Efficient** background rejection (e.g NCπ0 from $CC\nu_e$)

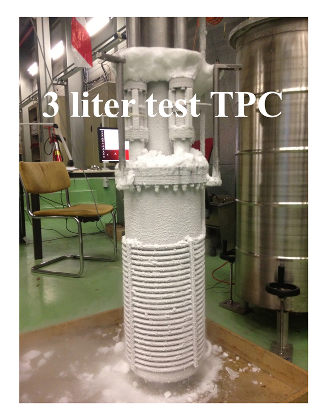
✓**High granularity**: ~0.05 cm in drift direction, 3mm in transverse direction

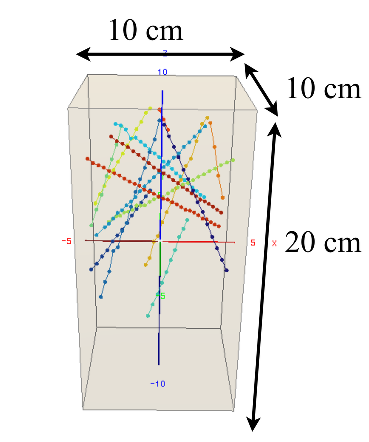
✓Very **high signal-to-noise** (>100) thanks to amplification in gas. => build large detectors with longer drifts (~20m) and larger readout capacitances.

✓**Adjustable** Energy threshold=>sensitivity from sub-GeV to multi-GeV

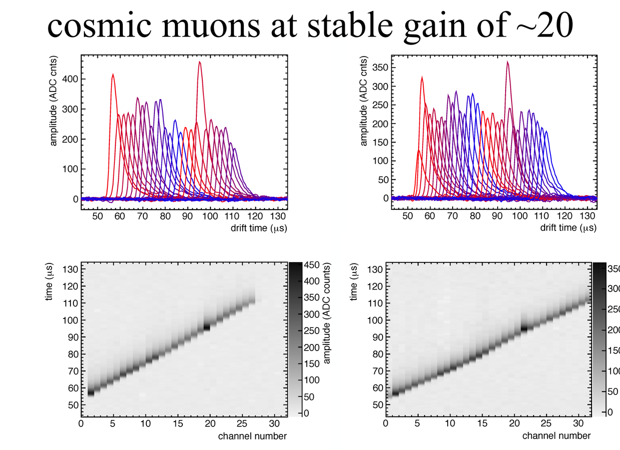


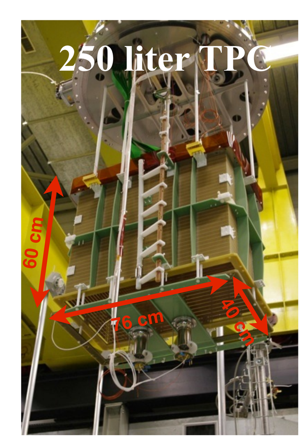
proof of principle on liter scale TPCs





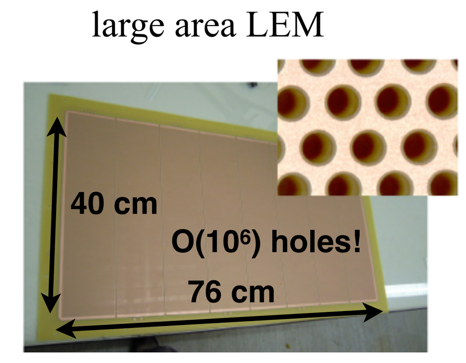
cosmic muons at stable gain of ~20



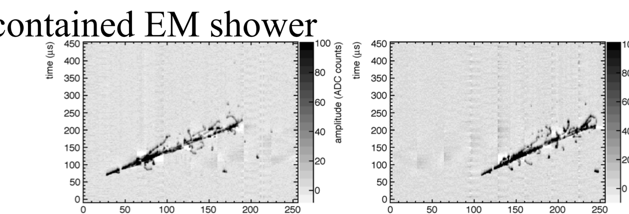


arXiv:1312.6487

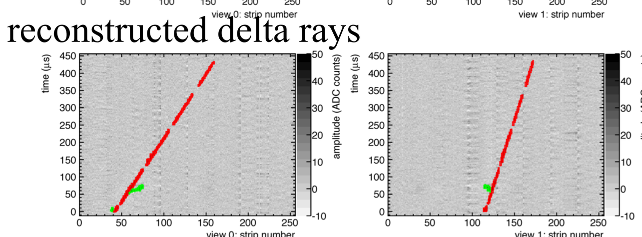
large area LEM



contained EM shower



reconstructed delta rays



CERN WA105: R&D towards LBNO scale far detectors

6x6x6 m³ (~300 ton) double phase LAr demonstrator in charged-particle test beam.

Development and proof-check of industrial solutions for GLACIER But also important and compelling physics:

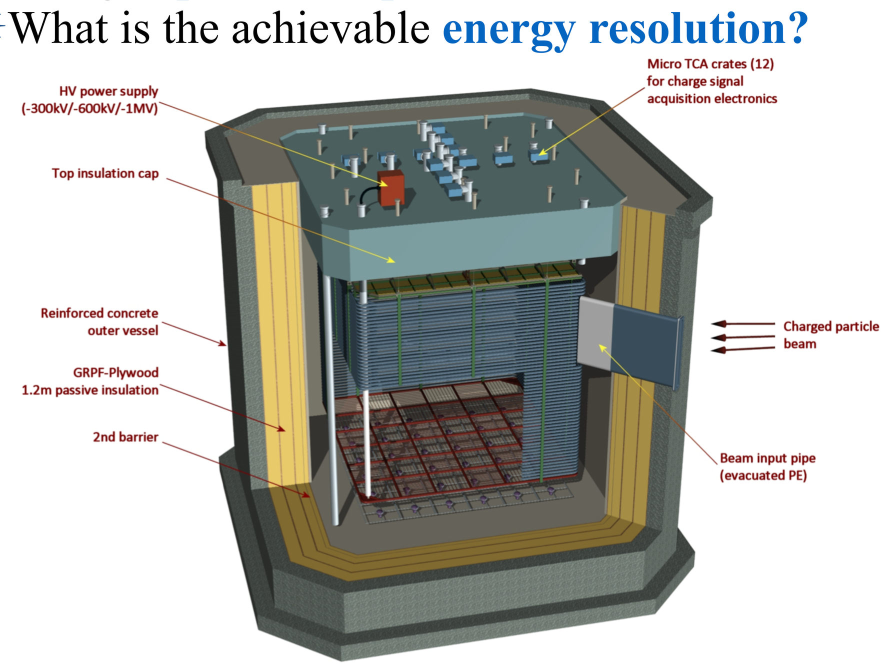
✴**Fully contained events from well defined** primary particles and energies

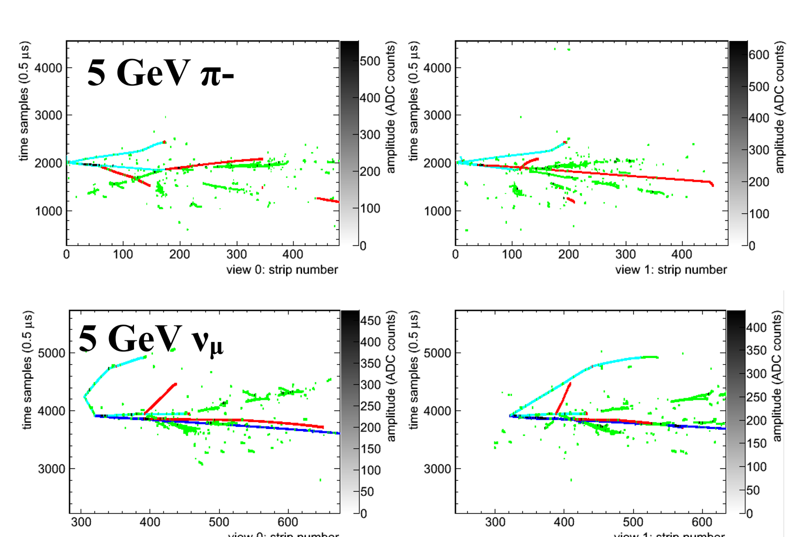
✴Development of automatic event **reconstruction**

✴**Test NC background rejection** algorithms (e/γ separation) on "ν_e free" events

✴Charged **pions and proton cross-section** on Argon nuclei.

✴What is the achievable **energy resolution?**





pions, electrons/positrons, protons, muons

Development of large scale readouts

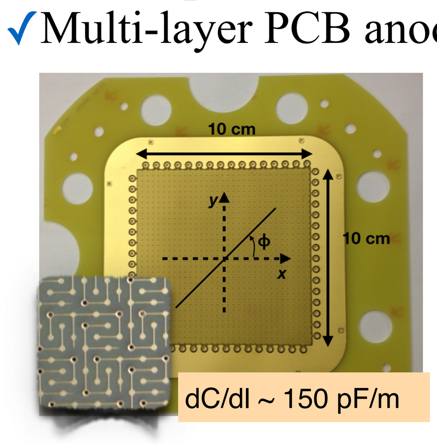
The Anode

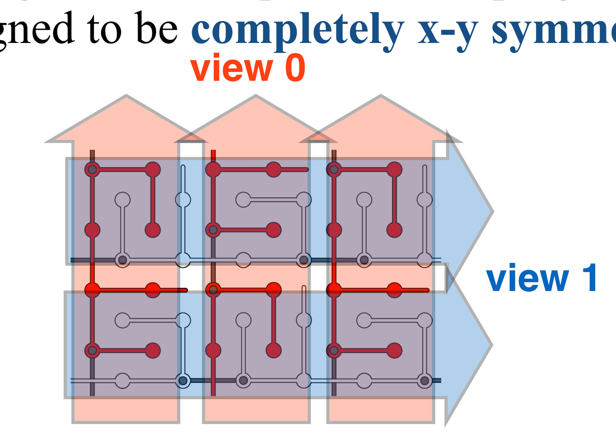
C Cantini et al 2014 JINST 9 P03017

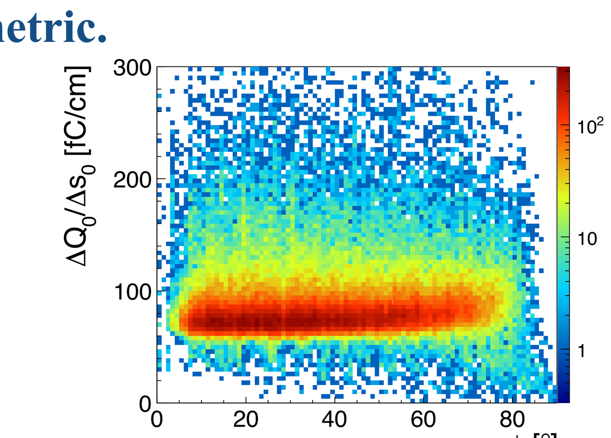
✓**Easy** to manufacture on **large scale**

✓**Low capacitance** to have long readout strips while keeping the noise to minimum.

✓Multi-layer PCB anode designed to be **completely x-y symmetric.**





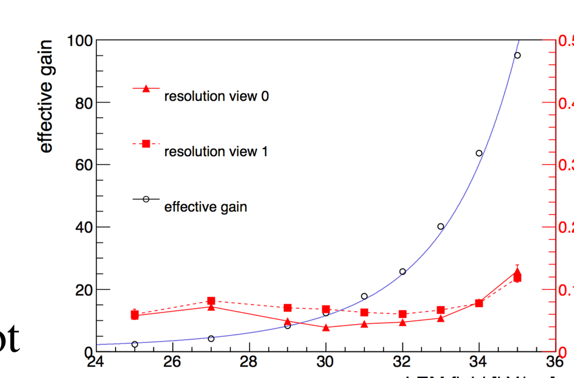


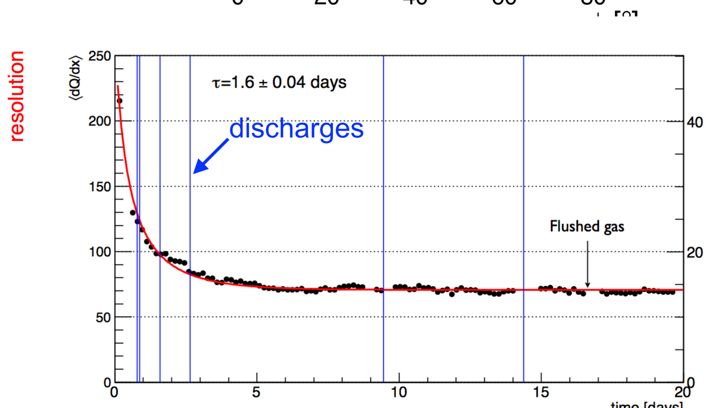
The LEM

✓reached **gains of 90**

✓**stable gain** of ~20 for 15 days after a charing-up period of ~1 day

✓**few discharges** that do not affect the overall gain



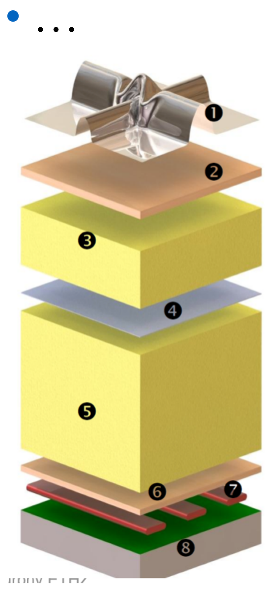


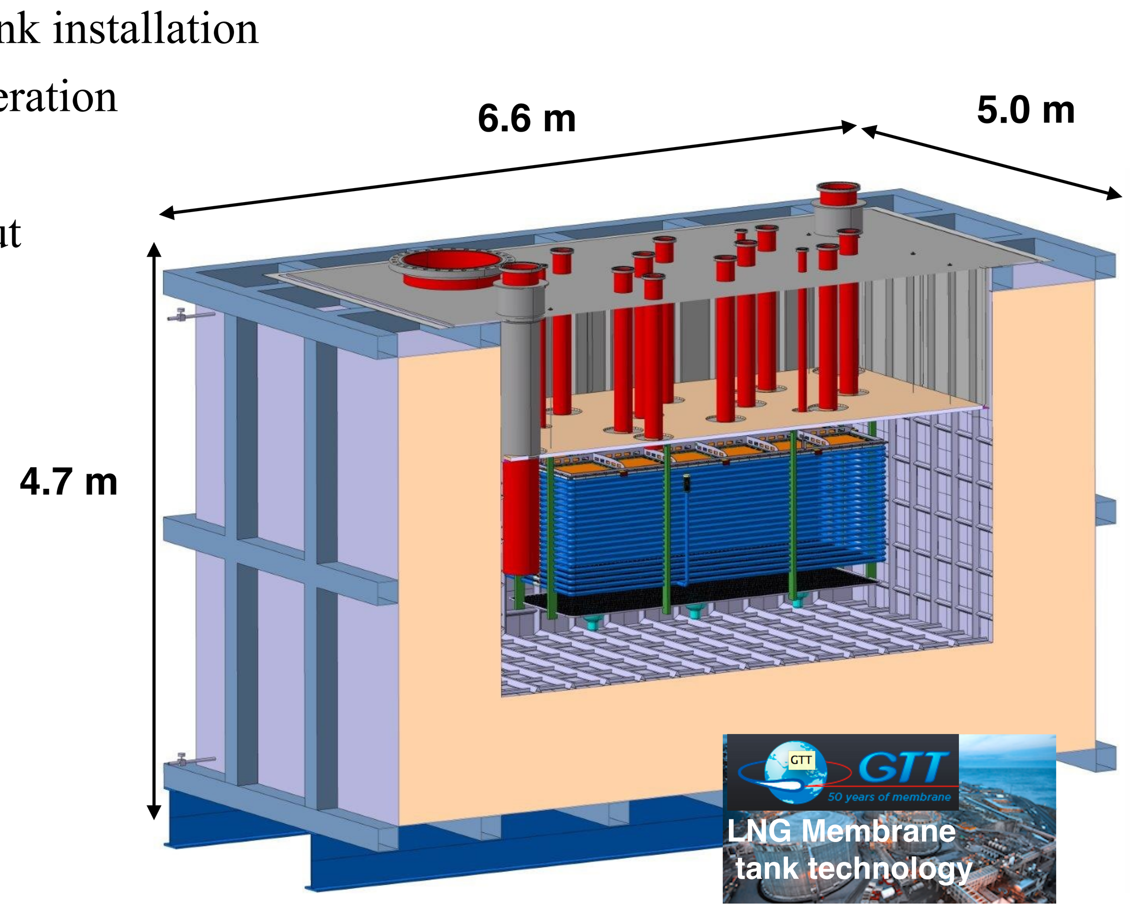
Near future: 24 tons of LAr and a 3 m³ Double Phase TPC

A 17 m³ membrane tank hosting a 3x1x1 m³ Double Phase TPC

Will allow to test/optimise many aspects of the 6x6x6 m³ prototype

- Membrane tank installation
- cryogenic operation
- insulation
- charge readout
- …

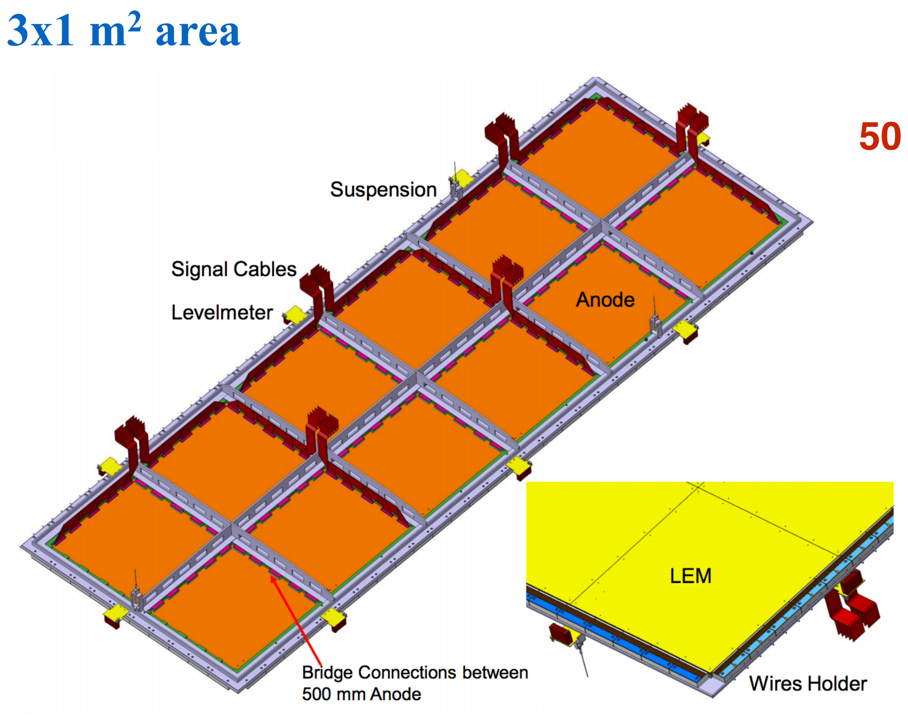


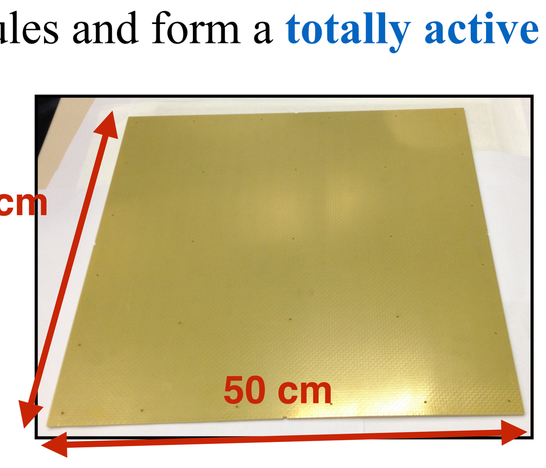


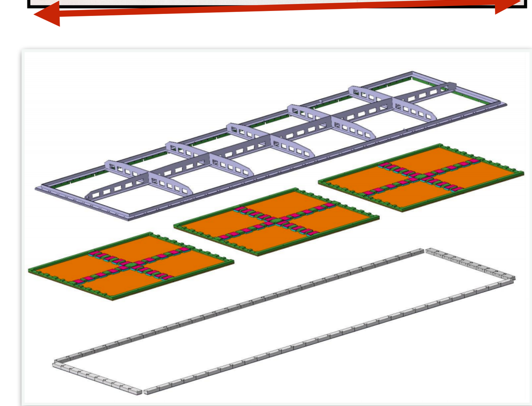
The Charge Readout Plane :

✓anode LEM and extraction grid grouped in a **single frame**

✓anode and LEM are made from 50x50 cm² modules and form a **totally active 3x1 m² area**







1m² mechanical mockup of the Charge readout plane