Liquid Scintillator Track on DORAEMON

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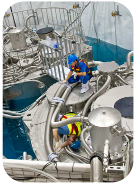
Liquid Scintillator Neutrino Detector

Proximity to 8 nuclear reactors
and **unprecedented size**

evolution of LS detectors

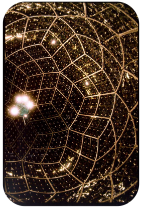
Reines & Cowan 300 L

Daya Bay 8 x 20 t

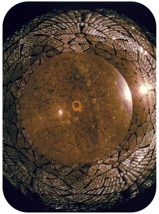


Borexino 300 t

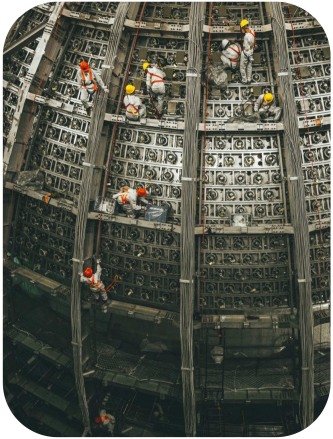
KamLAND 1,000 t



SNO+ 780 t



JUNO 20,000 t



Energy 0.1 MeV – 30 MeV where LS is needed

- Point source dominant; Multi-sited energy deposition of γ rays.

Particle reconstruction

A single particle in LS, PID of $\alpha\beta^+/\beta^-\gamma$.

- Grouping pixels
- Particle ID (e, mu, tau, p, gamma, pi, pi0, K, n...
- Start 3-position
- Start 3-direction
- Initial momentum magnitude
- ...

Interaction reconstruction

Interaction effects are neutrons, capture on H/Gd.

- Grouping particles (at pixel level)
- Primary particles (at pixel level, 2ndaries are “background”)
- ...

Geometric/Modality correspondence

- 2D hits => 3D segments inverse projection

Mostly Geometric (tier 3) tasks

Light generation

- Scintillation time profile, Birks' law

Light propagation

- Fundamental part is addressed by LUCiD in principle.
- Geometric boundary model is the remaining challenge.

Light detection

- PMT response modeling.

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Light detection

- PMT response modeling.

- GeV physics is potentially doable in LS, but more challenging than Cherenkov/LArTPC.
  - MeV photons on par with GeV Cherenkov events.
  - Not the scope of this evaluation.

Summary

- Active LS groups and major ν projects across all the continents.
- An LS track on DORAEMON is complementary to water-Cherenkov and LArTPC.
  - Scientific goals
    Energy range of 0.1 – 30 MeV, geo-/solar/reactor neutrino, $0\nu\beta\beta$.
  - Technology developments
    Geometric MC/data consistency and precise modeling is the major challenge.

Seven Years of Operational History

Ghost Hunter is a battle-tested infrastructure continuously operating since 2019.
7 Editions Hosted (2019 - 2025/26) with 500+ participants and 180+ teams.

- 1st (2019) 74 participants / 43 teams, PMT waveform analysis
- 2nd (2020) 60 participants / 44 teams, Particle identification
- 3rd (2021) , JUNO-like energy reconstruction
- 4th (2022) ~80 participants / 30 teams, JUNO-like event reconstruction
- 5th (2023) ~90 participants / ~40 teams, Continued JUNO-like reconstruction
- 6th (2024) 106 participants / 36 teams, Optical detector-response studies
- 7th (2025) 75 participants / 24 teams, Continued Optical detector-response