Study of target liquids for next-gen ν detectors

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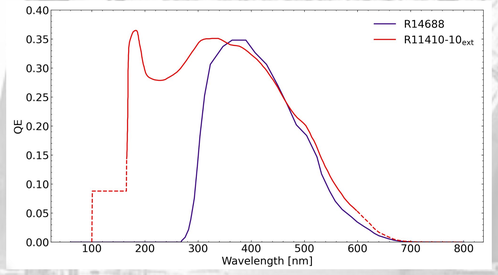
Next-gen Optical Neutrino Detectors

Optical liquid detectors have been the workhorse of neutrino physics for decades and continue to lead the field. These detector technologies still have room to improve or expand their capabilities, including simultaneous use of Cherenkov and scintillation light. These capabilities strongly depend on the choice of target liquid.

Simulated 17-ktonne spherical detector (14.7 m radius) with from 56,528 8-inch PMTs (69.4% coverage).

Simulated quasi-realistic 8-inch PMTs with an Extended QE for Hamamatsu R11410-10 PMT.



Target Liquid Models

We model and simulate both historically successful and novel target options in a 17-ktonne detector.

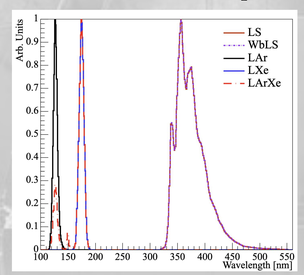
- **Water**
- **LS** Organic scintillator (linear alkylbenzene + 0.6 g/L PPO [2,5-Diphenyloxazole])
- **WbLS** Idealized water-based scintillator (90% water + 10% LS)
- **LAr** Liquid argon
- **LXe** Liquid xenon
- **LArXe** Xenon-doped liquid argon (LAr + 100 ppm$_\nu$ LXe)

Scintillation and Cherenkov photon yields for 2.5-MeV electrons

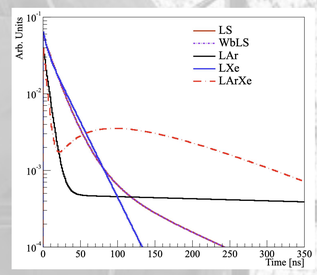
Target	Y_s	Y_C
Water	0	2,506
LS	16,443	3,330
WbLS	2,696	2,549
LAr	96,400	1,307
LXe	96,665	869
LArXe	96,443	1,289

Model Components

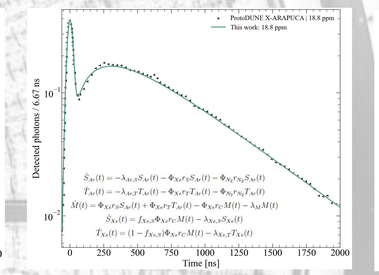
Scintillation emission spectra



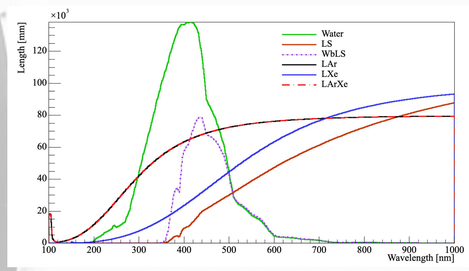
Scintillation emission times



LArXe emission time



Attenuation lengths

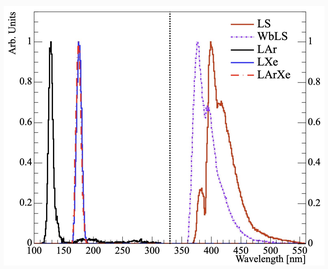


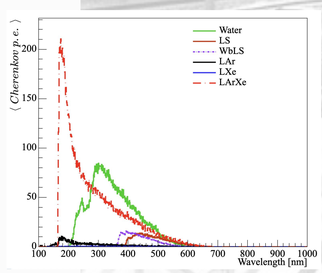
Collected photons

Mean number of detected photoelectrons for 2.5-MeV electrons at the center of the detector.

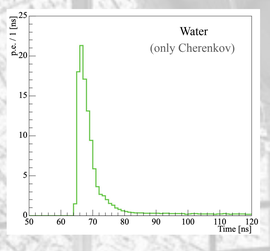
Target	$N_{p.e.}$(scint.)	$N_{p.e.}$(Cher.)
Water	NA	118.9
LS	543	43.2
WbLS	360	41.0
LAr	348	159.6
LXe	3,665	118.7
LArXe	20,026	143.7

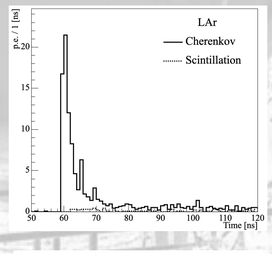
Wavelength distributions of detected photoelectrons produced by Cherenkov and scintillation photons. Quasi-realistic PMTs.

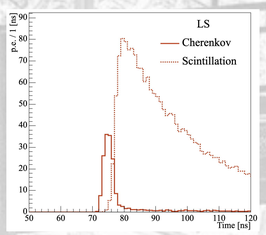


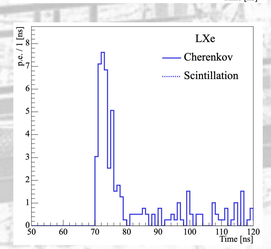


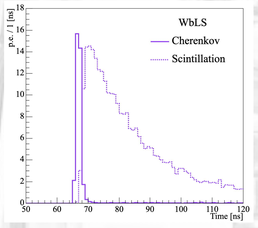
Cher/scint Distinction

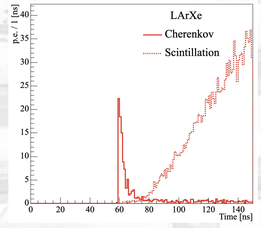






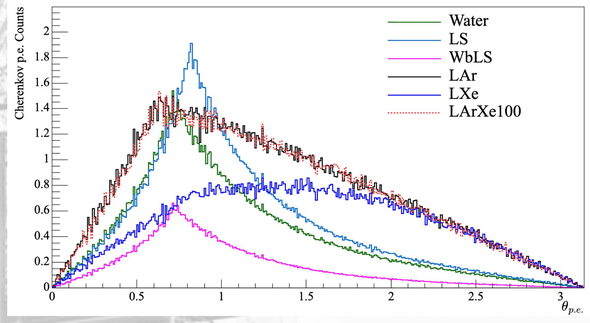






Directionality

Angle between detected photoelectrons to the true event direction.



Summary

Finalized study can recommend:

- ➢ Optimal targets (wavelength shifters, etc.)
- ➢ Optimal photosensors (QE, filters, etc.).

- LArXe offers the finest energy resolution (<1% @ 2.5 MeV).
- LArXe offers the highest Cherenkov yield (⇒ particle ID).

	Target	Scintillation	Cherenkov
1	LArXe	20,030	144
2	LXe	3,670	119
3	LS	540	43
4	WbLS	360	41
5	LAr	350	160
6	Water	-	119

Background generated by Gemini, Google, 2026/5