A LiCl-Rich Liquid Detector for Novel Neutrino Experiments

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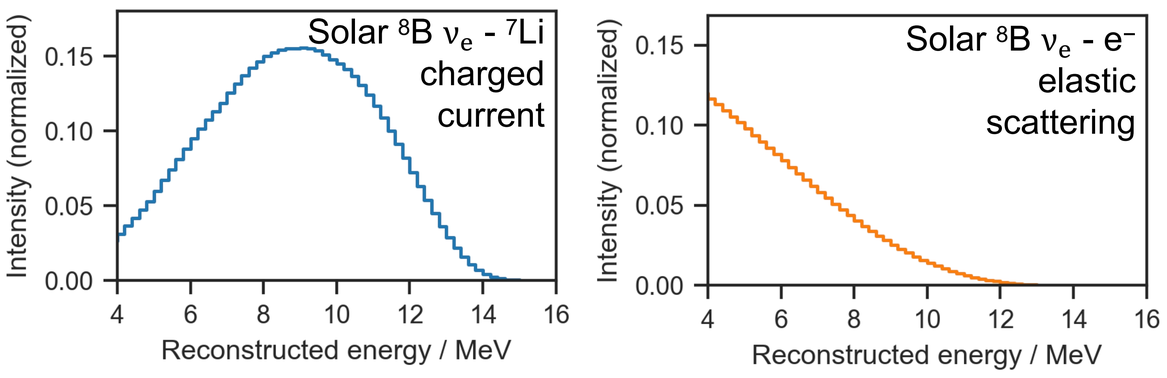
I. Introduction

Solar neutrino Spectrometry using LiCl

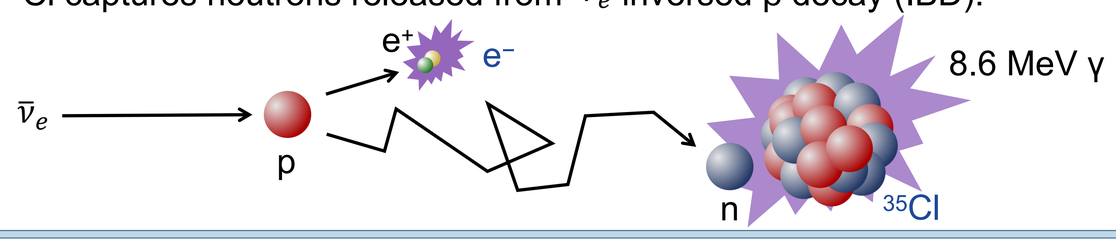
$$^{7}\mathrm{Li} + \nu_e \longrightarrow {}^{7}\mathrm{Be} + e^{-}, \quad E_{\mathrm{th}} = 0.862\ \mathrm{MeV}$$

- Charged current (CC) spectrum directly reflects the shape of solar ν_e spectrum:
$$E_\nu = E_e + E_{\mathrm{th}}$$
- Sensitive to potential distortion of spectrum in the vacuum-matter transition region.



Geoneutrino detection using LiCl

- ^{35}Cl captures neutrons released from $\bar{\nu}_e$ inversed β decay (IBD).



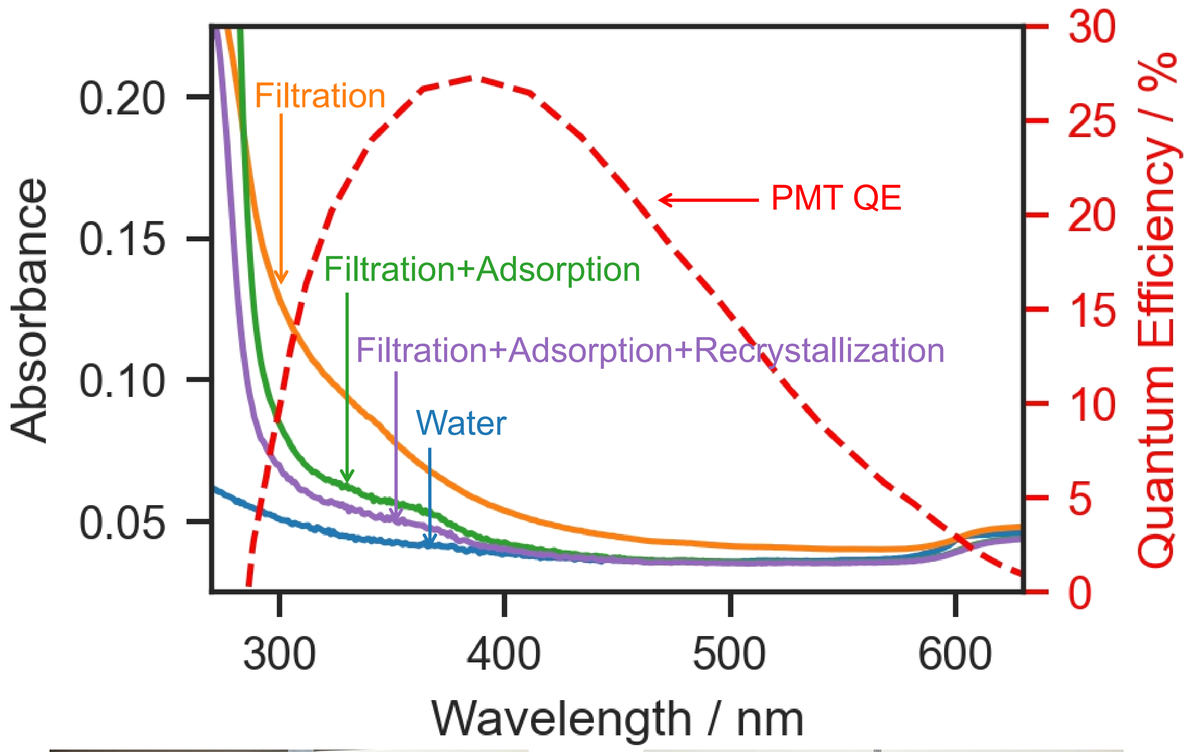
II. LiCl Solution Properties

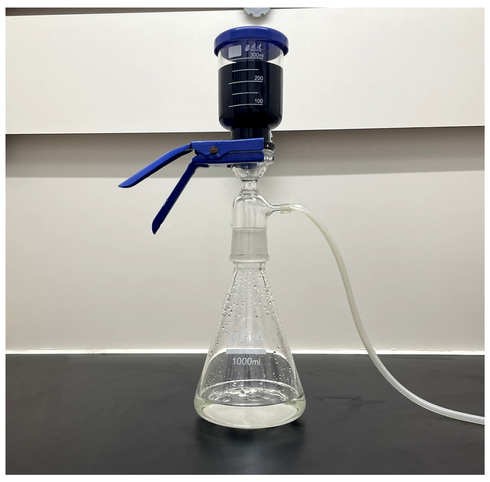
- ✓ Highly soluble in water, easy to make a large salt-rich liquid detector.
- ✓ Chemically stable, safe, economic.
- ✓ Compatible with water-soluble wavelength shifter to enhance light yield.
- ✓ No need for isotopic enrichment.

	Solubility g/100gH_2O	Saturated conc. w/w	^{nat}Li max conc. w/w	Chemical reactivity
LiCl	82.8	45.3%	7.5%	pH neutral, no redox reactivity
LiBr	166.7	62.5%	5.0%	Br^- reductive
$LiClO_3$	336.7	77.1%	5.9%	ClO_3^- highly oxidative
LiOH	12.9	11.4%	3.3%	OH^- strong alkali

III. Purification to Enhance Transparency

- Filtration, powdered activated carbon (PAC) adsorption and recrystallization are effective in improving the transparency of the saturated LiCl solution.

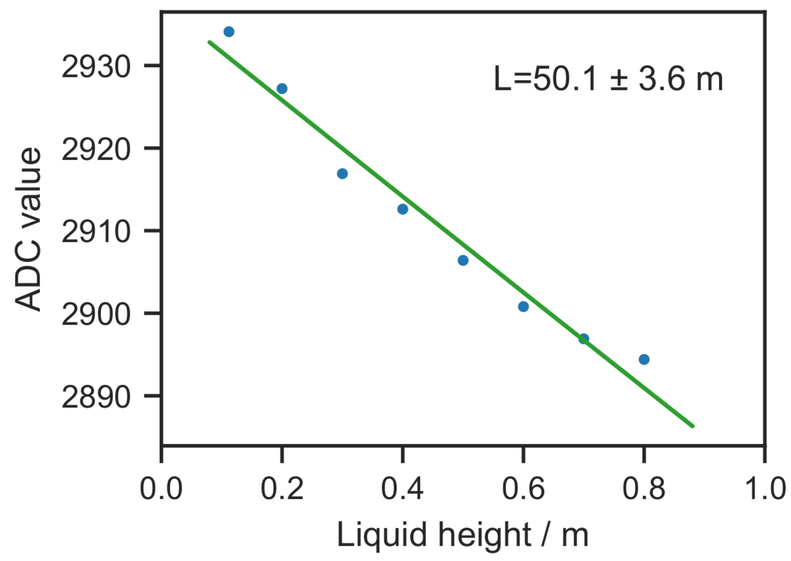


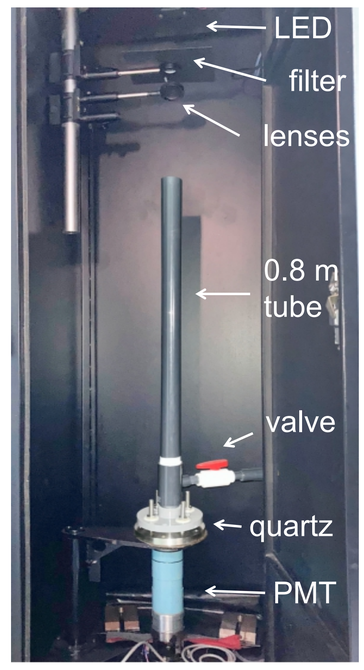

PAC adsorption and filtration


Recrystallization

IV. Attenuation Length

- Attenuation length of the purified LiCl solution reaches 50 m for 430 nm light, measured using a tubular system.

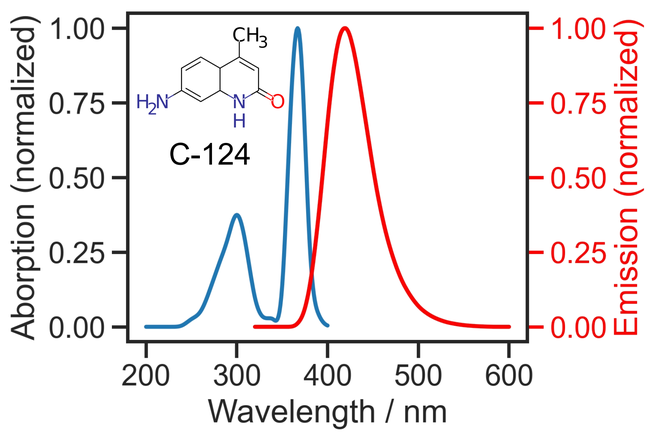


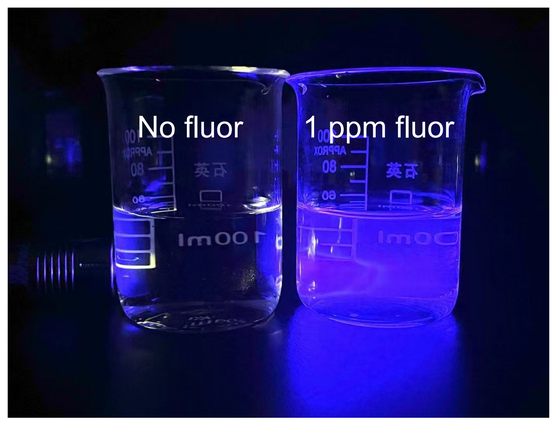


Tubular measuring system

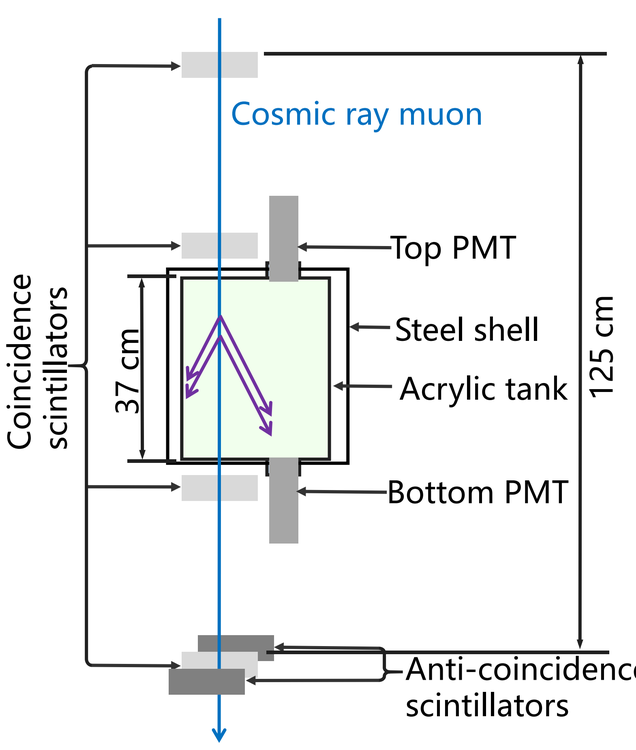
V. Light Yield

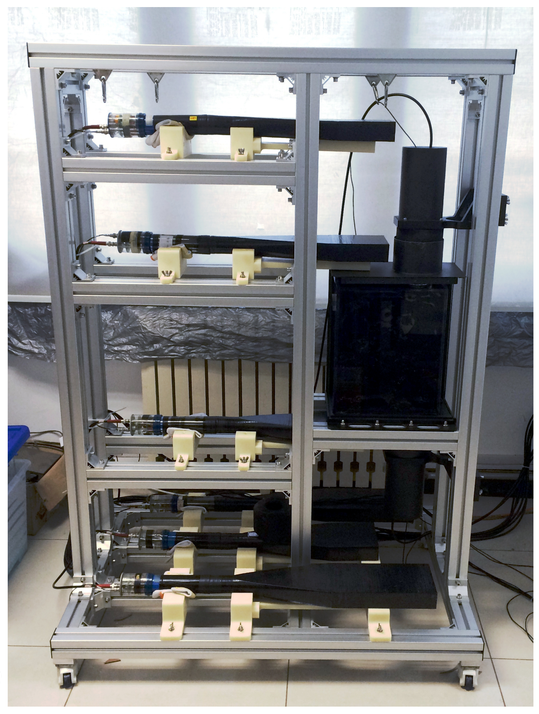
- Adding 1 ppm carbostyril 124 (C-124) significantly enhances the light yield.
- High concentration LiCl is compatible with C-124 up to ~100 ppm.





	Top PMT PEs (isotropic light)	Bottom PMT PEs (isotropic + directional Cherenkov)
Water	0.76 ± 0.08	15.8 ± 1.5
LiCl	0.54 ± 0.08	17.2 ± 1.5
LiCl, 1 ppm C-124	3.7 ± 0.4	16.0 ± 1.6




Light yield measuring system

VI. Summary

A LiCl-rich solution as a neutrino detection medium is prepared and characterized.

- the transparency can be improved by filtration, PAC adsorption, and recrystallization.
- The attenuation length is measured to be 50 meters.
- The light yield is enhanced by adding a water-soluble wavelength shifter.

References

- Liang Y, et al. 2023. J. Inst. 18(07):P07039. <arXiv:2211.05023>
- Shao W, et al. 2023. Eur. Phys. J. C. 83(9):799. <arXiv:2203.01860>
- Xu X, et al. 2023. Prog. Part. Nucl. Phys. 131:104043. <arXiv:2209.14832>