Technische Universität München

Scintillation and Cherenkov Light Separation in Novel Liquid Scintillators for Large Scale Neutrino Detectors

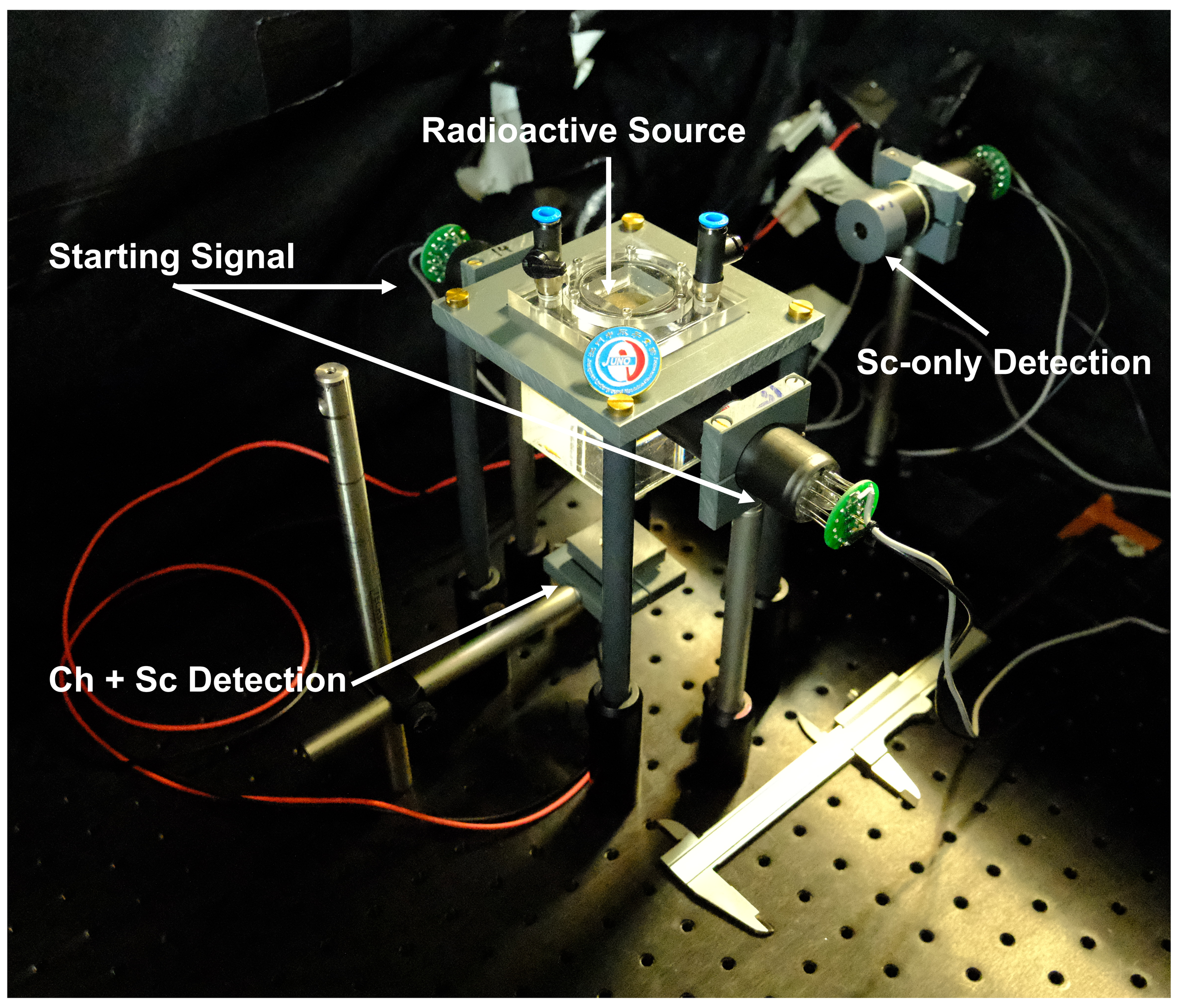
Meishu Lu[1], Hans Th. J. Steiger[1,2,3]
Matthias Raphael Stock[1], Manuel Böhles[2], Ulrike Fahrendholz[1], Lothar Oberauer[1]

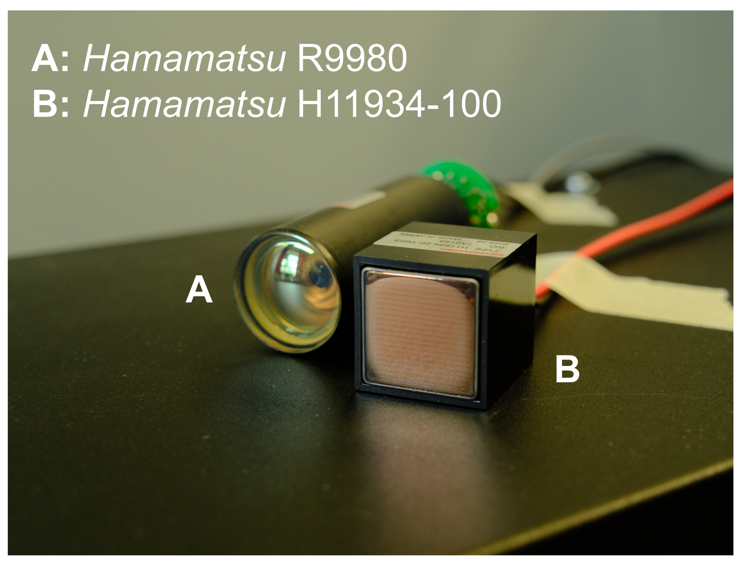
[1]School of Natural Sciences, Technische Universität München, Garching, Germany
[2]Institut für Physik, Johannes Gutenberg University Mainz, Mainz, Germany
[3]Cluster of Excellence PRISMA+, Mainz, Germany

The MSCS: Munich Scintillation Cherenkov Separator

1. The MSCS Setup

Time Correlated Single Photon Counting





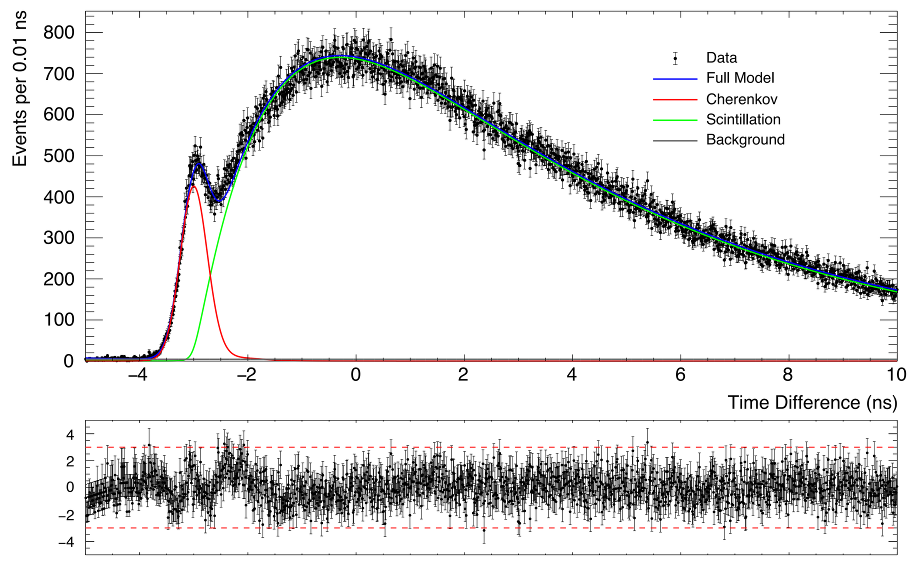
Using geological orientation to achieve Cherenkov + Scintillation detection.

Starting signal is generated from the coincidence of the two A-type PMTs directly attached to the vessel.

Detection mode can be switched between Ch+Sc/ Sc-only.

2. Measurements of Various LS Samples

JUNO-site sample (LAB + PPO + BisMSB)



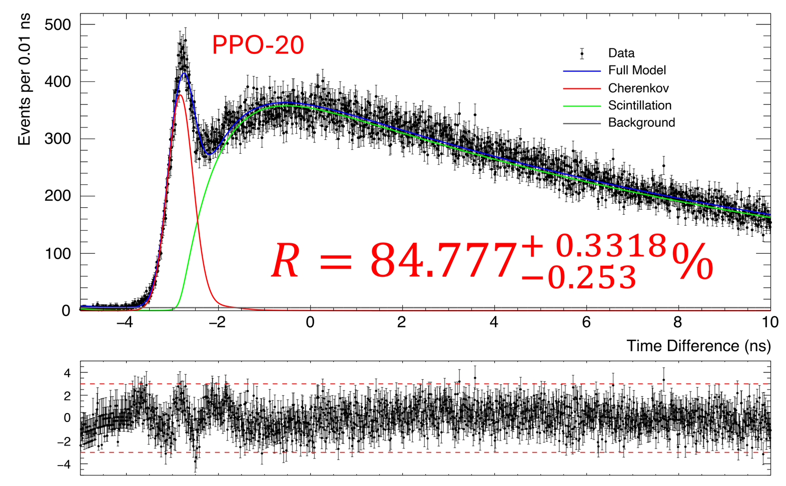
Ratio of Cherenkov in the separation area optimized by finding maximum position t of $^{Ch}/\sqrt{Ch+Sc}$ to give:

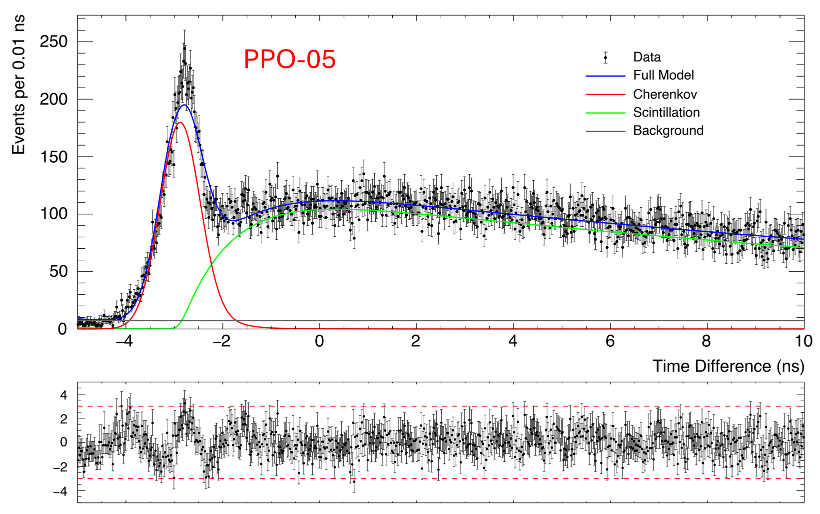
$$R = \frac{\int_{-\infty}^{t} Ch(t)dt}{\int_{-\infty}^{t} (Ch(t) + Sc(t))dt}$$

$R = 83.6329^{+0.2881}_{-2.73}\%$

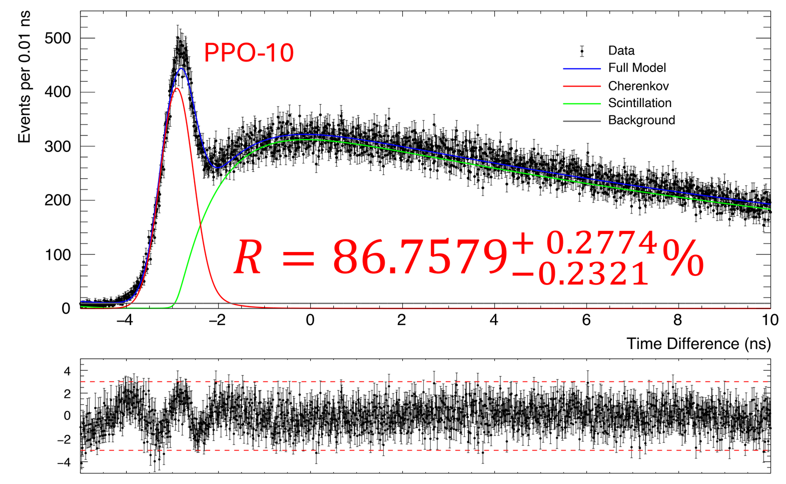
Bi-solvent "slow" mixtures (LAB + DIN + PPO) [1]

	LAB	DIN	PPO
PPO-20	90%	10%	2 g/L
PPO-15	90%	10%	1 g/L
PPO-05	90%	10%	0.5 g/L





$R = 88.5099^{+0.9109}_{-0.7034}\%$

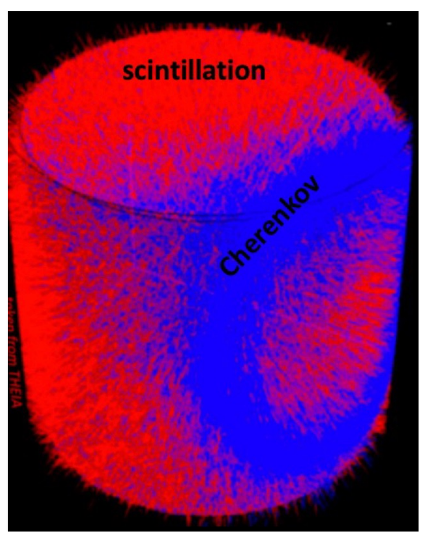


3. Outlook

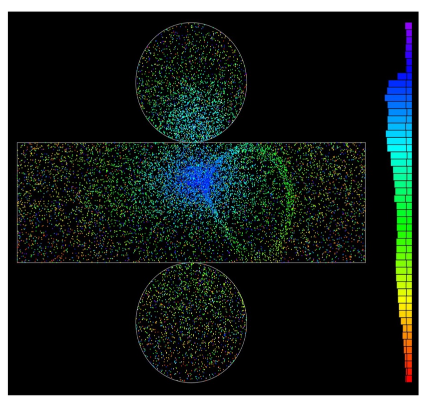
With in two common approaches for Ch/Sc separation, the water based liquid scintillator (WbLS)[3] has the main drawback in light yield and energy resolution.

The success in mixing a bi-solvent organic LS maintained the conventional advantage of organic-based LS in high light yield, but also achieved the goal of separation of Ch/Sc photons.

By implementing the separation, future large liquid scintillators like JUNO (20kt) and THEIA (100kt) can greatly benefit in background selection. Meanwhile, with the development of loading $0\nu\beta\beta$ targets, large scale LS detectors can also have a great potential in $0\nu\beta\beta$ search.



[2]



[2]

References

[1] H. Steiger et.al, "Development of a Bi-solvent Liquid Scintillator with Slow Light Emission". In: *arXiv preprint arXiv:2405.01100* (2024)

[2] M. Wurm. "Hybrid Cherenkov-Scintillation Detectors THEIA and EOS". URL: https://indico.phy.ornl.gov/event/217/contributions/1284/attachments/1012/2806/wurm_theia_eos_ornl_mar23.pdf.

[3] H.Steiger et.al, "Development, Characterization and Production of a novel Water-based Liquid Scintillator based on the Surfactant TRITON X-100". In: *arXiv preprint arXiv:2405.05743 (2024).*

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