Thermal Neutron Detection and Pulse Shape Discrimination using Polysiloxane Scintillators with B10-enriched Molecules

Mackenzie Duce†, Caleb Chandler‡, Dr. Alan Sellinger‡, Dr. Anna Erickson†
†Georgia Institute of Technology, ‡Colorado School of Mines
mduce@gatech.edu, chandler@ mines.edu

ETI Annual Workshop, February 20 - 21, 2024

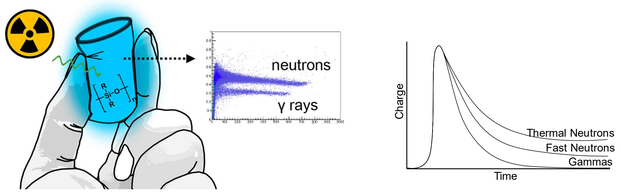
Poster # 14

Goals & Objectives

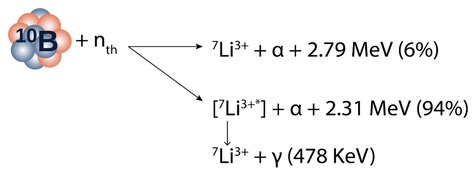
- Distinct scintillation response from:
  - Gamma rays
  - Fast neutrons
  - Thermal neutrons
- Long term stability in elastomers

Introduction

- Polysiloxanes have shown excellent radiation detection properties



- Boron-10 addition can allow for thermal neutron detection via nuclear reaction

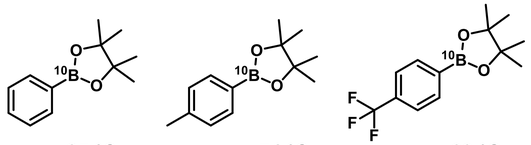


Methods

- Dopants dissolve in resins under mild heating
- Final samples cured at 150 ºC in air for 3 hrs

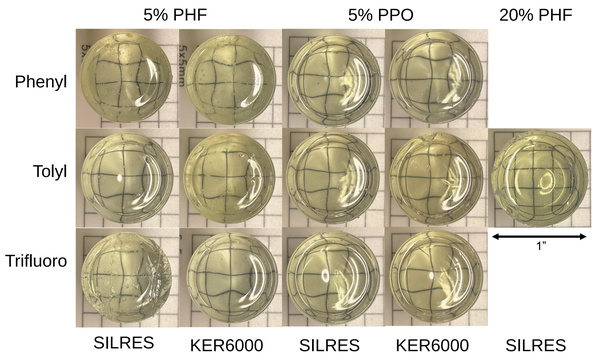
Resins: Shin-Etsu ***KER-6000*** WACKER SILRES® ***H62C***

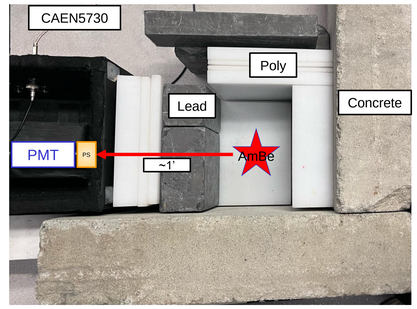
Boron-10 Additives:



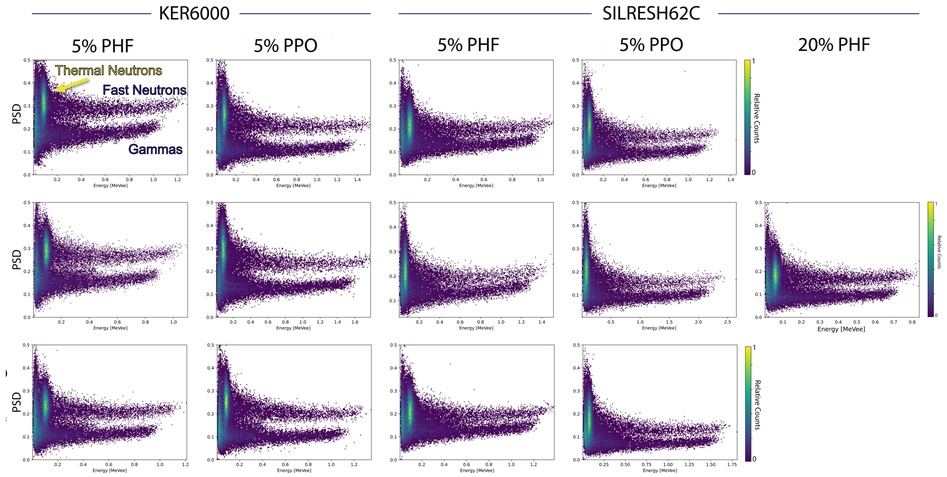
Results

- All samples had excellent clarity upon fabrication
- Thermal neutron detection via AmBe

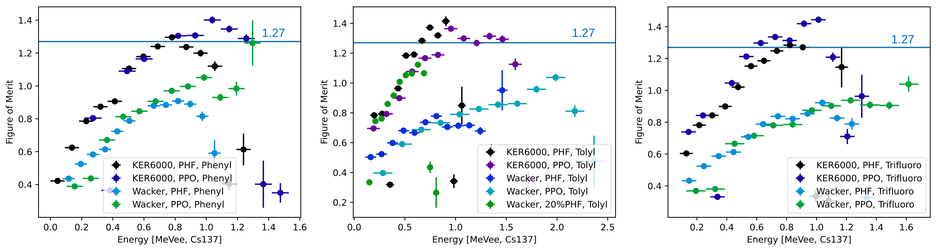




- Energy spectra – including thermal neutron lobe



- Pulse shape discrimination metrics compared

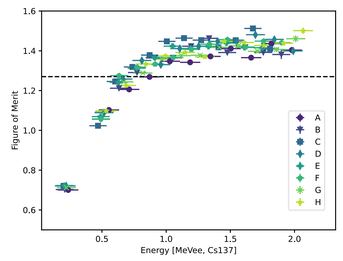


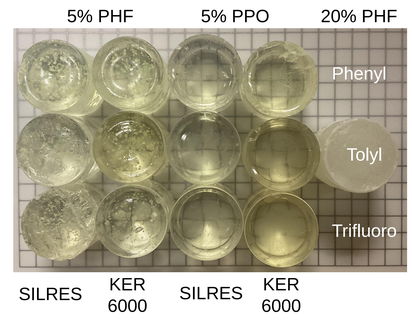
Discussion + Next Steps

- Fast neutron \ gamma discrimination best in Shin Etsu KER-6000
- Light yield degraded significantly in 10 months
- Additives can be modified for increased solubility in future formulations

		5% PHF			5% PPO			20% PHF		
B10	Matrix	*Fresh*	*Aged*	*Change*	*Fresh*	*Aged*	*Change*	*Fresh*	*Aged*	*Change*
Phenyl	KER6000	0.53	0.36	-32%	0.45	0.33	-27%			
	SILRES	0.49	0.42	-14%	0.45	0.31	-31%			
Tolyl	KER6000	0.62	0.46	-26%	0.39	0.35	-10%			
	SILRES	0.39	0.35	-10%	0.23	0.24	4%	0.71	0.35	-51%
Trifluoro	KER6000	0.55	0.38	-31%	0.51	0.35	-31%			
	SILRES	0.39	0.41	5%	0.33	0.26	-21%			

Values reported as fraction of similar size EJ200 under same experiment conditions.





Conclusions + Mission Relevance

- Shielded sources moderate neutron energy
- Boron-10 adds sensitivity to thermal neutrons
- Tolyl-B10 was best additive, but stability stands to be improved

References

1) Arrue, J. et al.; *Nucl. Instrum. Methods Phys. Res. A* **2023**, *1056*, 168650.
2) Lim, A. et al.; *ACS Appl. Polym. Mater.* **2020**, *2* (8), 3657–3662.
3) Marchi, T. et al.; *Sci. Rep.* **2019**, *9* (1), 9154.
4) Chandler, C.; Duce, M.; Arrue, J.; Porcincula, D.H.; Sellinger, A.; Erickson, A.S.; In Preparation for RSC Appl. Poly.

This material is based upon work supported by the Department of Energy / National Nuclear Security Administration under Award Number(s) DE-NA0003921.

National Nuclear Security Administration