

The Consortium for Enabling Technologies and Innovation

Virtual Summer Meeting for Young Researchers

Thrust 3, Project 2

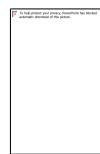
Polysiloxane Scintillators for Neutron and Gamma Ray Discrimination

Allison Lim,¹ Jonathan Arrue,² Dr. Alan Sellinger,¹ Dr. Anna Erickson²

¹ Colorado School of Mines, ² Georgia Institute of Technology

July 7, 2020





Acknowledgements

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

Sellinger Group:

Dr. Alan Sellinger
Joshua T. Koubek
Daniel Astridge
Caleb Chandler



Erickson Group:

Dr. Anna Erickson
Luke Maloney
Arith Rajapakse



Who are we?



Allison Lim

PhD Candidate, Colorado School of Mines

I am a fourth year developing novel plastic scintillators in Dr. Alan Sellinger's group, with an interest in developing soft functional materials.

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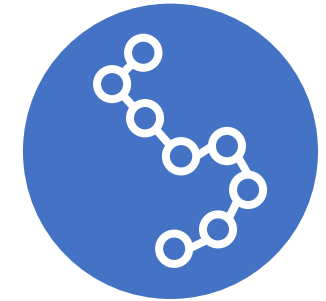


Jonathan Arrue

Master Student, Georgia Institute of Technology

I am a second year masters student working on the testing and qualification of organic scintillators in LANS research group lead by Dr. Anna Erickson.

How do we detect special nuclear materials?



	³ He	Single Crystal	Liquid	Plastic
Detection of special nuclear materials	✓	✓	✓	???
Ambient Stable	✗	✗	✗	✓
Scalable	✗	✗	✓	✓
Economical	✗	✗	✗	✓

Plastic scintillators are a cost-effective first line of detection for special nuclear materials.

Plastic scintillators are limited to applications suitable for **thermoplastics**.

What are thermoplastics?



Thermoplastics are meltable
but when solid tend to be
hard and brittle.

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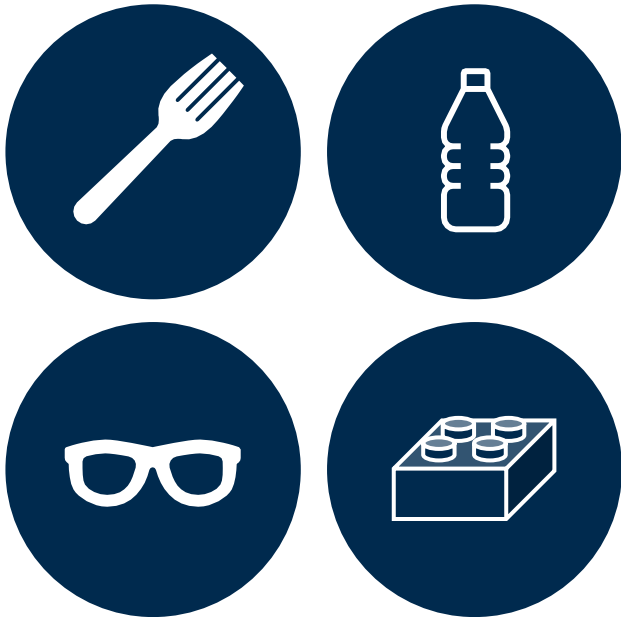
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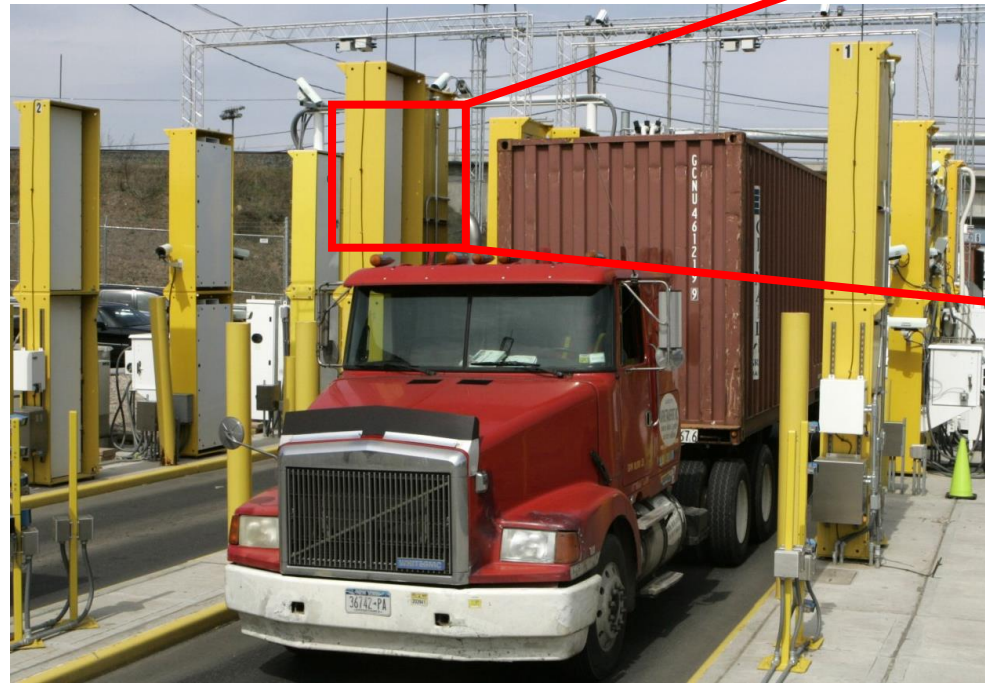
https://www.washingtonpost.com/business/dhs-plans-to-spend-300-million-on-troubled/2011/07/13/gIQA6gmPDI_story.html

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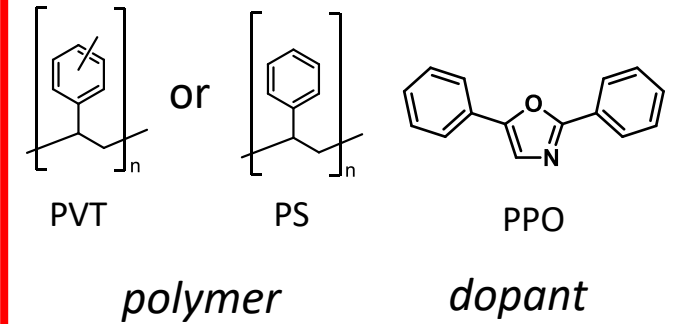
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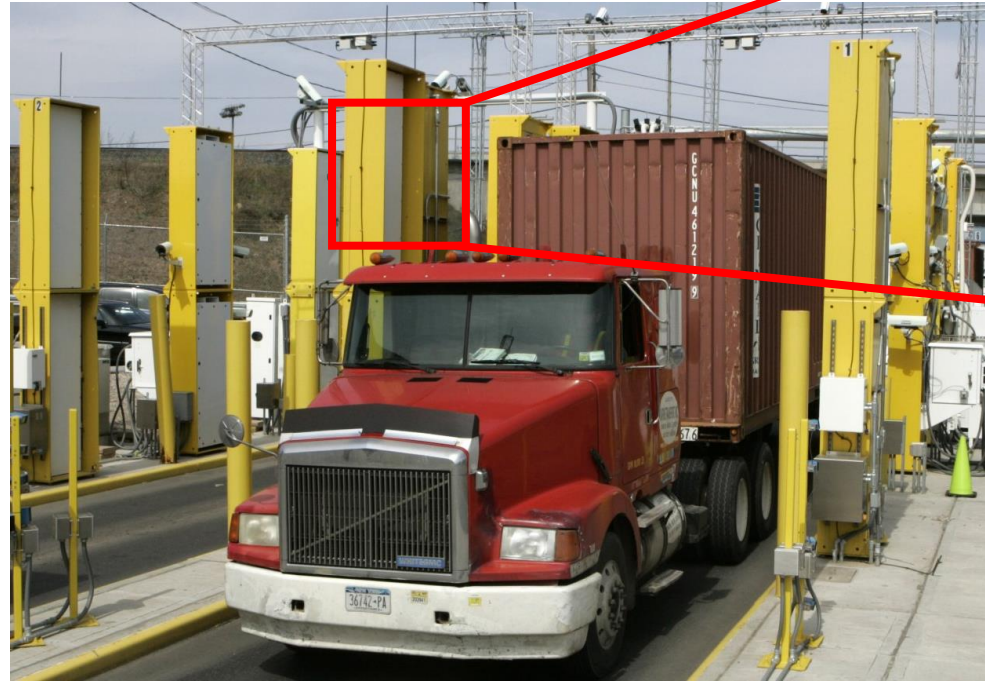


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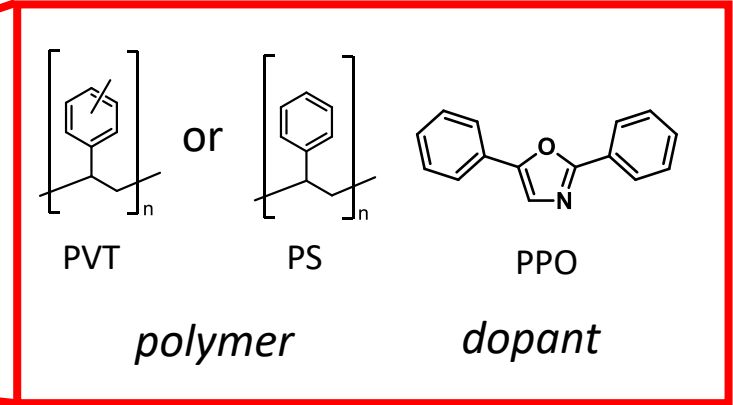
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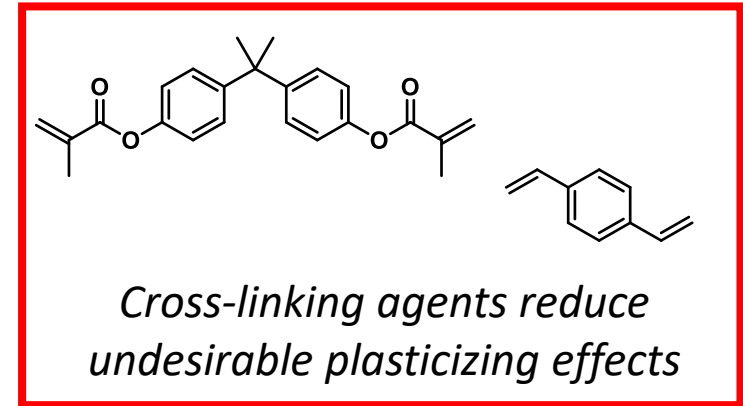
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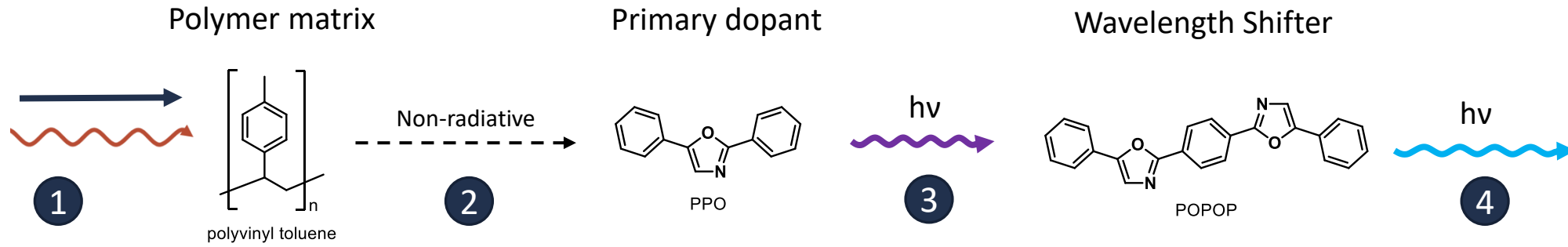
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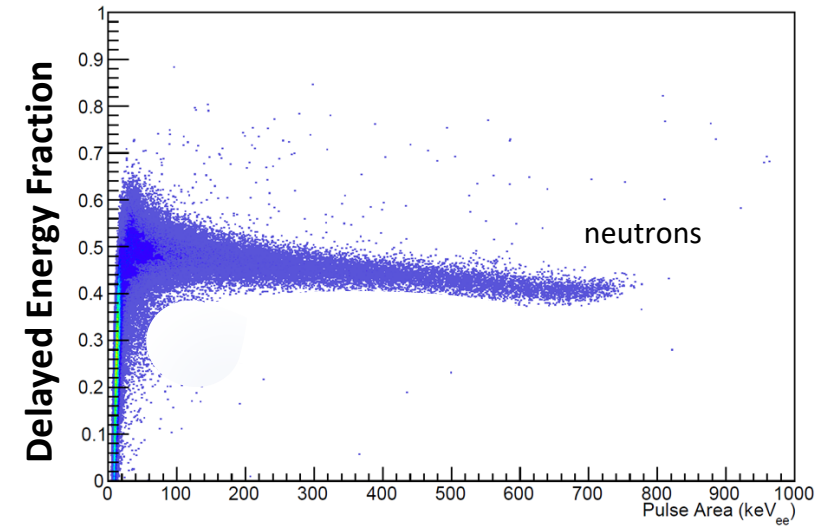
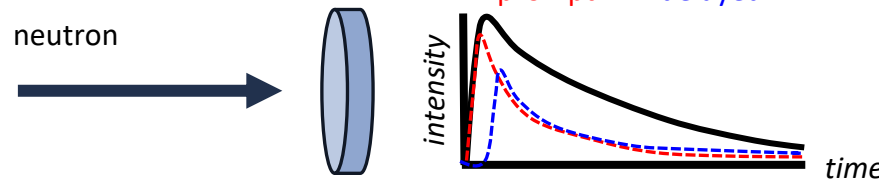
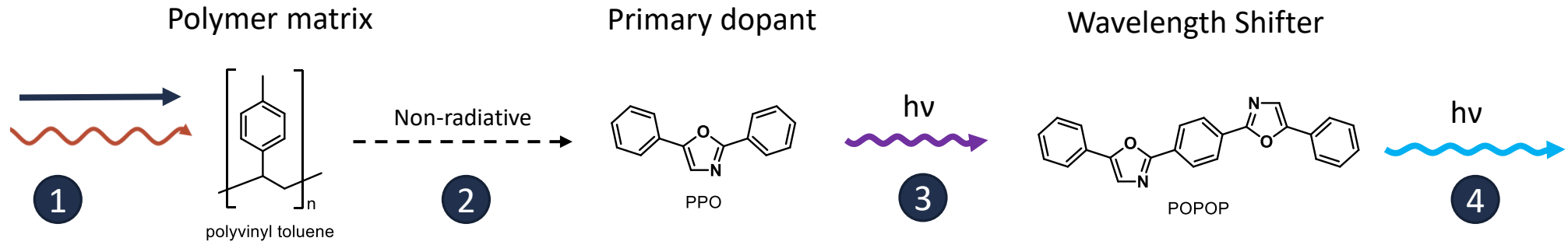
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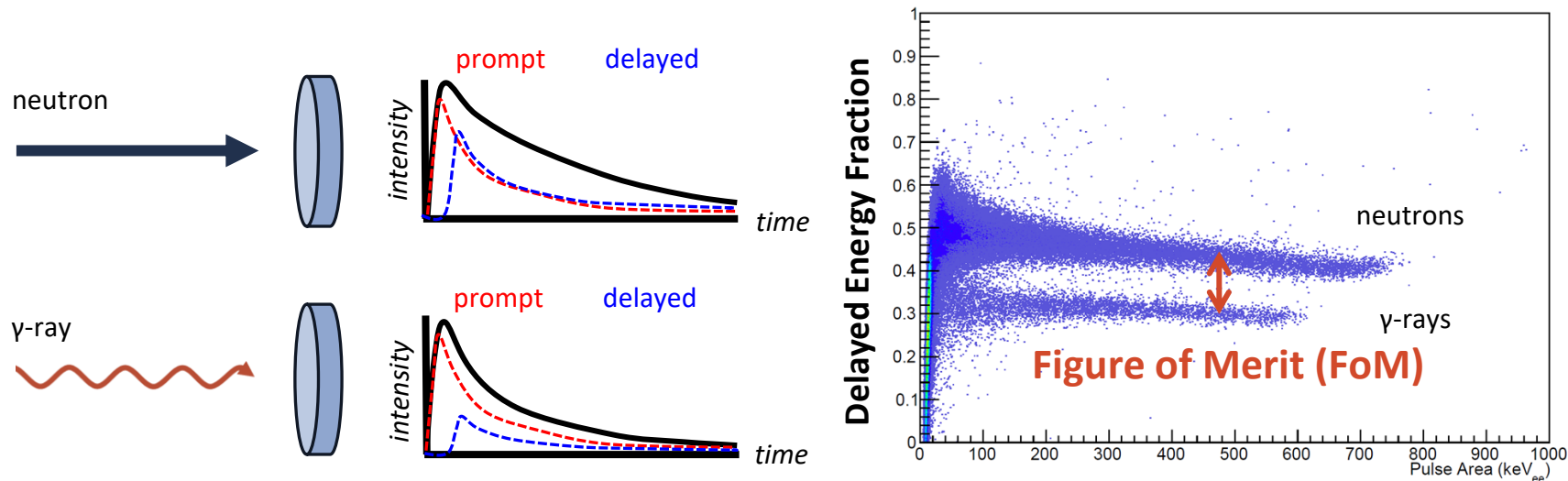
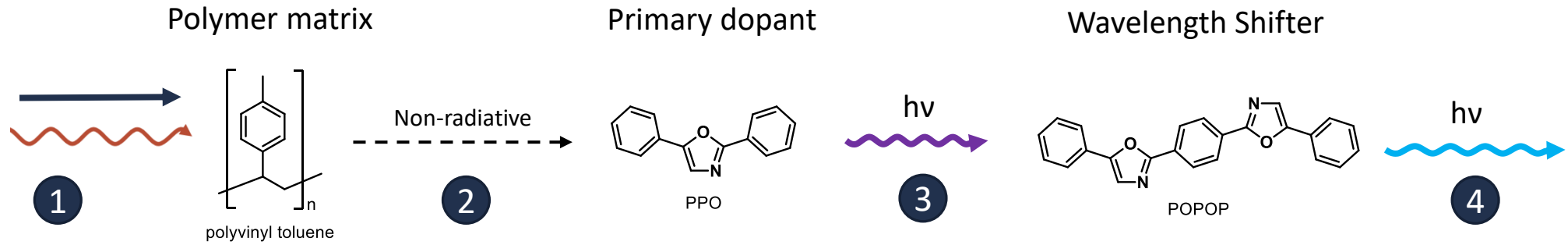
Plastic scintillators discrimination neutrons from gamma rays via pulse shape discrimination.



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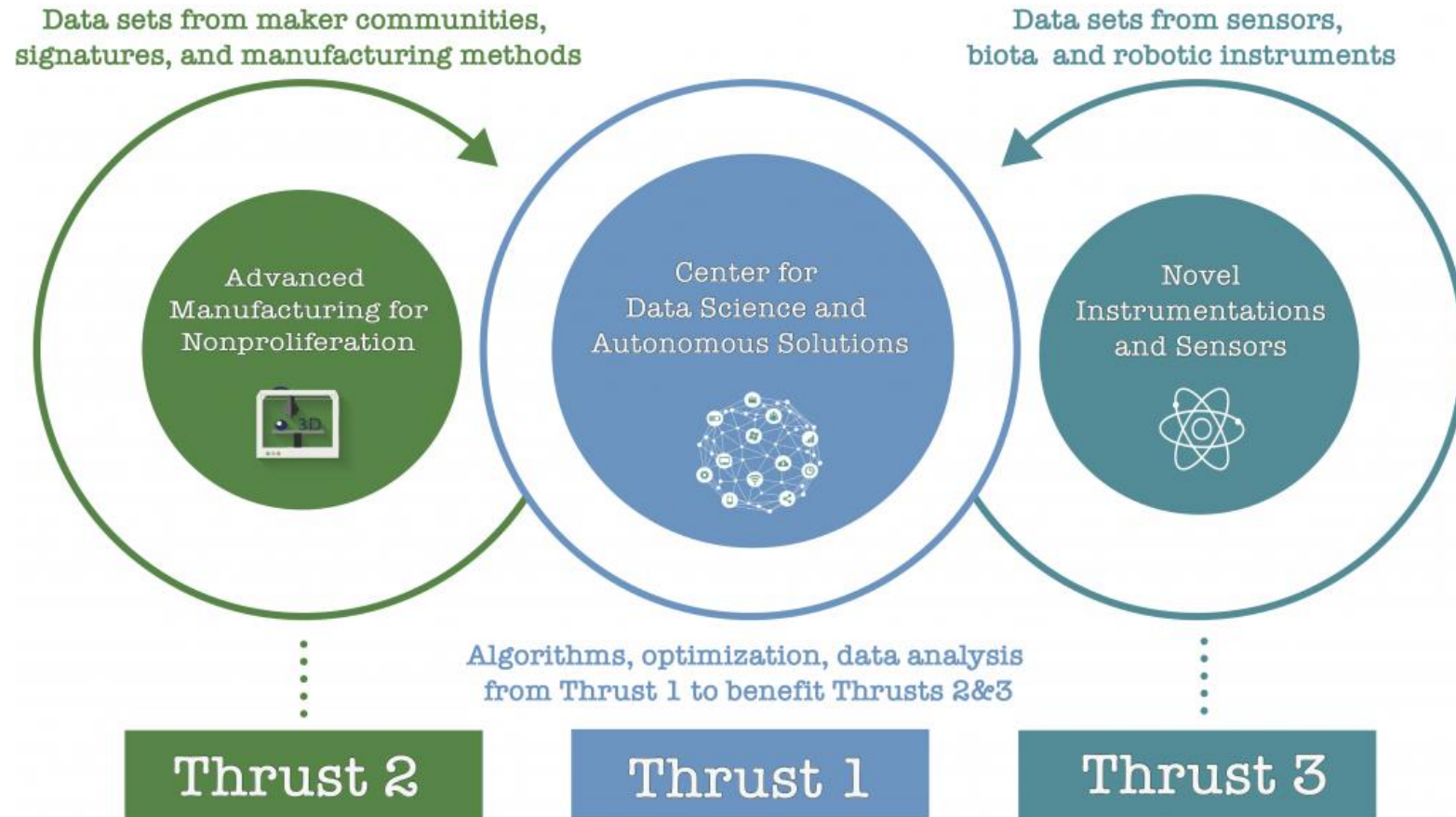


Plastic scintillators discrimination neutrons from gamma rays via pulse shape discrimination.



FoM quantifies the separation between neutrons and gamma rays – bigger is better!

How can organic and polymer chemistry help fabricate the next generation of plastic scintillators?



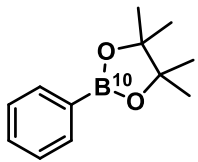
How can organic and polymer chemistry help fabricate the next generation of plastic scintillators?

Previous work:

Novel dopants

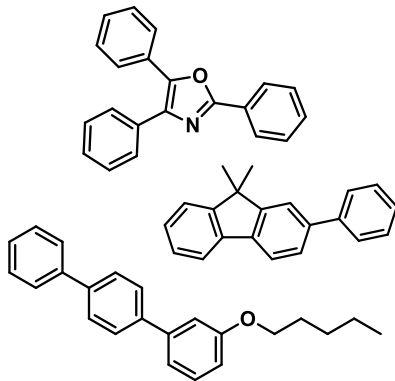


Thermal neutron detection



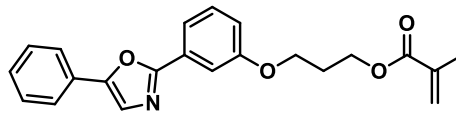
10.1038/srep13401
10.1016/j.nima.2016.01.073

PSD capable



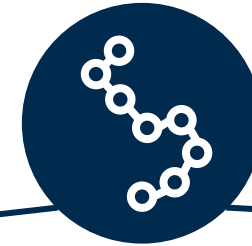
10.1002/chem.201700877

Polymerizable

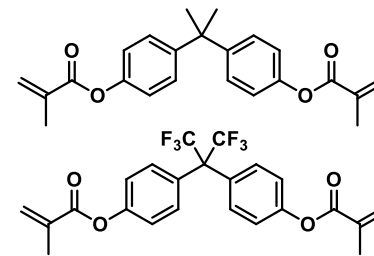


10.1021/acsapm.9b00188

Matrix modifications

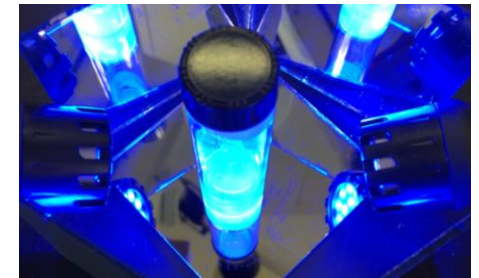


Cross-linked



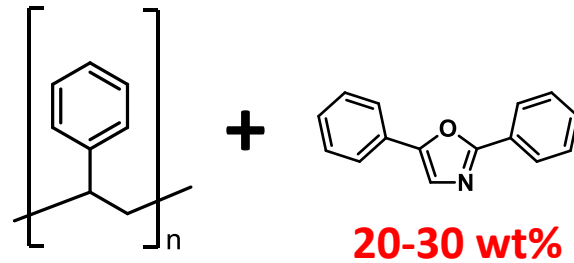
10.1016/j.nima.2017.11.091

Photopolymerized

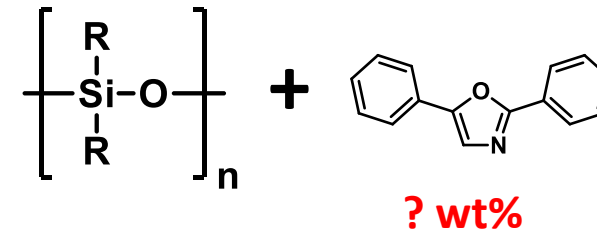


10.1002/app.47381

Polysiloxanes can be used as a flexible matrix for plastic scintillators.



Traditional Plastic Scintillators

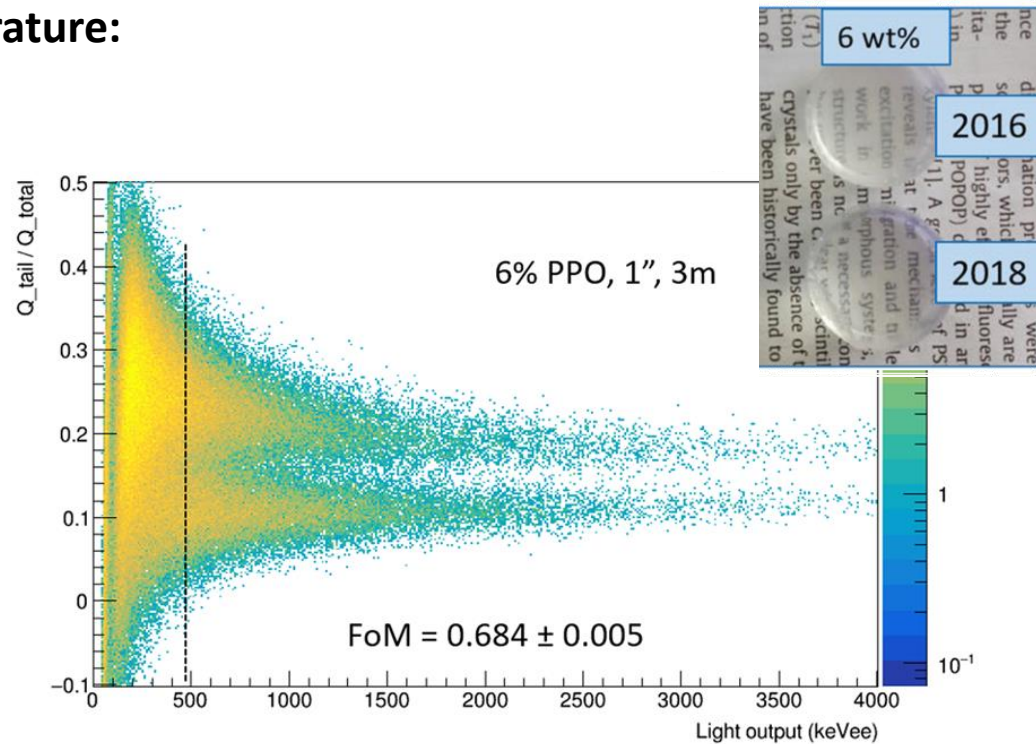


Polysiloxane Plastic Scintillators

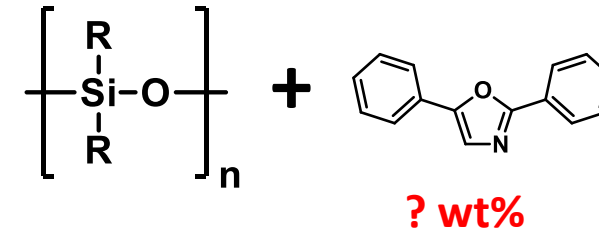
	Traditional Plastic Scintillators	Polysiloxane Plastic Scintillators
Flexibility	Rigid	Elastomeric
Fabrication	Air sensitive	Not air sensitive
PSD	Yes, high dopant loadings	???

Polysiloxanes can be used as a flexible matrix for plastic scintillators.

Literature:



Marchi et. al. showed polysiloxane-PPO scintillators capable of PSD, but FoM was less than 1.



Polysiloxane Plastic Scintillators

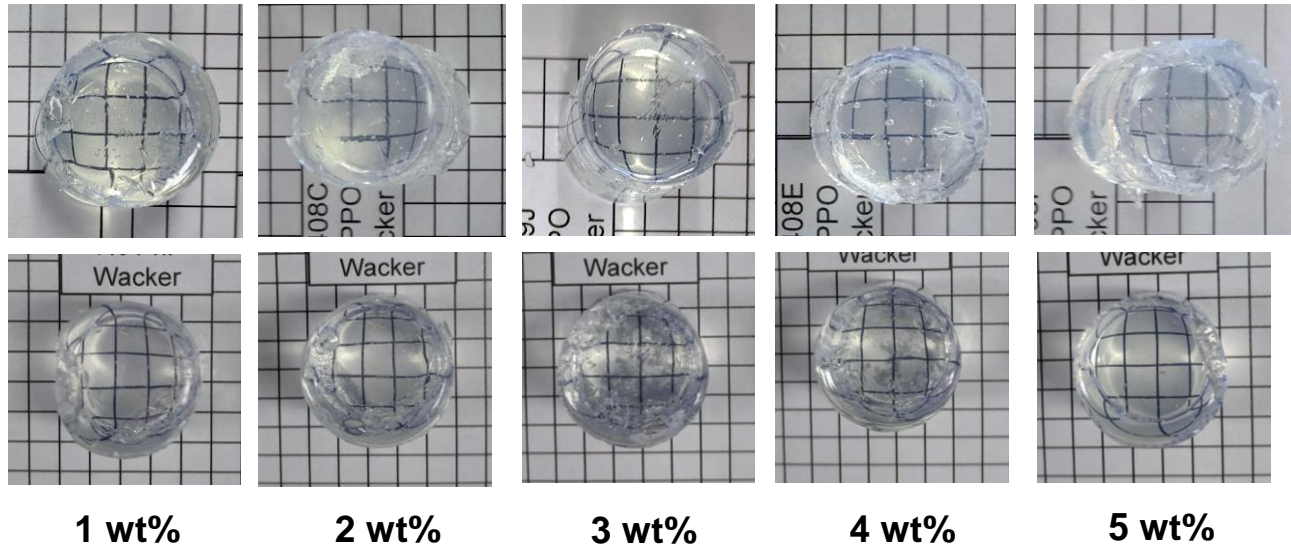
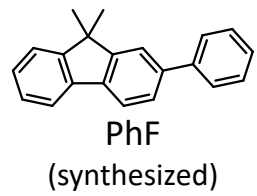
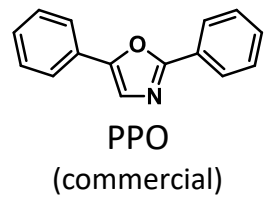
Elastomeric

Not air sensitive

???

Polysiloxane scintillators can be fabricated in **3 hours** and are **not sensitive to oxygen**.

Our work:

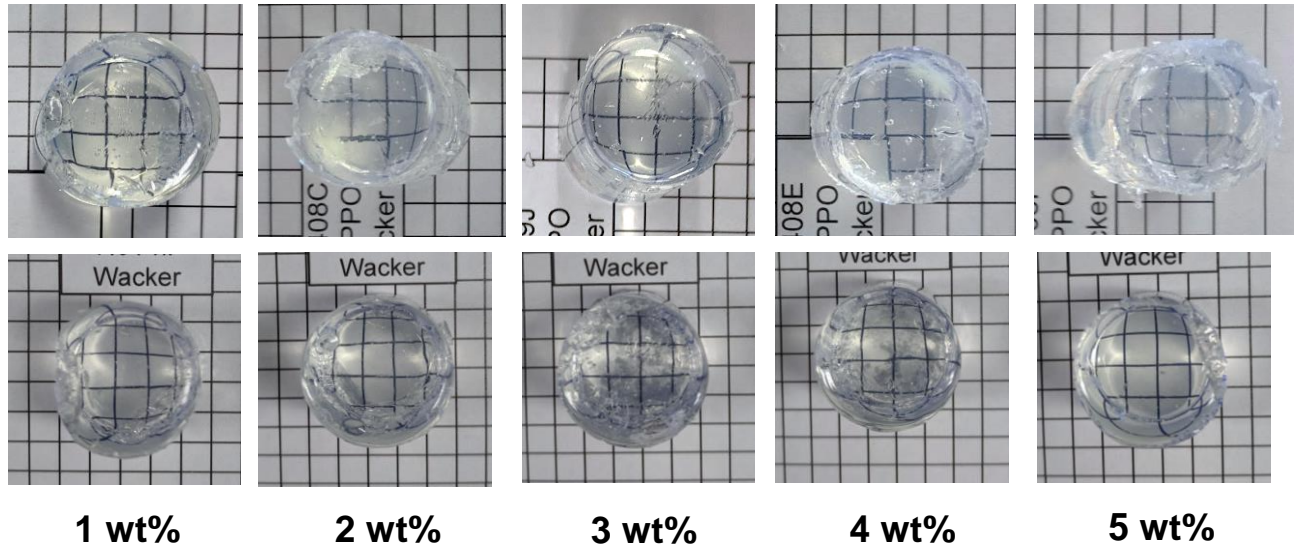
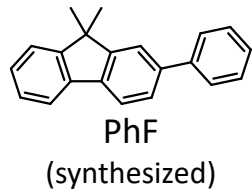
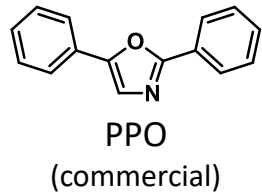


3 hour cure at 150°C in air of a commercial polysiloxane resin produced clear samples.

Lim, A.; Arrue, J.; Rose, P. B.; Sellinger, A.; Erickson, A. *ACS Appl. Polym. Mater.* **2020** <https://doi.org/10.1021/acsapm.0c00641>.

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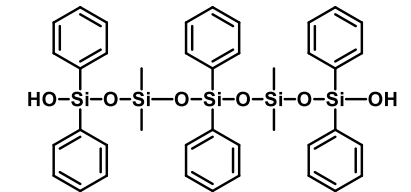
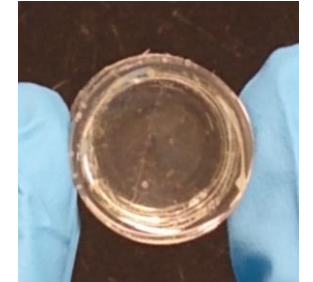


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Upcoming work



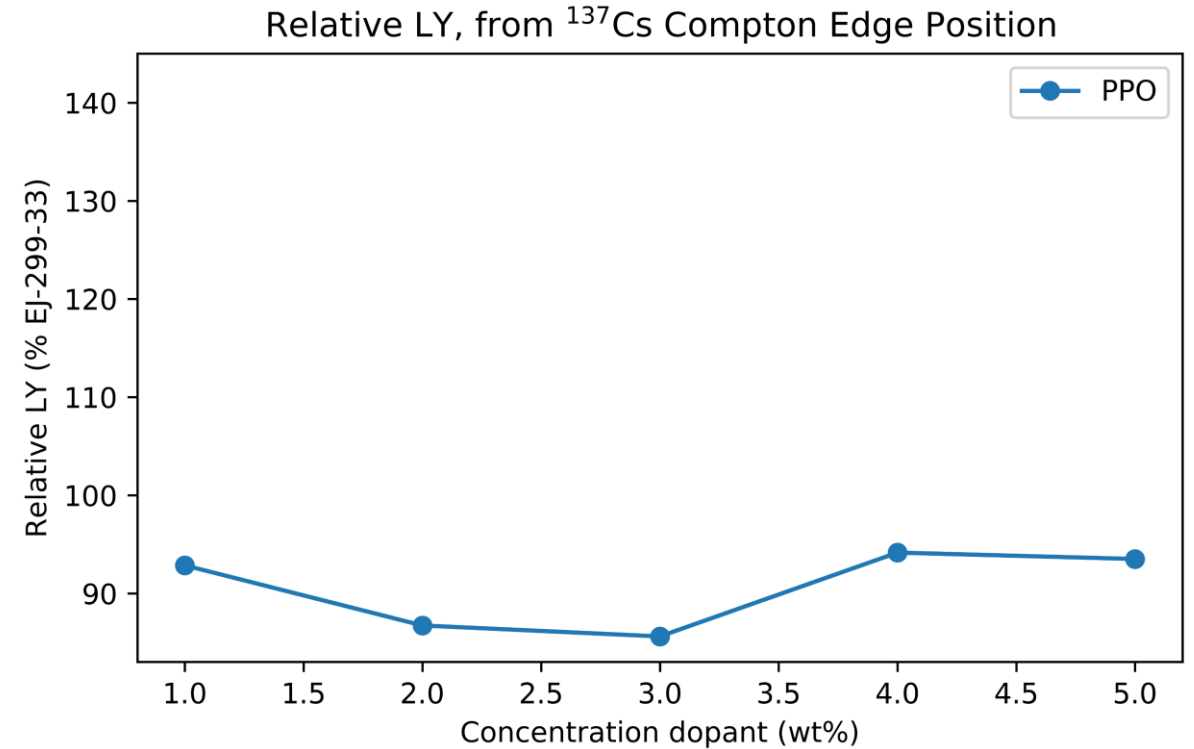
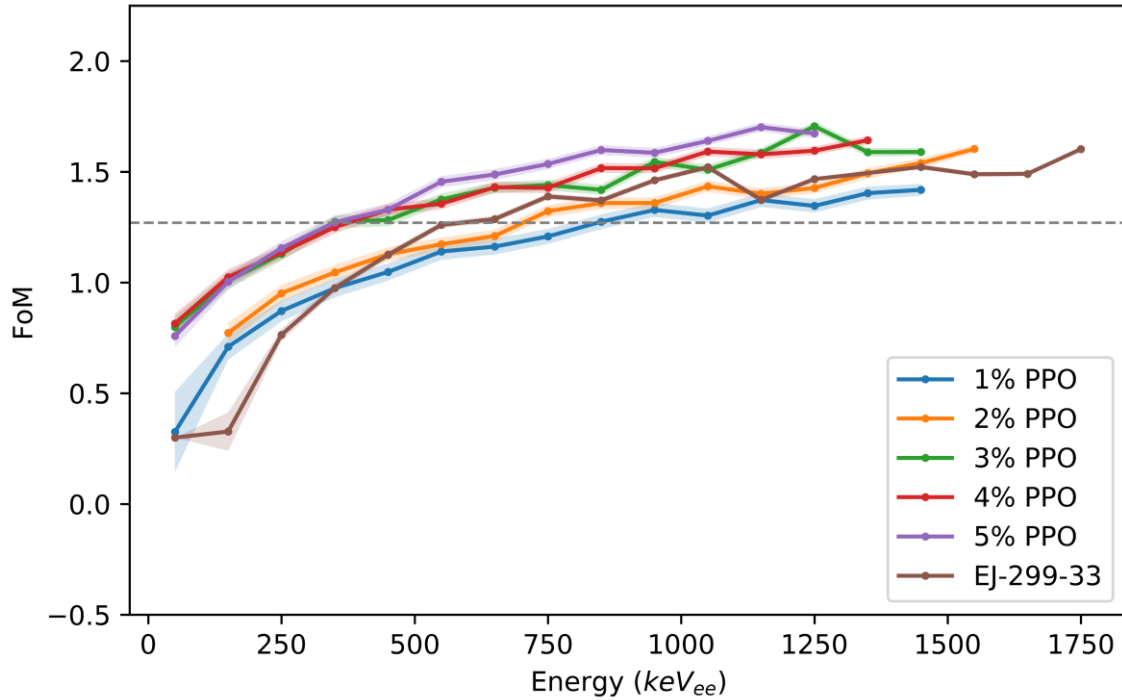
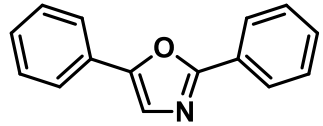
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Synthesizing custom polysiloxane matrices with control over phenyl-methyl distribution

Lim, A.; Arrue, J.; Rose, P. B.; Sellinger, A.; Erickson, A. *ACS Appl. Polym. Mater.* **2020** <https://doi.org/10.1021/acsapm.0c00641>.

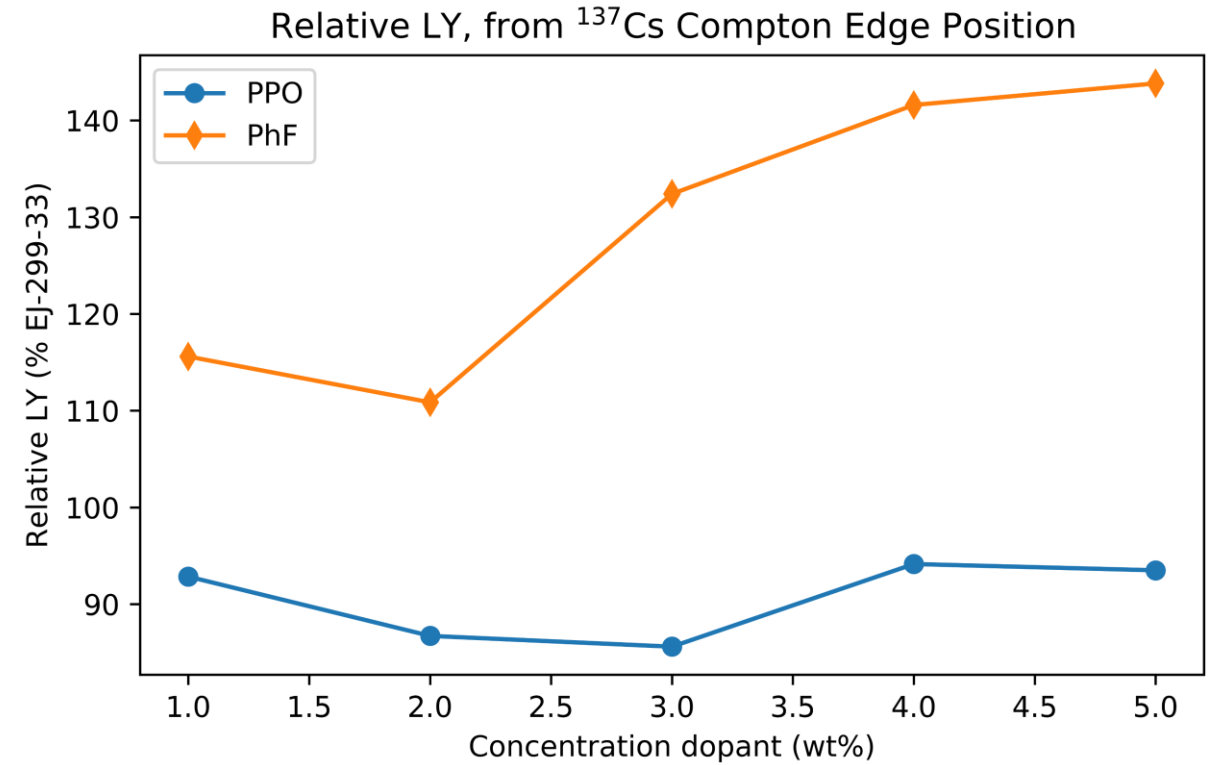
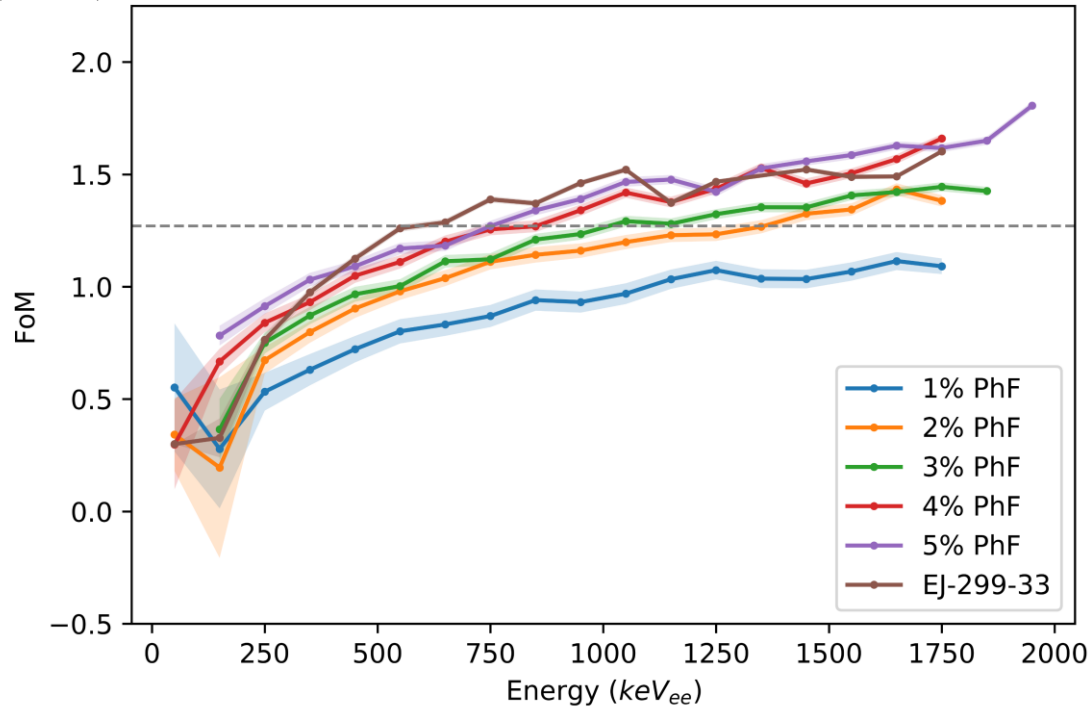
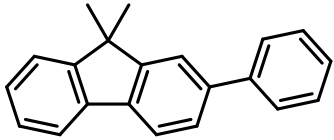
Polysiloxane scintillators with PPO have better FoM than commercial PVT scintillators.



PPO-polysiloxane scintillators had a higher FoM than EJ-299-33 at just 3 wt% PPO. LY was slightly worse but still comparable.

Lim, A.; Arrue, J.; Rose, P. B.; Sellinger, A.; Erickson, A. *ACS Appl. Polym. Mater.* **2020** <https://doi.org/10.1021/acsapm.0c00641>.

Polysiloxane scintillators with PhF have comparable FoM but higher LY than commercial PVT samples.

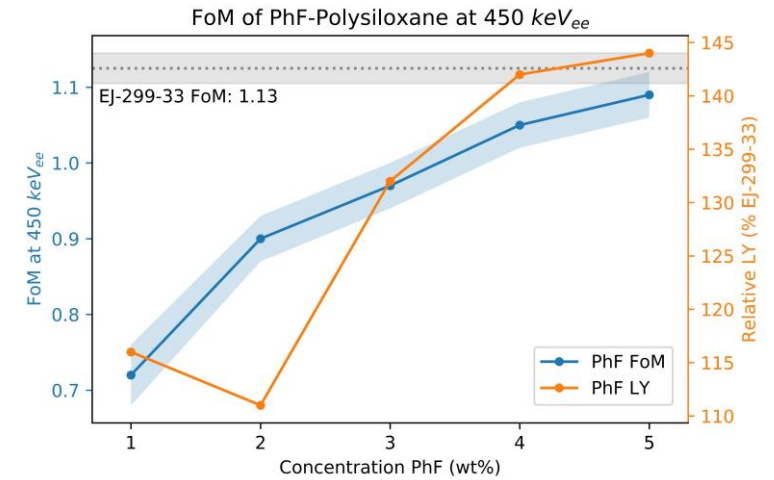
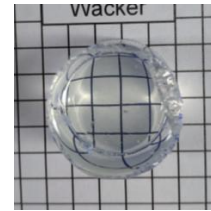
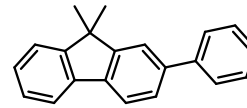
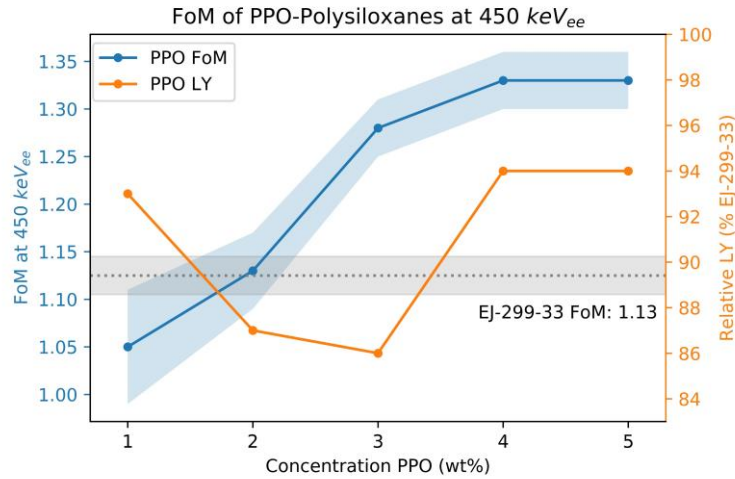
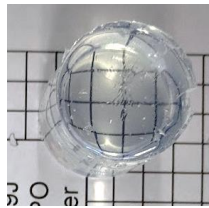
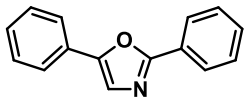


PhF-polysiloxanes appeared more stable than PPO analogues. The trend in higher LY was not observed in PhF-PVT scintillators.

Lim, A.; Arrue, J.; Rose, P. B.; Sellinger, A.; Erickson, A. *ACS Appl. Polym. Mater.* 2020 <https://doi.org/10.1021/acsapm.0c00641>.

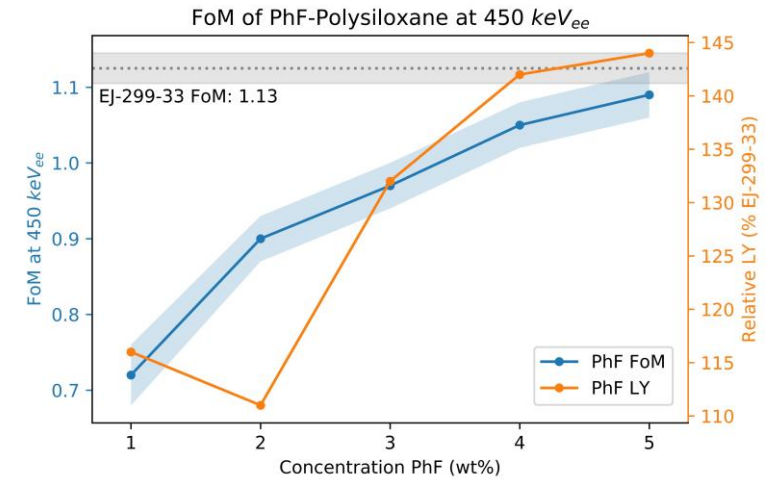
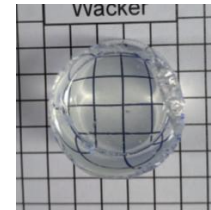
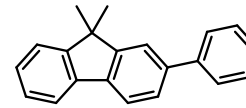
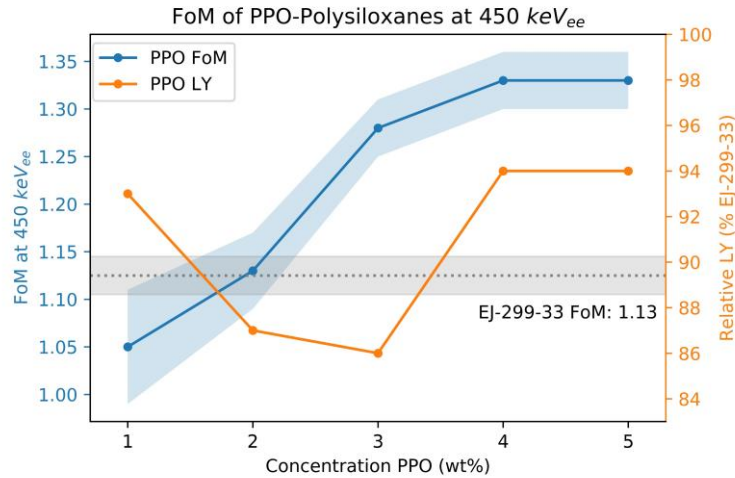
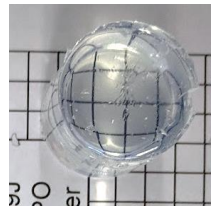
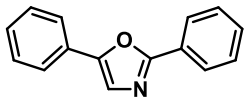
Polysiloxane scintillators capable of PSD comparable to EJ-299-33 were fabricated, but why do they work?

Summary:

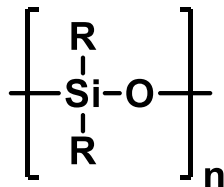


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Summary:



Future Work:



- Fabricate custom polysiloxane matrices
- Explore alternative dopants
- Mechanical testing
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Sellinger Group ETI Students:



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Questions?



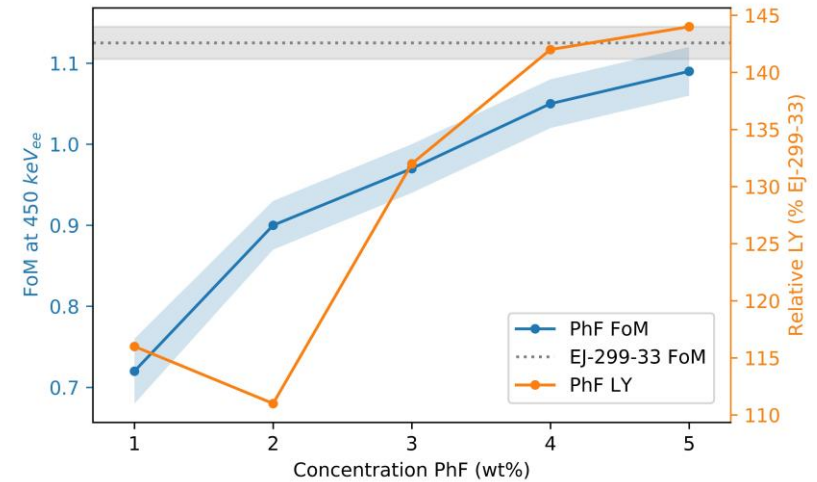
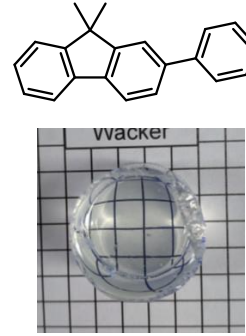
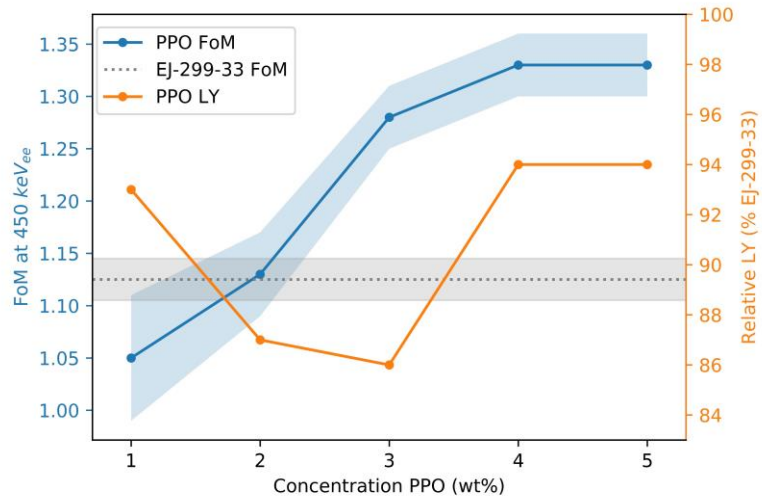
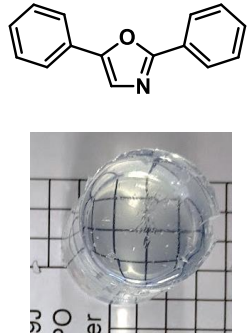
allisonlim@mines.edu
jarrue3@gatech.edu



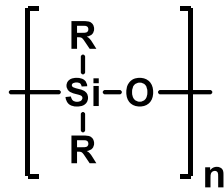
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