R&D on PET- and PEN-based Plastic Scintillators for Future Particle Physics Experiments[1]

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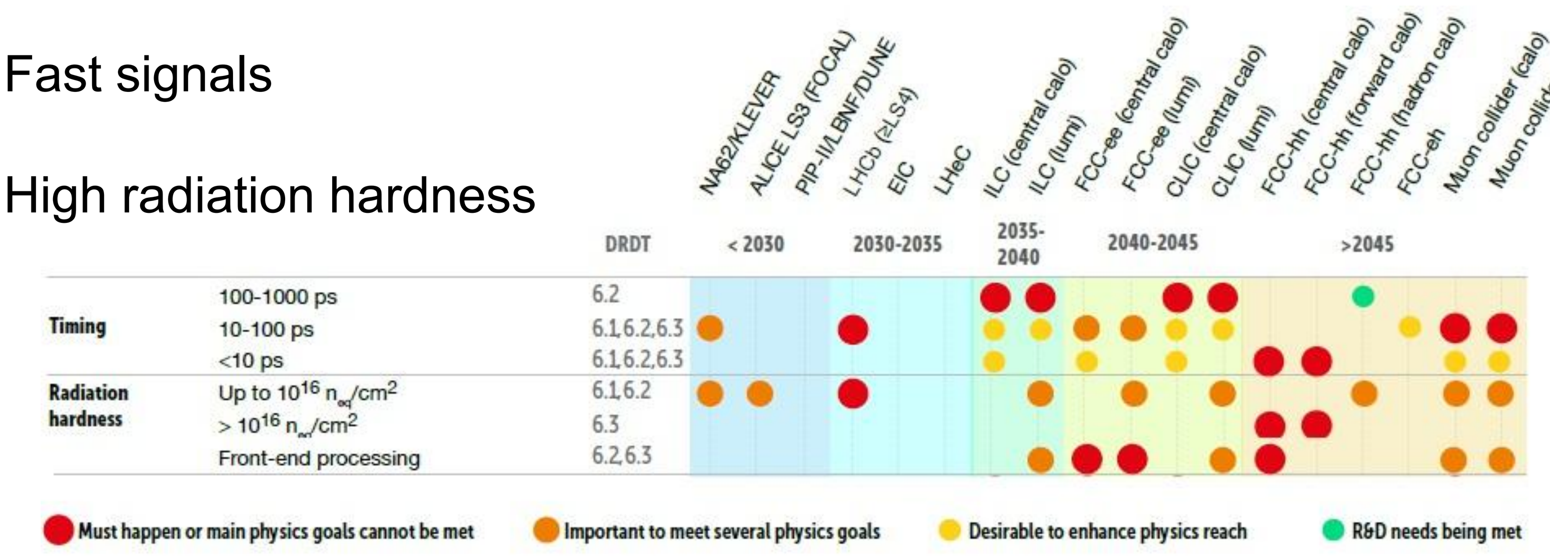
1. Why new scintillator materials?

Challenges for Future Detectors

- Large light yield
- Fast signals
- High radiation hardness



ECFA Detectors R&D Roadmap [2]

2. Why PET and PEN? [3]

PET
Polyethylene terephthalate

- Fast response
- Low cost
- Radiation damage recovery

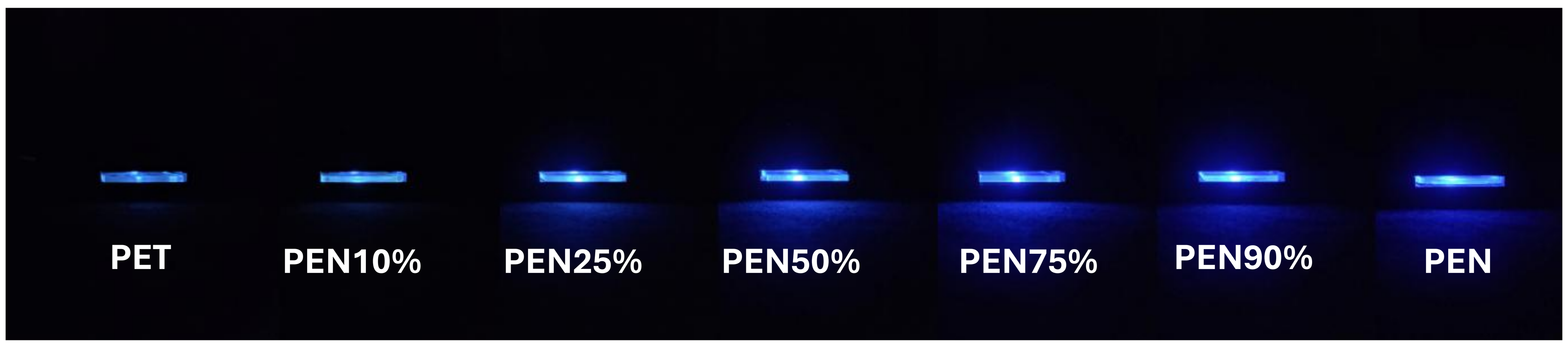
PEN
Polyethylene naphthalate

- High light yield
- Intrisic scintillator
- Radiation hardness

PET:PEN BLENDS

Can we combine their scintillation properties?

From PET to PEN



PET, PET:PEN blends and PEN samples excited by UV lantern

3. Production of Samples

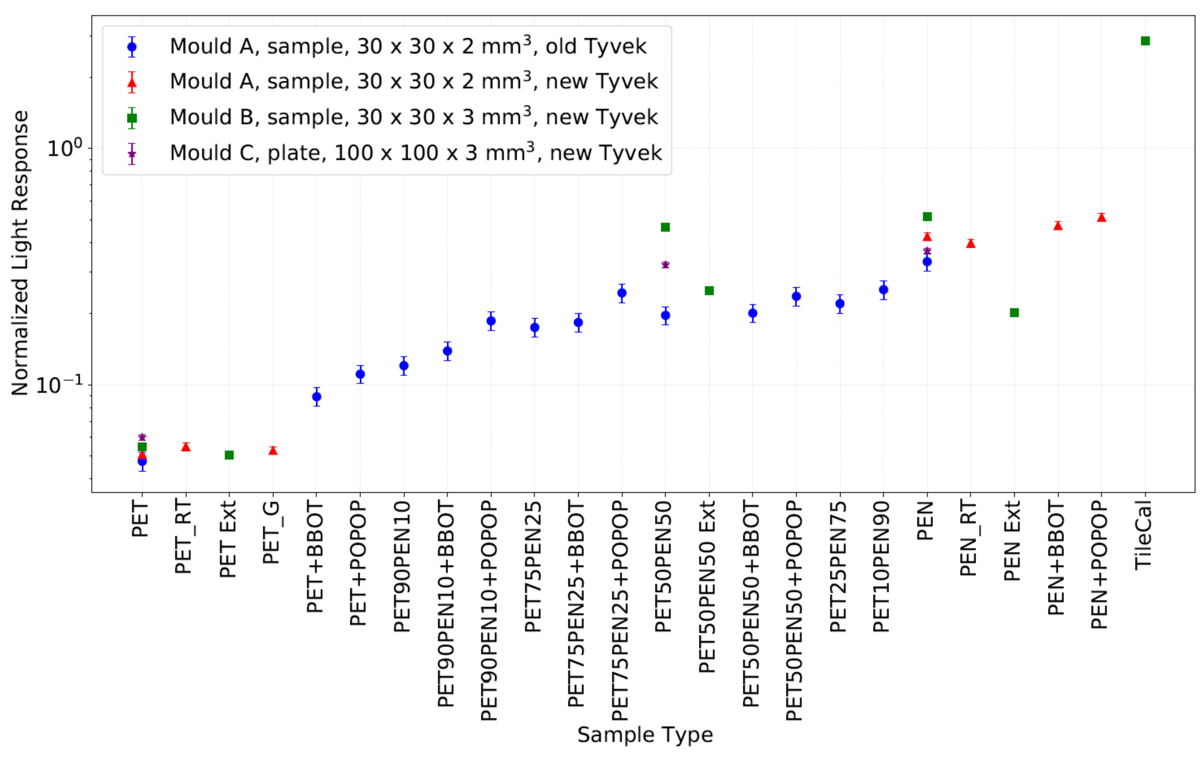
Polymer pellets

Injection moulding machine

Sample

Scintillation

4. Sample Light Response (LR)



- LR increases with PEN contente
- PEN shows ~7× higher LR than PET
- BBOT and POPOP enhance the LR
- The dopant effect is stronger in PET-rich compositions

5. Decay Time

Sample	Decay time [ns] τ or τ_{fast} / τ_{slow}
PET	5.6 ± 0.2
PET90:PEN10	4.9 ± 4.2 / 30.1 ± 1.3
PET75:PEN25	33.2 ± 0.6
PET50:PEN50	8.2 ± 0.6 / 37.7 ± 0.4
PET25:PEN75	12.2 ± 2.0 / 38.7 ± 0.7
PET10:PEN90	4.5 ± 0.3 / 35.3 ± 0.2
PEN	7.1 ± 3.4 / 34.9 ± 1.0
PET+BBOT	5.3 ± 0.1
PET+POPOP	5.0 ± 0.2
PEN+BBOT	6.5 ± 0.4 / 32.2 ± 0.6
PEN+POPOP	6.6 ± 0.8 / 32.6 ± 0.5

- PET and PEN decay times are consistent with literature values (PET: ~7 ns; PEN: ~35 ns [4])
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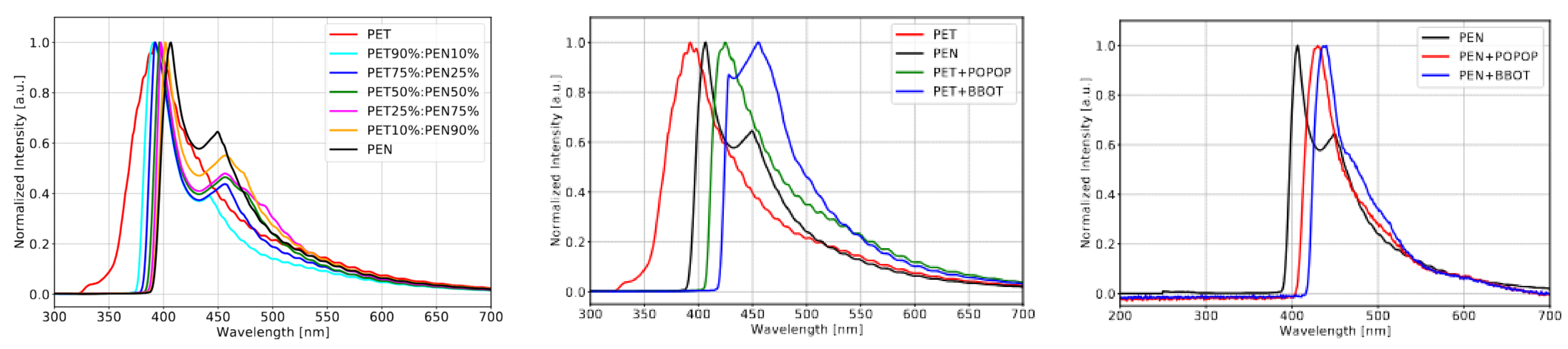
- PET:PEN blends are predominantly dominated by the slow decay component (~30–39 ns)
- BBOT and POPOP slightly reduce the decay time

6. Emission Spectrum



- The second emission peak becomes more prominent with increasing PEN contente
- The emission range matches the spectral sensitivity of the PMTs
- BBOT and POPOP shift the emission towards longer wavelengths, as expected

7. Conclusion

The complementary properties of PET and PEN make PET/PEN-based materials promising candidates for plastic scintillators

- Increasing PEN content enhances light response and strengthens the second emission feature
- PET is faster, while PEN and PET:PEN blends are dominated by a slow decay componente
- Fluorescent dopants provide an additional route to tune scintillation performance.

Acknowledgement

Acknowledgement

SFRH/PRT/BD/151543/2021, DOI 10.54499/PRT/BD/151543/2021
EXPL/EME-NUC/1311/2021, DOI 10.54499/EXPL/EME-NUC/1311/2021
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References

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[3] H. Nakamura et al., 2011, EPL 95, 22001, DOI: 10.1209/0295-5075/95/22001.
[4] J. Wetzel et al., Turk. J. Phys., vol. 44, no. 5, pp.437–441, 2020.