# Organic Electronic Neutron Detectors

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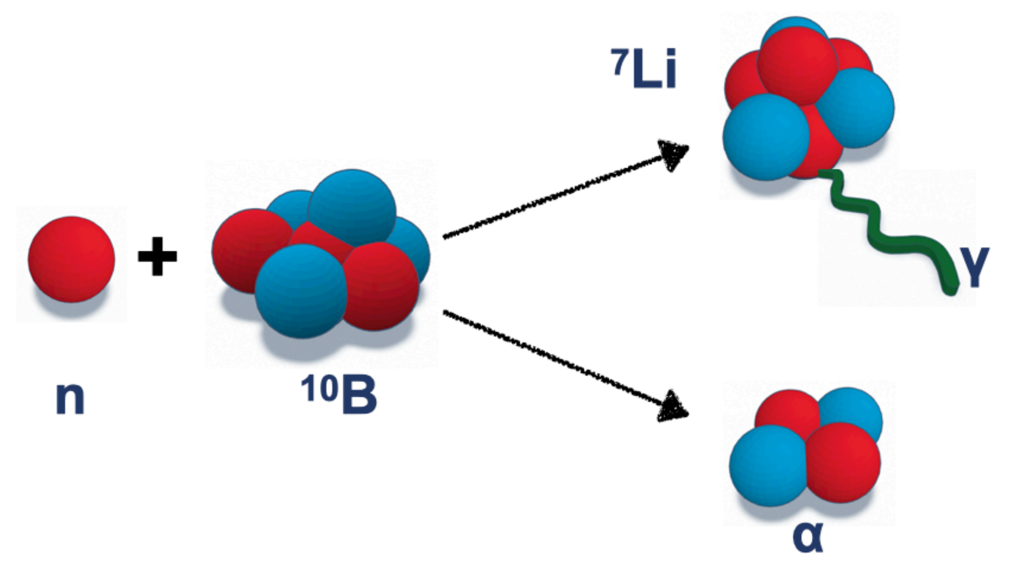
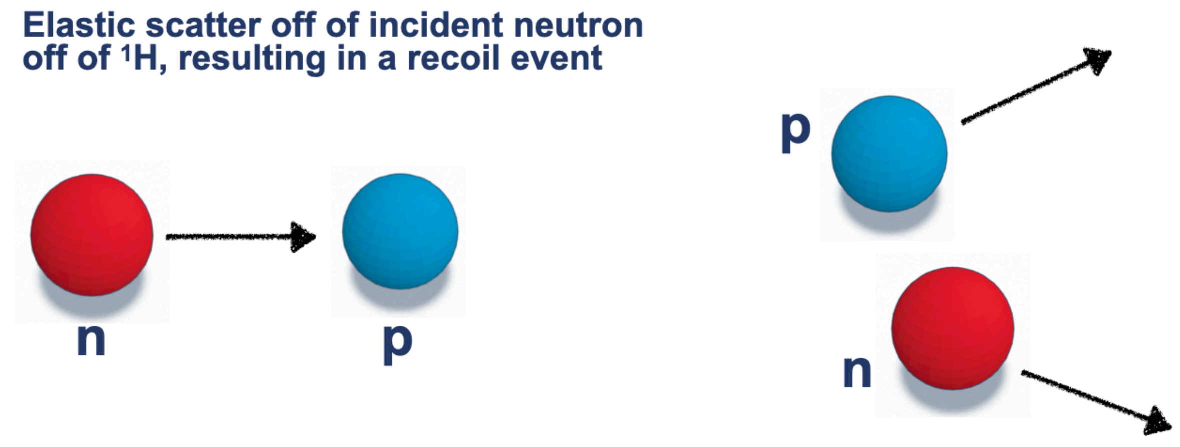
## Aim: Explore the feasibility of position sensitive organic electronic neutron detectors

## Use: Boron-Neutron-Capture for thermal, and elastic scattering for fast neutrons

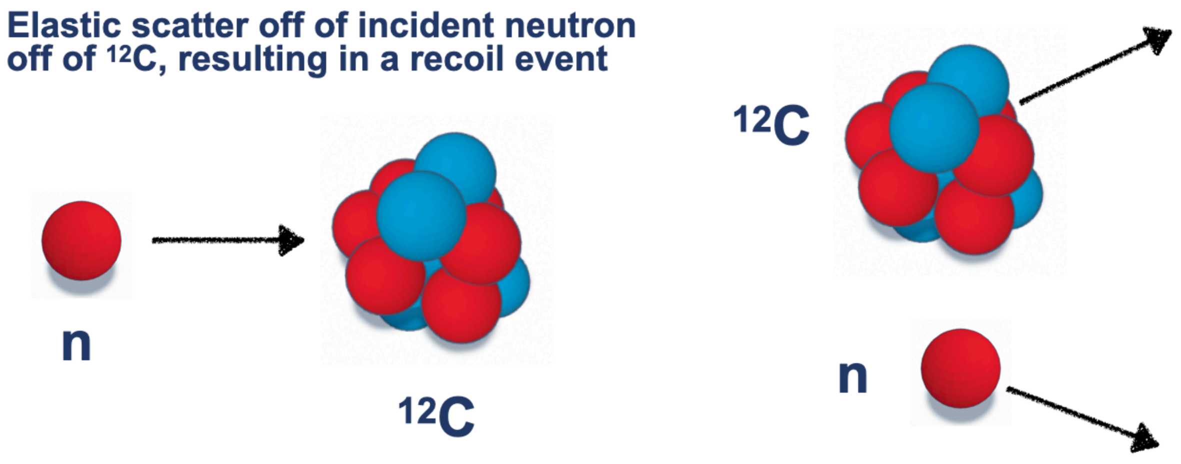
$$n + {}^{10}_{5}\mathrm{B} \rightarrow \begin{cases} {}^{4}_{2}\mathrm{He}\,(1.47\mathrm{MeV}) + {}^{7}_{3}\mathrm{Li}\,(0.84\mathrm{MeV}) + \gamma\,(0.48\mathrm{MeV}) & [93.7\%] \\ {}^{4}_{2}\mathrm{He}\,(1.78\mathrm{MeV}) + {}^{7}_{3}\mathrm{Li}\,(1.01\mathrm{MeV}) & [6.3\%] \end{cases}$$




Elastic scatter off of incident neutron off of $^{1}$H, resulting in a recoil event

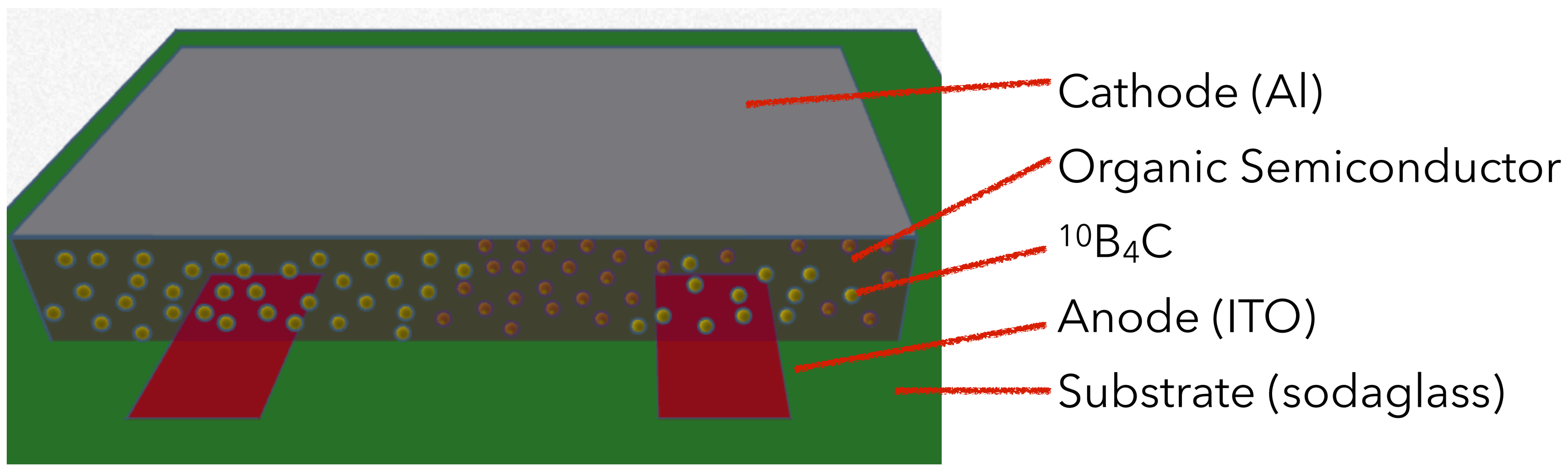



Elastic scatter off of incident neutron off of $^{12}$C, resulting in a recoil event

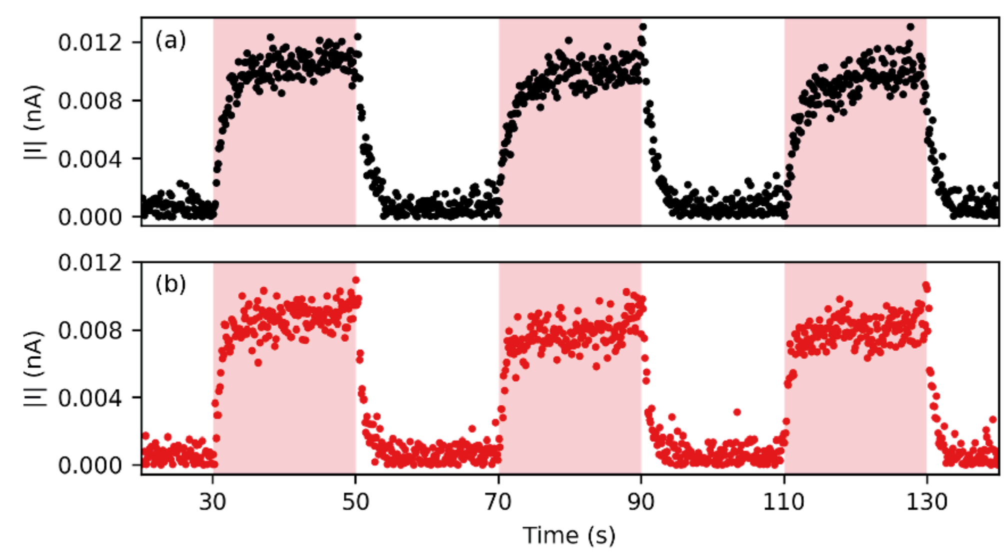



- Organics semiconductors are insensitive to γ radiation, so neutron capture results on average in 2.3MeV of ionisation energy from α and $^{7}$Li recoil.
- Elastic scatter from fast neutrons results in a spectrum of energies.
- Potentially scalable $^{3}$He alternative neutron detector technology.

## Method

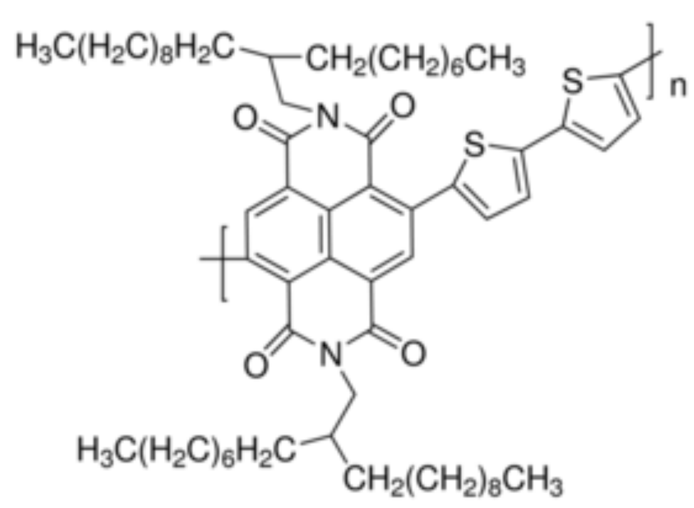



- Measure signals using Keithley 2635B source measure unit.
- P3HT:PCBM device response 20pA [1].



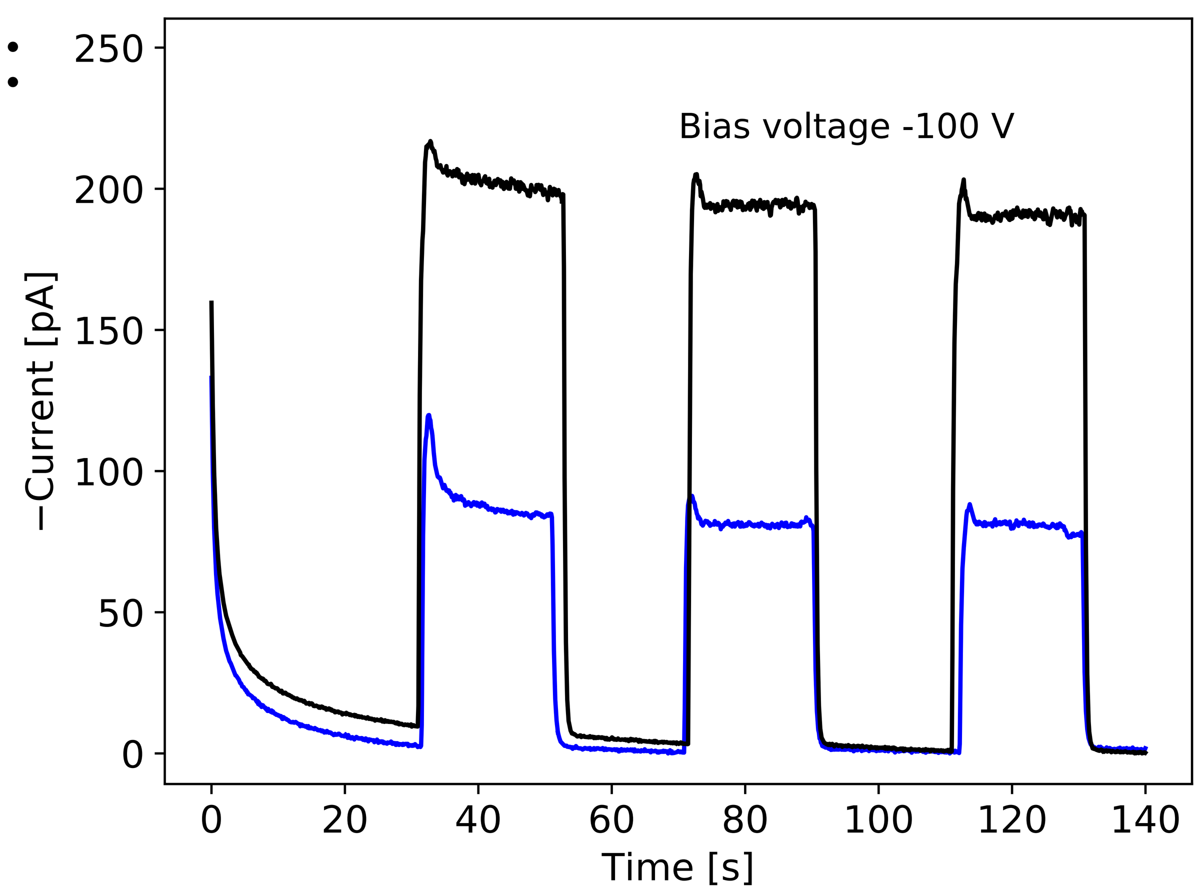

Use a data centric engineering approach:

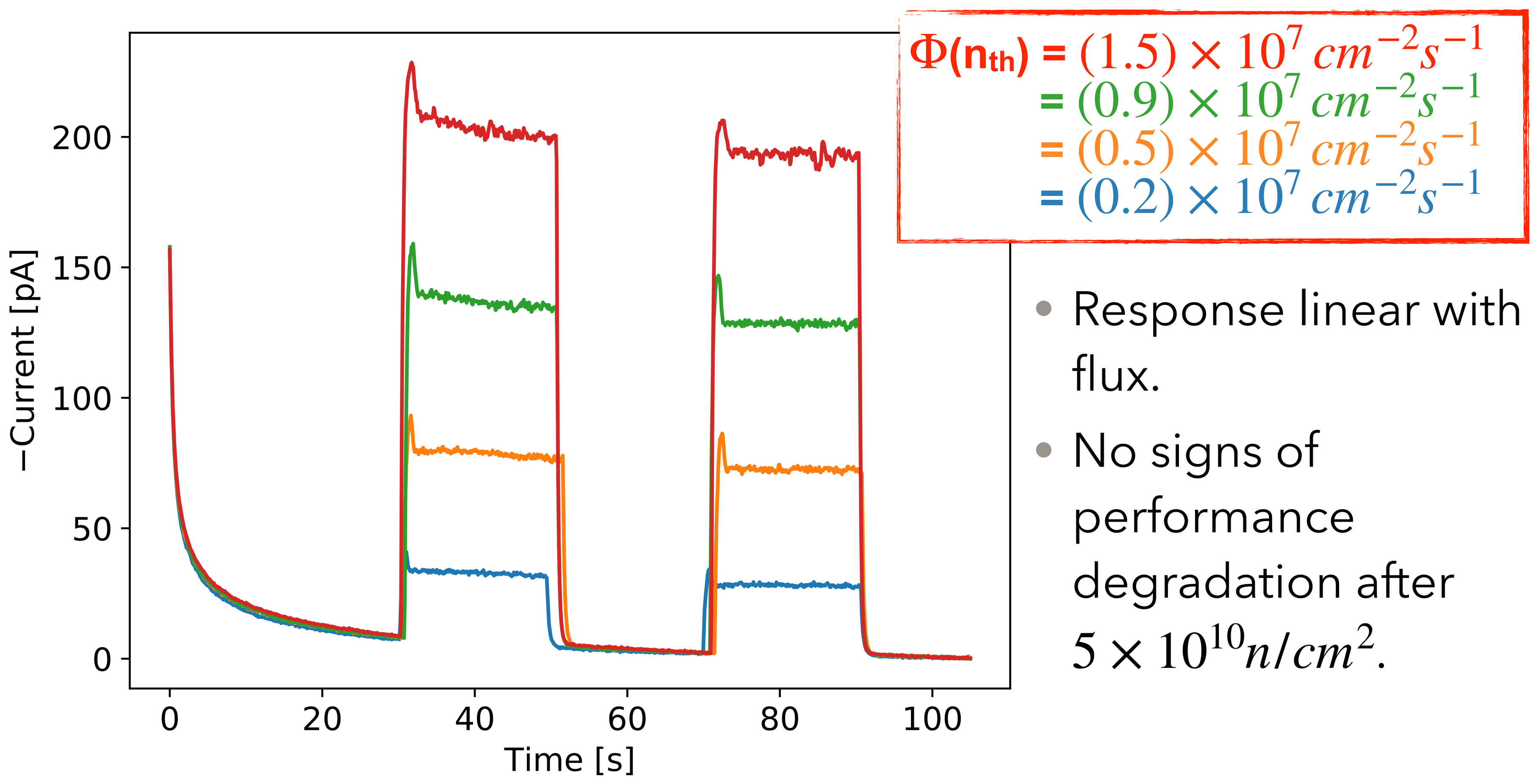
- GEANT4 simulation of the device, to identify materials and predict responses.
- Test new organic systems (donor, acceptor or blends) quickly without needing to synthesise
- Focus on most promising candidate materials
- Accelerated design cycle - study years worth of device configurations virtually in weeks using our digital twin approach.
- Use $^{241}$Am α to understand basic hadronic response of devices
- Use $^{90}$Sr and $^{60}$Co to test β and γ response



- ~200pA signal responses obtained with $^{241}$Am α and n's with PNDI
- Low drift
- few pA dark current
- S/N values up to 2000

## Results [2]:




- Response linear with flux.
- No signs of performance degradation after $5 \times 10^{10} n/cm^2$.

- Clear fast neutron response signature (blue).
- Thermal neutron response is difference between blue and black.

- Next steps: study multi-channel readout, improve data for fast and thermal neutron tests, and improve GEANT4 simulation to better understand elastic scatter and BNC response.

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**References**:

[1] F. E. Taifakou et. al., ACS Appl. Mater. Interfaces 13, 5, 6470–6479 (2021)

[2] J. Borowiec et al., Procs. Technical Meeting on Advances in Neutron Detectors for Neutron Scattering and Imaging, IAEA (2021)



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