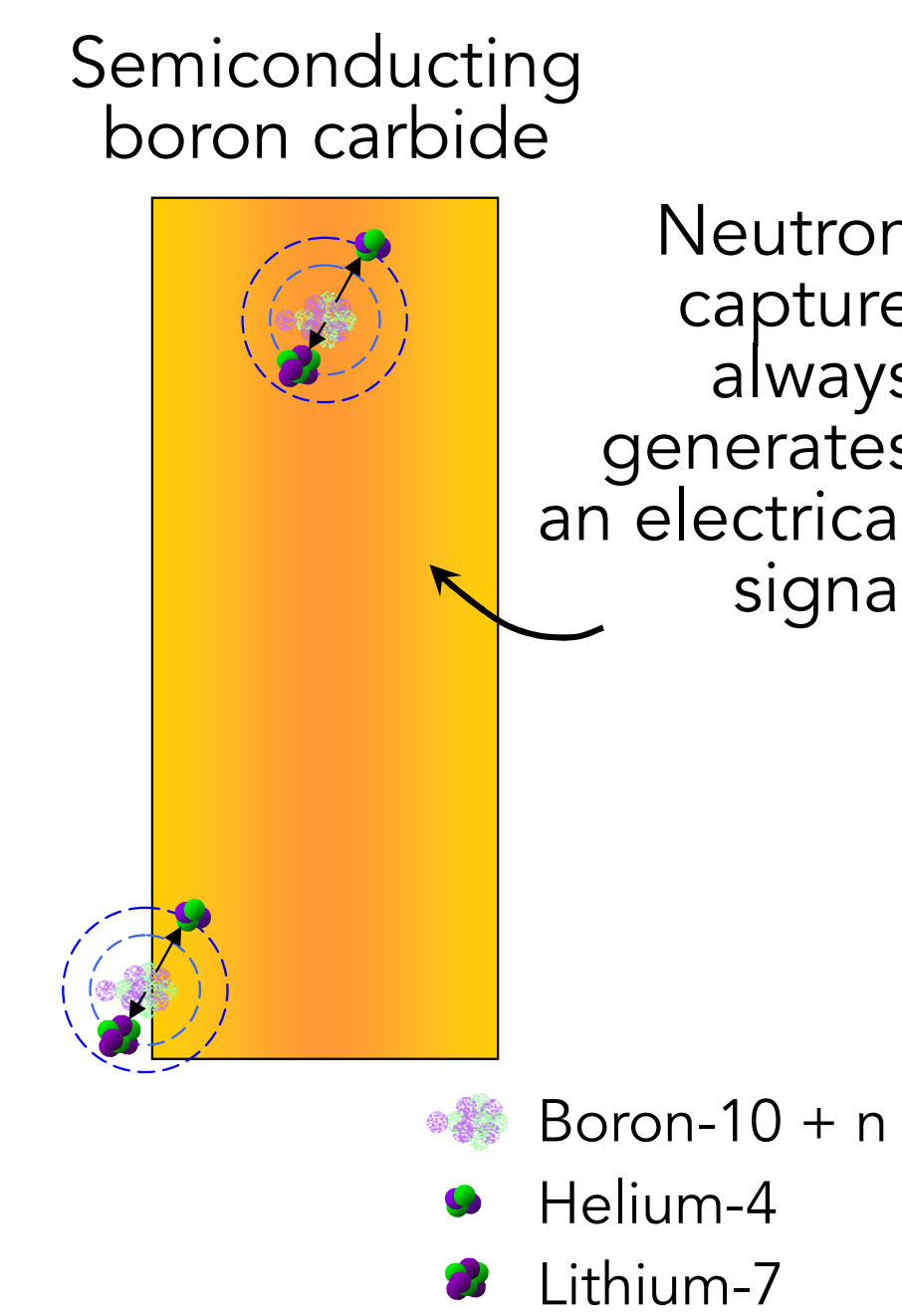
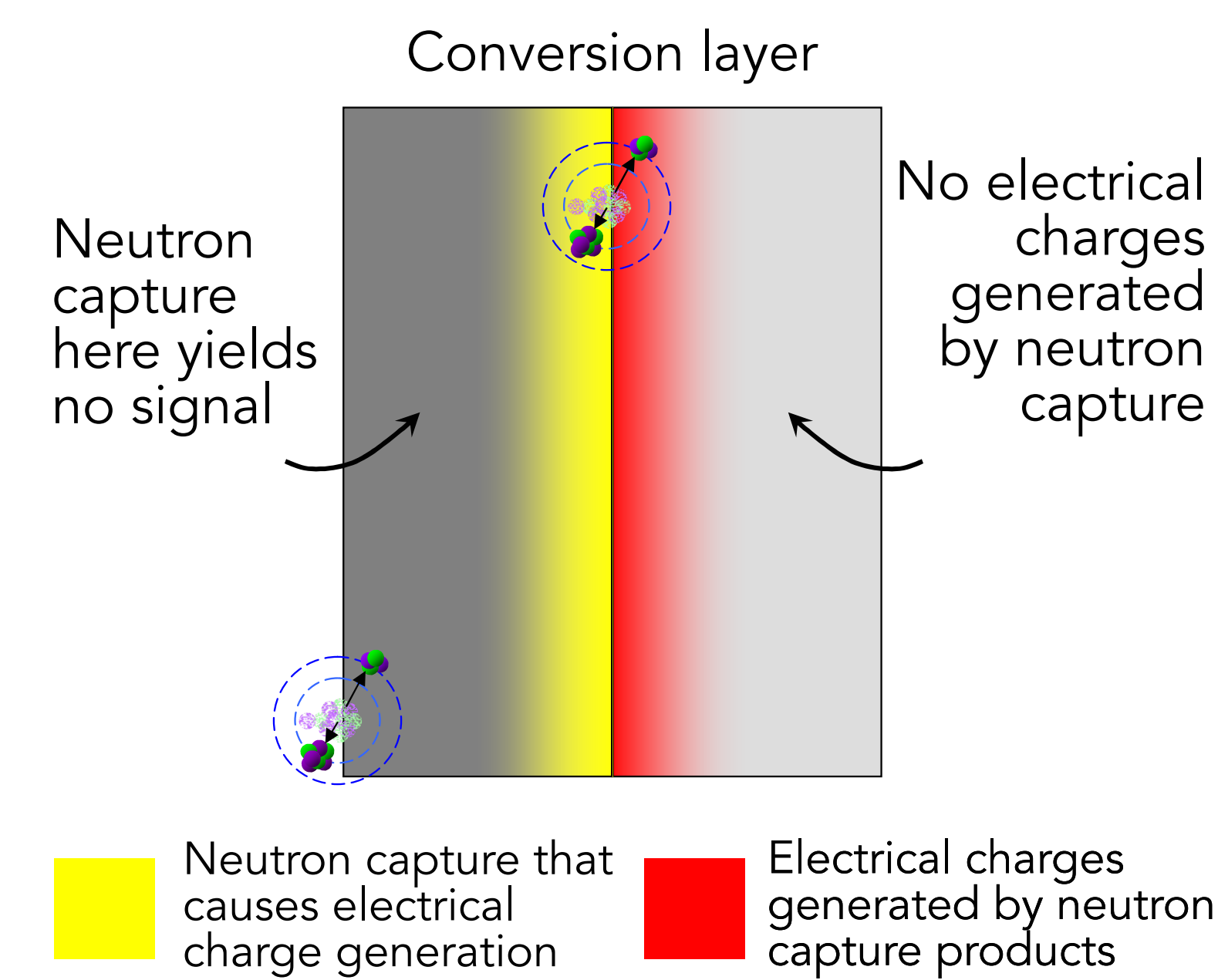
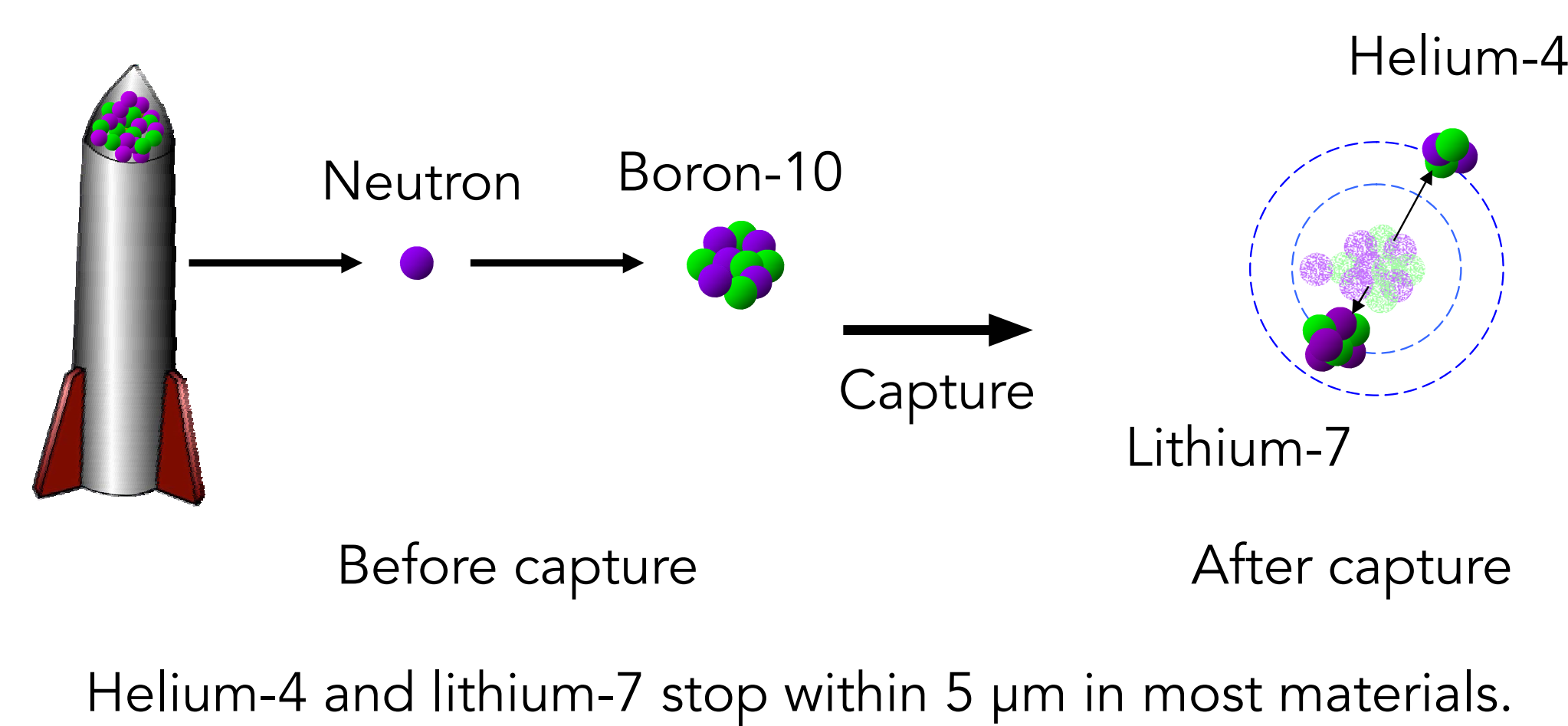


Motivation

- Commercial neutron detectors based on heterojunction and homojunction diodes contain conversion layers
- Efficiency decreased by intrinsic geometry and small active regions

Creating neutron detectors with increased efficacy

- Devices with heteroisomeric diodes leverage boron-rich boron carbide semiconductors without a conversion layer
- Improved sensitivity by increasing prevalence of ^{10}B and film thickness



Physical Principles

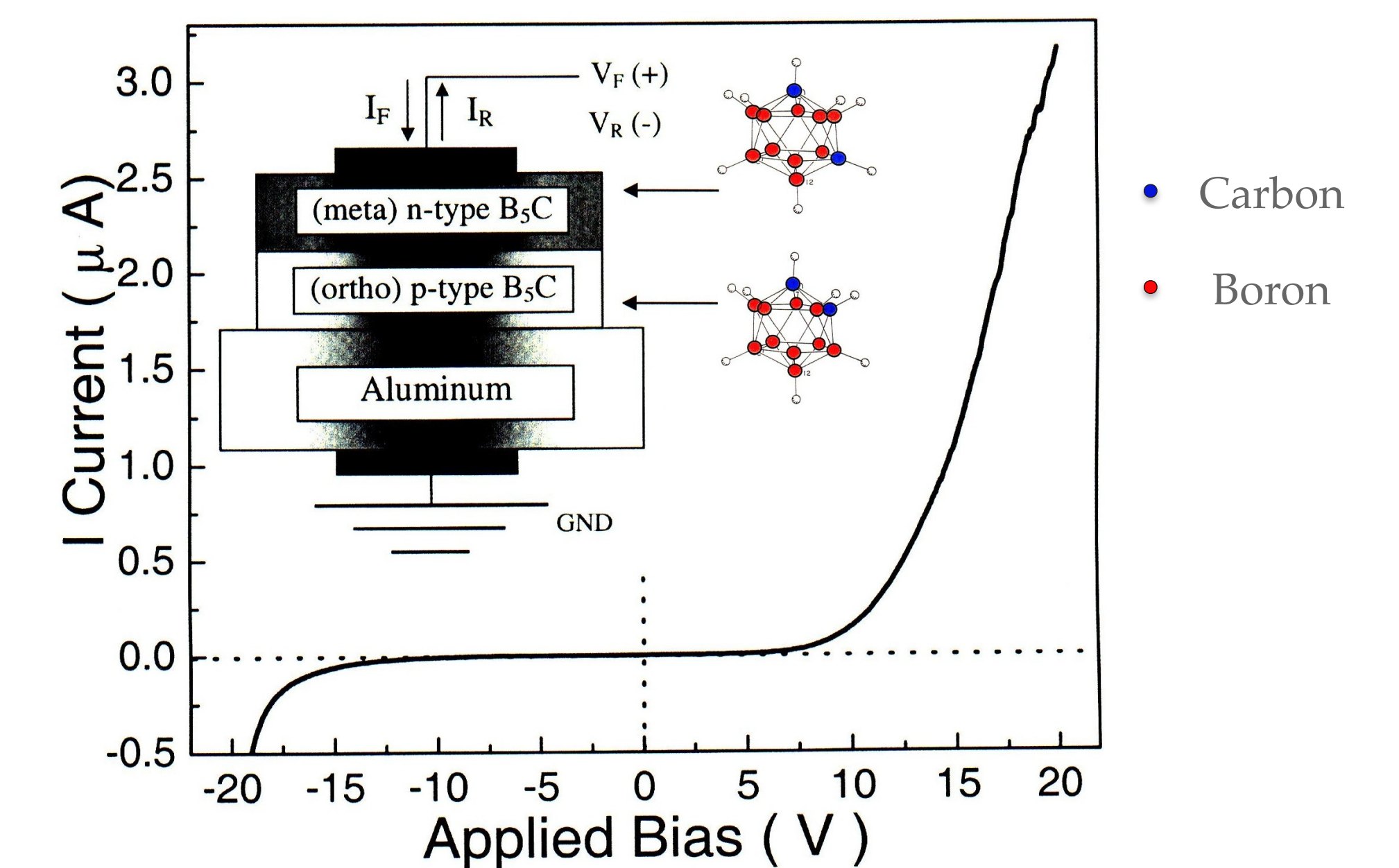
Neutron detection

- Large neutron cross-section of boron ^{10}B allows for catching neutrons
- Unstable ^{11}B splits into charged helium-4 (alpha particle) and lithium-7
- Thick films absorb virtually all epithermal neutrons and become opaque
- Improved sensitivity by increasing prevalence from 20% (^{10}B in boron-carbide) to 100% (pn-junction)

PN - Junction

Heteroisomeric diode

- Isomers orthocarborane and metacarborane are isoelectronic
- Orthocarborane is slightly p-type and metacarborane is strongly n-type due to differences in electronic structure
- Diodes are created through plasma enhanced chemical vapor deposition

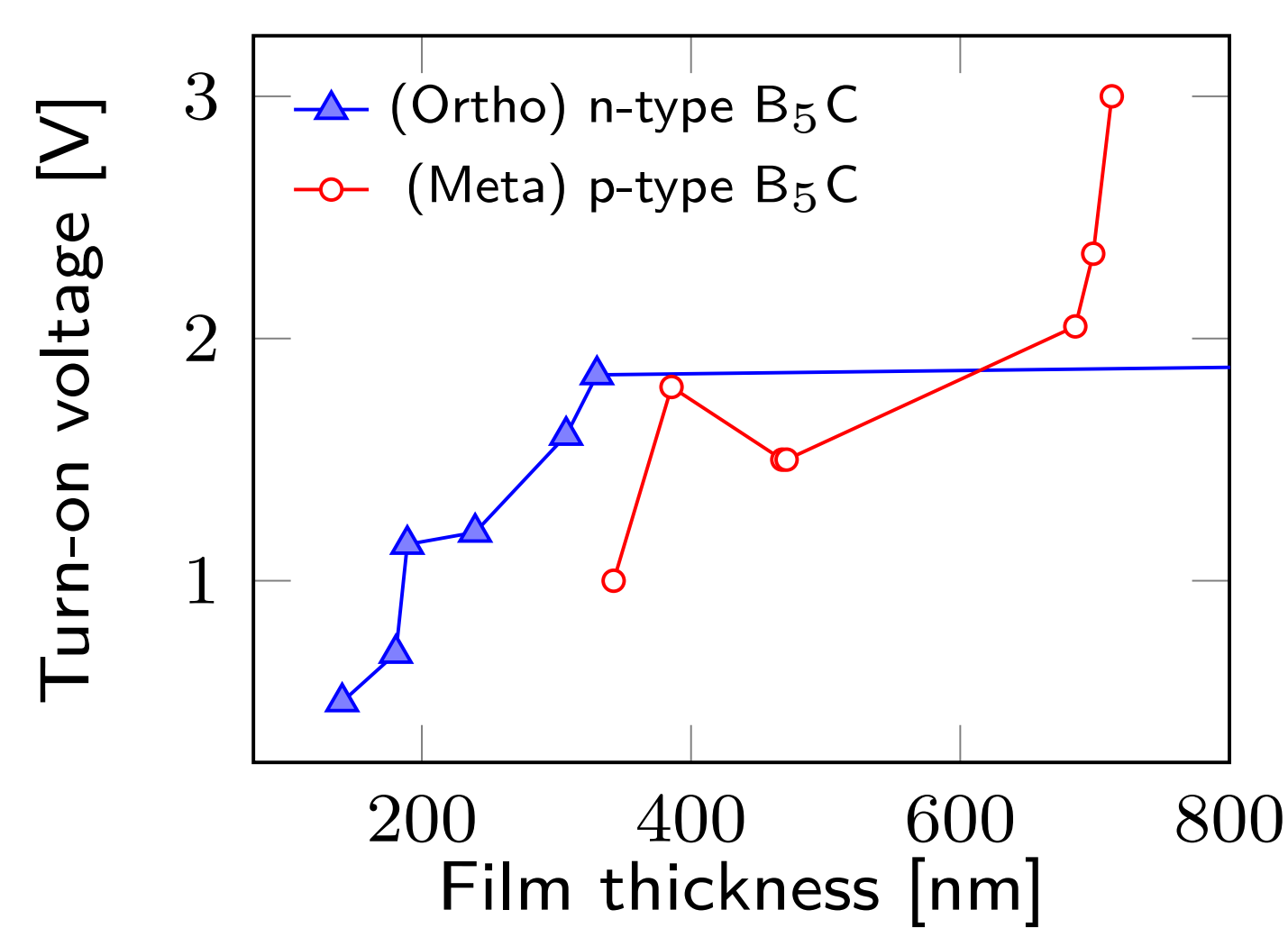


A.N. Caruso, R.B. Billa, S. Balaz, J.I. Brand and P.A. Dowben, J. Phys.: Condens. Matter 16, L139-L146 (2004)

Electronic Transport Properties

Enhanced energy efficiency

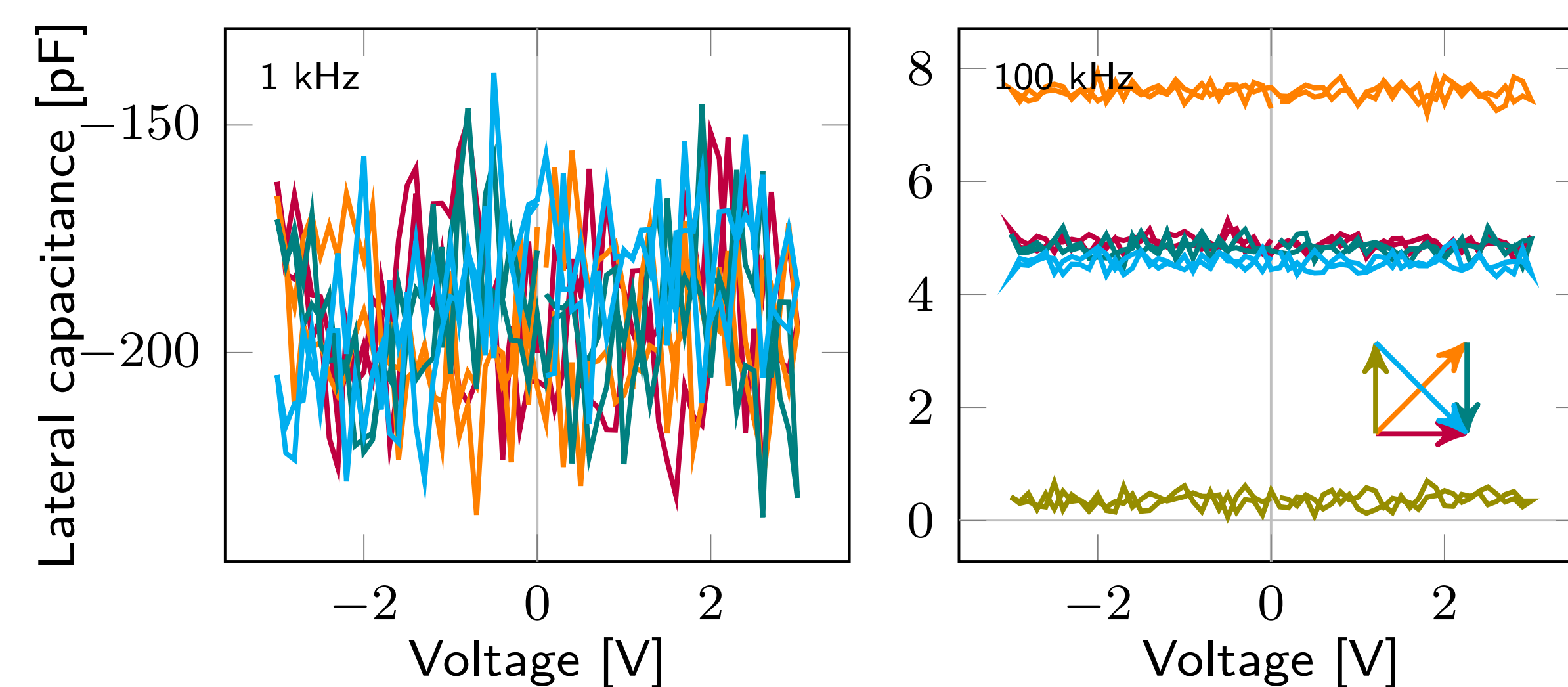
- Turn-on voltage significantly lower than expected
- Turn-on voltage (depletion zone) linearly increases with film thickness



Current perpendicular to plane.

Angle-dependent electronic transport

- Anisotropic and inhomogeneous DC conductivity and high-frequency capacitance
- Existence of nanocrystals within amorphous structure
- Behavior highly non-trivial but not critical for neutron detection



Current in plane.

Neutron Detection

Current generation

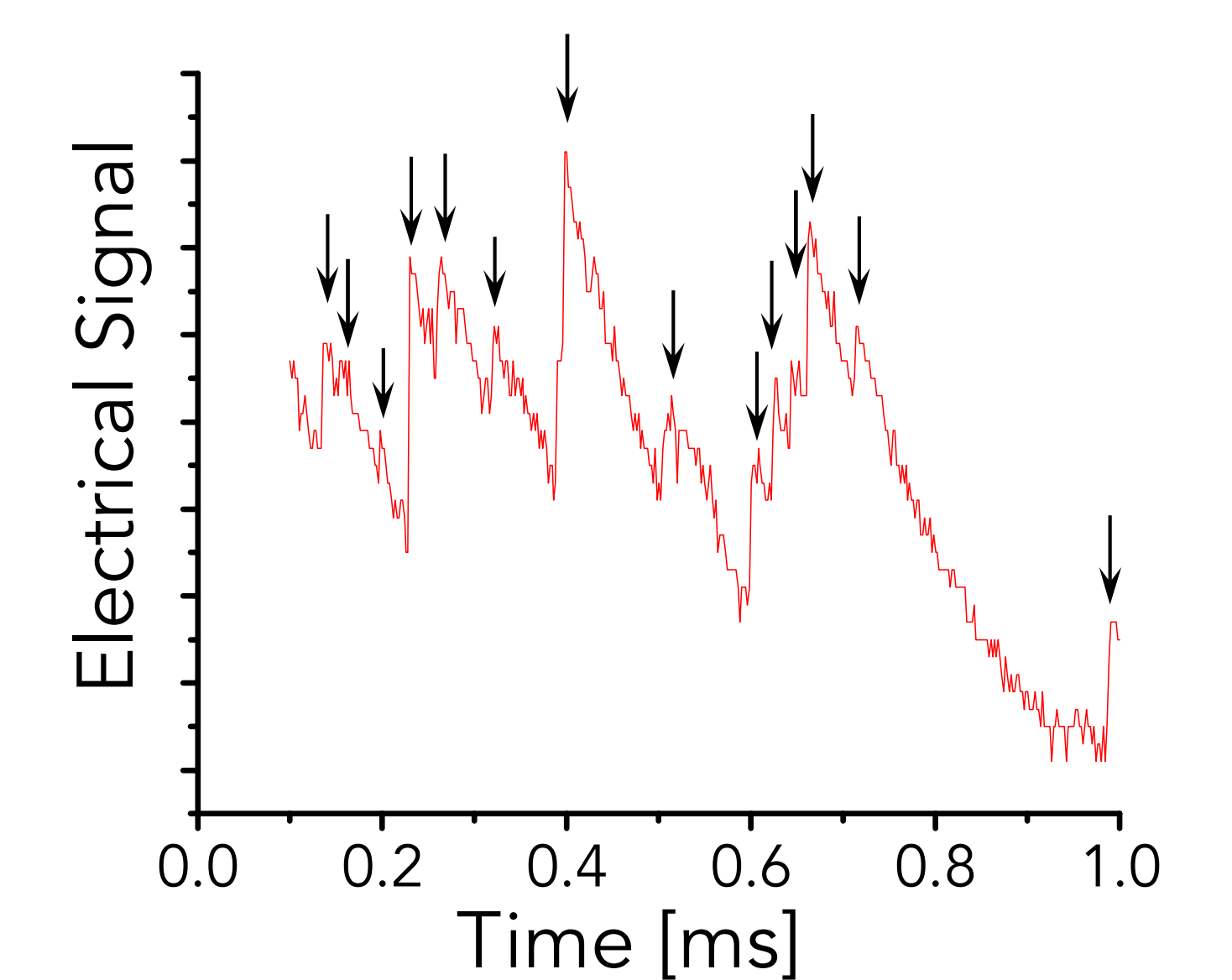
- One photon creates a single charge-hole pair
- One neutron generates more than 10^5 charge-hole pairs
- Detection of single thermal neutron possible
- Electrical signal is generated when ^{11}B splits into charged helium-4 (alpha particle) and lithium-7



On state refers to conducting diode.

Temporal evolution

- PN-junction constitutes resistor and capacitor with characteristic discharging time
- Response/detection time less than 20 μs



Arrows indicate neutron detection event.