Improving spatial resolution in neutron detectors with submicrometric B_4C layers: Monte Carlo simulation results

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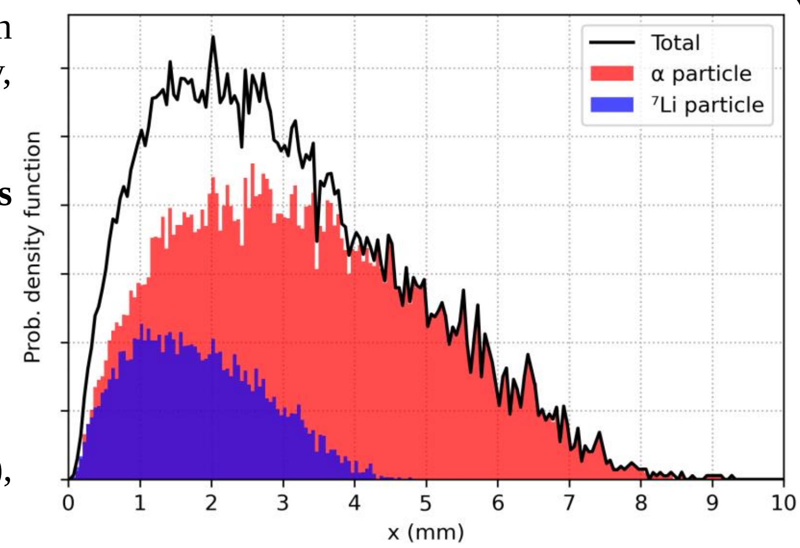
Limitations of gaseous boron PSND

Modern neutron research facilities rely on **high performance** position sensitive neutron detectors (PSND), in aspects such as detection efficiency, counting rate capability and **spatial resolution**.

Most PSND use **solid boron**, detecting the **heavy charged fission fragments** (α and ^{7}Li) produced when a neutron is captured by the ^{10}**B** isotope:

$$ {}^{10}_{5}B + n \rightarrow \underbrace{{}^{7}_{3}Li^{*}(0.84\ \text{MeV}) + {}^{4}_{2}\alpha\ (1.47\ \text{MeV})} $$

Ranges (x-projection) →



The range of the secondary particles can extend **up to ~8 mm** (1D projection), leaving a **long track of electrons** as they traverse the counting gas.

In some cases, this is the major **source of uncertainty** in the determination the neutron capture site, **limiting spatial resolution**.

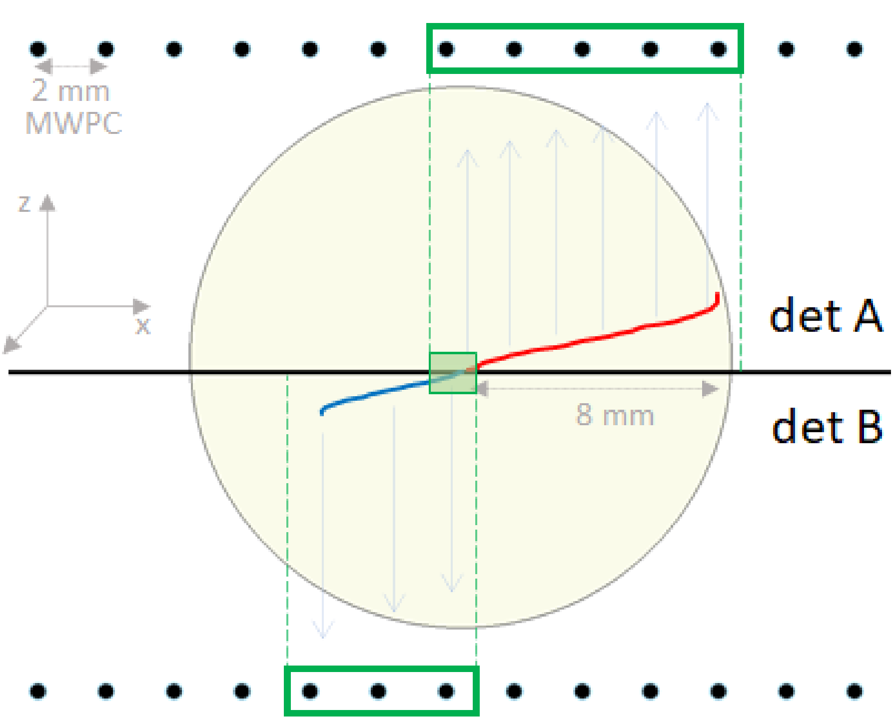
Coincidence Detector

The secondary neutron capture particles are emitted in the same line, with **opposite directions**.

Typical boron PSND use **detection layers** (converter + substrate) **too thick** for both capture particles to escape it, detecting **only one** for each neutron capture.

If **submicrometric** detection layers are used, **both particles** can escape it and ionize the surrounding gas on opposite sides.

By detecting both particles **simultaneously**, we can pinpoint the neutron interaction site with **more precision**.



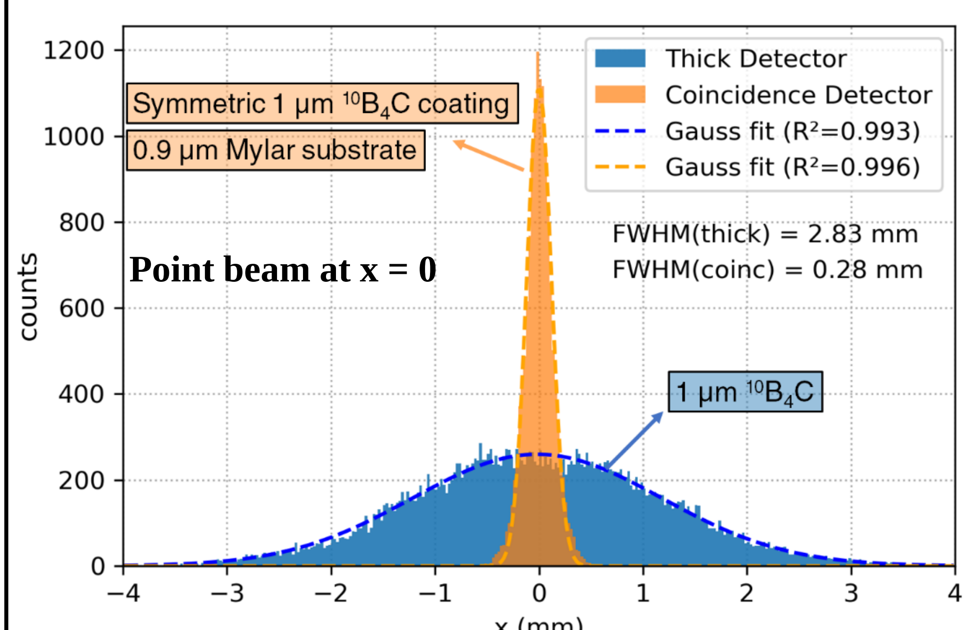
$$ x_{\text{coinc}} = \frac{x_A \cdot E_B + x_B \cdot E_A}{E_A + E_B} $$

Spatial Resolution

Through Monte Carlo simulation using **GEANT4**, the spatial resolution of a **conventional boron PSND** and of the **coincidence detector** was compared.

The optimal **coincidence detector** geometry was found to be a **1 µm B_4C coating** layer divided on both sides of a 0.9 µm **Mylar substrate**.

Simulation results showed the potential of achieving an **improvement of the spatial resolution** of boron PSND by a **factor of ~8** using the coincidence detection principle.



A conversion layer according to the geometry simulated was built and proof of concept neutron irradiation measurements will soon be carried.

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