The Impossible and the Unusable: From 2D to 4D Neutron Sensors

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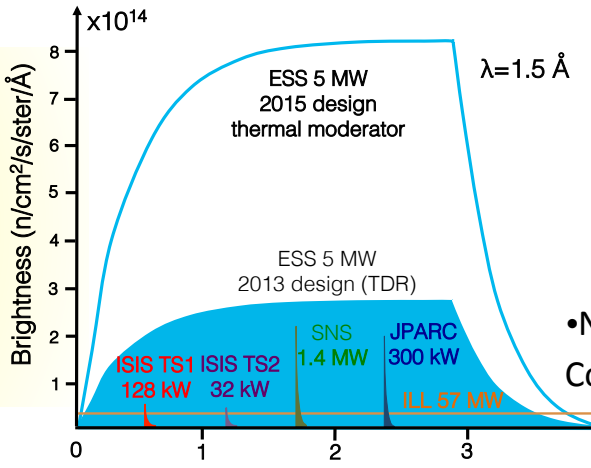
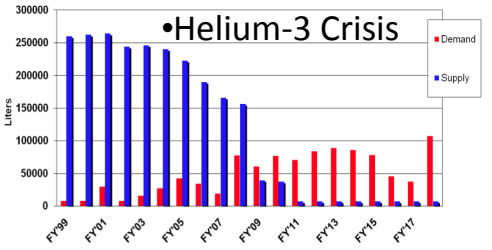
Introduction

Neutron Detectors: A Hot Topic

- Neutron Science Facilities undergoing renewal
- Landscape review in latest ESFRI roadmap
- New Facilities >100 instruments next decade
- Helium-3 Crisis necessitates replacement technologies
- Can we revolutionise neutron detection?





•New Powerful Sources under Construction: How to use the flux?

The Idea

The vision and building blocks towards energy sensitive neutron detectors with ultimate timing resolution, which would revolutionise the capabilities of neutron detectors.

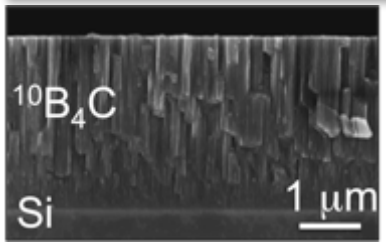
This dream aspires to take neutron detectors from 2D position sensitive devices to 4D sensors with energy and timing information. These extra dimensions of information are presently seen as impossible and unusable respectively. Novel instrumentation is nearly always the forerunner of new diagnostic methods. This vision is about enabling new transformational instrumentation that subsequently leads to novel interrogation techniques.

The first additional dimension is the holy grail for neutron detectors: energy measurement. This is presently unachievable and seen as impossible, as the information on the neutron energy is lost in the nuclear conversion of the neutron to detectable products. Advanced statistical methods may give the possibility to measure this.

Secondly, present-day timing resolution on neutron detectors is limited, rarely better than 10us, as few applications today require even this moderate timing resolution. However, the nature of the interaction in a thin layer detector allow imagination of a timing resolution of a factor 100 or more. Complex correlations may allow the exploitation of this for as yet unimagined investigations, if this capability were developed.

What is Possible

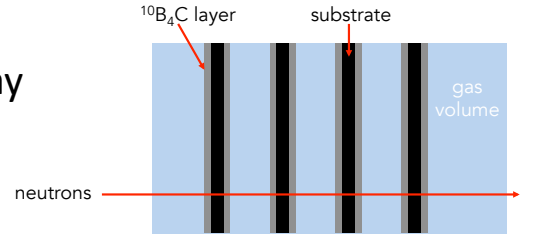
The potential for achieving these future capabilities is grounded in the intensive R&D efforts that have come since the Helium-3 crisis, and in particular the Boron-10 thin film detectors, where the neutron interacts in very thin layers of neutron sensitive material. Successful R&D thus far has led to a plethora of replacement technologies, which can already equal the performance of Helium-3 detectors.
By using a multi-disciplinary approach with developments linked across mathematical and statistical methods, material science and thin film technologies, and detector technologies, achieving this dream would give revolutionary instrumentation that would be transformational for neutron interrogation techniques.



Typical layer thickness 1um give potential time resolution of ns:
factor 1000 beyond today

Cross section is sensitive to neutron energy

$$\sigma \sim 1/\sqrt{E}$$



Multilayer detectors have sensitivity to energy with depth of interaction

Potential Impact

New instrumentation opens up new science possibilities

Energy measurement revolutionises inelastic studies

Timing resolution allows correlation studies at great detail

S:B, Flux and Precision