Australian Government

ANSTO
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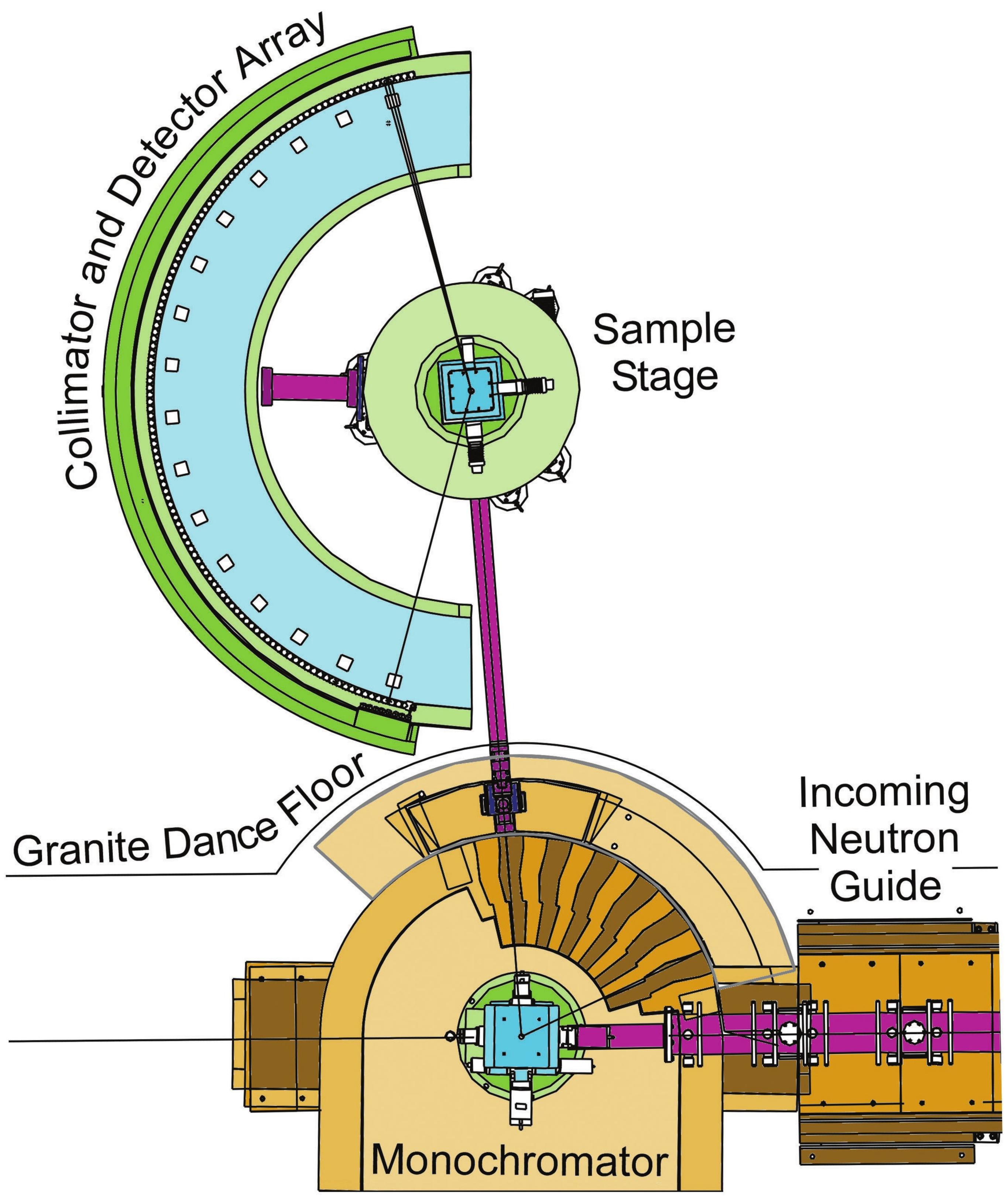
Australian Centre for Neutron Scattering (ACNS)

Echidna

High Resolution Neutron Diffractometer

Echidna is one of the world's best reactor-based high resolution powder diffraction instruments. Polycrystalline samples studied on Echidna include nuclear waste, magnetic materials, ionic conductors, battery materials, gas storage materials, and many others.



Diffraction

A neutron beam is scattered within a crystalline material creating a diffraction pattern which can be analysed to determine the arrangement of atoms within the material.

What makes Echidna special?

Echidna uses a single wavelength and a highly collimated, focused beam of neutrons to improve angular resolution. The high resolution enables closely-spaced peaks in the diffraction pattern to be separated. This diffraction technique can resolve structures very accurately to provide precise atomic and magnetic structures from samples.

Applications

High resolution neutron powder diffraction can be used to:

- Determine structures of newly-created materials
- Study light elements in the presence of heavy ones (e.g. oxides, borides, lithium conductors)
- Investigate materials with complex crystal structures, including catalysts, organic magnets, cements, and ionic conductors
- Study structural and magnetic phase transitions
- Investigate samples in extreme environments (temperature, magnetic and electric fields, and combinations of these)

SPECIFICATIONS

Location:
Thermal guide TG-1, 50mm (W) x 300mm (H)

Source-monochromator-sample-detector distances:
~58m – 2.5m – 1.29m

Monochromator:
23-slab vertically-focussing Ge(hhl), mosaicity 33'

Takeoff angle:
Continuously variable 90-140°, 155°

Wavelengths:
Typical 1.30, 1.62 or 2.44Å at 140° takeoff angle

Collimation:
α_1~0.2λ°, 10', 5'; α_2~1°, 10'; α_3=5'

Detector:
128 ^{3}He 25.4mm diameter x 300mm long tubes 1.25° apart, stationary coverage 158.75°

Accessible 2θ range:
-54 – 165° at 140° takeoff

Vertical detector aperture:
13.2°

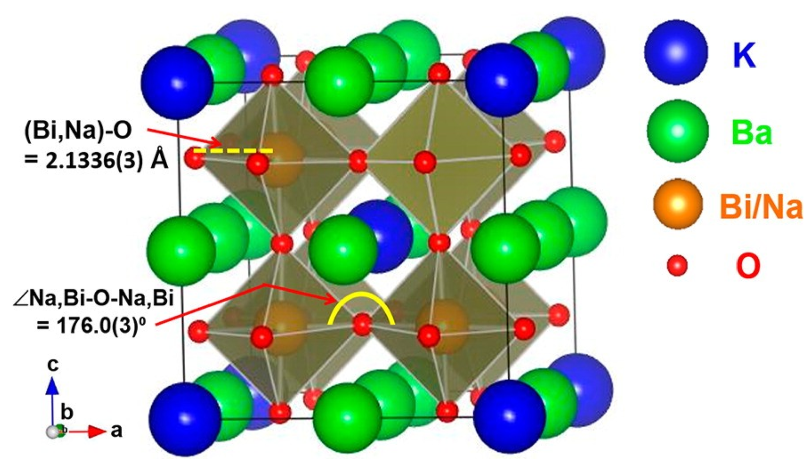
$\Delta d/d_{min}$:
~0.1%

Instrument reference:
Avdeev, M. and Hester, J. R. (2018) *J. Appl. Cryst*. **51**(6) 1597-1604

CASE STUDIES

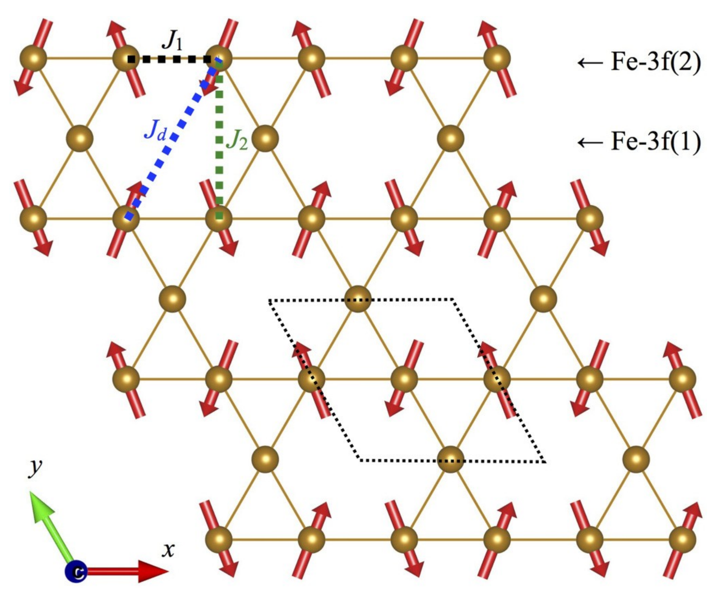
A new superconducting material

Superconductors are technologically important materials that losslessly conduct electricity when cooled sufficiently. The exact positions of the oxygen atoms in this material (red dots in the picture) have a strong influence on the appearance of superconductivity. Neutron powder diffraction is able to provide this information in the presence of much heavier atoms, in this case bismuth and barium. For more information, see Rubel et. al., *Chem. Mater.* (2016) **28**, 2, 459-465.



A complex magnetic structure

Unlike those obtained from X-rays, neutron diffraction patterns contain information about the magnetic structure of a material. An interesting example studied on Echidna is the magnetic structure of $Fe_4Si_2Sn_7O_{16}$ in which only two-thirds of iron atoms magnetically order into stripes while the remaining third remain magnetically idle.
For more information, see Ling et al. *Phys. Rev. B* (2017) **96**, 180410(R)



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