National Physical Laboratory

Use of radionuclide sources in neutron metrology

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CCRI webinar
Radioactive Sources in Metrology: Applications and Alternative Technologies
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Overview

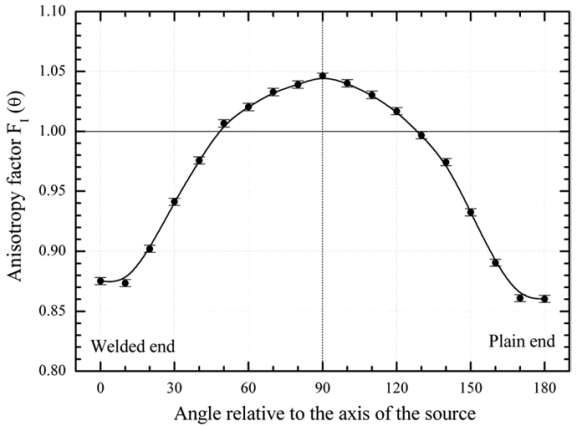
Neutron source types

Applications in neutron metrology

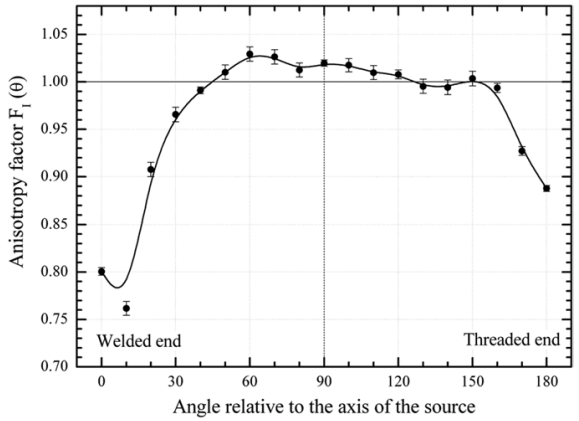
Alternatives

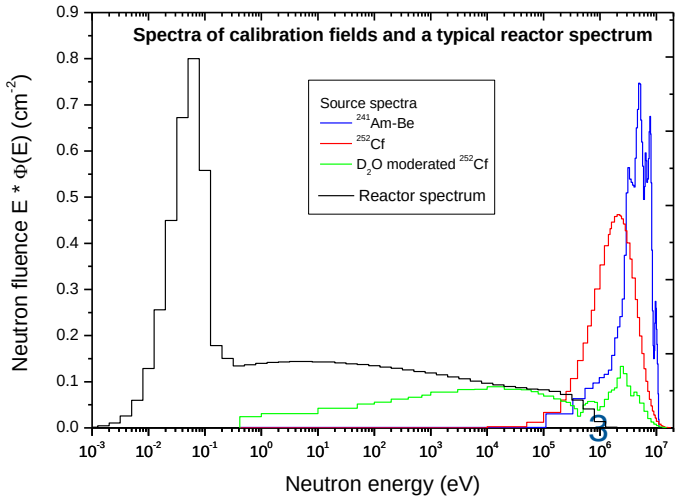
Types of radionuclide neutron source

- Encapsulated ^{252}Cf or mixture of α or γ emitter and target material (e.g. ^{241}Am and Be, ^{226}Ra and Be)
- Produce neutrons via spontaneous fission, (α,n) or (γ ,n) reactions
- Place source in Mn bath to measure emission rate
- Rates up to ~10^9 s^{-1} from a ^{252}Cf source (~12 $mSv.h^{-1}$ at 1m)
- Approximately a point source
- Cylindrical geometry so not isotropic
- Sources have broad energy spectra
- Can modify spectrum → thermal or workplace fields



Anisotropy profiles





Applications in neutron metrology

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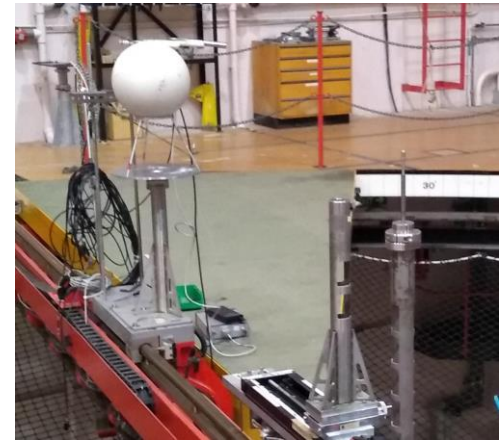
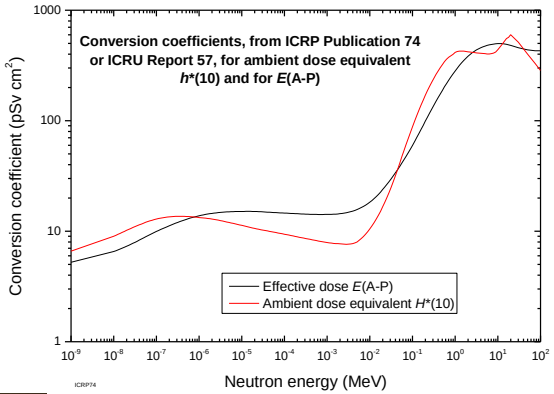
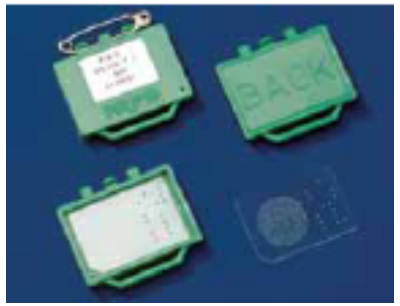
Reference standards for neutron fluence and neutron dose

- Fundamental method in use at all NMIs and secondary labs with neutron facilities (cannot measure neutron dose directly)
- Source with emission rate and anisotropy calibration placed a fixed distance from a device in a low scatter area
- Determine fluence from decay corrected emission rate, anisotropy factor and air attenuation
- Determine dose from spectrum-averaged fluence to dose conversion coefficients
- Can produce simulated workplace fields using D_2O sphere and/or shadow block)







Applications in neutron metrology

Thermal neutron fields

- Use one or more radionuclide neutron sources (Am-Be or Pu-Be) in a graphite or PE assembly
- Requires characterisation to determine fluence and dose
- Very stable field
- Low intensity
- Low maintenance

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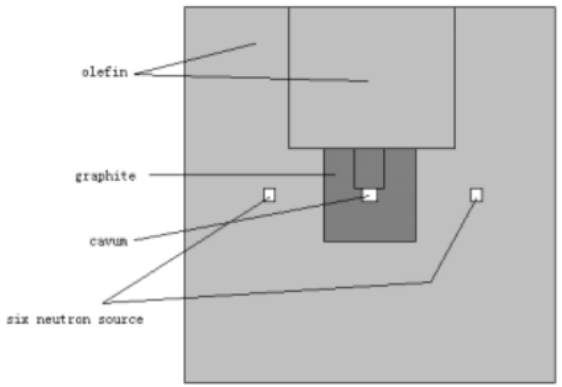

NRC

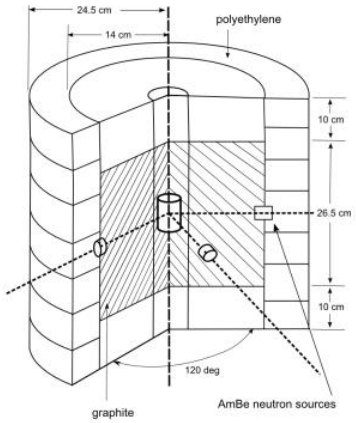

Figure 1: Thermal neutron standard at NRC.

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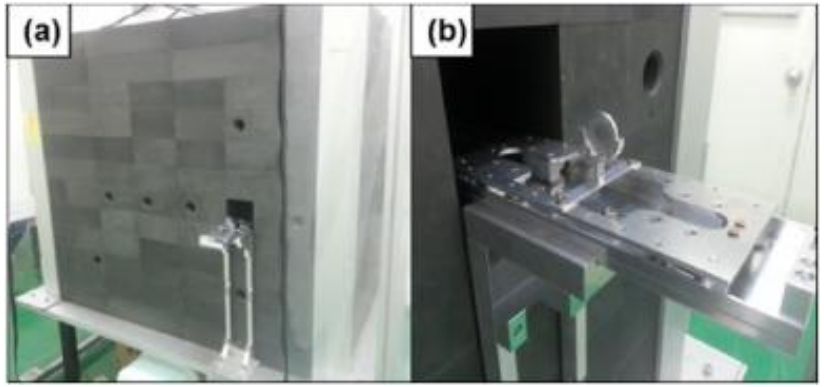
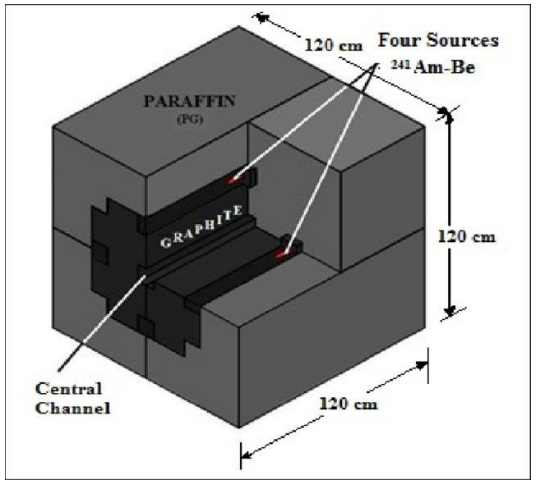


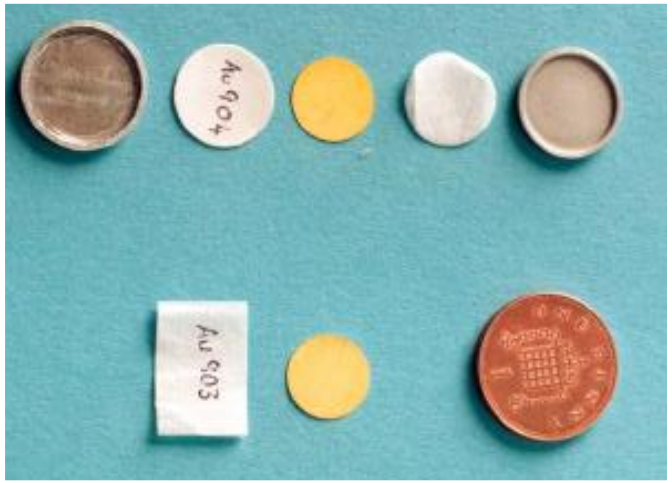
LNMRI

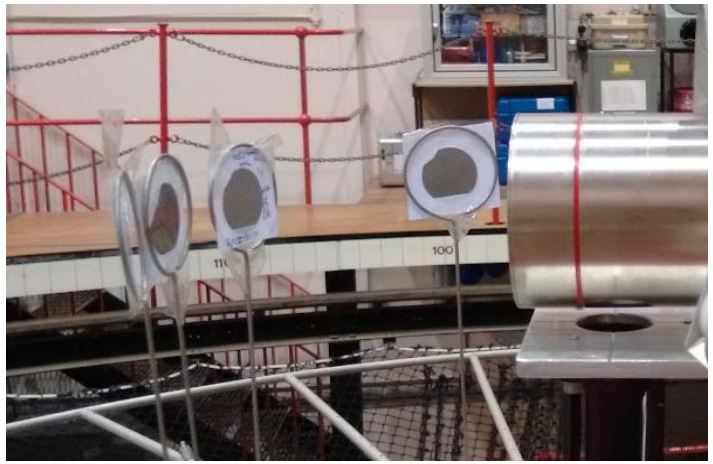


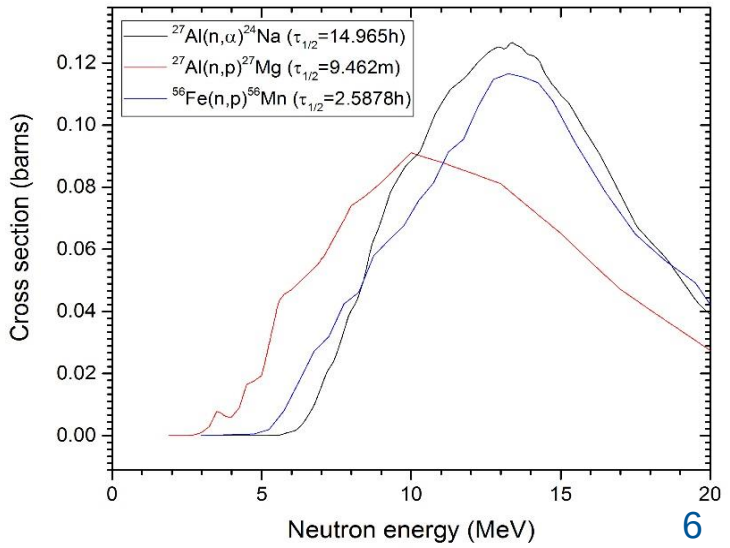
Applications in neutron metrology

Activation foils

- Metal foil placed in neutron field
- Activity of foil measured later by β, γ or β-γ counting
- Neutron fluence derived from activity and spectrum-averaged cross-section
- Select foil based on neutron energy
  - Gold or manganese for thermal neutrons
  - Iron or aluminium for 14.8 MeV neutrons
- Usually short half-lives and low activities



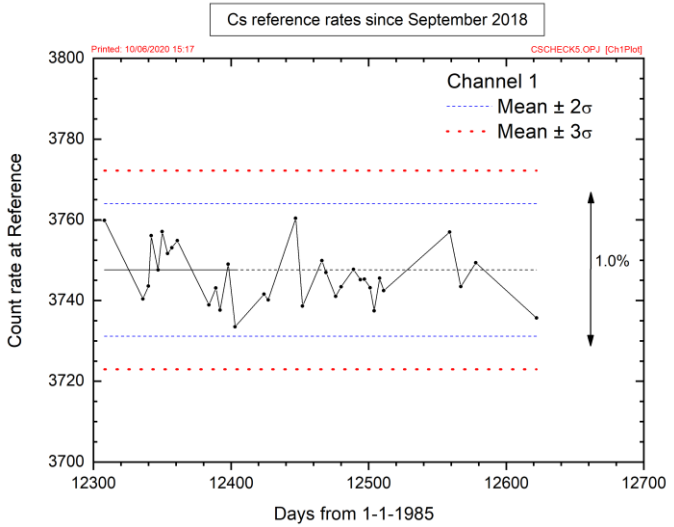




Applications in neutron metrology

As part of quality system

- Verifying performance
- Demonstrating long term stability
- For example:
  - Mn bath using Ra-Be or Am-Be source
  - Mn bath NaI detectors using ^{137}Cs sources
  - Long counters using Am-Be sources
  - Activation foil beta counters using ^{60}Co source
  - Bonner sphere detectors using an Am-Be source



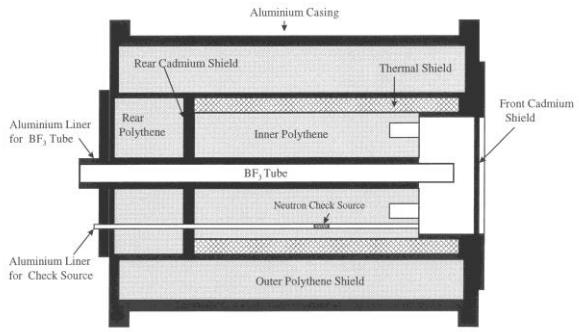
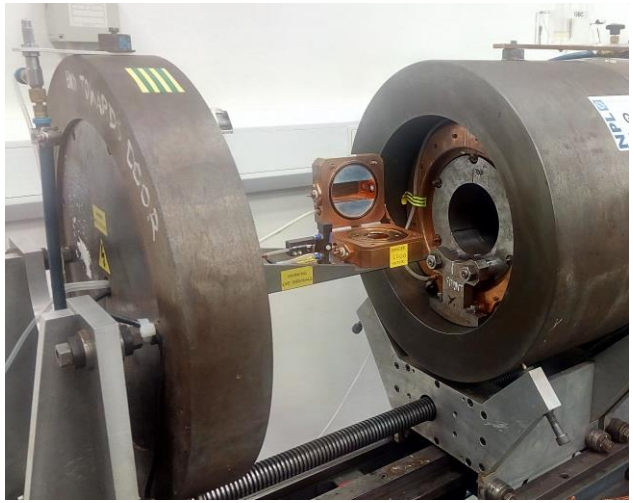


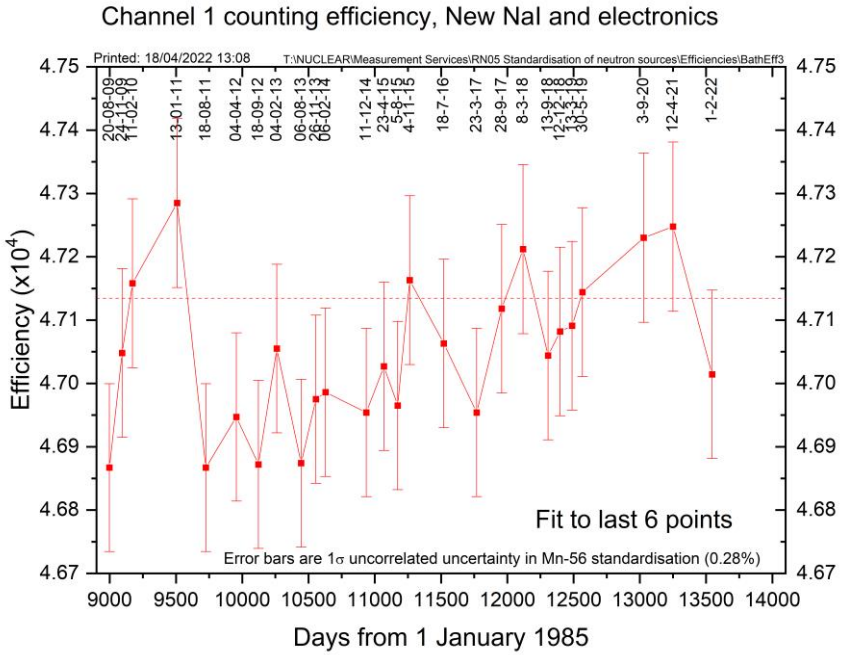
Figure 1.1: Schematic diagram of a De Pangher long counter



Applications in neutron metrology

Determining efficiency of Mn bath system

- Mn-56 solution produced in reactor or other thermal field
- Standardised by coincidence counting or in ion chamber
- Enables neutron emission rate to be derived from NaI count rate
- Measurements made several times per year



Alternatives to radionuclide neutron sources

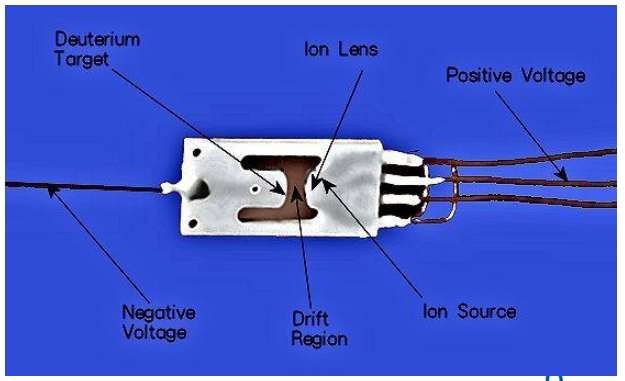
- Accelerators

  Large, expensive, high maintenance, output traceable to radionuclide sources
- Portable DT or DD generators

  Smaller, less expensive, low maintenance, output traceable to radionuclide sources, are they reliable enough for metrology?
- Reactor

  Very expensive, high maintenance, only thermal neutrons
- Neutristor

  Very small, new technology, inexpensive, low output, limited lifespan



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