FaNGaS: A New Instrument for Fast Neutron Gamma Spectroscopy at the FRM II Research Reactor, Garching

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Introduction

Fast Neutrons as Potential Probes for Nuclear Waste

Neutron induced prompt γ-rays analysis:
Cold/Thermal neutrons PGAA
Pros:
(n,γ) well known reaction
Cons:
Limited availability of neutron source
Less effective for large samples

Fast neutrons PGAA:
Pros:
Availability of neutron source esp neutron generators
Cons:
(n,n'γ) poorly known
Discrepancies between evaluated data library

FaNGaS experiment:
γ-ray spectroscopy for neutron inelastic scattering studies

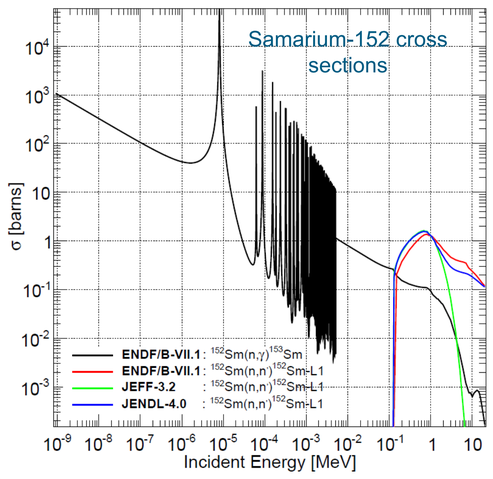
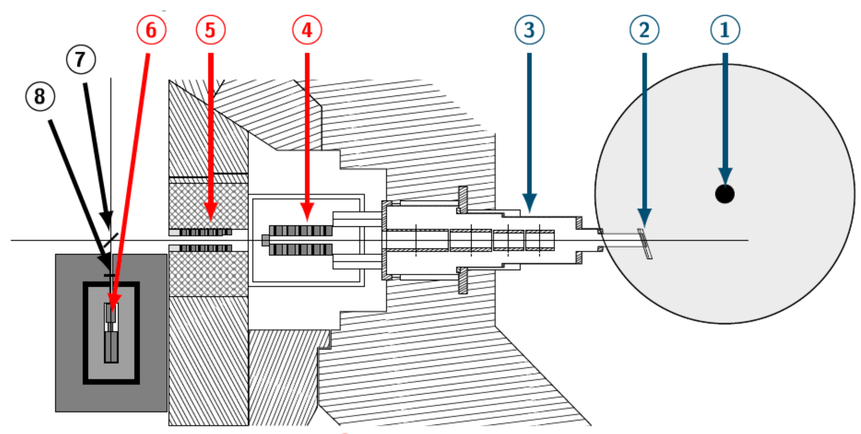


Fig. 1: Examplary (n,γ) and (n,n') cross sections. Source https://www-nds.iaea.org/exfor

The Facility



$D_{2\text{-}7}$ = 5480 mm
$D_{6\text{-}7}$ = 670 mm
$D_{6\text{-}8}$ = 172 mm

Fig. 2: Schematic sketch of FaNGaS facility at the FRMII research reactor, Garching

Fission Neutron Beam

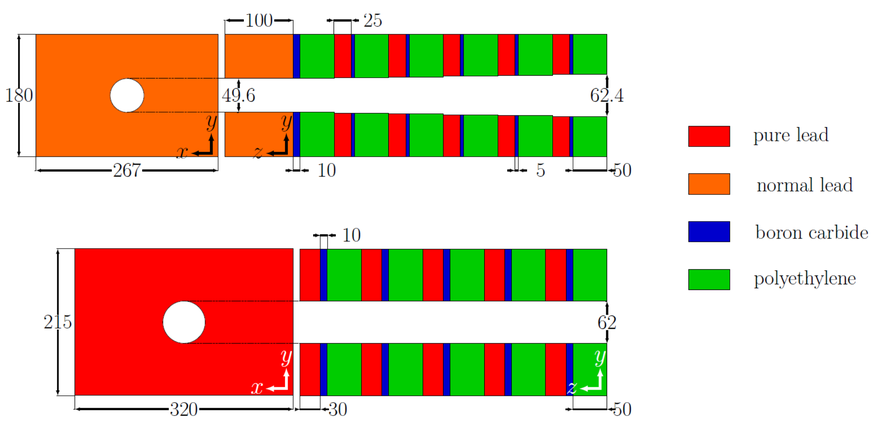


Fig. 3: Layout of the outer collimator (upper) and inner collimator (lower) . Units are in mm

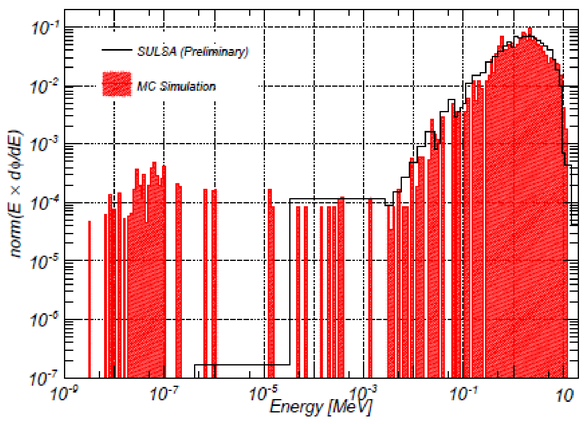


Fig. 4: Neutron beam energy distribution

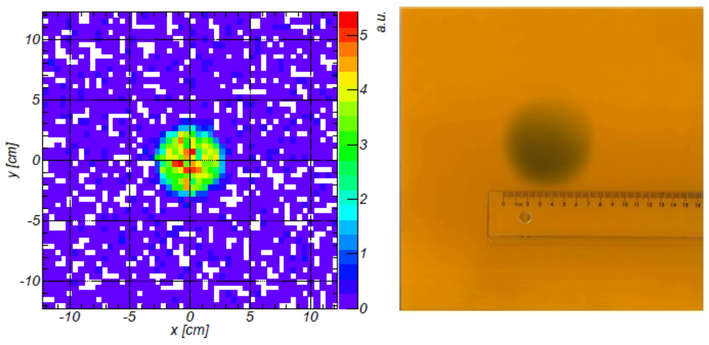


Fig. 5: Simulated neutron beam size (left) and picture of the beam (right) at the sample position

Average Energy : 1.9 MeV
Integrated flux : 8.0 10^7 – 1.2 10^8 $cm^{-2}s^{-1}$
Beam size : 40 mm (FWHM)

Detector System Characteristic

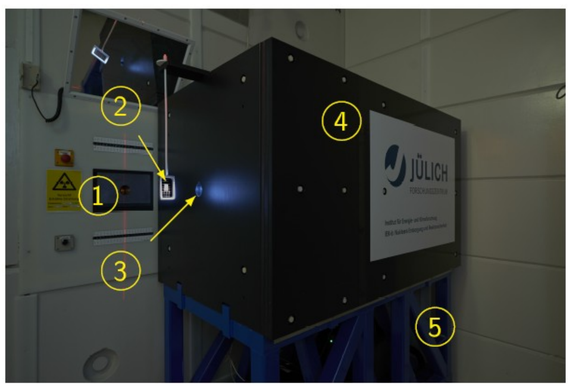


Fig. 6: Photograph of the FaNGaS detector shielding

Heavily shielded HPGe of 50% rel. efficiency

Shielding materials (from outer to inner layers):
Polyethylene – 320 mm thick
Boron carbide – 10 mm thick
Lead – 150 mm thick

Lithium-6 glass inserted in the detector collimator between the boron carbide and lead layers

Size : W x H x L = 1260 x 1260 x 2660 mm^3
Mass : 4 tonnes

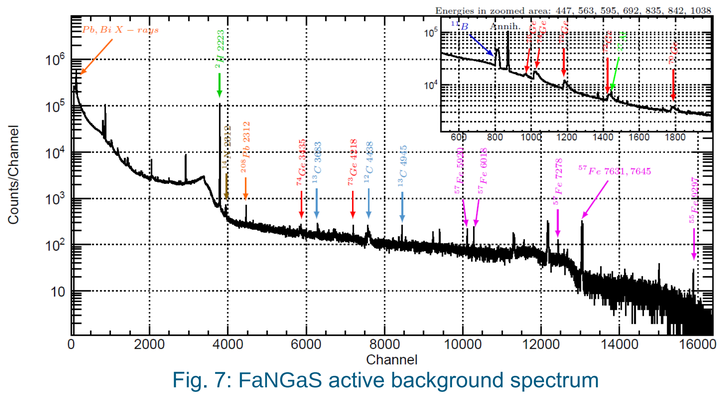


Fig. 7: FaNGaS active background spectrum

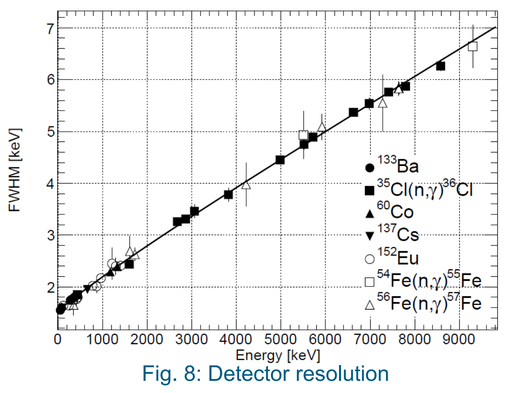


Fig. 8: Detector resolution

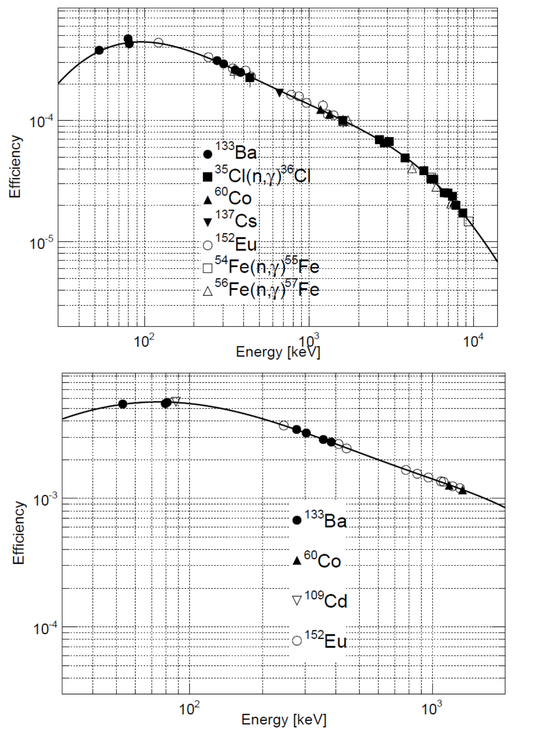
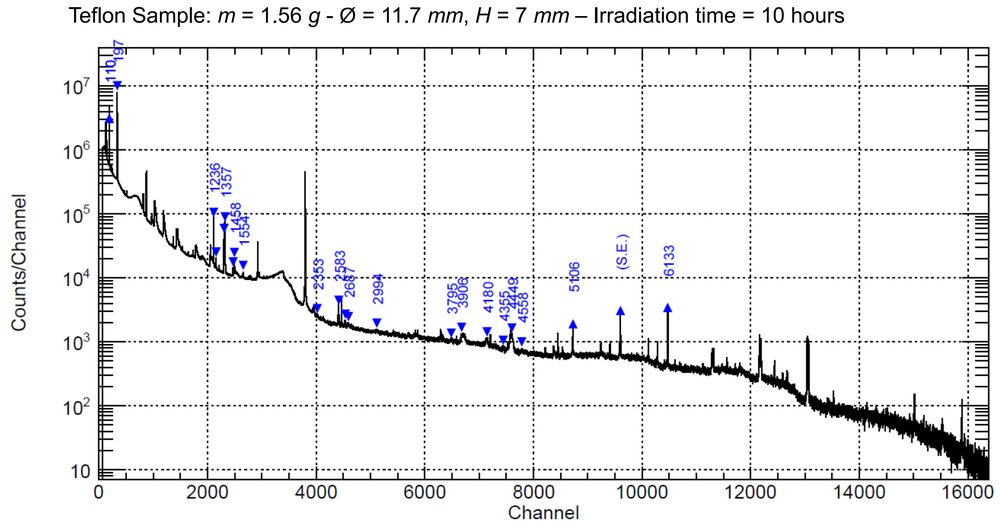


Fig. 9: Measured efficiency curves at the far-position (upper) and close-position (lower)

Benchmark Spectra

Teflon Sample: *m* = 1.56 *g* - Ø = 11.7 *mm*, *H* = 7 *mm* – Irradiation time = 10 hours



▽ *marker :* γ-rays found in A.M Demidov et al., ATLAS of Gamma-Ray Spectra from Inelastic Scattering of Reactor Fast Neutrons, Moscow (1978)

△ *marker :* γ-rays resolved by FaNGaS

Fig. 10: Fluorine spectrum at FaNGaS

Iron Sample - *m* = 1.38 *g* - *W x H* = 25 x 25 mm^2, thickness = 0.25 *mm* – Irradiation time = 10 hours

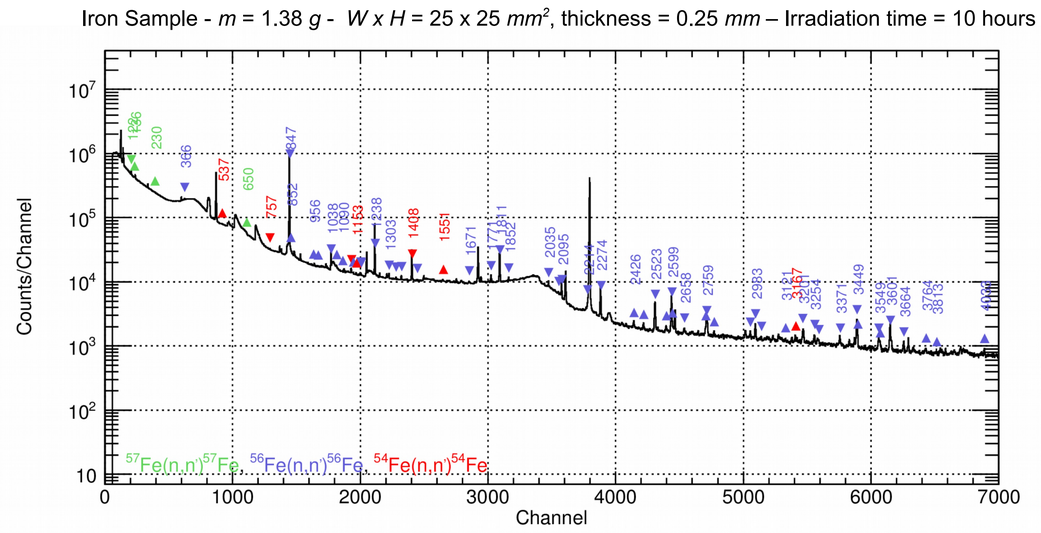


Fig. 11: Iron spectrum at FaNGaS

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