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PGAA: Prompt gamma and in-beam neutron activation analysis facility

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Abstract: **P**rompt **g**amma-ray **a**ctivation **a**nalysis (PGAA) is typically used for the determination of elemental composition and concentration of solid samples (ca. down to ppm range). Liquids and gaseous samples can also be measured. The instrument PGAA is operated by the Institute of Nuclear Physics, University of Cologne and the Technische Universität München.

1 Introduction

The PGAA method is based on the neutron capture in nuclei of the sample material and the subsequent detection of prompt gamma-rays emitted during deexcitation of the compound nuclei: $^{A}Z(n, \gamma)^{A+1}Z$.

PGAA is a non-destructive tool for the analysis of major and minor components, especially advantageous for the assay of light elements (unique for H and B) and certain trace elements (Cd, Hf, rare earths). In the strong neutron beam at FRM II, however, neutron activation can also be performed, and thus many more trace elements can be detected (elements in the 4 – 6 period).

2 Typical Applications

- Archaeology and cultural heritage objects (ceramics, coins, metals, conditionally bronze objects)
- Cosmochemistry (meteorites)
- Geology, petrology (macerals, sediments)
- Enviromental research (air pollution, river pollution)
- Medicine (B, Li, Cd in tissues, nano-particles for cancer therapy, radiation damage of DNA)
- Semiconductor or superconductor research and industry
- Analysis of new chemical materials (catalysts, clathrates, crystals)

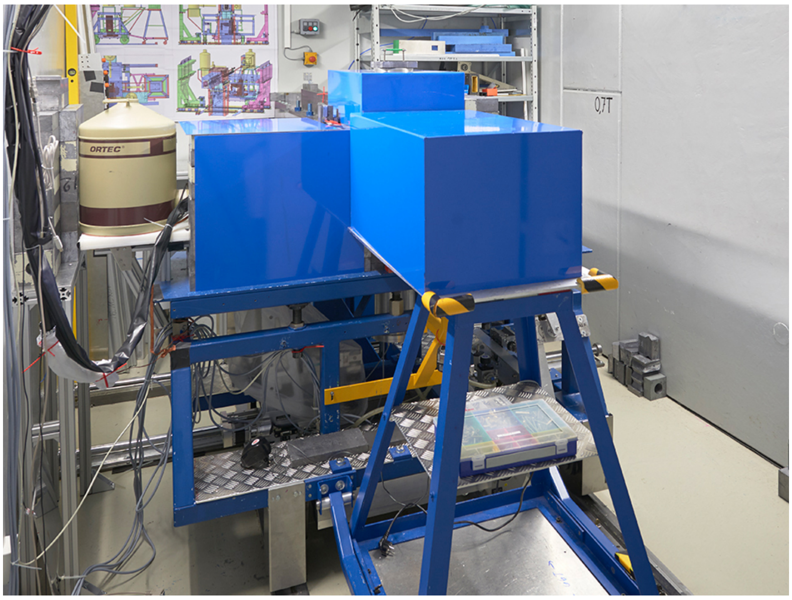

Figure 1: Instrument PGAA from the direction of the beam stop. On the left-hand side the Dewar of the detector can be seen. (Copyright by W. Schürmann, TUM).

- Reactor physics (shielding material, new fuel element), radiation hardness testing with cold neutrons (chips, scintillators)
- Fundamental research (nuclear data, low-spin excited states in nuclei, partial and total neutron capture cross-section measurements)
- Conditionally NAA after the PGAA irradiation

3 Technical Data

3.1 Neutron beam

- Cold neutron spectrum from NL4b (last section of 5.8 m elliptical focussing) with an average energy of 1.83 meV (6.7 Å)
- Two measuring conditions:
  - for large samples with collimation:
    - Beam size: 20 x 30 mm^2
    - Neutron flux max.: $2 \cdot 10^9$ n cm^{-2} s^{-1} thermal n. eq.
  - for small samples with 1.1 m elliptical guide:
    - Beam size: 11 x 16 mm^2
    - Neutron flux max.: $5 \cdot 10^{10}$ n cm^{-2} s^{-1} thermal n. eq.

3.2 Detection system

- For the standard PGAA, one Compton-suppressed spectrometer is used (60 % HPGe detector surrounded by a BGO scintillator and connected in anticoincidence mode). The signal is processed using a DSpec-50 digital spectrometer manufactured by Ortec.
- A new low-background counting chamber has also been installed next to the PGAA instrument for the acquisition of decay gamma spectra after activating the samples in the beam. A 30 % HPGe detector is used with a DSpec-50 unit.
- Energy range is from 30 to 12 000 keV.

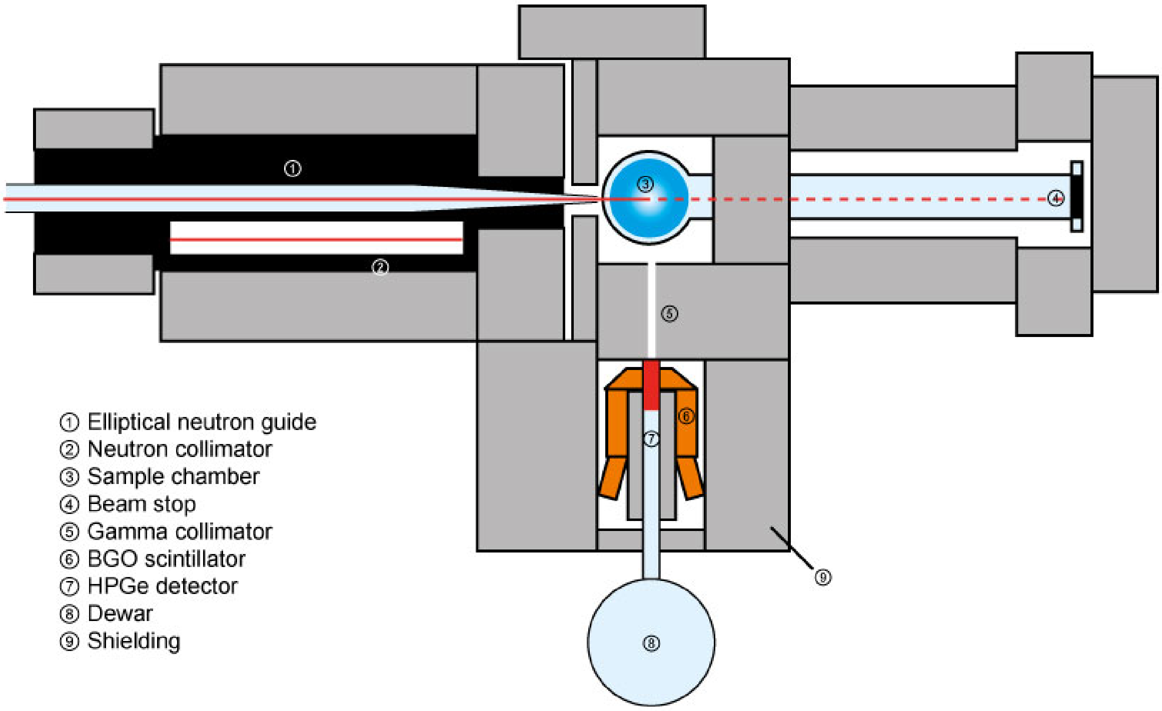

Figure 2: The shielding arrangement of the PGAA facility.

3.3 Measuring conditions

- Low vacuum (0.3 mbar) possible
- Sample weight: 0.1 mg – 10 g
- Max. sample dimensions: ca. 40 x 40 x 40 mm^3
- Automated measurement for max. six samples in a batch (vertical sample holder with six positions)
- Solid samples are usually sealed into thin FEP bags or other suitable material

3.4 Data acquisition and analysis

- An in-house software for the automated measurement of up to six samples in a batch run.
- Evaluation of the spectra and the calibration of the spectrometer (efficiency curve and non-linearity) using the software Hypermet PC developed in Budapest
- Determination of the elemental composition of samples using the Excel macro and Excel sheet package ProSpeRo
- Automated data acquisition using DSPEC-50 is currently under development