Neutron Activation Analysis (NAA) as a Versatile Technique for Elemental Analysis

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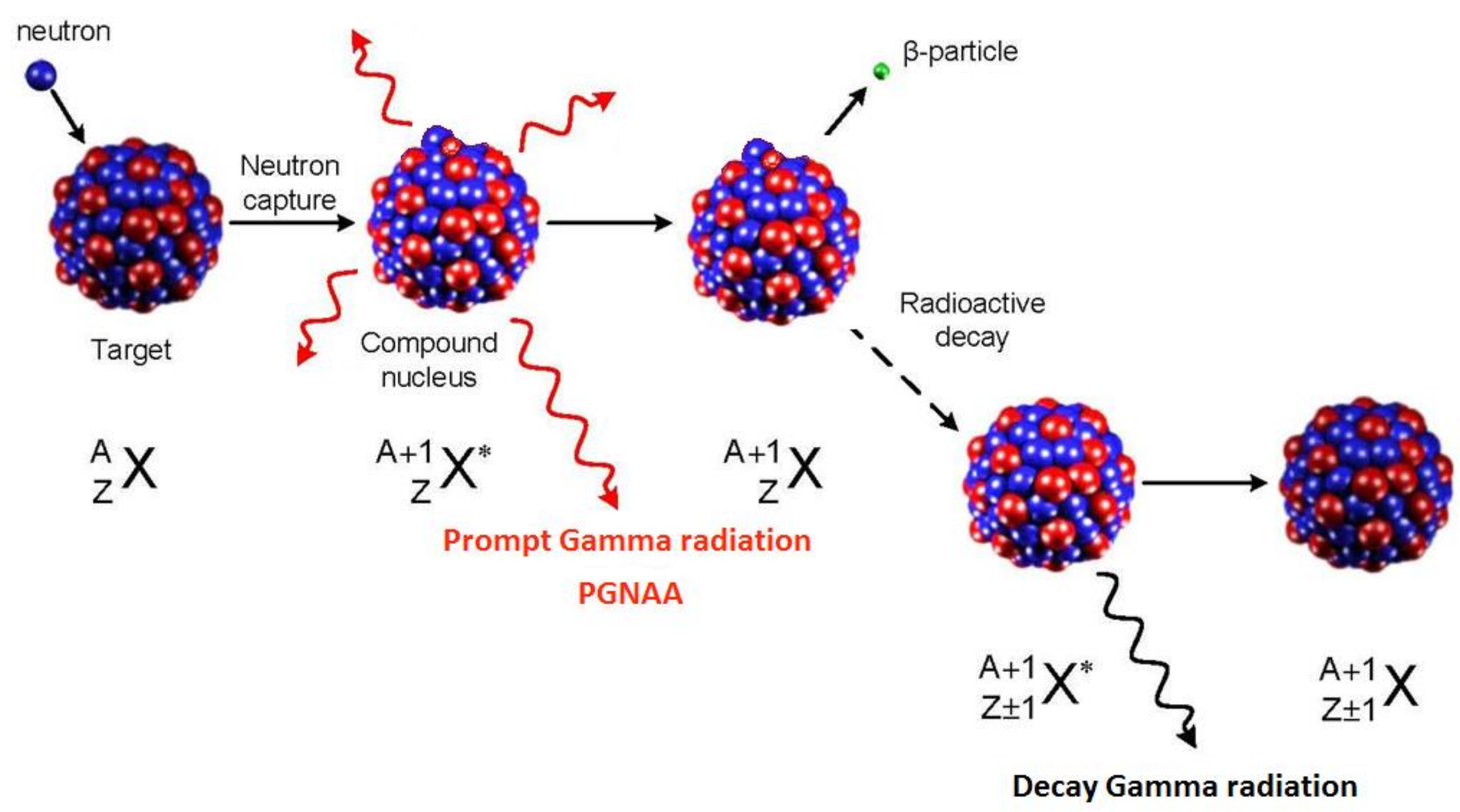
Overview of the NAA Technique

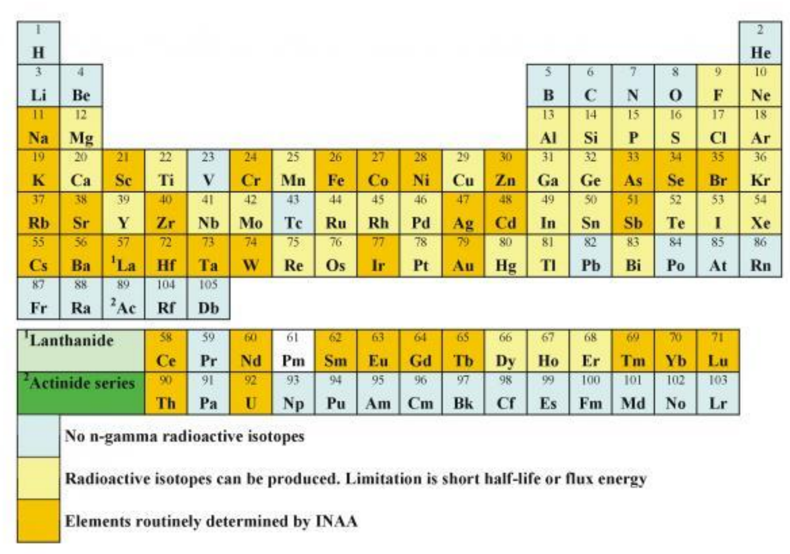
Neutron Activation Analysis (NAA) is a method for qualitative and quantitative determination of elements based on the measurement of characteristic radiation from radionuclides formed directly or indirectly by neutron irradiation of the material. It is an extremely useful technique in the determination of trace and minor elements in many disciplines. These include **nutritional** and **health** (**toxicity** and **pharmaceutical**) related studies, **environmental** analytical applications, **forensics**, **archeological**, **geological** as well as **material** sciences. The most suitable source of neutrons is usually a nuclear research reactor.

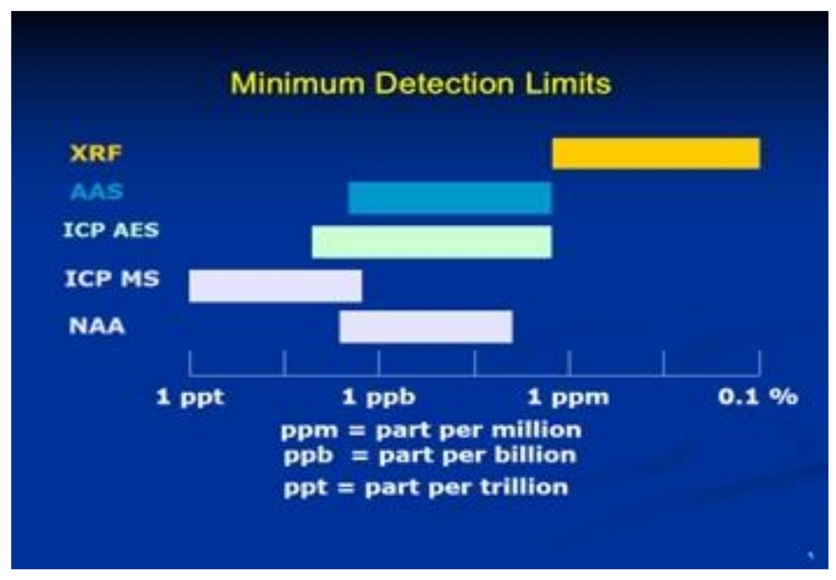
$${}^{A}_{Z}X + n \rightarrow {}^{A+1}_{Z}X^{*} \rightarrow {}^{A+1}_{Z+1}Y^{*} + \beta^{-} + \nu$$



Technique Characteristics

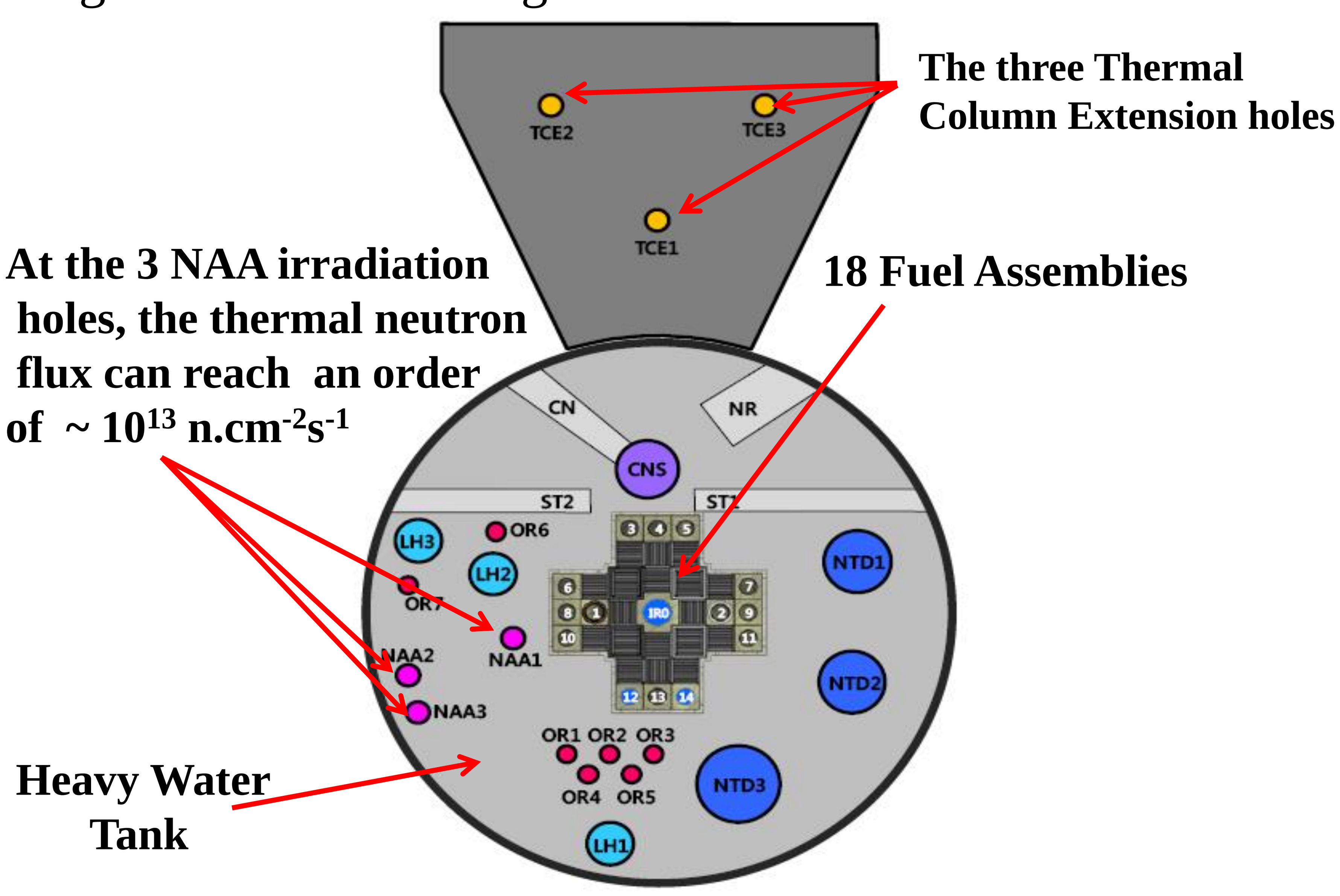
- Very low detection limits for 30–40 elements (see the Periodic Table below). The sensitivity can go down to part per billion (ppb) concentrations (see the chart below), depending on the particular element and bulk matrix composition.
- The possibility of non-destructive analysis with the Instrumental NAA (INAA) technique.
- The use of radiochemical separation to overcome interference in complex gamma-ray spectra (Radiochemical NAA or RNAA).
- An inherent capability for high levels of accuracy compared to other trace element analysis techniques.
- Relatively low cost compared to other techniques of elemental chemical analysis.



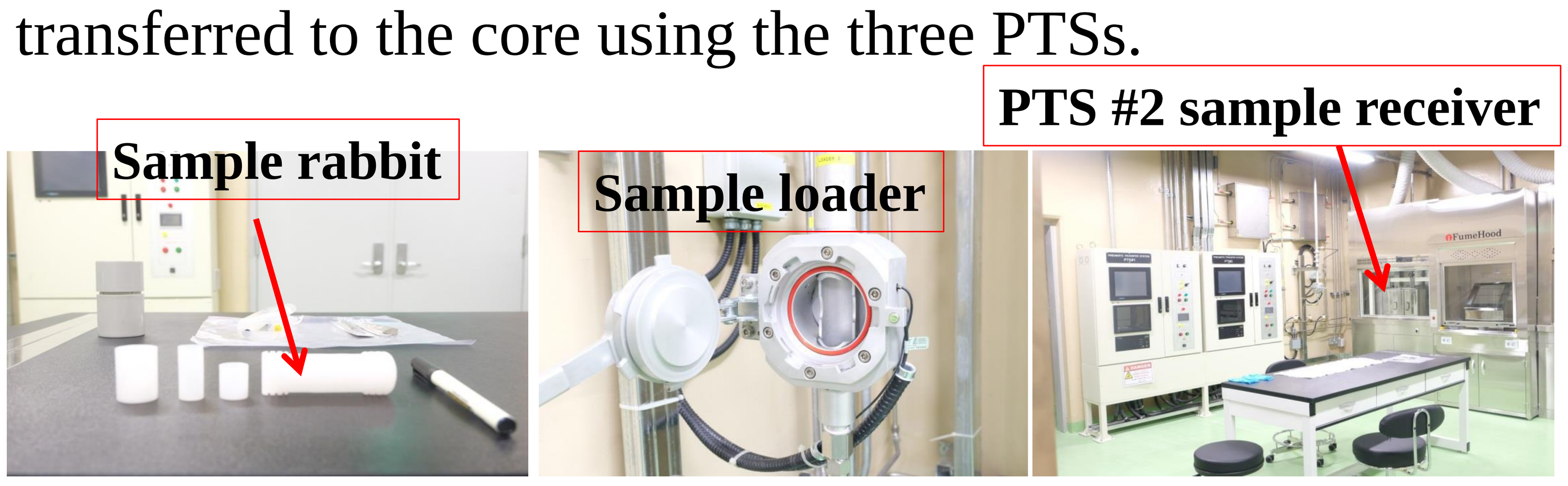


NAAF of Jordan Research and Training Reactor (JRTR)

Jordan Research and Training Reactor (JRTR) is a 5 MW_{th} reactor (upgradable to 10 MW_{th}). The core of the reactor contains 35 irradiation holes dedicated for a variety of applications including the production of radio-isotopes and NAA. Three of these holes are especially devoted to NAA work; namely the NAA1, NAA2 and NAA3 holes colored in magenta in the below figure.



Three Pneumatic Transfer Systems (PTSs) associated with the NAA holes are installed at the NAAF. The trip to-and-from the core takes about 15 seconds. Solid samples can be transferred to the core using the three PTSs.



Post-irradiation detection of the characteristic gamma rays is carried out using a High Purity Germanium (HPGe) detector (ε_{rel} ~ 40% , FWHM for 1332 keV of 1.72 keV). A gamma spectrum taken for a multi-element sample is shown below.