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Fast neutron detection based on delayed neutron measurement and innovative threshold samples

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Fast and high-energy neutrons could be produced by accelerators and high-power lasers. Standard detection and neutron spectrometry techniques start to have challenging problems with neutrons with energies of 20 MeV and higher. There are several groups trying to apply approach of scintillation detectors for this energy area; special layered Bonner spheres method also could be applied with some limited success. Moreover, there are two other methods, which have already been under development by our group for last several years. Quite standard multifoil activation and threshold methodology has been modified to be able to determine very short-lived activation products, which have to be detected specifically when high-power laser with low repetition rate is used for neutron generation. We use thick samples composed of several different materials (isotopes, elements, compounds) and correction coefficients for HPGe photopeak efficiency determination, as well as for gamma-attenuation and for neutron self-shielding. Neutron spectra are the generated via unfolding method based on several different mathematical approaches combined together. Method is capable to work up to several hundred MeV, if needed threshold and activation cross-section data are available (high-energy libraries could be used, TALYS based TENDL library or EXFOR database). We combine this more standard method with another more innovative one, method based on delayed neutron yields determination. Fission products yield function depends on mass number according to the well-known double maximum "camel"function. However, this function is different for different incident neutron energies and different actinide isotopes (or combination of isotopes like "enrichment"in case of uranium or Pu vector in case of plutonium). Delayed neutrons are usually divided into six groups depending on mother nuclei decay constants (sometimes are divided into two or eight groups). Delayed neutron groups have different fractions (relative ratio of number of neutrons in one group to number of all delayed neutrons produced per one fission reaction), which is determined by its mother nuclei fission yields. So, if these yields change, then fraction of delayed neutron in groups changes too. When we measure ratios of different groups depending on incident neutron energy we could find a monotonous function describing it. When we are able experimentally determine ratios of delayed neutron division into groups, then we could determine effective neutron energy initiating fission. Measurement of delayed neutrons ratios could be done either directly via neutron detection or indirectly through gamma spectrometry measurement of mother nuclei yields. Combining all the measurements together we are able to say a quite interesting information about fast or high-energy neutron field generated by accelerators or high-power lasers.

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