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Current Tendencies in the Development of Neutron and X-ray (Gamma) Detectors for Common Use

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The paper is a brief review of activities of National Research Nuclear University "MEPhI", and Federal State Unitary Enterprise "VNIIA" in the development of radiation detectors for common use. It describes design and operating characteristics of the following neutron and X-ray (Gamma) detectors.

1) Radiographic detectors for imaging X-rays and neutrons [1-9]:

- detectors for fast neutron radiography with a cone beam;
- detector for simultaneous imaging fast neutrons and X-rays;
- detector for pulsed radiography with a plasma focus generator.

2) Segmented 3-D arrays of scintillation detectors [10]. The 3-D array of scintillation detectors is a three dimensionally configured system consisting of scintillation elements coupled with photoreceivers and front-end electronics. The considered concept of highly segmented 3-D arrays of scintillation detectors is based on the application of crossed wavelength shifting (WLS) fibers reading out scintillation bursts generated in scintillation elements. The scintillation location (corresponding scintillation element) is being fixed by the intersection point of two crossed WLS fibers generating optical signals at their ends practically at the same time. The application of the crossed WLF fibers enables the large volume 3-D arrays design. One of the most important features of 3-D arrays is the capability of radiation source detection and imaging. At that 3-D arrays allow to:

- identify the radiation source;
- determine the source position;
- measure the source activity;
- discriminate neutrons and gamma rays in mixed radiation fields;
- reject background, and to improve sensitivity of interrogation systems.

3) Multi-energy X-ray sensors [11]. The operation of the described multi-energy sensor (MES) is based on the relationship between the spatial distribution of scintillation signal generated in a scintillation plate, stretched along the radiation beam, and the radiation spectrum. For that, the scintillation plate consists of a number of scintillators placed one after another with effective atomic charge increasing along the plate.The scintillators and their sequence are chosen in such a way that the radiation hitting any scintillator does not contain X ray quanta with the energy corresponding to the K-edge of the photo-absorption band and to the production of electron-positron pairs in this scintillator. MES can be used to measure X-ray energy distribution in the range of 15 keV-1 MeV.

4) Position sensitive detectors for well logging devices [12]. Position sensitive detectors have been invented for registering spatial distribution of both neutrons and gammas in a well while well logging. They consist of cylinder-shaped coaxial arrays of elongated scintillators. The opposite ends of each scintillator are connected to two photoreceivers. The arrays each provides registering a specific radiation. The scintillator type in an array and arrays positional relationship are accordingly chosen to register different radiation at the same time. Detectors axial resolution is supported by the amplitude comparison of two scintillation signals received by photoreceivers. Detectors azimutal resolution is privided by arrays segmention. Measurements of neutron and gamma spatial distributions provide more precise computing formation density and porosity, fixing the boring tool position in regard to the formation boundaries, as well.

5) Neutron electrometrical sensors [13]. Neutron electrometric sensors (NES) are based on accumulating electric charge when irradiated by neutrons. They contain the emitter and the absorber of charged particles. The absorbed charge can be measured in a variety of ways using, for example: the frequency of the emitter and the absorber electric locking, their displacement, the deformation of the elastic element (in the presence), electric field strength in the gap between the emitter and the absorber. NES may be used, for example, in control systems of nuclear reactors and subcritical assemblies, for measuring pulsed neutron flux, in scientific investigations, as well.

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