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High-Pressure, High-Temperature Gamma Ray Spectroscopy Measurements in the Oil Field: Data Quality Improvements Due to Cerium-Doped Lanthanum Bromide Scintillator Crystal Material

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In the oilfield industry, exploration of the subsurface is essential to answer questions regarding location, type, quantity and producibility of hydrocarbons. The subsurface environment in which logging tools are used can be severe. Downhole tools must perform at temperatures exceeding 175˚C while being exposed to repeated shocks of 100 g and more and at pressures that can exceed 200MPa. Under these harsh conditions, the tools must deliver accurate and reliable measurements while operating for hundreds of hours of operation.
Since drilling rig operation time is very expensive, the measurements must be acquired as fast as possible. Therefore, any improvement which reduces the statistical uncertainty of the measurements without increasing the time spent on the rig is welcome.

Nuclear modeling is widely used to design nuclear tools in the oilfield. It allows improving the measurements by optimizing the tool design without a lot of time-consuming experimentation, provides a very convenient method for checking the impact of environmental effects such as borehole fluid composition, pore fluid and rock composition on the tool response, and allows predicting measurement performance before building the first tool or evaluating performance for new scintillator materials.
Modeling of neutron induced gamma ray spectroscopy is more complex than that of any other nuclear measurements as it combines the spectral response in energy and time and requires modeling of the coupled neutron gamma ray transport and subsequent detector response combined with sensitivity to small amounts of specific materials with large neutron interaction cross sections.

NaI(Tl) is still the most commonly used scintillator material today. In the oilfield industry, NaI(Tl) was used initially for natural gamma ray detection, gamma ray scattering based density measurements, and the detection of neutron-induced capture and inelastic gamma rays. In the early 90s, BGO and GSO were introduced to the oilfield in downhole tools for the detection of natural gamma ray spectra, formation density measurements, and capture gamma ray spectroscopy. The new detector materials were well suited for gamma ray spectroscopy given their high density and average atomic number. However, their spectroscopy performance was not optimal and worsened rapidly with temperature. More recently, LaBr3:Ce was introduced in two new instruments, enabling step changes to the neutron-induced gamma-ray spectroscopy measurement performance.
In addition, the new material makes it possible to unlock information regarding elements such as oxygen, carbon, manganese, aluminum and increasing the information on the subsurface composition.

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