Contribution ID: **214** Type: **Oral presentation**

Significant improvement of GAGG based scintillation detector performance by control of the electronic excitation dynamics

Thursday 21 September 2017 11:15 (15 minutes)

Recently, we showed that the codoping of GAGG:Ce single crystal by Mg results in a strong acceleration of the rate of free carriers nonradiative recombination. This effect competes with the radiative recombination of free carriers via Ce3+ ions and, consequently, results in a decrease of the scintillator light yield. The nonradiative recombination occurs when a hole migrates to the vicinity of a Mg2+-related defect. Thus, a possible solution to recuperate the light yield loss is slowing down the hole migration rate. Due to a strong temperature (T) dependence of the migration rate w˜exp(-E/kT), where E is the constant, defined by the nature of the compound, k is the Boltzmann constant, the migration can be inhibited by cooling the crystal or the whole detecting unit. This report presents the results on a significant improvement of the performance of GAGG-based scintillation detector with temperature decrease. When temperature of a PMT-based detector is lowered to -45oC, its amplitude response at registration of γ-quanta is improved by 30%; 662 keV photo-absorption peak FHHM was found to be better by a factor of up to 0.85, whereas scintillation kinetics become even faster. All this opens an opportunity for a wide application of GAGG scintillation detectors, particularly in a combination with SiPM photo-sensors, the signal-to-noise ratio of which also improves with the temperature decrease.

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Session Classification: Characterization

Track Classification: S12_Characterization 2 (Orals)