Upgrade of the GADAST detector by 16 $LaBr_3$ scintillator detectors*

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The GAmma-ray Detector Around Secondary Target (GADAST) can be used in the middle of the FRS and Super-FRS fragment separators [1], which helps to exploit their unique performance in a separator−high-resolution-spectrometer mode. The main part of the GADAST consisted of 64 large-size scintillating CsI(Tl) crystals is in production at JINR, Dubna. The GADAST demonstrator of 16 such detectors has been successfully tested at FRS GSI in 2012 [2]. In order to upgrade the GADAST at forward angles, we build in addition an array of 16 $LaBr_3$ scintillator crystals (cylinders of 1x4 inches) with improved light readout and electronics being able to work at high counting rates up to 10^6 s^{-1} with the energy resolution of 3 %.

During the upgrade of GADAST, the 64 CsI(Tl) detectors have received a new mechanical structure (4 crystals in one cluster), which allows for various geometries of the GADAST setup depending on experimental task. Each crystal is coupled with a photo multiplier tube (PMT) either of R7600U-300 Hamamatsu (40 units in total) or 9106SB ET (24 units) types. The in-house developed electronics, being operated at +12 V only, provides a high-voltage (HV) bias, strong amplification of the detector signals and their shaping as well as logical signals via a delay line of 0.8 μs. However, the CsI(Tl) detectors work at counting rates $\leq 3*10^4$ s^{-1}, which is not sufficient at forward angles where counting rates are very high.

Figure 1: The components of the $LaBr_3$ detector.

Scintillation $LaBr_3$ crystals are much faster and provide better energy resolution. Thus we have developed a cluster of 16 detectors with $LaBr_3$ crystals. Dimensions of the crystals were chosen of 2.5 cm in diameter (in order to minimize a Doppler broadening of detected γ-rays) and 10 cm in length (to detect γ-rays up to energies of 10-20 MeV). We have chosen a PMT type 9142SB ET with an enforced voltage divider and a plate with combined HV-bias, preamplifier of dinode signals and shaper (similar to those developed for the CsI(Tl) detectors [2]). The components of the disassembled $LaBr_3$ detector are shown in Fig. 1.

Performance of the developed detectors is illustrated in Fig. 2, where the γ-ray spectrum measured from ^{137}Cs source shows the energy resolution of 3.0(1) % (the full width at half maximum (FWHM) of the peak of 662 keV γ-rays measured with a shaping time of 0.5 μs). The obtained energy resolution is even better than the resolution of 3.4 % reported by the St. Gobain manufacturer. The low energy detection threshold of $\sim$50 keV is achieved.

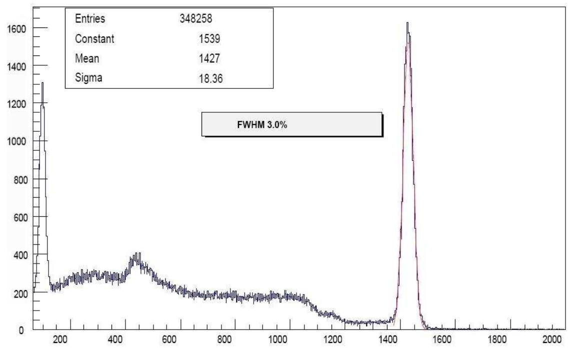

Figure 2: The γ-ray spectrum of a standard ^{137}Cs source measured with the developed $LaBr_3$ detector. The right peak corresponds to 662 keV γ-transitions.

The detector GADAST is ready for experiments since 2014. We plan to use it at the new ACCULINNA-2 (JINR, Dubna) fragment separator [3] and later at the FRS and the Super-FRS fragment separators [4]. Applications of the developed detectors are possible also for the other experiments of the NUSTAR collaboration of FAIR.

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References

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