Summary: The scintillation properties of LaBr₃(Ce), at present the brightest scintillator commercially available, providing an energy resolution as good as 2.8% at 662 keV (for small sized crystals), have been extensively studied in these latest years. However, the high cost of these crystals is the main drawback to use them in large apparatus experiment. Thus, coupling LaBr₃(Ce) crystal to another one, in the so-called phoswich configuration, appears to be an attractive solution that must be confirmed by detailed measurements, because of the scarcity of published results.

We studied the performances of the LaBr₃(Ce) scintillator when optically coupled to 6” long NaI(Tl) and CsI(Na) for the R&D of the gamma ray calorimeter PARIS (Photon Array for the studies with Radioactive Ion and Stable beams). This detector has the purpose to measure γ-energies in a wide range (100 keV-50 MeV), and it will be used principally as a part of the SPIRAL2 instrument at GANIL. The current project envisages the use of the advanced technology of the LaBr₃(Ce), either in a stand alone or in a phoswich configuration.

In this communication we will report on the study of the light yield and energy resolution under gamma excitation realized by coupling the phoswiches with various photomultiplier tubes, providing different characteristics. We were interested in investigating the degradation of the scintillation light produced by the LaBr₃(Ce) due to the fact that it has to pass through all the coupled crystal, before being detected on the photocathode.

The acquisition system
For this study we employed two different read-out systems, each providing a different level of events separation

1. Standard spectroscopic chain
   - The PMT's anode signals are sent to a NT1120, module of the IN2P3, for the formation of a signal on a CAMAC ADC module. The QDC measures the charge collected at the PMT's anode and is employed to determine the light produced in the LaBr₃(Ce) from that produced in NaI(Tl)/CsI(Na). The QDC gain is delayed with respect to the signal i.e., a system is defined for the energy resolution and the charge, measured at the anode, is correlated to the crystal decay time.

2. Waveform digitizer
   - The PMT's anode signal is sent to a MACHO digitizer for digitization (sampling at 150ks/s, dynamic range [0-5V]), the charge and the decay time of the collected signal can then be evaluated online.

The light yield homogeneity test
Scan along the phoswiches length with a collimated 137Cs source to test the scintillators light yield homogeneity

Conclusions and perspectives: In this work we tested three LaBr₃(Ce)-based phoswiches coupled to various PMTs. The Ph/CsI(Na) showed a serious degradation of the LaBr₃(Ce) energy resolution and a high level of light yield non-homogeneity, thus excluding the possibility to employ this scintillator for the PARIS apparatus. For the Ph/NaI(Tl) phoswiches we observed a degradation of the LaBr₃(Ce) energy resolution between 17 and 30%. The LaBr₃(Ce) in the Ph/(2)NaI(Tl) coupled to the PMT R7723-100 provided an energy resolution of 4.6% at 662 keV, which is still appealing for the PARIS experiment. As a matter of fact this configuration was the one chosen by the collaboration to build a 3x3 compact cluster as a demonstrator detector. The 3x3 cluster assembly is expected by the end of the year.