The LaBr\(_3\)(Ce) Properties

<table>
<thead>
<tr>
<th></th>
<th>LaBr(_3)</th>
<th>LYSO</th>
<th>YAP</th>
<th>Na(Tl)</th>
<th>BGO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/cm(^2))</td>
<td>1.37</td>
<td>2.30</td>
<td>2.90</td>
<td>3.67</td>
<td>7.13</td>
</tr>
<tr>
<td>Light Yield (p.e./MeV)</td>
<td>94%</td>
<td>105%</td>
<td>40</td>
<td>40</td>
<td>38</td>
</tr>
<tr>
<td>Decay time (ns)</td>
<td>800</td>
<td>26</td>
<td>45</td>
<td>250</td>
<td>300</td>
</tr>
<tr>
<td>Fo.M.</td>
<td>2.17</td>
<td>2.13</td>
<td>1.61</td>
<td>0.75</td>
<td>0.46</td>
</tr>
</tbody>
</table>

Emission spectrum = 340-420 nm (peak: 380 nm)

Detector Layout

The first large crystal assembly for high energy gamma detection O(50) MeV with a MPPC double readout scheme for:
- Maximal photosensor coverage area
- Optimal geometrical acceptance
- Very high photosensor granularity
- High rate sustainability
- Optimum energy, timing and position resolutions
- Insensitive to magnetic field

Detection efficiency and Energy Resolution

Monte Carlo simulations based on GEANT 4 and a custom code that includes the MPPC/SiPM response and the reconstruction algorithms

Data acquired with the available detectors (3" x 3" LaBr\(_3\)(Ce) coupled to PMT and 1"x4" LaBr\(_3\)(Ce) coupled to either PMT or MPPC) are also used to validate the simulation code

Results:
- Crystal size [diam. x length]: 3.5 x 8, 5 x 8, 6 x 8
- Energy resolution: 55 MeV

High very detection efficiency:
- For all cases: > 95%.
- Fraction of events above 50 MeV: > 47%, > 65%, > 70%

Excellent energy resolution:
- \(\sigma_E/E_p\) [%%]: 2.25(7)%, 1.23(3)%, 0.90(0)%

Time Resolution

Several timing algorithms have been tested the most performing resulting in:

The average among the timing calculated with the constant fraction (threshold = 15%) of the most intense amplitude and its neighbours: Cons. Frac. Ave. The timing of the most intense amplitude only is indicated here as: Cons. Frac. 

The intrinsic timing resolution is evaluated extracting the time at which the gamma enters inside the detector: \(T_{\text{int}}\)

Results:
- Crystal size [diam. x length]: 3.5 x 8
- Energy resolution: 55 MeV

Excellent timing resolution:
- \(\sigma_{T_{\text{int}}} [/\text{ps}]\): 32 ± 1, 60 ± 1

Summary and Outlook

LaBr\(_3\)(Ce) is a very attractive medium not only for low energy physics but also for high energy physics and in particular for the energy range of interest in charged Lepton Flavour Violation searches [1, 2, 3].

The well established MPPC/SiPM technology open the road to geometrical configurations never considered before (i.e.,multiple readout scheme, with sensors along the path of the incident radiation, high granularity, geometrical cut for the best detector acceptance, etc.) allowing to fully exploit the scintillation crystal characteristics [i.e., for 3.5" x 8" the energy resolution for single readout (back), single readout (front) and double readout are respectively: 7.8(2), 5.6(1)% and 2.5(1)%].

LaBr\(_3\)(Ce) detector prototype coupled to MPPC for high energy gamma calorimetry is under construction.

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References:

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