Absorber characterization
COMPASS thesis

Armando Brandonisio

April 24, 2016

Contents

Chapter 1

Absorber characterization

We investigated luminescence and scintillation properties of the $Gd_3Al_2Ga_3O_{12}:Ce$ (GAGG) produced by *Furukawa* company. The GAGG crystal has the highest light yield among oxide crystal at room temperature [1] and fast decay time for the detection of radioactivity and in nuclear and particle physics experiments.
A list of the most important parameters for GAGG is reported in Table 1.1.

Some fundamental features of this crystal are that it has no intrinsic radioactivity and it is a non-hygroscopic material. This allows a better usage for experimentation with low risk of contamination from ambient.

The measurements have been carried out by illuminating the scintillation rod with a X-ray beam.
*Si*PM and electronic chain parameters was varied measuring the relative position of the photo-peak in the spectrum produced by the scintillator.

Density $[g/cm^3]$	Light yield [photon/MeV]	Decay time [ns]	Peak emission [nm]	Energy resolution [% @662 keV]	Hygroscopicity
6.63	57000	88 (91%) 258 (9%)	520	5.2	No

Table 1.1: Physical and scintillation properties of GAGG

1.1 Experimental set-up

Laboratory measurements have been carried out using a single rod made of GAGG produced by *Furukawa* company.
The rod has a square-base parallelepipoidale shape with a height of 30mm and a side of 3mm , thus their dimension results 2/3 lower to the one expected for the polarimeter bars ($\sim 10mm$).
To minimize the loss of photons during scintillation, the bar was *wrapped* with Teflon Fig 1.1, that has a high reflection coefficient for small incident angles.

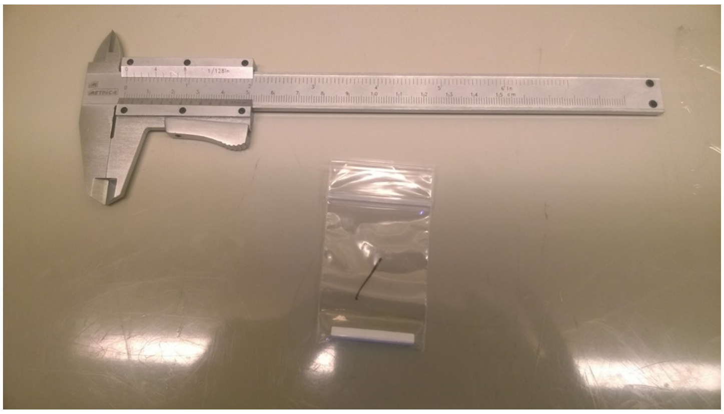

Figure 1.1: Scintillation rod made of GAGG wrapped with teflon

The rod has been placed over a single SiPM, model LCT4/9 produced by the Hamamatsu company.
Properties, CAD scheme and microscopic details of this SiPM are reported in Tab 1.2, Fig 1.2 and Fig 1.3 respectively.

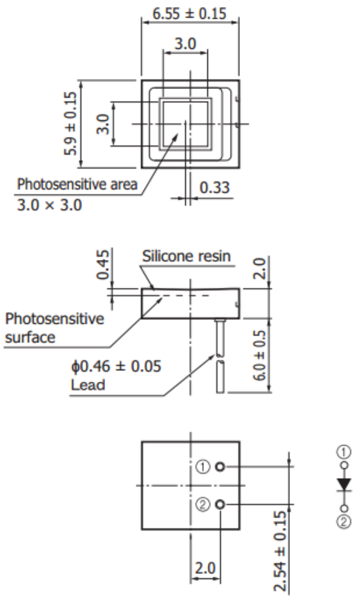

Figure 1.2: CAD scheme for LCT4/9

Cell pitch	$75\mu m$
Device size	$3 \times 3mm^2$
Microcells	1600
Surface coating	Silicone resin
Fill-factor	73%
Breakdown[1]	51.10 V

Table 1.2: Main physical features of the LCT/9

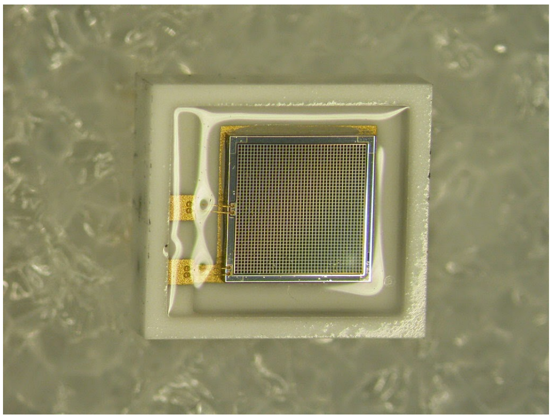

Figure 1.3: Image of LCT4/9 taken through a microscope.

This set of MPPCs produced by Hamamatsu, have an included proprietary circuit board with power supply for a direct hardware control from PC via USB connection (see Fig 1.4).
The C12332 is a simple evaluation starter kit for non-cooled MPPC. MPPC evaluation is possible by mounting an MPPC in the socket of the sensor circuit board. The power supply circuit board is equipped with the C11204-01, a high-accuracy, high-voltage power supply that provides the operating voltage from MPPC. It operates just by connecting to an extenal power supply ($\pm 5V$). It is also equipped with a USB interface that can be used to set the operating voltage and temperature compensation coefficient from a PC running the supplied sample software.
We used the power supply circuit board with serial number C12332 with nominal gain of 21 for LCT4/9.

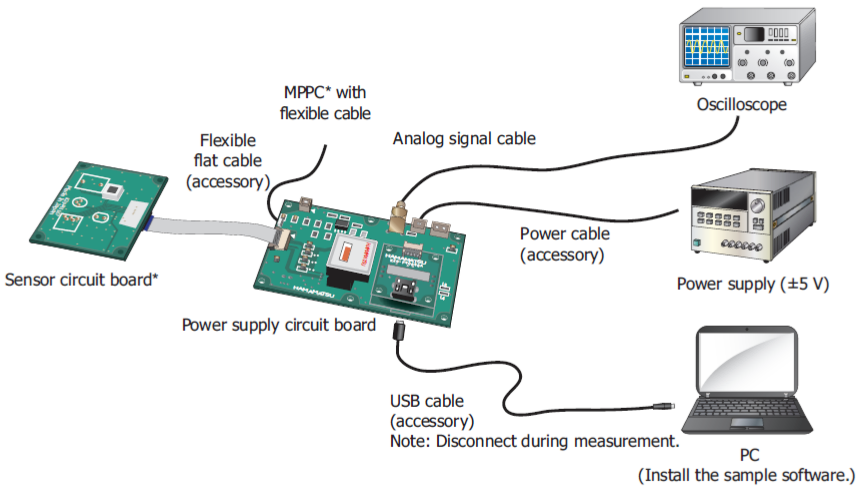

Figure 1.4: Connection example

Sensor circuit and power supply board have been both fixed on an aluminum support covered by black duct tape 1.5.

Figure 1.5: Circuit and sensor boards on support

The GAGG rod has been placed over a single SiPM. The extremity of the rod in contact with the SiPM window entrance has been covered with optical grease in order to improve the transmission of optical photons to the micro-cells.
A dedicated support has been projected and realized specifically for this experiment in order to hold the rod under study and to guarantee its contact with the SiPM.
The project drawing is reported in Fig 1.6 and the principal components legend below:

- (1) Aluminum support
- (2) secondary mobile support for power supply circuit board
- (4) dark box
- (6-7) support columns
- (8) support for rod-stops
- (9) rod stops
- (11) circular support for x-ray sources

The produced support inserted in the experimental set-up is shown in Fig 1.7.

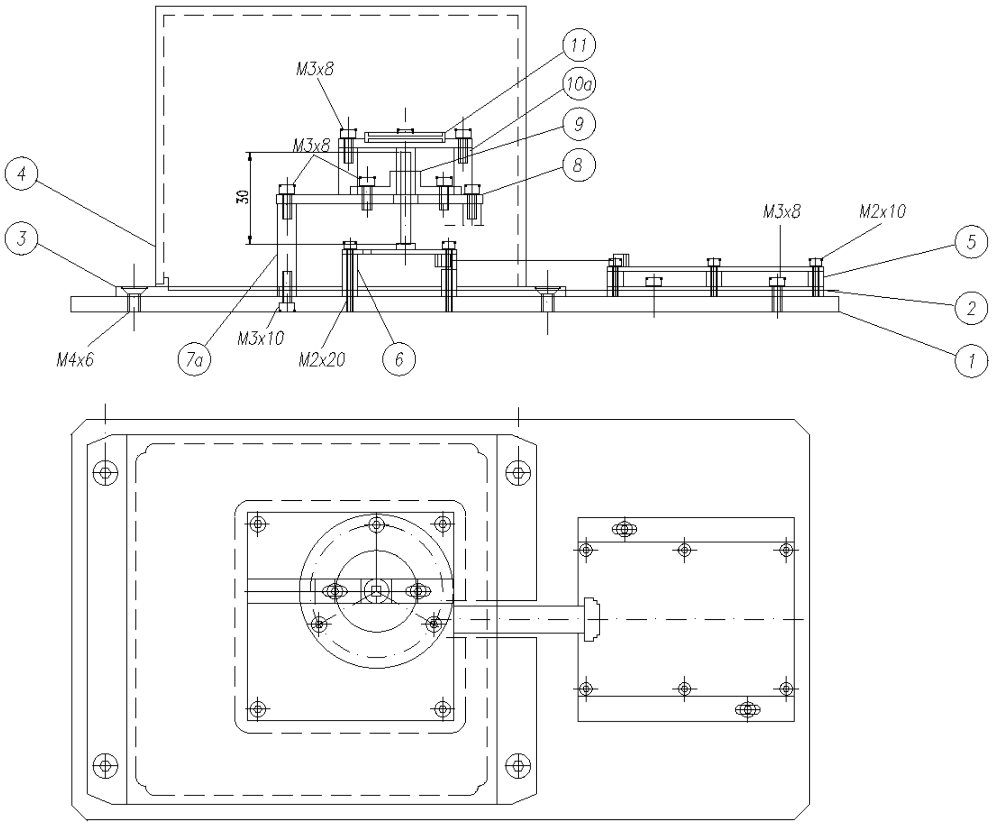

Figure 1.6: Front and side projection of entire setup.

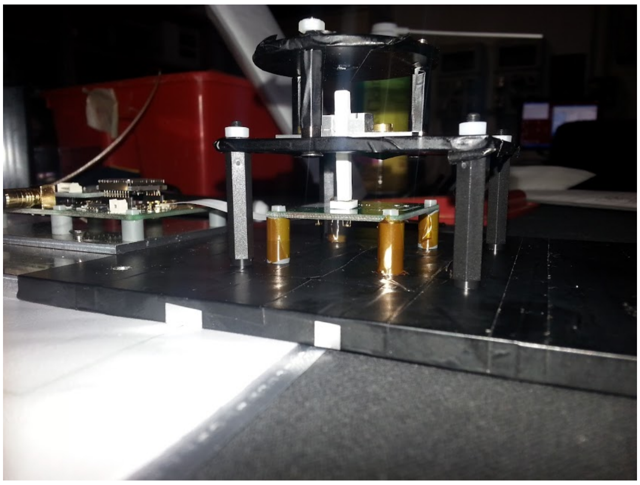

Figure 1.7: Built setup

Sources of ^{241}Am, ^{109}Cd, ^{133}Ba, ^{55}Fe, ^{137}Cs have been used to illuminate the rod, placed at a distance of about $5mm$ from the rod top, put on a circular aluminum support designed for the used radioactive sources. The source has a diameter of $1mm$. It's flux hasn't been collimated.
The alignment of the source along Z-direction has been carried out optically because the diameter of the beam spot was larger than the rod one, and therefore a rough alignment was sufficient.
The SiPM signal was read and processed by electronic chain whose diagram is reported in Fig.

1.2 Definition of the operative range

1.3 Circuit calibration with X-ray sources

1.4 Energy resolution measurement

Bibliography

[1] Hye-Lim Kim et al. Journal of Ceramic Processing Research. Vol. 16, No. 1, pp. 124-128, 2015