The Housing of the EUSO Photo-Detector Sensors

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Abstract

The current design of the EUSO Photo-Detector is based on multi-anode photo-multipliers sensors. As a large number of sensors is required (more than five thousands units) the design of the Photo-Detector is a challenging task, also because the Experiment has to operate on the International Space Station. In this paper the modular architecture of the sensor housing will be described, both from the functional and engineering point of view. The main aspects (functional, mechanical, electrical, optical, thermal and space qualification issues) will be discussed together with the requirements and constraints. The results of tests on some prototypes will be presented.

1. Introduction

The design of the Photo-Detector (PD) for EUSO is a challeng task due to the many requirements and constraints [1,2,3]. In particular the accommodation on the ISS has to be compatible with the (limited) resources available, including mass, volume, power and telemetry. Possibly unconventional solutions might be required.

The packing of the devices has to be optimized to reduce losses in the geometrical acceptance, due to dead regions between the close packed devices, and defocusing effects, originating from a positioning of the sensor at some distance from the ideal Focal Surface (FS). This makes the mechanical assembly a very complex task because a large number (about six thousands) of MAPMT are required. A modular structure is preferred. The overall structure shall consist of small functional units (elementary-cells, EC) assembled in larger modules. The elementary module consists of a limited number of MAPMT sharing some common resource like being installed on the same PCB base-board, having one common HV power supply and/or voltage divider, a common magnetic or electric screen (whenever required), common heat dissipation facilities, common miscellaneous services and monitoring devices, and all of the front-end electronics plus as much

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as possible of the trigger/readout electronics integrated in the EC. The EC can be thick multi-layered Printed Circuit Boards (PCB). A number of these modules, each one making an essentially autonomous system, are then put together to make a module. These are independent structures tied to each other by a common support structure and having a shape determined by the layout of the FS. MAPMT are therefore assumed to be packed in 2×2 elementary units, called EC. A realistic MAPMT pitch is assumed to be 27.0 mm to account also for the large tolerances on the MAPMT dimensions provided by the manufacturer (± 0.5 mm). The EC concept is useful because, in addition to introducing a modular structure, it allows sharing, of many resources, between MAPMT, such as PCB, HV/LV, MAPMT voltage divider, cables and connectors and electronic chips. This sharing improves the economy and make design, production and testing easier. It will be assumed that a module is made of an array of close-packed MAPMT with a suitable shape, possibly surrounded by a border of variable thickness running all around the MAPMT, to leave a sufficient clearance. Of course the detailed design of the module geometry will require the final fine-tuning of the geometry which needs the final design of the main EUSO optics, defining the FS. In principle, one might even want to optimize the PD granularity as a function of the location of the FS, according to the optics spot size, thus using different devices in different places.

2. The PD architecture

According to the previous discussion the PD is assumed to be arranged in a modular structure based on the following tree.

1. Single sensors (MAPMT).
2. An EC is both a physical and logical grouping of four sensors. It is an autonomous system with resource sharing, it is the maximum item which cannot be reworked.
3. A PD-Module (PDM) is a physical grouping of a suitable number of EC. The number of EC per PDM might be different for different PDM, according to the geometry. A macro-cell is a logical grouping of a suitable number of EC, for triggering and electronics purposes. The PDM and macro-cell concepts are *a priori* distinct.
4. The FS is divided into a suitable number of identical sectors, each one made of a suitable number of PDM and macro-cells.

One of the main driving points of the design is to combine different functions as much as possible, in order to save mass and volume.

3. The PD EC

The EC was conceived with the following main guidelines in mind.

1. To allow as close as possible packing of the MAPMT with a precise relative positioning.
2. To build a compact module with different functionalities integrated onto the base-board. The base-board acts as the structural element, housing the MAPMT, front-end electronics, and all the other required components, including the paths to carry the signals from the MAPMT to the front-end electronics and to the outside of the base-board and the components to deal with the heat generated on the base-board.
3. To allow a sharing of different resources between different MAPMT:

   (a) one common mechanical supporting structure and thermal dissipation capabilities;
   (b) voltage dividers common to different MAPMT and common HV/LV power connections;
   (c) common components such as heat bridges, cables and connectors for HV/LV, signal and controls;
   (d) possibly common front-end electronic chips for more than one MAPMT, depending on the number of channels chosen for the MAPMT;
   (e) additional components for services and monitoring (e.g. temperature monitoring);
   (f) any other required structural or functional element.

4. To be a single, self-contained and autonomous system, designed as a general purpose instrument to be used in other applications.

The base-board is fixed to the PDM supporting back-planes, by means of screws and dowel pins. This allows a precise relative positioning of the different EC onto the PDM and redundant support. The base-board is fixed on the back-plane supporting structure of the PDM by means of dowel pins and screwed by means of steel screws. Screws and dowel pins fit into metallized holes drilled into the PCB. They also act as thermal bridges to convey the heat generated on the base-board away from it, to the PDM. As any EC is totally autonomous and it is individually fixed to the PDM supporting back-planes, one has a complete flexibility in the choice of the shape of the PDM, including, possibly allowance for a curved shape. The signals from the MAPMT anodes are carried on the back-side of the thick base-board where to a front-end chip housed on the back-side of the base-board. The MAPMT side of the base-board also houses the components of the voltage dividers to power the dynode chain. Up to one voltage divider per MAPMT (i.e. four in total) can be housed onto the base-board. The thick base-board includes a copper layer, 0.5 mm thick, to help to drain away from the base-board the heat dissipated on the base-board by the voltage dividers and front-end electronics. This can be accomplished by conduction, through screws, pins and, possibly, dedicated heat bridges. Tests on the prototypes were also carried on, confirming the expectations. Prototypes were built and tested confirming the expectations. By using a surface-mount housing the thickness of the base-board can be kept relatively small, compatibly with the mechanical requirements, thus saving mass. Assuming to avoid a direct soldering of the MAPMT one needs a suitable socket. A prototype socket, for surface mounting, was produced. To ensure that the mechanical resistance and electrical contacts are kept all life long, and to ensure electrical insulation, good thermal conduction and good protection, both the volume between the MAPMT and socket and the volume between the socket and the base-board PCB shall be potted. Moreover potting between MAPMT and base-board and all around the four MAPMT will ensure electrical and mechanical insulation, mechanical damping, structural strength, components containment and, possibly, light tightness and thermal conduction. The impossibility to perform a complete visual inspection can be overcome, for instance, by X-ray inspection techniques and/or by defining a suitable alternative testing functional procedure, either for the MAPMT connections and for the ASIC. X-ray inspection has been already performed on the prototypes.

4. The PDM

Following a suitable layout of the MAPMT on the FS, the EC are installed onto the PDM supporting back-plane, by means of screws and dowel pins. Cables are routed to and from the EC via holes left on the PDM back-plane. Each PDM back-plane is fixed onto the FS supporting structure via a suitable number of screws, depending on the shape and dimensions of the PDM itself. Screws also help to drain the heat away from the EC. Tests on the prototypes were also carried on, confirming the expectations.

5. References

1. M. Ameri et al., *EUSO (Extreme Universe Space Observatory): the focal surface photo-detector*, Proc. 27th ICRC (2001);
   A. Petrolini, Nucl. Phys. Proc. Suppl., 113, 329-336, 2002.
2. M. N. Bleurvacq et al., *The mechanics of the focal surface of EUSO*, these proceedings.
3. N. Sakaki et al., *Development of multianode photomultipliers for the EUSO focal surface detector*, these proceedings.