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Shashlyk EM calorimeter prototype readout by MAPD with superhigh pixel density for COMPASS II

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The new-generation high-granularity Shashlyk EM calorimeter readout by micropixel avalanche photodiodes (MAPD) with precision thermostabilization based on the Peltier element is designed, constructed end tested. MAPD-3N with superhigh pixel density 1.5×10^4 mm^{-2} and area 3×3 mm^2 manufactured by the Zecotek Company were used in the photodetector unit.

A new high-granularity Shashlyk electromagnetic calorimeter ECAL0 covering larger photon angles was developed for the future measurements of generalized parton distributions at COMPASS II. The design of the Shashlyk module is shown in Figs.1 and 2. The module consists of the calorimeter and the photodetector unit. The mechanical design of the calorimeter is similar to the EM calorimeters described in [1, 2].

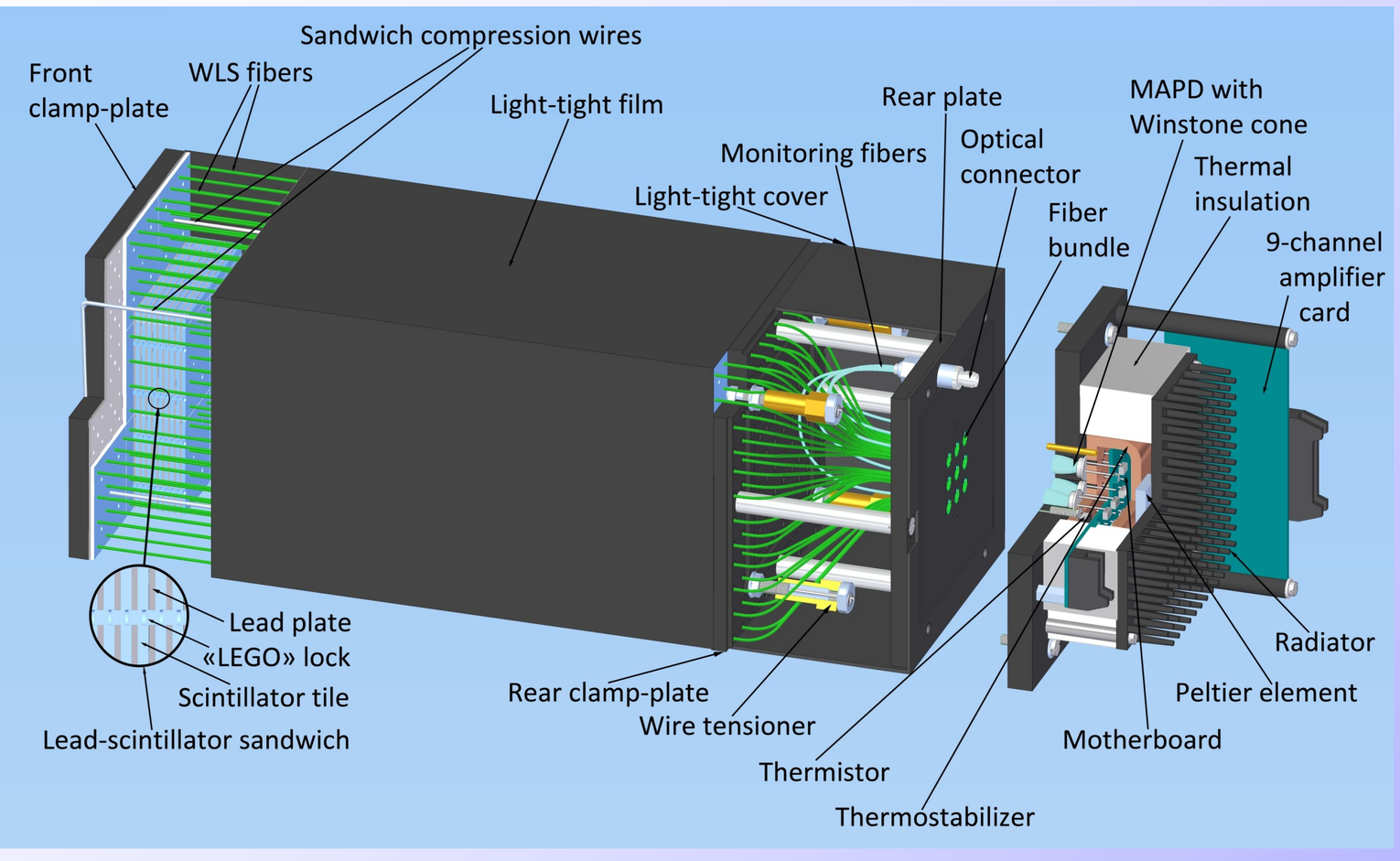

Fig.1. The Shashlyk calorimeter module design.

The Shashlyk EM calorimeter is a sandwich of alternative perforated stamped lead plates and injection-molded polystyrene-based scintillator (PS +2% PTP +0.05% POPOP) tiles readout by means of WLS fibers passing through holes in the scintillator and lead. There are 109 sampling layers, each layer consisting of a 0.8 mm thick lead plate with dimensions 119.8 ×119.8 mm^2 and nine 1.5 mm thick scintillator tile with dimensions 39.8 ×39.8 mm^2. The total length of the calorimeter is about 15 X_0.

The tiles has 16 holes equidistantly arranged in a 4 ×4 matrix with the spacing between the holes 10.6 mm for WLS fibers and one hole at the centre for the compression wire. The edges of the tiles were painted white and thus formed nine light-isolated towers. Each tower is readout by means of 16 BCF 91A WLS fibers 1.2 mm in diameter. The fiber ends are shaped into a bundle 6mm in diameter and glued inside the corresponding holes of the rear plate. Additionally a clear fiber was inserted in each bundle used to transport light from the monitoring optical connector. Other ends of WLS fibers were mirrored by special paint "SILVER SHINE" № M415001.

Each scintillator tile has four "LEGO"- type locks. These locks are used to simplify the module assembling process and maintain the alignment of the tiles and lead plates. The complete stack of lead-scintillator layers is held in compression by four stainless steel wires 1.2 mm in diameter between the front and rear plastic clamps-plates with the help of tensioners. Such a self-maintained design ensured high mechanical strength of the module due to static friction between the surfaces of the lead plates and scintillator tiles. The module is wrapped with a 0.1mm black polyester film for light tightness.

Since the ECAL0 calorimeter will be installed close to the magnet, the photodetector should be insensitive to magnetic field and a PMT cannot be used. Therefore the micropixel avalanche photodiodes MAPD-3N [3] with the gain 4×10^4, photon detection efficiency (PDE) 25 % in the green region, superhigh pixel density 1.5×10^4 mm^{-2} and area 3×3 mm^2 manufactured by the Zecotek Company [4] were used in the photodetector unit (Fig.1).

Because the fibers bundle is 6 mm in diameter while the sensitive area of MAPD-3N is 3×3 mm^2 square, polystyrene Winston cone light guide (L=10,1 mm, D_1= 7.2 mm, D_2= 3.3 mm) glued to the MAPD surface was used to increase light collection (Fig.3). Measured light collection efficiency of the Winston cone is about 95%.

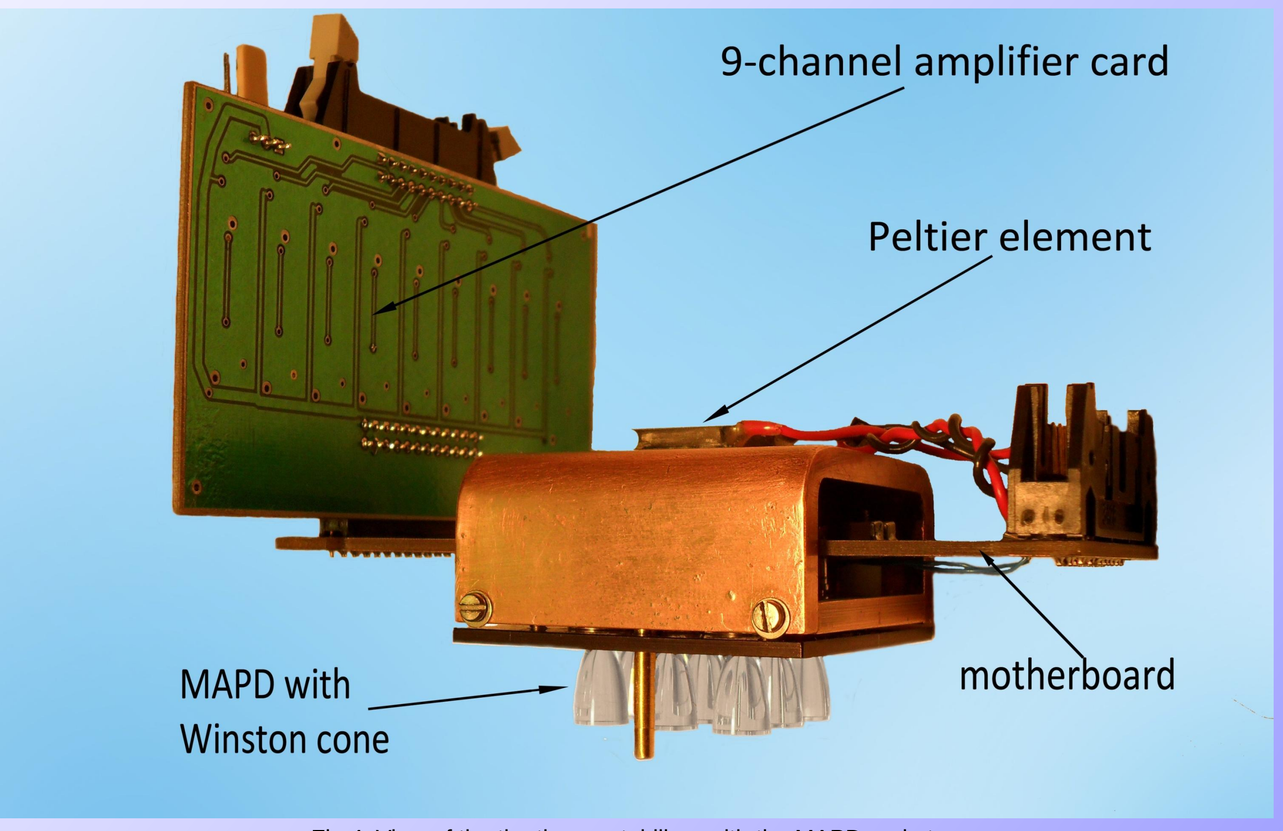

Fig.4. View of the the thermostabilizer with the MAPD and etc.

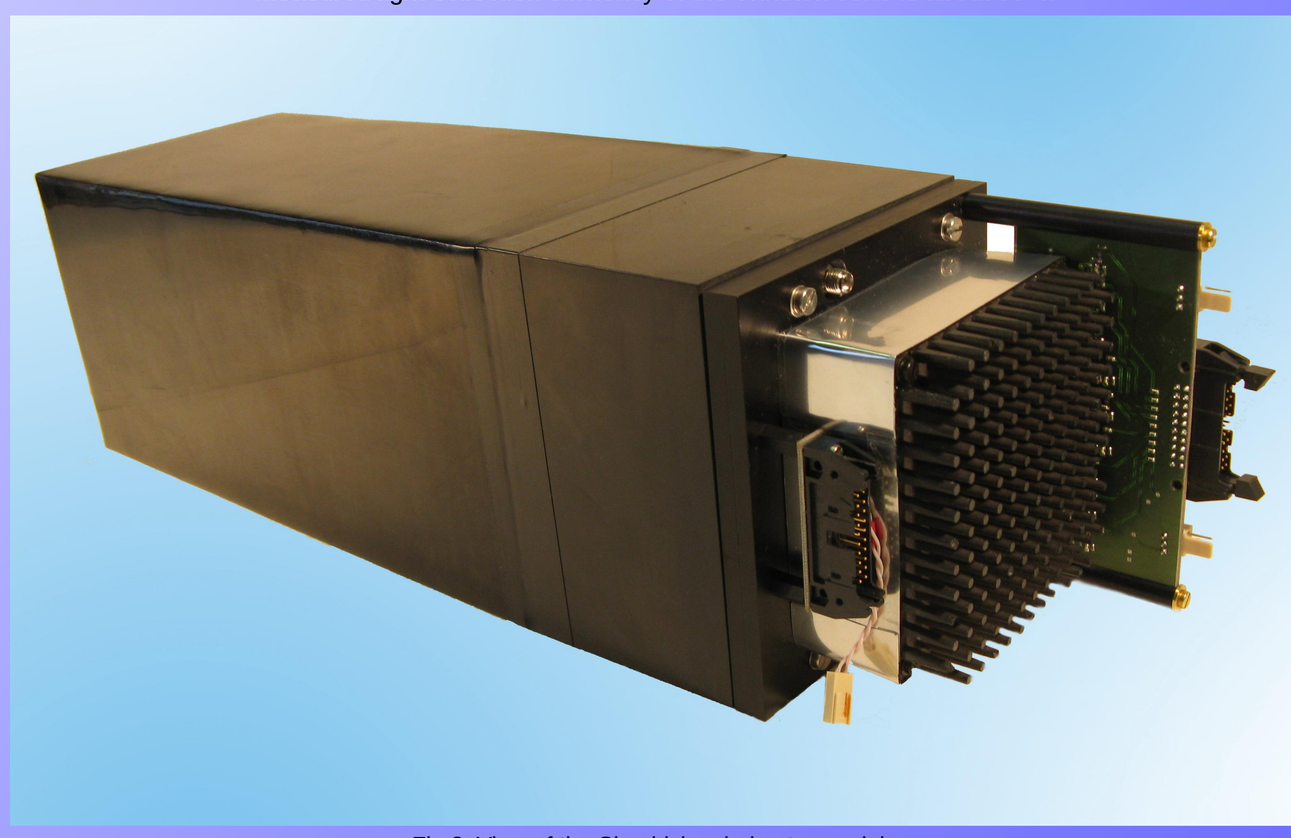

Fig.2. View of the Shashlyk calorimeter module.

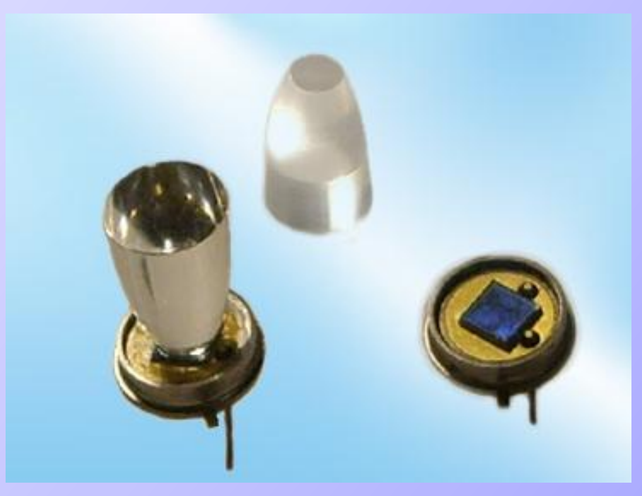

Fig.3. View of the MAPD with the Winston cone and without.

The gain and PDE of MAPD significantly depends on the environmental temperature (few percent per one degree). It is therefore necessary to stabilize the temperature of the MAPD.

The thermostabilizer of the photodetector unit is based on the Peltier element (15 ×15 mm^2) and is made of copper plates. The Peltier element was glued to the outside surface of the thermostabilizer by heat-conducting glue (Fig.4). The motherboard is installed on the thermostabilizer and has connectors for the MAPD, 9-channel amplifier card, power supply and electronic temperature stabilization system. The thermal insulation of the thermostabilizer against ambient is made of cellular polythene. The heat side of the Peltier element is cooled by the radiator. The thermostabilizer at the ambient temperature of 25°C kept the MAPD temperature at 15°C with an accuracy 0.05°C at power about 1W.

Preliminary results of the first studies of the ECAL0 3×3 module matrix at the T9 CERN PS test-beam facility is shown in Fig. 5.

References

[1] *G.S Atoian et al., Nucl. Instr. and Meth. A 584 (2008) 291.*
[2] *A.V. Arefev et al., Instr.Exp.Tech. V 51 (2008) № 4, 511.*
[3] *N. Anfimov et al., Nucl. Instr. and Meth. A 617 (2010) 78.*
[4] http://www.zecotek.com/

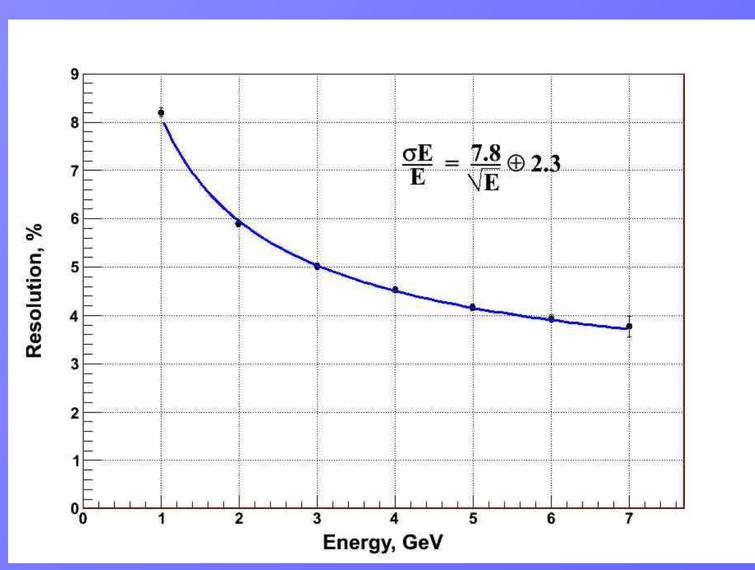

Fig.5. Energy resolutions of the ECAL0 3×3 module matrix readout by the MAPD at T=15° C versus the electron beam energy.