5.11 ELECTROMAGNETIC CALORIMETER (ECAL)

The Electromagnetic Calorimeter (ECAL) of the AMS-02 experiment is a fine grained lead-scintillating fiber sampling calorimeter that allows precise, 3-dimensional imaging of the longitudinal and lateral shower development, providing high ($\geq 10^6$) electron/hadron discrimination (identify particle type) in combination with the other AMS-02 detectors and good energy resolution (energy measurement). The calorimeter also provides a stand-alone photon trigger capability to AMS. The ECAL measures the energy of electrons, positrons and gamma rays up to 1 TeV.

The active sensing element of the ECAL consists of layers of lead foils and polymer scintillating fibers (Figure 5.11-1). Each lead foil a lead-antimony alloy with a density of 11.2 ± 0.5 gr/cm^{3}with an effective thickness of 0.04 inch (1 mm). Each lead layer is grooved (rolled) on both sides (Figure 5.11-2) to accommodate the PolyHiTech Polifi 0244-100 scintillating fibers. Each fiber is 1.0 mm in diameter and is secured in the aligned groves with BICRON BC-600 Optical glue that is applied as lead layers are assembled and pressed together. Each layer consists of 490 fibers across the 25.9 inch (658 mm) width of the layers Lead layers are grouped together in "superlayers" (Figure 5.11-3) that are comprised of eleven layers of lead foil and ten layers of scintillating fibers. Each superlayer has all scintillating fibers oriented in the same direction, alternating the direction orthogonally of the fibers with each of the superlayers (Figure 5.11.1), 9 in total. Once assembled and pressed, each cured superlayer is milled to a uniform thickness of 0.7 inch (18.5 mm) thick. The superlayers are assembled as larger elements and sized (milled) for flight into squares with 25.9-inch (658 mm) long sides. The last (bottom) lead layer of the bottom superlayer has been replaced with a milled aluminum plate to reduce weight of the overall ECAL. Estimated savings by replacing the last plate with aluminum is approximately 2 kg.

Figure 5.11-1 Three Superlayers Showing Alternating Layers Of Lead Foil And Scintillating Fibers And Alternating Superlayer Orientation

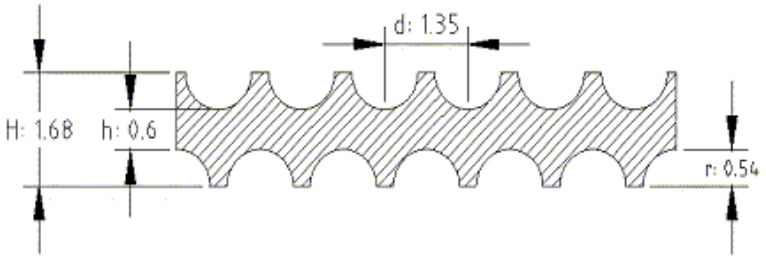


Figure 5.11-2 Individual Lead Foil Profile (Dimensions in mm)

The ”pancake” of lead layers with scintillating fibers is the foundation of the ECAL sensor. Sensitive photomultiplier tubes (PMTs) are positioned around the periphery of the brick to sense photons generated by the passage of particles, secured against the edges of the brick where the Superlayer fibers terminate. A position of one of these PMT locations with its four pixels is depicted in red in figure 5.11-3. A side view of the ECAL (before the PMTs are installed) is provided in Figure 5.11.4.

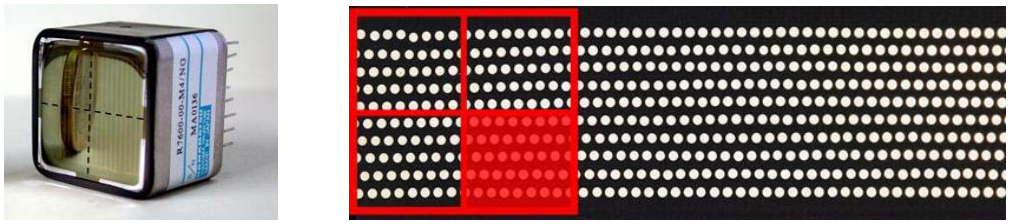


Figure 5.11-3 The 4-Anodes Photomultiplier (left) and the area it covers on a Superlayer (right)

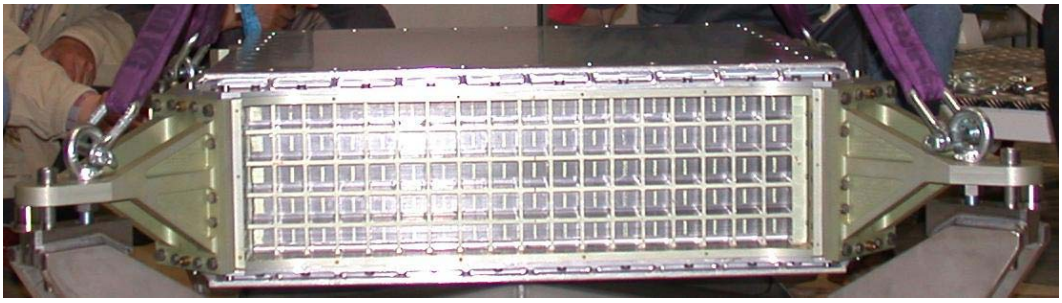
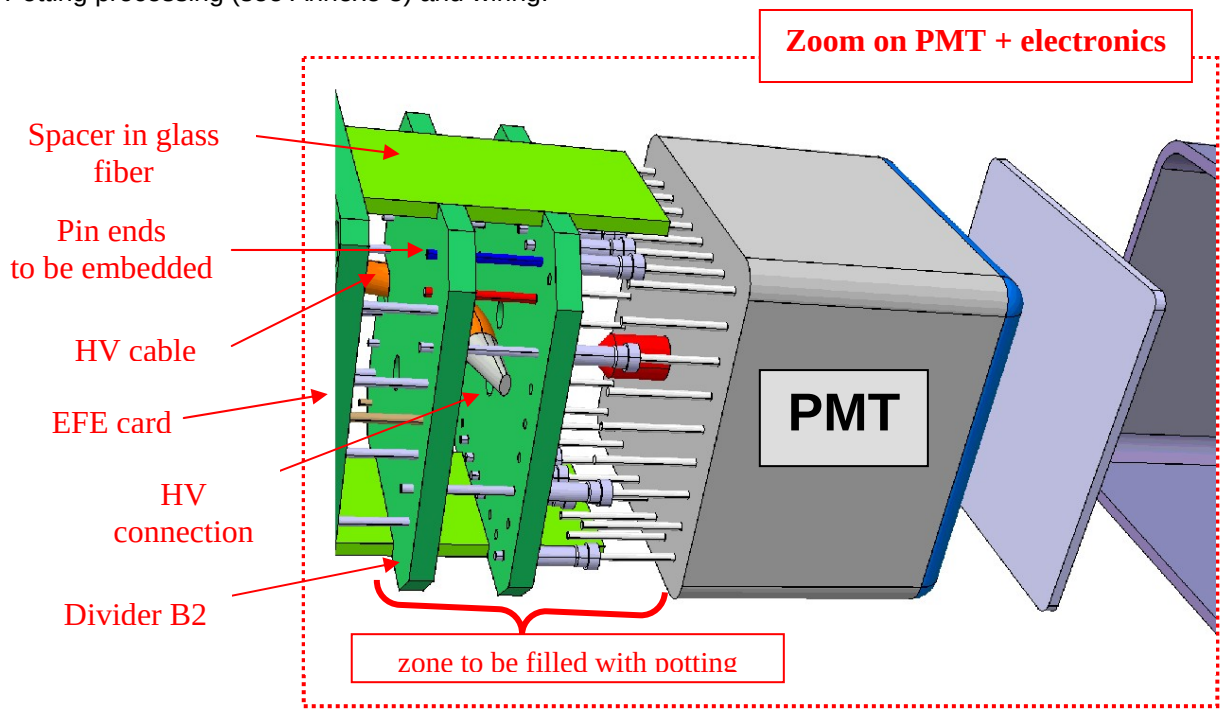


Figure 5.11-4 View of the ECAL showing the Side Panel grid prior to the installation of the PMTs

The ECAL is approximately 31.5 inches (800 mm) square x 9.8 inches (250 mm) high and weighs approximately 1478 lbs (643 Kg). Approximately 75% of this weight is due to the lead foils.

The ECAL "pancake" is supported by the ECAL "box". The box is made of 6 elements (Figure 5.11-5). The top and bottom pieces are aluminum honeycomb plates framed with aluminum. The plates are bolted to four lateral panels along the edges. The four lateral panels are made of Aluminum plates, 4 inch (10.16 cm) thick, carved with squared holes of 1.26-inch (32 mm) sides to house the light collection system. Four corner brackets, made of Aluminum plate, link the four plates together and connect the detector to the USS-02 at the bottom of the AMS-02 instrument (Figure 5.11-6). The four mounting locations include a pair of radially slotted holes so that the loads of the ECAL are transferred to the USS-02, but the loads from the USS-02 that are transferred into the ECAL are limited.

Item 41.
Potting processing (see Annexe 3) and wiring.



All the HV pins or connections are embedded in DC 93-500 potting. The process as described in the Annexe 3, is an injection of pre-outgassed DC93-500 through a transparent PMT box (visual inspection). Quality check: 1.Visual Inspection during injection (air bubbles), 2. Thermal Vacuum tests for each PMT Tube.
All HV cables are protected both with potting and shielding in Teflon.

Item 48.
Closed on Nov. 22, 2004

Item 49.

For the ECAL subdetector, optic fibers are found only in the so-called pancake, which consists of a lead/scintillating fiber sandwich in which the grooved 1mm thick lead foils are interleaved with scintillating fibers and glued together with epoxy (see picture)
The scintillating optic fibers are made of monomer polystyrene (C6H5CH=CH2) doped with organic molecules. The manufacturer is the company Pol.Hi.Tech. (Carsoli, AQ, Italy). The same material is used for the TOF scintillators and was used in AMS01.

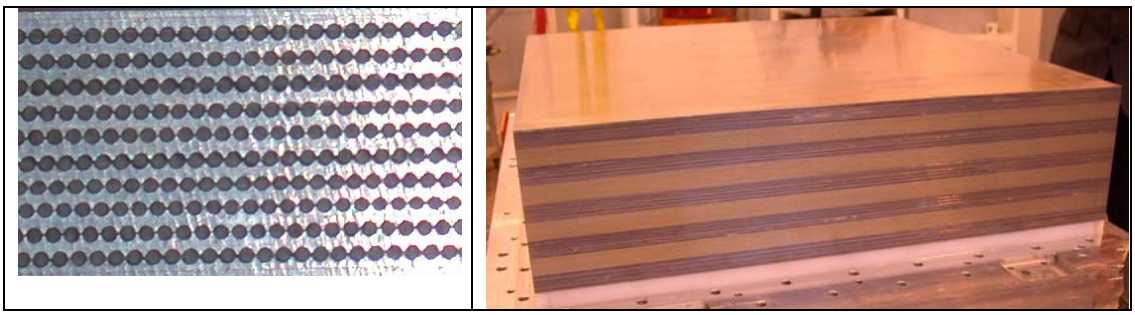


Fig : detail of the lead/scintillating fiber sandwich (left) and (right) pancake before assembly in the mechanical support structure.