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Studies of anticoincidence systems Application to Simbol – X and IXO/HXI

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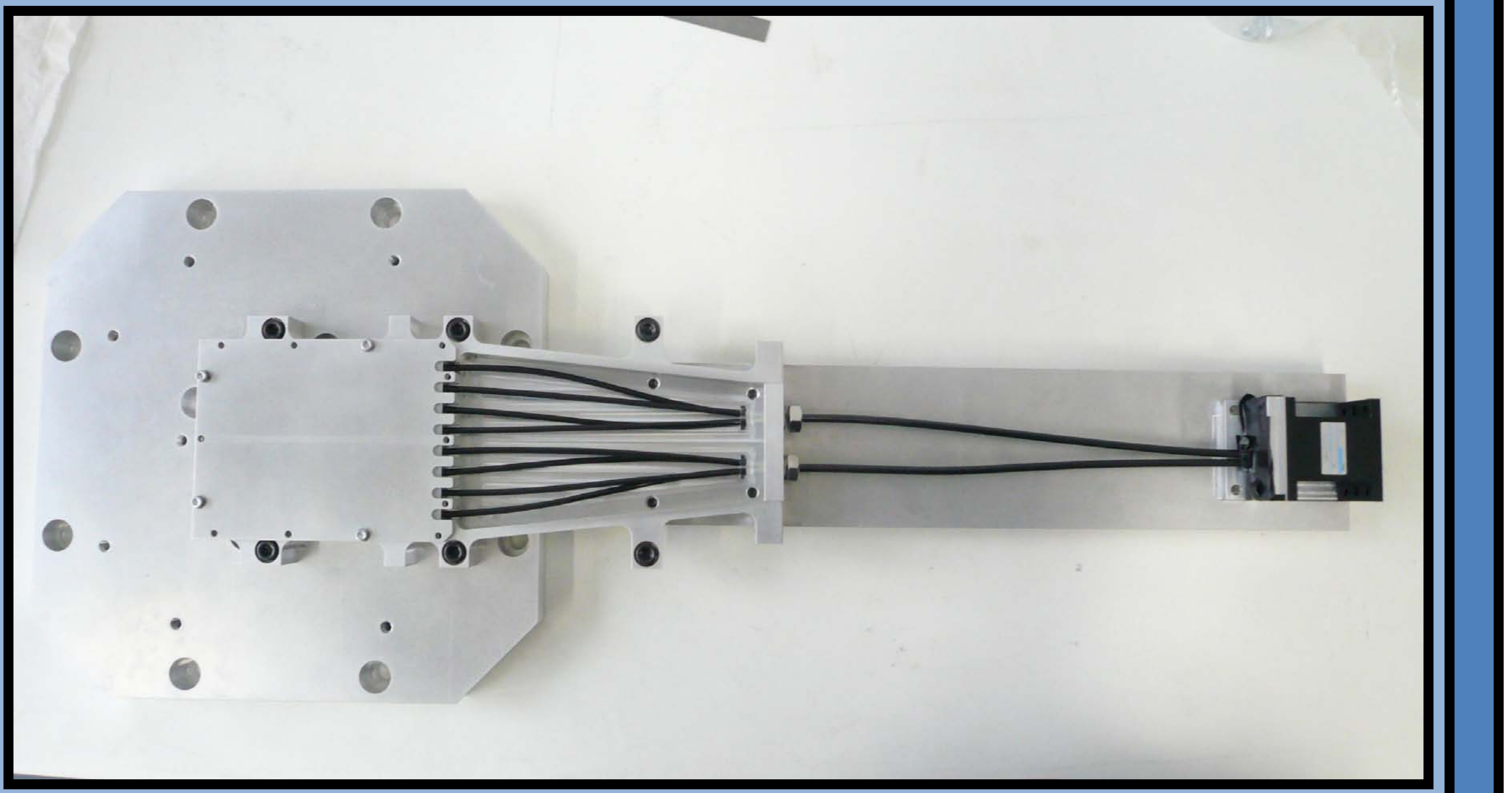
Abstract

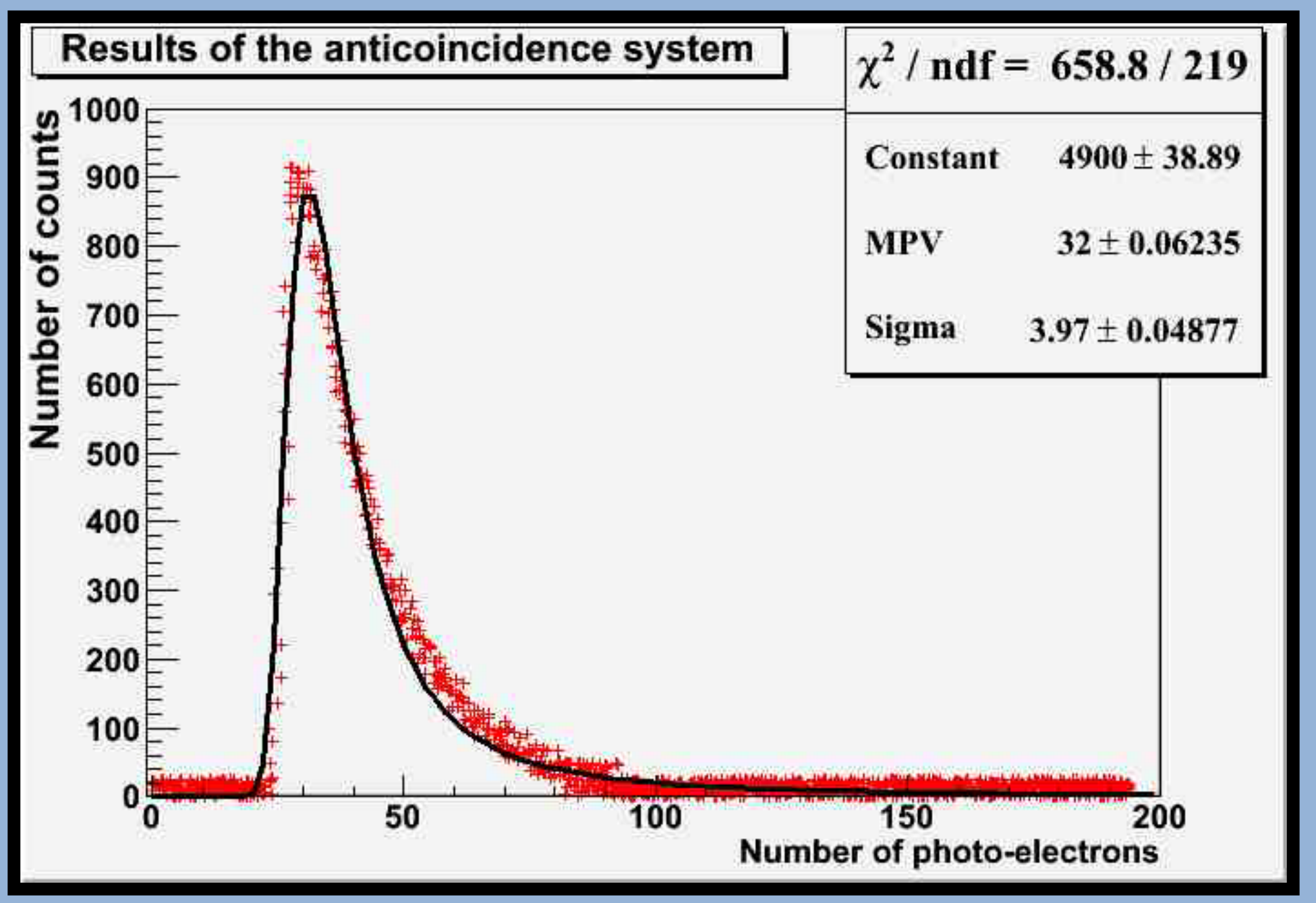
The scientific performances of future hard X-ray missions will necessitate a very low detector background level. This will imply thorough background simulations, and efficient background rejection systems. It necessitates also a very good knowledge of the detectors to be shielded. We got experience on these activities by conceiving and optimizing, in parallel to the high energy detector studies, the active and passive background rejection system of the Simbol-X mission. This anticoincidence detector, whose conception, optimization and realization are under responsibility of the APC Laboratory, Paris, is based on plastic scintillator plates associated to multi-anodes photomultipliers (MAPM) via optical fibers. Considering that this work may be naturally extended to other X-ray missions, we have followed up with CNES a R&D project on the study of background rejection systems mainly in view the IXO/HXI telescope, whose anticoincidence is constituted by BGO blocks readout by Si -APD. In this presentation, we will detail this R&D activity, based on prototypes realization and Geant 4/SLitrani modeling.

The main goal of the Simbol-X AC was to obtain at least 10 photo-electrons (pe) to have a rejection efficiency of 99.99%. We have thus created a AC prototype to check its performance. This prototype was composed by a BC-400 plastic scintillator readout by eight Y11 wavelength shifting (WLS) optical fibers. The fibers was glued, with a BC-600 glue, in grooves separated by 2 cm each other. Each WLS optical fiber is protected from the light with a hytrel tube. To prevent the break of the optical fibers at the sharp side of the scintillator, we have glued a resistant plastic cylinder. The 8 fibers are placed into 2 bunches of 4 fibers then, the two bunches are glued to a 4 2 aluminum holder, fixed in front of the 4 4 pixels front side of the Hamamatsu H8711 multi-anode PMT. We have put a thin silicon pad between the fibers and the PMT to increase the light collection. We have created and calibrated a muon telescope to check the AC performance. Our prototype was also successfully checked again vibrations at Institut d'Astrophysique Spatiale (Orsay).



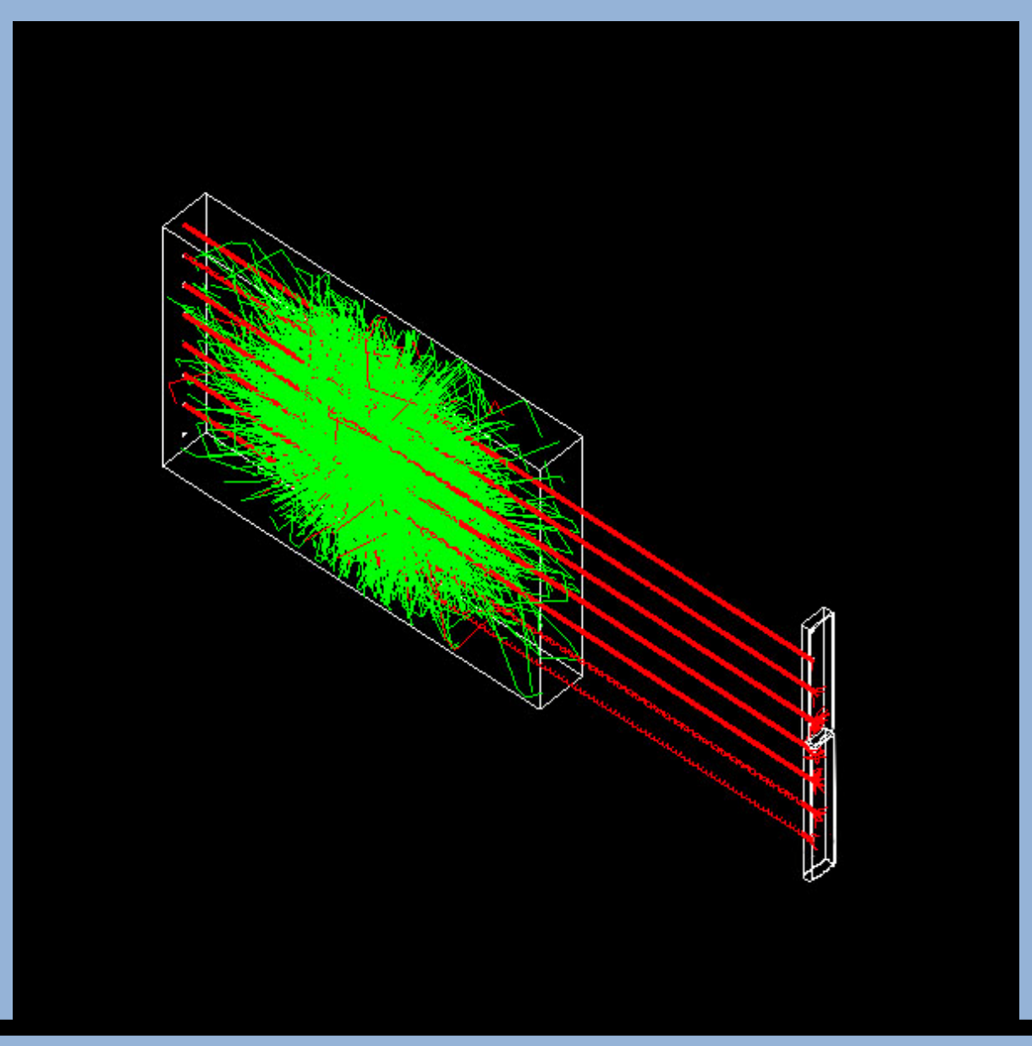
Experimental

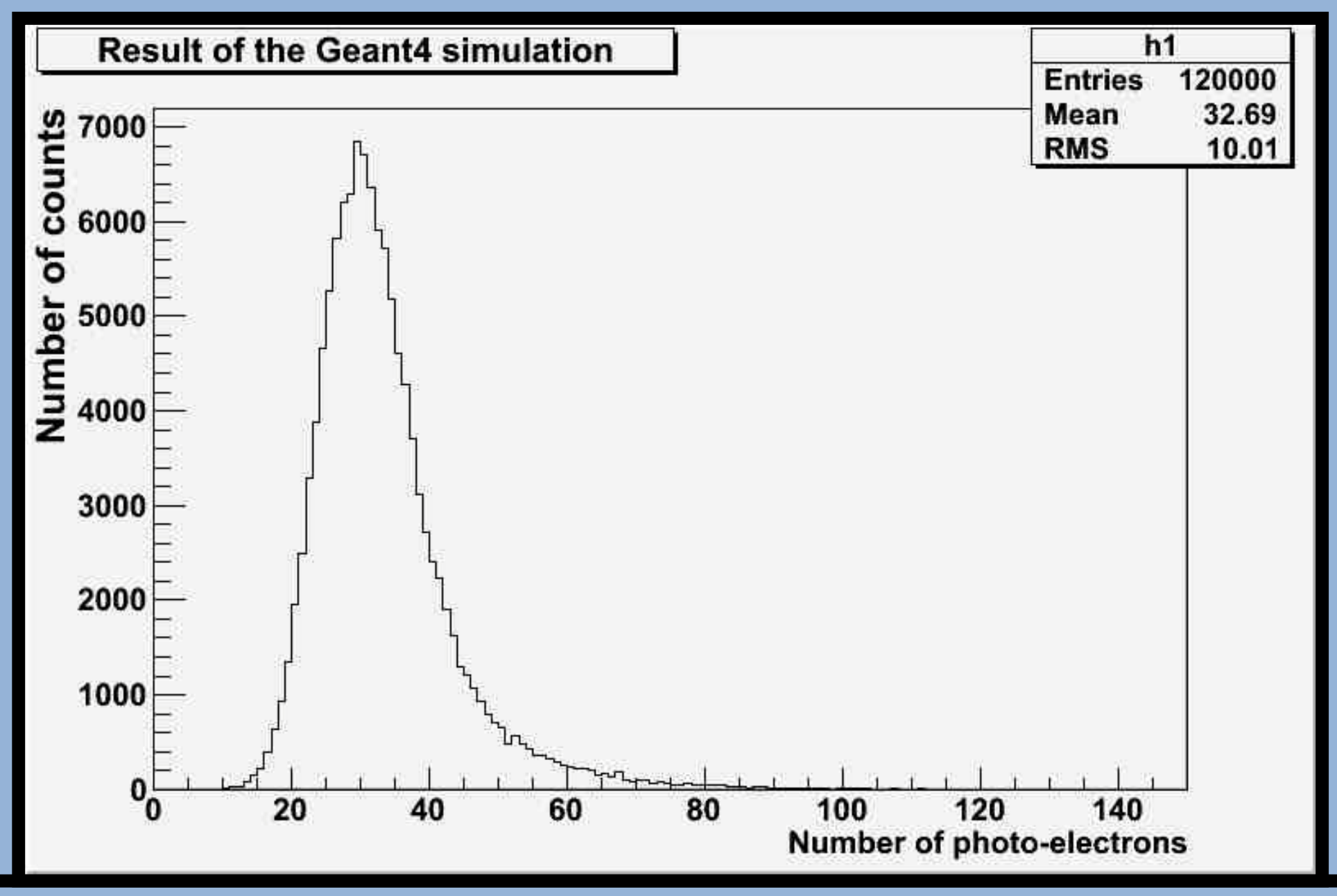
We put our prototype into the muon telescope (see below), and readout two pixels of the MAPMT. After three days of data acquired in coincidence between the muon telescope and the prototype, we obtain the following spectrum in response to atmospheric muons. We fit it with a Landau distribution, finding 33 pe for the two pixels.



Simulation

We have simulated our prototype with GEANT4. Using 1 GeV muons ,we obtained the result shown below. A fit with a Landau curve shows that we could obtain around 32 pe from the MAPMT, a result consistent with the measures.

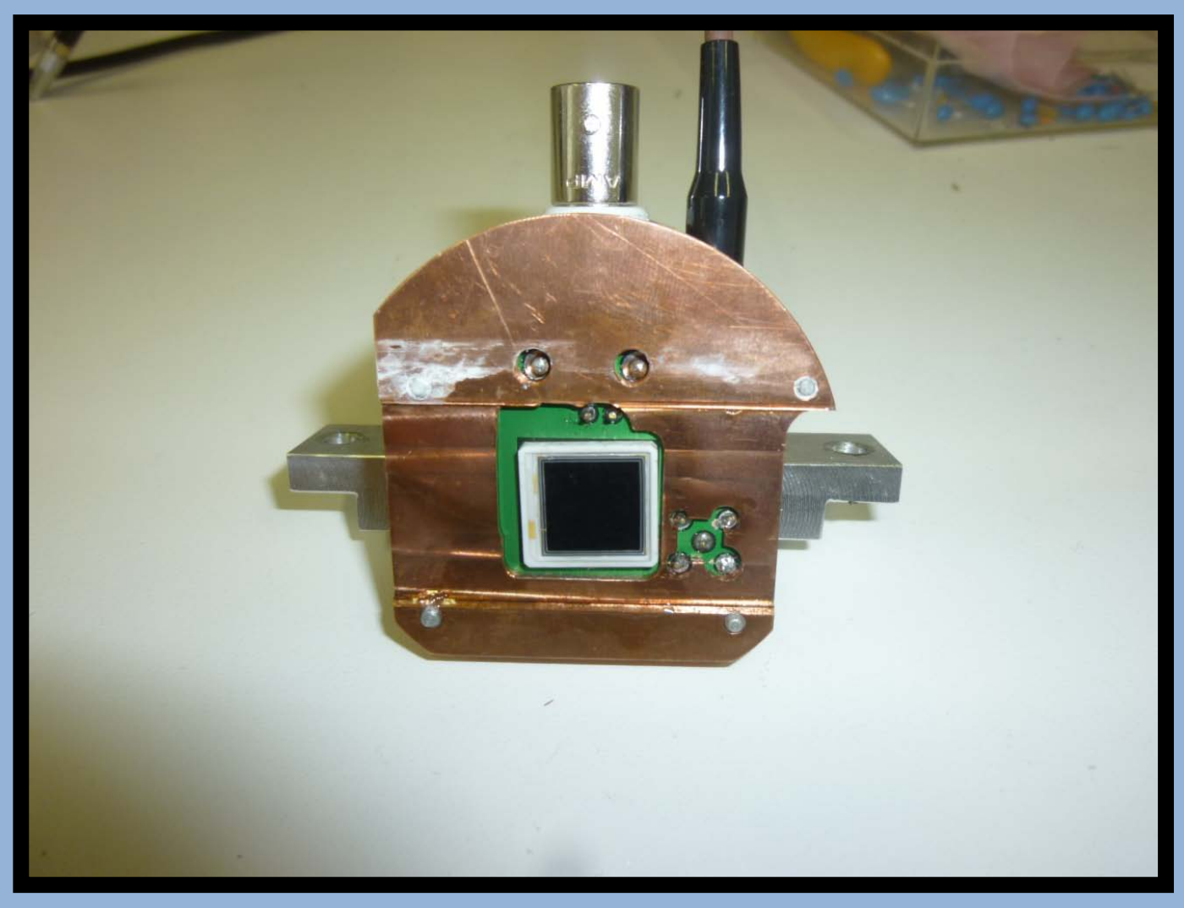




CONCLUSION:

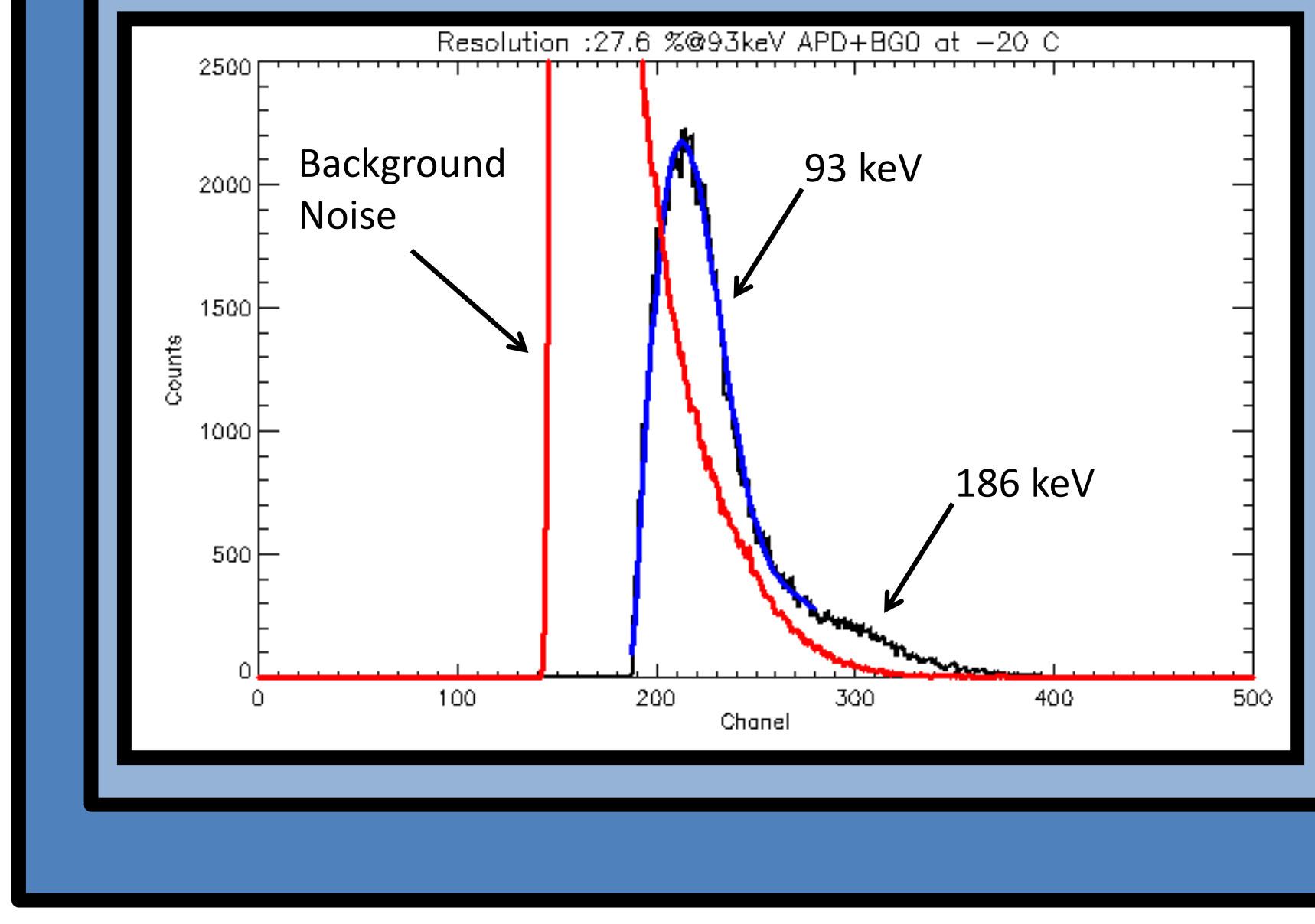
The good correlation we obtained between measures with our prototype and simulations have given us confidence that our design properties was well understood and that we could meet the Simbol-X specifications.

The IXO anticoincidence system is based on an inorganic scintillator of bismuth germinate (Bi4Ge3O12 - BGO) readout by an avalanche photodiode S8664-1010 (APD) from Hamamatsu. To obtain high performance, the unit should be cooled down to -20 C. We have realized a prototype of this anticoincidence enclosed in a black box with a Peltier cool down system. We also envelop the APD detector in a Faraday cage in order to protect it from external electric fields. We use optical grease to increase light collection between the crystal and APD.



Experimental

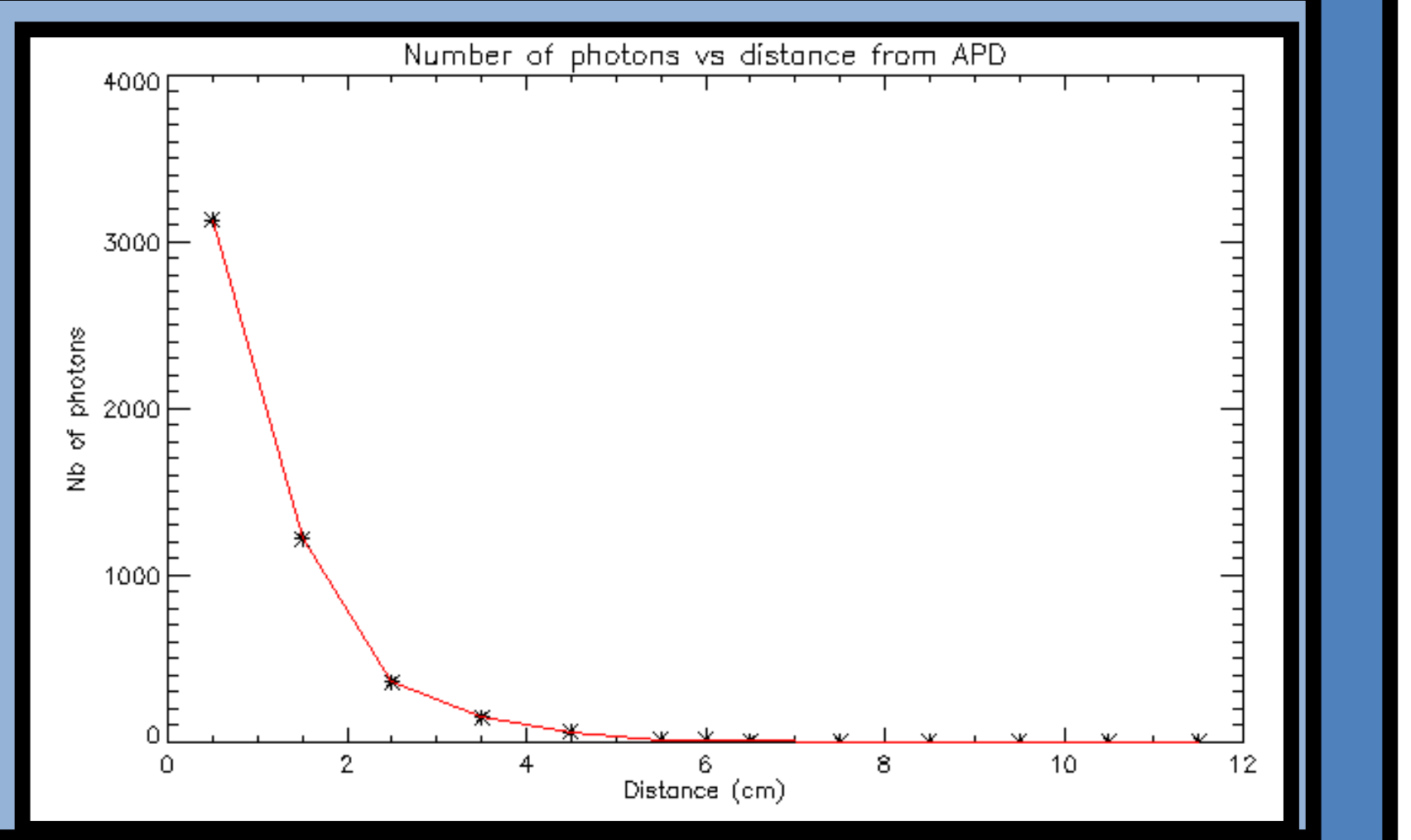
We measure our prototype's performances using a Uranium source with peaks at 93 and 186 keV. The measured spectra are shown below. In red is a background spectrum and in blue is the background subtracted uranium ones. The lines are clearly seen, and we have measured a resolution of 27.3%@93 keV.



This has shown that we can obtain in the laboratory a threshold around 75 keV, close to the IXO/HXI specified ones (60 keV). More measures with different settings and temperatures will be done in the next future.

Simulation

We use Slitrani to obtain this curve showing the number of photons received by the APD versus the distance of the source of 1 MeV photons. This will be compared with light yield measures already done by our Japanese colleagues.



CONCLUSION:

The first spectra show interesting results near the IXO/HXI requirements. The SLitrani software will be an very good complementary software to use with GEANT4 in order to create very efficiency simulation tools for space experiments.