



Hamamatsu Photonics receives CERN Award for its Avalanche Photodiodes APD (February 2003)

CMS is one of the 4 experiments for the new Large Hadron Collider (LHC) at CERN (the world's largest particle physics laboratory) in Geneva, Switzerland.

Hamamatsu Photonics have received the prestigious CERN Award for their outstanding work and achievements in the development and production of Avalanche Photodiodes.

The development was very challenging as the CMS collaboration needed highly sensitive and fast readout sensors for their Electromagnetic Calorimeter. The sensors were required to operate in a very high magnetic environment and, even more challenging, that they could withstand high levels of radiation.

At that time, there were only two choices available in the market, PIN Photodiodes and Photomultiplier Tubes (PMT). The PMT's could not be used because of the high magnetic fields and their size was also a problem. The PIN Photodiode could be used in high magnetic fields and the Hamamatsu Photodiodes had been proven to be radiation hard in other experiments. However there were two problems, the blue sensitivity was low, but this could be addressed, but a greater problem was that the crystals used did not shield the detector 100% from ionising particles. In silicon an MIP generates a signal, which cannot be distinguished from a light signal. It would make it totally impossible to separate the calorimeter signal from the background radiation.

At that time a new technology was emerging, the Avalanche Photodiode. However, they were small, not blue sensitive, had a high capacity and the packaging did not allow efficient coupling to a crystal. The main advantage of Avalanche Photodiodes compared to PIN Photodiodes is gain. This internal gain amplifies only the electrons generated by light and not those created by ionising particles. Therefore the scintillation signal to background noise ratio can be increased. Operation of the APD at a gain of 50 provided sufficient signal to noise ratio for the CMS experiment.

The route to success was not easy or straightforward for Hamamatsu Photonics as the manufacturer, the Paul Scherrer Institute PSI in Villigen, Switzerland and CERN who together carried out all the endless tests in radiation environments, simulating operation of the LHC over 10 years.

Once we had established the basic APD design the next challenge was to scale from prototype stage to mass production.

A total of 130,000 APD's, each with a size of 5x5 mm, fully tested, had to be delivered at a rate of 6000 pieces per month. CERN demands a survival rate of >99% after 10 years of operation of LHC. CERN, PSI and Hamamatsu Photonics have achieved that.

Even before LHC started, the Hamamatsu Photonics APD had already produced extraordinary results and made history in another experiment at CERN called ATHENA. ATHENA was the first experiment to produce and detect copious amounts of Cold Antihydrogen. The S8148 Avalanche Photodiode from Hamamatsu Photonics was used to read out the pure CsI Crystals used as a gamma ray detector. Working at temperatures of 140°K in a 3 Tesla magnetic field, they could achieve a signal to noise ratio of 100.

In parallel, this technology was attractive for another application but this time medical. A small Animal PET scanner was developed by the MPI in Munich using a Hamamatsu Photonics APD array matrix consisting of 4x8 APD, which are individually addressed for read out. The APD matrix is used to read out the small Lutetium-Oxyorthosilikat (LSO) crystals used in this setup. No other technology would enable a PET scanner of such a high resolution to be achievable. It will also allow planned developments to combine the PET scanner with the MRI scanner in the future. Using this technique, a combined image of both the organ and the chemical functionality could be achieved. This would allow precise location and fast diagnosis of the problem.

Hamamatsu Photonics will continue its development in this and many other technologies, always accepting the challenge to create products for a better future.

Marco Mayer
Hamamatsu Photonics

