Contribution ID: **59** Type: **Oral presentation**

Study on large area photomultipliers with super bialkali photocathode

Wednesday, 13 June 2012 16:40 (20 minutes)

Photomultipliers with large photocathode area have been widely used in proton decay, astrophysics and neutrino detectors in recent years, since large detection volumes can be reached with a reduced number of detectors. The sensitivity of a photomultiplier is described in terms of its quantum efficiency (QE), i.e. the number of photoelectrons emitted from the photocathode divided by the number of incident photons. QE is currently limited to typical values of around 25% at the spectral peak (400nm). Hamamatsu has developed a new super bialkali (SBA) photocathode which improves quantum efficiency up to 35%. Considering the detection efficiency of a detector as the number of detected events divided the number of events emitted by source, an increase of the quantum efficiency improves the detection efficiency as well as an increase in detection surface. With that in mind, a large study on performance of super bialkali large area photomultiplier type R7081 (10"photocathode) and type R5912 (8"photocathode) was done, and the results were compared to those of standard bialkali photocathode with the same mechanical design.

Firstly, measurements of the increase of the detection efficiency were performed carefully. In order to define whether the quantum efficiency improvement process could have secondary effects, time and charge characteristics, fraction of spurious pulses and dark count rate were investigated and compared with the measurements on a batch of 72 standard bialkali PMTs. Measurements of the parameters have been performed illuminating the whole photocathode surface using a 400 nm pulsed laser attenuated in single photoelectron condition. The results confirmed an increase in the quantum efficiency up to values of 35%, as declared by manufacturer. The main secondary effects of the super bialkali photocathode were an increase for the dark count rate and a considerable increase of the fraction of the after pulses. About the dark count rate, the tested SBA PMTs had a mean value of about 2 times greater than that measured on the batch of standard PMTs. The noise rate decay time after a short light exposure was measured for a standard and a SBA photomultiplier: the super bialkali PMT exhibited a decay time of over ten hours, greater of the time of about six hours measured on the standard PMT. The local measurements performed scanning the photocathode surface with a narrow laser beam confirm that the uniformity of the super bialkali photocathode is not worse than that of the standard PMTs.

Another important issue was the study on the influence of the Earth's magnetic field. It is well known that the performance of a photomultiplier tube is subject to significant variation due to magnetic fields. This is particularly true for large area PMTs, because of the long trajectories of electrons from the photocathode to the anode. While the effects of Earth's magnetic field on the performances of a large area photomultiplier are principally due to deflections in the trajectories of the photoelectrons drifting from photocathode to first dynode, trajectories of secondary electrons in the dynode chains can also be affected, depending on the orientation of the PMT relative to Earth's magnetic field. The influence of the Earth's magnetic field on the main parameters was studied on two Hamamatsu PMTs, 8-inch R5912 types, one of these with super bialkali photocathode, and compared with measurements on a 10-inch R7081 type with a standard bialkali photocathode. The various characteristics of the PMTs were measured while varying the PMT orientations with respect to the Earth's magnetic field. The effect of a mu-metal cage as magnetic shield was also studied. In general, for the 8"PMTs the impact of the magnetic field was found to be smaller than that on the 10"PMT. The super bialkali 8"PMT has shown the same behaviour of the standard one with respect to the Earth magnetic field. The increased quantum efficiency in the 8"super bialkali PMT almost compensated its smaller detection surface compared to the 10"PMT. It was also confirmed that the super bialkali photocathode produced significantly greater type-1 and type-2 after-pulsing than the standard bi-alkali photocathode.

At last, an accurate study and measurement about the ageing effects on two large area photomultipliers has been performed for over three years. The PMTs were 10", 10 stages Hamamatsu R7081, one with standard bialkali and the other one with super bialkali photocathode. Gain, dark count rate, charge and timing properties have been measured, as well as the fraction of the spurious pulses. During the ageing cycles, the anode current of the two photomultipliers has been monitored and recorded in order to measure the total output anode charge and determine the ageing grade. The ageing conditions have been set by the use of a 400nm LED regulated to about 3 photoelectrons at about 400 kHz. The ageing process was stopped when the total charge arrived up to about 2000 C for both the PMTs. Considering the main results, only the gain showed a

variation while all the other parameters remain quite stable. A first phase of up-drift shows an increase of the gain of about 10% and is followed by a final phase of down drift, which shows a faster diminution of the gain of about 30%. The mechanism of the gain drift has been modelled and compared with the results.

Primary author: Dr LEONORA, Emanuele (INFN section of Catania)

Co-authors: Dr LO PRESTI, Domenico (INFN, section of Catania); Dr AIELLO, Sebastiano (INFN section of Catania)

Presenter: Dr LEONORA, Emanuele (INFN section of Catania)

Session Classification: Vacuum photo-detectors