Slide 1:

Good morning/afternoon,

My name is Marcos Martinez and I are going to speak about the automation of the process of the measure of the tritium levels in water.

Slide 2:

So that I can explain you what is the aim of this task I have structured this presentation in three parts:

-First I will introduce the problem.

-Second I will explain this method to level of one channel.

-Finally I will conclude extending this explanation to several channels.

Slide 3:

We need to use SiPM in the Tritium Project for several reasons:

-First we need to use SiPM because this one have a bigger PDE (50%) than PMTs (30%). We will want detect low levels of the activity, i mean, we will have few events per second so is very important that our detector which are very efficient.

-Second SiPM need a lower supply voltage, of the order of tens of volts, than PMTs, which need high voltage. This is important too because the finally place of the detector won't have electricity and we want that this detector will be self-sustaining with photovoltaic card or something like this. Therefore we cannot develop a detector which consumes a lot of energy

but we have found new problems with SiPMs which we didn't have with PMTs:

The main problem is that the gain of the SiPM have a big dependence with the temperature. If we want to use this detector for monitor the level of the tritium in the water we need that the SiPMs have a constant gain so we have developed a method which allow maintain a constant gain which is fundamental to this project since there's not exist a exhaustive control of the temperature in the final location of the detector.

Slide 4:

SiPM is a two dimensional array of pixels, which can detect a photon every one

The model of the SiPM which we have used for do this task is this one. The main reason is that this one have a peak in his photo detection efficiency spectrum very near to the peak which we can find in the emission spectrum of the fibers, which we use in our detector. In this way we get optimize the efficiency of the detector, which we have already seen that this is very important.

The model, which we will use in the final prototipe, is this. This model have the same parameters of this one but this have a bigger active surface.

Slide 5:

Now I am going to show you how we can maintain a constant gain of SiPM, I mean, I am going to explain this method to level of one channel.

For I do this task,

* First I will speak about the experimental instrumentation which i have used.
* Second I will explain how you can calculate the gain of the SiPM from it charge spectrum.
* Third and fourth I will show you the dependences which exist:
  + On the one hand between gain and temperature.
  + On the other hand between gain and supply voltage
* Finally I will explain you the method which we have developed for compensating the change in the gain due to a change in the temperature with a change in the operational voltage.

Slide 6:

About the experimental instrumentation:

* First we have used a control system of the temperature which is necessary if we want work with SiPM.
* Second we have used two voltage generator so that I fed the SiPM and the card.
* Third we have used a diode LED, which emits photons to 435 nm and this one pretend to simulate the centelleated photons by the fiber. Moreover we used a pulse generator for fed this LED.
* Fourth we have used the SiPM which i have named before
* And Finally we used a card with a gain of one hundred seventy to twenty five degrees which transform the out signal of the SiPM, which is in current, to a voltage signal, which we need for analyzing this pulse with the oscilloscope.

Slide 7:

Now I are going to explain how we can calculate the gain of the SiPM.

The signal which we obtain from this system this where you can see several heights of the pulse which are associated which several number of pixels turn on simultaneously.

Moreover we use the synchronization signal like trigger. In this way i can split the signal of the system and other events which only are going to contribute in the background. Therefore I don't want to use this events in my analysis.

So that I calculate the gain of the SiPM I only have to calculate the gain of the system and I extract to this value the gain of the card like you can see in this equation.

Slide 8:

We calculate the gain from it charge spectrum. So that I obtain the charge spectrum I integer the signal in a temporary windows.

This windows have to be as narrow as you can because, in this way, you reduce the possible contribution of this events which, as I said before, only are going to contribute in the background. In this case this windows is about five hundred nanoseconds.

Now, you save this result in a histogram. In this histogram, which is a charge spectrum, you can see several Gaussians, which are associated with several height of the pulse. Therefore this Gaussians are associated with several number of the pixels, which have been turn on simultaneously. For instance, in this example, you can see from one until seven pixels.

In this calculate you have to take into account that the first Gaussian is associated with the pedestal of the system. The pedestal is the out signal of the system when the in signal is zero so I have to study the pedestal and extract to the histogram.

Slide 9:

Finally we have developed a macro with ROOT for analyzing this spectrum.

Between many things, this macro find the peaks of every Gaussians and plot this one in front of the number of the pixels.

Afterward, this macro fit this plot to this equation from which we can obtain the value of the gain. You have to remember that this gain is the gain of the system and you have to extract the gain of the card.

Finally, in this case, we obtained this value and if we compared with the value provided by Hamamatsu Photonics, we can check that the relative error is less than 6 percent so we can considered that this method is good.

Slide 10:

Now I am going to show you two dependence.

On the one hand I show you the dependence between the gain and the temperature. So that I obtain this dependence I have taken measurements in the range between fifteen and forty one degrees since this is the range of temperatures to which our detector will be subjected in it final place.

On the other hand I show you the dependence between the gain and the supply voltage. So that I obtain this dependence I have taken measurements in the range between break down voltage and this one plus five voltage.

Slide 11:

In this slide you can see the dependence between the gain and the temperature and the parameters of this fit. You can see that this is a really good fit which we have checked with a chi square test

Slide 12:

In this other slide you can see the dependence between the gain and the supply voltage and the parameters of this fit. You can see again that this is a good fit, which we have checked with a chi square test. Moreover from this fit we have calculated the value of the break down voltage and If you compare this value with the value provided by hamamatsu photonics you can see that there's exist a relative error of approximately zero point zero four percent.

Slide 13:

Finally, from both dependencies and with help of a mathematical development, we obtain a equation which tell us what is the variation in the supply voltage which maintain a constant value in the gain when a variation of temperature had happened. We have to take into account that, in this equation, we need a reference situation in both, supply voltage and temperature, whose value of the gain is the value which we will maintain constant. We have checked this method in this case in the range of temperature between twuenty one and twenty nine degrees.

Slide 14:

In this slide you can see the results of this testing where you can see that the maximum variation is about five over seven hundred fifteen which give us a maximum relative error of zero point seven percent.

Moreover we have done a fit of this values to a constant whose result have a relative error less than zero point three so you can see that this method have much precision.

Slide 15:

We have already develop a method which allow us to maintain the value of the gain against variation of the temperature.

Now we are going to extend this method for using several SiPM. In this way we can obtain a bigger signal of the tritium over signal of the background.

We have to take into account that the final design of our detector will have a big amount of SiPM so, now, the problem is that we cannot calibrate every SiPM. Moreover we cannot measure the variation of the temperature and we apply the variation of the supply voltage suitable all time.

Therefore we need to develop a method of automate these processes. These process include:

-Obtaining the charge spectrum and, from this one, calculate the value of the gain of every SiPM.

-Doing this task for several temperatures and several supply voltage and, from this, obtaining all parameters of the previous fits.

- This card will have a database where all parameters of every SiPM will be saved.

- Finally this card will apply a suitable variation of the supply voltage when a variation of the temperature have happened. This task will do automatically with help of some microprocessor, like arduino mega, and some control program, like LabView, which we will have to program properly.

Slide 16:

We don't know what is the number of SiPM which will contain our final design of the detector. We will have to study this one with several simulations. By the moment we will start with a first prototype which only will contain four or eight channel in which we will can check this concept.

So that we build this prototype we will rely on the experience which we have in several previous experiments like NEXT-100 which you can see in this slide.

This card will have some electric dispositive which allow activate or desactivate every channel for doing the task of calibration one to one. A good choice for this electric dispositive would be relays because this allow a physically split of every signal. In this way a signal from a channel will cannot be affected by the signal of the other channel which are desactivate. Moreover this card have several operational amplifiers which allow us obtain the signal of every SiPM with several amplifications.

10-15 minutos.