Stages LNF 2002

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MDT chambers cosmic ray test

Goal of the stage:

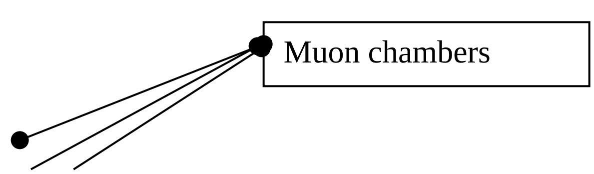
The goal of my work is to test the electronic noise of the MDT (Monitored Drift Tubes) Chambers, which will be a part of ATLAS (A Toroidal LHC ApparatuS) experiment.
One of the main purpose of this experiment is to prove the existence of the Higgs Boson, a particle previewed by the standard model. In ATLAS there will be several hundreds of muon chambers, and here in Frascati we are producing 94 middle size chambers (Fig.1). The others MDT chambers are being produced by other research institutes in several part of the Europe. The final detector will have a length of about 24 metres. Each MDT chamber is composed by several drift tubes (depending on the size of the chamber).
When an ionising particles passes through the chambers an electronic signal is generated in the tubes and collected by front-end and read-out electronics. A CPU VME downloads and stores data on a computer disk. In these chambers, electronic noise could produce spurious data, decreasing the efficiency. My work could be divided into three main items:

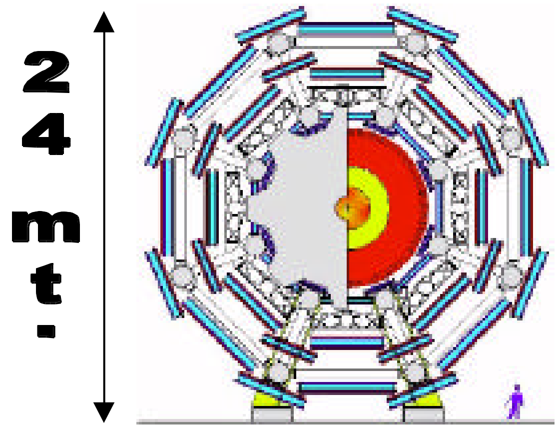
1. Acquire the signal coming from the chamber;
2. Analyse the data collected and produce histograms that show the noise ratio (Fig. 5);
3. If there are noisy channels, with a feedback approach, look for causes and repair it if possible.

Instruments used:

For the acquisition of the events and for formation of the trigger:
- Six couples of scintillators (Fig. 1)
- Phototubes (Fig. 2)
- Low Threshold Discriminator
- Coincidence Logic Unit (AND)
- OR Logic Unit
- Mezzanine cards (Fig. 3)
- CSM adapter
- CSM (Chamber Service Module)
- CPU(Central Processing Unit) VME (Versa Module Eurocard)
- Personal Computer
- Low-voltage generator
- High-voltage generator (Fig. 6)
- High-voltage splitter boxes

Diagnostic instrumentation:
- Digital oscilloscope
- Tester (Voltmeter)





Section of Atlas

Notions learned:

- Functioning of software and hardware applications for the acquisition of events by the CSM;
- Process of trigger formation;
- Function of electronic components in that process (mezzanine, CSM?)
- Filtering process of AND system and OR system;
- Binary code and its conversion into decimal and hexadecimal code.
- Utilisation of Linux and Lynx OS operating system, and the data analysis Octave on the PC.

Programs used:

- MDT acquisition software: it permits to format mezzanines, to receive data from CSM and storing them on the PC hard disk.
- Octave: on the basis of the events, it could elaborate histograms of all the mezzanines or of a single channel.

Structure of MDT chambers:

The MDT chambers are composed by two multilayer separated by an aluminium frame called "spacer". Each multilayer is composed by three rows of drift tubes filled with a mixture of $ArCO_2$ (93; 7) which is a gas that could be easy ionised when a cosmic particle passes through it. Each drift tube is made of an external aluminium cylinder with a wire of Tungsten and Rhenium (98; 2) in the centre, plated with gold. When a ionising particle passes through the tube, the gas is ionised and then attracted by the wire, producing an electric signal that is collected by the front end electronics. In both ending parts of each drift tube there are the insulating endplugs to make not the tubes leak and to maintain the correct wire location.

The trigger:

The "trigger" is a signal, which starts the acquisition of the events by the PC and it informs of the passage of an ionising cosmic particle through two couples of scintillators that are made of a material, which generate light when a charged particle passes through it. Generally is composed of plastic that contains special elements that are easily excited by the passage of a cosmic particle and, decaying

A scintillator also acts as an optical way guide, to address the photons produced towards a phototube (Fig. 2). The scintillators and phototubes are carefully wrapped in black plastic and tape so that no external light can get into it to give false signals (Fig. 1).
A phototube is a device that turns a small light signal into an electric current. Light striking the first electrode produces one or more electrons by the photoelectric effect. A sequence of electrodes arranged at increasing voltage, provides as an amplifier, which turns this initial small current into a measurable pulse of charge that can be converted to an electronic signal and recorded by a computer.
The signals outgoing from the phototubes are sent through a wire to a **discriminator**, which transforms analogic signals into digital ones. The signal coming from the discriminator is sent to a Coincidence Logic Unit. This receives 6 signals, one from each couple of scintillators, which inform of the passage of a ionising cosmic particle through them; the scintillators are disposed in this way: three couples over the MDT chamber, and other three couples, under it; for this, it's possible to know if the trajectory of the particles was secant to the MDT chamber. The trigger signal is the result of all possible coincidences between the upper and lower couples of scintillators. So each particle that crosses one of the three upper and one of the three lower couples of scintillators generates a trigger signal. This signal is sent to the **CSM** board and starts the acquisition. The CSM board provides the trigger signal to all the front-end electronics (**mezzanine boards**), mounted on the chambers, and collects all the data coming from them. The mezzanine performs the following operations (Fig. 3):

1. Amplifies the signals from the tubes;
2. Shape the signals in order to be processed;
3. Measures the arrival time of the signals with respect to the trigger;
4. Send data to the CSM board.

These data are finally sent to a PC by Ethernet **CPU VME** (Fig. 4 and 6)**.**

Data acquisition and analysis:

During the setup of the chamber, several problems have been met. First, there were some problems with high voltage splitter box in which there were two short circuited channels. This problem was discovered checking the splitter box with a voltmeter. The problem was solved reconnecting the channels. An other problem found in the trigger signal logic, was the output of the OR module broken, discovered observing the output signal with an oscilloscope. This problem was solved using the other module output.

Before starting the data acquisition with the trigger signal, in order to check the noise of the BML MDT chamber, it is necessary to acquire data with a random trigger signal. This kind of trigger can be generated using an electronic module called DUAL-TIMER that provides a signal uncorrelated with the one coming from the chamber. This allows to check the level of noise present in each tube of the chambers. Once the data has been acquired, the noise analysis can be performed displaying the histograms of the number of events occurred versus TDC channel number (that is, tube number) as shown in figure 5. The noise frequency can be calculated multiplying the number of hits by number of events acquired (100000) and by the TDC gate (1.6 μsec). From figure 5 it can be seen that, when the high voltage is ON, the noise level is about 6 kHz in each mezzanine with a maximum of 12 kHz in the mezzanine number 11.
The best mezzanine has a noise level in each tube of about 200 Hz, while for the worst one there are 6 kHz of noise in tube number 4. Probably noisy channels can be due to a bad electric contact between the tubes and the faraday cage.
A part one tube the noise level in the whole chamber is acceptable. Then it was possible to use the real trigger (generated by the scintillators) to acquire the signal coming from chambers. In this way the collected values are related to the ionising particles that cross the chamber and the scintillators. The analysis of the data shows a TDC spectrum (time of arrival versus number of hits) as reported in figure