Analysis of the first calibration data on the electromagnetic calorimeter of ATLAS

ATLAS collaboration at the LHC (Cern)
for the detection of the Higgs boson

Julien Baglio
Activity report, work done under Caroline Collard's supervision
ATLAS collaboration from the LAL laboratory

December 26, 2006

collard@lal.in2p3.fr - baglio@lal.in2p3.fr

Abstract

From May 29th to July 14th, I ran my L3 stage in a particle physics laboratory. I will present the laboratory which welcomed me, and then a small presentation of my work will be raised. Actually, it was about the analysis of data taken from beam tests in February 2006.

1 The laboratory

I obtained my internship during the Easter holidays, after having tried to go directly to CERN, using their summer student programm. After having been refused, I looked for an intership on internet website of particles physics laboratories in France. I contacted myself the laboratory where I have finally gone, and it was the Linear Accelerator Laboratory.

The Linear Accelerator Laboratory (LAL) is a CNRS laboratory working in particle physics, astrophysics and cosmology fields. It is located on Paris-XI University Campus, Building 200, in Orsay (France).

It was created fifty years ago. There are about 300 people working in it, including 65 scientists. Its name is connected with the old experiments that were made in the sixties, when a linear accelerator existed in the laboratory. Nowadays, it has been removed and the LAL laboratory essentially works within international teams : ATLAS, LHCb experiments in CERN (Geneva, Switzerland), D0 in Hamburg (Germany), BaBar in SLAC (Stanford, USA) etc....

2 The work done during the intership

I have worked within ATLAS team of the laboratory. My supervisor was Caroline Collard.

There are 17 people in the ATLAS team of LAL, working on the electromagnetic calorimeter of the detector, and involved in the detector and events simulations. In 2008, when the LHC accelerator will run, the team will also be involved in the data analysis, especially the analysis concerning the Higgs boson search.

2.1 Some theoretical recalling

This part explains the aim of the ATLAS project, that is to say the aim of my work.

The Standard Model of particles physics was created in the 70's, after 30 years of great effort to obtain a solid basis upon which the description of elementary particles and their interactions should rely on. It is based on gauge groups theories describing strong force, weak force and electromagnetic force : $SU(3) \otimes (SU(2)_L \otimes U(1)_Y)$. Electromagnetic forces are those who take account when dealing with the cohesion of matter, and they are involved in lots of aspects of our lives : how light works, what electricity is, how our television and our radio work, etc... Strong forces are necessary to bound together the components of the core of an atom. Finally, weak forces are involved during radioactivity processes.

Within the model, all particules mediating the interactions, called gauge bosons, are massless. Nevertheless, it is not the case for the weak force : the Z boson, for exemple, has a 90 GeV mass. In order to explain why the weak bosons are massive, another new particle has been introduced which should interact with the weak bosons, giving them their mass : the Higgs boson, which is the main target of the ATLAS detector, as this particle has not yet been observed for the last thirty years.

2.2 The calibration of the calorimeter

I worked on the electroagnetic calorimeter in ATLAS, which is used to detect the energy of the photons which should be created by the desintegration of a Higgs boson in the 120 GeV region. It is essential to understand very precisely how the calorimeter behaves, that is why the calibration analysis are very important.

The first week was devoted to the analysis of February 2006 data, in order to detect broken channels within the calorimeter. It was also a training in ROOT, the main software in particle physics, for me. Here are some graphs :

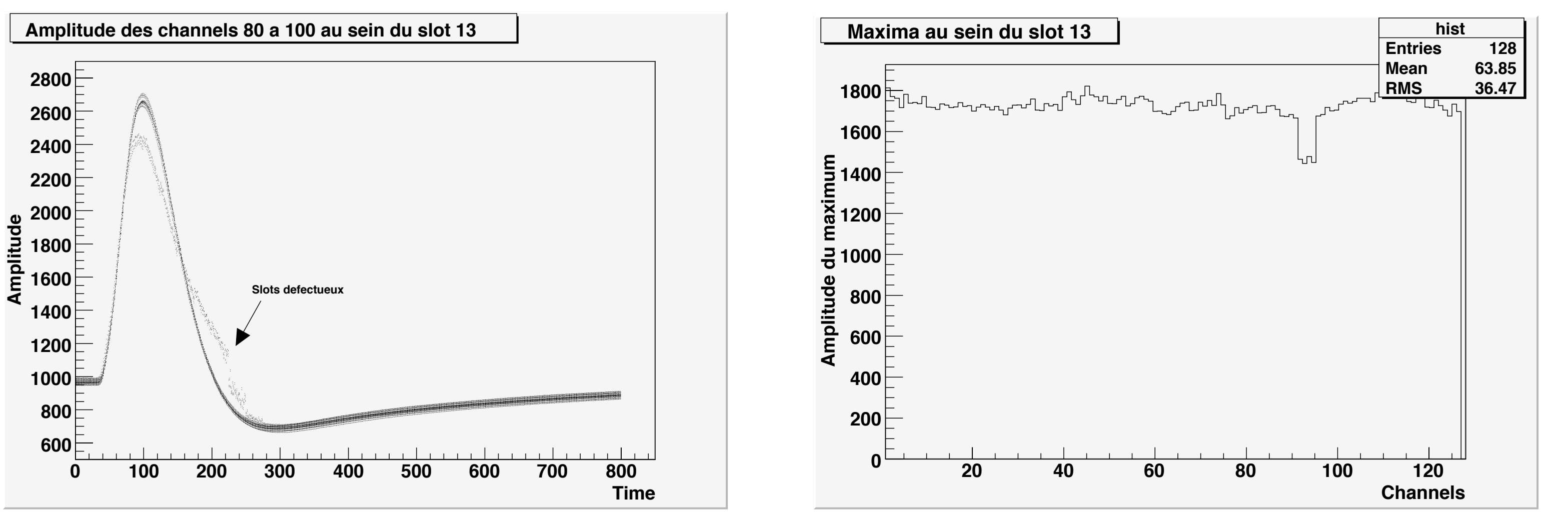

Figure 1: Calibration signal detected by the calorimeter in slot 13

They teaches us that channels 91 to 95 within slot 13 do not work well, as their maxima are not like that of the others within the slot.

Then, I entered in the main part of my work : the simulation of the signal given by calibration, which enables the ATLAS team to understand precisely the consequences of the electronics on the physical signal produced by the calorimeter, and helps the team to predict the signal form.

I worked on that modelisation :

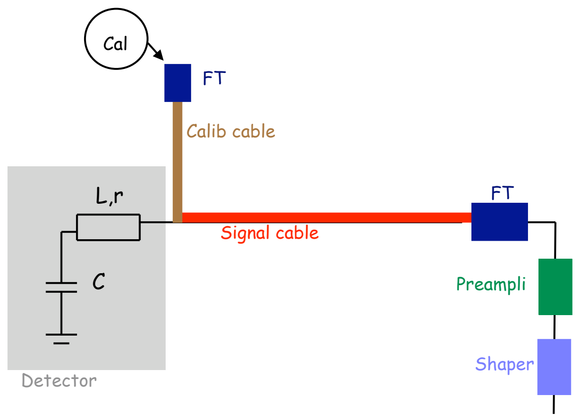

Figure 2: Electrical modelisation of the calorimeter

L indicates an inductance, C a capacity and r is for a resistive component. The two free parameters of the model are T_{shaper}, which concerns the shaper used to extend the signal as there is one collision per 25 ns in LHC ; and $Z_{\text{line},s}$, which is the impedance of the red circuit.

I did first some Fourier analysis in order to remove some frequencies which were useless for me. I decided to cut at 50 MHz. By a least square root method, I determined at best the two free parameters of the models. Here are the results, which are good compared to other simulations produced some months before :

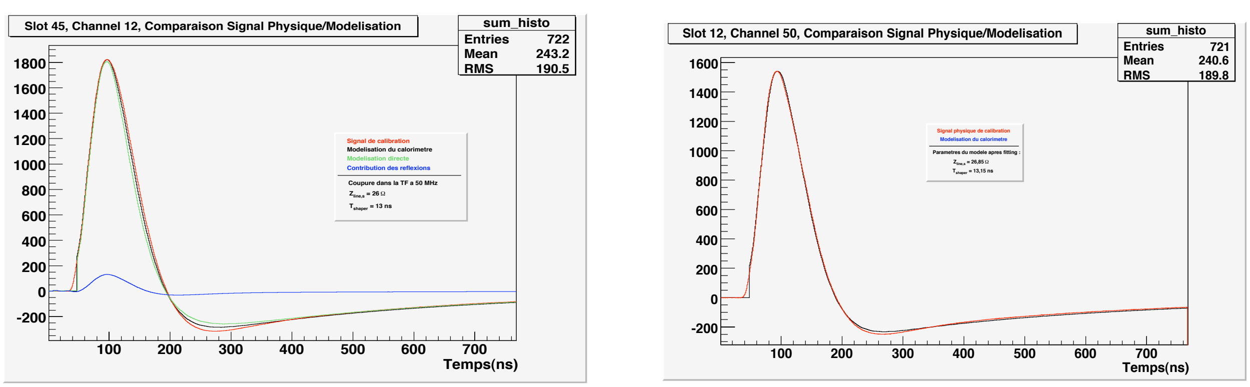

Figure 3: Comparaison between calibration data and modelisation

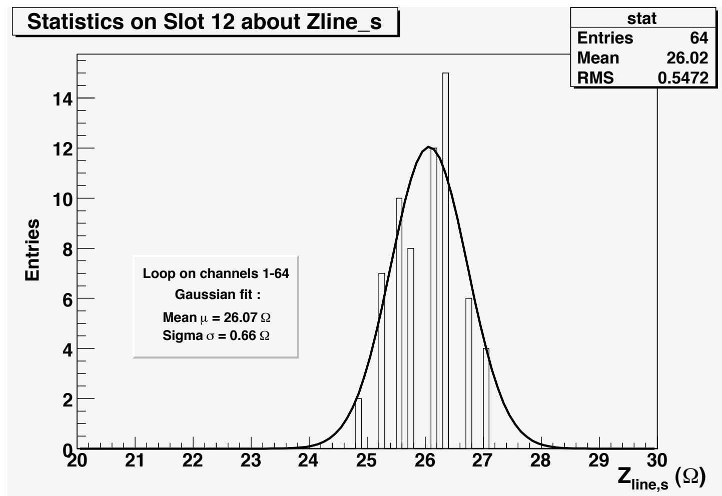

Figure 4: Statistical results on $Z_{\text{line},s}$ within slot 12

The evolution of $Z_{\text{line},s}$ is gaussian type, with an average of 26.1 Ω and a standard deviation of $\sigma = 0.7$ Ω.

3 Conclusion : what I have learnt, future and prospective

I ended my internship the July 14th. The month and a half I lived in this laboratory have learnt me two important things : C++ programmation and its use in particles physics, and how particle physics detectors work, especially calorimeters.

It has reinforced my will of working in that field, and I would like to thank you all the people whom I work with.

What is the future of ATLAS experiment ? Since September, a new test period have began, using cosmics muons. It has produced exciting results, especially for the electromagnetic calorimeter as it reproduced the signal form on which I worked. The detector should be achieved in summer 2007, and the LHC is to work at the end of the year 2007.

A Pictures of ATLAS

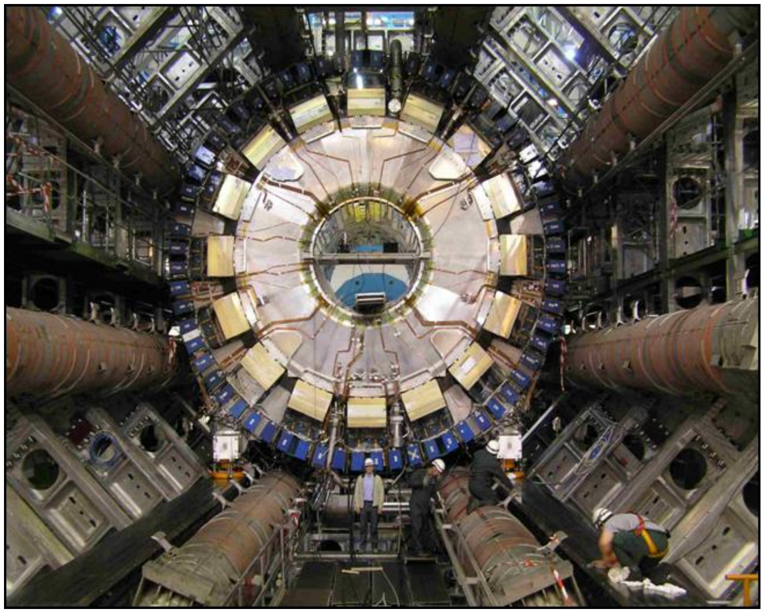

Figure 5: ATLAS detector in construction in CERN (picture taken in november 2005)

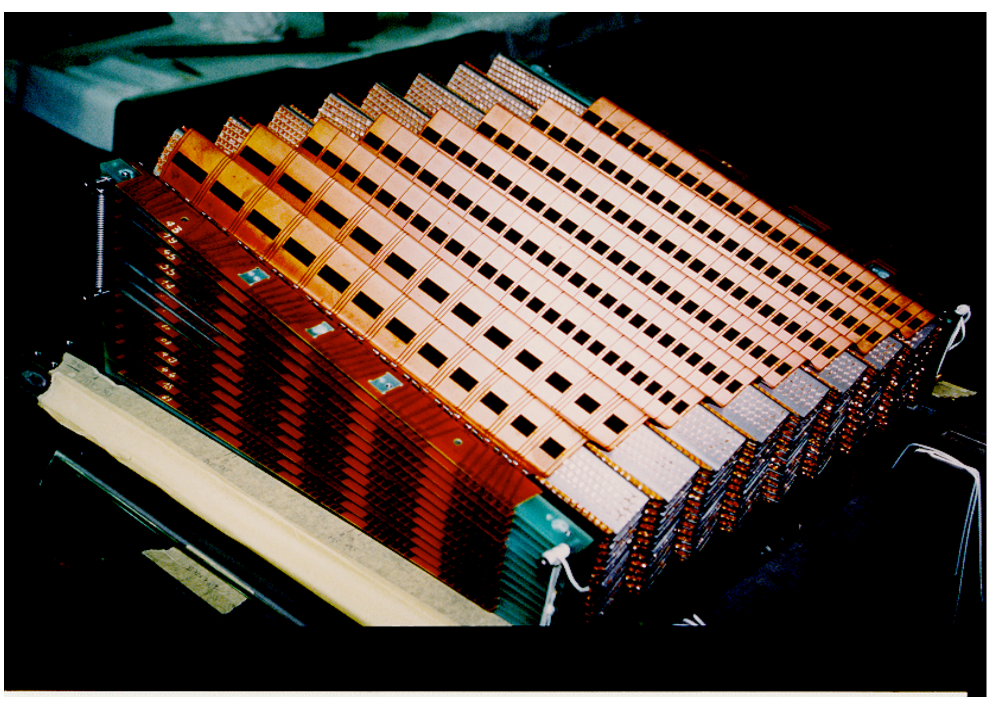

Figure 6: A part of the electromagnetic calorimeter

References

[1] Equipe ATLAS, *ATLAS au coeur de la matière*, L'actualité du LAL (2006).

[2] The ATLAS Collaboration, *ATLAS Detector and Physics Performance*, Tech. report, CERN, 1997.
URL : *http://atlas.web.cern.ch/Atlas/TDR/caloperf/TDR.bk.ps.gz*

[3] Lionel Leukermans, *Etalonnage du calorimètre électromagnétique d'ATLAS et recherche du boson de Higgs dans ses désintégrations invisibles*, Thèse de Doctorat, Laboratoire d'Annecy-Le-Vieux de physique des particules, 2002.

[4] P. Perrodo L. Neukermans et R. Zitoun, *Understanding the ATLAS electromagnetic barrel pulse shapes and the absolute electronic calibration*, ATLAS Internal Note, ATL-LARG-2001-008 (2001).