ATLAS TOMOGRAPH FOR THE MUONS CHAMBER TESTING CONTROLLED BY BRIDGEVIEW – LABVIEW FOR INDUSTRIAL AUTOMATION

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1 ABSTRACT

In the LHC[1], 27 km, we are installing detectors at various points. To detect the trajectory of the muons, they use the drifts (1,200) made in various laboratories and calculated by the detector ATLAS. These muons rooms consist of tungsten wire 50 um thick placed inside an aluminum tube 30 mm in diameter and 0.4 mm thick. The tubes are laid in layers and piled three or four thick.

A tomograph (scanner) defines the position of wire in the room and the distance between two wires with a precision of um. It uses two narrow x-ray beams that successively light sections of the room, while two scintillators record the profile of absorption. We record all the data in a VME interface and a PC running BridgeVIEW.

We use the BridgeVIEW application to supervise the tomograph. The application manages the ordering of the displacement of X sources, as well as the data acquired by the VME interface. Simultaneously, ATLAS controls the entire tomograph environment (temperature, moisture, pressure, etc.), manages the feedings for X sources, and maintains access control in the clean room.

2 THE CHALLENGE

The challenge of this application was to create a simple, easy-to-use program that was precise enough to control and test a Muons chamber and work effectively in a large proton collider.

3 THE SOLUTION

We built a test system using, first using LabVIEW from scratch to communicate with the VME crate through MXI™-2. We were able to scale our work to various platforms for this application, and used several different types of National Instruments hardware. We could not have completed our project without the ease of use and the scalability of LabVIEW, as well as the hardware from National Instruments.

We produced only one user interface, and grouped all I/O from different interfaces. We started with

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[1] Large Hadron Collider

LabVIEW, and easily ported it to BridgeVIEW – LabVIEW for Industrial Automation, without any reprogramming.
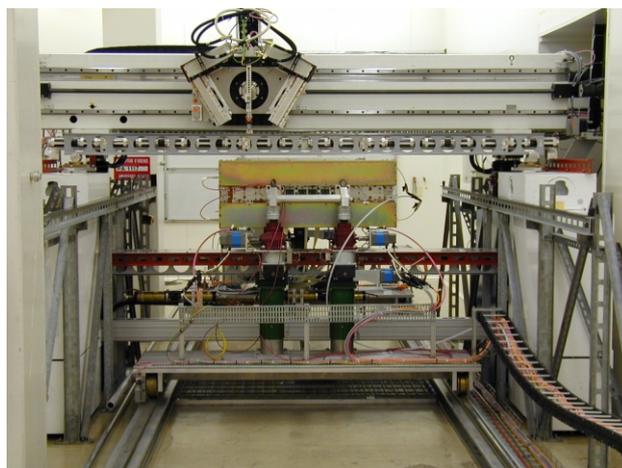

Figure 1: Muons Chamber under Test
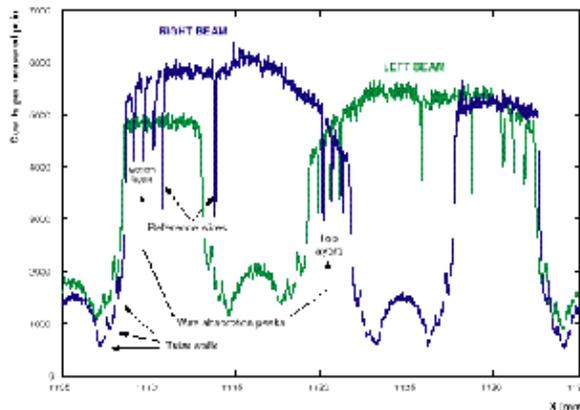
Figure2: Results of a Measurement

On Figure 1, you can see the chariot where the two X-ray beams are. They are on a rail, which moves from left to right. On the bottom, you can see the tiltmer, which counts the number of particles that arrive there. You can then define the graph like the one we do have on Figure 2. On Figure 2, we can see the two beams in which the position of the inverted center peaks indicates the position of the wires.

4 OUR GOAL

The ATLAS experiment is using 1,200 Muons chambers built in different laboratories around the world. The tomograph is a quality control tool that makes it possible to know the position of wires in the Muons chamber room, and the distance between two wires with a precision of 5 um.

To measure the distance between two wires, we place two X-ray sources on a mobile chariot at a certain angle with a V shape. These sources emit photons that are collected by scintillators through absorption as the photons pass through the room. Therefore, we can determine the location of the wires.

5 APPLICATION

We divided the architecture of the whole system in three different parts:

5.1 Acquisition

We collect the data of the two scintillators, the chamber temperatures, the chariot position in the four axes, as well as the temperature, humidity, and pressure of the room with a VME system. We wrote the program using C for an OS9 CPU system. We gather the data on a PC through a VME-MXI-2 interface. There are two different measurements – passive and active. The active measurement is the same as the passive one, with the exception that the gas (CO_2) in the tubes and a high voltage (4 kV) goes through the wires. We monitor the temperatures of the room with a NI-CAN™ interface.

5.2 Security

A S7 Siemens PLC assures hardware and personal security. Its role is to supervise the cooling system and the power supplies of the tubes for the X sources. The PLC also controls the water temperature and throughput. In addition, it supervises and controls the room access. The communication with this S7 PLC and the PC is done with a PC1500PFB PROFIBUS board.

5.3 Control Equipment

A Pentium PC with Windows NT manages all the system. All information of acquisition, command, or security arrives on the PC by different ways. We use several different means of communication, including RS-232, PROFIBUS, VME-MXI-2, and CAN.

Because the PC manages all these different communications, it must adapt to the surrounding configurations in addition to the PLC and VME, motion control for carriage displacements, scintillators with the chain of cable, and the reading of the Heidenhain rule.
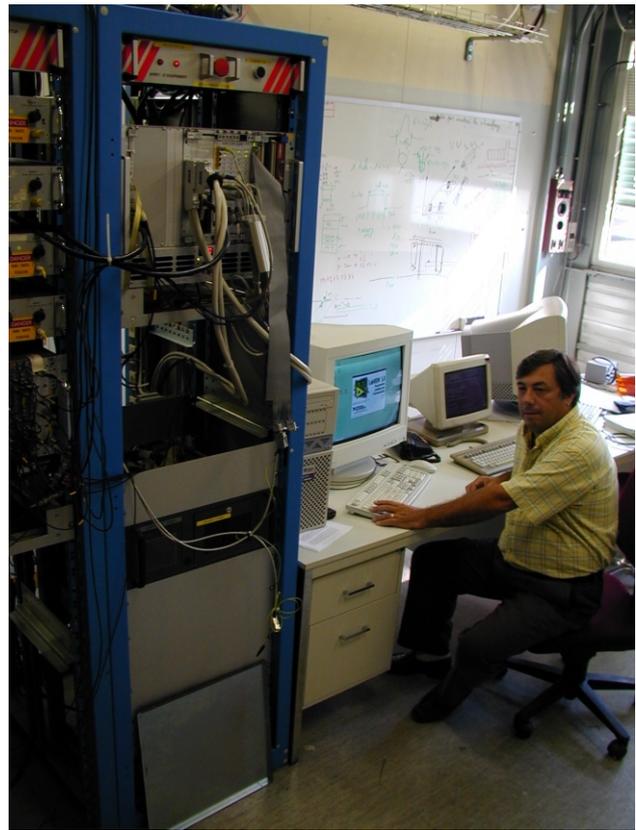
Figure 3: Control System

We initially controlled this application with National Instruments LabVIEW. When we decided to switch to National Instruments BridgeVIEW – LabVIEW for Industrial Automation, we were able to port the code unchanged.

On Figure 3, we can see the control application. The application itself (Figure 1) and the control part are in two different rooms. This is related to the X-rays radiation that appears during the test. This control room is made with a desktop PC, where we control a VME chassis through a PCI-MXI-2 interface from National Instruments. Therefore, we can share the memory of the VME controller (OS9 controller where a C program is running) with the desktop PC.

6 ATLAS EXPERIMENT

These tested MUONS chambers will then be used in the ATLAS detector. You can see a schematic of this one at Figure 4. Modern detectors consist of many different pieces of equipment that test for different aspects of an event. These many components are arranged in such a way that physicist can obtain the most data about the particles spawned by an event. The pieces of the detector are following:

The Beam Pipe: (red part on Figure 4) runs along the center of the detector, and carries the beams of protons. The protons travelling in opposite directions through the pipe collide at the middle of the detector.

Tracking Detector: (pink part on Figure 4) The inner region of the detector is filled with highly segmented sensing devices made from strips of silicon, so that charged particle trajectory can be very accurately determined.

Solenoidal Magnet: (gray part on Figure 4) The path of a charged particle curves in a magnetic field. The radius of curvature and direction tell the momentum and the sign of the charge. The solenoidal magnet is a large coil of wire would cylindrically to generate a straight uniform magnetic field inside the coil.

Electromagnetic Calorimeter: (yellow part on Figure 4) This device measures the total energy of e^+, e^- and photons. These particles produce showers of e^+/e^- pairs in the material. The e^-'s (or e^+'s) are deflected by the electric fields of atoms, causing them to radiate photons. The photons then make e^-/e^+ pairs, which then radiate photons, etc… This cascading sequence is called an "electromagnetic shower." The number of final e^+, e^- pairs is proportional to the energy of the initiating particle.

Hadron Calorimeter: (green part on Figure 4) This device measures the total energy of hadrons. The hadrons interact with the dense material in this region, producing a shower of charged particles. The energy that these charged particles deposit is then measured.

Muon Toroidal Magnets: (tubes on Figure 4) The path of a charged particle curves in a magnetic field. The radius of curvature and direction tell the momentum and the sign of the charge. The Muon Toroidal Magnets create magnetic fields to study muons. They are pipes with cables running through them that carry currents. The currents of all eight toroids generate a cylindrical magnetic field that runs through the center of the toroids, surrounding the inner portion of the detector.

Muon detectors: (blue part on Figure 4) Only muons and neutrinos get this far. The muons are detected, but the weakly interacting neutrinos escape. The presence of neutrinos can be inferred by the "missing" energy.
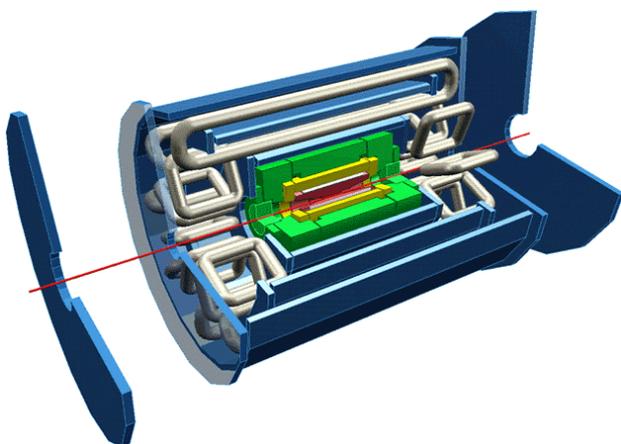

Figure 4: schematic diagram of the Atlas detector

7 CONCLUSION

National Instruments products greatly helped to realize this experiment and test these chambers which will be used in the LHC ring. We chose the National Instruments BridgeVIEW graphical SCADA development environment to create user friendly graphical user-interfaces (GUI). We designed the GUI so that anyone from any technical background could manipulate and use it.

8 MATERIAL USED

In this experiment, we used the following hardware:

- VME-MXI-2
- PCI-MXI-2 – shared memory with a CPU FIC8232 with OS9 OS
- AT-232 – five lines to control two power supplies for X sources, nine positioning motors, and one tiltmeter
- One DIO-96 to control the motors
- One AT-MIO-16E-1 board controls the room information
- BridgeVIEW – LabVIEW for Industrial Automation
- One PC1500PFB uses the PROFIBUS protocol

REFERENCES

[1] Christian Déchelette, CERN, Rte de Meyrin, Geneva, tel 022 767 6373, e-mail: christian.dechelette@cern.ch

[2] http://www.cern.ch/atlas ATLAS experiment tour.