Implementation of a Remote Session of Practical Work in Nuclear Physics on the Backscattering of α-Particles

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A. Fahli , A. Aït Taleb and M. Moussetad
Hassan II University, Mohammedia – Casablanca, Morocco

***Abstract*—This work presents the implementation of a hardware and software package used to conduct a physical experiment via the web to create remotely a practical work laboratory. For this reason, we chose to put online a model of experiment concerning the backscattering α-particles on a target material.**

***Index Terms*—e-lab, Backscattering of α particles, Card-based microcontroller, Web-base laboratory, Web-server.**

I. INTRODUCTION

Web-based laboratory environment is a distributed and flexible framework which allows a learner to perform experiments by interacting with real devices which are instruments and/or remote real mechanisms, through a suitable platform for telecommunications, with a system dedicated for the management of a number of software and hardware interfaces [1, 2 et 3].

The major challenge in this project is the conservation benefits of operational and educational experience, which requires a sufficient degree of interaction through the introduction of advanced solutions related to new information technologies and communication ensure environmental perception and evolution of the experiment. The user interface via the Internet is chosen as a communication medium [4].

II. CRITERIA OF CHOICE THE EXPERIMENT

The choice of the α-particles backscattering experiment is justified by the fact that it contains certain number of necessary operations for most part of the remote experiments. It requires the use:

Of a measuring chain, it consisting of a sensor (semi-conductor detector), amplifier and formatting stage and a counting stage.

Of a command and control parameters chain of the experiment, in our case, a chronometer for the management of the measuring intervals and an electro mechanical system (actuator) with its power supply unit, for the rotation angle command of the radioactive source support.

Of a server, this must handle requests from client (s) and ensure dialogue with the measurement and control interfaces. On the customer side, the browser has, through HTML pages, allowing the user sending the experimental data configuration, the reception, and the presentation of measurement results and monitoring the experiment progress through video interface.

III. DESCRIPTION AND PRINCIPLE

The backscattering experiment consists on sending α-particles on a golden thin sheet, recover and analyze the scattering particles to determine the target atomic number. It is based on the elastic scattering of incident particles beam (Coulomb interaction) on the target atom.

The principle of this technique uses the phenomenon of elastic scattering. This phenomenon that incidents particles undergo when entering Coulomb field of the nuclei of the target sheet. The energy of the backscattered particles, at a given angle, depends mainly on two phenomena:

- Energy loss of particles during their passage through the material sample (both in the aisle that the return) that depends on the stopping power of the target material.
- Energy loss of α-particles during the interaction, it depends mainly on the mass of the target atom and the projectile.

Figure 1 show the material used to realize this experiment in the laboratory [5].

IV. THE HARDWARE ADAPTATION OF THE EXPERIMENT

To adapt the experiment for making it a distance controlled, we have made changes on the material used. First the target is kept in fixed position, and for controlling the source rotation angle, we used a stepper motor with its gearbox and an electromechanical position sensors. The assembly is installed below the enclosure, and the movement is transmitted through one arm to the source rotation handle.

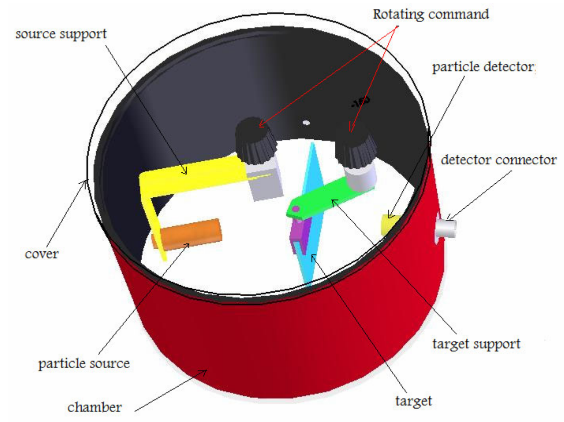

Figure 1. The experimental set up

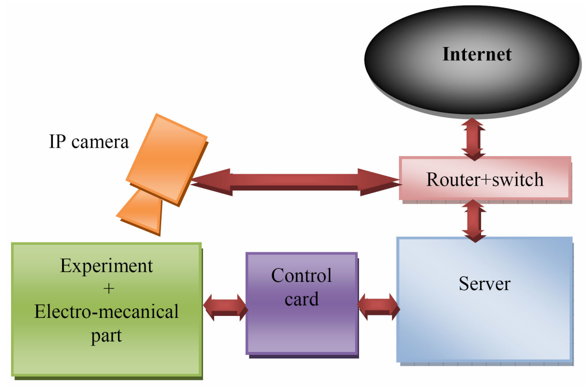

Figure 2. System block diagram

To do the measurement and the control, there is an electronic card-based microcontroller of Microchip family (PIC 16F876). The latter, it is paced by a 20 MHz quartz, and performs a time base of measurement, and ensures the counting operation. Even in a second time, it provides control of the stepper motor through a power interface.

The card is equipped with a four-digit display to monitor, locally, the information received from the server and measurements results. The card also provides asynchronous serial communications with the server, for receive parameters and transmit measurement results, as show in Figure 2.

In addition to this card, an IP camera is used to provide real-time visualization of the experiment.

The server and the camera are connected to the Internet through a router-switch. Most of the bandwidth of the connection is occupied by the video stream of the camera.

V. DEVELOPMENT OF THE SOFTWARE PART

This part focuses on the application web server. The latter, is developed under Visual C++ [6]. It provides communications through TCP / IP sockets with clients and it receives commands and parameters necessary to achieve the measurements, and send results. By another unit, it communicates with the electronic card. Its user interface allows control and monitoring of client connections.

On the client side, the server application provides, through a browser, like Internet Explorer, and HTML pages, the documentation necessary to the success of the experiment. This documentation consists of theoretical and instructions in the manual. In the experiment control, the user has two fields for entering the experiment parameters (values of the angle and duration of measures). In addition, on a list, he receives the results of the measurements.

The client interface provided through an ActiveX, a direct visualization of the experiment.

VI. FUNCTIONAL STUDIES

A. *Study the material part*

1) *Control card*

The card block diagram is shown in Figure 3.

The heart of the card is a Microchip PIC 16F876 [2]. This microcontroller has a set of module in a very small

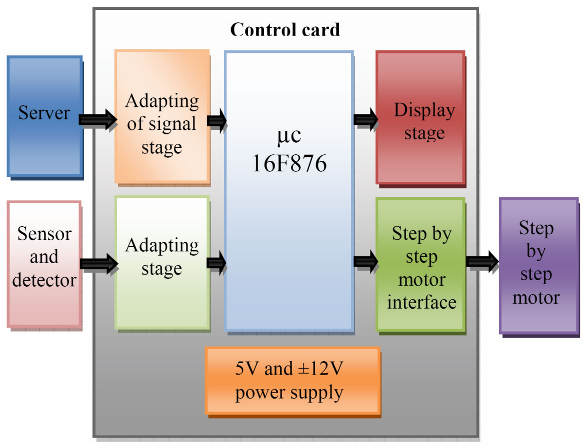

Figure 3. Block diagram of the control card

space. This circuit, over its three ports A, B and C, with 22 pin input/output, it includes three Timers, an USART, and a 10 bit ADC and other units.

The Timer0 is used as time base of duration of measures, while the Timer1 is a 16 bit register, is used for counting the pulses delivered from the detector. However, the USART is used for serial communication with the server. A part of the port A is used for multiplexing of, the display, and the signals control of stepper motor. The port B is used for their controlling. Part of the port C is used to acquire signals from sensors.

A block adaptation transistors-base interposed between the PIC and server to ensure communication. For formatting signals received from sensors, an interfaced block is used before attacking the microcontroller.

To control the stepper motor, a power stage based IC HA13421 is used [7]. The dual-voltage power supplies, 5V power supply to feed blocks adaptation, and PIC, and ±12V to feed the power stage and the serial communication adapting stage.

2) *Electro-mechanical system*

For this part, our job is the motorization of the rotation of the carrier of the source. Figure 4 shows the changes and the shape of the arm. The latter is made in transparent plastic in order not to hamper the observation of the interior of the enclosure.

Figure 5 gives the appearance of the final result.

For the accuracy of angular displacement, the stepper motor and his gearbox, allows an angular resolution of 0.09 degree.

VII. STUDY OF THE SOFTWARE PART

This part consists of two units. One unit is on the PIC 16F876, and the other on the server side.

For the PIC, management of operations is spread over several procedures. The main procedure is responsible for controlling the stepper motor, the display of parameters and results of measurements. Other procedures as time base, counting and communication with the server are in interruptible mode.

On the server side, the application consists of three units. The first unit handles the TCP/IP socket listening on port communication network. A dedicated procedure is

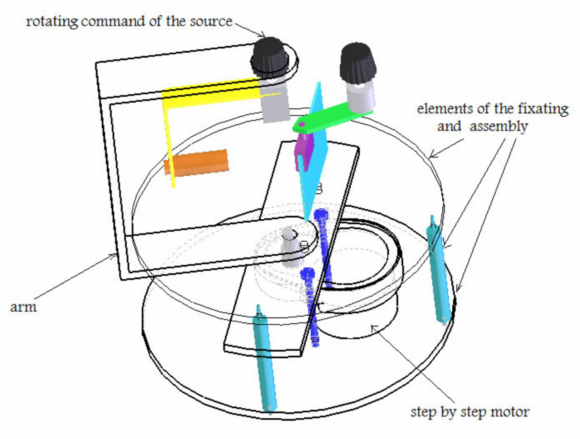

Figure 4. Assembling of the electromechanical

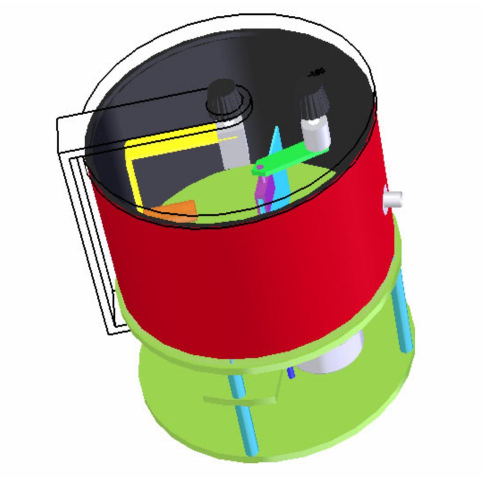

Figure 5. Final version of the motorization system

called by the socket in response to various requests received from clients. The second unit handles the serial communication with the control card. While the last unit, it manages the user interface for monitoring operations, upgrade or configuration.

VIII. CONCLUSION

In this work we conducted an experiment in physics concerning the Rutherford backscattering via the Web. The work presented in this paper proves that it is possible to work practices in line to benefit students. The advantages of such accomplishments numerous:

- Sharing of existing equipment with other institutions,
- Flexibility and freedom of time and space constraints,
- Protection of handling students presenting hazards (radiation ...),
- Reducing the cost of practical work where the material is expensive.

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AUTHORS

A. Fahli is a head of Modelisation and instrumentation laboratory , School of Science Ben M'Sik Hassan II Mohammedia University Casablanca Morroco (e-mail: fahli@univh2m.ac.ma).

A. Aït Taleb is a post-doc student (e-mail: abdellah_aittaleb@univh2m.ac.ma).

M. Moussetad is with School of Science Ben M'Sik Hassan II Mohammedia University Casablanca Morroco (e-mail: m.moussetad@univh2m.ac.ma).

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