Arab J. Nucl. Sci. Appl., Vol. 56, 2, 101-107 (2023)

Paper presented in the 10th African Conference on Research Reactor Safety, Operation & Utilization, Cairo (Egypt) 27 to 29 Nov. 2022, organized by the International Atomic Energy Agency in cooperation with the Egyptian Atomic Energy Authority

ISSN 1110-0451

Arab Journal of Nuclear Sciences and Applications

Web site: ajnsa.journals.ekb.eg

IAEA

Internet Reactor Laboratory IRL: An Effective Tool to Expend Nuclear Education in Africa

Chafik EL Younoussi*, Bilal EL Bakkari, Yassine Boulaich, AND Bouzekri Nacir

National Center for Nuclear Energy Sceinces and Technology CNESTEN

ARTICLE INFO

Article history:

Received: 3rd Nov. 2022

Accepted: 9th Jan. 2023

Keywords:

Internet Reactor Laboratory IRL;

IAEA;

TRIGA;

Core Experiments.

ABSTRACT

The Internet Reactor Laboratory (IRL) project is one of IAEA tools intended to increase the global supply of nuclear education based on the use of research reactors offering an additional option to access operating research reactors around the world suitable for this purpose. Thus, the project can deliver its maximum benefit to countries that are engaged in educating human capital for future nuclear programs but that do not have access to research reactor facilities. The IRL provides access to students from remote locations (guest institutions) to attend online the experiments carried out in a research reactor (Host institution) which are relevant in the process of developing human capacity related to nuclear. The project, launched by the IAEA in 2014, already covers several countries in Europe, Latin America and Asia. In March 2018 an agreement was signed between the National Center for Nuclear Energy Sciences and Technology CNESTEN (Morocco) and IAEA establishing the legal framework of the Internet Reactor Laboratory project in Africa. In This paper we describe the approaches regarding the development and implementation of the IRL capabilities at MA-1 TRIGA reactor and we discuss the content of internet based reactor experiments covered by the agreement. We also present the results and feedback collected after the organization of the first orientation workshop to train the guest institution representatives in the technical, pedagogical and logistical aspects of the experiments to be broadcasted and we outline the future plans of the project implementation.

1. INTRODUCTION

In addition to neutron activation analysis services and radioisotope production for medical applications, the MA-R1 TRIGA Mark II research reactor, operated by the National Center for Nuclear Energy Sciences and Technology (CNESTEN), is used to support research and training activities in the country. The reactor is a standard TRIGA MARK II design of 2MW thermal power, natural-convection-cooled reactor with a graphite reflector and contains 4 beam tubes and a thermal column. The reactor core uses solid homogenous fuel-moderator elements (U-ZrH), developed by General Atomics (Figure 1). First criticality was reached on 2 May 2007, and the commissioning program culminated with the successful completion of the full power ascending testing on 6 September 2007. The operating license was issued by the Ministry of Energy and Mines (Safety Authority) in February 2009.

The reactor provides supports to educational programs for institutions notably (but not limited to) Moroccan Universities. In fact, it is used for classes in nuclear engineering, at both the graduate and undergraduate levels to demonstrate numerous principles that have been presented in the classroom. Also, shorter-term demonstration experiments and practical courses are performed especially for master students.

Corresponding author: elyounoussi@cnesten.org.ma
DOI: 10.21608/ajnsa.2022.172298.1671

Fig. (1): Experimental Hall and reactor bloc (left) / TRIGA fuel elements and Reactor core (right)

The paper gives an overview of the Internet Reactor Laboratory IRL project implementation process at MA-R1 TRIGA MARK II reactor operated by CNESTEN and define the content of internet based reactor experiments that will be broadcasted. The paper describes also the broadcasting system and discuss the feedback from the orientation workshop organized at CNESTEN in November 2021 to prepare the guest institutions for the first transmissions.

2. Education and Training Activities at MA-R1 TRIGA Reactor

The reactor facility is available to provide a multi-disciplinary training: the reactor offers an easily accessible core, different irradiations facilities, an important scope of power variation, the ability to obtain flux maps (vertically) and simple devices to activate material probes used to generate radioactive sources in addition to a wide control room

The reactor educational activities cover nuclear engineering study programme at all academic levels and specialized courses given to master students. The study programmes, developed in French and English, are designed in such way that the theoretical knowledge on nuclear reactor physics given in the university is completed by experiments and practical exercises at the MA-R1 TRIGA MARK II research reactor and other laboratories.

Much of the work performed in education and training (E&T) at the reactor is in collaboration with Moroccan universities. Cooperative programs between the Rector Operation Division and several universities in Morocco have been established.

In Addition to the practical courses given to students in the frame of the CNESTEN support to Moroccan universities, a number of experiments on hands-on-training using TRIGA Mark II research reactor have been performed during several events organized in collaboration with International Atomic Energy Agency (IAEA), including “Workshop on Enhanced Use of Research Reactors for Education and Training Purposes” (September 2013), and “Regional Training Course on the Safety of Research Reactors” (June 2014), 2nd Afra Research Reactor School (November 2017).

3. INTERNET REACTOR LABORATORY (IRL) PROJECT

The IAEA’s Internet Reactor Laboratory (IRL) project was established in 2015 to provide nuclear scientists, students or related background specialists with practical reactor physics experiments. IRL provides a live connection with a research reactor (host facility) so that participants from remote institutions (guest facilities) can access remotely to a reactor and interact with the operators while practical experiments are conducted. The project was launched to be implemented following a regional approach and, usually, is targeted at participants from an IAEA's Member State without a research reactor. [1]

The project is funded by the United States as part of the Peaceful Uses Initiative (PUI) which aims, inter alia, increasing Nuclear Education & Training Programmes through Research Reactor Facilities.

IAEA began to put into place the global IRL project with two host reactor facilities. For Latin America, the host facility is the RA-6 research reactor, which is located at Bariloche research Centre (Centro Atómico Bariloche) in Argentina. In Europe, the previous host facility was the ISIS research reactor at the Saclay research Centre in France. Actually the VR-1 Research Reactor in the Czech Technical University in Prague is acting as host facility. Both reactors have been used extensively in both national and international nuclear education and training [2].

The IRL project was extended to Asia and Africa by the designation the MA-1 TRIGA Research Reactor operated by CNESTEN in Morocco and the AGN-201K zero power reactor of Kyung Hee University in Korea as host facilities for this project.

3.1 IRL project implementation in Africa:

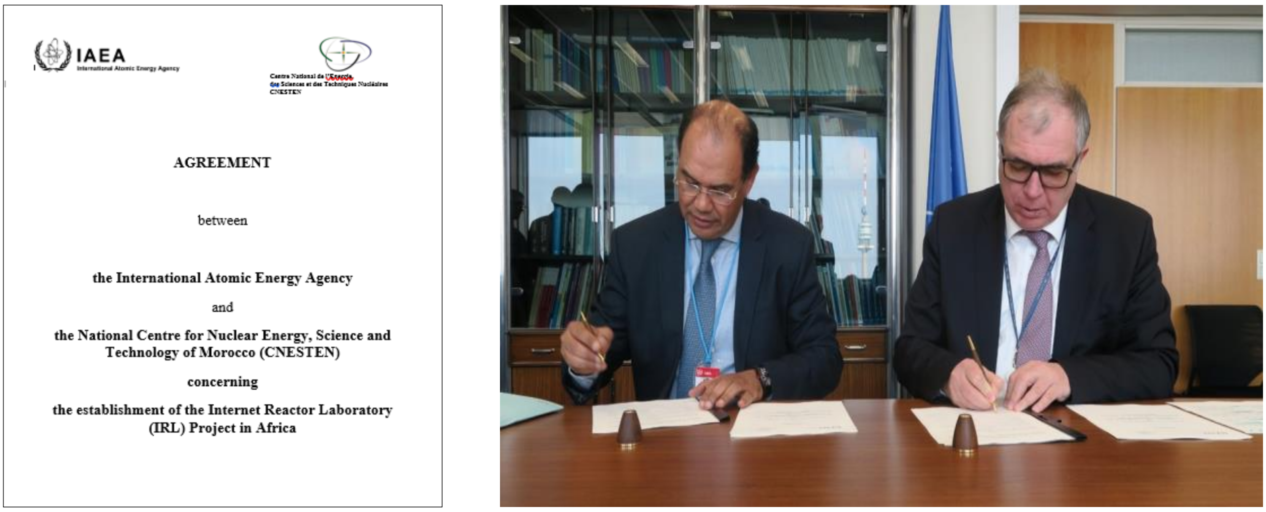
After the successful implementation of the project in Europe and Latin America, the IAEA and CNESTEN signed an agreement in March 2018 in order to implement the IRL project in Africa. This agreement established the basis for the collaboration between institutions, and defined the role of each one (Figure 2).

With this agreement, the MA-R1 TRIGA Mark II research reactor at CNESTEN received the equipment provided by IAEA to act as the host reactor of the IRL project in Africa. CNESTEN is committed to procures the internet infrastructure needed to support the project, to organize one or two orientation workshops to the remote professors and to broadcast each year six core experiments to guest institutions for a period of five years.

CNESTEN and IAEA worked together to define and purchase the needed material (software and hardware) for IRL implementation. Transmission equipment was received and installed in 2019 and the broadcasting tests were performed during 2020 after months of delay because of the incompatibility of some materials.

3.2 Experiment to be broadcasted in the frame of IRL project

Using the data acquisition system provided by IAEA, the reactor team developed an independent live data interface allowing the reproduction and numerical/graphical display of data as displayed on the reactor console (Figure 3). In this screen the user can find all the necessary data to perform the programed experiences: power evolution graphs, fuel temperature, water temperature; control rod positions, reactor period, etc.


IAEA

AGREEMENT

between

the International Atomic Energy Agency

and

the National Centre for Nuclear Energy, Science and Technology of Morocco (CNESTEN)

concerning

the establishment of the Internet Reactor Laboratory (IRL) Project in Africa

Fig. (2): Agreement signature between AIEA and CNESTEN to implement IRL project in Africa

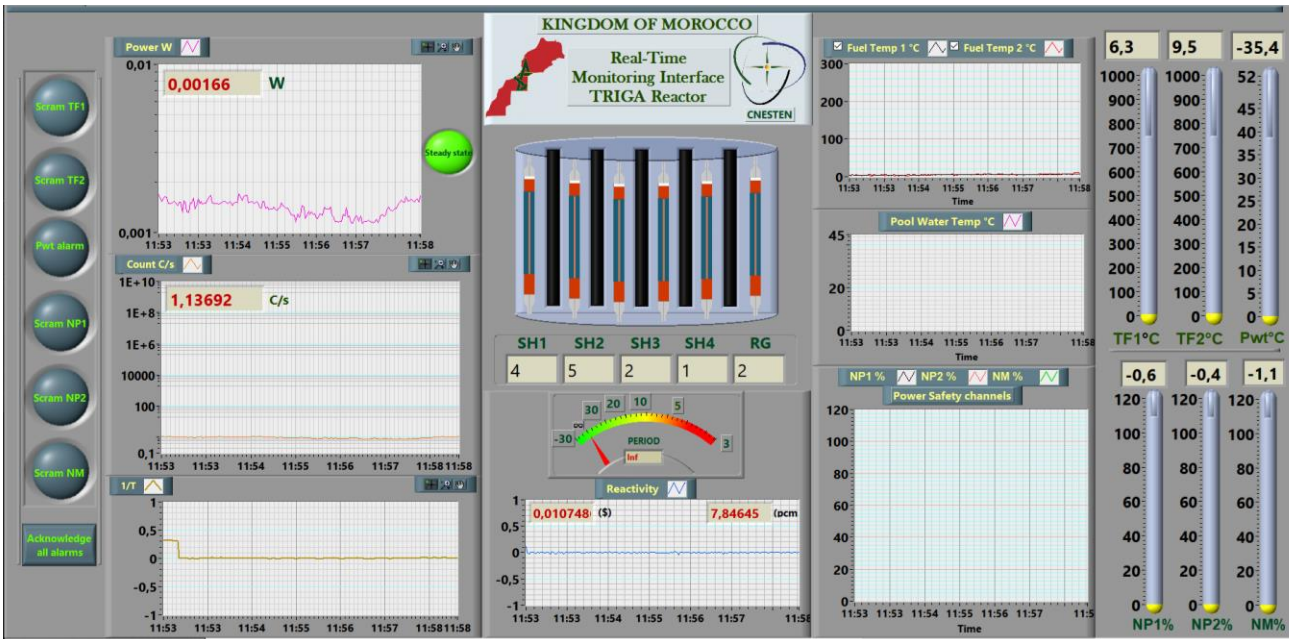
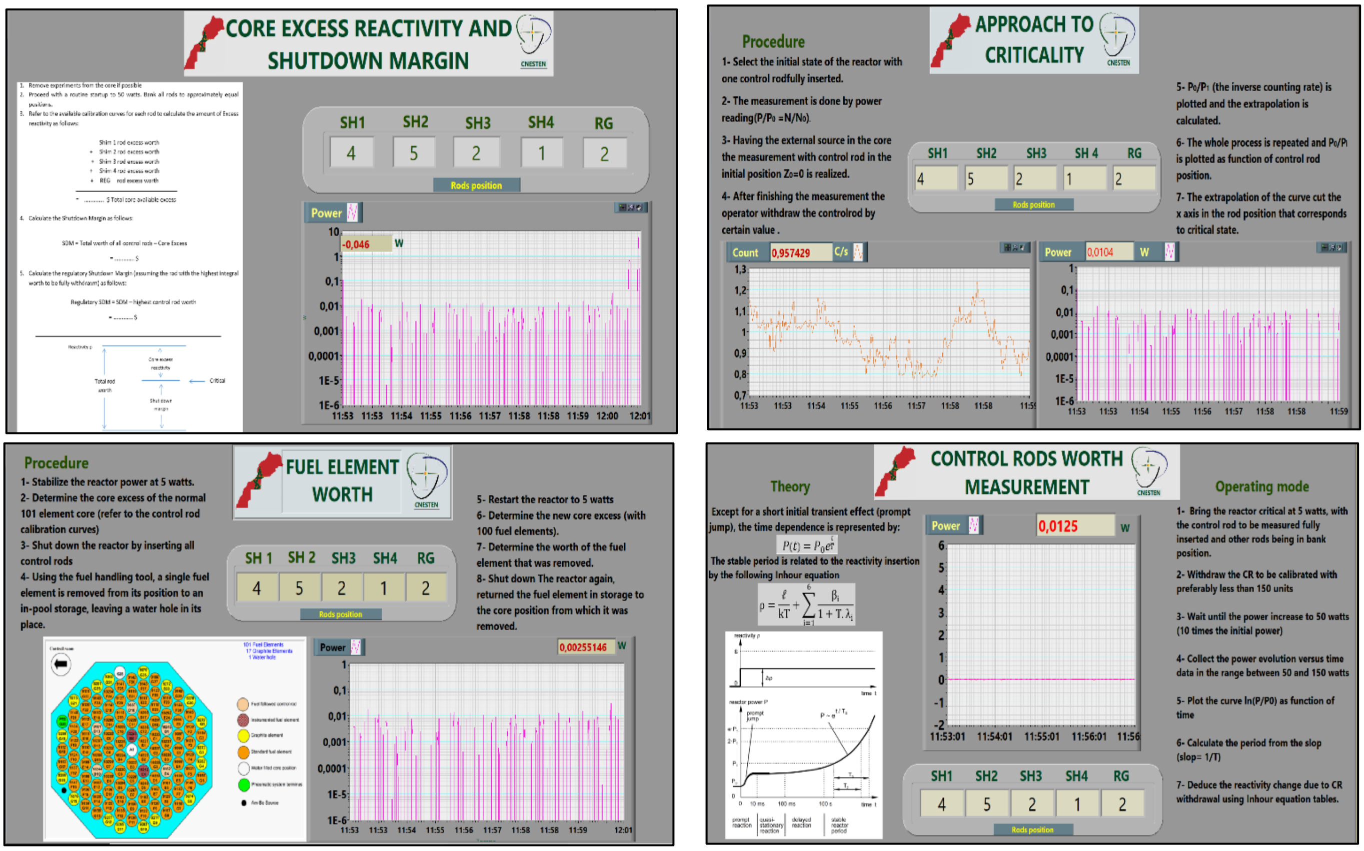


Fig. (3): Live Data Screen with all necessary data to perform the experiments

In the frame of IRL project, the Moroccan MA-1 TRIGA reactor will perform and broadcast every academic year six core experiments (Figure 4):

- Lab 1 – Reactor start up demonstration;
- Lab 2 – Approach to critical state;
- Lab 3 – Reactor power determination;
- Lab 4 – Control rod calibration (positive period method);
- Lab 5 – Fuel element worth determination;
- Lab 6 – void coefficient determination.



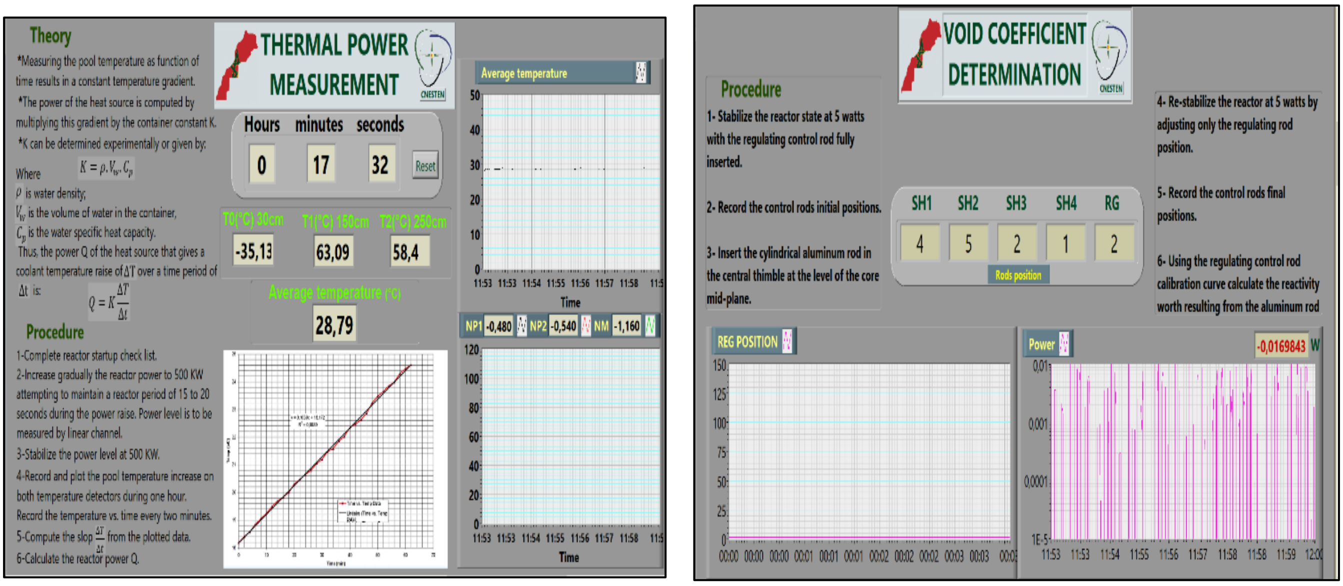


Fig. (4): Experiments to be broadcasted in the frame of IRL project

3.3 Broadcasting system at the MA-R1 reactor

The equipment installed in the reactor within IRL project includes a video conference system that can send two video signals in parallel. The camera given with video conference system has pre-set positions able to cover different angles in the control room. Two others cameras are installed in the reactor core and the training room respectively. The local instructor can switch or zoom in on the information to be transmitted to the guest according to the needs of the experiment (Figure 5).

Using this approach, the following information will be sent from the MA-1 TRIGA MARK II research reactor to remote classrooms at the guest institutions:

- Video signals from 3 different cameras:
  - Control room: signal from the videoconference system, the main link between the lecturer and the trainees;
  - Training room;
  - Reactor core: to follow any change or phenomena in the reactor core.
- PowerPoint presentations;
- Pages from a live data screen gathering all information needed to perform the experiment (graphs, curves, individual values, etc.);
- Tables of selected data recorded by the supervision system;
- Curves plotted using the recorded data after calculation.

3.4 Feedback from the first orientation workshop

A five days' orientation workshop was held in November 2021 at CNESTEN with the participation of six representatives from three African guest institutions: Kenya, Nigeria and Senegal (Figure 6).

During the workshop the participants shared information on existing academic programmes at the guest institutions related to reactor physics and on the academic curriculum at MA-R1 Reactor which involves reactor experiments.

CNESTEN staff organized a technical tool to familiarize participants with the facility and performed demonstrations of all experiments that will broadcasted within the IRL project.

Participants were also trained on the technical, pedagogical and logistic aspects of the experiments.

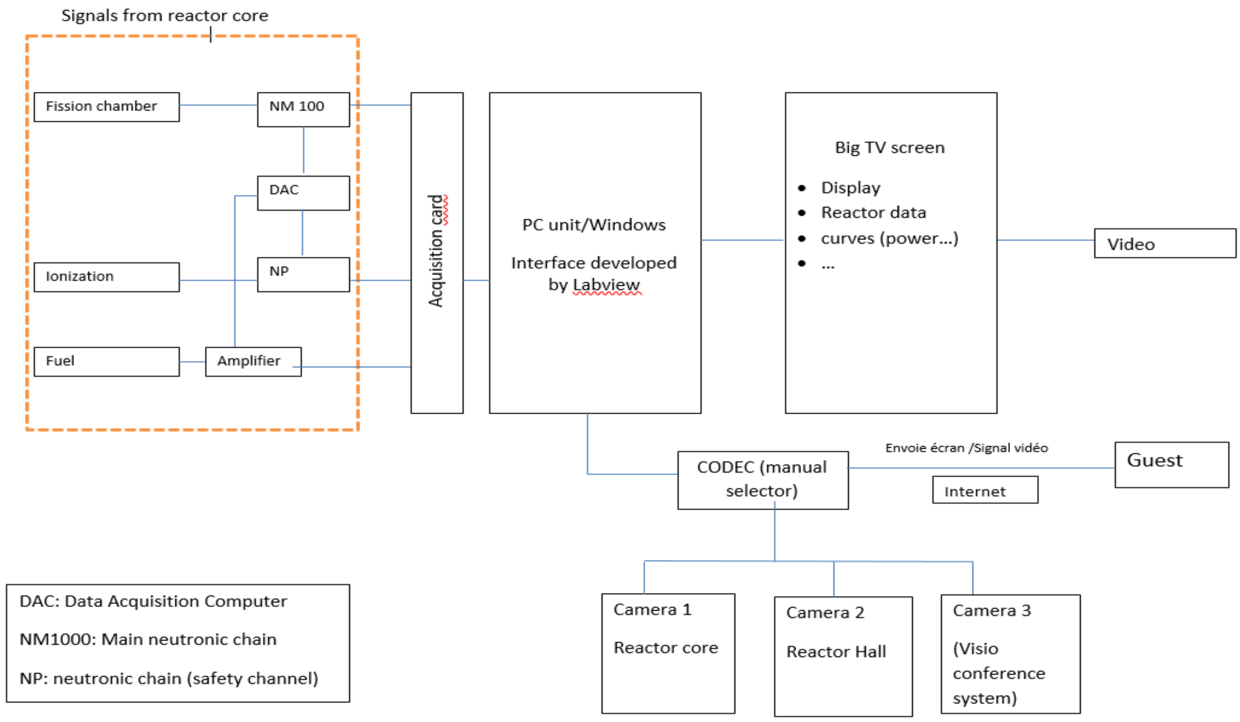


Fig. (5): Schematic representation of the capabilities of the system, which transmits two video signals from the reactor control room to the guest institution's classroom

Fig. (6): First Training and orientation workshop for the main instructors from guest institutions

Feedback and main conclusions from the Orientation Workshop were:

- Optimization of experiments in such way the time needed to stabilize the reactor after transient is filled by discussion with students.
- Communication by email may be considered to share data directly with students during experiments broadcasting.
- Communication with WhatsApp between remote and local instructors in case of technical problems.
- The theoretical part should be prepared in a way that could accommodate diverse group with different background.
- Students should have basic theoretical knowledge related to the 6 experiments prior the transmissions. This may include introduction to neutron and reactor physics (statics, kinetics, and dynamics), introduction to nuclear instrumentation (radiation measurement) and introduction to nuclear (research) reactors.

- Before each session, its suggested to hold a short preparatory video conference meeting between the host lecturer and the guest professors in order re-test the connection of videoconference systems and to briefly go through the content of the laboratory and agree on the way the laboratory will be delivered.
- Some terminology used in the host reactor protocols may not be much known for students in the guest institutions. This point can be addressed in the preparatory video conference between the local and remote teachers.
- Administrative aspects of the project (e.g. agreement with IAEA, procurement, and project approval) were identified as important aspect to be considered by guest institutions being aware that they may cause some delay in the project implementation schedule.
- Sharing curricula with host facility can be beneficial to harmonize the theoretical part of experiments.

CONCLUSION

IRL is seen as a cost effective way to contribute to the development of human resources needed for nuclear programs. It can greatly help states without research reactors to better train and evaluate their human capital and increase the global supply of E&T in nuclear science.

REFERENCES

[1] Internet Reactor Laboratory project (IRL): An effective collaboration between CNESTEN and IAEA to support nuclear Education in Africa. *International Conference on Research Reactors: Addressing Challenges and Opportunities to Ensure Effectiveness and Sustainability. 25–29 November 2019, Buenos Aires, Argentina*

C.El Younoussi, B.Nacir, B. EL Bakkari, Y.Boulaich

[2] Internet Reactor Laboratory project (IRL): status and experiences of the ISIS Research Reactor. *Conference Proceeding. RRFM Berline-Germany. 13-17 March 2016.* F.Foulon