The IAEA Internet Reactor Laboratory project: status, feedback from recent broadcasting and future expansion

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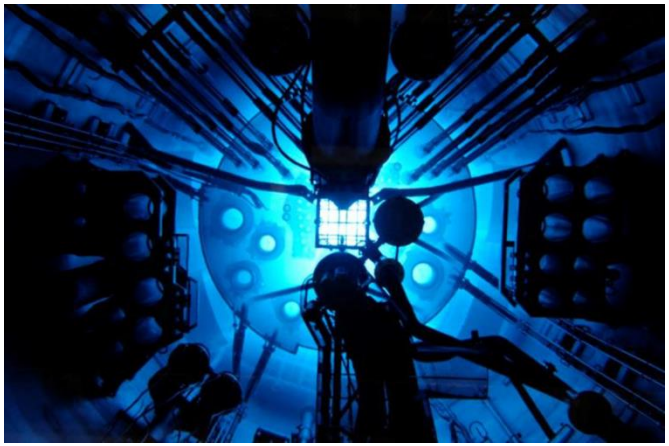
Outline

1. IRL Project – Framework and General concepts
2. IRL at CEA – ISIS
3. IRL at CNEA – RA-6
4. IRL at KHU – AGN-201K
5. IRL at CENESTEN – TRIGA MARK II
6. Future implementations
7. Conclusions

1. Introduction

The IAEA scheme for Nuclear Capacity Building based on Research Reactors



In the last few years the Research Reactor Section has developed a specific scheme of services for Nuclear Capacity Building in support of the Member States,

- operating research reactors (RR),
- willing to use RRs as a primary facility to develop nuclear competences
- as a supporting step to embark into a national nuclear programme.

The **scheme is composed of four complementary instruments**, each of them being targeted to specific objective and audience.

1. Nuclear Capacity Building based on RR

Distance Training:
Internet Reactor Laboratory (IRL)

Basic Training:
Regional Research Reactor Schools

To support Member States,
- to operate Research Reactors
- to develop nuclear competences
- to embark into a national nuclear programme.

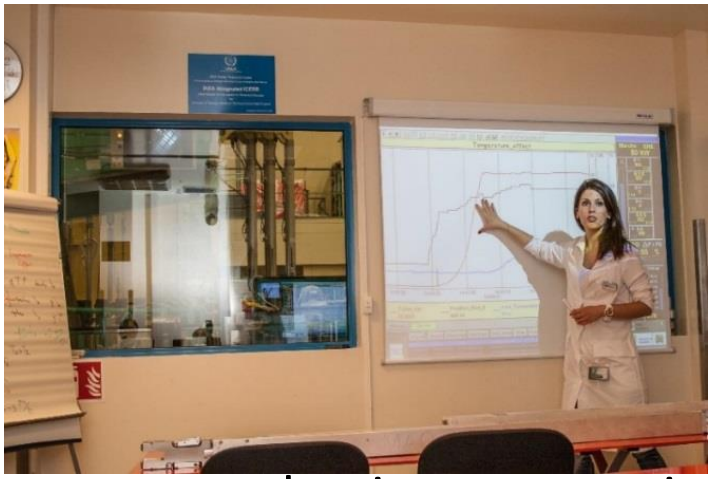
Intermediate Training:
EERRI Group Fellowship Course

Advanced Training at
International Centres based on Research Reactors (ICERRs)

1. Distance Training: Internet Reactor Laboratory

- Connects through internet an operating research reactor (Host reactor) to Guest institutions, generally Universities within the same region.
- Opportunity to add a practical component to academic programes in nuclear engineering and nuclear physics, when access to an operating research reactor in the country is not feasible.
- 5 or 6 half day sessions broadcasted every year (Approach to criticality, rod calibration, temperature effect, …)

1. Distance Training: Internet Reactor Laboratory



Objective:

Connects through internet an operating research reactor (Host reactor) to Guest institutions, generally Universities within the same region.

Offers the opportunity to add a practical component to academic programs in nuclear engineering, and nuclear physics, when access to an operating research reactor in the country is not feasible

Programe: 5 or 6 half day sessions broadcasted every year to Guest institutions (criticality exp., rod calibration, temperature effect, …)

Participants: Nuclear engineering and Nuclear physics students ; can be extended to other audiences with tailored experiments or demonstration exercises.

1. Distance Training: Internet Reactor Laboratory

First Sessions broadcasted in 2016

- Latin America, CNEA-RA6 (Argentina) to Colombia, Cuba and Ecuador
- Europe + Africa, CEA-ISIS (France) to Belarus, Lithuania, Tanzania, Tunisia

Expansion of the project in 2017-2018

- Asia Pacific, AGN-201K (Republic of Korea) + Guests under evaluation
- Africa, MA1 (Morocco) + Guests under evaluation
- Assistance to other National Internet Lab projects.

2. The IRL at CEA – ISIS

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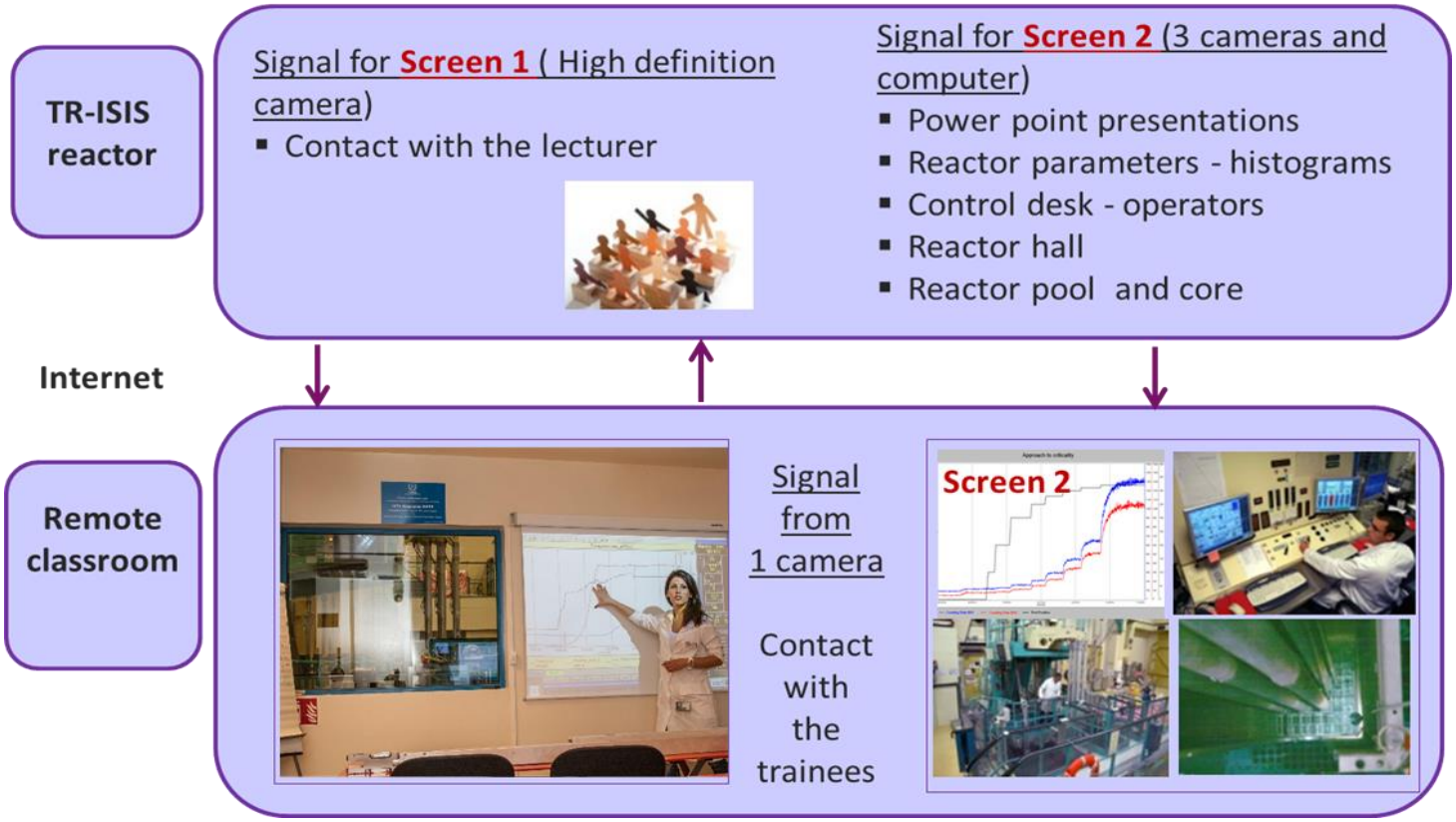
The platform architecture



2. The IRL at CEA – ISIS

Core experiments broadcasted

Lab 1: Fuel Loading

Lab 2: Approach to Criticality
Reactor Startup
Reactivity effect around Criticality

Lab 3: Reactivity effect of devices (cylinders and box) placed in the core
Rod calibration curve
Global worth by the rod drop technique

Lab 4: Role of precursors
Temperature effect
Operating Range of Each detection system and associated OLC

Lab 5: Detection system in pulse mode
Detection system in current mode

2. The IRL at CEA – ISIS

Resume and feedback of first year of broadcast

Date	Experience	Lecturer	Country		
			Lithuania	Belarus	Tunisia
9 November am	**Lab 5**	B.Lescop	**Broadcasting interrupted after an hour due to technical problems**		
5 December pm	**Lab 2**	S. Ivanovic	Medium quality of the received image	Satisfying quality of the received image	Late to join the course at the beginning due to the technical difficulties. After establishing connection everything went smooth with good image quality
6 December am	**Lab 3**	S. Ivanovic	Poor quality of the received image	Satisfying quality of the received image	Good quality of the received image
6 December pm	**Lab 4**	S. Ivapovic	Poor quality of the received image	Satisfying quality of the received image	Good quality of the received image
7 December pm	**Lab 1**	S. Ivanovic	Medium quality of the received image	Satisfying quality of the received image	Didn't participate

Country	Remarks
Lithuania	The experiments were broadcasted too late in the autumn semester. The lab description text could be improved or supplemented with additional information. Quality of the recived image wasn't satifying for every lab. Making the broadcasting even more interactive.
Belarus	The collected students' feedback was very positive regarding the interest and the effectiveness of this "nontraditional" learning tool. They concluded that the practical experience obtained from IRL strongly enhanced their background in nuclear reactor physics.The IRL project was widely covered in national mass-media.
Tunisia	Participants where students at their finaly year on Enery Systems Engineering. Labs were incorporated in the course "Nucelar energy". The students where delight to perform the course and they learned a lot.

3. The IRL at CNEA – RA-6

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When

4th of April 2013 - MOU

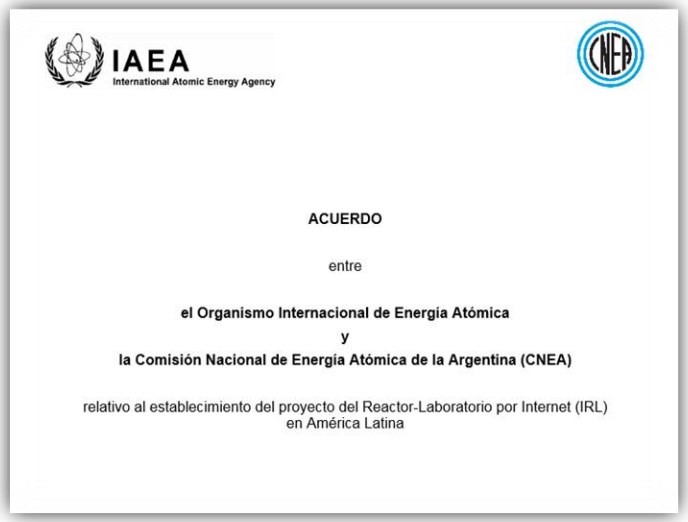
Objective

The establishment of the Internet Reactor Laboratory (IRL) Project in Latin America

Statements

- IAEA will pay for the Host Reactor's operating costs for broadcasting the IRL for a period of five years
- CNEA and its RA-6 reactor will serve as " host reactor"
- 6 experiences will be broadcasted, once a year during 5 years

Remote countries participating: Cuba, Ecuador and Uruguay. The list was the broadened to include Spain, Bolivia and Colombia maintaining three simultaneous connections



IAEA
International Atomic Energy Agency

ACUERDO

entre

el Organismo Internacional de Energía Atómica
y
la Comisión Nacional de Energía Atómica de la Argentina (CNEA)

relativo al establecimiento del proyecto del Reactor-Laboratorio por Internet (IRL) en América Latina

Experiences included

- Nuclear instrumentation in a Research Reactor;
- Critical approach;
- Control rod calibration;
- Control rod reactivity worth measurement (rod drop);
- Temperature reactivity coefficient;
- Void coefficient calculation.

3. The IRL at CNEA – RA-6

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Resume and feedback of first year of broadcast

YEAR 2016	Experience	Participants	Comments
13-09-2016	Nuclear instrumentation in a Research Reactor	Ecuador - Colombia	Cuba had connection clearance restrictions for the 4 first sessions.
27-09-2016	Critical approach	Ecuador - Colombia	
11-10-2016	Control rod calibration	Ecuador - Colombia	
25-10-2016	Control rod reactivity measurement (rod drop)	Ecuador - Colombia	
08-11-2016	Temperature reactivity coefficient	Ecuador – Colombia – Cuba	
22-11-2016	Void coefficient calculation	Ecuador – Colombia – Cuba	

YEAR 2017	Experience	Participants	Comments
12-09-2016	Nuclear instrumentation in a Research Reactor	Colombia	Ecuador didn´t participate due to lack of remote professors. Cuba had problems with the hurricane on first transmission
26-09-2016	Critical approach	Cuba – Colombia	
17-10-2016	Control rod calibration	Cuba – Colombia	
24-10-2016	Control rod reactivity measurement (rod drop)	Cuba – Colombia	
07-11-2016	Temperature reactivity coefficient	Cuba	
21-11-2016	Void coefficient calculation	Cuba – Colombia – CNESTEN	

3. The IRL at CNEA – RA-6

Feedback of first two years of broadcast

The general feedback from all the remote sites participating in the program was that it was very useful for them to have the opportunity to attend to real experiments developed in real facilities to complement the theoretical content that they have in their classes.
The remote participants find this tool very interesting and a good approach to real experiences in a virtual scenario.
The quality of the connection was very good in all cases.
The main issue was the connection clearance limitation that Cuba had for the first four session in 2016. This problem was solved and Cuba was online in 2017 from the second session (first didn´t because of the hurricane).
Ecuador didn´t participate during 2017, but they want to participate in 2018 again.
We starting the communications to analyse the option to include Madrid Polytechnic University in 2018.

4. The IRL at KHU – AGN-201K

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Test of Pilot IRL at KHU RREC (March 28, 2017)

Two monitor screens in the console at host site is broadcasted to the remote site in one-way direction as duplication without time delay with full resolution mode.
Therefore, students at the remote site can read console data just as they are in the host site.

4. The IRL at KHU – AGN-201K

Test of Pilot IRL at khu RREC (March 28, 2017)

Host Site

Guest Site

4. The IRL at KHU – AGN-201K

IRL Operation Syllabus in Plan (#1)

Week	Host Site	Client Site	Activity
1	-	Lecture	Introduction to Course & AGN-201K
2	-	Lecture	Theory for Exp.#1 (Rx Operation)
3	Experiment	Experiment	Exp.#1 (Rx Operation)
4	-	Lecture	Student Presentation for Exp.#1 Theory for Exp.#2 (Reactivity Measurement)
5	Experiment	Experiment	Exp.#2 (Reactivity Measurement)
6	-	Lecture	Student Presentation for Exp.#2 Theory for Exp.#3 (Criticality Approach)
7	Experiment	Experiment	Exp.#3 (Criticality Approach)
8	-	Lecture	Student Presentation for Exp.#3 Theory for Exp.#4 (Rod Worth Measurement)
9	Experiment	Experiment	Exp.#4 (Rod Worth Measurement)

4. The IRL at KHU – AGN-201K

IRL Operation Syllabus in Plan (#2)

Week	Host Site	Client Site	Activity
10	-	Lecture	Student Presentation for Exp.#4 Theory for Exp.#5 (Thermal Flux Mapping)
11	Experiment	Experiment	Exp.#5 (Thermal Flux Mapping)
12	-	Lecture	Student Presentation for Exp.#5 Theory for Exp.#6 (Temp. and Ref. Effects)
13	Experiment	Experiment	Exp.#6 (Temp. and Reflector Effects)
14	-	Lecture	Student Presentation for Exp.#6 Examination
15	Presentation	Presentation	Student Group Competition for the Best Presentation
16	-	Lecture	Wrap-up Class

4. The IRL at KHU – AGN-201K

Work Items	Expected Time	Notes
Installation of IRL equipment	Oct. 31, 2017	• Works will be done by the small company under contract
Test of remote site facility (domestic operation)	Dec. 30, 2017	• Test site will be positioned in Jeju National University as a national program
IRL orientation workshop	Jan. 15, 2018 (during winter vacation period)	• Invitation of all professors from guest sites • Provide hand-on experiment sessions and discussion sessions for 5 days.
The 1st operation of IRL (to 2~4 guests)	March 1~ May 30, 2018	• Broadcasting 5~6 experimental sessions at every other week.
Feedback meeting	June 2018	• Conclude the operation • Collect the feedback from guests • Evaluation to the IRL performed

5. The IRL at CNESTEN – TRIGA MARK II

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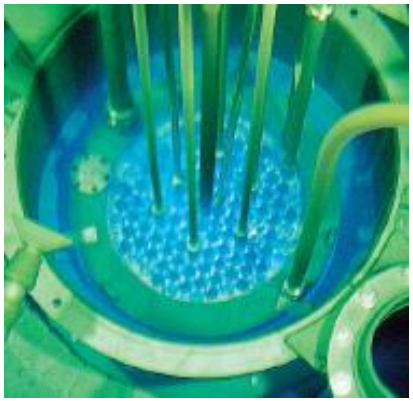
- The MA-1 TRIGA MARK II Research Reactor hosted by the National Center of Energy Sciences and Nuclear Techniques CNESTEN has been selected to be the host reactor for Africa.



Reactor core

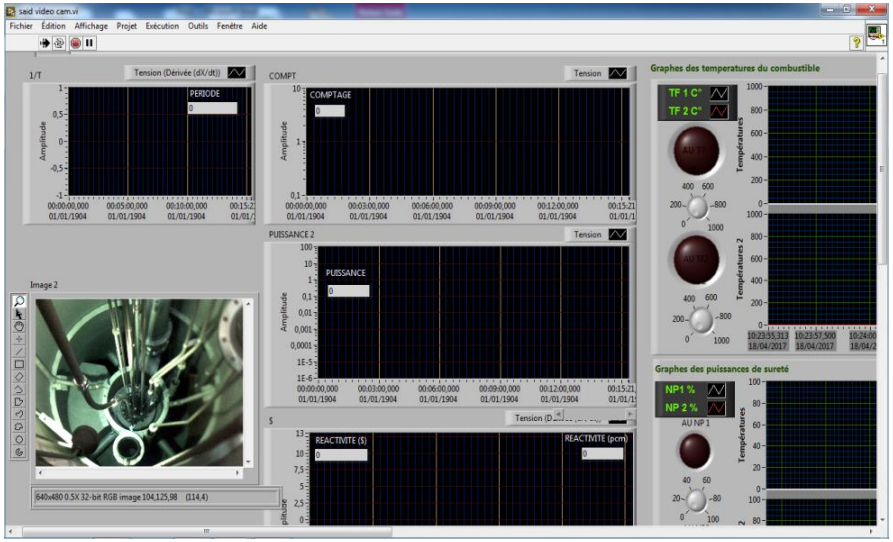
Reactor console

- The official notification was received from IAEA in April 2017

- it was agreed to schedule and broadcast the six (6) Core Experiments in a year, plus one or two orientations workshops to orient lecturers from guest institutions

5. The IRL at CNESTEN – TRIGA MARK II

- A graphical interface, developed by the reactor team, gathering all data needed to perform and broadcast the experiment was developed and successfully tested. This interface will greatly facilitate the project implementation.



- Two institutions had already presented themselves as recipient facilities:
  - The Tanzania Atomic Energy Commission
  - The Tunisian National Centre of Nuclear Sciences and Technologies

- It is expected that the agreement will be signed by the end of the 2017.

- The first broadcasting is expected in the second or the third quarter of 2018 after the organization of the first orientation workshop

5. The IRL at CNESTEN – TRIGA MARK II

List of experiment to be broadcasted

N°	Experiment
1	Reactor startup - Reactor control (operating modes) and stabilization - Reactivity Excess, shutdown margin determination
2	Approach to criticality
3	Reactivity measurement : Fuel element worth
4	Control rod worth measurement : Positive period method
5	Reactor dynamics: Void effect & coefficient
6	Reactor thermal power determination

5. Concluding remarks

Conclusions

- **We have, as the product of a successful collaboration between IAEA and MSs, an operative tool for remote training based on the online access to Research Reactors, which is part of the capacity building program.**
- **There is wide community of users in different regions very interested and committed with the project.**
- **The IRL is growing and next year will include the African and Asian-Pacific regions with the inclusion of CNESTEN and KHU.**
- **Indonesia is already developing the IRL capability with the support of the IAEA.**
- **Czech Republic and the Russian Federation are also planning to develop the IRL capabilities to join the program.**

Thank you for your attention