

The CEA logo consists of the letters 'cea' in a stylized, lowercase, sans-serif font. Above the letters are two horizontal orange lines, and below them are two horizontal green lines.

energie atomique • énergies alternatives

The instn logo features the word 'instn' in a bold, italicized, lowercase, sans-serif font. A blue arc is positioned above the letters 'i' and 'n'.

DEVELOPMENT OF EDUCATION AND TRAINING PROGRAMS USING ISIS RESEARCH REACTOR

# Development of education and training programs using ISIS research reactor

F. Foulon<sup>1</sup>, B. Lescop<sup>1</sup>, X. Wohleber<sup>2</sup>

1) National Institute for Nuclear Science and Technology, CEA-Saclay, France

2) Nuclear Reactors and Services Department, CEA-Saclay, France

Corresponding author: [francois.foulon@cea.fr](mailto:francois.foulon@cea.fr)





## 1. INSTN presentation

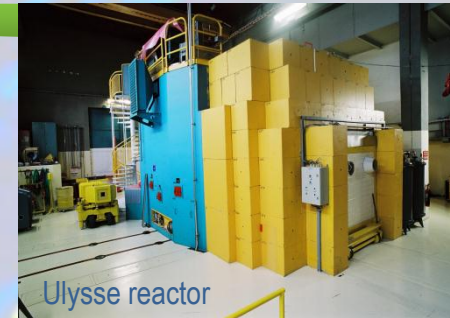
- As a part of CEA, the National Institute for Nuclear Science and Technology (INSTN) is a higher education institution under the joint supervision of the Ministries in charge of Education and Industry.
- INSTN was created in 1956, when France decided to launch its nuclear programme.
- INSTN's mission is to provide to students and professional a high level of scientific and technological qualification in all disciplines related to nuclear energy applications.
- Headquarter located at CEA-Saclay (20 km South of Paris), Four branches are set up in CEA's centres : Grenoble, Cadarache, Marcoule and Cherbourg (AREVA - La Hague).

## 1. INSTN presentation



- INSTN activity includes both Academic degree programs and Continuing education courses for professionals and PhD students.
- INSTN, in association with ENEN (European Nuclear Education Network), organises international courses covering the principle and operation of nuclear reactors, neutronics, thermo-hydraulics, fuel cycle, reactor dismantling, ...
- INSTN strategy is to complete theoretical courses by training courses and laboratory works carried out on an extensive range of training tools that includes software applications, simulators, as well as the use of research reactors.

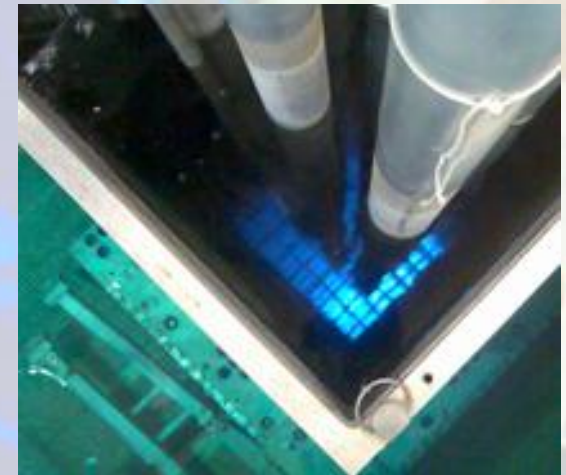
## 2. The use of research reactors by INSTN



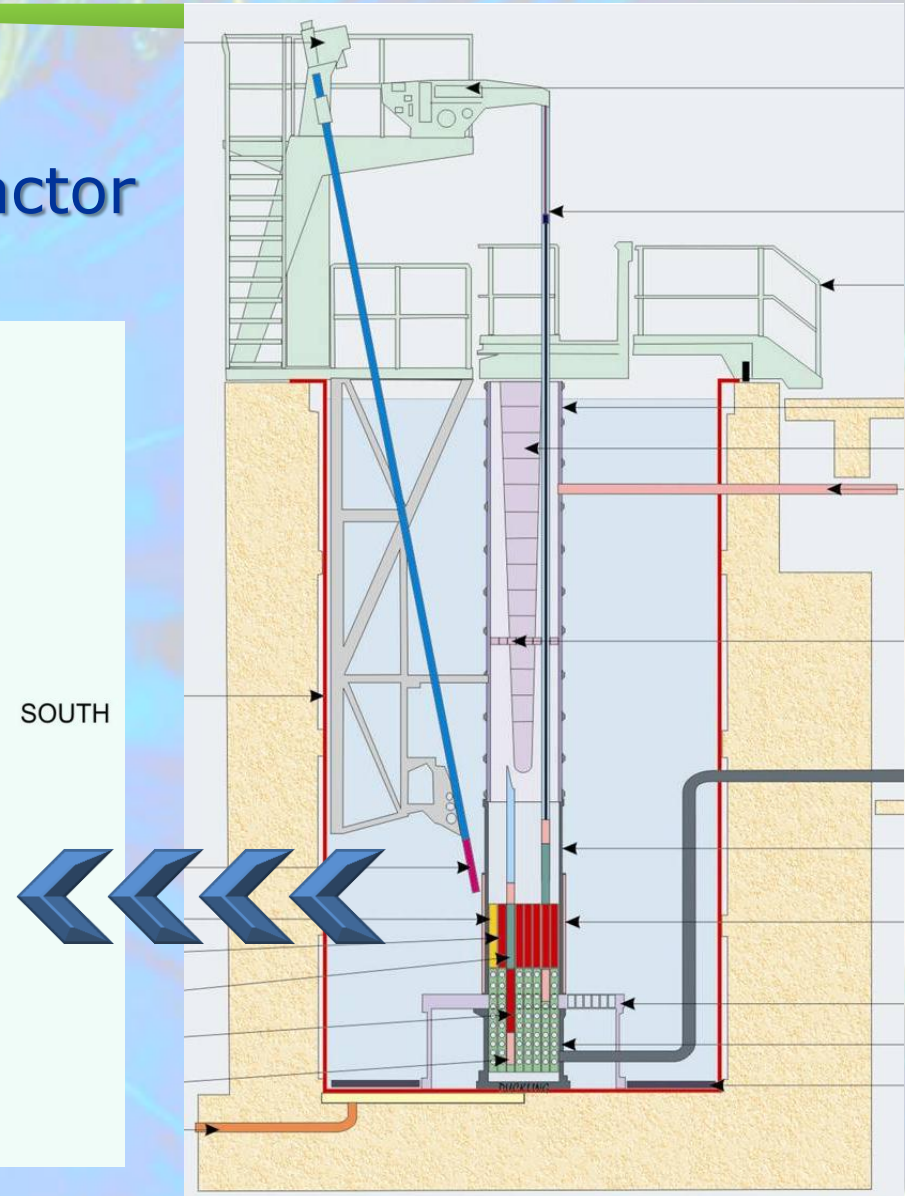
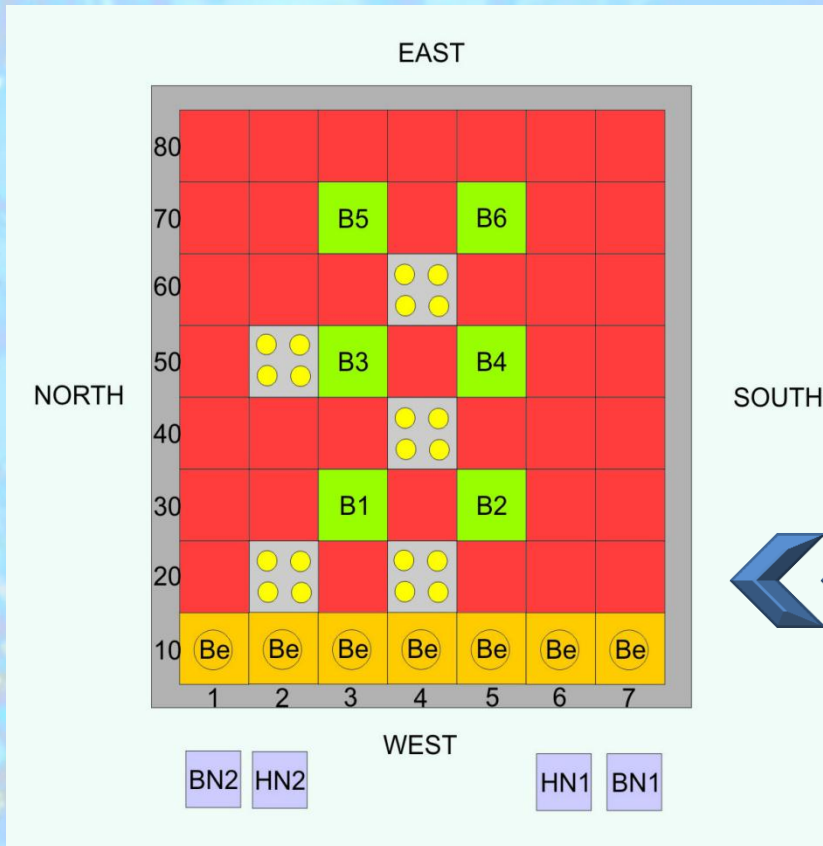
- From 1961 till 2007, INSTN has operated its own reactor (ULYSSE reactor, Argon type – 100 kW) for training courses.
- In 2003, the decision was taken to concentrate from 2007 the CEA's E&T activities on ISIS reactor located in Saclay.
- Conversion of ISIS reactor to E&T activities was based on :
  - Pedagogic background gained on ULYSSE reactor,
  - Evaluation of ISIS potential for E&T activities,
  - Establishment of modifications needed for E&T activities (material, safety documents, ...)
  - Ergonomic study - control system and control room
- ISIS refurbishment was carried out from 2004 till 2006

### 3. ISIS research reactor

- Open core pool type reactor
- Neutronic model of OSIRIS (70 MW – same facility)
- Nominal power : 700 kW,  
→ Limited to 50 kW for E&T
- Neutron flux :  $2 \cdot 10^{12}$  n/cm<sup>2</sup>.s
- MTR type fuel assemblies  $U_3Si_2Al$
- Water moderated and cooled
- Reflector: H<sub>2</sub>O + Be
- 6 control rods (Hafnium)

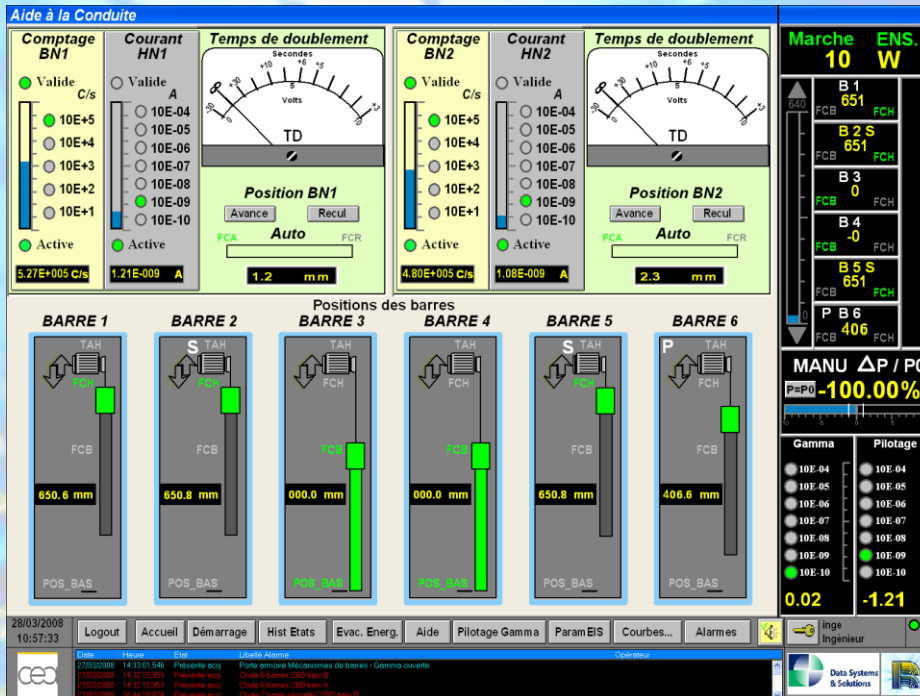


## 3. ISIS research reactor



## 3. ISIS research reactor

- Control room layout for 10 trainees



- Use of a supervision system to show the evolution of reactor parameters

## 4. Experiments carried out on ISIS

- Control of the reactivity during fuel loading
- Approach to criticality
- Reactor start up and stabilization
- Drawing of the calibration curve of a rod
- Evaluation of the global worth of a rod by the rod drop technique
- Influence of experimental devices on the core reactivity
- Reactivity change in the core – shadow effect
- Demonstration of the role of precursors (delayed neutrons) for the control of the reactor
- Study of the temperature effects (temperature coefficient , self-stabilisation)
- Radiation protection applied to reactor operation
- Study and setting of the neutron detection systems
- Neutron cartography / Neutron activation analysis
- Reactor operation under the supervision of ISIS staff and INSTN instructors

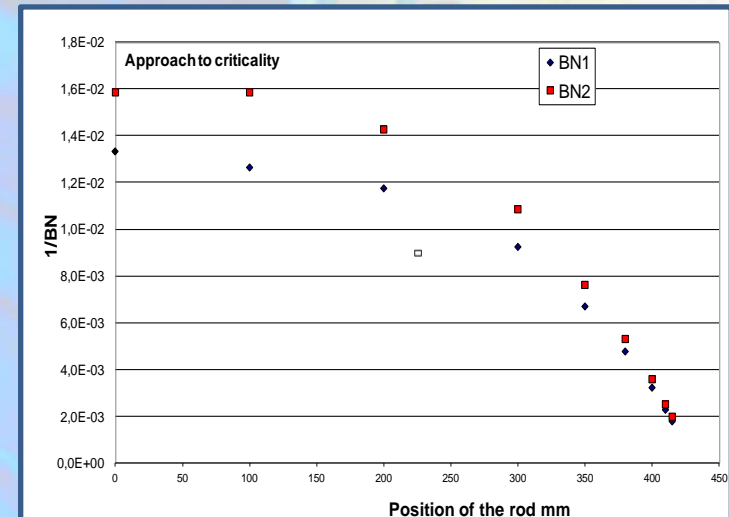
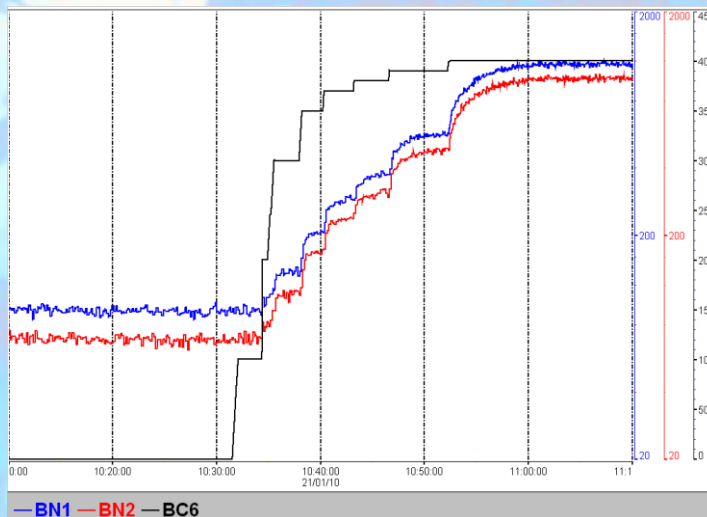


## 4. Experiments carried out on ISIS

- Nine training courses with a duration of 3 hours have been developed
- They are integrated in E&T programs from INSTN : depending on the public and pedagogical objectives, the trainees follow from 3 to 24 hours training courses
- Every year about 400 trainees participate to training course, corresponding to 360 hours distributed over 70 working days
- With an increase of the need for E&T, ISIS E&T activity could easily be increased up to 600 hours distributed over 120 working days

## 4. Experiments carried out on ISIS

- For each experiment, the evolution of a specific set of parameters can be shown using the supervision system
- Recorded data are extracted to make calculations and to show curves using the supervision system



## 5. E&T programs using ISIS reactor

- Training courses are integrated both in academic degree programs and continuing education courses.
- Academic degree:
  - International master in Nuclear Energy
  - Specialisation course in Nuclear Engineering
  - Nuclear engineering modules of various master and engineer degrees
  - Training courses (2,5 days) on ISIS reactor for three Swedish universities

## 5. E&T programs using ISIS reactor

- continuing education for professionals:
  - A 8 weeks course compulsory in the qualification process of the operators of the French research reactors,
  - Courses organized on a regular basis related to nuclear reactor (principle & operation, neutronics, thermohydraulic, ...)
  - Courses organised to respond to the specific need of the nuclear industry and nuclear programs: personal from the French regulator body, engineers from ENEL, project managers of EVN, teachers and professors from Polish Universities (training of the trainees).

## 5. E&T programs using ISIS reactor

- 1<sup>st</sup> example : 2,5 days training course on ISIS after theoretical courses ensured by Sweedish university.

- Control of the reactivity during fuel loading
- Approach to criticality
- Reactor start up and stabilization

- Drawing of the calibration curve of a rod
- Evaluation of the global worth of a rod by the rod drop technique
- Influence of experimental devices on the core reactivity
- Reactivity change in the core – shadow effect

- Demonstration of the role of precursors (delayed neutrons) for the control of the reactor

- Study of the temperature effects (temperature coefficient , self-stabilisation)

- Demonstration of the neutron detection systems

## 5. E&T programs using ISIS reactor

- 2<sup>nd</sup> example : Training courses in the frame of the 8 weeks course for the operators of RR
  - In addition to the 2,5 days program :
    - Radiation protection applied to reactor operation
    - Study and setting of the neutron detection systems
    - Neutron cartography
    - Reactor operation under the supervision of ISIS staff and INSTN instructors
  - The operating sequence includes : reactor start up, power stabilisation at 500 W, reactivity compensation with one rod ⇒ Instructors check trainees knowledge and skills to operate the reactor, including the response to stress.

## 6. Further development of E&T programs

- Further development of the INSTN E&T programs carried out through three major routes
- International courses developed on the basis of the IAEA standards and regular courses taught in French : 8 week course for the operators of the research reactors, in accordance with IAEA Safety guide NS-G-4.5.
- Specific international courses developed on request for industry, academy or regulatory body: content and duration defined by the requesting organization (recent examples: 1 to 12 weeks courses, courses in English with simultaneous translation in Chinese).

## 6. Further development of E&T programs

- Use of complementary pedagogical techniques such as the mix of distance and face to face learning techniques will be promoted in the future :
  - Theoretical courses by distance learning in the trainee's country
  - Face to face technique limited to the courses that need a close interaction between the lecturer and the trainees, as well as to lab work carried out on nuclear facilities (ISIS reactor).



## 7. Conclusion

- Training courses carried out on ISIS are addressed to a wide range of public : 3 to 24 hours program
- The feedback shows that training courses on ISIS reactor ensure a comprehensive understanding of the reactor principle and operation that cannot be gained only with theoretical courses and simulators.
- Courses contribute to an improvement in the safety culture of the personal involved in reactor operation.
- Thus, INSTN is continuously promoting the use of courses on ISIS reactor as they appear to be a very powerful tool for the development of the human resources needed by the nuclear industry.

cea

energie atomique • énergies alternatives

instn

## DEVELOPMENT OF EDUCATION AND TRAINING PROGRAMS USING ISIS RESEARCH REACTOR

Thank you  
for  
your attention

