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The French Sodium School : Teaching Sodium Technology for the present and future generations of SFR users

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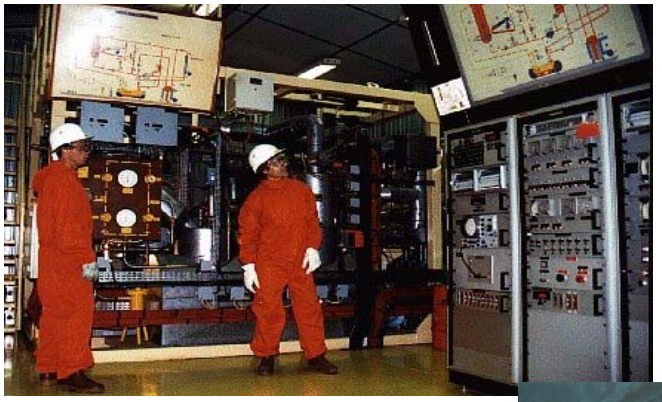

Presented by Dr Christian Latgé

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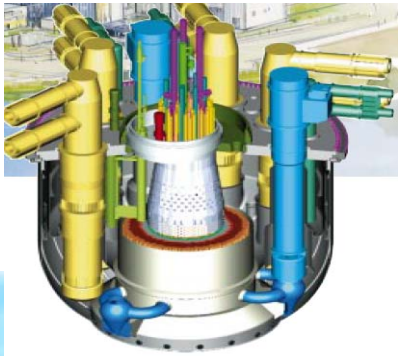
New project, new history to be written !

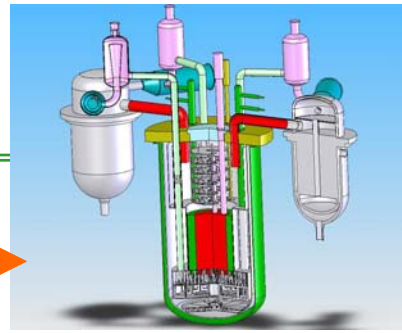
Rapsodie

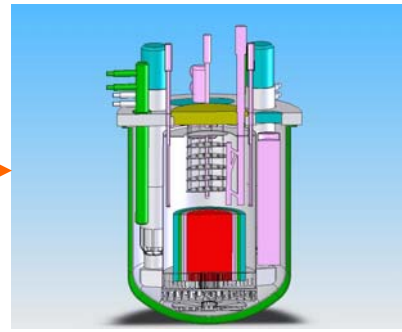
Phenix

SPX



EFR





ASTRID

New needs for Education & Training

Introduction

- **Since the beginning of nuclear development, France has significantly contributed to the development of Sodium cooled Fast Reactors and of Liquid Metal technology**
- **Due to the specificity of sodium technology, CEA (the French Atomic Energy Commission) has been in charge of developing specific courses in order to teach and transmit the associated knowledge and practice**
- **This presentation aims at providing a description of :**
  - ✓ **the French Sodium School located at the CEA Cadarache Research Centre**
  - ✓ **the Fast Reactor Operation and Safety School (FROSS) created in 2005 at the PHENIX NPP**
  - ✓ **the new training sessions, related to SFR, created within the framework of INSTN (*),**
- **It presents their recent developments and the current collaborations throughout the world with some other nuclear organizations and industrial companies**

*** Institut National des Sciences et Techniques Nucléaires.**

Sodium School: main objectives

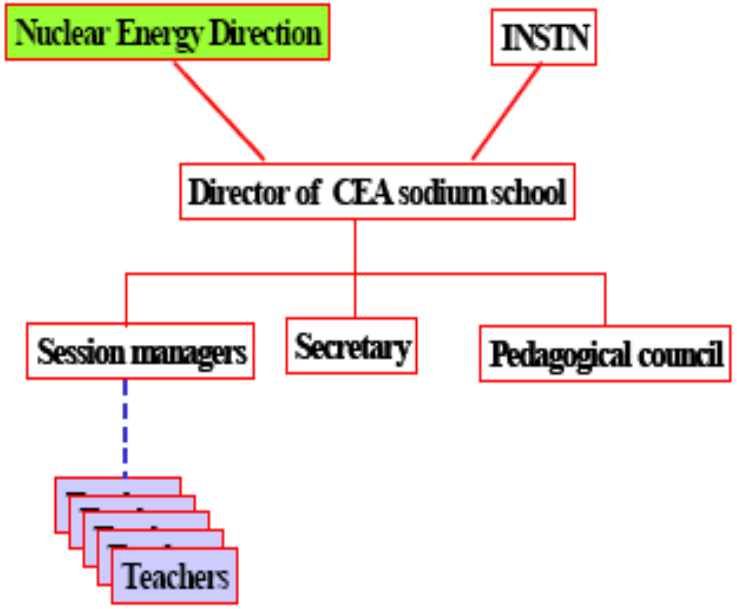
The objective of the sodium school is :

- ✓ **To train engineers and operators able to work on Sodium Cooled Fast Reactors**
- ✓ **To support R&D activities**

- **Its role has always been to adapt its offer and its content to the changing requirements of reactor operators,**

  And also,

  - **To the evolution of the context (support to decommissioning,…)**
  - **To new "customers" Operators of Dynamo experiments, Chemical Industry, Na suppliers,….**



The “Sodium School“ in Cadarache (ESML) 1/2

1975 : Creation of the Sodium School at Cadarache *(Training of Phenix NPP teams, training of R&D technicians and Engineers of CEA,…)*

- **1980 : Accreditation by EdF - Electricité de France – French utility *(Training of Superphenix NPP teams)***
- **1984 : School opened to foreign companies or utilities *(Training for SNR300 NPP team - Germany)***
- ***1989 : Training of Kobe (Japan) fire brigade (Harbour identified to receive Na for Monju)***
- **1995 : Partnership with the INSTN (French Nuclear Teaching Institute)**

The "Sodium School" in Cadarache (ESML) 2/2

1997 : Development of modular trainings (10 modules),

1998 : New set of modules more oriented towards decommissioning (theory and practice),

1999 : Specific session for Chemical Industry (USA),

2000 : Cooperation with JAEA (Japan Atomic Energy Agency – Japan) to provide 37 lectures at Monju reactor *(program schedule of 1 week per year during 5 years)*

➔ About 40 lectures given by CEA Engineers

2005 : Collaboration with FROSS (Fast Reactor Operation and Safety School) at Phenix NPP; specific sessions related to technology& operational feedback (for CIAE-China, Rosatom-Russia-Tacis,…), safety (IGCAR-India),…

Since 2007 : Partnership with INSTN to prepare new sessions related to SFR A new module is under preparation on GENERATION IV SFR (Sodium Fast reactors) design and main options: 3 new sessions (Sodium Fast Reactors, SFR design, Eranos), 1 in preparation (SFR: operation)

2009: 1st European Session (within the frame of ESFR project): "Na behaviour & Technology", partnership ESML-INSTN-Europe

Lectures given in Monju by CEA Teachers

Title of CEA lecture	Lecture date
Pollutions sources	2002
Quality monitoring	2002
Sodium purification	2002
Operation of cold traps	2002
Hydrogen risks	2002
Cleaning of components after draining	2002
Interventions on circuits for repair	2002
In Service Inspection and repair : Strategy, recent developments	2002
Corrosion with sodium	2003
Contamination in sodium fast reactors	2003
Decontamination in sodium fast reactors	2003
Cold trap processing	2003
Theory of sodium fires.	2003
Fires consequences, protections of installations	2003
Safety on sodium facilities	2003
Safety exercise with trainee participation (movie)	2003
Chemical properties of sodium	2004
Physical properties of sodium	2004
Movies on Chemical and Physical properties of sodium and alkali metals	2004
Technology of circuits	2004
General instrumentation for sodium circuits	2004
Sodium circuit operation	2004
Risks induced on structural materials by cleaning operations	2004
Sodium waste treatment	2004
Interaction between sodium and hydrocarbons	2005
Hydrogen diffusion through walls	2005
Cleaning of subassemblies	2005
Training on cleaning processes (movie)	2005
Ultra Sonic monitoring in sodium	2005
Sodium/water reaction in Steam Generators, hydrogen detection	2005
Sodium leak detection	2005
Experimental feedback of RAPSODIE decommissioning	2006
Experimental feedback of PHENIX in operation	2006
Experimental feedback of SUPERPHENIX in operation	2006
Strategy of sodium fast reactor decommissioning	2006
Chemical and physical properties of NaK	2006
Handling of NaK and safety	2006

The "Sodium School" in Cadarache (ESML) 2/2

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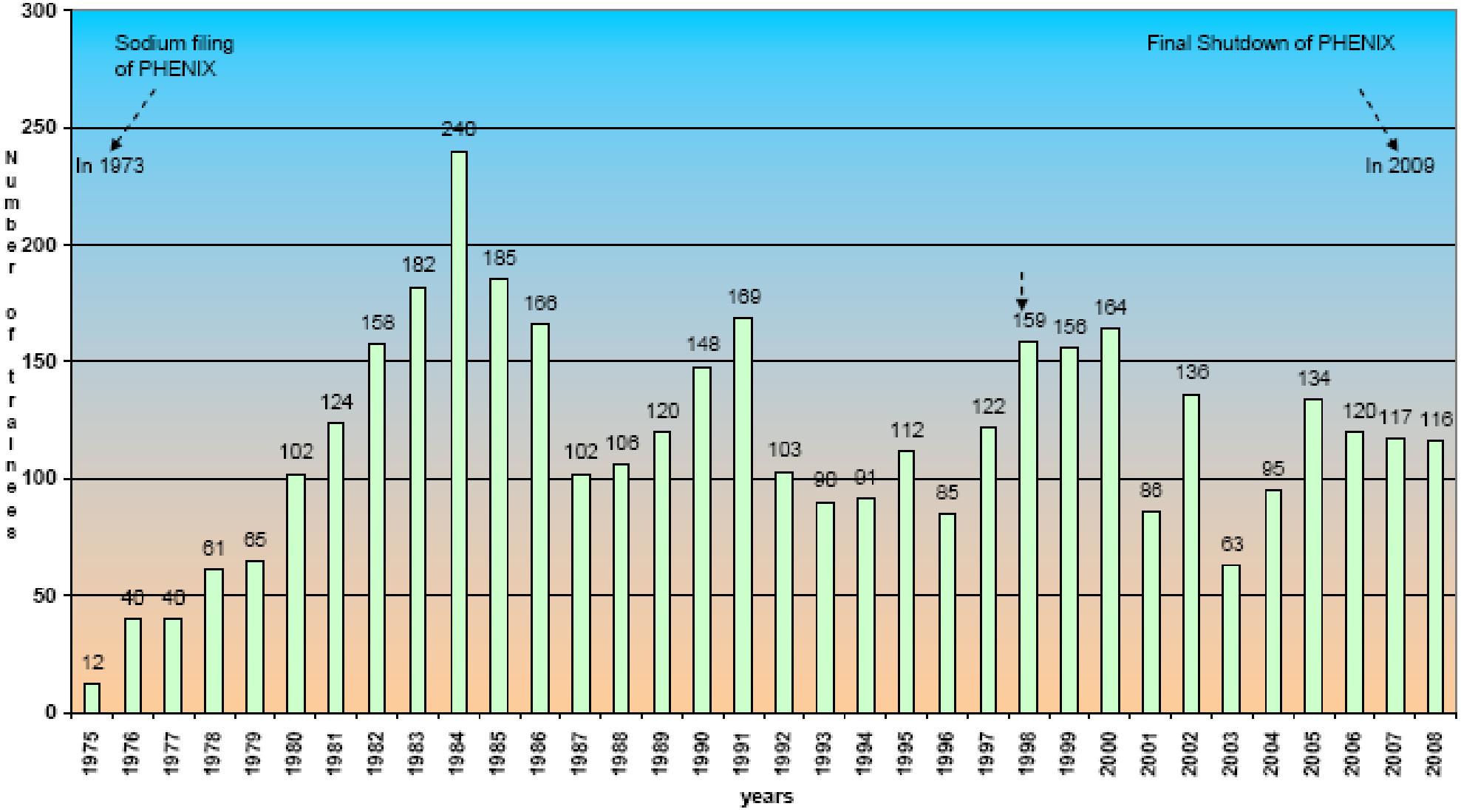
Up to now, more than 4,500 trainees, (end of 2009)



The “Sodium School”

- **Sodium School means**
  - ✓ **All the people delivering courses at the sodium school are engineers and technicians involved in sodium activities in CEA Departments or at PHENIX plant**
    - ❖ **Quality teaching given by specialists**
  - ✓ **Teaching and transmitting the sodium technology knowledge is assumed both through theoretical lectures and practical exercises:**
    - ❖ **Adapted means of communication**
    - ❖ **Practice exercise test rooms, using sodium circuits and specific instrumentation rooms**
    - ❖ **Sodium fire area, for training exercises**

Training on SUPERFENNEC

Training on sodium fire

The Sodium School

- **Sodium school means :**

  ✓ **There are ten different sessions (from 1 to 5 days long), focusing on four main purposes :**

  physico-chemistry of sodium coolant

  sodium technology

  sodium safety including exercise on a real sodium fire

  sodium decommissioning

✓ **The complete library of courses is made of about 80 documents, 40 of them being available in English. It is completed by a number of films and pictures, and by the visit of existing R&D sodium platforms**

FROSS: Fast Reactor Operation and Safety School

Fast Reactor Operation and Safety School created at Phenix in 2005

✓ To answer to the training needs of other international partners involved in the development & safe operation of Sodium Fast Reactors

Objectives:

✓ Provide, in English, a training on :

- Reactor and Sodium circuits technology description
- Safety and organizational aspects of SFR operation
- Circuit and plant operation, with emphasis on safety aspects
- Normal, incidental and accidental instructions

Phenix NPP is a prototype sodium Fast Breeder Reactor (FBR)

It has been operated for over 33 years :

- ✓ First divergence in 1973
- ✓ First connection to the French grid, in December 1973

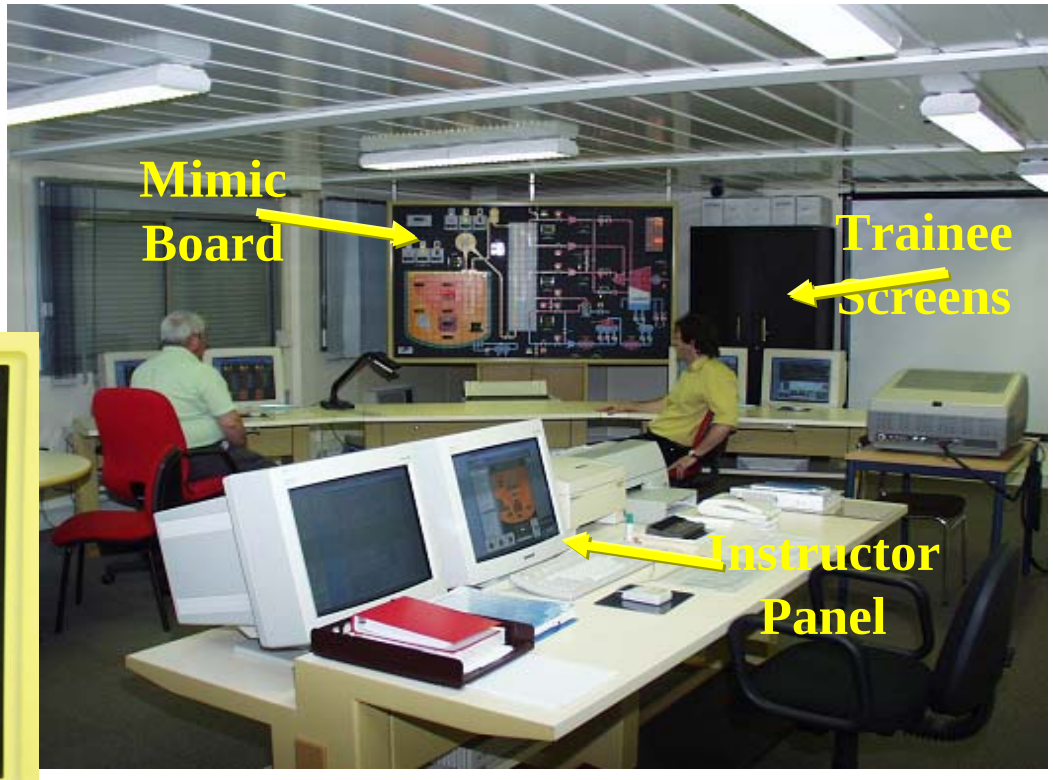
Phenix NPP was awarded as a "Nuclear Historic Landmark" by the American Nuclear Society in 1997

FROSS: Fast Reactor Operation and Safety School

Based on :

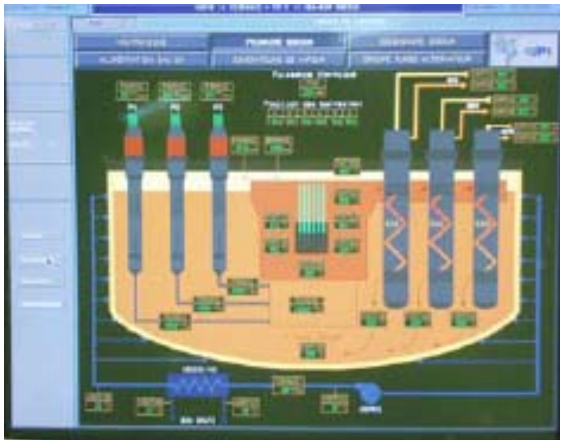
- ✓ Phenix own training programme of operators
- ✓ Operating instructions validated by 33 years of operation

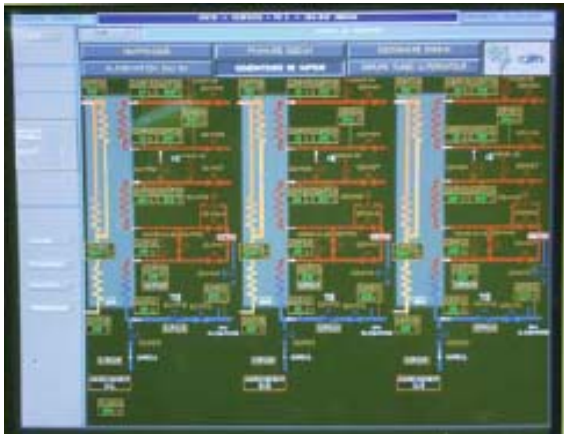
✓ Intensive use of SIMFONIX simulator with 13 years of teaching experience



Example of simulator training courses

- Subcritical Approach and criticality
- Reactivity step
- Rod calibration
- Reactor protection
- Feedback effects
- Plant start-up (Steam Generator in operation)
- Load reduction and normal shutdown
- Scram procedures
- Action to follow in the event of primary coolant pump failure
- Neutronic incidents
- Primary cooling system incidents
- Secondary cooling system incidents



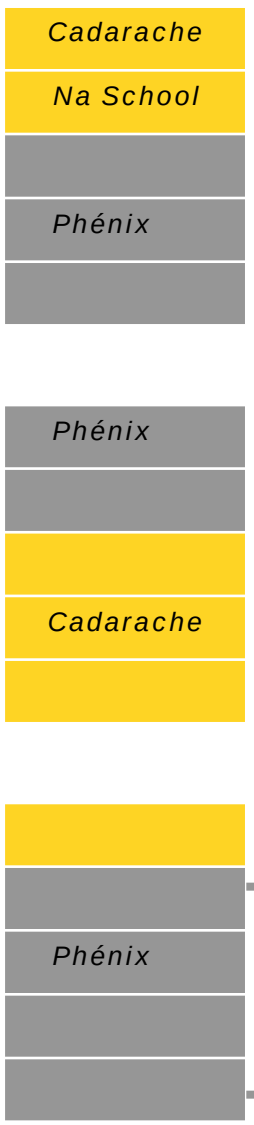


FROSS: Fast Reactor Operation and Safety School

Consists of a combination of :

- ✓ Lectures, associated with discussions with experts
- ✓ Demonstrations
- ✓ Simulator exercises
- ✓ Direct exchanges with operating staff: meetings with section managers, experience with a shift team

FROSS: Fast Reactor Operation and Safety School



Module 1 *(2 days)* Sodium technology and safety

Module 2 *(1.5 day)* Plant organisation

Module 3 (3.5 days) Plant operation

An example of a 3 week program

Module 4 *(4 days)* Sodium Technology

Module 5 (1 day) Na circuit and reactor commissioning

Module 6 (2.5 days) Plant accidental operation

Assessment of the training and conclusions

FROSS: Fast Reactor Operation and Safety School

- *Training of engineers, operators of the plants :*

✓ **CIAE (China Institute for Atomic Energy - China)**

- ❖ **3 sessions dedicated to reactor operation since March 2006**

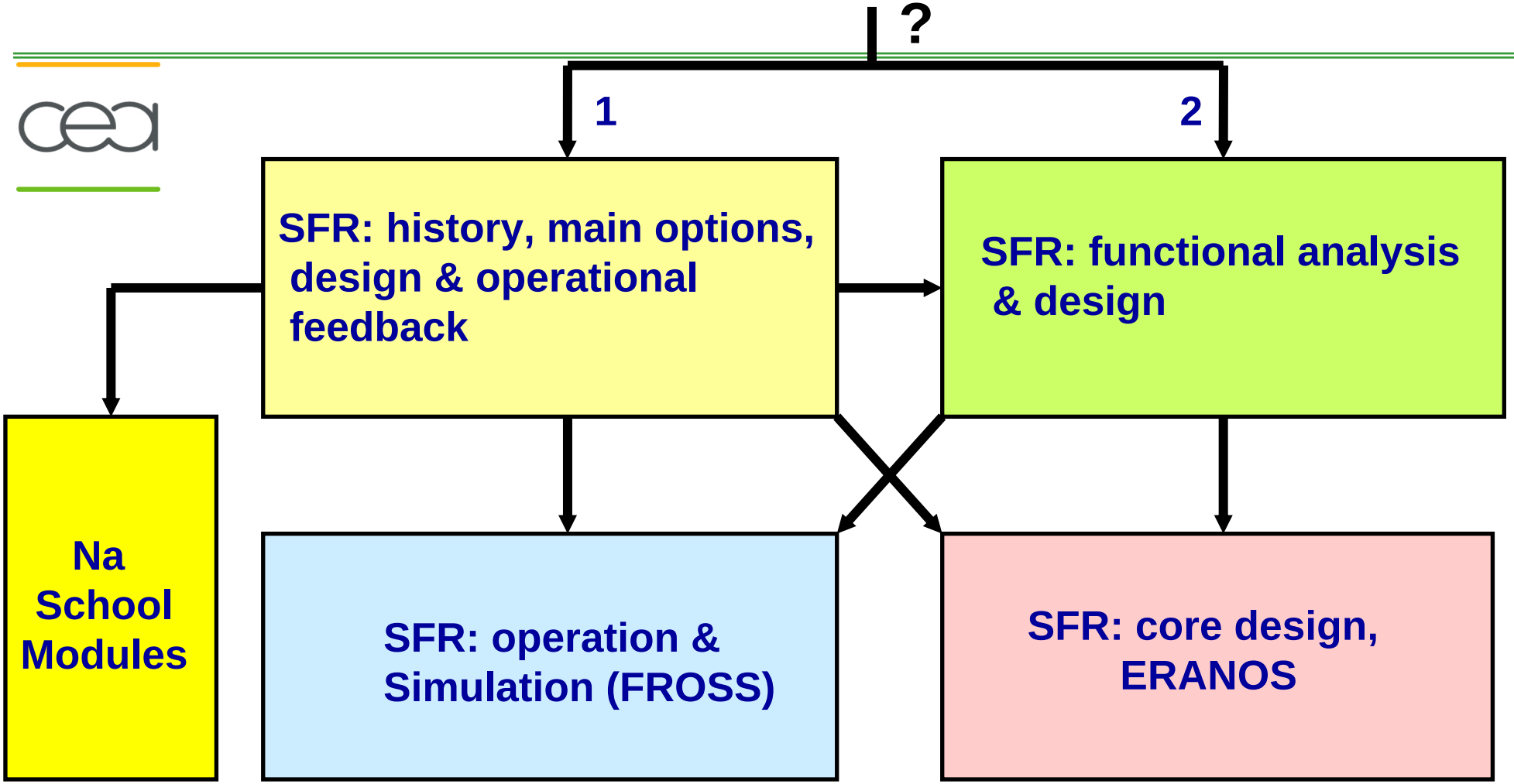
✓ **IGCAR (Indhira Gandhi Center for Atomic Research - India)**

- ❖ **4 sessions since November 2005 dedicated to Operation & Safety of SFR**

✓ **Rosatom (BN600-Russia) (TACIS program)**

- ❖ **3 sessions dedicated to Operation & Safety of SFR**

INSTN Sessions dedicated to SFR



Partnership with European Union: Education & Training

For ESFR : 5 Seminars

➔**Seminar N° 1: « SFR: Na behaviour & Safety »**

➔ **Cadarache INSTN: 2009 Nov. 23rd to 27th**

➔ **25 Teachers & Educators from France(CEA, IRSN, EDF, AREVA), Germany, Czech Republic and Latvia**

➔ **37 Trainees from Engineering Companies, Universities,… from Czech Rep. European JRC, France, Germany, Hungary, Italy, Latvia, Netherlands, South Korea, Spain, …**

Seminar N° 2: In Cadarache: SFR design: methology &

European Session Content

History, description of SFR
Na chemistry, thermal-hydraulics
Technology (SGU, pumps,
Instrumentation
Material behavior
Safety (Na fires, Na-H_2O interaction
Purification, cleaning, decontamination
Visit of Phenix

Other ways of Education & Training

- **Collaboration with French Universities (and more particularly with Marseille, Grenoble, Toulouse,…)**
  - **Teaching in Universities**
  - **PhD, Post-docs**
- **Exchange of students with other European Countries, Japan (JAEA),…**

-Chemical analysis of trace elements and nucleids in sodium coolant and argon cover gas of experimental fast reactor Joyo
In-
- Service Inspection of SG tubes of FBR,…

Scientific & cultural exchange !

Conclusion

- **Education & Training: a unique mean to share basic knowledge, operational feedback, safety approachs,**
- **Over 40 years of experience and expertise on sodium cooled installations**
- **The partnership “INSTN -Sodium School – FROSS”, are able to conceive and propose sessions, adapted to the people involved in SFR developments.**

Thank you for your kind attention !!