IAEA 60 Years
Atoms for Peace and Development

Collaborative Material Test Reactor Organizations

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Research Reactor Section
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Outline

- IAEA ICERR Scheme
- Research Reactor Networks
- Nuclear Science User Facilities
- Halden Research Project
- Jules Horowitz Reactor
- SCK-CEN

IAEA Capacity-Building Programs Based on RRs

- **Internet Reactor Laboratory (IRL):** connects an operating host reactor to guest institutions, generally universities within the same region. It provides live video and data connection with a research reactor where students can interact with the reactor team, while practical experiments are conducted
- **Regional Research Reactor Schools** : offer a unique on-site hands-on training experience taking advantage of practical research reactor experiments generally conducted at different research reactors within the same region
- **Eastern Europe Research Reactor Initiative (EERRI) Training Course:** a more extensive learning opportunity, including theoretical classes, facilities familiarization, and hands-on experimental activities. In Austria, Hungary, Czech Republic, but open enrolment
- **International Centers based on Research Reactors (ICERR):** very powerful mechanism for capacity building since it provides the access to the state-of-the-art nuclear facilities and competences for advanced training

IAEA ICERR Summary

- “International Centre based on Research Reactor”
- Mechanism to support MS research reactor (RR) organizations with available capabilities for sharing – pairing with MS organizations and researchers without RRs
- IAEA Designation only – no implied commitments from IAEA or facility

ICERR Background

- Many IAEA Member States (MS) are initiating or increasing their interest in the peaceful applications of nuclear science and technology, including nuclear power
- There is a need to develop **national competencies** as well as a **framework of research and development (R&D) strategies** to effectively support the implementation or expansion of their nuclear power programmes
- To achieve these goals, they often **require access to research reactors (RRs) and their ancillary facilities (AFs, e.g., hot laboratories)** to conduct nuclear R&D projects and to educate and train young generations of nuclear scientists, engineers and technicians
- Globally there are RR operating organizations that have developed a **comprehensive nuclear infrastructure** and have established **long-standing successful nuclear R&D and capacity building programmes** at an international/regional level
- Access to these nuclear infrastructure institutions can be challenging

ICERR Objectives

- The ICERR scheme is intended to **facilitate** IAEA MSs **gain timely access** to nuclear R&D institutions
- The **principal objective** of the ICERR scheme is to **recognize and incentivise** the following outcomes:
  - **To make available existing RRs and their AFs** to IAEA MSs that don't have access to such nuclear infrastructure
  - **To provide a scientific hub** for IAEA MSs (operating RRs or not) to support nuclear R&D and capacity building objectives relevant to their identified national priorities
  - **To improve accessibility of existing RRs,** thereby optimizing the need for new RRs and/or orienting the IAEA MSs for appropriate facility investments
  - **To facilitate joint activities** of IAEA MSs targeting the development of innovative nuclear technologies for various applications.
  - **To enhance the utilization of existing RRs** while supporting IAEA MSs to develop their nuclear R&D and capacity building programmes

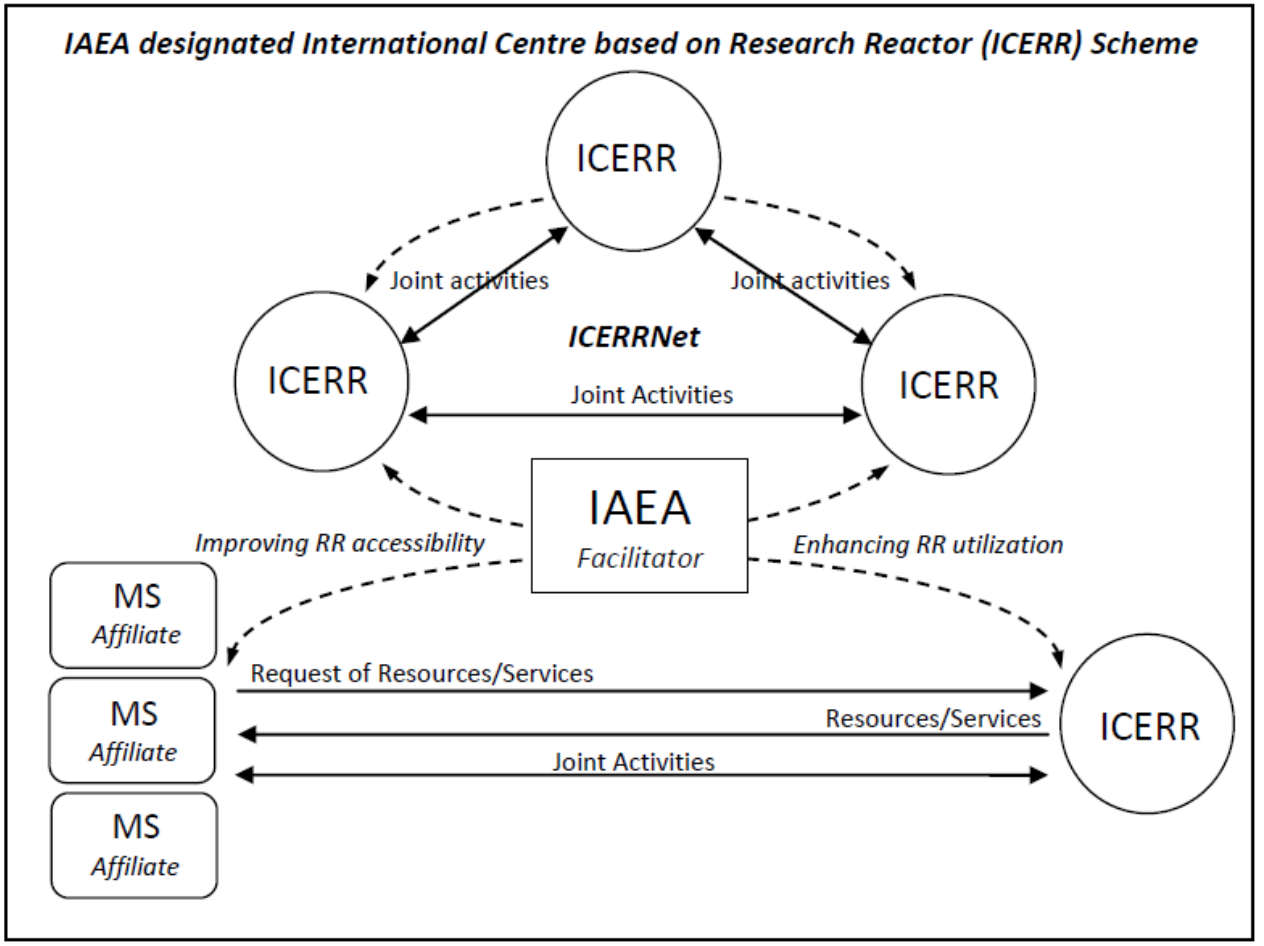
ICERR – Affiliate Arrangement

- **ICERRs** are IAEA MSs organizations and/or institutions operating or constructing one or more RR(s) and AFs that, upon request, **have been designated by the IAEA on the basis of established criteria**
- ICERRs are expected to make available, **on the basis of bilateral arrangements** (ICERR-MS), their RRs and AFs and resources to organizations of IAEA MSs seeking access to such nuclear infrastructure (named **Affiliates**)
- Affiliates Benefit:
  - Direct (or supervised) use of ICERRs' facilities
  - Expertise of ICERRs' staff
  - Processes and practices which have been established and adopted to operate ICERRs' facilities
  - Continued and/or expanded international collaboration to more fully exploit the combined infrastructure

IAEA Role in ICERR

- Within the ICERR scheme, The **functions of the IAEA** are the following:
  - **Facilitator** in the development of the relationship between an ICERR and Affiliates
  - **Facilitator** in fostering the collaboration among ICERRs
  - **Promoter** for enhancing utilization of existing RRs and AFs
  - **Designating body** responsible for ensuring that an ICERR candidate meets the establish criteria for the designation
- A network will be established by the IAEA (named **ICERRNet**) to
  - Serve as a **gateway to exchange information** between ICERRs, Affiliates, potential Affiliates, the IAEA
  - Facilitate ICERRs in **sharing experience and lessons learned**
  - Allow ICERRs to **coordinate and to rationalize their offer** of facilities, resources and services to interested MS

ICERR Scheme



ICERR Eligibility Criteria

- An **IAEA Member States' organization and/or institution is eligible** to be designated by the IAEA as ICERR if:
  - It operates or is constructing one or more RR(s)
  - It can demonstrate experience in hosting activities based on the RR with significant international/regional participation
- The Criteria for designation:
  - **Logistics Criteria**: having an established, demonstrated process, adequate infrastructure and internal organization and experience to host international/regional researchers
  - **Technical Criteria**: having demonstrated experience in promoting and participating in collaborations at international/regional level
  - **Sustainability Criteria:**
    - Demonstrated commitment from institution in terms of financial and human resources availability to assure continuous and reliable support to Affiliates
    - Capability to maintain sustainability for operation, training, licensing, waste management, etc.
    - Continuous improvement plan in place to provide potential users with access to relevant technology, methodology and standards in the area(s) of the research reactor activities for which designation is requested

ICERR Designation

- The ICERR designation process **takes into account and is limited to the specific area(s) of RR(s) activities for which the designation is requested** (such as education and training, reactor physics, thermo-hydraulic, neutron beams science, material testing, operation & maintenance, nuclear safety studies, facility management, radiation protection, emergency preparedness and response, etc.)
- The IAEA appoints a **Selection Committee** to review the application and conduct a **review mission at the ICERR candidate site(s)**
- The **assessment of the ICERR candidate** covers the **period of five (5) years** immediately preceding the date of the submission of the application
- Based on the outcome of the designation process, the **IAEA DG awards the applicant with the ICERR status** for **specific areas of activities** and for the period of 5 years from the date of the designation
- The **ICERR designation lasts for a period of five (5) years** starting from the date of the designation

IAEA Capacity Building Event

- A recent example of ICERR partnership event: **Workshop on Capacity Building in Research Reactor for IAEA Member States from the Asia and the Pacific Region** (24-27 April 2017), organized by French ICERR (CEA) in cooperation with the IAEA.
- The workshop was attended by 14 participants from 9 MSs (6 with operating RRs, 2 with planned RRs and 1 without a defined plan for RR construction)
- Topics included
  - CEA presentation of comprehensive **overview of the French ICERR activities, facilities and potential offers** in education and training, hands-on-training, R&D
  - Provided the participants with proper background to consider **what the ICERR could bring for capacity building at national and regional levels**
- Two follow up activities were identified:
  - Oganisation by the ICERR of a series of **practical and hands-on courses dedicated to specific topics** of interest for all the participant MSs or for a significant number of them
  - Use of the ICERR scheme for the **training of secondees and for join research and development activities**

Designated ICERRs

- **CEA (France) - Research Centres of Saclay and Cadarache** (2015) for “Education and Training”, “Hands-on Training” (Professional Training) and “Joint Research and Development (R&D) Projects”
- **Russian Research Institute of Atomic Reactors - OJSC “RIAR”** (2016) for “Joint Research and Development (R&D) Projects”
- **Belgian Nuclear Research Centre SCK•CEN** (2017) for “Education and Training”, “Hands-on Training” (Professional Training) and “Joint Research and Development (R&D) Projects”
- **United States Department of Energy (US DOE) - Idaho National Laboratory and Oak Ridge National Laboratory** (2017) for “Education and Training”, “Hands-on Training” (Professional Training) and “Joint Research and Development (R&D) Projects”

ICERR Future Plans

- Promote and expand the implementation of the ICERR scheme in all regions
  - Implement ICERR designation audit missions upon MS request (expected 2-3 per year for the coming 2-3 years)
  - Establishment of ICERRNet (in 2018)
  - Promote the ICERR Scheme as tool for nuclear capacity building within IAEA established TC mechanisms
  - Develop and host regional and topical workshops for ICERR affiliates

RR Networks and Coalitions

Objectives:

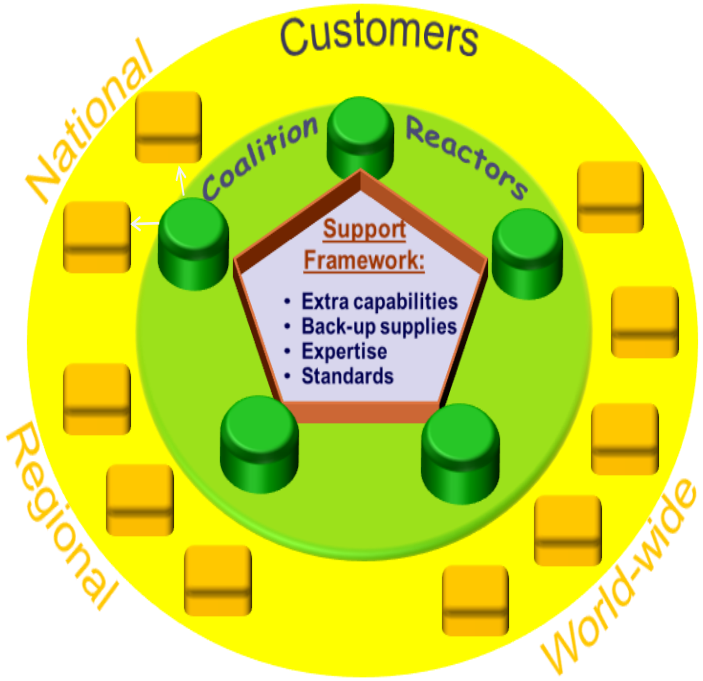
- Increase utilization & sustainability
- Promote regional/international cooperation
- Access to RRs from Member States without RRs

Role of the IAEA

- Catalyst and facilitator towards self-reliance
- Preparation of strategic and business plans
- Initial support via regional TC projects

Performance indicators:

- Number of RR facilities forming networks
- Number of non-RR countries forming networks
- Number of RRs with new/updated strategic plans
- Number of RRs with increased utilization/revenues



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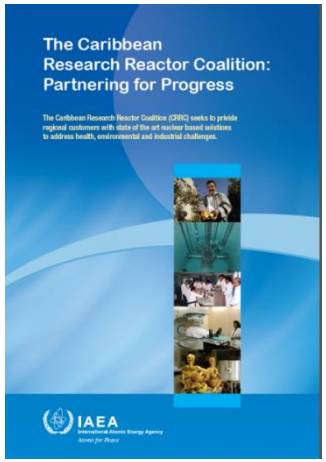
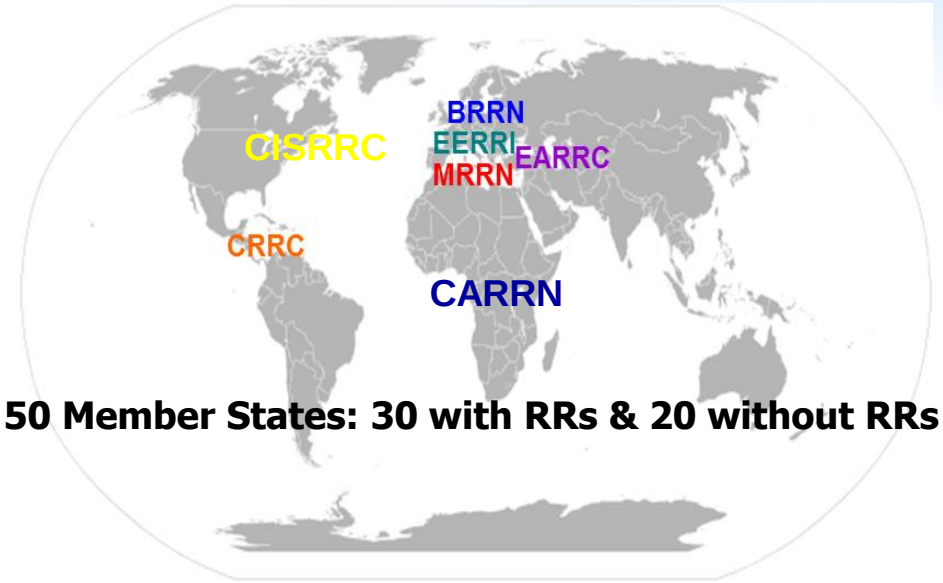
Status of RR Networks and Coalitions





1.	EERRI	Eastern European RR Initiative,	multipurpose,	6 MS
2.	CRRC	Caribbean RR Coalition,	mainly NAA,	3 MS
3.	EARRC	Eurasian RR Coalition,	isotope production,	5 MS
4.	BRRN	Baltic Research Reactor Network,	multipurpose,	10 MS
5.	MRRN	Mediterranean RR Network,	multipurpose,	12 MS
6.	CARRN	Central Africa RR Network,	multipurpose,	9 MS
7.	CISRRC	CIS RR Coalition,	multipurpose,	7 MS
8.	GTRRN	Global TRIGA RR Network,	multipurpose,	17 MS
9.	ICERRNET	ICERR MS Network	ICERR discussion	4 MS

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Regional Nuclear Education Networks

User Facilities in the United States

There are more than 60 major user facilities in the U.S. Unique facilities advance science in energy, physics, biology, high performance computing, nano-scale science, and the environment, and are open to researchers https://science.energy.gov/user-facilities

Advanced Photon Source

Before 2007 there were no user facilities to address the unique challenges of nuclear energy. In 2007, the Advanced Test Reactor (ATR) at the Idaho National Laboratory (INL) was designated a National Science User Facility to enable higher utilization by industry, universities, and regulatory agencies

Spallation Neutron Source

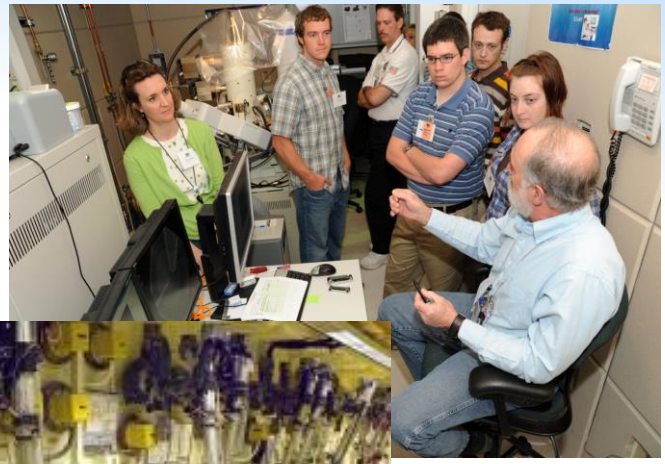
Meeting Nuclear Research Needs

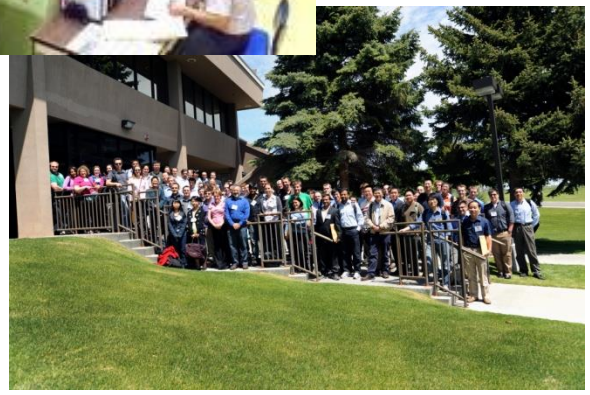
To perform the research required to support nuclear energy development requires specialized (expensive) and increasingly rare capabilities

- High flux reactors
- Hot cells and examination equipment
- Support infrastructure (shipping casks, test fabrication, etc.)

But also intellectual capital

- Universities
- Nuclear industry
- Innovative small businesses
- National laboratories





The Nuclear Scientific User Facilities merges the national nuclear research infrastructure with intellectual capital to pair the best ideas with needed capability

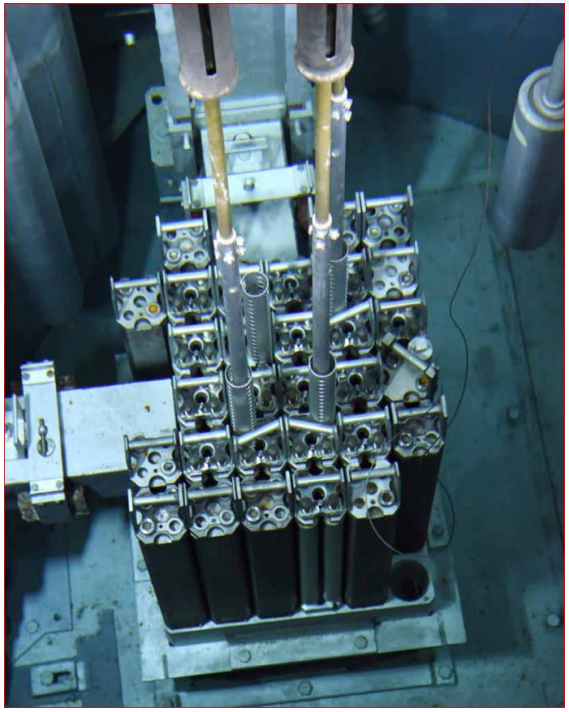
Nuclear Science User Facilities

- The Department of Energy Office of Nuclear Energy's only user facility
- Merges the national nuclear research infrastructure with intellectual capital to pair the best ideas with the needed capability
- The extensive nuclear research capabilities provided by the NSUF are typically beyond the reach of any individual laboratory
- Access to NSUF capabilities is through an open and competitive review process
- Access cost free to accepted proposals
- https://nsuf.inl.gov/

Transmission Electron Microscope (TEM), Materials Science & Technology Laboratory, Pacific Northwest National Laboratory (PNNL) USA

Types of Projects in NSUF

- Major Irradiation (neutron and ion), Post-Irradiation Examination (PIE), and Beamline Experiments
  - For large experiments that can be complex in nature and require neutron or ion irradiation and/or PIE
  - Applications are submitted annually through the Department of Energy Office of Nuclear Energy Consolidated Innovative Nuclear Research (CINR) Funding Opportunity Announcement (FOA). (See NEUP.gov)
- Rapid Turnaround Experiments (RTE) - Rolling call that closes three times per year for reviews.
  - RTEs offer researchers the opportunity to perform short-term analyses of a limited scope of work, use of an ion beam, or use of the PULSTAR reactor.
  - Use of Sample Library materials for investigation



Neutron Radiography Reactor (NRAD), INL, USA

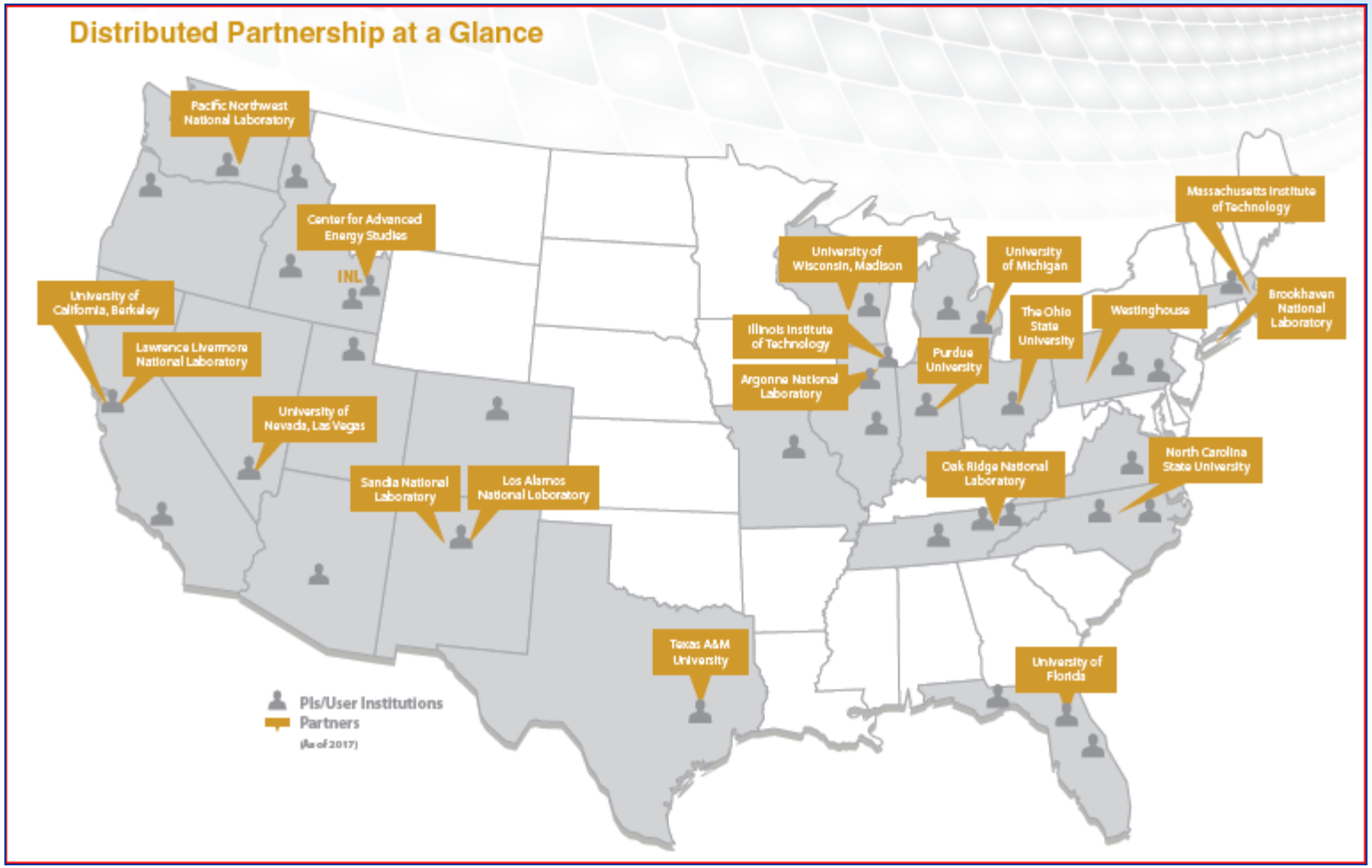
Educating New Experimenters is Critical!

- Student researcher partners
- Internships
- Faculty-student Research Teams
- ANS Student Conference Workshop, Best Speaker Awards
- TMS Meeting, Student Poster Awards
- Colloquium Series – Users, Students, Others
- Sabbatical Exchange
- University Seminar Visits

NSUF Partnerships

- Partnership Objectives
  - NSUF aims to meet customer needs
    - Experiments completed sooner
    - Enables more experiment awards
    - May not need full INL capabilities
  - Higher utilization of partner facilities
  - Support educational initiatives at the university (faculty research, student participation)
- NSUF will include additional capability that benefits users
  - University research reactors
  - Hot cells or hot laboratories
  - Material characterization laboratories
  - Accelerator facilities
- Partnership Process
  - Potential partners self-nominate
  - Evaluation and selection
  - Capabilities added to next proposal solicitation

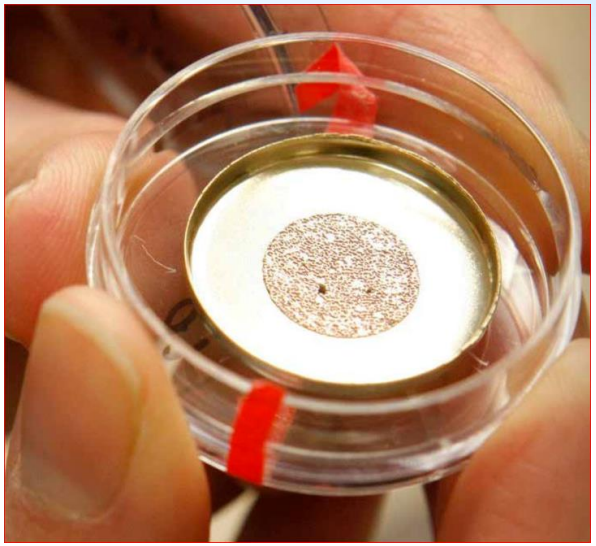
NSUF Partnership Facilities



Nuclear Science User Facilities, https://nsuf.inl.gov/Page/welcome

Sample Library—Expanding Research Opportunities

- Irradiation Experiments Performed by NSUF Researchers Investigate Novel Fuels and Materials
- More Samples are Irradiated than are Investigated due to Budget and Time Constraints.
- “Extra” Specimens are Made Available in the Sample Library to the Research Community
- Additional Samples are From Other Irradiation Projects (i.e., not NSUF)
  - Decommissioned reactors
  - Previous INL programs
  - Other laboratories



Research Samples, Radiochemistry Laboratories, University of Nevada – Las Vegas

Over 6000 irradiated specimens catalogued in the library by the end of 2016

Utilization of Legacy Reactor Hardware (NSUF Sample Library)

Proposals have been awarded to conduct investigations on legacy irradiated materials currently residing in the NSUF sample library

•Mitra Taheri, Drexel University

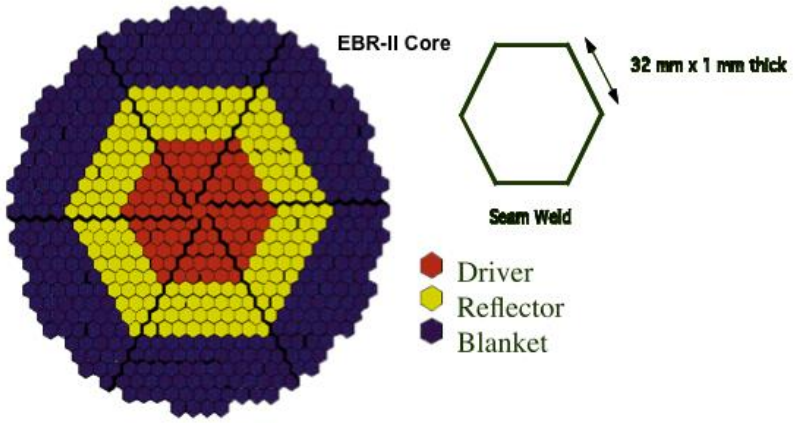
"Multi-scale Investigation of the Influence of Grain Boundary Character on RIS and Mechanical Behavior in LWR Steels"

- EBR – II 304 and 316 Hex Ducts, LANSCE Accelerator Production of Tritium- Steels

•Emmanuel Marquis, University of Michigan

"Radiation-induced segregation/depletion at grain boundaries in neutron irradiated 304SS at low dose rates"

- EBR-II Reflector Blocks



Hexagonal ducts and solid metal reflector blocks from several locations representing different temperature, dose, flux profiles have been saved for testing following the shutdown of the EBR-II reactor.

Halden Research Project, Norway

- With 20 member countries, more than 100 member organizations and almost 60 years of continuous research, the Halden Research Project is the largest international research cooperation in the world today.
- The Halden Project includes:
  - Practical-oriented research experiments in the Halden reactor
  - Studies of human interaction in control rooms
- The research provides a basis for safe operation of nuclear reactors
- IFE in Halden has been the host organization for the projec since 1958t
- Rooted in the organization through the organization NEA (Nuclear Energy Agency
- https://www.ife.no/en/ife/halden/hrp/the-halden-reactor-project

Inside the Halden Reactor hall,

HRP Joint Research Programme

- Extended fuel utilization: Basic data on how the fuel performs in commercial reactors, both at normal operation and transient conditions, with emphasis on extended fuel utilization.
- Degradation of core materials: Knowledge of plant materials behaviour under the combined deteriorating effects of water chemistry and nuclear environment.
- Man-Machine Systems: Advances in computerized surveillance systems, human factors and man-machine interaction in support of upgraded control rooms.
- Collectively known as The Joint Programme
- Key features of the Joint Programme:
  - Practical applicability of results
  - Continuously upgraded facilities
  - Qualified technical personnel
  - Innovative technologies

HRP Details

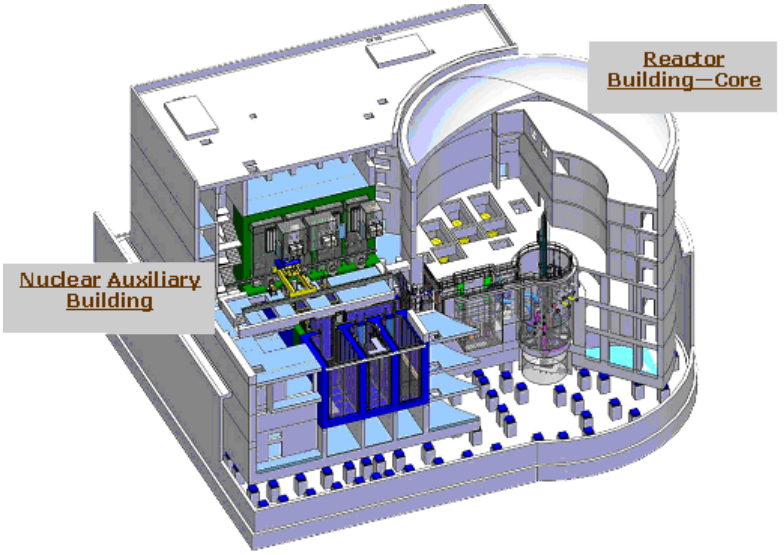
- The Joint Programme is financed by the participating countries and is renewed every three years. As host country, Norway covers about 30% of the Joint Programme cost.
- Has ~120 university graduates and ~25 foreign experts on temporary assignment.
- Programme results are systematically reported in Halden Work Reports and in Enlarged Halden Group Meetings. Participants' activities are also presented at these meetings.
- Special workshops with participation of experts are frequently arranged for in-depth assessments of specific issues
- A number of organizations in the participating countries execute their own development work in collaboration with the Project. These bilateral arrangements constitute an important complement to the Joint programme.
- All technologies and products developed in the programme are available to participants, who also have access to Halden facilities and expertise for their own development work. Several programme items have applications in a range of non-nuclear industries as demonstrated by a number of projects carried out in cooperation with participant organizations.

HRP (cont.)

- The organizations participating in the Halden Project represent a complete cross section of the nuclear community, including licensing and regulatory bodies, vendors, utility industry and research organizations.
- Active guidance and scrutiny exerted by all participants on the programmes ensure that they remain focused on issues of direct and practical relevance.
- The personnel involved in the reactor operation and maintenance have long experience and are continuously being updated on new methods and technologies. The plant is continuously modernized with new installations and components
- Tri-annual inspections of reactor facility are performed, including fracture mechanics testing of pressure vessel specimens and ultrasonic examination of the pressure vessel, with a final over-pressure test. The results constitute a solid technical basis securing future long term reactor operation.

Jules Horowitz Reactor, France

- MTR, pool, 100 MW
  - In core maximum fast flux ~1×10^{15} n/(cm^2·s)
  - Maximum thermal flux ~5×10^{14} n/(cm^2·s)
- In support of future nuclear power, Gen3+ & Gen4
- Dedicated for material/fuel irradiation and testing
- ***Funded and steered by an International Consortium***



SCK-CEN, Belgium

- Belgian Nuclear Research Centre founded in 1952
- Fundamental and applied research
- Three scientific institutes
  - Institute for Nuclear Materials Science
  - Institute for Advanced Nuclear Systems
  - Institute for Environment, Health, and Safety
- Future focus on MYRRHA as in ***Multi-purpose hYbrid Research Reactor for High-tech Applications***
  - Operates with **fast neutrons**, driven by **an accelerator**
  - The reactor is **cooled** by a **lead-bismuth alloy**.
  - The reactor is **subcritical** and consequently easily controllable.
- Educational and fellowship opportunities
- R&D partnerships
- https://www.sckcen.be/

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Thank you!

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