Defining Experimental Infrastructures – NSC Planned Activity and Link with NI2050

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NSC & DB: Main Areas of Work

Steering Committee for Nuclear Energy

- **CSNI** – Committee on the Safety of Nuclear Installations
- **CNRA** – Committee on Nuclear Regulatory Activities
- **RWMC** – Radioactive Waste Management Committee
- **CRPPH** – Committee on Radiation Protection and Public Health
- **NLC** – Nuclear Law Committee
- **NDC** – Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle
- **NSC** – Nuclear Science Committee
  - Nuclear Science Working Parties and Expert Groups
- **MBDAV** – Management Board for the Development, Application and Validation of Nuclear Data and Codes
  - NEA Data Bank

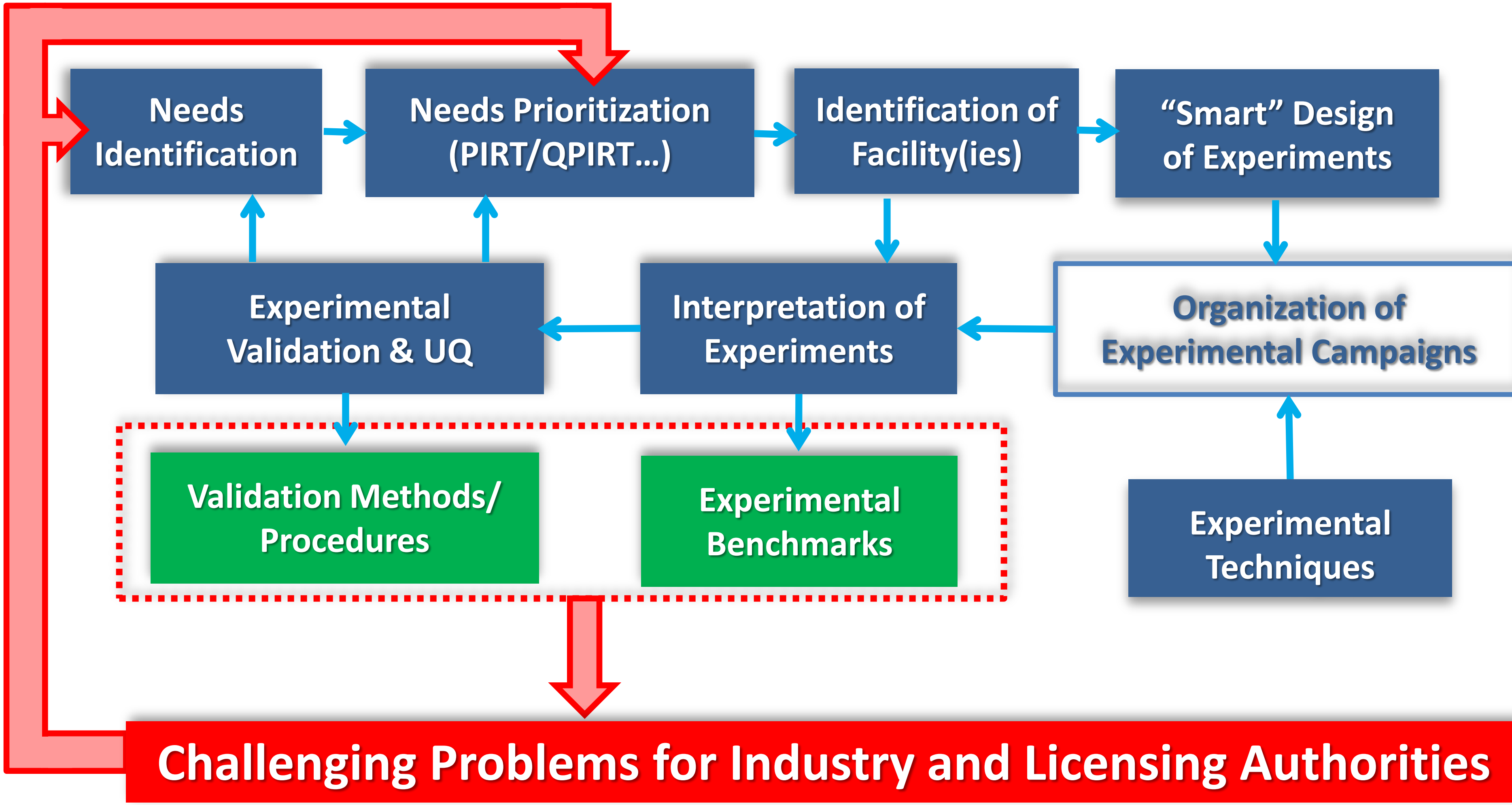
Main Areas of Work:

- reactor physics
- criticality safety
- fuel cycle physics and chemistry
- material science
- radiation shielding
- nuclear data

Motivation for Launching New Activity on Experimental Needs

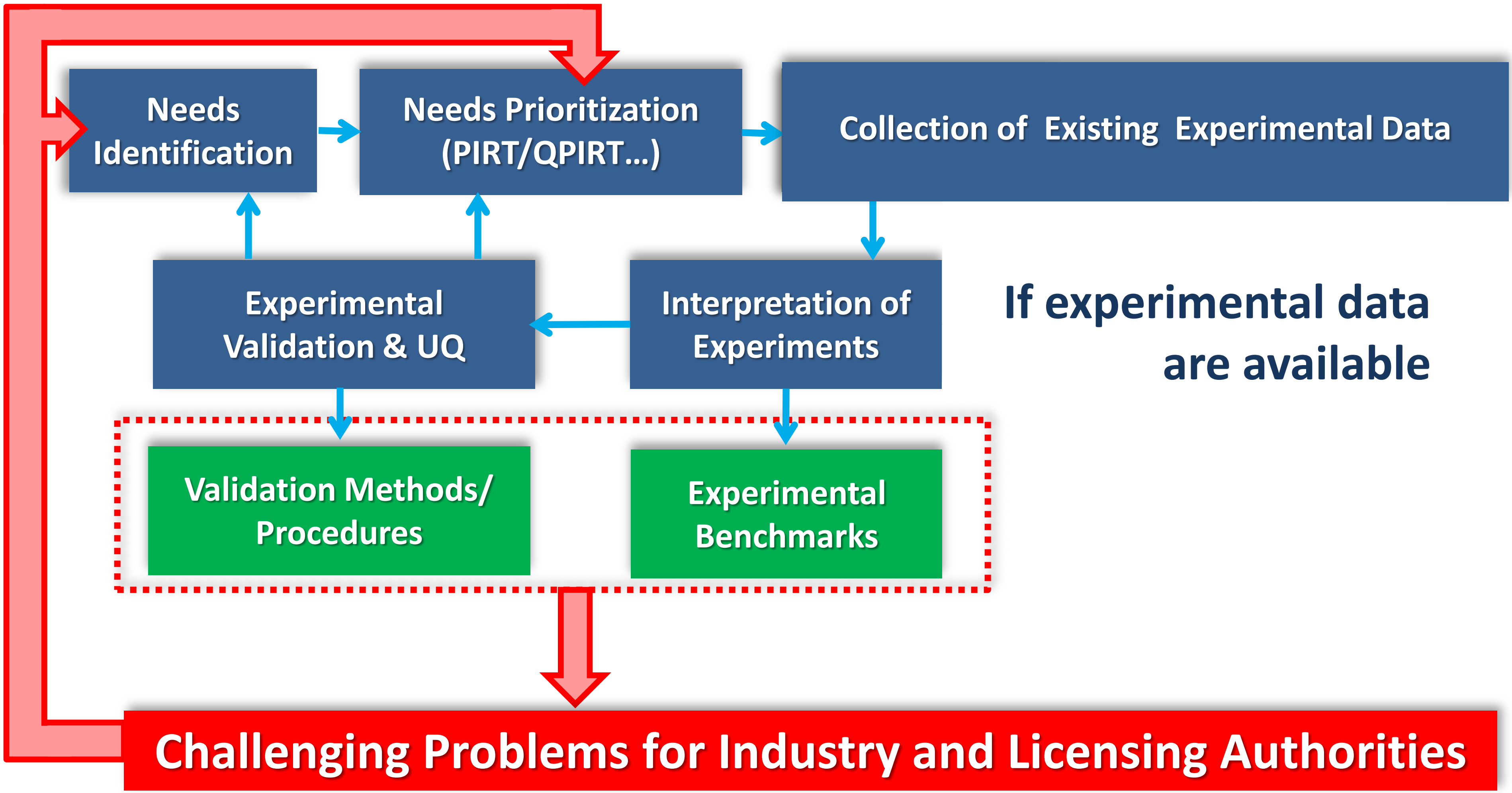
- Significant improvements in modeling – needs for validation
  - Requests for validation of multi-scale, multi-physics computations
- Ability to conduct validation experiments progresses slower than computational methods development due to
  - Shut-down experimental facilities
  - Increasing cost of experiments
  - Retirement of experts – problem of knowledge preservation and education
- Need to accelerate technology development and licensing process through
  - Smarter integration of code development, experimental approaches and validation techniques
  - Sharing experimental efforts for research and licensing
- International solutions to major challenges create more confidence in these solutions

Scope of Proposed Activity on Experimental Needs



Input from NI2050

Scope of Proposed Activity on Experimental Needs



Input from NI2050

Identification/Prioritization: Scope of Work

Objective: Coordinate needs expression via NEA activities and tools. Assist dialog of research, industry and regulators.

What is done/exist?

- WPEC high priority request list for nuclear data
- ICSBEP/IRPhEP list of priorities
- Priorities identified by CSNI

What can be done?

- **Use priorities identified by NI2050**
- Establish high priority request list of integral experiments
- Collect PIRT tables
- Develop method(s) for prioritization

"Smart" Design of Experiments and New Experimental Techniques

Objective:

Assist "smart" design of accurate experiments that

- enable reduction of uncertainty for novel technologies
- can be used for various applications

Assist development and use of new experimental technique

What is done/exist?

- Experience accumulated in ICSBEP/IRPhEP
- Experimental program for validation of damp MOX powders (example)

What can be done?

- Develop/implement "Smart" methods for experimental design
- Develop/implement novel experimental techniques to address needs for more fundamental and precise data
- Create/maintain nexus between experts in M&S and experimentalists

Identification of Experimental Facilities

Objective: Identify critical facilities and provide priority access. Assist matching existing experimental expertise and needs.

What is done/exist?

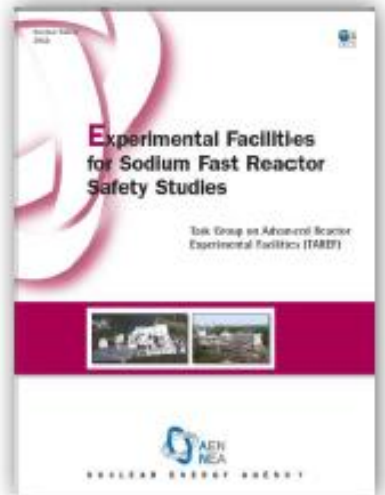
- Experimental Databases including Research and Test Facilities Database (RTFDB)
- Experimental Joint Projects
- Facilities identified by CSNI
- Membership in Advisory Boards of JHR (France) and MBIR (Russia)

What can be done?

- Re-design and update RTFDB
- **Develop/maintain contacts with experimental facilities**

Facilities Identified by CSNI

- Facilities for safety studies:
  - Experimental facilities for Sodium Fast Reactor Safety Studies (Task Group on Advanced Reactor Experimental Facilities, TAREF) (2011)
  - Experimental facilities for Gas-cooled Reactor Safety Studies (TAREF) (2009)
  - Support Facilities for Existing and Advanced Reactors (SFEAR) (2007)



C. High-temperature metallic materials

Issue C.1: Crack initiation and propagation (due to creep crack growth, creep, creep-fatigue, aging, subcritical crack growth)

Facility (Institution)	Availability	Capabilities
HTHL (NRI)	Available for out -of-pile tests. In-pile from 2011	Helium, max: 7 MPa, 900°C, 10 m^3/s, purification rate 5-10%, fast neutron flux 1×10^{14} n/cm^2s, space for samples 30×570 mm.
HTTL (INL)	Available, operational	It includes state-of-the-art high-temperature testing and examination equipment. In addition, several high-temperature (up to 3 000°C) furnaces are available for component testing.
High temp. mat. lab. (ORNL)	Available, operational	It includes a number of TEM, SEM, Auger, Atom Probe, etc. which are routinely used for irradiated materials.

From Experimental facilities for Gas-cooled Reactor Safety Studies

Research and Test Facilities Database (RTFDB)

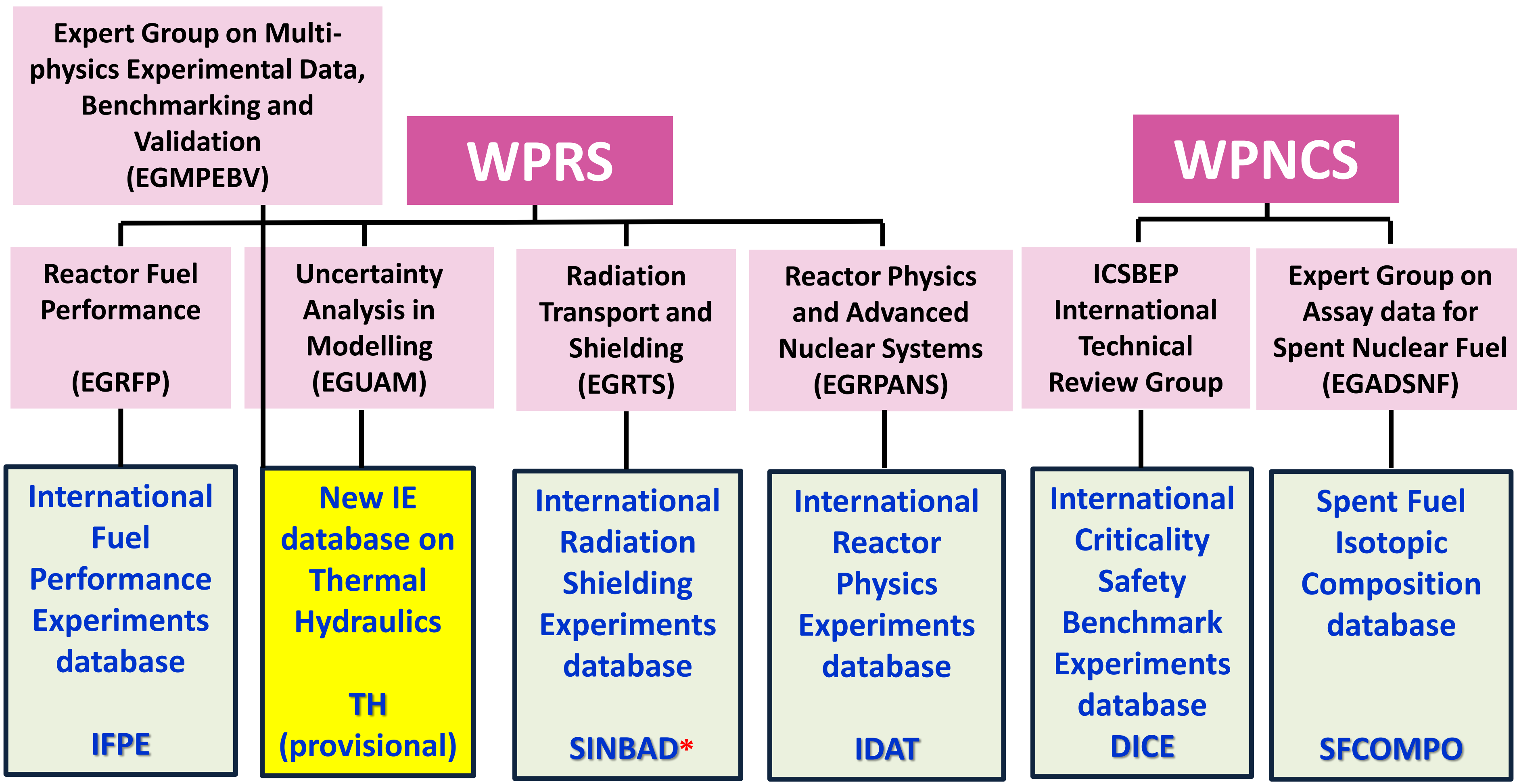
Created to review the worldwide status of facilities in the field of nuclear science and technology https://www.oecd-nea.org/rtfdb/

- Based on Report "Research and Test Facilities Required in Nuclear Science and Technology" (2009)
- Contains basic information about 1000 facilities worldwide
- On-going update of information and structure
- Information on European infrastructure provided by EC (Roger Garbil) will be incorporated into the database
- Will be linked with other NEA Databases

Requirements to RTFDB?

Recommendations from NI2050?

Existing NEA Integral Experiments Databases



*SINBAD is developed in cooperation with RSICC

Experimental Validation: Scope of Work

Objective: Assist development of validation processes that

- Clearly defines uncertainties for traditional and novel simulations
- Guides in the development of new validation experiments
- Can be transferred to industry and TSO

Components of validation methods:

- Representativity/similarity assessment
- Definition of validation domain
- Extrapolation beyond validation domain
- Uncertainty Quantification

Experimental Validation: Challenges

- Validation is constrained by advancement in modeling, benchmarking and validation methodology
- Preservation, analysis and availability of experimental data vary greatly in different domains
- Methods for experimental validation and benchmarking are fundamentally different in different domains
- Validation for multi-scale multi-physics - separate validation of single physics and coupling?
- Data science methods and out-of-the-box solutions are needed to resolve "Data-rich, knowledge-poor" situation

Experimental Validation

What is done/exist?

- EGMPEBV Task force on Validation of multi-physics methods
- WPRS/EGUAM forum for validation of neutronics and thermal-hydraulics simulations
- WPNCS/UACSA activities on validation of criticality calculations
- WPEC/Sg. 33, 39 on combined use of differential and integral data for validation of reactor physics simulation (focus on SFRs)
- WPEC/New SG (2018) on use of integral experiments for validation of nuclear data

What can be done?

- Develop novel validation methodologies, including extrapolation beyond validation domain
- Establish consensus guideline for utilization of validation data for validation
- Establish consensus recommendations for transitioning from the use of BEPU to novel validation methods
- Address major challenge problems in order to demonstrate value of experimental and validation efforts

Evaluation/Interpretation of Experiments (1/2)

Objective: Assist development of experimental benchmarks with

- Established benchmark uncertainties and correlations
- As simple as possible simulation models issued from experimental data

Components of evaluation:

- Collect experimental information
- Identify original experimental uncertainties
- Estimate uncertainties/biases due to material data, geometry, temperature etc.
- Simplify simulation model
- Create benchmark model with associated uncertainties
- Provide peer-review of the evaluation
- Make benchmarks available via handbooks/databases

Evaluation/Interpretation of Experiments (2/2)

What is done/exist?

- WPNCS/ICSBEP and WPRS/IRPhEP Handbooks and DICE/IDAT Databases of single-physics neutronics experiments

What can be done?

- Methods and experts for evaluation/interpretation of other single-physics and multi-physics experiments
- Commercially protected industrial experimental data

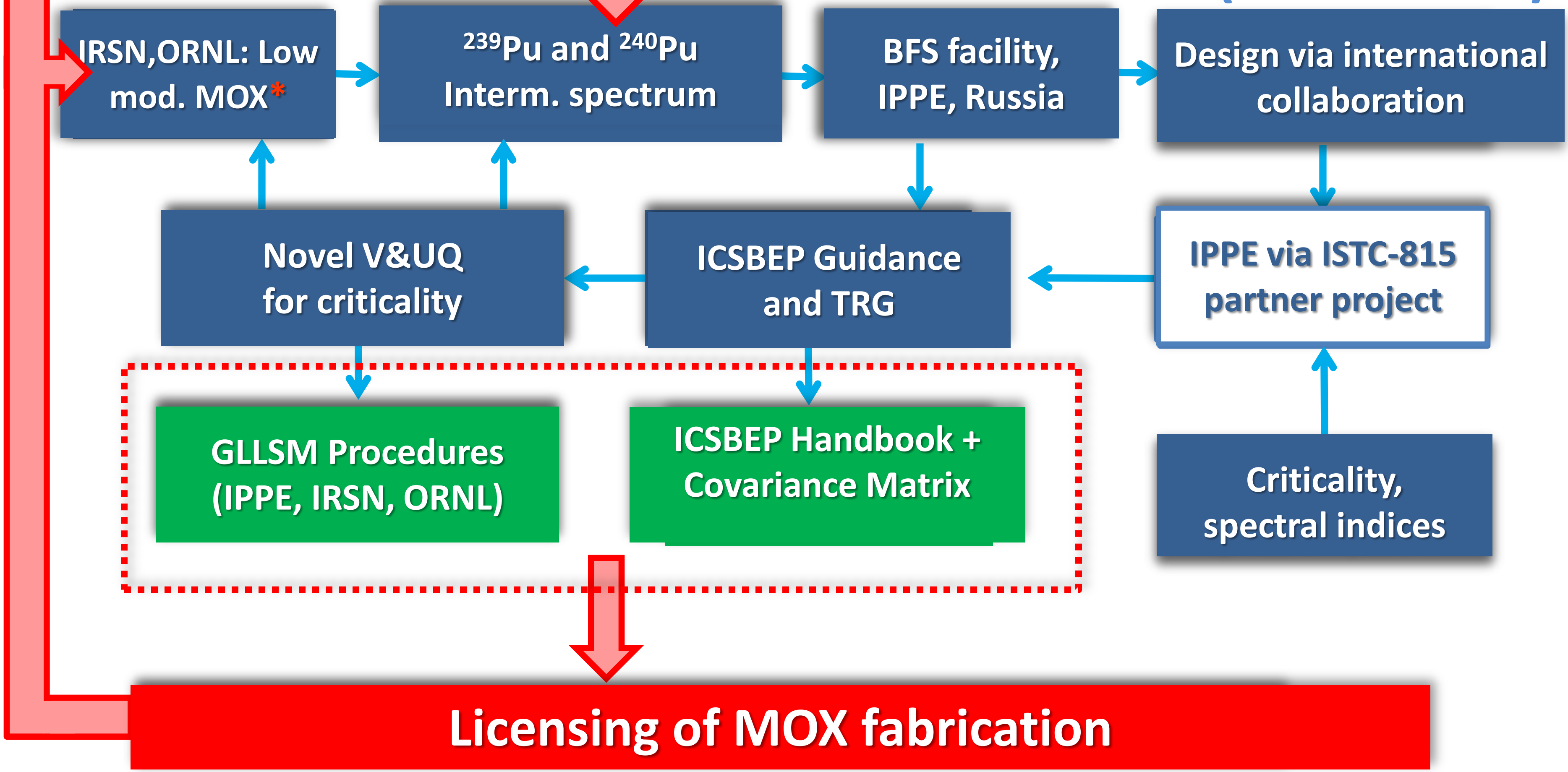
Added value of International cooperation: Example

ICSBEP/IRPhEP* budget over 20 years:

- The total cost over the past two decades is over $50 million
- The data can easily be valued at over $1.5 billion (conservatively estimated based on ~5000 experiments at $300 000 per experiment)

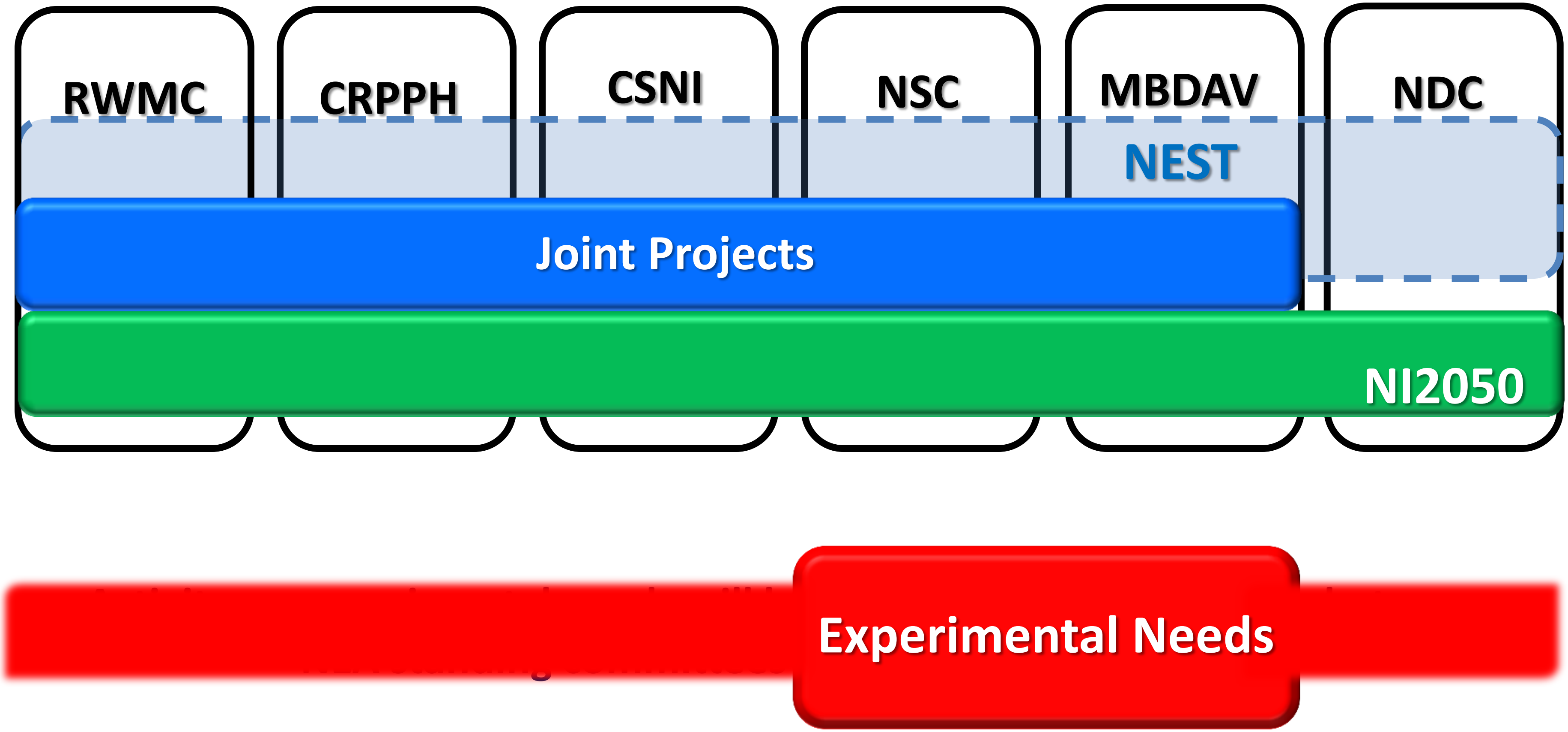
*G. Palmiotti et al "Applications of Integral Benchmark Data", NSE, 178, 295–310 (2014)

Added Value of International Cooperation: Example (2004-2009)



*The need for Integral Critical Experiments with Low-moderated MOX Fuels, **OECD-NEA/NSC**, 2004

“Experimental Needs” across NEA Activities



Proposal for Short-term Actions

- Create on-line high priority request list of integral experiments
- Collect PIRT tables across multiple technologies
- Re-design and update Research and Test Facility Database (RTFDB)
- Participate in the Advisory Board of the Experimental Facilities
- Identify a group of technical experts including representatives from research, industry, regulators and decision makers
- Prepare/distribute a survey related to experimental needs
- Organize a workshop with representatives from research, industry, regulators and decision makers
- Select challenging problems to be tackled

Establishment of New Activity: Status

Proposal to establish an activity on experimental needs

- Has been supported by NSC Bureau in January 2017

  Requirements:

  - Identify challenging problem(s) to be tackled
  - Identify NEA staff/resources to coordinate the activity

- Will be presented at the NSC meeting in June 2017 to address the requirements

Link with NI2050

The proposed activity on experimental needs

- Includes multiple tasks/components
- Can be built on the traditional role of NEA and led by NSC & MBDAV
- Requires collaboration between NEA committees and projects/frameworks with determining input from NI2050 that incudes:
  - Identification of key challenging problems
  - Identification of critical path items requiring experimental support
  - Requirements to RTFDB
  - Liaison with industry and licensing authority etc

Thank you for your attention

R&D for Support of Design and Safety

Design/Operation

Novel reactors | Conventional fleet

Target accuracy | Life time extension, instrumentation…

Safety

BEPU

NSC and MBDAV Activities

Analytical methods, models, input data…

MODELING AND SIMULATION

VVQ&UQ

Experimental evidence, analytical methods

Accuracy of design/operation parameters

Design Feasibility

Safety margins

Licensability