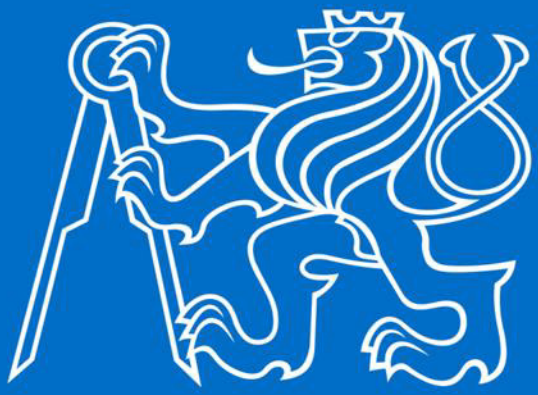


EERRI coalition as a platform for close cooperation - an enhanced utilization of research reactors in Central and Eastern Europe

L. Sklenka, J. Rataj, H. Böck, M.Villa, L. Snoj, J. Jaroszewicz, R. Baranyai, V. Broz

presented L. Sklenka

Czech Technical University in Prague

Outline

- EERRI Research reactor coalition
- Neutron beam applications activities
- Radioisotope production activities
- Fuel and material testing activities
- Education and training activities
- EERRI experiences and conclusions

EERRI Research reactor coalition

- Eastern European Research Reactor Initiative (EERRI) - the first reactor coalition established in January 2008
- 9 reactors in 7 countries
- Austria, Czech Rep., Hungary, Poland, Romania, Serbia, Slovenia
- 3 MTR/High flux reactors - BRR, Maria, LVR-15
- 3 Triga training reactors - ATI, ISJ, INR
- 2 Training reactors - VR-1, BUTE
- 1 Critical assembly - Vinca
- power - 20, 14, 10 MW ... 250, 1 kW ... 1W
- both steady state & pulse mode of operation

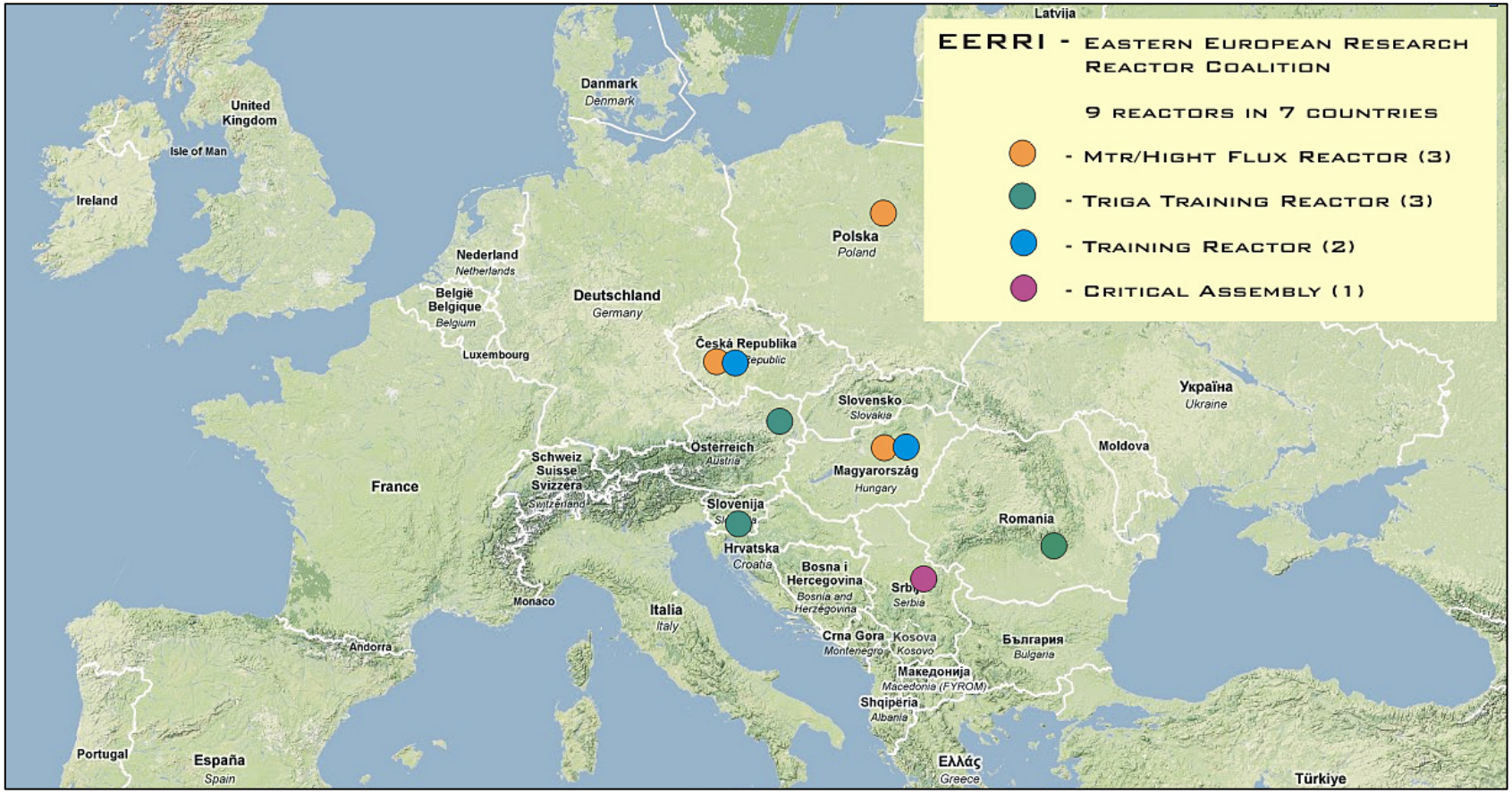
EERRI Research reactor coalition

NRI CTU IJS

IAE **Eastern European Research Reactor Initiative** ATI

BRR BUTE INS

EERRI Research reactor coalition



EERRI Research reactor coalition

Why?

- Coordination in utilization of the reactors
- Sharing the experimental facilities
- Providing complex services to customers
- Synergy benefit for EERRI members

What?

- Beam applications and neutron scattering
- Radioisotope production
- Fuel and material testing
- Nuclear Education and Training

EERRI Neutron beam applications

- Harmonisation of neutron beam experiments
- Review the existing neutron beam facilities and developing EERRI instrument database
  - 9 diffractometers
  - 5 small angle scattering instruments
  - 1 reflectometer
  - 6 spectrometers
  - 10 other types of beam instruments

EERRI Neutron beam applications

Abbrev.	Instrument Full Name	Facility
Diffractometers		
D-H5	Two axis neutron diffractometer at beam H5	MARIA
DIR1	High resolution crystal powder neutron diffractometer	TRIGA (ICN)
HOKAN6	Medium-resolution powder diffractometer	LVR-15
KSN-2	Two axis powder diffractometer	LVR-15
KSN-2	Two axis powder Diffractometer	LVR-15
MTEST	Material Test diffractometer	BRR
PSD	Powder diffractometer with position sensitive detector	BRR
SPN100	Multipurpose double axis diffractometer	LVR-15
Texdif	Multipurpose double axis diffractometer	LVR-15
TKSN-400	Multipurpose double axis diffractometer SPN-100	LVR-15
Small angle neutron scattering instruments		
MAUD	High resolution small angle neutron scattering diffractometer	LVR-15
SANS	Small angle neutron scattering instrument	TRIGA (ICN)
S-H3	Small angle neutron scattering diffractometer	MARIA
S-H4	Small angle neutron scattering diffractometer at beam H4	MARIA
Yellow submarine	Small angle neutron scattering instrument	BRR
Reflectometers		
PREF	Polarised neutron beam reflectometer	BRR

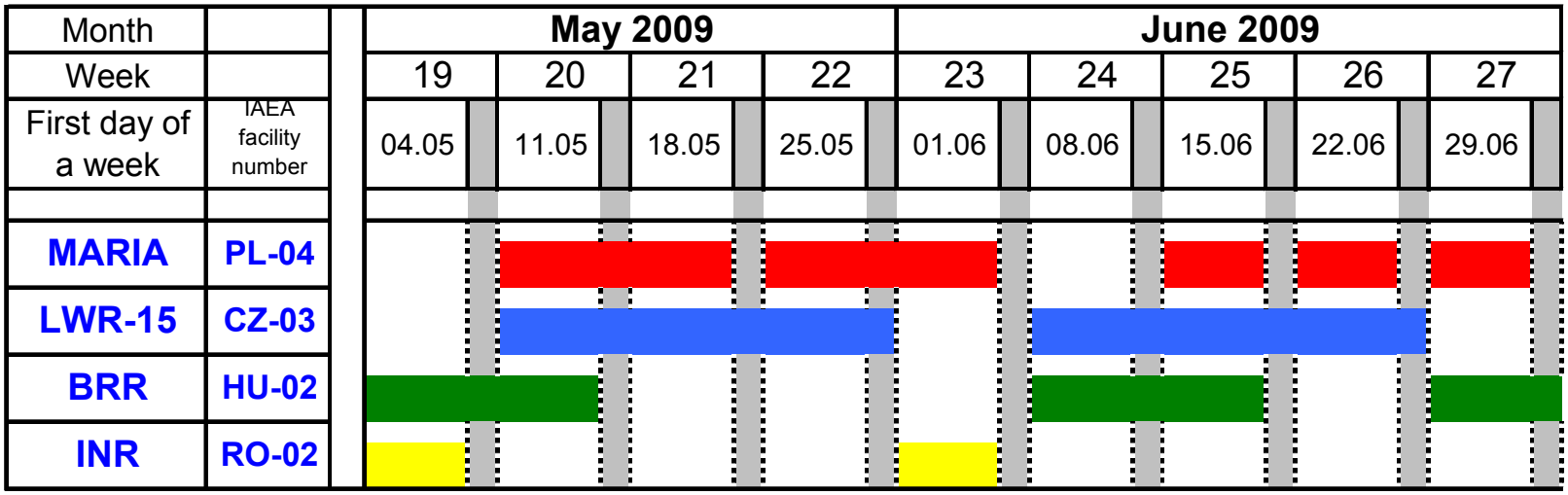
EERRI database of beam instruments (part of database, September 2010)

EERRI Neutron beam applications

- Join organization of special events
  - 2010 - Central European Training School on Neutron Scattering at BRR (FKFI Budapest Neutron Centre)
  - 2011 - workshop Concerted Actions in Research and Applications with Neutron Beams in Europe at BRR (FKFI Budapest Neutron Centre)

EERRI Radioisotope production

- Facilities for radioisotopes production - four reactors - MARIA, BRR, LVR-15 and TRIGA (ICN)
- Coordination of reactor operating schedules - the fist step in collaboration in radioisotope production



Coordination of EERRI reactors' operating schedules (2009)

EERRI Radioisotope production

- Cooperation between EERRI members:
  - capabilities of research reactors - periodically update technical data, operation schedules, maintenance periods
  - joint radioisotope production: available irradiation space, needs and offers
  - closer cooperation with radiopharmaceuticals producers and international organizations
  - integration with other European and Global initiatives
  - financial support of regional production centres

EERRI Fuel and material testing

- Facilities for fuel and material testing - four reactors - MARIA, BRR, LVR-15 and TRIGA (ICN)
- EERRI database of irradiation loops/rigs was created as a first step in future collaboration
- Fuel and material testing - difficult for collaboration:
  - testing is usually organised on a contract-basis
  - testing is significant source of operational incomes
  - customers' request for testing significantly decreased in last two years
  - utilisation of the experimental lops & rigs decrease also

EERRI Fuel and material testing

- Collaborate in fuel and material testing of the Gen IV and fusion reactors is more easily:
  - testing is closely connected with R&D
  - reactor coalition could take part in various international or national projects and grants
  - perspective field of interest of the EERRI coalition

EERRI Education and training activities

- Review of education and training activities
- EERRI database of educational subjects
- EERRI database of educational experiments
- EERRI training courses for IAEA

EERRI Education and training activities

Subject	Reactor	CTU	ATI	IJS	BUTE	KFKI	NRI
Regulatory requirements		yes		yes	yes		
Research reactors management		yes	yes	yes	yes	yes	yes
Research reactors review		yes	yes	yes	yes	yes	yes
Research reactors utilization		yes	yes	yes		yes	yes
Introduction to nuclear physics		yes	yes		yes		
Reactor physics		yes	yes	yes	yes		
Thermohydraulics of research reactors		yes			yes		
I&C Systems		yes	yes				
Maintenance and inspection programs		yes	yes			yes	yes
Fuel management, fuel cycle, fuel burnup				yes	yes	yes	yes
Water chemistry						yes	yes
Waste management					yes	yes	yes
Radiation protection		yes	yes		yes	yes	yes
Emergency procedures		yes			yes	yes	yes
Decommissioning of research reactor					yes	yes	yes

EERRI database of educational subjects (part of database, September 2011)

EERRI Education and training activities

Training Experiment	CTU	ATI	IJS	TUB	KFKI	Rez	Swierk	Pitesti	Vinca
Reactor operation - practical experience	R	R	R	R	-	-			
Critical experiment, approach to criticality:									
* full scale experiment - duration 2 weeks	A	-	-	-	-	-	-		
* mock-up experiment - by fuel adding	-	R	A	C	-	-	-		
* mock-up experiment - by moving rod	R	R	R	R	-	R	-		
Reactivity measurements:									
* Positive Period method	R	R	R	R	-	R	-		
* Source Jerk method	R	-	-	-	-	-	-		
* Rod Drop method	R	-	-	A	-	-	R		
* Source Multiplication method (Greenspan)	R	-	-	R	-	-	-		
* Noise analysis (Rossi-Alpha methods,...)	C	-	-	A	-	-	-		
* Digital Reactivity meter	C	-	R	C	-	-	R		
Control rods calibration:									
* Inverse Count Rate	R	-	-	A	-	-	-		
* Mutual Calibration method	R	-	-	-	-	R	R		
* Positive Period method	A	R	-	R	-	R	-		
* Rod Swap method	-	-	R	-	-	-	-		
* Rod insertion method	-	-	R	-	-	-	R		
Study of reactor dynamics:									
* zero power reactor with/without neutron source	R	-	R	R	-	-	-		
* delayed neutrons detection	R	U	-	R	-	-	-		
* thermal effects & coefficients	C	R	R	A	-	R	R		
R - Routine experiment, A - Advance experiment, U - Under-construction, C - Considered									

EERRI database of educational experiments (part of database, September 2011)

EERRI Education and training activities

- Some Member States with little or no existing nuclear skills / infrastructure:
  - request IAEA to assist in developing nuclear skills and resources in order to establish national nuclear power programme
  - plan to construct a research reactor as a first step to develop nuclear power programme
- EERRI Group Fellowship Training Program
  - to help IAEA in above mentioned issues
  - 6 weeks introductory course
  - theory, experiments & hands-on experiences
  - at 3 different research reactors in 2-3 European countries

EERRI Education and training activities

Module 01 **Technical visits** (minimum of three reactors listed below)
TRIGA Research Reactor in Vienna, TRIGA Research Reactor in Ljubljana, VR-1 Training Reactor in Prague, LVR-15 Research Reactor in Prague, Training Reactor in Budapest, BRR in Budapest

Module 02 **Introduction** (lectures)
Introduction to Research Reactor (RR), Introduction to RR utilization, Introduction to Nuclear Engineering, Overview of RRs types, Overview of Nuclear Power Plant (NPP) types

Module 03 **Theory** (lectures and computer based exercises)
Reactor physics of RRs, Introduction to reactor calculations, RRs reactor physics parameters and models, Calculation of RRs safety parameters, Introduction to computer codes – diffusion, transport & Monte Carlo codes, Thermal hydraulics

Module 04 **Basic reactor experiments** (lectures and practical exercises on RR)
Neutron detection, Neutron flux and distribution measurement at RRs, Reactor kinetics & dynamics (including study of delay neutrons), Critical Experiment, Calibration of control rods, Determination of excess reactivity, Reactivity Measurement methods, Demonstration prompt criticality, Measurement of reactivity coefficients

Standardized content of the EERRI course (October 2011)

EERRI Education and training activities

Module 05 **Reactor operation** (lectures and practical exercises on the reactor)
I&C Systems of nuclear reactor, Demonstration and practical exercises in RR start-up and operation, Demonstration of fuel handling out of core, RRs maintenance and in-service inspections, Radiation detection and protection – theory & practice, Waste management at RR, Water chemistry in RRs

Module 06 **Safe operation of RR** (lectures and practical implementation at RR)
IAEA & Regulatory requirements for safe operation of RRs, Code of Conduct for RRs, Safety Analysis Report of RRs, Operational limits and conditions, Emergency preparedness and emergency exercises, Public information / communication, Quality assurance in practice at RRs, Security and safeguards of RRs

Module 07 **RRs utilization** (lectures and demonstrations at the reactor)
Training of RRs operating personnel, Beam experiments, Material testing & hot cells, Isotope production, Neutron Activation Analysis

Standardized content of the EERRI course (October 2011)

EERRI Education and training activities

- 1. course - spring 2009
  - ATI, ISJ, BRR & BUTE (Austria & Hungary)
- 2. course - spring 2010
  - CTU, ATI, ISJ & NRI (Austria, Slovenia & Czech Rep.)
- 3. course - spring 2011
  - same as 1. course
- 4. course - spring 2011
  - same as 2. course
- 5. course - autumn 2011
  - same as 2. course

EERRI Education and training activities

- The first five EERRI courses:
  - 35 participants
  - from 12 countries (Azerbaijan, Brasilia, Colombia, Estonia, Jamaica, Jordan, Malaysia, Oman, Philippines, Saudi Arabia, Sudan, United Arab Emirates & Vietnam)
- Course standardization
  - experiences from first 4 courses
  - standardized course development - October 2011
- Next standardized courses are planned in 2012 / 2013
  - spring course - Austria & Hungary
  - autumn course - Austria, Slovenia & Czech Republic

EERRI Education and training activities

1. EERRI course (ATI)

EERRI Education and training activities

2. EERRI course (CTU)

EERRI Education and training activities

4. EERRI course (CTU)

EERRI experiences and conclusions

- Collaboration in:
  - education and training is very easy
  - beam experiments is easy
  - fuel and material testing is more difficult
  - isotopes productions is very difficult
- Collaboration between:
  - low power research reactors is very easy
  - medium power research reactors is easy
  - high power research reactors is difficult

EERRI experiences and conclusions

- Coalition is conflict between competition and collaboration
- Reactor with higher power is more costly than lower power reactor (running costs, nuclear fuel, number of staff), e.g. needs to be more competitive than lower power reactor
- In nuclear education & training and nuclear science (beam experiments,...) is much more easy to collaborate than in "commercial" nuclear applications (isotopes productions,...)

EERRI experiences and conclusions

- Reactor coalition does not have
  - legal status
  - headquarter, offices, staff,...
- Reactor coalition is informal cluster of reactors only similar to information platform only
- Reactor coalition needs to find effective and enthusiastic administrator of the coalition who will be real engine of the coalition
- Essential role of IAEA (organization & financial support) - not forever

EERRI experiences and conclusions

- EERRI business plan
  - way to establish sustainability
  - have not finished yet
- EERRI activities
  - education and training - excellent experiences
  - beam experiments - some activities
  - isotopes production and fuel and material testing - a few activities only

EERRI experiences and conclusions

- The six week course is a typical example of wide range course, which is extremely difficult to organise by single reactor or single university
- The EERRI course is an excellent example of a reactor coalition activity with the aim to transfer knowledge from one region (country) into another region (country)