IAEA
International Atomic Energy Agency

"Atoms for Peace and Development"

3rd Joint ICTP-IAEA Workshop on Physics and Technology of Innovative Nuclear Energy Systems

12 – 16 December 2022, Trieste, Italy

Innovative Nuclear Energy Systems: Introduction of IAEA Activities

Vladimir Kriventsev, *Nikoleta Morelova*

Fast Reactor Technology Development Team
Nuclear Power technology Development Section
Division of Nuclear Power
Department of Nuclear Energy
International Atomic Energy Agency

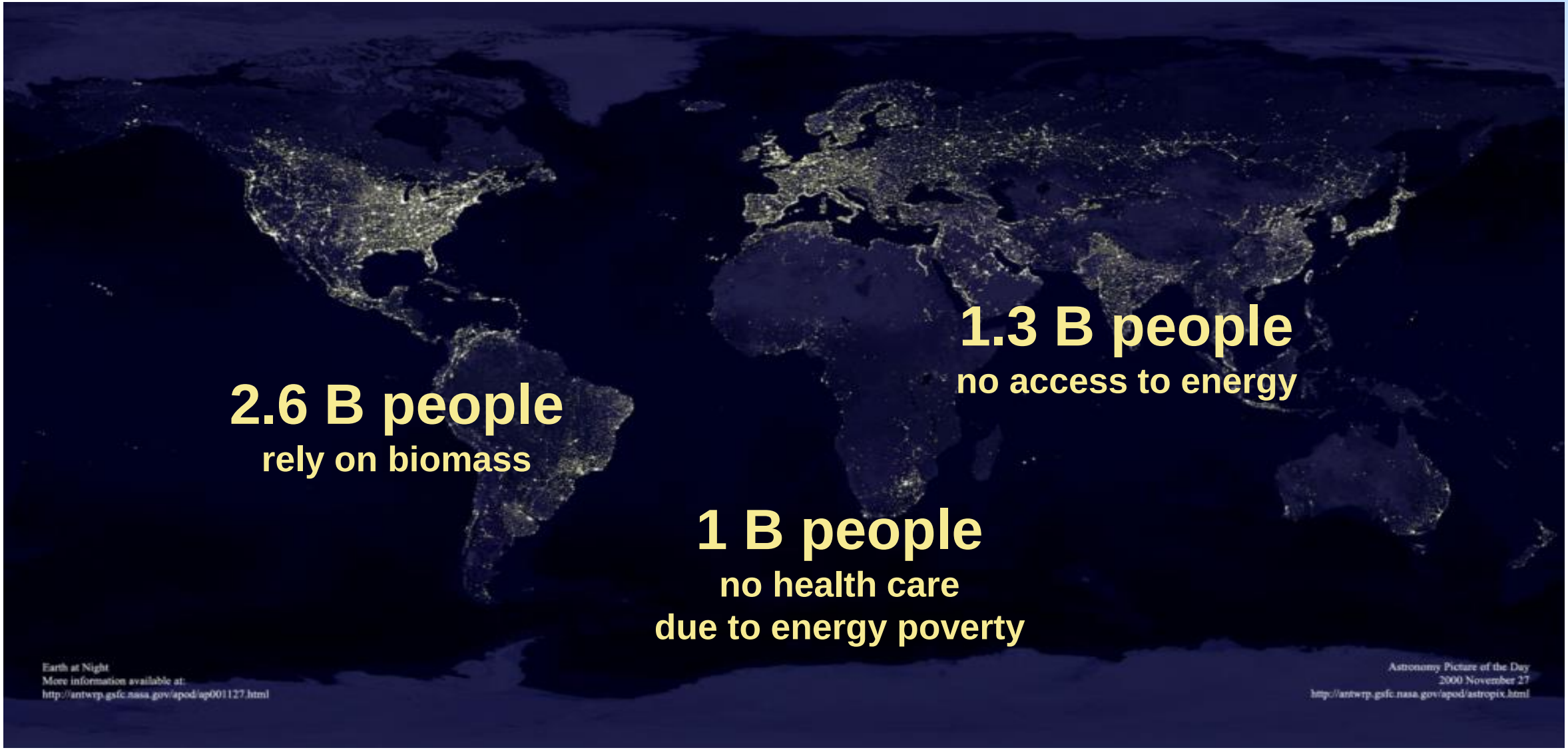
https://www.iaea.org/topics/fast-reactors

email: FR@IAEA.ORG

IAEA
International Atomic Energy

IAEA goals, mandate and assistance to the IAEA Member States

Energy


2.6 B people
rely on biomass
1.3 B people
no access to energy
1 B people
no health care
due to energy poverty
Earth at Night
More information available at:
http://antwrp.gsfc.nasa.gov/apod/ap001127.html
Astronomy Picture of the Day
2000 November 27
http://antwrp.gsfc.nasa.gov/apod/astropix.html

Nuclear Power Reactors Today

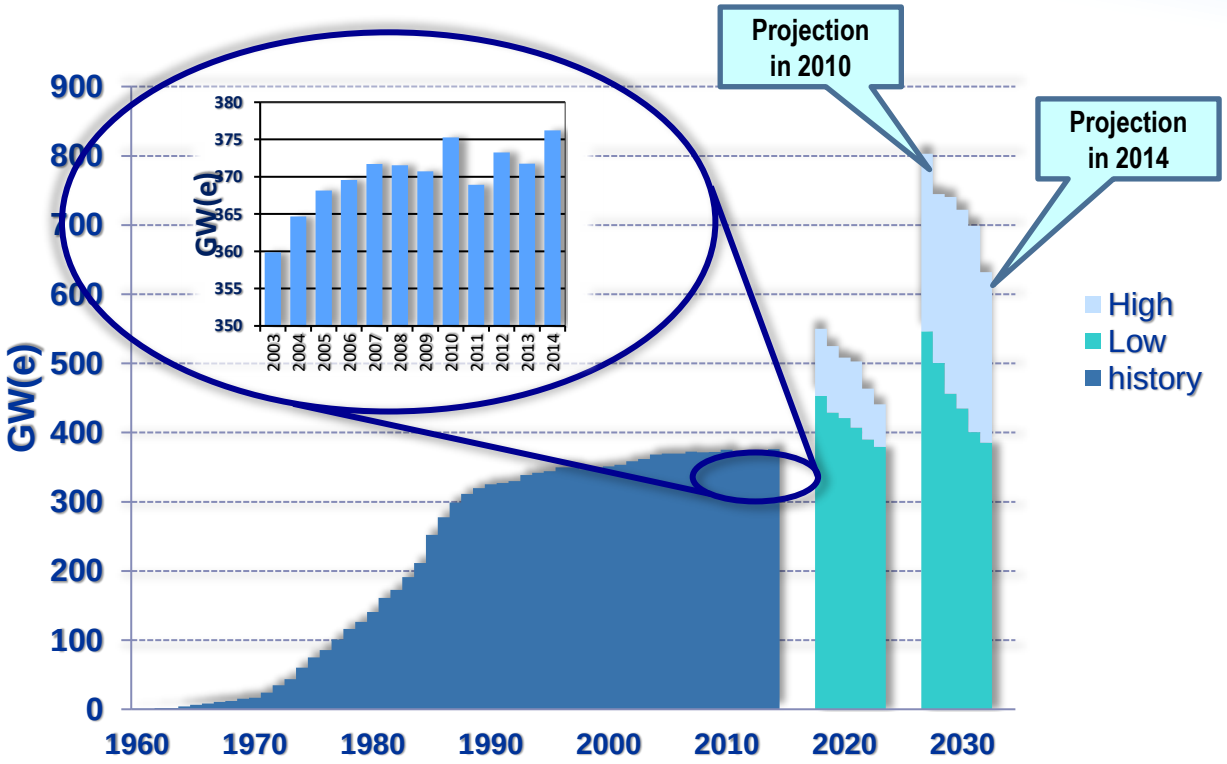
442 nuclear power reactors (~393 GWe)
in operation in 30 countries

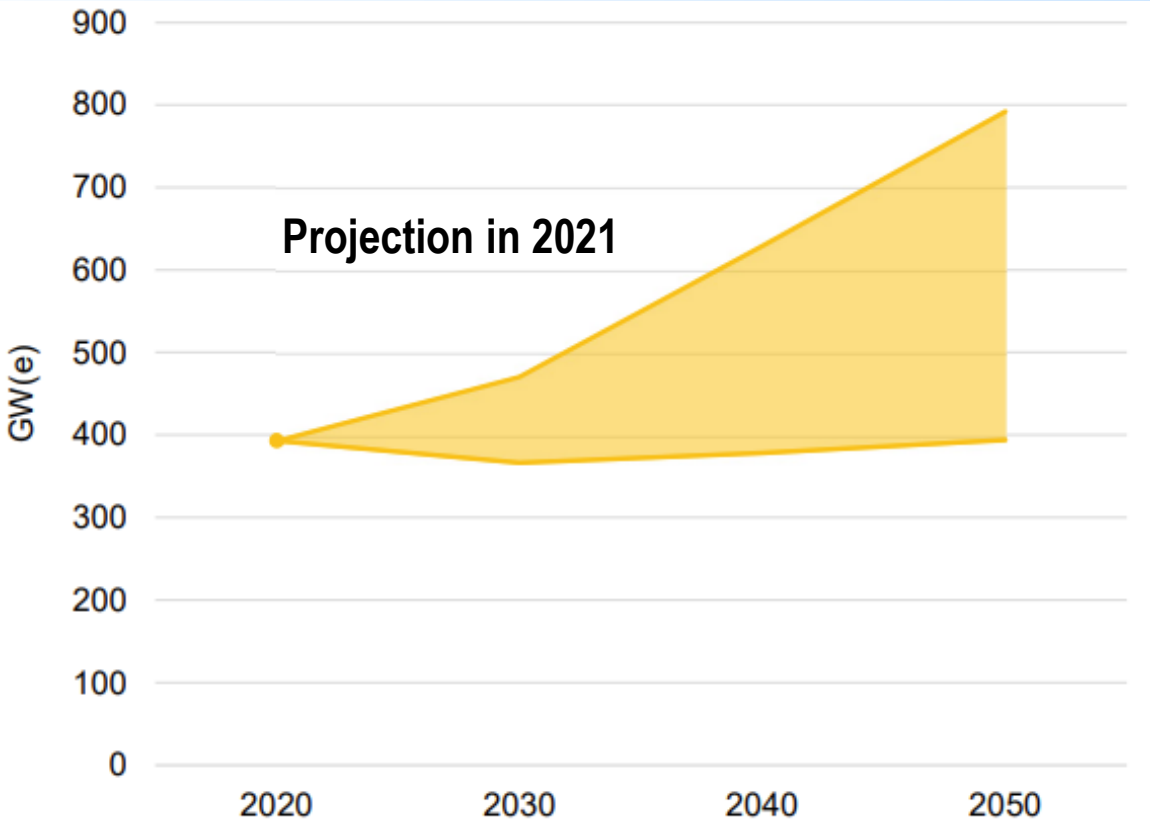
In 2020, nuclear power reactors generated 10.2% of total electricity

Generated in the world: 25124 TW h

52 new reactors, 54.4 GW(e) under construction in 15 countries (2 newcomer countries)

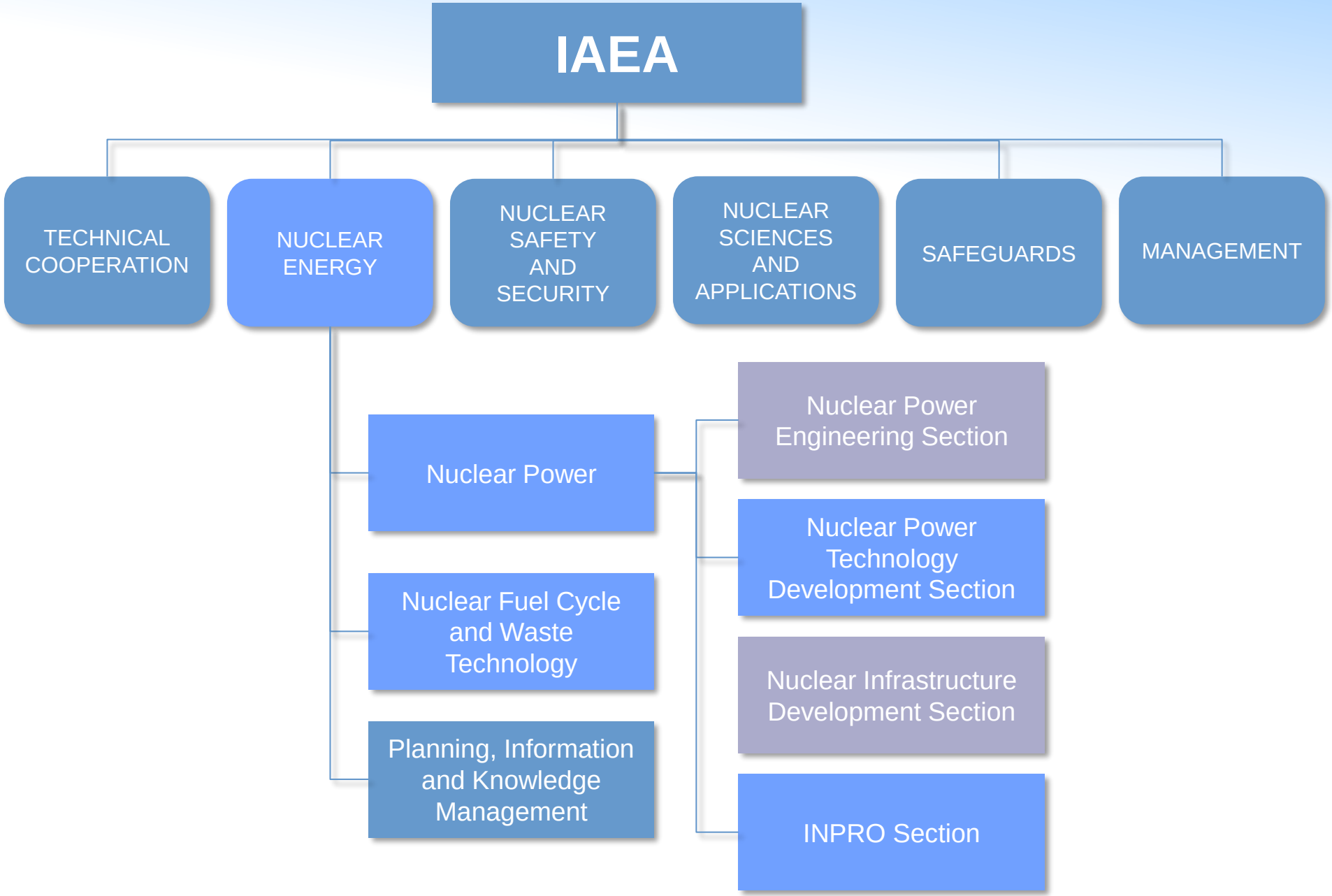
Nuclear Capacity 2020 – 2030: IAEA Projections



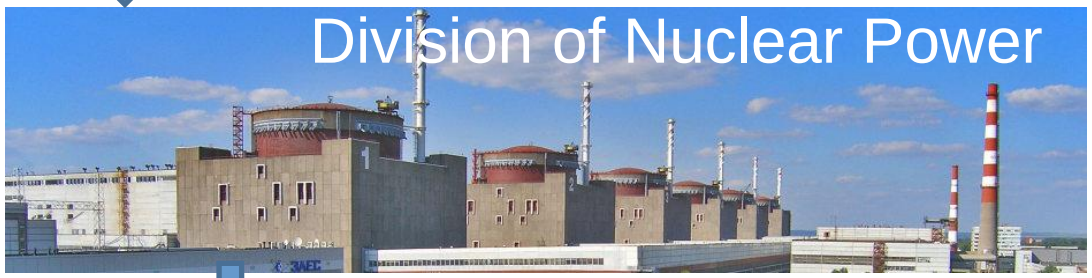


Ref.: Energy, Electricity and Nuclear Power Estimates for the Period up to 2050, 2015 Edition, IAEA

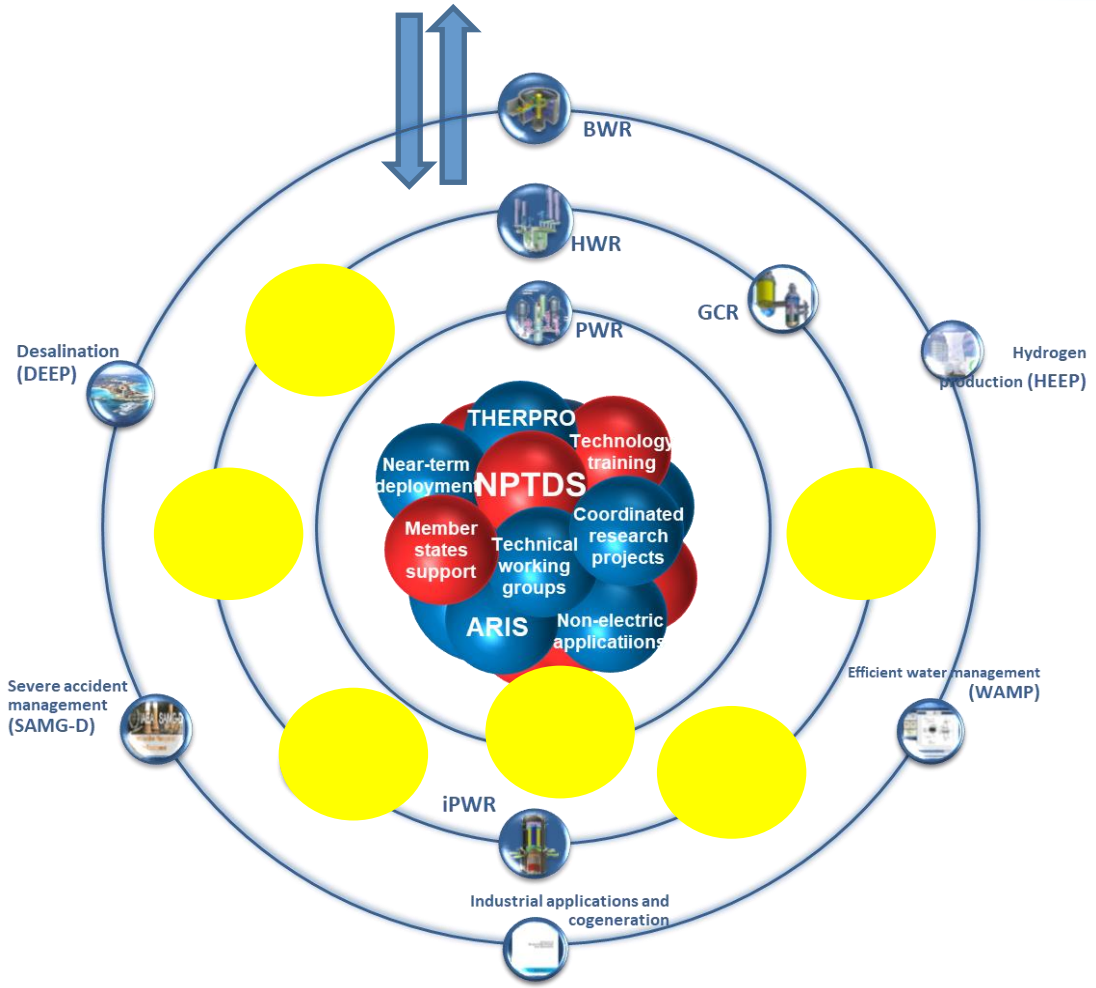
This is the IAEA


IAEA
TECHNICAL COOPERATION
NUCLEAR ENERGY
NUCLEAR SAFETY AND SECURITY
NUCLEAR SCIENCES AND APPLICATIONS
SAFEGUARDS
MANAGEMENT
Nuclear Power
Nuclear Fuel Cycle and Waste Technology
Planning, Information and Knowledge Management
Nuclear Power Engineering Section
Nuclear Power Technology Development Section
Nuclear Infrastructure Development Section
INPRO Section

Fast Reactor Technology Development Team



NPTDS:
Nuclear Power Technology Development Section



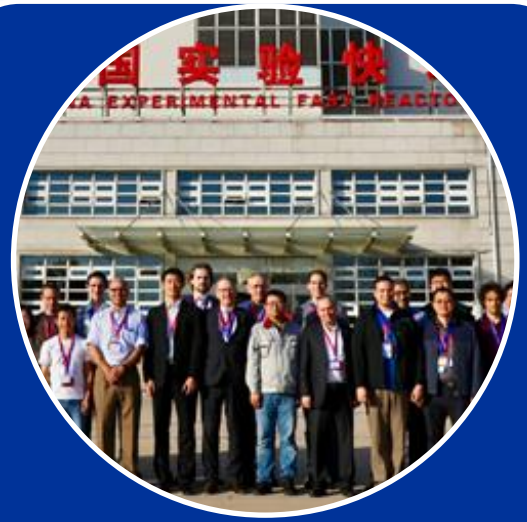
Main IAEA Activities on Advanced Reactors Technology

Knowledge Sharing

Publications

Conferences

TMs



Technology Development

Coordinated Research Projects (CRPs)

Capacity Building

Training Courses

Workshops

TECDOCs

IAEA Technical Working Group on Fast Reactors (TWG-FR)
New Term: 2022 - 2025

- Provide advice and guidance
- Forum for information exchange and knowledge sharing
- Link between IAEA activities and national communities
- Provide advice in planning and implementing of CRPs
- Develop and review selected documents
- Contribute to status report, technical meetings, topical conferences
- Identify important topics for SAGNE
- Encourage participation of young professionals in IAEA activities

Members of the IAEA Technical Working Group on Fast Reactors

Members

Argentina	**Belgium**
China	**Czech Republic**
France	Germany
India	Italy
Japan	Kazakhstan
Korea, republic of	Mexico
Netherlands	Romania
Russian Federation	Sweden
Switzerland	UK
Ukraine	USA

Observers

European Commission/JRC

OECD/NEA

Generation-IV International Forum (GIF)

From 2022: MSs as members; IOs as observers

53rd TWG-FR Meeting: **17-20 Nov 2020 (virtual)**

54th TWG-FR Meeting: **22-25 June 2021 (virtual)**

55th TWG-FR Meeting: **23-27 May 2022 (Hybrid)**

Main IAEA Activities on Fast Reactor Technology in 2021 - 2022

- CRPs/Benchmarks/Studies
  - Completed
    - NAPRO (2013 – 2018, in publishing)
    - PSFR Source Term (2016 – 2020, just published)
  - 3 Ongoing CRPs:
    - CEFR Start-Up Tests (2018 - 2022)
    - FFTF ULOF Test (2018 - 2022)
    - NACIE (2022-2026): Benchmark of Transition from Forced to Natural Circulation Experiment with Heavy Liquid Metal Loop
  - New CRPs proposals (to start in 2023+):
    - PLANDTL: PLANt Dynamics Test Loop Decay Heat Removal Thermal Hydraulics Tests
    - Modelling of Total Instantaneous Blockage of SFR F/A (Delayed)
    - Benchmarking LOF transient test in CLEAR-S HML Pool Facility (Delayed)
    - Benchmark Analysis of **STELLA-2** LOHS/LOF Tests
    - Thermal-hydraulic simulations of a high temperature helium facility S Allegro
  - Benefits and Challenges of Fast SMRs (published in 2021)
  - Structural Materials for HLM Reactors (published in 2021)
  - TM on Development and Application of Open-Source Modelling and Simulation Tools for nuclear Reactors (June 2022)
  - TM on State-of-the-art Thermal Hydraulics of Fast Reactors: ENEA Brasimone in September 2022

- Technical Working Group on Fast Reactors
  - 54th TWG-FR Meeting (Virtual), June 2021
  - 55th TWG-FR Meeting (Hybrid), May 2022
- Joint IAEA-GIF Workshops on LMFR Safety
  - 9th GIF-IAEA Workshop on LMFR Safety (2021)
  - 10th GIF-IAEA Workshop on LMFR Safety (2022)
- Basic Principles SFR Simulator
  - Factory Acceptance Test: 2021
  - Site Factory Acceptance Test: Jan 2022
  - Distribution to Member States: 2022
  - Training Course: 2022
- Training Courses and Workshops
  - Joint ICTP-IAEA Workshops on the Physics and Technology of Innovative Nuclear Energy Systems Trieste; December 2022
  - Regional Workshop on Advances in Modelling & Simulation of Thermal Hydraulics in LMFRs, India, November 2022
- Webinars
  - Repurposing sites of retired fossil plants with advanced nuclear reactors for clean energy transition; May 2022, available online
  - Multi-physics modelling and simulation of nuclear reactors using OpenFOAM (12 Lectures), Aug-Oct 2022, available online

IAEA Conference on Fast Reactors and Related Fuel Cycles **FR22**

Vienna **FR22**
19-22 April 2022

FR22: 365 Contributions
680 Registered participants
~120 in-person

1. **Innovative fast reactor designs**
2. **Fast reactor safety**
3. **Fuels, fuel cycles and waste management**
4. **Fast reactor coolants, structures, and components**
5. **Test facilities and experiments**
6. **Modelling, simulations and digitalization**
7. **Sustainability: Economics, environment and proliferation**
8. **Commissioning, Operation and Decommissioning**
9. **Education, professional development and knowledge management**

and Special Session on IAEA ongoing CRPs

Mr Bhaduri,
FR22 General Chair
India

FR22 Proceedings in preparation, expected Q1 2023

IAEA Coordinated Research Projects on FRs

The IAEA encourages and assists research on and development and practical use of atomic energy and its applications for peaceful purposes throughout the world. It brings together research institutions from its developing and developed Member States to collaborate on research projects of common interest, so-called **Coordinated Research Projects** (**CRPs**).

Completed CRPs

- **PHENIX** – EOL Tests
- **MONJU** – Na Natural Convection
- Analytical and Experimental Benchmark Analysis of **ADS**
- **EBR-II** Shutdown Heat Removal Tests
- **PSFR Source Term** – Radioactive Release Under Severe Accident Conditions

CRPs on Fast Reactors Technology

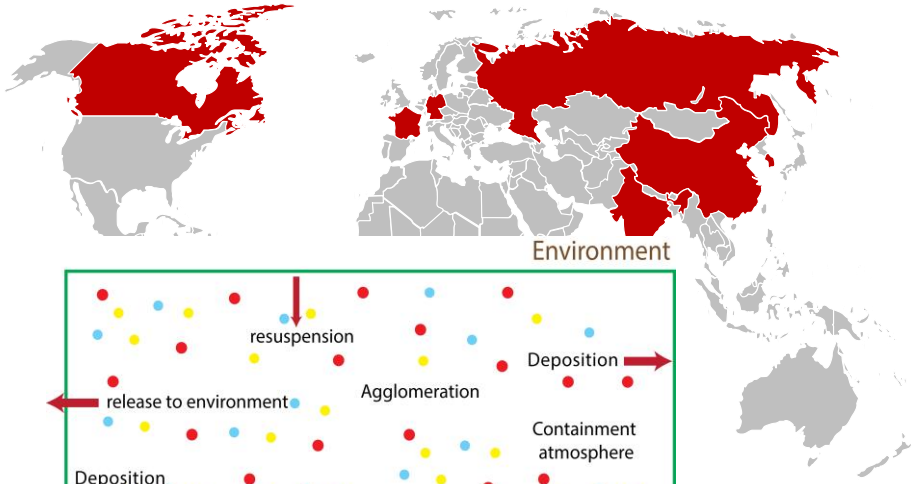
On-going CRPs

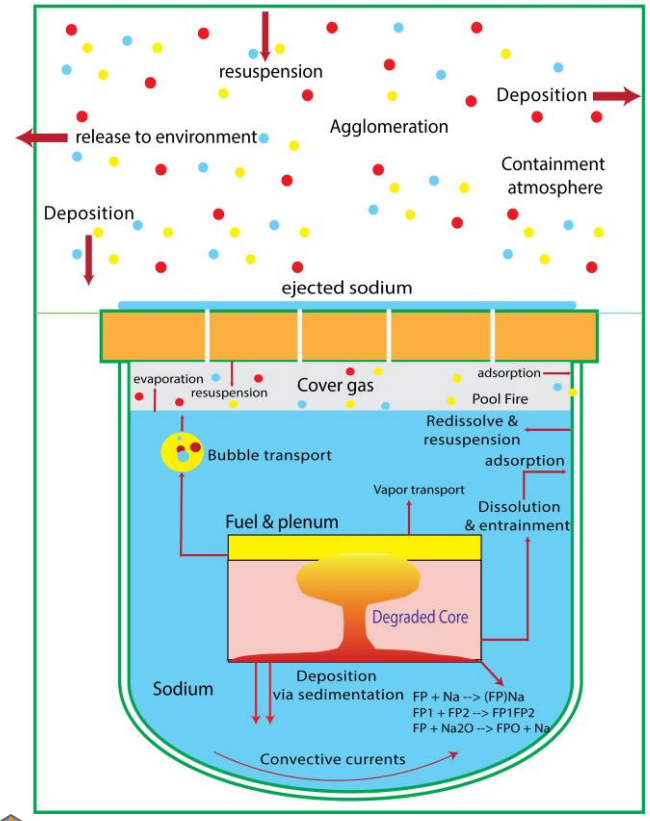
- **NAPRO** – Na Properties and Safe Operations of Exp. Facilities
  Ended in Sept 2018
  2 TECDOCs in Publishing
- Neutronics Benchmark of **CEFR** Start-Up Tests
- Benchmark Analysis of **FFTF** Loss of Flow Without Scram Test
- Natural Circulation in LBE Sub/Assembly: **NACIE** Tests

New Proposals

- Total Instantaneous Blockage of SFR Fuel Assembly
- Simulation of **CLEAR-S** Loss-of-Flow Experiment
- Benchmark Analysis of **STELLA-2** LOHS/LOF Tests
- **PLANDTL**: Decay Heat Removal Thermal Hydraulics Tests

CRP on Radioactive Release from Prototype SFR under Severe Accident Conditions (2016-2020): Summary





Reference design for the safety analysis:
500 MW(e) pool type **PFBR**

CRP on "Radioactive Release from the PSFR under Severe Accident Conditions"	
~~*Canada (UOIT)*~~	China (*CIAE*, *NCEPU, XJTU)*
France (~~IRSN~~, CEA)	~~Germany, (KIT)~~
India, IGCAR	Korea, Republic of, KAERI
Russia (~~IPPE~~, IBRAE)	Spain (CIEMAT)
Japan (~~NRA~~, JAEA)	US (*TerraPower)*

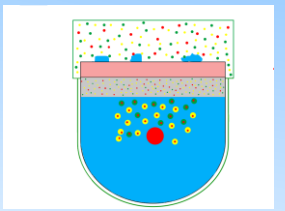
New Participant
- Japan JAEA joined in 2019 (SIMMER-IV code)

- 1st RCM: Vienna, May 2016
- 2nd RCM: IGCAR, November 2017
- 3rd RCM: Vienna, April 2019
- 4th RCM: Vienna, February 2020

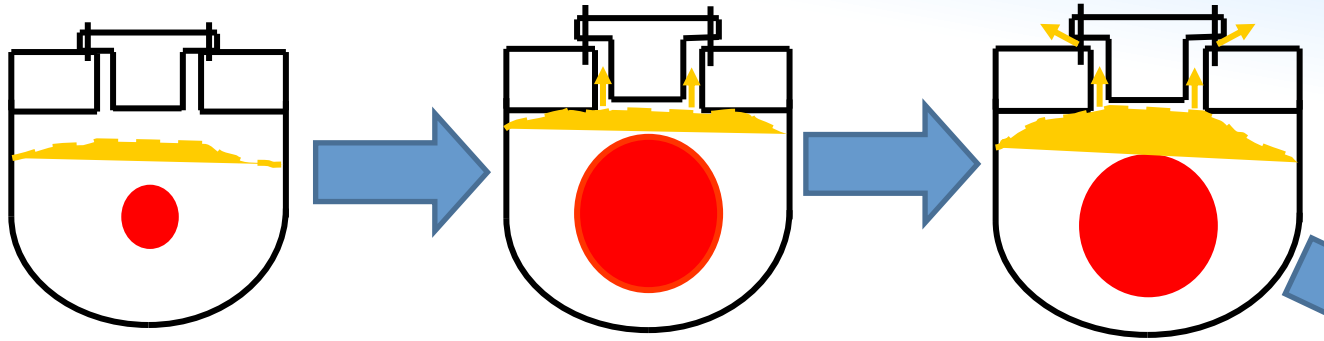
- CRP is completed
- TECDOC is published:

https://www-pub.iaea.org/MTCD/publications/PDF/TE-2006web.pdf

CRP on Radioactive Release from Prototype SFR under Severe Accident Conditions (2016- 2020)



CDA development and propagation in pool type SFR

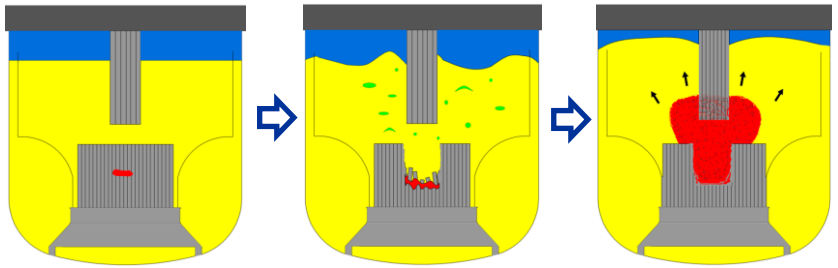


Initiation *(neutronics), and* ***Transition*** *(fuel relocation) Phases*

Core Melt/Bubble is formed

I. *Expansion Phase*

Core bubble expands in sub-cooled sodium



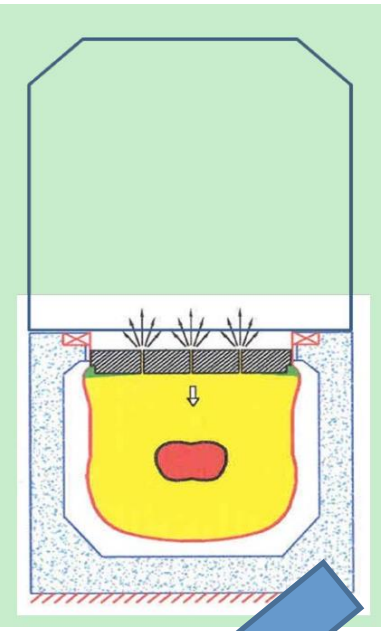
Incipient melting and early relocation

Extended relocation and core compaction

Rapid fuel vapor bubble expansion

II. *Quasi-static Phase*

Release of sodium to the Reactor Containment Building (RCB)



Reference design for the safety analysis:
500 MWe pool type PFBR

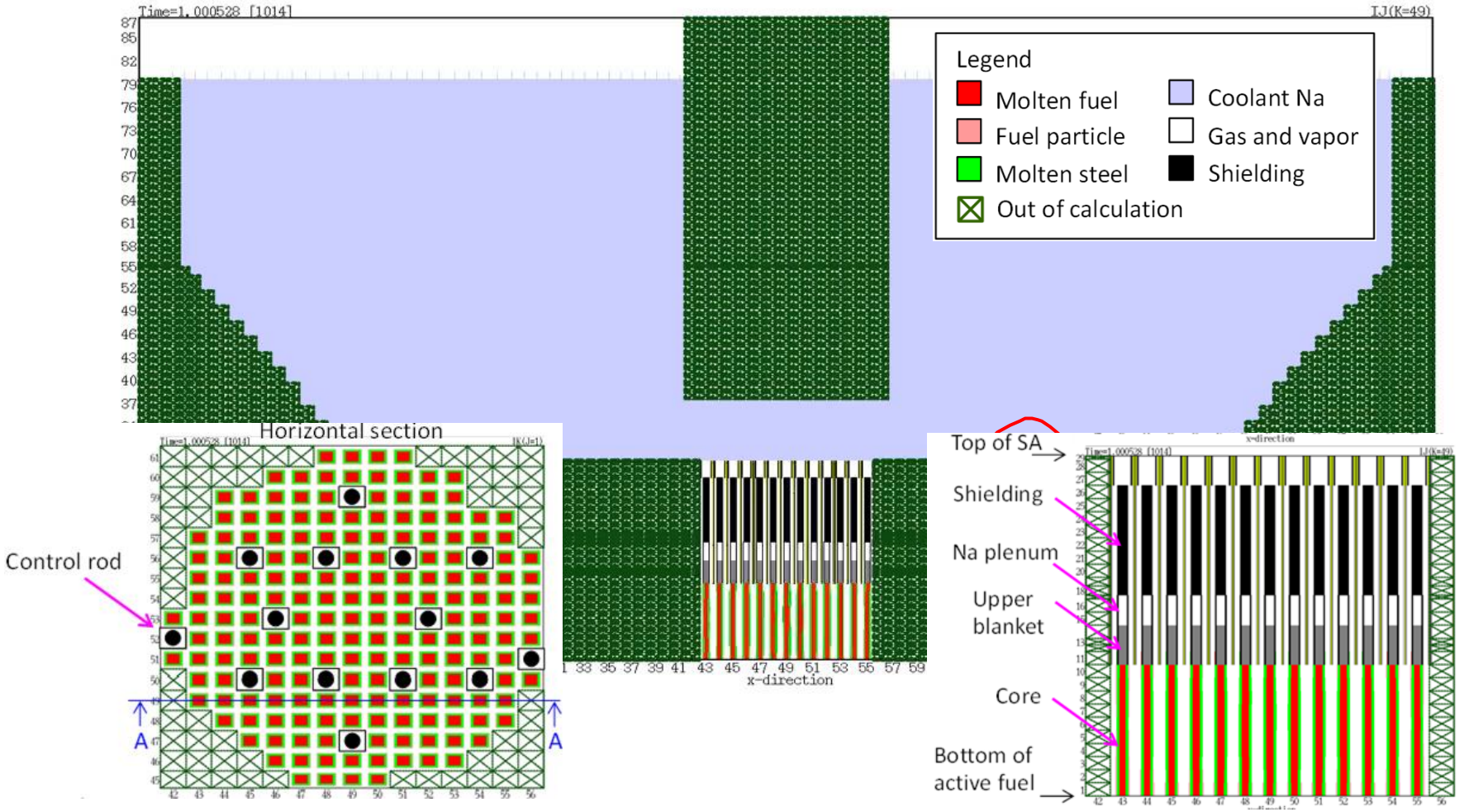
Very complicated multi-physics phenomenon
Can be a Standard Benchmark for Verification of Safety Analysis Codes and Models

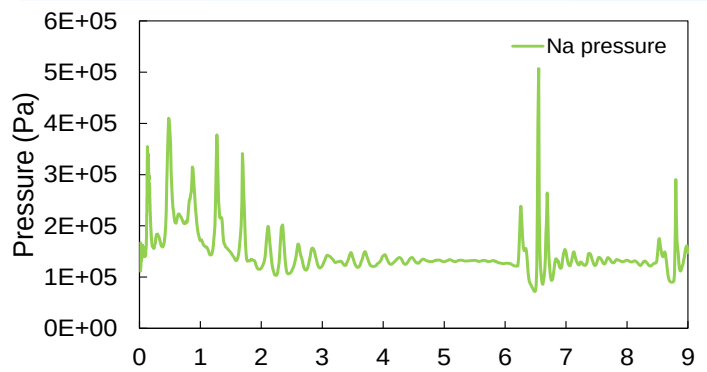
III. *Containment Source Term*

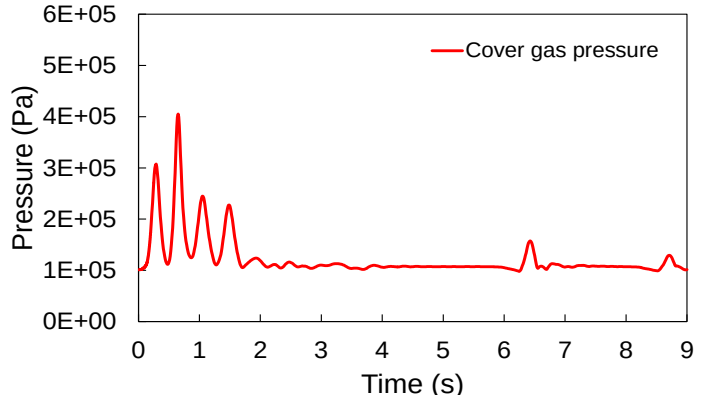
- Evaluation of multi-component aerosol evolution is required
- Two typical sodium fire accidents:
- *sodium pool fire accident*
- *sodium spray fire accident*

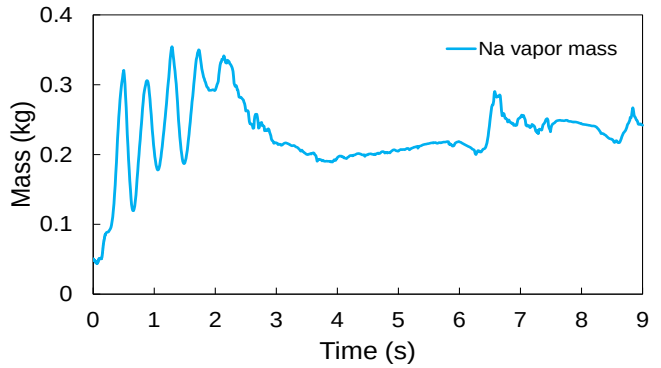
CRP on Radioactive Release from Prototype SFR under Severe Accident Conditions (2016- 2020): Expansion Phase

Click to play SIMMER-IV Video
(provided by JAEA)





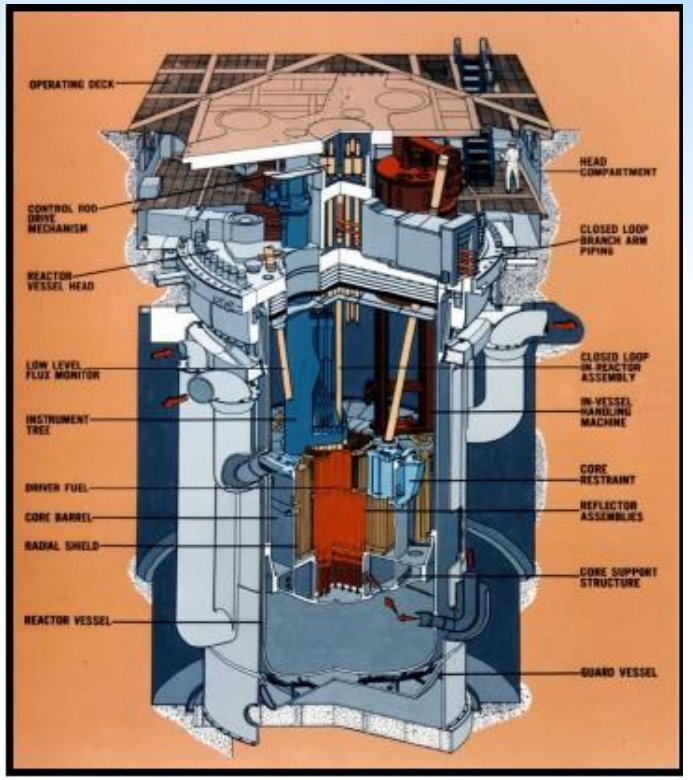




WP-1. *Sodium Bubble Expansion Phase*

CRP: **Benchmark Analysis of FFTF Loss of Flow Without Scram Test**

- FFTF (Fast Flux Test Facility) Reactor:
  - 400 MW_{th} sodium cooled fast test reactor
  - Mixed UO_2-PuO_2 (MOX) fuel
  - Loop type plant, axial and radial reflectors
  - Prototypic size
    - ~1m^3 core volume
    - ~91 cm high, ~120 cm diameter
  - Built to assist development and testing of advanced fuels and materials for fast breeder reactors
  - Series of Passive Safety Tests performed in 1986
    - Unprotected transients including 13 Loss of Flow without scram tests
    - Demonstrated passive safety of SFRs
    - Demonstrated efficacy of negative reactivity insertion safety devises (Gas expansion modules - GEMs)
  - This Benchmark analysis is based on the Test number 13, which was initiated at 50 % power and 100 % flow.



CRP: **Benchmark Analysis of FFTF Loss of Flow Without Scram Test**

Aim of the Benchmark:

- Support collaborative efforts within international partnerships on the validation of simulation tools and models in the area of SFR safety.

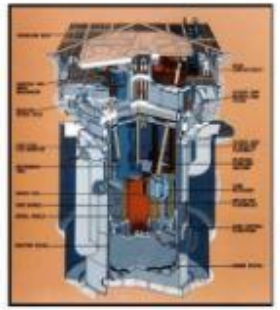
Outcomes:

- Improved understanding of loss of flow events in fast reactors and validation of the state-of the-art fast reactor analysis computer codes against the experimental data;
- Improved understanding of fast reactor neutronics, thermal-hydraulics, and system analysis;
- Improved understanding of the methodology employed to simulate fast reactor transient behaviour;
- Improved verification, validation, and qualification of the methodology;
- Reduced uncertainty in SFR codes, which will contribute to reducing costs of building liquid metal cooled fast reactors;
- Enhanced reliability of the behaviour predictions for new advanced reactor designs;
- Facilitated training of the young generation of reactor physicists; and
- Identified additional research and development work needed to resolve open issues.

Country	Organization
China	CIAE
China	INEST
China	NCEPU
China	XJTU
France	CEA
Germany	HZDR
Germany	KIT
India	IGCAR
Italy	NINE
Italy	Sapienza Uni of Rome
Japan	JAEA
Korea, Rep. of	KAERI
Netherlands	NRG
Russia	IBRAE
Russia	IPPE
Spain	CIEMAT
Sweden	KTH
Switzerland	EPFL
Switzerland	PSI
United States	ANL
United States	NRC
United States	PNNL
United States	TAMU
United States	TerraPower

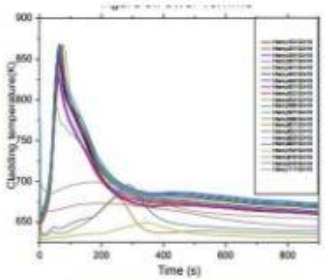
24 Participating Organizations from 13 Countries

CRP: **Benchmark Analysis of FFTF Loss of Flow Without Scram Test**

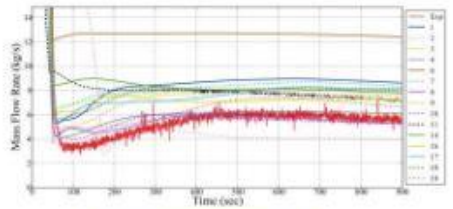


Plant Data

Modelling



Simulations



Benchmark

Kick Off: 1st RCM: October 2018, Vienna

Blind Phase Results Submissions, March 2020

Refined Simulation Submissions, November 2021

Final Simulation Results, June 2022

IAEA TECDOC Draft December 2022

Benchmark Specifications | Individual Simulations | Sharing of results and comparison with Experimental Data | Publication

1st Virtual Informal OM: October 2019, Vienna

2nd Virtual Informal OM: October 2020, Vienna

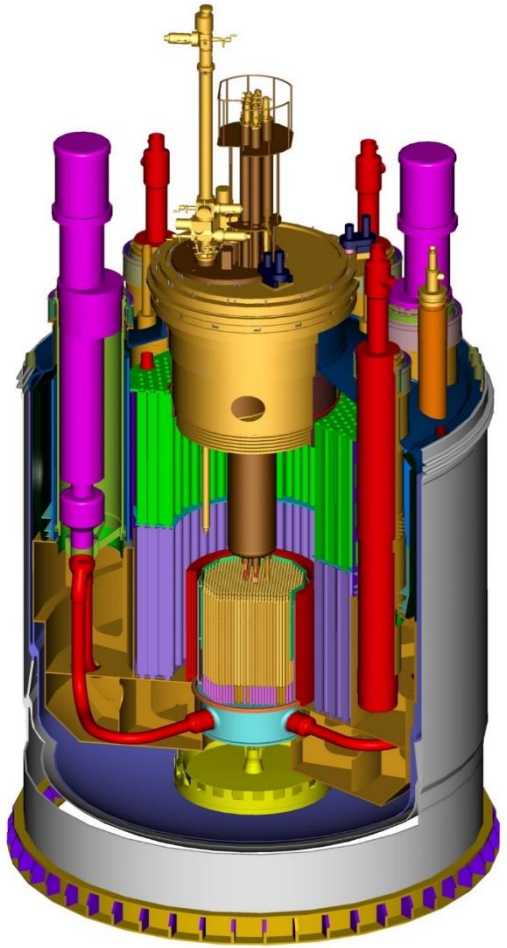
2nd RCM: December 2021, (virtual)

3rd RCM: November 2022, Italy

CRP: Neutronics Benchmark of CEFR Start-Up Tests

CEFR (China Experimental Fast Reactor)

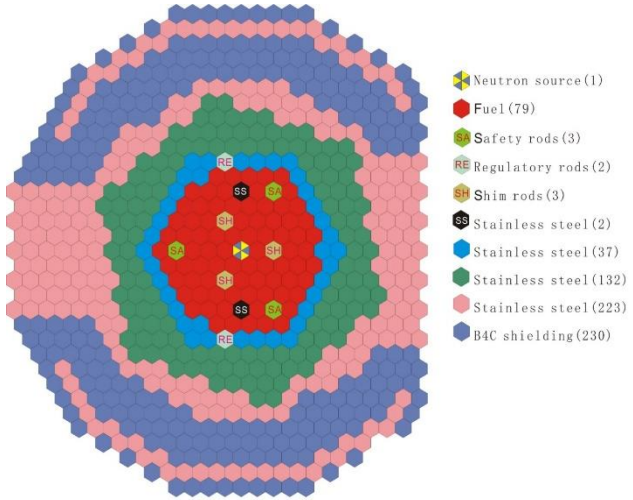
- Located in China Institute of Atomic Energy
- 65MWt (20MWe) sodium cooled fast reactor with a high neutron leakage core fuelled with uranium oxide and stainless-steel radial reflector.
- The primary system is a pool-type design, liquid sodium working fluid for the primary and secondary circuits.
- In 2010, CEFR went into first criticality.
- A series of start-up experiments were carried out to measure reactor physics and kinetics parameters.
- **6 experiments were selected for benchmark analysis**
  - evaluations of the criticality, control rod worth, sodium void worth, temperature effect reactivity, and various reaction rates.
- This CRP provides an excellent opportunity to the member states for validation of the physical models and neutronics simulation codes by comparing the calculated results to the recorded experimental data from the CEFR start-up tests.



CEFR Reactor Block

中国原子能科学研究院
中核集团 CHINA INSTITUTE OF ATOMIC ENERGY

China Experimental Fast Reactor Plant



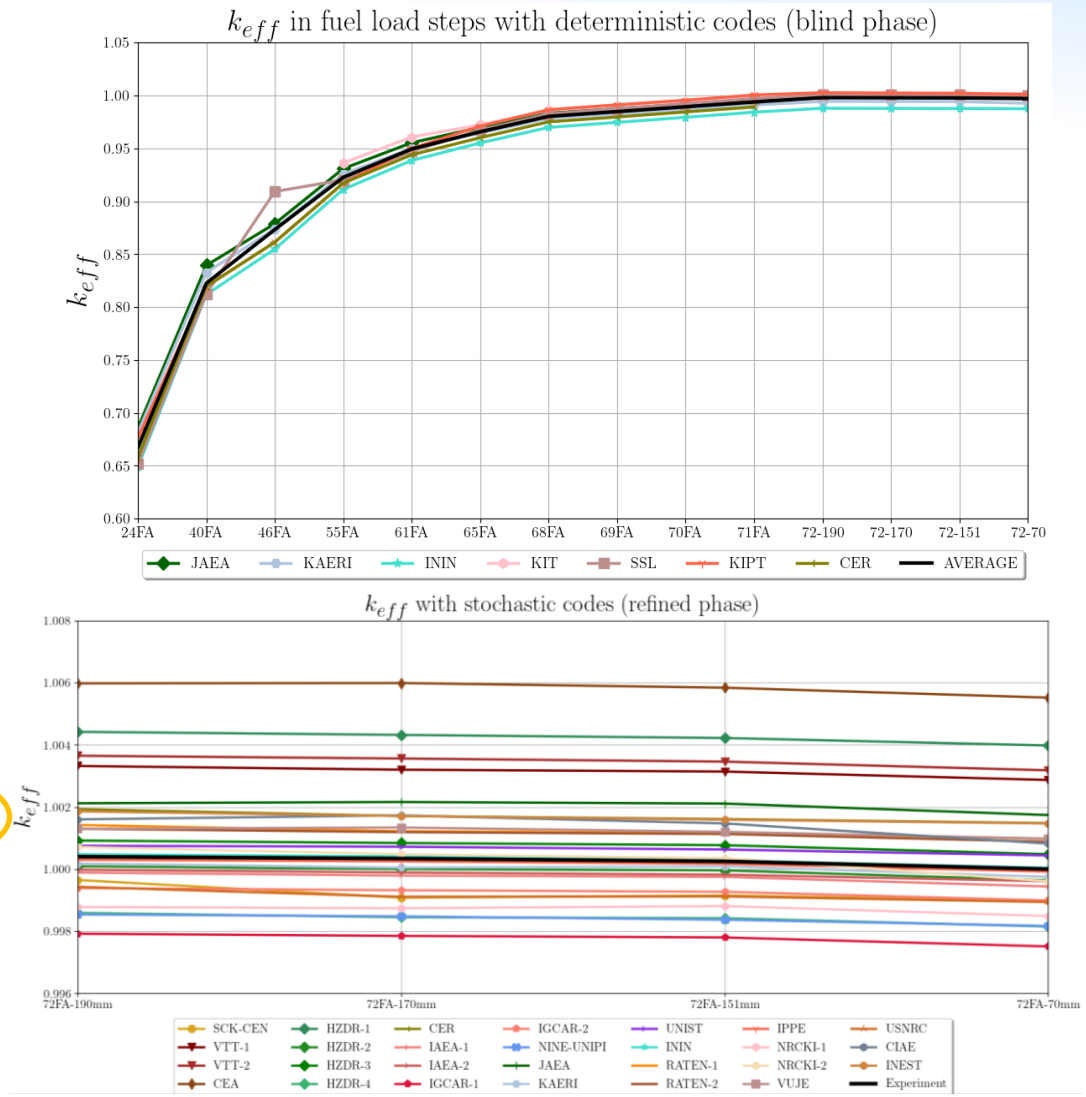
Core layout of the CEFR First Loading

CRP: Neutronics Benchmark of CEFR Start-Up Tests

WP1	Net criticality
WP2	Control Rod Worth
WP3	Temperature reactivity coefficient
WP4	Sodium void reactivity effect
WP5	Core S/A exchange reactivity effect
WP6	Reaction rate distribution
WP7	Reactivity coefficients and kinetic parameter
WP8	Analysis of Uncertainties

Separate TECDOC

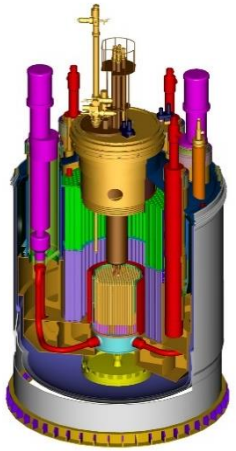
WP1. Net criticality



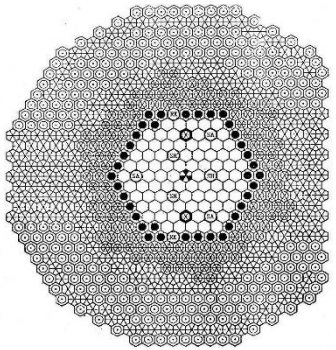
Country	Organization
Belgium	SCK•CEN
China	CIAE
China	INEST (FDS)
China	~~SNERDI~~
China	XJTU
Finland	VTT
France	CEA
Germany	HZDR
Germany	GRS
Germany	KIT
Hungary	~~BME~~
Hungary	CER
India	IGCAR
Italy	NINE
Italy	UNIPI
Japan	JAEA
Korea, Rep. of	KAERI
Korea, Rep. of	UNIST
Mexico	ININ
Romania	RATEN-ICN
Russia	~~IBRAE~~
Russia	IPPE
Russia	SSL
Russia	Kurchatov Ins. (NRCKI)
Slovakia	VUJE
Switzerland	PSI
Ukraine	KIPT
UK	Un. of Cambridge
United States	ANL
United States	NRC

30 Participating Organizations from 18 Countries

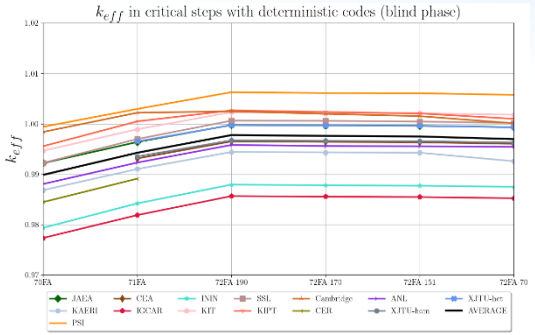
CRP: Neutronics Benchmark of CEFR Start-Up Tests



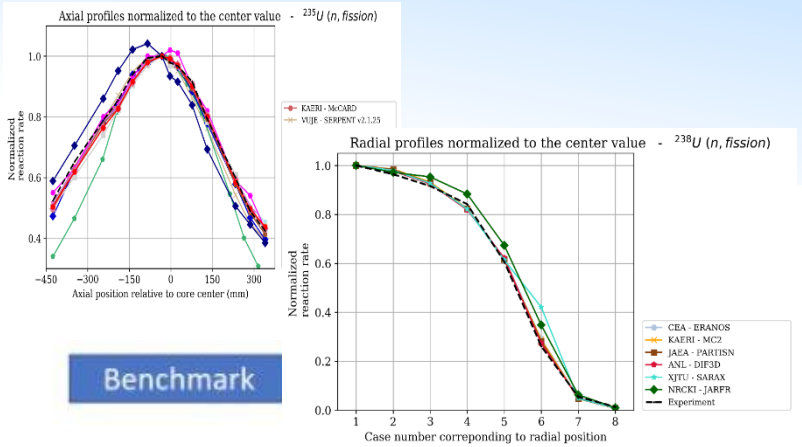
Plant Data



Modelling



Simulations



Benchmark

Kick Off: 1st RCM: June 2018, Vienna

2nd RCM: 28 October- 1 November 2019, Beijing *(Blind Phase* Results)

Refined Simulation Results, April 2021

IAEA TECDOC Draft October 2022

Benchmark Specifications → Individual Simulations → Sharing of results and comparison with Experimental Data → Publication

1st Online Update Meeting: June 2019, Vienna

2nd Online Update Meeting: November 2020, Vienna

3rd RCM: 6-9 April 2021 (Virtual)

4th RCM: 7-11 November 2022, Vienna)

CRP: **Neutronics Benchmark of CEFR Start-Up Tests**
Training Course Series

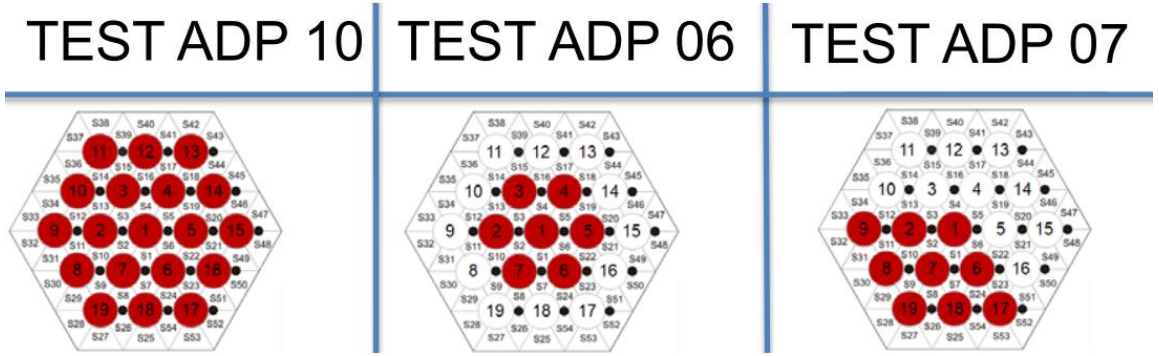
Training Course Series Documents
- Comprehensive Guidance and how-to perform MC simulations
- with SERPENT-2 and Open-MC
- Freely available IAEA Series of documents for capacity building
- Template for future CRP adaptations

Performing Neutronics Benchmark Calculations
- Intended for students or early career nuclear engineers.
- Can easily be implemented and used in classrooms.
- Also provides a valuable template for continuing benchmarking opportunities.

Finalized, under review
Expected Publication: Q4 2022, Q1 2023

CRP: **Benchmark of Transition from Forced to Natural Circulation Experiment with Heavy Liquid Metal Loop**

- The Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) proposed this CRP to TWG-FR 2020. ENEA operates the Natural Circulation Experiment Upgrade (NACIE-UP) facility:
  - Rectangular LBE flow loop
  - Containing a wire spaced 19 pin fuel pin simulator
  - Operating up to 250 kW for qualification and instrumentation testing.
- **Objective**: Validation of computational fluid dynamics (CFD), subchannel, and system analysis codes for heavy liquid metal systems.
- 22 proposals received
- **1st RCM 12-15 July 2022**
- **TECDOC publication – Mid 2025**



TM on State-of-the-Art Thermal Hydraulics of Fast Reactors

1. Fundamental Thermal Hydraulics

- heat transfer and friction factor correlations
- turbulent heat and mass transfer,
- multiphase flow
- low Re number flow
- natural and mixed convection
- fluids with internal heat generation
- gas dynamics and compressible flow

2. Test facilities and experimental thermal hydraulics

- Isothermal/ hydraulic experiments
- thermal hydraulic experiments
- in-pile experiments
- measurement techniques and instrumentation

3. Computational Modelling & Simulation

- sub-channel thermal hydraulics
- core thermal hydraulics
- pool and primary circuit thermal hydraulics
- integral system thermal hydraulics
- high fidelity simulation
- computational codes

4. Thermal Hydraulics of Transients and Accidents

- operational transients
- design basis accidents
- severe accidents (coolant boiling, fuel-coolant interaction, corium thermal hydraulics, source term, etc.)
- decay heat removal
- containment thermal hydraulics

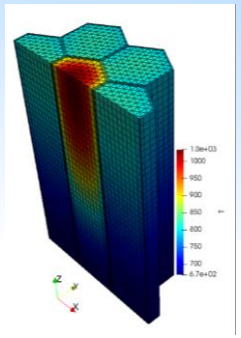
5. Multi-scale and Multi-physics Modelling

- multi-scale modelling and coupling (system code, sub-channel code, CFD, etc.)
- Multi-physics modelling and coupling (fluid-structure interaction, magneto hydrodynamics, neutronics - thermal hydraulics, fuel assembly bowing and buckling, core mechanics, etc.)

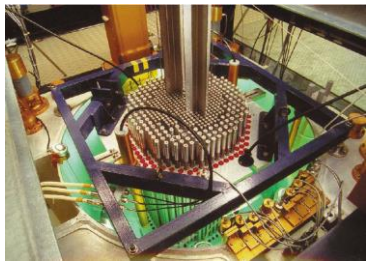
6. Verification, Validation and Uncertainty Analysis

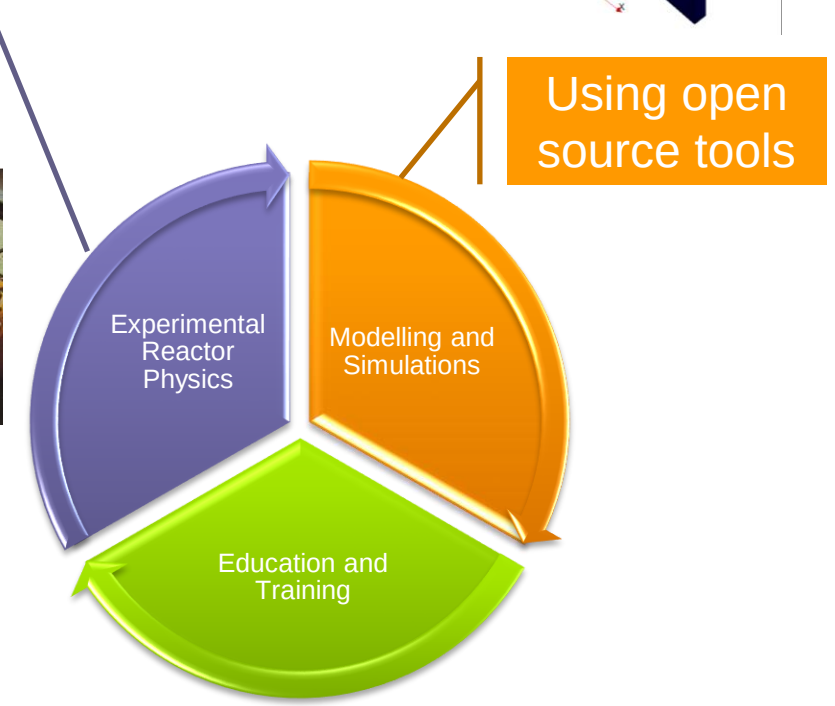
- verification and validation
- uncertainty and sensitivity analysis
- lessons learned from international benchmarks

Technical Meeting on **Development and Application of Open-Source Modelling and Simulation Tools for Nuclear Reactors (ONCORE)**



- Creating a common platform in the area of advanced reactor experiments and high-fidelity multi-physics nuclear simulation techniques for open-source code development and validation
- Links to 35+ Open source tools
  - Neutronics
  - Thermal-hydraulics, system analysis, containment
  - Structural mechanics
  - Multi-physics applications and libraries
  - Data processing, optimization, UQ, pre-post processing
  - Application frameworks
- 2 tools hosted and distributed by ONCORE
  - VSOP99/11: HTR pebble-type design and safety analysis
  - STACY: V/HTR safety analyses for the quantification of fission product release from the fuel
- TM on ONCORE 20-24 June 2022 in Milano
  - ~100 participants (50% online)





Fast Reactors Safety: Joint GIF-IAEA Workshops on Safety of LMFRs

A decade of cooperation

1st : June 2010
2nd : Dec 2011
3rd : Feb. 2013
4th : June 2014
5th : June 2015
6th : Nov. 2016

7th Joint GIF-IAEA Workshop on LMFR Safety
March 2018

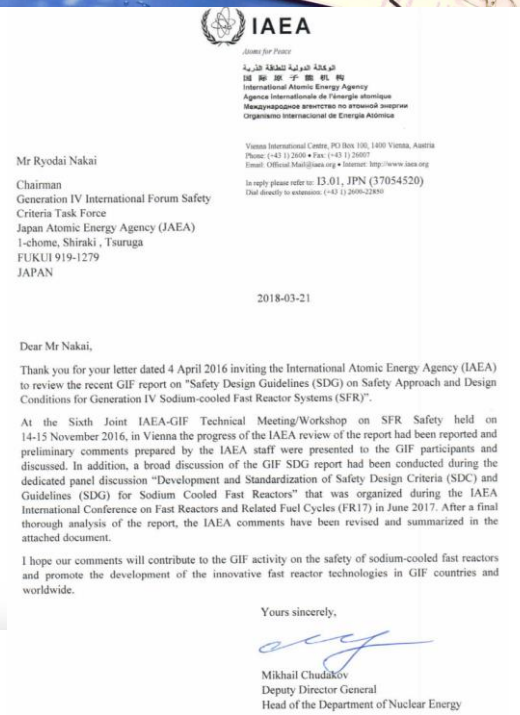
8th GIF-IAEA Workshop on LMFR Safety
20-22 March 2019

9th GIF-IAEA Workshop on LMFR Safety
30 March - 01 April 2021

- Review of GIF Report on "Safety Design Guidelines on Structures, Systems and Components for Gen-IV SFRs"
  - Discussion of review comments

10th GIF-IAEA Workshop on LMFR Safety
28 June – 1 July 2022

- Organized by NSNI



IAEA

Mr Ryodai Nakai

Chairman
Generation IV International Forum Safety
Criteria Task Force
Japan Atomic Energy Agency (JAEA)
1-chome, Shiraki , Tsuruga
FUKUI 919-1279
JAPAN

2018-03-21

Dear Mr Nakai,

Thank you for your letter dated 4 April 2016 inviting the International Atomic Energy Agency (IAEA) to review the recent GIF report on "Safety Design Guidelines (SDG) on Safety Approach and Design Conditions for Generation IV Sodium-cooled Fast Reactor Systems (SFR)".

At the Sixth Joint IAEA-GIF Technical Meeting/Workshop on SFR Safety held on 14-15 November 2016, in Vienna the progress of the IAEA review of the report had been reported and preliminary comments prepared by the IAEA staff were presented to the GIF participants and discussed. In addition, a broad discussion of the GIF SDG report had been conducted during the dedicated panel discussion "Development and Standardization of Safety Design Criteria (SDC) and Guidelines (SDG) for Sodium Cooled Fast Reactors" that was organized during the IAEA International Conference on Fast Reactors and Related Fuel Cycles (FR17) in June 2017. After a final thorough analysis of the report, the IAEA comments have been revised and summarized in the attached document.

I hope our comments will contribute to the GIF activity on the safety of sodium-cooled fast reactors and promote the development of the innovative fast reactor technologies in GIF countries and worldwide.

Yours sincerely,

Mikhail Chudakov
Deputy Director General
Head of the Department of Nuclear Energy

Joint ICTP-IAEA Workshops on Innovative Nuclear Energy Systems

- In **2016** and in August **2018** Trieste, Italy
- Contributed by NPTDS, INPRO, GIF, and other external experts
- Next Workshop: 12-16 December 2022

NAPRO: Sodium Properties Calculator

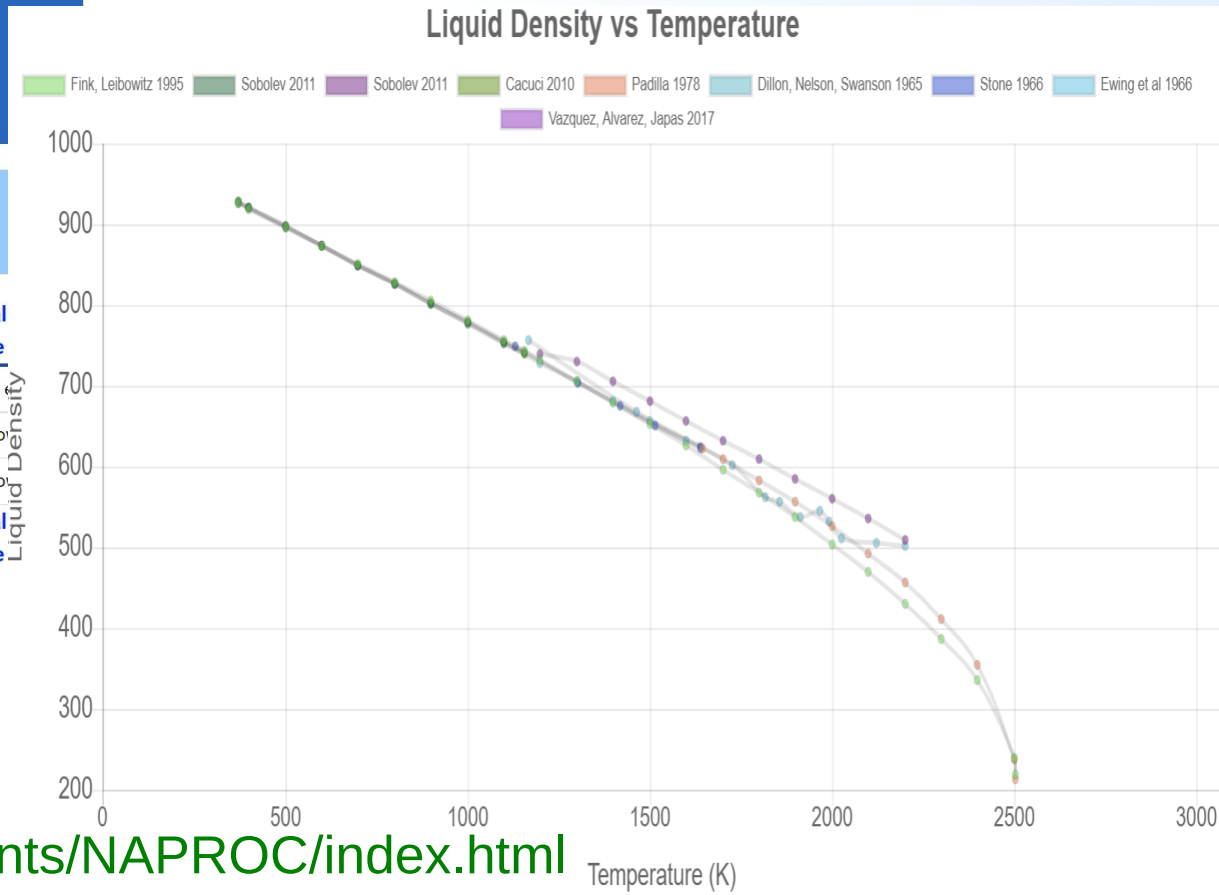
Home | About NAPRO | References | Temperature Indepedent Table | Property Table | Figure

NaProC — Sodium Properties Calculator

Enter Temperature (K): 800 | SUBMIT | CLEAR | T = 800 K

TEMPERATURE INDEPENDENT PROPERTIES	Value	Units	Principal Reference
MELTING POINT	370.90	K	Ohse
BOILING POINT	1154.7	K	Fink, Leibo
CRITICAL TEMPERATURE	2503.7	K	Fink, Leibo

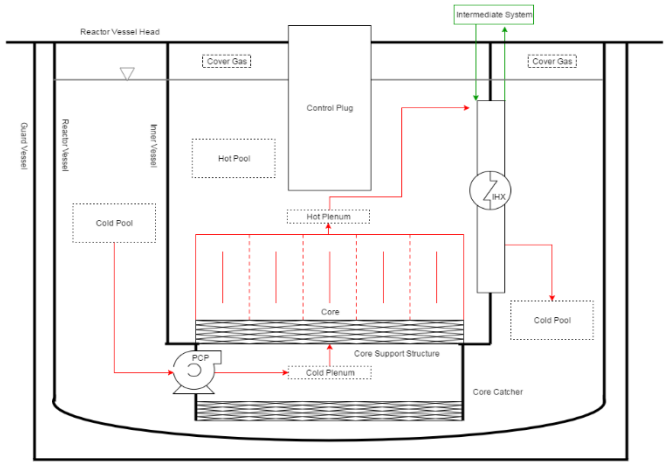
THERMODYNAMIC	TRANSPORT	Value	Units Function	Principal Reference

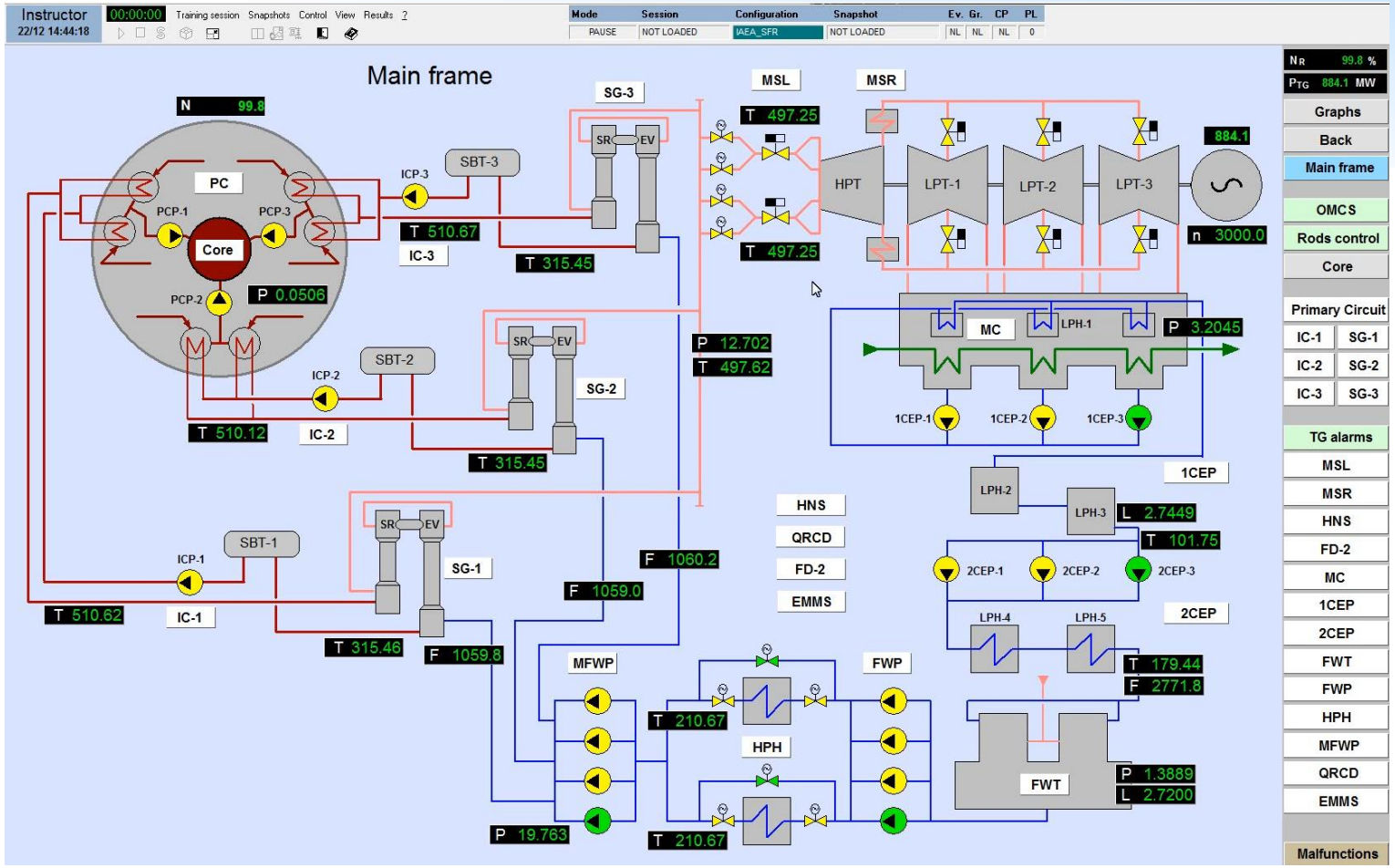


https://nucleus.iaea.org/sites/fr/Shared%20Documents/NAPROC/index.html

SFR Educational Simulator

- Pool type sodium cooled fast reactor simulator for education and training
- February 2021: Factory Acceptance Tests
- January 2022: Site Acceptance Test
- **2022: Distribution to Member States**





Fast Reactors: Main Events and Activities in 2022

Date	Title	Location
Apr 2022	**International Conference on Fast Reactors and Related Fuel Cycles (FR22)**	Vienna
May 2022	55th Meeting of TWG-FR	Vienna
Jun 2022	10th Joint IAEA–GIF Workshops on LMFR Safety (organized by NS)	Brasimone, IT
Jun 2022	TM on ONCORE (Development and Application of Multi-Physics Modelling and Simulation on Nuclear Reactor Using Open Source Tools)	Milan, IT
Jul 2022	1st RCM of CRP on Lead Flow Transient to Natural Circulation at NACIE Facility	Brasimone, IT
Sep 2022	TM on State-of-the-art Fast Reactor Thermal Hydraulics: TM was planned in 2021	Brasimone, IT
Nov 2022	4th RCM of CRP on Neutronics Benchmark of CEFR Start-Up Tests	Vienna
Nov 2022	3rd RCM of CRP on Benchmark Analysis of FFTF ULOF Test	Lucca, IT
Nov-Dec 2022	Regional WS on Advances in Modelling & Simulation of T-H in LMFRs	GCNEP, India
Dec 2022	Joint ICTP–IAEA Workshops on Physics and Technology of Innovative NESs	Trieste, Italy

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IMPORTANT NOTICE

If you are a candidate who has previously submitted a general application to the IAEA (e.g.: Internship, Consultant), please be informed that the IAEA has recently introduced a new IT platform for all its recruitment activities.

So if you wish to be considered for IAEA job opportunities in the future, please resubmit your application through our website at this link.

Current Vacancies

WEBINAR OF THE MONTH

IAEA
International Atomic Energy Agency

Atoms for peace and Development…

Thank You!

email: FR@IAEA.ORG

Workshop Programme

- Lectured during mornings and afternoons
- Evenings for group activities and poster sessions
- **Poster Session**: Please be present on the day assigned to you. The other groups and the lecturers will be invited to review the posters
- **Group Activities**

	Monday, 12 Dec	*Tuesday, 13 Dec*	*Wednesday, 14 Dec*	*Thursday, 15 Dec*	*Friday, 16 Dec*
08:30 – 09:00	**- Registration**	*Students arrive and lecturers prepare*			
09:00 – 10:30 (2)	**- Opening** - IAEA Activities on Innovative NES *Vladimir Kriventsev*	Thermal Hydraulics of Advanced Liquid Metal Cooled Reactors *Vladimir Kriventsev*	1. Global Scenarios for Nuclear Energy and Role of Innovative NES, and 2. IAEA INPRO Project *Alexander Bychkov*	Interaction between Sodium and Structures of Liquid Metal Cooled Reactors *Christian Latge*	Safety Analysis of Sodium-Cooled Fast Reactor and Innovative Numerical Approach *Takashi Takata*
10:30- 10:45	Coffee Break				
10:45 – 11:30 (1)	*Group Photo* Overview of Innovative Reactor Designs *Vladimir Kriventsev*	Repurposing sites of fossil plants with advanced nuclear reactors *Nikoleta Morelova*	Liquid metal coolants for Fast Neutron Reactors: properties & consequences. *Christian Latge*	Nuclear Fuel Cycle: Trends and Options for Innovative NES *Alexander Bychkov*	Legal and Institutional Aspects of New Nuclear Technologies Deployment *Alexander Bychkov*
11:30 – 12:30 (1)	Small and Medium sized or Modular Reactors *Chirayu Batra*	Innovative Nuclear Energy Systems: Core Design and Neutronics (1/2) *Adriaan Buijs (VC)*	Development status of sodium cooled fast reactor in Japan *Takashi Takata*	Liquid metal coolants for Fast Neutron Reactors:: focus on coolant quality control (1/2). *Christian Latge*	Group Presentations *All Participants*
12:30 – 13:30	Lunch Break				
13:30 – 15:00 (2)	1. Building Competencies in Strategic Planning for Sustainable Nuclear Energy Development; 2. Description of Group Activity 2 *Andrei Kosilov (VC)*	Reactor Physics of Innovative NES *Vladimir Artisyuk (VC)*	GIF: Gen IV Reactor Design Concepts *Chirayu Batra*	1. Technical and associated challenges in establishing a viable SMR *Akira Tokuhiro (VC)* 2. Innovative Nuclear Energy Systems: Core Design and Neutronics (2/2) *Adriaan Buijs (VC)*	**Final remarks, certificates distribution and closing session**
15:00 – 15:15	Coffee Break				
15:15 – 16:00 (1)	Hybrid nuclear-renewable systems for electricity production and non-electrical applications *Akira Tokuhiro (VC)*	Group Activities *Chirayu Batra* *Nikoleta Morelova*	Group Activities Discussion Session *Nikoleta Morelova* *Chirayu Batra*	1. Liquid metal coolants for Fast Neutron Reactors: focus on coolant quality control (2/2) *Christian Latge* 2. Final Discussion of Group Activities *All*	
16:00 – 17:00	Description and distribution of the Group Activity 1 *Vladimir Kriventsev* *Nikoleta Morelova*	Poster Session *Chirayu Batra* *Alexander Bychkov* *Christian Latge* *Takashi Takata?*	Poster Session *Chirayu Batra* *Alexander Bychkov* *Christian Latge* *Takashi Takata?*		

Our Lecturers

Chirayu Batra

- Chief Technology Officer, TerraPraxis and LucidCatalyst (2022– present)
  - Leading several projects on deployment of advanced nuclear reactors – defining strategies and technical solutions
  - Repowering Coal design group lead
  - Techno-economic analysis on use of nuclear energy for several power and non-electrical applications

Previous experience:

- Nuclear Engineer/Project Officer at the IAEA for Fast Reactors and Small Modular Reactors projects (2015-2022)
- Double MS in Nuclear Engineering and Nuclear Reactor Physics

Our Lecturers: **Prof. Andrei N. Kosilov**

Managing Director, Regional Network for Education and Training in Nuclear Technology STAR-NET

Professor, National Research Nuclear University MEPhI, Russian Federation

- Engineer-Physicist, PhD in Nuclear Engineering
- Areas of experience: Nuclear Engineering including Control and Instrumentation, Education and Training, Knowledge Management, R&D in Nuclear Technology, International Cooperation
- More than 50 years in nuclear field
- Former staff of the IAEA Nuclear Power Division
- American Nuclear Society Training Excellence Award (2001)
- Over 150 scientific publications

Our Lecturers: **Prof. Akira Tokuhiro**

- Member, Women in Nuclear – Canada; Ally of the Year awardee, 2021

- Formerly Dean; now Professor, Energy and Nuclear Engineering, “Ontario Tech University”, Canada.
- Taught & mentored, World Nuclear University, Summer Institute, 2022.
- Overall interest in energy R&D, experiments, modeling & simulations; advanced reactors & safety-in-design, thermohydraulics, reactor types: SFR/LMFBR, GCR, MSR, LWR, SMR. Currently, use of AR/VR, AI/ML in nuclear; applied complexity.
- At NuScale Power, during completion of Design Certification Application; submittal to USNRC. (design approved, EPZ methodology approved). 2014-2017.
- Served on American Nuclear Society President’s Committee on Fukushima Daiichi accident. 2011-2012.
- Past institutions and appointments:
  - Summer and appointments: (US) ANL, INL, PNNL; USNRC
  - US Universities: Idaho, Kansas State, Missouri. 2000-2014.
  - At Missouri-Rolla, held USNRC Senior Reactor Operator license.
  - PNC/JNC (now JAEA) International Fellow, 1995-2000.
  - Paul Scherrer Institute, Switzerland, 1990-1995. (late G. Yadigaroglu)
- Technical editor, book, “On the Brink. The Inside Story of Fukushima Daiichi”; later a movie, “Fukushima 50”.
- Some 200 publications and 45+ MS and PhD students to date.
- Born in Tokyo, educated in the U.S.; Ph.D., nuclear engineering, Purdue University, 1991. Late P.S. Lykoudis, supervisor.
- Linked-In; https://www.linkedin.com/in/akira-tokuhiro-b0612a6/

Our Lecturers: **Vladimir Artisyuk**

- Since 2019, Councillor, Advisor to DG State Atomic Energy Corporation “Rosatom”
- Since 2016, member of the Standing Advisory Group for Nuclear Energy (SAGNE) IAEA
- PhD from Obninsk Inst. for Nuclear Engineering in 1991, Dr. Eng. from Tokyo Institute of Technology in 1997, Dr Habl from Obninsk Inst. for Nuclear Engineering in 2004
- Vladimir was engaged in nuclear engineering and fuel cycle development in
  - TITech (Tokyo Inst. of Technology)
  - INPE (Obninsk)

  and knowledge transfer and competence building for nuclear infrastructure in the countries embarking on nuclear power programmes (Rosatom Technical Academy - RosatomTech)

Our Lecturers: **Prof. Adriaan Buijs**

- Professor of Engineering Physics at McMaster University, Hamilton, Canada
- Prof. Buijs specializes in nuclear reactor core physics of existing designs such as CANDU reactors and research reactors at Canadian Nuclear Laboratories (ZED-2) and McMaster (NMR), and future reactor designs, such as the Advanced CANDU reactor (ACR-1000), the Canadian Supercritical Water Reactor, and Molten Salt Reactors
- Prior to becoming professor at McMaster, Adriaan was the manager in charge of the reactor core design of the ACR-1000 at Atomic Energy of Canada, Limited
- Before coming to Canada, Mr Buijs was professor in experimental particle physics at Utrecht University, participating in experiments at LEP and the design of experiments at the Large Hadron Collider
- Prof. Buijs is a fellow and past-president of the Canadian Nuclear Society

Our Lecturers: **Alexander BYCHKOV**

- Senior nuclear engineering expert, INPRO Section
- Before re-joining IAEA had diplomatic post of ROSATOM's representative to the International Organizations in Vienna
- IAEA Deputy Director General, Head of the Department of Nuclear Energy, from 2011 to 2015
- From 2006 till 2011 served as Director General of the Research Institute of Atomic Reactors in Dimitrovgrad, Russian Federation, were worked from 1982.
- Graduated in chemistry from Moscow State University in 1982

- Main areas of R&D activity cover: the nuclear fuel cycle subjects including nuclear fuel, pyro-processing, fast reactors and high level wastes, radionuclide technologies and research reactors applications. He is expert in international cooperation and political aspects of nuclear energy.
- Dr Bychkov is a co-author of more than 160 scientific publications

Our Lecturers

Prof. Takashi Takata

- Since 2021, Professor, Department of Nuclear Engineering and Management, the University of Tokyo
  - Takata's major is nuclear safety engineering including PRA as well as thermal hydraulics and computational fluid dynamics.

- Since 2021, Takata is a chair of the Risk Assessment Technical Committee of the Standards Committee in Atomic Energy Society of Japan and a visiting researcher in Japan Atomic Energy Agency.
- PhD from Osaka University in 2004

Our Lecturers :
Dr. Christian Latge

- Since 2022 June 30th, Retired, Consultant & Scientific Advisor for CEA, located in Cadarache.
  - Christian supports scientific and Educational activities related to Gen-IV systems, with focus on SFRs systems. Expert in coolant's technology and chemistry.

- Christian has been working in nuclear engineering and technology since 1979
- PhD from Institut National Polytechnique de Toulouse (France)
- Involved in Superphenix start-up, ITER studies (H2 & tritium)… Waste processing as Head Section, Project Director MEGAPIE (Pb-Bi Spallation Target), ASTRID Project, GEN-IV International Collaborations Coordinator at CEA,
- Christian.latge@cea.fr

IAEA Lecturers

Nikoleta Morelová

- Since 2021, Nuclear Engineer in Fast Reactor Technology Development Team, IAEA
  - Nikoleta supports all IAEA activities on fast reactors, such Coordinated Research Projects (CRPs), Education and Training Workshops, International Conferences, etc.
- Nikoleta has been working in nuclear engineering and technology since 2016
- MSc from École polytechnique fédérale de Lausanne (EPFL) and Paul Scherrer Institute (PSI) in Nuclear Engineering (2016)
- PhD from Karlsruhe Inst. of Technology(KIT) in Natural Sciences (2022)

Vladimir Kriventsev

- Since 2016, Team Leader of Fast Reactor Technology Development Team, IAEA
  - Vladimir serves a Scientific Secretary for the IAEA activities on fast reactors, such Coordinated Research Projects (CRPs), Education and Training Workshops, International Conferences, etc.
- PhD from Obninsk Inst. for Nuclear Engineering in 1994
- Dr. Eng. from Tokyo Institute of Technology in 1999
- Vladimir has been working in nuclear engineering and fast reactor technology in
  - IPPE (Obninsk)
  - TITech (Tokyo Inst. of Technology)
  - JNC (JAEA now)
  - INPE (Obninsk) and
  - KIT (Germany, former FZK).