Technical Meeting on
Liquid Metal Reactor Concepts:
Core Design and Structural Materials
IAEA HQ, Vienna, *12–14 June 2013*

Recent IAEA Achievements in the Field of Fast Neutron Systems and Scope and Objectives of the Meeting

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International Atomic Energy Agency

Summary

- Framework of the IAEA activities on FR and ADS technology
- IAEA Research coordinated research activities in the field of fast reactors
- Recent IAEA publications on FR technology
- FR13 Conference: statistics, highlights and main outcomes
- Scope and main objectives of this technical meeting

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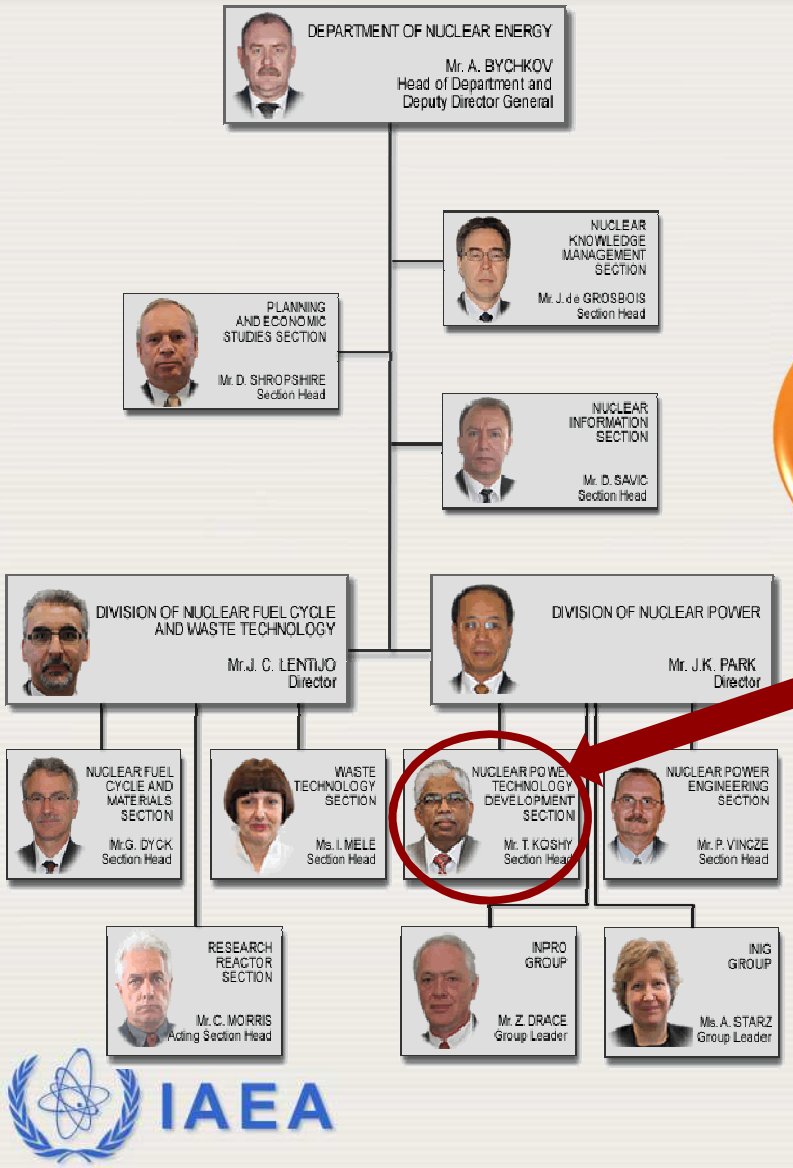
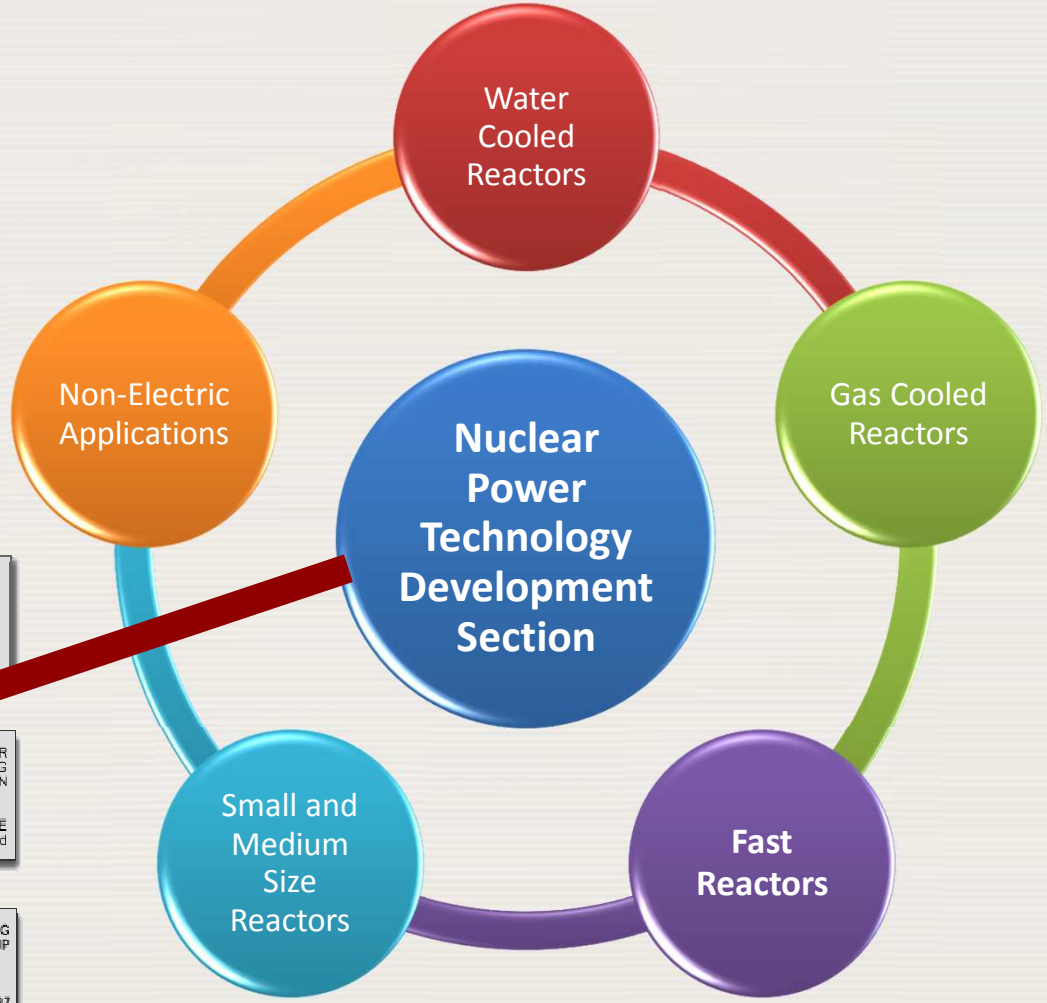
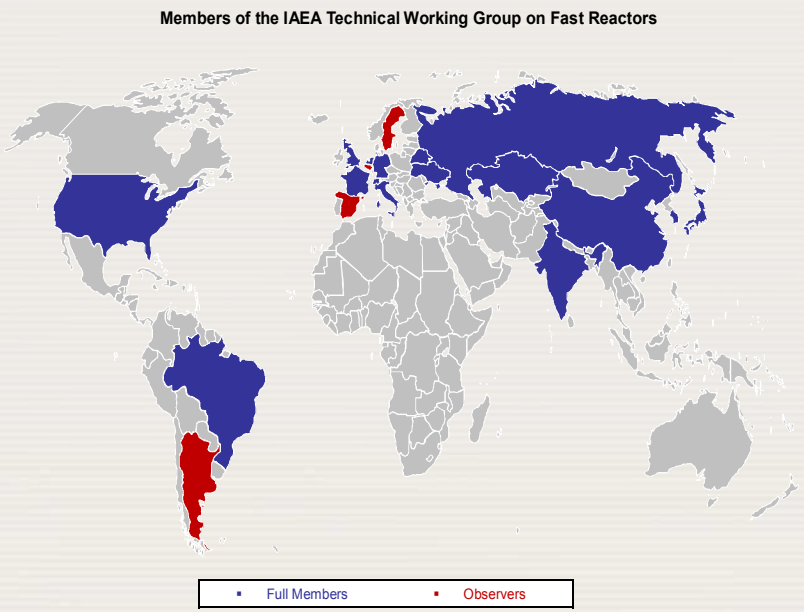




The IAEA Technical Working Group on Fast Reactors



Members of the IAEA Technical Working Group on Fast Reactors

Full Members

Belarus	Brazil
China	France
Germany	India
Italy	Japan
Kazakhstan	Korea, republic of
Netherlands	Russian Federation
Sweden	Switzerland
Ukraine	UK
USA	*European Commission*
OECD/NEA	

Observers

Argentina	Belgium
Spain	

46th Annual Meeting
IAEA - Vienna
21 – 24 May 2013

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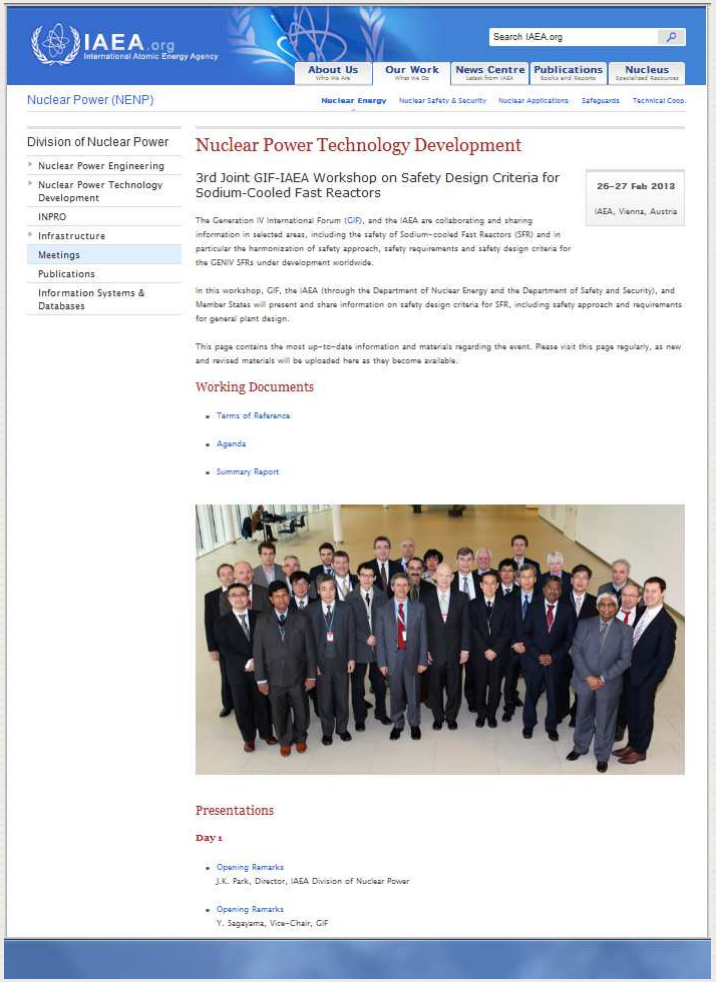
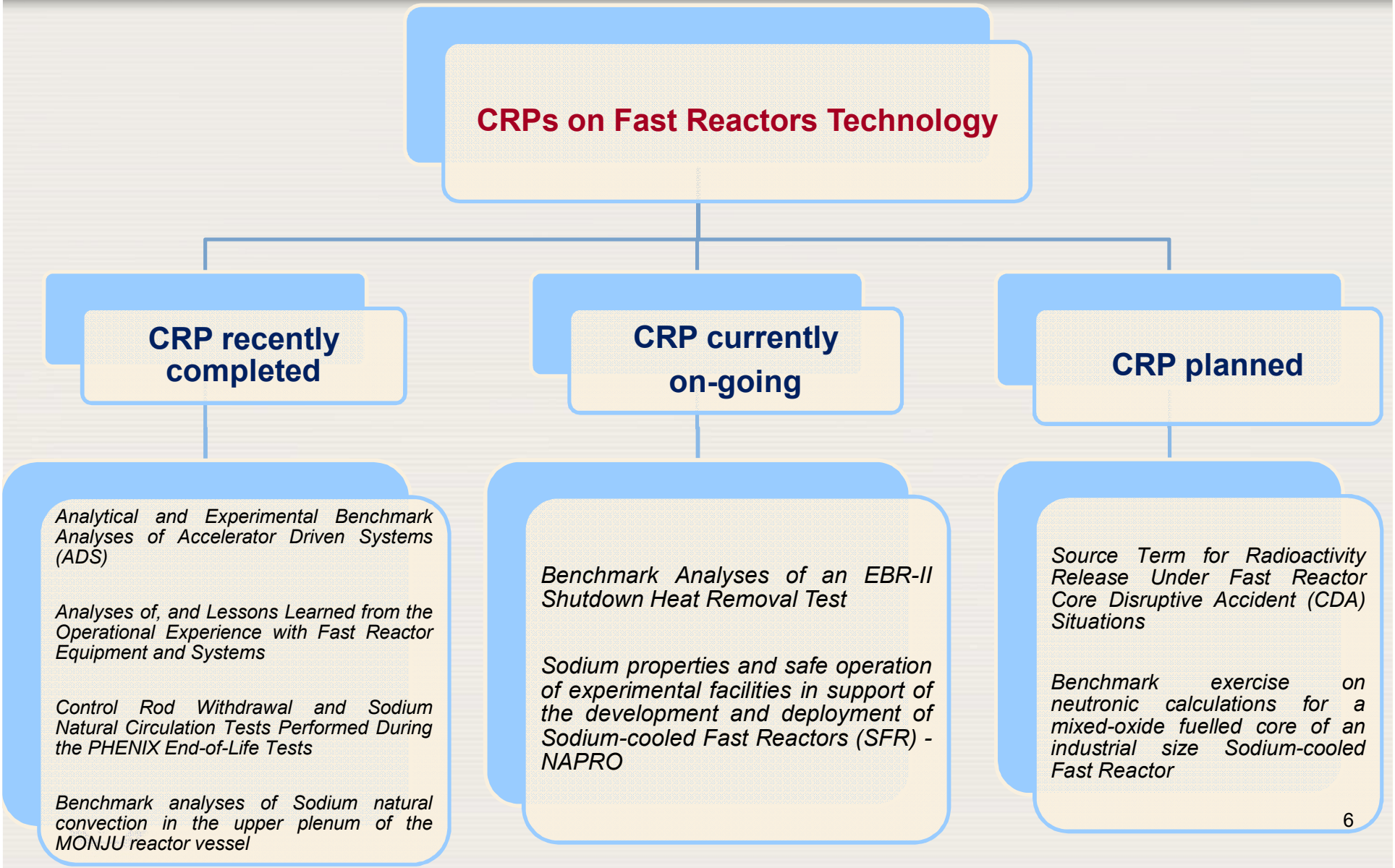
Recent IAEA Conferences, technical meetings and workshops/seminar on FR - June 2012-May 2013 (3/3)

- *(Third) Workshop on Safety Design Criteria for Sodium-cooled Fast Reactors, held in Vienna on 26 – 27 February 2013*



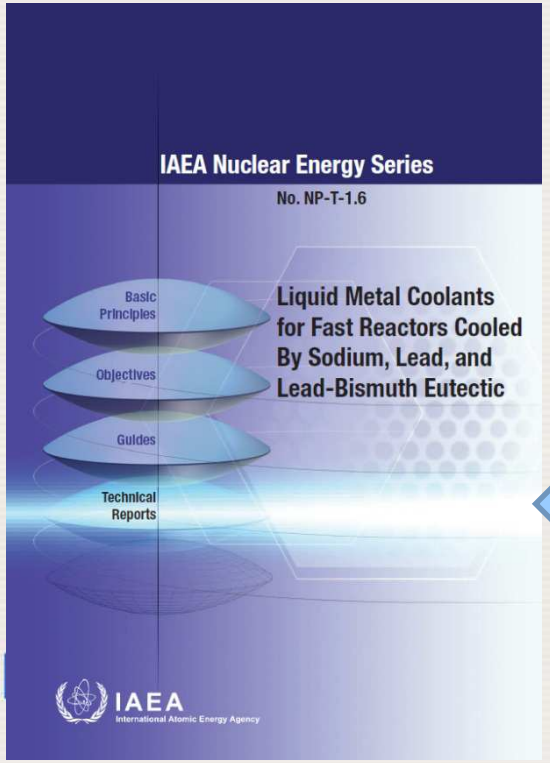
All the presentations of the workshop, which represent a useful resource for education and training purposes, are downloadable on the related IAEA webpage http://www.iaea.org/NuclearPower/Meetings/2013/2013-02-26-02-27-TM-SFR.html

IAEA Coordinated Research Activities on FR



Recent IAEA Technical Publications on Fast Reactors Technology

- ✓ Background and overview
- ✓ Operating experience with SFR
- ✓ Sodium-cooled FR Designs
- ✓ HLM-cooled FR Designs
- ✓ Gas-cooled FR Designs
- ✓ Status of FR core R&D
- ✓ Reactor plant engineering technology development
- ✓ Reactor safety design and analysis
- ✓ National strategies, international initiatives, public acceptance and final remarks



Summary of the status of liquid coolants technology for fast reactors with regard to basic data, main technological challenges and the various fast reactor concepts and designs that are being investigated, with a special emphasis on the choice of coolant

Coming IAEA Technical Publications on Fast Reactors (already approved by NE-Dept. and Publication Committees)

- Design features and operating experiences of experimental fast reactors

- Final reports of the completed CRPs
  - ✓ *"BN-600 hybrid core benchmark analyses", final report of the second part of the CRP on "Results from a coordinated research project on updated codes and methods to reduce the calculational uncertainties of the LMFR reactivity effects"*
  - ✓ *"Benchmark analyses on the natural circulation test performed during the PHENIX end-of-life experiment", final report of the first part of the CPR on "Benchmark analyses of sodium natural convection in the upper plenum of the MONJU reactor vessel"*

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IAEA Technical Publications on Fast Reactors Technology under preparation

- Proceedings of the FR13 Conference
- *Status of Accelerator Driven Systems Research and Technology Development*
- Final reports of the completed CRPs
  - ✓ *"Control row withdrawal tests performed during the PHENIX end-of-life experiments";*
  - ✓ *"Benchmark Analyses of Sodium Natural Convection in the Upper Plenum of the MONJU Reactor Vessel"*
  - ✓ *"Analyses of and lessons learned from the operational experience with fast reactor equipment and systems"*
  - ✓ *"Analytical and Experimental Benchmark Analyses on Accelerator Driven Systems"*

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Status of Innovative FR Designs

IAEA's Activities on FR: International Conference on Fast Reactors and Related Fuel Cycles, Status Report, TWG → information about innovative FR technologies, opportunities to interact with Developers

Advanced Reactor Information System (ARIS): Booklet as a supplement to ARIS for providing Members States with balanced, comprehensive and up-to-date information about advanced nuclear plant designs and concepts

Experience from "Booklet on the Status of SMRs": 2011 and 2012 editions, providing a brief overview of SMR designs

Niche for developing a Booklet on the "Status of Innovative Fast Reactor Designs"

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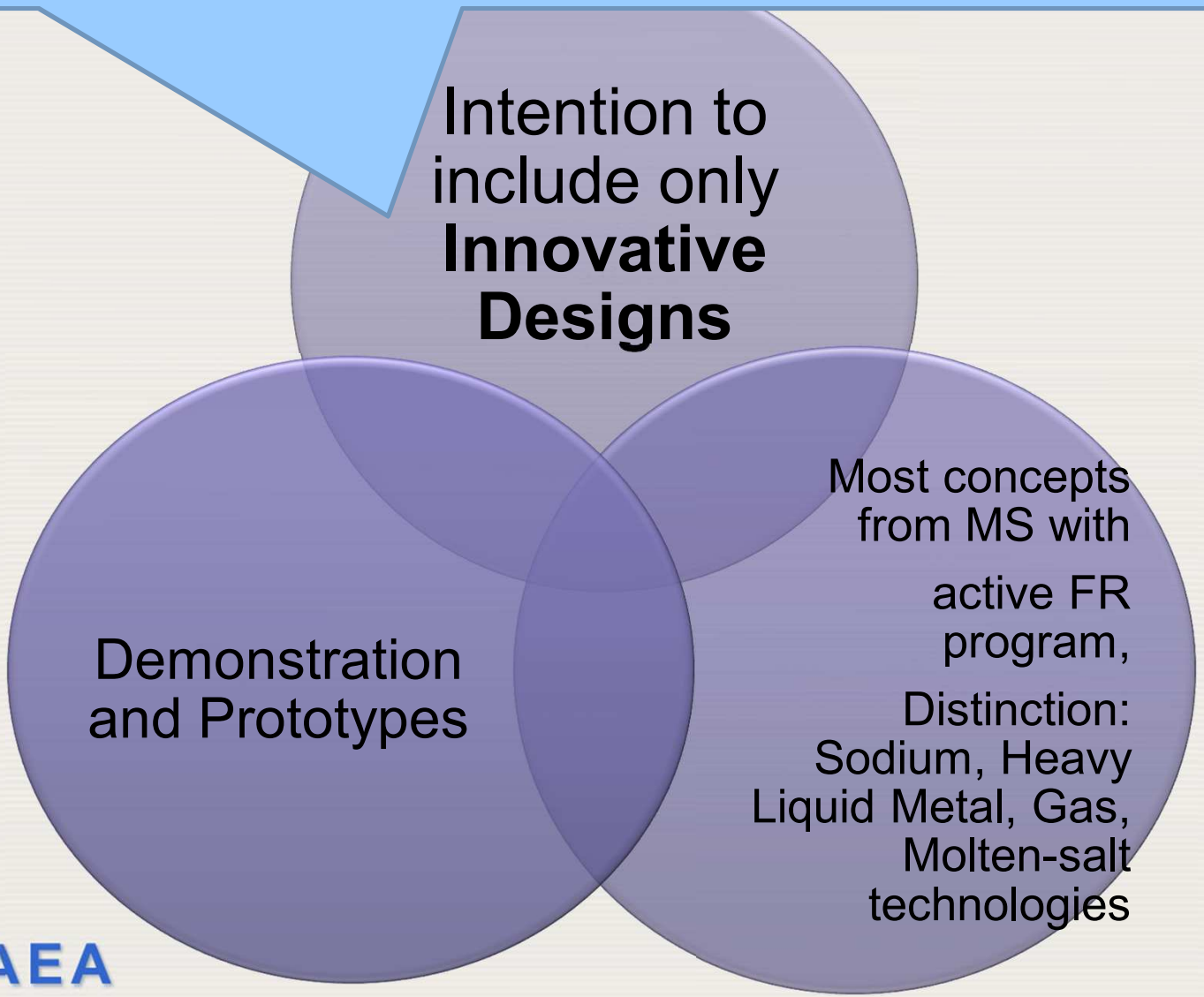
Innovative designs - advanced designs which incorporate radical conceptual changes in design approaches or configuration in comparison with existing practice. Substantial research and development efforts, feasibility tests, and a prototype or demonstration plant are probably required prior to the commercial deployment.



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Contents & Structure of the Publication

Previous Experience and Current Status Fast Reactors

Foreword, Introduction

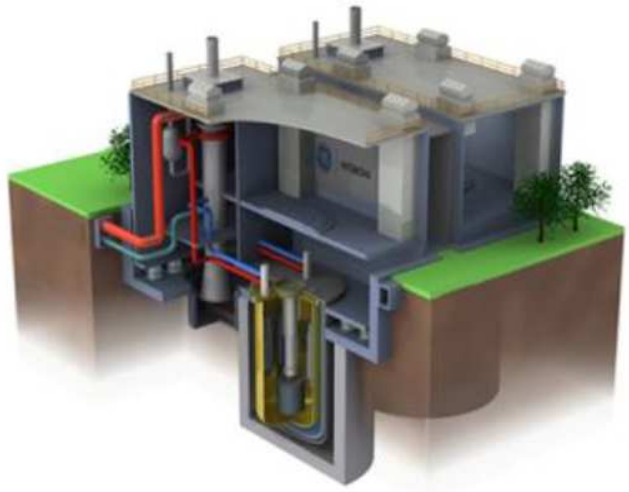
Innovative Fast Reactor Designs

- Sodium-cooled Fast Reactor Designs
- Heavy Liquid Metal-cooled Fast Reactor Designs
- Gas-cooled Fast Reactor Designs
- Molten-salt Fast Reactor Designs

Additional Material

- List of Acronyms
- Glossary
- Appendix: Tables presenting synoptically the status of the designs

Approach for design descriptions



Reactor type:	*Liquid metal cooled fast bree*
Electrical capacity:	*311 MWe*
Thermal capacity:	*840 MWt*
Coolant:	*Sodium*
Primary Circulation:	*Forced circulation*
System Pressure:	*Low pressure operation*
Core Outlet Temperature:	*485°C*

Two pages per design:

- 1st page: picture, table of main technical parameters
- 2nd page:
  - Introduction
  - Description of Nuclear Systems
  - Description of the Safety Concept
  - Non-electric Applications (if applicable)
  - Development Status and Planned Schedule

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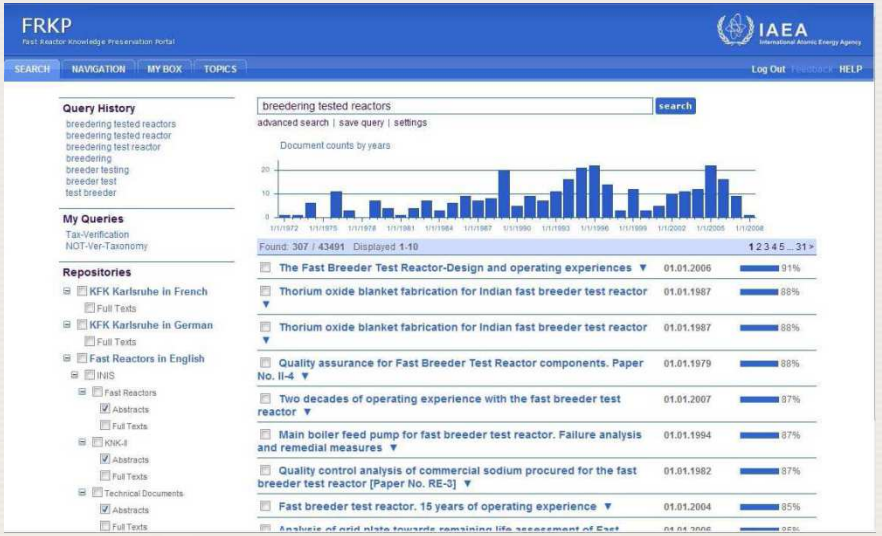
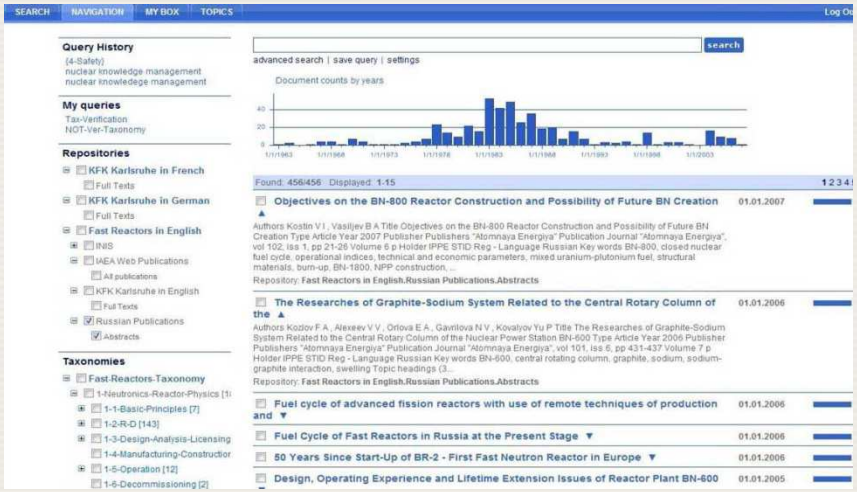
FRs Knowledge Preservation Portal: FR-KOS System https://nkm.iaea.org/nkm1/

- NKM Section developed a Fast Reactor Knowledge Organization System (FR-KOS): IT system to retrieve information stored in an international data base
- The NPTDS/FR Project collaborates with the NKM Unit to update the system and collect data and info to be uploaded into the system
- First version released to MSs for testing and stimulating contributions to FR-KOS
- Next TM on FR-KP: Vienna, 3-5 December 2013





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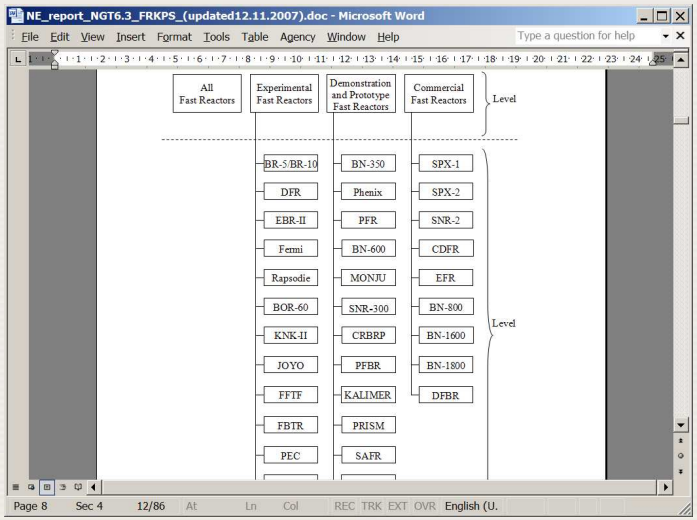
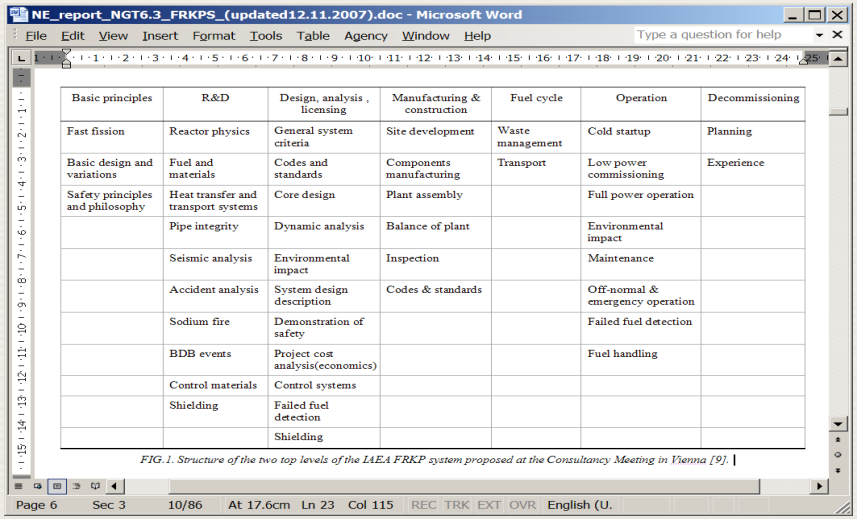
FR-KOS System: Fast Reactor Taxonomy

- Covers
  - ✓ all possible types of fast reactors
  - ✓ all aspects of fast reactors
  - ✓ all stages of implementation of fast reactor technology



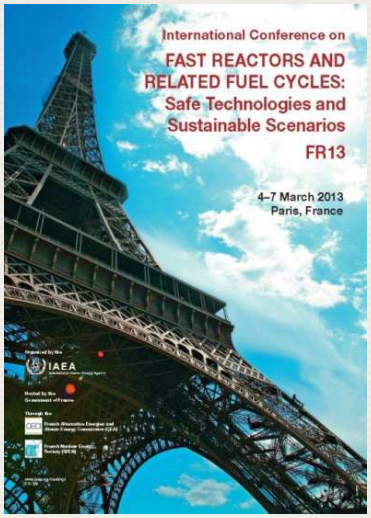
- Based on 2 dimensional matrix (2 top levels):
  - ✓ stages of implementation
  - ✓ technology elements



Basic principles	R&D	Design, analysis , licensing	Manufacturing & construction	Fuel cycle	Operation	Decommissioning
Fast fission	Reactor physics	General system criteria	Site development	Waste management	Cold startup	Planning
Basic design and variations	Fuel and materials	Codes and standards	Components manufacturing	Transport	Low power commissioning	Experience
Safety principles and philosophy	Heat transfer and transport systems	Core design	Plant assembly		Full power operation	
	Pipe integrity	Dynamic analysis	Balance of plant		Environmental impact	
	Seismic analysis	Environmental impact	Inspection		Maintenance	
	Accident analysis	System design description	Codes & standards		Off-normal & emergency operation	
	Sodium fire	Demonstration of safety			Failed fuel detection	
	BDB events	Project cost analysis(economics)			Fuel handling	
	Control materials	Control systems				
	Shielding	Failed fuel detection				
		Shielding				

FIG.1. Structure of the two top levels of the IAEA FRKP system proposed at the Consultancy Meeting in Vienna [9].

IAEA International Conference on *Fast Reactors and Related Fuel Cycles – FR13*



- Total number of participants: 642
- Participating countries: 27
- International Organizations: 4
- Plenary sessions 4
  - ✓ *Opening session* 5
  - ✓ *National and International Programmes* 9
  - ✓ *Safety Design Criteria* 7
  - ✓ *Sustainability of Advanced Fuel Cycles* 8
  - ✓ *Young Generation Event* 7
  - ✓ *Closing Session* 7
- Topical Tracks: 10
  - ✓ *Technical Sessions* 41
  - ✓ *Poster Sessions* 2
- Scientific Contributions: 371
  - ✓ *Oral presentations:* 214
  - ✓ *Poster presentations:* 157

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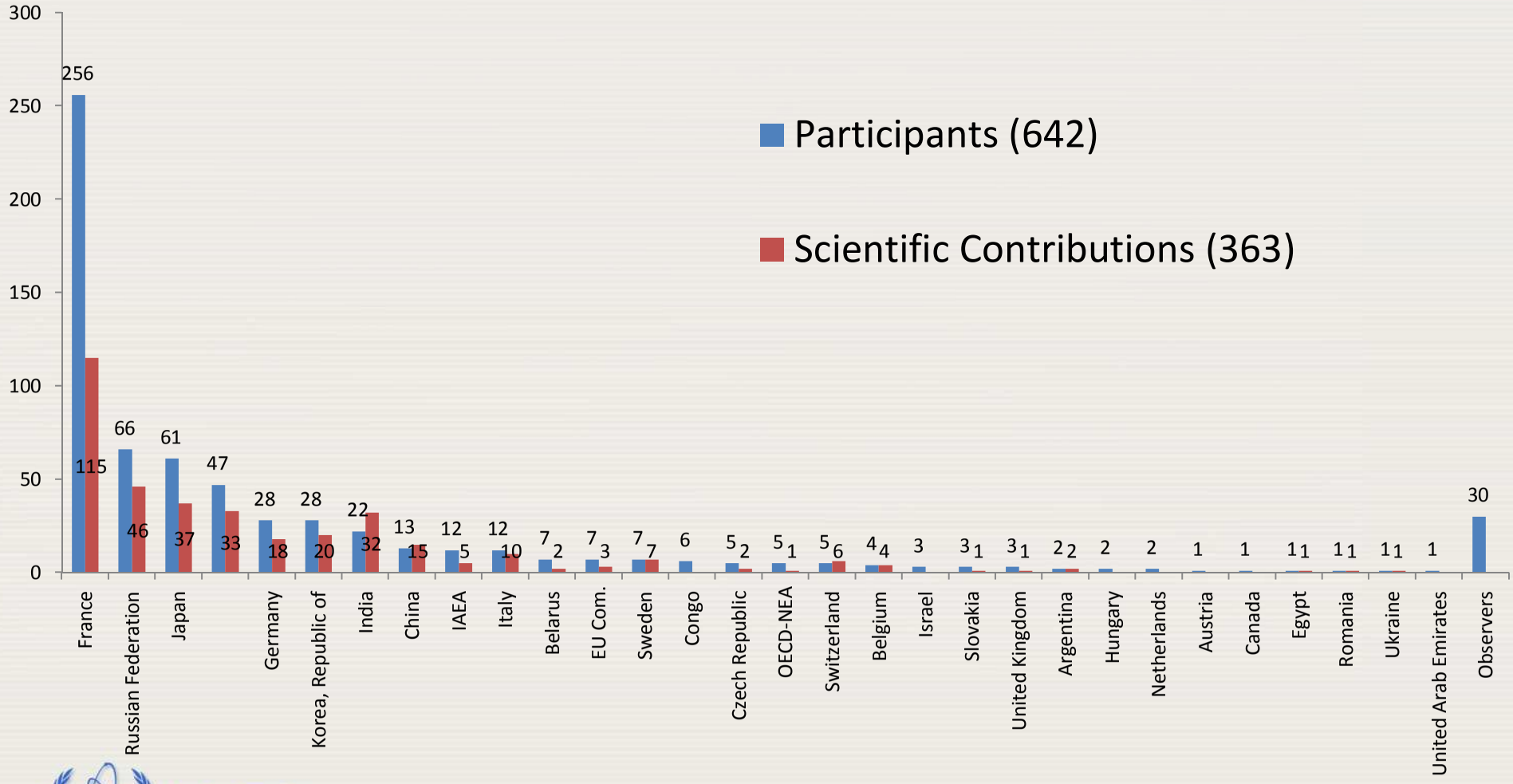
FR13 Participants and Scientific Contributions by Country



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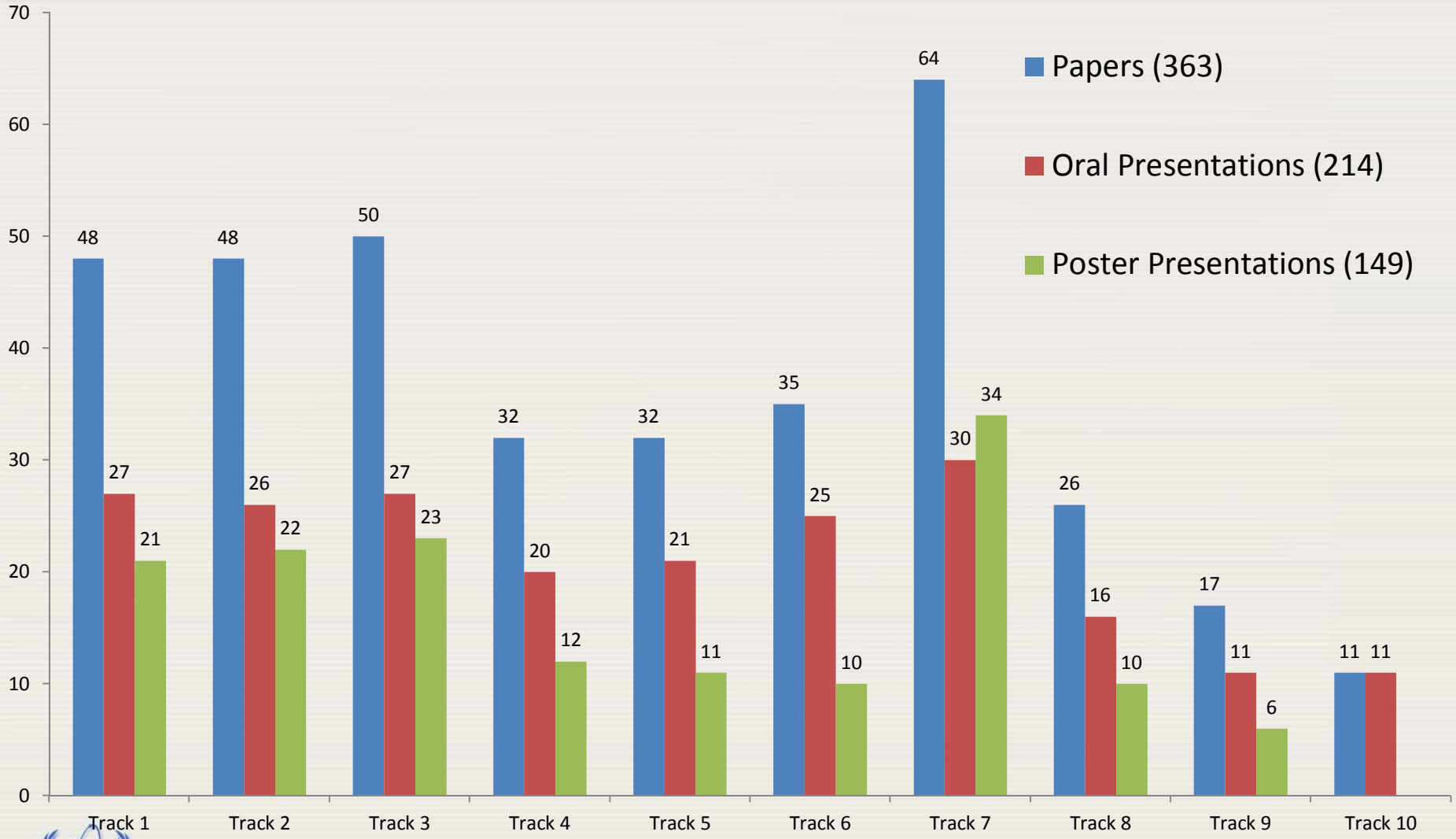
FR13 Scientific Contributions per Track



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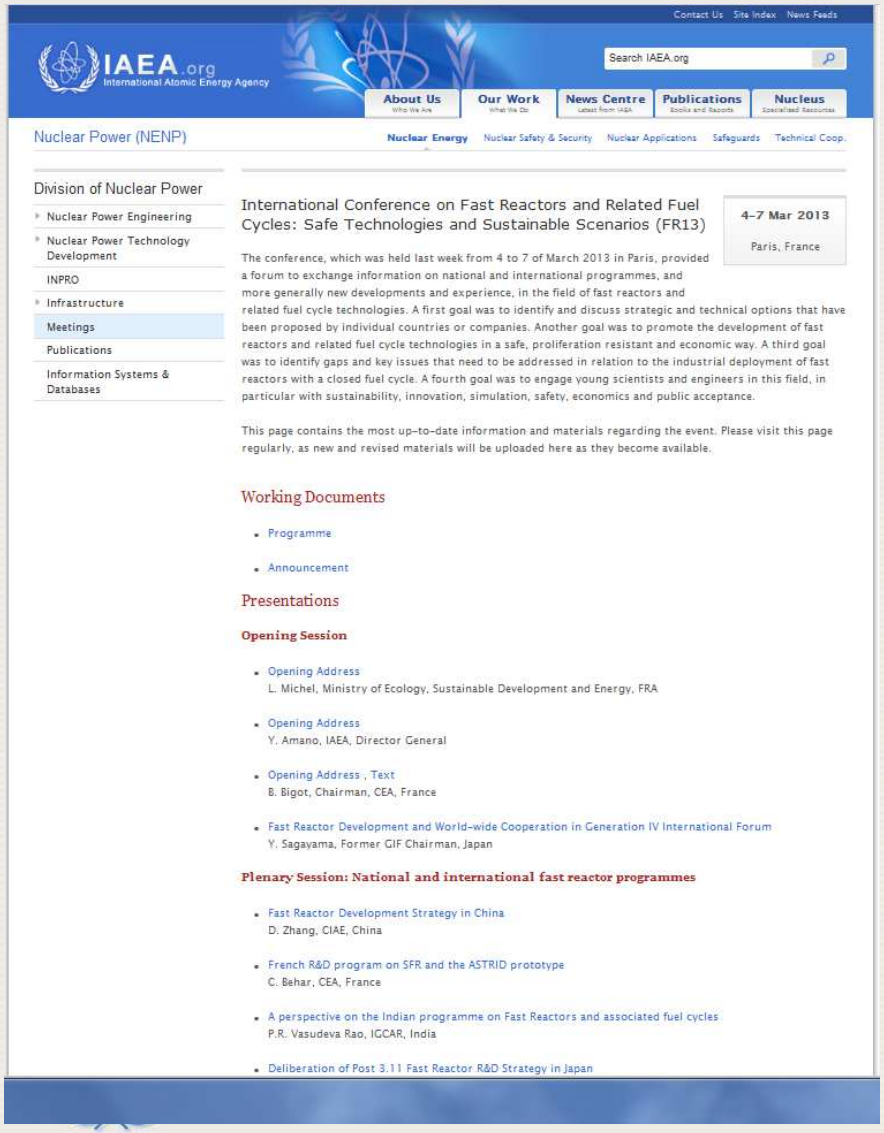
IAEA International Conference on *Fast Reactors and Related Fuel Cycles – FR13*



All the presentations given at FR13 Conference including opening addresses, closing remarks, panels' and YGE contributions are available at the following website:

http://www.iaea.org/NuclearPower/Meetings/2013/2013-03-04-03-07-CF-NPTD.html

Book of Abstracts and not-reviewed / not-edited full papers were distributed in an USB stick memory at the conference

FR13 Highlights and Main Outcomes
FR projects worldwide

- Research & Projects on Fast Neutron Reactors & related Fuel Cycles remain at sustained level worldwide
  - Near term projects of SFRs:
    - ✓ *India: PFBR (500 MWe) (2014, Kalpakkam) + 2 CFBR units (500 MWe)*
    - ✓ *Russia: BN-800 (800 MWe) (2014, Beloyarsk-4) -> BN-1200, MBIR (150 MWth) (~2019)*
    - ✓ *China: CFR-600 (600 MWe) (2023)*
  - Near term projects of LFRs:
    - ✓ *Russia: SVBR-100 (100 MWe) (2017)*
    - ✓ *Russia: BREST-300 (300 MWe) (~2020, Tomsk) -> BREST-1200*
  - SFR Demonstrations & Research
    - ✓ *Japan: Restart of MONJU, Safety tests & Continuing research (JSFR)*
    - ✓ *USA et al.: Continuing research on reactor, fuel & fuel cycle*
  - Gen-IV Systems Technology Demonstrators & Prototypes
    - ✓ *France: ASTRID (~ 600 MWe SFR) (2020s) -> ESFR (1500 MWe)*
    - ✓ *Europe: MYRRHA (~50-80 MWth LBE-FR) (~2020, Mol Belgium)*
    - ✓ *Europe: ALFRED (~300 MWth LFR) -> ELFR*
    - ✓ *Europe: ALLEGRO (~70 MWth GFR) (> 2025, CZ, SK, HR + PL)*
    - ✓ *USA: SMFR (50 MWe)*
    - ✓ *Rep. of Korea: PGSFR (150 MWe)*

FR13 Highlights and Main Outcomes

Track 4 - fast reactors materials: achievements and challenges

- Structural materials with improved resistance (high temperatures, high neutron flux, corrosion, 60y lifetime, etc.)
  - ✓ Advanced Austenitic steels
  - ✓ Advanced ferritic/martensitic steels

  } Improvement of ageing (creep, fatigue, creep-fatigue) mechanisms understanding

- Low swelling steels for fuel cladding
  - ✓ Advanced Austenitic Steels
  - ✓ Advanced Ferritic and Ferritic/Martensitic Steels
  - ✓ Oxide Dispersed Strengthened Steels (ODS)
  - ✓ SiC-SiC

- Large components (steam generators, pumps, etc.) materials
  - ✓ Research on codes for mechanical design

- Materials specific issues
  - ✓ SFR: alternative coatings for stellite replacement
  - ✓ LFR: control of steel corrosion in lead-alloys
  - ✓ GFR: SiC-SiC as fuel cladding, 9 Cr F/M steel for the vessel, Ni-alloys for HX

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FR13 Highlights and Main Outcomes
Final Conclusions

- FR13 Conference confirmed that, in spite of the recent Fukushima accident, nuclear energy remains a necessary resource to meet the expected significant increase in the world energy demand
- Fast reactors and the corresponding closed fuel cycles will play a key role to guarantee a long term sustainable energy supply
- FR13 represented an effective framework to share updates on national programs of fast reactor developments, projects of new builds and plans for the future
- The importance of international collaborations was firmly remarked. In this regards, FR13 represented a catalyst for further collaborations and alliances
- The conferences effectively provided a forum to review new developments arising from R&D programmes in the key areas of fast reactors technology
- Next conference FR17 was announced to be held in Russian Federation in 2017

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Scope of this technical meeting

- Within FR development programmes, significant research and development (R&D) efforts are devoted to the design of innovative reactor cores
  - intrinsic safety features (enhanced negative reactivity feedbacks, reduced coolant void reactivity effects, etc.),
  - high performance (in terms of cycle length, high fuel burnup, breeding gain, etc.)
  - Minor Actinide transmutation capability
- The development of high performance in-core structural materials represents one of the most challenging aspects
  - high neutron flux
  - liquid metal coolant
  - high temperatures

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Objectives and expected outcomes

- Present and discuss results of studies and on-going R&D and design activities in the field of innovative reactor core concepts
- Present and discuss results of studies and on-going R&D activities in the field of advanced reactor core structural materials
- Identification of research and technology gaps to be covered through new R&D initiatives to be carried out under the aegis of the IAEA.

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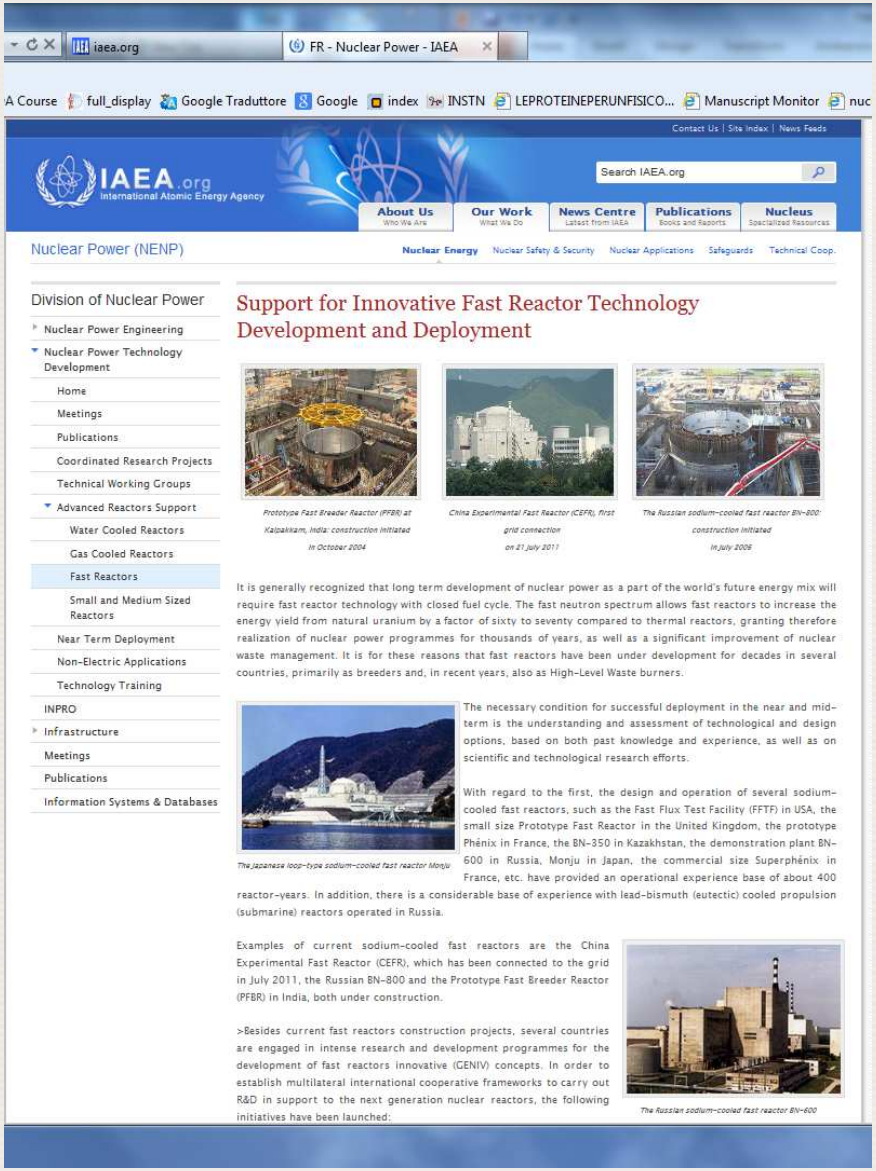
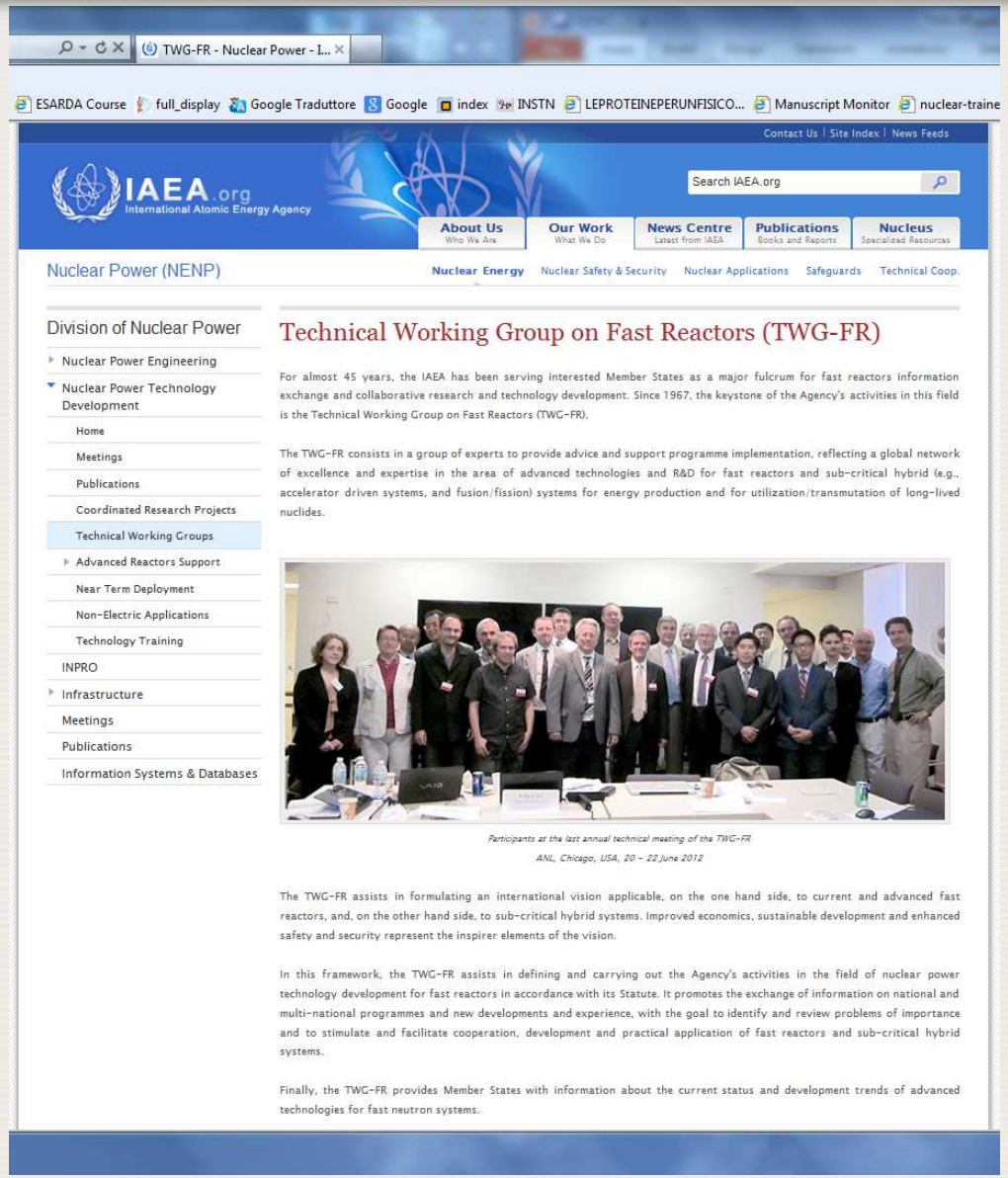
FR Project WEB-site: http://www.iaea.org/NuclearPower/FR/



TWG-FR WEB-site
http://www.iaea.org/NuclearPower/Technology/TWG/TWG-FR/



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http://www.iaea.org/NuclearPower/FR/

Thanks for Your Attention !

…Atoms for Peace

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