The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2137-4

Joint ICTP-IAEA Advanced Workshop on Multi-Scale Modelling for Characterization and Basic Understanding of Radiation Damage Mechanisms in Materials

12 - 23 April 2010

Introduction and opening

V. Inozemtsev
IAEA
Vienna
Austria

IAEA activities in the areas of advanced radiation-resistant materials development and fuel performance analysis

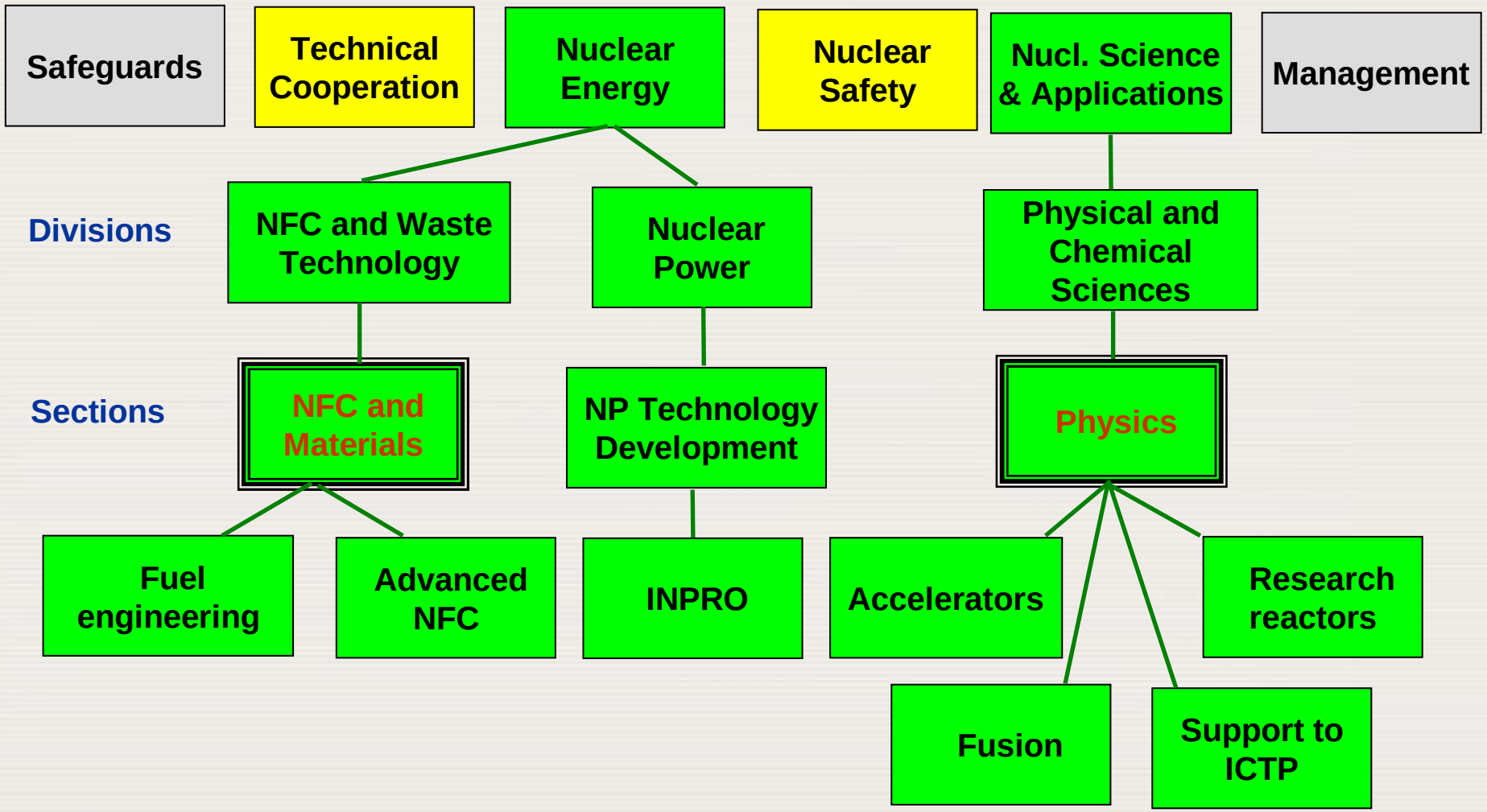
V. Inozemtsev

Nuclear Fuel Cycle and Materials Section

IAEA
International Atomic Energy Agency

ICTP-2010

Advanced materials in the IAEA Major Programme 1 "Nuclear power, fuel cycle and nuclear science"



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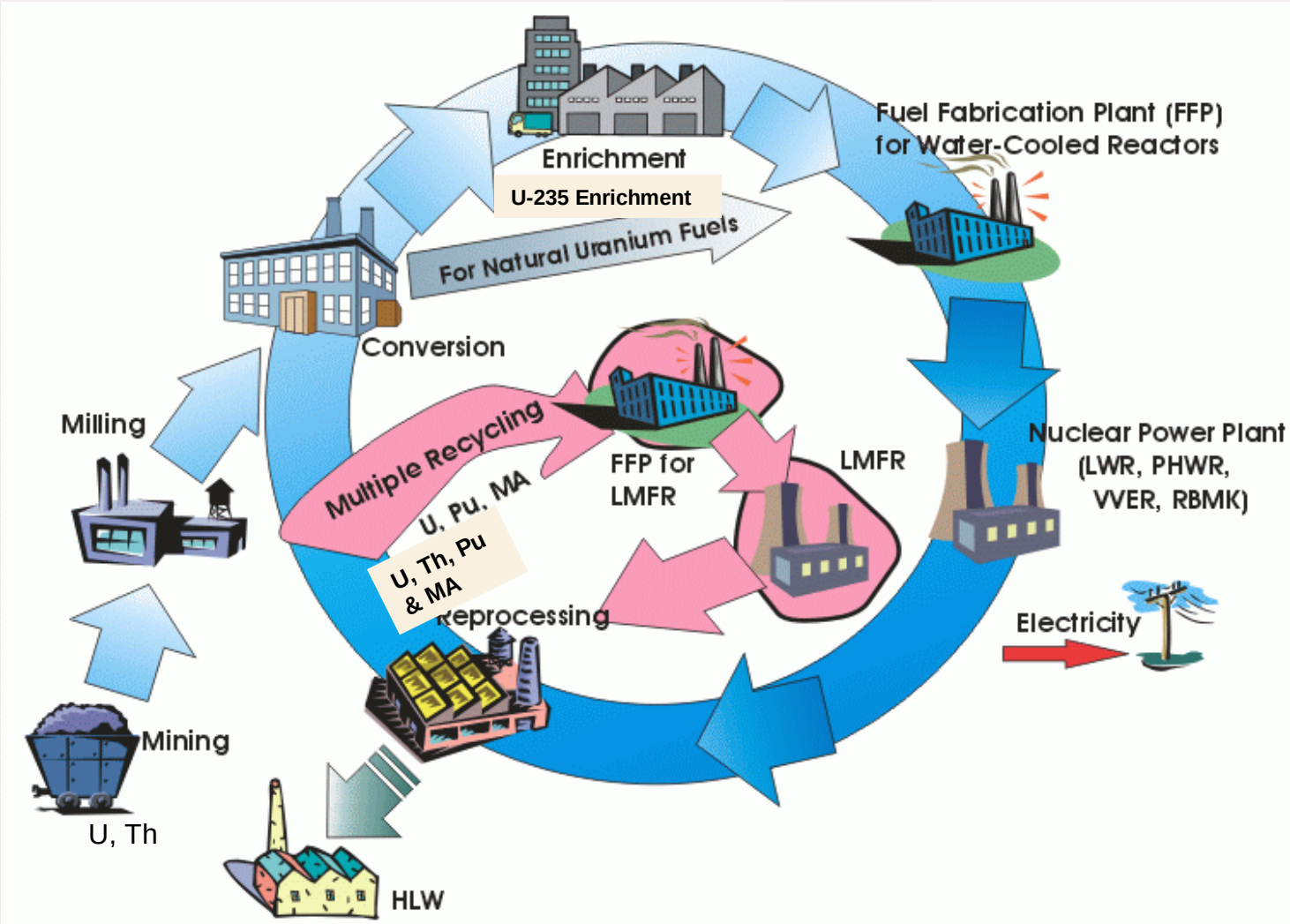
Nuclear Fuel Cycle and Materials Section



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Research on Nuclear Fuel and Materials

- Development, design and manufacturing, in-reactor behaviour
  Advice through: Technical Working Group on Fuel Performance and Technology
  25 Member States, OECD/NEA, EC

- Nuclear fuel cycle materials processing and management
  Advice through: Technical Working Group on Nuclear Fuel Cycle Options and Spent Fuel Management

Tools:
Workshops and Conferences
Technical Meetings (TM)
Expert reviews
Databases
Coordinated Research Projects (CRP)

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Workshops

2009

The Abdus Salam
International Centre for Theoretical Physics

Joint ICTP/IAEA Advanced Workshop on
Development of Radiation Resistant Materials

20 – 24 April 2009

(Miramare – Trieste, Italy)

The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, in cooperation with the International Atomic Energy Agency (the IAEA), Vienna, Austria, is organizing the Advanced Workshop on Development of Radiation Resistant Materials, to be held at ICTP, Trieste, from 20 to 24 April 2009.

Within the frame of the INPRO and Generation IV initiatives, the next generations of nuclear power reactors are under assessments and in the R&D process. Almost all new reactor concepts are specified by higher efficiency and better utilization of nuclear fuel with minimization of nuclear waste. For the sustainability of the nuclear option, there is currently a renewed interest worldwide in new reactors and closed fuel cycle research and technology development; however, such an approach means that a new class of structural materials with significantly better radiation resistance will have to be introduced. To achieve the high performance parameters, more focused research and testing of new candidate materials are necessary.

Recent development of new classes of materials with improved microstructural features, such as composite materials (SiC) and Oxide Dispersed Strengthen (ODS) or advanced Ferritic-Martensitic (FM) steels, is quite promising since they have very good radiation resistance properties. In view of the successful and timely implementation of design parameters, new structural materials - in particular for primary circuits - have to be developed in the next decade. The on-going research has proved that recent progress in material science, supported by computer modeling, can accelerate the R&D process for development of new structural materials.

The scope of the Workshop is education, training and information exchange. Participants will be familiarized with the physics, materials and engineering aspects of structural materials for selected reactor designs. A comprehensive review of fission, as well as fusion reactor designs of the innovative material concepts presently under consideration, will be given.

PROGRAMME:

The programme will consist of lectures, tutorials and computer demonstrations. Participants will also be invited to make short (10-15 minute) presentations covering their own research activities. The participants will study and discuss the theoretical foundation of all aspects related to the material problems including key issues, as radiation effects on microstructure and properties, advanced post-irradiation methodologies and multi-scale modeling as well as qualification of new structural materials. In addition, the attendees will gain knowledge related to structural materials of selected reactor designs as well as most critical areas from a structural materials point of view. The students will be familiarized with the modern theoretical approaches for the development of quantitative models of radiation-induced material degradation. They will learn the principles of the qualification methodologies and become acquainted with the current status of R&D and new challenges in radiation material science. Based on the discussion of the impact of the present uncertainties on the performance of structural materials for innovative reactor systems, the need for theoretical & experimental testing and validation procedures will be justified.

PARTICIPATION:

Scientists and engineers from all countries who are members of the United Nations, UNESCO or IAEA may attend. They should hold a university degree or postgraduate degree/diploma in physics, engineering or related subjects. The School will be conducted in English and participants must therefore have adequate language knowledge. Although the main purpose of the Centre is to help researchers from developing countries, graduate students and post-doctoral scientists from developed countries would equally benefit from the School and are encouraged to apply.

As a rule, travel and daily subsistence expenses of participants are borne by their home institutions; limited funds are, however, available for those participants, who are nationals of, and working in a developing country, and who are not more than 45 years old – this support is available only to those attending the entire activity. Every effort should be made by candidates to secure support for their travel fare (or at least part of the fare).
There is no registration fee to be paid.

HOW TO APPLY FOR PARTICIPATION:

The application form can be accessed at the activity website: http://agenda.ictp.it/smr.php?2026
Once in the website, comprehensive instructions will guide you step-by-step, on how to fill out and submit the application form **before 20 January 2009**.

SECRETARIAT:

Elizabeth Brancaccio (Ms)

Telephone: +39-040-2240284 E-mail: smr2026@ictp.it Telefax: +39-040-224163
http://www.ictp.it/

Jointly with the
International Atomic Energy Agency

DIRECTORS:

V. INOZEMTSEV
and
A. ZEMAN
(IAEA, Vienna, Austria)

LOCAL ORGANIZER:

S. SCANDOLO
(ICTP, Trieste, Italy)

KEY TOPICS:

Radiation damage phenomenon

Microstructures and mechanical properties of nuclear power structural materials

Key material parameters and operational conditions of selected reactors designs

Multi-scale approach in modeling of material properties under irradiation

Advanced microstructural probing methods

Qualification of new structural materials

Pathways to development of new structural materials

On-going challenges in radiation materials science

DEADLINE
20 January 2009

December 2008

2008

The Abdus Salam
International Centre for Theoretical Physics

WORKSHOP on
BASIC RADIATION MATERIALS SCIENCE

10 - 21 November 2008

Miramare, Trieste, Italy

The Abdus Salam International Centre for Theoretical Physics (ICTP, Trieste, Italy), in cooperation with the International Atomic Energy Agency (IAEA, Vienna, Austria), is organizing a Workshop on the Training in Basic Radiation Materials Science and its Applications to Radiation Effects Studies and Development of Advanced Radiation-Resistant Materials, to take place in Trieste from 10 to 21 November 2008.

Background:

Growing requirements on nuclear fuel performance parameters (e.g. higher burnup, residence time, operation temperatures) increasingly demand the introduction of technical innovations and advanced materials. The testing of such materials by direct irradiation carries an increase in cost and duration of these studies. Within this context, it is clear that the development of theoretical models of radiation effects and nuclear fuel behavior acquires a prominent role. Radiation materials science provides the basic understanding of the nature of radiation damage, and allows for an adequate comparison and interpretation of simulation experiments against data collected in accelerators and other irradiation devices.

Content Description:

The Workshop is intended to provide participants with basic information about present and future requirements on nuclear materials, modeling and simulation of radiation effects, advanced experimental tools and modern approaches for development of radiation-resistant materials. Specific topics include:

- Operational conditions and requirements for nuclear materials
- Physics of radiation damage and radiation effects
- Modern post-irradiation examination techniques and methods
- Modelling of radiation effects and nuclear fuel behavior under irradiation
- Applications of accelerators for modeling of radiation damage
- Development of materials subject to high dose irradiation

Participants are encouraged to present their work in a Poster session to be held during the first week of the Workshop. A few posters will be selected, and their authors will be offered the opportunity to give a brief oral presentation.

Participations:

The invitation to the Training Workshop is directed to scientists and managers in academia, industry and possibly in the governmental sector who are involved in research in the general area of radiation damage of materials subject to very high dose radiation, e.g. materials used in nuclear reactors.

Applicants from all countries who are members of the UN, UNESCO or IAEA may apply. As the Workshop will be held in English, participants must have a good working knowledge of that language. Although the main purpose of the Centre is to help research workers from developing countries, through a programme of training activities within a framework of international co-operation, a limited number of students and post-doctoral scientists from developed countries are also welcome to attend.

As a rule, travel and subsistence expenses of the participants should be borne by the home institutions. However, limited funds are available for some participants who are nationals of, and working in, a developing country and who are not more than 45 years old, to be selected by the Organizers. As scarcity of funds allows travel to be granted only in a few exceptional cases, every effort should be made by candidates to secure support for their fare (or at least half-fare) from their home country. It is stressed that participants whose travel expenses are paid by ICTP are required to attend the entire activity. For logistics reasons, the total number of participants is limited. There is no registration fee for this activity.

The Application Form is obtainable from the ICTP WWW server: http://cdsagenda5.ictp.it/full_display.php?ida=a07478 (which will be progressively up-dated), or from the activity Secretariat. It should be completed and returned before **10 JULY 2008** to:

***Workshop on Basic Radiation Materials Science* (smr1969)**
the Abdus Salam International Centre for Theoretical Physics
(c/o Elizabeth Brancaccio)
Strada Costiera 11, I-34014 Trieste, Italy

The decision of the Organizers will be communicated to all candidates as soon as possible.

If sending your applications by e-mail: smr1969@ictp.it
(please save and send file attachments in RFT formats)

Telephone: +39-040-2240284 **Telefax: +39 040 224163**
E-mail: smr1969@ictp.it **ICTP Home Page: http://www.ictp.it/**

Trieste, April 2008

in cooperation with

International Atomic Energy Agency
Vienna

DIRECTORS

V. INOZEMTSEV
(IAEA, Vienna)

J. KOHANOFF
(Queen's University, Belfast)

LOCAL ORGANIZER

S. Scandolo
(ICTP, Trieste)

DEADLINE
for requesting participation

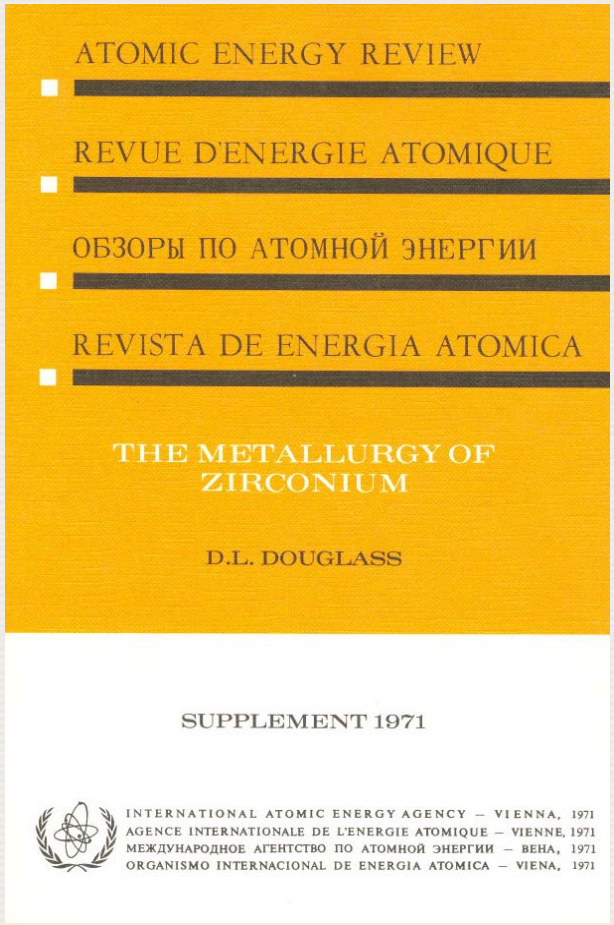
10 July 2008

IAEA

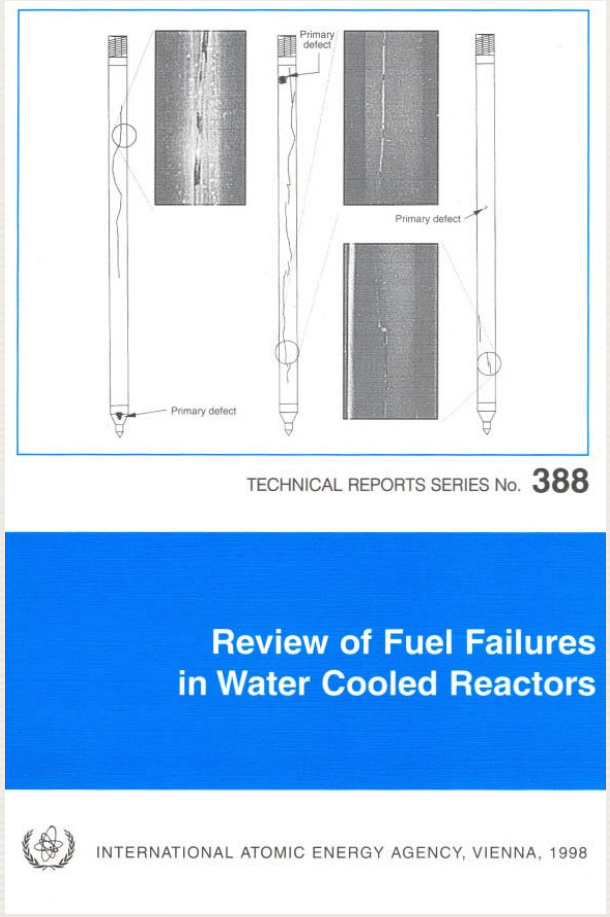
Technical Meetings (TWGFPT-2008)

Technical Meetings	Host	1	2	3	4	5	6	7	8	9	10	11
TWGFPT	IAEA											
Advanced PIE examination techniques for water reactor fuel - TECDOC-1277	Russia											
Fuel behavior under transient and LOCA conditions - TECDOC-1320	Norway											
Fuel failure in water reactors: causes and mitigation - TECDOC-1345	Slovakia											
Poolside inspection and repair of water reactor fuel - WM-25642	Czech Rep.											
Improved fuel pellet materials and designs-TECDOC - 1416	Belgium											
Structural behavior of fuel assemblies, TECDOC - 1454	France											
Behavior of high corrosion-resistant Zr-based alloys	Argentina											
Fuel behavior modeling under normal, transient and accident conditions and high burnup	UK											
High burnup fuel experience and economics	Bulgaria											
Hot cell PIE and poolside inspection techniques for water reactor fuel	Argentina											
PHWR fuel modelling	India											
Fuel rod instrumentation and in-pile measurement techniques	Norway											
PHWR fuel design, fabrication and performance	Argentina											
Advanced fuel pellet materials and fuel rod designs for water cooled reactors	Switzerland											
Fuel behavior and modeling under LOCA and RIA conditions	Japan											
Water chemistry and clad corrosion/hydriding/deposition including fuel failures	Ukraine											
Design, manufacturing and radiation behaviour of FR fuels (joint)	Russia											
Fuel integrity during normal operation and accident conditions in PHWR	Romania											
Hot-cell PIE and pool-side inspection (in cooperation with HOTLAB)	Slovakia											
Fuel modelling	Finland											

Expert Reviews



2010: Zr-book



2010: new edition, 1994-2006

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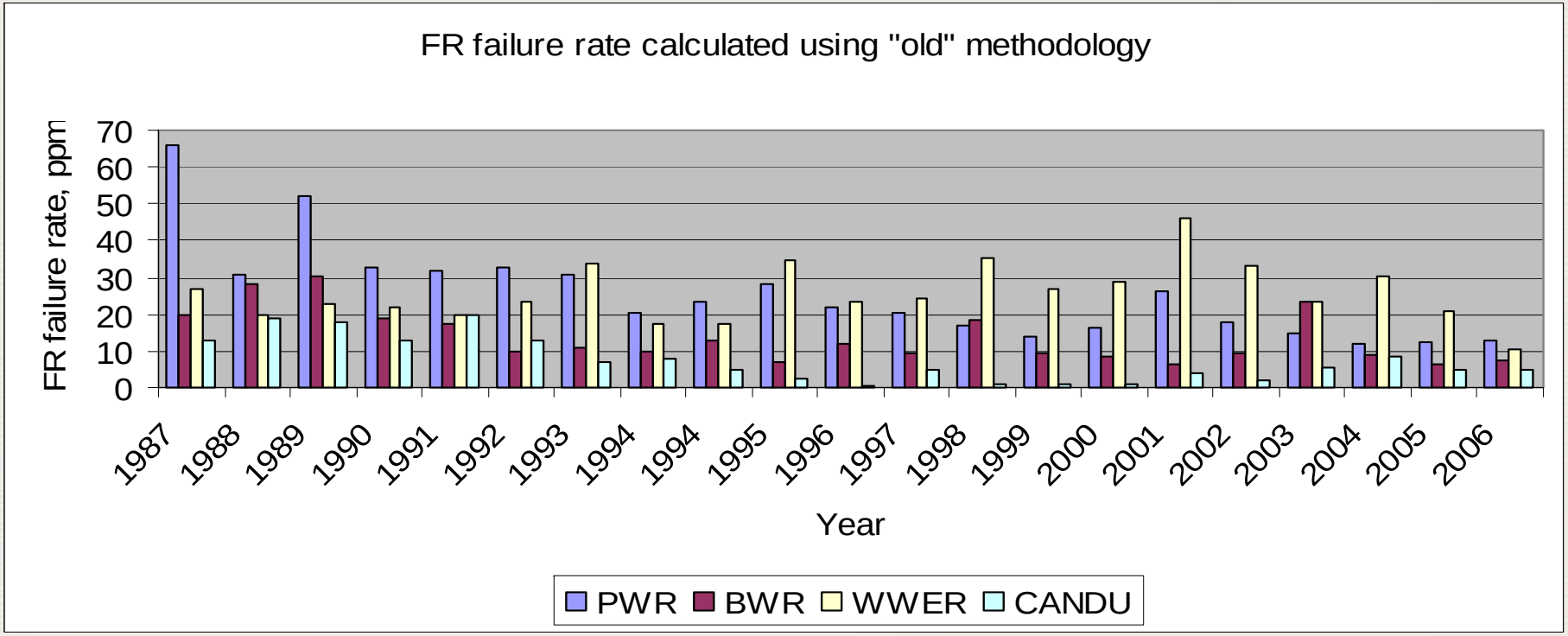
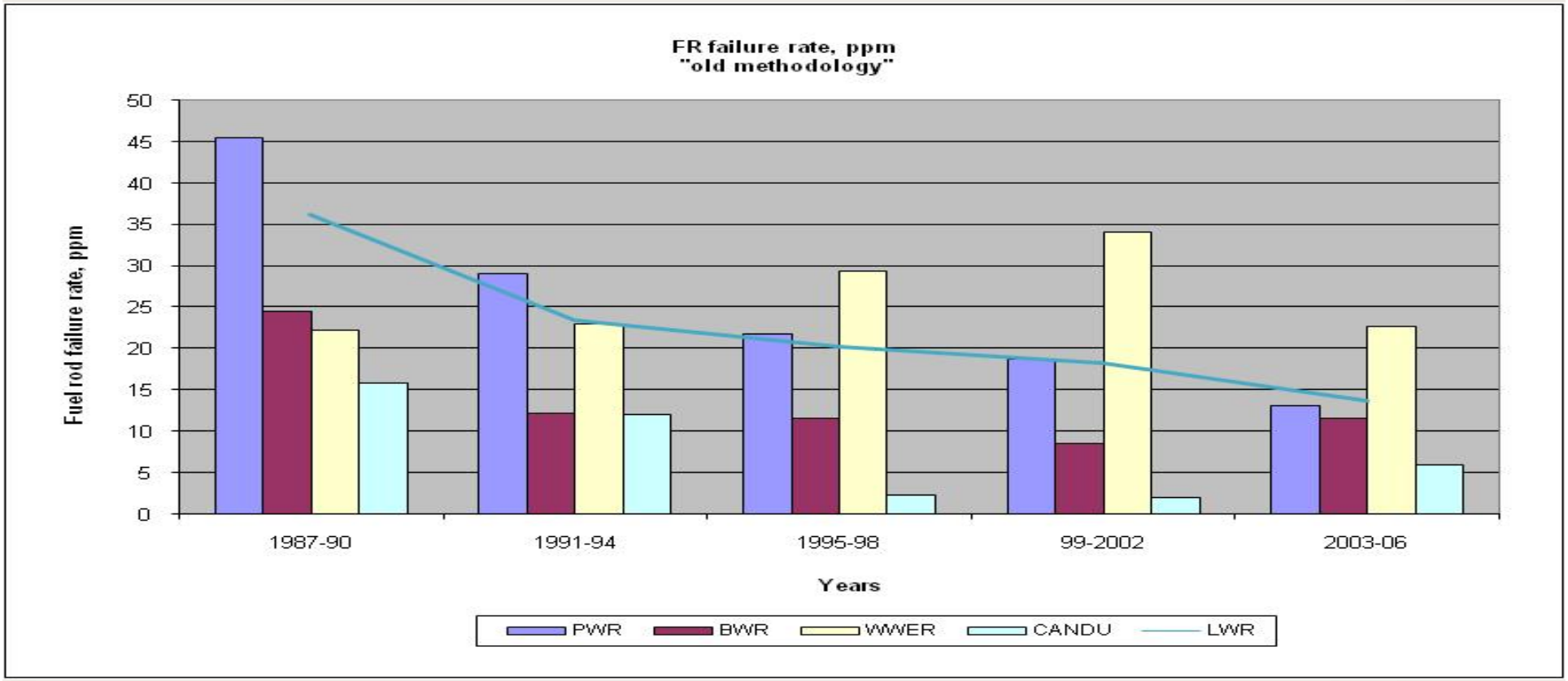
Evolution of fuel failure rate: 1987 -2006



The combination of results from the previous and present IAEA Fuel Failure Reviews reveals a tendency for reduction of fuel failure rate, but with recurrent increases linked mainly to massive fuel failures.

IAEA

Evolution of fuel failure rate: 1987 -2006



4-year averaged picture shows the tendency clearer with overall LWR trend defined by the PWR majority.

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IAEA Databases Related to NFC

Information Sources

- **Member States (Contact Points)**
- **Consultants**
- **IAEA Meetings**
- **Reliable Publications**

Inputs

- **Nuclear power projections**
- **Nuclear fuel cycle options**
- **Reactor physics calculations**

NFCIS

UDEPO

PIE

VISTA

http://www-nfcis.iaea.org

Internet
iNFCIS

- Navigation through facilities
- Search capabilities
- Summary reports for country specific or worldwide
- Country nuclear fuel cycle profiles
- Long term nuclear fuel cycle requirements for different scenarios

NFCIS : Nuclear Fuel Cycle Information System
UDEPO : World Distribution of Uranium Deposits
PIE : Post Irradiation Examination Facilities Database
VISTA : Nuclear Fuel Cycle Simulation System
MADB : Minor Actinide Property DB – **New!**

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IAEA Coordinated Research Projects (CRP): Fuel Behaviour Modelling Program

- DCOM (1981-1985). Development of Computer Models for fuel element behaviour in water reactors. 15 participants from 12 countries. *Need to improve temperature and FGR predictions.*
- FUMEX-1 (1993-1996). Fuel modelling at extended burnup.19 participants from 14 countries. International Fuel Performance Experimental database (IFPE). *Need to improve mechanical interaction and extend burnup for FGR*.
- FUMEX-2 (2001-2006). 18 participants from 16 countries. *Uncertainty on high burnup effects, rim structure and PCMI*.
- FUMEX-3 (2008-2011). About 30 participants from 20 countries. The exercise is designed to consider transient behaviour, mechanical interaction and other high burnup behaviours.

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Joint OECD/NEA–IAEA International Fuel Performance Experiment (IFPE) Database:

The public IFPE Database on for the purpose of fuel behaviour code development and validation is located at:

http://www.nea.fr/ntml/science/fuel/ifpelst.html

Well-qualified data on Zr - UO_2 fuel that illustrate specific aspects of fuel performance.

In addition to direct in-pile measurements, the database includes PIE information on clad diameters, oxide thickness, hydrogen content, fuel grain size, porosity, Electron Probe Micro Analysis (EPMA) and X-ray Fluorescence (XRF) measurements on caesium, xenon, other fission product and actinides.

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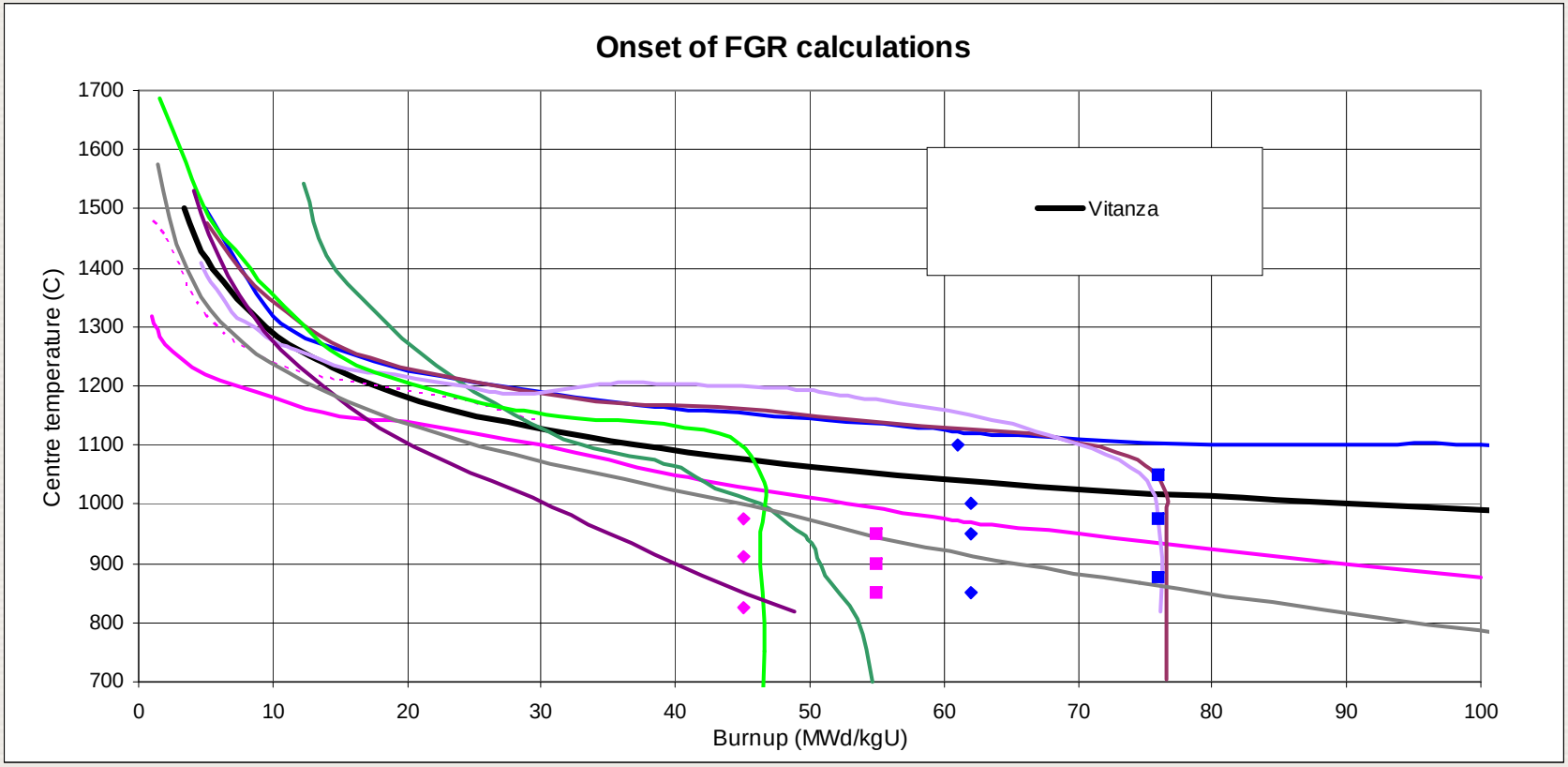
Predictions of the Vitanza threshold (CRP FUMEX)

The codes were asked to predict the temperature at which 1% fission gas release occurs as a function of burnup. The Vitanza threshold is experimentally derived, but only to a burnup of around 40GWd/tU



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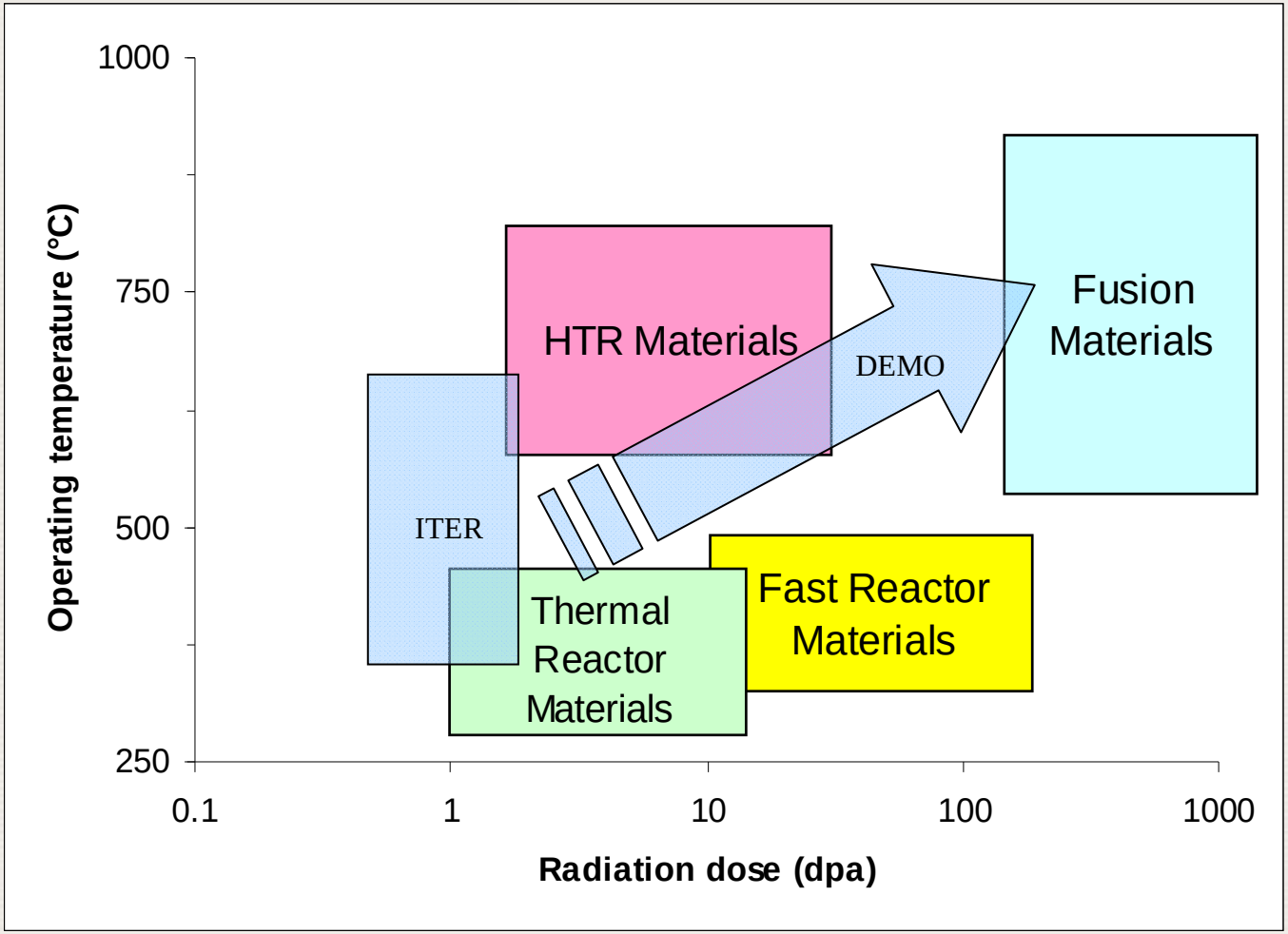
Increasing demands on structural materials



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CRP on Accelerator Simulation and Theoretical Modeling of Radiation Effects (SMoRE)

WHY

- Growing operational requirements and their variability
- Growing cost and duration of direct irradiation tests
- Not sufficient understanding of radiation effects

WHAT

- Perspective high-dose structural materials (focul on ODS)
- Both experimental and theoretical studies

WHEN

2007 – Round Table at the AccApp'07, Consultancy in the IAEA

2008 – Technical Meeting in the KIPT, Ukraine
1st Research Coordination Meeting (RCM) in Vienna

2009 – Contracts and Agreements: Belgium (SCK.CEN), China (CIAE), France (CEA, EdF), India (BARC), Japan (KU), Kazakhstan (INR), Korea (KAERI), Poland (IAE), Russia (IPPE, KI), Slovakia (BU), Spain (IFN), Switzerland (PSI), Ukraine (KIPT), USA (LANL, LLNL), OECD (NEA)

2010 – Consultancy in Sapporo, 2nd RCM in Paris

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You are welcome!

Thank you
for your attention!