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

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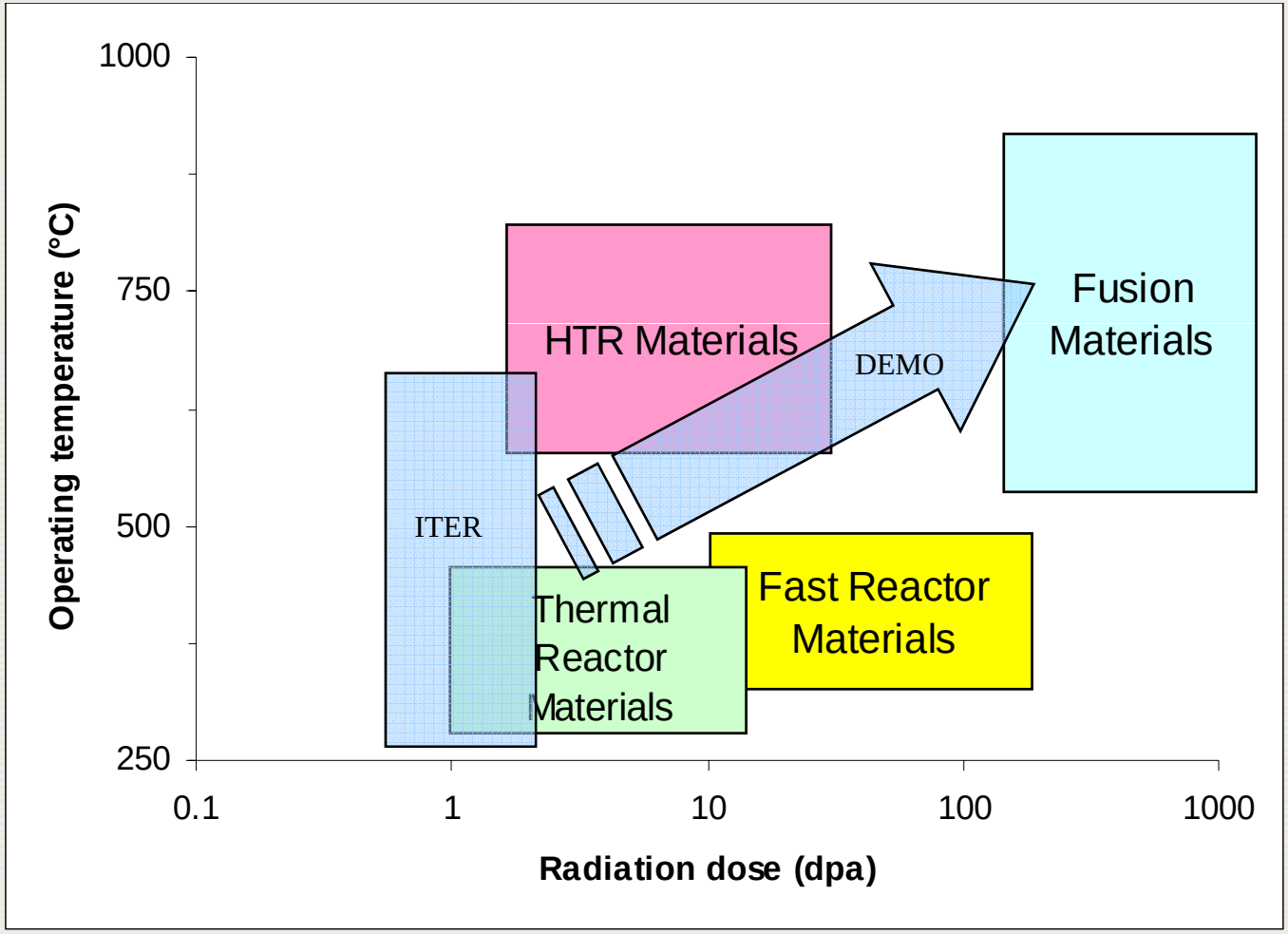
IAEA
International Atomic Energy Agency

ICTP, 20-24 April 2009

Increasing demands on structural materials



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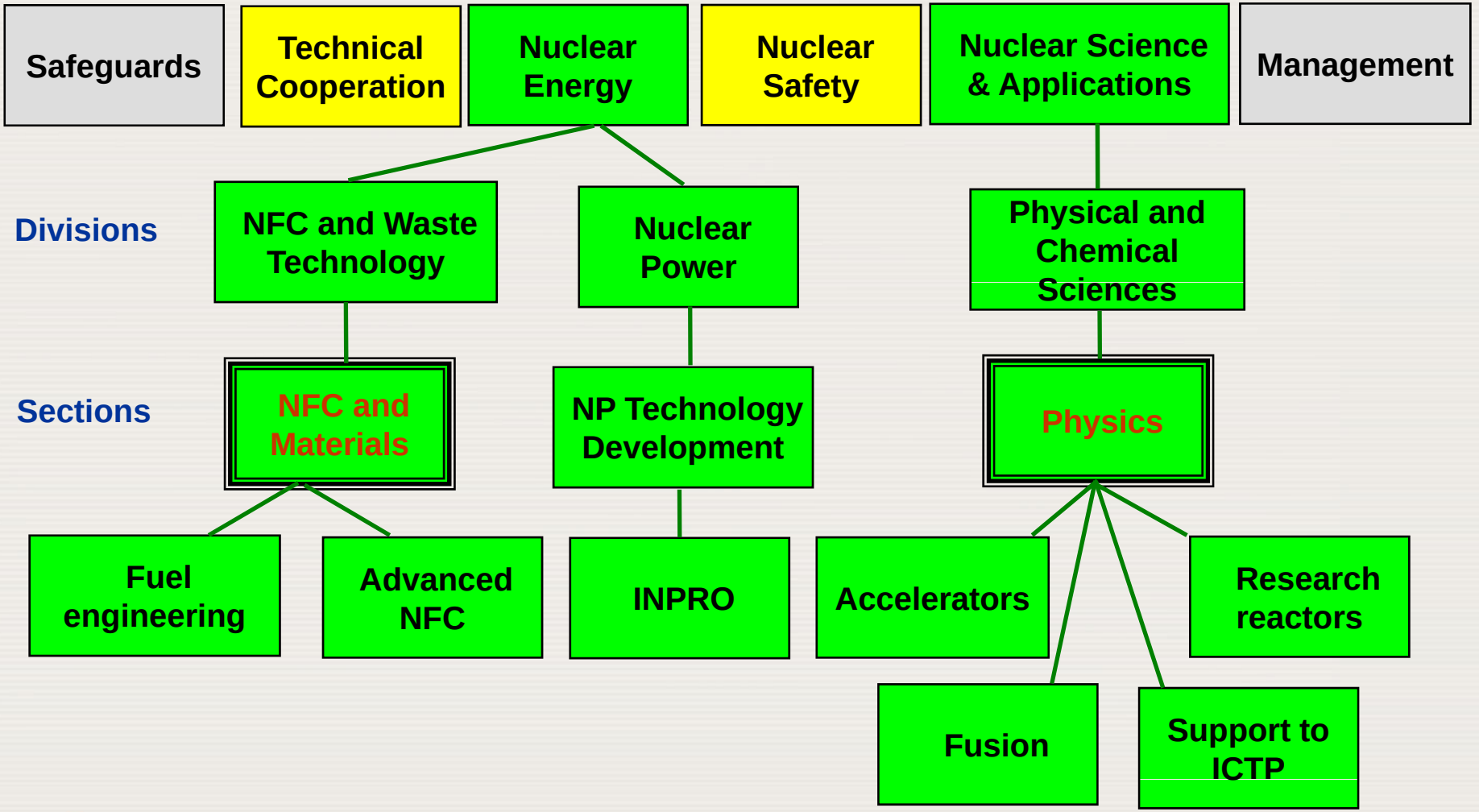
Advanced materials in the IAEA Major Programme "Nuclear power, fuel cycle and nuclear science"



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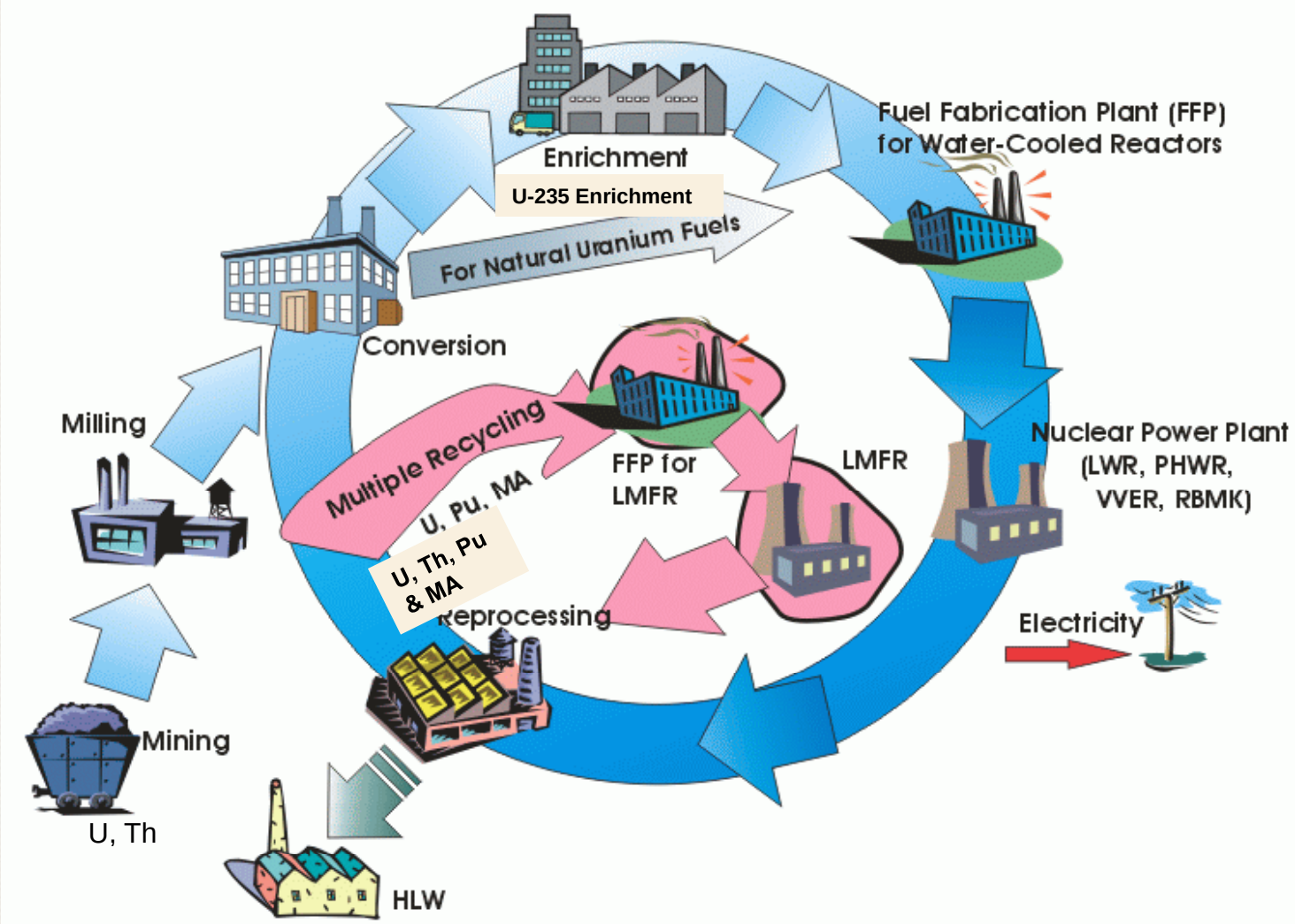
Nuclear Fuel Cycle and Materials Section



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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											

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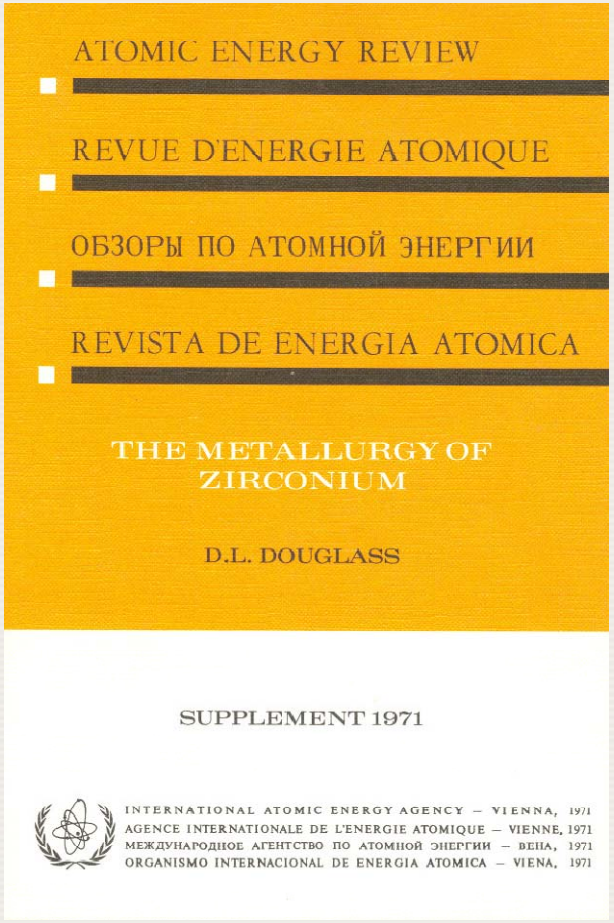
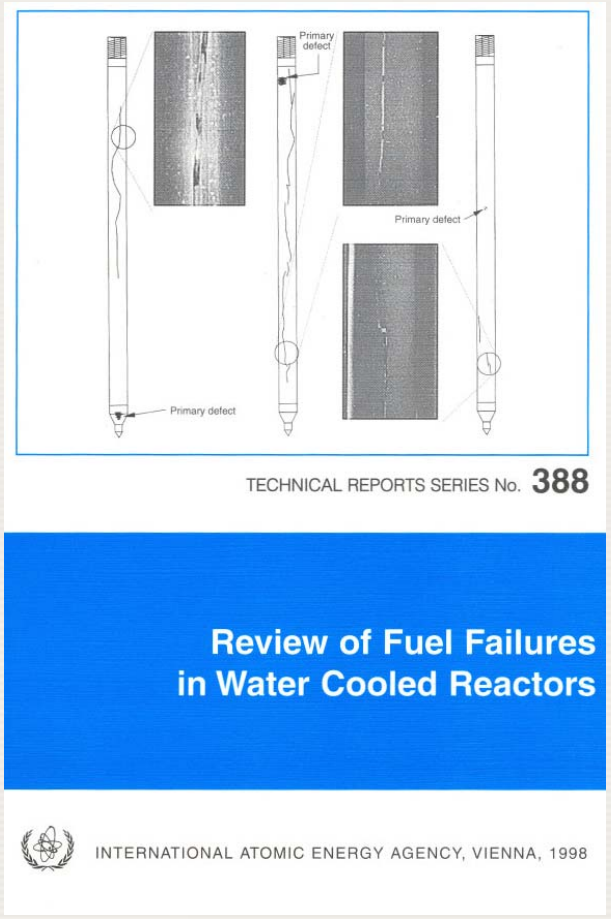
Expert Reviews



2009: Zr-book



2009: new edition, 1994-2006

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Contents of the IAEA Review of fuel failures in water-cooled reactors (1994-2006, 94% of WRs)

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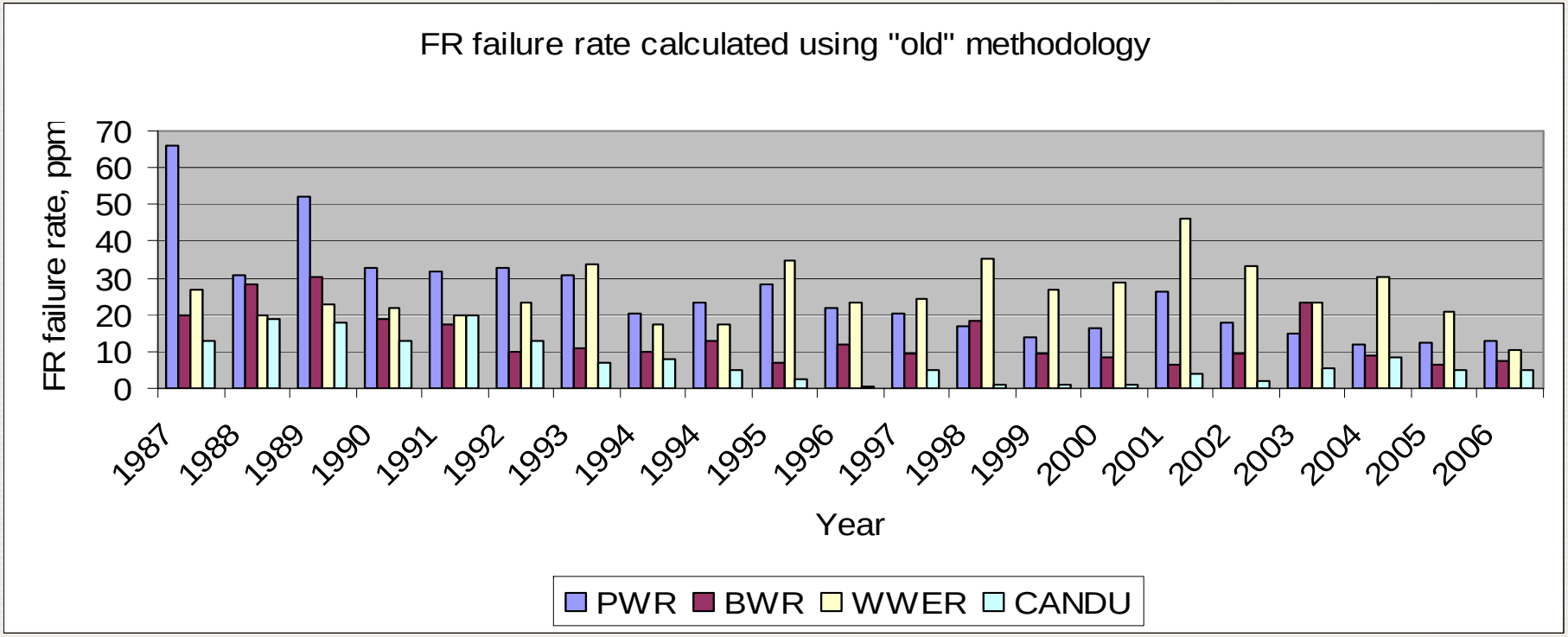
Evolution of fuel failure rate: 1987 -2006



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.

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IAEA Coordinated Research Projects (CRP): Delayed Hydride Cracking (DHC)

Phase 1: DHC-1 "Delayed Hydride Cracking in Zr alloys in pressure tube nuclear reactors" 1998-2002
IAEA TECDOC-1410

ORGANIZATION	COUNTRY
AECL	Canada
STUDSVIK	Sweden
CNEA	Argentina
BARC	India
KAERI	R. of Korea
LEI	Lithuania
PINSTECH	Pakistan
INR	Romania
VNIINM	Russia
NPIC	China

Phase 2: DHC-2 "Delayed Hydride Cracking of Zr alloys fuel cladding" 2005 - 2009
(TECDOC under preparation)

ORGANIZATION	COUNTRY
STUDSVIK	Sweden
TOMARI Consulting	Canada
CNEA	Argentina
BARC	India
KAERI	R. of Korea
LEI	Lithuania
PINSTECH	Pakistan
INR	Romania
VNIINM	Russia
IPEN	Brazil

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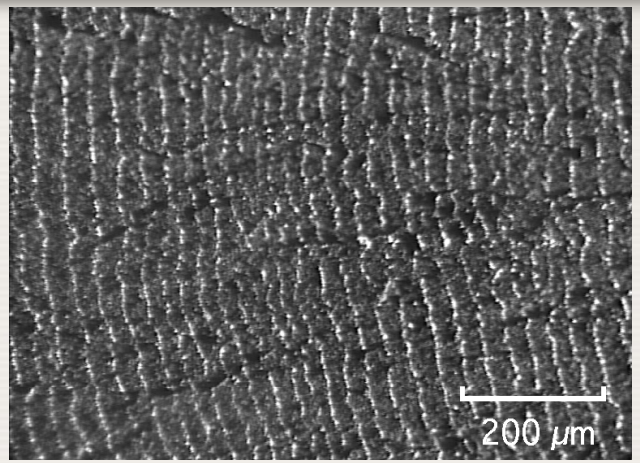
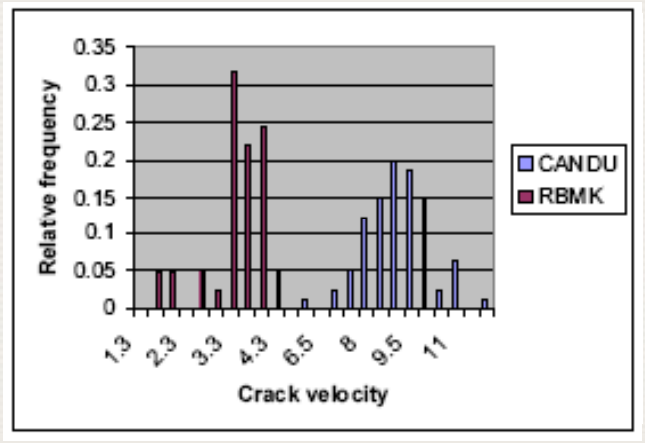
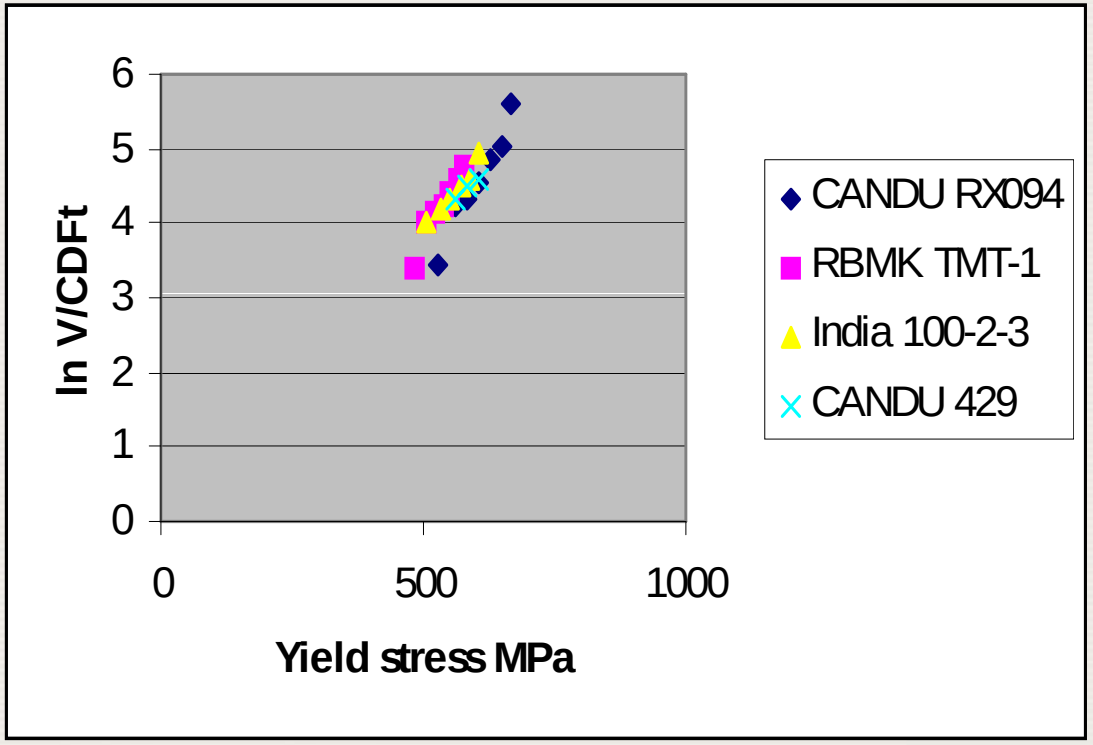
DHC: Zr-2.5% Crack Velocity Results



DHC striations, CANDU, 283°C



CANDU and RBMK, 250°C (m/s x 10^{-8})



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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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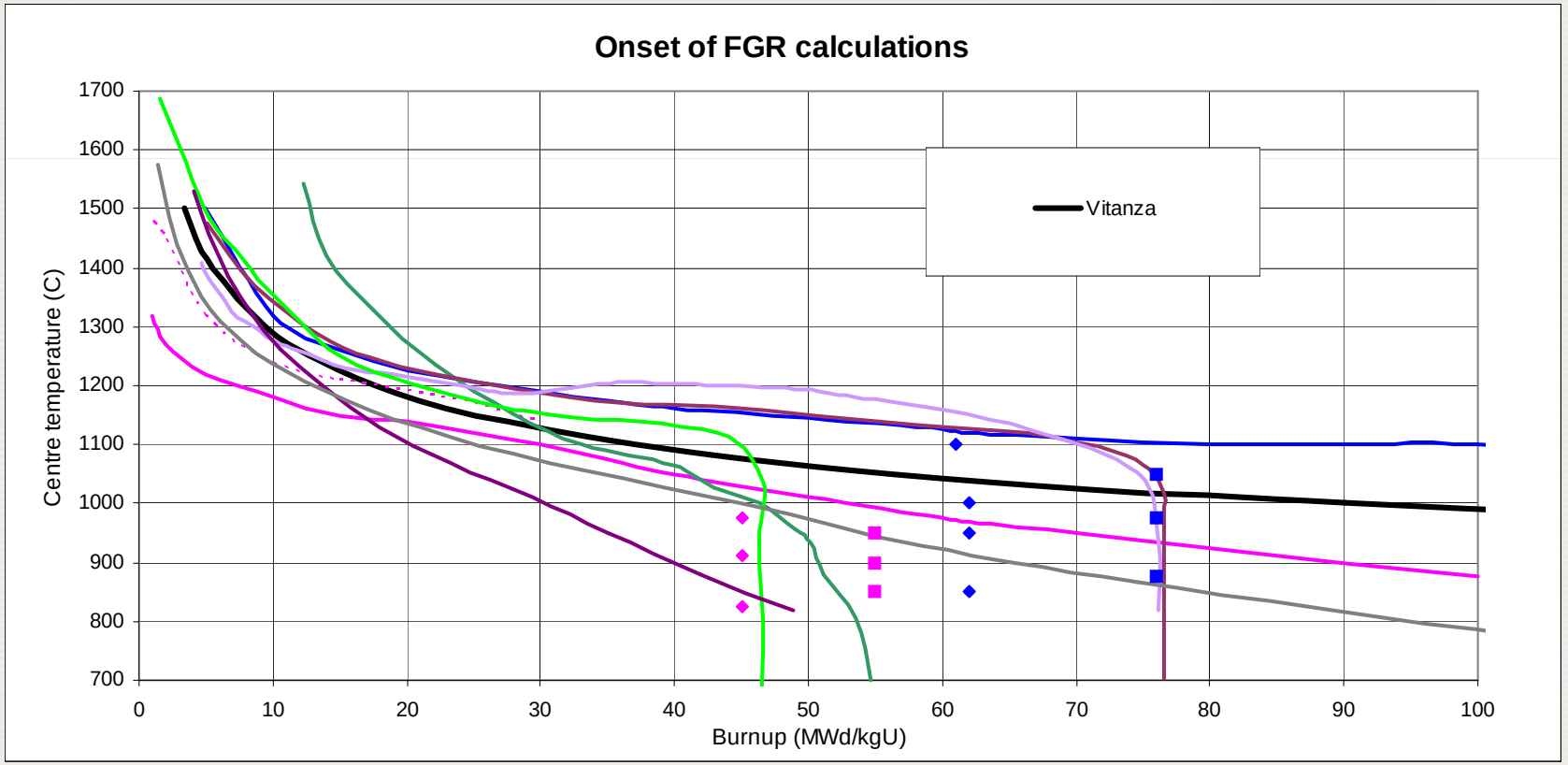
Predictions of the Vitanza threshold (CRP FUMEX)

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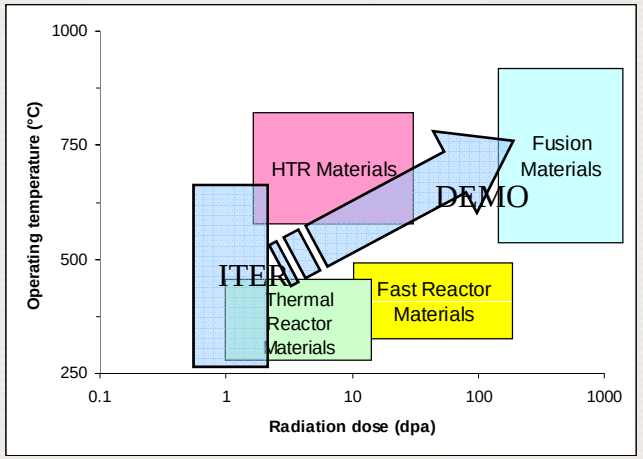
CRP on Accelerator Simulation and Theoretical Modeling of Radiation Effects (SMoRE)

WHY

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



WHAT

- Both existing and perspective structural materials
- Both practical tasks and basic research

WHEN

- 2007 – Round Table at the AccApp'07, Consultancy in the IAEA
- 2008 – Technical Meeting in KIPT
  1st Research Coordination Meeting in Vienna
- 2009 – Contracts and Agreements: Belgium (SCK.CEN), China (CIAE), France (CEA, EdF), India (BARC), Poland (IAE), Russia (IPPE, KI), Slovakia (BU), Spain (IFN), Ukraine (KIPT), USA (LLNL), OECD (NEA), RoK (KAERI)

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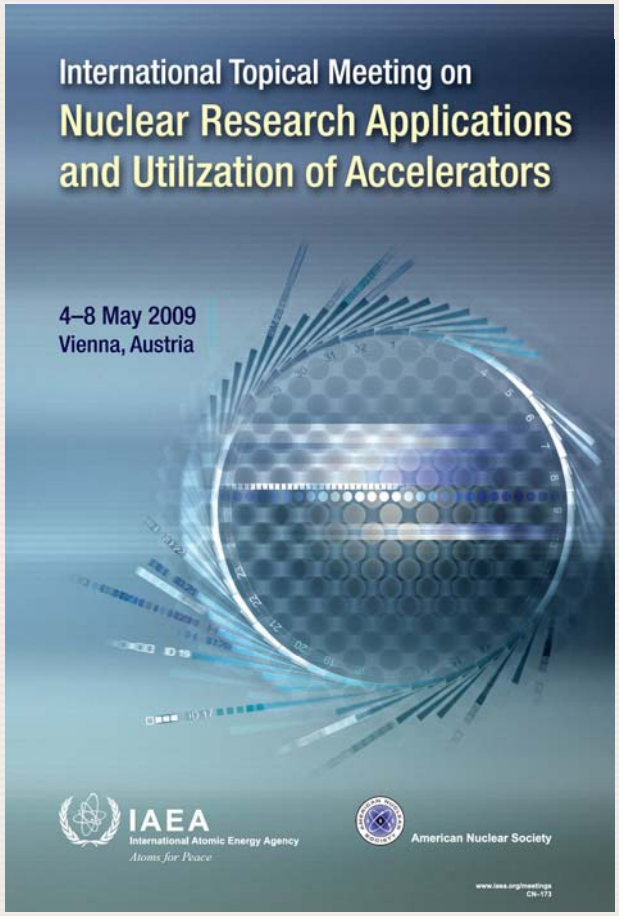
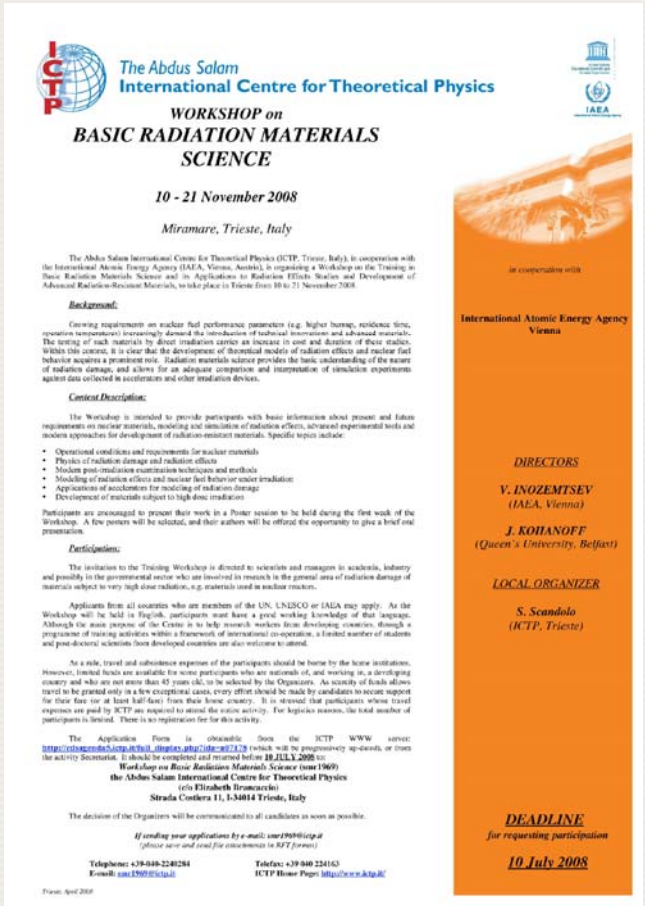
Workshops and Conferences (NE+NA)

2009





2008, 2009, (2010)

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You are welcome!