IAEA Coordinated Research Projects (CRP) in the area of Fuel Engineering and ATF plans

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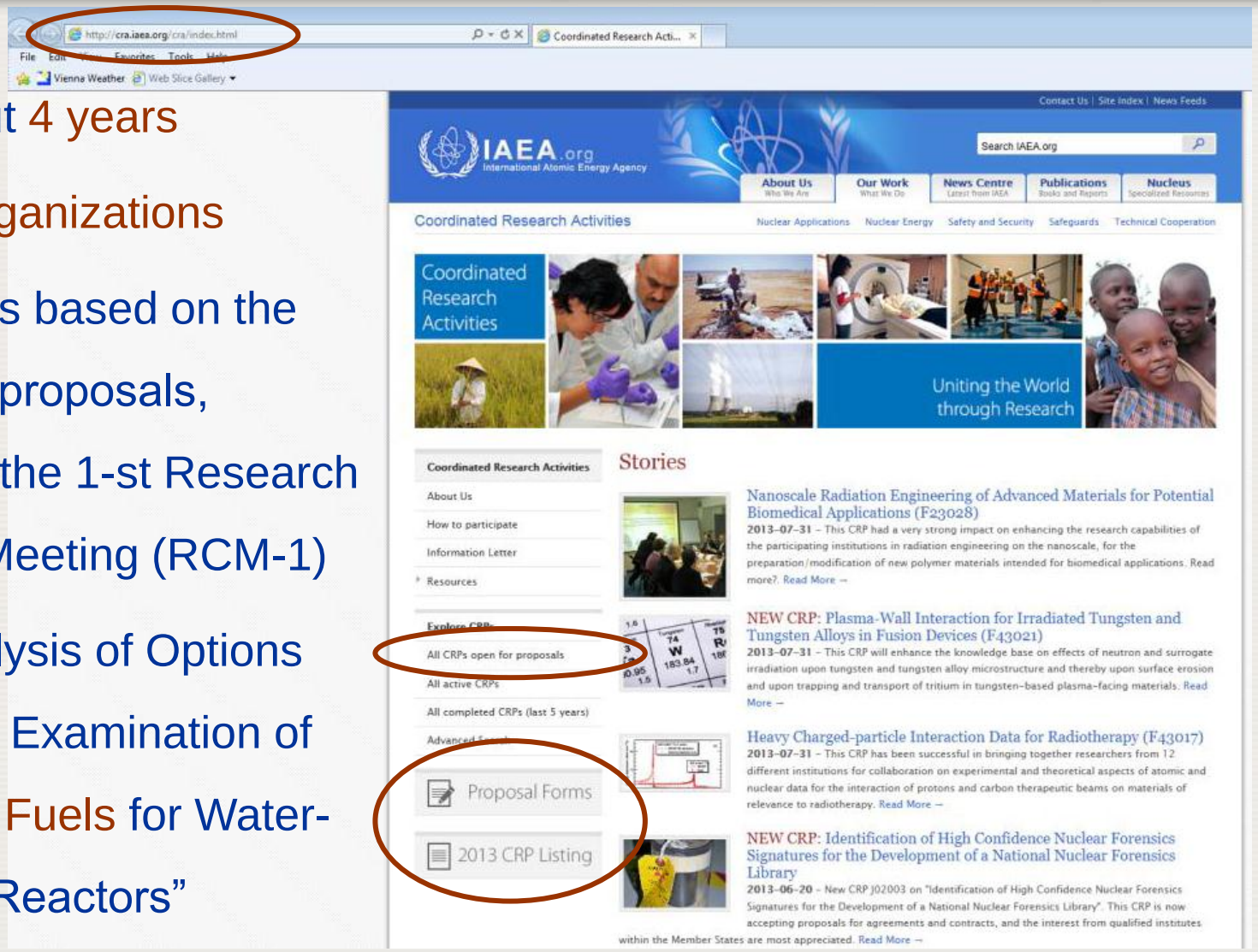
International Atomic Energy Agency

CRPs on the IAEA web-site: http://cra.iaea.org/cra/index.html

- Duration is about 4 years
- Members are organizations
- Joint work plan is based on the organizations' proposals, and agreed at the 1-st Research Coordination Meeting (RCM-1)
- CRP-2018 "Analysis of Options and Experimental Examination of Accident Tolerant Fuels for Water-Cooled Reactors"



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Coordinated Research Projects in 2005-2015

DONE | APPROVED | PLANNED

Coordinated Research Projects	05	06	07	08	09	10	11	12	13	14	15	16	17
Delayed Hydride Cracking of Zr alloy fuel cladding, DHC-2 (TECDOC-1649, 2010)													
Optimization of water chemistry, FUWAC (TECDOC-1666, 2011)													
Modelling of transport of radioactive substances in the primary circuit (TECDOC-1672, 2012)													
Fuel behaviour modelling at extended burnup, FUMEX-2 (TECDOC-1687, 2012)													
Improvement of computer codes used for fuel behaviour simulation, FUMEX-3 (TECDOC-1697, 2013)													
Accelerator simulation and theoretical modelling of radiation effects, SMoRE (draft NE Series Report)													
Evaluation of conditions for H-induced degradation of Zr alloys, K_{IH}													
Benchmarking of structural materials for advanced nuclear reactors, ODS													
Options for deployment of Th based nuclear energy													
Reliability of high power, extended burnup and advanced PHWR fuels (CRP-T12027, RCM-1 in Oct 2014)													
Management of severely damaged spent fuel and corium, B3 (CRP-T13015)													
Fuel modelling in accident conditions, FUMAC (CRP-T12028, RCM-1 in Nov 2014)													
Analysis of options and experimental examination of accident tolerant fuels for water-cooled reactors, ACTOF (CRP-2018)													

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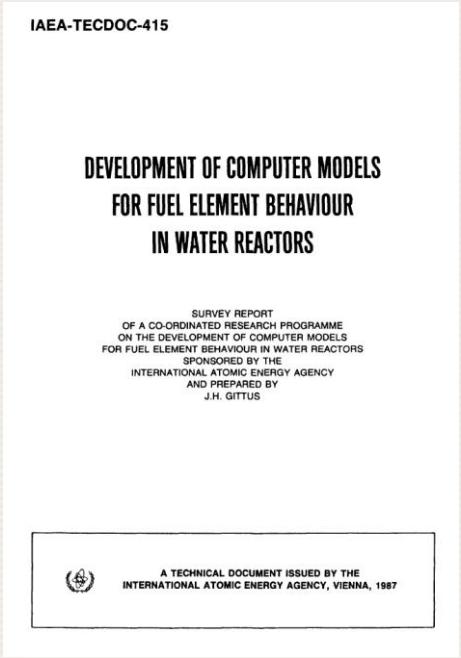
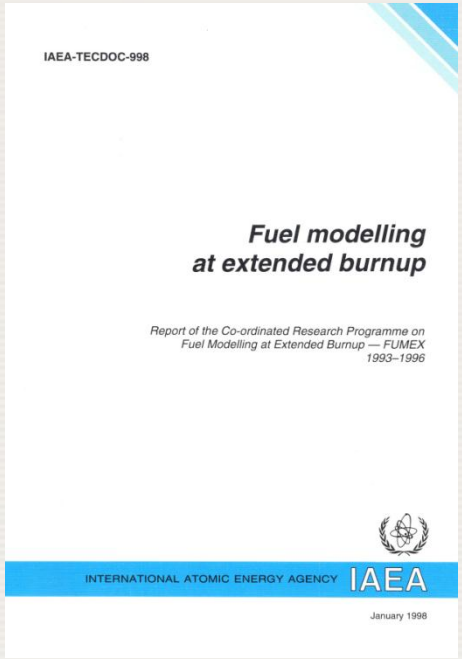
CRP series on fuel modelling (1982-2012)

Joint NEA-IAEA International Fuel Performance Experimental (IFPE) Database

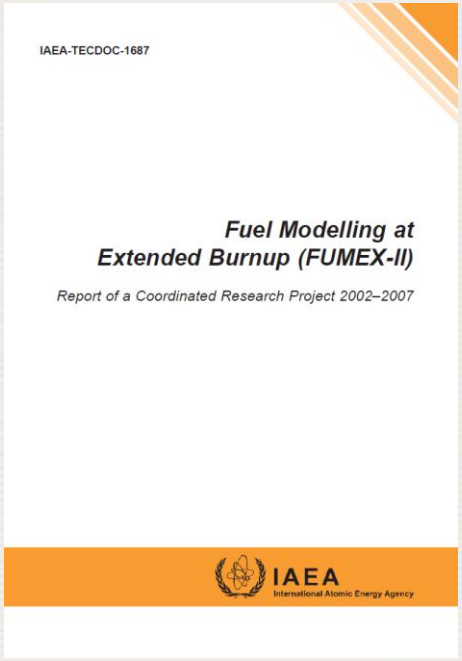
Blind exercises



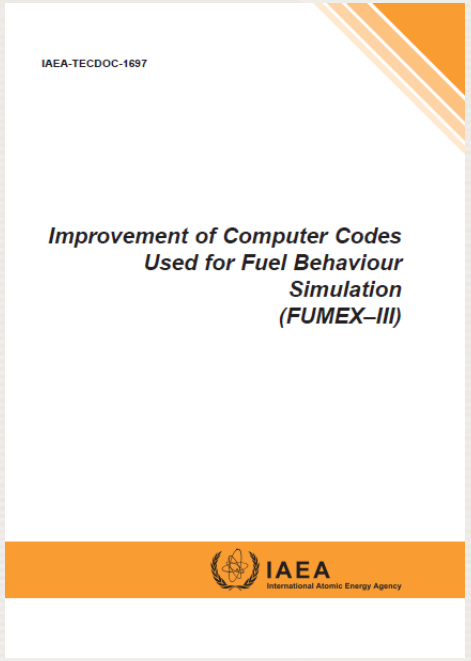
CRP D-COM
1982-1984
published in 1987



CRP FUMEX
1993-1996
published in 1998



CRP FUMEX-2
2002-2007
published in 2012



CRP FUMEX-3
2008-2012
published in 2013

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FUMEX-3
34 members from 21 countries and ITU/JRC/EC

Argentina	2	India	1
Belgium	1	Italy	2
Brazil	2	Japan	3
Bulgaria	2	Korea	1
Canada	1	Romania	1
China	3	Russia	2
Czech Rep	1	Switzerland	1
Finland	1	UK	2
France	1	Ukraine	1
Germany	2	USA	2
Hungary	1	ITU/JRC/EC	1

Data from the Halden Reactor Project (observer) and from CRP participants →

≈1500 datasets in the NEA-IAEA Int'l Fuel Performance Experiments Database

(http://www.oecd-nea.org/science/wprs/fuel/ifpelst.html)

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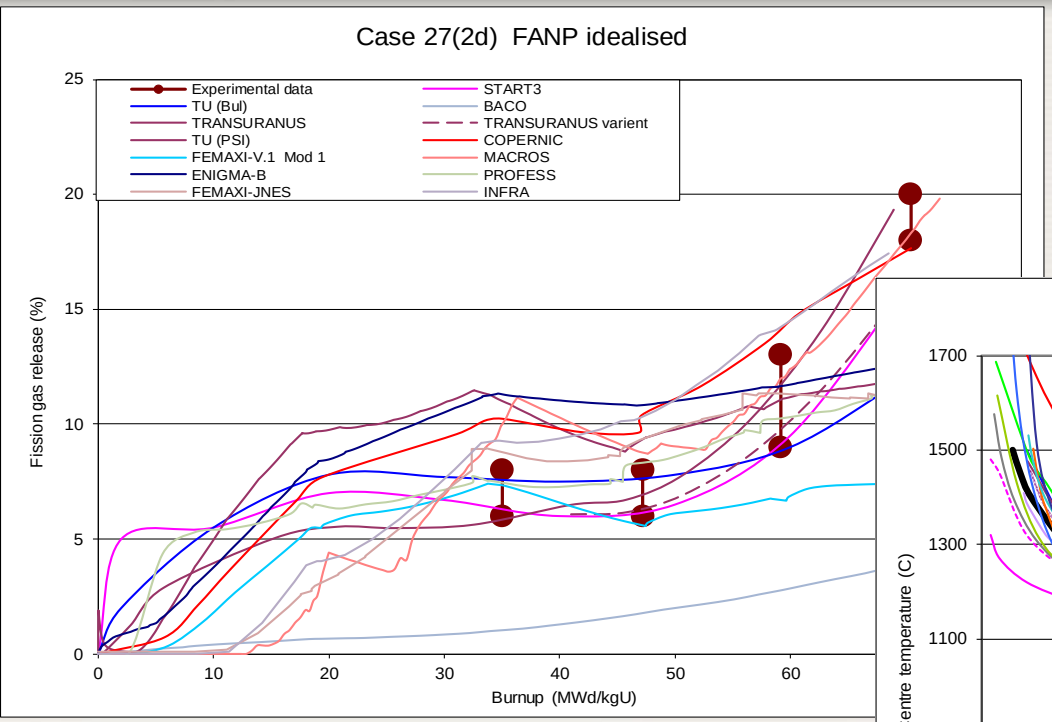
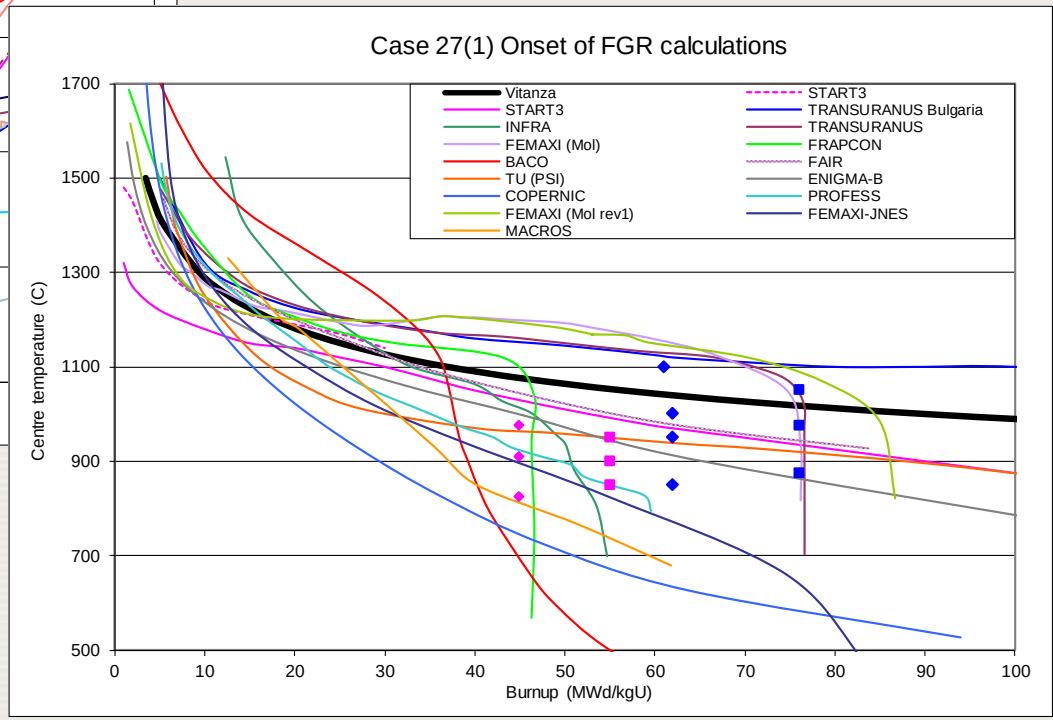
FUMEX: fission gas release prediction



FUMEX-2, IAEA-TECDOC-1687, 2012



Vitanza threshold - the temperature of 1% FGR, experimentally derived up to around 40 MWd/kgU

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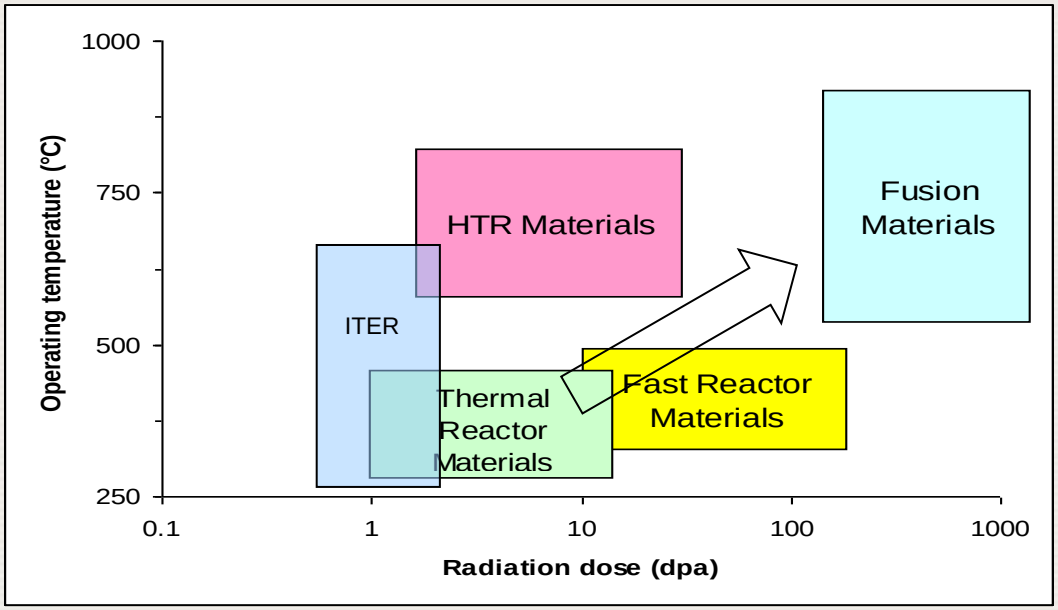
SMoRE (Accelerator Simulation and Theoretical Modelling of Radiation Effects)



Nuclear Technology Review, IAEA, Vienna, 2007

Reasons:

- Economically driven growth of conventional fuels burn-up
- Introduction of new fuels for innovative nuclear systems
- Insufficient basic understanding of radiation damage mechanisms

SMoRE Objectives:

- enhancement of simulation capabilities of accelerators for materials testing
- contribution for better physical understanding of high-dose radiation effects

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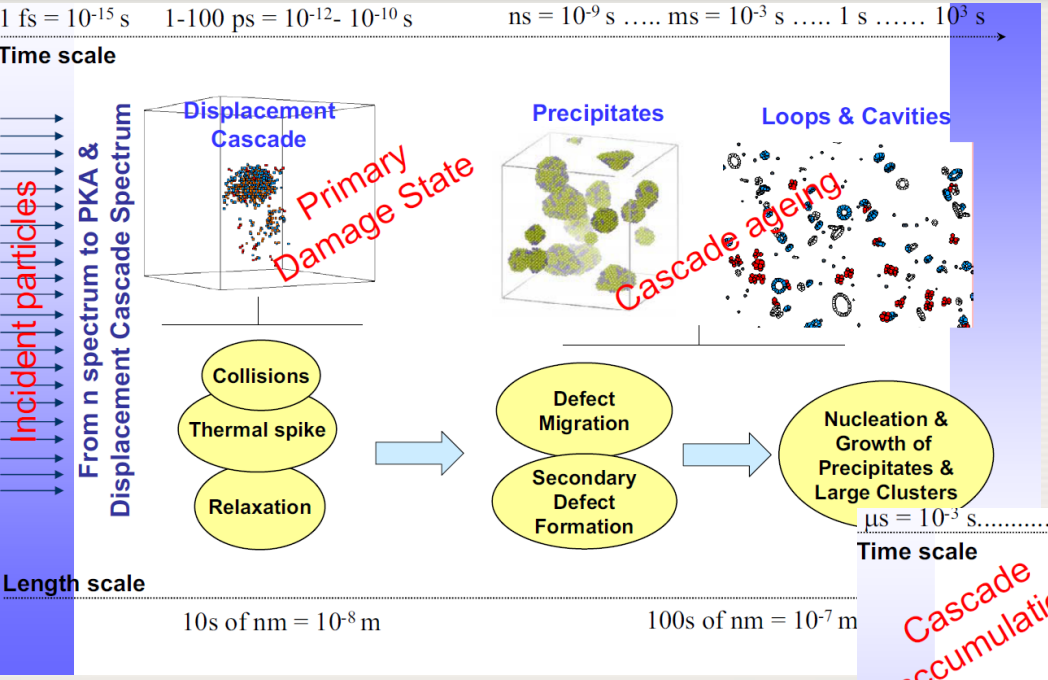
SMoRE: Multi-scale approach (NEA WPMM)



Radiation effects are inherently a multi-scale problem

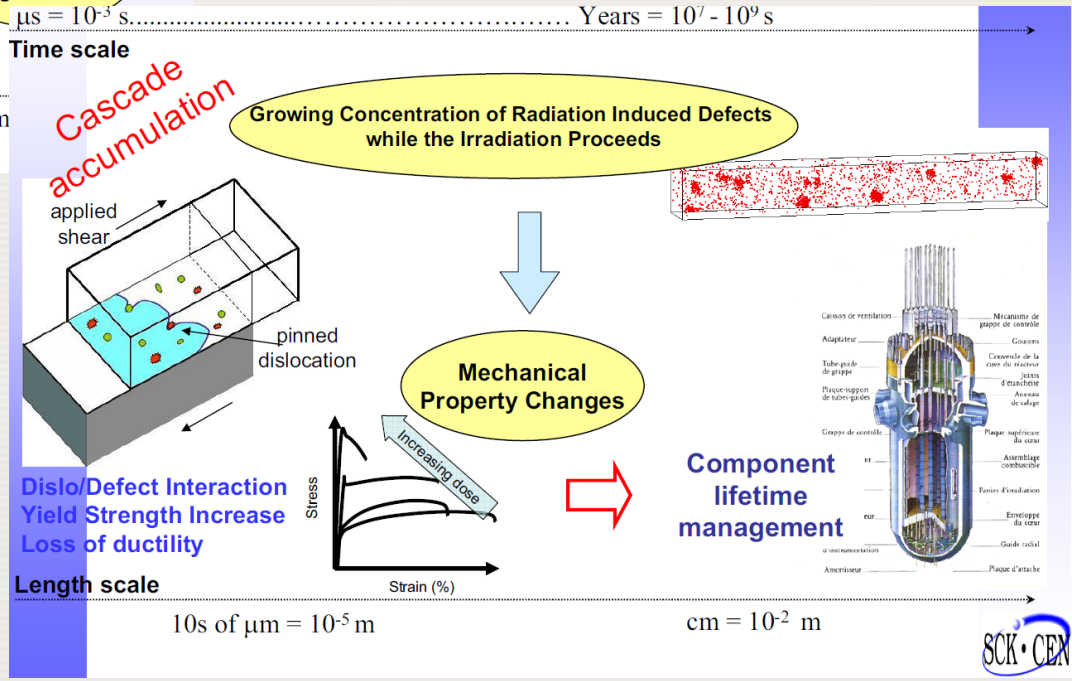
Quantum Mechanics →

Molecular Dynamics →

Kinetic Monte Carlo →

Dislocation Dynamics →

Elasticity / Plasticity



L. Malerba /SCK.CEN

Joint ICTP-IAEA Advanced Workshop on Multi-scale Modelling for Characterisation and Basic Understanding of Radiation Damage Mechanisms in Materials, Apr. 2010

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SCK•CEN

SMoRE (2008-2013): 19 members from 15 countries

1. Belgium: SCK.CEN (L. Malerba) – Fe-Cr potentials, their use in MD and MC, EPA experiments;
2. China: CIAE (Sh. Zhu) – CLAM irradiation up to 85 dpa, temp. effects, tripple beam H/He synergy;
3. France: CEA (F. Willaime), EdF (G. Monnet) – MSM in Fe, Fe-Cr, ODS, Jannus tripple beam, DD;
4. India: BARC (P. V. Durgaprasad) – MD, DD in Fe, Fe-Cr, small-punch tests of T91;
5. Japan: Kyoto University (A. Kimura) – Al-added-ODS, phase stability, He-trapping, dual beam;
6. Kazakhstan: INP (O. Maksimkin) – F/M and AS, comparison with BN-350, martensite degradation;
7. Korea, Rep: KAERI (J. Kwon) – MD, DD in F/M steels, TEM, atom probe, EPA, nano-identation;
8. Netherlands: JRC-Petten (L. Debarberis) – Fe-Cr ODSs (non-irradiated), EPA, SANS, TEP, TEM;
9. Poland: IAE (W. Szteke) – small-punch testing of non-irradiated AS;
10. Russia: IPPE (V. Pechenkin), Kurchatov Institute (A. Ryazanov) – F/M steels, neutrons, MSM, RIS;
11. Slovakia: Bratislava University (V. Slugen) –ODS MA956, ODM751 and Eurofer comparisons, EPA;
12. Spain: Madrid University, Institute of Fusion (J. Perlado) – Fe-Cr potentials, defect formation energies;
13. Switzerland: PSI (M. Pouchon) – micro-pillar nano-identation, analysis and modelling;
14. Ukraine: KIPT (V. Voyevodin) – high-dose ion irradiation, comparisons with neutrons, MSM;
15. USA: LLNL (M. Fluss), LANL/UCB (P. Hosemann) – ODS MA956, MA957 and K3; micro-studies;

    Rad. Effects Consulting (F. Garner) – chief consultant of the project;

    NEA / OECD – observer, many participating members and discussions at WPMM.

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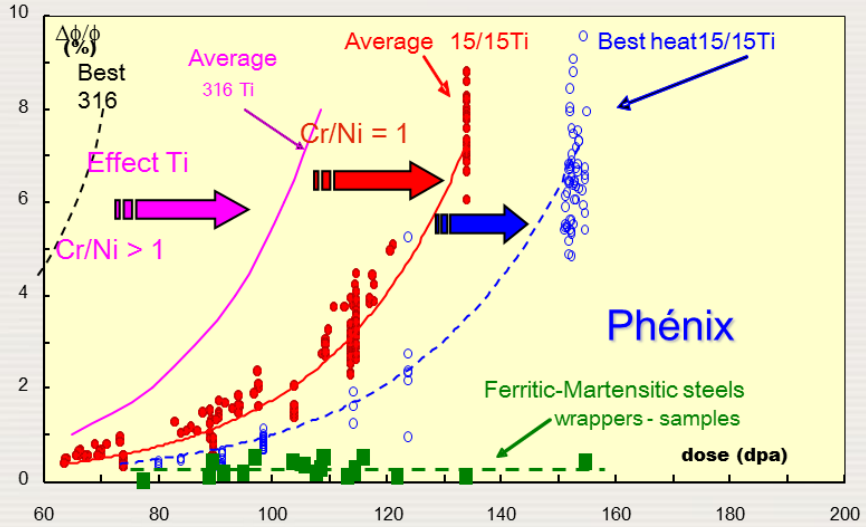
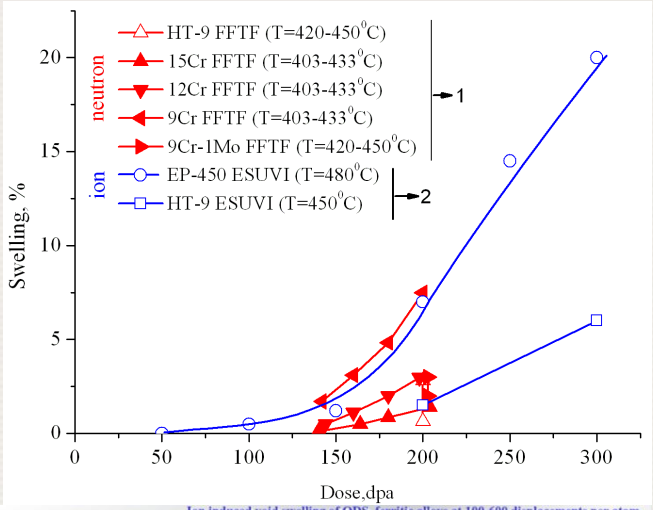
CRP SMoRE

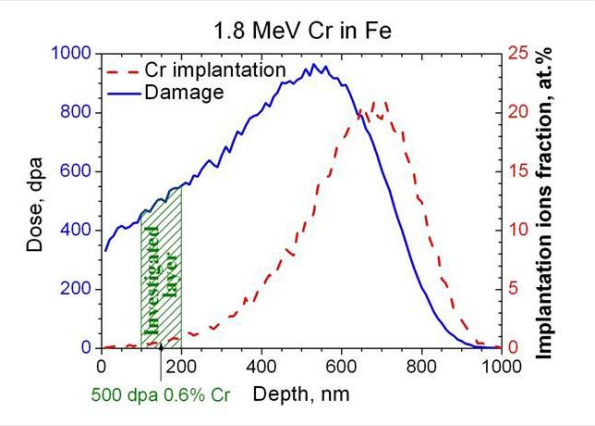
Swelling under fast neutron irradiation:
IAEA TM on FR Fuels, IAEA-TECDOC-1689, 2013
PHÉNIX data, Ph. Dubuisson, CEA, France

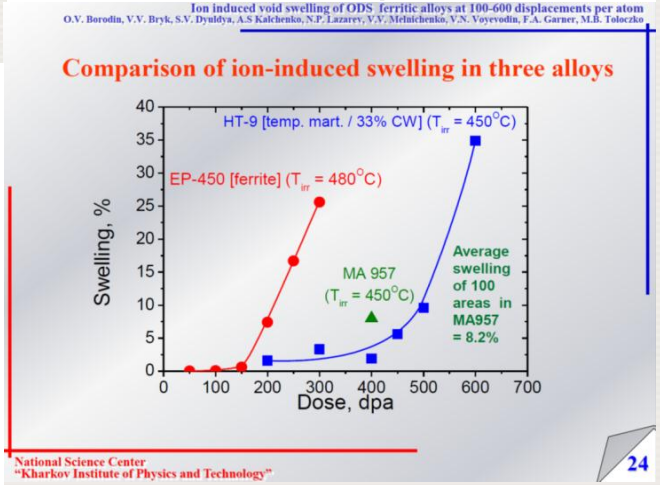


Accelerator simulations, SMoRE & ODS CRPs
V. Voyevodin et al, KIPT, Ukraine,



DPA/NRT issue:
NEA/WPMM/EG-PRD
and IAEA/CRP PRD





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IAEA Nuclear Safety Action Plan: FUMAC

CRP "FUel Modelling in Accident Conditions" (FUMAC, 2014-2018)

is aimed at better understanding of fuel behaviour in accident situations through identification of best practices in the application of relevant physical models and computer codes, used in different Member States, and enhancement of their predictive capacities. Well checked results of accident simulation experiments will be selected, integrated into the joint NEA-IAEA International Fuel Performance Experiments (IFPE) Database, and used for codes verification and comparisons.

- TM "Fuel behaviour and modelling under severe transient and LOCA conditions", Mito, Japan, 2011
- TM "Modelling of water-cooled fuel including design basis and severe accidents", Chengdu, China, 2013
- Consultants Meeting on FUMAC outline and organization, Vienna, 11-13 March 2014
- 1st Research Coordination Meeting of FUMAC, Vienna or Karlsruhe, 10-14 November 2014

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IAEA Nuclear Safety Action Plan: ACTOF

CRP "Analysis of Options and Experimental Examination of Fuels with Increased Accident Tolerance" (ACTOF, 2015-2019)

will examine approaches for development of water-cooled reactor fuel with improved tolerance to the severe accident conditions (ATF) that intensified after Fukushima accident, with the ultimate goal to replace the currently used Zr alloy fuel cladding, which is vulnerable to steam-zirconium reaction and hydrogen release when active cooling in the reactor core is lost. Technological, operational and economic aspects of ATF manufacturing and implementation are also to be considered.

- TM "Accident Tolerant Fuel concepts for Light Water Reactors", Oak Ridge, USA, 13-17 October 2014
- Consultancy and RCM-1 in 2015

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Topics:

- ✓ Materials, design, technology, and safety requirements for ATF with regard to possible reactor operation in normal, transient, and accident conditions;
- ✓ R&D on ATF, including:
  - Zr alloys modification and advancements
  - Alternative cladding concepts
  - Alternative fuel concepts
- ✓ Modelling ATF behaviour;
- ✓ Economic aspects of ATF implementation;
- ✓ ATF-relevant experience and lessons learned from Fukushima and other accidents;
- ✓ CRP ACTOF round-table discussion

Background, Objectives, Organization, Deadlines, Venue and Accommodation, Expenditures

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Thanks
for your attention, and
welcome to CRP ACTOF!

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