The Abdus Salam
International Centre
for Theoretical Physics

2359-18

Joint ICTP-IAEA Workshop on Physics of Radiation Effect and its Simulation for Non-Metallic Condensed Matter

13 - 24 August 2012

PHYSICS OF RADIATION EFFECT AND ITS SIMULATION FOR NON-METALLIC CONDENSED MATTER

A. Zeman
IAEA, Vienna
Austria

Strada Costiera, 11 - 34151 - Trieste - Italy • Tel. +39 0402240111 • Fax. +39 040224163 • sci_info@ictp.it • www.ictp.it
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IAEA-ICTP Worshop

Trieste, Italy, 20-24 August 2012

PHYSICS OF RADIATION EFFECT AND ITS SIMULATION FOR NON-METALLIC CONDENSED MATTER

Andrej Zeman

NAPC / Physics section

IAEA

International Atomic Energy Agency

Outline

IAEA and PS introduction

Science & education

Coordinated Research

Upcoming events

International Atomic Energy Agency (IAEA)

Atoms for Peace (1953)
addressed by D.Eisenhower, to the UN-GA Plenary Meeting

- **Founded 1957**
- HQ in Vienna, Austria
- **154 Member States**
- 6 Departments
- 2200 Staff
- About 300 MEuro Budget
- www.iaea.org

IAEA

Pillars of the IAEA

❖ Science & Technology

the world's focal point to mobilize peaceful applications of nuclear science and technology for critical needs in developing countries

❖ Safeguards & Verification

the world's nuclear inspectorate

❖ Safety and Security

helps countries to upgrade nuclear safety and security

IAEA's 55 Anniversary - Atoms for Peace (2012)

IAEA

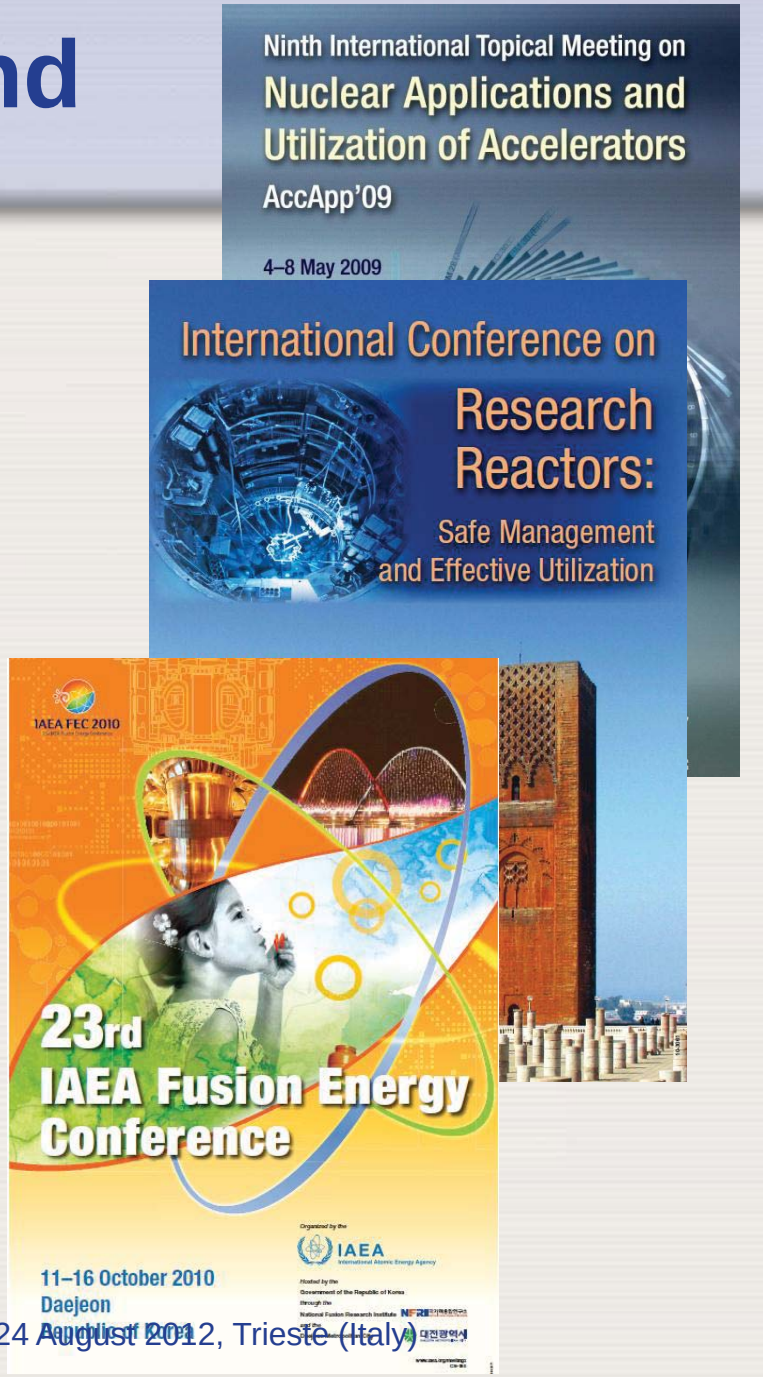
Motivation & background

The PS supports the IAEA Member States regarding utilization of:

- Accelerators
- Research reactors
- Material science (energy)
- Controlled fusion
- Nuclear instrumentation

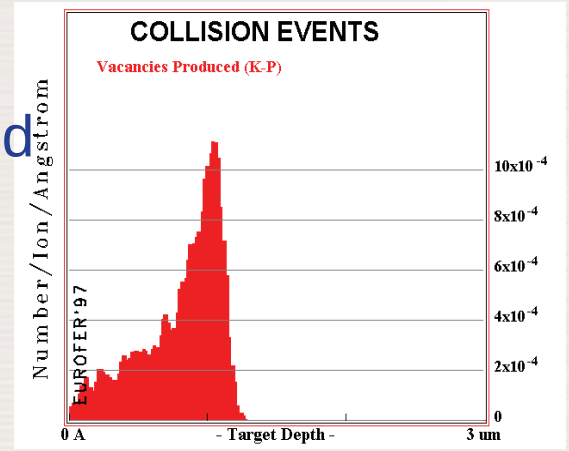
PS implements P&B activities based on MS demand, organisation of Int. conferences, Technical and expert meetings, CRP, Networks, DBs, TC….

Objective is to promote nuclear science & technology, specifically applied physics and material science related to nuclear energy.



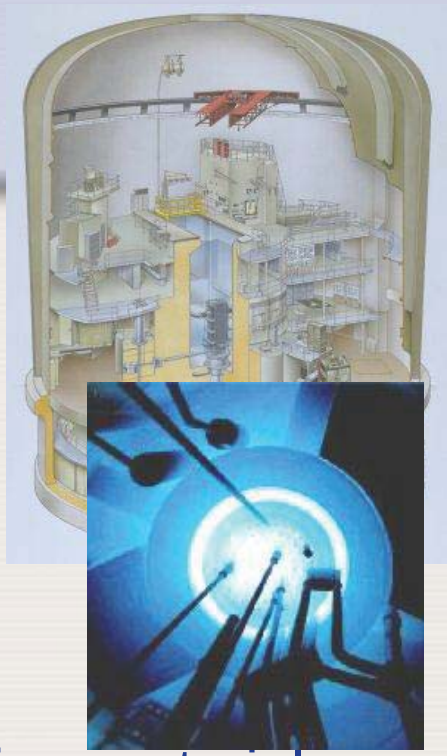
Application of accelerators

- In total more than 15.000 accelerators used world-wide, multidisciplinary use.
- Small and medium size facilities; particle and X-ray machines (CC scheme),
- Research & industrial applications, non-nuclear (semiconductors, medicine, biology, geology, archeology, etc.) & nuclear (fusion and fission reactors)
- Applications various probing methods (IBA, PIXE, PIGE, SAXS, XFR, etc.), recently development & characterization of novel materials for hydrogen production, storage and conversion.



www-naweb.iaea.org/napc/physics/accelerators/database/index.html

Research reactors utilisation

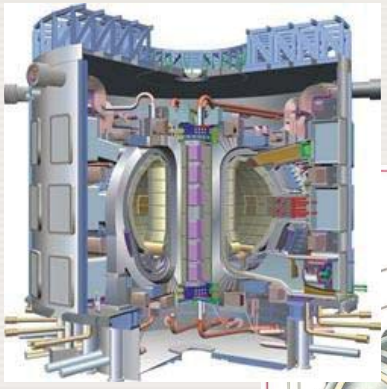


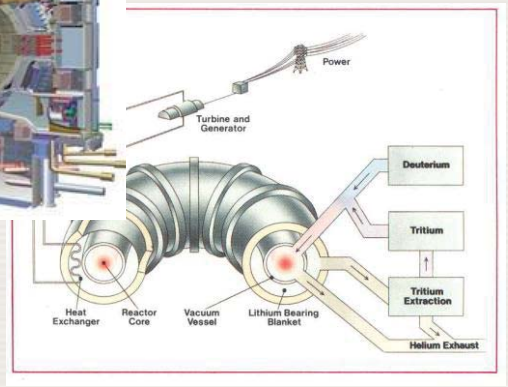
- Approx. 670 research reactors constructed around the world, about 240 are still operating
- Irradiation programs (radio-isotopes, R&D structural materials, nuclear and non-nuclear energy applications)
- Training activities and know-how dissemination (professionals & students)
- Support of basic & applied research (neutron physics, material science, industrial applications)
- Non-nuclear areas: biology, medicine, semiconductors, hydrogen energy systems (storage & conversion).
- Operational safety: monitoring and assessment of core components

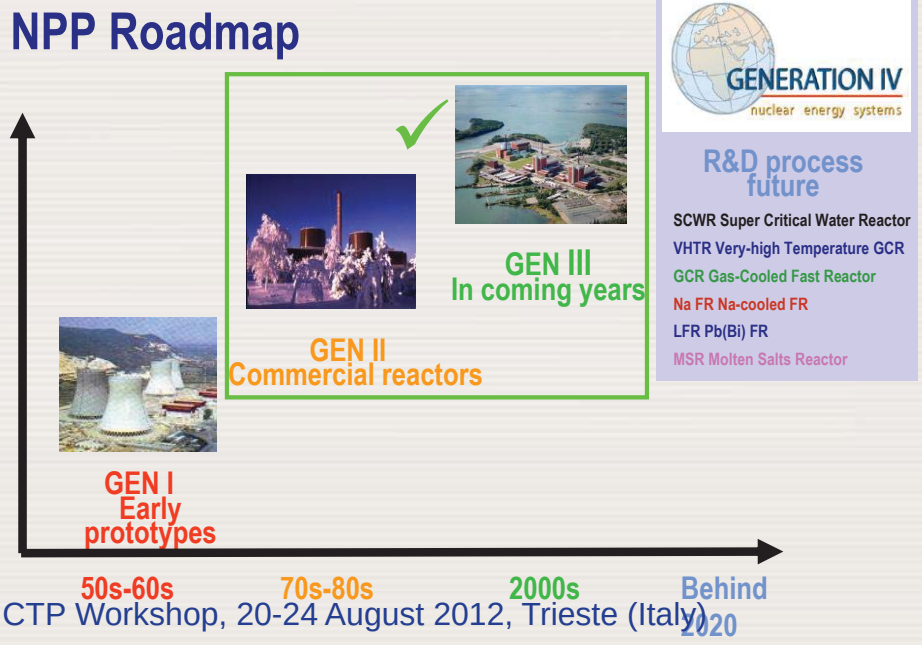
www-naweb.iaea.org/napc/physics/research_reactors/database/database.html

Advanced reactors (fusion & fission)

- Support of MS in R&D, primarily advanced & innovative structural materials (ODS, RAFM, composites), coordination with other R&D initiatives (GIF, SNETP, ITER, F4E, IEA-FA)
- Activities on investigation of present class of NPP structural materials, studies of various degradation mechanisms.
- Non-nuclear area (H2 production, storage and conversion).



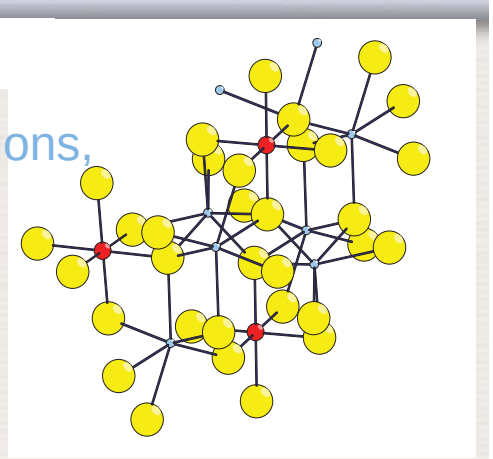




Nuclear materials

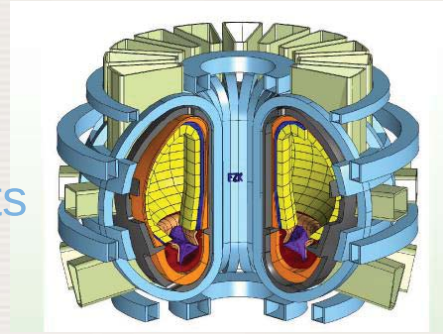
Material science:

- Cross cutting activities related to the nuclear energy applications, primarily fission, fusion and hybrid reactor systems.
- Study of various degradation mechanisms and support of ongoing international initiatives.
- Non-nuclear areas: hydrogen energy systems (production, storage & conversion).



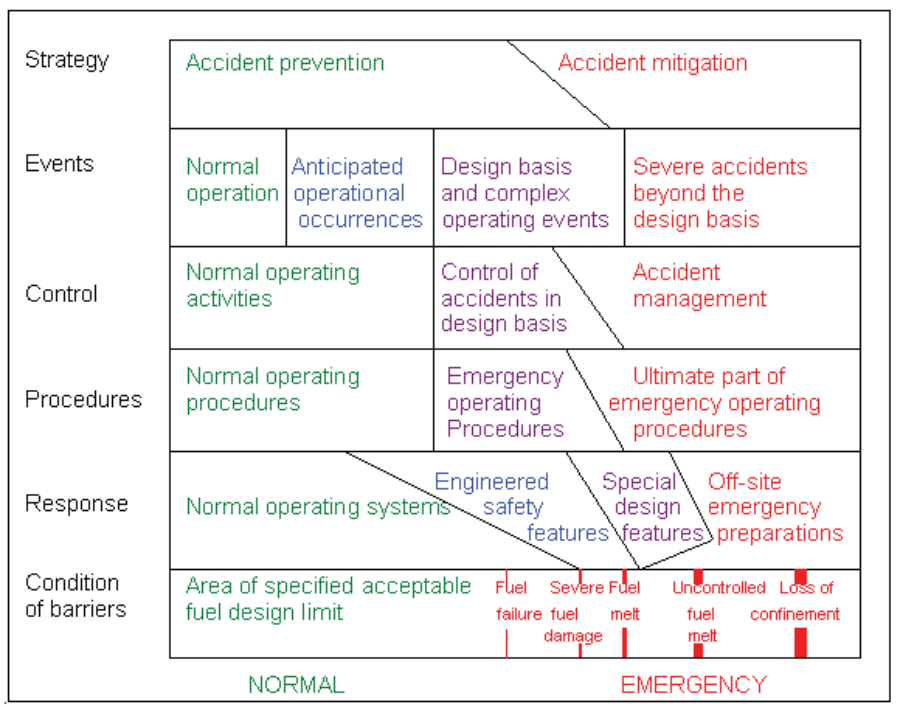
Controlled fusion:

- Support of national and international initiatives (small and medium size tokomaks).
- Plasma physics and further fusion technology developments (main components and instrumentation), incl. operational safety.
- Memorandum of understanding on cooperation with ITER.
- Biannual fusion conference and IFC meetings



Nuclear materials

Enhanced safety features – inherent and passive safety systems



- Physical barriers and protection in depth

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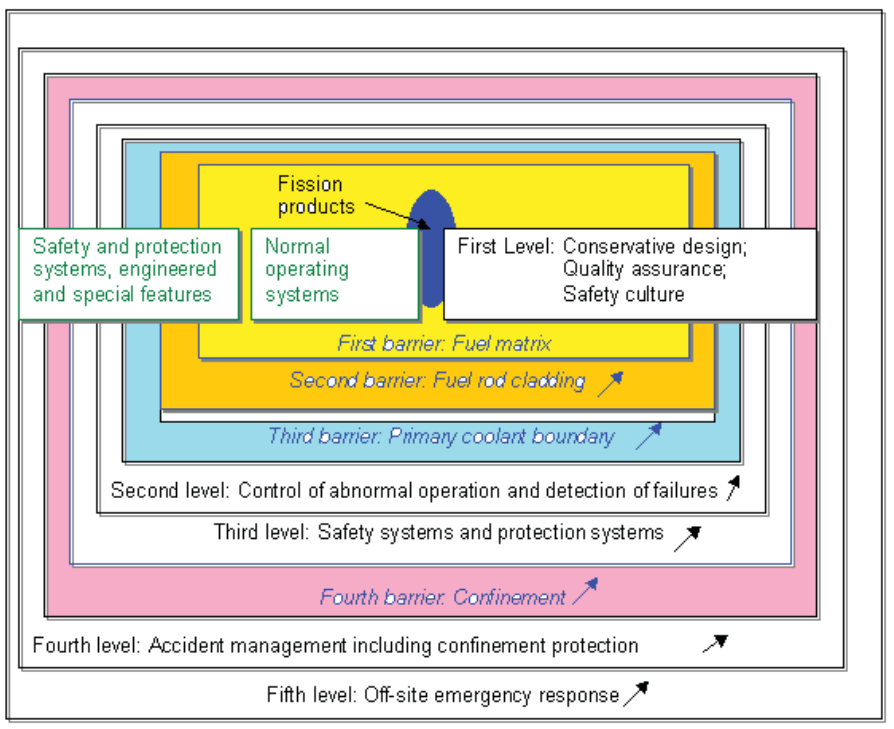
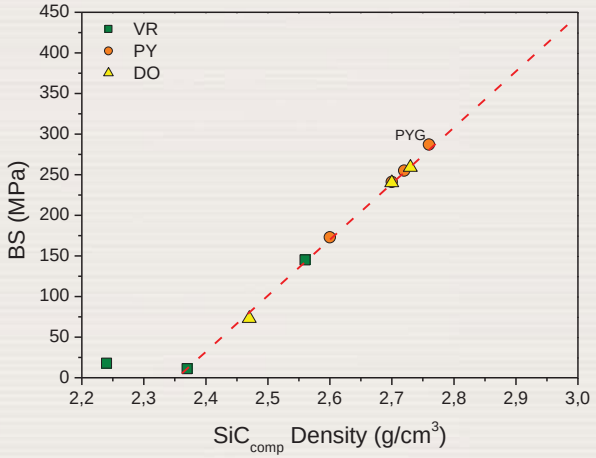
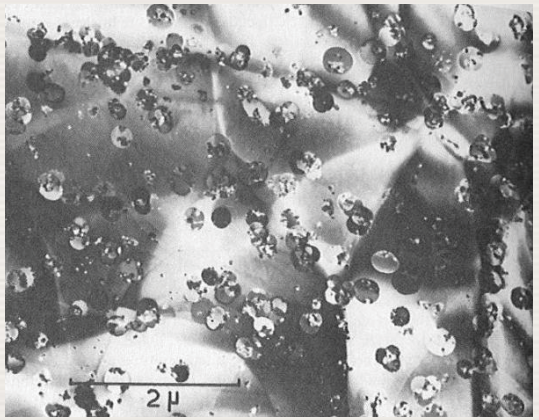


Nuclear materials

Examples of R&D on non-metallic materials

	VHTR	SFR	GFR	SCWR	LFR
Metals lechanics, Corrosion	F/M steels ODS Ni-alloys	F/M steels ODS Austenitic Steels	*F/M steels ODS Ni-Alloys*	Clad & structures Ni-alloys Radiolysis	
Ceramics & Composites	Graphite C/C, SiC_f/SiC		SiC, TiC Ceramics		
Component mock-ups	IHX & HX, RPV (9 Cr) Control rods	HX, SG	IHX & HX RPV & DHR		
1ry system Technology	He test benches & Loops MW	ISIR	*He test benches & Loops MW*	Heat transfer SCW Loops Water chemistry	Corrosion Purity control
Mechanical)esign Rules	HT Design Codification	ASME RCCM-R	*HT Design Codification*	HT Design Codification	





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Main activities

Highlights from recent IAEA GC, ref. RES/10 Agency's activities related to nuclear science, technology & appl.

*(1) Secretariat has to encourage further R&D and fostering the exchange of **scientific and technical information** and the training of scientists and experts in the field of peaceful uses of atomic energy*

*(2) Stressing that **nuclear science, technology and applications address and contribute to wide variety of basic socio-economic human development needs of MS**, in such areas as energy, materials, industry, food, etc.*

(3) IAEA should continue to pursue activities of the Agency

*in the areas of **nuclear science, technology and applications for meeting sustainable development***

(4) Strengthening infrastructures and fostering science, technology and engineering.

IAEA

Recent events

JRC EUROPEAN COMMISSION — Institute for Energy

IAEA International Atomic Energy Agency — Atoms for Peace

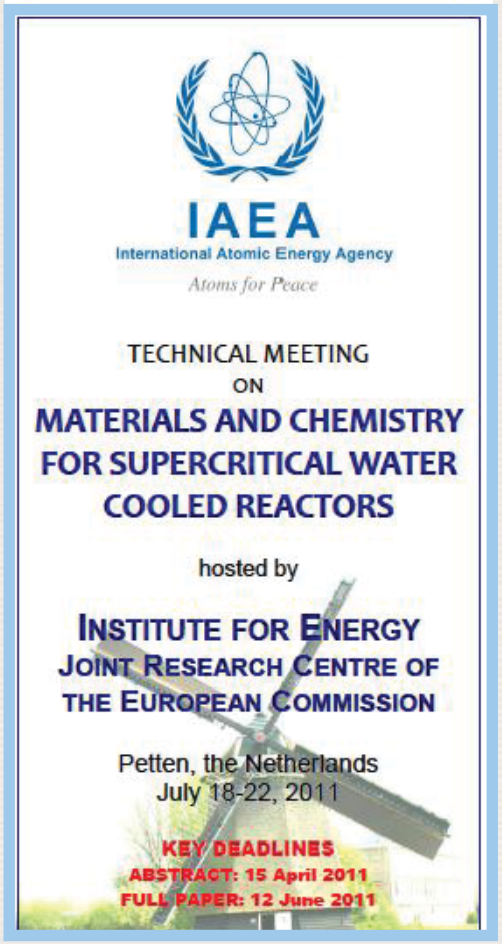
Development of new structural materials for advanced fission and fusion reactors

In cooperation with

FUSION FOR ENERGY

16 – 20 April 2012

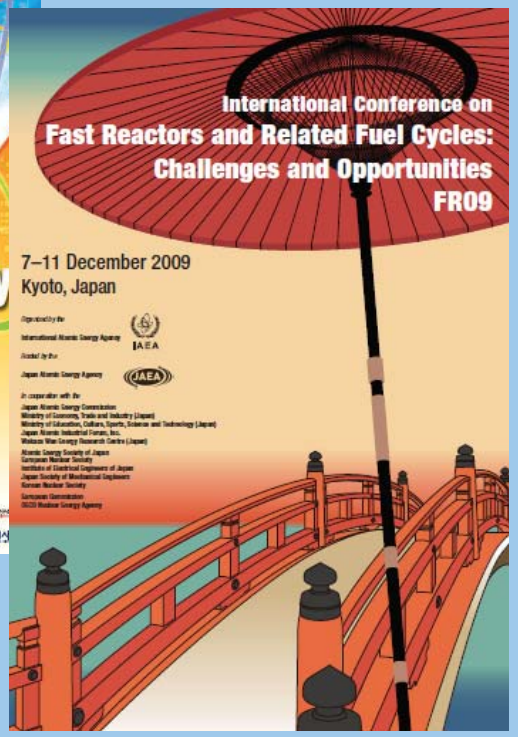
Hosted by JRC Ispra (Italy)



http://www.iaea.org/NuclearPower/Technology/Meetings/2011-July-18-22-TM.html
http://www-pub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID=41429

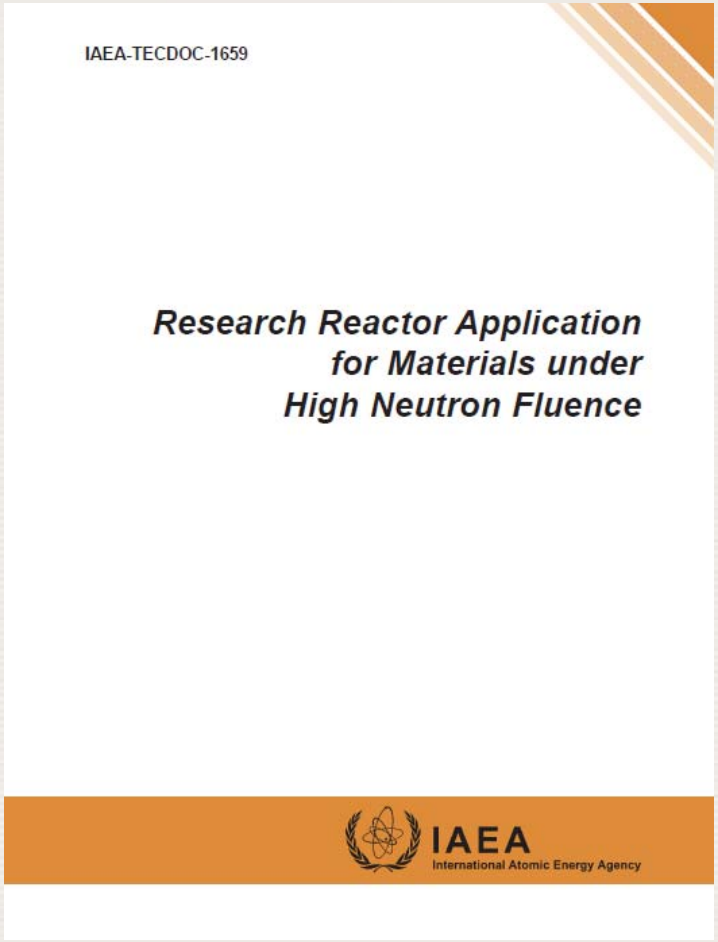
IAEA

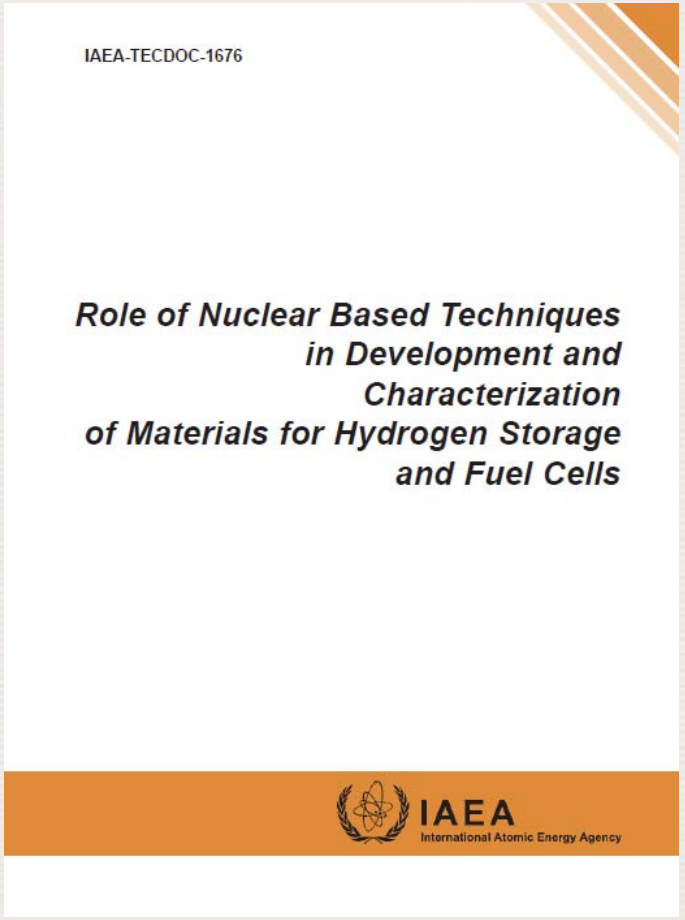
Scientific events



http://www-pub.iaea.org/MTCD/Meetings/Meetings.asp

Technical publications





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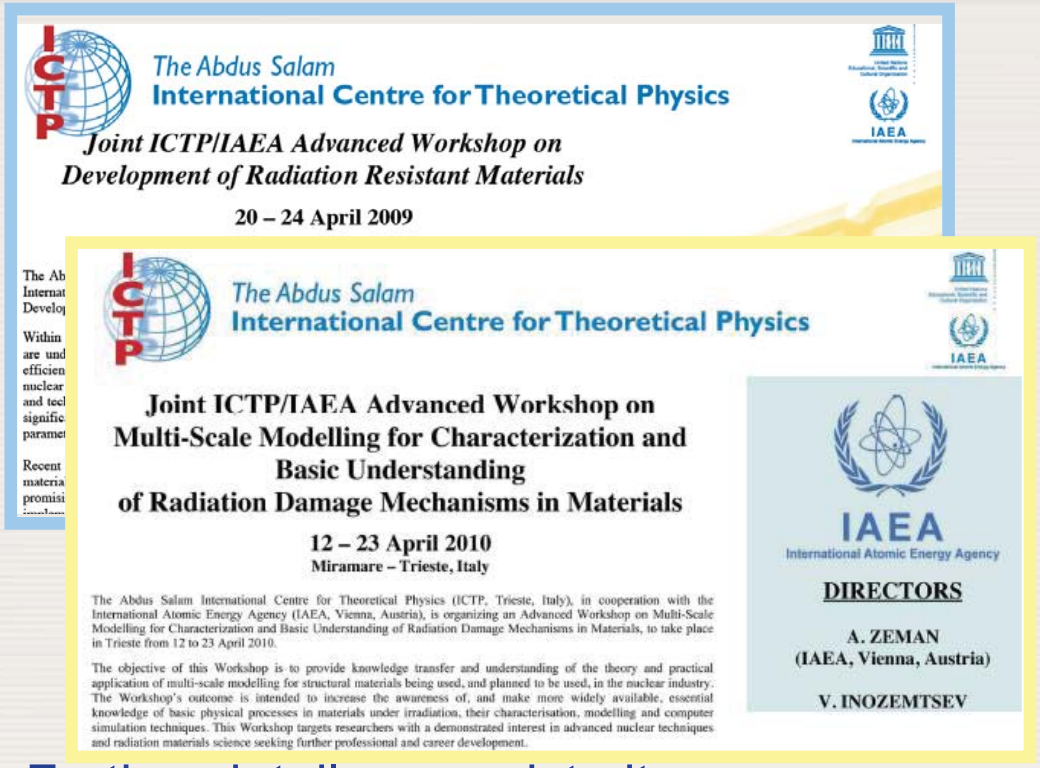
Education & training activities



The Abdus Salam
International Centre for Theoretical Physics

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

20 – 24 April 2009

The Abdus Salam
International Centre for Theoretical Physics

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

12 – 23 April 2010
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 an Advanced Workshop on Multi-Scale Modelling for Characterization and Basic Understanding of Radiation Damage Mechanisms in Materials, to take place in Trieste from 12 to 23 April 2010.

The objective of this Workshop is to provide knowledge transfer and understanding of the theory and practical application of multi-scale modelling for structural materials being used, and planned to be used, in the nuclear industry. The Workshop's outcome is intended to increase the awareness of, and make more widely available, essential knowledge of basic physical processes in materials under irradiation, their characterisation, modelling and computer simulation techniques. This Workshop targets researchers with a demonstrated interest in advanced nuclear techniques and radiation materials science seeking further professional and career development.

IAEA
International Atomic Energy Agency

DIRECTORS

A. ZEMAN
(IAEA, Vienna, Austria)

V. INOZEMTSEV

The Abdus Salam
International Centre for Theoretical Physics

Joint ICTP-IAEA Workshop on PHYSICS OF RADIATION EFFECT AND ITS SIMULATION FOR NON-METALLIC CONDENSED MATTER

13 - 24 August 2012

ICTP, Miramare - Trieste, Italy

The Abdus Salam International Centre for Theoretical Physics (ICTP) will organize the above *Workshop* to be held at the ICTP in Trieste, from 13 to 24 August 2012.

The purpose of this workshop is to review the current status of ion induced radiation effects in non-metallic materials specifically semiconductors and insulators; and provide advanced training and an information exchange platform for early stage researchers as well as more-experienced scientists interested in this important subject. An emphasis will be given to microstructure response and evolution, movement both in time and space, recombination and generation, etc. This also includes the appropriate application of computer tools. Basic theoretical principles of radiation damage phenomena and specific features of non-metallic materials will be presented. Special attention will be given to the application of these types of materials specifically for detectors, hidden radiation protection, electronics, optics and nuclear materials.

The Workshop will focus on modeling and simulation approaches (Binary Collision Approximation and Molecular Dynamics calculations etc.) and experimental approaches (ion beam induced charge, time resolved, deep level transient spectroscopy, photoluminescence or positron annihilation spectroscopy etc.). The workshop will also summarize recent scientific results on radiation damage by electrons, protons, heavy ions and neutrons. A short overview on the R&D initiatives will be given including future trends and perspective areas for further development.

PARTICIPATION:

Early stage researchers (primarily post-docs and PhD students) in the field of computer modelling and solid state physics related to the radiation-matter based interactions are invited to submit their application. All participants should present the results of their research work in the form of a poster. Appropriate time will be allocated for scientific discussions in order to stimulate further development and co-operation among the participants.

Participants from all countries that are members of the UN, UNESCO or IAEA can attend the School. The Workshop will be conducted in English therefore participants must 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 Workshop and are encouraged to apply.

As a rule, travel and subsistence expenses of the participants should be borne by the home institution. Every effort should be made by candidates to secure support for their fare (or at least half-fare). Limited funds will be available for some participants who are nationals of, and working in, a developing country, and who are not more than 45 years old. There is no registration fee.

The online application form for this Workshop is available at:
http://cdsagenda5.ictp.it/full_display.php?email=0&ida=a11182

Workshop Secretariat (smr2359)
c/o Elizabeth Brancaccio
The Abdus Salam International Centre for Theoretical Physics
Strada Costiera 11
34151 Trieste, Italy

e-mail: smr2359@ictp.it ph: +39-040-2240359 fax: +39-040-224163 ICTP Home page: www.ictp.it

April 2012

Directors:

Aliz Simon
&
Andrej Zeman
(IAEA, Vienna)
Sandro Scandolo
(ICTP, Trieste)

Invited Lecturers

Wim Bras
(ESRF, Grenoble - France)
Ivana Capan
(RBI, Zagreb - Croatia)
Sehila Gonzalez
(EFDA, Garching - Germany)
Peter Haehner
(IET-JRC, European Commission)
Milko Jaksic
(RBI, Zagreb - Croatia)
Paolo Olivero
(University of Turin, Italy)
Jyrki Raisanen
(University of Helsinki, Finland)
Vladimir Skuratov
(JINR, Dubna - Russia)
Roger Smith
(University of Louhborough, UKD)
Ettore Vittone
(University of Turin, Italy)
György Vizkelethy
(Sandia Laboratories, USA)
Steve Zinkle
(ORNL, Oak Ridge - USA)

Main topics

- Basics and complex modelling principles of electron, proton, heavy ion and neutron irradiation
- Characterization of defects evolution in electronic materials, ion-solid interaction models
- Investigation of advanced materials as ceramics, semiconductors and non-metallic crystallite structures.
- Radiation degradation of novel detector materials: including characterization and modification.
- State-of-the-art on nuclear materials such as: SiC, ZrO and other types of materials with nanostructure features.
- Charge carrier transport models in the presence of defects, theory and simulation.
- Advanced accelerator-based techniques to study ion irradiation effects (in-situ and real-time approach).
- Multidisciplinary approach related to the radiation effects in harsh radiation environments.

DEADLINE

30 April 2012

Further details: www.ictp.it

- Support of international and regional education and trainings.
- Cooperation with ICTP and other collaborating centres (ANL, ANSTO, RID, ELETTRA, etc.).

IAEA

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Coordinated Research Activities Website - Windows Internet Explorer
http://www-crp.iaea.org/
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Coordinated Research Project (finished)

IAEA CRP on Accelerator Simulation and Theoretical Modelling of Radiation Effects (jointly NA-NE)

Deals with several issues related to the proton and ion beam irradiation in order to achieve very high radiation damage, project aims to facilitate following issues:

(1) Better understanding of radiation effects and mechanisms of material damage and basic physics of accelerator irradiation under specific conditions,

(2) Improvement of knowledge and data for the present and new generation of structural materials,

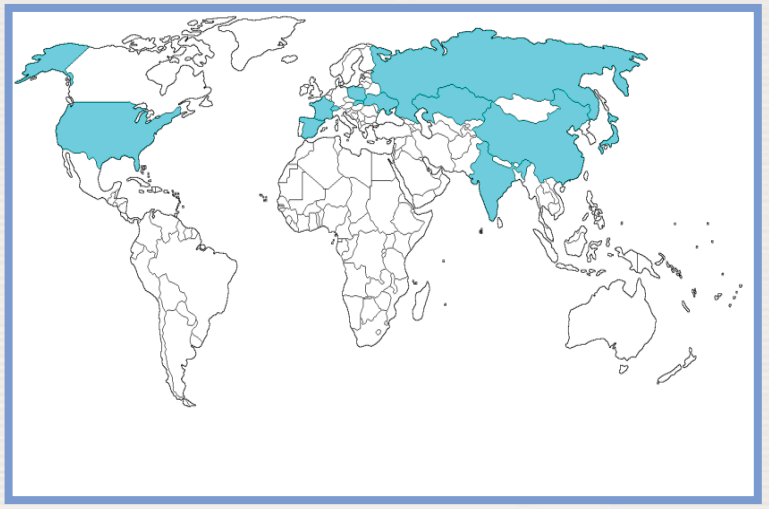
(3) Contribution to developmental of theoretical models for radiation degradation mechanism,

(4) Fostering of advanced and innovative technologies by support of Round Robin testing, collaboration and networking.

Coordinated Research Project (on-going)

IAEA CRP on Accelerator Simulation and Theoretical Modelling of Radiation Effects (jointly NA-NE) - FACTS

Extensive theoretical and experimental studies are being carried out among participating laboratories form BEL, CHN, EC, FRA, IND, JAP, KOR, KAZ, POL, RUS, SPA, SVK, UKR, and USA, (18 full members).

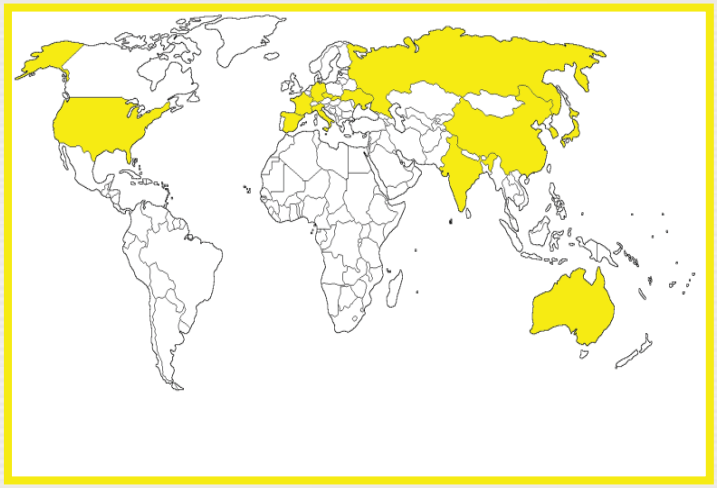


- Project launched 01/2009, final reporting RCM November 2011.
- Members have presented recent achievements on experimental testing of various ODS (MA957, PM2000, EUROFER, K3, etc.).
- Irradiation experiments at various temp study of dpa/ dose rate and H/He effect.
- Further improvement of recent theoretical models (incl. experimental validation).

Coordinated Research Project (on-going)

IAEA CRP on Benchmarking of advanced materials pre-selected for innovative nuclear reactors (jointly NA-NE)

Critical review of structural materials pre-selected for innovative reactor systems (focus on FR technology), stimulation of further technological improvements in SM area



- MS demand regarding R&D of str. Materials via coordinated mechanism.
- Performance testing of materials pre-selected for primary components of new innovative reactor systems.
- Round Robin testing of various ODS grade steels; application of testing methods.
- Assessment and harmonisation of techniques & methods, (sub-size samples, mimic of neutron irradiation, in-situ experiments, etc.).
- Inter-comparision of results, development of DB (mechanical / microstructure)
- **Project launched, 1st meeting will take place 2-6 May 2011, Vienna!**

IAEA

Coordinated Research Project (on-going)

Review of research proposals

18/22 proposals accepted (AUS, CHN, CZR, FRA, GER, IND, ITA, JAP, KOR, NET, ROM, RUS, SPA, SVK, UKR, USA; Int. org. EC, NEA/OECD.

Supply of ODS-grade steels for CRP Round Robin:

ORNL (14YWT), Bochvar (EP450 ODS), KAERI (12Cr), IGCAR (9Cr), Kyoto Uni (9 and 16Cr), USTB (12, 14, 18Cr), CIEMAT (TBC).

Main objectives:

- Development and harmonization of test procedures (pre-qualification phase).
- Test matrix to be harmonised during RCM, principle same test to be carried out, at least, by 2 different labs!
- Results collected – evaluated/reviewed - compared - verified
- Data will be compiled in form of inputs for database

Coordinated Research Project (on-going)

Subject of coordinated research

- **Mechanical properties**: instrumented Charpy, fracture toughness (morphology, fracture surface analysis), small punch, tensile tests and (micro)hardness, etc.
- **Microstructure**: grain size, particle size and distribution, dislocation density, tools: TAP, (HR)TEM, SANS, EDX, XRD, (FE)SEM, PAS, MS, FE-EPMA, FE-Auger, etc,
- **Chemical stability and interaction with coolant**: oxidation/corrosion behaviour of ODS steels in Pb, Pb-Bi eutectics at elevated temp, control of oxygen, study of oxidation kinetics (weight change, scale thickness), phase-structure and composition of oxide layers, similar tests proposed for SCWR environment (O and H).
- **Methodology:** correlation between standard and sub-size fracture toughness
- **Specific ion-irradiation tests:** simulation of fission fragments (different temp and dpa), radiation stability of nano-size particles.

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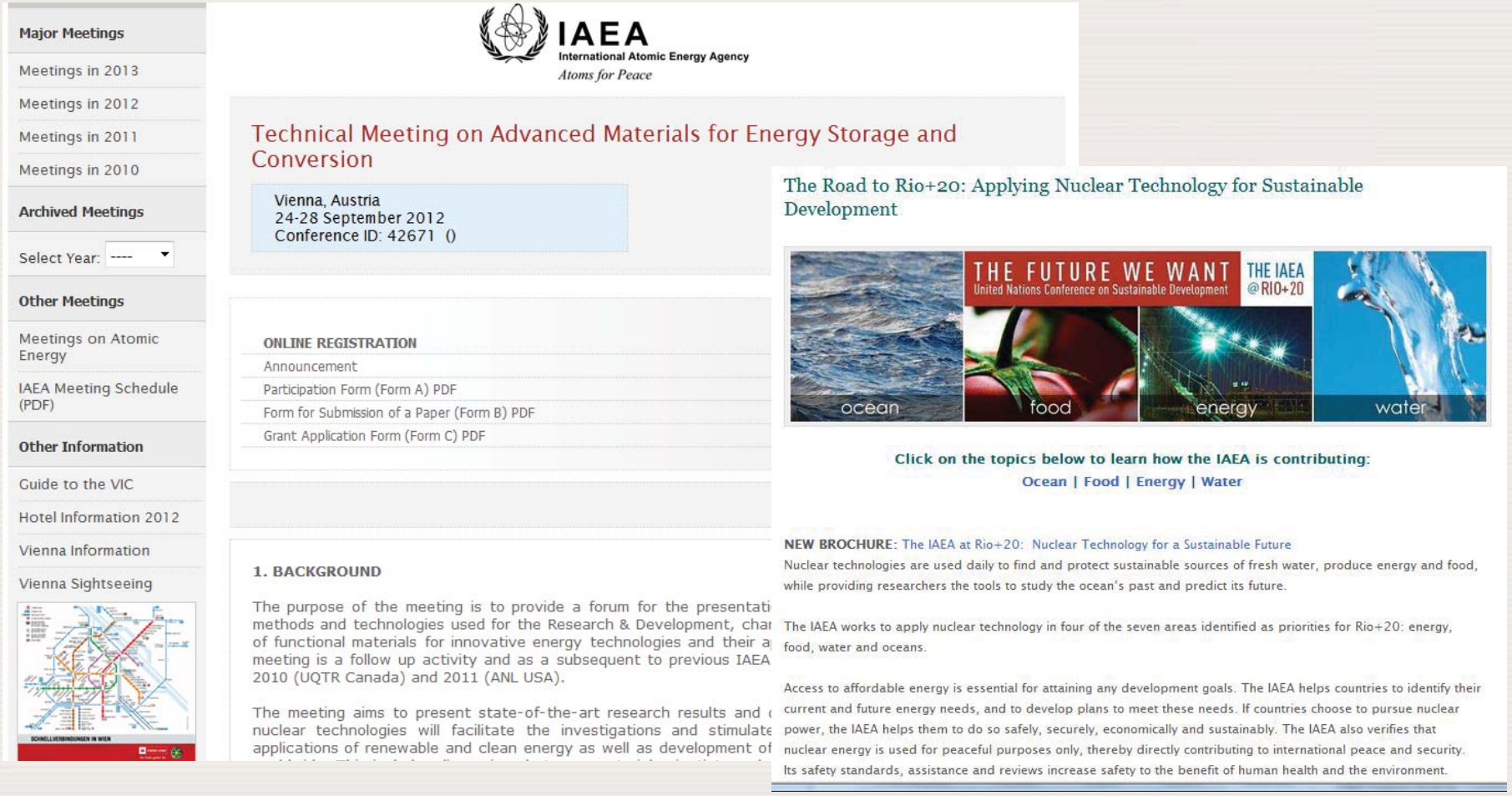

http://www-pub.iaea.org/iaeameetings/42671/Technical-Meeting-on-Advanced-Materials-for-Energy-Storage-and-Conversion

IAEA

Thank you for your attention

email: a.zeman@iaea.org

IAEA