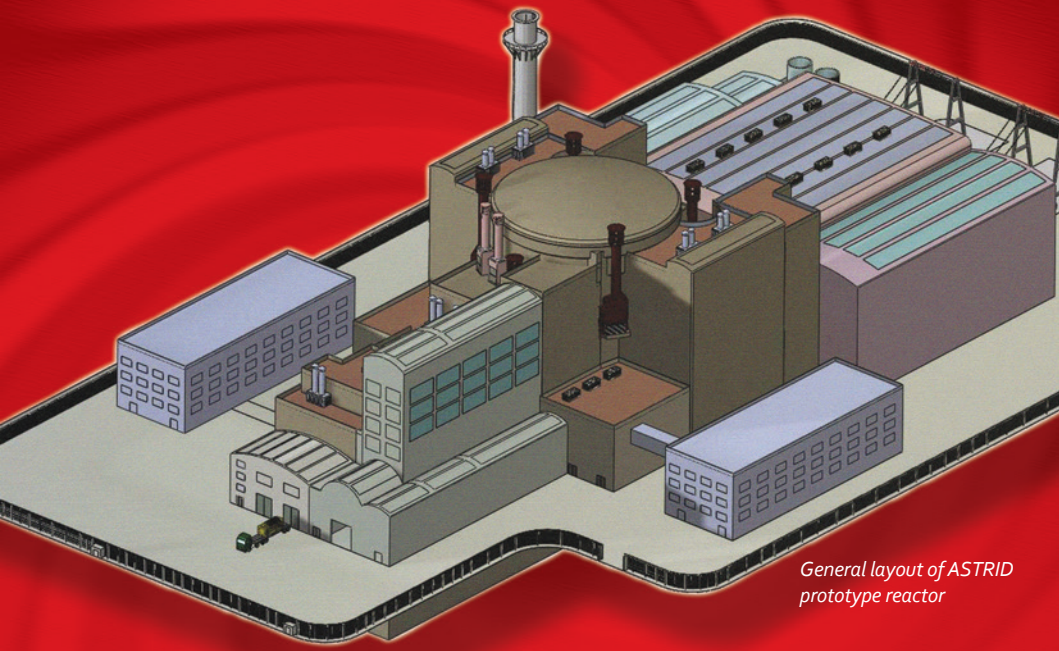
2013

INTERNATIONAL SCHOOL IN NUCLEAR ENGINEERING



General layout of ASTRID prototype reactor

Cadarache, Marcoule, Saclay - France

6 Doctoral-level Courses
in Nuclear Engineering
From November 18 to December 13, 2013
and from January 13 to 24, 2014

DE LA RECHERCHE À L'INDUSTRIE

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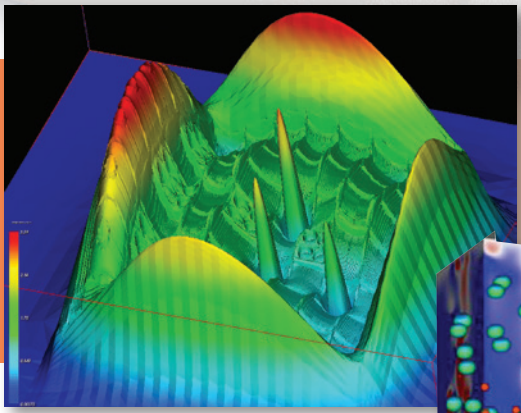
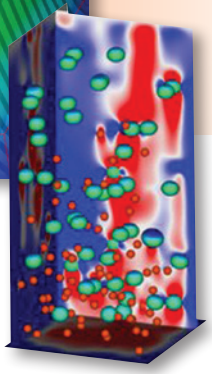
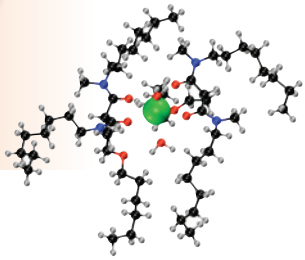


OSIRIS nuclear power distribution

Pin-type fuel element of Gas Fast-cooled Reactor (GFR)



Large scale bubble simulation



Actinide complex solvated by extraction molecule

ABOUT THE SCHOOL

- The National Institute for Nuclear Science and Technology (INSTN) and the Nuclear Energy Division (DEN) of CEA are continuing their international school in Nuclear Engineering, aiming at promoting knowledge in the field of reactor physics and engineering at a high education level.
- The 2013 edition will offer 6 one-week advanced courses in nuclear engineering to be held in France (Cadarache, Marcoule, or Saclay), in November 2013 and January 2014.
- The courses are designed for young researchers, PhD students, post-doctorates and engineers, already having a Master of Science in nuclear engineering as a background. The courses will present the international state-of-the-art in the main topics of nuclear engineering: reactor core physics, thermal hydraulics, materials, fuels, fuel cycle, nuclear waste.
  3 ECTS will be awarded for each successfully completed course (one week).
- Lecturers are internationally known experts mostly from CEA, the leading research organisation in France for nuclear energy.

OUTLINE PROGRAMME OF COURSES

Reactor Core Physics: Deterministic and Monte Carlo Methods

(C. Diop, A. Santamarina)

- The neutron transport equation
- The neutron diffusion equation
- Solving the transport equation
- Solution algorithms for discrete ordinates methods
- The Monte Carlo method for solving the transport equation
- Monte Carlo techniques: fixed source, variance reduction, criticality, perturbation calculations, adjoint calculation, applications to shielding

Thermal Hydraulics and Safety

(D. Bestion, J-M. Seiler, E. Studer)

- Basic modelling of two-phase flow
- Two-phase flow phenomena in LWRs
- Multi-scale approach of LWR thermal hydraulics
- System code modelling of reactor thermal hydraulics, including advanced modelling
- Simulation of LWR design basis accidents
- Application of two-phase CFD to reactor thermal hydraulic issues
- Multiphase phenomena and modelling of severe accidents in LWRs
- Hydrogen risk (production, dispersion, combustion, mitigation)

Materials for Nuclear Reactors, Fuels and Structures

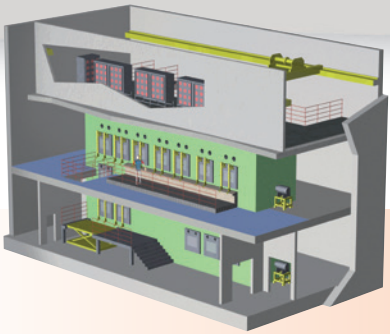
(J-L. Béchade, F. Garrido, J-C. Brachet)

- Mechanisms of irradiation damage: neutrons, photons, electrons
- Behaviour of materials under irradiation: ferritic steels for reactor pressure vessel, austenitic stainless steels for internals or fuel cladding (FBR), Zr alloys for fuel cladding and fuel assemblies (LWR)
- Fuel materials (UO_2, PuO_2): microstructure evolution, thermomechanical behaviour
- Materials for high temperature conditions: SiC, ZrC, low swelling alloys
- Materials for fusion: low activation materials, resistance to high-energy neutrons, breading blankets

Nuclear Fuels for Light Water Reactors and Fast Reactors

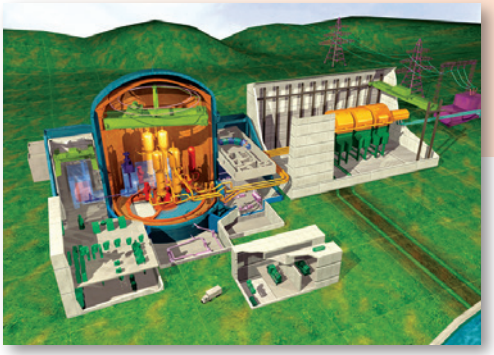
(D. Parrat, J. Noirot)

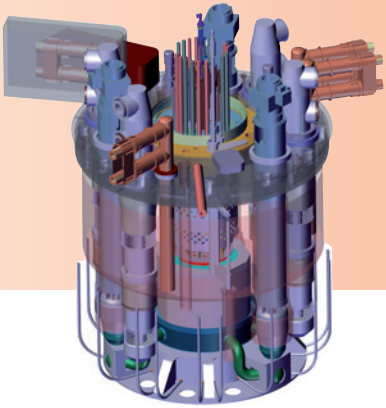
- Nuclear fuels fundamentals
- Fuel element thermal performance and temperature effects
- Nuclear fuel behaviour under irradiation



ATALANTE facility

The EPR





Reactor vessel of the ASTRID SFR prototype

- Main limiting phenomena in the different types of fuels
- Fuel behaviour during some off-normal conditions
- Modelling of fuel behaviour
- Fuel challenges for the future

Nuclear Fuel Cycle and Reprocessing

(B. Boullis, Ch. Poinssot, P. Baron)

- Fuel cycle and spent fuel
- Fundamentals of fuel cycle: chemistry of actinides and fission products in solution
- PUREX spent fuel processing: fundamental knowledge and industrial process
- Minor actinide reprocessing
- Advanced fuel cycles

Nuclear Waste Management

(B. Bonin)

- General considerations on nuclear waste
- Waste conditioning
- Waste storage and disposal
- Perspectives

INFORMATION

- **Venue**
  The courses will be held at INSTN locations in Saclay (20 km southwest of Paris), Cadarache (40 km from Aix-en-Provence) and Marcoule (30 km from Orange).

- **Registration fee**
  Professionals: 2100 € for the first course, 1000 € for each additional course.
  Students: 500 € for each course.
  CEA: special rate.
  Fee covers lectures, documentation and lunches (and local transportation for Cadarache and Marcoule).

- **Contacts**
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  Information: Corinne Carreaux
  Phone: +33 1 69 08 25 02 - E-mail: nuclear-school@cea.fr

Thermal Hydraulics and Safety
Cadarache, November 18 to 22, 2013
Nuclear Fuels for Light Water Reactors and Fast Reactors
Cadarache, November 25 to 29, 2013

Registration deadline: October 18, 2013

Reactor Core Physics: Deterministic and Monte Carlo Methods
Saclay, December 2 to 6, 2013
Materials for Nuclear Reactors, Fuels and Structures
Saclay, December 9 to 13, 2013

Registration deadline: October 30, 2013

Nuclear Fuel Cycle and Reprocessing
Marcoule, January 13 to 17, 2014
Nuclear Waste Management
Marcoule, January 20 to 24, 2014

Registration deadline: November 29, 2013

MAIN LECTURERS

Lecturers are experienced in teaching in several Masters of Science and Engineering programmes. They also supervise PhD students in their research activities.

Pascal Baron is Deputy Head of the Waste Treatment and Conditioning Department of the Nuclear Energy Division, CEA Marcoule. He has been working for more than 30 years on the back-end of the fuel cycle. His main fields of expertise are the development and modelling of solvent extraction processes, including the PUREX, COEX™, DIAMEX, SANEX processes. He is author or co-author of more than 45 articles published in international journals and conference proceedings.

Jean-Luc Béchade is Head of Material Microstructural Analysis Laboratory in the Department for Nuclear Materials at CEA Saclay. He is Professor at INSTN and Senior Expert in materials science, more precisely for nuclear materials with the specialty: metallurgy of Zirconium alloys, determination of microstructure with advanced characterization techniques.

Dominique Bestion is Research Director at CEA. He has been working more than 20 years at the development and qualification of two-phase flow models for the CATHARE system code. He is now involved in the development of the NEPTUNE multi-scale thermal hydraulic platform as a coordinator of two-phase flow modelling activities. He is also coordinating thermal hydraulic activities of the NURESAFE European Project for a nuclear reactor multi-disciplinary and multi-scale software platform, and a Working Group of OECD-NEA for the application of CFD to nuclear safety.

Bernard Boullis is Director of fuel cycle and waste management research programmes at CEA. He has been, for over 30 years, involved in nuclear fuel recycling and final waste management, both in the field of research (he was formerly in charge of the CEA's Radiochemistry Department) and for the design of La Hague plant. He is Professor at INSTN and teaches in French Universities and High Schools.

Bernard Bonin is deputy scientific Director in the CEA's Nuclear Energy Division and Professor at INSTN. He has a background in fundamental research in high energy physics and materials physics. Between 1996 and 2000, he was Head of a Service for Research and Studies on Nuclear Waste, within CEA's Institute for Nuclear Protection and Safety. His studies then aimed at obtaining an overall view of the scientific basis for nuclear waste management. In 2000, he was appointed Assistant to the Director of R&D in COGEMA, in charge of the organisation of the R&D on the fuel cycle front-end, and on future nuclear energy systems.

Jean-Christophe Brachet is Senior Expert on nuclear materials and Professor at INSTN. His expertise covers physical metallurgy of chromium-rich ferritic-martensitic steels and zirconium alloys (development of "new" alloys, behaviour in LOCA accidental conditions...). He authored more than 50 papers and participated to numerous international symposiums or workshops as lecturer or as chairman of specific sessions. He is inventor or co-inventor of 5 patents.

Cheikh M'Backe Diop is Research Director at CEA and Professor at INSTN, working at the Service of Reactor Studies and Applied Mathematics. He was Head of the Laboratory of Shielding Studies and Probability. He is co-author of a book on Radiation Protection and Nuclear Engineering. He teaches radiation shielding computational methods and the Monte Carlo method for simulating the particle transport in matter. He is the scientific manager of the Master's in Nuclear Reactor Physics and Engineering (INSTN - Université Paris-Sud, Orsay).

Frederico Garrido is Professor of Materials Chemistry at the Université Paris-Sud, Orsay. He is an expert in the interaction of energetic particles with matter and radiation damage physics, especially applied to nuclear ceramic materials used as transmutation matrices (oxides and carbides). He has co-authored over 100 scientific papers in peer-reviewed journals. He became also a recipient of the Bronze Medal of the French National Centre for Scientific Research. In addition he is co-Director of the Master Nuclear Energy, which is run by a consortium of academic institutions (Université Paris-Sud, INSTN, ParisTech, Supélec, Ecole Centrale Paris).

Jean Noirot is International Expert at CEA. He has been working for more than 20 years in the field of nuclear fuel post-irradiation examination. With techniques going from gamma-scanning to micro-analyses, he has gained a wide experience on fuel behaviour, fast breeder reactor fuel, pressurized reactor fuel, including MOX, or dedicated experimentation on fuel in French or foreign test reactors. He has authored or co-authored more than 40 publications and book chapters.

Daniel Parrat is International Expert at CEA. He has been working for many years in the field of nuclear fuel behaviour, in particular on the release of fission products. He developed new methods and techniques for detection and characterization of failed LWR fuel rods in power plants for which he won a CEA prize. He has authored more than 40 papers in international conferences.

Christophe Poinssot is Head of the Radiochemistry & Processes Department of the Nuclear Energy Division, CEA Marcoule. He has been working for more than 15 years on different fields within the back-end of the fuel cycle, first on geological disposal, in particular the radionuclides migration and the long-term behaviour of non-reprocessed spent nuclear fuel, then on actinides recycling strategies regarding in particular their respective sustainability. He is Professor at INSTN, and invited Professor in actinides materials at the University of Sheffield. He has authored more than 100 papers and communications. He has been distinguished as Officer within the *Ordre des Palmes Académiques*.

Alain Santamarina is Research Director at CEA. He is Professor of neutronics at INSTN. He was Head of EOLE and MINERVE reactor teams. When involved in fusion research, he coordinated the ITER neutronics/shielding and EFF nuclear data library. He is currently in charge of the validation of the French code package APOLLO2. Professor Santamarina is an Officer of the *Palmes Académiques*.

Jean-Marie Seiler is Research Director at CEA and Grenoble University. He has a deep expertise in the analysis and modelling of severe accidents for Light Water Reactors and Liquid Metal Fast Breeder Reactors. He has participated in many international working groups, experimental programmes and peer reviews.

Etienne Studer is a Senior Expert at CEA in fluid mechanics and hydrogen risk issues. He has 20 years of experience working in the field of hydrogen risk in nuclear power plants. He is currently involved in experimental programmes (MISTRA facility) and modelling activities ($CAST_3M$ CFD code). He has participated to international experimental programmes, international working groups and state-of-the-art reports.