

Basic Research in support of Innovative Fuels Design for the GEN IV systems Roadmap of a bridge construction

The partners "builders"



Framework

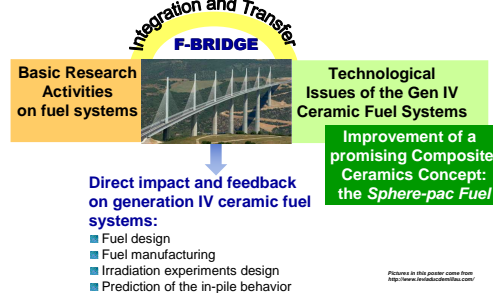


- Framework of the Euratom Work programme (FP7)
- Area: **Advanced Nuclear Systems**
 - improve efficiency of present systems and fuels
 - investigate advanced systems and fuel in collaboration with efforts of GEN IV, especially upstream research (material science, study of fuel cycle and innovative fuels)
- Topic: Fission -2007-2.2.1: **Innovative fuels and claddings for generation IV systems**
 - Development and qualification of innovative fuels and claddings
 - Impact: increase efficiency of EU research support to GIF
 - Focusing on cross-cutting and generic issues

The needs

- International effort to **increase efficiency in designing innovative fuels**
 - ⇒ to improve present fuel-cladding systems
 - ⇒ to design those for tomorrow
- Up to now fuel development and qualification: successful but long and expensive process essentially based on an **empirical approach**
- Innovative fuel systems: empirical approach **has reached its limit** / difficult to extrapolate to new materials, new environments, or new operating conditions
- **Basic underlying mechanisms** governing manufacturing, behaviour and performance remain largely poorly understood
- **Challenge** for the next years: complement the empirical approach by a more physically based description of ceramic fuel and cladding materials

The idea



Objective 1: "raise the pillars"



Obtain data, mechanisms and models from basic research for an improved description of fuel and ceramic cladding under irradiation

- generate basic data, identify mechanisms, develop models
- develop multi-scale modelling and characterization tools to build the necessary elementary understanding of the phenomena involved

Objective 2: build the "apron"



Ensure transfer and integration between technological issues of Generation IV systems and basic research

- Ensure bi-directional transfer and translation between technological issues of Generation IV systems and basic research
- Integration of all scales to ensure the impact and feedback of basic research results on innovative fuel design, manufacturing, in-pile behaviour prediction and optimization of irradiation experiment design

Objective 3: towards final use "the road surface"



Assess a promising composite ceramic fuel for GEN IV systems: "sphere-pac" fuel

- Wet fabrication route of kernel facilitating minor actinides insertion whilst reducing number of process
- Manufactured by vibratory compacting allowing interstitial space and accommodating so, a large amount of gaseous fission products
- Manufacture of advanced sphere-pac fuels and performance evaluation of improvements proposed

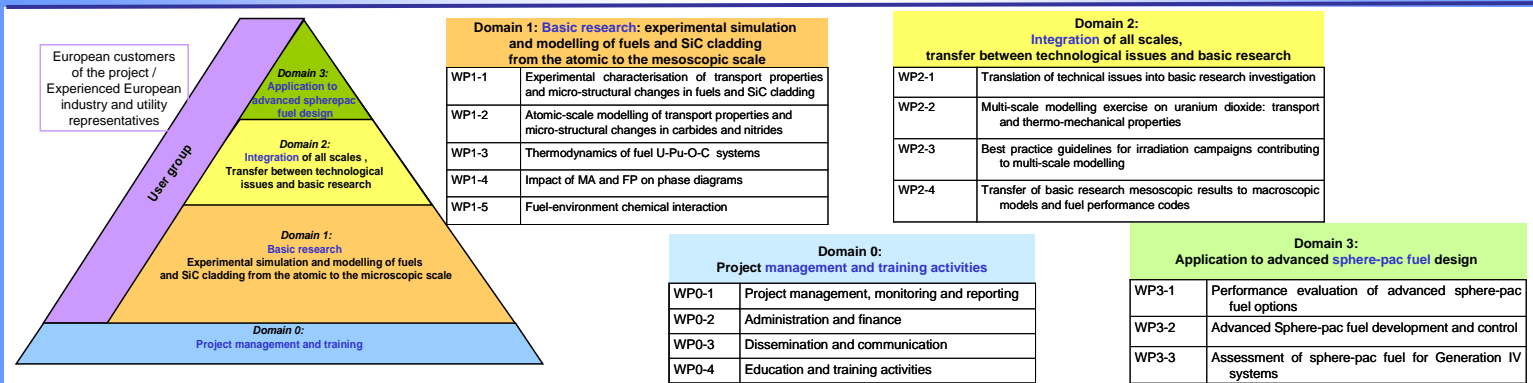
Objective 4: training/ transmission to young's



Ensure result dissemination, education and training

- Organize summer schools for young scientists to promote research in the field of fuel materials, thus preparing to meet tomorrow's challenges
- Train Ph.D. students and post-doctoral associates involved in the project
- Organize workshops for scientists, design engineers and end-users to ensure exchange of results and ideas among the participants in the project and also exchange with the international community in the field.

The rationale



Beyond the state of the art

- **Novel approach:** brings together numerous significant actors of the nuclear fuel field: scientists, engineers and end-users
- A special team: shall ensure a direct translation of technological issues into basic research investigations, as well as a facilitated transfer of the knowledge acquired to fuel performance codes, design and manufacturing.
- **First integrated project on non-metallic nuclear fuels and cladding**
 - All relevant length and time scales from the atomic description to macroscopic systems
 - Investigation of important properties of fuel and ceramic cladding materials using a combination of modelling and experiments
- **Main contribution:** to capitalise on recent advances in both theoretical approaches and experimental techniques to develop fuel behaviour descriptions that have a much sounder physical basis
- **Atomic scale modelling:** Challenging because of insulating and actinides materials / panel of new methods to better describe actinides / grain boundaries studies
- **Multi-scale modelling:** from atomic to macroscopic scale / links between scales / links with experimental characterization
- **Thermodynamics:** at the cutting edge for phase diagrams of plutonium and other actinides carbides, nitrides and oxides / modelling coupled to new experimental approaches
- **Experimental:** separate effects studies coupled to irradiation testing experiments / methodology to be applied to various nuclear materials / use of large facilities
- "Sphere-pac" fuels: innovative procedures of fuel micro sphere fabrication compared to existing ones / a concept which seems to meet the requirements of GEN IV systems

Expected Impact at European level

- Gather scattered European basic research teams
- Link basic research teams and their clients:
 - Developers of fuel performance codes
 - Design engineers
 - Test irradiation designers
 - Industrials
- Conclusive results and recommendations on the applicability of sphere-pac fuels for Generation IV systems
- Contribution to European answer to GEN IV initiative
- A challenging multi-scale approach structuring links between basic research and its clients is also starting elsewhere (US, Japan ...).

F-BRIDGE in names and numbers

- Start of F-BRIDGE / Duration: 01/03/2008 / 48 months
- Partners / Countries: 19 / 8 + EU
- Total Budget / EC grant: 10,2 M€ / 5,45 M€
- Education and Training budget: 5% total budget
- Post-doc and Ph.D.: ~2 Ph.D. (3y) / 5 PD (2y)
- Effort / Participants: - 17 pers/year during 4 years / - 90 pers
- EC project officer: Georges van Goethem, EC
- Coordinator / Deputy Coordinator: Carole Valot / Marjorie Bertolus, CEA
- Project Management Officer: Vincent Chauvet, LGI
- Basic Research Domain Leader: Rudy Konings, JRC-ITU
- Integration Domain Leader: Sander de Groot, NRG
- Sphere pac fuel assessment DL: Joe Somers, JRC-ITU
- Work Package Leaders: Marie-France Barthe (CNRS), Christine Guéneau, Jacques Léchelle, Yannick Guerin (CEA), Marcella Iannuzzi (PSI), Paul van Uffelen (JRC-ITU), Luc van den Durpel (LISTO), Ping Xiao (Cambridge Univ.)