

DE LA RECHERCHE À L'INDUSTRIE



Code Strategy for Simulating Severe Accident Scenario

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- **INTRODUCTION AND CONTEXT**
- **REFERENCE SET OF CODES**
- **REFERENCE SET OF CODES ASSESSMENT**
- **PRA CODE**
- **CONCLUSIONS**

INTRODUCTION AND CONTEXT

■ Severe Accident scenarios

- Overall faults : ULOF, ULOSSP, ULOHS, TOP...
- Local faults : TIB, CRW

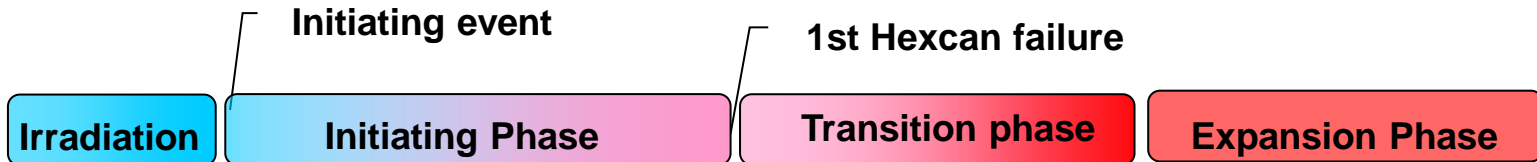
■ Various phenomena:

- core degradation (initiating phase, transition phase and expansion phase) thermohydraulics, neutronics, pin mechanics, ...
- corium progression towards the core catcher
- corium behaviour on the core catcher
- energetic corium/sodium interactions
- structure mechanical behaviour during expansion phase
- containment behaviour
- and fission production release and transport

■ Scales

- From pellets and fission products to containment

Core degradation

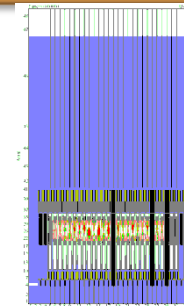
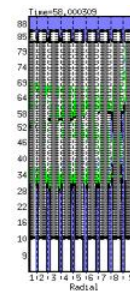
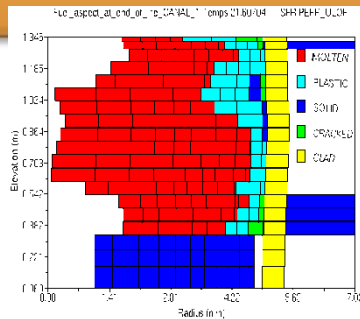


SAS-SFR :

- Channel approximation,
- Single average pin,
- point neutronic kinetics.

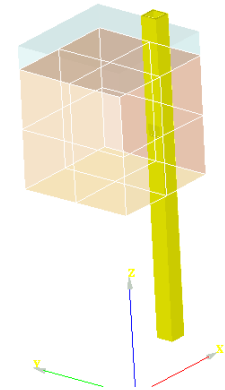
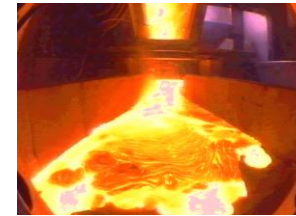
SIMMER III or IV :

- Core calculation,
- Spatial neutronic kinetics,
- 2 cells per subassembly (SIMMER IV).



Melt Progression towards the core catcher

- SIMMER III and SIMMER IV
- Development of new models
- Parallelisation of the TH module

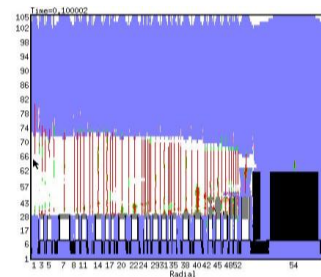


Energetic corium/sodium interactions

- Development of a new models
- Jet fragmentation model needed ⇒ Possible improvements of MC3D or Texas code



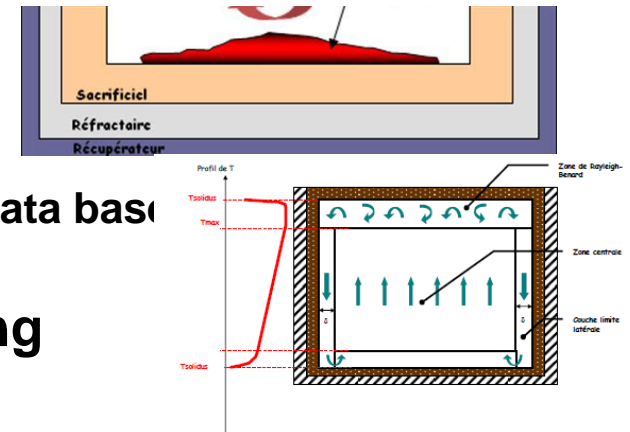
A: Kelvin-Helmholtz instability
B: Rayleigh-Taylor instability



- If FCI and core degradation are simultaneous ⇒ Implementation in SIMMER of simplified models

Corium behavior on the core catcher

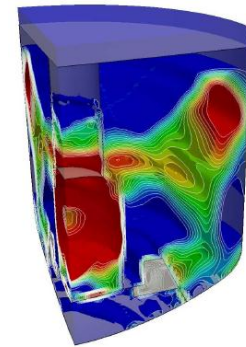
- **TOLBIAC-ICB → TOLBIAC-SFR**
 - ✓ Versatile geometry
 - ✓ 1D pool discretization
 - ✓ Sacrificial material properties (GEMINI data base)
- **TRIO_U, CATHARE : core catcher cooling**
- **CAST3M: core catcher mechanical behavior**
- **TRIPOLI, ERANOS : corium criticality**
- **LIDEB or other : debris bed cooling**



Structural mechanical behavior during expansion phase

■ EUROPLEXUS :

- fluid-structure interaction,
- 1-D, 2-D or 3-D domains composed of solids and fluids,
- Lagrangian Eulerian description,
- geometric non linearity,
- non-linearity of materials.



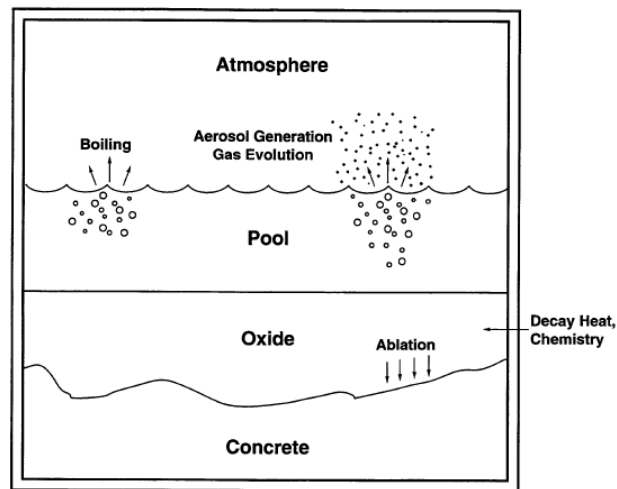
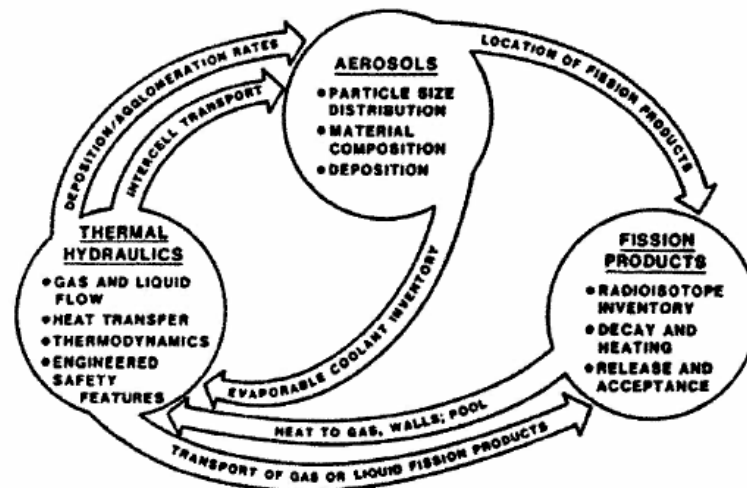
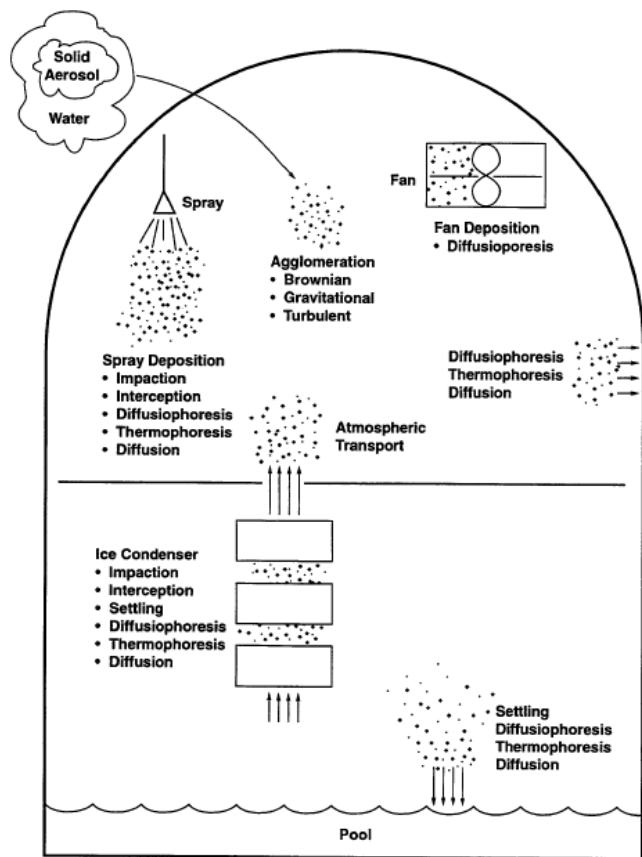
Instant : 0.25 ms

Fission product release and transport

■ A review to establish the needs

Containment behavior

CONTAIN LMR



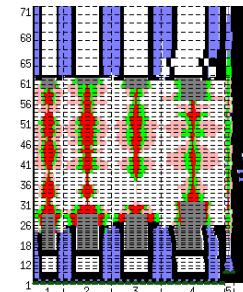
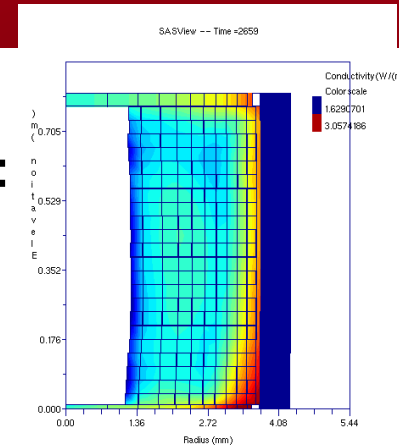
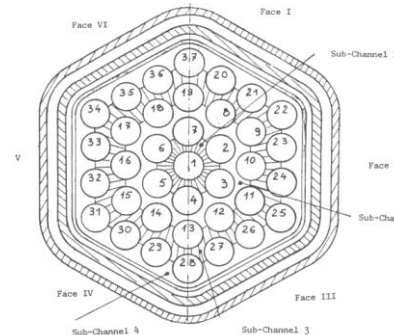
Core degradation

■ CABRI 1, CABRI 2, CABRI FAST and CABRI RAST :

- SAS-SFR assessment (collaboration JAEA-KIT-CEA)
- Single pin, various transient and cooling conditions
- Fresh and spend fuel

■ SCARABEE-N :

- SIMMER assessment
- Fresh fuel
- TIB, inter subassembly corium progression, boiling pool...



■ SAIGA : (Severe Accident In-pile program for Generation IV reactors and ASTRID project)

- Proposed Program to be carried out by IAE/NNC-RK in IGR (Kazakhstan)
- (Feasibility under study)
- For SIMMER assessment
- Degradation of axially heterogeneous pins
- Study of pin assembly degradation under TIB and TOP conditions

Mitigation

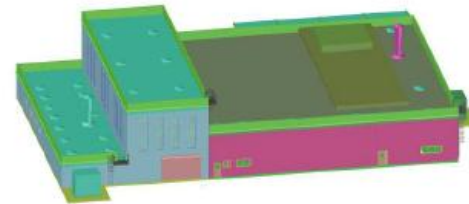
■ EAGLE 1 & 2 :

- Out-of-pile (simulant material) and in-pile experiments
- JAEA Program carried out by IAE NNC RK in IGR (Kazakhstan)
- Upward and downward discharge of corium through ducts
- SIMMER III and IV assessment

Other

■ FOURNAISE facility: (Furnace for Oxides of Uranium aimed at simulating Nuclear severe Accidents In large Scale Experiments)

- Feasibility study under way for go/no-go decision in June 2013
 - 2 options studied: dedicated to SFR or SFR&LWR
- Prototypic corium up to 500kg
- 3 SFR objectives :
 - ❑ Core catcher development
 - ❑ Mitigation devices development (complementary tests to EAGLE1&2)
 - ❑ FCI :Complementary tests to FARO-THERMOS, CORECT II, MFTF-B05 and MFTF-B06



Probabilistic Risk Analysis (L2PSA)

- **Scenario analysis : sequences and alternative branches**

Code

- **Simple coupled models:**

- Derived from test data base and/or reference code models
- Analytical simplified equations and possible Black box approach when necessary

- **Software architecture:**

- Heterogeneous models
- Flexible time-marching scheme

Statistics

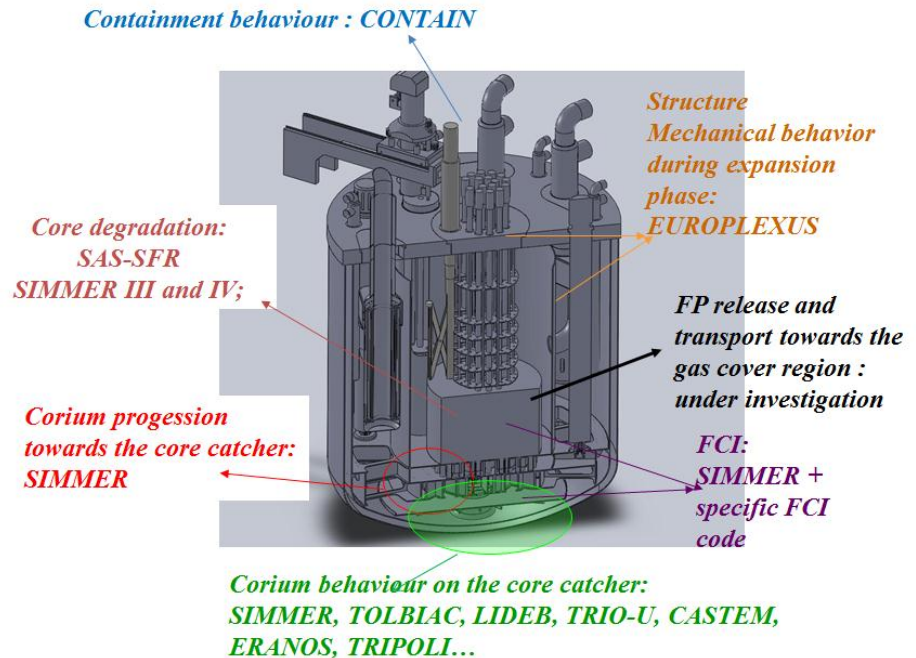
- **Model, scenario or design parameter sampling**
- **Sensitivity decomposition analyses**
- **Margin assessment towards design and safety criteria**

Two complementary approach :

- Reference set of codes :
 - ✓ Progressive extension of the application domain
 - ✓ Performance improvement
- Simplified code for PRA

Code assessment:

- Existing experimental data base
- EAGLE 1&2
- SAIGA
- FOURNAISE



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