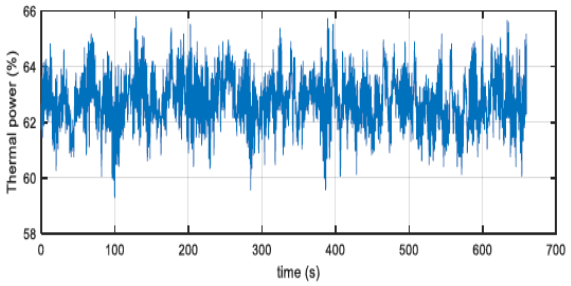
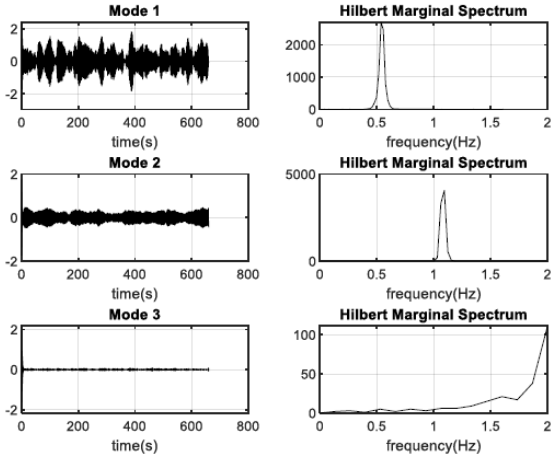
Decay Ratio Evaluation using Variational Mode Decomposition method

- **Background**
  - PSI Methodology based on ARMA models has some limitations in evaluating DR at certain conditions
  - Variational Mode Decomposition (VMD) method is promising Algorithm dealing with most ARMA limitations, e.g. mode mixing problems, non-stationary signals, etc
  - VDM method decomposes the signal to system intrinsic modes on which DR estimation will be based

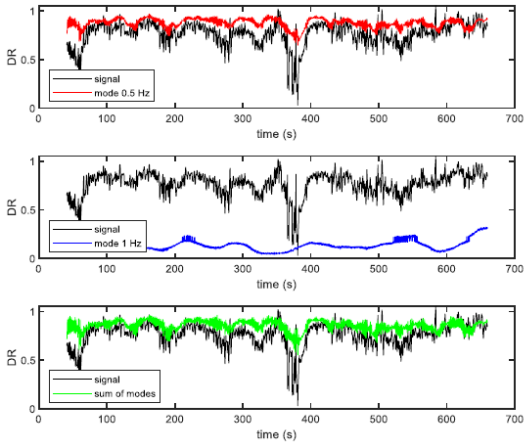
- **Semester and Master's Project**
  - Development of MATLAB program based on VMD method to evaluate the dominant intrinsic modes and evaluation of DR based on these modes using KKL GETARS/COSMOS signals
  - Comparison of VMD based results to those of current methodology
  - Integration of the new method in the STARS TSAR methodology



Detector Signal



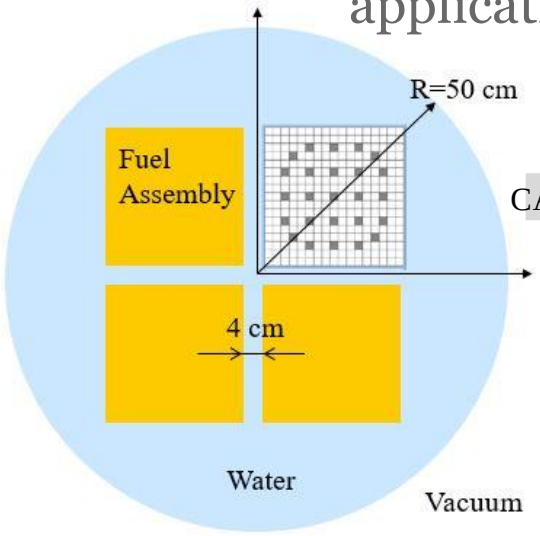
Mode Decomposition



DR Mode estimation

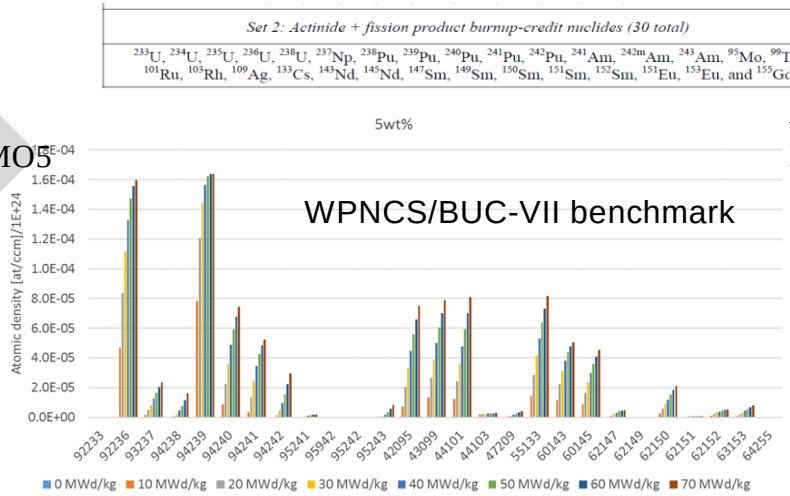
Contact:  Hamid Dokhane (Abdelhamid.Dokhane@psi.ch)

Burnup credit and criticality safety evaluations of a pseudo-application case for final disposal of used nuclear fuel



Pseudo-Application Case

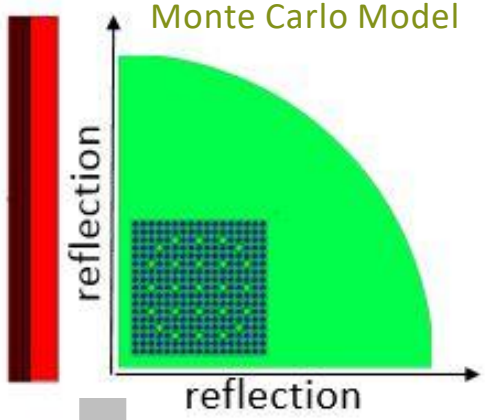
CASMO5



Nuclear Fuel Composition

AC + FP Nuclides

Monte Carlo Model

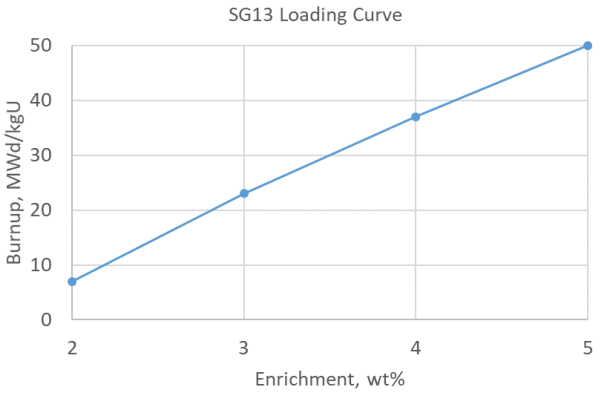


MCNP

Goals

Quantify sensitivity of loading curves (burnup required to comply with upper subcritical limit vs. initial fuel enrichment) with respect to

- Input parameter variations of the pseudo-application case
- Modifications and refinements, e.g. added reflector, solid absorbers, pin-wise resolution in the depletion calculations
- List of credited actinide and fission product nuclides
- More realistic axial burnup profiles (“End Effect”)
- Used nuclear data libraries



Contact:  Matthias Frankl (Matthias.Frankl@psi.ch)

Fast Neutron Detector Modeling

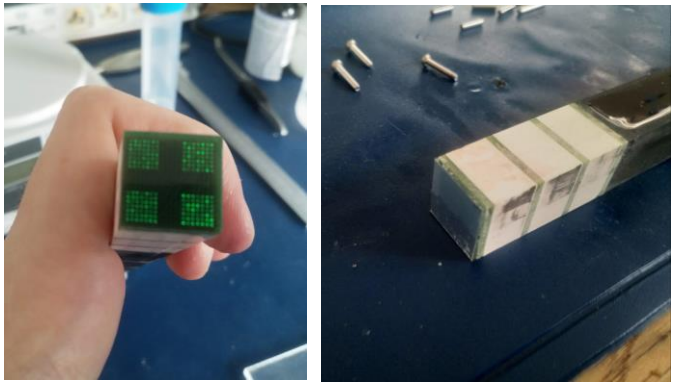
Background

- A fast neutron detector that is gamma blind was developed for spent fuel characterization
- Several aspects of the design could be improved
- The physics of the detection process is complex (neutron scattering, scintillation light, fiber optics)

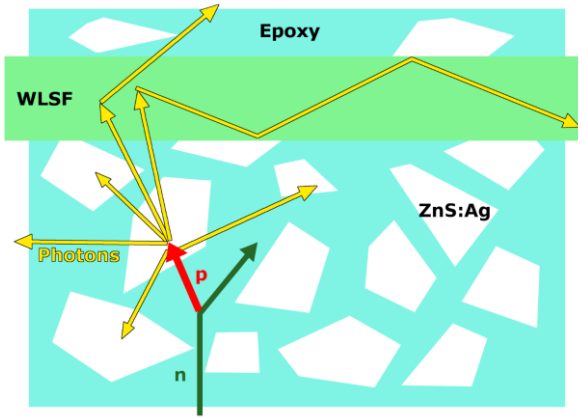
Semester and Master Project

- Modeling of the detector with Geant4 using previous models
- Compare predictions with sets of experiments performed for model verification
- Investigate change in detector performances with varying design

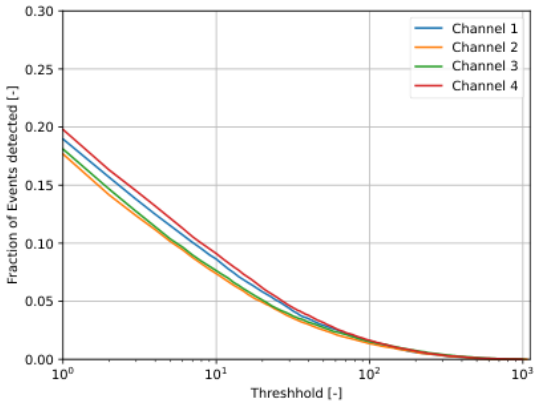
Fast Neutron Detector



Detection Physics



Example of Modeling Predictions



Contact:   Gregory Perret and Dominik Werthmüller (gregory.perret@psi.ch, dominik.werthmueller@psi.ch)

CFD simulations of turbulent penetration in T-junctions

Background

- Temperature fluctuations caused by turbulent penetration produce thermal fatigue in T-junctions from NPPs.
- OECD/NEA benchmark was recently launched to assess the capabilities of CFD simulations to model turbulent penetration in dead legs.

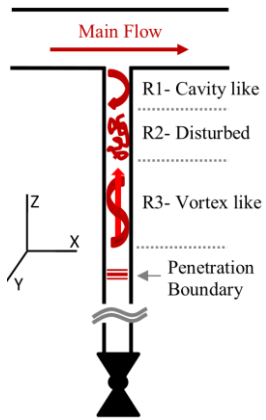
Semester and Master Project

- CFD simulation of selected benchmark cases using OpenFOAM.
  - Detailed description of fluid flow and heat transfer. Comparison with available experimental data.
  - Evaluation of the predicting capabilities of turbulent models and numerical tools.

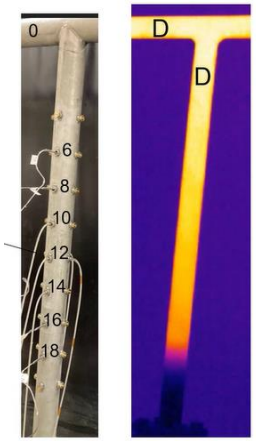
PhD Potential

- Complete the model assessment and perform blind simulations. Possible development of improved URANS closure and coarse-mesh wall models.

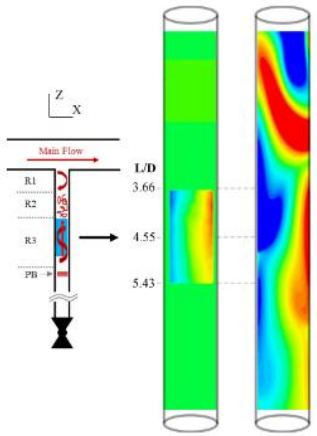
T-junction phenomena



Model validation with experimental data



Detailed flow description



Downing et al., 2022

Contact:  Ezequiel Fogliatto (ezequiel.fogliatto@psi.ch)

Thermal Modelling of Prismatic HTGRs

Background

- High Temperature Test Facility (HTTF) at Oregon State University (OSU) studies heat transfer in prismatic high temperature gas-cooled reactors
- OCED/NEA HTTF benchmark recently launched to compare (CFD/systems) code predictions using HTTF data

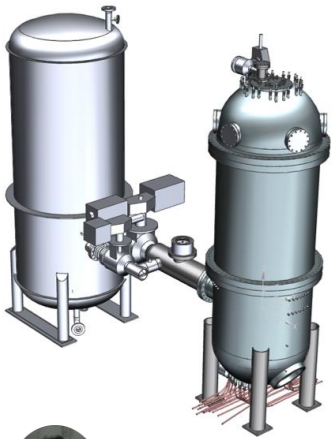
Semester and Master Project

- Thermal modelling of HTTF benchmark cases using OpenFOAM
  - Obtain high-resolution reference solution
  - Develop multi-scale model and solve selected benchmark problem

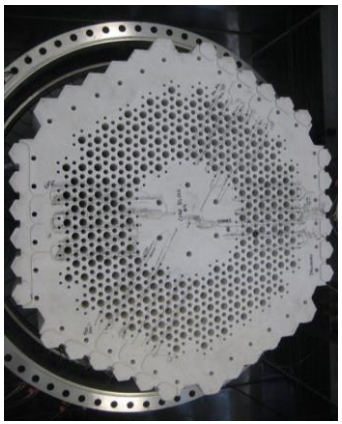
PhD Potential

- Several modern micro-reactor concepts use monolithic block cores, like HTTF
- Possible PhD research studying heat transfer and system behaviour in space micro-reactors

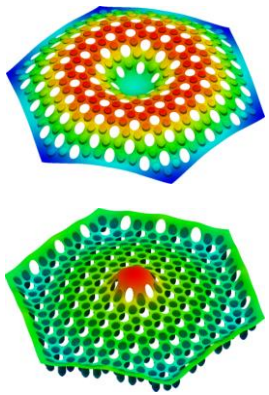
High Temperature Test Facility (HTTF)



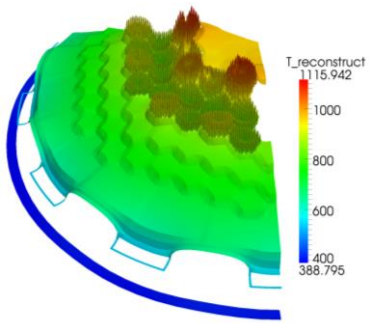
HTTF Core



Multiscale Method of Clifford (2013)



Reduced order model training



Reconstructed full-core solution

Contact:  Ivor Clifford (ivor.clifford@psi.ch)

Effects of load-follow operation on SMR fuel safety

Background

- Future SMR designs will need to integrate in energy systems with fluctuating renewable sources
- Effect of load follow of fuel integrity needs to be assessed

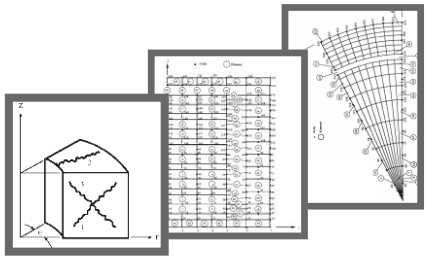
Semester and Master Project

Analysis of SMR fuel behavior under conditions of enhanced power maneuvering will include one of the following modeling aspects:

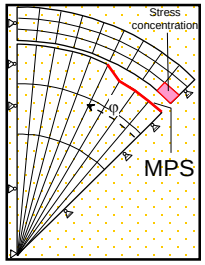
- Prediction of PCI/SCC failure of the fuel cladding, using a Cumulative Damage Index based methodology.
- Simulation of effects on cladding bonding, and 'burst' Fission Gas Release in the fuel due to additional fuel fragmentation (cracking).
- Evaluation of effects on the cladding fatigue induced failure.

Results and conclusions of the work may be used as input to initiating new SMR fuel safety-related activities within the OECD/NEA-CSNI Work Group for Fuel Safety (WGFS)

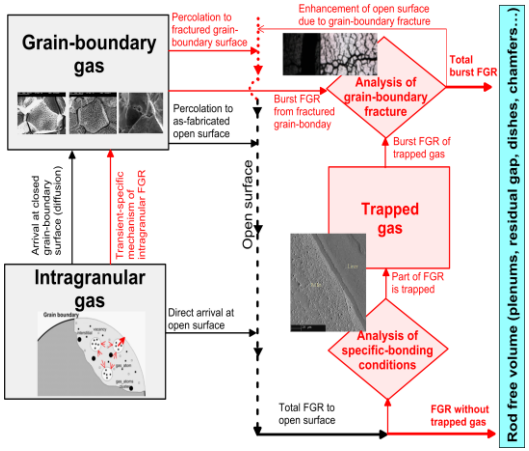
FEM based approach:



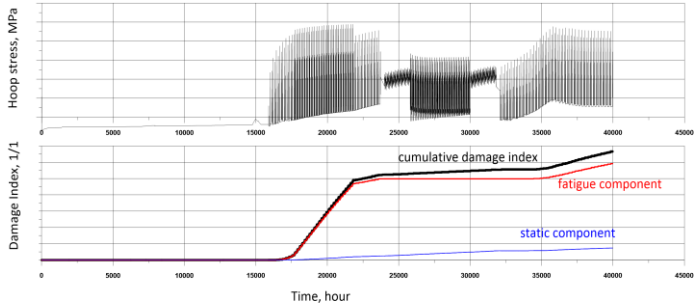
Load-follow: Effects of enhanced pellet macrocracking and/or MPS



Load-follow: Effects of enhanced pellet microcracking and fuel fragmentation



Load-follow: Effects of cladding fatigue



Contact:  Grigori Khvostov (grigori.khvostov@psi.ch)

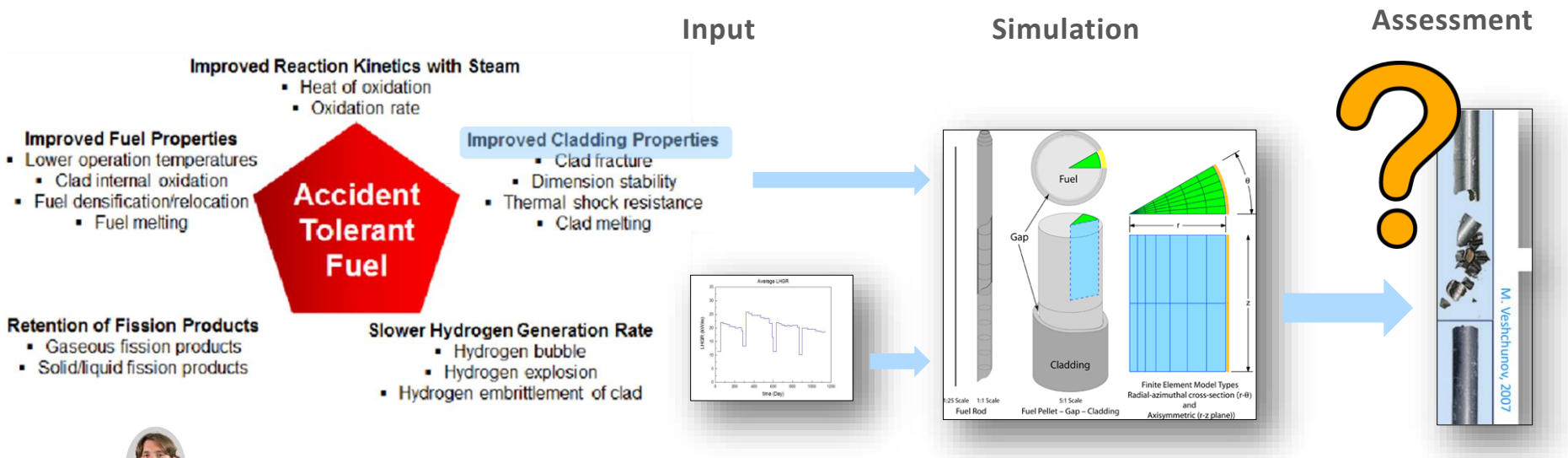
Thermo-mechanical behaviour of ATF composite cladding

Background

- SiC/SiC_f composite is a revolutionary ATF concept under development, tested in CH and elsewhere
- The low thermal conductivity leads to high thermal gradient, therefore generating stress in the matrix
- The integrity of the material may be compromised even in operating conditions → EU-project SCORPION

Semester and Master Project

- Implement the thermal properties (conductivity, expansion coefficient,…) in Falcon
- Simulate the stress in the cladding for a representative scenario (compare with reference material)
- Assess the suitability of the ATF candidate (a cracking threshold is provided by experimentalists)



Contact: Cedric Cozzo (cedric.cozzo@psi.ch)