Power-Buildup Phase of Super Promptcritical Event in MYRRHA

Investigation of a Hypothetical Core Disruptive Accident Scenario in MYRRHA

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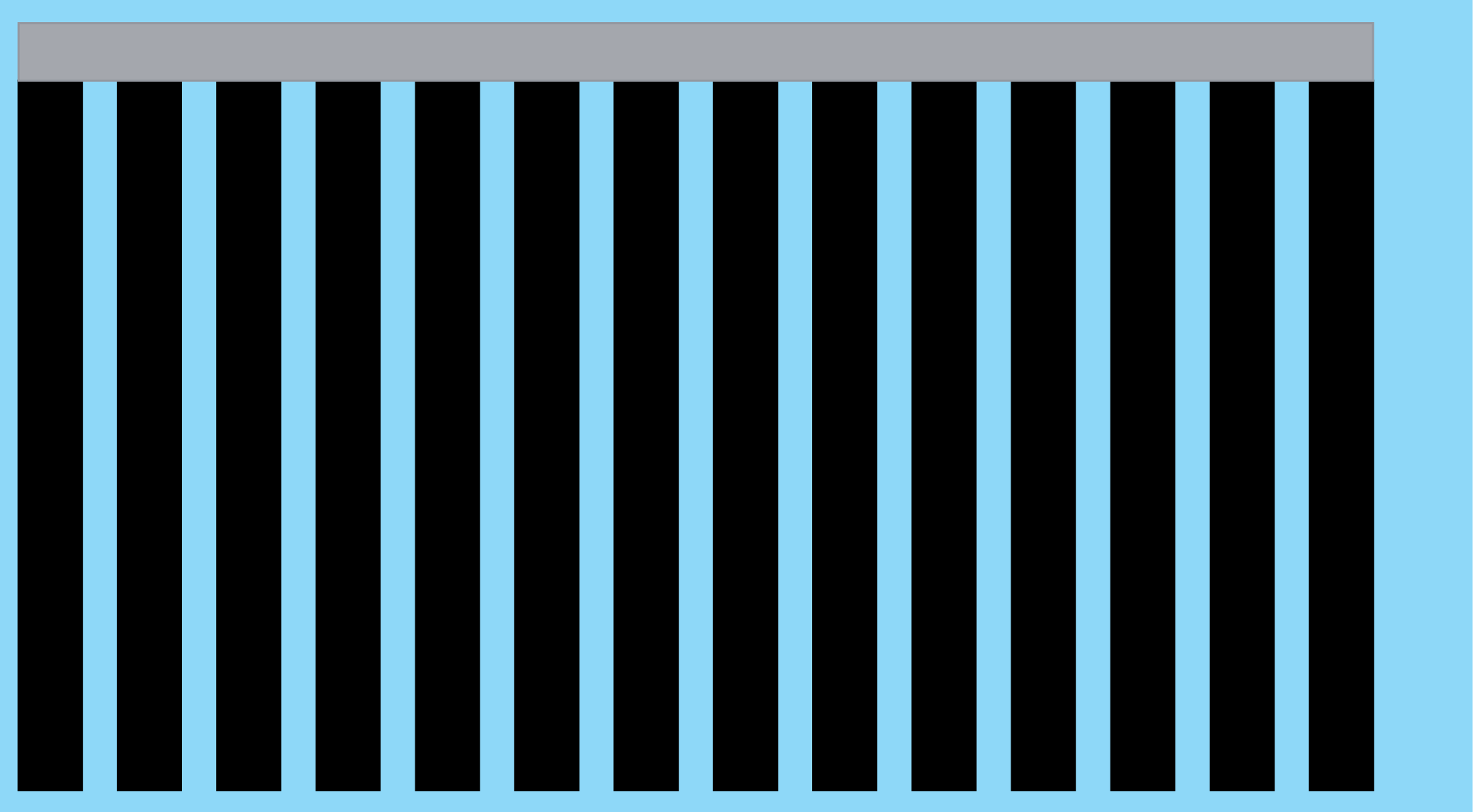
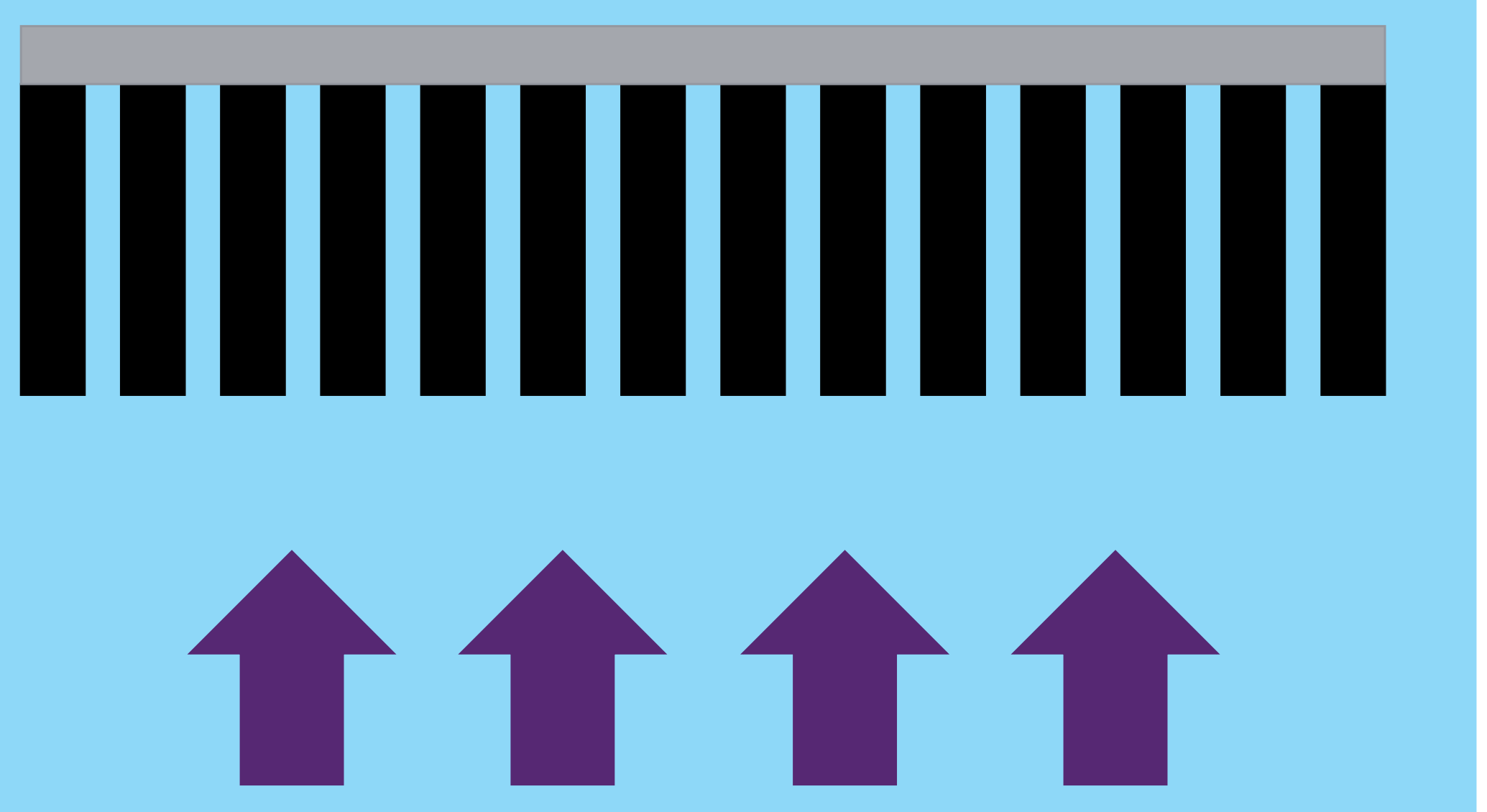
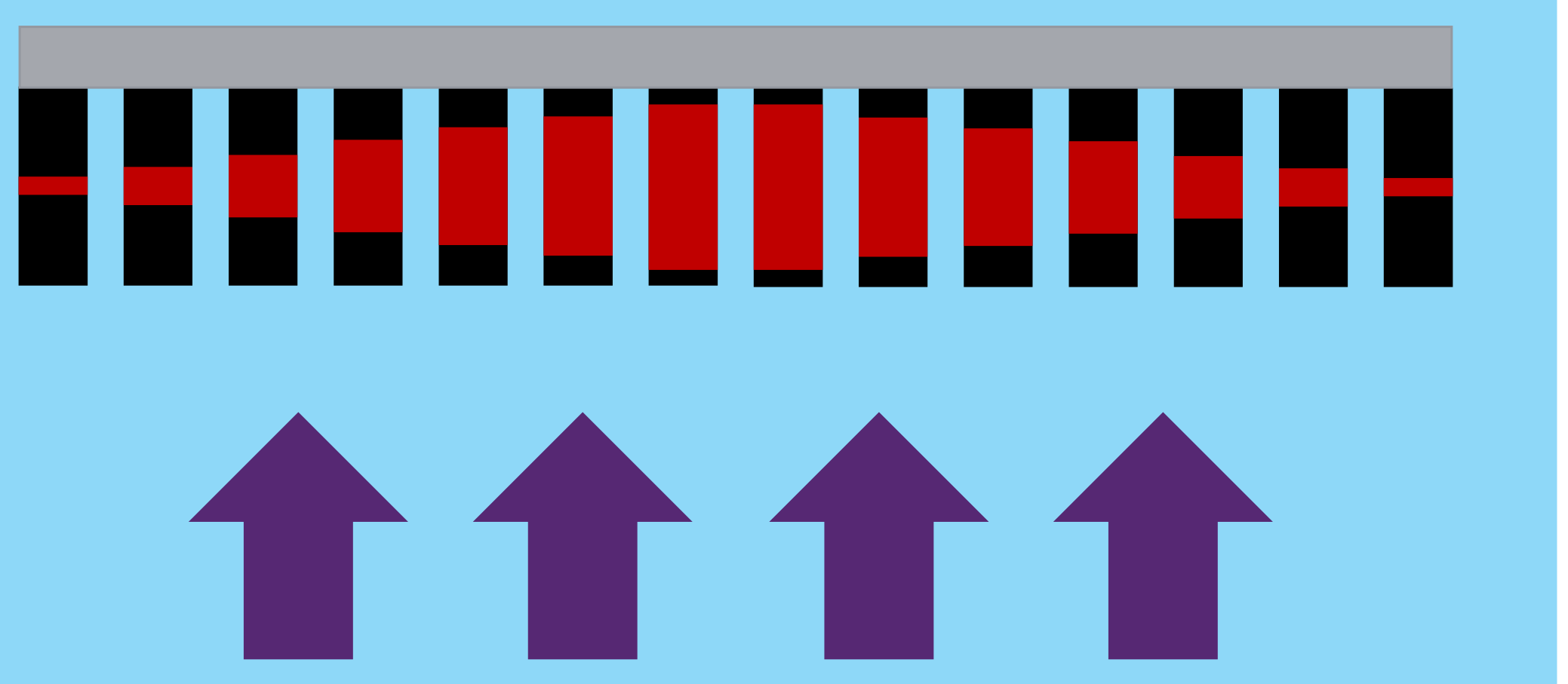
Intact Core Geometry



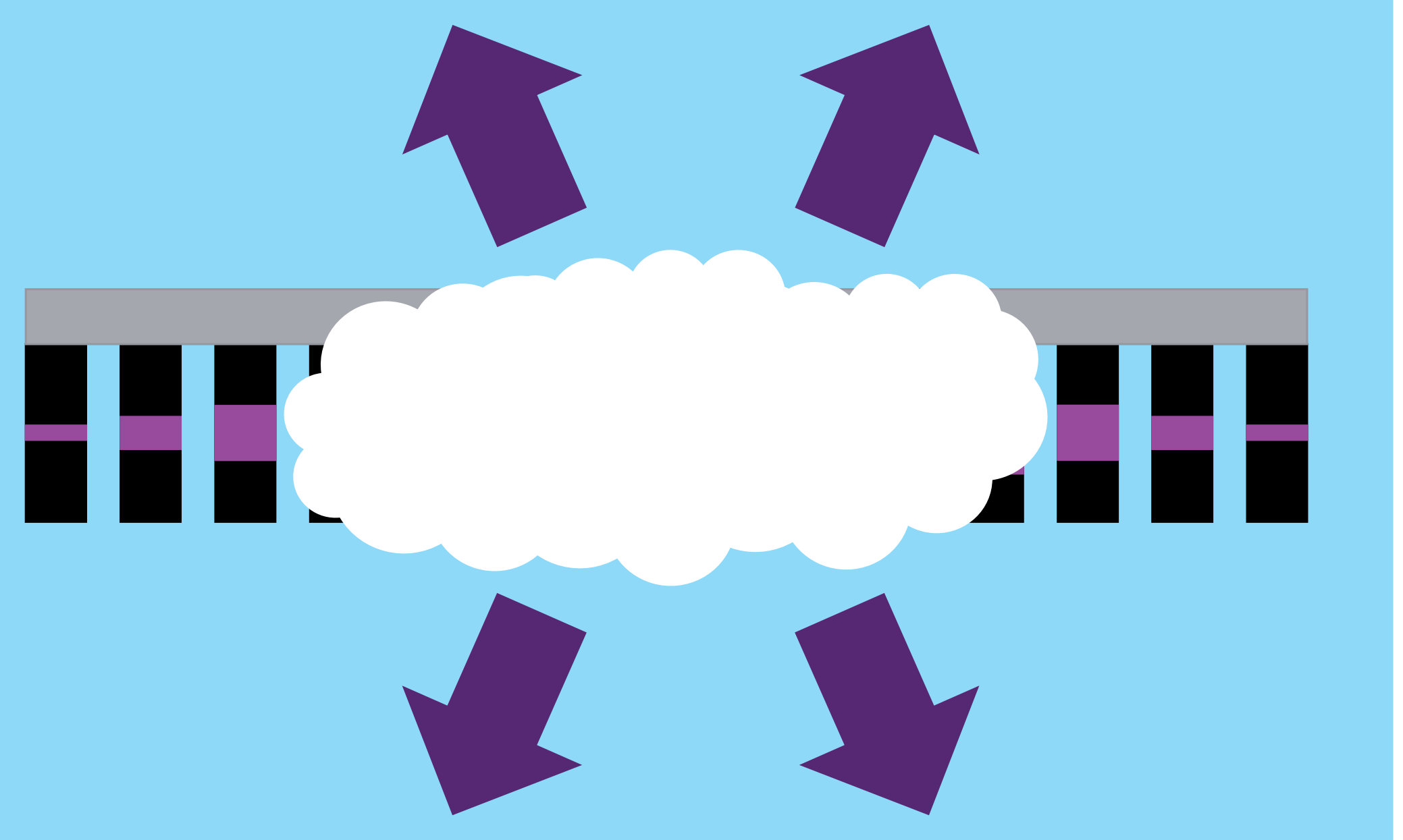
Core Compaction



Power Buildup



Fuel Dispersion



Introduction

MYRRHA (Multipurpose hYbrid Research Reactor for High-tech Applications) is a fast neutron spectrum facility cooled by Lead-Bismuth Eutectic (LBE), currently under development at Belgian Nuclear Research Centre (SCK•CEN). The main purpose of MYRRHA is to demonstrate the feasibility of an Accelerator Driven System based on a Lead-cooled Fast Reactor.

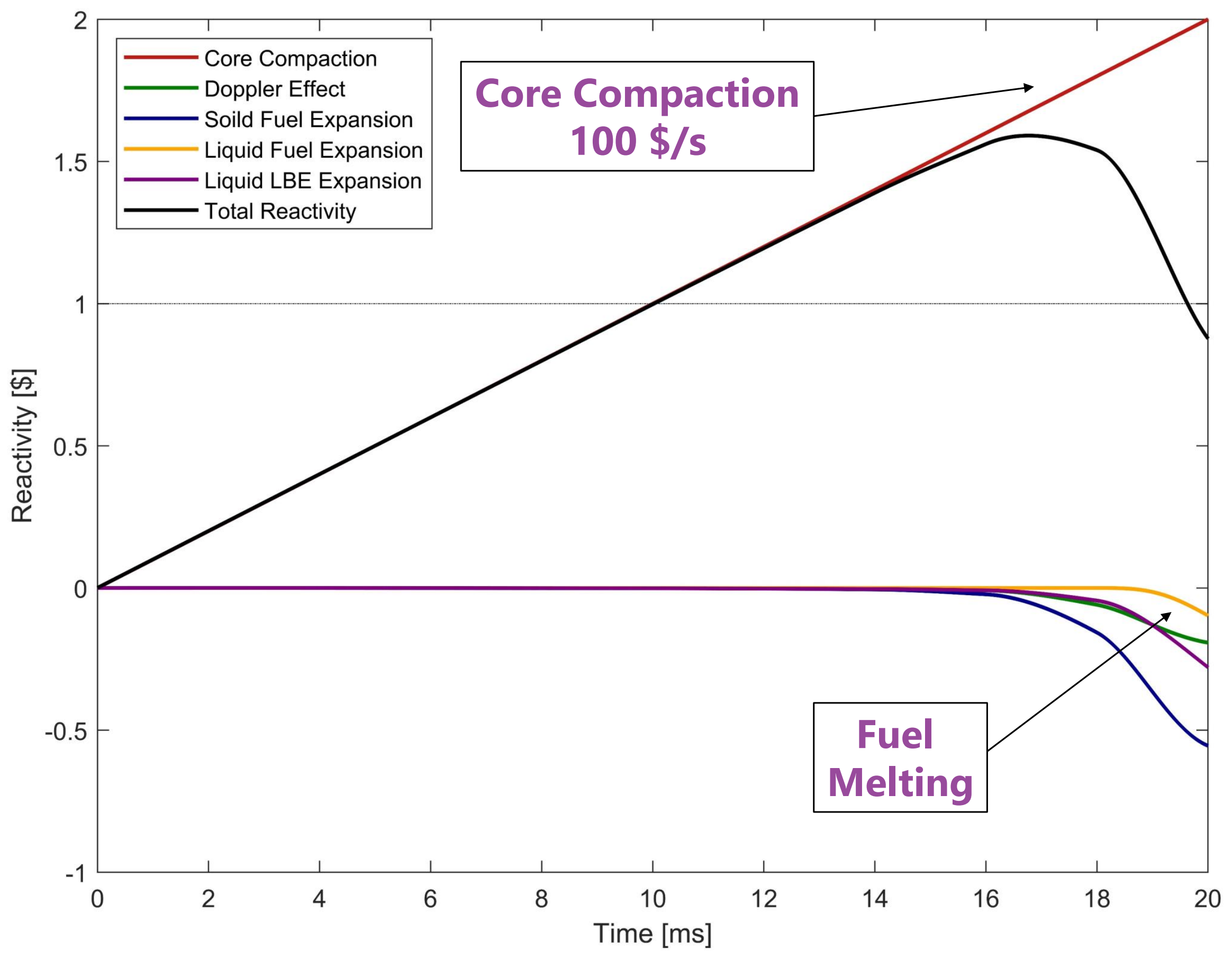
As an ultimate safety barrier in the case of a severe accident, MYRRHA intends to rely on **in-vessel retention of the nuclear fuel material.**

Objectives

In order to determine the viability of the in-vessel retention strategy, an enveloping severe accident case is postulated: the **Hypothetical Core Disruptive Accident** (HCDA). In the course of the HCDA, core degradation and subsequent fuel relocation are assumed to happen in a way that will lead to a compaction of fissile material with a maximum increase of core reactivity. This further results in a **power excursion** that leads to coolant boiling and consequent **overpressure** in the reactor vessel.

Core Reactivity Evolution

The reactivity evolution in this phase is determined by reactivity insertion due to the core compaction, which is modeled by ramp reactivity input, and reactivity feedbacks due to **Doppler effect**, **expansion of core materials** due to temperature increase, and **fuel melting**. The power-buildup phase is effectively terminated by fuel expansion due to fuel melting.



Reactivity reversal is caused by the combination of Doppler effect and thermal expansion of the core materials.

Expansion due to fuel melting rapidly drives the reactor core reactivity **below prompt supercritical level**.

Sensitivity studies indicate that the reactivity reversal mechanism and the sequence of events considered within the power-buildup phase **do not depend** on the **magnitude of the reactivity insertion rate**.

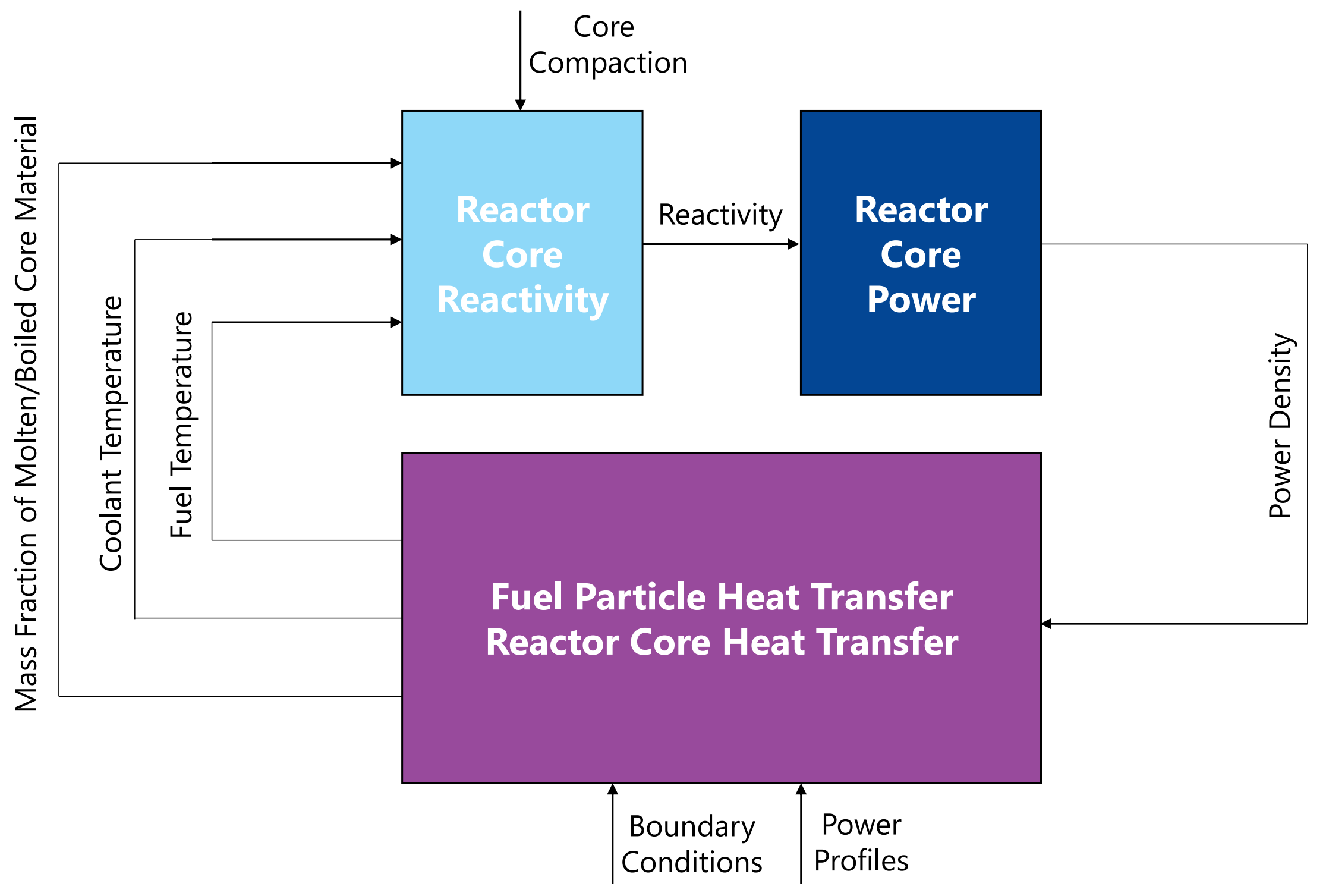
Methods

The phenomena related to the HCDA in MYRRHA were first studied with the computer code **SIMMER-III**. Three phases are considered to describe the HCDA:

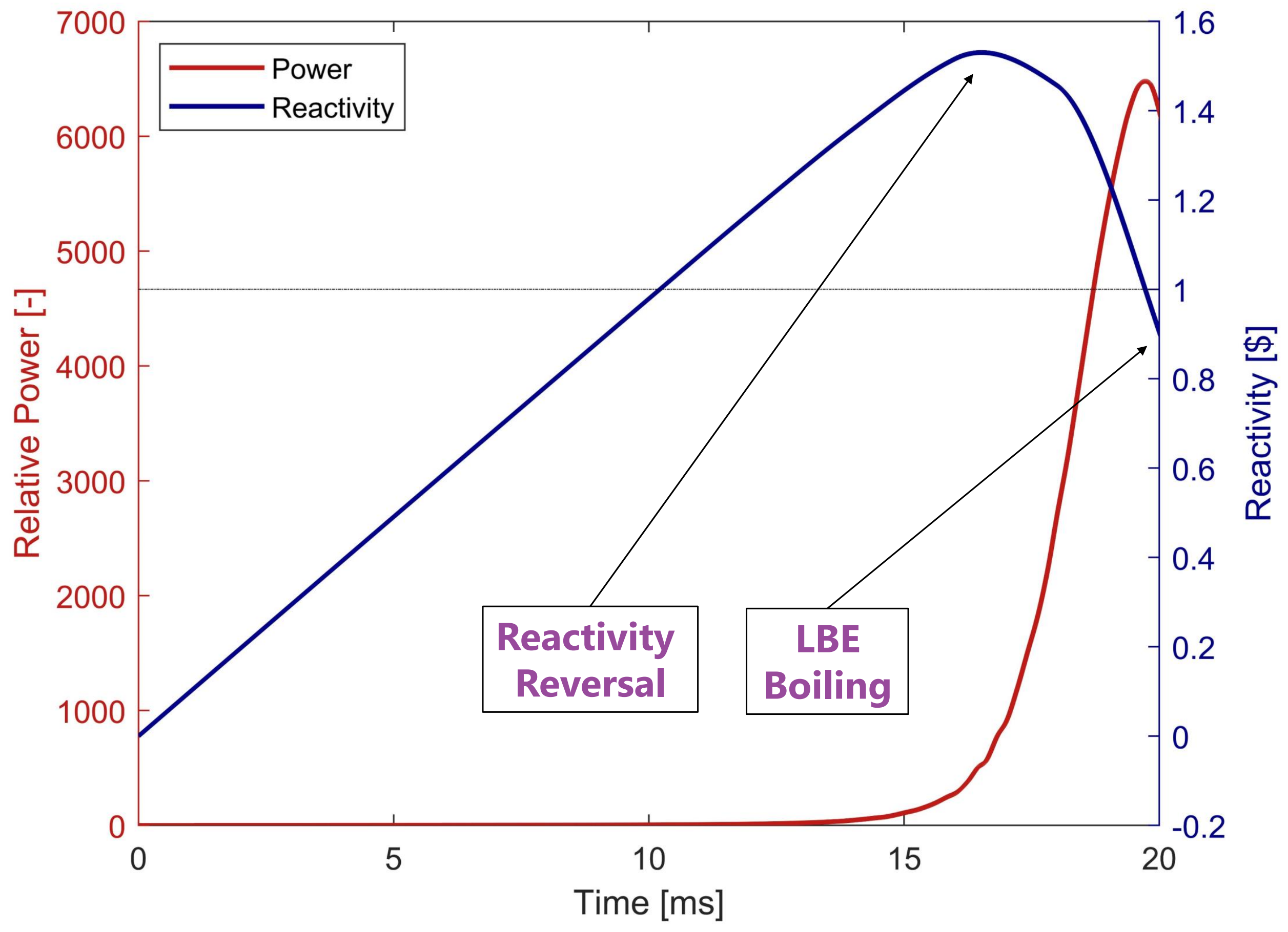
- Core compaction phase leading to prompt supercriticality
- **Power-buildup phase** until delayed supercriticality
- Fuel-dispersion phase

Since the power profile does not change significantly up until the point of LBE boiling, a **Point Reactor Kinetics** (PRK) approach can be used to reproduce reactivity in the power-buildup phase. PRK parameters and reactivity feedback coefficients were obtained by employing Serpent-2 Monte Carlo code. This model is further coupled to a **1D heat transfer model** in order to investigate the dynamics of the power-buildup phase.

Herein developed model based on the basic principles of reactor physics and heat transfer can **successfully reproduce** SIMMER-III results.



Core Power Evolution



Due to thermal inertia, **LBE boiling** happens after the prompt supercritical phase and results in fuel dispersion, thereby stopping the core compaction.

Conclusions

Fuel expansion due to fuel melting rapidly drives the reactor core reactivity **below prompt supercritical level**.

Reactivity reversal is caused by the combination of Doppler effect and thermal expansion of the core materials.

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