Fluid flow analysis through FSI code interaction
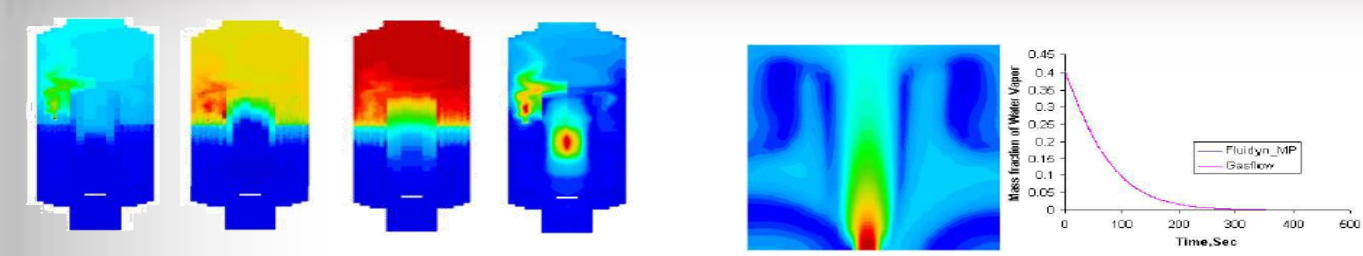
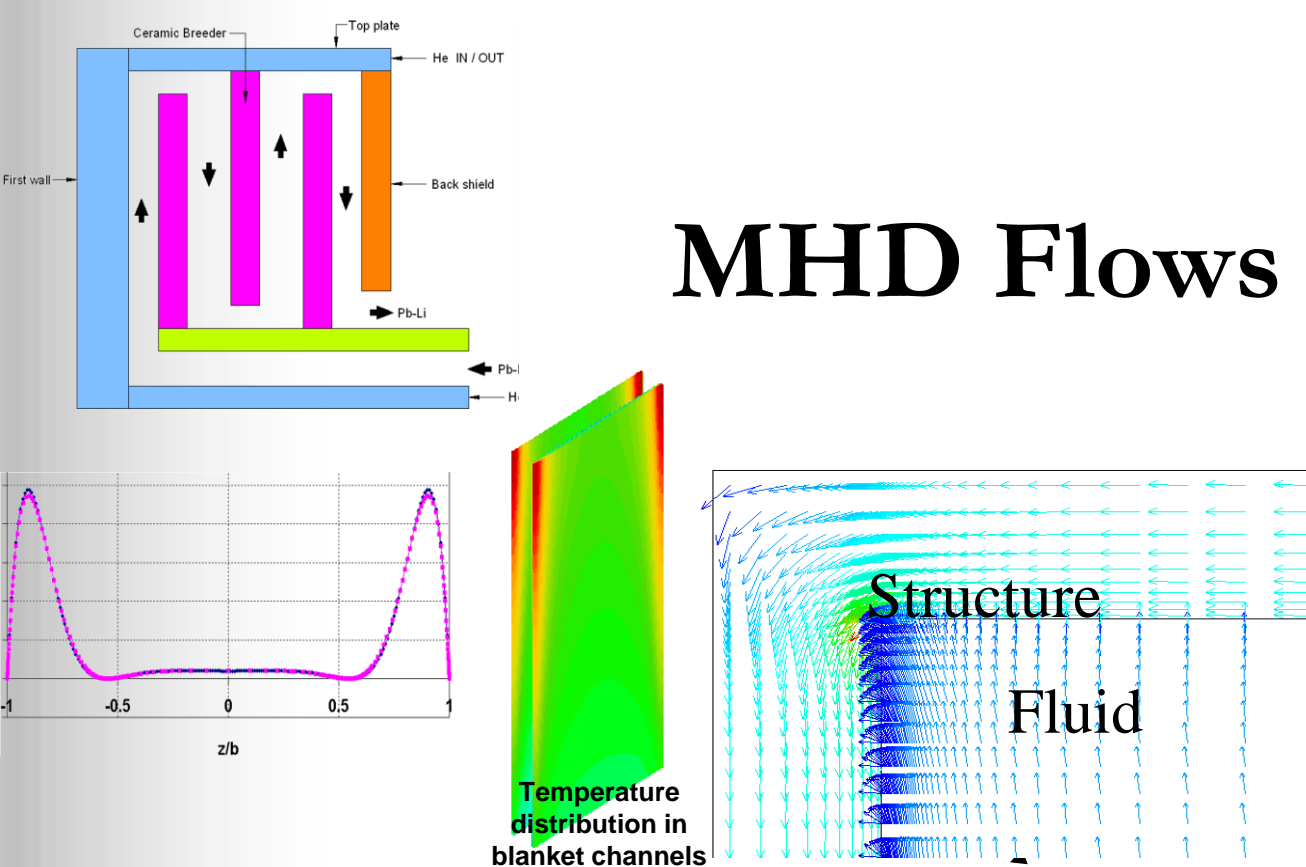Vidya KAUSHIK[1], Anil KUMAR [2], Jerome HAMBURGER[3]

[1]Fluidyn North America, [2]Fluidyn India, [3]Fluidyn France

Thermo-Hydraulics

Fluidyn-MP's Thermohydraulic module is a full 3D simulator, for robust and accurate modeling of flow and dispersion in reactors, pipes, containments, etc... in stationary and/or transient (accidental) conditions. It includes :
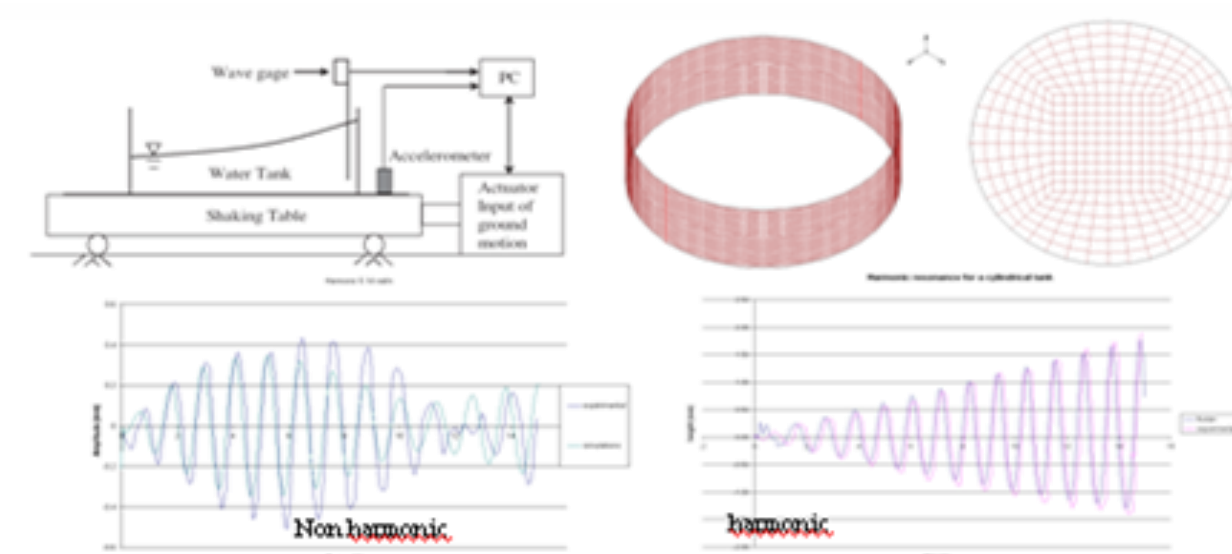
❖ HEM models validated for high performance computations

❖ Adapted models for turbulent flows

❖ Bulk and film condensation

❖ Heat exchange through structures for accurate modeling

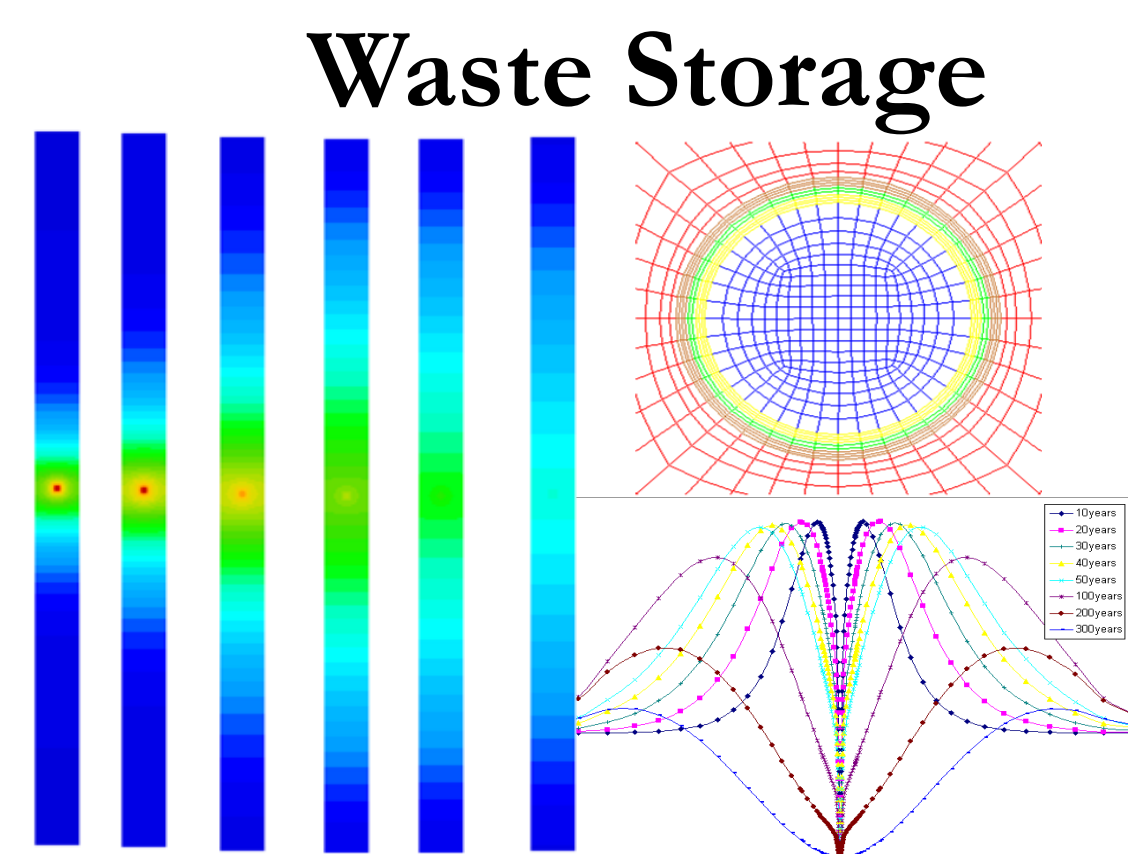❖ Validated on ThAI, PANDA and other benchmarks for thermohydraulics

Safety - Seismic

Fluidyn-MP allows to perform complex and accurate modeling of 3D fluid-structure dynamic load and structure dynamic response interaction due to diverse excitation phenomena, such as:

❖ Static loads, mode analysis (structure alone)

❖ Sloshing (3D fluid-structure coupling)

❖ Hydrodynamic loads (condensation oscillations)

❖ Seismic loads

❖ MP models are an alternative for a better prediction of fluid-structure interaction in seismic impact modeling on structures

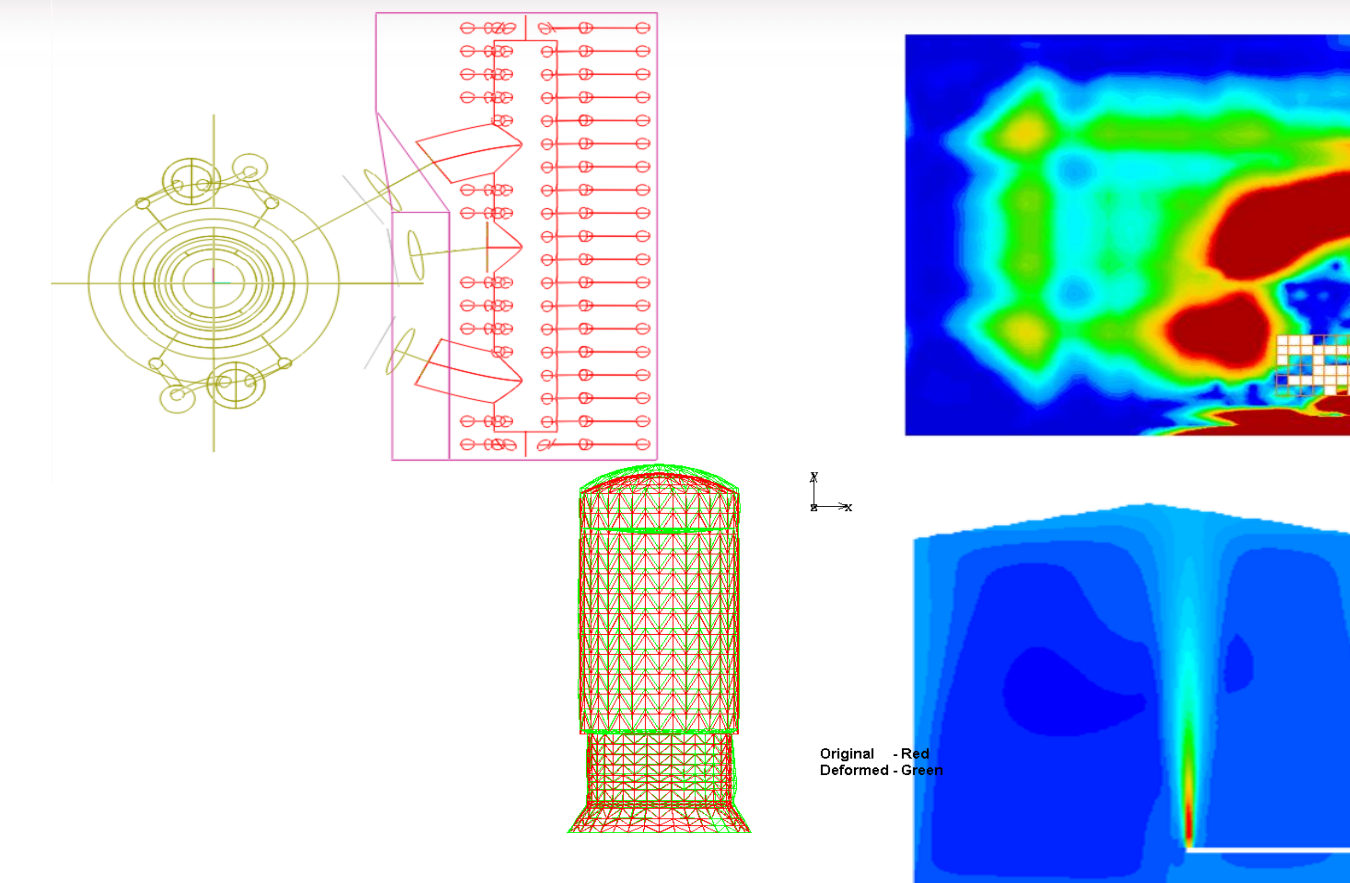## Accidents - Risk Analysis
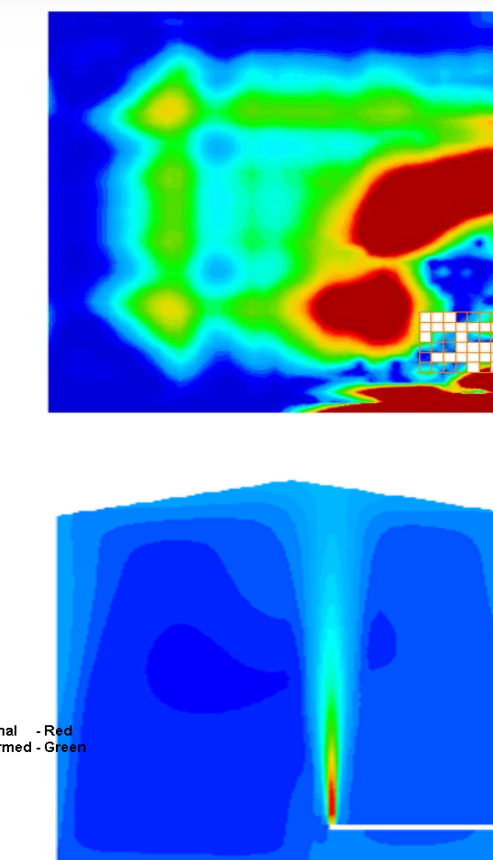
Risk analysis and process engineering are two closely related fields for nuclear applications. Both intensively use the CFD and fluid-structure interaction of the *fluidyn*-MP® platform:

❖ CAE : Computed Aided Engineering for all applications

❖ Single phase and multi-phase flow analysis

❖ Structure analysis (stress/deformations)

❖ Rupture analysis

❖ Leakage/ LOCA applications

❖ Coupled acoustic flows

❖ Fire and explosions

Process Engineering

MHD Flows

Structure

Fluid

Temperature distribution in blanket channels

Fluidyn-MP's MHD module allows to perform fluid flow of electroconducting fluids in an electromagnetic environment. MHD is used for primary coolant system of a fusion reactor, where an electroconducting fluid is used to carry heat. Fluidyn is part of ITER blanket breeder system verification and validation through numerical simulation. MHD module integrates (highlights) :

❖ Both potential and induction method for MHD flow solution

❖ Full validation for duct flows for Ha > 30000

❖ Models validated for 3D flows

❖ Modeling of fluid domain and surrounding structures

Waste Storage

Fluidyn has developed and validated unsaturated 2-phase flow and thermal coupled modeling in soils for application to deep nuclear waste storage, taking into account :

❖ Capillary pressure - desaturation

❖ Saturation/permeability relations : (Van Genuchten)

❖ Water drift filling and emptying procedure

❖ Coupled thermal expansion and pressure distribution in whole 3D domains through combined Darcy-RANS simulations

ITER Electromagnetics / Rarefied flows
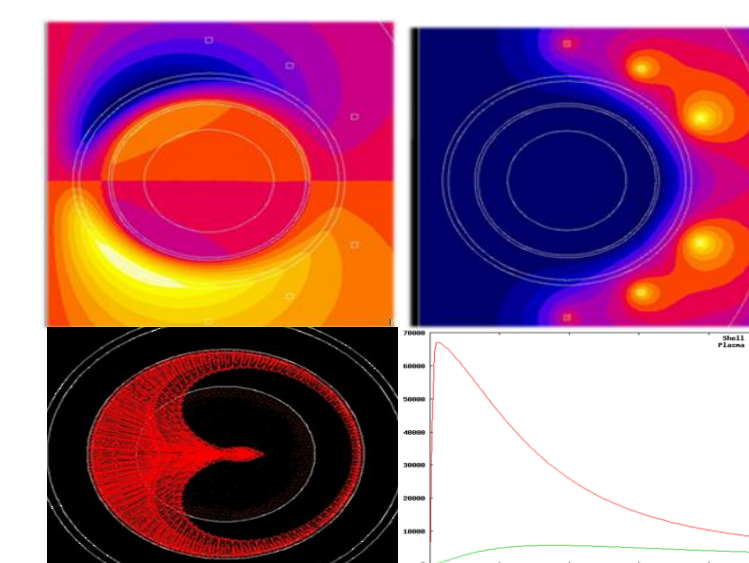
Fluidyn is involved in ITER R&D project through different types of analysis:

❖ Vacuum Vessel leaks in Tokamak: Modeling of dense to rarefied flow transition in blankets through DSMC-RANS coupling

❖ Electromagnetic forces modeling

❖ MHD flows in Blanket breeder system

CFD and Fluid-Structure interactions for NUCLEAR APPLICATION

CFD for Nuclear Reactor Safety Applications (CFD4NRS-3) Workshop

AEN NEA

IAEA