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SAFIR2022 FINAL SEMINAR

# EMBER

Enhanced multi-physics calculation capabilities for fuel  
behaviour and reactor analyses

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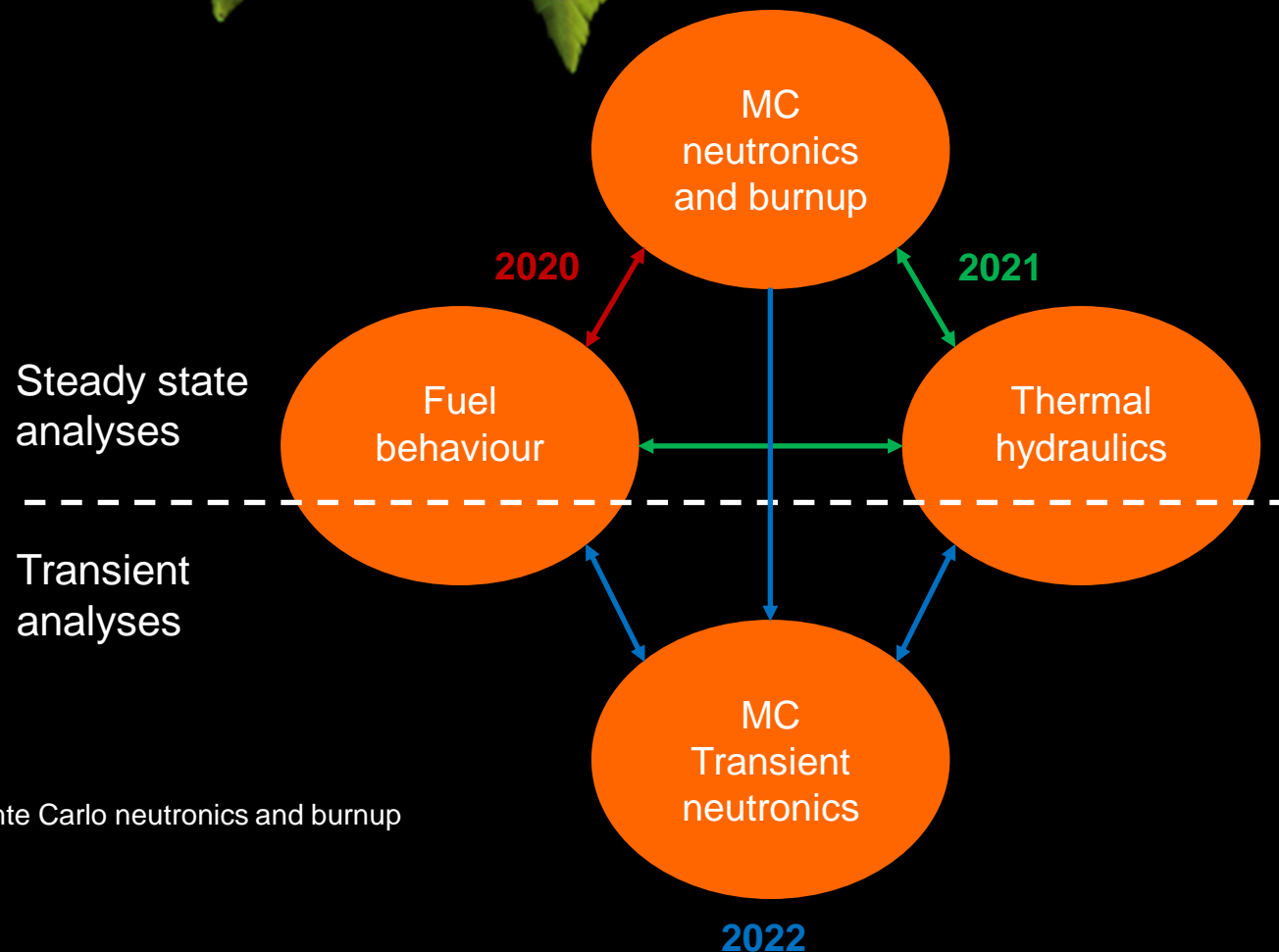
# GENERAL OVERVIEW OF EMBER

»» Developing coupled multi-physics calculation capabilities at LUT

- »» Neutronics, thermal hydraulics and fuel behaviour
- »» Couple existing solvers

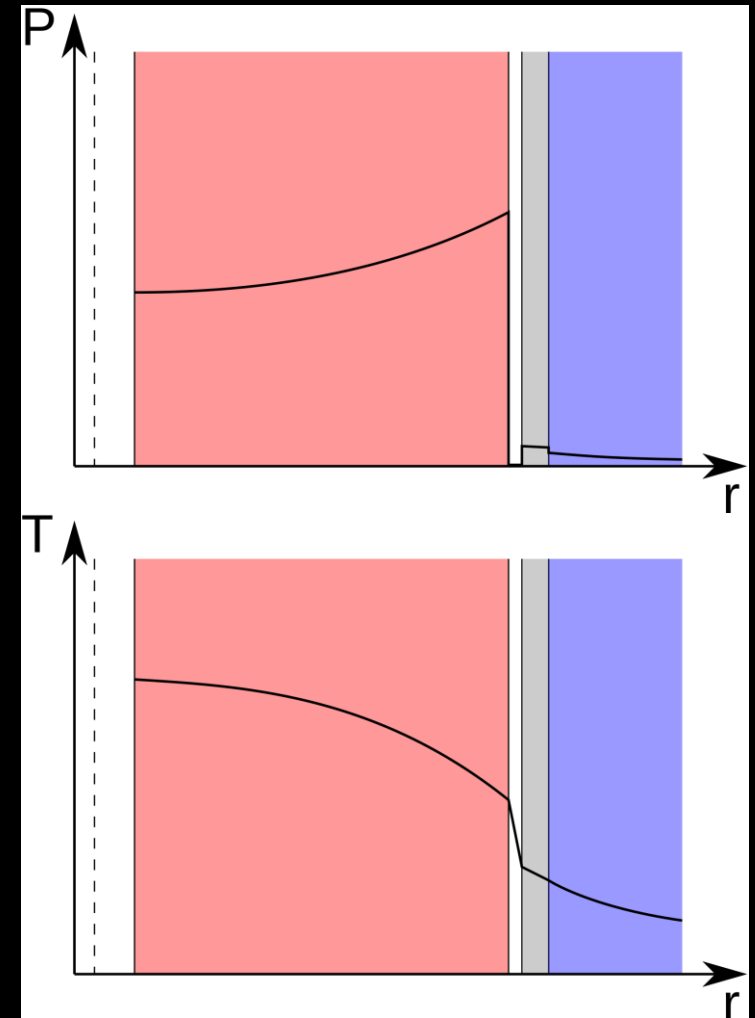
»» EMBER started in 2020:

- »» Extending coupling developed between Serpent and TRANSURANUS by including
  - Possibility to use nuclide concentrations calculated by Monte Carlo neutronics and burnup
  - Solving subchannel thermal-hydraulics
  - Support for transient analyses



# MONTE CARLO REACTOR PHYSICS, 1.5D FUEL BEHAVIOUR CODE AND SUBCHANNEL THERMAL-HYDRAULIC COUPLING

- Fuel behaviour codes
  - Calculates fuel rod behaviour in operation conditions
    - Prevention of fuel failures
  - Traditional 1.5D fuel behaviour code calculates single pin at a time
    - Single pin model not taking neighbouring pins into account
- MC reactor physics provides accurate results
  - Computationally costly
- Subchannel thermal hydraulics
  - Temperature of coolant



# SERPENT-TU-SUBCHANFLOW COUPLING

## »» SUBCHANFLOW

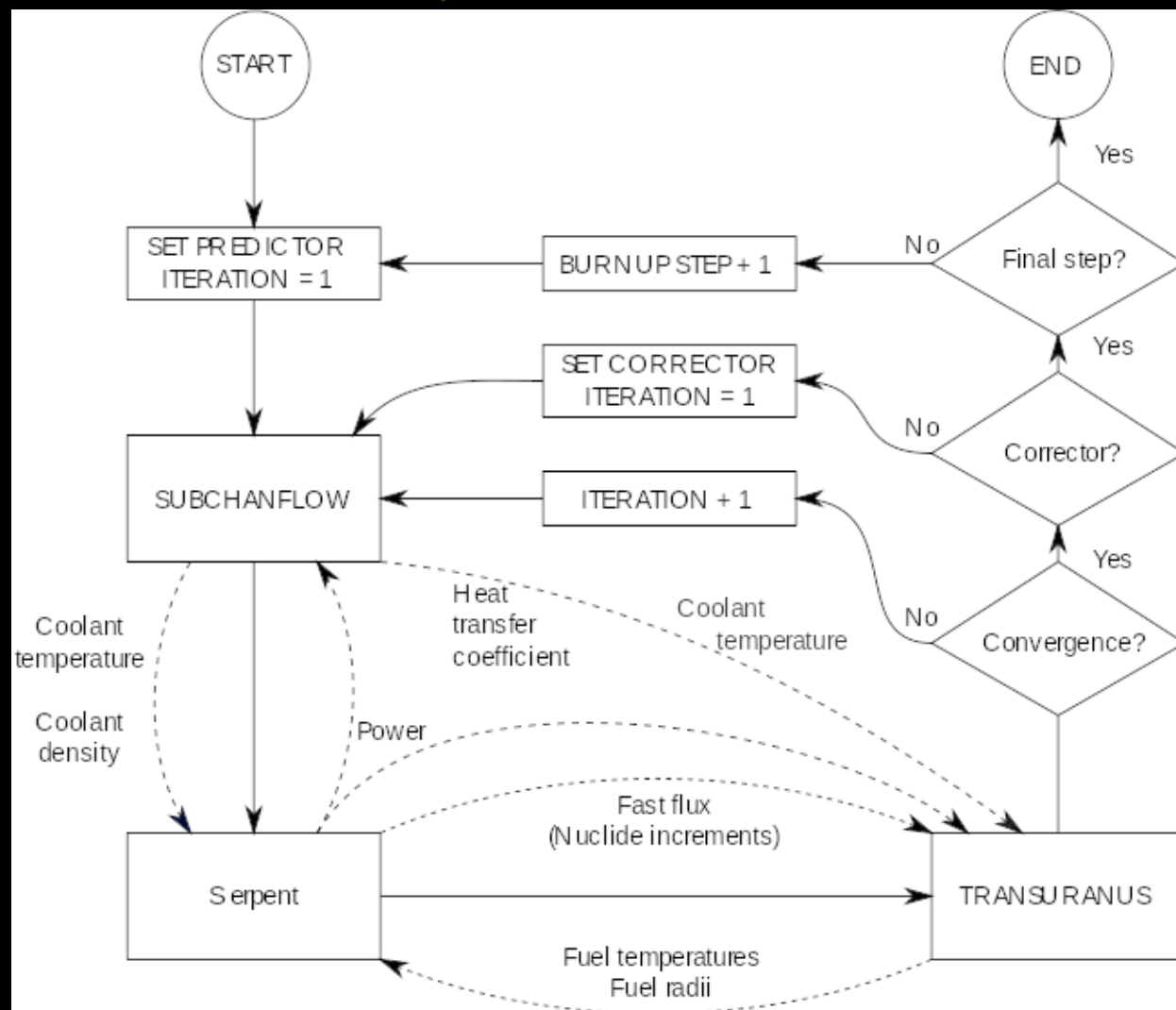
- »» Temperatures and densities of coolant transferred to Serpent
- »» Heat transfer coefficient and coolant temperature to TRANSURANUS

## »» Serpent

- »» Fission power to TRANSURANUS and SUBCHANFLOW
- »» Fast flux in cladding to TRANSURANUS
- »» Nuclide concentrations to TRANSURANUS

## »» TRANSURANUS

- »» Fuel temperatures and radii to Serpent



# RESULTS

- »» Multi-physics coupling code Kytkin was improved during EMBER
  - »» Nuclide transfer from Serpent to TRANSURANUS was implemented to coupling
  - »» Sub-channel thermal hydraulics (SUBCHANFLOW) added to coupling
  - »» Transient coupling implemented between Serpent and TRANSURANUS
- »» Publications
  - »» “Supplementing fuel behaviour analyses via coupled Monte Carlo neutronics and fission product solution”, Nuclear Engineering and Design, Vol. 389, Art. Num. 111668, 2022
  - »» “Development of a Calculation System Coupling Monte Carlo Neutronics, Subchannel Thermal-Hydraulics and 1.5D Fuel Thermo-Mechanics” in PHYSOR2022
  - »» “Coupling Monte Carlo neutronics with thermal hydraulics and fuel thermo-mechanics”, doctoral thesis, Ville Rintala 11/2022

## CONCLUSIONS

- Multi-physics capabilities have been developed during EMBER project
  - Results should be more accurate than with simpler (and faster) methods
    - Coupling can be used to make comparisons and improve development of simpler tools
    - Direct solving of special problems which are known to be challenging with normal tools



# THANK YOU

»» Questions?

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