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Severe Accident Scenario Uncertainty Analysis using the Dynamic Event Tree Method

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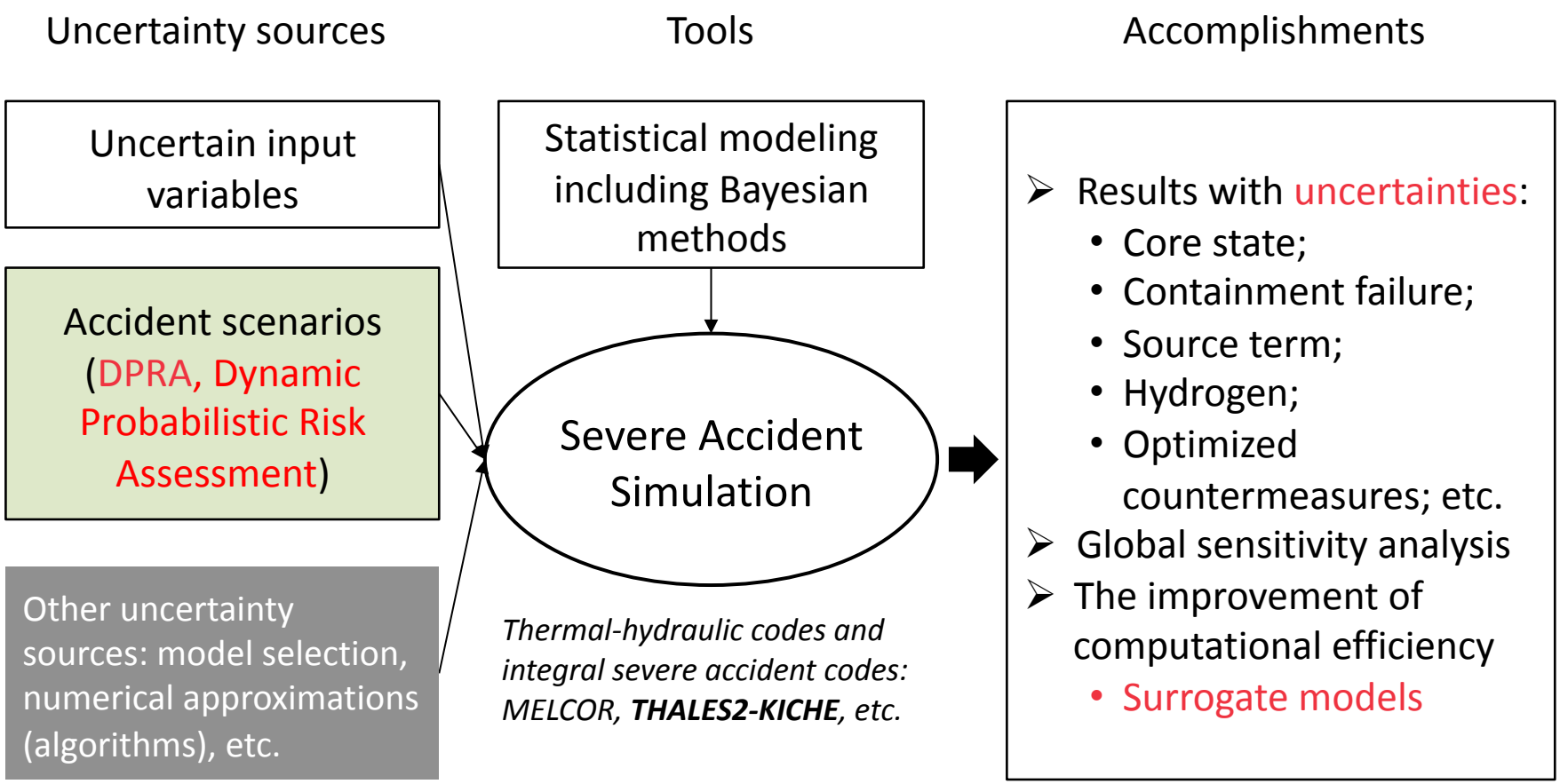
Uncertainty Analysis for Severe Accident Simulation at JAEA

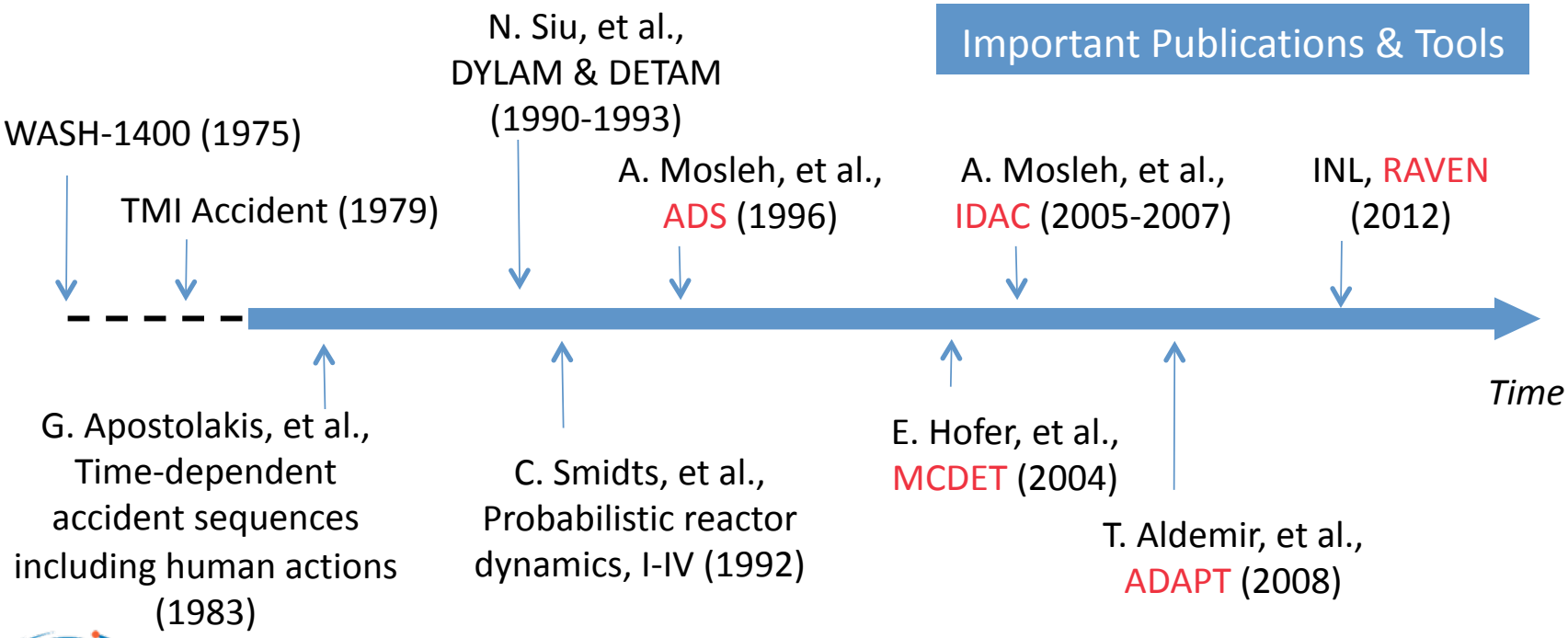


Introduction

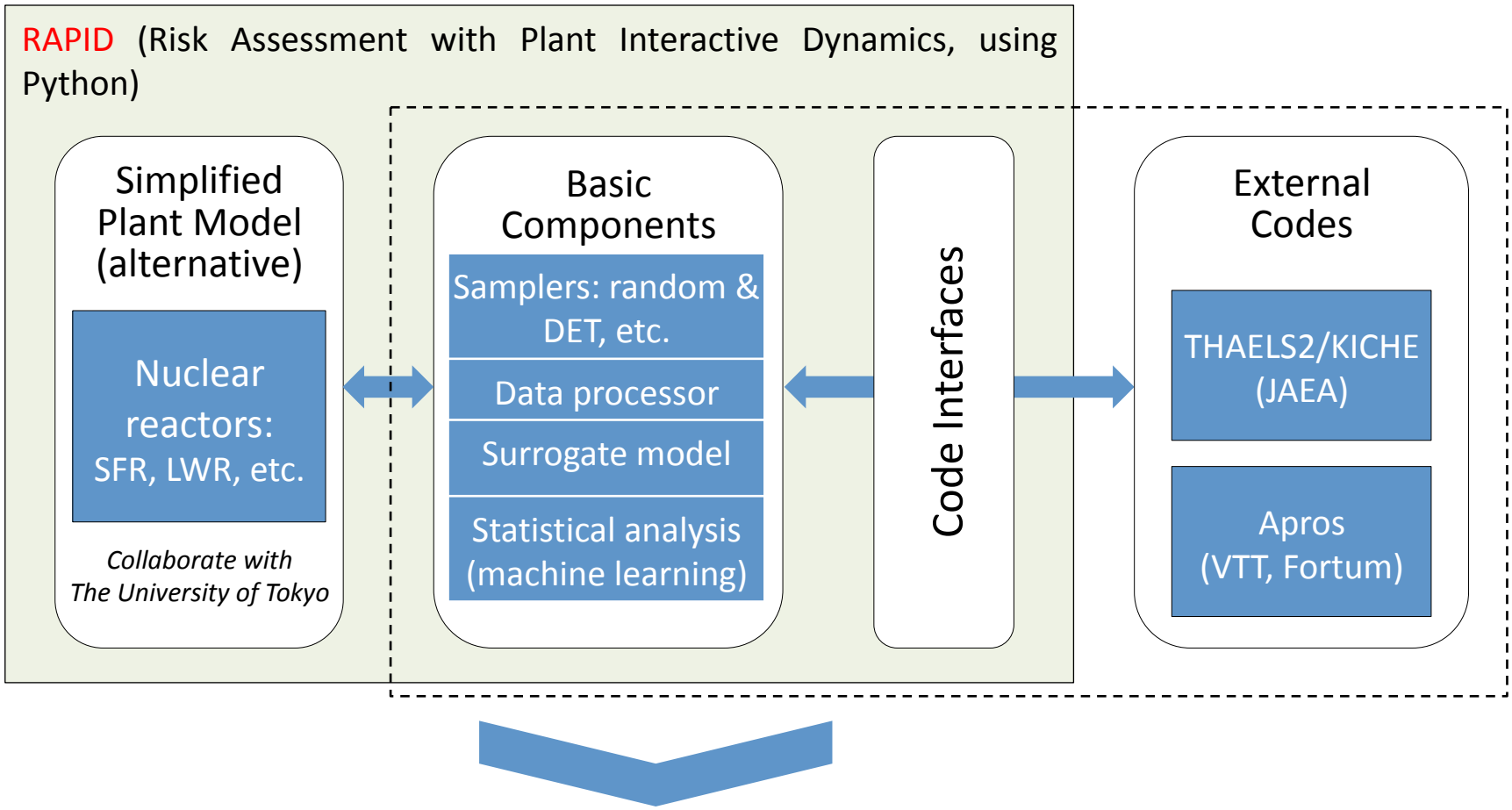
- JAEA started to investigate methodologies of Dynamic Probabilistic Risk Assessment (DPRA) since 2017, under the financial support from Nuclear Regulatory Authority (NRA) of Japan.
- The objective is to develop methods and tools for risk quantification of nuclear power plants, including Level 1 and Level 2 PRA.
- This presentation:
  - Review of DPRA methods and tools
  - Introduce the framework of a JAEA-developed DPRA tool, RAPID
  - A preliminary computational test

Review of DPRA Researches

- Dynamic PRA: model-based simulation approaches for generating risk scenarios; tightly coupled with severe accident simulation codes.
- Own tool coupling with severe accident codes, to extend source term uncertainty analysis and PRA, etc. at JAEA.



Code Structure of the DPRA tool: RAPID

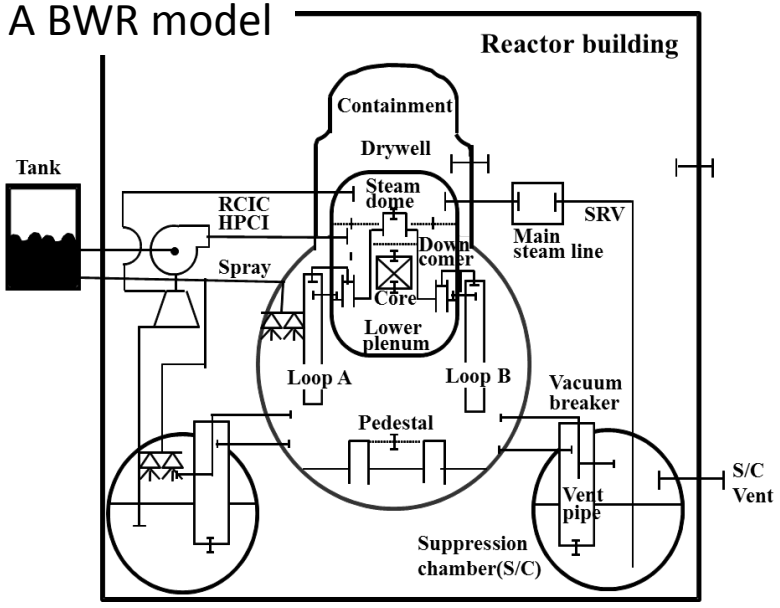


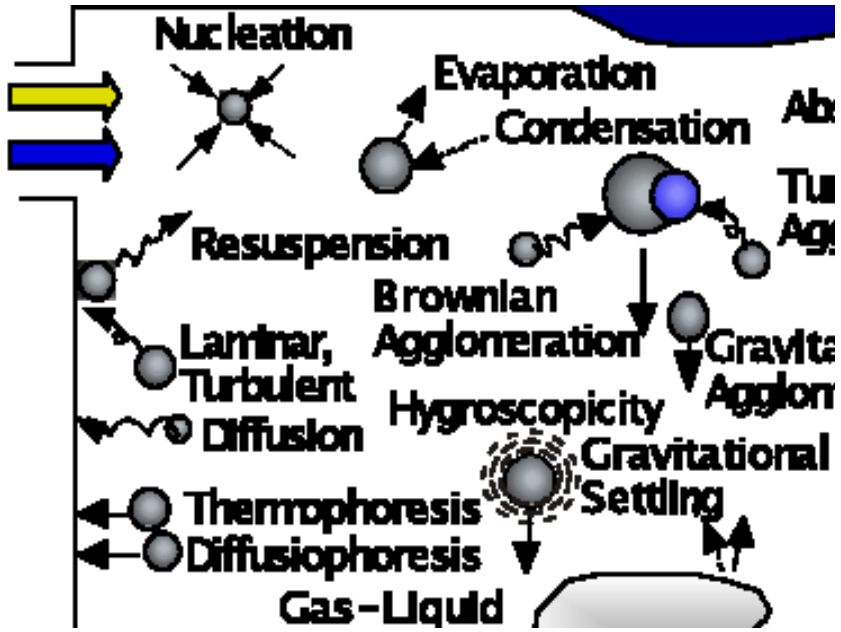
Simulation-based risk quantification for Level 1 & 2 PRA

Severe Accident Simulation using THALES2/KICHE

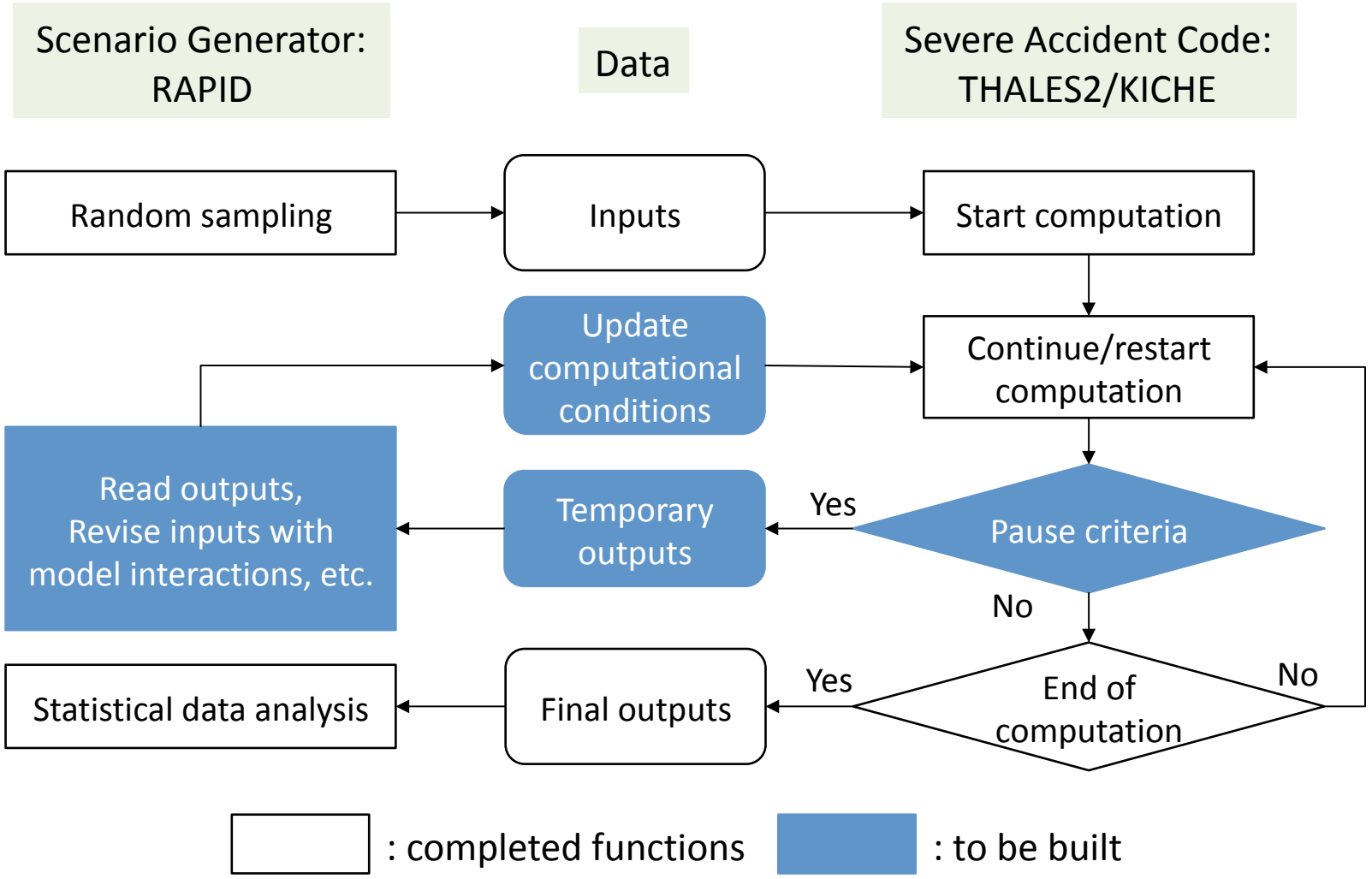
THALES2/KICHE	
THALES2 ➢ Fast running capability with simplified modeling for thermal-hydraulics and core melt progression ➢ Covering major phenomena for in-vessel and ex-vessel transport of radioactive materials	KICHE ➢ Mechanistic modeling for iodine chemical reaction kinetics in aqueous phase

A BWR model



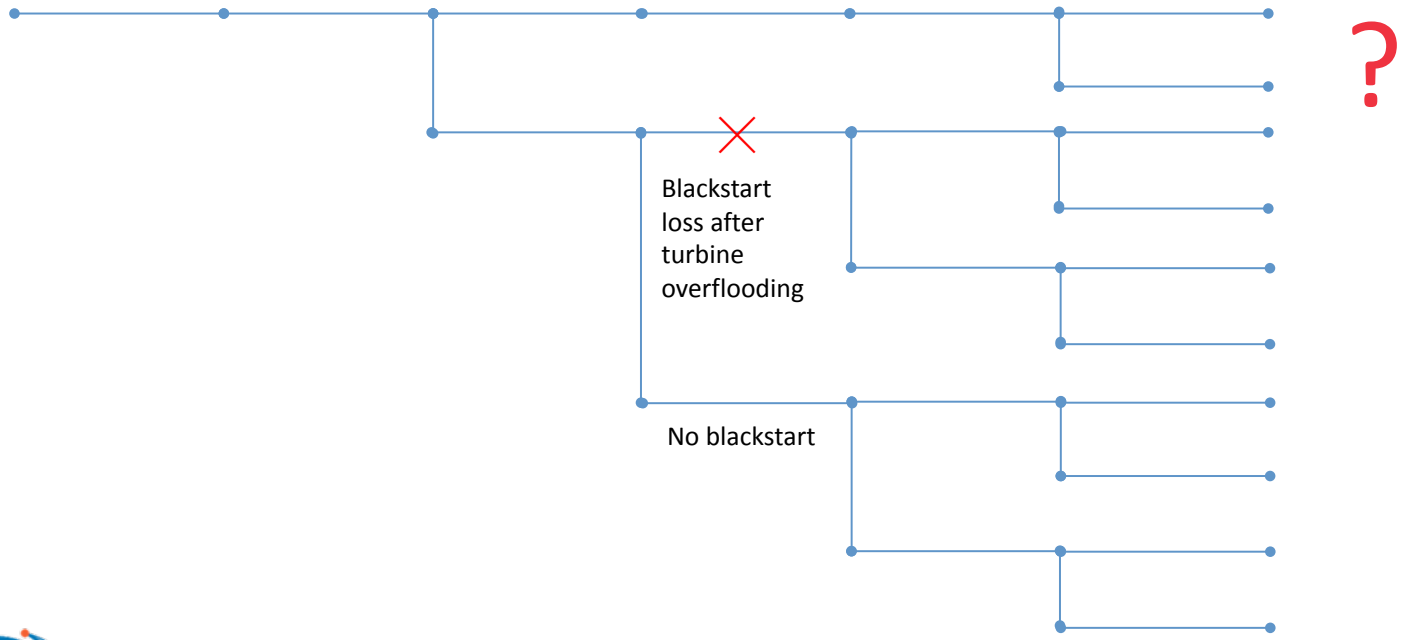


Interface between RAPID and THALES2/KICHE



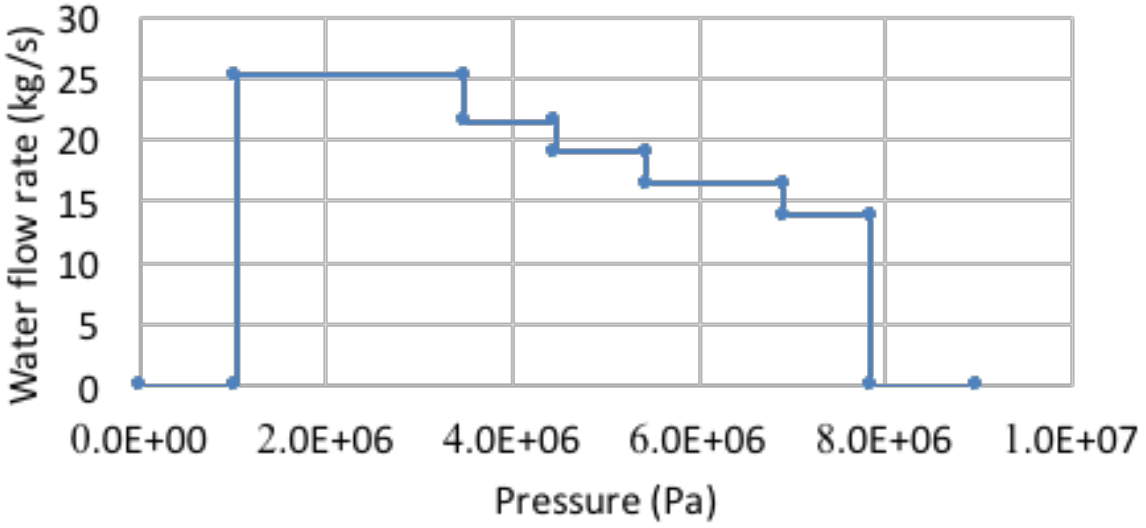
A Simplified Event Tree Model of Station Blackout (SBO)

Total loss of offsite AC power and all EDGs (onsite AC power)	Reactor scram, reactor isolation, containment isolation	DC power (duration)	Steam-driven RCIC & HPCI (pressure-dependent water flow rate)	Recovery of EDGs (timing, status, etc.)	Reactor SRVs (stochastic and thermal failures)	Core Damage Status

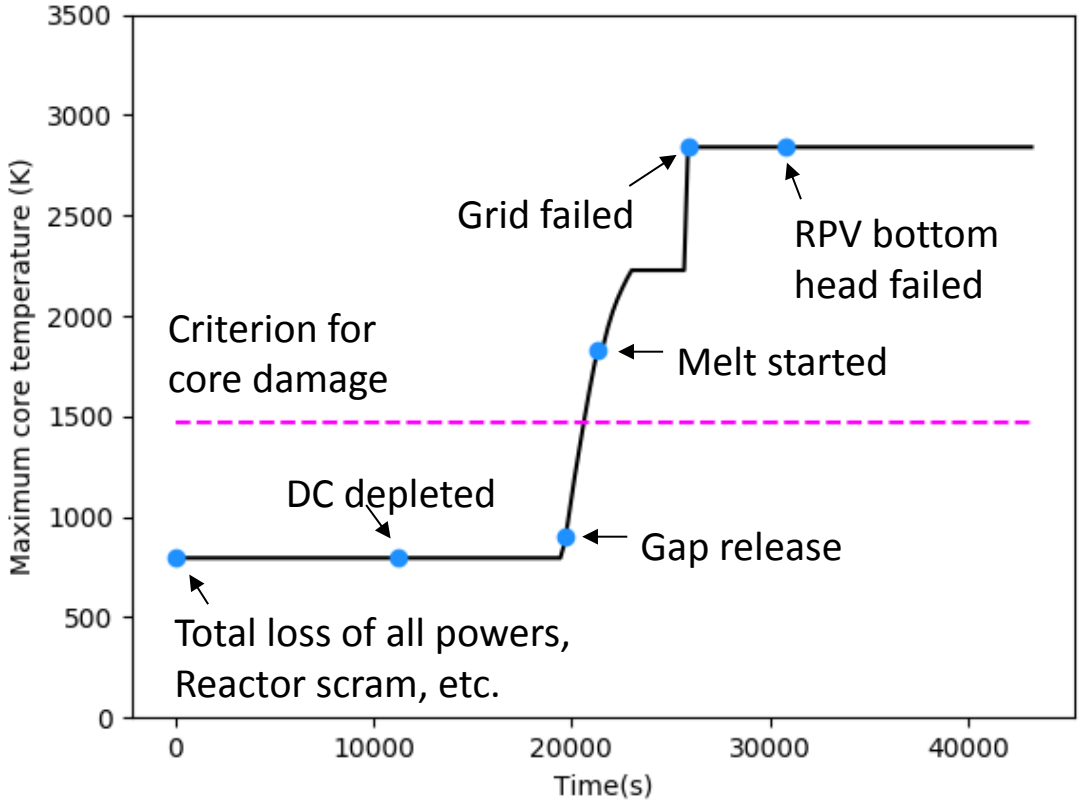


Interactions between ET model and Accident Simulation

- Dependency may exist between ET model and accident progression.
- A hypothetical model for RCIC water flowrate that depends on the pressure of the coolant system of BWR (Proportional or inversely proportional)
- Seamless interaction between the controller and severe accident simulation is expected to be created using output monitoring function in RAPID.

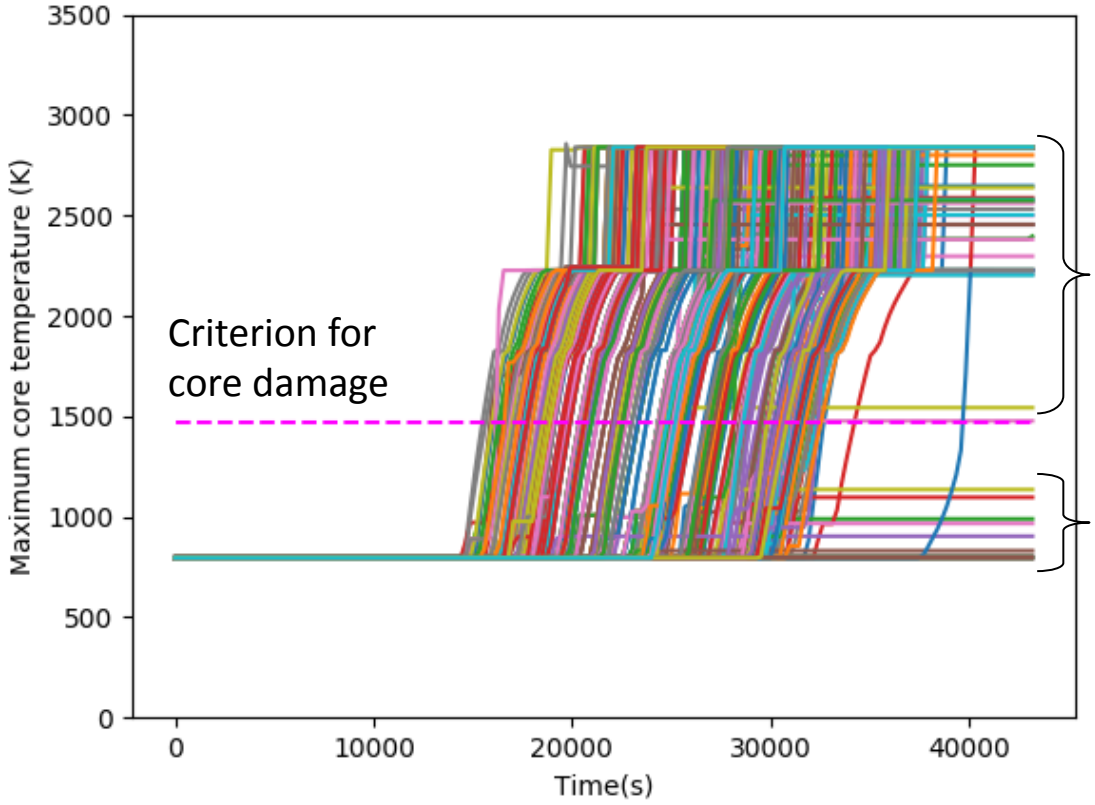


A Typical Accident Sequence Sampled via DET



Results

500 times of severe accident simulations



Group 1: 434 cases
Conditional Pr=0.868
(tentative results, with hypothetical setting of probabilistic models)

Group 2: 66 cases
Conditional Pr=0.132

Summary and Future Plan

- We have started the dynamic PRA research at JAEA, for a better risk quantification of nuclear power plants.
- A statistical tool, RAPID, is created to couple with severe accident codes for the realization of risk assessment, including uncertainty analysis, surrogate modeling, etc.
- Current analysis is still immature, and RAPID is not user-friendly. More attributes should be developed for further research.
- The interaction between RAPID and severe accident codes, is a main topic in future, including the realistic modeling of dependency between ET and severe accident simulation.