Analysis of a Reactivity Transient for the DIDO Type Research Reactors Using RELAP5

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ENS RRFM 2006
10th International Topical Meeting on Research Reactor Fuel Management (RRFM)
Sofia, Bulgaria 30 April – 3 May 2006

Outlines

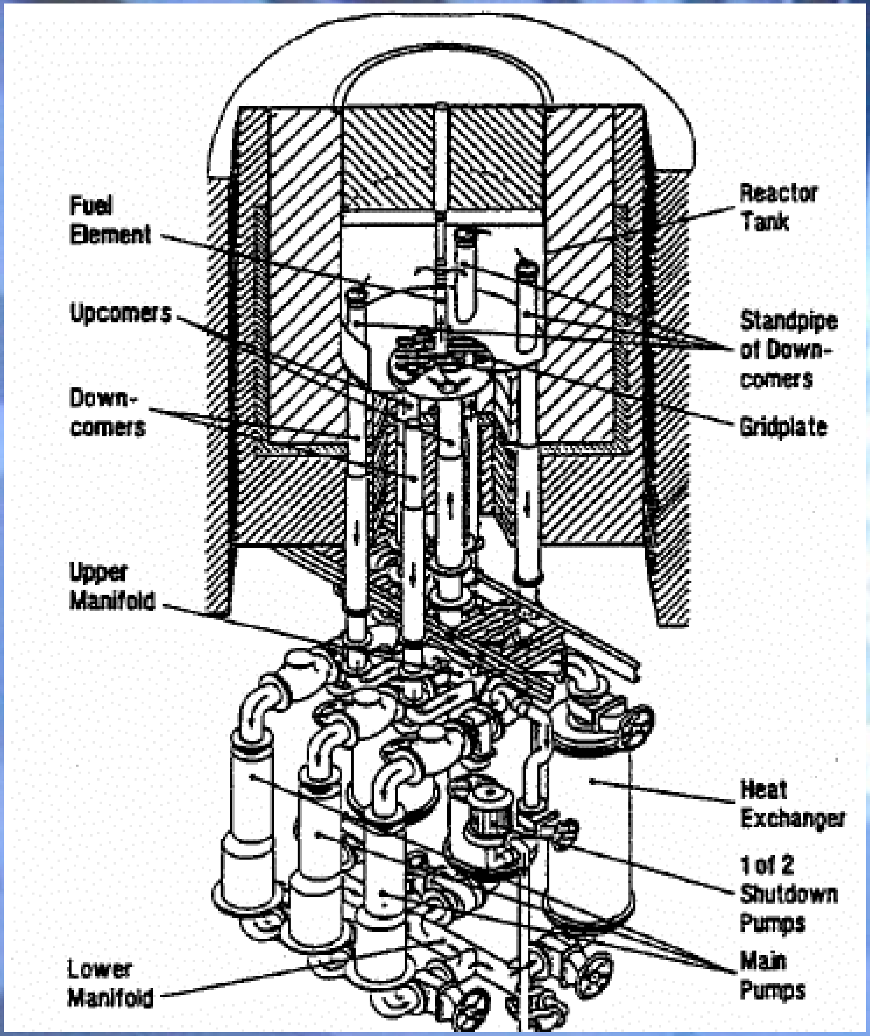
- Need for the application of Best Estimate method for RR safety analysis
  - Reduction of conservative safety margins
  - Mitigation of constraining limits
- Application of BE thermalhydraulic codes for the analysis of RR transients (RELAP5/mod3.3 & CATHENA)
- Comparison of the results for an anticipated fast reactivity transient
- Consequences of the transients
- Conclusions

Objective of the Work

- The work mainly aims at the comparison of the results of the two sophisticated codes under the consideration of the modelling differences and the numerical approaches respectively.

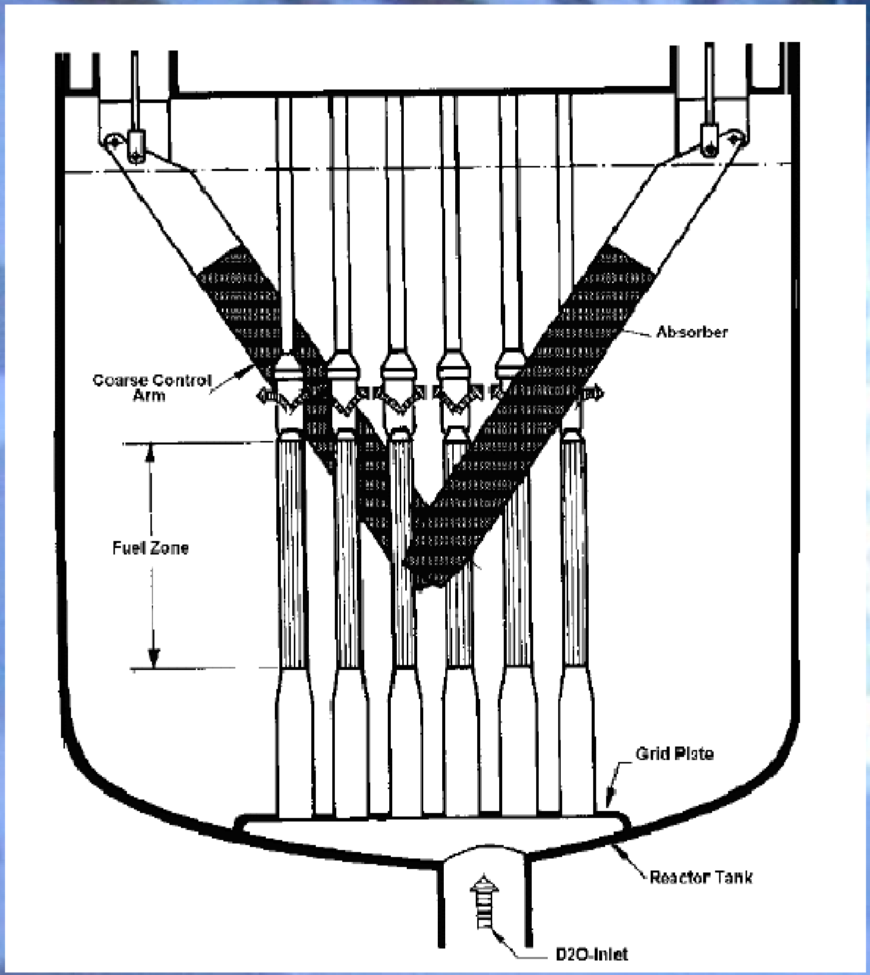
- The simulation is related to a hypothetical fast reactivity transient, which is assumed to be caused by the failure of one shutdown arm during the reactor operation causing a reactivity insertion by an amount of **2.7%dk/k** during the reactor operation. .

Reactor Block and Primary Components

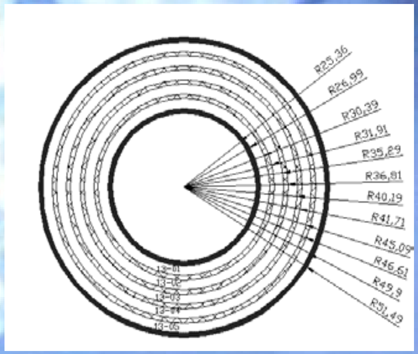


- Tank type RR
- 23 MW
- Graphite reflector
- Moderator and coolant: heavy water at atmospheric pressure
- Use:
  - material research
  - irradiation purposes

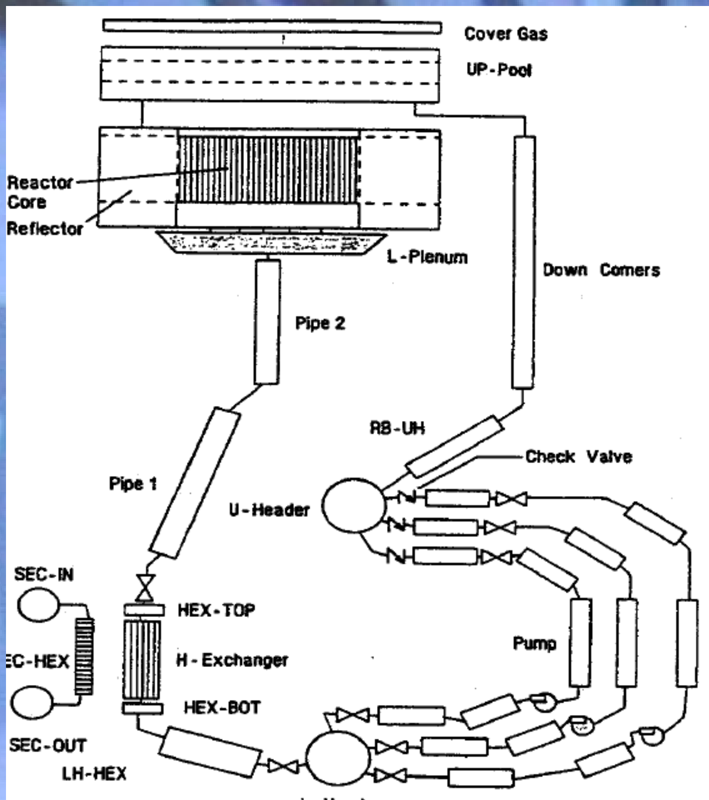
Vertical cross section of Al Tank



- 25 tubular MTR HEU FEs cooled by upward flow of D2O
- 6 CCAs (operation and shut down)
- 3 Rapid Shut Down Rods



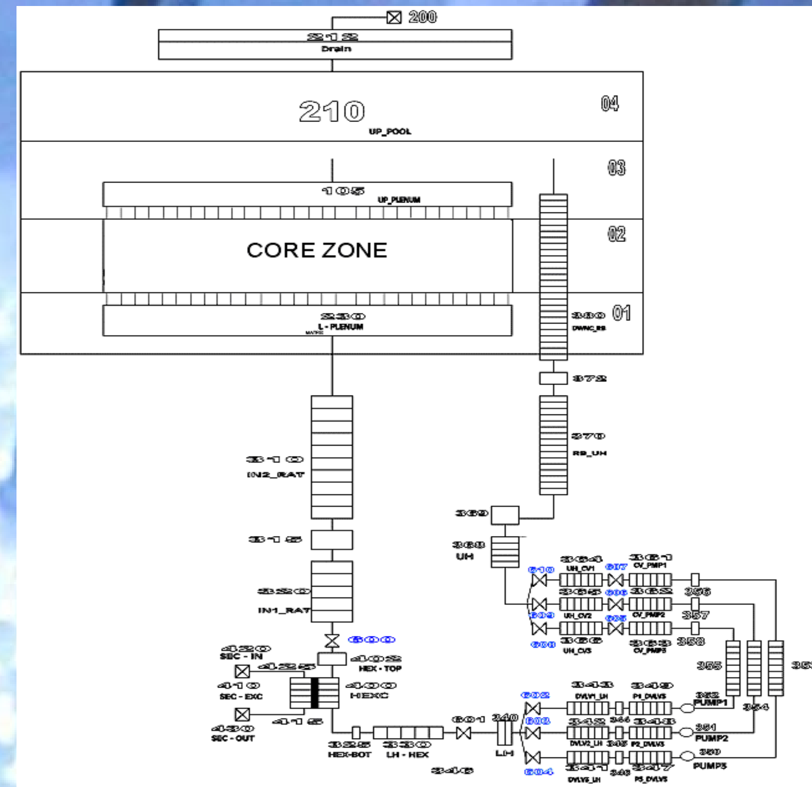
CATHENA nodalization



FRJ 2 Research Reactor

Cathena input deck

General scheme

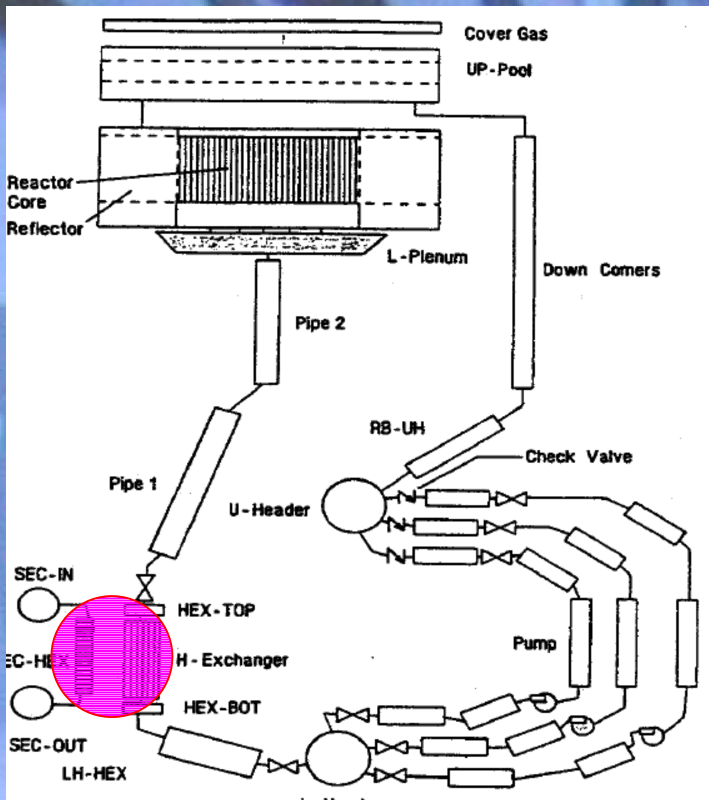


FRJ 2 Research Reactor

Relap5 mod3.3 input deck

General scheme

CATHENA nodalization



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Cathena input deck

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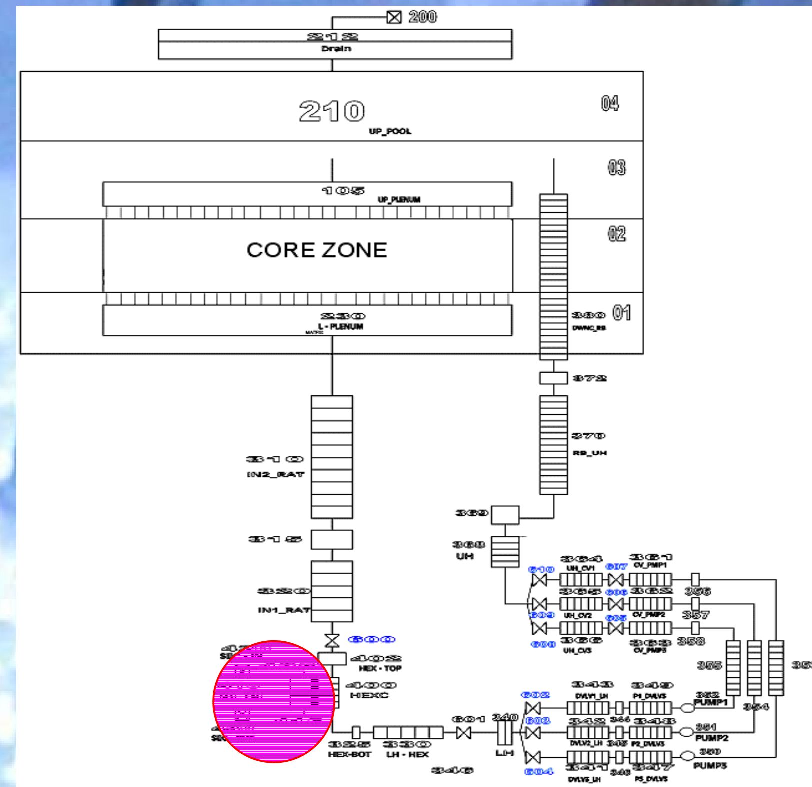

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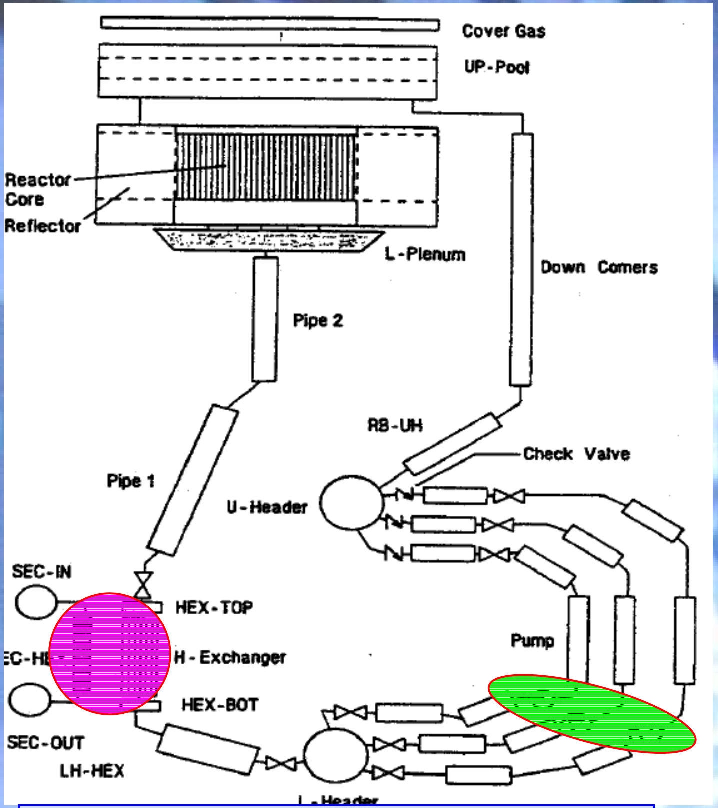

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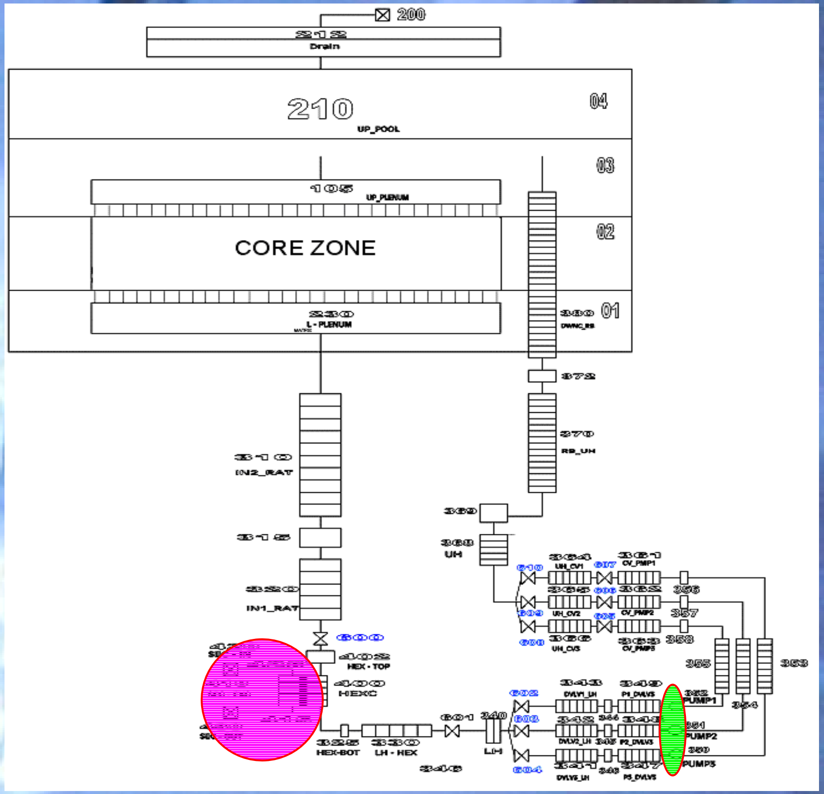

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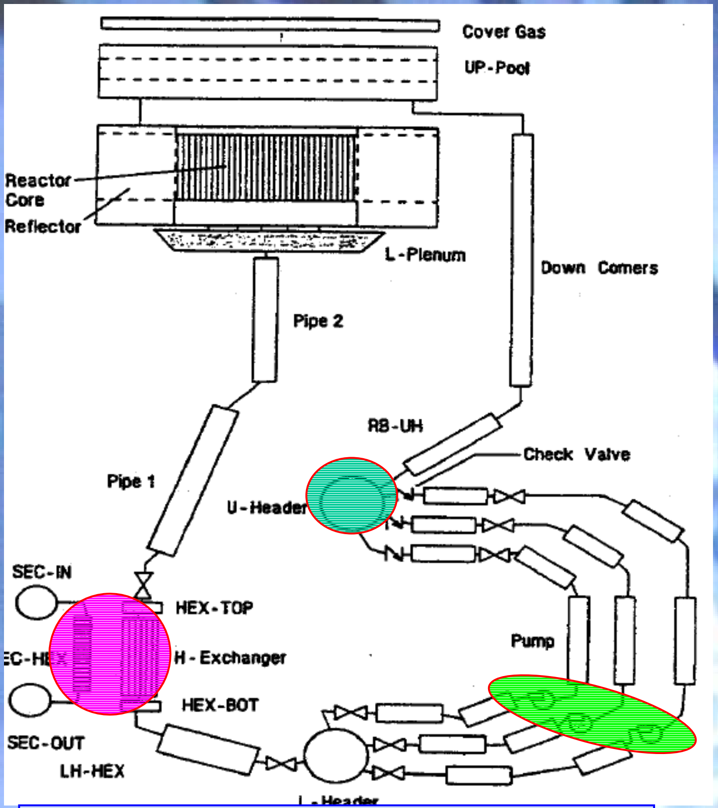

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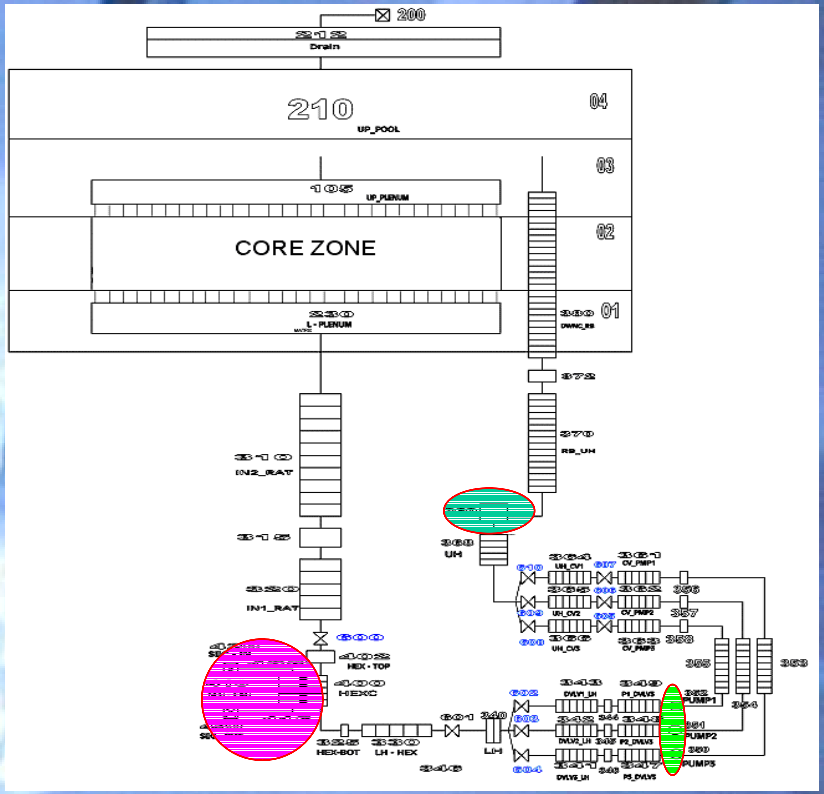

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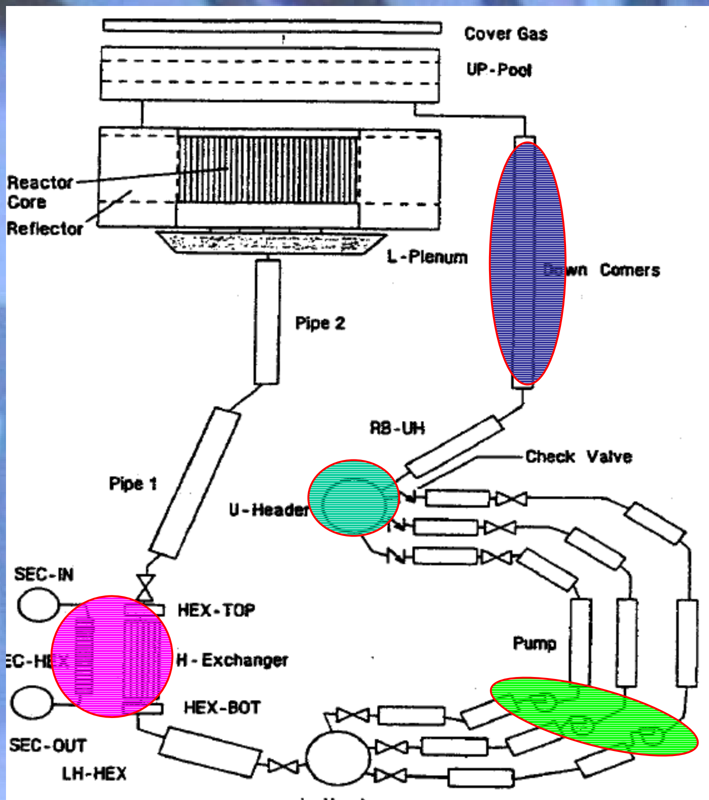
General scheme

CATHENA nodalization



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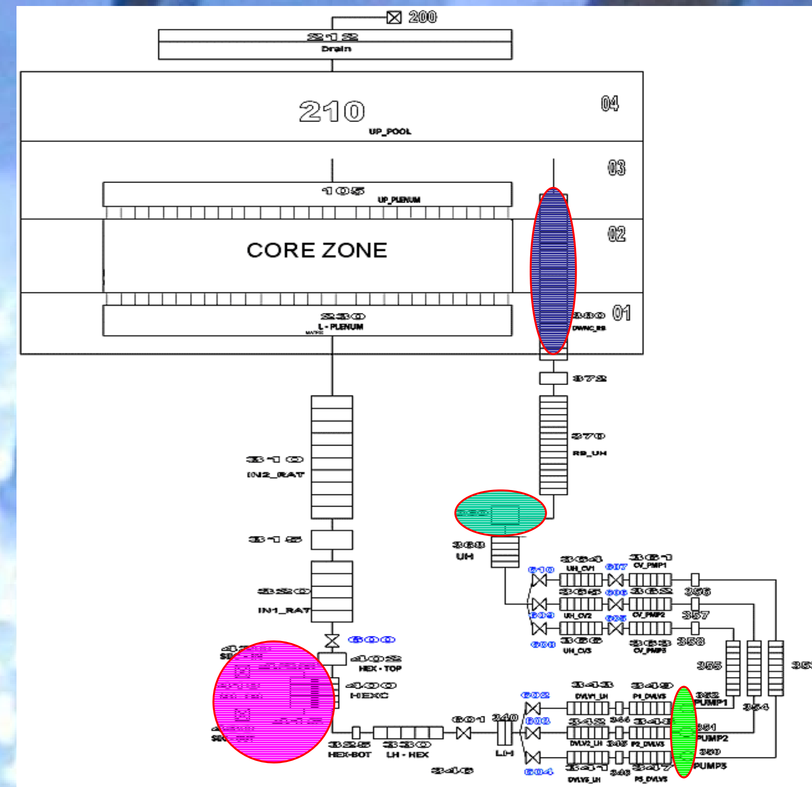

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Relap5 mod3.3 input deck

General scheme

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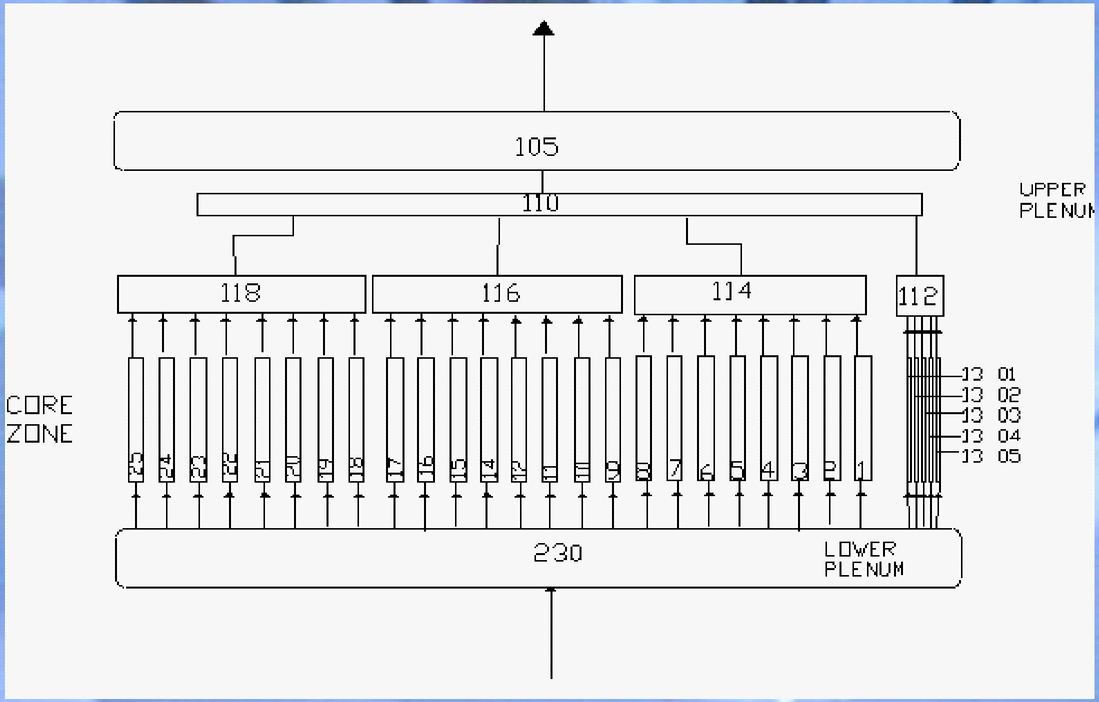
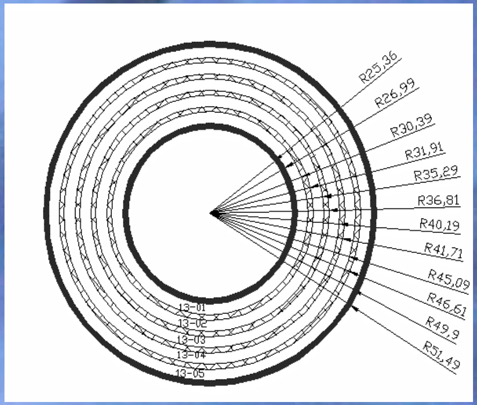
RELAP5 Core Zone nodalization





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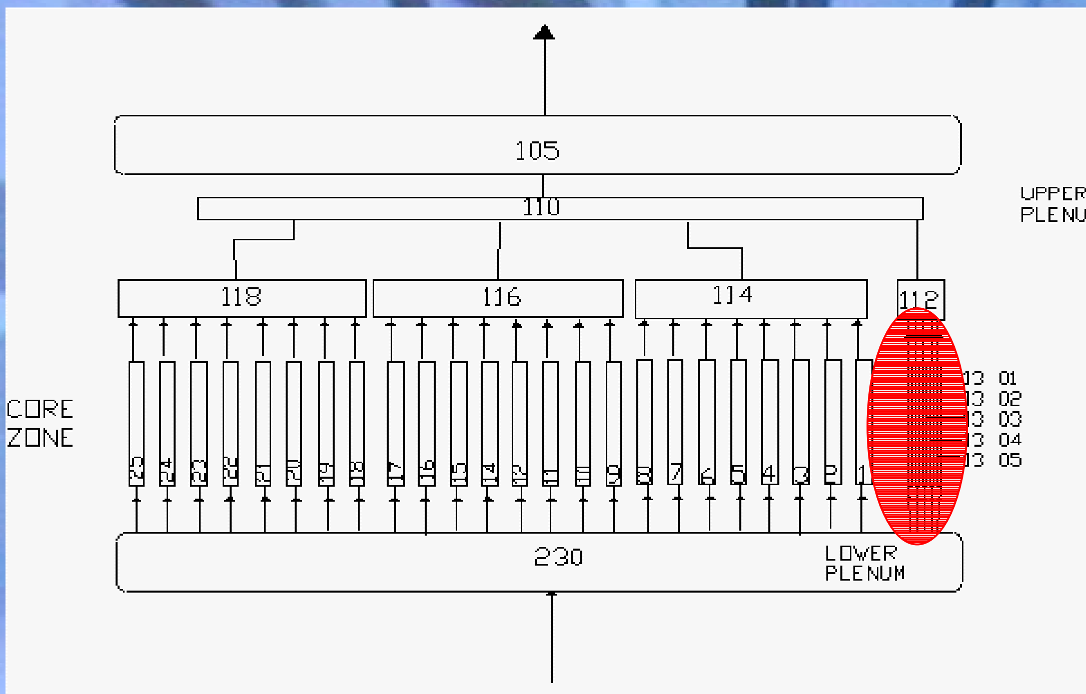

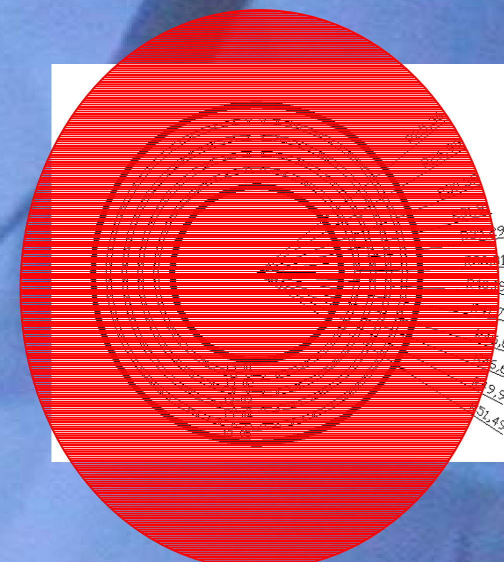

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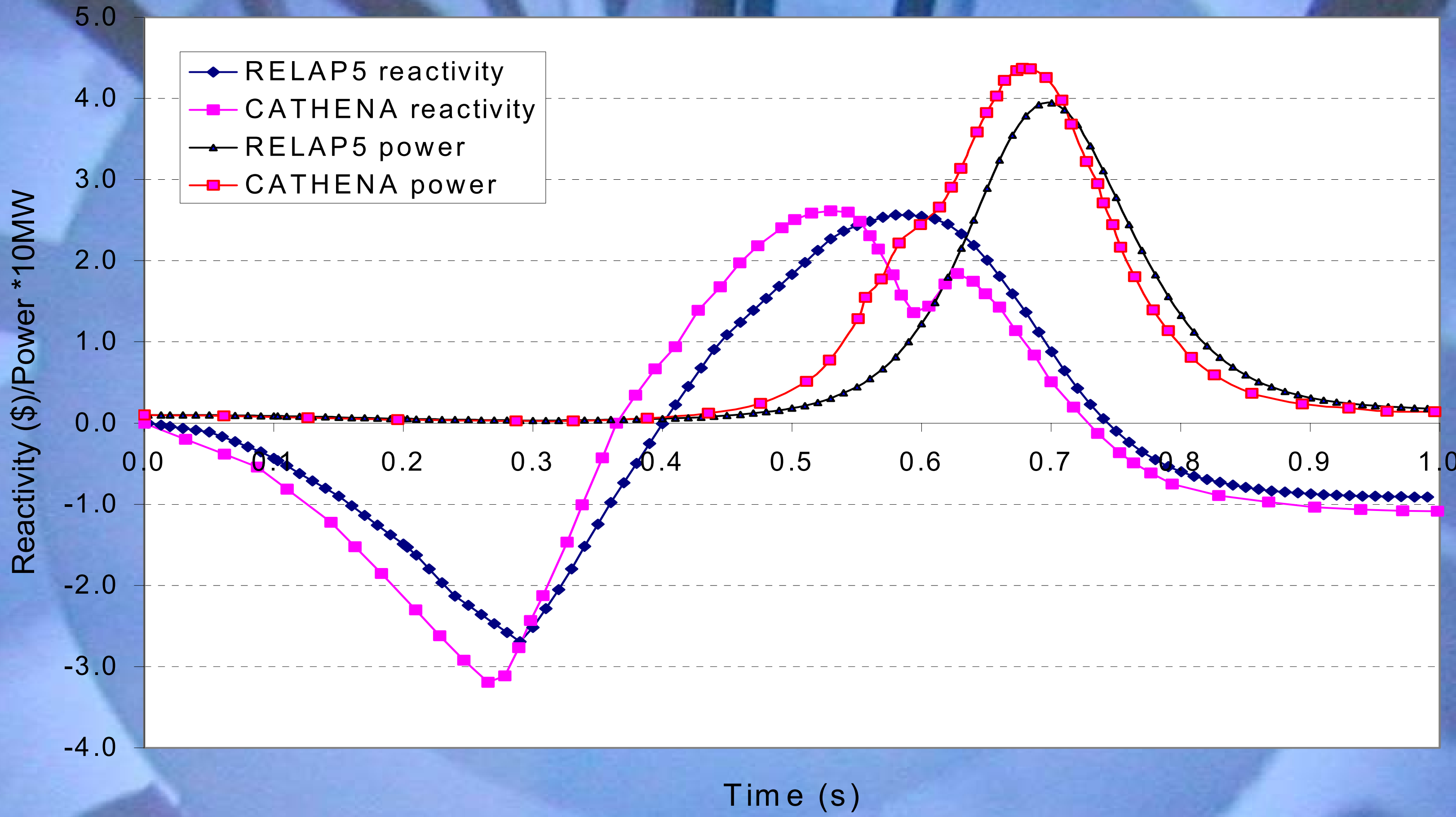
Description of the transient

Hypothetical fast reactivity transient

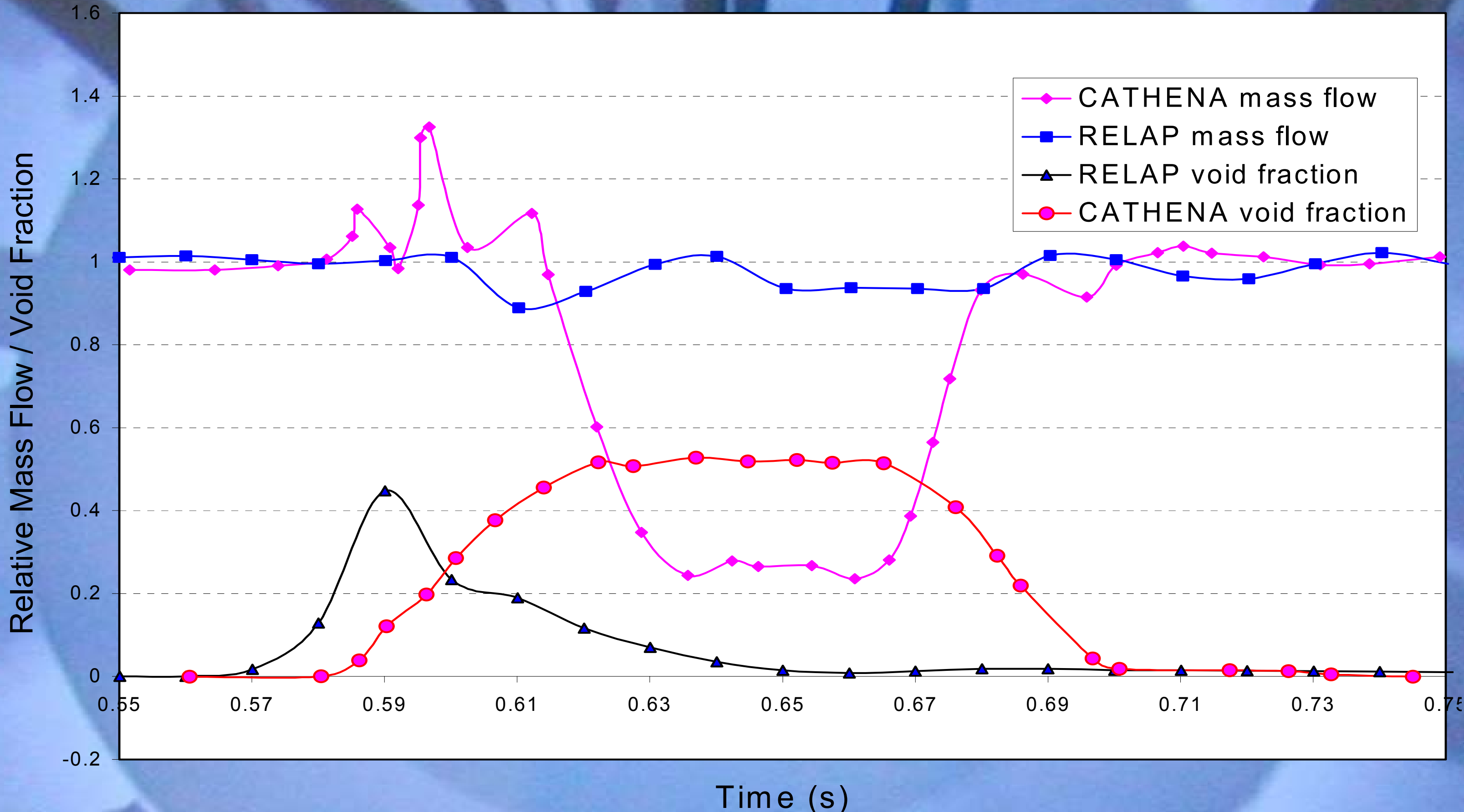
Transient key Parameters	RIA
Initial power (MW)	Nominal 23 MW
Scram setting point	Disabled
Maximum reactivity absorption	$ 2.8 (1.9%dk/k)
Maximum reactivity insertion	$ 3.3 (2.27%dk/k)

Results



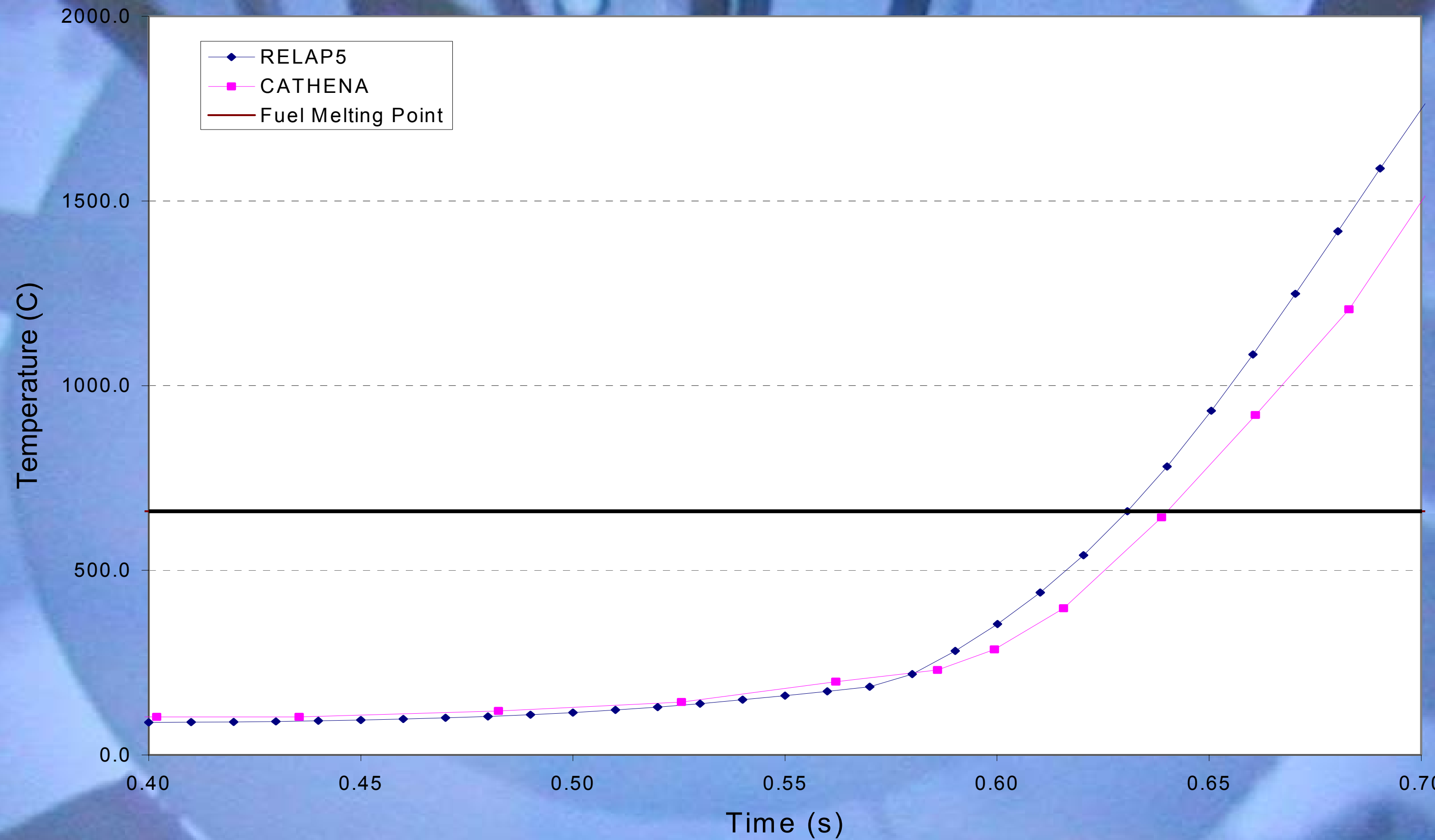
Reactivity/Core Power

Results



Mass Flow / Void Fraction

Results



Fuel Temperature

Conclusions

- RELAP5 until now has been mainly used for the analysis of nuclear power systems.
- The RELAP5 results were assessed by considering the **code-to-code comparison** using the results of the system code CATHENA.
- In both codes it is clear that the hypothetical accident would cause **damage** in the core.
- Due to the fast course of the transient and slow response of the cooling system a **rapid rise of the fuel temperature** takes place; both codes predict fuel temperatures **exceeding the melting point** resulting in fuel element damage
- Due to forced convection only a small fraction of the external reactivity added to the core is compensated by the temperature feedback mechanism.

Conclusions

- The results of the two codes are in agreement in the **initial phase** of the transient.
- Differences appear when the flow regime undergoes to **fully developed nucleate boiling**.
- The possible reasons are related to:
  - heat transfer correlations
  - correlations and criteria for transition boundaries between the flow regimes
  - numerical errors under low pressure conditions – large variations in the numerically calculated void fraction.
- The analysis of the differences with respect to the models is subject to further investigations.