

**NUCLEAR ENGINEERING**  
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# RELAP5-3D Simulations of Hot Leg Break LOCA Scenarios

International RELAP5-3D User's Group Meeting  
Idaho Falls, ID  
October 6-7, 2016

Presenters: **Rodolfo Vaghetto and Alessandro Vanni**



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# Content

- Intro
- Input Model Description
- Simulation Results
- Core Exit CCFL Sensitivities

No Proprietary Information Disclosed  
ML15246A126 – A129



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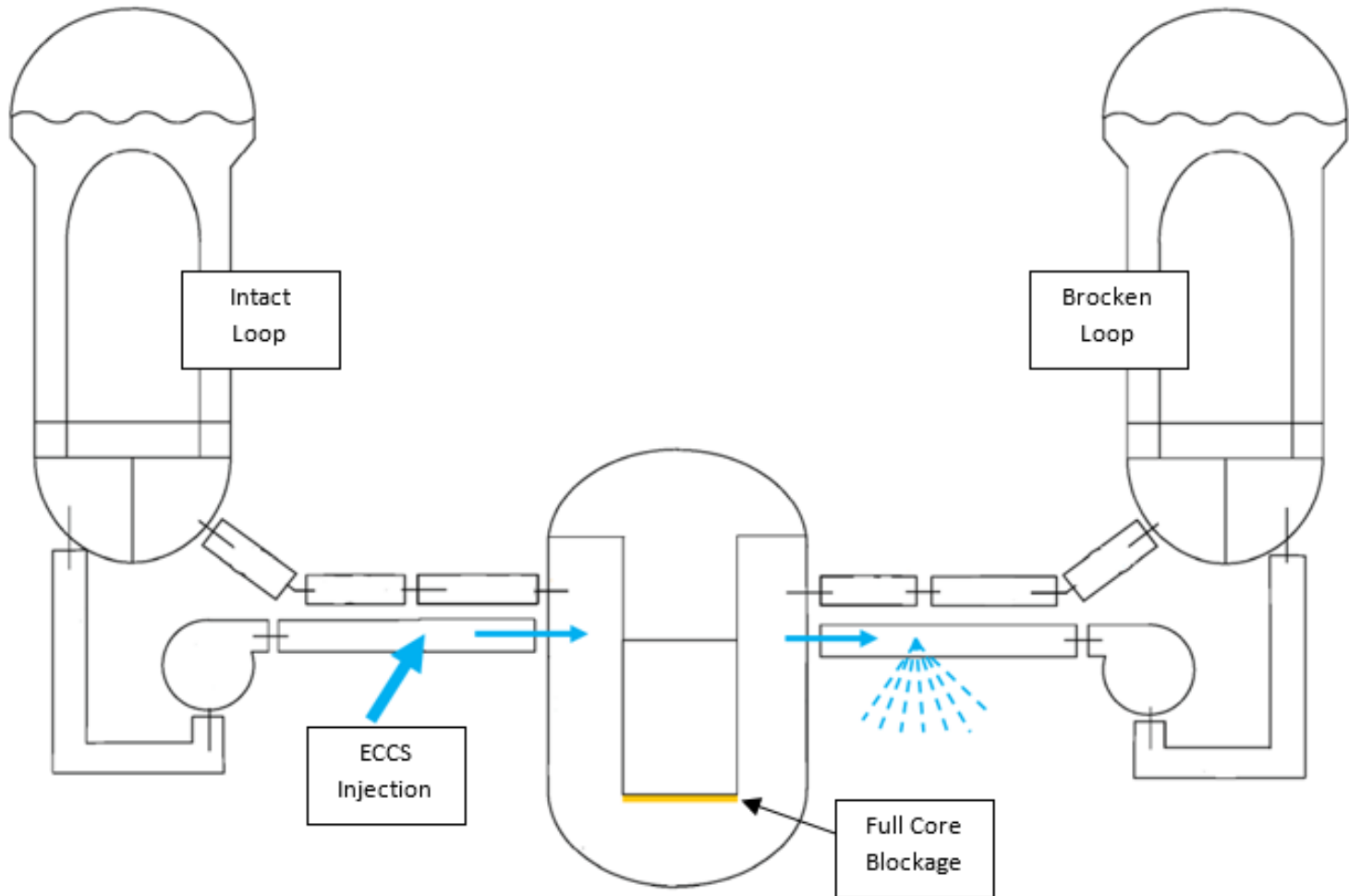
# Intro



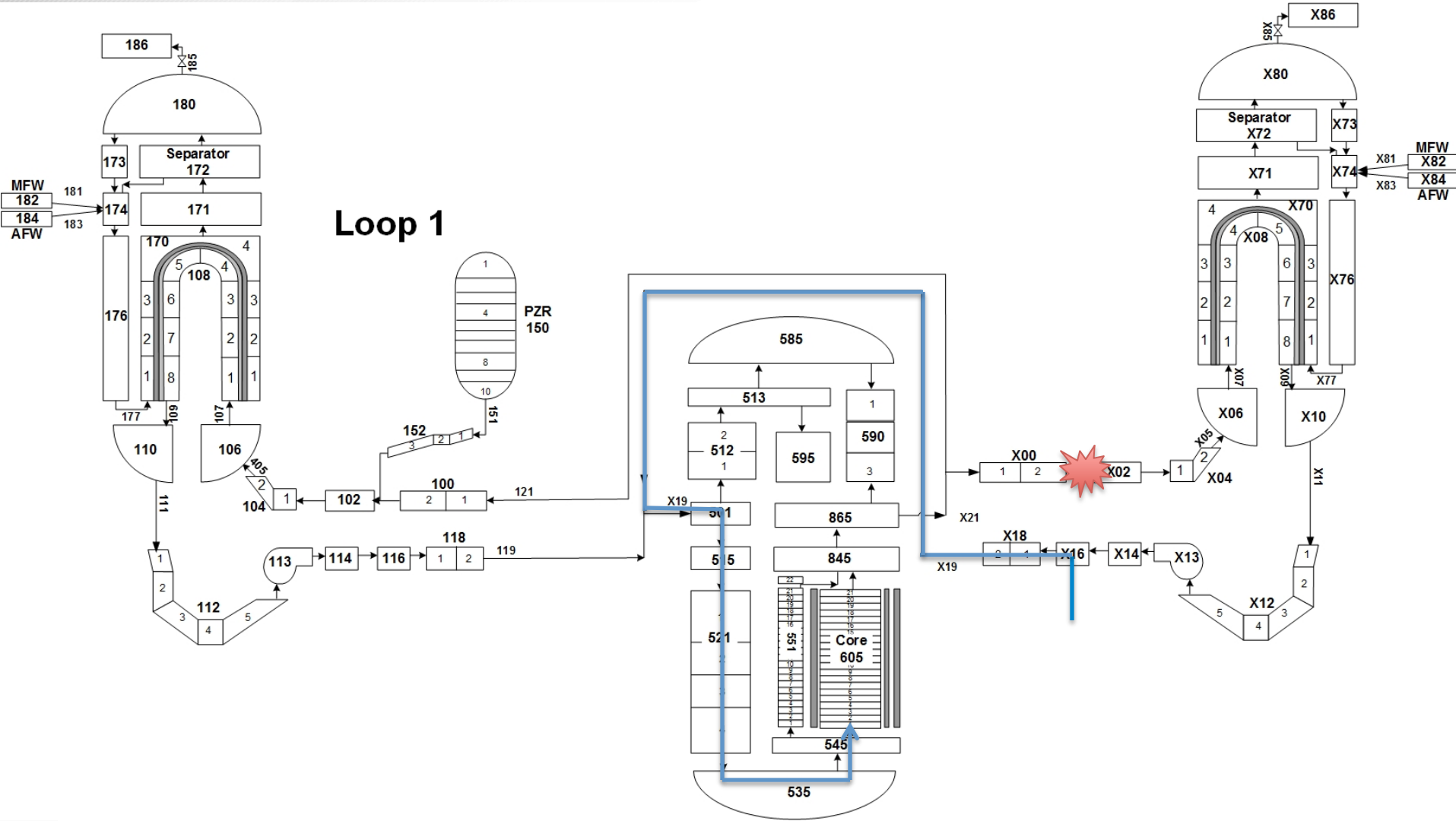
# LOCA Long Term Core Cooling (LTCC)

- Emergency Core Cooling System – ECCS - pumps deplete RWST
- Water from the containment sump is injected into the primary system
- Debris is carried into the primary system
- Core coolability may be compromised
- Alternative flow paths

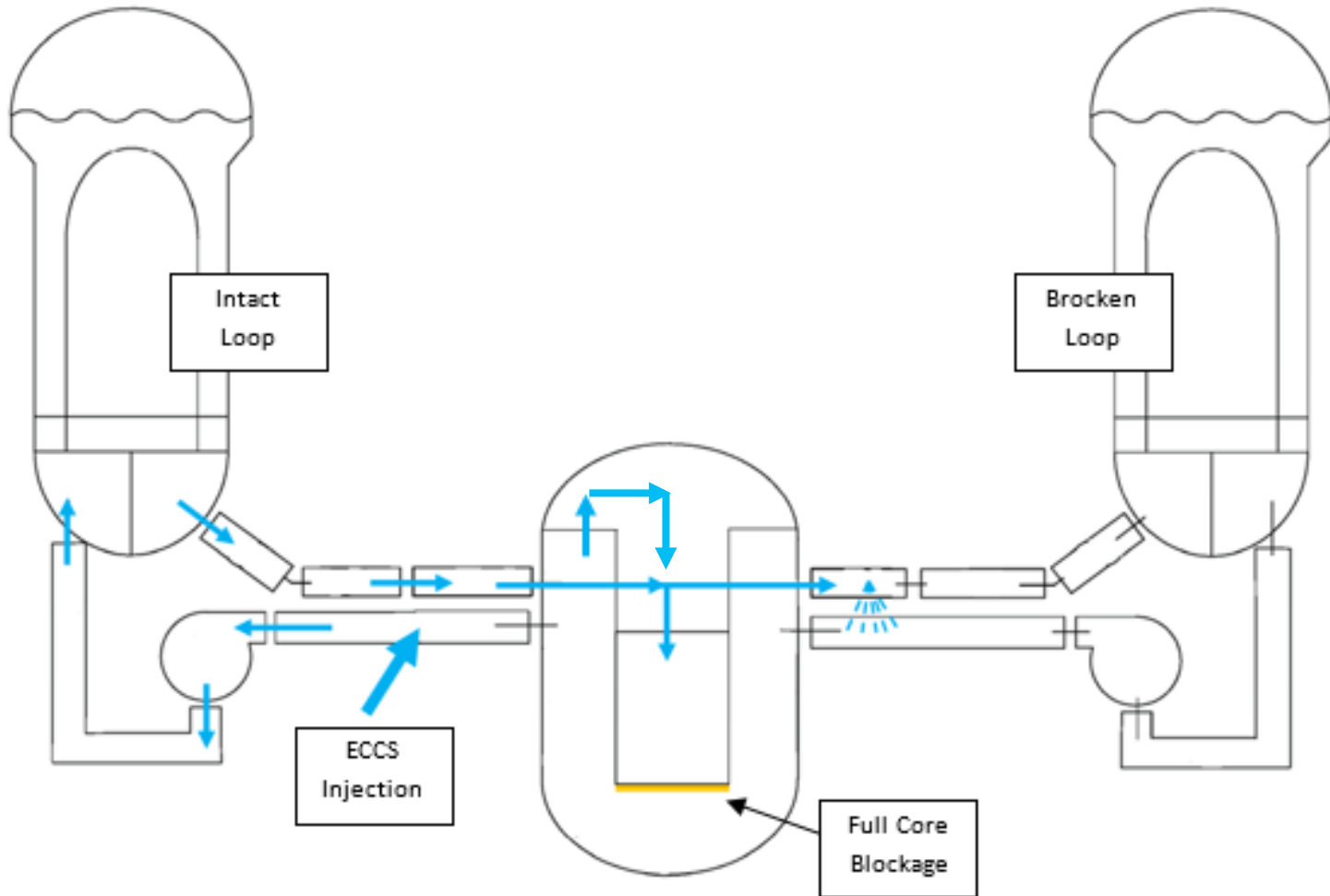
# GSI-191: Cold Leg Break Scenarios



# GSI-191: Hot Leg Break Scenarios

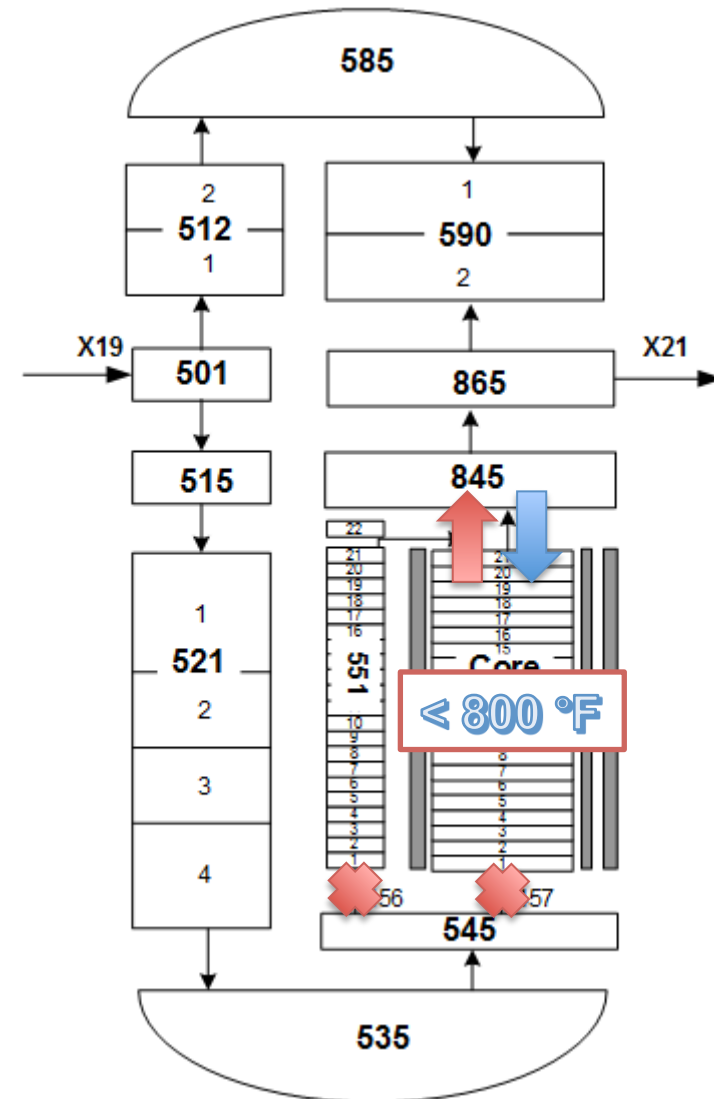


# GSI-191: Hot Leg Break Scenarios



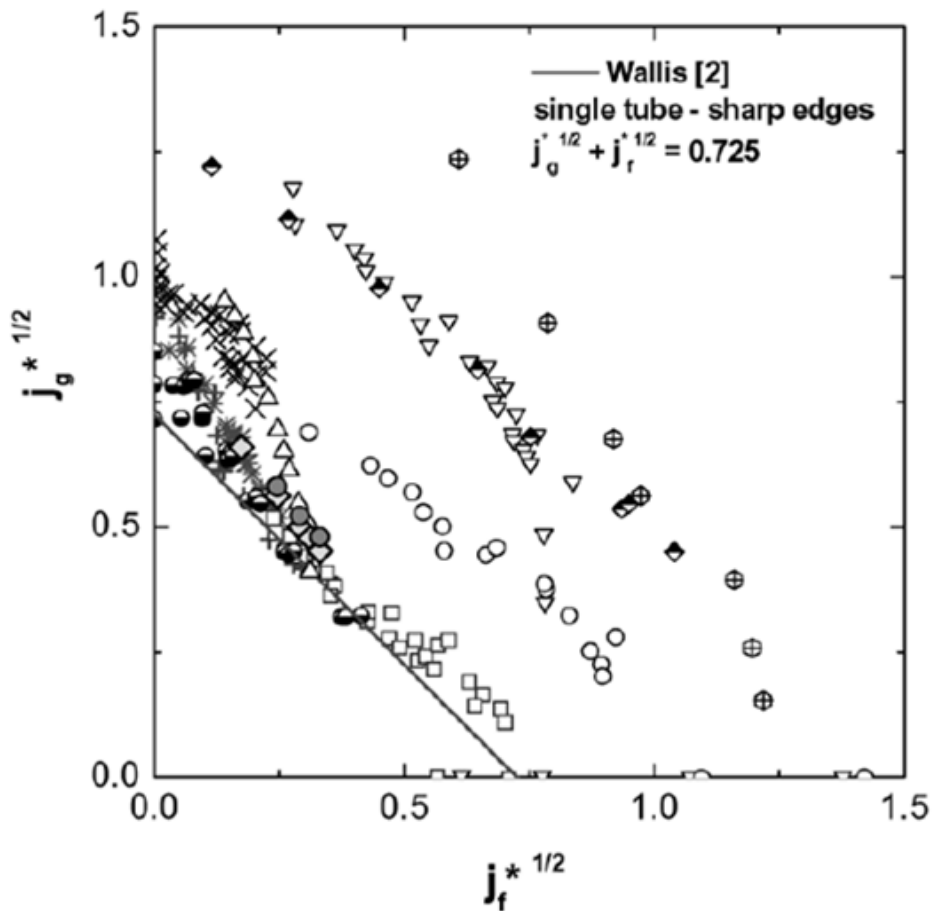
# Core Coolability

- Counter Current Flow at core exit
- Pass / Fail Criterion?





# CCFL Experimental Data



|   | d(cm)-t(cm) - n - p(cm)           |
|---|-----------------------------------|
| ● | Present Data 5 - 1 - 4 - 9.6      |
| ◆ | Present Data 5 - 4 - 4 - 9.6      |
| □ | Bankoff [4] 2.86 - 2 - 2 - 3.58   |
| ○ | Bankoff [4] 1.05 - 2 - 3 - 1.43   |
| ▽ | Bankoff [4] 1.05 - 2 - 15 - 1.43  |
| △ | Lee [5] 2.93 - 1.27 - 3           |
| ◆ | Sobajima [6] 1.05 - 2 - 25 - 1.43 |
| ● | Celata [7] 1.2 - 0.12 - 1         |
| × | Celata [7] 2.0 - 0.2 - 1          |
| ⊕ | Kokkonen [8] 0.5 - 2 - 52         |
| * | Zhang [9] 3.6 - 7.2 - 3 - 11.6    |
| + | Zhang [9] 3.6 - 72 - 3 - 11.6     |

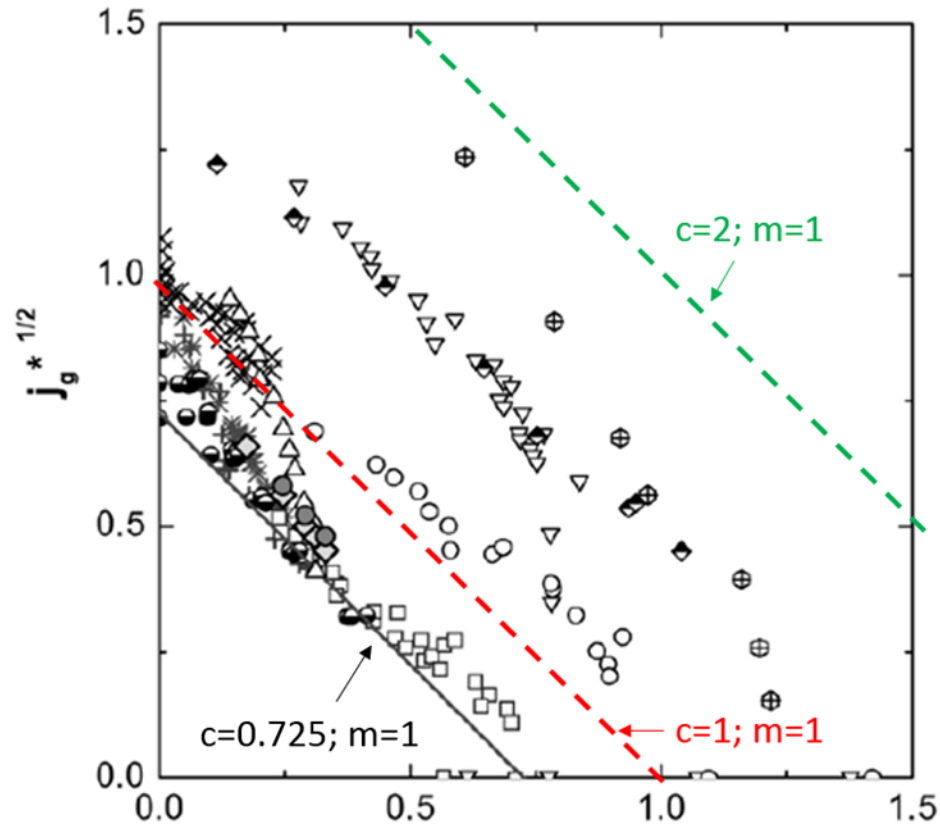
d: hole diameter

t: plate thickness

n: number of holes

p: pitch between neighboring holes

# CCFL Coefficients



| Case           | $\beta$  | c     | m | Notes                                     |
|----------------|----------|-------|---|---|
| LTCC EM - Base | 0        | 1     | 1 | Wallis – Smooth-edges. Bounding condition |
| Sensitivity 1  | 0.038422 | 2     | 1 | Bankoff – STP Geometry                    |
| Sensitivity 2  | 0        | 0.725 | 1 | Wallis – Sharp-edges. Worst Condition     |



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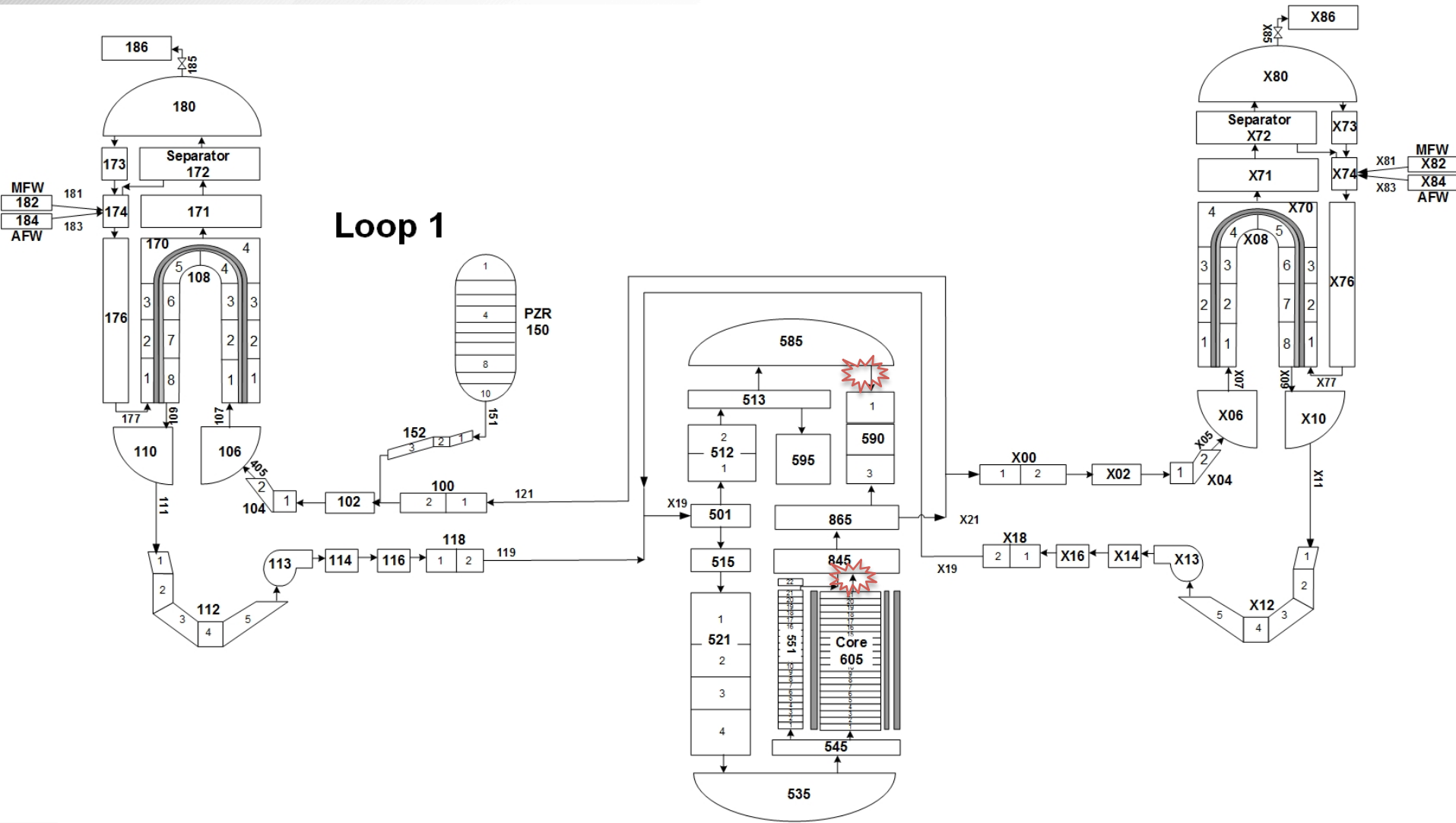
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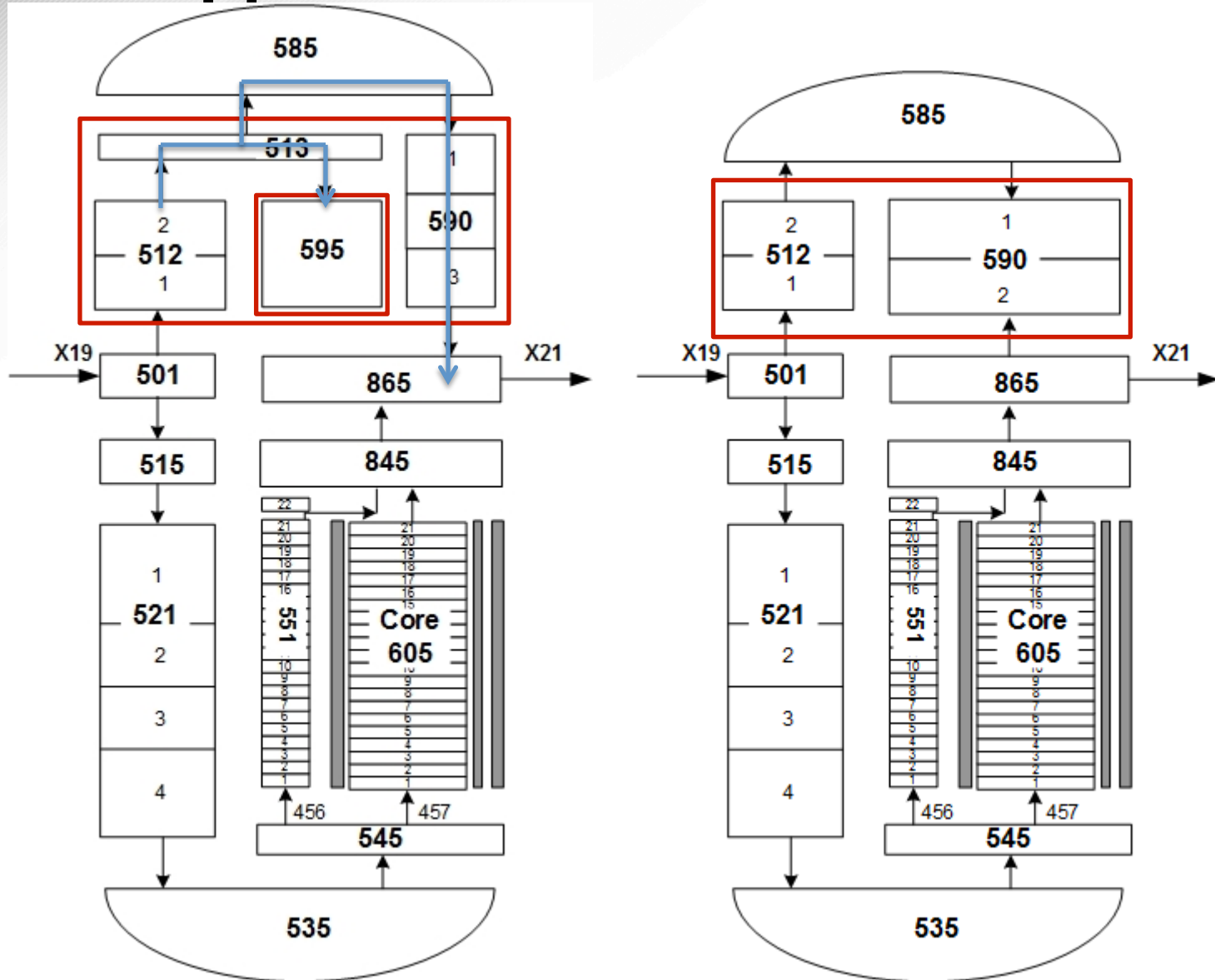
# Input Model Description



# System Nodalization



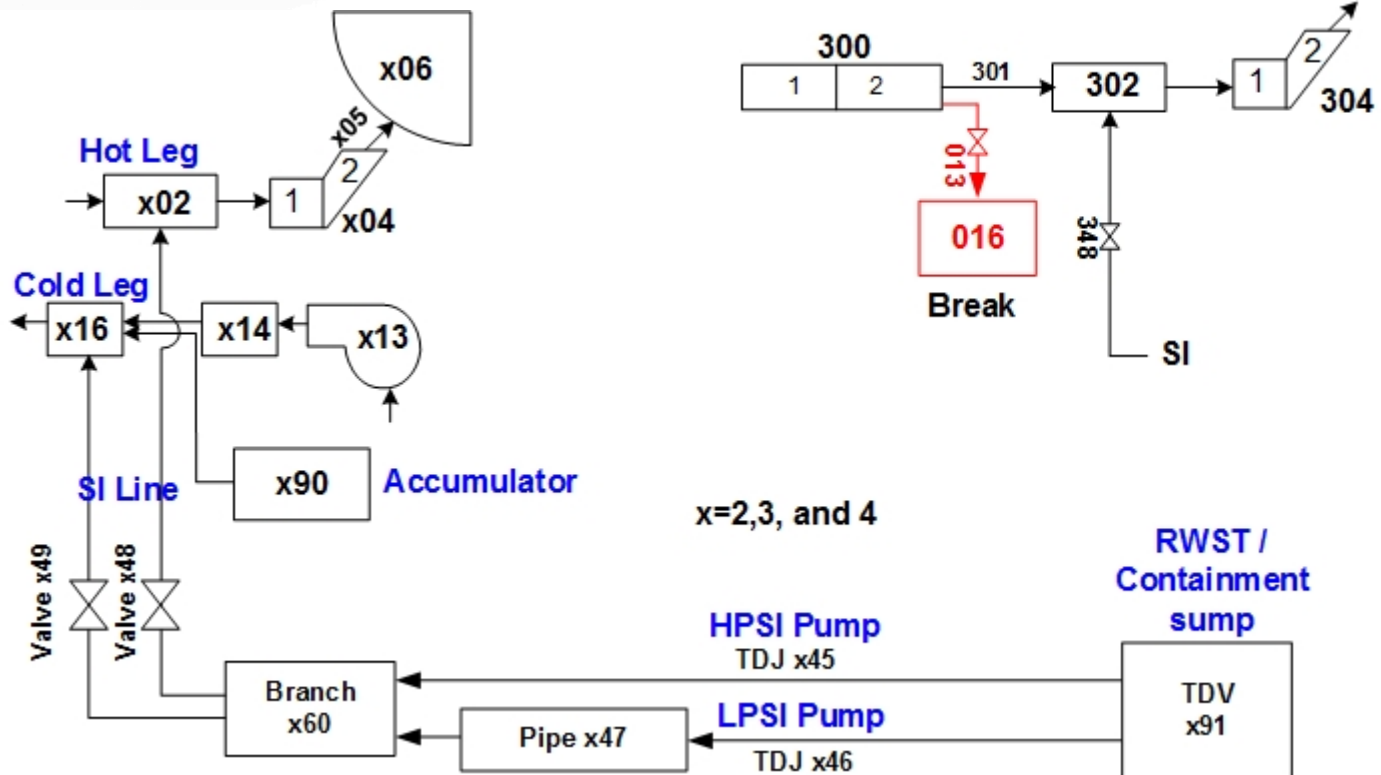
# Upper Plenum Nodalization



# Break and ECCS Nodalization

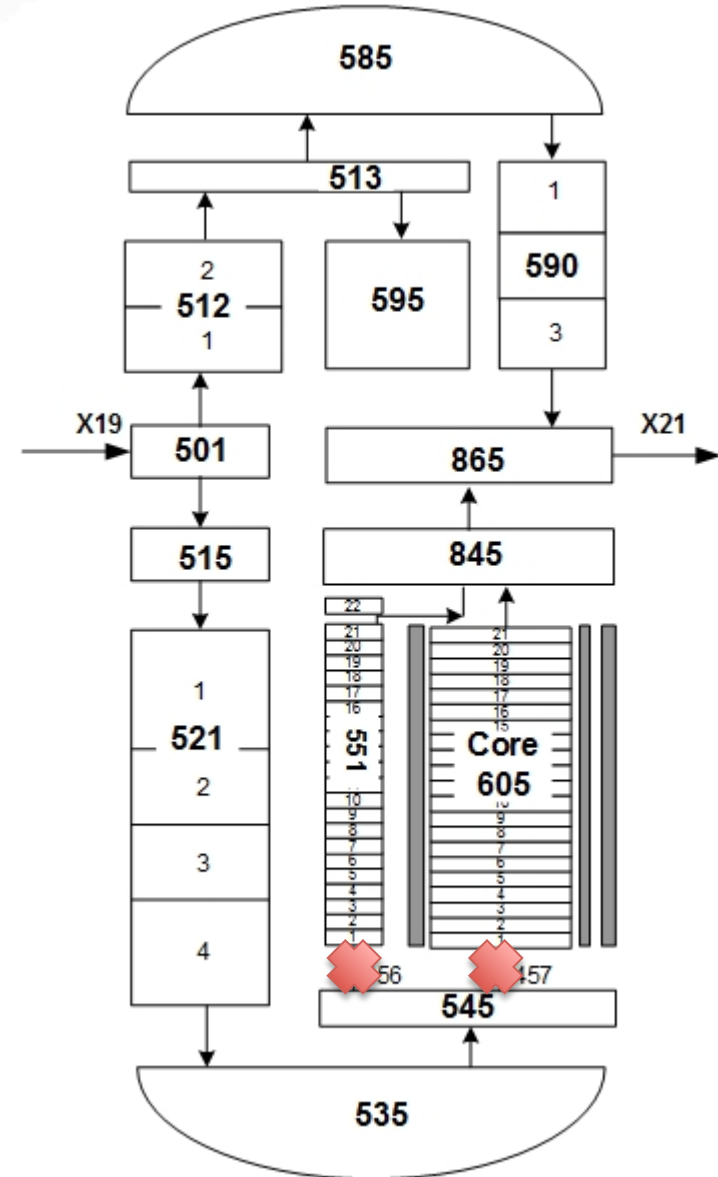
3 SI Trains

HL Large Break (16")



# Core Blockage Approach

- Full Core Blockage (Both core and core bypass blocked)
- 360s after the sump switchover time, 456 and 457 trip valves closure occurs





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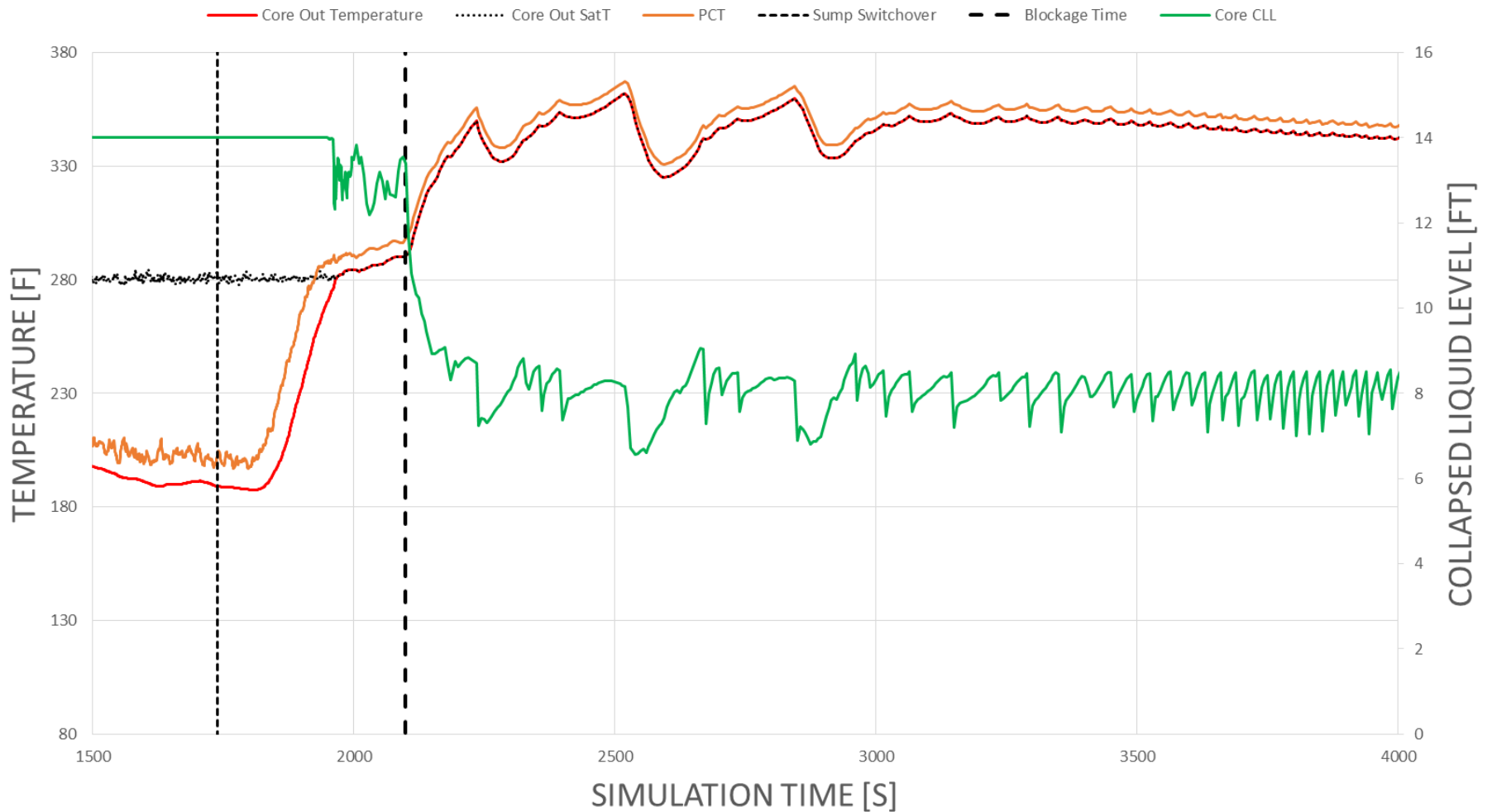
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# Simulation Results

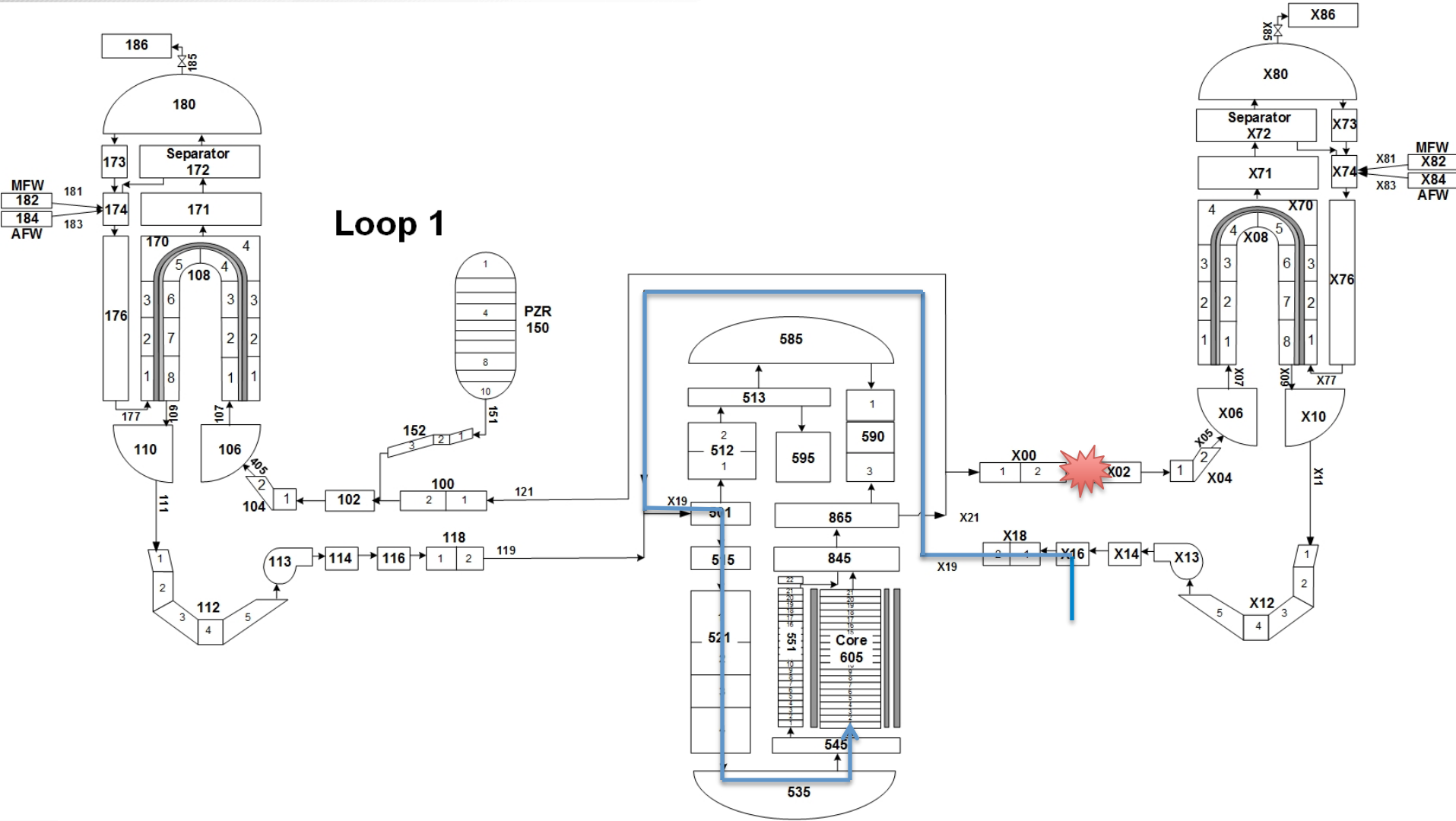




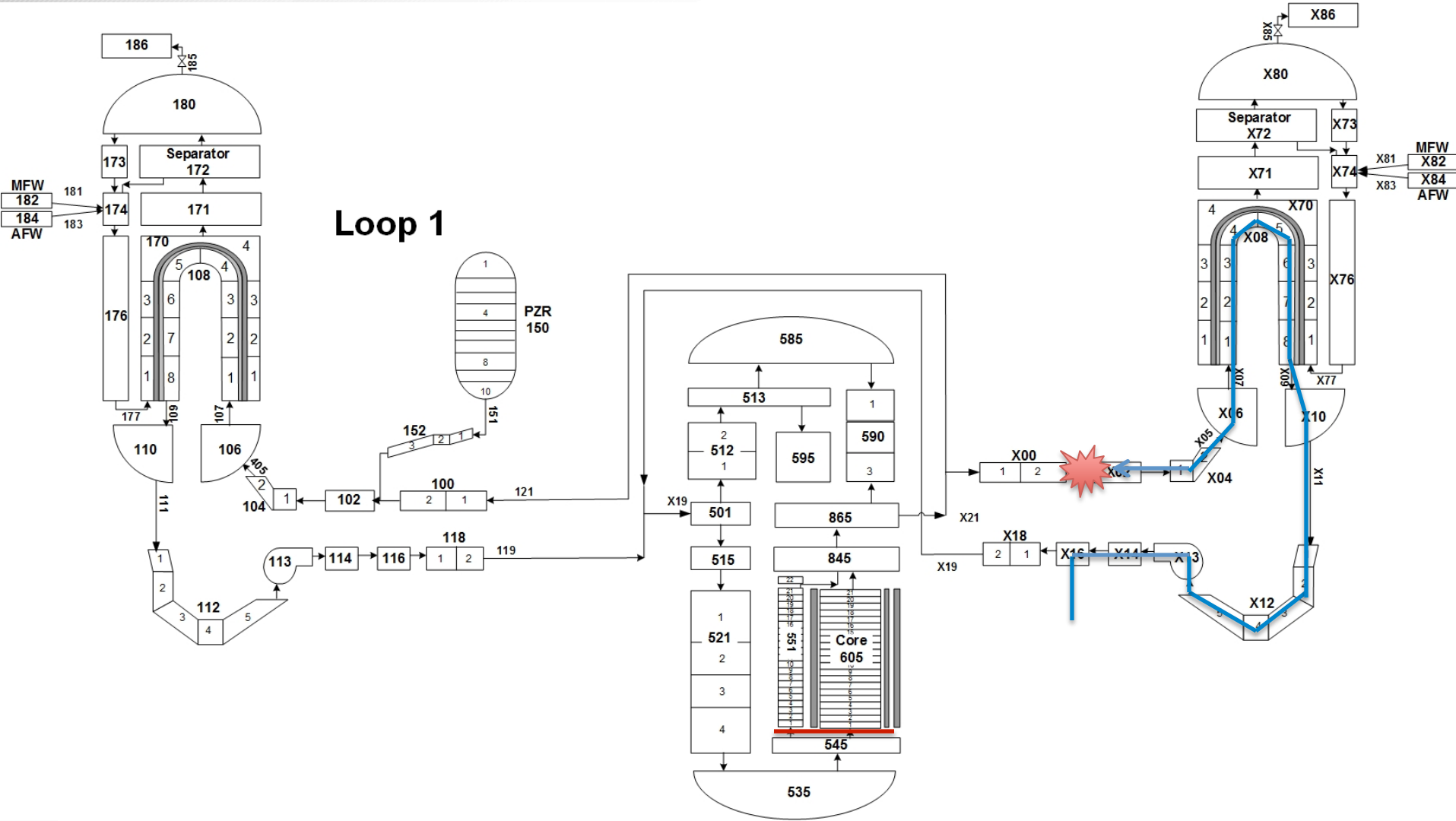
# Core PCT and CLL



# ECCS Water Flow Path – Broken Loop

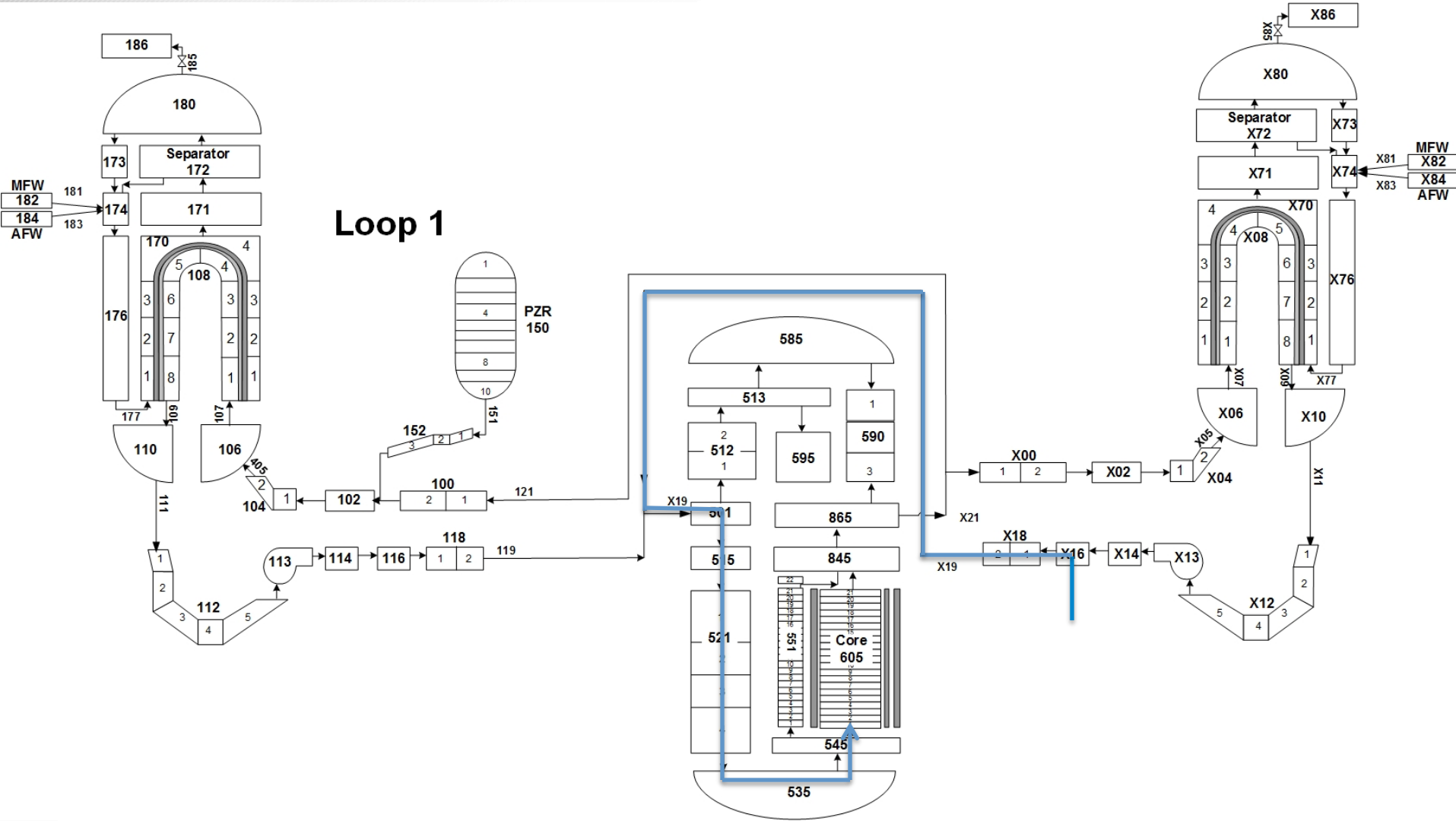


# ECCS Water Flow Path – Broken Loop

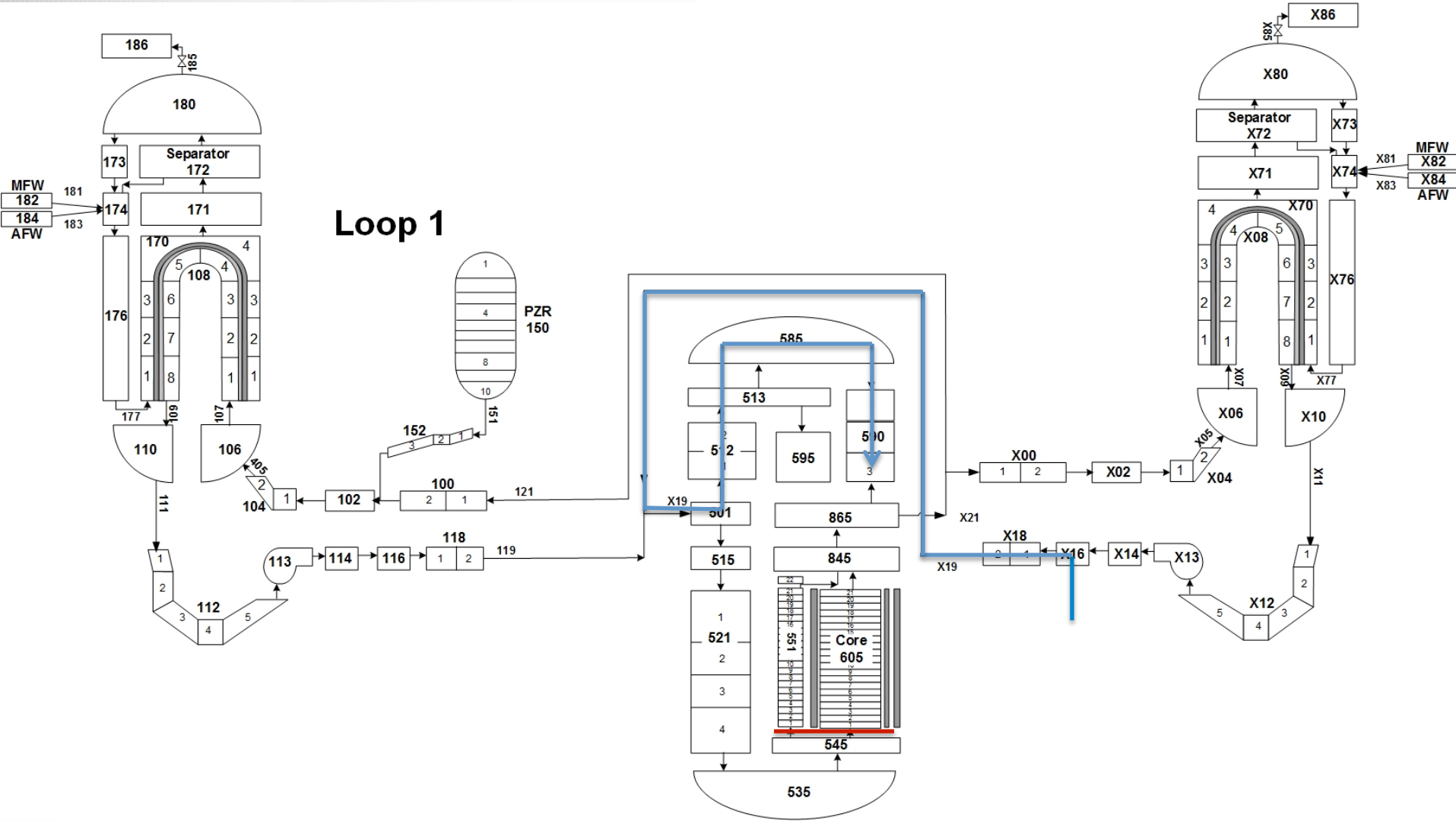




# ECCS Water Flow Path – Intact Loops



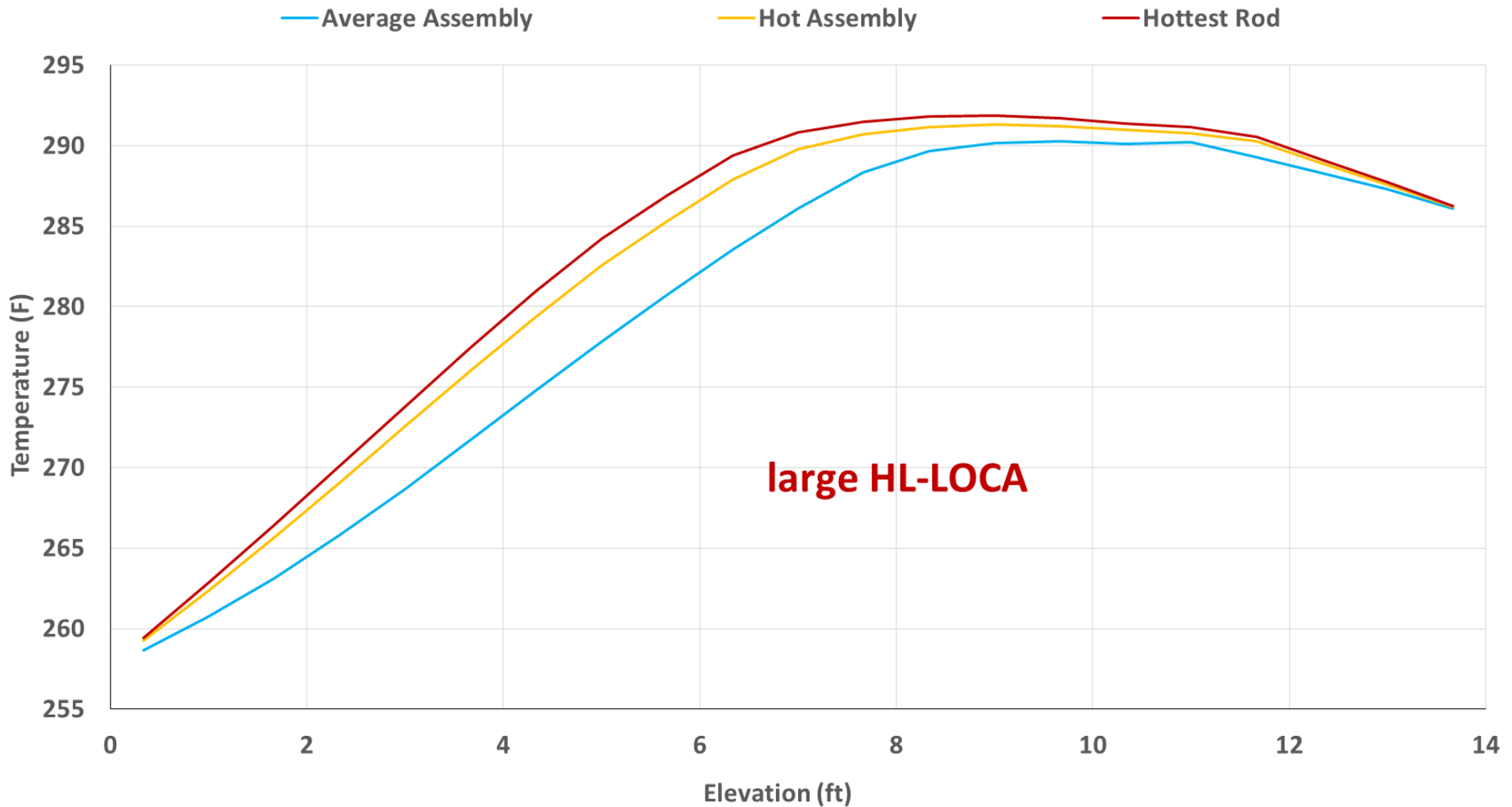
# ECCS Water Flow Path – Intact Loops





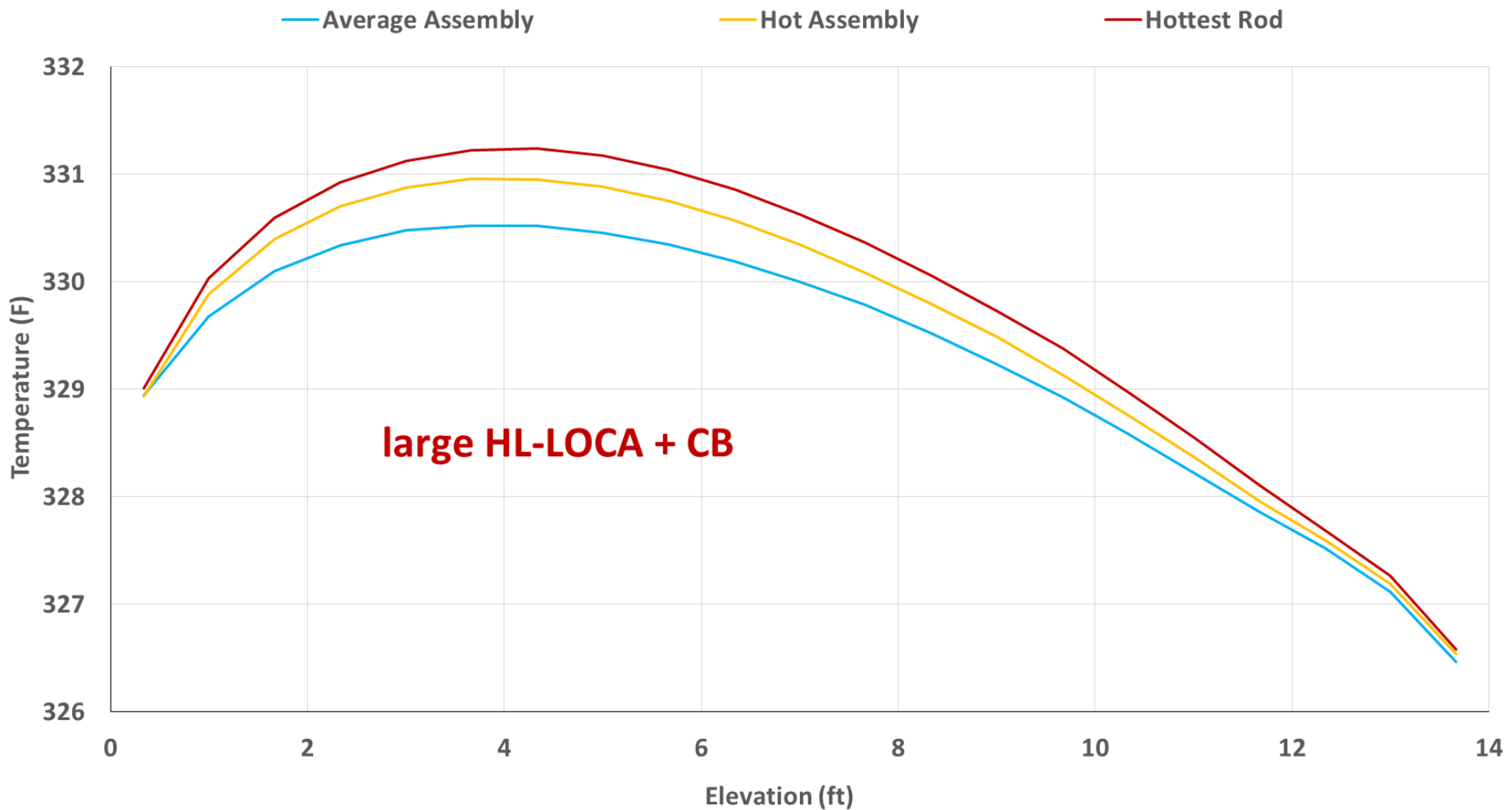


# Core Axial Temperature Profile





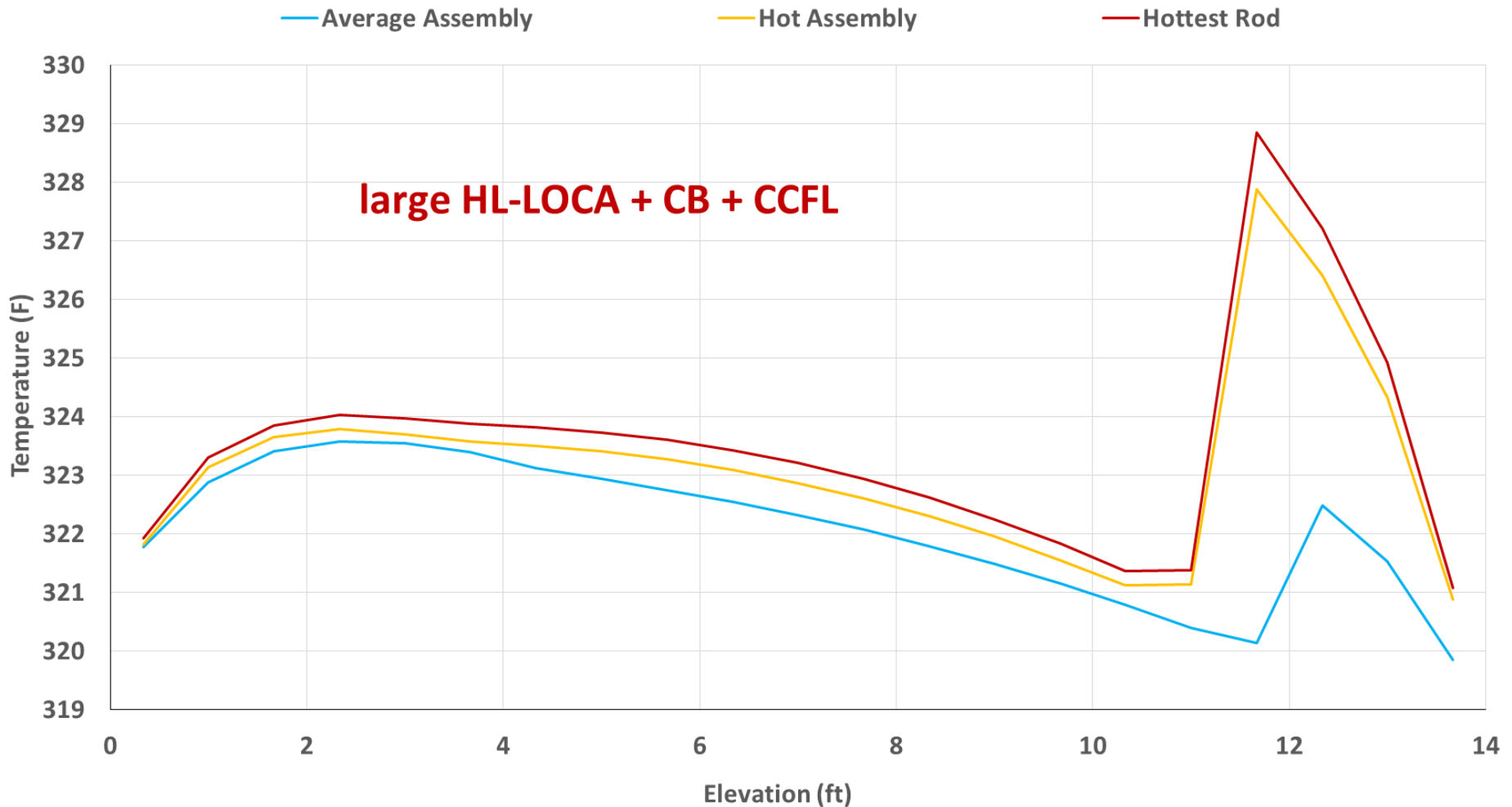
# Core Axial Temperature Profile





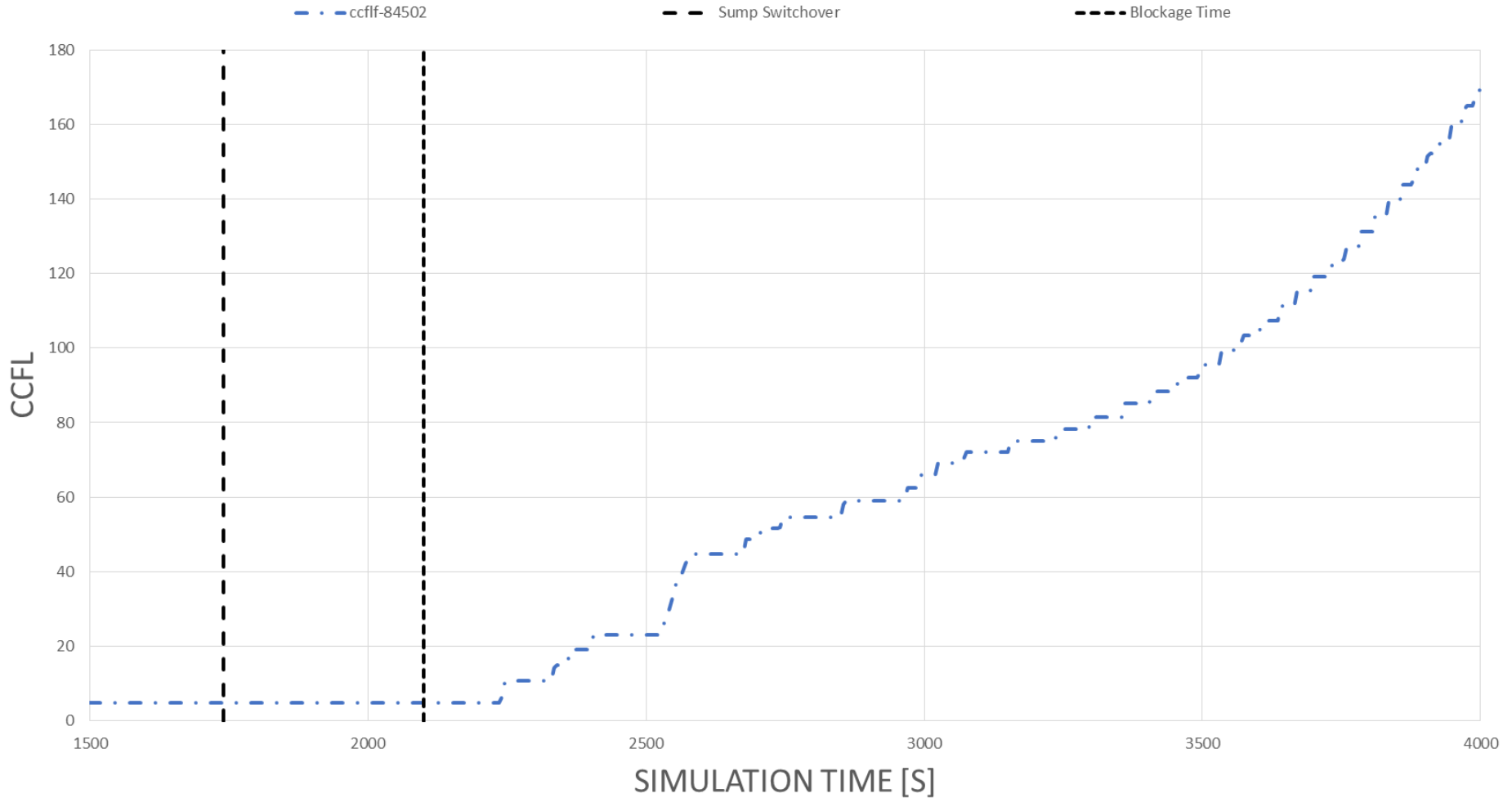


# Core Axial Temperature Profile





# Cumulative CCFL-limited Time





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# Core Exit CCFL Sensitivities

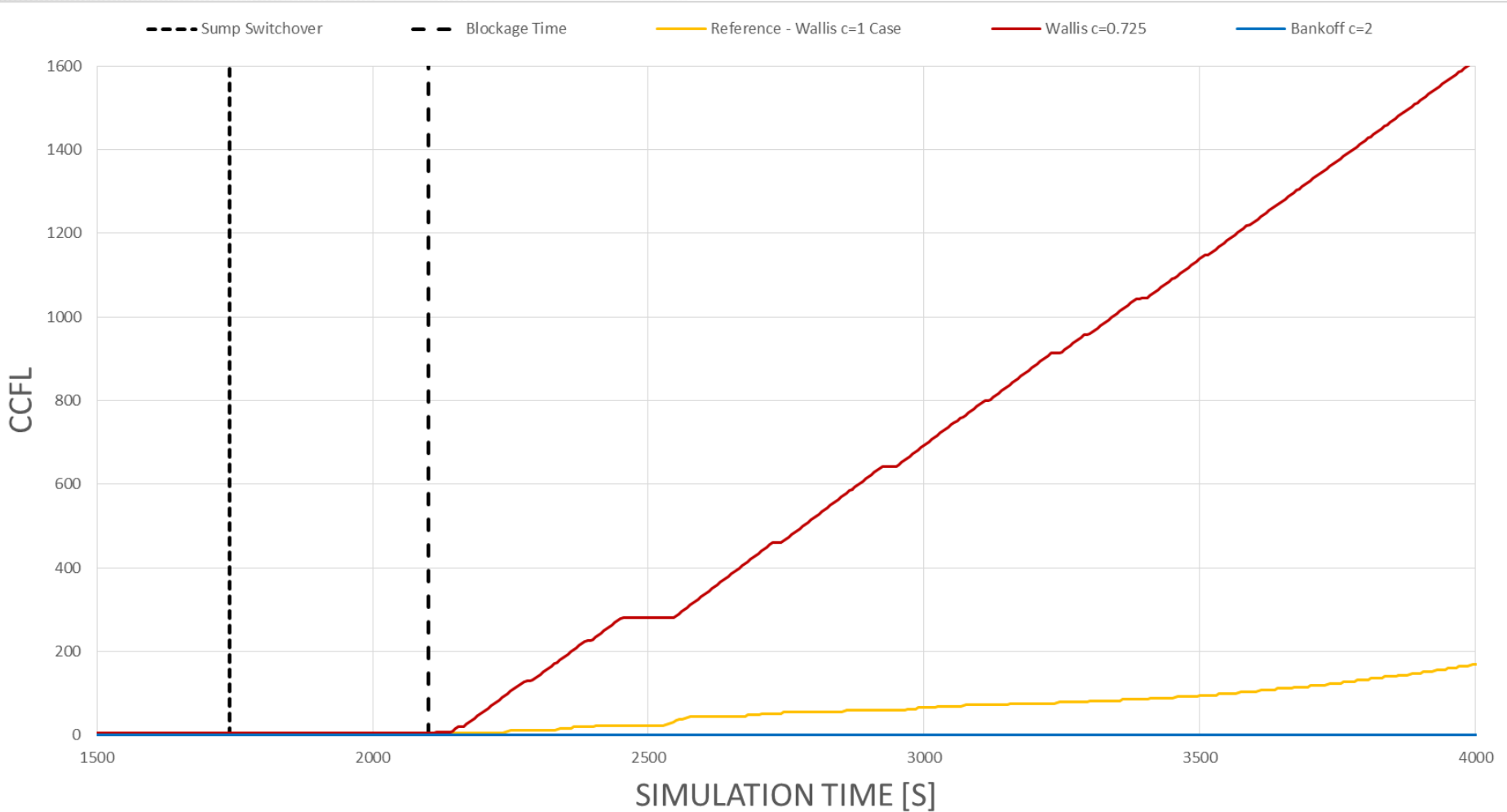


# Sensitivity Table

| Case           | $\beta$  | c     | m | Notes  |
|----------------|----------|-------|---|--|
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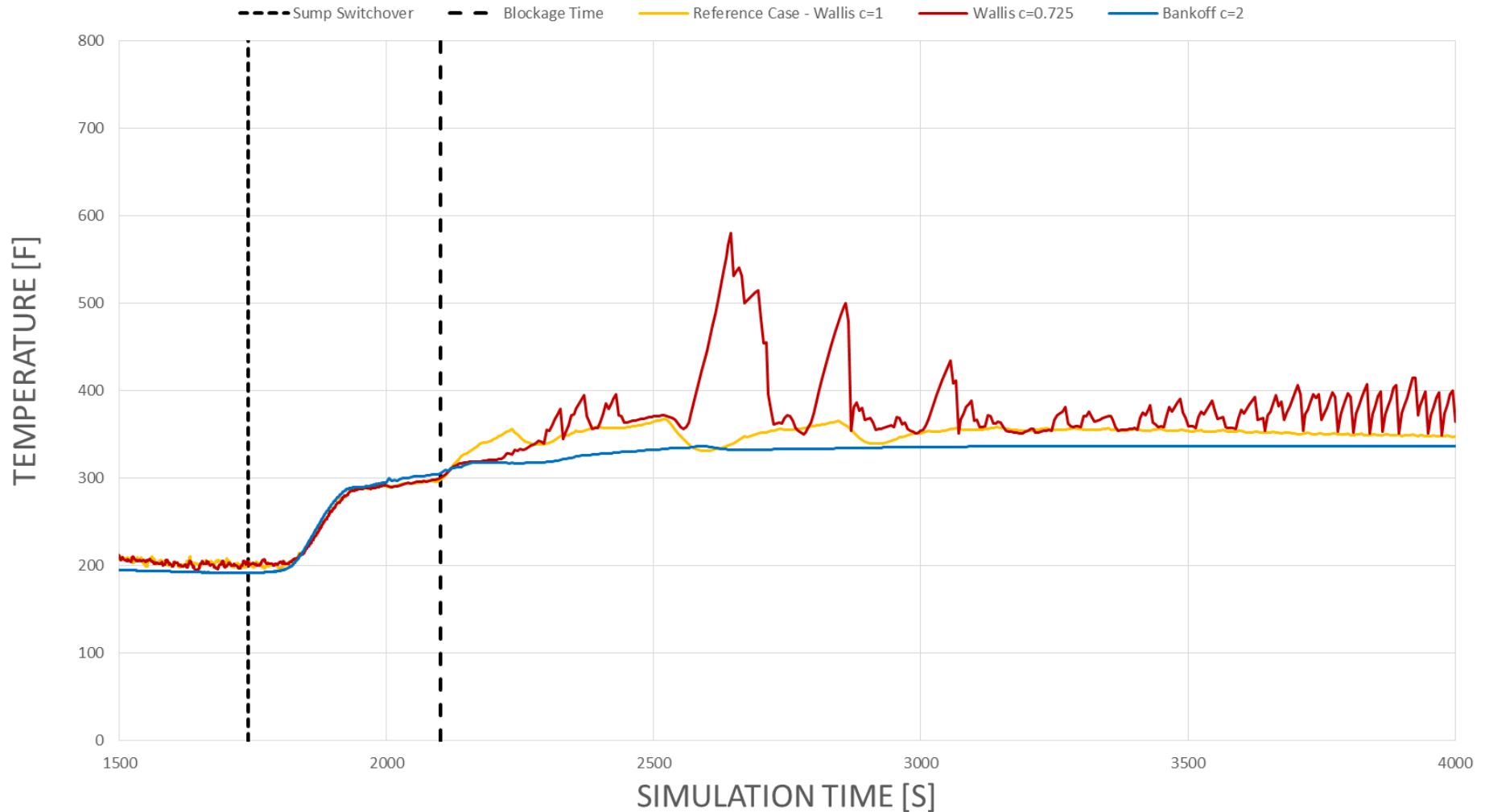


# CCFL Comparison

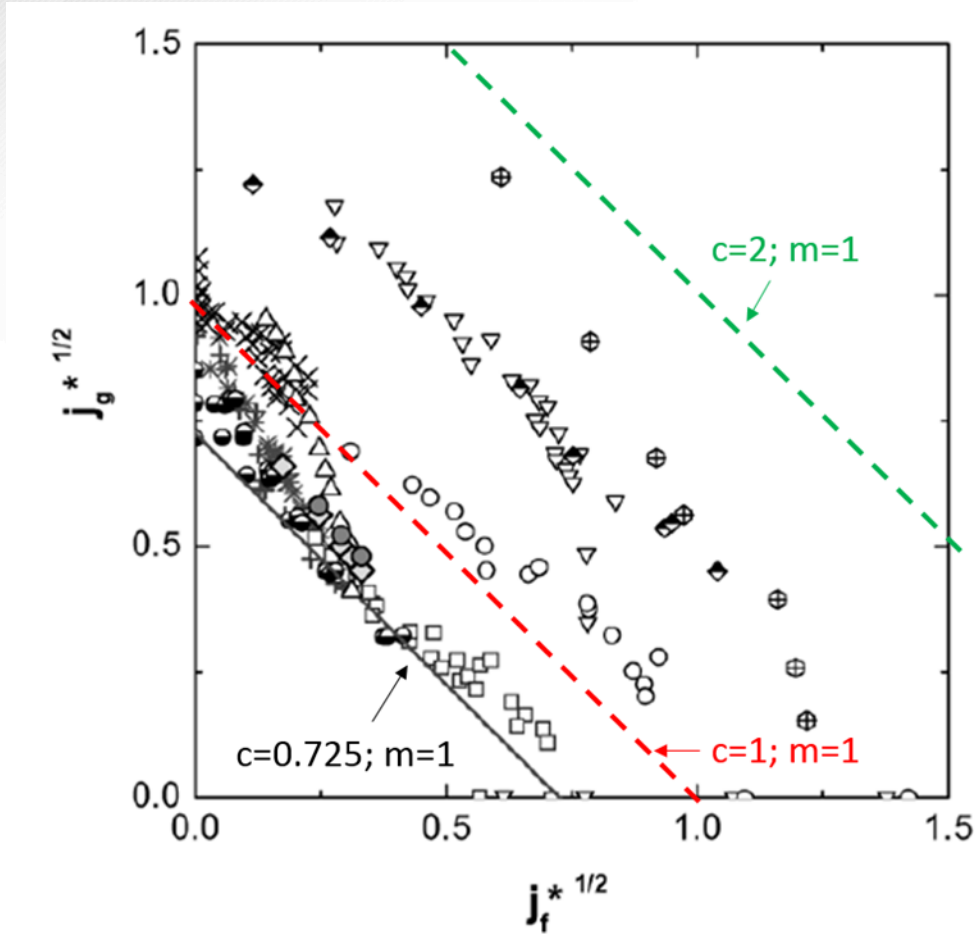




# PCT Comparison



# CCFL Coefficients





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# *Render unto Caesar*

Dr. Shin Kang

Mr. Ernie Kee

Mr. Timothy Crook





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Questions?