



## Stability Measurements for the ATRIUM™ 10XM BWR Fuel Bundle

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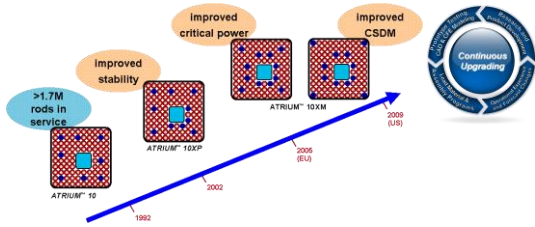
### Presentation Scope

- ▶ ATRIUM™ 10 Design Evolution
- ▶ History of AREVA stability testing at the KATHY Loop
- ▶ Evolution of KATHY Loop to test reactor for ATRIUM™ 10XM
- ▶ Sample test results

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## ATRIUM™ 10 Design Evolution & Testing



### ▶ Experimental program in KATHY Loop motivated by

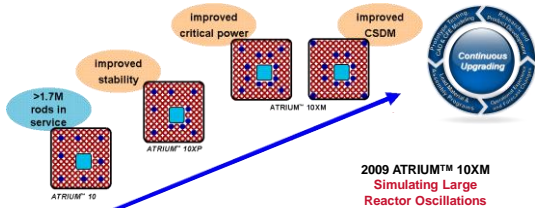
- ◆ Need to quantify performance improvements
- ◆ Need to acquire quality data to support methods development and qualification

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## HISTORY of AREVA Stability Testing



2009 ATRIUM™ 10XM  
Simulating Large  
Reactor Oscillations

1999 ATRIUM™-10  
Dryout/Rewet

1992 ATRIUM™-9

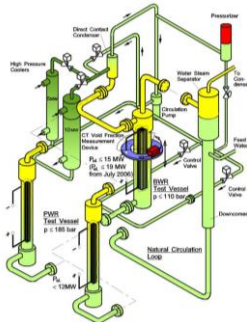
- Design Configurations
- Noise measurements
  - Small amplitude oscillations

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## KATHY Loop Natural Circulation for Stability Testing



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## Stability Testing Scope for ATRIUM 10XM Simulating Reactor Conditions

- ▶ **More realistic BWR conditions**
  - ◆ Pure hydraulic instability requires high power to excite, thus limits oscillation amplitude prior to dryout
  - ◆ Power feedback using the new SINAN software simulates reactor conditions
    - Power feedback lowers stability power threshold
    - Large magnitude flow and power oscillations made possible
- ▶ **Observed stable and growing power/flow oscillations in both the global and regional modes**
- ▶ **New experimental observations**
  - ◆ Fill a recognized need for data
  - ◆ Cyclical dryout and rewetting persist for high oscillation amplitudes
  - ◆ Failure to rewet occurs at very high oscillation amplitudes
  - ◆ Highly nonlinear oscillatory behavior and limit cycles with inlet flow reversal

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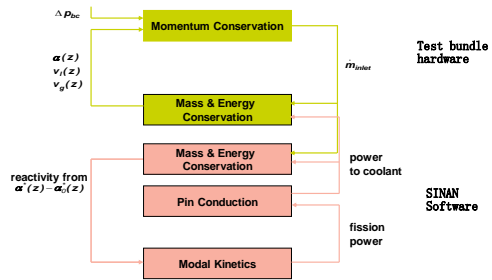
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## SINAN Transforms KATHY Loop to Test Reactor



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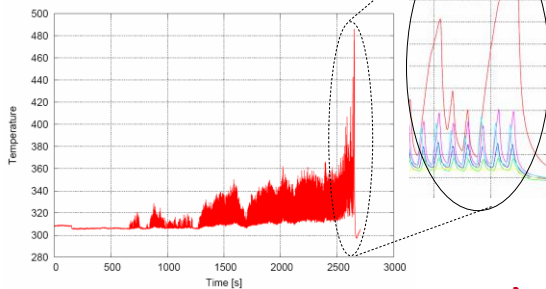
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## Example of a Pure Thermalhydraulic Test



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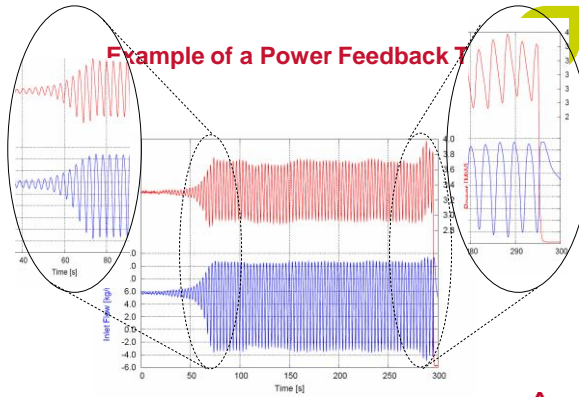
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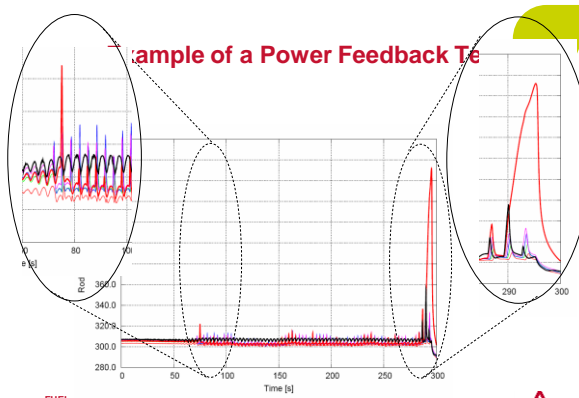
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## Closing Remarks

- ▶ **The ATRIUM-10XM test program surpassed previous testing in scope and findings**
- ▶ **Stability Testing**
  - ◆ Pure thermalhydraulic testing for continuity with previous practice; additionally
  - ◆ Closed feedback loop better simulates BWR conditions
  - ◆ Extensive data on very large oscillations including large inlet flow reversal
  - ◆ Cyclical dryout/rewetting data
- ▶ **These unique measurements extend the excellent validation basis of AREVA's methodologies and strongly enhance the knowledge supporting the development of new fuel designs e.g. ATRIUM™-11**

*Thank You*

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