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Mining Coverage Data for Test Set Coverage Efficiency

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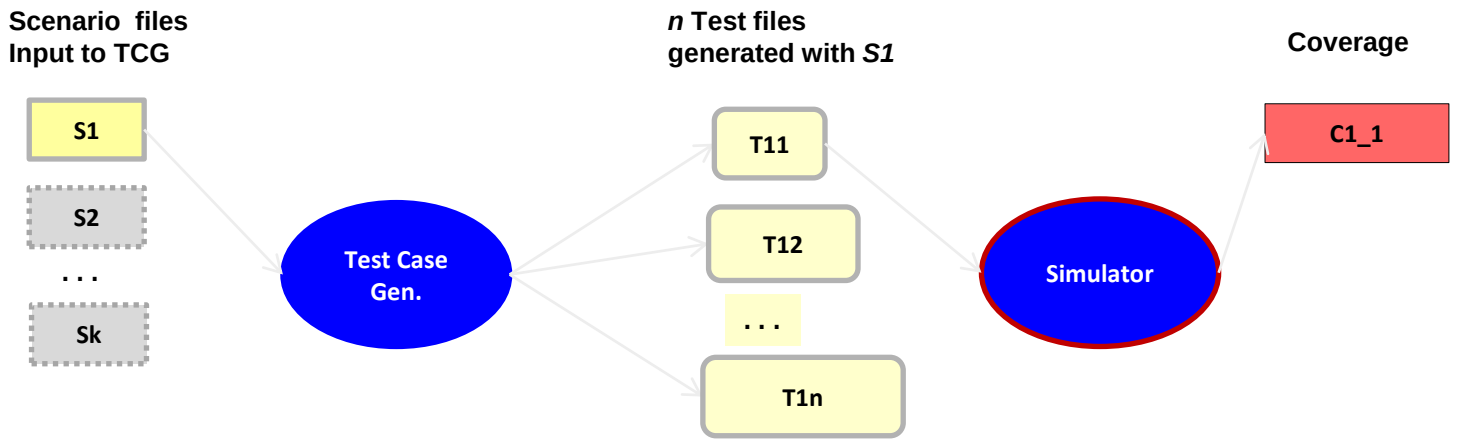
Outline

- Coverage Efficiency
  - Coverage in Time
  - First Time Per Test Coverage
  - Hard To Hit Coverage
- Coverage Distribution
  - Scenarios to Waves
  - Wave Windows of Probability
- Controlling the Test Load
- Results & Conclusion
- Acknowledgments / References

Coverage Efficiency



- 12000 scenario files
- Millions of tests
- Coverage
  - All Events 150k
  - Hard-to-Hit 73k
  (< than 2k hits for1M tests)
  - Never-Hit events 15k

- Coverage driven verification
- Coverage driven test case generation
- Graph based test case generation

Automatic or manual targeting

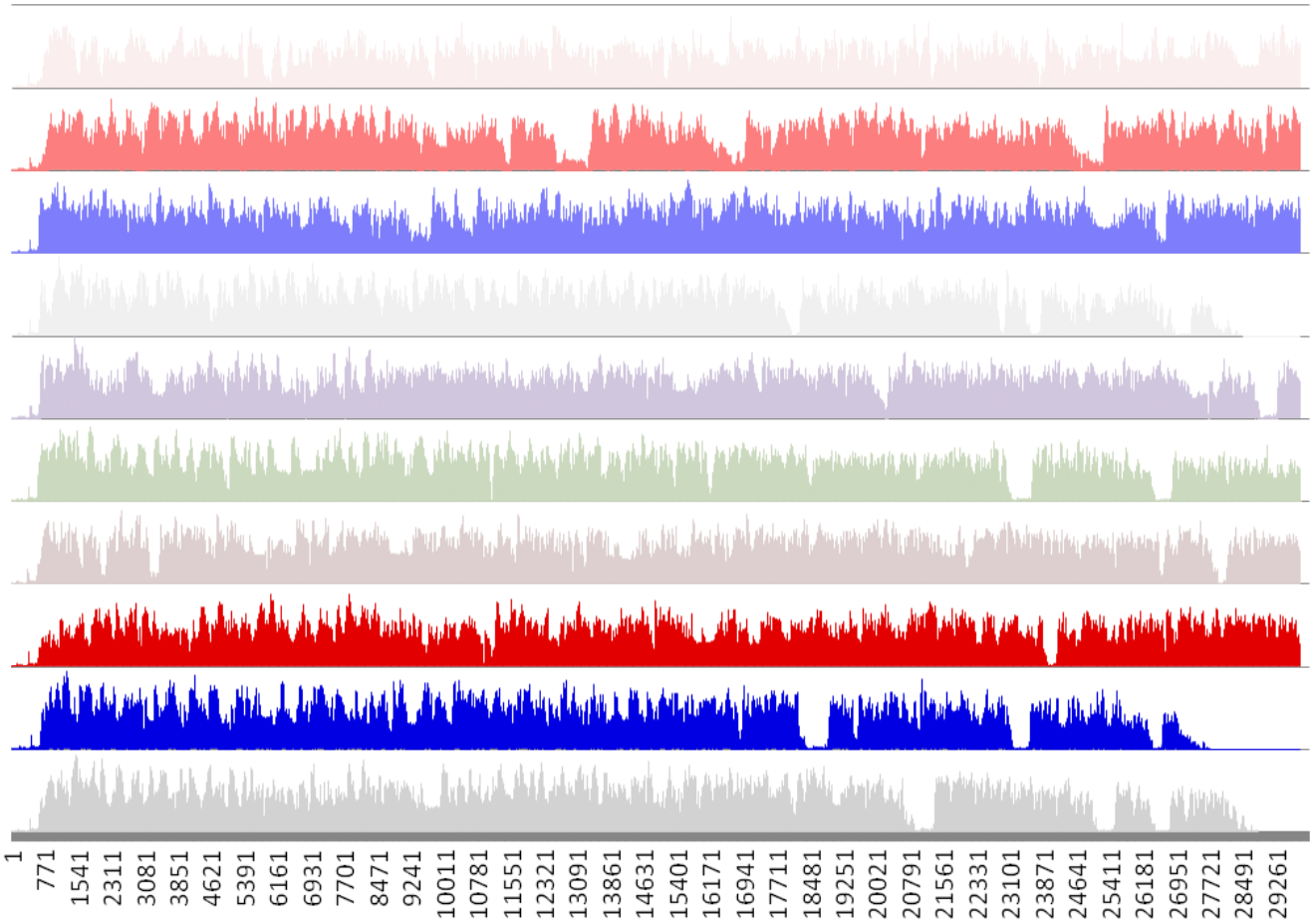
Coverage Efficiency

- Coverage
  - Never-Hit
  - Hard-to-Hit
  - Often-Hit => redundancy

  } used to drive the verification process
- Efficiency
  - Achieve coverage goal less resources
  - Reduce redundancy
- Observe
  - Summarization, model identification, probability
- Control
  - Control the test case generation

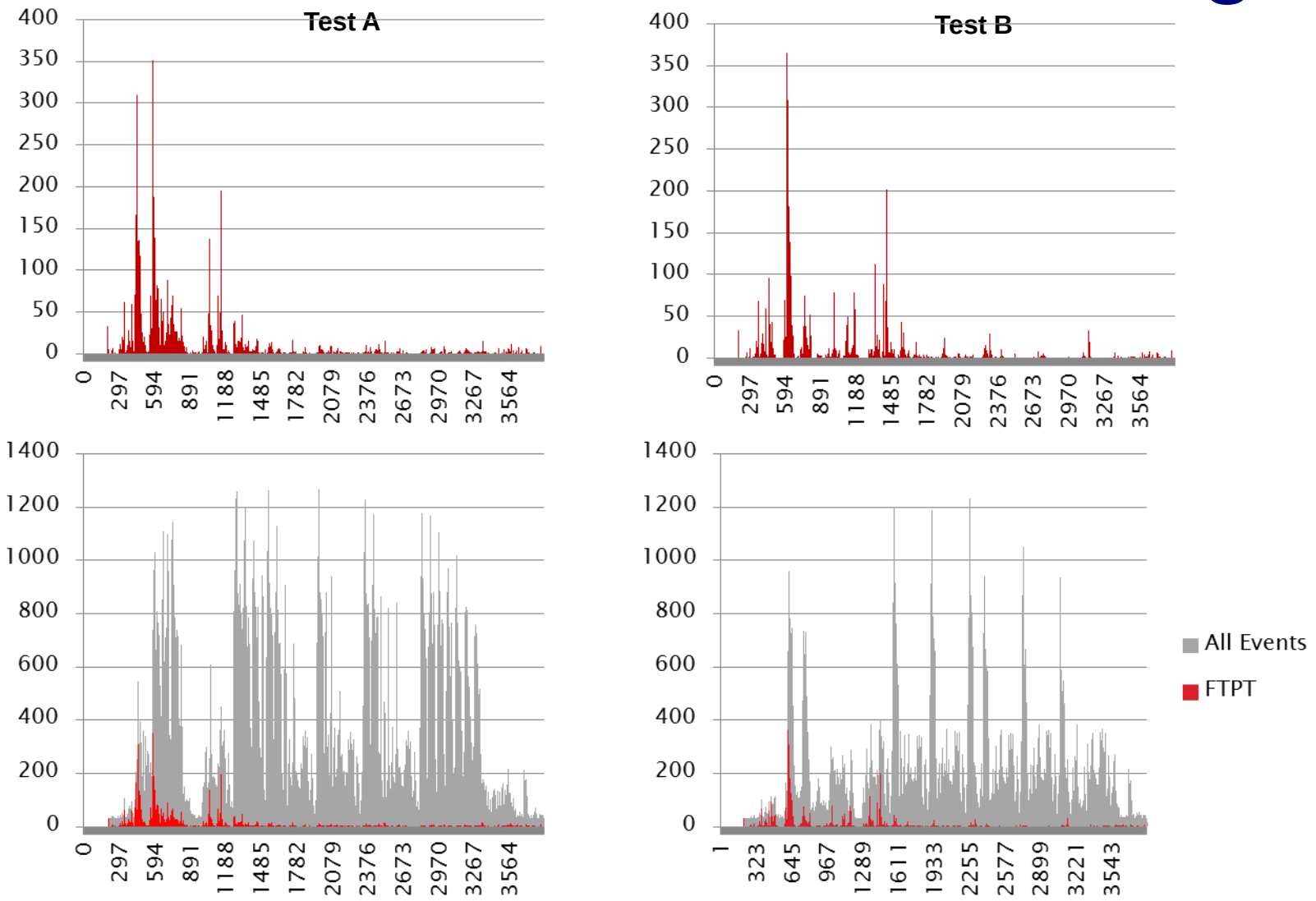
Coverage in Time

- Same scenario:
  - Semaphores Locking mechanism
- Same load
  - Nb. of instr.
  - Nb. of cycles

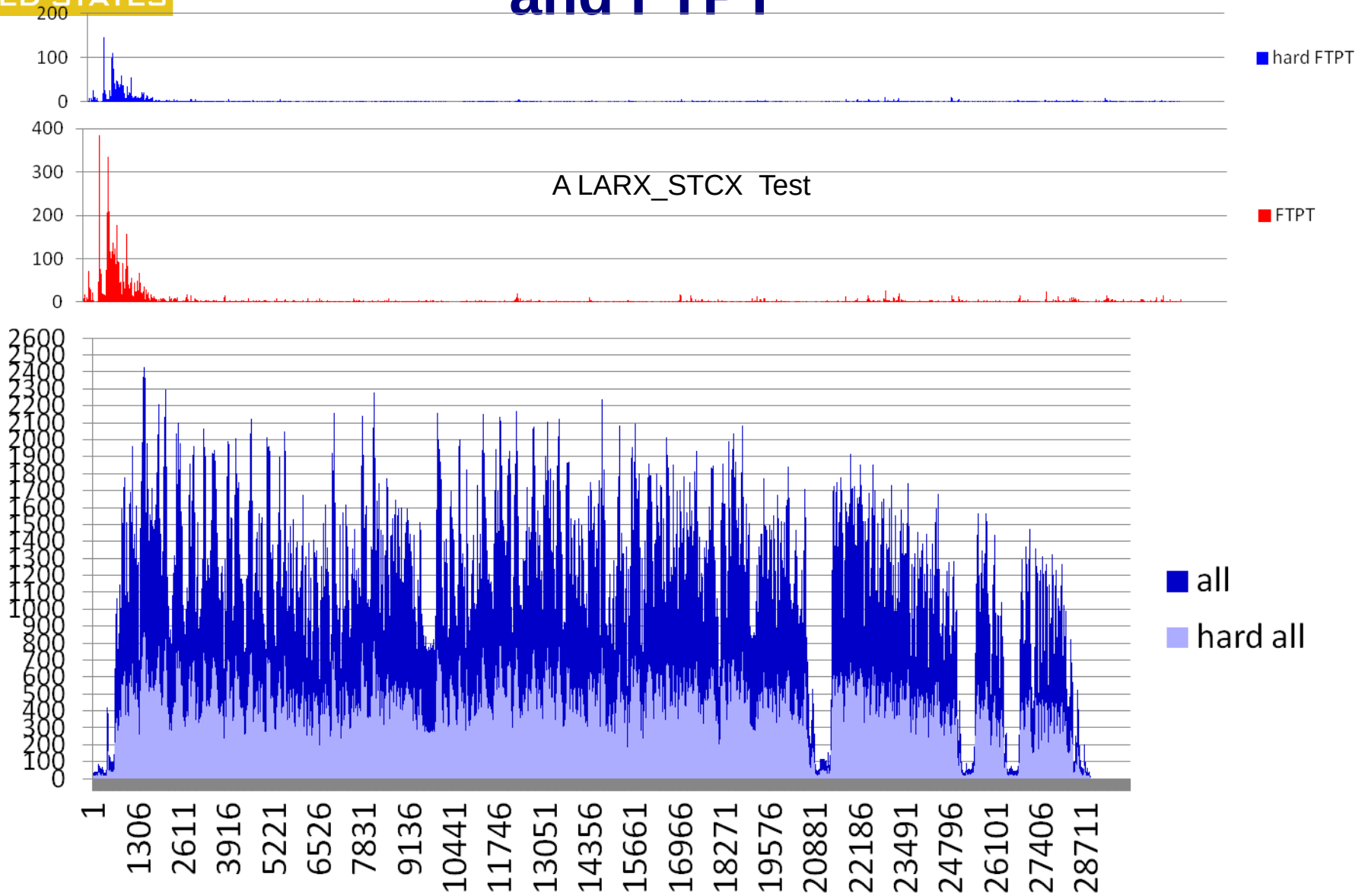


First Time Per Test Coverage

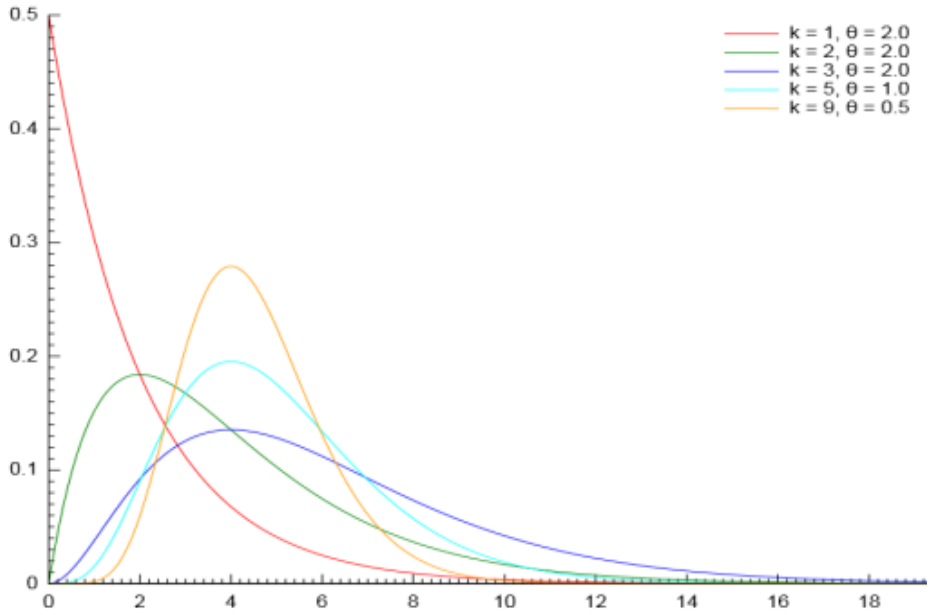
Same Scenario
DSI_EAO

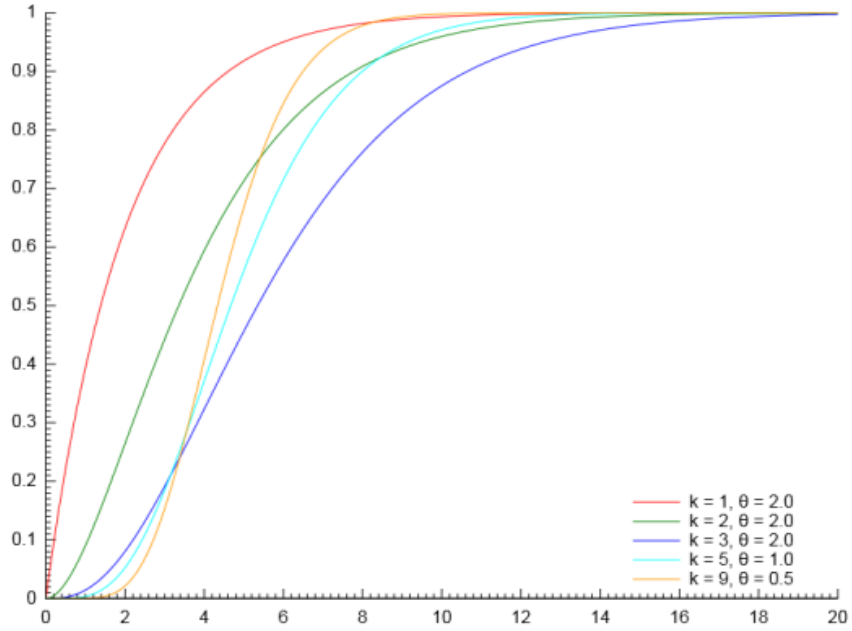


HTH Coverage in Time and FTPT



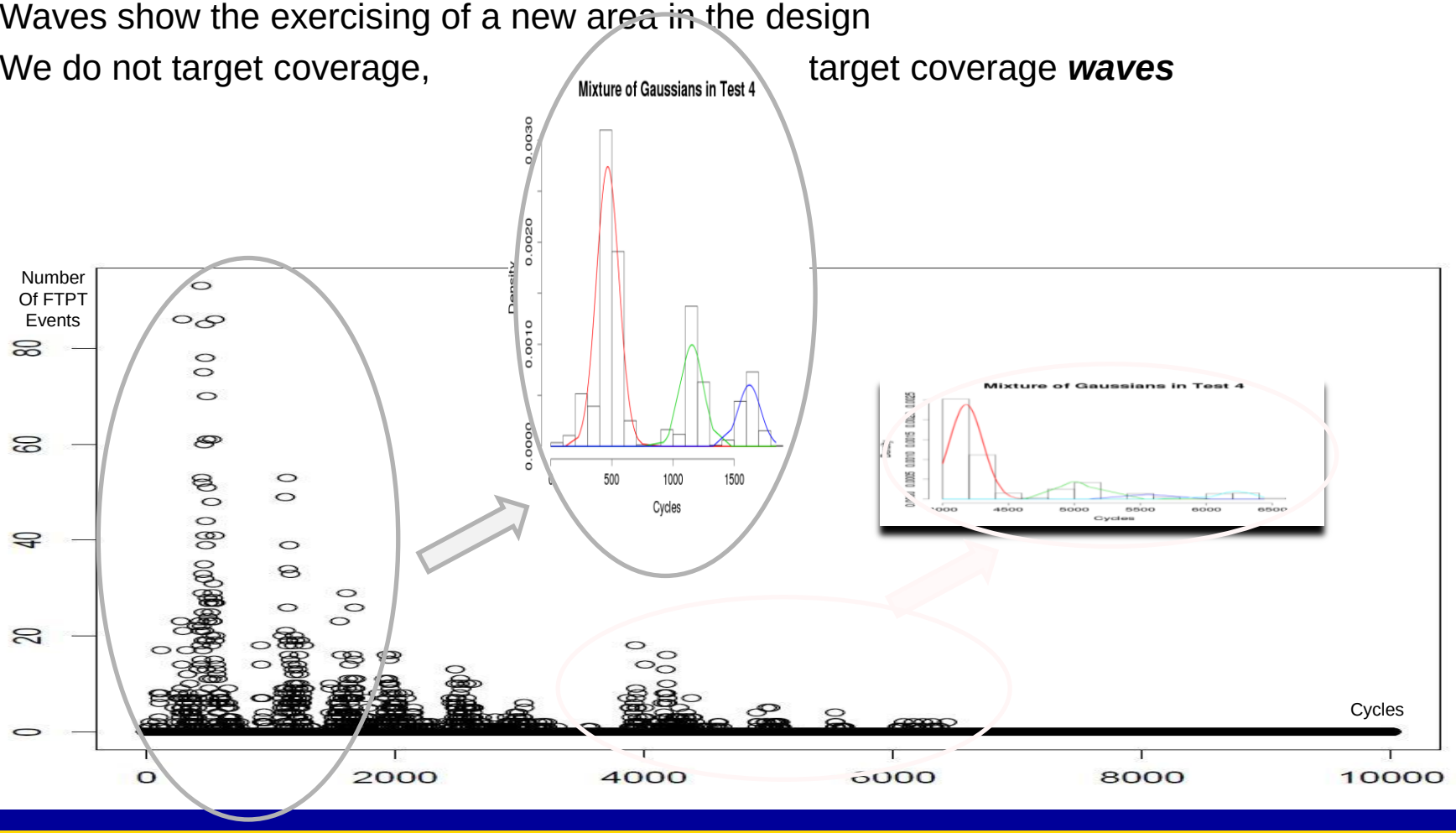
FTPT Gamma Distribution



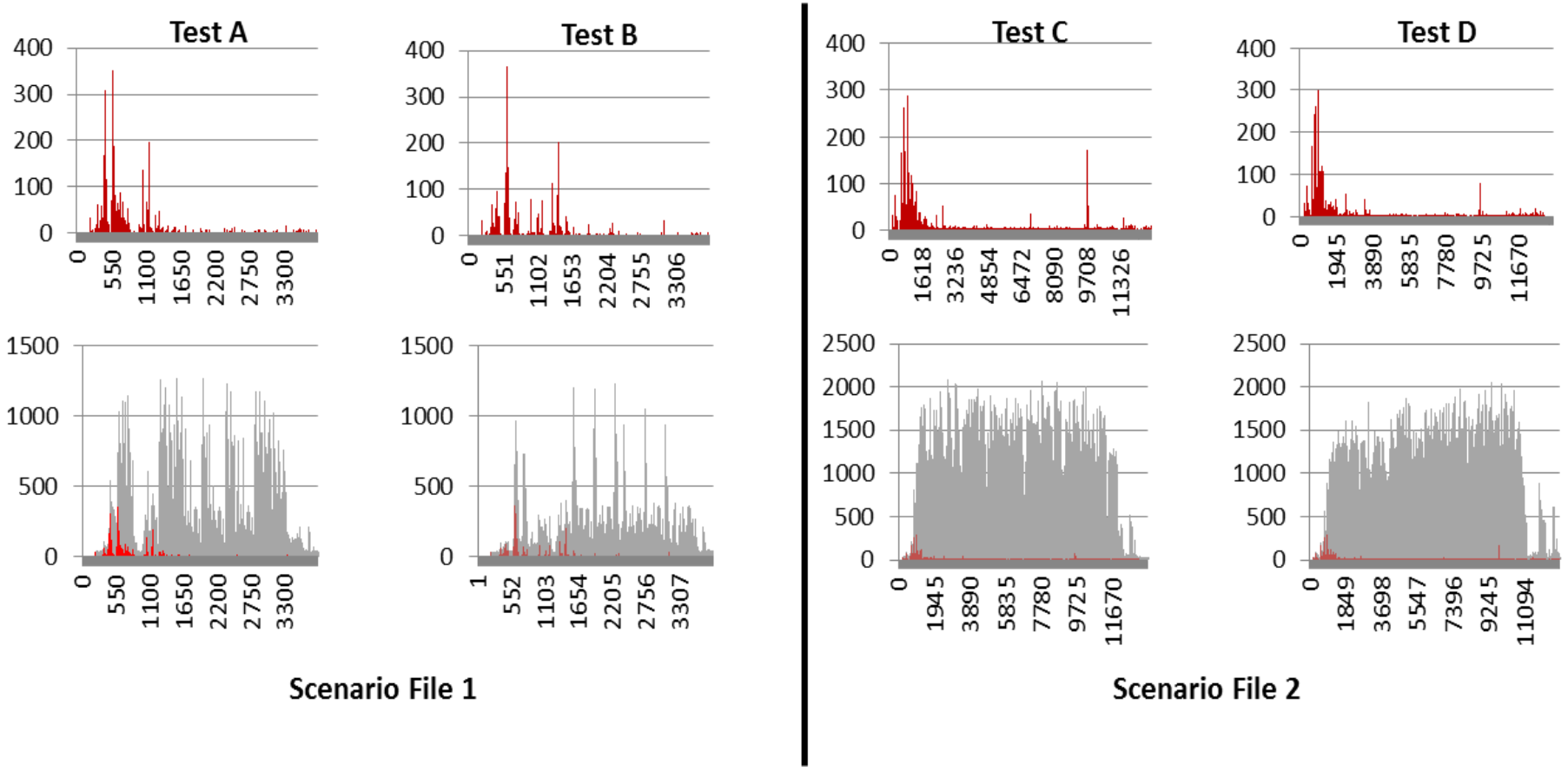


Mixture of Coverage Waves

- Expectation Minimization (EM) algorithm to identify the mixture of Gaussians
- Waves show the exercising of a new area in the design
- We do not target coverage, target coverage ***waves***



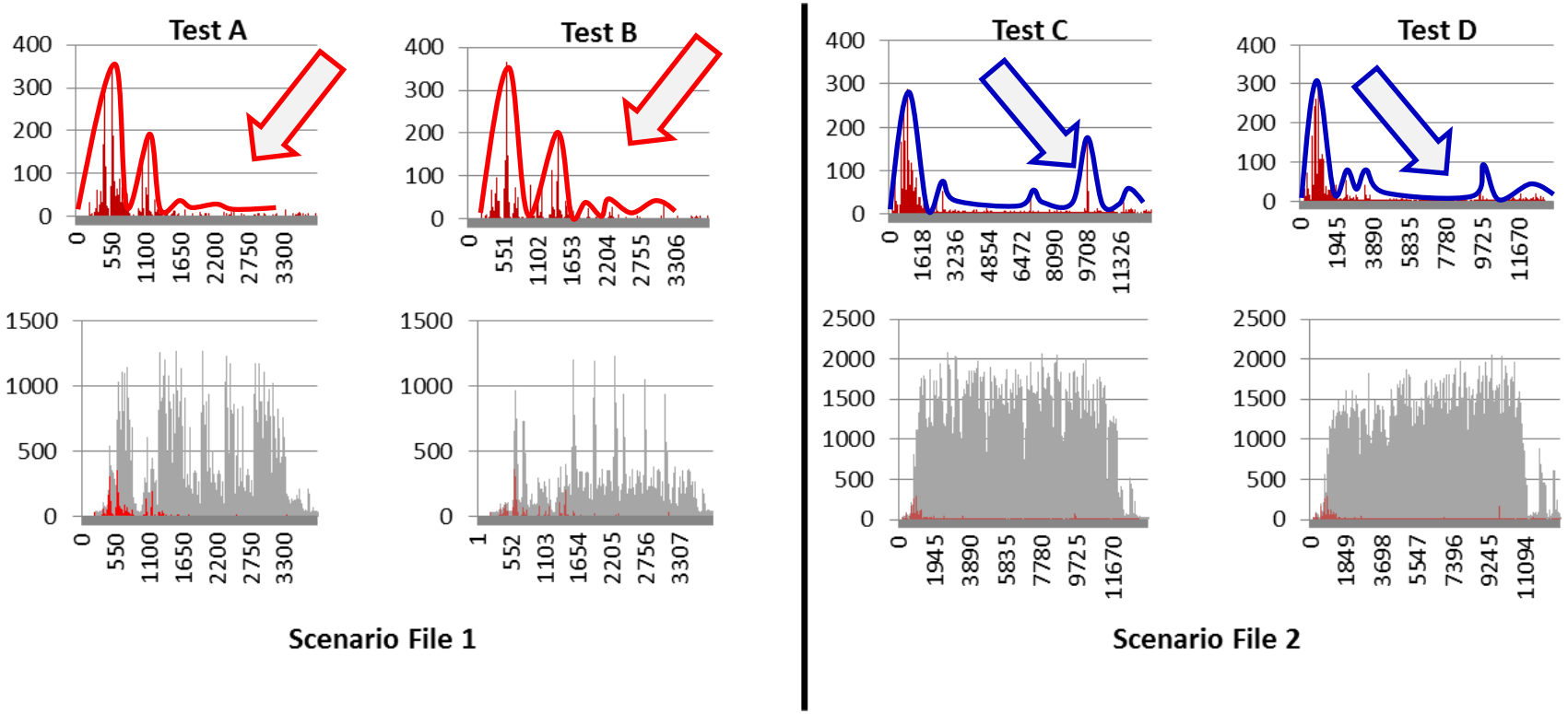
Different Scenarios



Four tests, two different scenarios

(DSI_EAO 456 and 163 and ATOMIC 58 and 20)

Scenarios to Generate Certain Waves



Particular wave(s) targeted by each scenario =>

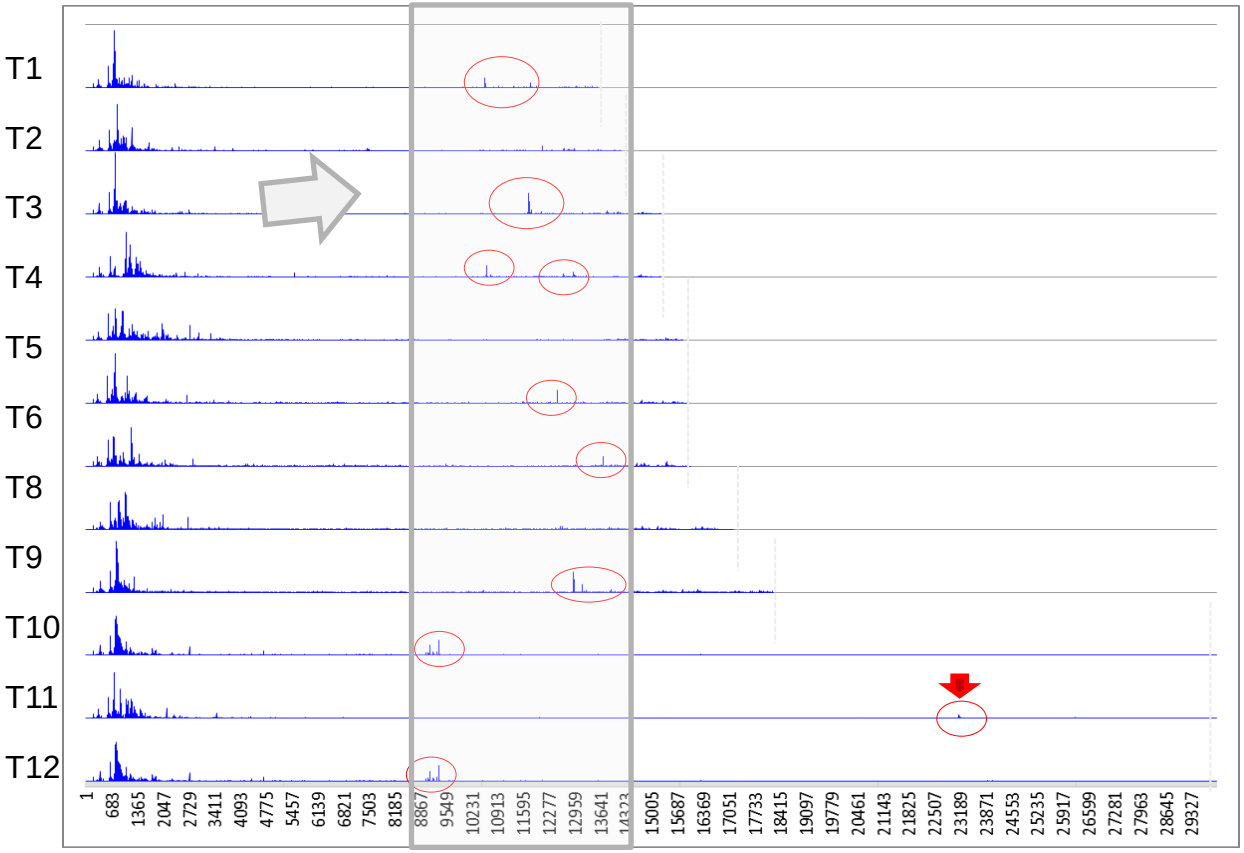
Focus on the Hard-To-Hit waves for each scenario

HTH Coverage Wave Windows

For each scenario

- Identify which hard-to-hit wave it targets
- Identify the conditions under which it succeeds to achieve it.

Cycle window likely to see a given wave.

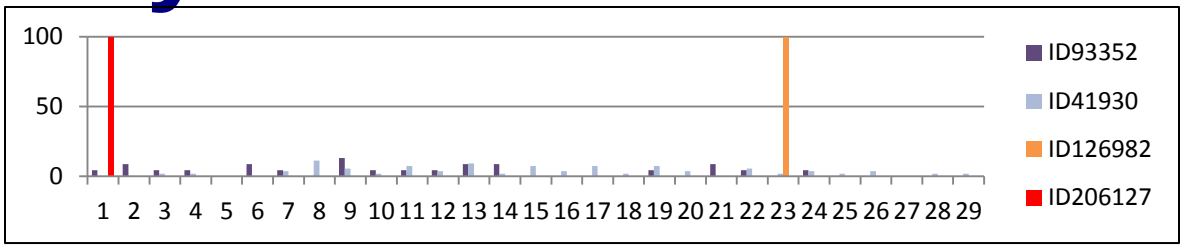


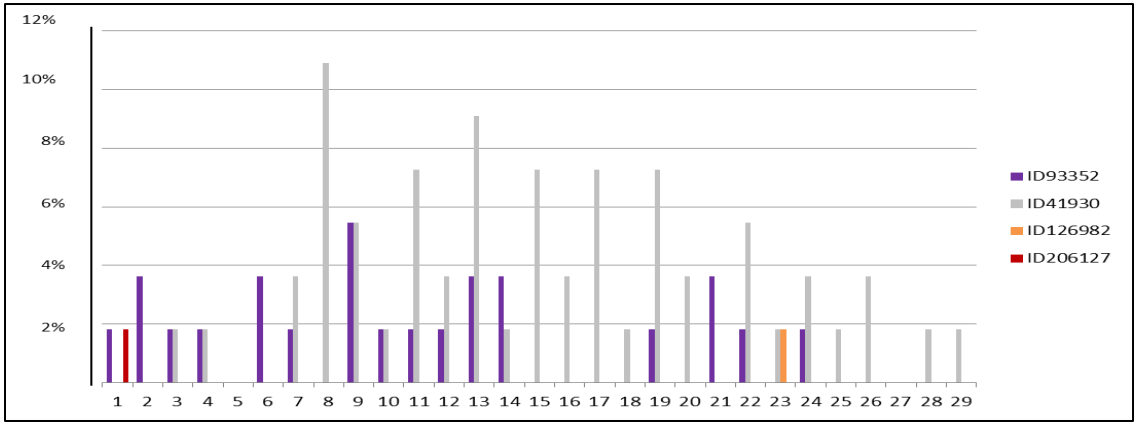
Probability Mass Function

- Overall Probability

=>

Identifies the Hard-to-Hit cycle windows





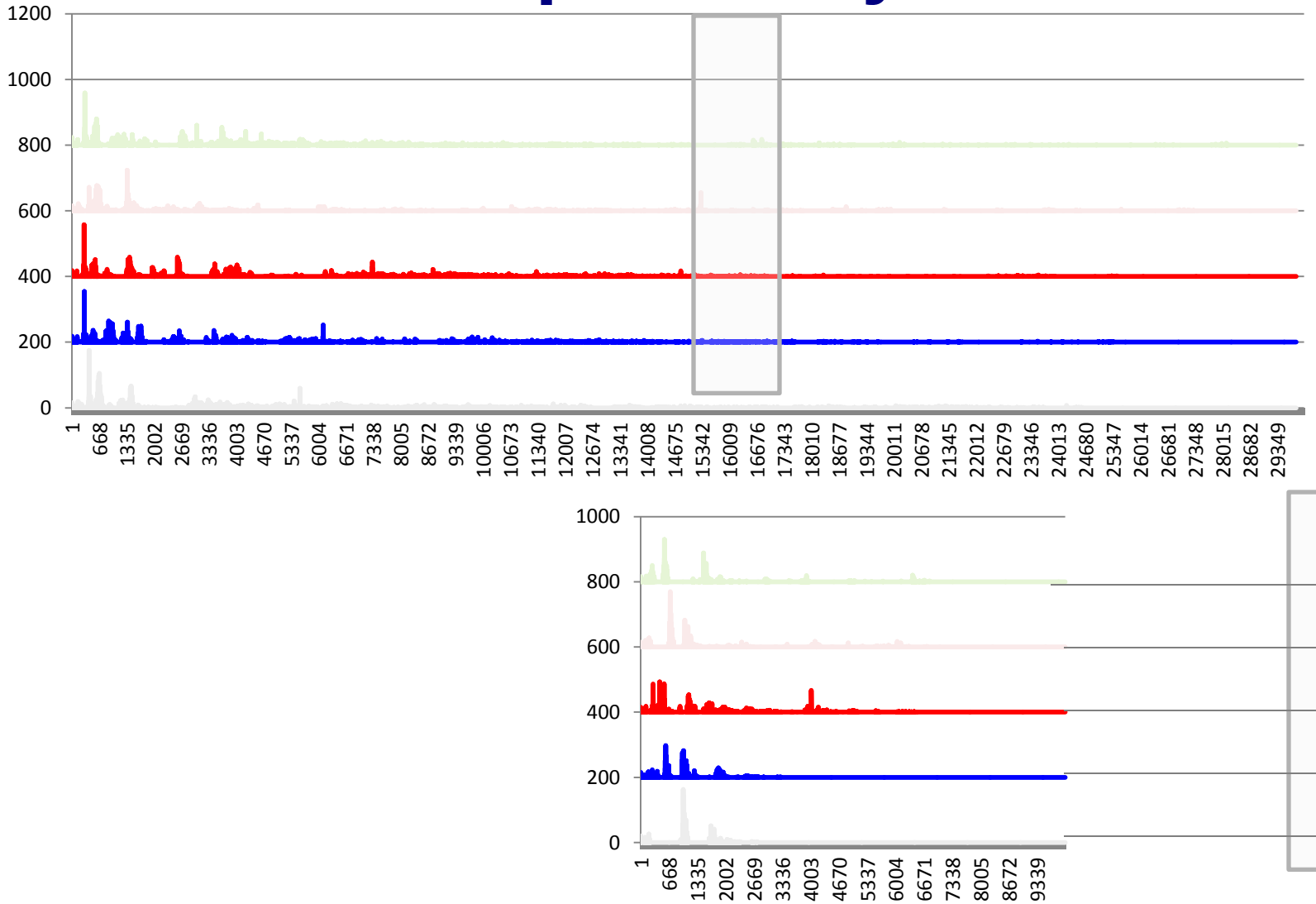
- **Probability mass function for event e**

$$\Pr(\{event\ e\ hit; cycle = c\});$$

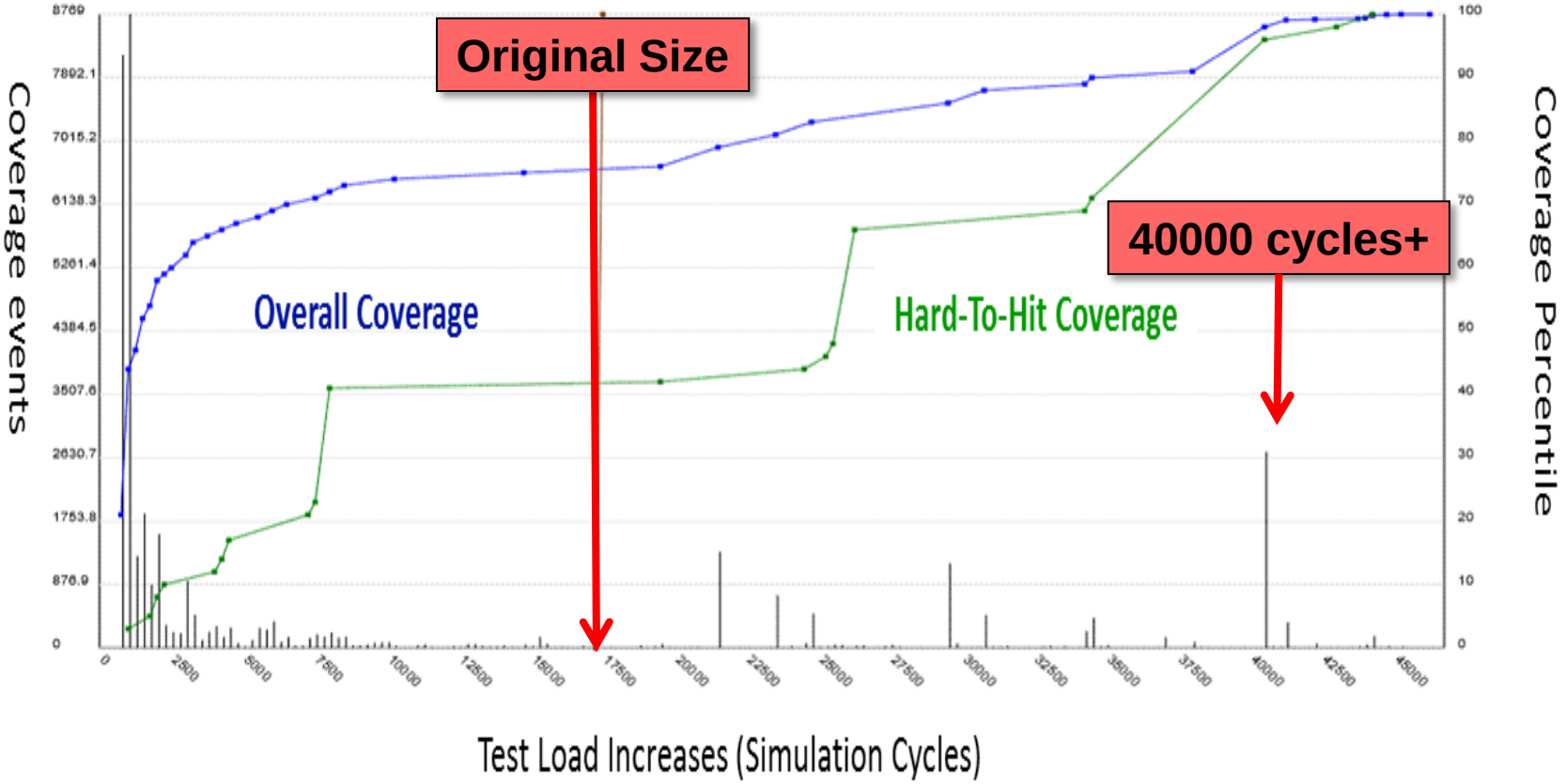
Probability test to hit *e*

$$P(e) = \frac{\text{N tests\_hit\_e}}{\text{N tests}}$$

HTH-FTPT Load Dependency



Experimental
Test Size to HTH Coverage



40 tests; TM

Summary

- Coverage Efficiency
- Observe
  - Coverage in Time
  - FTPT Coverage in Time – HTH
  - Coverage waves Mixture – Model Fitting
  - Probability distributions
- Control
  - Test case number of instructions
- Industry results

Results

- Decreased hard-to-hit by **12%**
  - 73,000 to 64,000
- Never-hit before events decreased by 13%
  - 15,000 to 13,000
  - saving 18 Person/Months.
- Less redundancy on easy-to-hit coverage.
- Shifted manual work to the automatic process
- Decreased time to achieve targeted coverage => enabled finding bugs earlier.

Acknowledgments

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References

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