



Design, Automation & Test in Europe
18-22 March, 2013 - Grenoble, France

The European Event for Electronic
System Design & Test

Machine Learning-based Anomaly Detection for Post-silicon Bug Diagnosis

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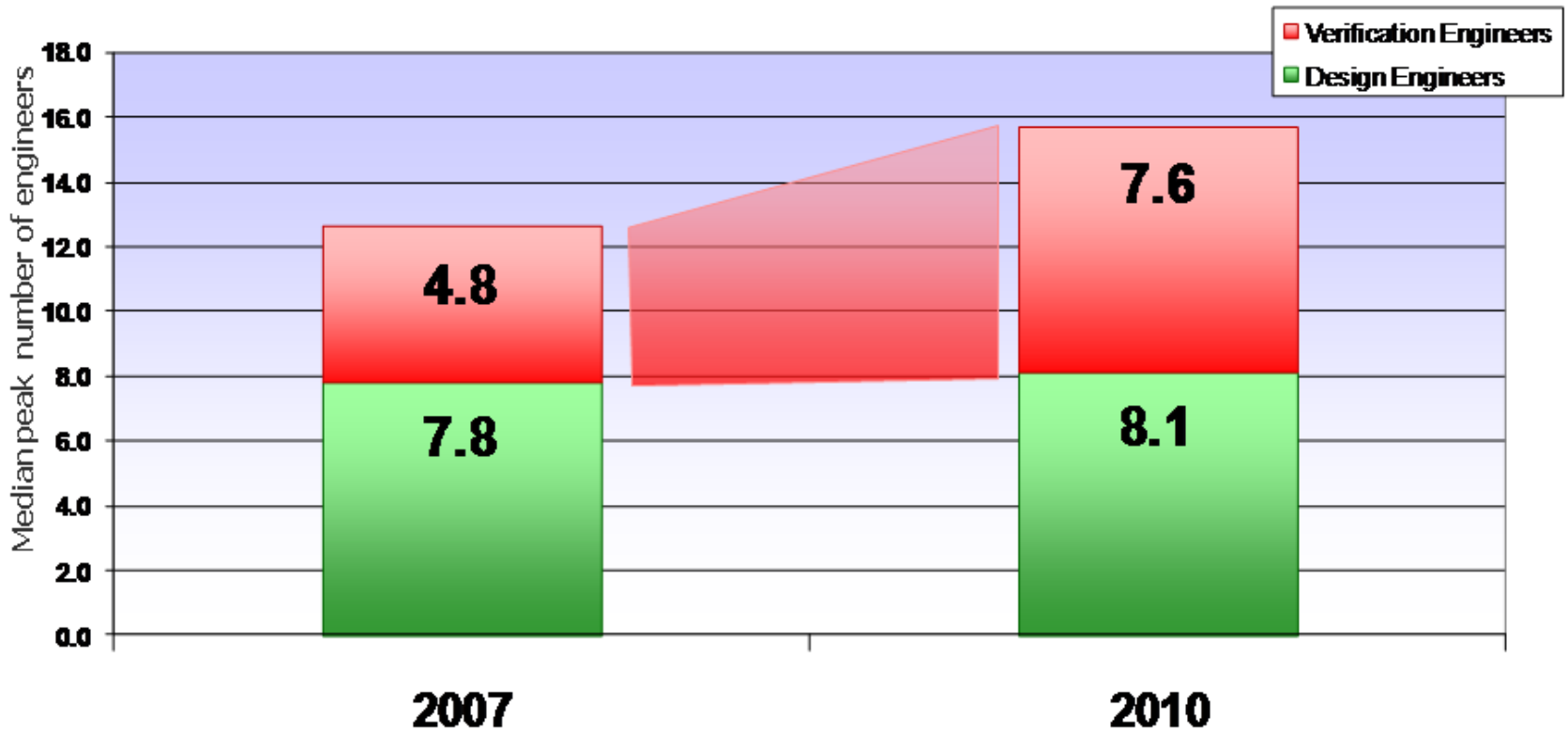


University of Michigan



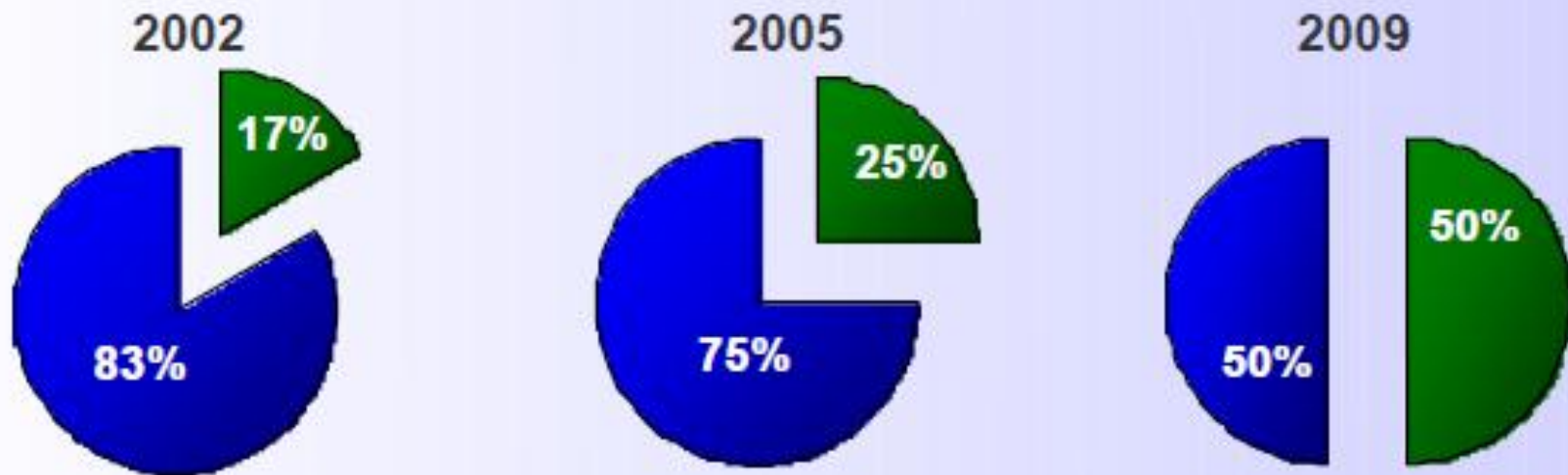
University of Illinois

Verification trends



Wilson Research Group and Mentor Graphics
[2010 Functional Verification Study](#)

Increasing post-silicon validation



Design and pre-silicon verification effort

Post-silicon validation effort

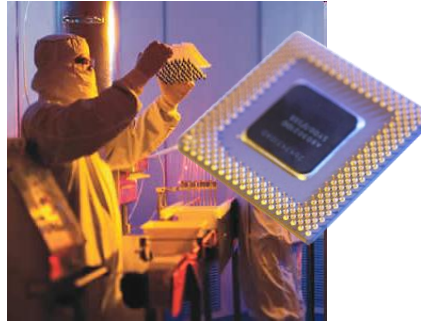
Bob Barton, Intel. Invited talk at GSRC.

Post-silicon validation

Pre-silicon



Post-silicon



Product

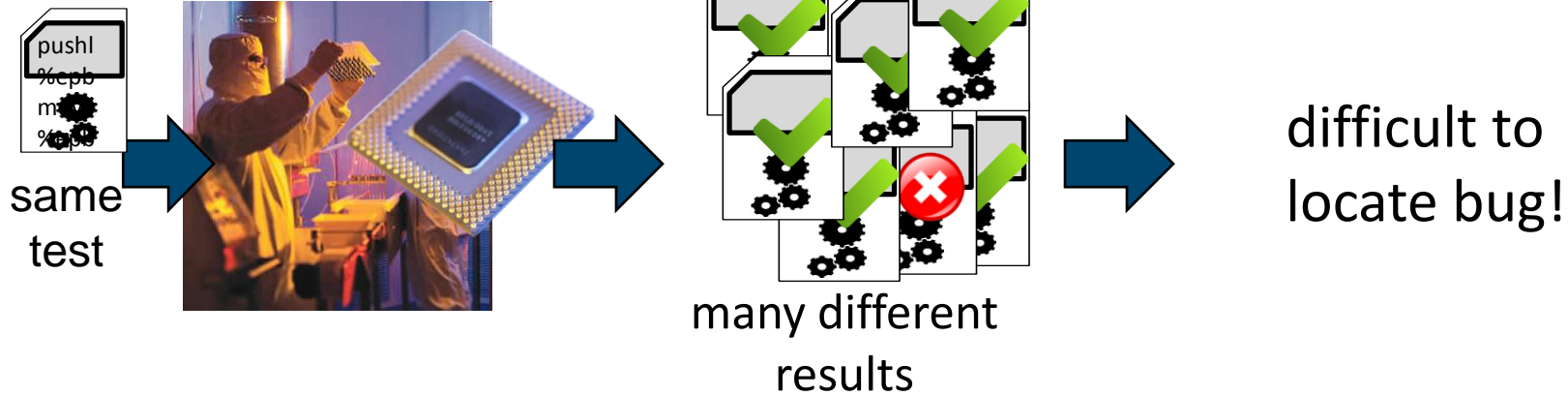


Goal: locate bug

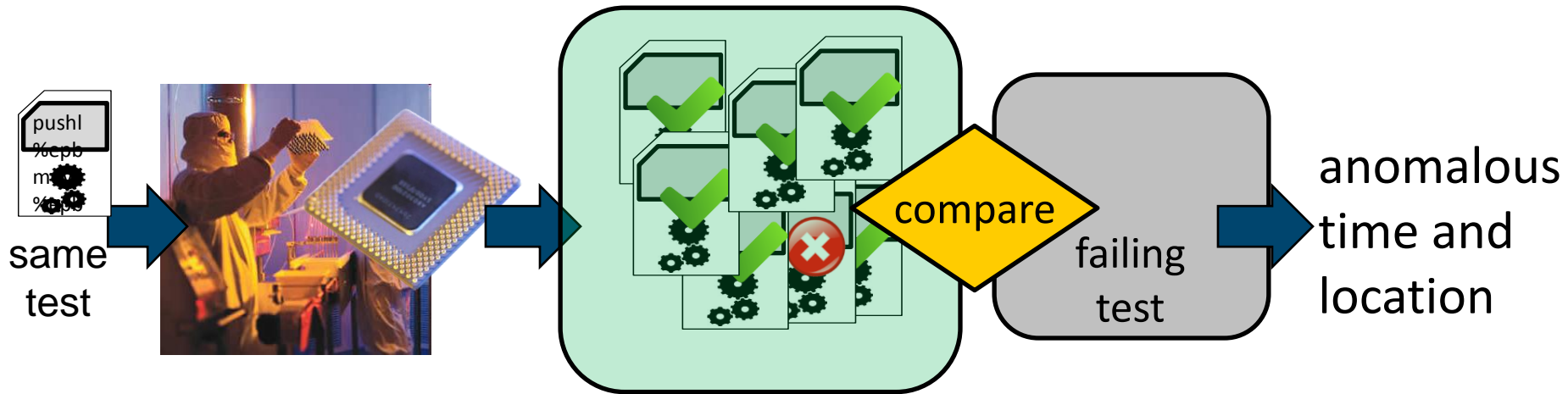
- + Fast prototypes
- + High coverage
- + Test full system
- + Find deep bugs

- Poor observability
- Slow off-chip transfer
- Noisy
- Intermittent bugs

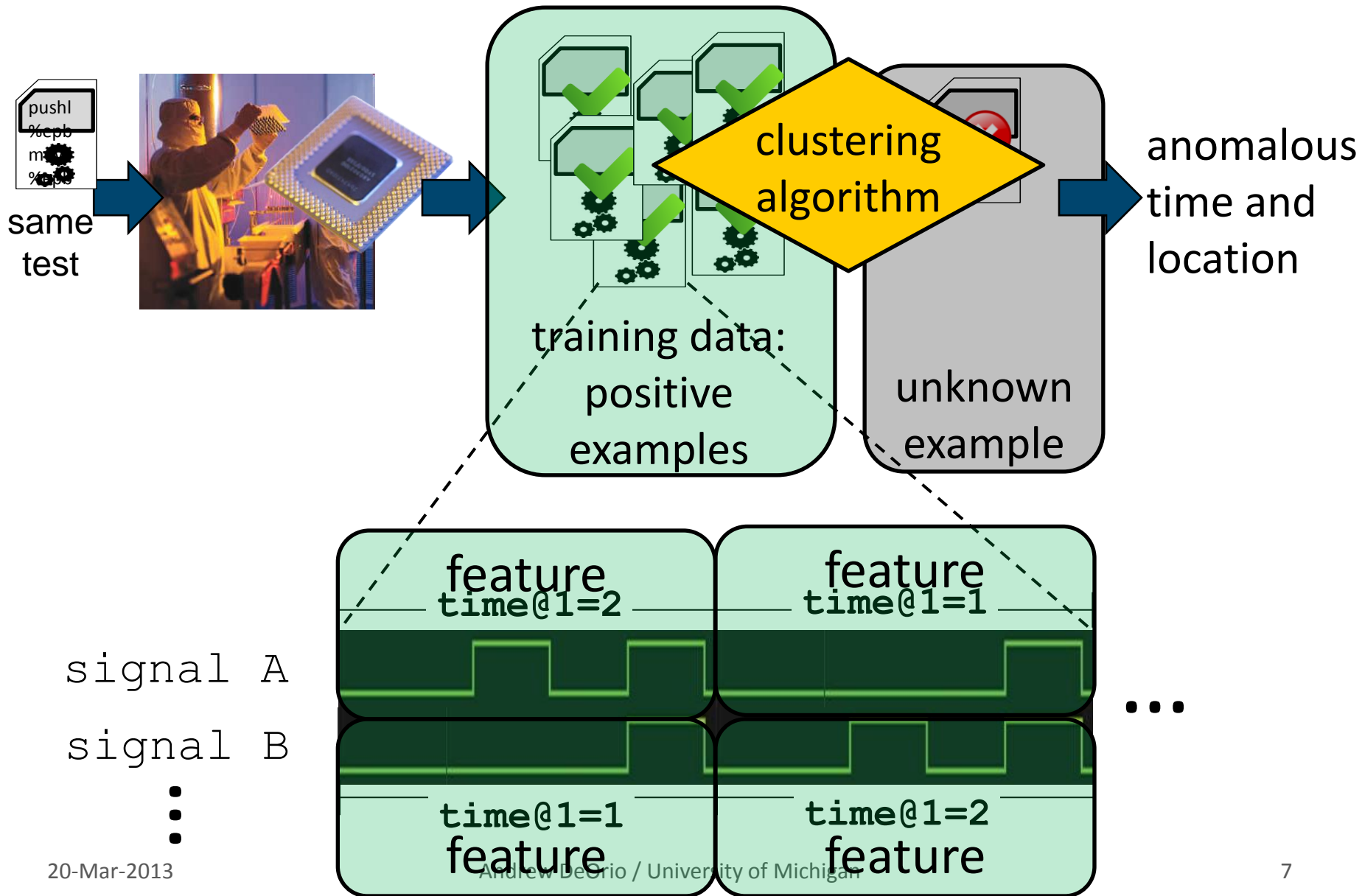
Post-silicon and credit cards



Post-silicon and credit cards

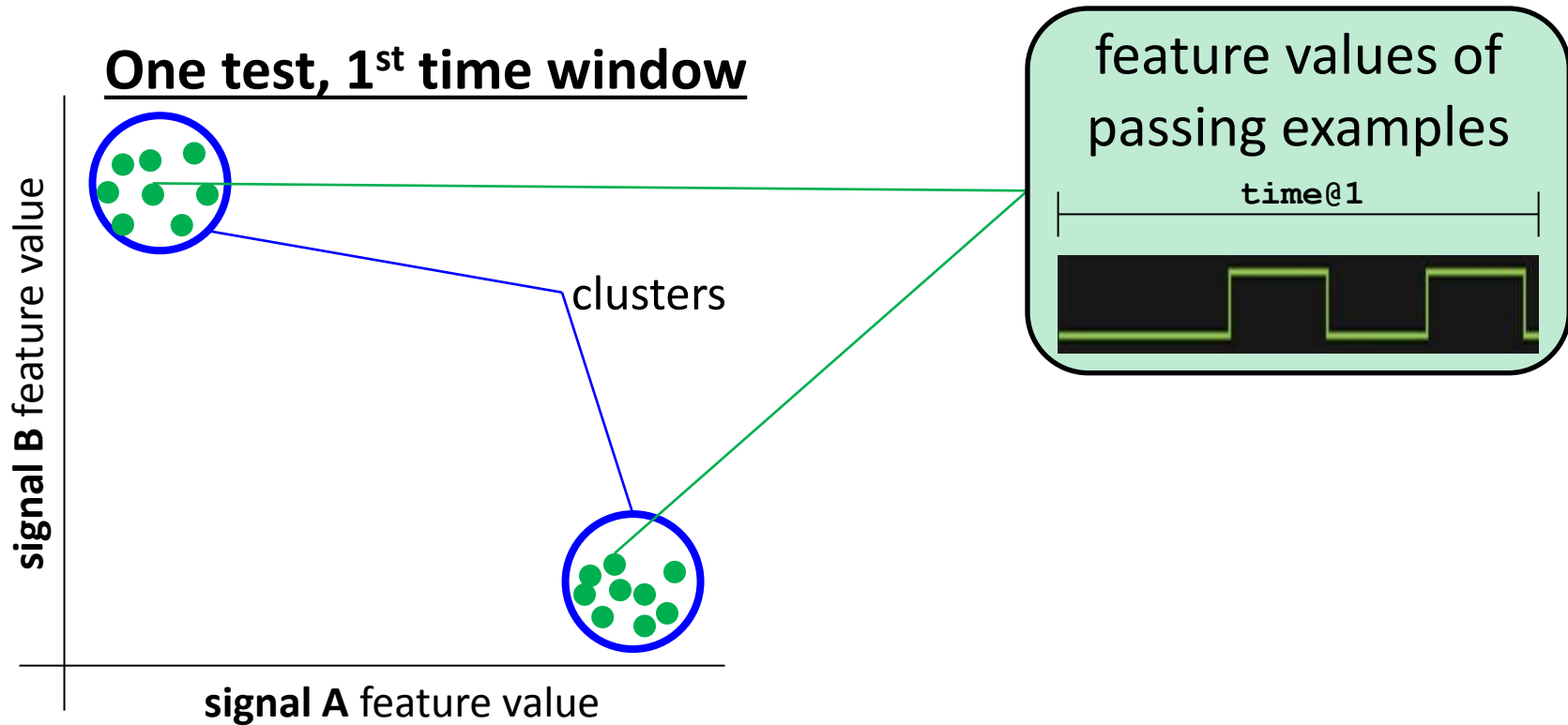


Post-silicon and credit cards



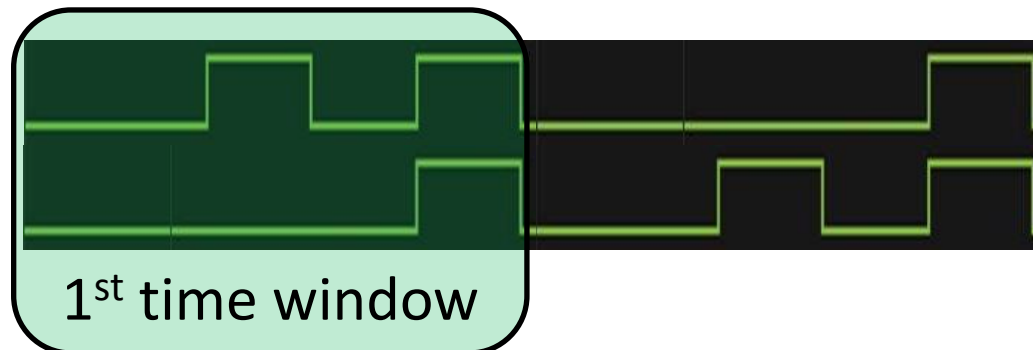
Learning clusters

clustering
algorithm



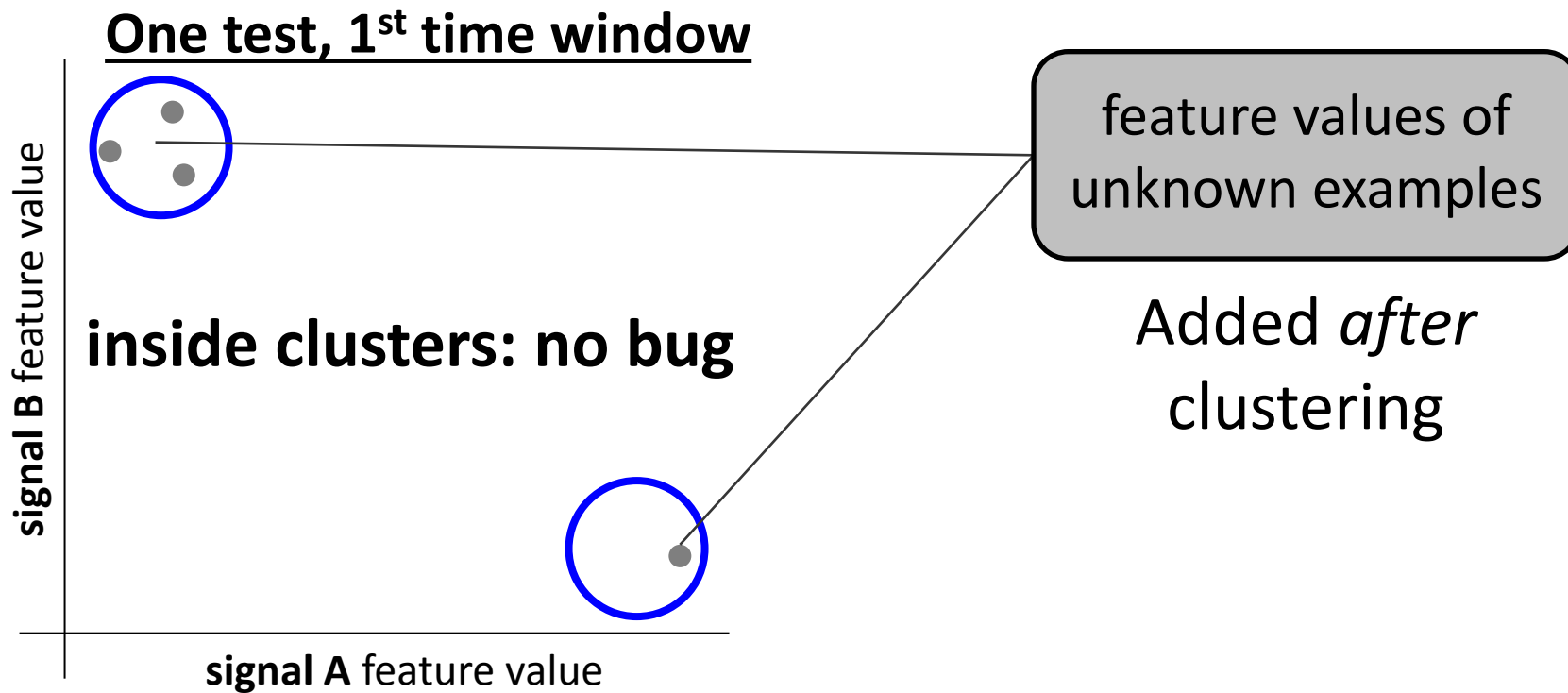
signal A

signal B



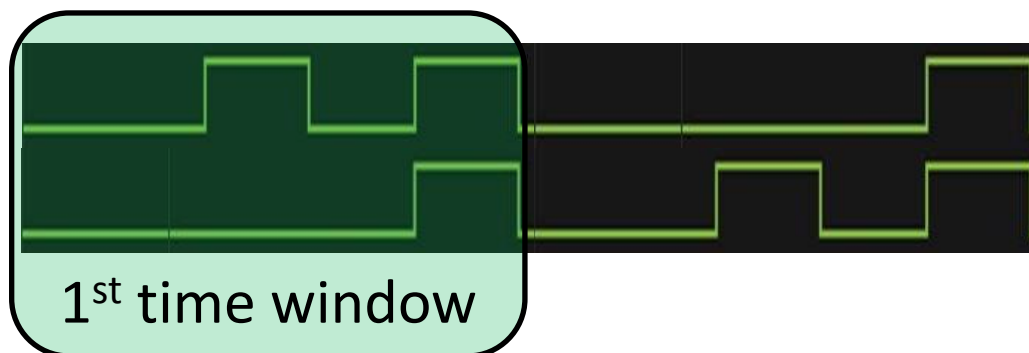
Searching for anomalies

clustering
algorithm



signal A

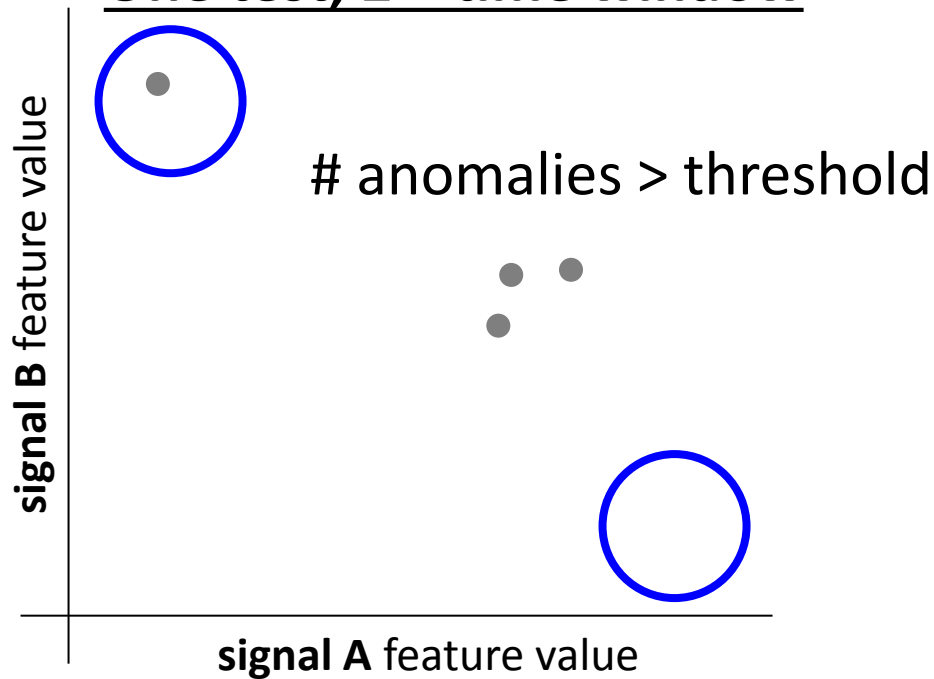
signal B



Searching for anomalies

clustering
algorithm

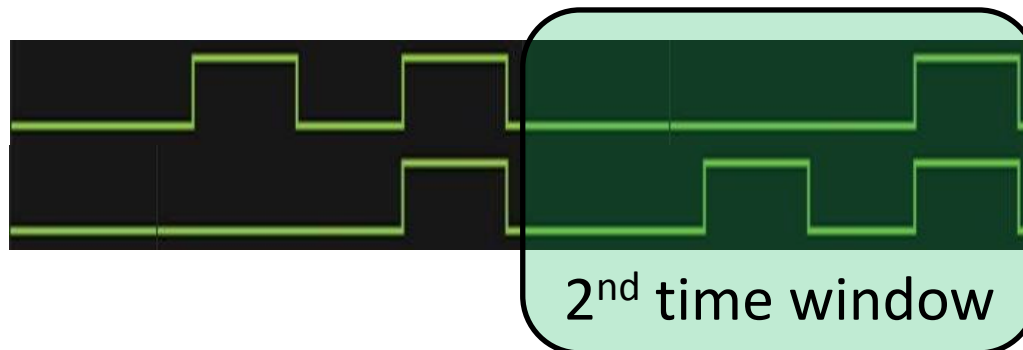
One test, 2nd time window



Outside clusters:
bug found

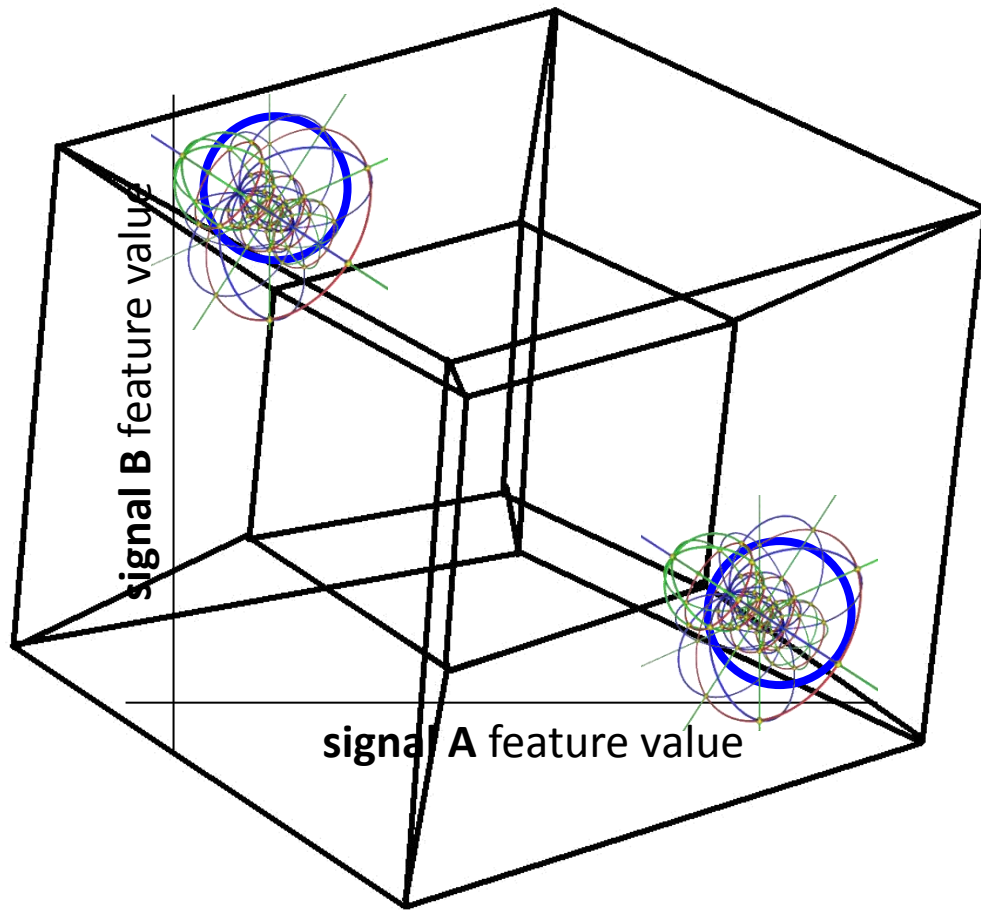
signal A

signal B



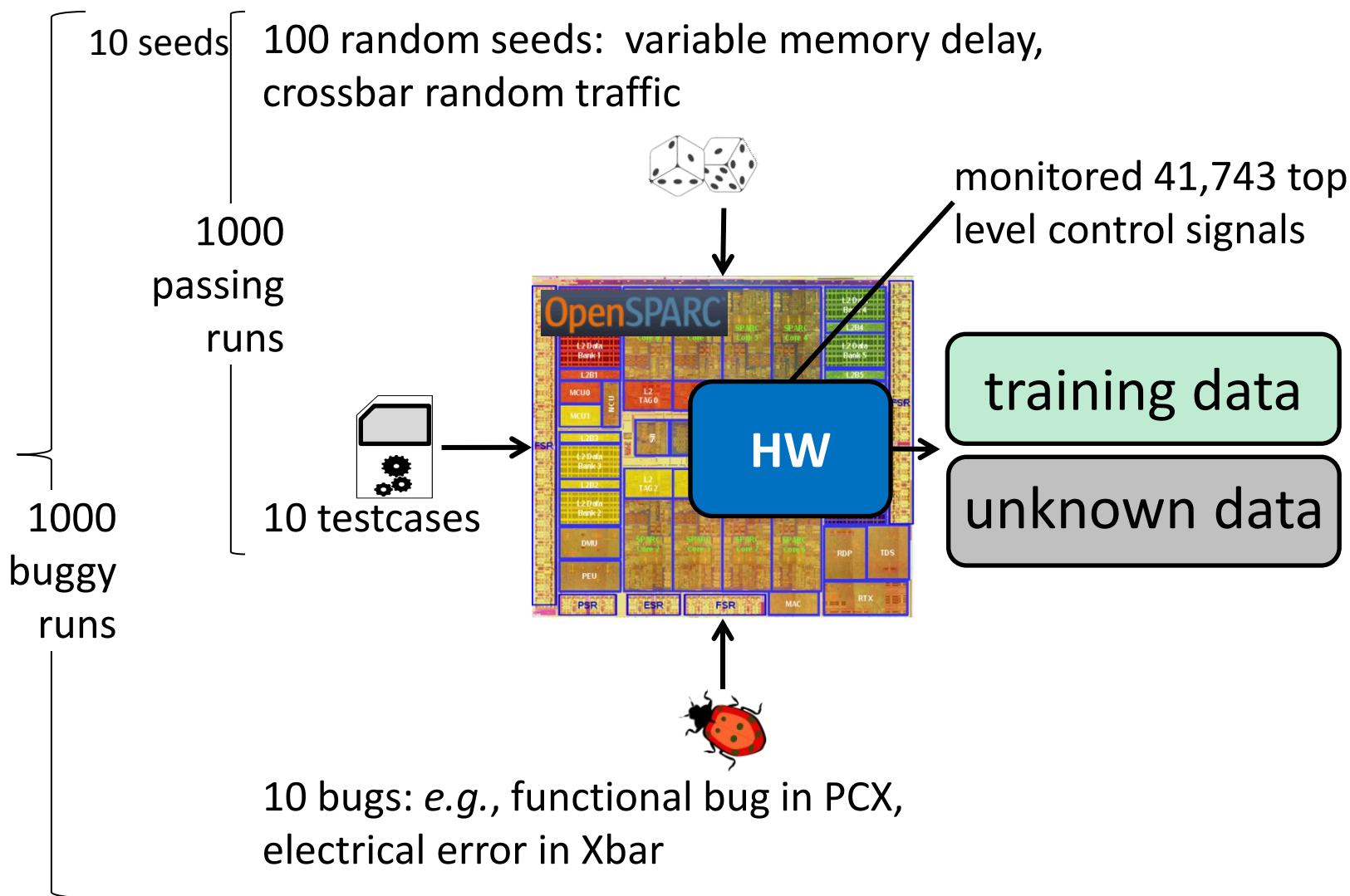
Clustering in X,000 dimensions

clustering
algorithm



- Each signal is a dimension
 - Circular clusters become hyper-spheres
 - High dimensionality is a challenge
- In practice:
 - Cap #signals in one clustering set (500)
 - Group signals by module(s) (100-500 signals)
 - Apply clustering to each group

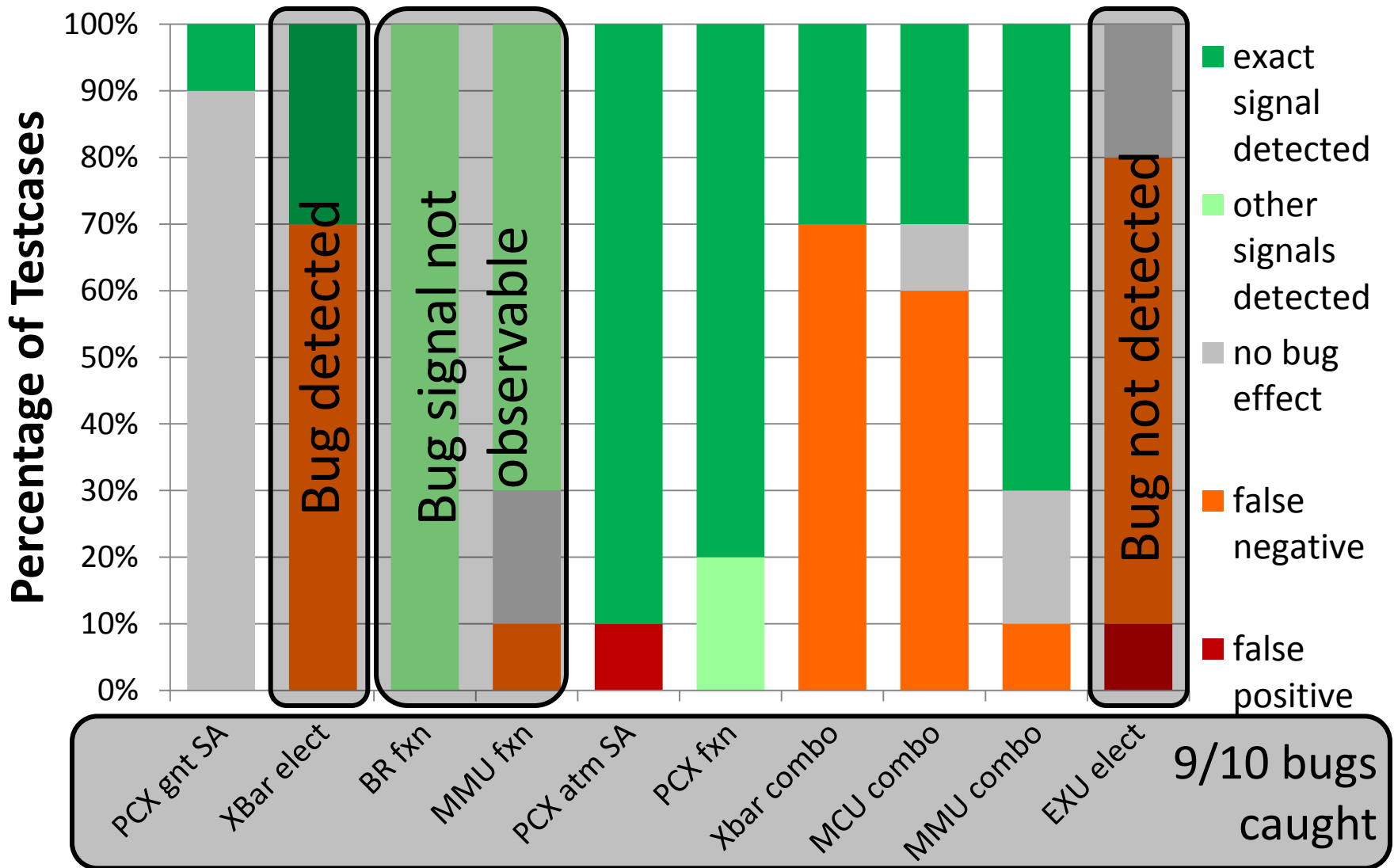
Experimental Setup



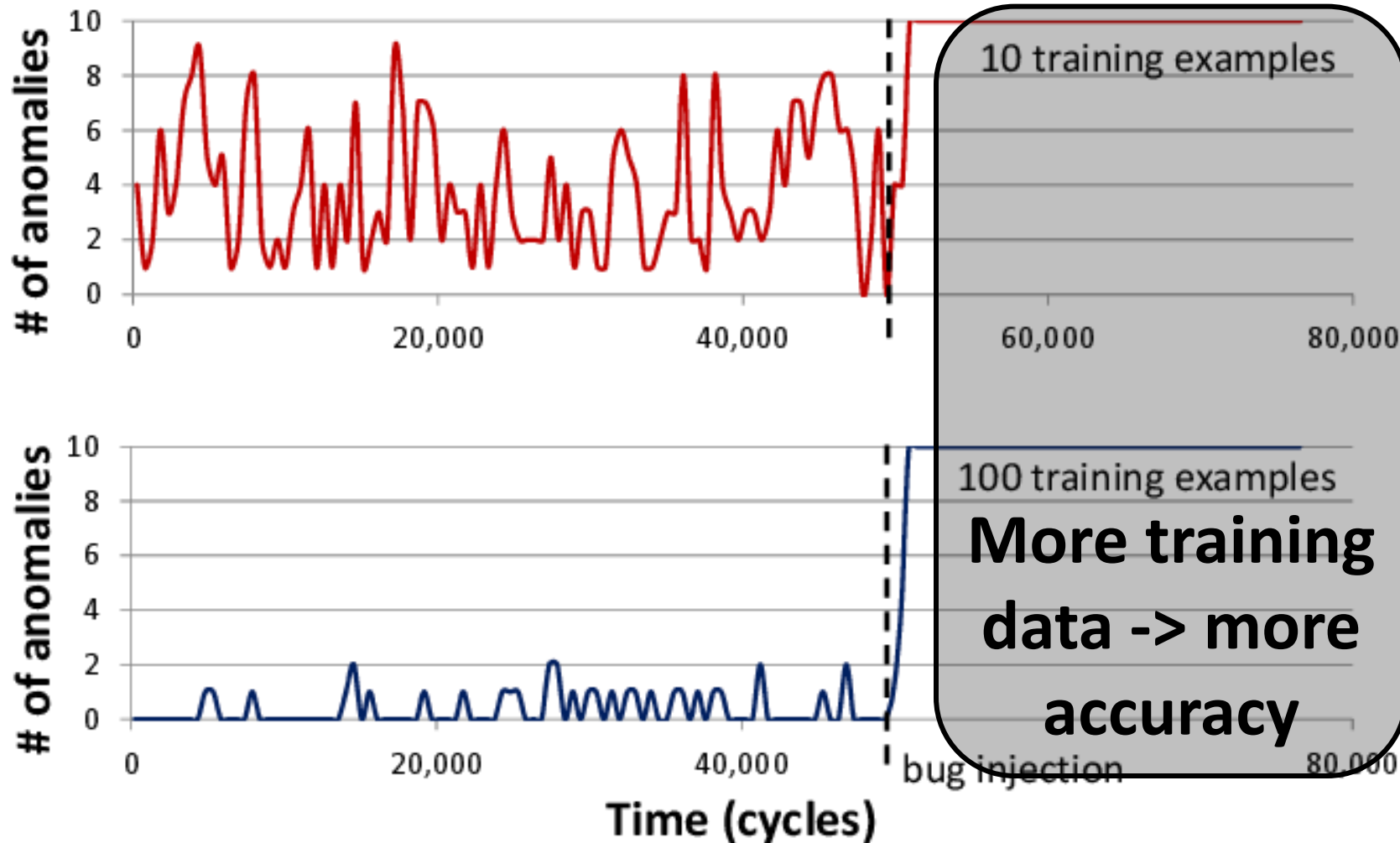
Bug injection

Bug	Description
PCX_gnt SA	Stuck-at in PCX grant
Xbar elect	Electrical error in crossbar
BR fxn	Functional bug in branch logic
MMU fxn	Functional bug in memory controller
PCX_atm SA	Stuck-at in PCX atomic grant
PCX fxn	Functional bug in PCX
XBar combo	Combined electrical errors in Xbar/PCX
MCU combo	Combined electrical errors in mem/PCX
MMU combo	Combined functional bugs in MMU/PCX
EXU elect	Electrical error in execute unit

Bug detection on OpenSPARC T2



Bug signal vs. noise



Conclusions

- Machine learning automatically localizes **bug time and location**
- Leverages a **statistical approach** to tolerate noise
- Effective for a **variety of bugs**: functional, electrical and manufacturing
 - 336 cycles, 347 signals on average