

# Accelerating Bandgap Reference High-Sigma Verification with Additive AI Technology



 Microsoft **SIEMENS**

SPONSORED BY



# Bandgap verification to high-sigma with an iterative workflow is challenging

## Analog design challenges:

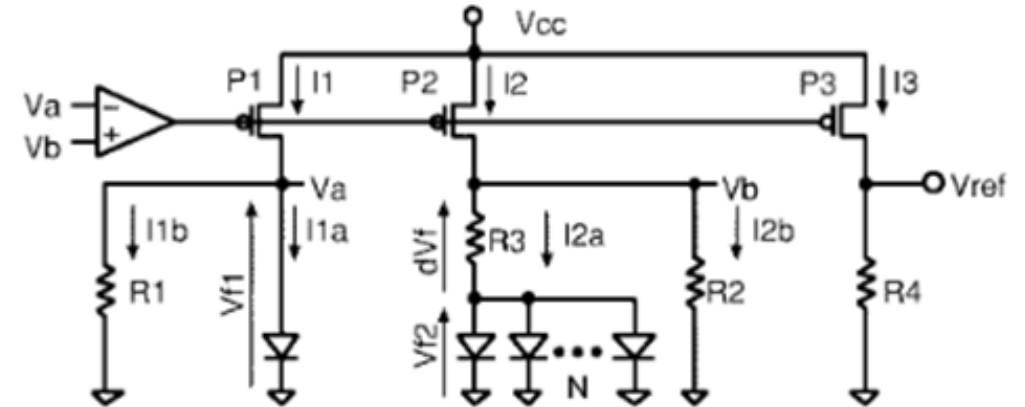
- Precision voltage references are particularly challenging in advanced FinFET processes
- Design cycle is iterative, and the complexity increases due to the need for series/parallel transistors

## Iterative high-sigma verification challenges:

- Circuit verification is required to meet 6 sigma levels
- Brute-force Monte Carlo simulations are impractical
- Multiple iterations are needed during design cycle
- Current verification takes 6 hours, need it faster



Need a solution that meets both **accuracy** and **performance** requirements and saves across iterations



Banba et al., "A CMOS bandgap reference circuit with Sub-1-V operation," IEEE J. Solid-State Circuits, May 1999

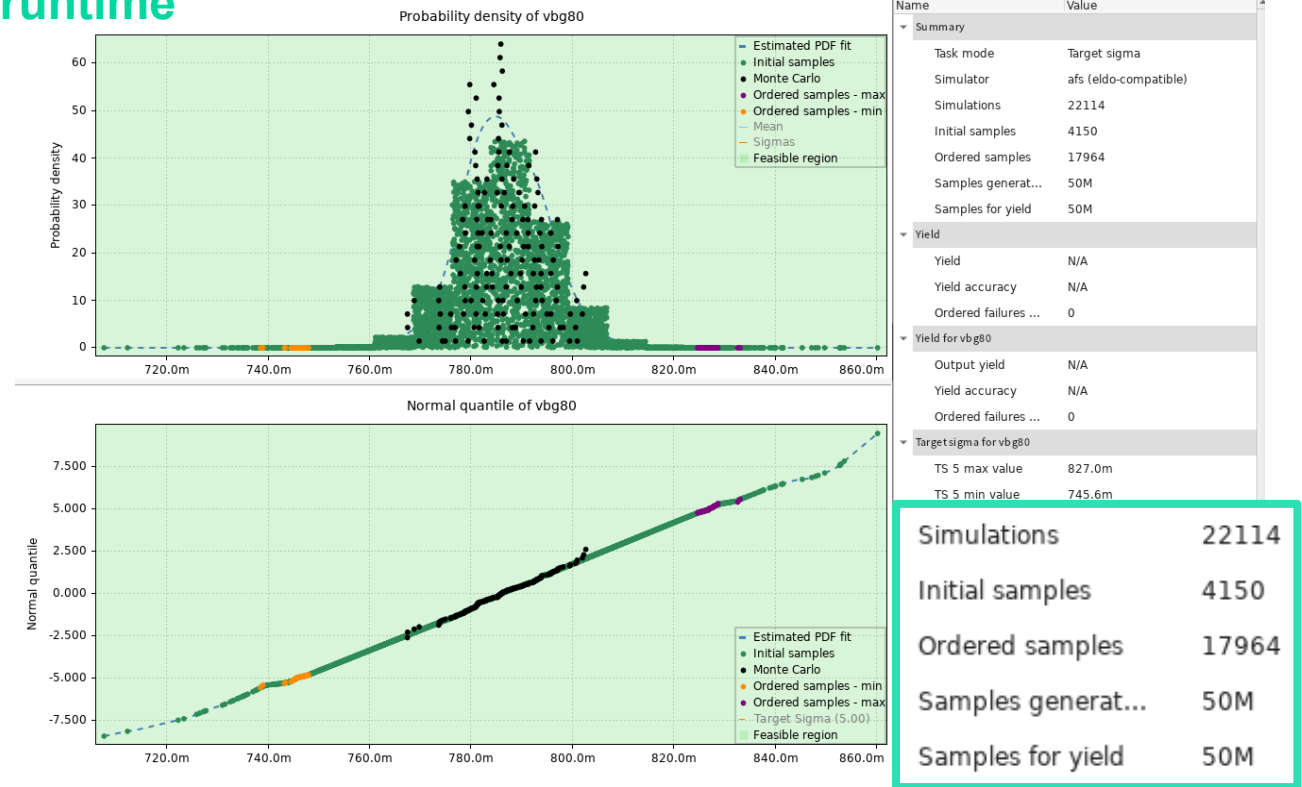
# Solido high-sigma technology addresses modern design challenges

Solido High-Sigma Verifier provides **brute-force accurate**, sign-off level verification at high sigma **within production runtime**

- Real simulations at and beyond target sigma, no extrapolation
- Brute-force Monte Carlo sample populations verify to within +/- 0.1 sigma

Bandgap verification:

- Verified to 5-sigma in **22,114** simulations
- Brute force would have taken **50M** simulations
- **2,261x** speedup



High-Sigma Verifier run on a bandgap circuit verifying to 5 sigma



# Introducing Solido Additive Learning technology for iterative workflows

## Traditional verification workflow:



## Solido iterative workflow:



# Additive Learning: retains and reuses AI models to speedup iterative workflows

To tackle these challenges, we have adopted an Additive AI-based methodology, which enhances **speed** **accuracy**, and is **fully automated**

## ⚡ Fast

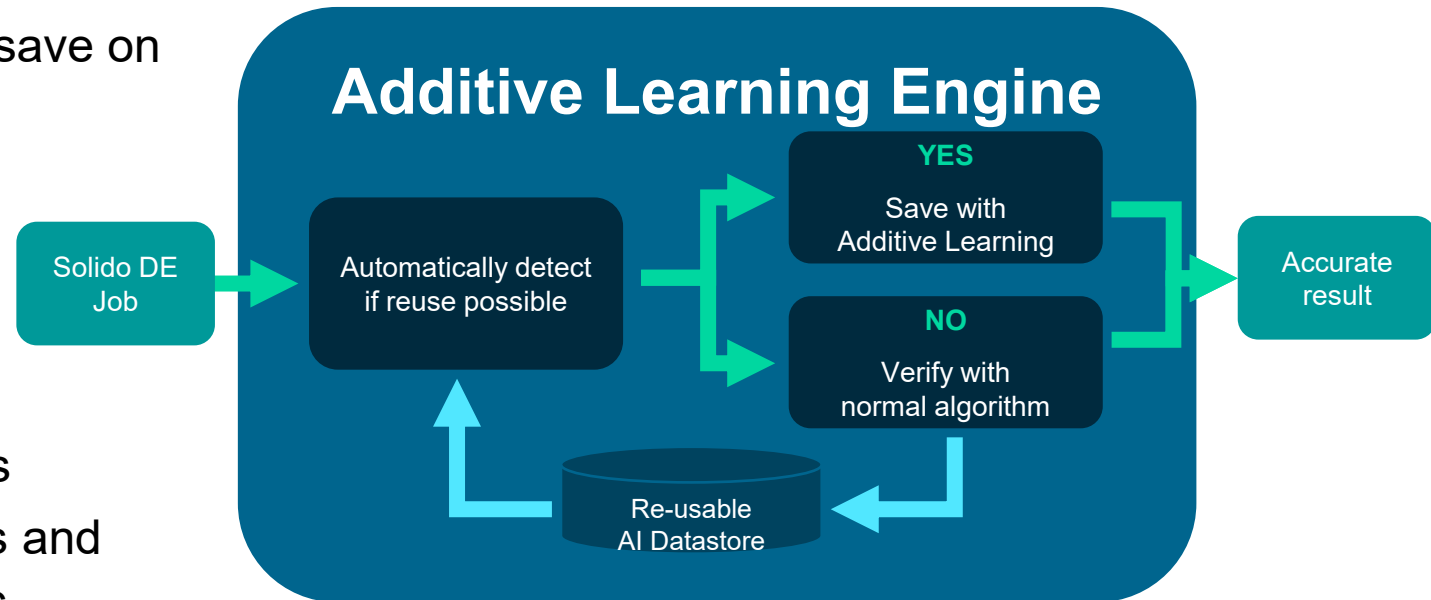
- Reuses AI models from previous jobs to save on each iteration, when applicable

## 🎯 Accurate

- Equivalent to a full verification job

## 🧠 Automatic

- No user-input or AI knowledge needed
- AI constantly tracks and makes decisions
- Automatically check variables (definitions and counts), netlist (names and includes), etc.



# Additive Learning datastore is light-weight, optimized, and multi-user friendly

## Light-weight & optimized

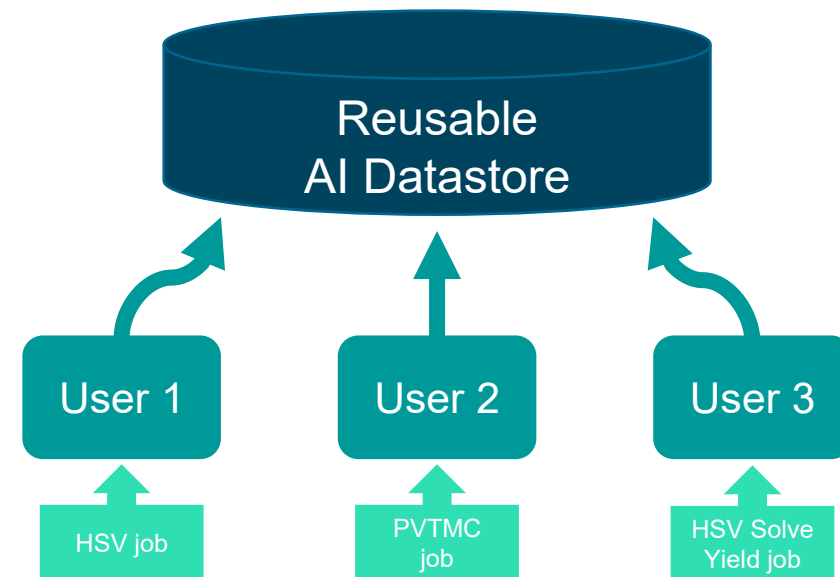
- Optimized for Additive Learning engine (fast lookup)
- Stores AI models and previous simulation data

## Multi-user support

- Supports parallel read/write
- Configurable location

## Small disk footprint

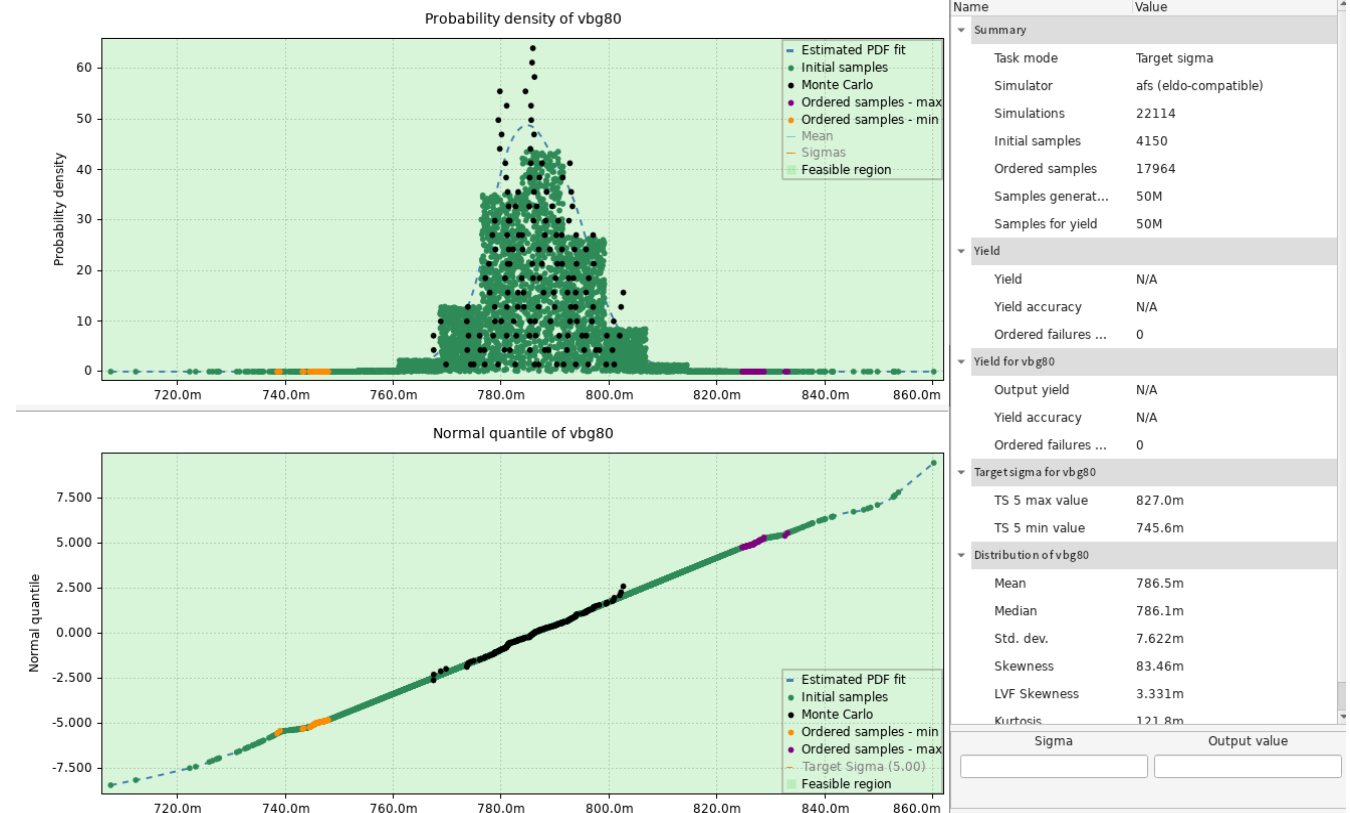
- Can safely delete Solido DE results while preserving future speedup opportunities



# Base verification job

## Solido High-Sigma Verifier (base job)

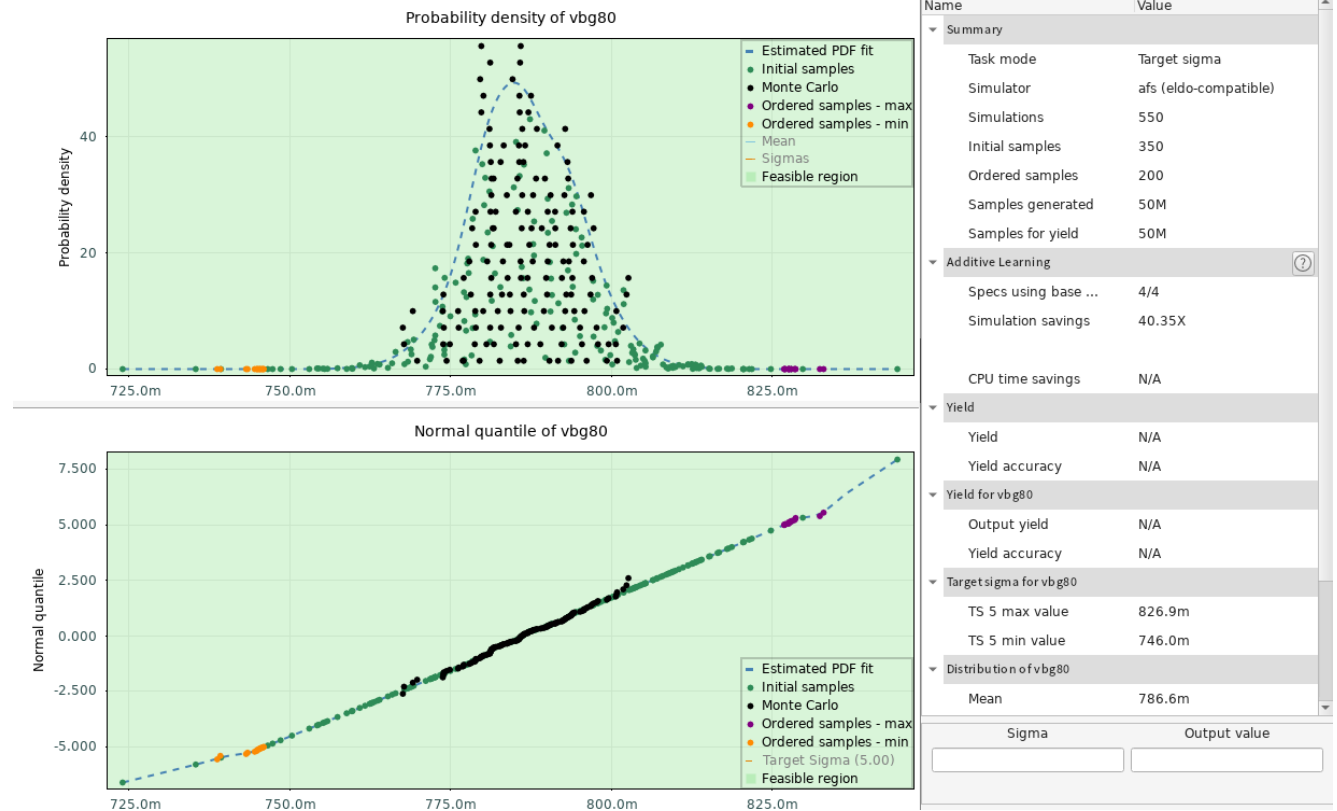
- 5 sigma verified with brute-force accuracy
- **22,143 simulations**
- **5hr 49min**
- Solido Additive Learning was enabled and captured needed information for reuse regarding the result



# Iterative run showing 40x simulation savings and 19x wallclock time speedup

## Power supply changed +/-10% (iterative job)

- Re-ran High-Sigma Verifier **with Additive Learning**
- **550 simulations (40.4x)**
- **18min (19.4x)**
- Solido Additive Learning used saved models from the above base run to **significantly reduce time**





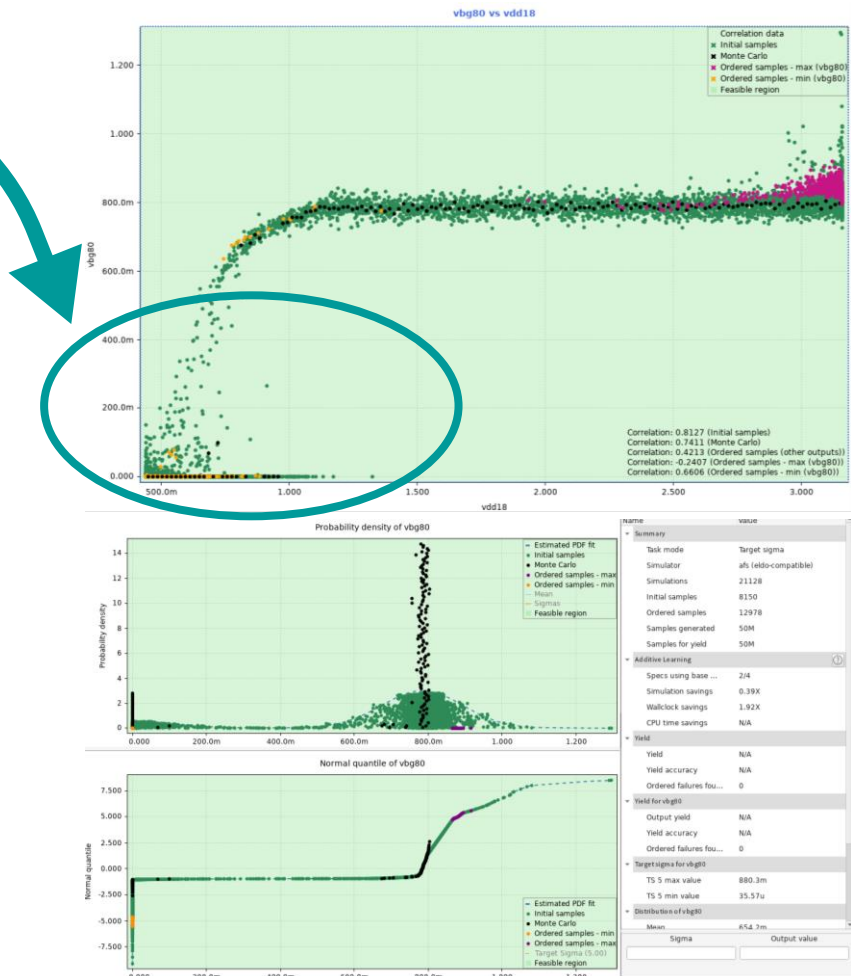
# Pushing the technology to an extreme boundary proves robustness of the methodology

## Design was pushed to an extreme power supply

- This demonstrated new behavior from the circuit

## Additive Learning automatically checks if savings possible

- Runs the full job to get verified results when extreme power supply significantly affects circuit behavior
- Identifies significant design changes and automatically chooses to run the full job, even if no savings are demonstrated
- Eliminates the need for manual intervention in decision-making, which is crucial for the design team



# Summary: Proposed methodology provides 40x simulation and 19x wallclock time speedups

## Our team's challenges with the case

- Precision voltage references are particularly challenging in advanced FinFET processes
- Design cycle is iterative, and the complexity increases due to the need for series/parallel transistors

## Solution requirements

- ⚡ **Fast:** Reduce the current 6-hour verification time and speedup the iterative re-verification workflow
- 🎯 **Accurate:** Can provide accurate results to the target 6-sigma
- 🧠 **Automated:** It needs to “just work”, with minimal to no user manual work

## Solido Additive AI-based proposed methodology

- Leverages Artificial Intelligence to speedup iterative verification jobs, automatically with full accuracy
- Retains AI models in a datastore, and reuses them with every rerun when applicable

Additive Learning provided **40x simulation** savings and **19x wallclock** time speedup, saving **compute resources** and **boosting production timeline**



# Thank you!



SPONSORED BY

