Don’t Let Your Favorite Benchmarks Lie to You

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Benchmarking Issues

- Benchmark Problems
  - Synthetic tests are not always real world indicators
  - Most focus on isolated situations
  - Typically use only worst case data entropy
  - Some use Me**bi**byte/s (MiB/s) vs. Me**ga**byte/s (MB/s)
  - Do not require the drive to be in a "used" state (preconditioned)

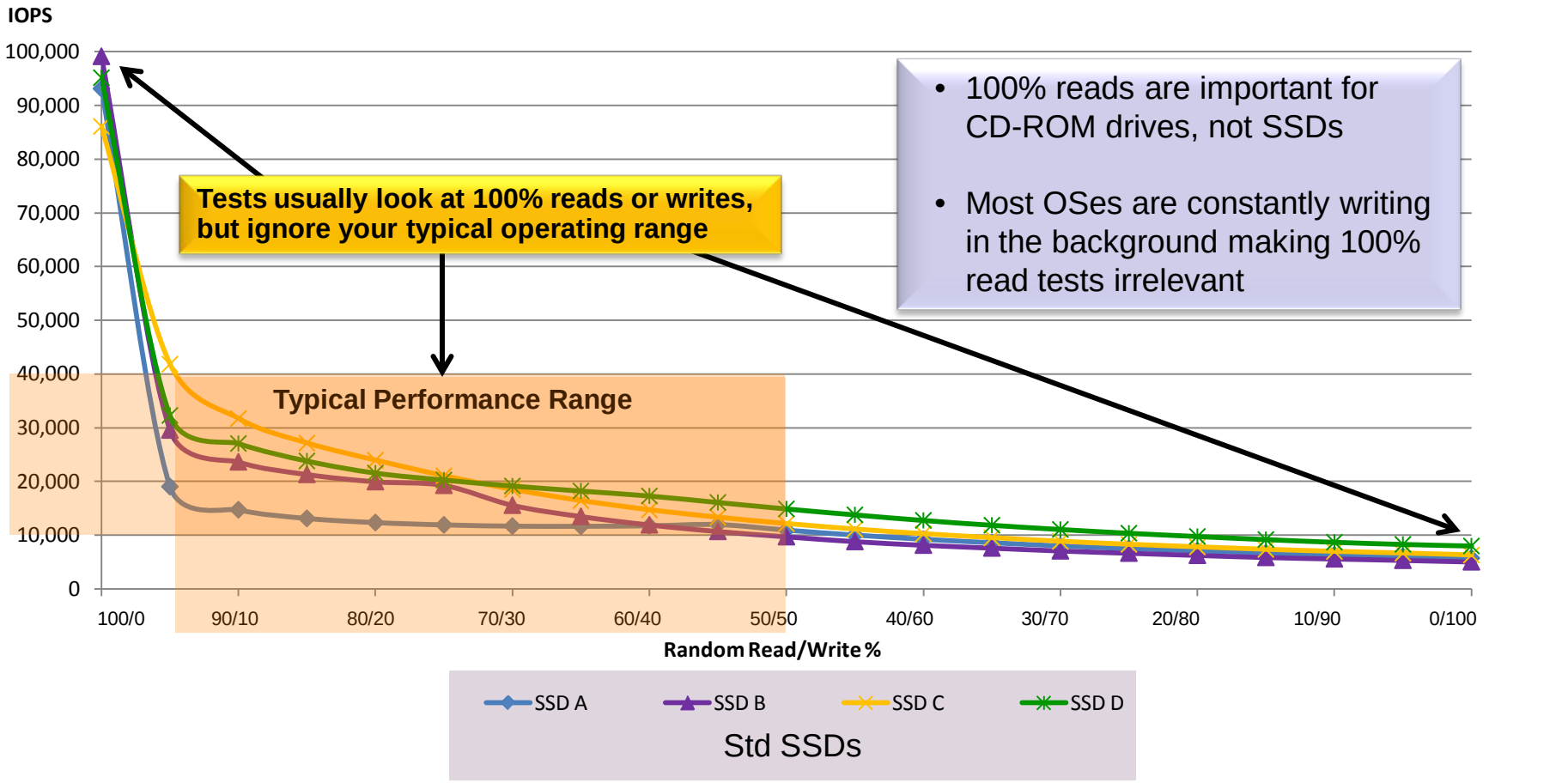
"What is preconditioning?"

- Operator Errors
  - Not manually preconditioning or doing it incorrectly
  - Misunderstanding results like data entropy
  - Not testing other relevant data
    - Power per GB written
    - Battery life
    - Write amplification
    - Background vs. foreground garbage collection

"I don't precondition because it takes too long"

Most benchmark results only show part of the bigger picture

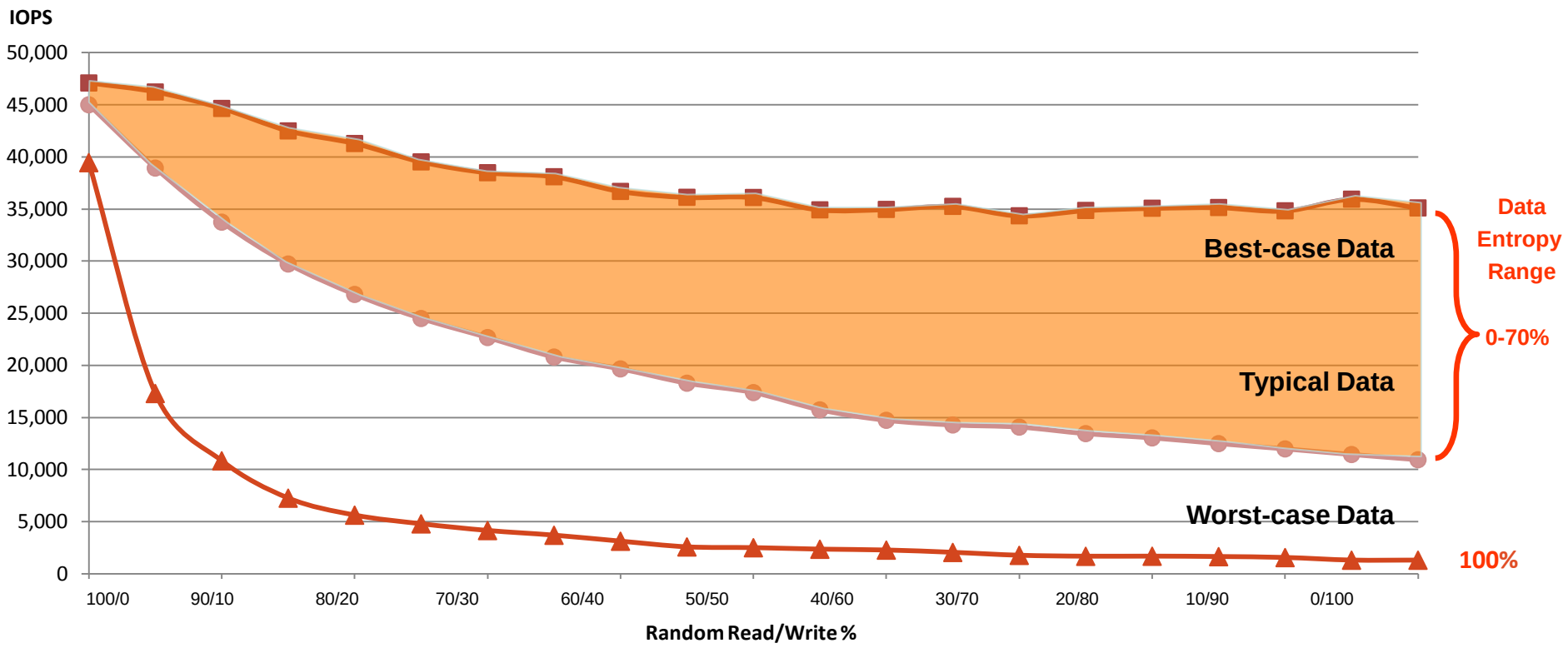
Synthetic Tests Often Highlight Unrealistic Data



With just 5% writes typical SSDs lose 50-80% performance

Random IOPS after Random Writes preconditioning; data collected using VDBench

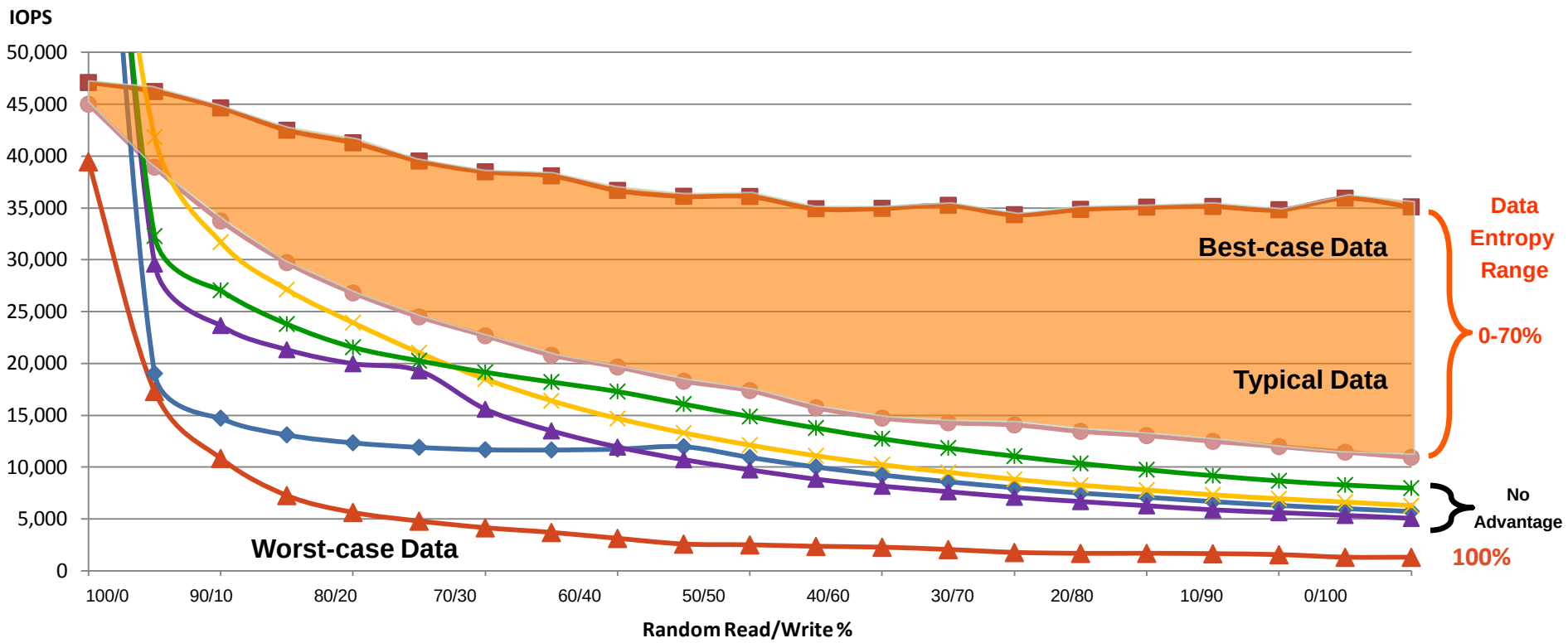
Why Does Entropy Testing Matter?



Performance increases with lower entropy for data reduction technology like DuraWrite™

Random IOPS after Random Writes preconditioning; data collected using VDBench

Why Does Entropy Testing Matter?

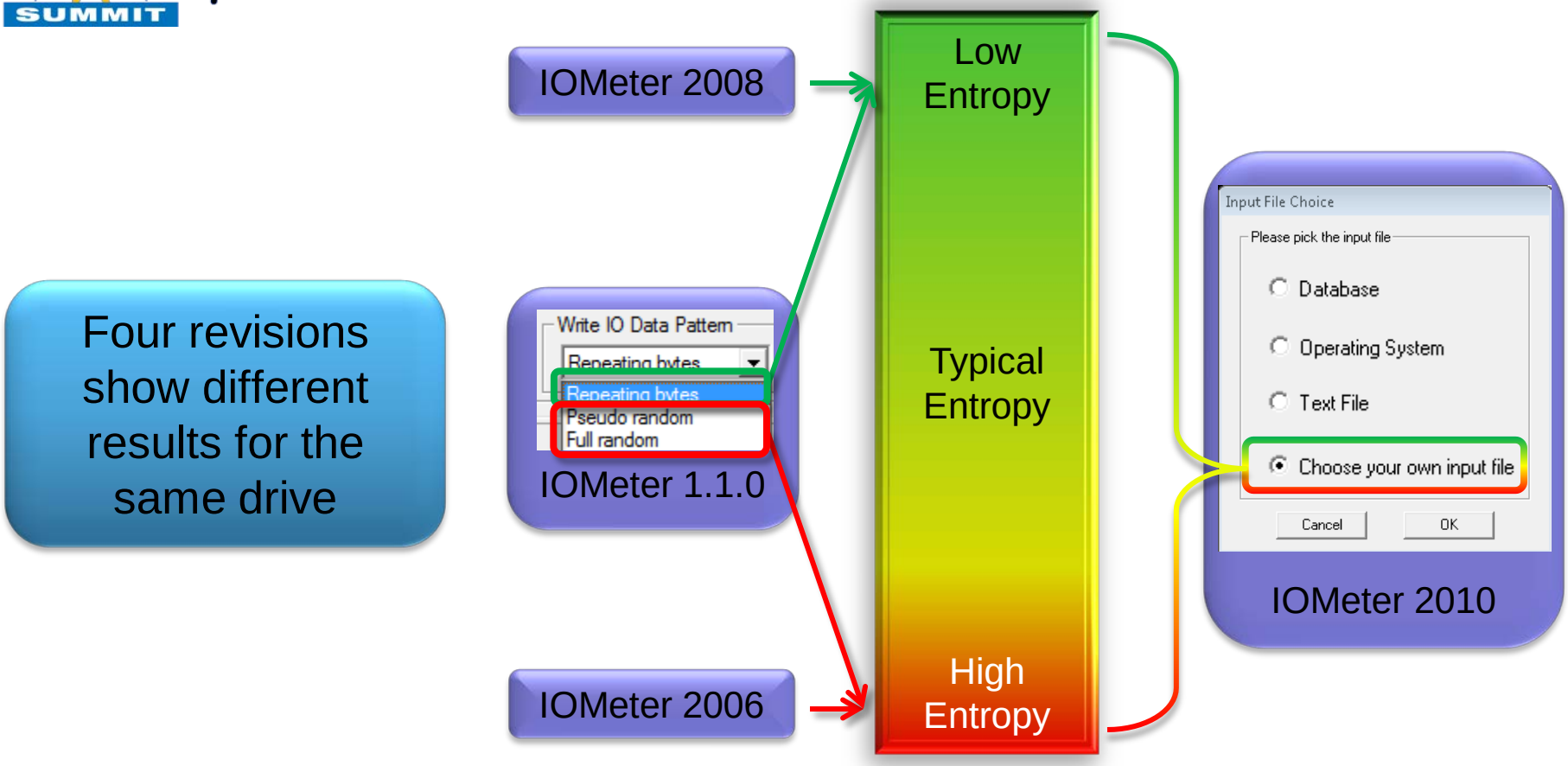


SSDs without data reduction technology have no advantage with entropy

Random IOPS after Random Writes preconditioning; data collected using VDBench

IOMeter – Multiple Versions Available

Entropy is the primary difference



IOMeter 2010 permits entropy testing for typical data

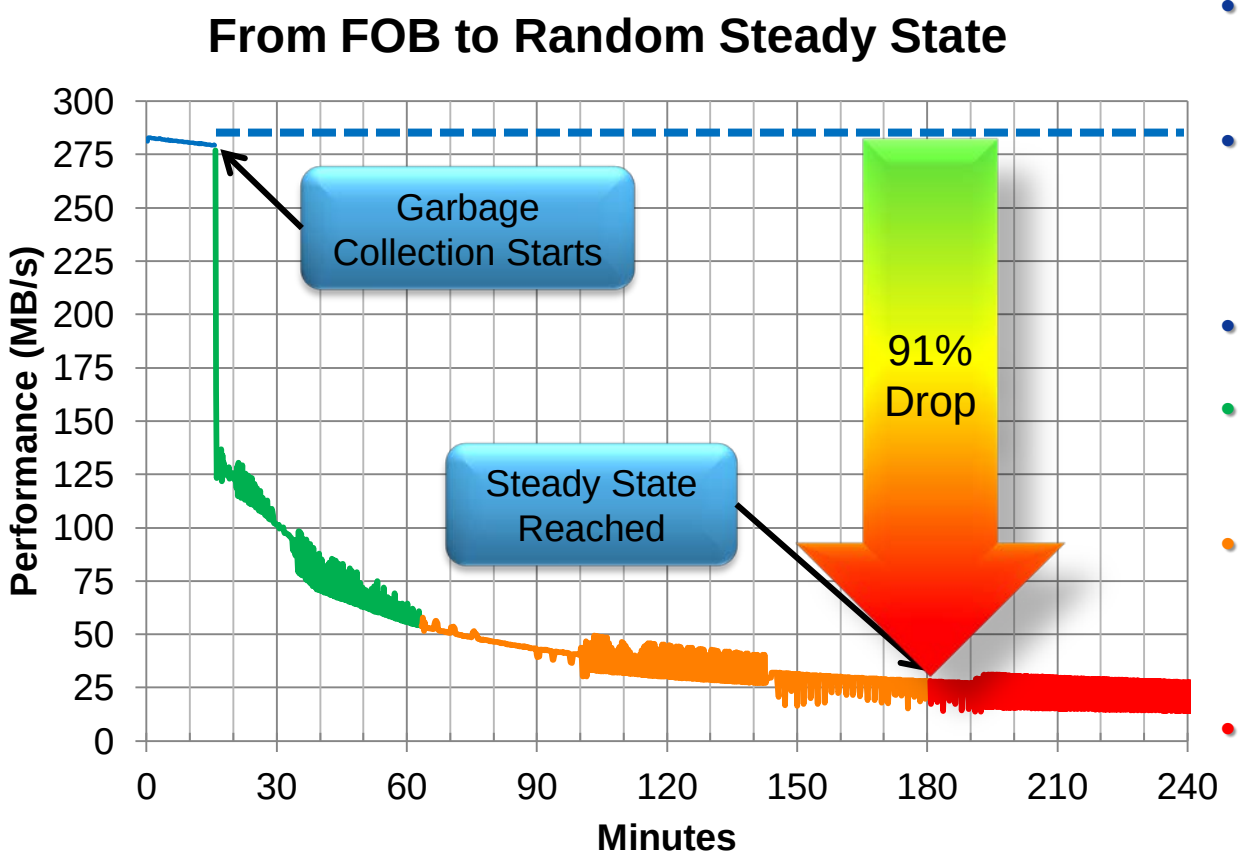
Does Preconditioning Really Matter?

Absolutely!

- All NAND SSDs perform Garbage Collection (GC)
  - Starts after writing one full capacity worth of data
  - Represents >99.9% of the SSD's life
  - Mainly affects write performance

Just How Much Can Preconditioning Matter?

Preconditioning Impact on an SSD



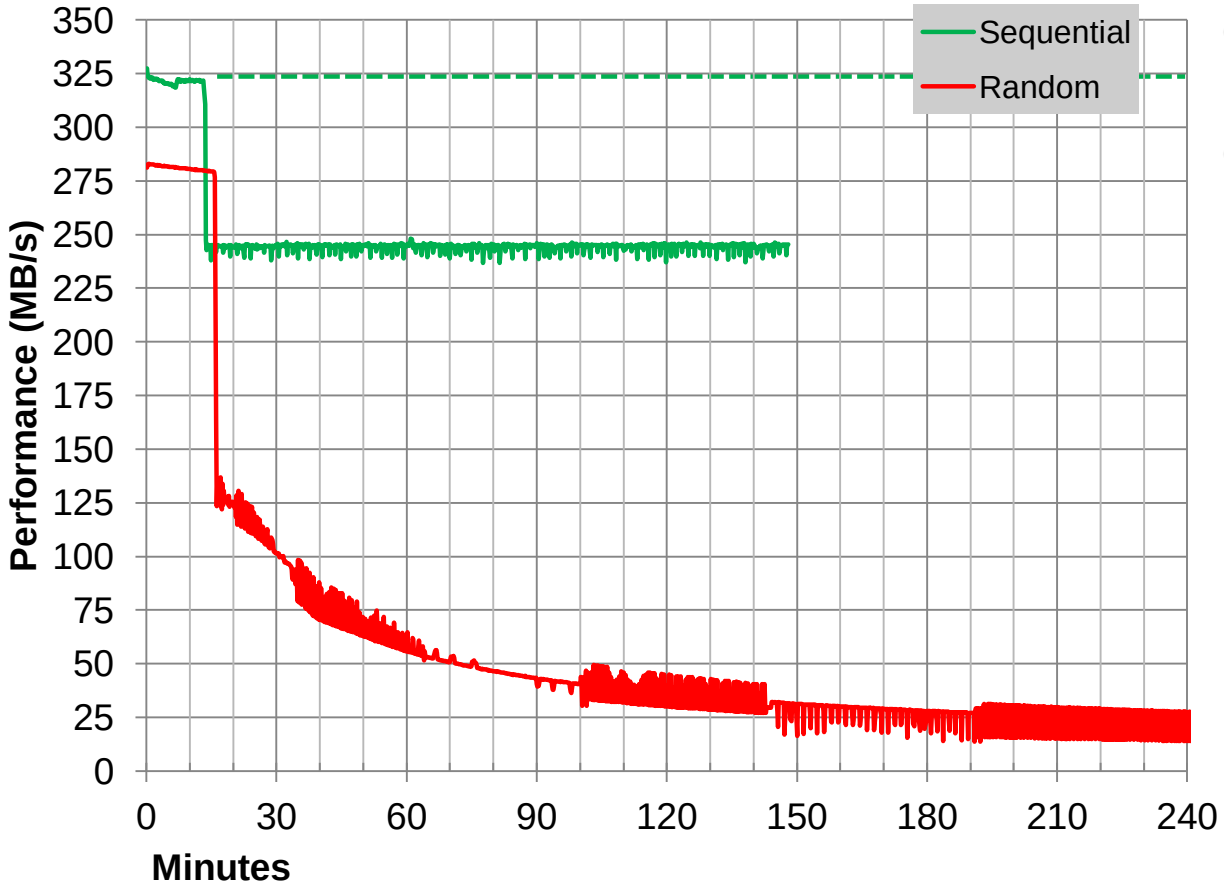
- Secure erase SSD for Fresh-Out-of-Box (FOB)
- After 16 minutes drive wrote 256GB (one full capacity write)
- Garbage Collection starts
- After ~62 minutes it wrote 2x capacity
- After ~3 hours it wrote 3x capacity, and finally hit steady state
- Now you can run drive tests to represent reality

Properly precondition before random tests for true-life results

IOMeter Test Parameters:
- Transfer size and access type: 4K random write
- Test duration: 240 minutes

Sequential vs. Random Preconditioning

FOB to Steady-state Write Performance Compared



- Sequential precon generally hits steady-state very quickly
- Random precon can take over 10x longer

Don't use only sequential preconditioning because it is convenient

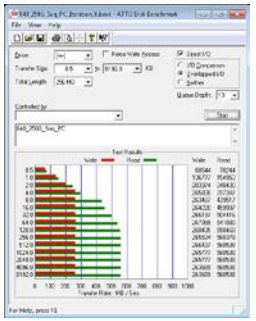
The Benchmarks

Before and After
Proper Preconditioning

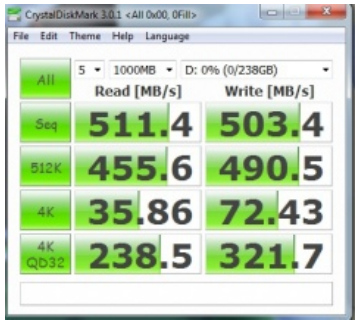
Commonly Used Benchmarks

Anvil's Storage Utilities

AS-SSD Benchmark

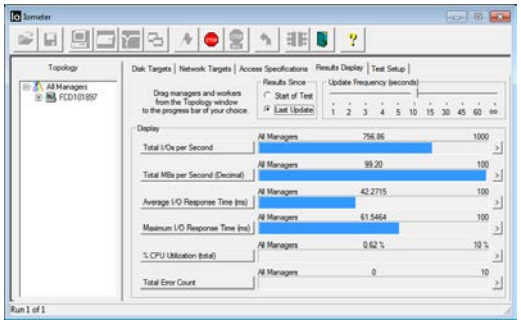


ATTO Disk Benchmark



Crystal Disk Mark

PCMark Vantage/7

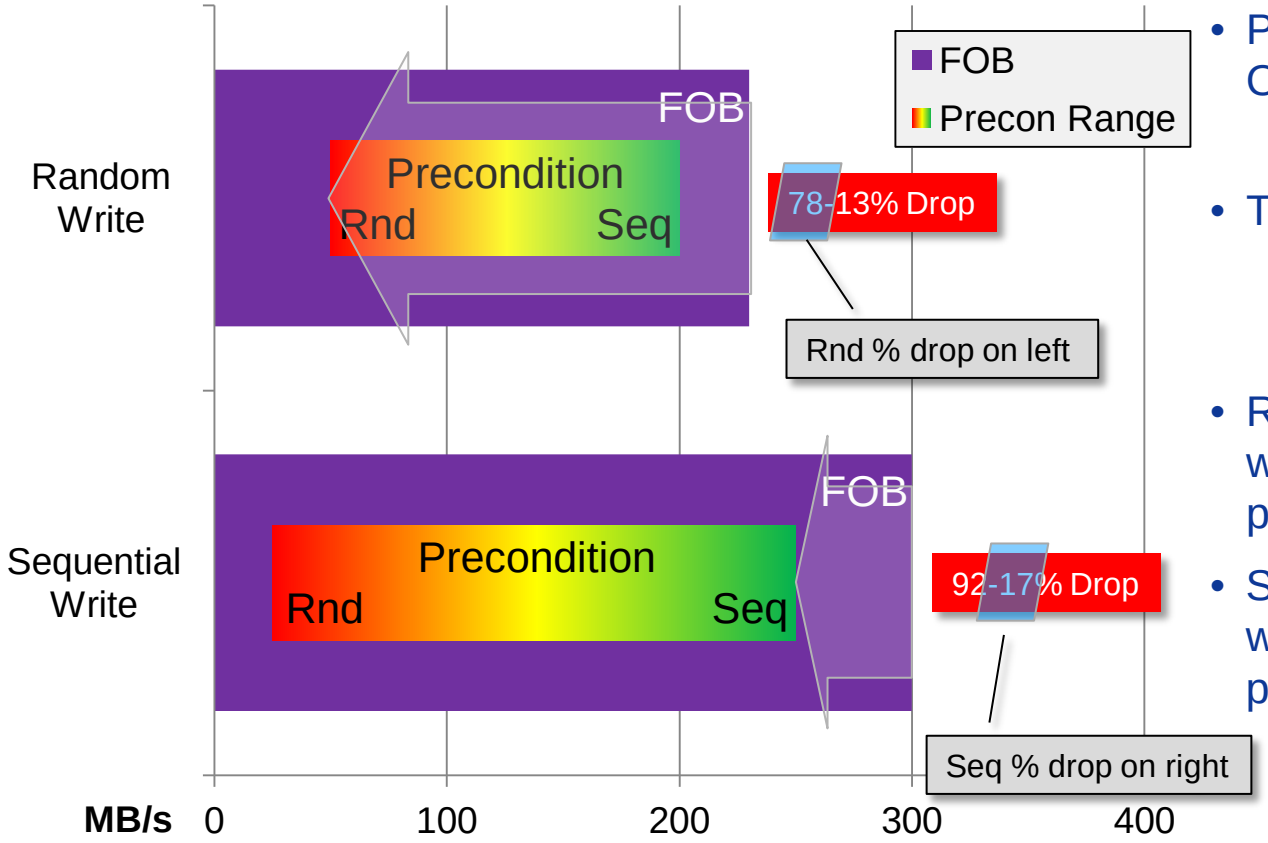


IOMeter

How to Read the Charts

Before and After Preconditioning

	FOB	Rnd Precon	Seq Precon
Rnd Write	230	50	200
Seq Write	300	25	250

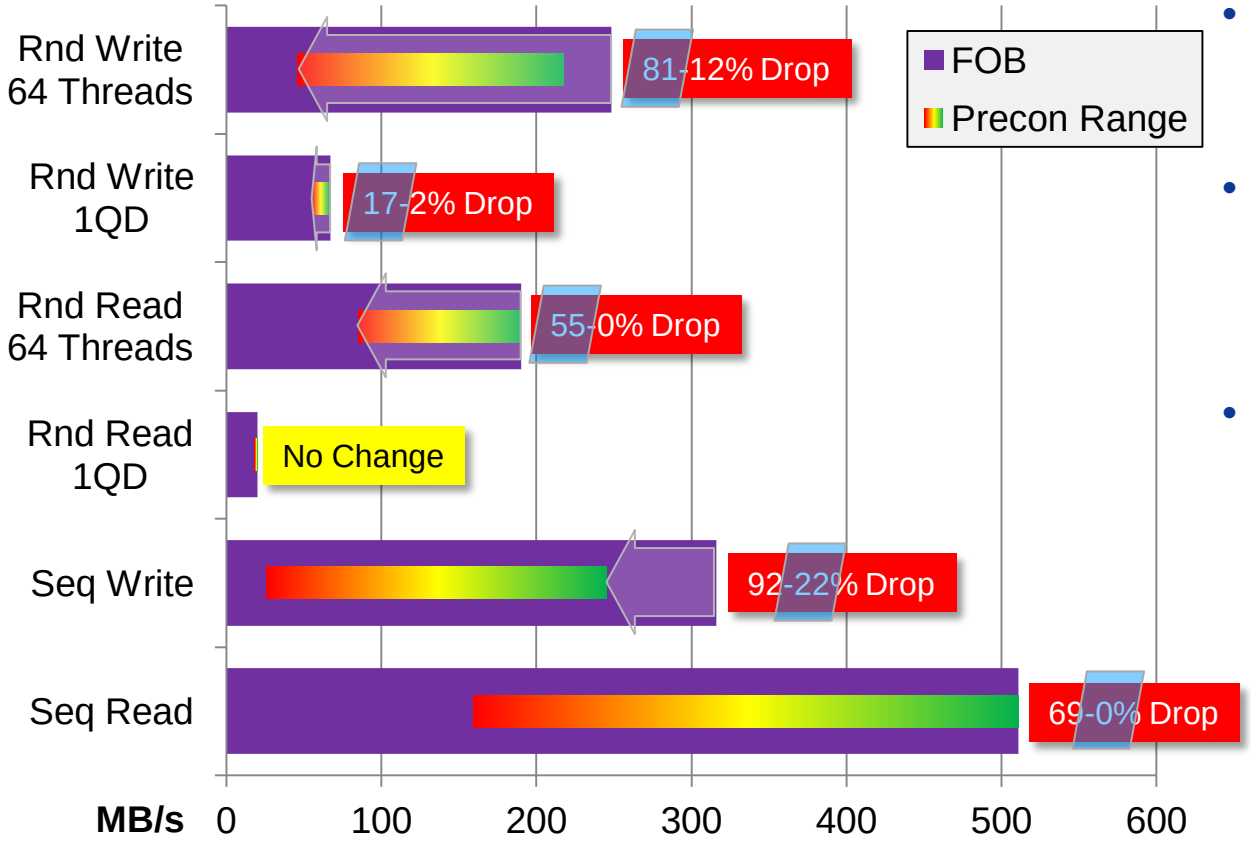


- Purple shows Fresh-Out-of-Box performance
  - Max, but not real
- True performance range
  - Green is sequential
  - Red is random
- Random test results would use the red precon zone results
- Sequential test results would use the green precon zone results

This might seem complicated, but it is critical to proper measurements

AS SSD

Before and After Preconditioning



- Misleading results without preconditioning
- This SSD is truly up to 81% slower for random writes
- Uses only high entropy data which shows only worst case for SSDs with data reduction technology

Up to 81% reduction in performance after preconditioning

LSI Storage. Networking. Accelerated.

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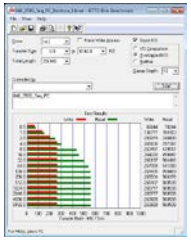
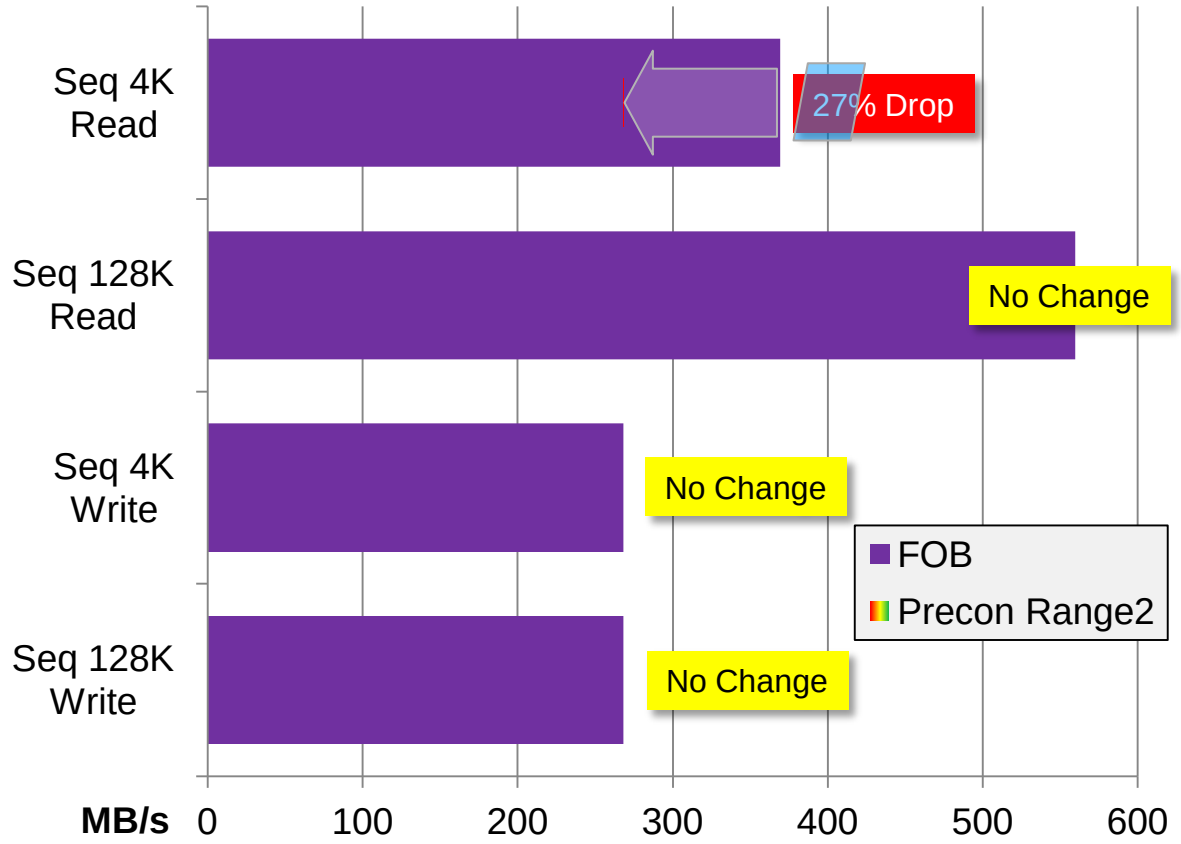
High Entropy

ATTO

Before and After Preconditioning



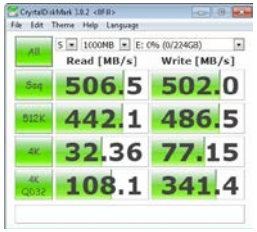


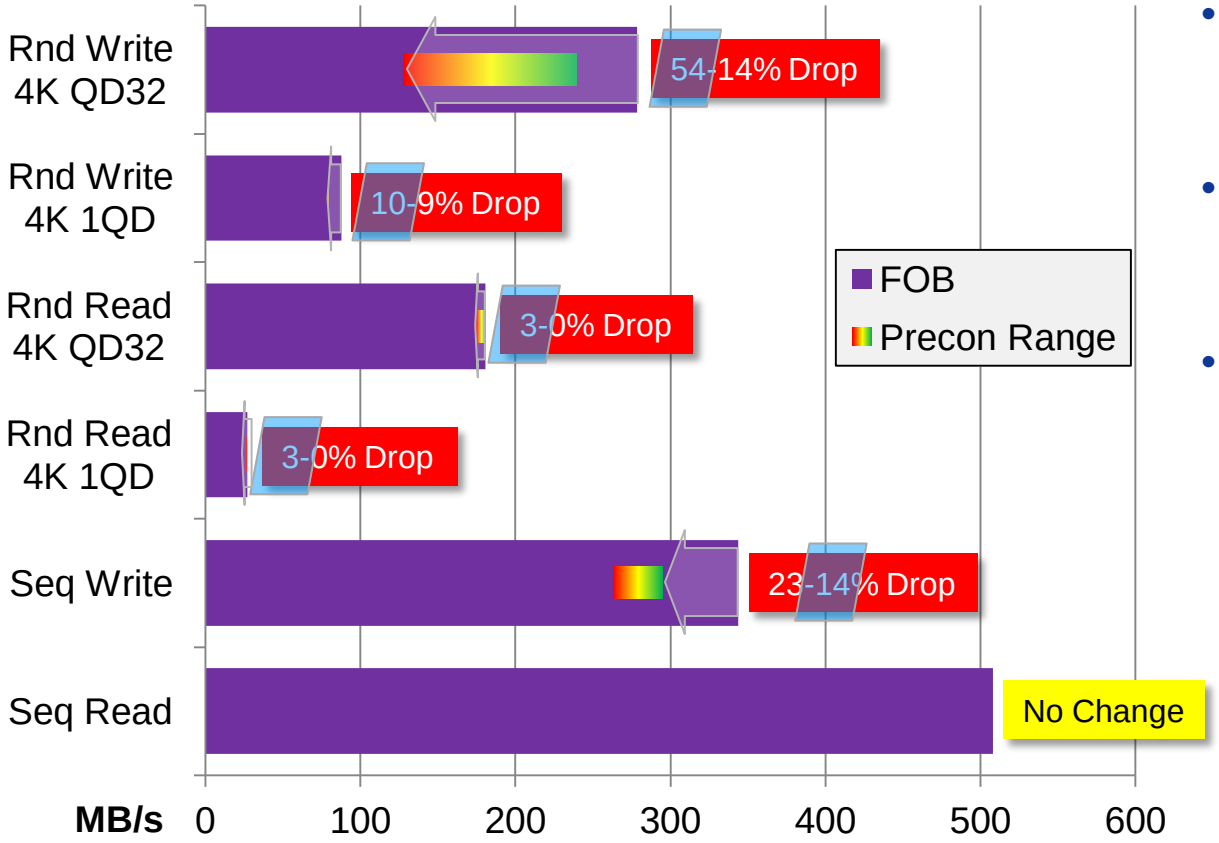
- All sequential tests; generally only look at sequential precondition
- Sequential operations are not greatly impacted by preconditioning except when randomly preconditioned
- ATTO was the only test that did not show performance indicative of other tests

Tests only sequential performance, but results are questionable

Crystal Disk Mark (CDM)

Before and After Preconditioning





- Misleading results without preconditioning
- SSD is truly up to 54% slower for random writes
- Default uses only high entropy data which shows only worst case for SSDs with data reduction

Up to 54% reduction in performance after preconditioning

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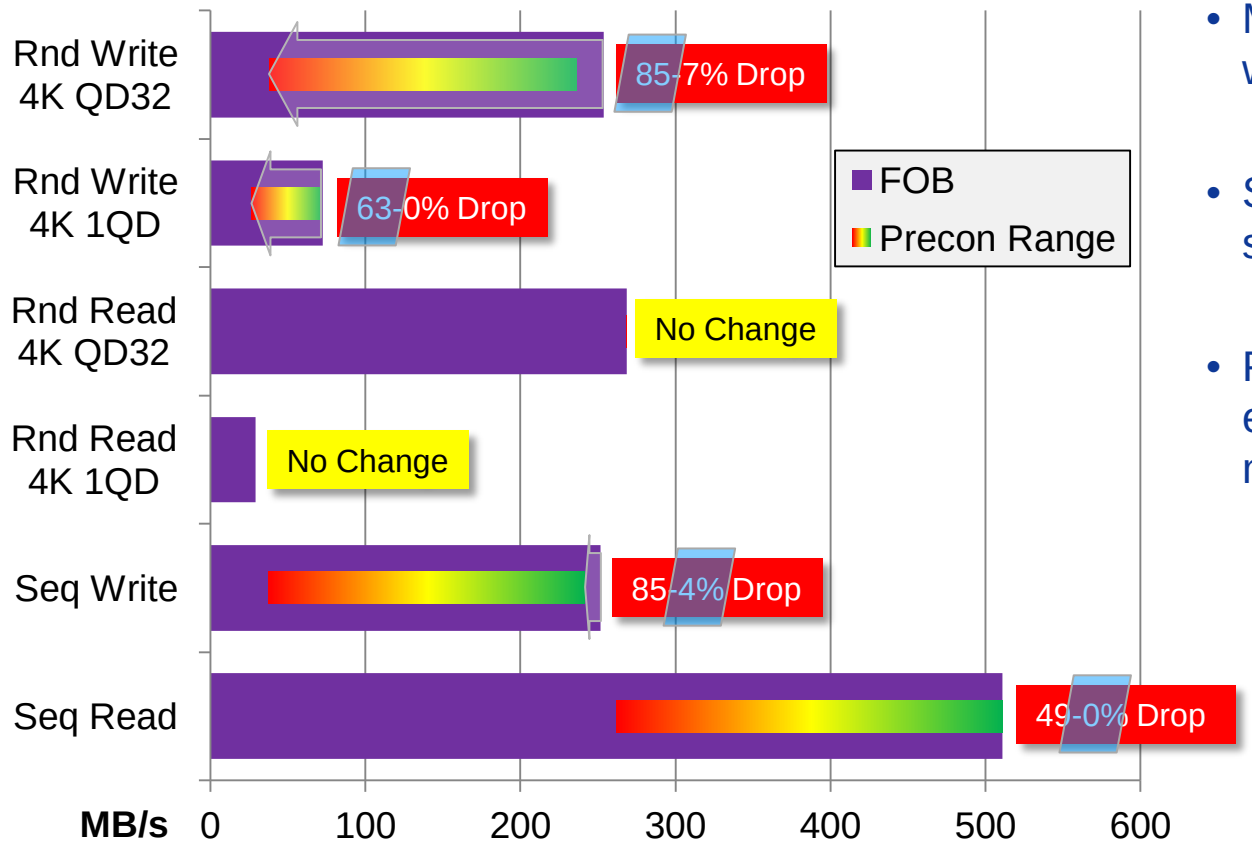
Anvil

Before and After Preconditioning

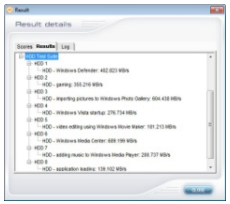


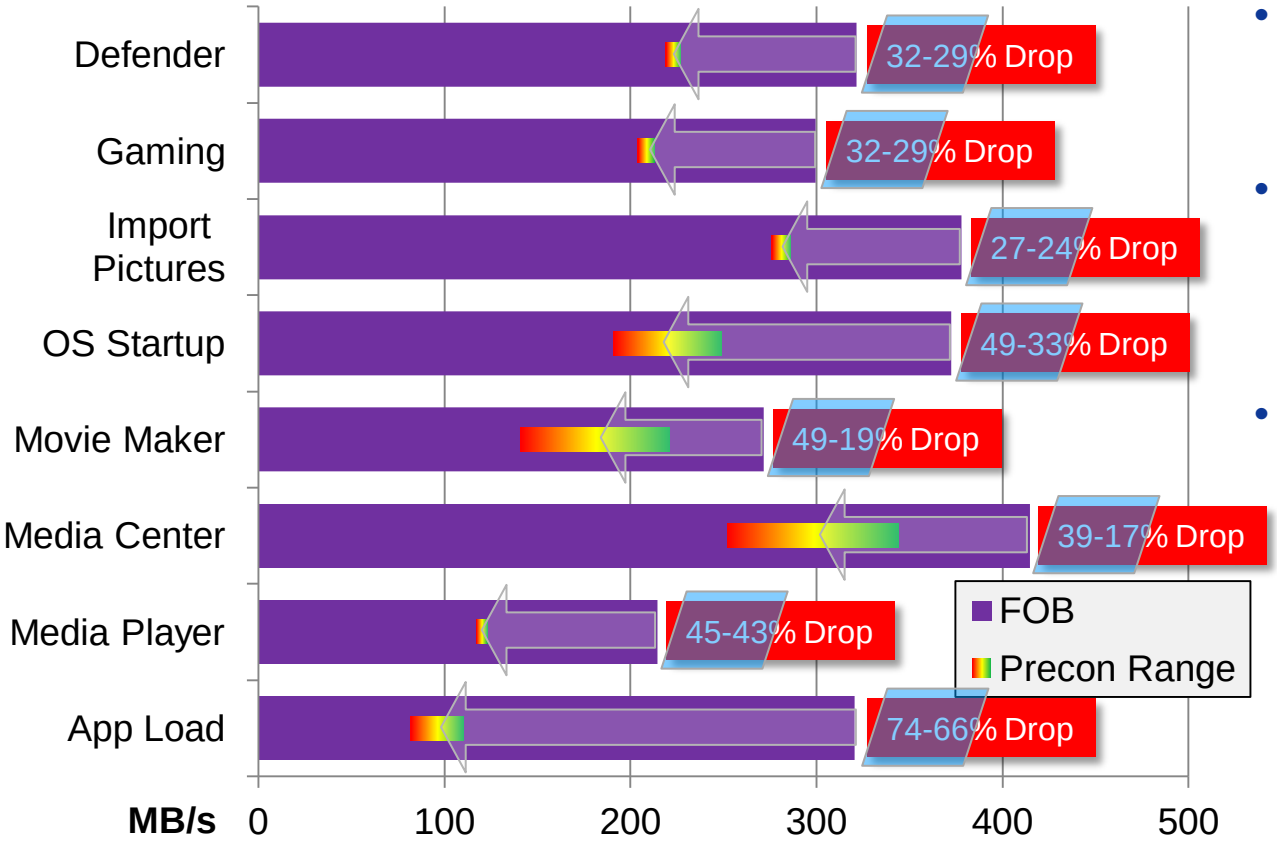
- Misleading results without preconditioning
- SSD is truly up to 85% slower for random writes
- Provides a number of entropy options to match user environment

Up to 85% reduction in performance after preconditioning

PC Mark Vantage

Before and After Preconditioning





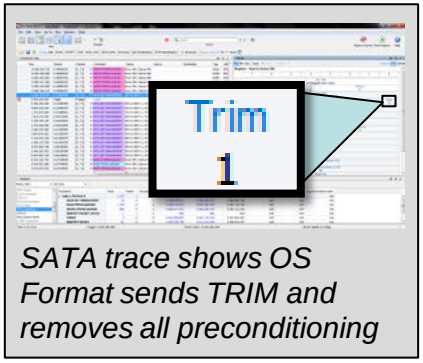
- Misleading results without preconditioning
- SSD is truly up to 74% slower for the App Load test
- Real-world results would vary based on more random or sequential data already present on SSD

Up to 74% reduction in performance after preconditioning

Precondition Procedure Used

- Secure erase
- Create partition
- Quick format* NTFS
- Default allocation size
- Open IOMeter
  - If entropy testing use IOMeter 2010 and select extracted Anvil entropy file (0%, 46%, 100%) as data type
  - Set LBA count to capacity of drive minus 10GB
    - Simulates full drive with 10GB free
  - Select created partition as target
  - Precondition sequentially until steady-state
- Run GUI benchmarks and record all results
  - Close each GUI benchmark before moving on to next GUI test to clear temporary GUI data on drive
- Repeat IOMeter step with Random preconditioning until steady-state
- Rerun GUI tests and record all results
- Note range of results for each test

*Do not format after preconditioning because it TRIMs drive to empty state



SATA trace shows OS Format sends TRIM and removes all preconditioning

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- **Attend the LSI keynote on Thursday 8/15 @ 11:30am**
  - *Optimizing Flash Controller Technology for Next-Gen Flash*
  - Greg Huff, LSI Senior Vice President and CTO

- **Visit us at booth #402**
  - Experience new LSI flash storage innovations
  - See live demos of LSI SandForce Driven SSDs
  - Enter to win SandForce Driven SSDs from **Adata, Mushkin and Kingston**
    - Drawings held on Wednesday 12-2pm & 5-7pm, Thursday 12-2pm
    - **Up to 3 winners every 30 minutes!**

Test Equipment

- CPU
  - Intel Core i5-3550 @ 3.70 GHz
- RAM
  - 8 GB RAM 1333 MHz
- Motherboard
  - Intel Z77 Express Chipset
- Host Driver
  - Intel RST 11.7.0.1013 (AHCI Enabled)
- Operating System
  - Windows 7
  - Vista
- SSDs
  - Various SandForce Driven and non-LSI controller based SSDs with 256GB flash

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