NVIDIA SLI and stutter avoidance: a recipe for smooth gaming and perfect scaling with multiple GPUs

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Stutter – A Vast Topic

- Two topics today only:
  - One measurement – percentiles
  - One cause – memory over-commitment
- See Cem Cebenoyan's broader, extensive treatment from China GDC 2012

Stutter Matters

- Critical to game-play experience
- As important as average FPS?
- More important?
- Ultra-low tolerance in VR

"This is a confirmed fix"

"I was able to play smoothly without any problems"

"we see heavy perf drop/severe stutter"

"[the fix] didn't do anything for me"

No Supporting Data

Why Measure Stutter?

- Quantify your claims
- Prove your fixes
- Measure before you can fix
- Regression test
- Trust numbers (with time)

GEFORCE®

How to Grok Percentiles

99.87% of frames < 53ms
0.13% of frames > 53ms

99% of frames < 29ms
1% of frames > 29ms

Bad

Good

60

40
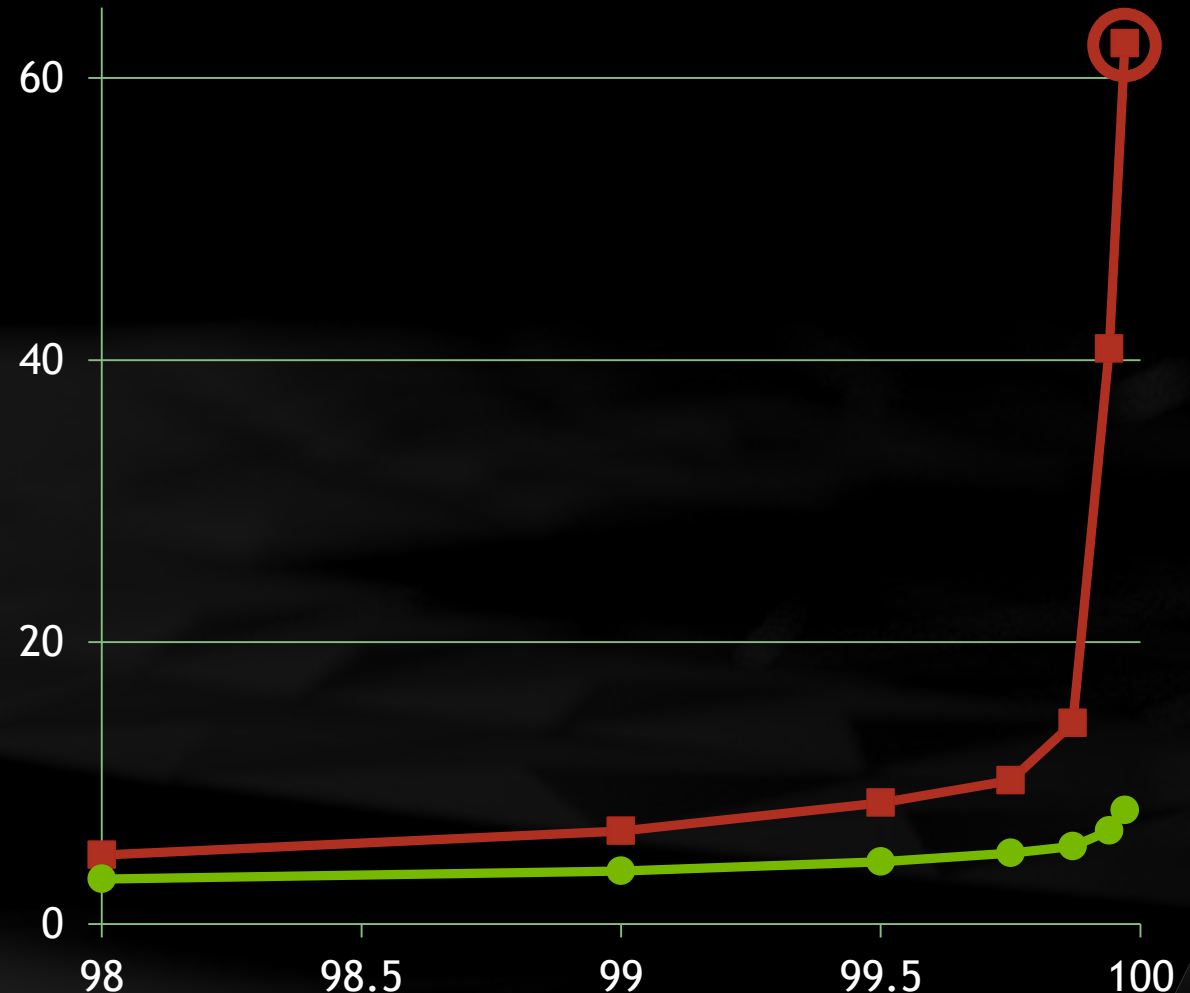
20

0

96

98

99%

99.87%
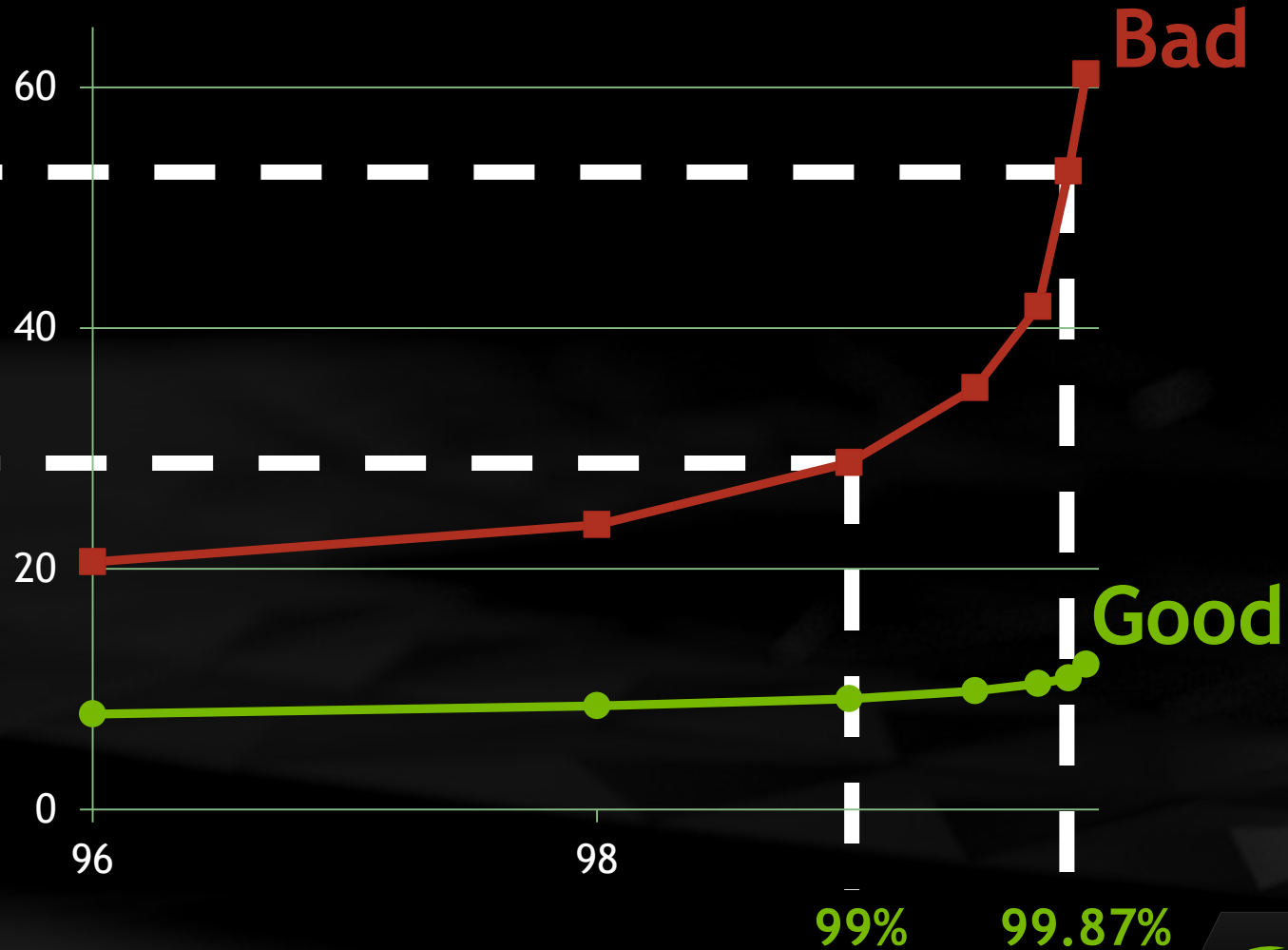
How to Compute Percentiles

- Common in statistics
- Excel
- Fraps2percentile tool – source published:

https://developer.nvidia.com/content/analysing-stutter-%E2%80%93-mining-more-percentiles-0
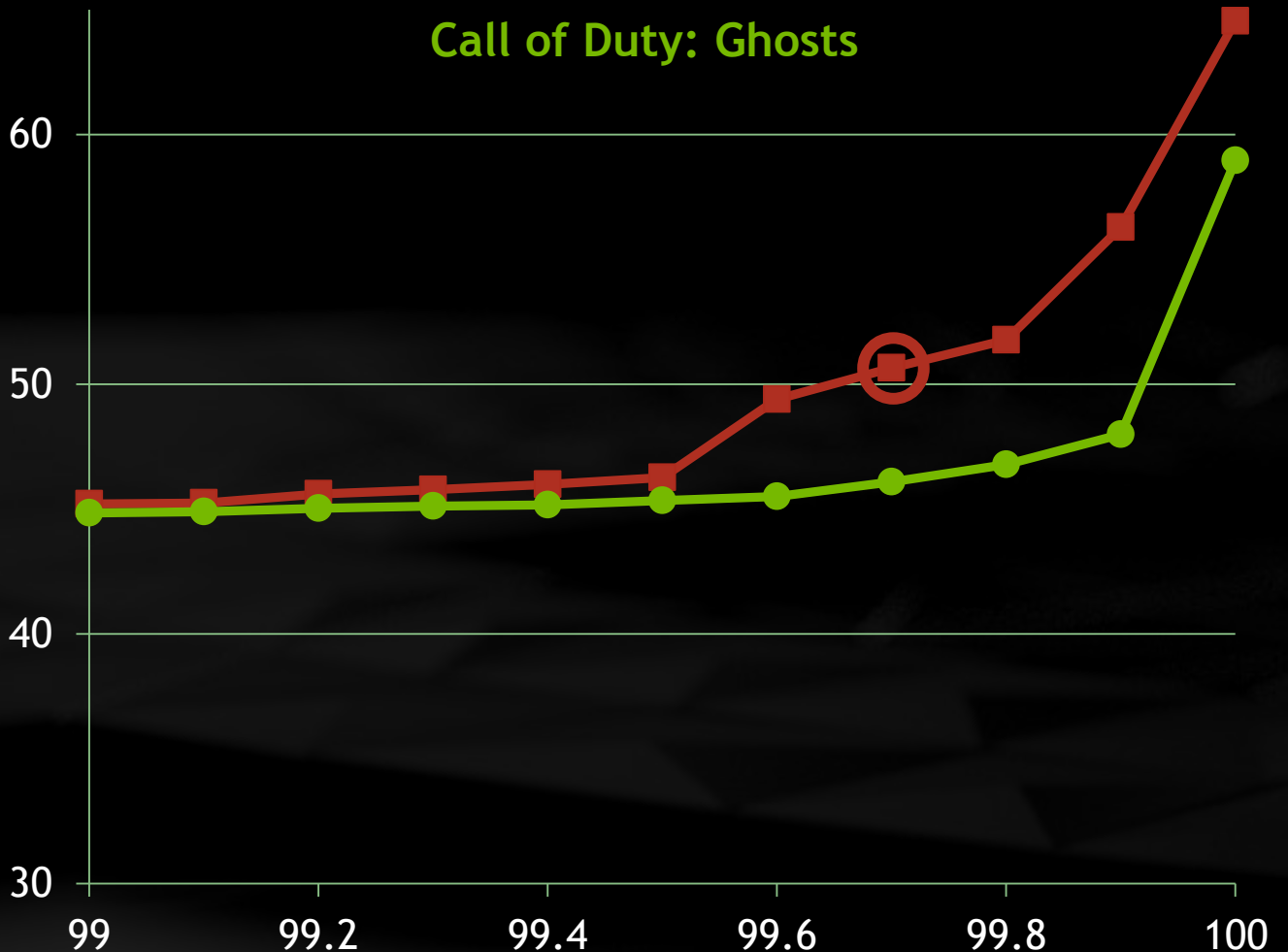
Example: Battlefield 4

- Fixed a stutter bug in game (not driver)
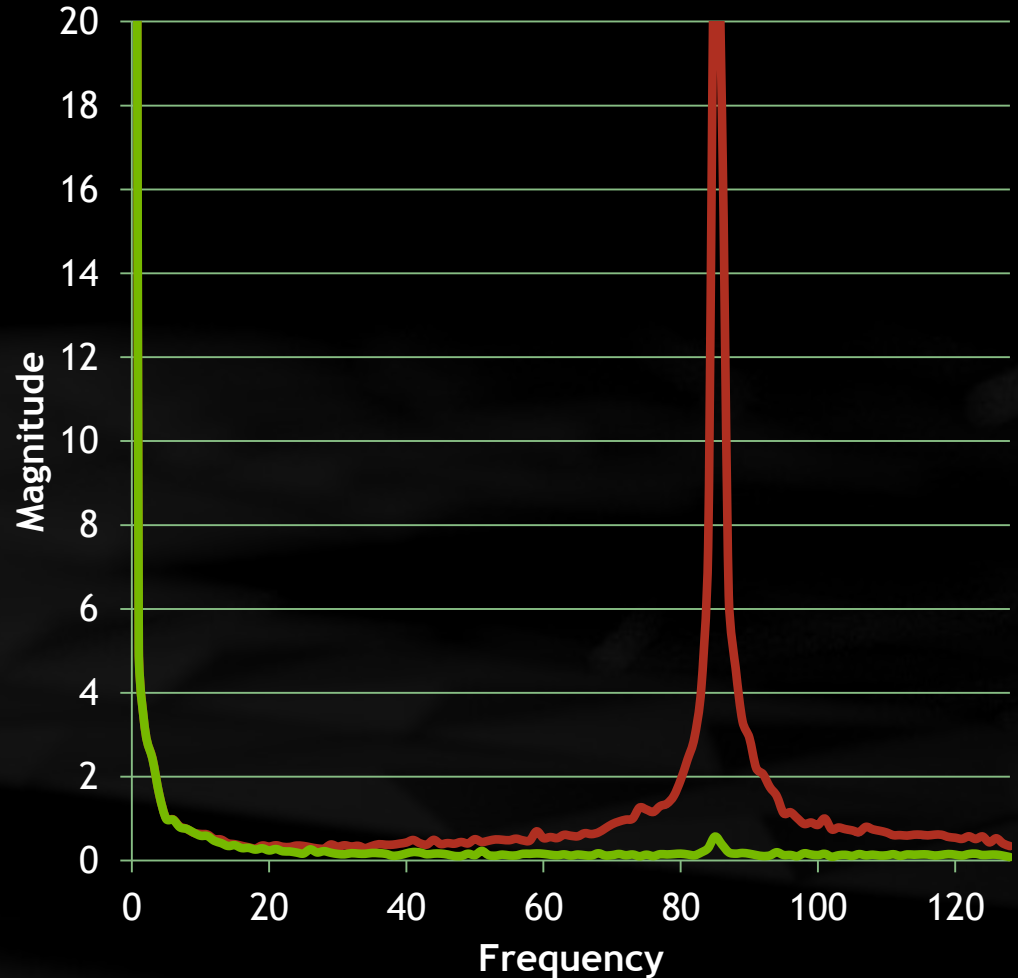- Before/after clear picture (for >99.5%)
- *Measured!*

Example: GeForce Driver

- GeForce driver opts for shader compilation
- End-user improvement with no changes to game
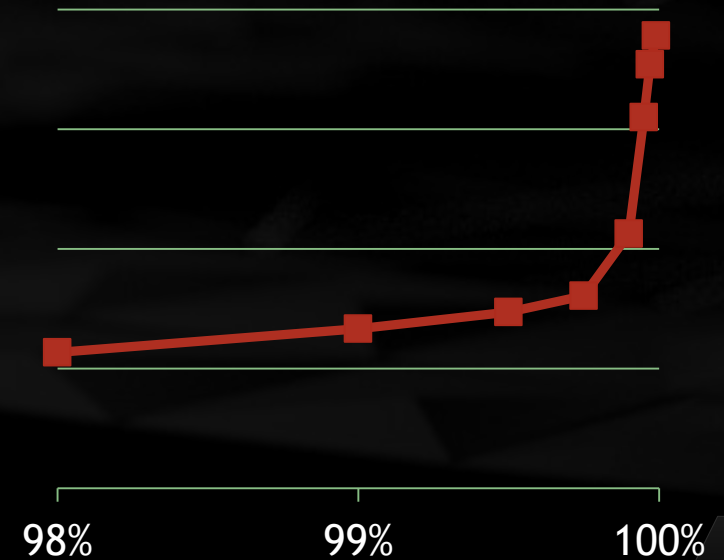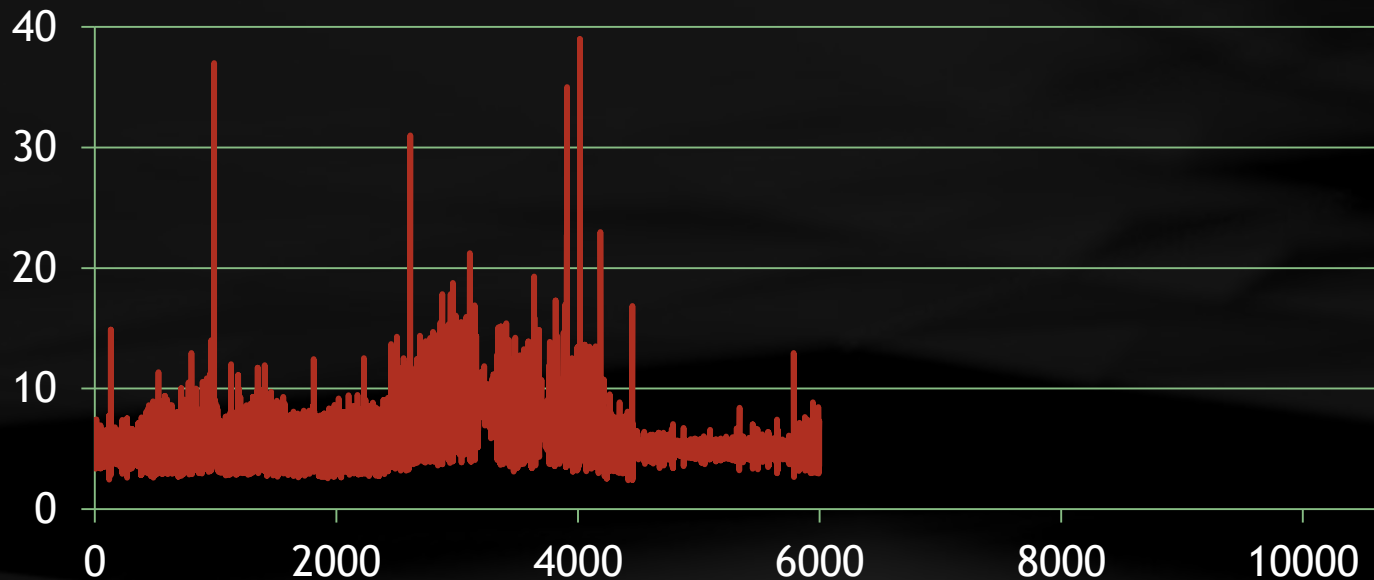- *Measured!*

Call of Duty: Ghosts

Other Measures

- Stdev
- Count > threshold
- Count > median over window
- Fourier analysis
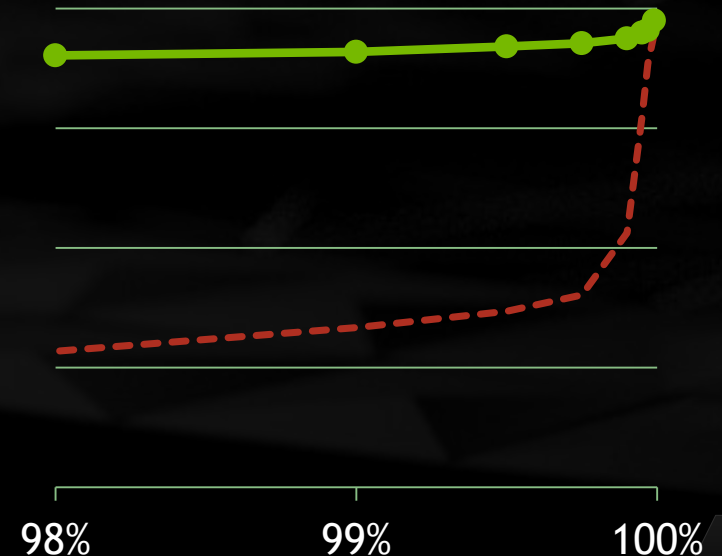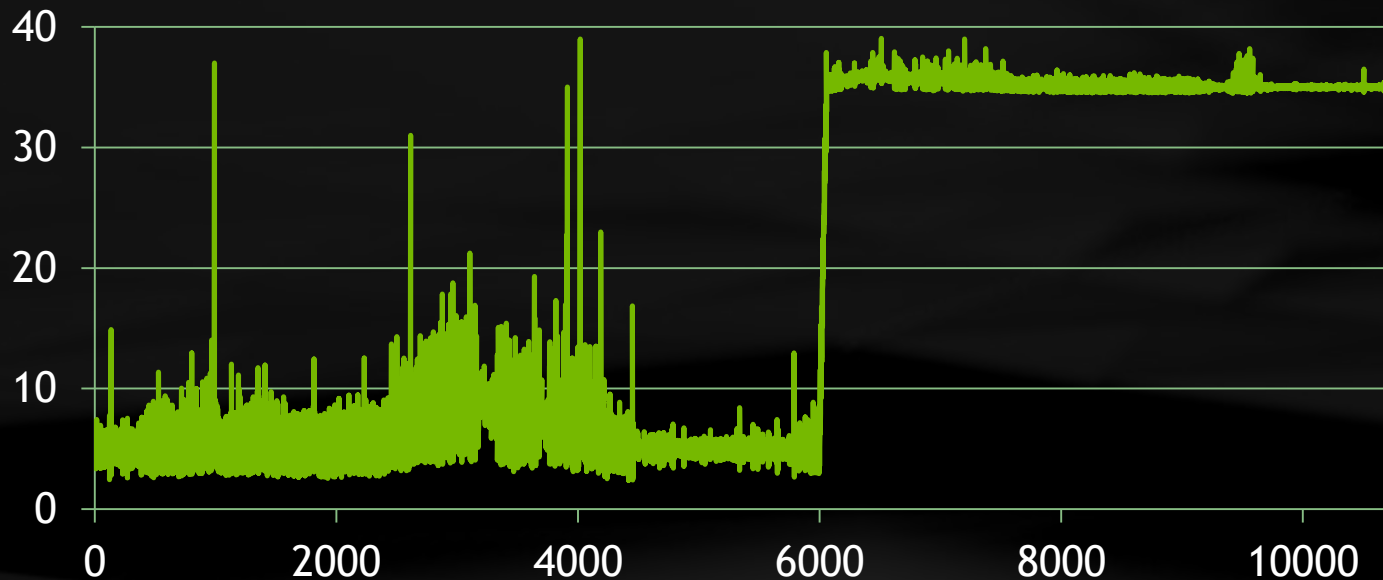- Any spike, even one, == a Bad Thing

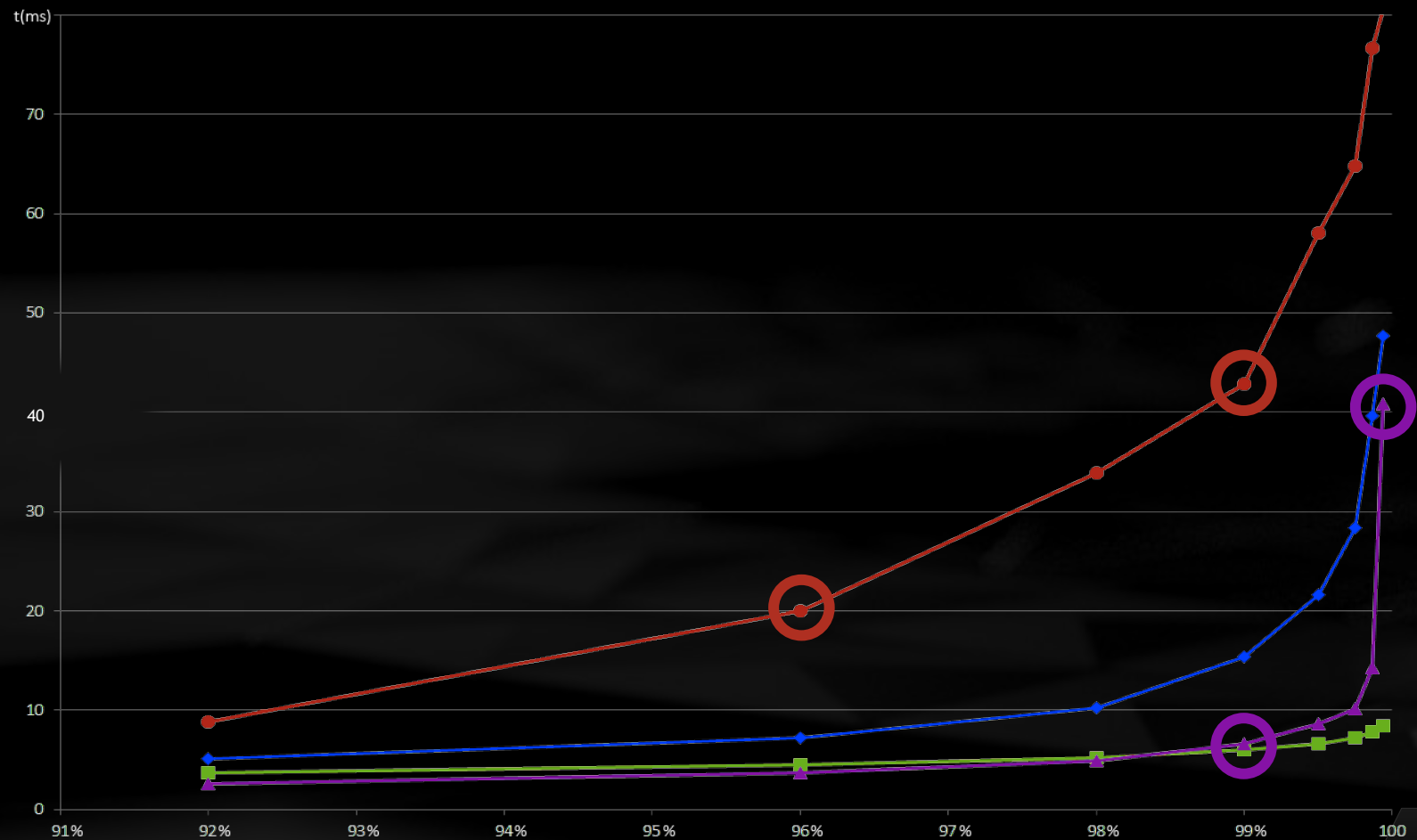# Limitations of Percentiles

- Definitely spikey
- Percentiles agree

Limitations of Percentiles

- Average frame time jumps up
- Masks the earlier spikes
- Analyse a small window instead?

Stutter is Complex and Varied

Percentile graphs capture variety

Limitations of Percentiles

- Cannot graph many results
- Too complex for a single scalar representation

99%-ile frame time analysis (ms)	Win 8.1						Win 7 SP1	
	1920x1200		2560x1600		3840x2160		1920x1200	
	Maximum Quality	Extreme Quality	Maximum Quality	Extreme Quality	Maximum Quality	Extreme Quality	Maximum Quality	Extreme Quality
Delta (99%-ile frame time) – (1000/Avg FPS)								
GTX 750	12.3	23.6						
GTX 750 Ti	19.6	68.6						
GTX 660	31.9	44.6						
GTX 960	26.1	23.1					20.5	18.6
GTX 970	10.1	21.2	24.8	40.9				
GTX 780 Ti	8.9	15.6	14.5	39.7				
GTX 980	9.1	13.8	16.1	21.6	21.7	30.5		

Stutter is Complex and Varied
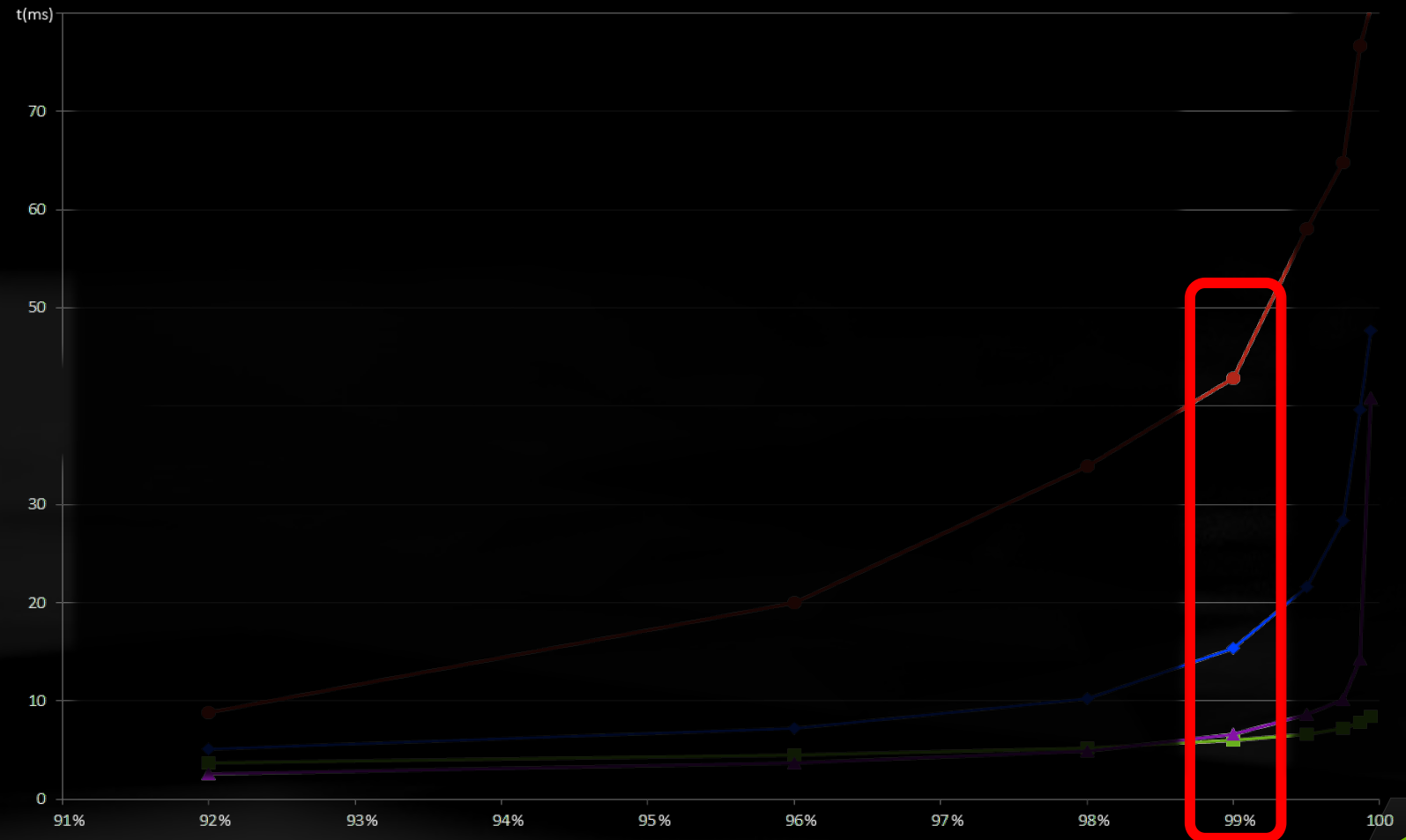
Top Five Causes of Stutter

- *See Cem's China GDC 2012 presentation*
1. *Shader compilation*
2. *Video memory oversubscription*
3. *Resource mis-management (mapping)*
4. *Queued frames*
5. *Improper queries*

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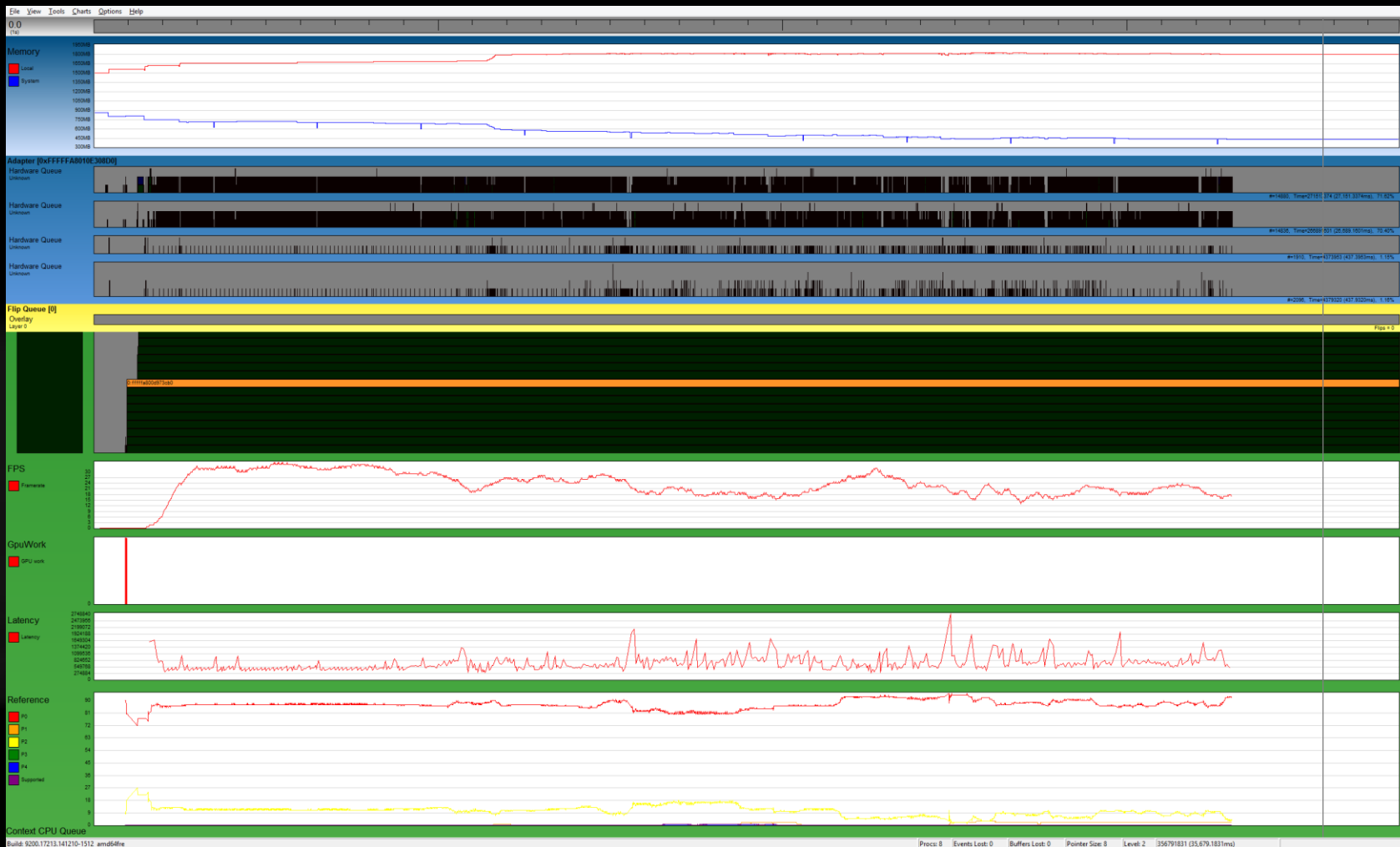4. Queued frames
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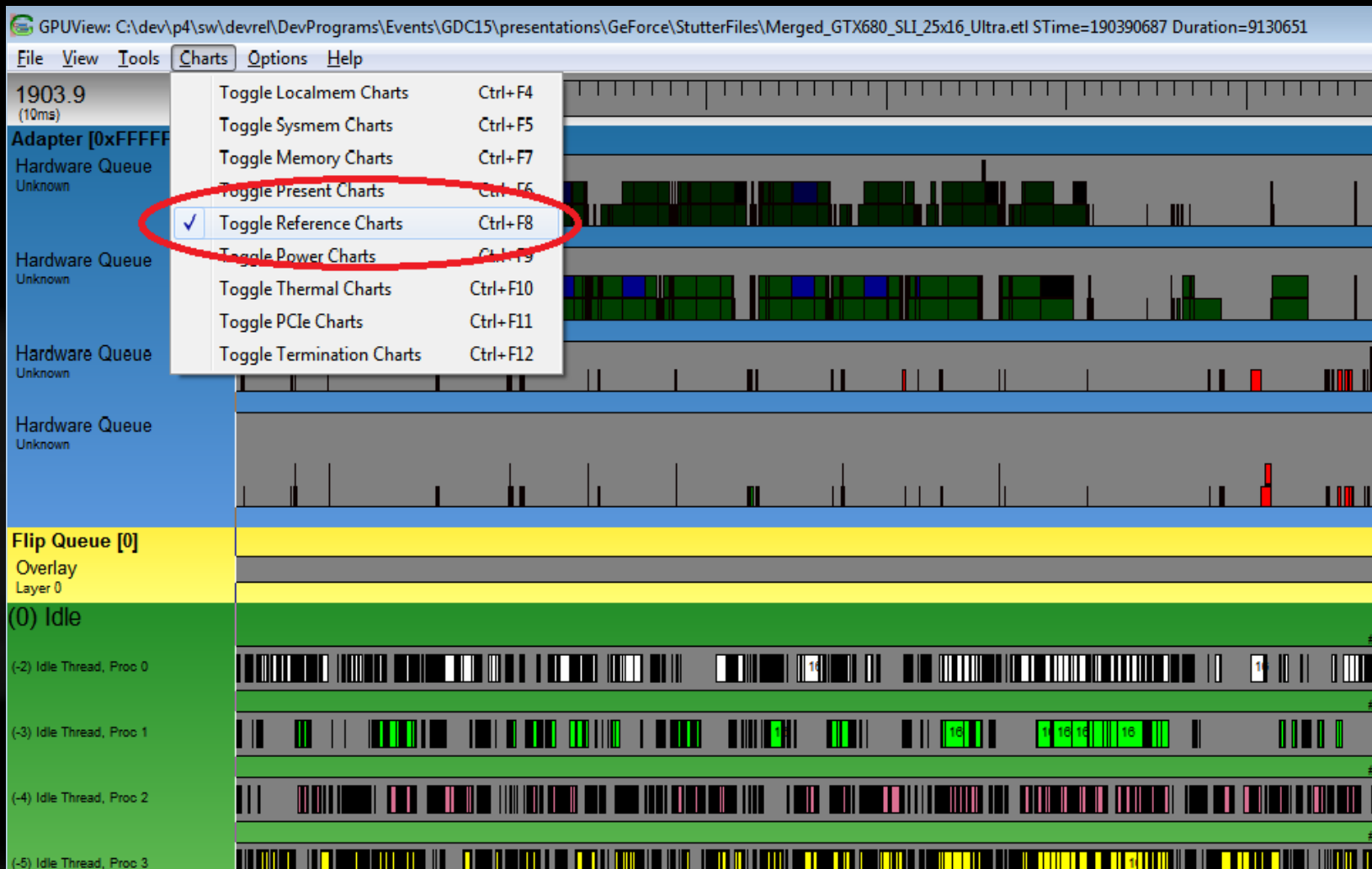
Fixing - A Simple Tip

- GPUView
  - (get Microsoft's Windows Performance Toolkit)
- Memory over-commitment
- P2 references > 0% correlate with stutter
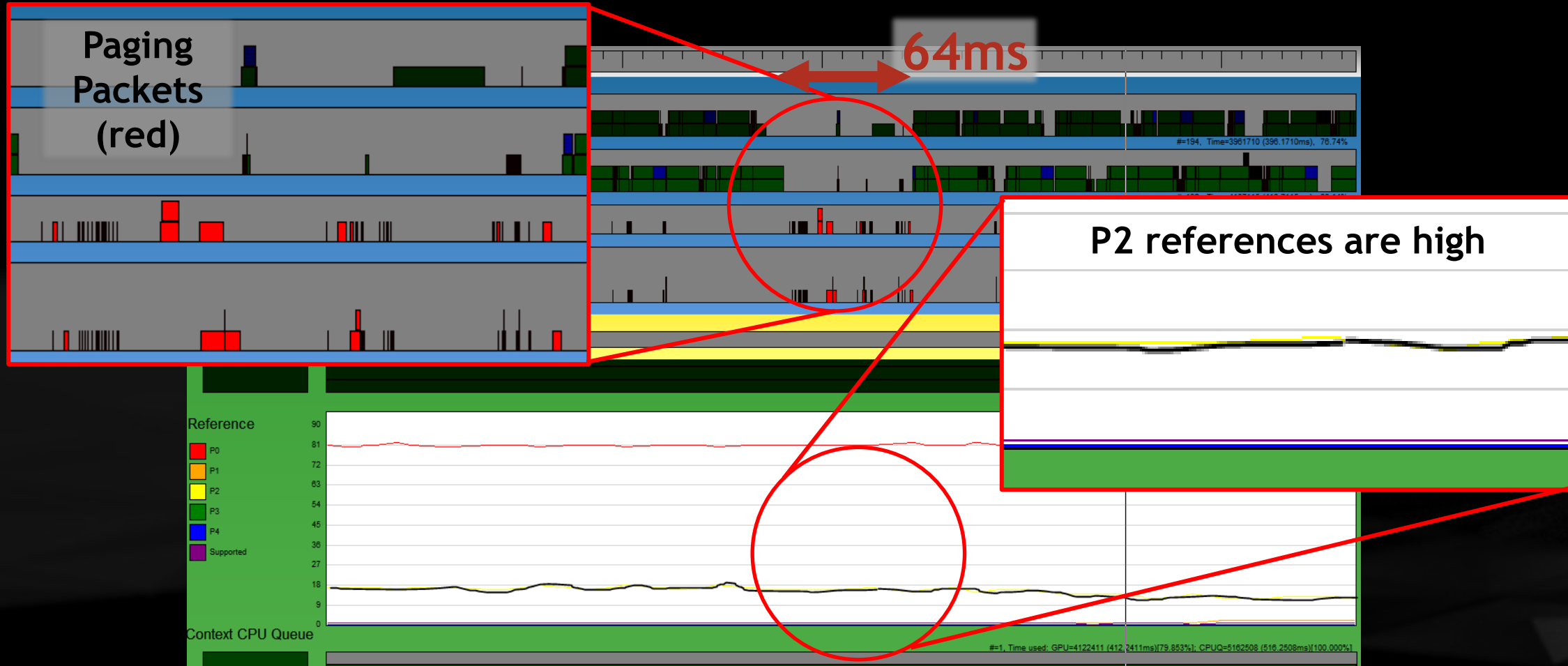- Plenty more fix tips in Cem's presentation (see references)
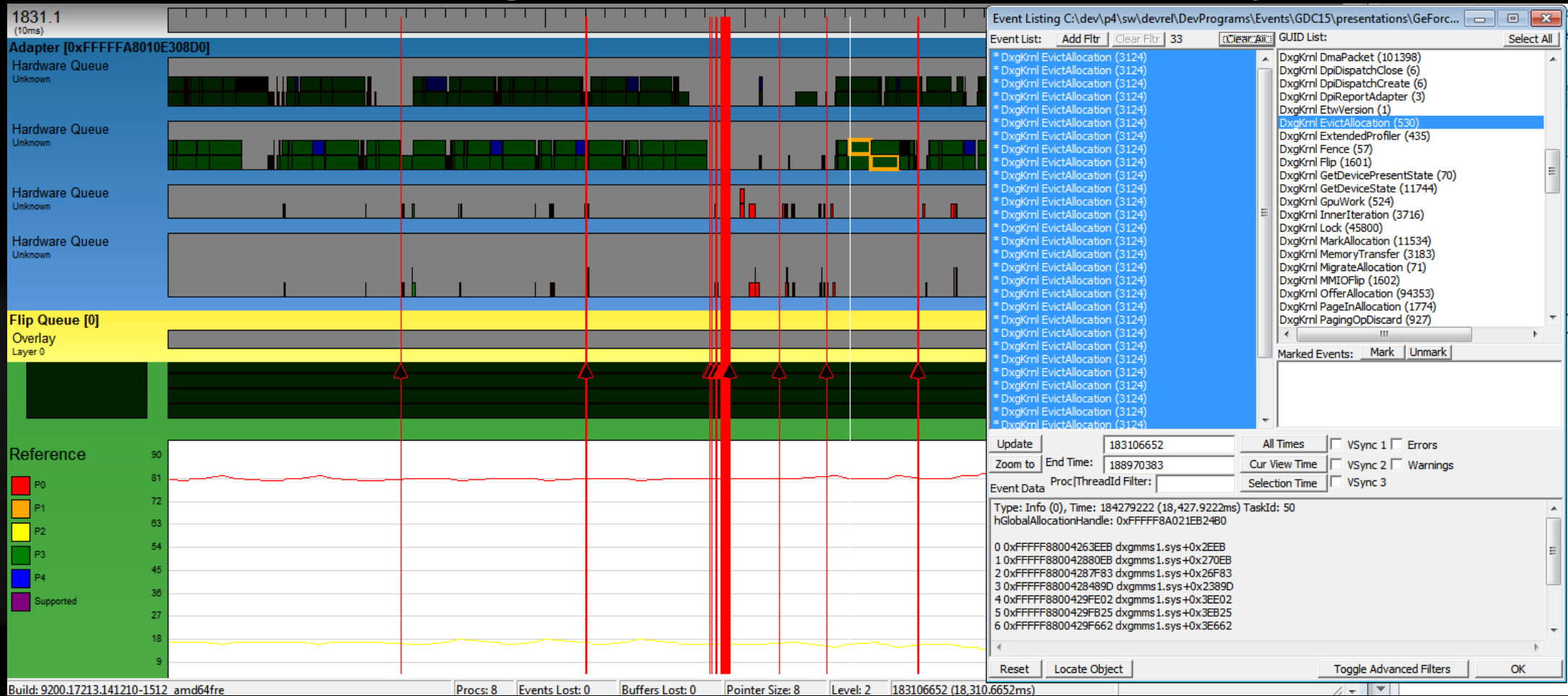
Fixing Stutter - GPUView

Fixing Stutter - GPUView

Fixing Stutter - Memory

Paging Packets (red)

64ms

P2 references are high

Reference
- P0
- P1
- P2
- P3
- P4
- Supported

90
81
72
63
54
45
36
27
18
9
0

Context CPU Queue

#=194, Time=3961710 (396.1710ms), 76.74%

#=1, Time used: GPU=4122411 (412.2411ms)[79.853%]; CPUQ=5162508 (516.2508ms)[100.000%]

Fixing Stutter - Memory

gameworks.nvidia.com | GDC 2015

Summary
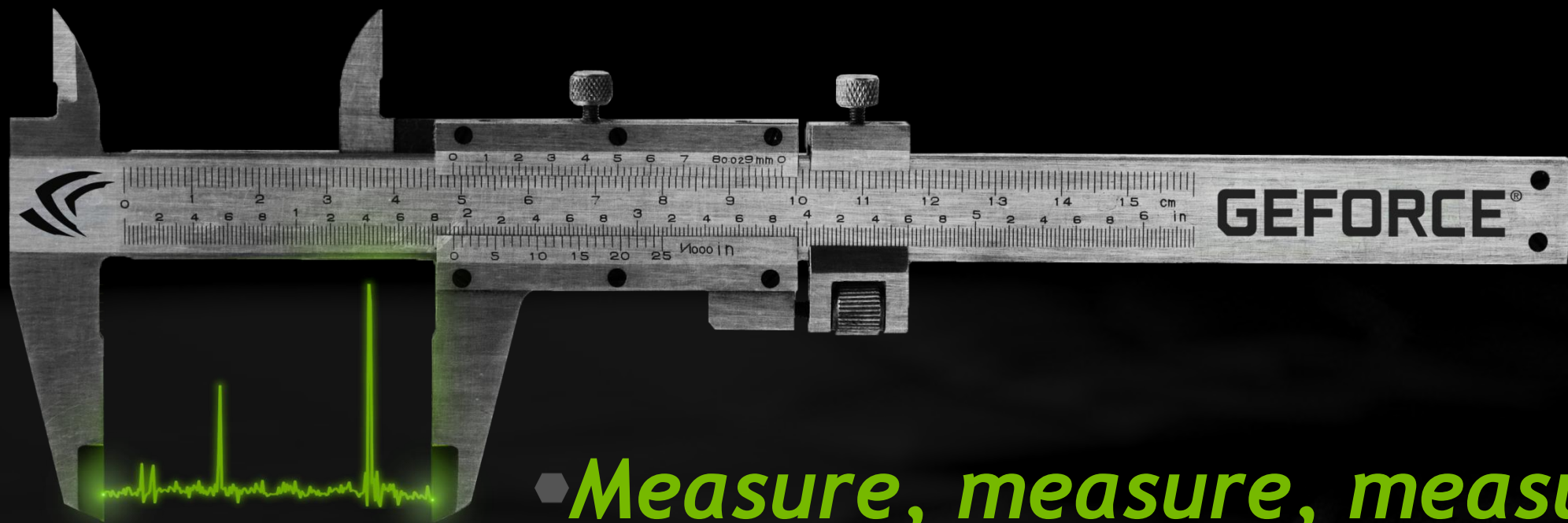
- *Measure, measure, measure*
- *Add measures to your game*
- *Then fix*

Questions / Further Reading

https://developer.nvidia.com/sites/default/files/akamai/gameworks/CN/Stuttering_Analysis_EN.pdf

http://techreport.com/review/21516/inside-the-second-a-new-look-at-game-benchmarking

https://developer.nvidia.com/content/analysing-stutter-%E2%80%93-mining-more-percentiles-0

http://graphics.stanford.edu/~mdfisher/GPUView.html

http://developer.amd.com/gpu_assets/Using%20GPUView%20to%20Understand%20your%20DirectX%2011%20Game.pps

GameWorks

- Get the latest information for developers from NVIDIA and continue the discussion
- gameworks.nvidia.com