IBM z Systems

z/VM Paging with SSD and Flash-Type Disk Devices

Version 2.5

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VM Workshop 2015
Binghamton University

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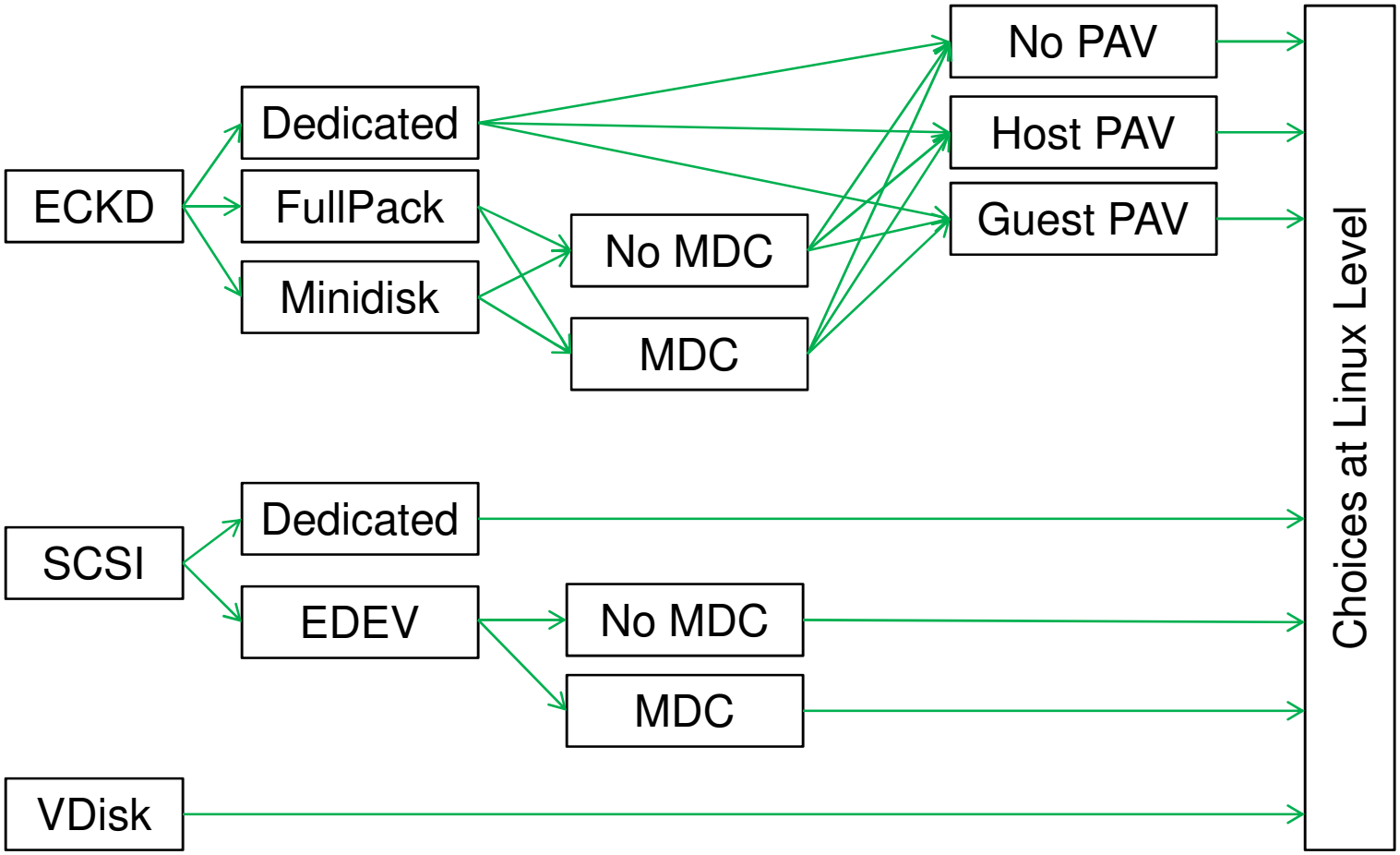
Agenda

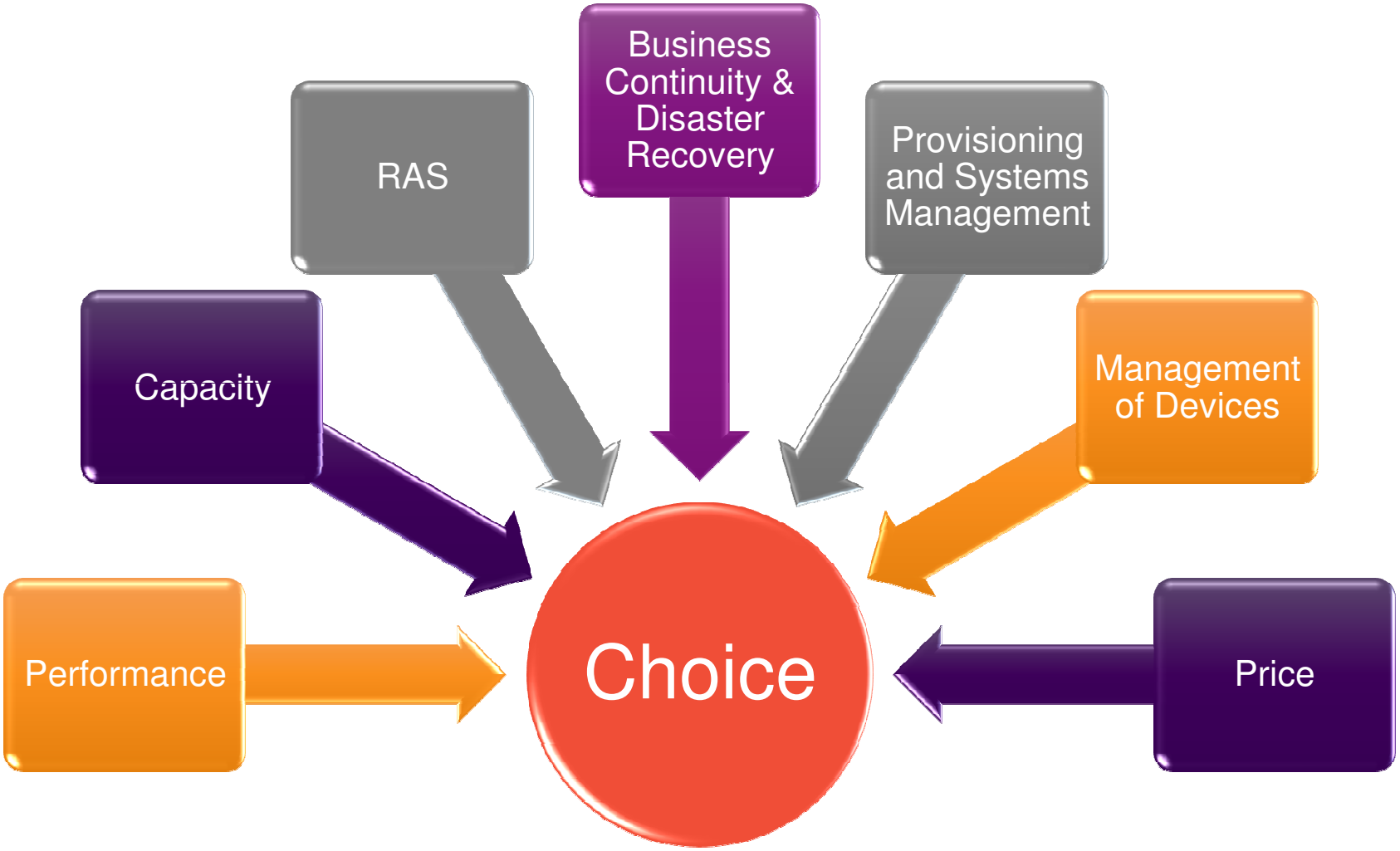
- Choosing the right disk storage
- High Performance Paging Options
- The Need for Faster Paging
- Case Study

Choosing the Right Disk Storage

So Many Choices



Look at All Attributes – Not Just One



A "loose" z/VM ECKD to SCSI Comparison

ECKD	SCSI
1TB disk supported – Full volume only beyond 65520 cyl	1 TB – 4K CP LUN supported – Guest LUN up to hardware max
Flashcopy & PPRC supported from host	Flashcopy & PPRC supported only from hardware interfaces
Exploits HyperPAV concurrent I/O on behalf of guests, or if guest exploits	Exploits concurrent I/O for CP paging (except XIV), or if guest exploits
Supported by GDPS	No GDPS
Less host CPU utilization per start	High host CPU utilization per start for CP managed volumes, very low utilization for guest passthru
Host backup to FICON Tape	No host backup to SCSI tape, but guest can backup to SCSI tape
No midrange storage option available	Supports V7000 or other midrange storage through an SVC
Supports solid state DASD options	Supports solid state DASD options & IBM Flash Systems, but host Flash Systems requires an SVC
Fully supported by SSI	SSI PDR & Install not supported
No concurrent code load issues	Concurrent code loads restricted on SVC & V7000
Eliminates WWPN Management, but consumes space for Count/Keys	WWPN Management Issues

A Few More Things to Think About

- Lack of PAV & HyperPAV support makes the size of ECKD DASD for z/VM paging important. We want to not have I/Os queued up on these volumes but at same time balance this with work to administer the number of DASD volumes involved.

- Even if ECKD volumes could be infinitely large and infinitely fast, we would probably still want as many as there are logical processors for z/VM.

- FCP SCSI for z/VM Paging provides a level of parallelism but at a cost in processor time
  - Greater Bandwidth
  - Higher CPU costs

High Performance Paging Options

Flash vs. SSD and Terminology

- Purists will say “Flash” is not the equivalent of “SSD”
  - Solid State Disk – most often used to describe a device where the access is through an existing disk interface
  - Flash – access to it via direct interface to the memory

- Common Attributes:
  - Storage capacity
  - Write speed
  - Read speed
  - Active power
  - Standby power
  - Write endurance or wear-out
  - Type: NAND, NOR

Flash Express

- Flash Express Feature of zEC12 and zBC12 processors
- PCIe I/O Adapter with NAND Flash SSDs
- Accessed using Extended Asynchronous Data Mover Facility (EADMF)
- RAID 10 mirrored Pairs
- Protected with 128-bit AES encryption

- Maximum of 4 Cards provides 5.6 TB of usable storage
- Not supported by z/VM at this time. ☹

IBM FlashSystem

- IBM FlashSystem V840 - Based off technology from acquired Texas Memory System
  - Uses eMLC Flash
- FCP SCSI Only
- For use as z/VM Paging volumes, must be behind an SAN Volume Controller (SVC)
  - Some models of FlashSystem include SVC
- Various Features:
  - Easy Tier support
  - Compression
  - Data replication

DS8870

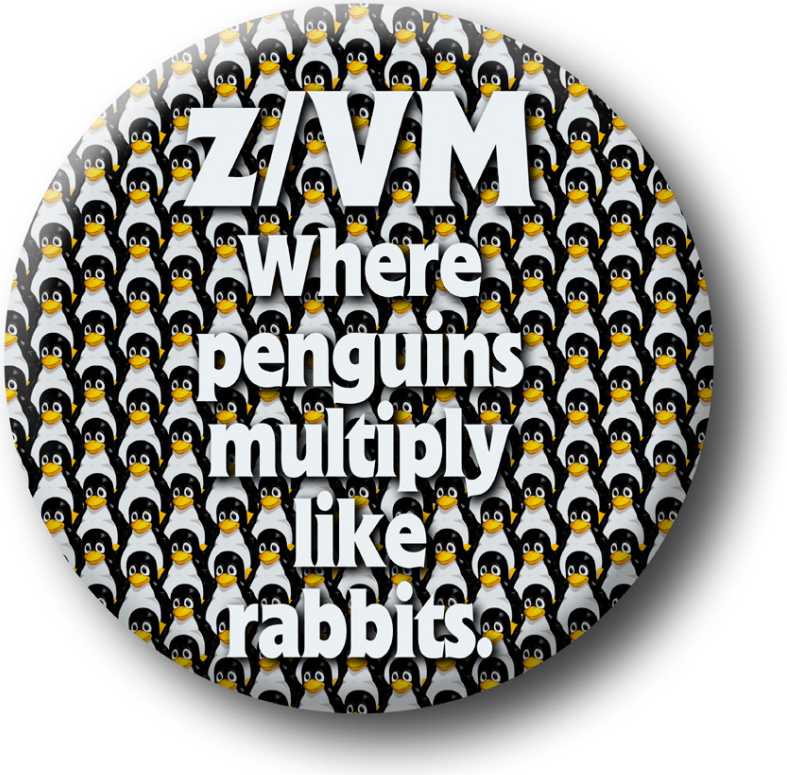
- Part of the IBM DS8000® Series
- Can be equipped with SSD drives
- HPFE (High Performance Flash Enclosure) – Newest Option
- ECKD or FCP SCSI
- Lots of features/capabilities
  - RAID 5,6,10
  - Easy Tier
  - GDPS
  - Encryption
  - Etc.
- Maximum configuration 3072 TB

Flash also Available for Other Options

- Storwize V7000
  - Internal flash drives available
  - External IBM FlashSystem Storage

- XIV
  - Flash optimized options

The Need



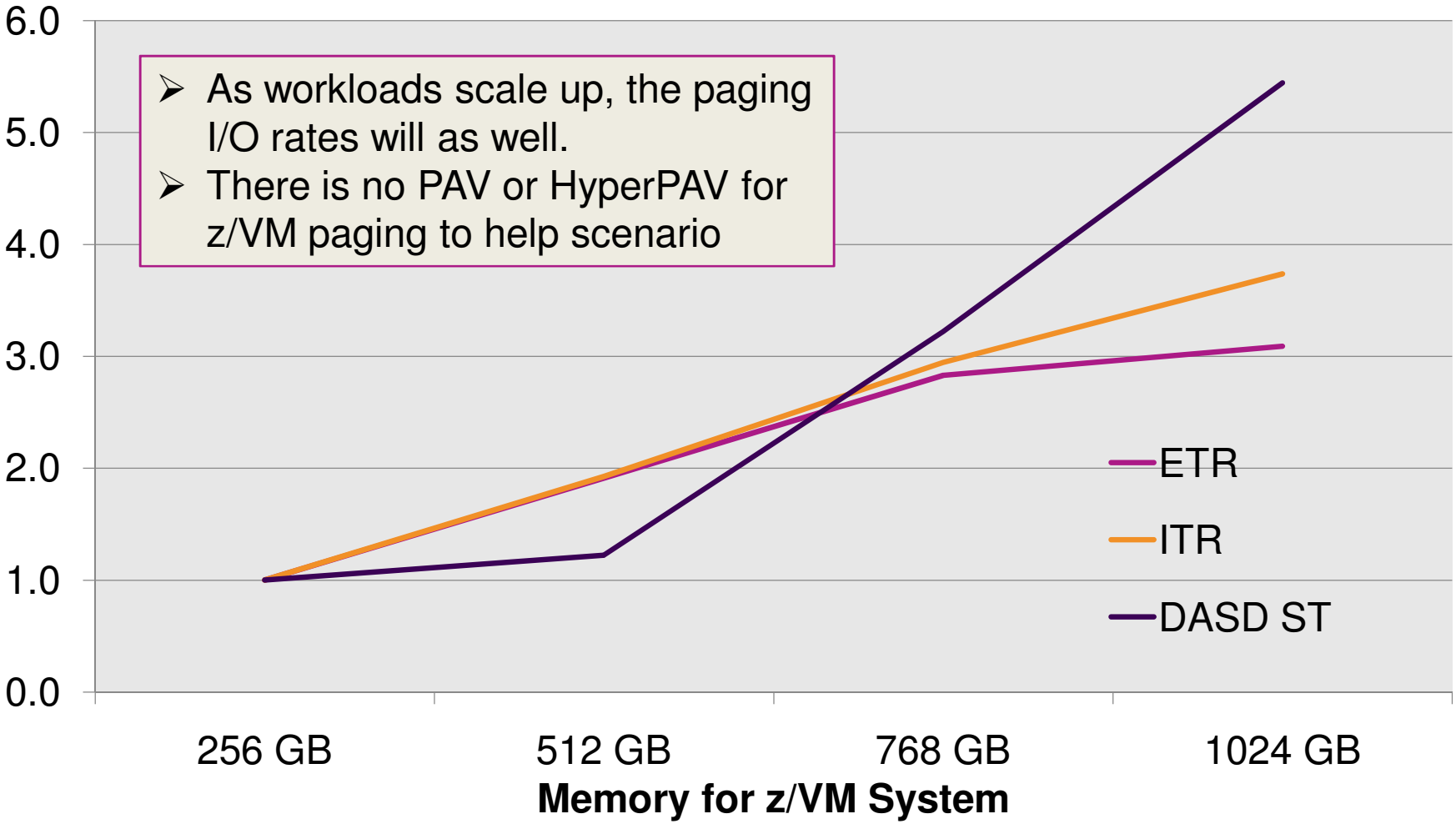
I/O Rates and Latency

- Two aspects of paging I/O
  - Overall capacity: IOPS or MB/Second
  - Performance or Latency: delay per page read

- Historically, top-end storage servers could not be saturated by z/VM Paging

- Changing History:
  - Larger amount of memory supported and page rates increasing
    - If z/VM 6.3 allows 4 times number of virtual machines, then 4 times the page rate when you add those virtual machines.
  - Elimination of scaling problems in z/VM that allow greater paging rates
  - Better determination of the actual disk paging bandwidth
    - z/VM 6.3 algorithms changed to better estimate and utilize disk paging bandwidth

Apache Workload in Scaling Overcommitted



ETR = External Throughput; ITR = Internal Throughput; DASD ST = Paging DASD Service Time

Virtual to Real Memory Overcommitment

- One of the factors often forgotten is the performance (capacity and bandwidth) of the paging configuration.

- A 100 GB real memory system with 125 GB of active virtual memory basically means being able to constantly turn over 25 GB
  - Potentially more based on the amount of memory that is changing and resulting in page writes in addition to page reads.

- As virtual machines are delayed for paging, pages that are resident tend to be needed longer, creating more demand and potential spiral-effect.

Paging Best Practices

- All paging volumes should have the same attributes:
  Size, Performance, etc.
- Do not mix page space with other data types
- Do not mix FCP SCSI and ECKD paging volumes
- Be aware of any shared hardware in the path (channels, control units) and who/what is sharing them
- Follow planning guidelines for amount of space

Case Study

Customer Proof of Concept

- Customer moved paging volumes from multiple z/VM LPARs and CECs to a DS8870

- For this study, everything was placed in one Logical Control Unit (LCU)
  - This is not recommended but for part of the experiment
  - Limiting to one LCU restricted full use of DS8870 cache and processing power

- The area that came under question what happens when you IPL multiple z/VM systems and need to restart 100s and 100s of virtual machines?

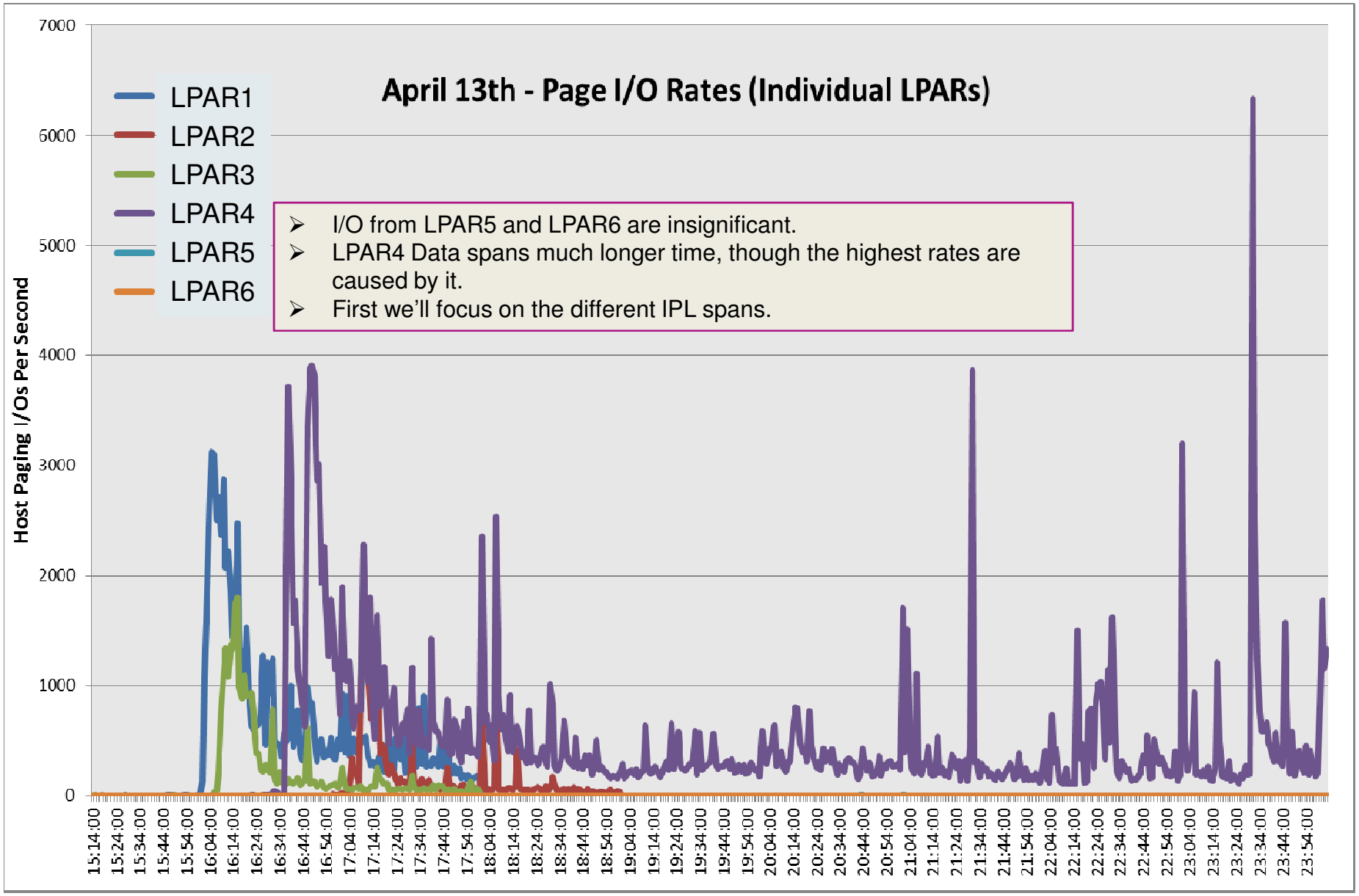
Key Observations

- Performance of DS8870 is a significant improvement over spinning disk.
- No single number can really portray that performance
- Factors that will be examined:
  - Peaks across different LPARs
  - Data per I/O
  - Read / Write Ratio
- Study will explore the data in the different dimensions above
- Brief comparison to the non SSD storage servers

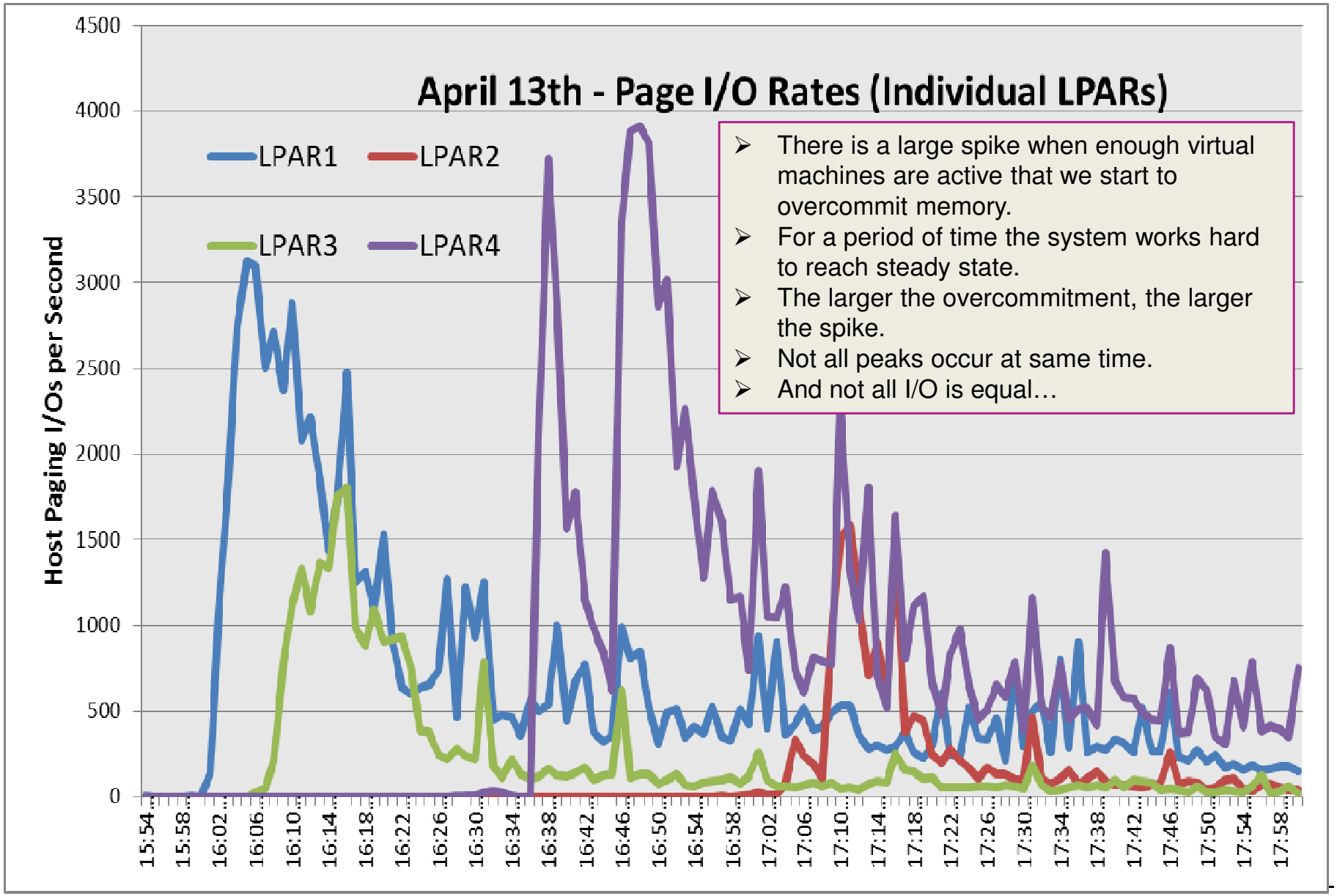
Summary of Systems from April 13th Data

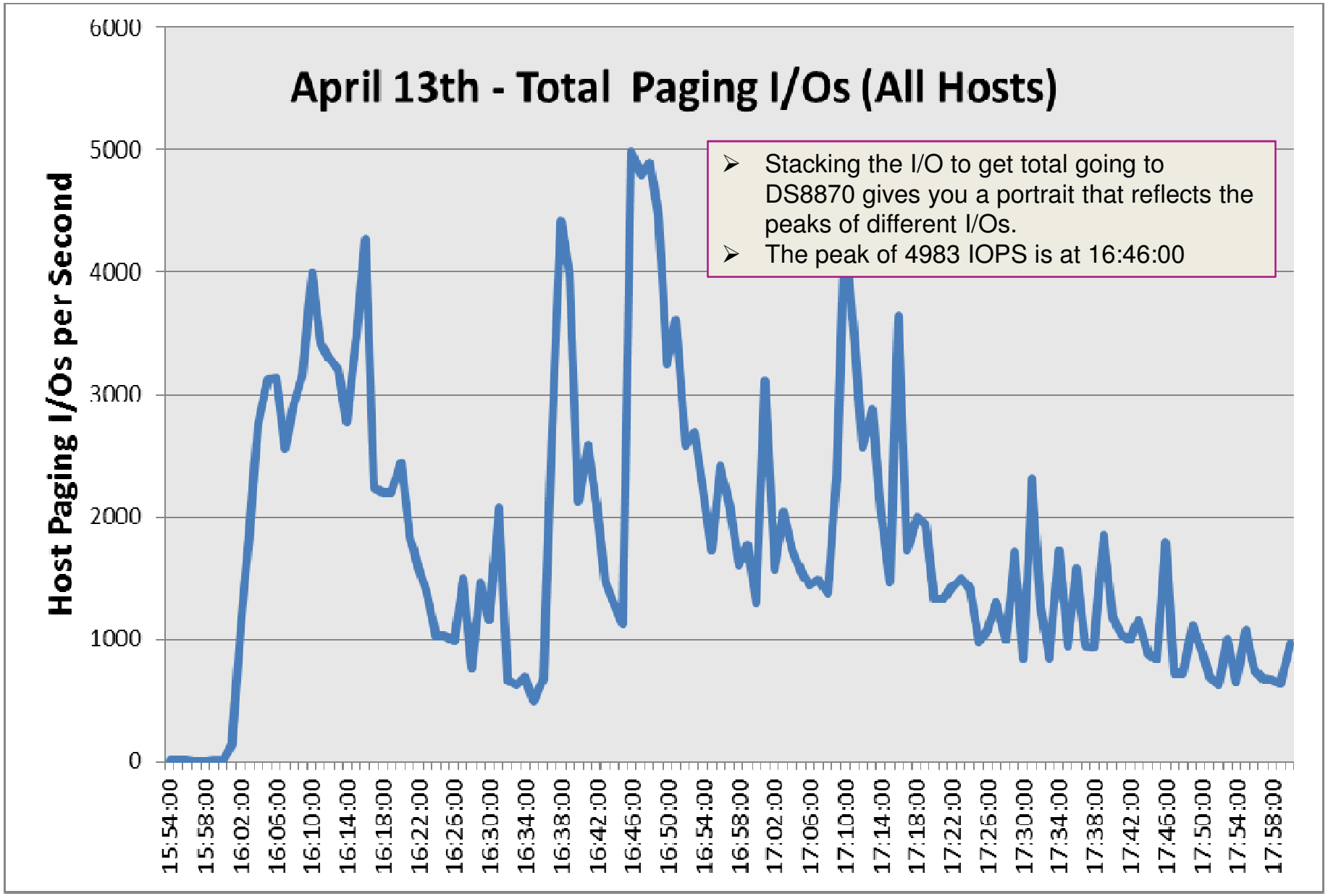
LPAR	z/VM	Page Vols	Memory Virt:Real	IPL Time	Peak Page Rate	Peak Page Time
LPAR1	6.3.0	43	2.36	15:11:14	73690	16:04:00
LPAR2	6.3.0	41	2.34	15:51:33	39865	17:10:00
LPAR3	6.3.0	29	1.76	15:11:30	39800	16:16:00
LPAR4	6.3.0	49	2.48	15:41:23	93229	16:38:00
LPAR5	6.3.0	27	2.36	15:11:34	170	21:01:00
LPAR6	6.3.0	10	0.87	15:11:10	30	15:26:00

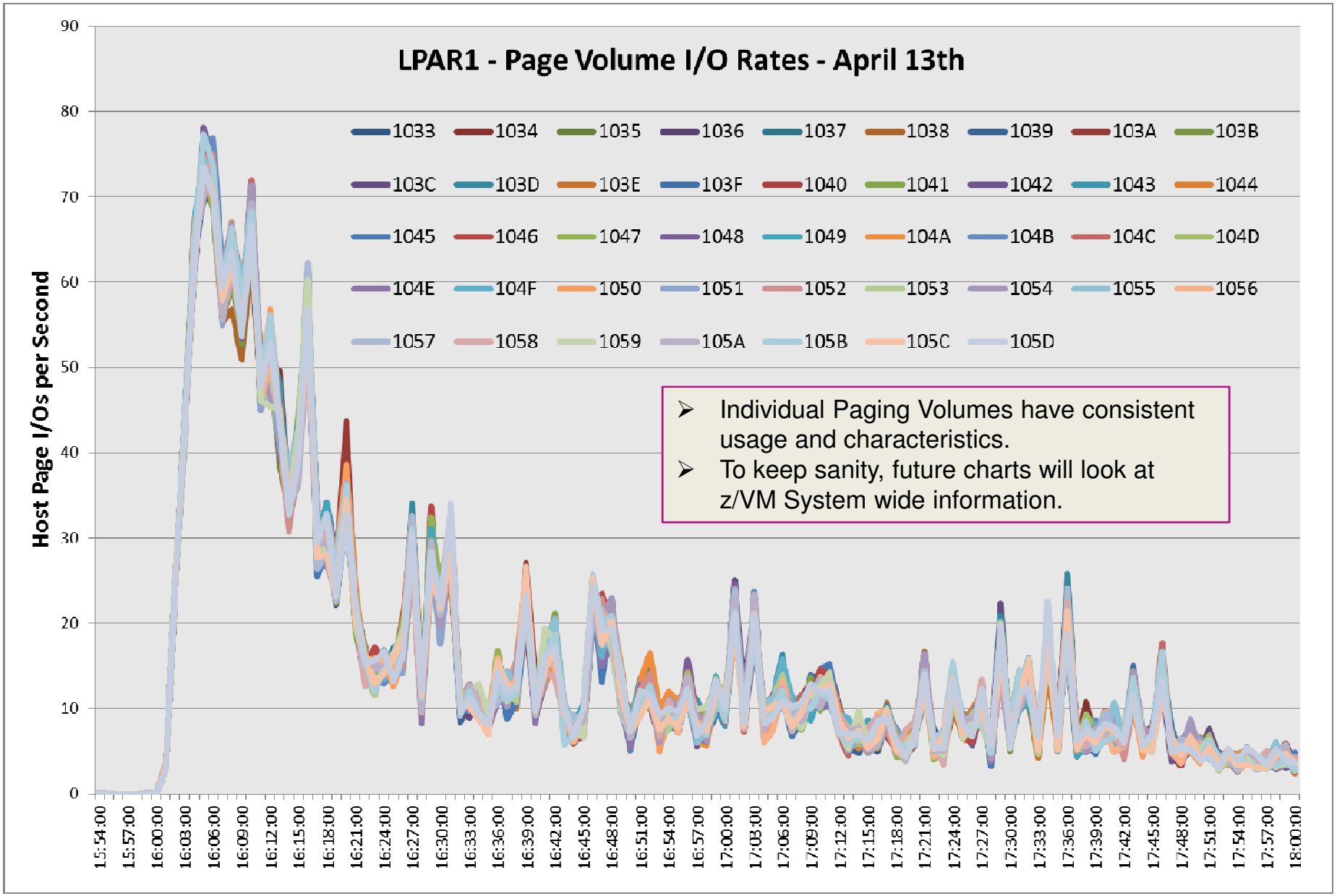
- Peak Page Rate: 4KB Pages/Second, includes read and write
- IPL Time: Time at which z/VM system was IPLed, not necessarily when all virtual machines were brought online.
- LPAR5 and LPAR6 are boring, from a performance perspective.



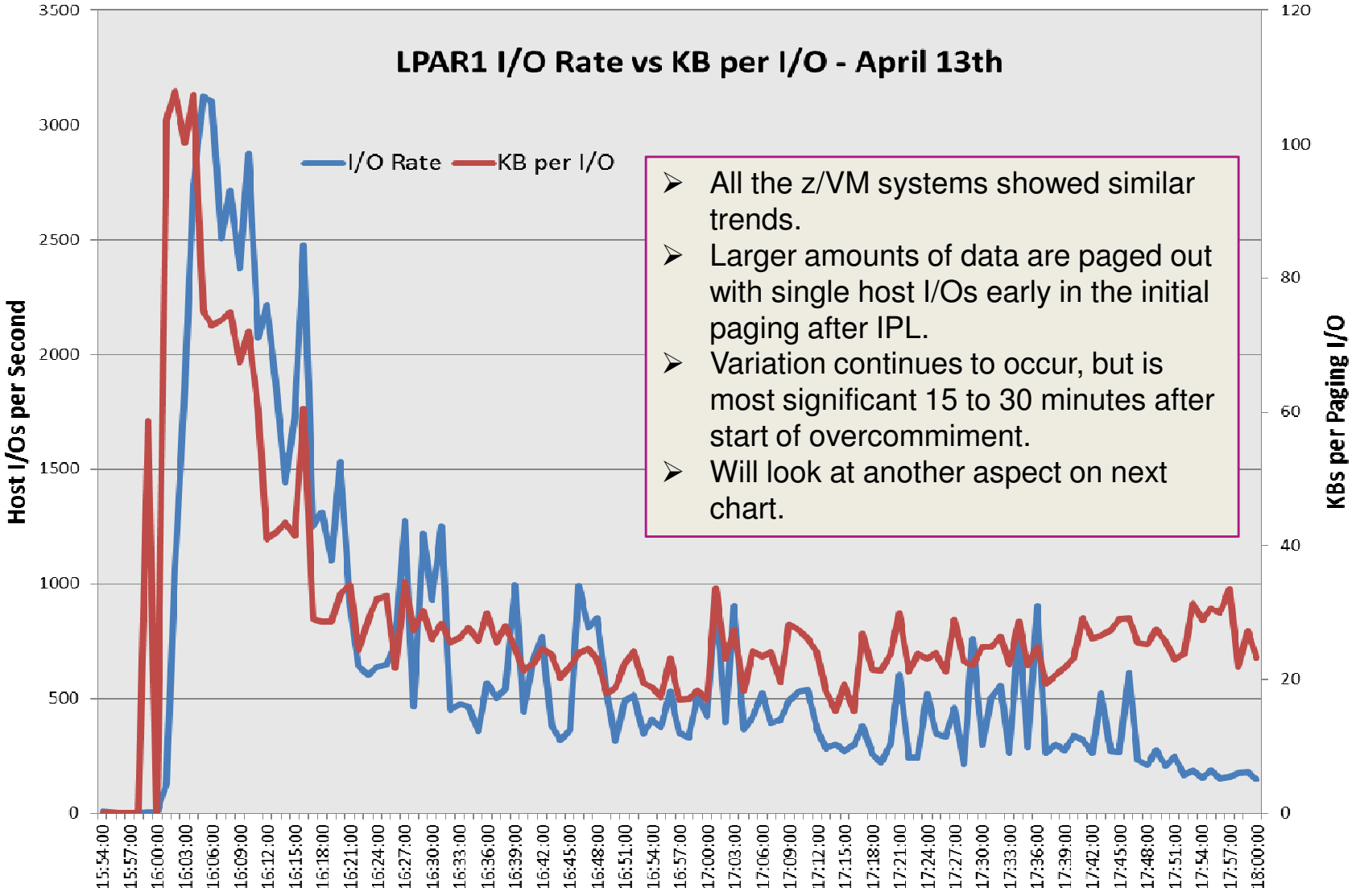
- I/O from LPAR5 and LPAR6 are insignificant.
- LPAR4 Data spans much longer time, though the highest rates are caused by it.
- First we'll focus on the different IPL spans.



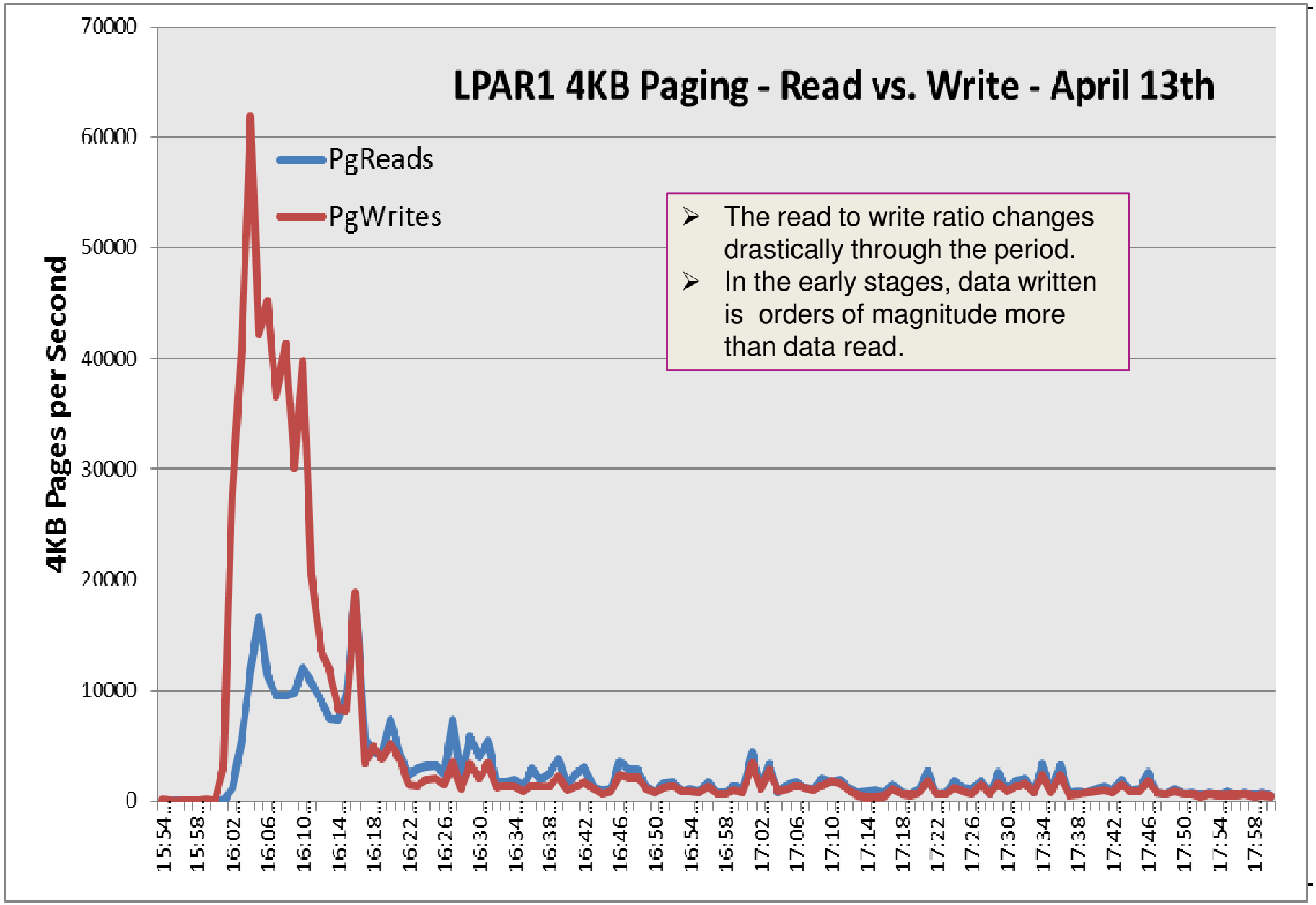


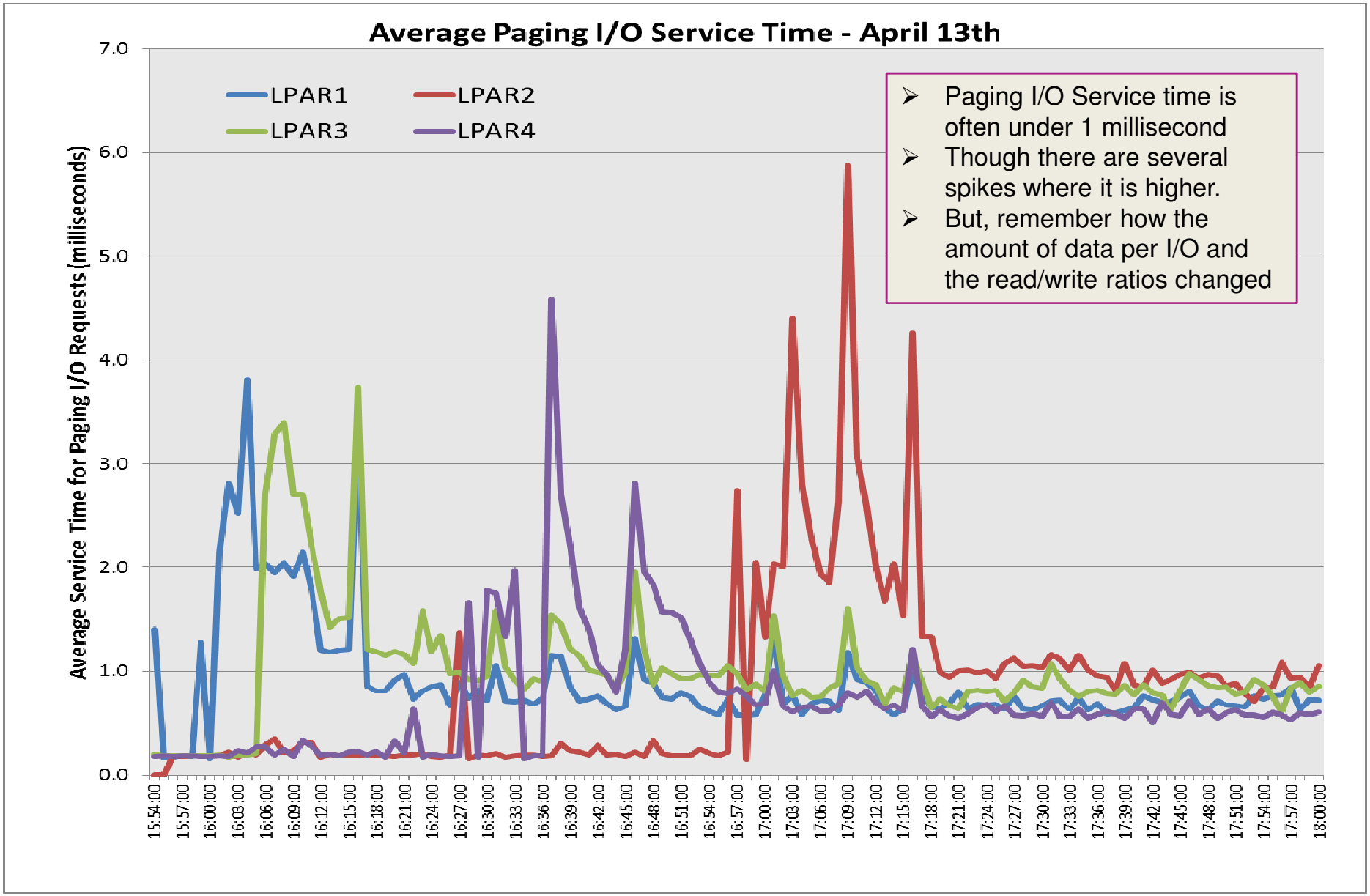


- Individual Paging Volumes have consistent usage and characteristics.
- To keep sanity, future charts will look at z/VM System wide information.



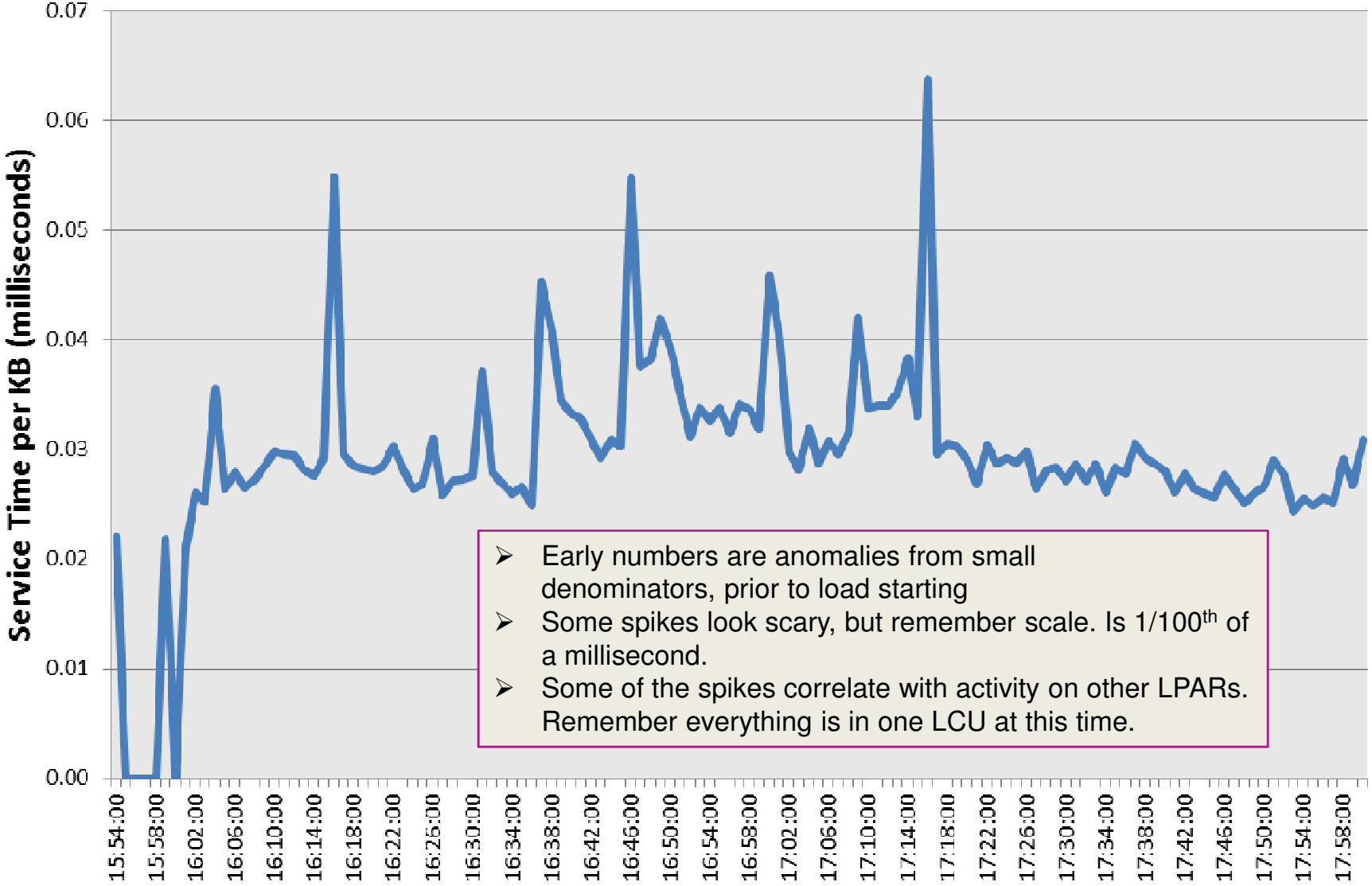
- All the z/VM systems showed similar trends.
- Larger amounts of data are paged out with single host I/Os early in the initial paging after IPL.
- Variation continues to occur, but is most significant 15 to 30 minutes after start of overcommiment.
- Will look at another aspect on next chart.





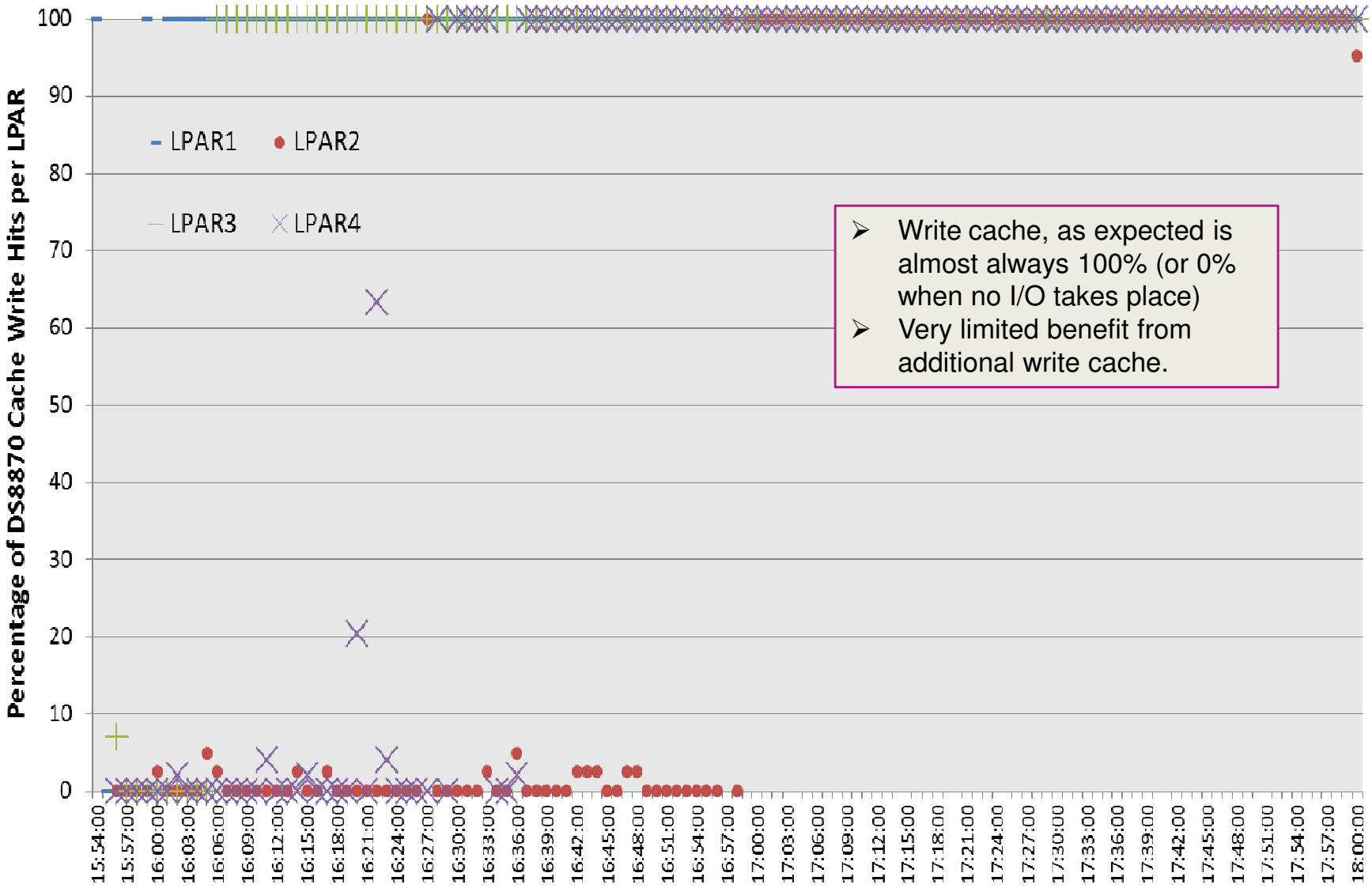
- Paging I/O Service time is often under 1 millisecond
- Though there are several spikes where it is higher.
- But, remember how the amount of data per I/O and the read/write ratios changed

LPAR1- Service Time per KB - April 13th

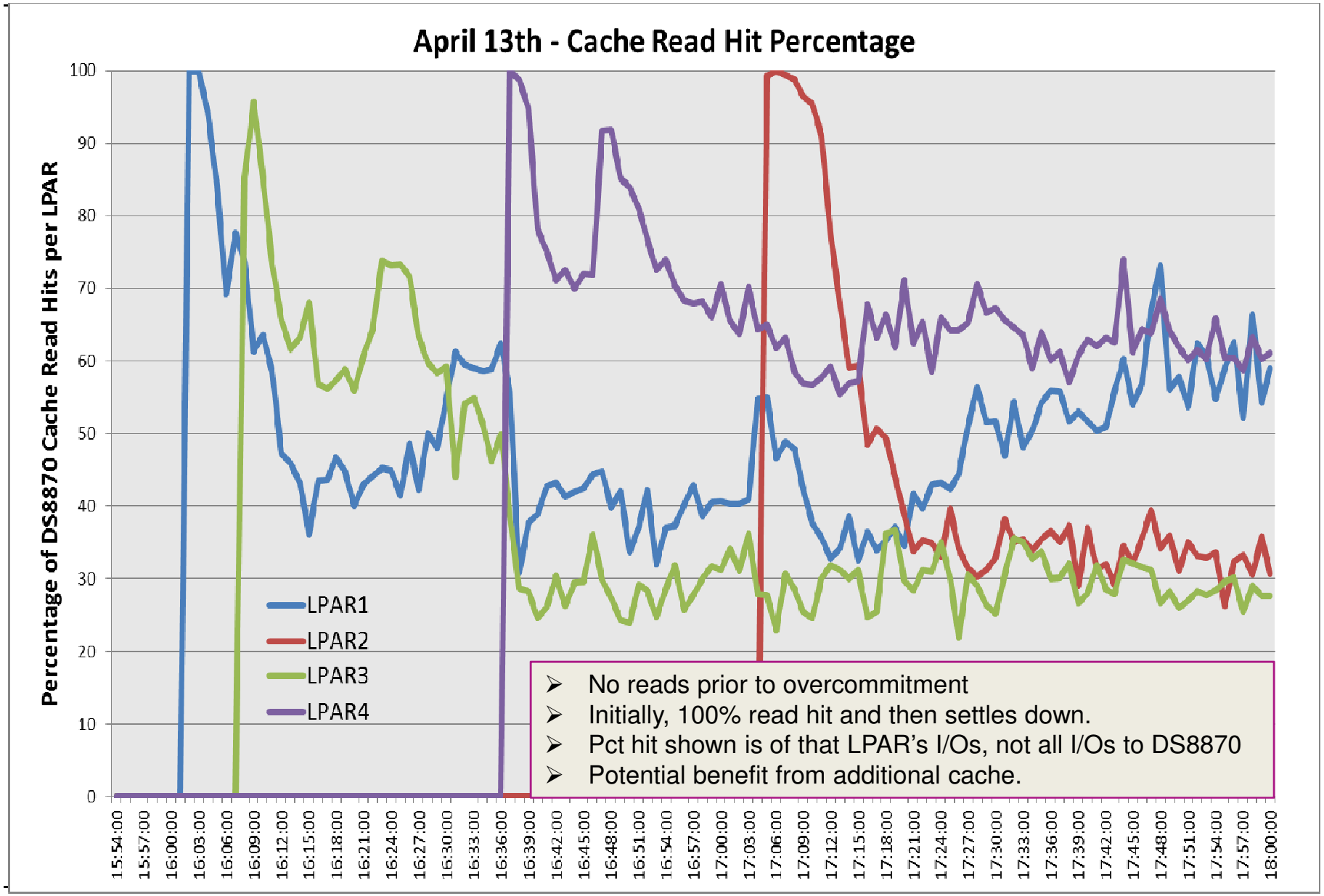


- Early numbers are anomalies from small denominators, prior to load starting
- Some spikes look scary, but remember scale. Is 1/100th of a millisecond.
- Some of the spikes correlate with activity on other LPARs. Remember everything is in one LCU at this time.

April 13th - Cache Write Hit Percentage



- Write cache, as expected is almost always 100% (or 0% when no I/O takes place)
- Very limited benefit from additional write cache.



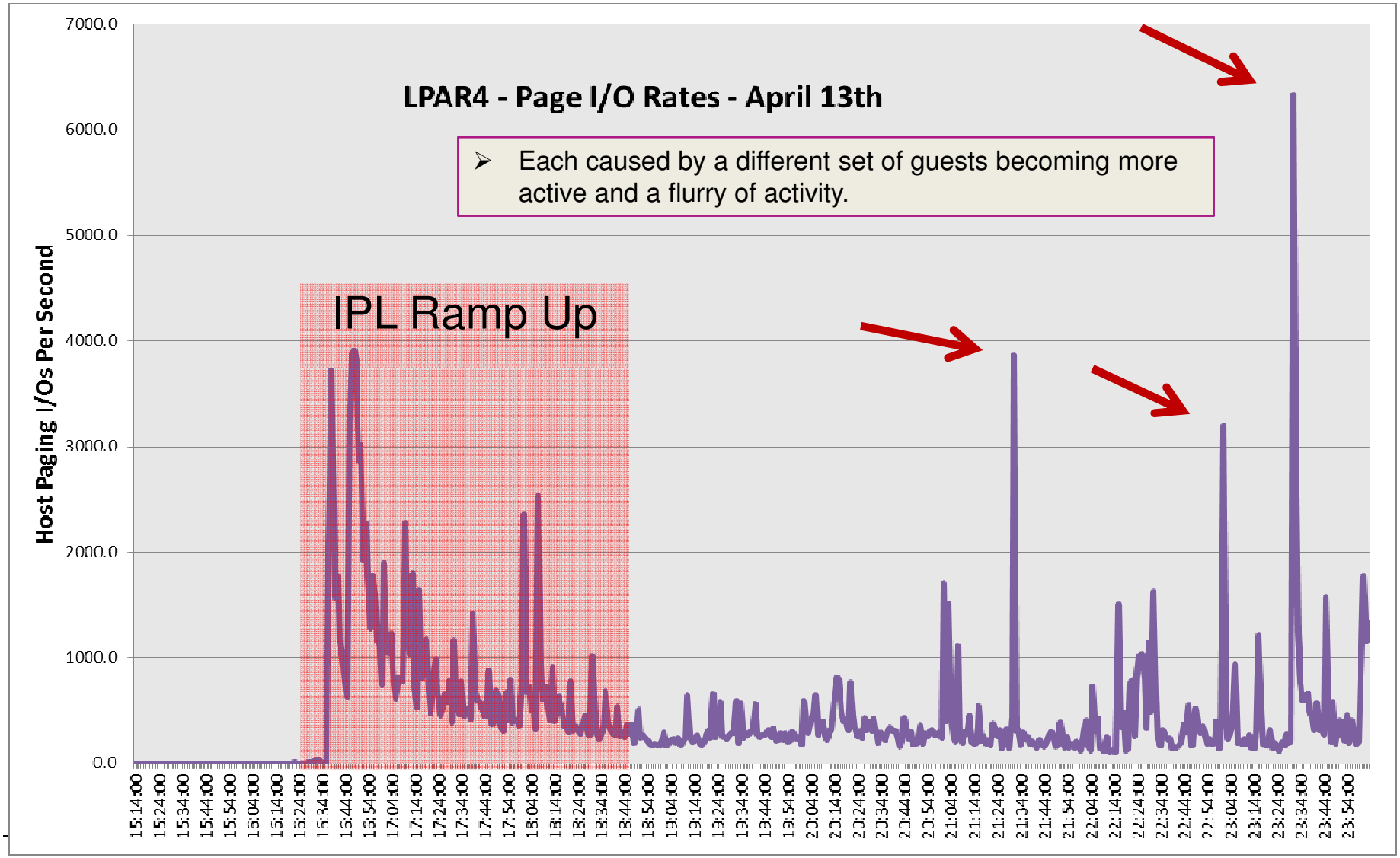
- No reads prior to overcommitment
- Initially, 100% read hit and then settles down.
- Pct hit shown is of that LPAR's I/Os, not all I/Os to DS8870
- Potential benefit from additional cache.

Does the new DS8870 Make a Difference?

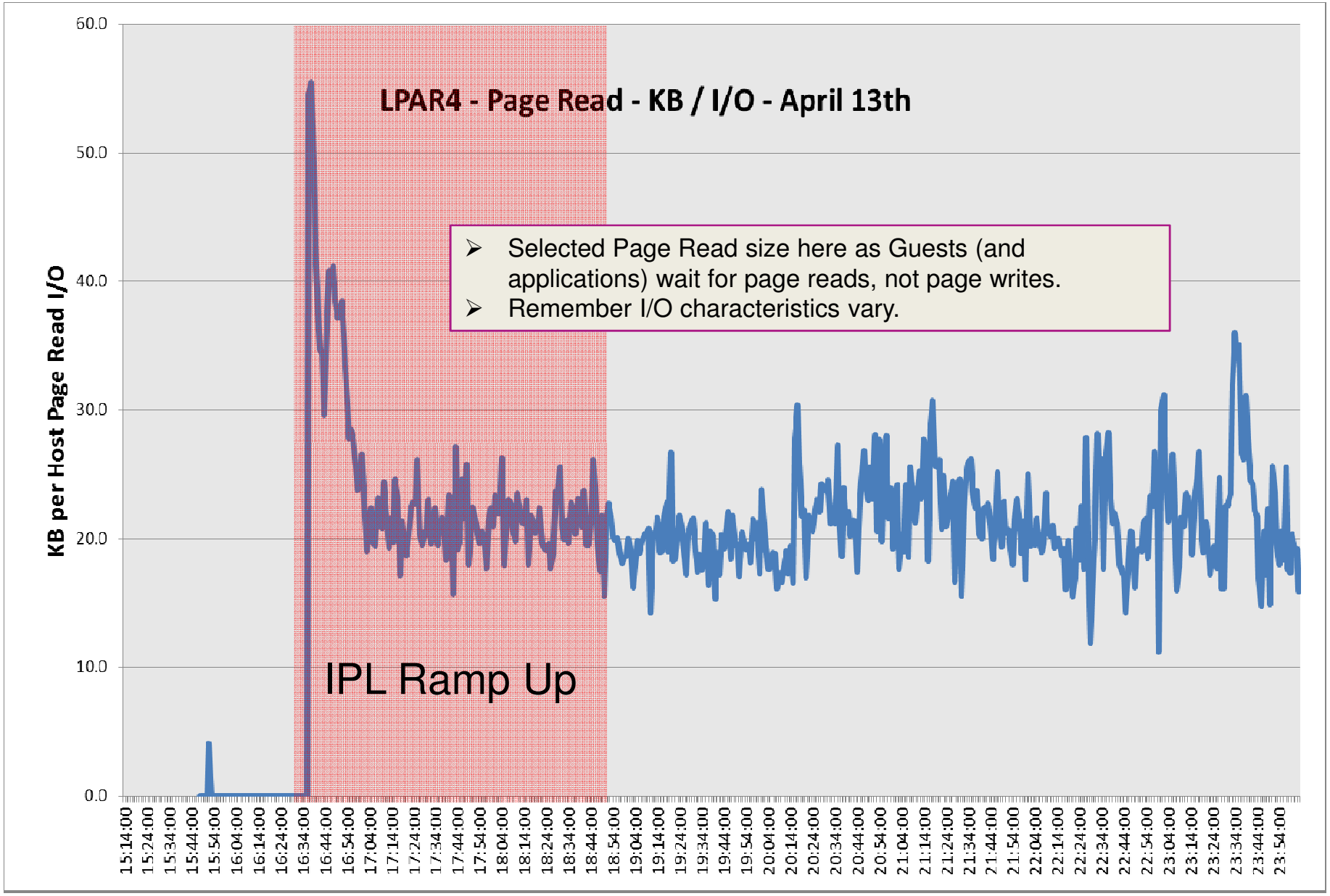
- Yes!
- How much is always hard to quantify without perfectly controlled environment.
- A few items from LPAR1 (Remember not apples to apples)
  - Shutdown processing is as “interesting” as IPL processing

Metric	w/o DS8870	w/ DS8870	Difference
Mload (z/VM Measurement of Paging Subsystem Performance)	36.8	3.7	-90%
Average Queue Length of Paging Volumes	12.9	0.44	-97%
Average %PGW from State Sampling	6%	0%	-100%
Average Service Time on Paging Volumes (milliseconds)	17.4	0.21	-99%

Remember Other Spikes on LPAR4?



- Each caused by a different set of guests becoming more active and a flurry of activity.



Perfect Storms

- The z/VM systems are started at different offsets, but spent some time looking at what would happen if they did align.

- It would be significantly more activity, still containable, but I would recommend holding to the staggered start.

Metric	Actual Peak	Perfect Storm
Host Page I/Os	4983/second	11,963/second
Paging MB/second	385 MB/Second	963 MB/Second

Summary

- DS8870 with SSD is providing much better I/O performance characteristics compared to spinning disk.
  - Bonus benefit in Processor resource savings
- The process of restarting 100s of Linux guests impacts paging performance significantly, though the characteristics can be different from high paging rates after the system has stabilized.
- Need to continue to track I/O operations and data rates, as well as the normal performance metrics:
  - Page wait
  - Asynchronous Page wait
  - Available List management
- The need for higher IOPS and bandwidth can be important to z/VM
  - Other limits eliminated
  - Higher consolidation workloads

QUESTIONS & DISCUSSION