Data Archive challenges for sPhenix 2025

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March 20th, 2025

ISGC 2025, Taipei

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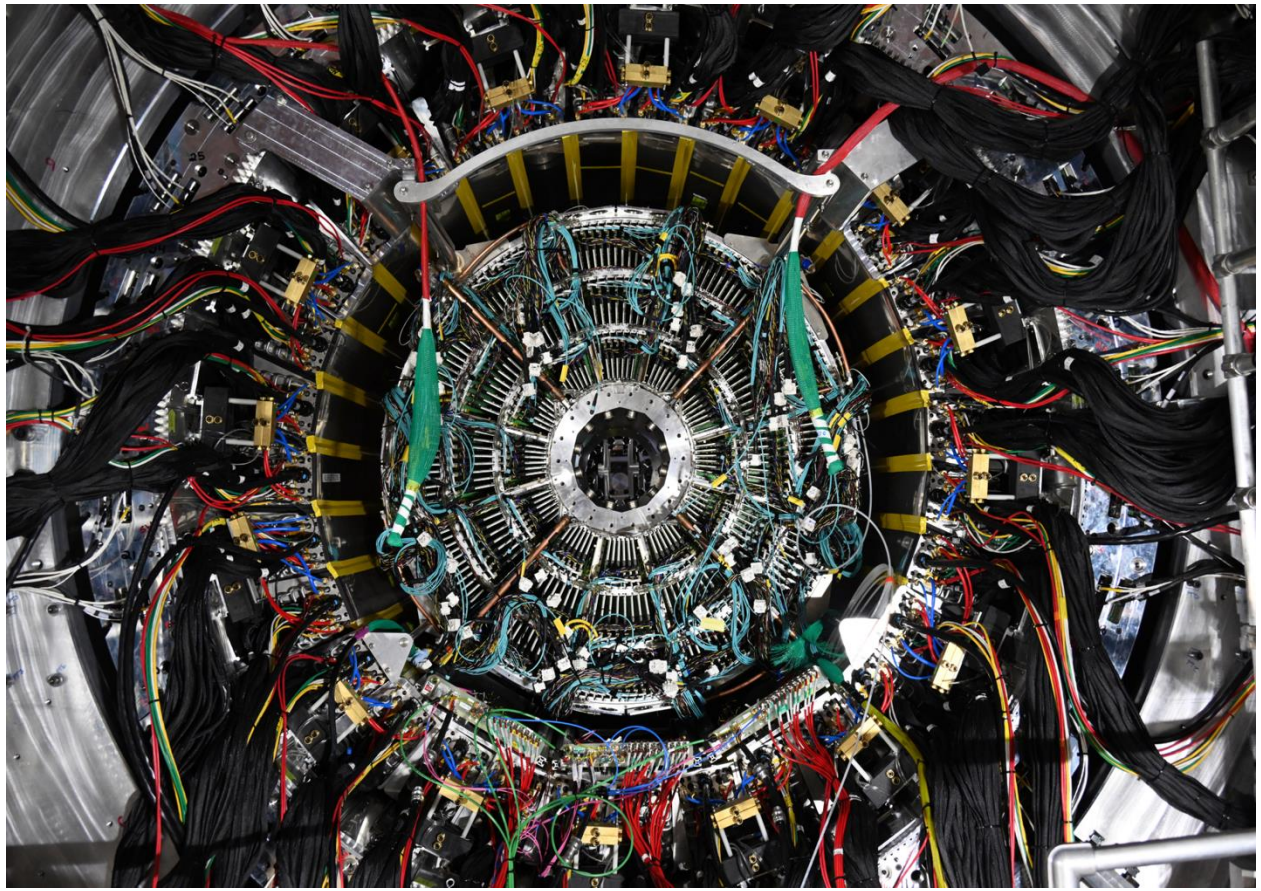
sPhenix

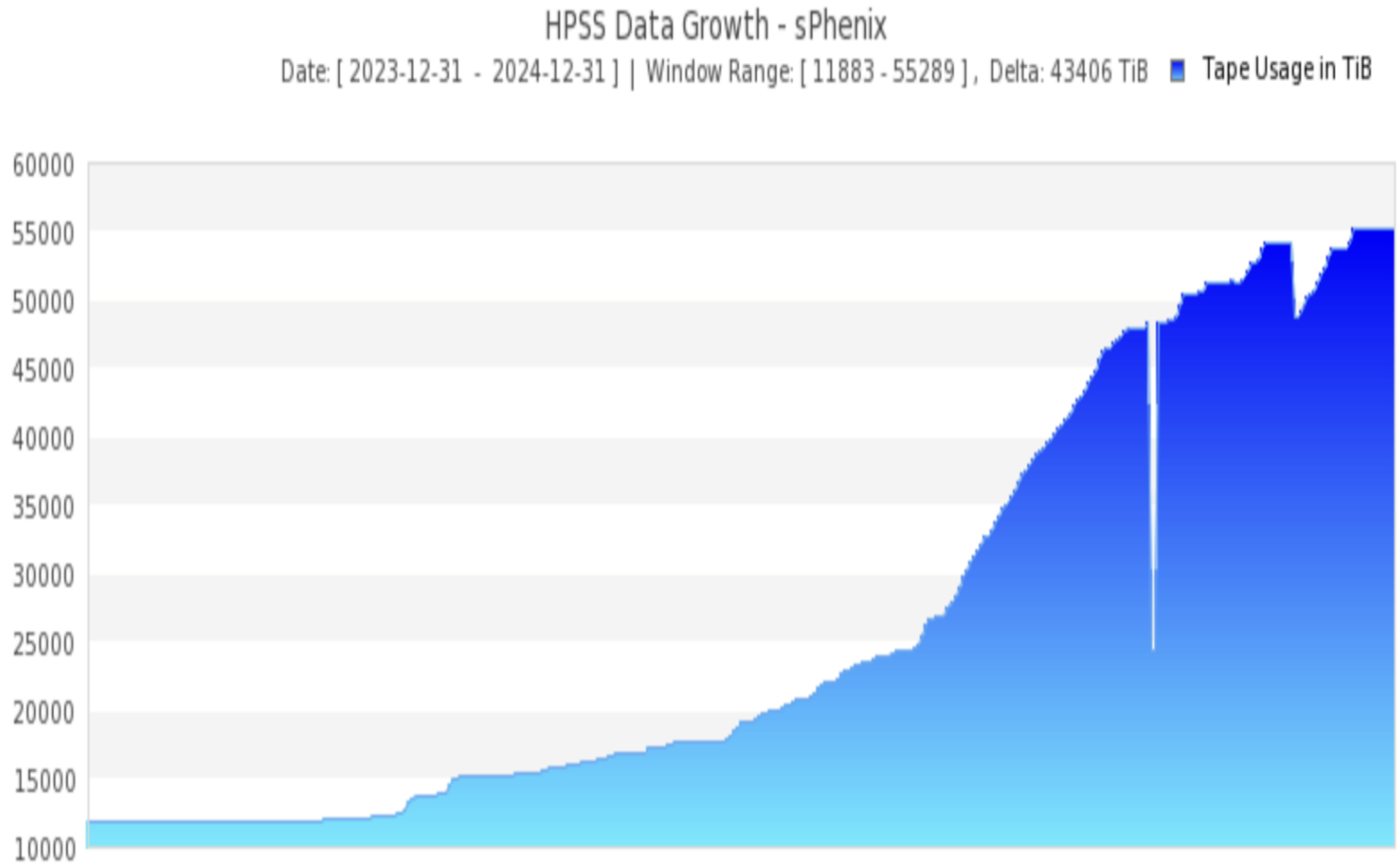
- The sPhenix detector will capture snapshots of 15,000 particle collisions per second, more than three times faster than PHENIX.



sPhenix Archive Data volume

- FY24 48.9 PB
- FY25 200 PB

- Data archived to tape will not be purged
- Requires 20GB/sec

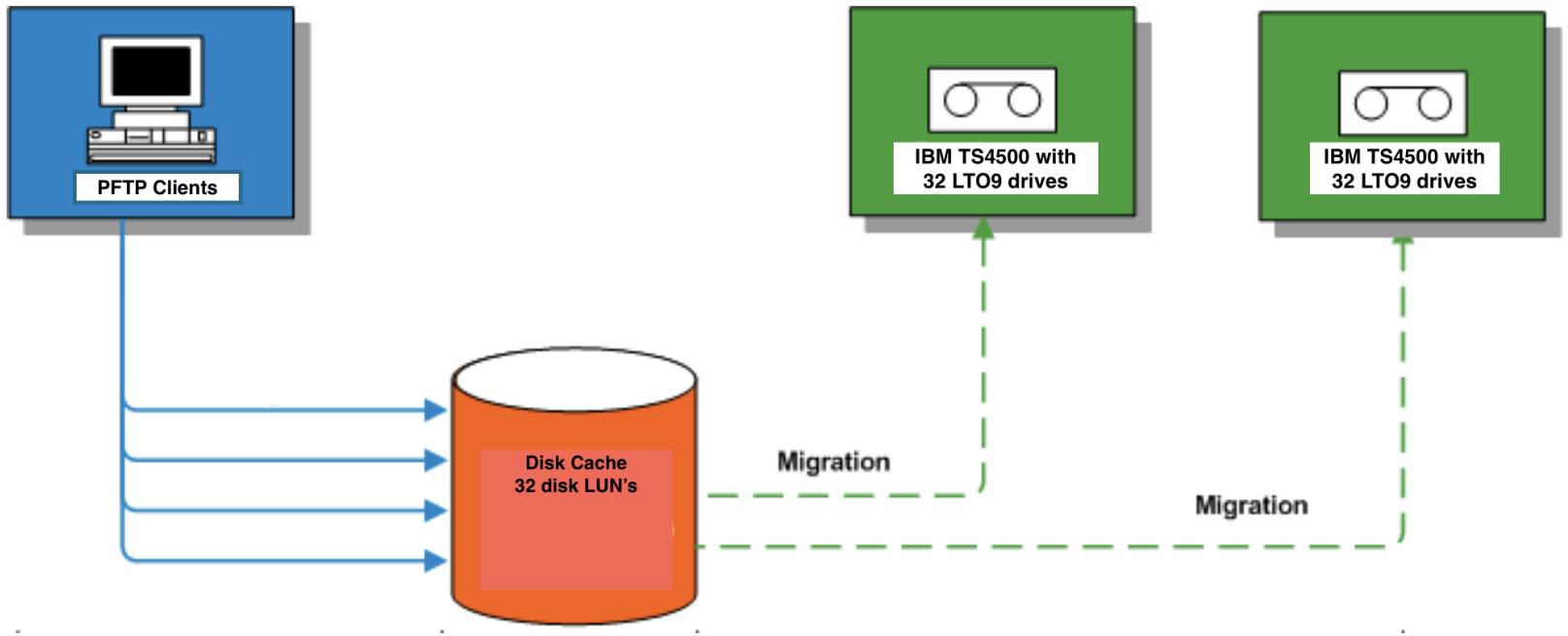


sPhenix Data Storage services

- Disk storage service is running Lustre
- Tape storage service is HPSS
- Raw and MC Data concurrently injected to disk and tape
  - One copy to disk, and the other to tape
- Data on tape will be read, once the required data is purged on disk

sPhenix Tape Storage Configurations

- Pftp and HSI clients.
- Data movers
- Disk cache
- Four Tape libraries
- ✓ Sustain 20GB/sec



Data Archive considerations

- Tape libraries
  - Tape slot count
  - Number of tape drives
  - Robotics mount count per hour
  - Floor footprint, number of silo frames
  - Robotics redundancy with fail-over features
- Disk cache
  - SSD, Disk array with controllers or JBOD
  - Data I/O throughput
  - Data path redundancy
- Movers
  - Network connections and redundancy
  - Fiber Channel connections and multipath

Tape Libraries

Four units of IBM TS4500

- 1st two units, each has
  - 8-frame, 8,806 tape slots
- 2nd two units, each has
  - 9-frame, 10K tape slots
- 25 LTO9 drives on each library
  - 100 drives total, aggregated 36GB/sec
- To ensure equal usage on four libraries
  - Each tape volume creation is alternated evenly across 4 libraries

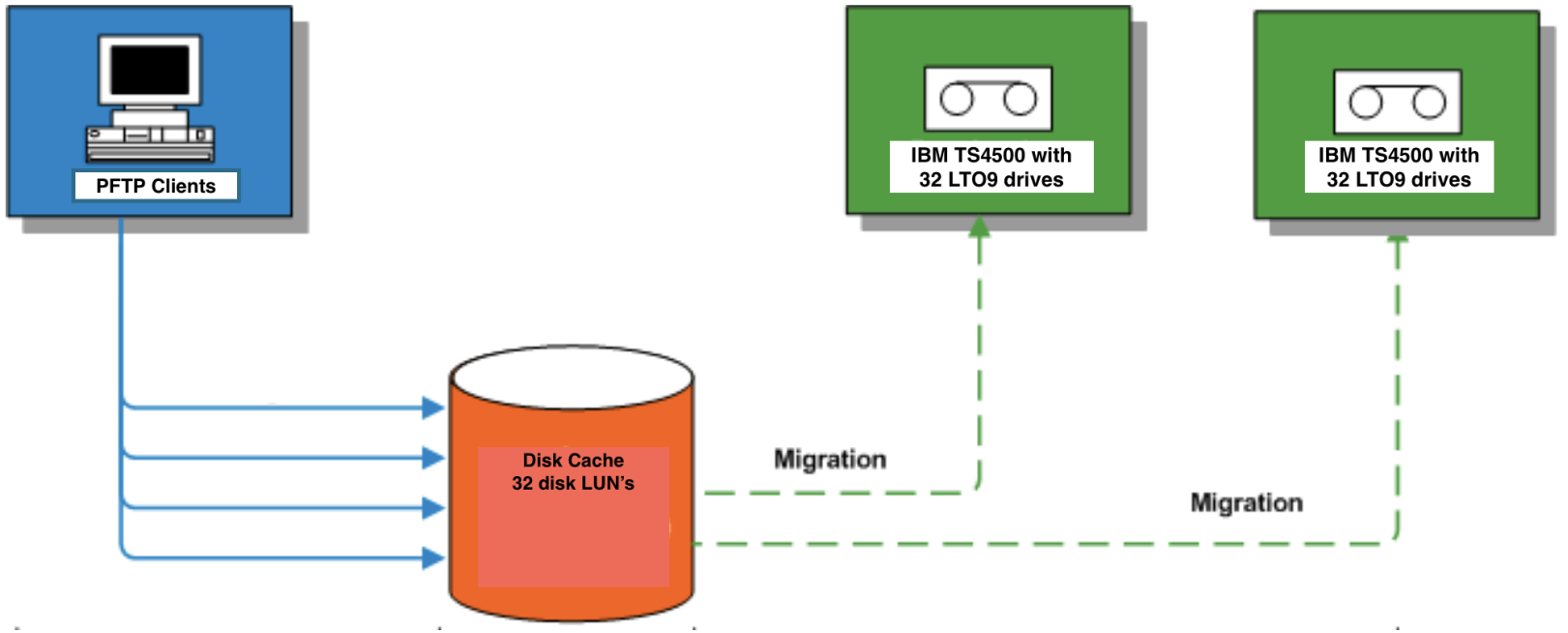
Disk Cache

- To sustain 20 GB/sec, Disk Cache needs 40GB/sec throughput
- To hold 48 hours of injection, we need at least 3PB of space
  - 9 units of NetApp HDD arrays
    - with SSD, the capacity is too low for the same budget
    - JBOD is too slow after disabling buffering (required by application)
  - Each disk array has
    - 11 RAID-6 LUN's (8+2) plus 2 global hot spares
  - 99 disk LUN's total
    - 6PB of total disk cache

Movers

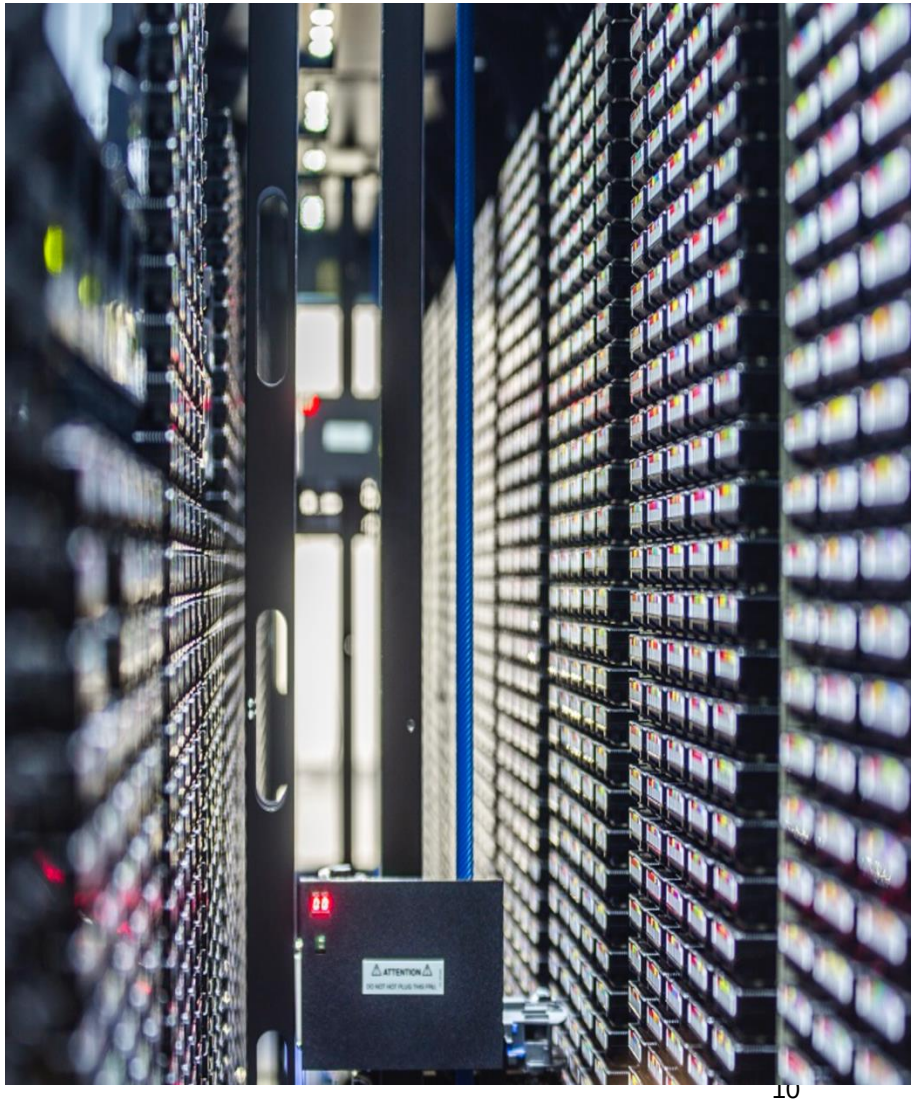
Nine data movers, each connects…

- 200GbE (100GbE x 2 LACP)
  - 18 100Gb connections total
- LTO9 drives x 12
  - 100 LTO9 drives total
- Disk LUN's x 11
  - 99 disk LUN's total
  - 6 PB of total disk cache



Tape Mount Testing

- Mount 32 drives, 151 sec (4.72 sec/mount)
  - 762 mounts/hour on each library
  - Exclude time for tape loads by the drives.
- Dismount 32 drives, 168 sec (5.25 sec/dismout)
  - 640 dismounts/hour on each library
  - Exclude the time for tape unloads by the drives
  - TS4500 automatically remap the home slot address of a mounted tape to a nearest physical slot. This expedites the subsequent mounts of this loaded tape.
- 361 tapes can be swapped each hour
  - Dismount + Mount = Swap tapes
  - The highest mount rate observed in Atlas is 285/hour
- When tapes go to deeper tiers, it gets slower



Tape Data Injection Testing

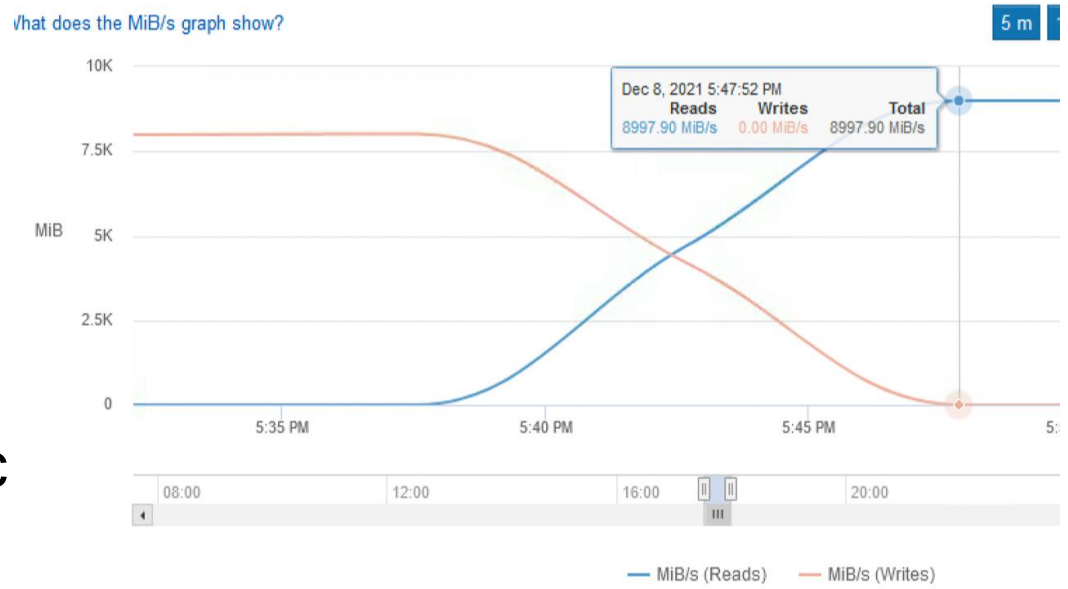
Concurrent injections to 64 LTO9 drives

- 64-drive total throughput 23,728.6 MiB/sec
- Average drive throughput 371.0 MiB/sec/drive
  - LTO9 drive spec is 400MB = 390MiB/sec/drive
  - All tapes are mounted and positioned before writes
  - File size is 20GB per file

Disk Cache Testing

32 disk LUN’s on 4 data movers

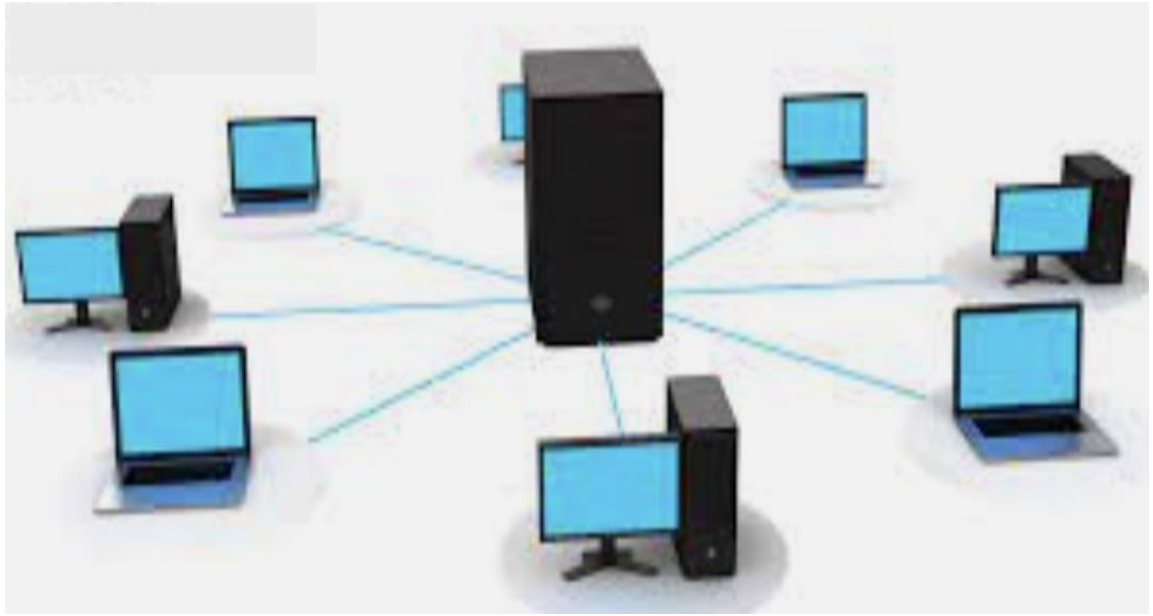
- 100% write throughput 24,454.5 MiB/sec
  - Data injection to all 32 LUN’s concurrently
  - 764.2MiB/sec per LUN (100% write)
  - Each LUN contains 8+2 HDD’s (RAID-6)
  - 32 Gb/sec FC connections
- 50% Read and 50% Write, 26,740 MiB/sec
- 100% Read, 25,780 MiB/sec



Data Mover Network Testing

Each mover has two 100Gb ethernet connections(LACP), 4 Movers

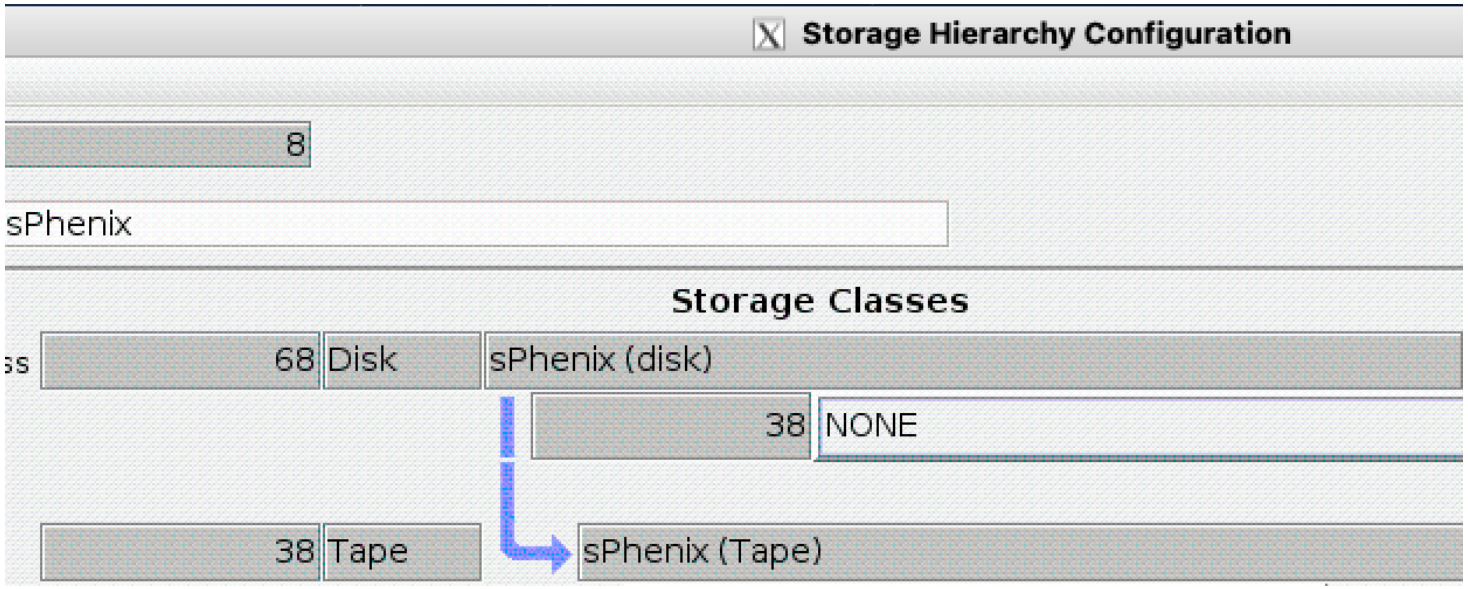
- Total network throughput on 4 movers: 48,845 MiB/sec
  - Each mover transfer data to the other three movers with 10 connections
  - No disk and tape I/O involved



Tape service configuration

A dedicated Class Of Service for sPhenix

- Disk Storage Class
  - 6 PB, 99 LUN's
- Tape Storage Class
  - LTO9 (18TB per tape)
  - Four IBM tape libraries
  - 36K slots
- pftp and HSI clients



Tape Migration Policy

Disk cache to tape migration policy

- File migration ordered by directory instead of by time stamp
- Migration runs every 48 hours, or at 90% disk cache usage
- Migration data streams always split evenly across FOUR tape libraries
- RAW, DST and MC data will be separated into different tape sets (File Families)

Staging from tape

Staging requests are submitted to Batch application

- Staging requests are grouped by tapes
  - To minimize tape mounts
- Files on the tapes are read in tape position order
  - To minimize tape repositioning
- Call-back mechanism provided when a request completes

FILE STAGING REAL-TIME STATUS

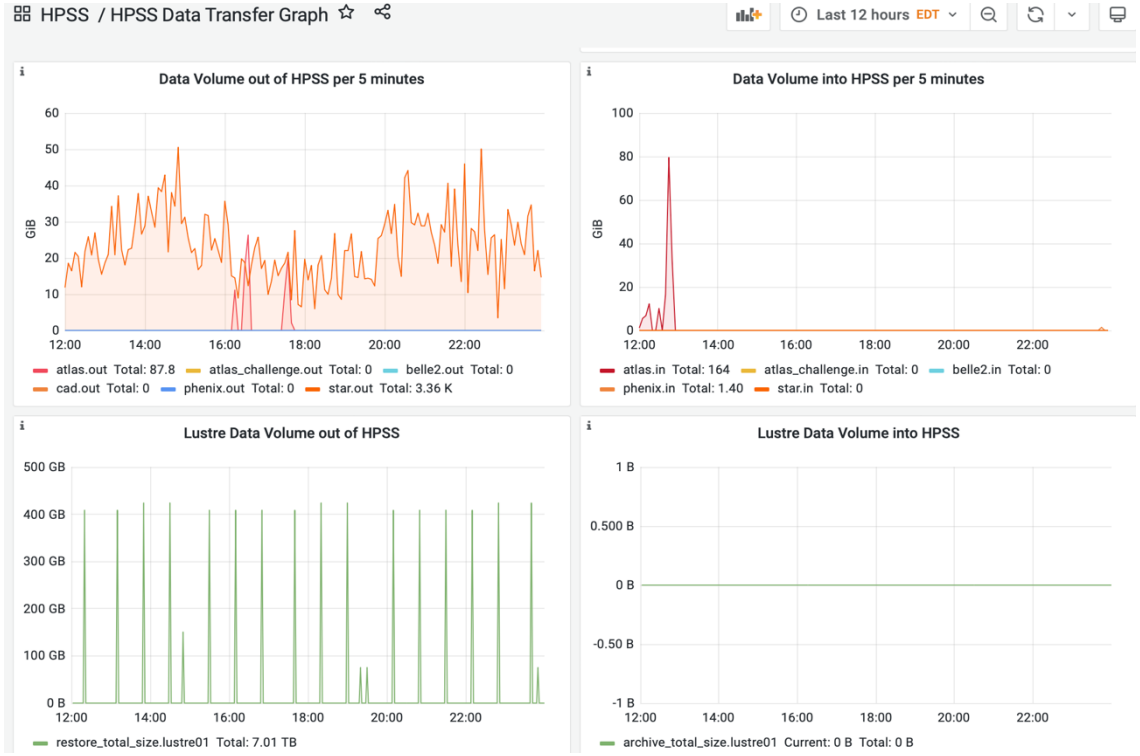
atlasdat

Tape Info	Tape ID	Files	Avg size	Status	Files staged	GB Staged	Avg MB/s	Files failed	Last staged	Mount Time	Drv Addr	Drv Type
Atlas Large LTO-7	A70574	2 / 268	475,889,685	Reading	1459	651.17	201.15		3-15 20:56:32	3-15 20:01:43 (00:54:58)	2,0,1,2	IBM LTO7
Atlas Large LTO-7	A70575	2 / 220	484,991,224	Reading	1491	665.99	207.92		3-15 20:55:57	3-15 20:01:51 (00:54:50)	2,3,1,0	IBM LTO7
Atlas Large LTO-7	A70578	2 / 280	465,058,091	Reading	1375	614.50	191.38		3-15 20:56:05	3-15 20:01:59 (00:54:42)	2,0,1,14	IBM LTO7
TOTAL:	3 Tapes	6 Files		Avg 200.15 MB/s/dr								

System Monitoring

Grafana and MySQL DB

- Operational numbers such as network traffic, tape mounts, disk and tape usage … etc are monitored and recorded,
- Recorded numbers are displayed on Grafana



System Alerts

Alerts on software and hardware errors

- Email alerts are sent to related staffers on system errors, include software and hardware errors

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+++ Tape HW Alert 03/19/23 06:05:01 AM +++
sp7mvr01 /dev/hpss/L9/262D -> /dev/st8   000788F3DB IBM-LTO9 P90200L9
Drive humidity: 1

/dev/hpss/L9/262D   19C   66%

rcfmvr31 /dev/hpss/lto7/0  -> /dev/st1  4,13,1,1   IBM-LTO7 Empty
Cleaning requested: 1

rcfmvr21 /dev/hpss/lto6/4  -> /dev/st1  4,0,1,13   IBM-LTO6 S52759L5
Hard error: 1 Read failure: 1 Diagnostics required: 1
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Thank you!

Q & A…