



Introduction to JobMon at NHR@KIT

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JobMon

History

- Started as a research project as part of J. Schmitt's Bachelor's thesis in 2021/2022
- Contributions from employees (B. Bytyqi, H. Obermaier) and student assistants (D. Schild, J. Schmitt, F. Wedler)
- Basis for D. Schild's master's thesis in 2024/2025

Overview

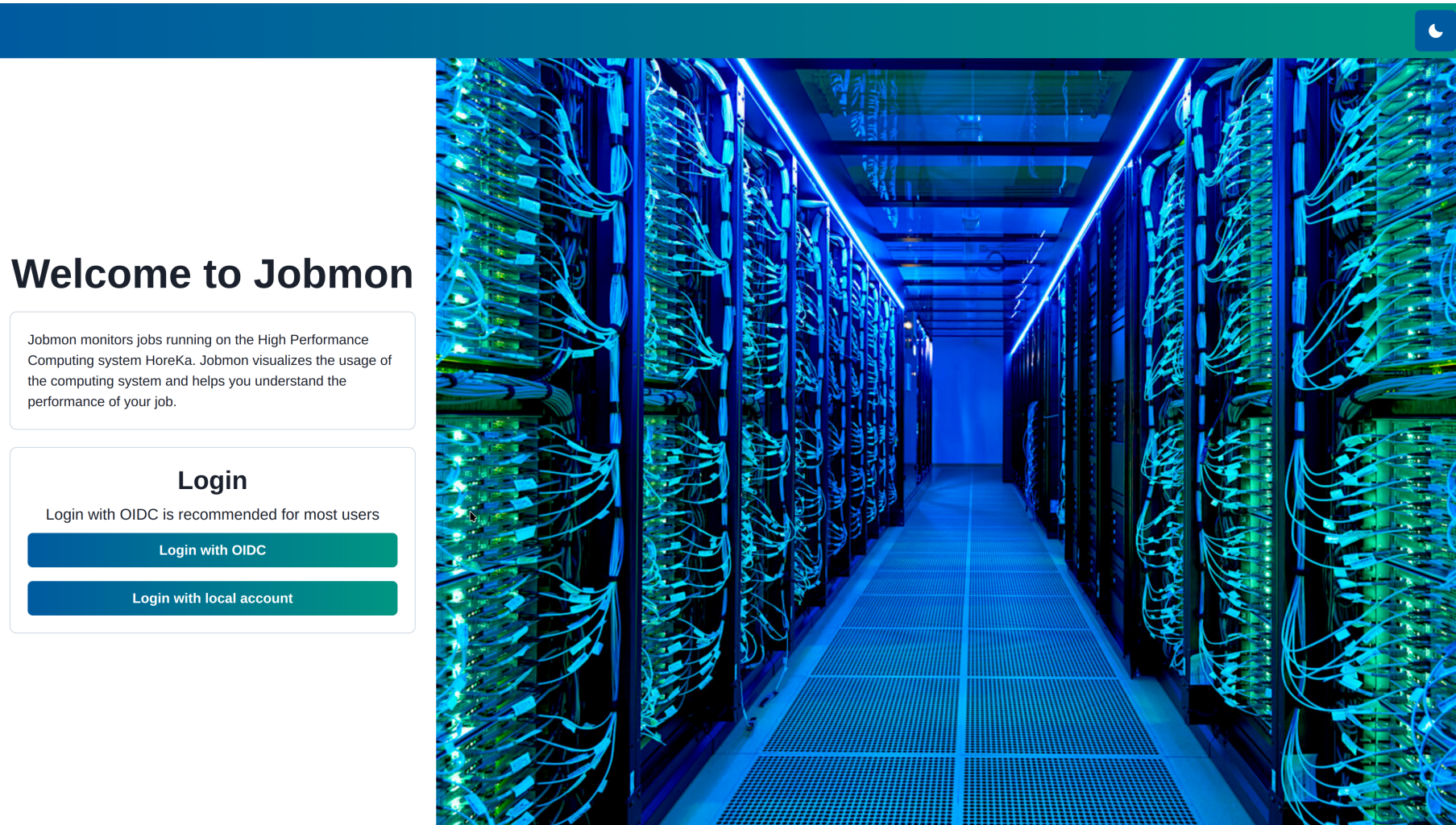
- Web Service: JobMon [↗](#)
- Access with HoreKa user account
- Same networks restrictions apply as for HoreKa (VPN)
- Visualizes performance metrics
- Aggregates performance metrics for improved clarity
- Metrics are continuously collected on cluster nodes
- Metrics are stored $\Rightarrow$ Performance changes over time can be tracked.
- **Note:** Shared nodes show the whole node metrics, no split by job usage is done!!
 - Allocate jobs with `-exclusive` flag, for reliable performance measurements.

Demo Application Workloads

Categories

- *Compute Bound*
 - Performance is limited by floating point performance
 - Benchmark *DGEMM*[↗](#) performs a matrix matrix multiplication
- *Memory bound*
 - Performance is limited by memory bandwidth
 - Benchmark *Stream*[↗](#) / *BabelStream*[↗](#) performs vector computations
 - Benchmark *HPCG* performs the conjugate gradients method with a sparse matrix
- *Communication bound*
 - Performance is limited by interconnect bandwidth or latency
 - Benchmark *OSU Micro-Benchmarks*[↗](#) performs MPI point to point communication
- *IO bound*
 - Performance is limited by filesystem throughput or metadata rate
 - Benchmark *IOR*[↗](#) performs parallel IO operations

Login page



Welcome Page







Welcome to Jobmon

Jobmon monitors jobs running on the High Performance Computing system HoreKa. Jobmon visualizes the usage of the computing system and helps you understand the performance of your job.

Your Activities



Running jobs

2

Jobs in the last 24 hours

5

Jobs in the last week

5

Your account



Username: bq0742

Role: user

Your jobs



This system monitors jobs. You can take a look at them in by using on the link below.

Your Jobs

Need Help?



You can find further information about jobmon by using the link below.

Further Information

Jobs page

⇒ Overview of the personal HoreKa batch jobs

Filter options

- Batch partition
- Number of nodes or GPUs
- Job status (Running or finished)
- Job execution time
- Exit code ⇒ successful or non-successful job run
- Tags assigned to the job ⇒ group jobs by your needs

Jobs page - Filter







Users:

Partitions: All 

From: 



Nb. nodes



Exit code:

Status: All 

To: 



Nb. GPUs





Reset

Apply

Jobs per page: 

Sort by: 

Compact view: ☒

Jobs page - Spider Plot

Spider Plot

- Plot that characterizes the overall job performance
- High level view on performance limitations
- Allows categorization as:
 - IO bound
 - Memory bound
 - Compute bound
 - Communication bound
- Average and maximum values for the metrics:
 - CPU floating point operations per second
 - CPU memory bandwidth
 - GPFS IO operations
 - GPFS metadata operations
 - GPU utilization
 - GPU memory utilization
 - InfiniBand bandwidth

Spider Plot - Compute Bound Workl. (cpuonly)

Id: **3015837**

User: bq0742 (hk-project-scs)

Partition: cpuonly

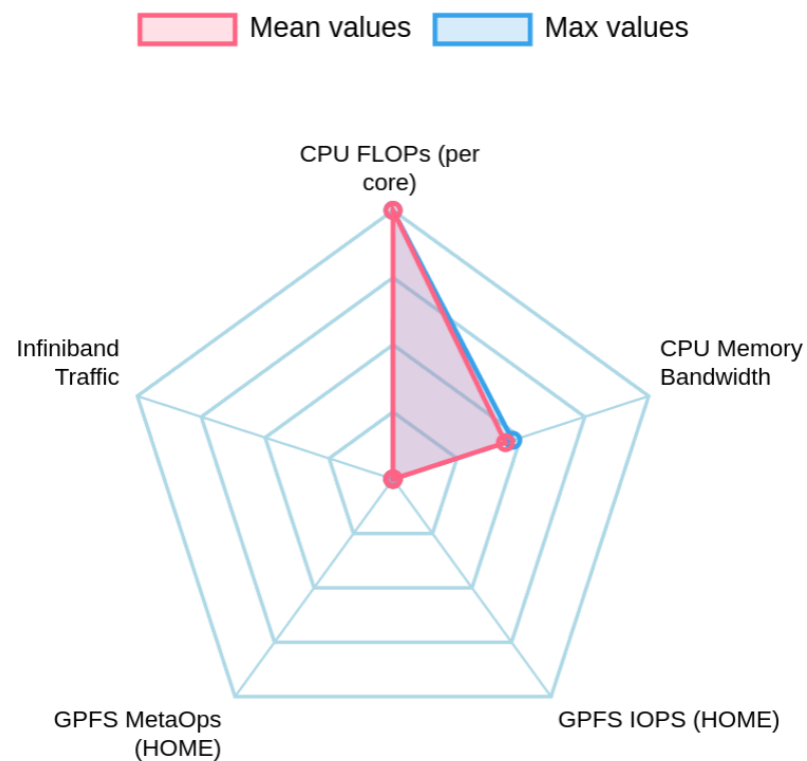
Name: cpu.dgemm

Nodes: 1

Start: 27.3.2025, 16:25:13

End: 27.3.2025, 17:21:28

Exit code: 0



Spider Plot - Memory Bound Workl. (cpuonly)

Id: **3015838**

User: bq0742 (hk-project-scs)

Partition: cpuonly

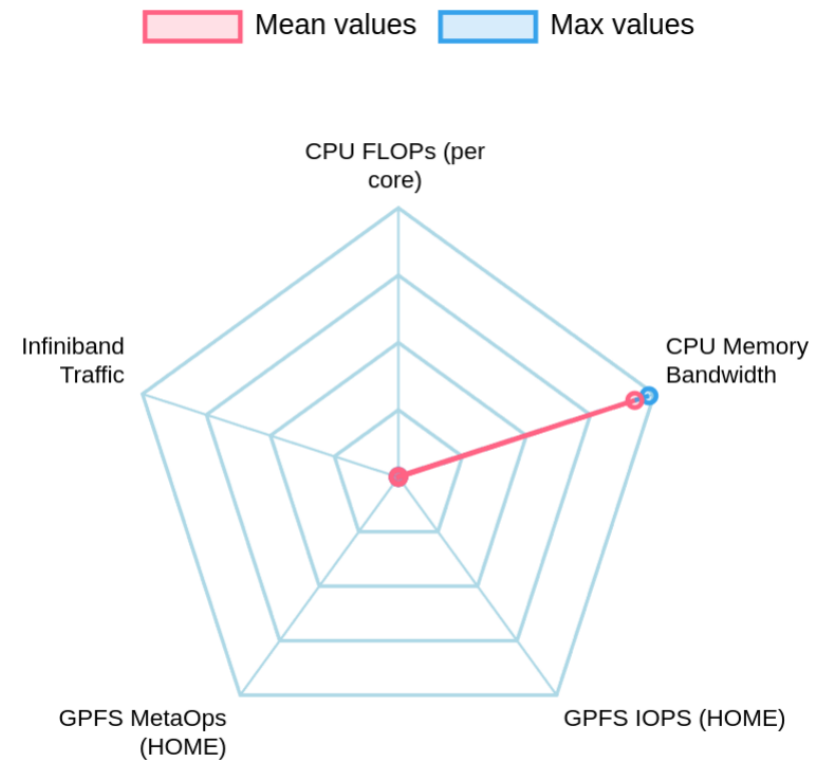
Name: cpu.stream

Nodes: 1

Start: 27.3.2025, 16:25:13

End: 27.3.2025, 17:27:08

Exit code: 0



Spider Plot - Communication Bound Workl. (cpuonly)

Id: **3019847**

User: bq0742 (hk-project-scs)

Partition: cpuonly

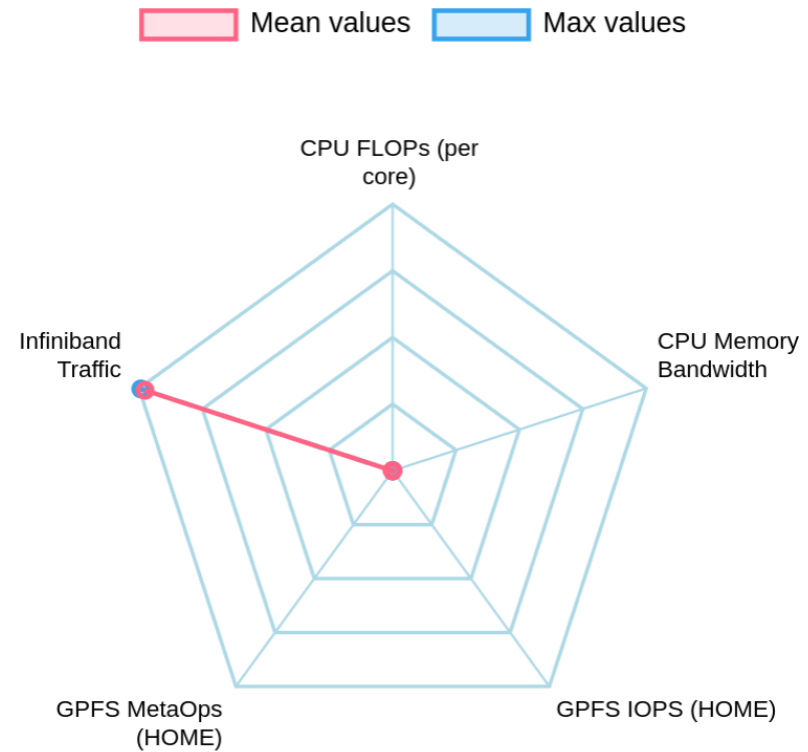
Name: cpu.omb,mpi,node

Nodes: 2

Start: 28.3.2025, 15:30:33

End: 28.3.2025, 16:28:00

Exit code: 0



Spider Plot - Compute Bound Workl. (accelerated)

Id: **3015828**

User: bq0742 (hk-project-scs)

Partition: accelerated

Name: gpu.dgemm

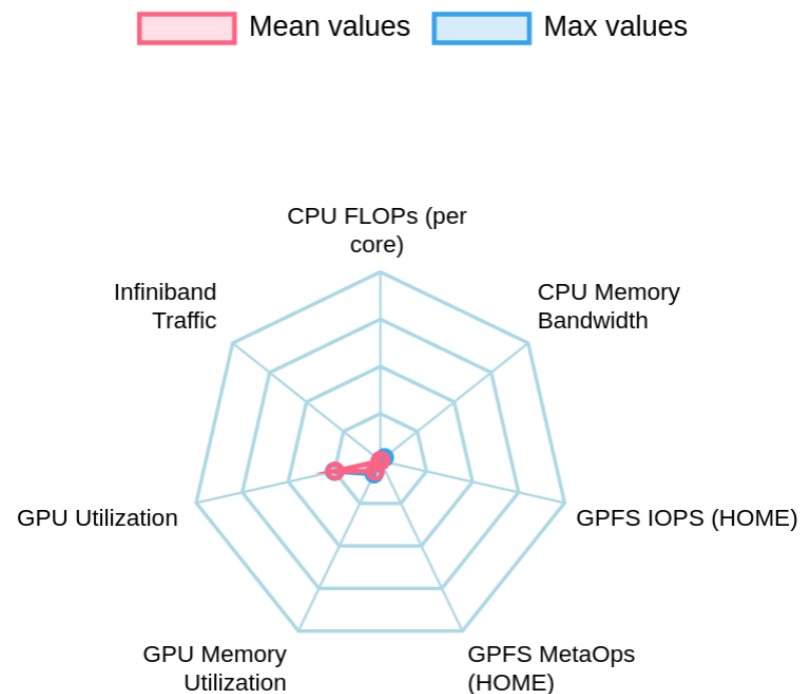
Nodes: 1

GPUs: 4

Start: 26.3.2025, 13:58:52

End: 26.3.2025, 14:57:36

Exit code: 0



Spider Plot - Memory Bound Workl. (accelerated)

Id: **3013359**

User: bq0742 (hk-project-scs)

Partition: accelerated

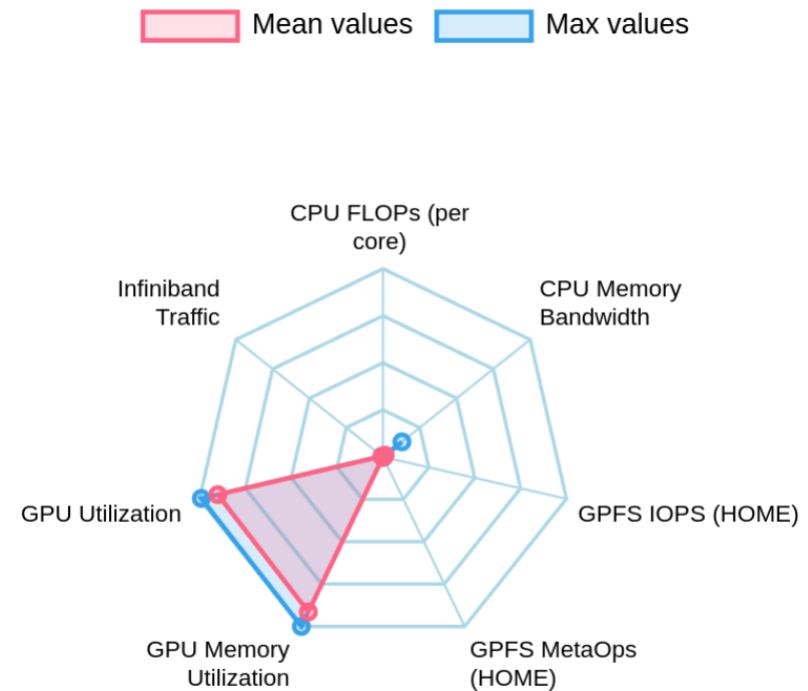
Name: gpu.hpcg,apptainer

Nodes: 1 GPUs: 4

Start: 25.3.2025, 11:56:12

End: 25.3.2025, 13:02:09

Exit code: 0



Spider Plot - Comm. Bound Workl. (accelerated)

Id: **3016899**

User: bq0742 (hk-project-scs)

Partition: accelerated

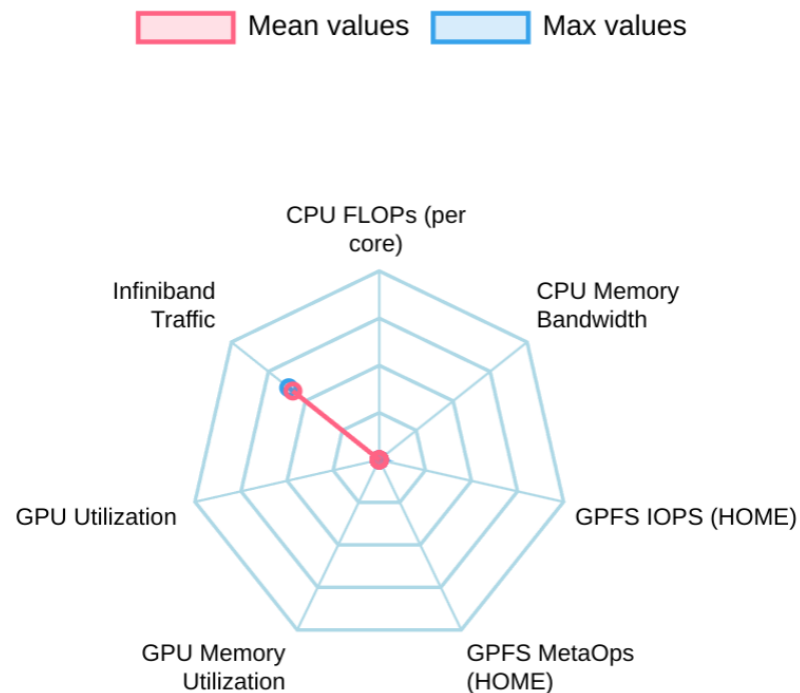
Name: gpu.osu,apptainer

Nodes: 2 GPUs: 2

Start: 27.3.2025, 10:36:13

End: 27.3.2025, 10:49:12

Exit code: **0**



Job page

Filtering options

- Select subset of nodes (text filtering)
- Select time range (range slider)
- Select subset of metrics (checkboxes for each metric of the selected category)

Toggles

- *Automatic Scaling* ⇒ Select y-axis limits depending on metrics limits
- *Quantile View* ⇒ Only plot quantiles
- *Changepoints* ⇒ Identify times where performance metric behavior changes. **Disabled!!**

Buttons

- *Modify tags* ⇒ Add or remove tags to you job
- *Export as CSV* ⇒ Export data for further analysis
- *Reset time range* ⇒ Reset the time range selection
- *Choose sample rate* ⇒ Choose different sample intervals

Job page - Options, Toggles, ...

Id: 3019847

User: bq0742 (hk-project-scs)

Partition: cpuonly

Name: cpu.omb,mpi,node

Nodes: 2

Start: 28.3.2025, 15:30:33

End: 28.3.2025, 16:28:00

Exit code: 0

course

Nodes (2) ▾

Metrics ▾

Changepoints ☐
Quantile View ☐
Automatic Scaling ☒

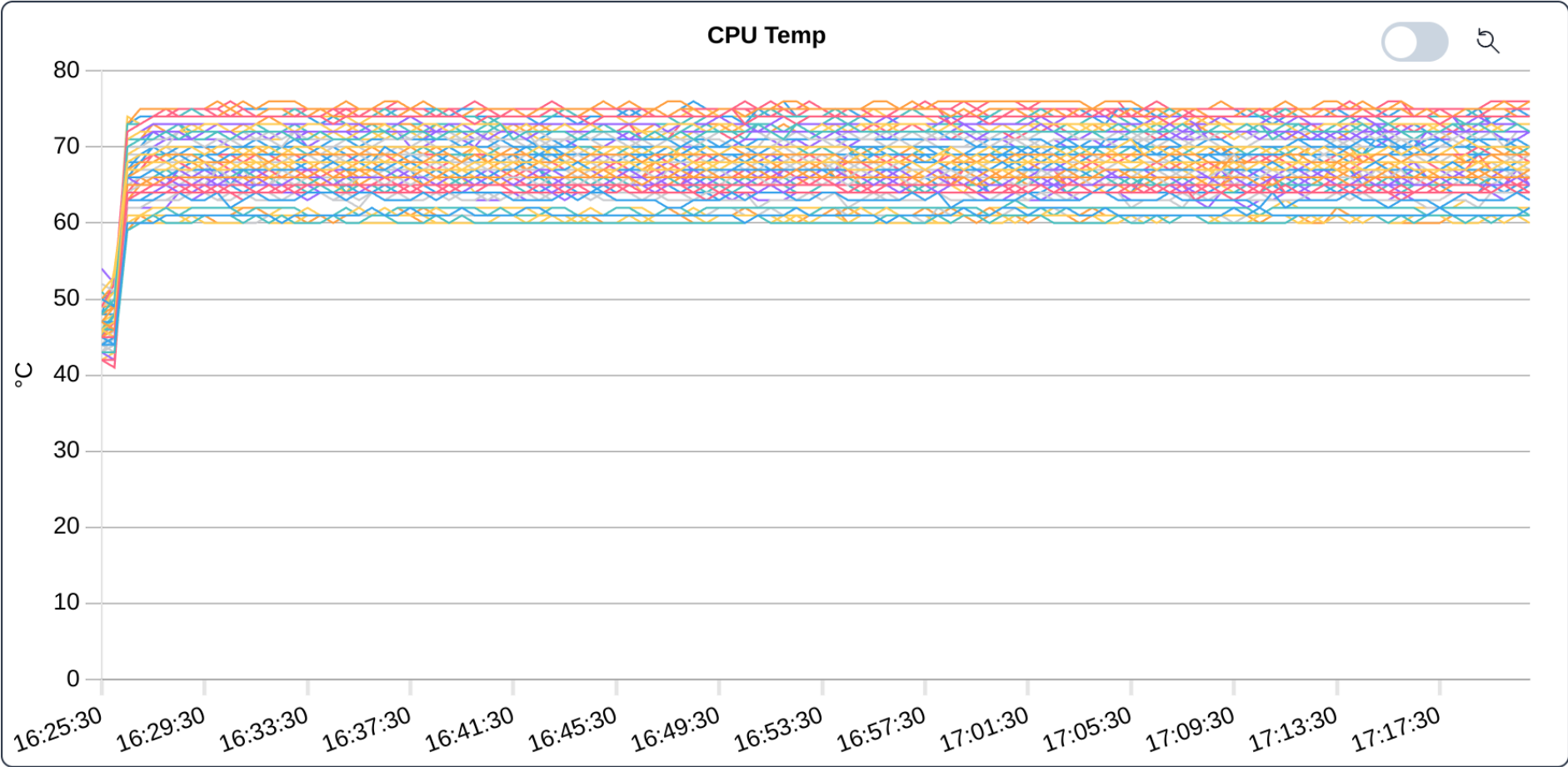
[Filesystem](#) |
 [Memory](#) |
 [Energy](#) |
 [Interconnect](#) |
 [Performance](#) |
 [Temperature](#)

Job page - Toggle: Quantile View

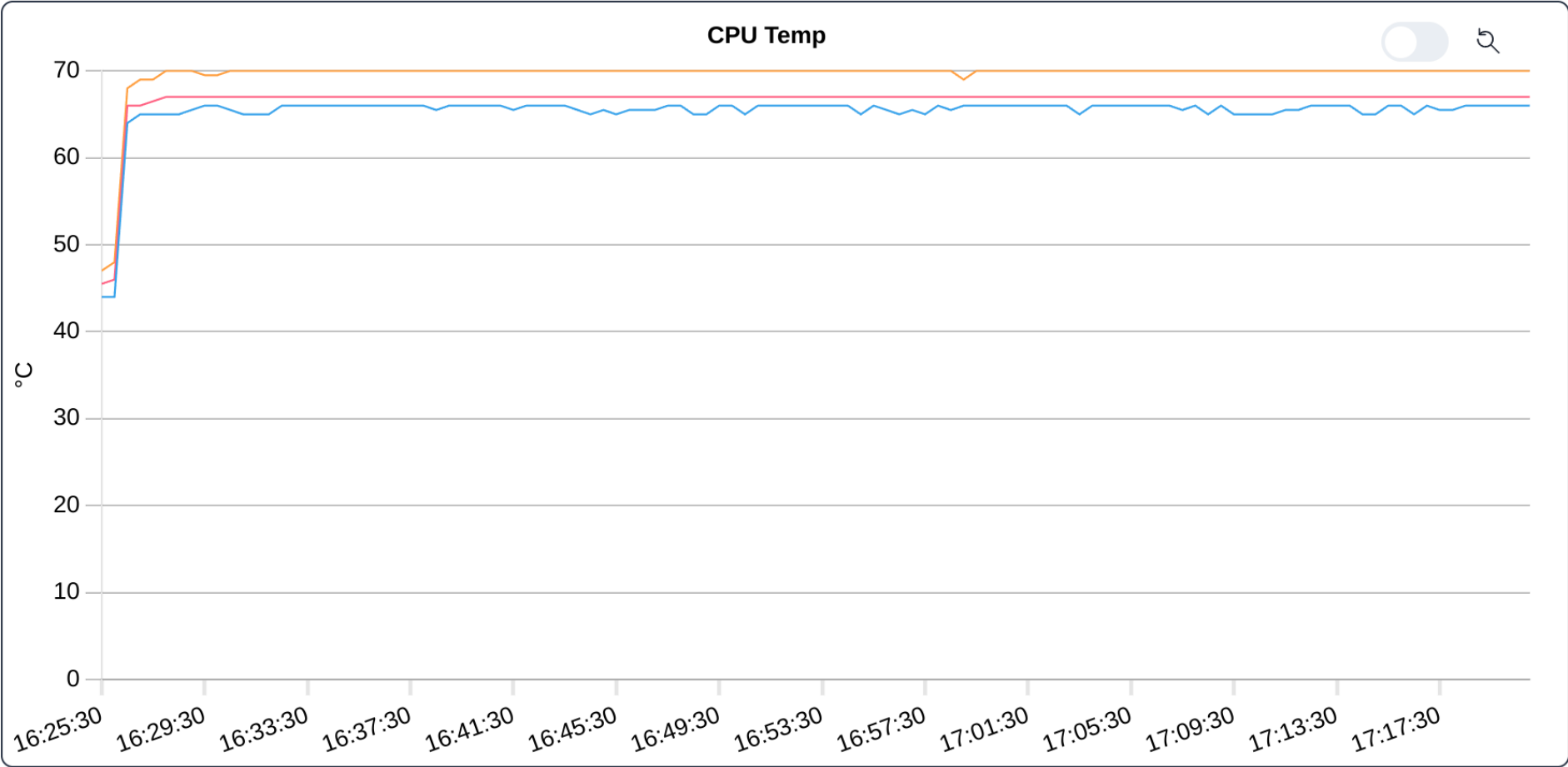
Quantile View

- Improve clarity when too many graphs are displayed in one diagram
- Only three graphs (25% / 50% / 75% Quantile = Quartiles) are drawn
- 25% Quantile $\Rightarrow$ 25% of the measured values are below this graph
- 50% Quantile $\Rightarrow$ Median
- Difference between upper and lower Quantile $\Rightarrow$ Measure for the spread of the metrics

Toggle: Quantile View Off - CPU Temperature



Toggle: Quantile View On - CPU Temperature

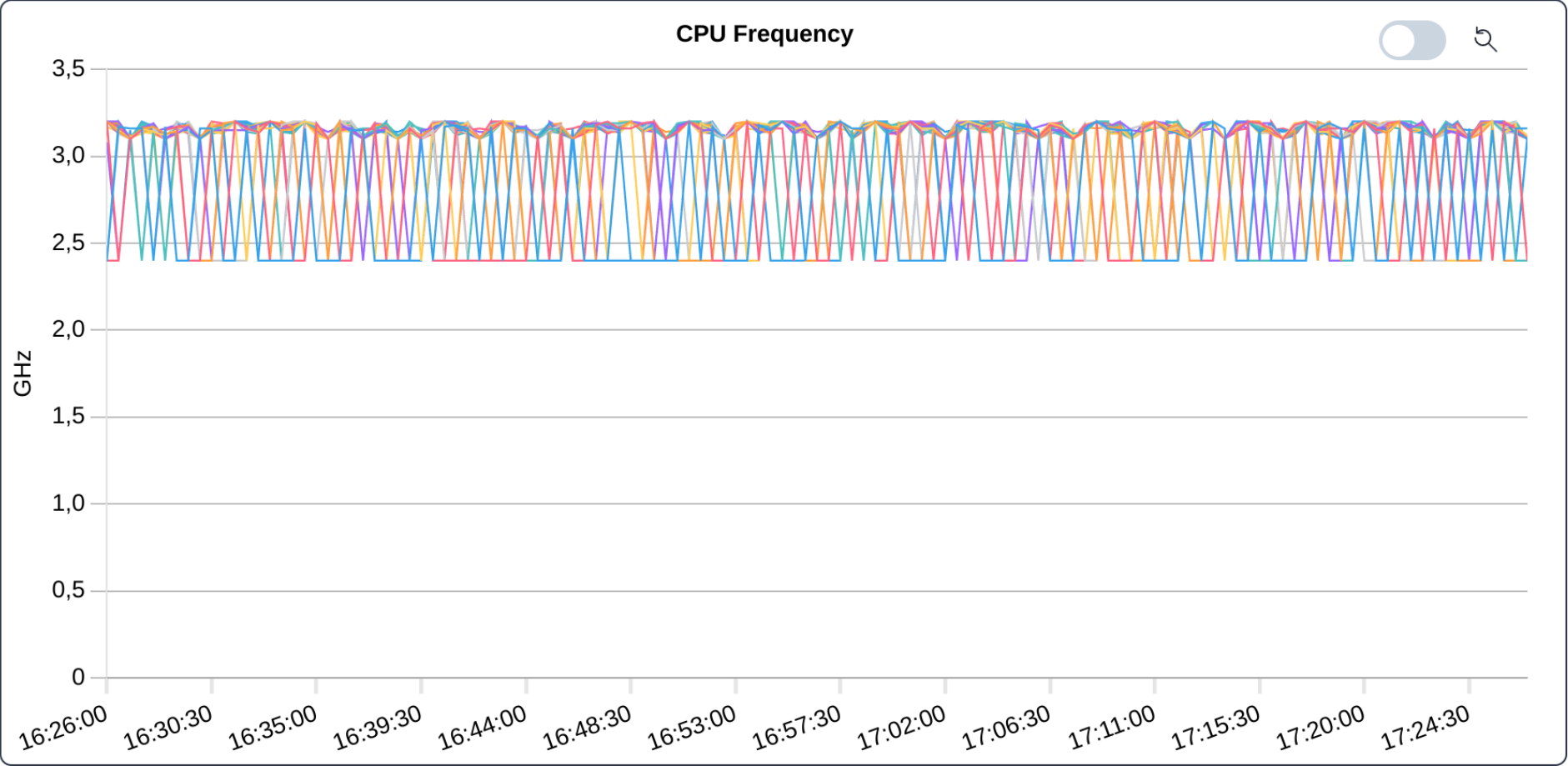


Quantile View - Insight

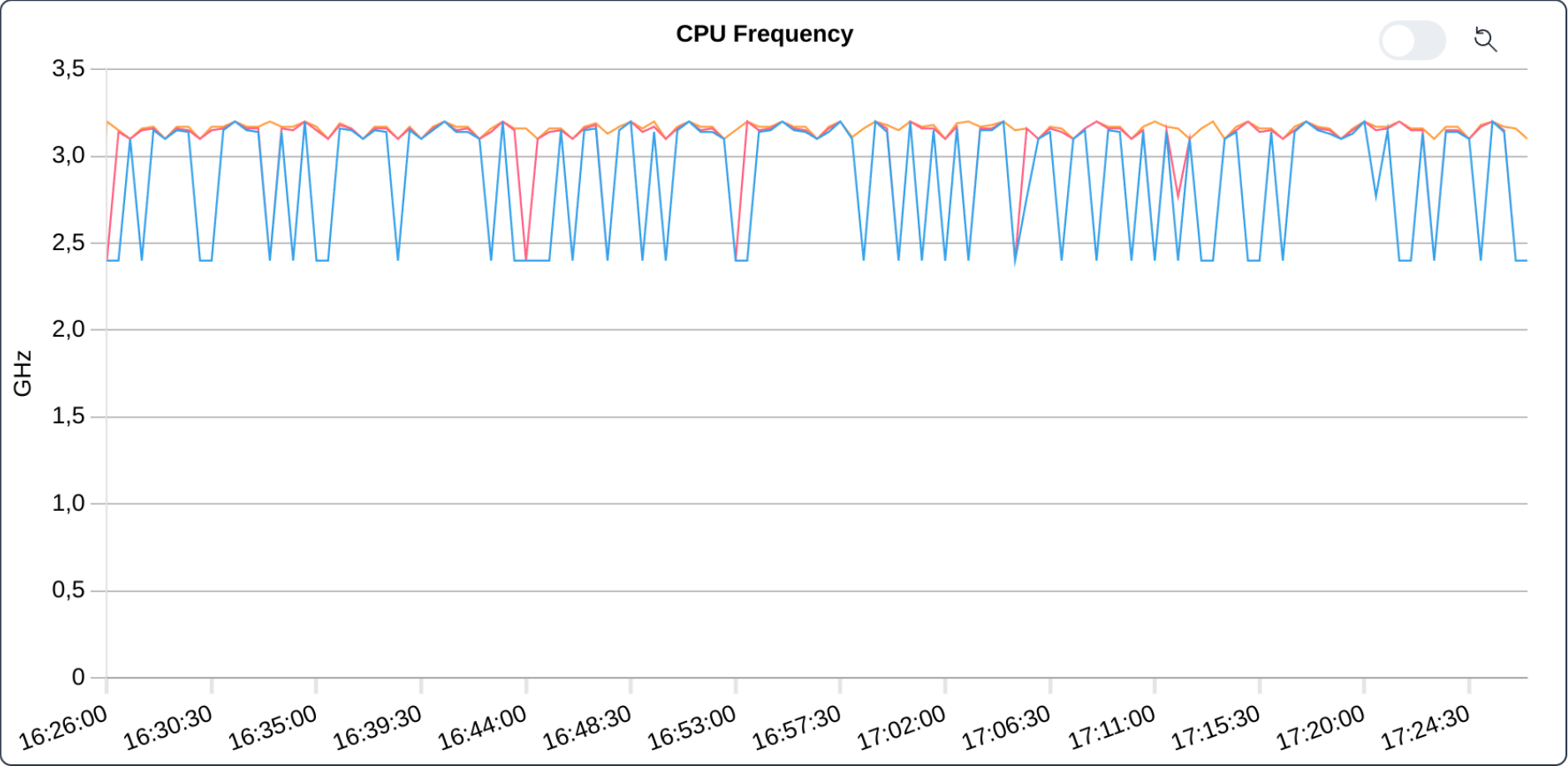
Insight

- CPU temperatures are collected per hardware thread
⇒ Diagram appears very cluttered
- Quantile View shows the distribution of the CPU temperatures much clearer

Toggle: Quantile View Off - CPU Frequency



Toggle: Quantile View On - CPU Frequency



Quantile View - CPU Frequency

Insight

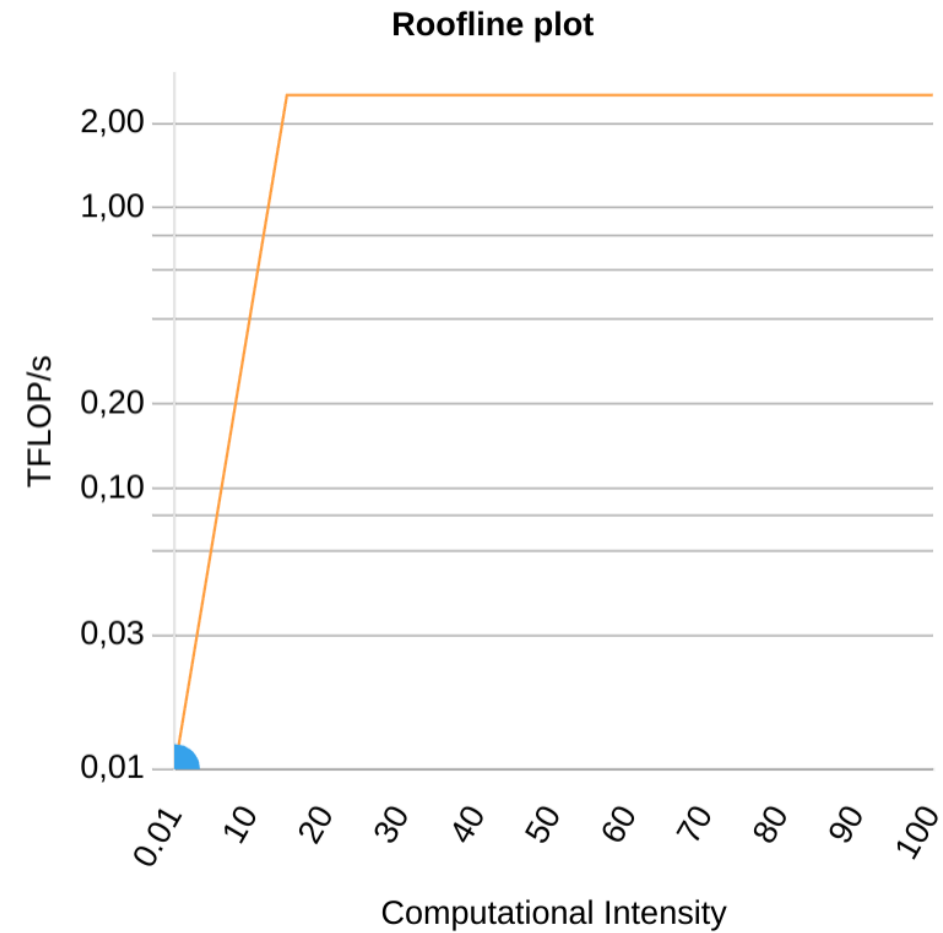
- CPU frequencies are collected per CPU core
⇒ Diagram appears very cluttered
- Quantile View shows the distribution of the CPU frequencies much clearer

Job page - Roofline Plot

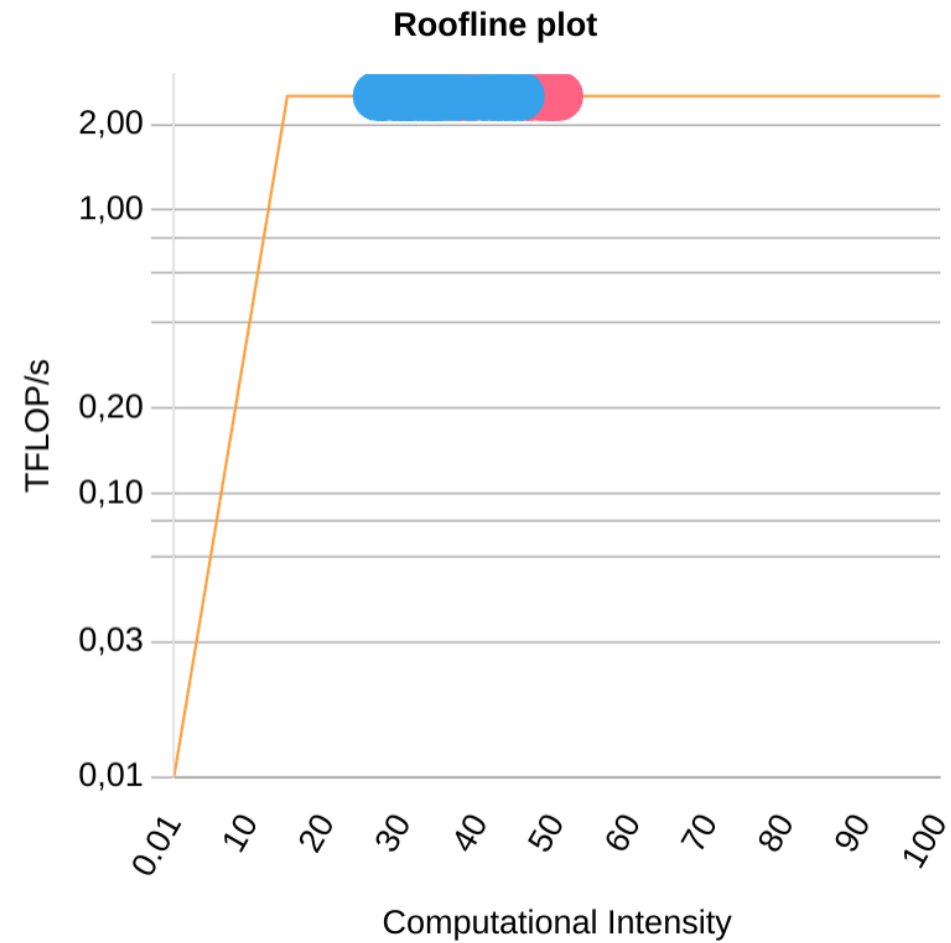
Roofline Plot

- Diagram with:
 - y-Axis: Floating point operations per second (FLOP/s)
 - x-Axis: Computational intensity (FLOP/s / byte)
- Roofline shows two performance limiting factors:
 - For *low* computational intensity: Memory bandwidth
 - For *high* computational intensity: Processor peak performance
- Plot point:
 - For each CPU package
 - For each measurement interval

Roofline Plot - Stream



Roofline Plot - DGEMM



Roofline Plot - Insight

Insight

- Stream (memory bound)
 - ⇒ Low computational intensity
 - ⇒ Limiting factor: Memory bandwidth
- DGEMM (compute bound)
 - ⇒ High computational intensity
 - ⇒ Limiting factor: Processor peak performance

Job page - Metric Categories

Categories

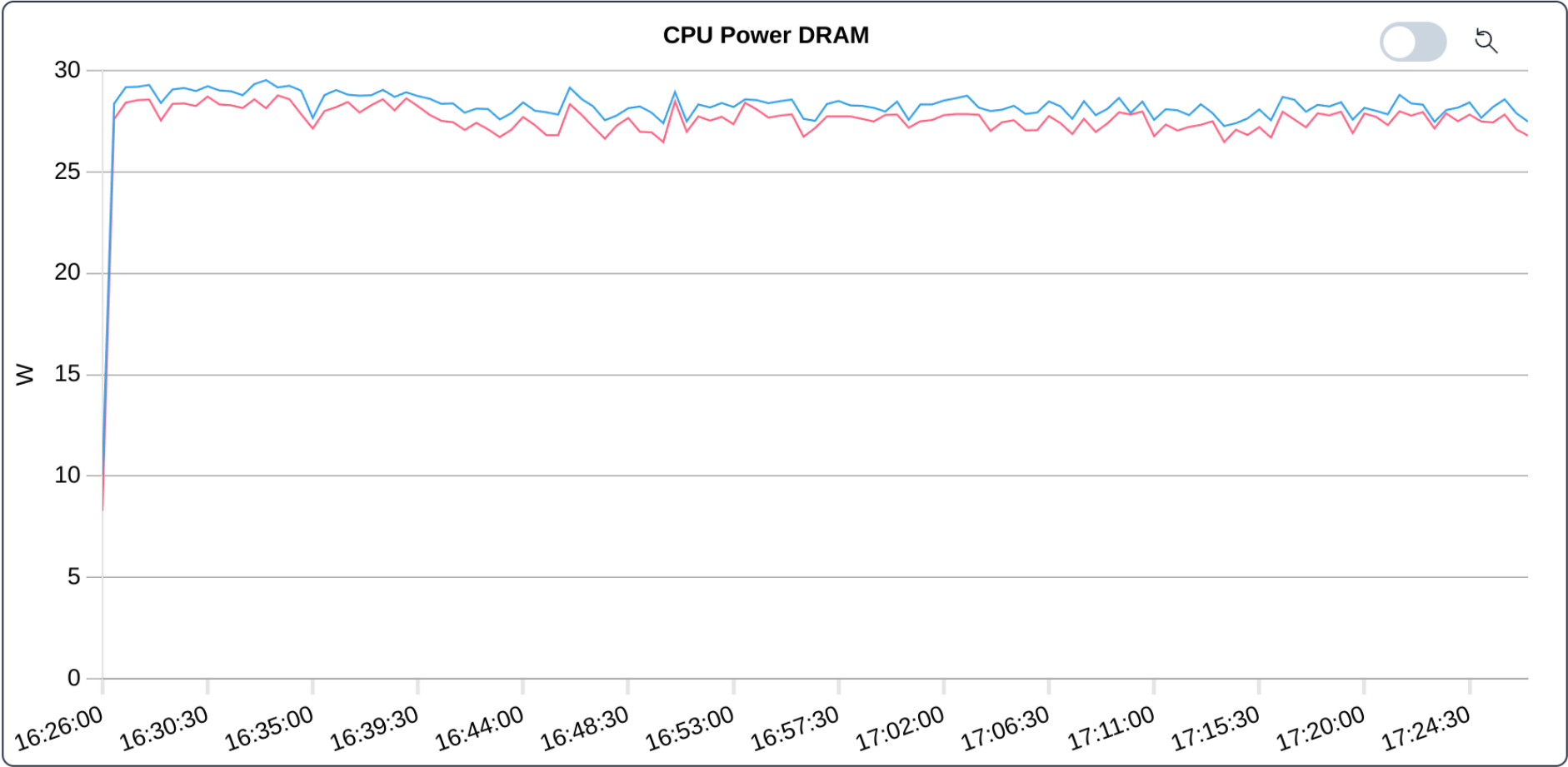
- Energy - CPU,GPU, Memory energy consumptions
- File system - IOPS, MetaOPS, Throughput
- Interconnect - Packets send(received), Traffic send(received)
- Memory - Memory usage, bandwidth
- Performance - Flops, IPC, Kernel Time, User Time.
- Temperature - CPU, GPU Temperature

Job page - Metrics Category Energy

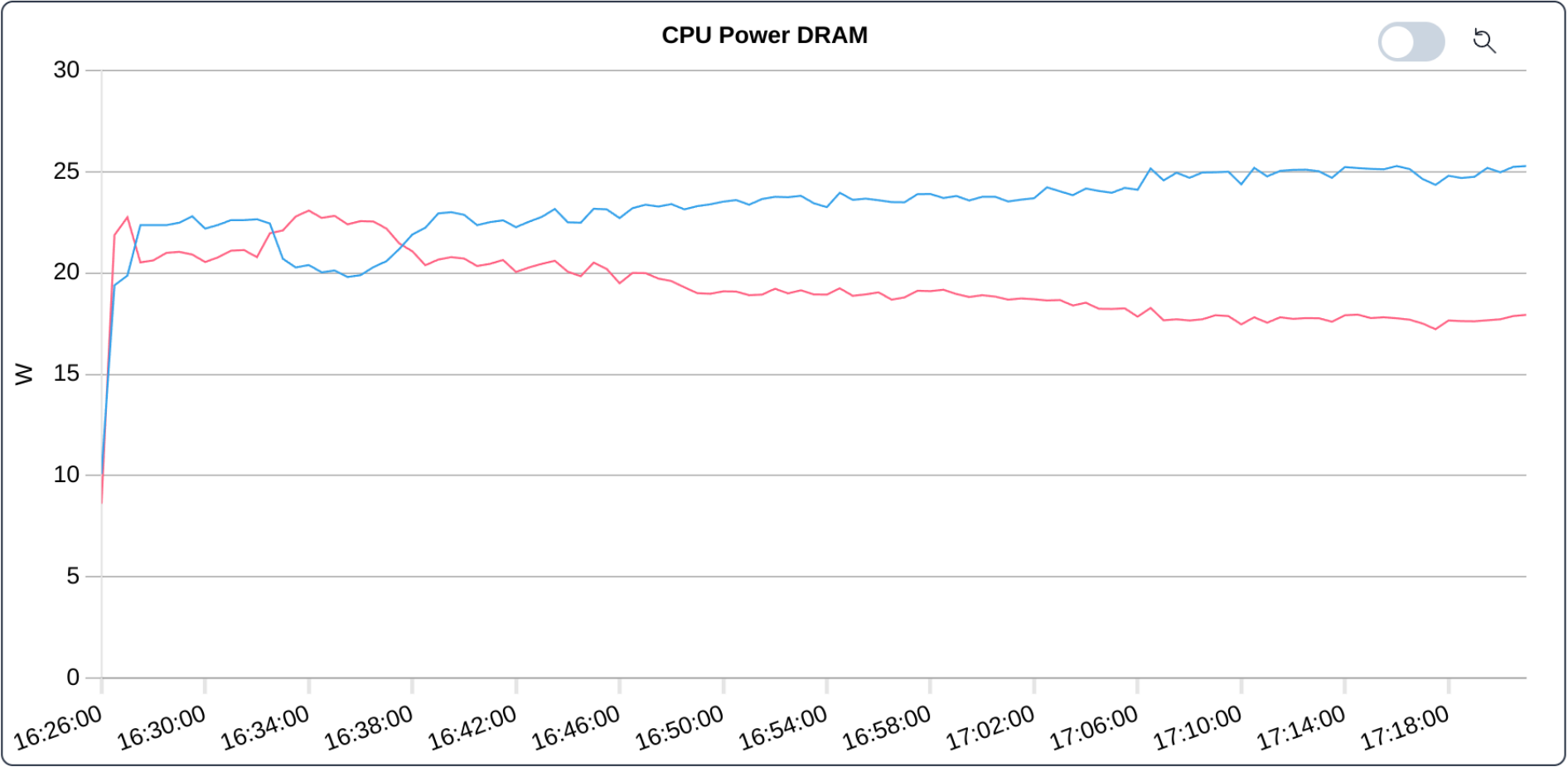
Metrics Category Energy

- CPU power consumption of DRAM channels and the package
- GPU power consumption
- Server system power consumption

Metrics Category Energy - Stream



Metrics Category Energy - DGEMM

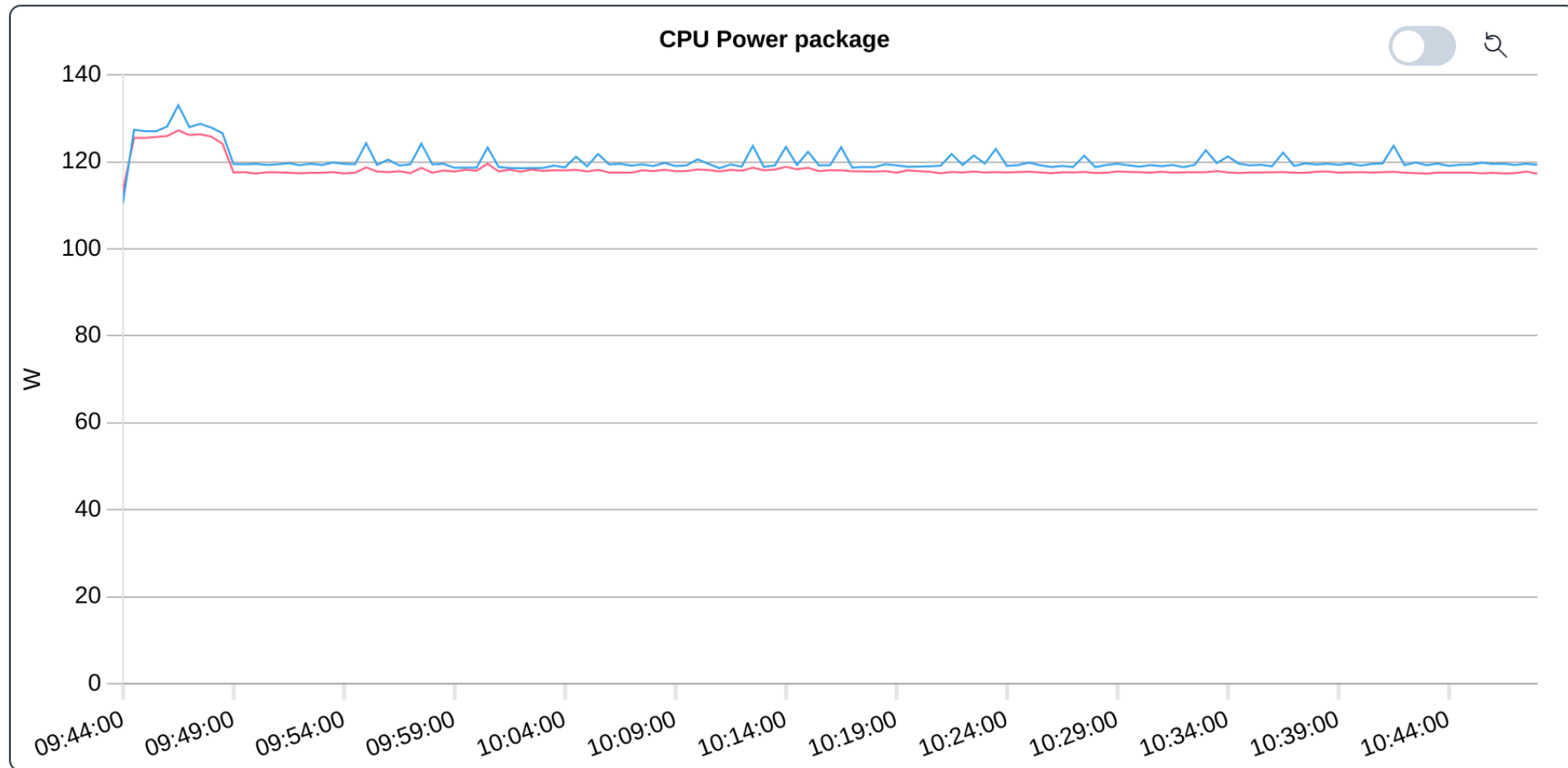


Metrics Category Energy - Insight

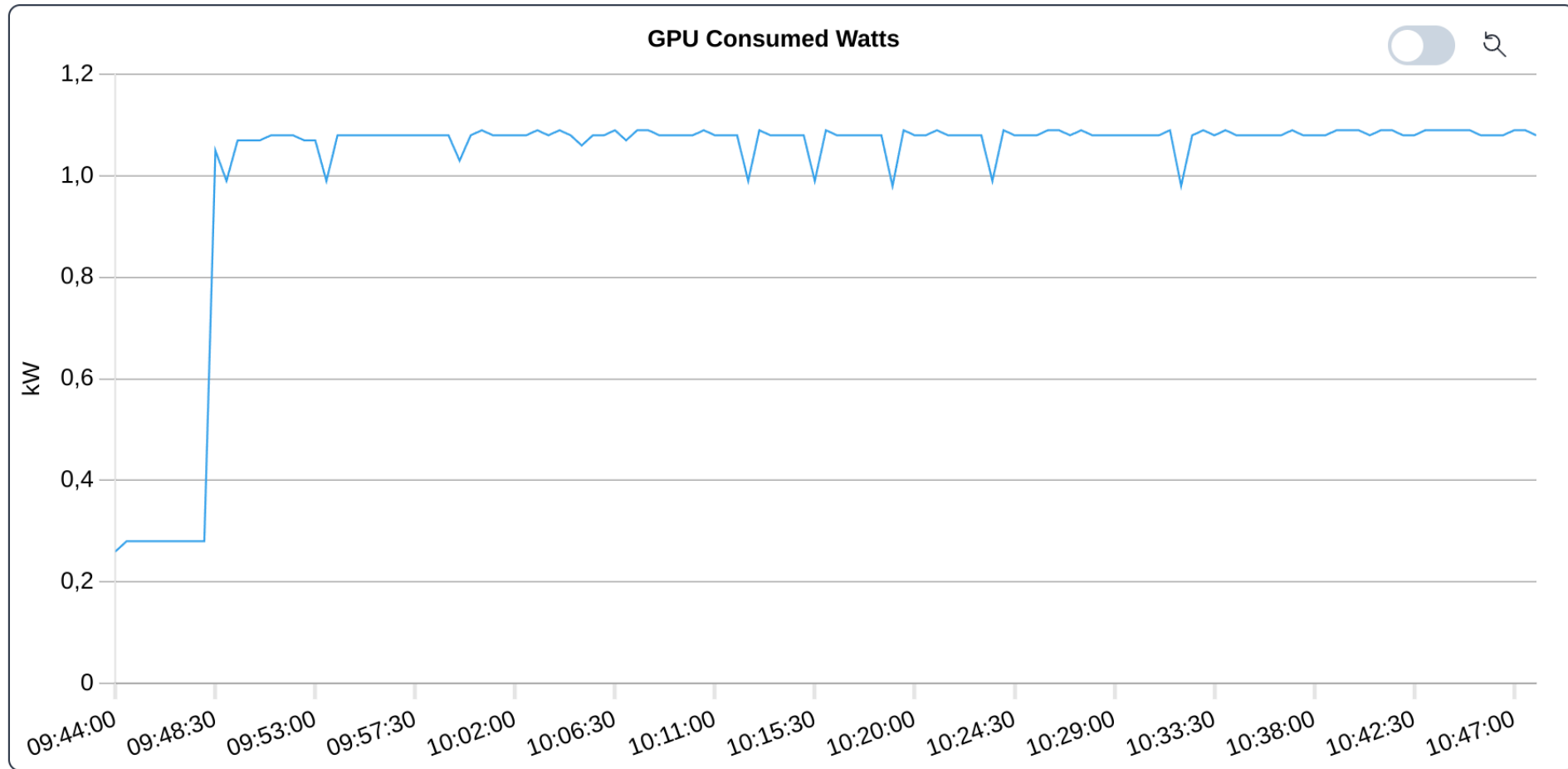
Insight

- Stream (memory bound)
 - ⇒ constantly high pressure on the DRAM subsystem
 - ⇒ Constantly high energy consumption
- DGEMM (compute bound)
 - ⇒ Less pressure on the DRAM subsystem
 - ⇒ Varying power consumption over time

Metrics Category Energy - HPCG



Metrics Category Energy - HPCG



Metrics Category Energy - Insight

Insight

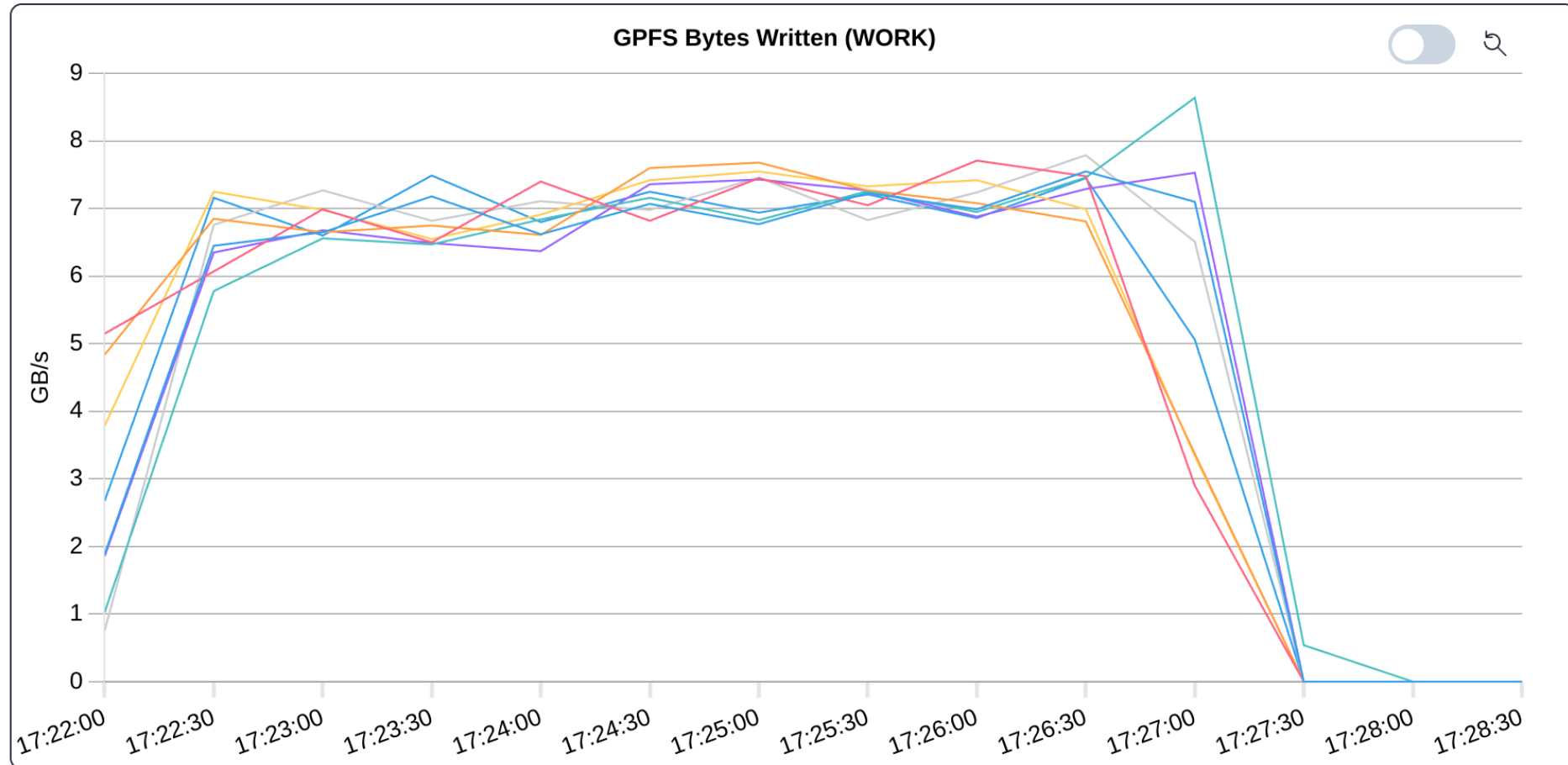
- GPU-HPCG benchmark
 - Preparation phase executed on the CPUs
 - Computation phase executed on the GPUs
- CPU package power consumption: Higher in preparation phase than in the compute phase
- GPU power consumption: Higher in compute phase than in preparation phase

Job page - Metrics Category Filesystem

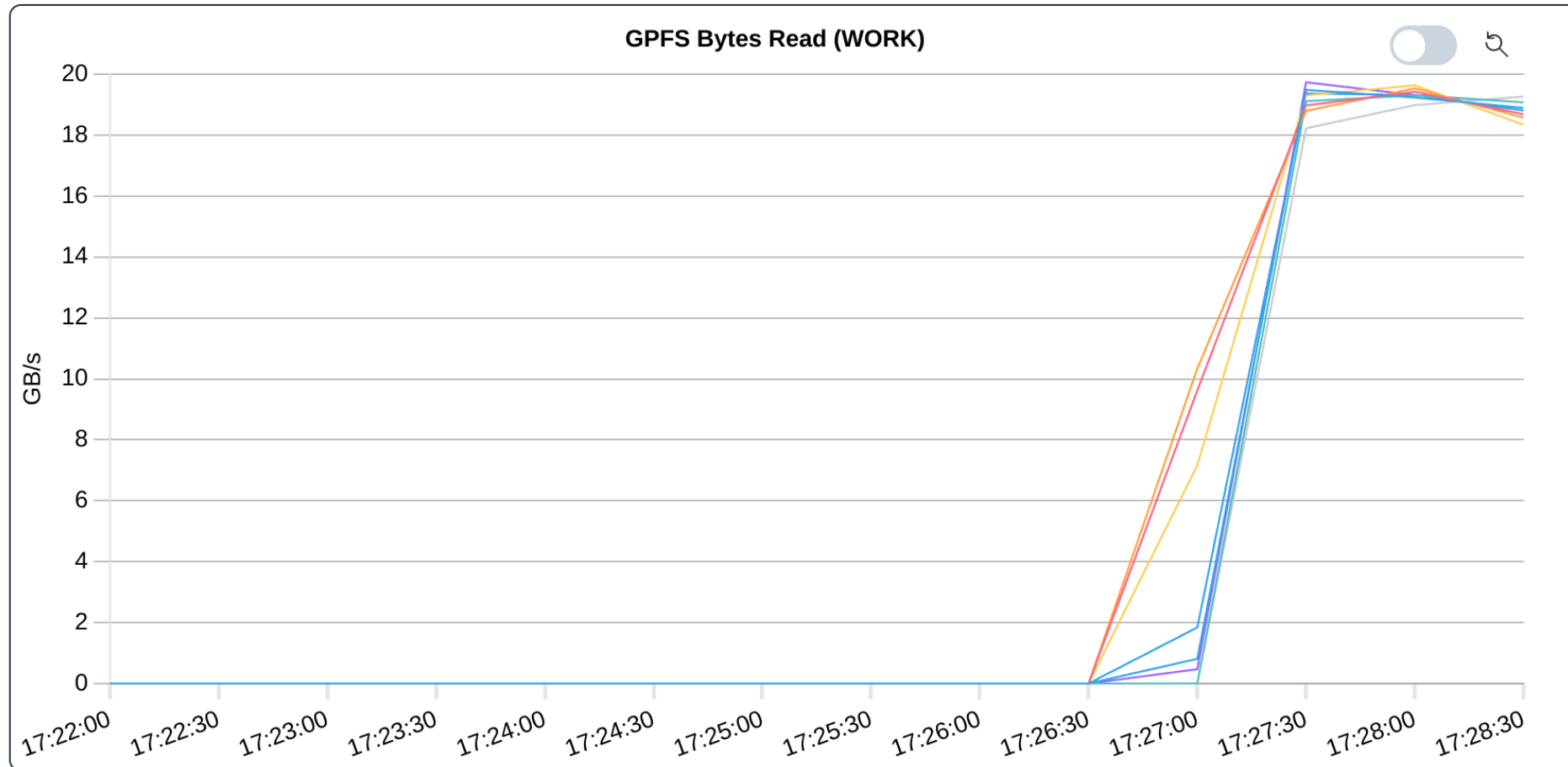
Metrics Category Filesystem

- IO operations
 - Number of reads/s
 - Number of writes/s
- Meta data operation
 - Number of file open / closes
 - Number of directory reads
 - Number of inode updates
 - ...
- IO throughput
 - Bytes read / written
 - Number of read / writes

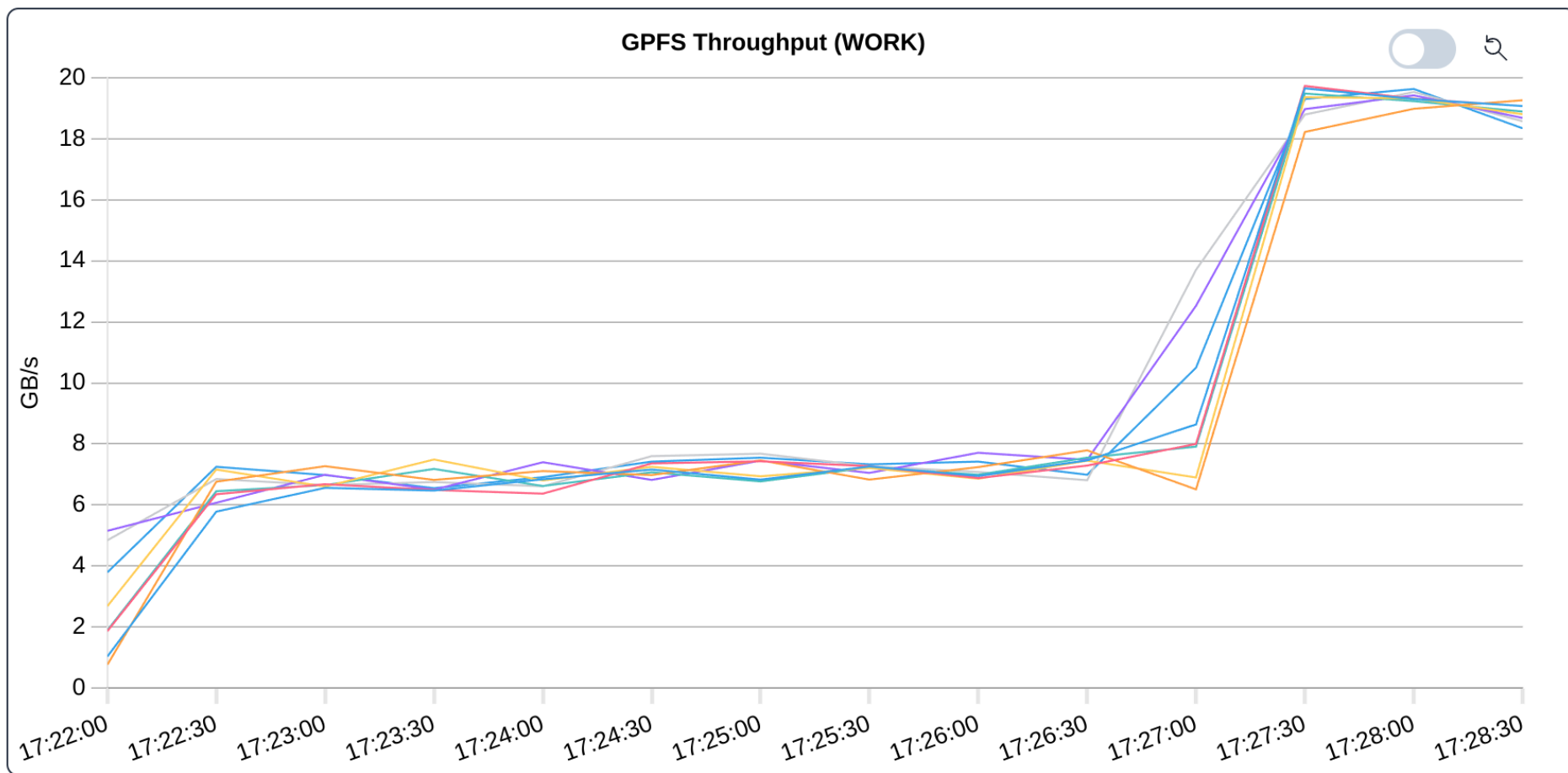
Metrics Category Filesystem - IOR



Metrics Category Filesystem - IOR



Metrics Category Filesystem - IOR



Metrics Category Filesystem - Insight

Insight

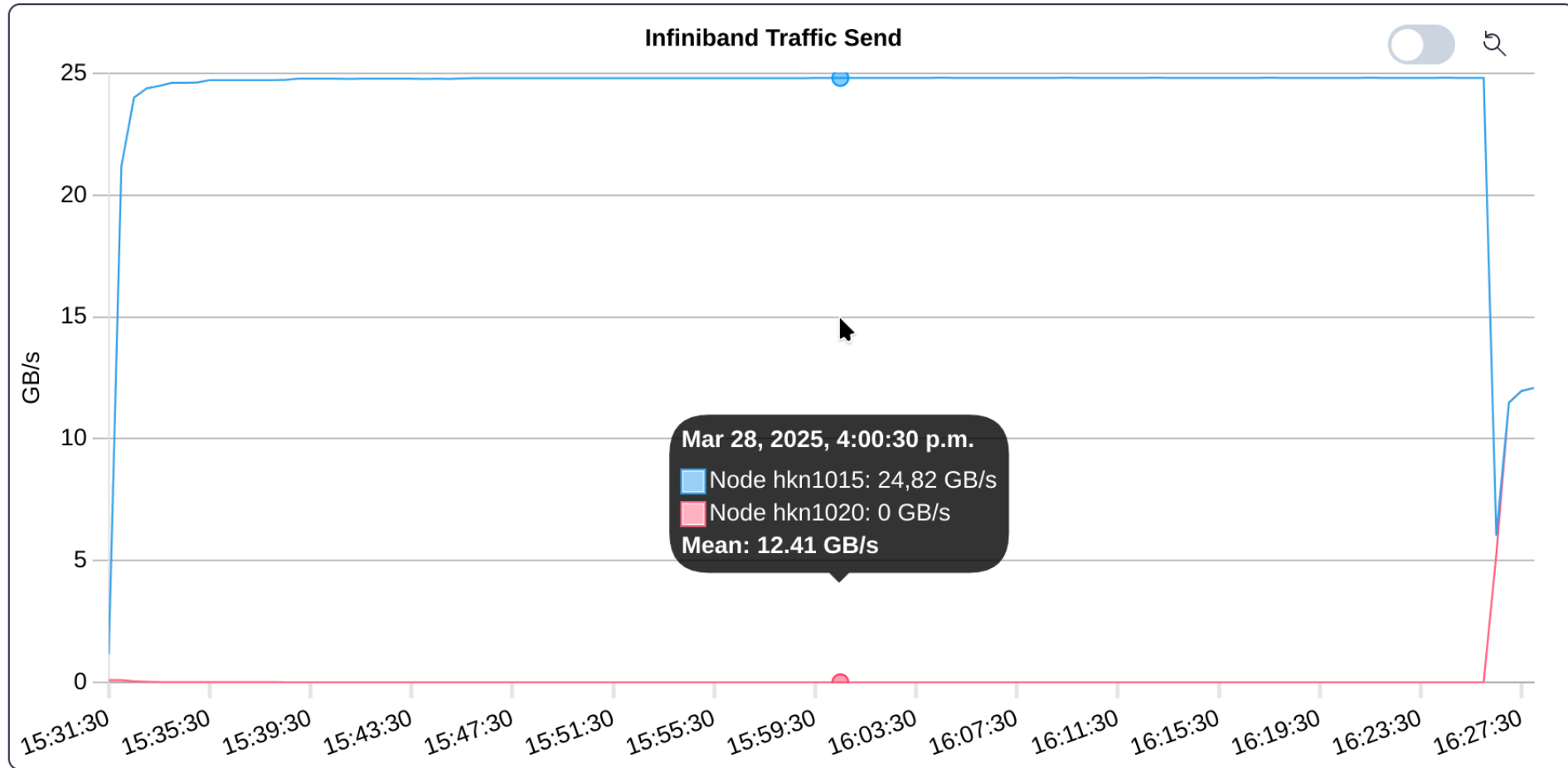
- Parallel IO: Performed from multiple nodes
- Two phases:
 - Phase 1: Files are written
 - Phase 2: Files are read
- Read throughput is higher than write throughput

Job page - Metrics Category Interconnect

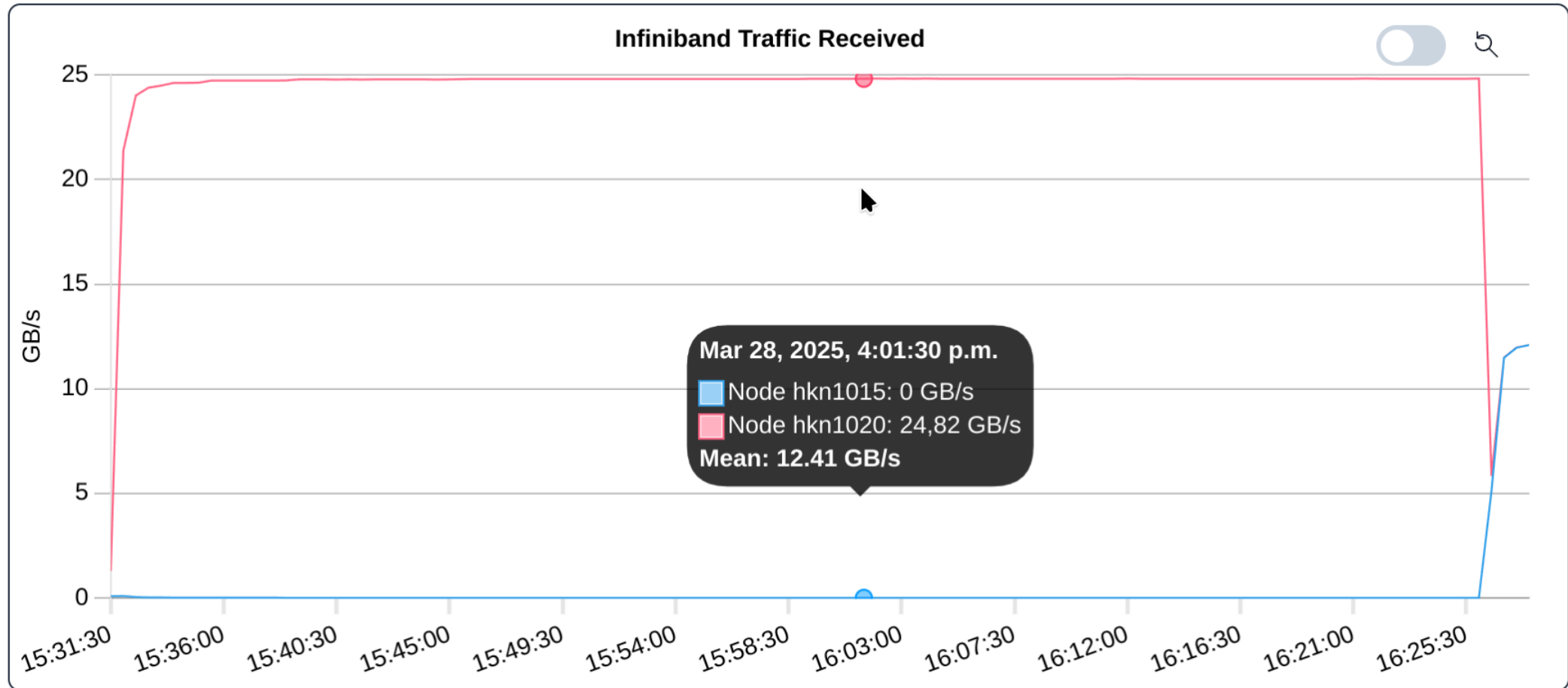
Metrics Category Interconnect

- InfiniBand bandwidth
 - Sent
 - Received
 - Aggregated sent and received
- InfiniBand number of packages
 - Sent
 - Received
 - Aggregated sent and received

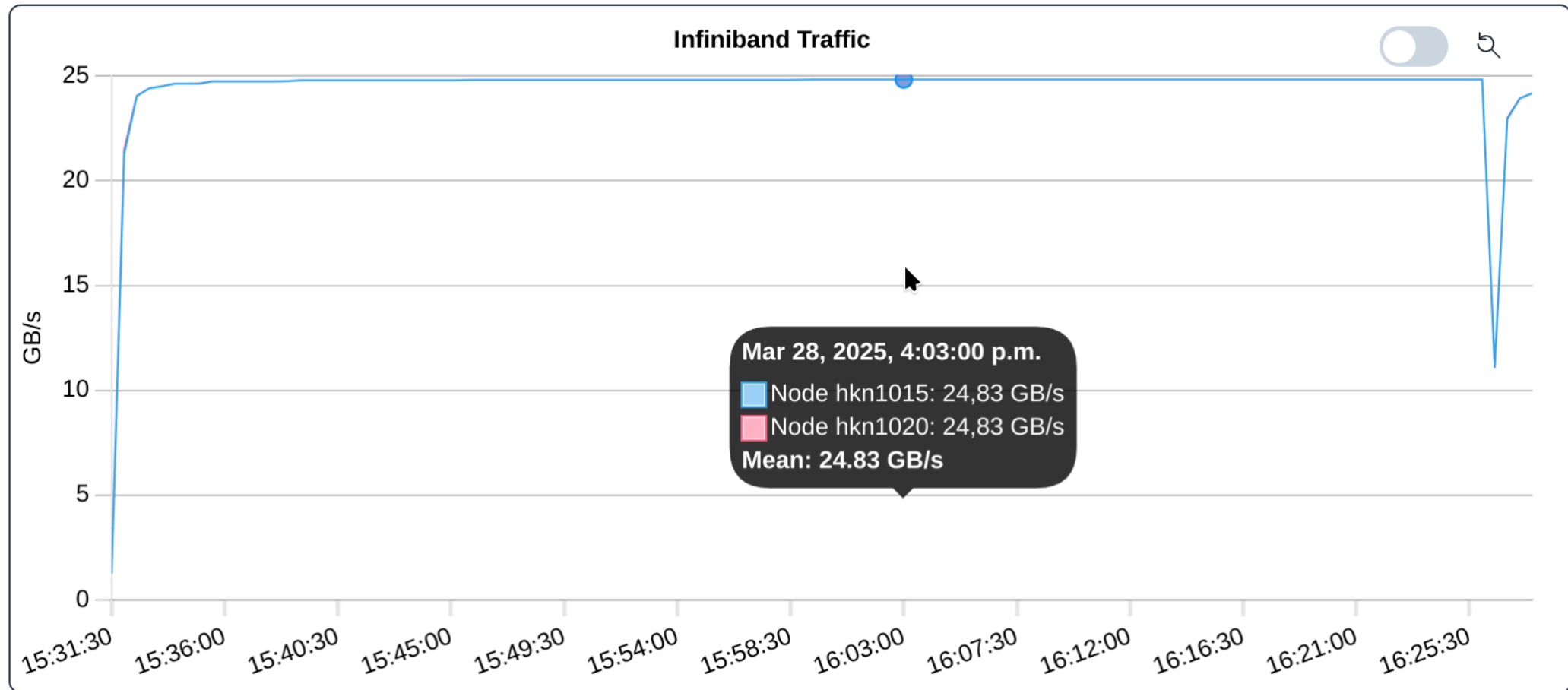
Metrics Category Interconnect - OMB



Metrics Category Interconnect - OMB



Metrics Category Interconnect - OMB



Metrics Category Interconnect - Insight

Insight

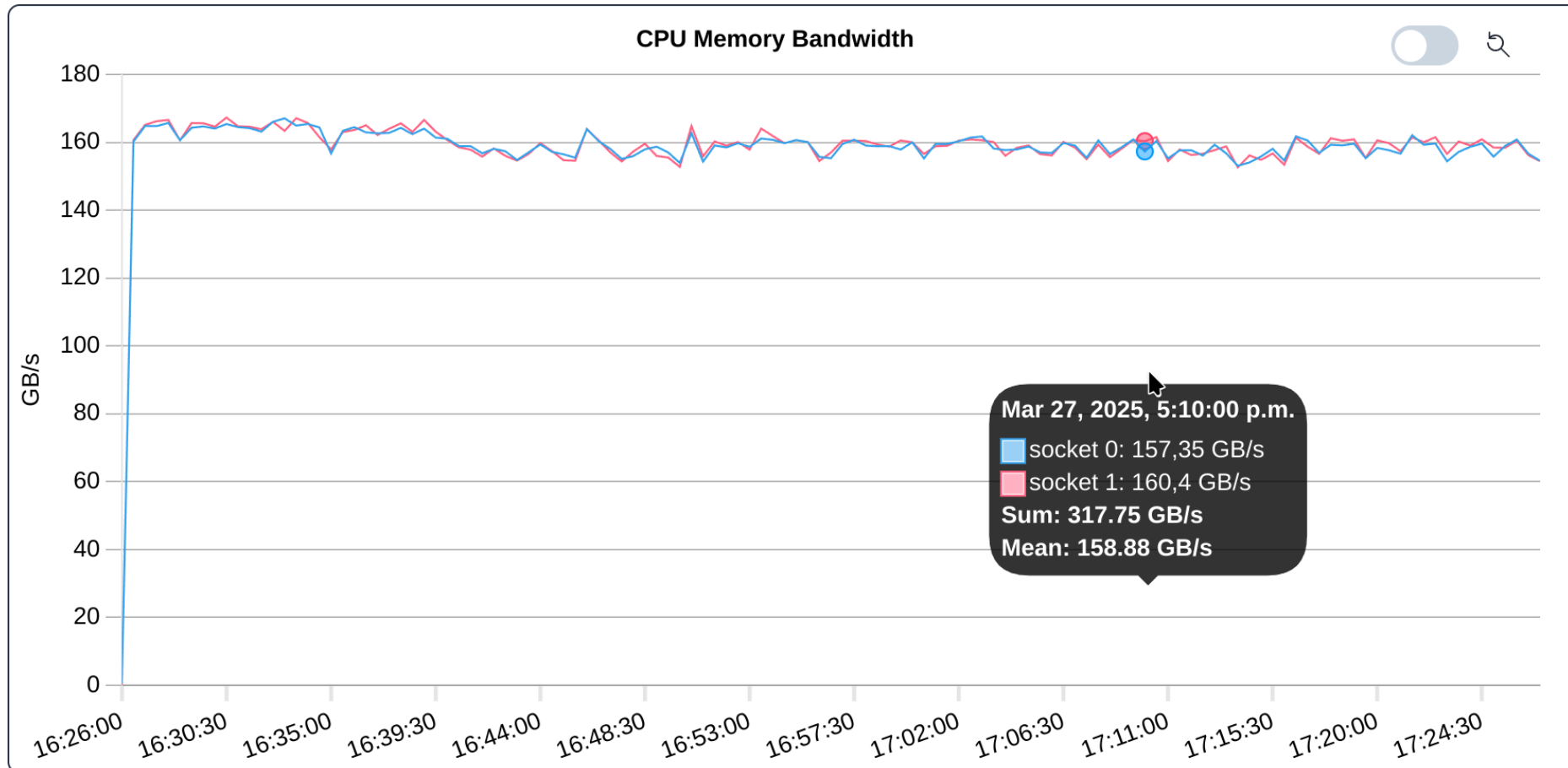
- OSU Micro-Benchmark performs MPI point to point communication:
 - Node hkn1015 only sends data (receive bandwidth is zero)
 - Node hkn1020 only receives data (send bandwidth is zero)

Job page - Metrics Category Memory

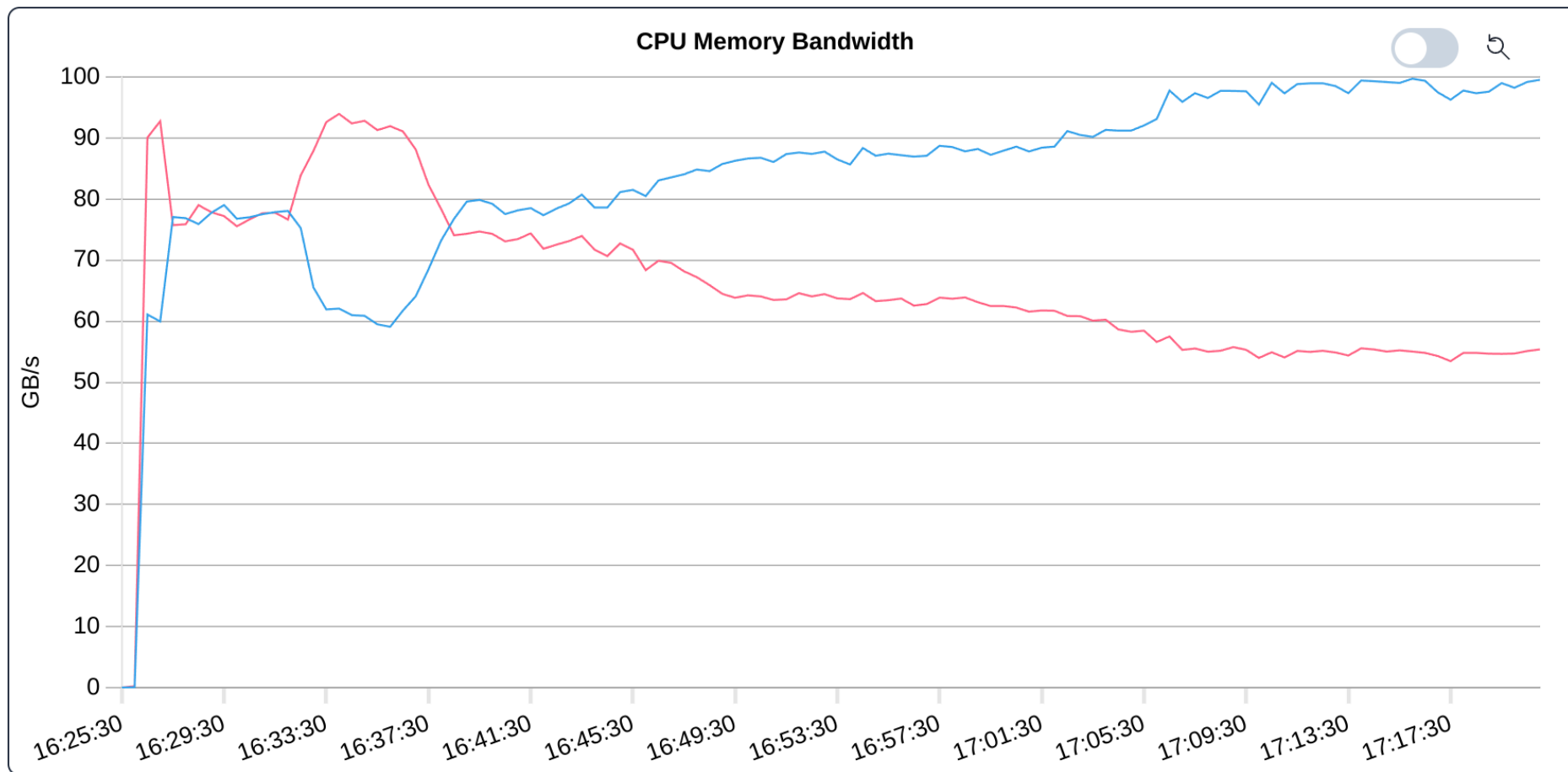
Metrics Category Memory

- Amount of memory used
 - On the system
 - On the GPU
- CPU memory bandwidth
- GPU memory
 - Utilization (in %)
 - Frequency

Metrics Category Memory - Stream



Metrics Category Memory - DGEMM

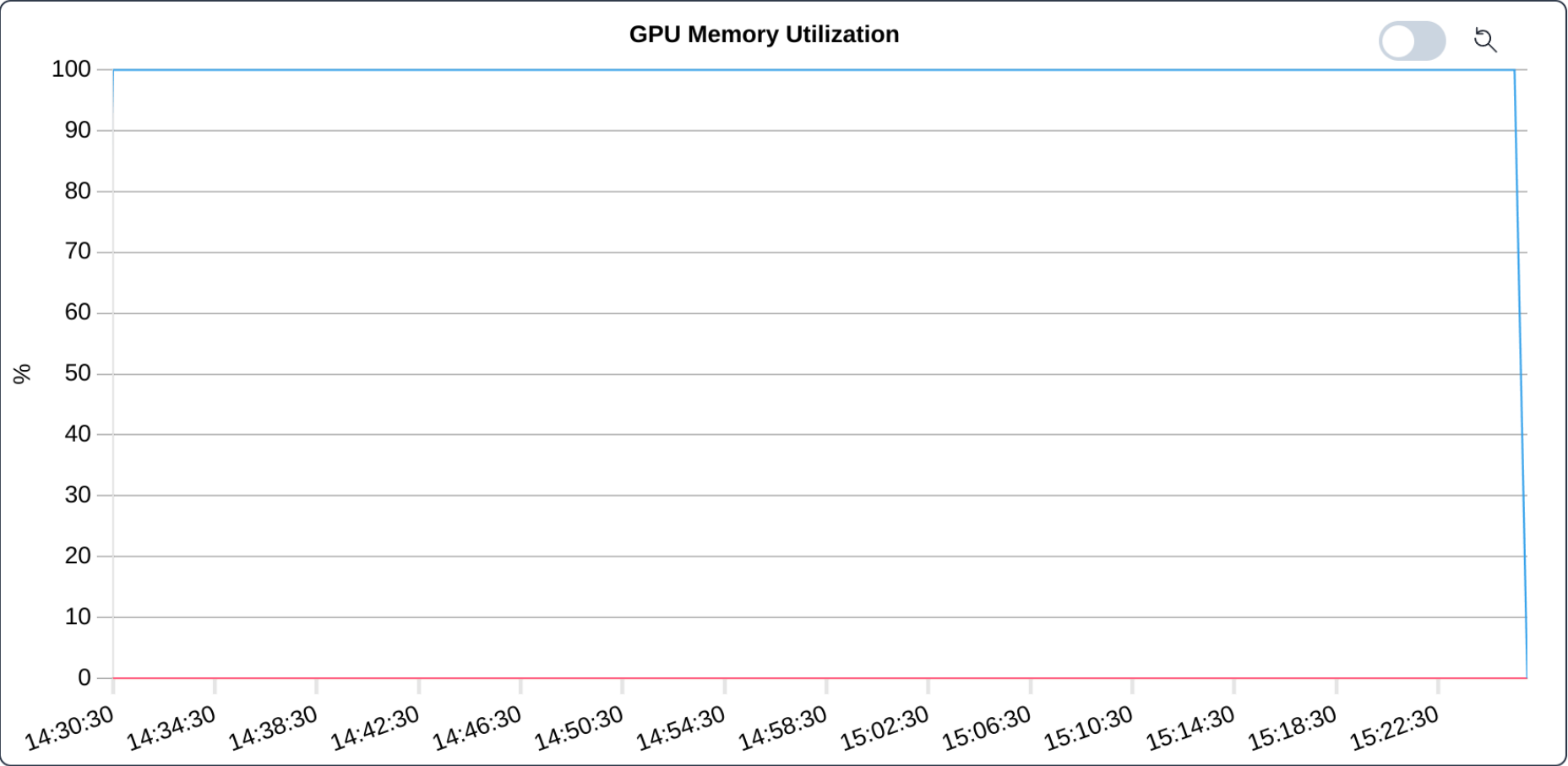


Metrics Category Memory - Insight

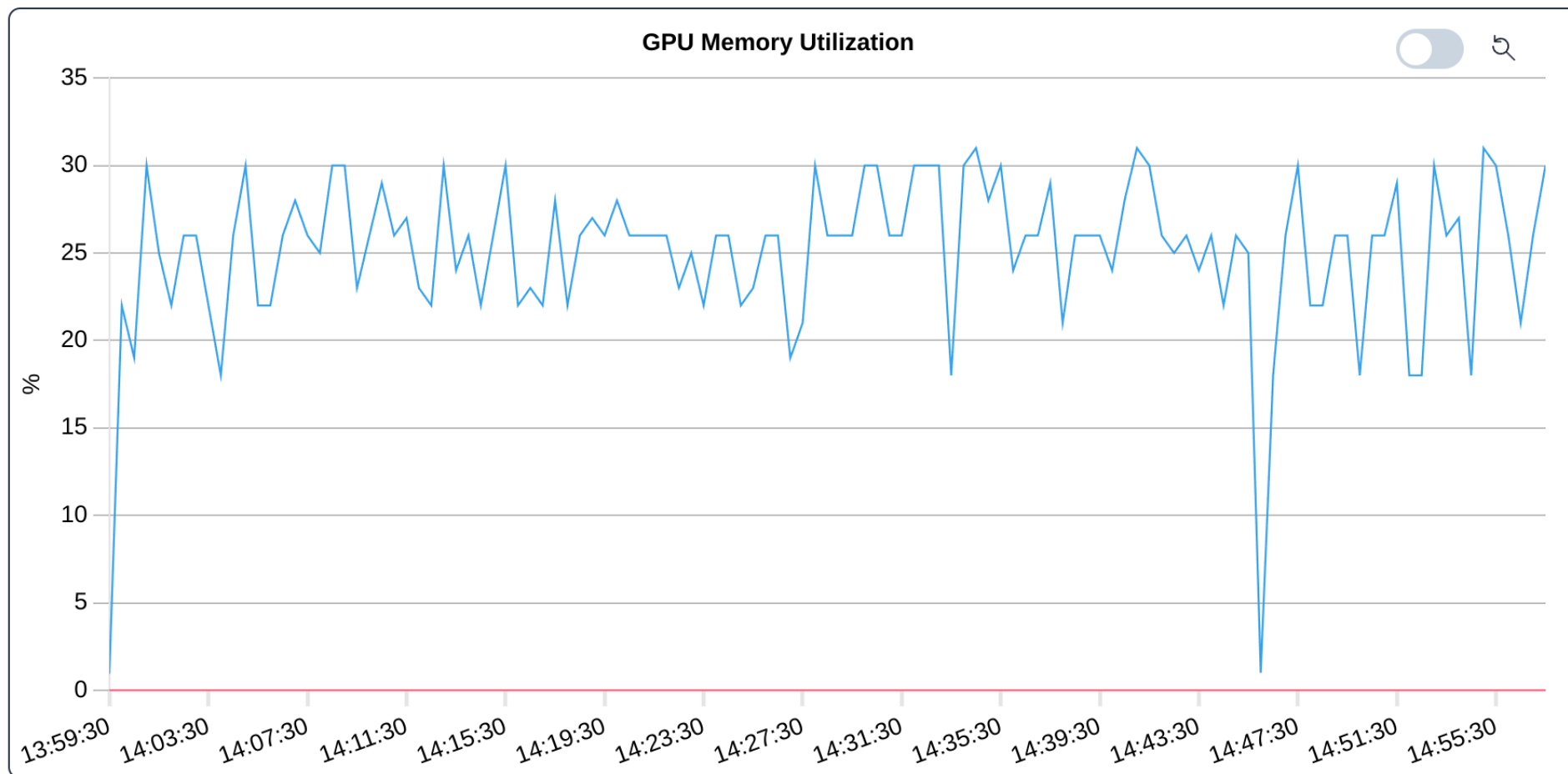
Insight

- Stream (memory bound):
 - ⇒ Constantly high pressure on the memory subsystem
- DGEMM (compute bound):
 - ⇒ Less pressure on the memory subsystem
 - ⇒ Varying bandwidth over time

Metrics Category Memory - BabelStream



Metrics Category Memory - DGEMM



Metrics Category Memory - Insight

Insight

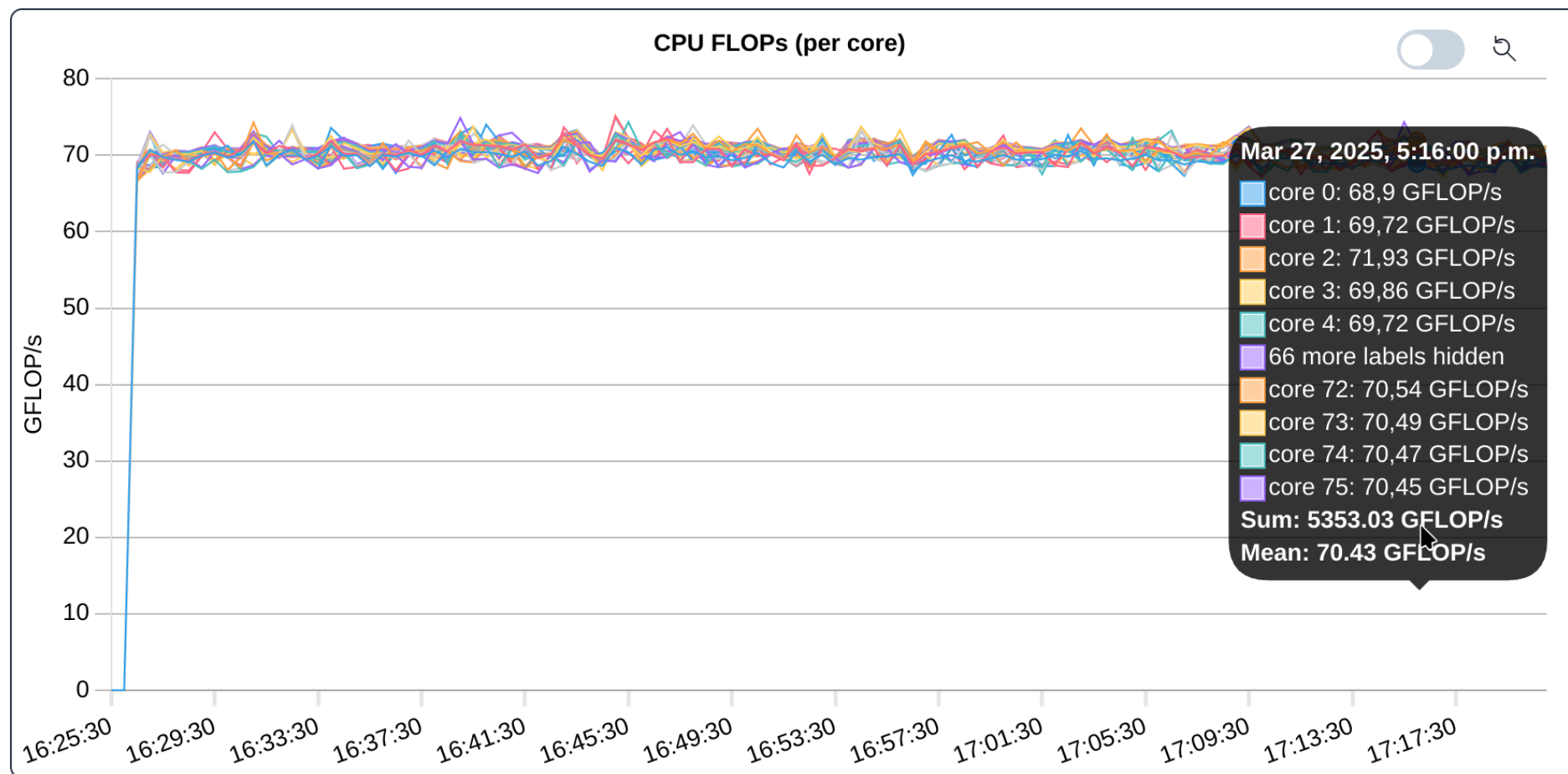
- BabelStream (memory bound):
 - ⇒ Fully utilizes the memory subsystem of the GPU
- GPU-DGEMM (compute bound):
 - ⇒ Less pressure on the GPU memory subsystem
 - ⇒ Varying utilization over time.

Job page - Metrics Category Performance

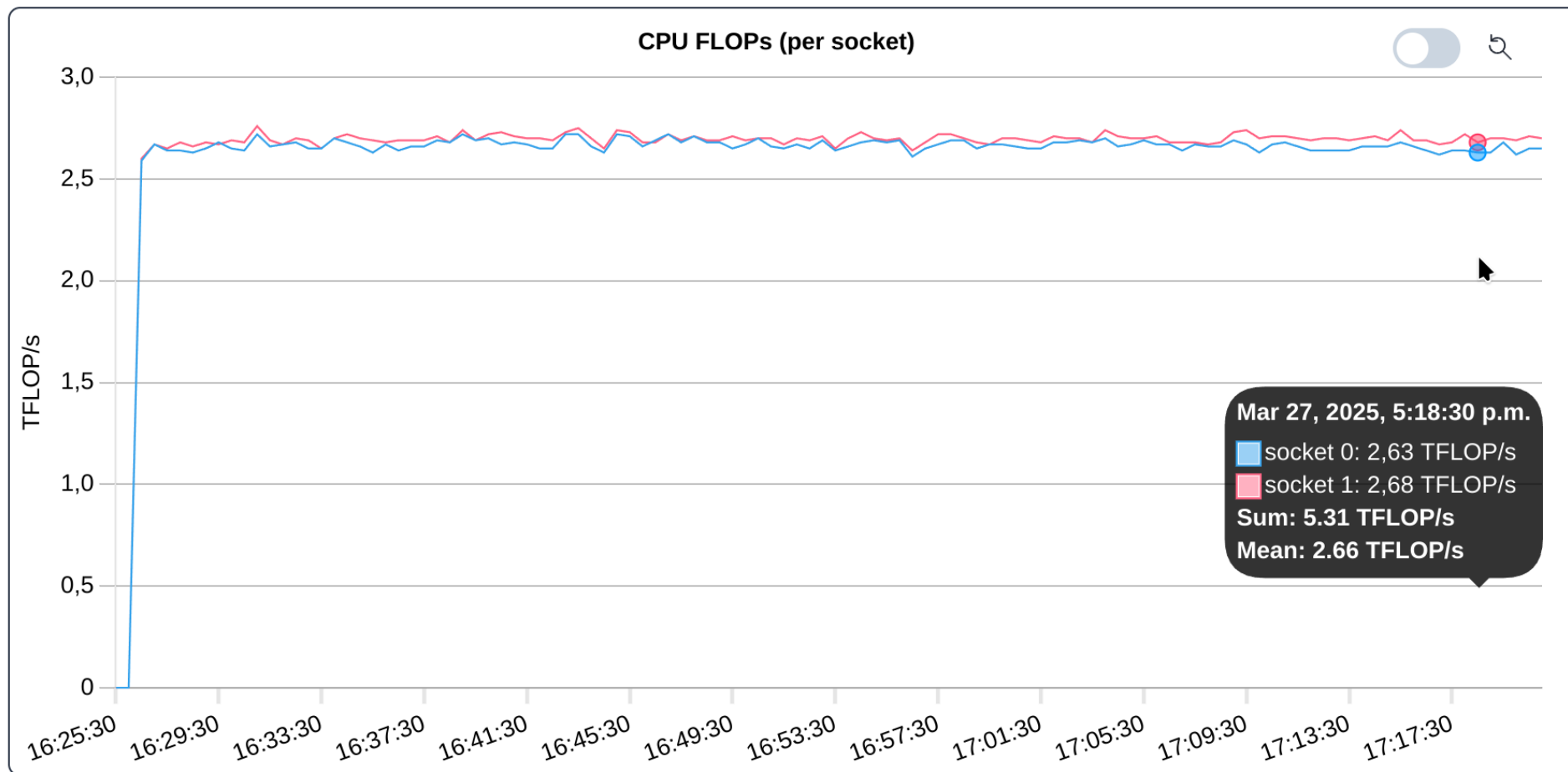
Metrics Category Performance

- Floating point operation per second (FLOP/s),
collected per *hardware thread*,
aggregated per *core* or per *socket*
- Instructions per cycle (IPC),
collected per *hardware thread*,
aggregated per *core* or per *socket*
- CPU time spend in kernel and in user space
- One minute Linux load average
- GPU utilization
- CPU and GPU frequency

Metrics Category Performance - DGEMM



Metrics Category Performance - DGEMM



Metrics Category Performance - Insight

Insight

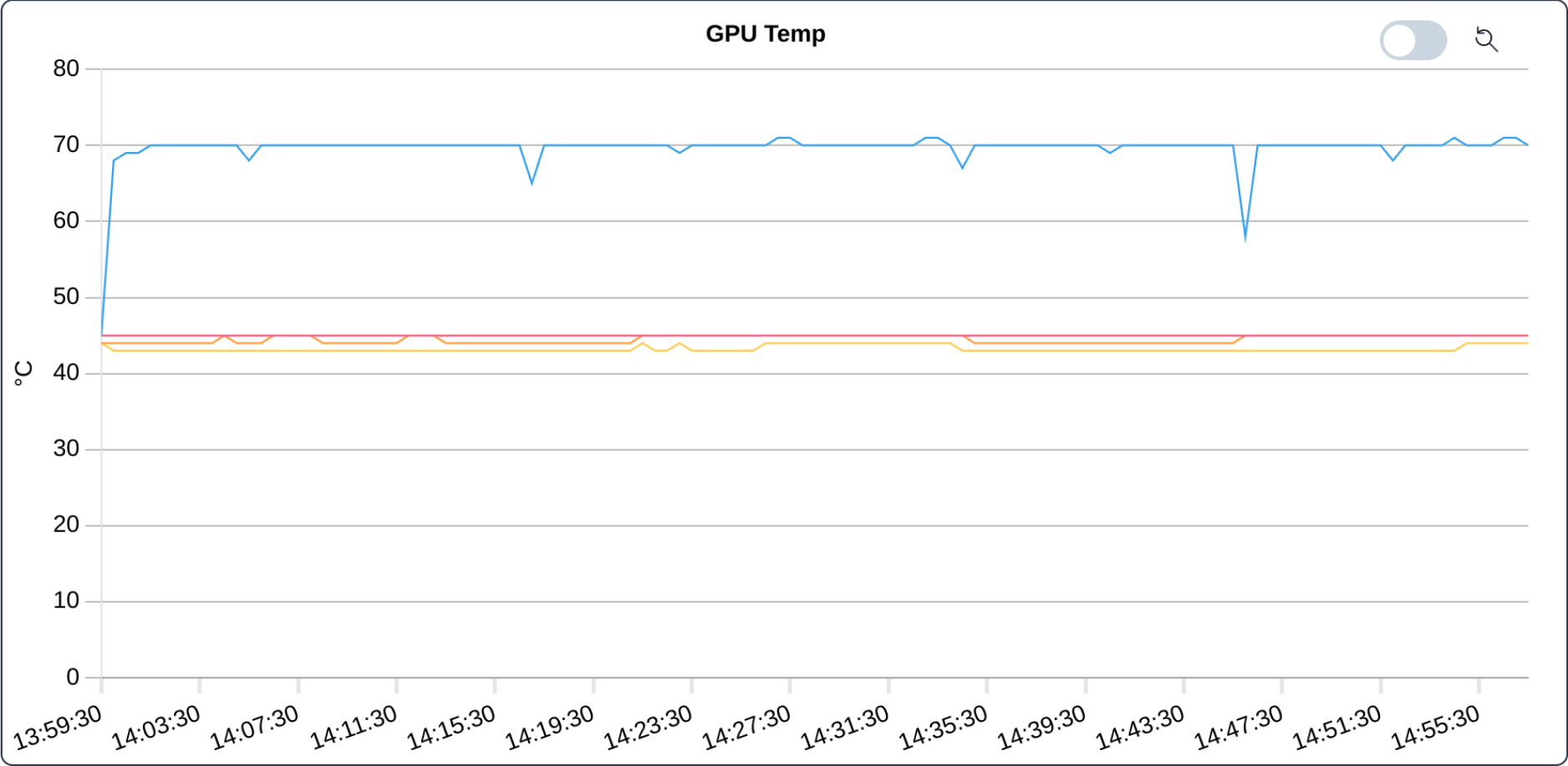
- Floating point operation per second (FLOP/s) are collected per hardware thread
- Examine even utilization of cores
 - ⇒ Aggregate per core
- Examine even utilization of CPU sockets
 - ⇒ Aggregate per socket
- Summed FLOP/s is the same in both diagrams

Job page - Metrics Category Temperature

Metrics Category Temperature

- CPU
- GPU

Metrics Category Temperature - DGEMM

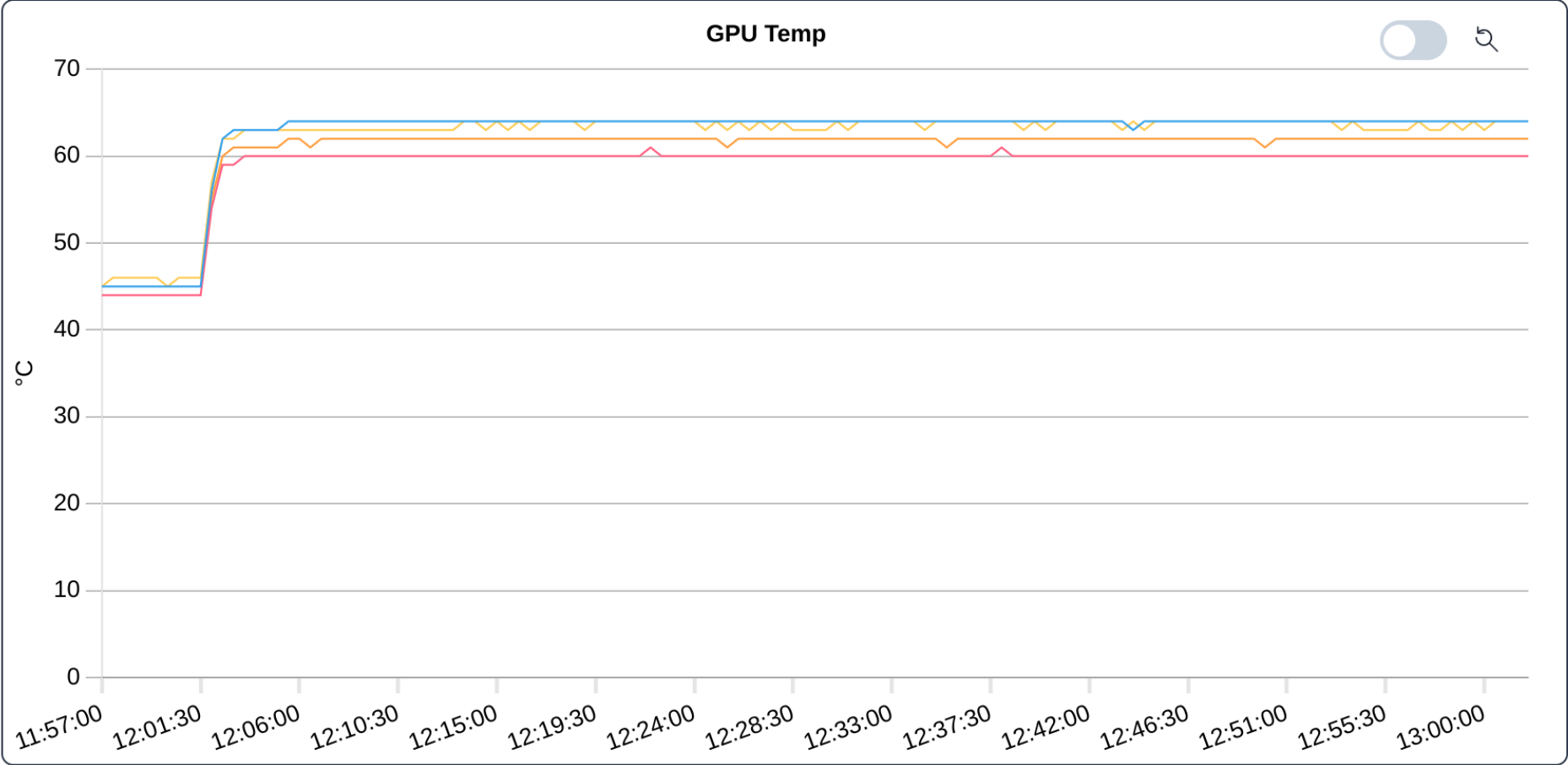


Metrics Category Temperature - Insight

Insight

- GPU-DGEMM only utilizes one GPU
- Only this GPU gets hot
- Other GPUs maintain lower temperatures

Metrics Category Temperature - HPCG



Metrics Category Temperature - Insight

Insight

■ GPU-HPCG

- Preparation phase executed on the CPUs
 - ⇒ GPUs not utilized
 - ⇒ Low temperature
- Computation phase executed on the GPUs
 - ⇒ Higher temperature

Job page - Additional Features

Additional Features

- For multi-node jobs there is a configuration option to select the per-node aggregation function used (e.g. average, sum, maximum)
- Live view of running jobs
- Download CSV file
 - All metrics
 - Use in spread sheet application or Python
- Outlook
 - Availability for Cluster uc3
 - Automatic job analyzer
 - ⇒ Assign tags for detected characteristics