Introduction to ROC-Profiler (`rocprof`)

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LUMI Advanced Training
Nov 12th, 2026

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AMD ROCm Developer Tools Portfolio

Profiler and debugger toolchain for AMD GPUs

Cluster ⟷ Instruction

ROCm Optiq
Interactive Visualization and Analysis

ROCprof Compute Viewer
Visualizer for Advanced Thread Traces (ATT)

Omnistat

Low-overhead cluster-wide GPU telemetry

GPU and HBM utilization, power, thermals

ROCm Systems Profiler

System-wide profiler

CPU + GPU + MPI + OS

ROCm Compute Profiler

Deep per-kernel hardware analysis

roofline, memory & SOL

rocprofv3

Lightweight command-line profiling tool

PC sampling, ATT, SPM

ROCgdb

Source-level CPU + GPU debugging in one session

breakpoints, backtrace, thread/lane switching, state inspection

ROCprofiler-SDK

- API Tracing
- Parallelism API Integration
- Counter Collection
- Advanced Thread Trace
- PC Sampling
- SPM (Streaming Performance Monitor)

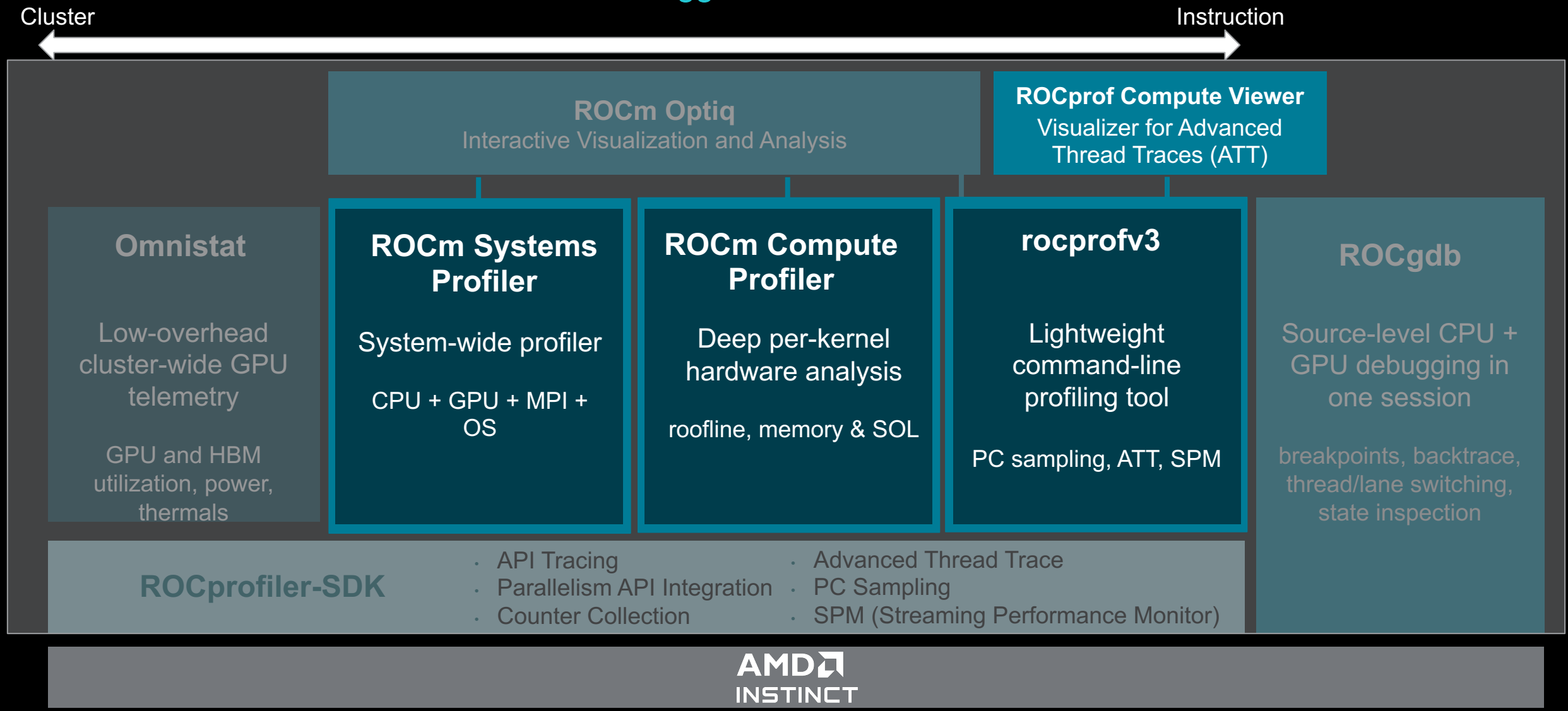
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Profiler and debugger toolchain for AMD GPUs



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Background – AMD Profilers

ROC-profiler (rocprof)

Hardware Counters	Raw collection of GPU counters and traces	
	Counter collection with user input files	Counter results printed to a CSV
Traces and timelines	Trace collection support for	
	CPU copy	HIP API	HSA API	GPU Kernels
Visualisation	Traces visualized with Perfetto	

rocprof-sys

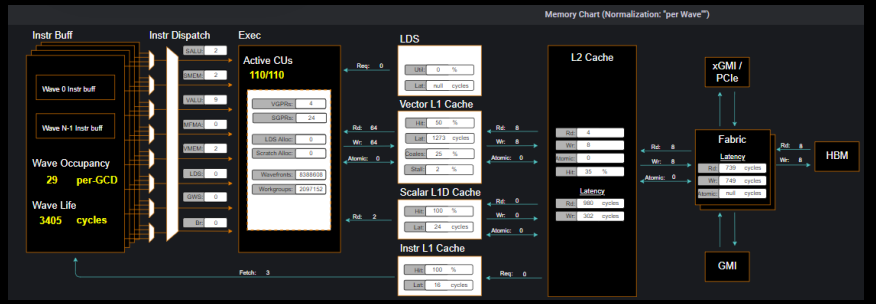
Trace collection	Comprehensive trace collection				
	CPU	GPU			
Supports	CPU copy	HIP API	HSA API	GPU Kernels	
	OpenMP®	MPI	Kokkos	p-threads	multi-GPU
Visualisation	Traces visualized with Perfetto				

rocprof-compute

Performance Analysis	Automated collection of hardware counters			
	Analysis	Visualisation		
Supports	Speed of Light	Memory chart	Rooflines	Kernel comparison
Visualisation	CLI or GUI			

	A	B	C	D	E
1	Name	Calls	TotalDura	AverageN	Percentage
2	hipMemcpyAsync	99	3.22E+10	3.25E+08	44.14872
3	hipEventSynchronize	330	2.42E+10	73394557	33.225
4	hipMemsetAsync	87	7.76E+09	89232696	10.64953
5	hipHostMalloc	9	5.41E+09	6.01E+08	7.415198
6	hipDeviceSynchronize	28	1.32E+09	47006288	1.805515
7	hipHostFree	17	1.05E+09	61534688	1.435014
8	hipMemcpy	41	8.11E+08	19791876	1.113161
9	hipLaunchKernel	1856	58082083	31294	0.079676
10	hipStreamCreate	2	46380834	23190417	0.063625
11	hipMemset	2	18847246	9423623	0.025854
12	hipStreamDestroy	2	15183338	7591669	0.020828
13	hipFree	38	8269713	217624	0.011344
14	hipEventRecord	330	2520035	7636	0.003457
15	hipMalloc	30	1484804	49493	0.002037
16	__hipPopCallConfigura	1856	229159	123	0.000314
17	__hipPushCallConfigur	1856	224177	120	0.000308
18	hipGetLastError	1494	100458	67	0.000138
19	hipEventCreate	330	76675	232	0.000105
20	hipEventDestroy	330	64671	195	8.87E-05
21	hipGetDevicePropertie	47	51808	1102	7.11E-05
22	hipGetDevice	64	11611	181	1.59E-05
23	hipSetDevice	1	401	401	5.50E-07
24	hipGetDeviceCount	1	220	220	3.02E-07

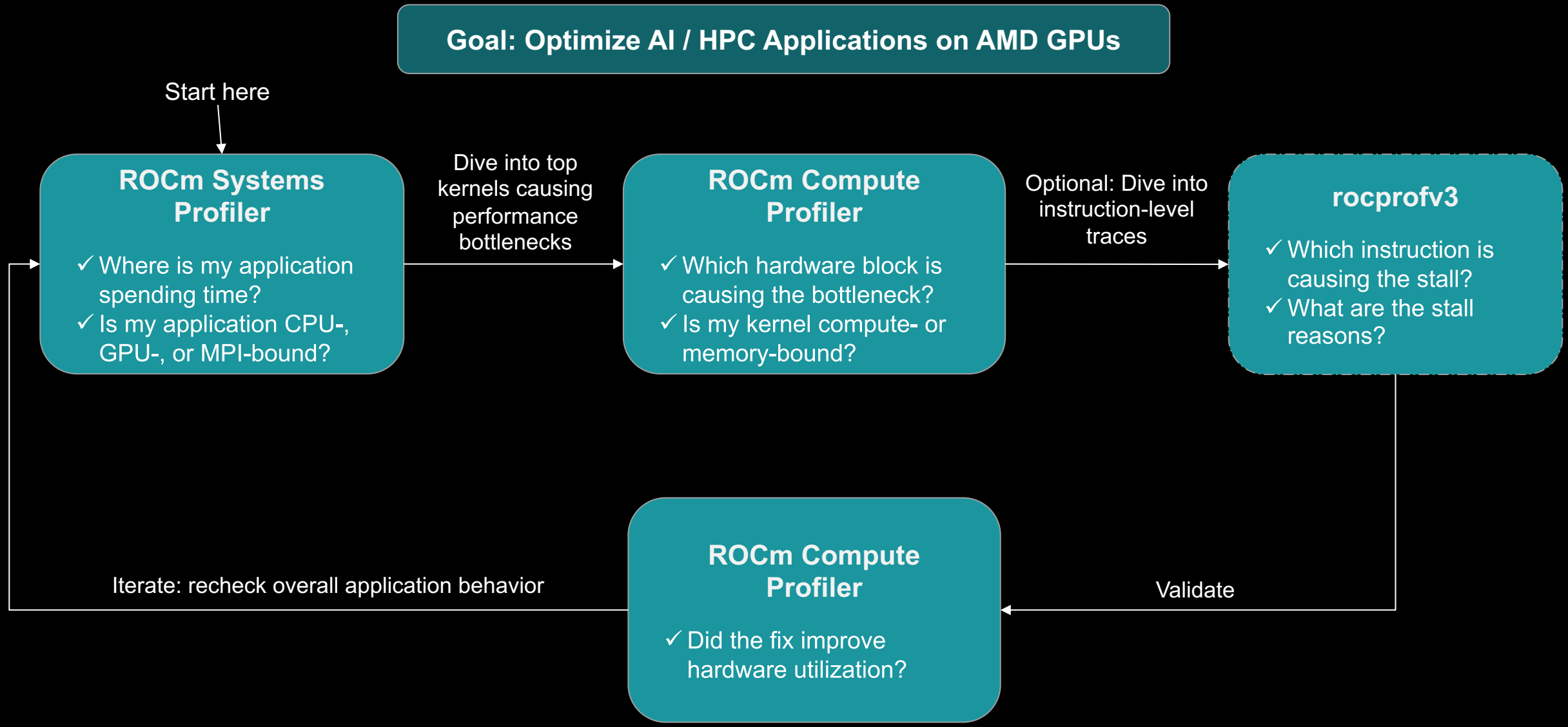




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Workflow for Application Developers & Scientists



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ROCm on LUMI

Latest Pytorch and other AI frameworks require this version

Introduced many performance improvements

Many stability and performance improvements for performance libraries

Improved support for lower precisions for AI

Tunned for AI inference engines

Native OpenXLA support

Included preview rocprofiler-sys/compute

rocprofiler-sys/compute default

Rocprof/rocprofv2 deprecated

Tuned BLAS for lower precisions (FP8/Int8) – emulated for MI250x

rocJPEG support

amd-smi to replace rocm-smi

Legacy stream as CUDA

Wavefront macro deprecation

Rocprofv3 default

Rocsolver improvements for Eigen solvers and SVD

Improved support for OpenMP offload profilling

Megatron-LM tunned attention kernels (fused)

rocAL DLPack support

warpSize is not a constant anymore

ROCm-DS (Data science)

Decoupling user-level and driver versions

Newer GPU generation support

amd-flang toolchain

CUDA 12.9.1 support for hipification

Official support for Ray and llama.cpp

Parallel LTO (–fgpu-rdc faster builds)

ROCm-LS (Life sciences)

Sync. Intrinsics (e.g. shfl_sync) enabled by default

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	Jun 2024	Nov 2024	Mar 2025	Sep 2025	Nov 2025	…
User level	6.1.3	**6.2.4**	6.3.4	6.4.4	7.0.3	… ?
Driver			**6.3.0**			Abusing the driver could work but unsupported

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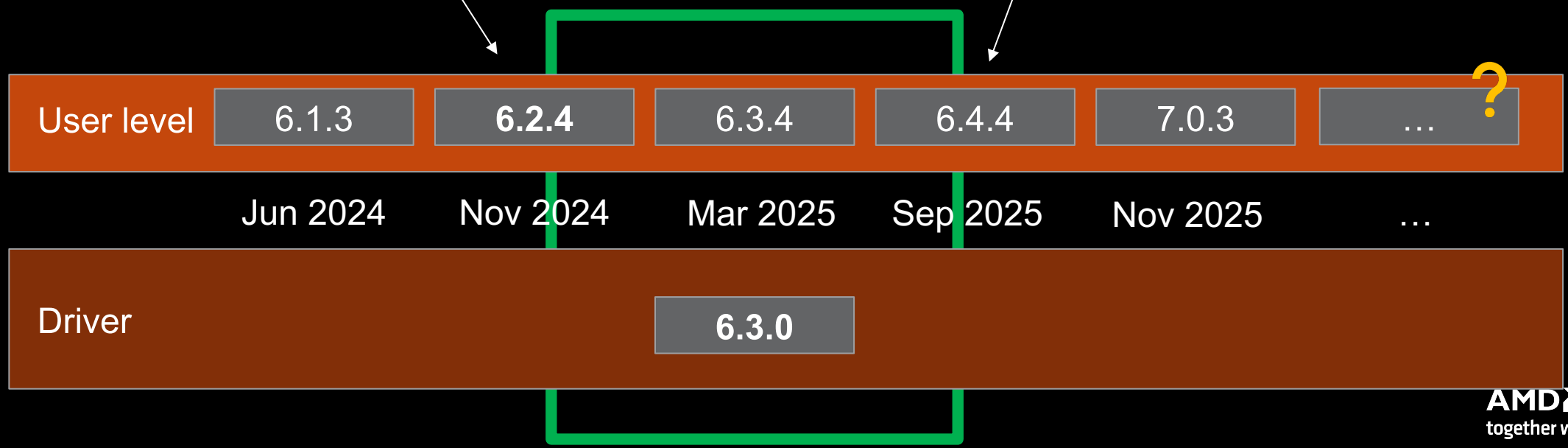
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ROCm on LUMI

ROCPROF V3 Introduced

ROCPROF V3 Default

AMD ROCm



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What is ROC-Profiler (v1-v2-v3)?

- ROC-profiler (also referred to as `rocprof`) is the command line front-end for AMD's GPU profiling libraries
  - Repo: https://github.com/ROCm-Developer-Tools/rocprofiler
- rocprof contains the central components allowing application traces and counter collection
  - Under constant development
- Distributed with ROCm
- The output of `rocprofv1` can be visualized in the Chrome browser with Perfetto (https://ui.perfetto.dev/)
- There are ROCProfiler V1 and V2 (roctracer and rocprofiler into single library, same API)
- ROC-profiler-SDK is a profiling and tracing library for HIP and ROCm application. The new API improved thread safety and includes more efficient implementations and provides a tool library to support on writing your tool implementations. It is still in beta release.
- `rocprofv3` uses this tool library to profile and trace applications.

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rocprof (v1): Getting Started + Useful Flags

- To get help:
  `${ROCM_PATH}/bin/rocprof -h`
- Useful housekeeping flags:
  - `--timestamp <on|off>` - turn on/off gpu kernel timestamps
  - `--basenames <on|off>` - turn on/off truncating gpu kernel names (i.e., removing template parameters and argument types)
  - `-o <output csv file>` - Direct counter information to a particular file name
  - `-d <data directory>` - Send profiling data to a particular directory
  - `-t <temporary directory>` - Change the directory where data files typically created in /tmp are placed. This allows you to save these temporary files.
- Flags directing rocprofiler activity:
  - `-i input<.txt|.xml>` - specify an input file (note the output files will now be named input.*)
  - `--hsa-trace` - to trace GPU Kernels, host HSA events (more later) and HIP memory copies.
  - `--hip-trace` - to trace HIP API calls
  - `--roctx-trace` - to trace roctx markers
  - `--kfd-trace` - to trace GPU driver calls
- Advanced usage
  - `-m <metric file>` - Allows the user to define and collect custom metrics. See rocprofiler/test/tool/*.xml on GitHub for examples.

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rocprof (v1): : Kernel Information

- rocprof can collect kernel(s) execution stats

```
$ /opt/rocm/bin/rocprof --stats --basenames on <app with arguments>
```

- This will output two csv files:
  - `results.csv:` information per each call of the kernel
  - `results.stats.csv:` statistics grouped by each kernel
- Content of results.stats.csv to see the list of GPU kernels with their durations and percentage of total GPU time:

```
"Name","Calls","TotalDurationNs","AverageNs","Percentage"
"JacobiIterationKernel",1000,556699359,556699,43.291753895270446
"NormKernel1",1001,430797387,430367,33.500980655394606
"LocalLaplacianKernel",1000,280014065,280014,21.775307970480817
"HaloLaplacianKernel",1000,14635177,14635,1.1381052818810995
"NormKernel2",1001,3770718,3766,0.2932300765671734
"__amd_rocclr_fillBufferAligned.kd",1,8000,8000,0.0006221204058583505
```

- In a spreadsheet viewer, it is easier to read:

	A	B	C	D	E
1	Name	Calls	TotalDurationNs	AverageNs	Percentage
2	JacobiIterationKernel	1000	556699359	556699	43.2917538952704
3	NormKernel1	1001	430797387	430367	33.5009806553946
4	LocalLaplacianKernel	1000	280014065	280014	21.7753079704808
5	HaloLaplacianKernel	1000	14635177	14635	1.1381052818811
6	NormKernel2	1001	3770718	3766	0.293230076567173
7	__amd_rocclr_fillBufferAligned	1	8000	8000	0.000622120405858

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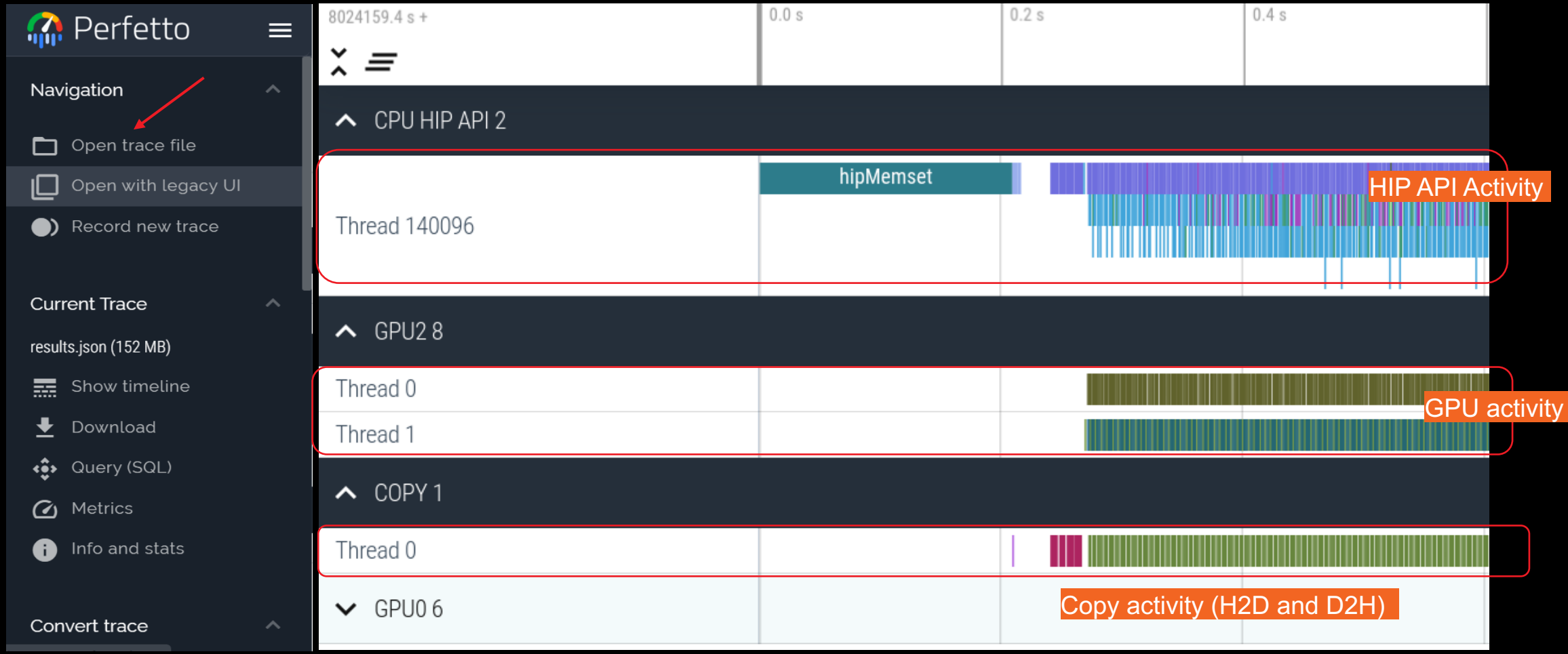
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rocprof (v1): + Perfetto: Collecting and Visualizing App Traces

- rocprof can collect traces

  ```
  $ /opt/rocm/bin/rocprof --hip-trace <app with arguments>
  ```

  This will output a .json file that can be visualized using the Chrome browser and Perfetto (https://ui.perfetto.dev/)



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rocprofv3: Getting Started + Useful Flags

- To get help:
  `${ROCM_PATH}/bin/rocprofv3 -h`
- Useful housekeeping flags:
  - `--hip-trace` For Collecting HIP Traces (runtime + compiler)
  - `--hip-runtime-trace` For Collecting HIP Runtime API Traces
  - `--hip-compiler-trace` For Collecting HIP Compiler generated code Traces
  - `--marker-trace` For Collecting Marker (ROCTx) Traces
  - `--memory-copy-trace` For Collecting Memory Copy Traces
  - `--stats` For Collecting statistics of enabled tracing types
  - `--hsa-trace` For Collecting HSA Traces (core + amd + image + finalizer)
  - `--hsa-core-trace` For Collecting HSA API Traces (core API)
  - `--hsa-amd-trace` For Collecting HSA API Traces (AMD-extension API)
  - `--hsa-image-trace` For Collecting HSA API Traces (Image-extenson API)
  - `--hsa-finalizer-trace` For Collecting HSA API Traces (Finalizer-extension API)

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rocprofv3: Getting Started + Useful Flags (II)

- Useful housekeeping flags:
  - `-s, --sys-trace` For Collecting HIP, HSA, Marker (ROCTx), Memory copy, Scratch memory, and Kernel dispatch traces
  - `-M, --mangled-kernels` Do not demangle the kernel names
  - `-T, --truncate-kernels` Truncate the demangled kernel names
  - `-L, --list-metrics` List metrics for counter collection
  - `-i INPUT, --input INPUT` Input file for counter collection
  - `-o OUTPUT_FILE, --output-file OUTPUT_FILE` For the output file name
  - `-d OUTPUT_DIRECTORY, --output-directory OUTPUT_DIRECTORY` For adding output path where the output files will be saved
  - `--output-format {csv,json,pftrace} [{csv,json,pftrace} ...]` For adding output format (supported formats: csv, json, pftrace)
  - `--log-level {fatal,error,warning,info,trace}` Set the log level
  - `--kernel-names KERNEL_NAMES [KERNEL_NAMES ...]` Filter kernel names
  - `--preload [PRELOAD ...]` Libraries to prepend to LD_PRELOAD (usually for sanitizers)

  - rocprofv3 requires double-hyphen (--) before the application to be executed, e.g.

```
$ rocprofv3 [<rocprofv3-option> ...] -- <application> [<application-arg> ...]
$ rocprofv3 --hip-trace -- ./myapp -n 1
```

  - Instructions: https://rocm.docs.amd.com/projects/rocprofiler-sdk/en/docs-6.2.1/how-to/using-rocprofv3.html

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rocprofv3: Kernel Information

- rocprof can collect kernel(s) execution stats

```
$ /opt/rocm/bin/rocprofv3 --stats --kernel-trace -T -- <app with arguments>
```

- This will output four csv files (XXXXX are numbers):
  - XXXXX_agent_info.csv: information for the used hardware APU/GPU and CPU
  - XXXXX_kernel_traces.csv: information per each call of the kernel
  - XXXXX_kernel_stats.csv: statistics grouped by each kernel
  - XXXXX_domain_stats.csv: statistics grouped by domain, such as KERNEL_DISPATCH, HIP_COMPILER_API
- Content of results.stats.csv to see the list of GPU kernels with their durations and percentage of total GPU time:

```
"Name","Calls","TotalDurationNs","AverageNs","Percentage","MinNs","MaxNs","StdDev"
"NormKernel1",1001,365858158,365492.665335,53.49,360561,449240,3460.551681
"JacobiIterationKernel",1000,171479968,171479.968000,25.07,162040,205241,10113.842491
"LocalLaplacianKernel",1000,135771713,135771.713000,19.85,130400,145121,3349.580100
"HaloLaplacianKernel",1000,7777189,7777.189000,1.14,7000,12120,349.399610
"NormKernel2",1001,3107927,3104.822178,0.4544,2200,138681,6466.048652
"__amd_rocclr_fillBufferAligned",1,2720,2720.000000,3.977e-04,2720,2720,0.00000000e+00
```

- In a spreadsheet viewer, it is easier to read:

	A	B	C	D	E	F	G	H
1	Name	Calls	TotalDurationNs	AverageNs	Percentage	MinNs	MaxNs	StdDev
2	NormKernel1	1001	365858158	365492.665	53.49	360561	449240	3460.552
3	JacobiIterationKernel	1000	171479968	171479.968	25.07	162040	205241	10113.84
4	LocalLaplacianKernel	1000	135771713	135771.713	19.85	130400	145121	3349.58
5	HaloLaplacianKernel	1000	7777189	7777.189	1.14	7000	12120	349.3996
6	NormKernel2	1001	3107927	3104.82218	0.4544	2200	138681	6466.049
7	__amd_rocclr_fillBufferAligned	1	2720	2720	3.98E-04	2720	2720	0

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rocprofv3: Collecting Application Traces

- rocprof can collect a variety of trace event types, and generate timelines in JSON format for use with Perfetto, currently, however better use the pftrace output format (*--output-format pftrace*):

Trace Event	rocprof Trace Mode
HIP API call	`--hip-trace`
GPU Kernels	`--kernel-trace`
Host <-> Device Memory copies	`--hip-trace or --memory-copy-trace`
CPU HSA Calls	`--hsa-trace`
User code markers	`--marker-trace`
Collect HIP, HSA, Kernels, Memory Copy, Marker API	`--sys-trace`
Scratch memory operations	`--scratch-memory-trace`

- You can combine modes like --stats `--hip-trace --hsa-trace --output-format pftrace`

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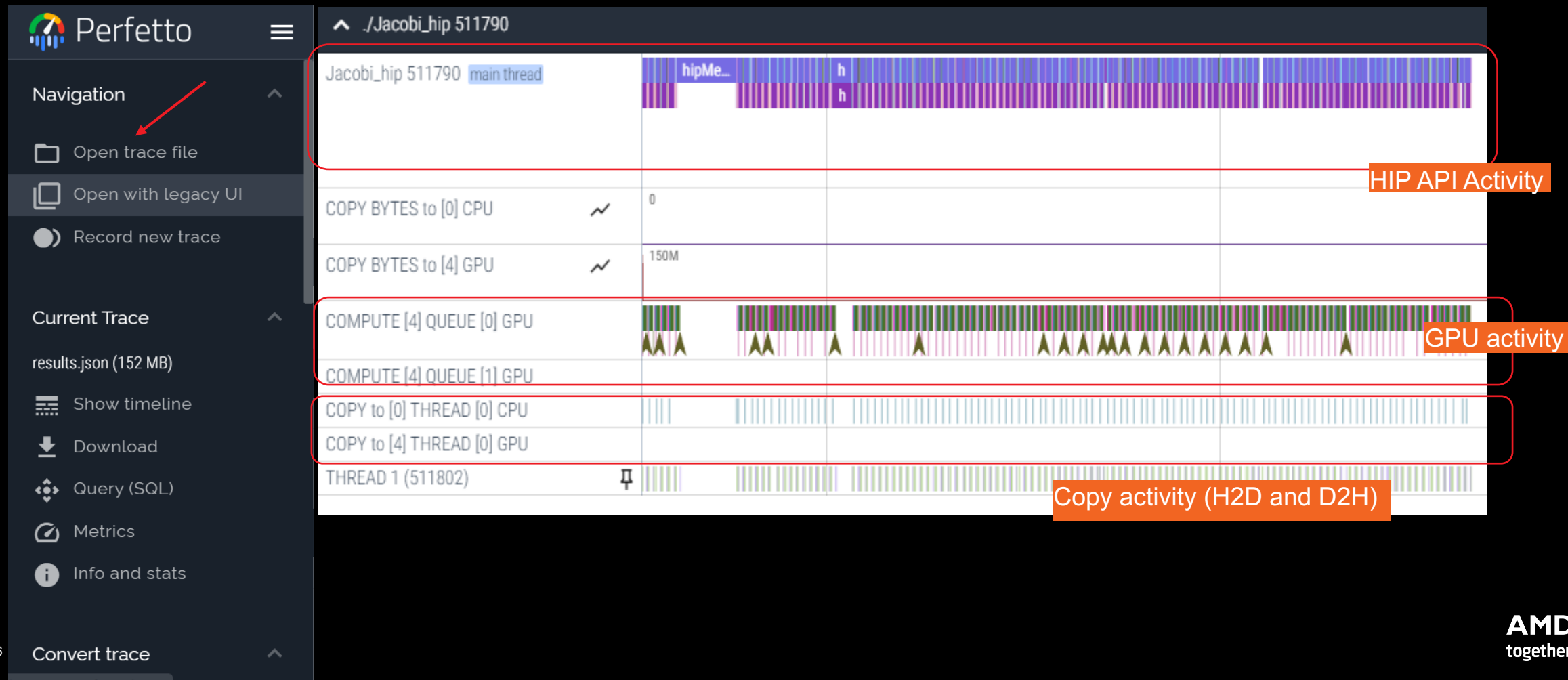
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rocprof + Perfetto: Collecting and Visualizing Application Traces

- rocprof can collect traces

```
$ /opt/rocm/bin/rocprofv3 --hip-trace --output-format pftrace -- <app with arguments>
```

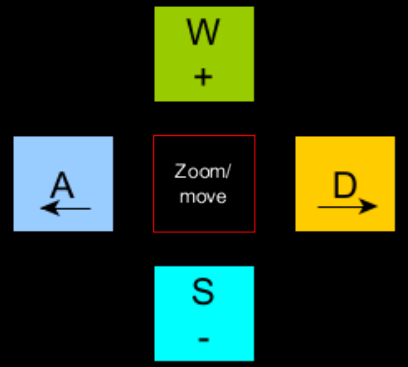
This will output a pftrace file that can be visualized using the chrome browser and Perfetto (https://ui.perfetto.dev/)



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Perfetto: Visualizing Application Traces



- Zoom in to see individual events
- Navigate trace using WASD keys



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Perfetto: Kernel Information and Flow Events

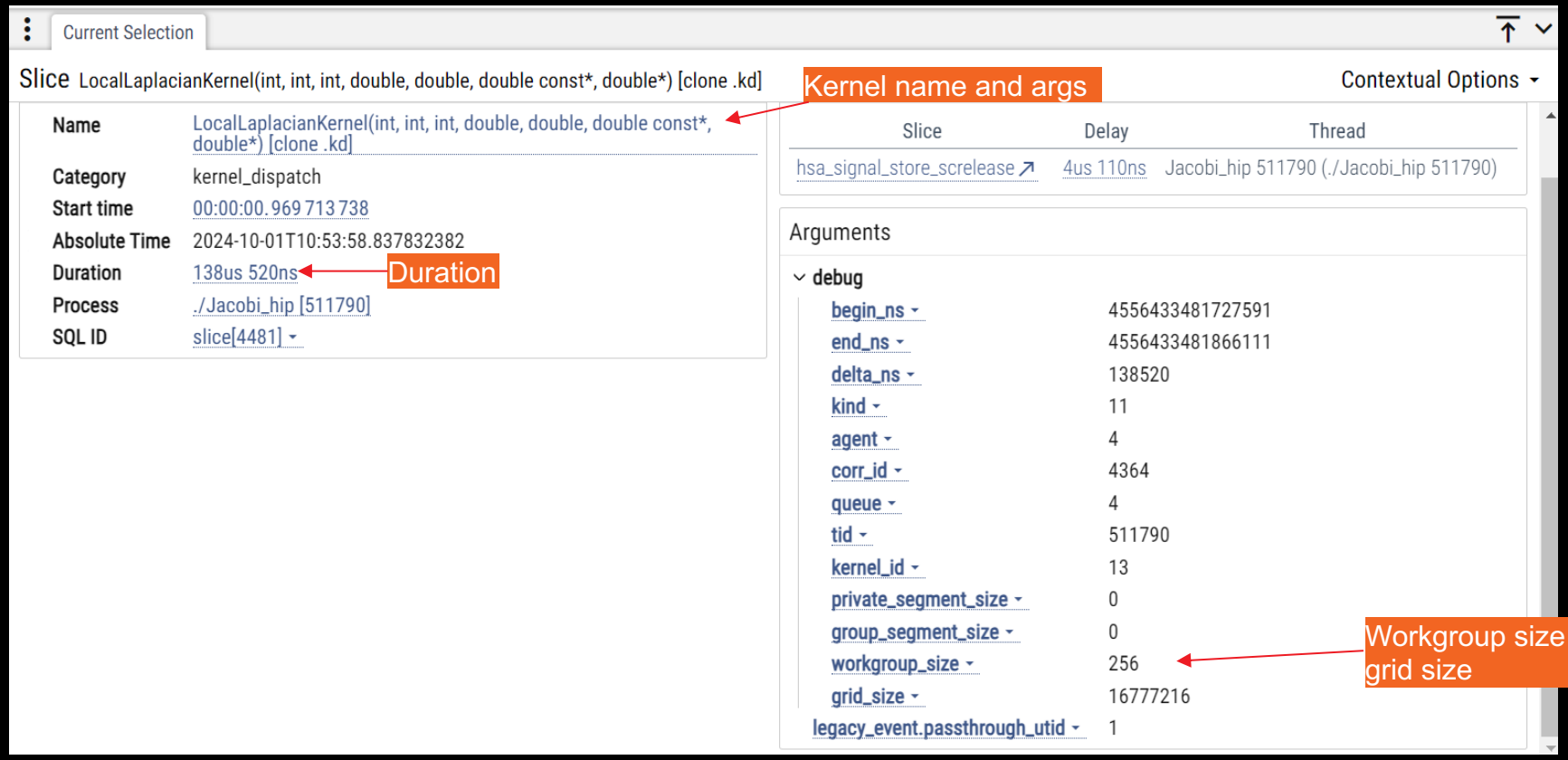
- Zoom and select a kernel, you can see the link to the HIP call launching the kernel
- Try to open the information for the kernel (button at bottom right)



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Perfetto: Kernel Information



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rocprofv3: Collecting Application Traces with rocTX Markers and Regions

- rocprofv3 can collect user defined regions or markers using rocTX
- Annotate code with roctx regions:

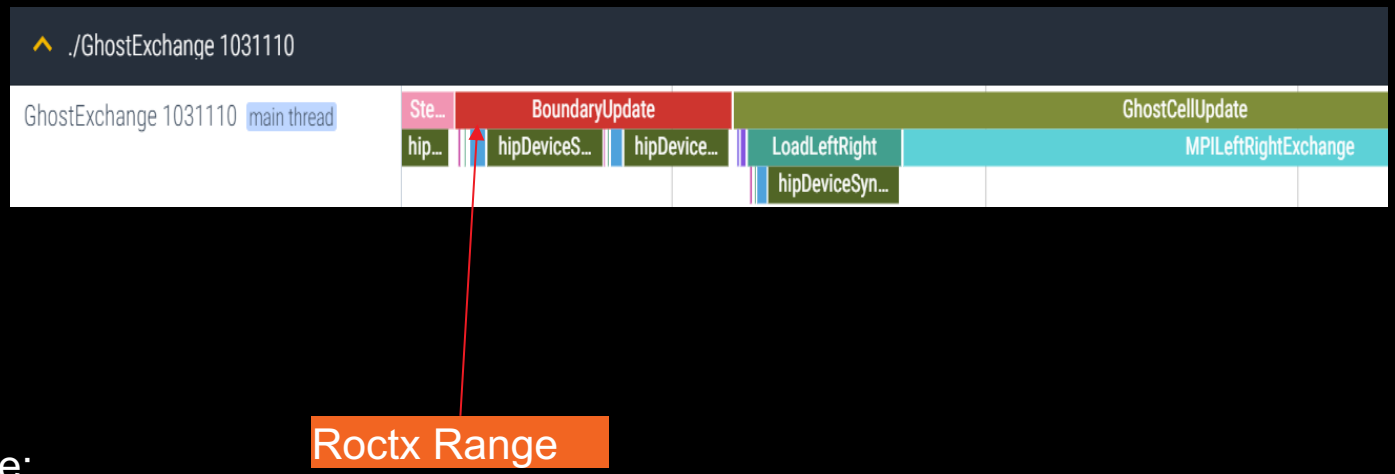
```
#include <rocprofiler-sdk-roctx/roctx.h>
...
    roctxRangePush("reduce_for_c");
    reduce_function ();
    roctxRangePop();
...
```

- Annotate code with roctx markers:

```
...
    roctxMark("start of some code");
    // some_code
    roctxMark("end of some code");
...
```

- Add roctx and roctracer libraries to link line:

```
-L${ROCM_PATH}/lib -lrocprofiler-sdk-roctx -lroctracer64
```



- Profile with `--roctx-range` option:

```
$ /opt/rocm/bin/rocprofv3 --hip-trace --marker-trace -- <app with arguments>
```

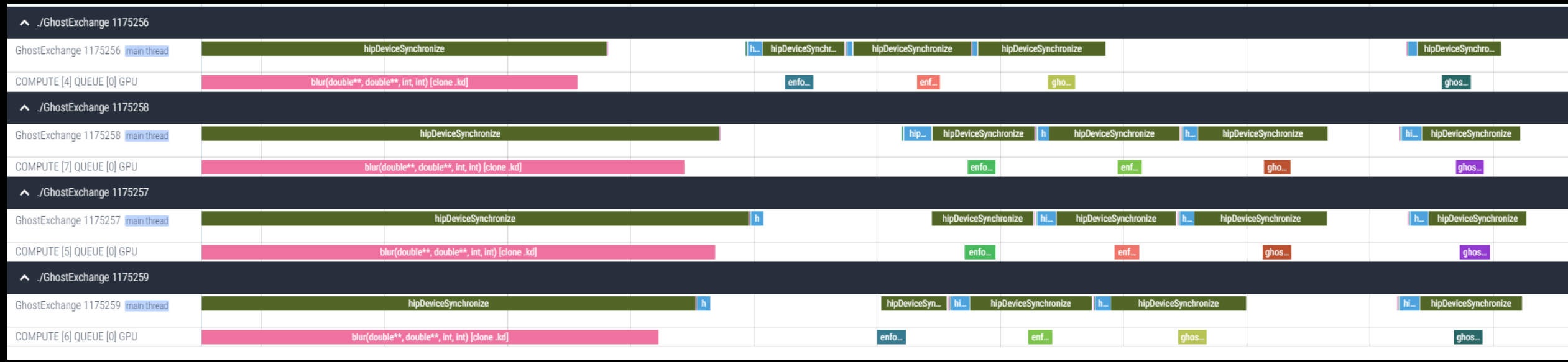
- Important: There is some difference regarding roctx between rocprof and rocprofv3

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Rocprofv3: Merge traces

- When you have one pftrace per MPI processes you can merge them as follows:
  - For example cat XXXXX_results.pftrace > all_ghostexchange.pftrace
  - Then visualize the file called all_ghostexchange.pftrace



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rocprofv3: Commonly Used GPU Counters

VALUUtilization	The percentage of ALUs active in a wave. Low VALUUtilization is likely due to high divergence or a poorly sized grid
VALUBusy	The percentage of GPUTime vector ALU instructions are processed. Can be thought of as something like compute utilization
FetchSize	The total kilobytes fetched from global memory
WriteSize	The total kilobytes written to global memory
MemUnitStalled	The percentage of GPUTime the memory unit is stalled
CU_OCCUPANCY	The ratio of active waves on a CU to the maximum number of active waves supported by the CU
MeanOccupancyPerCU	Mean occupancy per compute unit
MeanOccupancyPerActiveCU	Mean occupancy per active compute unit

Full list at: https://github.com/ROCm/rocprofiler/blob/amd-master/test/tool/metrics.xml

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rocprofv3: Collecting Hardware Counters

- rocprofv3 can collect a number of hardware counters and derived counters
  - `$ /opt/rocm/bin/rocprofv3 -L`

- Specify counters in a counter file. For example:
  - `$ /opt/rocm/bin/rocprofv3 -i rocprof_counters.txt -- <app with args>`
  - `$ cat rocprof_counters.txt`

    ```
    pmc: VALUUtilization VALUBusy FetchSize WriteSize MemUnitStalled
    pmc: GPU_UTIL CU_OCCUPANCY MeanOccupancyPerCU MeanOccupancyPerActiveCU
    ```

  - A limited number of counters can be collected during a specific pass of code
    - Each line in the counter file will be collected in one pass
    - You will receive an error suggesting alternative counter ordering if you have too many / conflicting counters on one line

  - One directory per pmc line will be created, for example pmc_1 and pmc_2 for the two lines in the file with the counters.
  - One agent_info and one counter_collection csv file per MPI process will be created containing all the requested counters for each invocation of every kernel

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rocprof: Profiling Overhead

- As with every profiling tool, there is an overhead
- The percentage of the overhead depends on the profiling options used
  - For example, tracing is faster than hardware counter collection
- When collecting many counters, the collection may require multiple passes
- With rocTX markers/regions, tracing can take longer and the output may be large
  - Sometimes too large to visualize
- The more data collected, the more the overhead of profiling
  - Depends on the application and options used
- rocprofv3 has less overhead than rocprof (v1) on various examples with extensive ROCm calls

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Summary

- rocprofv3 is the open source, command line AMD GPU profiling tool distributed with ROCm 6.2 and later
- rocprofv3 provides tracing of GPU kernels, through various options, HIP API, HSA API, Copy activity and others
- rocprofv3 can be used to collect GPU hardware counters with additional overhead
- Perfetto seems to visualize pftrace files without significant issues
- Other output files are in text/CSV format

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Hands-on exercises

https://hackmd.io/@sfantao/lumi-training-cph-2026#Rocprof

We welcome you to explore our HPC Training Examples repo:

https://github.com/amd/HPCTrainingExamples

A table of contents for the READMEs if available at the top-level **README** in the repo

Relevant exercises for this presentation located in **Rocprof** directory.

Link to instructions on how to run the tests: **Rocprof/README.md and subdirectories**

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