



# Introduction to OmniTrace

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AMD @HLRS  
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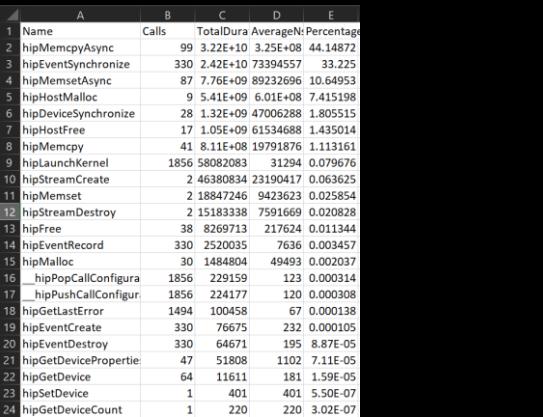
# Profiling

# 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

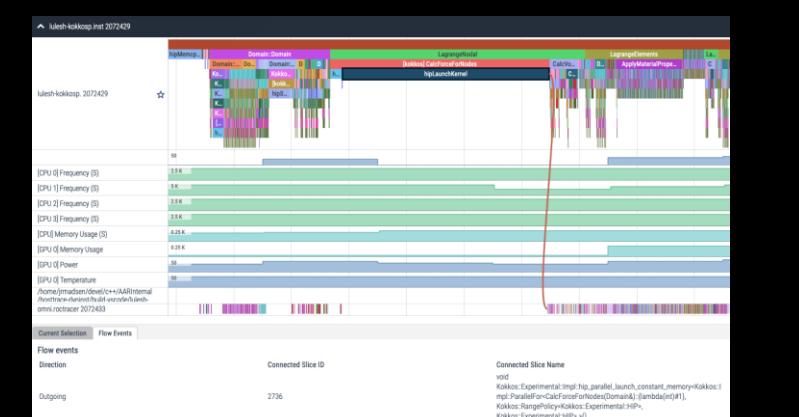
Traces and timelines	Trace collection support for			
	CPU copy	HIP API	HSA API	GPU Kernels

Visualisation	Traces visualized with Perfetto
	

## Omnitrace

Trace collection	Comprehensive trace collection			
	CPU		GPU	

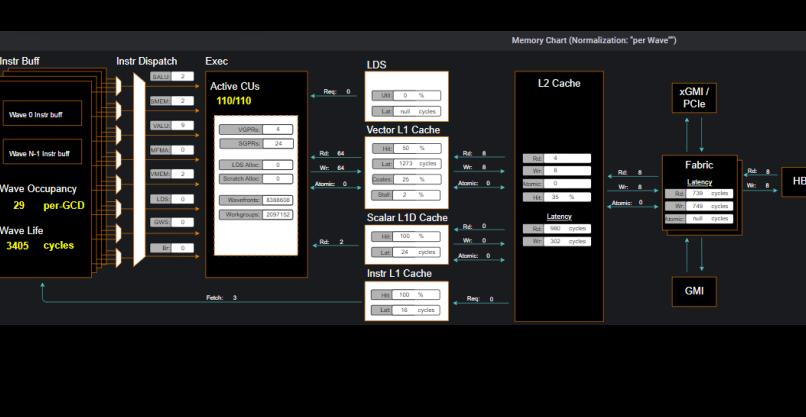
Supports	CPU copy	HIP API	HSA API	GPU Kernels	
	OpenMP®	MPI	Kokkos	p-threads	multi-GPU

Visualisation	Traces visualized with Perfetto
	

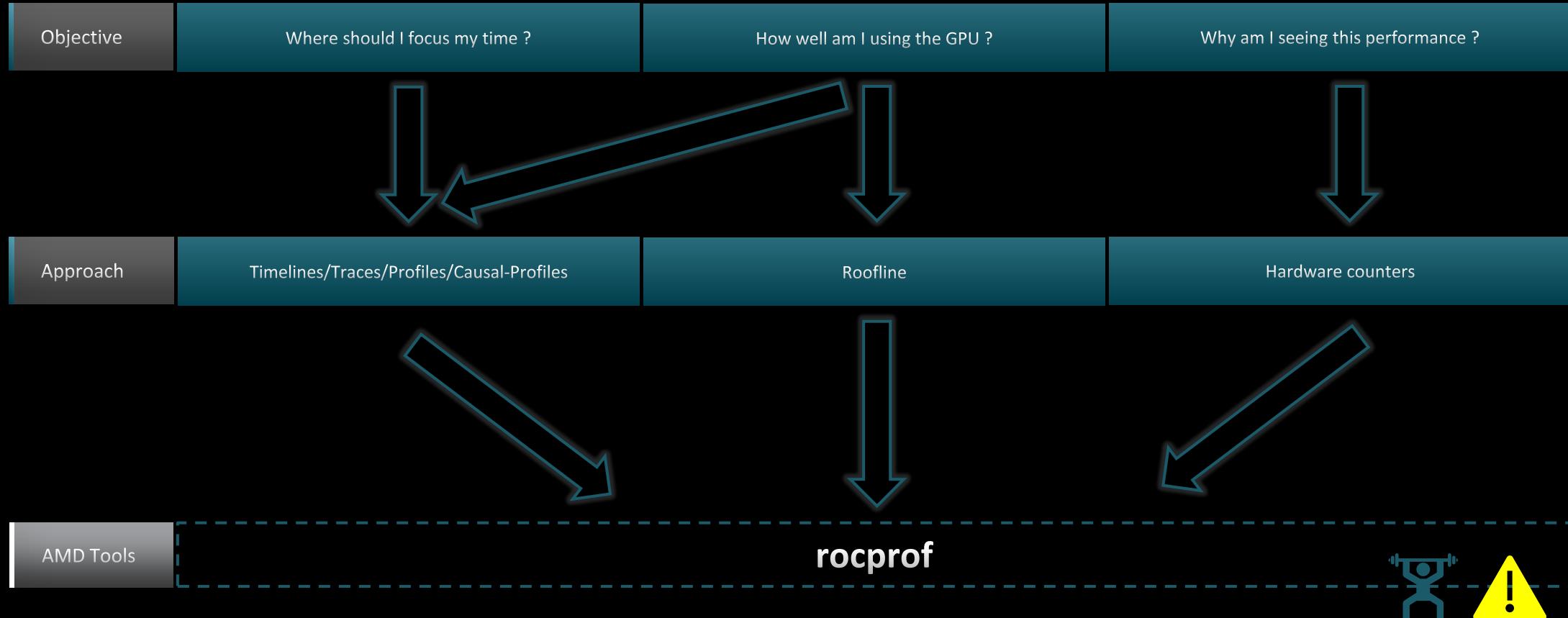
## Omniperf

Performance Analysis	Automated collection of hardware counters		
	Analysis		Visualization

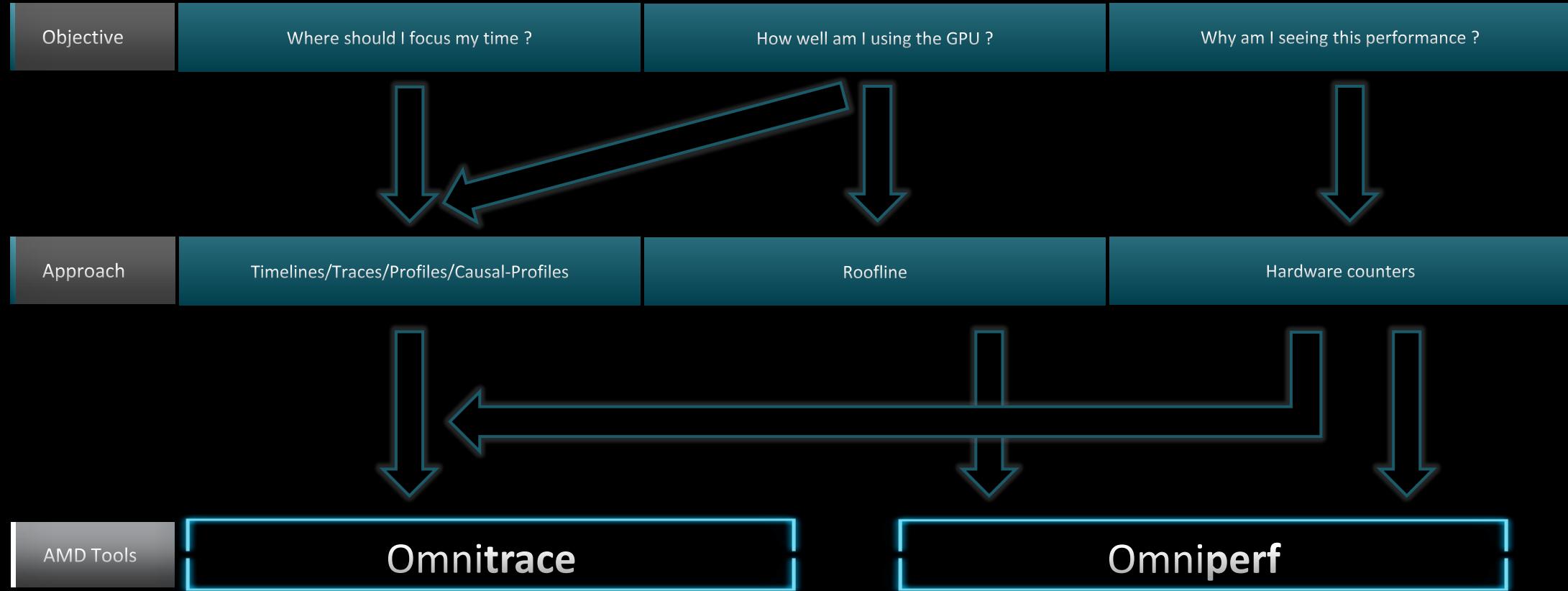
Supports	Speed of Light	Memory chart	Rooflines	Kernel comparison
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Visualisation	With Grafana or standalone GUI
	

# Background – AMD Profilers



# Background – AMD Profilers

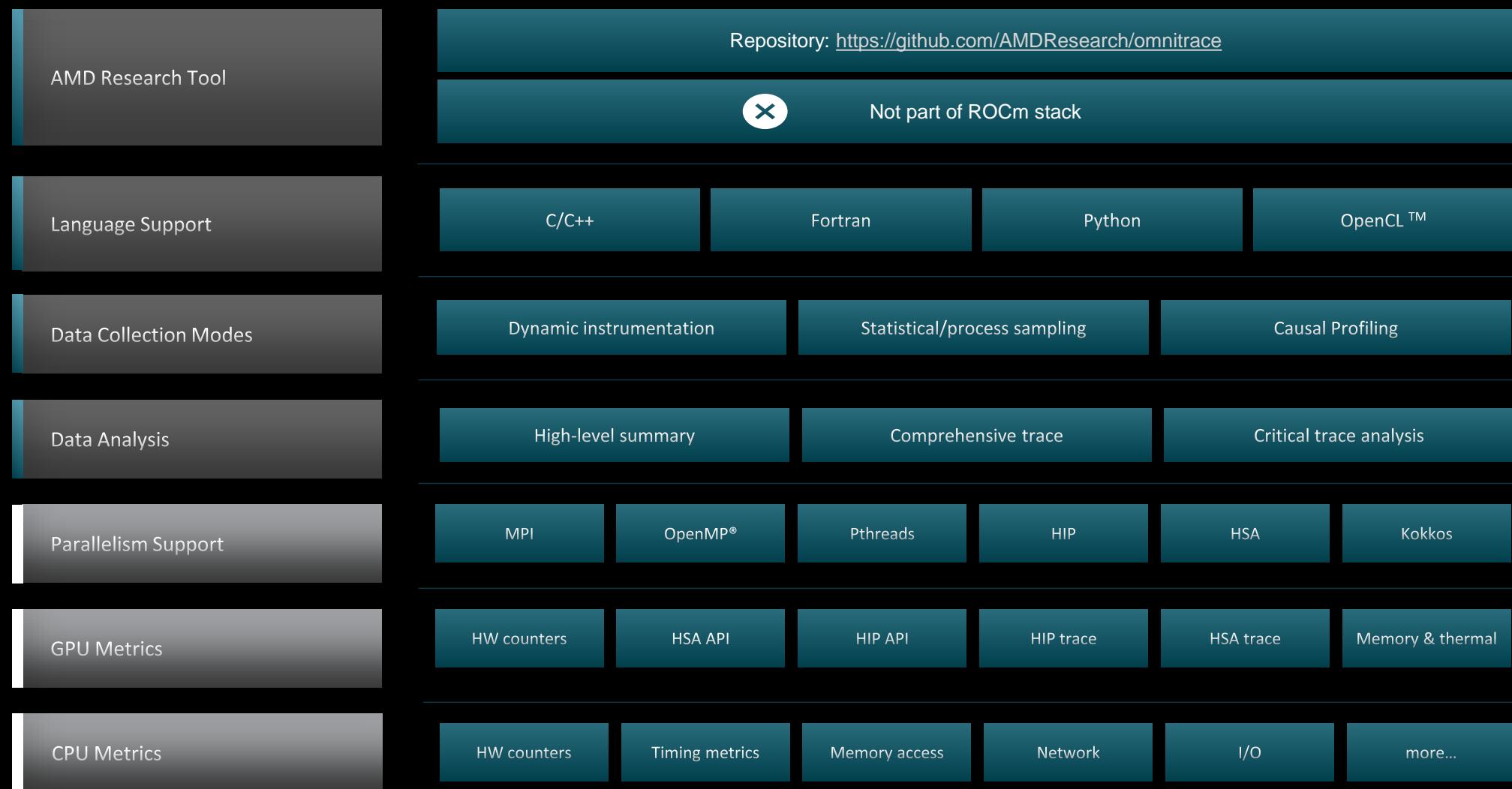




A close-up photograph of an AMD Radeon Instinct GPU. The card features a black shroud with a textured pattern and a prominent 'RADEON INSTINCT' logo. The text is white with a blue outline, positioned diagonally across the shroud. The GPU has multiple heat sinks with visible fins and a complex internal structure. A small AMD logo is located at the bottom center of the shroud. The background is dark, emphasizing the card's design.

OmniTrace

# Omnitrace: Application Profiling, Tracing, and Analysis



Refer to [current documentation](#) for recent updates

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# Installation (if required)



To use pre-built binaries, select the version that matches your operating system, ROCm version, etc.



Select OpenSUSE operating system for HPE/AMD system:

omnitrace-1.7.4-opensuse-15.4-  
ROCM-50400-PAPI-OMPT-Python3.sh



There are .rpm and .deb files for installation also. In future versions, binary installers for RHEL also available.



Full documentation: <https://amdr esearch.github.io/omnitrace/>

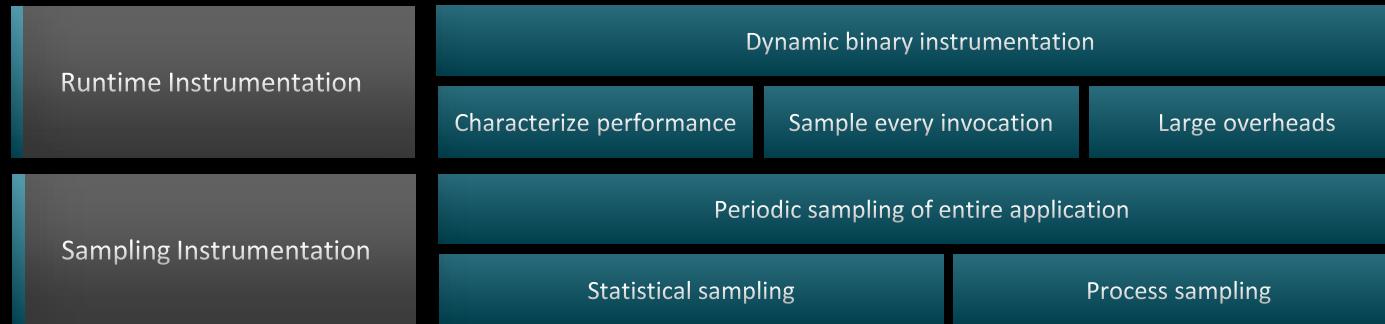
```
export OMNITRACE_VERSION=latest
export ROCM_VERSION=5.4.3
export OMNITRACE_INSTALL_DIR=</path/to/your/omnitrace/install>
wget https://github.com/AMDR esearch/omnitrace/releases/${OMNITRACE_VERSION}/download/omnitrace-install.py
python3 omnitrace-install.py -p ${OMNITRACE_INSTALL_DIR} --rocm ${ROCM_VERSION}
```

**Set up environment:**

```
source ${OMNITRACE_INSTALL_DIR}/share/omnitrace/setup-env.sh
```

**Note: If installing from source, remember to clone the omnitrace repo recursively**

# Omnitrace instrumentation Modes



## Basic command-line syntax:

```
$ omnitrace [omnitrace-options] -- <CMD> <ARGS>
```

For more information or help use -h/--help/? flags:

```
$ omnitrace -h
```

Can also execute on systems using a job scheduler. For example, with SLURM, an interactive session can be used as:

```
$ srun [options] omnitrace [omnitrace-options] -- <CMD> <ARGS>
```

For problems, create an issue here: <https://github.com/AMDRResearch/omnitrace/issues>

Documentation: <https://amdrresearch.github.io/omnitrace/>

# Omnitrace Configuration

```
$ omnitrace-avail --categories [options]
```

Get more information about run-time settings, data collection capabilities, and available hardware counters. For more information or help use -h/--help flags:

```
$ omnitrace-avail -h
```

Collect information for omnitrace-related settings using shorthand -c for --categories :

```
$ omnitrace-avail -c perfetto
```

```
$ omnitrace-avail -c perfetto
```

ENVIRONMENT VARIABLE	VALUE	CATEGORIES
OMNITRACE_PERFETTO_BACKEND	inprocess	custom, libomnitrace, omnitrace, perfetto
OMNITRACE_PERFETTO_BUFFER_SIZE_KB	1024000	custom, data, libomnitrace, omnitrace, perfetto
OMNITRACE_PERFETTO_FILL_POLICY	discard	custom, data, libomnitrace, omnitrace, perfetto
OMNITRACE_TRACE_DELAY	0	custom, libomnitrace, omnitrace, perfetto, profile, timemory, trace
OMNITRACE_TRACE_DURATION	0	custom, libomnitrace, omnitrace, perfetto, profile, timemory, trace
OMNITRACE_TRACE_PERIODS		custom, libomnitrace, omnitrace, perfetto, profile, timemory, trace
OMNITRACE_TRACE_PERIOD_CLOCK_ID	CLOCK_REALTIME	custom, libomnitrace, omnitrace, perfetto, profile, timemory, trace
OMNITRACE_USE_PERFETTO	true	backend, custom, libomnitrace, omnitrace, perfetto

Shows all runtime settings that may be tuned for perfetto

# Omnitrace Configuration

```
$ omnitrace-avail --categories [options]
```

Get more information about run-time settings, data collection capabilities, and available hardware counters. For more information or help use -h/--help/? flags:

```
$ omnitrace-avail -h
```

Collect information for omnitrace-related settings using shorthand -c for --categories :

```
$ omnitrace-avail -c omnitrace
```

For brief description, use the options:

```
$ omnitrace-avail -bd
```

ENVIRONMENT VARIABLE	DESCRIPTION
OMNITRACE_CAUSAL_BINARY_EXCLUDE	Excludes binaries matching the list of provided regexes from causal experiments (separated by tab, semi-colon, and/or quotes (single or double)).
OMNITRACE_CAUSAL_BINARY_SCOPE	Limits causal experiments to the binaries matching the provided list of regular expressions (separated by tab, semi-colon, and/or quotes (single or double)).
OMNITRACE_CAUSAL_DELAY	Length of time to wait (in seconds) before starting the first causal experiment.
OMNITRACE_CAUSAL_DURATION	Length of time to perform causal experimentation (in seconds) after the first experiment has started. ...
OMNITRACE_CAUSAL_FUNCTION_EXCLUDE	Excludes functions matching the list of provided regexes from causal experiments (separated by tab, semi-colon, and/or quotes (single or double)).
OMNITRACE_CAUSAL_FUNCTION_SCOPE	List of <function> regex entries for causal profiling (separated by tab, semi-colon, and/or quotes (single or double)).
OMNITRACE_CAUSAL_RANDOM_SEED	Seed for random number generator which selects speedups and experiments -- please note that the lines are separated by tabs.
OMNITRACE_CAUSAL_SOURCE_EXCLUDE	Excludes source files or source file + lineno pair (i.e. <file> or <file>:<line>) matching the list of provided regexes (separated by tab, semi-colon, and/or quotes (single or double)).
OMNITRACE_CAUSAL_SOURCE_SCOPE	Limits causal experiments to the source files or source file + lineno pair (i.e. <file> or <file>:<line>).
OMNITRACE_CONFIG_FILE	Configuration file for omnitrace
OMNITRACE_CRITICAL_TRACE	Enable generation of the critical trace
OMNITRACE_ENABLED	Activation state of timemory
OMNITRACE_OUTPUT_PATH	Explicitly specify the output folder for results
OMNITRACE_OUTPUT_PREFIX	Explicitly specify a prefix for all output files
OMNITRACE_PAPI_EVENTS	PAPI presets and events to collect (see also: papi_avail)
OMNITRACE_PERFETTO_BACKEND	Specify the perfetto backend to activate. Options are: 'inprocess', 'system', or 'all'
OMNITRACE_PERFETTO_BUFFER_SIZE_KB	Size of perfetto buffer (in KB)
OMNITRACE_PERFETTO_FILL_POLICY	Behavior when perfetto buffer is full. 'discard' will ignore new entries, 'ring_buffer' will overwrite... If > 0.0, time (in seconds) to sample before stopping. If less than zero, uses OMNITRACE_SAMPLING_DURA...
OMNITRACE_PROCESS_SAMPLING_DURATION	Number of measurements per second when OMNITRACE_USE_PROCESS_SAMPLING=ON. If set to zero, uses OMNITRACE_SAMPLING_FREQ.
OMNITRACE_PROCESS_SAMPLING_FREQ	ROCM hardware counters. Use ':device=N' syntax to specify collection on device number N, e.g. ':device... CPU to collect frequency information for. Values should be separated by commas and can be explicit or...
OMNITRACE_SAMPLING_EVENTS	Time (in seconds) to wait before the first sampling signal is delivered, increasing this value can fix...
OMNITRACE_SAMPLING_THREADS	If > 0.0, time (in seconds) to sample before stopping
OMNITRACE_SAMPLING_FREQ	Number of software interrupts per second when OMNITRACE_USE_SAMPLING=ON
OMNITRACE_SAMPLING_THREADS	Devices to query when OMNITRACE_USE_ROCM_SMI=ON. Values should be separated by commas and can be expli...

## Create a config file

Create a config file in \$HOME:

```
$ omnitrace-avail -G $HOME/.omnitrace.cfg
```

To add description of all variables and settings, use:

```
$ omnitrace-avail -G $HOME/.omnitrace.cfg --all
```

Modify the config file \$HOME/.omnitrace.cfg as desired to enable and change settings:

```
<snip>
OMNITRACE_USE_PERFETTO = true
OMNITRACE_USE_TIMEMORY = true
OMNITRACE_USE_SAMPLING = false
OMNITRACE_USE_ROCTRACER = true
OMNITRACE_USE_ROCM_SMI = true
OMNITRACE_USE_KOKKOSP = false
OMNITRACE_USE_CAUSAL = false
OMNITRACE_USE_MPIP = true
OMNITRACE_USE_PID = true
OMNITRACE_USE_ROCPROFILER = true
OMNITRACE_USE_ROCTX = true
<snip>
```

## Contents of the config file

Declare which config file to use by setting the environment:

```
$ export OMNITRACE_CONFIG_FILE=/path-to/.omnitrace.cfg
```

# **Dynamic Instrumentation**

Runtime Instrumentation



# Dynamic Instrumentation – Jacobi Example

Clone jacobi example:

```
$ git clone https://github.com/amd/HPCTrainingExamples.git
$ cd HPCTrainingExamples/HIP/jacobi
```

Requires ROCm and MPI install, compile:

```
$ make
```

Run the non-instrumented code on a single GPU as:

```
$ time mpirun -np 1 ./Jacobi_hip -g 1 1
real    0m2.115s
```

## Dynamic instrumentation

```
$ time mpirun -np 1 omnitrace-instrument -- ./Jacobi_hip
-g 1 1
real 1m45.741s
```

Extra time is the overhead of dyninst reading every binary that is loaded, not overhead of omnitrace during app execution

```
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libutil-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libz.so.1.2.11'...
[omnitrace][exe] [internal] binary info processing required 0.322 sec and 70.724 MB
[omnitrace][exe] Processing 72 modules...
[omnitrace][exe] Processing 72 modules... Done (0.101 sec, 12.084 MB)
[omnitrace][exe] Found 'MPI_Init' in '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/Jacobi_hip'. Enabling MPI support
[omnitrace][exe] Finding instrumentation functions...
[omnitrace][exe] 2 instrumented funcs in ../../orte/orted/orted_submit.c
[omnitrace][exe] 1 instrumented funcs in libamdg_comgr.so.2.4.50403
[omnitrace][exe] 15 instrumented funcs in libamdhip64.so.5.4.50403
[omnitrace][exe] 1 instrumented funcs in libm-2.28.so
[omnitrace][exe] 10 instrumented funcs in libmpi.so.40.20.3
[omnitrace][exe] 8 instrumented funcs in libopen-pal.so.40.20.3
[omnitrace][exe] 17 instrumented funcs in libopen-rte.so.40.20.3
[omnitrace][exe] 2 instrumented funcs in libtinfo.so.5.9
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/available.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/available.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/instrumented.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/instrumented.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/excluded.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/excluded.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/overlapping.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_hip-output/2023-03-14_17.24/instrumentation/overlapping.txt'... Done
[omnitrace][exe] Executing...
[omnitrace][1649192][omnitrace_init_tooling] Instrumentation mode: Trace
```



# Dynamic Instrumentation – Jacobi Example

Clone jacobi example:

```
$ git clone https://github.com/amd/HPCTrainingExamples.git
$ cd HPCTrainingExamples/HIP/jacobi
```

Requires ROCm and MPI install, compile:

```
$ make
```

Run the non-instrumented code on a single GPU as:

```
$ time mpirun -np 1 ./Jacobi_hip -g 1 1
real    0m2.115s
```

## Dynamic instrumentation

```
$ time mpirun -np 1 omnitrace-instrument -- ./Jacobi_hip
-g 1 1
real 1m45.742s
```

Available functions to instrument:

```
$ mpirun -np 1 omnitrace-instrument -v 1 --simulate --
print-available functions -- ./Jacobi_hip -g 1 1
```

Here, -v gives a verbose output from omnitrace

The simulate flag does not run the executable, but only demonstrates the available functions

```
[available] HaloExchange.cpp:
[available] [HaloExchange.cold.21][14]
[available] [HaloExchange][1267]
[available] [_GLOBAL__sub_I_HaloExchange.cpp][8]

[available] Input.cpp:
[available] [ExtractNumber][19]
[available] [FindAndClearArgument][38]
[available] [ParseCommandLineArguments][206]
[available] [PrintUsage][12]

[available] JacobiIteration.cpp:
[available] [JacobiIteration][71]

[available] JacobiMain.cpp:
[available] [main.cold.0][5]
[available] [main][35]

[available] JacobiRun.cpp:
[available] [Jacobi_t::Run][155]

[available] JacobiSetup.cpp:
[available] [FormatNumber][53]
[available] [Jacobi_t::ApplyTopology][234]
[available] [Jacobi_t::CreateMesh][459]
[available] [Jacobi_t::InitializeData][552]
[available] [Jacobi_t::Jacobi_t.cold.30][15]
[available] [Jacobi_t::Jacobi_t][1043]
[available] [Jacobi_t::PrintResults][107]
[available] [Jacobi_t::~Jacobi_t][167]
[available] [PrintPerfCounter][34]
[available] [_GLOBAL__sub_I_JacobiSetup.cpp][8]
[available] [std::__cxx11::basic_stringbuf<char, std::char_traits<char>, std::allocator<char>>::~basic_stringbuf][16]
[available] [std::__cxx11::basic_stringbuf<char, std::char_traits<char>, std::allocator<char>>::~basic_stringbuf][18]
```

Functions found in each module detected by omnitrace

# Dynamic Instrumentation – Jacobi Example

Clone jacobi example:

```
$ git clone https://github.com/amd/HPCTrainingExamples.git
$ cd HPCTrainingExamples/HIP/jacobi
```

Requires ROCm and MPI install, compile:

```
$ make
```

Run the non-instrumented code on a single GPU as:

```
$ time mpirun -np 1 ./Jacobi_hip -g 1 1
real    0m2.115s
```

## Dynamic instrumentation

```
$ time mpirun -np 1 omnitrace-instrument -- ./Jacobi_hip
-g 1 1

real 1m45.742s
```

Available functions to instrument:

```
$ mpirun -np 1 omnitrace-instrument -v 1 --simulate --
print-available functions -- ./Jacobi_hip -g 1 1
```

Custom include/exclude functions\* with -I or -E, resp. For e.g:

```
$ mpirun -np 1 omnitrace-instrument -v 1 -I
'Jacobi_t::Run' 'JacobiIteration' -- ./Jacobi_hip -g 1 1
```

Include two functions to instrument

```
[omnitrace][exe] [internal] parsing library: '/opt/rocm-5.4.3/lib/librocsmi64.so.5.0.50403'...
[omnitrace][exe] [internal] parsing library: '/opt/rocm-5.4.3/lib/librocmtools.so.1.5.0'...
[omnitrace][exe] [internal] parsing library: '/opt/rocm-5.4.3/lib/librocprofiler64.so.1.0.50403'...
[omnitrace][exe] [internal] parsing library: '/opt/rocm-5.4.3/lib/libroctracer64.so.4.1.0'...
[omnitrace][exe] [internal] parsing library: '/opt/rocm-5.4.3/lib/libroctx64.so.4.1.0'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/libomnitrace-dl.so.1.8.0'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/libomnitrace-rt.so.11.0.1'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/libomnitrace-user.so.1.8.0'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libcommon.so.11.0.1'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libbdw-0.182.so'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libelf-0.182.so'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libgotcha.so.2.0.2'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libpfm.so.4.11.1'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libtbb.so.2'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libtbbmalloc_proxy.so.2'...
[omnitrace][exe] [internal] parsing library: '/share/contrib-modules/omnitrace/omnitrace1.8.0/lib/omnitrace/libunwind.so.99.0.0'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/ld-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libBrokenLocale-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/liblbanl-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libc-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libcrypt.so.1.1.0'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libdl-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libgcc_s-8-20210514.so.1'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_compat-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_dns-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_files-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libpthread-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libresolv-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/librt-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libstdc++.so.6.0.25'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libthread_db-1.0.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libutil-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libz.so.1.2.11'...
[omnitrace][exe] [internal] binary info processing required 0.257 sec and 66.740 MB
[omnitrace][exe] Processing 72 modules...
[omnitrace][exe] Processing 72 modules... Done (0.089 sec, 11.080 MB)
[omnitrace][exe] Found 'MPI_Init' in '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/Jacobi_hip'. Enabling MPI support...
[omnitrace][exe] Finding instrumentation functions...
[omnitrace][exe]   1 instrumented funcs in JacobiIteration.cpp
[omnitrace][exe]   1 instrumented funcs in JacobiRun.cpp
[omnitrace][exe]   1 instrumented funcs in Jacobi_ hip
[omnitrace][exe]   1 instrumented funcs in libamdhpl64.so.5.4.50403
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_12.40/instrumentation/available.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_12.40/instrumentation/available.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_12.40/instrumentation/instrumented.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_12.40/instrumentation/instrumented.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_12.40/instrumentation/excluded.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_12.40/instrumentation/excluded.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_12.40/instrumentation/instrumentation.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_12.40/instrumentation/instrumentation_overlapping.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_12.40/instrumentation/instrumentation_overlapping.txt'... Done
```

Only these two functions  
are shown to be  
instrumented

# Dynamic Instrumentation

Binary Rewrite



# Binary Rewrite – Jacobi Example

## Binary Rewrite

```
$ omnitrace-instrument [omnitrace-options] -o <new-name-of-exec> -- <CMD> <ARGS>
```

Generating a new executable/library with instrumentation built-in:

```
$ omnitrace-instrument -o Jacobi_ hip.inst -- ./Jacobi_ hip
```

This new binary will have instrumented functions

## Subroutine Instrumentation

Default instrumentation is main function and functions of 1024 instructions and more (for CPU)

To instrument routines with 50 or more cycles, add option "-i 50" (more overhead)

```
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libgcc_s-8-20210514.so.1'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_compat-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_dns-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libnss_files-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libpthread-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libresolv-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/librt-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libstdc++.so.6.0.25'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libthread_db-1.0.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libutil-2.28.so'...
[omnitrace][exe] [internal] parsing library: '/usr/lib64/libz.so.1.2.11'...
[omnitrace][exe] [internal] binary info processing required 0.666 sec and 110.500 MB
[omnitrace][exe] Processing 9 modules...
[omnitrace][exe] Processing 9 modules... Done (0.001 sec, 0.000 MB)
[omnitrace][exe] Found 'MPI_Init' in '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/Jacobi_ hip'. Enabling MPI support...
[omnitrace][exe] Finding instrumentation functions...
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip.inst-output/2023-03-15_12.57/instrumentation/available.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip.inst-output/2023-03-15_12.57/instrumentation/available.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip.inst-output/2023-03-15_12.57/instrumentation/instrumented.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip.inst-output/2023-03-15_12.57/instrumentation/instrumented.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip.inst-output/2023-03-15_12.57/instrumentation/excluded.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip.inst-output/2023-03-15_12.57/instrumentation/excluded.txt'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip.inst-output/2023-03-15_12.57/instrumentation/overlapping.json'... Done
[omnitrace][exe] Outputting 'omnitrace-Jacobi_ hip.inst-output/2023-03-15_12.57/instrumentation/overlapping.txt'... Done
[omnitrace][exe] The instrumented executable image is stored in '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/Jacobi_ hip.inst'
[omnitrace][exe] Getting linked libraries for /home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/Jacobi_ hip...
[omnitrace][exe] Consider instrumenting the relevant libraries...
[omnitrace][exe] /lib64/libgcc_s.so.1
[omnitrace][exe] /lib64/libpthread.so.0
[omnitrace][exe] /lib64/libm.so.6
[omnitrace][exe] /lib64/librt.so.1
[omnitrace][exe] /home/ssitaram/cp2k-hip/libs/install/openmpi/lib/libmpi.so.40
[omnitrace][exe] /opt/rocm-5.4.3/lib/librocrtx64.so.4
[omnitrace][exe] /opt/rocm-5.4.3/lib/libroctracer64.so.4
[omnitrace][exe] /opt/rocm-5.4.3/hip/lib/libamdhip64.so.5
[omnitrace][exe] /lib64/libstdc++.so.6
[omnitrace][exe] /lib64/libc.so.6
[omnitrace][exe] /lib64/ld-linux-x86-64.so.2
```

Path to new instrumented binary

# Binary Rewrite – Jacobi Example

## Binary Rewrite

```
$ omnitrace-instrument [omnitrace-options] -o <new-name-of-exec> -- <CMD> <ARGS>
```

Generating a new /library with instrumentation built-in:

```
$ omnitrace-instrument -o Jacobi_ hip.inst -- ./Jacobi_ hip
```

Run the instrumented binary:

```
$ mpirun -np 1 omnitrace-run -- ./Jacobi_ hip.inst -g 1 1
```

## subroutine instrumentation

Default instrumentation is main function and functions of 1024 instructions and more (for CPU)

To instrument routines with 50 or more cycles, add option "-i 50" (more overhead)

Binary rewrite is recommended for runs with multiple ranks as omnitrace produces separate output files for each rank

[omnitrace][3624331][omnitrace\_init\_tooling] Instrumentation mode: Trace



```
omnitrace v1.8.0
[953.765] perfetto.cc:58656 Configured tracing session 1, #sources:1, duration:0 ms, #buffers:1, total buffer size:1024000 KB, total sessions:1, uid:0 session name: ""
Topology size: 1 x 1
Local domain size (current node): 4096 x 4096
[omnitrace][0][pid=3624331] MPI rank: 0 (0), MPI size: 1 (1)
Global domain size (all nodes): 4096 x 4096
Rank 0 selecting device 0 on host TheraC60
Starting Jacobi run.
Iteration: 0 - Residual: 0.022108
Iteration: 100 - Residual: 0.000625
Iteration: 200 - Residual: 0.000371
Iteration: 300 - Residual: 0.000274
Iteration: 400 - Residual: 0.000221
Iteration: 500 - Residual: 0.000187
Iteration: 600 - Residual: 0.000163
Iteration: 700 - Residual: 0.000145
Iteration: 800 - Residual: 0.000131
Iteration: 900 - Residual: 0.000120
Iteration: 1000 - Residual: 0.000111
Stopped after 1000 iterations with residue 0.000111
Total Jacobi run time: 1.5470 sec.
Measured lattice updates: 10.84 GLU/s (total), 10.84 GLU/s (per process)
Measured FLOPS: 184.36 GFLOPS (total), 184.36 GFLOPS (per process)
Measured device bandwidth: 1.04 TB/s (total), 1.04 TB/s (per process)
```

Generates traces for application run

```
[omnitrace][3624331][0][omnitrace_finalize] finalizing...
[omnitrace][3624331][0][omnitrace_finalize]
[omnitrace][3624331][0][omnitrace_finalize] omnitrace/process/3624331 : 2.364423 sec wall_clock, 645.964 MB peak_rss, 388.739 MB page_rss, 4.330000 sec cpu_clock, 183.1 % cpu_util [laps: 1]
[omnitrace][3624331][0][omnitrace_finalize] omnitrace/process/3624331/thread/0 : 2.355893 sec wall_clock, 1.293230 sec thread_cpu_clock, 54.9 % thread_cpu_util, 645.964 MB peak_rss [laps: 1]
[omnitrace][3624331][0][omnitrace_finalize] omnitrace/process/3624331/thread/1 : 2.345084 sec wall_clock, 0.000261 sec thread_cpu_clock, 0.0 % thread_cpu_util, 642.676 MB peak_rss [laps: 1]
[omnitrace][3624331][0][omnitrace_finalize]
[omnitrace][3624331][0][omnitrace_finalize] Finalizing perfetto...
```

# List of Instrumented GPU Functions

```
$ cat omnitrace-Jacobi_hip.inst-output/2023-03-15_13.57/roctracer-0.txt
```

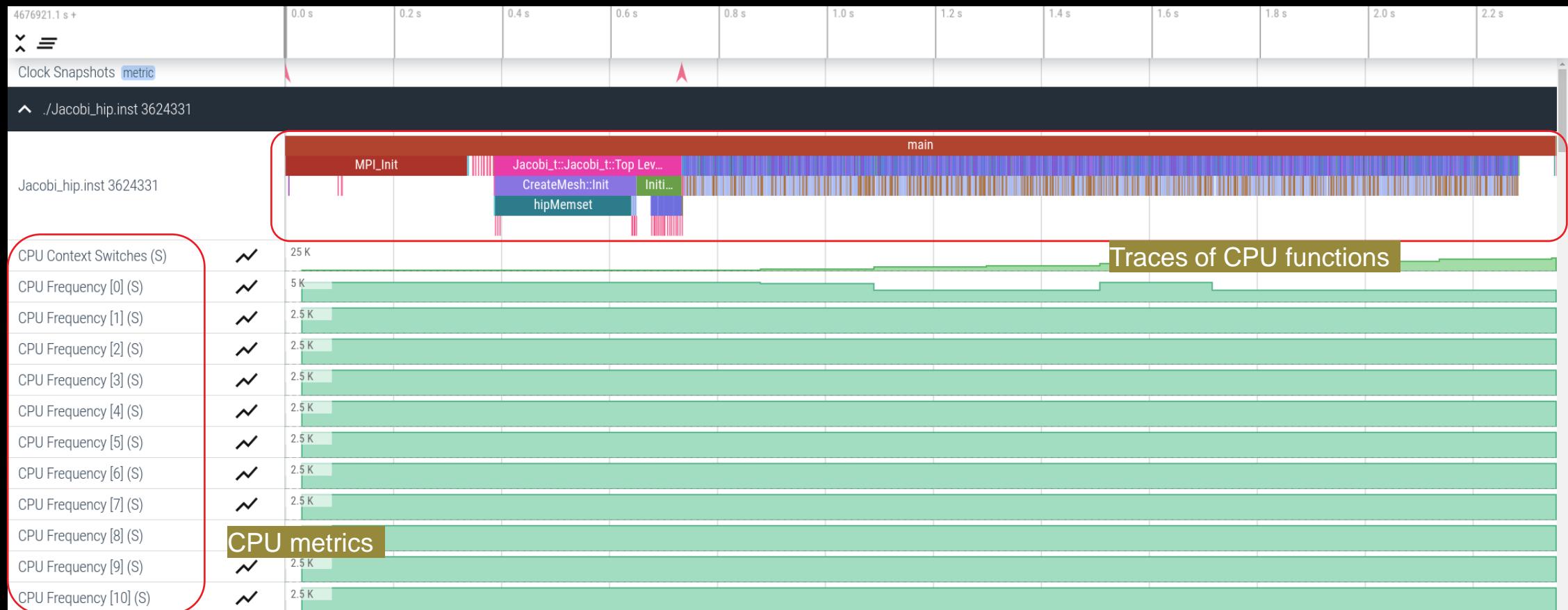
ROCM TRACER (ACTIVITY API)							
LABEL	COUNT	DEPTH	METRIC	UNITS	SUM	MEAN	% SELF
>>> pthread_create	1	0	roctracer	sec	0.000353	0.000353	0.0
>>>  _start_thread	1	1	roctracer	sec	2.344864	2.344864	100.0
>>> hipInit	1	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipGetDeviceCount	1	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipSetDevice	1	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipHostMalloc	3	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipMalloc	7	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipMemset	1	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipStreamCreate	2	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipMemcpy	1005	0	roctracer	sec	0.000000	0.000000	0.0
>>>  _LocalLaplacianKernel(int, int, int, double, double const*, double*)	999	1	roctracer	sec	0.279368	0.000280	100.0
>>>  _HaloLaplacianKernel(int, int, int, double, double const*, double const*, double const*, double*)	990	1	roctracer	sec	0.014761	0.000015	100.0
>>>  _JacobiIterationKernel(int, double, double, double const*, double const*, double const*, double*)	959	1	roctracer	sec	0.531156	0.000554	100.0
>>>  _NormKernel1(int, double, double, double const*, double*)	997	1	roctracer	sec	0.430196	0.000431	100.0
>>>  _NormKernel2(int, double const*, double*)	999	1	roctracer	sec	0.004342	0.000004	100.0
>>> hipEventCreate	2	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipLaunchKernel	5002	0	roctracer	sec	0.000000	0.000000	0.0
>>>  _JacobiIterationKernel(int, double, double, double const*, double const*, double const*, double*)	1	1	roctracer	sec	0.000552	0.000552	100.0
>>>  _NormKernel1(int, double, double, double const*, double*)	1	1	roctracer	sec	0.000425	0.000425	100.0
>>> hipDeviceSynchronize	1001	0	roctracer	sec	0.000000	0.000000	0.0
>>>  _NormKernel1(int, double, double, double const*, double*)	2	1	roctracer	sec	0.000850	0.000425	100.0
>>>  _NormKernel2(int, double const*, double*)	1	1	roctracer	sec	0.000004	0.000004	100.0
>>>  _HaloLaplacianKernel(int, int, int, double, double const*, double const*, double const*, double*)	9	1	roctracer	sec	0.000133	0.000015	100.0
>>>  _JacobiIterationKernel(int, double, double, double const*, double const*, double const*, double*)	40	1	roctracer	sec	0.022204	0.000555	100.0
>>>  _LocalLaplacianKernel(int, int, int, double, double const*, double*)	1	1	roctracer	sec	0.000281	0.000281	100.0
>>> hipEventRecord	2000	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipStreamSynchronize	2000	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipEventElapsedTime	1000	0	roctracer	sec	0.000000	0.000000	0.0
>>>  _HaloLaplacianKernel(int, int, int, double, double const*, double const*, double*)	1	1	roctracer	sec	0.000015	0.000015	100.0
>>> hipFree	4	0	roctracer	sec	0.000000	0.000000	0.0
>>> hipHostFree	2	0	roctracer	sec	0.000000	0.000000	0.0

Roctracer-0.txt shows duration of  
HIP API calls and GPU kernels

# Visualizing Trace

## Use Perfetto

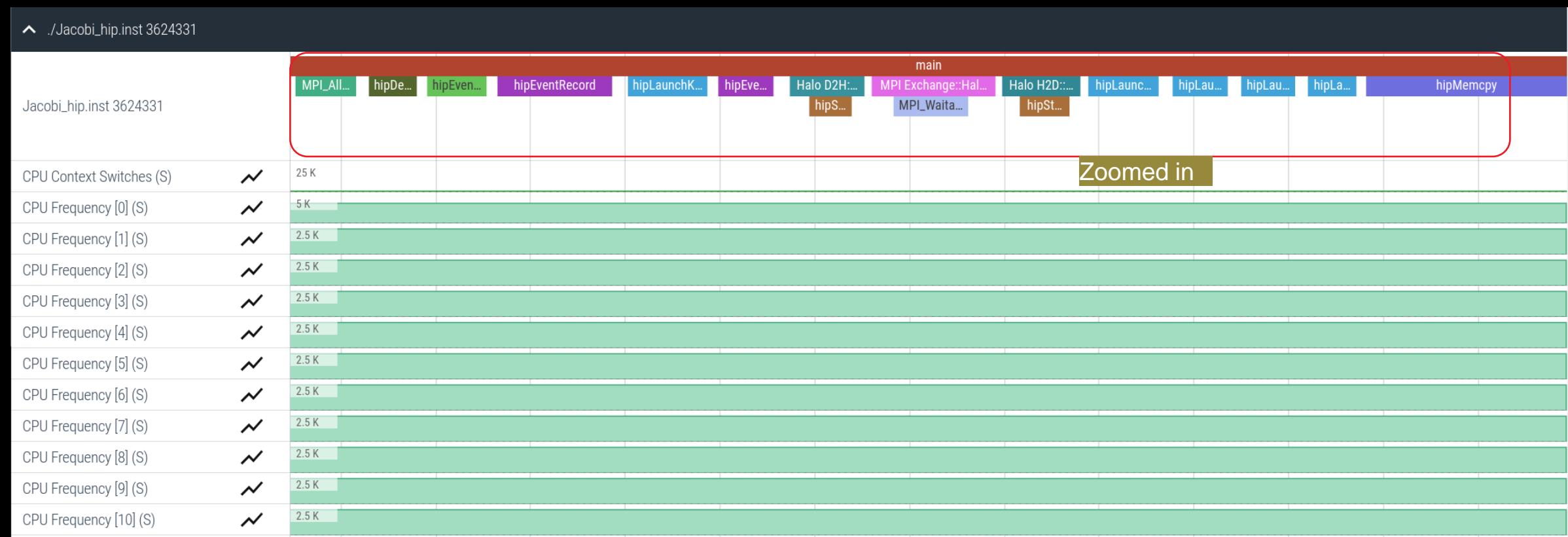
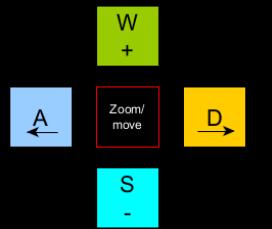
Copy perfetto-trace-0.proto to your laptop, go to <https://ui.perfetto.dev/>, Click "Open trace file", select perfetto-trace-0.proto



# Visualizing Trace

Use Perfetto

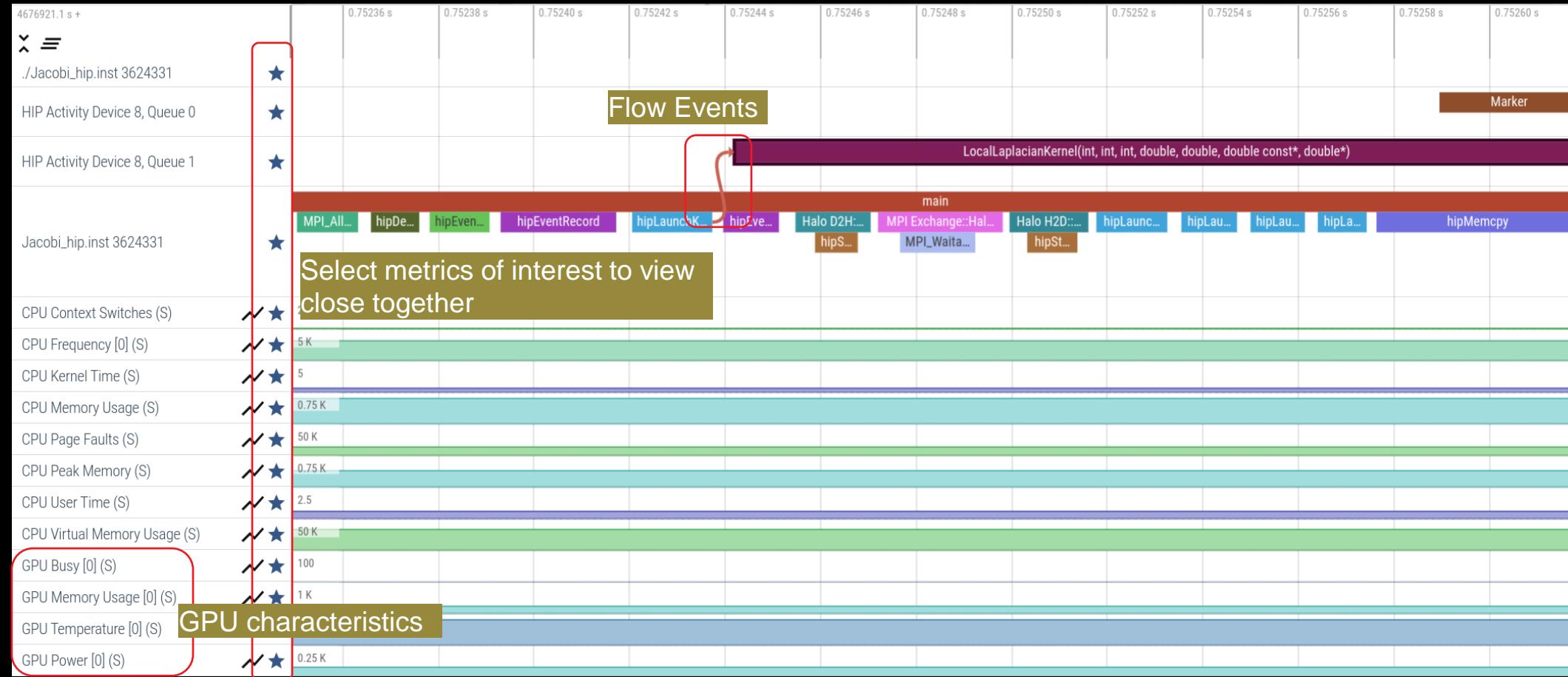
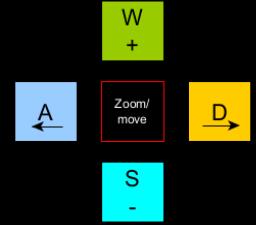
Zoom in to investigate regions of interest



# Visualizing Trace

Use Perfetto

Zoom in to investigate regions of interest



# Hardware Counters



# Hardware Counters – List All

```
$ mpirun -np 1 omnitrace-avail --all
```

Components, Categories

COMPONENT	AVAILABLE	VALUE_TYPE	STRING_IDS	FILENAME	DESCRIPTION	CATEGORY
allinea_map	false	void	"allinea", "allinea_map", "forge"		Controls the AllineaMAP sampler.	category::external, os::supports_linux, t...
caliper_marker	false	void	"cali", "caliper", "caliper_marker"		Generic forwarding of markers to Caliper ...	category::external, os::supports_unix, tp...
caliper_config	false	void	"caliper_config"		Caliper configuration manager.	category::external, os::supports_unix, tp...
caliper_loop_marker	false	void	"caliper_loop_marker"		Variant of caliper_marker with support fo...	category::external, os::supports_unix, tp...
cpu_clock	true	long	"cpu_clock"	cpu_clock	Total CPU time spent in both user- and ke...	project::timemory, category::timing, os::...
cpu_util	true	std::pair<long, long>	"cpu_util", "cpu_utilization"	cpu_util	Percentage of CPU-clock time divided by w...	project::timemory, category::timing, os::...
craypat_counters	false	std::vector<unsigned long, std::allocato...	"craypat_counters"	craypat_counters	Names and value of any counter events tha...	category::external, os::supports_linux, t...

ENVIRONMENT VARIABLE	VALUE	DATA TYPE	DESCRIPTION	CATEGORIES
OMNITRACE_CAUSAL_BINARY_EXCLUDE	%MAIN%	string	Excludes binaries matching the list of pr...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_BINARY_SCOPE	0	string	Limits causal experiments to the binaries...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_DELAY	0	double	Length of time to wait (in seconds) before...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_DURATION	0	double	Length of time to perform causal experime...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_FUNCTION_EXCLUDE		string	Excludes functions matching the list of p...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_FUNCTION_SCOPE		string	List of <function> regex entries for caus...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_RANDOM_SEED	0	unsigned long	Seed for random number generator which se...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_SOURCE_EXCLUDE		string	Excludes source files or source file + li...	analysis, causal, custom, libomnitrace, o...
OMNITRACE_CAUSAL_SOURCE_SCOPE		string	Limits causal experiments to the source f...	analysis, causal, custom, libomnitrace, o...

Environment Variables

HARDWARE COUNTER	AVAILABLE	DESCRIPTION
CPU		
PAPI_L1_DCM	true	Level 1 data cache misses
PAPI_L1_ICM	false	Level 1 instruction cache misses
PAPI_L2_DCM	true	Level 2 data cache misses
PAPI_L2_ICM	true	Level 2 instruction cache misses
PAPI_L3_DCM	false	Level 3 data cache misses
PAPI_L3_ICM	false	Level 3 instruction cache misses
PAPI_L1_TCM		Level 1 cache misses

CPU Hardware Counters

perf::CYCLES	true	PERF_COUNT_HW_CPU_CYCLES
perf::CYCLES:u=0	true	perf::CYCLES + monitor at user level
perf::CYCLES:k=0	true	perf::CYCLES + monitor at kernel level
perf::CYCLES:h=0	true	perf::CYCLES + monitor at hypervisor level
perf::CYCLES:period=0	true	perf::CYCLES + sampling period
perf::CYCLES:freq=0	true	perf::CYCLES + sampling frequency (Hz)
perf::CYCLES:precise=0	true	perf::CYCLES + precise event sampling
perf::CYCLES:excl=0	true	perf::CYCLES + exclusive access

TCC_NORMAL_WRITEBACK_sum:device=0	true	Number of writebacks due to requests that...
TCC_ALL_TC_OP_WB_WRITEBACK_sum:device=0	true	Number of writebacks due to all TC_OP wri...
TCC_NORMAL_EVICT_sum:device=0	true	Number of evictions due to requests that ...
TCC_ALL_TC_OP_INV_EVICT_sum:device=0	true	Number of evictions due to all TC_OP inva...
TCC_EA_RDREQ_DRAM_sum:device=0	true	Number of TCC/EA read requests (either 32...)
TCC_EA_WRREQ_DRAM_sum:device=0	true	Number of TCC/EA write requests (either 3...
FETCH_SIZE:device=0	true	The total kilobytes fetched from the vide...
WRITE_SIZE:device=0	true	The total kilobytes written to the video ...
WRITE_REQ_32B:device=0	true	The total number of 32-byte effective mem...
GPUBusy:device=0	true	The percentage of time GPU was busy.
Wavefronts:device=0		Total wavefronts.
VALUInsts:device=0		The average number of vector ALU instruct...
SALUInsts:device=0		The average number of scalar ALU instruct...
SFetchInsts:device=0	true	The average number of scalar fetch instru...
GDSInsts:device=0	true	The average number of GDS read or GDS wri...
MemUnitBusy:device=0	true	The percentage of GPUtime the memory unit...
ALUSTalledByLDS:device=0	true	The percentage of GPUtime ALU units are s...

GPU Hardware Counters

A very small subset of the counters shown here

# 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 GPUMTime 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
L2CacheHit	The percentage of fetch, write, atomic, and other instructions that hit the data in L2 cache
MemUnitBusy	The percentage of GPUMTime the memory unit is active. The result includes the stall time
MemUnitStalled	The percentage of GPUMTime the memory unit is stalled
WriteUnitStalled	The percentage of GPUMTime the write unit is stalled

Full list at: <https://github.com/ROCM-Developer-Tools/rocprofiler/blob/amd-master/test/tool/metrics.xml>

## Modify config file

Create a config file in \$HOME:

```
$ omnitrace-avail -G $HOME/.omnitrace.cfg
```

Modify the config file \$HOME/.omnitrace.cfg to add desired metrics and for concerned GPU#ID:

```
...
OMNITRACE_ROCM_EVENTS = GPUBusy:device=0,
Wavefronts:device=0, MemUnitBusy:device=0
...
```

To profile desired metrics for all participating GPUs:

```
...
OMNITRACE_ROCM_EVENTS = GPUBusy, Wavefronts,
MemUnitBusy
...
```

# Execution with Hardware Counters

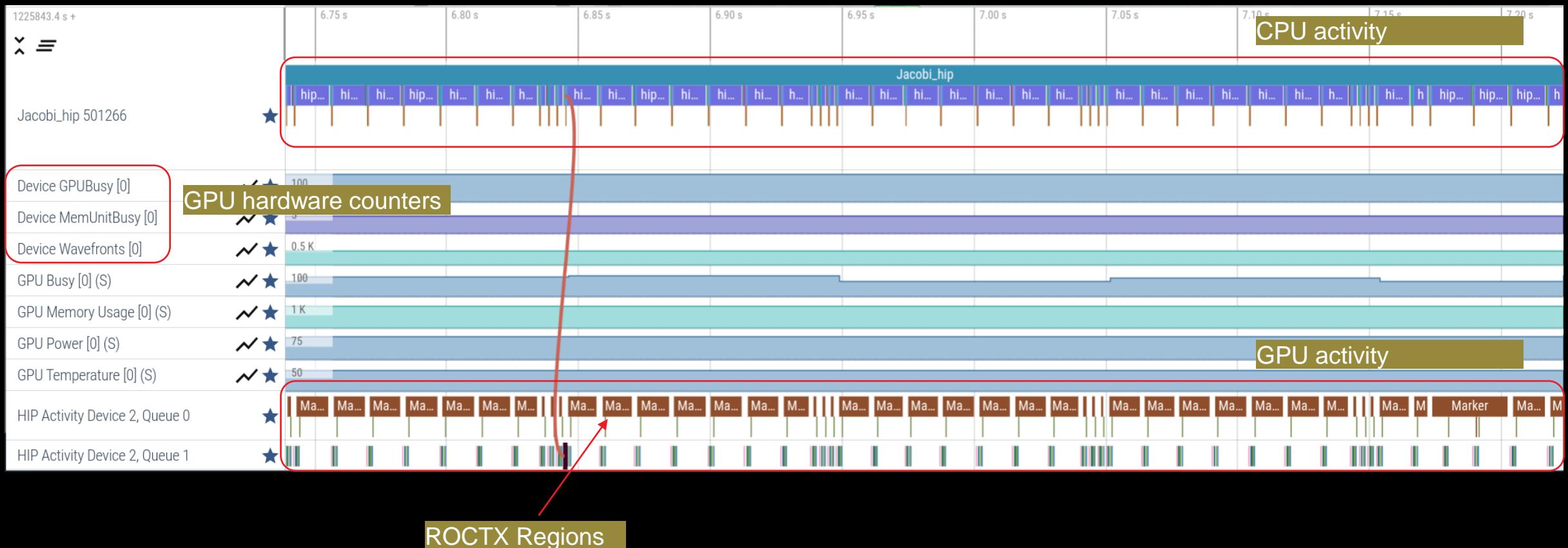
(after modifying cfg file to set up OMNITRACE\_ROCM\_EVENTS with GPU metrics)

```
$ mpirun -np 1 omnitrace-run -- ./Jacobi_ hip.inst -g 1 1
```

```
[omnitrace][501266][0][omnitrace_finalize] Finalizing perfetto...
[omnitrace][501266][perfetto]> Outputting '/shared/prod/home/ssitaram/HPCTrainingExamples/HIP/jacobi/omnitrace-Jacobi_ hip-output/2023-03-15_22.57/perfetto-trace-0.proto' (11
.. Done
[omnitrace][501266][rocprof-device-0-GPUBusy]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/rocprof-device-0-GPUBusy-0.json'
[omnitrace][501266][rocprof-device-0-GPUBusy]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/rocprof-device-0-GPUBusy-0.txt'
[omnitrace][501266][rocprof-device-0-Wavefronts]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/rocprof-device-0-Wavefronts-0.json'
[omnitrace][501266][rocprof-device-0-Wavefronts]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/rocprof-device-0-Wavefronts-0.txt'
[omnitrace][501266][rocprof-device-0-MemUnitBusy]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/rocprof-device-0-MemUnitBusy-0.json'
[omnitrace][501266][rocprof-device-0-MemUnitBusy]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/rocprof-device-0-MemUnitBusy-0.txt'
[omnitrace][501266][trip_count]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/trip_count-0.json'
[omnitrace][501266][trip_count]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/trip_count-0.txt'
[omnitrace][501266][wall_clock]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/wall_clock-0.json'
[omnitrace][501266][wall_clock]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/wall_clock-0.txt'
[omnitrace][501266][roctracer]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/roctracer-0.json'
[omnitrace][501266][roctracer]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/roctracer-0.txt'
[omnitrace][501266][sampling_percent]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_percent-0.json'
[omnitrace][501266][sampling_percent]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_percent-0.txt'
[omnitrace][501266][sampling_cpu_clock]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_cpu_clock-0.json'
[omnitrace][501266][sampling_cpu_clock]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_cpu_clock-0.txt'
[omnitrace][501266][sampling_wall_clock]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_wall_clock-0.json'
[omnitrace][501266][sampling_wall_clock]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_wall_clock-0.txt'
[omnitrace][501266][sampling_gpu_memory_usage]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_gpu_memory_usage-0.json'
[omnitrace][501266][sampling_gpu_memory_usage]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_gpu_memory_usage-0.txt'
[omnitrace][501266][sampling_gpu_power]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_gpu_power-0.json'
[omnitrace][501266][sampling_gpu_power]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_gpu_power-0.txt'
[omnitrace][501266][sampling_gpu_temperature]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_gpu_temperature-0.json'
[omnitrace][501266][sampling_gpu_temperature]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_gpu_temperature-0.txt'
[omnitrace][501266][sampling_gpu_busy_percent]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_gpu_busy_percent-0.json'
[omnitrace][501266][sampling_gpu_busy_percent]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/sampling_gpu_busy_percent-0.txt'
[omnitrace][501266][metadata]> Outputting 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/metadata-0.json' and 'omnitrace-Jacobi_ hip-output/2023-03-15_22.57/functions-0.json'
[omnitrace][501266][0][omnitrace_finalize] Finalized: 31.657272 sec wall_clock, 0.000 MB peak_rss, 179.700 MB page_rss, 29.950000 sec cpu_clock, 94.6 % cpu_util
[889.832] perfetto.cc:60129 Tracing session 1 ended, total sessions:0
```

GPU hardware counters

# Visualization with Hardware Counters



# Tracing Multiple Ranks



# Profiling Multiple MPI Ranks – Jacobi Example

## Binary Rewrite

Generating a new /library with instrumentation built-in:

```
$ omnitrace-instrument -o Jacobi_hip.inst --  
./Jacobi_hip
```

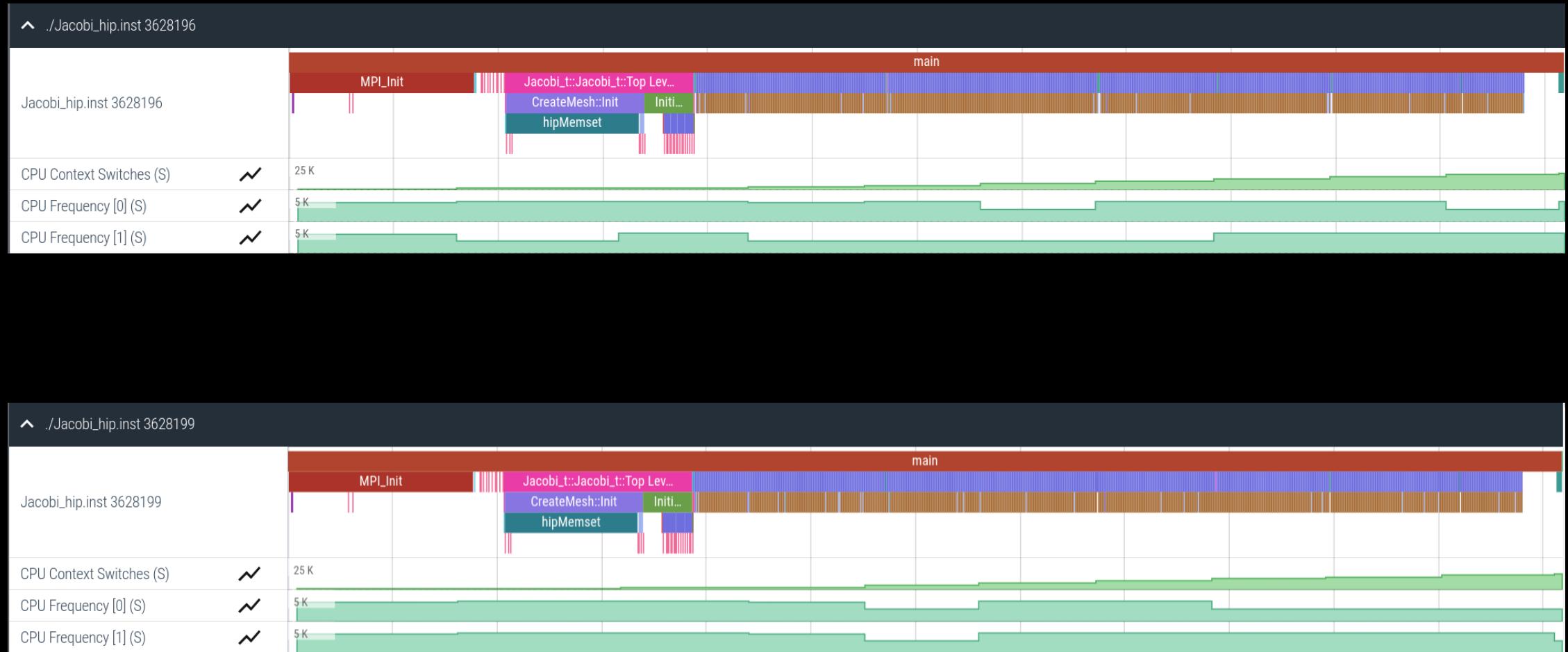
Run the instrumented binary with 2 ranks:

```
$ mpirun -np 2 omnitrace-run --./Jacobi_hip.inst -g  
2 1
```

```
[omnitrace][3628199][perfetto]> Outputting '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/perfetto-trace-1.proto'  
[perfetto]> Outputting '/home/ssitaram/git/HPCTrainingExamples/HIP/jacobi/omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/perfetto-trace-0.proto' (7856.71 KB / 7.86 M  
  
[omnitrace][3628199][wall_clock]> Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/wall_clock-1.json'  
[omnitrace][3628196][wall_clock]> Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/wall_clock-0.json'  
[omnitrace][3628199][wall_clock]> Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/wall_clock-1.txt'  
[omnitrace][3628196][wall_clock]> Outputting 'omnitrace-Jacobi_hip.inst-output/2023-03-15_18.02/wall_clock-0.txt'
```

All output files are generated for each rank

# Visualizing Traces from Multiple Ranks - Separately

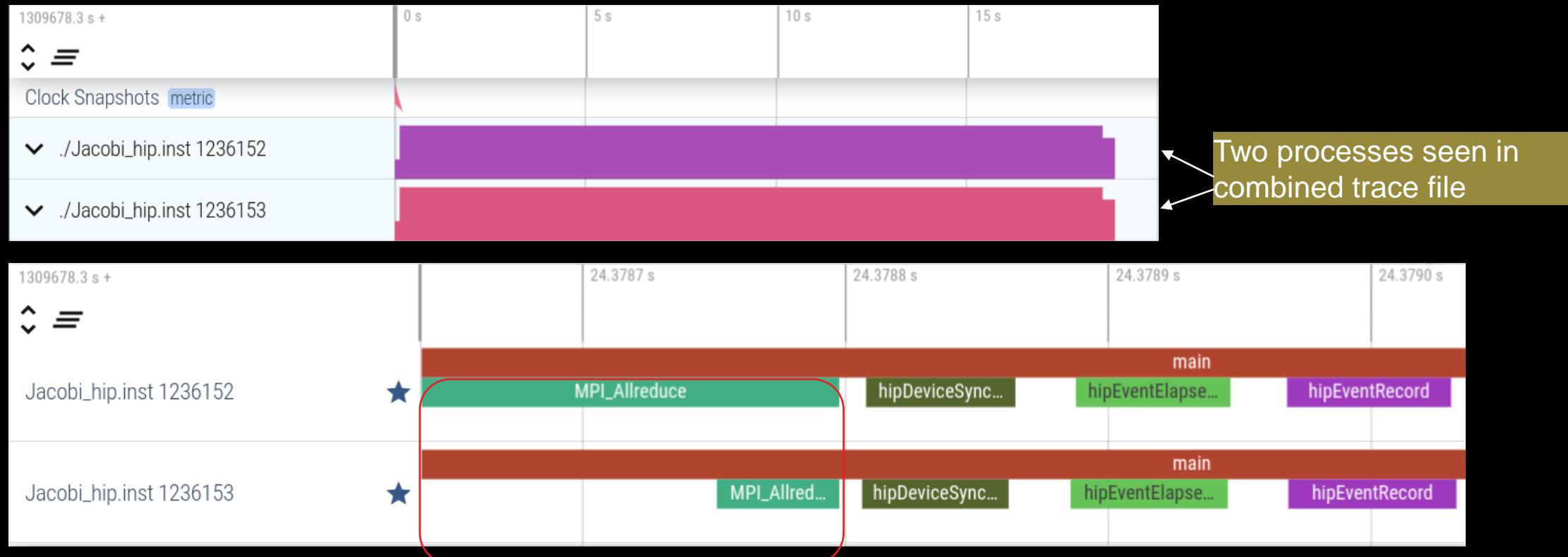


# Visualizing Traces from Multiple Ranks - Combined

## Merge Perfetto

Use the following command to merge and concatenate multiple traces:

```
$ cat perfetto-trace-0.proto perfetto-trace-1.proto > allprocesses.proto
```

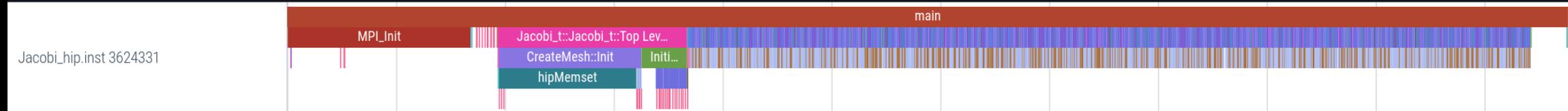


# Statistical Sampling

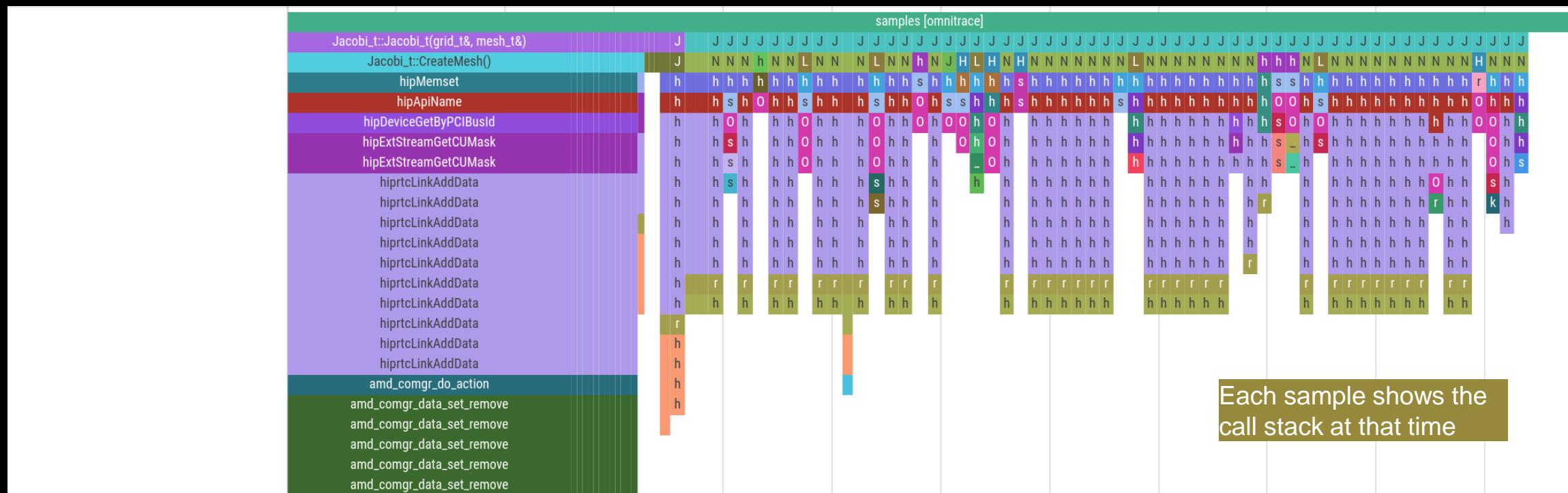


# Sampling Call-Stack (I)

OMNITRACE\_USE\_SAMPLING = false



OMNITRACE\_USE\_SAMPLING = true; OMNITRACE\_SAMPLING\_FREQ = 100 (100 samples per second)



Scroll down all the way in Perfetto to see the sampling output!

# Sampling Call-Stack (II)

Zoom in call-stack sampling

samples [omnitrace]											
Jacobi_...	Jacobi_t::Run()	Jacobi_t::Run()	Jacobi_t::Run()	Jacobi_t::Run()	Jacobi_t::Run()	Jacobi_t::Run()	Jacobi_t::Run()	Jacobi_t::Run()	Jacobi_t::Run()	Jacobi_t::Run()	Jacobi_t::Ru...
Norm(gr...	LocalLaplacian(gri...	Norm(grid_t&, me...	Norm(grid_t&, me...	hipEventRecord	Norm(grid_t&, me...	JacobIteration(...	HaloExchange(gri...	LocalLaplacian(g...	HaloExchange(grid_...	Norm(grid_t&...	
hipMemc...	hipLaunchKernel	hipMemcpy	hipMemcpy	std::basic_string<...	hipMemcpy	hipLaunchKernel	hipStreamSynchro...	hipLaunchKernel	hipStreamSynchroni...	hipMemcpy	
hipApiN...	std::basic_string<...	hipApiName	hipApiName	OnUnload	hipApiName	std::basic_strin...	std::basic_strin...	hipMemPoolGetAtt...	hipLaunchHostFunc	hipApiName	
hiprtcL...	OnUnload	hiprtcLinkAddData	hiprtcLinkAddData	OnUnload	hiprtcLinkAddData	OnUnload	OnUnload	hip_impl::hipLau...	OnUnload	hiprtcLinkAd...	
hiprtcL...	OnUnload	hiprtcLinkAddData	hiprtcLinkAddData		hiprtcLinkAddData			hipGetCmdName	OnUnload	hiprtcLinkAd...	
hiprtcL...	OnUnload	hiprtcLinkAddData	hiprtcLinkAddData		hiprtcLinkAddData			_hipGetPCH	OnUnload	hiprtcLinkAd...	
hiprtcL...	std::ostream& std::...	hiprtcLinkAddData	hiprtcLinkAddData		hiprtcLinkAddData			hipLpcGetEventHa...		hiprtcLinkAd...	
hiprtcL...	std::ostreambuf_it...	hiprtcLinkAddData	hiprtcLinkAddData		hiprtcLinkAddData					hiprtcLinkAd...	
hiprtcL...		hiprtcLinkAddData	hiprtcLinkAddData		hiprtcLinkAddData					hiprtcLinkAd...	
hiprtcL...		hiprtcLinkAddData	hiprtcLinkAddData		hiprtcLinkAddData					hiprtcLinkAd...	
roctrac...		roctracer_disabl...	roctracer_disabl...		roctracer_disabl...					roctracer_di...	
hsa_amd...		hsa_amd_image_ge...	hsa_amd_image_ge...		hsa_amd_image_ge...					hsa_amd_imag...	

Thread 0 (S) 3625610

Sampling data is annotated with (S)

## Other Features



# Kernel Durations

```
$ cat omnitrace-Jacobi_ hip.inst-output/2023-03-15_13.57/wall_clock-0.txt
```

If you do not see a wall\_clock.txt dumped by omnitrace, try modify the config file \$HOME/.omnitrace.cfg and enable OMNITRACE\_USE\_TIMEMORY:

```
...
OMNITRACE_USE_PERFETTO           = true
OMNITRACE_USE_TIMEMORY          = true
OMNITRACE_USE_SAMPLING           = false
...
```

															Durations
0>>>	_MPI_Allreduce														100.0
0>>>	_hipDeviceSynchronize														94.4
0>>>	_NormKernel1(int, double, double, double const*, double*)														100.0
0>>>	_NormKernel2(int, double const*, double*)														100.0
0>>>	_MPI_Barrier														100.0
0>>>	_hipEventRecord														100.0
0>>>	Halo D2H::Halo Exchange														0.0
0>>>	_hipStreamSynchronize														100.0
0>>>	MPI Exchange::Halo Exchange														0.0
0>>>	_MPI_Waitall														100.0
0>>>	Halo H2D::Halo Exchange														0.0
0>>>	_hipStreamSynchronize														100.0
0>>>	_hipLaunchKernel														100.0
0>>>	_mbind														100.0
0>>>	_hipMemcpy														99.9
0>>>	_LocalLaplacianKernel(int, int, int, double, double, double const*, double*)														100.0
0>>>	_HaloLaplacianKernel(int, int, int, double, double, double const*, double const*, double*)														100.0
0>>>	_JacobiIterationKernel(int, double, double, double const*, double const*, double*, double*)														100.0

Call Stack

Durations

Text file is for quick reference. JSON output is easy to script for and can be read by Hatchet, a Python package (<https://hatchet.readthedocs.io/en/latest/>)



# User API

Omnitrace provides an API to control the instrumentation

API Call	Description
<code>int omnitrace_user_start_trace(void)</code>	Enable tracing on this thread and all subsequently created threads
<code>int omnitrace_user_stop_trace(void)</code>	Disable tracing on this thread and all subsequently created threads
<code>int omnitrace_user_start_thread_trace(void)</code>	Enable tracing on this specific thread. Does not apply to subsequently created threads
<code>int omnitrace_user_stop_thread_trace(void)</code>	Disable tracing on this specific thread. Does not apply to subsequently created threads
<code>int omnitrace_user_push_region(void)</code>	Start user defined region
<code>int omnitrace_user_pop_region(void)</code>	End user defined region, FILO (first in last out) is expected

All the API calls: [https://amdr esearch.github.io/omnitrace/user\\_api.html](https://amdr esearch.github.io/omnitrace/user_api.html)

# OpenMP®

We use the example omnitrace/examples/openmp/

Build the code with CMake:

```
$ cmake -B build
```

Use the openmp-lu binary, which can be executed with:

```
$ export OMP_NUM_THREADS=4
$ srun -n 1 -c 4 ./openmp-lu
```

Create a new instrumented binary:

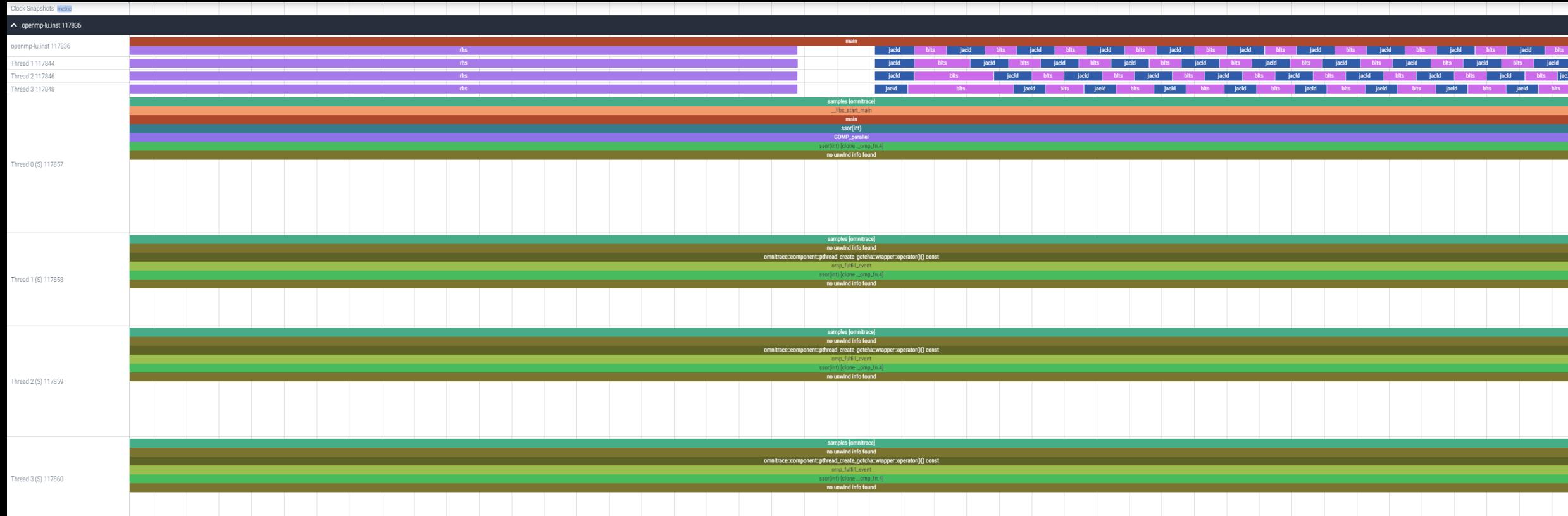
```
$ srun -n 1 omnitrace-instrument -o openmp-lu.inst --
./openmp-lu
```

Execute the new binary:

```
$ srun -n 1 -c 4 omnitrace-run -- ./openmp-lu.inst
```

REAL-CLOCK TIMER (I.E. WALL-CLOCK TIMER)											
LABEL	COUNT	DEPTH	METRIC	UNITS	SUM	MEAN	MIN	MAX	VAR	STDDEV	% SELF
0>>> main	1	0	wall_clock	sec	1.096702	1.096702	1.096702	1.096702	0.000000	0.000000	9.2
0>>>  _pthread_create	3	1	wall_clock	sec	0.002931	0.000977	0.000733	0.001420	0.000000	0.000385	0.0
3>>>  _start_thread	1	2	wall_clock	sec	2.451520	2.451520	2.451520	2.451520	0.000000	0.000000	57.7
3>>>  _erhs	1	3	wall_clock	sec	0.001906	0.001906	0.001906	0.001906	0.000000	0.000000	100.0
3>>>  _rhs	153	3	wall_clock	sec	0.229893	0.001503	0.001410	0.001893	0.000000	0.000116	100.0
3>>>  _jacld	3473	3	wall_clock	sec	0.170568	0.000049	0.000047	0.000135	0.000000	0.000005	100.0
3>>>  _blts	3473	3	wall_clock	sec	0.232512	0.000067	0.000040	0.000959	0.000000	0.000034	100.0
3>>>  _jacu	3473	3	wall_clock	sec	0.166229	0.000048	0.000046	0.000148	0.000000	0.000005	100.0
3>>>  _buts	3473	3	wall_clock	sec	0.236484	0.000068	0.000041	0.000391	0.000000	0.000031	100.0
2>>>  _start_thread	1	2	wall_clock	sec	2.452309	2.452309	2.452309	2.452309	0.000000	0.000000	58.1
2>>>  _erhs	1	3	wall_clock	sec	0.001895	0.001895	0.001895	0.001895	0.000000	0.000000	100.0
2>>>  _rhs	153	3	wall_clock	sec	0.229776	0.001502	0.001410	0.001893	0.000000	0.000115	100.0
2>>>  _jacld	3473	3	wall_clock	sec	0.204609	0.000059	0.000057	0.000152	0.000000	0.000006	100.0
2>>>  _blts	3473	3	wall_clock	sec	0.192986	0.000056	0.000047	0.000358	0.000000	0.000026	100.0
2>>>  _jacu	3473	3	wall_clock	sec	0.199029	0.000057	0.000055	0.000188	0.000000	0.000007	100.0
2>>>  _buts	3473	3	wall_clock	sec	0.198972	0.000057	0.000048	0.000372	0.000000	0.000026	100.0
1>>>  _start_thread	1	2	wall_clock	sec	2.453072	2.453072	2.453072	2.453072	0.000000	0.000000	58.6
1>>>  _erhs	1	3	wall_clock	sec	0.001905	0.001905	0.001905	0.001905	0.000000	0.000000	100.0
1>>>  _rhs	153	3	wall_clock	sec	0.229742	0.001502	0.001410	0.001894	0.000000	0.000115	100.0
1>>>  _jacld	3473	3	wall_clock	sec	0.206418	0.000059	0.000057	0.000934	0.000000	0.000016	100.0
1>>>  _blts	3473	3	wall_clock	sec	0.186097	0.000054	0.000047	0.000344	0.000000	0.000023	100.0
1>>>  _jacu	3473	3	wall_clock	sec	0.198689	0.000057	0.000055	0.000186	0.000000	0.000006	100.0
1>>>  _buts	3473	3	wall_clock	sec	0.192470	0.000055	0.000048	0.000356	0.000000	0.000022	100.0
0>>>  _erhs	1	1	wall_clock	sec	0.001961	0.001961	0.001961	0.001961	0.000000	0.000000	100.0
0>>>  _rhs	153	1	wall_clock	sec	0.229889	0.001503	0.001410	0.001891	0.000000	0.000116	100.0
0>>>  _jacld	3473	1	wall_clock	sec	0.208903	0.000060	0.000057	0.000359	0.000000	0.000017	100.0
0>>>  _blts	3473	1	wall_clock	sec	0.172646	0.000050	0.000047	0.000822	0.000000	0.000020	100.0
0>>>  _jacu	3473	1	wall_clock	sec	0.202130	0.000058	0.000055	0.000350	0.000000	0.000016	100.0
0>>>  _buts	3473	1	wall_clock	sec	0.176975	0.000051	0.000048	0.000377	0.000000	0.000016	100.0
0>>>  _pintgr	1	1	wall_clock	sec	0.000054	0.000054	0.000054	0.000054	0.000000	0.000000	100.0

# OpenMP® Visualization



# Python™

The omnitrace Python package is installed in  
`/path/omnitrace_install/lib/pythonX.Y/site-packages/omnitrace`

Setup the environment:

```
$ export PYTHONPATH=/path/omnitrace/lib/python/site-
packages/:${PYTHONPATH}
```

We use the Fibonacci example in  
`omnitrace/examples/python/source.py`

Execute the python program with:

```
$ omnitrace-python ./external.py
```

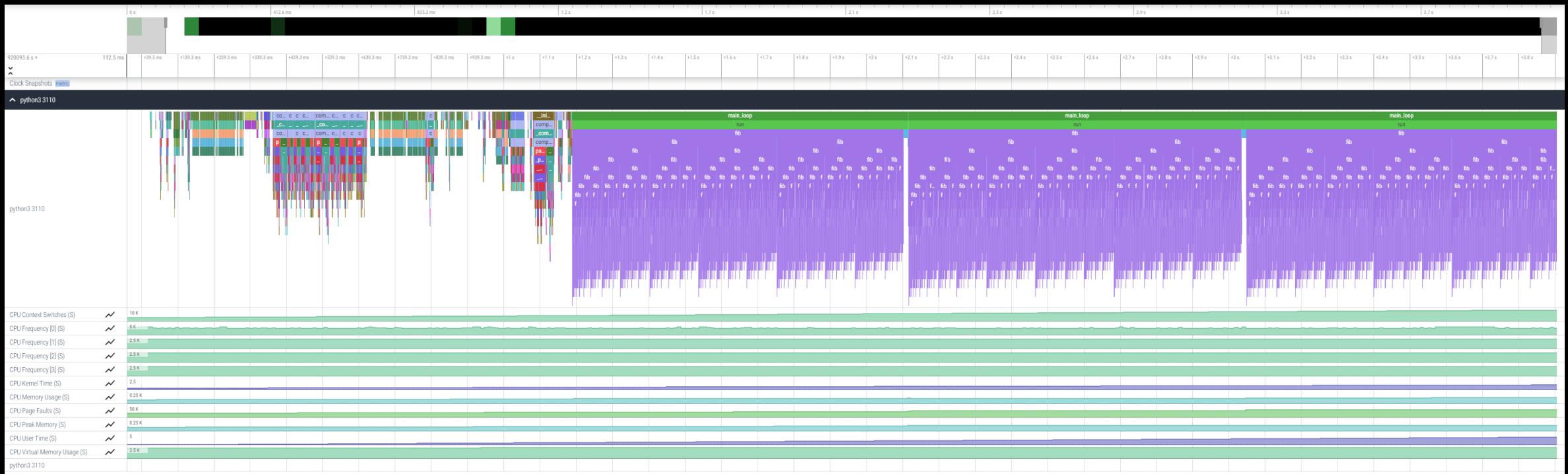
Profiled data is dumped in output directory:

```
$ cat omnitrace-source-output/timestamp/wall_clock.txt
```

REAL-CLOCK TIMER (I.E. WALL-CLOCK TIMER)											
LABEL	COUNT	DEPTH	METRIC	UNITS	SUM	MEAN	MIN	MAX	VAR	STDDEV	% SELF
@>>> main_loop	3	0	wall_clock	sec	2.786075	0.928692	0.926350	0.932130	0.000009	0.003042	0.0
@>>>  _run	3	1	wall_clock	sec	2.785799	0.928600	0.926250	0.932037	0.000009	0.003043	0.0
@>>>  _fib	3	2	wall_clock	sec	2.750104	0.916701	0.914454	0.919577	0.000007	0.002619	0.0
@>>>  _fib	6	3	wall_clock	sec	2.749901	0.458317	0.348962	0.567074	0.013958	0.118145	0.0
@>>>  _fib	12	4	wall_clock	sec	2.749511	0.229126	0.133382	0.358765	0.006504	0.080650	0.0
@>>>  _fib	24	5	wall_clock	sec	2.748734	0.114531	0.050867	0.217030	0.002399	0.048977	0.1
@>>>  _fib	48	6	wall_clock	sec	2.747118	0.057232	0.019302	0.134596	0.000806	0.028396	0.1
@>>>  _fib	96	7	wall_clock	sec	2.743922	0.028583	0.007181	0.083350	0.000257	0.016026	0.2
@>>>  _fib	192	8	wall_clock	sec	2.737564	0.014258	0.002690	0.051524	0.000079	0.088887	0.5
@>>>  _fib	384	9	wall_clock	sec	2.724966	0.007096	0.000973	0.031798	0.000024	0.004865	0.9
@>>>  _fib	768	10	wall_clock	sec	2.699251	0.003515	0.000336	0.019670	0.000007	0.002637	1.9
@>>>  _fib	1536	11	wall_clock	sec	2.648006	0.001724	0.000096	0.012081	0.000002	0.001417	3.9
@>>>  _fib	3072	12	wall_clock	sec	2.545260	0.000829	0.000016	0.007461	0.000001	0.000758	8.0
@>>>  _fib	6078	13	wall_clock	sec	2.342276	0.000385	0.000016	0.004669	0.000000	0.000404	16.0
@>>>  _fib	10896	14	wall_clock	sec	1.967475	0.000181	0.000015	0.002752	0.000000	0.000218	28.6
@>>>  _fib	15060	15	wall_clock	sec	1.404069	0.000093	0.000015	0.001704	0.000000	0.000123	43.6
@>>>  _fib	14280	16	wall_clock	sec	0.791873	0.000055	0.000015	0.001044	0.000000	0.000076	58.3
@>>>  _fib	8826	17	wall_clock	sec	0.330189	0.000037	0.000015	0.000620	0.000000	0.000050	70.9
@>>>  _fib	3456	18	wall_clock	sec	0.096120	0.000028	0.000015	0.000380	0.000000	0.000034	81.0
@>>>  _fib	822	19	wall_clock	sec	0.018294	0.000022	0.000015	0.000209	0.000000	0.000024	88.9
@>>>  _fib	108	20	wall_clock	sec	0.002637	0.000019	0.000016	0.000107	0.000000	0.000015	94.9
@>>>  _fib	6	21	wall_clock	sec	0.000104	0.000017	0.000016	0.000019	0.000000	0.000001	100.0
@>>>  _inefficient	3	2	wall_clock	sec	0.035450	0.011817	0.010096	0.012972	0.000002	0.001519	95.8
@>>>  _sum	3	3	wall_clock	sec	0.001494	0.000498	0.000440	0.000537	0.000000	0.000051	100.0

Python documentation: <https://amdr esearch.github.io/omnitrace/python.html>

# Visualizing Python™ Perfetto Tracing



# Kokkos

Omnitrace can instrument Kokkos applications too.

Edit the \$HOME/.omnitrace.cfg file and enable omnitrace:

```
...
OMNITRACE_USE_KOKKOSP = true
...
```

Profiling with omnitrace produces \*kokkos\*.txt files:

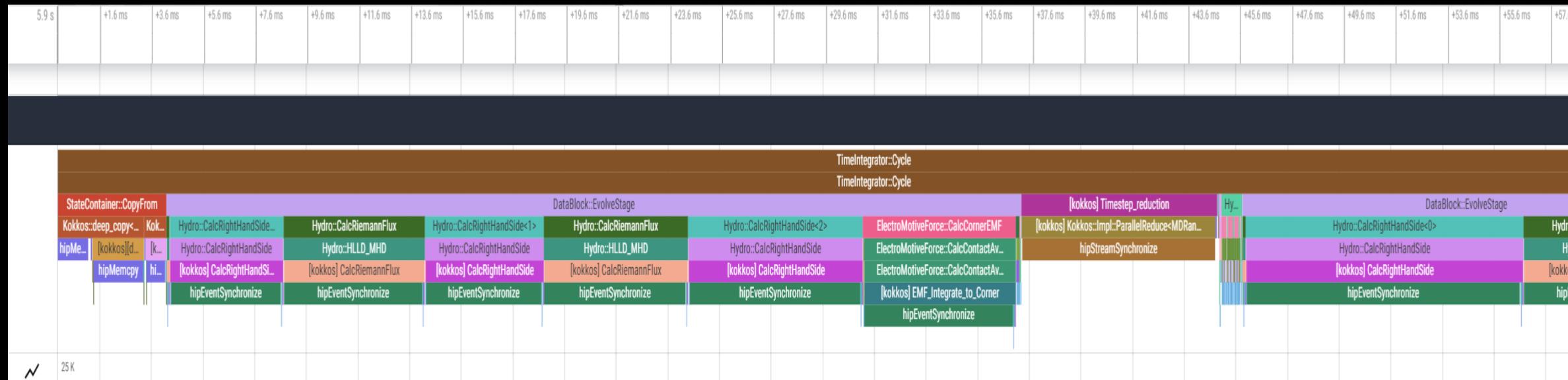
```
$ cat kokkos_memory0.txt
```

```
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_[kokkos][dev0] Host=DataBlock_A2_mirror HIP=DataBlock_A2
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, pre view equality check
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, pre view equality check
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_[kokkos][dev0] Host=DataBlock_dV_mirror HIP=DataBlock_dV
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, pre view equality check
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, pre view equality check
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_DataBlockHost::SyncToDevice()
| 0>> |_[kokkos][dev0] HIP=Hydro_Vc Host=Hydro_Vc_mirror
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, pre view equality check
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, pre view equality check
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_[kokkos][dev0] HIP=Hydro_InvDt Host=Hydro_InvDt_mirror
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, pre view equality check
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, pre view equality check
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_[kokkos][dev0] HIP=Hydro_Vs Host=Hydro_Vs_mirror
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, pre view equality check
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, pre view equality check
| 0>> |_[kokkos][dev0] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
| 0>> |_[kokkos] Kokkos::deep_copy: copy between contiguous views, post deep copy fence
```

1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	2	kokkos_memory	MB	142	142	100					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	2	kokkos_memory	MB	140	140	100					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	1	kokkos_memory	MB	0	0	0					
1	2	kokkos_memory	MB	1124	1124	100					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	2	kokkos_memory	MB	140	140	100					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	2	kokkos_memory	MB	426	426	100					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					
1	3	kokkos_memory	MB	0	0	0					

# Visualizing Kokkos with Perfetto Trace

- Visualize perfetto-trace-0.proto (with sampling enabled)



# Other Executables

- **omnitrace-sample**
  - For sampling with low overhead, use `omnitrace-sample`
  - Use `omnitrace-sample --help` to get relevant options
  - Settings in the OmniTrace config file will be used by `omnitrace-sample`
  - Example invocation to get a flat tracing profile on Host and Device (-PTHD), excluding all components (-E all) and including only rocm-smi, roctracer, rocprofiler and roctx components (-I ...)  
`mpirun -np 1 omnitrace-sample -PTHD -E all -I rocm-smi -I roctracer -I rocprofiler -I roctx -- ./Jacobi_hip -g 1 1`
- **omnitrace-causal**
  - Invokes causal profiling
- **omnitrace-critical-trace**
  - Post-processing tool for critical-trace data output by omnitrace

Current documentation: <https://amdr esear ch.github.io/omnitrace/development.html#executables>

# Tips & Tricks

- My Perfetto timeline seems weird how can I check the clock skew?
  - Set OMNITRACE\_VERBOSE=1 or higher for verbose mode and it will print the timestamp skew
- It takes too long to map rocm-smi samples to kernels.
  - Temporarily set OMNITRACE\_USE\_ROCM\_SMI=OFF
- What is the best way to profile multi-process runs?
  - Use OmniTrace's binary rewrite (-o) option to instrument the binary first, run the instrumented binary with mpirun/srun
- If you are doing binary rewrite and you do not get information about kernels, set:
  - HSA\_TOOLS\_LIB=libomnitrace.so in the env. and set OMNITRACE\_USE\_ROCTRACER=ON in the cfg file
- My HIP application hangs in different points, what do I do?
  - Try to set HSA\_ENABLE\_INTERRUPT=0 in the environment, this changes how HIP runtime is notified when GPU kernels complete
- My Perfetto trace is too big, can I decrease it?
  - Yes, with v1.7.3 and later declare OMNITRACE\_PERFETTO\_ANNOTATIONS to false
- I want to remove the many rows of CPU frequency lines from the Perfetto trace
  - Declare the OMNITRACE\_USE\_PROCESS\_SAMPLING = false

# Summary

- OmniTrace is a powerful tool to understand CPU + GPU activity
  - Ideal for an initial look at how an application runs
- Leverages several other tools and combines their data into a comprehensive output file
  - Some tools used are AMD uProf, rocprof, rocm-smi, roctracer, perf, etc.
- Easy to visualize traces in Perfetto
- Includes several features:
  - Dynamic Instrumentation either at Runtime or using Binary Rewrite
  - Statistical Sampling for call-stack info
  - Process sampling, monitoring of system metrics during application run
  - Causal Profiling
  - Critical Path Tracing

# Questions?

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