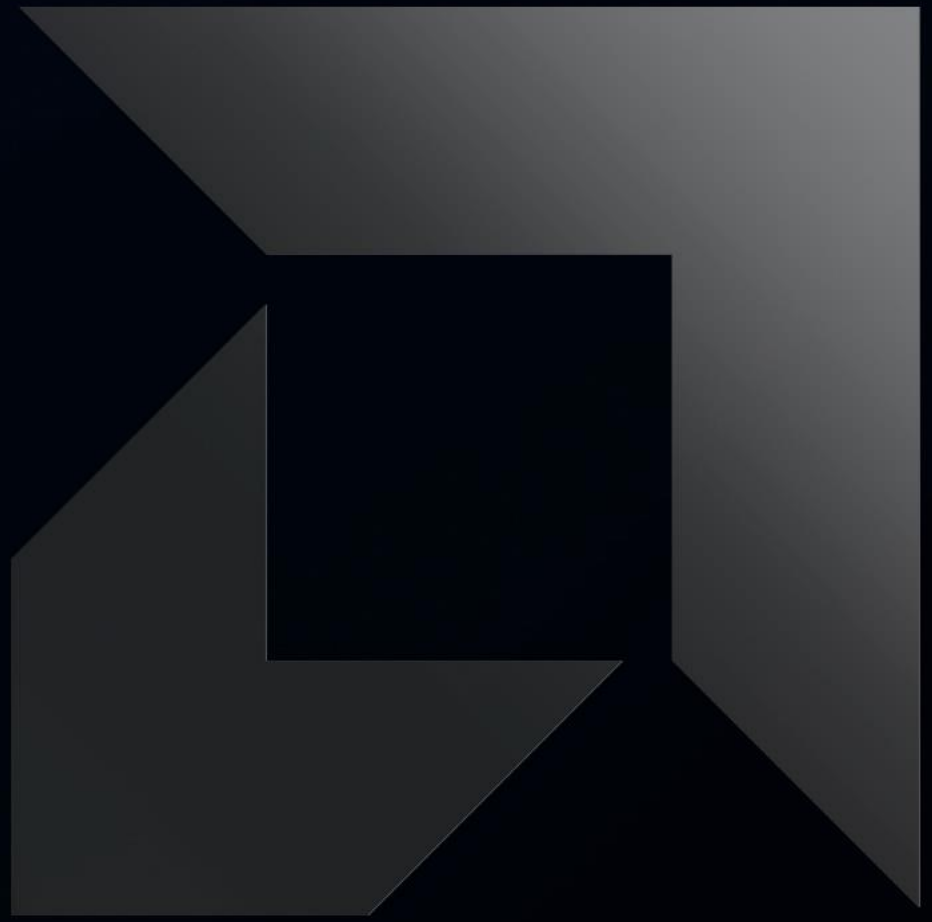

AMD Debugger: ROCgdb

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LUMI Comprehensive Training

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AMD

together we advance_

Rocgdb

- AMD ROCm ™ source-level debugger for Linux®
- based on the GNU Debugger (GDB)
  - tracks upstream GDB master
  - standard GDB commands for both CPU and GPU debugging
- considered a prototype
  - focus on source line debugging
  - no symbolic variable debugging yet
- As GDB fork it can be used with other tools that use GDB as backend

- Exercises: https://hackmd.io/@sfantao/lumi-training-ams-2024#Debugging

Simple saxpy kernel

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      hipMalloc(&d_x, size);
21      hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n, d_x, 1, d_y, 1);
26      hipDeviceSynchronize();
27  }
28
```

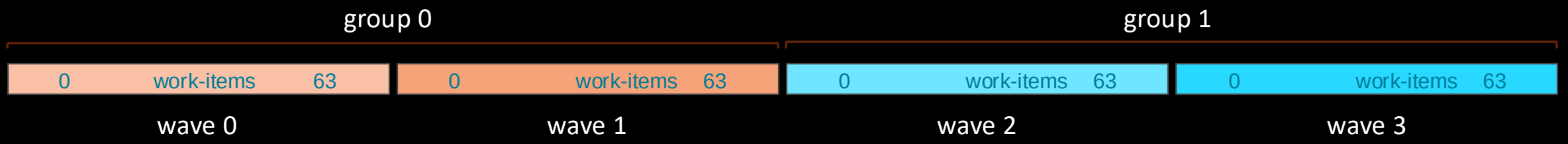
classic saxpy operation

one array index = one work-item

size of arrays = 256

two groups

each 128 work-items



Cause a page fault

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      // hipMalloc(&d_x, size);
21      // hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n, d_x, 1, d_y, 1);
26      hipDeviceSynchronize();
27  }
28
```

Could break it by forcing out of bounds read here by changing the index

Easer through commenting out the allocations. (also possible to initialize the pointers to nullptr)

It's important to synchronize before exit.
Otherwise, the CPU thread may quit before the GPU gets a chance to report the error.

Compilation with hipcc

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      // hipMalloc(&d_x, size);
21      // hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n,
26      hipDeviceSynchronize();
27  }
28
```

Need to set the target hardware

- gfx906 – MI50, MI60, Radeon™ 7
- gfx908 – MI100
- gfx90a – MI200
- gfx942 - MI300A

Can set multiple targets for different devices

```
saxpy$ hipcc --offload-arch=gfx90a -o saxpy saxpy.cpp
```

Execution

```hip
#include <hip/hip_runtime.h>

__constant__ float a = 1.0f;

__global__
void saxpy(int n, float const* x, int incx, float* y, int incy)
{
    int i = blockDim.x*blockIdx.x + threadIdx.x;
    if (i < n)
        y[i] += a*x[i];
}

int main()
{
    int n = 256;
    std::size_t size = sizeof(float)*n;

    float* d_x;
    float* d_y;
    // hipMalloc(&d_x, size);
    // hipMalloc(&d_y, size);

    int num_groups = 2;
    int group_size = 128;
    saxpy<<<num_groups, group_size>>>(n,
    hipDeviceSynchronize();
}
```

```
saxpy$ hipcc --offload-arch=gfx90a -o saxpy saxpy.cpp
saxpy$ ./saxpy
```

Get a page fault

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      // hipMalloc(&d_x, size);
21      // hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n, d
26      hipDeviceSynchronize();
27  }
28
```

```
saxpy$ hipcc --offload-arch=gfx90a -o saxpy saxpy.cpp
saxpy$ ./saxpy
Memory access fault by GPU node-2 (Agent handle: 0x2284d90) on address (nil). Reason: Unknown.
Aborted (core dumped)
saxpy$
```

And BOOM, here is our expected memory violation

Common gdb commands

Start GDB (GNU Debugger)

- **gdb <program> [core dump]**
- **gdb –args <program> <args>**
- **gdb -help**

Run commands

r[un] - Runs the program until a breakpoint or error
c[ontinue] - Continues running the program until the next breakpoint or error
q[uit] or kill - Quits gdb
fin[ish] - Runs until current function or loop is finished
n[ext] - Runs the next line of the program
  n N - Runs the next N lines of the program
s[tep] - Runs the next line of the program, stepping into any called routines
until N - Runs until you get N lines after the current line

Breakpoint commands

b[reakpoint] <where> – set breakpoint
  b main - Puts a breakpoint at the beginning of the program
  b - Puts a breakpoint at the current line
  b N - Puts a breakpoint at line N
  b +N - Puts a breakpoint N lines down from the current line
  b fn - Puts a breakpoint at the beginning of function "fn"
  b/w <where> if <condition – conditional breakpoint or watch
i[nfo] b[reak] - list breakpoints
dis[able] N - disable breakpoint number N
en[able] N – enables breakpoint number N
d[elete] N – delete breakpoint number N
clear – clear all breakpoints

Print commands

[h]elp <command>
[p]rint var - Prints the current value of the variable "var"
[l]ist – list lines
bt (backtrace) - Prints a stack trace

Movement

up - Goes up a level in the stack
[do]wn - Goes down a level in the stack

Execution with rocgdb

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      // hipMalloc(&d_x, size);
21      // hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n, d_
26      hipDeviceSynchronize();
27  }
28
```

```
saxpy$ rocgdb saxpy
```

Remember to use rocgdb –args when passing arguments to program being debugged

Get more information

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      // hipMalloc(&d_x, size);
21      // hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n,
26      hipDeviceSynchronize();
27  }
28
```

```
(gdb) run
Starting program: /home/gmarkoma/saxpy
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib64/libthread_db.so.1".
[New Thread 0x7fffed428700 (LWP 10456)]
Warning: precise memory violation signal reporting is not enabled, reported
location may not be accurate.  See "show amdgpu precise-memory".

Thread 3 "saxpy" received signal SIGSEGV, Segmentation fault.
[Switching to thread 3, lane 0 (AMDGPU Lane 1:2:1:1/0 (0,0,0)[0,0,0])]
0x00007ffff7ec1094 in saxpy(int, float const*, int, float*, int) () from file:///home/gmarkoma/s
axpy#offset=8192&size=13832
(gdb)
```

Reports segmentation fault in the saxpy kernel.

Compile with -ggdb

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      // hipMalloc(&d_x, size);
21      // hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n,
26      hipDeviceSynchronize();
27  }
28
```

```
saxpy$ hipcc -ggdb --offload-arch=gfx90a -o saxpy saxpy.cpp
```

Get more details

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      // hipMalloc(&d_x, size);
21      // hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n, d
26      hipDeviceSynchronize();
27  }
28
```

```
(gdb) run
Starting program: /home/gmarkoma/saxpy
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib64/libthread_db.so.1".
[New Thread 0x7fffed428700 (LWP 10637)]
Warning: precise memory violation signal reporting is not enabled, reported
location may not be accurate.  See "show amdgpu precise-memory".

Thread 3 "saxpy" received signal SIGSEGV, Segmentation fault.
[Switching to thread 3, lane 0 (AMDGPU Lane 1:2:1:1/0 (0,0,0)[0,0,0])]
0x00007ffff7ec1094 in saxpy () at saxpy.cpp:10
10          y[i] += a*x[i];
(gdb)
```

more details
- what kernel
- what file:line

But where's my stack trace?

To get exceptions reported precisely: `set amdgpu precise-memory on`

List threads

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      // hipMalloc(&d_x, size);
21      // hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n,
26      hipDeviceSynchronize();
27  }
28
```

```
(gdb) i th
  Id   Target Id                                    Frame
  1    Thread 0x7ffff7fe6e80 (LWP 10633) "saxpy" 0x00007fffee0fc499 in rocr::core::InterruptSign
al::WaitRelaxed(hsa_signal_condition_t, long, unsigned long, hsa_wait_state_t) ()
   from /opt/rocm-5.2.0/lib/libhsa-runtime64.so.1
  2    Thread 0x7fffed428700 (LWP 10637) "saxpy" 0x00007ffff5e1972b in ioctl ()
   from /lib64/libc.so.6
* 3    AMDGPU Wave 1:2:1:1 (0,0,0)/0 "saxpy"     0x00007ffff7ec1094 in saxpy () at saxpy.cpp:10
  4    AMDGPU Wave 1:2:1:2 (0,0,0)/1 "saxpy"     0x00007ffff7ec1094 in saxpy () at saxpy.cpp:10
  5    AMDGPU Wave 1:2:1:3 (1,0,0)/0 "saxpy"     0x00007ffff7ec1094 in saxpy () at saxpy.cpp:10
  6    AMDGPU Wave 1:2:1:4 (1,0,0)/1 "saxpy"     0x00007ffff7ec1094 in saxpy () at saxpy.cpp:10
(gdb)
```

What segfaulted is a GPU wave.
It does not have your CPU stack.
List threads to see what's going on.

Switch to the CPU thread

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      // hipMalloc(&d_x, size);
21      // hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n,
26      hipDeviceSynchronize();
27  }
28
```

t 1
(thread 1)
It's in the HSA runtime.

```
(gdb) t 1
[Switching to thread 1 (Thread 0x7ffff7fe6e80 (LWP 10633))]
#0  0x00007fffee0fc499 in rocr::core::InterruptSignal::WaitRelaxed(hsa_signal_condition_t, long,
 unsigned long, hsa_wait_state_t) () from /opt/rocm-5.2.0/lib/libhsa-runtime64.so.1
(gdb)
```

But how did it get there?

See the stack trace of the CPU thread

```
#include <hip/hip_runtime.h>

__constant__ float a = 1.0f;

__global__
void saxpy(int n, float const* x, int incx, float* y, int incy)
{
    int i = blockDim.x*blockIdx.x + threadIdx.x;
    if (i < n)
        y[i] += a*x[i];
}

int main()
{
    int n = 256;
    std::size_t size = sizeof(float)*n;

    float* d_x;
    float* d_y;
    // hipMalloc(&d_x, size);
    // hipMalloc(&d_y, size);

    int num_groups = 2;
    int group_size = 128;
    saxpy<<<num_groups, group_size>>>(n, d_
    hipDeviceSynchronize();
}
```

The CPU thread is currently waiting on the device to finish ☺

HSA runtime

HIP runtime

```
(gdb) where
#0  0x00007fffee0fc499 in rocr::core::InterruptSignal::WaitRelaxed(hsa_signal_condition_t, lo
ng, unsigned long, hsa_wait_state_t) () from /opt/rocm-5.2.0/lib/libhsa-runtime64.so.1
#1  0x00007fffee0fc36a in rocr::core::InterruptSignal::WaitAcquire(hsa_signal_condition_t, long,
 unsigned long, hsa_wait_state_t) () from /opt/rocm-5.2.0/lib/libhsa-runtime64.so.1
#2  0x00007fffee0f0869 in rocr::HSA::hsa_signal_wait_scacquire(hsa_signal_s, hsa_signal_conditio
n_t, long, unsigned long, hsa_wait_state_t) () from /opt/rocm-5.2.0/lib/libhsa-runtime64.so.1
#3  0x00007ffff67bdd43 in bool roc::WaitForSignal<false>(hsa_signal_s, bool) ()
   from /opt/rocm-5.2.0/lib/libamdhip64.so.5
#4  0x00007ffff67b5836 in roc::VirtualGPU::HwQueueTracker::CpuWaitForSignal(roc::ProfilingSignal
*) () from /opt/rocm-5.2.0/lib/libamdhip64.so.5
#5  0x00007ffff67b77cf in roc::VirtualGPU::releaseGpuMemoryFence(bool) ()
   from /opt/rocm-5.2.0/lib/libamdhip64.so.5
#6  0x00007ffff67b9523 in roc::VirtualGPU::flush(amd::Command*, bool) ()
   from /opt/rocm-5.2.0/lib/libamdhip64.so.5
#7  0x00007ffff67b9db0 in roc::VirtualGPU::submitMarker(amd::Marker&) ()
   from /opt/rocm-5.2.0/lib/libamdhip64.so.5
#8  0x00007ffff678ec2e in amd::Command::enqueue() () from /opt/rocm-5.2.0/lib/libamdhip64.so.5
#9  0x00007ffff678f1e0 in amd::Event::notifyCmdQueue(bool) ()
   from /opt/rocm-5.2.0/lib/libamdhip64.so.5
#10 0x00007ffff678f28c in amd::Event::awaitCompletion() ()
   from /opt/rocm-5.2.0/lib/libamdhip64.so.5
#11 0x00007ffff6791fdc in amd::HostQueue::finish() () from /opt/rocm-5.2.0/lib/libamdhip64.so.5
#12 0x00007ffff65c25f9 in hipDeviceSynchronize () from /opt/rocm-5.2.0/lib/libamdhip64.so.5
#13 0x000000000020d615 in main () at saxpy.cpp:25
(gdb)
```

Quick tip

- CPUs on LUMI nodes have 64 cores / 128 threads.
- If you're debugging an app with OpenMP threading and OMP_NUM_THREADS is not set you will see 128 CPU threads in rocgdb.
- Set OMP_NUM_THREADS=1 when debugging GPU codes that don't have CPU specific OpenMP regions
- For debugging with MPI, attach rocgdb to individual MPI processes

Breakpoints – Common pitfalls

We try to put a breakpoint in line 22 but it is declared as line 24.

```
--Type <RET> for more, q to quit, c to continue without paging--For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from saxpy...
(gdb) b saxpy.cpp:22
Breakpoint 1 at 0x20d57f: file saxpy.cpp, line 24.
(gdb)
```

Simple saxpy kernel – Where is our code?

```
1   #include <hip/hip_runtime.h>
2
3   __constant__ float a = 1.0f;
4
5   __global__
6   void saxpy(int n, float const* x, int incx, float* y, int incy)
7   {
8       int i = blockDim.x*blockIdx.x + threadIdx.x;
9       if (i < n)
10          y[i] += a*x[i];
11  }
12
13  int main()
14  {
15      int n = 256;
16      std::size_t size = sizeof(float)*n;
17
18      float* d_x;
19      float* d_y;
20      hipMalloc(&d_x, size);
21      hipMalloc(&d_y, size);
22
23      int num_groups = 2;
24      int group_size = 128;
25      saxpy<<<num_groups, group_size>>>(n, d_x, 1, d_y, 1);
26      hipDeviceSynchronize();
27  }
28
```

Breakpoints – If possible, debug with optimization turned off

We try to put a breakpoint in line 22 but it is declared as line 24.

```
--Type <RET> for more, q to quit, c to continue without paging--For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from saxpy...
(gdb) b saxpy.cpp:22
Breakpoint 1 at 0x20d57f: file saxpy.cpp, line 24.
(gdb)
```

Default compiler optimization for hipcc is –O3, compile with –O0

```
saxpy$  hipcc -ggdb -O0 --offload-arch=gfx90a -o saxpy saxpy.cpp
```

Creating a breakpoint again and it is declared in the correct line

```
--Type <RET> for more, q to quit, c to continue without paging--For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from saxpy...
(gdb) b saxpy.cpp:22
Breakpoint 1 at 0x219dec: file saxpy.cpp, line 22.
(gdb)
```

Running and architecture

Running with the keystroke ***r*** and stops at the breakpoint

```
--Type <RET> for more, q to quit, c to continue without paging--For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from saxpy...
(gdb) b saxpy.cpp:22
Breakpoint 1 at 0x219dec: file saxpy.cpp, line 22.
(gdb) r
Starting program: /home/gmarkoma/saxpy
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib64/libthread_db.so.1".
[New Thread 0x7fffed428700 (LWP 16916)]

Thread 1 "saxpy" hit Breakpoint 1, main () at saxpy.cpp:22
(gdb)
```

More information about the thread with the command ***i th***

```
(gdb) i th
  Id   Target Id                                  Frame
* 1    Thread 0x7ffff7fe6e80 (LWP 16912) "saxpy" main () at saxpy.cpp:22
  2    Thread 0x7fffed428700 (LWP 16916) "saxpy" 0x00007ffff5e1972b in ioctl () from /lib64/libc.so.6
(gdb)
```

We can see on what device is the thread with the ***show architecture*** command

```
(gdb) show architecture
The target architecture is set to "auto" (currently "i386:x86-64").
(gdb)
```

Breakpoint kernel and architecture

Breakpoint on the kernel called saxpy with the command ***b saxpy***

```
(gdb) b saxpy
Function "saxpy" not defined.
Make breakpoint pending on future shared library load? (y or [n]) yBreakpoint 2 (saxpy) pending.
(gdb)
```

You can continue with he command ***c***

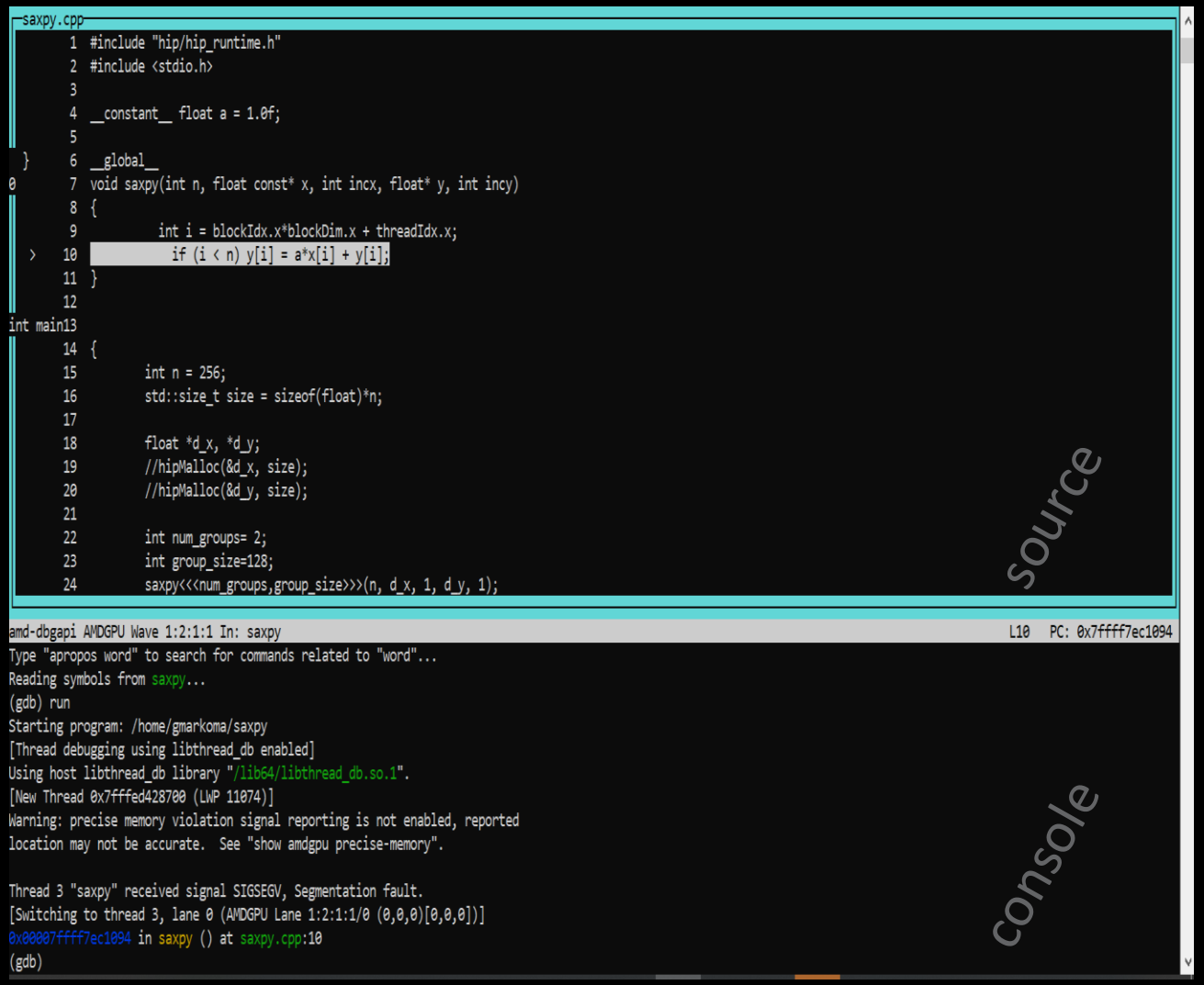
```
(gdb) c
Continuing.
[New Thread 0x7fffdefff700 (LWP 16937)]
[New Thread 0x7fffecaff700 (LWP 16938)]
[Thread 0x7fffdefff700 (LWP 16937) exited]
[Switching to thread 5, lane 0 (AMDGPU Lane 1:2:1:1/0 (0,0,0)[0,0,0])]

Thread 5 "saxpy" hit Breakpoint 2, with lanes [0-63], saxpy (n=256, x=0x7fffec700000, incx=1, y=0x7fffec701000, incy=1) at saxpy.cpp:9
```

We can see on what device is the thread with the command ***show architecture***

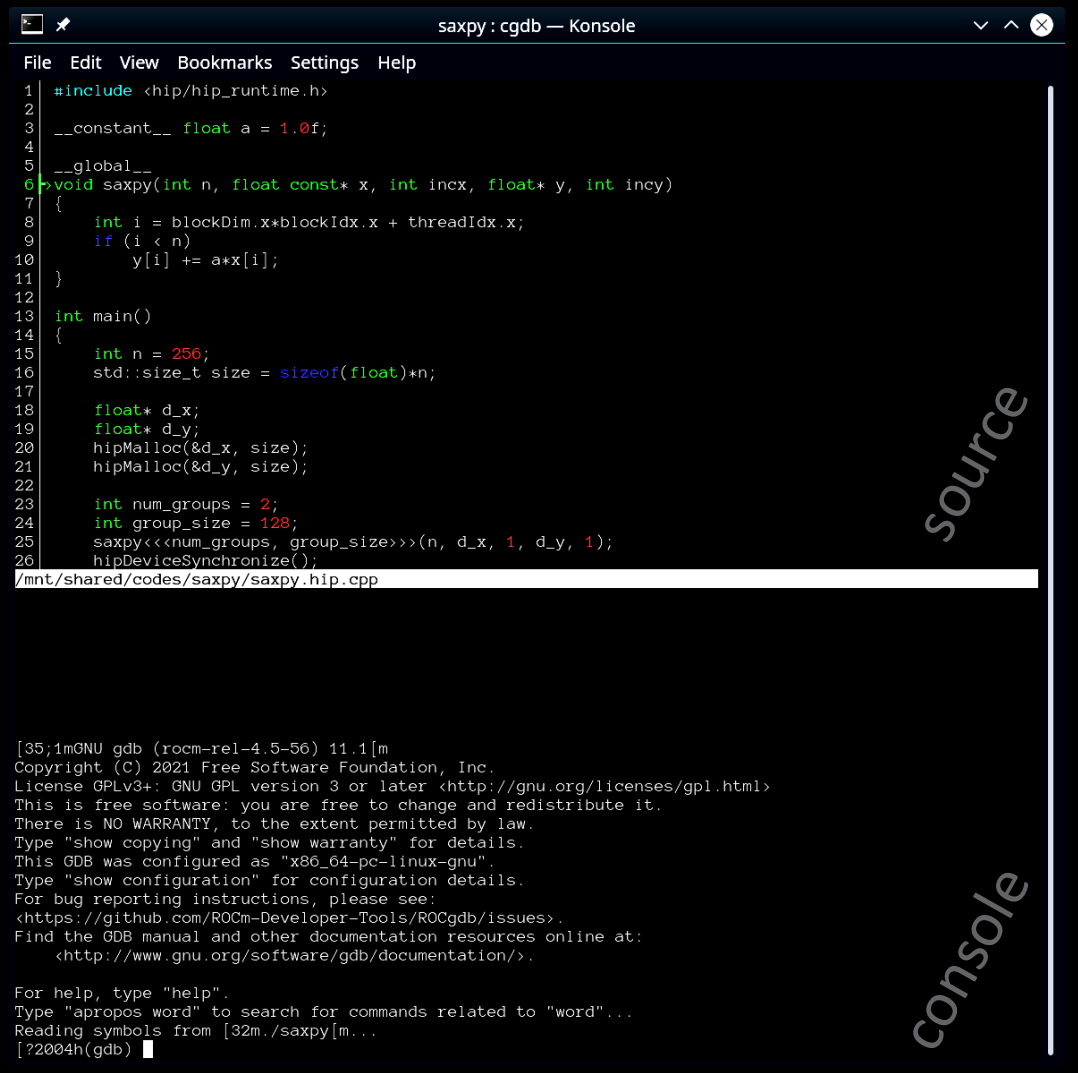
```
(gdb) show architecture
The target architecture is set to "auto" (currently "amdgcn:gfx90a").
```

“GUIs”

rocgdb -tui saxpy

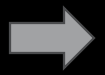


cgdb -d rocgdb saxpy



rocgdb + gdbgui

breakpoint in CPU code



Load Binary /mnt/shared/codes/saxpy/saxpy

show filesystem | fetch disassembly | reload file | jump to line | /mnt/shared/codes/saxpy/saxpy.hip.cpp:22 (27 lines total)

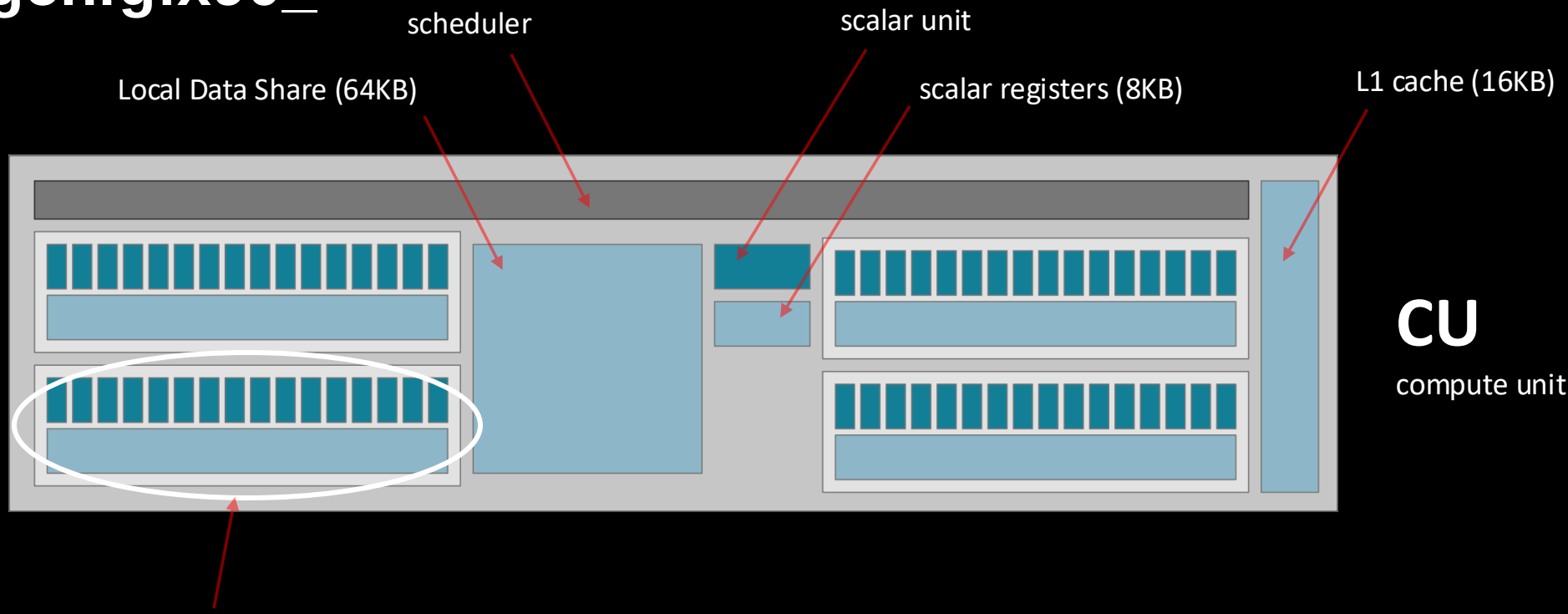
```
1  #include <hip/hip_runtime.h>
2
3  __constant__ float a = 1.0f;
4
5  __global__
6  void saxpy(int n, float const* x, float* y)
7  {
8      int i = blockDim.x*blockIdx.x + threadIdx.x;
9      if (i < n)
10         y[i] += a*x[i];
11 }
12
13 int main()
14 {
15     int n = 256;
16     std::size_t size = sizeof(float)*n;
17
18     float* d_x;
19     float* d_y;
20     hipMalloc(&d_x, size);
21     hipMalloc(&d_y, size);
22
23     int num_groups = 2;
24     int group_size = 128;
25     saxpy<<<num_groups, group_size>>>(n, d_x, d_y);
26 }
27
    (end of file)
```

source

```
running command: /opt/rocm/bin/rocgdb

GNU gdb (rocm-rel-4.5-56) 11.1
Copyright (C) 2021 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
Type "show copying" and "show warranty" for details.
This GDB was configured as "x86_64-pc-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<https://github.com/ROCm-Developer-Tools/ROCgdb/issues>.
Find the GDB manual and other documentation resources online at:
    <http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".
Type "apropos word" to search for commands related to "word".
New UI allocated
(gdb)
```

console

amdgcn:gfx90_



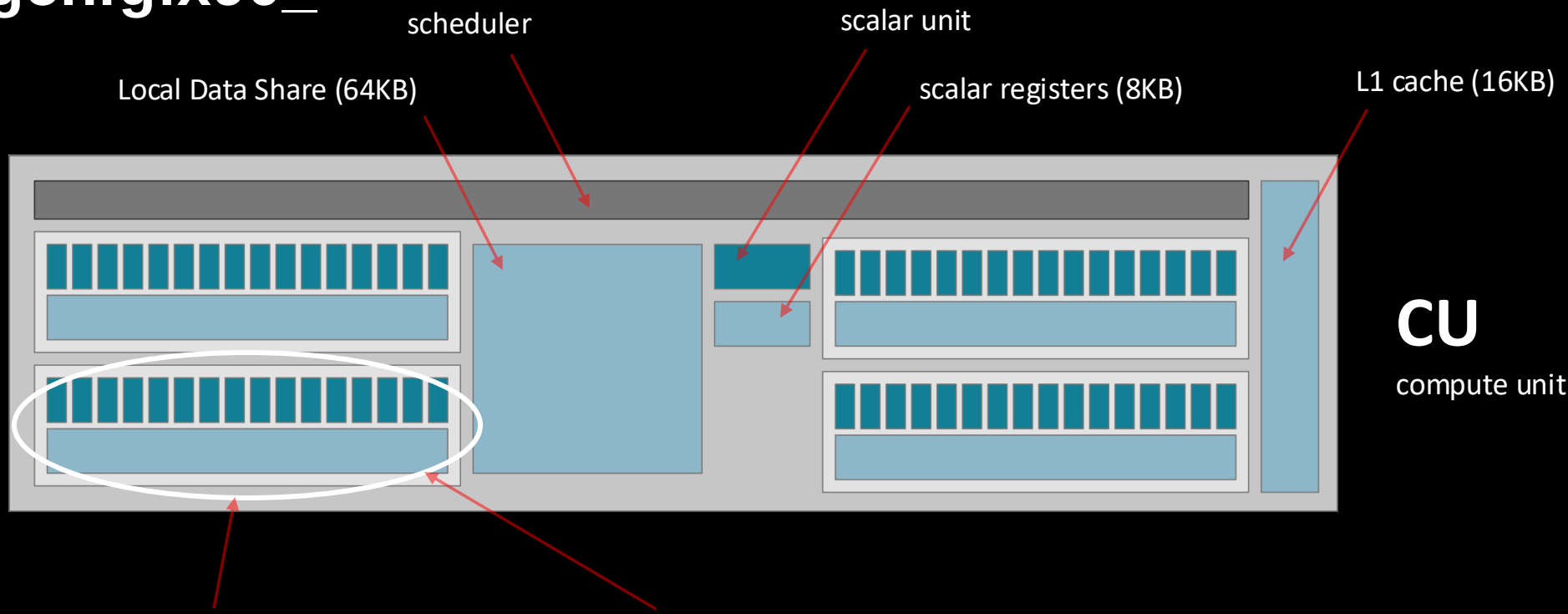
CU

compute unit

typically described as

- a 16-way SIMD unit
- with 64KB of registers

amdgcn:gfx90_



CU

compute unit

typically described as
- a 16-way SIMD unit
- with 64KB of registers

from the standpoint of rocGDB
- a **core**
- executing up to 10 **threads**
- with vector length of 64 **lanes**
- and containing 256 vector **registers**

List threads / waves

i th
(info threads)

some CPU threads

4 GPU “threads” (waves)

```
(gdb) i th
  Id   Target Id                                         Frame
  1    Thread 0x7ffff7fe6e80 (LWP 16912) "saxpy" 0x00007fffee0fc4c0 in rocr::core::InterruptSignal::
t) () from /opt/rocm-5.2.0/lib/libhsa-runtime64.so.1
  2    Thread 0x7fffed428700 (LWP 16916) "saxpy" 0x00007ffff5e1972b in ioctl () from /lib64/libc.so.
  4    Thread 0x7fffecaff700 (LWP 16938) "saxpy" 0x00007fffee0fc4af in rocr::core::InterruptSignal::
t) () from /opt/rocm-5.2.0/lib/libhsa-runtime64.so.1
* 5    AMDGPU Wave 1:2:1:1 (0,0,0)/0 "saxpy"     saxpy (n=256, x=0x7fffec700000, incx=1, y=0x7fffec7
  6    AMDGPU Wave 1:2:1:2 (0,0,0)/1 "saxpy"     saxpy (n=256, x=0x7fffec700000, incx=1, y=0x7fffec7
  7    AMDGPU Wave 1:2:1:3 (1,0,0)/0 "saxpy"     saxpy (n=256, x=0x7fffec700000, incx=1, y=0x7fffec7
  8    AMDGPU Wave 1:2:1:4 (1,0,0)/1 "saxpy"     saxpy (n=256, x=0x7fffec700000, incx=1, y=0x7fffec7
```

Wave details

`agent-id:queue-id:dispatch-num:wave-id (work-group-x,work-group-y,work-group-z)/work-group-thread-index`

```
(gdb) i th
  Id   Target Id                                        Frame
  1    Thread 0x7ffff7fe6e80 (LWP 16912) "saxpy" 0x00007fffee0fc4c0 in rocr::core::InterruptSignal:
t) () from /opt/rocm-5.2.0/lib/libhsa-runtime64.so.1
  2    Thread 0x7fffed428700 (LWP 16916) "saxpy" 0x00007ffff5e1972b in ioctl () from /lib64/libc.so
  4    Thread 0x7fffecaff700 (LWP 16938) "saxpy" 0x00007fffee0fc4af in rocr::core::InterruptSignal:
t) () from /opt/rocm-5.2.0/lib/libhsa-runtime64.so.1
* 5    AMDGPU Wave 1:2:1:1 (0,0,0)/0 "saxpy"     saxpy (n=256, x=0x7fffec700000, incx=1, y=0x7fffec
  6    AMDGPU Wave 1:2:1:2 (0,0,0)/1 "saxpy"     saxpy (n=256, x=0x7fffec700000, incx=1, y=0x7fffec
  7    AMDGPU Wave 1:2:1:3 (1,0,0)/0 "saxpy"     saxpy (n=256, x=0x7fffec700000, incx=1, y=0x7fffec
  8    AMDGPU Wave 1:2:1:4 (1,0,0)/1 "saxpy"     saxpy (n=256, x=0x7fffec700000, incx=1, y=0x7fffec
```

agent (GPU) ID

(HSA) queue ID

dispatch number

wave ID

workgroup (x, y, z)

wave ID (within group)

More advanced things you can do

- inspect / modify registers
- inspect / modify memory
- inspect / modify LDS
- step through the assembly one instruction at a time
- Check race conditions by stepping code in separate GPU waves

List agents

info agents
- shows devices + properties

```
(gdb) info agents
  Id State Target Id                 Architecture Device Name Cores Threads Location
* 1  A     AMDGPU Agent (GPUID 31957) gfx90a       aldebaran   440   3520    29:00.0
```

gfx90a
MI200 series

SIMDs
(CUs x 4)

max waves
(SIMDs x 8)

List queues

info queues
- shows HSA queues

```
(gdb) info queues
  Id   Target Id                    Type          Read   Write  Size     Address
  1    AMDGPU Queue 1:1 (QID 0) HSA (Multi)  4      4      4096     0x00007ffff7eb6000
* 2    AMDGPU Queue 1:2 (QID 1) HSA (Multi)  0      2      262144   0x00007ffff7e40000
(gdb)
```

agent ID

queue ID

(AQL) packets read

(AQL) packets written

Dispatch details

info dispatches

- shows kernel dispatches

```
(gdb) info dispatches
  Id   Target Id                        Grid      Workgroup Fence   Kernel Function
* 1    AMDGPU Dispatch 1:2:1 (PKID 0) [256,1,1] [128,1,1] B|Aa|Ra saxpy(int, float const*, int, float*, int)
```

agent ID

queue ID

dispatch ID

grid dimensions

group dimensions

kernel

AMD_LOG_LEVEL=3

```
:3:devprogram.cpp           :2978: 157529658660 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: _Z5saxpyiPKfiPfi
:3:hip_module.cpp           :365 : 157529658684 us: 224178: [tid:0x7f59c7439e80] ihipModuleLaunchKernel ( 0x0x12e9720, 256, 1, 1, 128, 1, 1, 0, stream:<null>, 0x7fff94e2e07
0, char array:<null>, event:0, event:0, 0, 0 )
:3:rocdevice.cpp            :2686: 157529658695 us: 224178: [tid:0x7f59c7439e80] number of allocated hardware queues with low priority: 0, with normal priority: 0, with hig
h priority: 0, maximum per priority is: 4
:3:rocdevice.cpp            :2757: 157529663975 us: 224178: [tid:0x7f59c7439e80] created hardware queue 0x7f59c72f4000 with size 4096 with priority 1, cooperative: 0
:3:devprogram.cpp           :2675: 157529852150 us: 224178: [tid:0x7f59c7439e80] Using Code Object V4.
:3:devprogram.cpp           :2978: 157529853058 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_fillImage
:3:devprogram.cpp           :2978: 157529853065 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_fillBufferAligned2D
:3:devprogram.cpp           :2978: 157529853070 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_fillBufferAligned
:3:devprogram.cpp           :2978: 157529853076 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_copyImage1DA
:3:devprogram.cpp           :2978: 157529853080 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_copyBufferAligned
:3:devprogram.cpp           :2978: 157529853084 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_streamOpsWait
:3:devprogram.cpp           :2978: 157529853087 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_copyBuffer
:3:devprogram.cpp           :2978: 157529853091 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_streamOpsWrite
:3:devprogram.cpp           :2978: 157529853094 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_copyBufferRectAligned
:3:devprogram.cpp           :2978: 157529853096 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_gwsInit
:3:devprogram.cpp           :2978: 157529853099 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_copyBufferRect
:3:devprogram.cpp           :2978: 157529853101 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_copyImageToBuffer
:3:devprogram.cpp           :2978: 157529853105 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_copyBufferToImage
:3:devprogram.cpp           :2978: 157529853108 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: __amd_rocclr_copyImage
:3:rocvirtual.cpp           :753 : 157529853195 us: 224178: [tid:0x7f59c7439e80] Arg0:   = val:256
:3:rocvirtual.cpp           :679 : 157529853200 us: 224178: [tid:0x7f59c7439e80] Arg1:   = ptr:0x7f59bbb00000 obj:[0x7f59bbb00000-0x7f59bbb00400]
:3:rocvirtual.cpp           :753 : 157529853205 us: 224178: [tid:0x7f59c7439e80] Arg2:   = val:1
:3:rocvirtual.cpp           :679 : 157529853209 us: 224178: [tid:0x7f59c7439e80] Arg3:   = ptr:0x7f59bbb01000 obj:[0x7f59bbb01000-0x7f59bbb01400]
:3:rocvirtual.cpp           :753 : 157529853213 us: 224178: [tid:0x7f59c7439e80] Arg4:   = val:1
:3:rocvirtual.cpp           :2723: 157529853216 us: 224178: [tid:0x7f59c7439e80] ShaderName : _Z5saxpyiPKfiPfi
:3:hip_platform.cpp         :676 : 157529853233 us: 224178: [tid:0x7f59c7439e80] ihipLaunchKernel: Returned hipSuccess :
:3:hip_module.cpp           :509 : 157529853237 us: 224178: [tid:0x7f59c7439e80] hipLaunchKernel: Returned hipSuccess :
:3:hip_device_runtime.cpp   :476 : 157529853243 us: 224178: [tid:0x7f59c7439e80] hipDeviceSynchronize (  )
:3:rocdevice.cpp            :2636: 157529853248 us: 224178: [tid:0x7f59c7439e80] No HW event
:3:rocvirtual.hpp           :62  : 157529853255 us: 224178: [tid:0x7f59c7439e80] Host active wait for Signal = (0x7f59c7442600) for -1 ns
:3:hip_device_runtime.cpp   :488 : 157529853267 us: 224178: [tid:0x7f59c7439e80] hipDeviceSynchronize: Returned hipSuccess :
:3:hip_memory.cpp           :536 : 157529853279 us: 224178: [tid:0x7f59c7439e80] hipFree ( 0x7f59bbb00000 )
:3:rocdevice.cpp            :2093: 157529853291 us: 224178: [tid:0x7f59c7439e80] device=0x12d34f0, freeMem_ = 0xfefffc00
:3:hip_memory.cpp           :538 : 157529853296 us: 224178: [tid:0x7f59c7439e80] hipFree: Returned hipSuccess :
:3:hip_memory.cpp           :536 : 157529853300 us: 224178: [tid:0x7f59c7439e80] hipFree ( 0x7f59bbb01000 )
:3:rocdevice.cpp            :2093: 157529853306 us: 224178: [tid:0x7f59c7439e80] device=0x12d34f0, freeMem_ = 0xff000000
:3:hip_memory.cpp           :538 : 157529853310 us: 224178: [tid:0x7f59c7439e80] hipFree: Returned hipSuccess :
:3:devprogram.cpp           :2978: 157529853333 us: 224178: [tid:0x7f59c7439e80] For Init/Fini: Kernel Name: _Z5saxpyiPKfiPfi
```

How to use rocgdb + gdbgui + Chrome

test if X forwarding works

```
ssh -X USERNAME@server
ssh -X login1._______.olcf.ornl.gov
srun -A VEN113 -N 1 -n 1 -c 64 --x11 --pty bash
xmessage -center hello!
```

install gdbgui

```
python3 -m pip install --user pipx
python3 -m userpath append ~/.local/bin
pipx install gdbgui
```

install Chrome

- Go to https://www.google.com/chrome/
- Click *Download Chrome*
- Click *64 bit .rpm (For Fedora/openSUSE)*
- Click *Accept and Install*

```
scp google-chrome-stable_current_x86_64.rpm USERNAME@home.ccs.ornl.gov:
ssh -X USERNAME@home.ccs.ornl.gov
mkdir ~/chrome
cd ~/chrome
rpm2cpio ../google-chrome-stable_current_x86_64.rpm | cpio -id
```

run rocgdb with gdbgui in Chrome

```
ssh -X USERNAME@home.ccs.ornl.gov
ssh -X login1._______.olcf.ornl.gov
srun -A VEN113 -N 1 -n 1 -c 64 --x11 --pty bash
gdbgui -g /opt/rocm/bin/rocgdb --no-browser &
~/chrome/opt/google/chrome/google-chrome 2>/dev/null &
```

- In Chrome, go to: http://127.0.0.1:5000
- Click *Load Binary* to load your binary (compiled with -ggdb)
- Step into a kernel
- Click *fetch disassembly*

```
show architecture
info threads
info queues
info dispatches
info registers
info reg vcc
info reg exec
s
si
n
ni
...
```

More resources for rocgdb

- /opt/rocm<-version>/share/doc/rocgdb/
  - rocgdb.pdf -- has additions for GPU commands
  - rocrefcard.pdf -- standard gdb reference card
- Presentations
  - https://www.olcf.ornl.gov/wp-content/uploads/2021/04/rocgdb_hipmath_ornl_2021_v2.pdf -- Justin Chang (AMD)
  - https://lpc.events/event/11/contributions/997/attachments/928/1828/LPC2021-rocgdbdemo.pdf – Andrew Stubbs (Siemens) – See https://youtu.be/IGWFph4SlpU for 24 min video from presentation of debugging GCC offloading code (OpenACC and OpenMP)

Hands-on exercises

https://hackmd.io/@sfantao/lumi-training-ams-2024#Debugging

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 **Rocgdb** directory.

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

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