ROCgdb Documentation

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INSTALL

This is the documentation for AMD ROCm Debugger (ROCgdb) for Linux, which is the AMD source-level debugger based on the GNU Debugger (GDB). For documentation on ROCgdb for Windows, see AMD ROCm debugger for Windows. ROCgdb enables heterogeneous debugging on the ROCm software that consists of an x86-based host architecture along with commercially available AMD GPU architectures supported by the AMD Debugger API Library (ROCdbgapi). ROCdbgapi is included with ROCm.

ROCgdb provides the following features:

- Debugs ROCm applications running on AMD GPU-supported hardware.
- Debugs applications without the potential variations introduced by simulation and emulation environments.
- Offers a seamless debugging environment that allows simultaneous GPU and CPU code debugging within the same application, just like programming in HIP, which is a seamless extension of C++ programming.
- Additional features to support debugging ROCm device code on top of the existing GDB debugging features, which are inherently present for debugging the host code.
- Supports HIP kernel debugging.
- Allows you to set breakpoints, single-step ROCm applications, and inspect and modify the memory and variables of any given thread running on the hardware.

The code is open source and hosted at: https://github.com/ROCm/ROCgdb

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To contribute to the documentation, refer to Contributing to ROCm.

You can find licensing information on the Licensing page.

CHAPTER

ONE

INSTALLING ROCGDB

This topic provides information required to build and install ROCgdb.

1.1 System requirements

- A system supporting ROCm. See the supported operating systems.
- A C++17 compiler such as GCC 9 or Clang 5.
- AMD Debugger API Library (`ROCdbgapi`) that can be installed as part of the ROCm release using the `rocm-dbgapi` package.
- Install the required packages according to the OS:

Ubuntu

```
apt install bison flex gcc make ncurses-dev texinfo g++ zlib1g-dev \
libexpat-dev python3-dev liblzma-dev libgmp-dev libmpfr-dev
```

RHEL

```
yum install -y epel-release centos-release-scl bison flex gcc make \
texinfo texinfo-tex gcc-c++ zlib-devel expat-devel python3-devel \
xz-devel gmp-devel ncurses-devel mpfr-devel
```

SLES

```
zypper in bison flex gcc make texinfo gcc-c++ zlib-devel libexpat-devel \
python3-devel xz-devel gmp-devel ncurses-devel mpfr-devel
```

Note: ROCgdb might become unresponsive in SELinux-enabled distributions. To learn more about this issue, see installation troubleshooting.

1.2 Building ROCgdb

An example command line to build ROCgdb on Linux:

```
cd rocgdb
mkdir build
cd build
../configure --program-prefix=roc \
--enable-64-bit-bfd --enable-targets="x86_64-linux-gnu,amdgcn-amd-amdhsa" \
--disable-ld --disable-gas --disable-gdbserver --disable-sim --enable-tui \
--disable-gdbtk --disable-gprofng --disable-shared --with-expat \
--with-system-zlib --without-guile --without-babeltrace --with-lzma \
--with-python=python3
make
```

If `ROCdbgapi` is not installed in the system's default location, specify `PKG_CONFIG_PATH` to make the correct build configuration available to `pkg-config`. If `ROCdbgapi` is installed in `/opt/rocm-$ROCM_VERSION` (default for ROCm packages), use `PKG_CONFIG_PATH=/opt/rocm-$ROCM_VERSION/share/pkgconfig`.

If the system's dynamic linker is not configured to locate `ROCdbgapi` where it is installed, configure and build ROCgdb using `LDFLAGS="-Wl,-rpath=/opt/rocm-$ROCM_VERSION/lib"`. Alternatively, use `LD_LIBRARY_PATH` at runtime to indicate where `ROCdbgapi` is installed.

You can find the built ROCgdb executable in `build/gdb/gdb` and the user manual in `build/gdb/doc/gdb.info`.

1.3 Installing ROCgdb

To install ROCgdb, use:

```
make install
```

This installs ROCgdb in `<prefix>/bin/rocgdb`.

1.4 Installing libraries

To execute ROCgdb, you must install the `ROCdbgapi` library and its dependent `Comgr` library. These can be installed as part of the ROCm release using the `rocm-dbgapi` package:

- `librocm-dbgapi.so.0`
- `libamd_comgr.so`

To generate the ROCgdb user guide as a PDF, use:

```
make pdf
```

This generates the PDF in `build/gdb/doc/gdb.pdf`.

Note: For ROCgdb user guide in HTML format, see ROCgdb user guide.

CHAPTER

TWO

ROCGDB QUICK START

After *installing ROCgdb*, follow the *setup* to start debugging your application.

2.1 Source compilation

Before debugging, compile your software with debug information.

To compile your source with debug symbols, use:

```
$ hipcc -ggdb -O0 saxpy.cpp -o saxpy
```

Or, compile using amd-llvm:

```
amdclang++ -ggdb -O0 -x hip --offload-arch=native saxpy.cpp -o saxpy
```

Adding the `-g` flag to your compilation command generates debug information even when optimizations are turned on. Note that higher optimization levels make debugging more difficult, so it might be helpful to turn off these optimizations with the `-O0` compiler option.

For saxpy source code, see main.hip.

2.2 Debugging using ROCgdb

You can either launch and run your application under debugger control or attach the debugger to a running process and continue execution.

To start debugging your application under debugger control, follow these steps:

1. Launch your application under debugger control:

   ```
   $ rocgdb ./saxpy
   [...]
   ```

   At this point, the application is not running, but you'll have access to the debugger console. On the console, you can use any *gdb option* for host debugging along with ROCgdb-specific features for device debugging.

2. Set a breakpoint before running the application with debugger.

   ```
   tbreak my_app.cpp:458
   ```

   This places a temporary breakpoint at the specified line. To start your application, use:

```
(gdb) run
```

If the breakpoint is in the device code, the debugger shows the device and host threads. The device threads are not individual work items; instead, they represent a wavefront on the device. You can switch between the device wavefronts as you can between the host threads.

To attach the debugger to a running process and continue execution, use:

```
$ rocgdb -pid <process_id>
[...]
(gdb) continue
```

Use `ps` command to get the <process_id> of the running application, to which the debugger needs to be attached.

You can also switch between layouts, which allows you to use different layouts for different situations while debugging.

```
layout src
layout asm
```

The `src` layout is the source code view, while the `asm` is the assembly view. For more layouts, see TUI-specific commands.

After starting or attaching your application with the debugger, you can utilize these *ROCgdb commands for key operations* to perform further operations.

2.3 ROCgdb user guide

The ROCgdb user guide provides detailed information about using ROCgdb. This user guide is also installed in the following directories when you install ROCm:

- `/opt/rocm/share/info/rocgdb/gdb.info` as a texinfo file
- `/opt/rocm/share/doc/rocgdb/rocgdb.pdf` as a PDF file

For specific information about debugging heterogeneous programs on ROCm software, refer to the following chapters in the ROCgdb user guide:

- **Debugging Heterogeneous Programs:** Provides general information about debugging heterogeneous programs. It also discusses features and commands that are not currently implemented but provisionally planned for future versions.
- **Configuration-Specific Information > Architectures > AMD GPU:** Provides specific information about debugging heterogeneous programs on ROCm software with supported AMD GPU hardware. This section also lists the implementation status and known issues of the current version.

You can use the standard GDB commands for both CPU and GPU code debugging.

CHAPTER

THREE

ROCGDB COMMANDS FOR KEY OPERATIONS

This topic summarizes the ROCgdb commands for key operations.

3.1 Inspecting kernel state

Here are the commands used to inspect the kernel state:

3.1.1 View kernel code

```
(gdb) list
```

Sample output:

```
1  #include <hip/hip_runtime.h>
2  #include <algorithm>
3  #include <iostream>
4  #include <numeric>
5  #include <vector>
6  #include <cstddef>
8  __global__ void saxpy_kernel(const float a, const float* d_x, float* d_y, const unsigned int size)
9  {
10      // Compute the current thread's index in the grid.
11      const unsigned int global_idx = blockIdx.x * blockDim.x + threadIdx.x;
12      // The grid can be larger than the number of items in the vectors. Avoid out-of-bounds addressing.
13      if(global_idx < size)
14      {
15          d_y[global_idx] = a * d_x[global_idx] + d_y[global_idx];
16      }
17  }
18  int main()
19  {
....
99  }
```

3.1.2 View disassembly

```
(gdb) disassemble
```

Sample output:

```
Dump of assembler code for function _ZL3bari:
    0x00007ffff608e2b0 <+0>:     s_waitcnt vmcnt(0) expcnt(0) lgkmcnt(0)
    0x00007ffff608e2b4 <+4>:     s_mov_b32 s25, s33
    0x00007ffff608e2b8 <+8>:     s_mov_b32 s33, s32
    0x00007ffff608e2bc <+12>:    s_xor_saveexec_b64 s[16:17], -1
    0x00007ffff608e2c0 <+16>:    buffer_store_dword v36, off, s[0:3], s33 offset:52
    .....
    0x00007ffff608e92c <+1660>:  s_mov_b64 exec, s[4:5]
    0x00007ffff608e930 <+1664>:  s_mov_b32 s33, s25
    0x00007ffff608e934 <+1668>:  s_waitcnt vmcnt(0)
    0x00007ffff608e938 <+1672>:  s_setpc_b64 s[30:31]
End of assembler dump.
```

3.1.3 View system information

The following commands are related to heterogeneous debugging:

- **Agents:**

  The following command lists the information shown in the sample output for each heterogeneous agent:

  ```
  (gdb) info agents
  ```

  Sample output:

  ```
    Id State Target Id                    Architecture Device Name       Cores Threads␣
  ↪Location
  * 1  A      AMDGPU Agent (GPUID 35090) gfx90a       AMD Instinct MI210 416    3328     ␣
  ↪0000:4a:00.0
    2  A      AMDGPU Agent (GPUID 34915) gfx90a       AMD Instinct MI210 416    3328     ␣
  ↪0000:09:00.0
    3  A      AMDGPU Agent (GPUID 56224) gfx90a       AMD Instinct MI210 416    3328     ␣
  ↪0000:0c:00.0
    4  A      AMDGPU Agent (GPUID 33385) gfx90a       AMD Instinct MI210 416    3328     ␣
  ↪0000:11:00.0
  ```

  For more information, see info agents command.

- **Queues:**

  The following command lists the information shown in the sample output for each heterogeneous queue:

  ```
  (gdb) info queues
  ```

  Sample output:

  ```
    Id   Target Id                Type         Read   Write  Size     Address
    1    AMDGPU Queue 1:1 (QID 0) HSA          2      2      4096    ␣
  ```

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```
↪0x00007ffff626e000
* 2    AMDGPU Queue 1:2 (QID 1) HSA          0      2      1048576 ␣
↪0x00007fffe5800000
```

For more information, see info queues command.

- **Dispatches:**

  The following command lists the information shown in the sample output for each heterogeneous dispatch:

```
(gdb) info dispatches
```

  Sample output:

```
 Id   Target Id                         Grid    Workgroup Fence   Kernel Function
* 1    AMDGPU Dispatch 1:2:1 (PKID 0) [1,1,1] [1,1,1]   B|Aa|Ra kern()
```

  For more information, see info dispatches command.

- **Threads:**

  In some operating systems where a single program might have more than one thread of execution, the threads are akin to multiple processes with a shared address space but individual registers, execution stack, and perhaps private memory.

  To facilitate debugging such multi-thread programs, the following command lists the threads created on all heterogeneous agents:

```
(gdb) info threads
```

  Sample output:

```
  Id   Target Id                                   Frame
  1    Thread 0x7ffff6288180 (LWP 645917) "nosimple" 0x00007ffff207d586 in ?? ()␣
↪from /opt/rocm-7.1.0/lib/libhsa-runtime64.so.1
  2    Thread 0x7fffe81ff6c0 (LWP 645924) "nosimple" __GI___ioctl (fd=3,␣
↪request=3222817548) at ../sysdeps/unix/sysv/linux/ioctl.c:36
  4    Thread 0x7fffe61ff6c0 (LWP 645926) "nosimple" __GI___ioctl (fd=3,␣
↪request=3222817548) at ../sysdeps/unix/sysv/linux/ioctl.c:36
  6    Thread 0x7ffff5fff6c0 (LWP 645930) "nosimple" __GI___ioctl (fd=3,␣
↪request=3222817548) at ../sysdeps/unix/sysv/linux/ioctl.c:36
* 7    AMDGPU Wave 1:2:1:1 (0,0,0)/0 "saxpy"      kern () at /home/user/saxpy.cpp:7
```

  For more information, see Debugging programs with multiple threads.

- **Lanes:**

  On some heterogeneous systems there can be heterogeneous agents that support Single Instruction Multiple Data (SIMD) or Single Instruction Multiple Threads (STMT) machine instructions. On these target architectures, a single machine instruction can operate in parallel on multiple heterogeneous lanes.

  To facilitate debugging heterogeneous programs, the following command displays information about individual source language threads of execution that are mapped to SIMD-like lanes of a thread.

```
(gdb) info lanes
```

  Sample output:

```
  Id   State Target Id                                    Frame
* 0    A     AMDGPU Lane 1:2:1:1/0 (0,0,0)[0,0,0] kern () at /home/user/saxpy.cpp:7
```

For more information, see Debugging heterogeneous programs.

3.1.4 View back trace

```
(gdb) backtrace
```

Sample output:

```
#0  saxpy (tid=0) at /home/oogunbow/saxpy.cpp:33
#1  0x00007ffff608ee40 in kern () at /home/user/saxpy.cpp:4
```

3.1.5 View stack frames

```
(gdb) info frame
```

Sample output:

```
Stack level 0, frame at private_wave#0x800:
pc = 0x7ffff608e3bc in bar (/home/user/saxpy.cpp:33); saved pc = 0x7ffff608ee40
called by frame at private_wave#0x0
source language c++.
Arglist at private_wave#0x800, args: tid=0
Locals at private_wave#0x800, Saved registers:
v36 at private_wave#0x1500, v37 at private_wave#0x1600
```

3.1.6 View frame arguments

```
(gdb) info args
```

Sample output:

```
tid = 0
```

3.1.7 View frame local variables

```
(gdb) info locals
```

Sample output:

```
No locals.
```

3.1.8 View GPU registers

```
(gdb) info registers
```

This command dumps the content of the current wavefront's registers.

Sample output:

```
v0              {0x30 <repeats 64 times>}
....
s41             0x0                 0
m0              0x1008              4104
pc              0x7ffff608e3bc      0x7ffff608e3bc <saxpy(int)+268>
exec            0x5555555555555555  6148914691236517205
vcc             0xffffffffffffffff  18446744073709551615
```

This command dumps only the general-purpose registers, which provide all-inclusive data about the state of the current wavefront.

To get data for all registers, use:

```
(gdb) info all-registers
```

3.1.9 View GPU data @ address spaces

```
(gdb) x/nfu global#0xdeadbeef
(gdb) x/nfu local#0xdeadbeef
(gdb) x/nfu generic#0xdeadbeef
(gdb) x/nfu private_wave#0xdeadbeef
(gdb) x/nfu private_lane#0xdeadbeef
```

For more information, see AMD GPU address spaces.

3.1.10 View CPU/GPU threads

```
(gdb) info threads
```

Sample output:

```
  Id   Target Id                                      Frame
  1    Thread 0x7ffff648bf80 (LWP 1981864) "saxpy" 0x00007ffff5a6c9ef in ?? () from /opt/
↪rocm-7.1.0/lib/libhsa-runtime64.so.1
  2    Thread 0x7ffff55ff6c0 (LWP 1981871) "saxpy" __GI___ioctl (fd=3,␣
↪request=3222817548) at ../sysdeps/unix/sysv/linux/ioctl.c:36
  4    Thread 0x7fffeffff6c0 (LWP 1981873) "saxpy" __GI___ioctl (fd=3,␣
↪request=3222817548) at ../sysdeps/unix/sysv/linux/ioctl.c:36
  6    Thread 0x7ffff5dff6c0 (LWP 1981877) "saxpy" __GI___ioctl (fd=3,␣
↪request=3222817548) at ../sysdeps/unix/sysv/linux/ioctl.c:36
* 7    AMDGPU Wave 1:2:1:1 (0,0,0)/0 "saxpy"       saxpy_kernel () at saxpy.cpp:8
```

3.1.11 Switch threads

```
(gdb) thread <id>
```

3.2 Printing kernel data

Commands to print the kernel data:

3.2.1 Print variable

```
(gdb) print foo
```

3.2.2 Print array

```
(gdb) print *foo[2]@8     -- i.e. (gdb) print *<address>@<count>
```

3.2.3 Print expressions

```
(gdb) print foo[4] >> 1
```

3.2.4 Print formats

```
// (gdb) p/<code> <value>
(gdb) p/x foo[1]
```

The values for <code> are:

- x - hexadecimal
- d - decimal
- u - unsigned decimal
- o - octal
- t - binary (two)
- a - address (hex + offset)
- c - character
- f - float
- s - string
- z - hexadecimal with leading zeros
- r - raw (skips pretty printing)

3.3 Modifying kernel data

The commands to modify the kernel data:

3.3.1 Using set command

Use the `set` command to modify kernel data directly.

```
(gdb) set var foo[1]=45
```

3.3.2 Using print command

The `print` command is an indirect way to modify the kernel data.

```
(gdb) print foo[3]=3
```

3.4 Changing kernel focus

Commands to change the kernel thread, lane, or frame:

3.4.1 Change thread

```
(gdb) thread 9
```

3.4.2 Change lane

```
(gdb) lane 5
```

3.4.3 Change frame

```
(gdb) frame <index>
(gdb) up <count>
(gdb) down <count>
```

3.5 Controlling kernel execution

Commands to control kernel execution:

3.5.1 Set breakpoints

```
(gdb) break saxpy.cpp:47
(gdb) break func_foo
(gdb) break *0x01234567
```

3.5.2 Set temporary breakpoints

```
(gdb) tbreak saxpy.cpp:47
(gdb) tbreak func_foo
(gdb) tbreak +24
```

3.5.3 Set conditional breakpoints

```
(gdb) break func_foo if idx == 9
(gdb) break func_foo if $_agent == 2
(gdb) break func_foo if $_queue == 1
(gdb) break func_foo if $_dispatch == 6
(gdb) break func_foo if $_thread == 7
(gdb) break func_foo if $_lane == 15
(gdb) break func_foo if $_thread_workgroup_pos == 3
(gdb) break func_foo if $_lane_workgroup_pos == "[0,0,0]"
```

3.5.4 Set watchpoints

```
(gdb) watch foo[4]
```

3.5.5 Set catchpoints

```
(gdb) catch load            -- Catch loads of shared libraries (debug dynamic linking).
(gdb) catch unload          -- Catch unloads of shared libraries (track cleanup/
↪unloading).
(gdb) catch rethrow         -- Catch an exception, when rethrown (trace exception␣
↪propagation).
(gdb) catch signal SIGSEGV  -- Catch signals by their names and/or numbers (debug␣
↪crashes or signals).
(gdb) catch syscall open    -- Catch system calls by names, groups, or numbers (trace␣
↪system-level calls).
(gdb) catch throw           -- Catch an exception, when thrown (trace exception origins).
(gdb) catch vfork           -- Catch calls to vfork (monitor child process creation).
```

3.5.6 Set scheduler locking (waves)

```
(gdb) set scheduler-locking on
```

For more information, see Scheduler locking mode.

3.5.7 Set scheduler non-stop (waves)

```
set non-stop non
```

For more information, see Non-stop mode.

3.5.8 Set scheduler all-stop (waves)

```
set non-stop off
```

For more information, see All-stop mode.

3.5.9 Disable breakpoint, watchpoint, catchpoint

```
disable 4
```

3.5.10 Enable breakpoint, watchpoint, catchpoint

```
enable 4
```

3.5.11 Delete breakpoint, watchpoint, catchpoint

```
// delete <list>
delete 4
```

3.5.12 Step execution (source line)

```
(gdb) step
(gdb) next
```

3.5.13 Step execution (multiple source lines)

```
(gdb) step 3
(gdb) next 3
```

3.5.14 Step execution (stack frame)

```
(gdb) until
(gdb) until 0x0000ffffdeadbeef
(gdb) finish
```

3.5.15 Step execution (machine instruction)

```
(gdb) stepi
(gdb) nexti
```

3.5.16 Resume execution

```
(gdb) continue
```

Command sequence:

```
(gdb) break saxpy.cpp:47
command BREAKPOINT_NUMBER
continue
end
```

CHAPTER

FOUR

SETTING UP THIRD-PARTY TOOLS

This topic discusses how to configure third-party tools or plugins such as the GDB dashboard and Visual Studio (VS) Code GUI for debugging applications using ROCgdb.

Note: AMD is not responsible for providing any support for issues or bugs reported on these third-party tools. To report such issues, visit the GitHub or webpage for these third-party tools. AMD doesn't guarantee that these third-party tools will work seamlessly across ROCm releases.

4.1 Setting up GDB dashboard TUI

The GDB dashboard is a Text User Interface (TUI). It's a standalone `.gdbinit` file written using the Python API, that provides a modular interface for showing relevant information about the program being debugged.

4.1.1 Installation

To install the GDB dashboard, download the .gdbinit file and move it to your home directory.

4.1.2 Layout setup

During debugging, the default dashboard layout setup appears automatically every time the inferior program stops. The GDB dashboard's purpose is to reduce the number of GDB commands needed to inspect the current program's status, allowing you to focus on the control flow.

To display the default set of views, use this command:

```
(gdb) dashboard -layout
```

Sample output:

```
Dashboard    (default TTY)
assembly     (default TTY)
breakpoints  (default TTY)
expressions  (default TTY)
history      (default TTY)
memory       (default TTY)
registers    (default TTY)
source       (default TTY)
```

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```
stack        (default TTY)
threads      (default TTY)
variables    (default TTY)
```

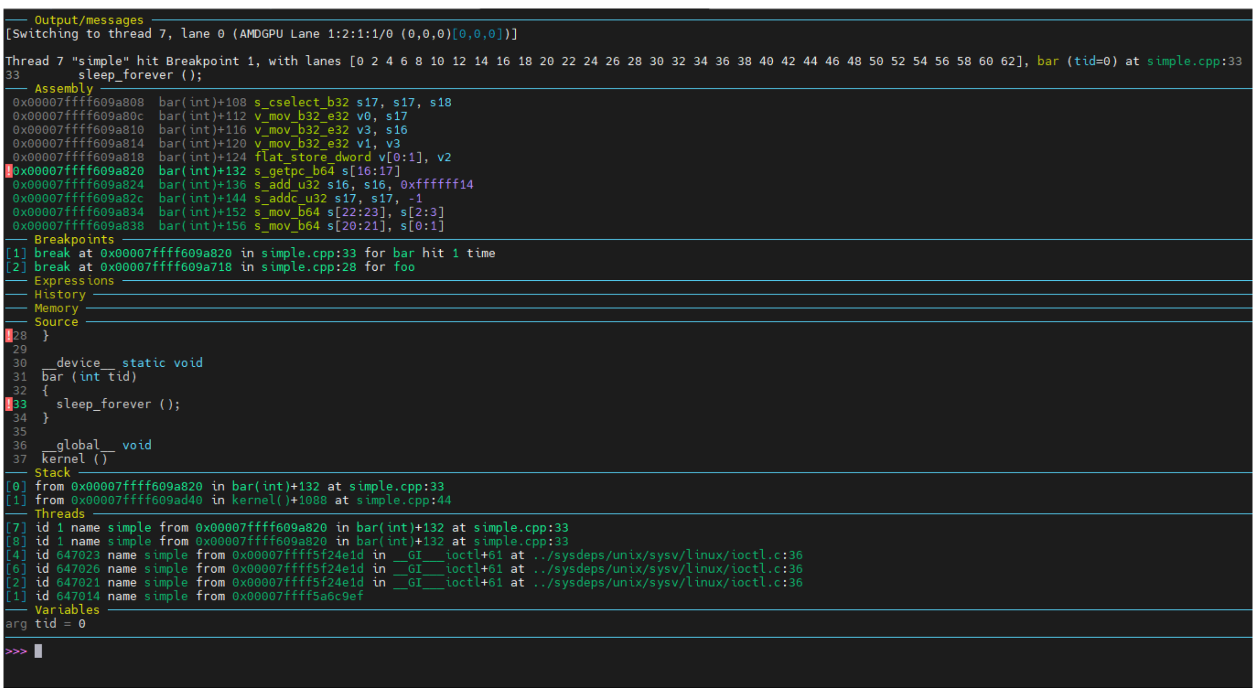
4.1.3 Customizing the dashboard

The GDB dashboard TUI is customizable. For example, you can customize the TUI to exclude less commonly used views from the default display during a debug session, such as **Expressions**, **History**, and **Memory** views.

To avoid a cluttered display with many AMD GPU registers displaying constantly on the dashboard, you can omit the **Register** view from the default dashboard using the following commands:

```
(gdb) dashboard registers
registers module disabled
(gdb) dashboard expressions
expressions module disabled
(gdb) dashboard history
history module disabled
(gdb) dashboard memory
memory module disabled
```

Here is how compact the customized dashboard will look:



Furthermore, the dashboard offers several stylable attributes that can be modified via the `-style` command, which applies to both the dashboard and individual modules. For example, the height of the **Source view** can be increased using the following command:

```
(gdb) dashboard source -style height 35
```

4.1.4 Dashboard command-line options

The following table lists the `dashboard` command-line options:

Table 4.1: dashboard cli options

Option	Description
`configuration`	Dumps or saves the dashboard configuration.
`enabled`	Enables or disables the dashboard.
`layout`	Sets or shows the dashboard layout.
`output`	Sets the output file or TTY for the whole dashboard or individual module.
`style`	Configures the stylable attributes.
`assembly`	Configures the assembly module. Using without arguments toggles its visibility.
`breakpoints`	Configures the breakpoints module. Using without arguments toggles its visibility.
`expressions`	Configures the expressions module. Using without arguments toggles its visibility.
`history`	Configures the history module. Using without arguments toggles its visibility.
`memory`	Configures the memory module. Using without arguments toggles its visibility.
`registers`	Configures the registers module. Using without arguments toggles its visibility.
`source`	Configures the source module. Using without arguments toggles its visibility.
`stack`	Configures the stack module. Using without arguments toggles its visibility.
`threads`	Configures the threads module. Using without arguments toggles its visibility.
`variables`	Configures the variables module. Using without arguments toggles its visibility.

To see the complete list of `dashboard` subcommands, you can also use `help`:

```
help dashboard
```

- For full documentation of a subcommand, use `help dashboard` followed by the subcommand name.
- To search for commands related to a "word", use `apropos <word>`.
- For full documentation of commands related to a "word", use `apropos -v <word>`.

You can also pass command name abbreviations as "word", if unambiguous.

For more information on GDB dashboard, see GDB dashboard wiki.

4.2 Setting up VS Code GUI

This section provides information on configuring Visual Studio (VS) Code GUI for debugging applications using ROCgdb.

4.2.1 Installing extensions

To use ROCgdb within the VS Code, you need to install some VS Code extensions. Only two extensions are required from external vendors while the rest are provided by Microsoft. These extensions are grouped into three categories:

- Must-have extensions. These are required for HIP debugging.
- Extra extensions for Python tracing.
- Optional extensions.

Must-have extensions

- C/C++ for VS Code by Microsoft
- C/C++ for Extension Pack by Microsoft
- C/C++ Themes by Microsoft
- Remote SSH by Microsoft
- Remote Explorer by Microsoft
- Remote Development by Microsoft
  - This installs Dev Containers and Remote Tunnels by Microsoft, which is necessary for tracing under Docker.
- Docker by Microsoft

Extra extensions for Python tracing

- Pylance by Microsoft
- Python by Microsoft
- Python Debugger by Microsoft
- Python C++ Debugger by BeniBenj

Note: VS Code requires you to install the extensions on the remote system as well.

Optional extensions

- Jupyter by Microsoft
- GitHub Pull Request by Microsoft

4.2.2 Configuring the Remote Debugger settings

After installing the VS Code extensions, you need to configure the Remote Debugger settings. The settings help VS Code to connect (Attach) to the machine hosting the HIP program to be debugged and execute the program under ROCgdb.

Follow these steps to configure the Remote Debugger settings:

1. Select **Remote Explorer** and add the new remote:
   - Add the ssh command line `ssh <user_name>@<remote_server_url>`.
2. Connect to the remote system.
3. Open the repo folder on the remote system. You can use a previously cloned CLR repo from the public GitHub.
4. Click on **Run and Debug** button on the left panel.
5. Click on **Create a launch.json** file.
6. Select **GDB** in the drop out menu and add these two configurations: **(gdb) Attach** and **(gdb) Launch**.
   - Attach doesn't require any extra setup.
   - Launch requires the environment variable `LD_LIBRARY_PATH` to point to the debug build of runtime.

- If required, set the debugger path to `rocgdb` installation path. For example, `miDebuggerPath: /opt/rocm-7.2.0/bin/rocgdb`.

4.2.3 Configuration file: launch.json

The launch.json configuration file contains information required by VS Code to Launch or Attach to a program for debugging. This information includes path information for the debugger and the program including the arguments and environment variables.

Here is a sample launch.json file:

```
{
   "version": "0.2.0",
   "configurations": [
      {
         "name": "(gdb) Attach",
         "type": "cppdbg",
         "request": "attach",
         "processId": "${command:pickProcess}",
         "program" : "/usr/bin/python3",
         "miDebuggerPath": "/opt/rocm-6.4.0/bin/rocgdb",
         "MIMode": "gdb",
         "setupCommands": [
         {
            "description": "Enable pretty-printing for gdb",
            "text": "-enable-pretty-printing",
            "ignoreFailures": true
         },
         {
            "description": "Set Disassembly Flavor to Intel",
            "text": "-gdb-set disassembly-flavor intel",
            "ignoreFailures": true
         }
         ]
      },
      {
         "name": "(gdb) Launch",
         "type": "cppdbg",
         "request": "launch",
         "program": "/home/test_dir/graph/graph",
         "args": [
         "Unit_hipMemcpy_MultiThread-AllAPIs"
         ],
         "stopAtEntry": true,
         "cwd": "/home/test_dir/graph/",
         "environment": [
         {
            "name": "LD_LIBRARY_PATH",
            "value": "/home/test_dir/udp/clr/build/install/lib/:/opt/rocm/lib"
         },
         {
            "name": "DEBUG_HIP_MEM_POOL_VMHEAP",
            "value": "1"
```

(continues on next page)

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```
            }
            ],
            "externalConsole": false,
            "MIMode": "gdb",
            "setupCommands": [
            {
               "description": "Enable pretty-printing for gdb",
               "text": "-enable-pretty-printing",
               "ignoreFailures": true
            },
            {
               "description": "Set Disassembly Flavor to Intel",
               "text": "-gdb-set disassembly-flavor intel",
               "ignoreFailures": true
            }
            ]
        }
    ]
}
```

4.2.4 Launching the debugger

After the debugger settings are configured, the **Run and Debug** tab will show these two options:

- **(gdb) Attach option:** This option is used to connect the debugger to a running process.
- **(gdb) Launch option:** This option is used to start a process under debugger control.

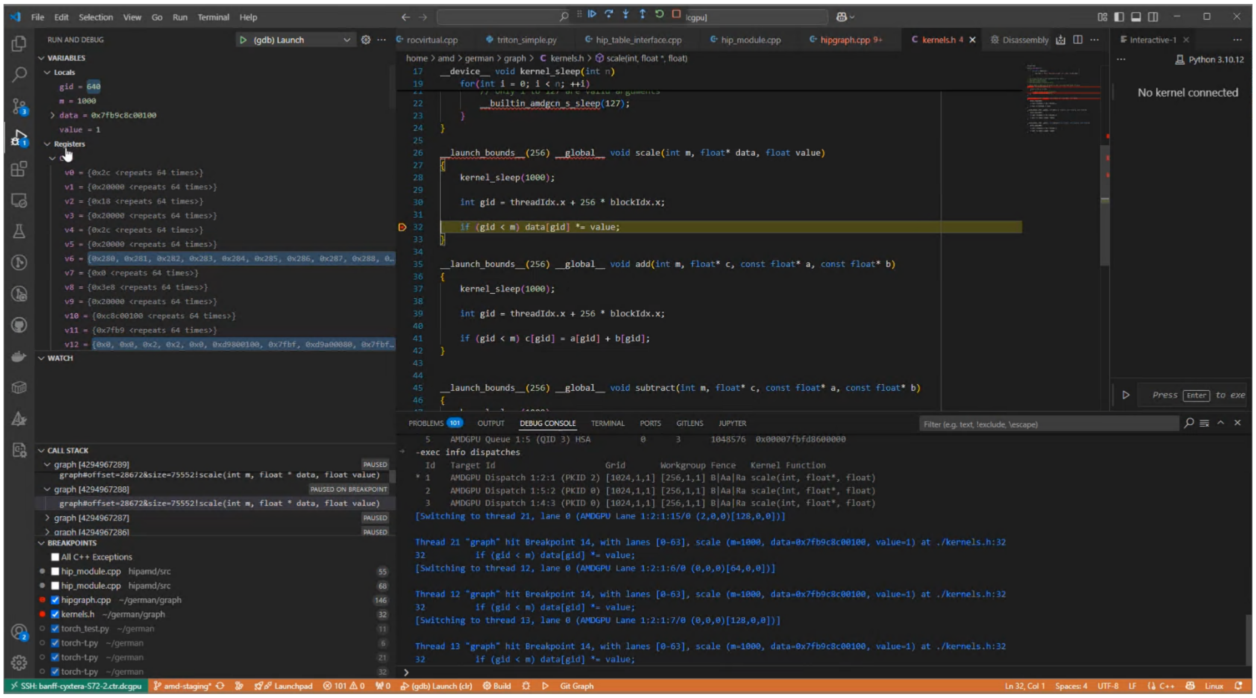
To start remote debugging, follow these steps:

1. Click on the **Launch** option to start the application under debugger control:
   - `stopAtEntry: true` stops the application on `main()`.
2. Navigate in the repo and set breakpoints in the application or runtime source code.
3. VS Code enables pretty printers by default.
   - STL classes are easily modifiable like regular data sets.
   - ROCgdb might require `~/.gdbinit` for pretty printers:

   ```
   python
   import sys
   sys.path.insert(0, '/usr/share/gcc/python')
   from libstdcxx.v6.printers import register_libstdcxx_printers
   register_libstdcxx_printers (None)
   end
   ```
4. ROCgdb also facilitates device kernel tracing. Breakpoints, variables, and registers work automatically.

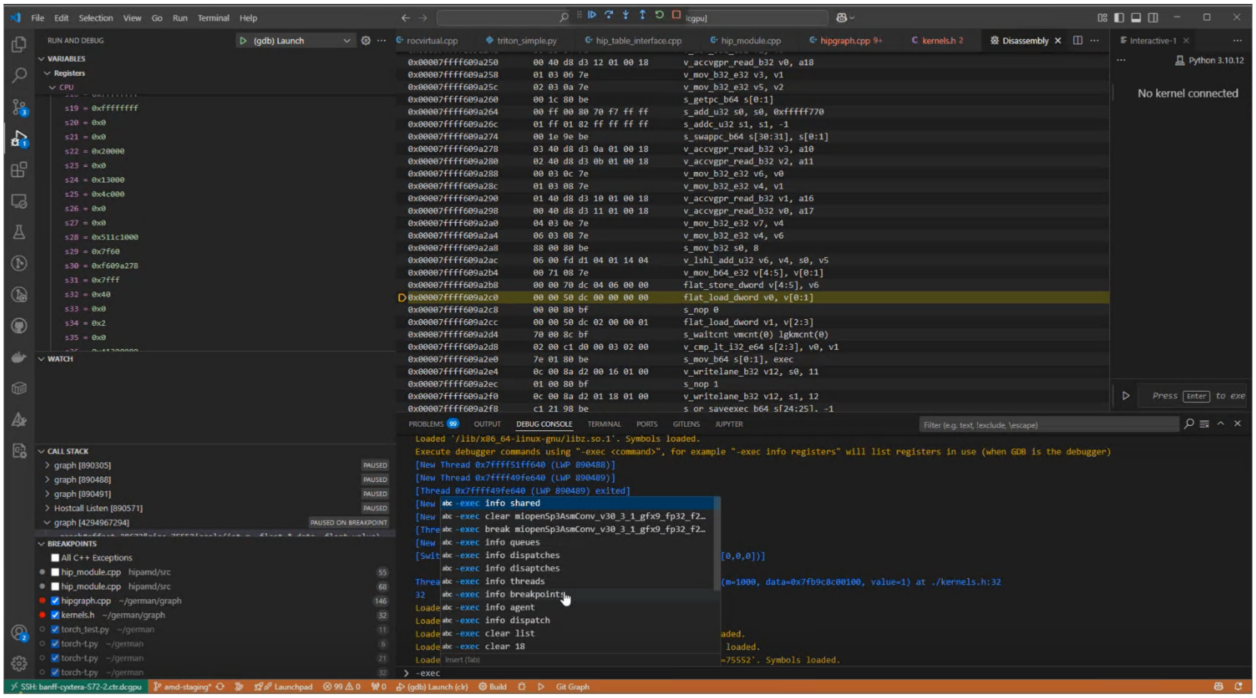
4.2.5 Debugger displays

During an active debug session, several tabs are available for displaying the running program and kernel states. These include tabs to display kernel variable, call stack frame, GPU registers, and source code breakpoint locations.



4.2.6 Debug console

During a debug session when the inferior is stopped, you can enter ROCgdb commands in the Debug console. All such commands must be entered with a `-exec` prefix. For example, all GPU threads can be displayed using `-exec info threads`.



CHAPTER

FIVE

DEBUGGING PYTHON KERNEL CODE

This topic provides information on debugging Python (Pytorch) kernel code that offloads HIP compute kernels to AMD GPU.

5.1 Installing extensions

To debug the Python kernel code, you must install the **Extra Additions For Python tracing** extensions on the remote system. These extensions help you to set a breakpoint at the Python layer, C/C++ layer, and/or HIP kernel layer simultaneously.

5.2 Getting started

To start debugging Python code, follow these steps:

1. Install Python extensions on the remote system or Docker.
2. Add Python Debugger configuration.
3. Specify the Python version using interpreter (Ctrl+Shift+P).
4. Select **Python C++ Debugger Custom** option in the configurations. It launches the Python Debugger and attaches gdb to the Python process.
5. Verify the (gdb) Attach configuration. You might need to run `echo 0|sudo tee /proc/sys/kernel/yama/ptrace_scope` to allow attach.
6. You can now see the Python Debugger and gdb threads in the **CALL STACK** window. The **Breakpoint** window works for both and is easy to navigate.

5.2.1 Key considerations

- The Python extension doesn't support gdb for Python and C++ tracing.
- Breaks in the Python script don't activate gdb automatically.
- Ensure that Python picks the correct runtime libraries. To see the location of the loaded libraries, use `-exec info shared`.
- There are multiple terminal windows. Switch as required.

5.3 Configuration file: launch.json

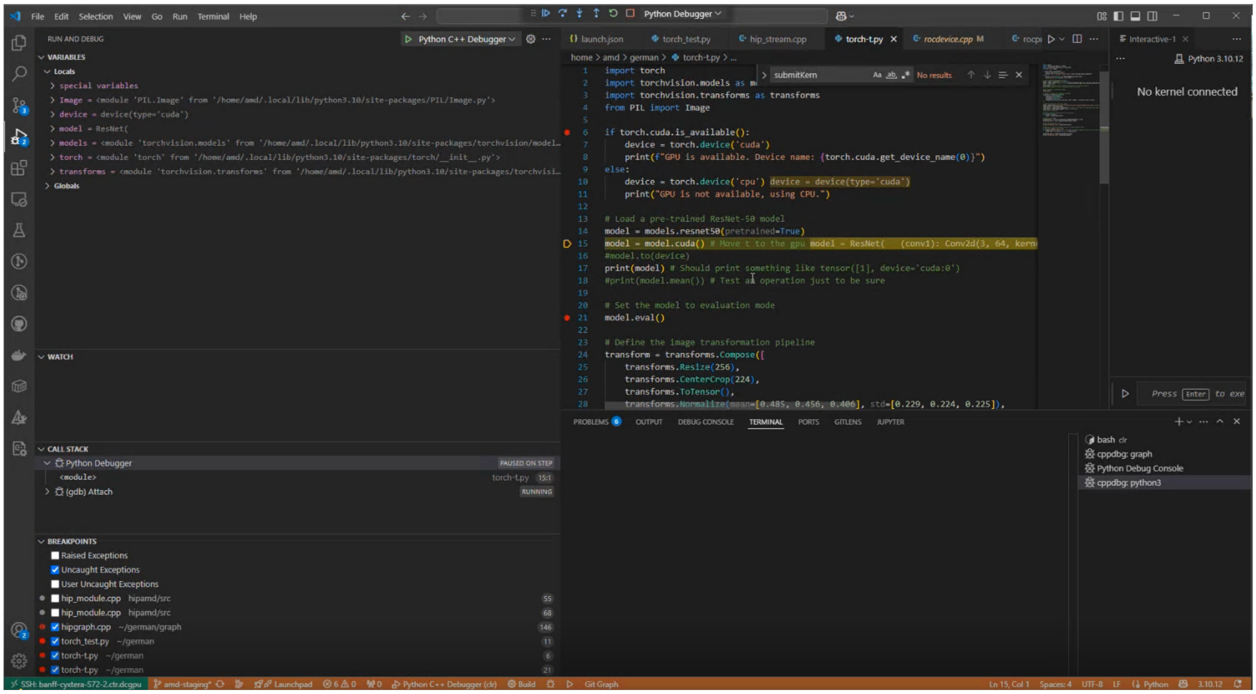
The launch.json configuration file contains the information required by VS Code to debug the Python program. This information includes the path information and environment variables required for the Python program.

See the configuration items in the following sample launch.json configuration file:

```
{
    "name": "Python C++ Debugger",
    "type": "pythoncpp",
    "request": "launch",
    "pythonLaunchName": "Python Debugger",
    "cppAttachName": "(gdb) Attach"
},
{
    "name": "Python Debugger",
    "type": "debugpy",
    "request": "launch",
    "program": "/home/test_dir/test.py",
    "console": "integratedTerminal",
    "cwd": "/home/test_dir/",
    "env": {
        "PYTHONPATH":"${PYTHONPATH}:/opt/rocm/bin:/opt/rocm/lib:/home/myenv-py311/lib/
↪python3.11/site-packages",
        "LD_LIBRARY_PATH":"/home/test_dir/udp/clr/build/install/lib/:/opt/rocm/lib",
        "AMD_LOG_LEVEL":"4"
}
},
```

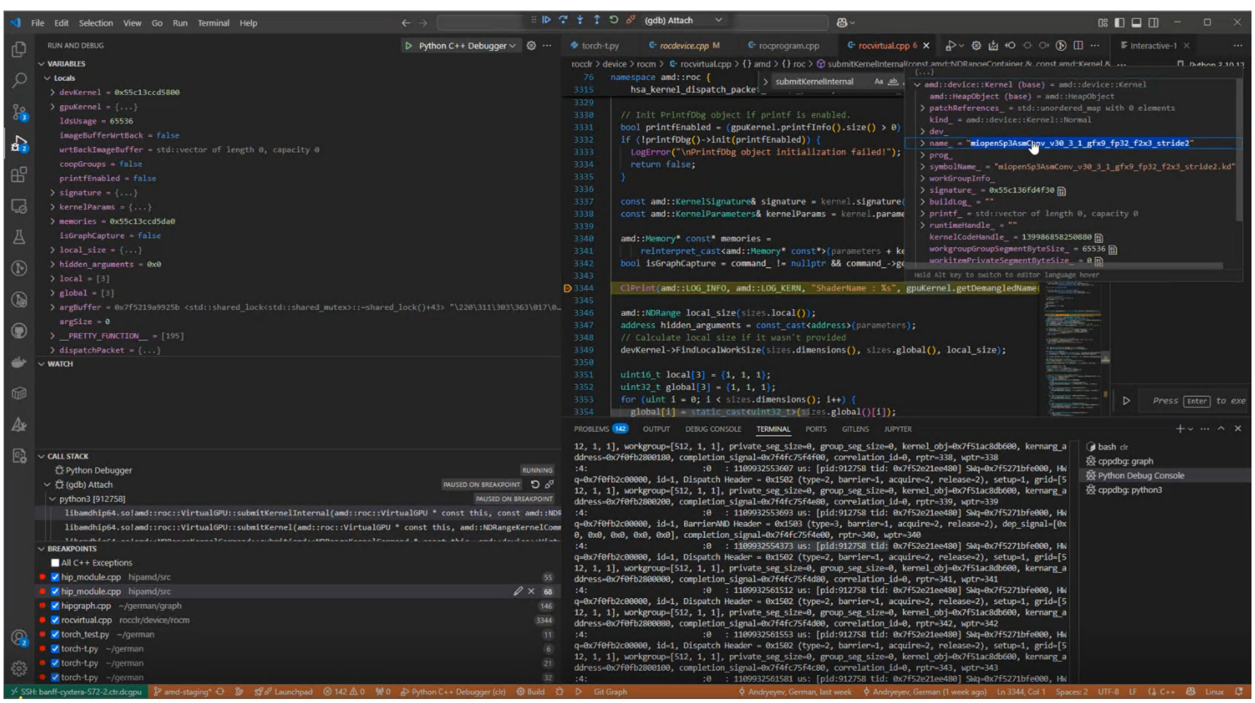
5.4 Python and C++ breakpoints

Running the launch configuration for the Python C++ Debugger starts program execution in the Python code and stops it at any preset breakpoint. As shown in the following image, there will be two entries in the **CALL STACK** window: one for **Python Debugger** and another for **(gdb) Attach**:



Whenever Python code execution pauses at a breakpoint, additional breakpoints can be set in the C/C++ code layer so that when Python code execution resumes and calls down to the C/C++ layer, program execution will stop at that C/C++ layer breakpoint.

Under the **CALL STACK** window in the following image, see the call stack hierarchy under the (gdb) Attach inferior. If the C/C++ layer breakpoint is set at the `amd::roc::VirtualGPU::submitKernel()` function, the name field for the `amd::device::kernel` object shows the name of the HIP kernel about to be submitted.



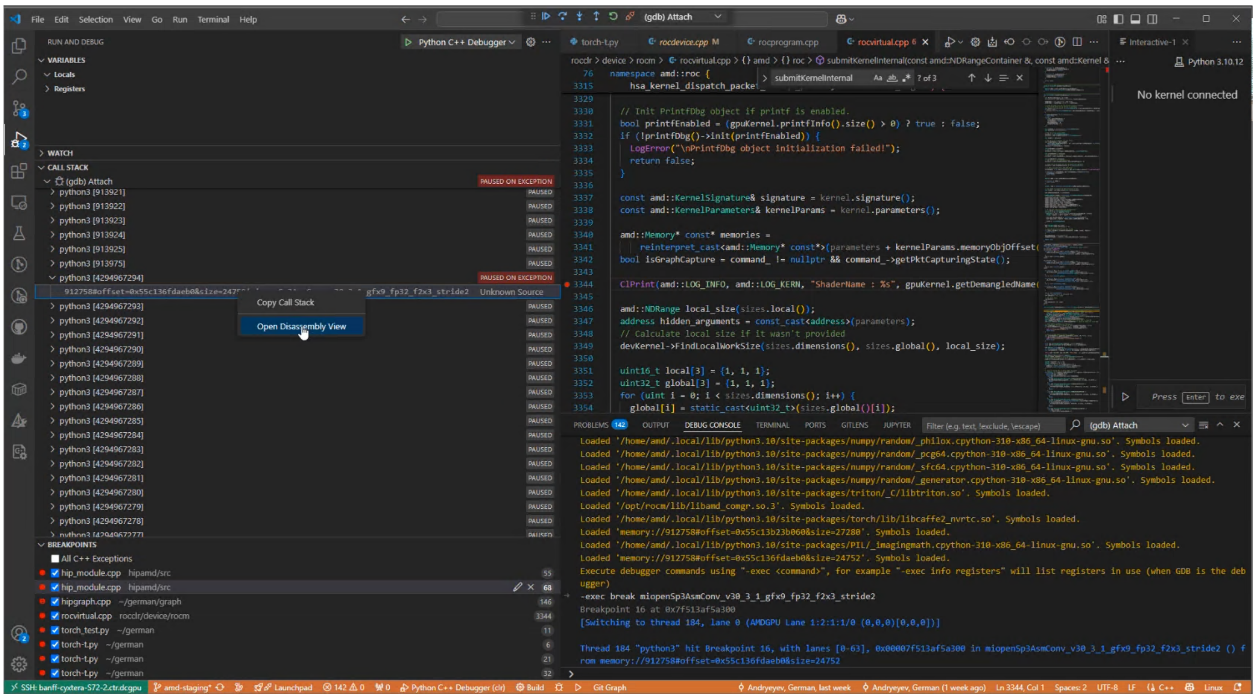
5.5 C++ and HIP kernel breakpoints

Once a breakpoint in the C/C++ layer is hit, a HIP kernel breakpoint can be set in the DEBUG CONSOLE using `-exec break <kernel_name>`. Once execution continues and the specified kernel is executed, Python will be **PAUSED ON EXCEPTION**.

To inspect the HIP kernel state:

1. Navigate to the **CALL STACK** window.
2. Search for the python3 [ID] with the **PAUSED ON EXCEPTION** status.
3. Selecting this python3 [ID] will change the debugger focus.
4. To view its disassembly, right click on this python3 [ID] and select **Open Disassembly View**.

The following image demonstrates the HIP kernel breakpoints:



CHAPTER

SIX

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```
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