AMD EPYC

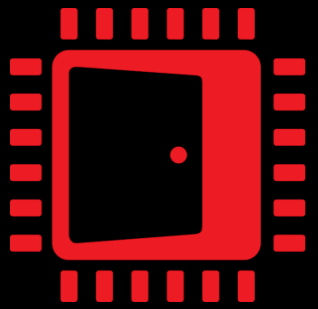
AMD RYZEN

AMD RADEON

OPTIMIZING GAME PERFORMANCE WITH THE RADEON™ DEVELOPER TOOL SUITE

CHRIS HESIK

CAN ALPER



AMD GPUOpen

AMD

together we advance_

ABOUT THIS PRESENTATION

Part 1: **Overview of the Radeon™ Developer Tool Suite**

- What is in it
- What's new since GDC 2022
- Dive into new features and improvements
- RADV & Steam Deck support

Part 2: **Collaboration with external tool developers**

- Microsoft® PIX on Windows
- RenderDoc
- GFXReconstruct

AMD RADEON GPU Profiler

AMD RADEON Memory Visualizer

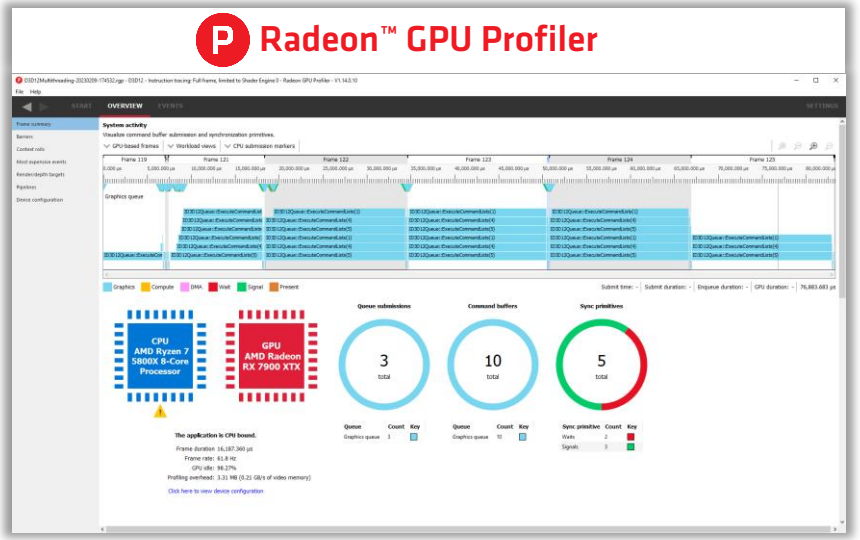
AMD RADEON Raytracing Analyzer

AMD RADEON GPU Analyzer

AMD RADEON Developer Panel

RADEON DEVELOPER TOOL SUITE - OVERVIEW

Radeon GPU Profiler (RGP)

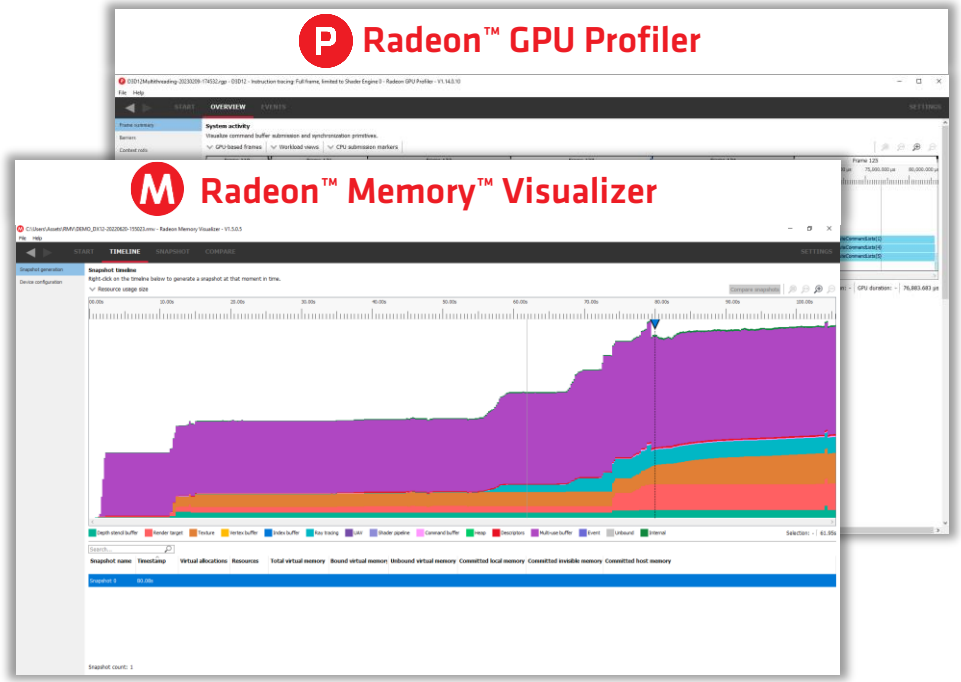


- Get a bird's eye view of how your command buffers got submitted to each GPU queue, including synchronization between the queues
- Understand how your wavefronts were pushed through the GPU, and correlate wavefronts to the API-level Draws/Dispatches which launched them
- Learn how your frame utilizes the various GPU memory caches
- Quickly and easily find hotspots in your shaders using the instruction timing view
- Identify parts of the frame using ray tracing and gain insights into the different shaders that make up a ray tracing pipeline, including which parts may be the bottleneck
- Find out which barriers flushed caches, caused a synchronization point or even ran their own, internal shaders
- Discover which events and which pipelines are the most expensive.
- Get insight into the render targets used by your frame

RADEON DEVELOPER TOOL SUITE - OVERVIEW

Radeon Memory Visualizer (RMV)

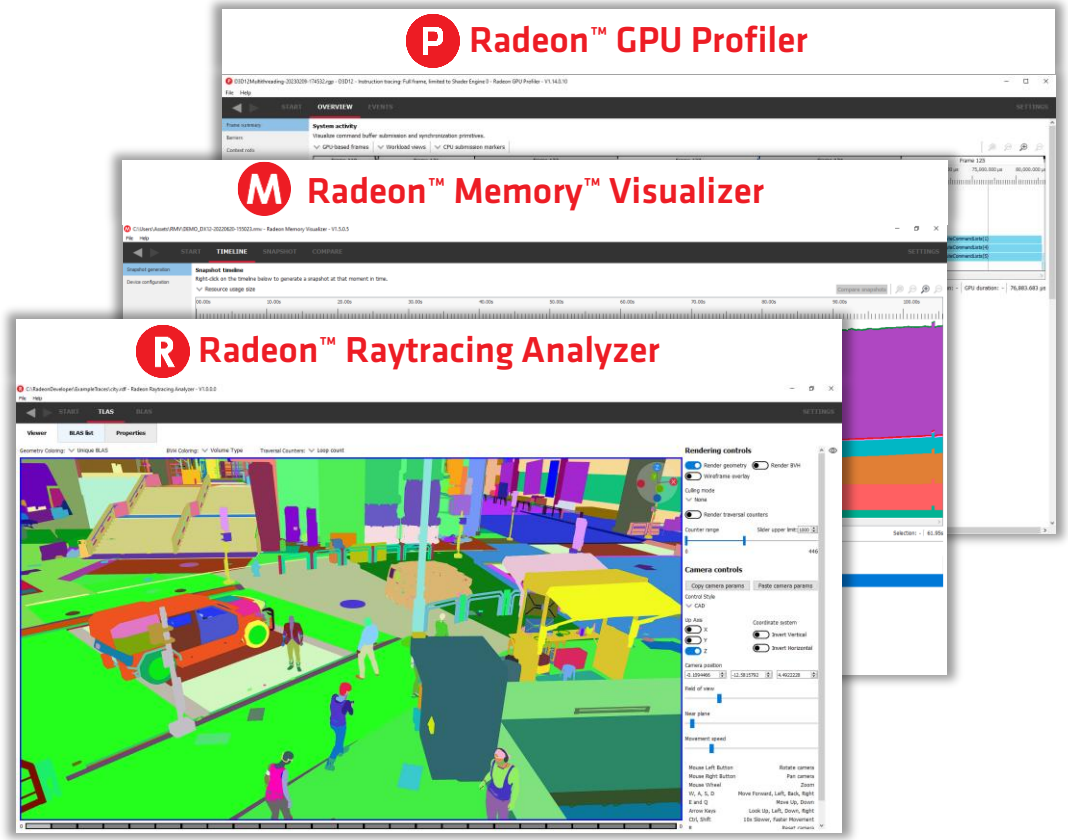
- Tracks the GPU memory usage of a running application
- Create detailed snapshots of memory state
- Visualize heap over-subscription
- Quickly find resources which are not in the optimal heaps
- Understand which resources require the most memory, which heaps they are in, and how your heaps are sub-allocated
- Identify fragmentation and understand how you are managing memory in each heap
- Understand the balance between dedicated and placed resources
- Easily find memory leaks in your application by comparing snapshots
- Use the DirectX® 12 or Vulkan® API to customize the names of your resources then search and view the details in the Resource list



RADEON DEVELOPER TOOL SUITE - OVERVIEW

Radeon Raytracing Analyzer (RRA)

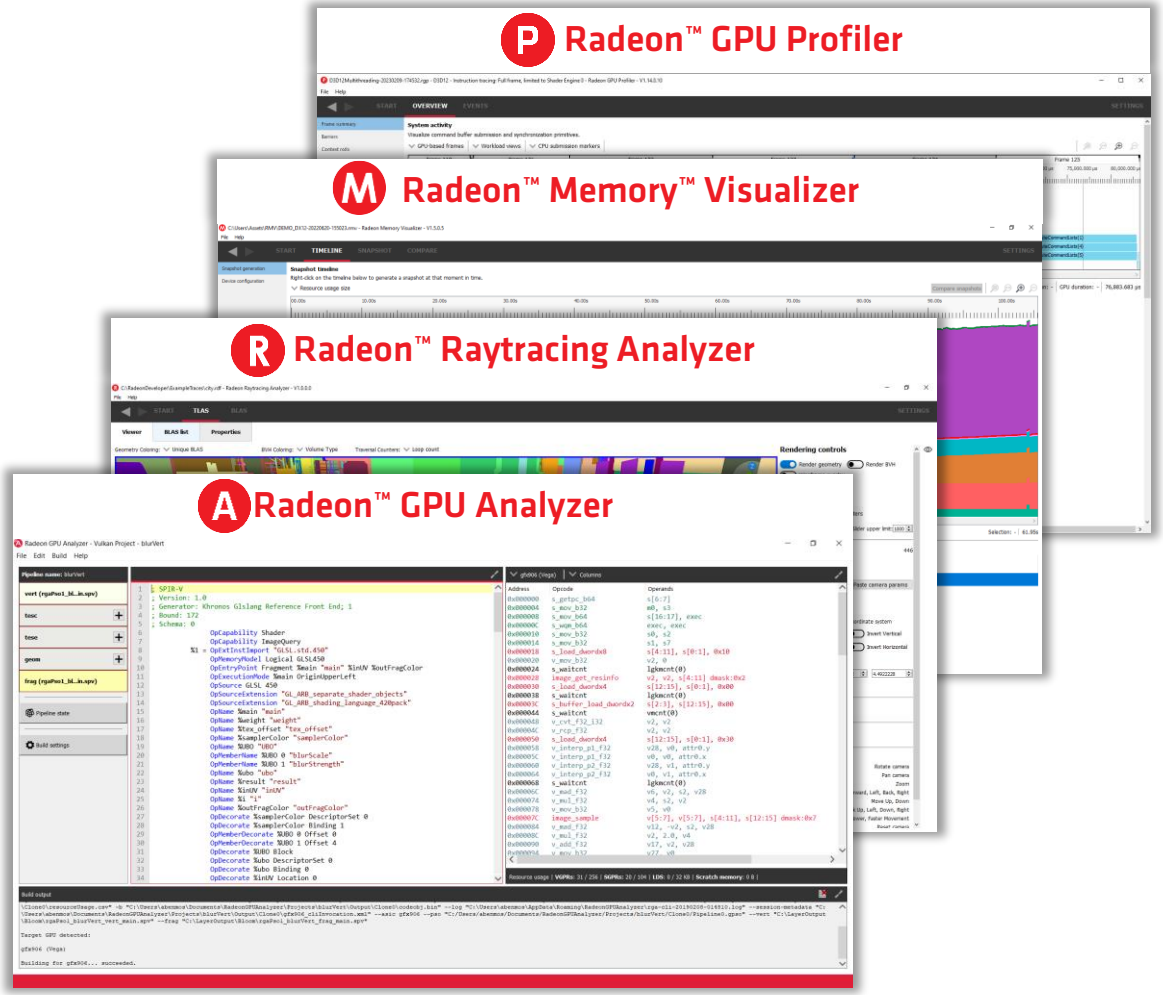
- Visually inspect your acceleration structures (TLAS and BLAS), select coloring modes to highlight areas of interest
- Use traversal counter rendering mode to find hotspots for loop count, instance overlaps and more
- View and validate primitives and attributes that were passed to the driver by your application
- High-level statistics for every acceleration structure in your scene, including things such as memory usage and triangle counts



RADEON DEVELOPER TOOL SUITE - OVERVIEW

Radeon GPU Analyzer (RGA)

- Compile and analyze shaders and kernels for AMD GPUs
- Inspect disassembly and static hardware resource usage
- Identify areas with high VGPR pressure
- Independent of the physically installed GPU
- CLI support for DirectX®12, DXR, DirectX®11, Vulkan®, SPIR-V™, OpenGL®, and OpenCL™
- GUI support for Vulkan and OpenCL



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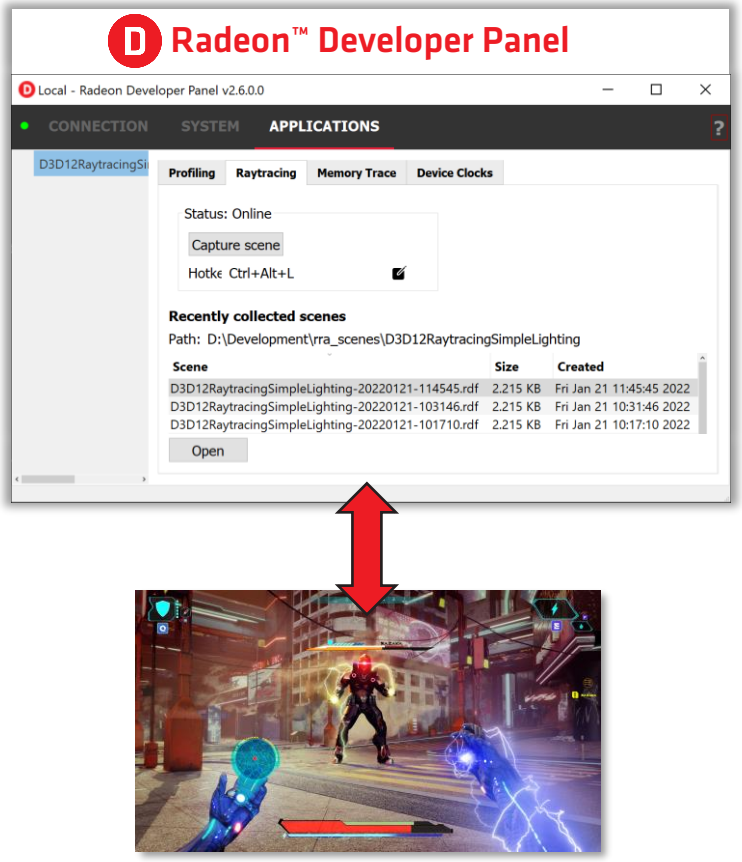
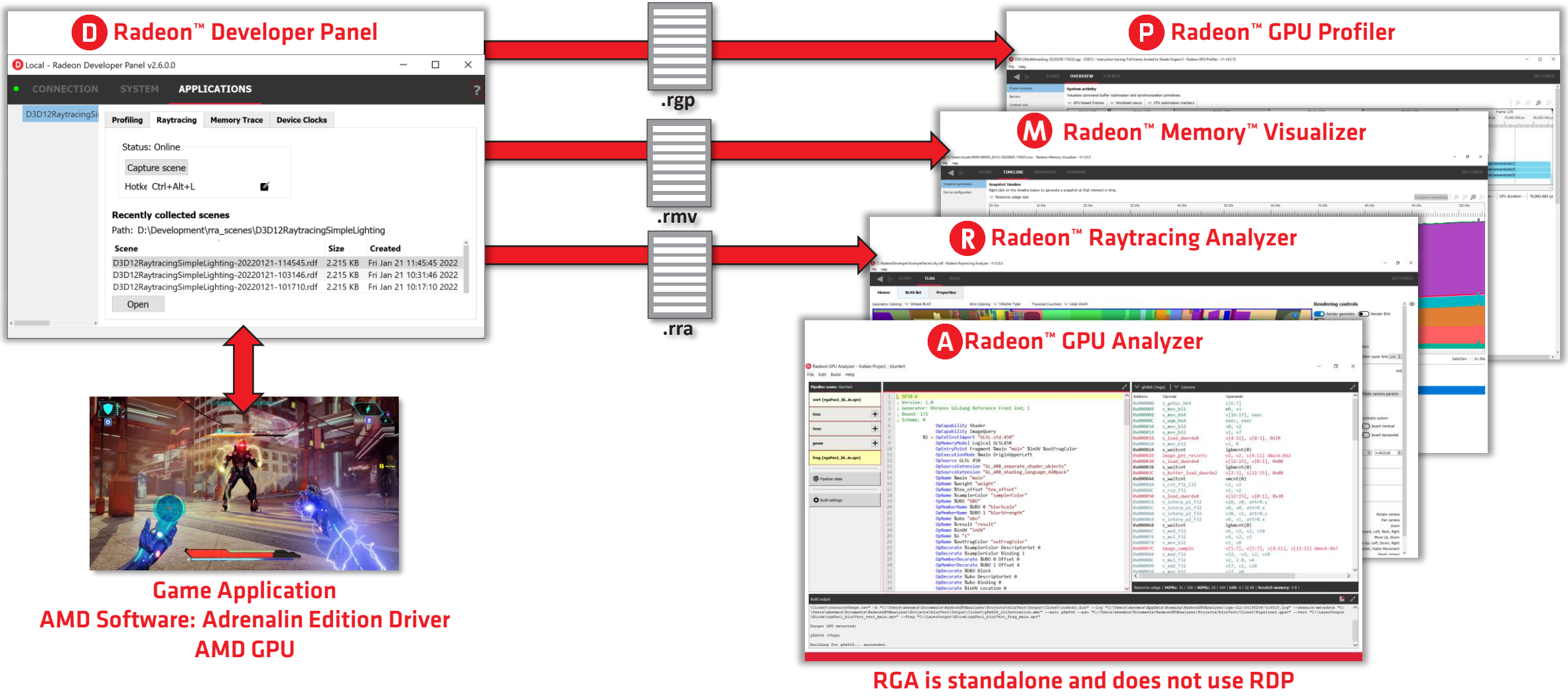


Game Application
AMD Software: Adrenalin Edition Driver
AMD GPU

Radeon Developer Panel (RDP)

- RDP connects to the Radeon™ Adrenalin driver to enable developer mode
- Developer mode generates:
  - Correlated hardware tracing, driver and application timing data for the Radeon™ GPU Profiler (RGP)
  - Memory usage data for the Radeon™ Memory Visualizer (RMV)
  - Acceleration structure information for RRA
- Supports local and remote data gathering
- RDP supports default and custom workflows to simplify data gathering from your applications

RADEON DEVELOPER TOOL SUITE - OVERVIEW

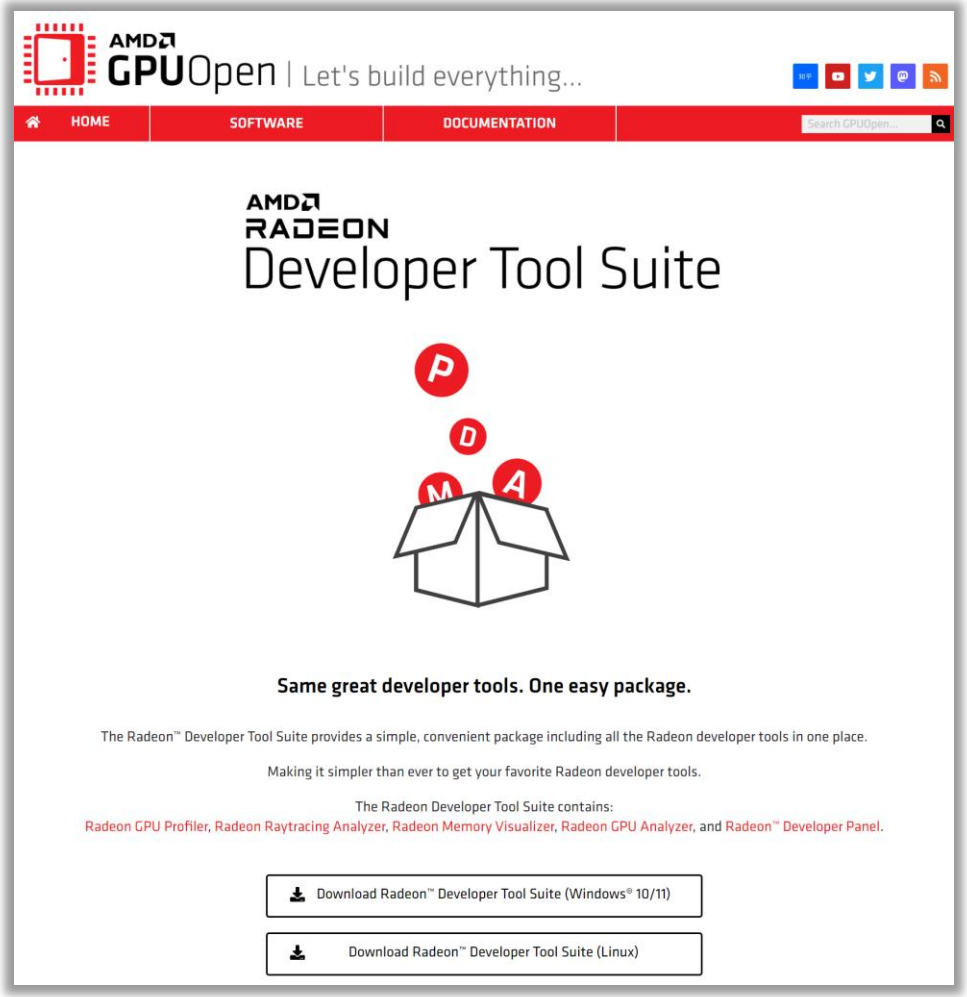


Game Application
AMD Software: Adrenalin Edition Driver
AMD GPU

RGA is standalone and does not use RDP

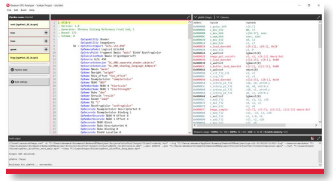
RADEON DEVELOPER TOOL SUITE

- Download: **gpuopen.com/tools**
- **ZIP file containing**
  - Radeon GPU Profiler
  - Radeon Memory Visualizer
  - Radeon Raytracing Analyzer
  - Radeon GPU Analyzer
  - Radeon Developer Panel
- No installer needed
- Videos: **gpuopen.com/videos**

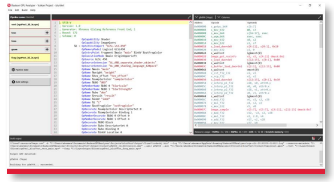


WHAT'S NEW?

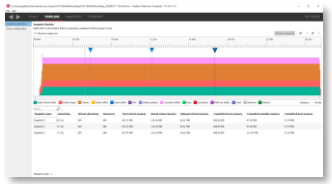
RGP 1.13.1
Bug fixes



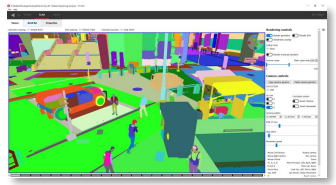
RGA 2.6.1
Support for RX 680M
VS2022 compilation
DXR/DX12 offline mode



RGA 2.6.2
OpenGL offline mode

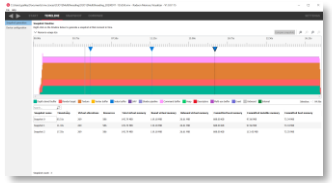


RMV 1.4
Smart Access Memory support

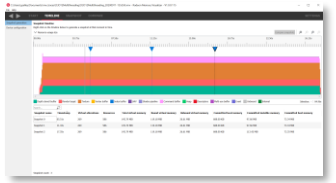


RRA 1.0
BVH Viewer

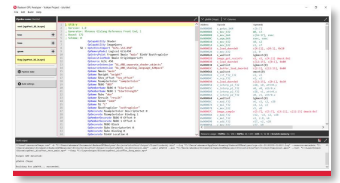
RGP 1.13
Raytracing perf counters
Inline raytracing support



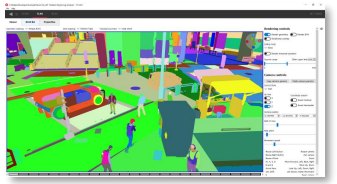
RMV 1.4.1
Ubuntu 20.04



RMV 1.5
Raytracing support



RGA 2.7
DirectX 11 offline mode
VGPR Pressure UI



RRA 1.1
Opensource code,
rebraiding, triangle splitting,
instance masks, traversal
counter histogram

RGP 1.14
HIP support, OpenCL/HIP
instruction timing,
ExecuteIndirect Raytracing
support

RDNA3 support

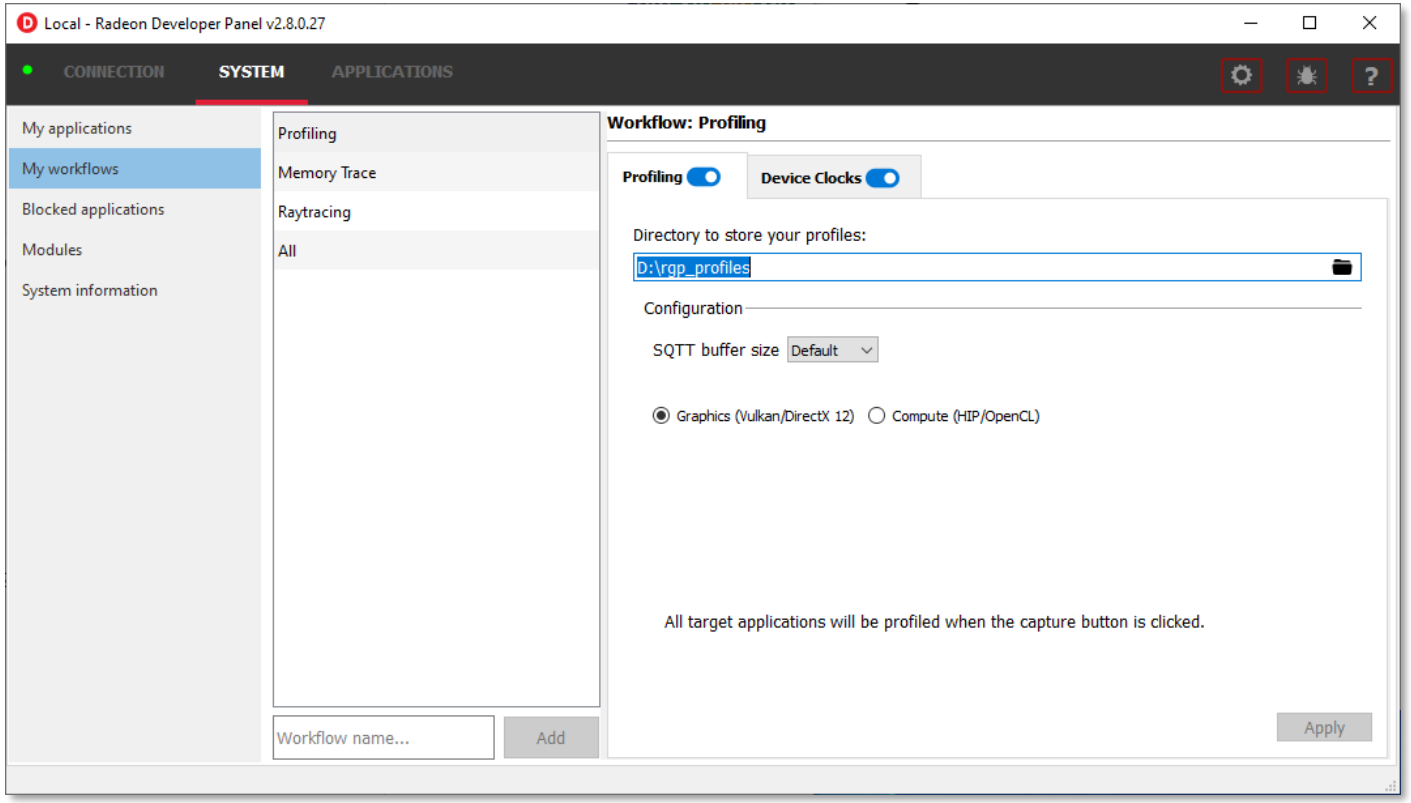
GDC 2022 — **GDC 2023**

March | April | May | June | July | Aug | Sept | Oct | Nov | Dec


AMD
RADEON
Developer Panel

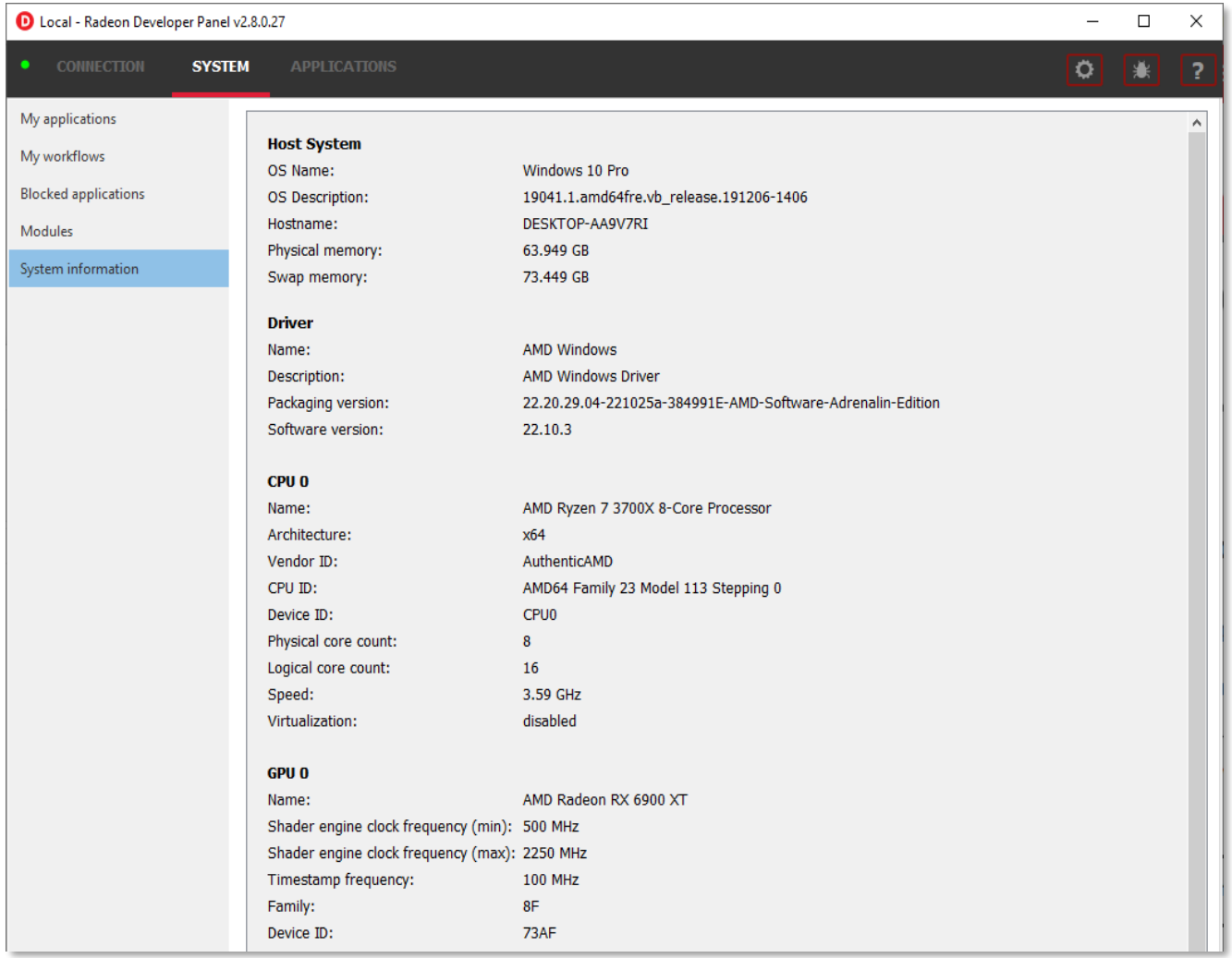
RADEON DEVELOPER PANEL 2.8 UPDATE

- Workflow UI improvements



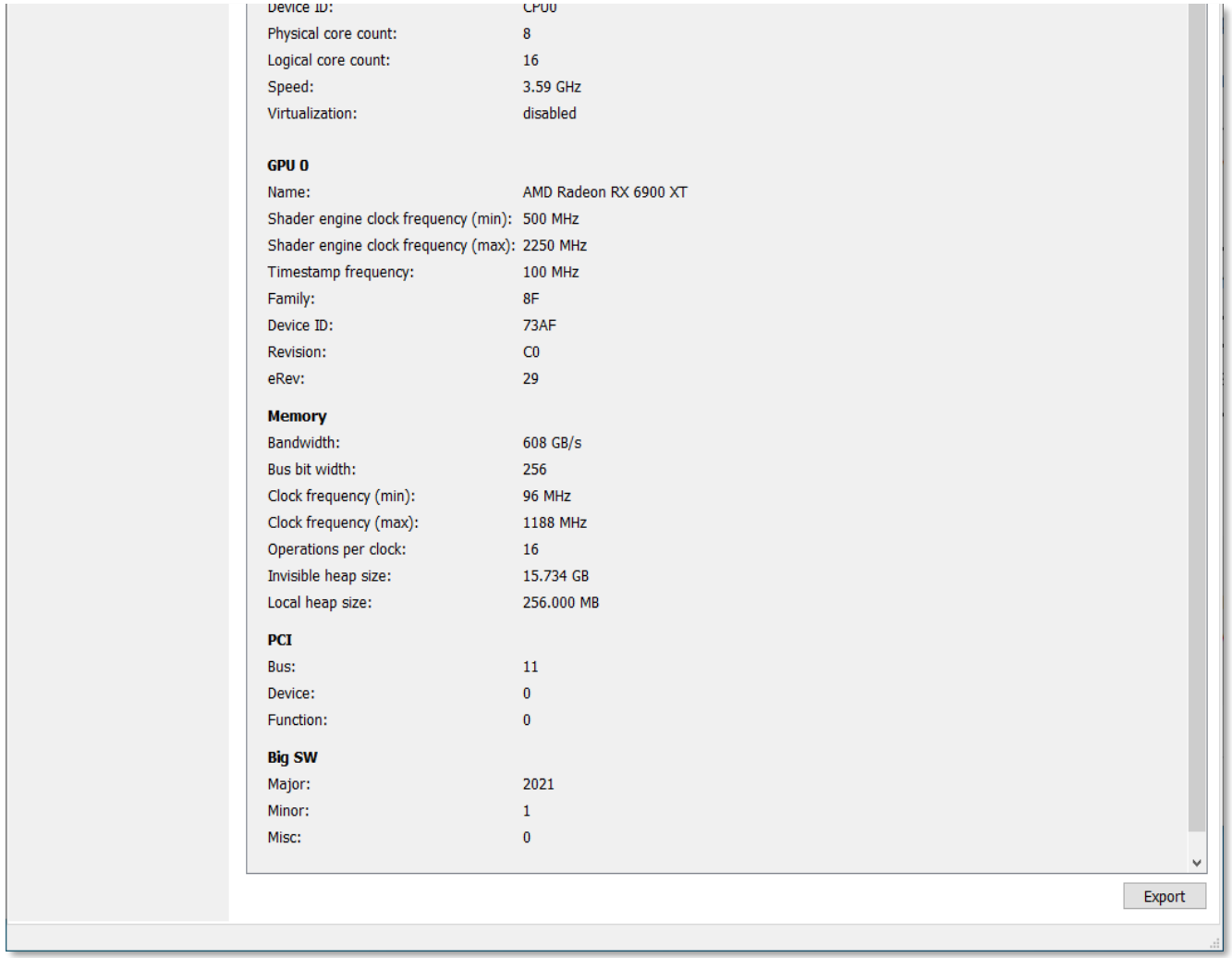
RADEON DEVELOPER PANEL 2.8 UPDATE

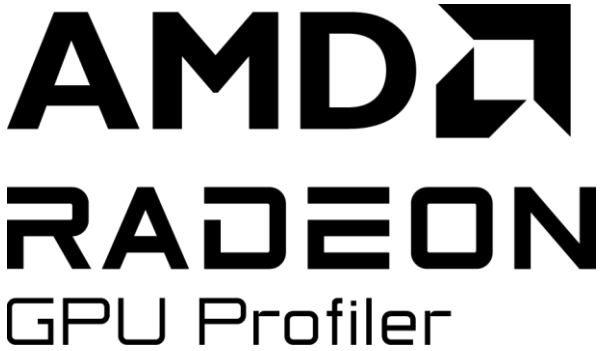
- Workflow UI improvements
- New - System Information



RADEON DEVELOPER PANEL 2.8 UPDATE

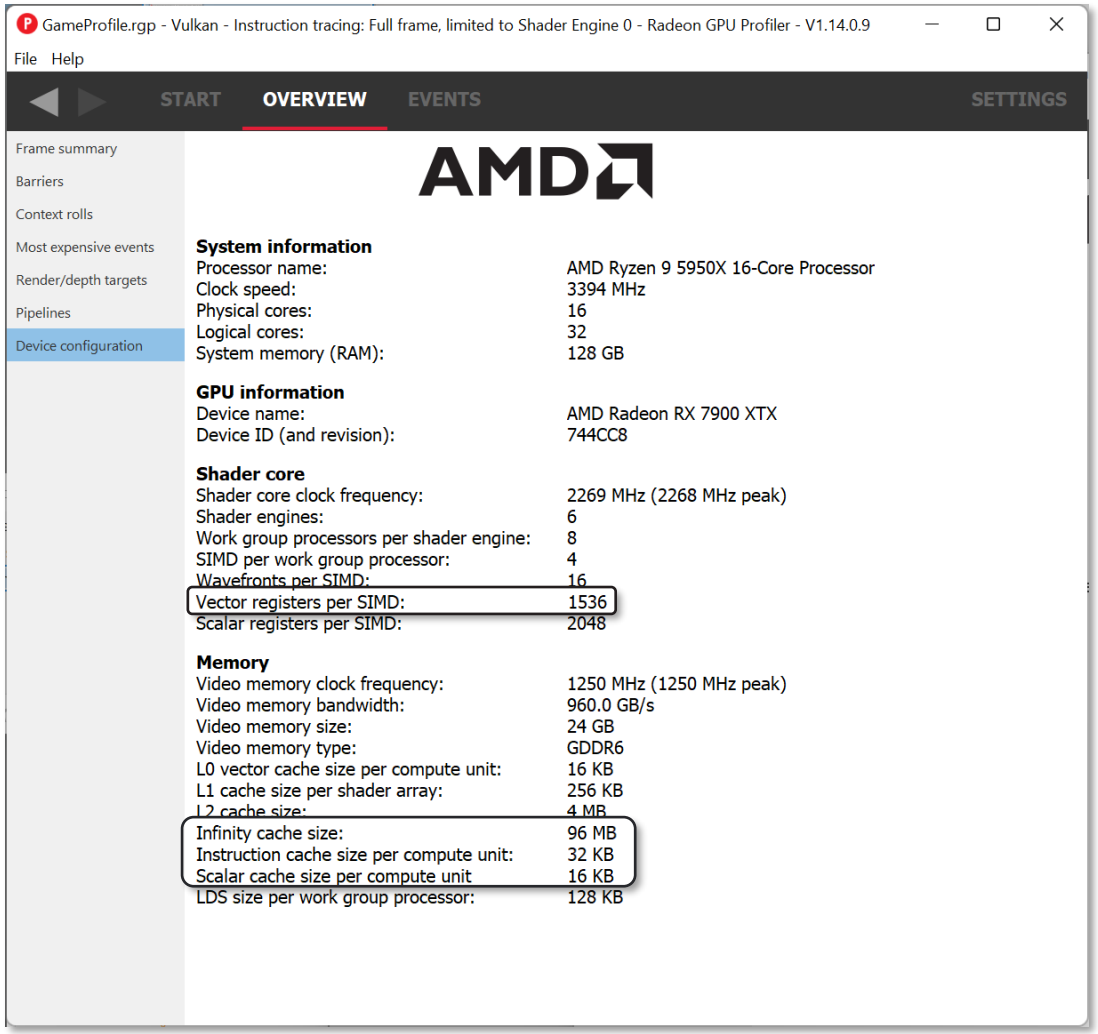
- Workflow UI improvements
- New - System Information
  - With Export (JSON)
- RDNA3 Support
- Stability





https://github.com/GPUOpen-Tools/radeon_gpu_profiler

RADEON GPU PROFILER 1.14 – RDNA 3 SUPPORT

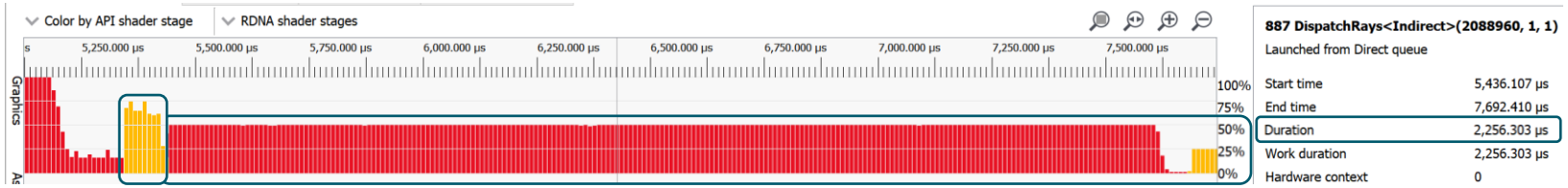


- Additional cache size info in the Device Configuration pane
- More Vector registers per SIMD

RADEON GPU PROFILER 1.14 – RDNA 3 SUPPORT

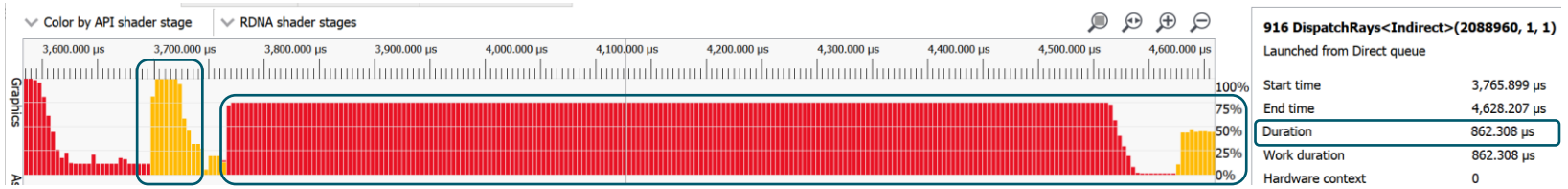
AMD Radeon RX 6800

AMD Ryzen 7 5800X 8-Core Processor, 3793 MHz, 64GB RAM, Microsoft Windows 11 Pro



AMD RX 7900 XTX

AMD Ryzen 7 5800X 8-Core Processor, 3793 MHz, 64GB RAM, Microsoft Windows 11 Pro



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- Improved Wavefront occupancy for some workloads, including ray tracing events that use Indirect shader pipelines

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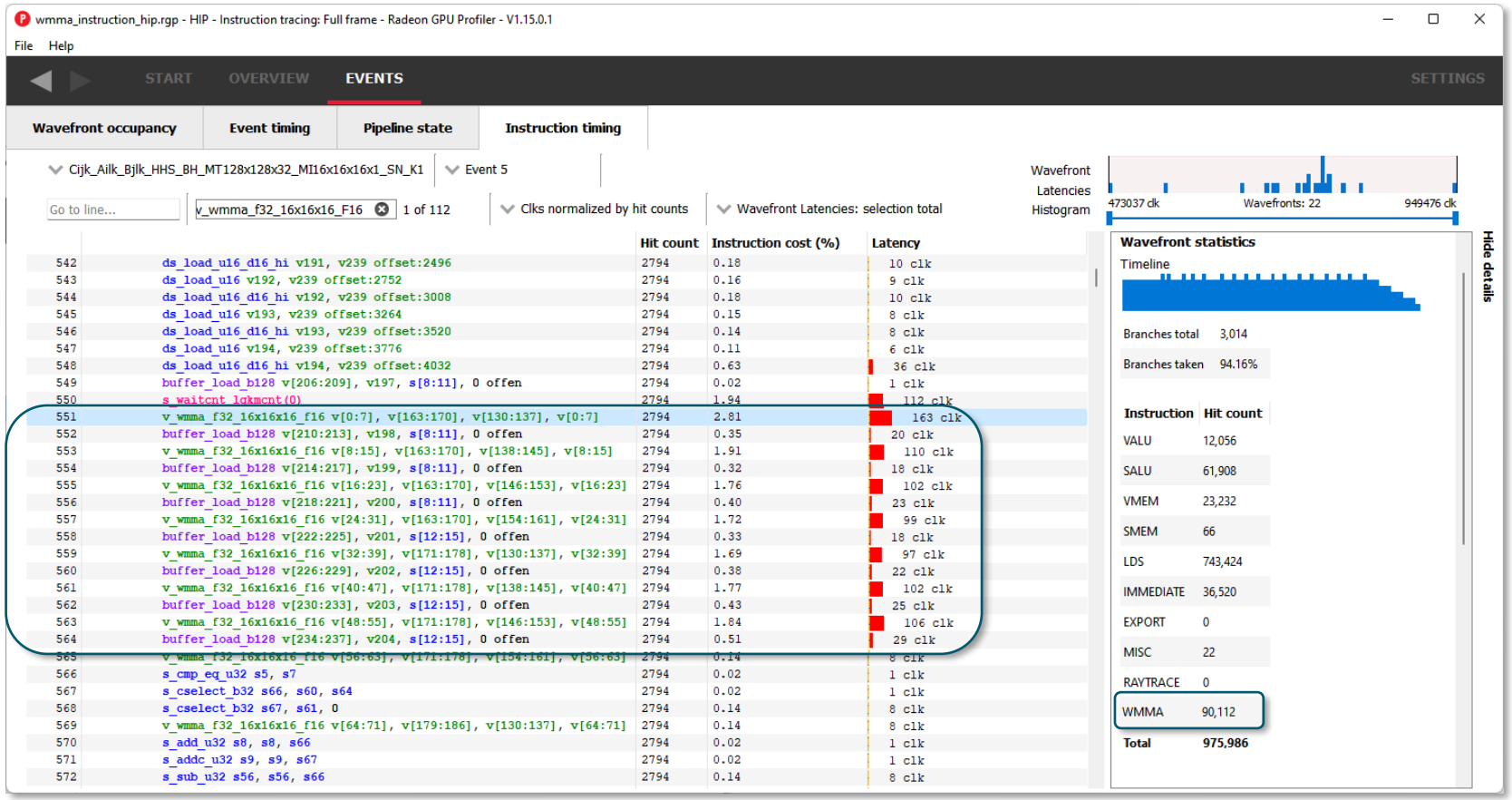

- Additional cache size info in the Device Configuration pane
- More Vector registers on RDNA 3
- Improved Wavefront occupancy for some workloads, including ray tracing events that use Indirect shader pipelines
- WMMA instructions

RADEON GPU PROFILER 1.14 - RAY TRACING UPDATES

- RGP can identify parts of the frame which perform inline raytracing
  - Pipelines
  - Events

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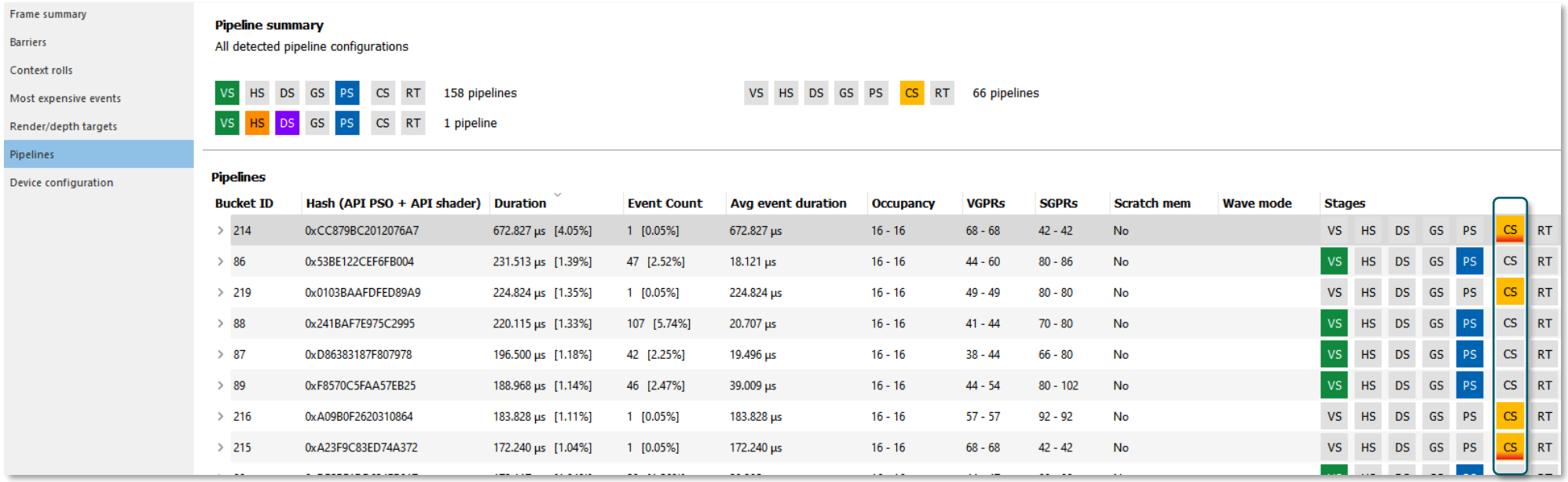

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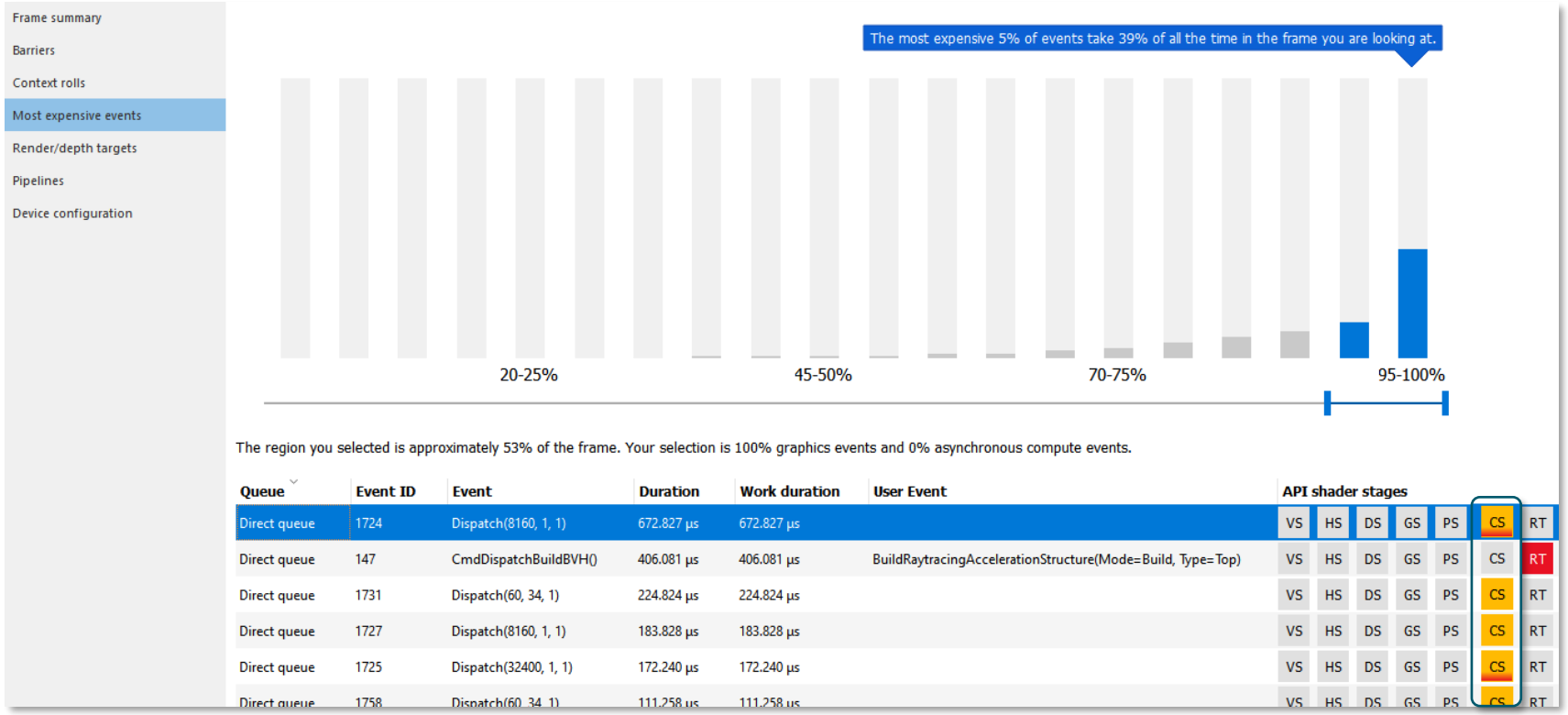

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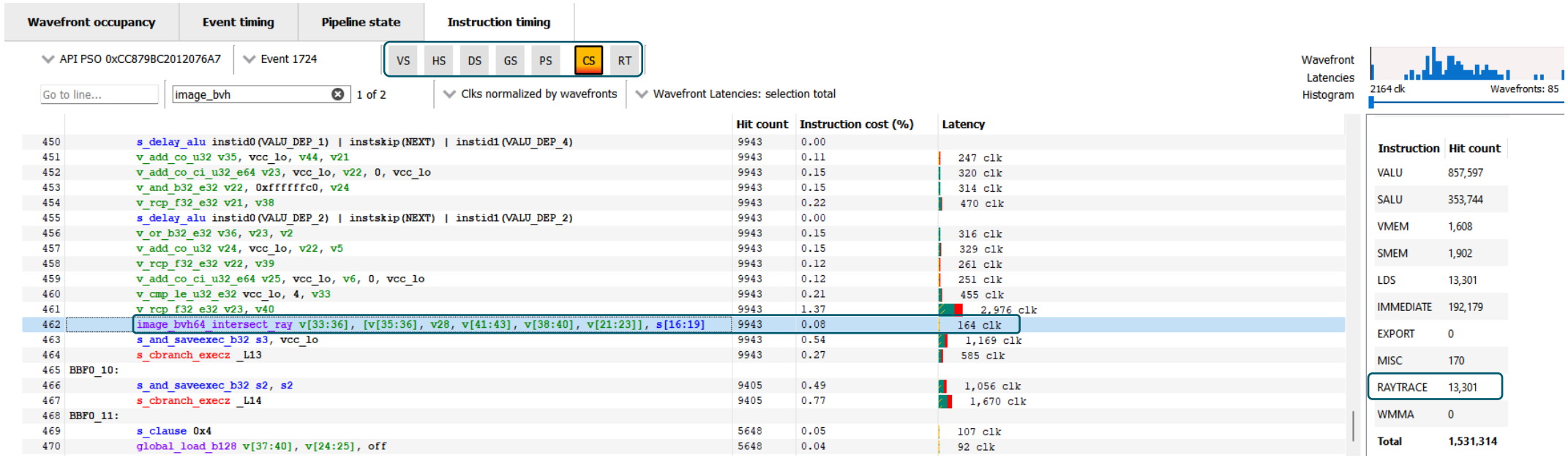

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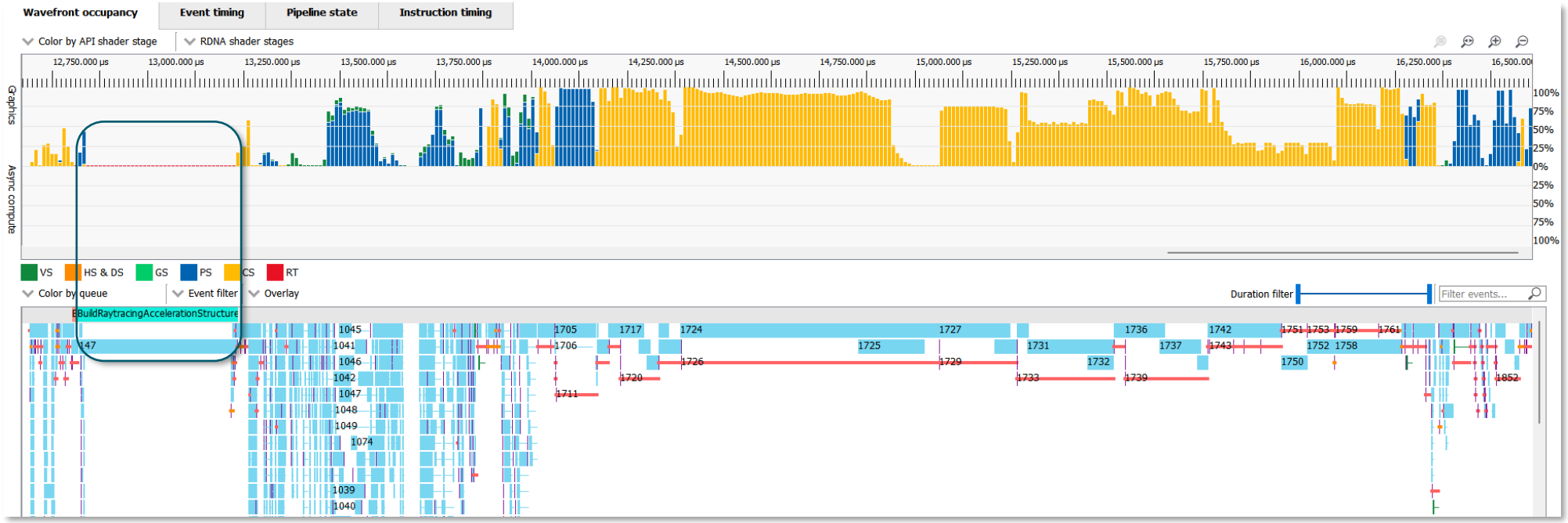

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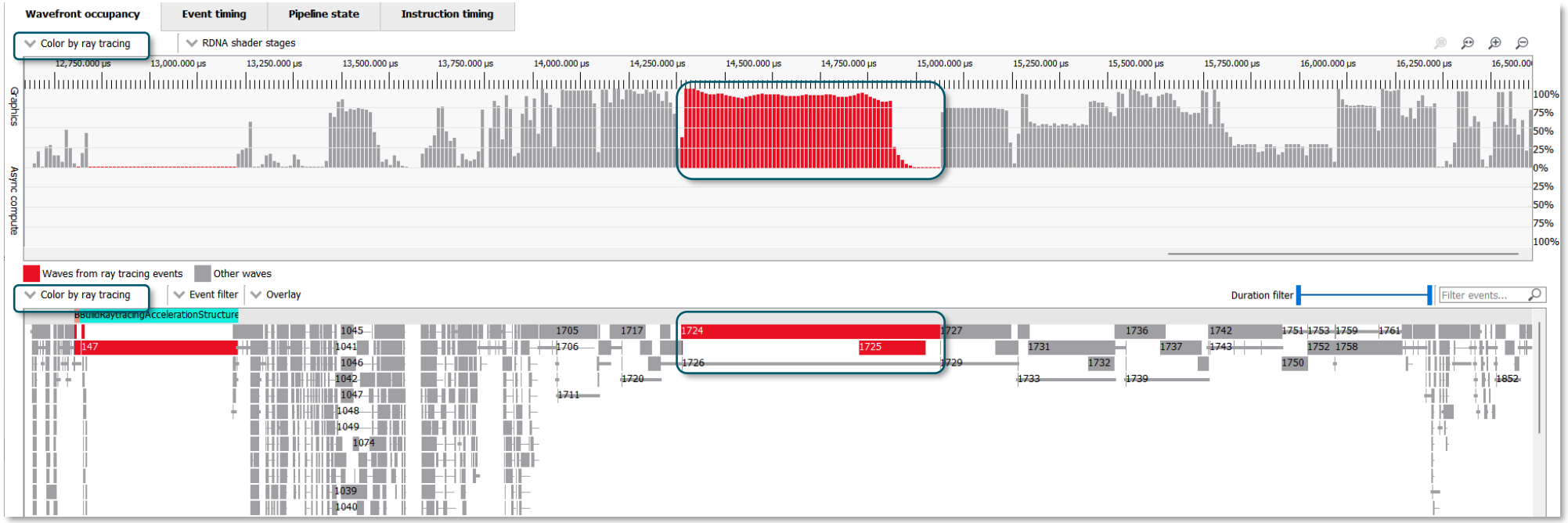
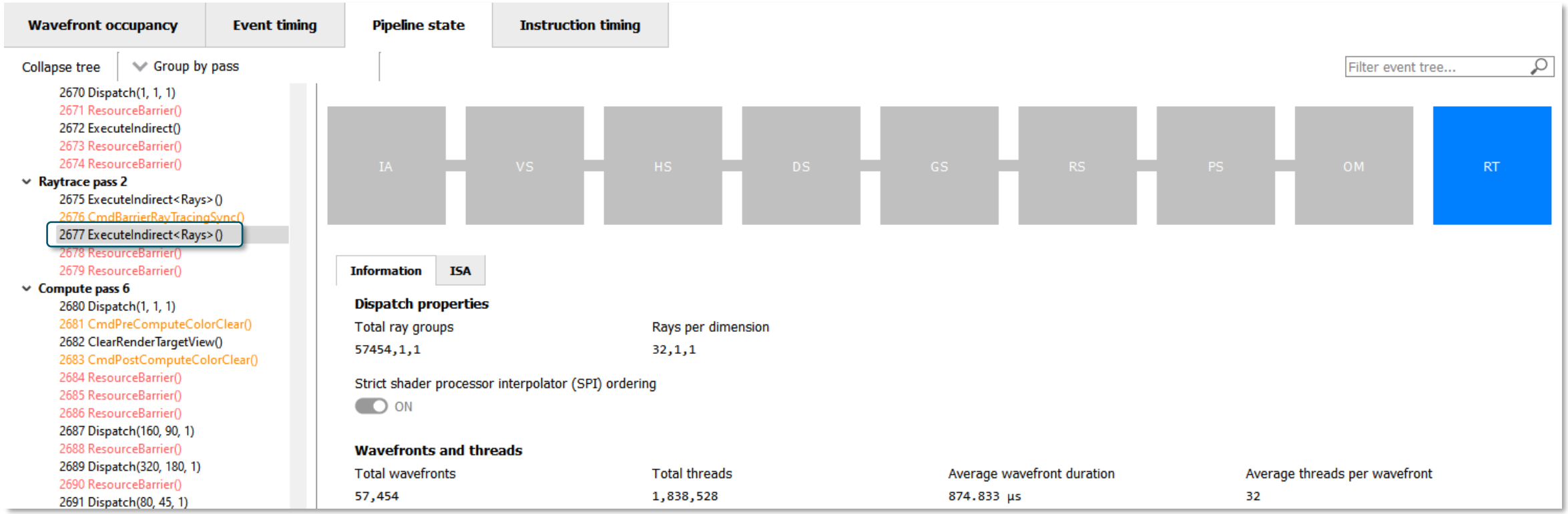


RADEON GPU PROFILER 1.14 - RAY TRACING UPDATES

- Support for ExecuteIndirect calls that perform ray tracing



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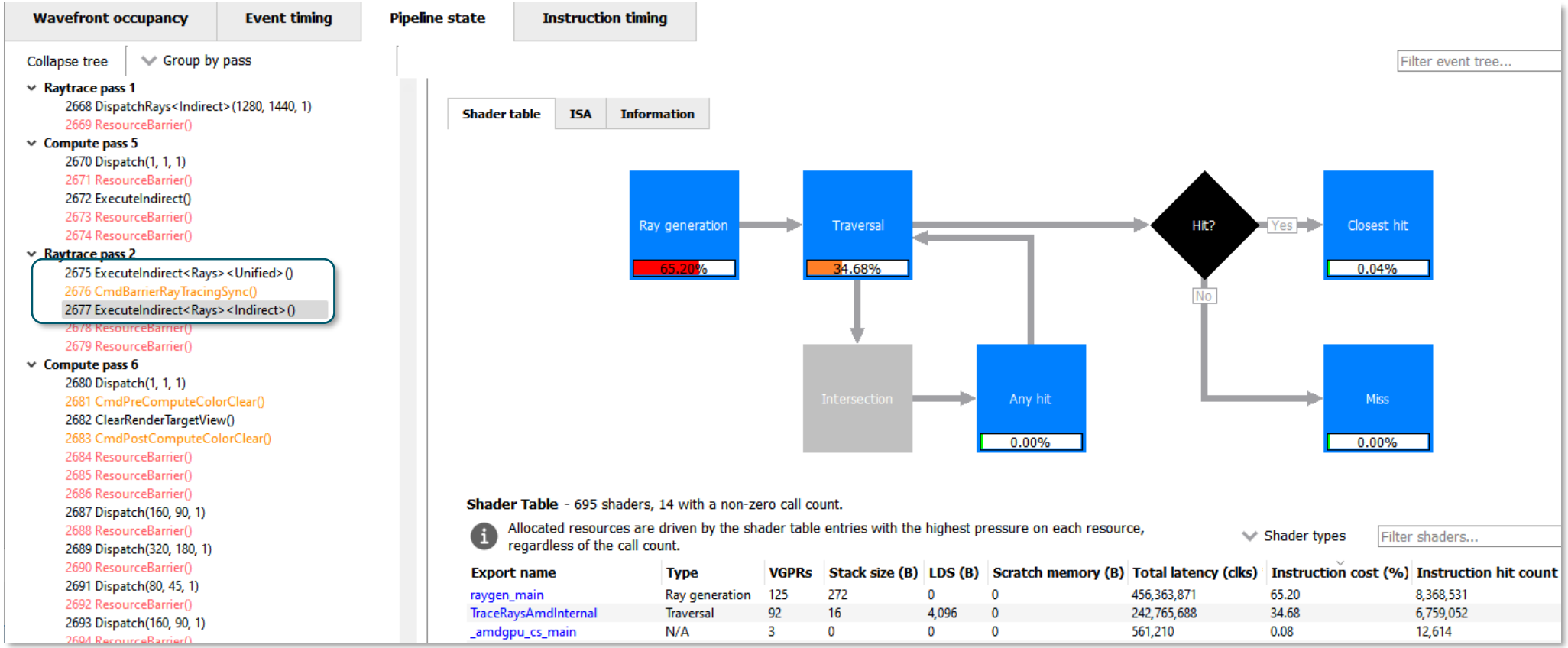
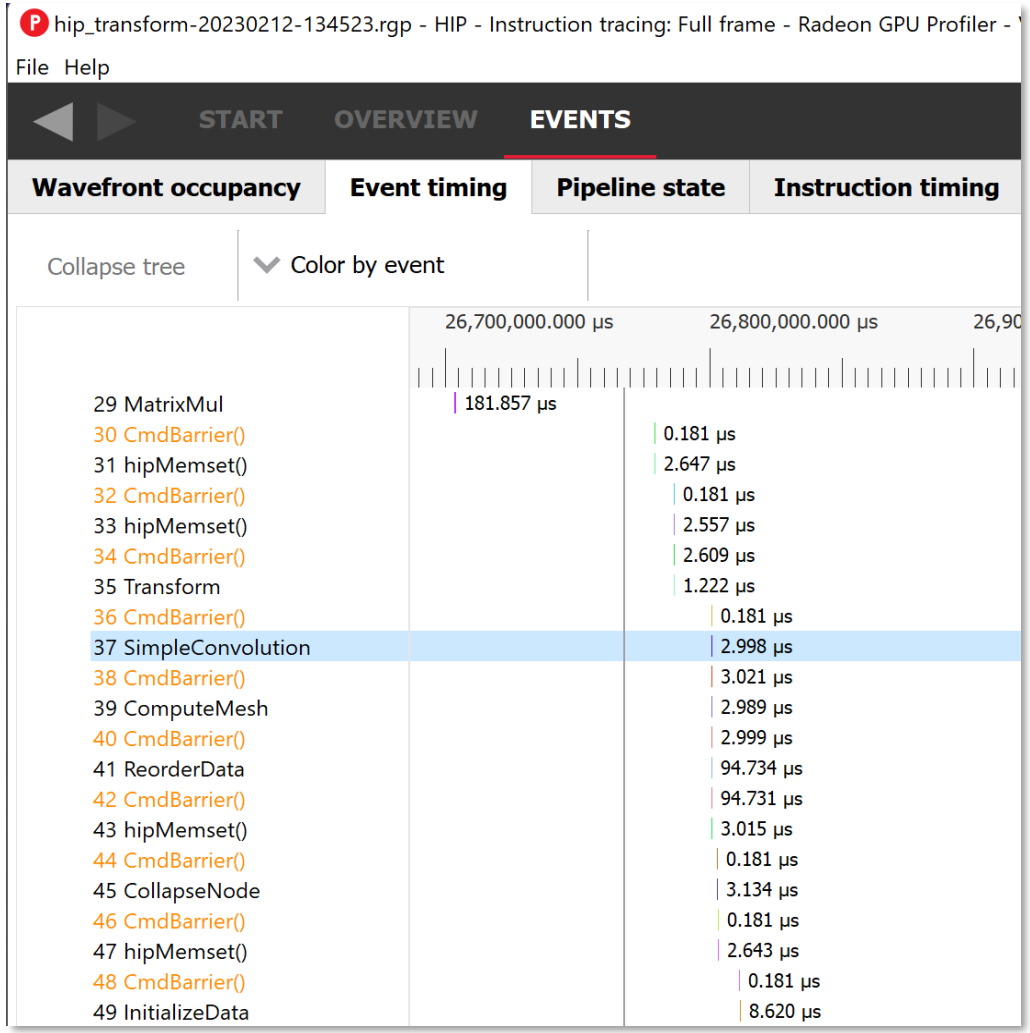
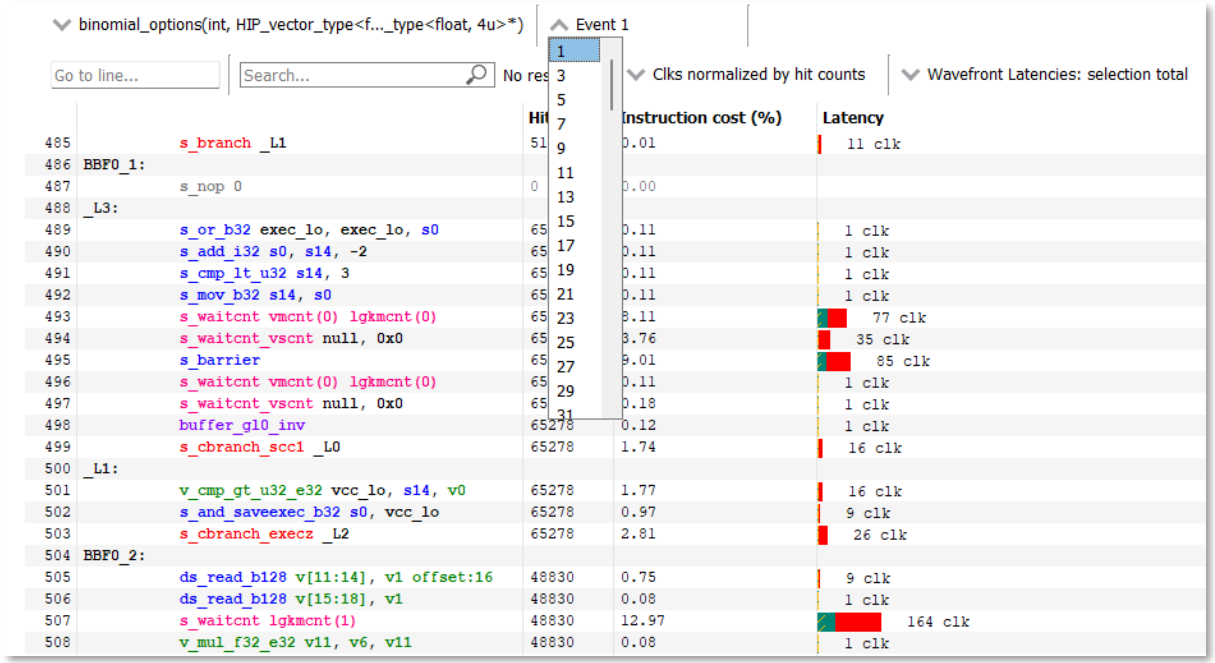


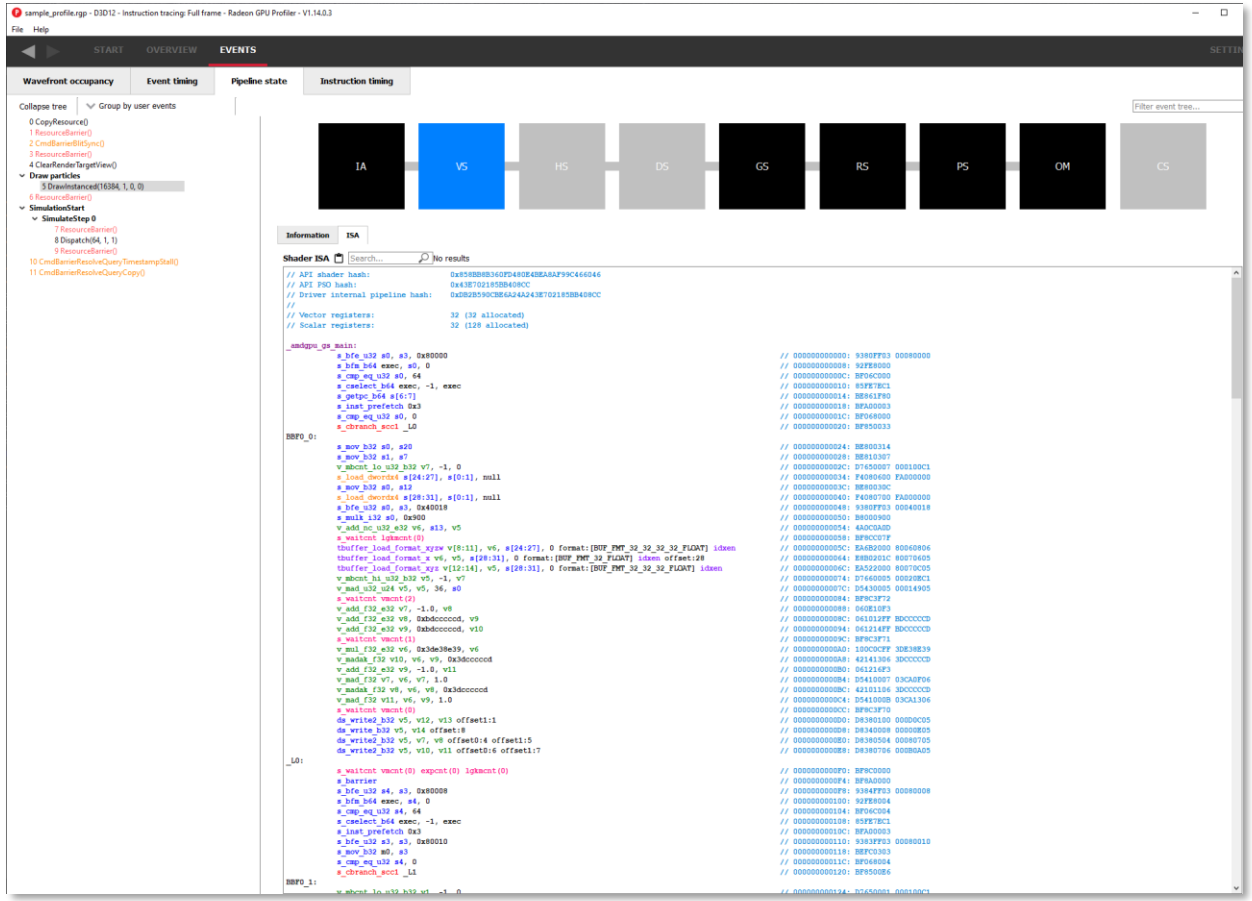
RADEON GPU PROFILER 1.14 - HIP/OPENCL SUPPORT

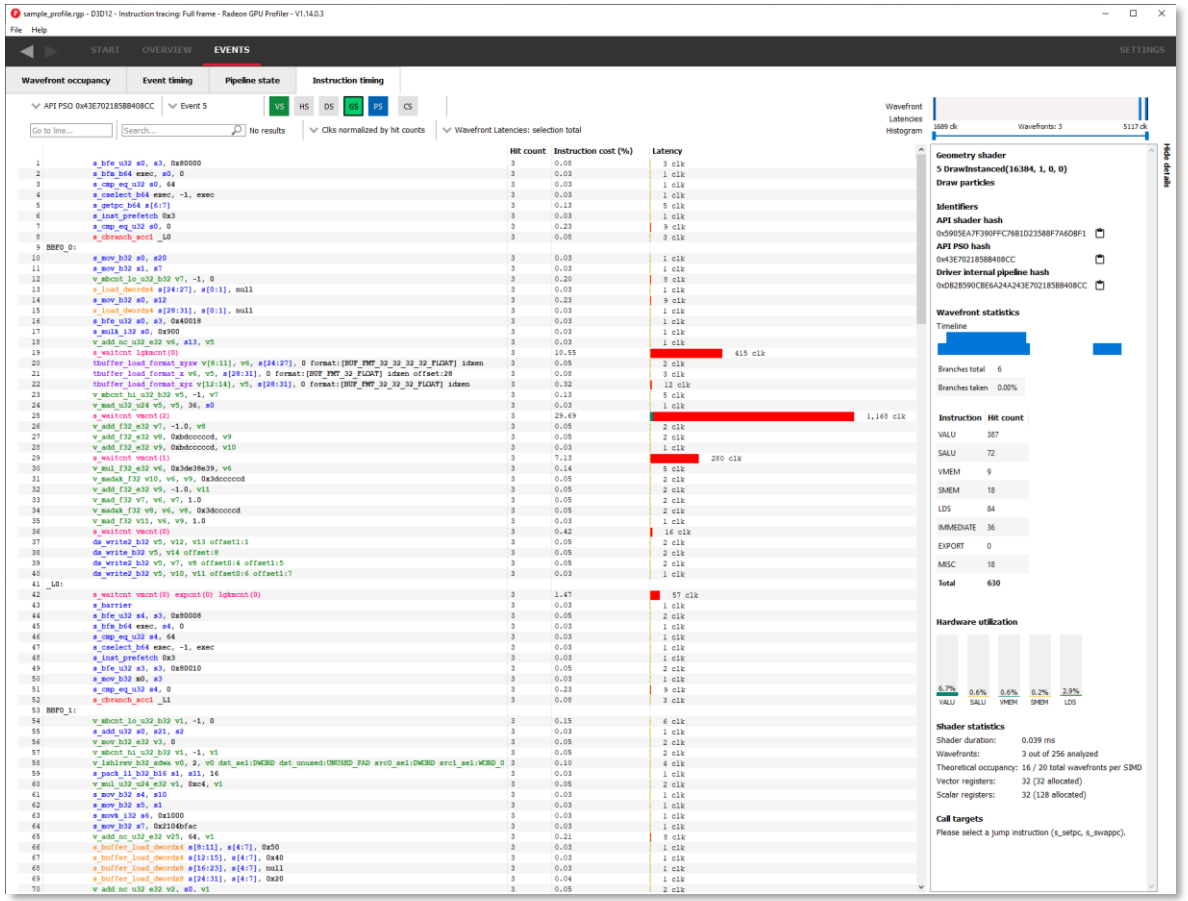




RADEON GPU PROFILER - UPCOMING WORK – NEW ISA VIEW

- Motivation – differences in current ISA views





AMD

RADEON

Raytracing Analyzer

Detailed video of RRA

"Introduction to Raytracing with the Radeon Developer Tools Suite"

gpuopen.com/videos

https://www.youtube.com/watch?v=i4Evh4SJtUg

RADEON DRIVER - NEW RAYTRACING FEATURES

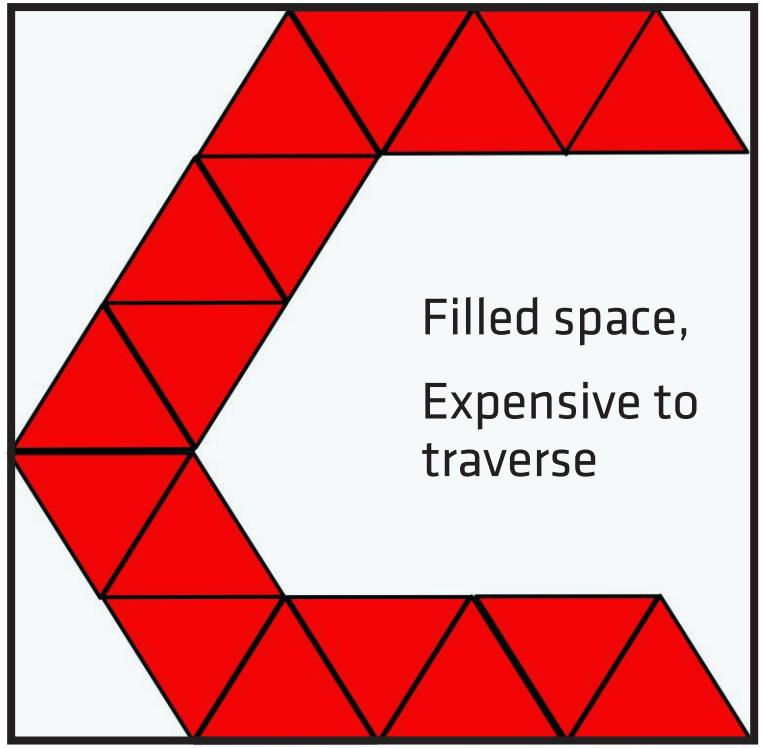
Instance Rebraiding and Triangle Splitting

- Improved spatial coherence
- Overall traversal speedup
- May occupy larger memory
- Might take longer to build
- Automatically activated by the driver
- No user input required!

RADEON RAYTRACING ANALYZER 1.1 - UPDATE

Instance Rebraiding

- Instances are automatically rebraided based on transform and BLAS complexity by the driver
- The immediate child nodes of BLAS root will be encoded into the TLAS when the instance is rebraided
- Traversal loop may perform less iterations as a result of reduced surface area



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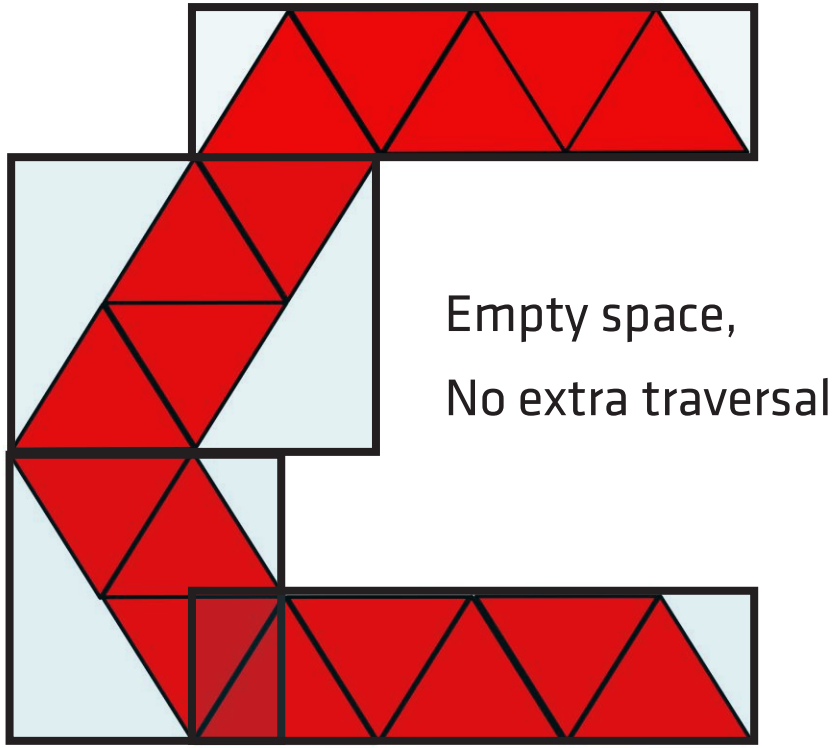
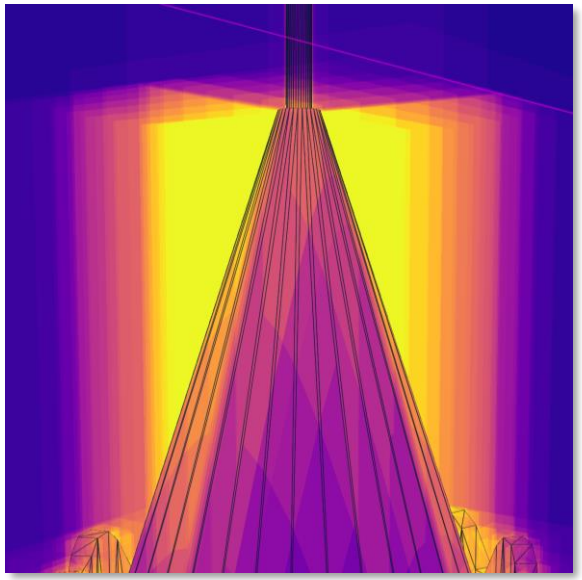


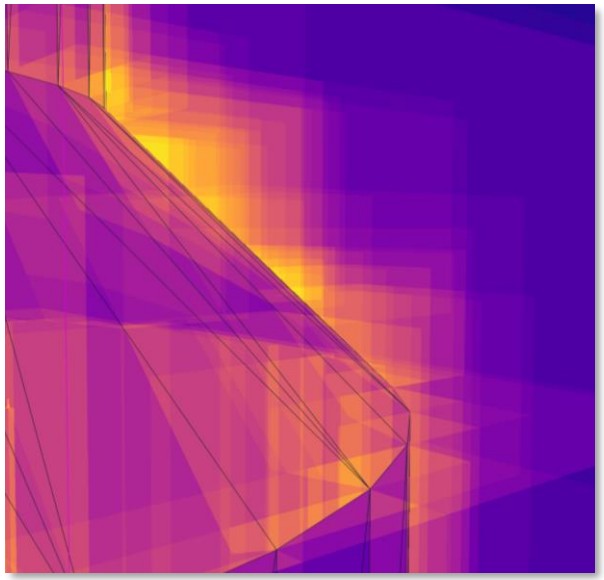
RADEON RAYTRACING ANALYZER 1.1 UPDATE

Triangle Splitting

- Triangle nodes are automatically split based on size and orientation by the driver to provide better early termination in ray-triangle tests
- If a triangle node is split, the parent bounding boxes will overlap with parts of the triangle but still point to the same geometry and primitive index



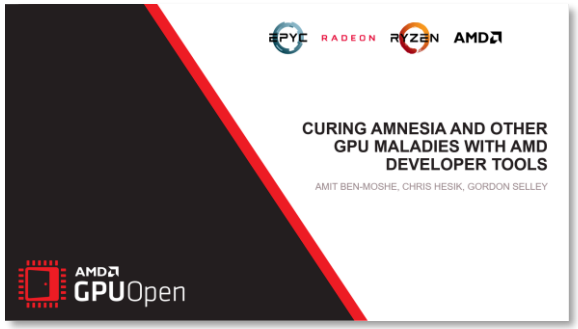
Without triangle splitting,
Compounding traversal cost



With triangle splitting
Reduced traversal cost

(Heatmap - yellow is more expensive to traverse)

AMD RADEON Memory Visualizer



Detailed video of RMV

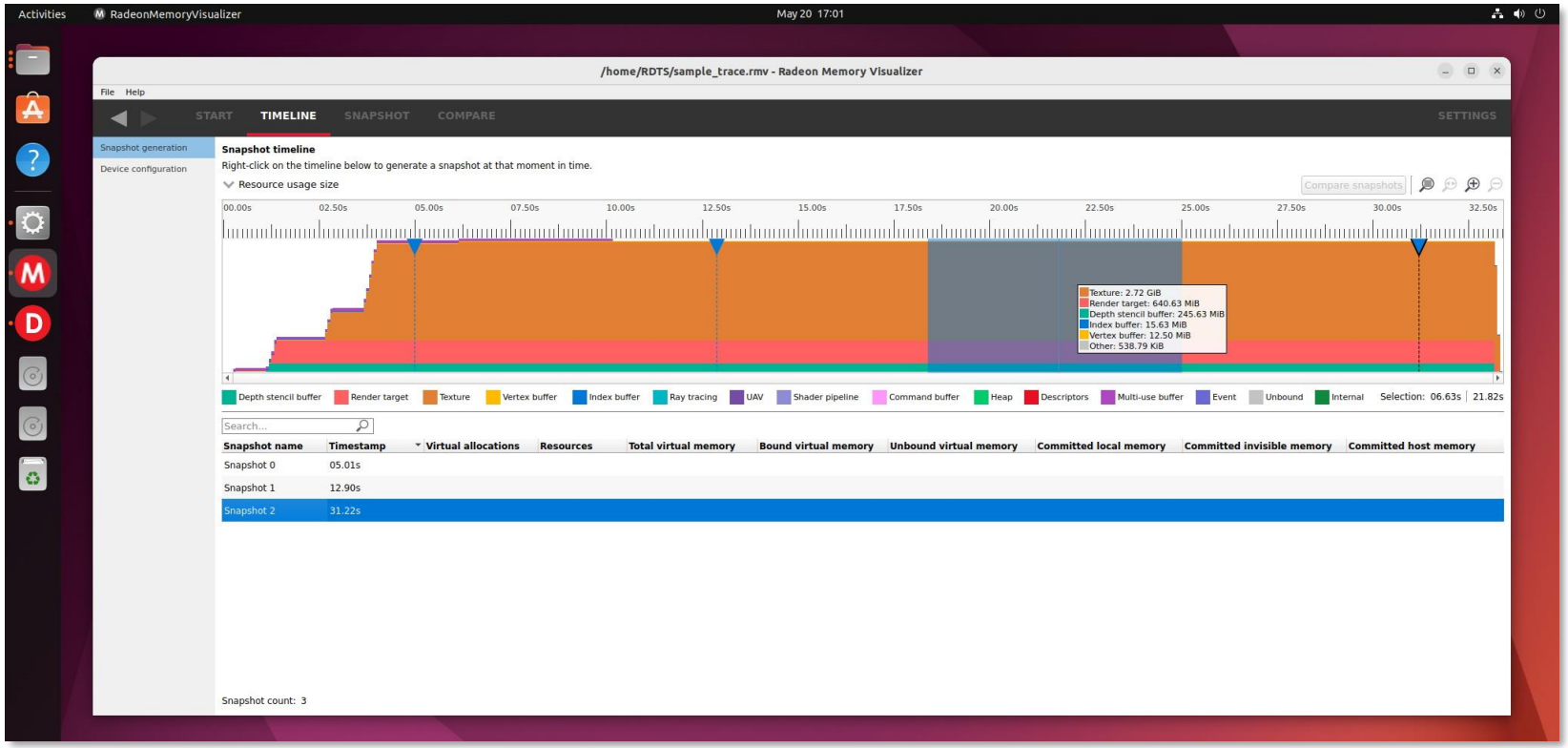
"Curing Amnesia and Other GPU Maladies with AMD Developer Tools"

gpuopen.com/videos

http://www.youtube.com/watch?v=2tmLQVn36P8?t=24m48s

RADEON MEMORY VISUALIZER 1.4.1 - UPDATE

Introduced full capture and visualization on Linux

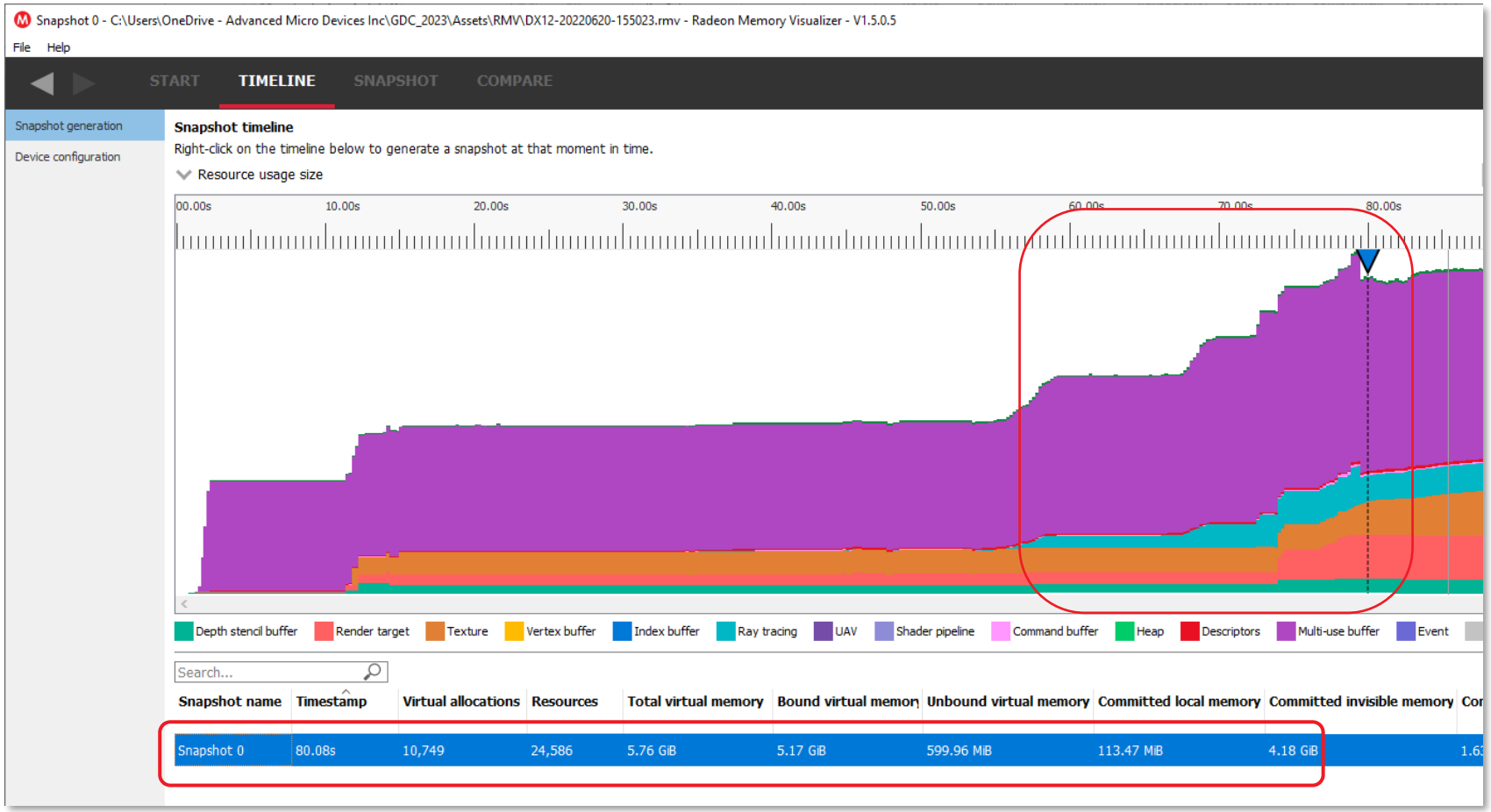


* Note: Raytracing support dependent on AMD driver version

RADEON MEMORY VISUALIZER 1.5 - UPDATE

Ray tracing resources are colored in all views as

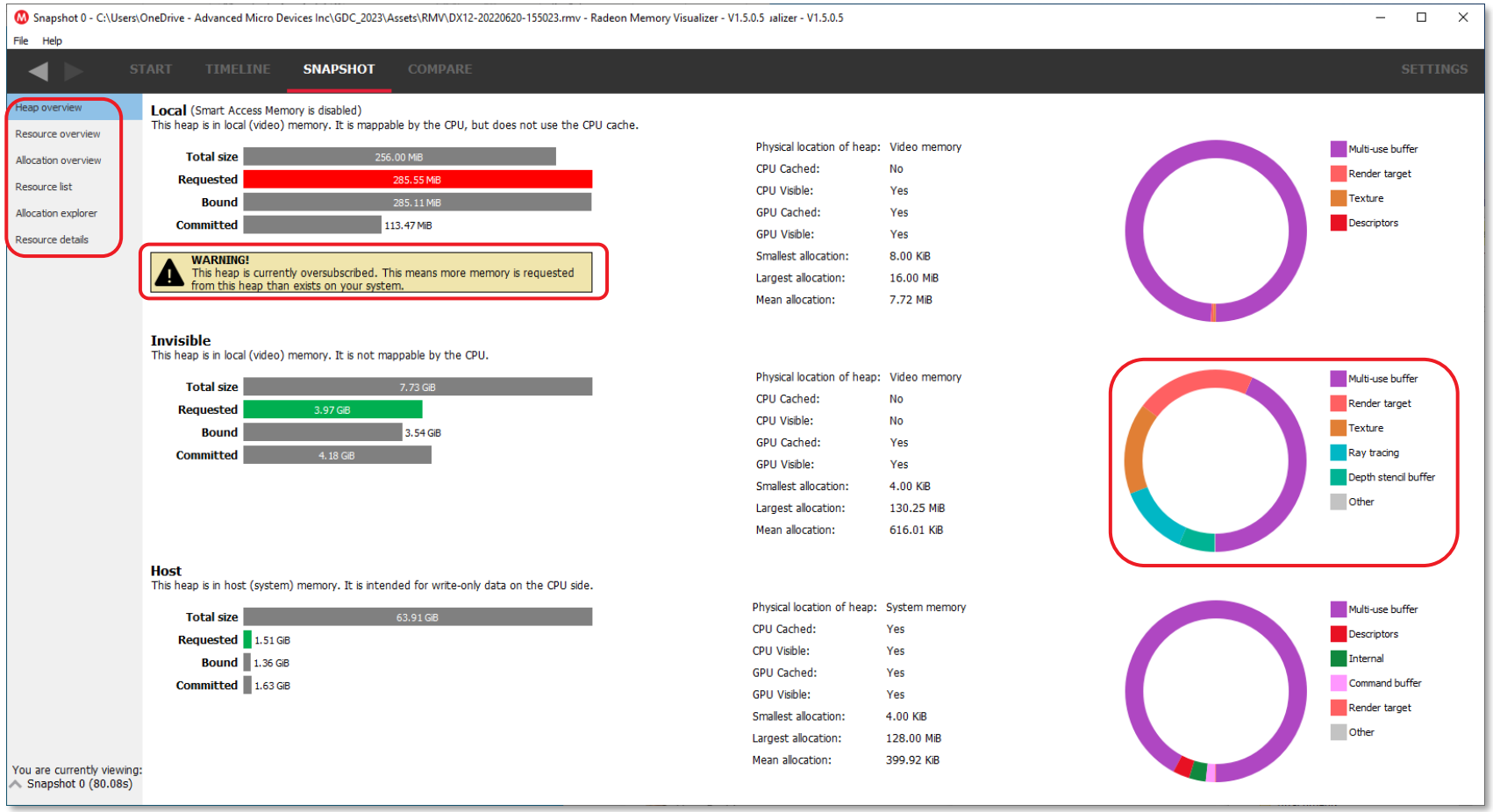
- Timeline view



RADEON MEMORY VISUALIZER 1.5 - UPDATE

Ray tracing resources are colored in all views as

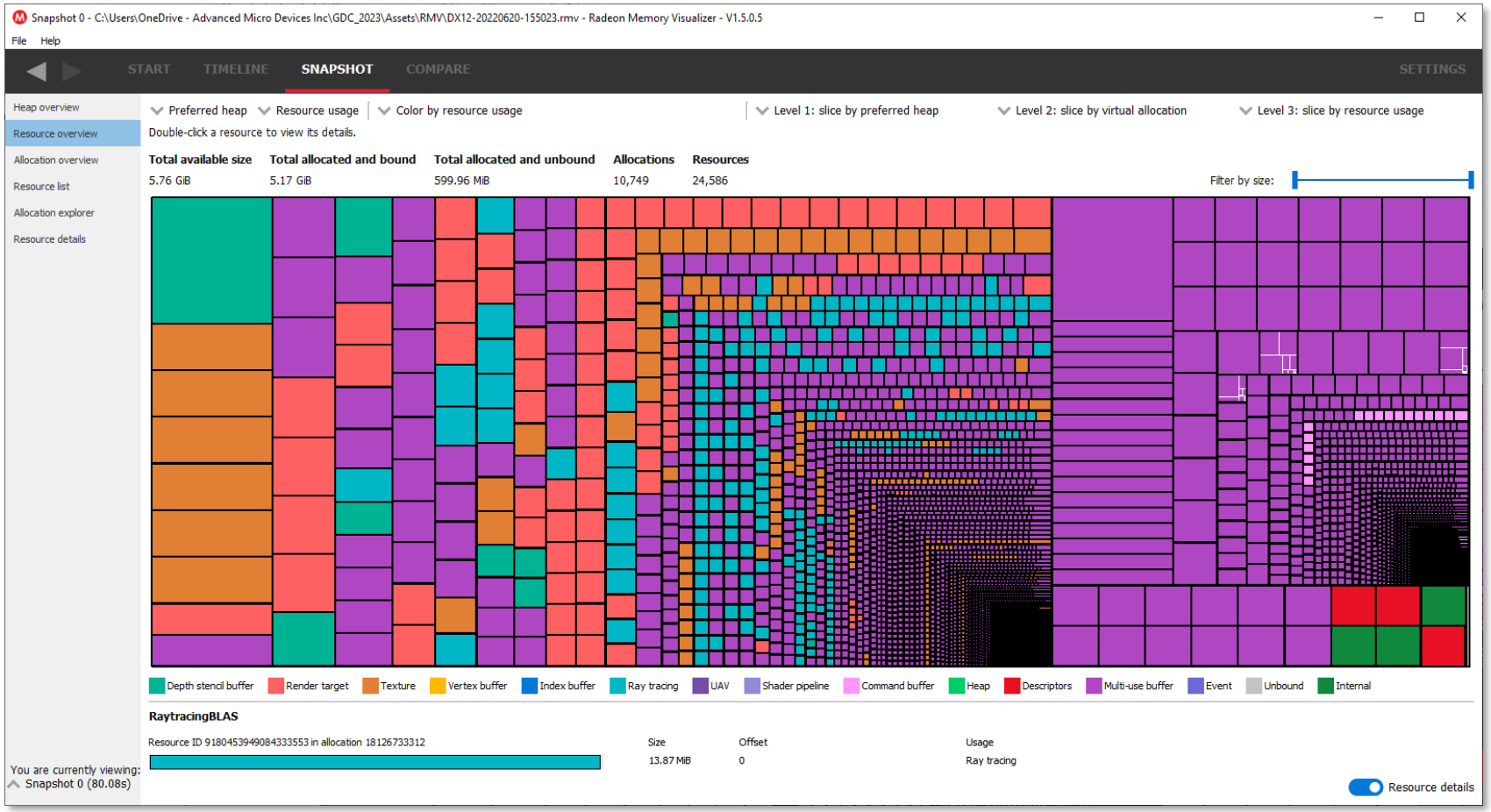
- Timeline view
- Heap overview



RADEON MEMORY VISUALIZER 1.5 - UPDATE

Ray tracing resources are colored in all views as

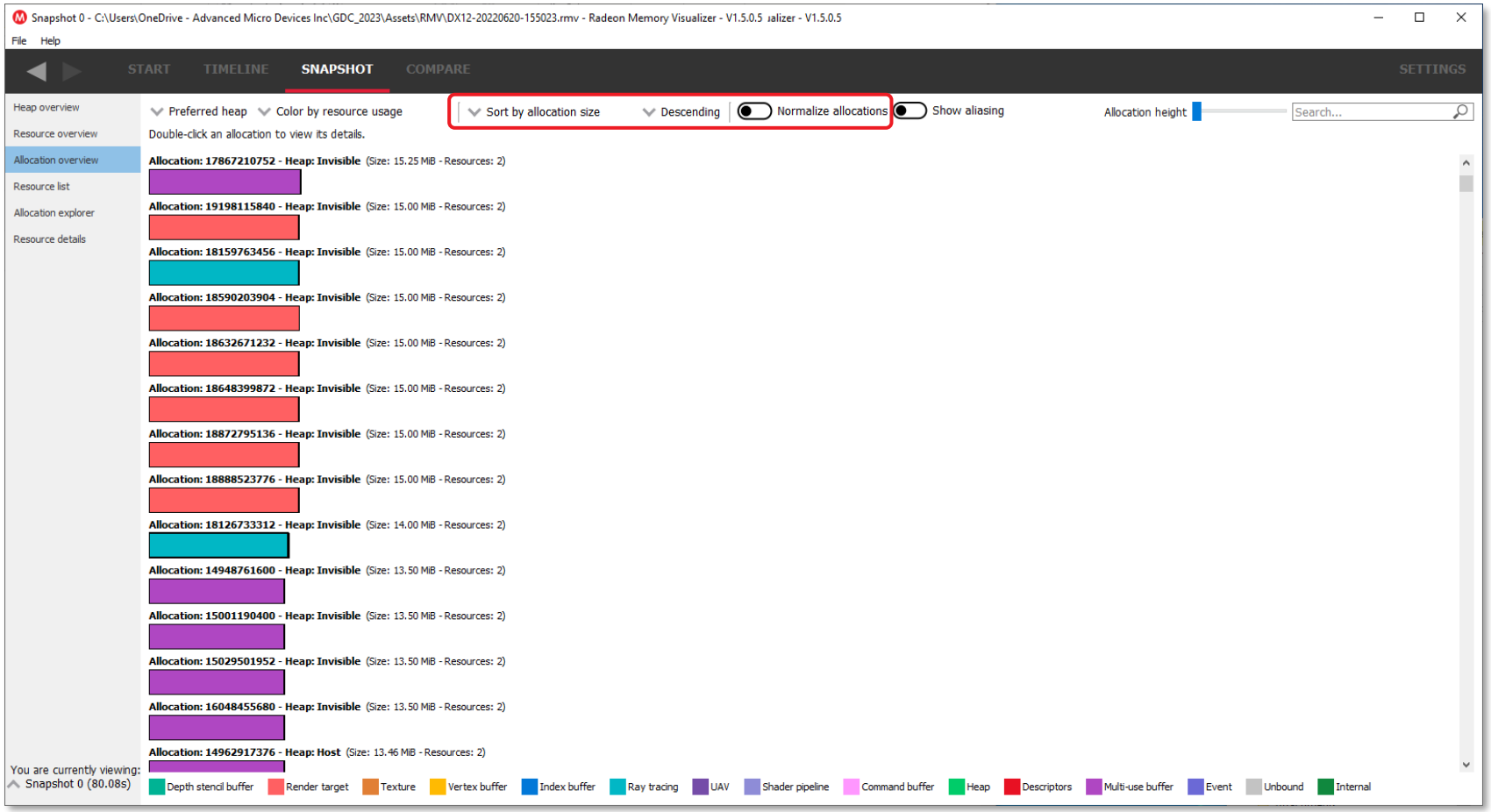
- Timeline view
- Heap overview
- Resource overview



RADEON MEMORY VISUALIZER 1.5 - UPDATE

Ray tracing resources are colored in all views as

- Timeline view
- Heap overview
- Resource overview
- Allocation overview



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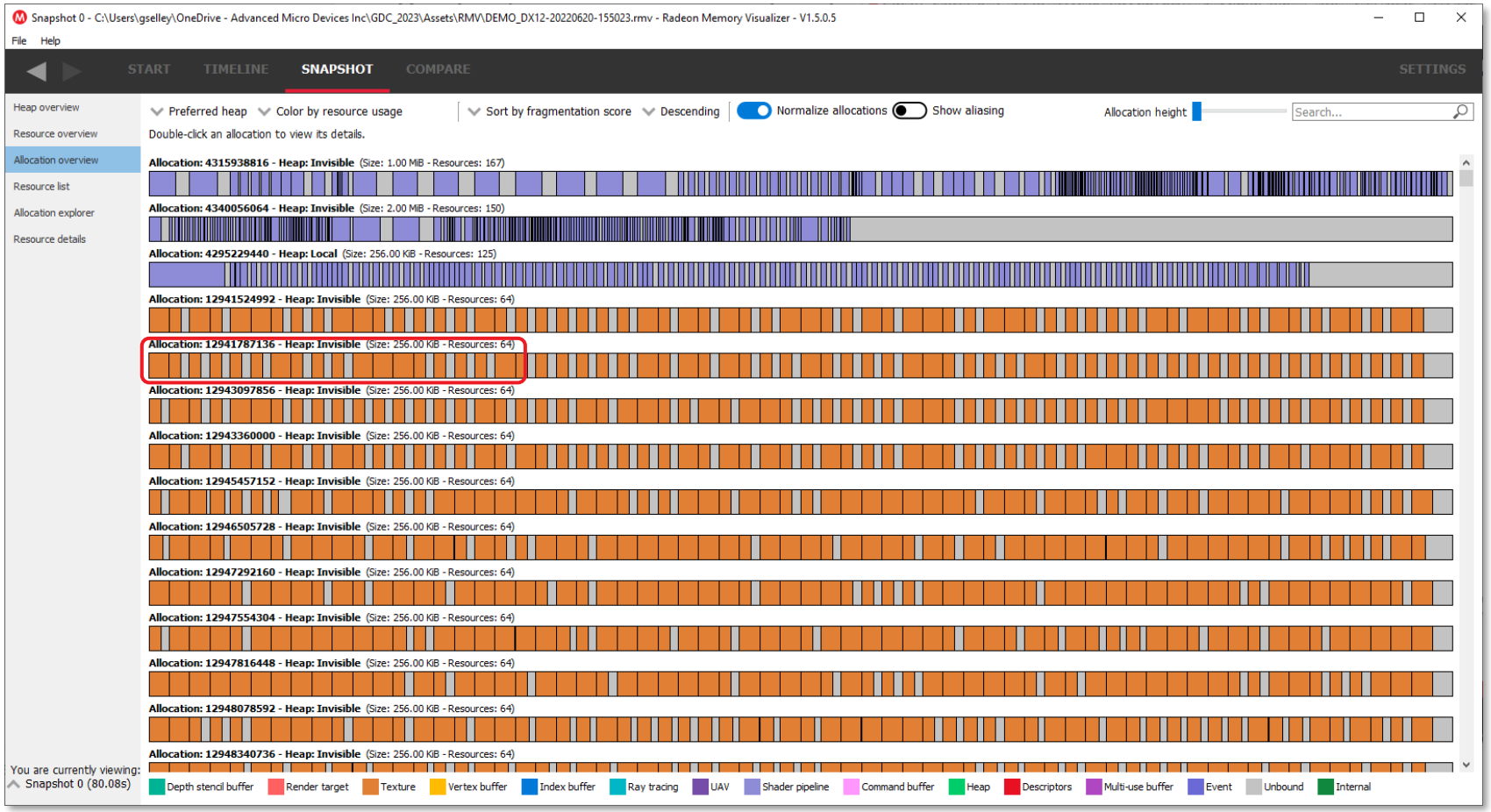
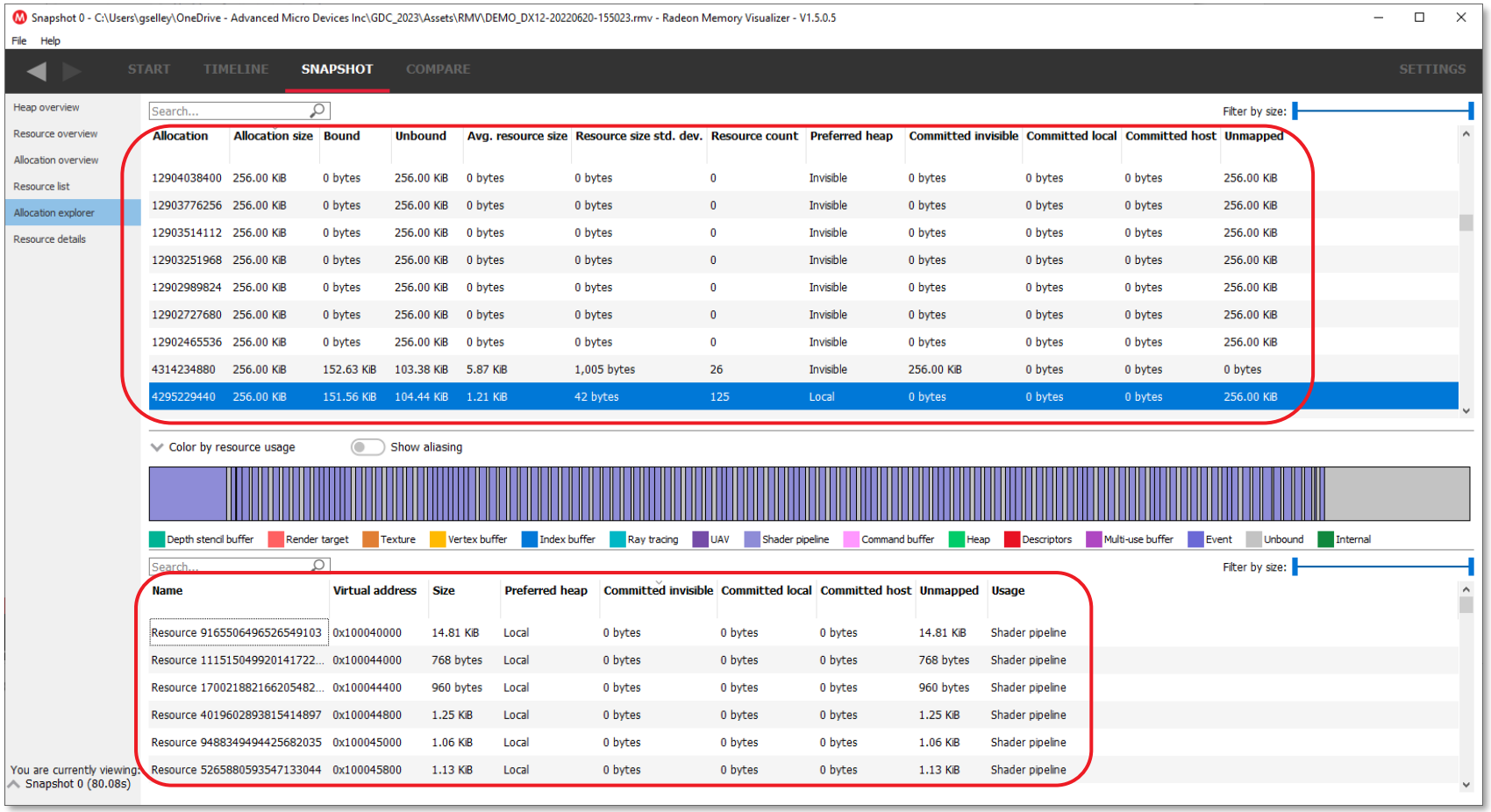


RADEON MEMORY VISUALIZER 1.5 - UPDATE

Ray tracing resources are colored in all views as

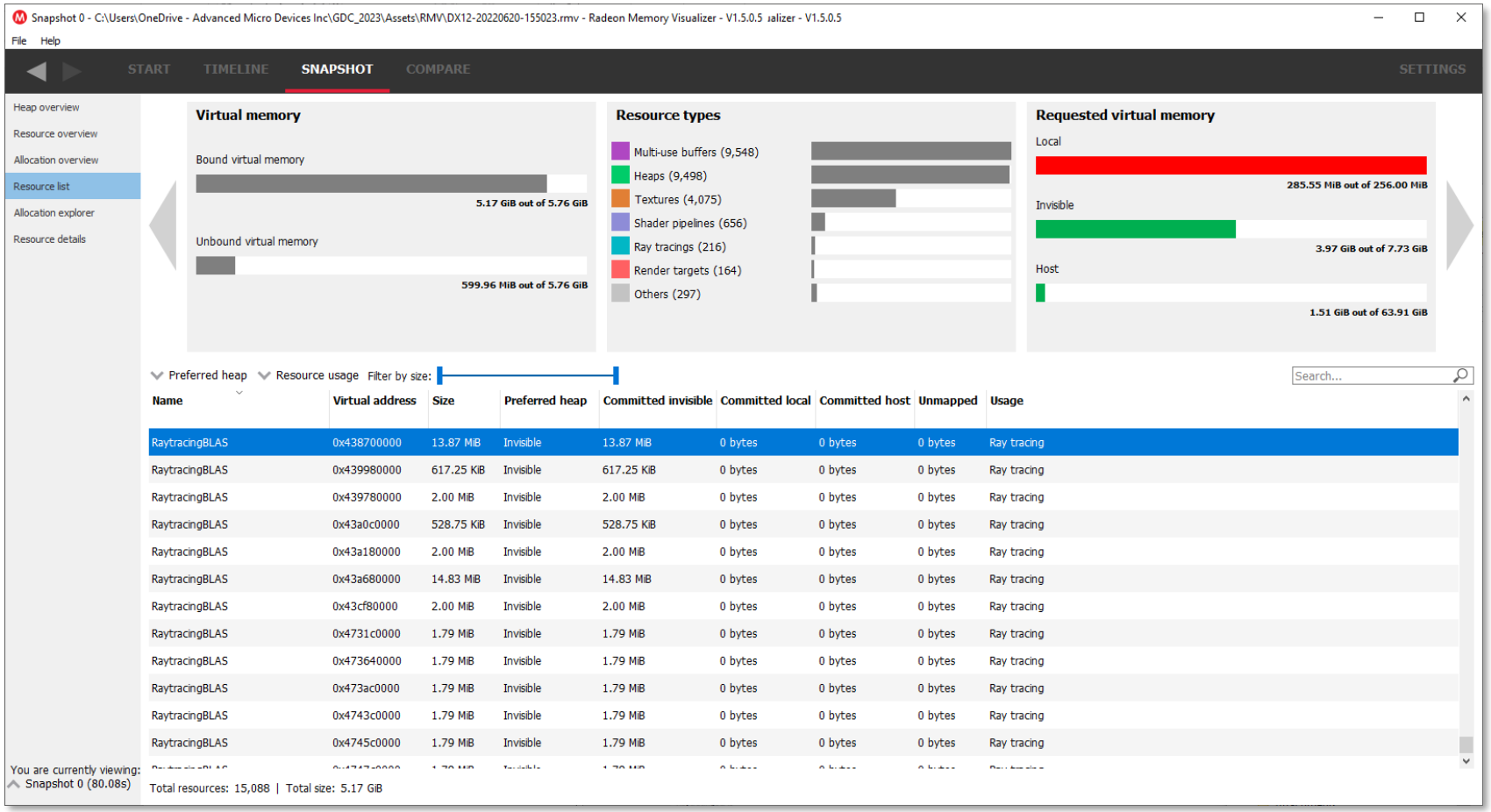
- Timeline view
- Heap overview
- Resource overview
- Allocation overview
- Allocation explorer



RADEON MEMORY VISUALIZER 1.5 - UPDATE

Ray tracing resources are colored in all views as

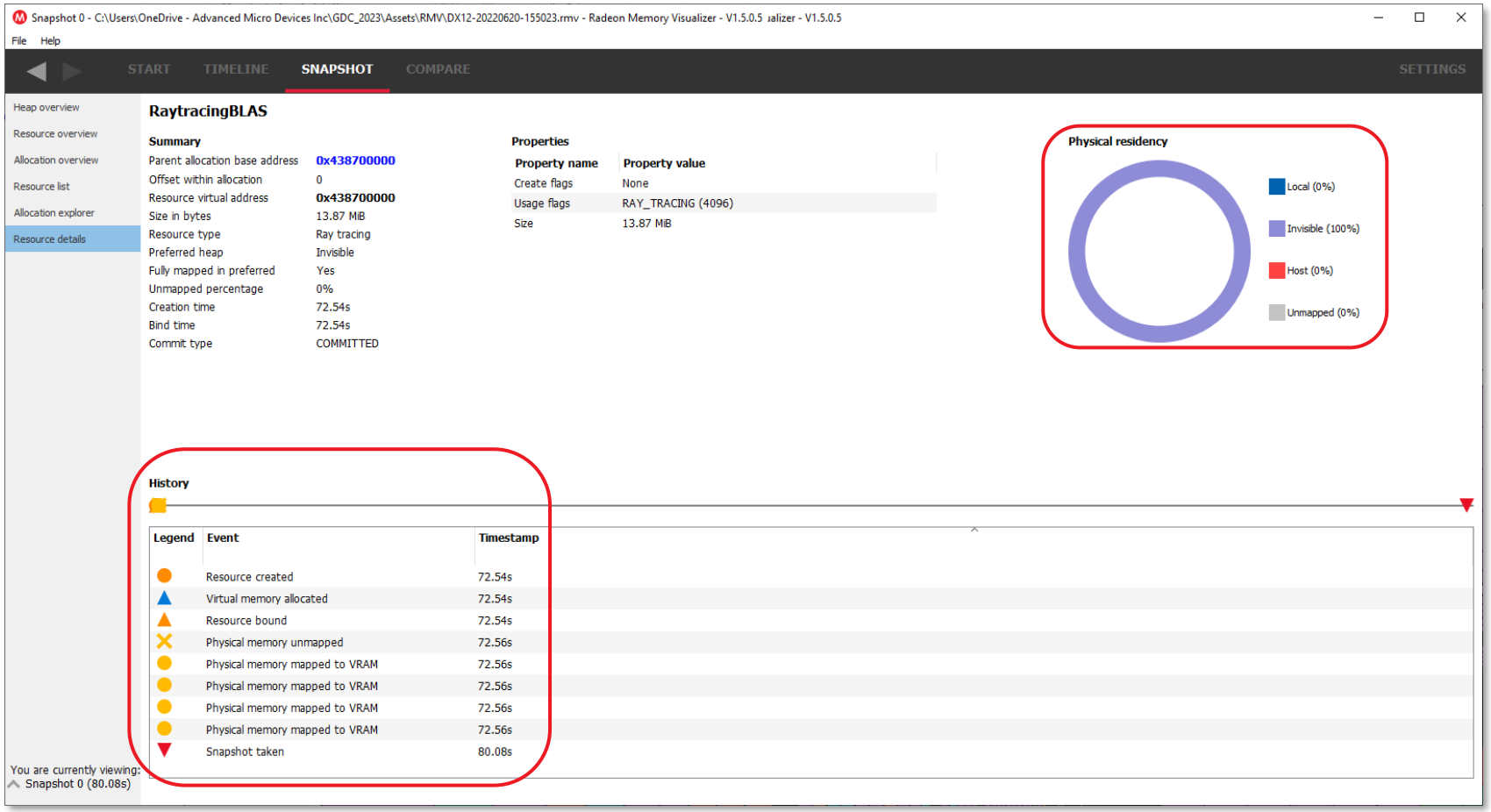
- Timeline view
- Heap overview
- Resource overview
- Allocation overview
- Allocation explorer
- Resource List



RADEON MEMORY VISUALIZER 1.5 - UPDATE

Ray tracing resources are colored in all views as

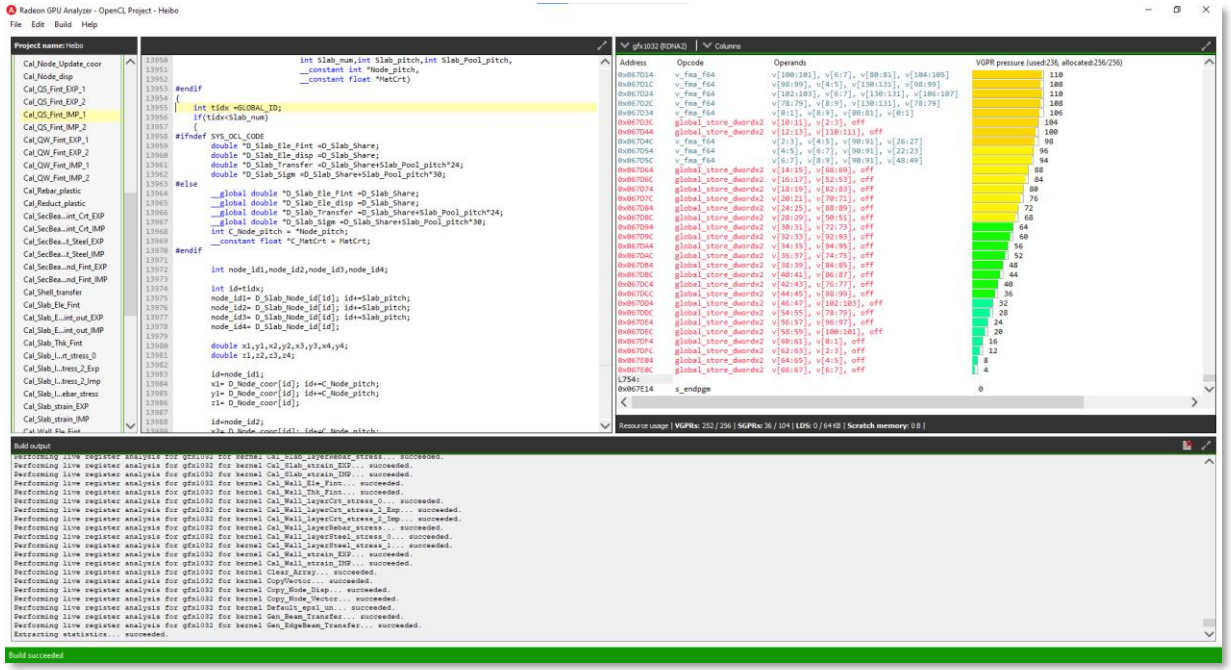
- Timeline view
- Heap overview
- Resource overview
- Allocation overview
- Allocation explorer
- Resource List
- Resource Details




AMD
RADEON
GPU Analyzer

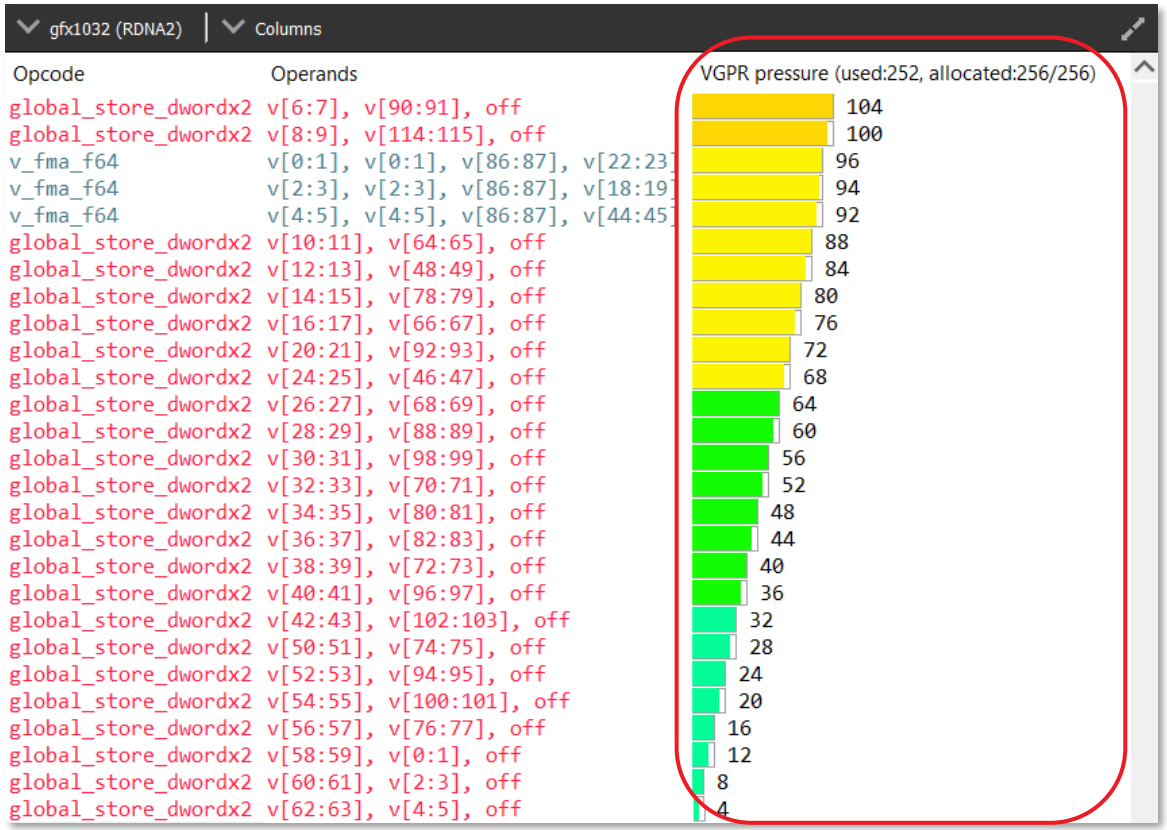
RADEON GPU ANALYZER 2.7 - UPDATE

- **Compile and analyze shaders and kernels for the RDNA3™ architecture (gfx1100, RX 7000 series GPUs)**
  - Without a physical RDNA3™ card installed on your system
- **New VGPR pressure GUI**
  - Displays highest VGPR pressure and helps you identify where to focus your optimization
- **DirectX®11 mode (-s dx11) is now an offline mode**
  - Works regardless of the installed driver. Support in this mode was limited to VS, PS and CS
- Updates to Vulkan® and OpenGL® backend components
- OpenCL™ mode now uses an updated version of AMD's LLVM-based Lightning Compiler



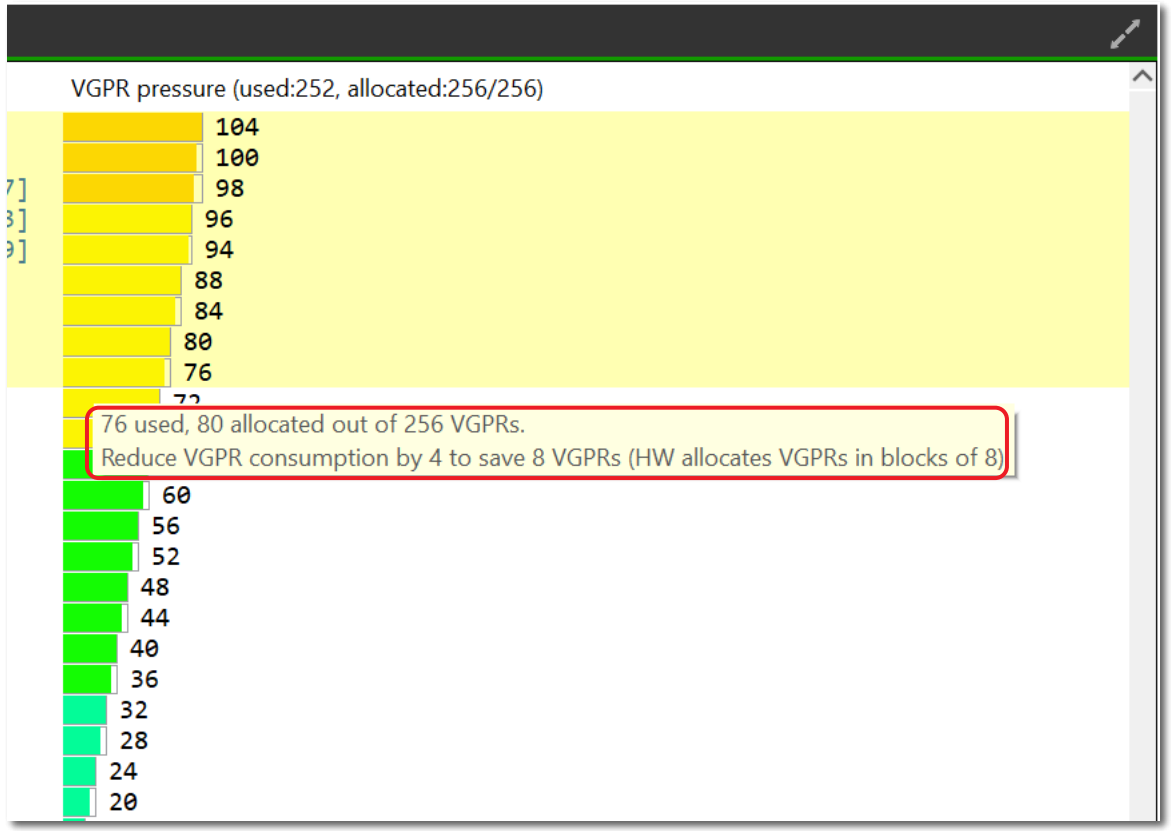
RADEON GPU ANALYZER 2.7 - UPDATE

- Displays number of VGPRs used and allocated
- Utilization bars that visualize the VGPR usage and the VGPR block utilization



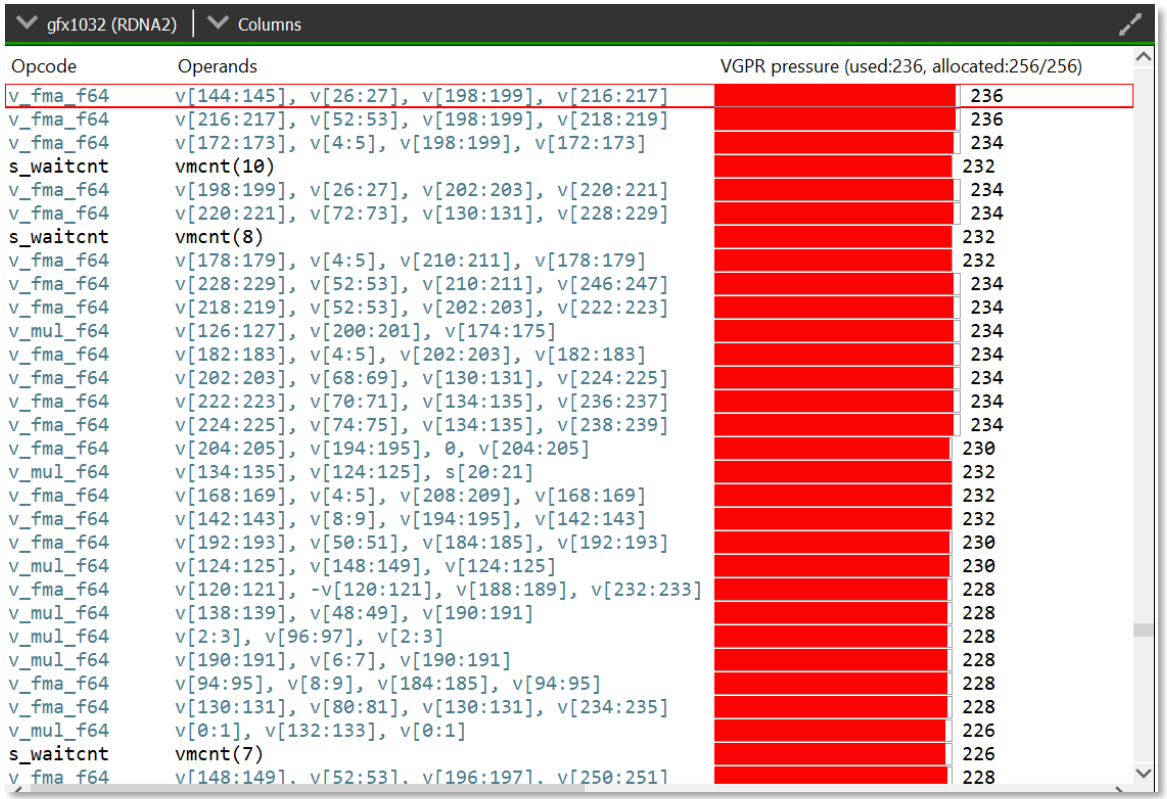
RADEON GPU ANALYZER 2.7 - UPDATE

- Displays number of VGPRs used and allocated
- Utilization bars that visualize the VGPR usage and the VGPR block utilization
- Tooltips of live VGPRs per instruction with reduction hints



RADEON GPU ANALYZER 2.7 - UPDATE

- Displays number of VGPRs used and allocated
- Utilization bars that visualize the VGPR usage and the VGPR block utilization
- Tooltips of live VGPRs per instruction with reduction hints
- F4 shortcut will cycle through the lines with maximum VGPRs. Shift+F4 will do the same in reverse order



RADV & STEAM DECK SUPPORT

- RADV is a Vulkan® driver for AMD Radeon™ GPUs written for Linux® by the community as part of the Mesa project
- Radeon tools support in RADV enabled via environment variables for Steam Deck device
  - RGP support
    - RADV_THREAD_TRACE=*frameindex*
    - RADV_THREAD_TRACE_TRIGGER=*filename*
    - "RGP Capture" button in the SteamOS Devkit client
  - RRA support
    - Added in Mesa 22.3
    - RADV_RRA_TRACE=*frameindex*
    - RADV_RRA_TRACE_TRIGGER=*filename*
  - RMV support
    - Added in Mesa 23.0 (also requires Linux kernel 5.10 or newer)
    - MESA_VK_MEMORY_TRACE=*frameindex*
    - MESA_VK_MEMORY_TRACE_TRIGGER=*filename*

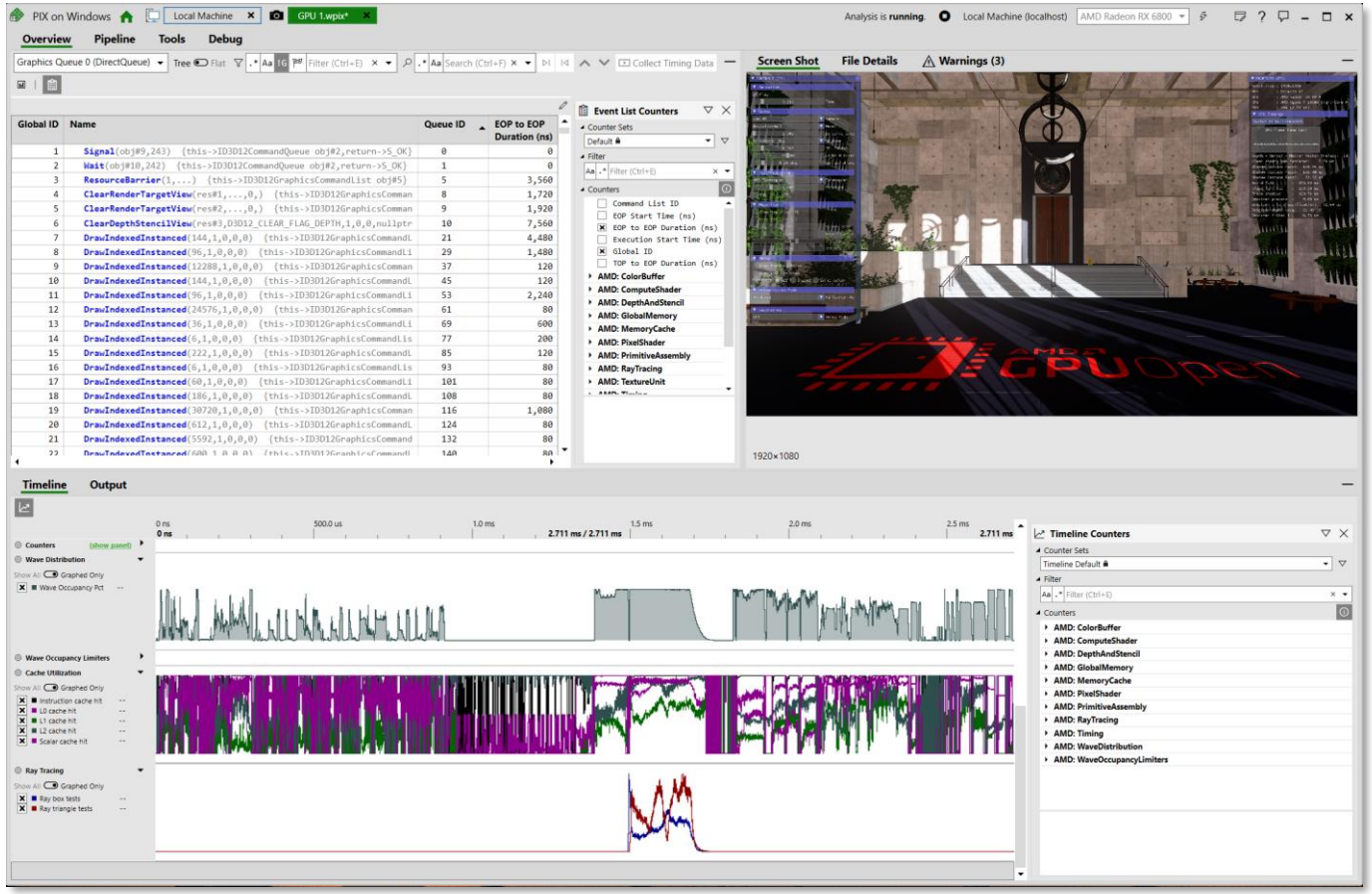
THIS PRESENTATION

- Part 1: **Overview of the Radeon™ Developer Tool Suite**
  - What is in it
  - What's new since GDC 2022
  - Dive into new features and improvements
  - RADV & Steam Deck support

- Part 2: **Collaboration with external tool developers**
  - Microsoft® PIX on Windows
  - RenderDoc
  - GFXReconstruct

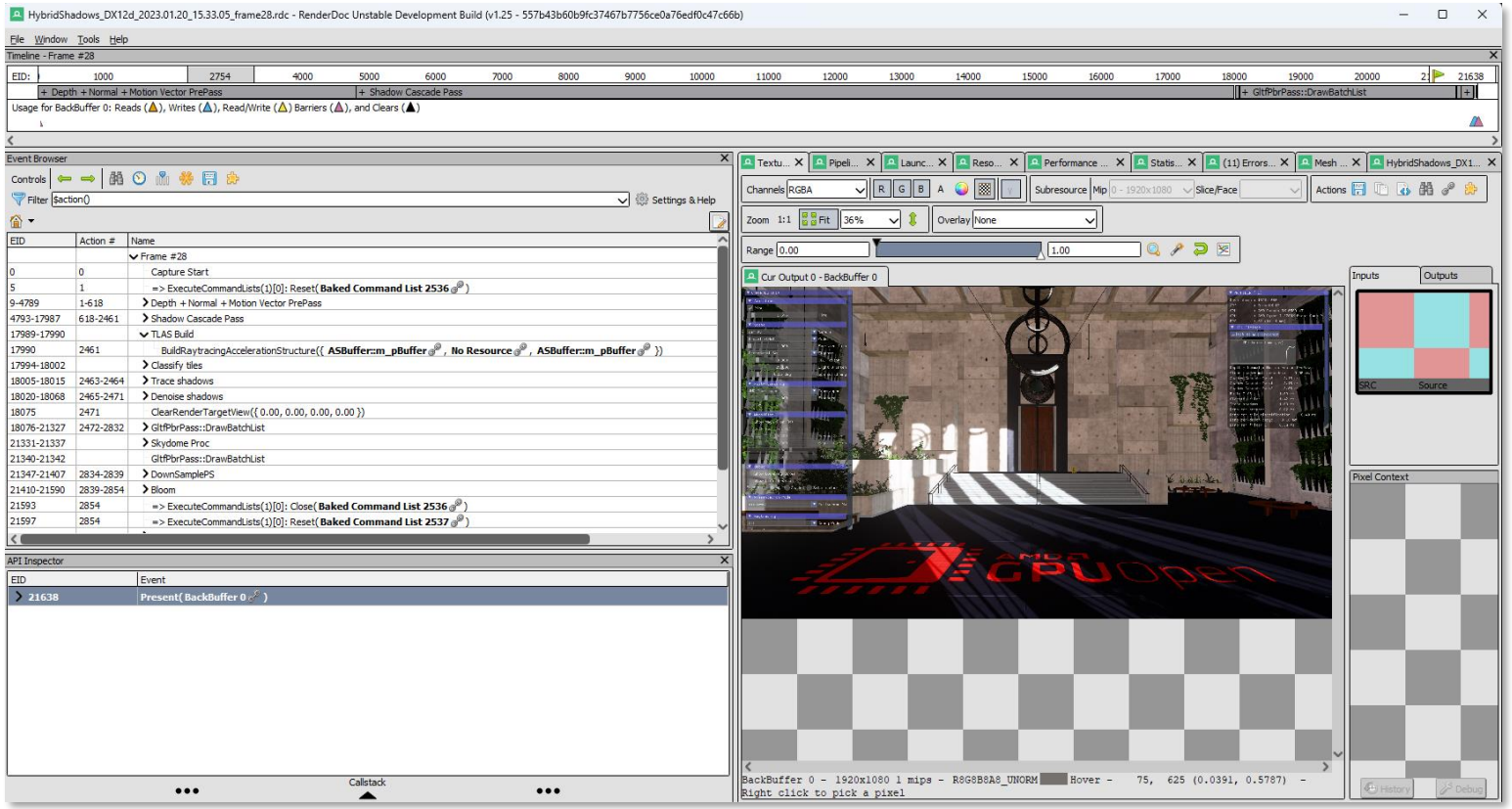
MICROSOFT PIX ON WINDOWS

- Debugging and performance analysis
- Event List Counters
- High frequency counter graphs
  - Wave distribution
  - Wave occupancy limiters
  - Cache utilization – **NEW!**
    - Scalar cache hit
    - Instruction cache hit
    - L0/L1/L2 cache hit
  - Raytracing – **NEW!**
    - Ray box tests
    - Ray triangle tests
- https://devblogs.microsoft.com/pix/
- DirectX Discord server: discord.gg/directx



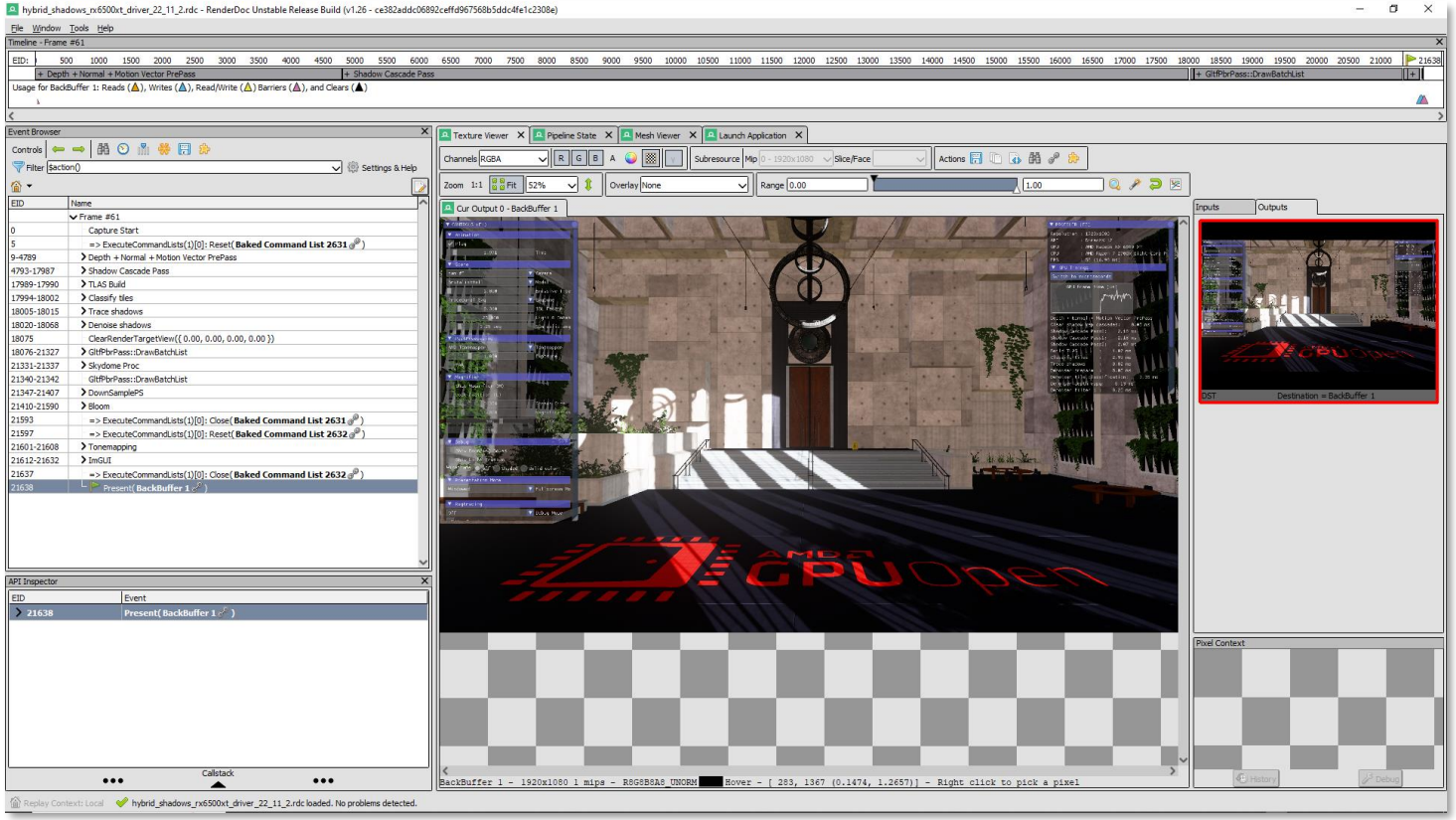
RENDERDOC - OVERVIEW

- RenderDoc is a free MIT licensed stand-alone graphics debugger
- Allows quick and easy single-frame capture and detailed introspection
- Applications using Vulkan, D3D11, OpenGL & OpenGL ES or D3D12 across Windows, Linux, Android
- RDNA3 GPA Counter support – **NEW!**



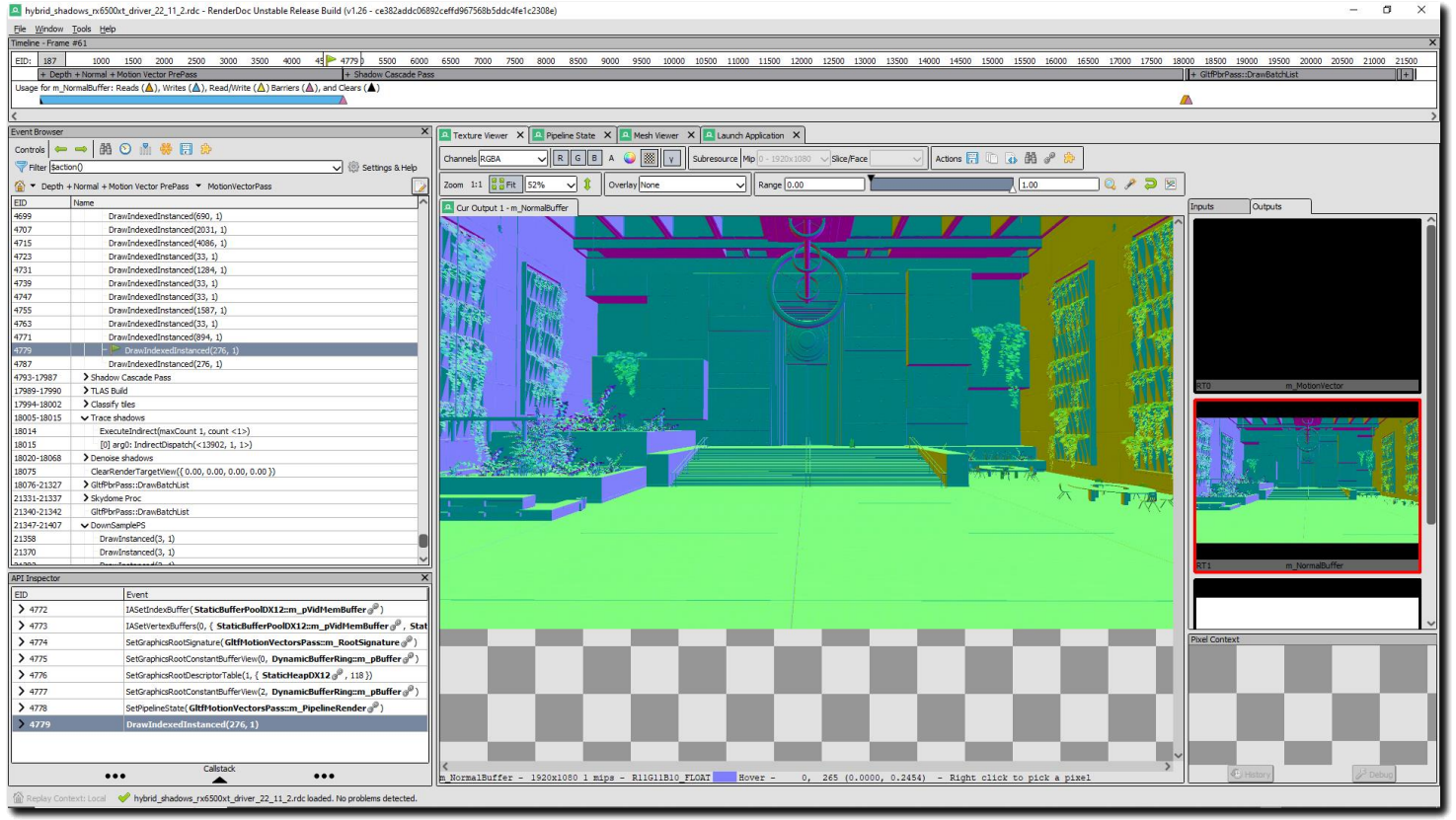
RENDERDOC – WORK IN PROGRESS

- Collaboration between AMD and Baldur Karlsson to support capture of DXR applications
- DXR Support
  - Capture/replay DXR workload



RENDERDOC – RGP INTEROP

- Generate RGP profile from capture file
- Profile opened in RGP
- Select event in RenderDoc
- Jump to same event in RGP
- Select event in RGP
- Jump to same event in RenderDoc



GFXRECONSTRUCT + D3D12 + DXR

- **What is it?**
  - Graphics workload capture/replay software suite
  - Replacement for vktrace
  - Command line based
  - Added D3D12 + DXR support in joint venture between LunarG and AMD

- **Highlights**
  - Supports ray tracing
  - Fully open-source
  - Extensible software architecture
  - Can capture/replay thousands of frames
  - Lightweight

GFXRECONSTRUCT + D3D12 + DXR

- **Provided components**
  - Writing: DLLs to capture a GPU workload
  - Reading: executables to replay and process the captured workload

- **Main tools:** gfxrecon-replay.exe and gfxrecon-optimize.exe

- **Other tools, that can:**
  - Display the capture file metadata
  - Change the compression algorithm
  - Generate a human readable API dump

- **Use cases**
  - Open-source toolkit
  - Profiling specific frames
  - Debugging visual artifacts
  - Stress testing
  - Experimentation platform

- **How to get it**
  - Source code and binaries: https://github.com/LunarG/gfxreconstruct
  - Blog: https://gpuopen.com/learn/amd-lunarg-gfxreconstruct-dx12-dxr

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Radeon Developer Tool Suite

https://gpuopen.com/tools/

Tool Suite Videos

https://gpuopen.com/videos/

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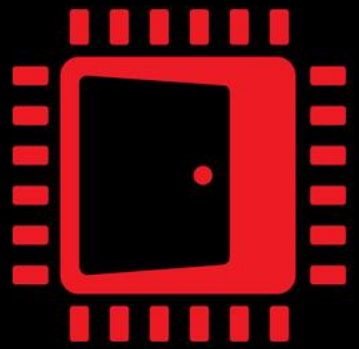

AMD GPUOpen

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together we advance_

AMD
EPYC

AMD
RYZEN

AMD
RADEON

ANY QUESTIONS?

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Radeon Developer Tool Suite

https://gpuopen.com/tools/

Tool Suite Videos

https://gpuopen.com/videos/