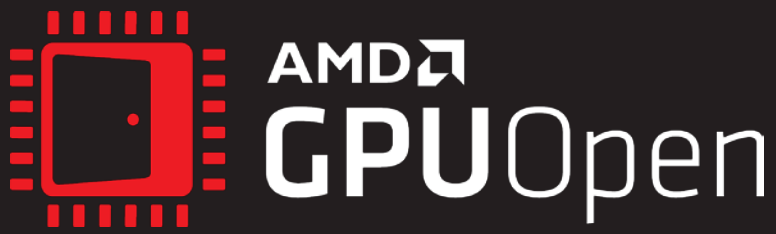
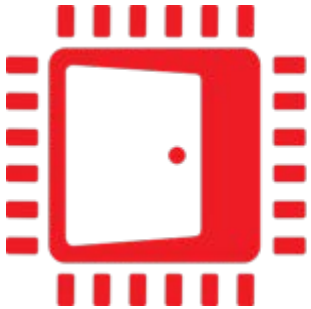
A REVIEW OF GPUOPEN EFFECTS

TAKAHIRO HARADA & JASON LACROIX



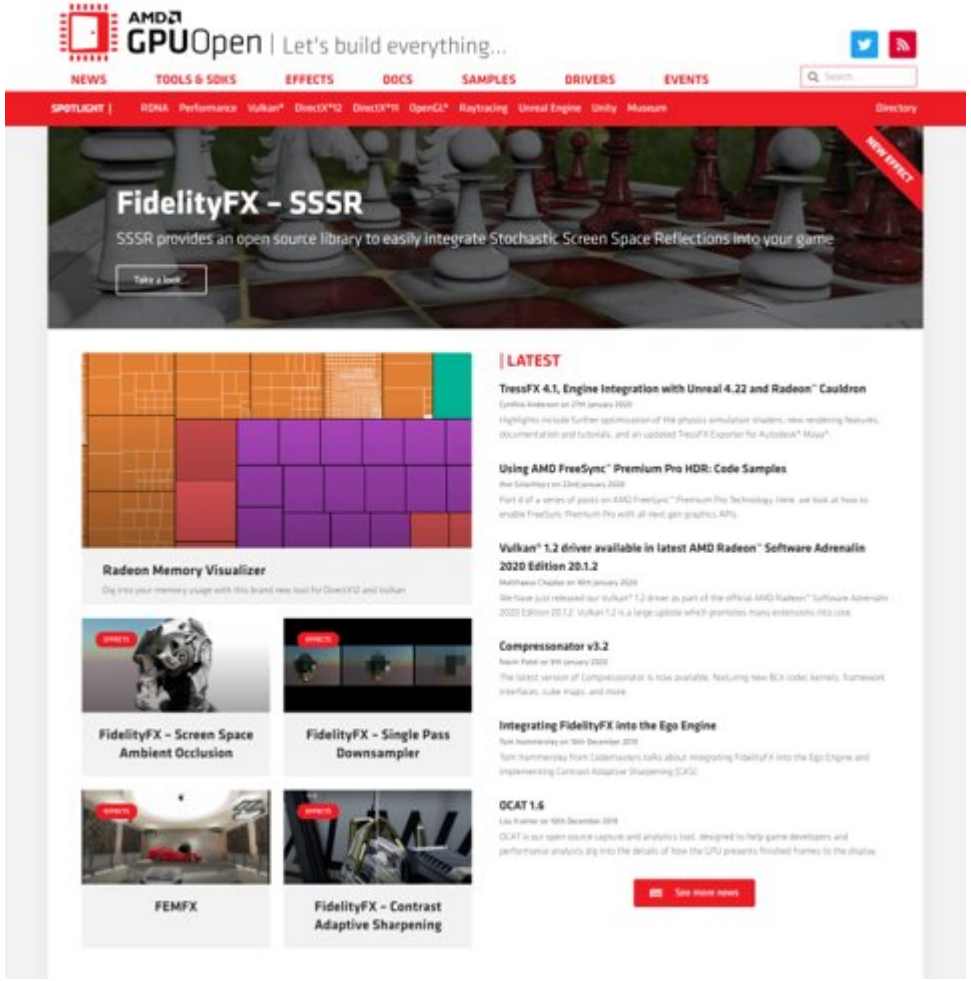


AMD GPUOpen

- An initiative designed to help developers make better content by “opening up” the GPU
- Contains a variety of software modules across various GPU needs:
  - Effects and render features
  - Tools, SDKs, and libraries
  - Patches and drivers
- Software hosted on GitHub with no “black box” implementations or licensing fees
- Website provides:
  - The latest news and information on all GPUOpen software
  - Tutorials and samples to help you optimise your game
  - A central location for up-to-date GPU and CPU documentation
  - Information about upcoming events and previous presentations

LET’S BUILD A NEW GPUOPEN…

- Brand new, modern, dynamic website
- Easy to find the information you need quickly
- Read the latest news and see what’s popular
- Learn new tips and techniques from our engineers
- Looks good on mobile platforms too!
- New social media presence
  - @GPUOpen

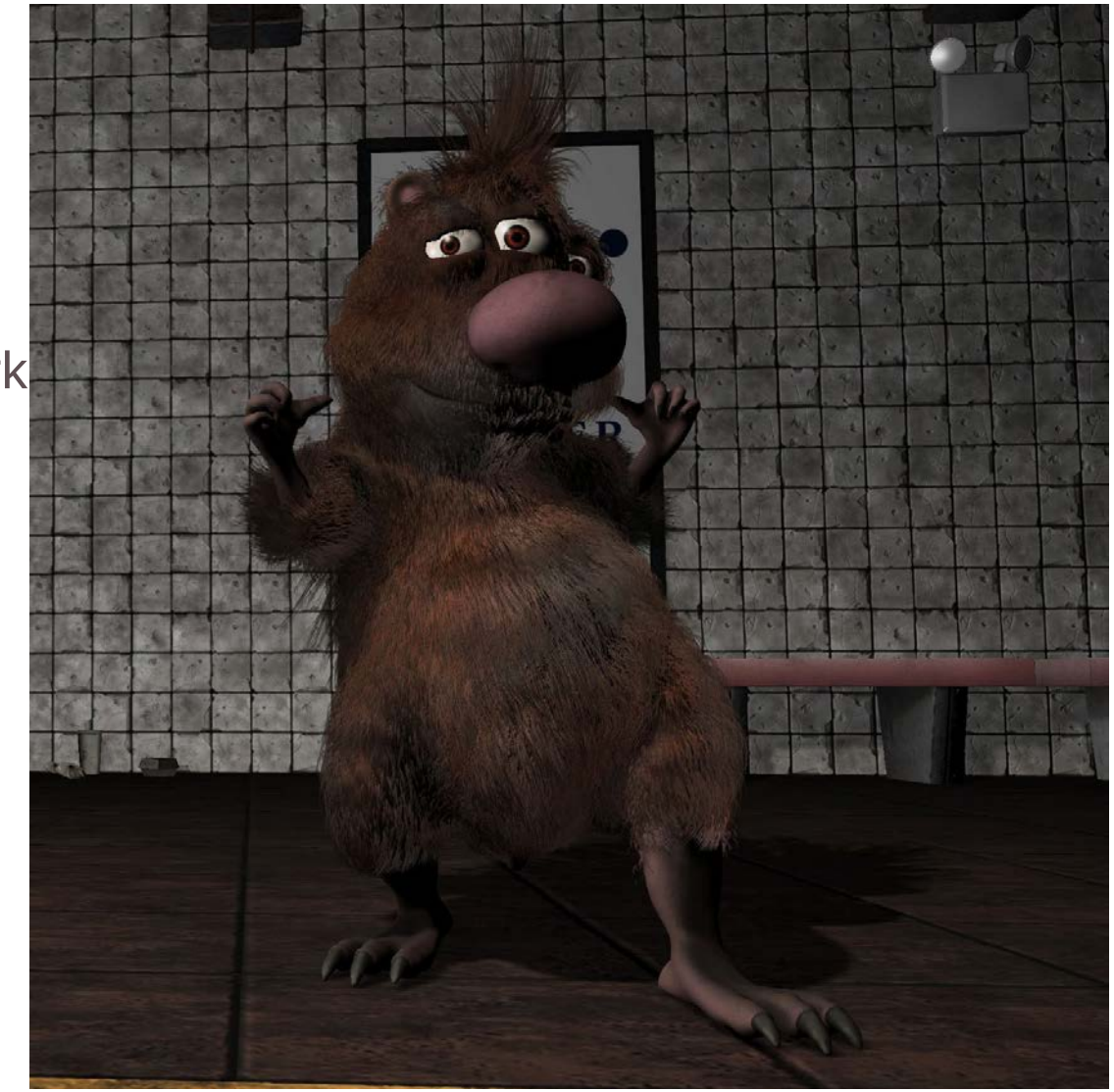


EFFECTS

A look at recently released samples

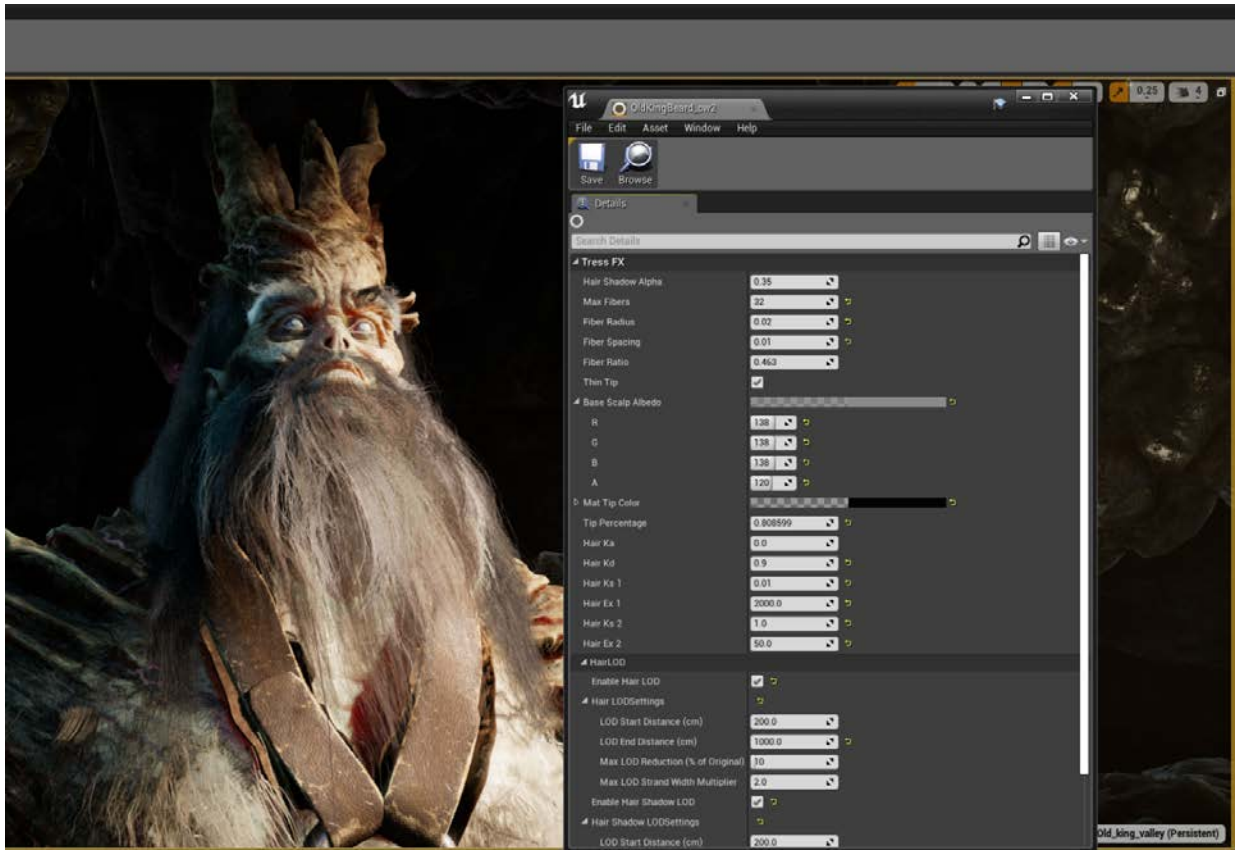
TRESSFX 4.1

- Self-contained solution for hair simulation
- Implementation into Radeon® Cauldron framework
  - DirectX® 12 and Vulkan® with full source
- Optimized physics simulation
  - Faster velocity shock propagation
  - Simplified local shape constraints
  - Reorganization of dispatches
- StrandUV support
- New LOD system
- New and improved Autodesk® Maya® exporter



TRESSFX 4.1 – UE4 ®

- External code module requiring minimal hooks
- Reference renderer for hair
- Provides a starting point for developers to integrate TressFX into their Unreal ® -based games
- Features
  - Unreal ® shadow system support*
    - *Dynamic lights only
  - Parameter blending via blend maps
  - TressFX component
  - .uasset support for TressFX data files
    - Can be drag and dropped into Unreal ®



DEMO

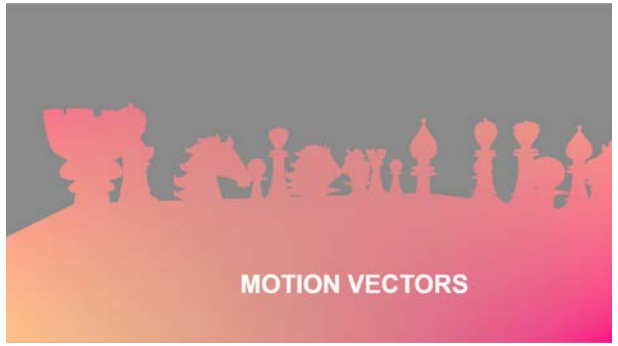
Tressfx 4.1 UE4

FIDELITYFX – SSSR

- Stochastic screen space reflections (SSSR)
- Based on industry leading algorithm
- Hierarchical depth buffer traversal kernel
- Glossy reflections via Ray Jittering
- High performant spatio-temporal denoisers
- Tile classifier that allows skipping non-reflective areas
- HLSL SM 6.0 with wave-level optimizations
- D3D12
- Vulkan (coming soon)

FIDELITYFX – SSSR

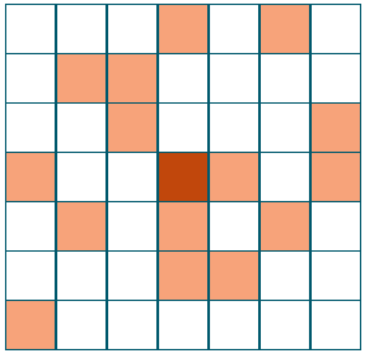
- Surface requirements
  - Depth Hierarchy (2x2 minimum)
  - Per pixel motion vectors
  - Resolved scene
  - Normals for current and last frame
  - Roughness for current and last frame



FIDELITYFX – SSSR

- Tile Classification Pass
  - Which pixel needs a ray
  - Which tile needs a denoiser
- Intersection Pass
  - Hierarchical trace through the depth buffer to find first intersection
  - Looks up environment map as fallback
  - Variable rate traversal
    - 1 ray per pixel for mirror surfaces
    - 1 ray per 4 pixels for rough surfaces
- Denoiser Passes

FIDELITYFX – SSSR



- Spatial Denoiser Pass
  - 16 samples of Halton Sequence (2,3) discretized to 7x7 region
  - Edge stopping weight based on normal
  - Gaussian weight based on depth difference
  - Accumulate all radiance values
  - Normalize using accumulated weights
- Temporal Denoiser Pass
  - Temporal reprojection based on surface position
  - Temporal reprojection based on hit position
  - Picks the best result between the two
- Edge-Aware À-Trous Wavelet Filter (EAW)
  - Get rid of remaining spatial noise

DEMO

FidelityFX: SSSR

FIDELITYFX – CACAO

- Combined Adaptive Compute Ambient Occlusion (CACAO)
- A highly optimized implementation of SSAO
- Multiple settings which balance performance and quality
- Requirements
  - Depth buffer
  - Normal buffer (optional)
- Supports
  - DX12
  - Vulkan (coming soon)

DEMO

FidelityFX: CACAO

FIDELITYFX – LPM

- Luma Preserving Mapper
  - Help balance content for HDR and wide gamut
  - Tonemap(Luma(RGB)) rather than Luma(Tonemap(RGB))

- Key Takeaways:
  - Works with any positive RGB input
  - Targets any RGB output
    - Presets for available for common colorspaces
      - REC709, P3, REC2020, HDR10, FS2
  - Completely ALU based solution without LUT
    - Can be easily decoupled to run to async compute queue
  - Supports FP16
    - Better perf on Vulkan

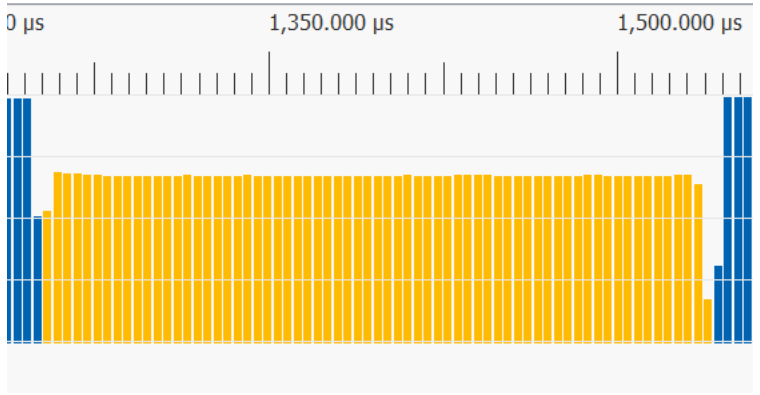
- Available for Vulkan and D3D12

DEMO

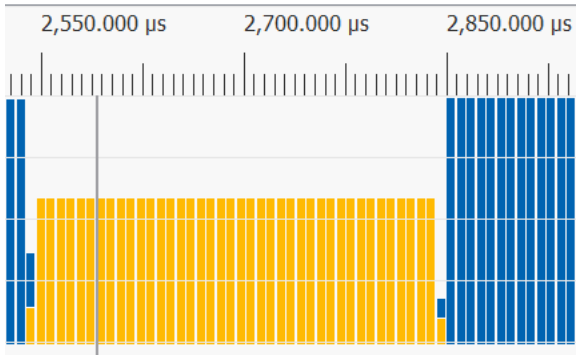
FidelityFX: Luma Preserving Mapper

FIDELITYFX – CAS

- Contrast Adaptive Sharpening (CAS)
- First effect in the FidelityFX library
- For **sharpening** and optional upsampling
  - Enhances sharpness and local high-frequency contrast lost due to TAA
  - Created to provide natural sharpness without artifacts with low overhead
  - Upsampling designed for Dynamic Resolution Scaling (DRS)
- Single compute dispatch call

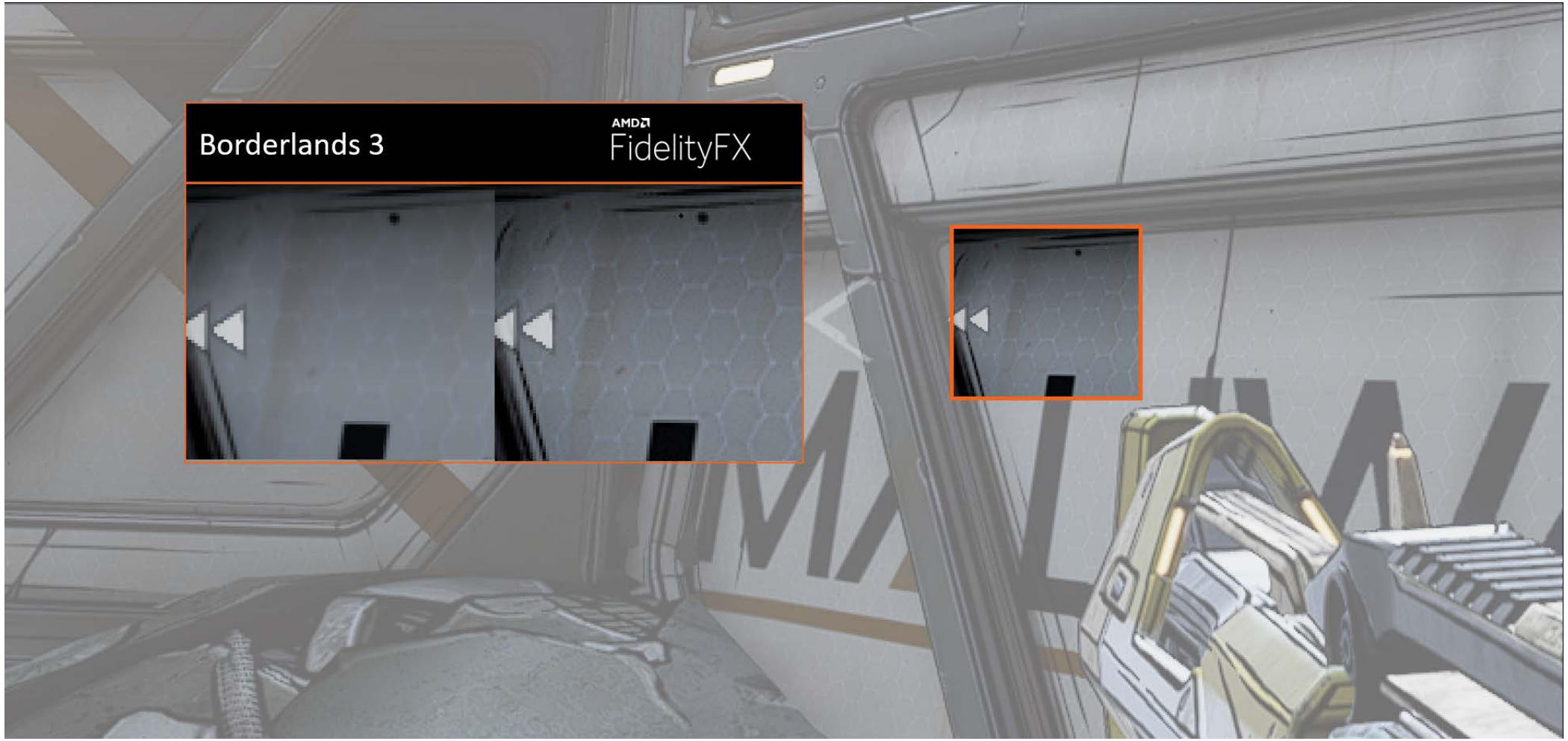


CAS Upsample & Sharpen 1440p to 4K: 0.287ms RX 5700 XT



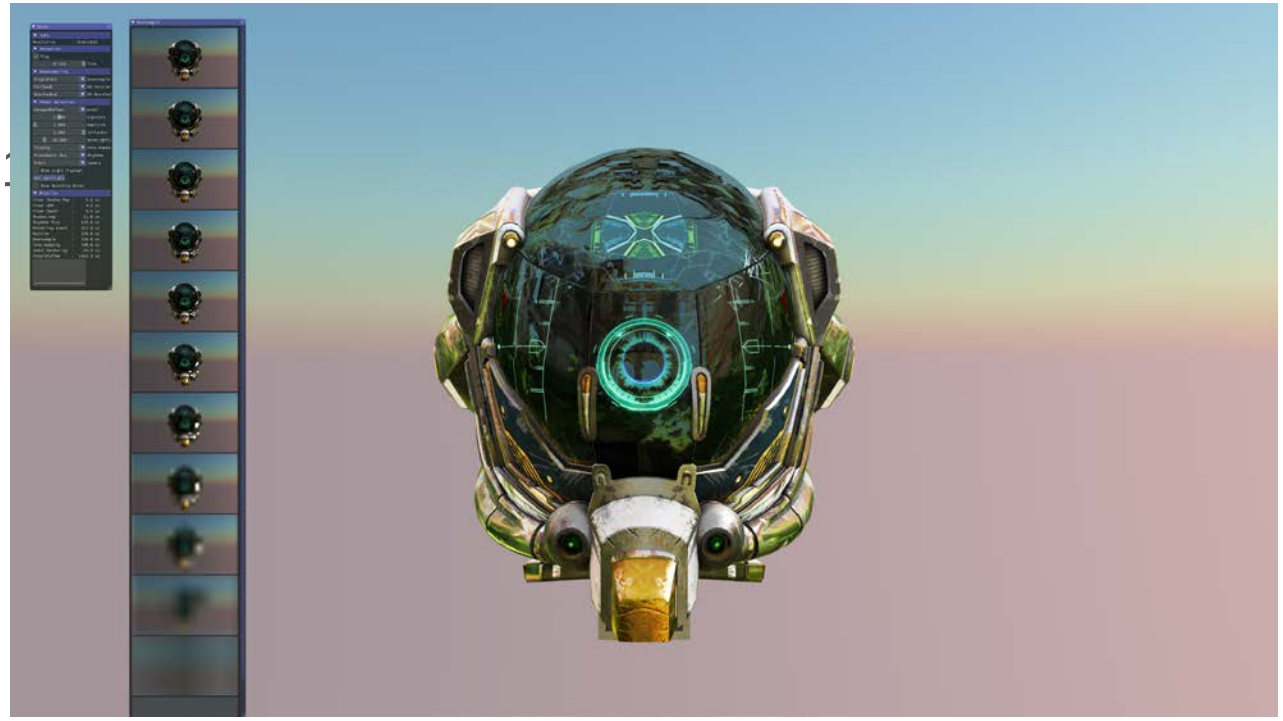
CAS Sharpen Only 4K: 0.301ms RX 5700 XT

FIDELITYFX – CAS



FIDELITYFX – SPD

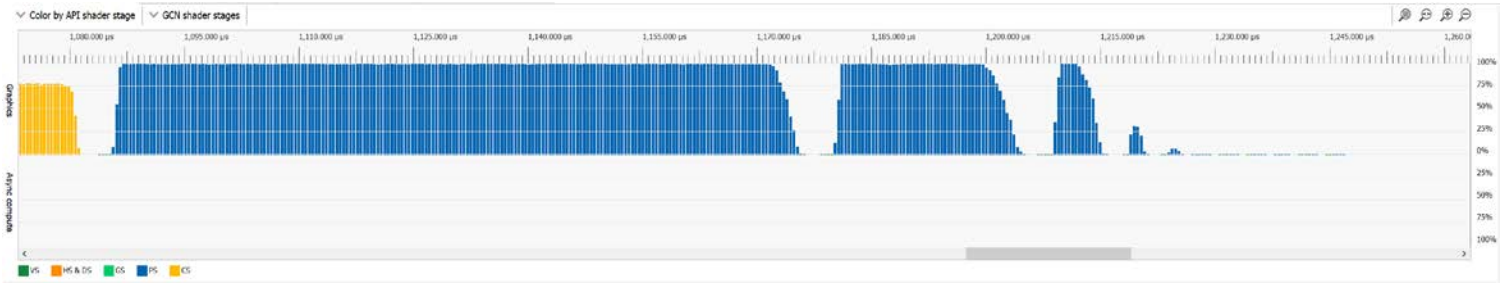
- Single Pass Downsampler (SPD)
- Downsamples texture from 4kx4k down to 1
- User configurable 2x2 reduction operation
- GLSL and HLSL code available
- Compute shader based solution
- Suitable for async compute
- 2 modes of execution
  - Using wave operations and LDS
  - Using LDS without wave operations
- FP16 support



FIDELITYFX – SPD

- SPD vs.
  traditional multipass pixel shader
- 4k source image
- 11 mip levels generated
- SPD: 0.127 ms
- Multi-pass Pixel Shader: 0.166 ms

SPD - 0.127 ms on Radeon RX 5700 XT

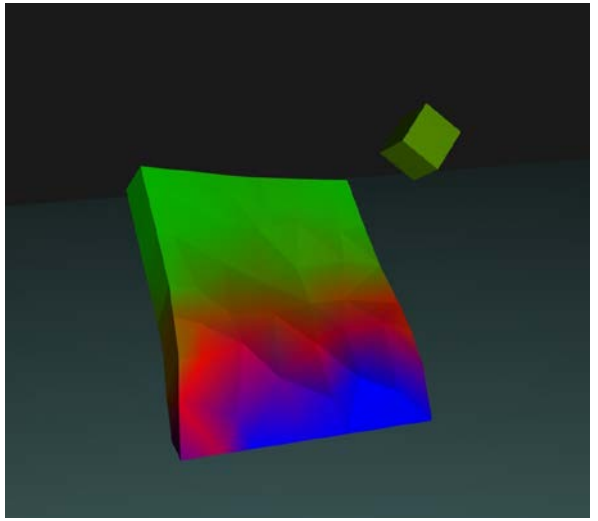


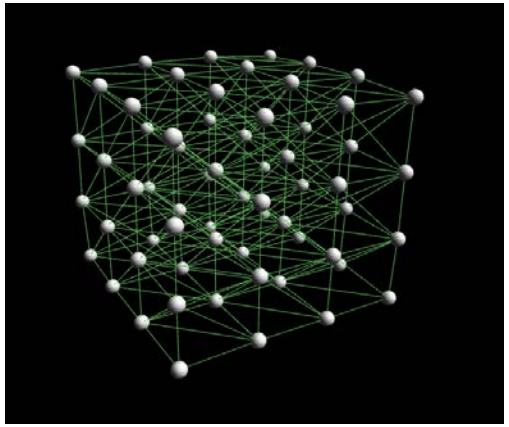
Multi-pass Pixel Shader - 0.166 ms on Radeon RX 5700 XT

FEMFX

FEM FUNDAMENTALS

- Physics method for deformable materials
- Models a solid as a mesh of elements (tetrahedra)
- Each element has material parameters
  - Stiffness
  - Volume preservation
  - Stress limit before permanent (plastic) deformation
  - Stress limit before fracture

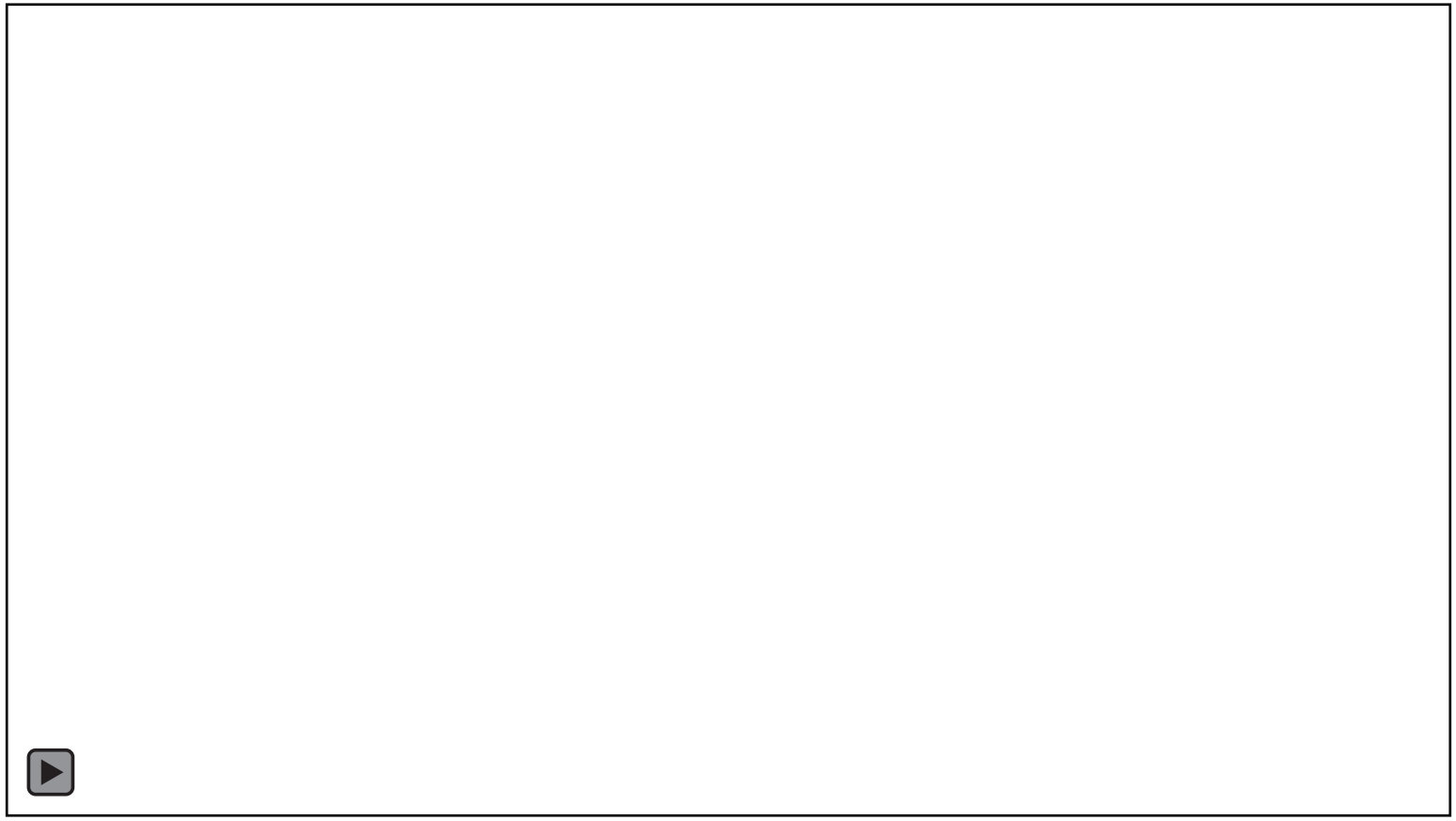




BENEFITS

- A different kind of physics for different effects
- Simulates deformable materials
  - Bending metal
  - Wood that flexes and breaks
  - Compressing, bouncing tires
  - Melting objects
  - “Alien” materials
- Improves fidelity
  - Realistic flexing
  - Storing and release of energy
  - Snap when breaking
  - Less brittle-looking fracture
- New interaction possibilities

DEMO



FEMFX LIBRARY

- Open source with GPUOpen license
- Multithreaded CPU implementation
  - For interaction with gameplay and other systems
  - Following trend of increasing CPU cores
  - SIMD optimizations
- Release includes
  - Houdini authoring tools
  - UE4 Plugin as example engine integration

IMPLEMENTATION HIGHLIGHTS

- Implicit integration for stiff materials
  - Benefits stability and convergence
- Constraint-based contact between objects
  - Supports stacking
  - Compatibility with rigid-body solvers
- Continuous collision detection
  - Reduces missed collisions, tunneling
  - Using approximate method
- Multiplicative plasticity
  - Found behavior better than additive
  - Intuitive limits
- Sleeping feature to freeze slow-moving objects
- Disabling feature to remove object from simulation
- Non-fracture groups

THREADING APPROACH

- Library uses all async threading
  - Dispatched tasks detect completion of work
  - One of these tasks submits a task to continue
  - Handles all the task synchronization
- High level threading features implemented in the library
  - Parallel for
  - Task graph
- Has a callback interface to support external task systems
  - Mostly just async task submit

RENDERING

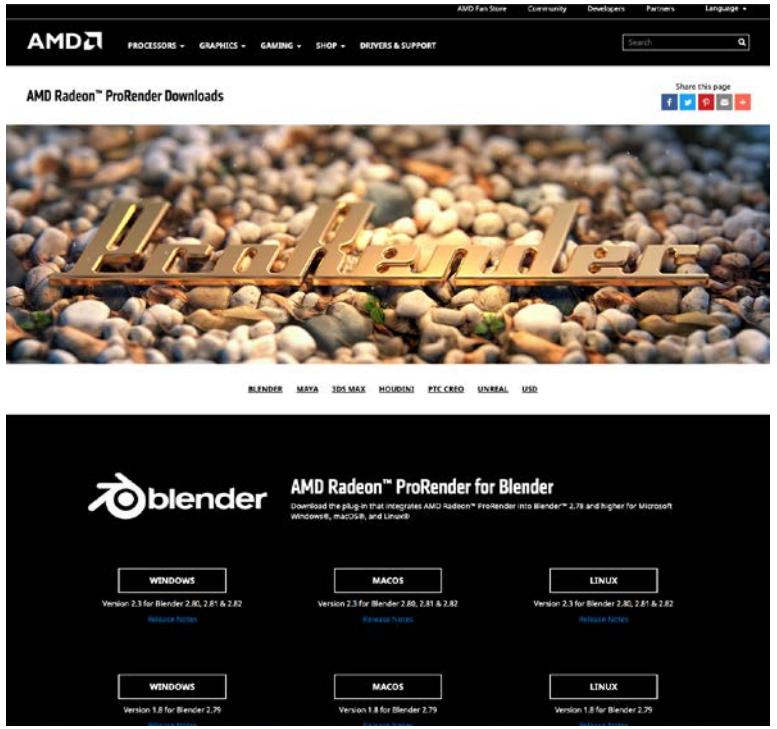
- Demonstrated in UE4 Plugin
- Render mesh is separate from tetrahedral mesh
  - Allows more visual detail than simulation detail
- Preprocessing finds correspondence between them
  - Attaches each render vertex to closest tetrahedron
  - Finds barycentric coords of vertex in tetrahedron (four weights)
- At run-time vertices driven by tetrahedral mesh and weights
  - Like skinning
  - Can be done in a vertex shader
- Render meshes authored in pieces
  - Which break up with fractures in the tetrahedral mesh
- After fracture, may re-assign vertex to another tetrahedron
  - To keep vertices of the same render mesh piece together

RADEON™ PRORENDER

RADEON™ PRORENDER

- A powerful physically-based path traced rendering engine
- Supports GPUs and CPUs (OpenCL™ or Apple® Metal®)
- Works across Windows®, Linux®, and macOS®

- Plugins, integrations for artists
  - Maya, Max, Blender plugins
  - Integrations from our partners
  - USD Hydra delegate (Houdini)
- https://www.amd.com/en/technologies/radeon-prorender-downloads



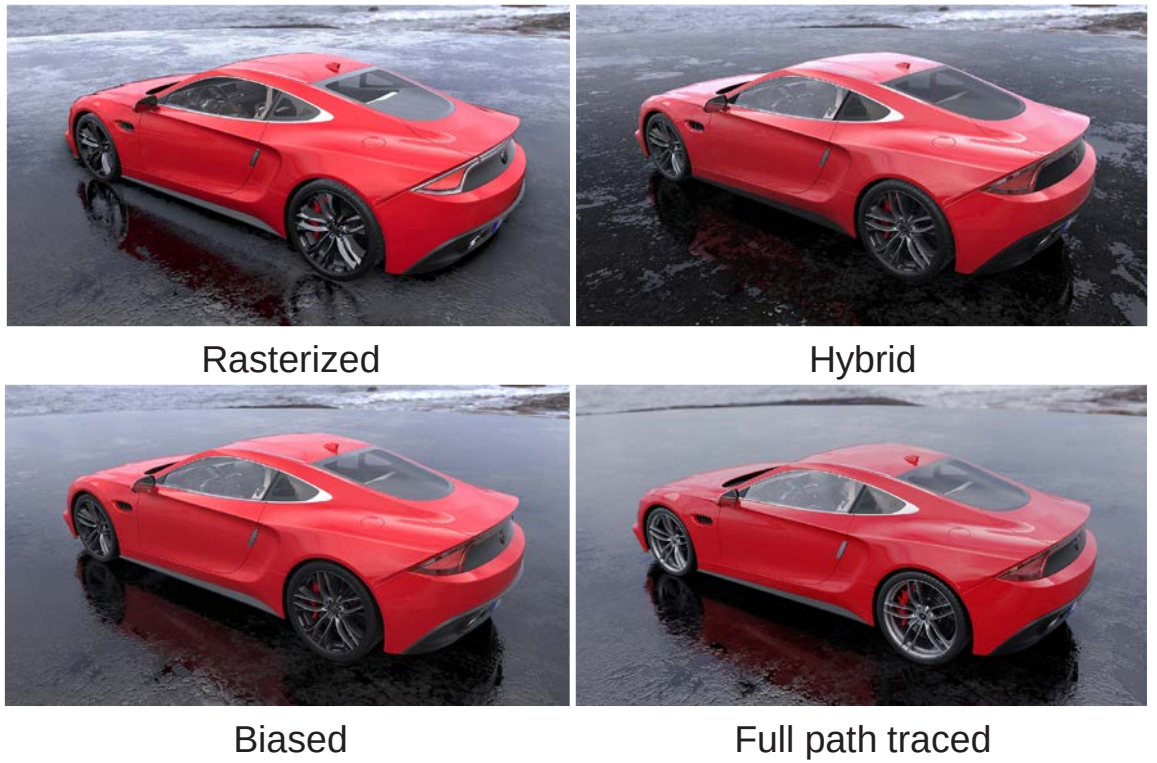
RADEON™ PRORENDER

- SDK for developers
- Open access to the SDK at GDC2020
- Radeon ProRender 2.0
  - Re architected for better experience
  - Improvements
    - Rendering speed
    - GPU memory reduction
    - MaterialX support

RADEON™ PRORENDER

FULL SPECTRUM RENDERING

- Approximated faster render modes
- Cross-platform, cross-vendor
- Implemented using
  - Vulkan, RadeonRays 3.0
  - DX12, RadeonRays 4.0
- Render modes:
  - Raster
  - Hybrid
  - Biased path tracer
- Dynamic lightmap GI
- Voxel GI



Rasterized | Hybrid

Biased | Full path traced

RADEON RAYS

- Radeon Rays 4.0
  - Releasing at GDC 2020

- Radeon Rays 3.0
  - Implemented in Vulkan®
  - Supports both AMD GPUs and CPUs
  - Feature highlight
    - GPU-accelerated Bounding Volume Hierarchy (BVH) building
    - Half-precision (FP16) computation support
  - Works across Windows® and Linux®

- Radeon Rays 2.0
  - Implemented in OpenCL™
  - Supports both GPUs and CPUs
  - Works across Windows® and Linux®

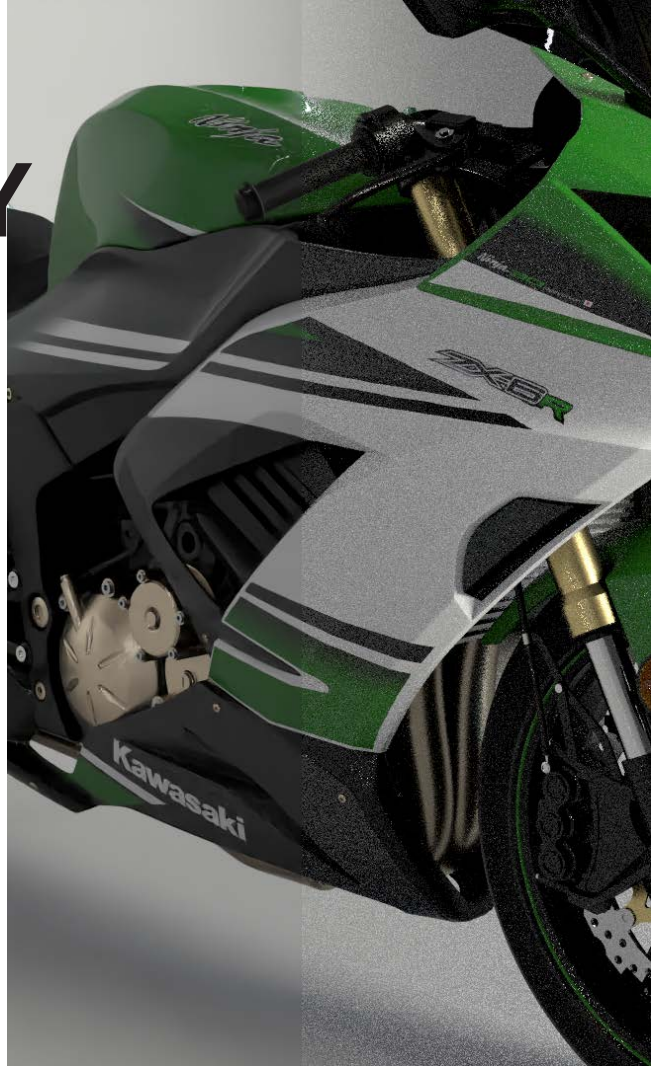
RADEON RAYS 4.0

- Unifies the zoo of SW/HW raytracing APIs
- Today, we have A LOT of APIs
  - Windows: DX12 Compute/DXR, Vulkan Compute/RT
  - Linux: Vulkan Compute/RT
  - MacOS: Metal Performance Shader
- Makes it platform / API independent
- Different level of intersection APIs depending on your needs
- Supports more intersection primitives

RADEON RAYS 4.0

- Batch intersection
  - Good for pro apps
  - No graphics / compute API interop required
  - Cross-vendor
- DXR1.1 compute shader intrinsic (via interop)
  - AMD only
  - For performance critical workflows / gaming
- Fully customizable BVH traversal from compute shader
  - AMD only
  - For ultimate performance on AMD
  - Enables algorithms not available with DXR
    - Flexible LOD, early traversal stop, mixed nodes, on-the-fly BVH generation, etc.

RADEON™ IMAGE FILTER LIBRARY



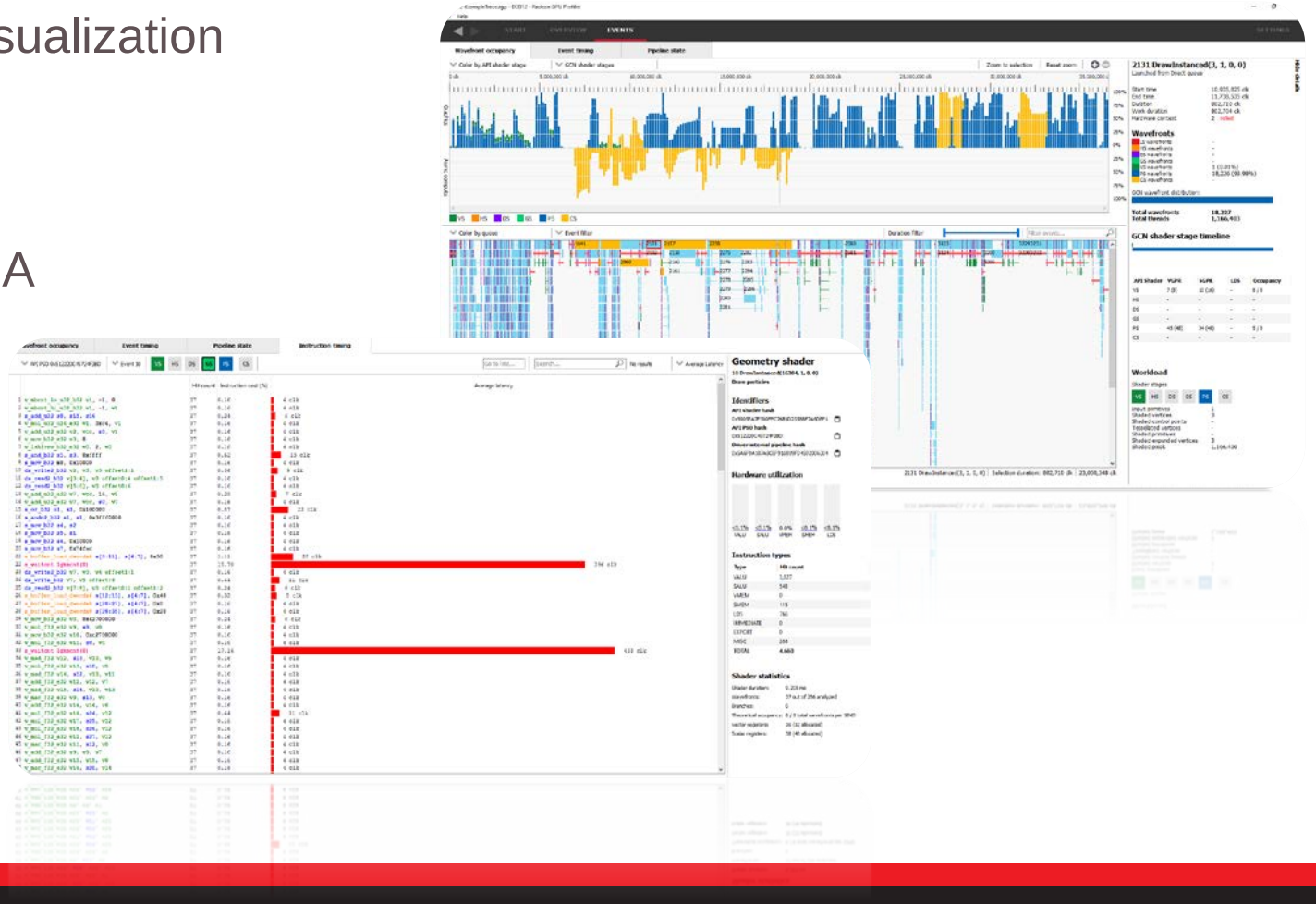
- Collection of image post processing filters
- Started to provide post processing effect for Radeon™ ProRender
  - Tone mapping
  - Denoising
  - Bloom
  - etc…
- Now includes our AI effects for denoising and upsampling.
- Based on OpenCL™, Metal, **DX12** (new for GDC) and **DML for AI**
  - Interop with OpenCL™, Metal, DX12 but also OpenGL & DX11
- Part of RPR SDK
  https://www.amd.com/en/technologies/radeon-prorender-developers
  https://radeon-pro.github.io/RadeonProRenderDocs/rif/about.html

TOOLS

The right tools for building great effects

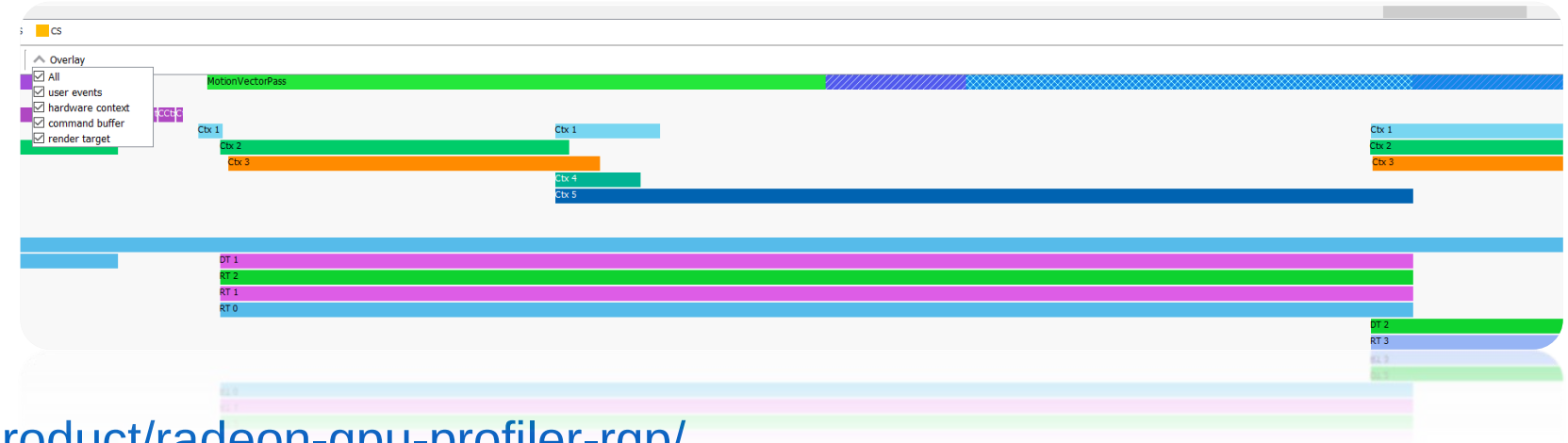
RADEON GPU PROFILER

- Draw, compute, and barrier visualization
- Pipeline state inspection
- WGP occupancy
- Instruction timings & RDNA ISA



RADEON GPU PROFILER

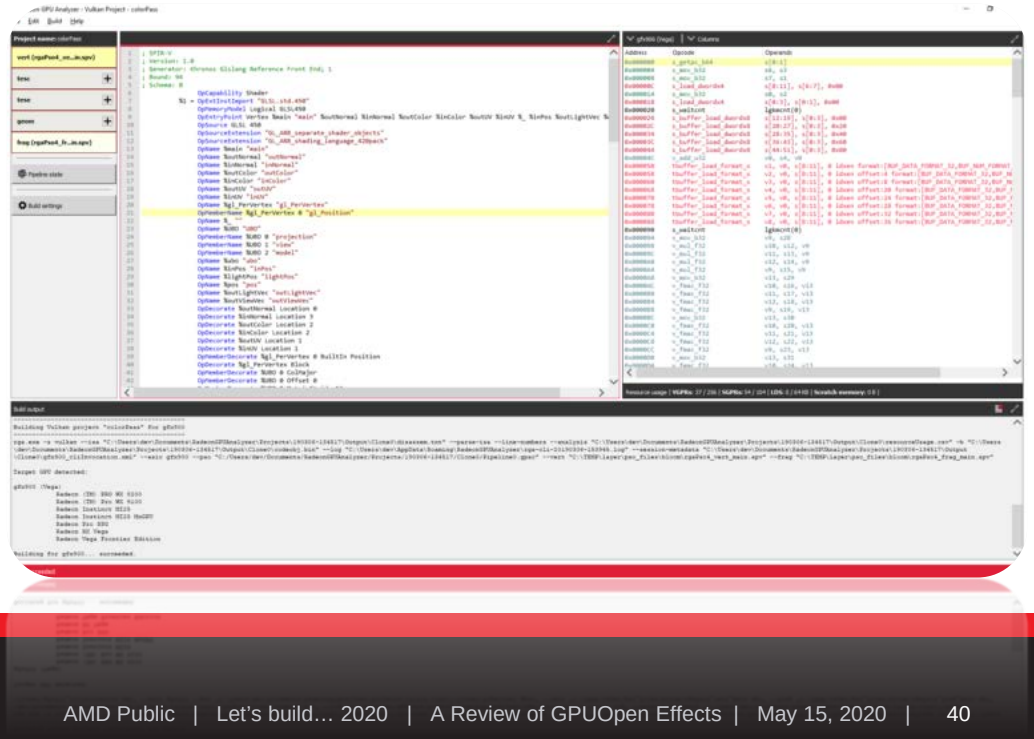
- RGP 1.7
  - Support for Radeon RX 5500 and Radeon RX 5300
  - New pipelines overview pane
  - New flag to show wave32 vs wave64 on RDNA hardware
  - New overlays:
    - User events
    - Hardware contexts
    - Command buffers
    - Render targets



https://gpuopen.com/gaming-product/radeon-gpu-profiler-rgp/

RADEON GPU ANALYZER

- Offline compilation of shaders to AMD GCN ISA / RDNA ISA
- Shader register liveness analysis
- Support for DX11, OpenCL & Vulkan (SPIR-V)
- Full support for D3D12 Pipeline Compilation as of v2.3



RADEON MEMORY VIEWER

- Create deep-dive snapshots at any point in time (even after the fact)
- Track memory-related events over time
  - Resource creation (render target, buffer, etc.)
  - Full virtual & physical memory map
  - Memory paging
  - Generate full history of any resource
  - Understand when resources were last accessed
- Snapshot comparisons
  - Detect memory leaks

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