Ivans Minajevs

Salamander

Graphics Programming II

Overview

High-Level Overview

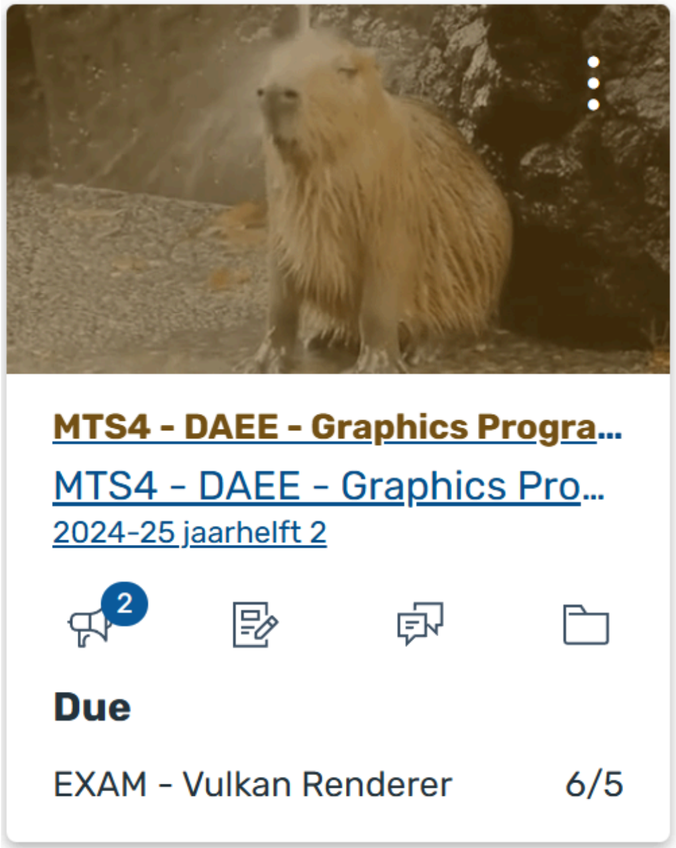
Code Architecture

Feature Showcase

Memory Usage

Graphics Debug Capture

Performance Statistics



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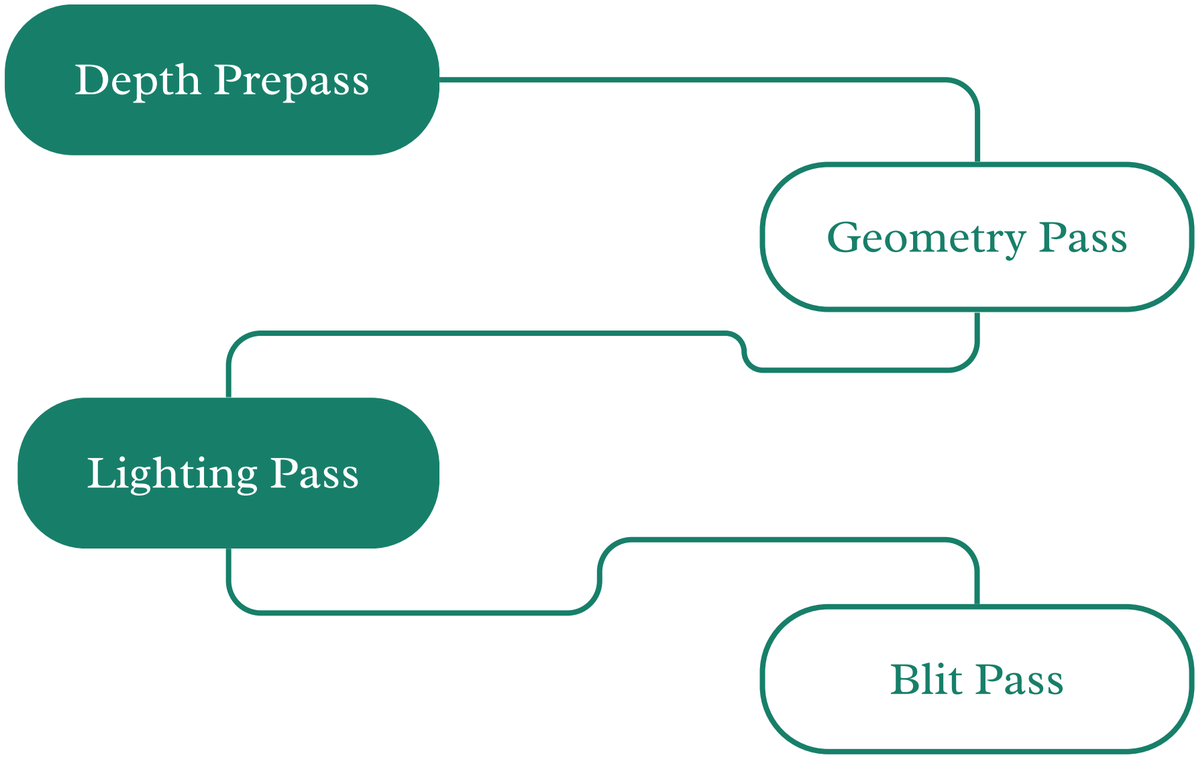


Depth prepass

Depth–Stencil-Only Pass

Depth attachment cleared and configured (no color outputs)

Push Constants

vertexBufferAddress → GPU address to SSBO buffer with vertex data

Draw Sequence

1. Bind depth-only pipeline
2. Bind index buffer and descriptor set
3. Loop over primitives → *vkCmdPushConstants* → *vkCmdDrawIndexed*

Layout Transitions & Copy

1. Per-frame depth image: UNDEFINED → DEPTH_STENCIL_ATTACHMENT_OPTIMAL
2. After rendering: DEPTH_STENCIL_ATTACHMENT_OPTIMAL → GENERAL
3. Copy depth into a sampling texture via *vkCmdCopyImage*
4. Transition both images to DEPTH_STENCIL_READ_ONLY_OPTIMAL

Result

1. Per-frame depth buffer
2. Separate *depth texture* ready for sampling in later passes (world position from depth, skybox check)

Depth prepass

Geometry Pass

Attachment Setup

- Albedo: VK_FORMAT_R8G8B8A8_SRGB
- Normal: VK_FORMAT_R8G8B8A8_UNORM
- Params: VK_FORMAT_R8G8_UNORM
- Depth: VK_FORMAT_D32_SFLOAT

Layout Transitions

1. Albedo/Normal/Params: UNDEFINED → COLOR_ATTACHMENT_OPTIMAL
2. Depth: already in DEPTH_STENCIL_READ_ONLY_OPTIMAL
3. Lastly Albedo/Normal/Params: COLOR_ATTACHMENT_OPTIMAL → SHADER_READ_ONLY_OPTIMAL

Fragment Outputs & Encoding

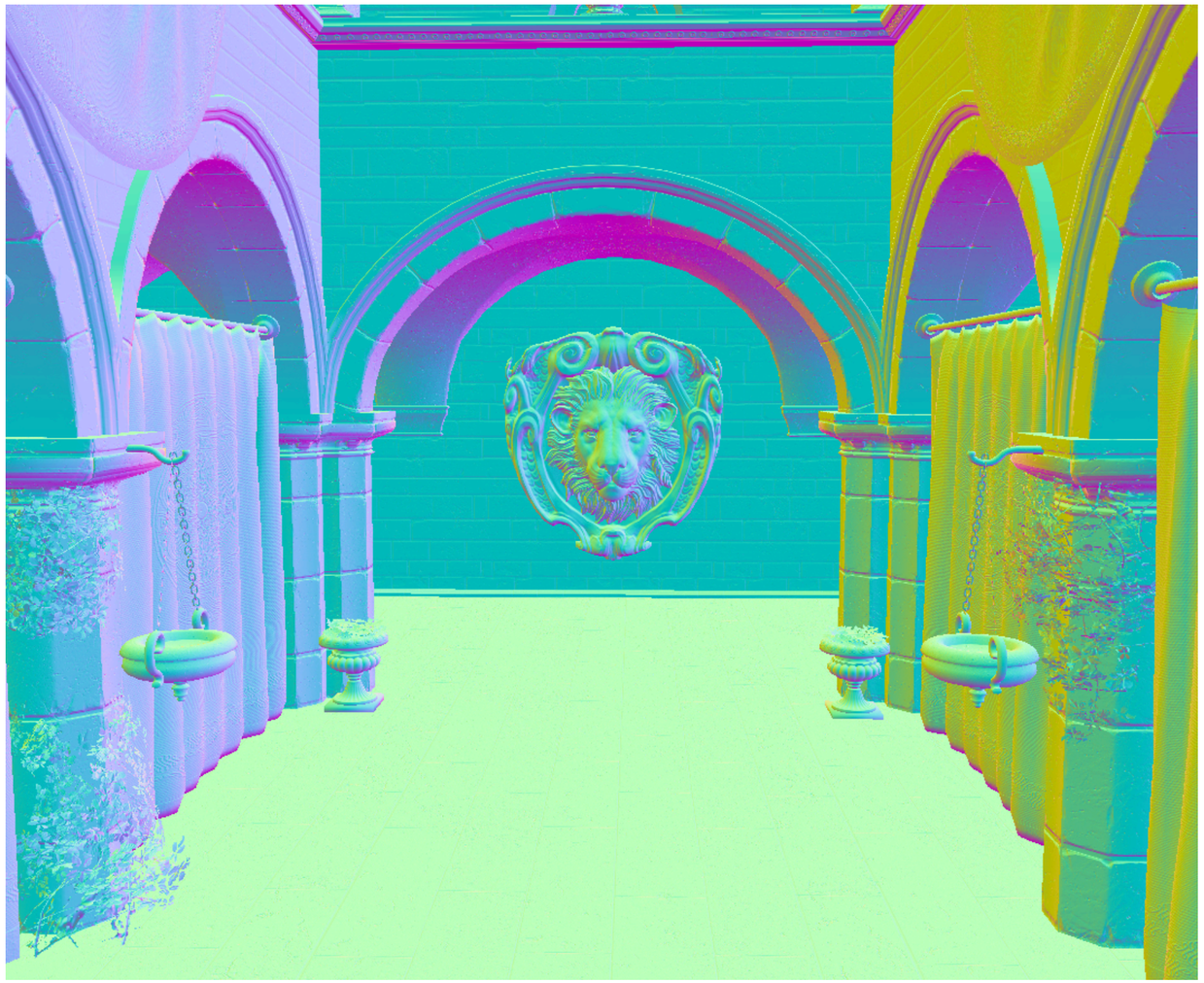
1. *Albedo*: Sample *base color*, *alpha-test*
2. *Normal*: Sample *normal map* (if present) → apply *TBN* → compute *world-space normal* → encode final normal as *(normal * 0.5) + 0.5* → store in RG8B8A8 UNORM
3. *Params*: Sample metallic-roughness →
   Roughness → store in R,
   Metallic → store in G

Result

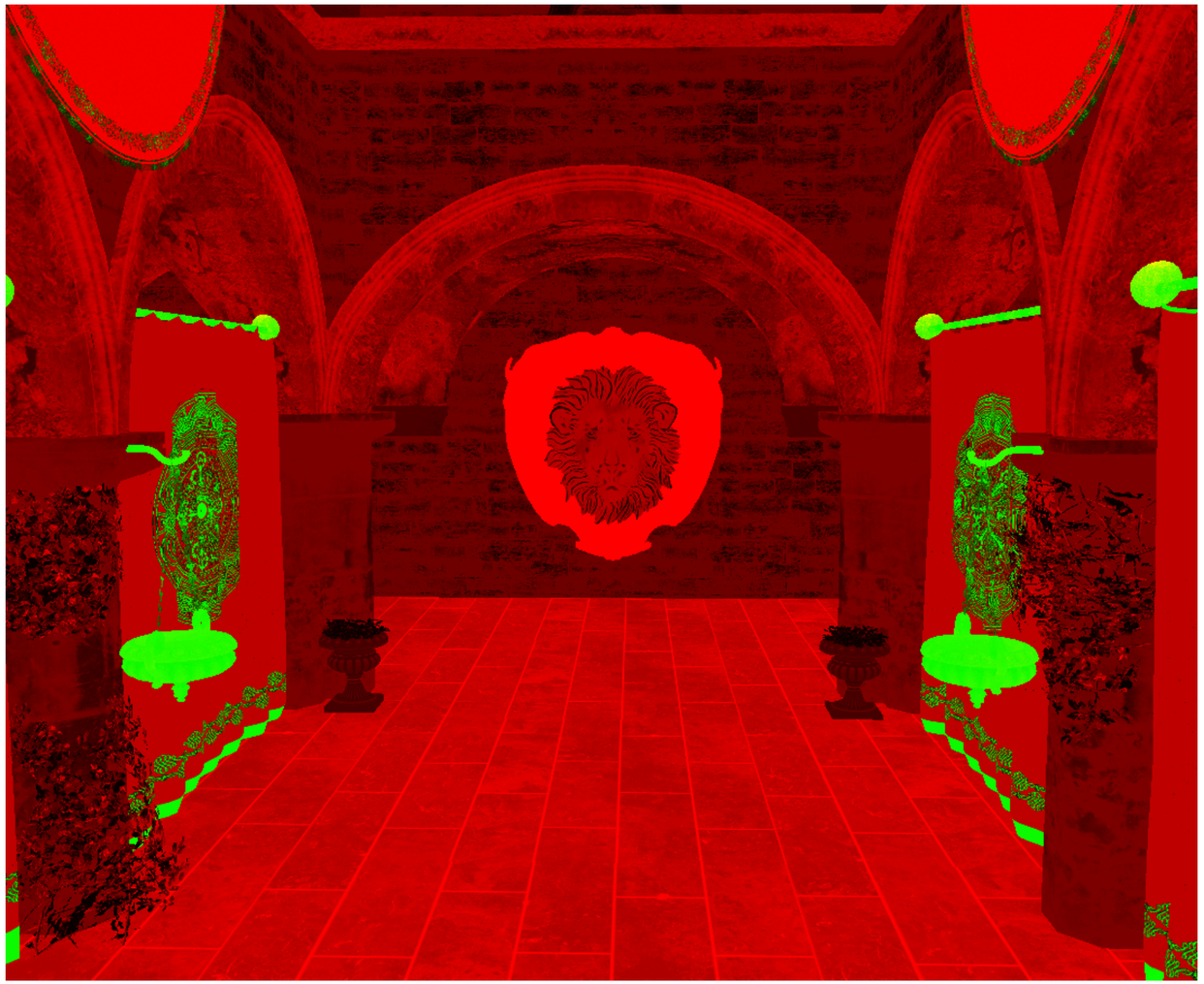
1. Three shader-readable G-buffer textures (*albedo, normal, roughness/metallic*)
2. Ready for deferred *Lighting Pass*

Geometry Pass - Albedo

Geometry Pass - Normals



Geometry Pass - R/M



Lighting Pass

Fragment Outputs & Encoding

- *Sample G-Buffer*:
  Albedo (RGBA8 SRGB)
  Normal (decoded from UNORM)
  Roughness/Metallic (RG8)
  Depth (D32_FLOAT) → reconstruct world position
- *Direct Lighting (PBR)*:
  Directional: shadow + Cook-Torrance BRDF
  Point: attenuation + Cook-Torrance BRDF
- *Indirect (IBL)*:
  Sample irradiance cubemap (diffuse) → ambient term

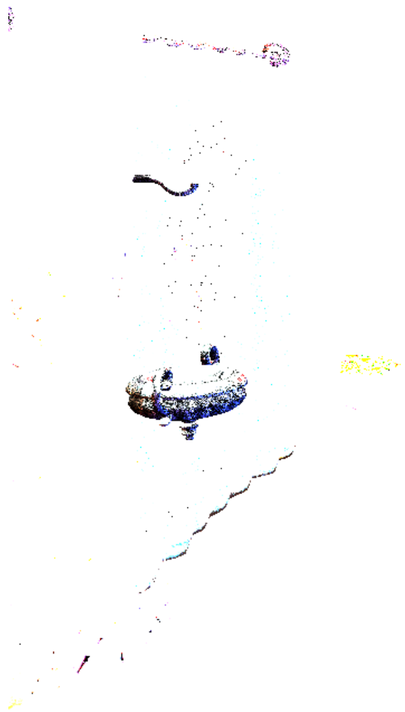
Begin Dynamic Rendering

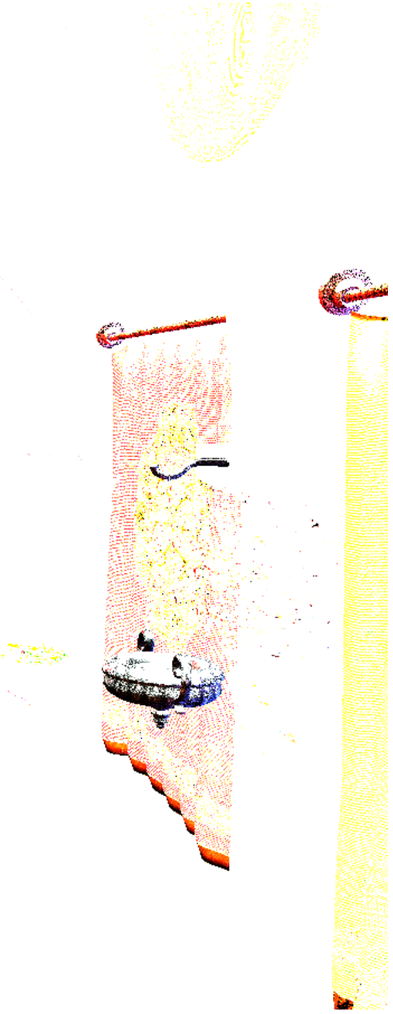
- Bind lighting pipeline & descriptor set (G-Buffer + depth + IBL + shadow map + light UBOs)
- *Full-screen triangle* draw (no vertex/index buffers)

Result

1. Combined PBR color → HDR target
2. Transition HDR: COLOR_ATTACHMENT_OPTIMAL → SHADER_READ_ONLY_OPTIMAL (for post)

Lighting Pass





Tone Mapping Pass

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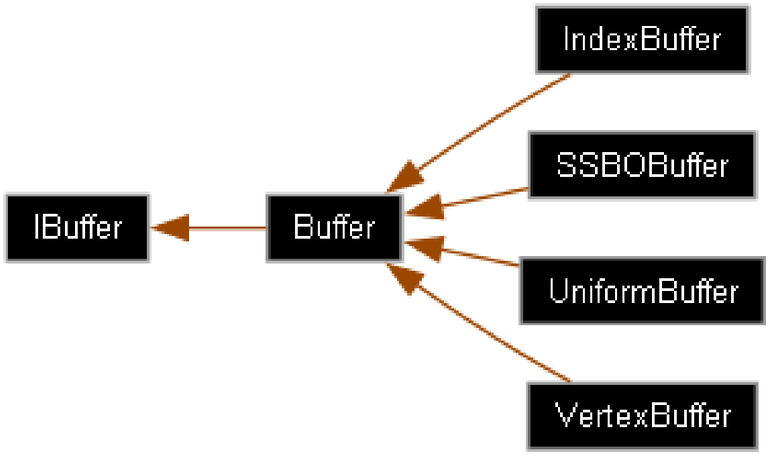
Buffers setup



BufferManager Class Reference

```
#include <buffer_manager.h>
```

Public Member Functions

	BufferManager (VkDevice device, VmaAllocator allocator, CommandManager *commandManager)
	BufferManager (const BufferManager &)=delete
BufferManager &	operator= (const BufferManager &)=delete
	BufferManager (BufferManager &&)=delete
BufferManager &	operator= (BufferManager &&)=delete
ManagedBuffer	createBuffer (VkDeviceSize size, VkBufferUsageFlags usage, VmaMemoryUsage memoryUsage)
void	copyBuffer (VkBuffer srcBuffer, VkBuffer dstBuffer, VkDeviceSize size) const
VmaAllocator	allocator () const

Code Architecture

Texture manager

TextureManager Class Reference

```
#include <texture_manager.h>
```

Public Member Functions

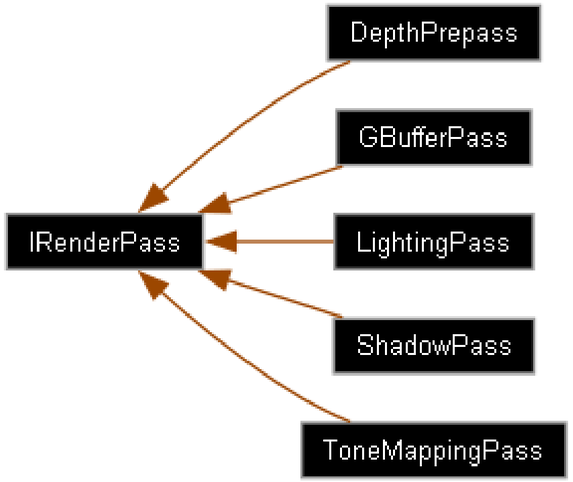
```
                                    TextureManager (VkDevice device, VmaAllocator allocator, CommandManager *commandManager, BufferManager *bufferManager, DebugMessenger
                                    *debugMessenger)
                                    TextureManager (const TextureManager &)=delete
                  TextureManager & operator= (const TextureManager &)=delete
                                    TextureManager (TextureManager &&)=delete
                  TextureManager & operator= (TextureManager &&)=delete
                  ManagedTexture & loadTexture (const std::string &filepath, VkFormat format=VK_FORMAT_R8G8B8A8_SRGB)
                  ManagedTexture & loadHDRTexture (const std::string &path)
                  ManagedTexture & createTexture (uint32_t width, uint32_t height, VkFormat format, VkImageUsageFlags usage, VmaMemoryUsage memoryUsage, VkImageAspectFlags
                                    aspect, bool createSampler=false)
                  ManagedTexture & createTexture (const unsigned char *data, uint32_t width, uint32_t height, uint32_t channels)
                  ManagedTexture & createCubeTexture (uint32_t size, VkFormat format, VkImageUsageFlags usage, VmaMemoryUsage memoryUsage)
                             void createImage (uint32_t width, uint32_t height, VkFormat format, VkImageTiling tiling, VkImageUsageFlags usage, VmaMemoryUsage memoryUsage,
                                    VkImage &image, VmaAllocation &allocation, uint32_t layers, VkImageCreateFlags flags) const
const std::vector< ManagedTexture > & getTextures () const
```

Static Public Member Functions

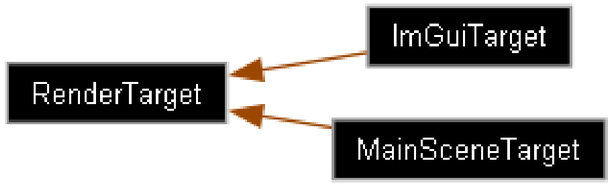
```
static void transitionSwapChainLayout (VkCommandBuffer cmd, VkImage image, VkImageLayout oldLayout, VkImageLayout newLayout, VkPipelineStageFlags2 srcStageMask,
            VkPipelineStageFlags2 dstStageMask, VkAccessFlags2 srcAccessMask, VkAccessFlags2 dstAccessMask)
 static int getSamplerIndex ()
static void incrementSamplerIndex ()
```

Code Architecture

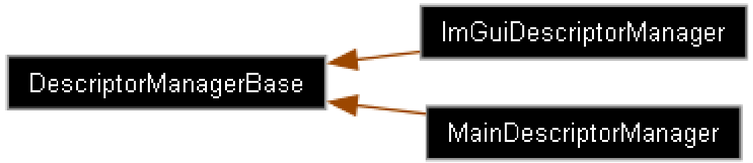
Rendering



Render passes



Render targets



Descriptor manager

Feature showcase

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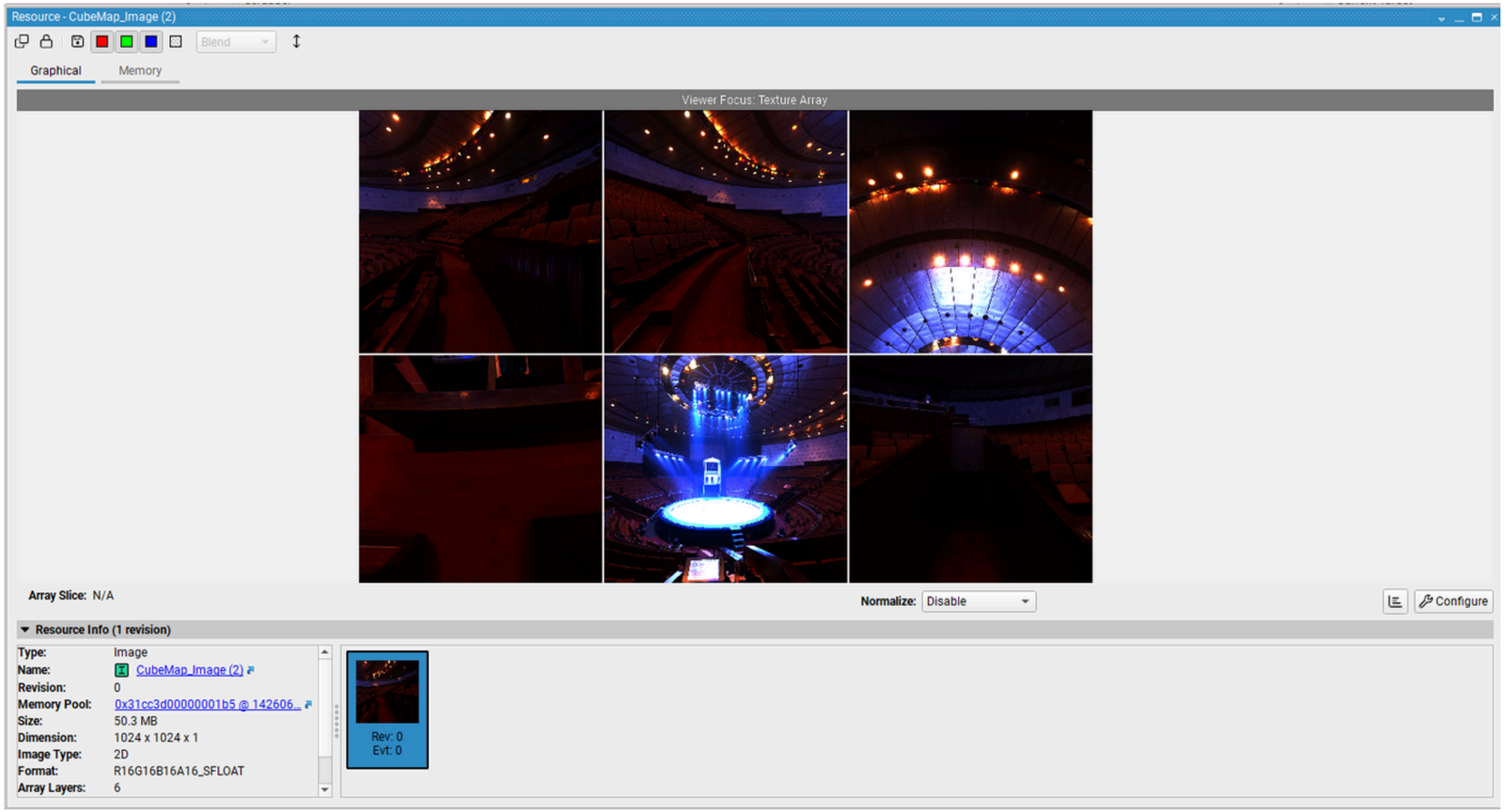
Environment cube map

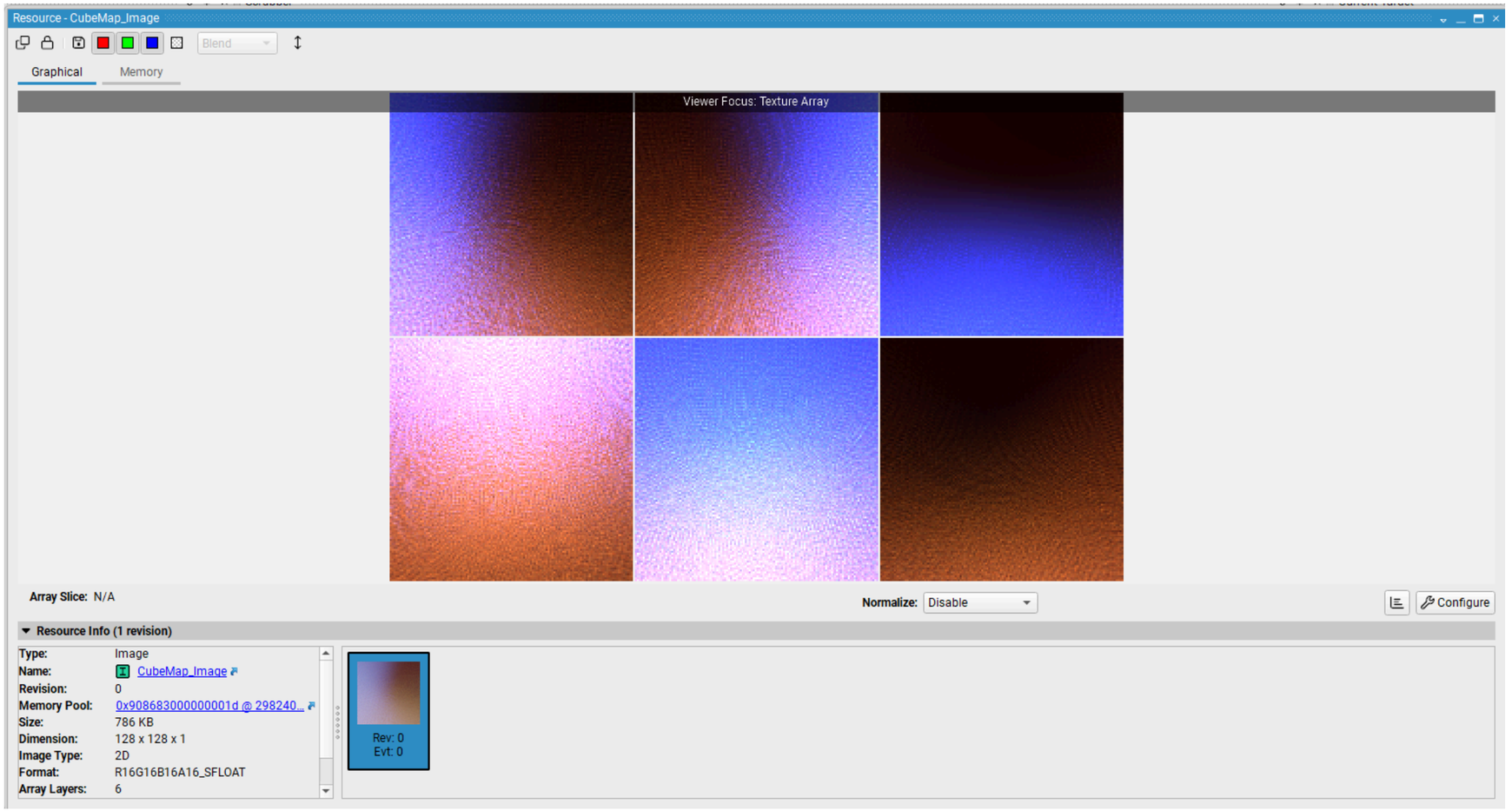


Feature showcase

Skybox

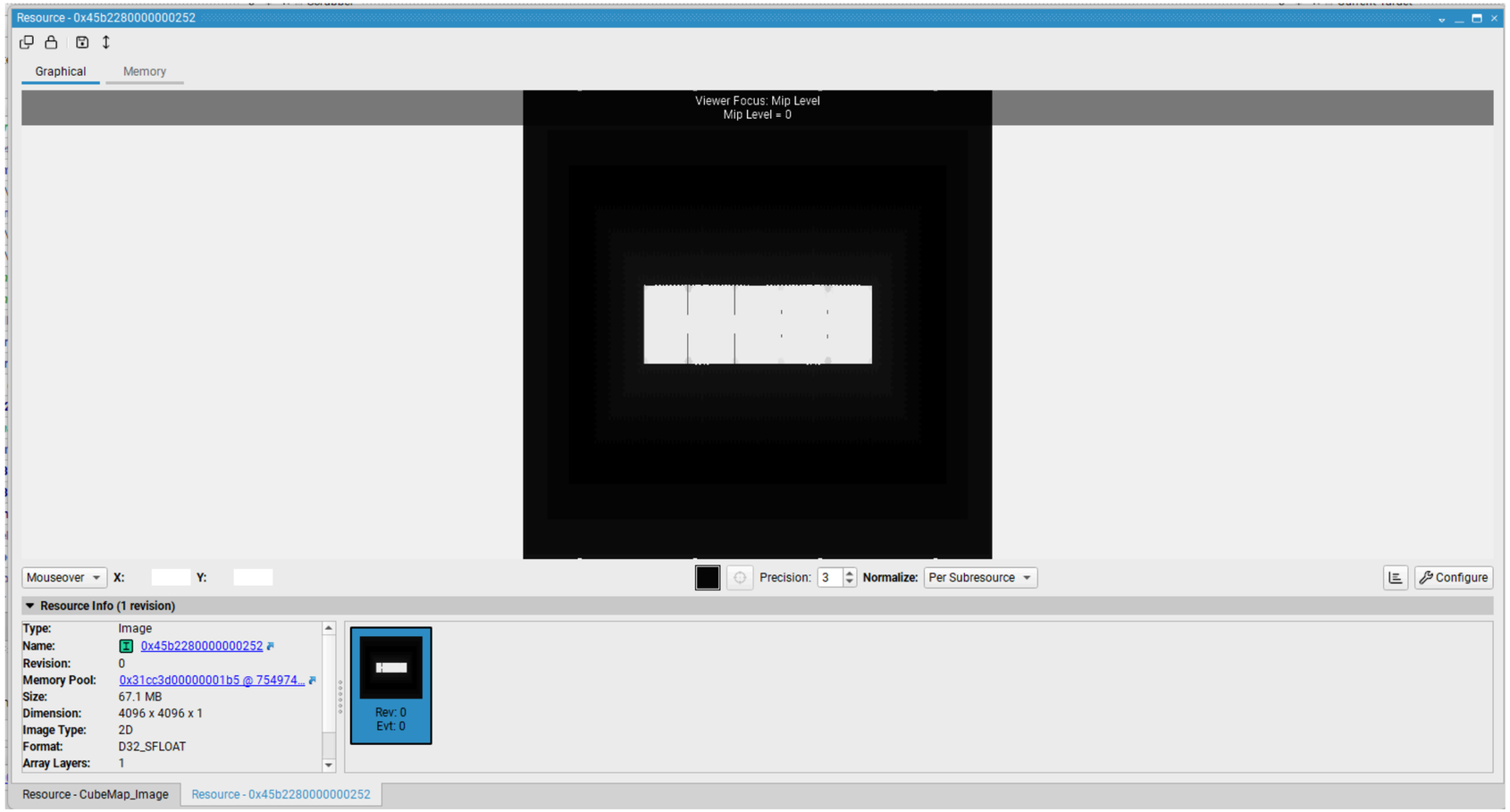
Feature showcase

Diffuse irradiance



Feature showcase

Shadows



Memory Usage

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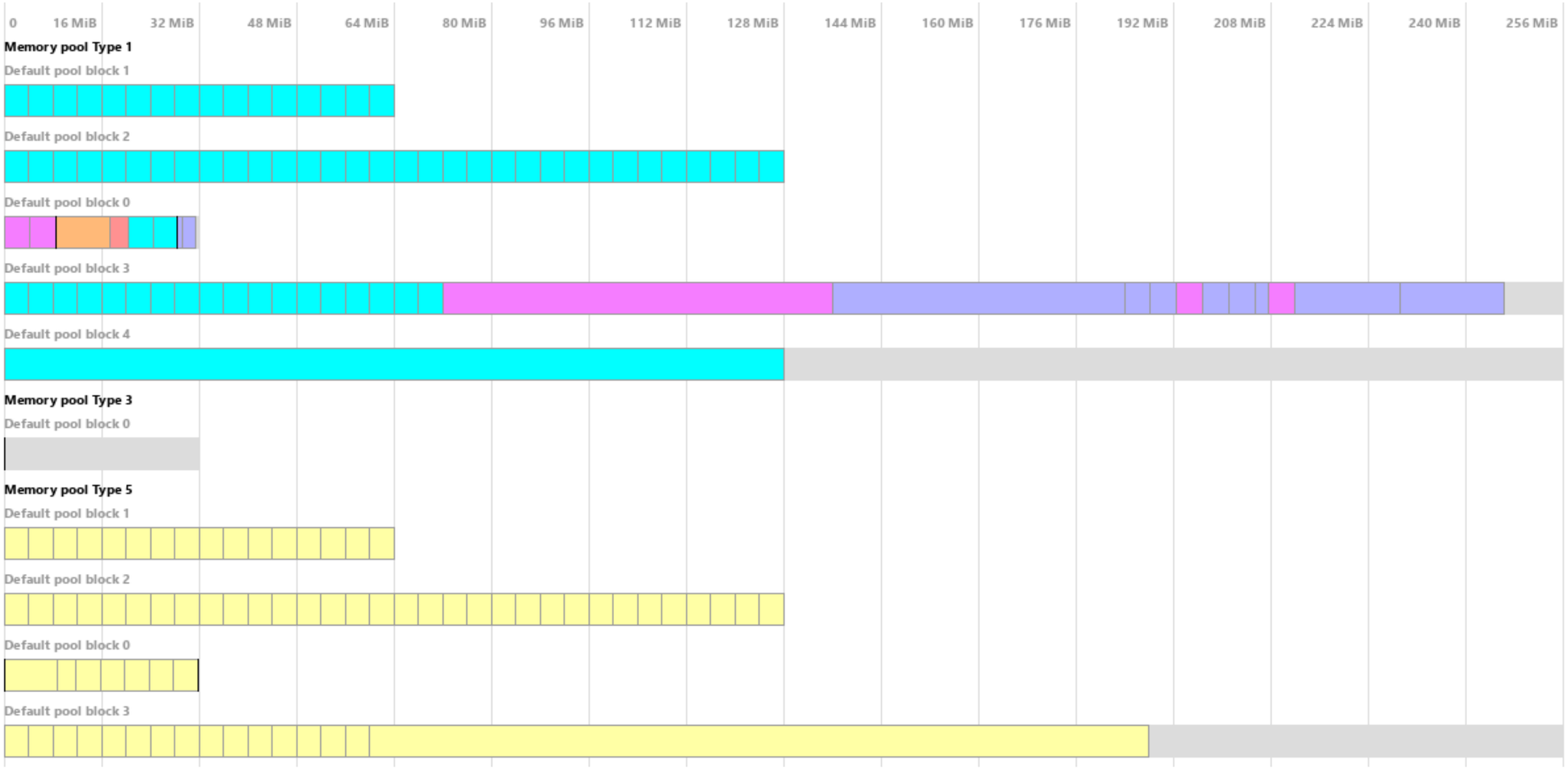

Graphics Debug Capture

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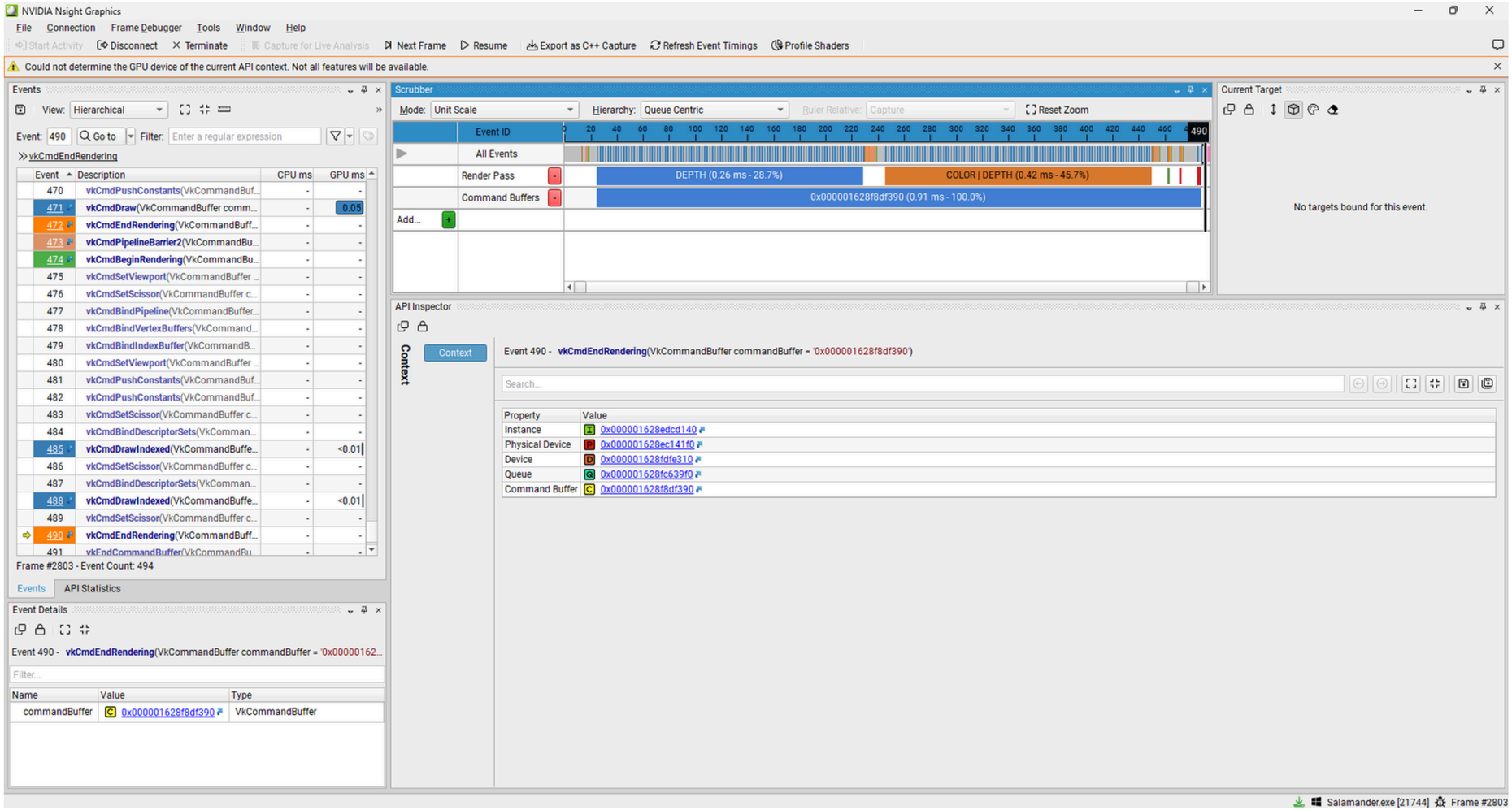

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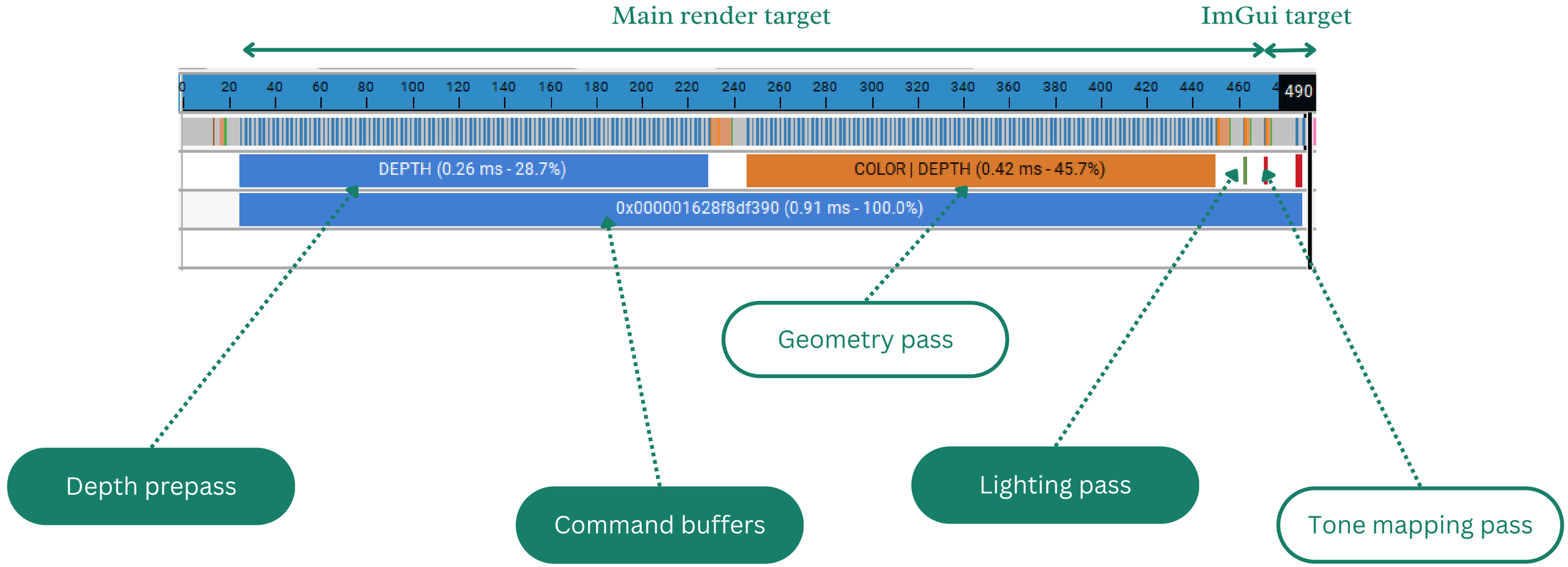
Graphics Debug Capture

Closer view



Performance Statistics

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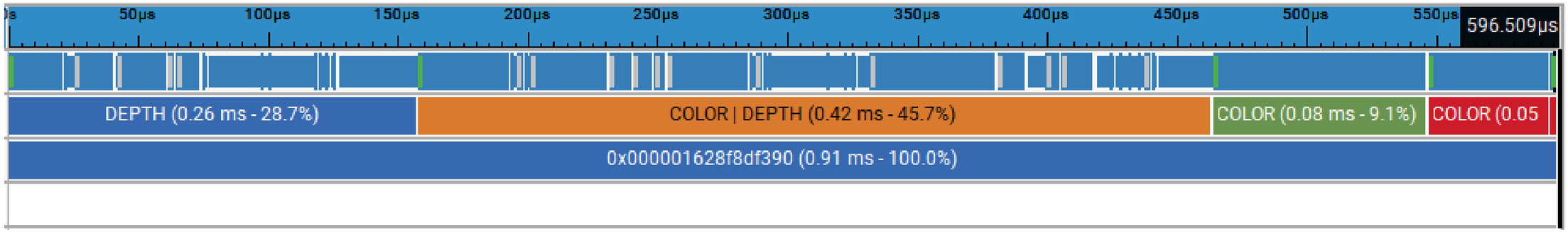


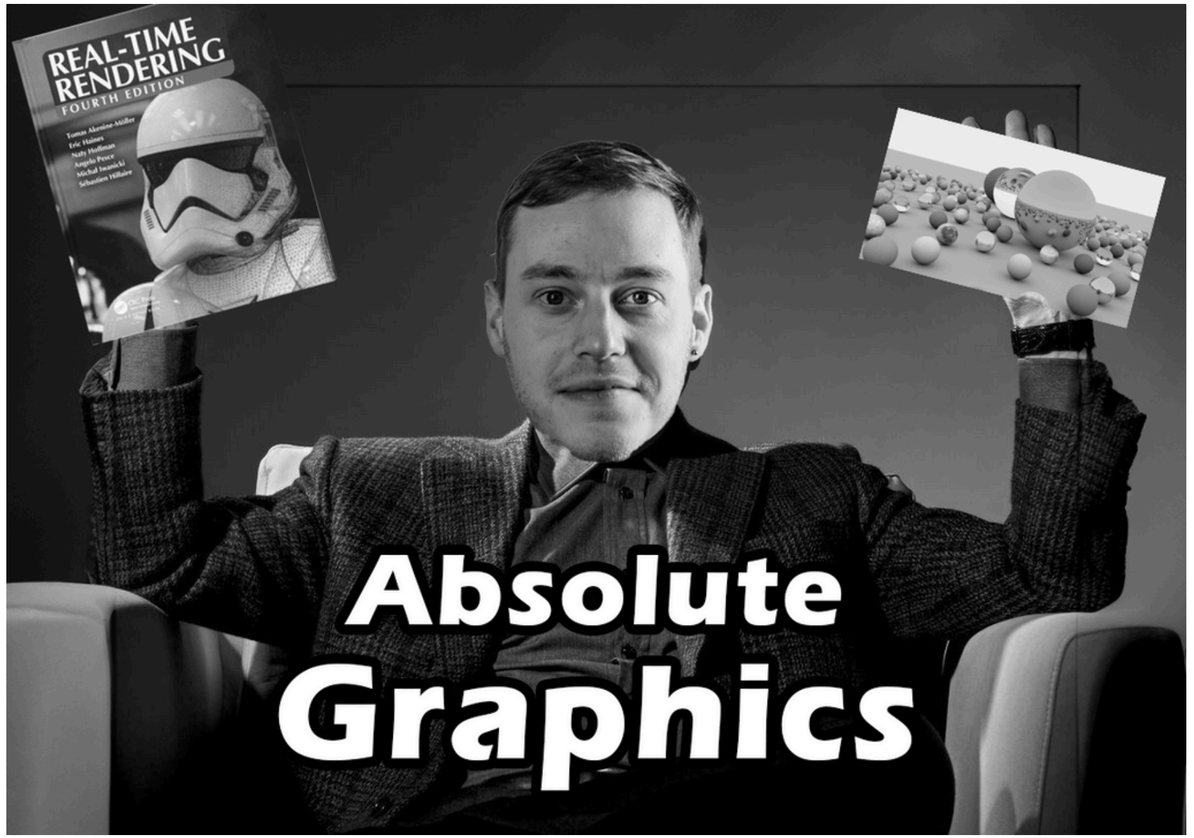
Small "proud of" moment

```
struct DescriptorUpdateInfo {
    uint32_t binding;
    VkDescriptorType type;
    union {
        VkDescriptorBufferInfo* bufferInfo;
        VkDescriptorImageInfo* imageInfo;
    };
    uint32_t descriptorCount;
    bool isImage;
};
```



```
std::vector<MainDescriptorManager::DescriptorUpdateInfo> updates = {
    {
        .binding = 0,
        .type = VK_DESCRIPTOR_TYPE_UNIFORM_BUFFER,
        .bufferInfo = &m_globalData->frameData[i].bufferInfo,
        .descriptorCount = 1,
        .isImage = false
    },
    {
        .binding = 1,
        .type = VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER,
        .imageInfo = &albedoInfo,
        .descriptorCount = 1,
        .isImage = true
    },
    {
        .binding = 2,
        .type = VK_DESCRIPTOR_TYPE_COMBINED_IMAGE_SAMPLER,
        .imageInfo = &normalInfo,
        .descriptorCount = 1,
        .isImage = true
    },
```

Thank you for an amazing course!



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