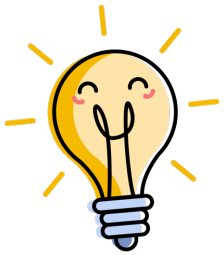
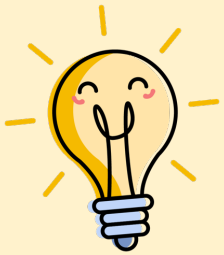


LumiBench

a benchmark suite for hardware ray tracing

IISWC 2023

Lufei Liu, Mohammadreza Saed, Yuan Hsi Chou, Davit Grigoryan, Tyler Nowicki, and Tor M. Aamodt



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Ray Tracing

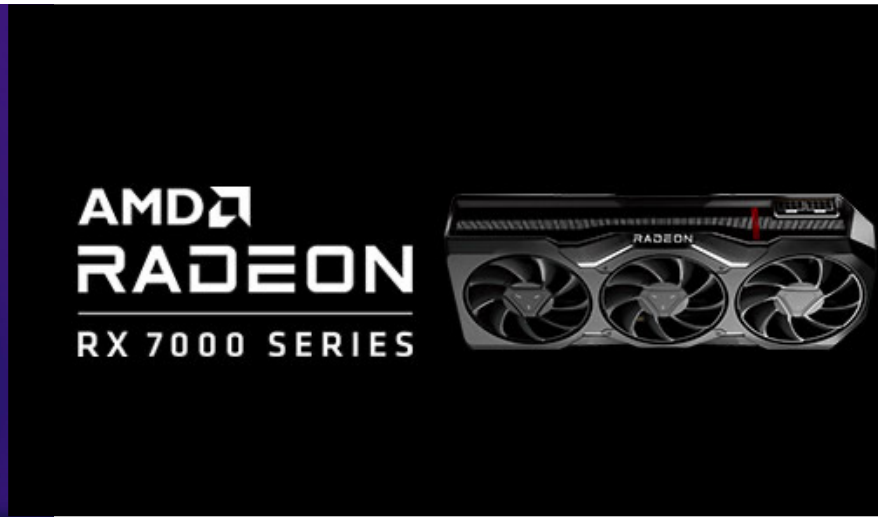
physically-based photo-realistic computer renderings

[EA] https://www.ea.com/seed/news/seed-project-picapica

Ray Tracing Hardware

[NVIDIA] https://www.nvidia.com/en-gb/geforce/rtx/

[Intel] https://www.intel.ca/content/www/ca/en/products/details/discrete-gpus/arc.html

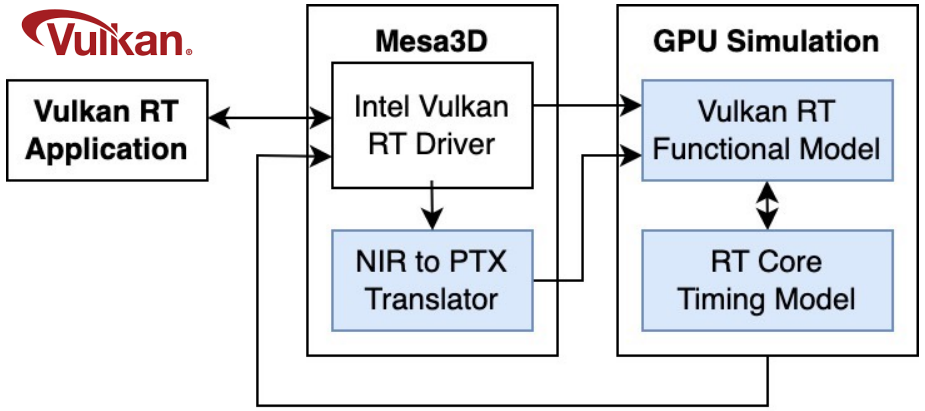


[AMD] https://www.amd.com/en/graphics/radeon-rx-graphics

further improvements are still necessary

Vulkan-Sim

[MICRO 2022] Saed et al. "Vulkan-Sim: A GPU Architecture Simulator for Ray Tracing"



- extends GPGPU-Sim cycle-level architectural simulator
- models hardware ray tracing accelerator
- supports Vulkan API ray tracing applications

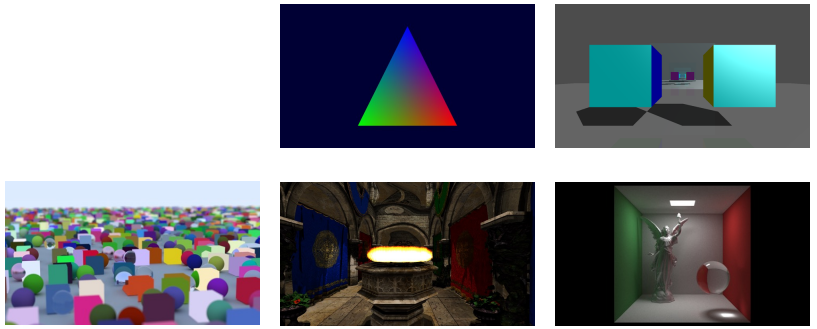
***LumiBench** is designed to execute with Vulkan-Sim*

Ray Tracing Benchmarks

← realistic workloads **detailed evaluations →**

Real RTX Game

Vulkan-Sim Scenes



← realistic workloads

detailed evaluations →

LumiBench

Many scene options
Millions of triangles
Complex lighting effects
Lacks detailed profiling

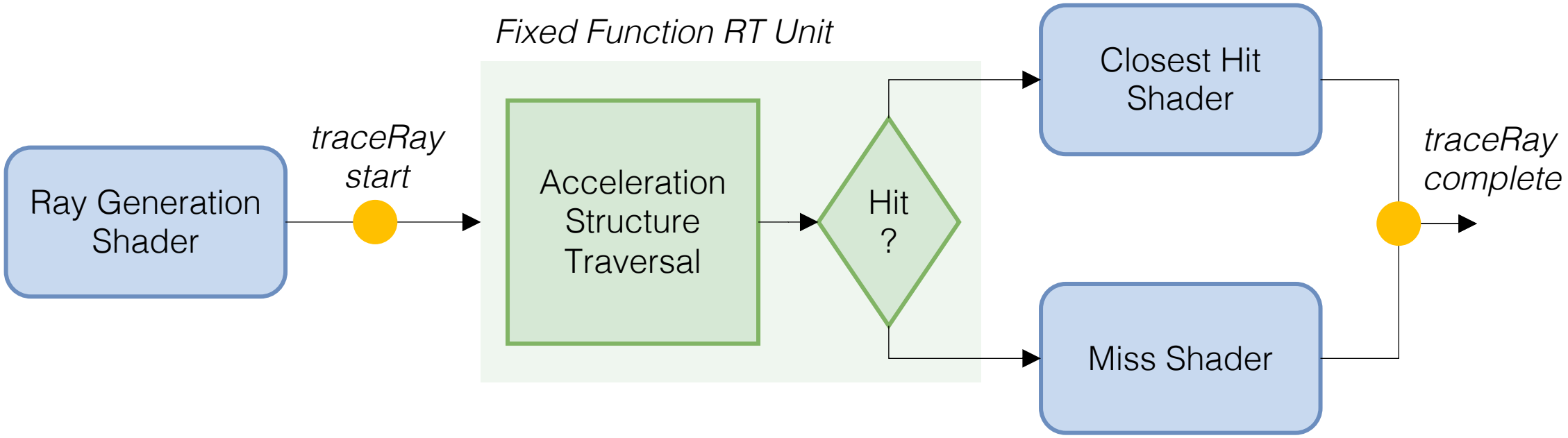
Only 5 scenes available
Low triangle count
Limited ray behavior
Cycle-level simulation

Outline

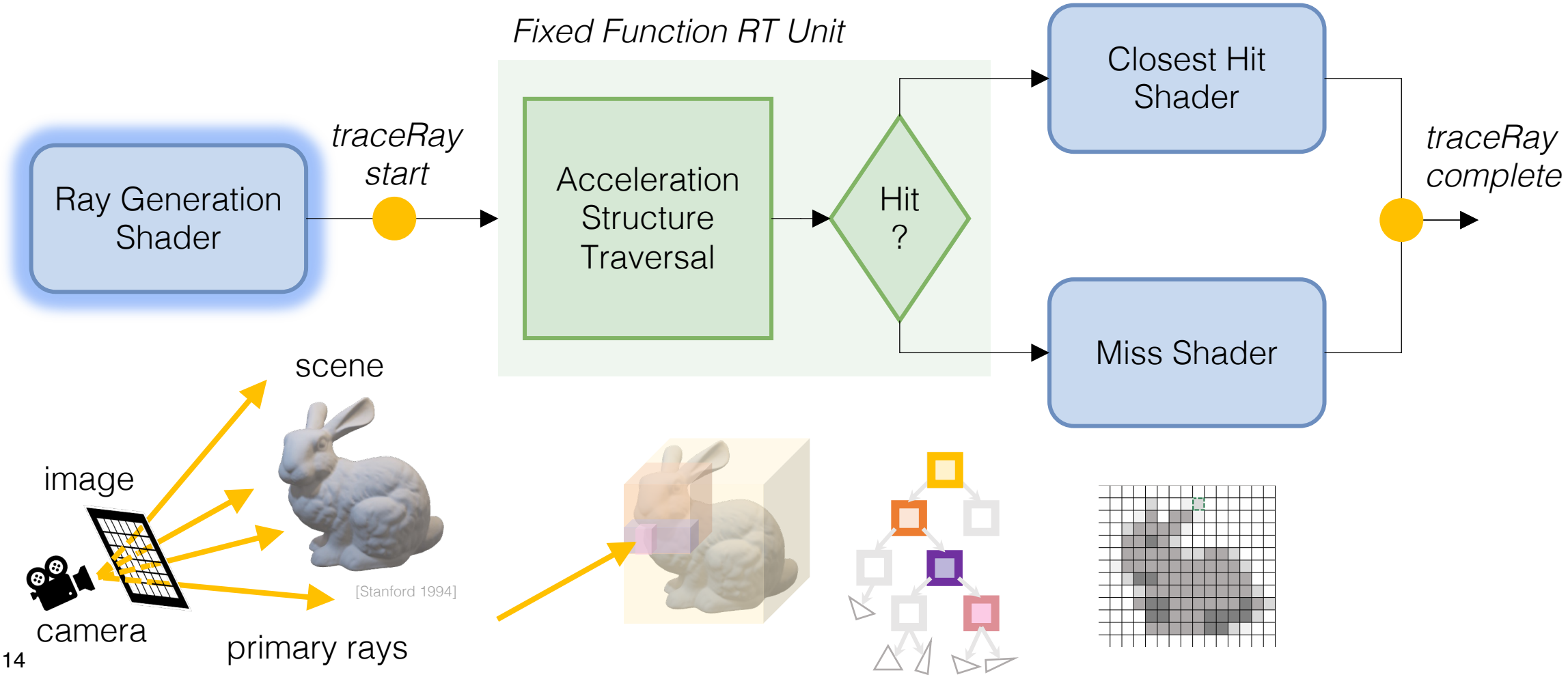
1. Background and motivation
2. Benchmark design
3. Diversity analysis
4. Characterization results
5. Conclusion

Benchmark Design

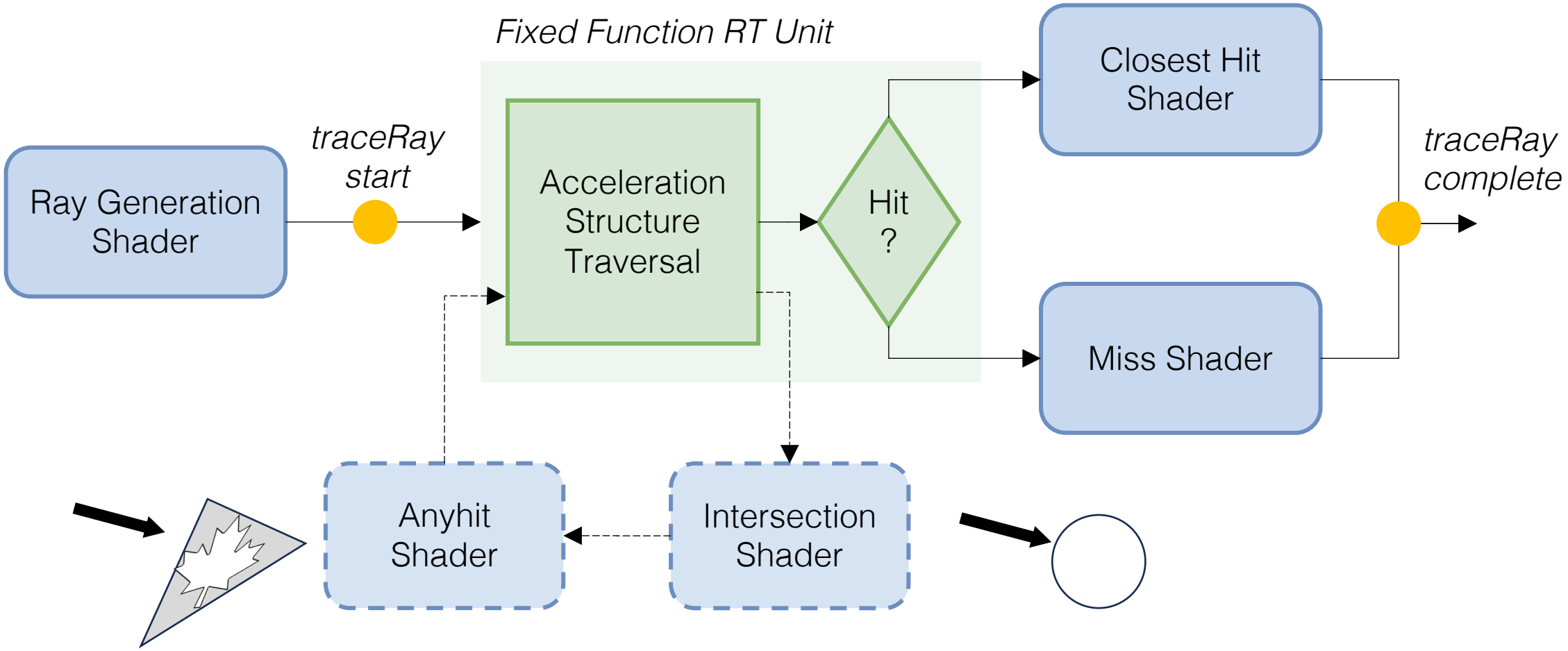
The Ray Tracing Pipeline



The Ray Tracing Pipeline



The Ray Tracing Pipeline



LumiBench Goals

Non-proprietary models

- avoid 3D models with artistic IPs
- choose from public repositories:
  - Computer Graphics Archive
  - Blender Demo
  - …

Fast simulation time

- simulates in hours to days
- simple shaders and materials
- lower resolution images

Coverage of different scenarios

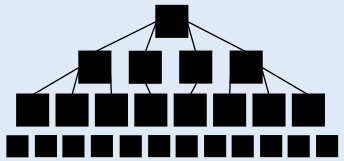
- scenes with stress cases
- common ray behavior
- use of optional shaders

More analysis in paper!

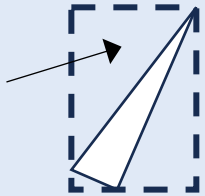
Benchmark Design

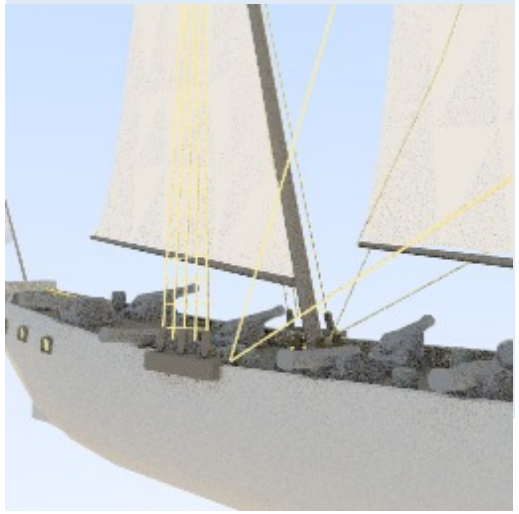
Stress Cases

Large Working Set

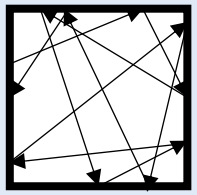


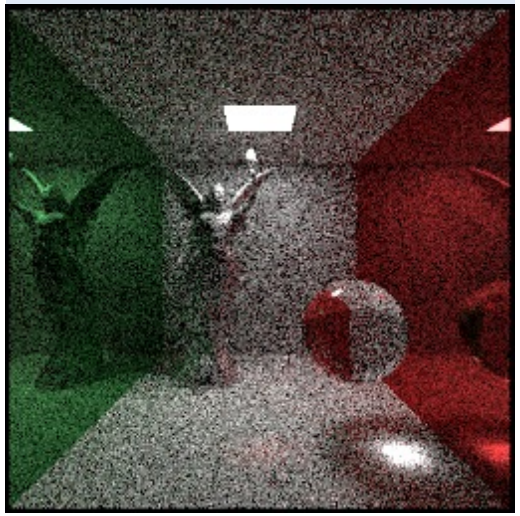
Long and Thin



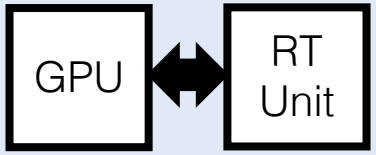


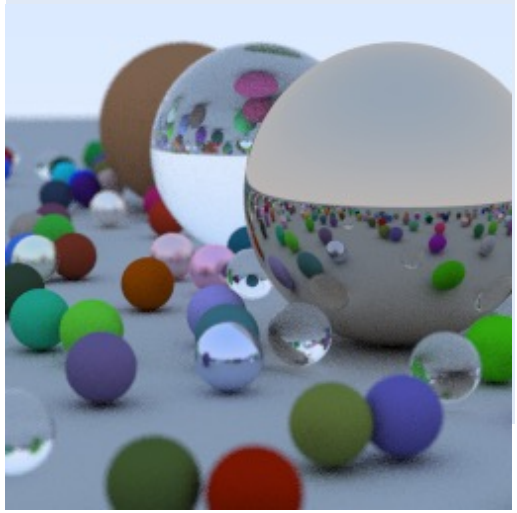
Indoor and Enclosed





Optional Shaders

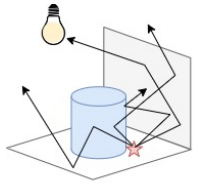




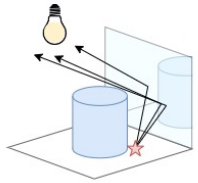
Benchmark Design

Ray Generation

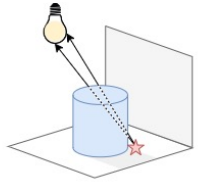
Scenes with stress cases | **Common ray behavior** | Use of optional shaders



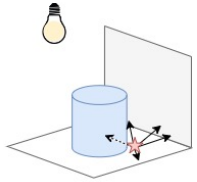
Full path tracing



Mirror-like reflections



Direct lighting shadows



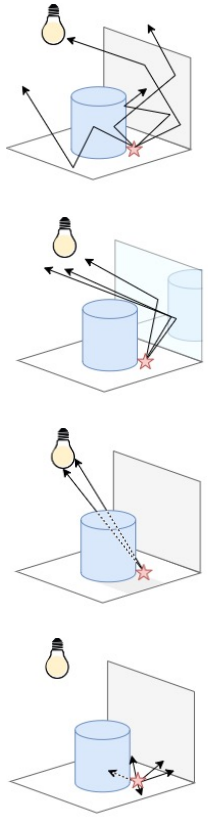
Ambient occlusion

Benchmark Design

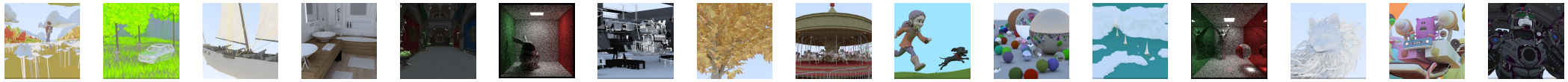
The Full Benchmark

Scenes with stress cases | **Common ray behavior** | Use of optional shaders

rays



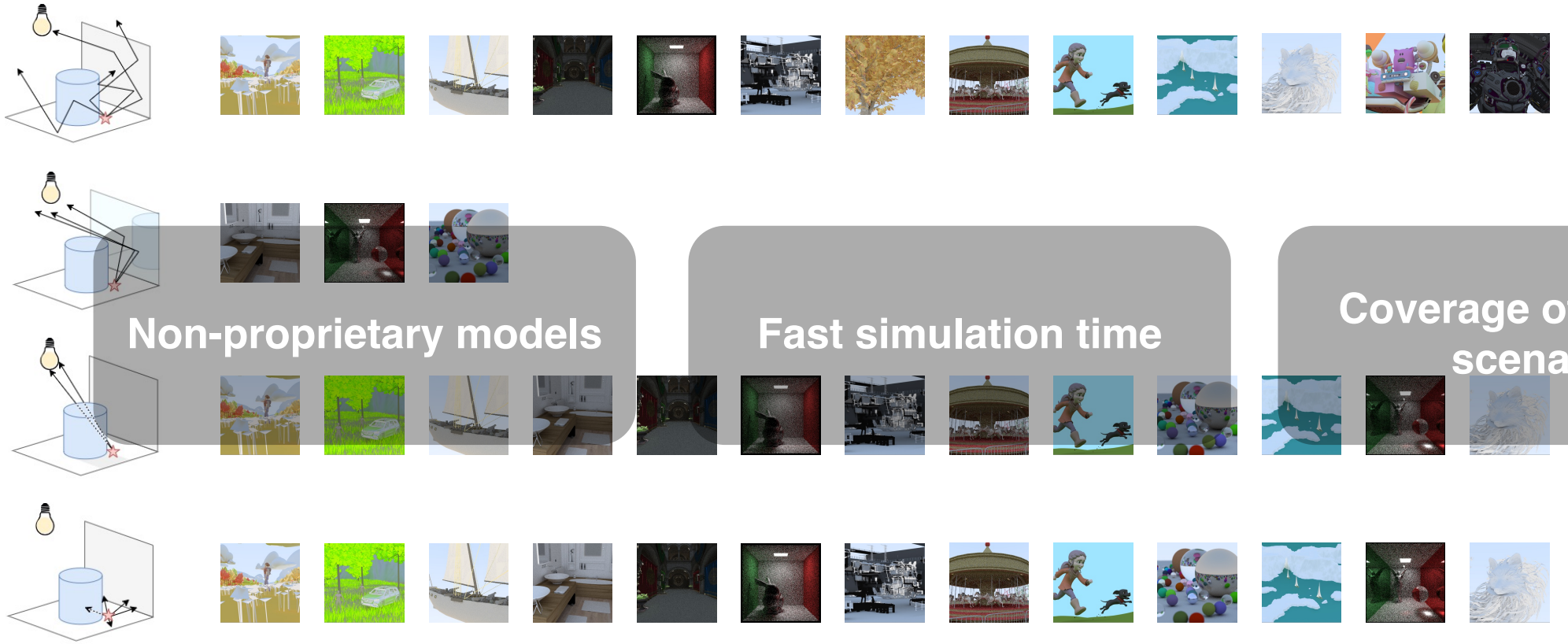
scenes



The Full Benchmark

Scenes with stress cases | Common ray behavior | **Use of optional shaders**

The Full Benchmark



Non-proprietary models

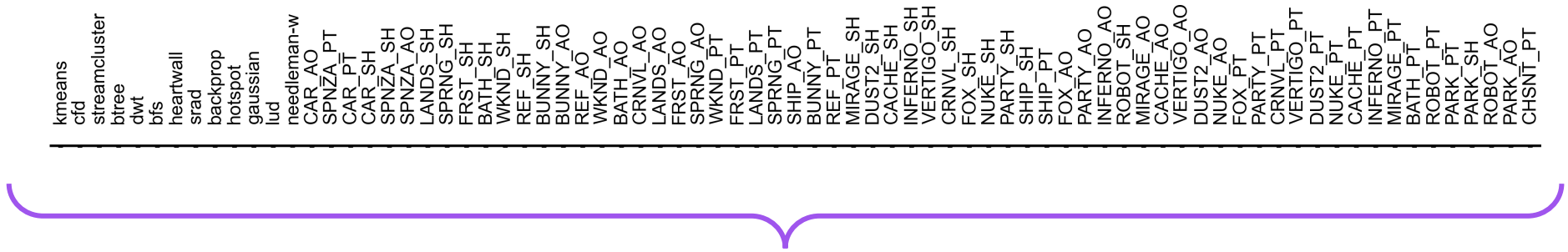
Fast simulation time

Coverage of different scenarios

Diversity Analysis

Measuring Similarity

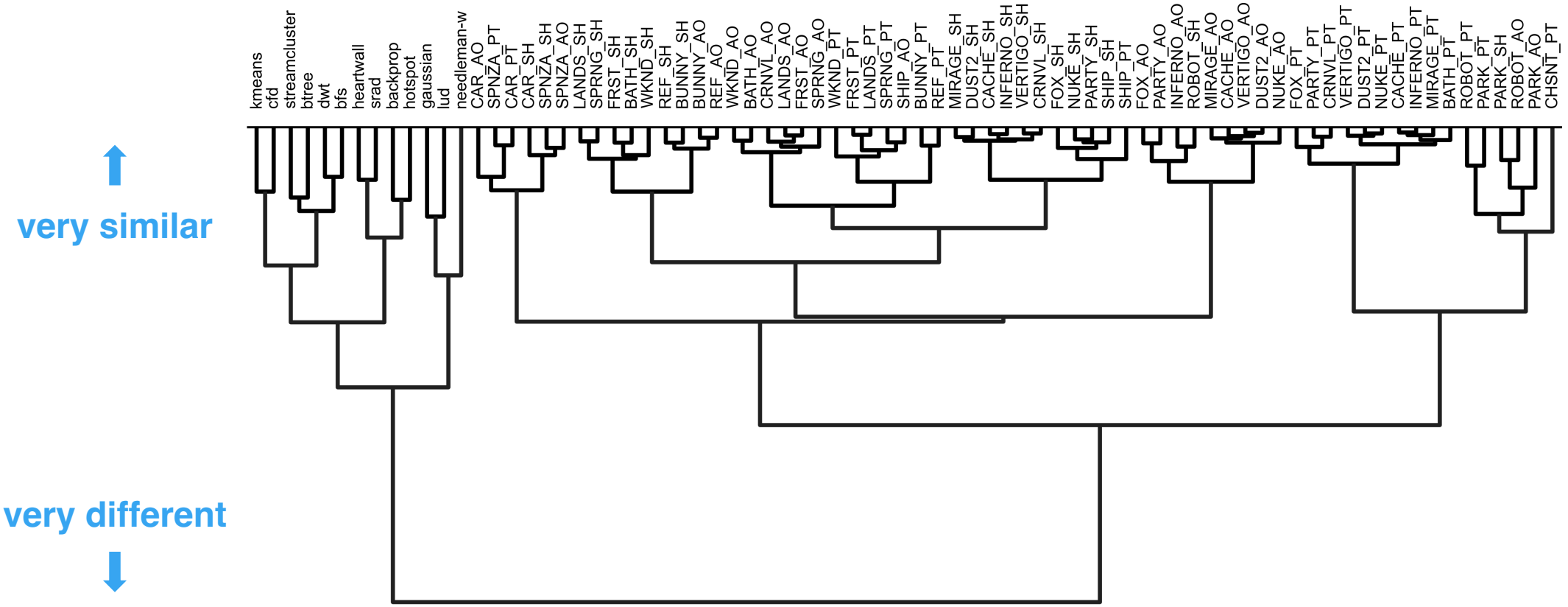
Apply Principal Component Analysis using a comprehensive set of metrics collected from Vulkan-Sim



- Rodinia workloads
- CS:GO game scenes
- LumiBench workloads

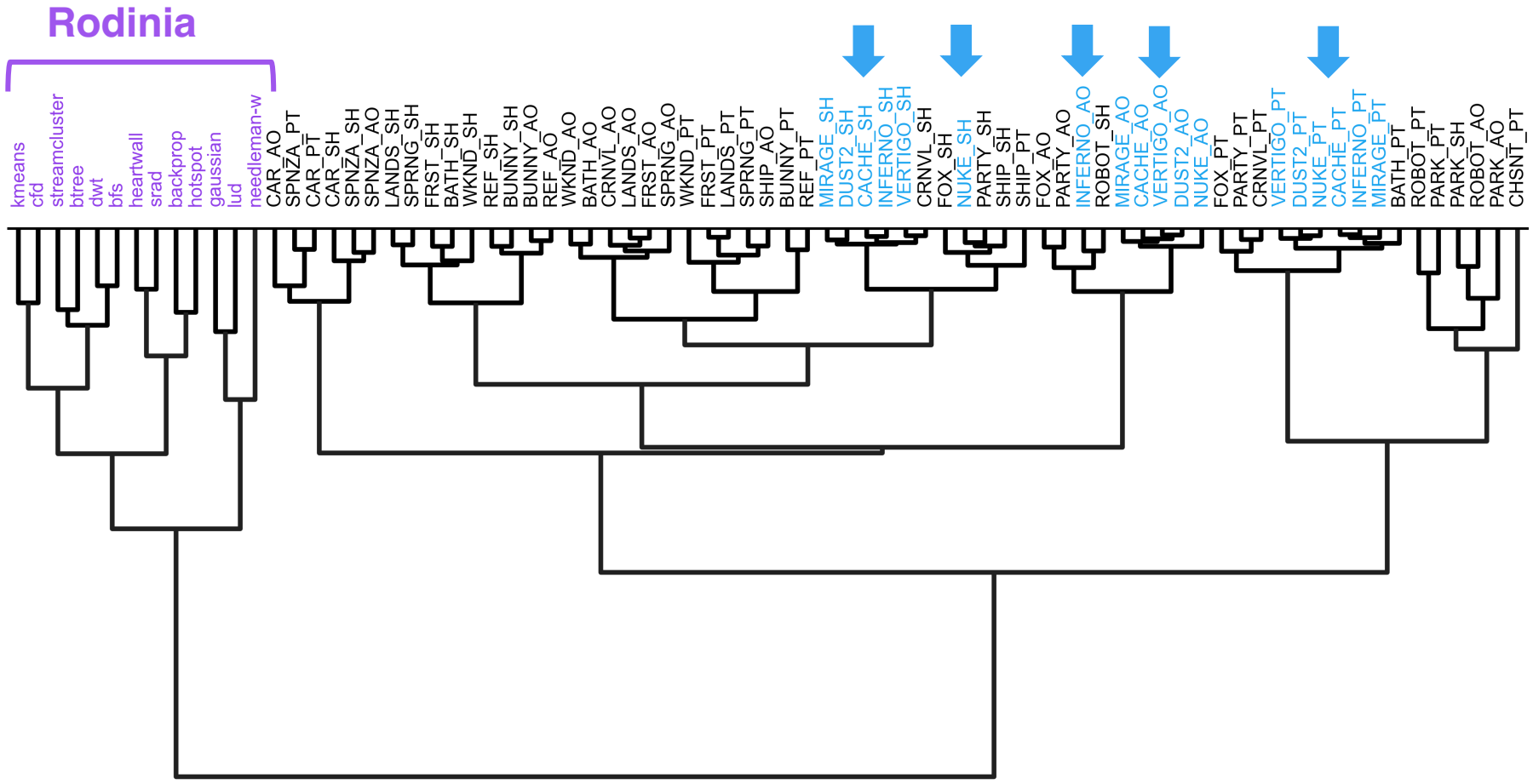
Measuring Similarity

Apply Principal Component Analysis using a comprehensive set of metrics collected from Vulkan-Sim



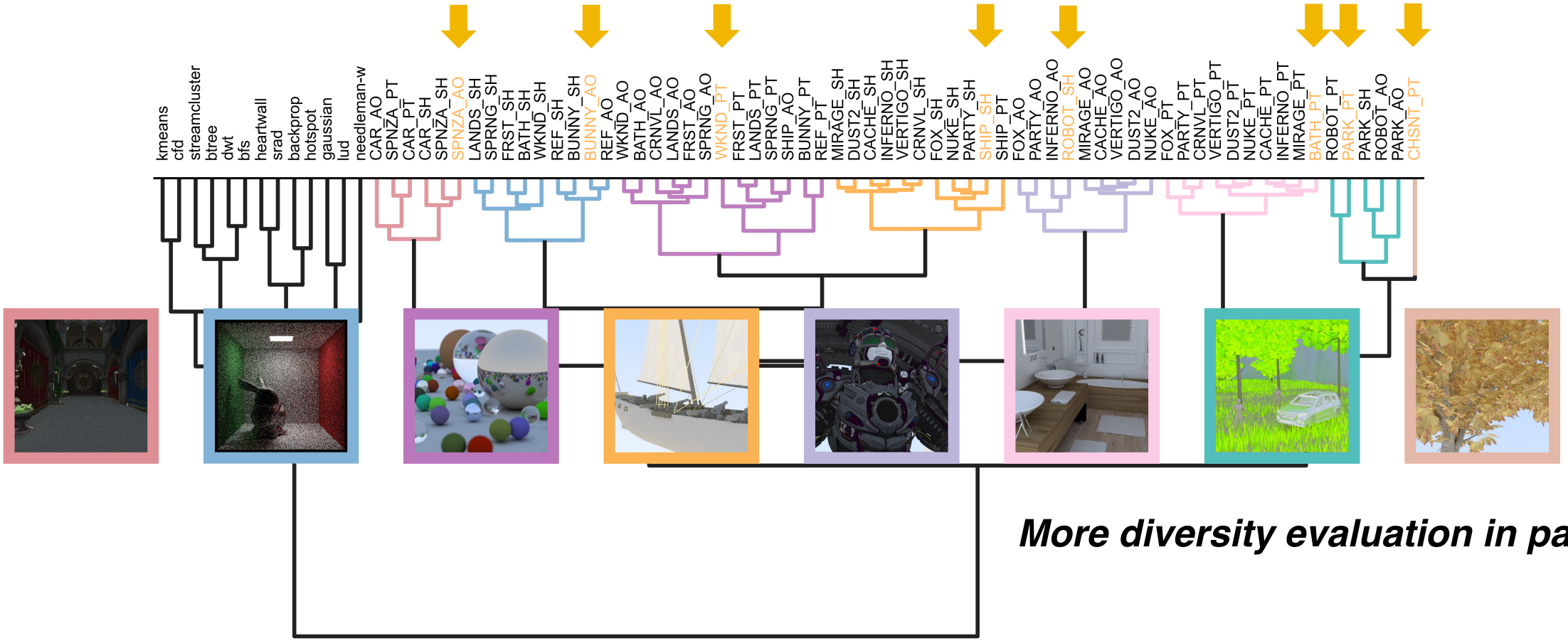
Similarity to Real Games

CS:GO *https://store.steampowered.com/app/730/CounterStrike_Global_Offensive/*



Representative Subset

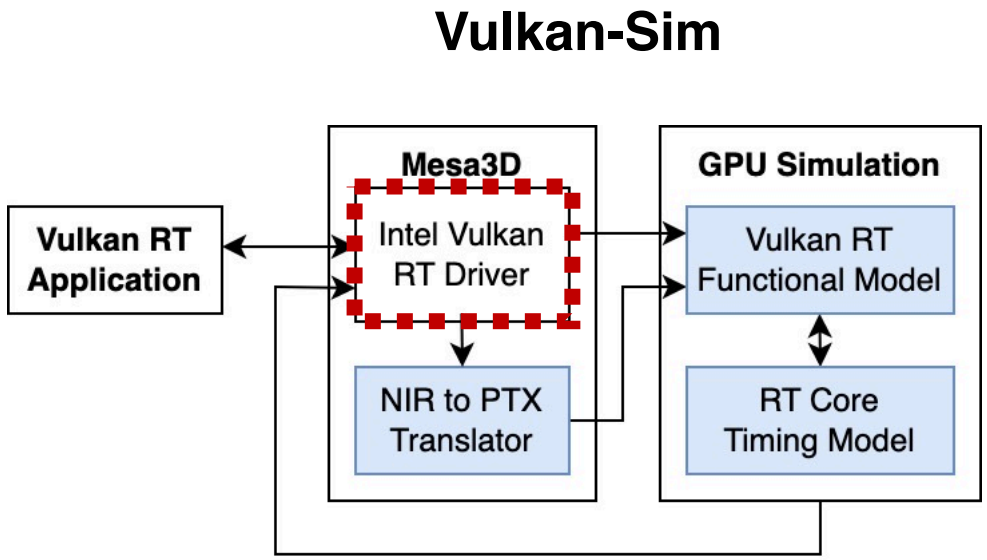
LumiBench Subset



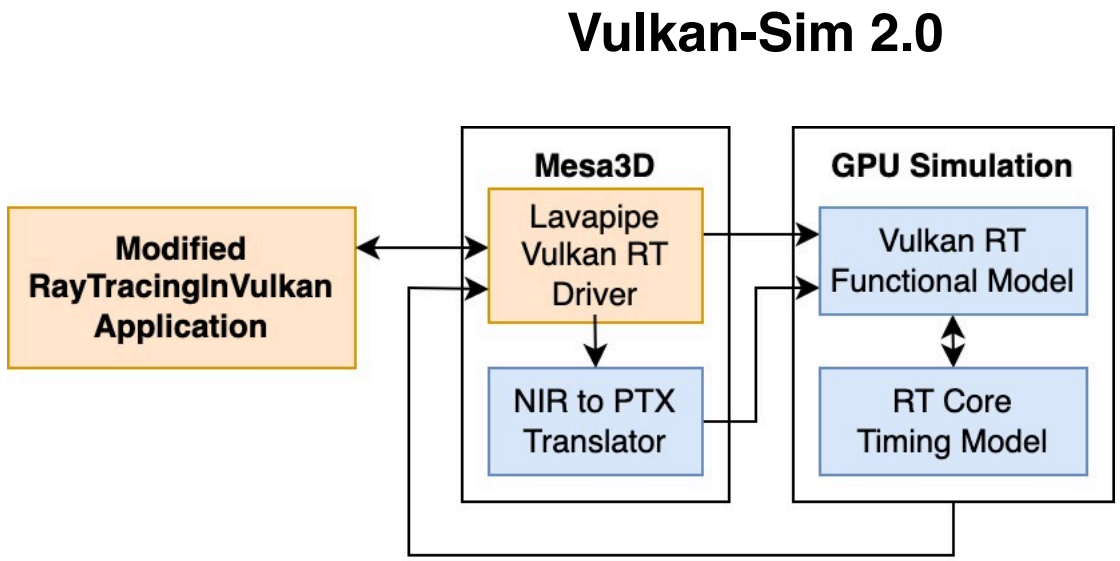
More diversity evaluation in paper!

Characterization Results

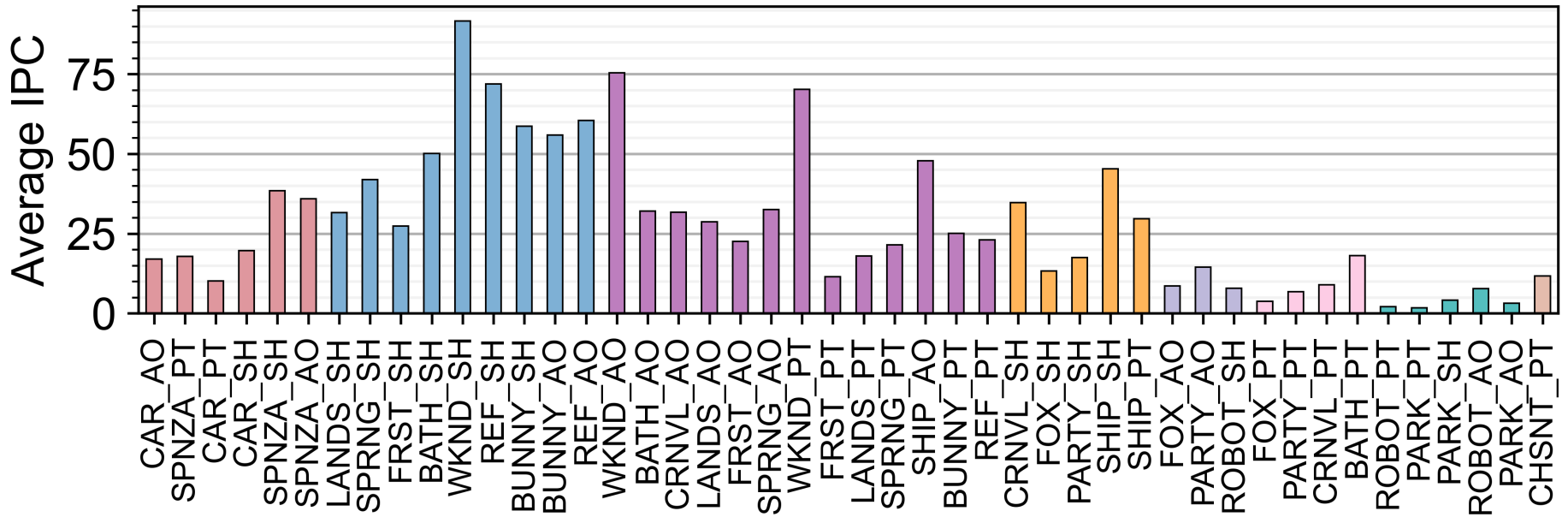
Methodology



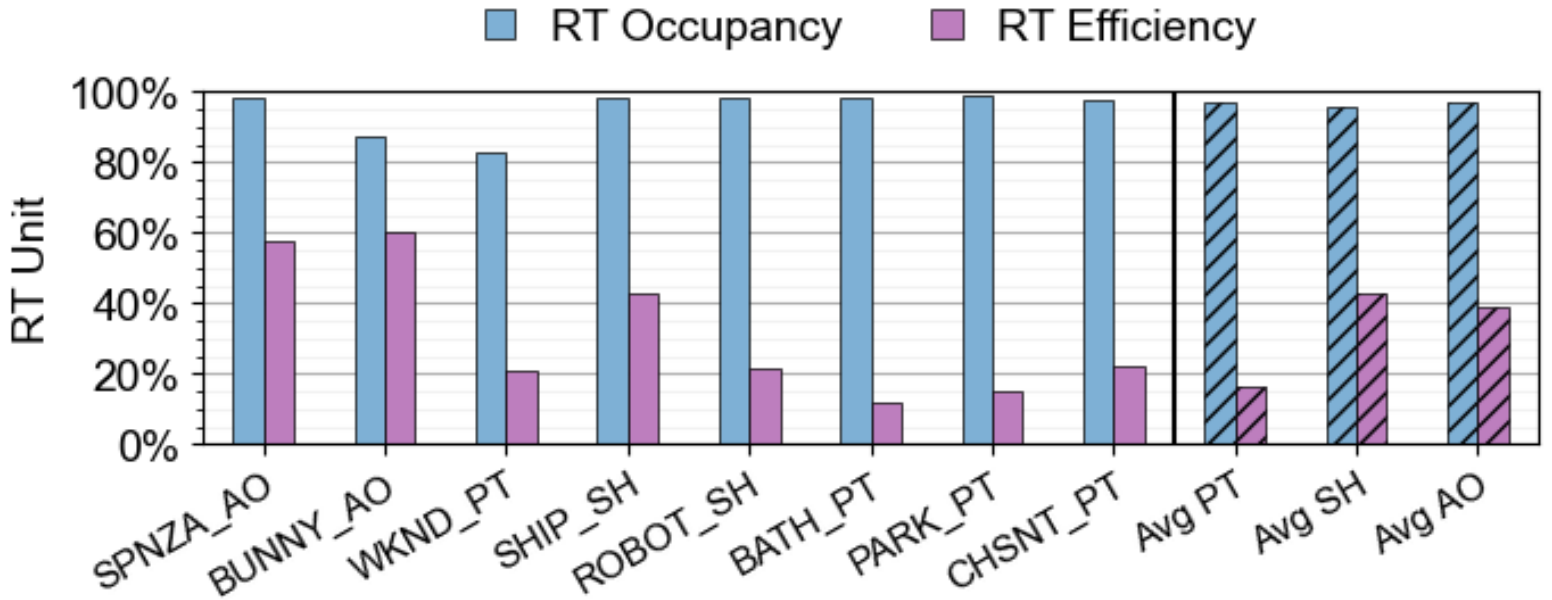
Methodology



Performance



RT Unit Efficiency



RT Occupancy: average number of active warps in the RT unit

RT Efficiency: average number of active rays per warp in the RT unit

More characterization in paper!

Conclusion

LumiBench is:

- *the first benchmark suite for evaluating ray tracing hardware using a microarchitecture simulator*
- *composed of a diverse set of scenes, shaders, and ray types*
- *different from existing general purpose GPU benchmarks*
- *useful for identifying insights for architectural research*

Thank you!

LumiBench

https://github.com/ubc-aamodt-group/vulkan-sim