Real-Time Ray Casting for Virtual Reality

Warren Hunt

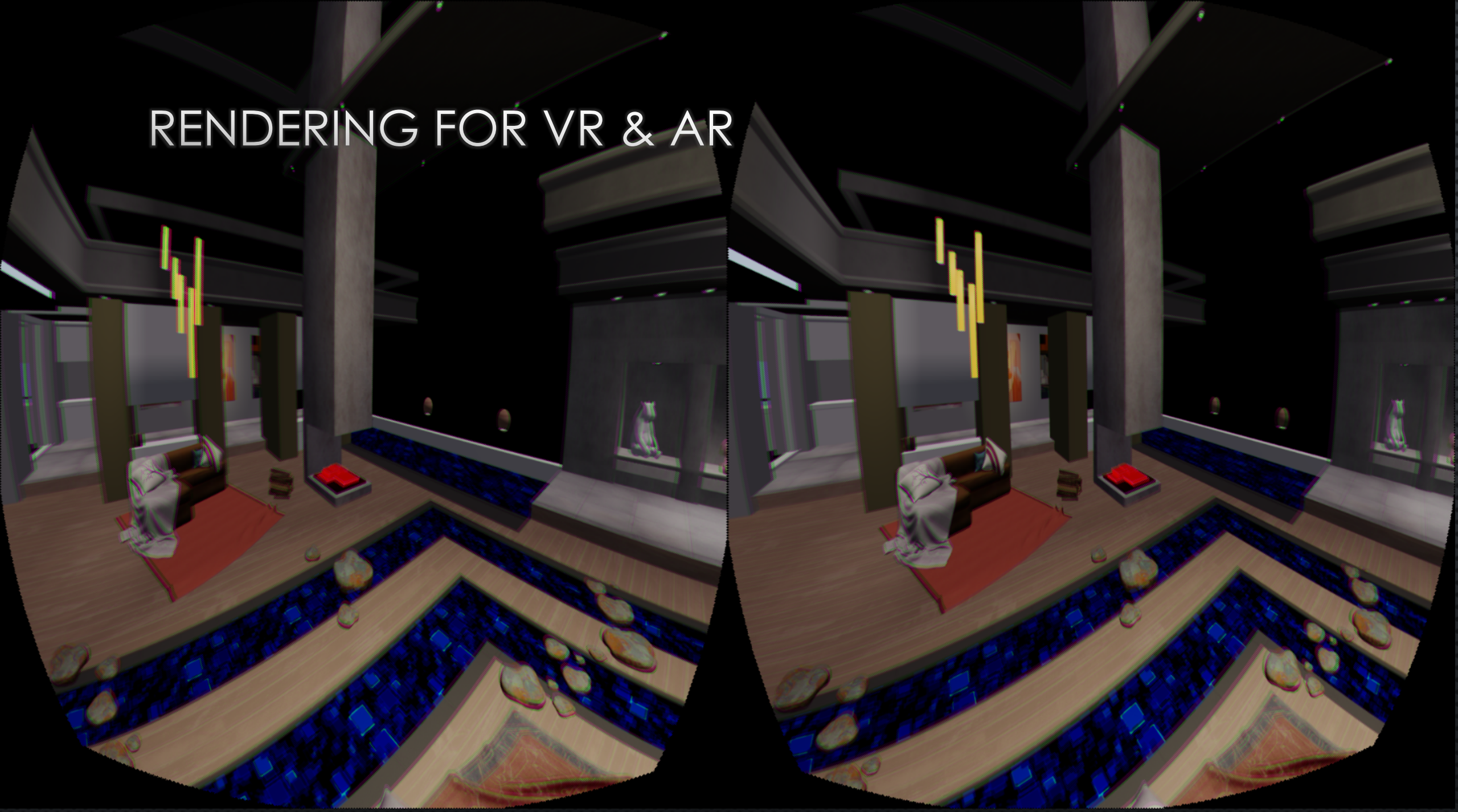
Oculus Research

Ray casting is a viable alternative to rasterization for VR/AR

This Talk

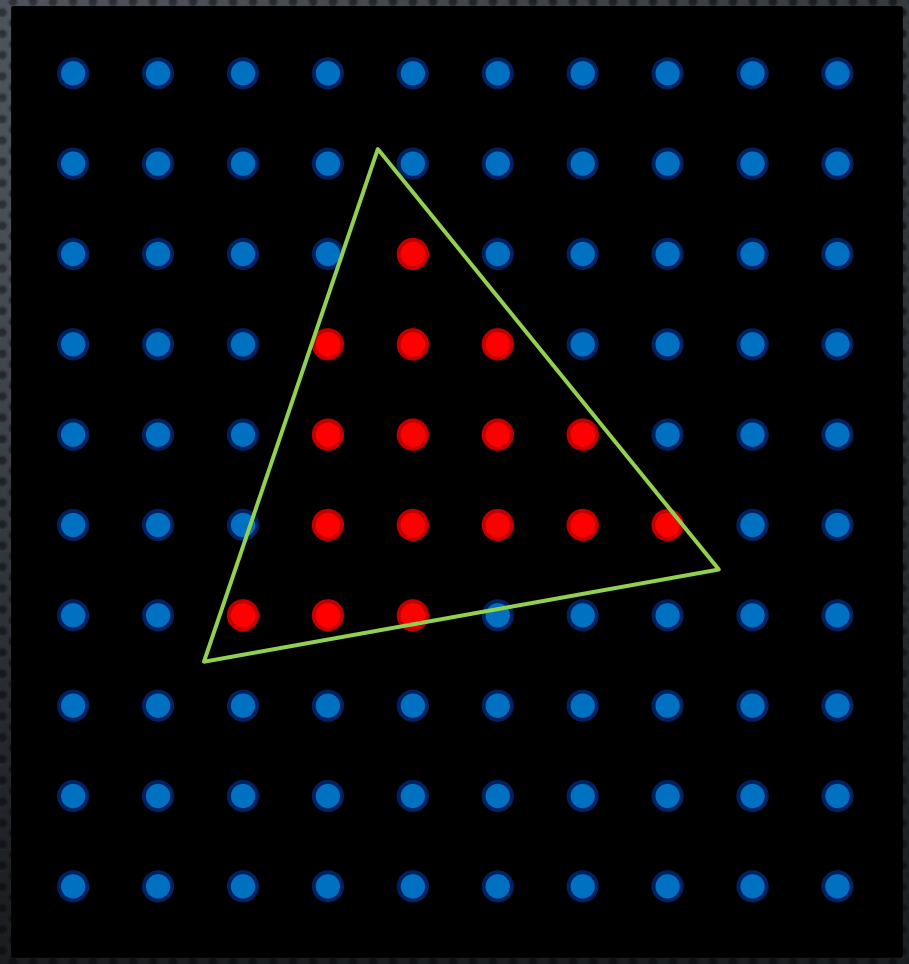
- Applicability of ray casting for VR/AR
- Reference ray casting framework: HVVR
- Open problems/Call for participation

RENDERING FOR VR & AR



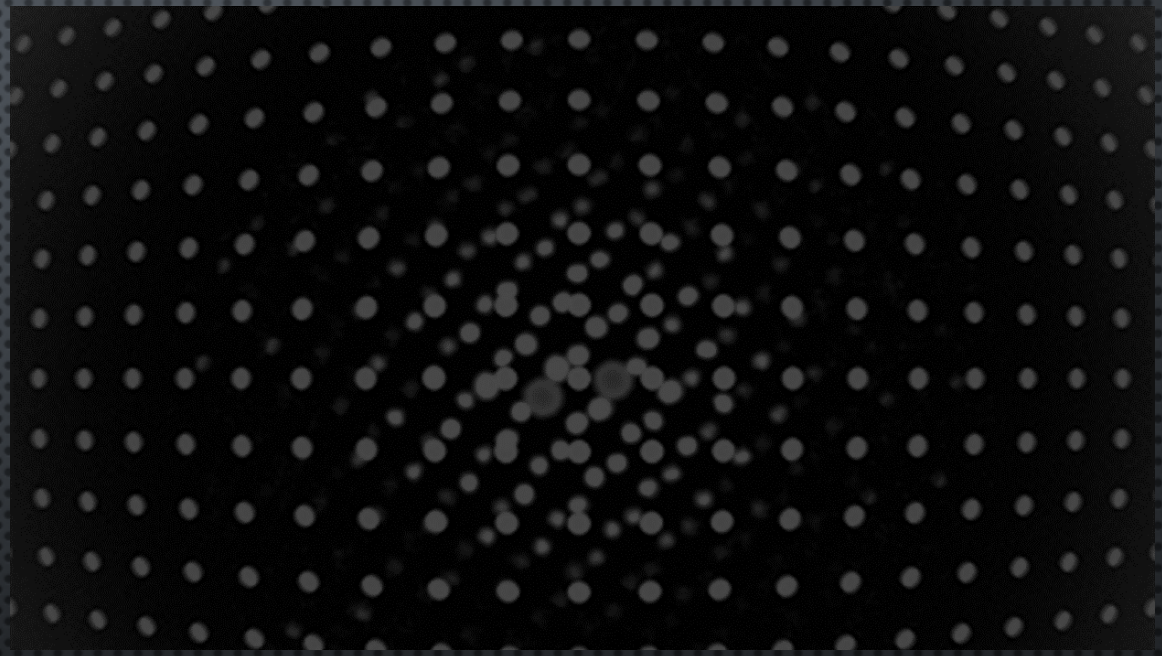
RASTERIZATION

- Fast, mature hardware available
- Fundamentally based on grids
- Well matched to current displays



A NEW SET OF REQUIREMENTS!

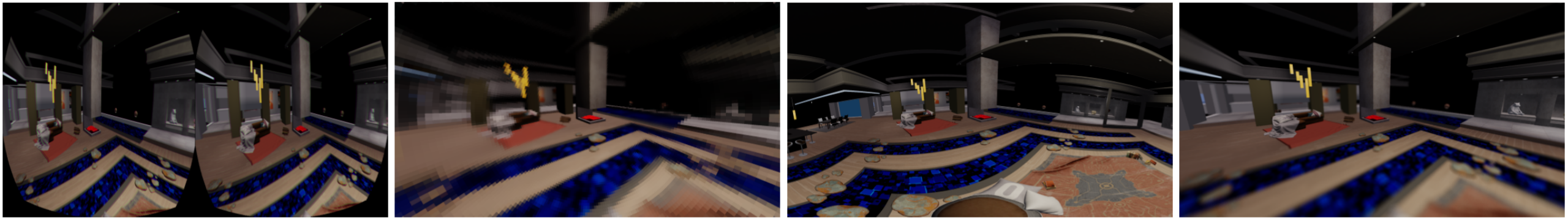
- Wide field of view
- Lens distortion
- Sub-pixel rendering
- Low latency
- Rolling display correction
- Depth of Field
- High resolution & Frame rate
- Foveated rendering
- Efficient Anti-Aliasing



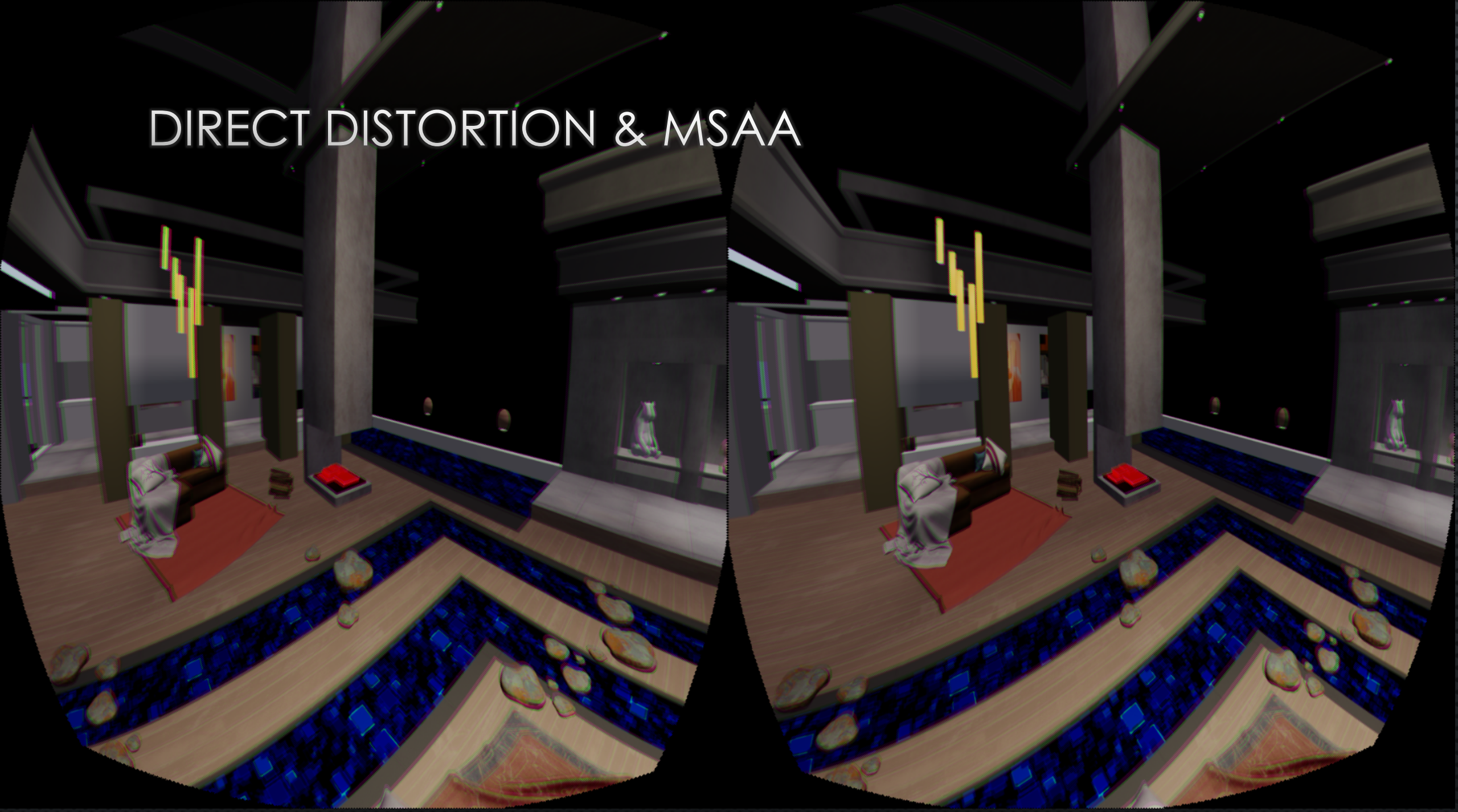
Feature	Rasterization	Ray Tracing	Ray Casting
Wide Field of View	—	✓	✓
Lens Distortion	—	✓	✓
Sub-Pixel Rendering	✗	✓	✓
Low Latency	✗	✓	✓
Rolling Shutter Correction	✗	✓	✓
Depth of Field	—	✓	✓
Foveated Rendering	—	✓	✓
High Resolution + Frame Rate	✓	✗	✓
Efficient Anti-aliasing	✓	✗	✓

Hierarchical Visibility for Virtual Reality

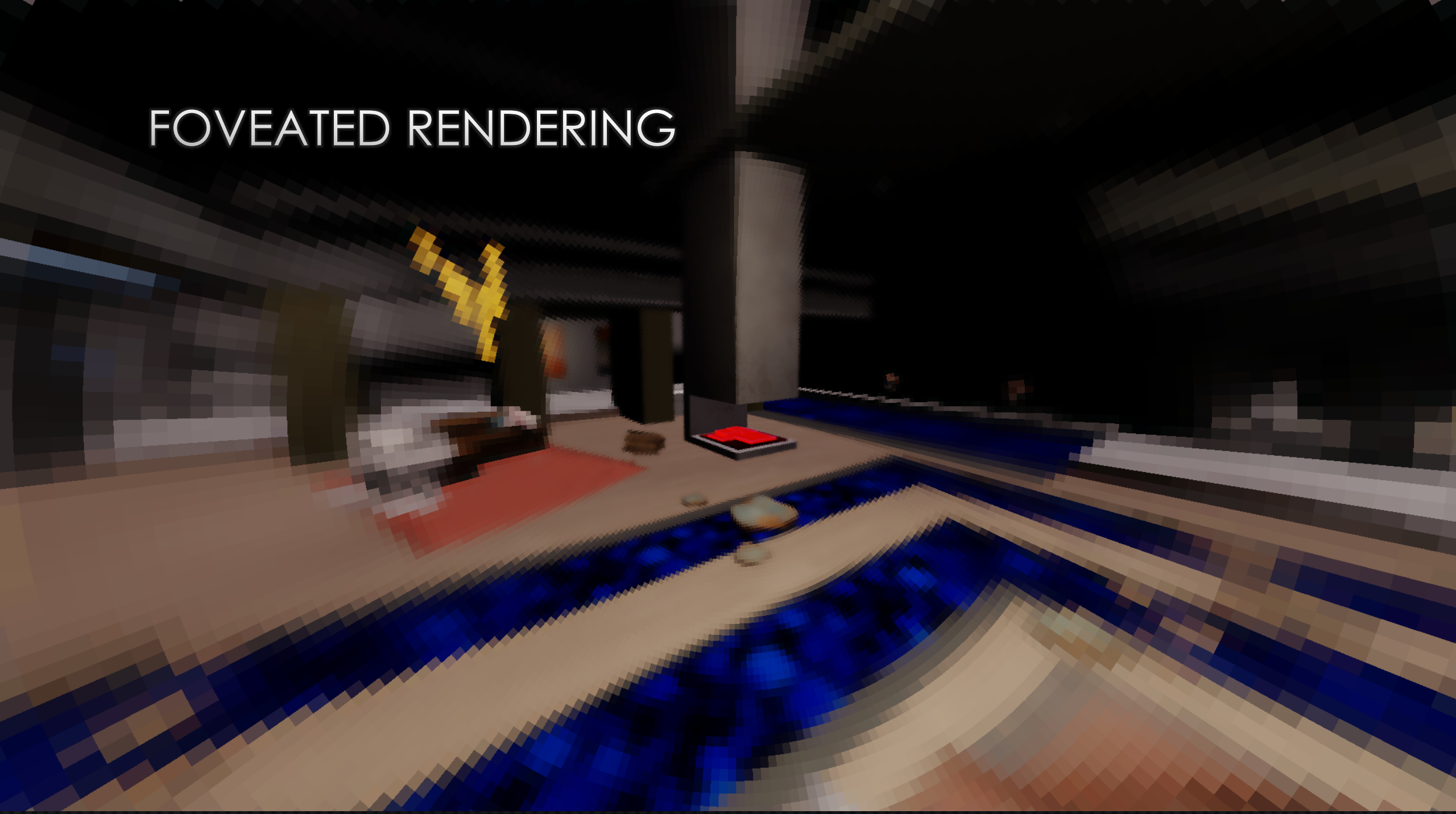
- 10+Brays/s including shading on commodity hardware
- Full dynamic scene support
- Arbitrary coherent ray distributions
  - Including non-point-origin!

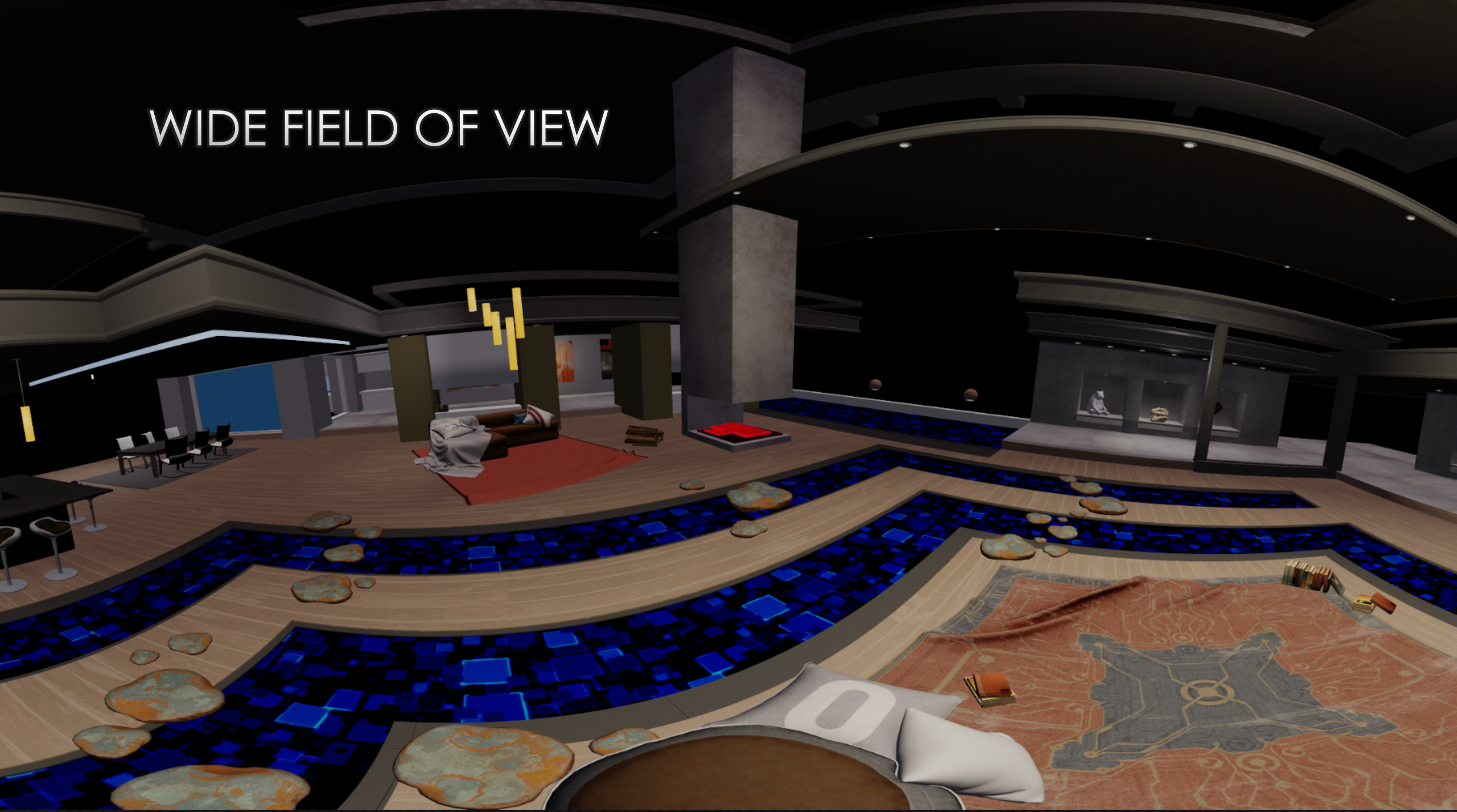


DIRECT DISTORTION & MSAA

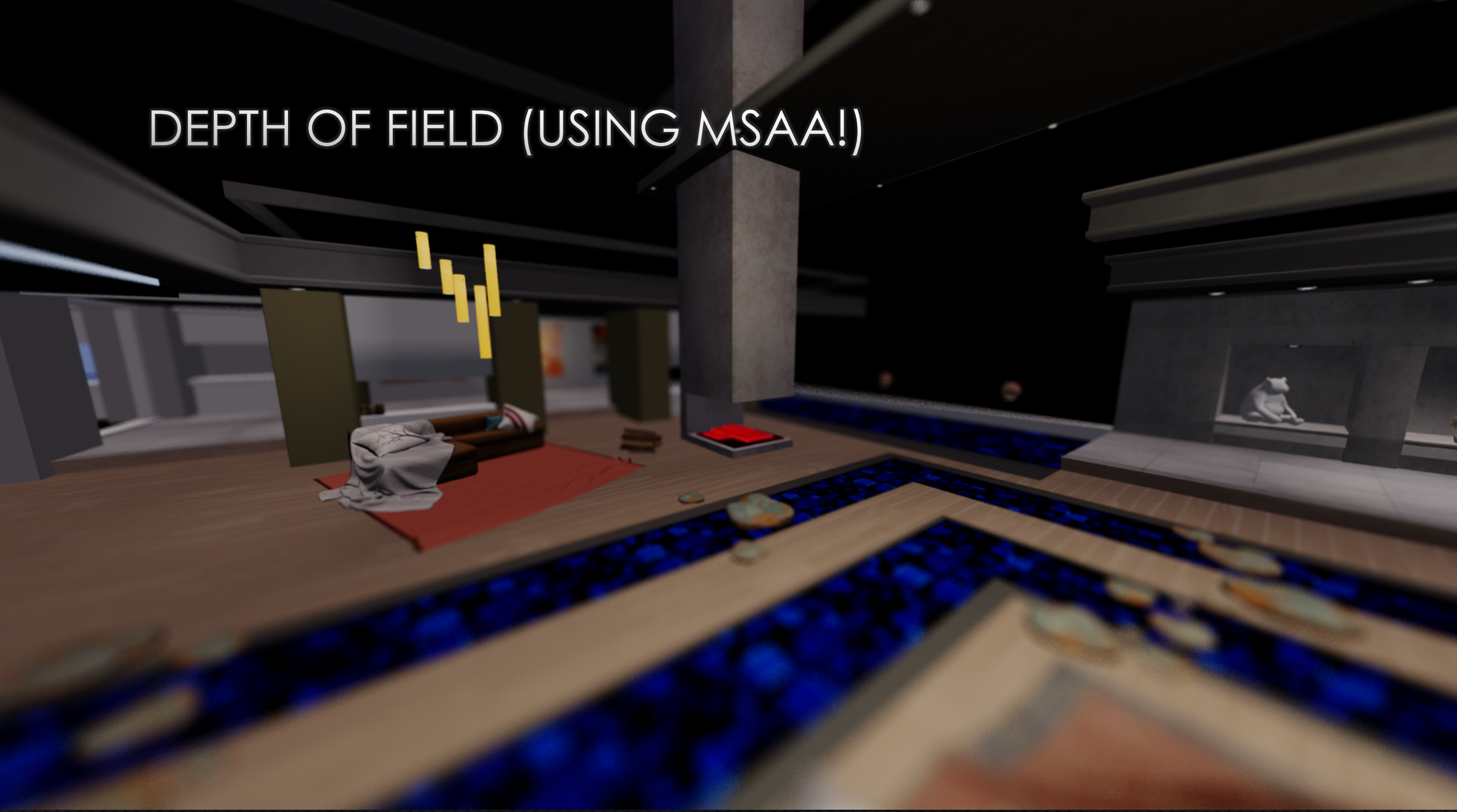


FOVEATED RENDERING




WIDE FIELD OF VIEW

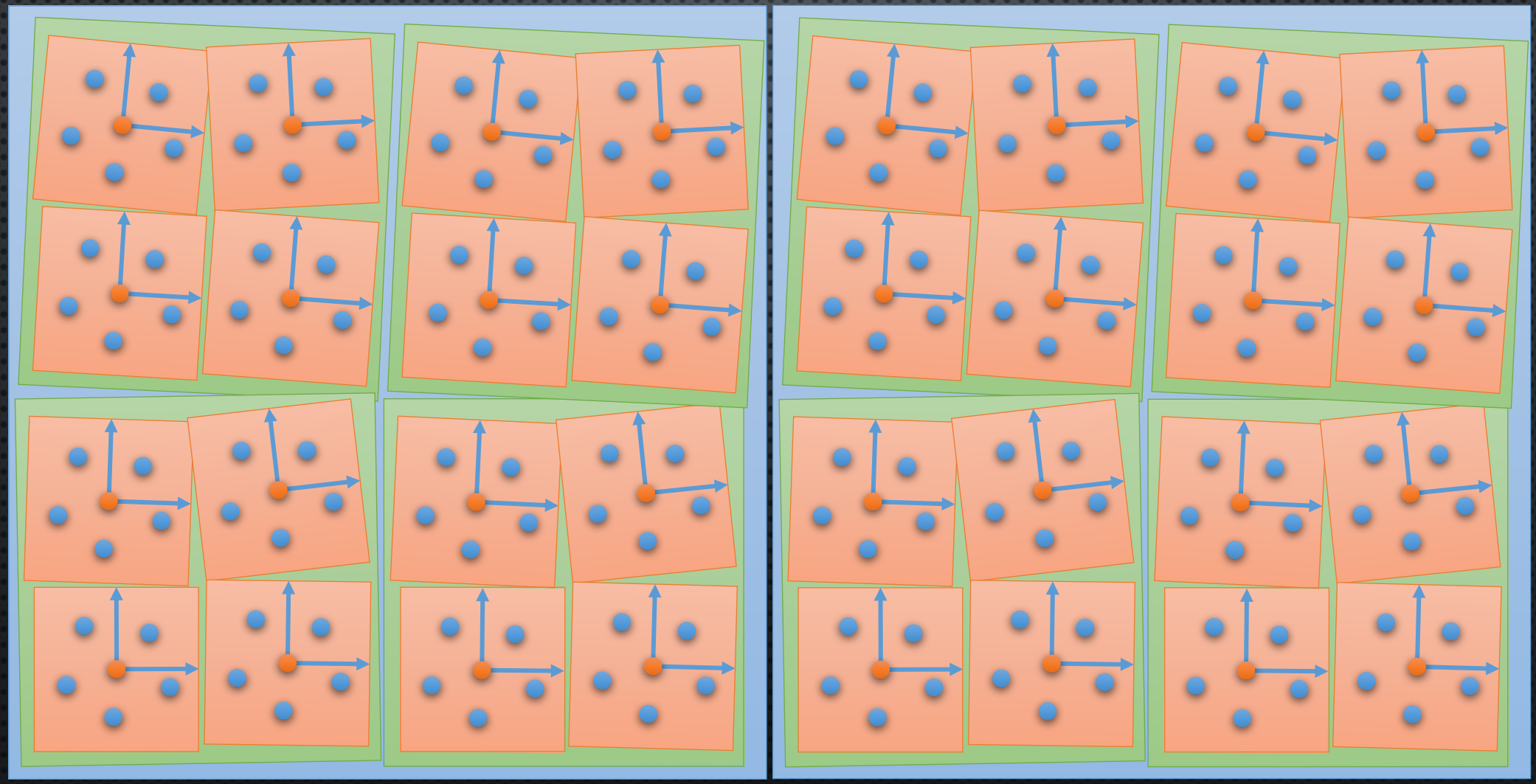
DEPTH OF FIELD (USING MSAA!)



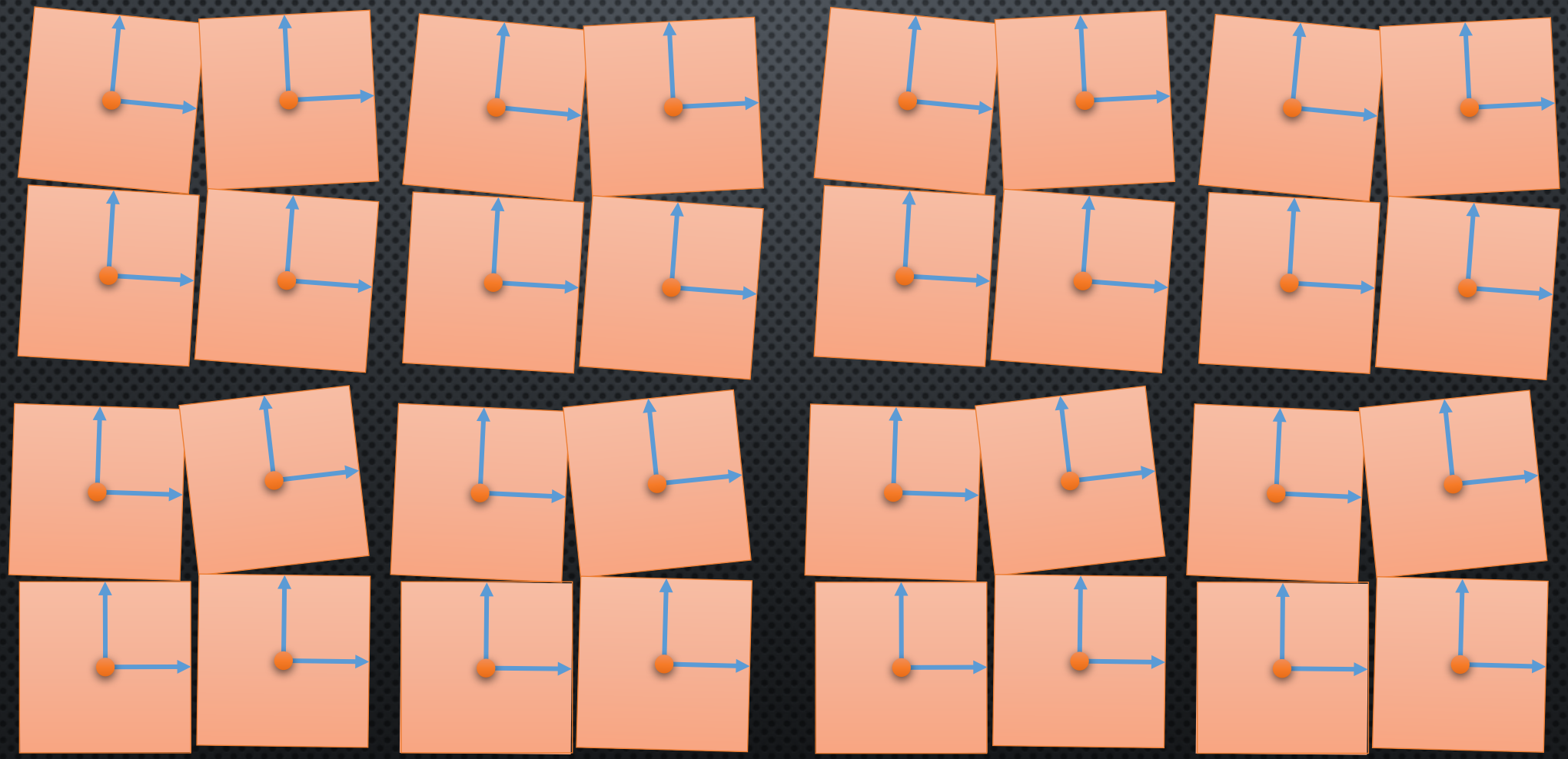
Hierarchical Visibility for Virtual Reality

- 3-stage Heterogeneous compute entry-point search algorithm
  - Large packet traversal (CPU)
  - Small packet traversal (CPU)
  - Ray/triangle intersection And Shading (GPU)

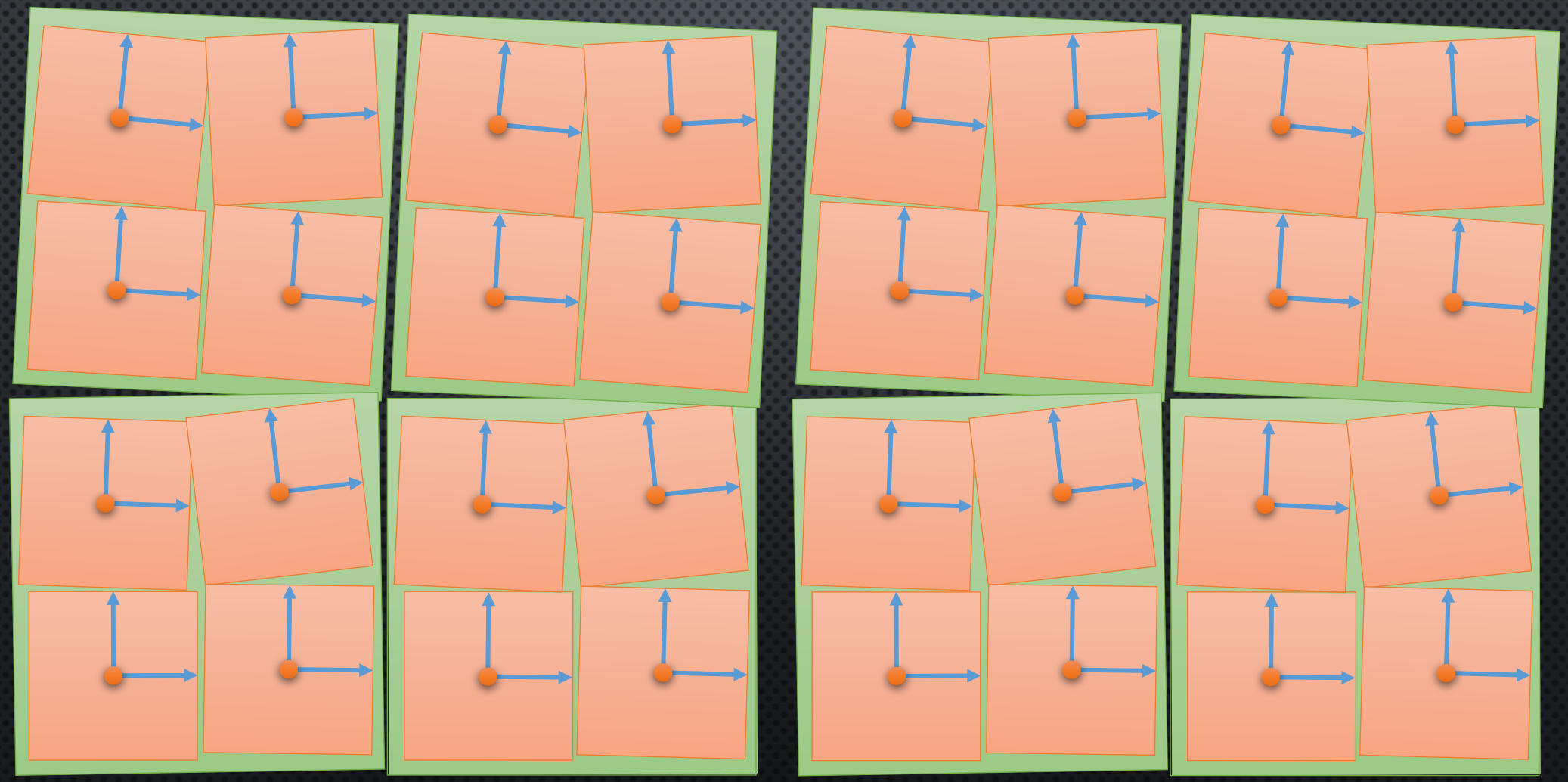
RAY SAMPLE HIERARCHY



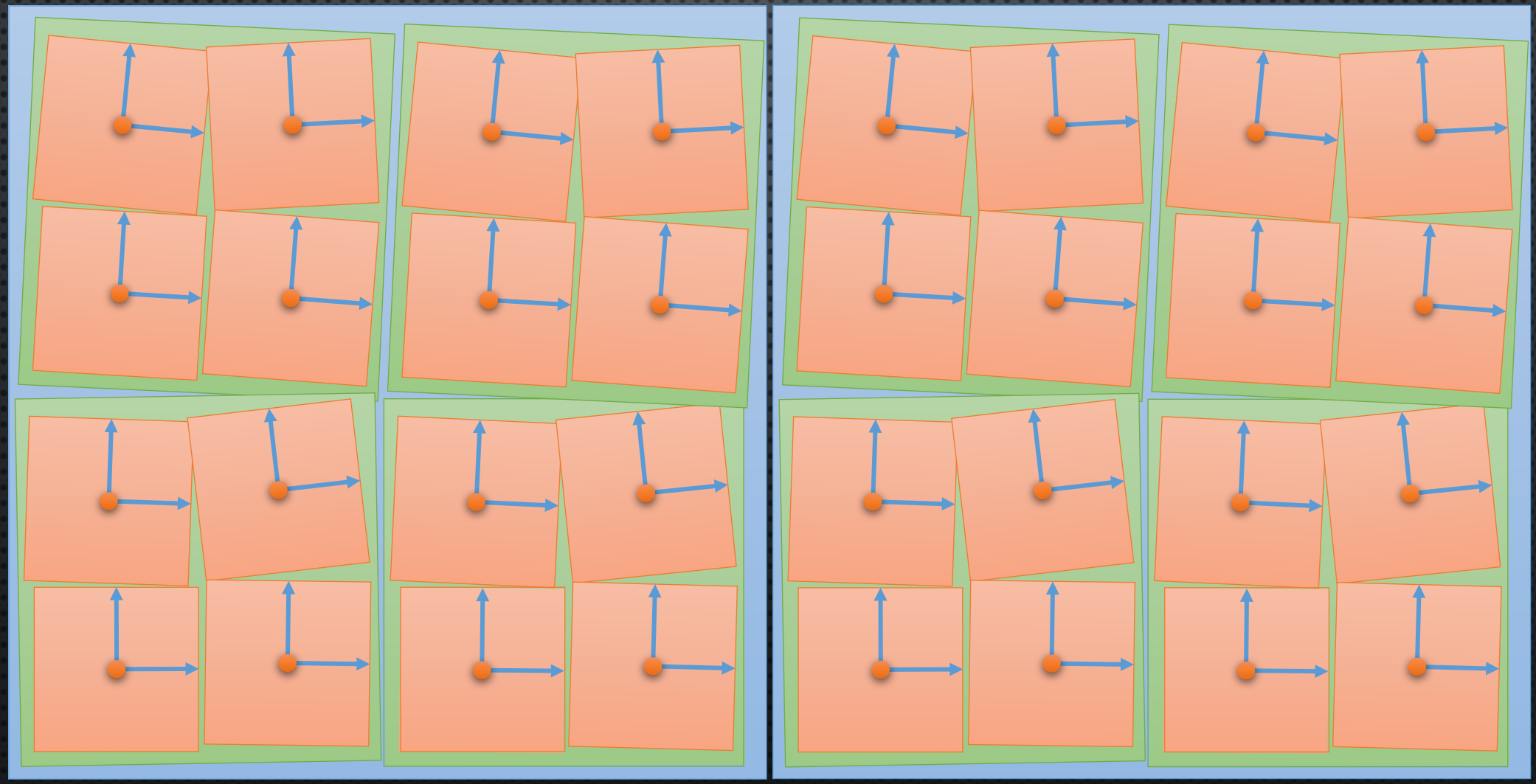
BUILDING THE RAY SAMPLE HIERARCHY



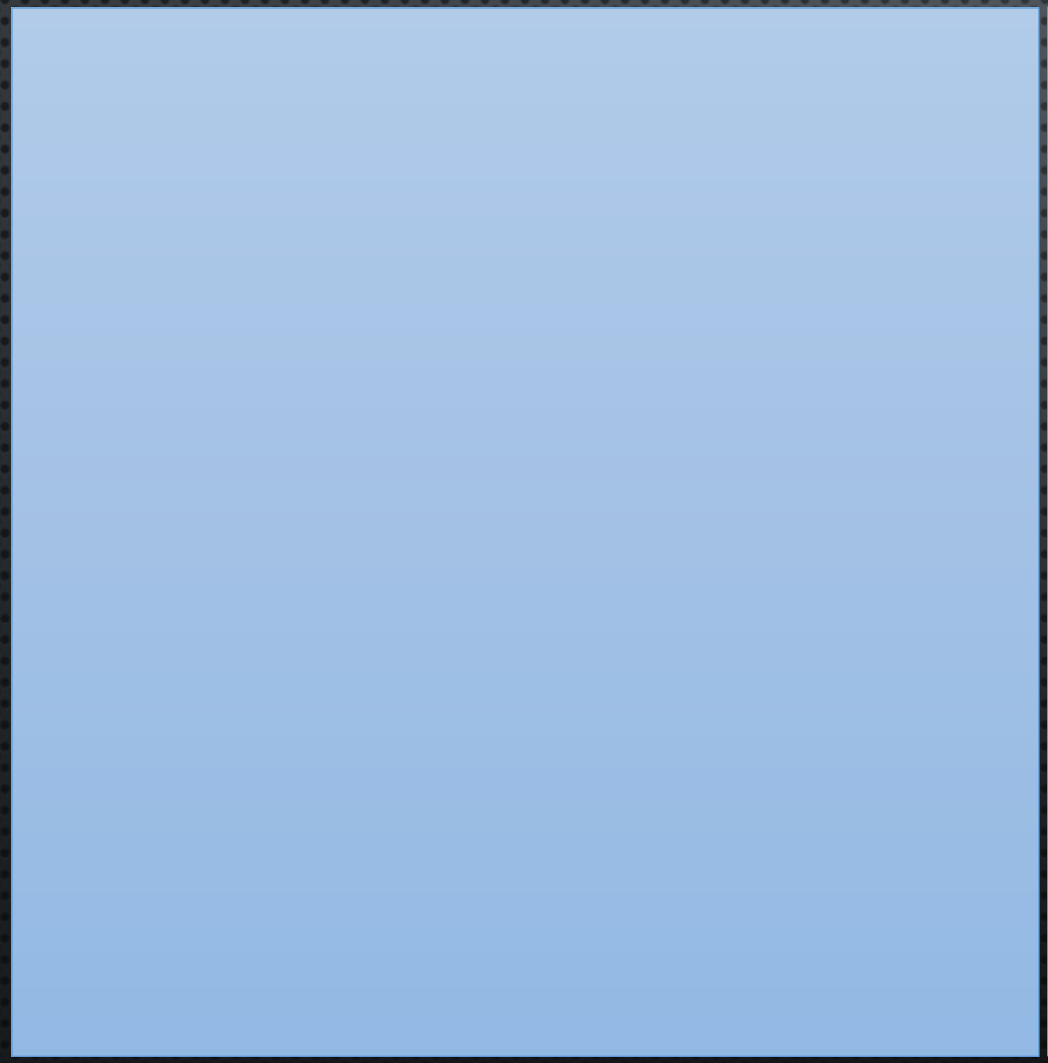
BUILDING THE RAY SAMPLE HIERARCHY

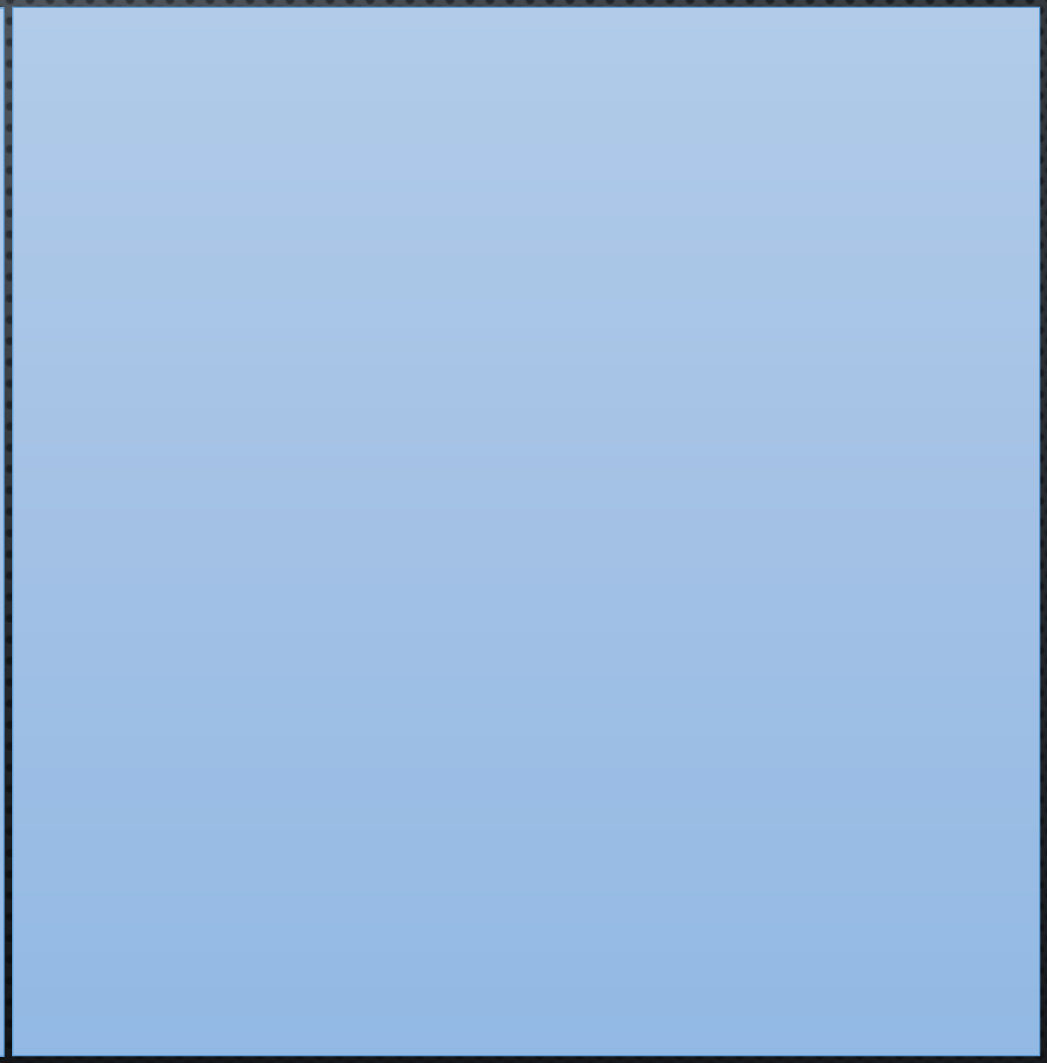


BUILDING THE RAY SAMPLE HIERARCHY

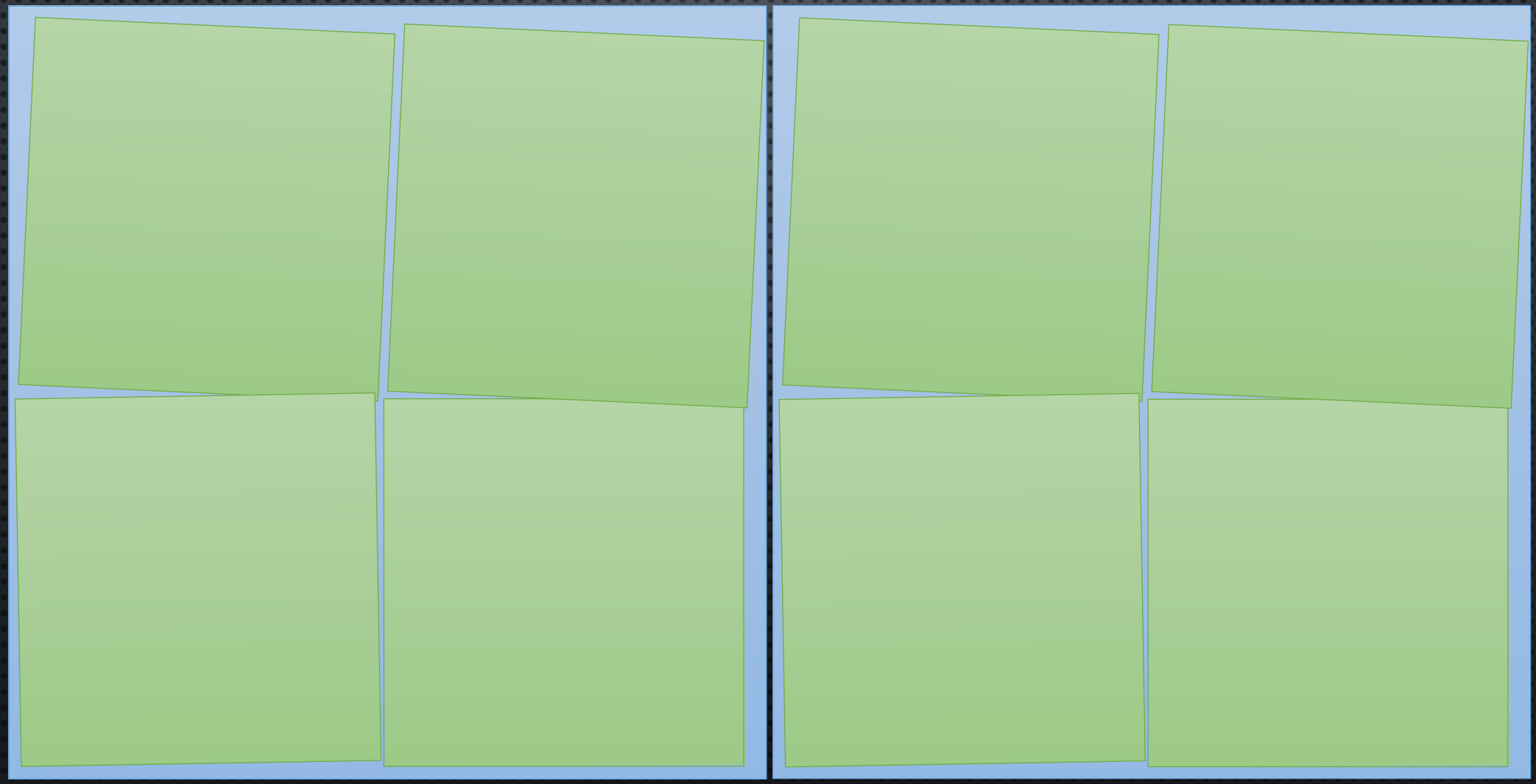


CASTING THE RAY SAMPLE HIERARCHY

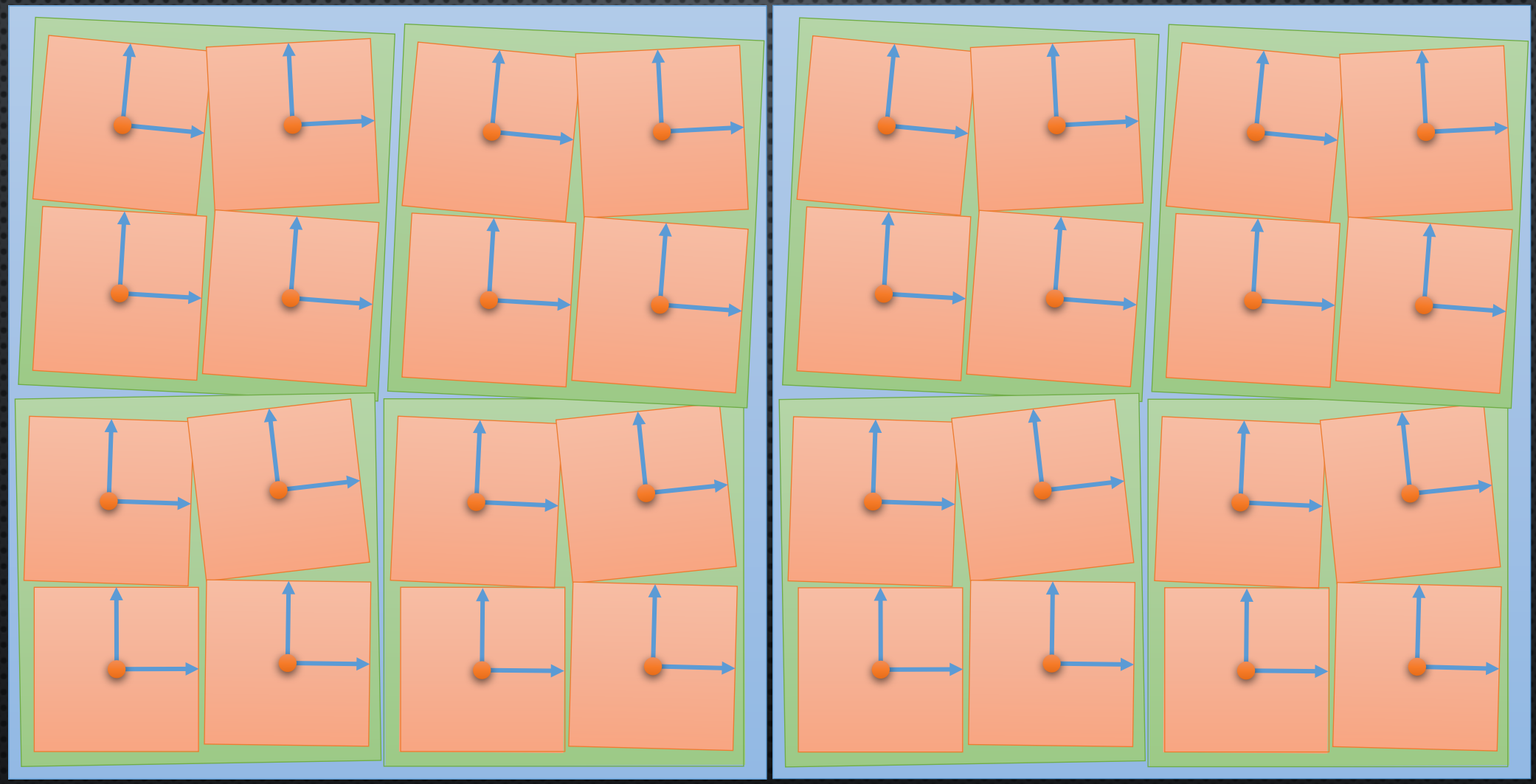




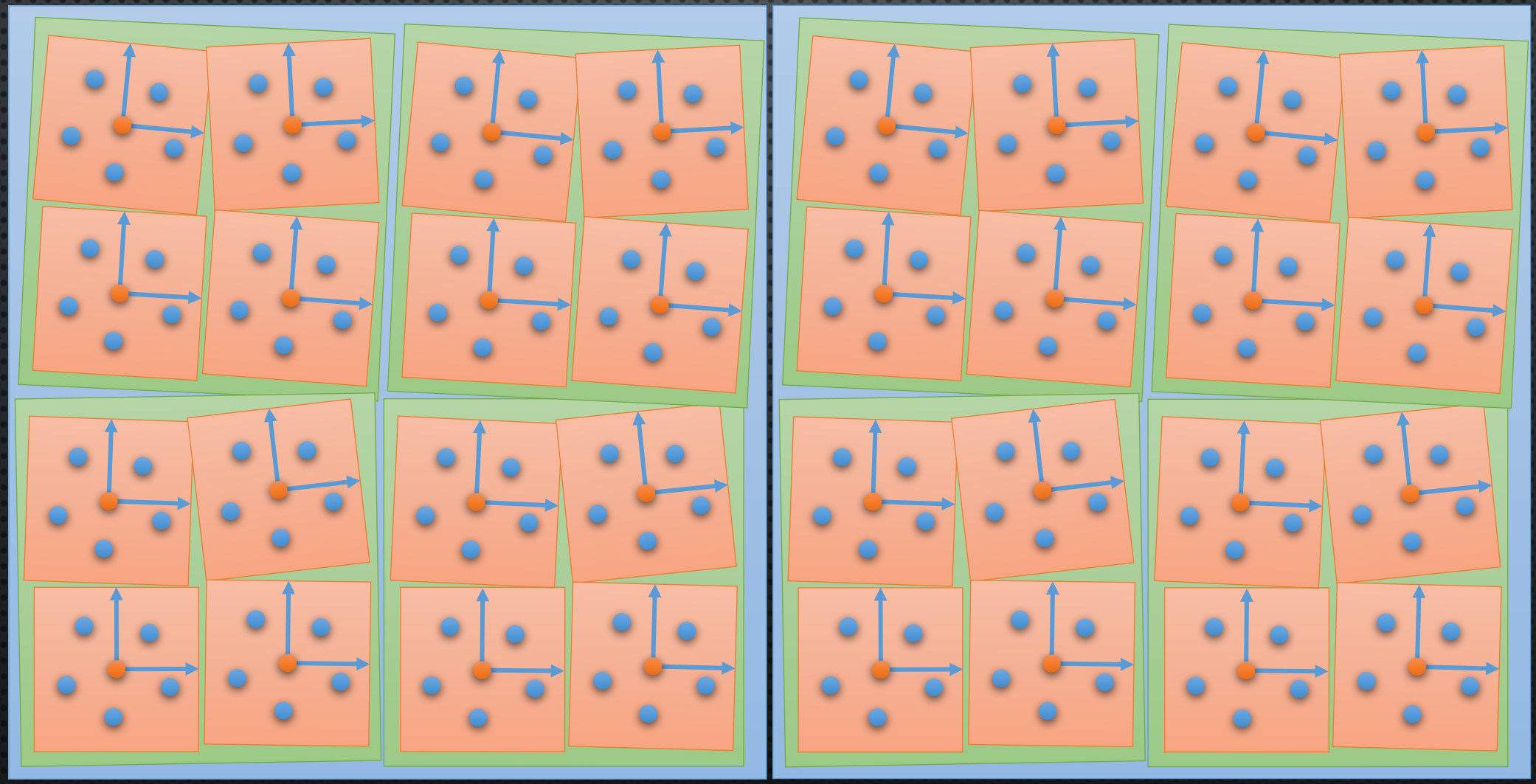
CASTING THE RAY SAMPLE HIERARCHY



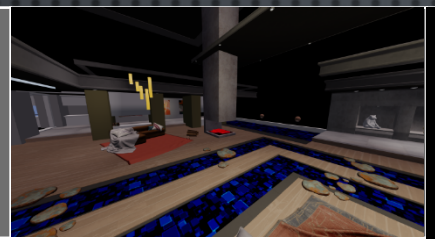
CASTING THE RAY SAMPLE HIERARCHY



CASTING THE RAY SAMPLE HIERARCHY

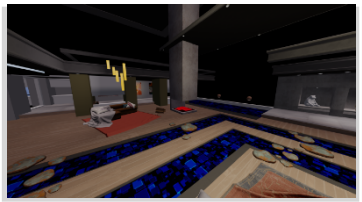
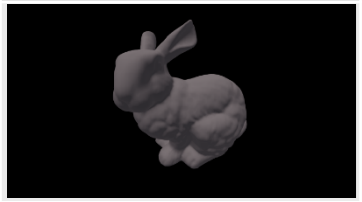
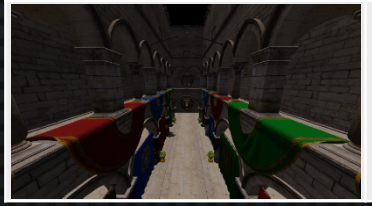


COHERENCE = PERFORMANCE!

				
HVVR	18,432	24,674	15,840	12,375
OptiX Prime	578	529	568	552
Embree	322	543	263	223

MRay/s, 2160x1200, 32xAA (per sub-pixel)

BVH REFIT IS FAST!

Scene	#Triangles	Total Refit Time (µs)
	159,588	139
	69,451	69
	331,179	482
	262,137	208

Real-time ray casting open problems

Call for participation!

IT'S OPEN SOURCE!

https://github.com/facebookresearch/HVVR

Special Thanks to Michael Mara and Alex Nankervis!

Ray Casting API

- Primary Visibility is First Class!
  - Implicit coherence
  - Distinct sub-pixel distortions, layouts and differentials
  - Beam racing/demand driven rendering
  - Multi-sample anti-aliasing

- HVVR API goal: unify and extend established APIs
  - Come talk to us about it!

Opportunities for Collaboration!

- Multi-Level BVHs: Static + Dynamic Geometry & Instancing
- Multiple Materials, Transparency & Improved Shading Efficiency
- Support for Particle Systems
- Beam racing, Motion Blur & Rolling Shutter

Oculus Research is hiring!

- Software Engineers
- Graphics Post-doc
- GPU Architect
- Visiting professors
- Also: Research grants

In short:

- Ray casting is well matched to augmented and virtual reality
- HVVR is an open source real-time ray casting platform from Oculus Research
- Come collaborate: https://github.com/facebookresearch/HVVR