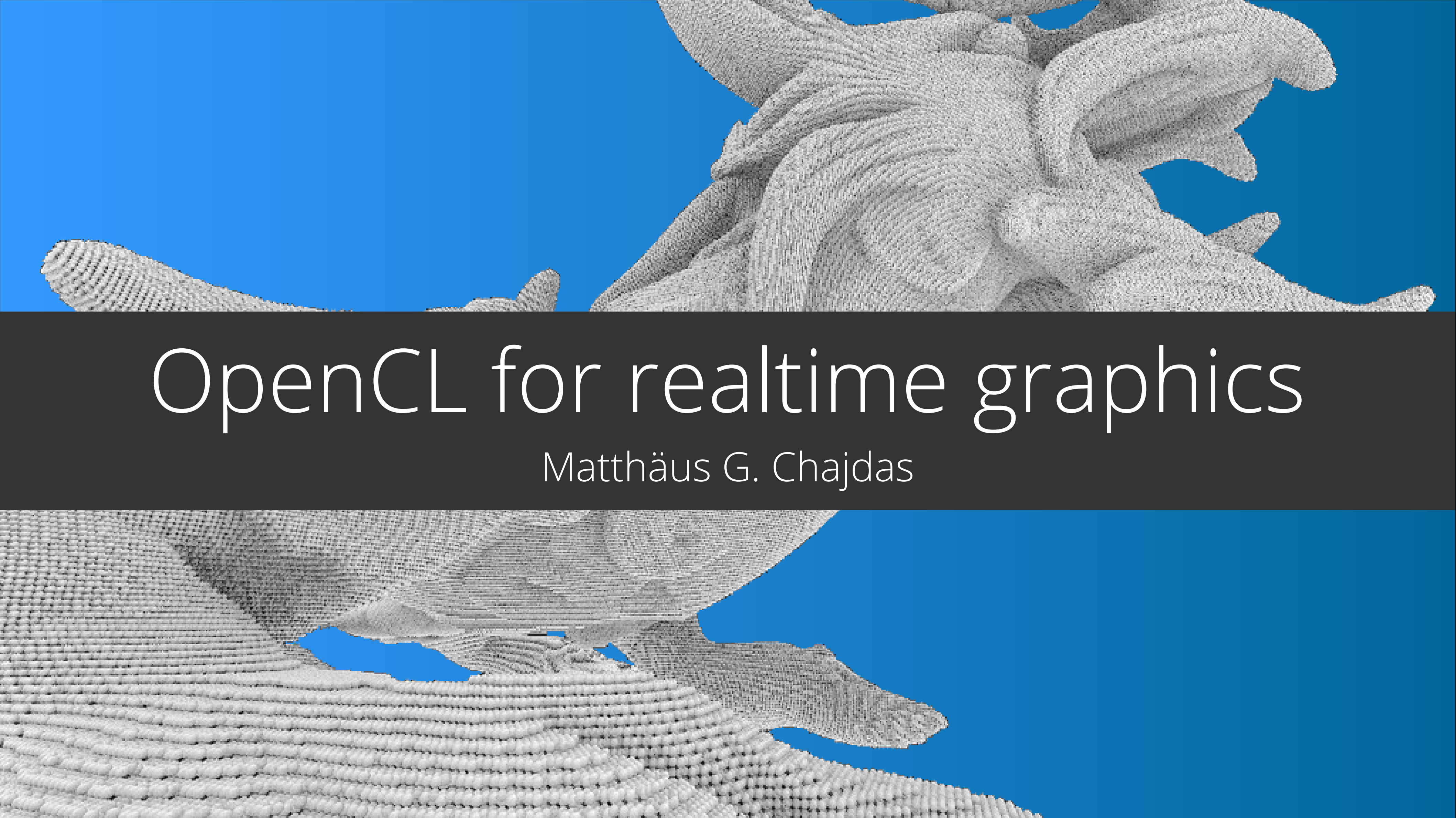


OpenCL for realtime graphics

Matthäus G. Chajdas

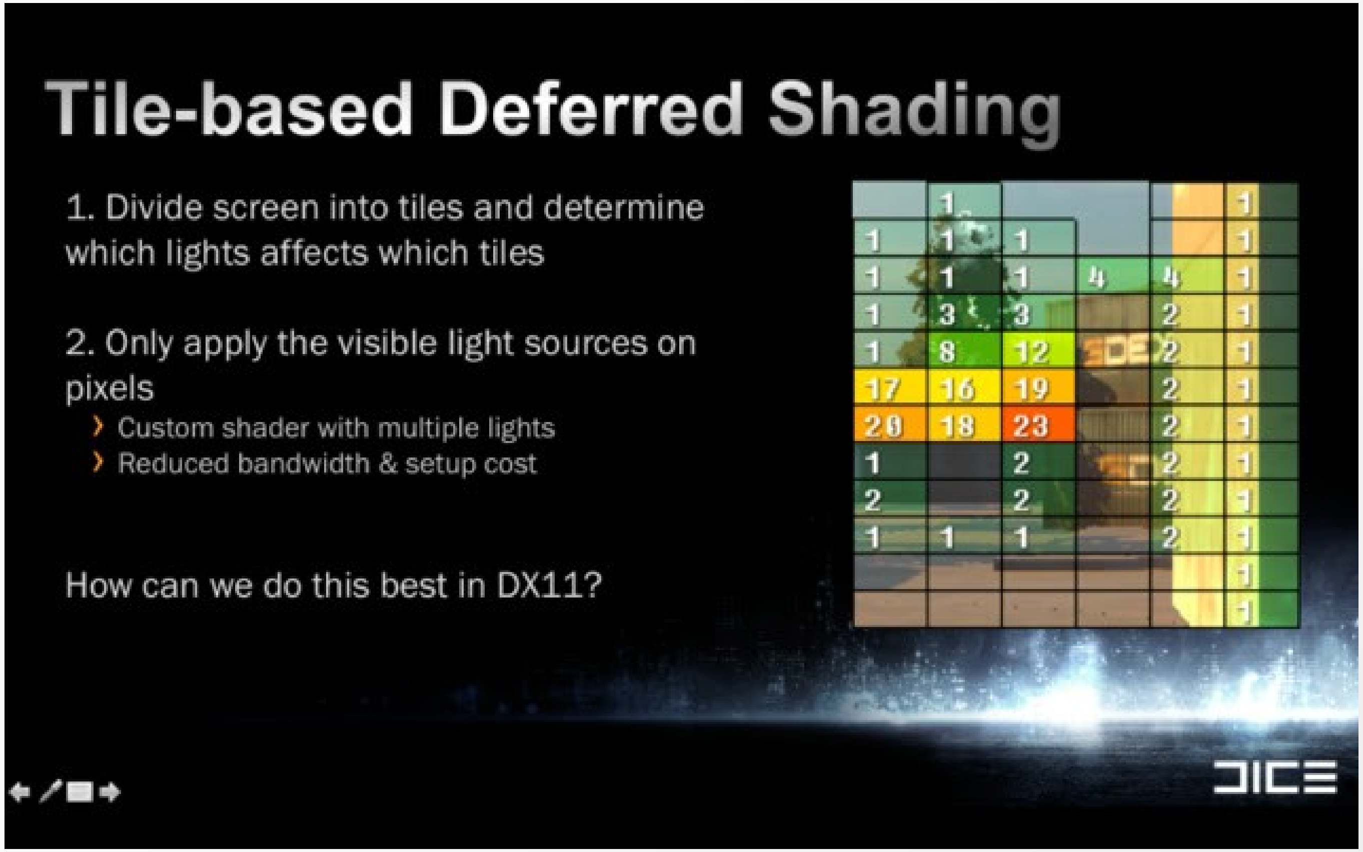
Why OpenCL?

- Because OpenCL does it all
  - **Single source** for **all** graphics APIs (D3D9, D3D10, D3D11, OpenGL 2.x – 4.x)
  - Mobile support
  - Web support
- Clean interop API
- Easy debugging (printf on CPU!)

Interop API

- Acquire resource, map/unmap
- Automatic synchronization
- Minimal code required
  - Full production implementation: 900 LoC
  - Includes error checking & comments
  - Supports OpenCL 1.1 & 1.2, OpenGL, Direct3D11 KHR/NV

Tile based deferred shading



Tile-based Deferred Shading

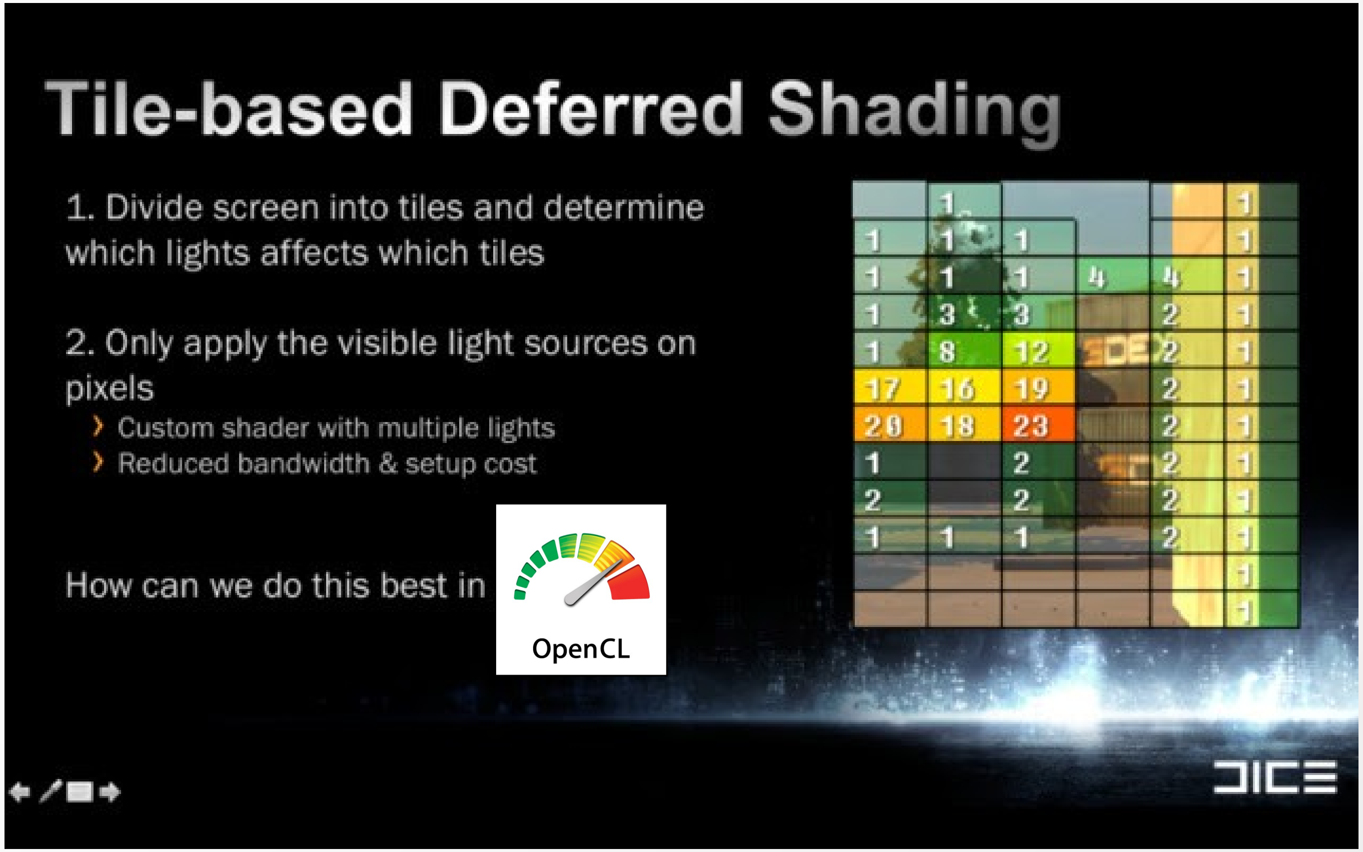
1. Divide screen into tiles and determine which lights affects which tiles

2. Only apply the visible light sources on pixels
   - Custom shader with multiple lights
   - Reduced bandwidth & setup cost

How can we do this best in DX11?

1 1
1 1 1 1
1 1 1 4 4 1
1 3 3 2 1
1 8 12 2 1
17 16 19 2 1
20 18 23 2 1
1 2 2 1
2 2 2 1
1 1 1 2 1
1
1
DICE

Tile based deferred shading



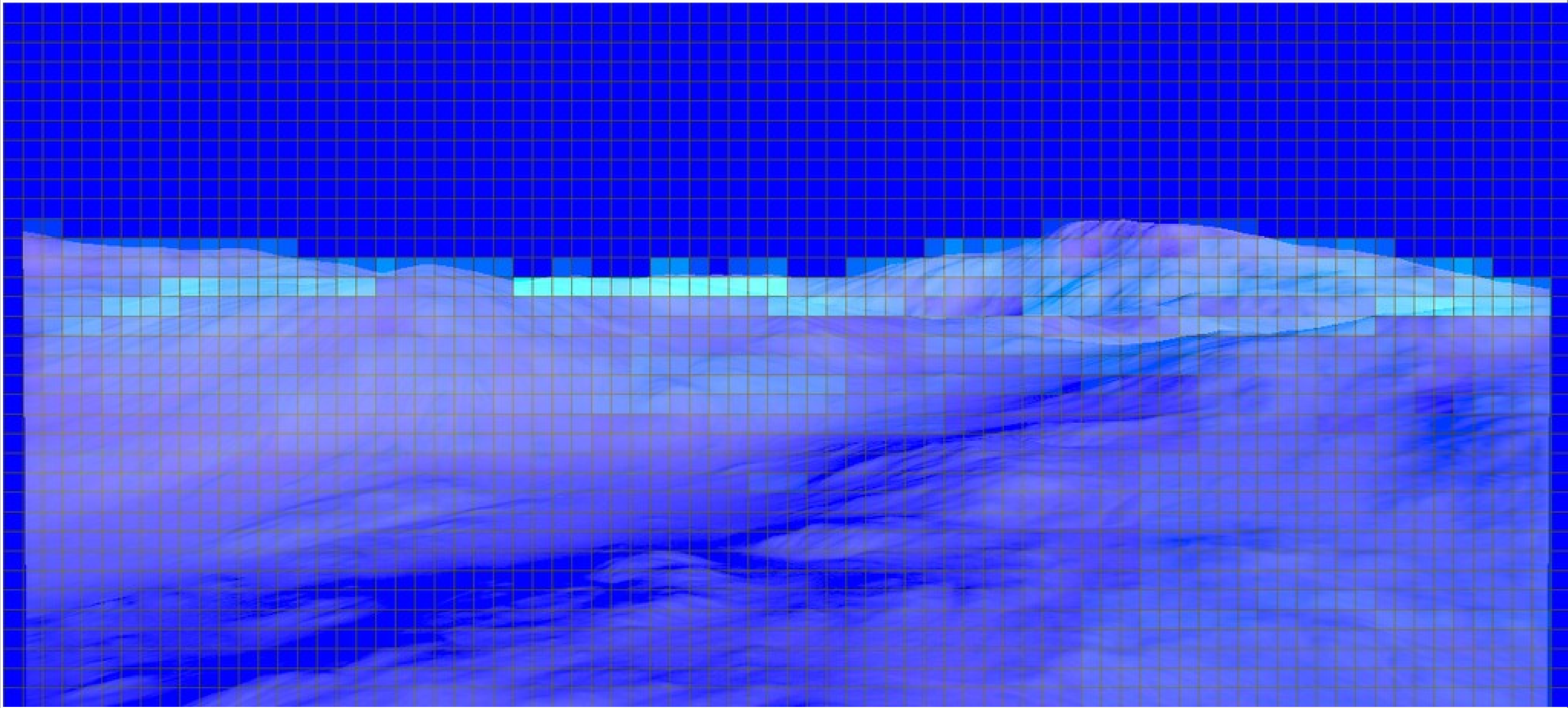
Tile-based Deferred Shading

1. Divide screen into tiles and determine which lights affects which tiles

2. Only apply the visible light sources on pixels
   - Custom shader with multiple lights
   - Reduced bandwidth & setup cost

How can we do this best in OpenCL

Tile based deferred shading

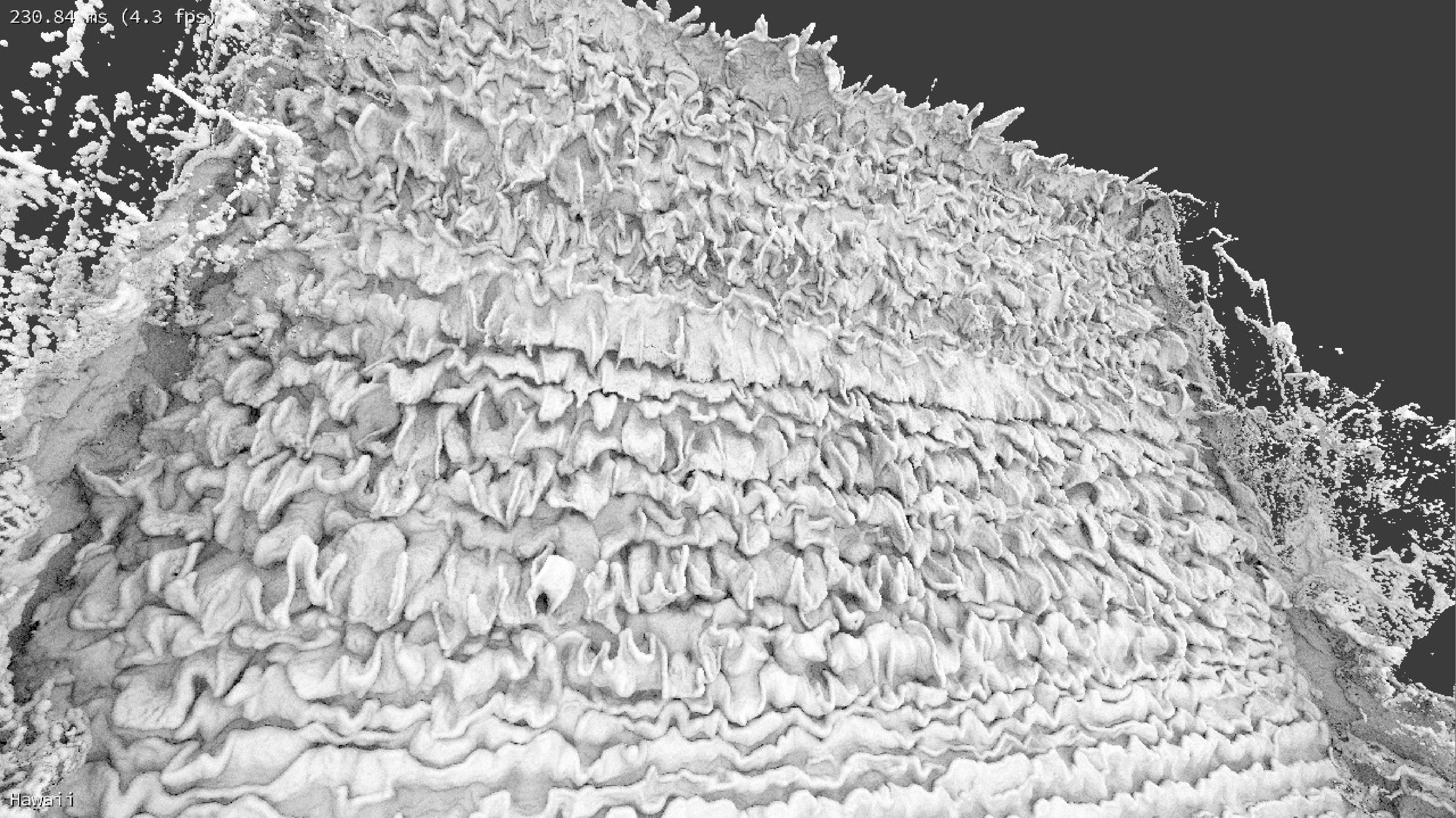


Tile based deferred shading

- Works!
- Performance roughly the same as DirectCompute
- Some limitations apply though …

Tile based deferred shading

- No image read/write
  - Just map image twice & get the desired undefined behavior :)
  - Fixed in OpenCL 2.0
- No depth images
  - Fixed by extension (for OpenGL)
- No MSAA images
  - Fixed by extension (for OpenGL)

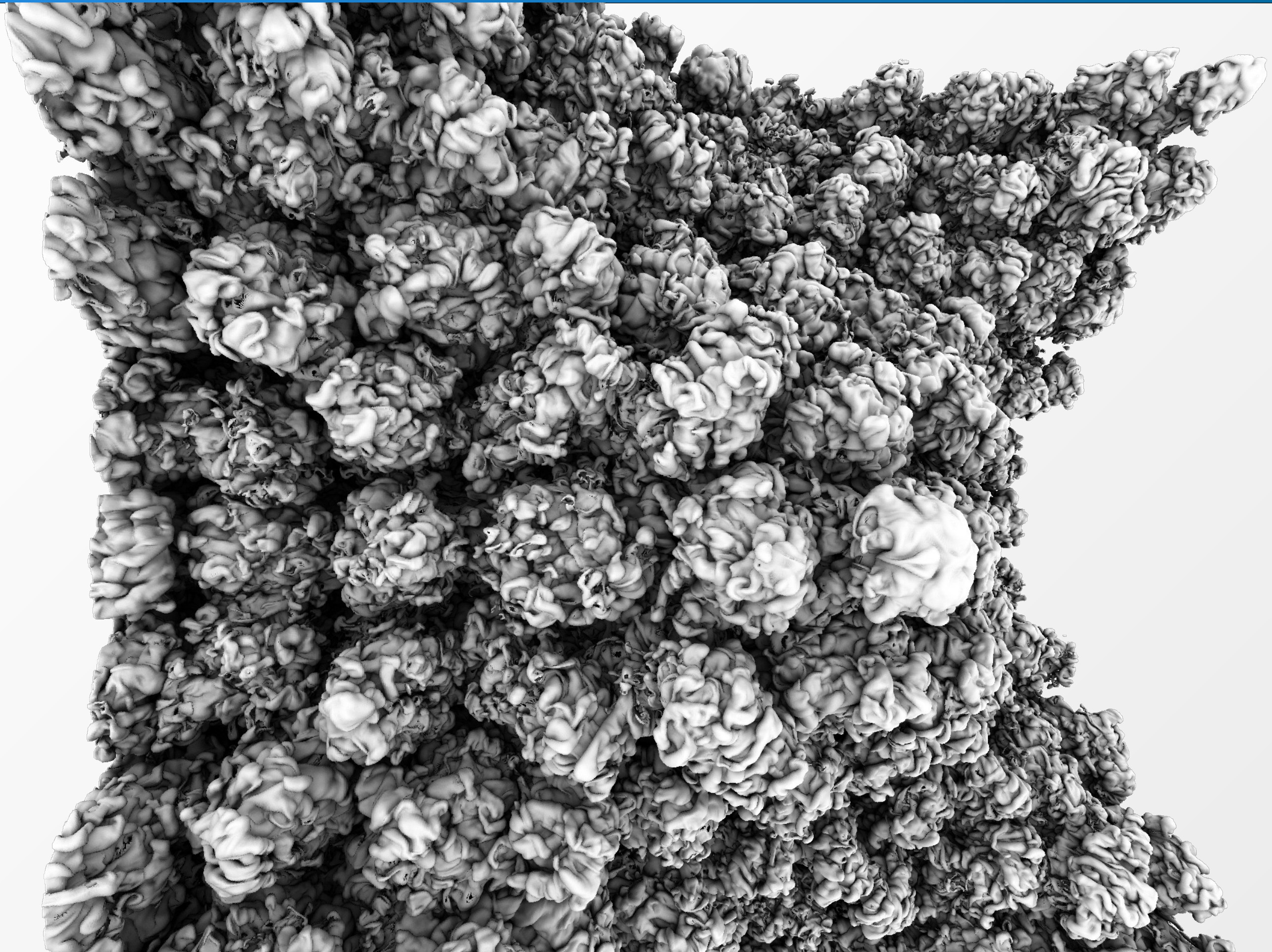

230.84 ms (4.3 fps)
Hawaii

Real compute

- Voxel raytracing
  - 600 LoC of kernel code
  - Tree traversal
  - Per-thread stacks
- Run out of GPU memory?
  - Current GPUs max out at 16 GiB (AMD) or 12 GiB (NVIDIA)
  - CPUs max out at ... well ...

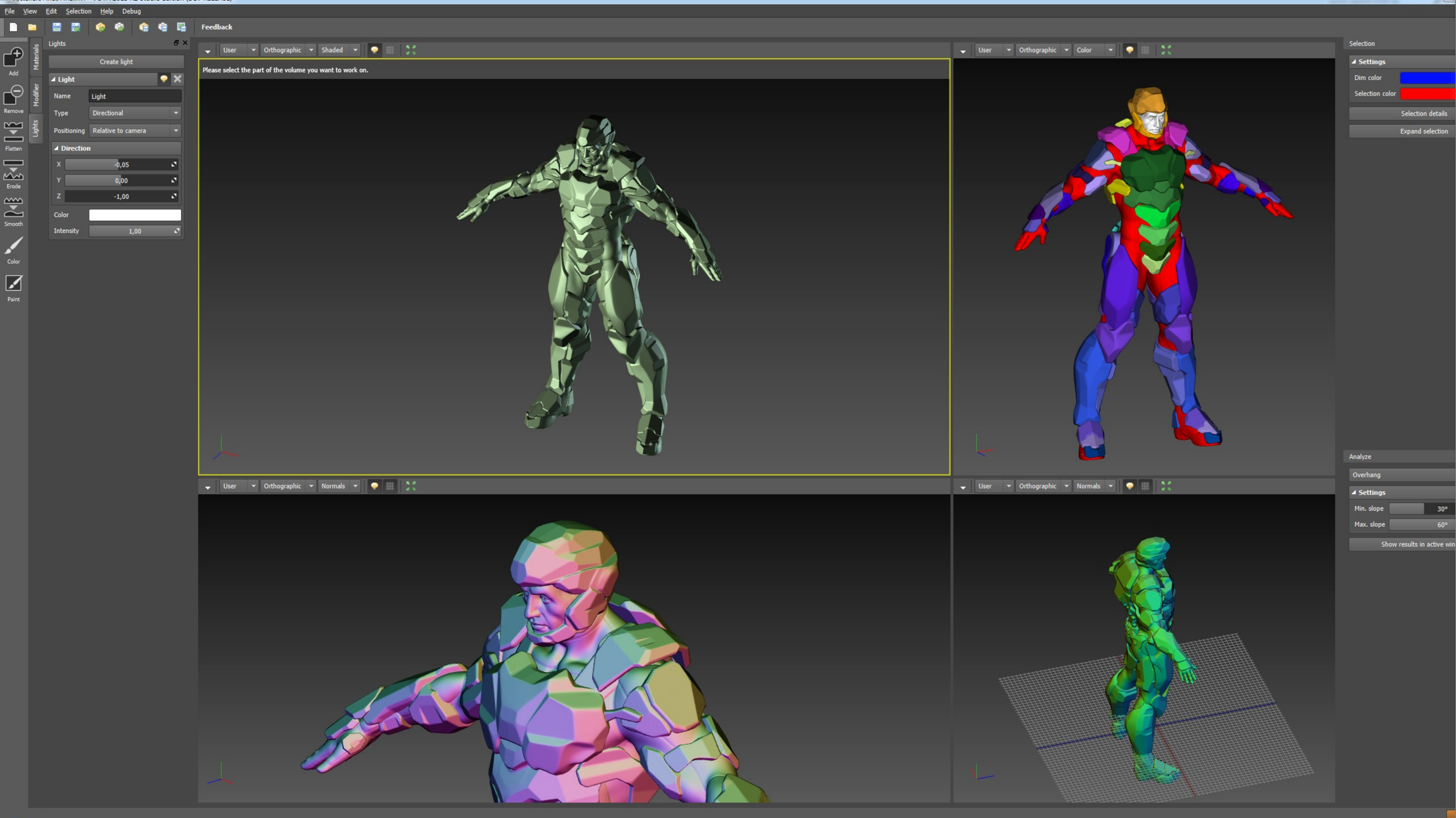
Voxel raytracing

- Same code
- Really!
- Portable performance is not a myth!



Voxel raytracing

- GPU optimizations benefit CPU and vice versa
- No special casing
  - Avoid some “obviously” slow paths
  - AMD & NVIDIA* get comparable performance/efficiency
  - CPU performance ~ 30% slower than extremely optimized ISPC code



Please select the part of the volume you want to work on.

Light

Name	Light
Type	Directional
Positioning	Relative to camera

Direction

X	-0,05
Y	0,00
Z	-1,00
Color	⬜
Intensity	1,00

Settings

Dim color	🟦
Selection color	🟥

Settings

Min. slope	30°
Max. slope	60°

Shipping products/VOTA

- Voxel editor
- All editing is done in OpenCL only
- Graphics interop running all the time
  - OpenCL prepares data for visualization
  - Minimal CPU intervention (to minimize buffer sizes)

VOTA, lessons learned

- All users have OpenCL installed
- AMD doesn't have a kernel cache (just do it on your own)
- Compiler quality is “good enough”
  - Still, we eagerly wait for SPIR
  - Initial startup takes quite some time due to compiling
- Query everything which is implementation specific

OpenCL/Graphics interop state

- AMD
  - Direct3D: Works
  - OpenGL: Works mostly* (Linux & Windows)
- NVIDIA
  - Direct3D: Through _NV extension, _KHR not supported.
  - OpenGL: Works (Linux & Windows)

OpenCL/Graphics interop state

- AMD's implementation is much stricter (similar to OpenGL)
- Both have occasionaly issues with memory management
  - Need extension to force GPU memory defragment & query where buffer ended up
- For debugging/profiling, use CodeXL/KernelAnalyzer
  - NVIDIA stopped supporting OpenCL profiling some time ago

Reporting bugs

- AMD: Just report through normal channels. They got back to me quickly & and you get status updates (cool)
- NVIDIA, best report through CUDA bug report form. They don't say much about it, but they still fix OpenCL bugs.
- Intel: The forums seem to work fine.

OpenCL for graphics, the road ahead

- With OpenCL 2.0, OpenCL will far surpass DirectCompute/OpenGL compute shaders
  - GPU pipelining
  - Shared CPU/GPU memory data structures
  - AMD is aggressively working on it, first OpenCL 2.0 SDK should come this June
  - Intel most likely working on it as well

Conclusion

- You can ship an application built on OpenCL **today**
- For games, you'll likely want the MSAA/depth extensions
  - Vendors should do it instantly **once requested**
  - Can start writing the game today without problems
- In future, hard to avoid
  - OpenCL 2.0 allows GPU to traverse scene graph, prepare draw commands, then issue draw calls from CPU, with zero copy overhead

Thanks to …

- The whole Volumerics team
  - @janjorrit, @mreitinger
- @repi
- AMD
  - @grahamsellers, @JCBaratault
- Codeplay & Khronos
  - @codeandrew, @neilt3d