Parallel Irradiance Caching on the GPU

Nathaniel Jones

18.337/6.338 Parallel Computing

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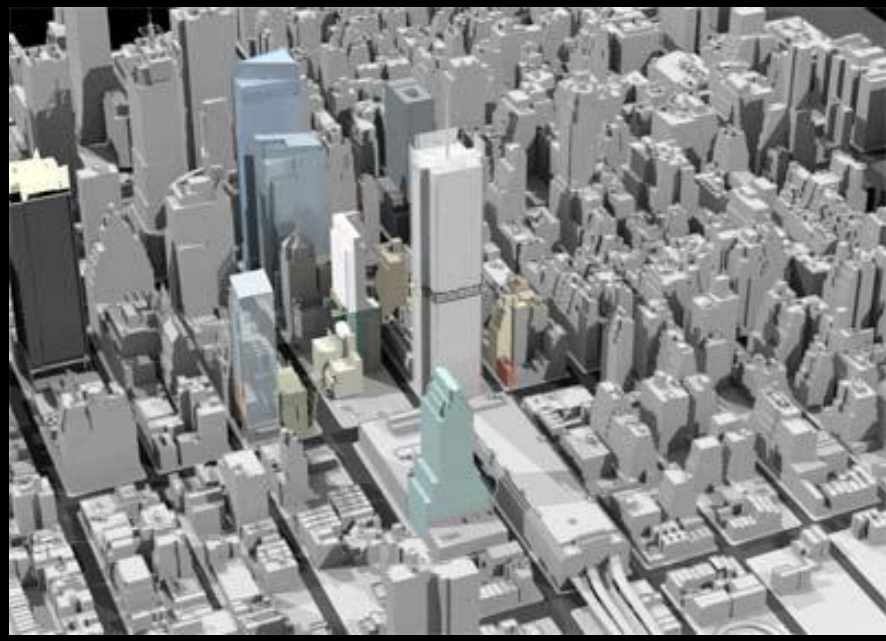
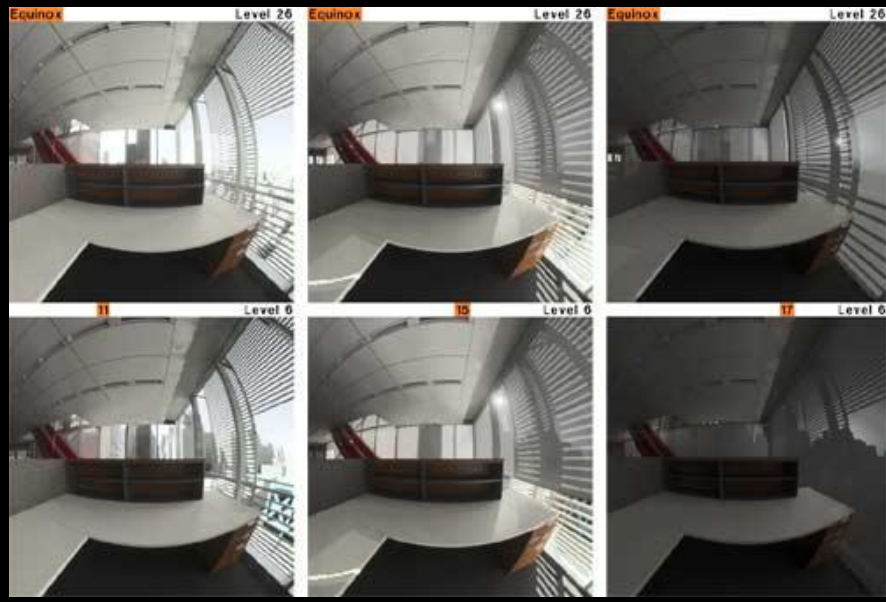
Radiance

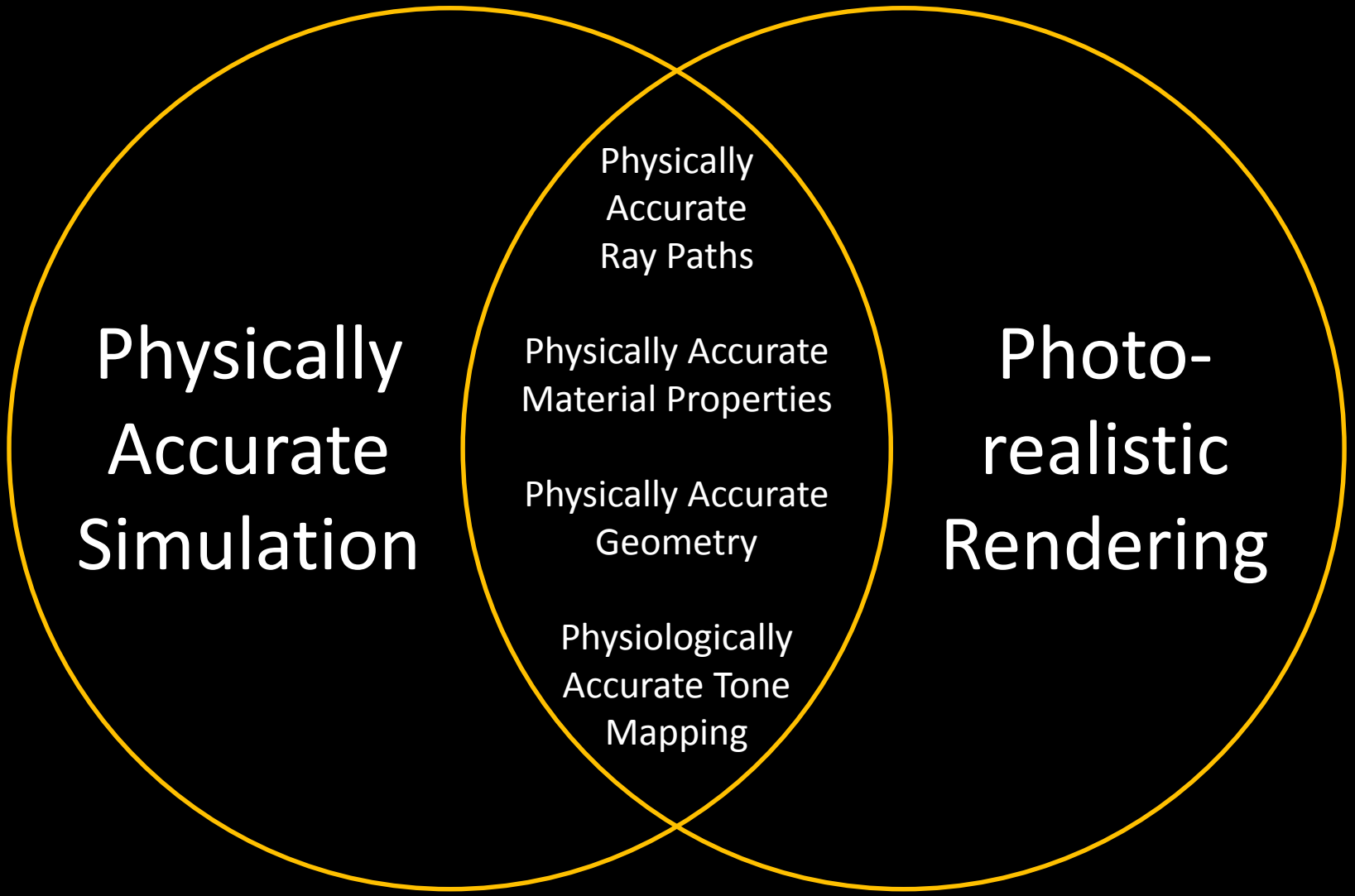
- Architectural lighting and daylighting simulation
- Backward ray tracing tool
- Simulation engine used by
  - IES<VE>
  - Ecotect
  - OpenStudio
  - DIVA
  - DAYSIM
- Open source
- Written in the 1980's





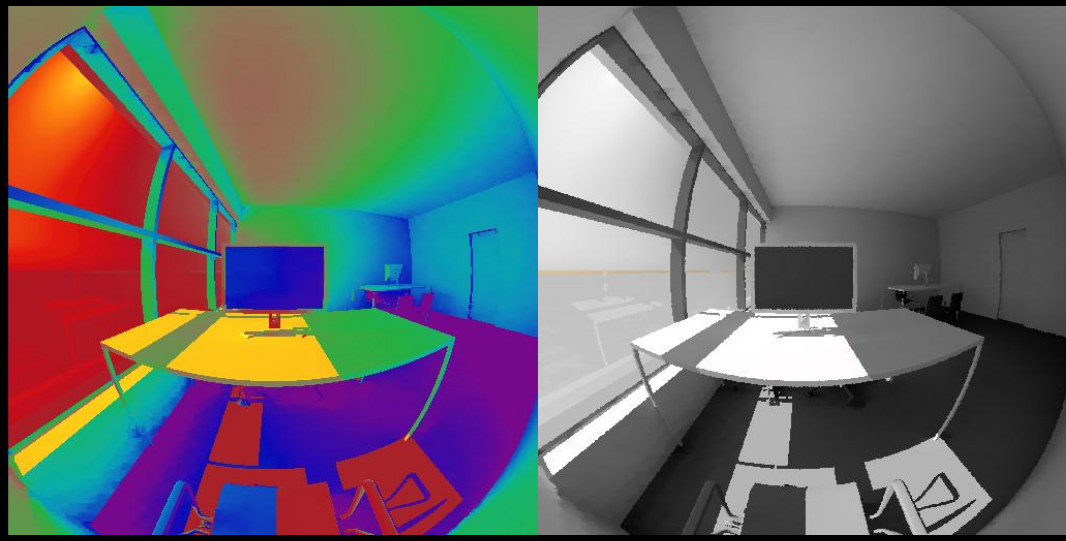
http://windows.lbl.gov/comm_perf/nyt_visualizing.html

Radiance

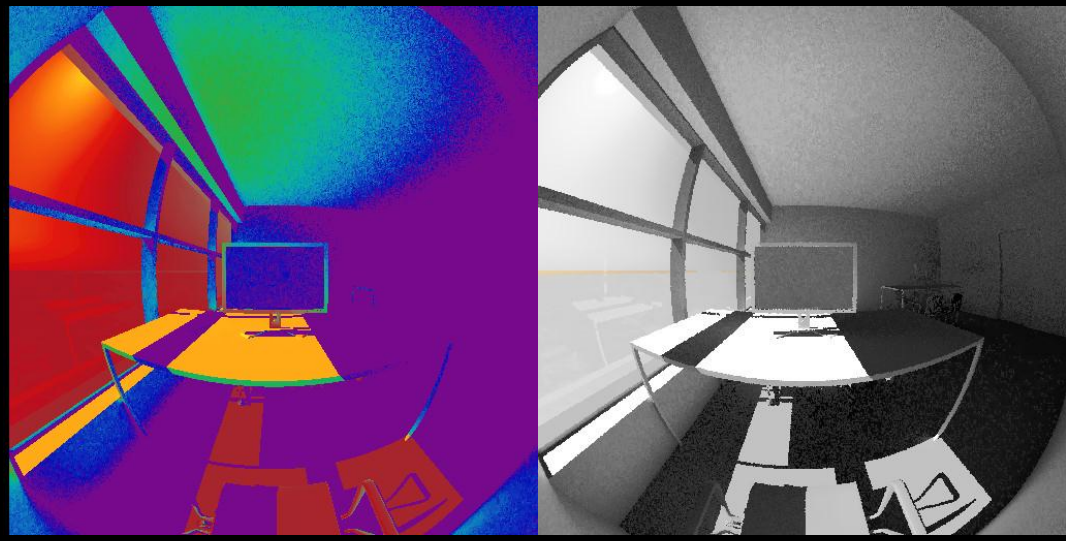

Physically Accurate Simulation
Physically Accurate Ray Paths
Physically Accurate Material Properties
Physically Accurate Geometry
Physiologically Accurate Tone Mapping
Photo-realistic Rendering

Radiance

- Radiance is slow
- Speed affects use
  - Slow simulations occur after design is complete
  - Fast simulations can be repeated as part of the design process
- Low-quality simulations are faster

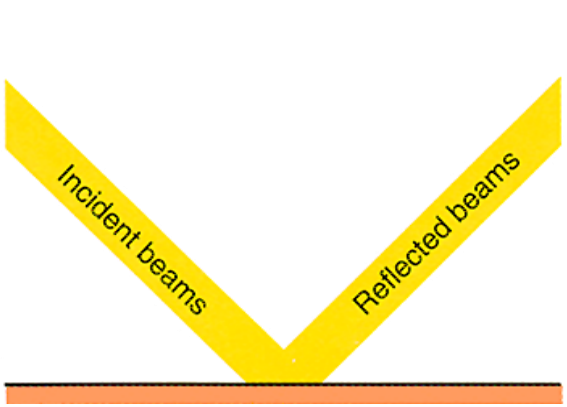


138,844,405 Rays
1.43 Hours

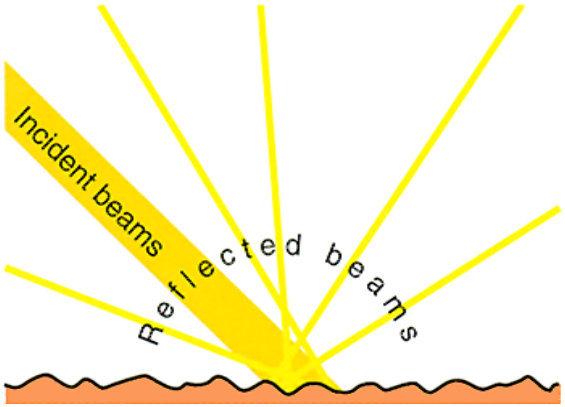


41,010,721 Rays
3.98 Minutes

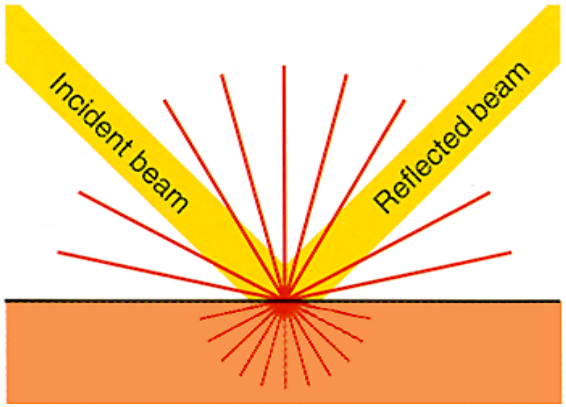
Phong Reflection Model



Specular



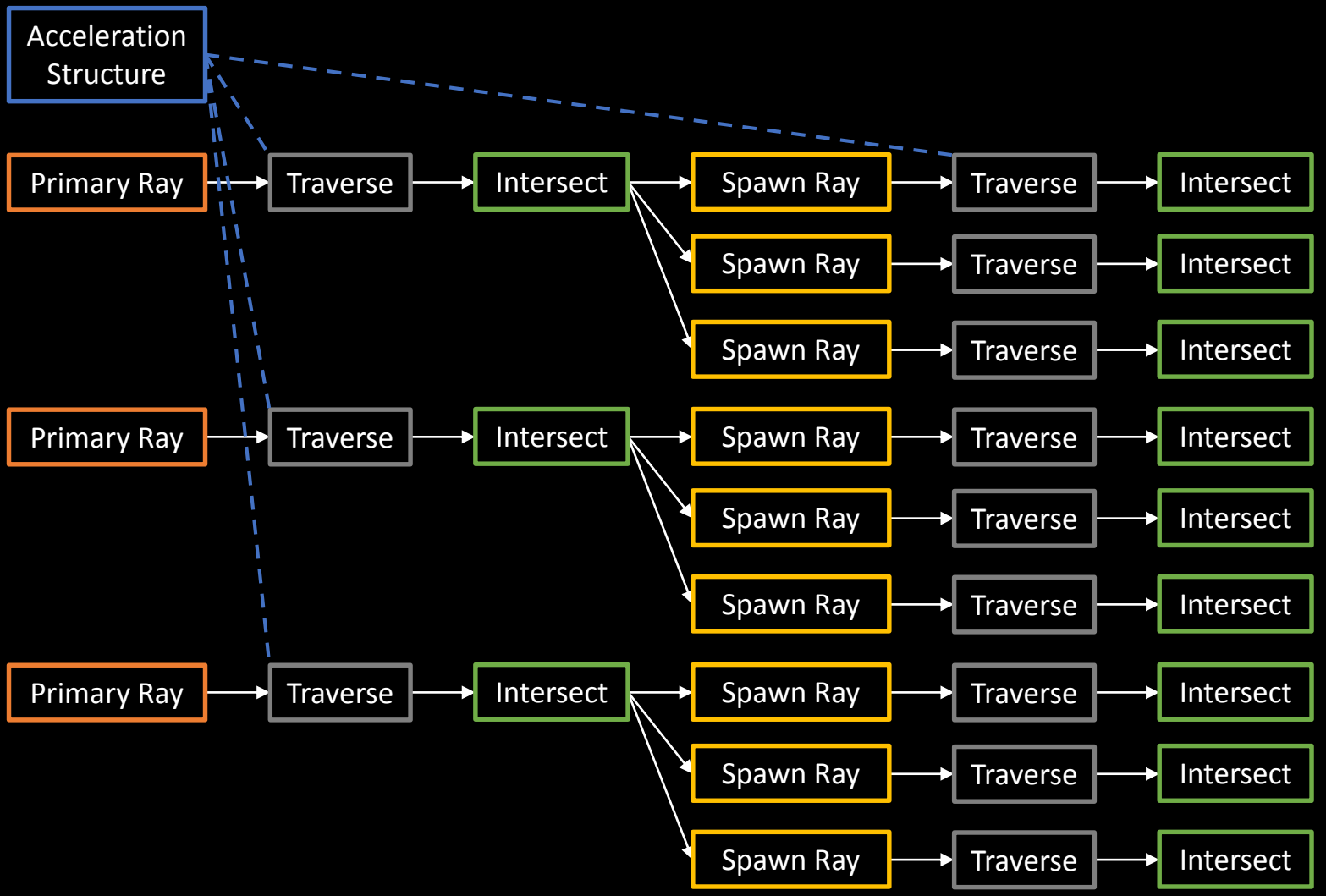
Diffuse



Combination

Roy S. Berns. *Billmeyer and Saltzman's Principles of Color Technology*, 3rd Ed. 2000, John Wiley & Sons, Inc. p 12.

Backward Ray Tracing



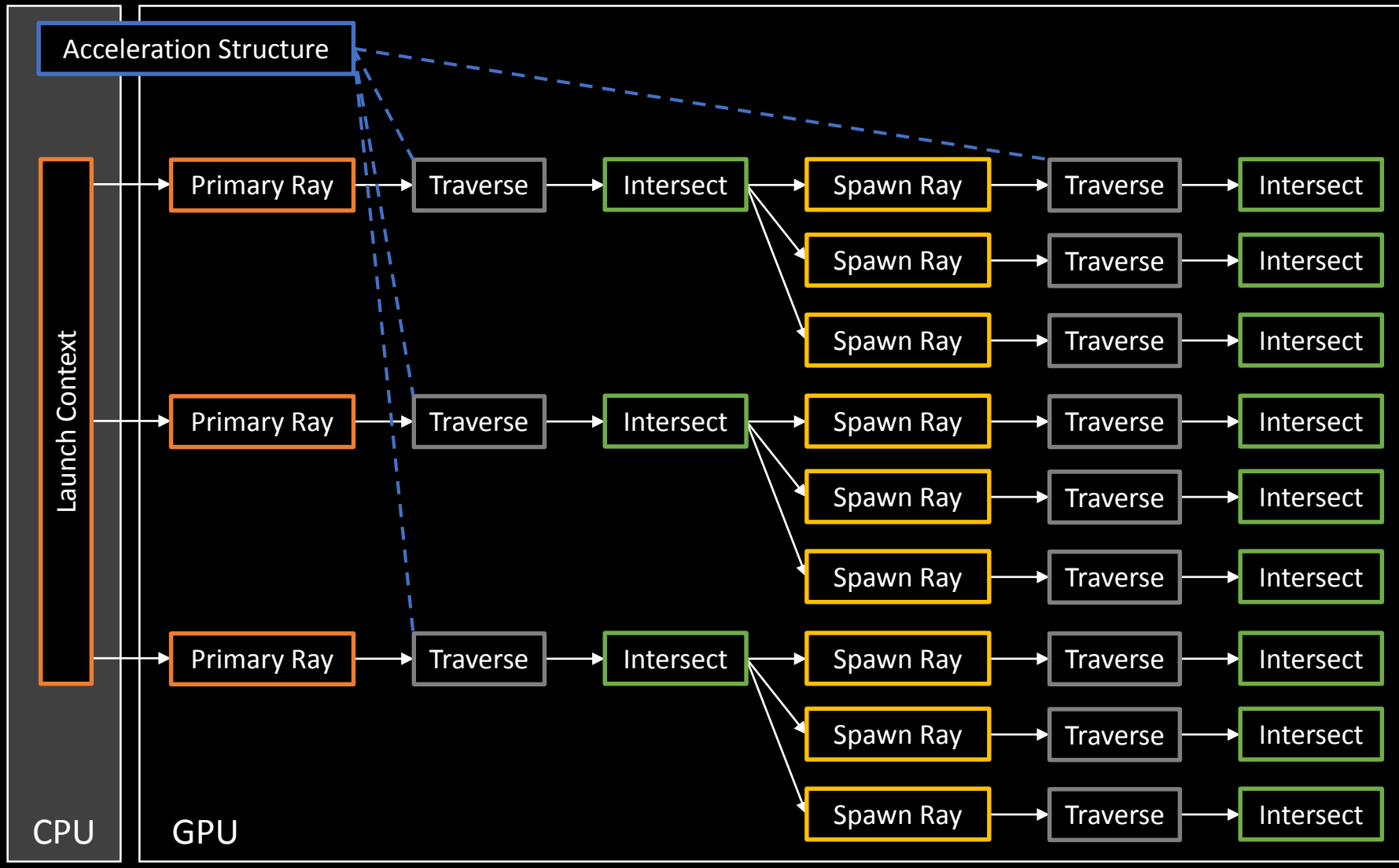
Replace the Engine

http://www.pakwheels.com/blog/2011/12/09/man-straps-cruise-missiles-jet-engine-to-the-roof-of-his-car/

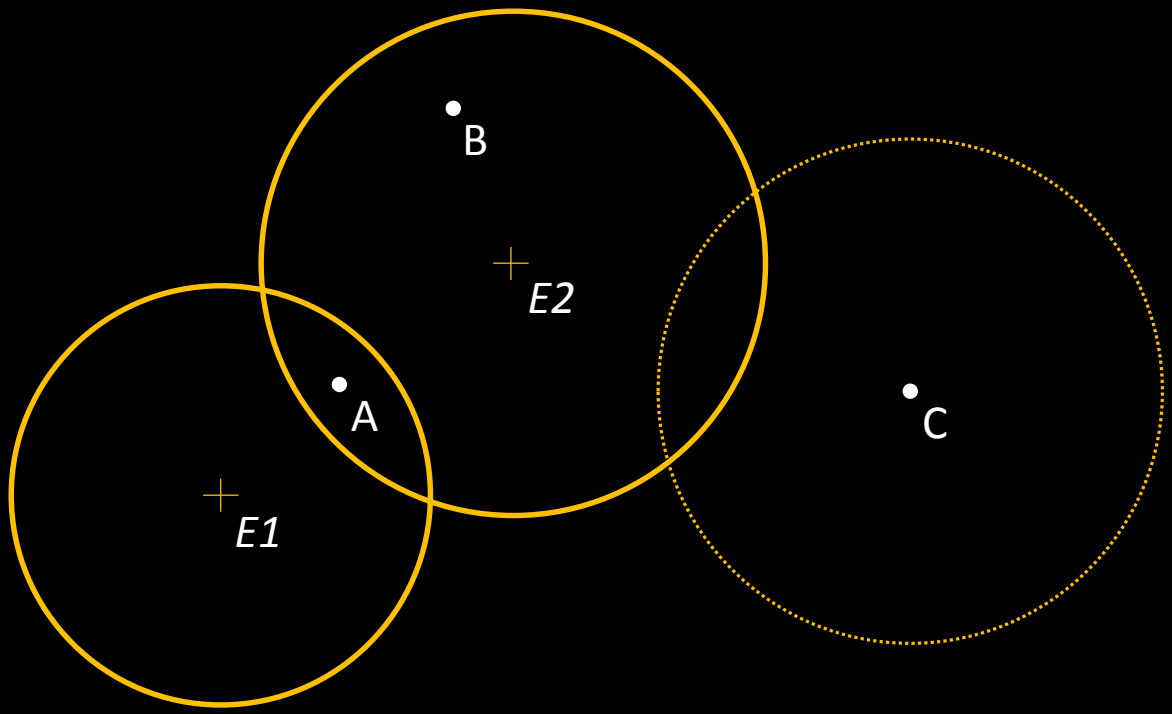
OptiX™

- Free ray tracing engine from NVIDIA®
- Built on top of CUDA™
- Provides
  - Ray traversal using BVH or KD trees
  - User-defined shader programs for ray generation, intersection testing, closest hit, any hit, and miss
  - Interop with OpenGL, Direct3D, and CUDA
- Limitations
  - No `syncthreads()`
  - No `cudamalloc()`

Backward Ray Tracing with OptiX™

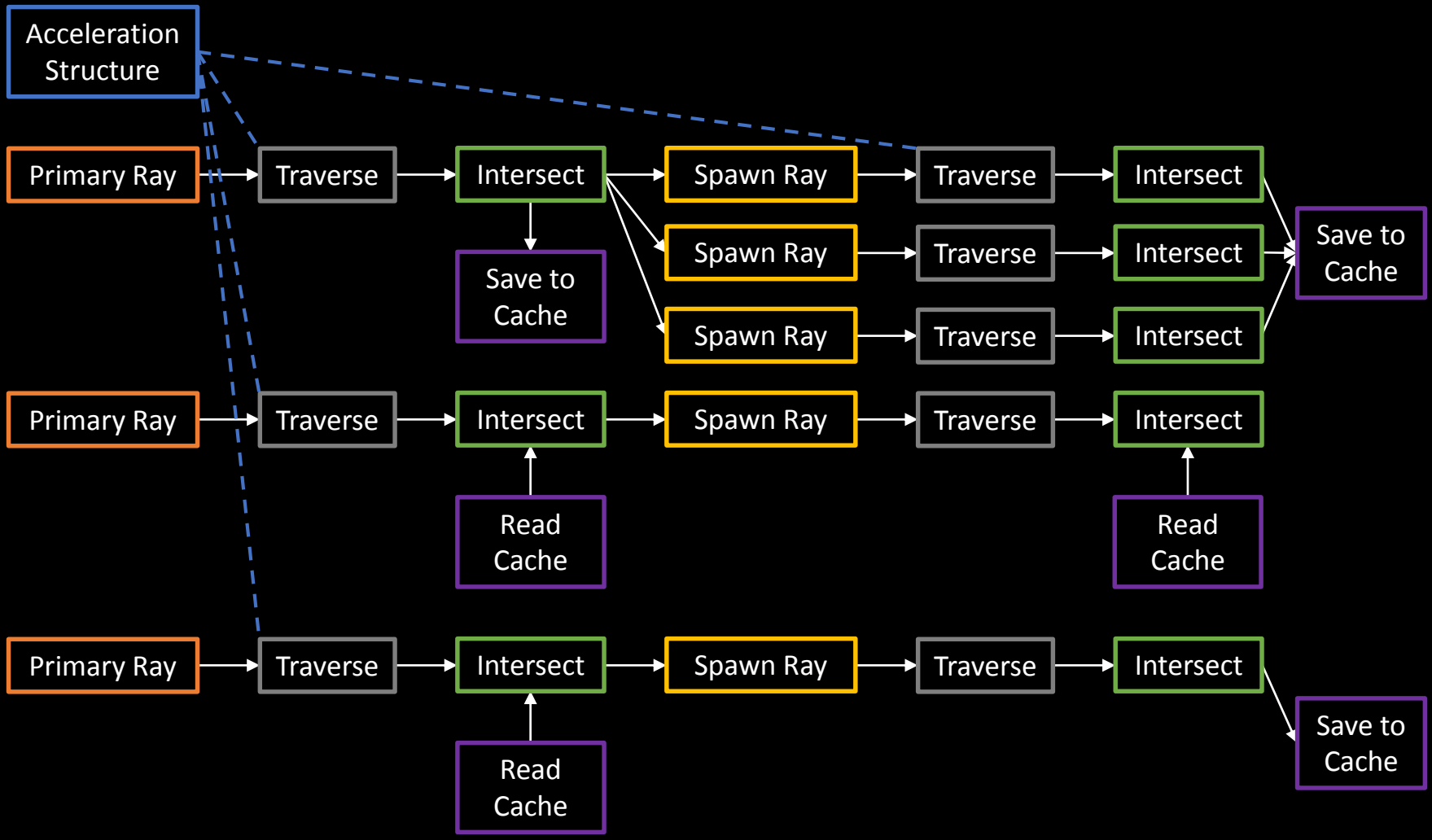


Irradiance Caching



Gregory Ward Larson and Robert Shakespeare, 1998. *Rendering with Radiance*. San Francisco: Morgan Kaufmann Publishers, Inc. p 544.

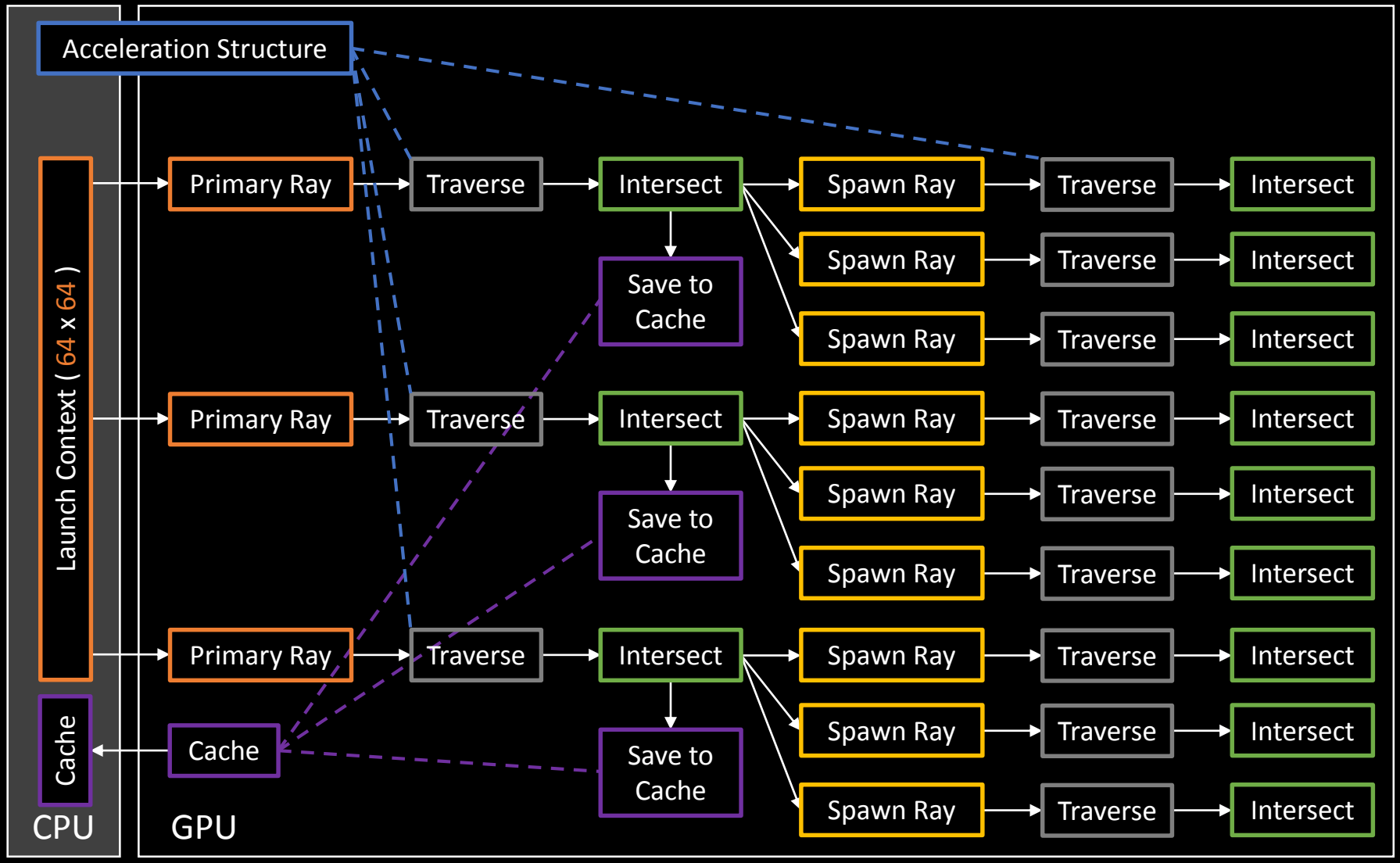
Irradiance Caching



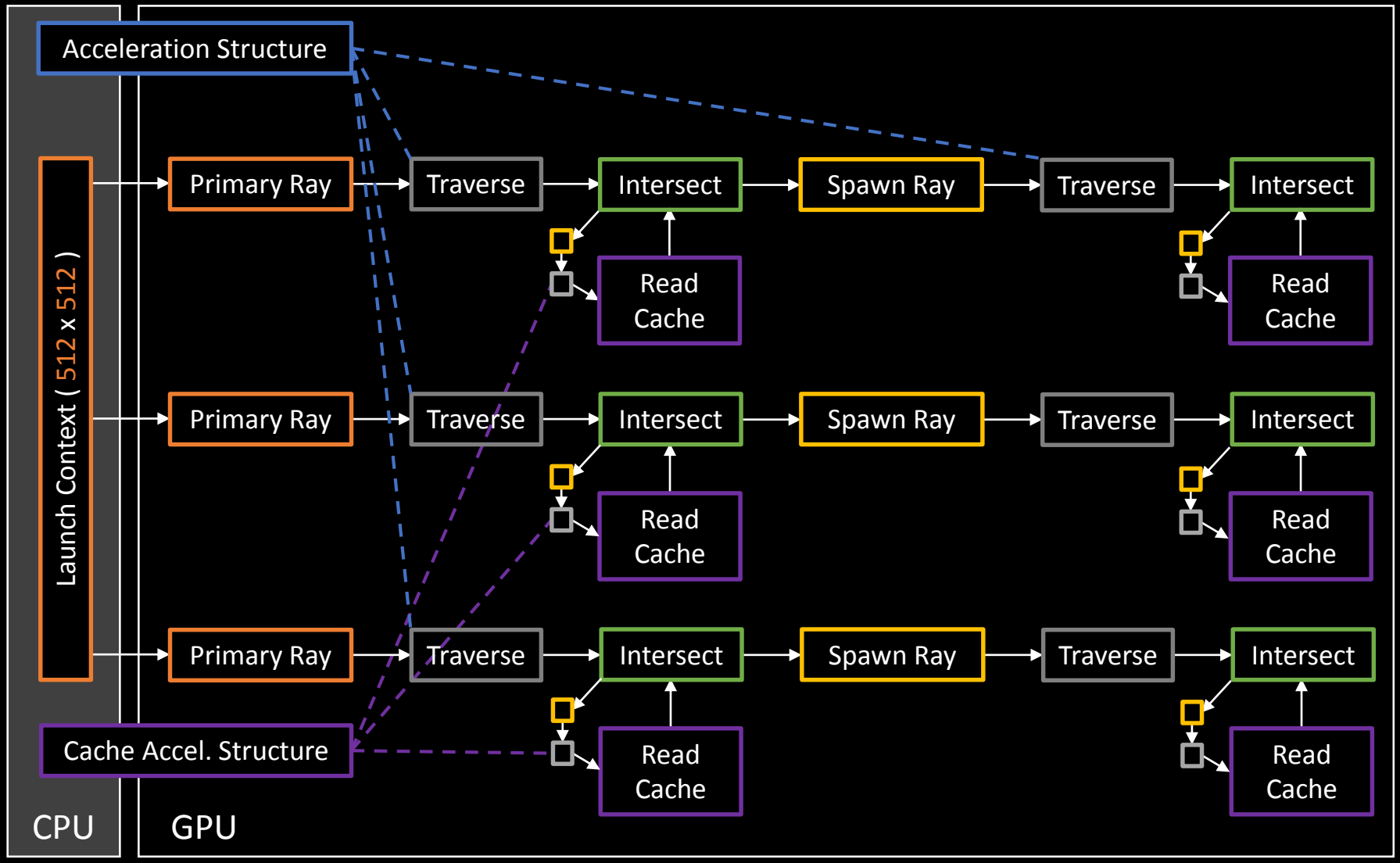
Irradiance Caching

- CPU cluster
  - Network file locks [Larson and Shakespeare, 1998]
  - MPI [Koholka *et al*., 1999][Debattista *et al*., 2006]
  - Wait-free cache [Dubla *et al*., 2009]
- GPU
  - Photon mapping [Wang *et al*., 2009]
  - Splatting [Křivánek and Gautron, 2009]
  - Multi-pass [Frolov *et al*., 2012]

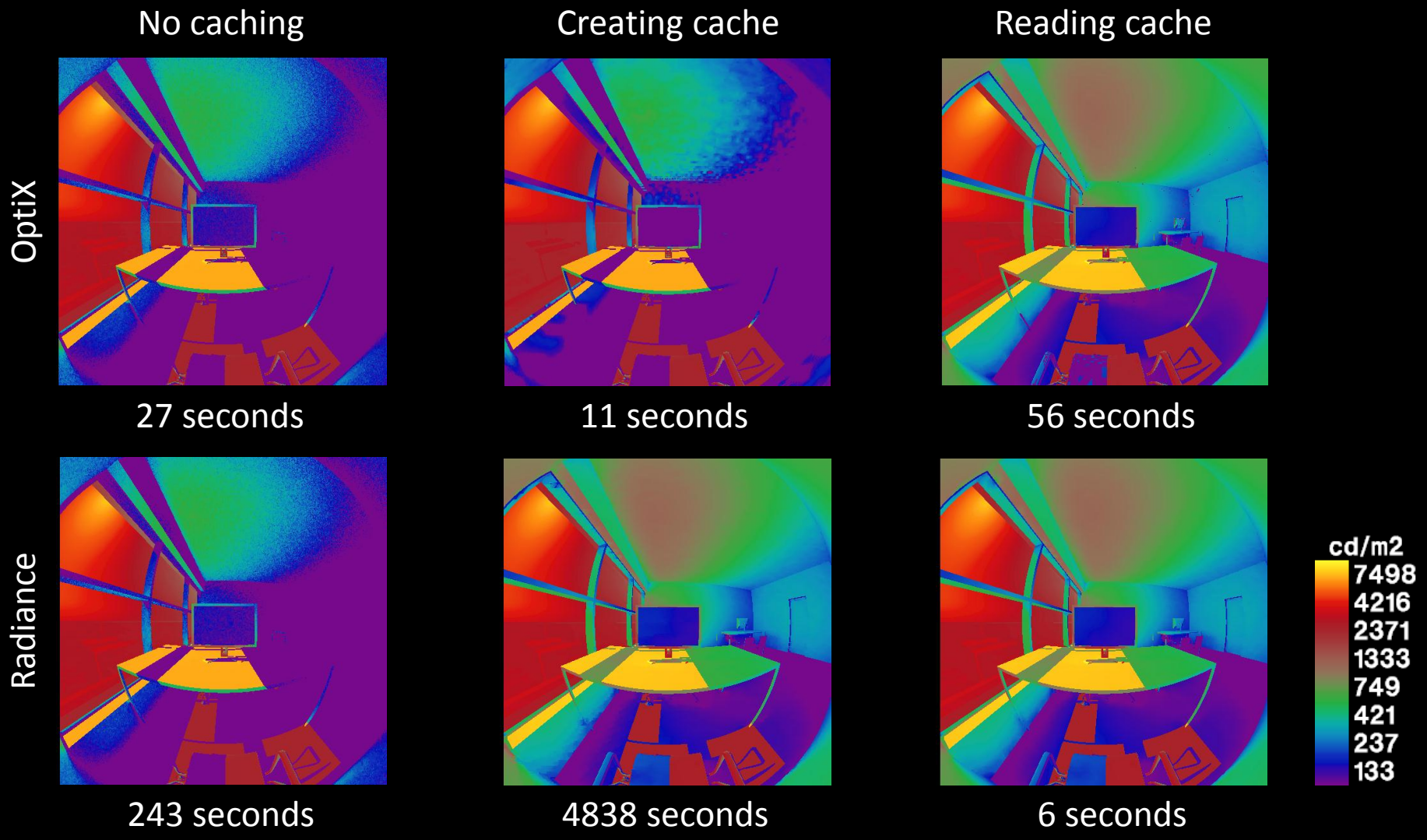
Irradiance Caching with OptiX™



Irradiance Caching with OptiX™

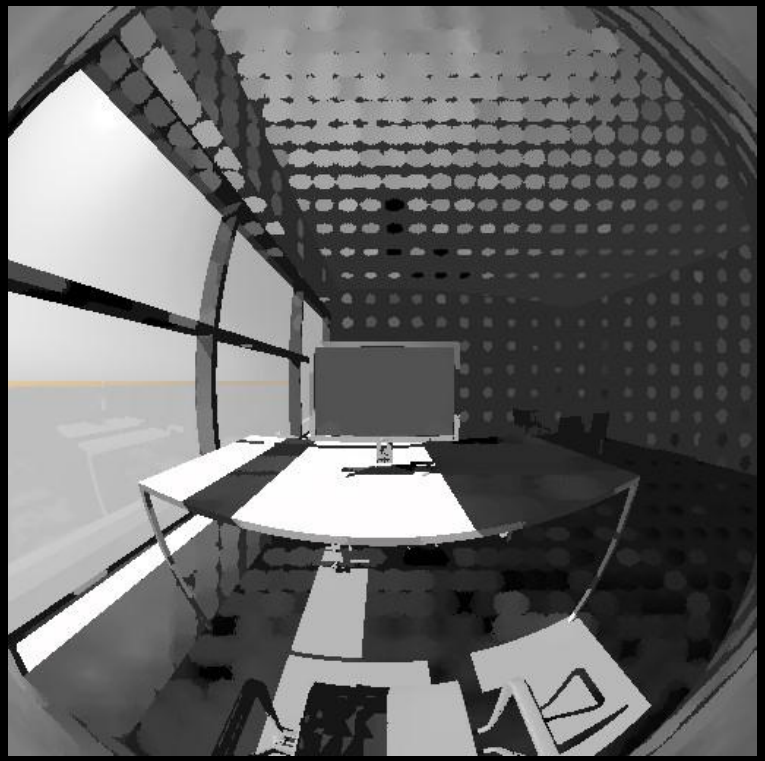


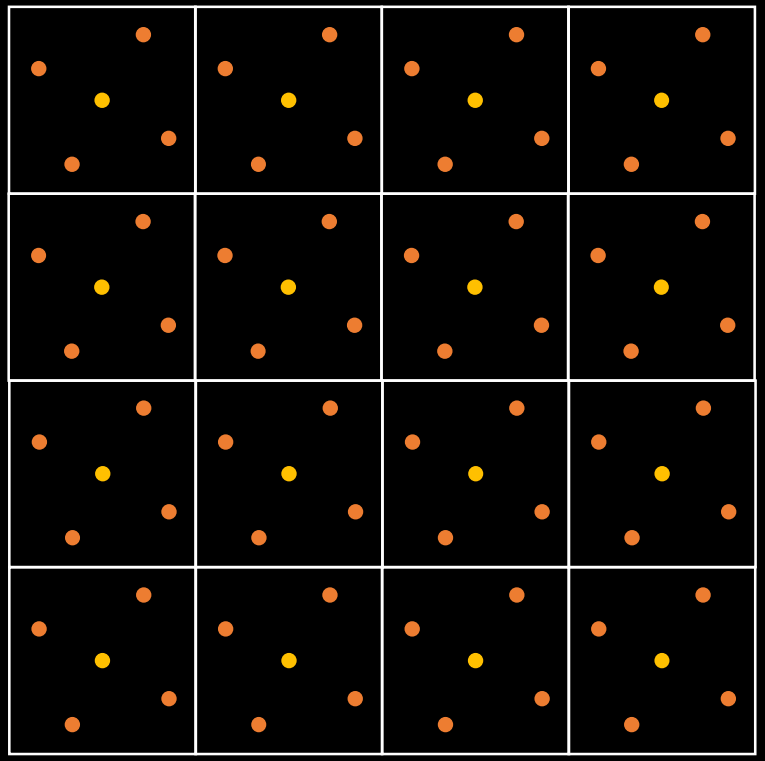
Results


No caching
Creating cache
Reading cache
OptiX
Radiance
27 seconds
11 seconds
56 seconds
243 seconds
4838 seconds
6 seconds
cd/m2
7498
4216
2371
1333
749
421
237
133

To Do...

- Adaptive cache sampling density





To Do...

- Adaptive cache sampling density
- Missing radiance problem
  - Reduce ray extinction rate
  - Cache 2nd and 3rd bounces
- Improve timings
  - Code optimization
  - Reduce memory transfer
  - Better hardware

Questions?

Nathaniel Jones <nljones@mit.edu>