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Adaptive Environment Sampling on CPU and GPU

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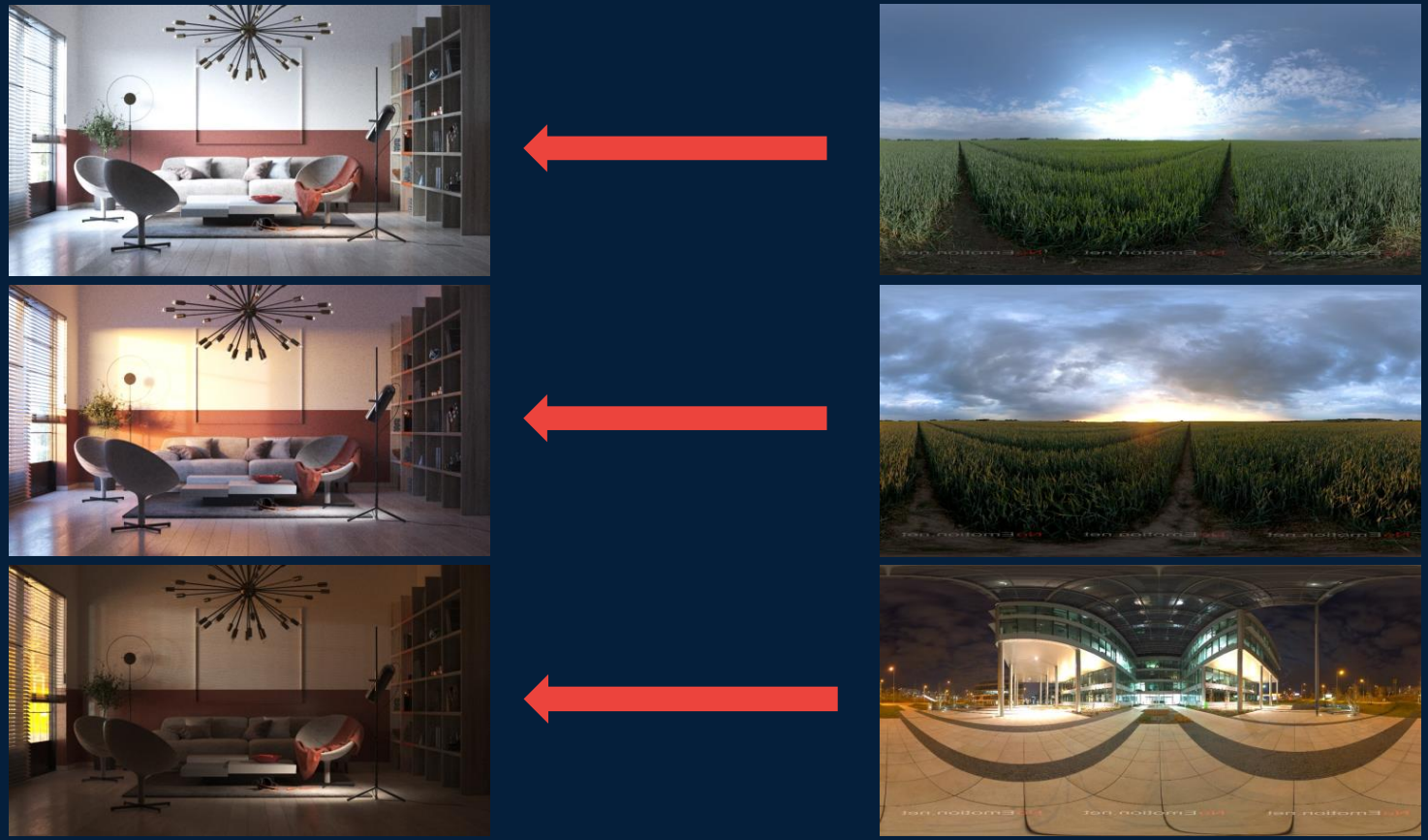
Image-based lighting (IBL)



HDR images courtesy of NoEmotion

IBL noise

Portals

Existing solutions

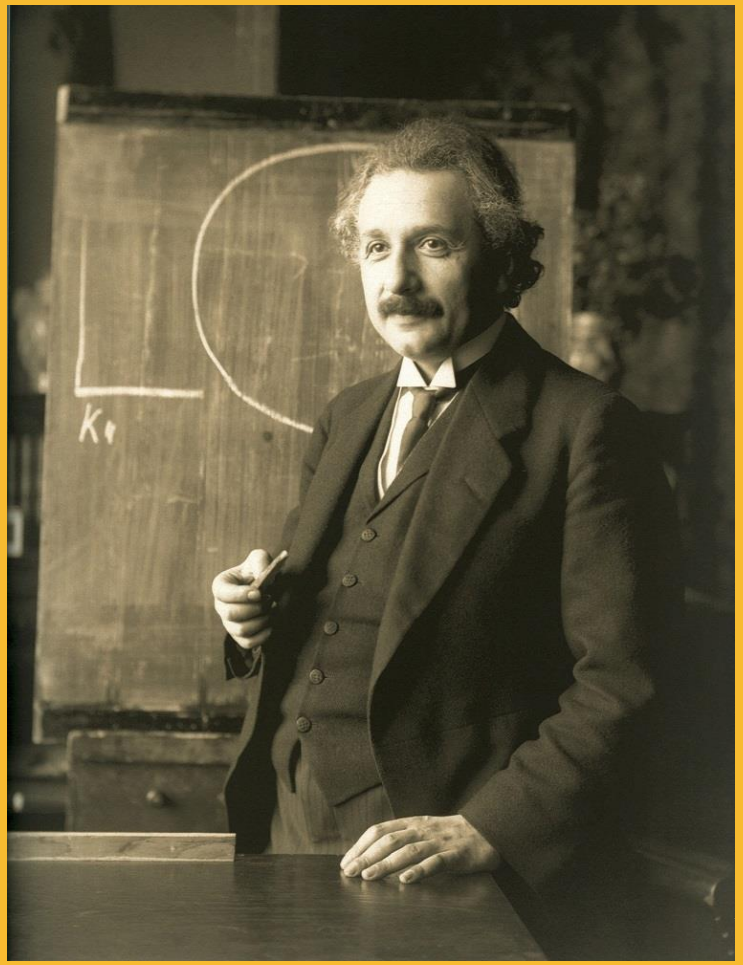
- Rely on portals
- High memory consumption
- Expensive computation
- Complex data structures

Guidelines

- Complex production occluded scenes
- CPU and GPU
- Account for visibility
- Lightweight sampling procedure
- No user manual work
- Low memory usage
- Simple to implement

Everything should be made as **simple** as possible, but not simpler.

~Albert Einstein

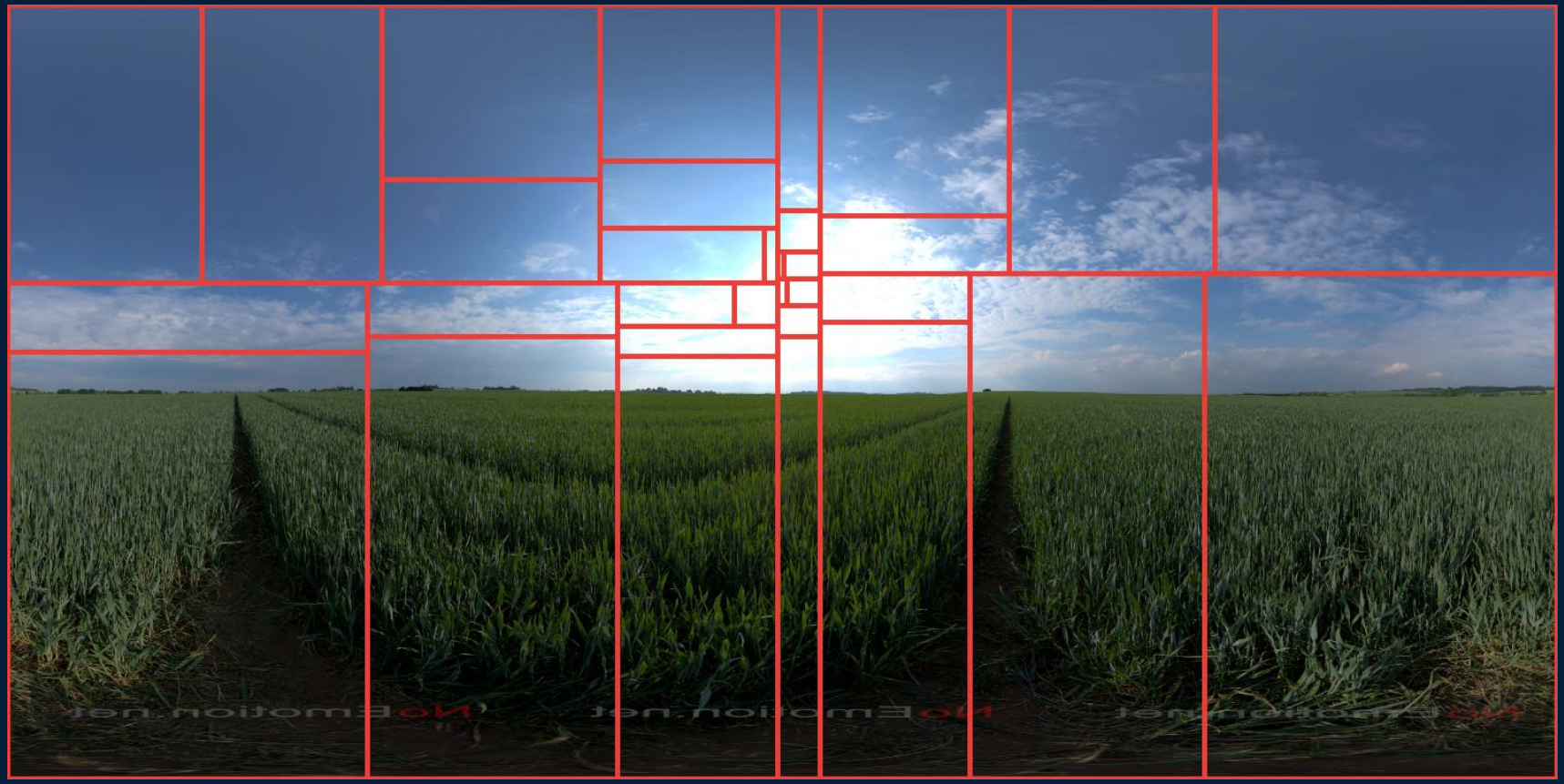


Our Adaptive Sampling

- Partition the environment map
- The Light Grid
  - Visibility cache
  - In the camera space
- Two-phase approach
  - Learning
  - Rendering

Office scene courtesy of Evermotion

32 equal-energy tiles



HDR image courtesy of NoEmotion

32 equal-energy tiles

HDR image courtesy of NoEmotion

32 equal-energy tiles - very **thin** tiles

HDR image courtesy of NoEmotion

4 x 8 equal-sized tiles

HDR image courtesy of NoEmotion

Equal-energy tiles

- Thin and long tiles
- Degenerate tiles around bright spots
- Traversal or more memory for point-in-tile test

HDR images courtesy of NoEmotion

Equal-sized tiles

- Equal square tiles
- Robust and simple partitioning
- Faster point-in-tile test

The Light Grid

- G_x x G_y spherical grid - $G_x = 2G_y$
- In the camera space

The Light Grid

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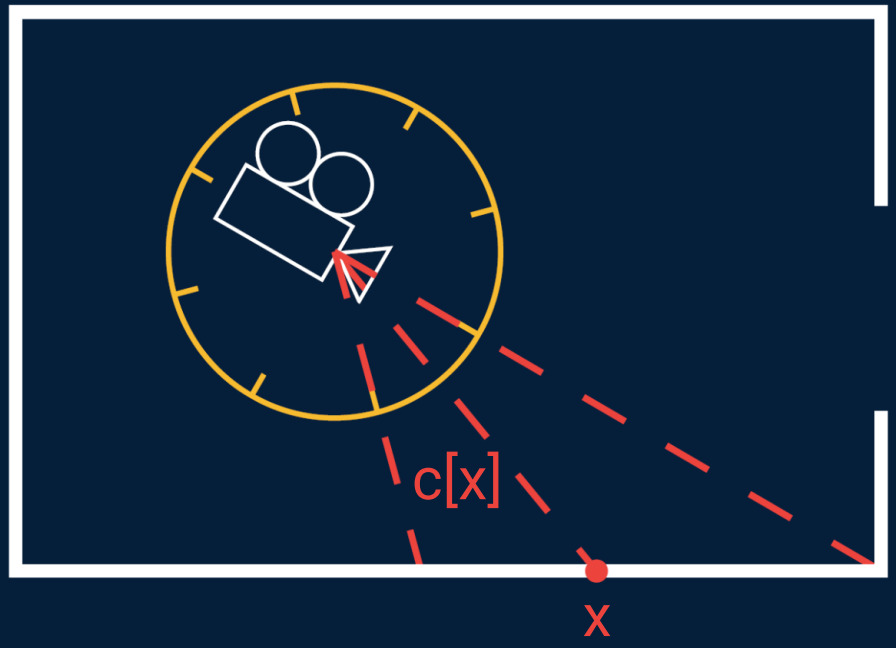
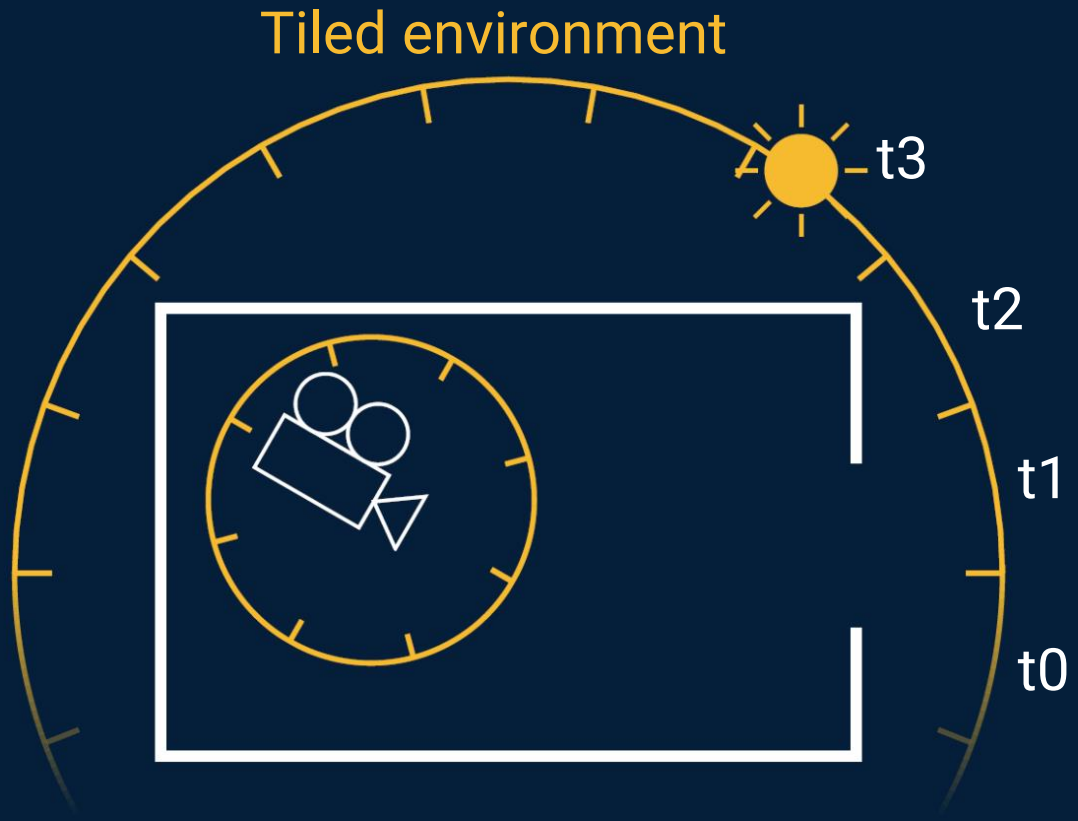
- Each scene point belongs to a Light Grid cell

The Light Grid

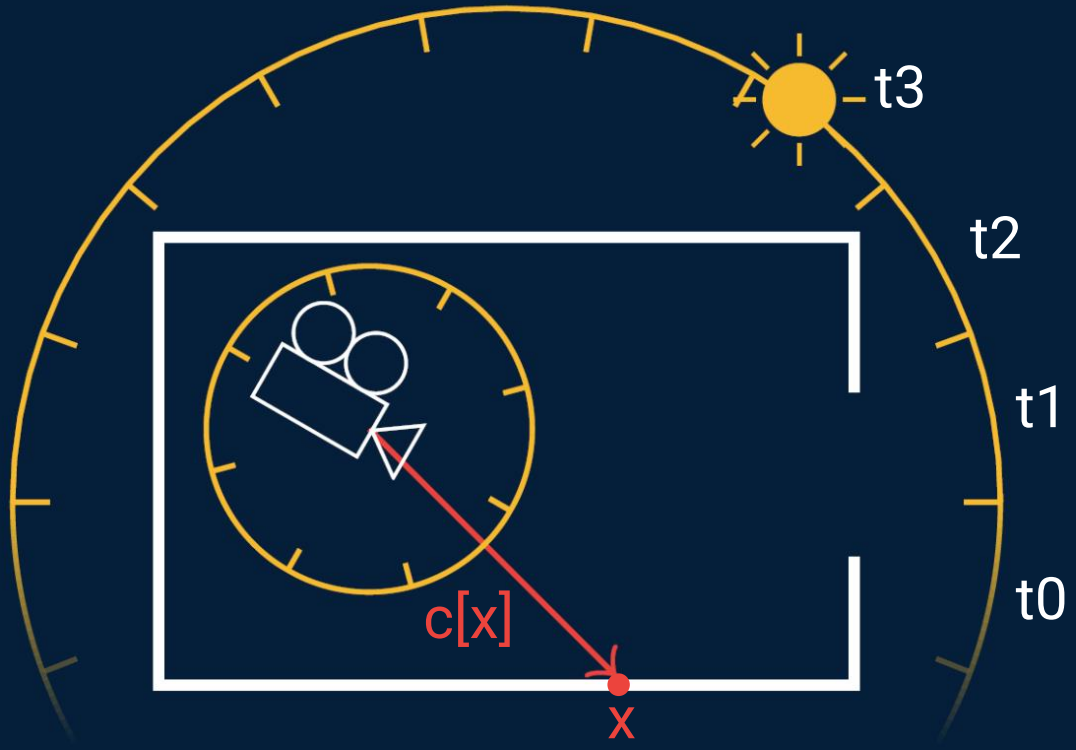


- G_x x G_y spherical grid - $G_x = 2G_y$
- In the camera space
- Each scene point belongs to a Light Grid cell

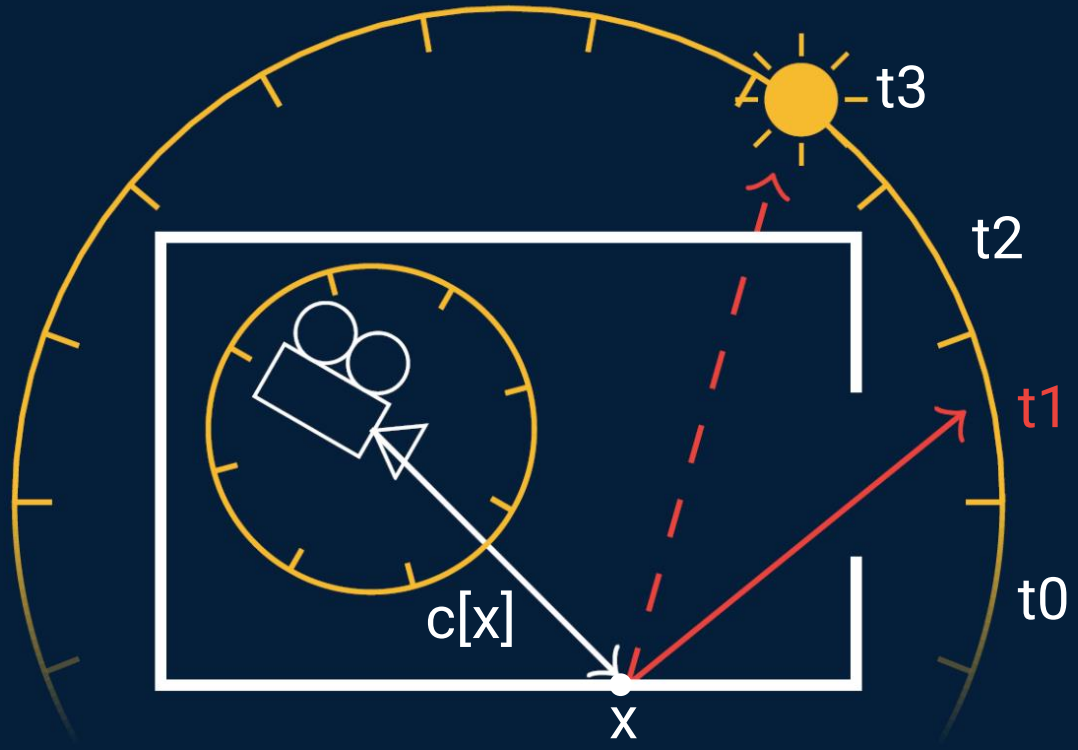
Learning phase



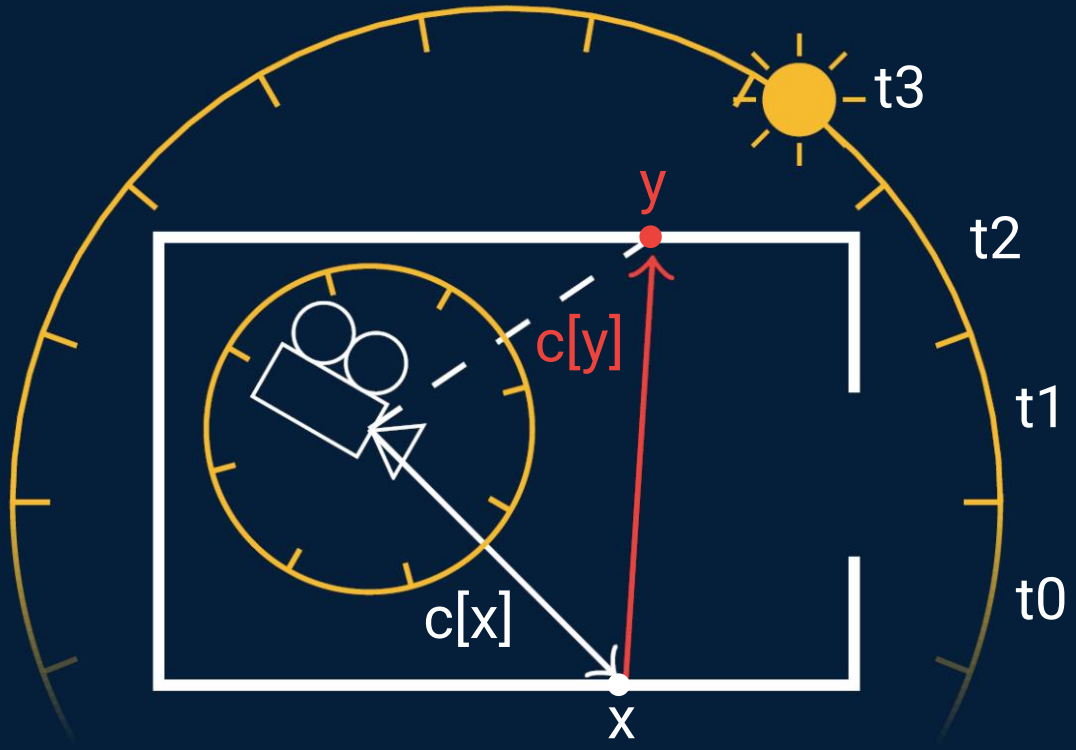
Learning phase



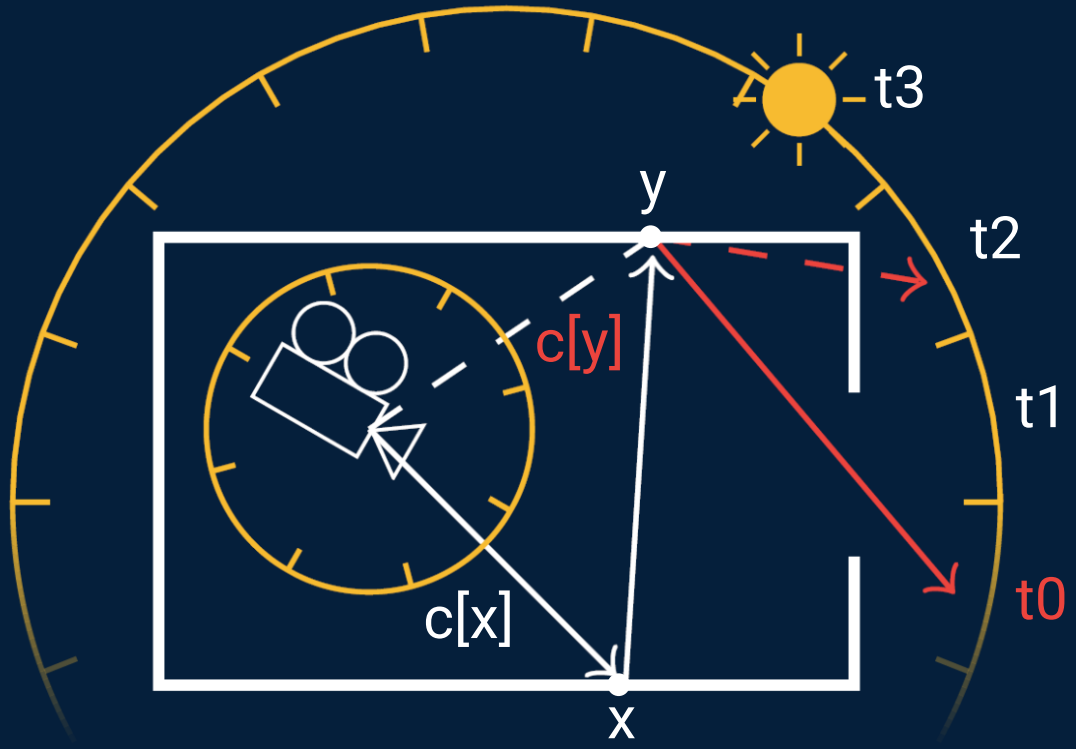
Learning phase



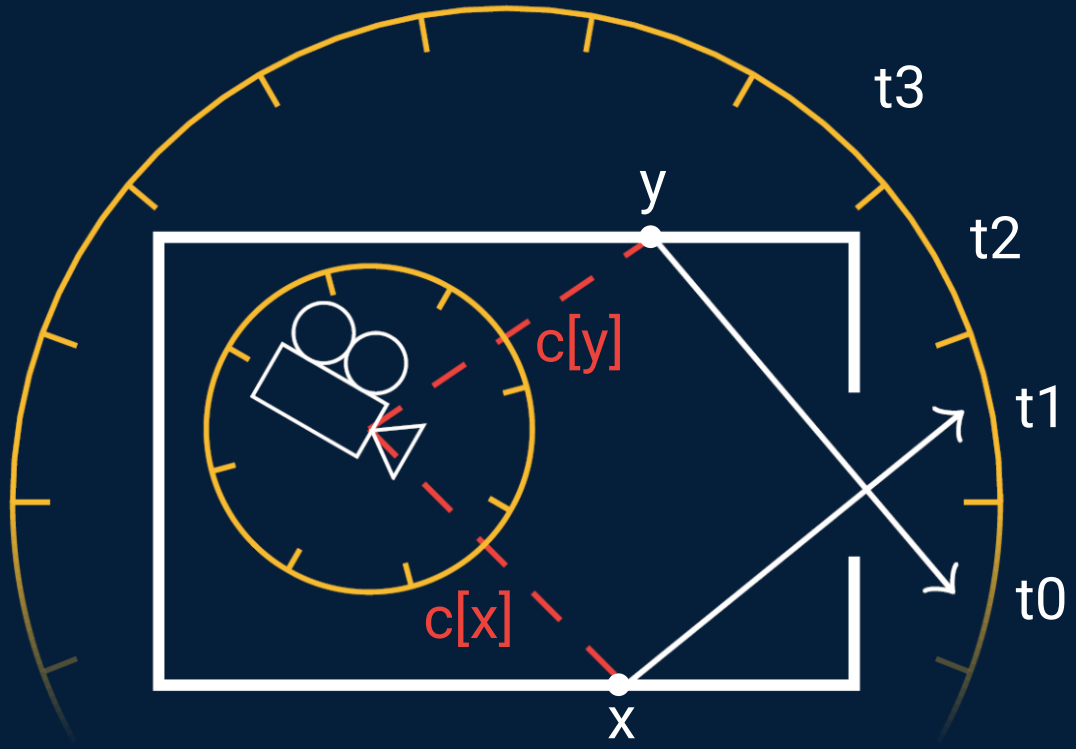
Learning phase



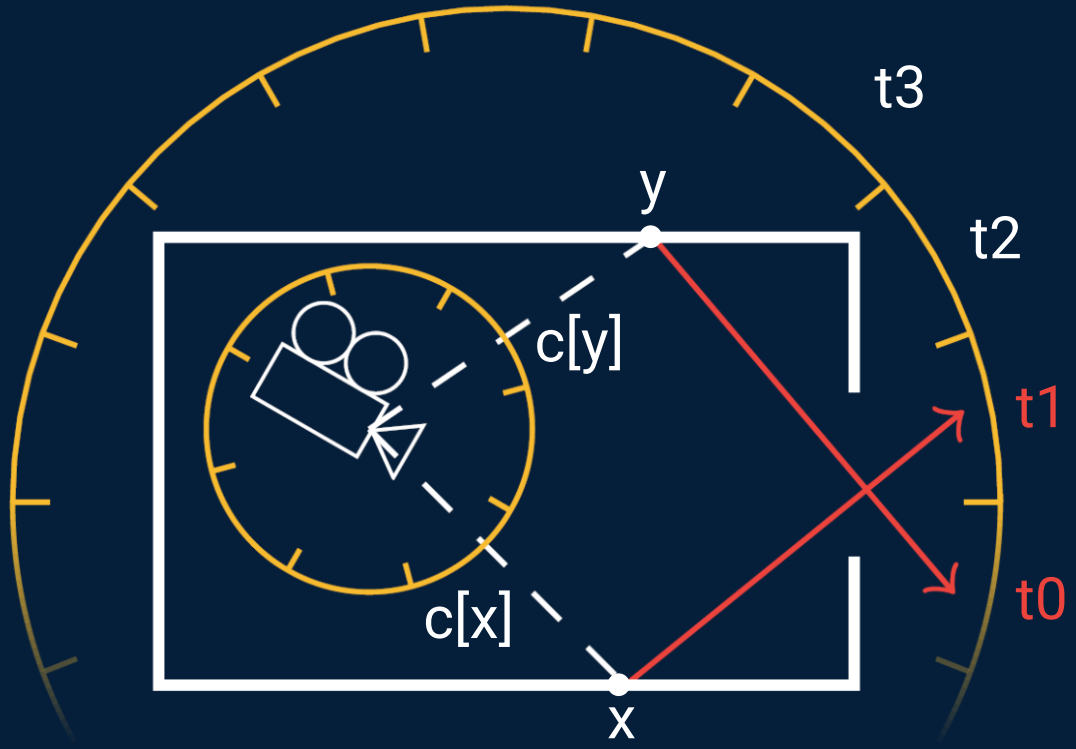
Learning phase



Rendering phase

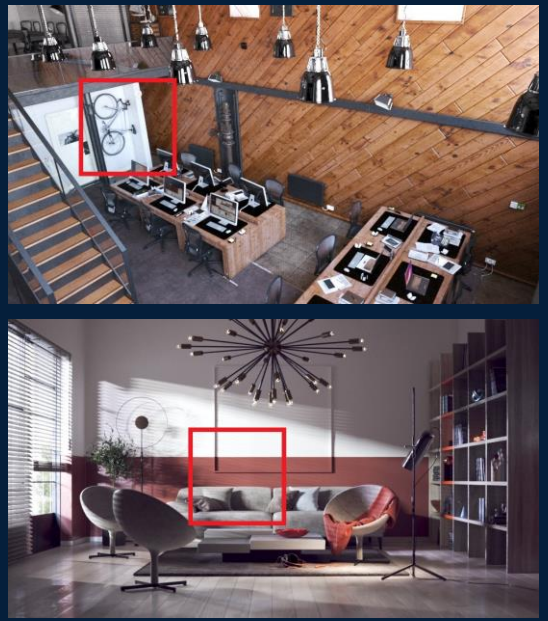


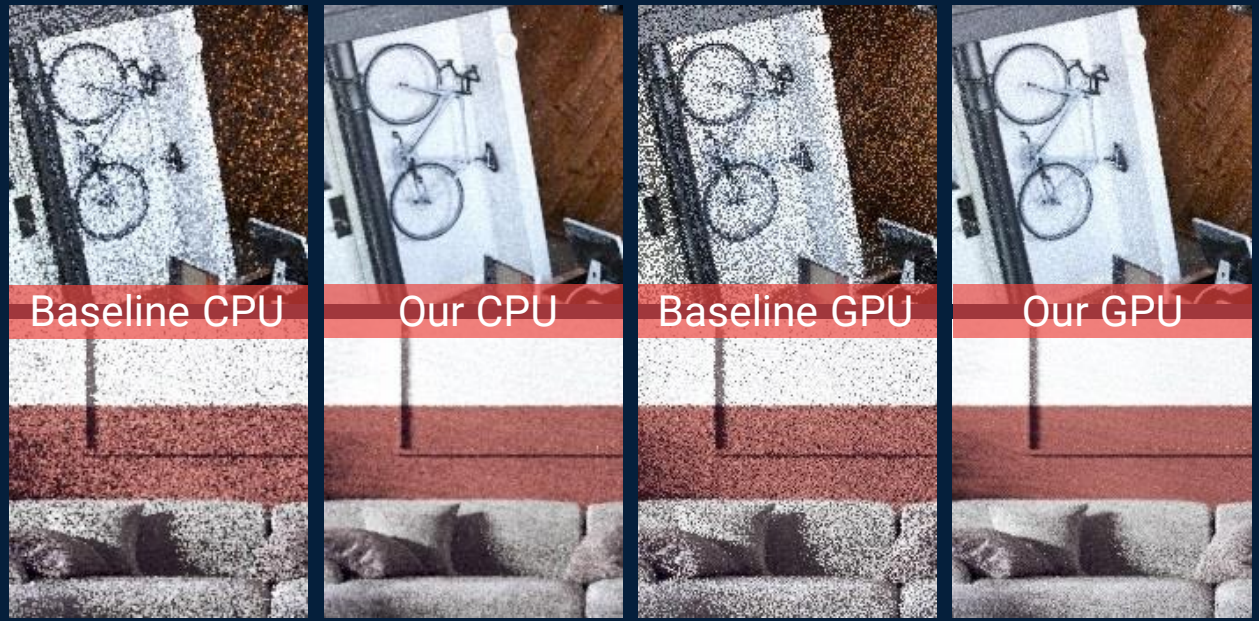
Rendering phase



Results

Office CPU: x6.6 GPU: x3.8





Living room CPU: x2.7 GPU: x2.4

Office scene courtesy of Evermotion

Results

HDR “Day”

CPU: x2.2 GPU: x1.6

HDR “Sunset”

CPU: x1.9 GPU: x1.6

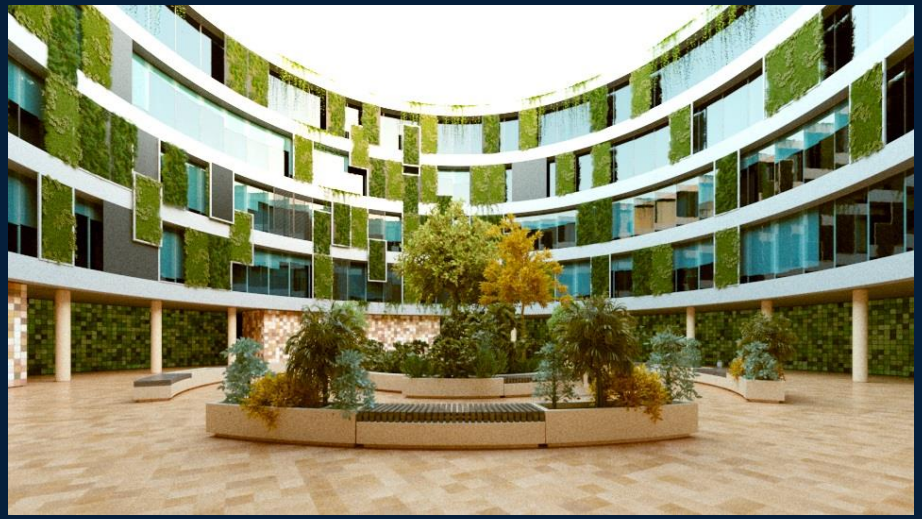
HDR “Night”

CPU: x3.8 GPU: x3.0

HDR images courtesy of NoEmotion

Exterior and participating medium

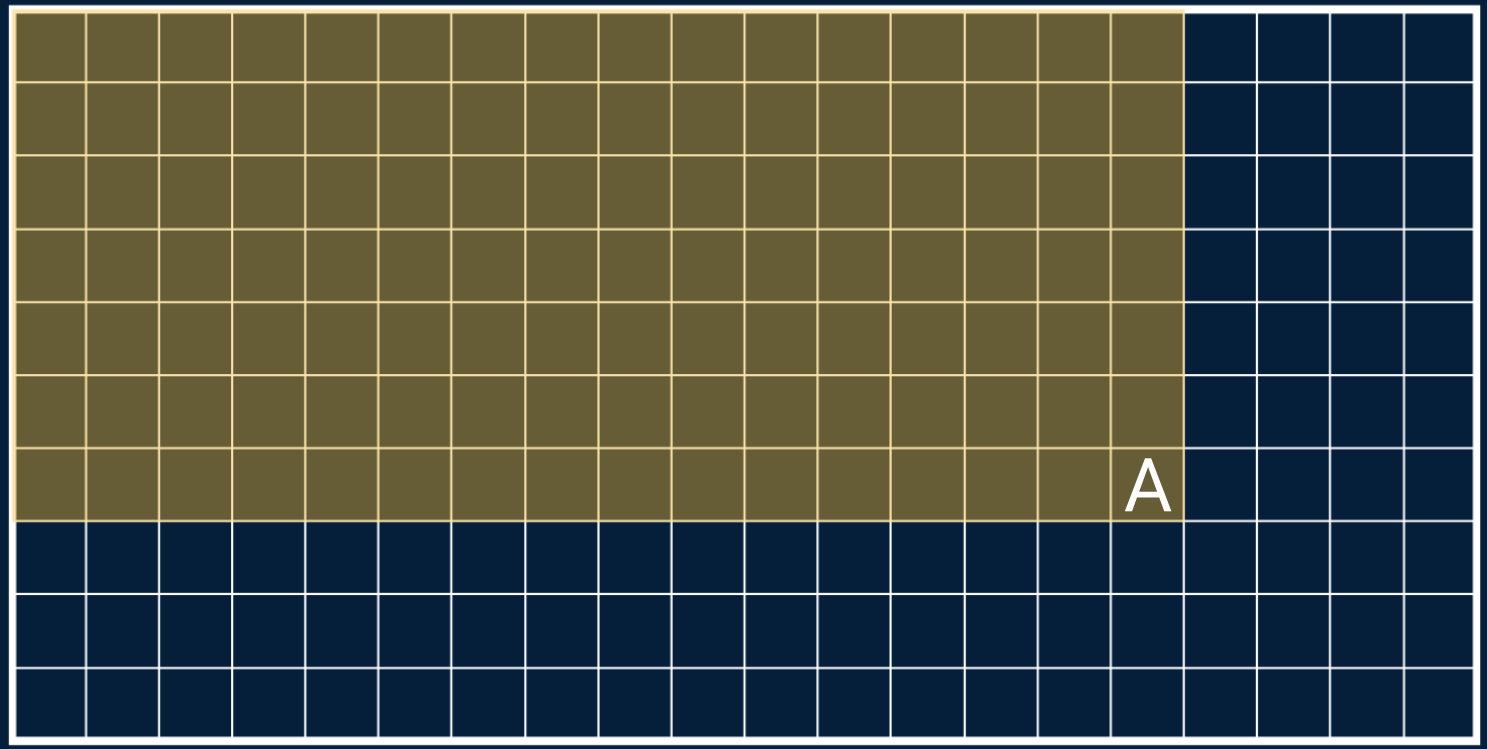
CPU: x2.3 GPU: x1.8 CPU: x3.4 GPU: x2.6



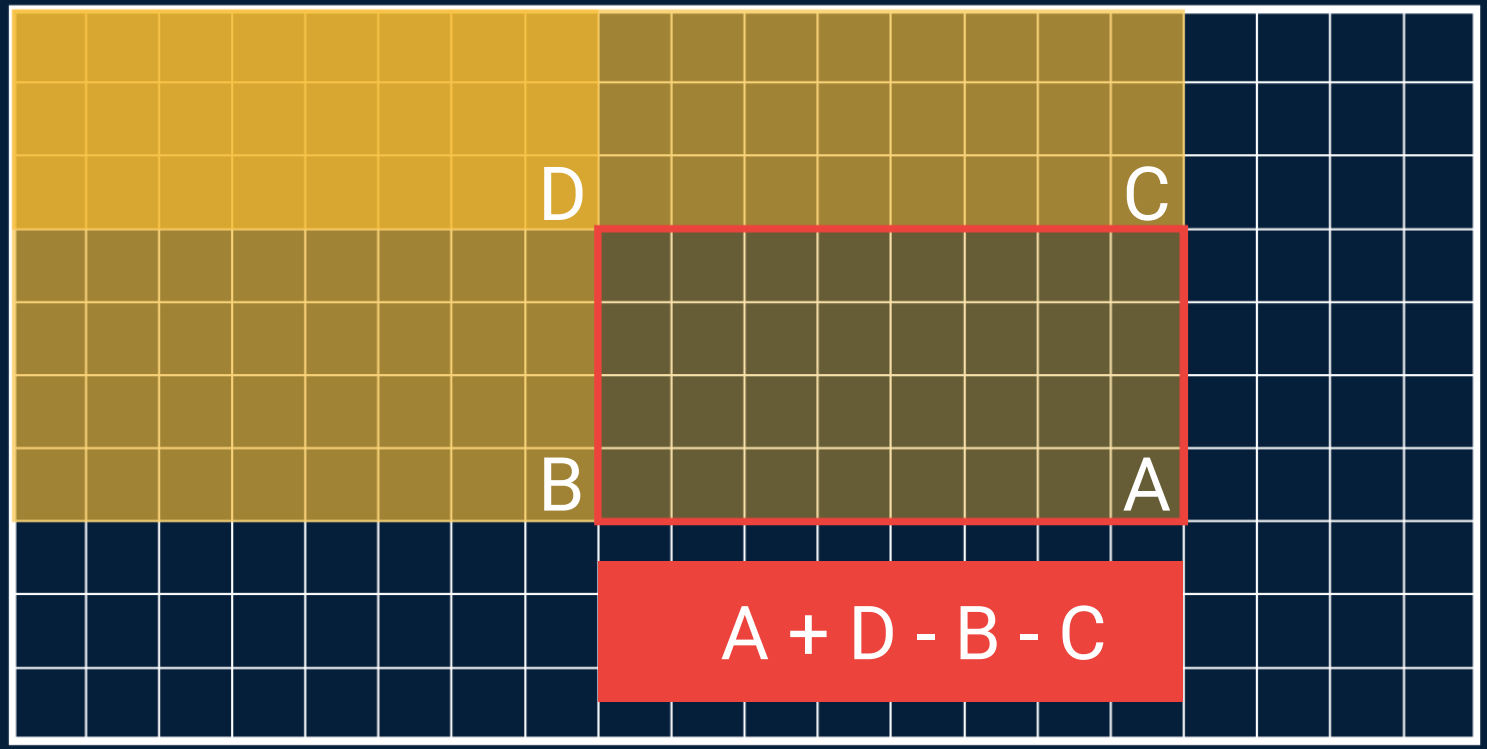
Implementation details

- CPU and GPU
- 10% - 700% speedup
- 10MB memory
- Learning:
  - 10^6 camera paths
  - ~ 1% of the render time
  - accumulation with fetch-and-add instructions
- Summed Area Table for sampling

Summed-area table (SAT)



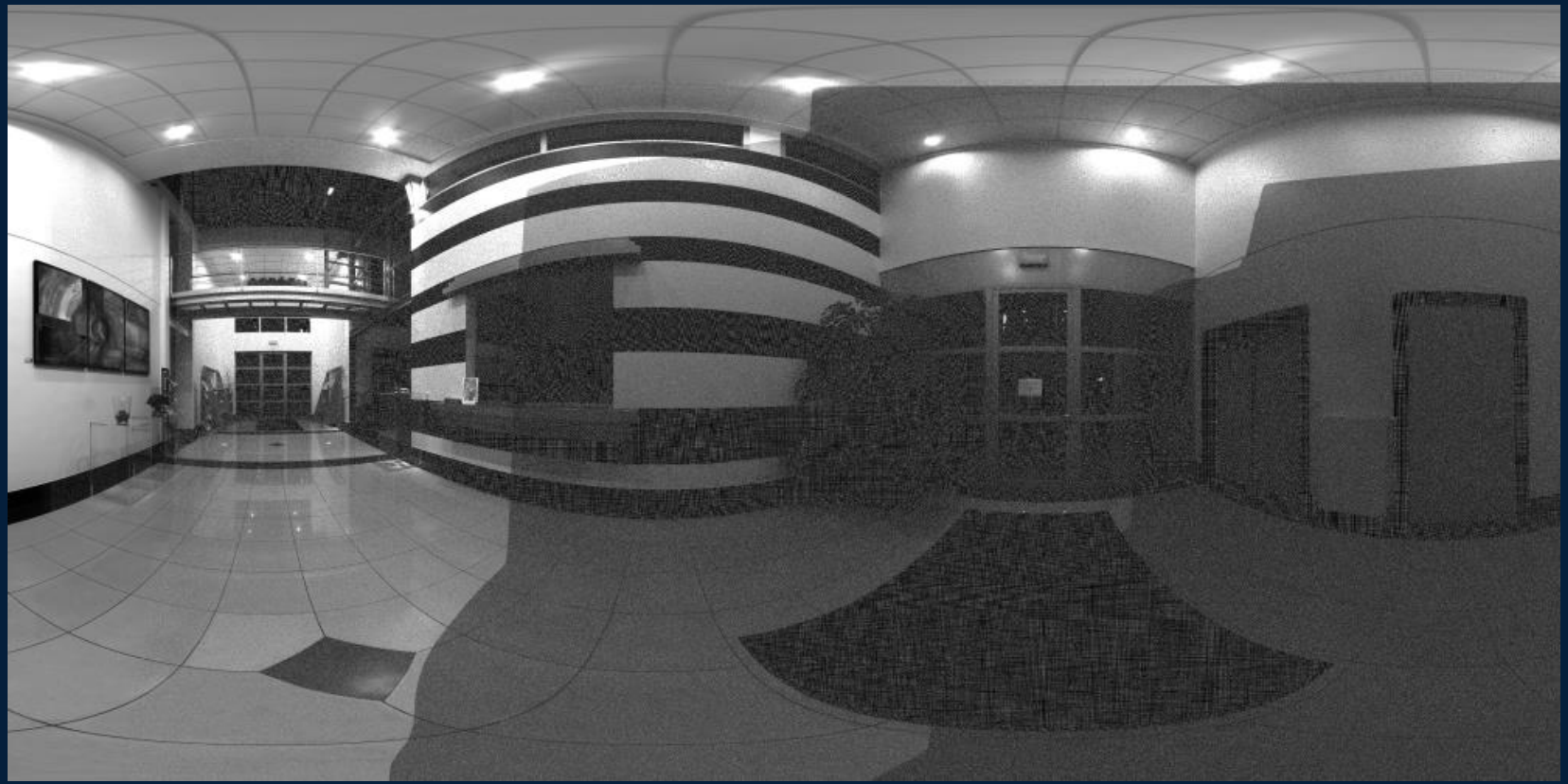
SAT for sampling



Hallway HDR image (10000x5000)

HDR image courtesy of Wouter Wynen (Aversis 3D)

Sampling reconstruction - 32-bit Float SAT



HDR image courtesy of Wouter Wynen (Aversis 3D)

Sampling reconstruction - 32-bit Integer SAT

HDR image courtesy of Wouter Wynen (Aversis 3D)

Integer-valued SAT vs. float-valued SAT

HDR image	Resolution	Int MSE	Float MSE
Hallway	10000x5000	1.0×10^{-5}	3.8×10^{-1}
Day	15000x7500	4.9×10^{-7}	8.6×10^{-3}
Night	3000x1500	1.4×10^{-8}	4.1×10^{-4}
Sunset	3000x1500	1.1×10^{-8}	3.6×10^{-4}

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Q & A