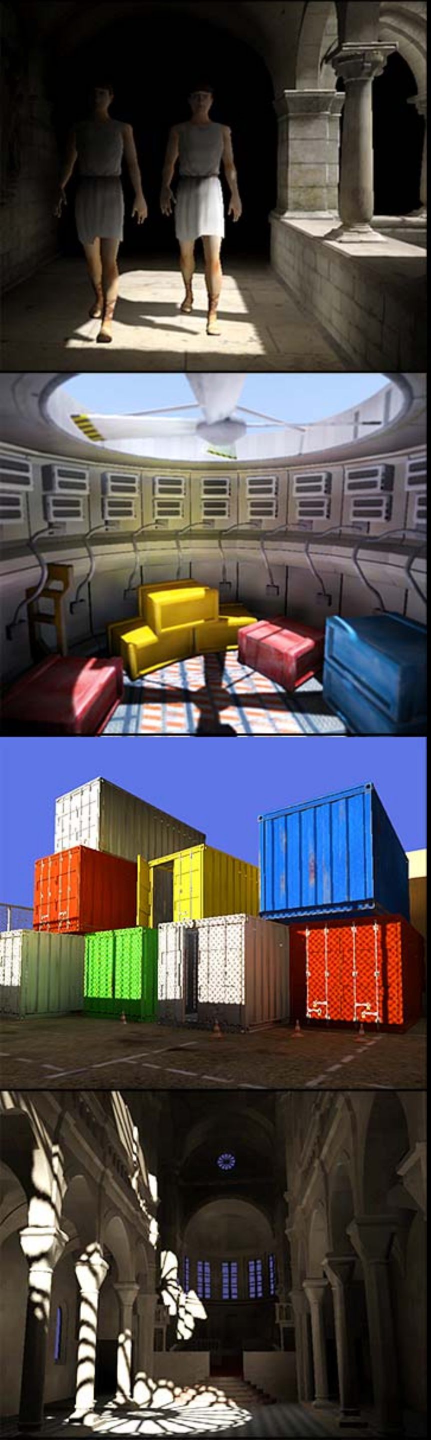

Real-Time Diffuse Global Illumination Using Radiance Hints

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HPG 2011

Motivation

- Why build yet another RTGI method?
  - Significant number of existing techniques
  - RSM, CLPV, VBGI etc

Motivation

- Why build yet another RTGI method?
  - Significant number of existing techniques
  - RSM, CLPV, VBGI etc
- Wanted a diffuse GI method that:
  - Is stable enough (no view dependence, no flickering etc)
  - Can capture multiple light bounce effects
  - Is fast enough to be of practical use
  - Has limited requirements → easy to integrate to rendering engines

Main Idea

- Why not combine the benefits of existing methods?
- RT Radiance Caching
  - Fast to sample
  - Stable
- But use Reflective Shadow Maps to populate RC
  - Cheap creation (additional data in SM MRTs)
  - Camera view independent
  - Good scaling (e.g. importance sampling)
- Additional functionality for multiple bounces and occlusion

Method Outline

Repeat for all RSMs

For all Radiance Hints (all RH volume texels):

- Sample RSM radiance and encode it as SH

Repeat for 2…N bounces

For all Radiance Hints (all RH volume texels):

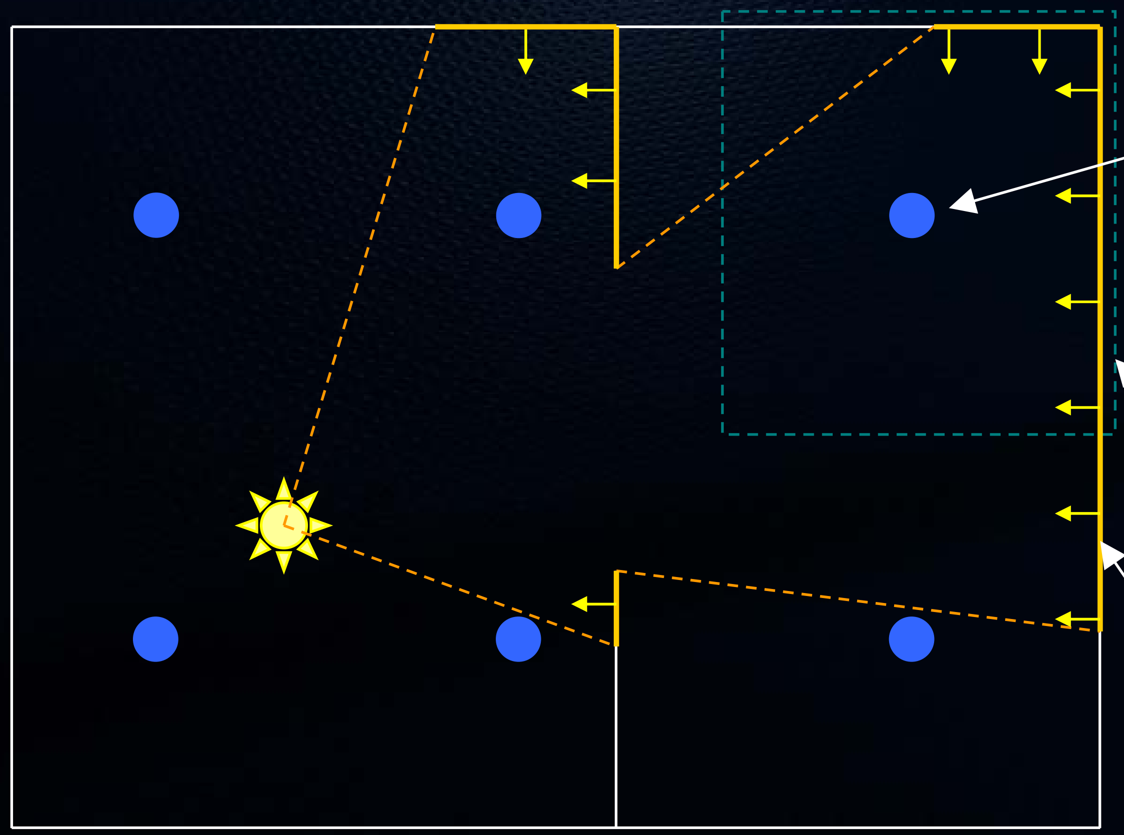
- Sample RH volume for sec. bounce radiance

Radiance field estimation

For each (visible) geometry fragment sample RH volume to reconstruct GI

GI rendering

RH Configuration



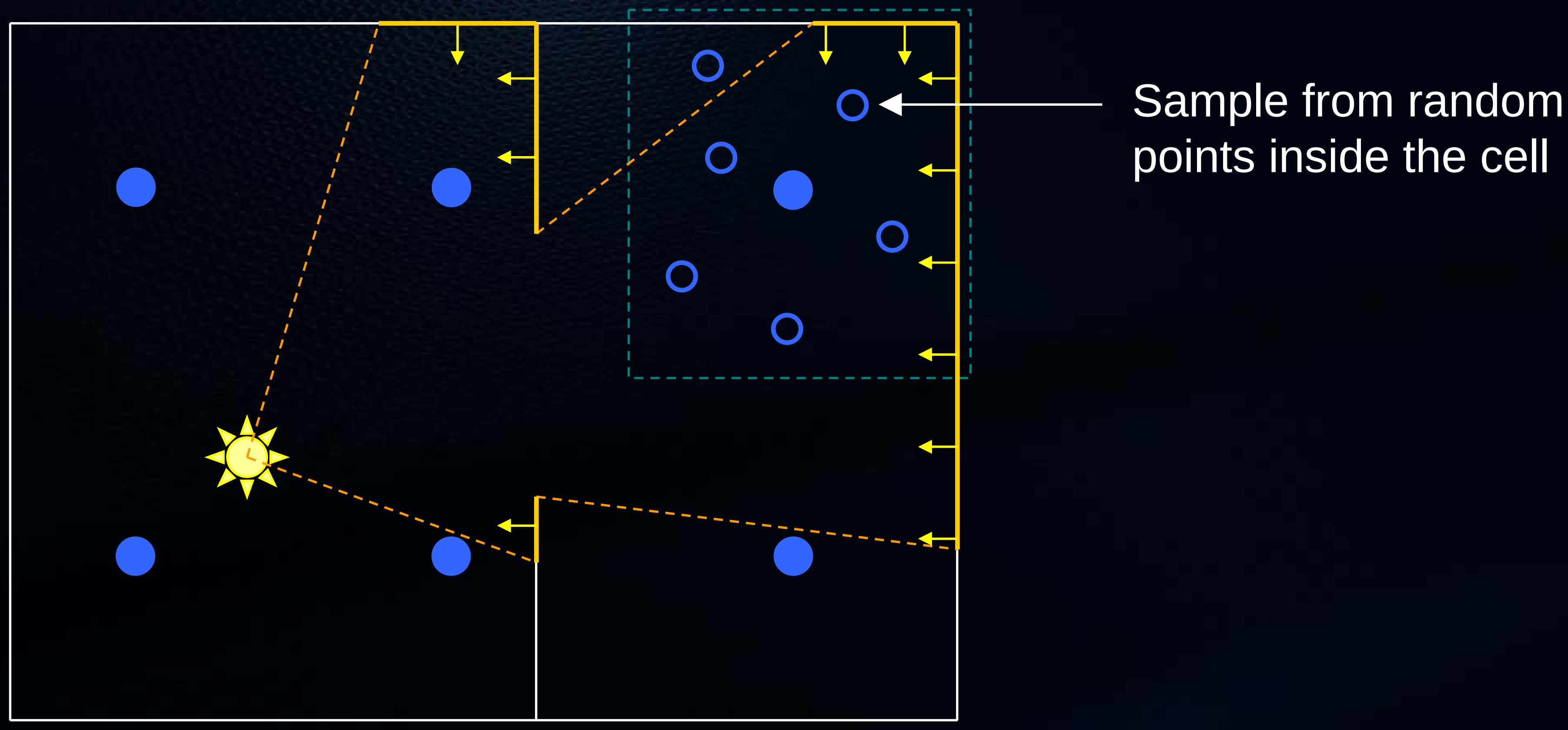
RH points are the nodes of a 3D grid

The grid covers any part of the scene

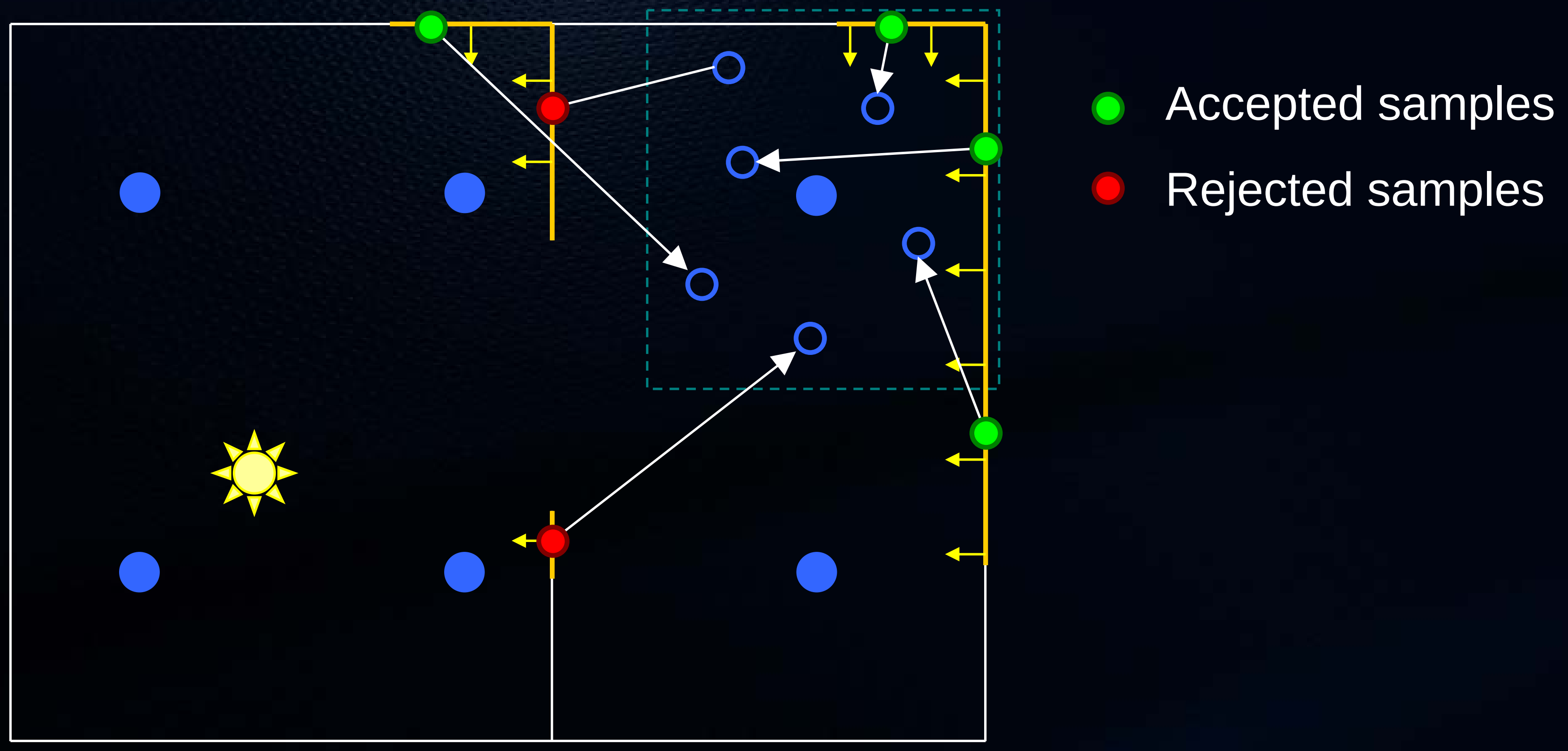
Extents of each RH grid cell

RSM data (position, flux, normals)

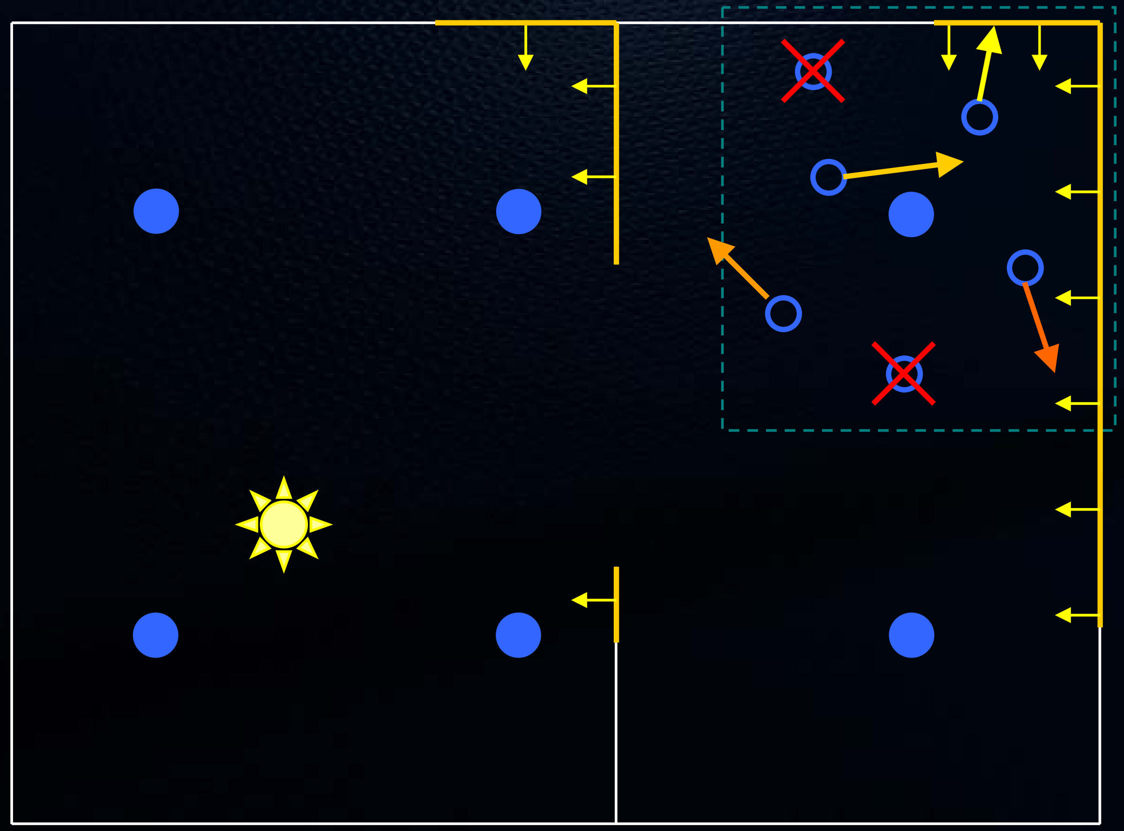
RSM Sampling



RSM Sampling



Radiance Encoding



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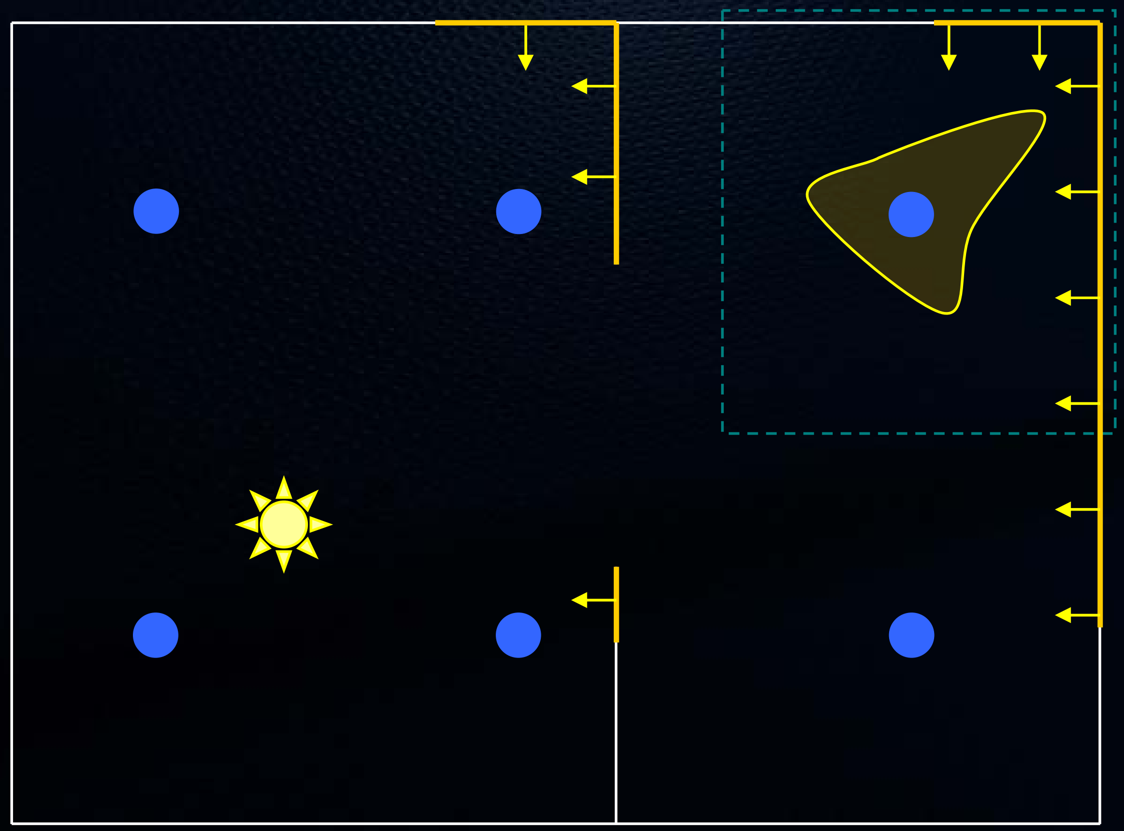
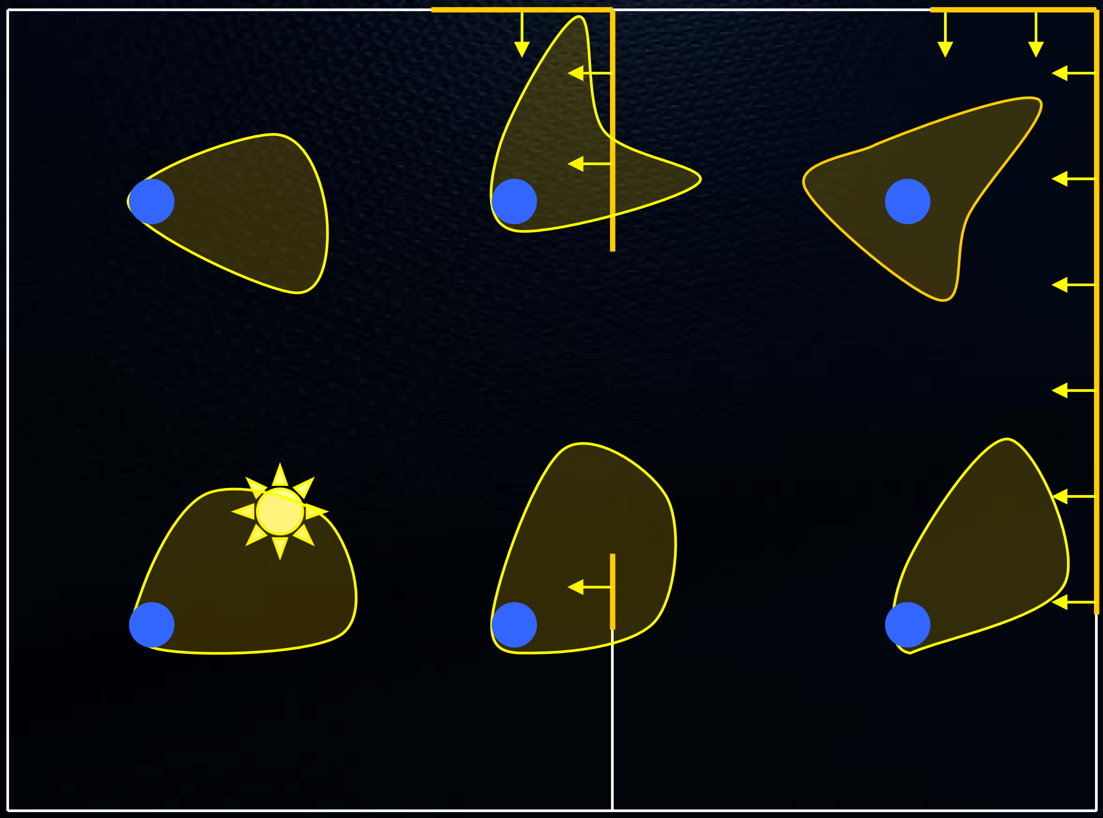


RH radiance is encoded as spherical harmonics

Radiance Encoding



With up to 8 MRTs:

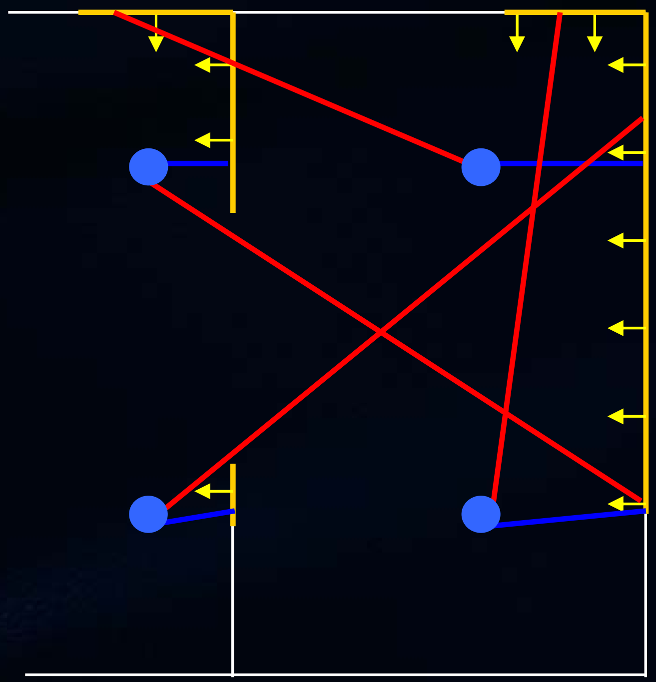
4- and 9-coefficient spherical harmonics can encode RGB radiance field

Comments: RH Sample Distribution

- Uniform distribution of sample points in RH cell
- Why?
  - There is nothing special about RH location!
  - It should be representative of entire cell volume

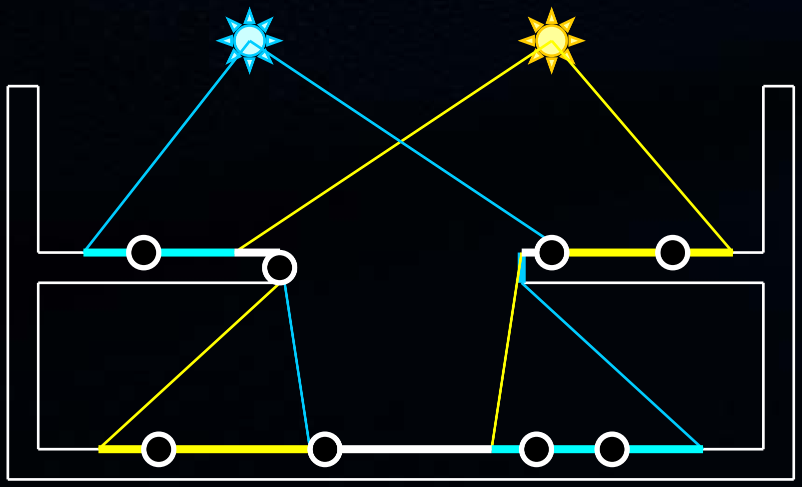
Min and Max RSM Sample Distances

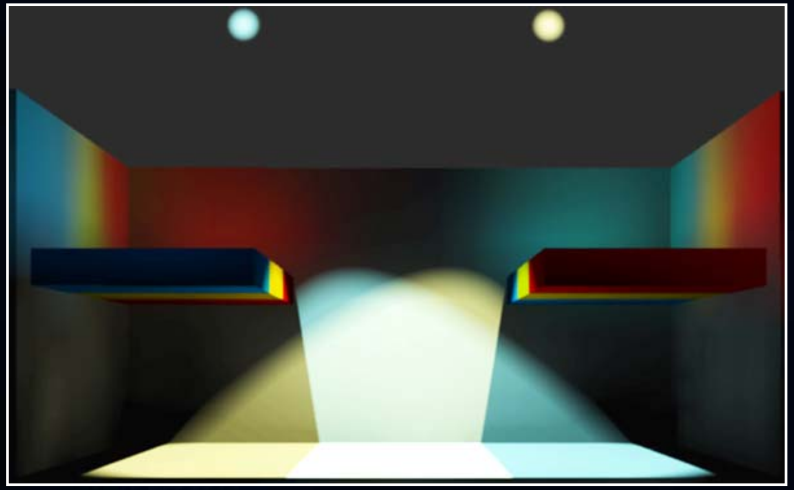
- For reasons that will become apparent next, also maintain and store for each RH:
  - Min distance to RSM sample
  - Max distance to RSM sample



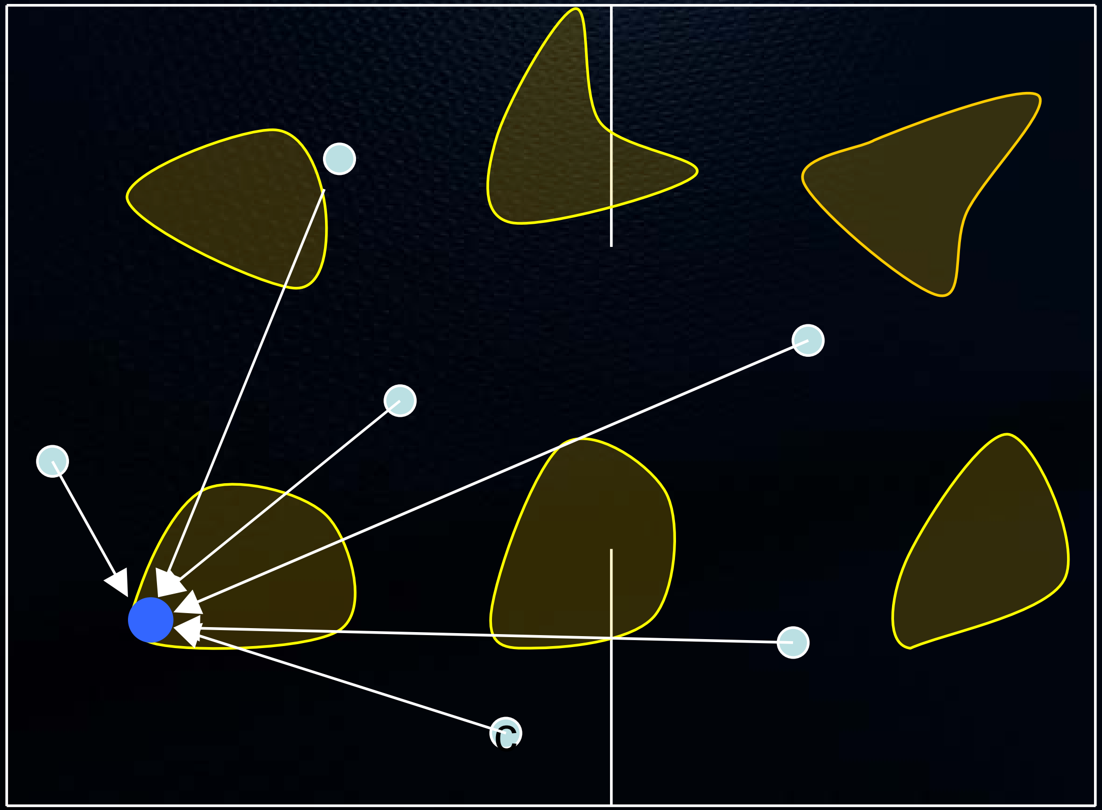
Comments: Multiple RSMs

- For multiple RSMs (multiple/omni-directional):
  - A fixed number of samples is distributed among RSMs
  - Ideal for importance sampling of light sources





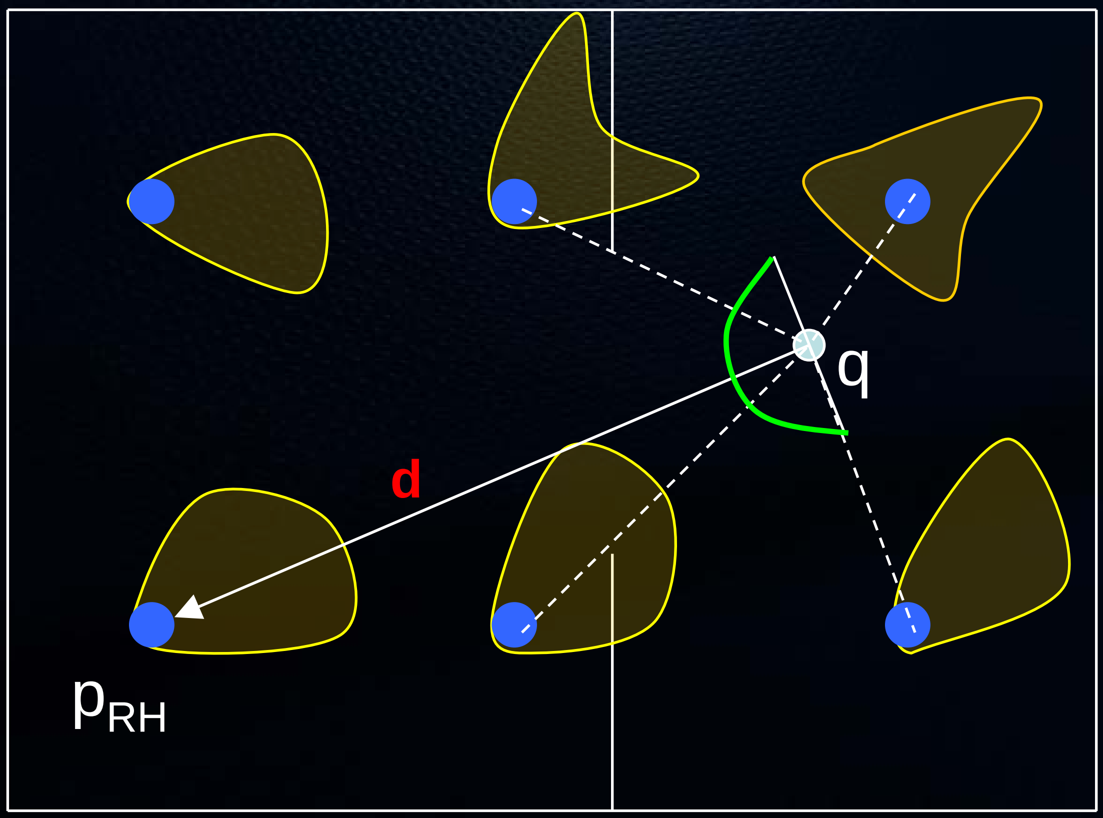
Secondary Bounces



Geometry-less:

Randomly sample the radiance field!

Secondary Bounces



Interpolate SH from nearest RHs (volume texture tri-linear interpolation)

Integrate incident radiance on the hemisphere aligned with d:

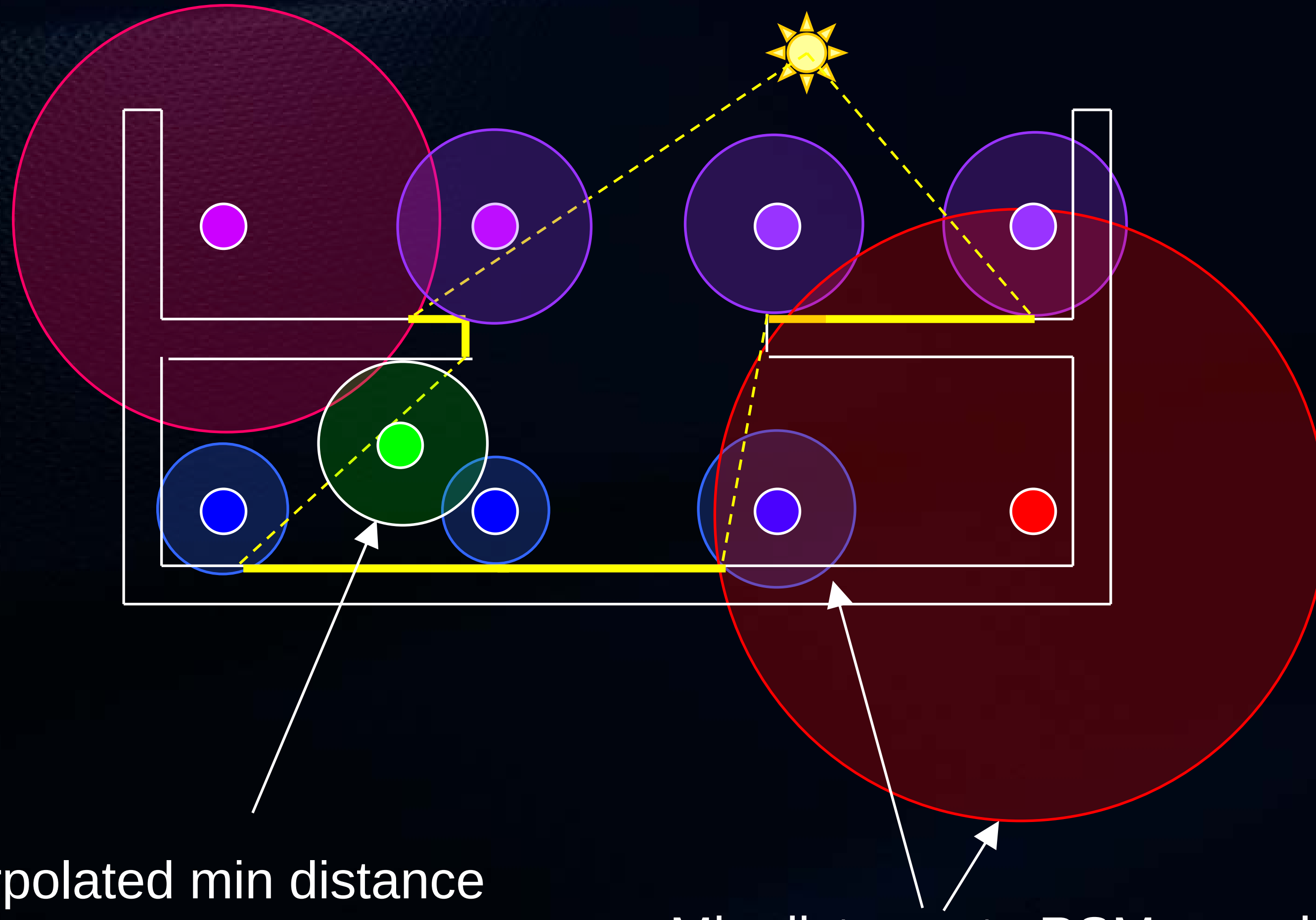
→ "reflected" radiance on an imaginary surface aligned with d

Secondary Bounces: RH Reliability

- Are all random RH samples equally reliable?
  - Certainly not !
  - RH near surfaces are more reliable → must be favored
  - But …we know nothing about the geometry

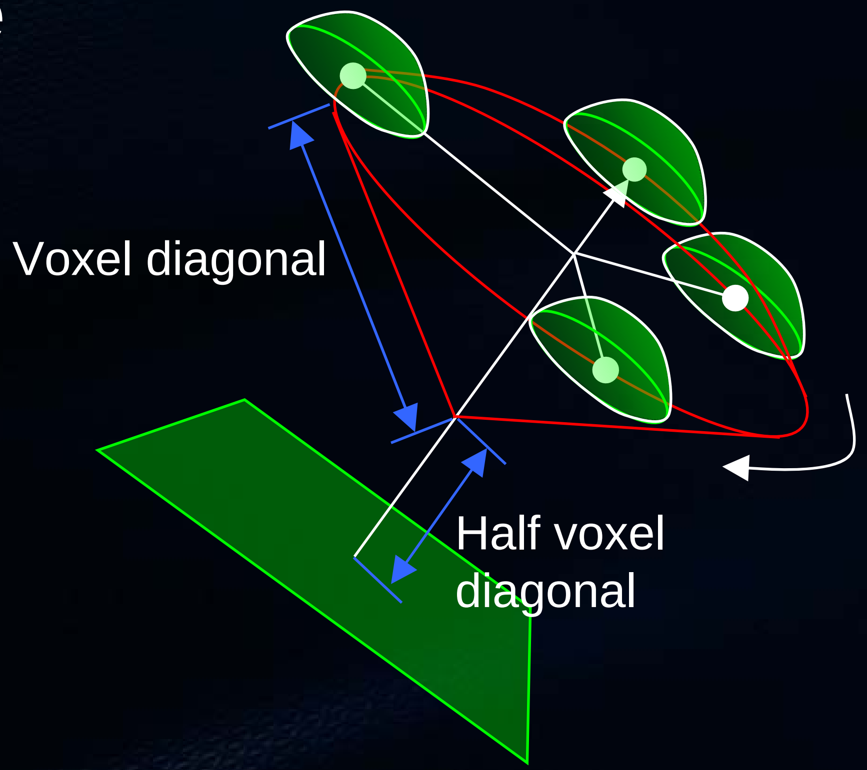
- Solution:
  - For each RH, use the minimum distance r_{min} from RSM sample positions
  - Bias RH contribution using r_{min}

Secondary Bounces: RH Reliability

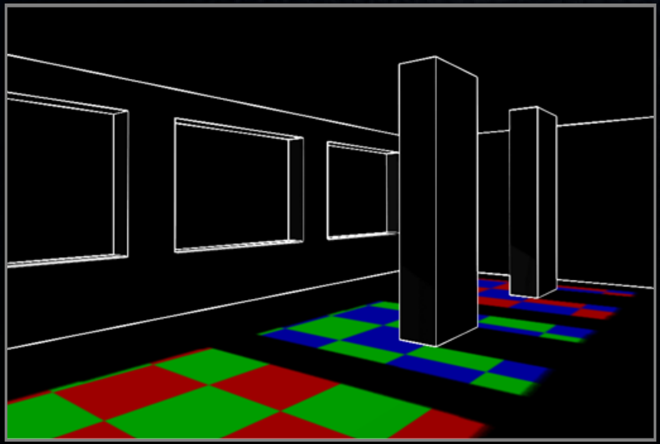


Diffuse GI Reconstruction

- Directly sample the RH volume textures at 4 locations in a rotating kernel above the surface
- Perform integration in SH domain over the surface-aligned hemisphere



A Simple Example



Direct illumination

1^{st} bounce

2^{nd} bounce (total 11.6ms)

Path tracing

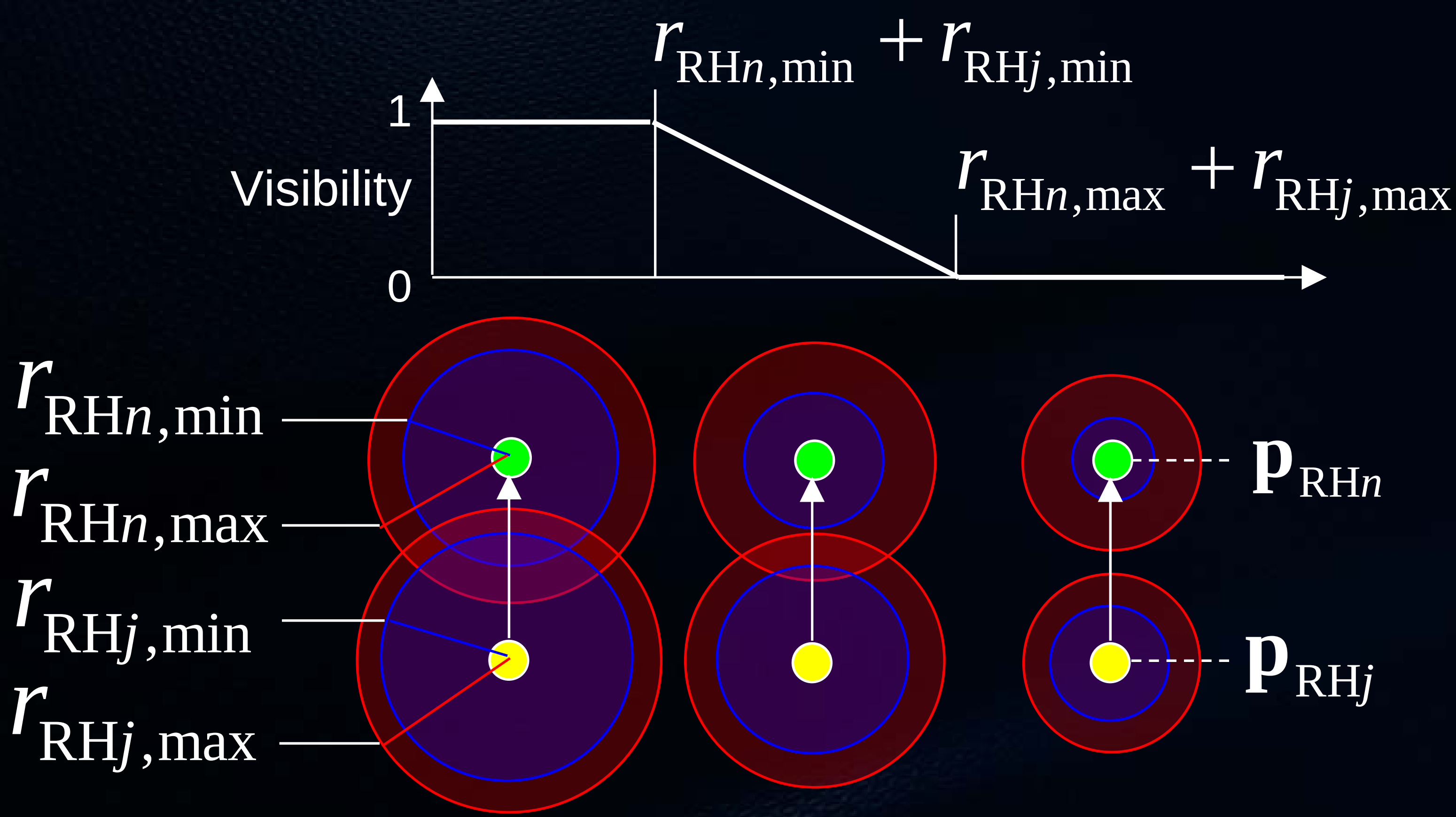
Occlusion

- What about visibility tests?
  - RSMs alone are not very helpful
- Store “blocking” information? Trying to avoid:
  - View-dependent geometry injection
  - Volume-based occlusion. Can be slow to generate and requires multiple texture reads per sample

- Can I use existing data?
  - Yes, but only in secondary bounces
  - Special treatment for first bounce

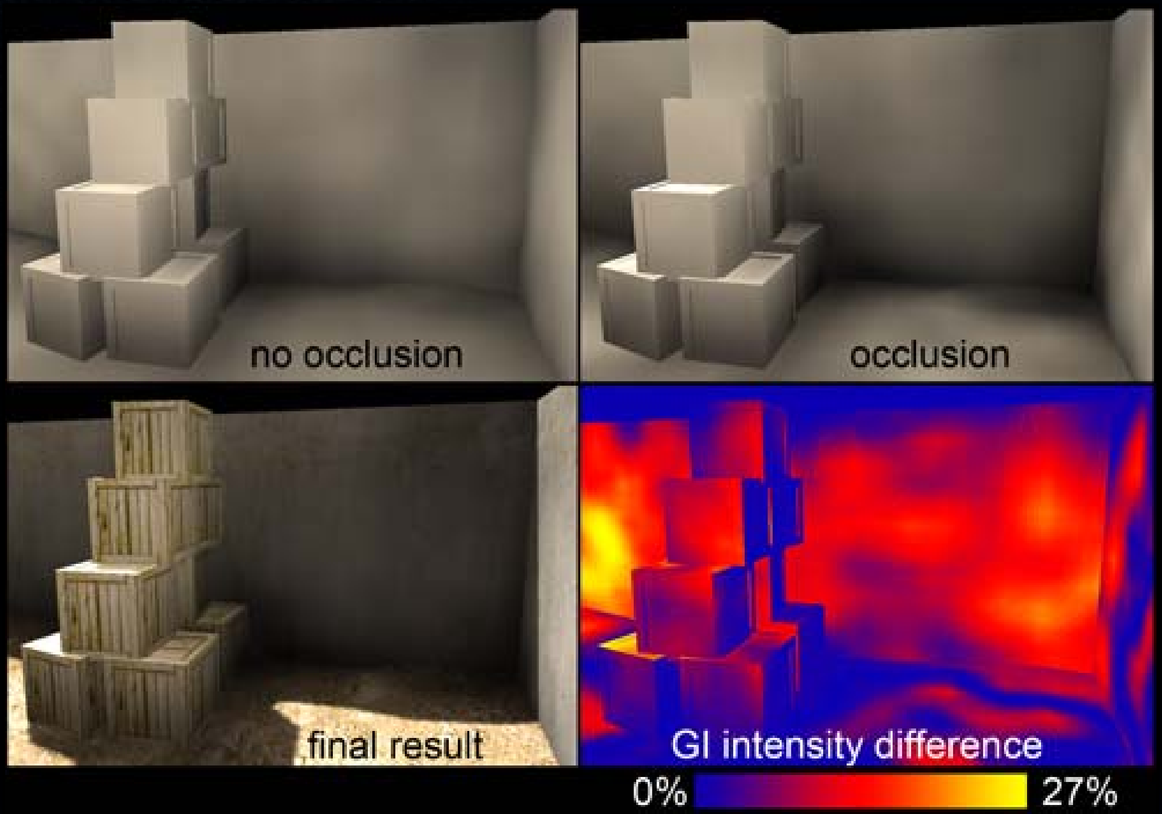
Secondary Bounce Occlusion

- We can use a probabilistic (heuristic) attenuation metric using the stored min/max distances



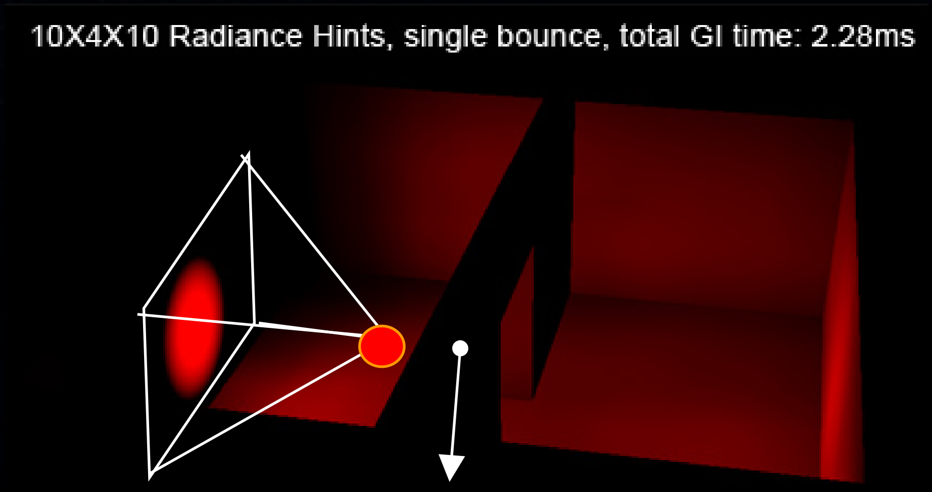
Secondary Bounce Occlusion Example

- The secondary bounce attenuation is not as important as the first bounce one but is almost for free.



What About First-Bounce Occlusion?

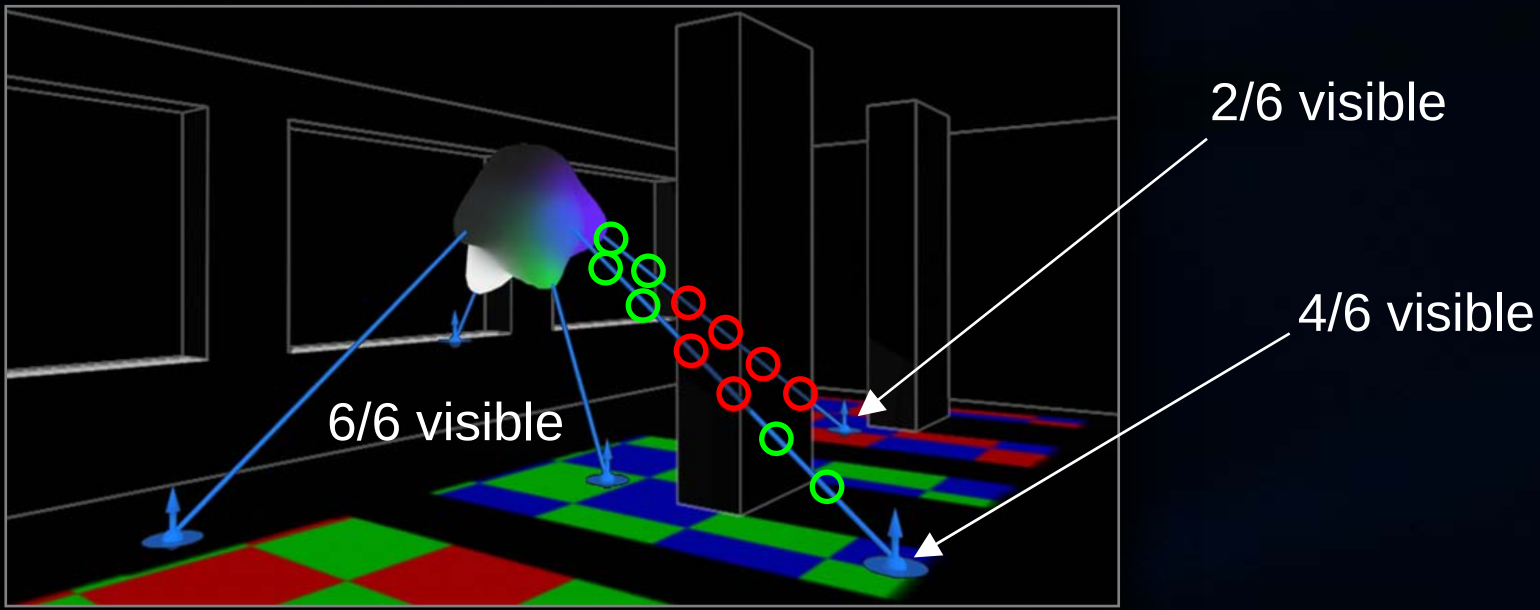
- Most important occlusion stage
- Large RSM scene coverage “masks” occlusion (but results are still far from ground truth)
- Small RSM scene coverage leads to erroneous cases:



Wall not present in RSM

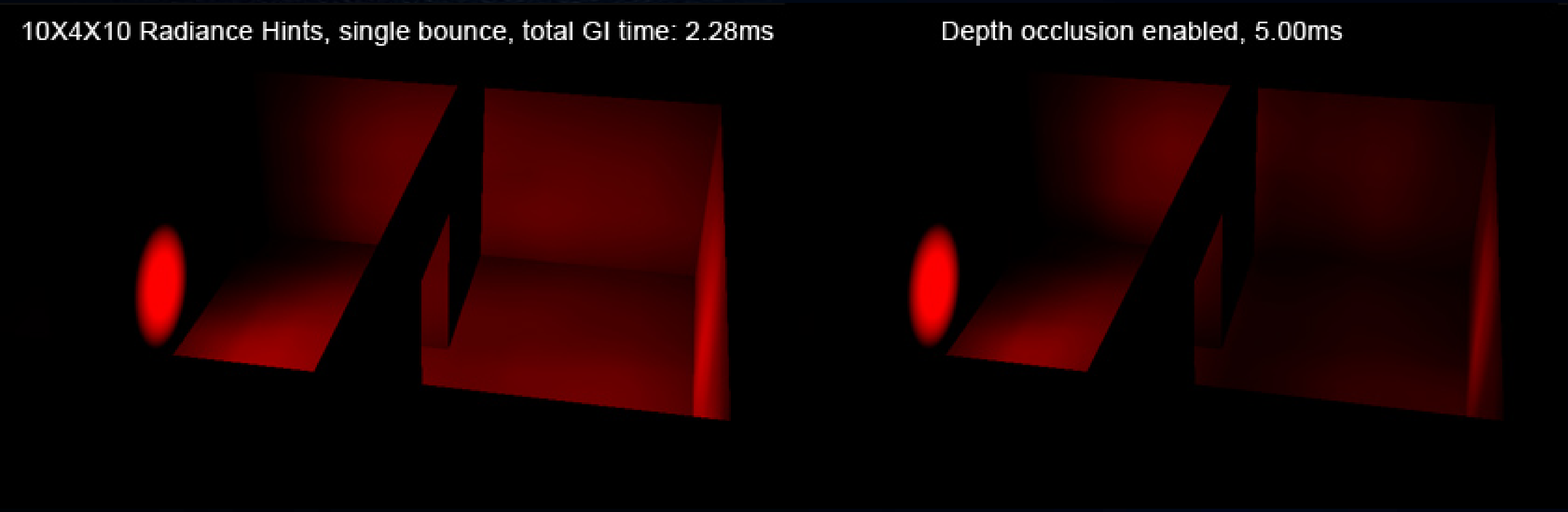
Depth-based Occlusion (Extension)

- Use camera depth map to intercept RSM samples
- Uses a voting system to attenuate RSM samples:
- Test a few points on the RH-RSM line of sight against the depth map



Depth-based Occlusion (Extension)

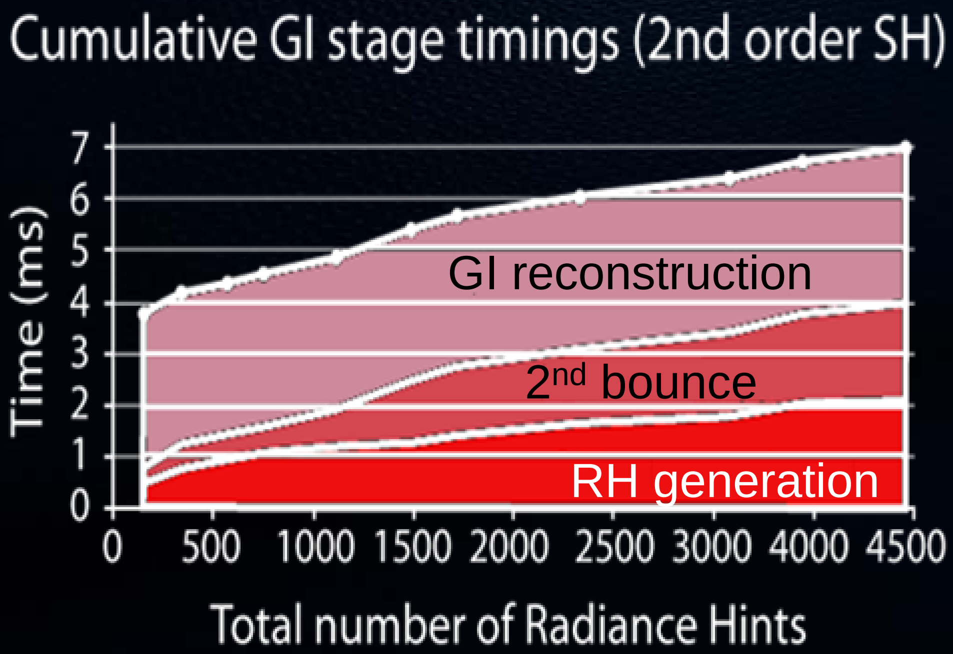
- View-dependent, but:
- Not a binary visibility test ! → Time-coherent

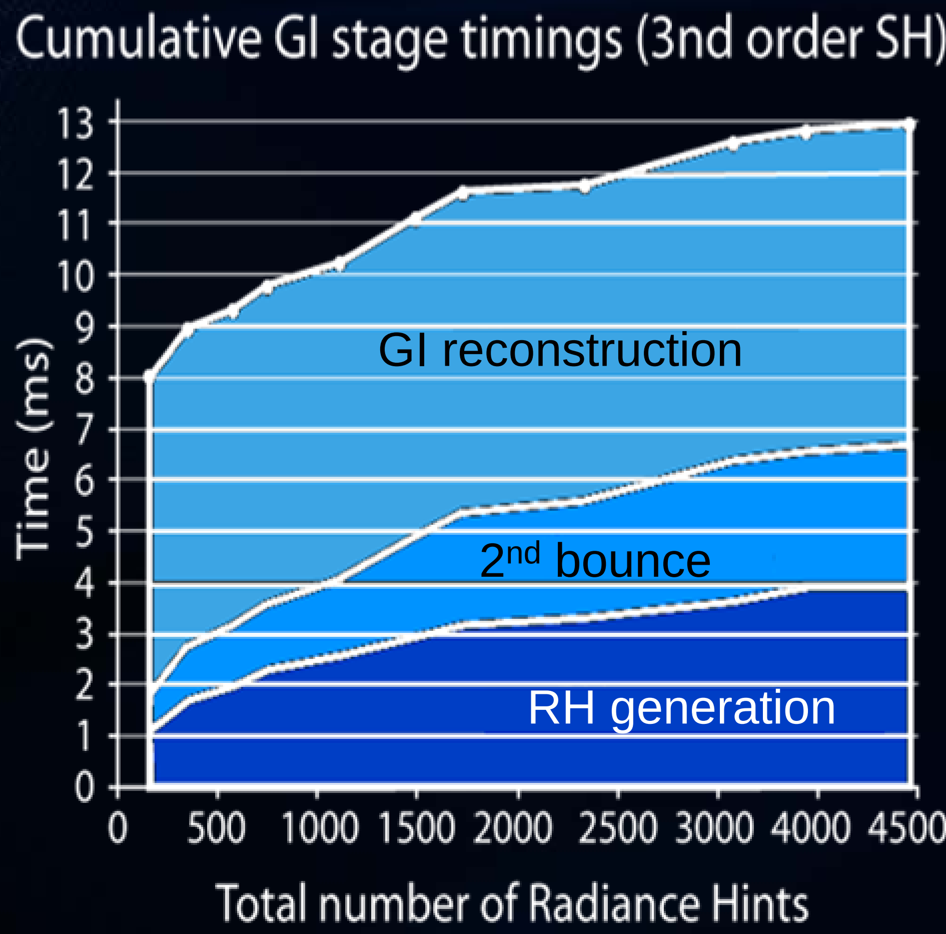


No occlusion

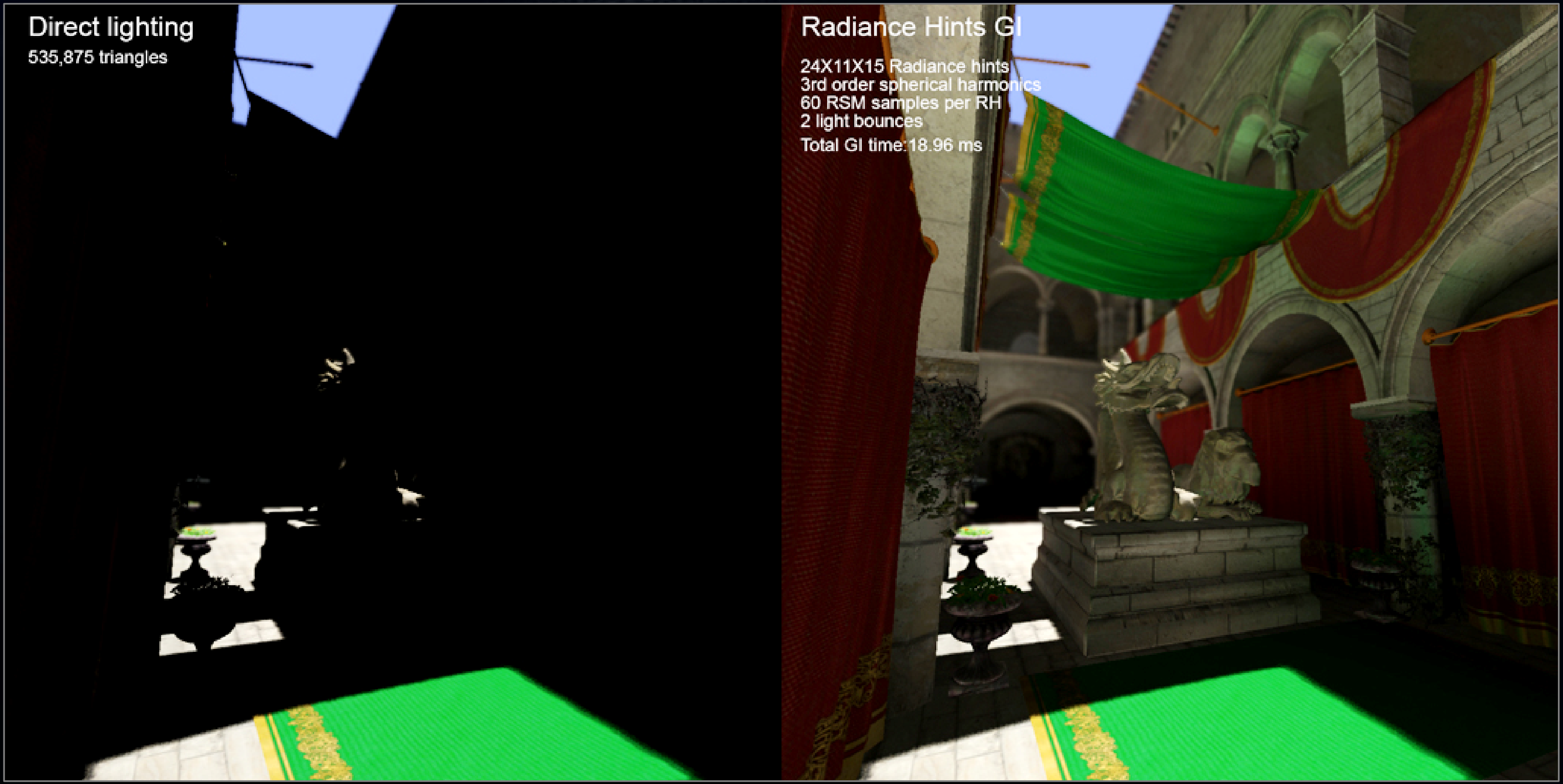
Depth-based attenuation

Performance

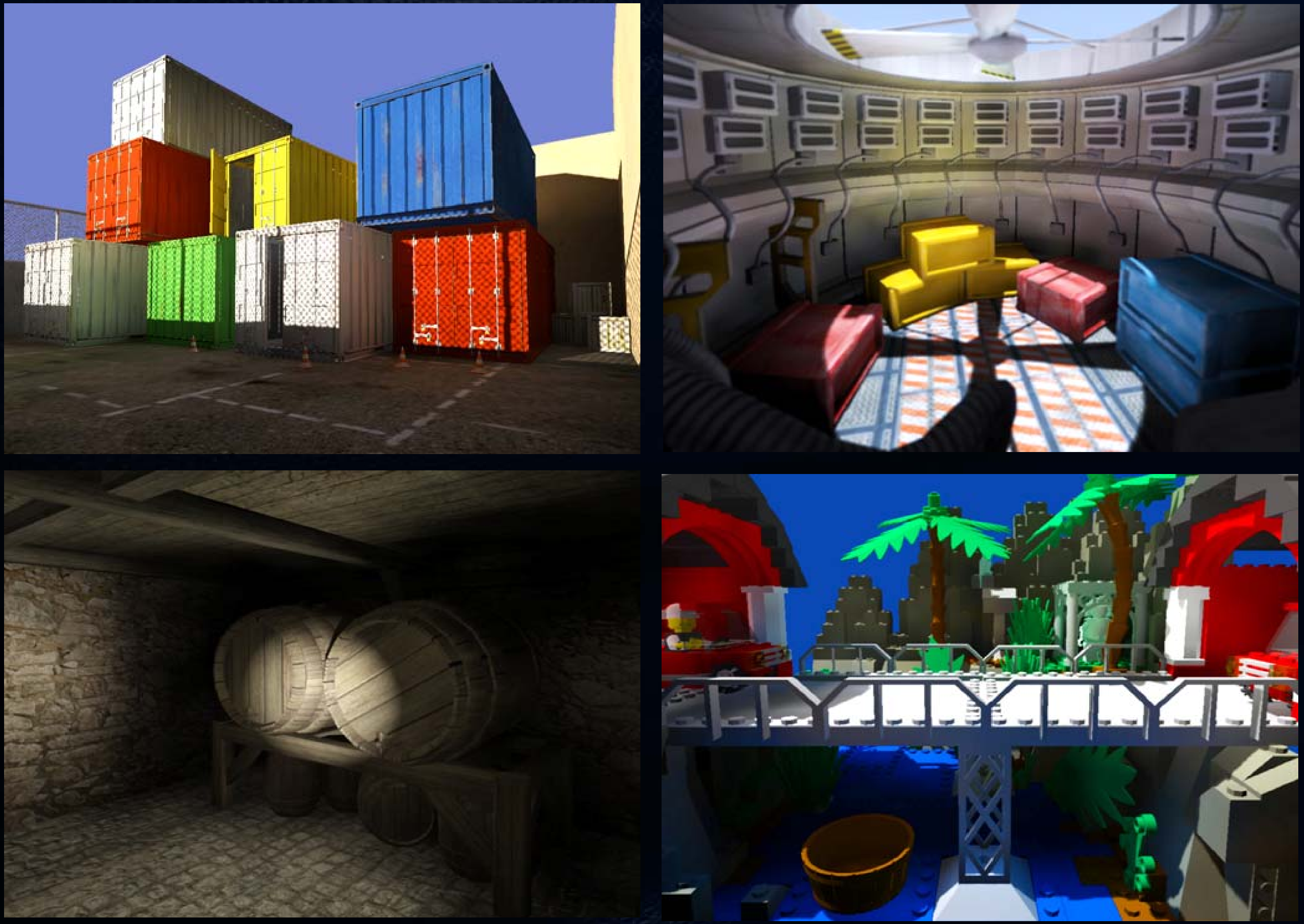




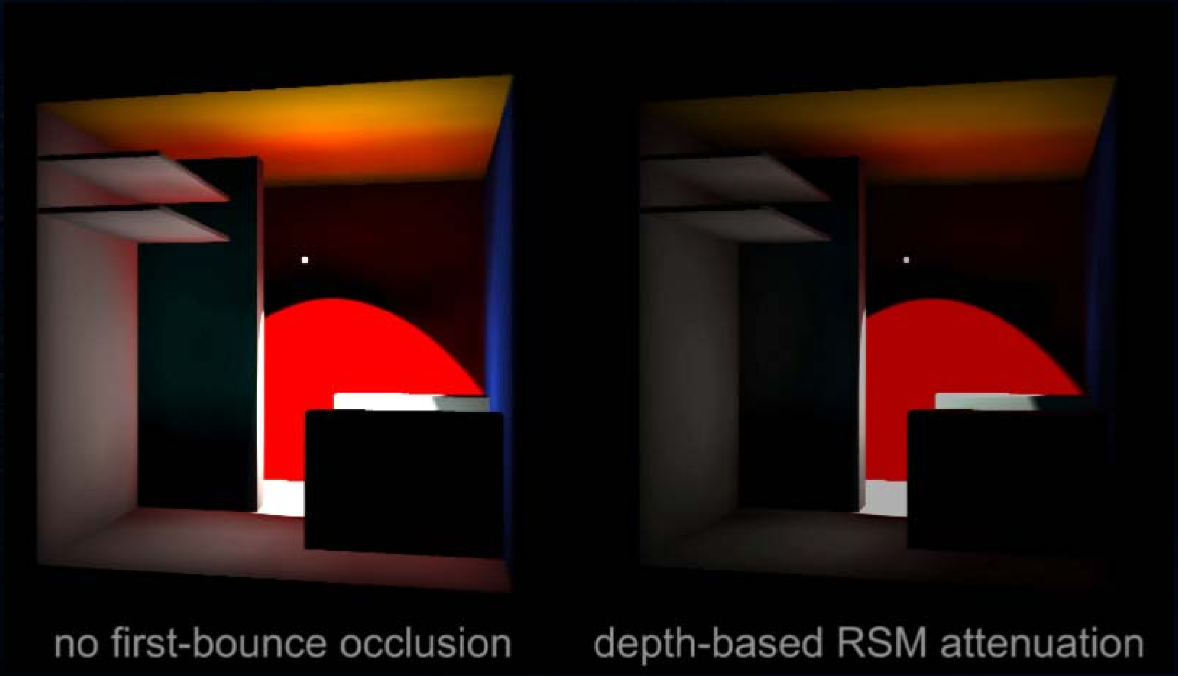
Examples – No 1st Bounce Occlusion

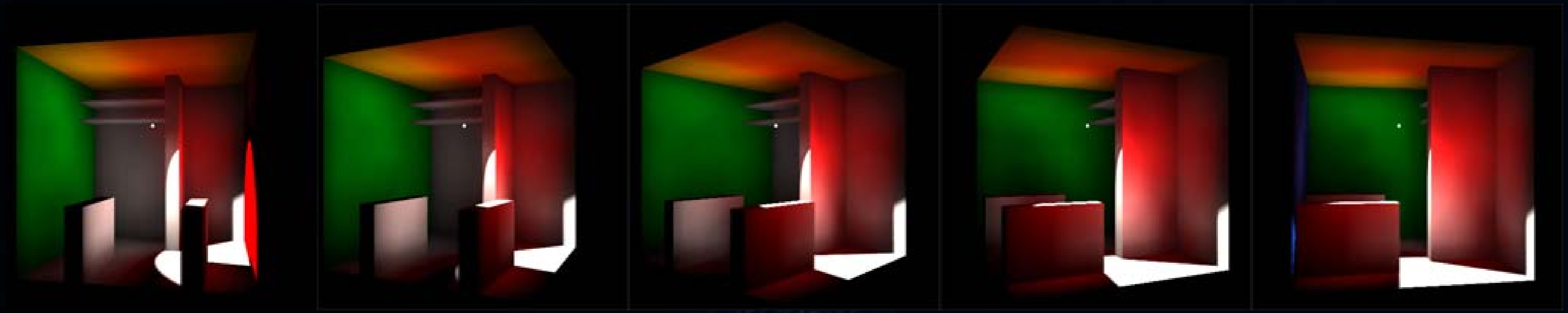


Examples - No 1st Bounce Occlusion



Examples - With 1st Bounce Occlusion





Input and Requirements

- Just the light source RSMs (modern rendering engines require them for other tasks anyway)

- No geometry is rendered during GI calculations
- No geometry shaders are needed
- No pre-processing of any kind
- No post-processing

- Can be used in direct and deferred renderers

Other Extensions

- Small RH volumes can be placed in disjoint locations
  - More effective coverage of important areas
  - Nested RH volumes (for more detail)
- Due to their linear form (SHs, distances), RHs can be automatically mip-mapped and hierarchically sampled

Pros and Cons

- The good news are:
  - Yes, it is versatile and easy to configure
  - Has minimal requirements
  - Handles multiple bounces
  - The (core) method is view-independent
- But:
  - Is an approximate approach
  - Heuristically handles occlusion

Thank You

- Please visit the AUEB Graphics Group web site (http://graphics.cs.aueb.gr) for:
  - Shader source code
  - Additional demo images and videos

- A complete mathematical analysis can be found in the paper.

Pitfalls

- Same problems as any other RSM-based method:
  - No sufficient coverage of geometry by RSMs → Not enough reliable samples

Path tracing　　VBGI　　RH + occlusion　　LPV / RH