State of the Art in Interactive Ray Tracing

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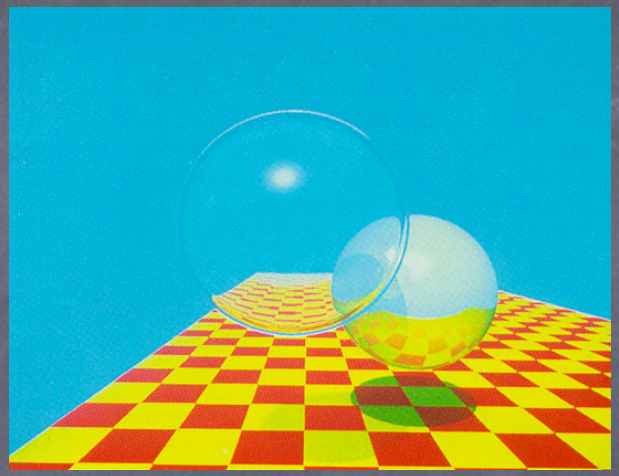
Course overview

What is going on this year in ray tracing (most of course) and what we think the big open problems are.

Why now?



- 1979, Turner Whitted, 74 minutes at 640x480
- 18 Moore's Law CPU doublings in 27 years
  - 12 doublings 74min -> 1 sec
- We should now have 1024x1024 at 16 f.p.s.

Why now? (2)

- RT is naturally sublinear with scene size
- RT naturally supports good shading
- RT maps well to multi-core architectures
- If Moore's law continues
  - 9 years -> 2048^2 with 16 samples per pixel

Moore's Law and Screens

- Moore's law: about 100x every decade
- Moore's law per pixel: 50x every decade2

First "real" IRT

- Mike Muuss 1995

Some terminology

- Spatial/object subdivision
- Animated model
- SIMD
- Ray packet/bundle
- Multicore
- Whitted-style ray tracing
- Cook-style ray tracing

Animated models

- General (hard)
- Interactive modification (easier)
- Deformable (easier still)
- Articulated (easiest)

SIMD

- Several identical operations done at once
- SSE is the common example

```
const __m128 uvmask4 = _mm_cmple_ps(_mm_mul_ps(uplusv4, det4),
                                    _mm_mul_ps(det4, det4));
const __m128 voverd4 = _mm_mul_ps(rcp4, v4);
const __m128 vmask4 = _mm_cmpge_ps(voverd4, zeroes4);
mask4 = _mm_and_ps(mask4, uvmask4);
mask4 = _mm_and_ps(mask4, vmask4);
```

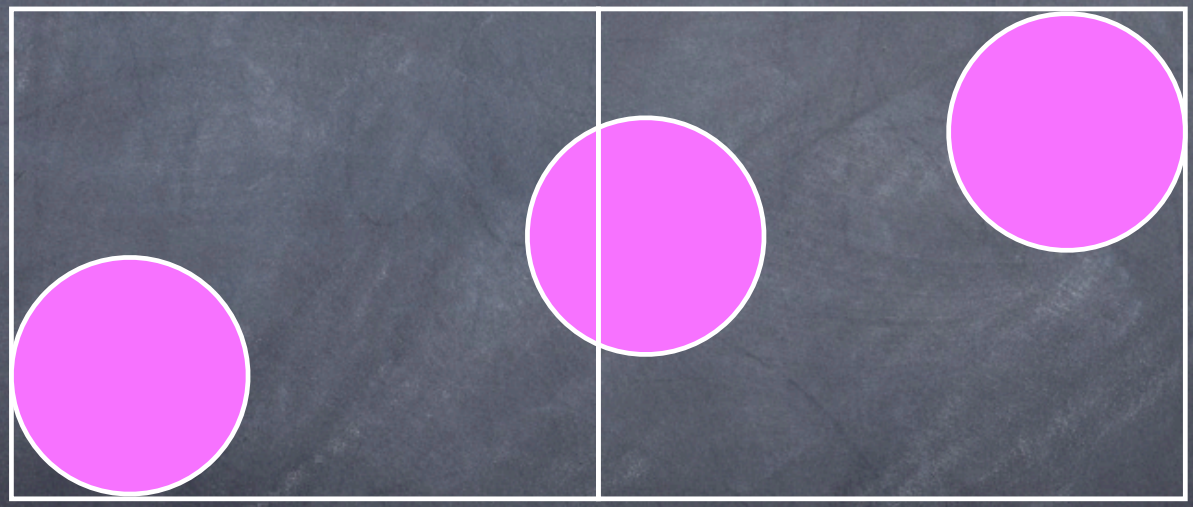
Ray Packets (Bundles)

- A list of rays
- Some may be inactive
- Some spatial/directional coherence implied
- Useful both for SIMD and non-SIMD

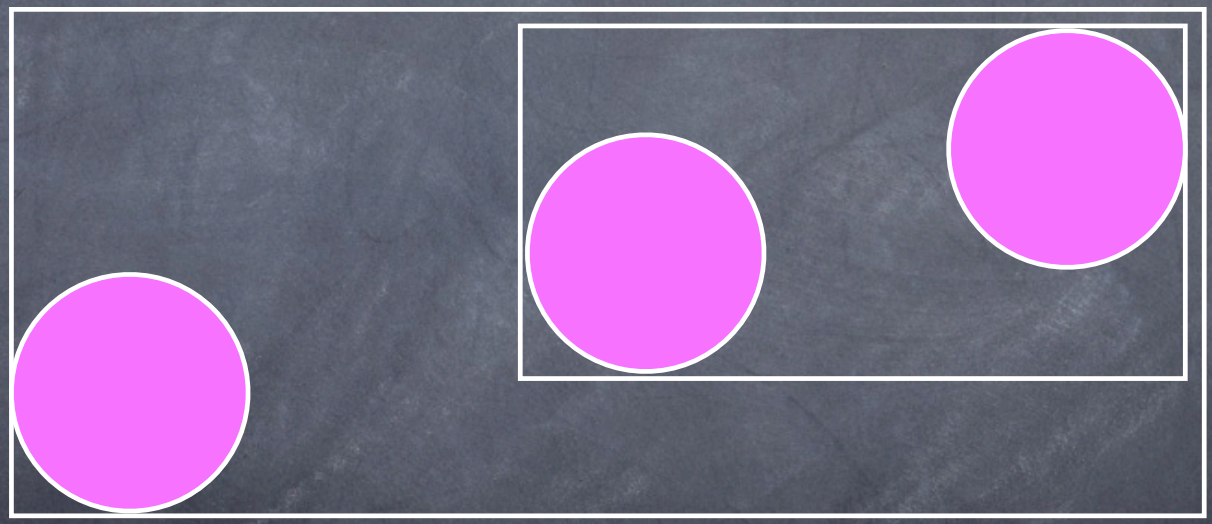
Multicore

- Several CPUs on one chip (or board)
- Most systems are now multicore

Spatial subdivision



Object subdivision

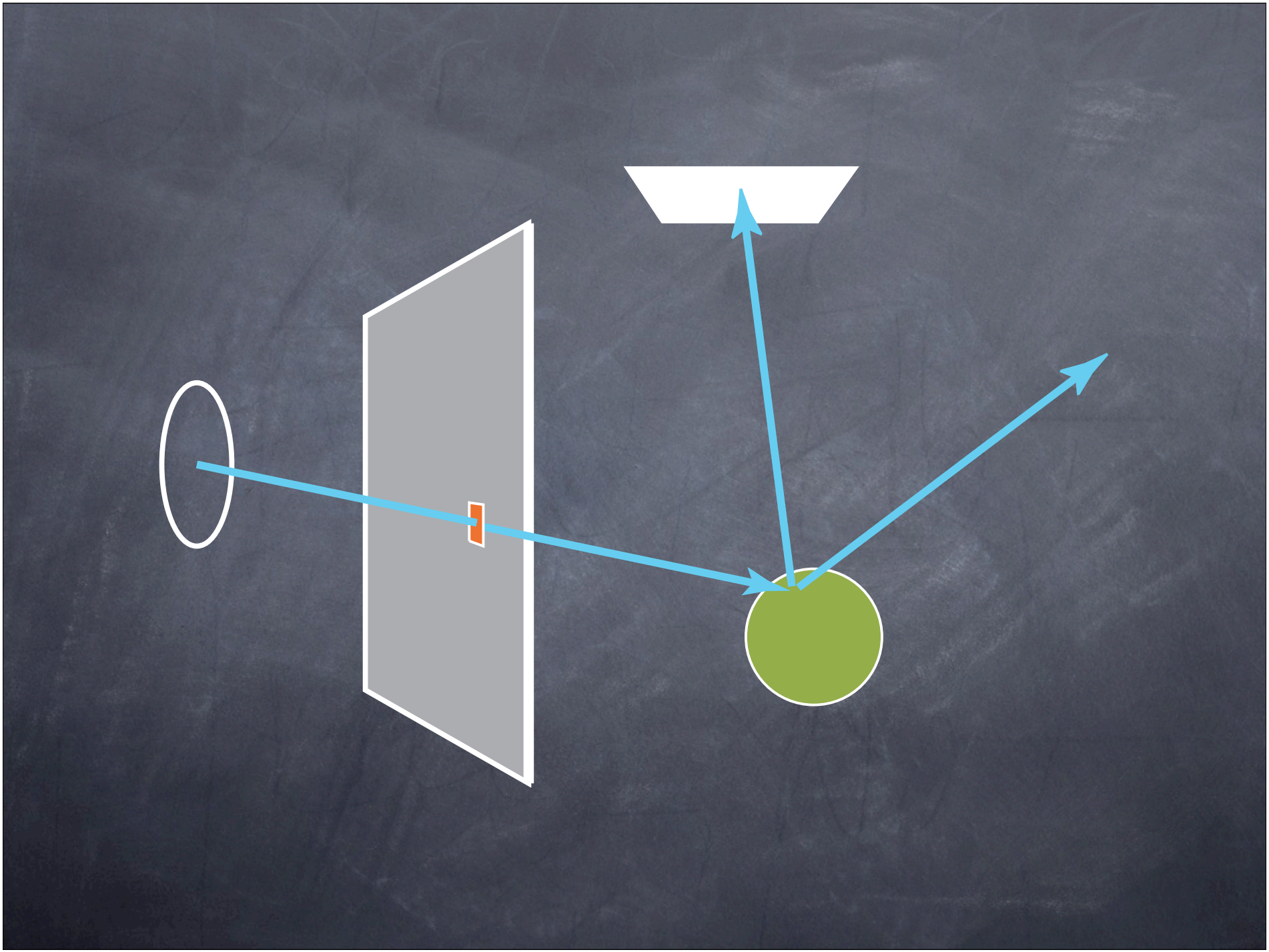


Whitted-Style RT

- About one ray per pixel
- Hard shadows
- Sharp reflections
- Pinhole camera

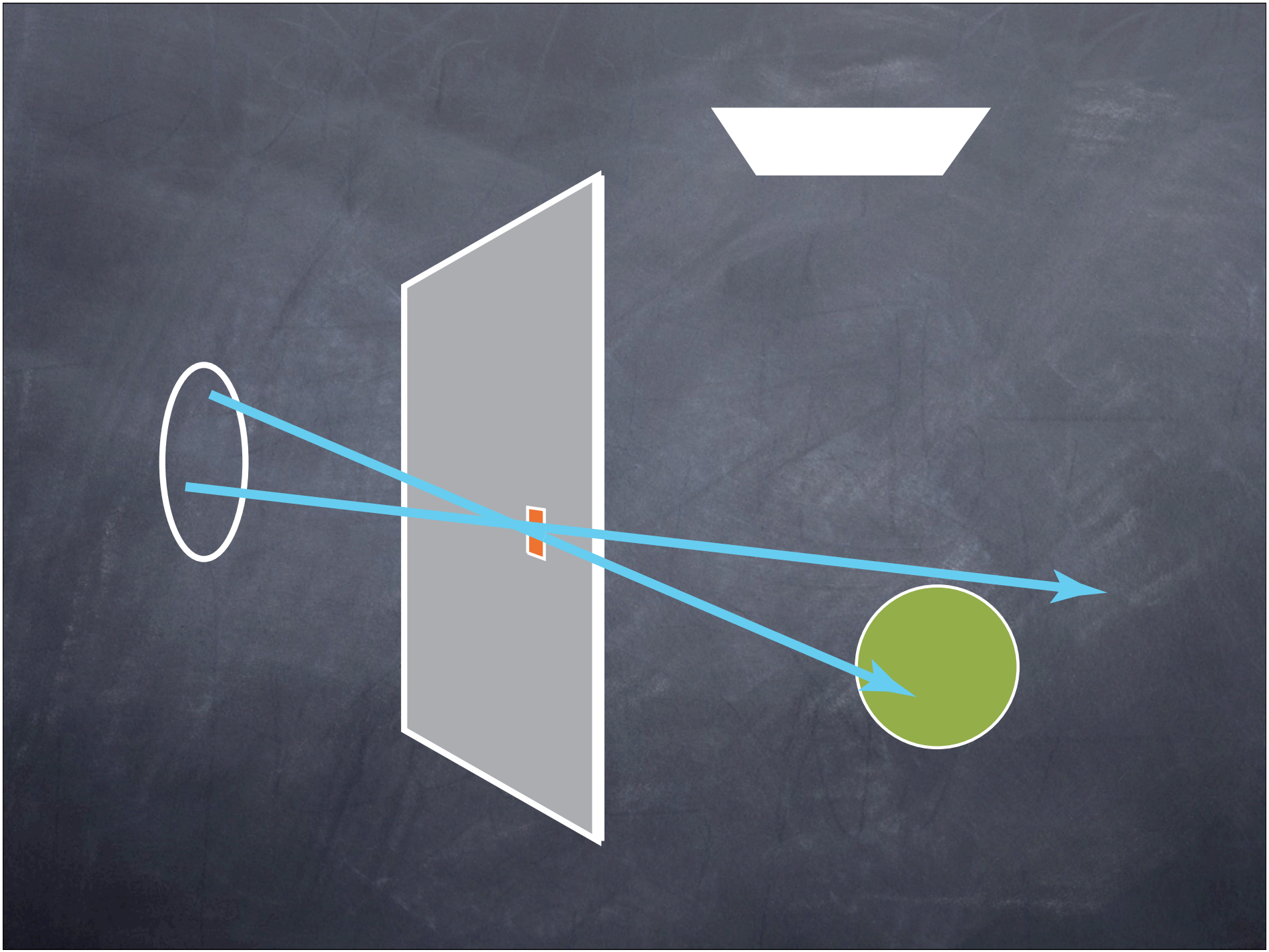
Whitted advantages

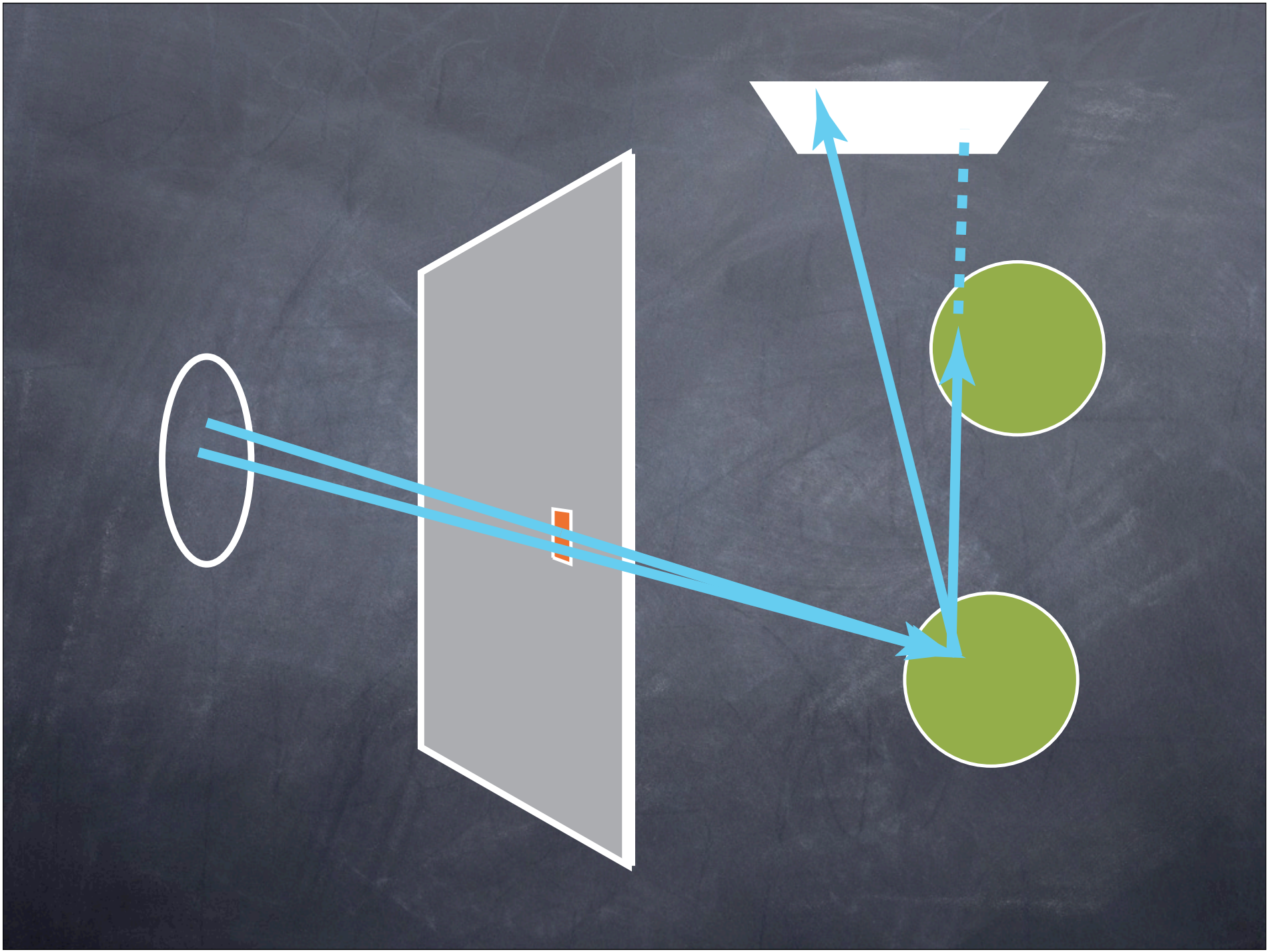
- Caching works
- Many CPUs work
- Few samples per pixels needed

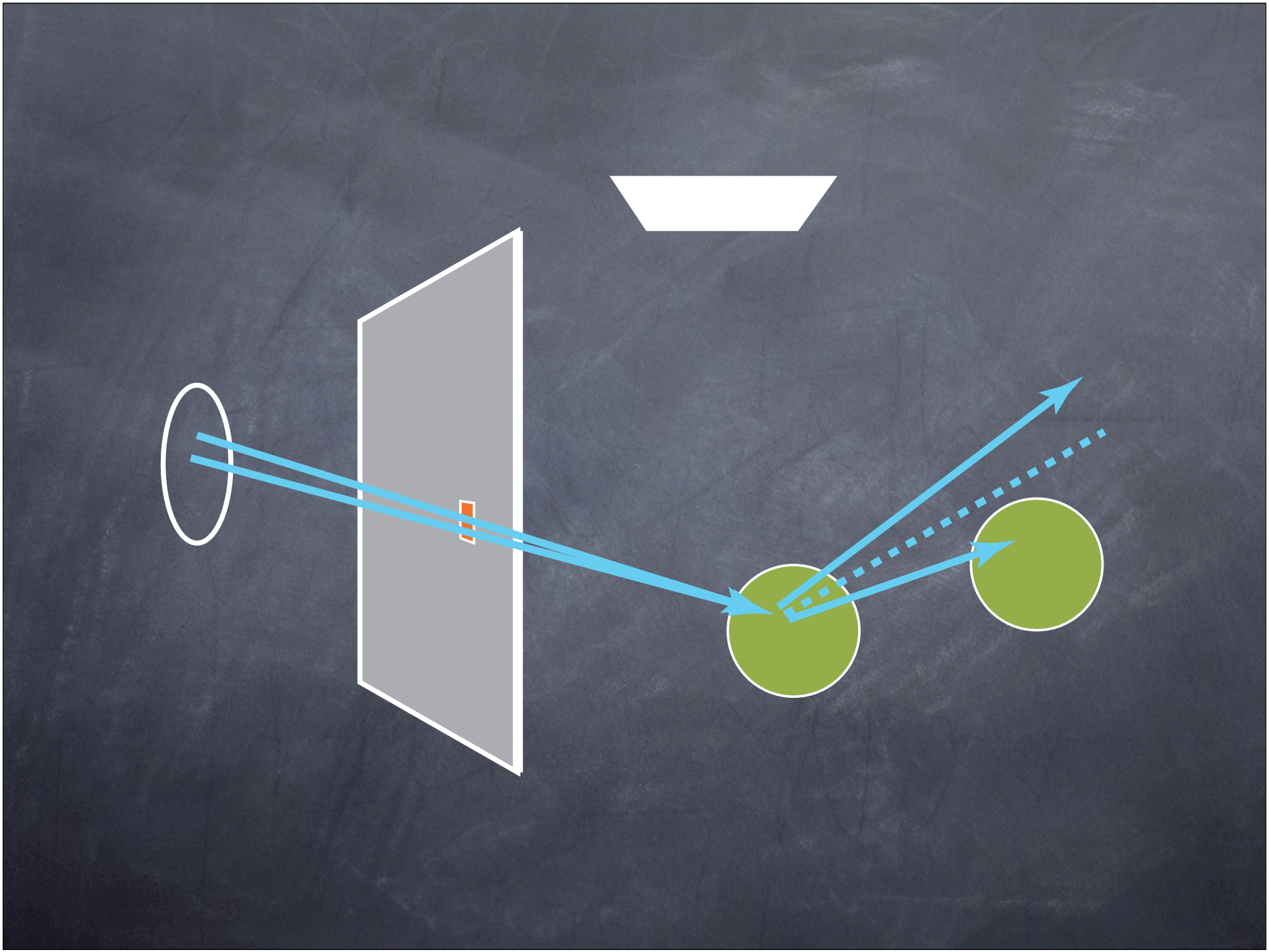


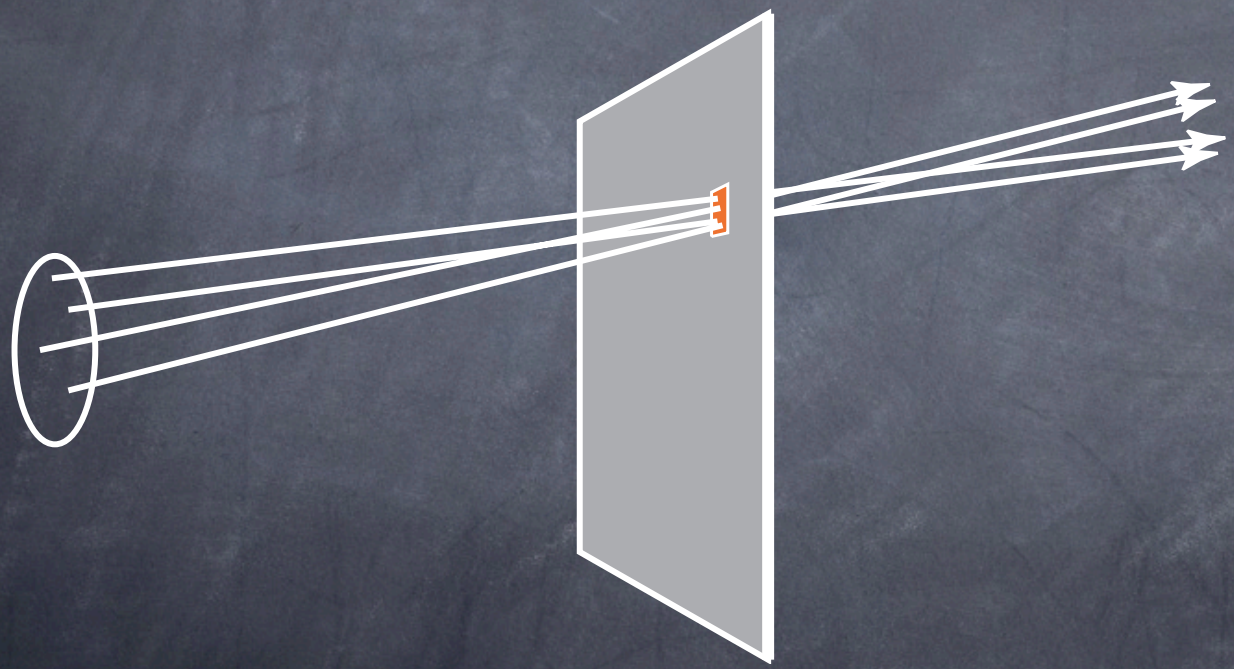
Cook-Style RT

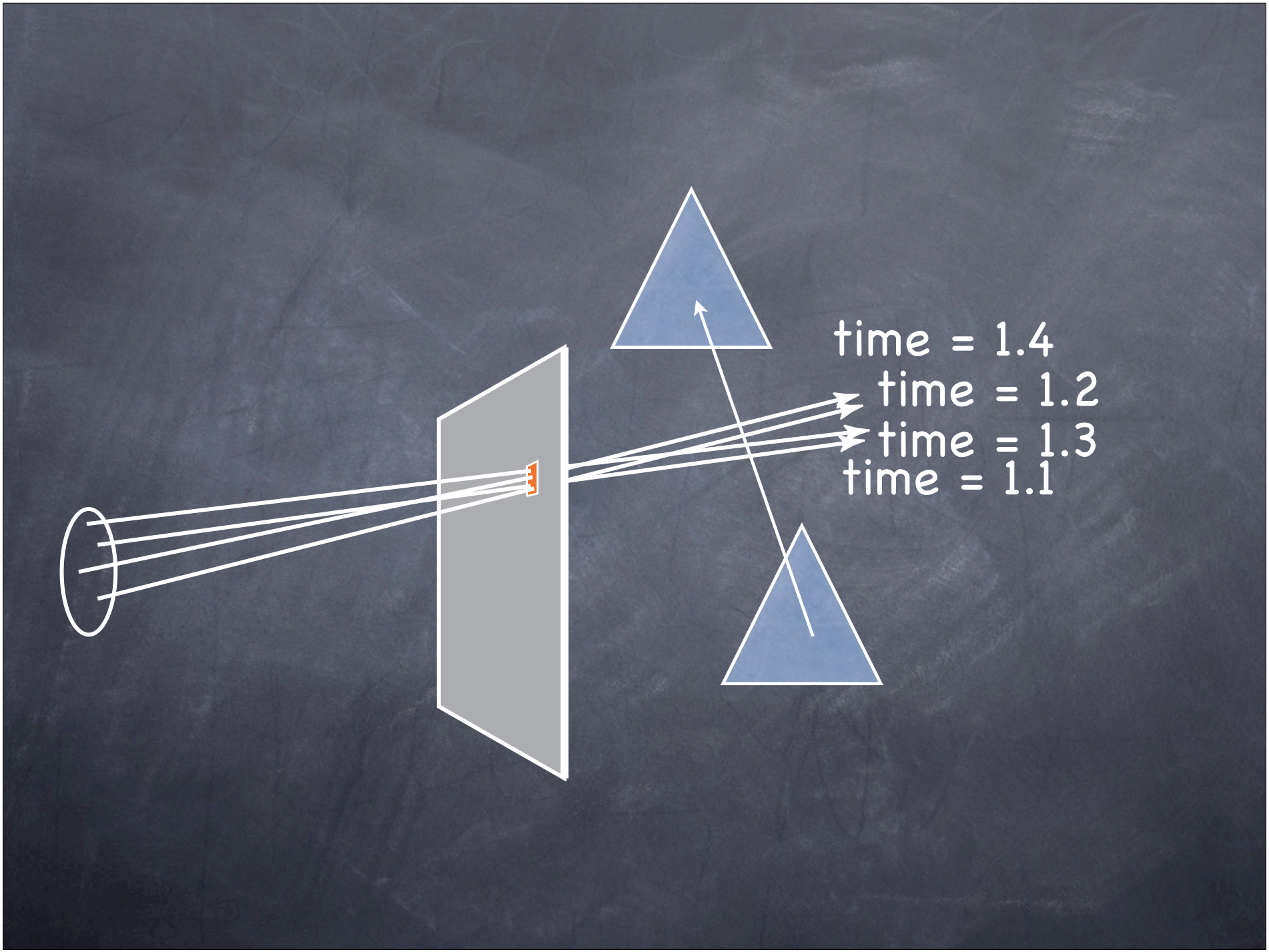
- Tens of rays per pixel (no branching)
- Soft shadows
- Fuzzy reflections
- Depth-of-field





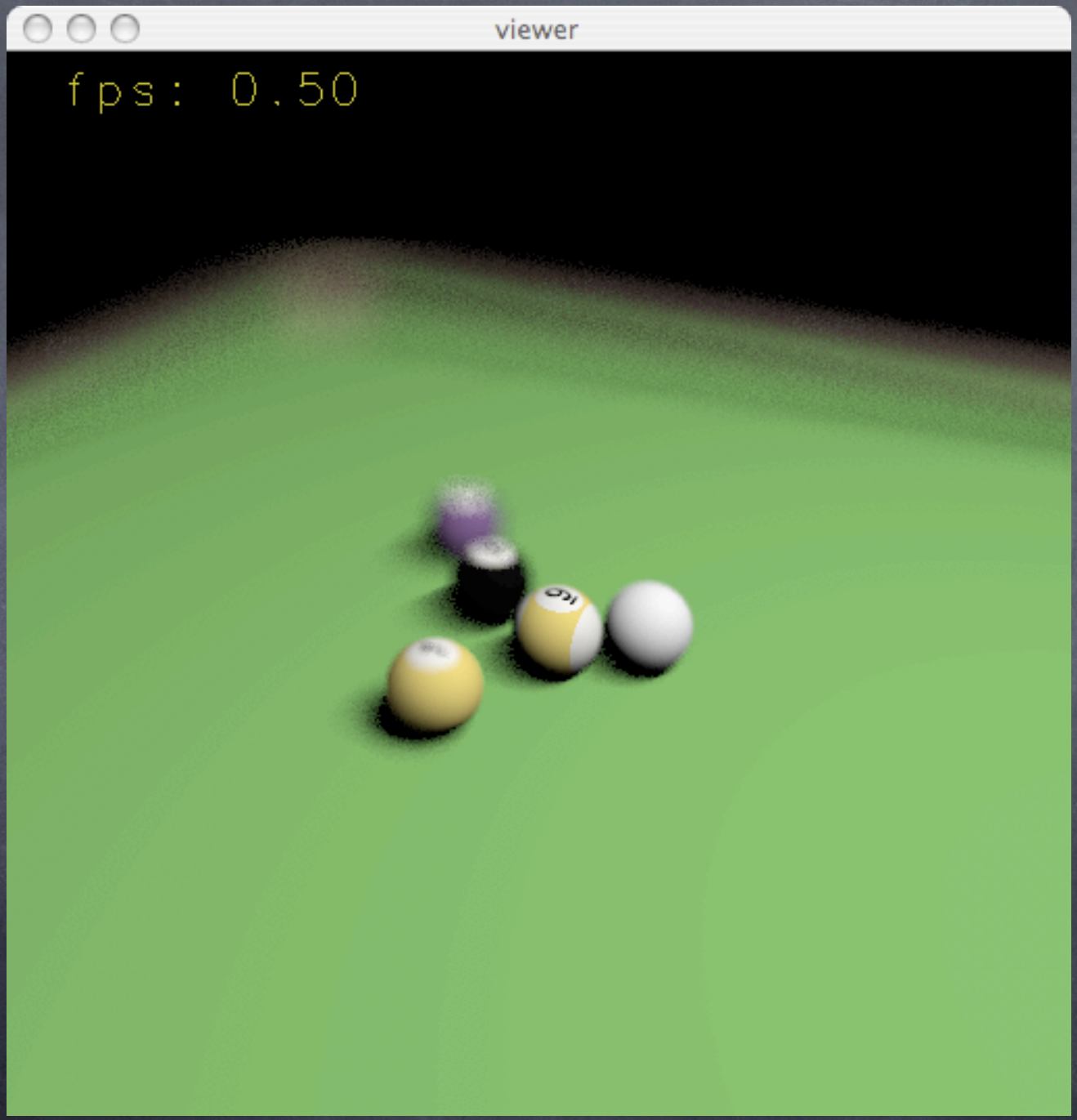





time = 1.4
time = 1.2
time = 1.3
time = 1.1


viewer
fps: 0.71


viewer
fps: 0.64


viewer
fps: 0.50


viewer
fps: 0.25

Hybrid

- Use Cook just for some effects with branching
- Common for shadows

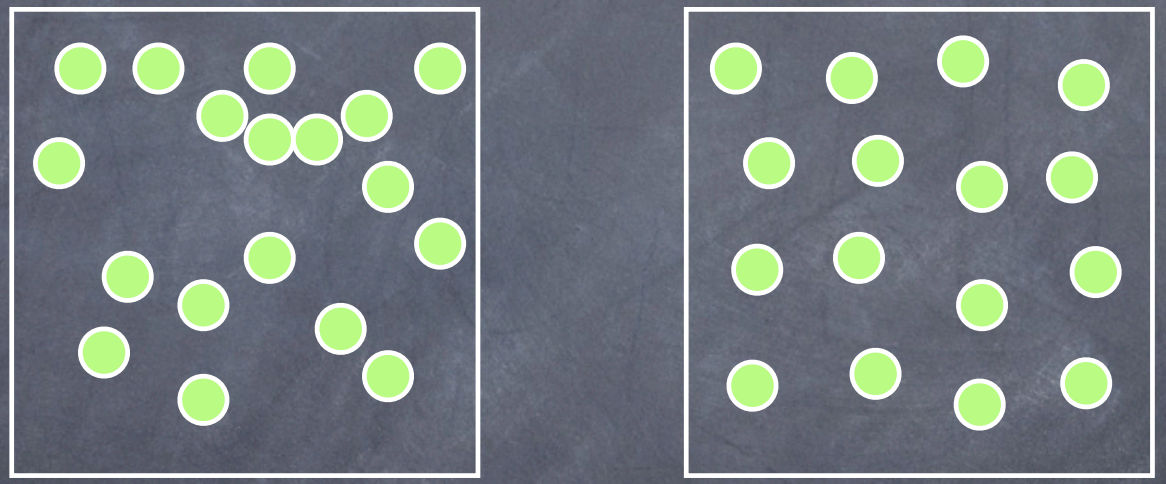
Each ray has

- pixel position
- lens position
- light position
- time

Branching

- Typically, there is little or none
- Each ray creates a path (not a tree)

Stratification



Some open questions

- Which of BVH vs k-d vs grid?
- What are the target scenes/applications?
- What hardware will we use?
- Adaptive or constant sampling?
- Interface to batch renderers?
- Procedural geometry?
- API?

Academics' dilemma

- The number of papers "mine-able" is proportional to the awkwardness of approach
- Interactive Ray Tracing 2006, next month (Poster abstracts due Aug 6)

Morning schedule

8:30–9:15	Intro	Shirley, Boulos
9:15–10:15	Optimizing RT	Stoll
Break		
10:30–11:00	Dynamic Environments	Manocha, Lauterback
11:00–noon	Dyn. Models	Wald
noon–12:15	Cook RT	Boulos

Afternoon schedule

1:30-1:50	Big iron	Stephens
1:50-2:30	LODs & Data layout	Manocha, Yoon
2:30-3:30	Razor	Stoll, Mark
Break		
3:45-4:45	Architectures	Slusallek Schmidt
4:45-5:30	Open prob's	All

Where are we now?
(demo: Solomon Boulos)

Questions?