HWRT

THE UNIVERSITY OF UTAH

CS 6958
LECTURE 13
INTRO TO ANTI-ALIASING, PATHTRACING

March 3, 2014

What is Aliasing?

- Imagine this is our scene

Source: Physically Based Rendering, Pharr & Humphreys

What is Aliasing?

- If we render it with our ray tracers…

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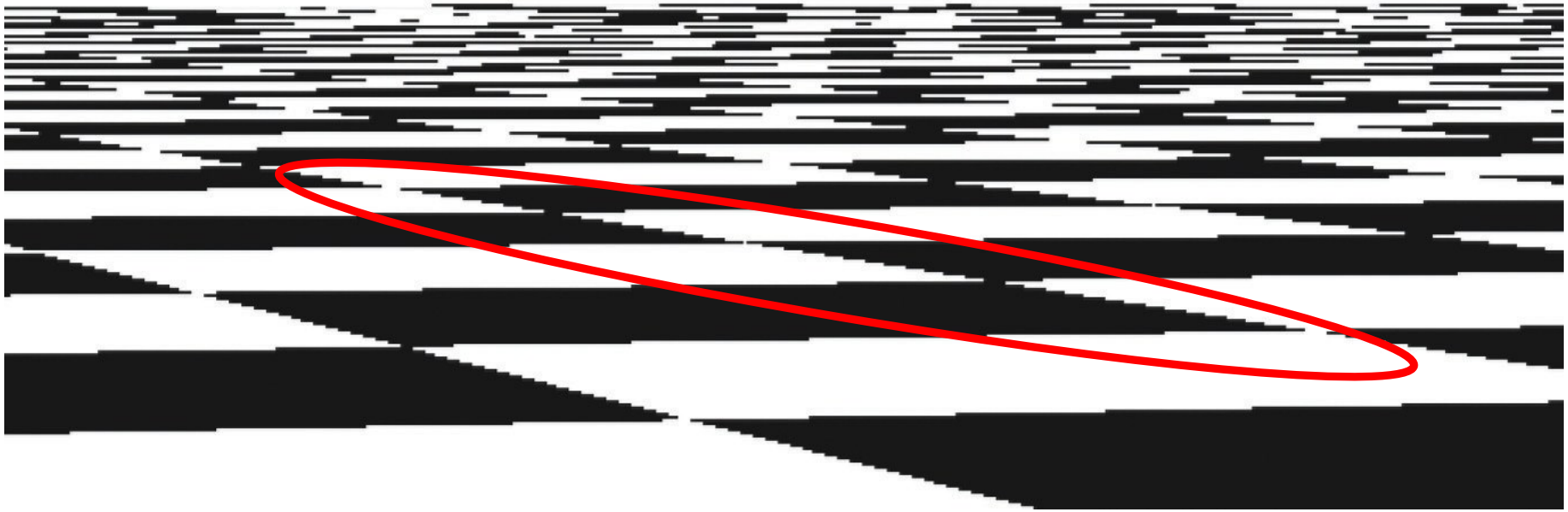
What is Aliasing?

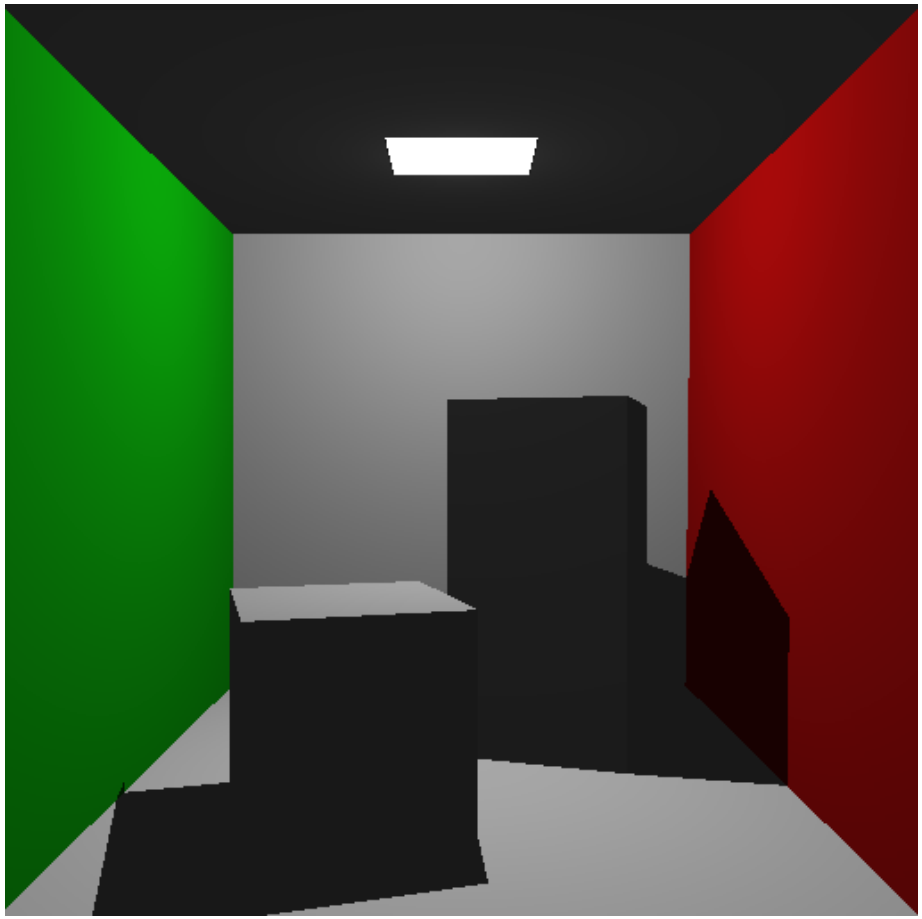
- If we render it with our ray tracers…



Source: Physically Based Rendering, Pharr & Humphreys

What is Aliasing?

- Consider our Cornell Box



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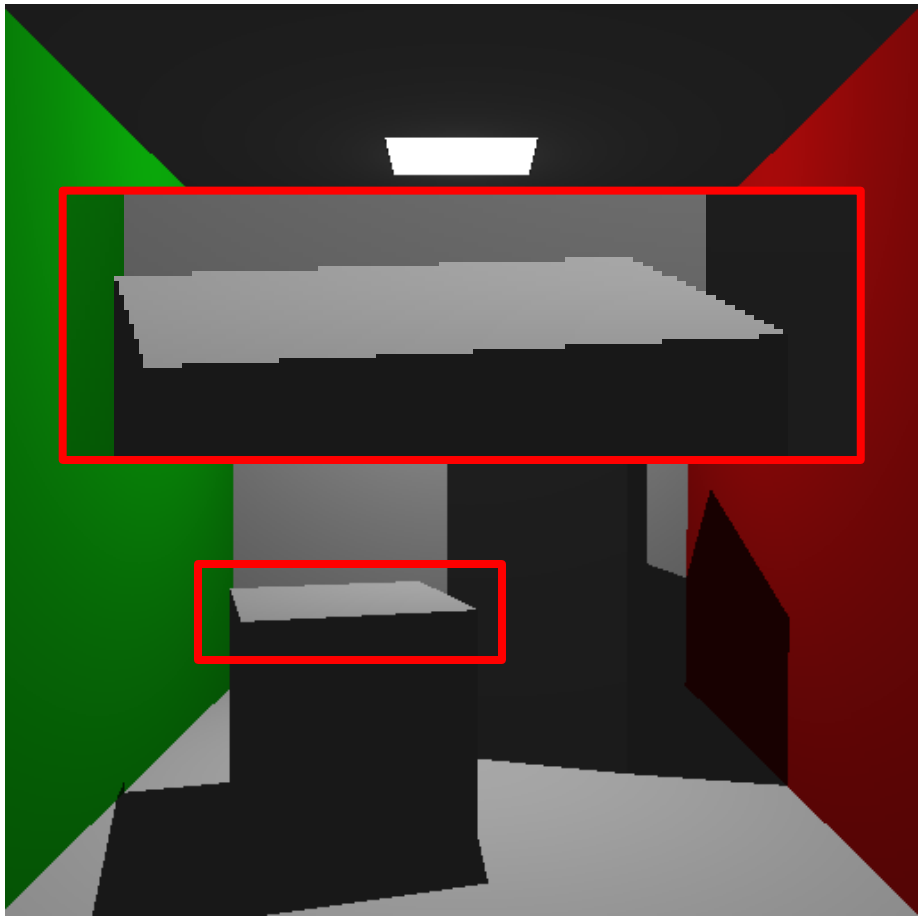

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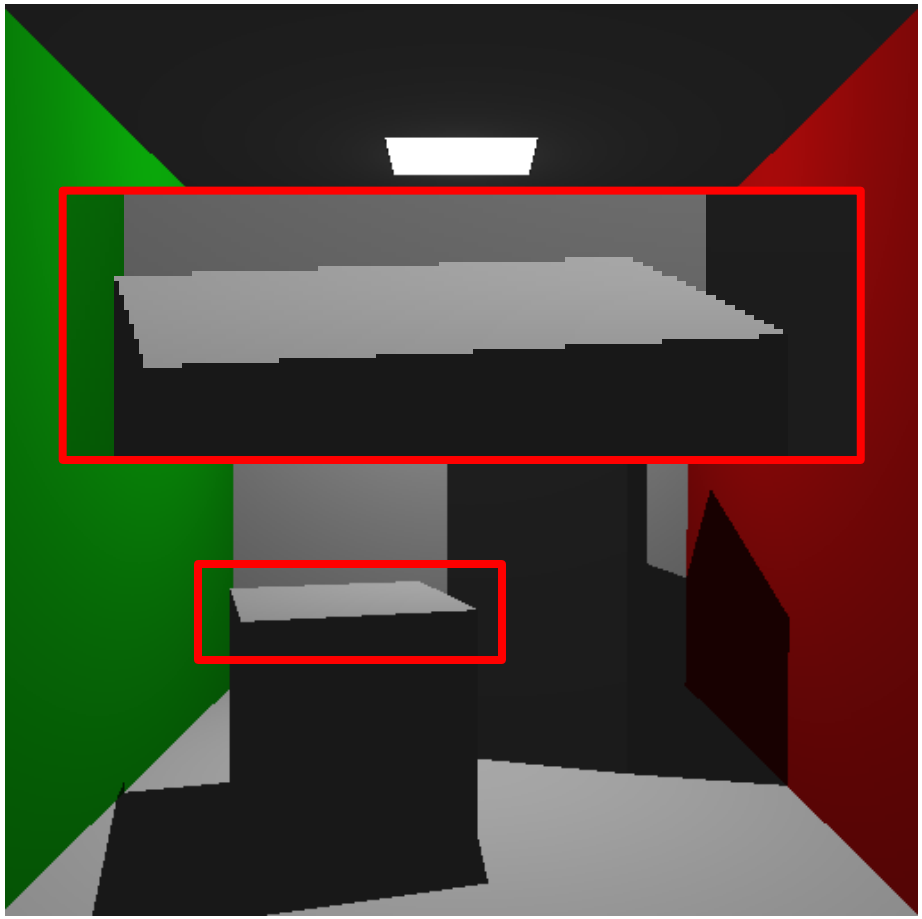
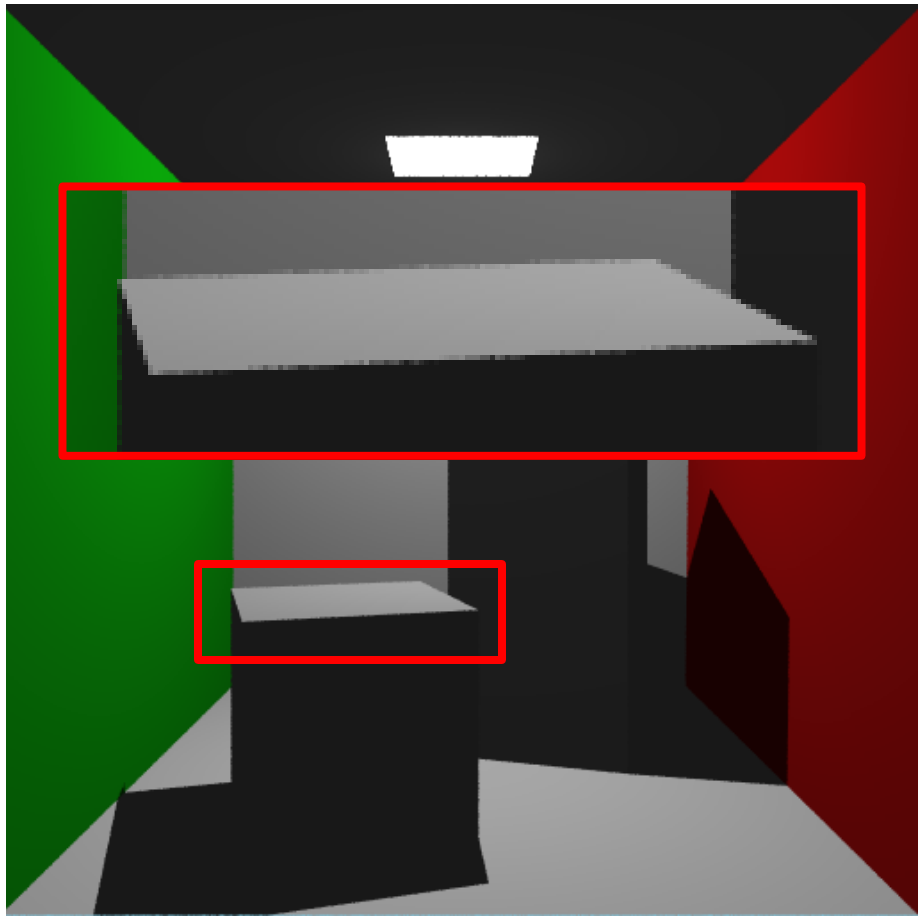




Anti-Aliasing

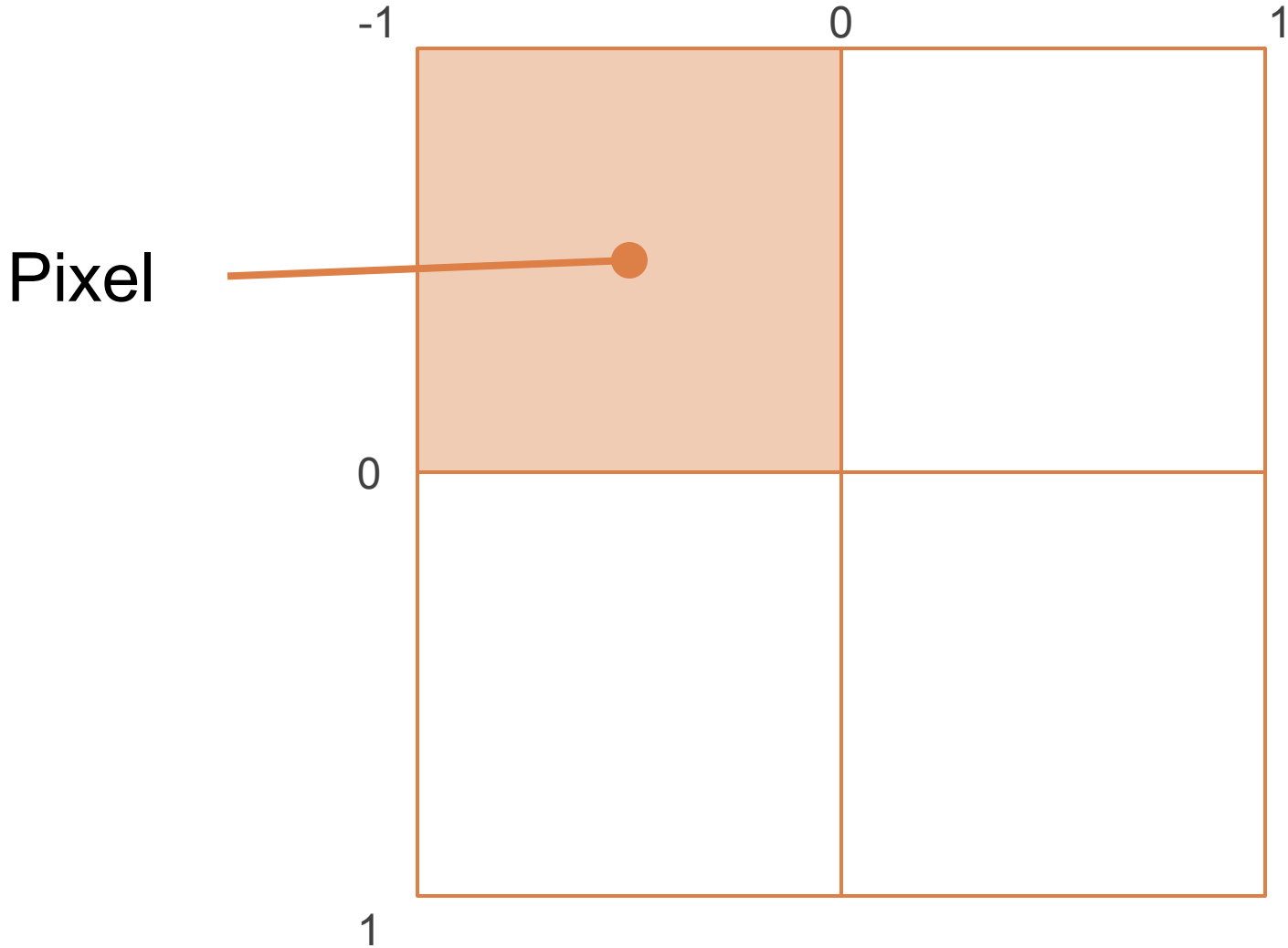
- Issue:
  - Our sampling can't reconstruct original signal
  - Nyquist-Shannon sampling theorem
- Solution:
  - better sampling
  - better reconstruction of original signal
- Lots of literature and theory on sampling and reconstruction techniques

Sampling Techniques

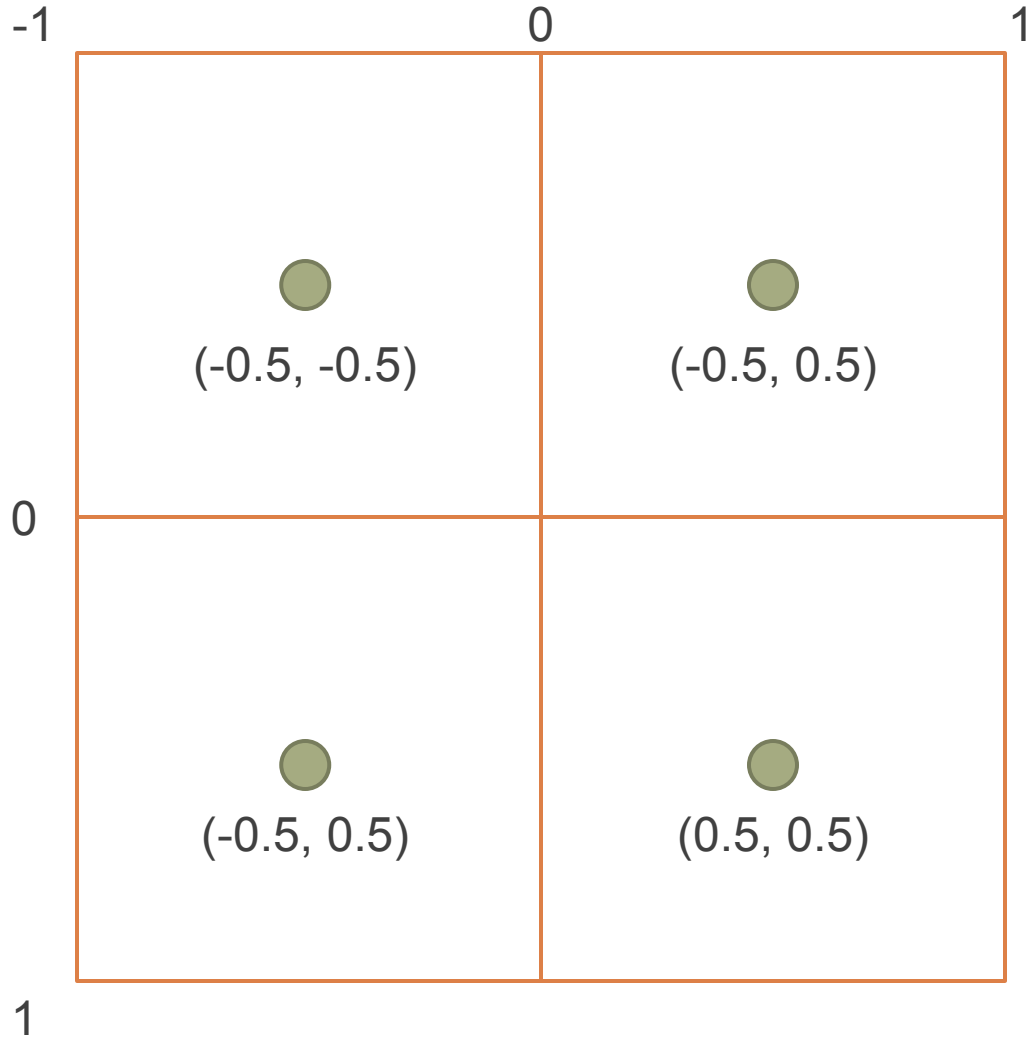
- currently: through center of each pixel
- 1 sample not enough! Use many and “average”

- how do we pick samples?
  - uniform
  - random
  - jittered

Consider a 2x2 image

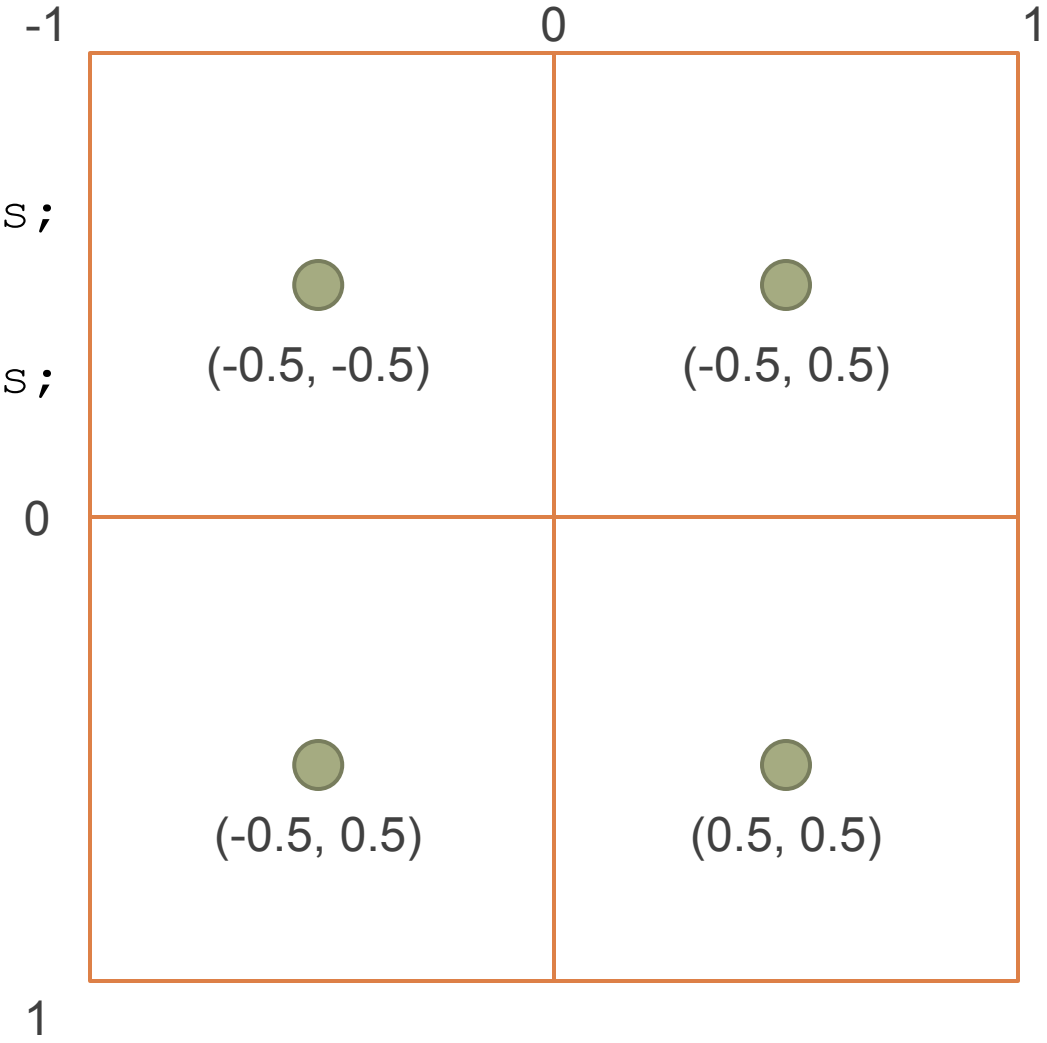


Pixel centers



Pixel centers

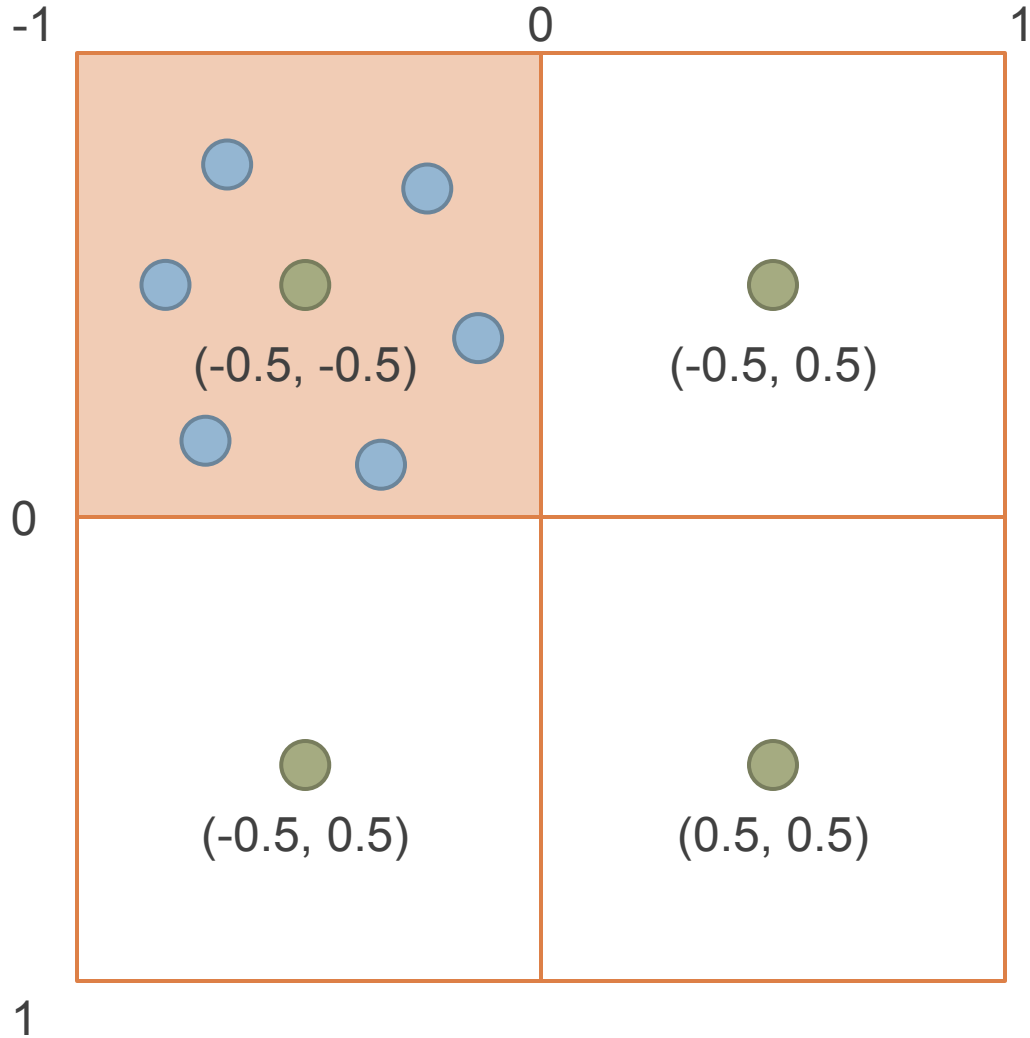

```
foreach pixel(i, j)
x = 2.0f *
 (j - xres/2.f + 0.5f)/xres;
y = 2.0f *
 (i - yres/2.f + 0.5f)/yres;
```



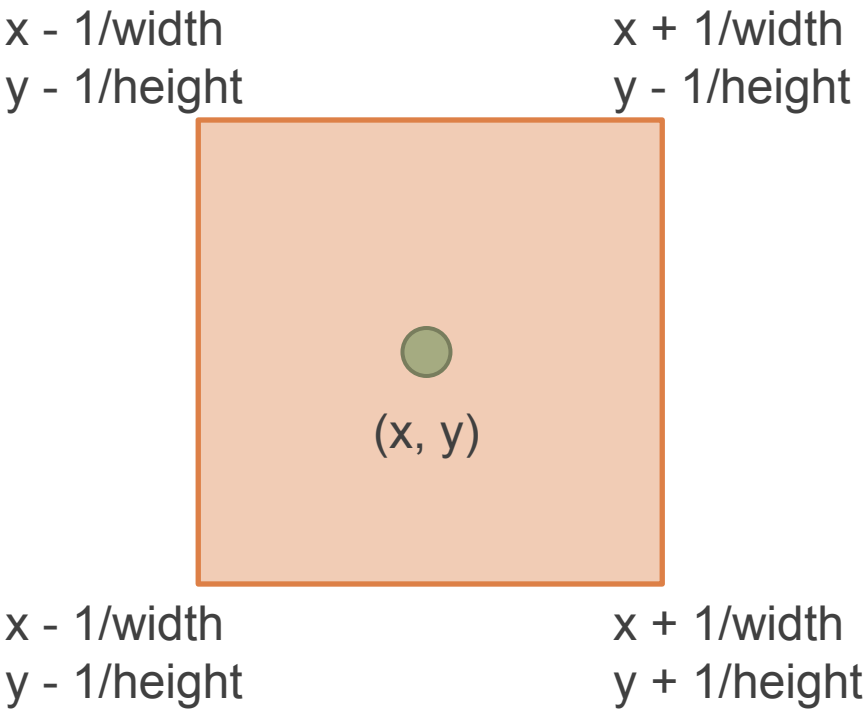
This is our current ray generation method

Sampling a pixel

- pick location other than center
  - or perturb center
- stop when n reached



Generating pixel samples

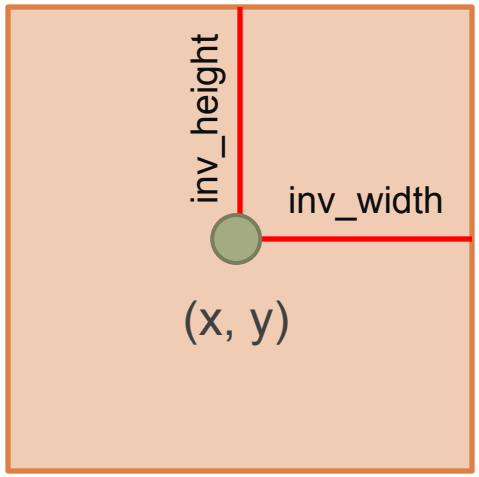


inv_width = loadf(0, 2)

inv_height = loadf(0, 5)

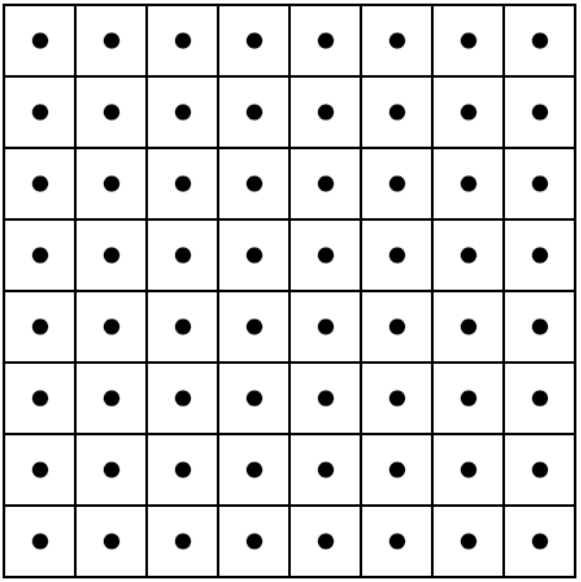
Generating pixel samples


```
// value between 0, 1
x_off = (trax_rand() - .5f) * 2.f;
y_off = (trax_rand() - .5f) * 2.f;

// scale offsets to pixel coords
x_off *= inv_width;
y_off *= inv_height;

// offset from center
x += x_off;          y += y_off;

// generate ray
camera.makeRay(ray, x, y);
```



Different sampling strategies

uniform



Source: Physically Based Rendering, Pharr & Humphreys

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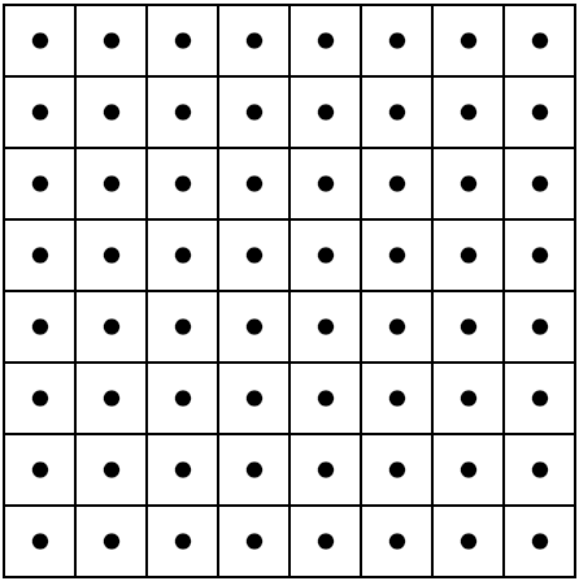
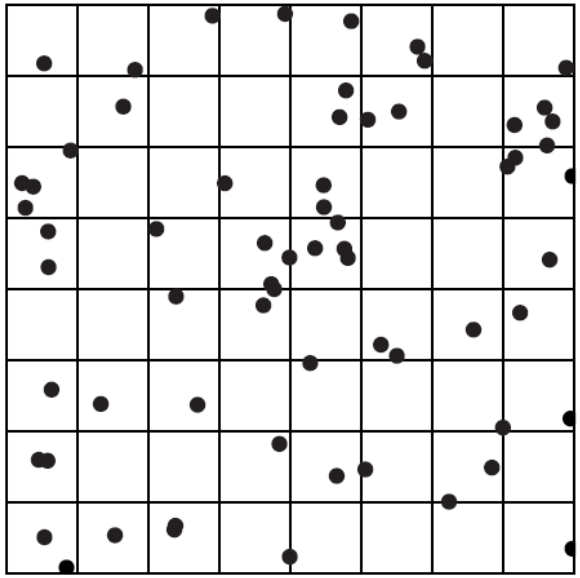


random



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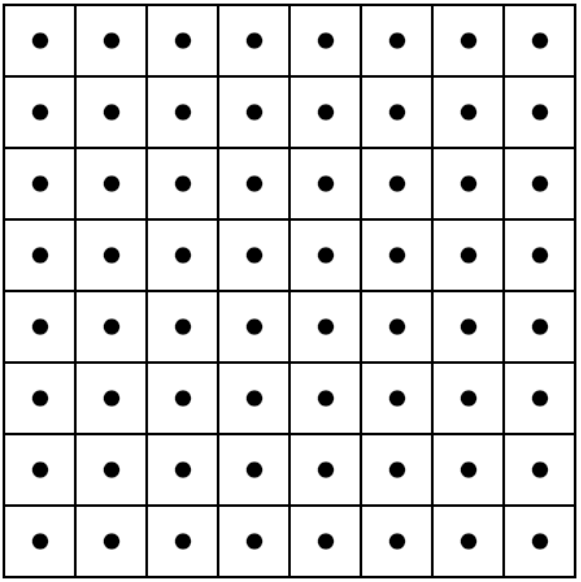
Different sampling strategies

uniform



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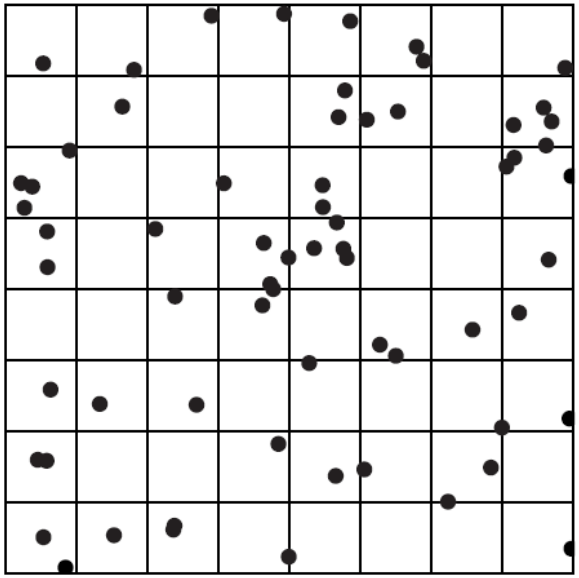
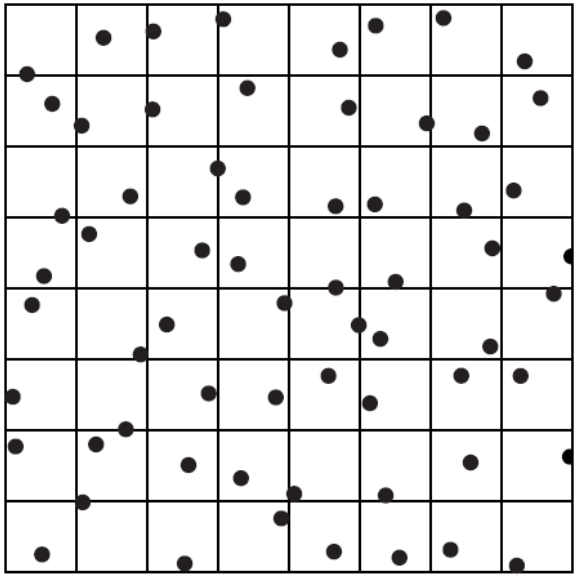


jittered



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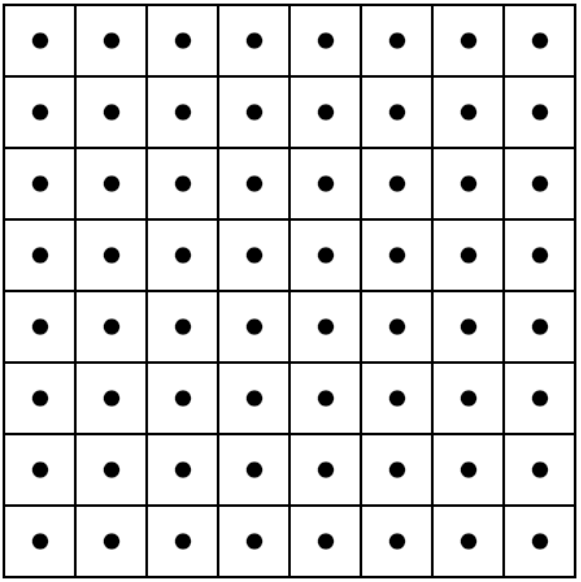

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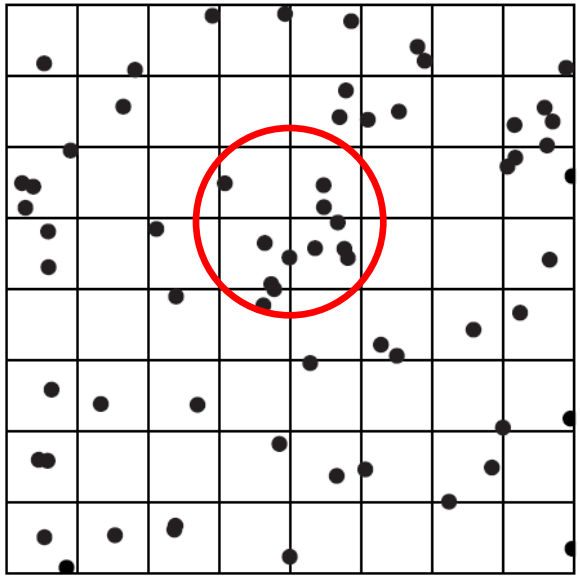

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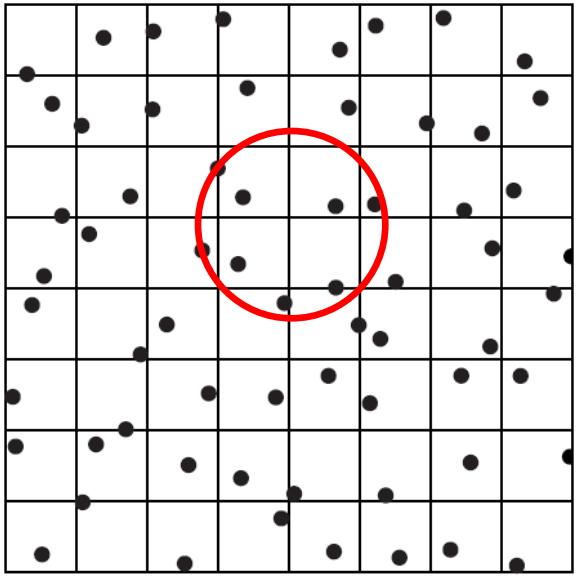


Difference between random and jittered, is that jittered has only 1 sample within each cell. It's still randomly perturbed!

Source: Physically Based Rendering, Pharr & Humphreys

Reconstruction filters

- once we have samples, must recombine to get final color

- most popular
  - box
  - triangle
  - Gaussian

Putting it all together

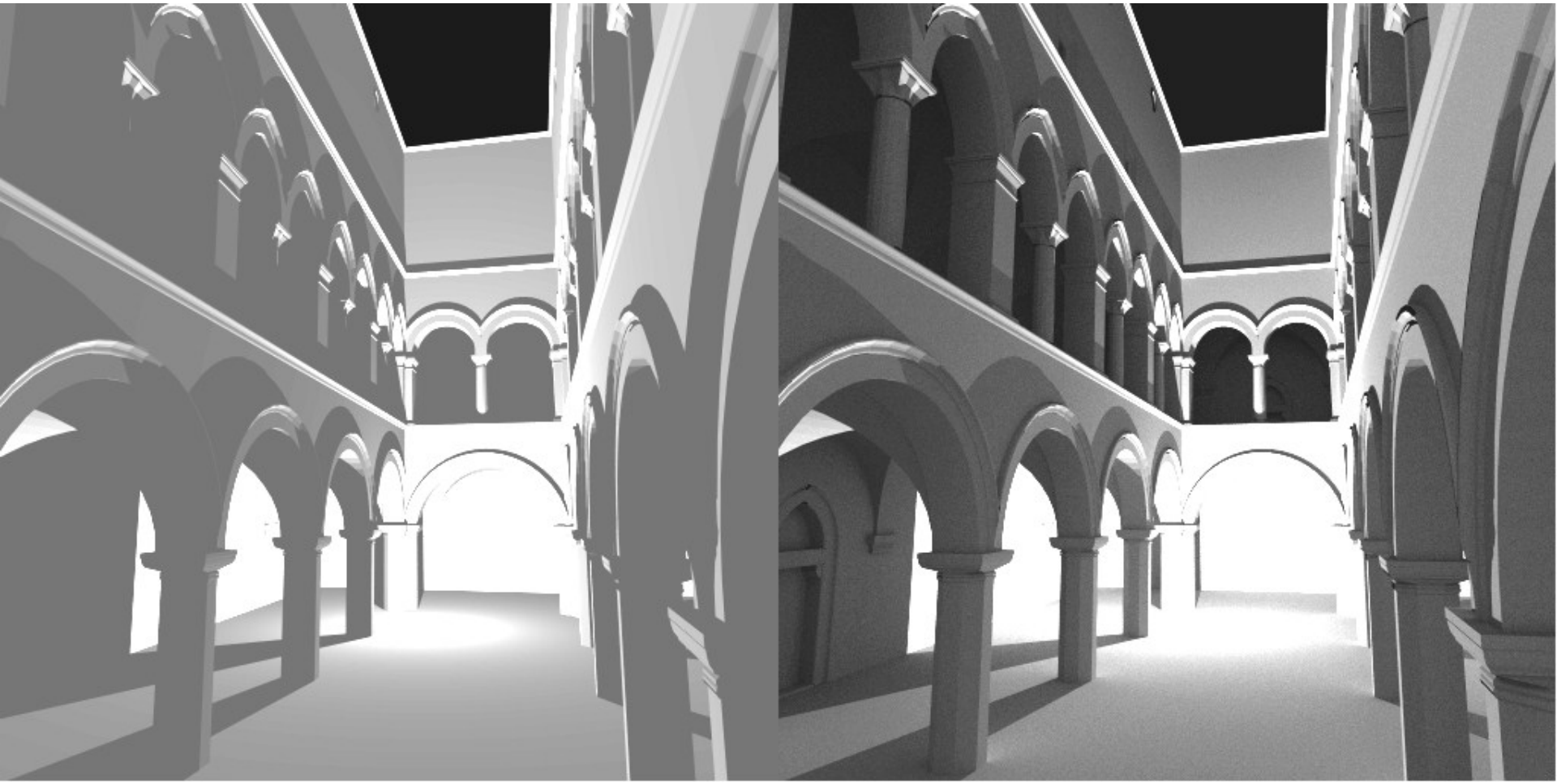

```
foreach pixel
    for(number_samples)
        x, y = getNewSampleLocation(pixel);
        camera.makeRay(ray, x, y);

        bvh.intersect(hit, ray);
        result += shade( ... );      // box filter

    result /= number_samples;        // box filter
    image.set(pixel, result);
```

Global Illumination

- so far, we've looked at
  - point lights (no area)
  - direct illumination (no inter-reflections)
  - non-physical Phong shading
  - fake ambient light term

- our world behaves a little differently
- we have all the tools to get it (mostly) right!

Global Illumination



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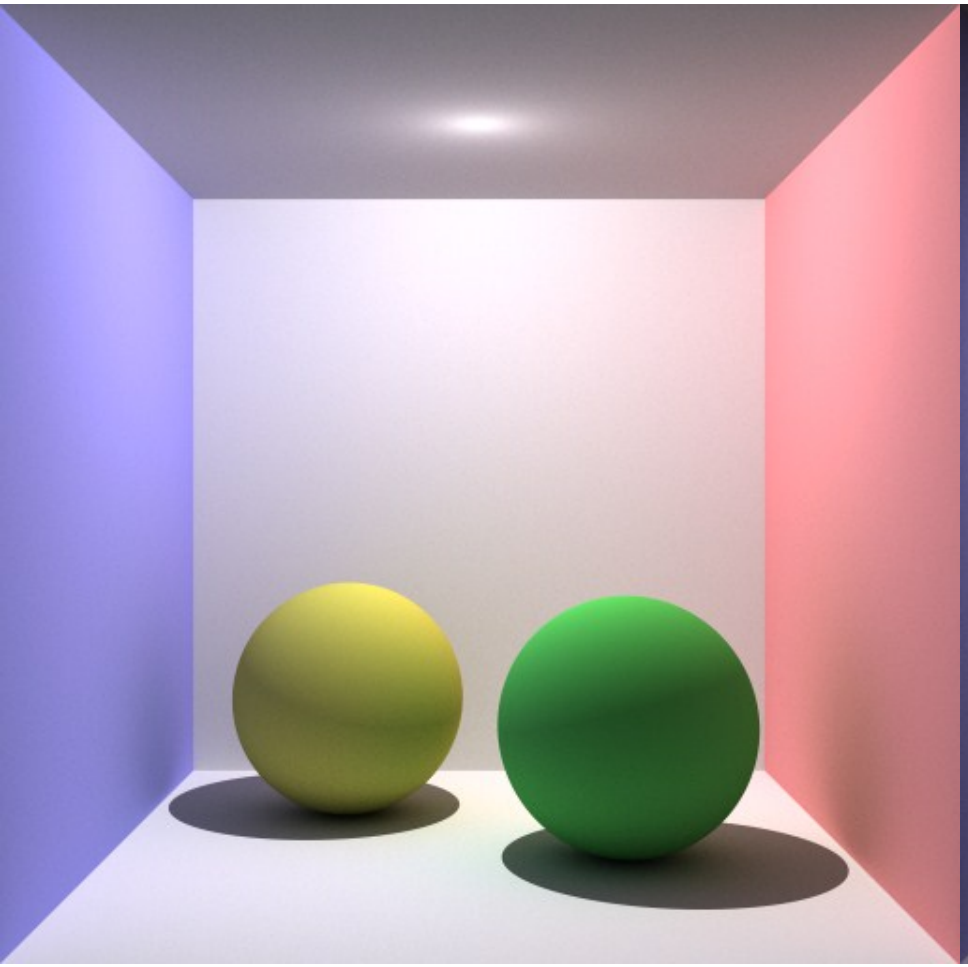

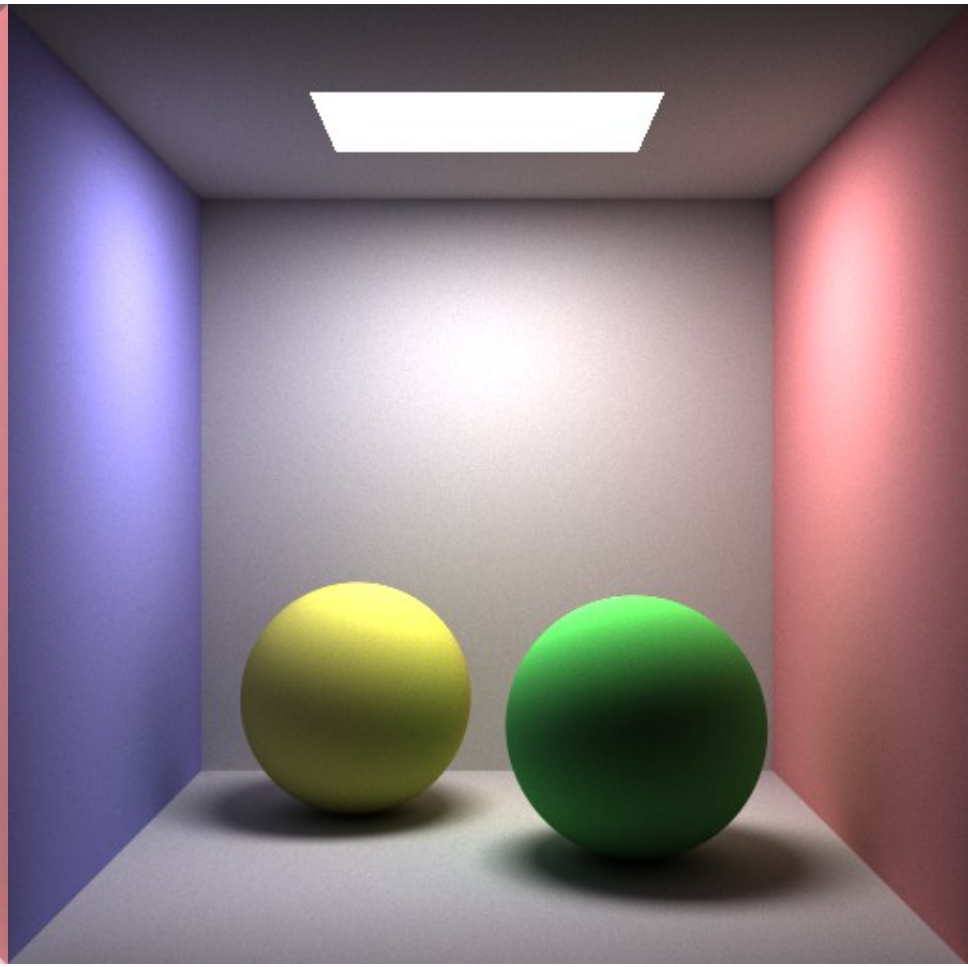

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Let’s try to derive path tracing

- Board time!
- Slides online will include this info

Path tracing algorithm


```
...
for(number_samples)
    attenuation = Color(1.f, 1.f, 1.f);
    ray = generateNewRay( ... );
    while(depth < max_depth) {
        HitRecord hit;
        bvh.intersect(hit, ray);
        result += shade(…) * attenuation;// box filter
        attenuation *= mat_color;
        r = hemiRay(…);
        depth++
    }

result /= number_samples;                // box filter

// tone map!
image.set(pixel, result);
```

End