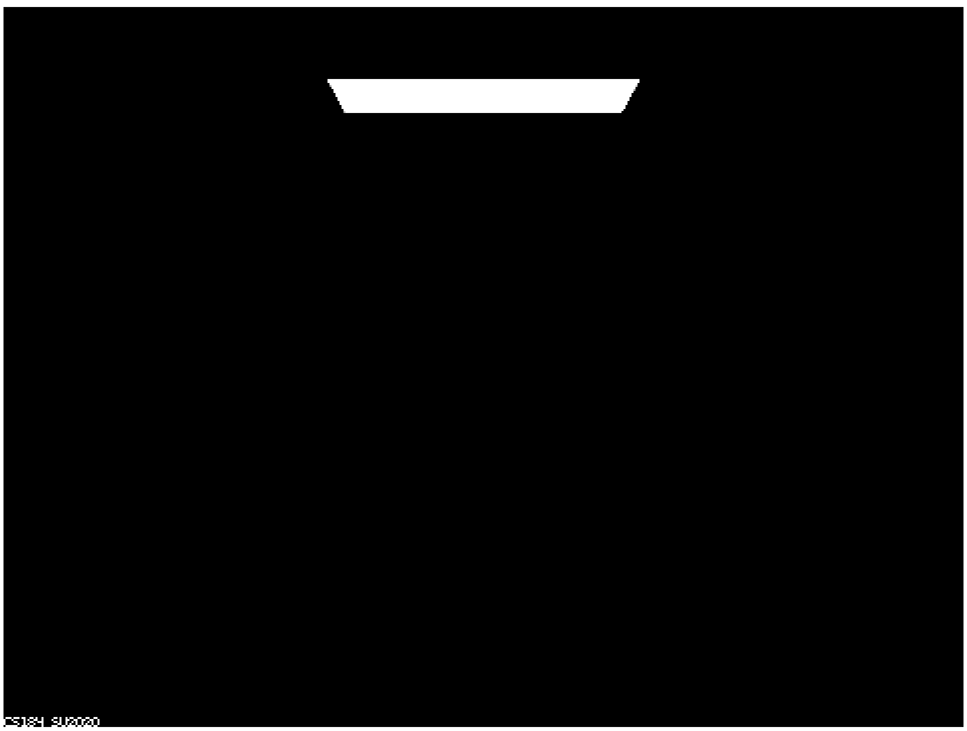
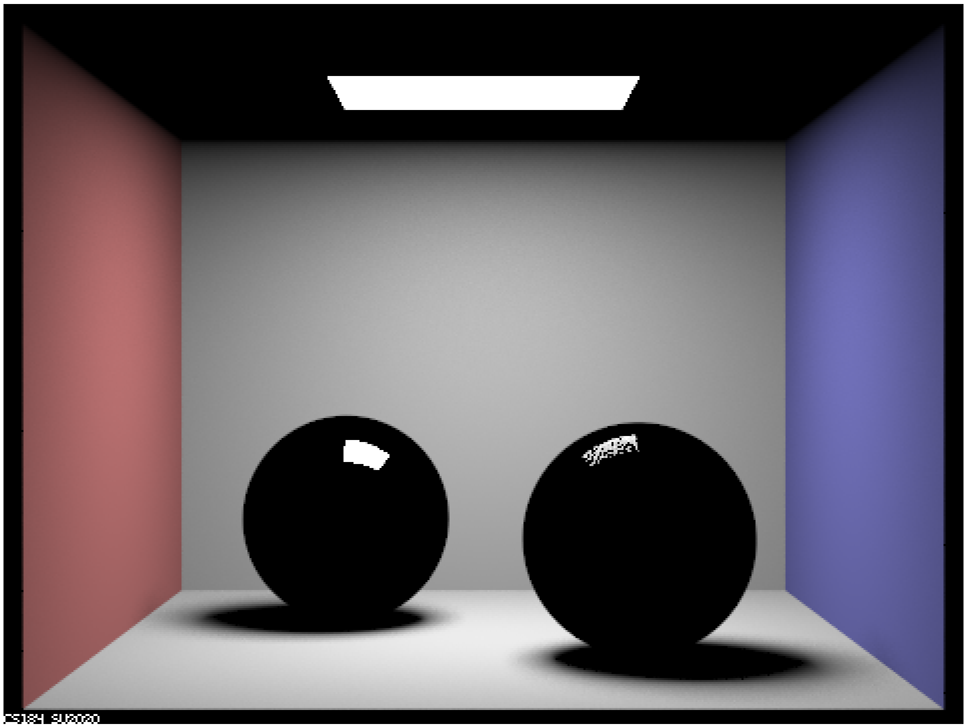
Part 1

- Show a sequence of six images of scene `CBspheres.dae` rendered with `max_ray_depth` set to 0, 1, 2, 3, 4, 5, and 100. The other settings should be at least 64 samples per pixel and 4 samples per light.
- 0
  - No bounces, so no pixels except emission materials.
  
- 1
  - Only one bounce. Thus only direct lighting is calculated and we can see how glass balls only reflect emitting

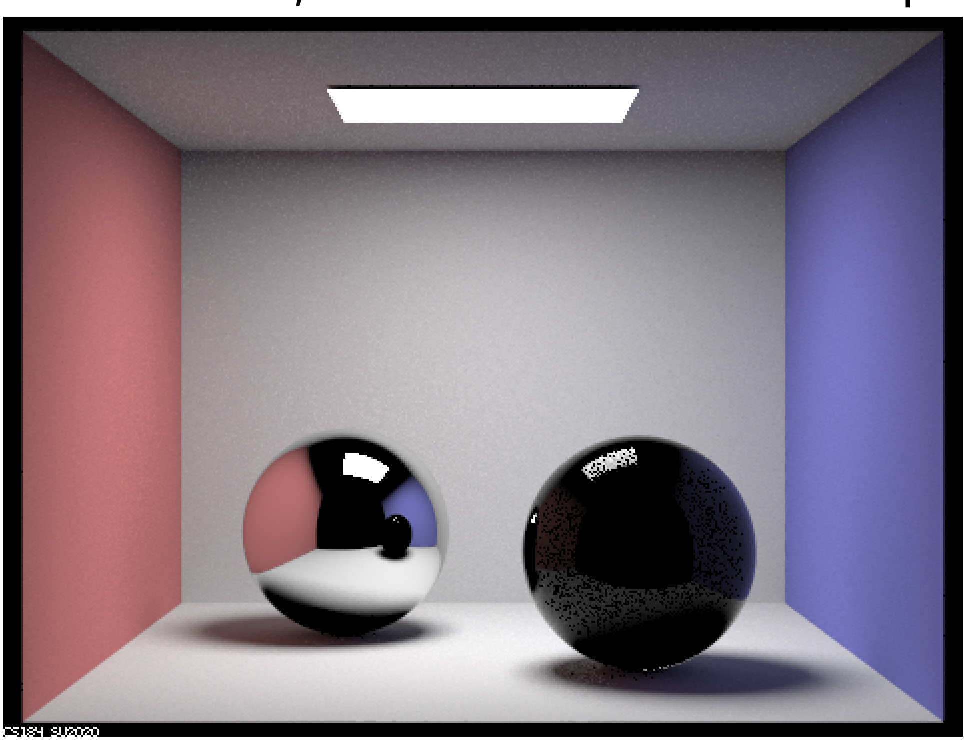
objects.

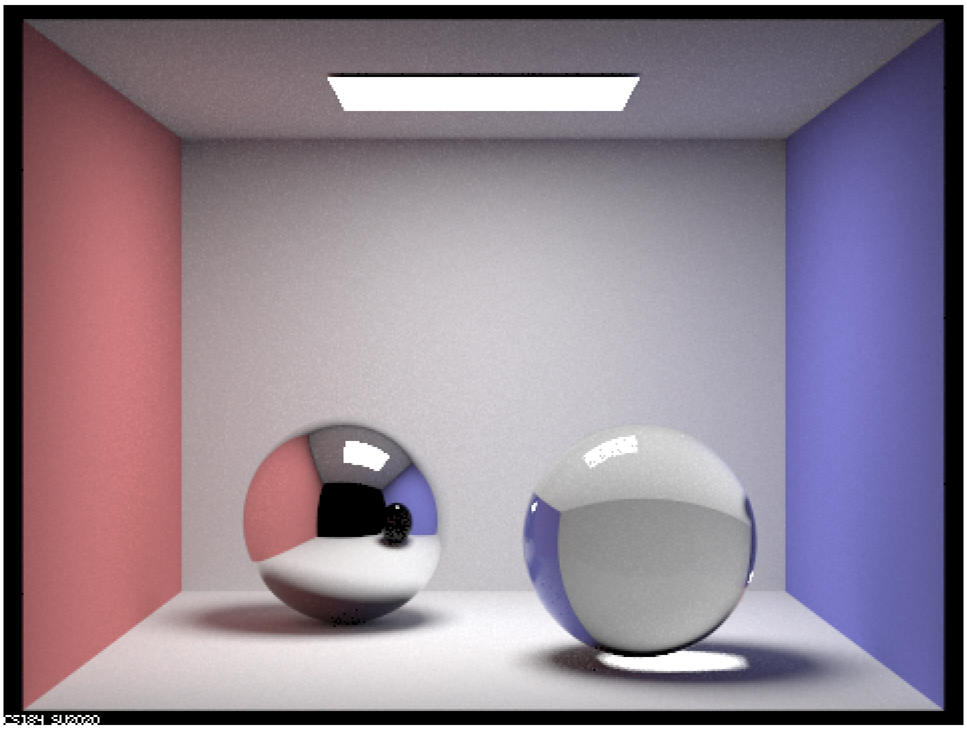


- 2

  \- Refraction effect shows up

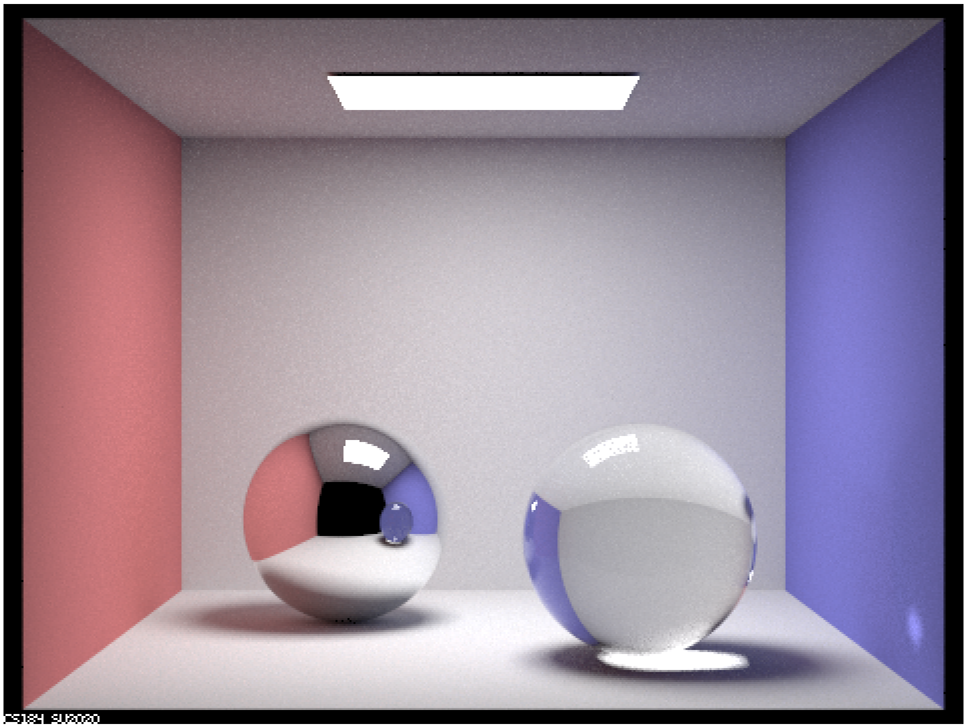
  \- The ceiling and floor reflected in the left reflective ball is still dark. Because it wil require 2 bounces for the ceiling and some part of the floor to be bright, for they are not directly casted light on. Thus, to appear correct in reflection, 3 bounces would be required.

- 3
  - Ceiling and floor appeared brighter in left ball.
  - Refraction effect correct in right ball.
  - Right ball is still dark in the reflection of left ball.
  Because it only get bright in 3 bounces, 1 more bounce would be required for the reflected radiance to reach the camera.
  

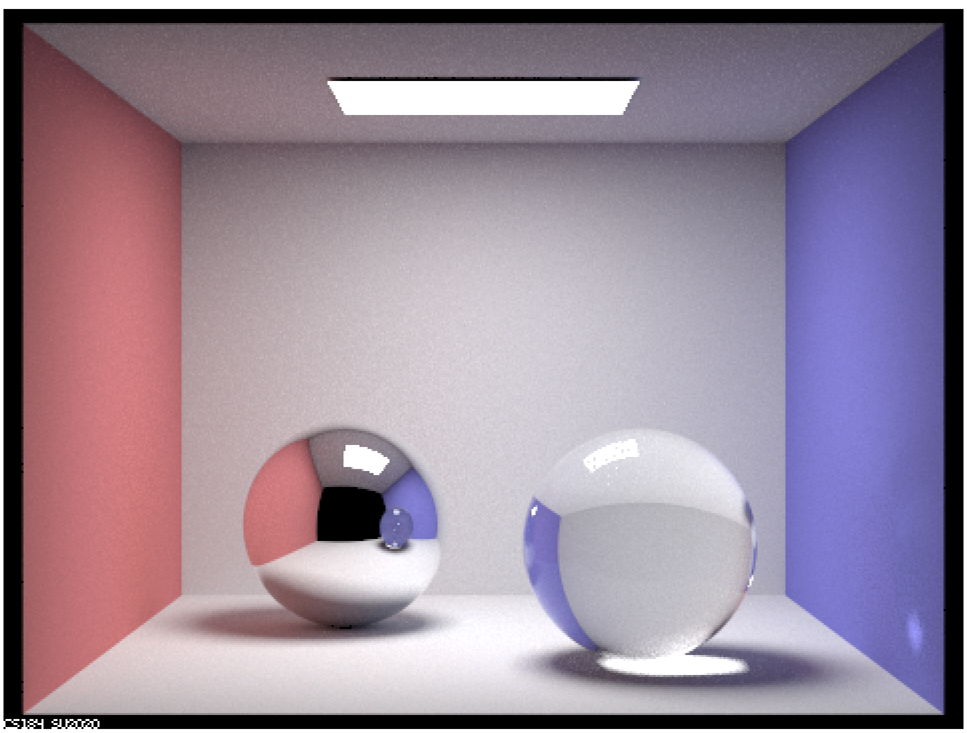
- 4
  - The right ball appeared normal now in the reflection of left ball.
  - A small area in the right blue wall as it shows the

refraction from the upper light source.



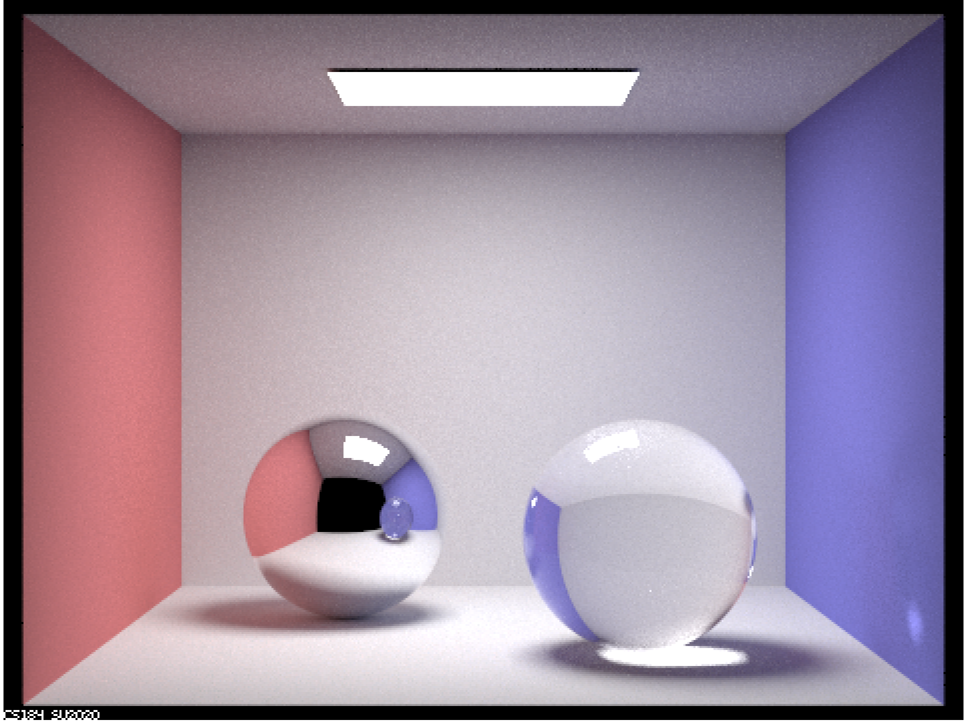
- 5

  \- Almost correct result.



- 100

  \- Almost correct result.



Part 2

- Show a sequence of 4 images of scene `CBdragon_microfacet_au.dae` rendered with α set to 0.005, 0.05, 0.25 and 0.5. The other settings should be at least 128 samples per pixel and 1 samples per light. The number of bounces should be at least 5. Describe the differences between different images. Note that, to change the α, just open the .dae file and search for `microfacet`.
  The sequence of images of scene `CBdragon_microfacet_au.dae` rendered with increasing values of α (0.005, 0.05, 0.25, 0.5) is expected to show the impact of changing the surface roughness on the appearance of the object. As α increases, the surface of

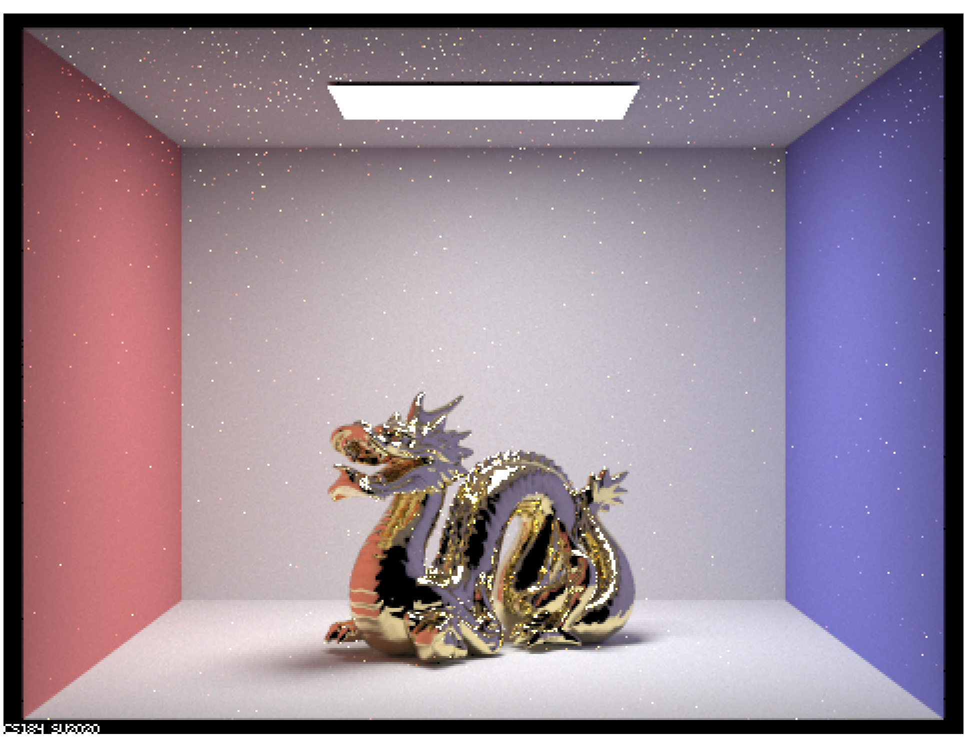
the object becomes rougher, which results in a more diffused reflection of light.

At α = 0.005, the surface is almost perfectly smooth, resulting in a sharp and well-defined reflection. Thus, we can see in the rendered image, many noisy points appeared because the lighting of this material has a high frequency.

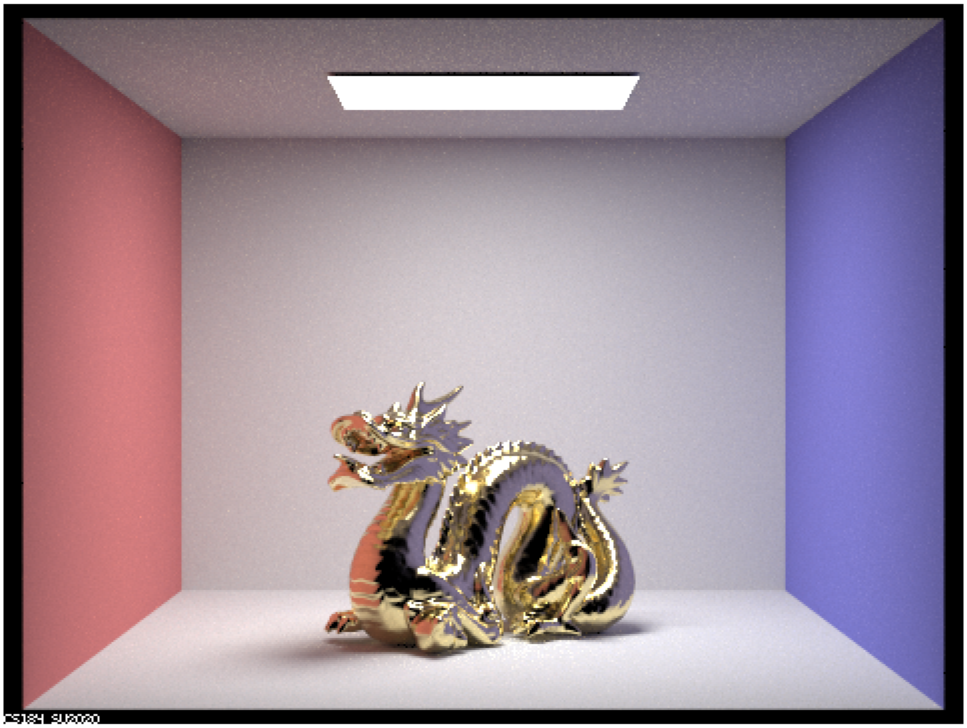
As α increases, the reflection becomes increasingly diffuse, resulting in a softer and less defined reflection. At α = 0.5, the surface is very rough, resulting in a highly diffuse reflection that spreads light in many directions.

Overall, increasing α results in a change in the object's surface appearance, with rougher surfaces producing a softer and more diffuse reflection of light.

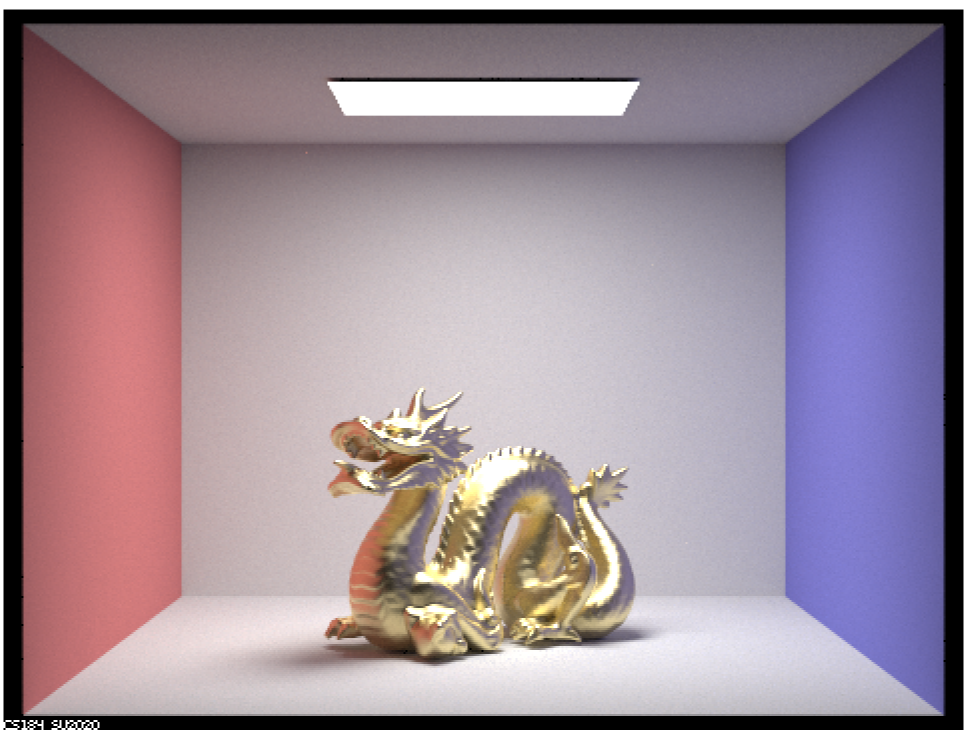
- 0.005



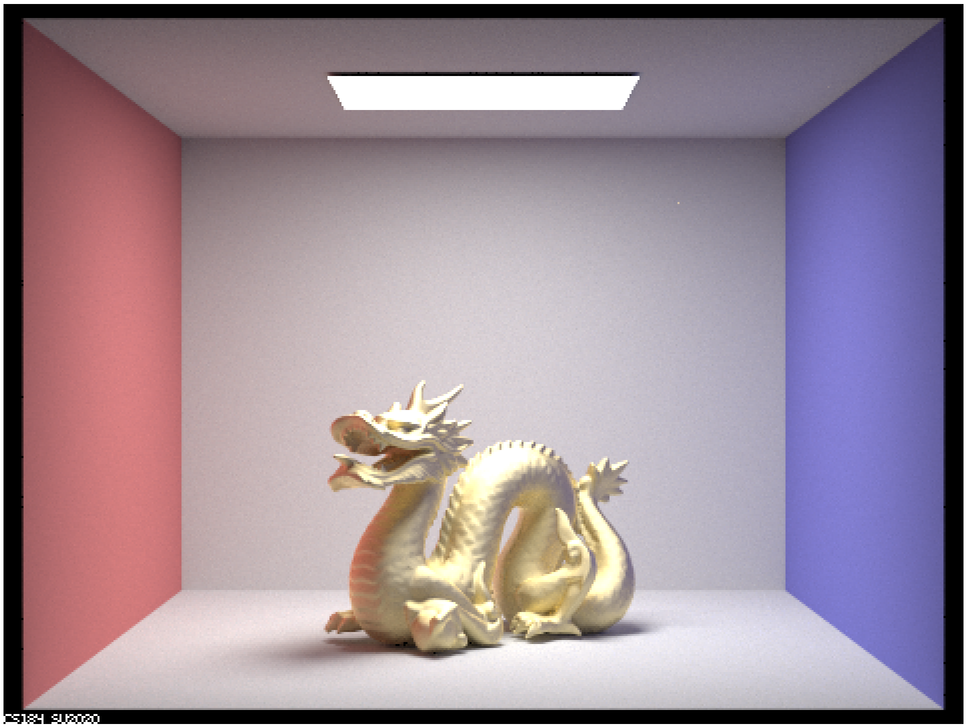
- 0.05



- 0.25

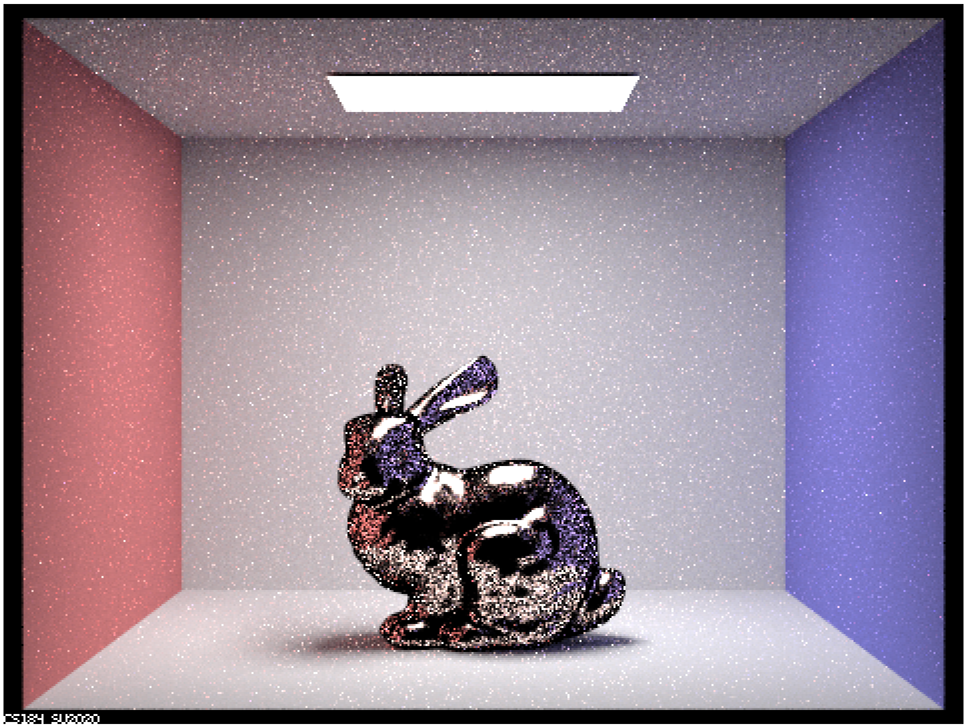


- 0.5

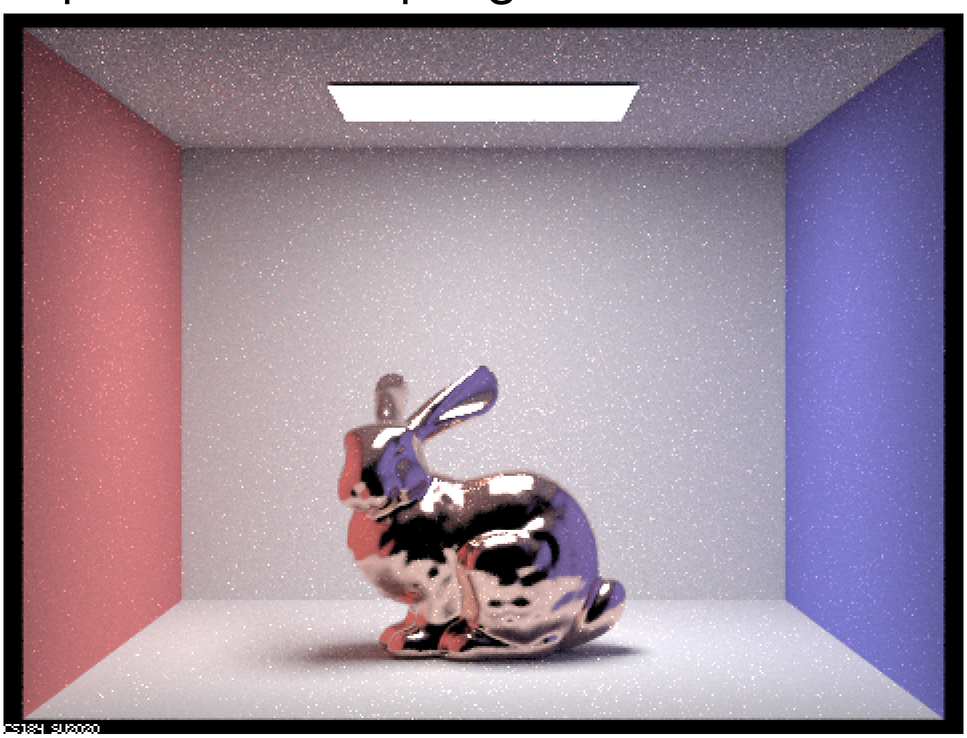


- Show two images of scene `CBbunny_microfacet_cu.dae` rendered using cosine hemisphere sampling (default) and your importance sampling. The sampling rate should be fixed at 64 samples per pixel and 1 samples per light. The number of bounces should be at least 5. Briefly discuss their difference.

- hemisphere

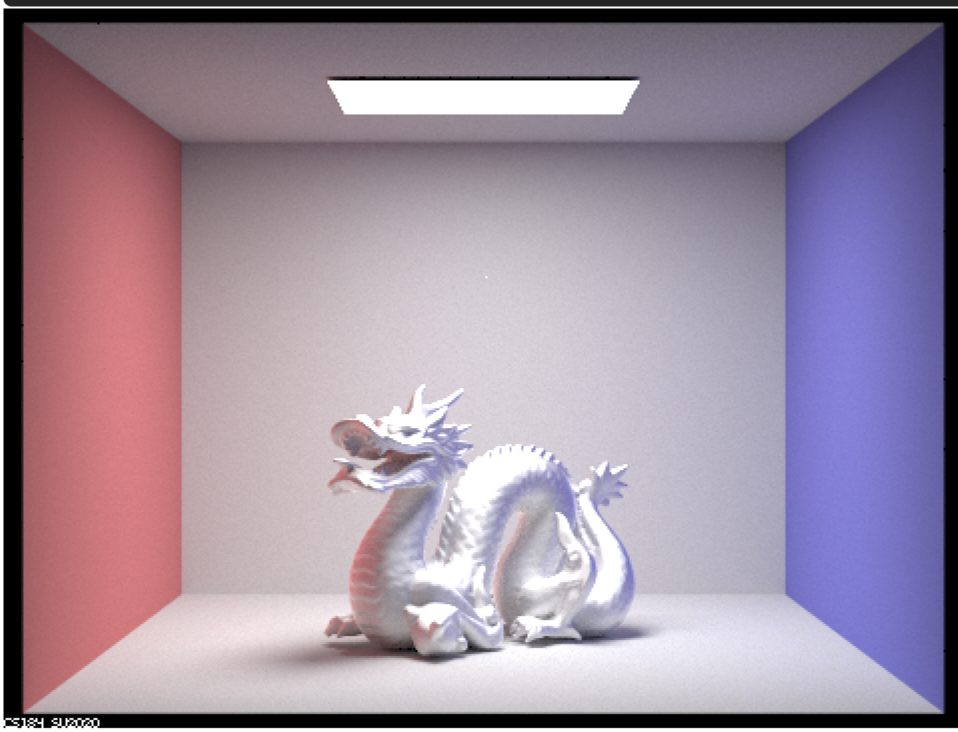


- importance sampling



- Importance sampling can achieve cleaner images with the same sampling rate.

- Show at least one image with some other conductor material, replacing `eta` and `k`. Note that you should look up values for real data rather than modifying them arbitrarily. Tell us what kind of material your parameters correspond to
  - Silver(Ag) Cooresponding value of `eta` and `k` stored in `dae/sky/CBdragon_microfacet_au_silver.dae`

Part 3

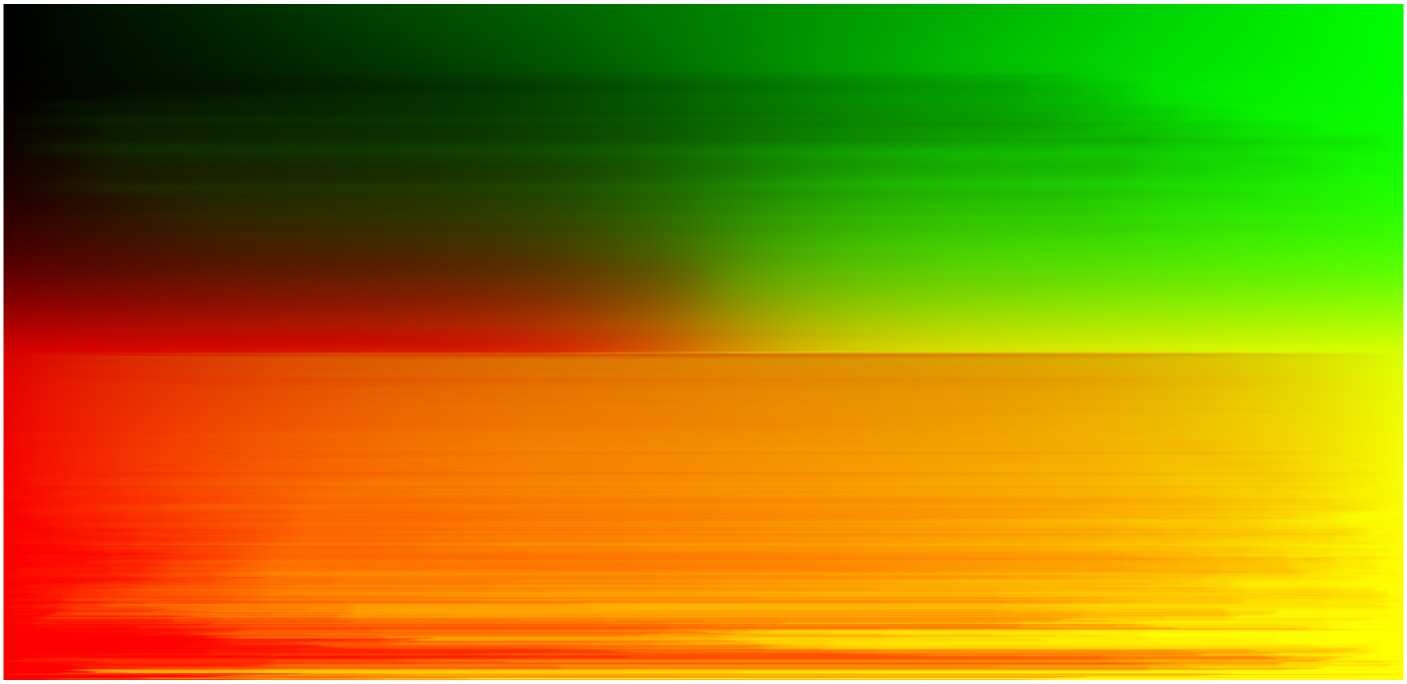
Pick one *.exr* file to use for all subparts here. Include a converted *.jpg* of it in your report so we know what map you are using.

- In a few sentences, explain the ideas behind environment lighting (i.e. why we do it/how it works).

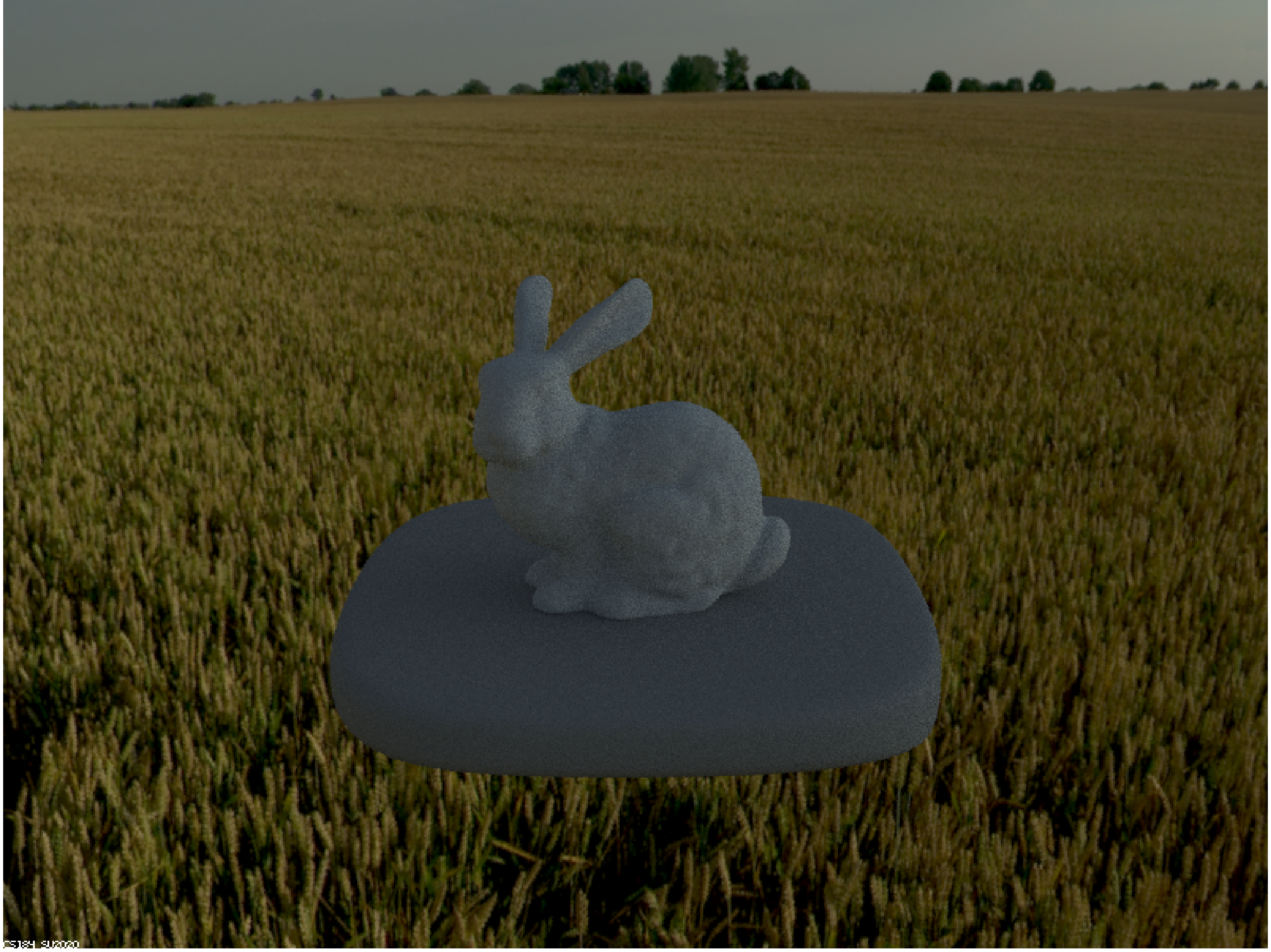
Environment lighting refers to the process of simulating the natural lighting conditions of a scene or environment in computer graphics. It is done to create a more realistic and immersive visual experience by accurately representing how light interacts with objects in the environment.
Image-based environment lighting uses high dynamic range images (HDRIs) of real-world environments to provide an accurate representation of the lighting conditions. These images are mapped onto a sphere or dome surrounding the scene, and the light information is projected onto the objects in the scene.

- Show the $probability\_debug.png$ file for the $.exr$ file you are using, generated using the `save_probability_debug()` helper function after initializing your probability distributions.

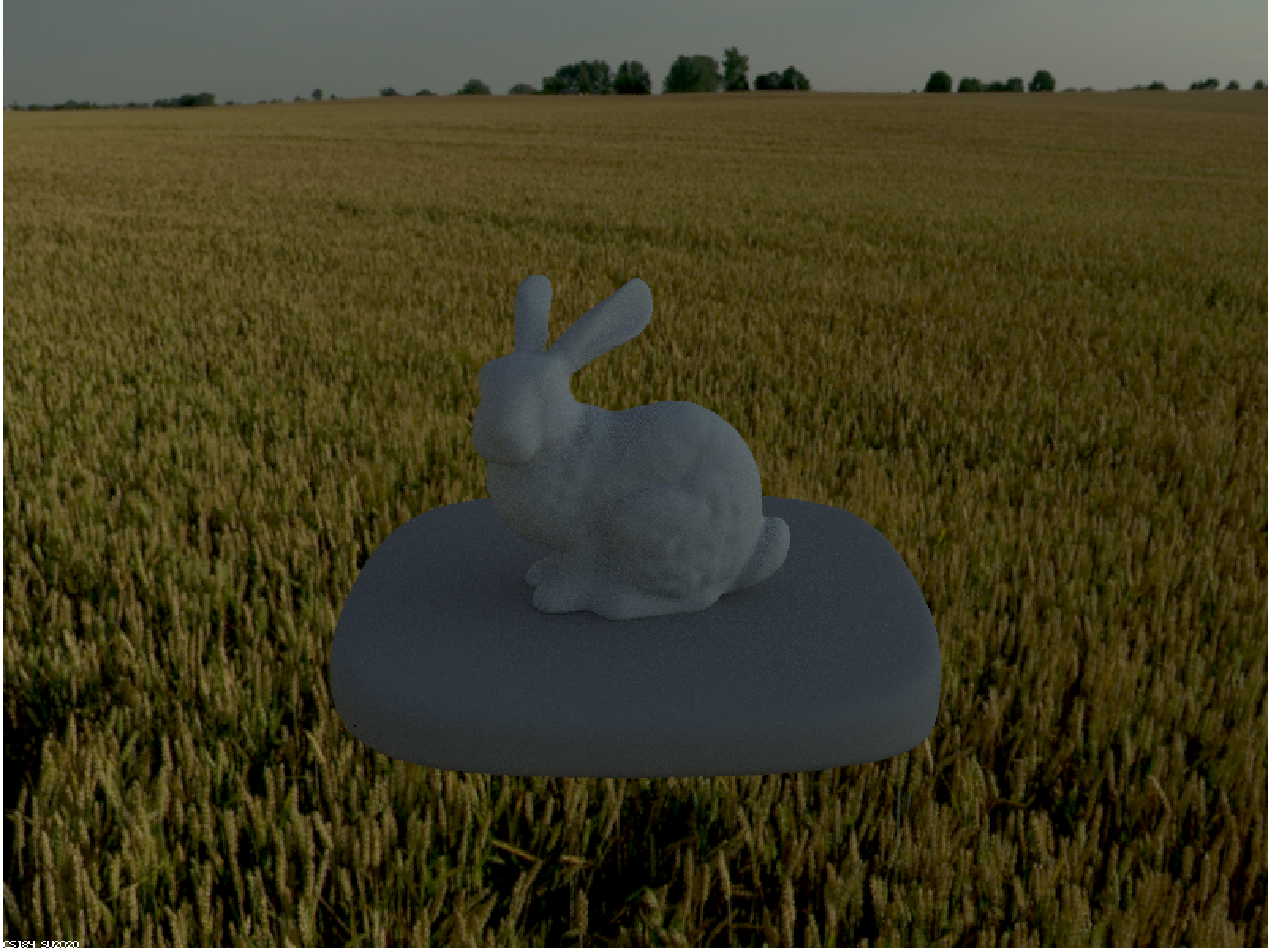
`probability_debug.png` generated using `field.exr`



- Use the `bunny_unlit.dae` scene and your environment map $.exr$ file and render two pictures, one with uniform sampling and one with importance sampling. Use 4 samples per pixel and 64 samples per light in each. Compare noise levels.
  uniform

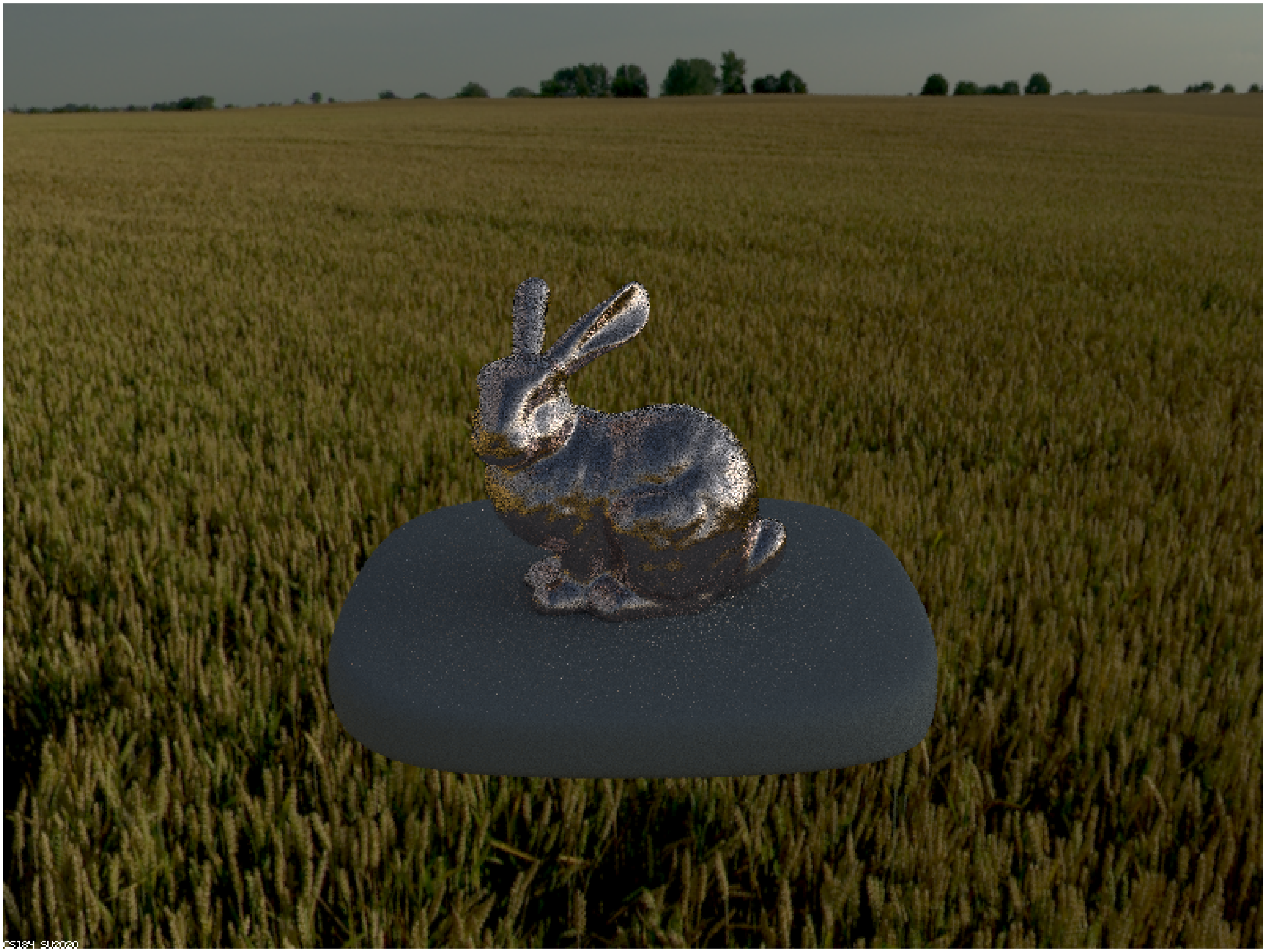


importance

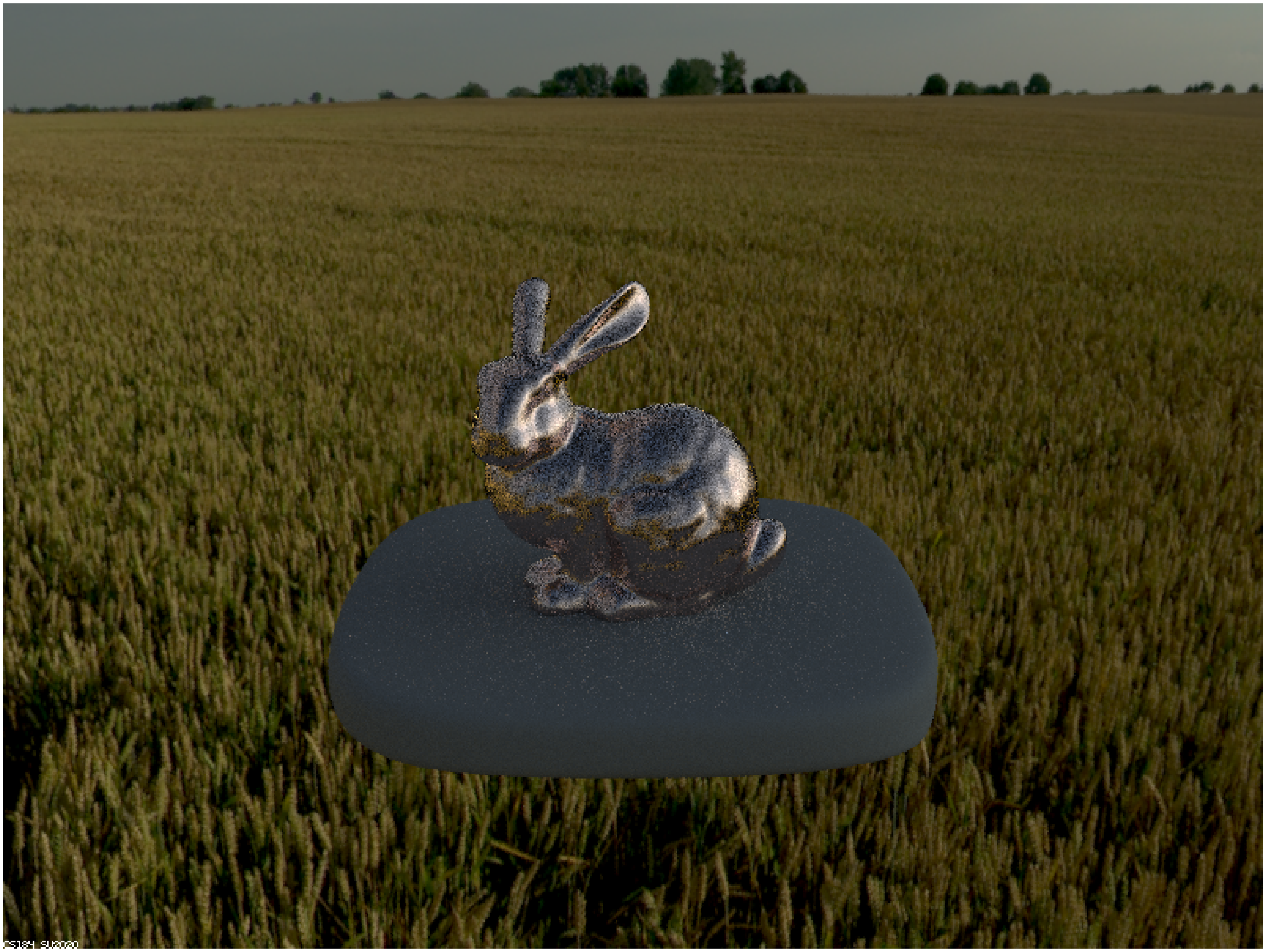


- Use a different image (if you did part 2, we recommend `bunny_microfacet_cu_unlit.dae`) and your environment map $.exr$ file and render two pictures, one with uniform sampling and one with importance sampling. Use 4 samples per pixel and 64 samples per light in each. Compare noise levels.

uniform



importance



Part 4

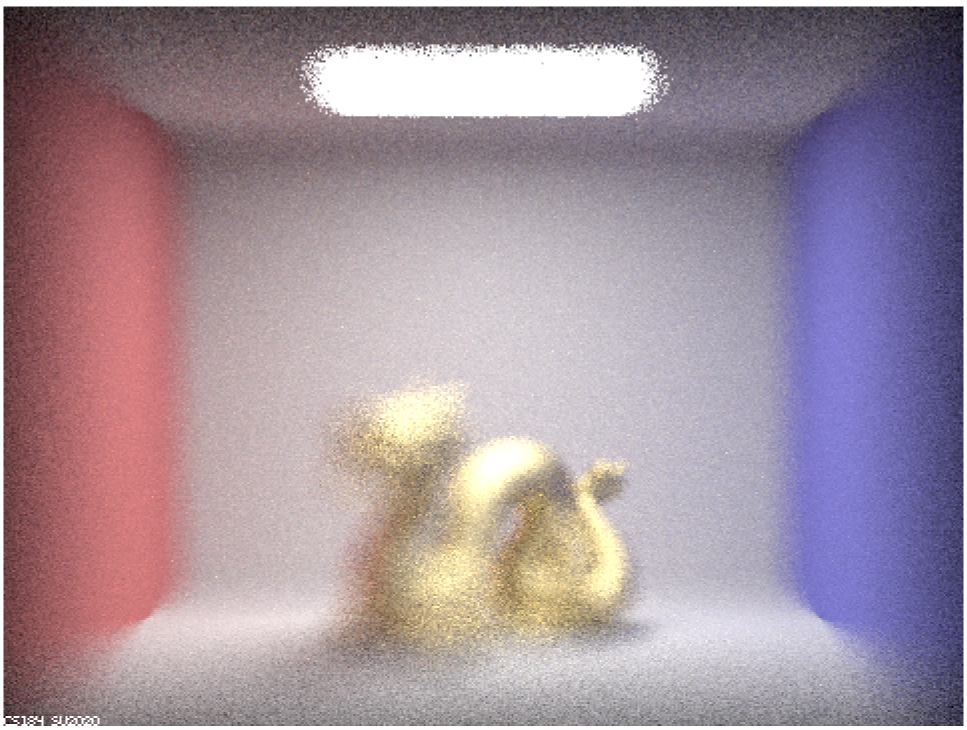
For these subparts, we recommend using a microfacet BSDF scene to show off the cool out of focus effects you can get with depth of field!

- In a few sentences, explain the differences between a pinhole camera model and a thin-lens camera model.
  The pinhole camera model is a simple, theoretical camera model that represents light passing through a small aperture and projecting an inverted image onto a

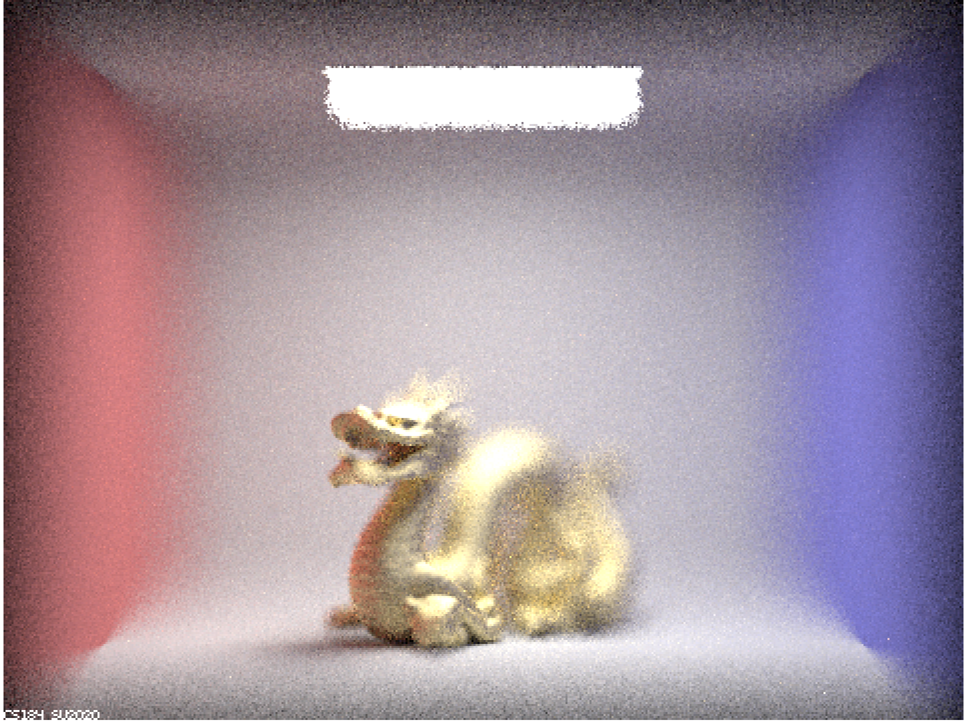
flat plane. In contrast, the thin-lens camera model uses a convex lens to focus light onto the camera sensor, resulting in a non-inverted image. The thin-lens model is more complex but also more accurate, as it takes into account the effects of lens distortion and aberration, which can significantly impact image quality.

- Show a "focus stack" where you focus at 4 visibly different depths through a scene.

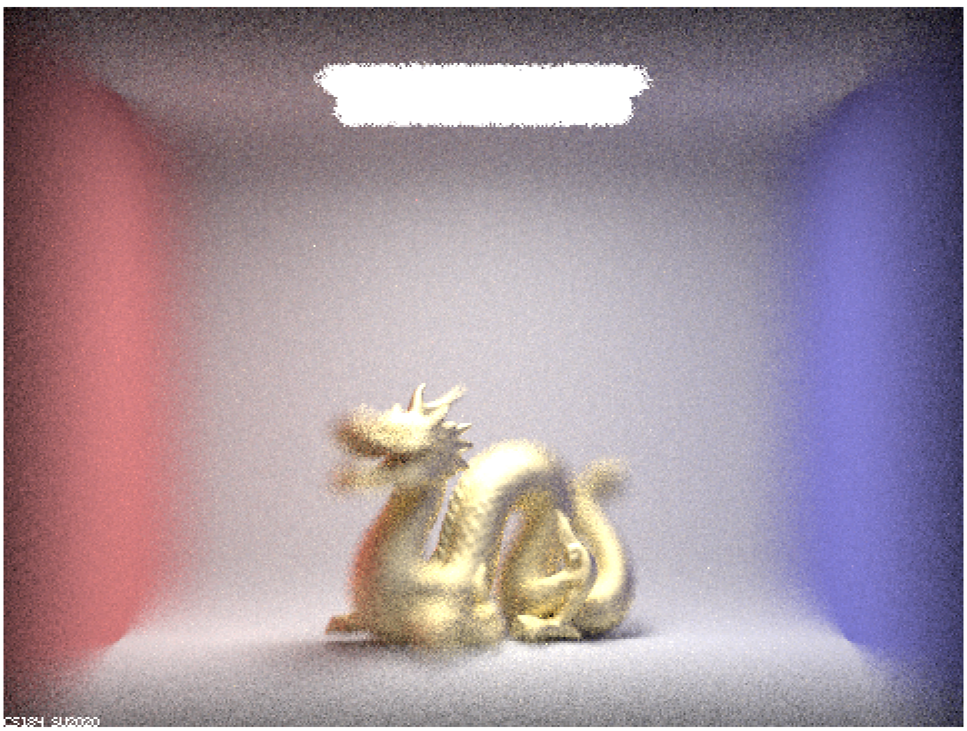
  depth: 4.6

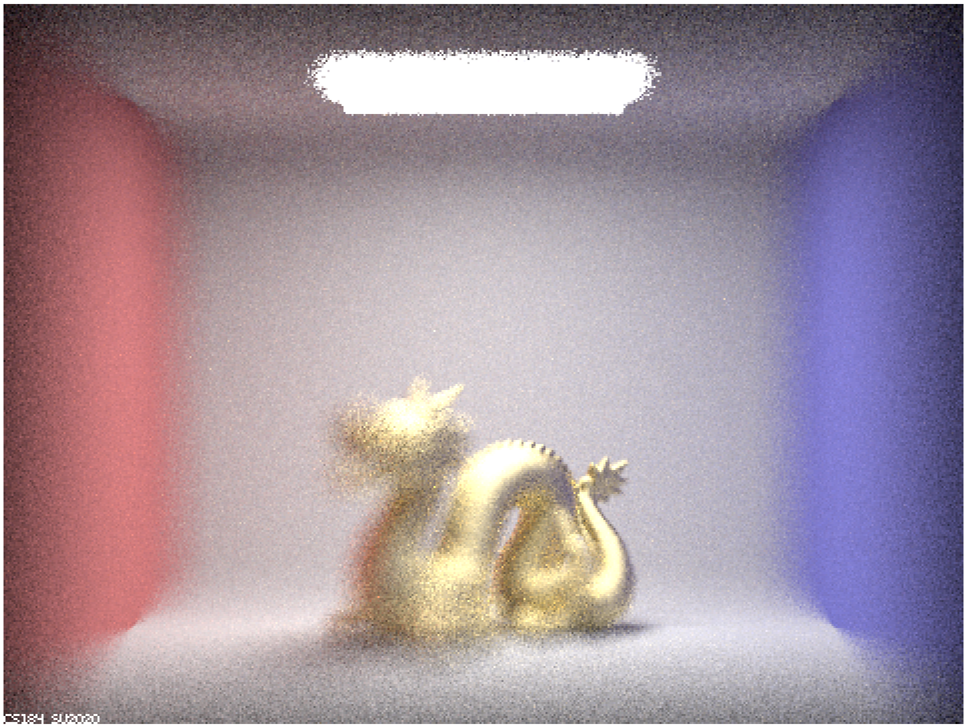
  depth: 4.8



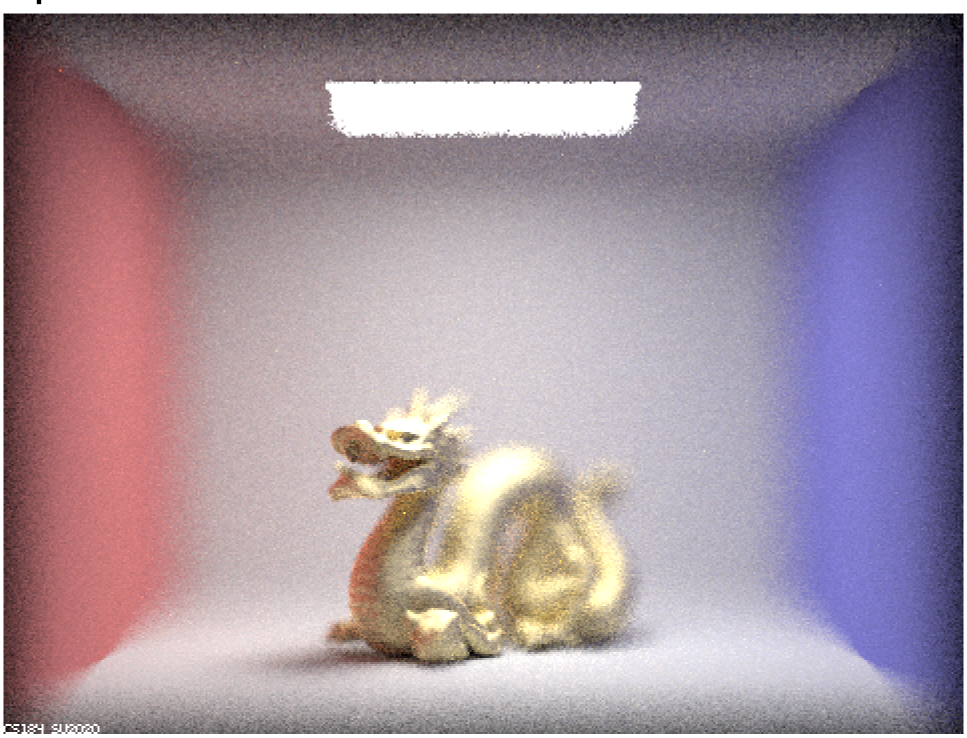
depth: 5.0



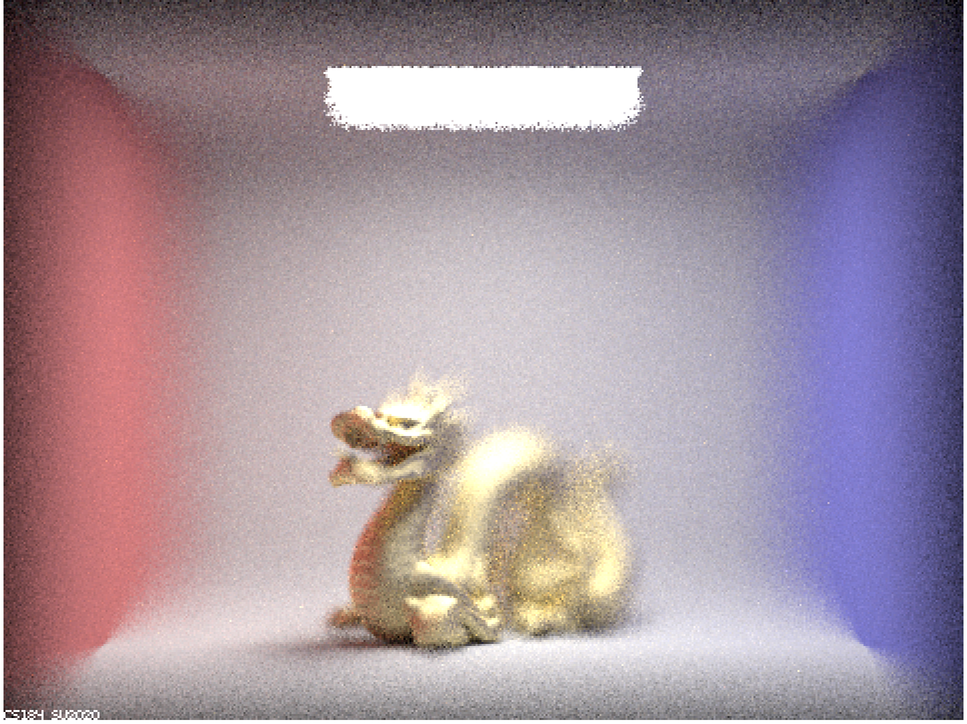
depth: 5.2



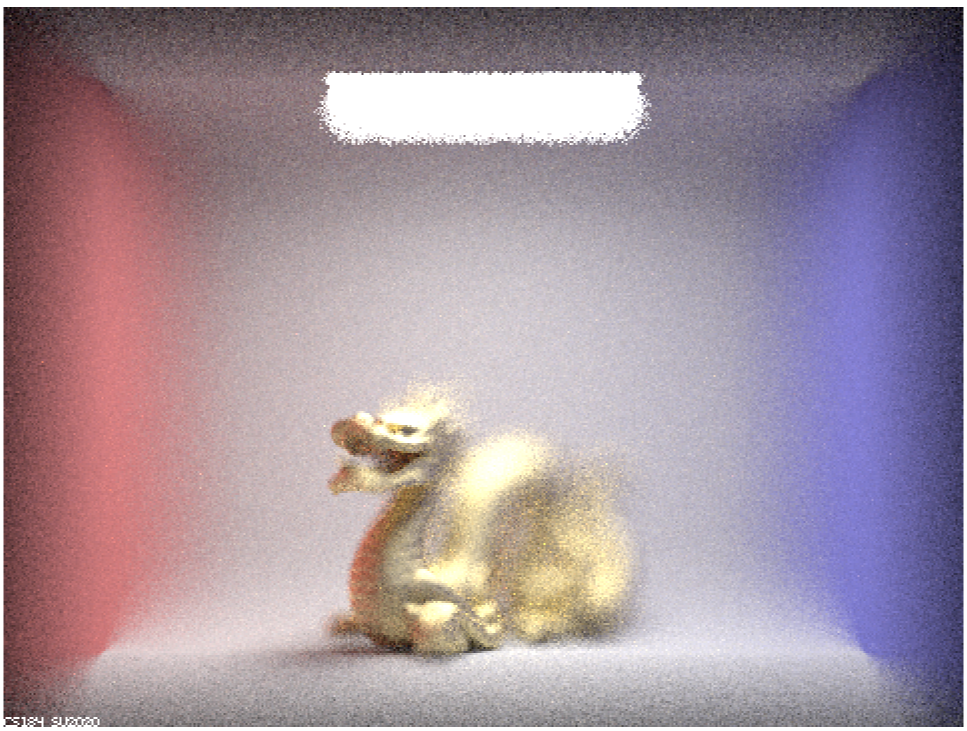
- Show a sequence of 4 pictures with visibly different aperture sizes, all focused at the same point in a scene.
  aperture size 0.5

  aperture size 0.7



aperture size 0.9



aperture size 1.1