

Portal-Masked Environment Map Sampling

Benedikt Bitterli ^{1,2}

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Wojciech Jarosz ²

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² Disney Research Zurich



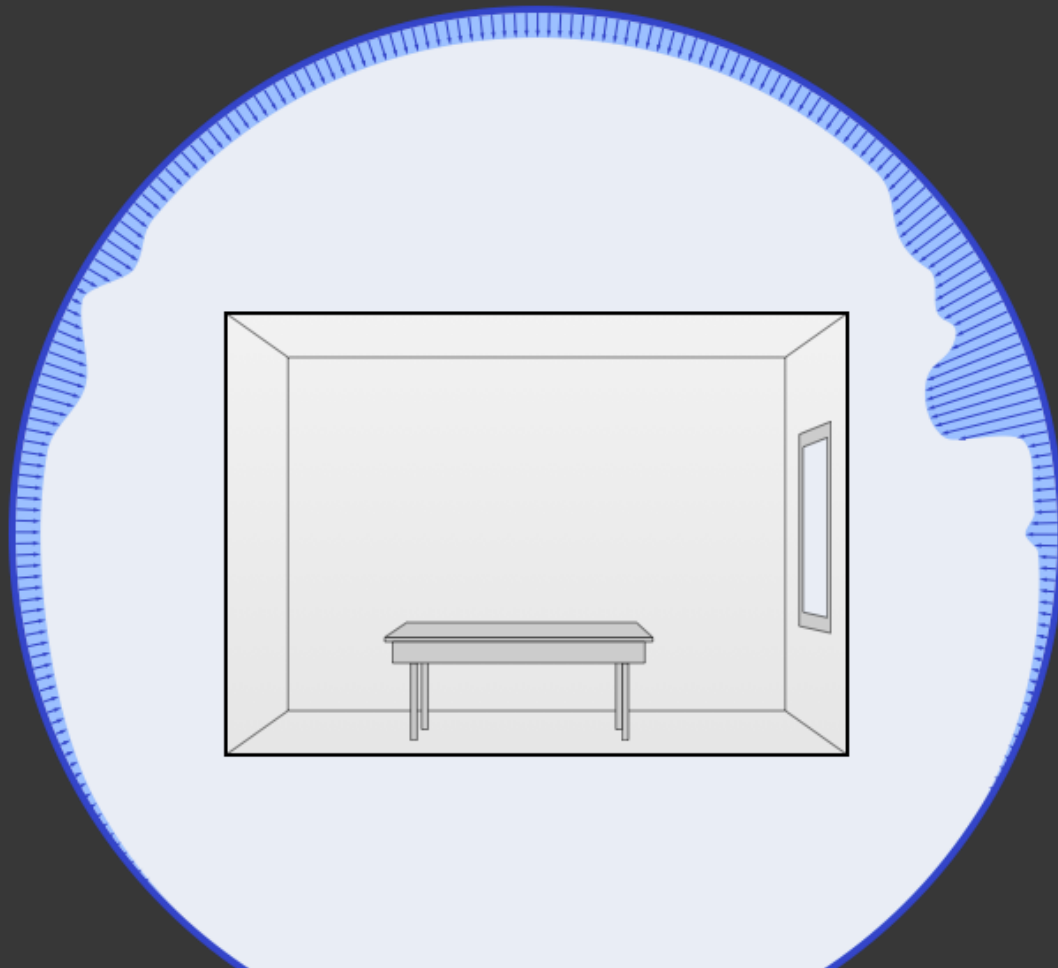
Motivation



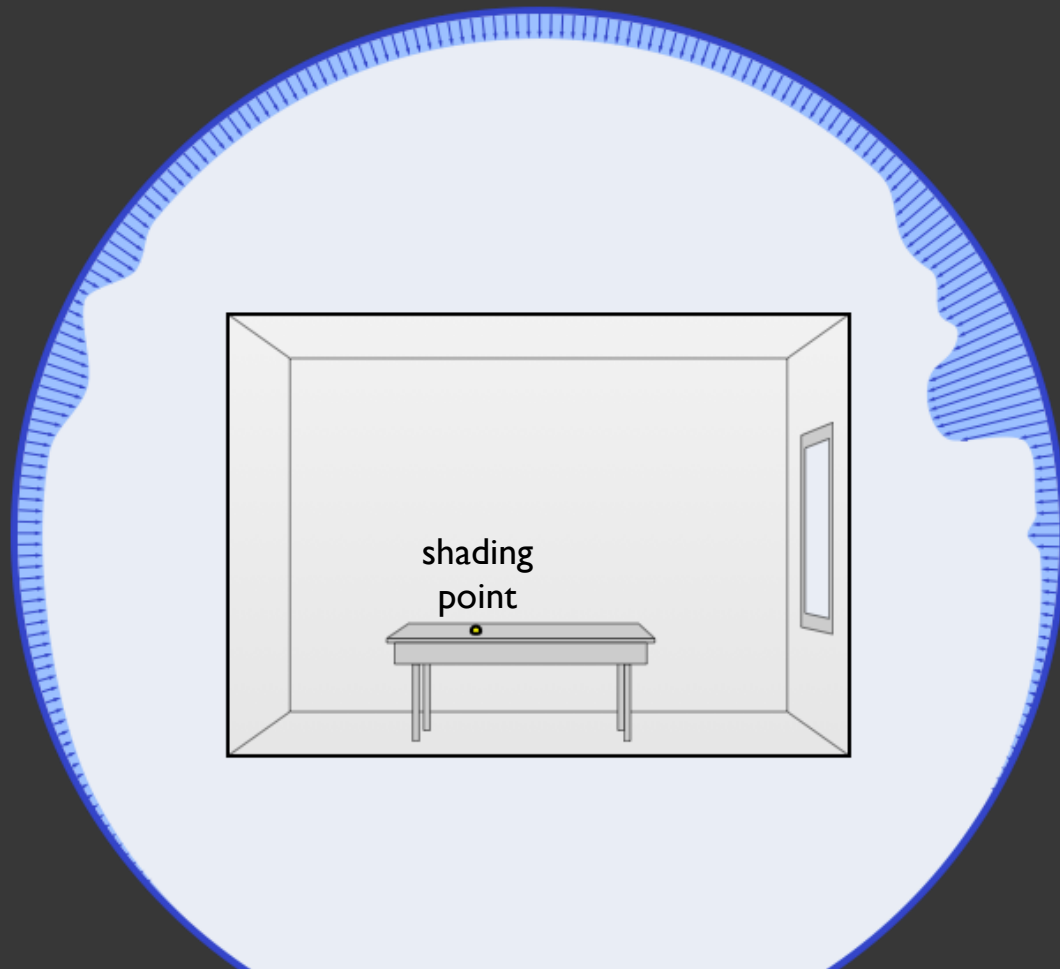
Motivation



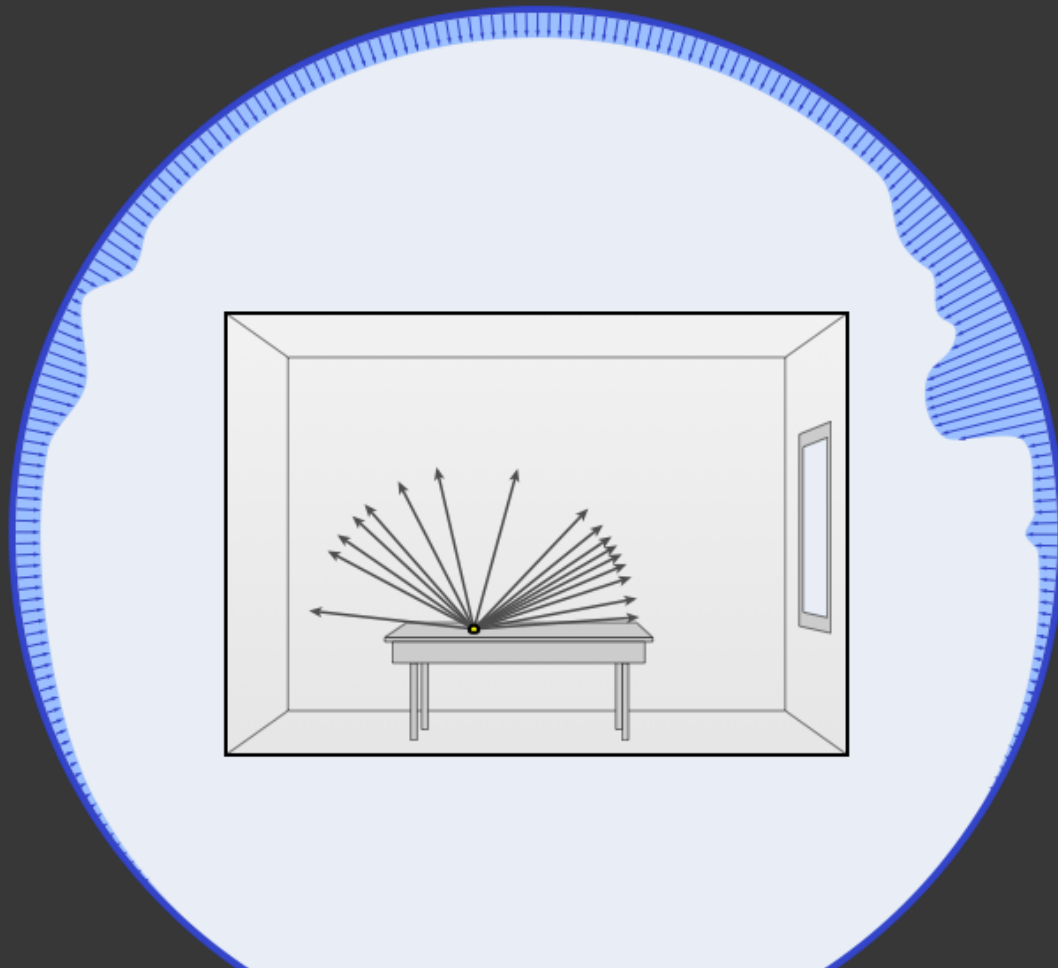
Environment Map Sampling



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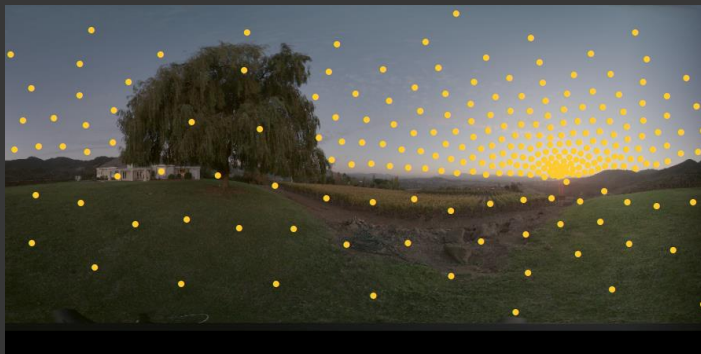


Environment Map Sampling

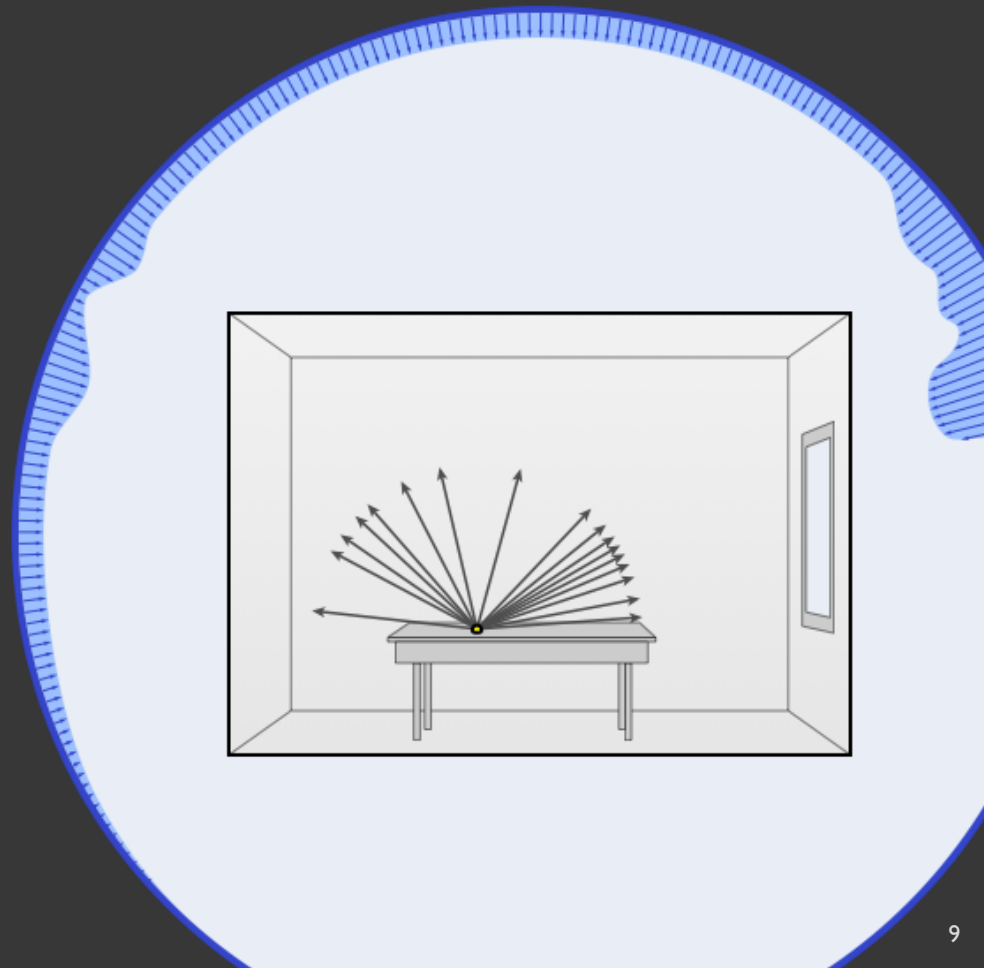


Environment Map Sampling

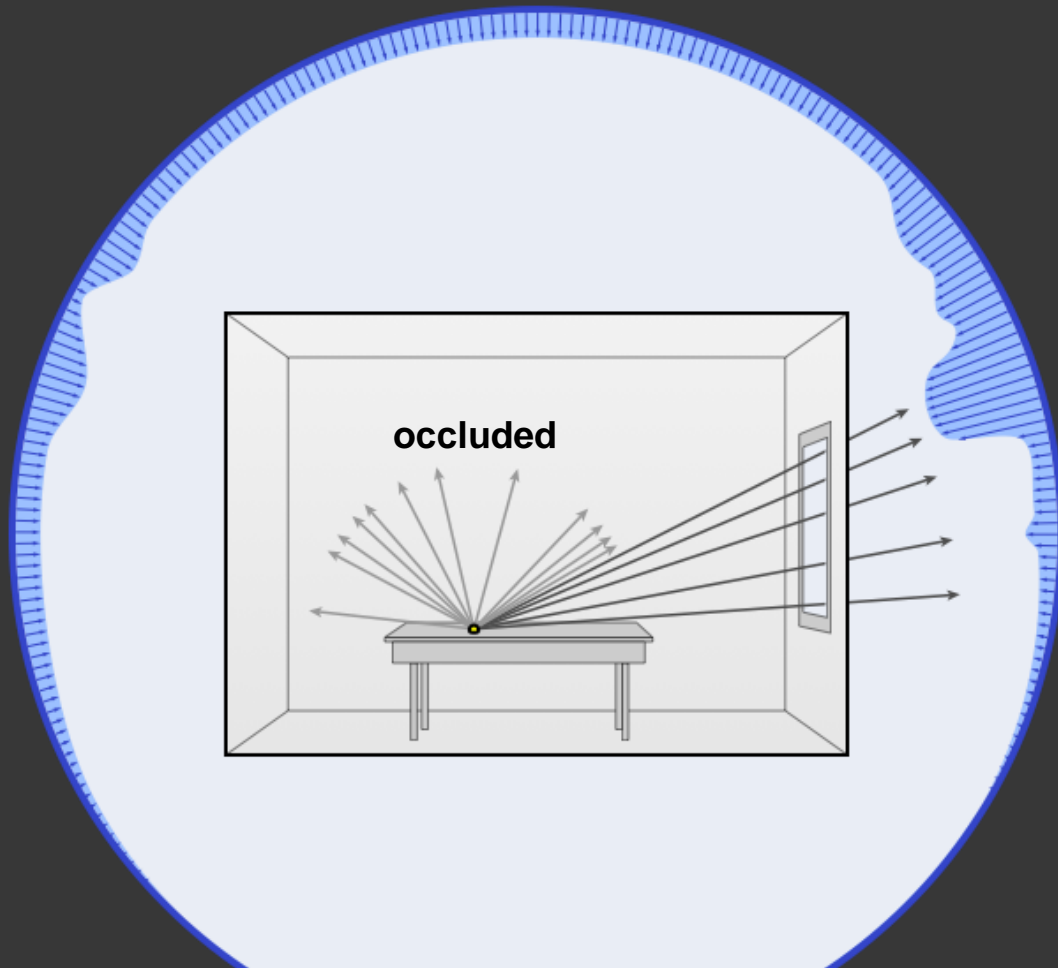
[Kollig and Keller]



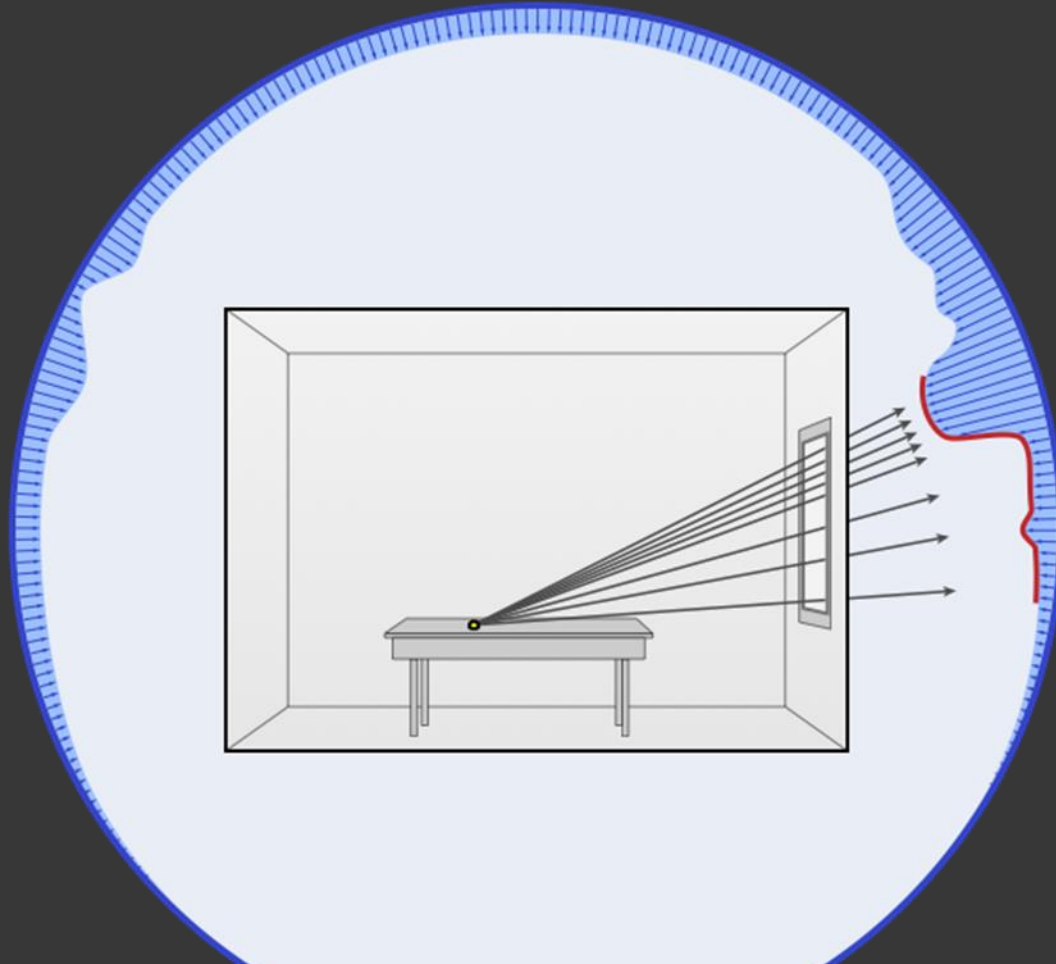
[Ostromoukhov et al.]



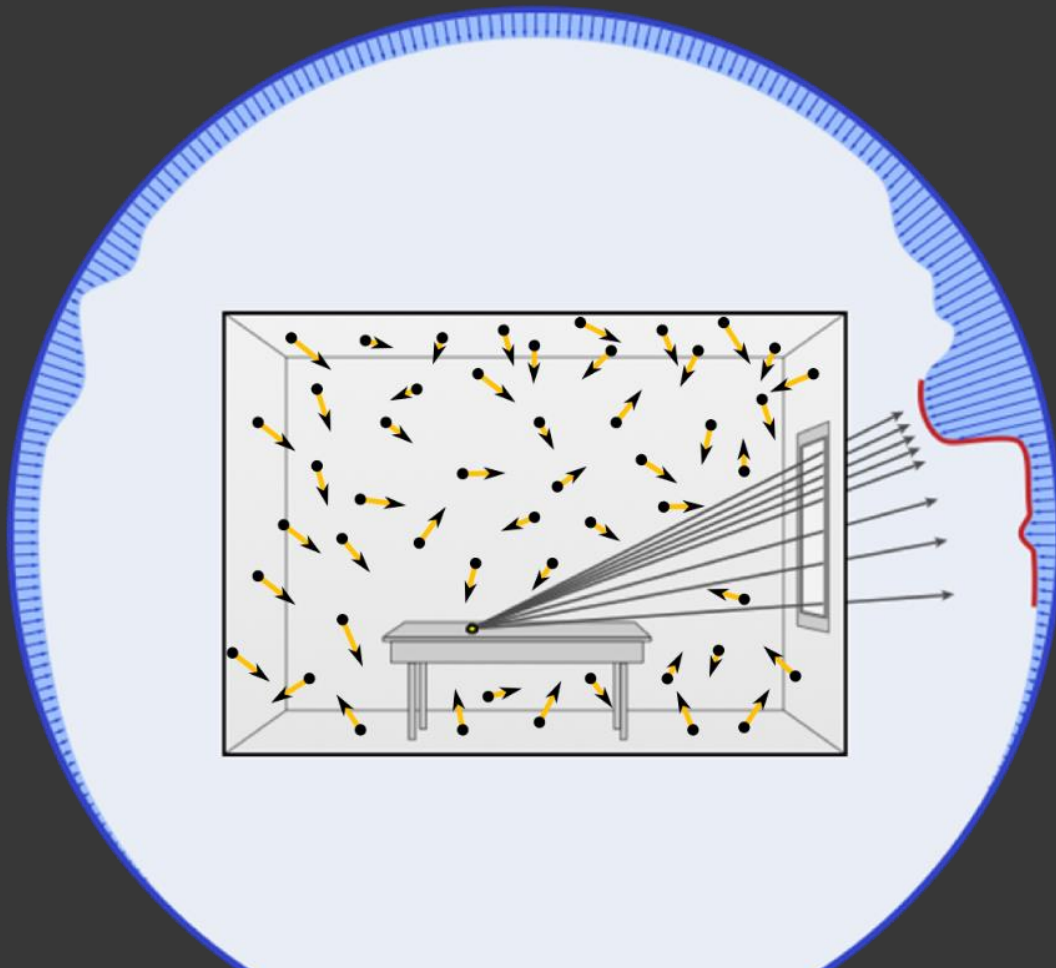
Environment Map Sampling



Problem Statement



Visibility Caching

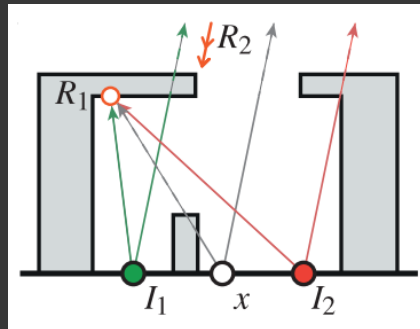


Visibility Caching

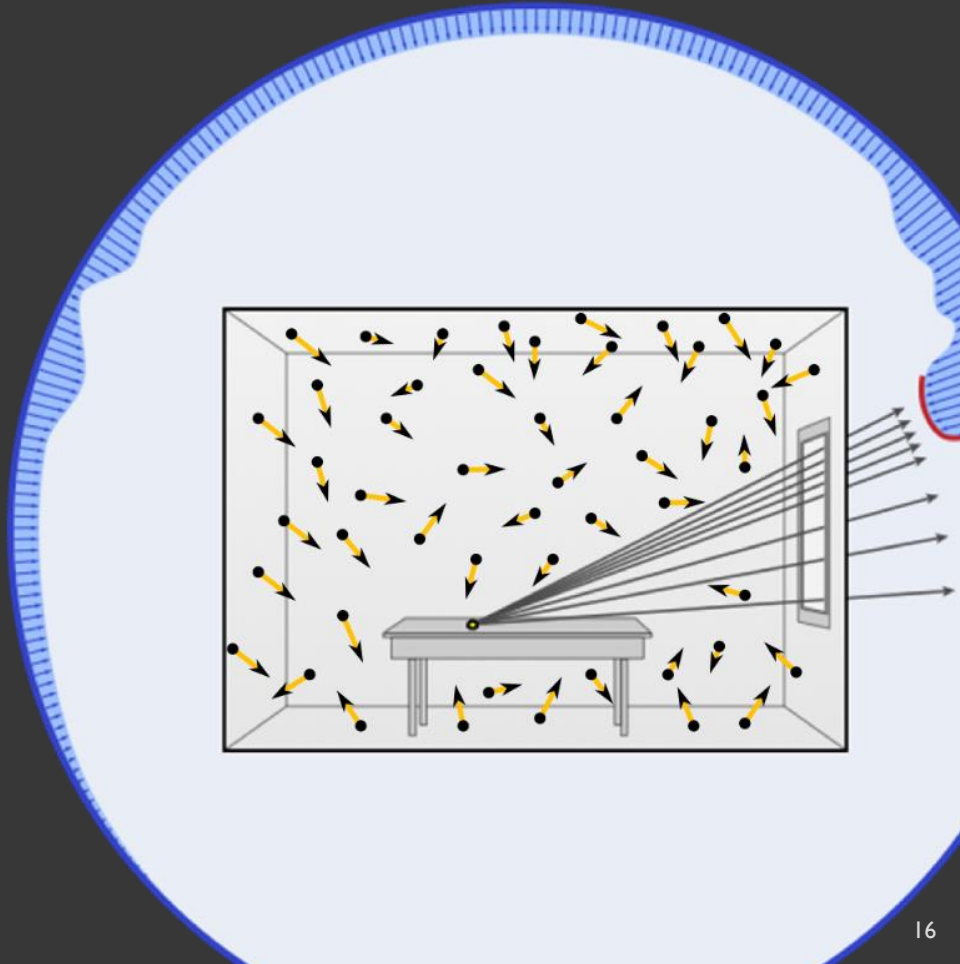
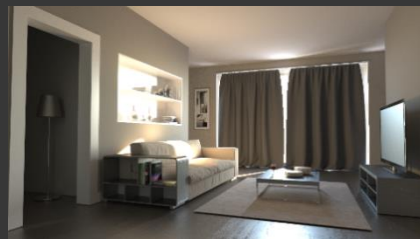
[Jensen '95]



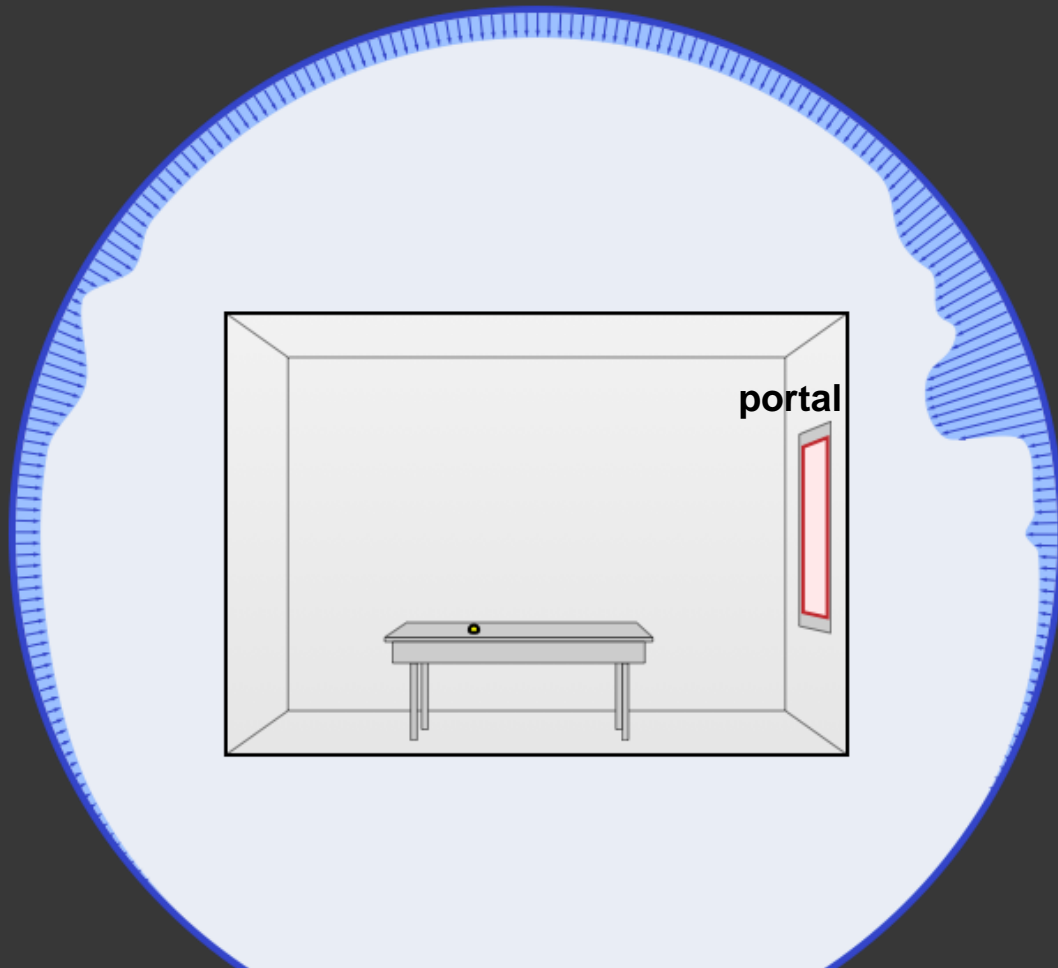
[Georgiev et al.]



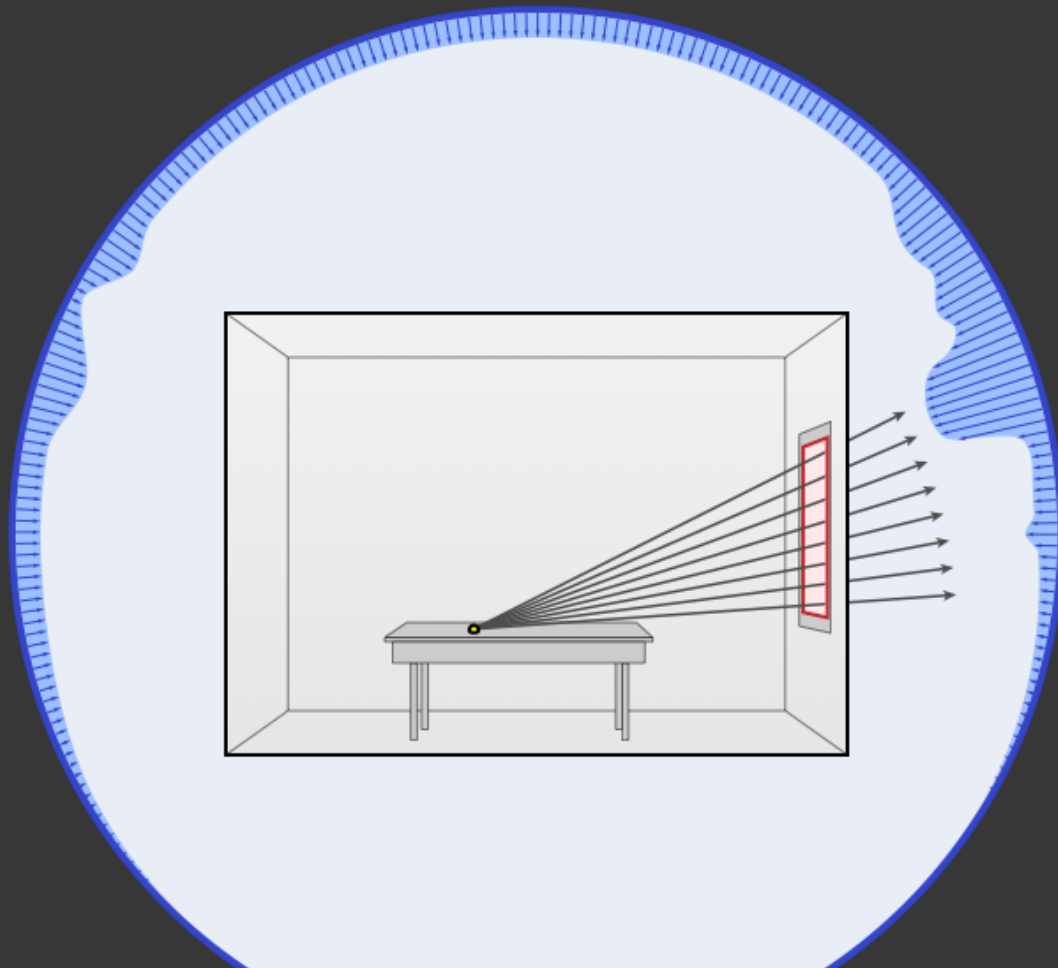
[Vorba et al.]



Portal Sampling

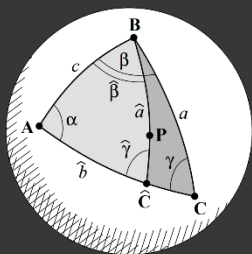


Portal Sampling

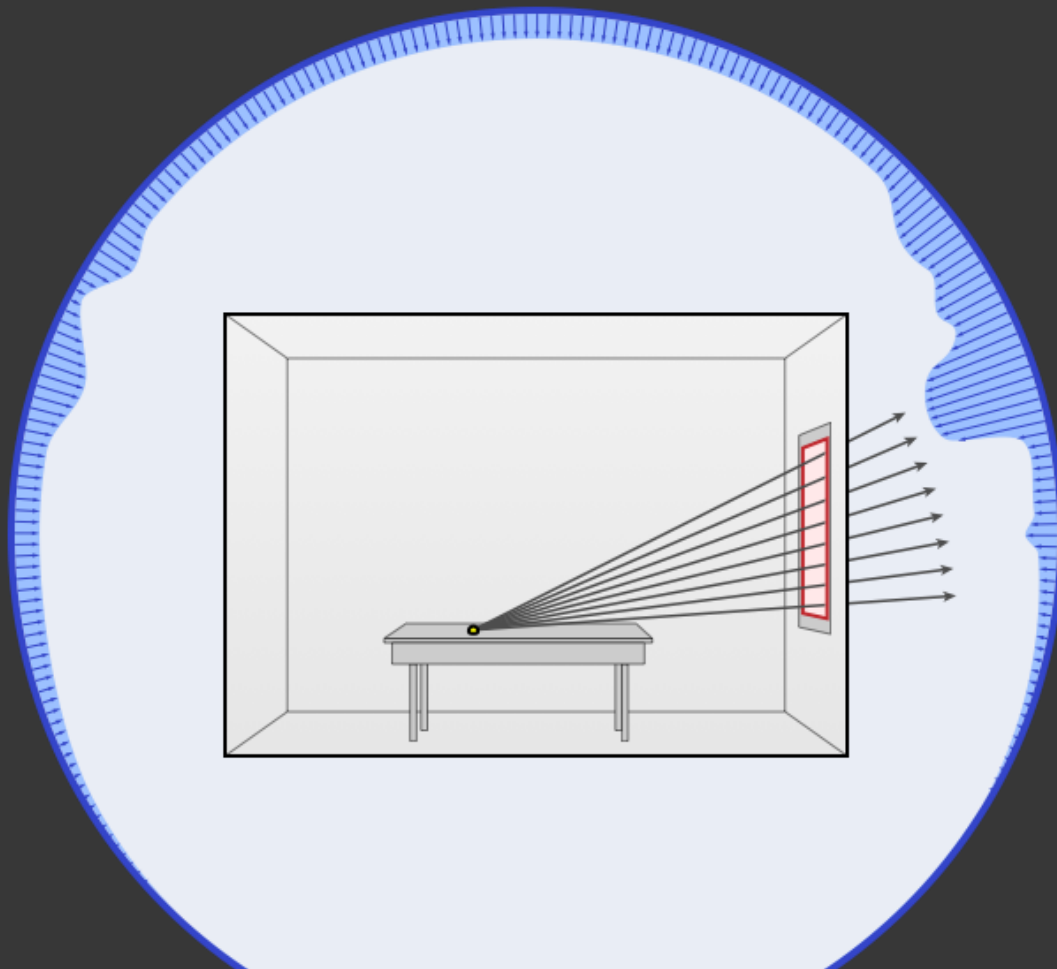
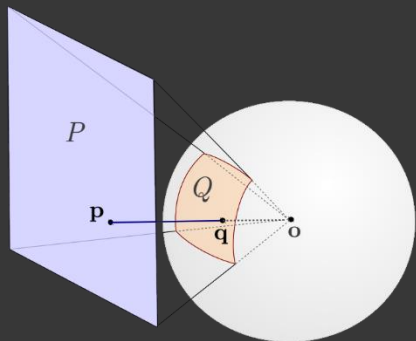


Portal Sampling

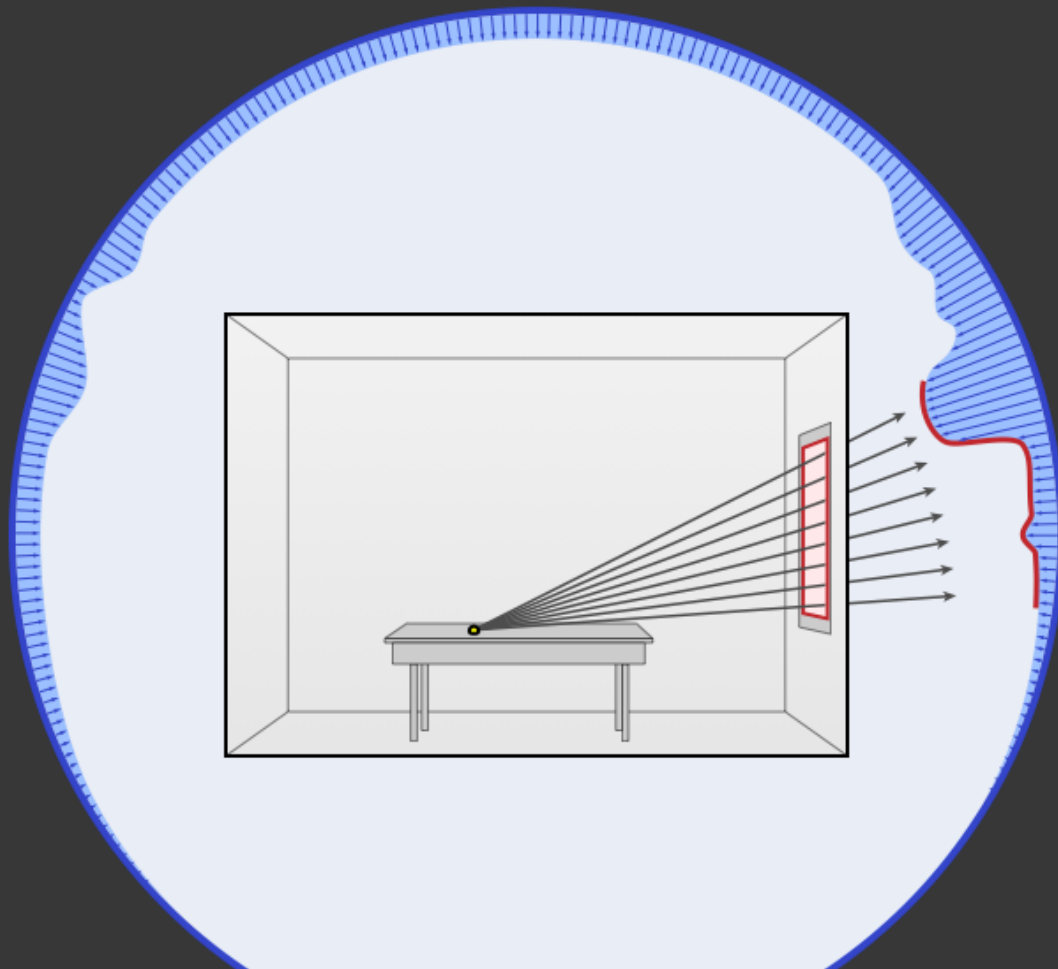
[Arvo '95]



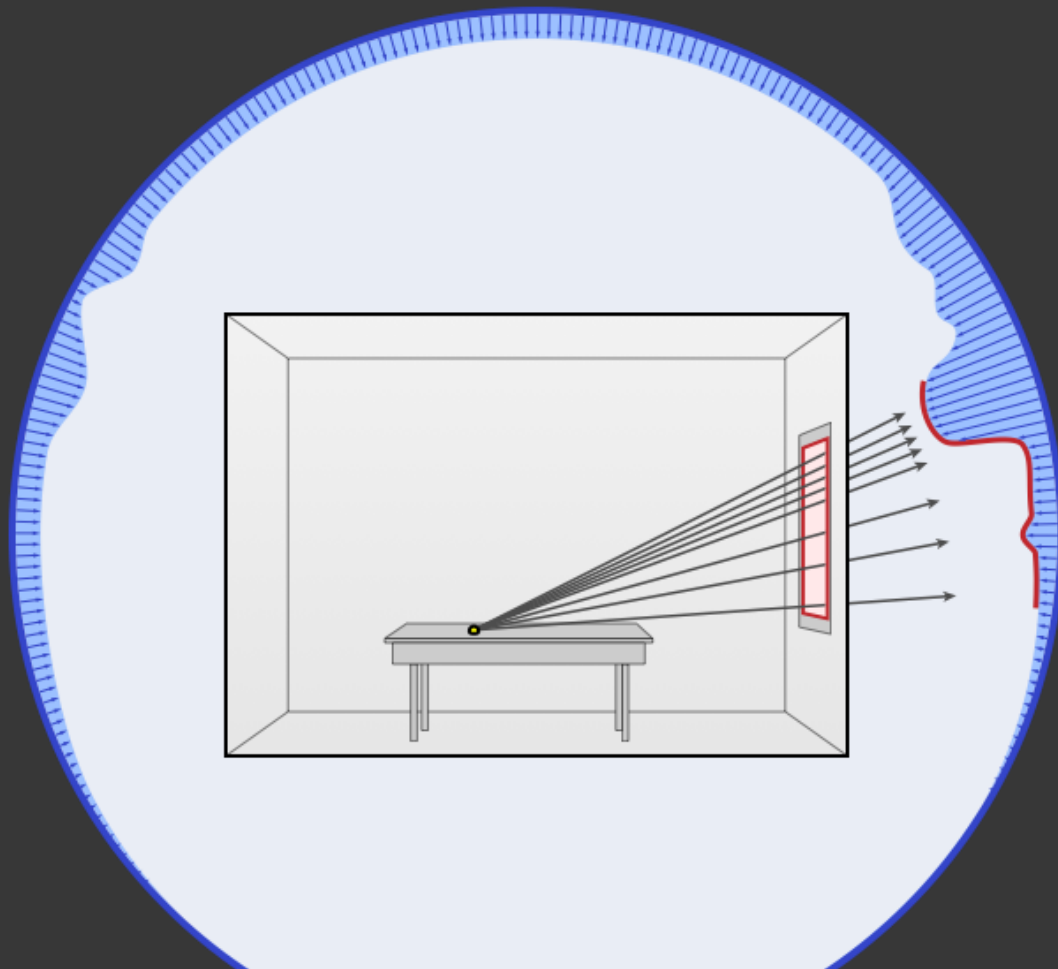
[Ureña et al.]



Portal Sampling



Ours

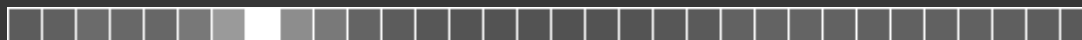


Environment Map Sampling

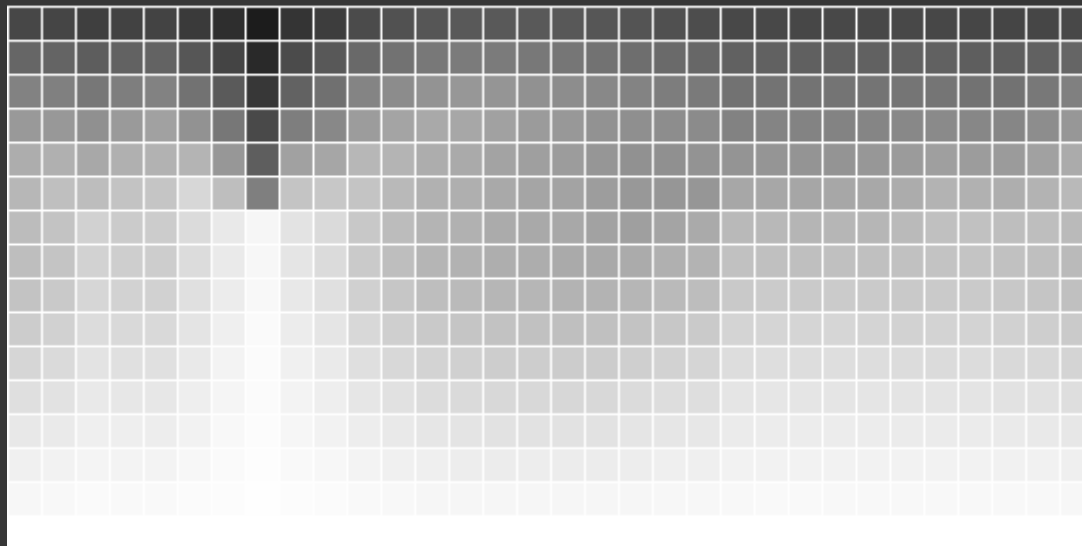


Environment Map Sampling

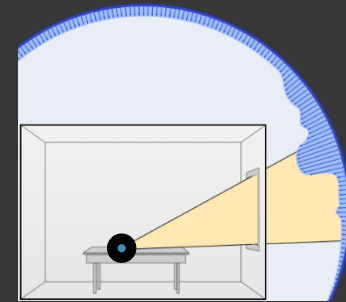
marginal distribution



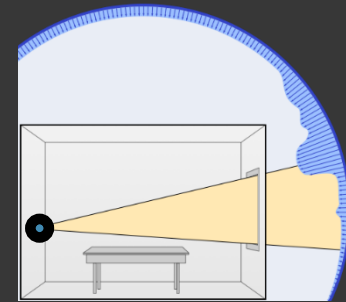
conditional distributions



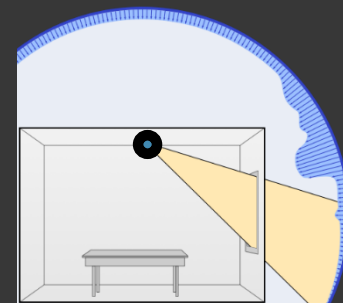
Visible Region



Visible Region



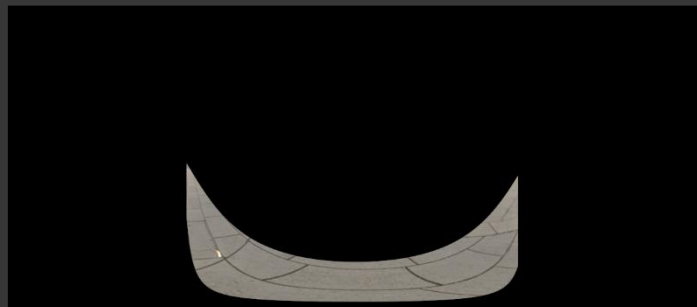
Visible Region



Portal-Masked Environment Map Sampling

Challenges:

- 1) Visible regions have complex shapes
Marginal/conditional decomposition difficult



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Environment Map Parameterizations

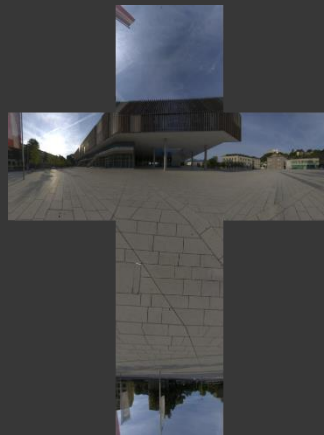
Latitude/Longitude



Light probe



Cube map



Environment Map Parameterizations

Latitude/Longitude



Light probe



Cube map



Visible regions **not rectangular** in these mappings

Environment Map Parameterizations

Latitude/Longitude



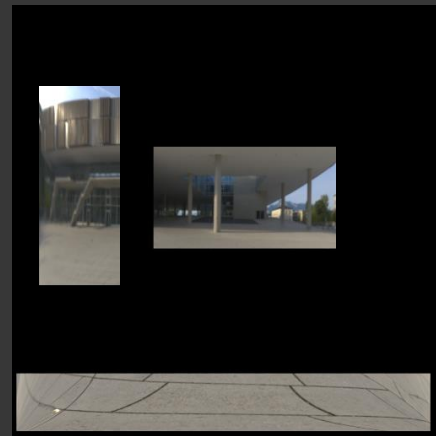
Light probe



Cube map

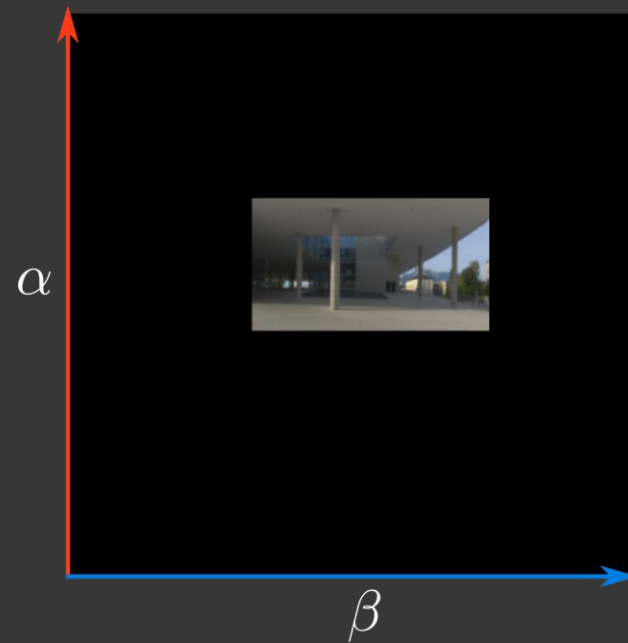


Rectified Coordinates

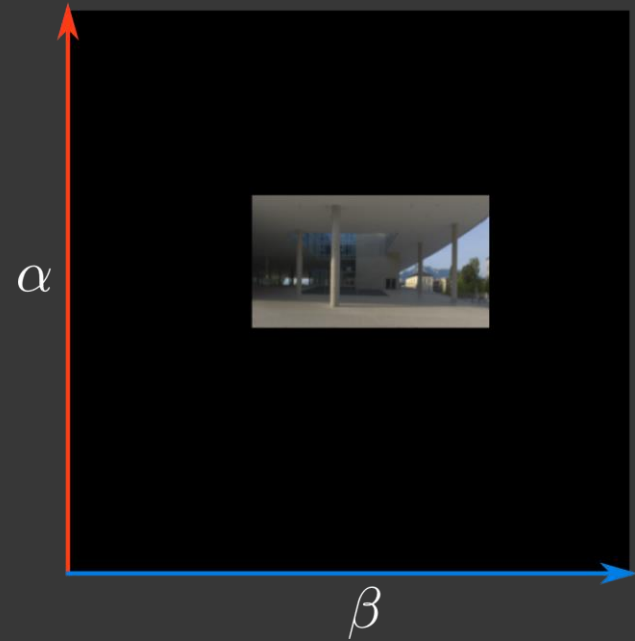
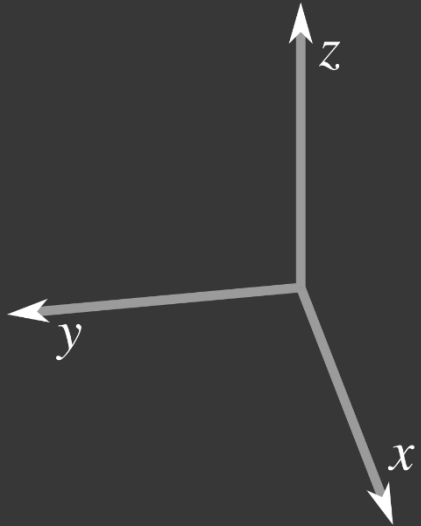


Visible regions **not rectangular** in these mappings
Let's create one in which they are!

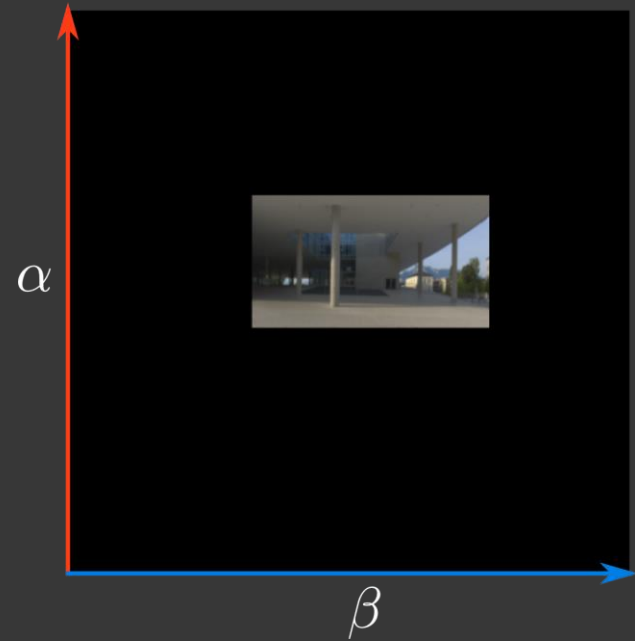
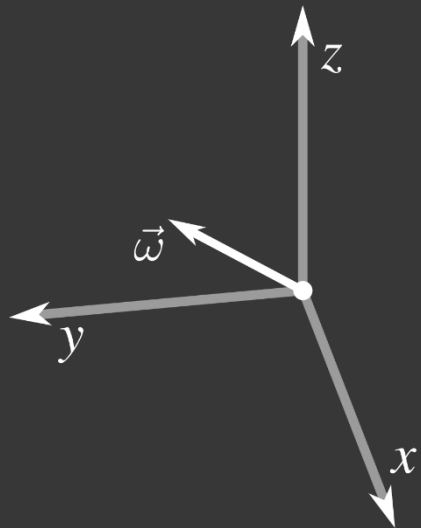
Rectified Coordinates



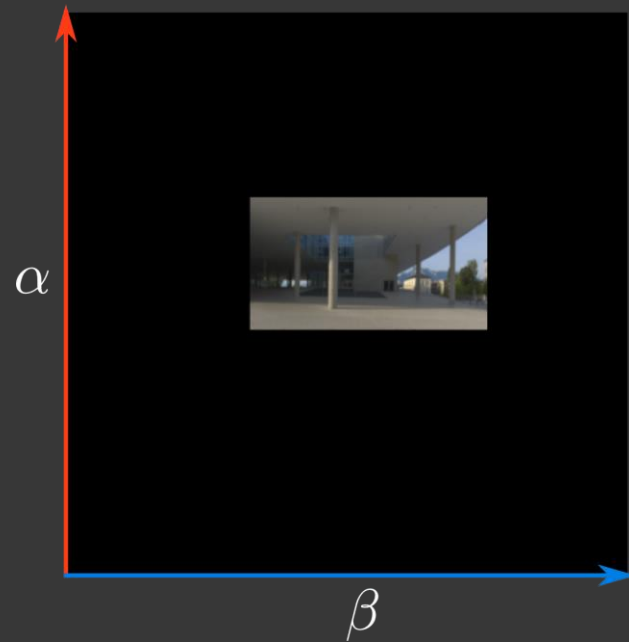
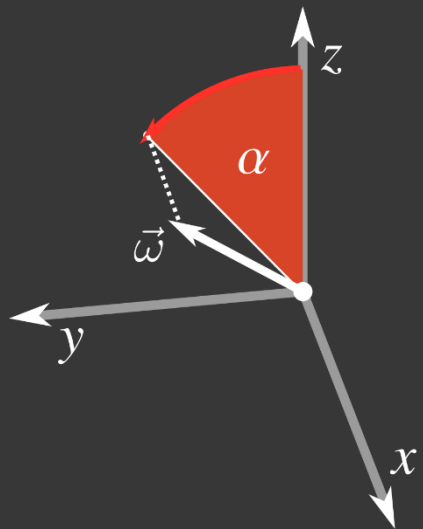
Rectified Coordinates



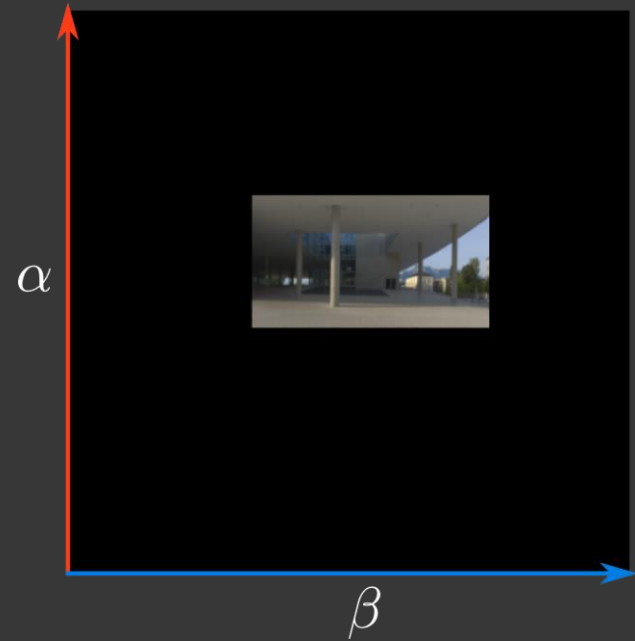
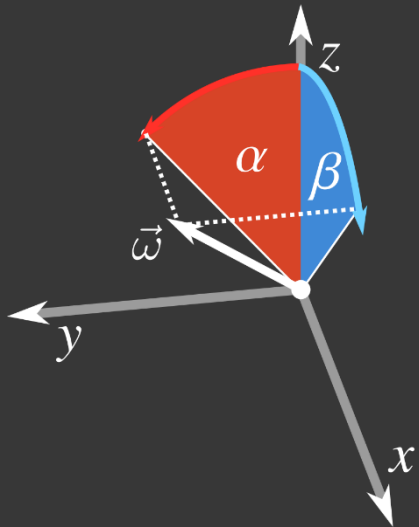
Rectified Coordinates



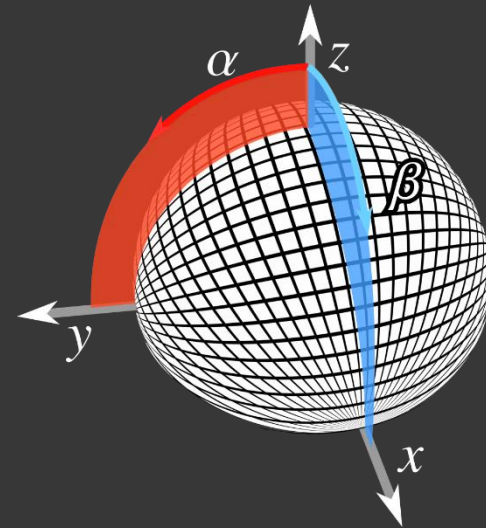
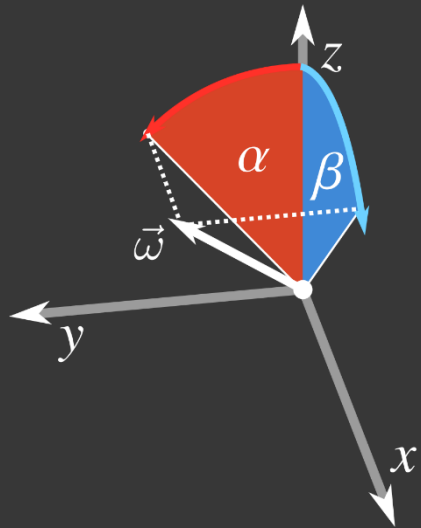
Rectified Coordinates



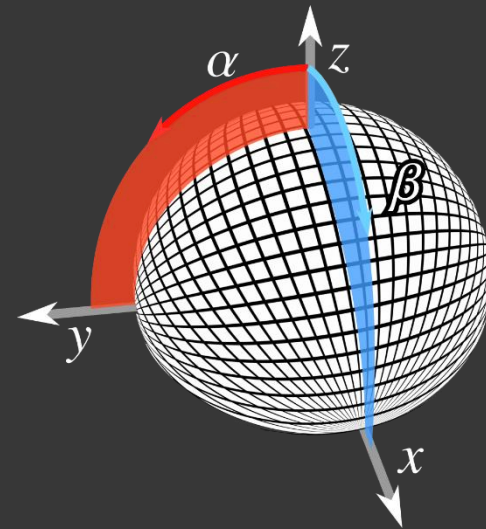
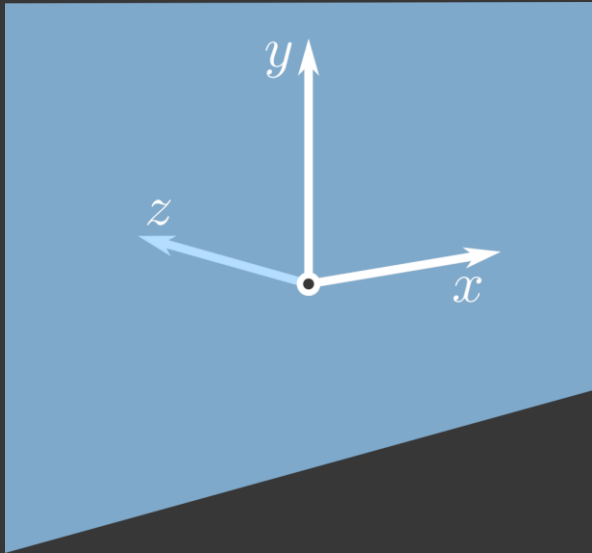
Rectified Coordinates



Rectified Coordinates

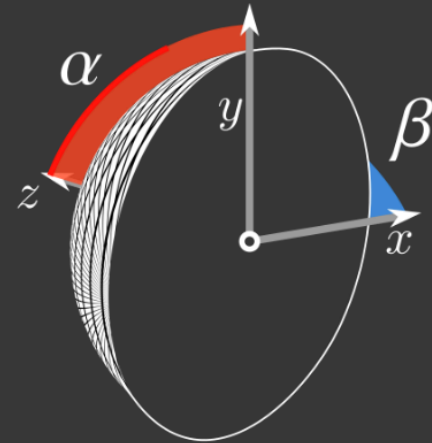
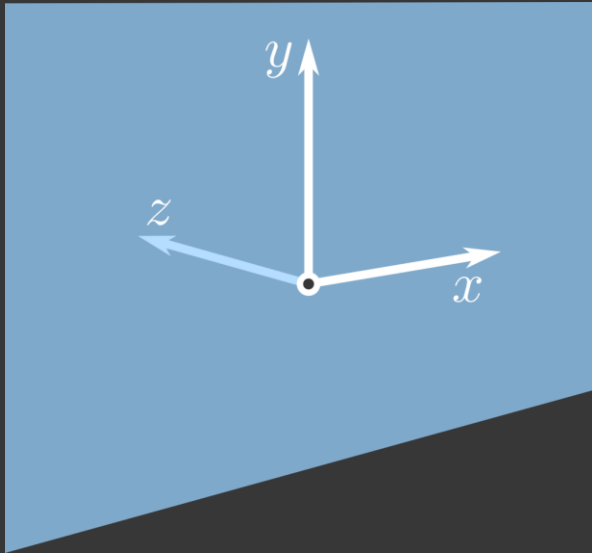


Rectified Coordinates



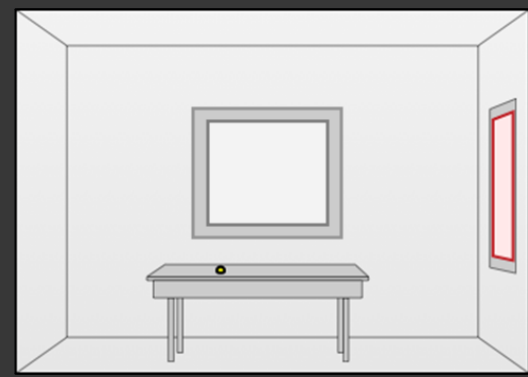
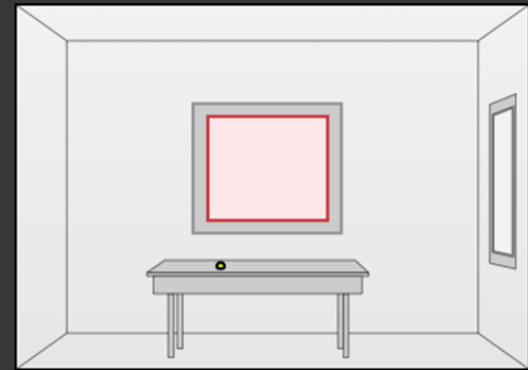
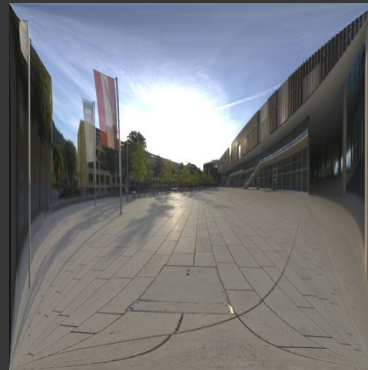
Parametrization is **aligned** with the portal

Rectified Coordinates



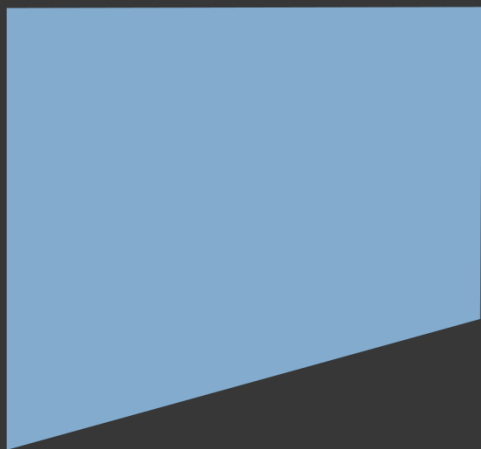
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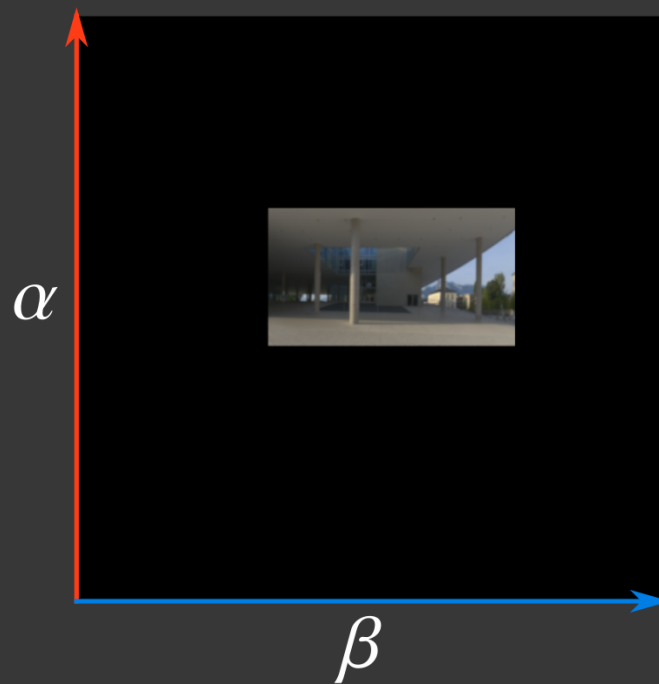


Need separate environment map **per portal**

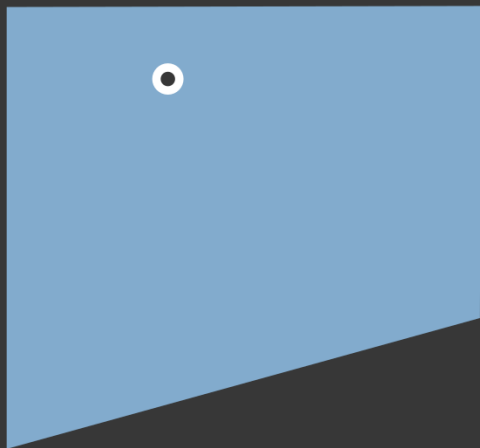
Rectified Coordinates



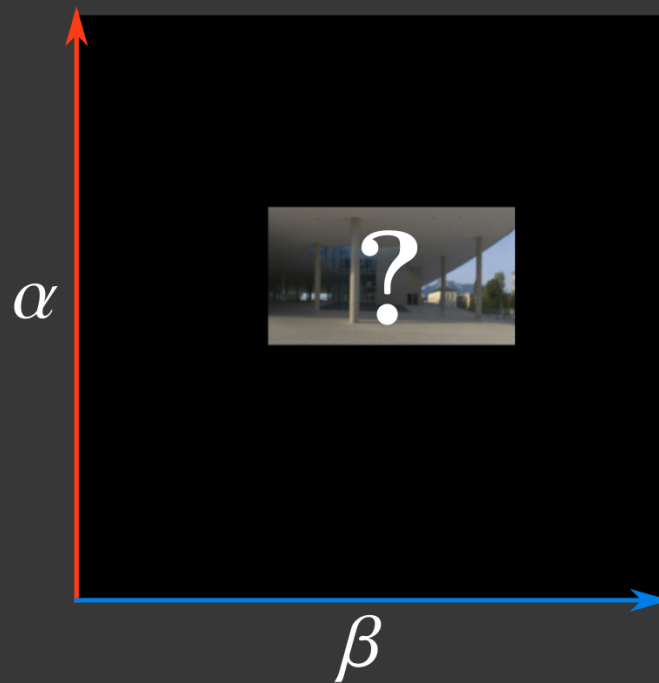
\circ_s



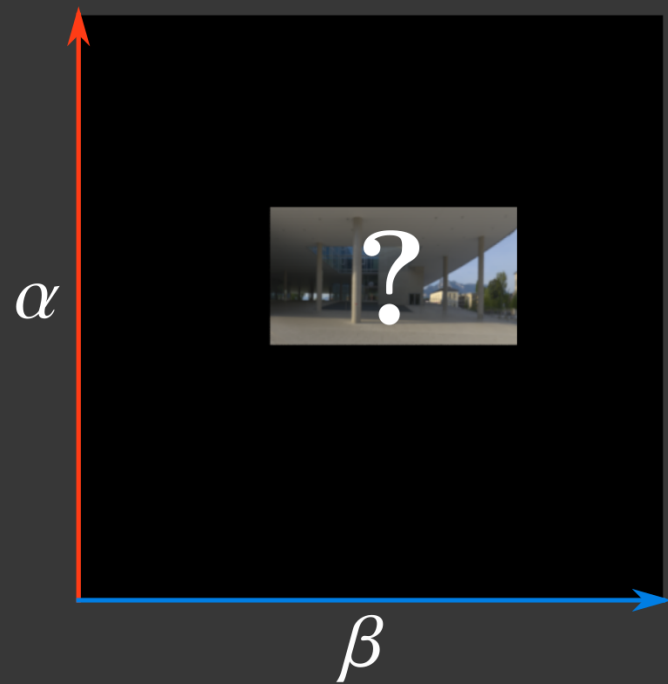
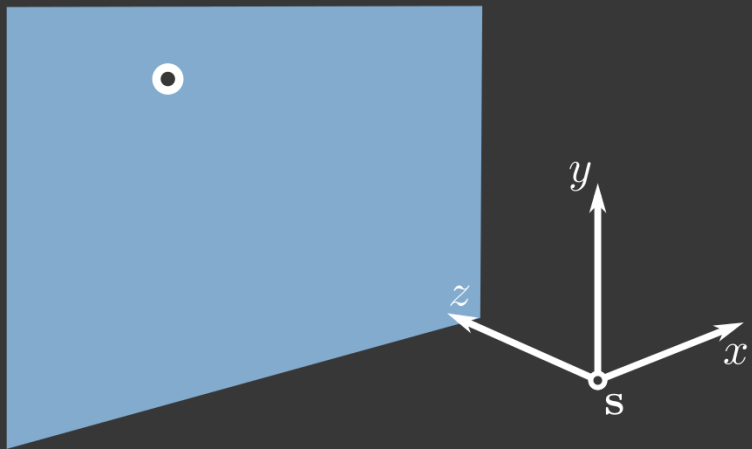
Rectified Coordinates



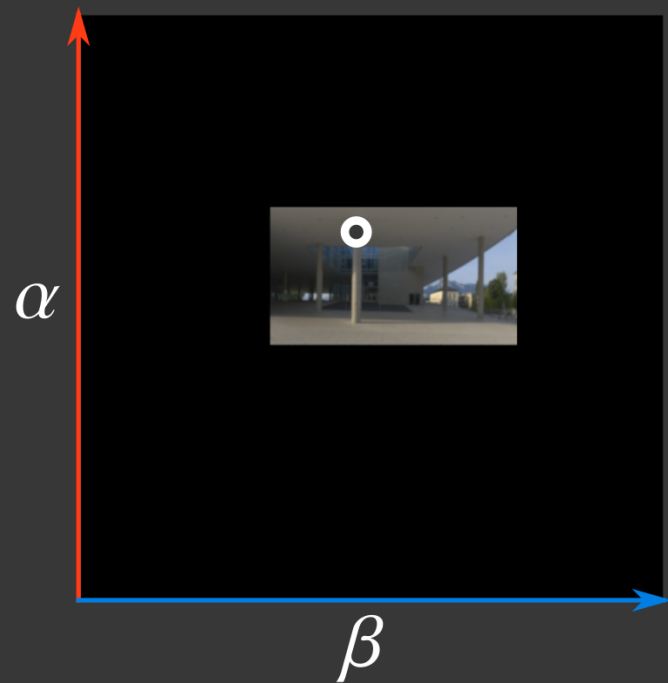
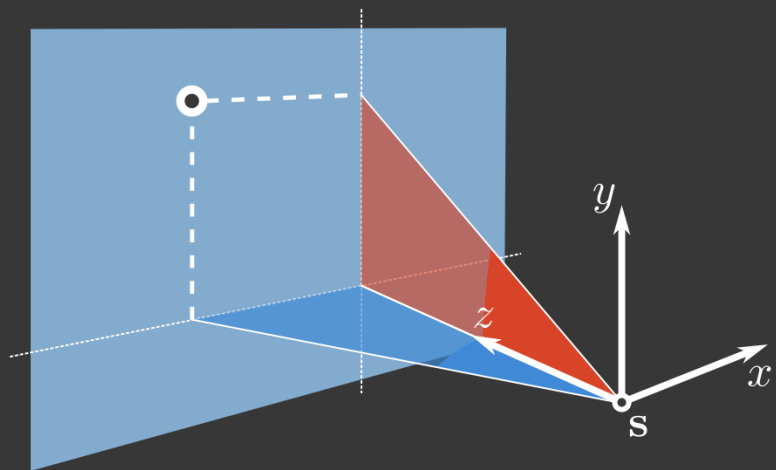
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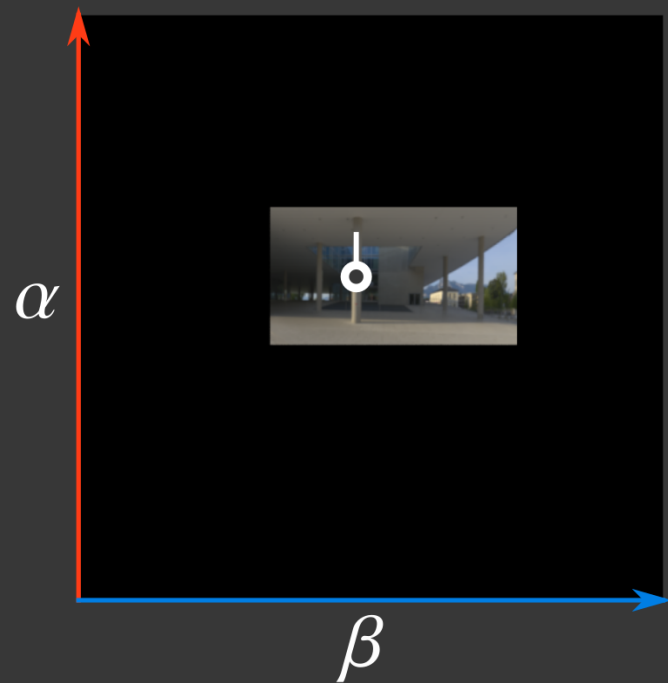
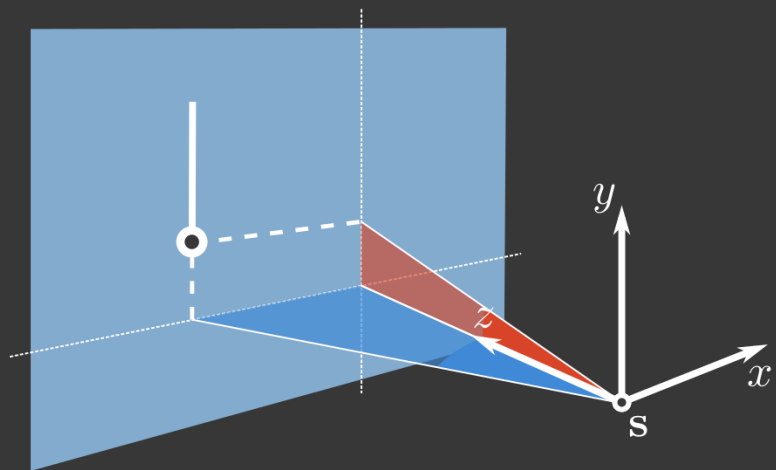
Rectified Coordinates



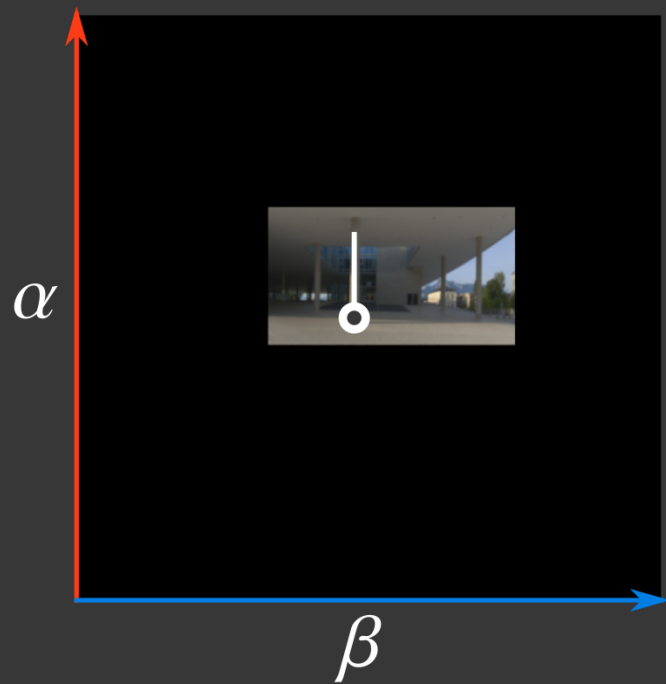
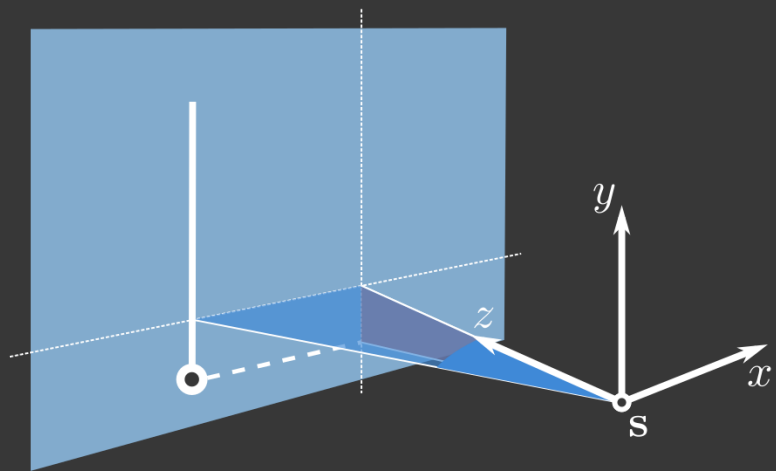
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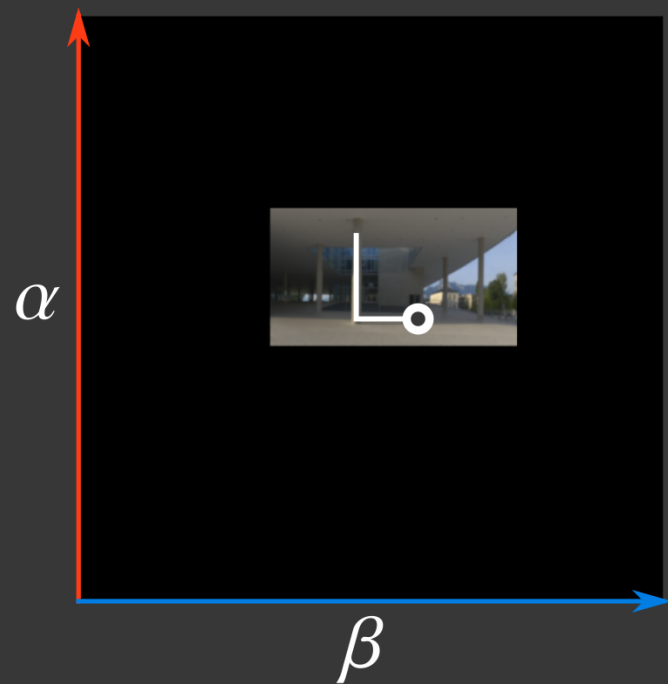
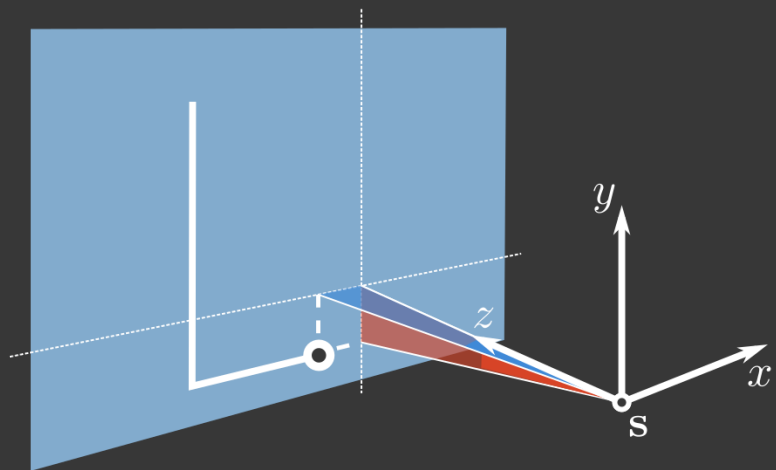
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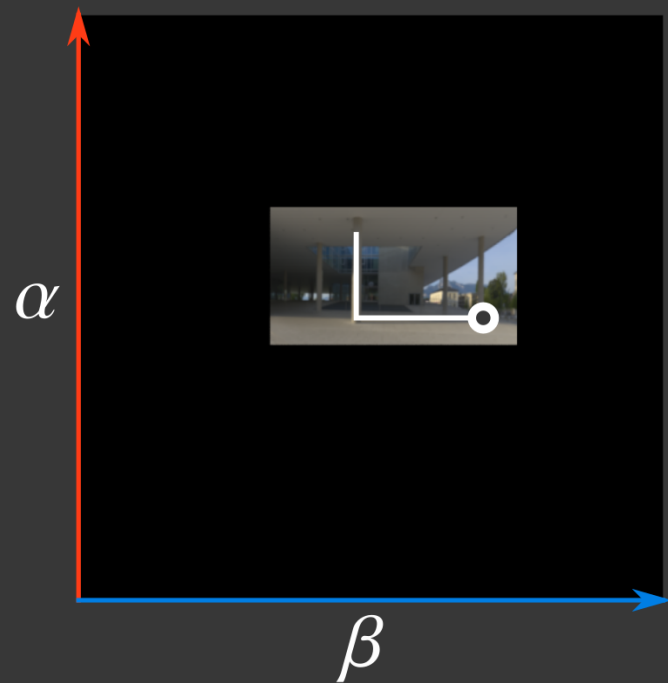
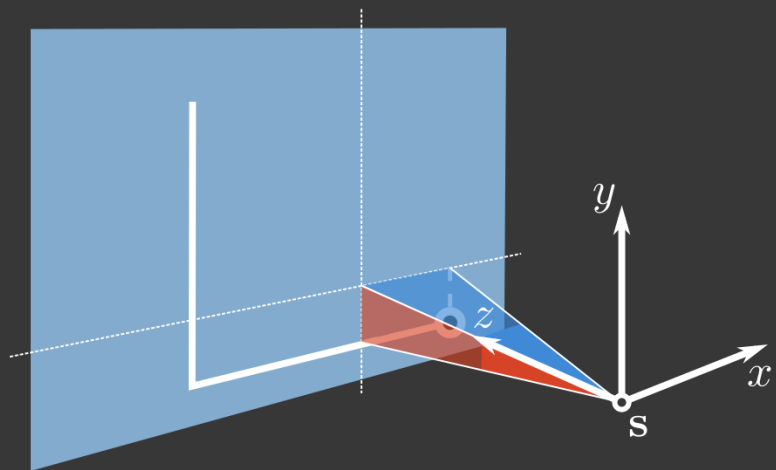
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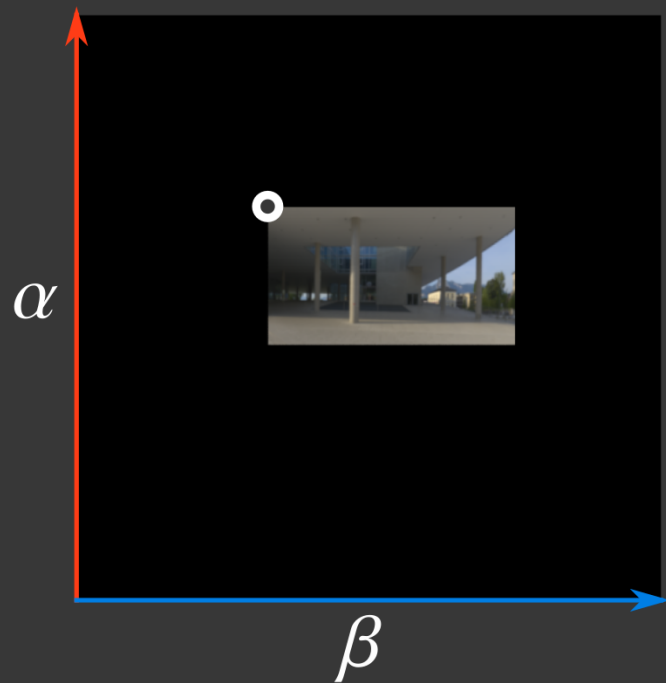
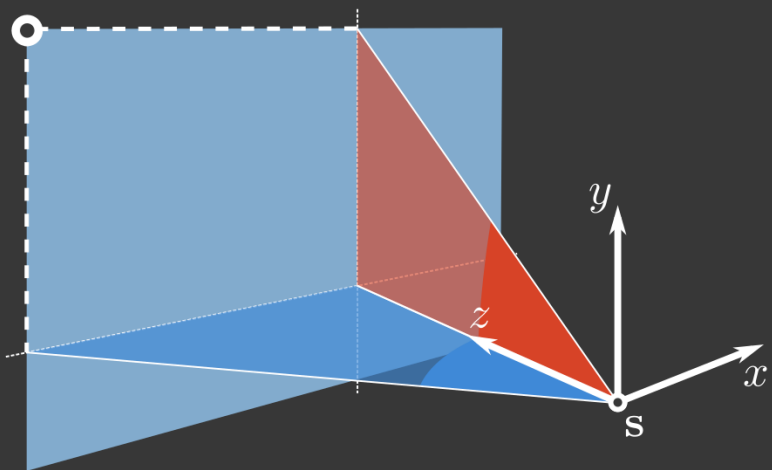
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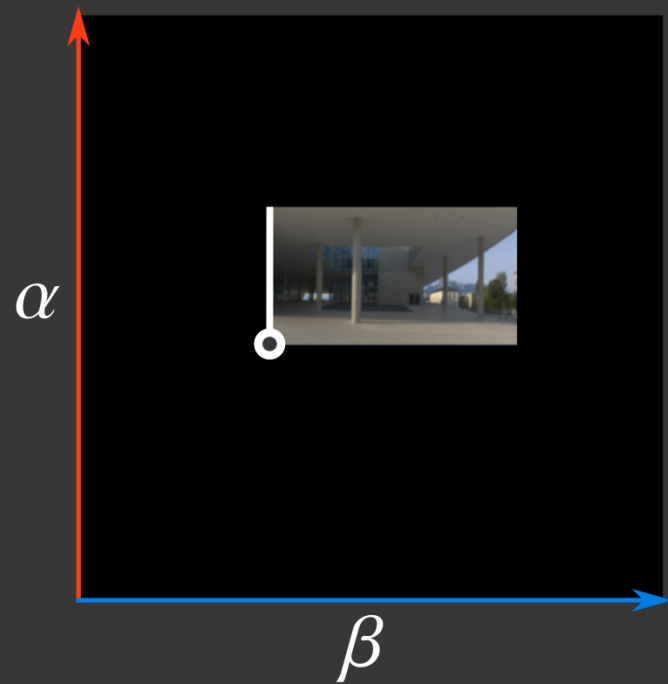
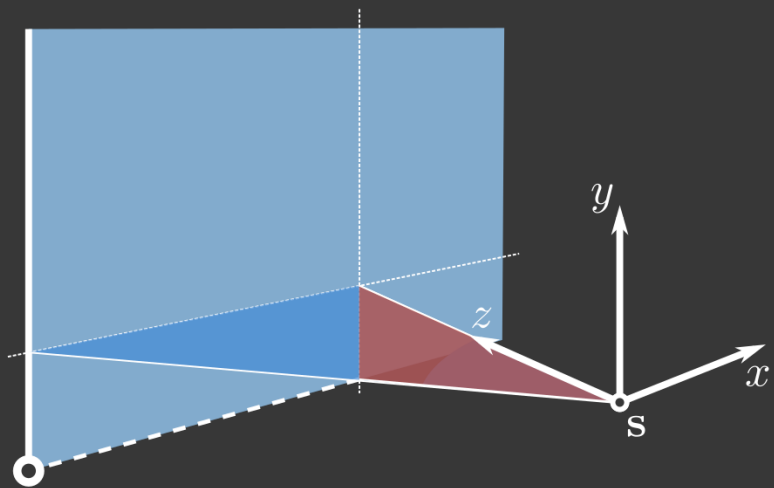
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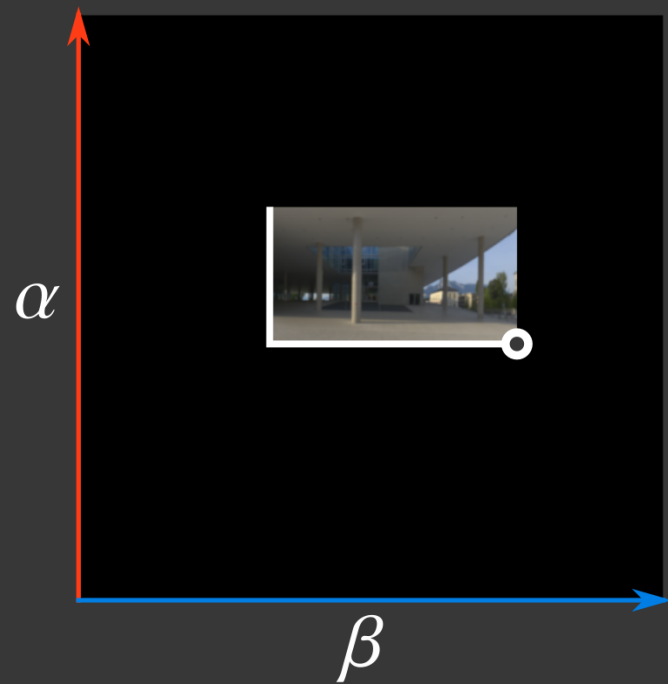
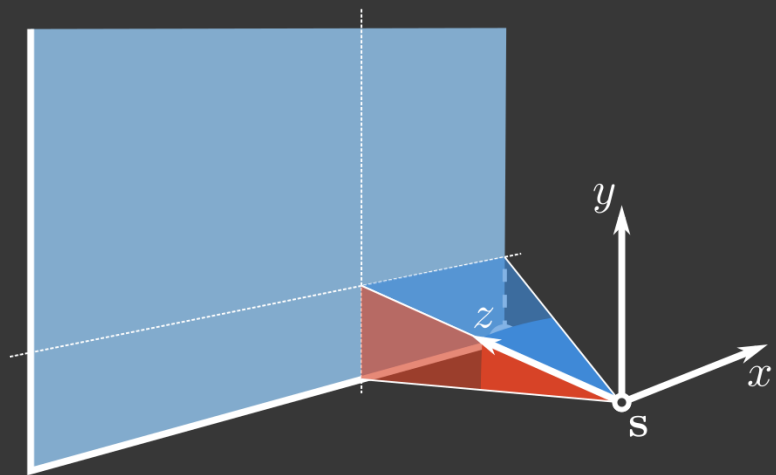
Rectified Coordinates



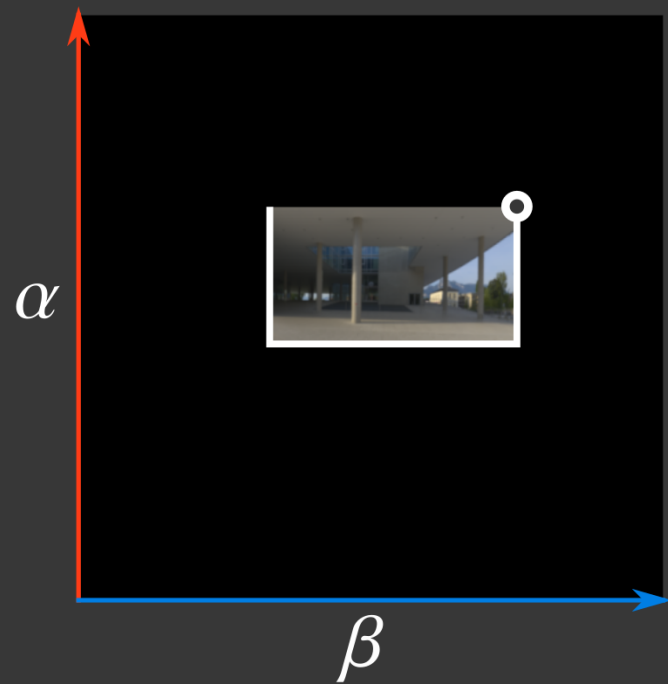
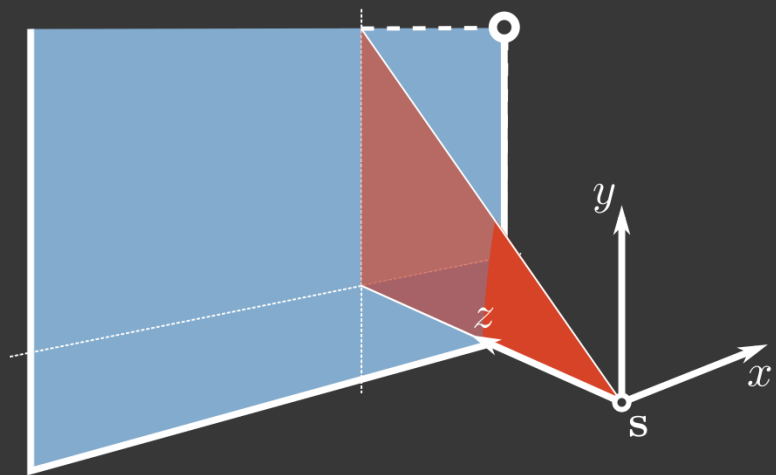
Rectified Coordinates



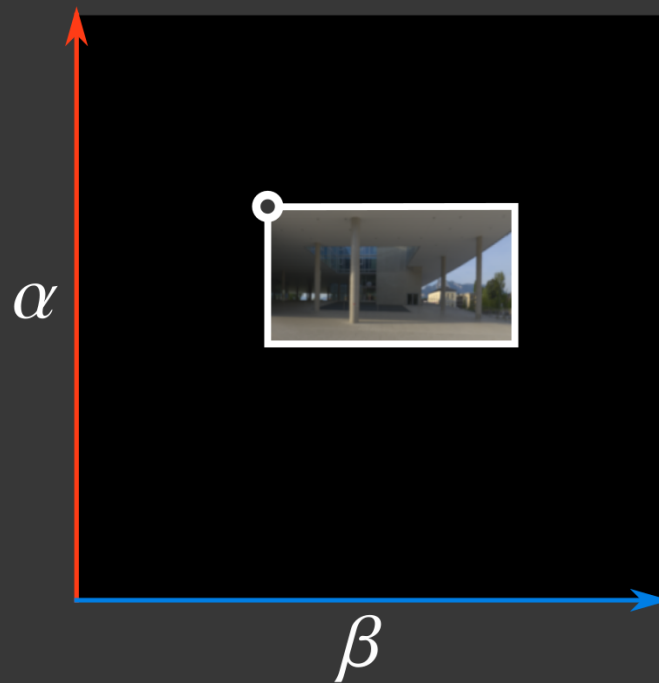
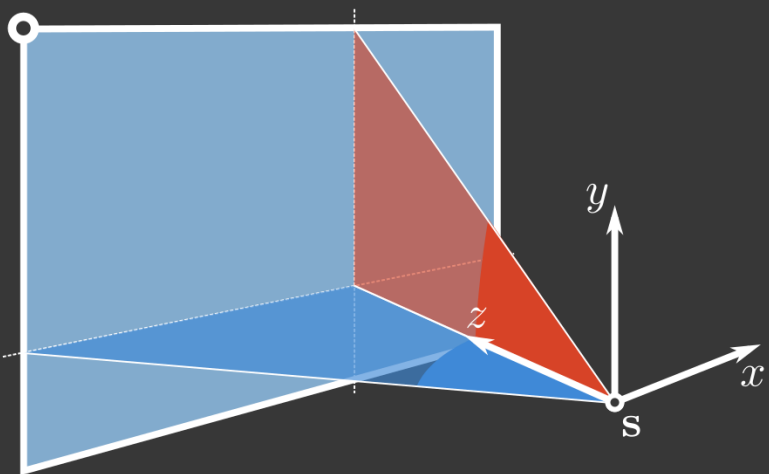
Rectified Coordinates



Rectified Coordinates



Rectified Coordinates



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Challenges:

- 1) Visible regions have complex shapes
Marginal/conditional decomposition difficult
- 2) Visible regions different for each shading point
Marginal/conditional cannot be precomputed



Portal-Masked Environment Map Sampling

Challenges:

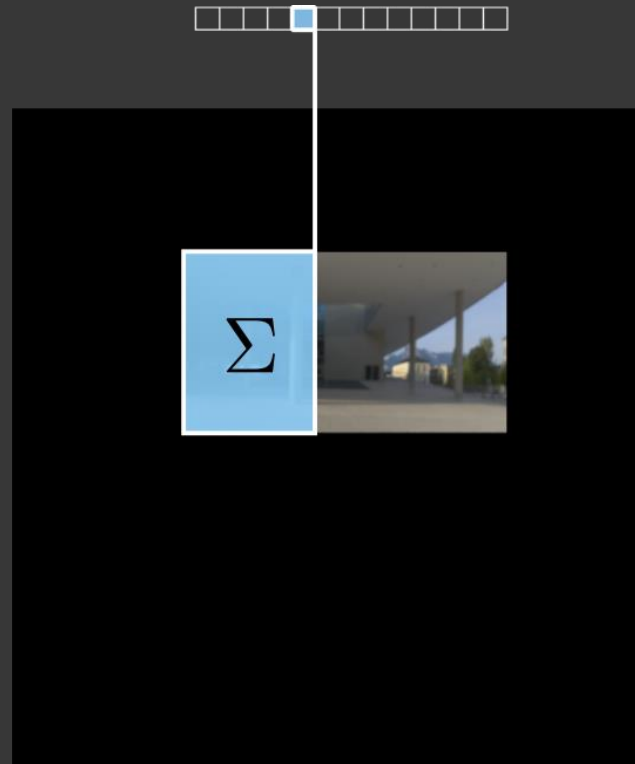
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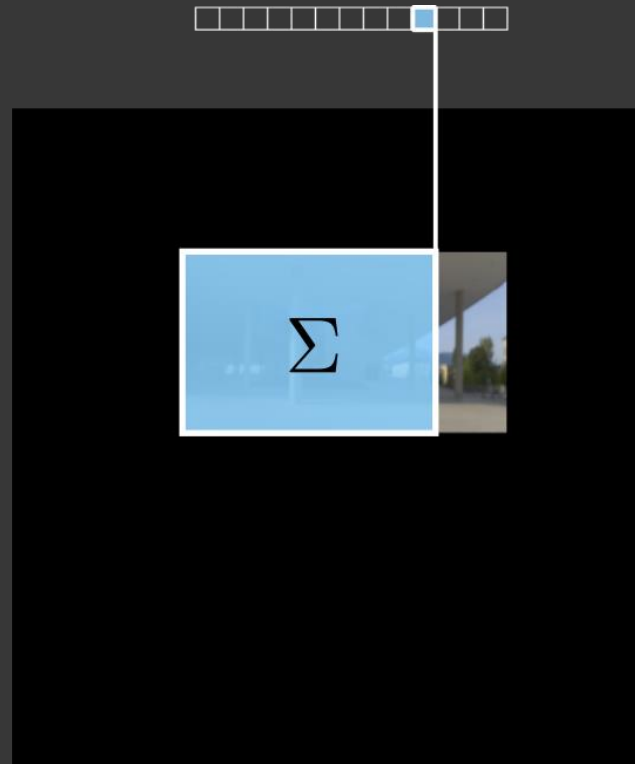
Sampling the Visible Region

- 1) Construct marginal/conditional distribution
- 2) Invert marginal/conditional distribution

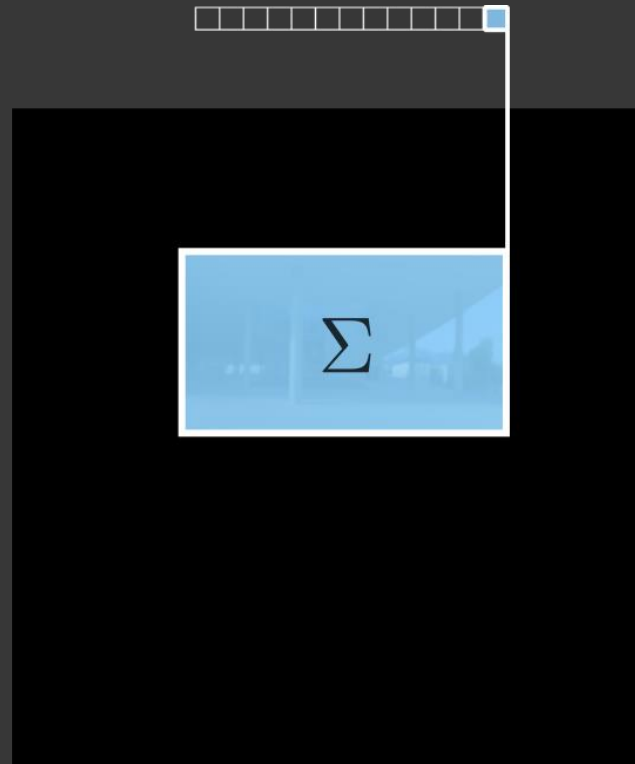
Marginal Distribution



Marginal Distribution

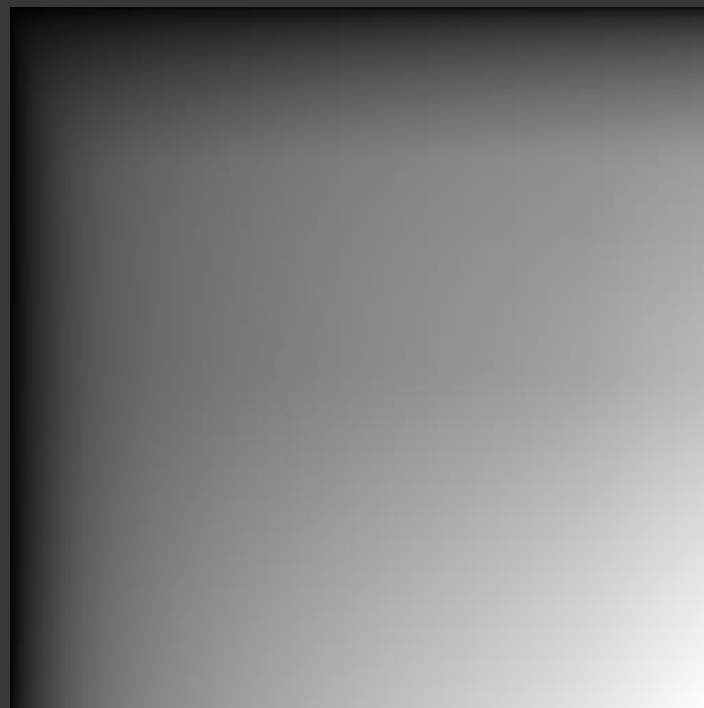
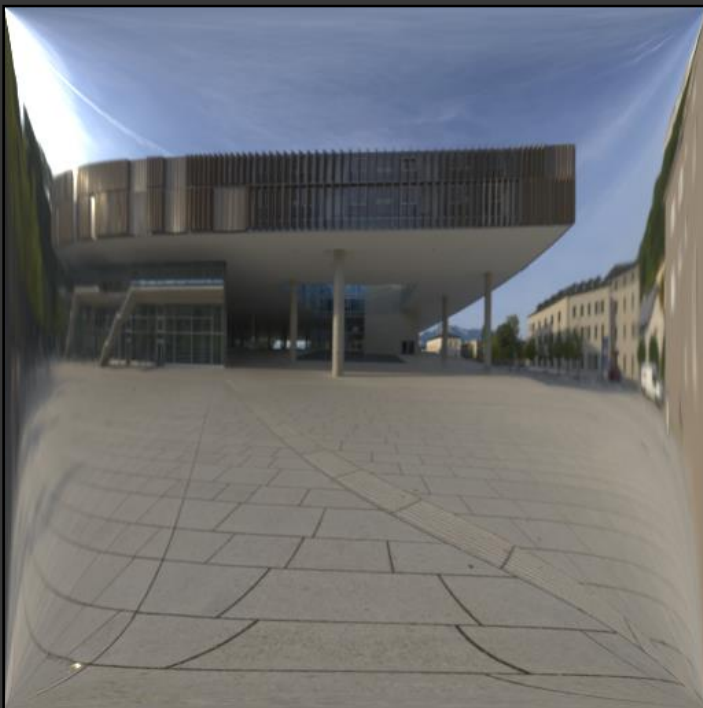


Marginal Distribution



Marginal Distribution

Precompute summed-area table instead [Crow '84]



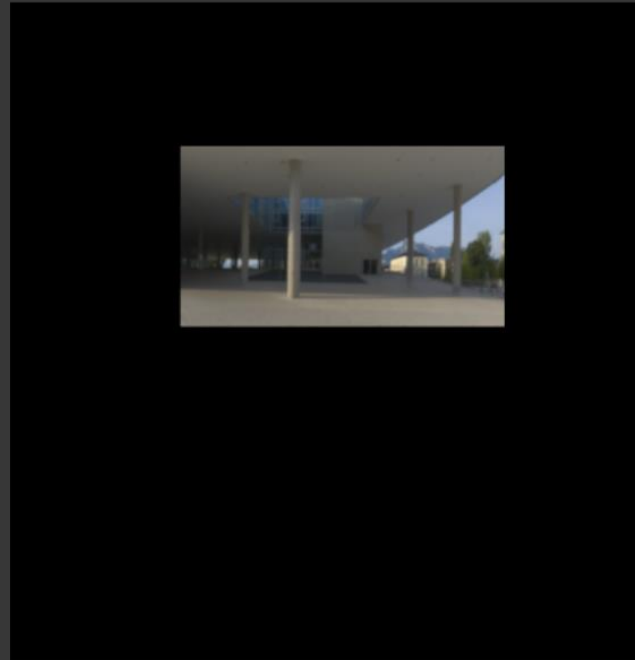
Sampling the Visible Region

1) Construct marginal/conditional distributions

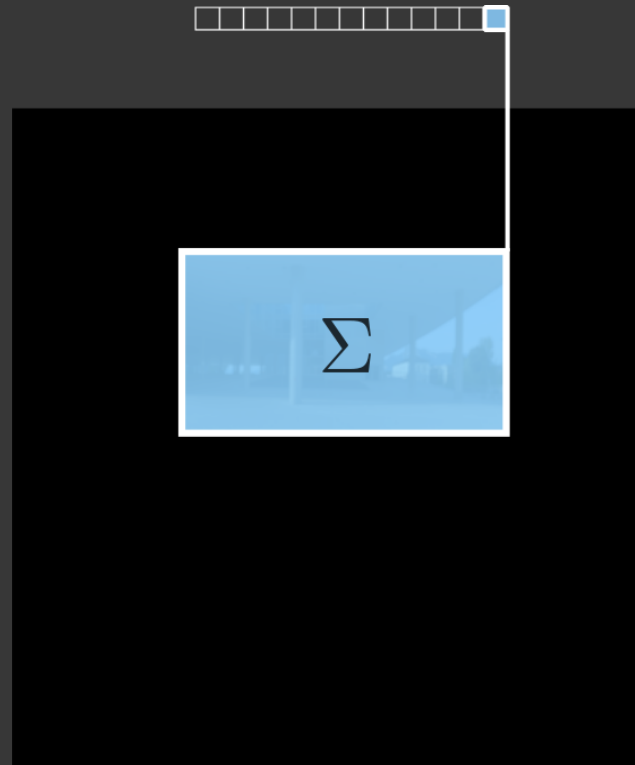
Precompute summed-area table instead [Crow '84]

2) Invert marginal/conditional distributions

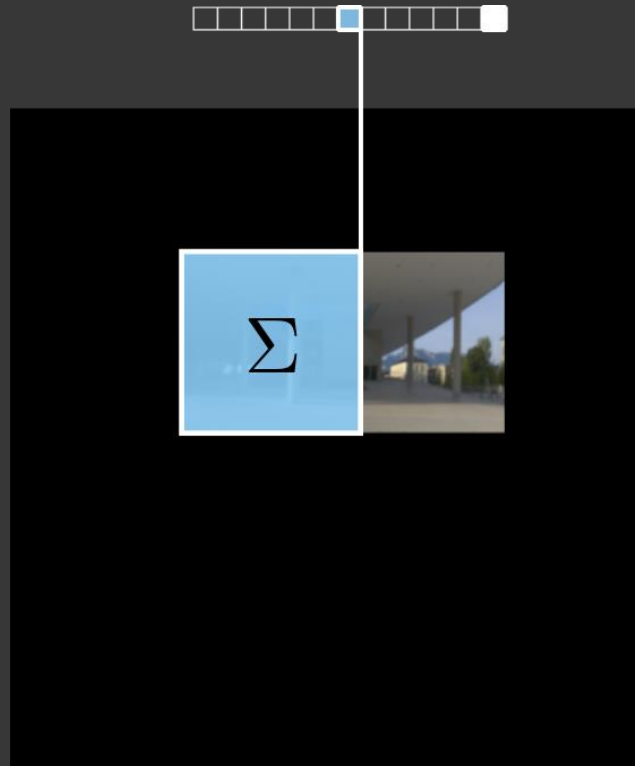
Inverting the Marginal Distribution



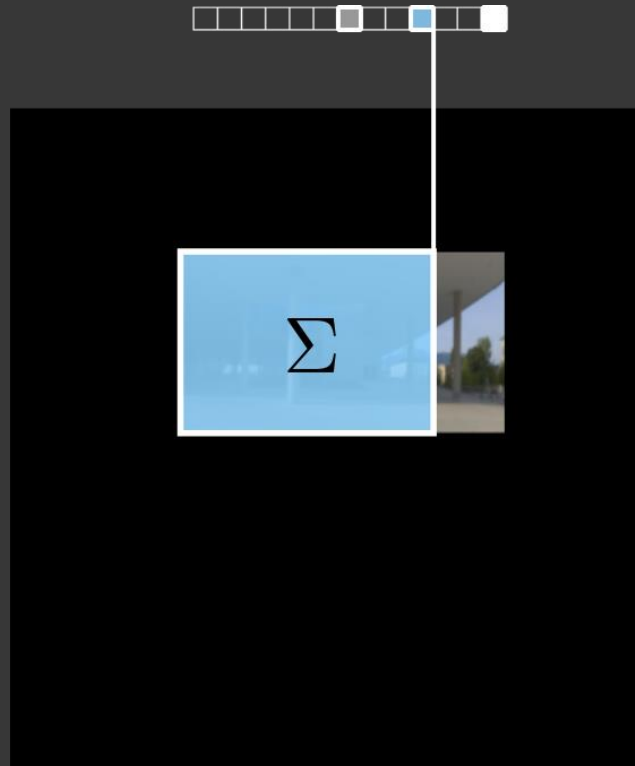
Inverting the Marginal Distribution



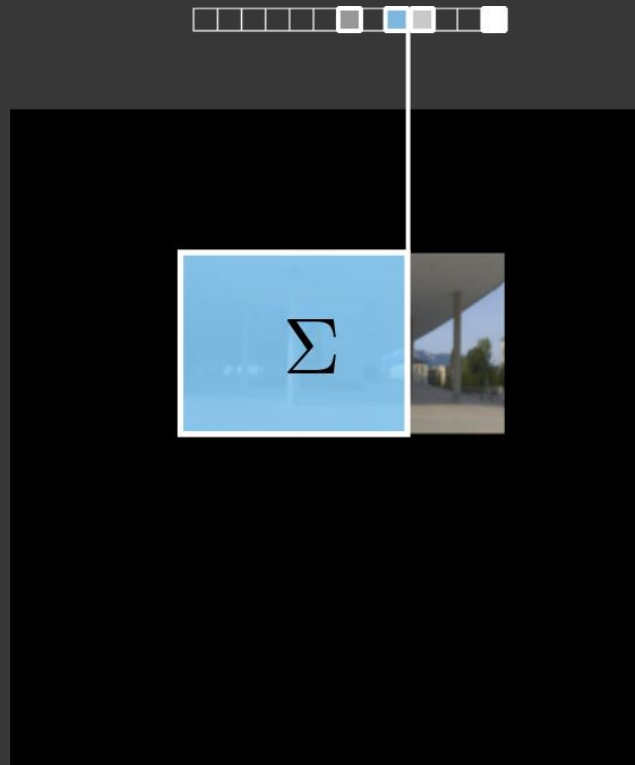
Inverting the Marginal Distribution



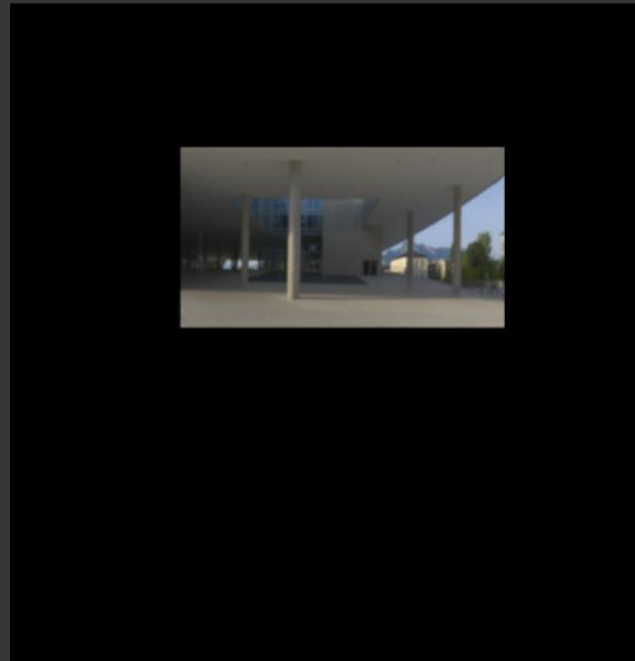
Inverting the Marginal Distribution



Inverting the Marginal Distribution



Inverting the Marginal Distribution



Sampling the Visible Region

1) Construct marginal/conditional distributions

Precompute summed-area table instead [Crow '84]

2) Invert marginal/conditional distributions

Use bisection algorithm for logarithmic complexity

Results

Results

Comparison of:

- a) Environment map sampling
- b) Portal solid angle sampling [Ureña et al. 2013]
- c) Multiple importance sampling of a) and b) [Veach 1998]
- d) Ours

at equal sample count (8spp)

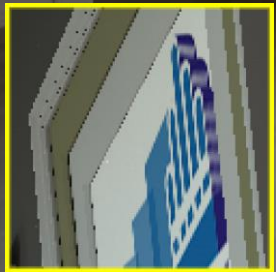
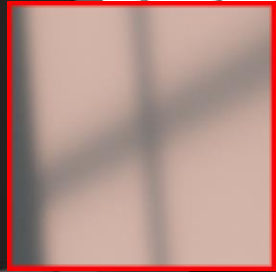
All methods combined with 1 BRDF sample using MIS



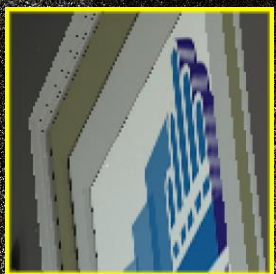
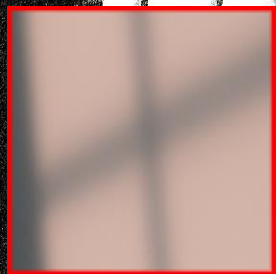






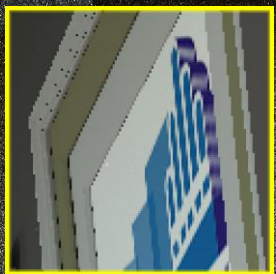
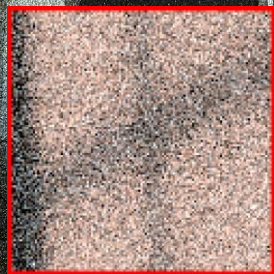
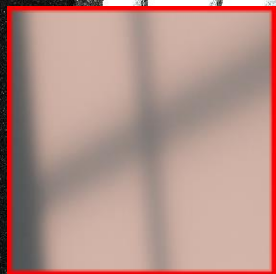


Reference
RMSE



Reference
RMSE

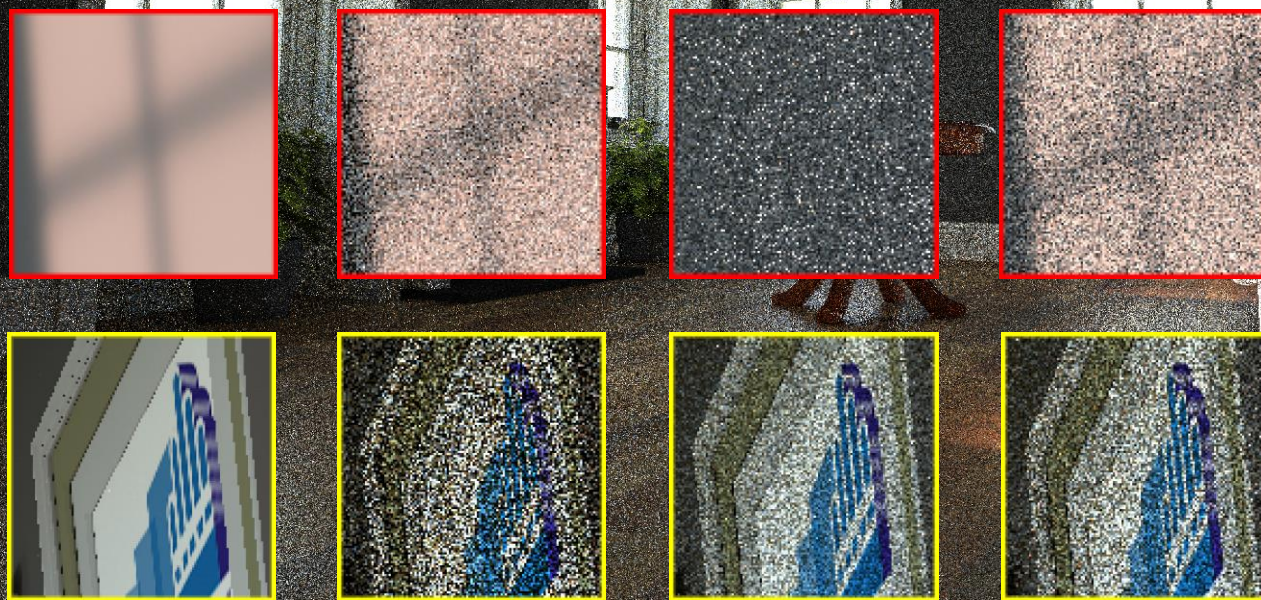
Env. Map
0.23



Reference
RMSE

Env. Map
0.23

Portal S.Angle
3.31

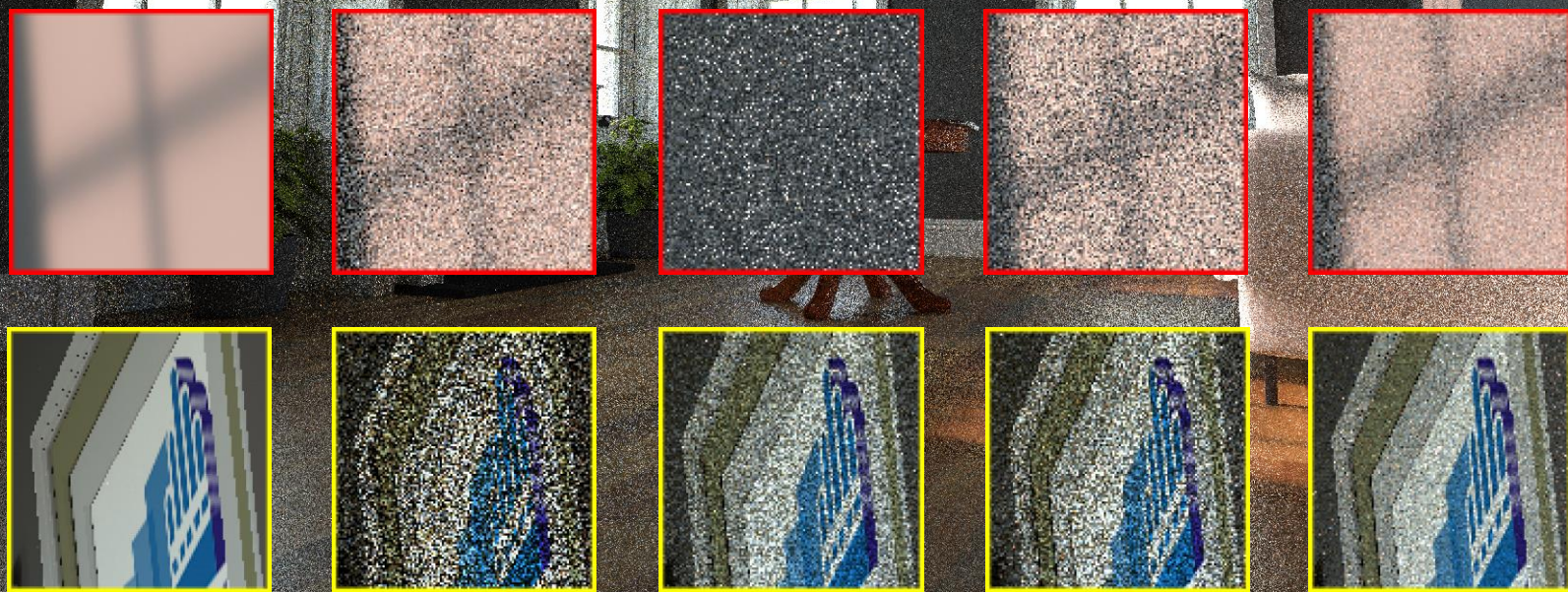


Reference
RMSE

Env. Map
0.23

Portal S.Angle
3.31

MIS
0.26



Reference
RMSE

Env. Map
0.23

Portal S.Angle
3.31

MIS
0.26

Ours
0.16

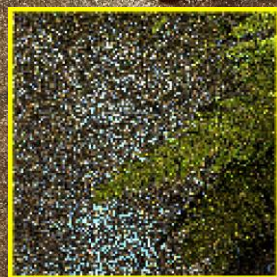
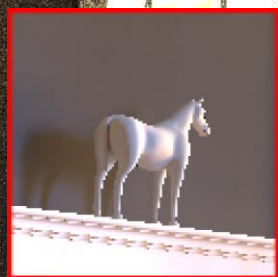








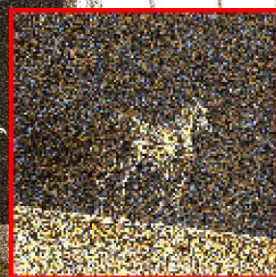
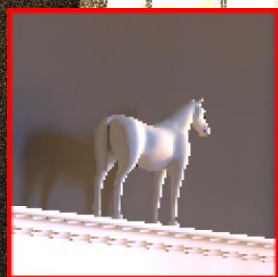
Reference
RMSE



Reference
RMSE

Env. Map
0.59

Portal S.Angle
0.74

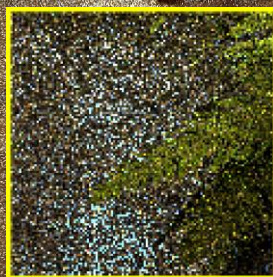
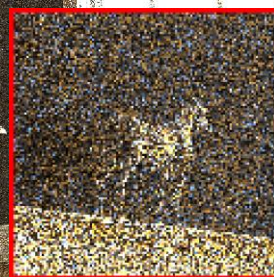
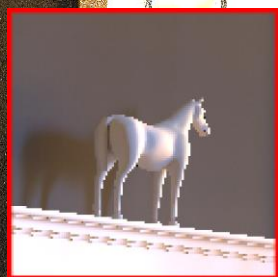


Reference
RMSE

Env. Map
0.59

Portal S.Angle
0.74

MIS
0.60



Reference
RMSE

Env. Map
0.59

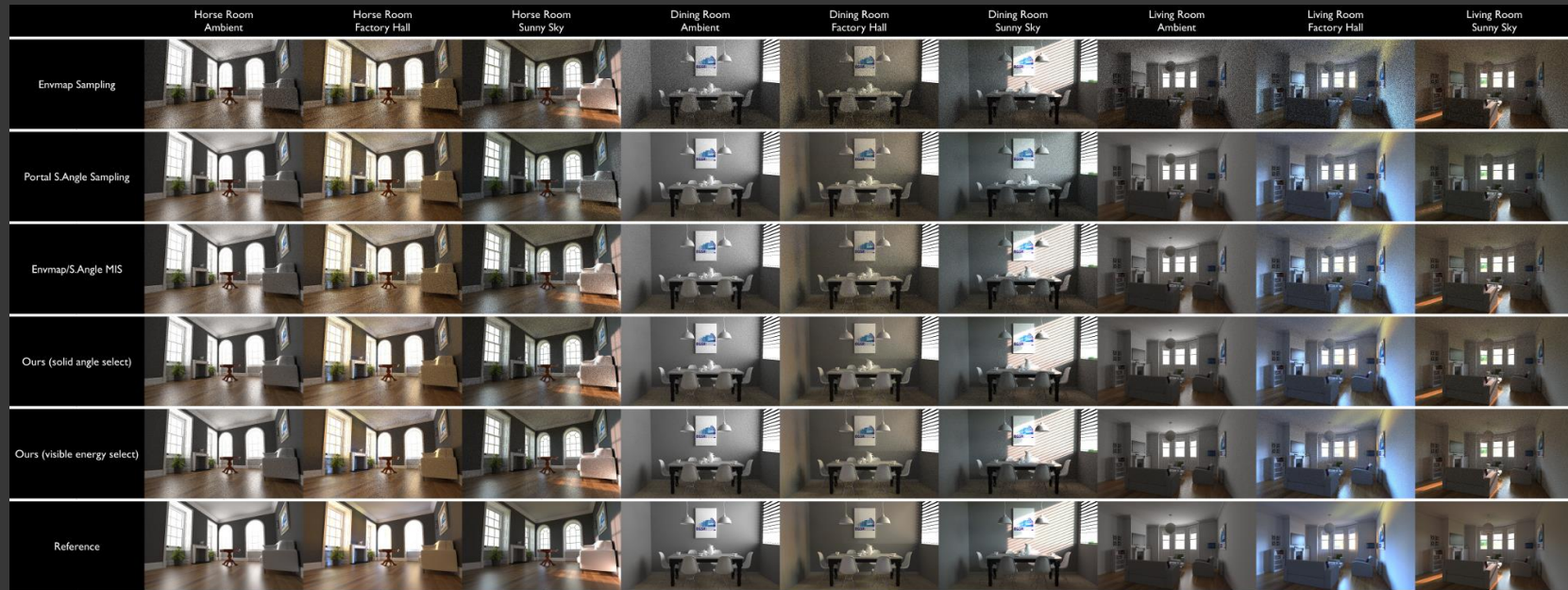
Portal S.Angle
0.74

MIS
0.60

Ours
0.34

More Results

Please see supplementary material



By the numbers

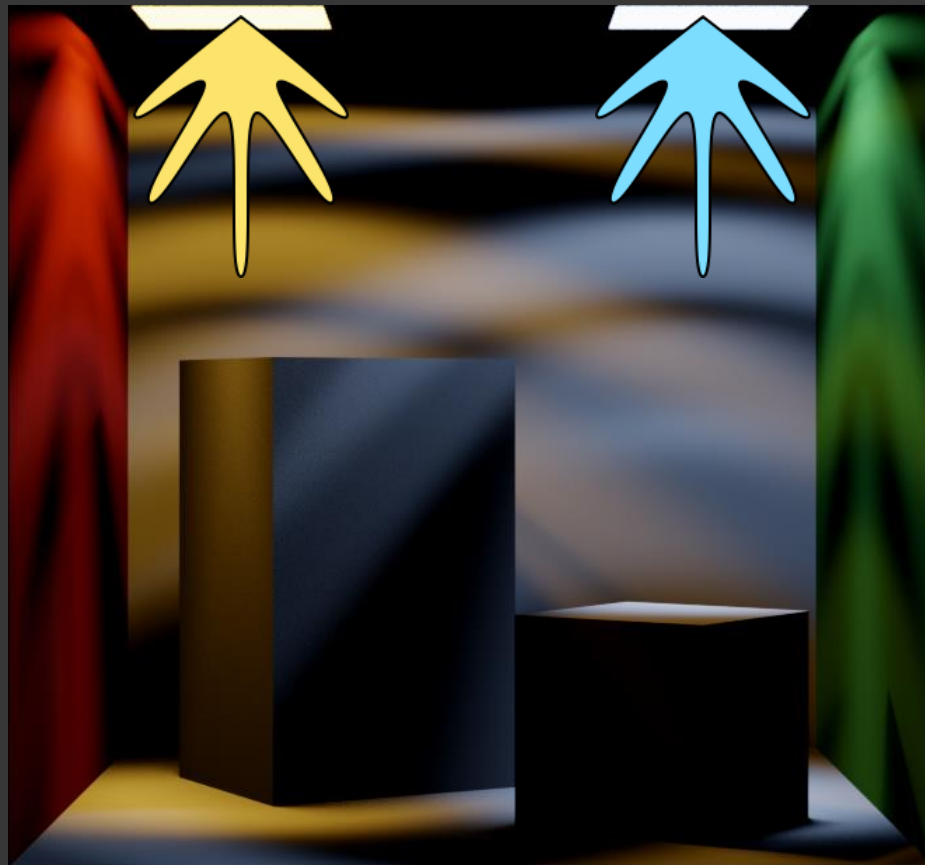
Equal time:

- 33% less shadow rays than Env. Map sampling

Equal quality:

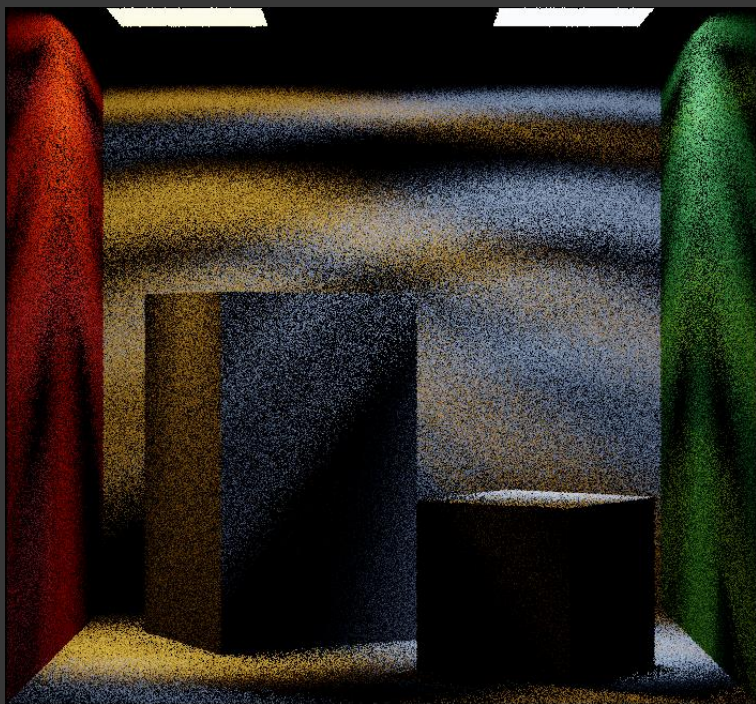
- 2x – 8x speedup w.r.t. Env. Map sampling
- 2x – 5x speedup w.r.t. Env Map/Portal MIS

Area lights with directional profile

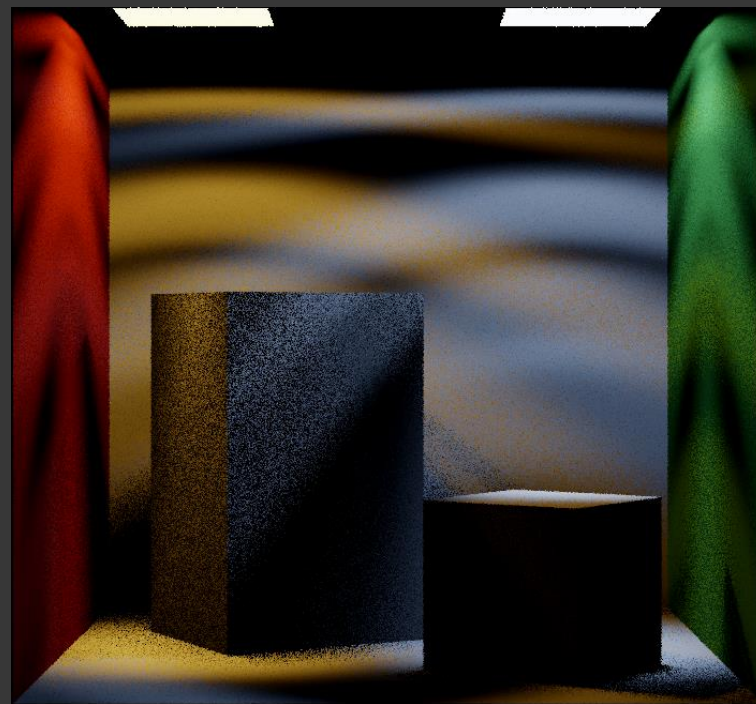


Area lights with directional profile

Uniform Solid Angle Sampling



Ours



10x speedup

Conclusion

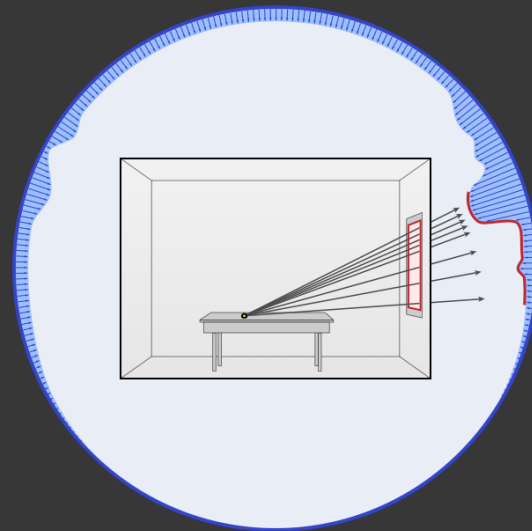
Take away from this talk:

- Can importance sample visibility x Env. Map
- Need single (precomputed) SAT per portal
- Easy to implement!

Conclusion

Take away from this talk:

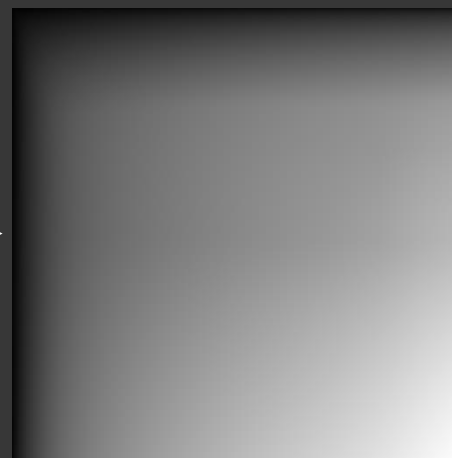
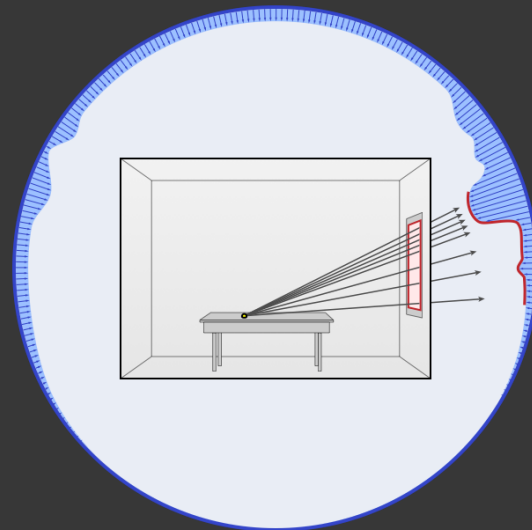
- Can importance sample visibility \times Env. Map
- Need single (precomputed) SAT per portal
- Easy to implement!



Conclusion

Take away from this talk:

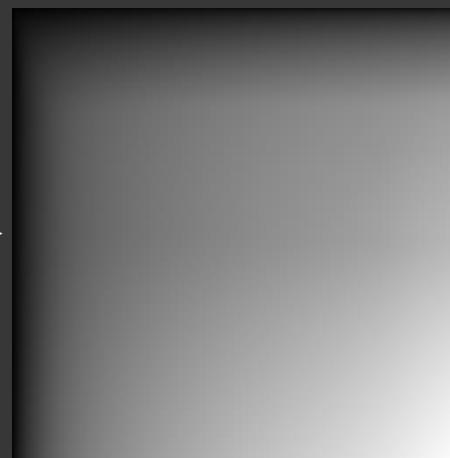
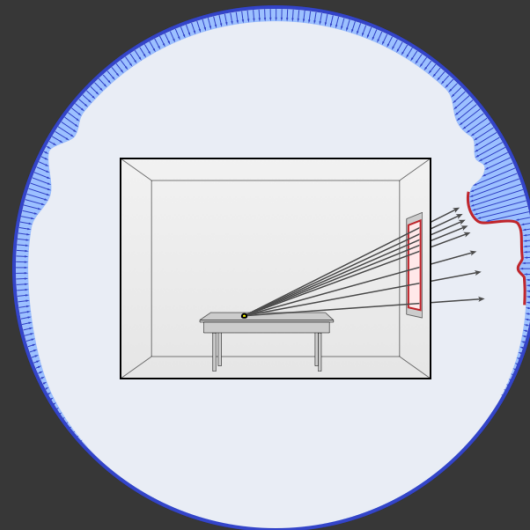
- Can importance sample visibility \times Env. Map
- Need single (precomputed) SAT per portal
- Easy to implement!



Conclusion

Take away from this talk:

- Can importance sample visibility \times Env. Map
- Need single (precomputed) SAT per portal
- Easy to implement!



Limitations

- Needs a portal to work

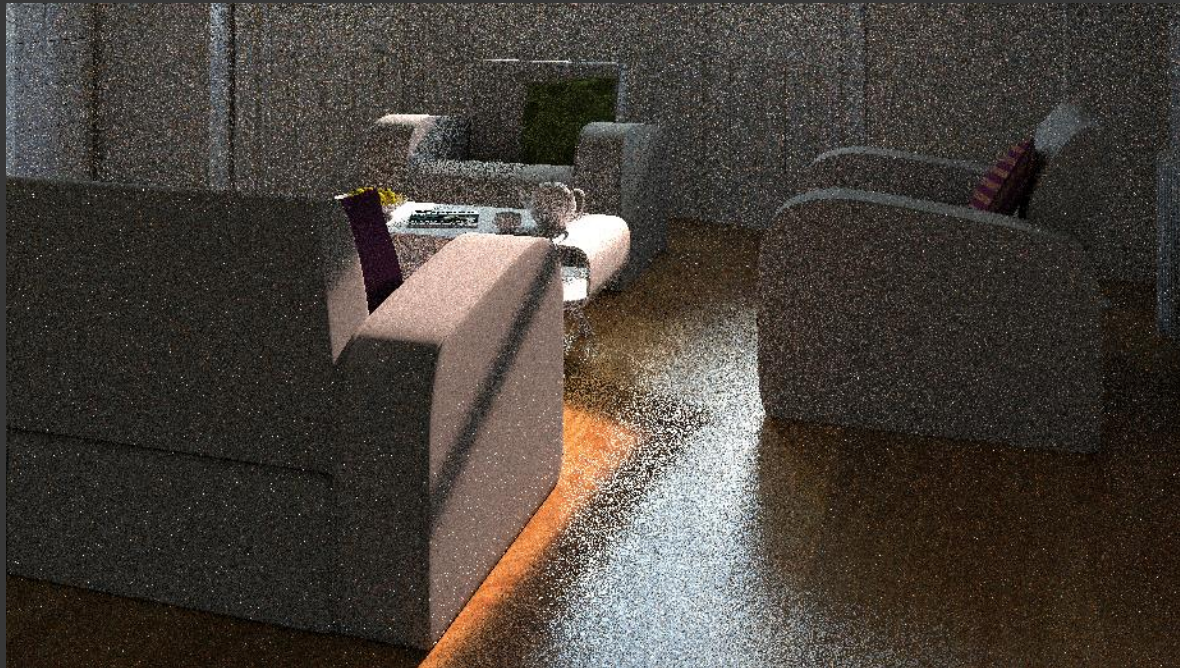
Limitations

- Needs a portal to work
- Only considers visibility through a rectangle



Limitations

- Needs a portal to work
- Only considers visibility through a rectangle

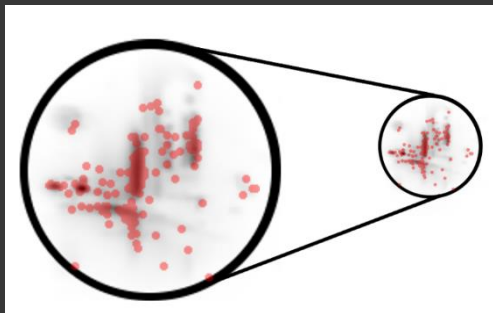


Future Work

Incorporate BRDF:

Combine with product sampling techniques

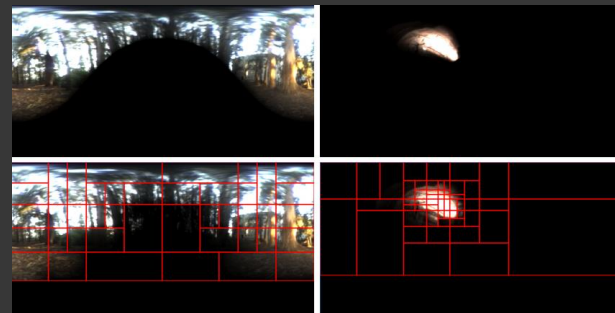
[Burke et al.]



[Clarberg et al.]



[Cline et al.]



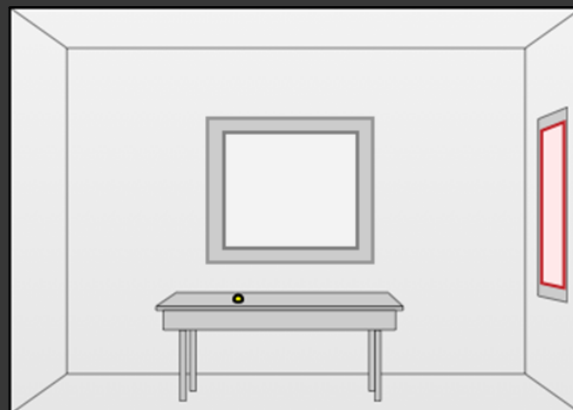
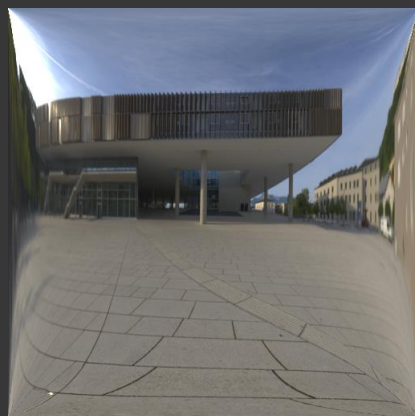
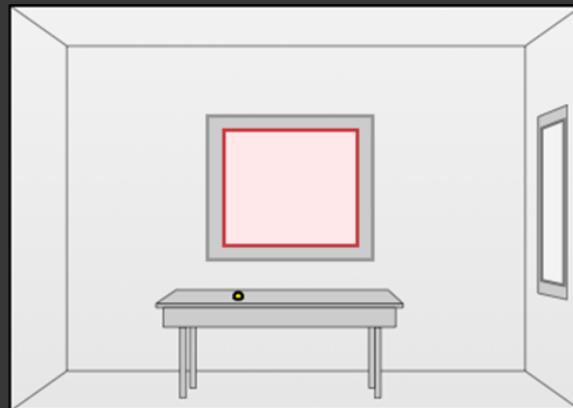
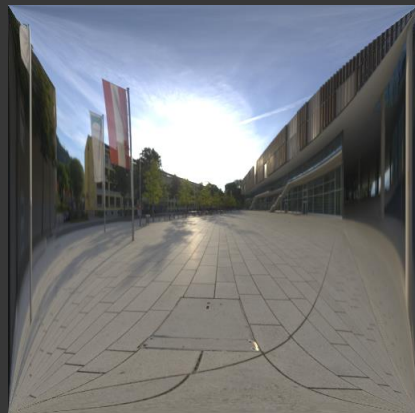
Thanks!

Acknowledgements:

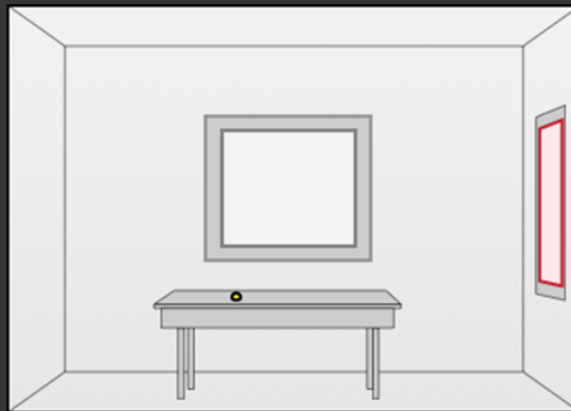
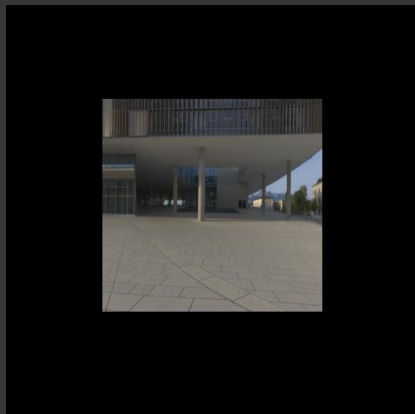
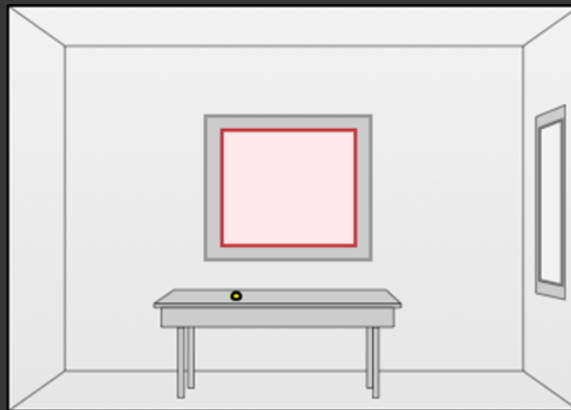
- Environment maps: Bernhard Vogl, <http://openfootage.net>
- Scenes: Jay Hardy, Wayne

Bonus Slides

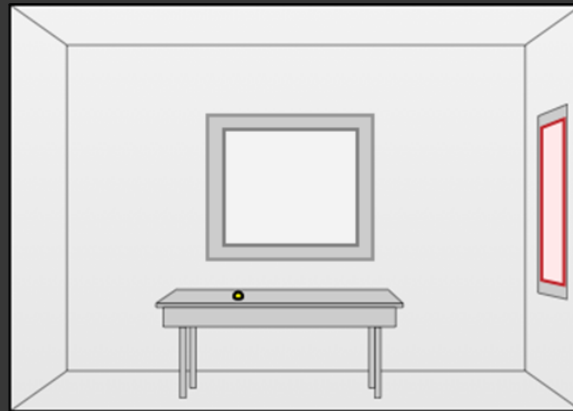
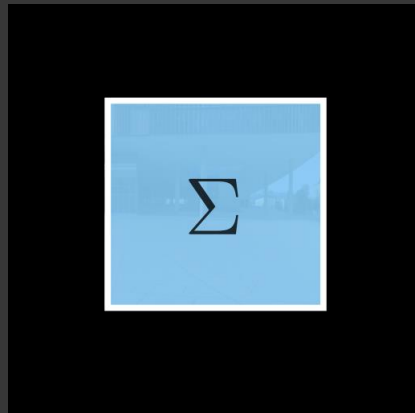
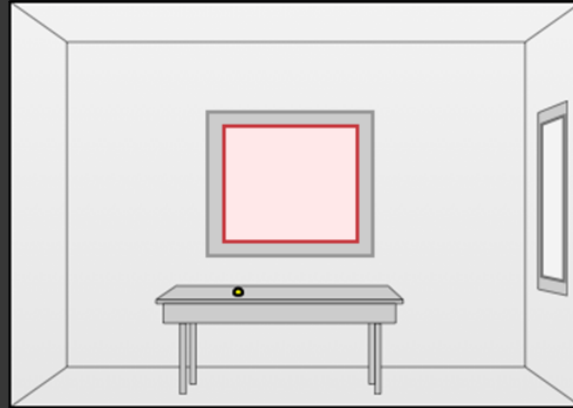
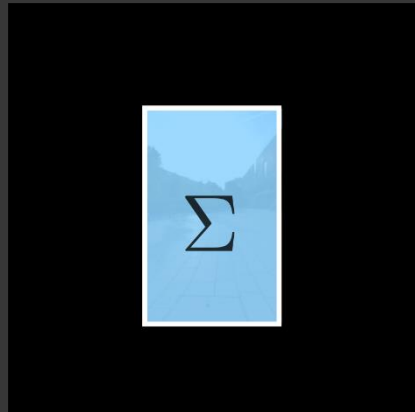
Sampling multiple portals



Sampling multiple portals

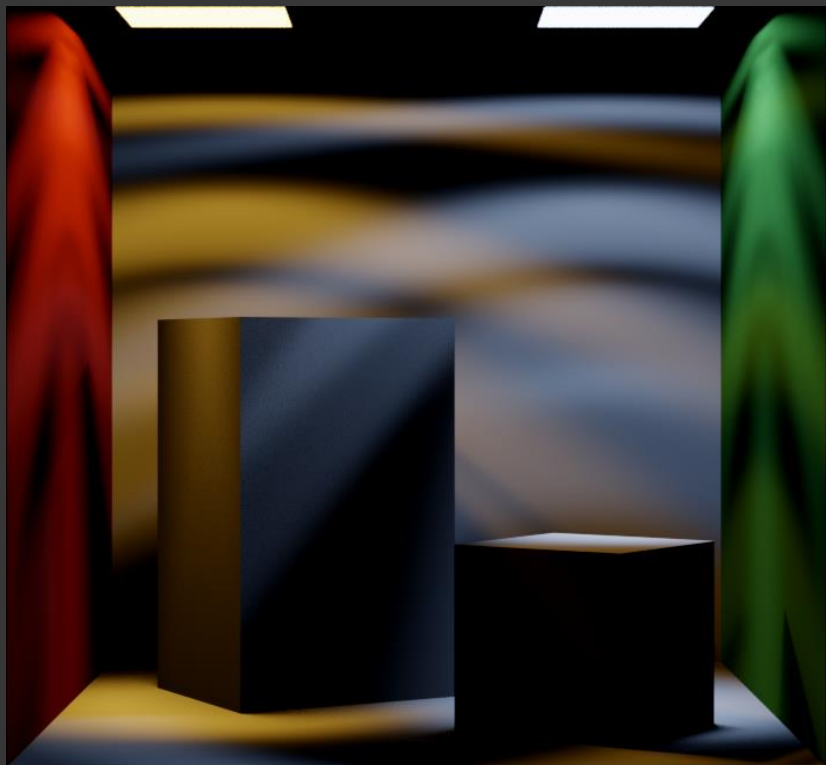


Sampling multiple portals



Sampling multiple portals

Scene



Sample Allocation

