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Radiance Workshop, 2009

#### Image based Sky Models: Presentation Outline

1 Rationale: Accuracy of lighting simulations

2 Technique: High Dynamic Range Photography

**Image Based Lighting** 

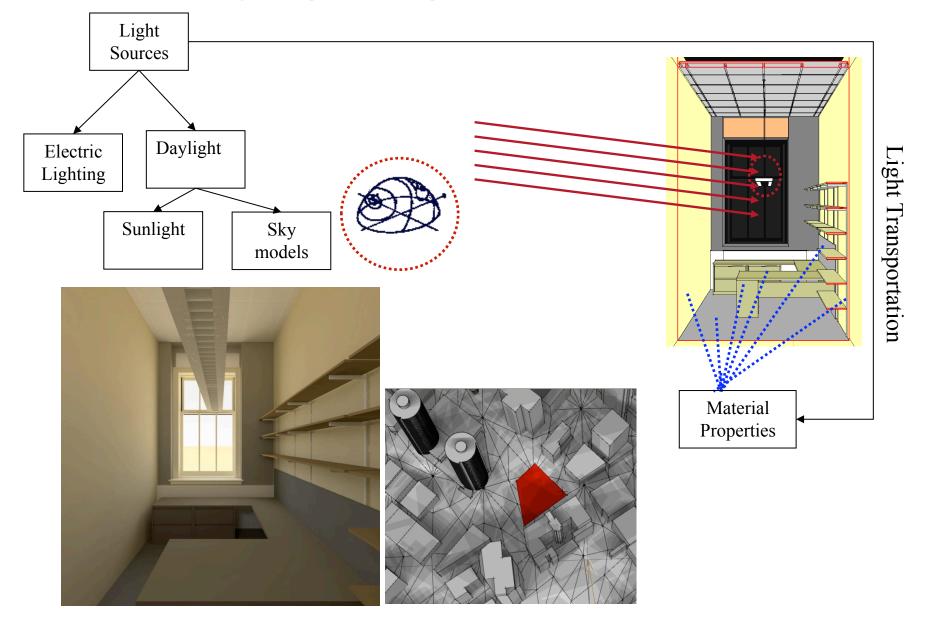
3 Evaluation: Theoretical Evaluation

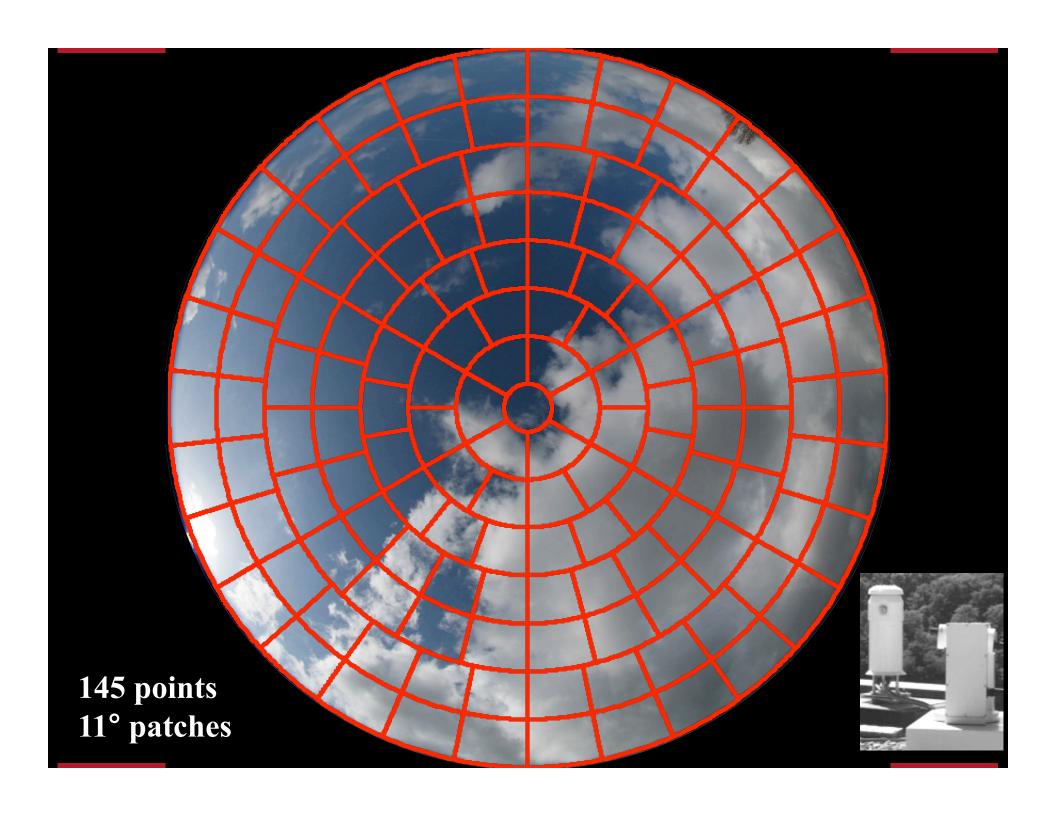
**Empirical Evaluation** 

4 Applications Daylighting Simulation

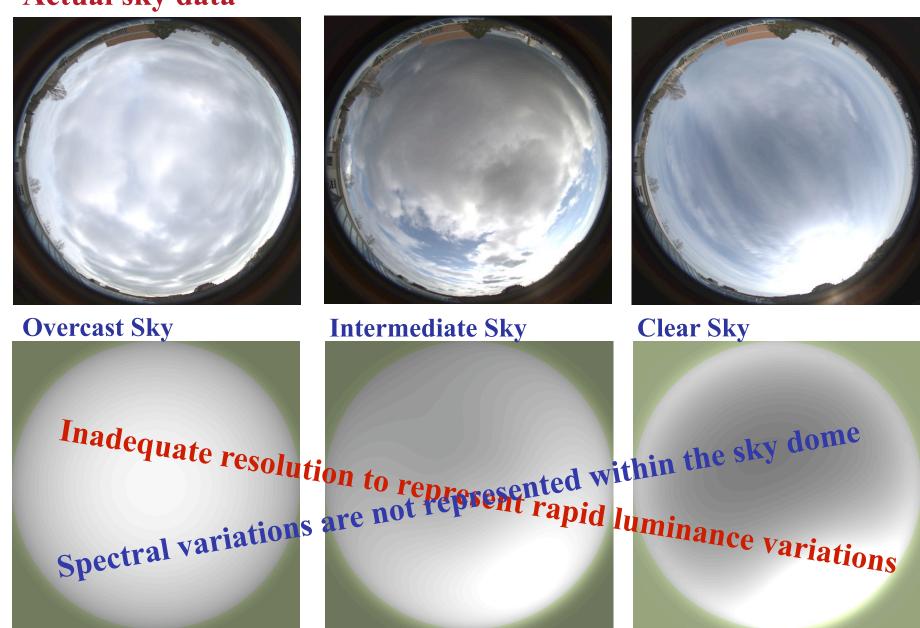
**Future directions** 

# Daylighting Simulation





#### Actual sky data

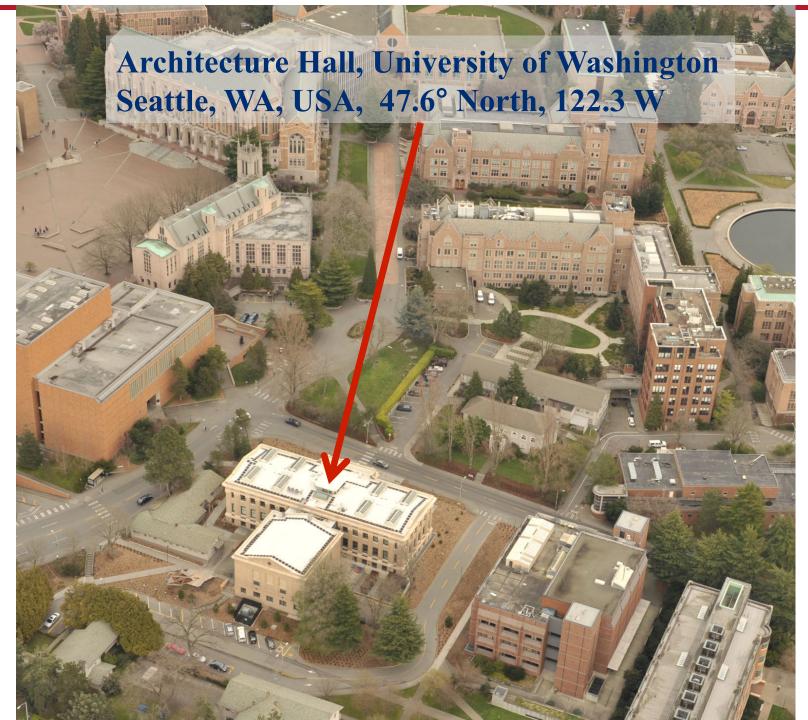


**Generic CIE models** 

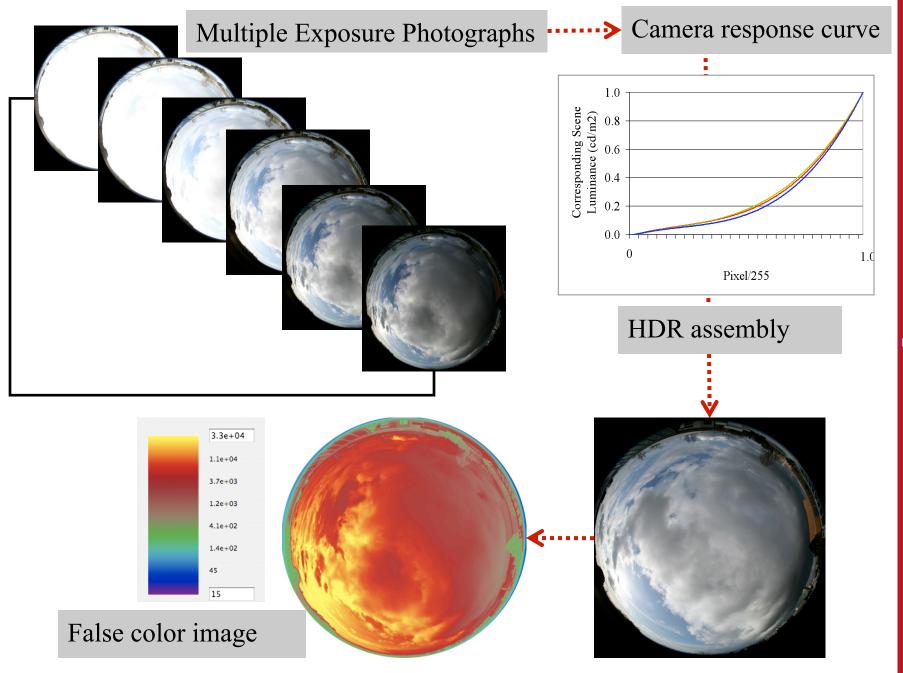
#### Technique

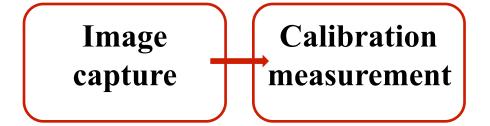
1 High Dynamic Range Photography

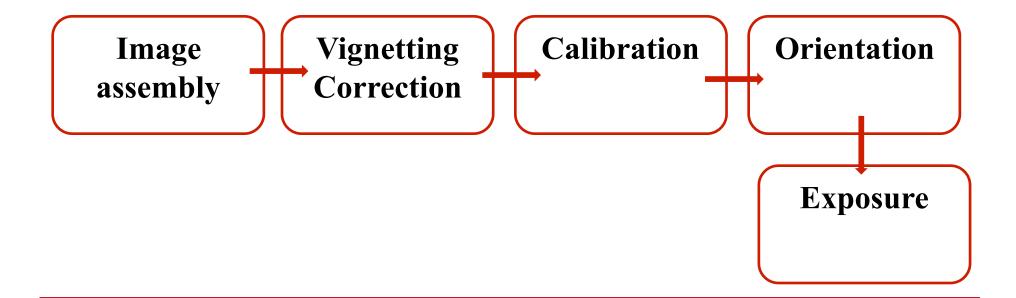
2 Image Based Lighting



Aerial Photo: John Statmets

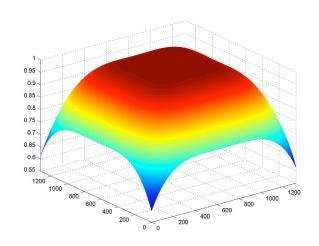




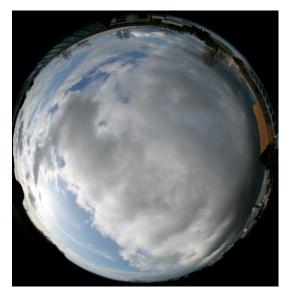


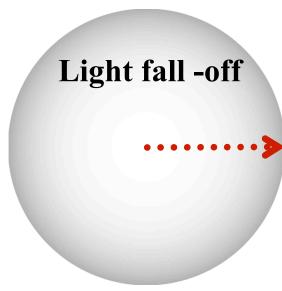
#### Post processing: Vignetting Correction



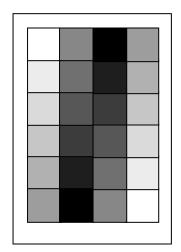


Digital Vignetting Filter





# Post processing: Luminance Calibration



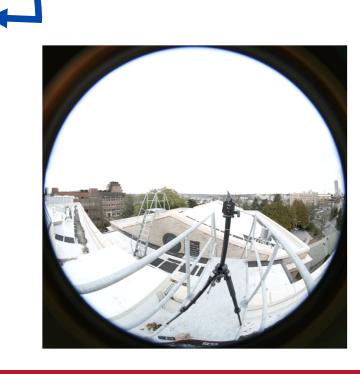






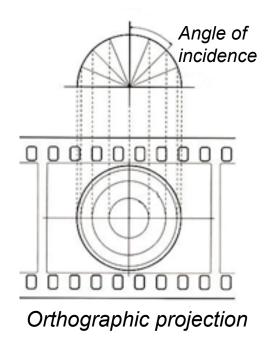
# Post processing: Lighting Calibration using

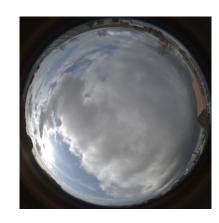




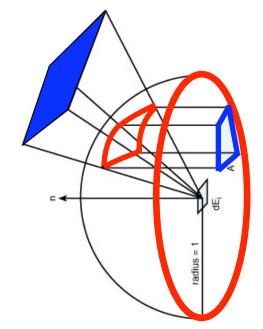


# Post processing: Lighting Calibration using Illuminance meter



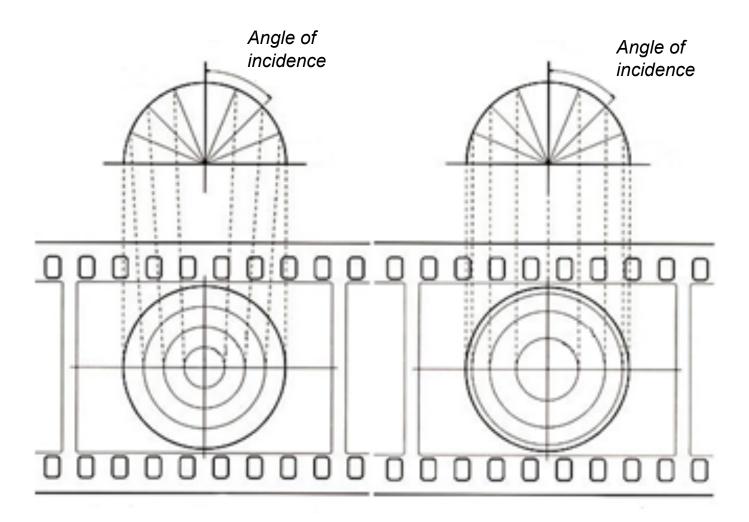


$$x = \sin \theta \cos \phi$$
$$y = \sin \theta \sin \phi$$
$$z = \cos \theta$$



$$E = \pi L$$

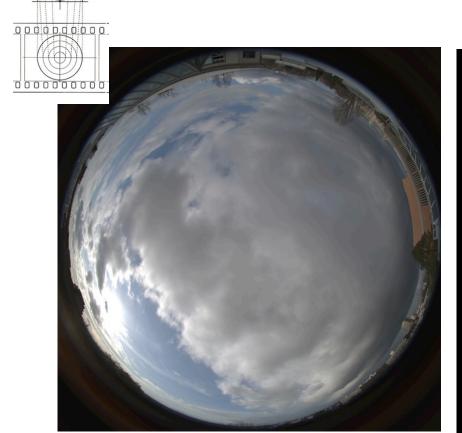
# Post processing: Calibration

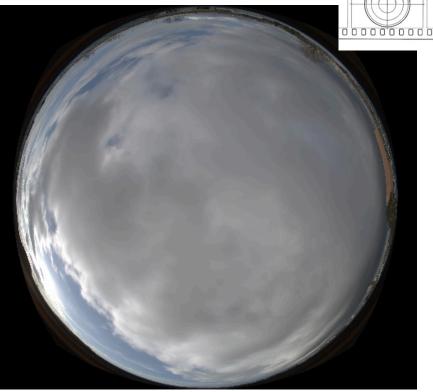


Equidistant projection

Orthographic projection

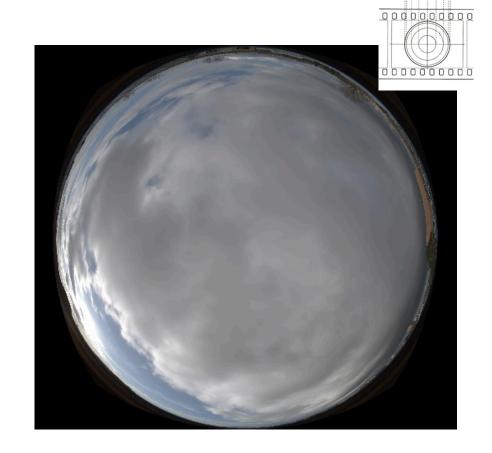
# Post processing: Calibration





pinterp –vf input.hdr –vth –x 1024 –y 1024 –ff input.hdr hemi.hdr

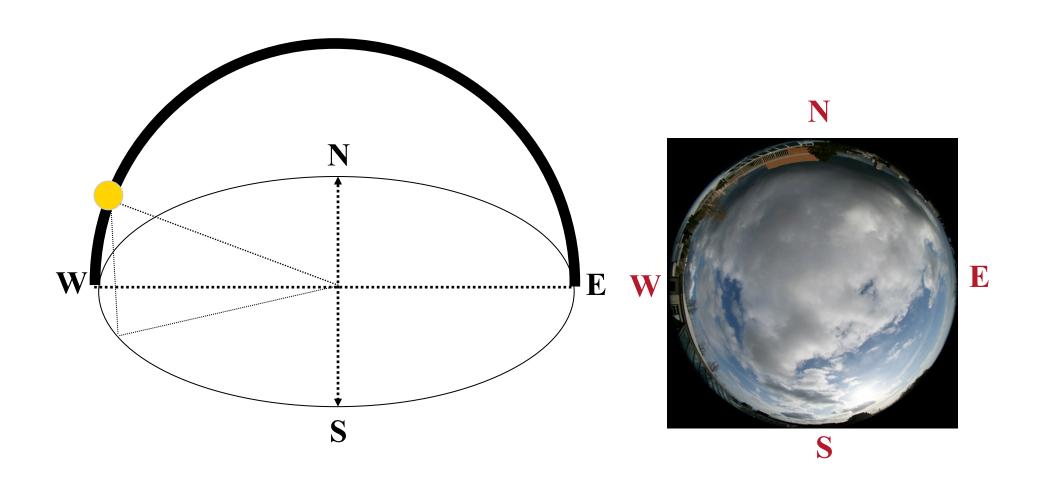
# Post processing: Calibration



$$E = \pi L$$

pinterp –vf input.hdr –vth –x 1024 –y 1024 –ff input.hdr hemi.hdr

# Post processing: Orientation

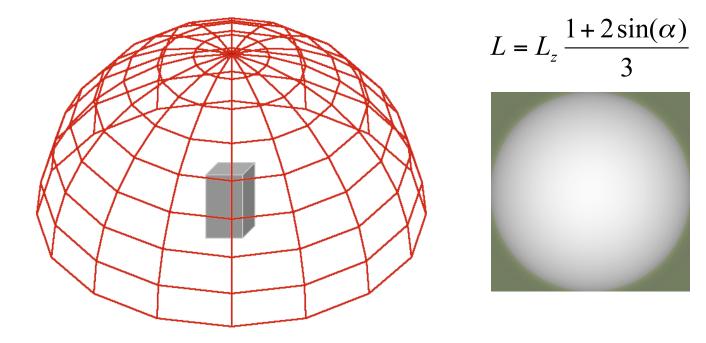


## Post Processing

Adjust exposure to 1 in sky images

pfilt -1 -e ... sky1.hdr > sky1e.hdr

## Daylighting Simulation



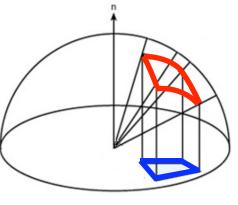
Geometry: Sky dome is a hemisphere that is centered over the extends of the environment.

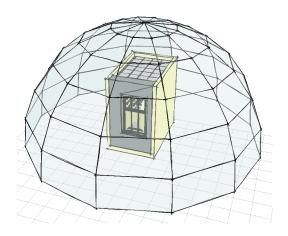
Distribution: Determined from a generic sky model

# Image based Sky Model



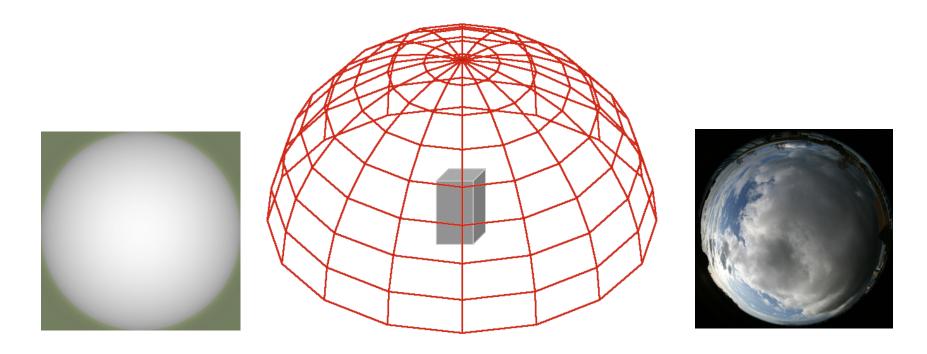




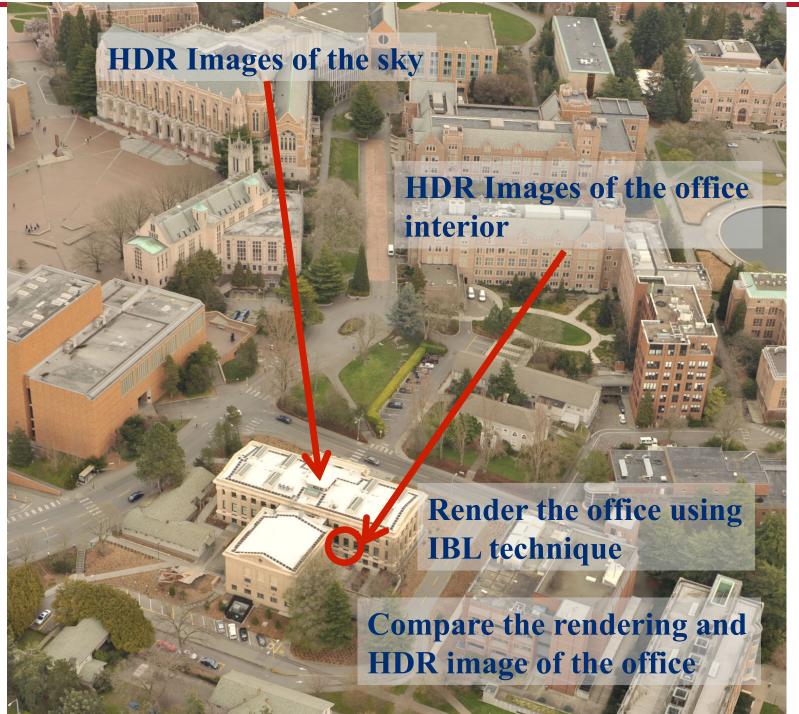


Light Emitting Hemisphere

# Image based Lighting

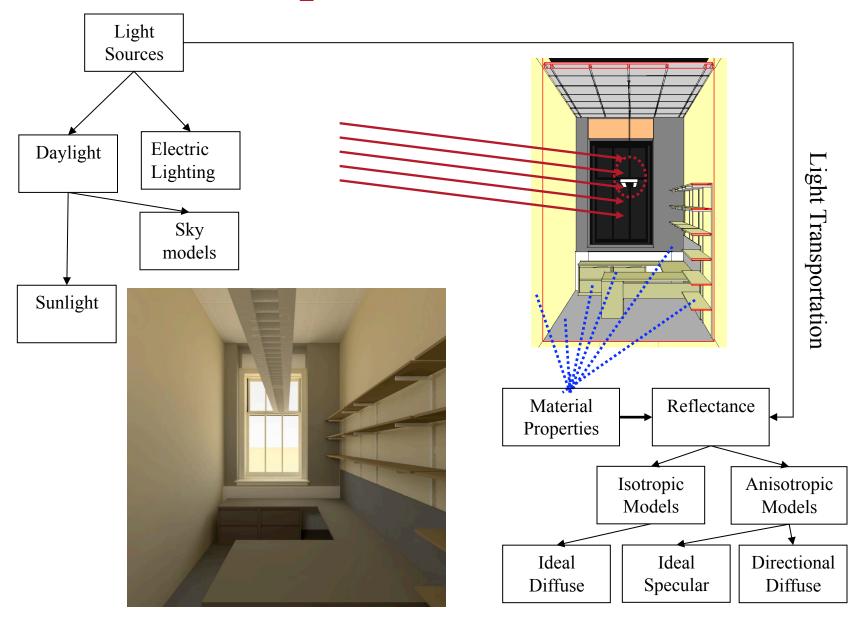


Mathematical model of sky dome versus image based model

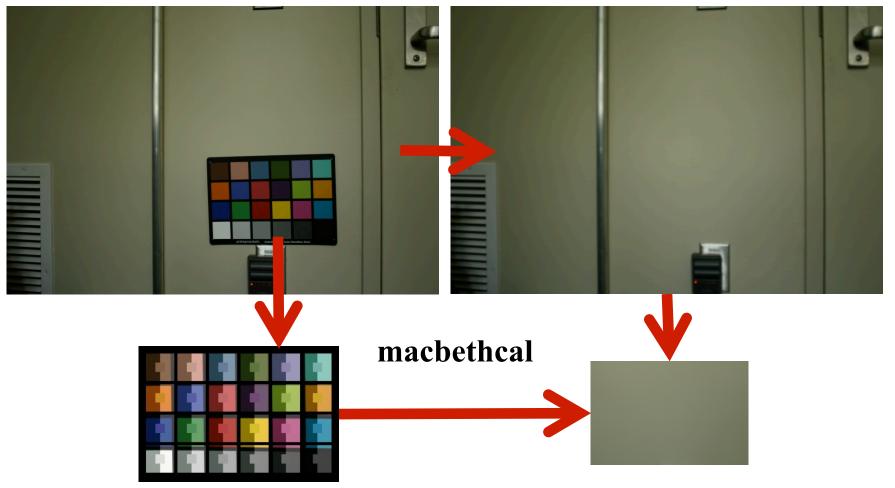


Aerial Photo: John Statmets

# Computer Simulation

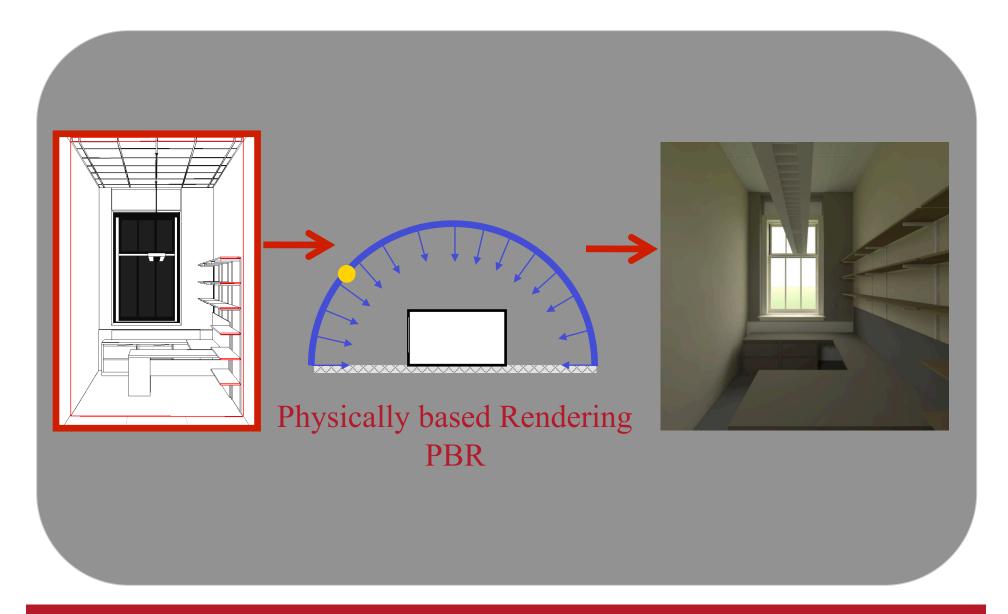


#### **Material Definitions**

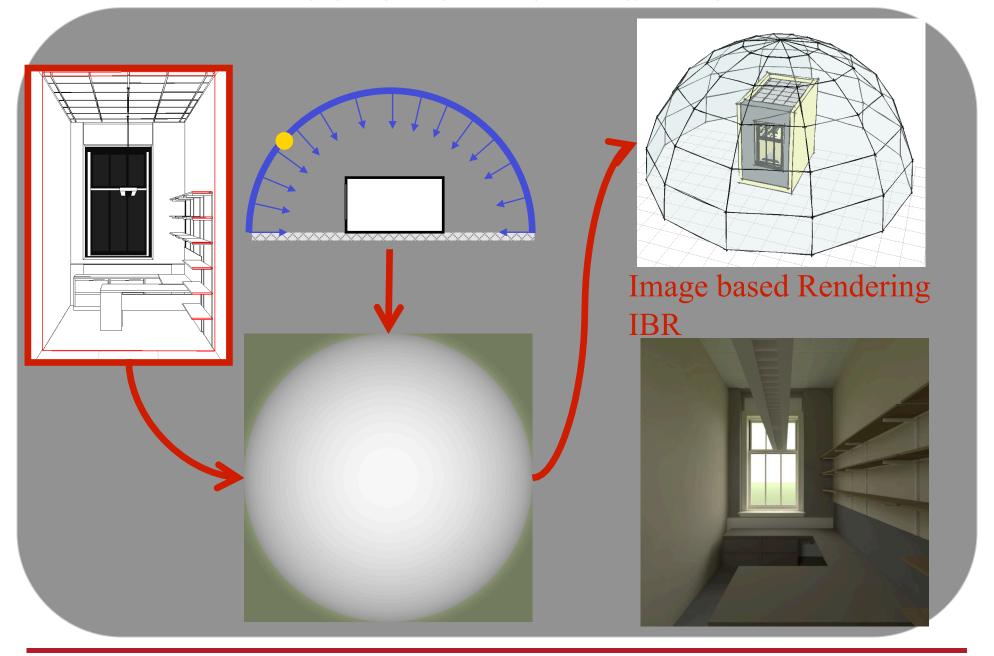


R: 0.6677 G: 0.6161 B: 0.4585

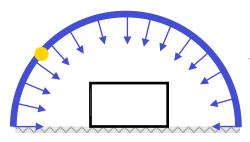
 $Ref_{diff} = 0.265 * R + 0.670 * G + 0.065 * B$ 



#### Theoretical Validation

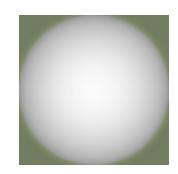


## Theoretical Validation



$$L = L_z \frac{1 + 2\sin(\alpha)}{3}$$

**PBR** 



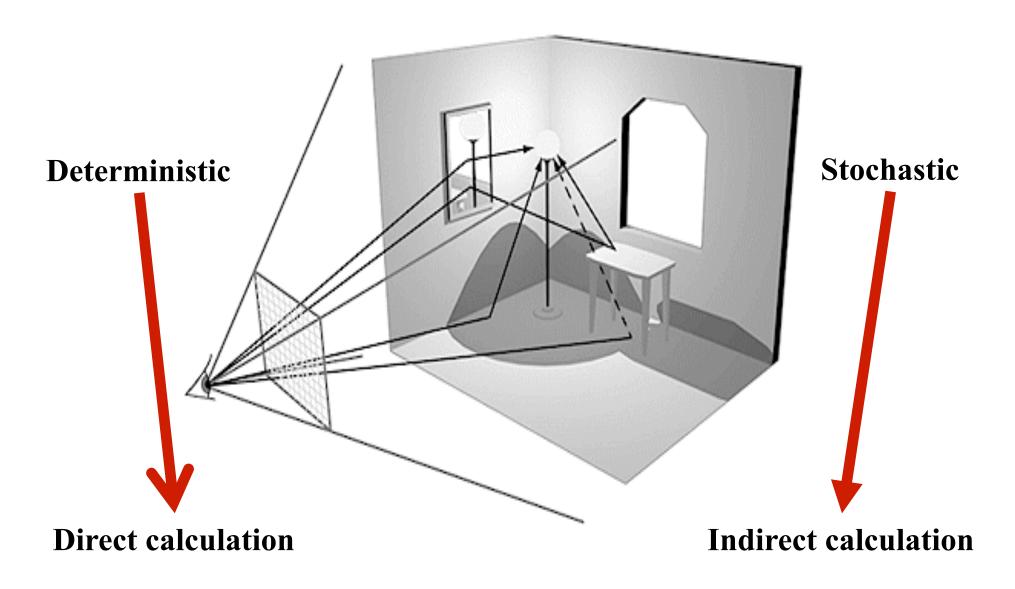
**IBR** 





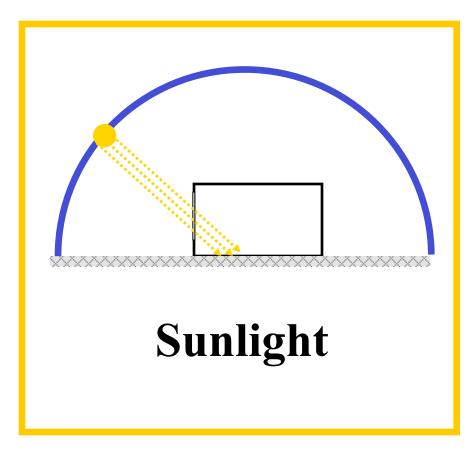
Visual and numerical match?

#### Radiance

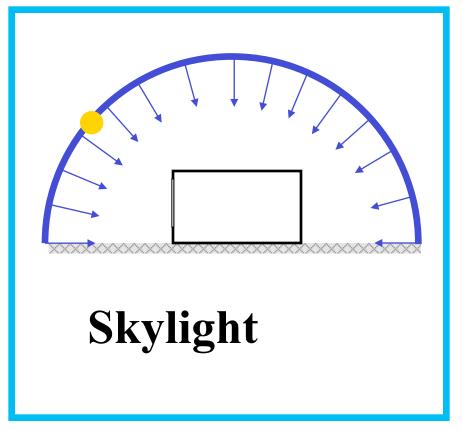


# Physically based Rendering

**Direct Calculation** 

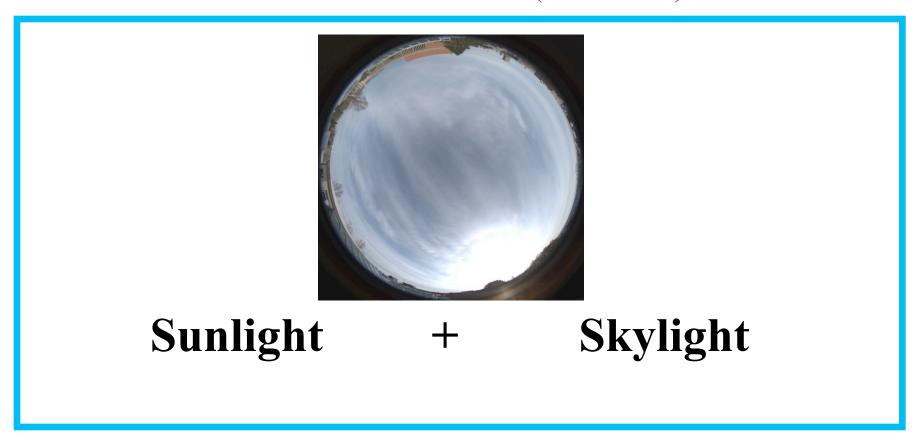


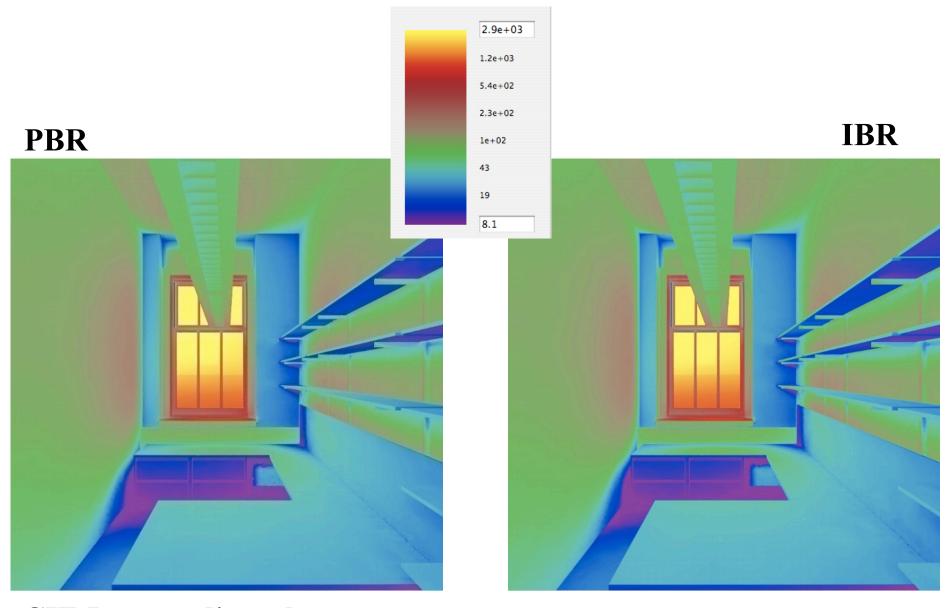
**Indirect Calculation** 



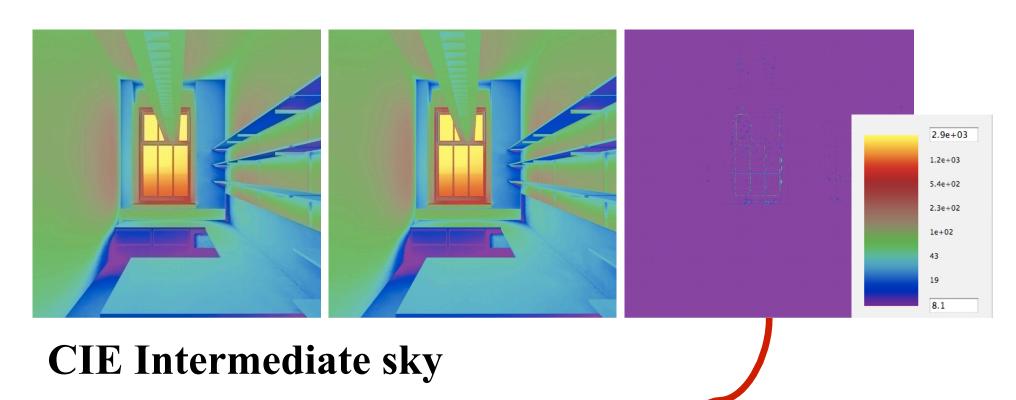
# Image based Lighting

Indirect Calculation (Stochastic)





**CIE Intermediate sky** 

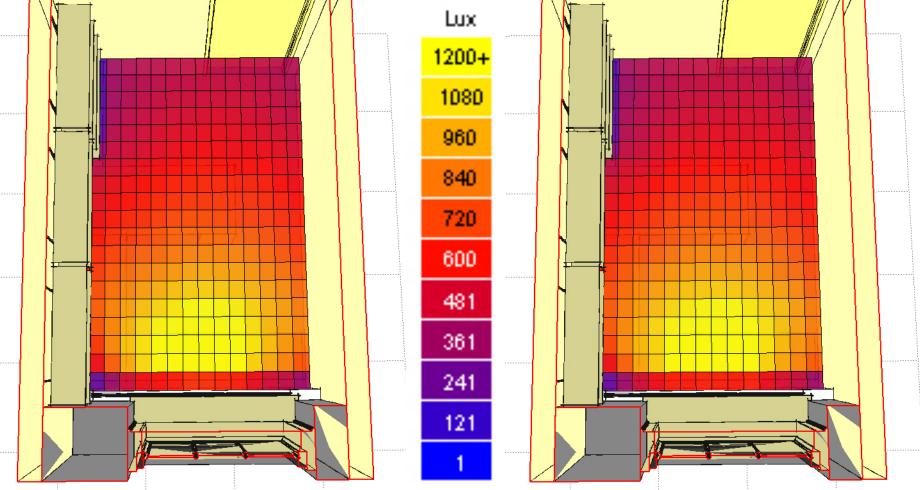


Average difference: 1.6%

PBR

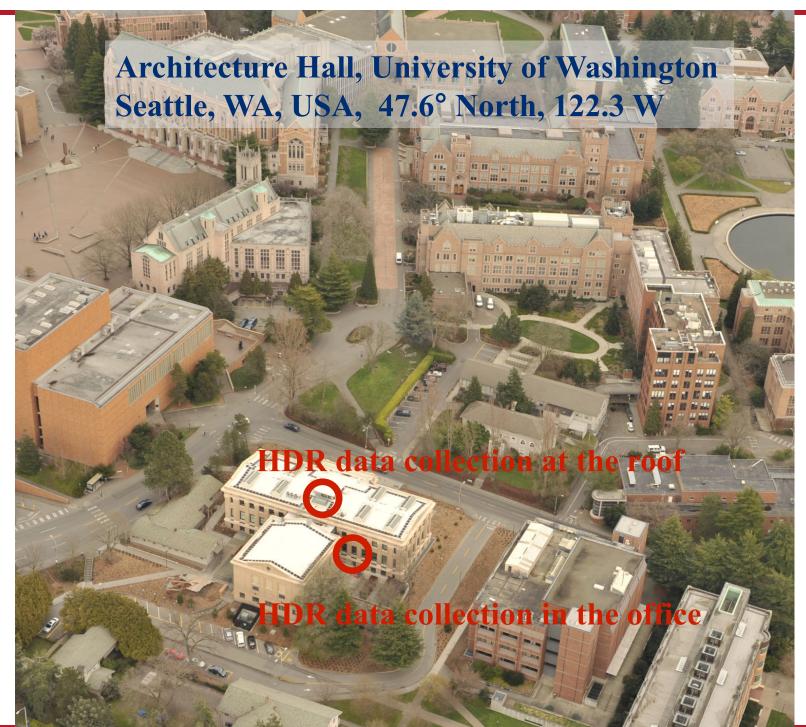
Lux

1200+



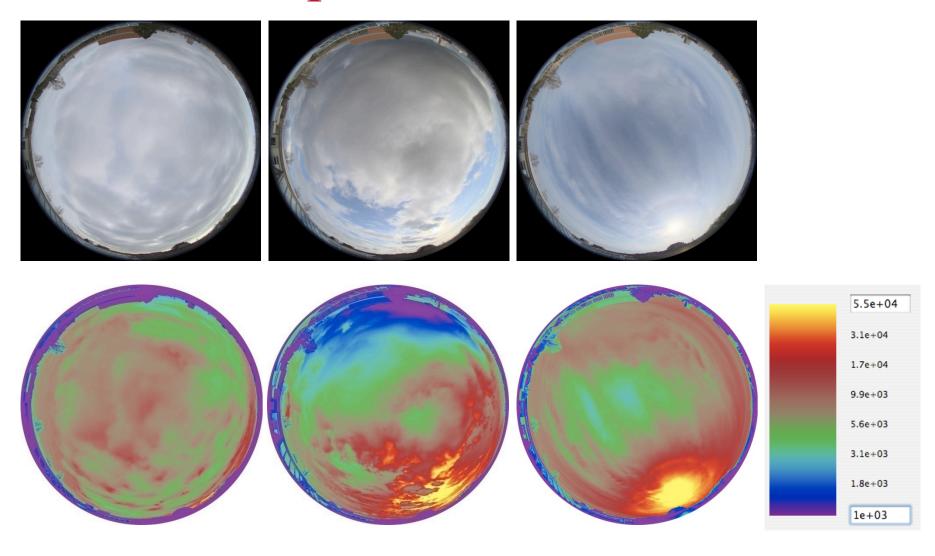
**CIE Clear sky** 

Average difference: 3%



Aerial Photo: John Statmets

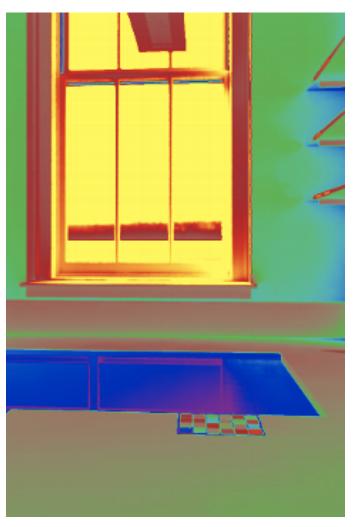
# Location specific Empirical Evaluation



#### Evaluation with Real-world data

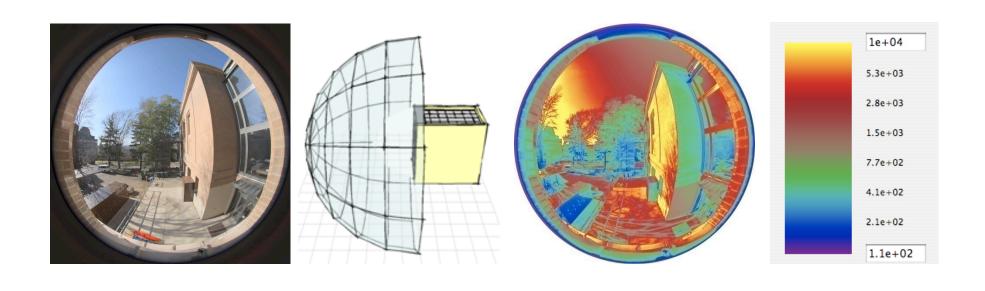
HDRI IBR





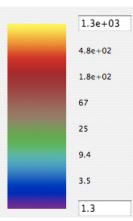
**Partly Cloudy Sky** 

# Site specific Empirical Evaluation



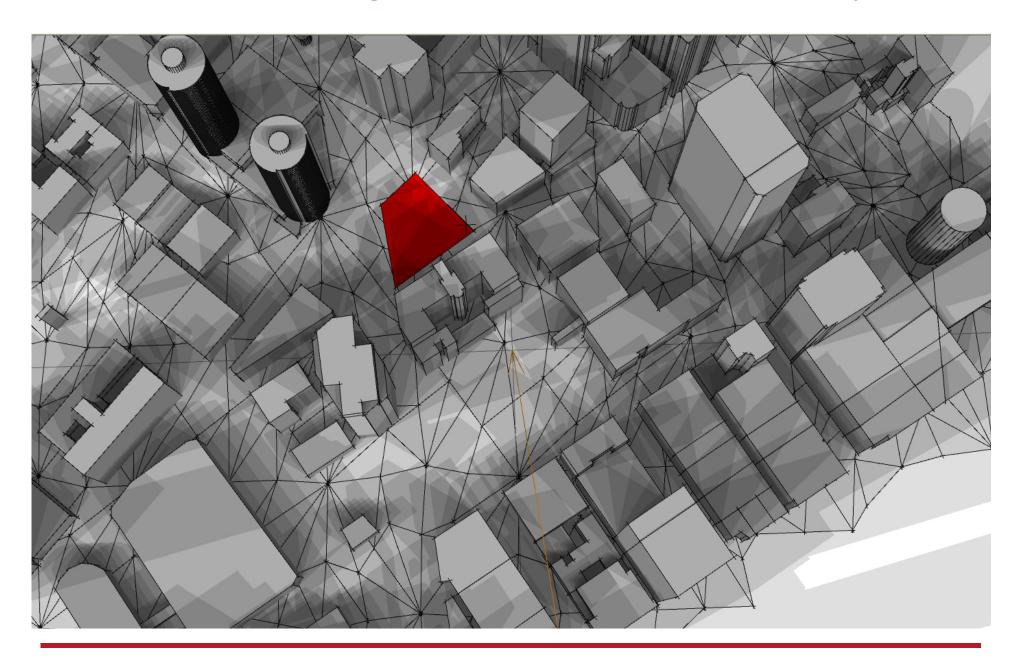
**HDRI** IBL



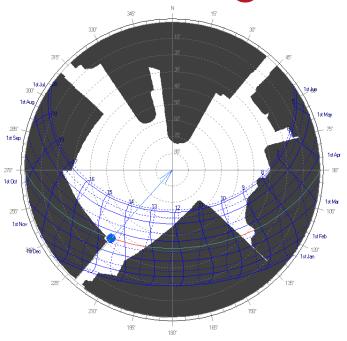




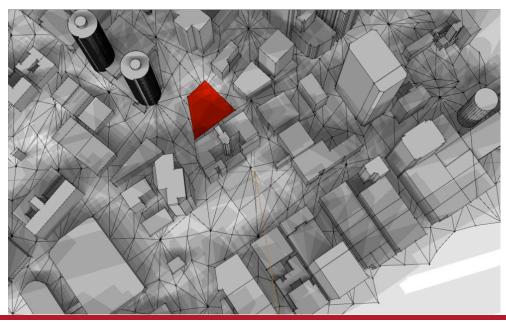
#### Surrounding urban fabric and forestry



## Surrounding urban fabric and forestry







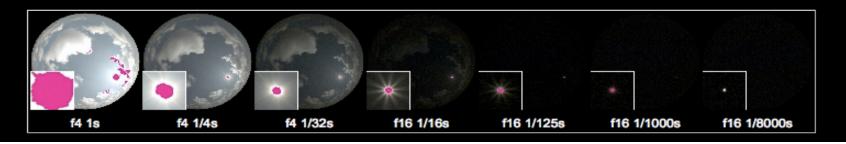


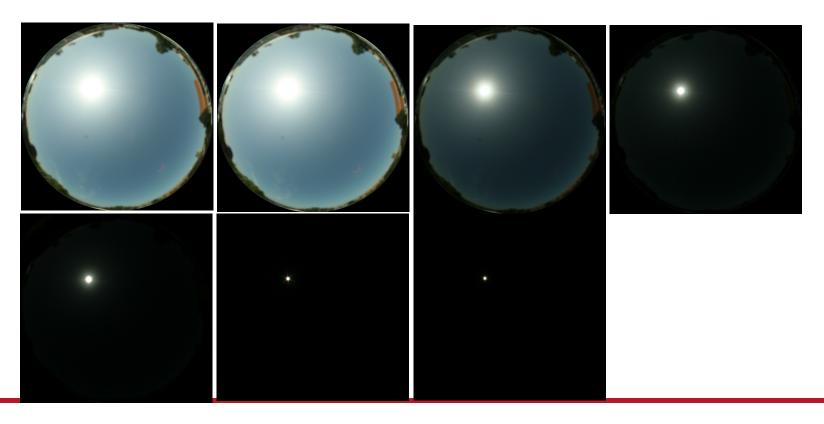
#### **Direct HDR Capture of the Sun and Sky**

AFRIGRAPH 2004 Paper SIGGRAPH 2004 Poster

#### Jessi Stumpfel Andrew Jones Andreas Wenger Chris Tchou Tim Hawkins Paul Debevec

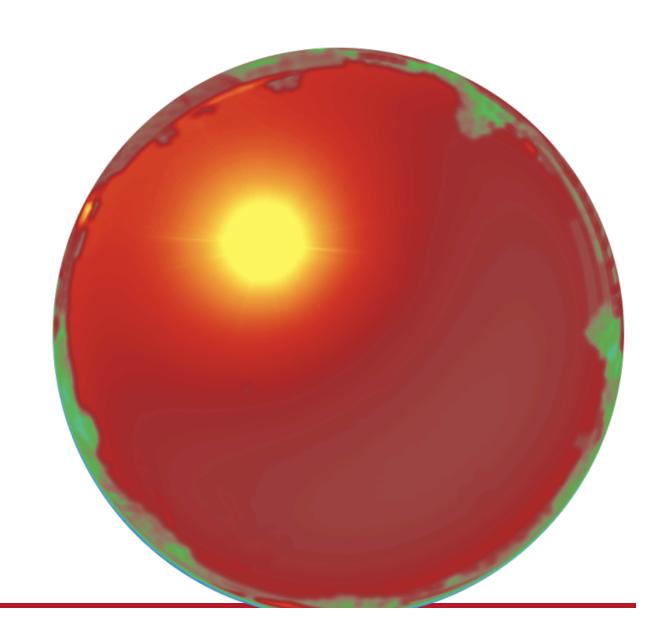
USC Centers for Creative Technologies











#### Conclusion

Image Based Sky models provide a more accurate and efficient way of defining:

- Sky luminance distributions
- Surrounding structures
- Surrounding forestry

#### Acknowledgements

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