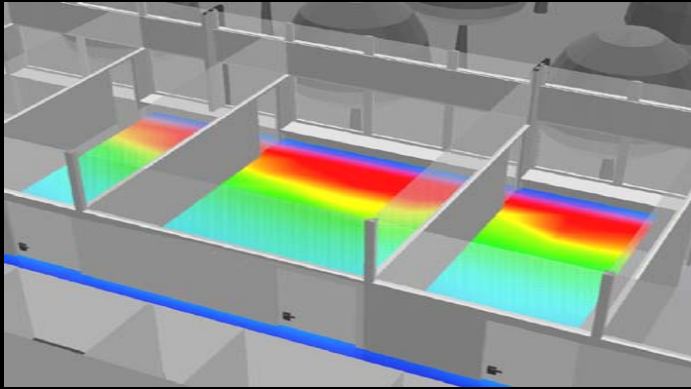
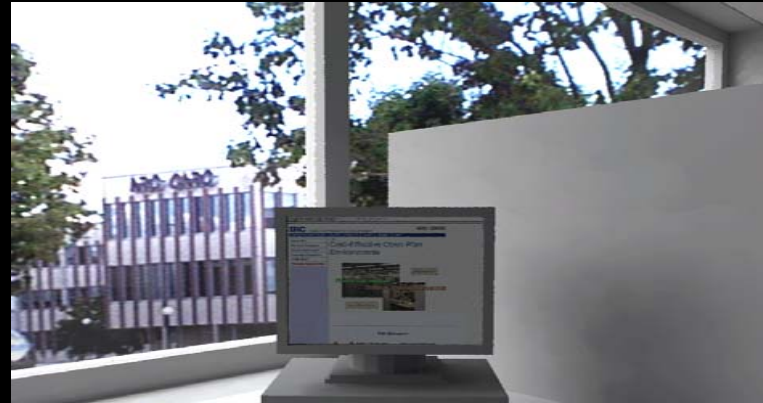


Natural Light in Design

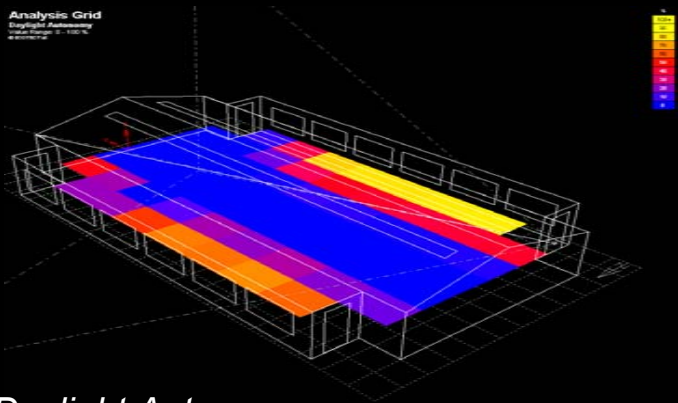
Using simulation tools to explore realistic daylight-responsive solutions



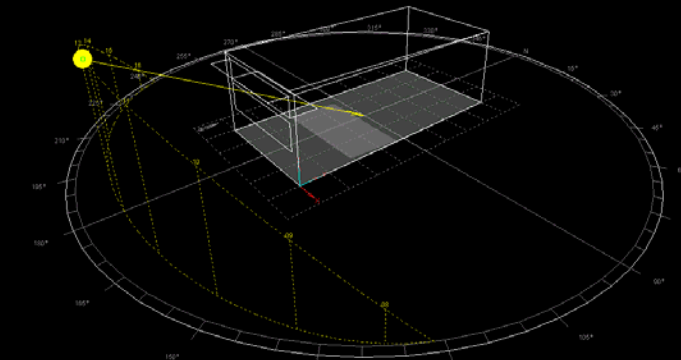
Daylight Factor



Visual Comfort



Daylight Autonomy



Avoidance of Direct Sunlight

Overview - Radiance

Christoph Reinhart, Ph.D.

Overview - Radiance

Tuesday, Jan 24th 2006

time slot	Content	instructor
Mon 9.30	Welcome, class introduction, design project (teams formed next morning)	MA, all
Mon 10.00	- General Introduction to daylighting (benefits, history, some case studies)	MA
Mon 10.30	- Introduction to Building Simulation (why simulations for architects, tools used in this course)	CR
Mon 11.00	coffee break	
Mon 11.15	<ul style="list-style-type: none"> - Photometry (definition, measurement, typical values, DF definition) (MA) - Static Daylighting Metrics (context of LEED, selected results from NRC survey, DF & Solar Shading) (CR) - Daylight factor calculations: protractor method, LEED spreadsheet method, sky models CIE and Perez (MA) - Daylight factor simulation: design sky, split flux method in Ecotect (CR) <ul style="list-style-type: none"> ▪ Hands-on exercise: DF calculation in Ecotect (split flux) (CR) ▪ Hands-on exercise: solar shading module in Ecotect (CR) 	MA, CR, all
	<ul style="list-style-type: none"> - Intro to Radiance (CR) <ul style="list-style-type: none"> ▪ Hands-on exercise: Radiance visualizations (CR) ▪ Hands-on exercise: DF calculation in Ecotect (Radiance) (CR) 	
Mon 13.00	lunch (on your own)	
Mon 14.00	<ul style="list-style-type: none"> - Climate Data (kind of data and measurement, weather files, E+ weather data directory) (MA) <ul style="list-style-type: none"> ▪ Hands-on exercise: weather tool in Ecotect (CR) - Overview on visual comfort (glare, contrast, requirements, health) (MA) - Dynamic Metrics & related tools (CR) 	MA, CR, all
Mon 15.45	coffee break	
Mon 16.00	<ul style="list-style-type: none"> ▪ Hands-on exercise: Daysim exercise from tutorial interrupted by discussions on: <ul style="list-style-type: none"> - Short time steps dynamics - Daylight Coefficients - User Behavior Model - Daylight Autonomy Results 	all
Mon 17.00	<ul style="list-style-type: none"> ▪ Hands-on exercise: students to repeat at DF, Solar Shading & DA analysis on their own 	all
Mon 17.30	end of first day	

Objectives for this module

- **Export to Radiance**
- **Radiance Algorithm**

Advanced Radiance Visualizations IV



simulation: NRC

Some Facts on Radiance

Physically based backward raytracer – no fudge factors.

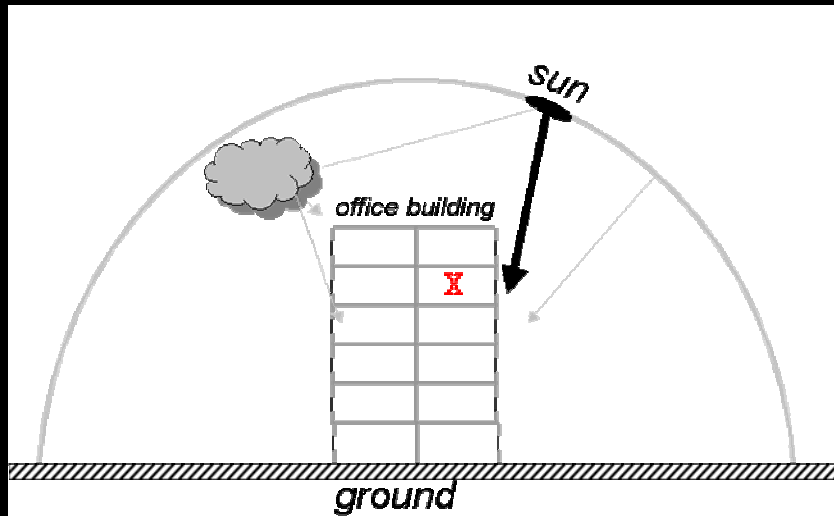
A wide variety of material properties and sky models.

Longish learning curve.

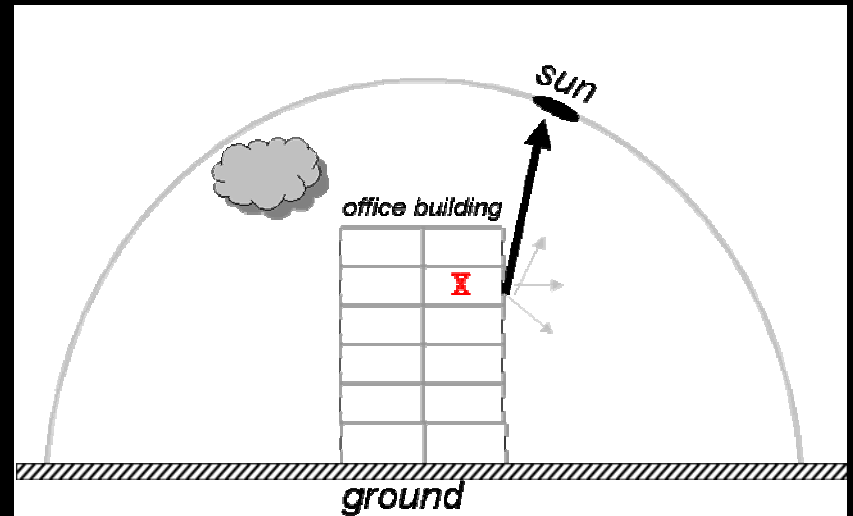
“Magic” lies in simulation parameters.

2004 Survey: >180 participants, 40 different tools, >50% of picks for Radiance based tools.

Backward vs. Forward Raytracing



forward raytracer



backward raytracer (Radiance)

Radiance Validation Studies I

Light. Res. & Technology
Mardaljevic, 1995

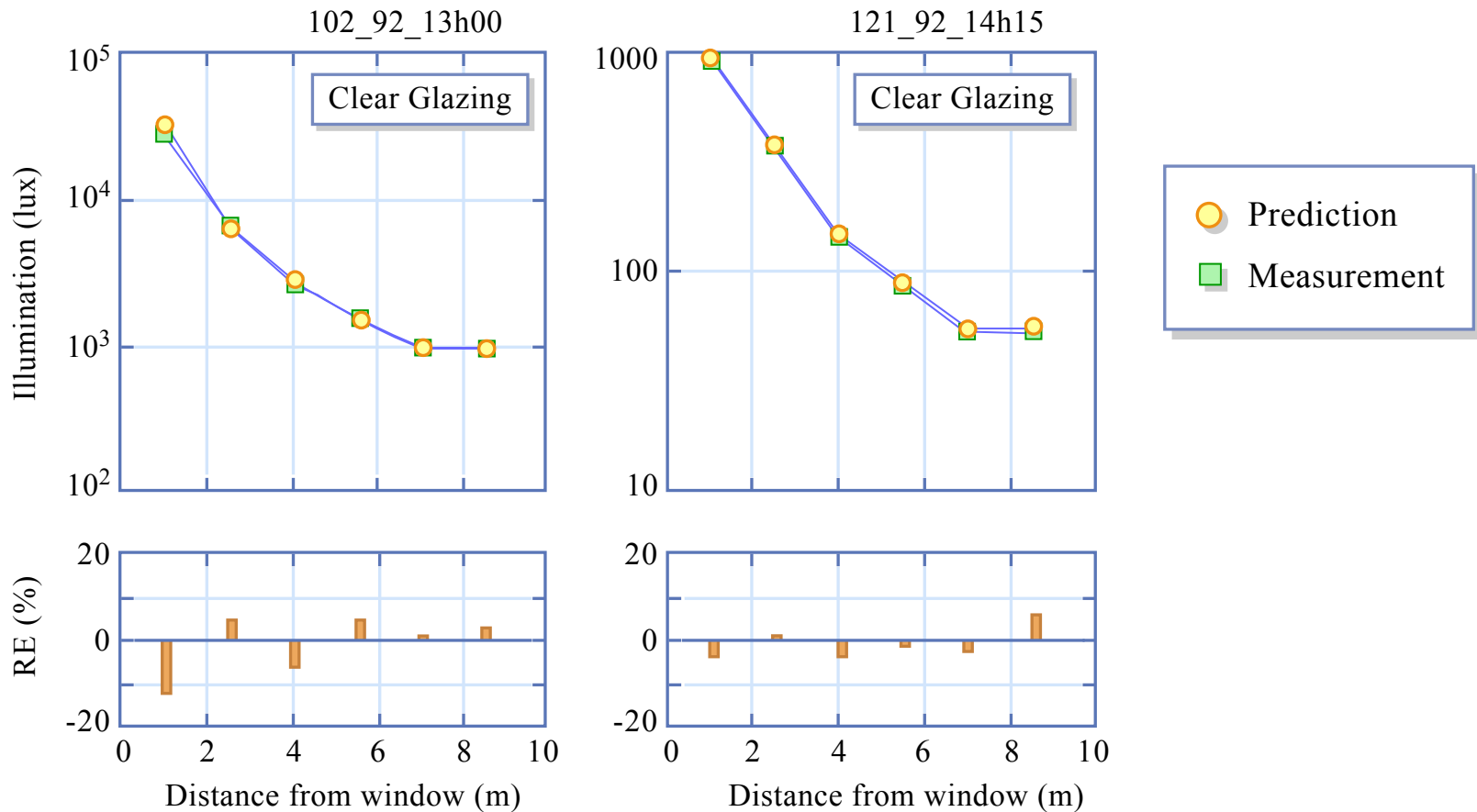
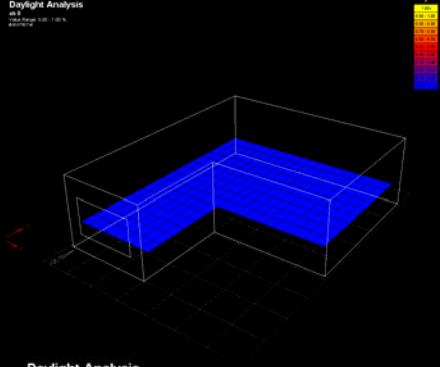


Figure by MIT OCW.

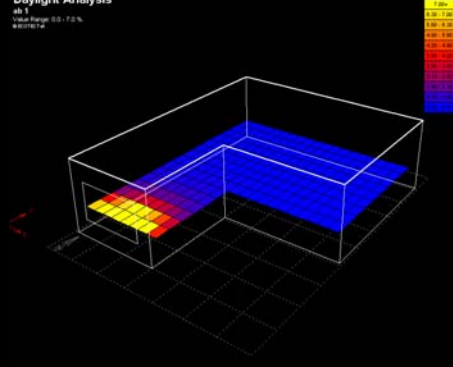
Validation Radiance/ sky scanner data for a clear glazing with/without a lightshelf (Radiance materials: “plastic”, “metal”, “glass”)

Parameter Study Radiance: ab 0 to ab 8

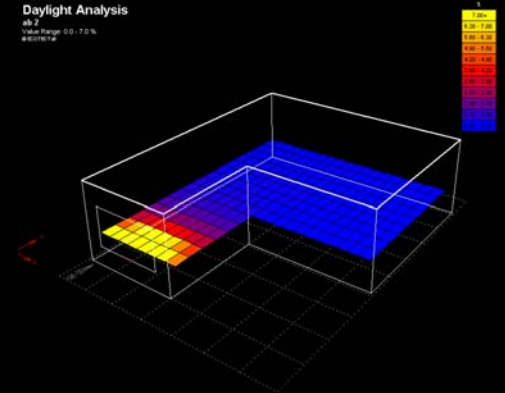
Daylight Analysis
ab 0
Value Range: 0.0 - 7.0 %
#RADIANCE



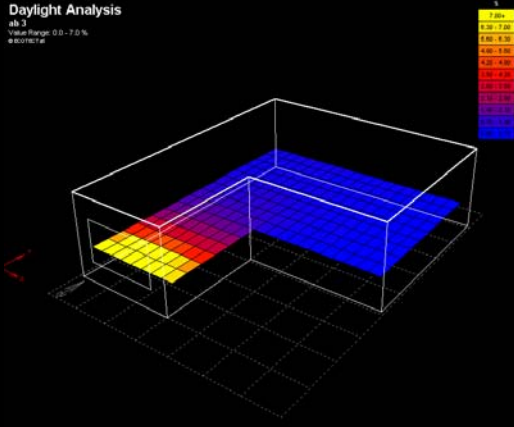
Daylight Analysis
ab 1
Value Range: 0.0 - 7.0 %
#RADIANCE



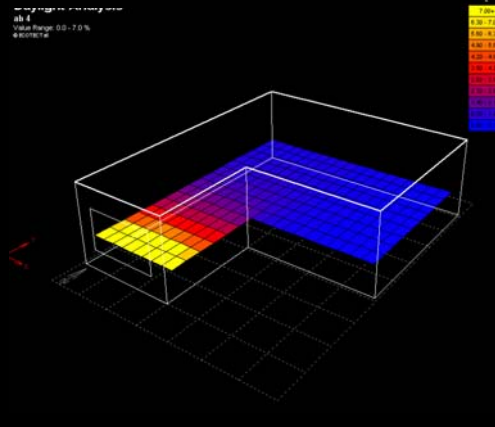
Daylight Analysis
ab 2
Value Range: 0.0 - 7.0 %
#RADIANCE



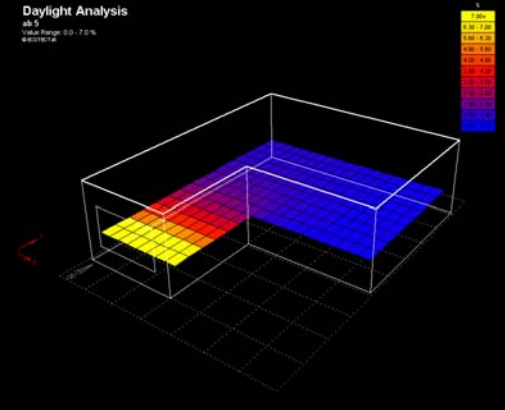
Daylight Analysis
ab 3
Value Range: 0.0 - 7.0 %
#RADIANCE



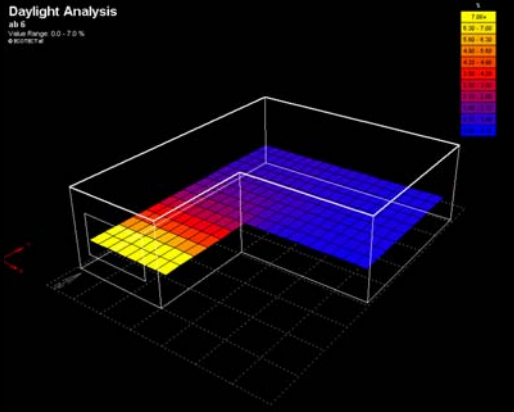
Daylight Analysis
ab 4
Value Range: 0.0 - 7.0 %
#RADIANCE



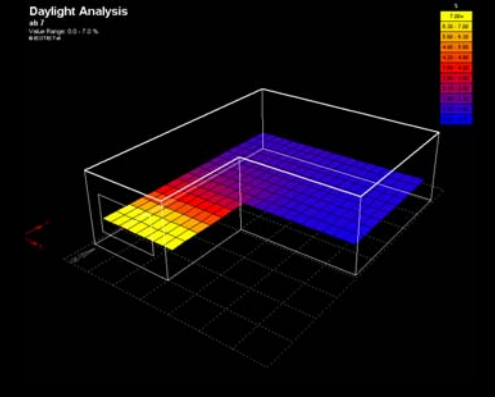
Daylight Analysis
ab 5
Value Range: 0.0 - 7.0 %
#RADIANCE



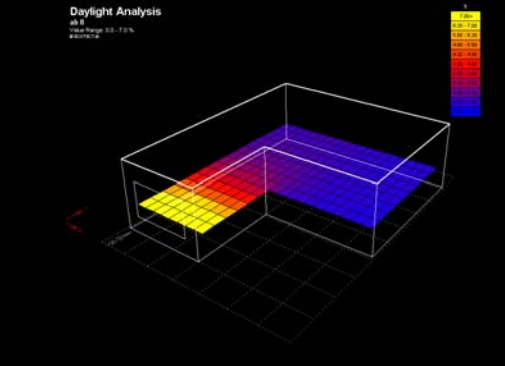
Daylight Analysis
ab 6
Value Range: 0.0 - 7.0 %
#RADIANCE



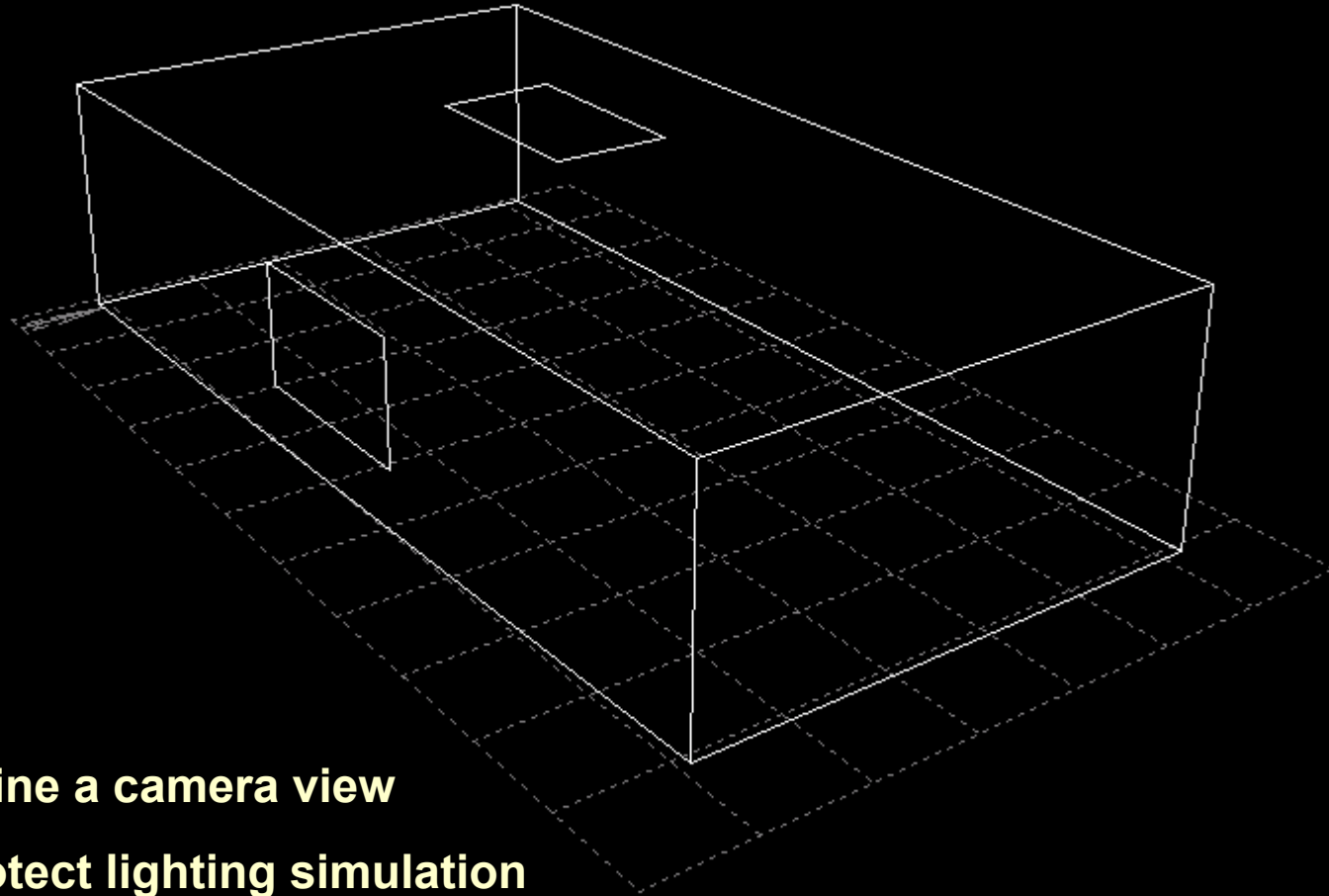
Daylight Analysis
ab 7
Value Range: 0.0 - 7.0 %
#RADIANCE



Daylight Analysis
ab 8
Value Range: 0.0 - 7.0 %
#RADIANCE



Ecotect Demo – Export to Radiance



- (1) define a camera view
- (2) Ecotect lighting simulation
- (3) Export to Radiance
- (4) Visualization (ab 1 & sunny)

Export to Radiance Menu

Radiance Export

ECOTECT: Calculation Wizard... [X]

| radiance analysis | STEP 8 OF 8 (SUMMARY) Tool Hints [] **HELP!**

Output Options: Run in RadianceCP [v] Use DOS 8.3 filenames Generate Point Data
D:\tmp\D10\vr.rad [] Save separate zone files Current 2D analysis grid
Scaling Factor: 0.001 [] Run in minimised window Current 3D analysis grid
 View images when done Objects tagged as shaded
 Pause on completion Currently selected objects

Include Material Definitions Check for Material.rad files **Electric Light Objects**
 Check for #Zone.rad files Generate Automatically [v]

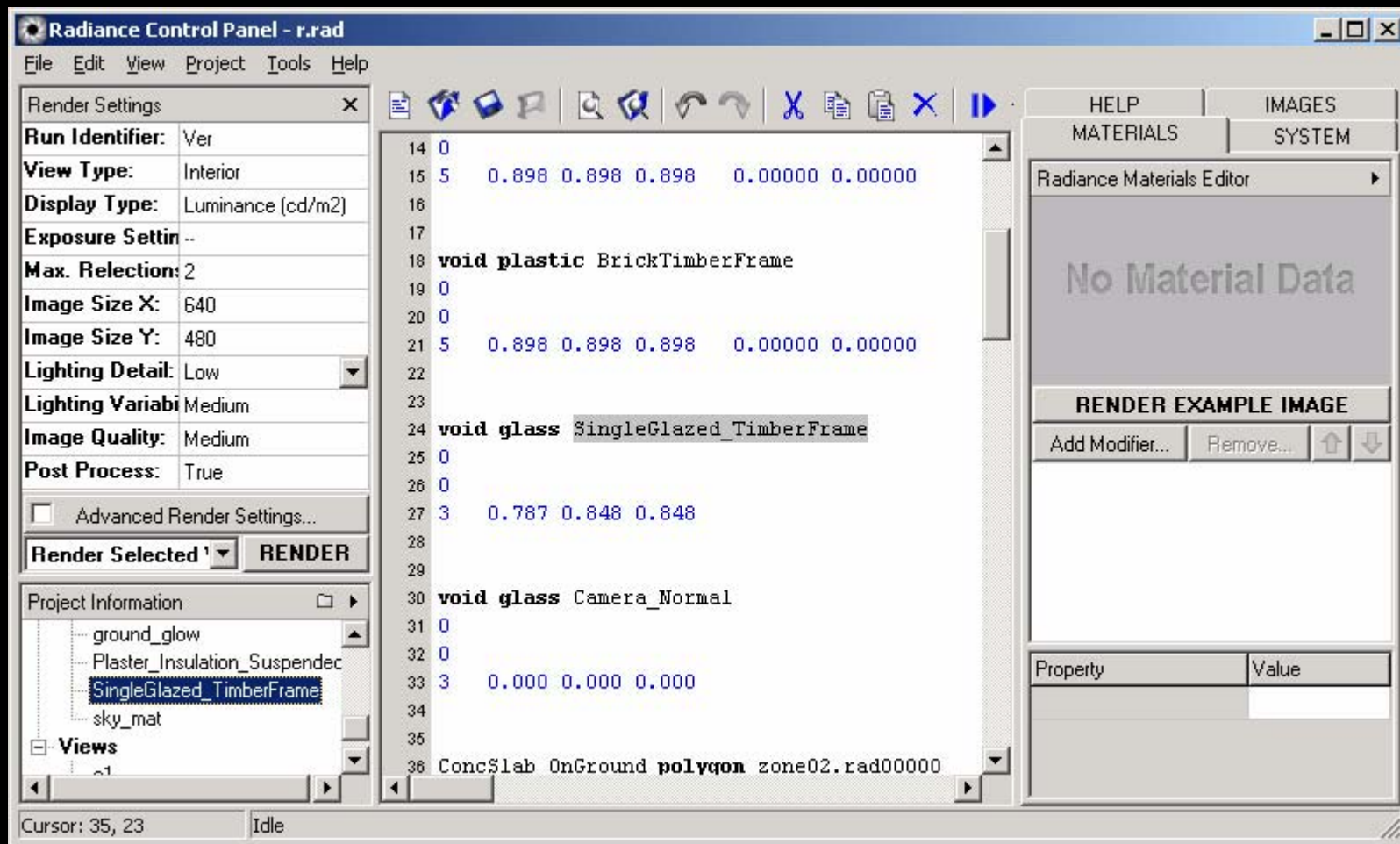
Sky Definition: Sunny with sun [v] [] Use ECOTECT design sky Use ECOTECT sun angles

RIF File Include camera views Type: Luminance (cd/m2) [v] **Model Detail:** MEDIUM [v]
 Use current model view View type: Interior Side [v] **Light Variability:** MEDIUM [v]
Indirect reflections: 2 [v] **Image Size:** 640 x 480 **Image Quality:** MEDIUM [v]

Use Wizard Always skip this wizard. << **Back** **OK** **Cancel**

Export to Radiance Menu

Radiance Control Panel



sky.rad

```
# Sky definition.
!gensky 4 1 12.76 -c -a 45.500 -o -73.700 -m -75.000 -B 40.307263

skyfunc glow sky_mat
0 0 4 1 1 1 0

sky_mat source sky
0 0 4 0 0 1 180

skyfunc glow ground_glow
0 0 4 1 .8 .5 0

ground_glow source ground
0 0 4 0 0 -1 180
```

Gensky (sky description in Radiance)

Under Google type: Radiance – gensky

-s Sunny sky without sun. The sky distribution will correspond to a standard CIE clear day.

+s Sunny sky with sun. In addition to the sky distribution function, a source description of the sun is generated.

-c Cloudy sky. The sky distribution will correspond to a standard CIE overcast day.

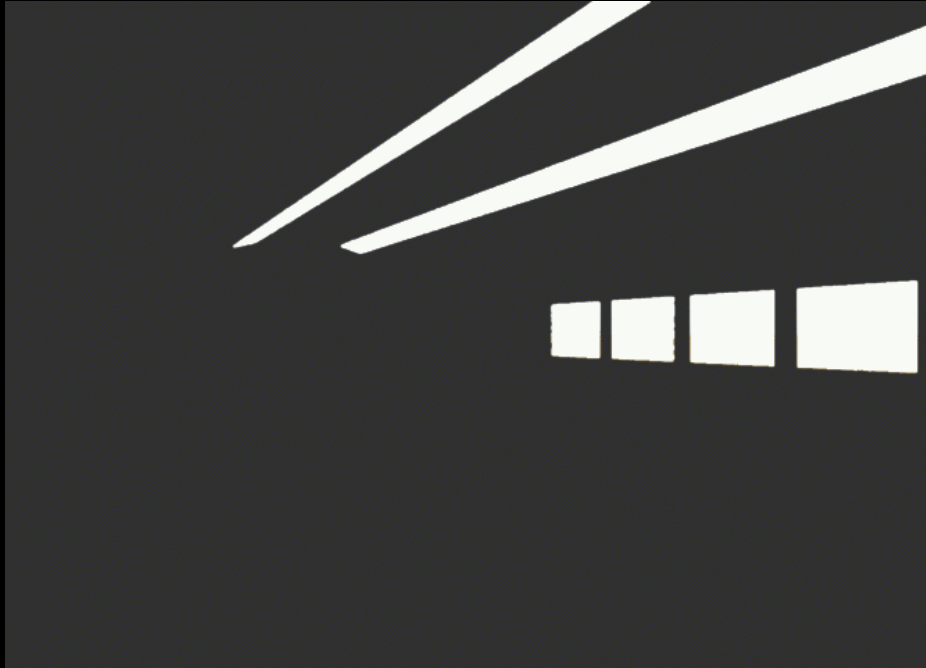
-i Intermediate sky without sun. The sky will correspond to a standard CIE intermediate day.

+i Intermediate sky with sun. In addition to the sky distribution, a (somewhat subdued) sun is generated.

-u Uniform cloudy sky. The sky distribution will be completely uniform

Visualization – internal vs. external

interior view



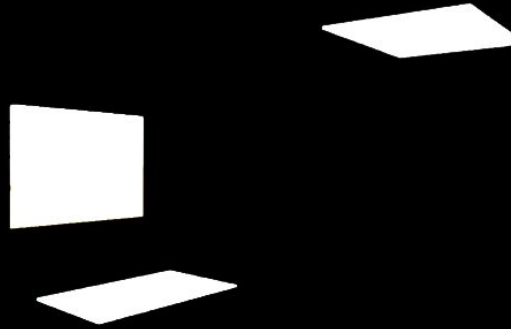
exterior view



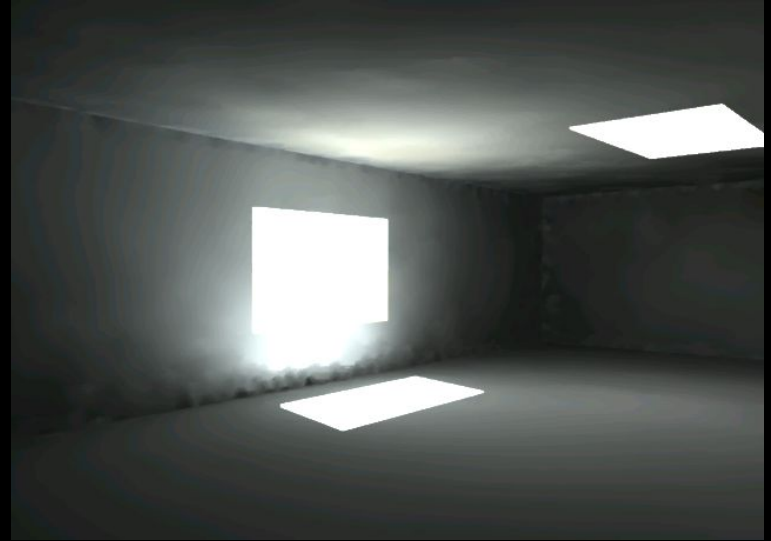
indirect *0*
detail *medium*
variability *medium*
quality *medium*

Visualization – ab 0,1,2,3,

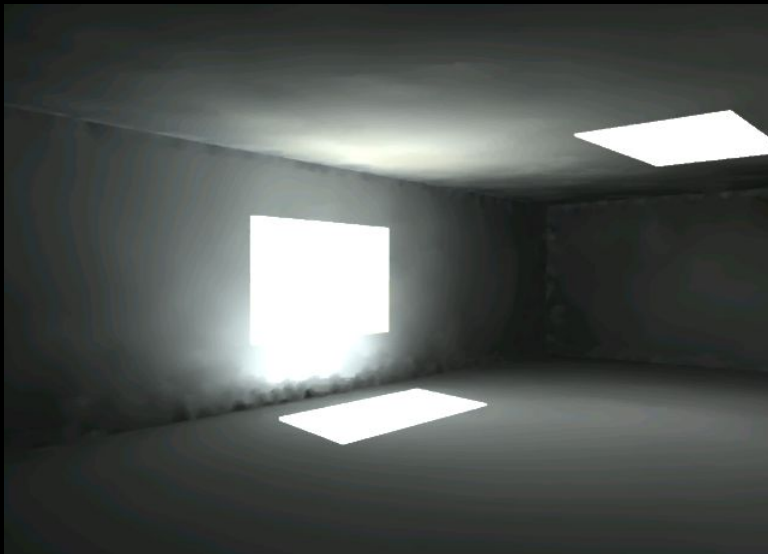
ab 0



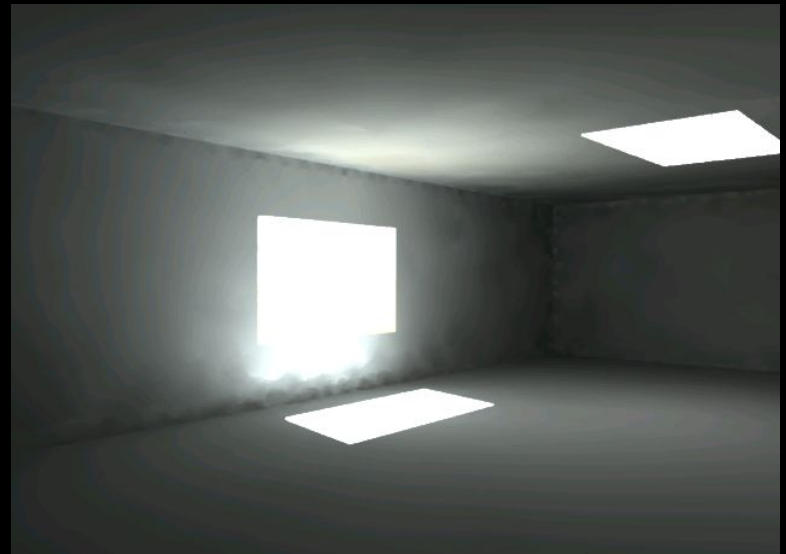
ab 1



ab 2



ab 3



detail medium - variability medium - quality medium

Image Parameters



ab 5

Detail: low

Variability: low

Quality: low



ab 5

Detail: **high**

Variability: low

Quality: low

Image Parameters



ab 5

Detail: low

Variability: low

Quality: low



ab 5

Detail: low

Variability: **high**

Quality: low

Image Parameters



ab 5

Detail: low

Variability: low

Quality: low



ab 5

Detail: low

Variability: low

Quality: **high**

Image Parameters



ab 5

Detail: low

Variability: low

Quality: low



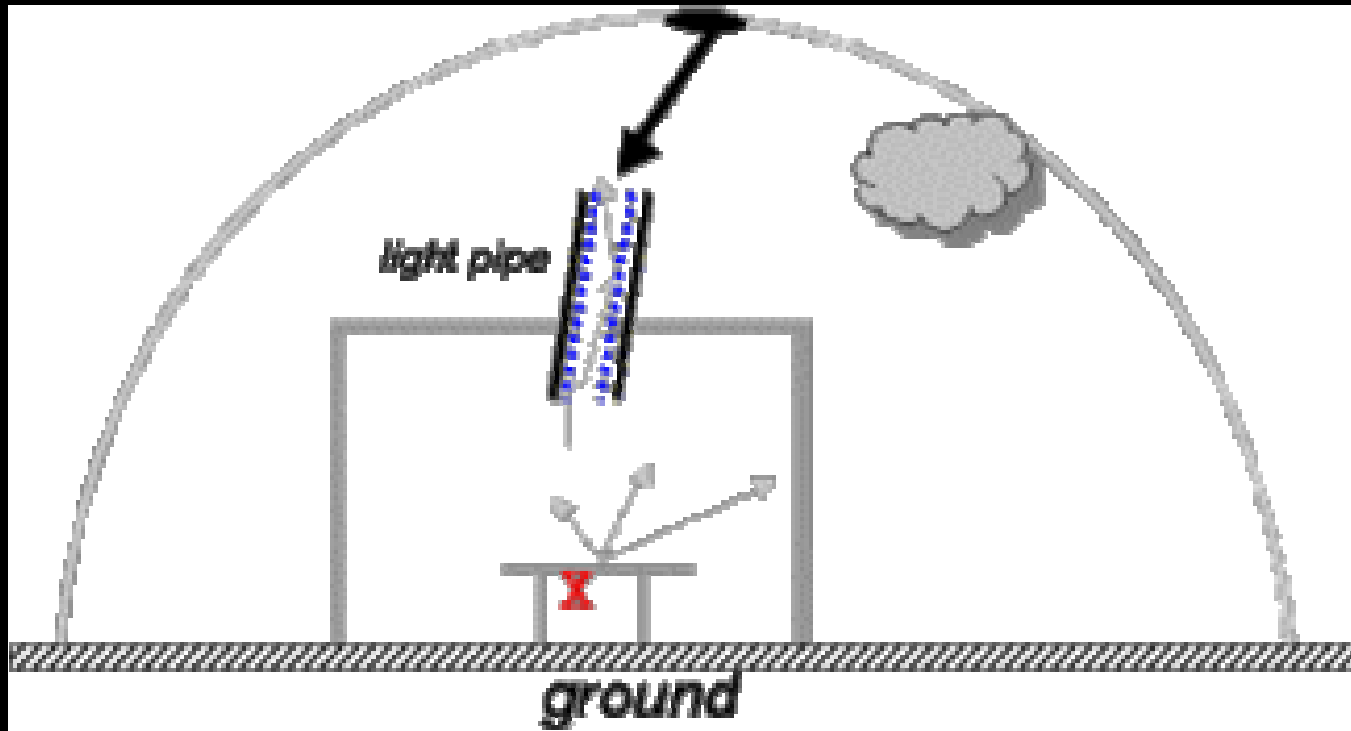
ab 5

Detail: high

Variability: high

Quality: high

Limitations of Radiance



Radiance will not necessarily `find` the sun.