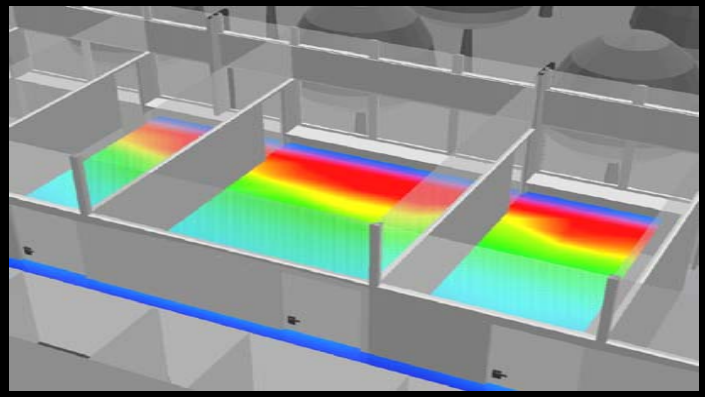
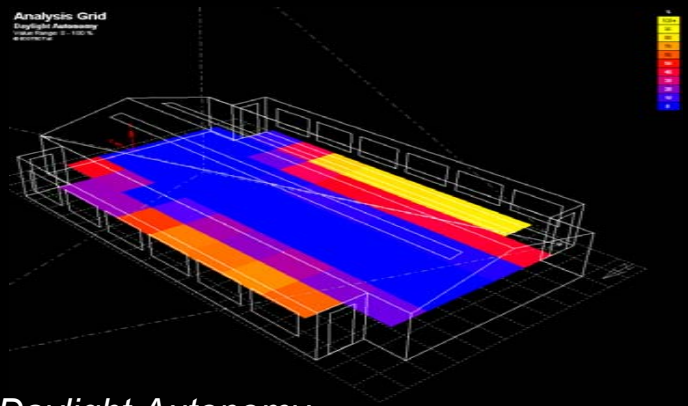
Natural Light in Design

Using simulation tools to explore realistic daylight-responsive solutions

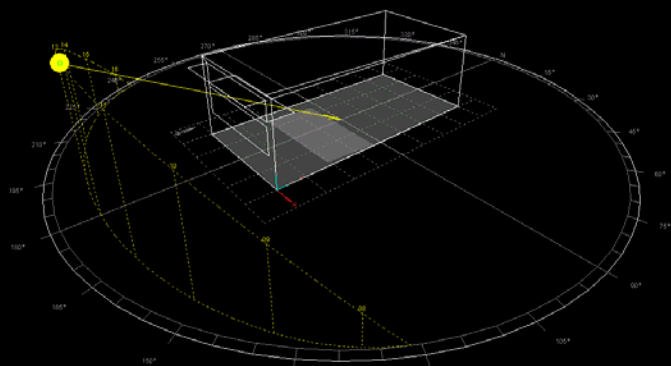


Daylight Factor

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	- 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) ▪ Hands-on exercise: DF calculation in Ecotect (split flux) (CR) ▪ Hands-on exercise: solar shading module in Ecotect (CR)	MA, CR, all
	- Intro to Radiance (CR) ▪ 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	- Climate Data (kind of data and measurement, weather files, E+ weather data directory) (MA) ▪ 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	▪ Hands-on exercise: Daysim exercise from tutorial interrupted by discussions on: - Short time steps dynamics - Daylight Coefficients - User Behavior Model - Daylight Autonomy Results	all
Mon 17.00	▪ 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.

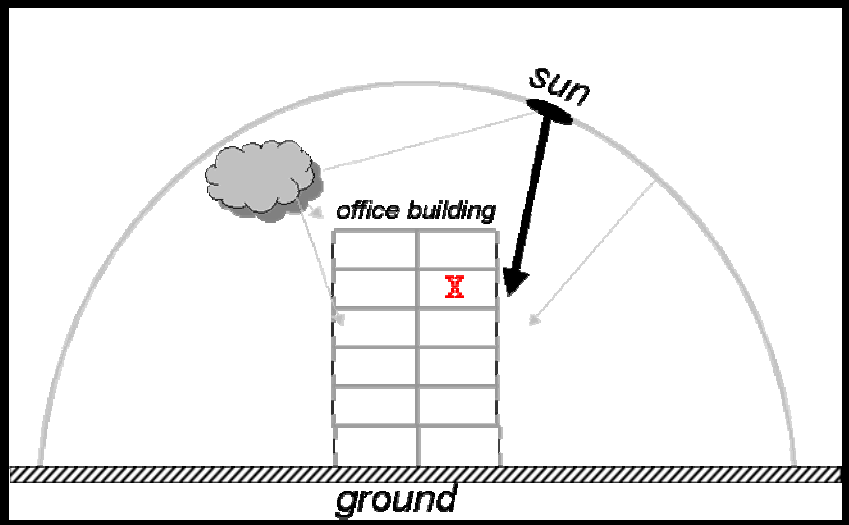
A wide variety of material properties and sky models.

Longish learning curve.

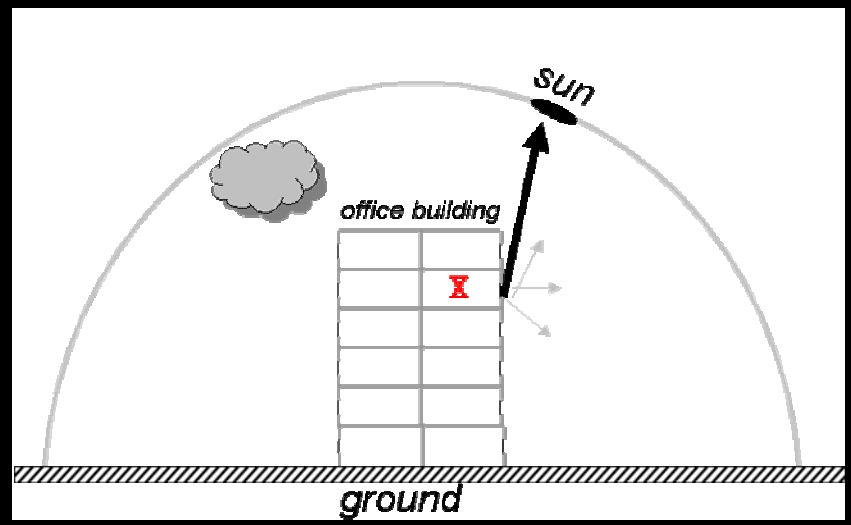
“Magic” lies in simulation parameters.

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

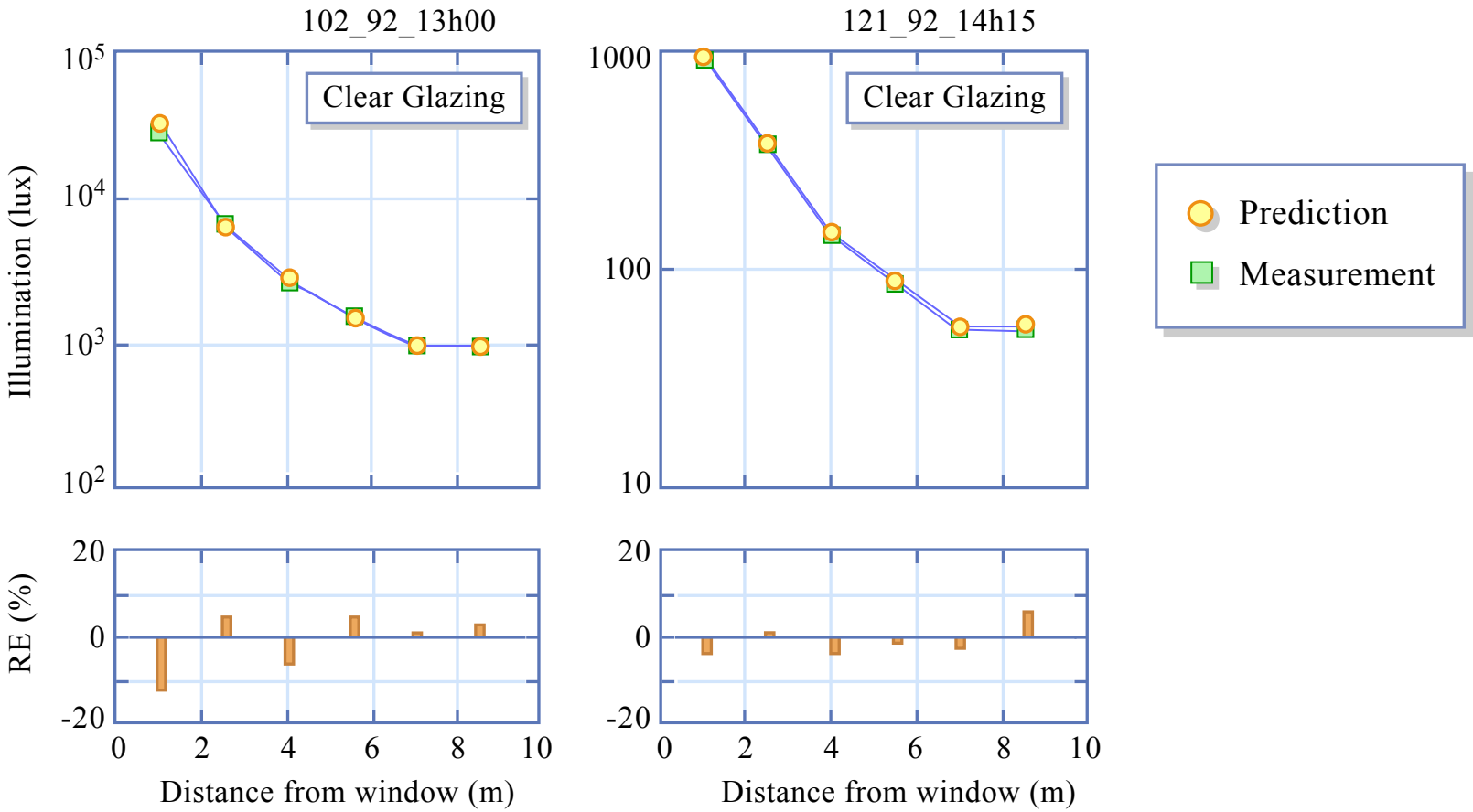
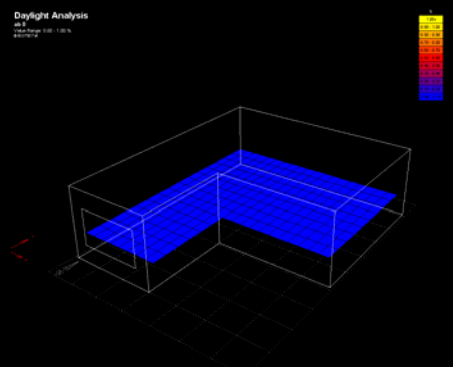
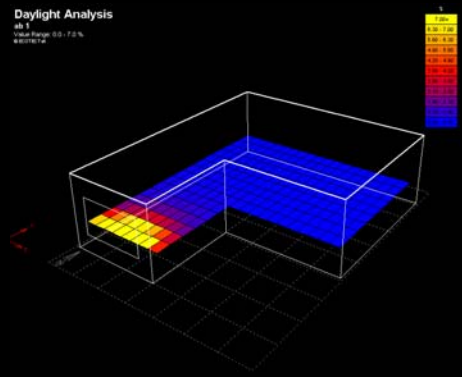


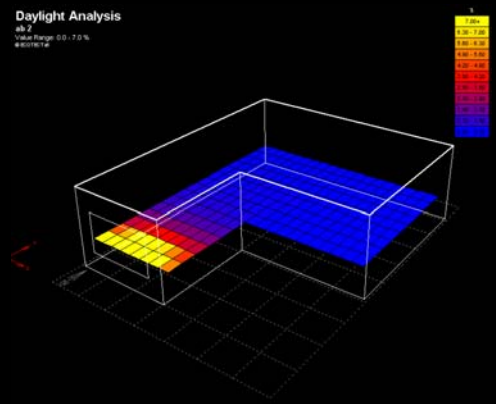
Figure by MIT OCW.

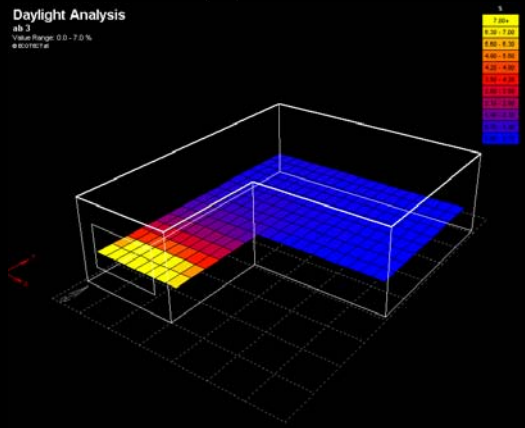
Validation Radiance/ sky scanner data for a clear glazing with/without a lightshelf (Radiance materials: "plastic", "metal", "glass")

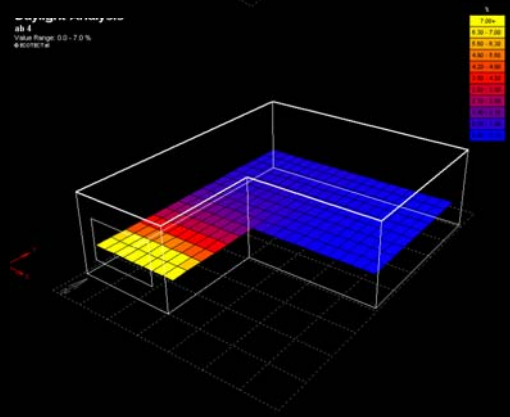
Parameter Study Radiance: ab 0 to ab 8

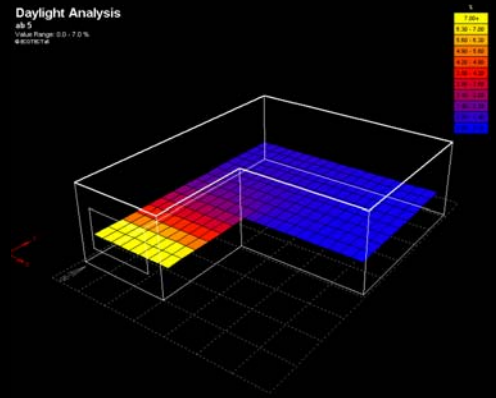


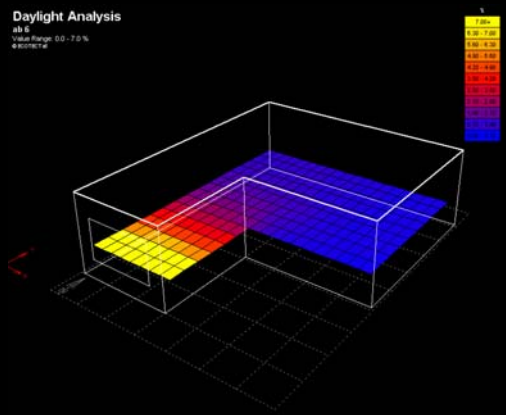


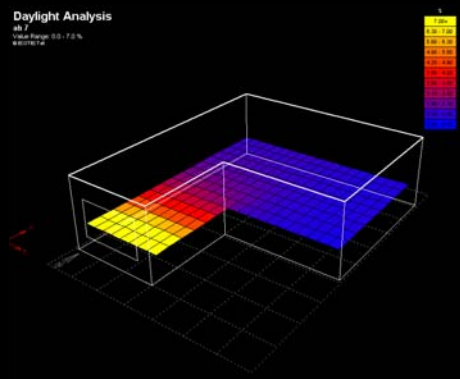


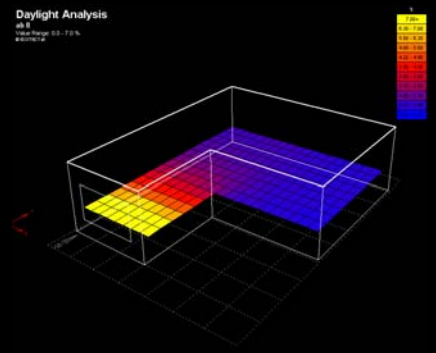




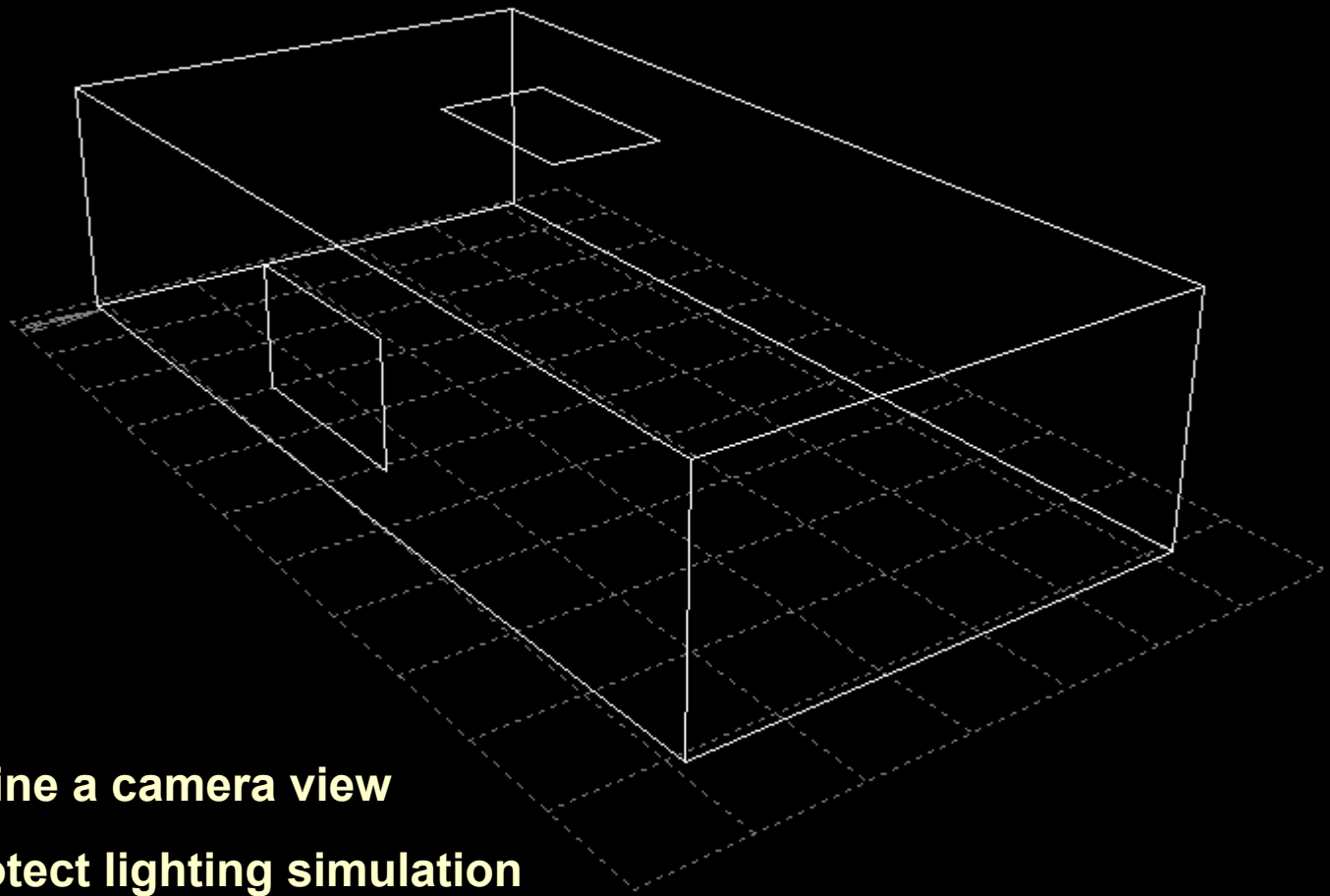








Ecotect Demo – Export to Radiance



(1) define a camera view

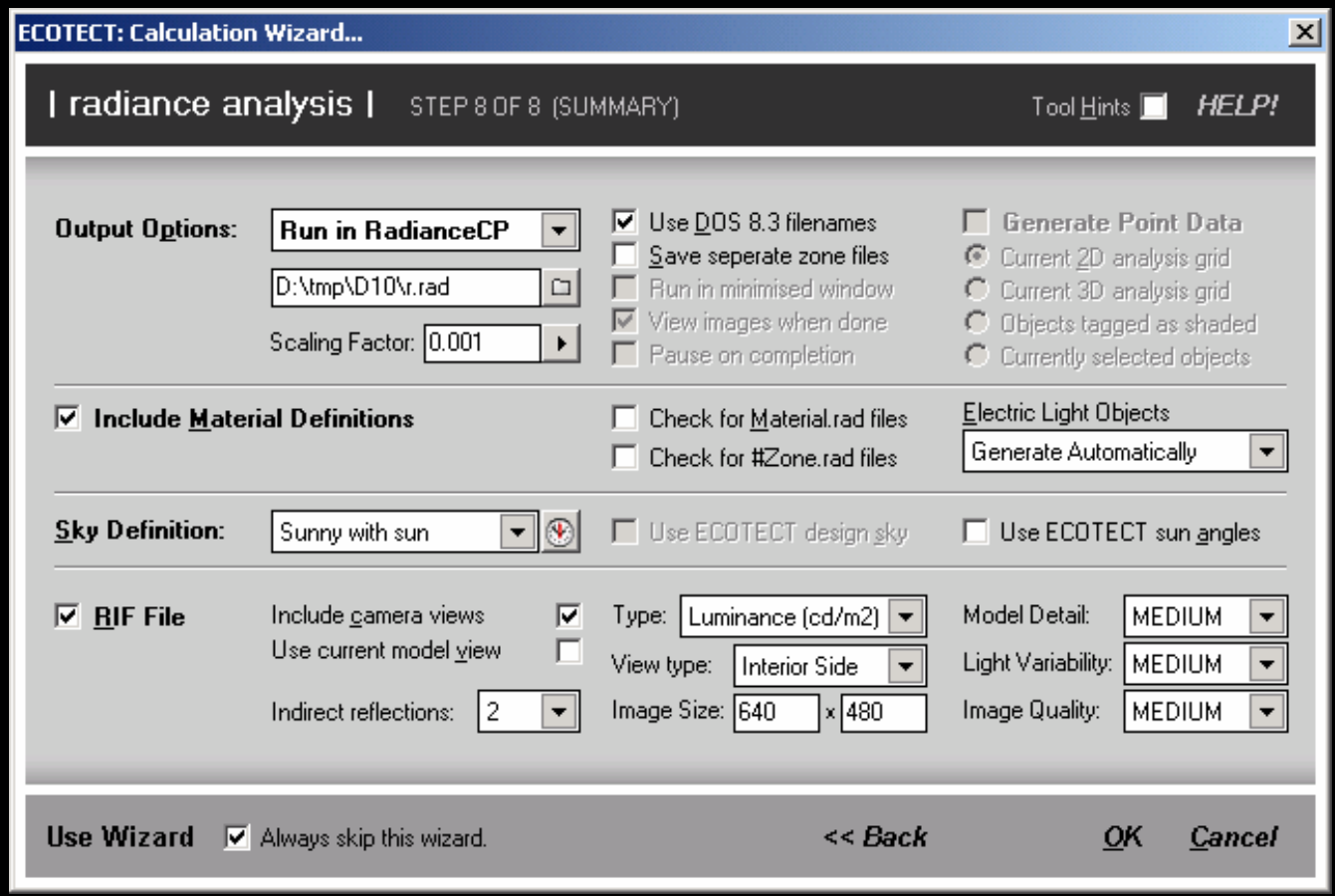
(2) Ecotect lighting simulation

(3) Export to Radiance

(4) Visualization (ab 1 & sunny)

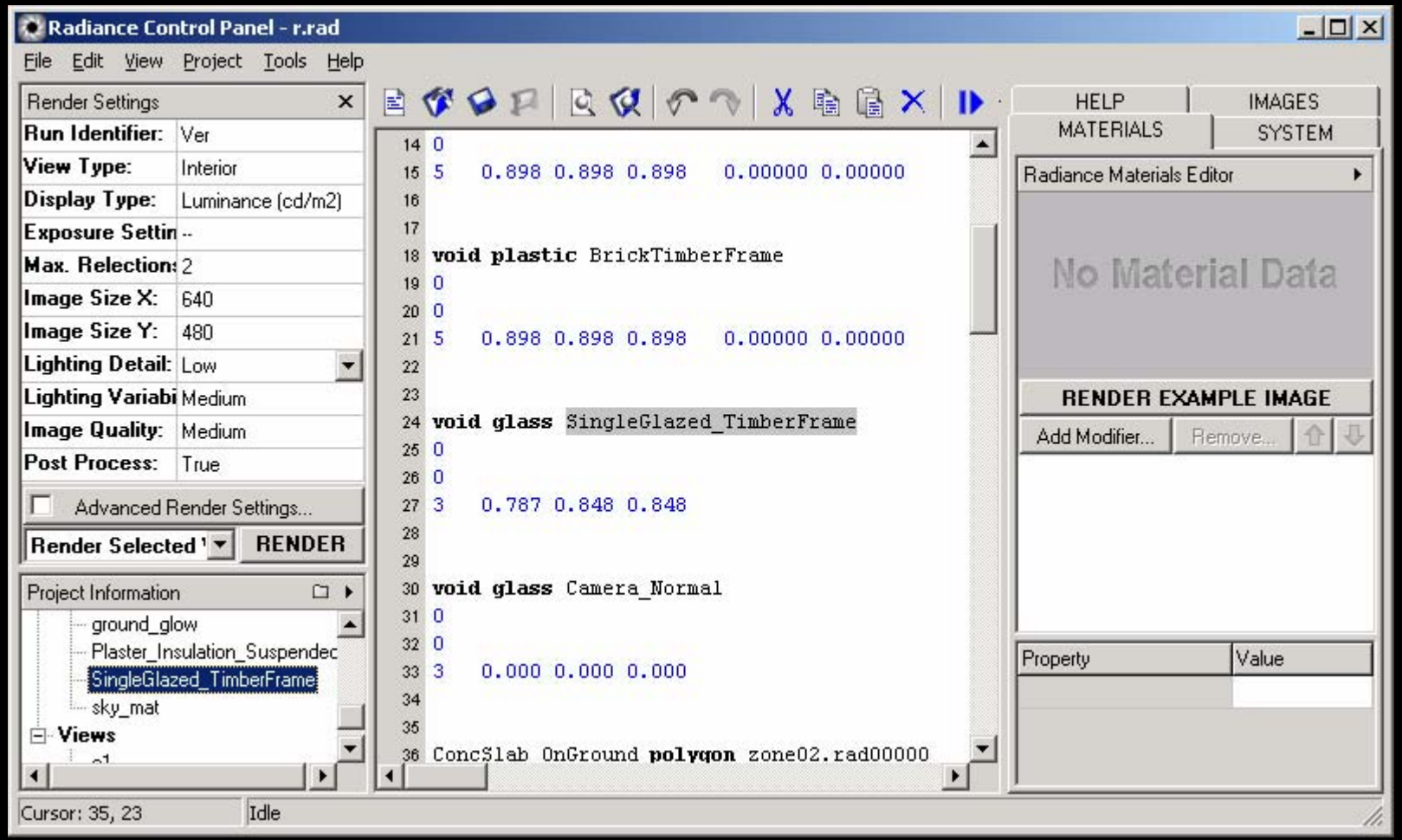
Export to Radiance Menu

Radiance Export



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.

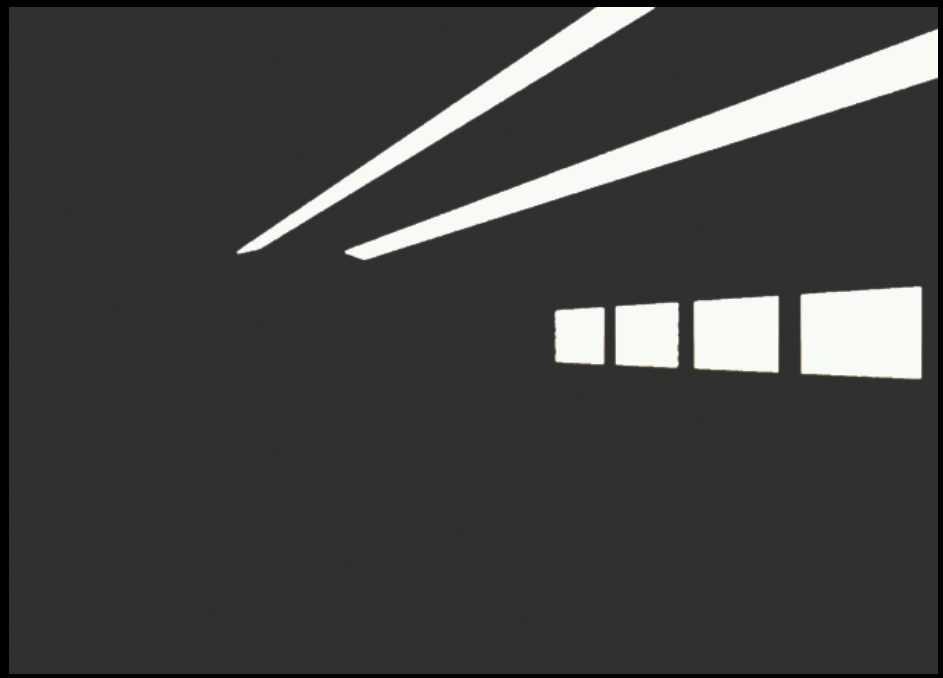
-i Intermediate sky without sun. The sky will correspond to a standard CIE intermediate day.

+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

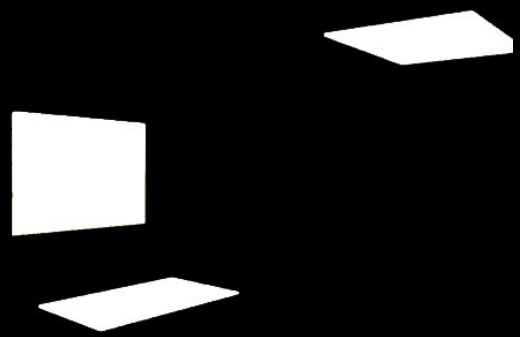


exterior view

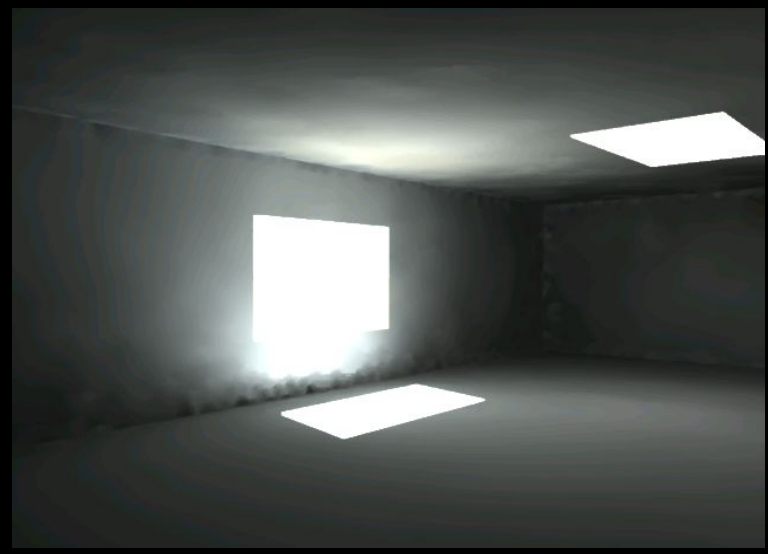
indirect *0*
detail *medium*
variability *medium*
quality *medium*

Visualization – ab 0,1,2,3,

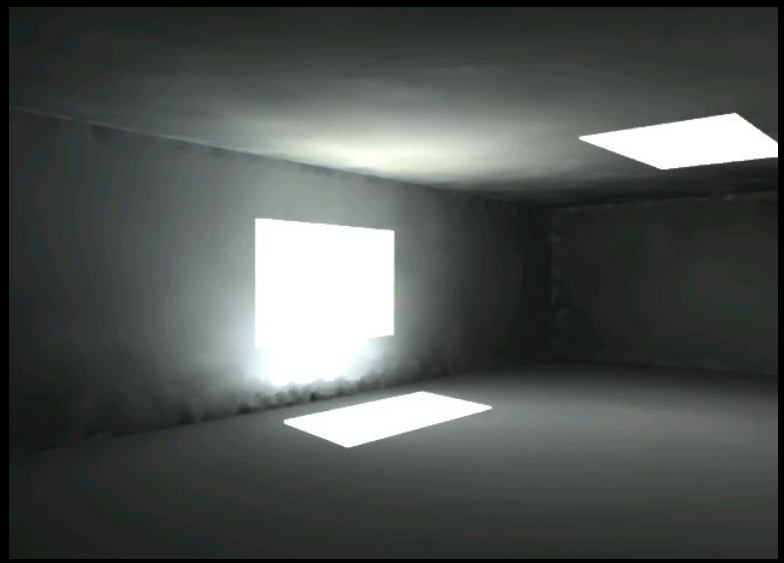
ab 0



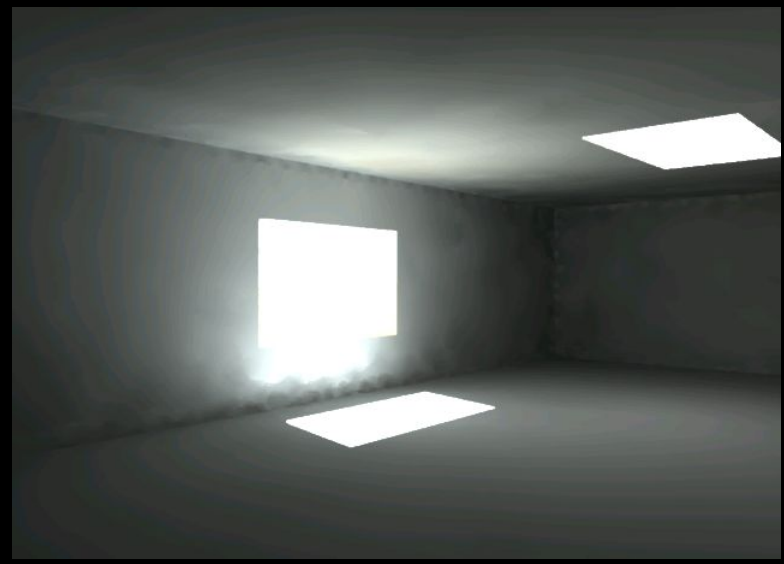
ab 1



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

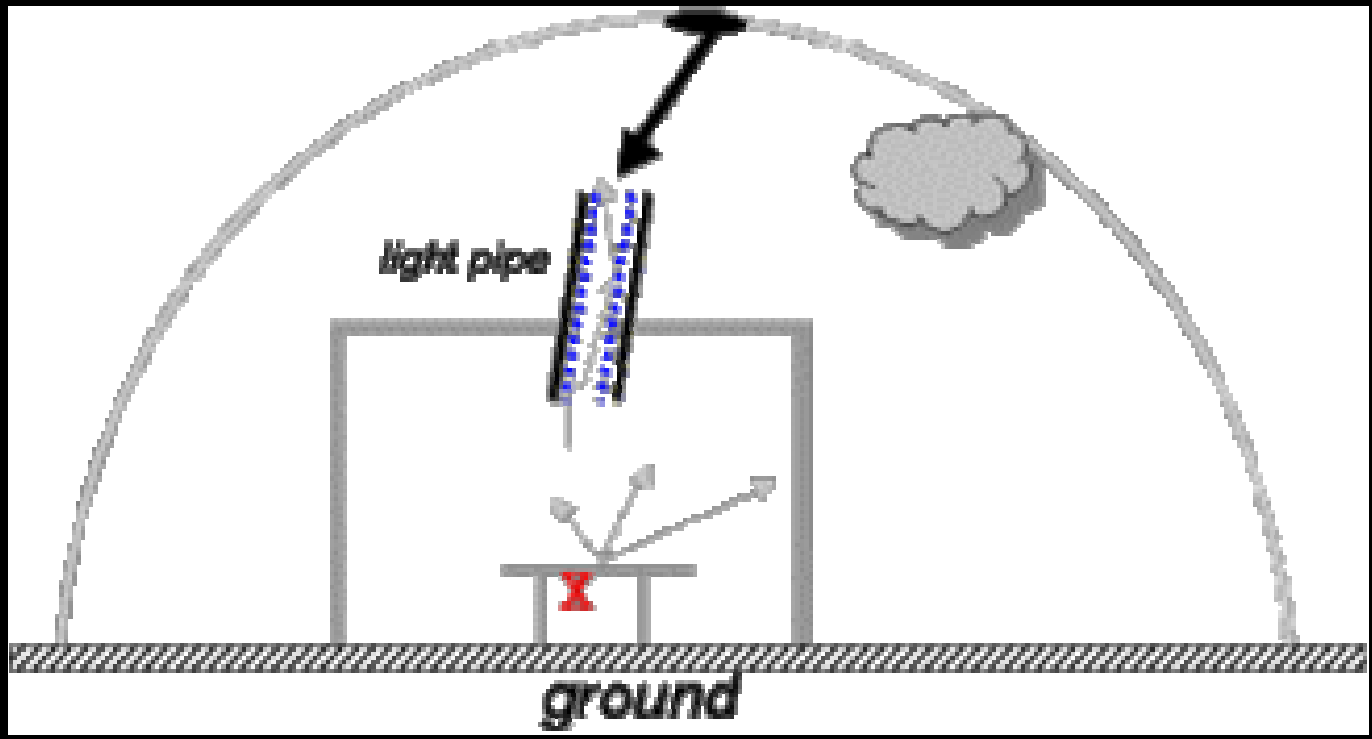
ab 5

Detail: high

Variability: high

Quality: high

Limitations of Radiance



Radiance will not necessarily `find` the sun.