

# **eLAD** eLearning platform for Lighting and Daylighting

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<https://elad.lbl.gov>

grant-supported project through LBNL  
by the US Department of Energy (DOE)

Main team members:

LBNL:

Randolph Fritz (Radiance Scripting)

Maria Konstantoglou (Radiance Scripting)

Kirsten Heming (Project Coordinator)

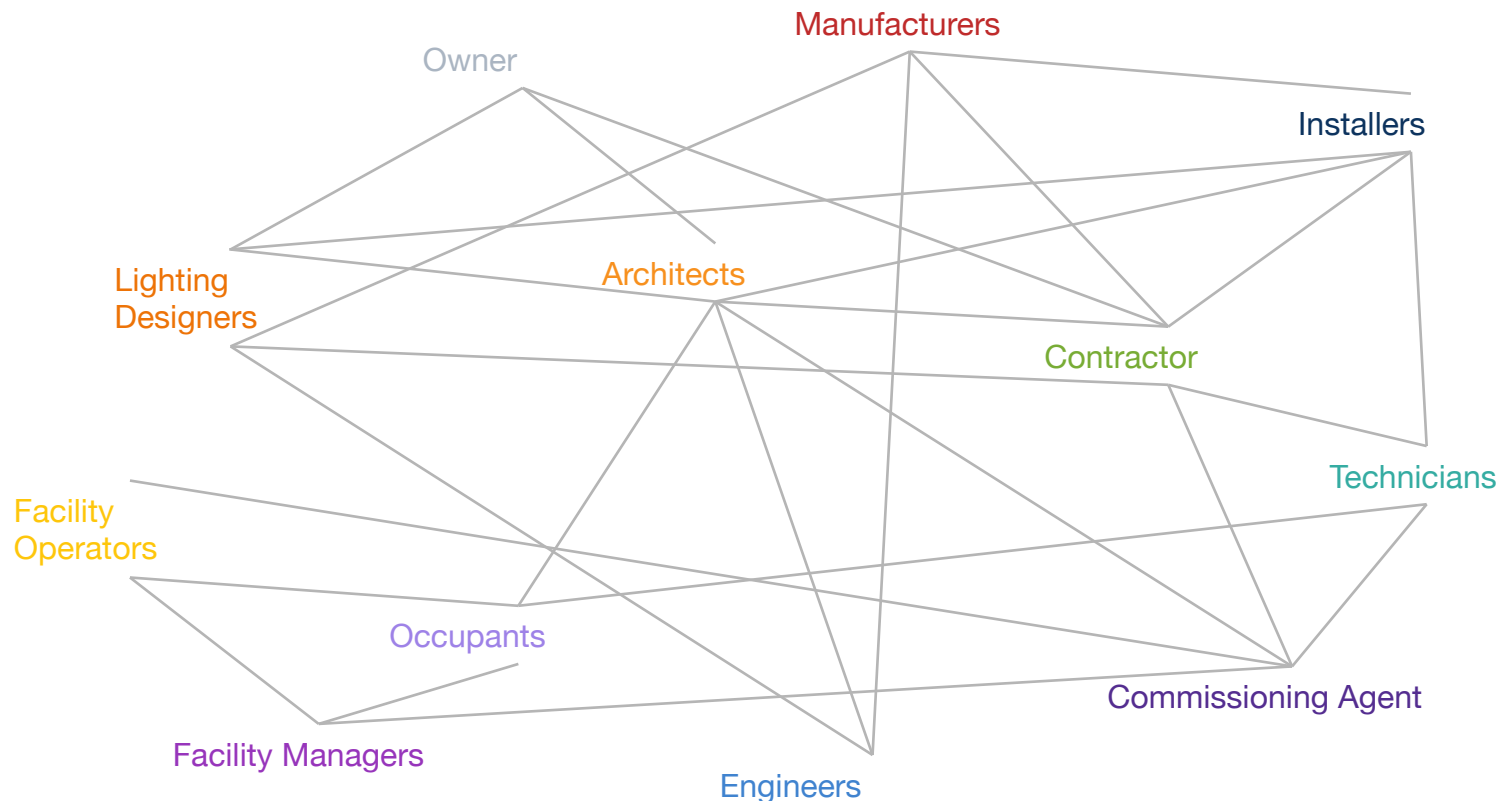
SuPerB, Institute for the Sustainable Performance of Buildings:

Joseph Deringer (Project Leader)

## INTRODUCTION: what is eLAD

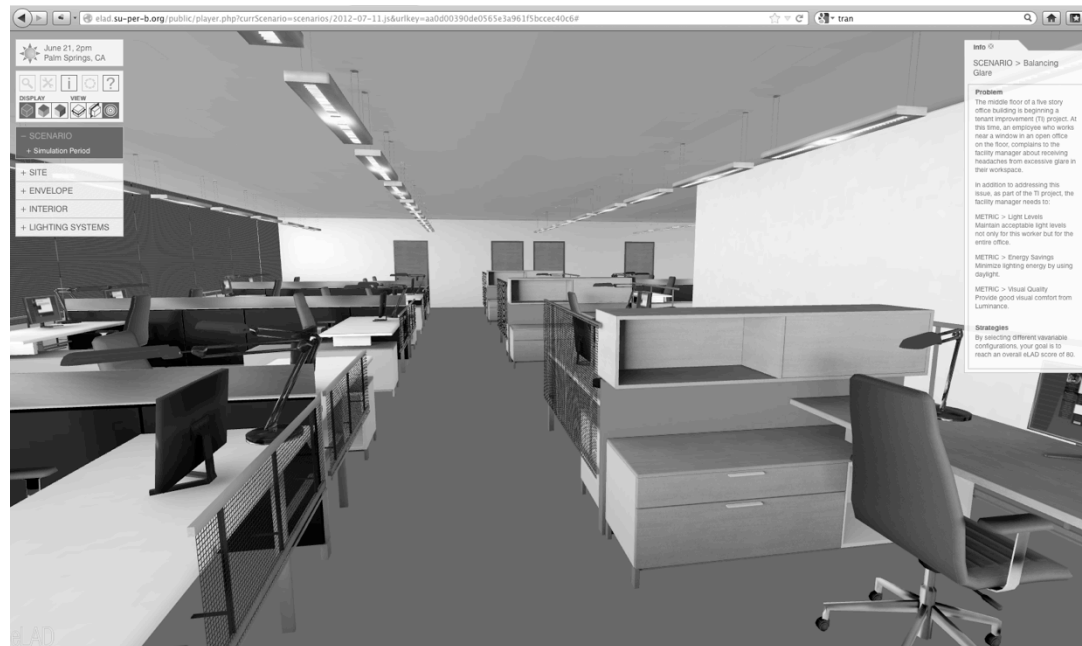
# eLAD enables users to learn about lighting and daylighting for commercial buildings

# eLAD is intended to be used in academic and applied professional settings



eLAD provides an interactive 3D environment enabling users to explore and learn about optimizing and integrating lighting systems

- # Open-source.
- # Available at no cost to users via web-based, public-domain delivery platforms.
- # Customizable, allows for scalability and flexibility to be used as a training guide, to a supplementary educational tool.



## INTRODUCTION: what is eLAD

### Participants:

- # Lawrence Berkeley National Laboratory
- # Stanford Research Institute
- # SuPerB, Institute for the Sustainable Performance of Buildings
- # International panel of lighting experts



Hayden McKay, [Horton Lees Brogden Lighting Design](#)  
Matthew Tanteri, [Parsons School of Constructed Environments](#)  
Prasad Vaidya, [The Weidt Group](#)  
Kevin Van Den Wymelenberg, [University of Idaho](#)  
Christopher Meek, [University of Washington](#)  
Aris Tsangrassoulis, [University of Thessaly](#)  
Heather Burpee, [University of Washington](#)  
Richard Mistrick, [Penn State](#)  
Susan Ubbelhode, [University of Berkeley](#)  
Michael Donn, [Victoria University of Wellington](#)  
Christoph Reinhart, [Harvard University](#)

## eLearning Software Platform

System Logic:

Using existing LBNL simulation  
Engines:

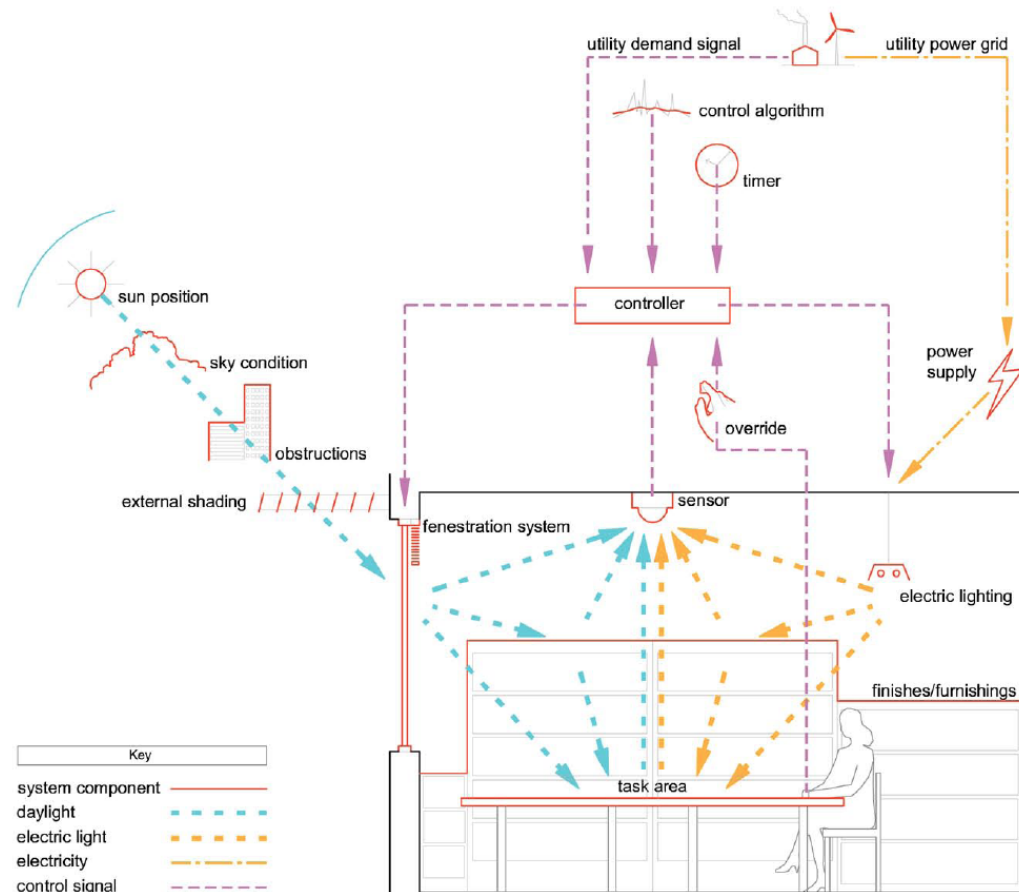
# **Radiance,**

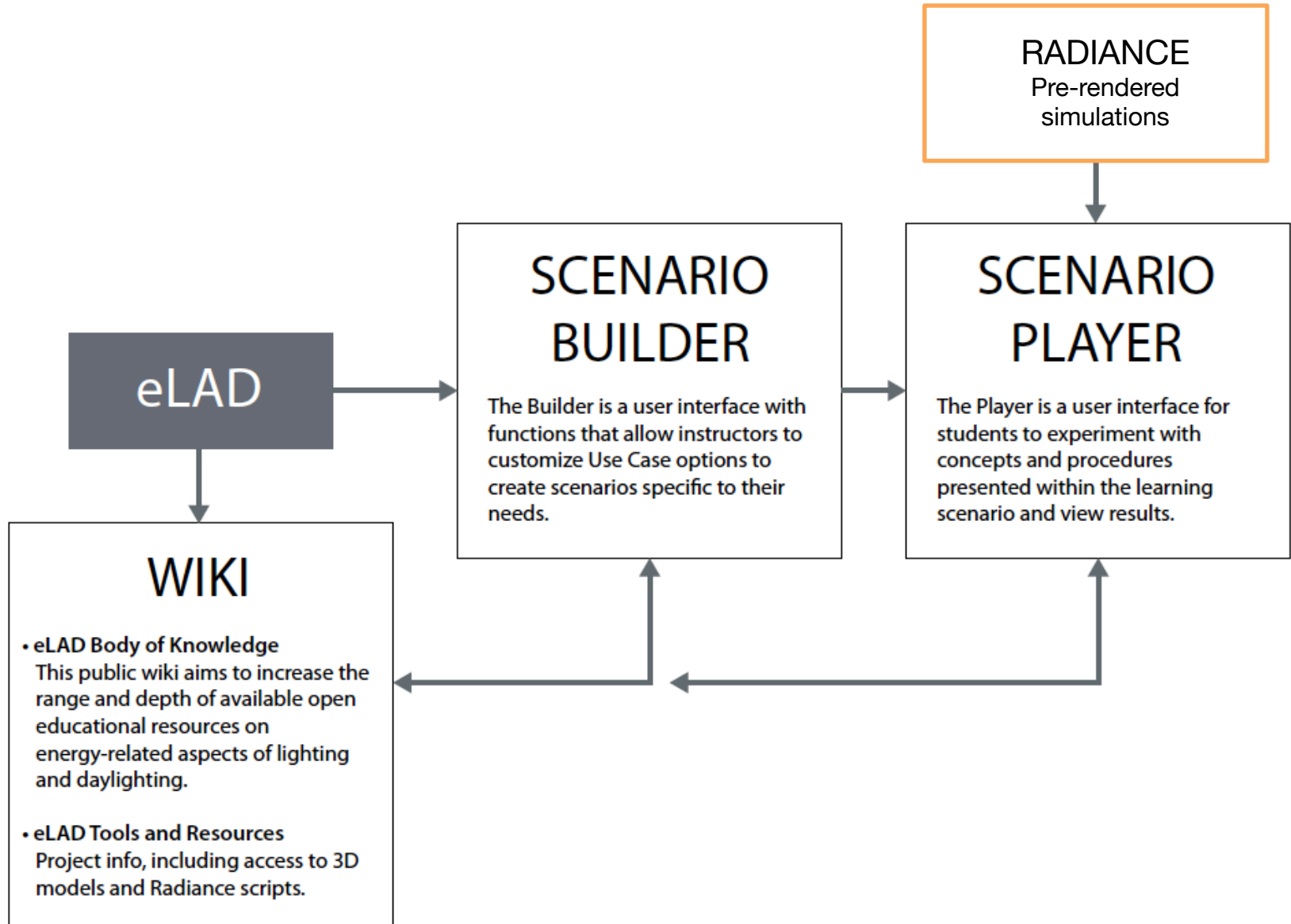
For simulation-driven lighting  
and daylighting Scenarios

eLAD is an early adopter of WebGL

# WebGL provides support for 3D  
animated graphics in web sites

eLAD is built partly in Kuda, an  
authoring environment for WebGL






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# Light Sources and Ballasts

## Contents [hide]

- 1 Incandescent Lamps
  - 1.1 Halogen
- 2 Fluorescent Lamps
- 3 High intensity discharge lamps
  - 3.1 Metal Halide
  - 3.2 Standard MH lamps
  - 3.3 Pulse Start MH lamps
  - 3.4 Ceramic MH Lamps
- 4 LEDs

## Lamps

[! Switches](#)
[! Dimmers](#)
[! Scene Control](#)
[! Scheduling](#)
[! Timers](#)
[! Load Shedding](#)
[! Emergency Overrides](#)
[! Occupancy/Vacancy](#)
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[! Sun, Shading and Glazing Controls](#)
[! Control Protocols](#)
[! Integrating Control Systems](#)
[! Occupant Behavior](#)
[! Installation and Maintenance](#)

Incandescent lamps are filament lamps that generate light by passing current through a tungsten filament, which heats the tungsten to a high temperature that causes it to glow (emit light). The hotter the filament, the higher the color temperature of the light. This method of generating light is inherently inefficient, however, as significantly more heat is generated than light.

The color quality of light generated by a glowing filament is generally quite good, with a smooth spectral power distribution that has increased output with increased wavelength, creating warm light (CCT of approximately 2800 for standard incandescent lamps operated at rated voltage) with high CRI.

As the filament can become exceedingly bright, some incandescent lamps are frosted to diffuse the light over the surface area of the bulb. Clear bulbs permit more optical control, since reflectors and other optical devices can be designed to carefully control light from a small filament.

The Energy Policy Act of 1992 (EPACT) and recent legislation (Energy Independence Security Act, 2007) have effectively outlawed a number of commonly used incandescent lamps, with the 2007 legislation banning many of the standard lamps used in residences in phases between 2012 and 2014. After these

recent lamps that are sold in the U.S. will be required to meet specific energy efficiency and labeling targets. The goal is for consumers to switch to comparable compact fluorescent lamps, which offer significant energy savings. Some incandescent products will be converted to EISA compliant halogen

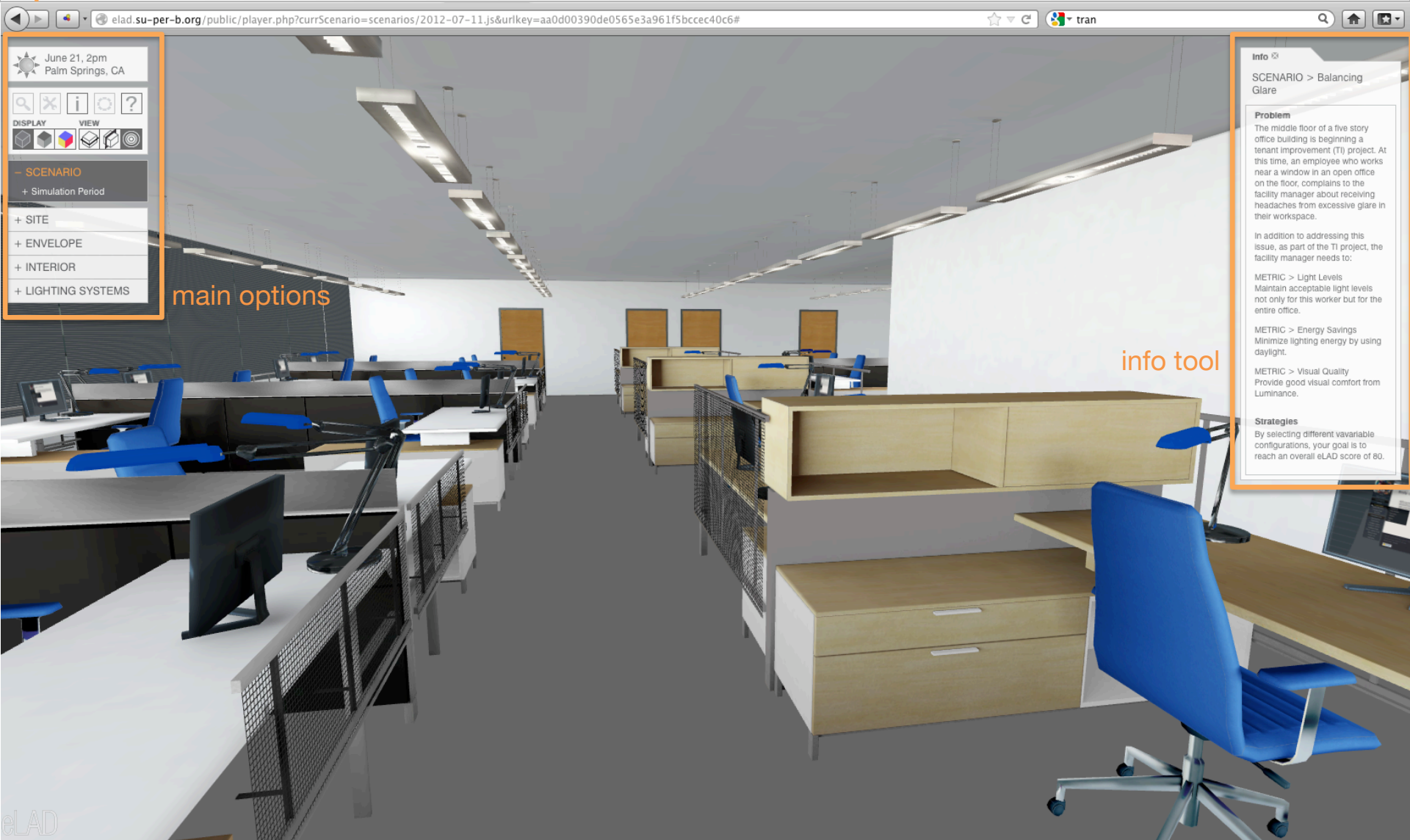
Incandescent lamps are easily dimmed by lowering the supplied voltage to the lamp. Dimming results in a reduction in both efficacy and lamp color temperature.

Phase 1 of the project completed in the end of July 2012

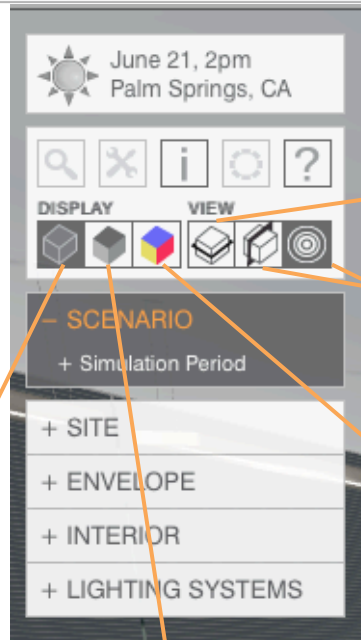
Demo available in the wiki:

**[http://elad.lbl.gov/index.php/Demo\\_eLAD](http://elad.lbl.gov/index.php/Demo_eLAD)**

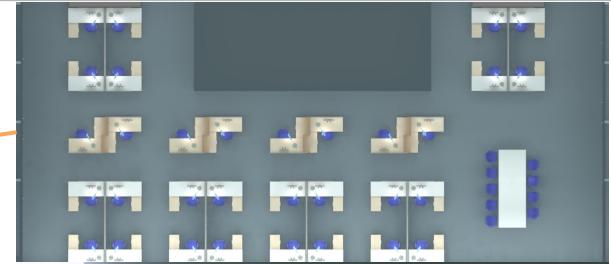
# SCENARIO PLAYER: Graphic User Interface



# SCENARIO PLAYER: Graphic User Interface



Plan



Section



Hotspot



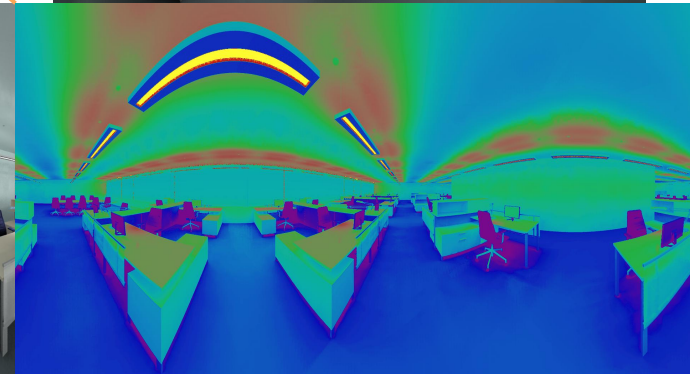
Solid view  
(webGL)



Vision  
(Radiance)

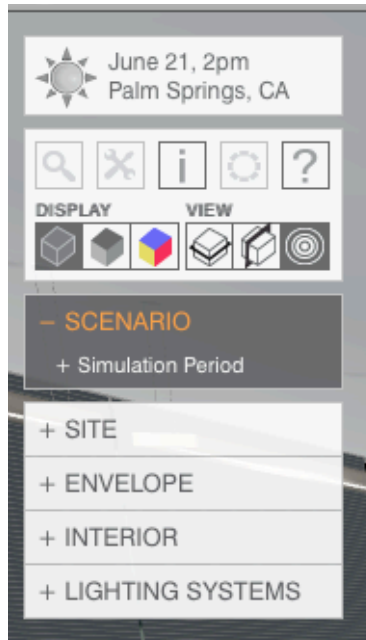


Falsecolor  
(Radiance)



# SIMULATION variables

Combinations of variables lead to simulation cases



Building System	Variable	Phase 1 Variable Options - current
Scenario	Scenario Description	
	Simulation Period	<ul style="list-style-type: none"> <li>▪ June 21, 2pm</li> <li>▪ Dec 21, 10am</li> </ul>
Site	Location	<ul style="list-style-type: none"> <li>▪ Palm Springs, CA</li> <li>▪ Pittsburgh, PA</li> </ul>
	Site Context	<ul style="list-style-type: none"> <li>▪ High urban (20 stories)</li> <li>▪ Low suburban (1 story)</li> </ul>
	Sky Condition	<ul style="list-style-type: none"> <li>▪ Clear sky</li> <li>▪ Cloudy</li> </ul>
Building	Building Orientation	▪ Azimuth = 0
	Office Orientation	▪ South
	Number of Floors	▪ 5
	Floor location in Building	▪ 3rd
Space Use	Space Type	▪ Open office
	Occupancy	
Envelope	Skin Type	▪ Single skin
	Wall Type	▪ Curtain wall
	Glass Type	▪ Single pane
	Glass Transmittance	<ul style="list-style-type: none"> <li>▪ 0.4</li> <li>▪ 0.6</li> </ul>
	Internal Shading	<ul style="list-style-type: none"> <li>▪ View window - blinds (closed)</li> <li>▪ View window - blinds (horizontal)</li> <li>▪ View window - none (up)</li> </ul>
	External Shading	<ul style="list-style-type: none"> <li>▪ Fixed overhang/shelf</li> <li>▪ None</li> </ul>
	Shading Controls	
	Window-Wall Ratio	<ul style="list-style-type: none"> <li>▪ 0.4</li> <li>▪ 0.6</li> </ul>
Interior	Surface Reflectance	<ul style="list-style-type: none"> <li>▪ High (wall 0.8, ceiling 0.9, floor 0.3, work surface 0.6, partition 0.7)</li> <li>▪ Low (wall 0.4, ceiling 0.7, floor 0.1, work surface 0.4, partition 0.5)</li> </ul>
	Ceiling Height	<ul style="list-style-type: none"> <li>▪ 9'</li> <li>▪ 11'</li> </ul>
	Partition Height	<ul style="list-style-type: none"> <li>▪ 42"</li> <li>▪ 54"</li> </ul>
	Furniture Layout	<ul style="list-style-type: none"> <li>▪ Rectilinear #1</li> <li>▪ Rectilinear #2</li> </ul>
Lighting	Lighting Vintage	<ul style="list-style-type: none"> <li>▪ 2000 Ceiling mounted</li> <li>▪ 2010 Task ambient</li> </ul>
	Controls	<ul style="list-style-type: none"> <li>▪ Ceiling mounted (on/off)</li> <li>▪ Ceiling mounted (daylight dimming)</li> <li>▪ Task (on/off) ; ambient (on/off)</li> <li>▪ Task (on/off) ; ambient (daylight dimming)</li> </ul>

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	Site Context	<ul style="list-style-type: none"> <li>High urban (20 stories)</li> <li>Low suburban (1 story)</li> </ul>
	Sky Condition	<ul style="list-style-type: none"> <li>Clear sky</li> <li>Cloudy</li> </ul>
	Building Orientation	<ul style="list-style-type: none"> <li>Azimuth = 0</li> <li>South</li> <li>5</li> <li>3rd</li> </ul>
	Floor Location, Building	<ul style="list-style-type: none"> <li>Open office</li> </ul>
Occupancy	Occupancy	
Lighting	Lighting	<ul style="list-style-type: none"> <li>0.3, work surface 0.6, partition 0.7)</li> <li>0.1, work surface 0.4, partition 0.5)</li> </ul>
	Controls	<ul style="list-style-type: none"> <li>11'</li> <li>42"</li> <li>54"</li> <li>Rectilinear #1</li> <li>Rectilinear #2</li> <li>2000 Ceiling mounted</li> <li>2010 Task ambient</li> <li>Ceiling mounted (on/off)</li> <li>Ceiling mounted (daylight dimming)</li> <li>Task (on/off) ; ambient (on/off)</li> <li>Task (on/off) ; ambient (daylight dimming)</li> </ul>

# SIMULATION variables

## Naming

v - view,  
m - mode,  
d - date,  
g - geometry,  
n - neighborhood,  
s- sky conditions,  
t - transmittance,  
i - internal shading,  
e - external shading,  
w - window/wall ratio,  
r - reflectance,  
p - partition height,  
f - furniture layout,  
z - ceiling height,  
l - lighting vintage,  
c - controls

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	Glass Type	<ul style="list-style-type: none"> <li>Single pane</li> </ul>
	Glass Transmittance	<ul style="list-style-type: none"> <li>0.4</li> <li>0.6</li> </ul>
	Internal Shading	<ul style="list-style-type: none"> <li>View window - blinds (closed)</li> <li>View window - blinds (horizontal)</li> <li>View window - none (up)</li> </ul>
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	Shading Controls	
	Window-Wall Ratio	<ul style="list-style-type: none"> <li>0.4</li> <li>0.6</li> </ul>
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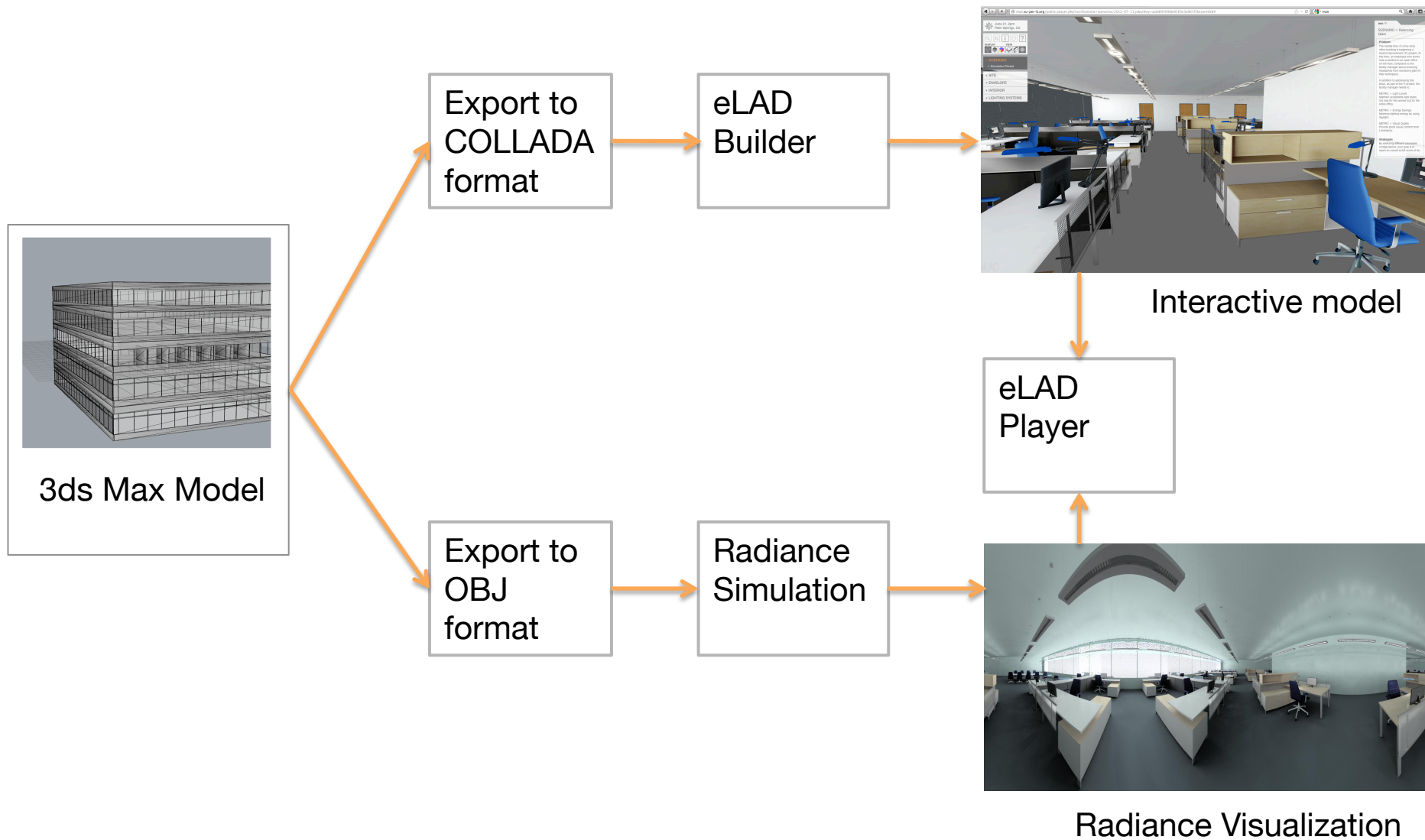
## SIMULATION variables: Naming

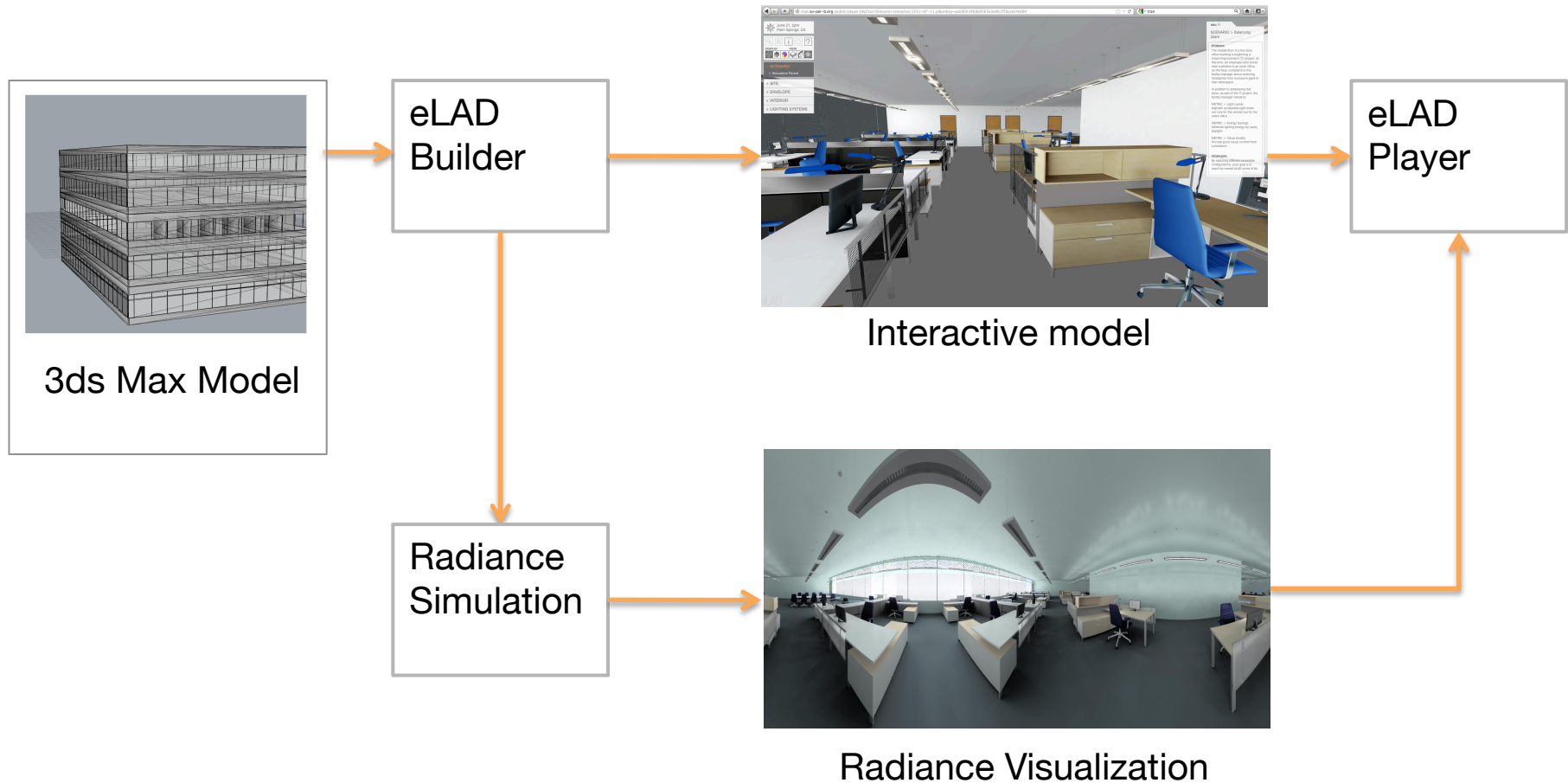


v3-m1-d1-g1-n1-s1-t1-i2-e1-w1-r1-p1-f1-z2-l2-c2

Radiance is used to calculate and visualize the results of student decisions

- # Integration into a workflow with 3ds Max and WebGL
- # simulation of daylighting controls





Scripts for Radiance renderings are written in:

- # C Shell,
- # Python,
- # AWK.

Scripts may run directly:

- # in any unix-like environment,
- # or as batch jobs in the Portable Batch System.

Lawrence Berkeley National Labs Lawrencium cluster was used for the rendering process

Two main groups of simulation scripts:

A: scripts used to run simulations [e.g.: run.csh]

B: scripts that support the simulation group

# some generate the files and directories used by the first group  
[e.g.: Gen\_numbered\_runset gathers the files for a group of simulations]

C: Secondary group with scripts specific to the cluster

# e.g.: a few scripts used to organize JPEG files or to rerun specific simulations

1/ `gen_runset` is used to create simulation case directories named after simulation case codes: e.g. “d1-g1-n1-s1-t1-i1-e1-w1-r1-p1-f1-z1-l1-c1”

2/ These codes are then linked with shorter case numbers such as “C00001”

3/ `Run.csh` is then used, either directly or as a batch job, to run the simulations for a single simulation case

- # It sets up a working directory and then defines the path to the directory depending on the case number

- # It generates the Radiance control script by calling the `gen_rif_file`

- # It sets up the selected views to render

4/ When images are generated, `gather_jpegs` gathers all the jpeg renderings into a single “jpegs” directory



If the median illuminance on a row of desks is less than 600 lux  
the overhead luminaires over that row are turned on

When desk lamps are present, the following rule is used:  
when median illuminance in a row is:

- # over 600 lux, 25% of the desk lamps will be on
- # between 300 and 600 lux, 50% of the desk lamps will  
be on
- # under 300 lux, all the desk lamps will be on

meter\_workplane\_illuminance script -- measure the  
median illuminance on each row of desks

```
meter_workplane_illuminance casecode \  
>median_ill_by_row
```

Script body:

```
# Create the octree  
# Run rtrace  
# Convert irradiances to illuminances  
# Find the median illuminance of each row
```

### Aliasing is used to control luminaires in the model

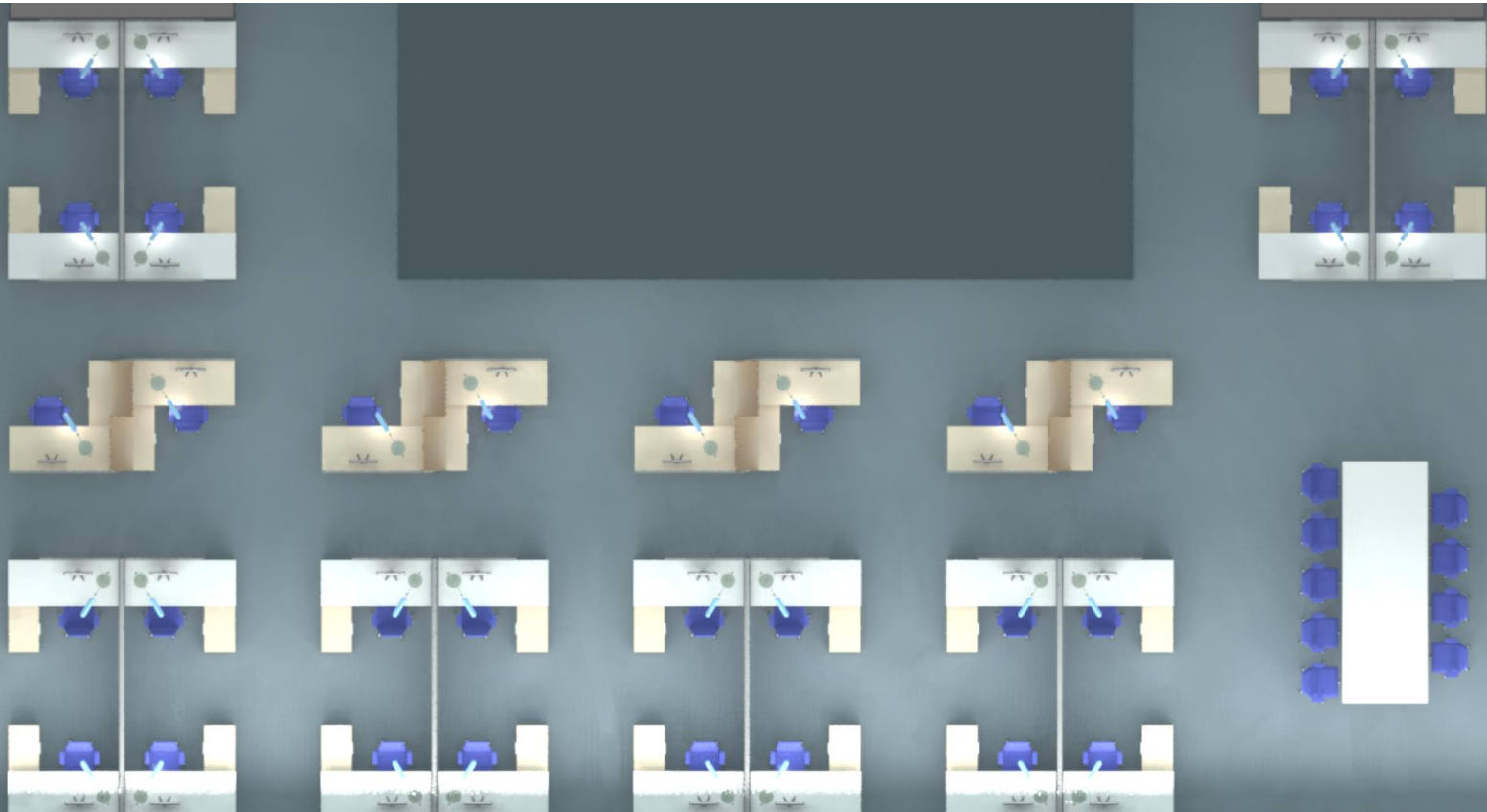
```
# Ceiling luminaire row 4
inherit alias ceiling_illum_r4 luminaire_pendant3_CB087_light
inherit alias ceiling_glow_r4 mat_luminaire_pendant_interior

# Desk luminaire row 4 level lo
inherit alias desklamp_illum_r4_lo light_off
inherit alias desklamp_glow_r4_lo glow_off

# Desk luminaire row 4 level med
inherit alias desklamp_illum_r4_med desk_lamp_one_light
inherit alias desklamp_glow_r4_med glow_off

# Desk luminaire row 4 level hi
inherit alias desklamp_illum_r4_hi desk_lamp_one_light
inherit alias desklamp_glow_r4_hi glow_off
```

## RADIANCE Renderings: Plans



# RADIANCE Renderings: Sections

 June 21, 2pm  
Palm Springs, CA



DISPLAY



VIEW



SCENARIO

+ Simulation Period

+ SITE

+ ENVELOPE

+ INTERIOR

+ LIGHTING SYSTEMS



Info ⓘ

SCENARIO > Balancing Glare

**Problem**

The middle floor of a five story office building is beginning a tenant improvement (TI) project. At this time, an employee who works near a window in an open office on the floor, complains to the facility manager about receiving headaches from excessive glare in their workspace.

In addition to addressing this issue, as part of the TI project, the facility manager needs to:

METRIC > Light Levels  
Maintain acceptable light levels not only for this worker but for the entire office.

METRIC > Energy Savings  
Minimize lighting energy by using daylight.

METRIC > Visual Quality  
Provide good visual comfort from Luminance.

**Strategies**

By selecting different variable configurations, your goal is to reach an overall eLAD score of 80.

eLAD

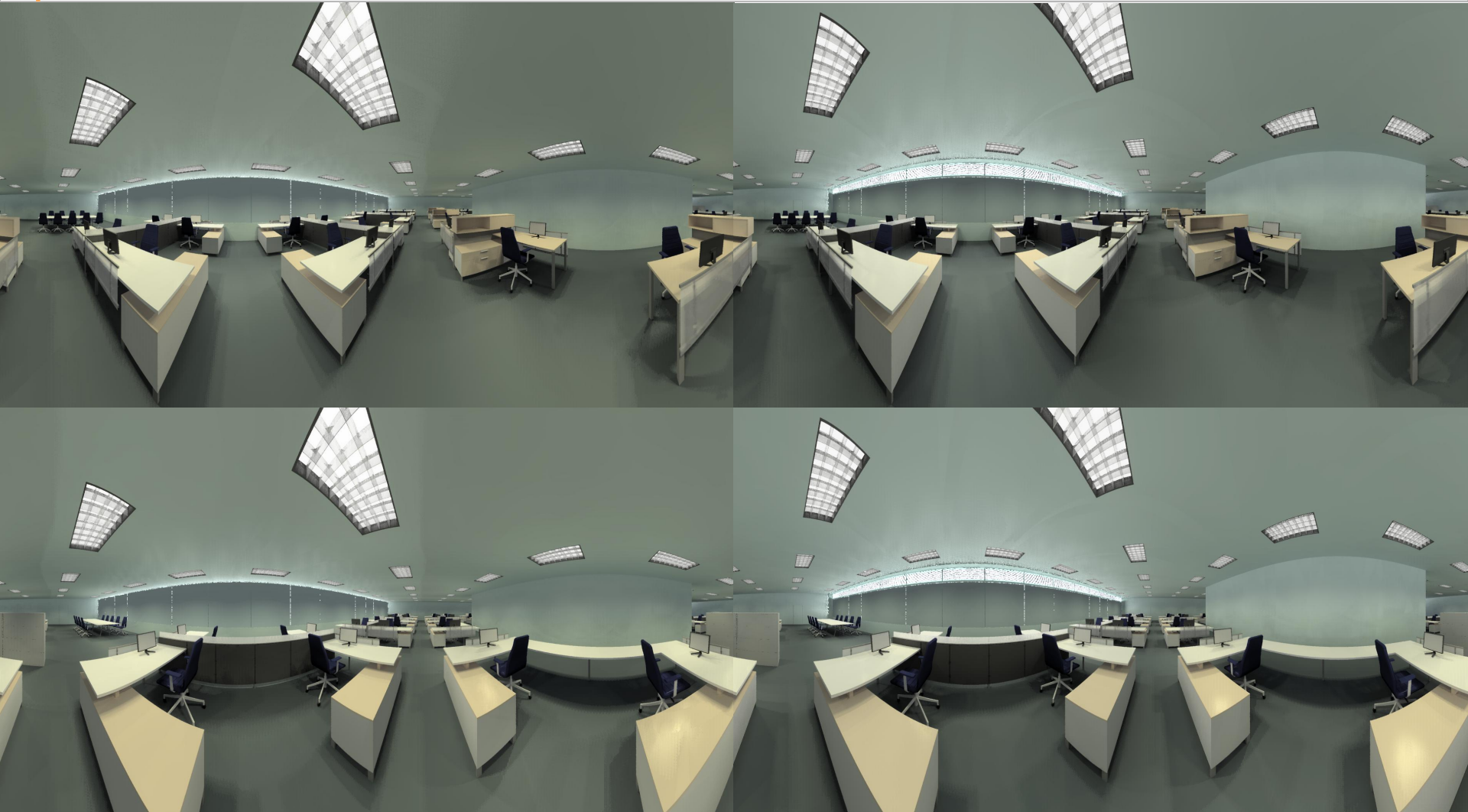
## RADIANCE Renderings: Panoramic Views

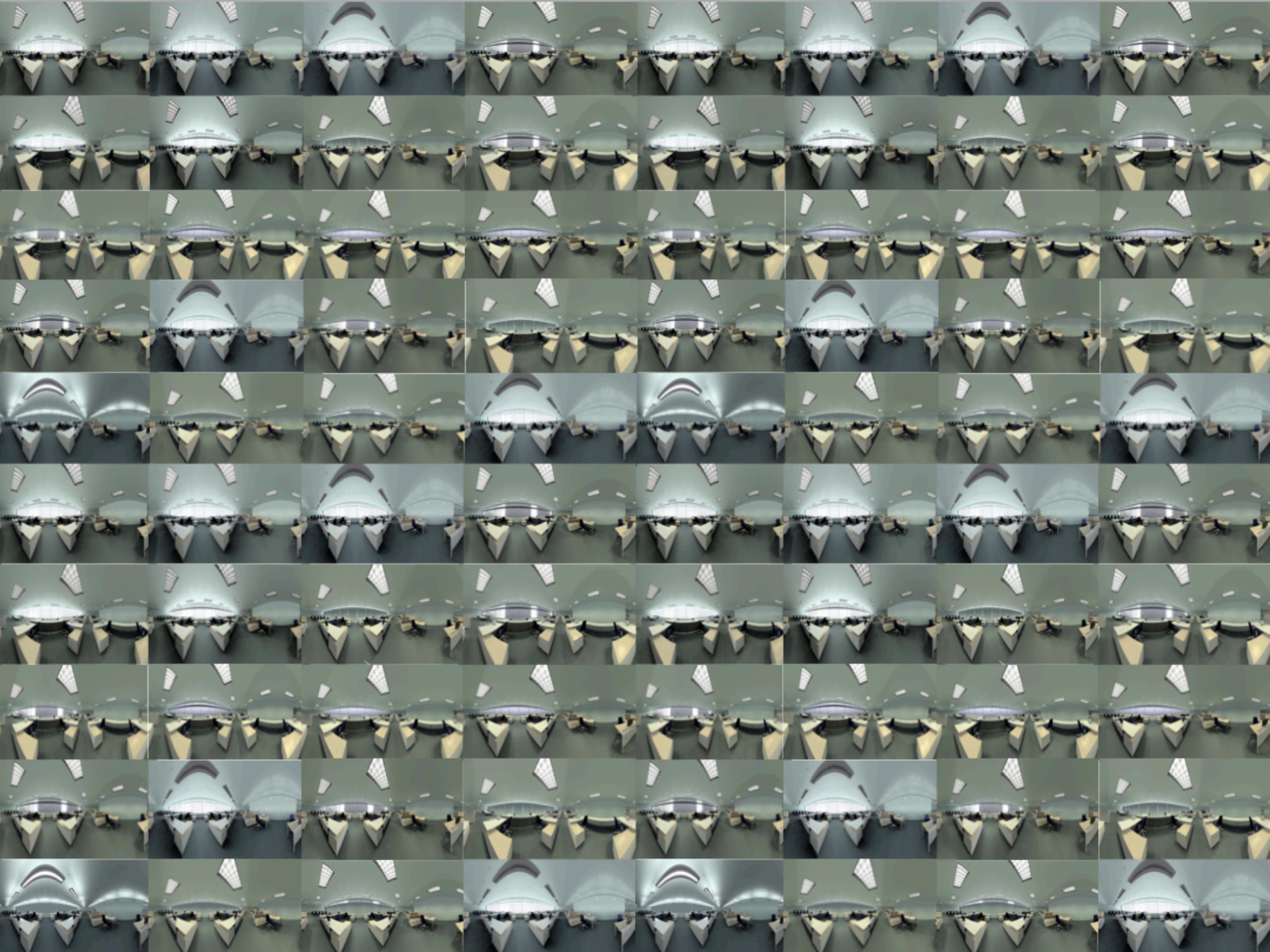


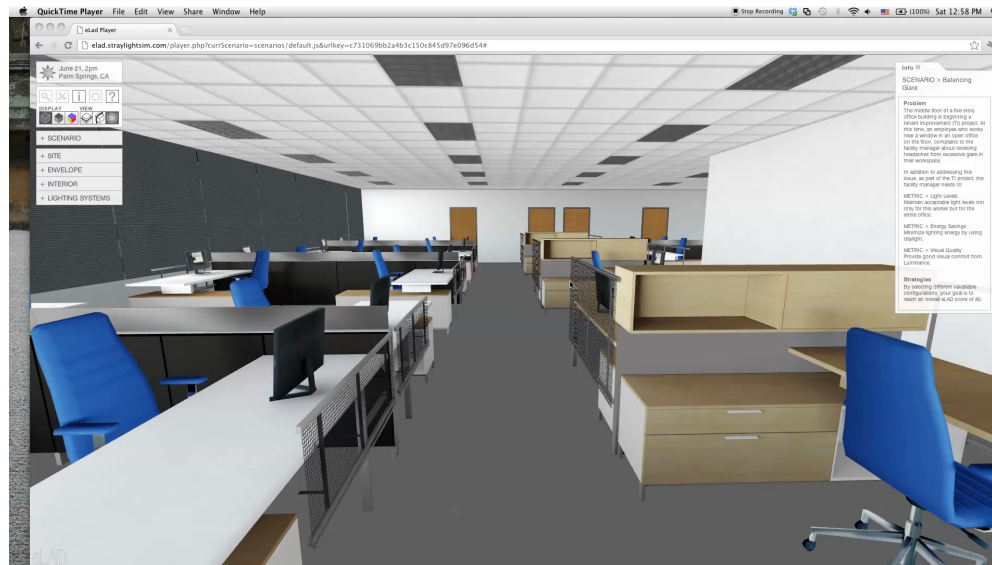
## RADIANCE Renderings: Panoramic Views



## RADIANCE Renderings: Panoramic Views







### eLAD development:

Adding more variables in Phase 2

#### Radiance:

- # Integrating Radiance into the Builder
- # Annual and Seasonal Simulations
- # Producing more renderings
- # Running renderings on a web server from JavaScript
- # Improving Daylighting Controls

# eLAD eLearning platform for Lighting and Daylighting

Thank you.

[mkonstantoglou@lbl.gov](mailto:mkonstantoglou@lbl.gov)  
<https://elad.lbl.gov>