Recent Practical Applications Using *Radiance*

- 2003 *Radiance* Workshop
  - Matt Franks, Arup Lighting
  - Andrew McNeil, Arup Lighting

Overview

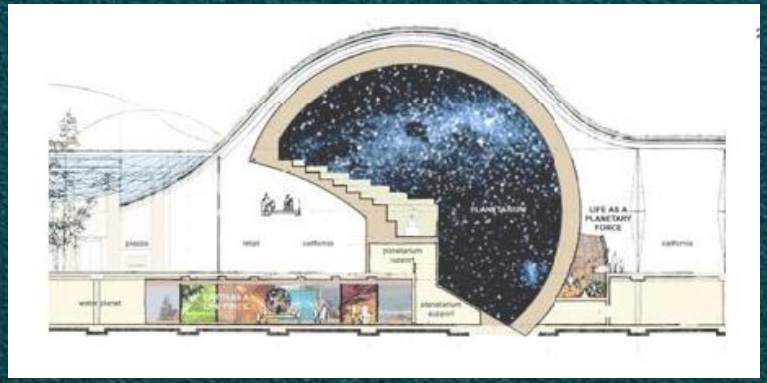
- California Academy of Science – San Francisco, CA
  - Skylight geometry opimization
  - Historical weather data
- Battersea Power Station Residential Development – London, UK
  - Code compliance analysis
  - “Modular” modeling process
- Acoustical Reflector Analysis
  - Using *Radiance* for geometrical studies of reflector coverage

The California Academy of Sciences

Coral Reef Studies

Project Overview

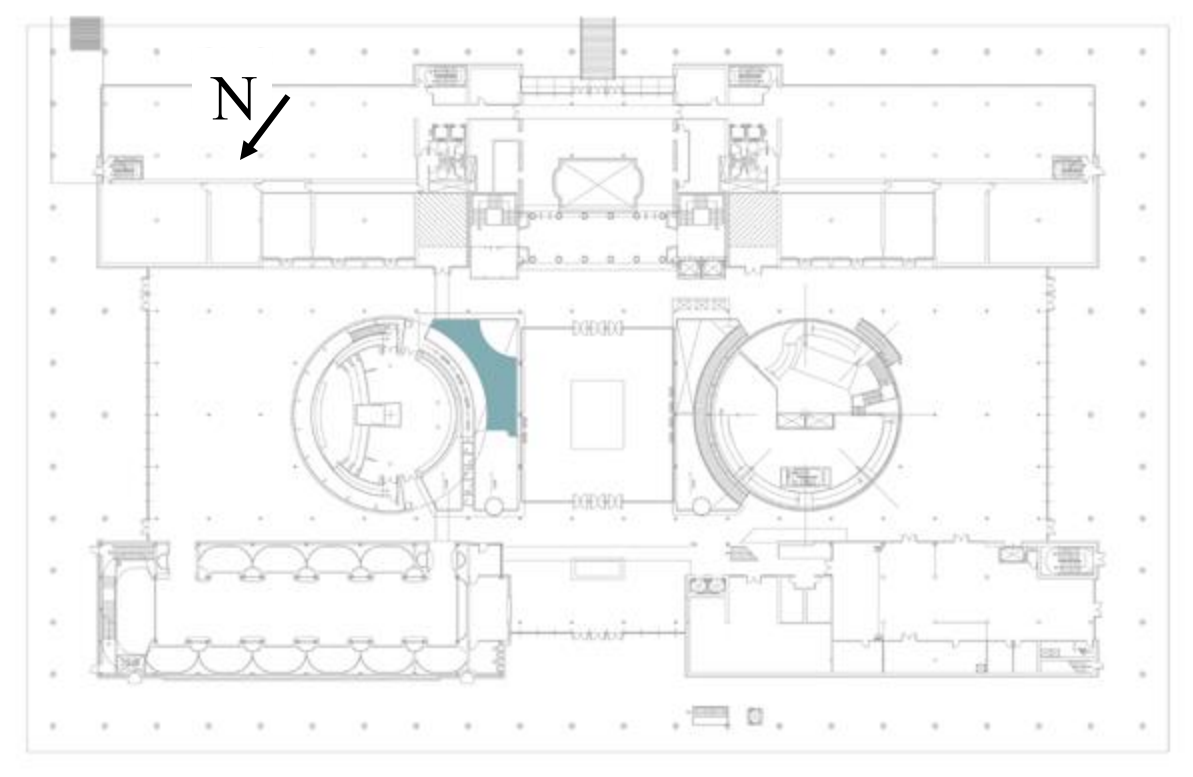
- Rain Forest



- Planetarium

Project Overview

- Coral Reef



Objectives

- Objectives
  - Maximize direct sun on the coral reef.
  - Minimize solar heat gain (reduce skylight glazing)
- Tasks
  - Identify where skylights should be located to maximize direct solar radiation.
  - Quantify hours of direct solar radiation on the coral reef.

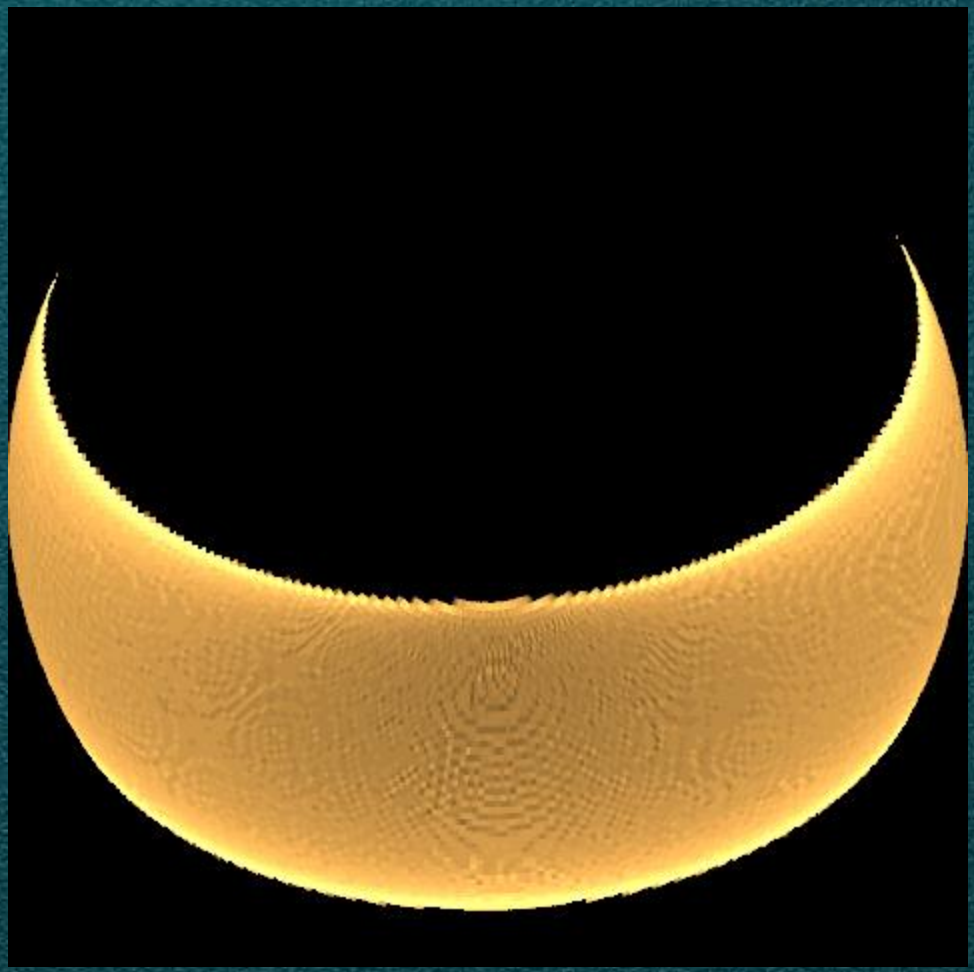
Determining “Effective” Skylight Placement.

- Method #1 – Assign luminance values to sky based on probability of sun. FAILED
- Method #2 – Trace rays in direction of sun for a Yes/No response. SUCCESS

Method #1

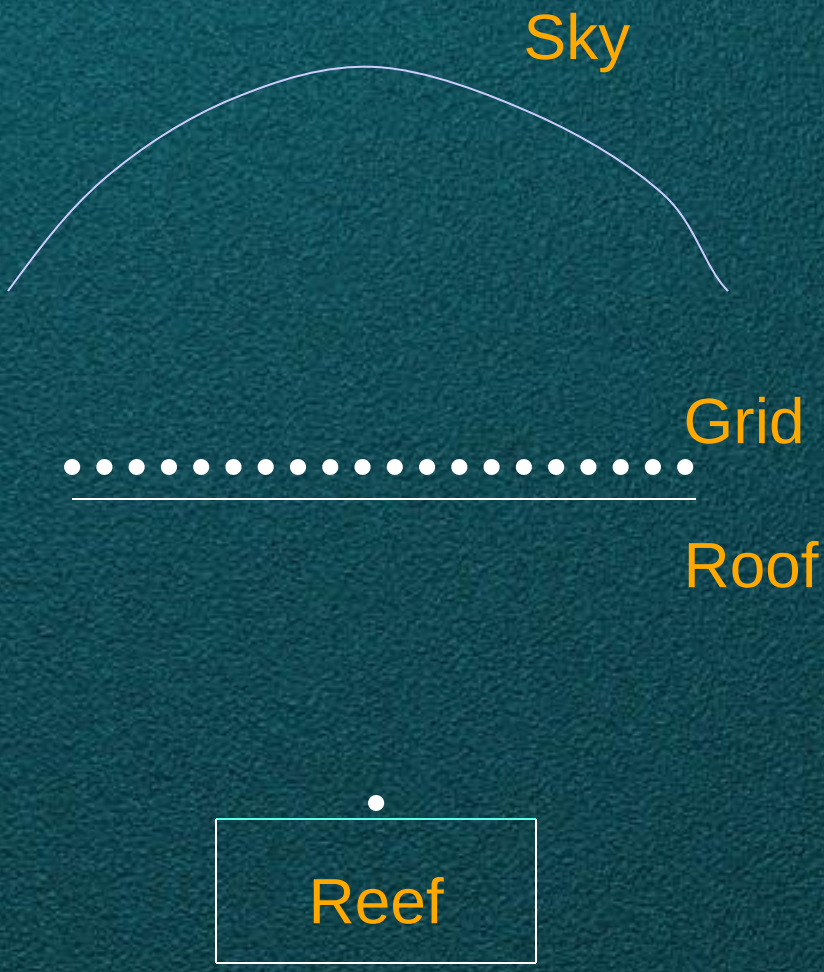
- **Step 1**

  Luminance values were assigned to the sky based on the number of hours the sky was in each segment (we used 360 x 180 segements).



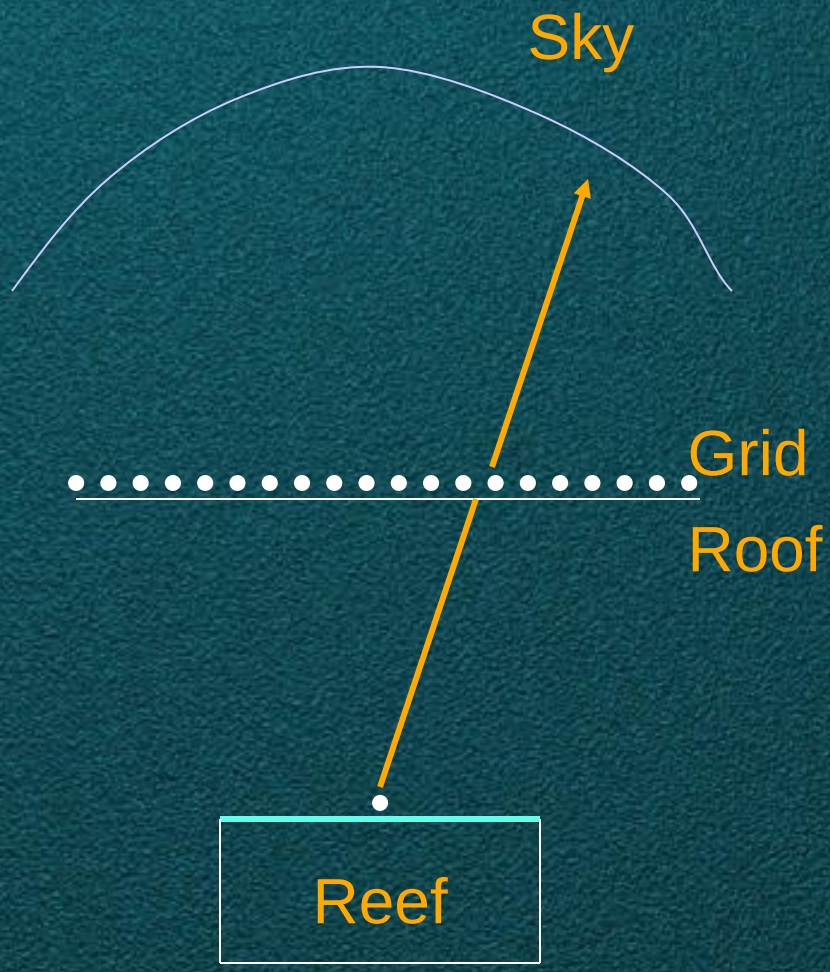
Method #1

- **Step 2**
  - **A grid was defined on the roof.**
  - **A point in the center of the coral reef was designated as the origin point.**



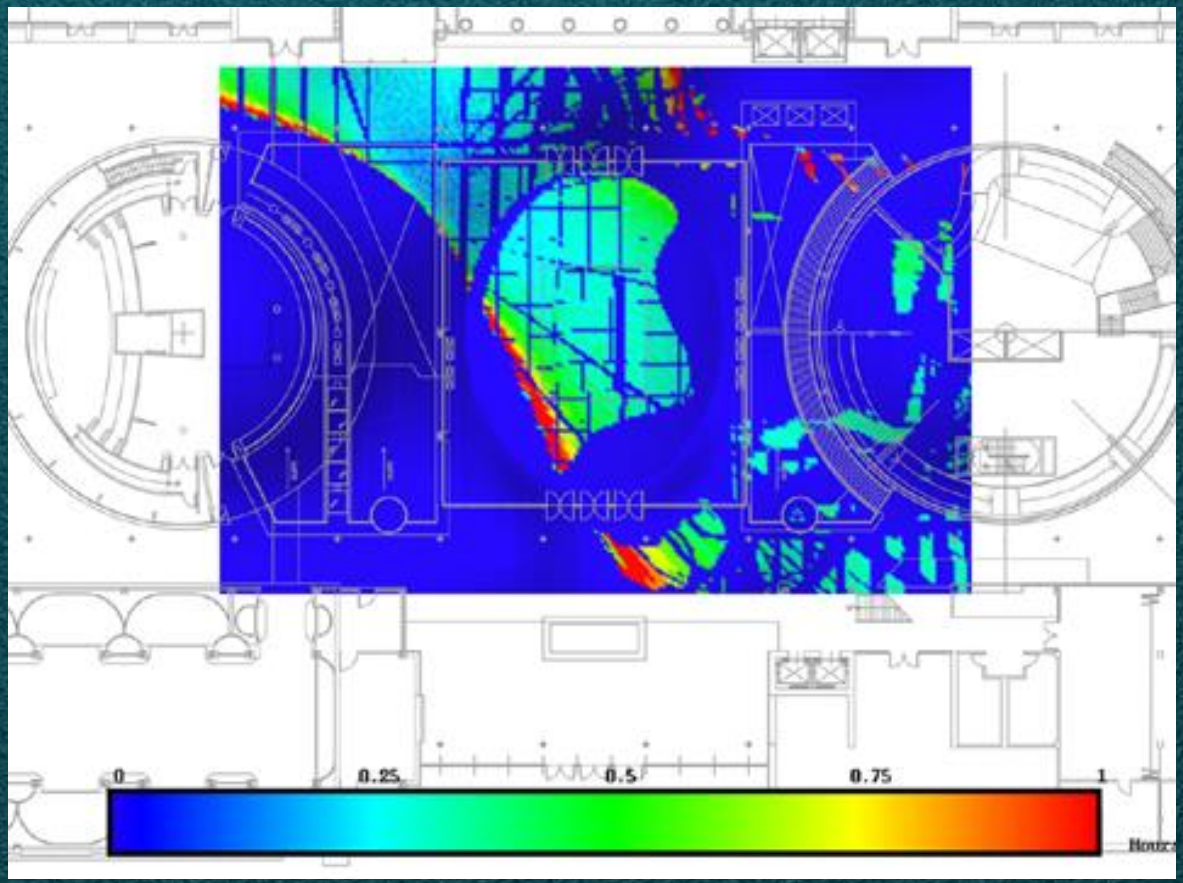
Method #1

- Step 3
  - A direction is calculated for each grid point using the point and the reef "origin."
  - That direction is used to test the sky. A value equal to the number of hours the sun spends in that portion of the sky is returned.



Method #1

- Result



Amount of sun (in hours) that from a given point on the roof that lands on the coral reef "origin" per year.

Method #1

Method #1 failed because:

- It only accounted for sun landing on one point of the coral reef.
- The generated sky seemed to be skewed towards the solstices.

These problems might have been overcome, but a better method came to us.

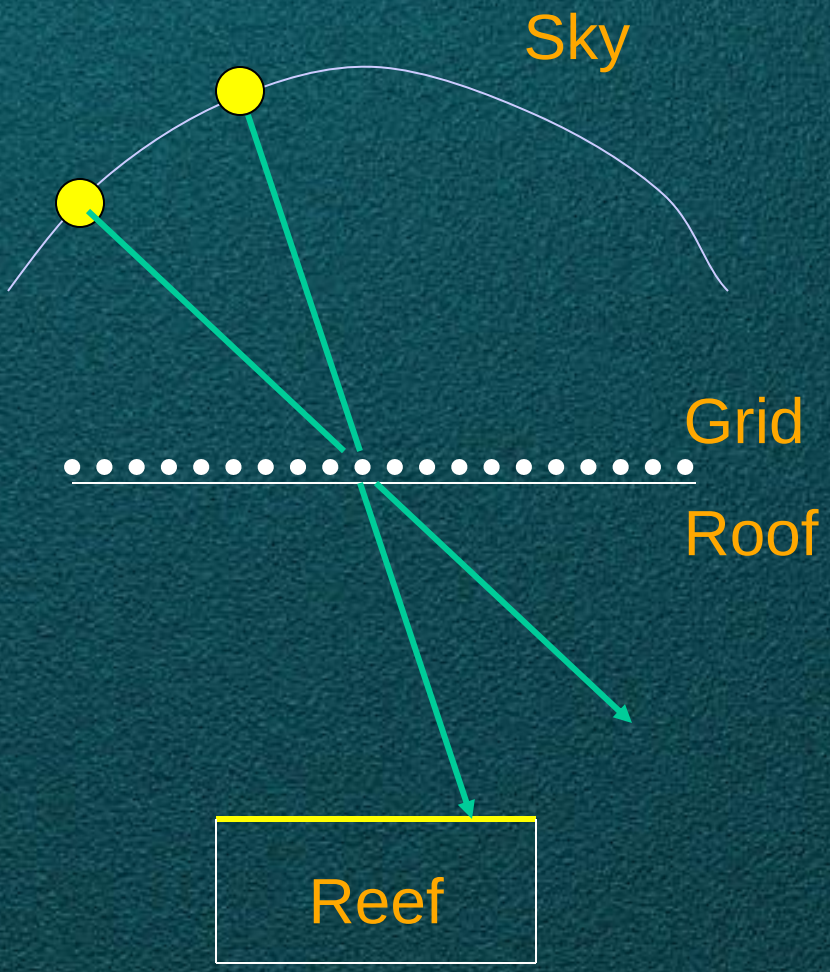
Method #2

- **Step 1**

  Assign a glow material to the surface of the coral reef.

- **Step 2**

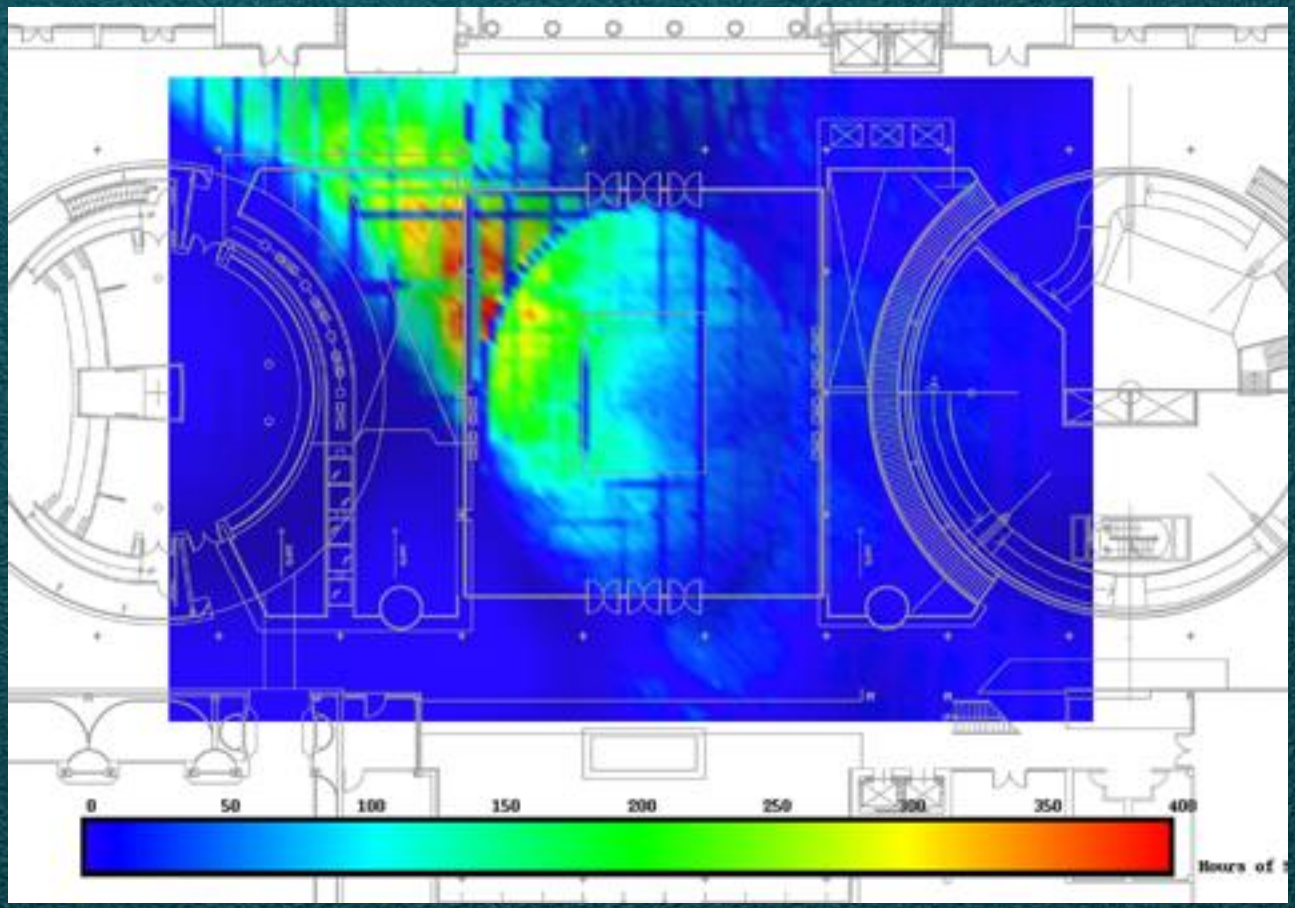
  Trace a ray from the roof grid downwards in the direction of the the sun for every hour of the year.



Method #2

- **Result**

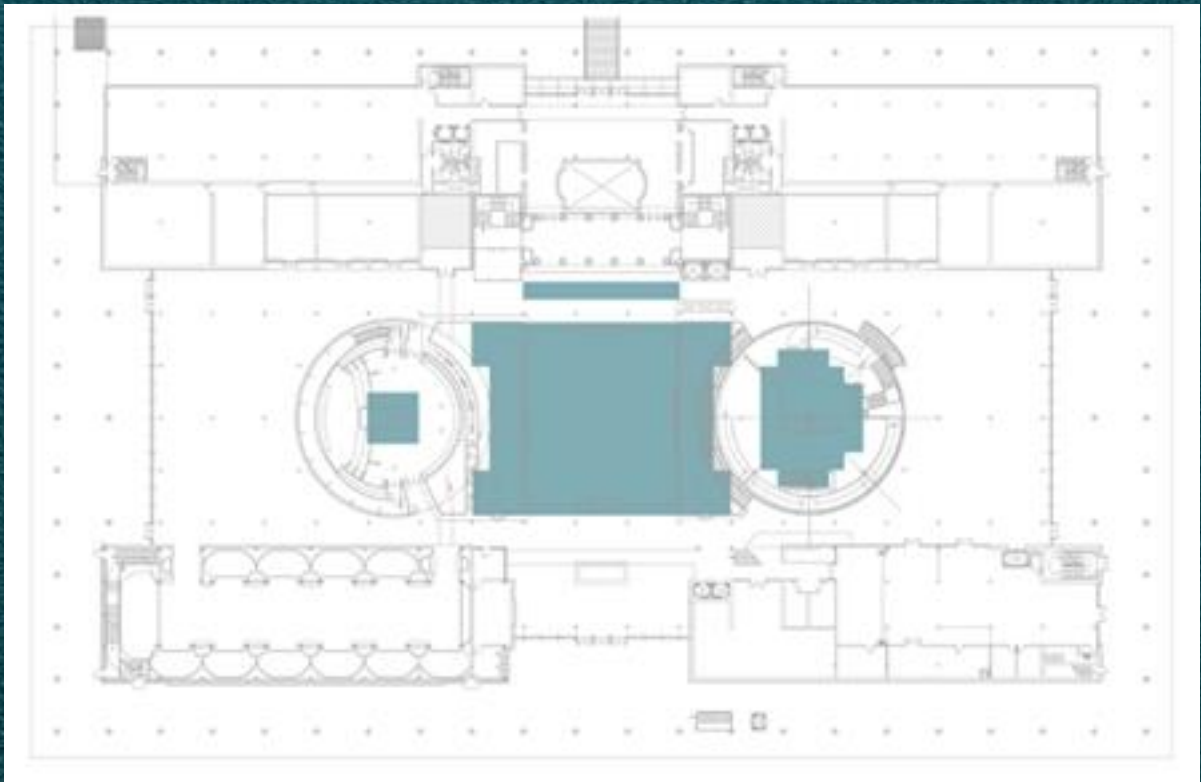
  The entire reef is considered instead of just one point.



Amount of sun (in hours) that from a given point on the roof that lands on the coral reef per year.

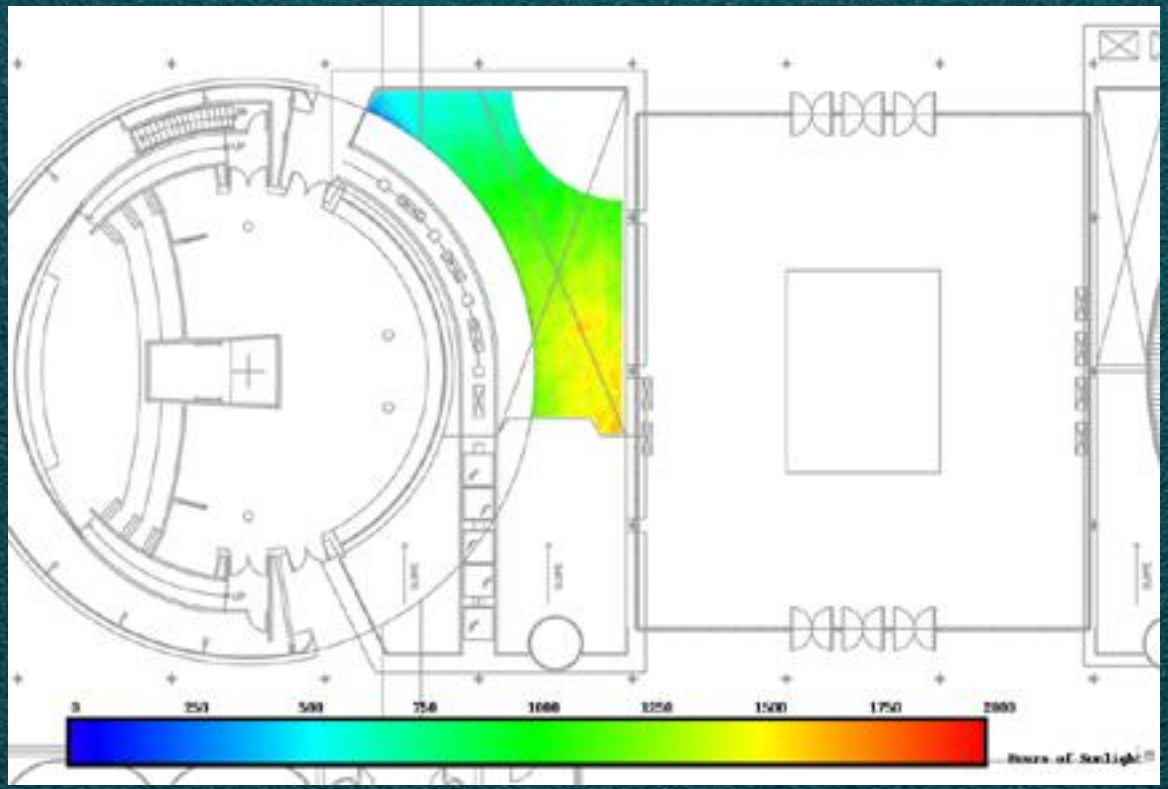
Initial Skylight Configuration

- Original skylight configuration (shaded areas are skylights).



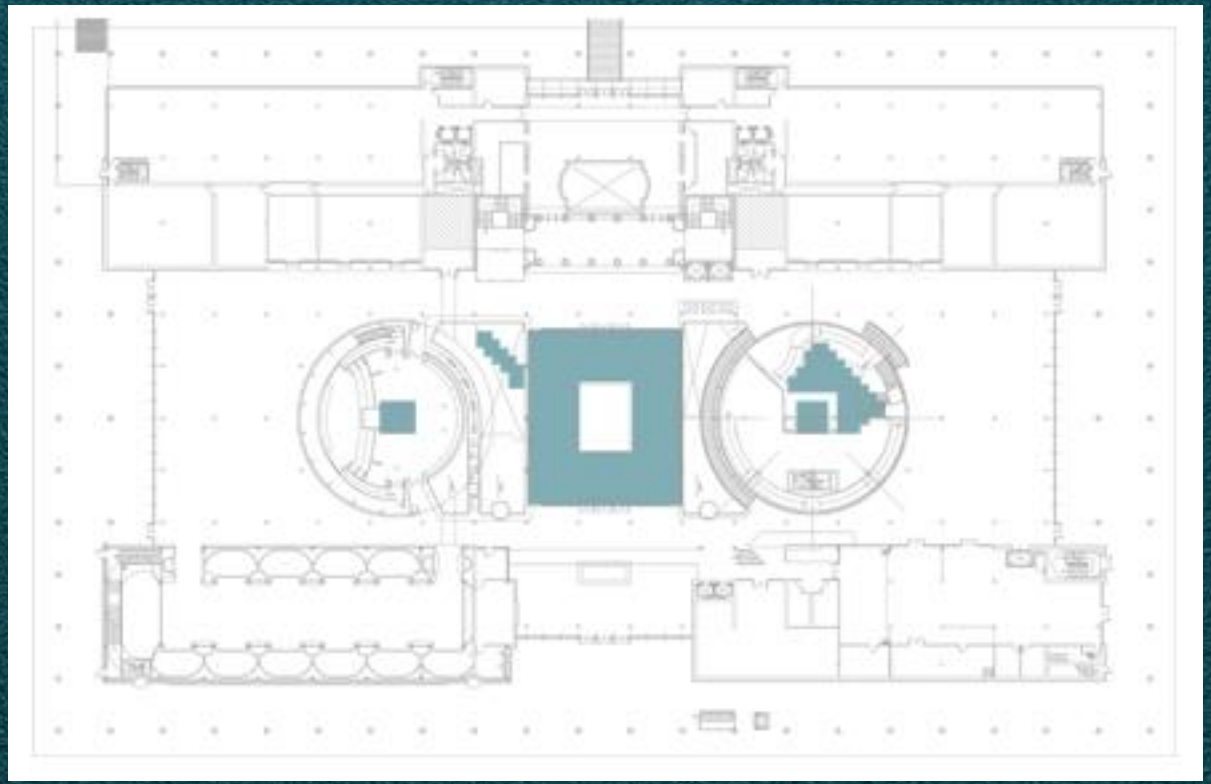
Initial Skylight Configuration

- Hours of direct sun on coral reef per year (during a completely sunny year).



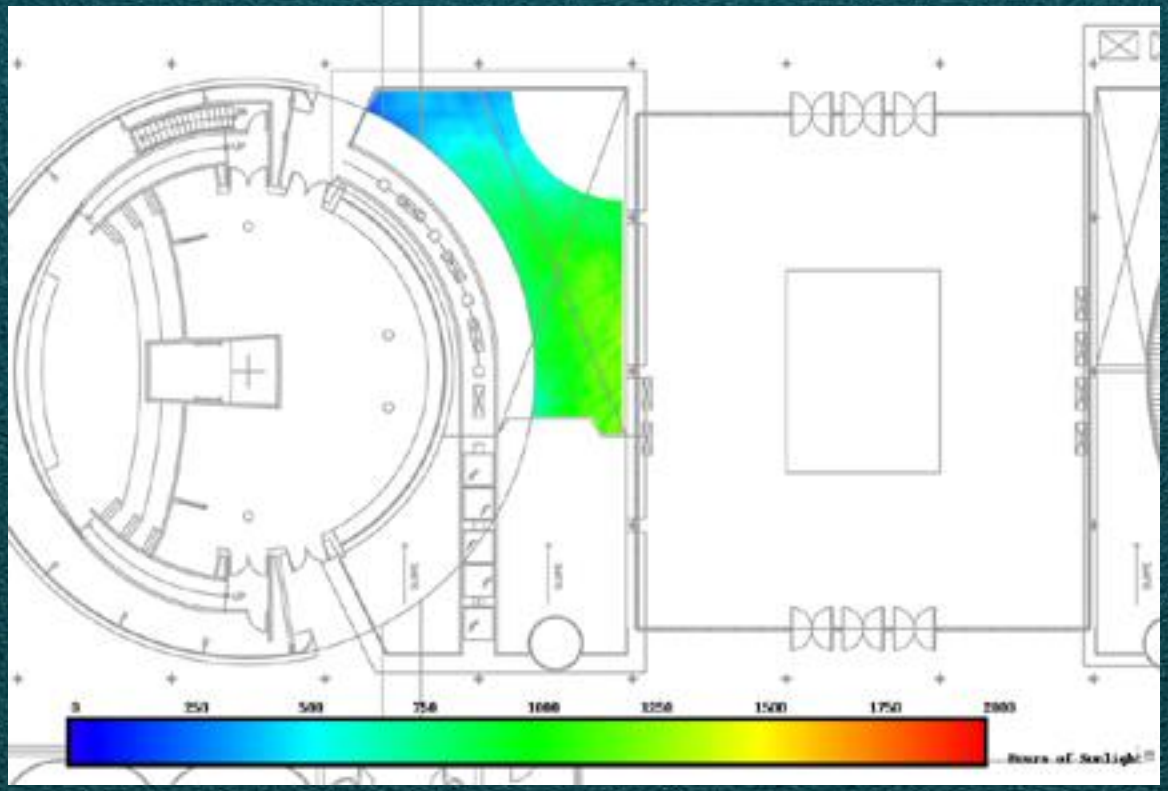
Revised Skylight Configuration

- Revised skylight configuration (shaded areas are skylights).



Revised Skylight Configuration

- Hours of direct sun on coral reef per year (during a completely sunny year).



Revised Skylight Configuration

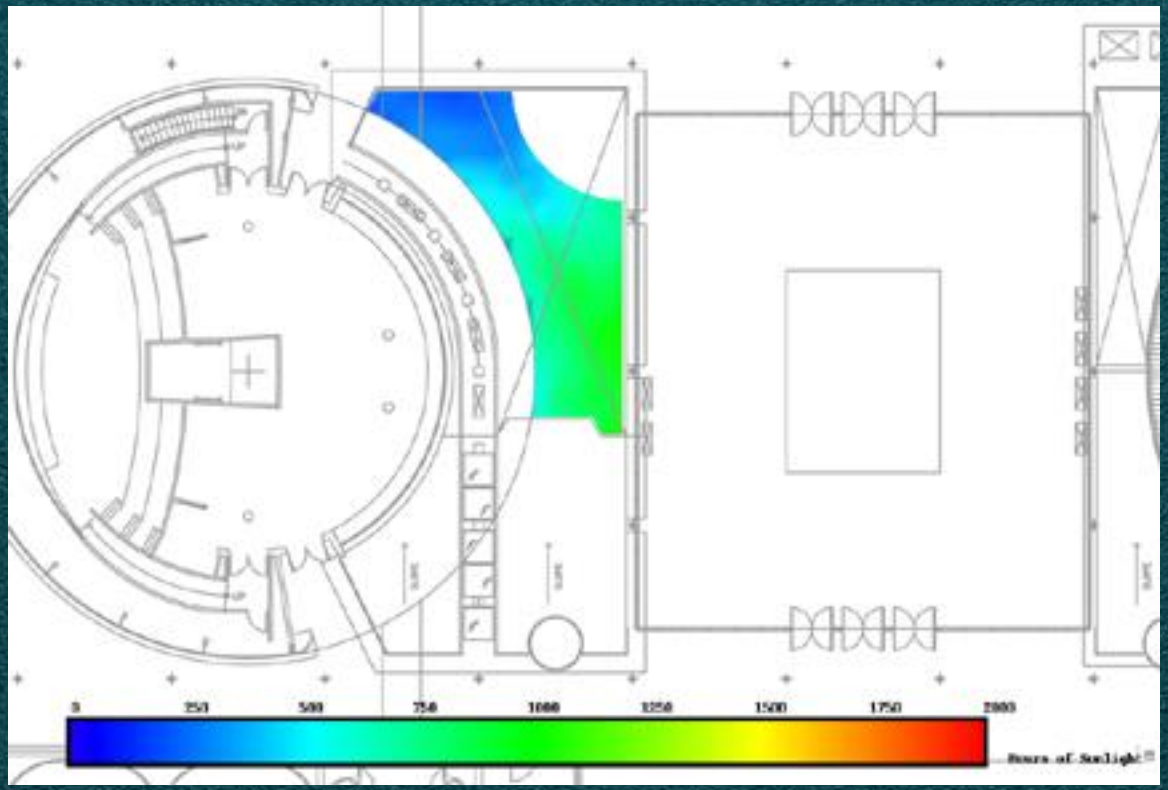
- **Solar Gain Reduced by more than 70%**
  (considering skylights associated with coral reef)
- **Hours of direct sunlight reduced by only 33%**

Incorporating Weather Data

- What good is data from a “completely sunny year?”
  - It provides a basis for comparison
  - Dosen’t help to understand actual performance.
- SAMSON Data (has solar and sky radiation data)
  - Hourly data integrates well with hourly analysis!

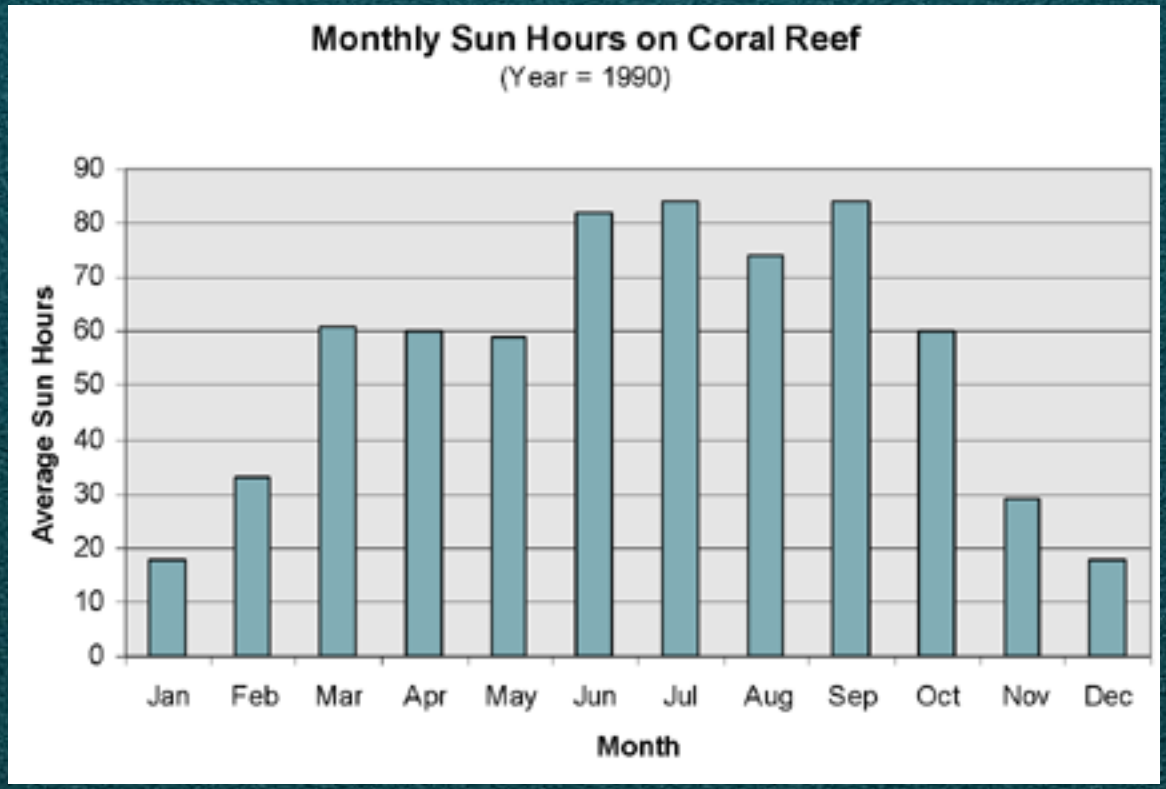
Incorporating Weather Data

- Hours of direct sun on coral reef during 1990.



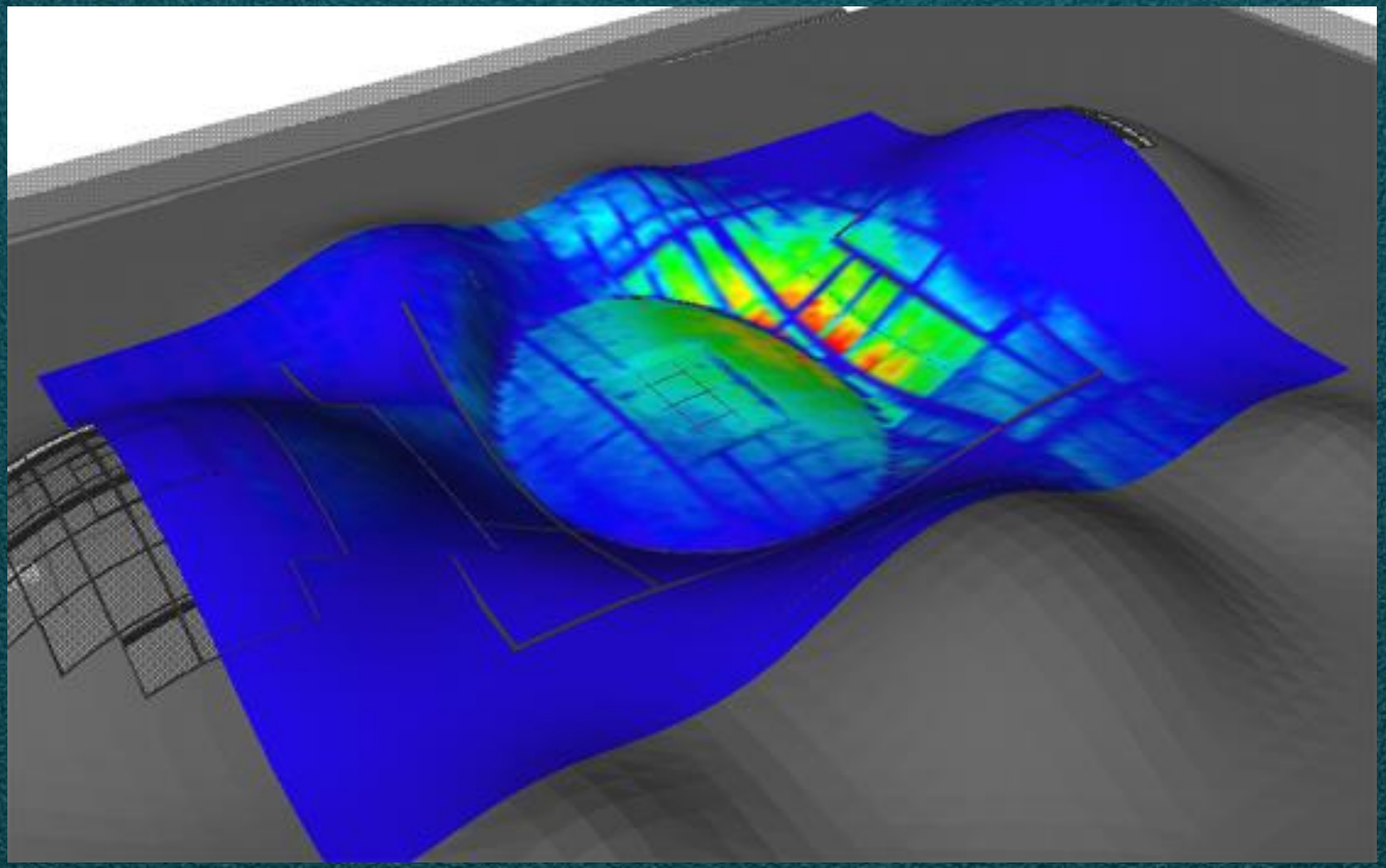
Incorporating Weather Data

- Average hours of direct sun on coral reef by month during 1990.



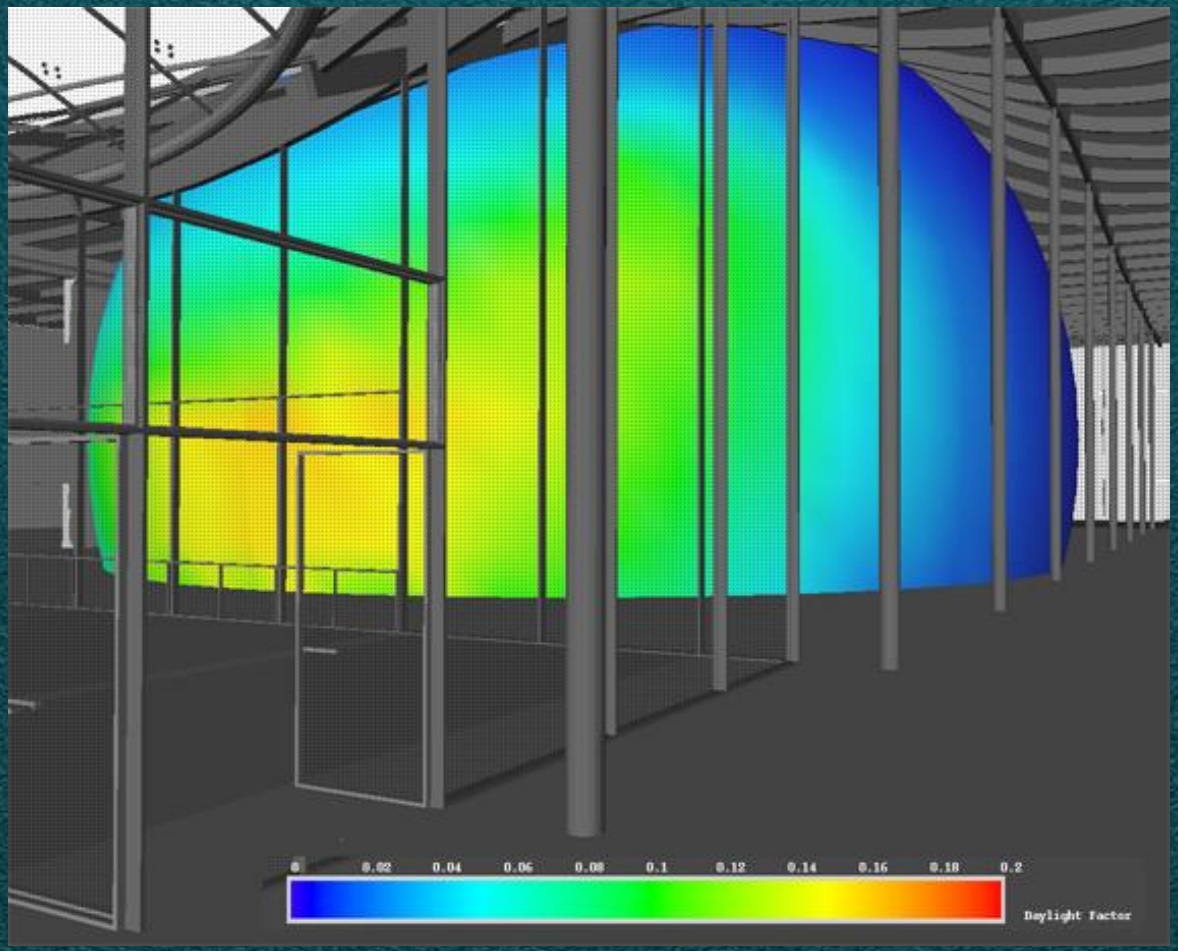
Pictures

- Perspective image of grid & roof.



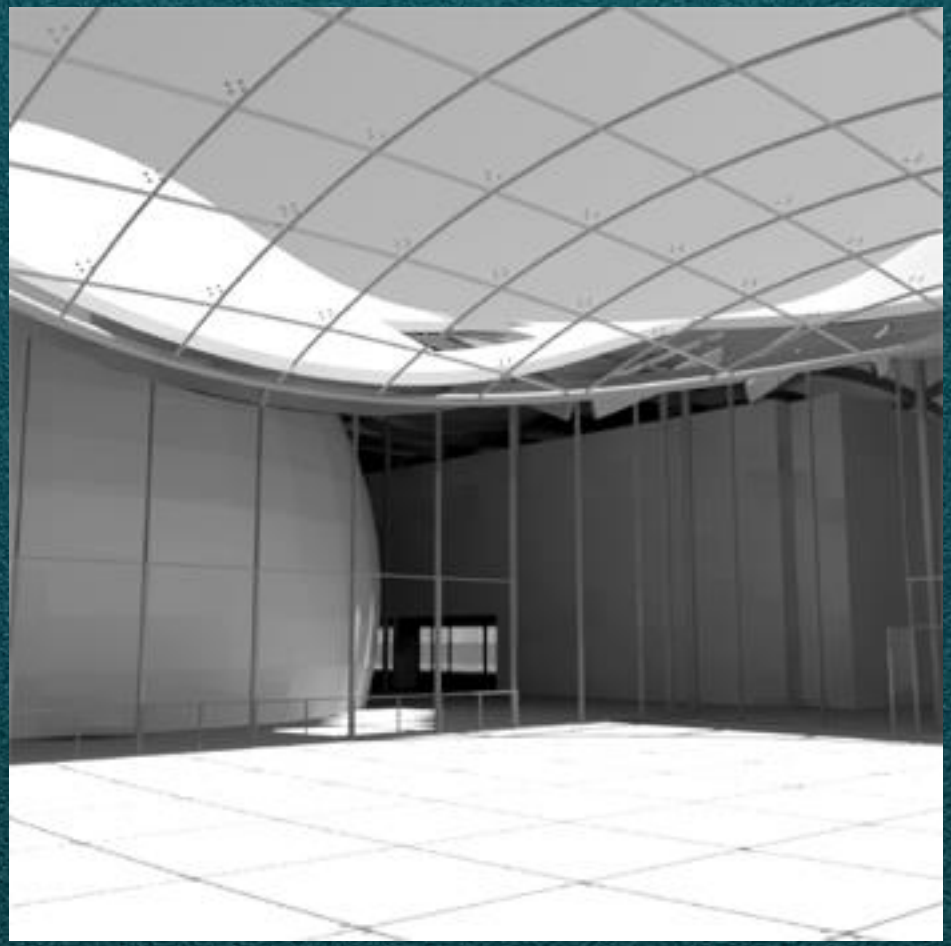
Pictures

- Daylight factor on planetarium dome.



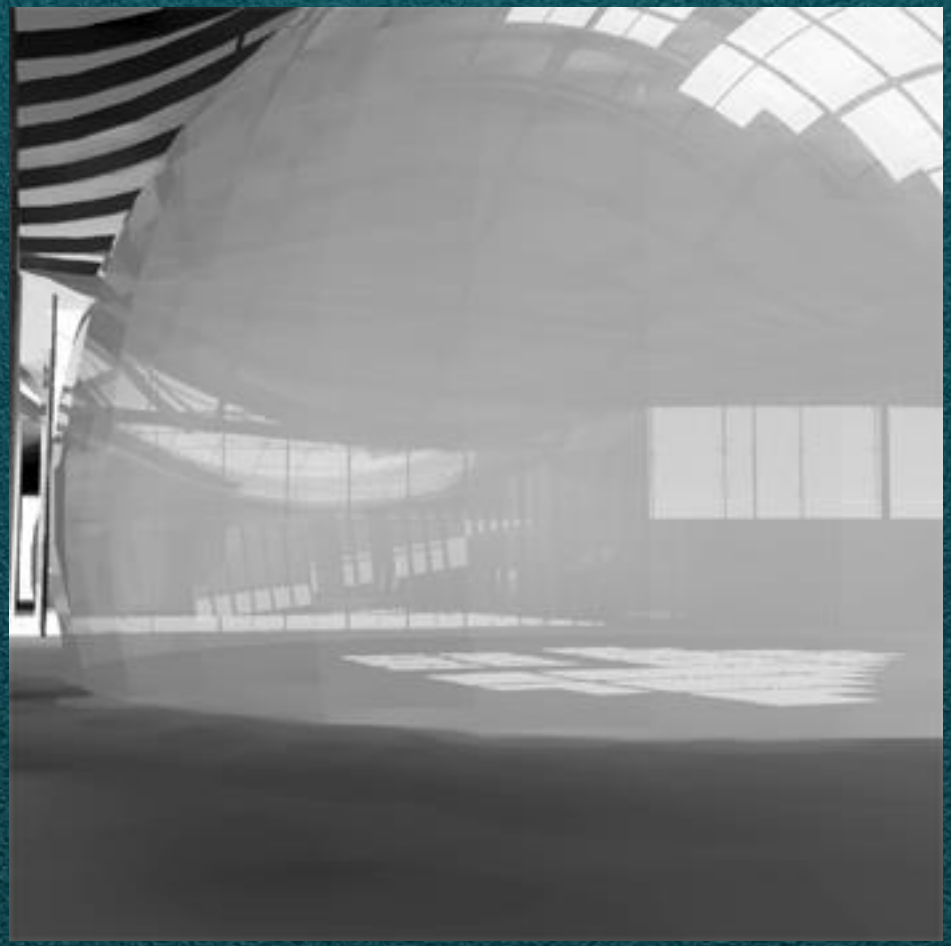
Pictures

- Rendering of coral reef area from piazza.



Pictures

- Rendering through rainforest (translucent dome).



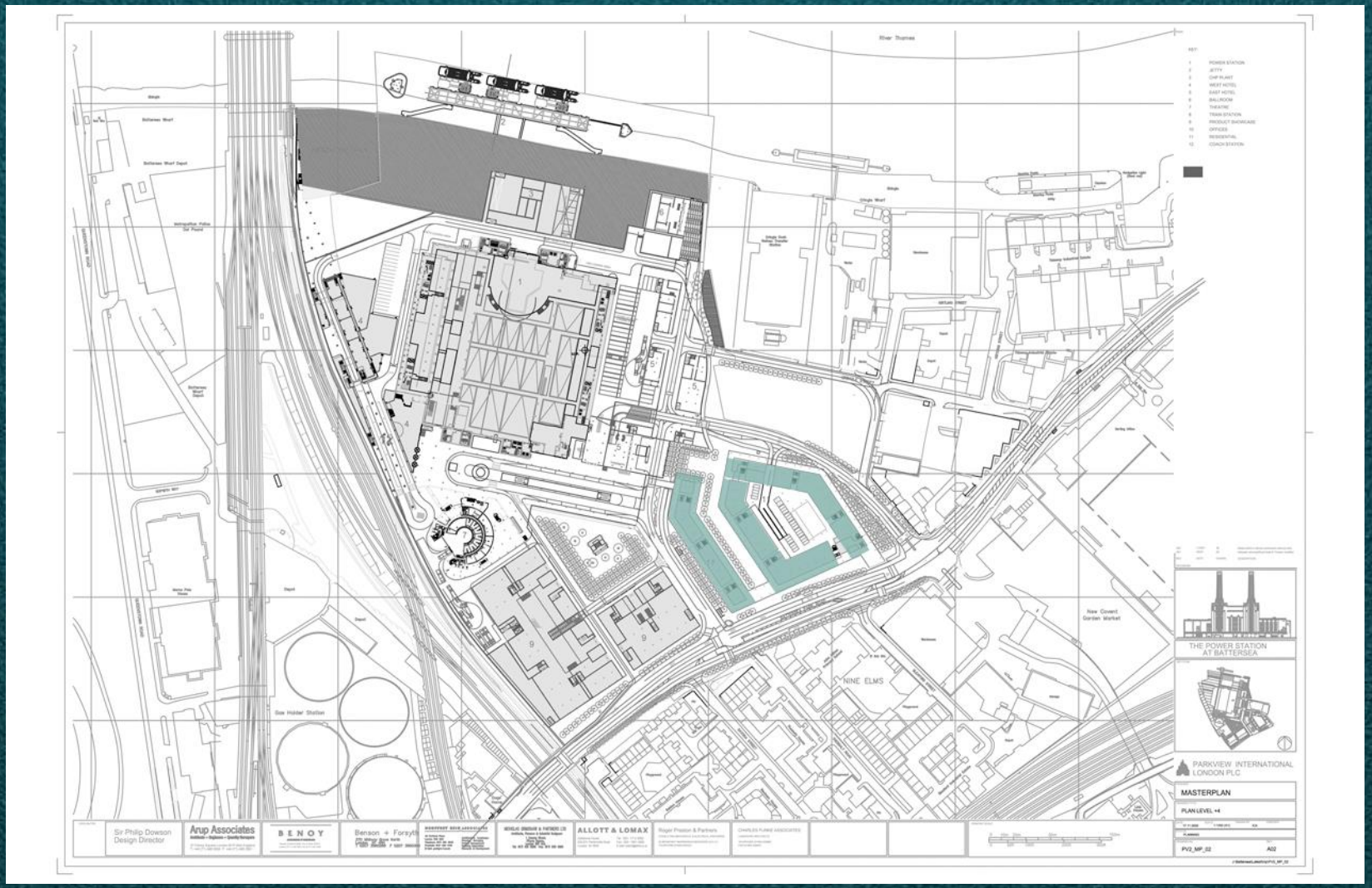
Pictures

- Rendering of building entrance.

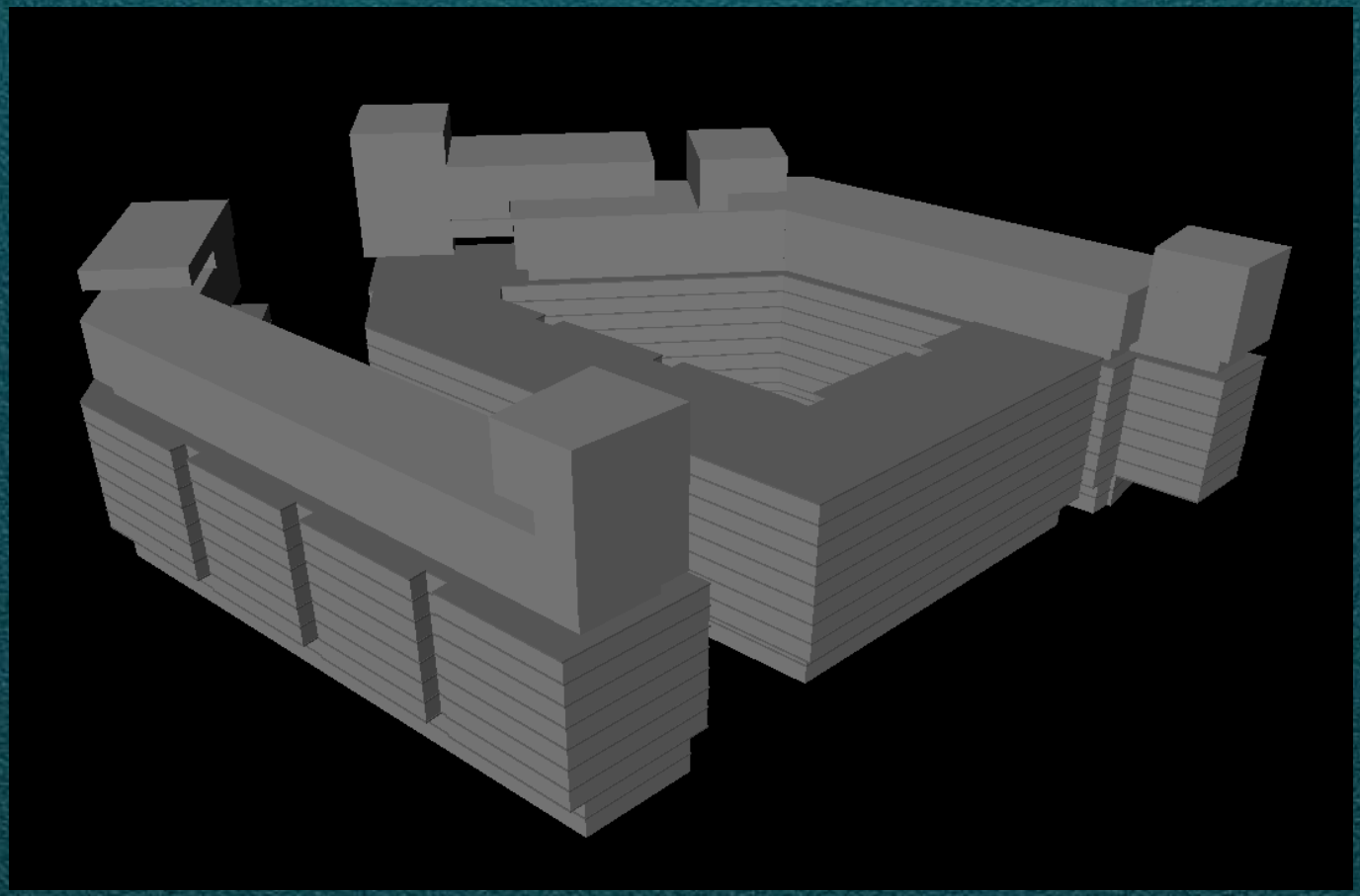
Battersea Power Station Residental Development

- Three apartment blocks as part of a larger redevelopment
- London, UK
- British Standard - BS 8206-2
  - Lighting For Buildings – Part 2: Code of Practice for Daylighting
- Goal: Determine compliance with the standard

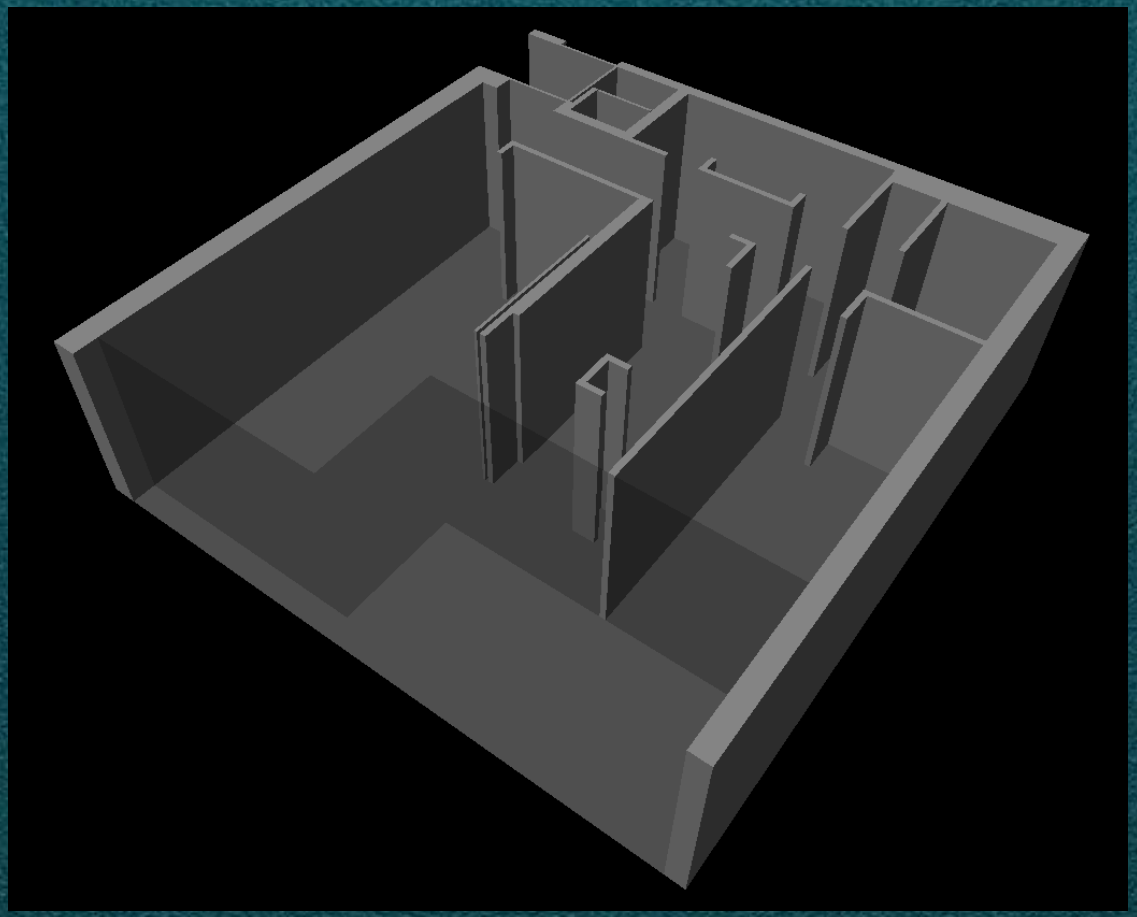
Site Plan


River Thames
THE POWER STATION AT BATTERSEA
PARKVIEW INTERNATIONAL LONDON PLC
MASTERPLAN
PLAN LEVEL +4
PV2_MP_02
A02
Sir Philip Dowson Design Director
Arup Associates
BENOY
Benson + Forsyth
ALLOTT & LOMAX
Roger Preston & Partners
CHARLES FUNKE ASSOCIATES
NINE ELMS
New Covent Garden Market
Gas Holder Station

Apartment Blocks



Individual Apartments



Model Detail

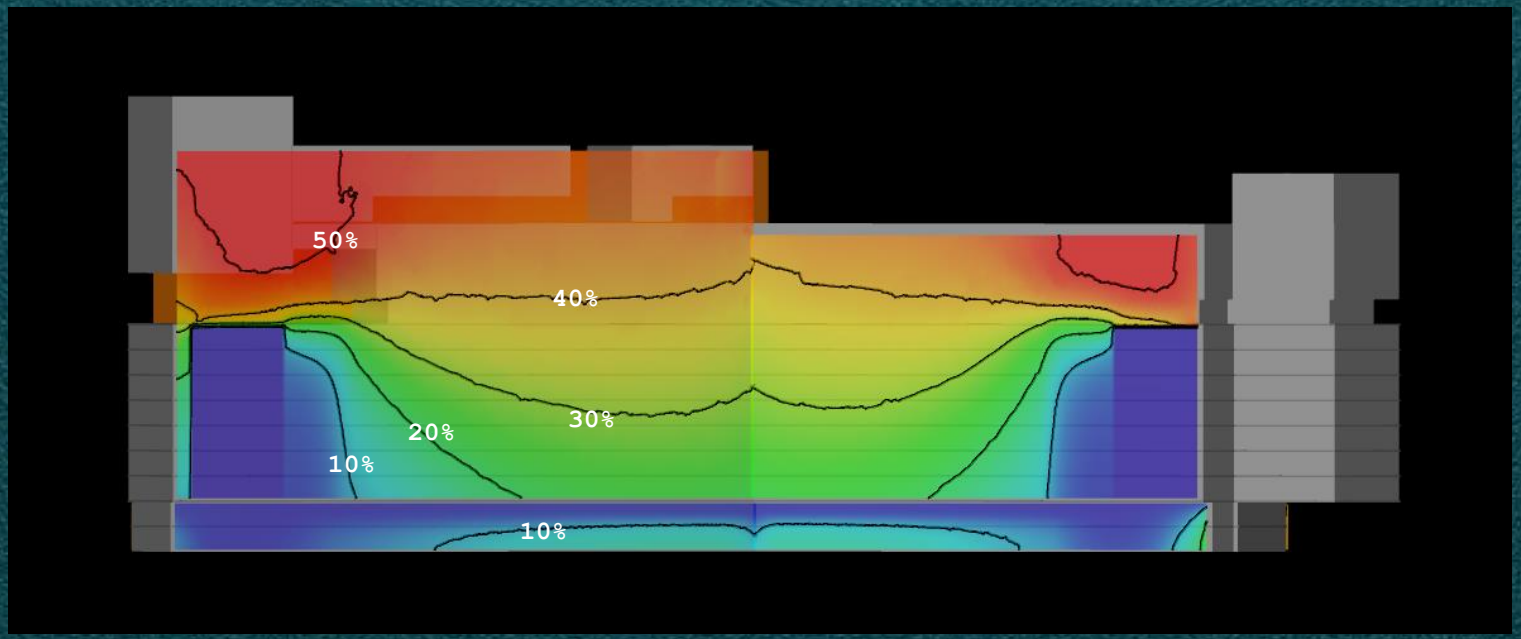
- Early study
- Very simplified model
- Assumptions for materials
- Not included:
  - Façade screen
  - Surrounding buildings

Goals

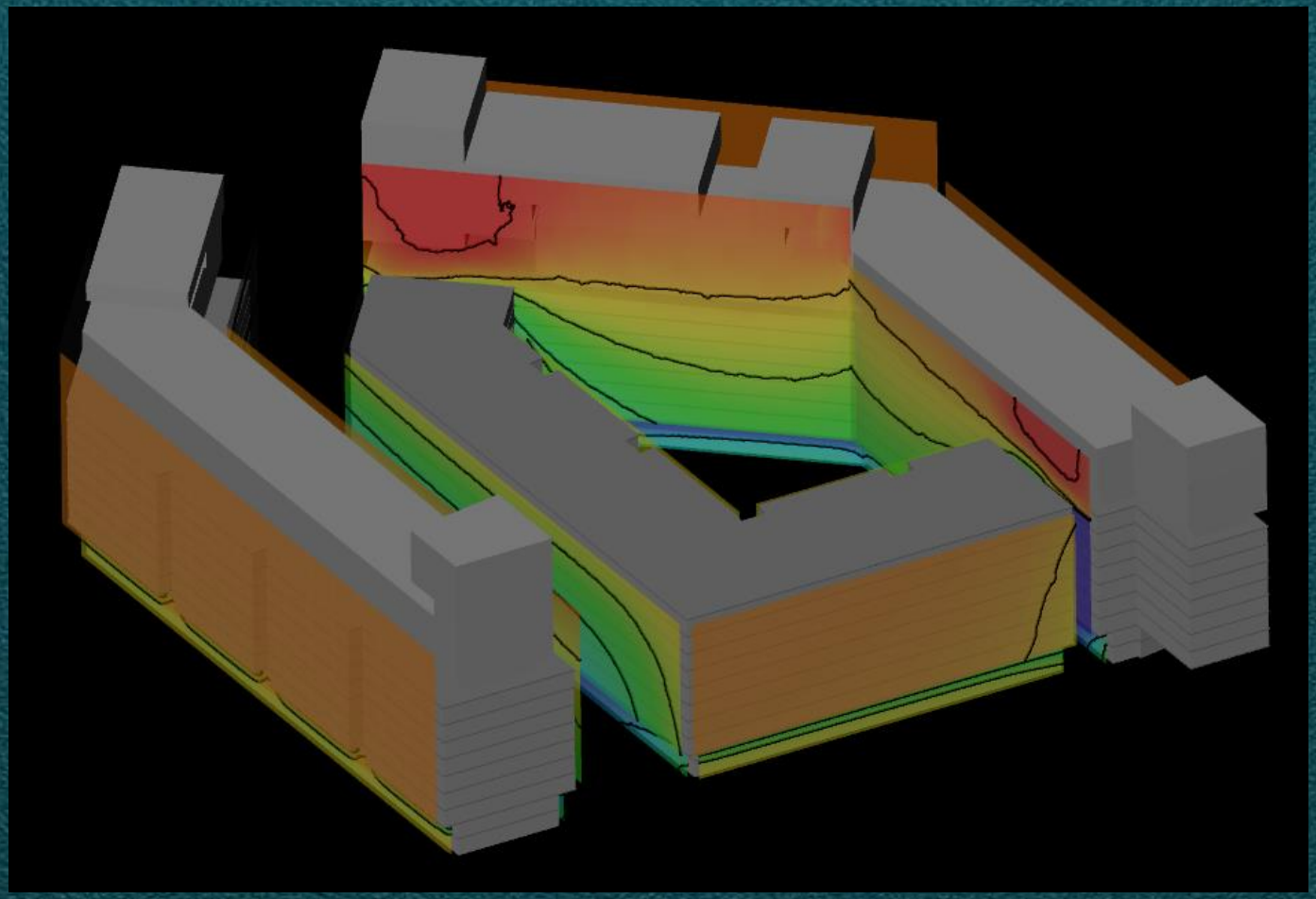
- Determine compliance with British Standard for Daylighting
  - Step 1 – Determine “worst case” apartments
  - Step 2 – Calculate daylight factor in “worst case” apartments
  - Step 3 – Produce “Compliance Contours”
  - Step 4 – Determine percentage possible sunlight in “worst case” apartments

Step 1 – Determine “Worst Case” Apartments

- Daylight factor distribution on each façade
- Overcast sky model

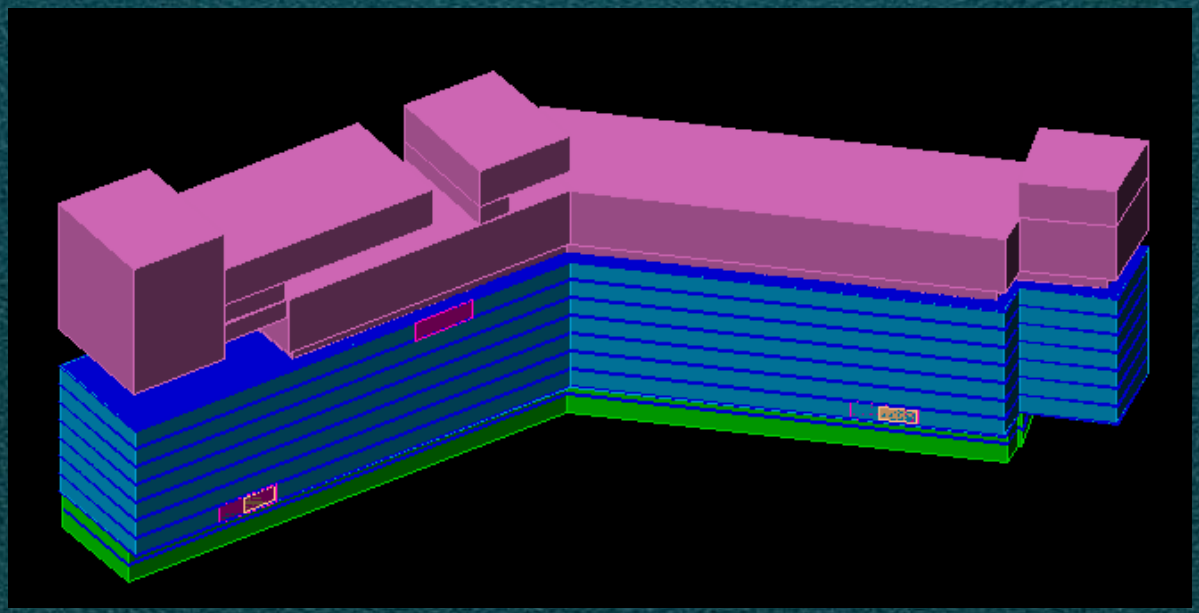


Step 1 – Determine “Worst Case Apartments”



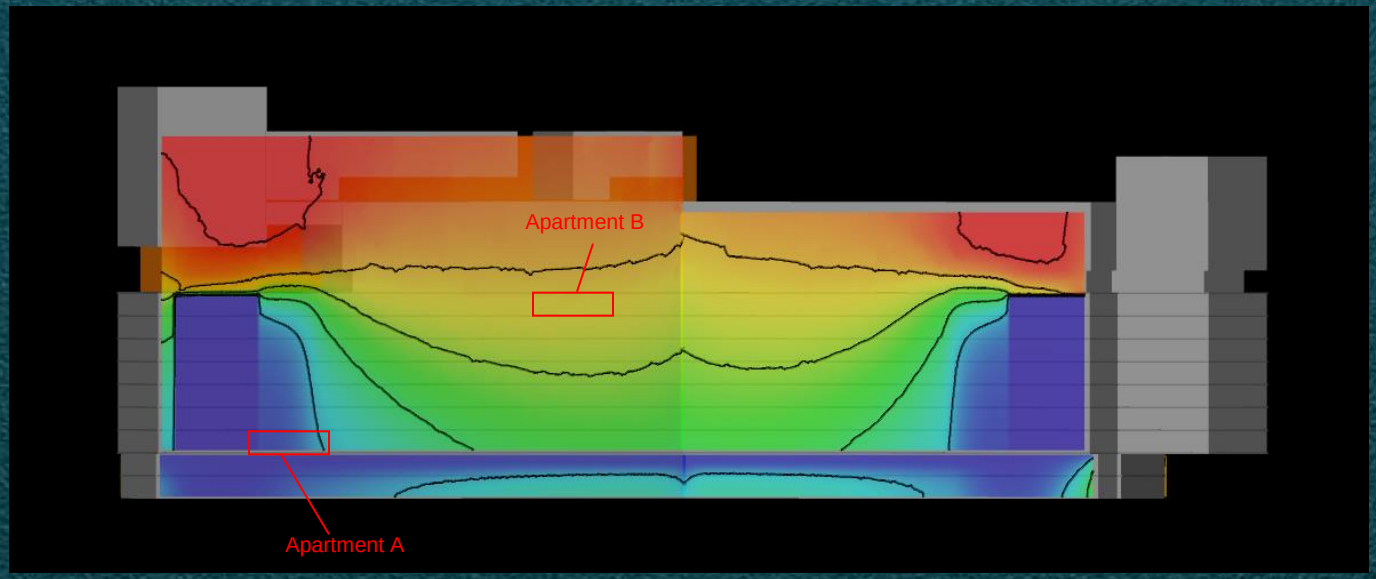
Step 2 – Calculate D. F. in "Worst Case" Apartments

- Model built as simple blocks (no interior)
- Use `mkillum` to "capture" daylight distribution landing on façade



Step 2 – Calculate D. F. in "Worst Case" Apartments

- Apply `mkillum` distribution to individual apartment model
  - 1 model – many possible distributions
  - Hand edited `mkillum` output



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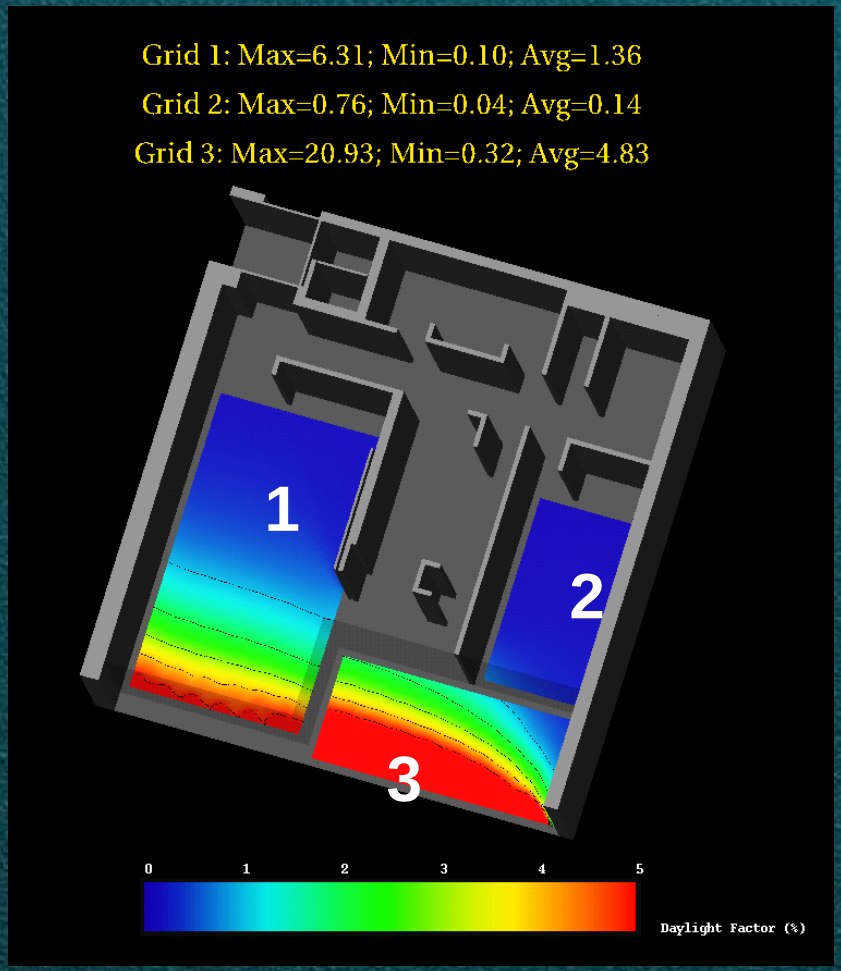
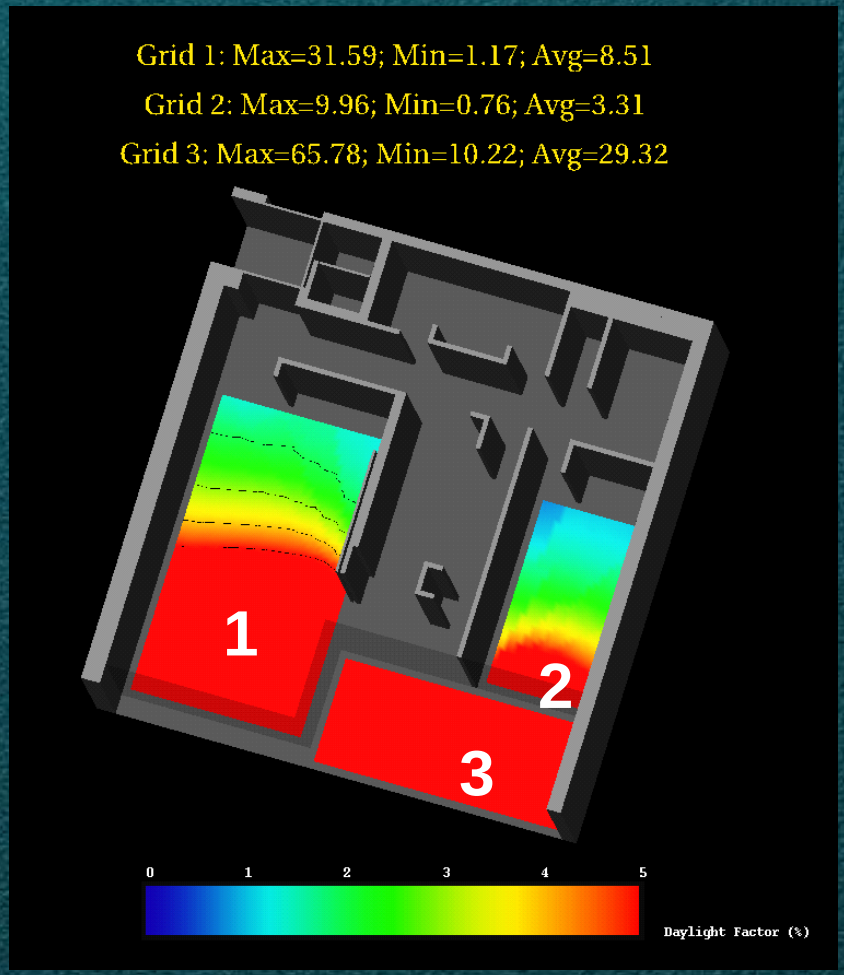


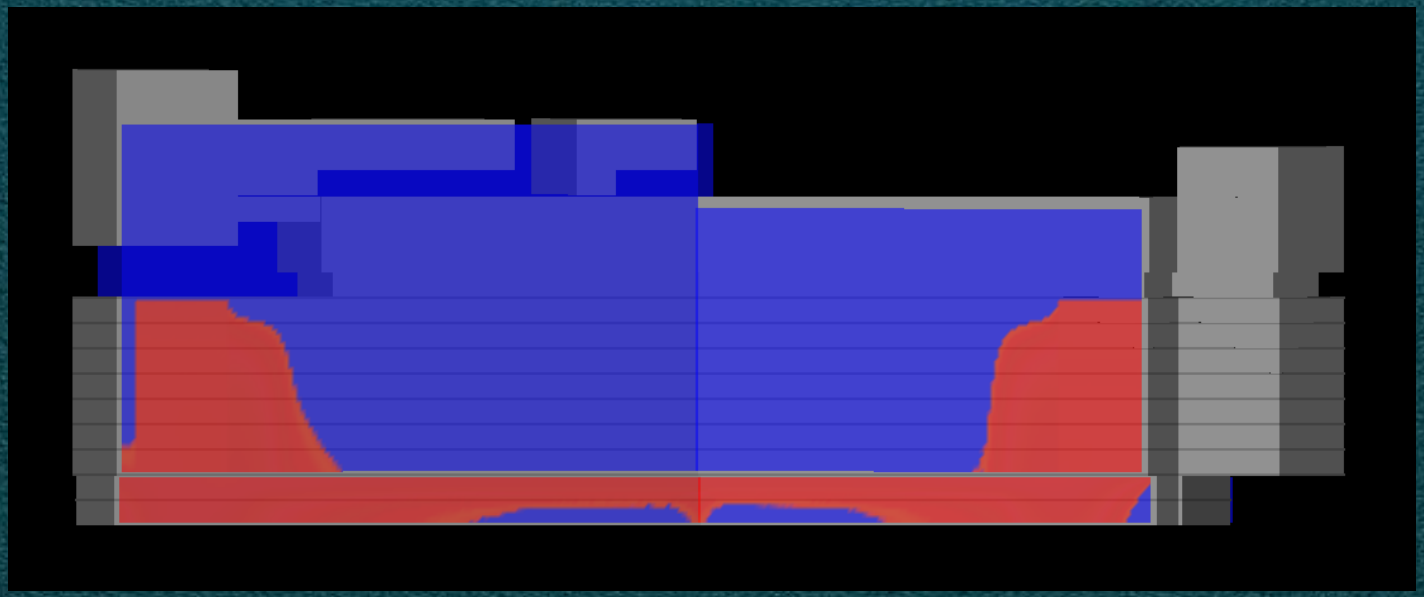
Apartment A



Apartment B

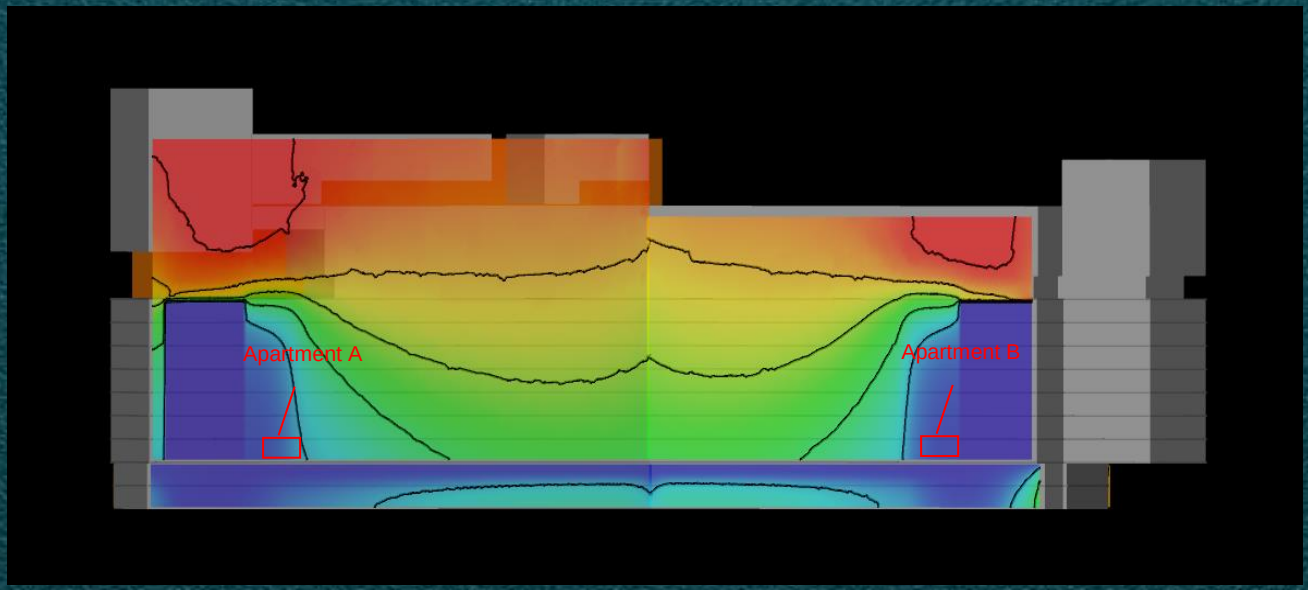
Step 3 – Produce “Compliance Contours”

- Determine relationship between daylight factor on façade and daylight factor in apartment
  - Bedroom: 1% minimum average d.f.
  - Living Room: 1.5% minimum average d.f.

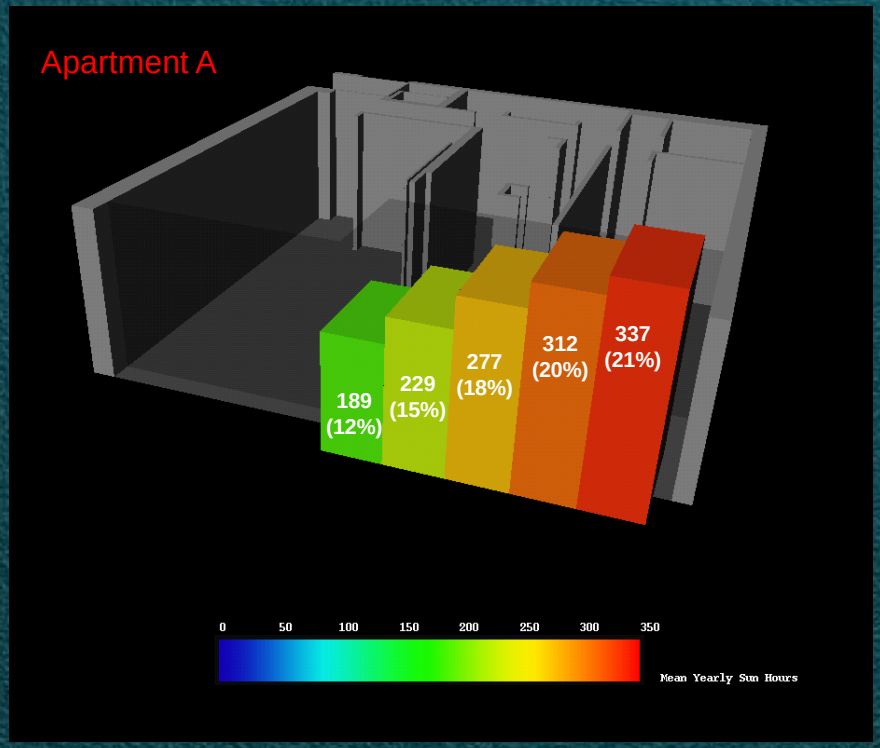


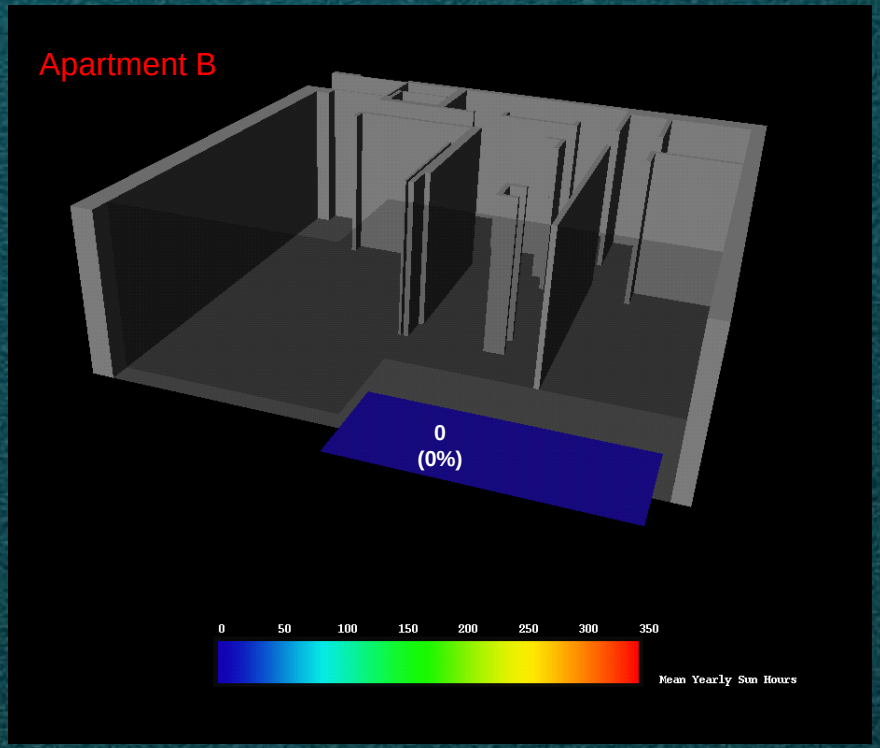
Step 4 – Percentage possible sunlight

- Calculated for balcony area only
- Simplified model using monthly probabilities
- Minimum 25% possible hours



Step 4 – Percentage possible sunlight





Acoustical Reflector Analysis

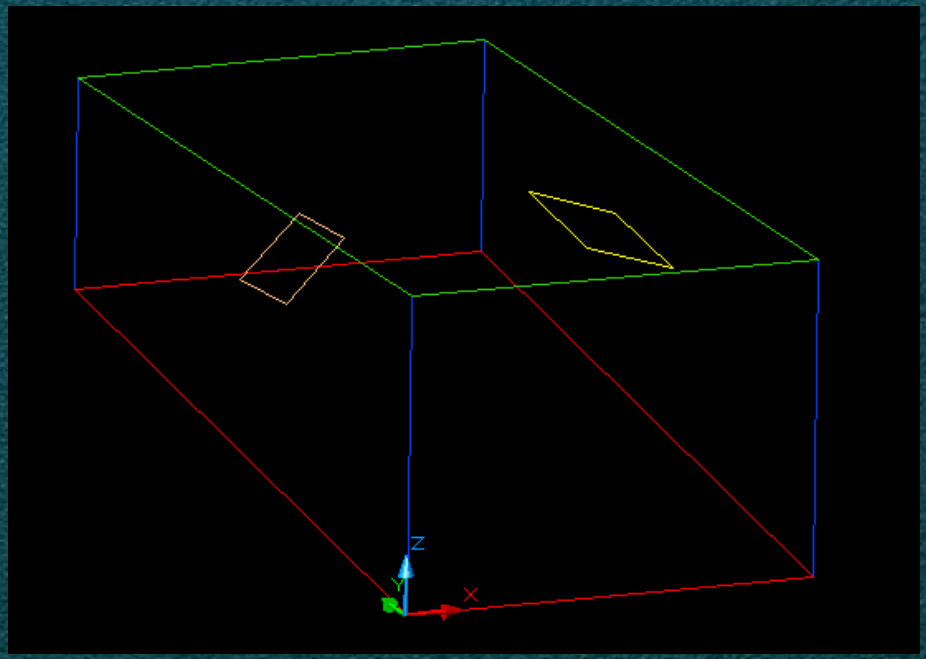
- **Problem**
  - **Need method to show patterns of acoustical reflector coverage in a 3D model**
  - **Apparently no available acoustical software to do this**
- **Why use *Radiance*?**
  - **Easy to model complex spaces**
  - **Acoustical reflections similar to light reflections**
  - **Ability to change image generating parameters**
    - Material properties
    - Exposure
    - Combining images

Early development of process

- First try – not very successful
  - Acoustical source modeled as light source
  - Acoustical reflectors modeled as mirrors (colored)
  - Single model, single rendering
  - Visibility of reflected patches was a problem
- Second try – split renderings and combine later
  - More control over exposure
  - More post-processing options
  - More flexible

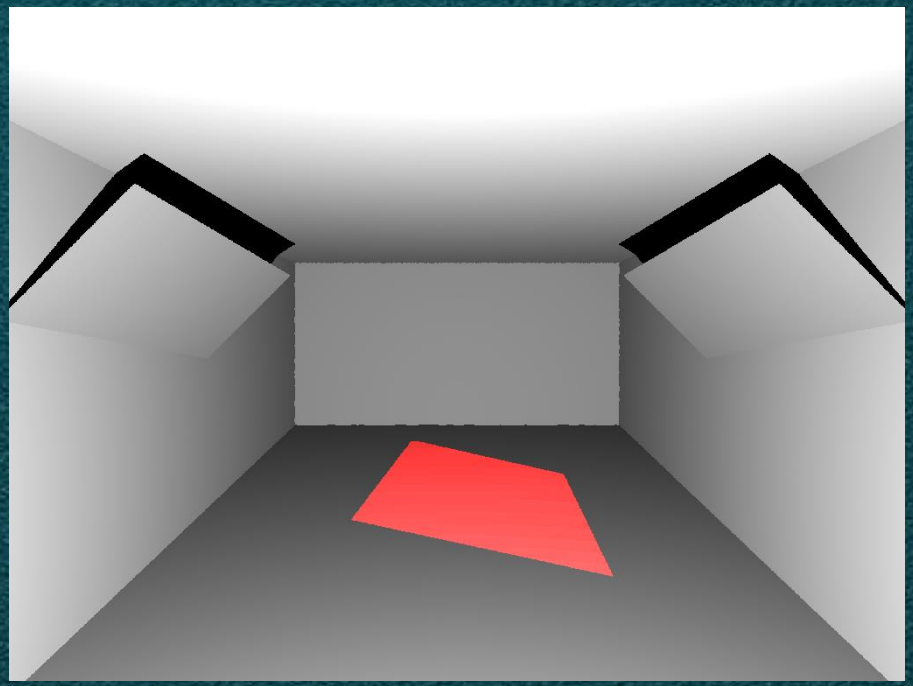
Simple test room

- Acoustical source – small “light” sphere
- Acoustical reflector – colored “mirror” with substituted plastic
- Floor, walls, ceiling – plastic



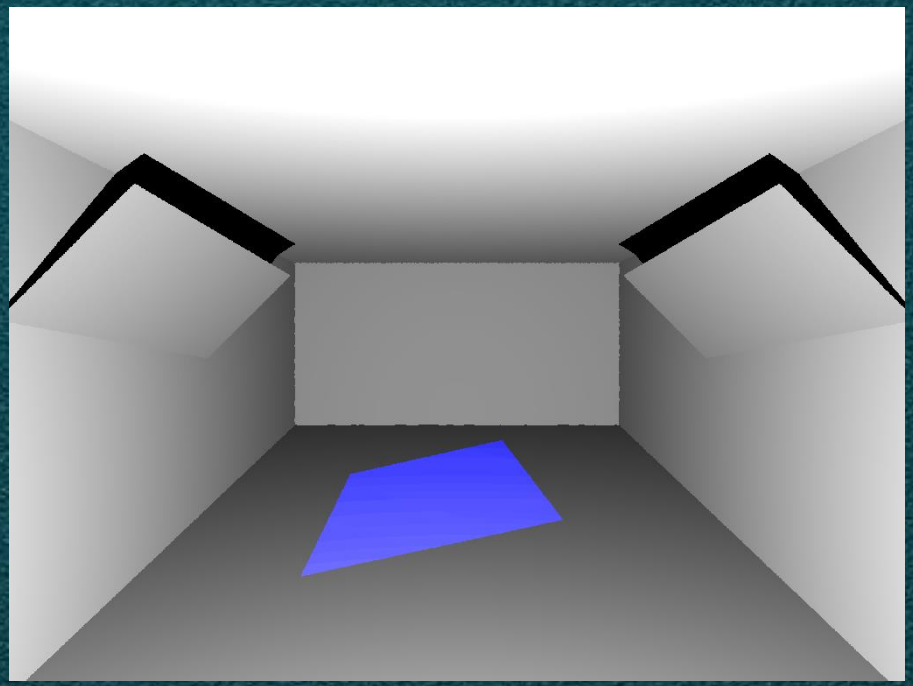
Red Reflector Image

- Right reflector as red mirror
- Left reflector as grey plastic
- Viewpoint just in front of source



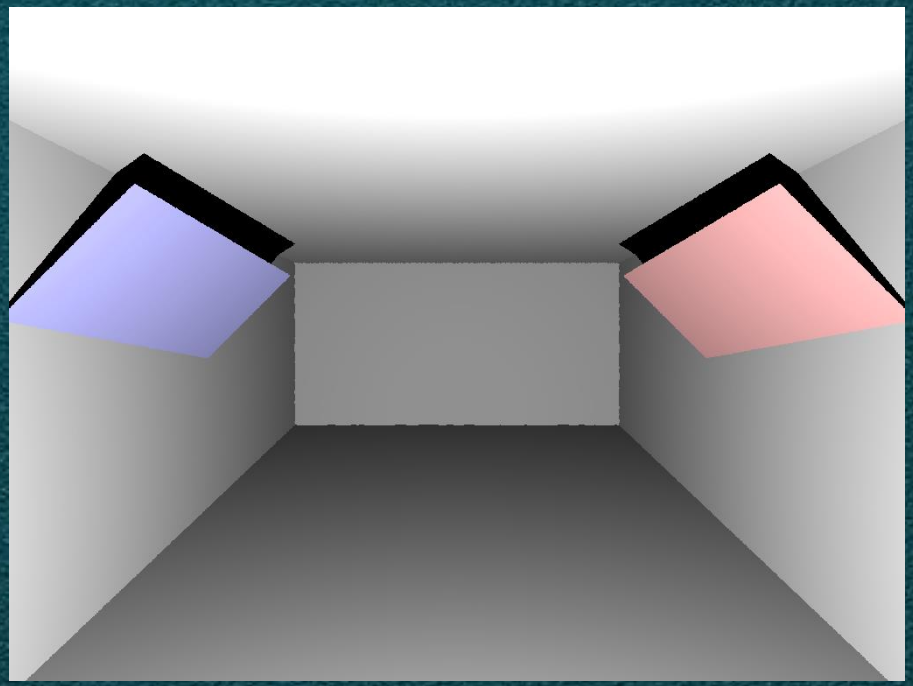
Blue Reflector Image

- Right reflector as grey plastic
- Left reflector as blue mirror
- Viewpoint just in front of source



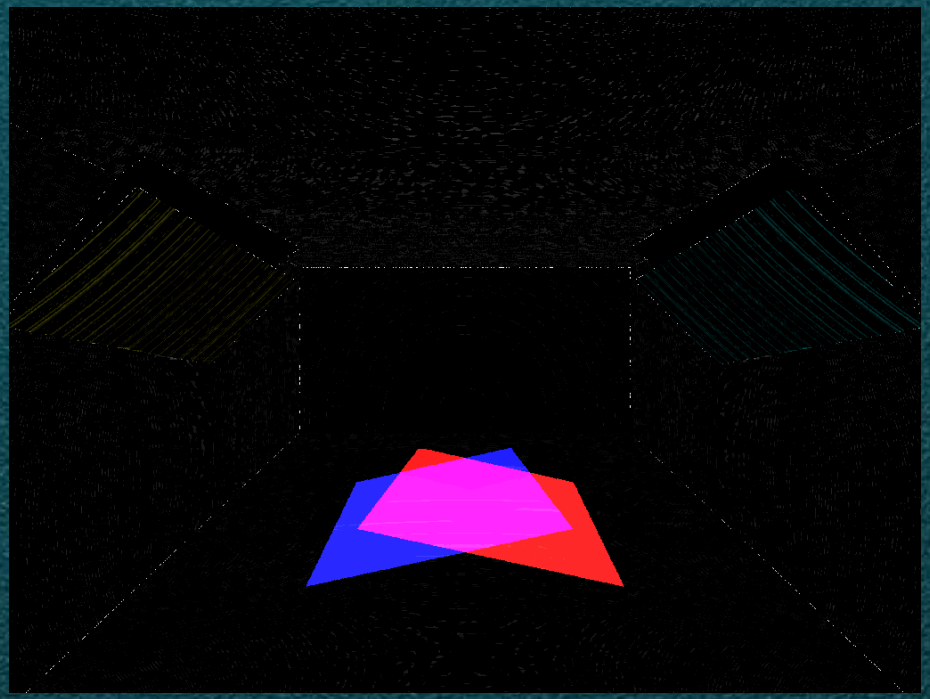
Diffuse Image

- Right reflector as red plastic
- Left reflector as blue plastic
- Viewpoint just in front of source
- Same light source



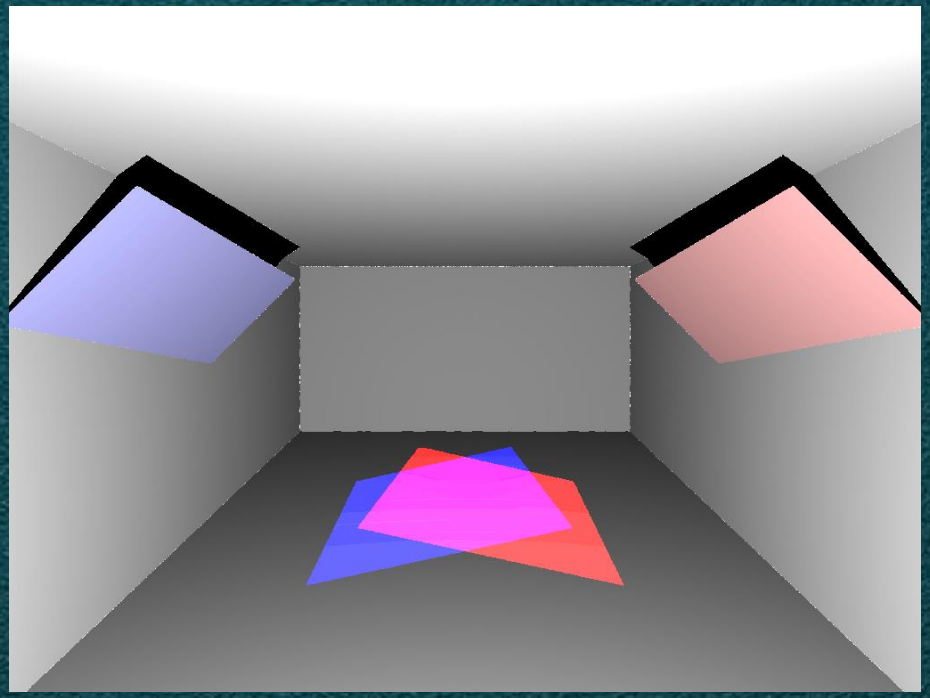
Subtract Ambient Light

- Leaves only reflected patches



Add Patches to Diffuse Image

- Visualization of reflector coverage in 3D space

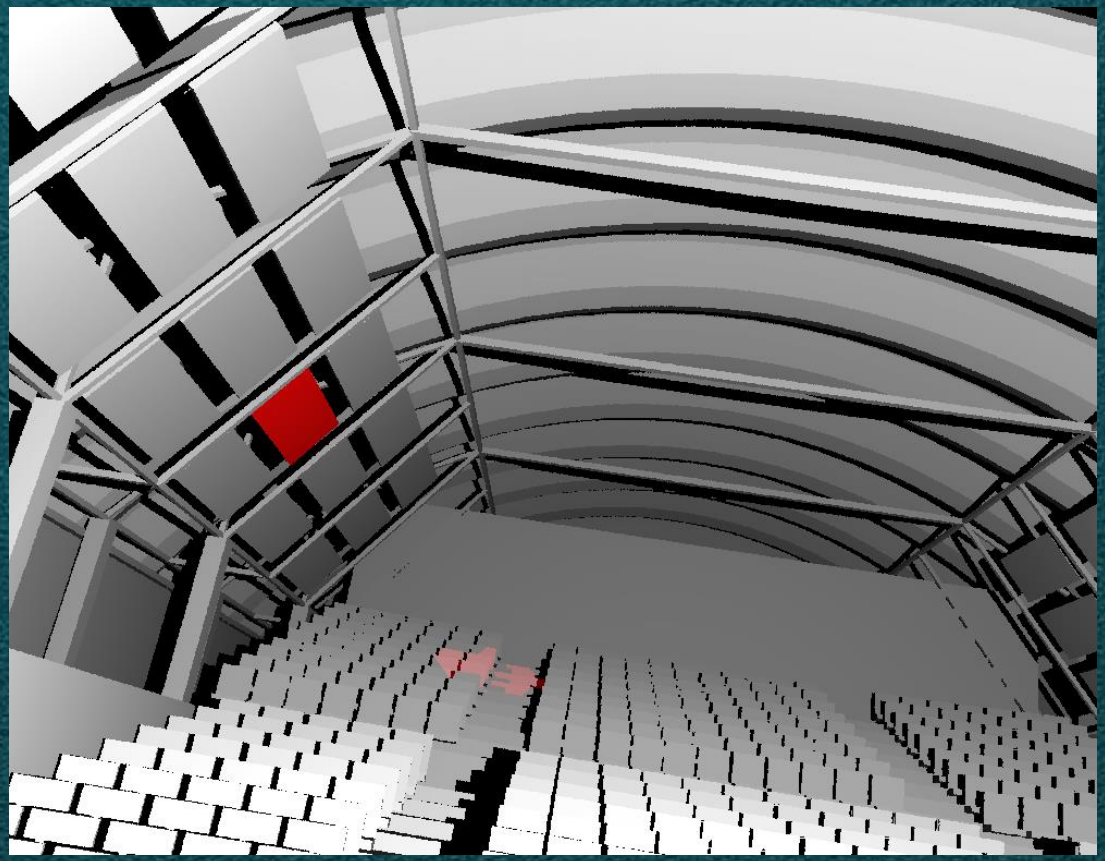


Next Steps

- More complex model
  - More reflectors
  - More colors
- Limitations
  - Reflectors should be smooth, not faceted
  - Limited number of colors
  - More colors makes a more complicated process for adding/subtracting images

Project Example

- Queen's Hall, Trinidad



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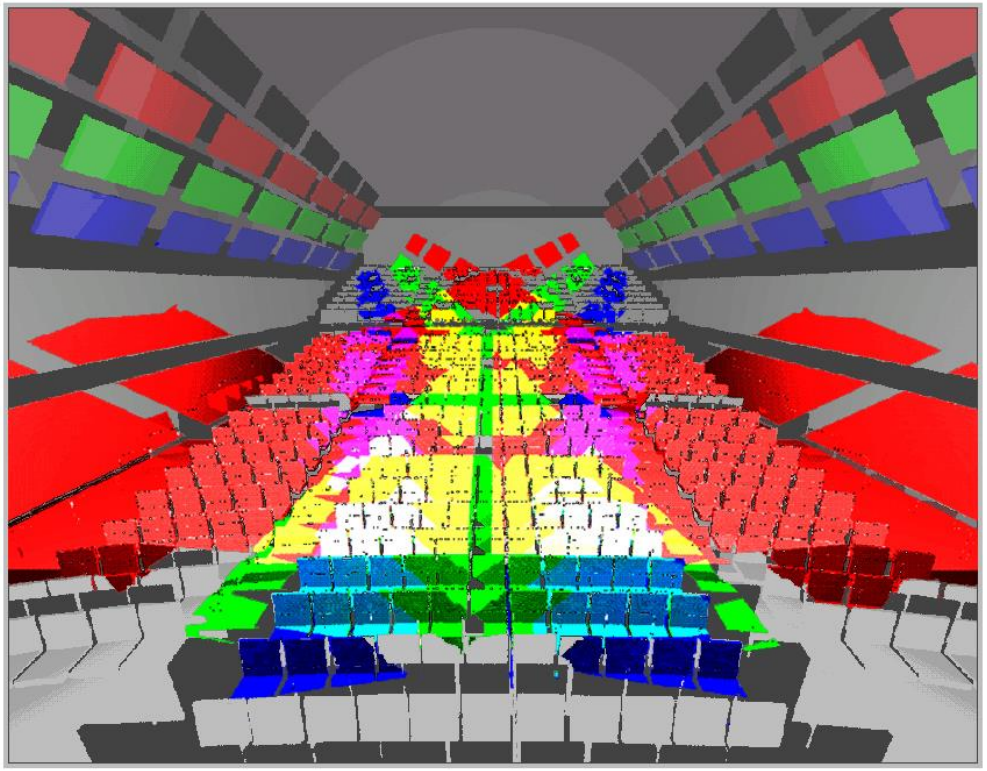
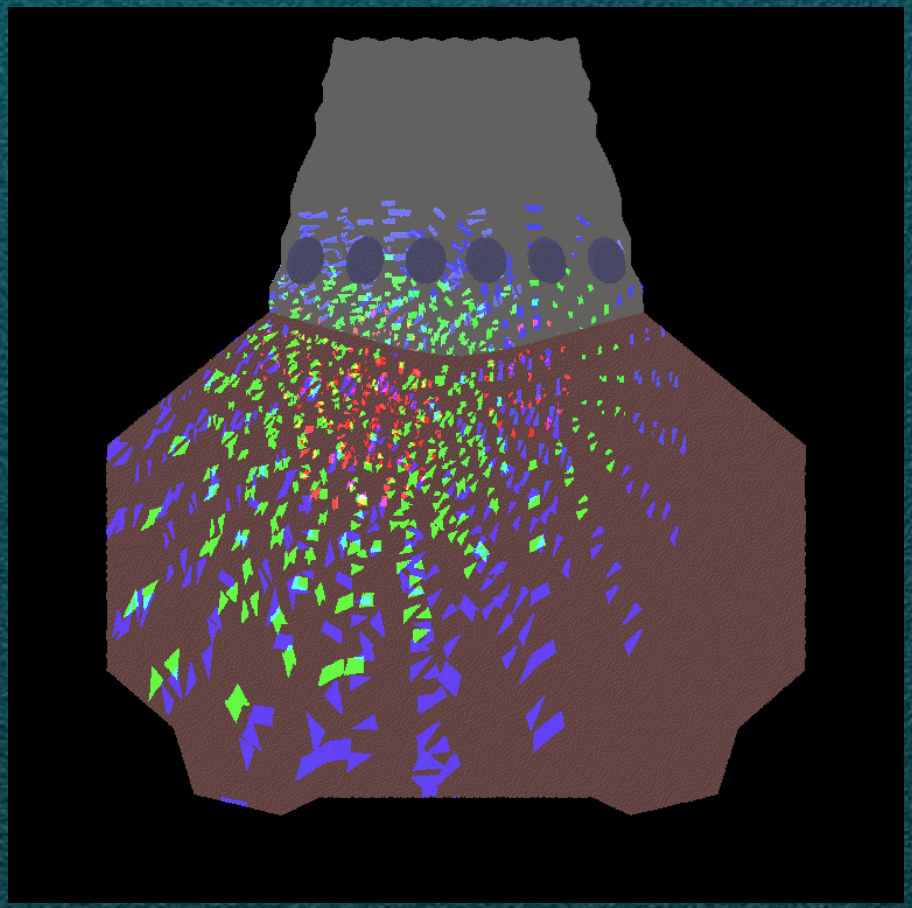
- Queen's Hall, Trinidad



Project Example

- Sydney Opera House



Project Example

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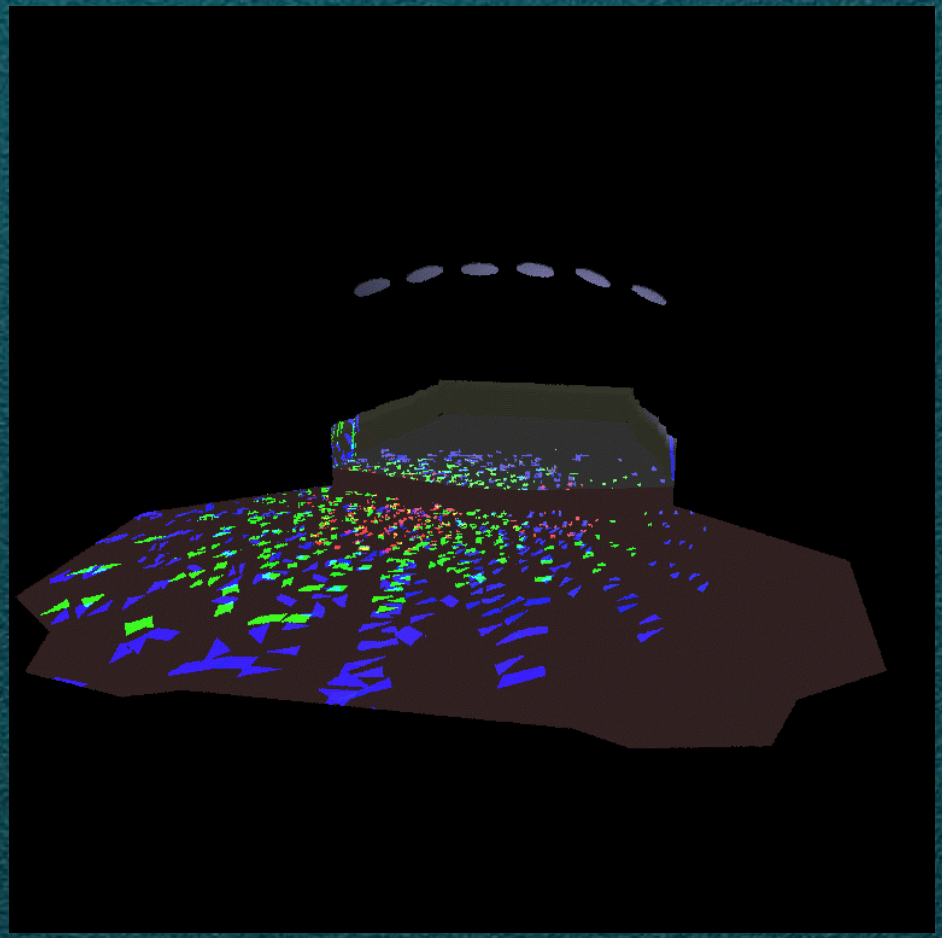

Thank You, any Questions?