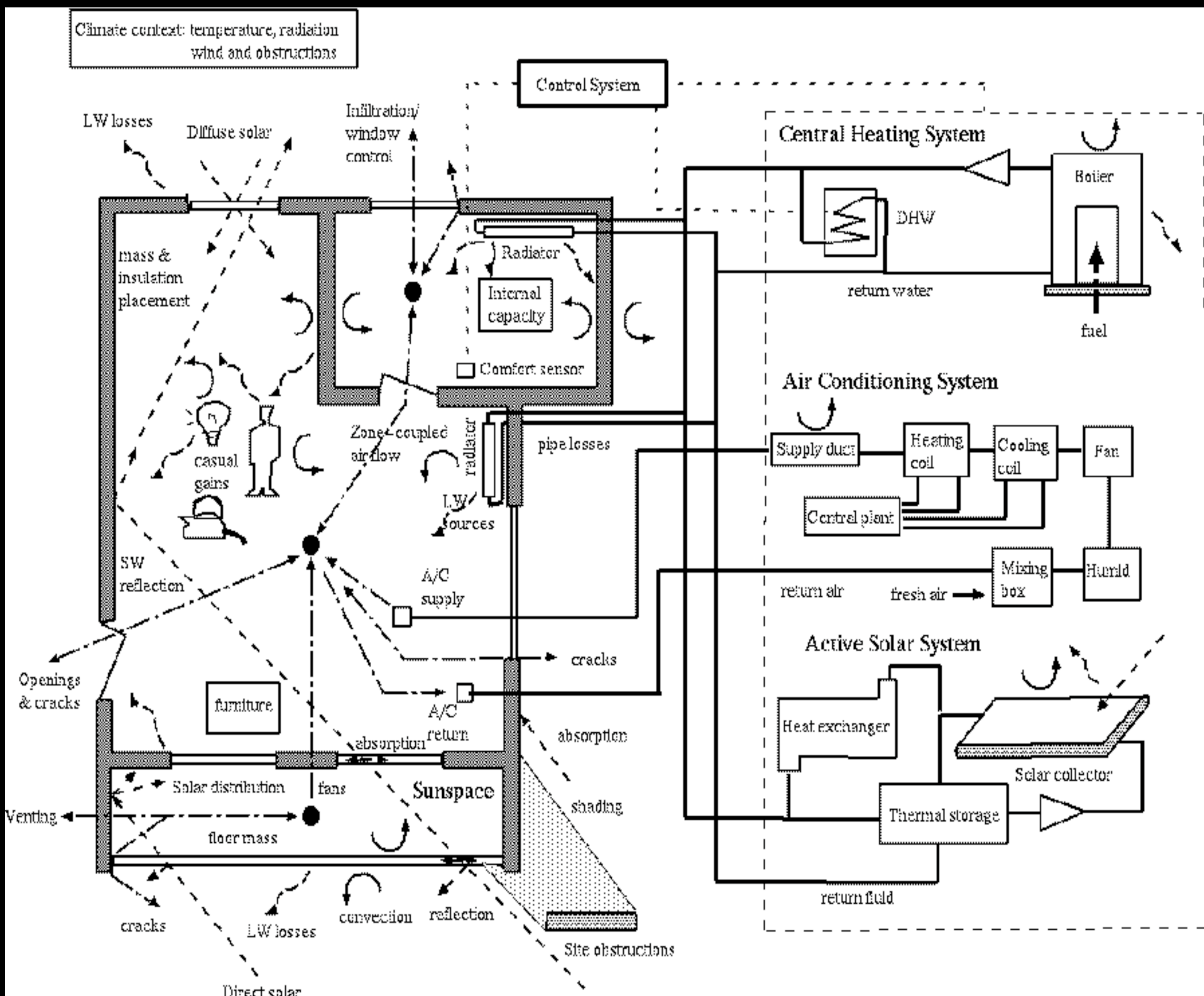
Integrated Building Simulation

Iain A Macdonald

Energy Systems Research Unit

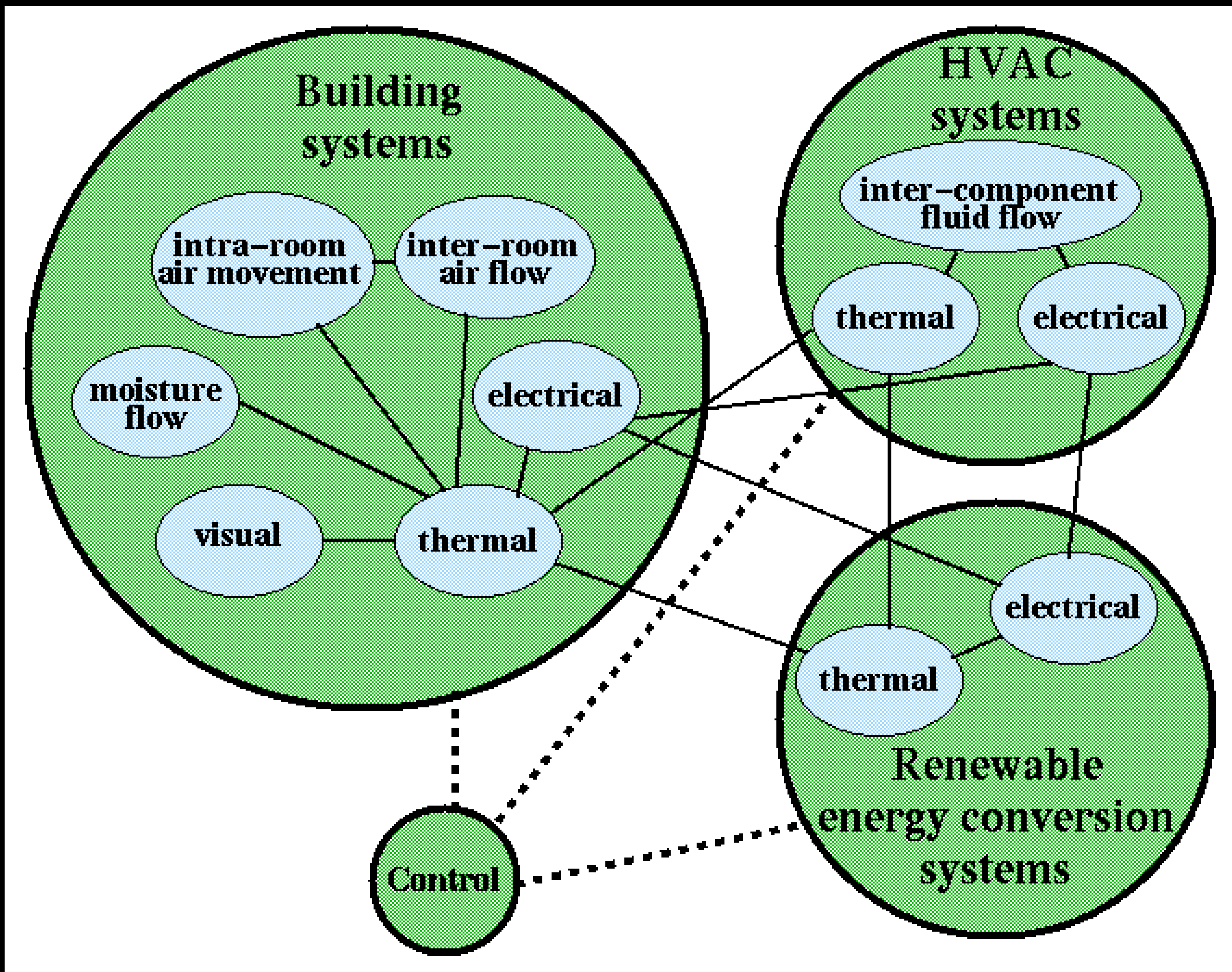
www.esru.strath.ac.uk

Integrated building simulation



- Buildings are complex.
- Interaction between systems.
- Detailed models of technical domains.

Technical domains



- Solar irradiance.
- Daylight availability.
- Artificial lighting.

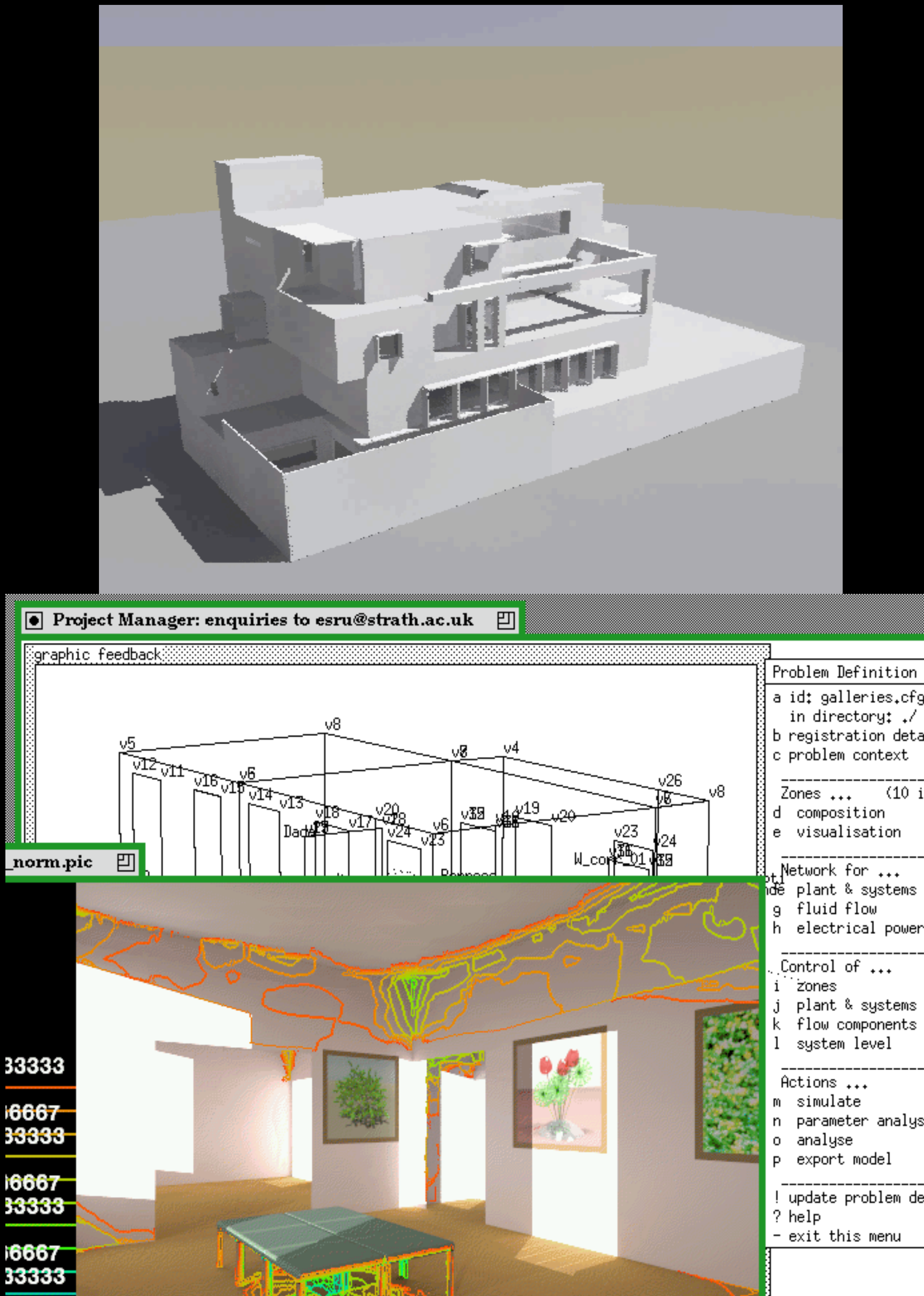
Integration

Advantages:

- ESP-r and Radiance are based on fundamental physical models,
- Both tools open source, well used and validated, and
- Quicker developments possible.

Disadvantages:

- Must ensure consistency between data models.



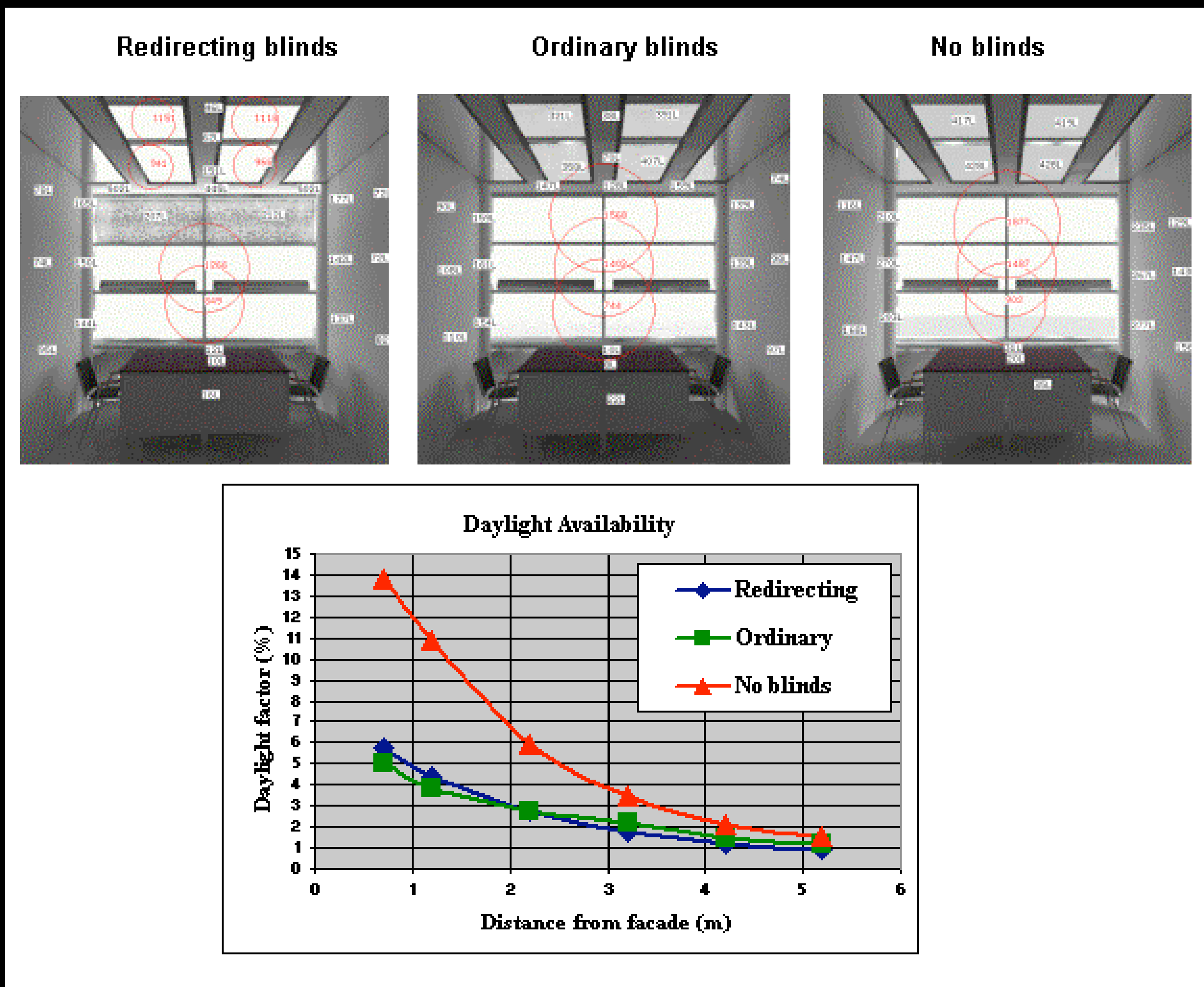
History

Work started as an Msc project in 1993.

Further developments through 1990s in EU funded projects.

Development continues at present on an ad hoc basis to take advantage of new Radiance features.

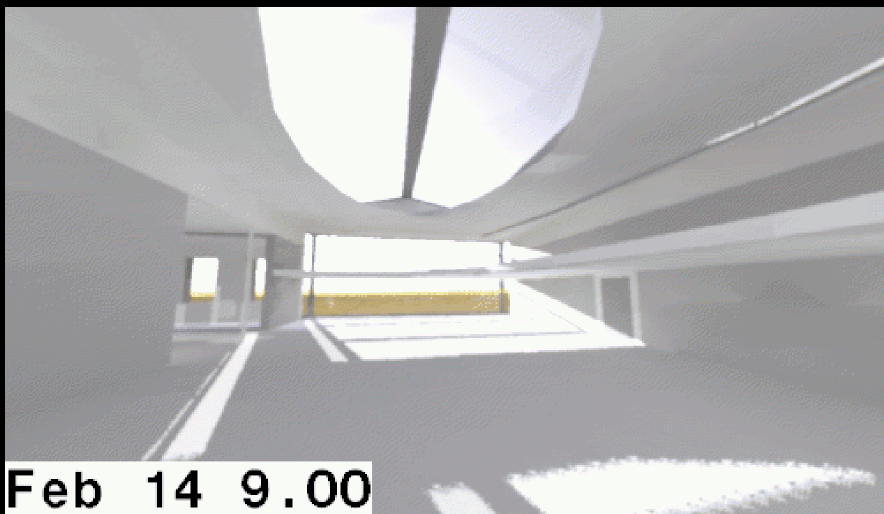
Controlling Radiance

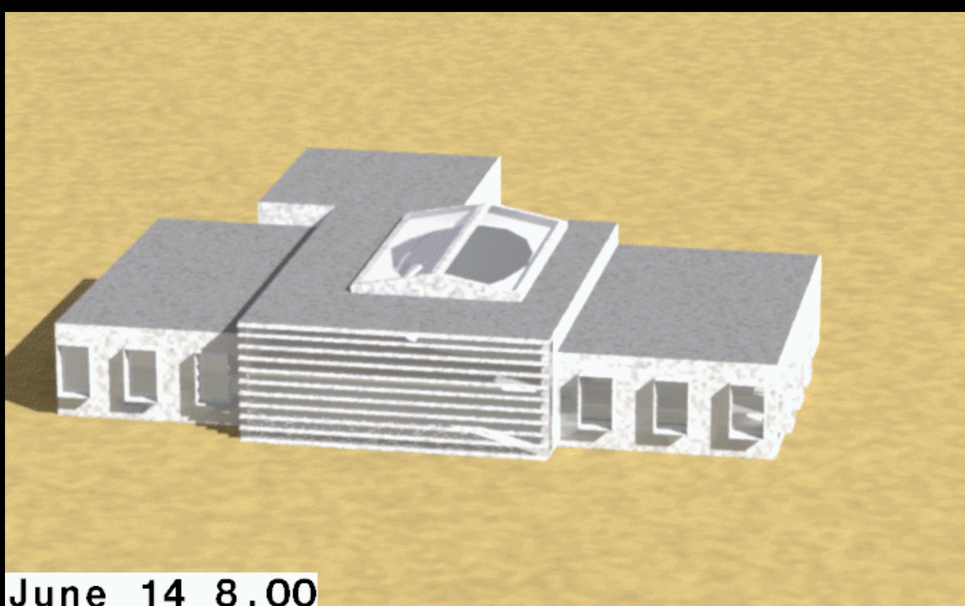


Need to define purpose:

- Internal view,
- External view,
- Daylight factors,
- Glare, or
- Control sensor.

Internal/external views

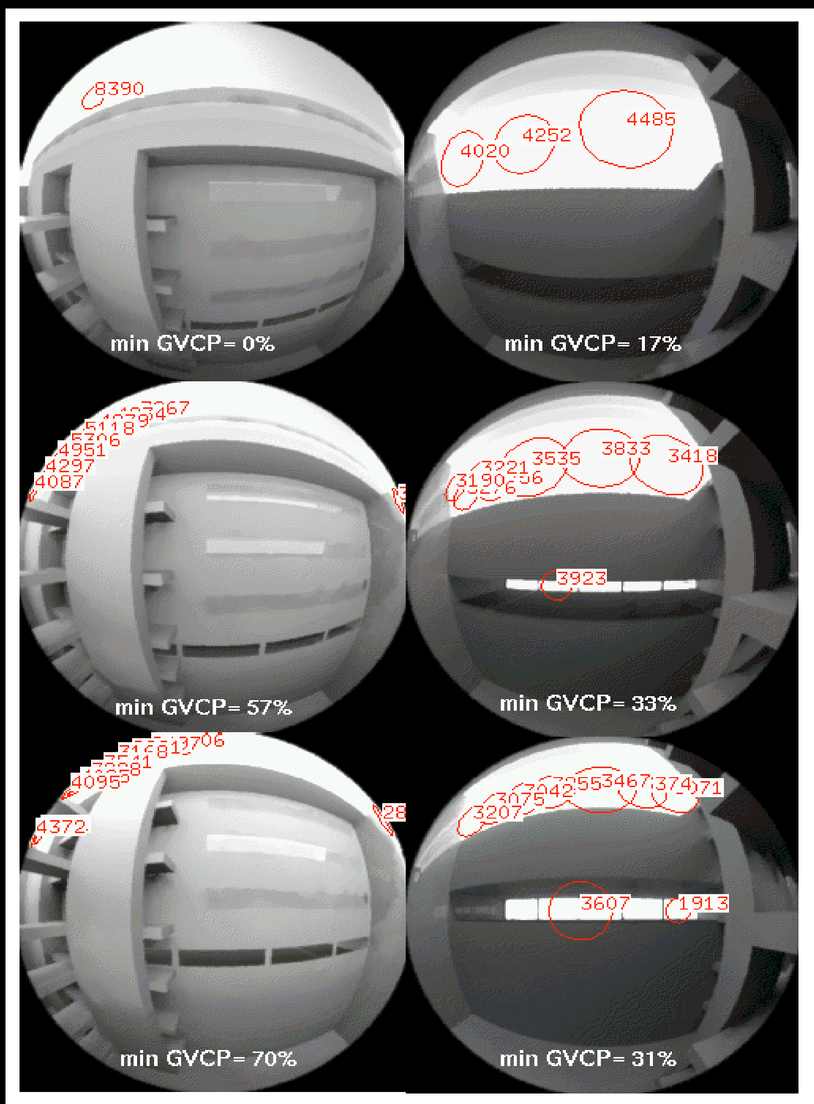




Cheap and cheerful images:

- av set to default values (1 or 10),
- Image quality and detail level set to medium, and
- Illuminance variation set to high.

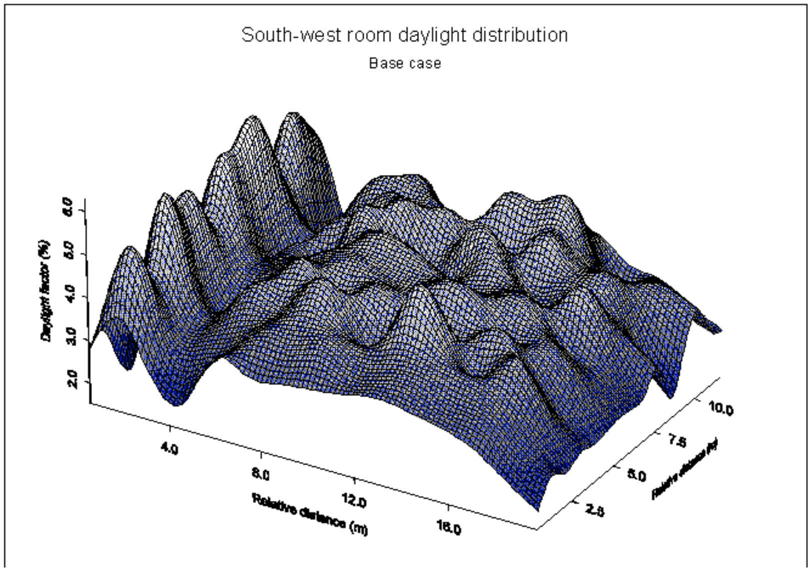
Glare assessment

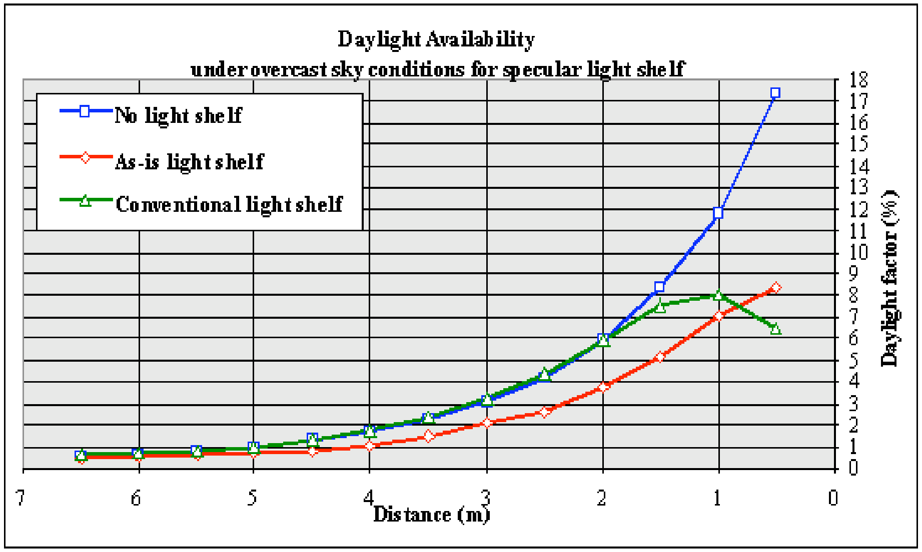


Accurate renderings required:

- Ambient bounces permitted
- av set to 0.0
- Image quality, variability and detail as before.
- UGR default glare quantification.

Daylight factors

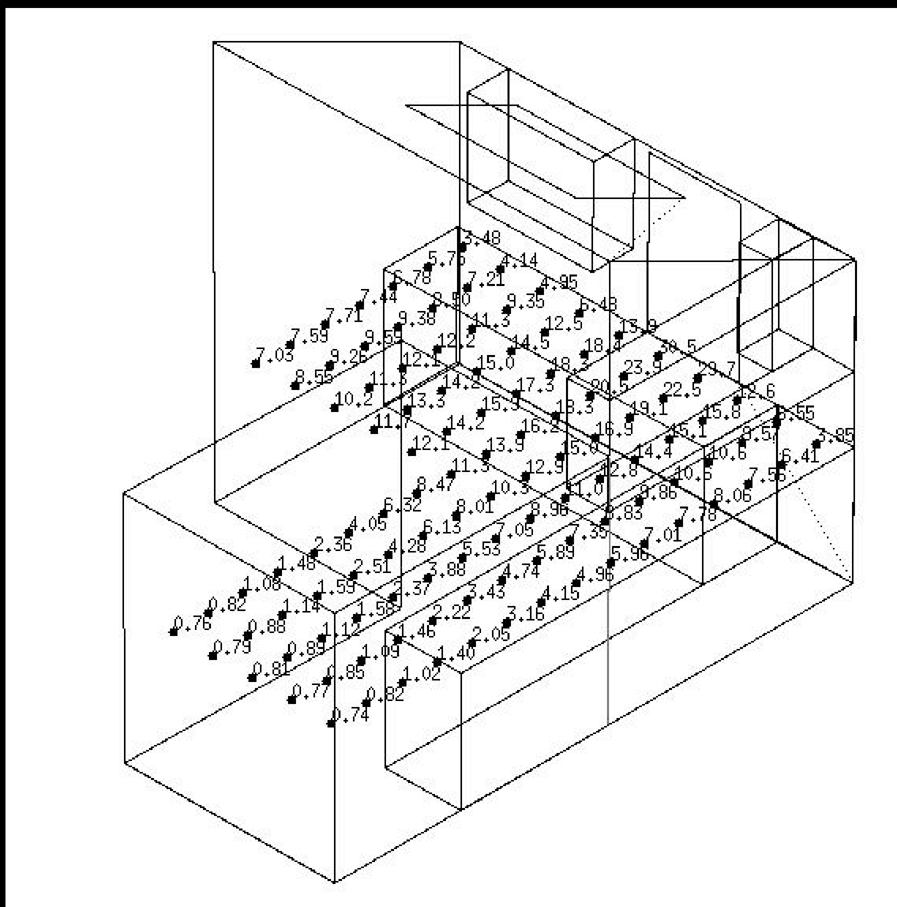




Accurate ray tracing with rtrace:

- Use rad to set majority of parameters, and
- Iterative approach adopted to set ambient parameters.

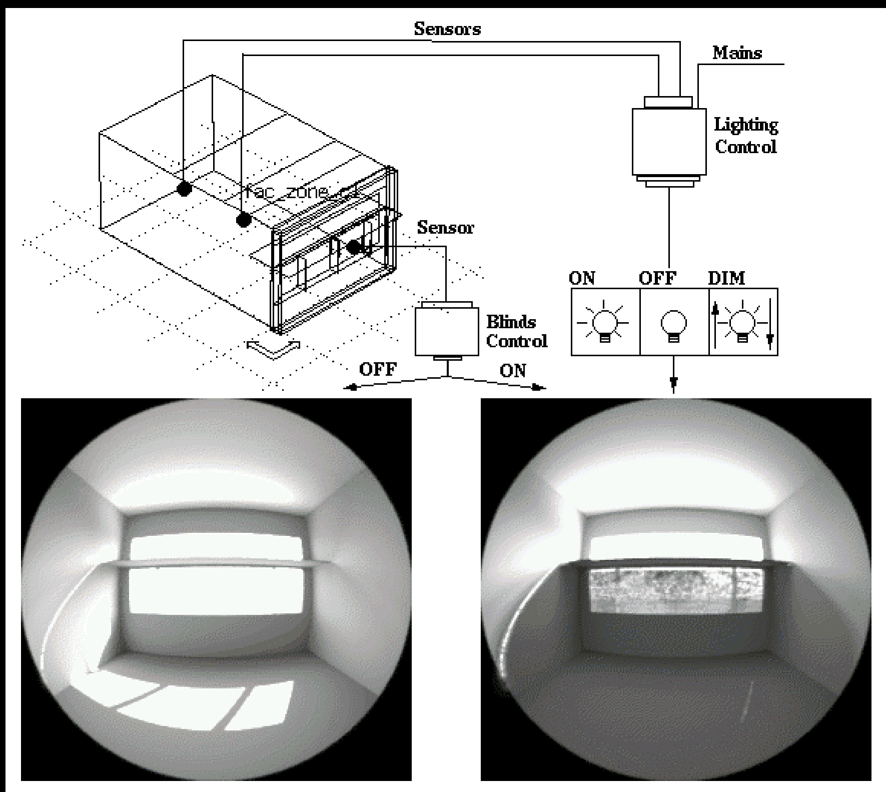
Daylight factors



Iterative approach:

- *ab*=1, *ad* and *as* set by rad,
- Double value of ad until converged,
- Now double as (limit of ad/2), and
- Finally increase ab.

Luminaire control

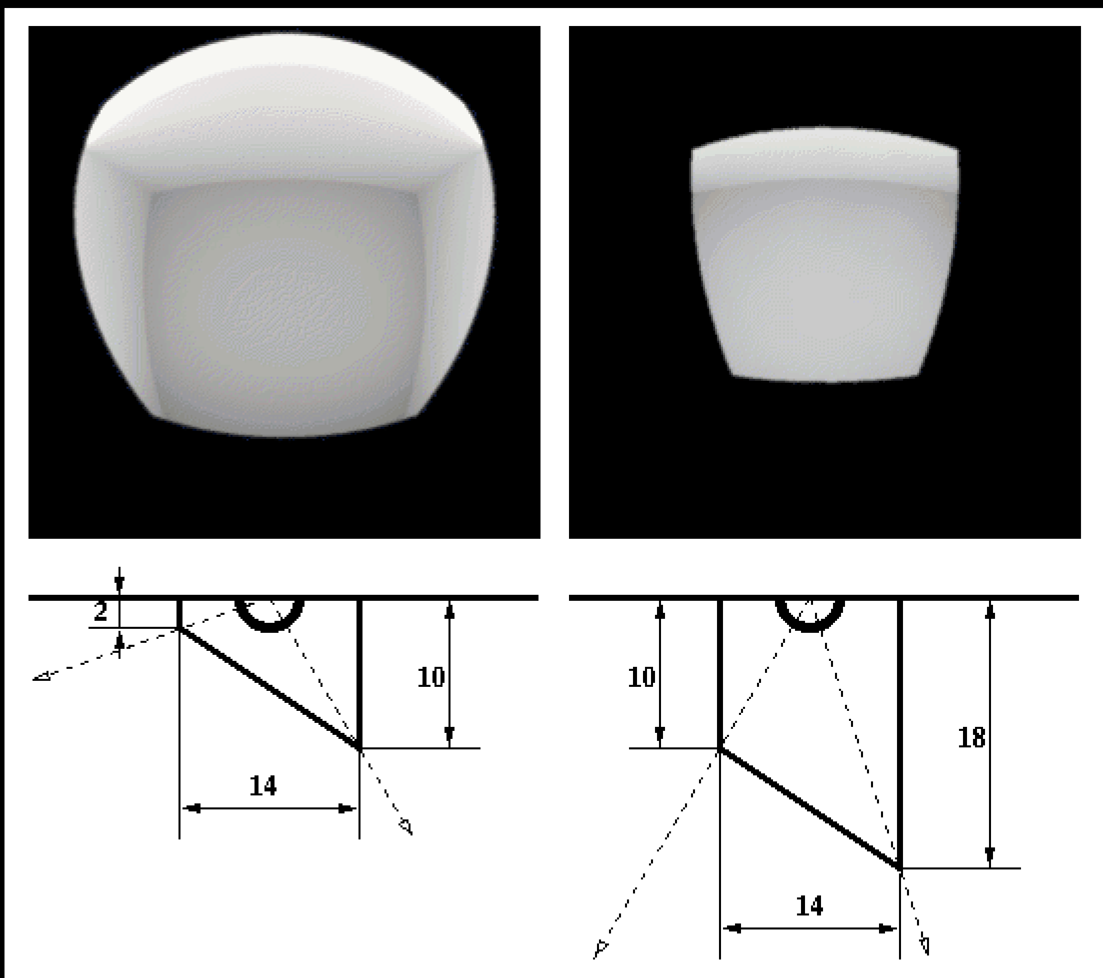


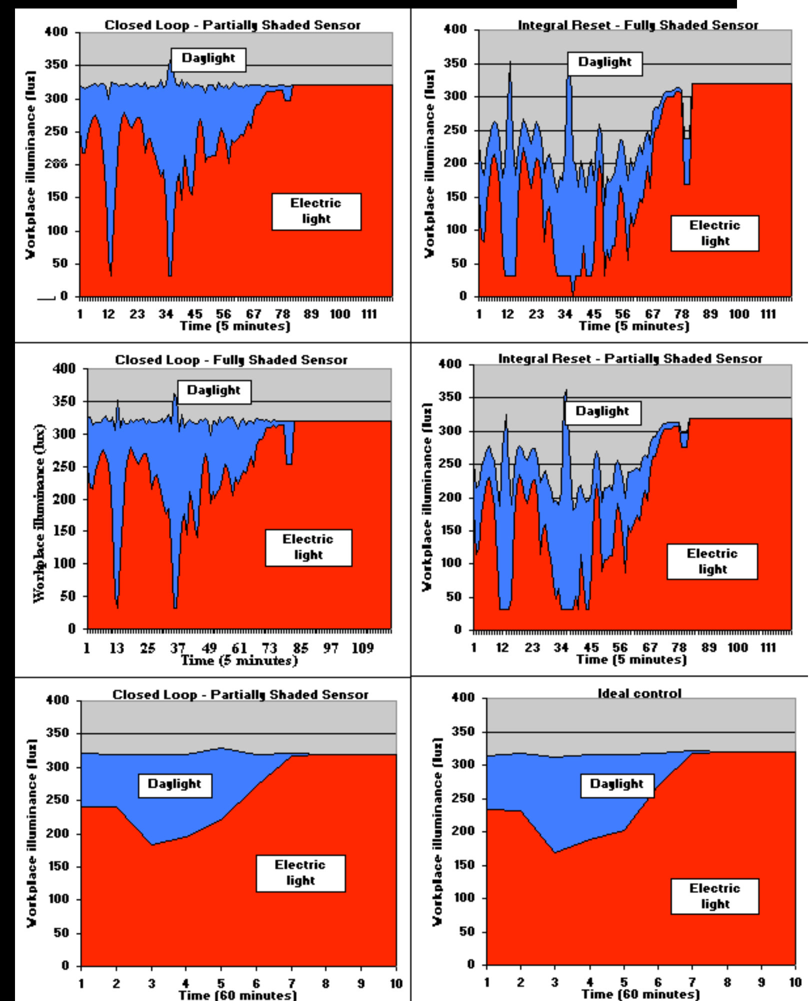
Radiance used to calculate sensed illuminance.

Arbitrary complexity accommodated.

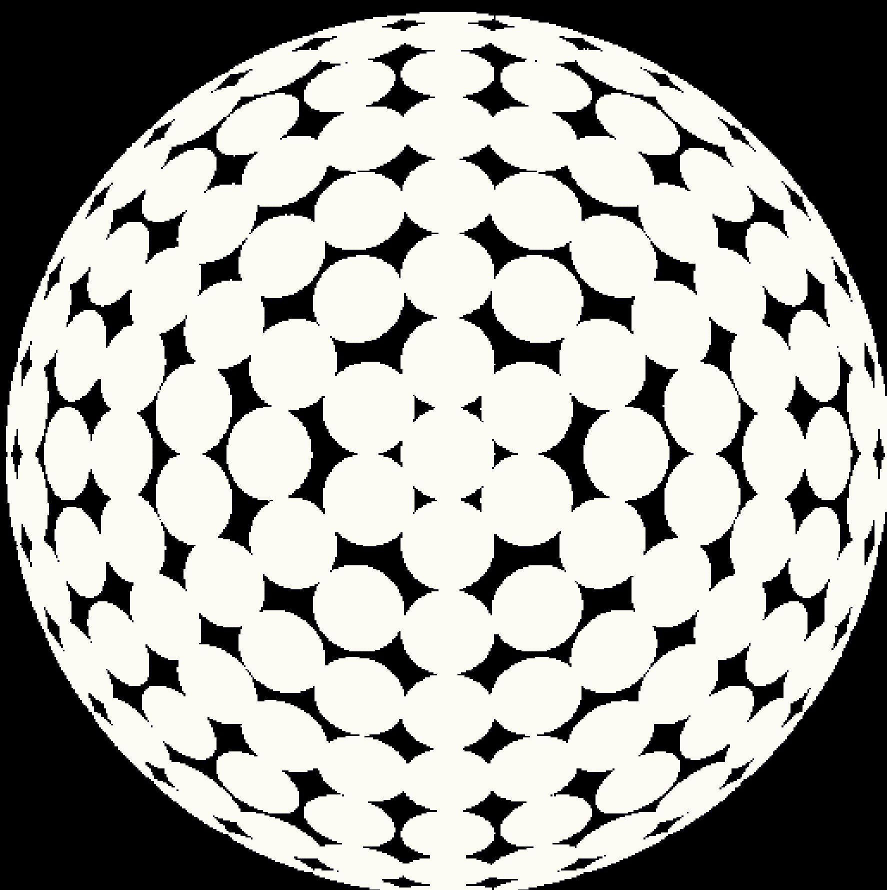
Control action affects all other modelled domains.

Luminaire control





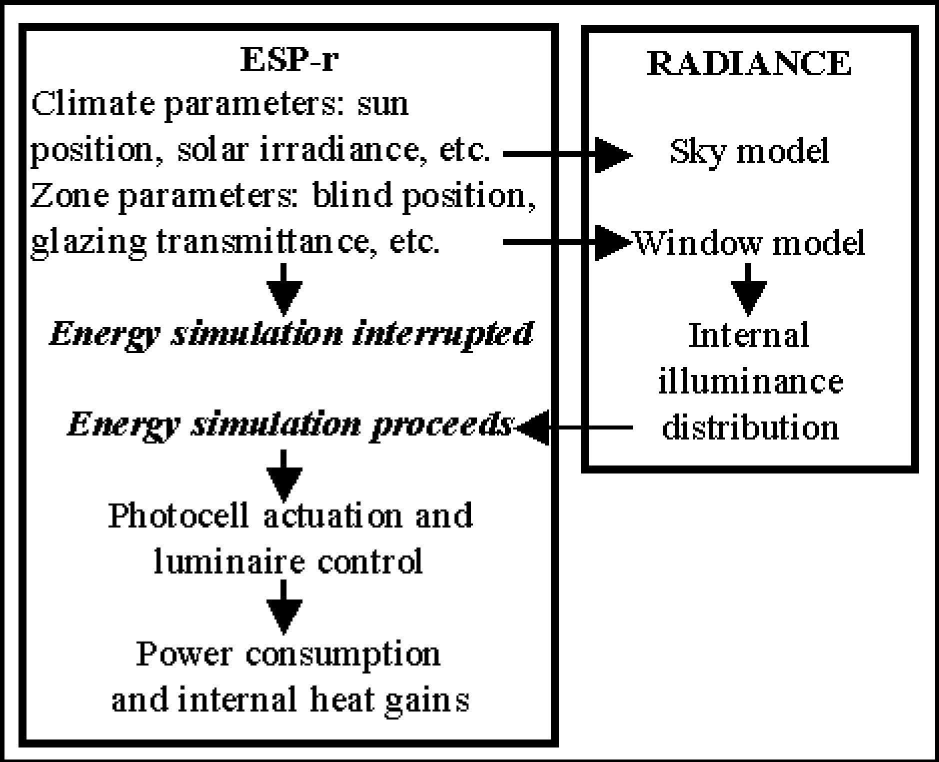
Integrated simulations



Daylight coefficients:

- Sky subdivided into 145 patches,
- Contribution from each patch pre-calculated,
- Fast integrated simulation.

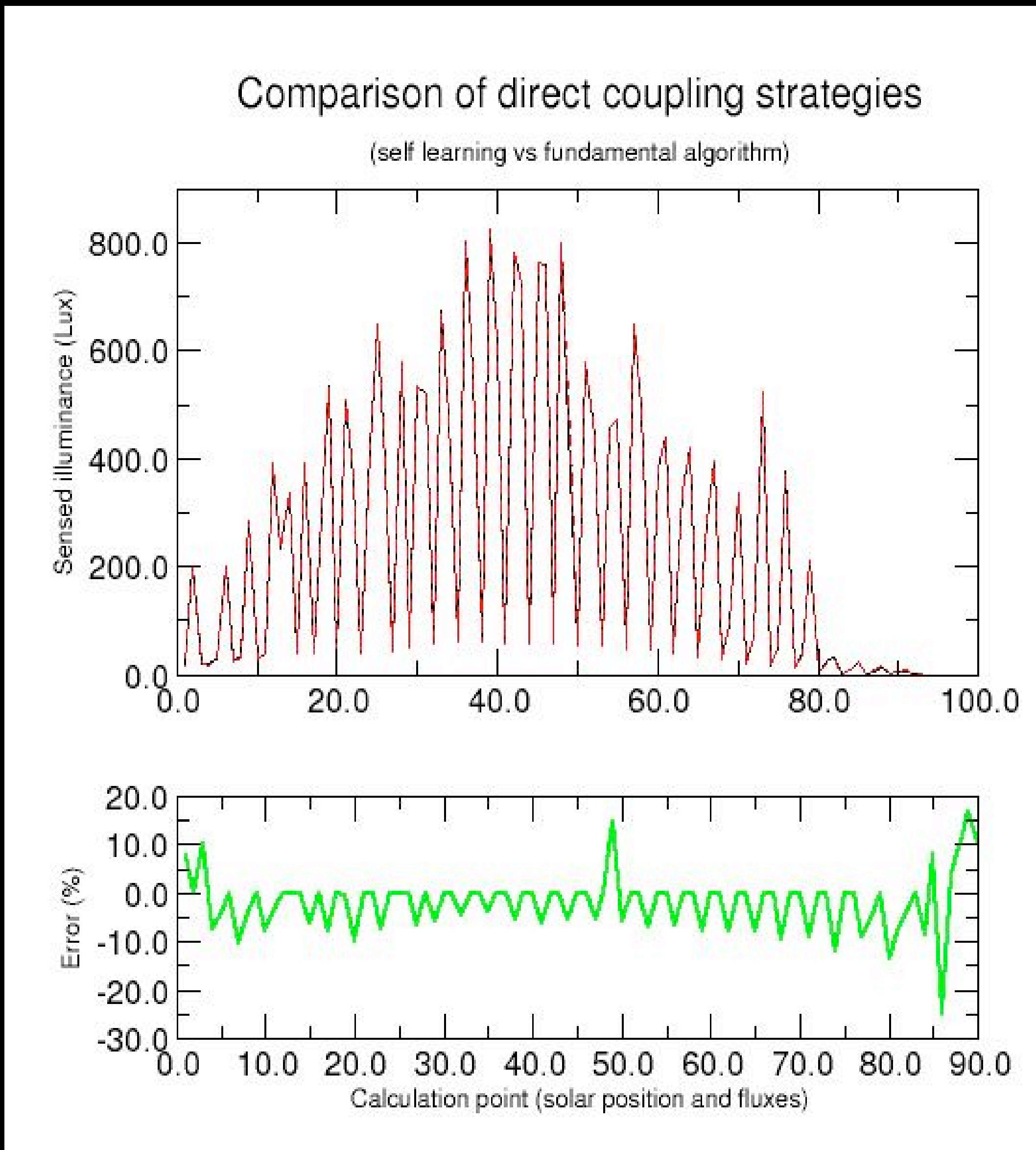
Integrated simulations



Direct coupling:

- ESP-r and Radiance used sequentially,
- No pre-calculation,
- Depending on complexity of model can be more or less computationally intensive.

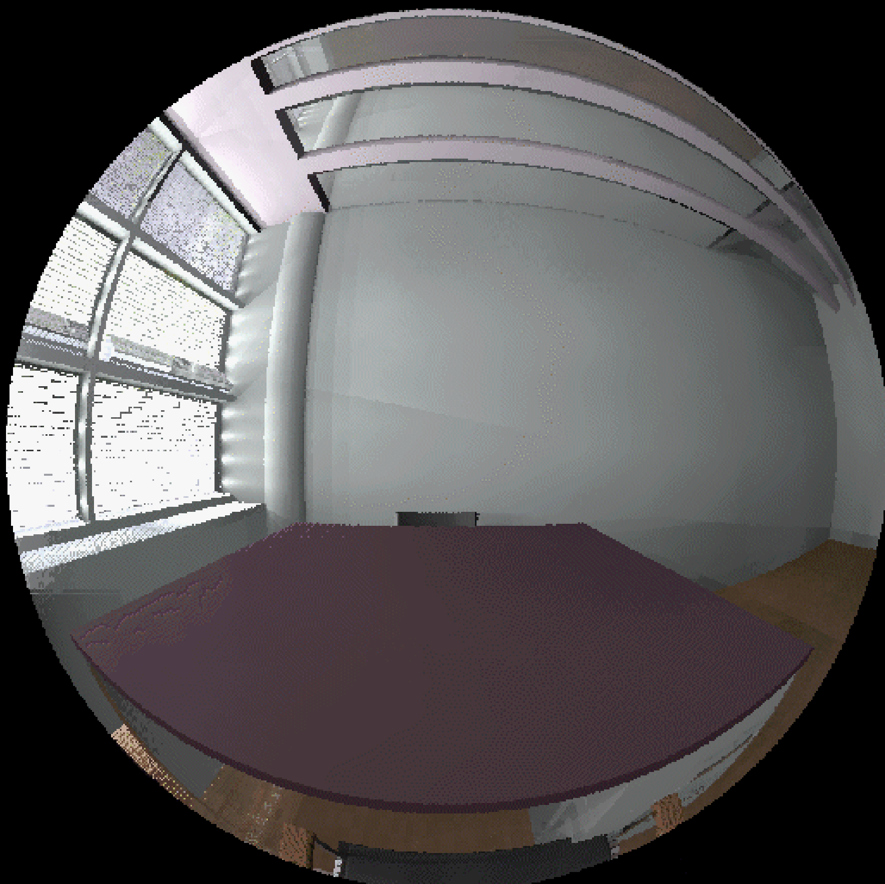
Integrated simulations



Self learning with direct coupling:

- Use previous results if applicable,
- Variables – solar position, direct/ diffuse ratio and blind position,
- Regression equation based.

What next?



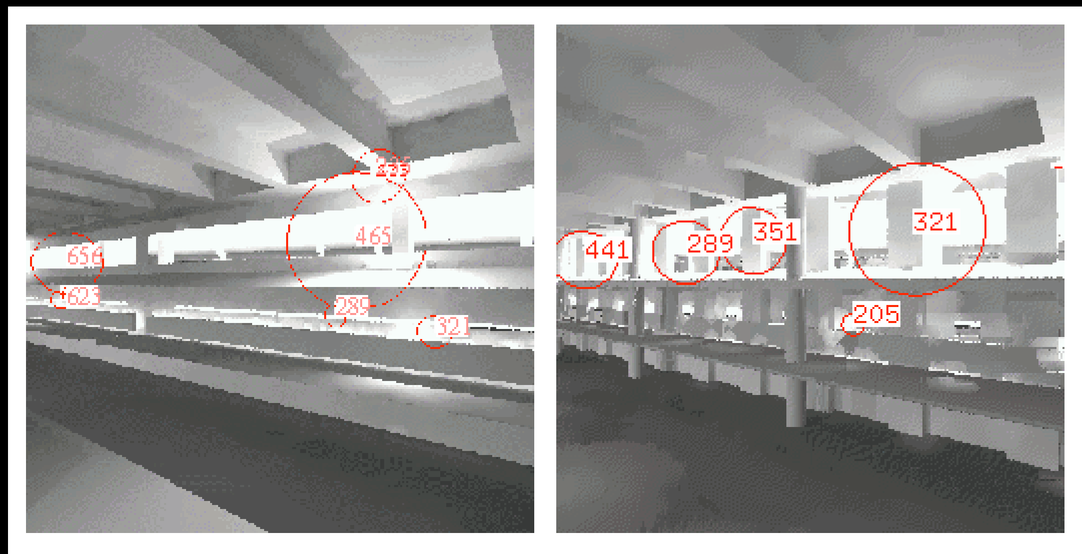
Daylight coefficients

Glare assessment

Solar irradiation

Surface properties

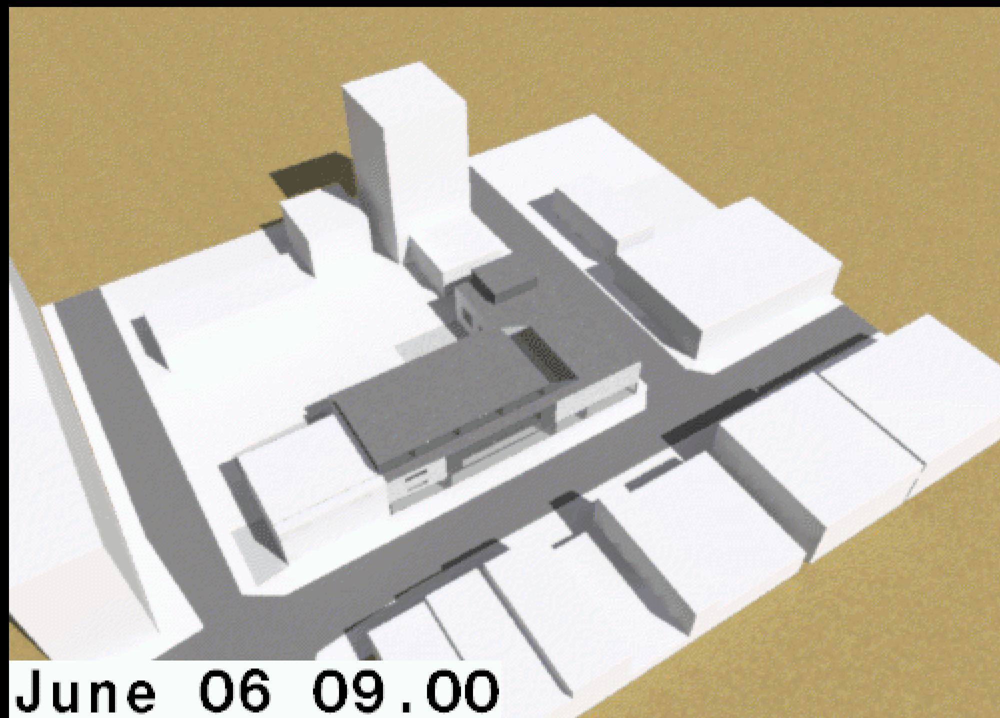
Glare



Problem: time, location, orientation, sky and blind conditions specific.

Need: measurement that copes with these variations..?

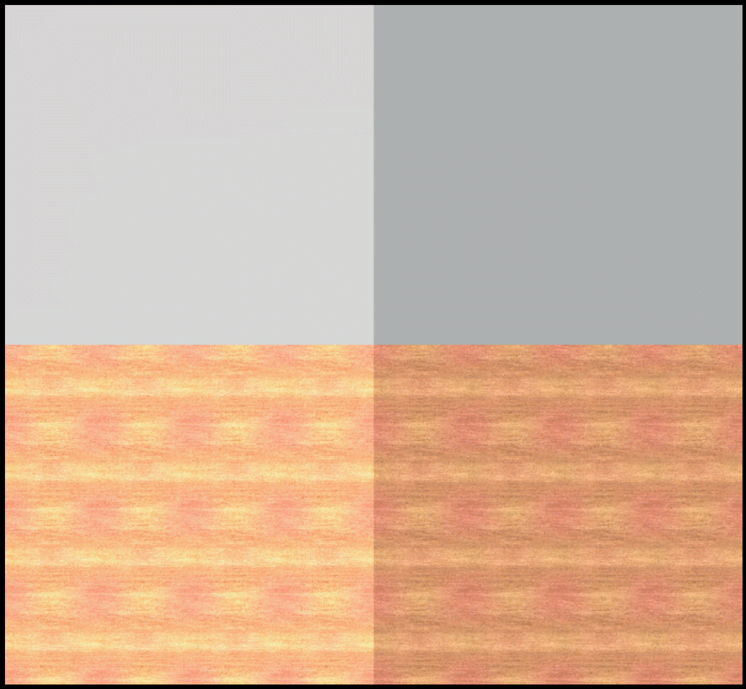
Solar irradiation



Problem: solar irradiation of building surfaces in arbitrarily complex environment.

Needs: Radiance to calculate irradiation for use in thermal calculations.

Surface properties



Tools: digital camera and luminance gun

->normpat image -> plastic material with measured reflectivity -> error?

Conclusions

Integration of open source physically based models allowing greater insights to building performance

Human interactions/ comfort needs better understanding and implementation in algorithms

Input databases required (surface properties etc.)