Complex Glazing Summary

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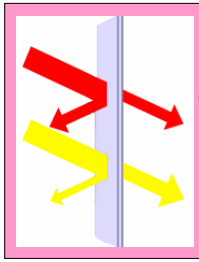
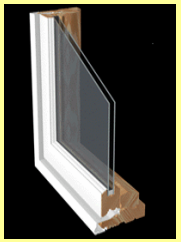
Windows & Daylighting Research Group
March 2008

Software Tools Overview

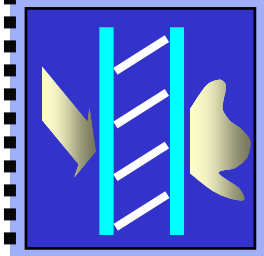
IGDB
(Specular Glass Data Source)



Optics
(Window Glass)



THERM
(Window Frame)



CGDB
(Complex Glazing Data Base)

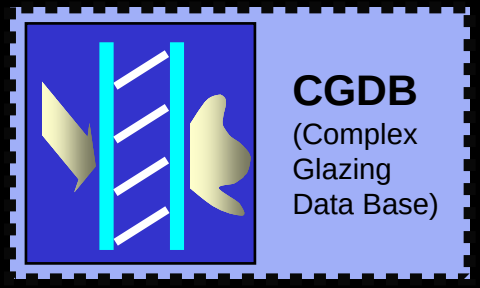
WINDOW
(Whole Window)

Design / Simulation Tools
DOE-2, EnergyPlus
Radiance

COMFEN
(Whole Building Commercial)

RESFEN
(Whole Building Residential)

WINDOW6



CGDB
(Complex
Glazing
Data Base)

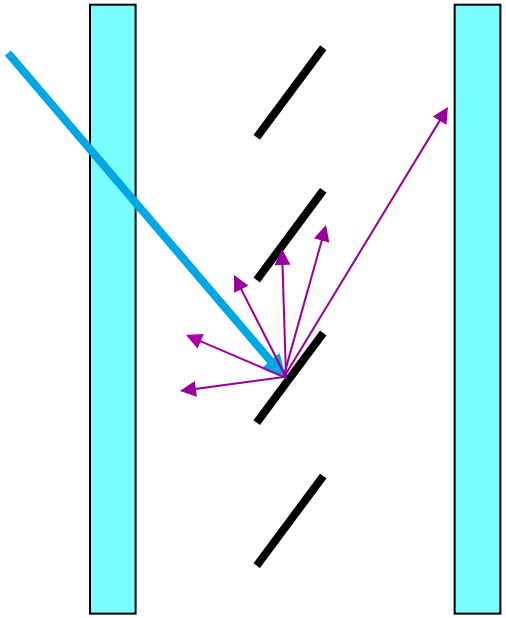
WINDOW
(Whole Window)

Specular vs Complex Glazings

- WINDOW4 and WINDOW5 have focused on specular glazings. These are products that are non-diffusing, such as clear or coated glass.
- WINDOW6 can handle ‘complex glazing devices’

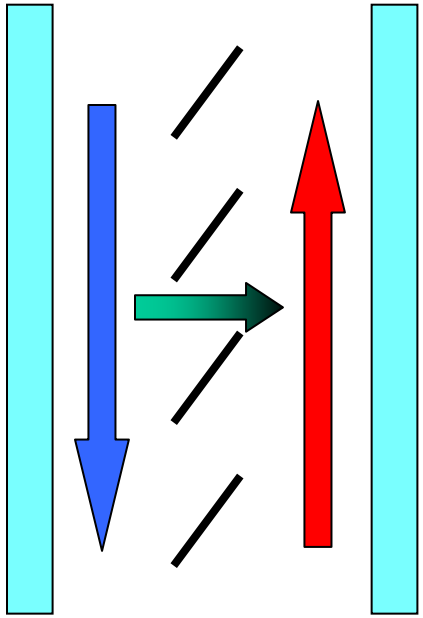
Component Characterization

Optical



- Visible & Solar
- Far Infrared

Thermal



- Conduction
- Convection

Complex Shading Device Types

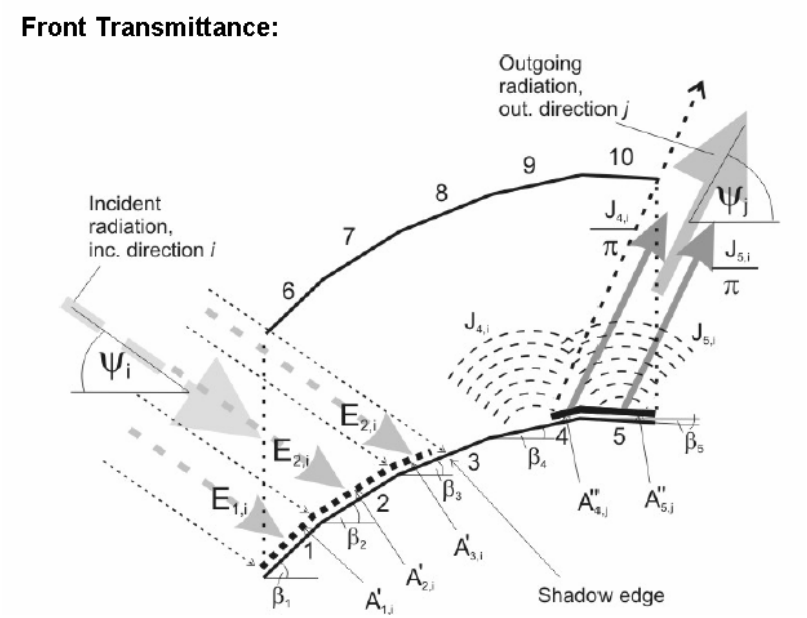
Diffuse • Patterned glass • Translucent interlayers • **Fritted glass**	Woven shades • Complex weaves • Bi-color threads
Plexiglass/Acrylic • Honeycombs • Prismatic panels	Non-woven Planar Shades • Roller shades • Solid Vinyl shades
Slat shading • **Diffuse** • Specular • Transparent	Drapes • Woven material with pleated, non-planar shapes
Square weave products • **Bug screens** • **Simple, uniform weave**	Honeycomb Shade
Other products	

Optical Measurements and Models

- Integrating Sphere Measurement
- Angular Scan Measurement
- Radiosity Model
- Ray Tracing

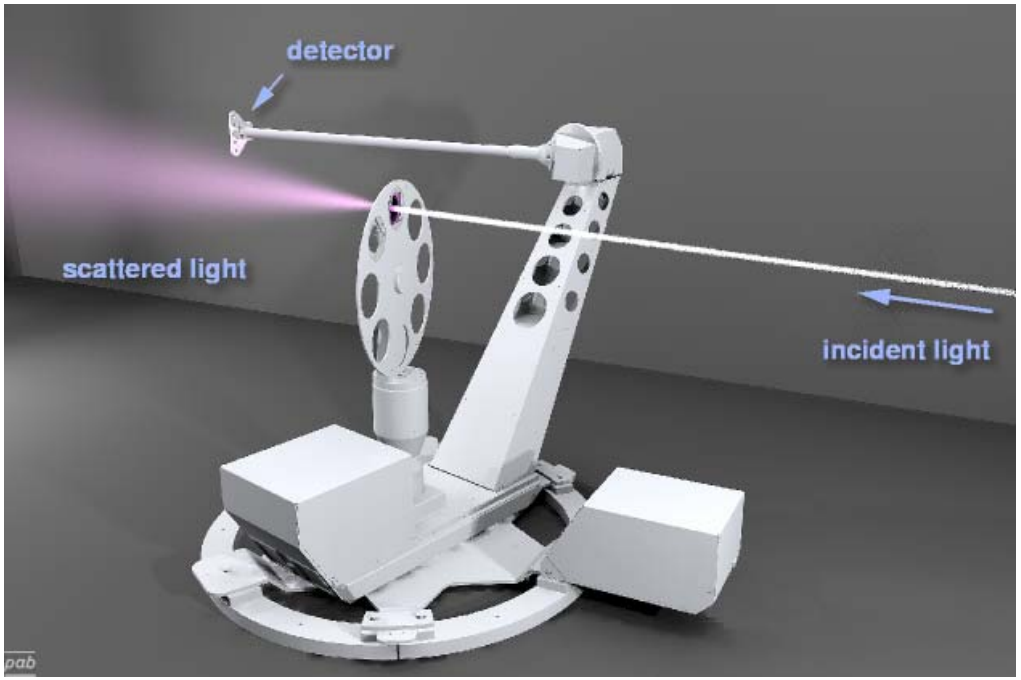
Optical – Radiosity Model

- Calculation method based on defined geometry, diffuse component materials only
- Large effort to develop model, quick calculations
- Venetian blind slat example:



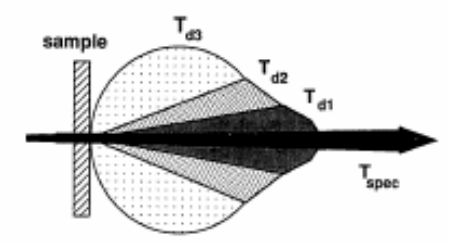
Optical – Direct Scan

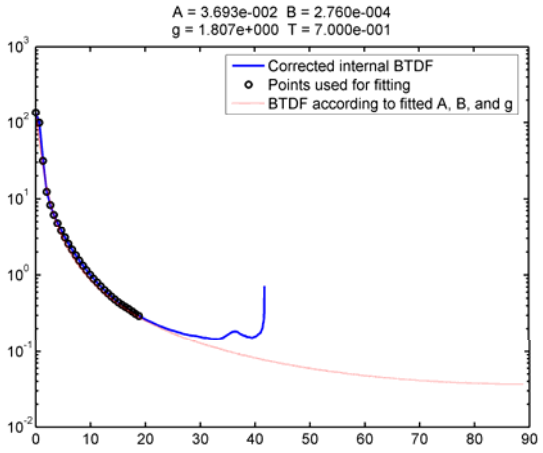
- Scanning all scattering directions mechanically
- Data stored in CGDB without model (except compression)



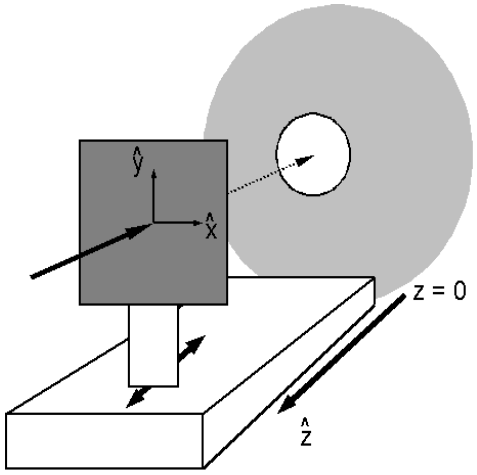
Optical– Integrating Sphere

- Total hemispherical data
- Limited BTDF data
- Might be enough for isotropic samples





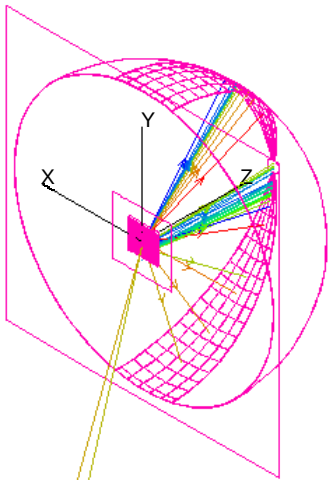
BTDF Output



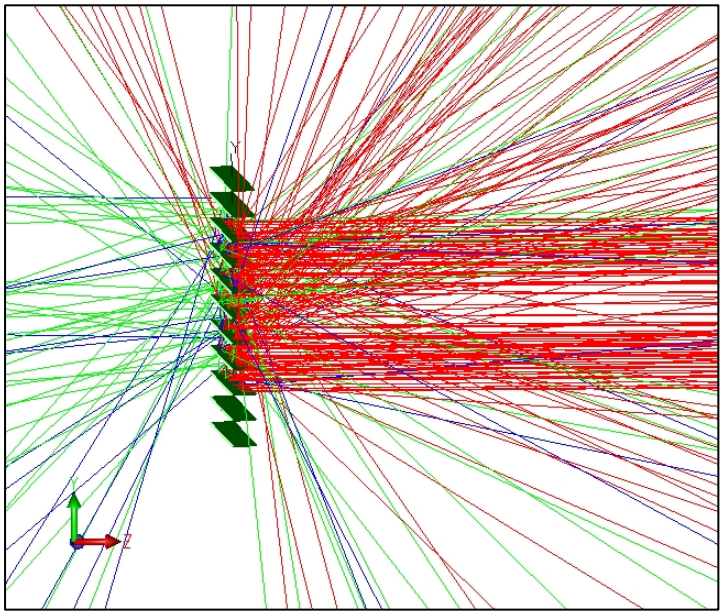
Sphere Schematic

Optical– Ray Trace

- Material properties obtained with experimental methods.
- CAD model using measured material properties.
- Data stored explicitly without any model.

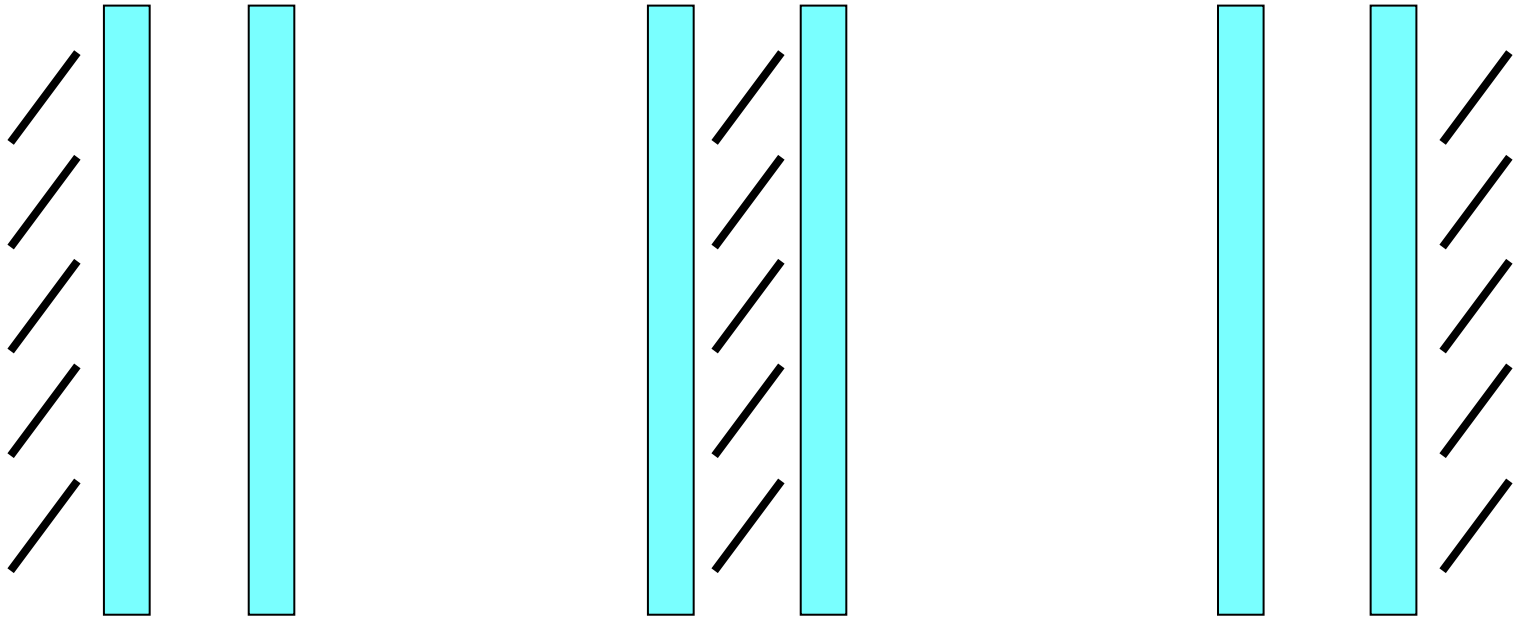


Virtual Goniospectroradiometer in Ray Trace software



Ray Traced Geometric / Optical model

Product Location



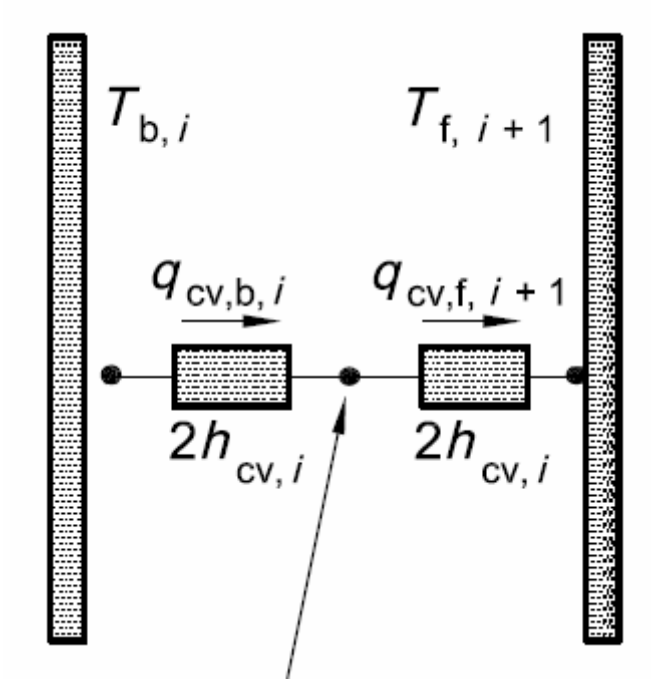
Exterior Integral Interior

Thermal Models

- ISO 15099
- Convective Scalar
- Waterloo (Integral venetian blind)
- Waterloo (Interior shade)

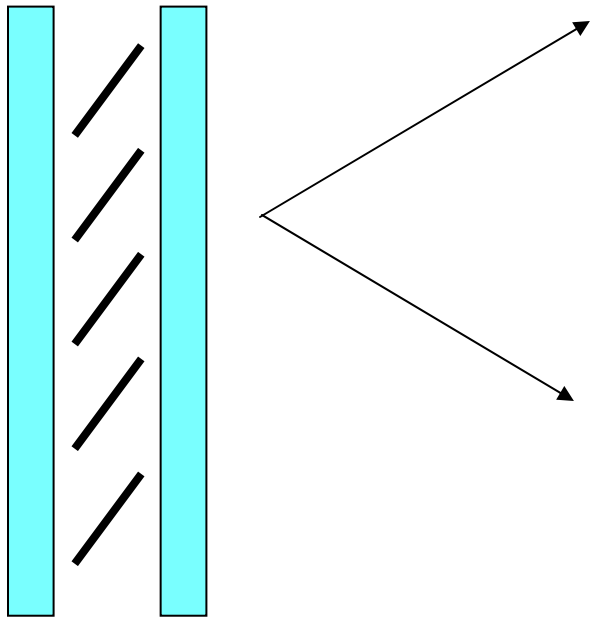
Thermal – ISO 15099

- Chapter 7, Shading Devices
- Glazing cavity is divided into 3 sections
- Minimal effect of openness of shade and gaps at top and bottom of shade

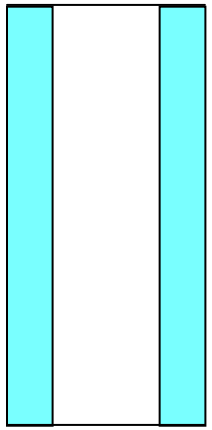


Thermal – Convective Scalar

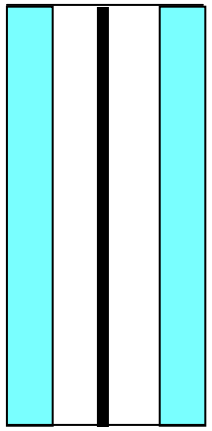
- Only applies to convection
- Radiation is calculated based on real geometry



Actual system



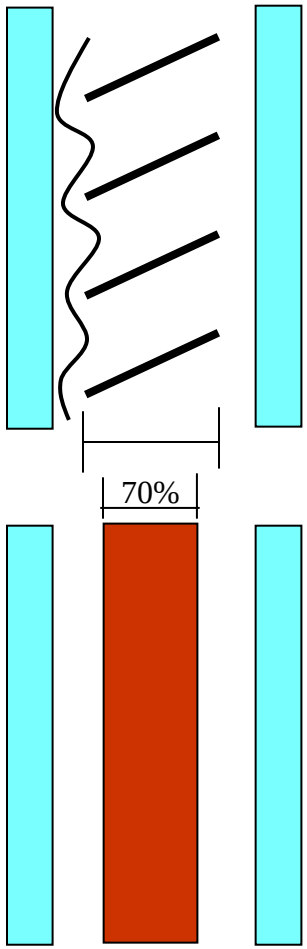
Convective Scalar = 0



Convective Scalar = 1

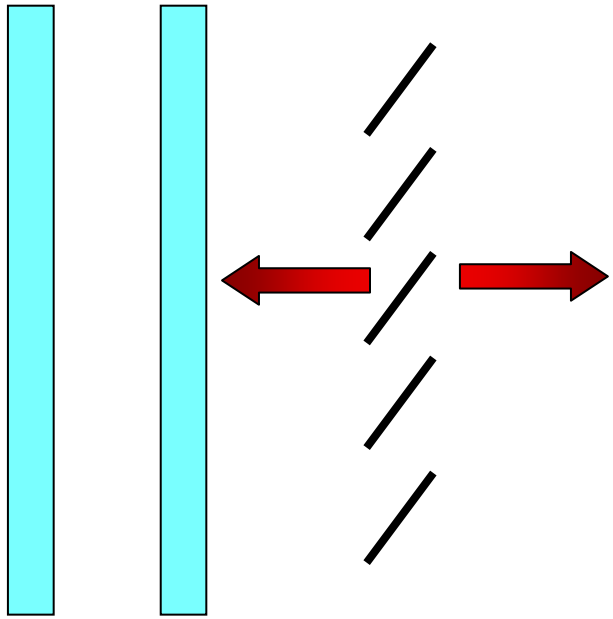
Thermal – Waterloo Integral

- Specific to Venetian Blinds
- Convection only
- Radiation is calculated based on real geometry



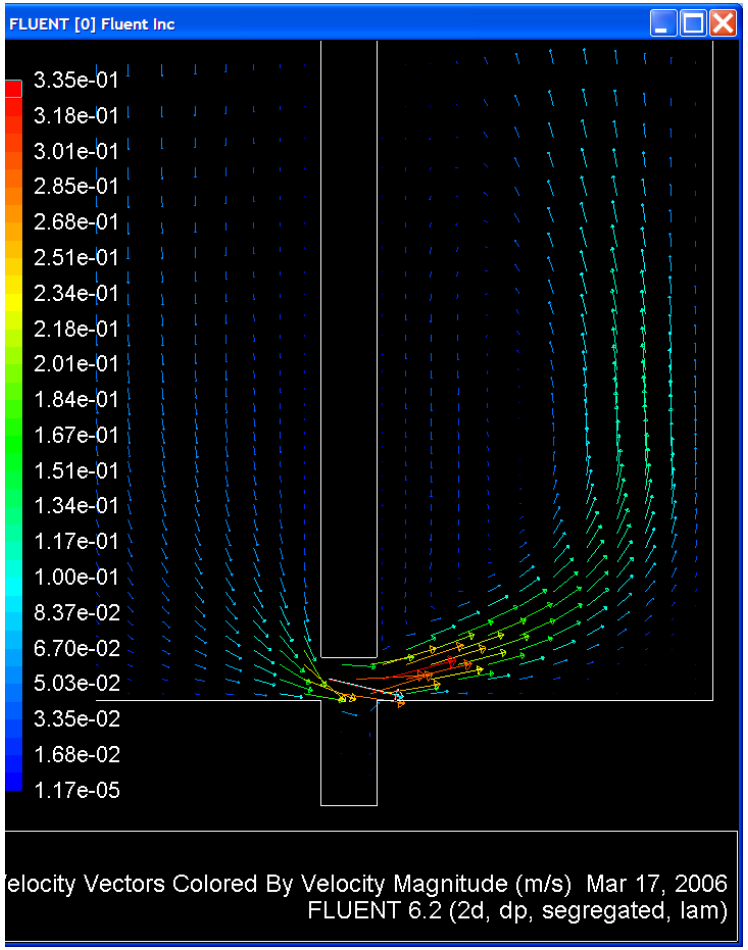
Thermal – Waterloo Interior

- Based on CFD correlations
- Developed for ASHRAE
- Convection only
- Radiation is calculated based on real geometry

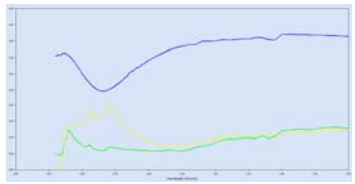


Thermal – CFD

- Detailed calculation to verify model parameters or develop new models
- Calculation intensive



Material, Layer, System

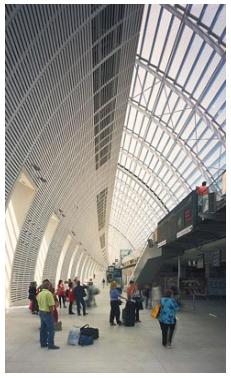
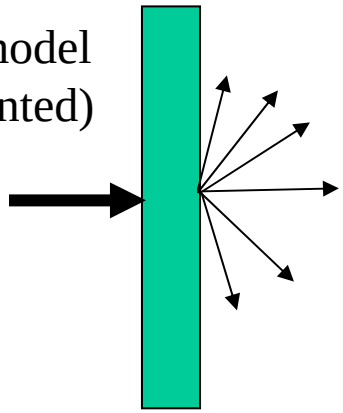


Material

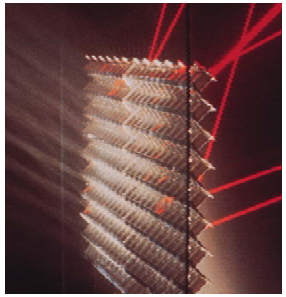
Layer

System

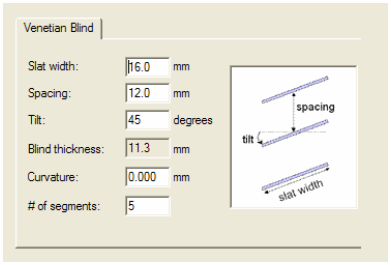
Diffuse Products

Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
Diffuse • Patterned glass • Translucent interlayers • Fritted glass  	Material Characterization • Angle scan Layer Characterization • Angle Scan • Integrating sphere (possibly) • W6 Frit model (Implemented) 	Same as WINDOW 5

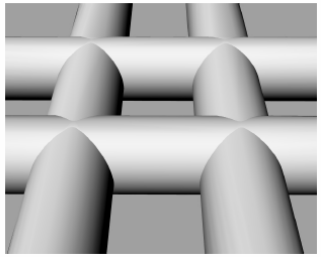
Plexiglass / Acrylic Products

Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
Plexiglass/Acrylic • Honeycombs • Prismatic panels 	Material Characterization: • Standard nonscattering test for base material Layer Characterization • W6 Radiosity Model (To be developed) • Raytrace	Issues • Need better thermal conductivity (Keff) of layers • Treat as a solid layer

Slat Products

Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
Slat shading (such as venetian blind) • Diffuse • Specular • Transparent 	Material Characterization • Measure slat material Layer Characterization • W6 Radiosity model (Implemented)  • Raytrace needed for specular slats	Interior shading systems: • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo/Nusselt (not yet implemented) Integral (between glass) shading systems: • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo (Implemented) Exterior shading systems: • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) Issues • Sensitivity studies to compare the results between models

Square Weave Products

Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
Square weave products • Bug screens • Simple, uniform woven material 	Material Characterization • Measure thread material Layer Characterization • W6 Radiosity model (Ross McCluney) (Implemented) 	Interior systems: • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo/Nusselt (not yet implemented) Integral (between glass) systems: • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo (??) (Implemented) Exterior systems: • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) Issues • Thermal performance depends on gaps between shades and window frame (top, bottom, left and right)

Woven, Non-uniform Products

Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
Woven shades • Complex weaves (not square, not uniform) • Bi-color threads • Roller shades 	Material Characterization • Angle scan • Integrating sphere (maybe) Layer Characterization • Angle scan • Integrating sphere (maybe) • Generalized W6 Radiosity bug screen model to accept any geometry (To be developed) • Ray trace (to determine accuracy of using the simple bug screen model for complex, non-uniform weave patterns)	Interior systems: • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo/Nusselt (not yet implemented) Integral (between glass) systems: • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo (??) (Implemented) Exterior systems: • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) Issues • Thermal performance depends on gaps between shades and window frame (top, bottom, left and right)

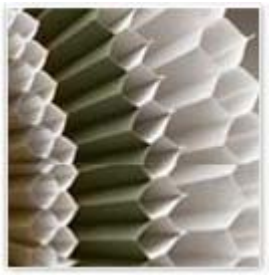
Non-Woven Planar Products

Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
Non-woven Planar shades • Solid vinyl shade  	Material Characterization • Angle scan of material	Issues: • Is material IR transparent • Thermal performance depends on gaps between shades and window frame (top, bottom, left and right) • Convective scalar may be most appropriate

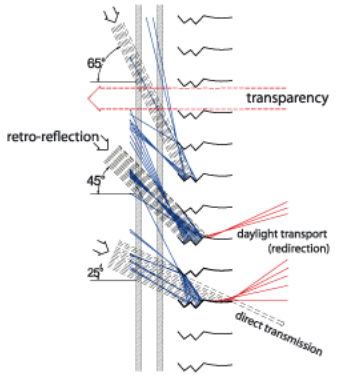
Drapes

Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
Drapes • Woven material with pleated, non-planar shapes 	Material Characterization • Angle scan Layer Characterization • Angle scan • W6 Radiosity model (To be developed) – maybe Wright / Waterloo ?	Issues: • Minimal insulation from material • Thermal performance depends on gaps between shades and window frame (top, bottom, left and right) • Determine material IR transparency • Review existing research

Honeycomb Products

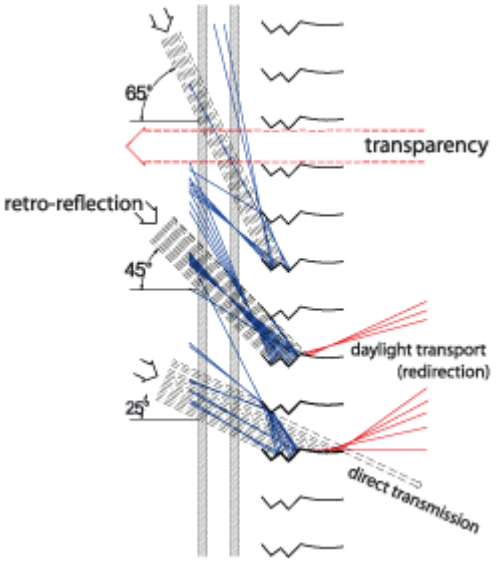
Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
Honeycomb shade: • Geometry of honeycomb depends on how far the shade is "extended" 	Material Characterization • Measure fabric Layer Characterization • W6 Radiosity model (To be implemented) • Ray trace	Issues: • Material can be insulating • Thermal performance depends on gaps between shades and window frame (top, bottom, left and right) • Determine material IR transparency • Review existing research

Other Products

Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
Other Products • Products that do not fall into previous categories (Koester blind) • Complex / arbitrary geometries, etc 	Material Characterization • N/A Layer Characterization • Develop BSDF (Ray trace, goniometer, etc)	Issues:

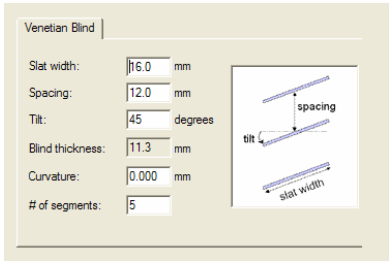
BSDF for Advanced Systems

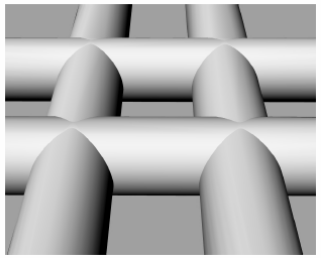
- Bi-directional Scattering Distribution Function (BSDF) is a data format that can store information on how a product affects light transmission
- Any product that currently not has a specific model in WINDOW6, can be defined by a BSDF
- Retrolux Koester blind.
  - Complicated geometry
  - Can be Raytraced or Measured and stored into BSDF format
  - WINDOW6 reads BSDF

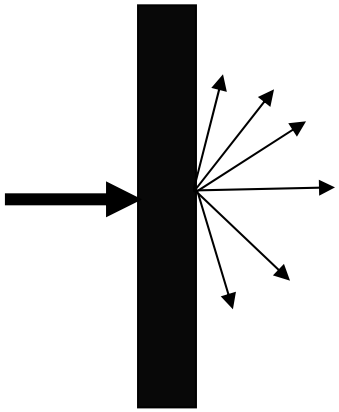


Creating Layer Data

- Venetian Blind Model
  - Specify slat angle, slat width, slat spacing and curvature
- Woven Shade Model
  - Specify thread diameter and thread spacing
- Fritted Glass Model
  - Specify coverage percentage
- BSDF-XML Input
  - Specify XML file







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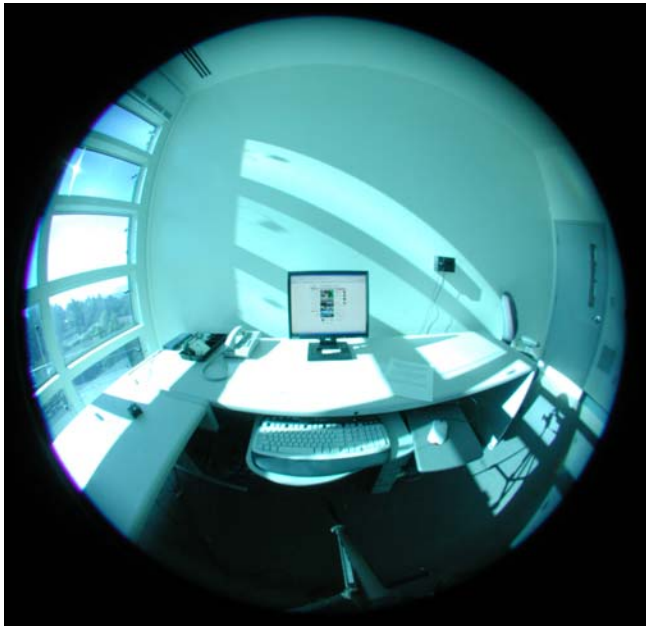
Complex Glazing Test Facility

- Provide objective, comparative data on emerging façade technologies in order to understand the risks, benefits, and costs of using such systems in commercial buildings



Availability

- Downloadable from our website:

`http://windows.lbl.gov/software/window/6`