

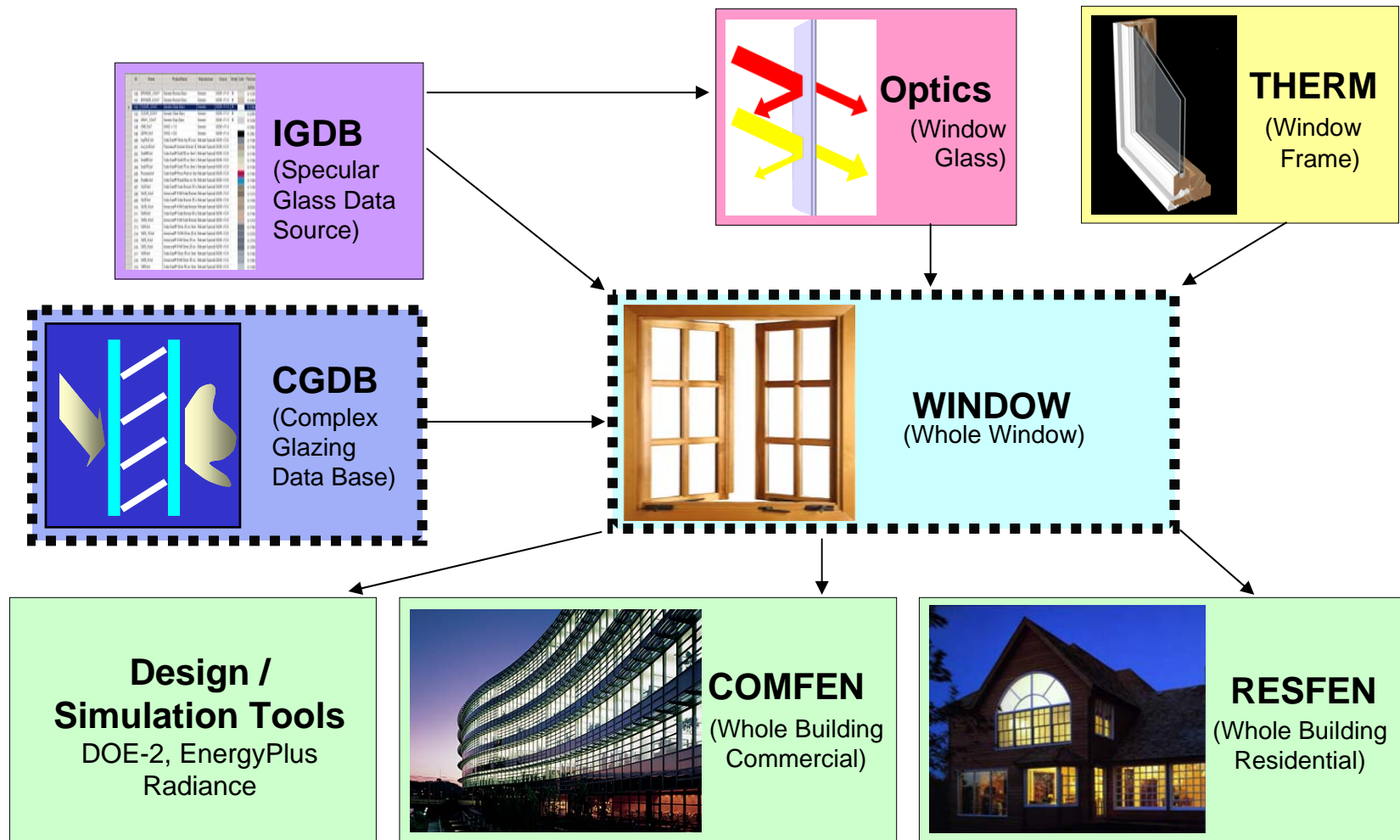


Complex Glazing Summary

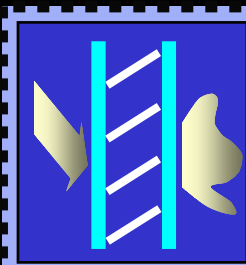
Christian Kohler, Mike Rubin, Jacob Jonsson
Dariush Arasteh, Robin Mitchell

Windows & Daylighting Research Group
March 2008

Software Tools Overview



WINDOW6



CGDB
(Complex
Glazing
Data Base)



WINDOW
(Whole Window)

Specular vs Complex Glazings



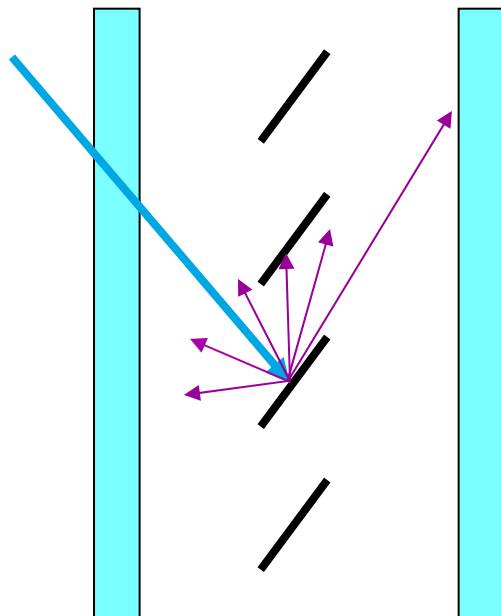
- WINDOW4 and WINDOW5 have focused on specular glazings. These are products that are non-diffusing, such as clear or coated glass.
- WINDOW6 can handle 'complex glazing devices'



Component Characterization

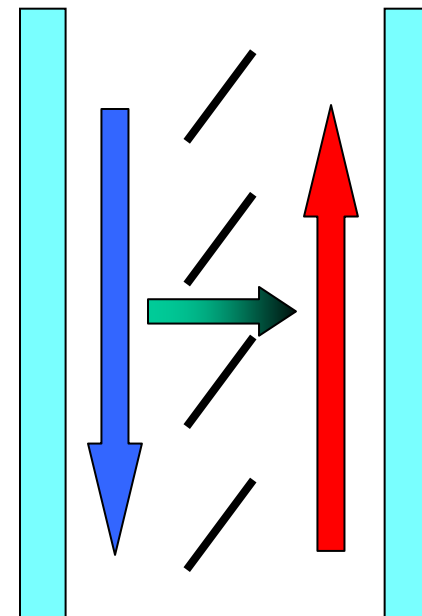


Optical



- Visible & Solar
- Far Infrared

Thermal



- Conduction
- Convection

Complex Shading Device Types



<u>Diffuse</u> <ul style="list-style-type: none"> • <u>Patterned glass</u> • <u>Translucent interlayers</u> • <u>Fritted glass</u> 	<u>Woven shades</u> <ul style="list-style-type: none"> • <u>Complex weaves</u> • <u>Bi-color threads</u>
<u>Plexiglass/Acrylic</u> <ul style="list-style-type: none"> • <u>Honeycombs</u> • <u>Prismatic panels</u> 	<u>Non-woven Planar Shades</u> <ul style="list-style-type: none"> • <u>Roller shades</u> • <u>Solid Vinyl shades</u>
<u>Slat shading</u> <ul style="list-style-type: none"> • <u>Diffuse</u> • <u>Specular</u> • <u>Transparent</u> 	<u>Drapes</u> <ul style="list-style-type: none"> • <u>Woven material with pleated, non-planar shapes</u>
<u>Square weave products</u> <ul style="list-style-type: none"> • <u>Bug screens</u> • <u>Simple, uniform weave</u> 	<u>Honeycomb Shade</u>
<u>Other products</u>	

Optical Measurements and Models



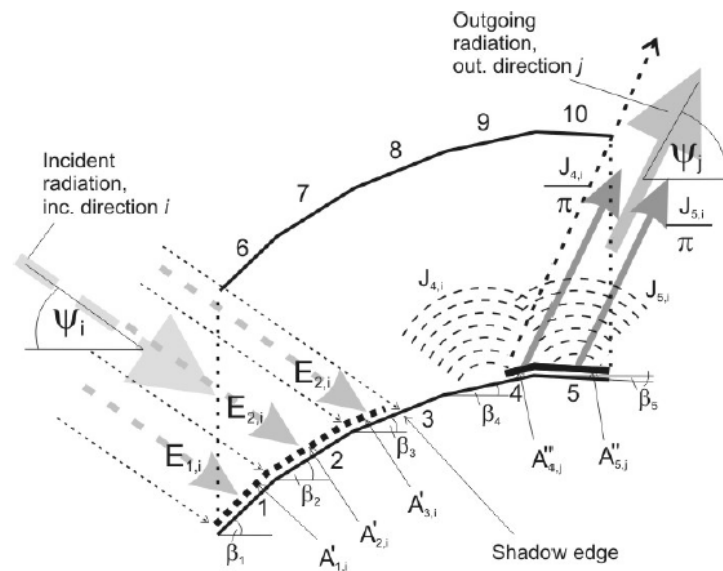
- Integrating Sphere Measurement
- Angular Scan Measurement
- Radiosity Model
- Ray Tracing

Optical – Radiosity Model



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

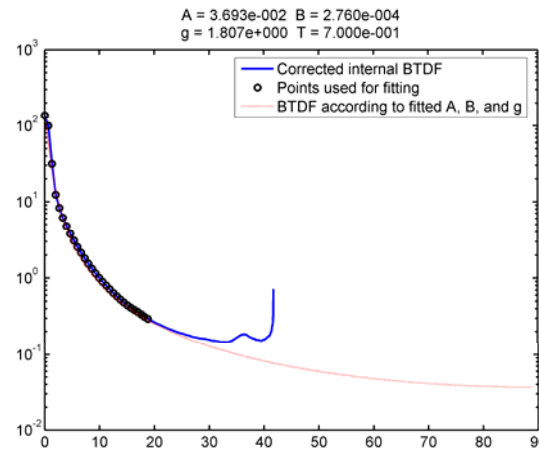
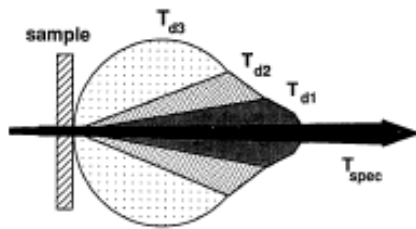
Front Transmittance:



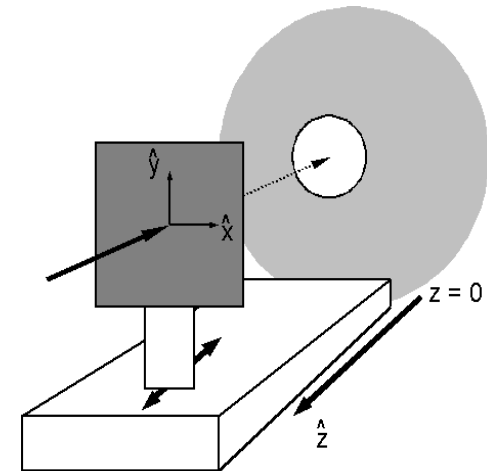
Optical– Integrating Sphere



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



BTDF Output

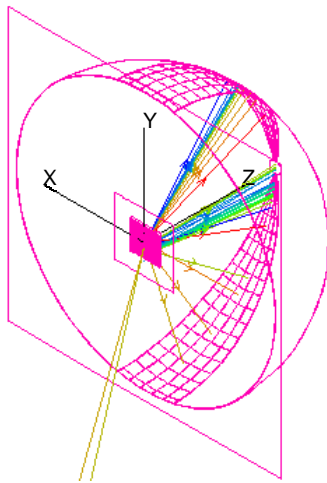


Sphere Schematic

Optical– Ray Trace

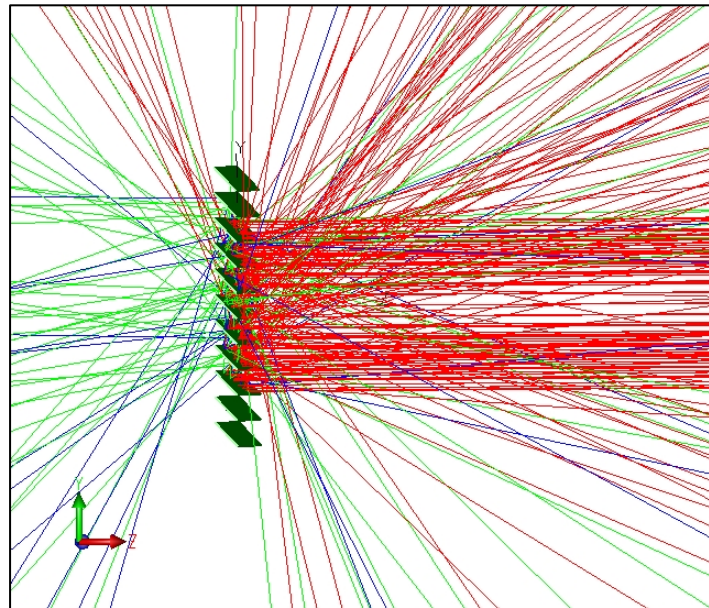


- Material properties obtained with experimental methods.
- CAD model using measured material properties.
- Data stored explicitly without any model.



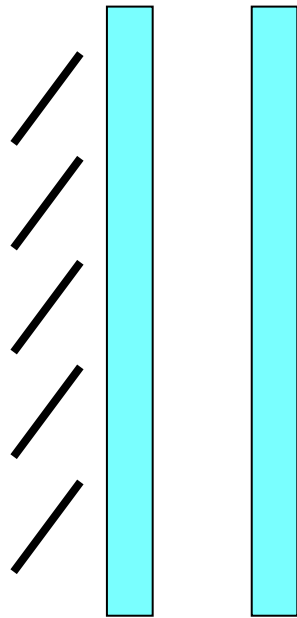
Virtual

Goniospectroradiometer in
Ray Trace software

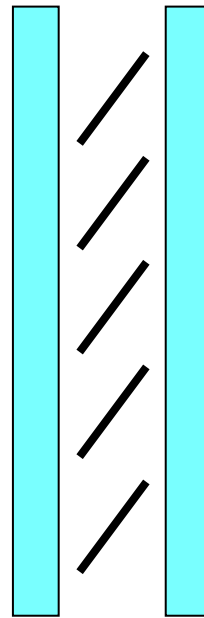


Ray Traced Geometric / Optical model

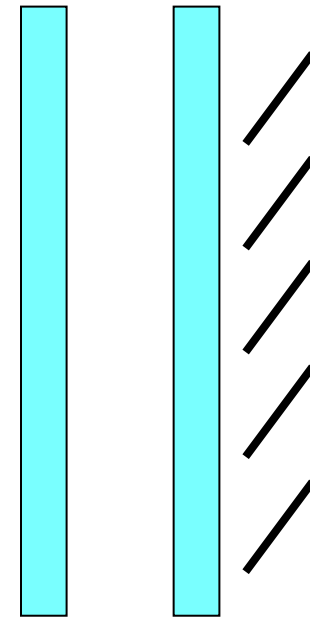
Product Location



Exterior



Integral



Interior

Thermal Models

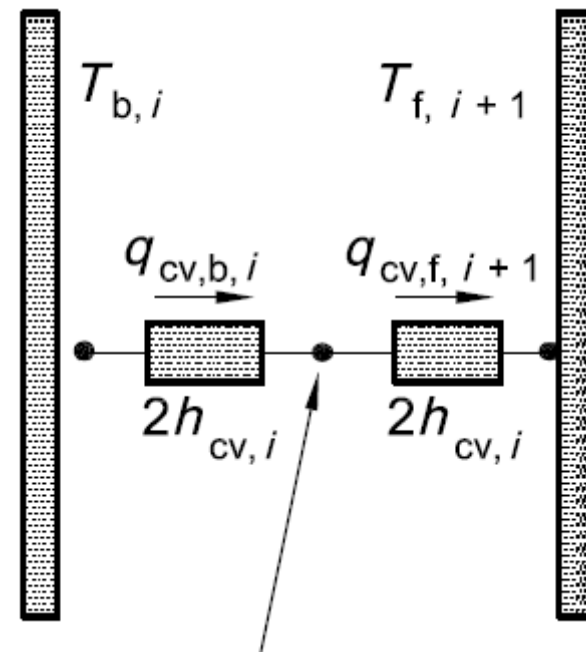


- ISO 15099
- Convective Scalar
- Waterloo (Integral venetian blind)
- Waterloo (Interior shade)

Thermal – ISO 15099



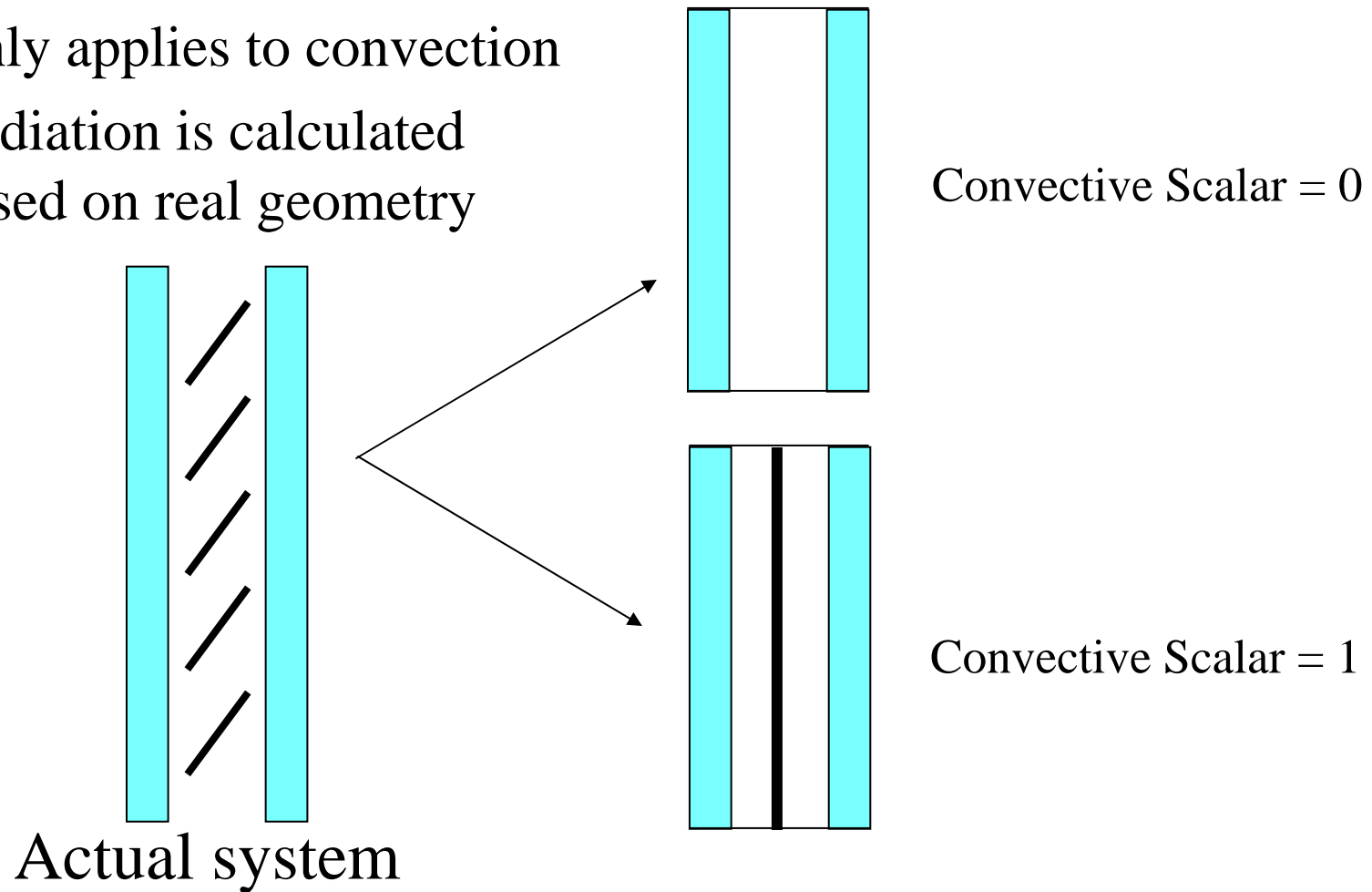
- Chapter 7, Shading Devices
- Glazing cavity is divided into 3 sections
- Minimal effect of openness of shade and gaps at top and bottom of shade



Thermal – Convective Scalar



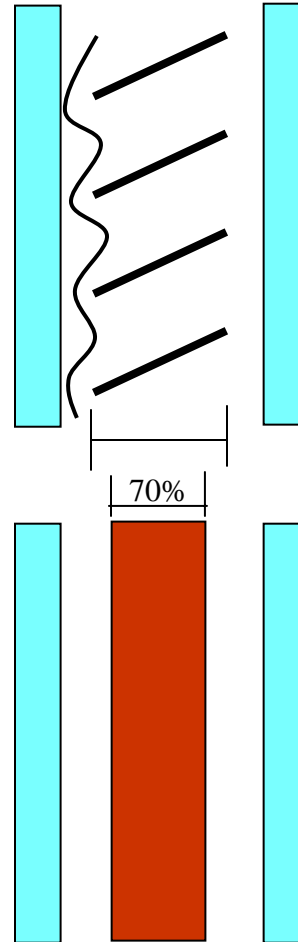
- Only applies to convection
- Radiation is calculated based on real geometry



Thermal – Waterloo Integral



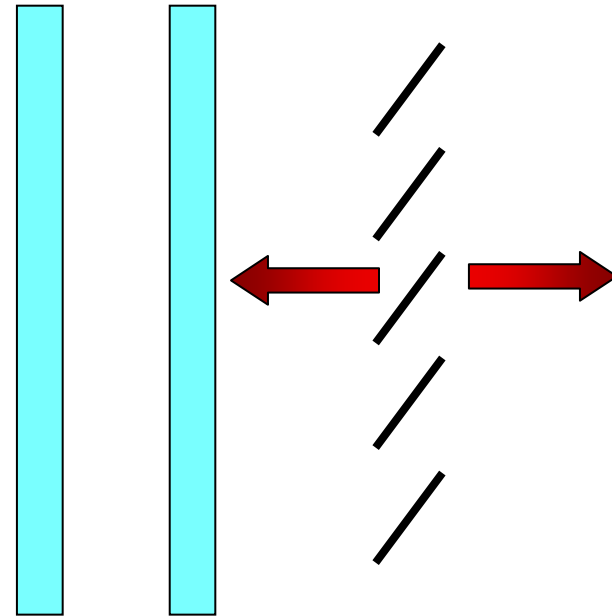
- Specific to Venetian Blinds
- Convection only
- Radiation is calculated based on real geometry



Thermal – Waterloo Interior



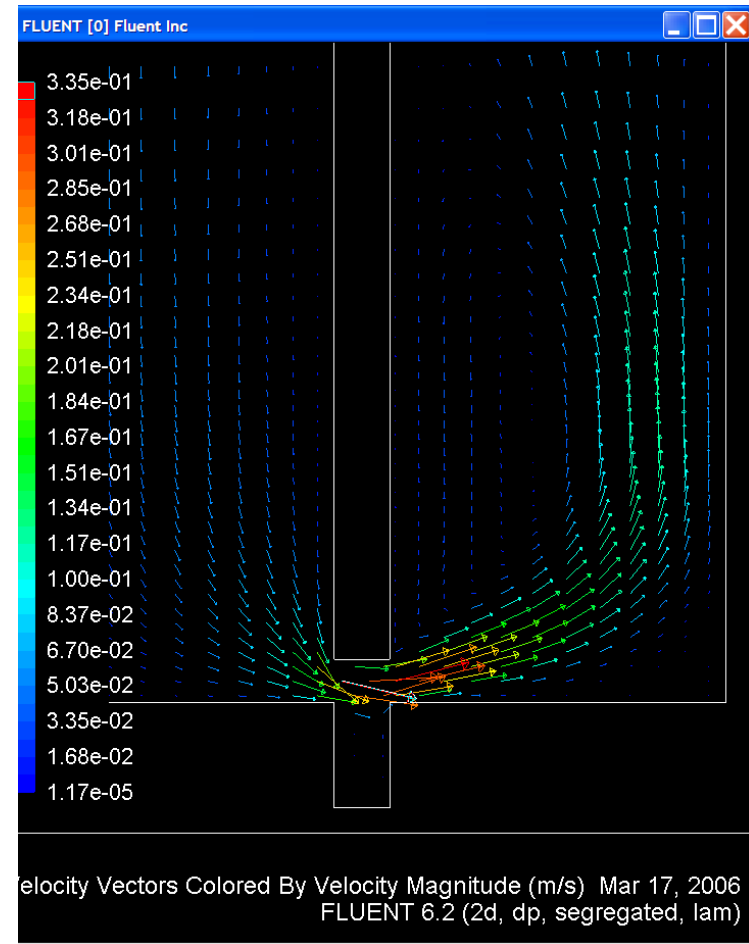
- Based on CFD correlations
- Developed for ASHRAE
- Convection only
- Radiation is calculated based on real geometry



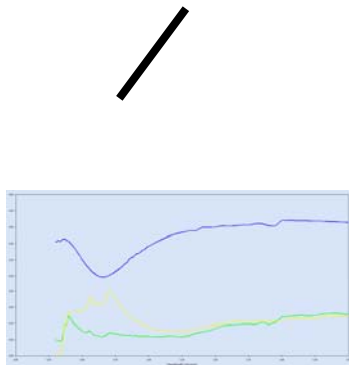
Thermal – CFD



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



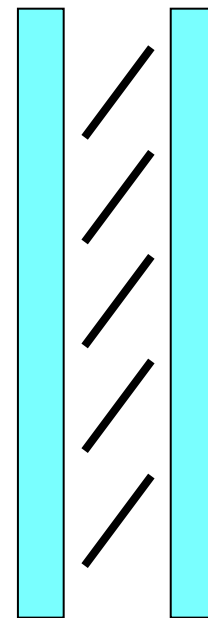
Material, Layer, System



Material



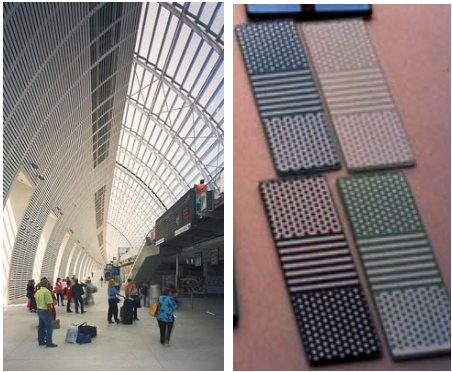
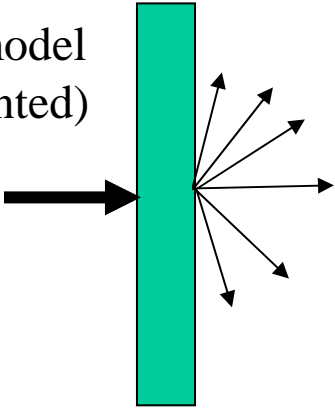
Layer



System

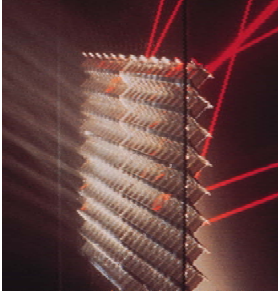
Diffuse Products



Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
<p>Diffuse</p> <ul style="list-style-type: none">• Patterned glass• Translucent interlayers• Fritted glass 	<p>Material Characterization</p> <ul style="list-style-type: none">• Angle scan <p>Layer Characterization</p> <ul style="list-style-type: none">• Angle Scan• Integrating sphere (possibly)• W6 Frit model (Implemented) 	<p>Same as WINDOW 5</p>


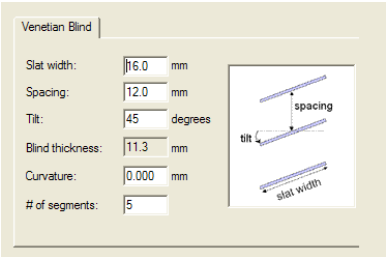
Plexiglass / Acrylic Products



Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
<p>Plexiglass/Acrylic</p> <ul style="list-style-type: none">• Honeycombs• Prismatic panels 	<p>Material Characterization:</p> <ul style="list-style-type: none">• Standard nonscattering test for base material <p>Layer Characterization</p> <ul style="list-style-type: none">• W6 Radiosity Model (To be developed)• Raytrace	<p>Issues</p> <ul style="list-style-type: none">• Need better thermal conductivity (K_{eff}) of layers• Treat as a solid layer


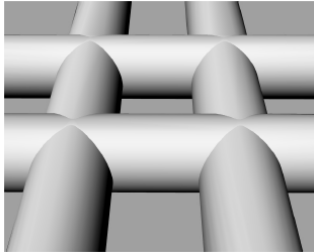
Slat Products



Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
<p>Slat shading (such as venetian blind)</p> <ul style="list-style-type: none"> • Diffuse • Specular • Transparent 	<p>Material Characterization</p> <ul style="list-style-type: none"> • Measure slat material <p>Layer Characterization</p> <ul style="list-style-type: none"> • W6 Radiosity model (Implemented)  <ul style="list-style-type: none"> • Raytrace needed for specular slats 	<p>Interior shading systems:</p> <ul style="list-style-type: none"> • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo/Nusselt (not yet implemented) <p>Integral (between glass) shading systems:</p> <ul style="list-style-type: none"> • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo (Implemented) <p>Exterior shading systems:</p> <ul style="list-style-type: none"> • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) <p>Issues</p> <ul style="list-style-type: none"> • Sensitivity studies to compare the results between models

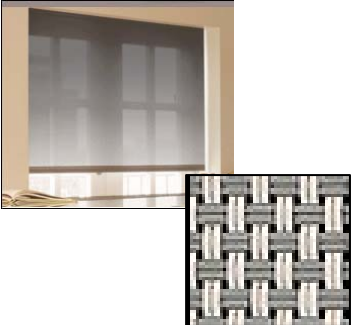
Square Weave Products



Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
<p>Square weave products</p> <ul style="list-style-type: none"> • Bug screens • Simple, uniform woven material 	<p>Material Characterization</p> <ul style="list-style-type: none"> • Measure thread material <p>Layer Characterization</p> <ul style="list-style-type: none"> • W6 Radiosity model (Ross McCluney) (Implemented) 	<p>Interior systems:</p> <ul style="list-style-type: none"> • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo/Nusselt (not yet implemented) <p>Integral (between glass) systems:</p> <ul style="list-style-type: none"> • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo (??) (Implemented) <p>Exterior systems:</p> <ul style="list-style-type: none"> • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) <p>Issues</p> <ul style="list-style-type: none"> • 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
<p>Woven shades</p> <ul style="list-style-type: none"> • Complex weaves (not square, not uniform) • Bi-color threads • Roller shades 	<p>Material Characterization</p> <ul style="list-style-type: none"> • Angle scan • Integrating sphere (maybe) <p>Layer Characterization</p> <ul style="list-style-type: none"> • 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) 	<p>Interior systems:</p> <ul style="list-style-type: none"> • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo/Nusselt (not yet implemented) <p>Integral (between glass) systems:</p> <ul style="list-style-type: none"> • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) • Waterloo (??) (Implemented) <p>Exterior systems:</p> <ul style="list-style-type: none"> • ISO 15099 (Implemented) • Convective Scalar – LBL (Implemented) <p>Issues</p> <ul style="list-style-type: none"> • 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
<p>Non-woven Planar shades</p> <ul style="list-style-type: none">• Solid vinyl shade 	<p>Material Characterization</p> <ul style="list-style-type: none">• Angle scan of material	<p>Issues:</p> <ul style="list-style-type: none">• 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

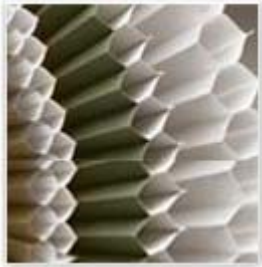
Drapes



Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
<p>Drapes</p> <ul style="list-style-type: none">Woven material with pleated, non-planar shapes 	<p>Material Characterization</p> <ul style="list-style-type: none">Angle scan <p>Layer Characterization</p> <ul style="list-style-type: none">Angle scanW6 Radiosity model (To be developed) – maybe Wright / Waterloo ?	<p>Issues:</p> <ul style="list-style-type: none">Minimal insulation from materialThermal performance depends on gaps between shades and window frame (top, bottom, left and right)Determine material IR transparencyReview existing research

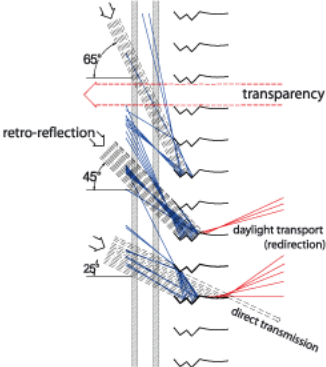
Honeycomb Products



Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
<p>Honeycomb shade:</p> <ul style="list-style-type: none">• Geometry of honeycomb depends on how far the shade is “extended” 	<p>Material Characterization</p> <ul style="list-style-type: none">• Measure fabric <p>Layer Characterization</p> <ul style="list-style-type: none">• W6 Radiosity model (To be implemented)• Ray trace	<p>Issues:</p> <ul style="list-style-type: none">• 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

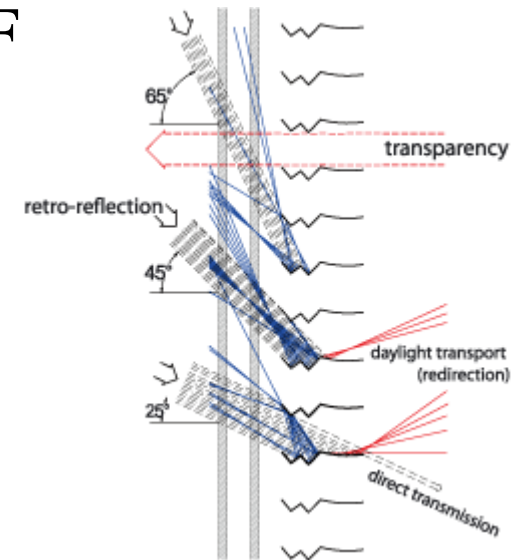


Device Type	Optical Characterization & Calculation Method	Thermal Calculation Method
<p>Other Products</p> <ul style="list-style-type: none"> • Products that do not fall into previous categories (Koester blind) • Complex / arbitrary geometries, etc 	<p>Material Characterization</p> <ul style="list-style-type: none"> • N/A <p>Layer Characterization</p> <ul style="list-style-type: none"> • Develop BSDF (Ray trace, goniometer, etc) 	<p>Issues:</p>

BSDF for Advanced Systems



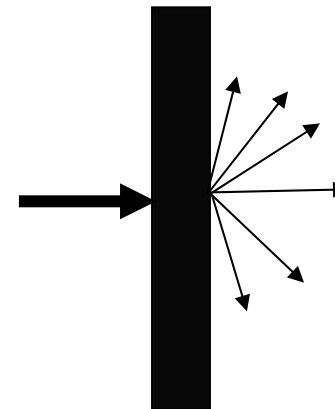
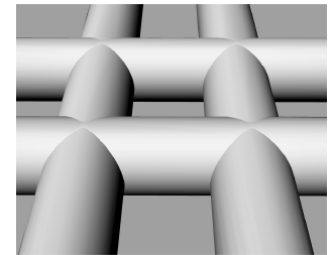
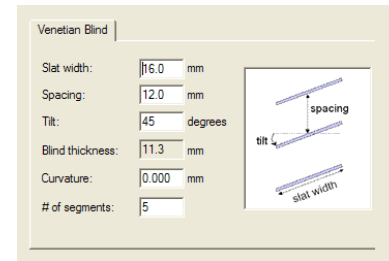
- Bi-directional Scattering Distribution Function (BSDF) is a data format that can store information on how a product affects light transmission
- Any product that currently not has a specific model in WINDOW6, can be defined by a BSDF
- Retrolux Koester blind.
 - Complicated geometry
 - Can be Raytraced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



Creating Layer Data

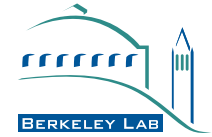


- Venetian Blind Model
 - Specify slat angle, slat width, slat spacing and curvature
- Woven Shade Model
 - Specify thread diameter and thread spacing
- Fritted Glass Model
 - Specify coverage percentage
- BSDF-XML Input
 - Specify XML file

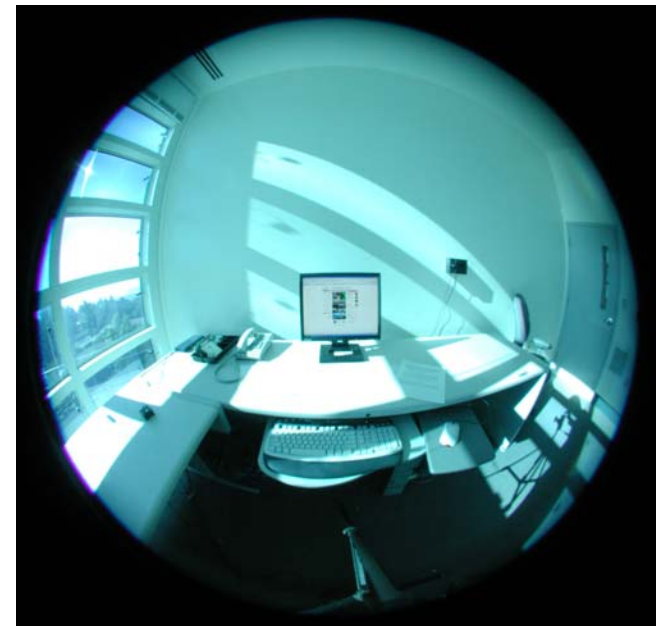


```
<XML>  
<Layer>...</Layer>  
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```

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`