Scientific Applications Using Radiance
University of Applied Sciences of Fribourg
Sep. 30 - Oct. 1, 2002.

POST-PROCESSING OF RADIANCE IMAGES:

VIRTUAL LIGHTING LABORATORY

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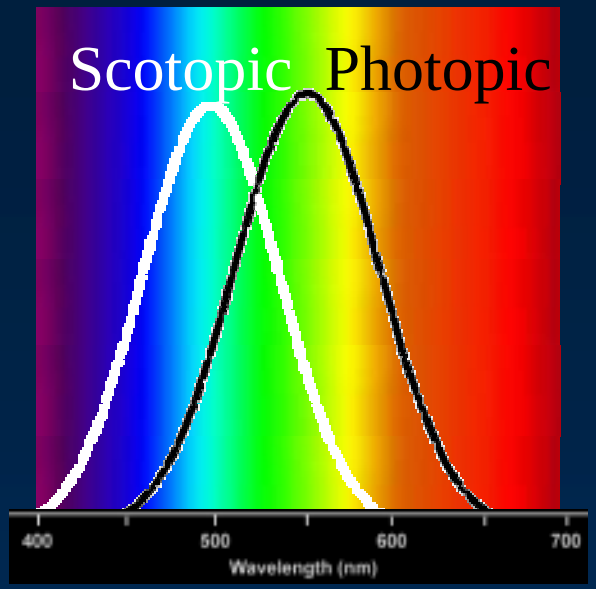
Dynamic Range of Human Visual System



Starlight Moonlight Indoor lighting Daylight / Sunlight

10^{-6} 10^{-3} 1 10 100 10^{+4} 10^{+8}

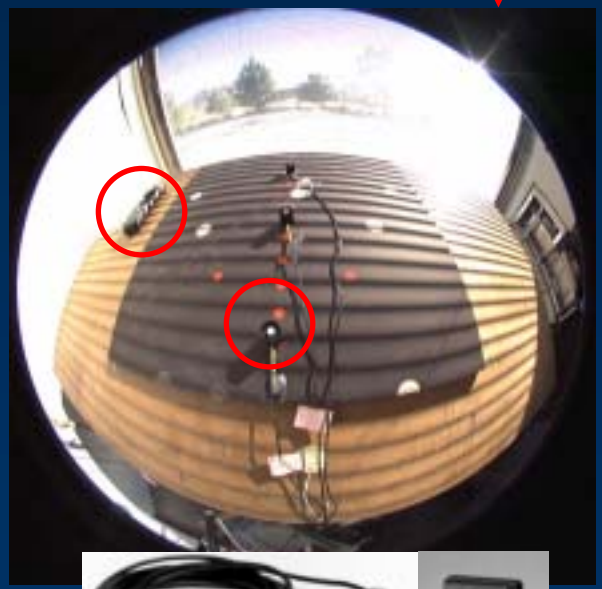
Scotopic Mesopic Photopic

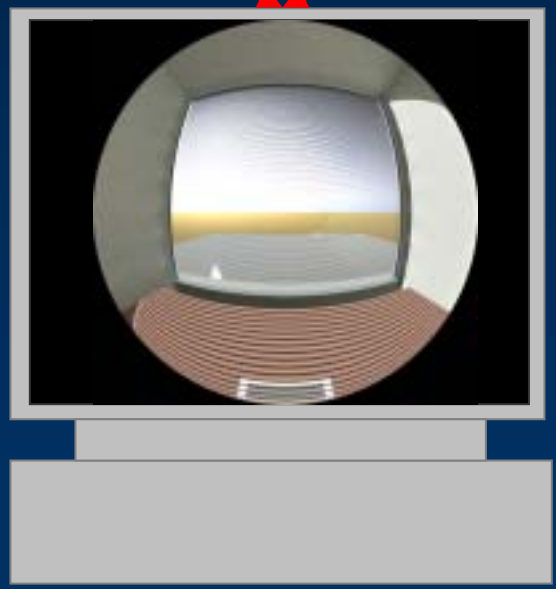
[1]

Basic Quantities

- Illuminance

Luminance





Analytical Studies

- Visual Comfort
  - Visual Comfort Probability
  - Unified Glare Rating
  - Daylight Glare index
- Visual Performance
  - Visibility Model
    - Contrast Rendering Factor (CRF)
    - Disability Glare Factor (DGF)
    - Transient Adaptation Factor (TAF)
  - Relative Visual Performance

[2]

Computer Approach

Starlight

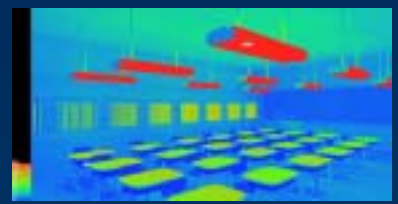
Sunlight

10^{-6} 10^{-3} 1 10 100 10^{+4} 10^{+8}

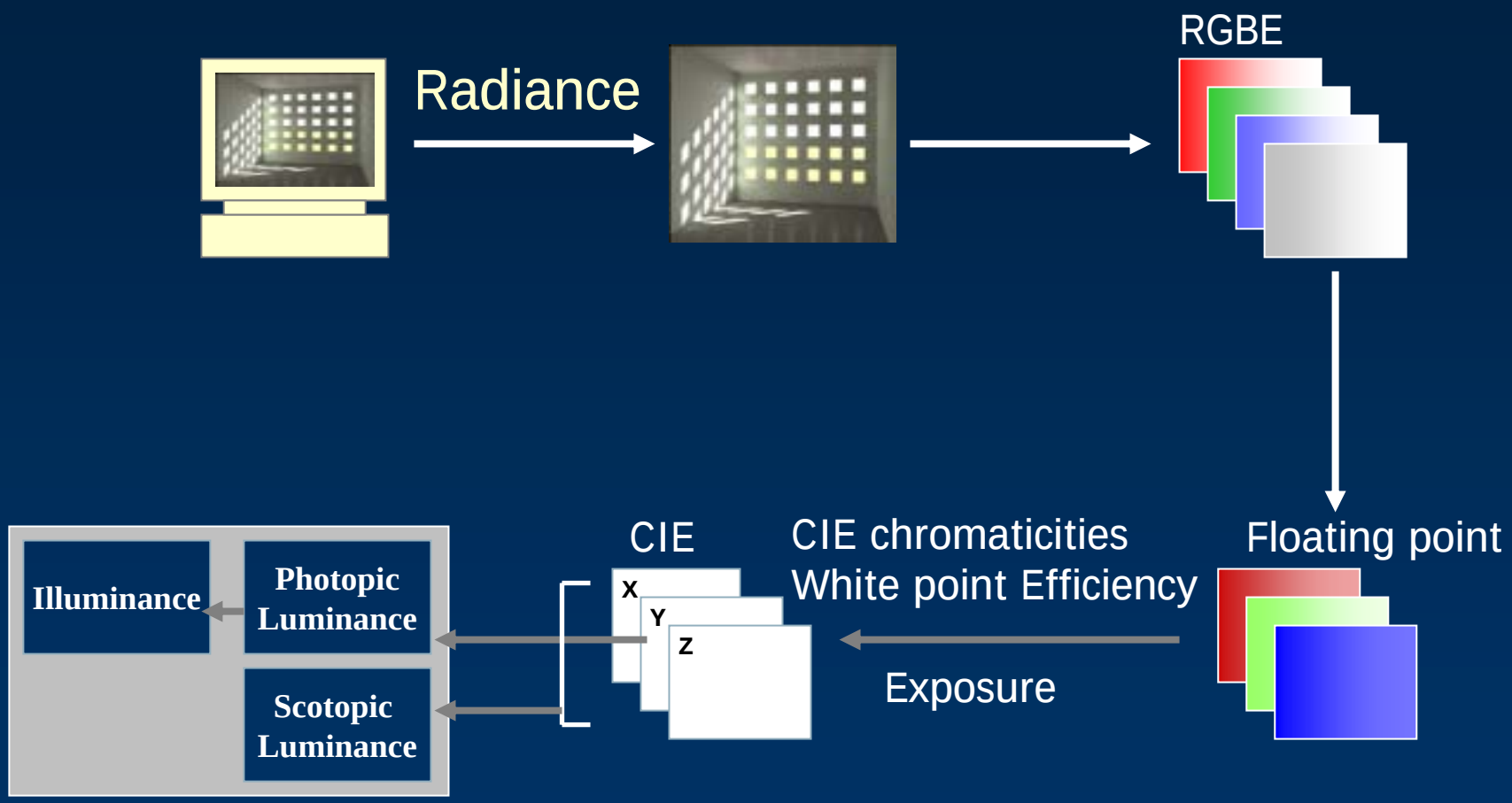
Computer Screen

[1]

RGBE file format



Virtual Lighting Laboratory (VLL)



Radiance Features

- Physically accurate rendering
- High Dynamic Range physical data and compliant image format
- Projection and viewpoint

Goals

- Development of the Virtual Lighting Laboratory;
- Endorsement of lighting analysis by making indices accessible outside laboratory conditions;
- Exploration of new lighting indices.

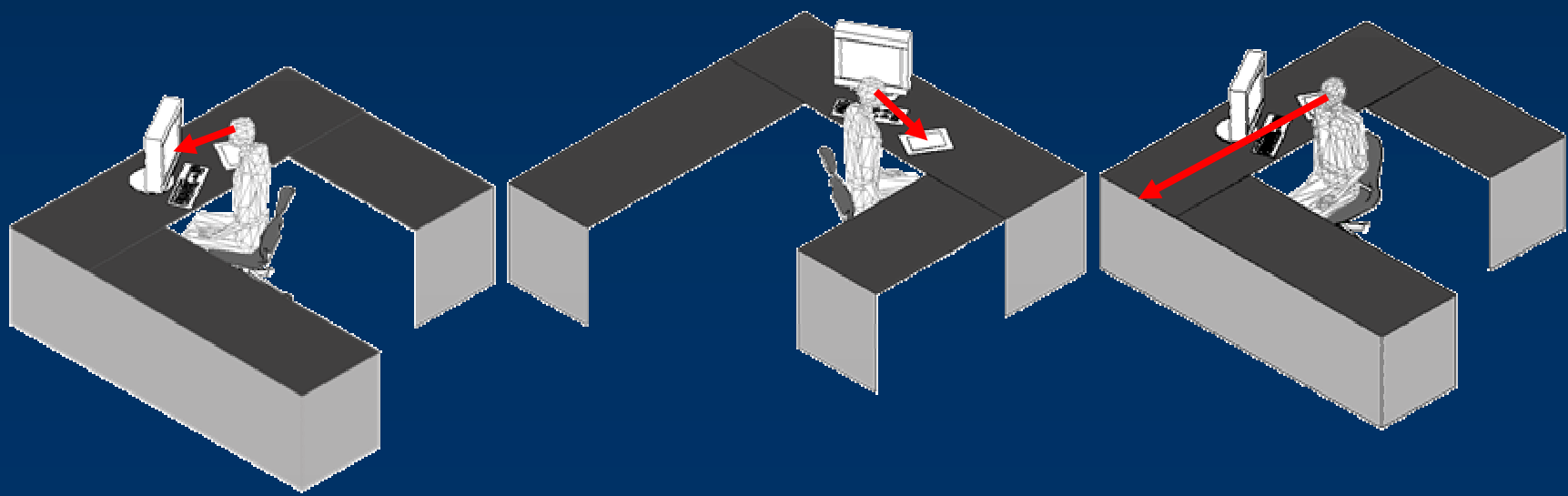
Lighting Analysis

Spatial Dynamism

Eye to pc

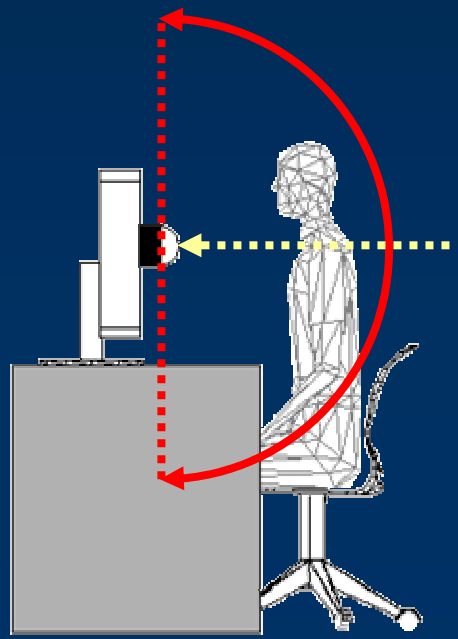
Eye to paper

Eye to window



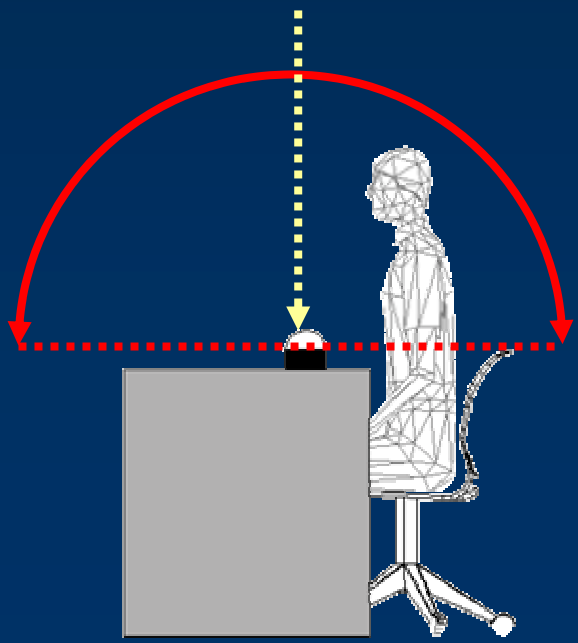
Pc view

Vertical illuminance on screen

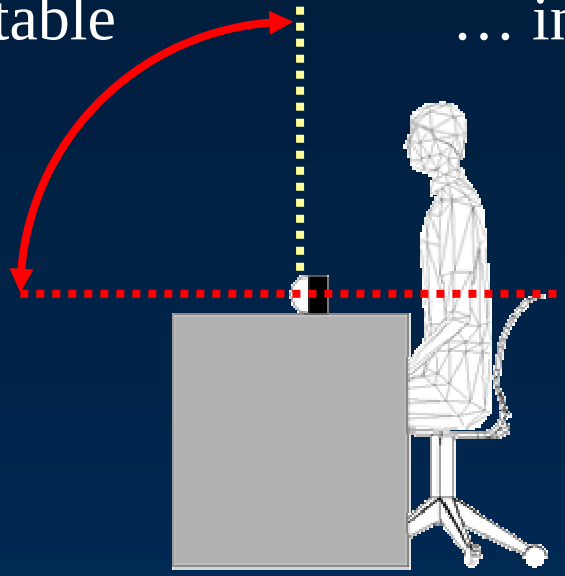


Paper view

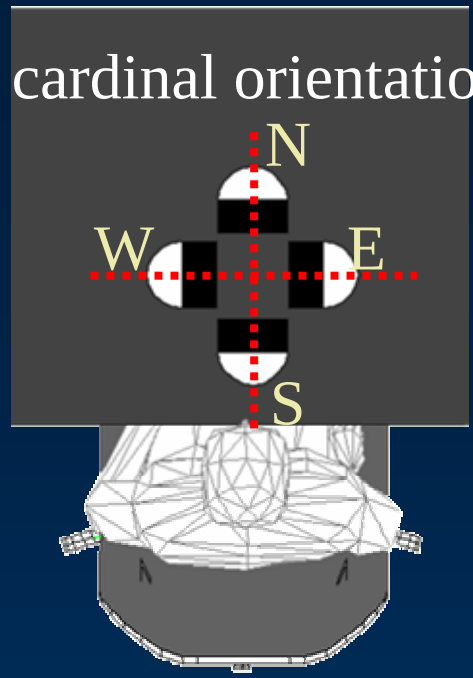
Horizontal illuminance on table

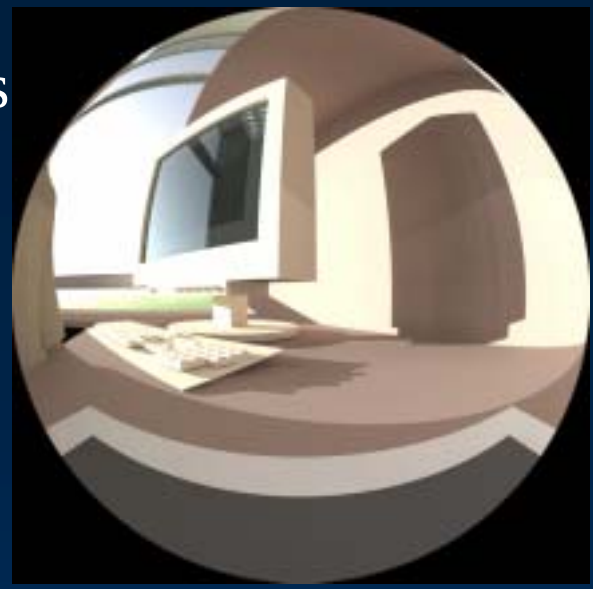


Vertical illuminance on table



… in 4 cardinal orientations





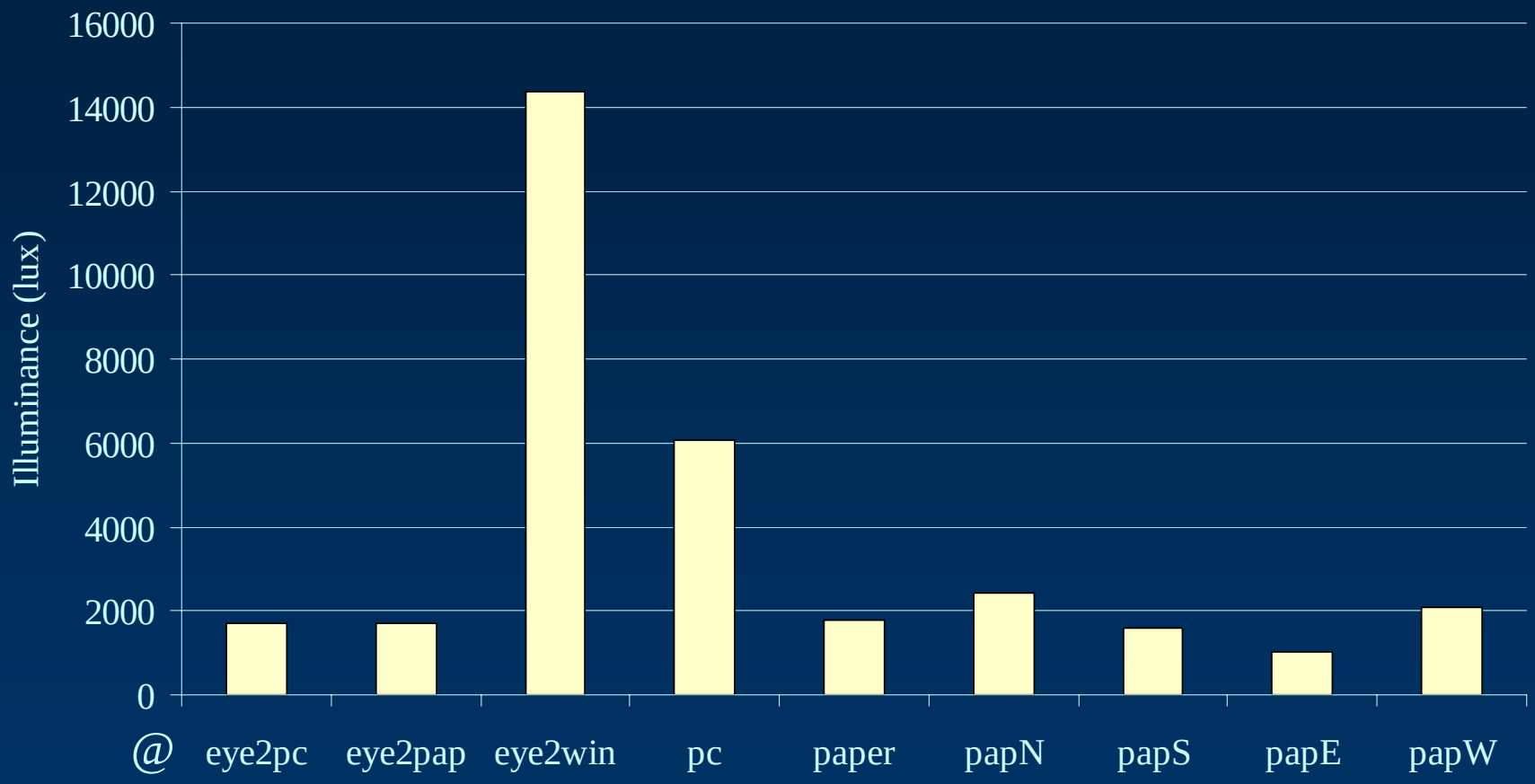
W

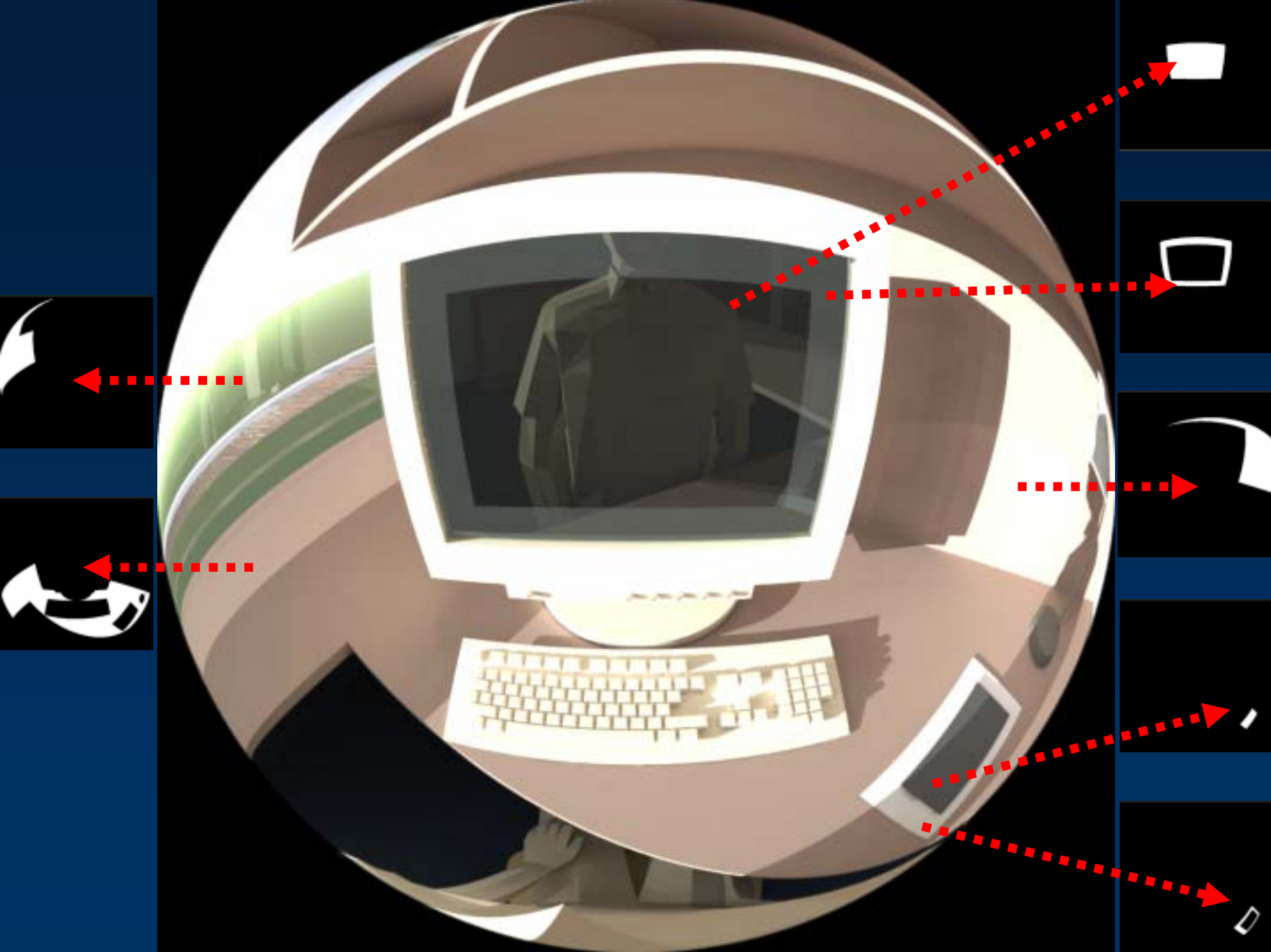
E

S

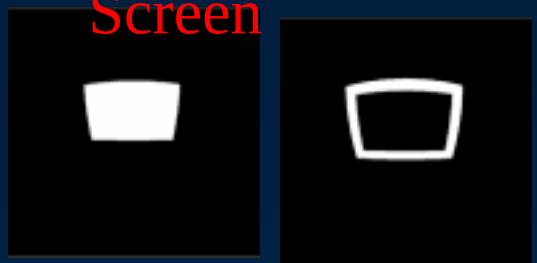
N

Illuminance





Screen



Min L	9 cd/m2
Max L	2403
Min: Max	1 : 267
Contrast	0.26

Paper

Min L	53 cd/m2
Max L	3814
Min: Max	1 : 72
Contrast	0.90

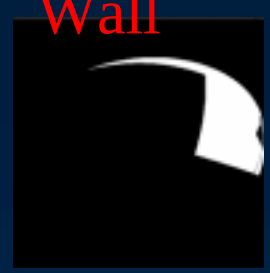
Window

Min L	54 cd/m2
Max L	4823
Range	4769
Min: Max	1 : 89
Mean	1097

Table

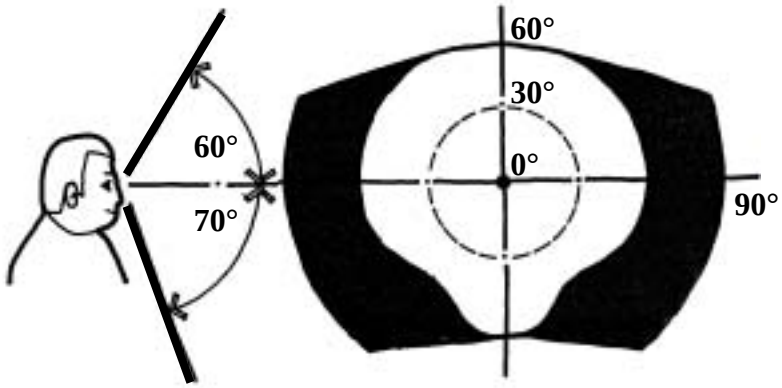
Min L	2 cd/m2
Max L	4039
Range	4037
Min: Max	1 : 2020
Mean	380

Wall



Min L	58 cd/m2
Max L	3353
Range	3295
Min: Max	1 : 58
Mean	606

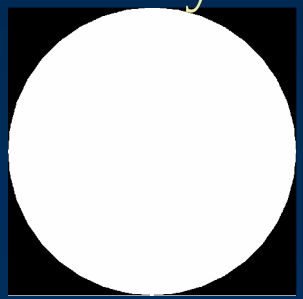
	E (lux)	Max. L (cd/m2)	L ratio (task: surround)	L ratio (task: wall)
IESNA	200-300	850	3:1	10:1 40:1 max



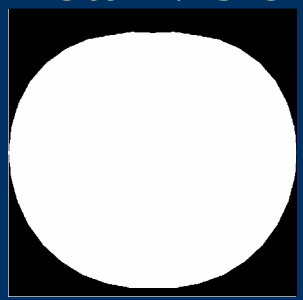
Visual Field

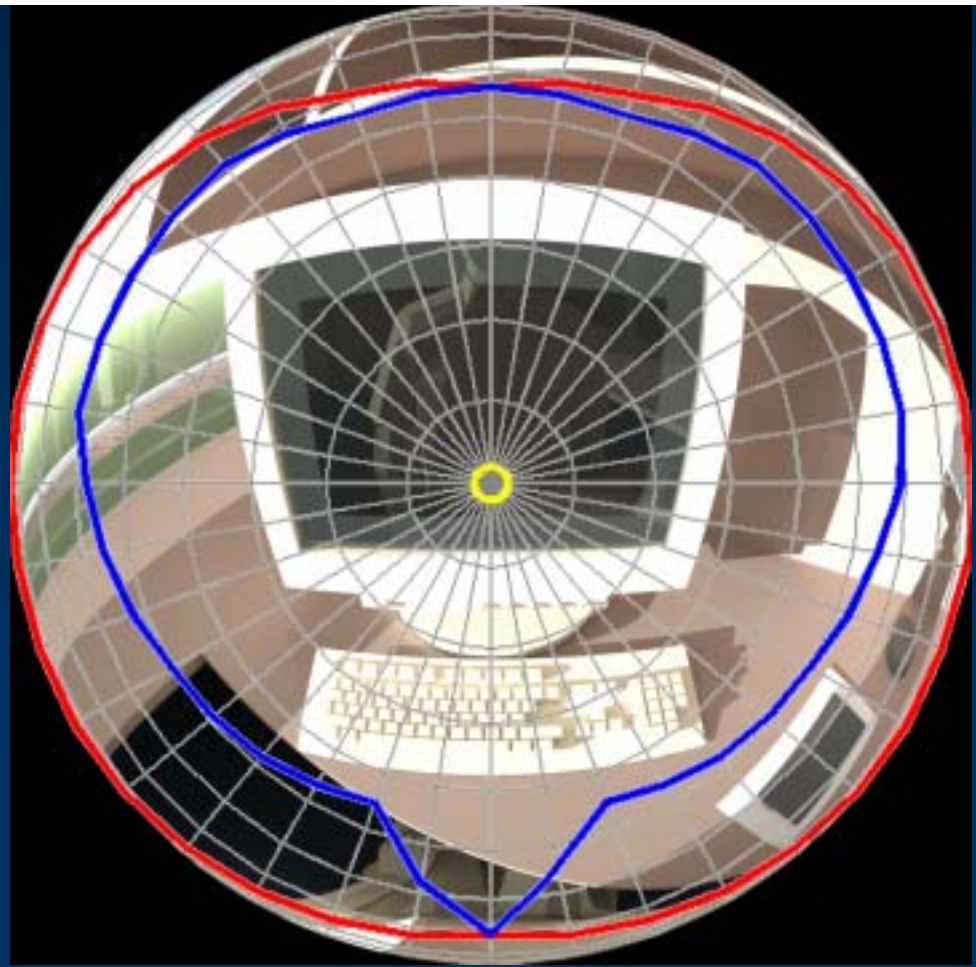
[3]

Fisheye

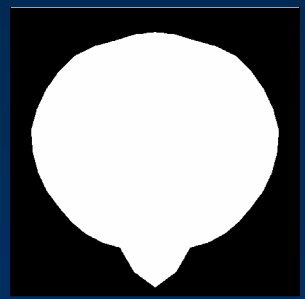


Total vision

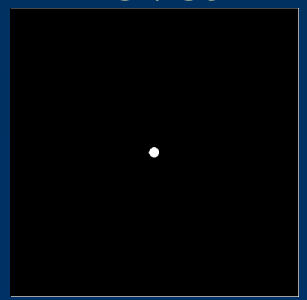


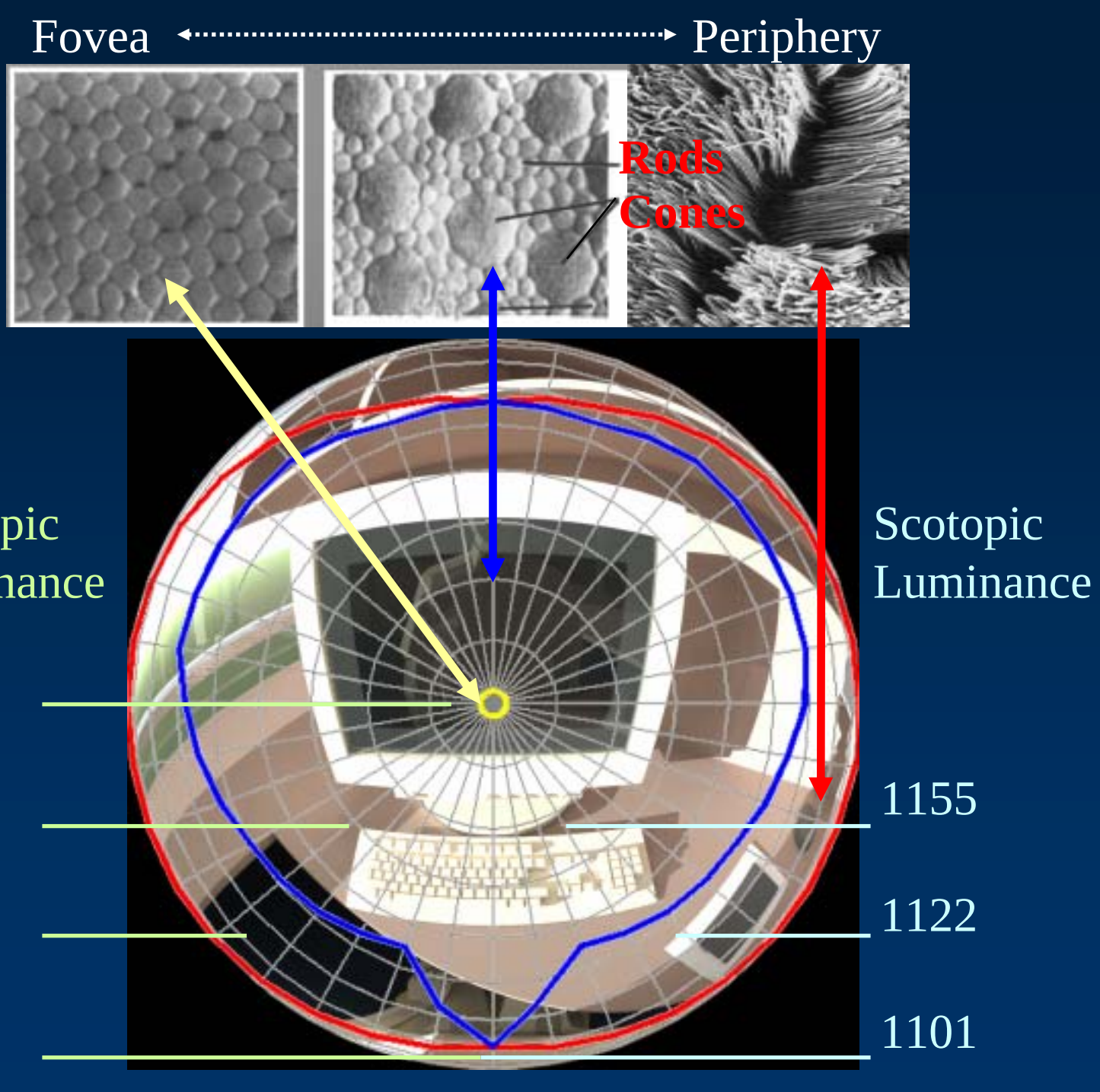


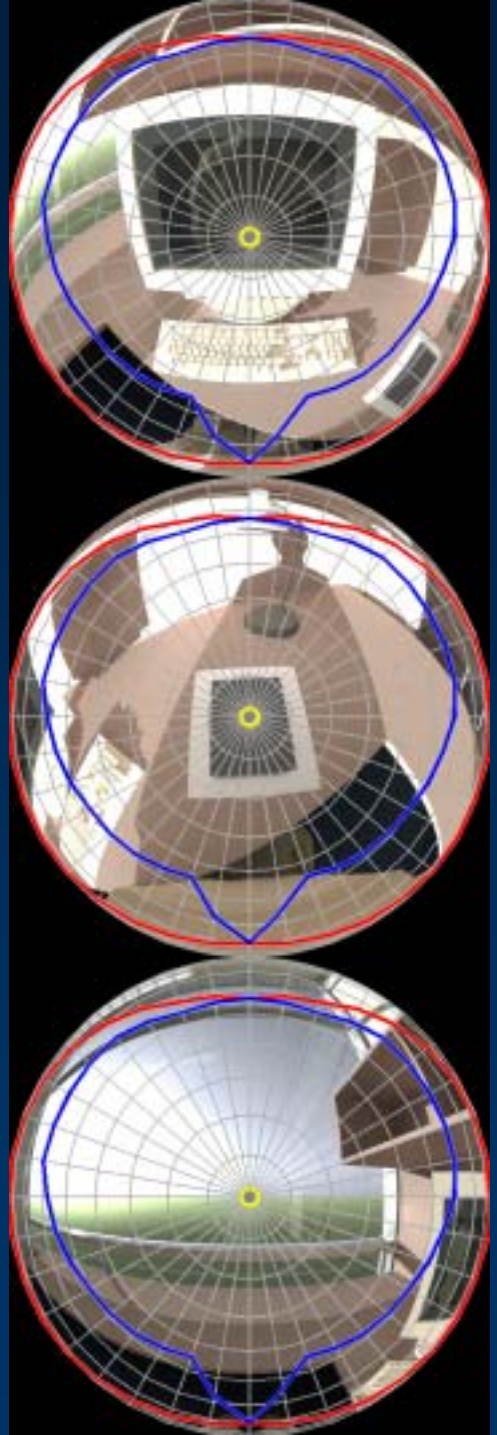
Binocular



Foveal

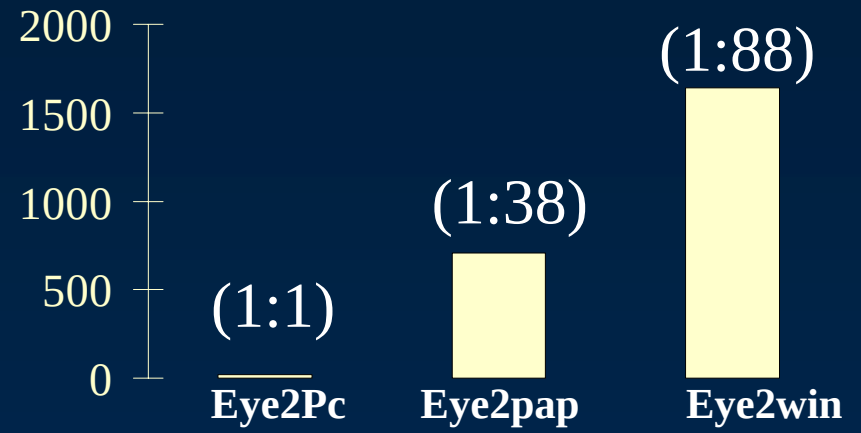



Fovea
Periphery
Rods
Cones
Photopic Luminance
19
584
560
549
Scotopic Luminance
1155
1122
1101

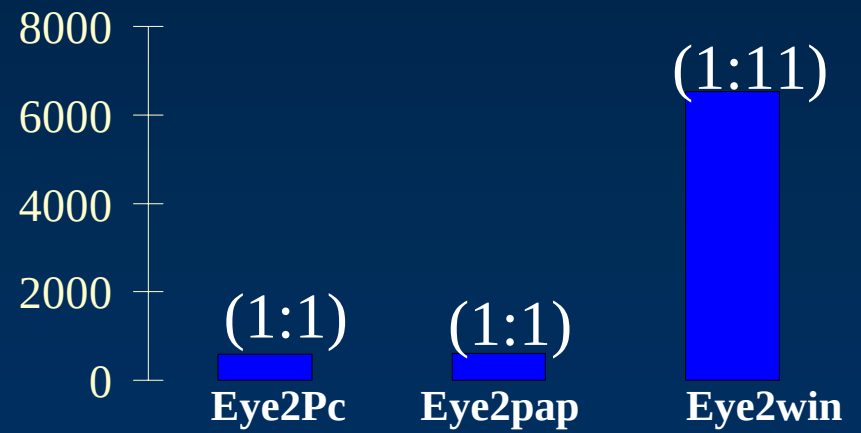


Luminance (cd/m2)

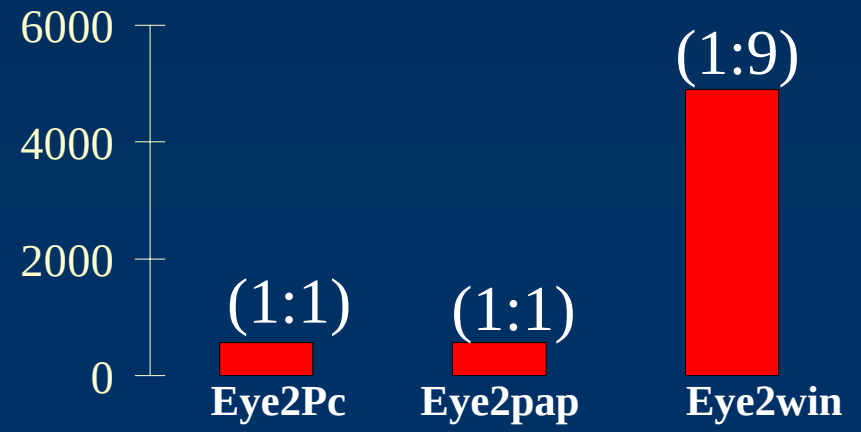
Foveal Vision



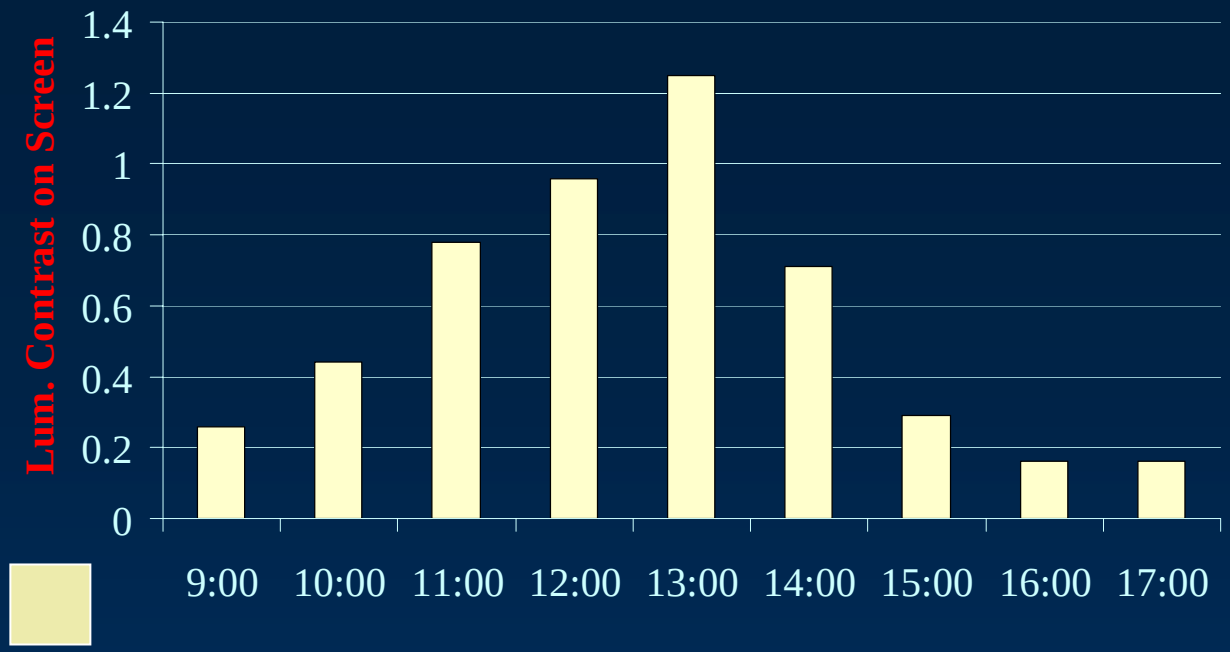
Binocular Vision



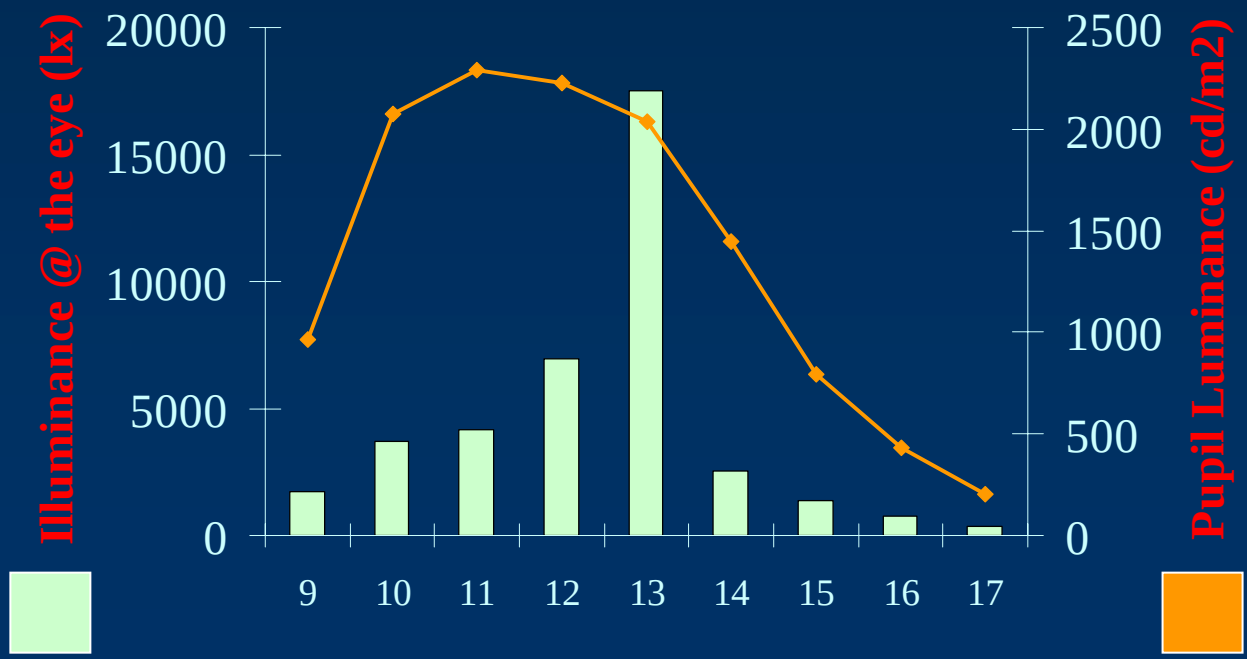
Total Vision (Binocular + Peripheral)



Temporal Dynamism



$$C = \frac{L_f}{L_b}$$

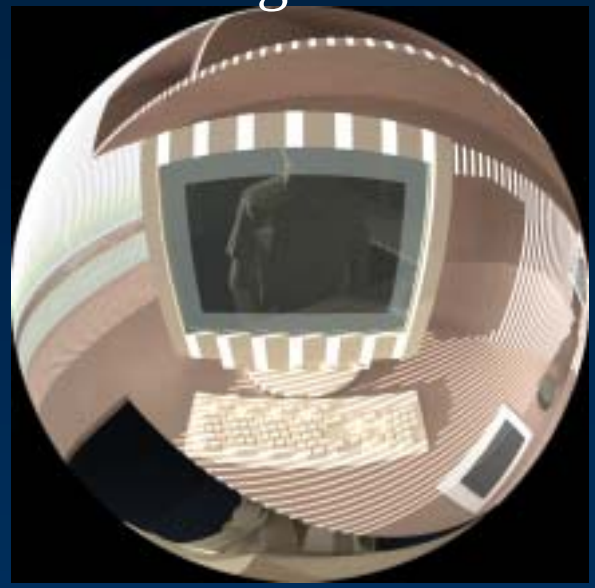


$$L_p = P\left(\frac{S}{P}\right)^{0.78}$$

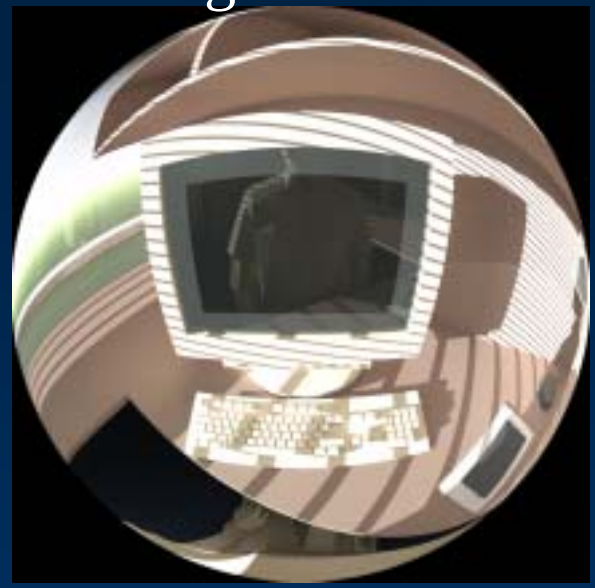
Design Decision Making

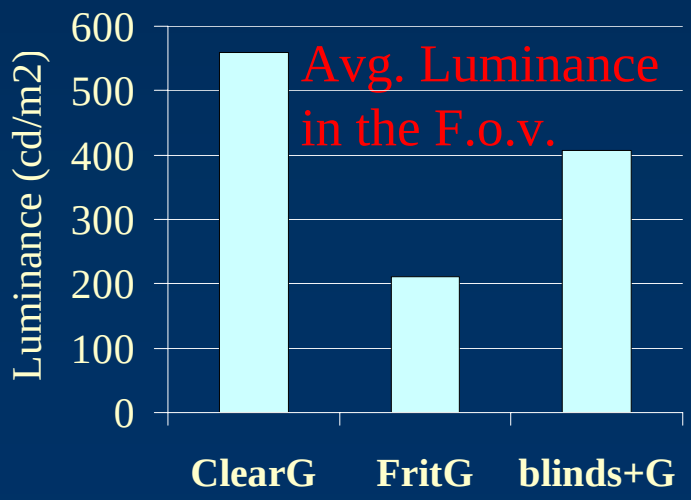
Clear glass

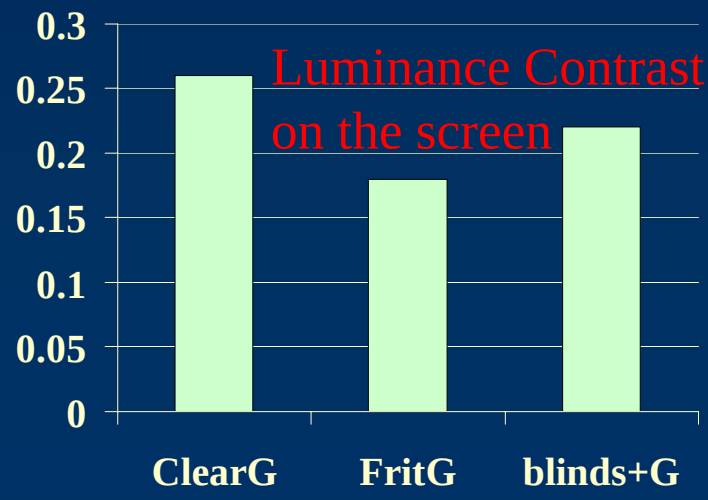
Fritted glass



Clear glass w/blinds



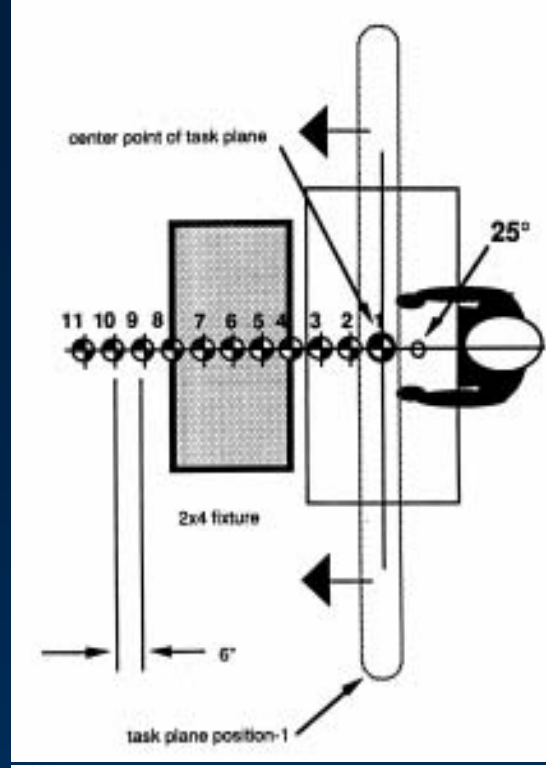


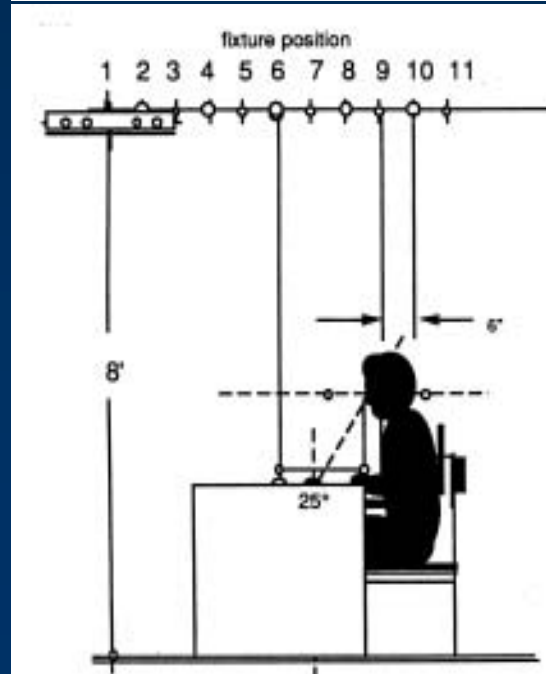


Contrast Rendering Factor CRF)

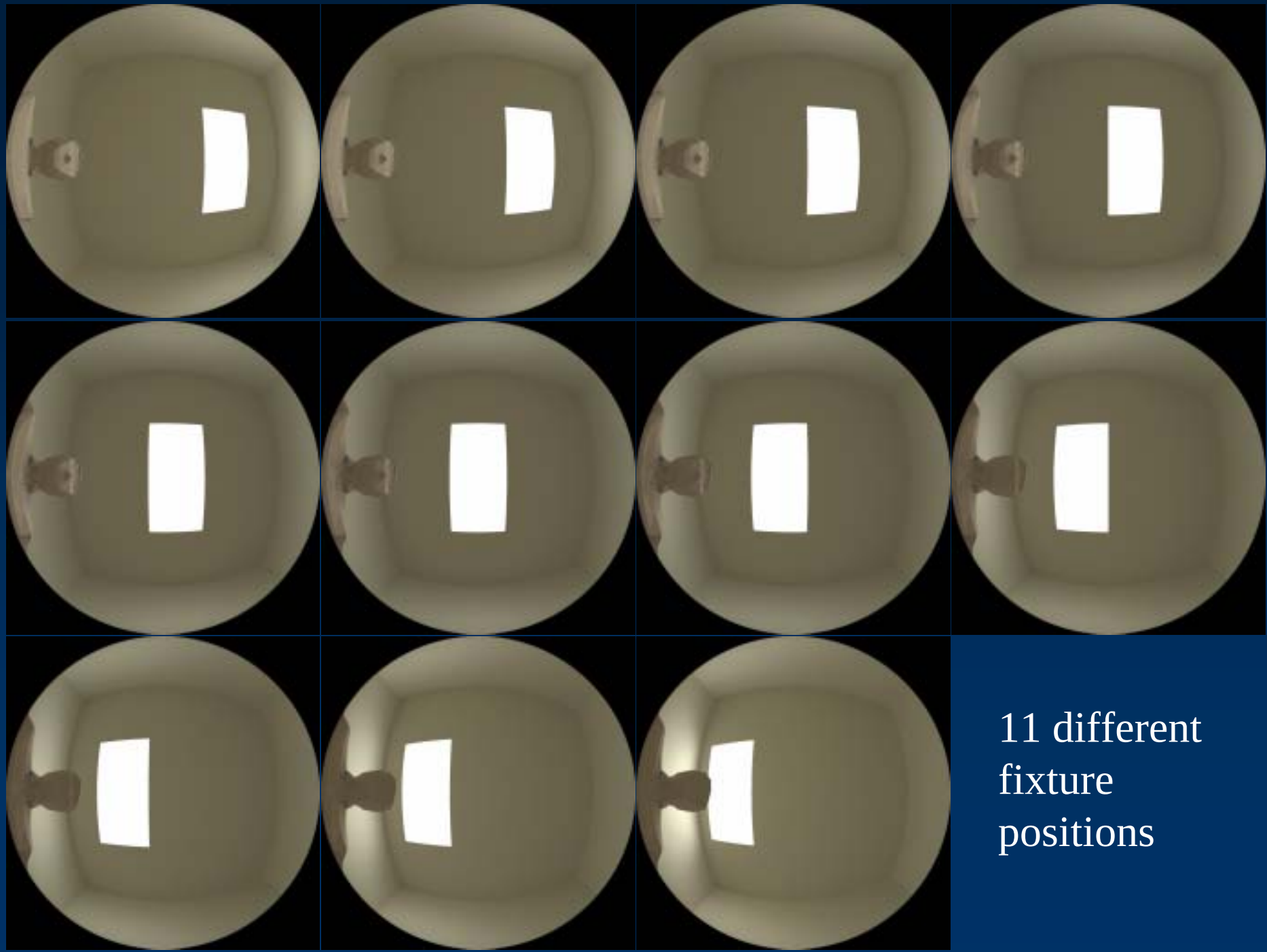
Veiling reflection occurs when light strikes a task and produces shiny reflections that reduce or veil contrast between details of the task and background, such as print or photos on paper. Lower contrast reduces visibility, which can cause eyestrain and impaired productivity.

There are many ways to minimize veiling reflections, including moving the light source, installing different reflectors or lenses, and moving or reorienting the task … *[2]*



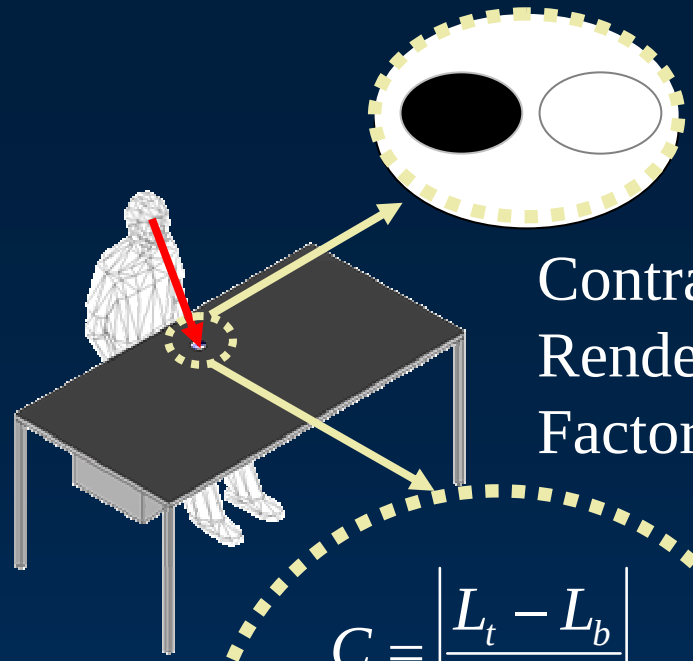


[4]



11 different fixture positions

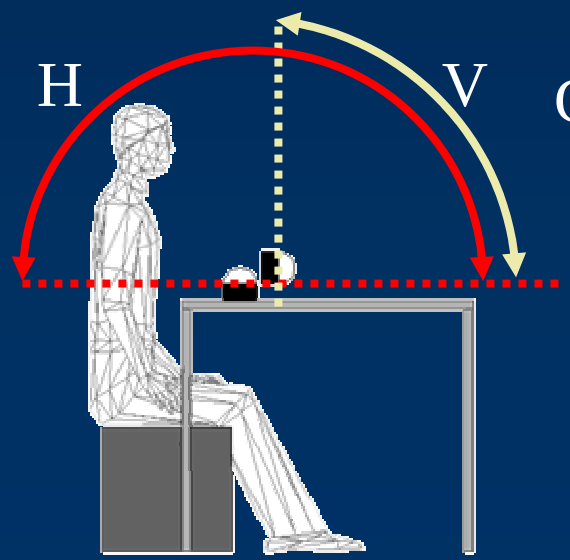
Contrast Rendering Factor CRF)



Contrast Rendering Factor

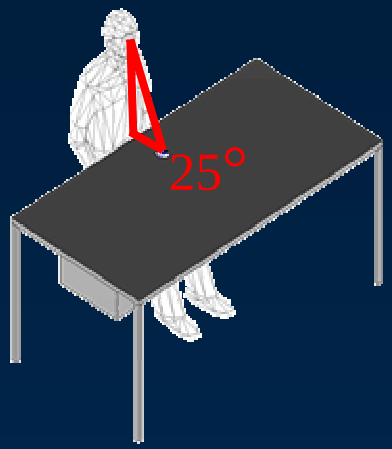
$$C = \left| \frac{L_t - L_b}{L_b} \right|$$

$$CRF = \frac{C}{C_{ref}}$$

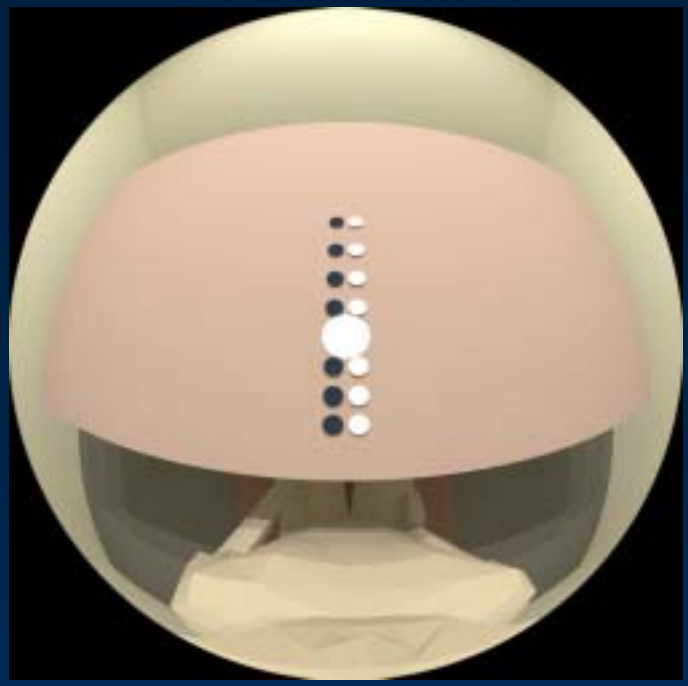


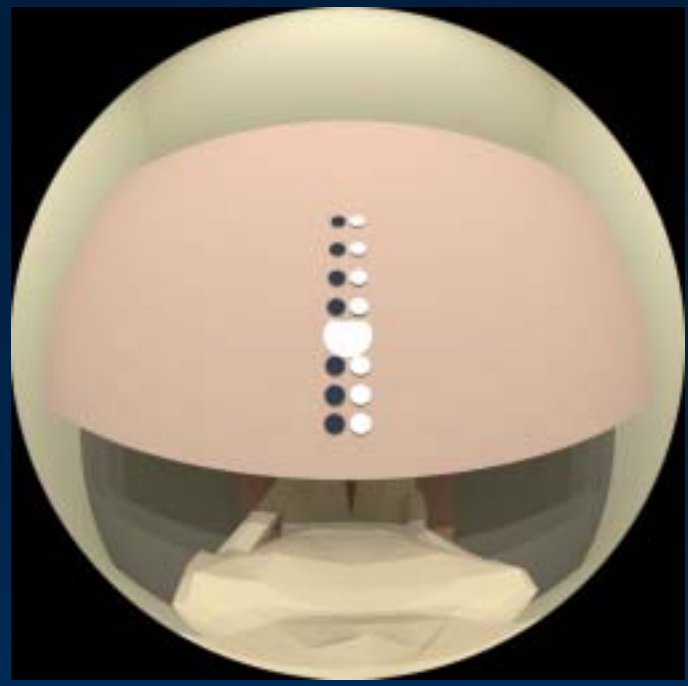
Contrast Potential

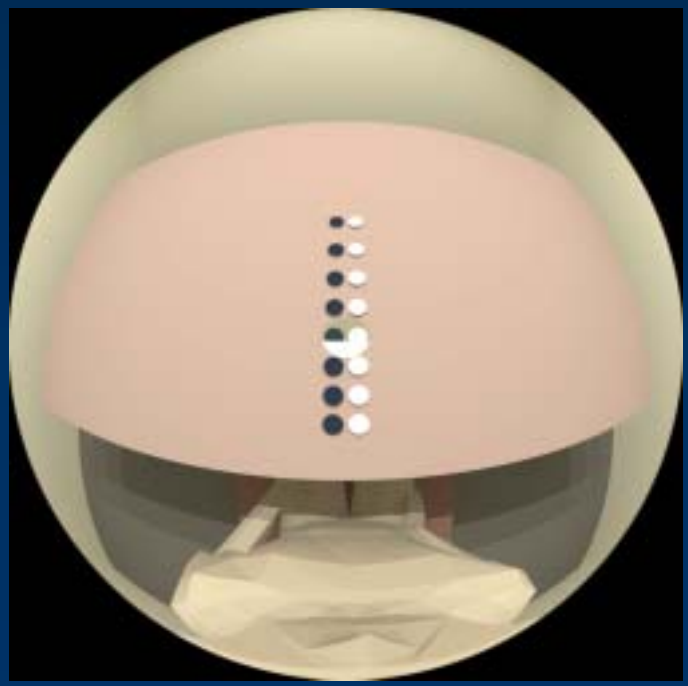
$$CP = \frac{H - V}{H}$$

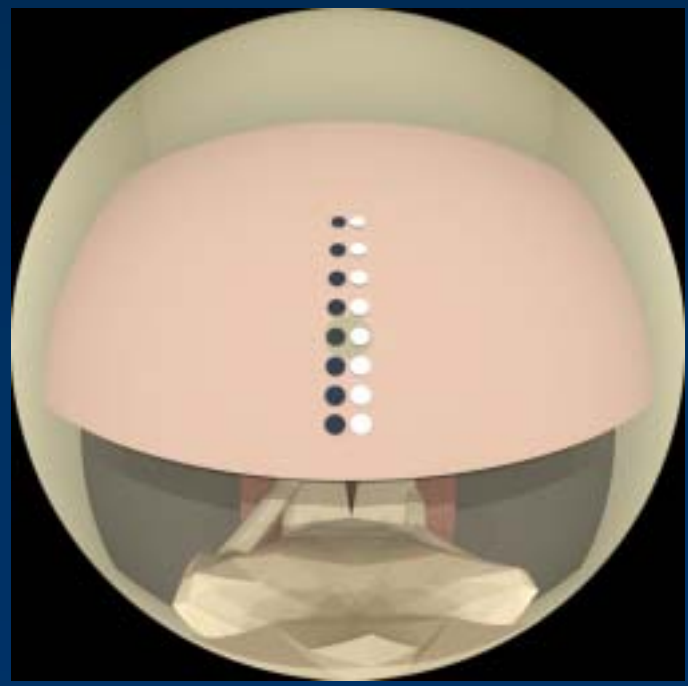


CRF

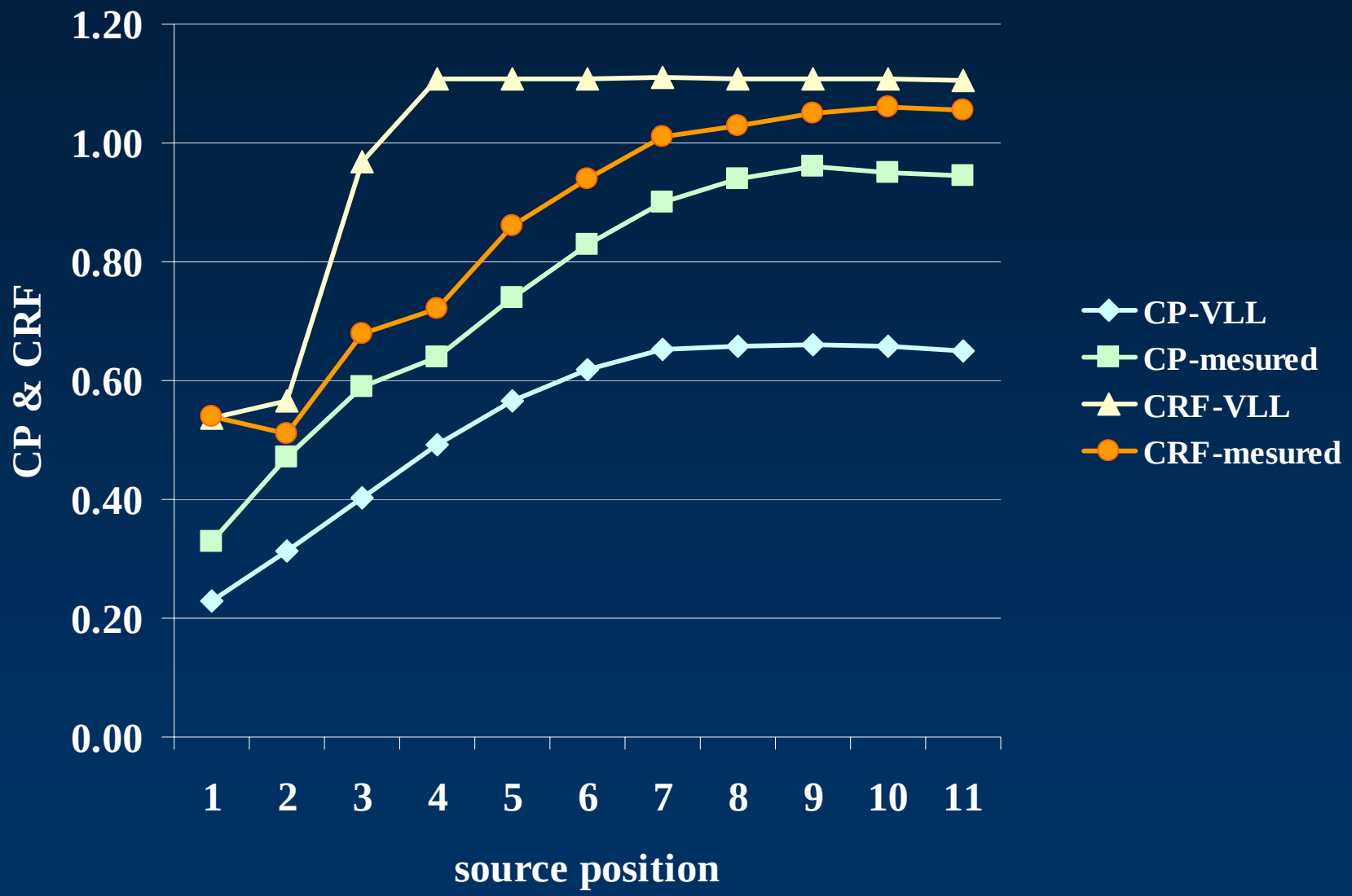








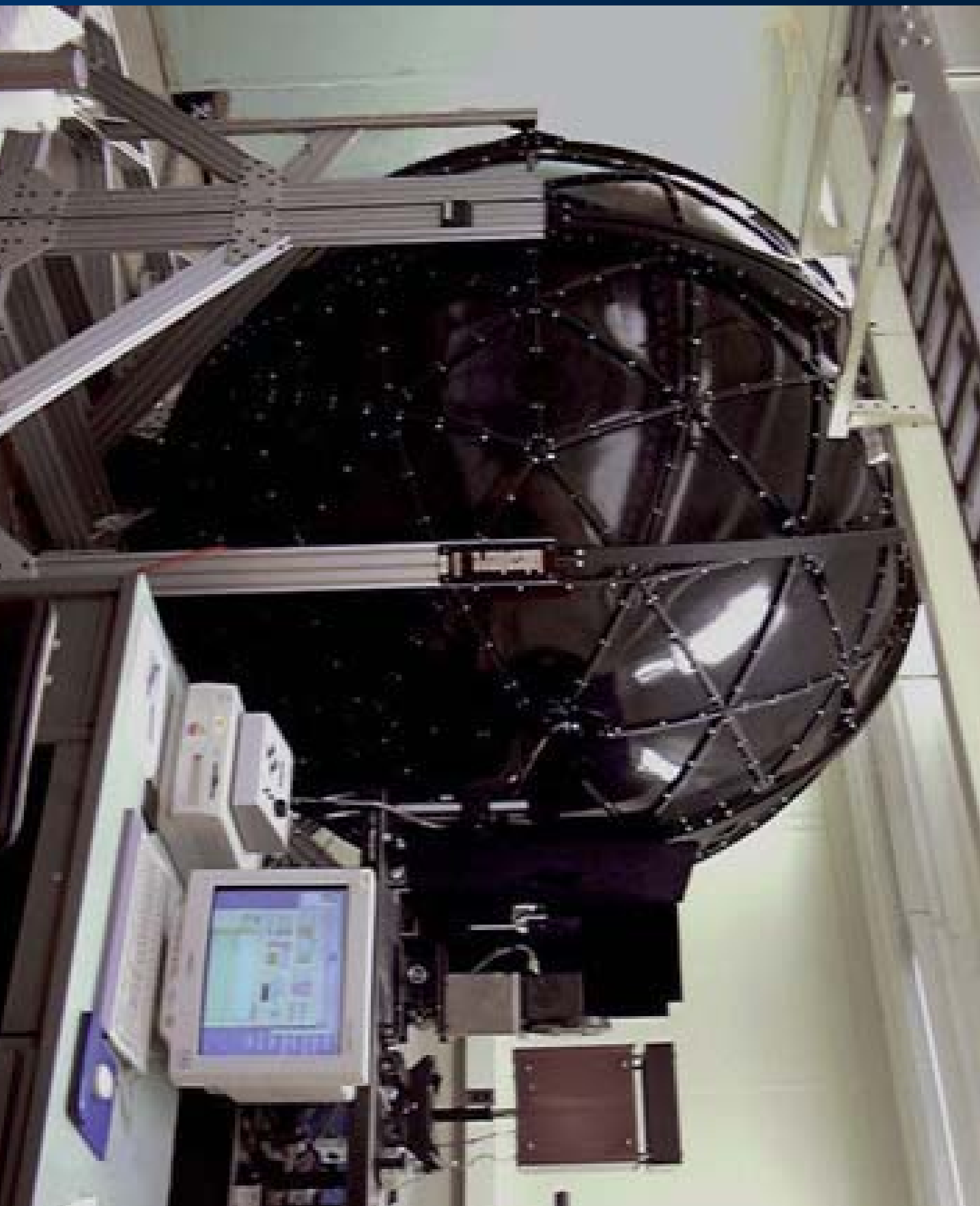
CRF


1.20
1.00
0.80
0.60
0.40
0.20
0.00
CP & CRF
1
2
3
4
5
6
7
8
9
10
11
source position
CP-VLL
CP-mesured
CRF-VLL
CRF-mesured

VLL: for conducting complex lighting analysis in comparison to full-scale physical measurements.

- It does not require physical space;
- It does not require expensive equipment;
- It does not require laborious measurements;
- Reproducibility of the reference task is not a problem;
- The measurements are free from operator, who screens off the parts of the environment during measurements.

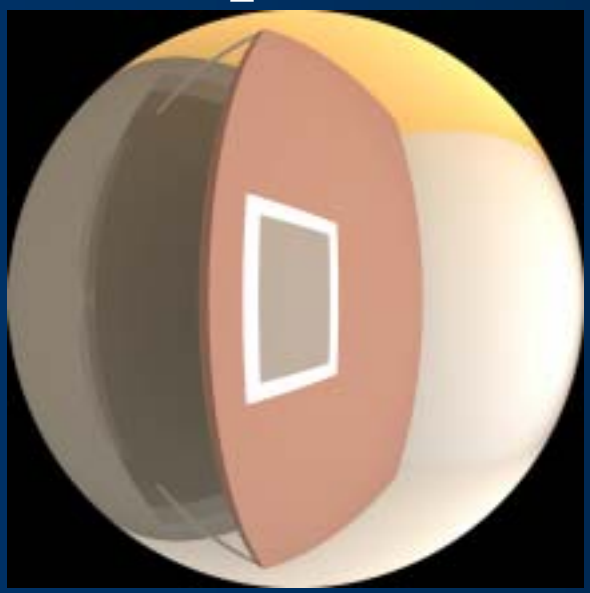
Integrating Sphere

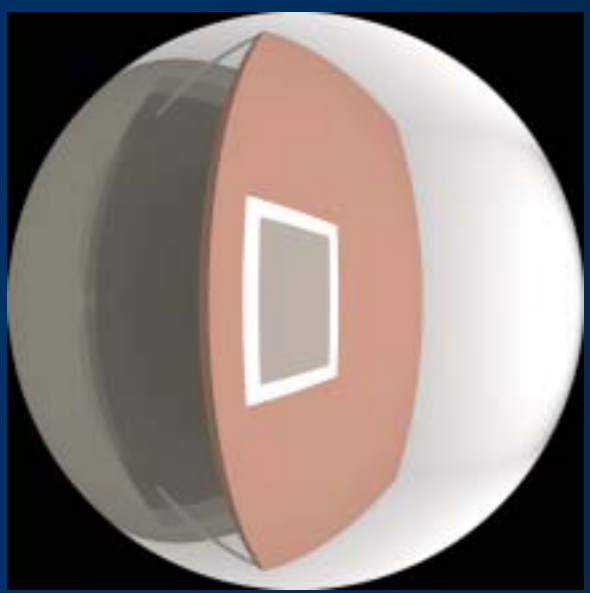


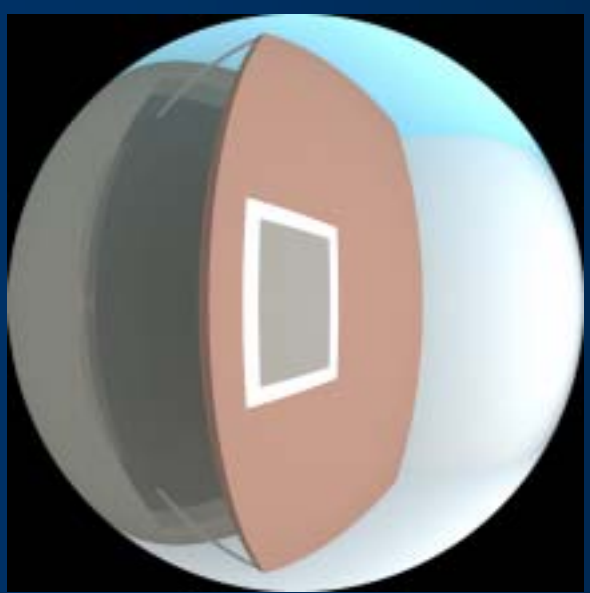
VLL: for simulating expensive laboratory equipment in virtual environment

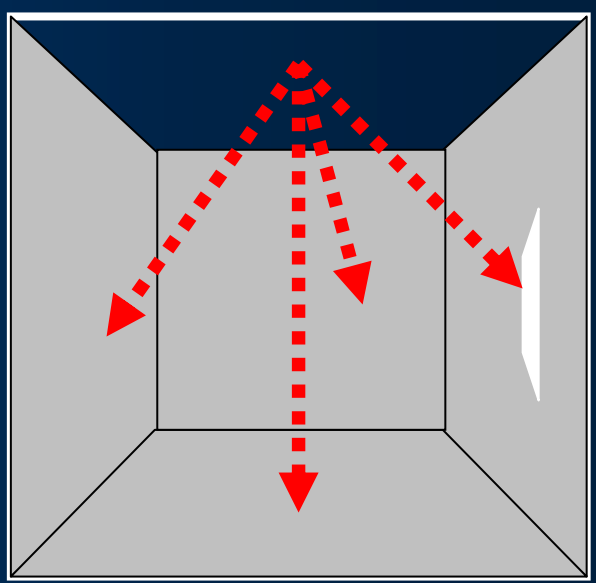
- Perfectly diffuse material;
- Physical requirements, such as aperture in the sphere wall for the measurement purposes are not needed in virtual environments;
- Flexible size.

Scotopic / Photopic Ratio

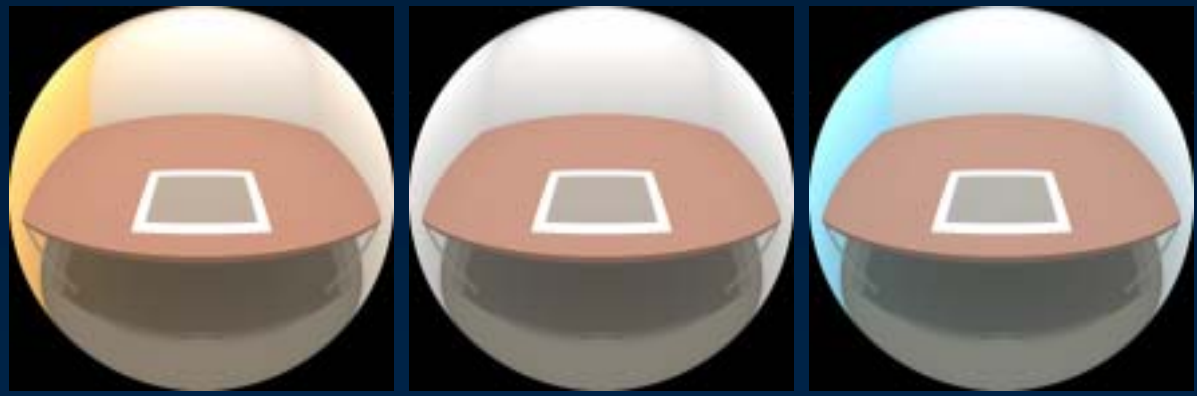


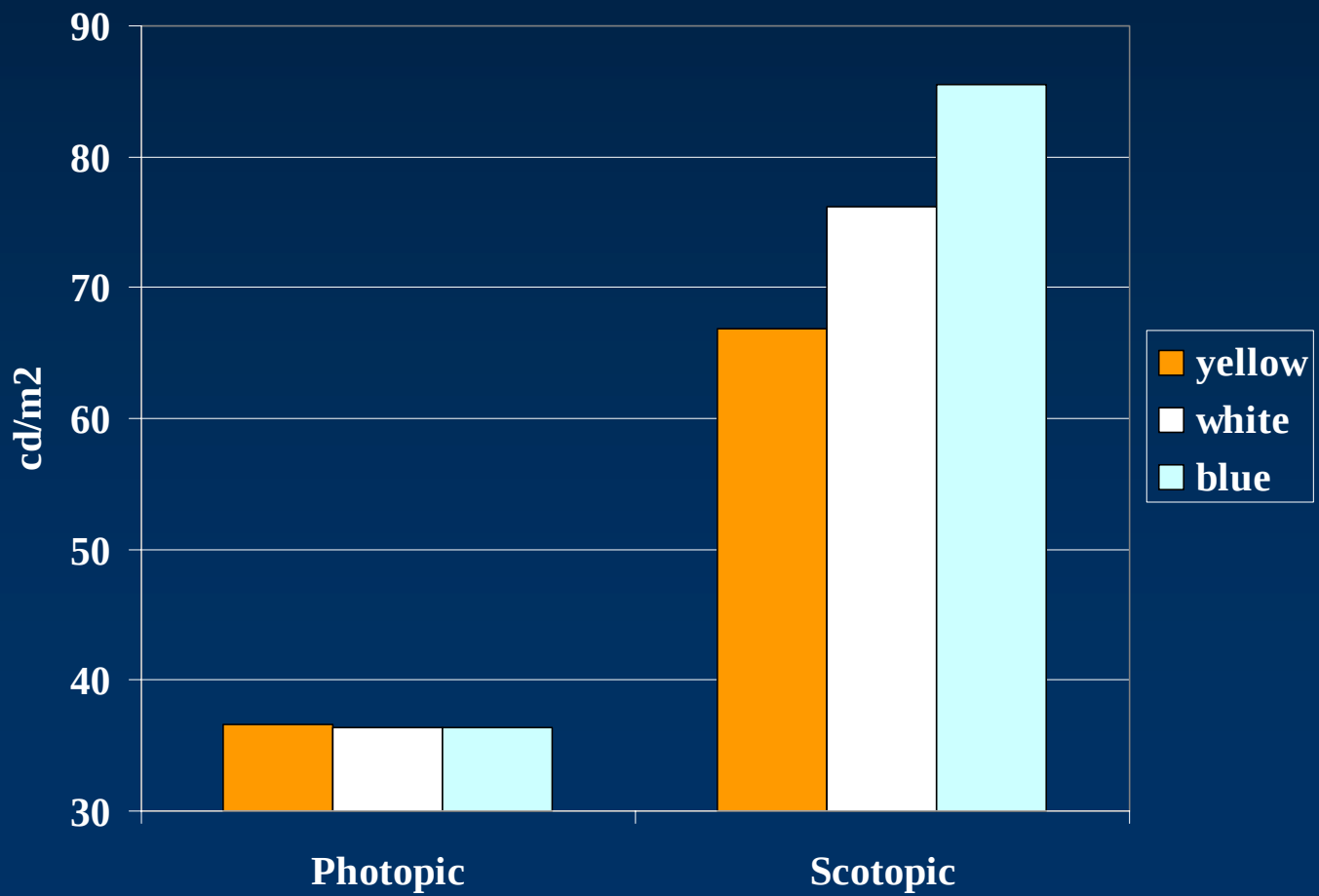






Scotopic / Photopic Ratio





VLL: for innovative lighting analysis

- To demonstrate that photopic luminance is not sufficient alone to analyze luminous environment;
- To transform the recent research findings into current lighting practice;
- To devise a new luminous environment indicator

Remarks

- Restructuring in Architectural Lighting Analysis with:
  - Transformation of complex indices from laboratory environments to real architectural applications;
  - Transformation of expensive lighting equipment to general usage;
  - Transformation of recent research findings into current practice;
  - Generation of new indices;
  - Transformation of psychophysical experiments from simple scenes to real architectural applications; and
  - Transformation of lighting analysis from static lighting indices to dynamic lighting indices.

Image courtesy of…

1. Ferwerda, J.A. "Elements of Early Vision for Computer Graphics", *IEEE Computer Graphics and Applications*, Vol. 21, no 5, September/October 2001, pp. 22-33.
2. *Advanced Lighting Guidelines*, New Buildings Inc., 2001.
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POST-PROCESSING OF RADIANCE IMAGES:

VIRTUAL LIGHTING LABORATORY

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