Glare and Diffuse Sources

Characterizing Glare

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ARUP

3 Questions

What is Glare?

How do we *Measure* Glare?

How do we *Predict* Glare?


What is
Glare?

Disability Glare

E Patterson / Understanding Disability Glare

Lee Sullivan / Lake Norman Media

Failure to form a retinal image due to ***excessive brightness*** or ***low contrast***

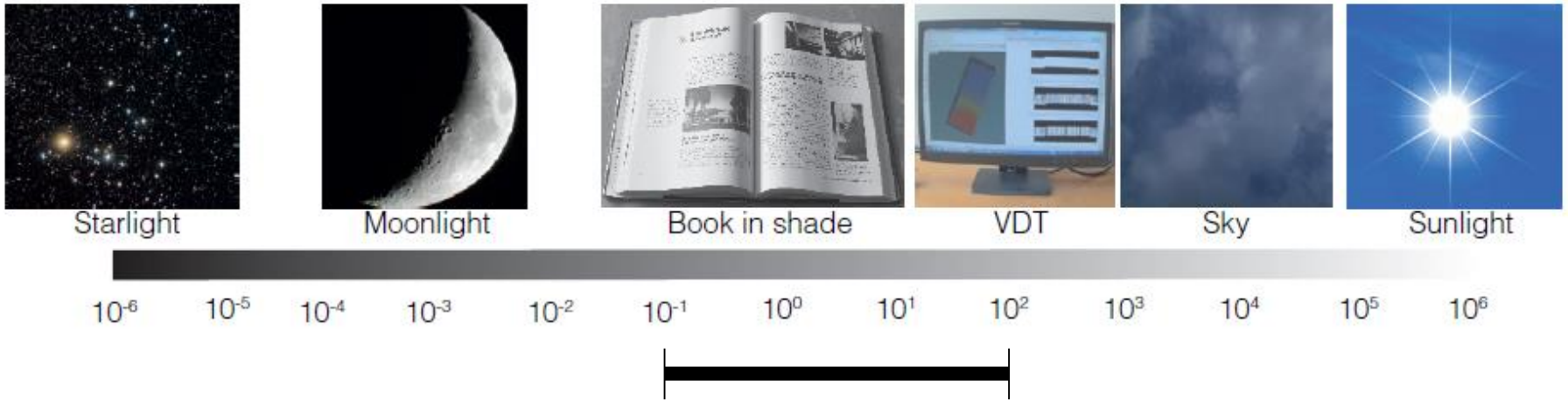
Discomfort Glare

Alstan Jakubiec / Christoph Reinhart

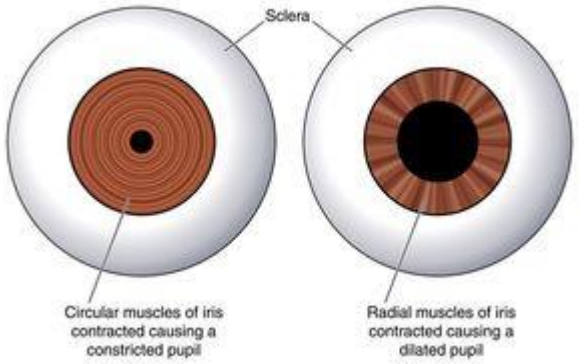
Naomi Miller / PNNL

Pain caused by object in the field of view that is brighter than the luminance to which the observer is ***adapted***

Visible Range



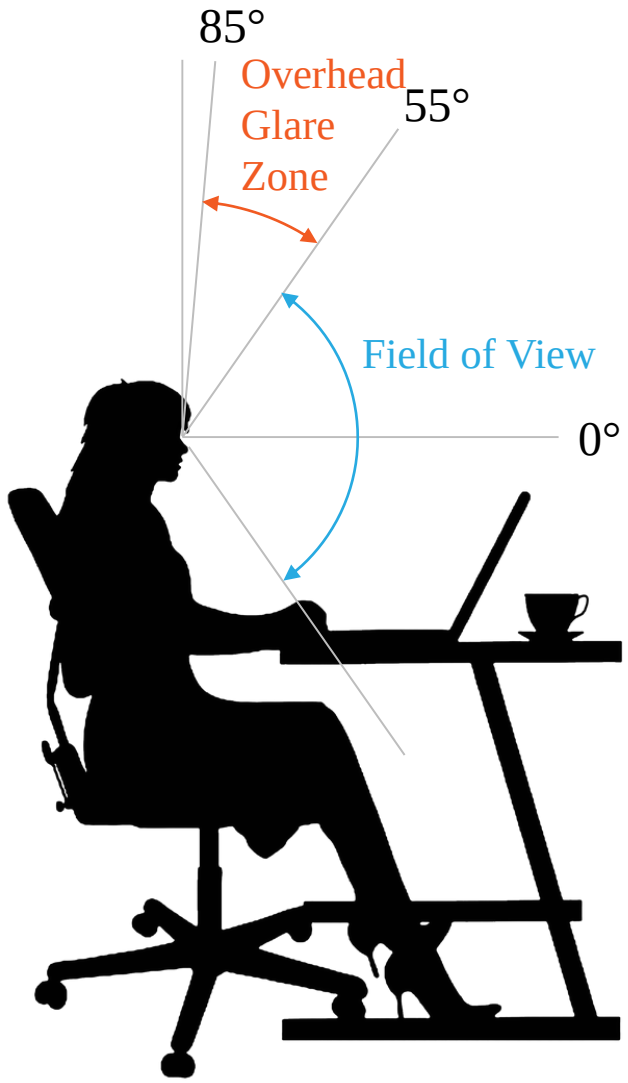
We perceive only ***3 orders of magnitude*** in luminance without adjusting our eyes



Christoph Reinhart / Daylighting Handbook and Peter Lamb

Rules of Thumb

Field of View

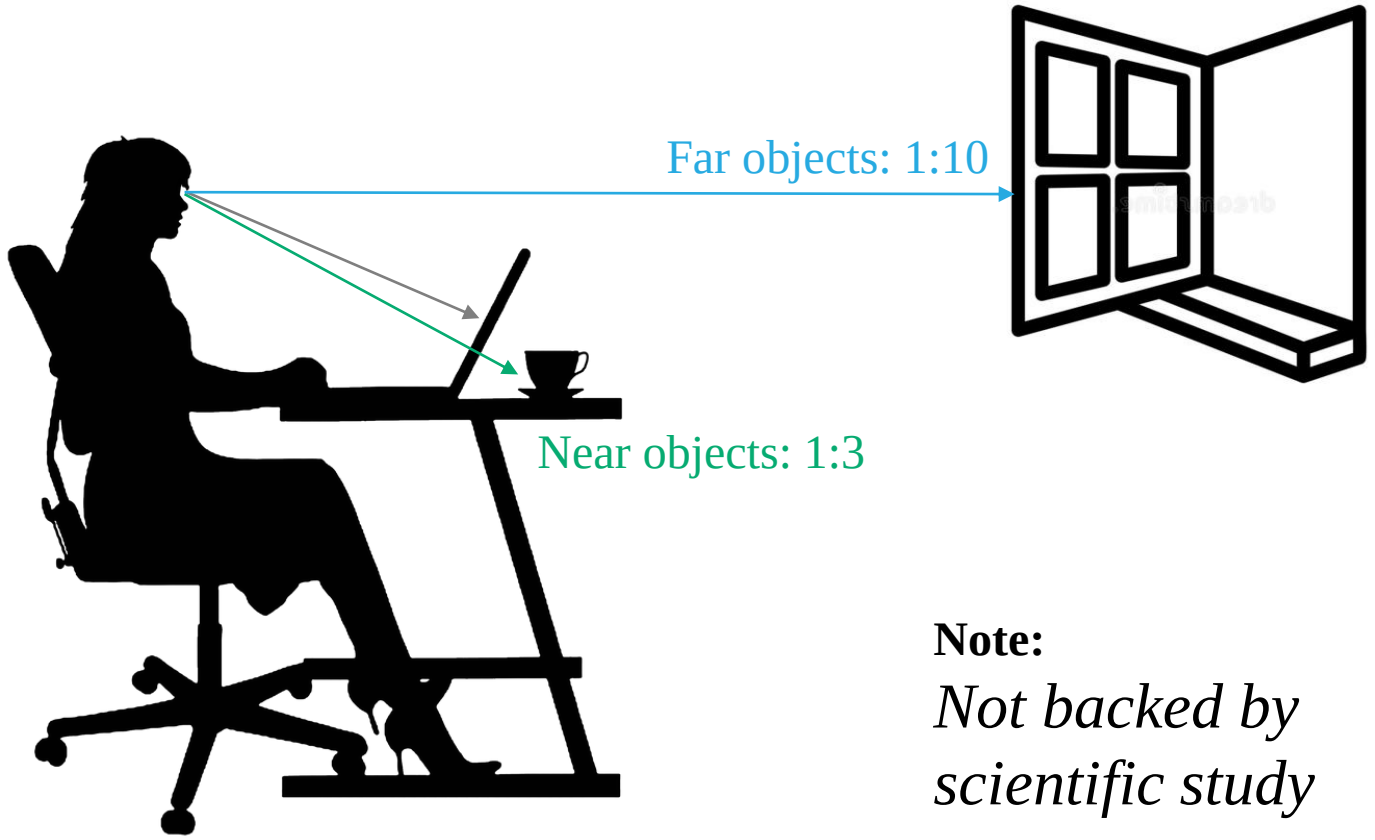


Assumption:

Don't look up!

Based on IES DG-18-08

Rules of Thumb
Contrast Ratio



Note:
Not backed by scientific study

Based on IESNA Lighting Handbook, 9th edition

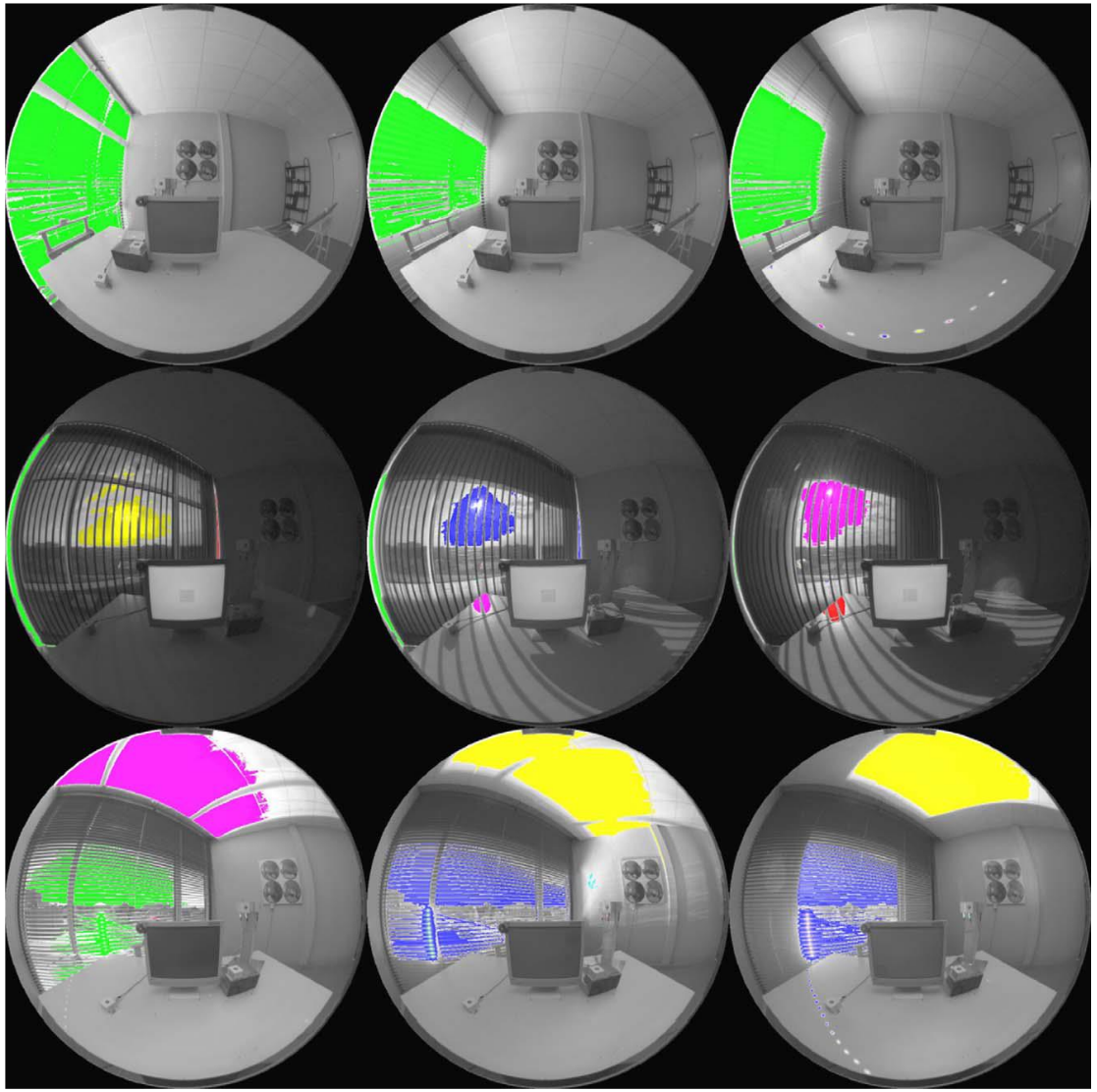
Colors might “clash”

but

Color is not considered in glare

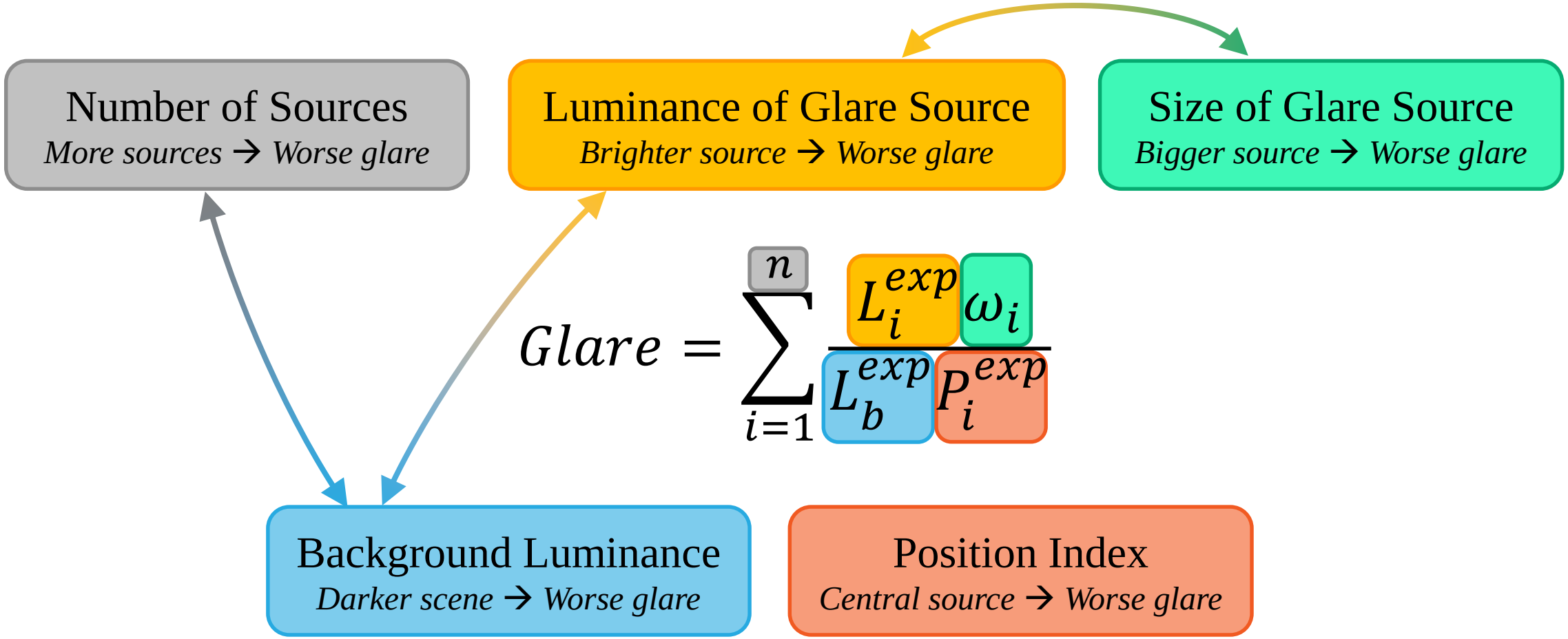

How do we
Measure
Glare?

Photographing Glare

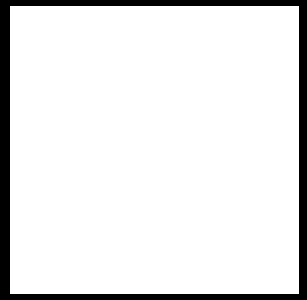


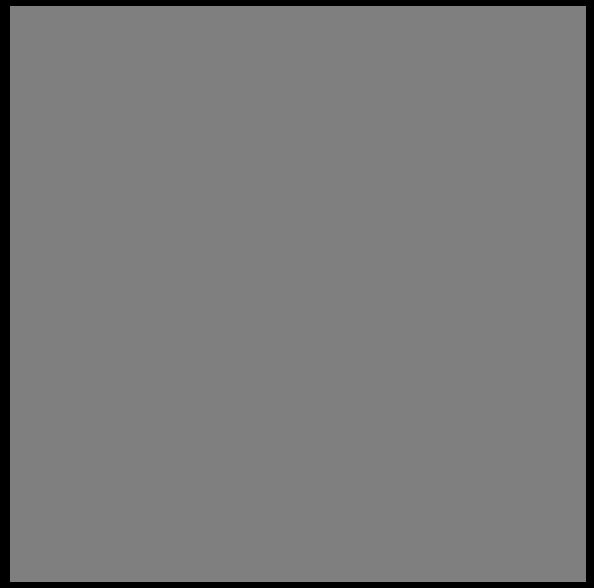
Jan Wienold and Jens Christoffersen, 2006

Glare Metrics

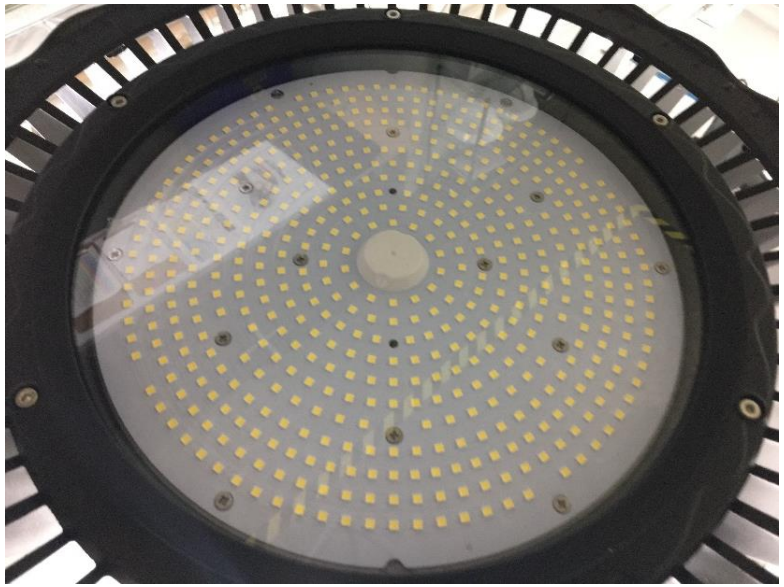


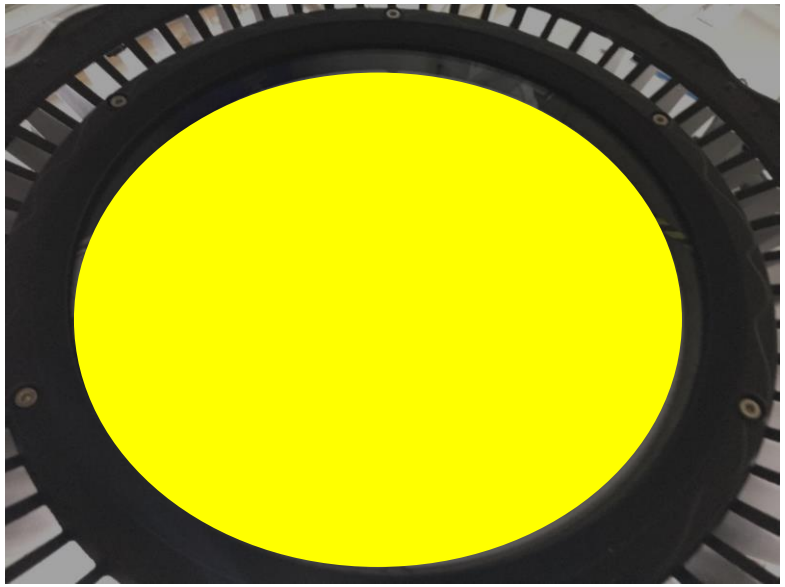
Luminance *vs* Contrast





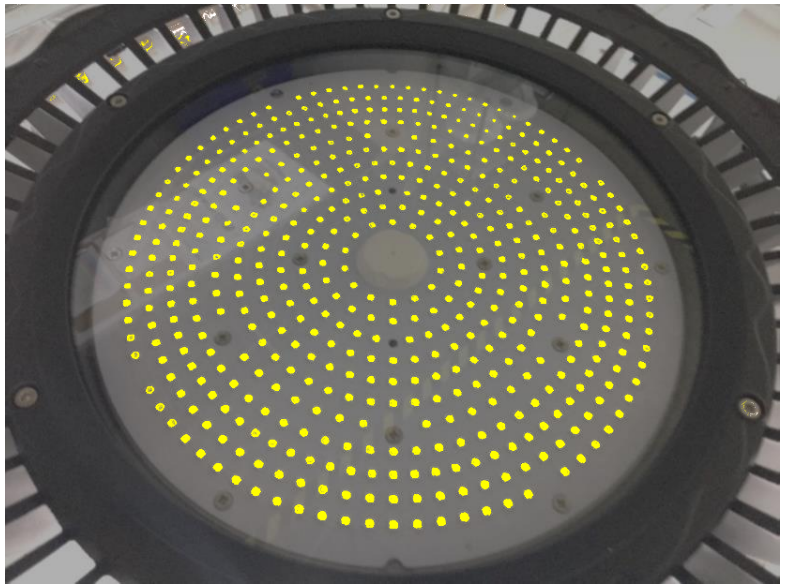
How Big is the Light Source?





Large solid angle

25-30,000 cd/m^2

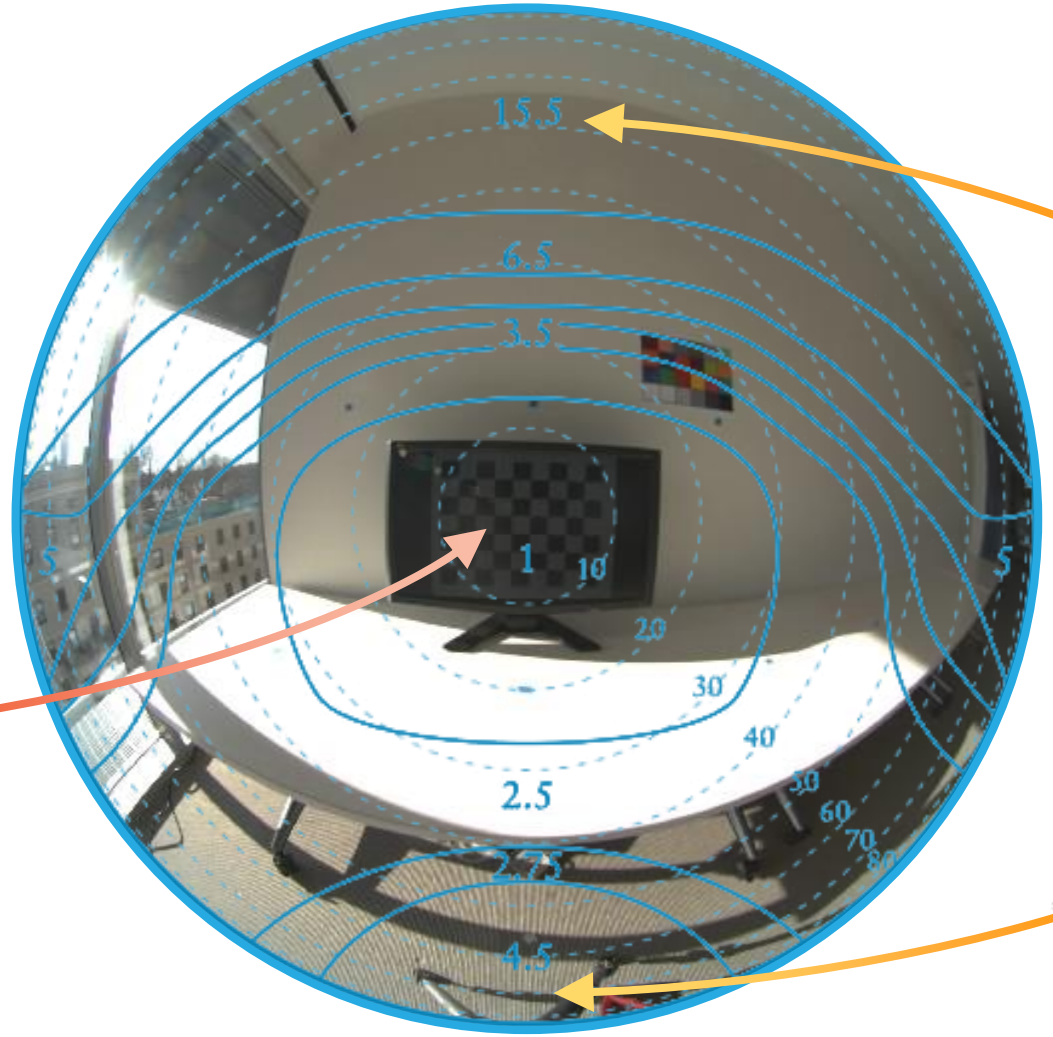


Small solid angles

1.5 million cd/m^2

CIE JTC7 provides an approach for calculating "effective" luminous area

Position Index



Center of View
High sensitivity

Brow
Shaded

Nose
Shaded

Glare Metrics

Visual Comfort Probability

$$VCP = 279 - 110 \times \log_{10} \sum_{i=1}^{n} \left(\frac{0.5 L_i \left(20.4\omega_i + 1.53\omega_i^{0.2} - 0.075\right)}{E_{avg}^{10.44} P_i} \right)^{n^{-0.0914}}$$

CIE Glare Index

$$CGI = 8 \times \log_{10} 2 \frac{1 + E_d/500}{E_d + E_i} \sum_{i=1}^{n} \frac{L_i^2 \omega_i}{P_i^2}$$

$$Glare = \sum_{i=1}^{n} \frac{L_i^{exp} \omega_i}{L_b^{exp} P_i^{exp}}$$

Unified Glare Rating

$$UGR = 8 \times \log_{10} \frac{0.25}{L_b} \sum_{i=1}^{n} \frac{L_i^2 \omega_i}{P_i^2}$$

For in between sources
Electric lights

Daylight Glare Probability

$$DGP = 5.87 \times 10^{-5} E_v + 0.0918 \times \log_{10} \left(1 + \sum_{i=1}^{n} \frac{L_i^2 \omega_i}{E_v^{1.87} P_i^2}\right) + 0.16$$

For large diffuse sources
Sky

For small bright sources
Sun

Daylight Glare Index

$$DGI = 10 \times \log_{10} 0.48 \sum_{i=1}^{n} \frac{L_i^{1.6} \Omega_i^{0.8}}{L_b + 0.07\omega_i^{0.5} L_i}$$

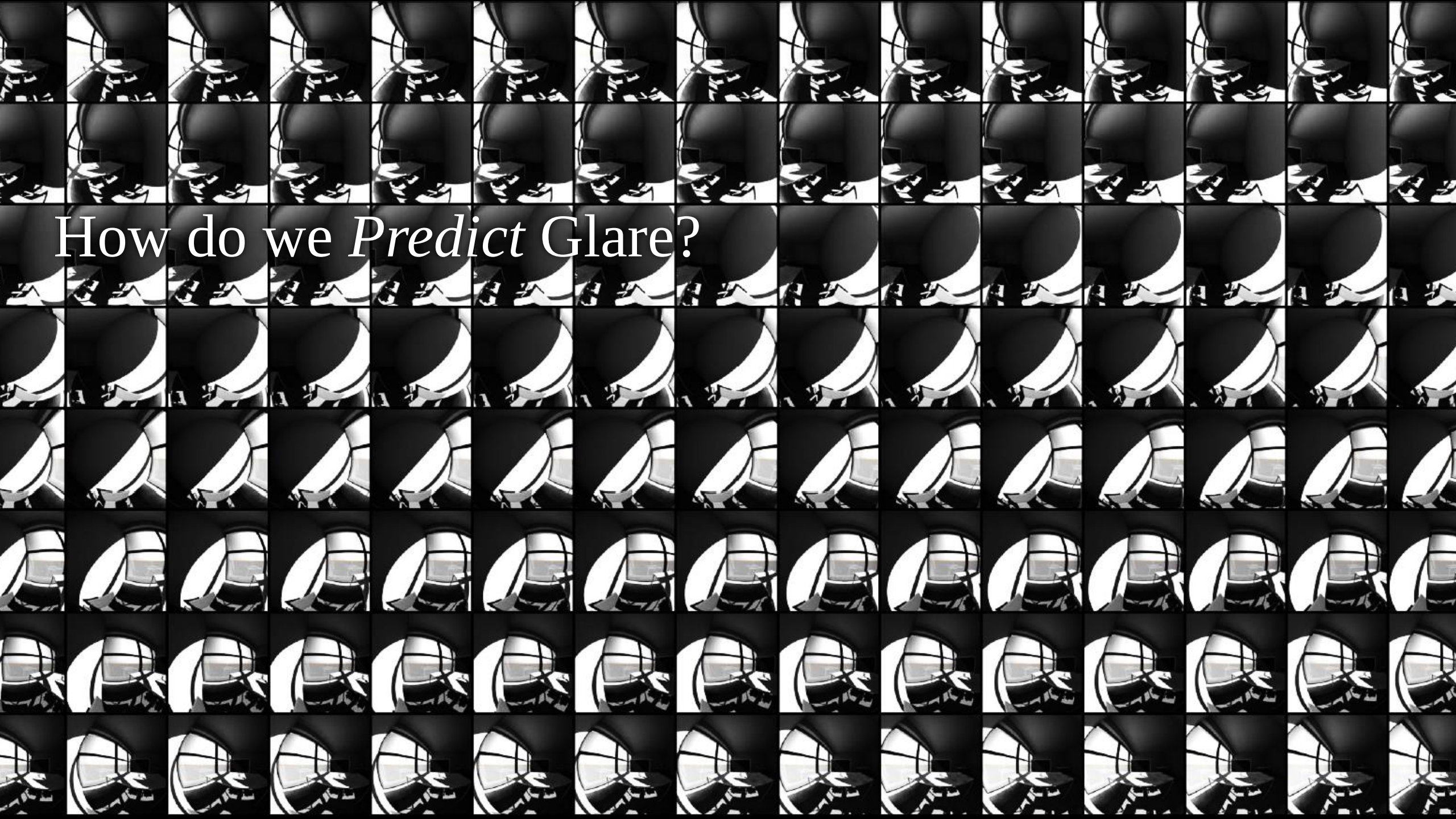
Glare Metrics

	DGP	DGI	UGR	VCP	CGI
Imperceptible	<0.35	<18	<13	80 – 100	<13
Perceptible	0.35 – 0.40	18 – 24	13 – 22	60 – 80	13 – 22
Disturbing	0.40 – 0.45	24 – 31	22 – 28	40 – 60	22 – 28
Intolerable	>0.45	>31	>28	<40	>28
	For Daylight		For Electric Light		

Unified Glare Rating Limit

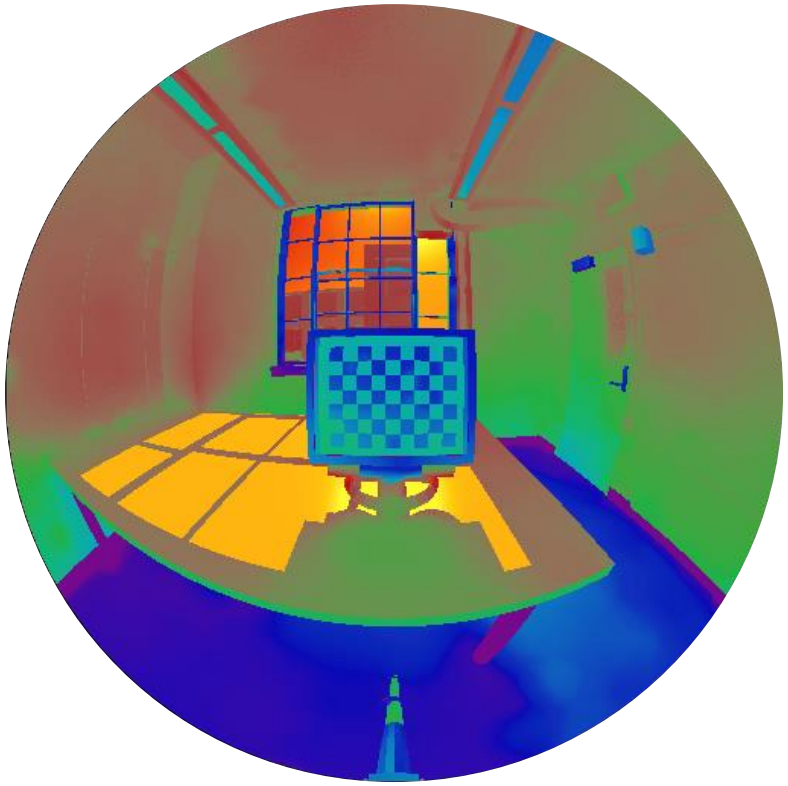
	UGR		UGR-L
Imperceptible	<13		
Perceptible	13 – 22	Technical drawing	16
		Offices	19
		Reception areas	22
Disturbing	22 – 28	Archives, stairs and lifts	25
		Corridors and passageways	28
Intolerable	>28		

EN 12464-1

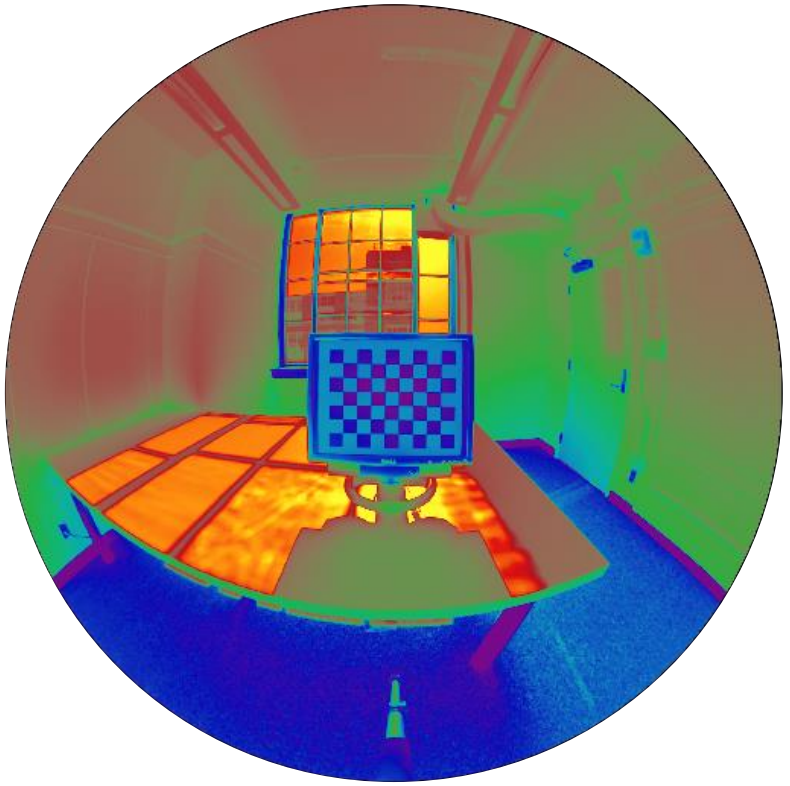

How do we *Predict* Glare?

Simulation

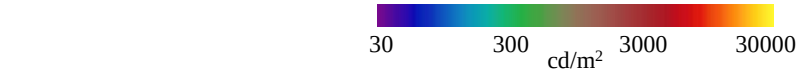
Simulations can match reality with extreme closeness …



Simulation



HDR Photograph



… and now many software products let you do this

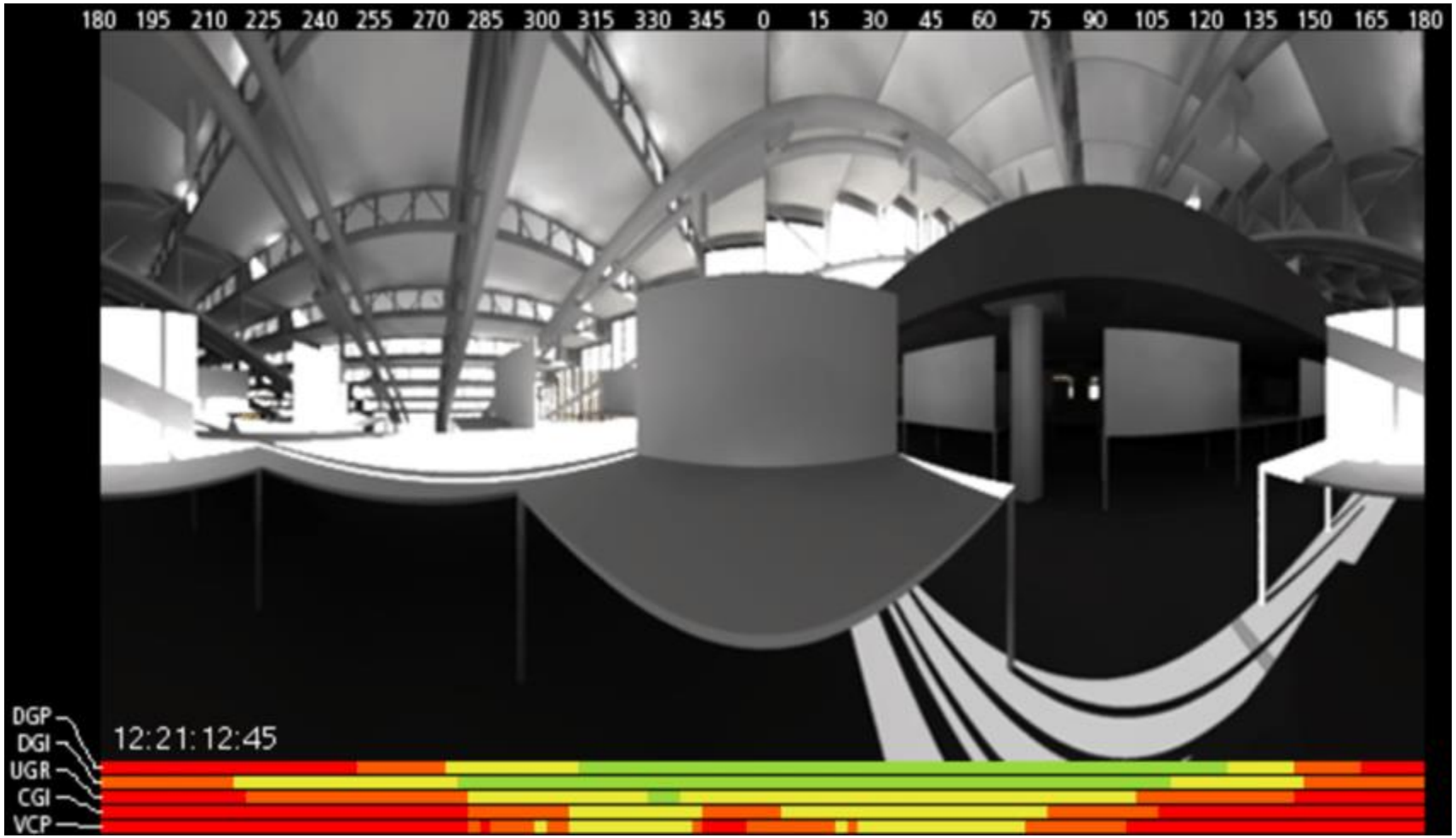
Radiance

DIALux

Ladybug Tools

SOLEMMA

360° Glare



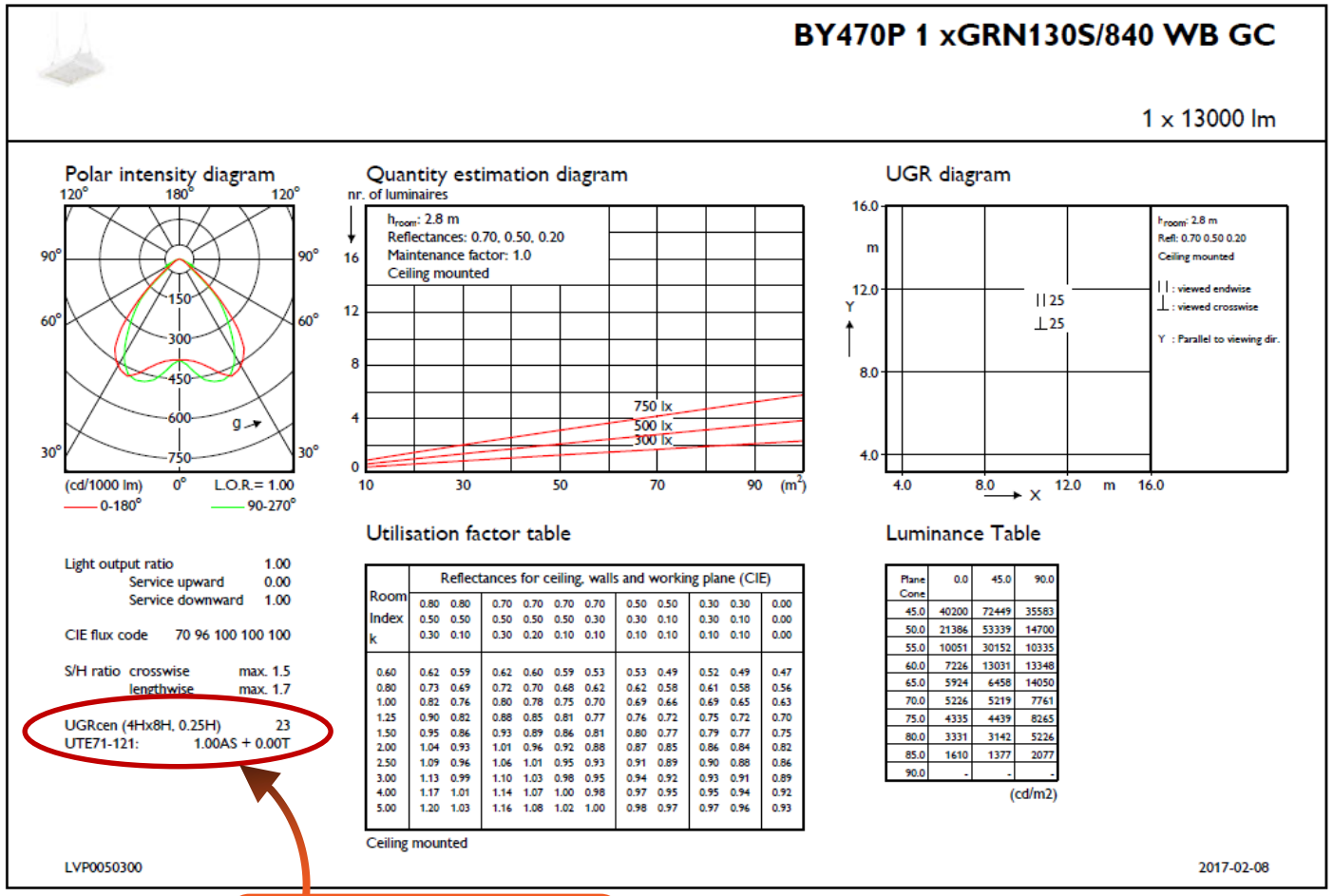
Imperceptible Perceptible Disturbing Intolerable

Lesson:

Your view direction, the room shape, and its furniture and finishes matter!

Alstan Jakubiec

Reported Luminaire “Glare”

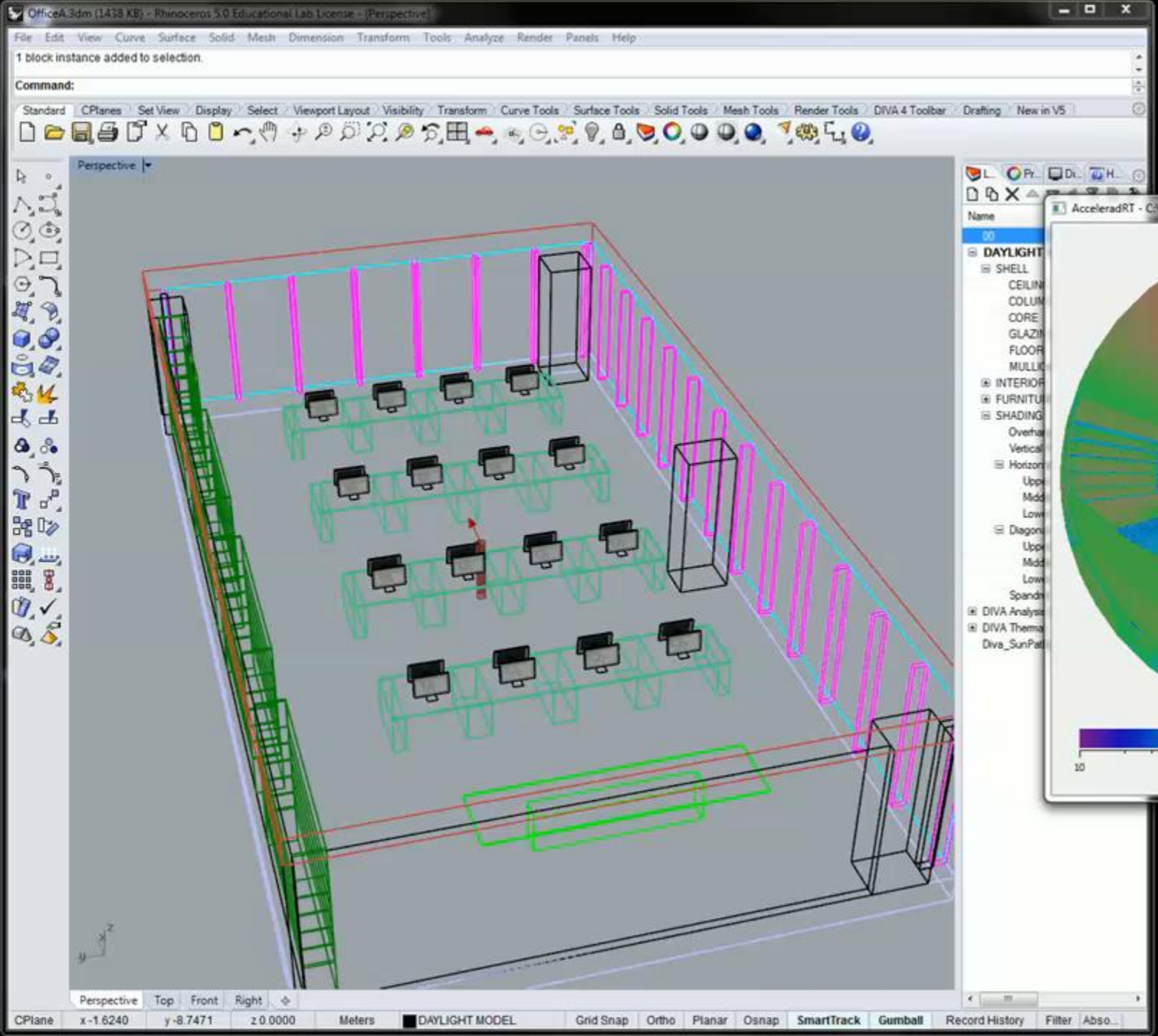


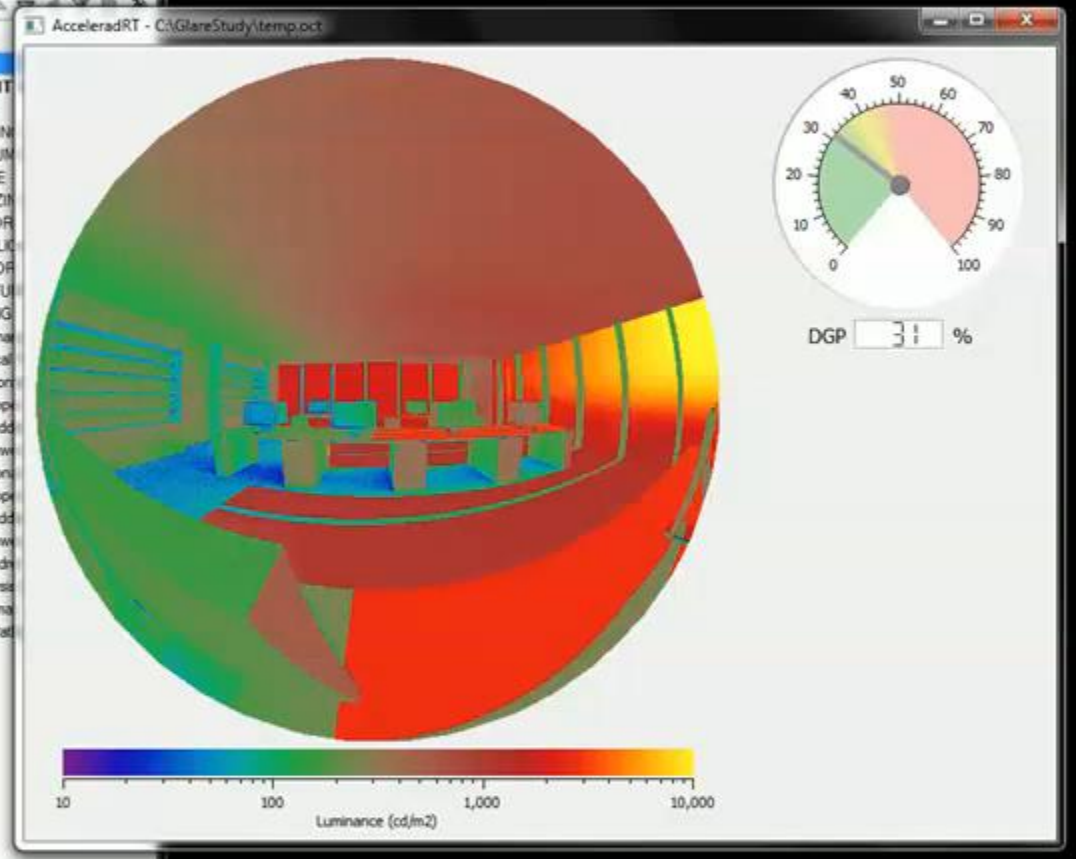
UGR = 23

Note:

This is **not** *what the occupant experiences*

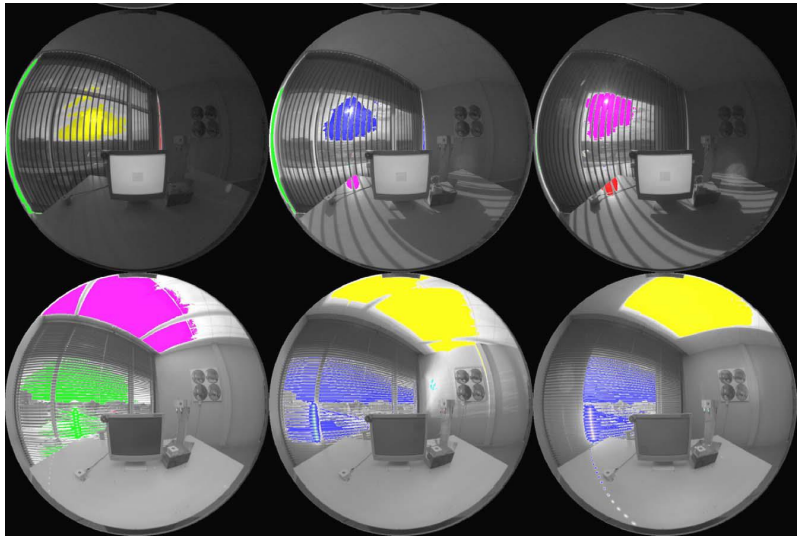
Accelerad


OfficeA.3dm (1438 KB) - Rhinoceros 5.0 Educational Lab License - [Perspective]
File Edit View Curve Surface Solid Mesh Dimension Transform Tools Analyze Render Panels Help
1 block instance added to selection.
Command:
Standard CPlanes Set View Display Select Viewport Layout Visibility Transform Curve Tools Surface Tools Solid Tools Mesh Tools Render Tools DIVA 4 Toolbar Drafting New in V5
Perspective
Name
DAYLIGHT
SHELL
INTERIOR
FURNITU
SHADING
DIVA Analysis
DIVA Therma
Diva_SunPat
Perspective Top Front Right
CPlane x -1.6240 y -8.7471 z 0.0000 Meters DAYLIGHT MODEL Grid Snap Ortho Planar Osnap SmartTrack Gumball Record History Filter Abso...

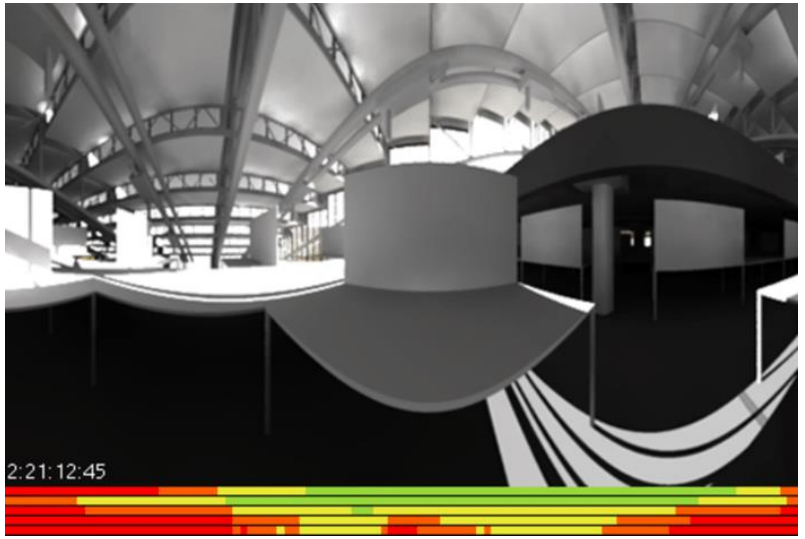

AcceleradRT - C:\GlareStudy\temp.oct
DGP 31 %
10
100
1,000
10,000
Luminance (cd/m2)

In Summary

Glare happens when there is ***too much luminance*** for the eye to (comfortably) handle



We can measure glare using ***photography*** or ***simulation*** – but existing metrics are imperfect



Glare measurement must account for the ***luminaire***, the ***room***, and the ***viewer***

Glare and Diffuse Sources

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