Photobiological Safety in Lighting Applications

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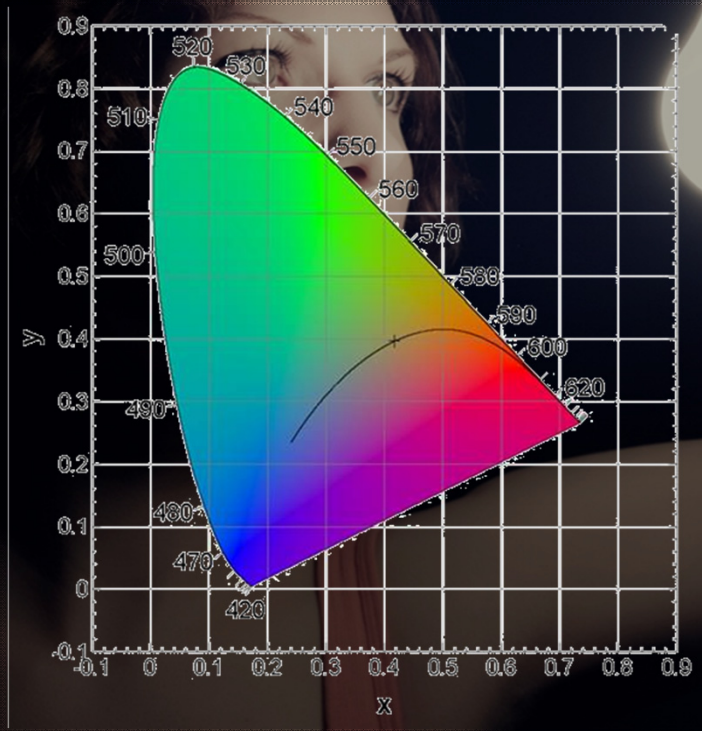
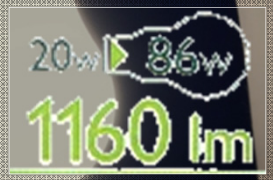
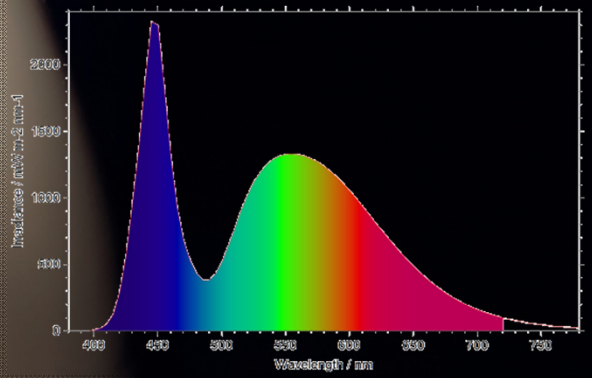
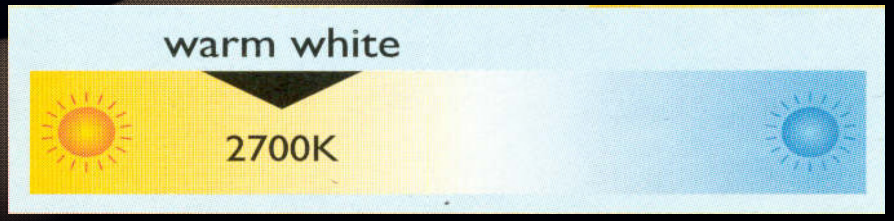
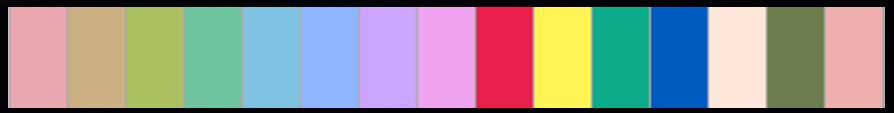
We are all familiar with the visual characteristics of lighting products











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What other impact might these sources have?

Glare?

Photometric Flicker?

Circadian Disruption (or therapy)?

Photobiological Safety Hazards?

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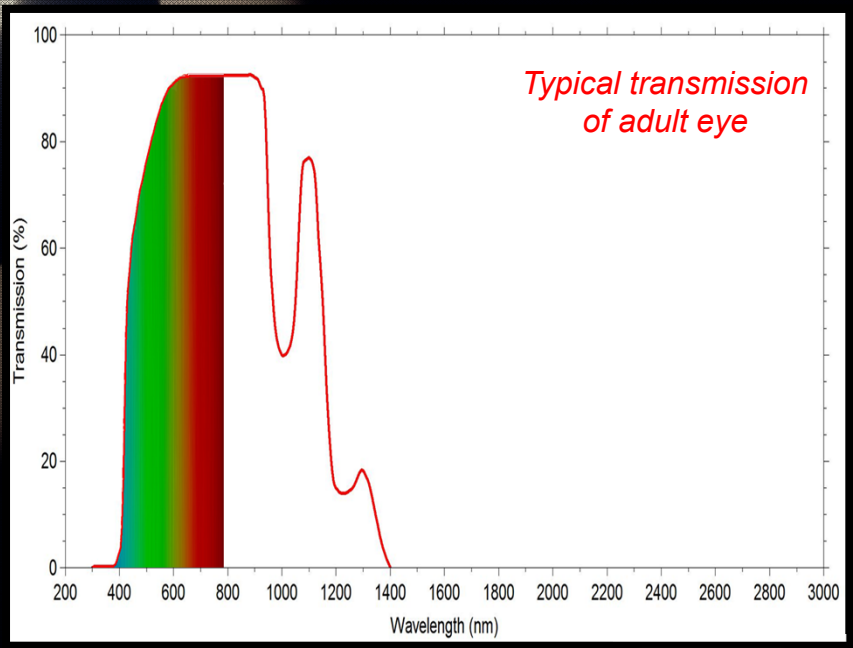
Photobiology : the study of the interaction of optical radiation with living organisms

Optical radiation strongly absorbed by tissue – skin, front surface of eye and retina potentially at risk

Band	Wavelength Range (nm)
UVC	100-280 (<2[illegible]nm, vacuum UV)
UVB	280-315
UVA	315-400
Visible	380-780
IRA	780-1400
IRB	1400-3000
IRC	30[illegible]-10000



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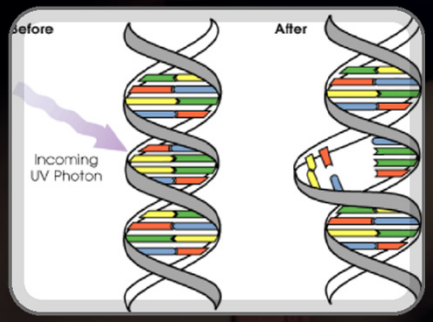
Light-Tissue Interactions

Thermal interaction

· Increase in local temperature => tissue damage

· Power dependent

· Wavelength independent



Photochemical interaction

· Breaking or re-organising chemical bonds in cellular molecules

· Strongly wavelength dependent

· Dose dependent according to Bunson-Roscoe law of reciprocity

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Hazards identified by ICNIRP

Hazard	Wavelength Range (nm)	Bioeffect	
		Eye	Skin
Actinic UV	200-400†	Cornea - Photokeratitis Conjunctiva - Conjunctivitis Lens – Cataractogenesis	Erythema Elastosis
Near UV	315-400	Lens – Cataractogenesis	
Blue Light	300-700†	Retina – Photoretinitis	
Retinal Thermal	380-1400†	Retina - Retinal burn	
IR Radiation Eye	780-3000	Cornea - Corneal burn	
Thermal Skin	380-3000		Skin burn

For each hazard, exposure limit values are published

International Commission on Non-Ionizing Radiation Protection (ICNIRP)

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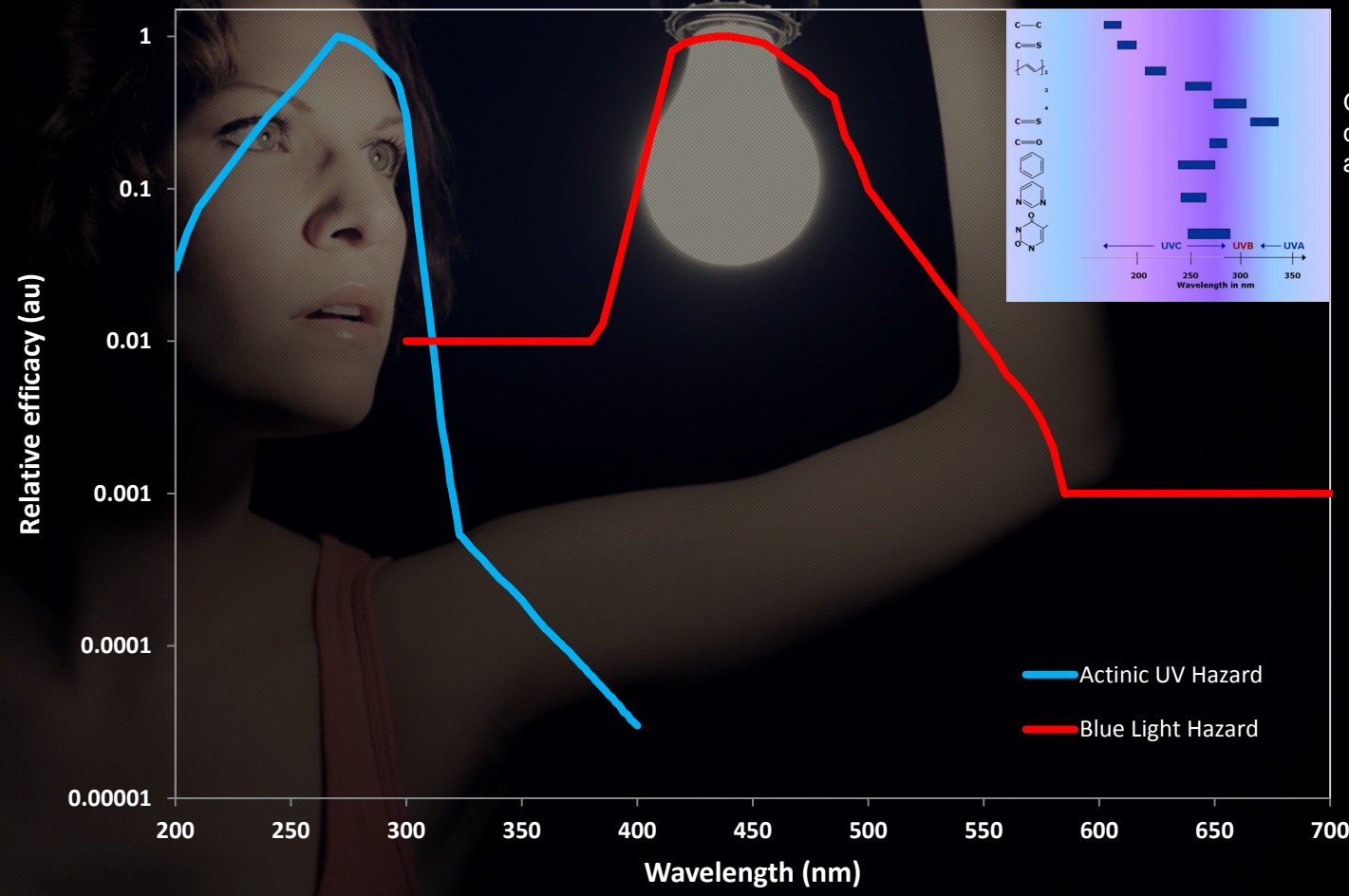
Strong wavelength dependence of photochemical interactions



Organic chromophore absorption bands

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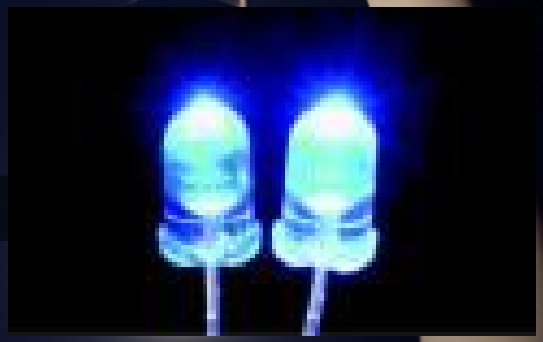
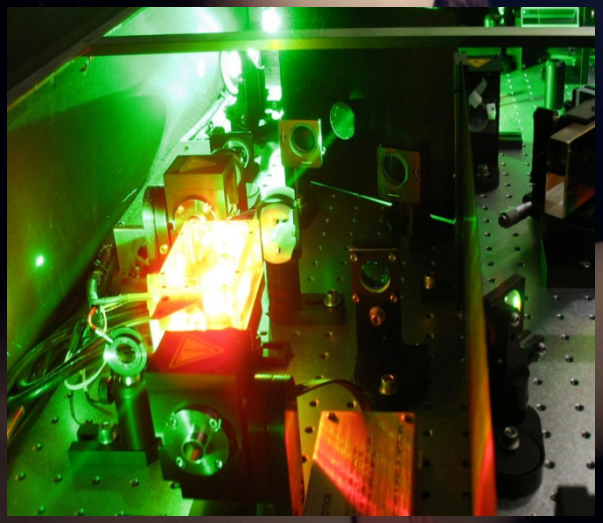
LED Photobiological Safety Standards

From 1993, IEC 60825



From 2006, IEC 62471



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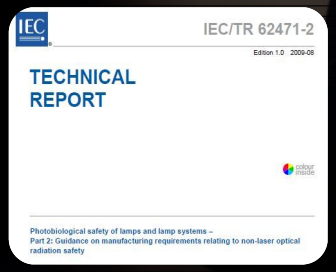
IEC62471 Series Standards


NORME INTERNATIONALE
INTERNATIONAL STANDARD
CEI IEC 62471
CIE S 009:2002
Première édition First edition 2006-07
Sécurité photobiologique des lampes et des appareils utilisant des lampes
Photobiological safety of lamps and lamp systems

IEC62471-1:2006 "Photobiological Safety of Lamps and Lamp Systems"


IEC/TR 62471-2
Edition 1.0 2009-08
TECHNICAL REPORT
Photobiological safety of lamps and lamp systems – Part 2: Guidance on manufacturing requirements relating to non-laser optical radiation safety

IEC TR 62471-2:2009 "Guidance on manufacturing requirements relating to non-laser optical radiation safety"

EN62471:2008 harmonised to EU **Low Voltage Directive** and applied by **Artificial Optical Radiation Directive**

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Scope of IEC 62471

Considers six hazards (and exposure limits) identified by ICNIRP

Electrically-powered incoherent broadband sources of optical radiation

Risk Group	Philosophical Basis
Exempt	No photobiological hazard
RG1	No photobiological hazard under normal behavioural limitation
RG2	Does not pose a hazard due to aversion response to bright light or thermal discomfort
RG3	Hazardous even for momentary exposure

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Measurements Required

Measurement of Spectral Irradiance (200-3000nm)

- Evaluate hazards to the skin and front surfaces of eye

Measurement of Spectral Radiance (300-1400nm)

- Evaluate hazards to the retina

Application	Evaluation distance
General lighting service	That at which source produces illuminance of 500 lux
All other sources	200mm from (apparent) source

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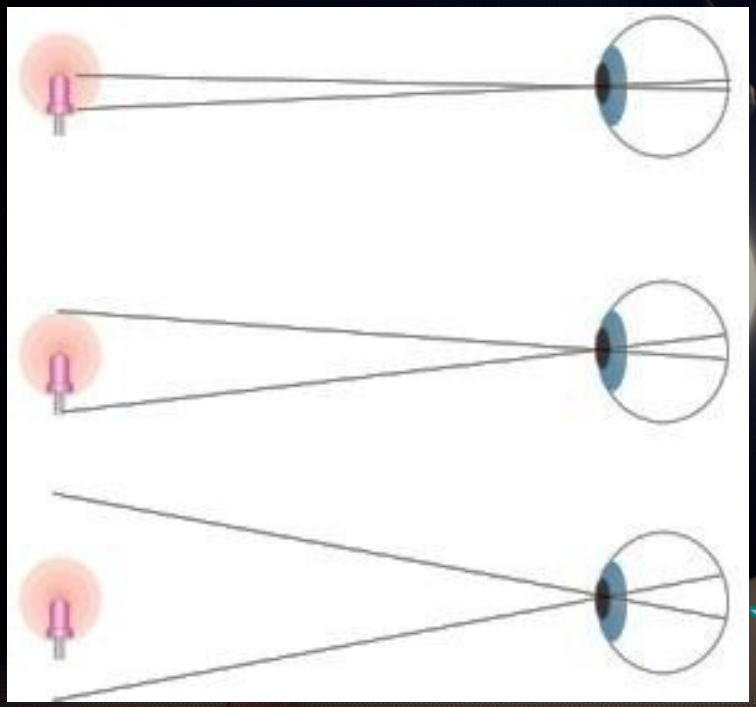
Time Dependence of Retinal Irradiance



Increasing Exposure Time

Exposure Time (s)	Angle of Acceptance (mrad)
<0.25	1.7
0.25-10	$11\sqrt{(t/10)}$
10-100	11
100-10000	$1.1\sqrt{t}$
>10000	100

Physiological radiance accounts for light falling on a given area of the retina

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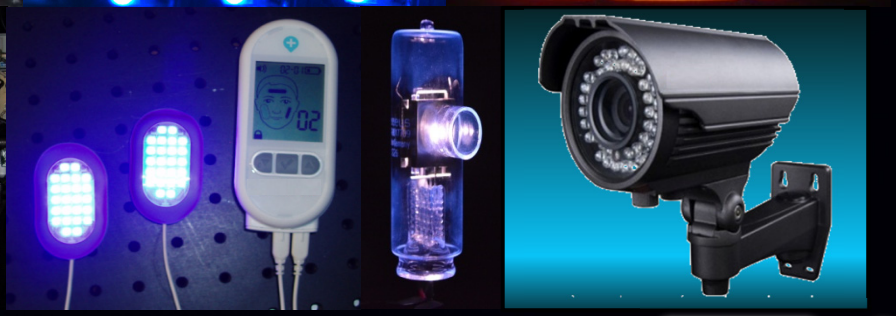
A few of the myriad sources in scope…





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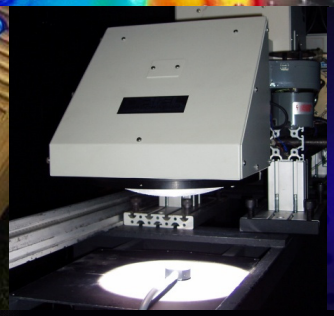
Non-GLS Source Evaluation

Irradiance-based hazards up to RG3

Blue light hazard up to RG2, retinal thermal hazard exempt except bare discharge lamp



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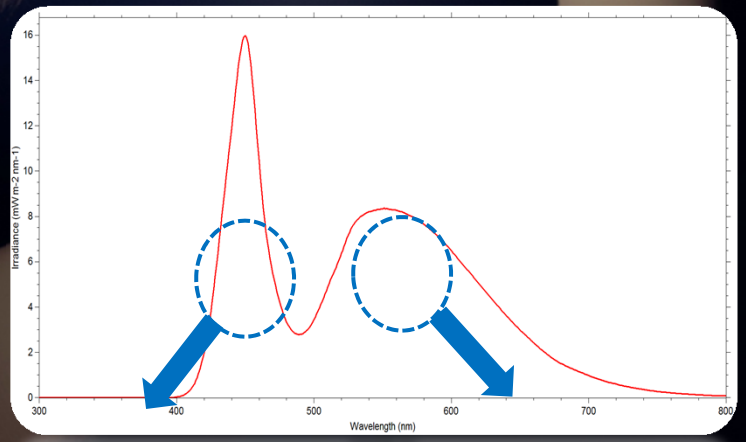
GLS Evaluation at 500lx (Exempt)



$$Blue\ Light\ Irradiance\ (Wm^{-2}) = \int_{300}^{700} E(\lambda).B(\lambda).d\lambda$$

$$Illuminance\ (lux) = 683.\int_{380}^{780} E(\lambda).V(\lambda).d\lambda$$

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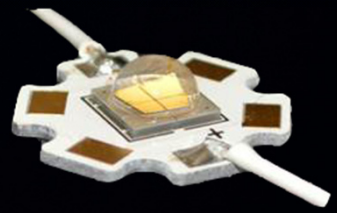
Potential Hazards Dependent on Lamp Type

UV hazard will be considered in implementing a specific effective irradiance limit (2 (6) mW.klm-1)

IR hazard will be considered by one incandescent lamp vertical standard

Blue light hazard will be dealt with in implementation of IEC TR 62778



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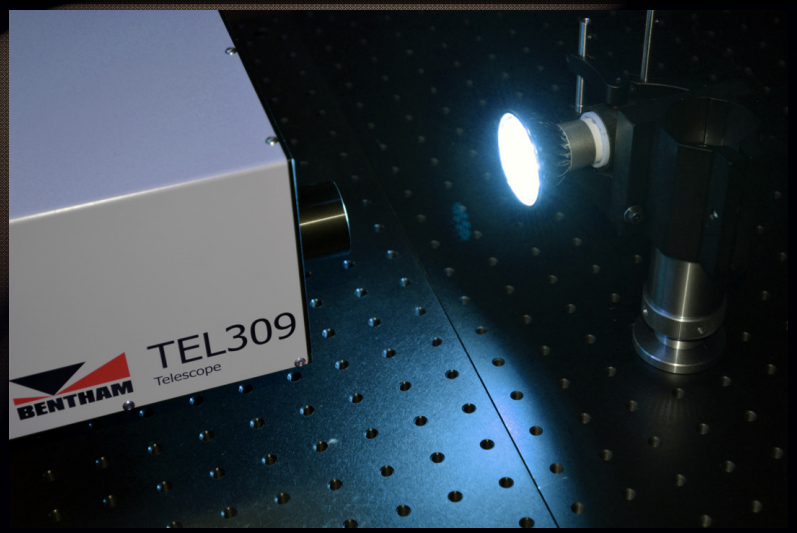
IEC TR 62778

Considers only blue light hazard of component lamps/ LEDs and finished product luminaires

Spectral radiance 300-780nm at 200mm in an 11mrad FOV

Where result yields Exempt/ RG1 no further action required => Exempt / RG1 “Unlimited”



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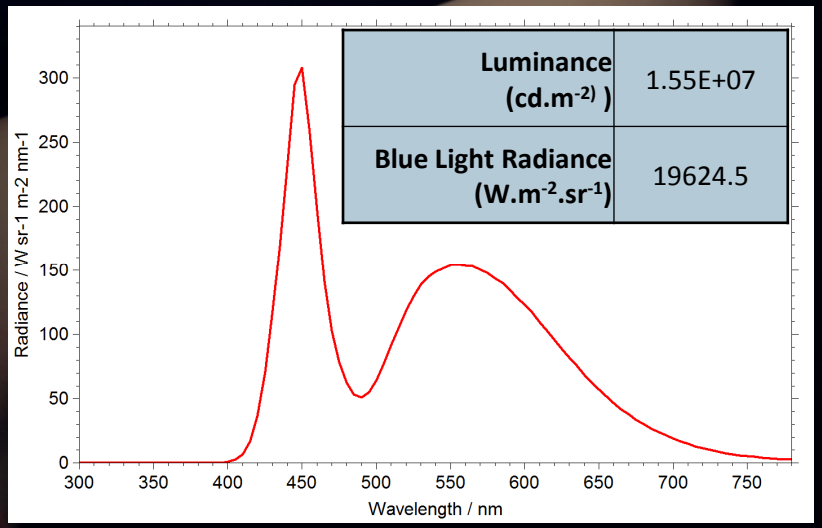
RG2 at 200mm, RG1 at E_{thr}

E_{thr} illuminance at which RG1 found

E_{thr} =luminance ($cd.m^{-2}$)/ blue light radiance ($W.m^{-2}.sr^{-1}$))

For component LEDs, report E_{thr}



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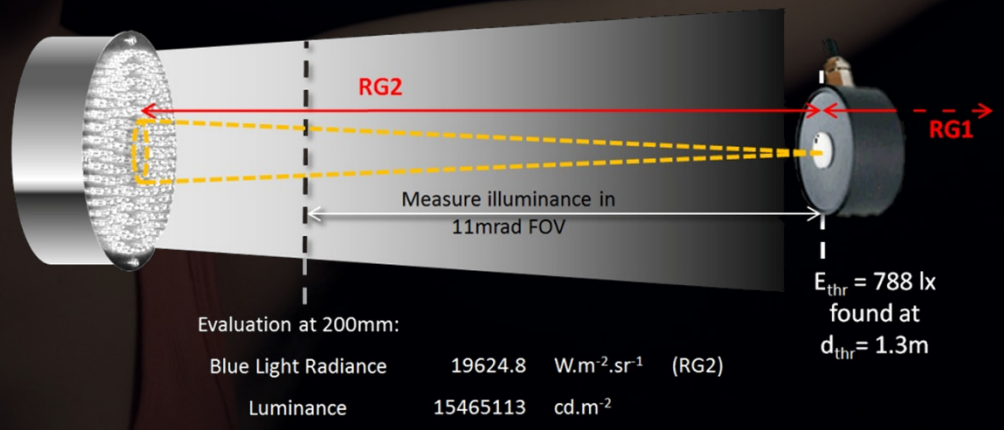
Finished Products, Report d_{thr}

Determine d_{thr} using goniophotometric data and the inverse square law

Alternatively use illuminance meter

Source subtense >11mrad at d_{thr}, estimate conservative



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Future Prospects

As lamp and luminaire standards are harmonised to the LVD, IEC 62471 will no longer be applied directly

Chronic low level exposure should be considered (age-related macular degeneration etc.)

Lamp technology is still on the move with the use of UV rather than blue LEDs and even laser diodes to pump phosphors- the impact of which is yet to be seen

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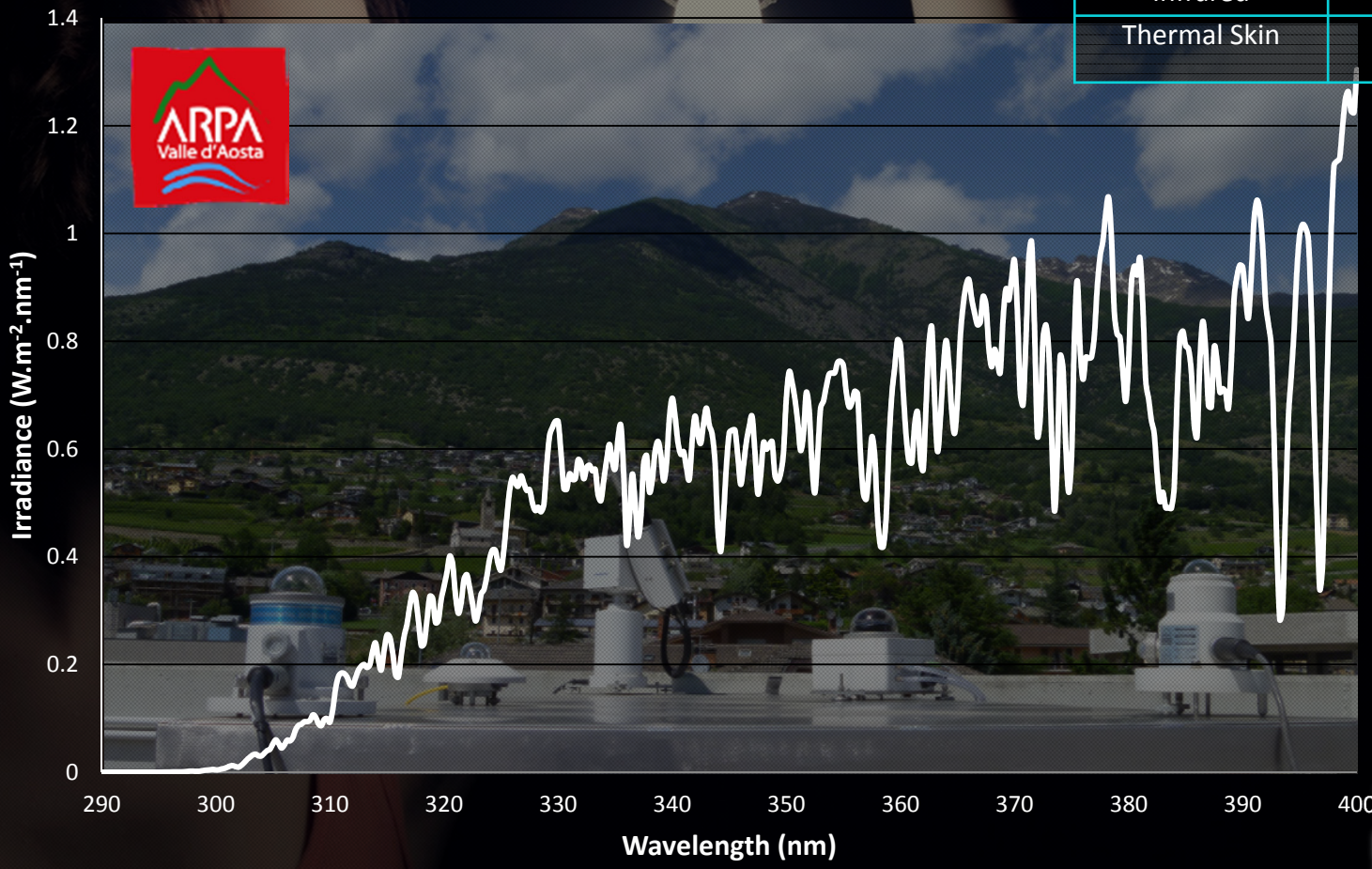
A Little Local Context

Hazard	Risk Group
Actinic UV	RG3
Near UV	RG2
Blue Light	RG2
Retinal Thermal	RG2
Infrared	Exempt
Thermal Skin	Pass



ARPA Valle d'Aosta

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Thank You for Your Attention
Any Questions?
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