



XICATO[®]

**Wat je moet weten over LEDtechnologie
VPT-vakmeeting licht: Waar let je op bij led?
Patrick van der Meulen**

Licht Bronnen

- Gloeilamp
- Halogeenlamp
- TL-lamp
- Ontladingslamp
- LEDs

Belangrijkste Kenmerken

- Afmeting
- Verlichtingssterkte
- Rendement
- Levensduur
- Spectrale Verdeling
 - Kleur Verschijning
 - Kleur Weergave

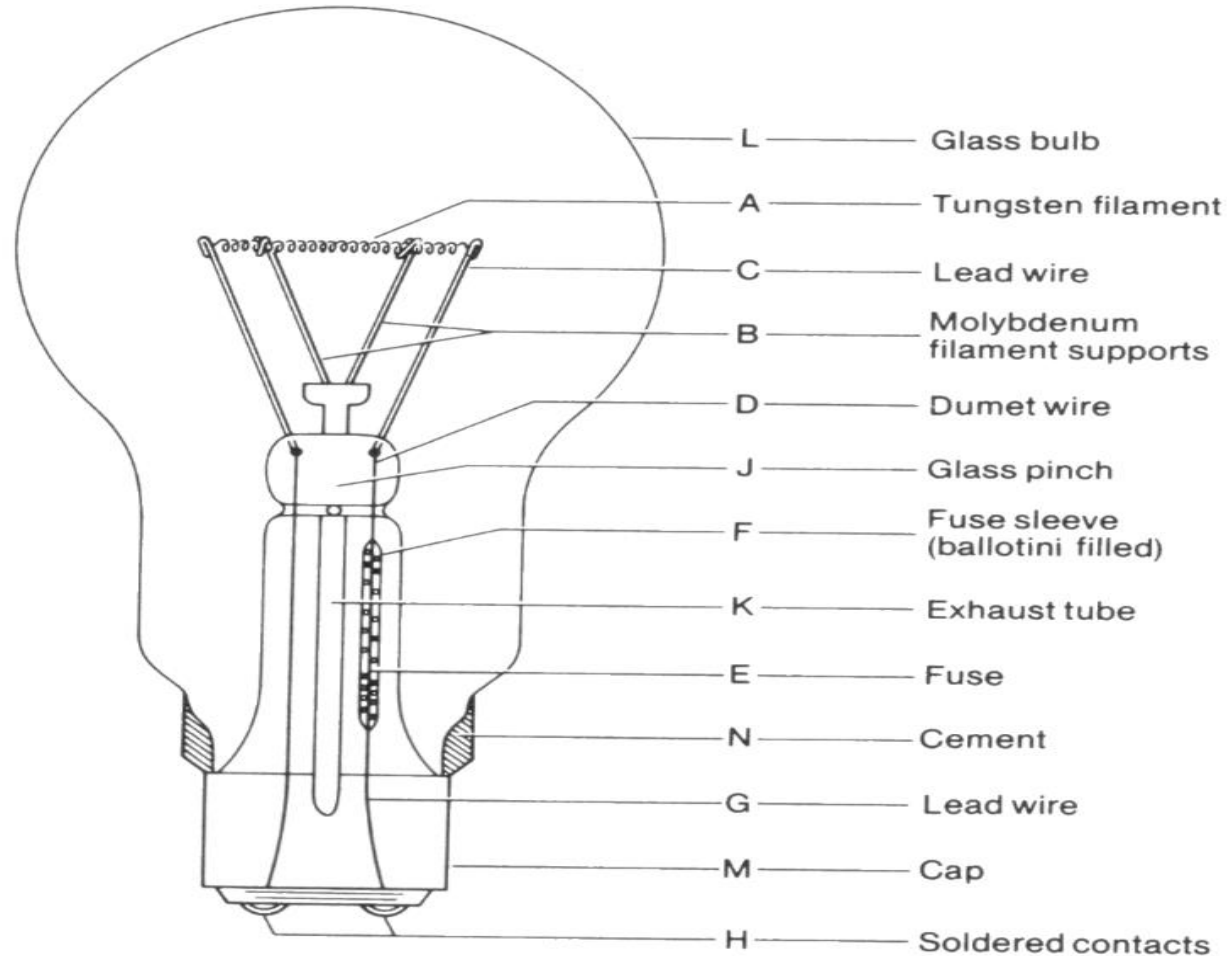
Andere Kenmerken

- Start tijd
- Herstart tijd
- Thermische Beperkingen
- Dimming
- Electronica

Gloeilamp

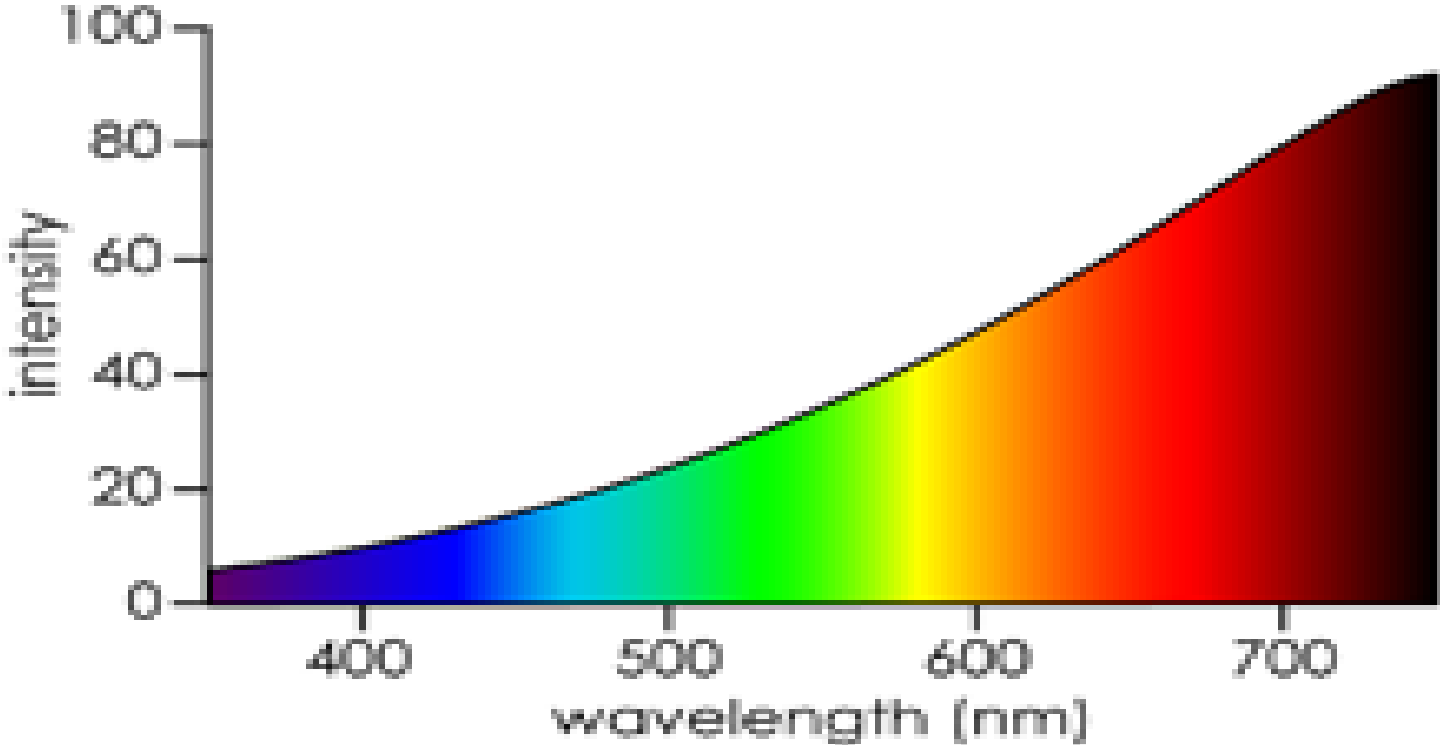
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Light from a heated coiled coil



- Size: point source
- Luminous Flux: In common usage up to 1200lm (100W GLS)
- Efficacy: 10-12lm/W.
- Life: other than 'rough service' 1000hrs
- Spectral Power Distribution
 - Colour Appearance: 2700K
 - Colour Rendering: 100

Incandescent SPD



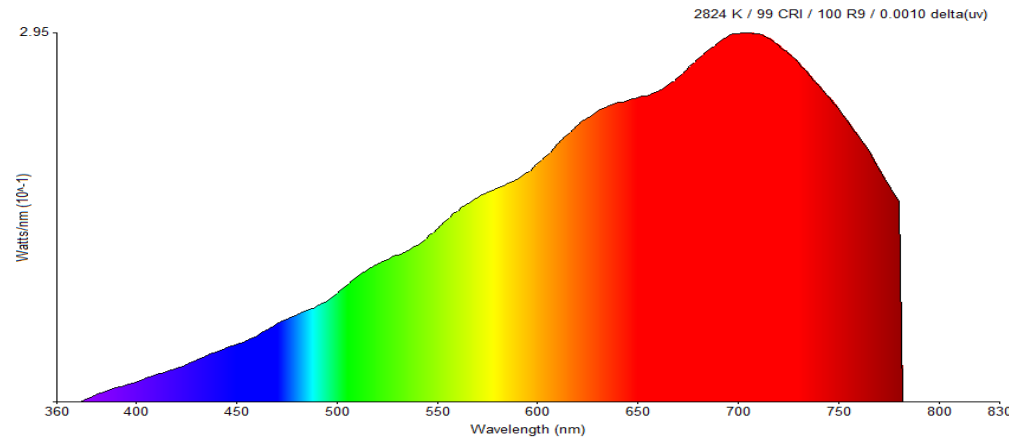
Incandescent issues

- Low energy usage has led to its being banned

Halogeenlamp

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Light from a protected heated coiled coil



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- Size: point source
- Luminous Flux: In common usage up to 1000lm (50W low voltage dichroic)
- Efficacy: 15-25 lm/W. (mains / ELV)
- Life: 2-5khrs (practical / laboratory!)
Specialist 10khrs
- Spectral Power Distribution
 - Colour Appearance: 3000K (4000K with filters)
 - Colour Rendering: 98-100



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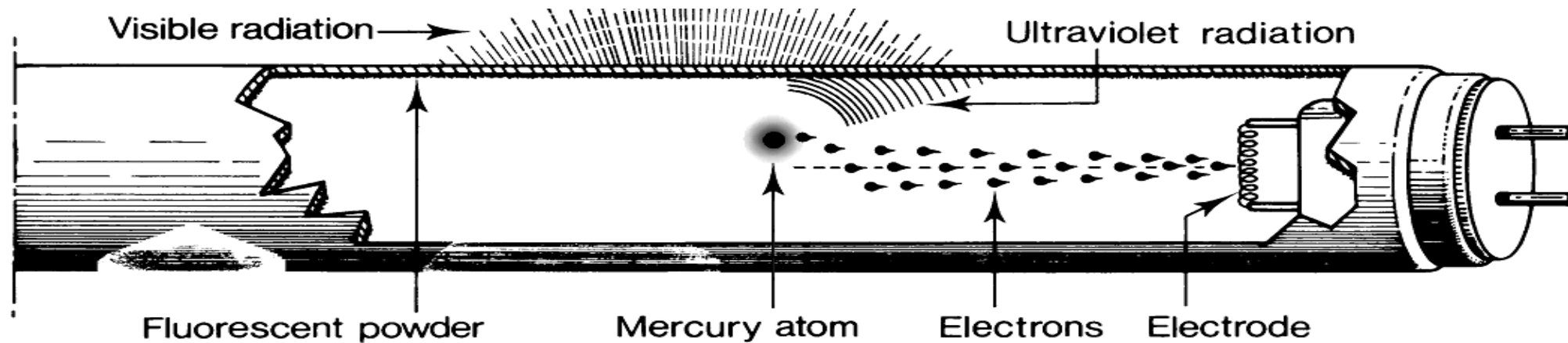
Halogen issues

- Due to UV content special UV block halogen lamps for museums / galleries
- 4000K only possible via filtering out warmer wavelengths – efficacy trade-off
- Only dichroic versions have no heat in the beam – with others, eg Al reflector – this can be an issue
- Attention on number of lamps per transformer
- Attention on touching capsules
- Warms when dimmed – can be advantage or disadvantage depending upon application

TL-lamp

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Light from fluorescing phosphors activated by low pressure mercury discharge

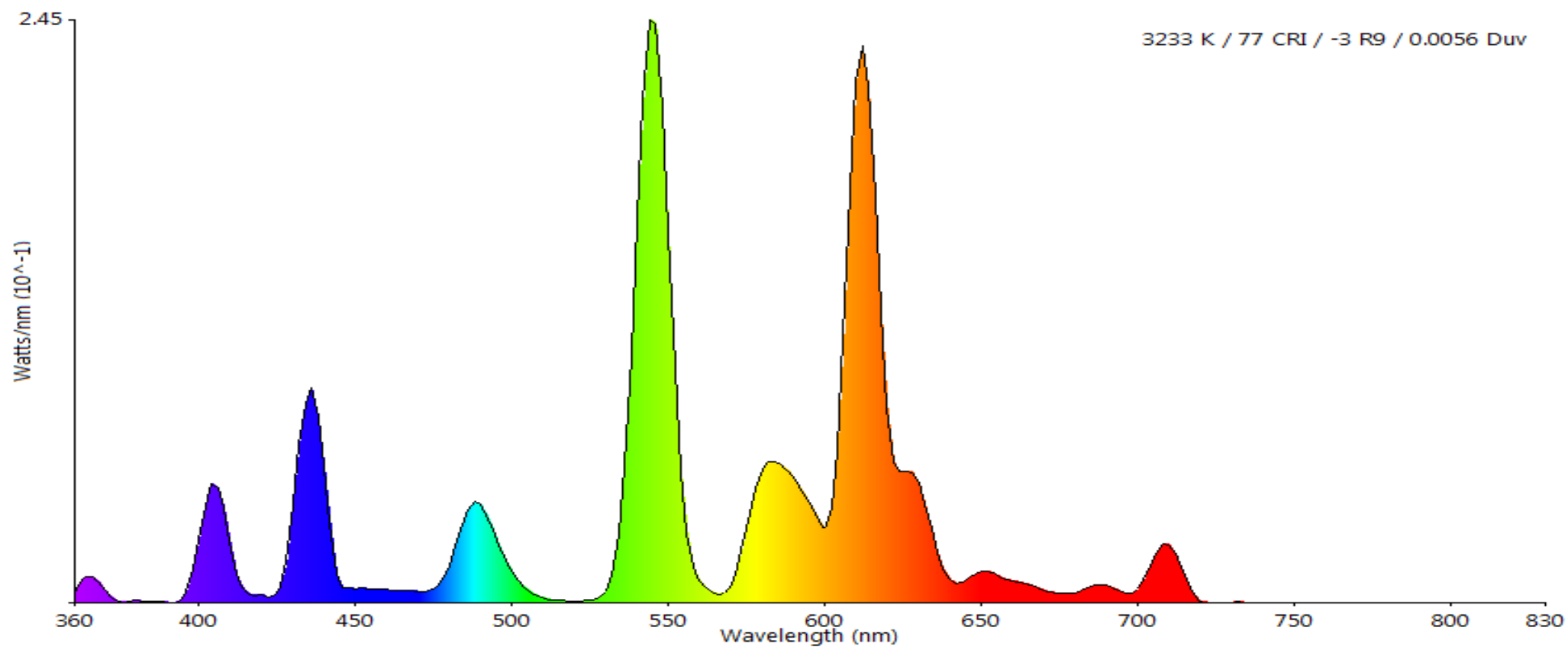


- Size: linear. CFLs: even with multiple DT bends spot lighting out. Linear dia: T12 => T8 => T5
- Luminous Flux: In common usage up to 5000lm (1.5m TL5)
- Efficacy: Up to 100 lm/W. (only a little over half for CFLs)
- Life: Up to 12khrs. Note definition of life not 50% failures as with incandescent and halogen, but time to 50% lumen depreciation. (Induction lamps have longer life, eg 50khrs)
- Spectral Power Distribution
 - Colour Appearance: phosphor related. Commonly 2700K, 3000K, 4000K and 'daylight' – either 5000K or 6500K
 - Colour Rendering: 80+ or 90+ (efficacy trade-off)



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CFL, 3000K, 80+ CRI



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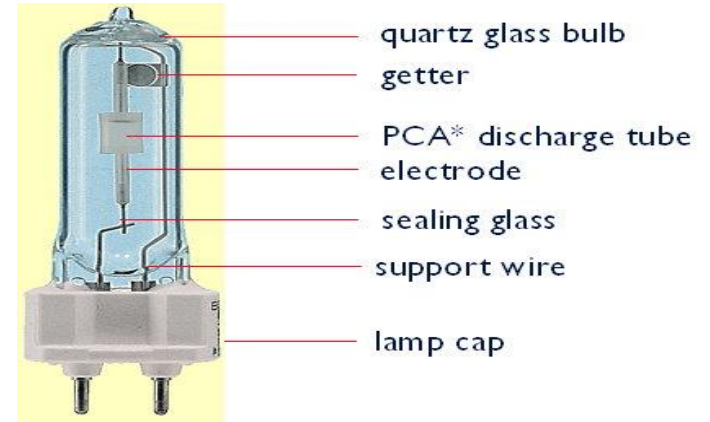
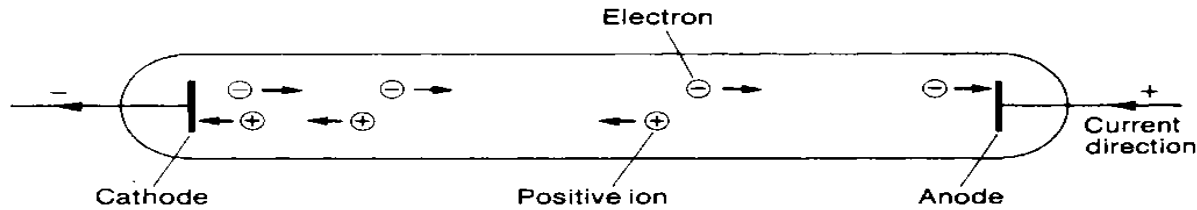
Fluorescent issues

- CFL light can be pinkish at deep dimming
- Generally HF electronic control gear since the 1990s has solved many ballast / ignitor compatibility issues. Still black-ending / striations are possibilities with wrong lamp / ballast combinations
- Warm-up time of 1m +
- Apart from TL min separate source needed in EM luminaires
- Efficacy drops with low temperatures – ie external applications
- Unsaturated rendering of reddish colours

Ontladingslamp

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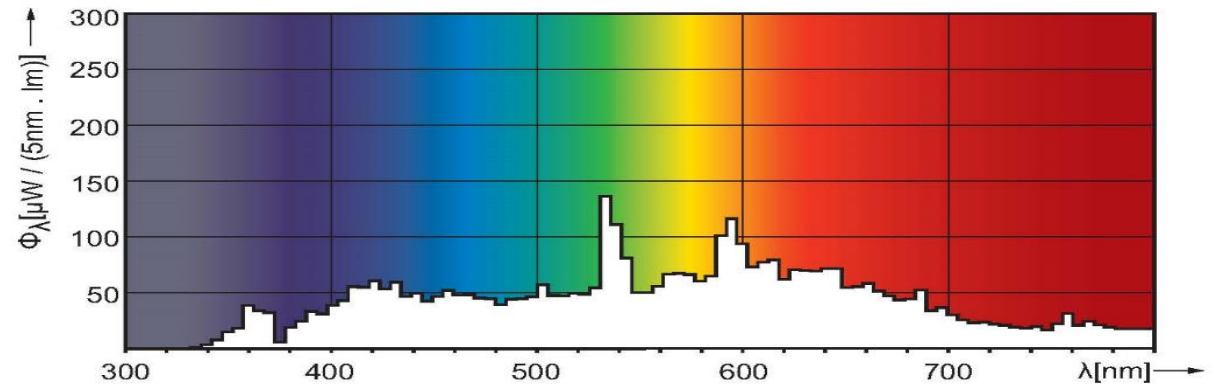
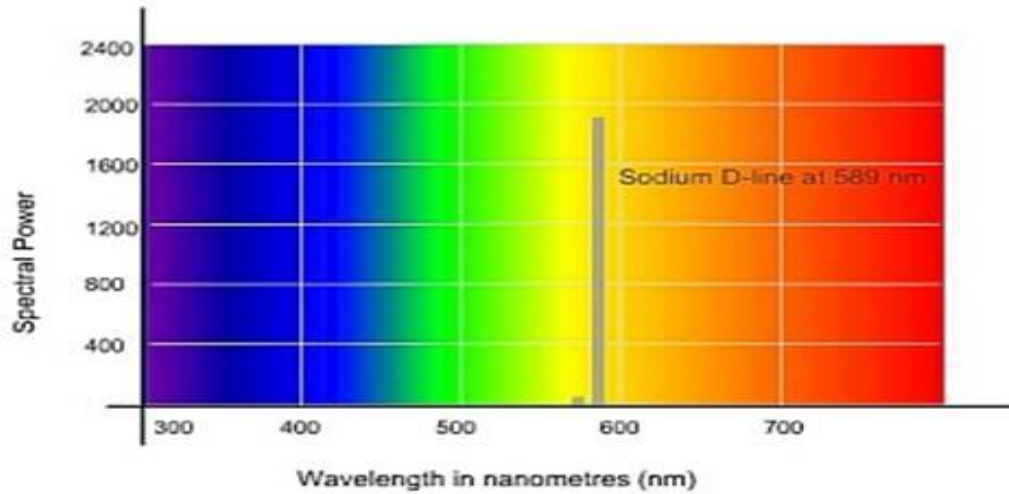
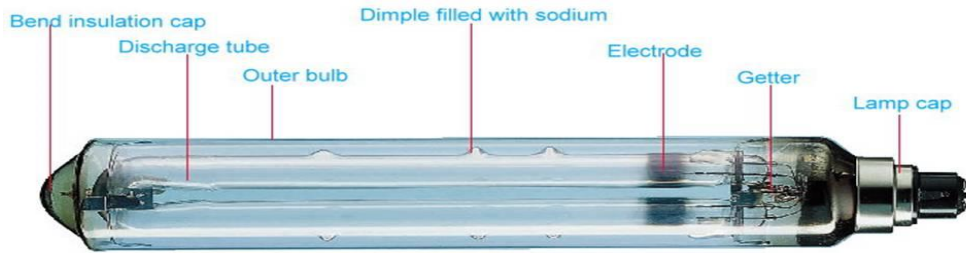
Light directly from gas discharges



- Size: Varies from LPS to SON to High Pressure mercury / Metal Halide which are large for street and area lighting. CMH is by definition more compact: smaller fluxes for interior lighting, and spots possible
- Luminous Flux: Varies from 200klm for sports lighting to 2klm for retail accents.
- Efficacy: +/-100 lm/W for CRI 80+ sources
- Life: Up to 16khrs. Note definition of life not 50% failures as with incandescent and halogen, but time to 50% lumen depreciation
- Spectral Power Distribution
 - Colour Appearance: commonly 3000K and 4000K for the CRI 80+ sources. (Lower for sodium lamps)
 - Colour Rendering: 80+ the norm. Some or 90+ (0-20 for sodium lamps)

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Discharge light quality extremes: SPDs for low pressure sodium and compact metal halide



Discharge issues

- Circuitry can be complex and need experience – eg series or semi-parallel ignitors etc
- Not always universal burning (VBU, VBD or HOR)
- UV output from mercury based HID lamps
- High starting voltages (>3 kV)
- ‘Non-passive failures’ a possibility with HID
- No dimming without colour shift
- Even best CMH lamps have issues portraying deep reds (R9)
- Separate lamp for EM
- Typical re-strike times for HID lamps, say in the event of a supply interruption, are 5 to 15 minutes. (Some lamps for special applications, e.g. studio lighting, sports stadia, are designed for hot re-strike, but then HV pulse ~50 kV)

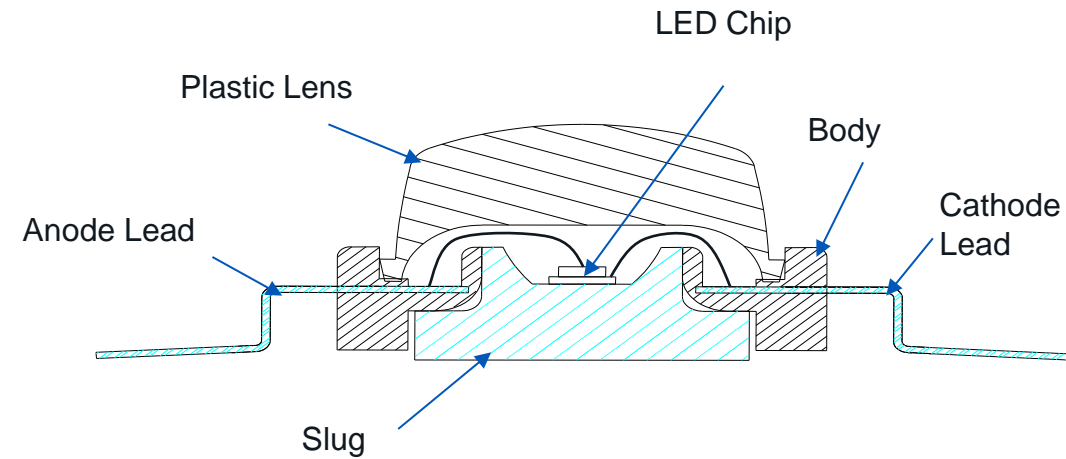
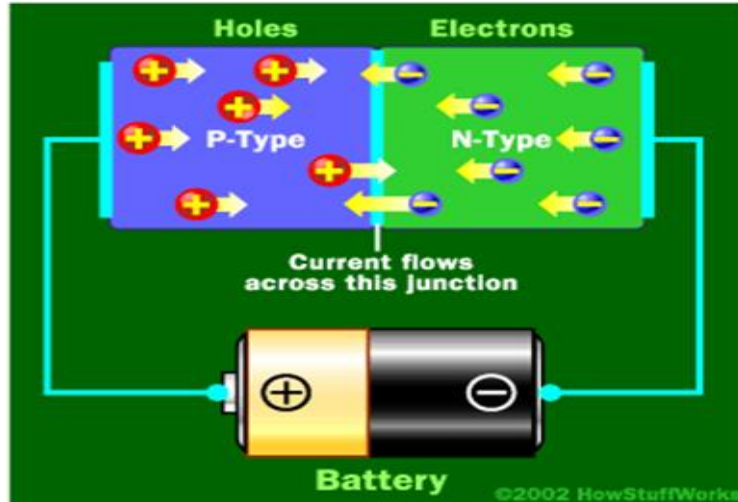


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LEDs

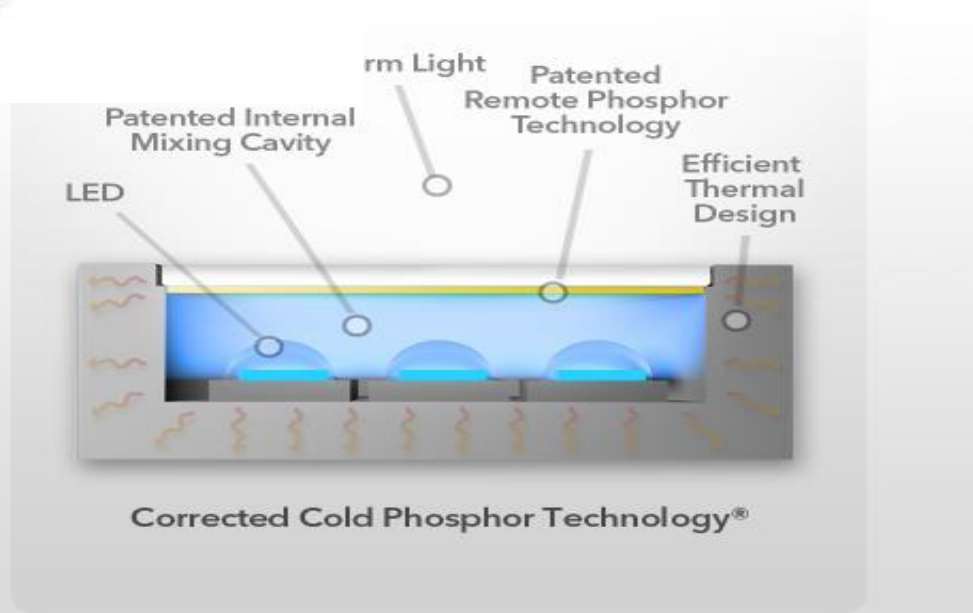
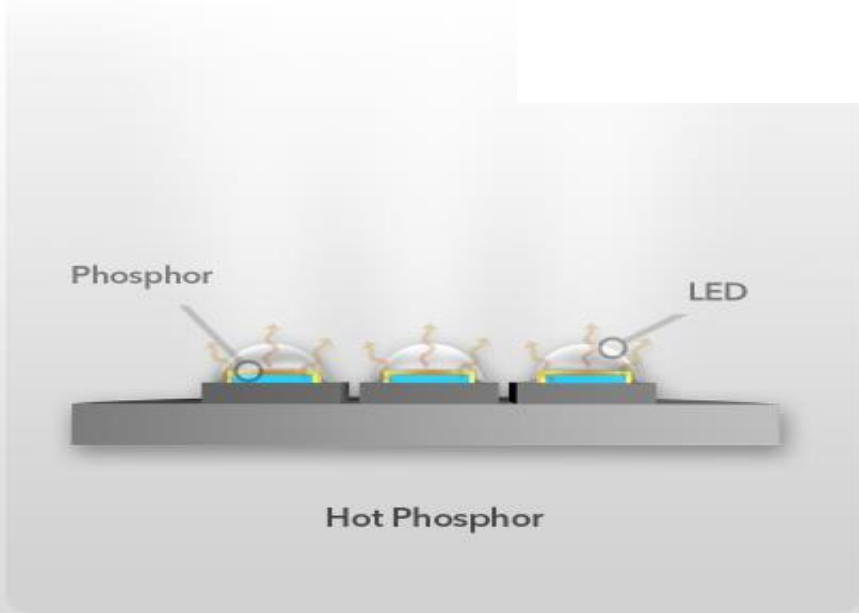
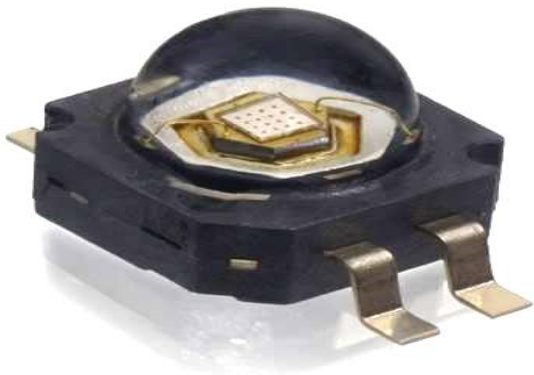
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Light directly from semi-conductor discharges



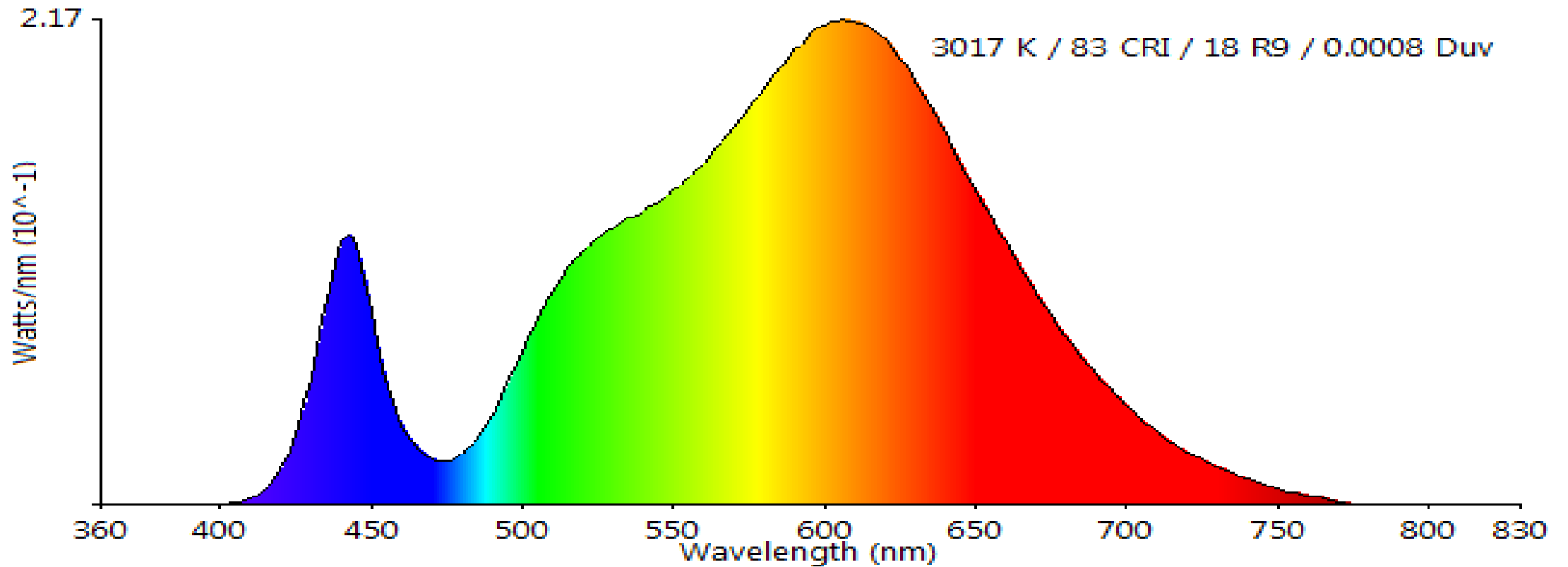
- Size: Small but comparatively large LES (issue for narrow beams)
- Luminous Flux: Commonly up to 5klm for general lighting applications
- Efficacy: +/-100 lm/W for CRI 80+ sources
- Life: Many definitions. Commonly quoted is 50khrs for L80 B50
- Spectral Power Distribution
 - Colour Appearance: phosphor related. Commonly 2700, 3000K and 4000K
 - Colour Rendering: 80+ the norm. Some or 90+ or even 95+

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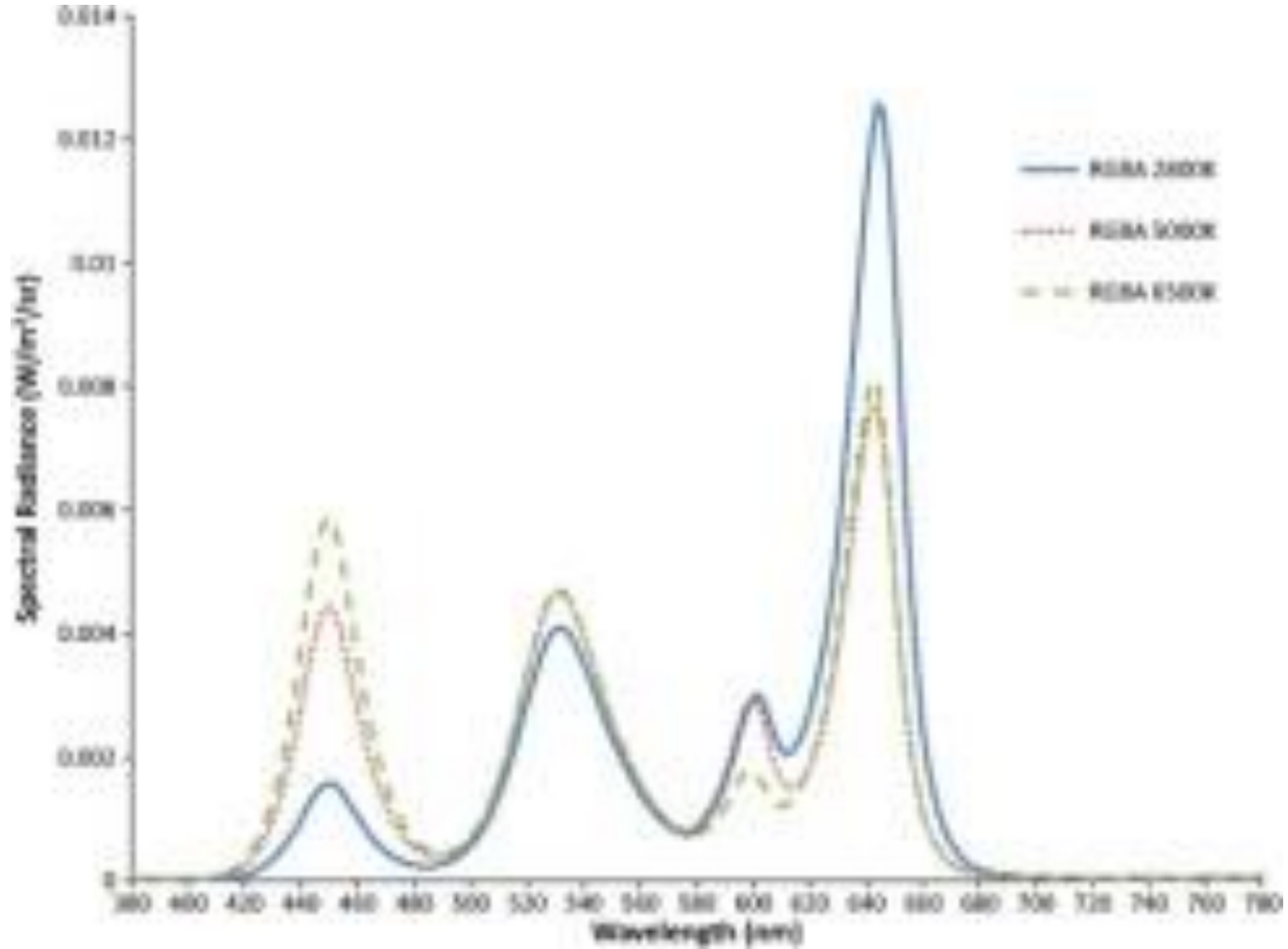
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LED, 3000K, 80+ CRI



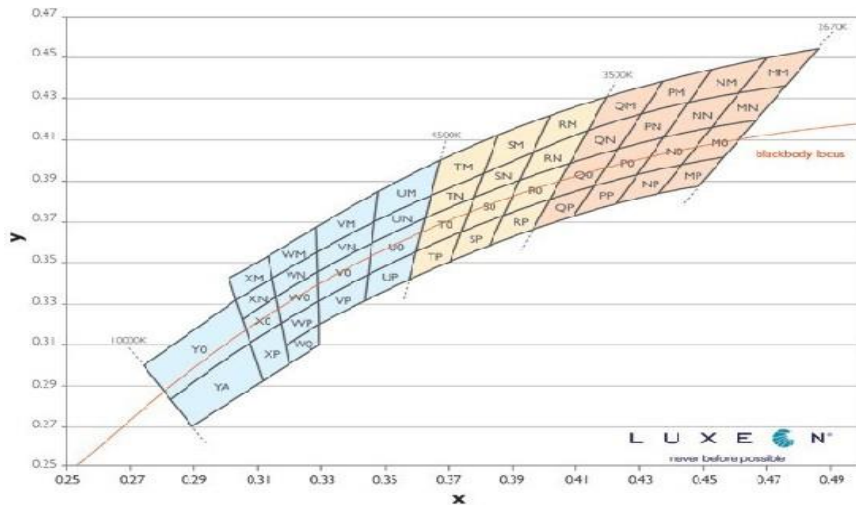
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LED RoodGroenBlauwAmber

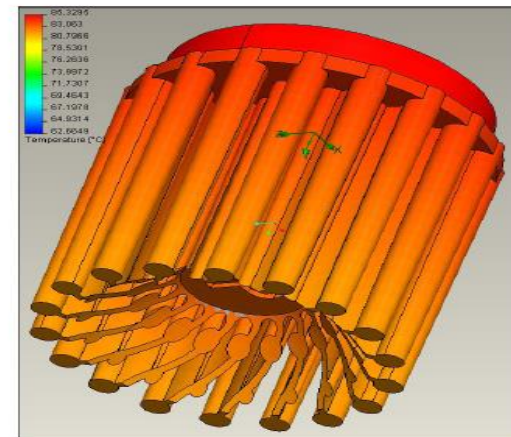


LED issues

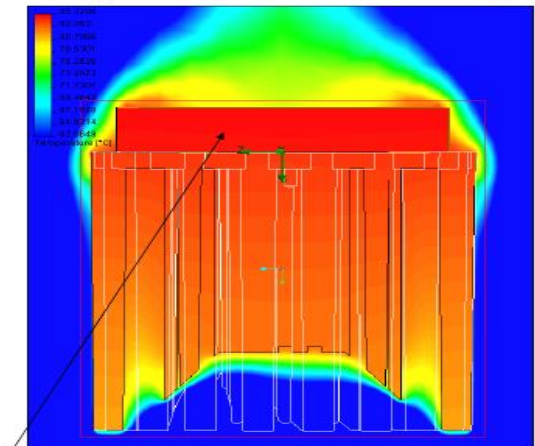
- Colour shift – initial, widening over time and through dimming cycle
- Connected with above binning can lead to supply issues
- Design for dissipation of conducted heat restricts luminaire design and is an issue with retrofit LED lamps
- Future proofing as efficacies improve rapidly, especially concerning circuitry



Temperature Results-180 degree orientation



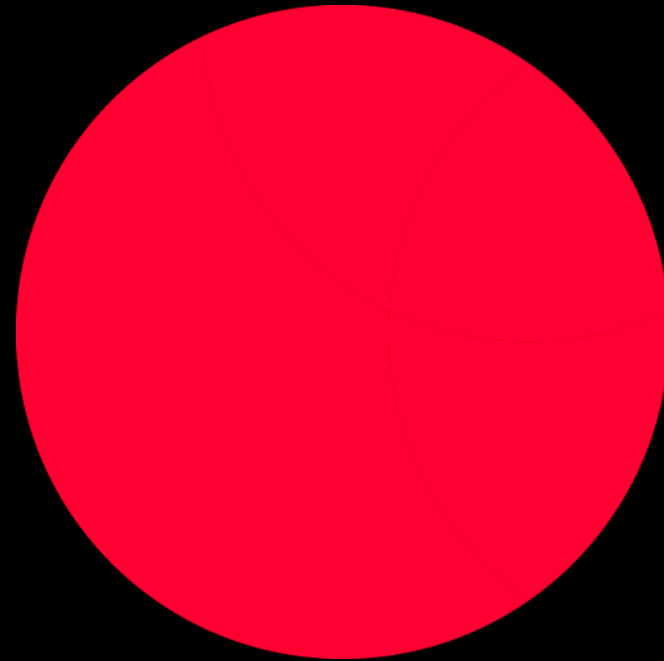
Surface temperature distribution



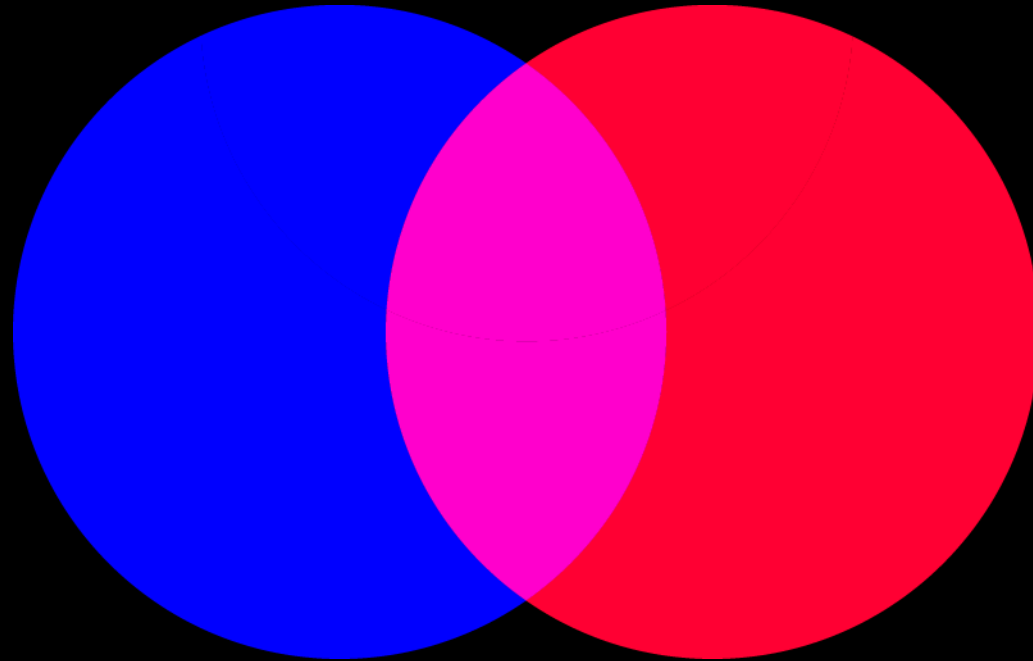
$T_p = 85.3^\circ\text{C}$ Cross section temperature & flow distribution

Kleuren

Additive Color Mixing

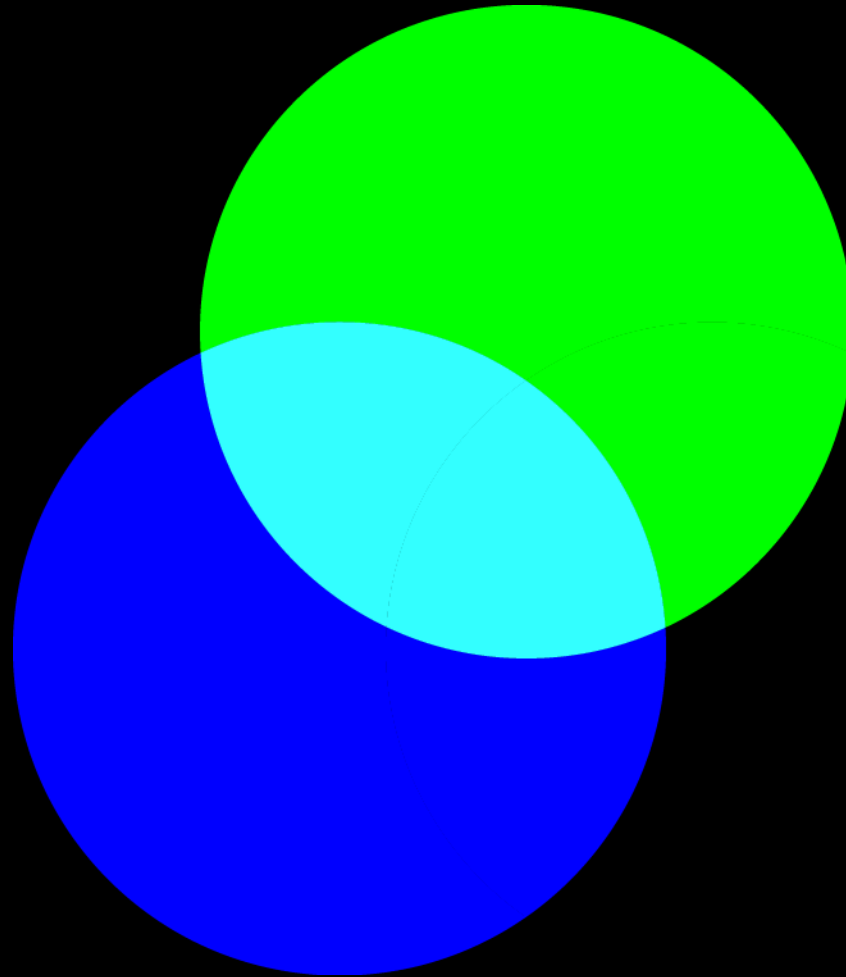


Additive Color Mixing



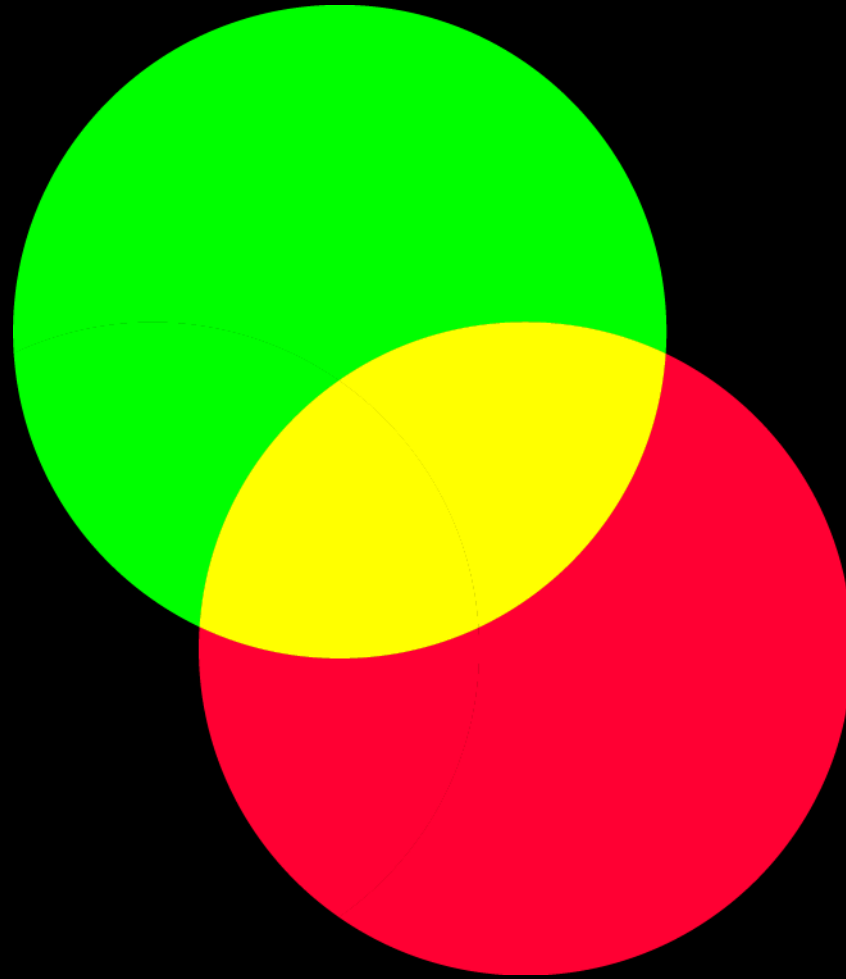
Red + Blue → Magenta

Additive Color Mixing



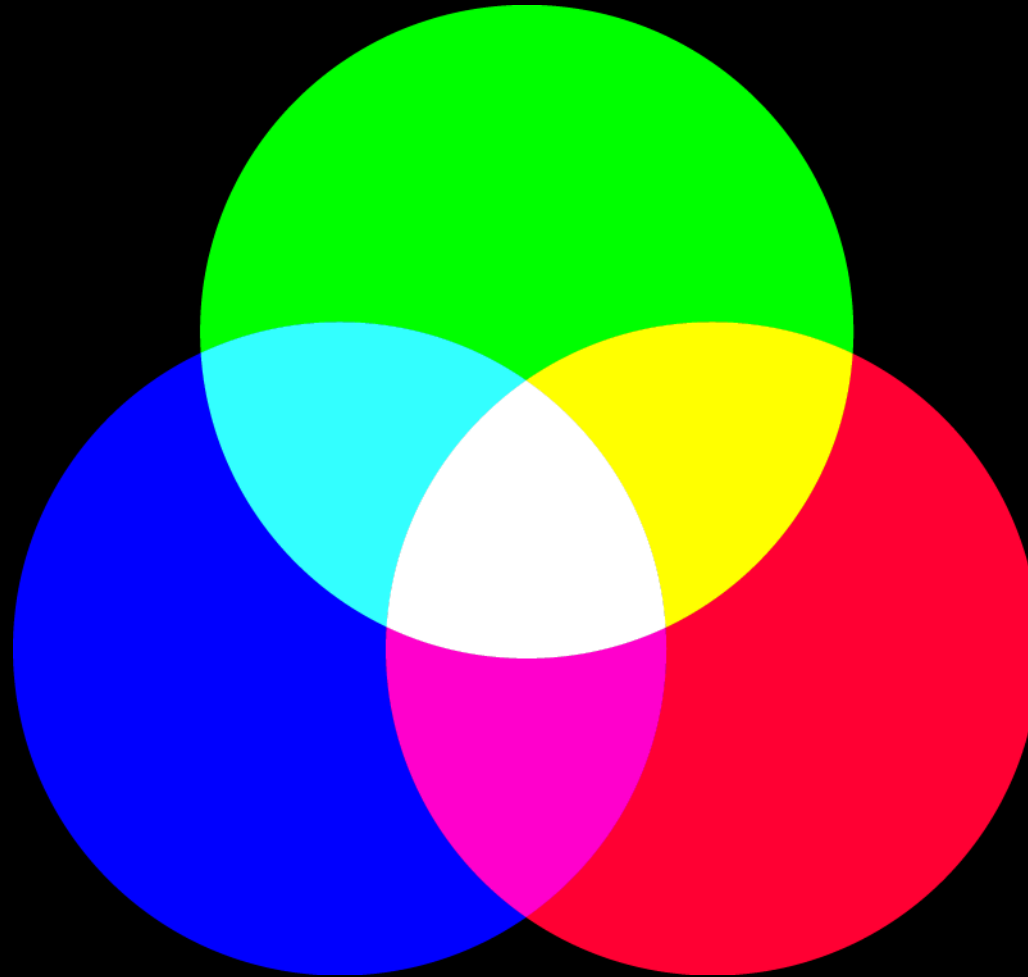
Green + Blue → Cyan

Additive Color Mixing



Red + Green → Yellow

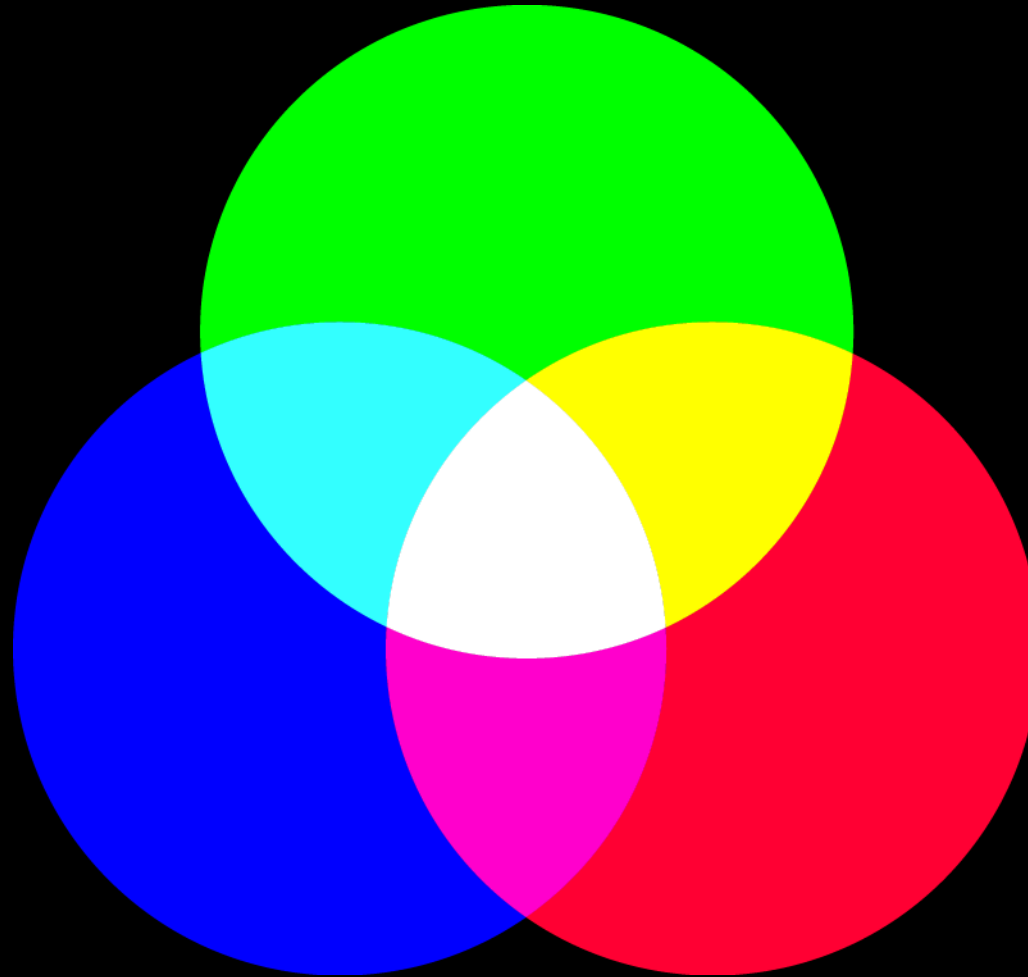
Additive Color Mixing



Red + Blue + Green → White

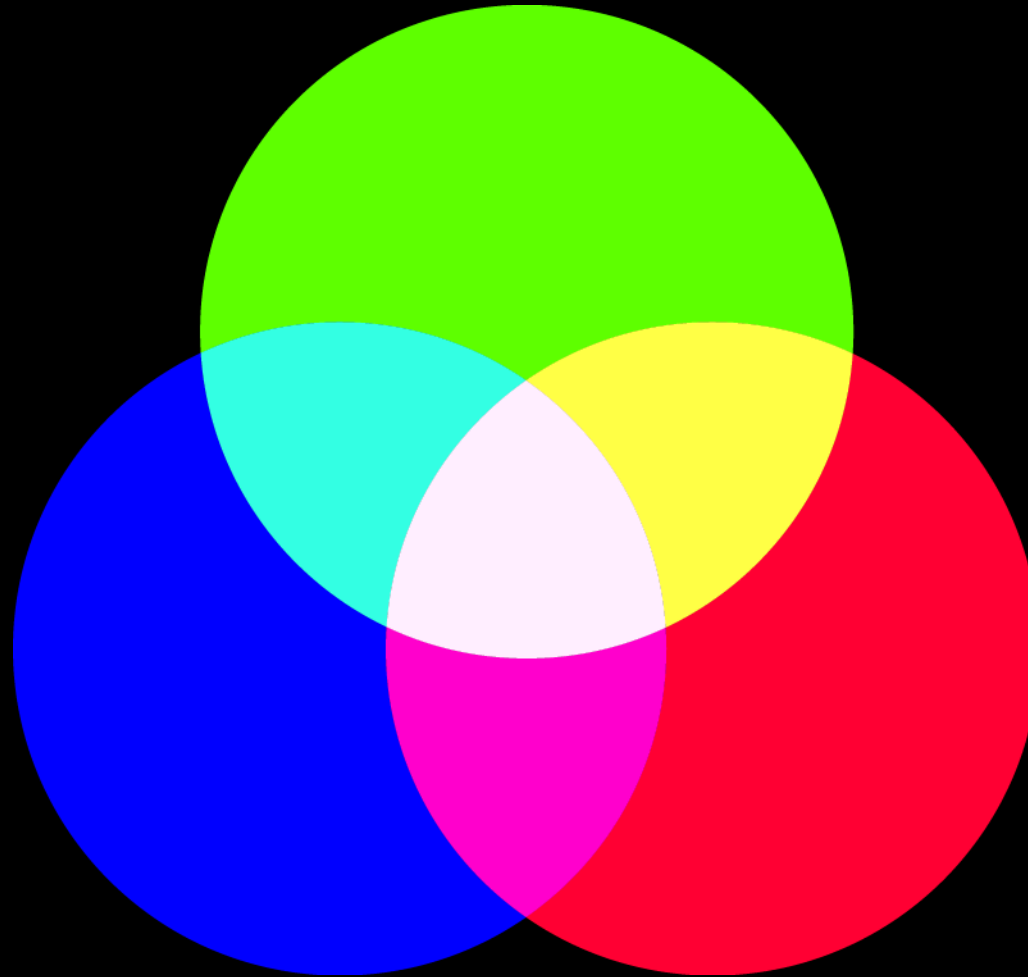
Kleur Nauwkeurigheid

Color Accuracy



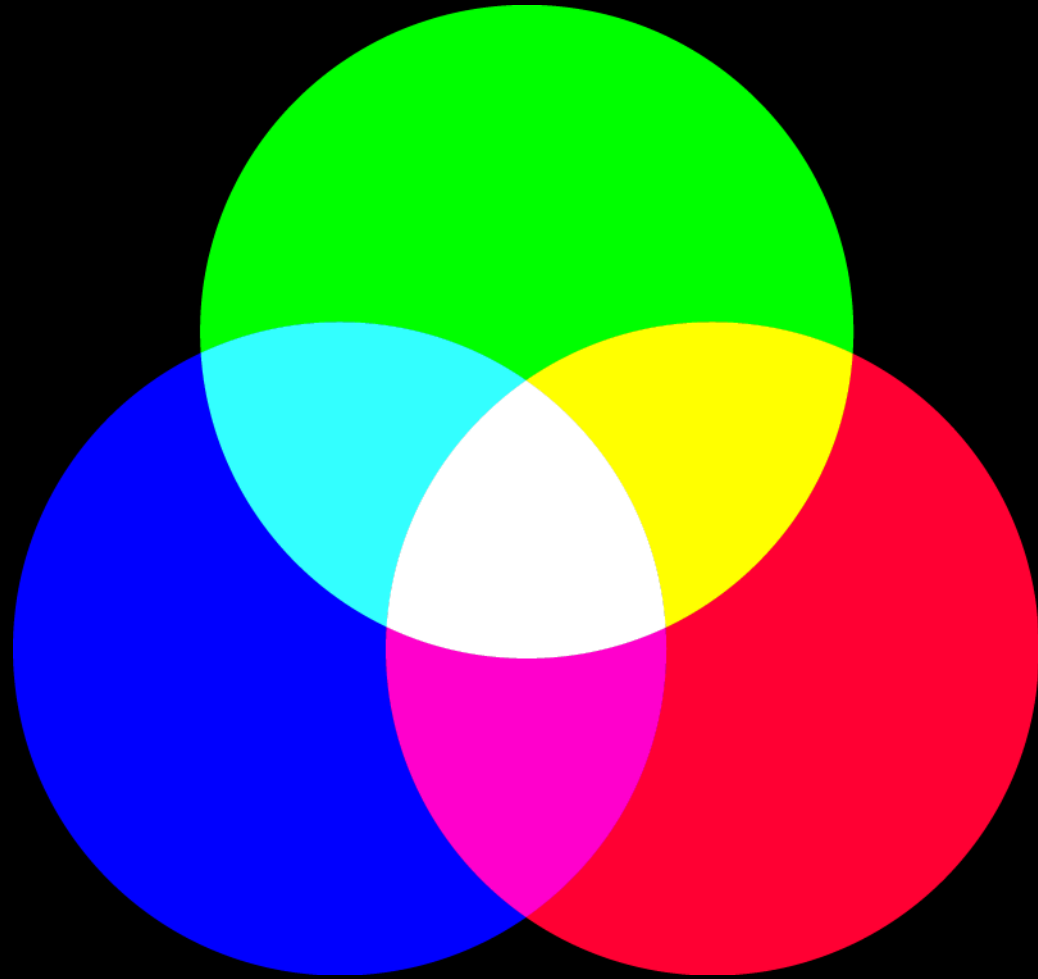
Balancing the primaries is critical for accurately making white

Color accuracy

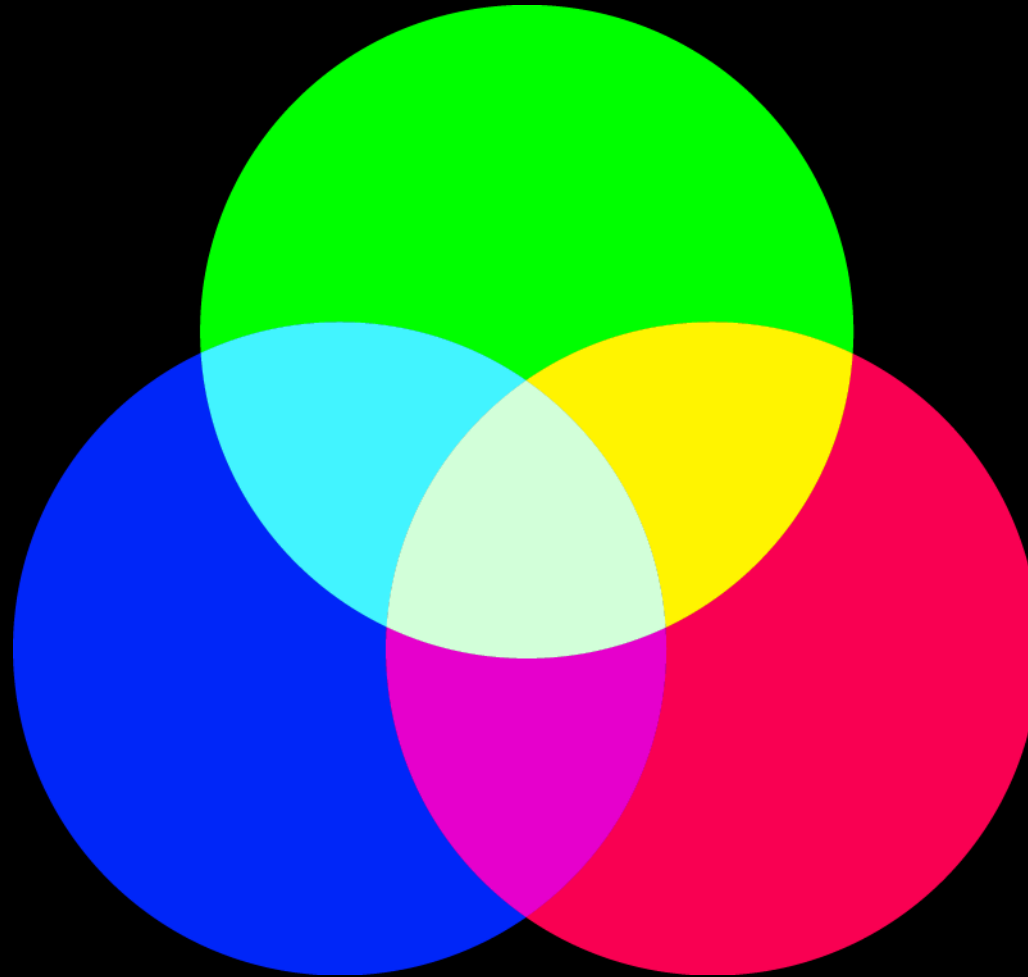


Less green makes the light appear pinkish and off-white

Color accuracy



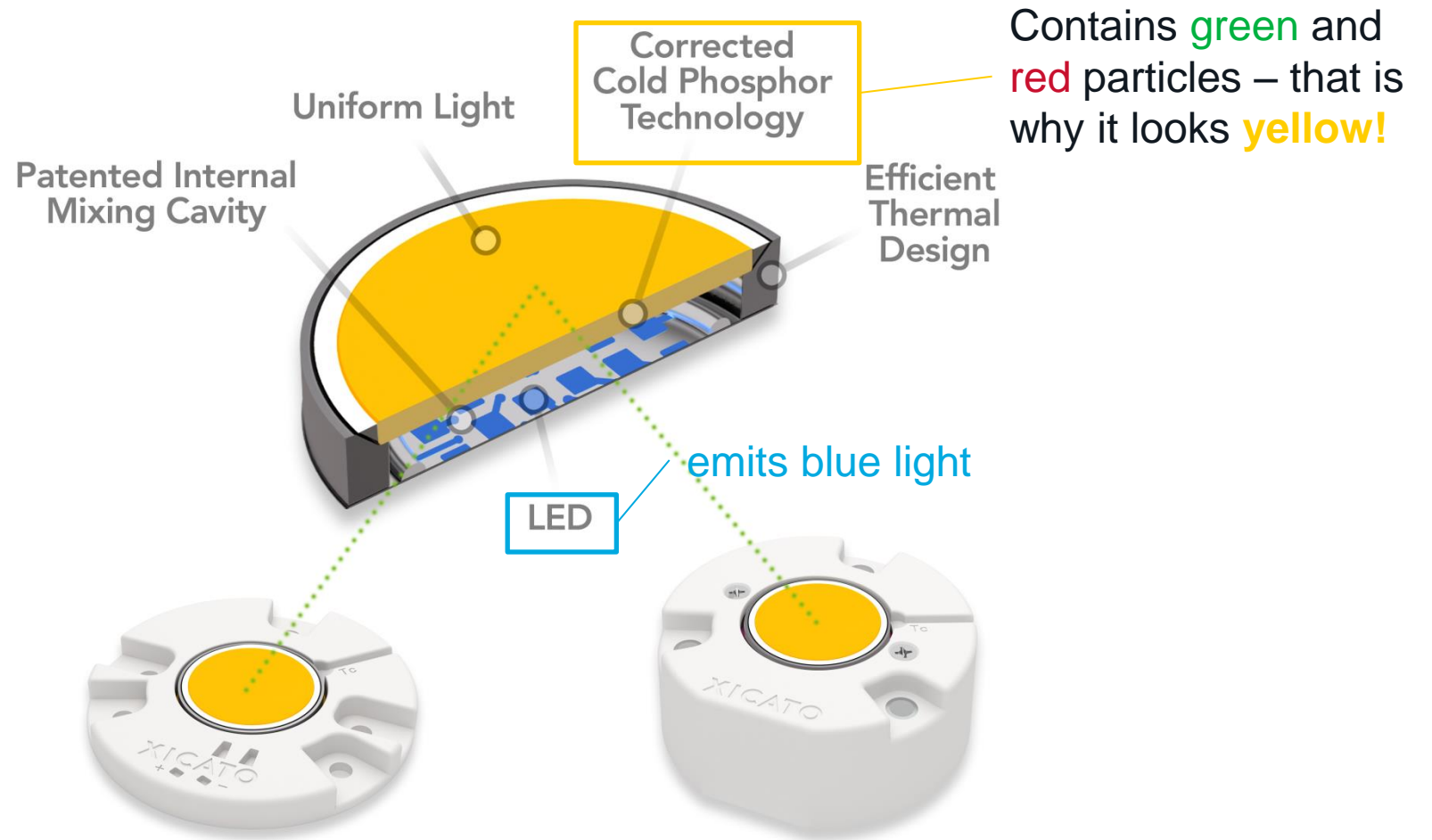
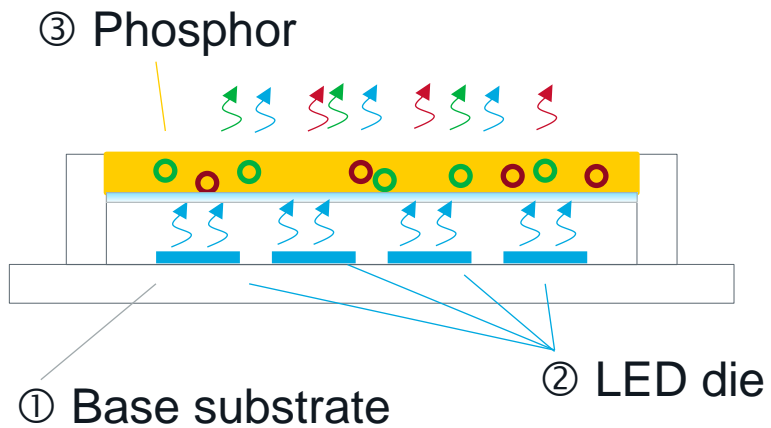
Color accuracy



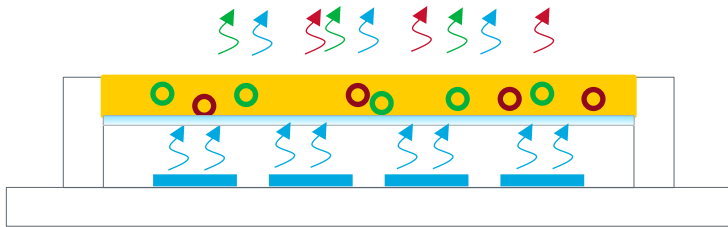
More green makes the light appear greenish and off-white

Anatomy of an LED module

Next Generation Corrected Cold Phosphor[®]



LED module with Corrected Cold Phosphor vs. standard LED



Corrected cold phosphor uses a multi step process for color correction

Apply 1st phosphor layers



Measure



Calculate Adjustment



Apply 2nd phosphor layers



Measure ✓

Successful outcome depends largely on ability to measure accurately!

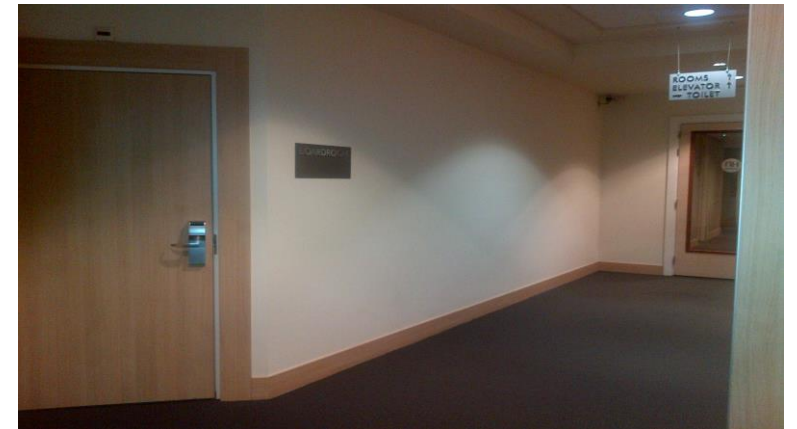
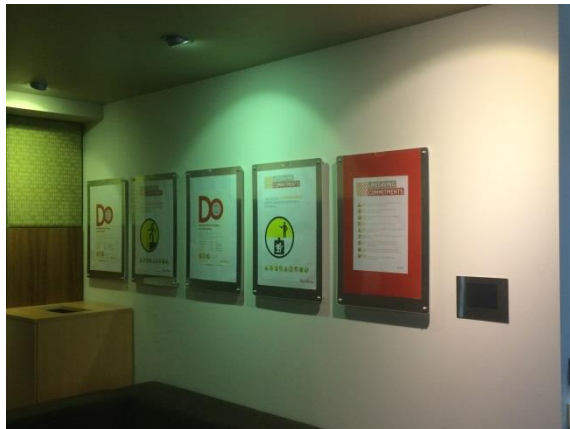
Color appearance – Initial and Maintained color points



McAdam ellipse: the region on a chromaticity diagram which contains all colours which are indistinguishable, to the average human eye, from the colour at the center of the ellipse. Contour of ellipses represent increasingly noticeable differences of chromaticity.

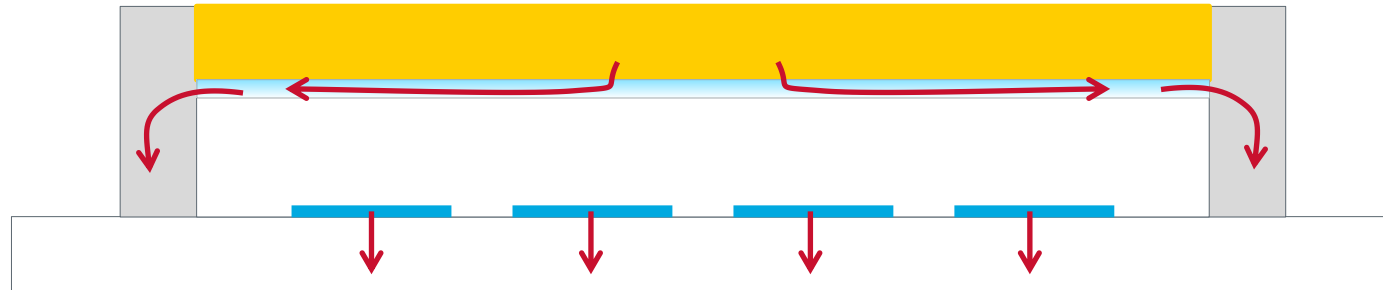
Do the objects have different color or does the light cause them to look differently?

Colour Consistency: getting it wrong



Kleur Stabiliteit

LED module with Corrected Cold Phosphor vs. standard LED



Corrected cold phosphor – heat extraction from phosphor is separated from heat extraction from LED

LED module with Corrected Cold Phosphor vs. standard LED

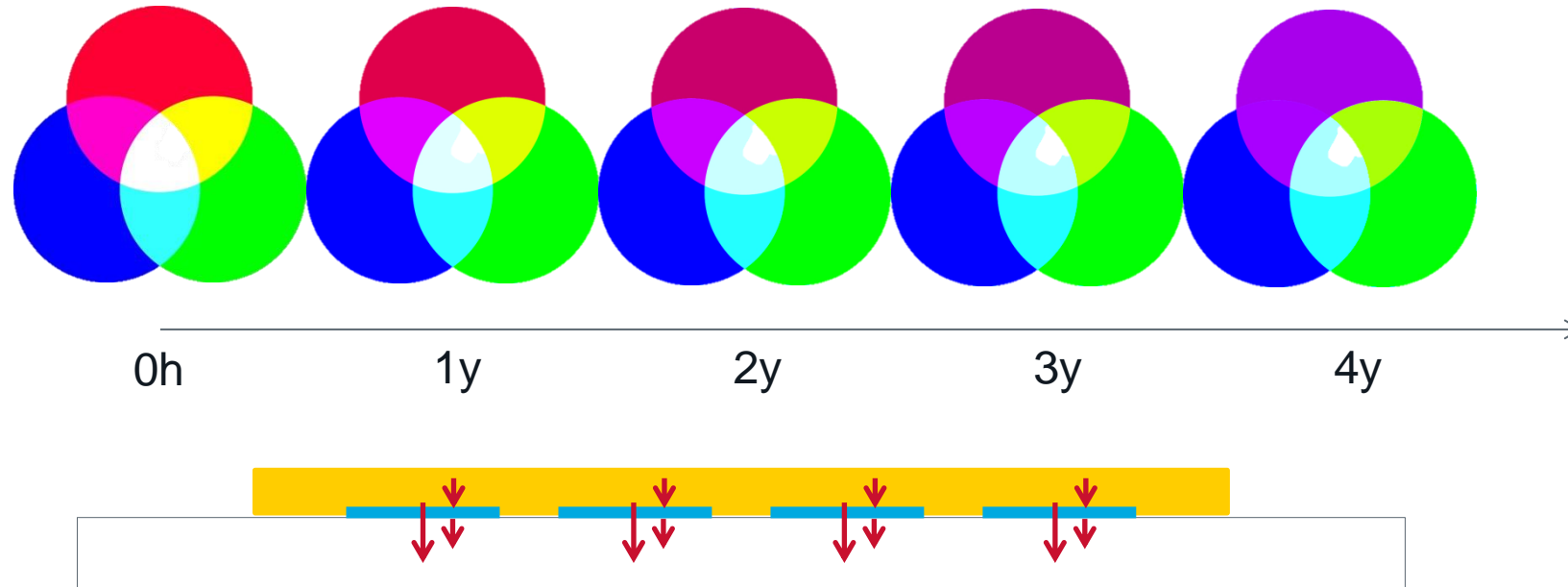


Standard LED – phosphor is right on top of LED
LED heats phosphor directly
Phosphor heats LED directly
Heat extraction from Phosphor has to pass through LED
As a result: higher phosphor temperatures

LED module with Corrected Cold Phosphor vs. standard LED

Example of color shift over time:

Red phosphor gets weaker
LED shifts towards cyan

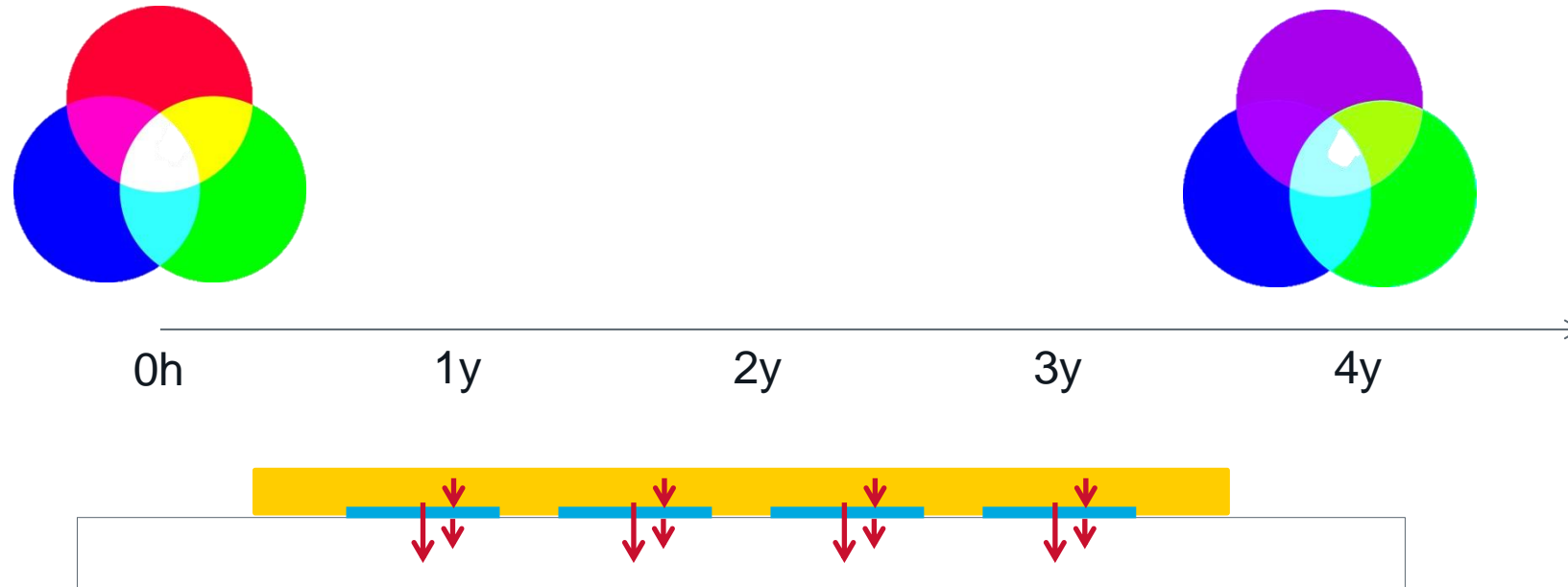


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Example of color shift over time:

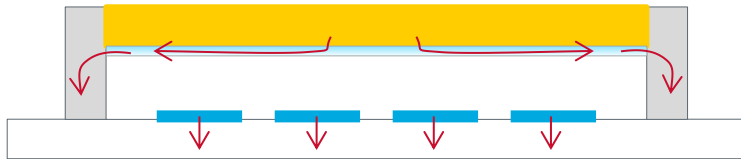
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LED heats phosphor directly
Phosphor heats LED directly
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LED module with Corrected Cold Phosphor vs. standard LED

Corrected Cold Phosphor



Cool phosphor



Phosphor stable over life



Color stable over life

Standard LED



Higher phosphor temperatures



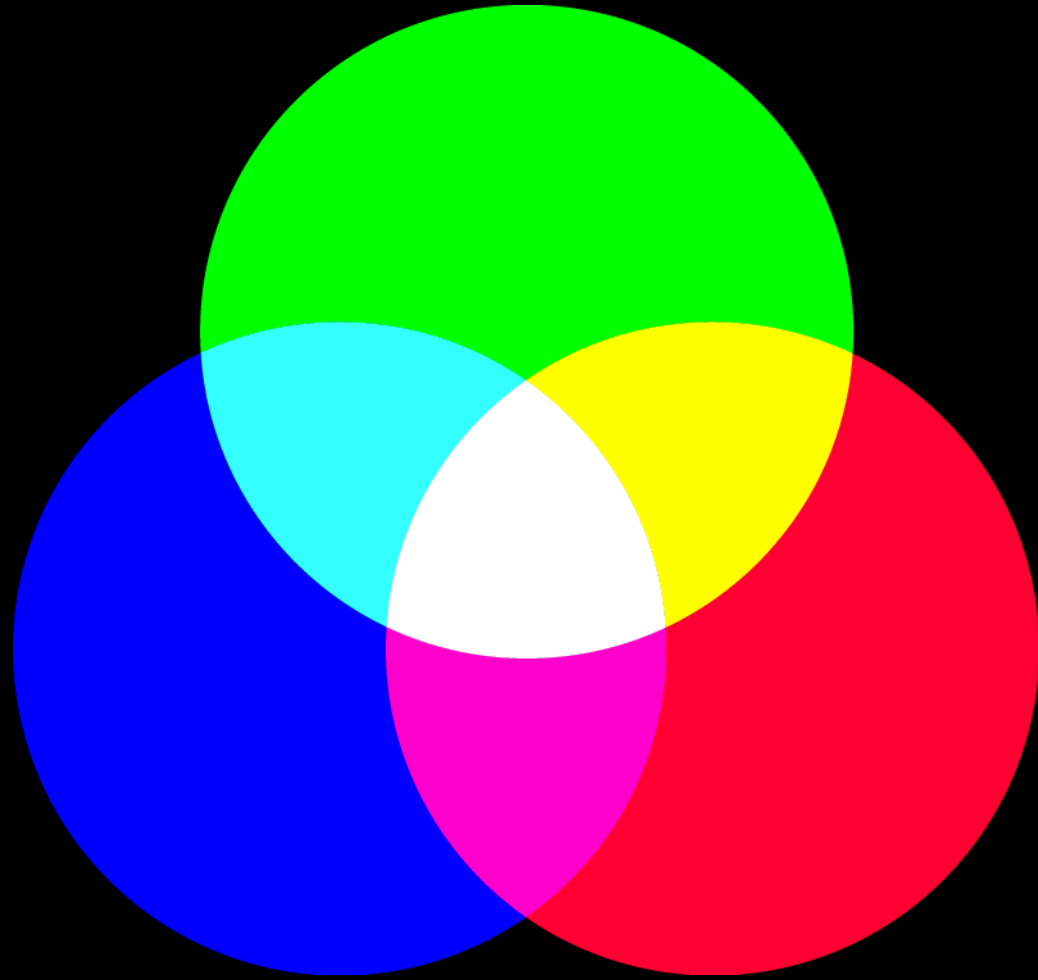
Increased phosphor degradation



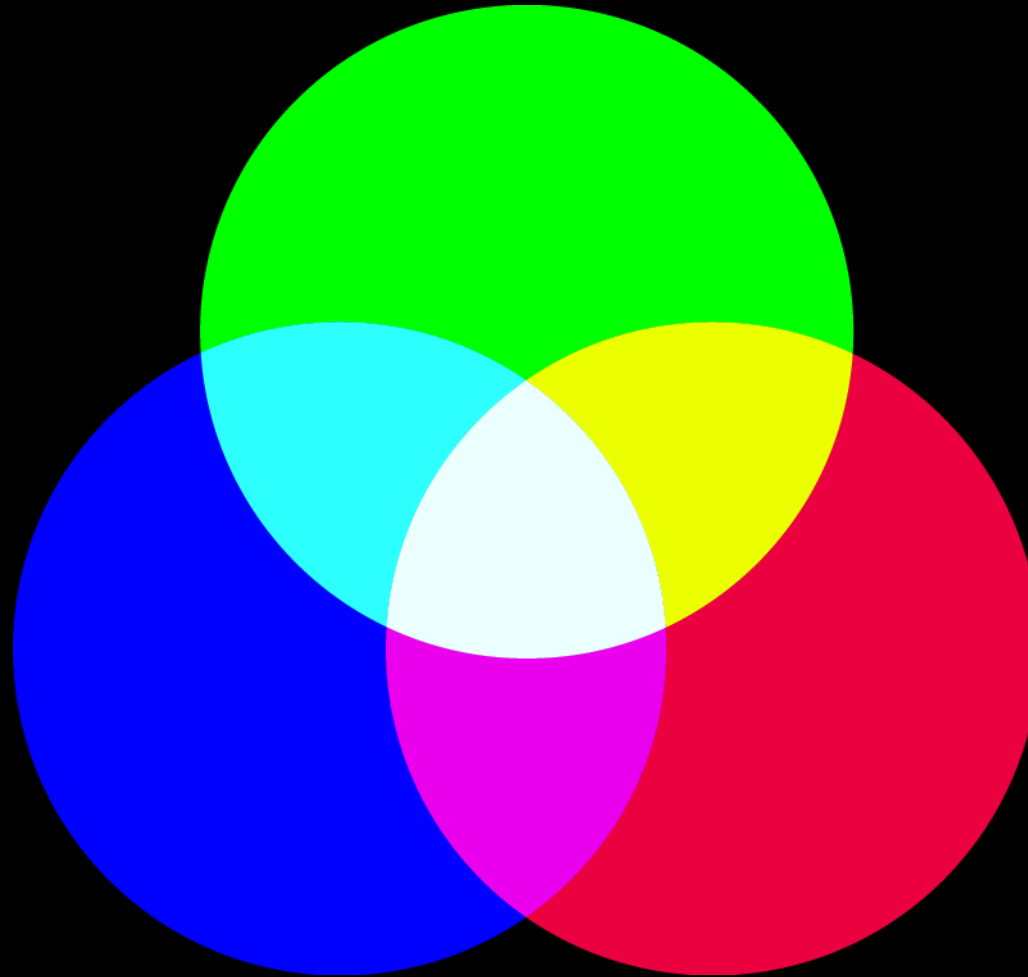
Color shift

Kleur Temperatuur (CCT)

Changing color temperature

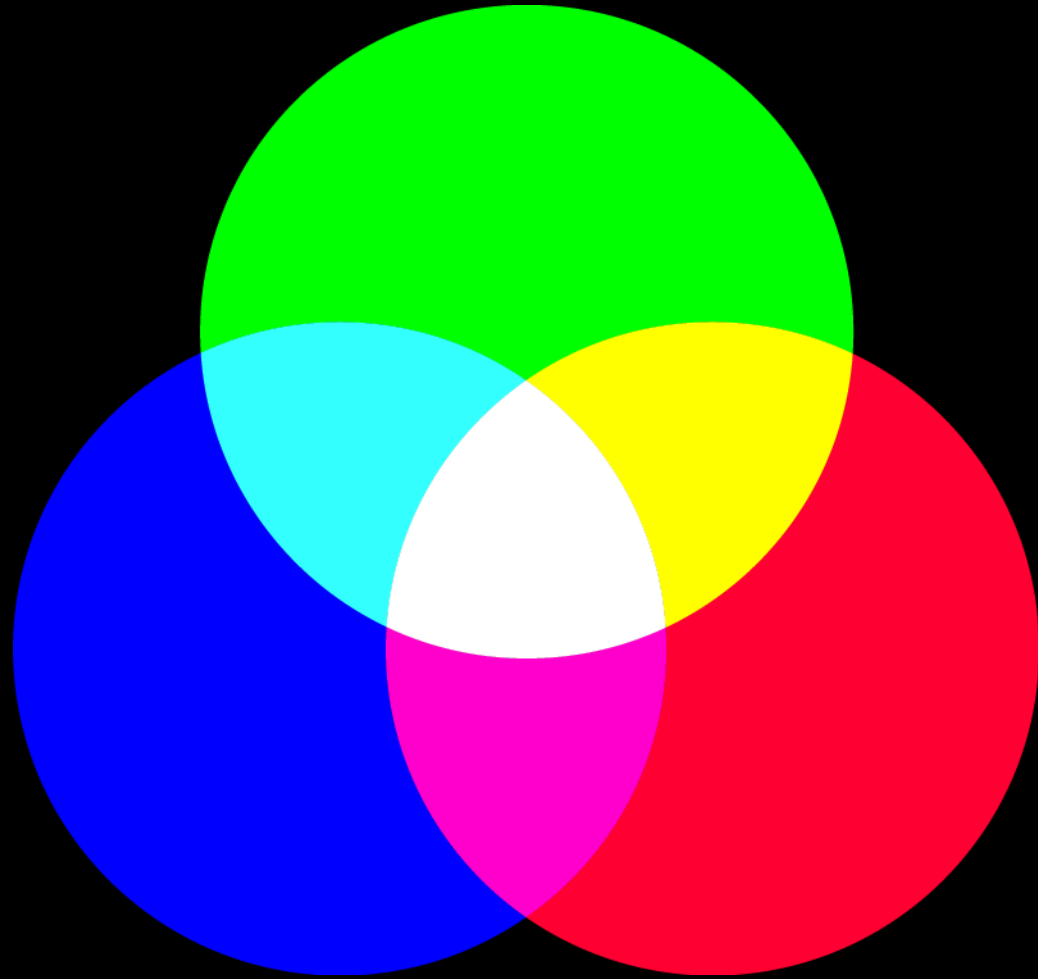


Changing color temperature

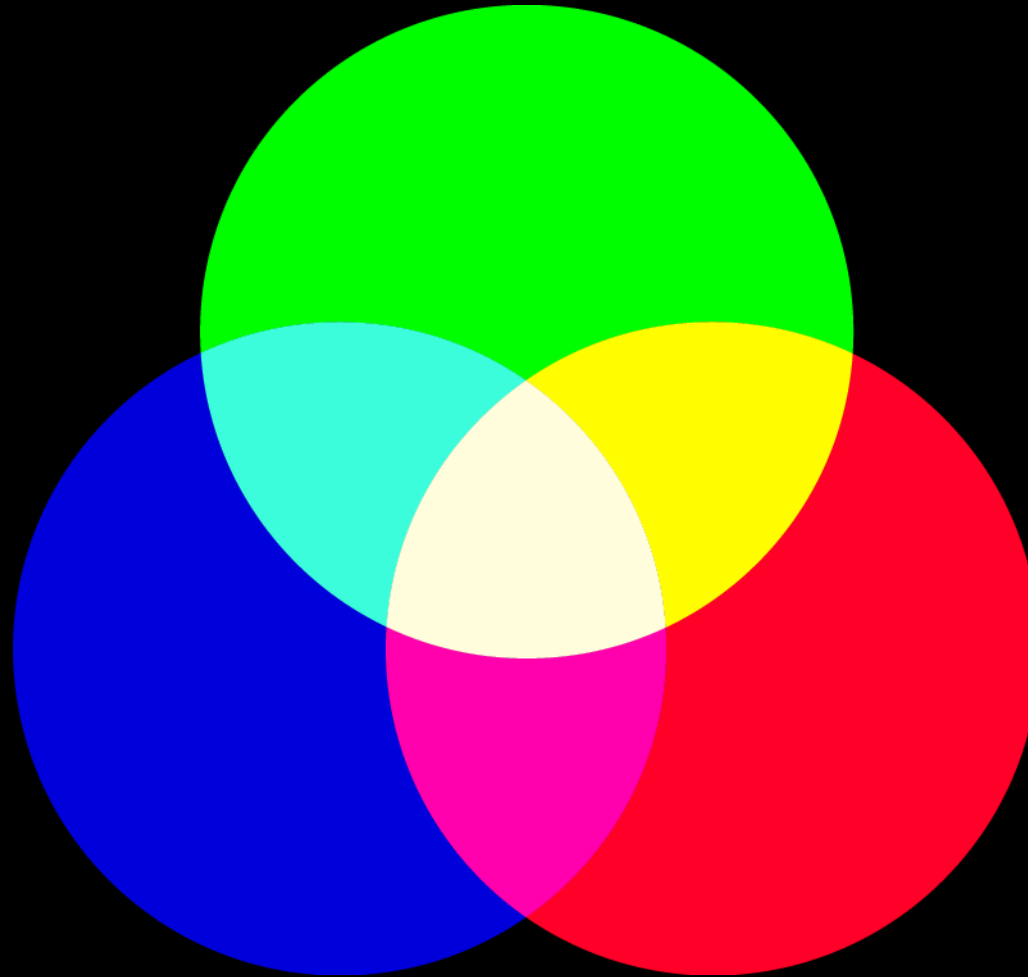


Less red makes the light appear colder → higher CCT

Changing color temperature

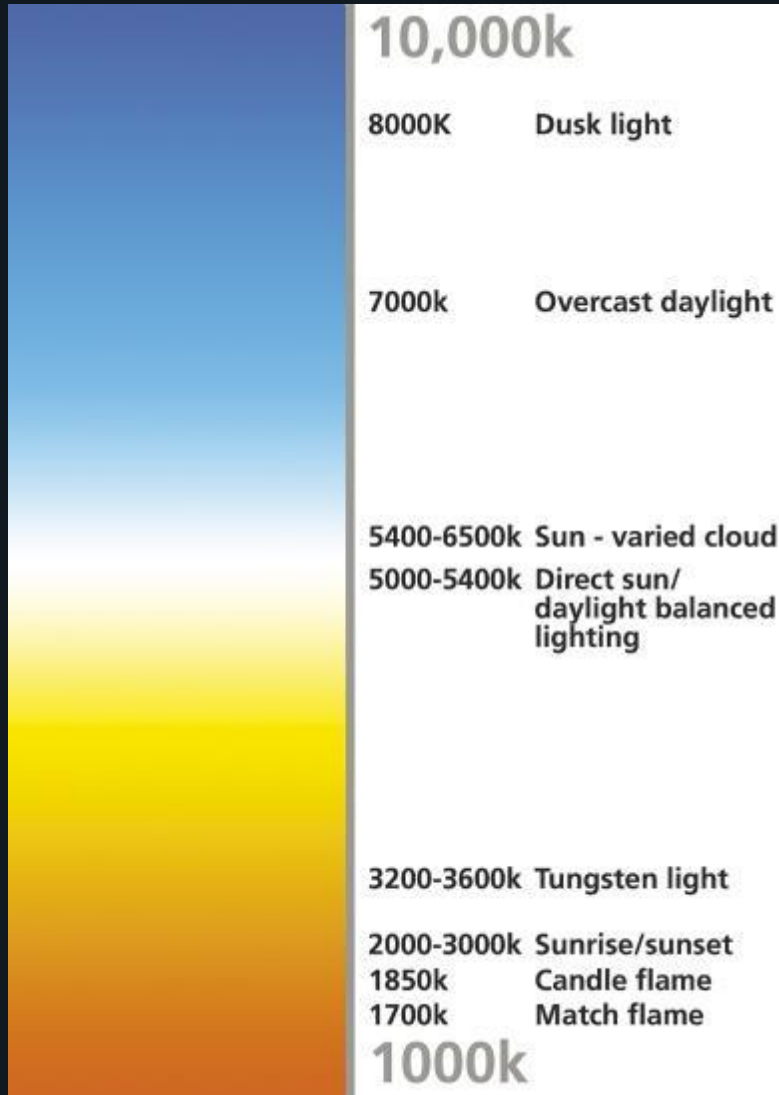


Additive Color Mixing



Less blue makes the light appear warmer → lower CCT

Colour Temperature



1800K

match flame



1800K

10000K



1930K

candle flame



3500K

quartz lights



7500K

sky overcast



2900K

sunrise / sunset



5400K

sun direct at noon



8000K

outdoor shaded areas



3000K

Tungsten lamp 500W - 1KW



6500K

sun through clouds



10000K

partly cloudy sky



Working with CCT



2200K



2700K



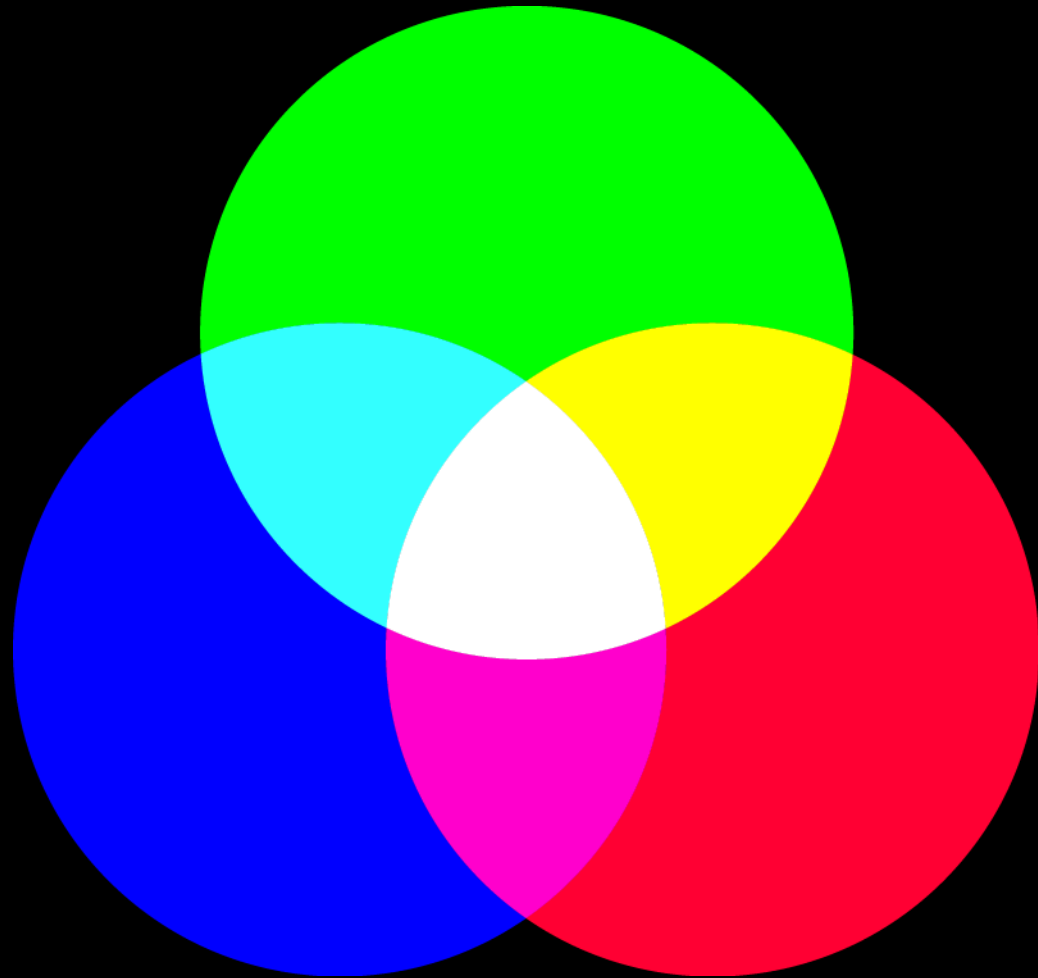
3000K



4000K

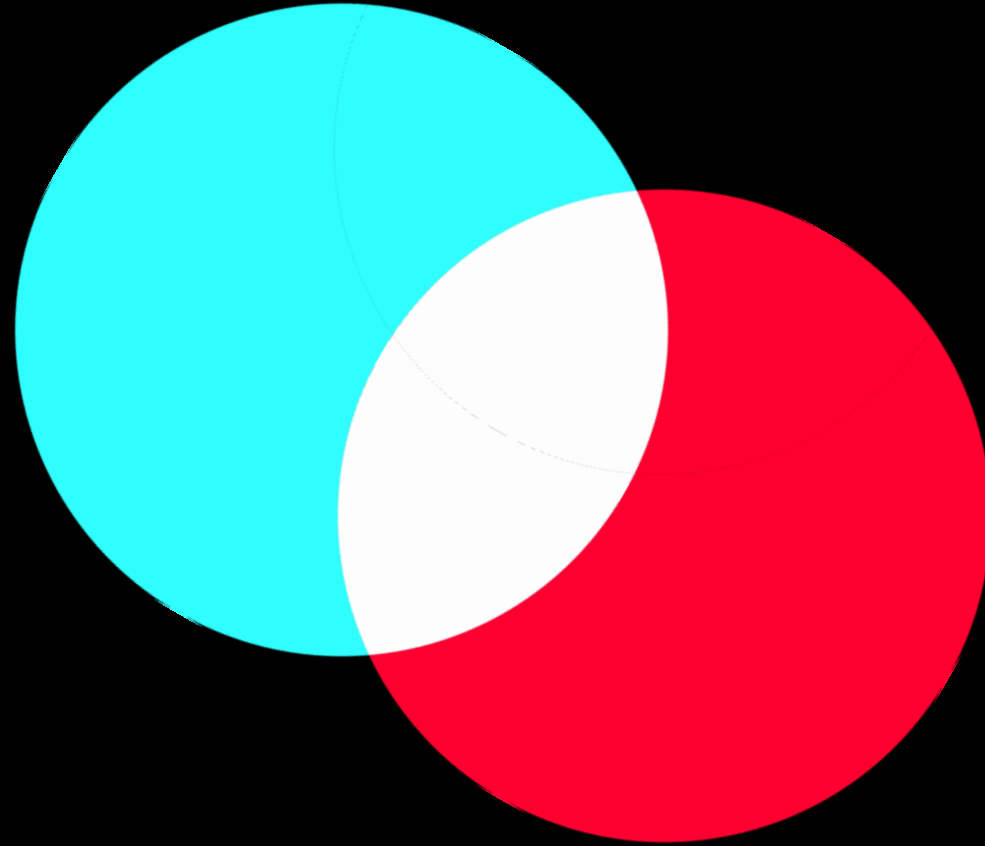
Kleur Weergave

Additive Color Mixing



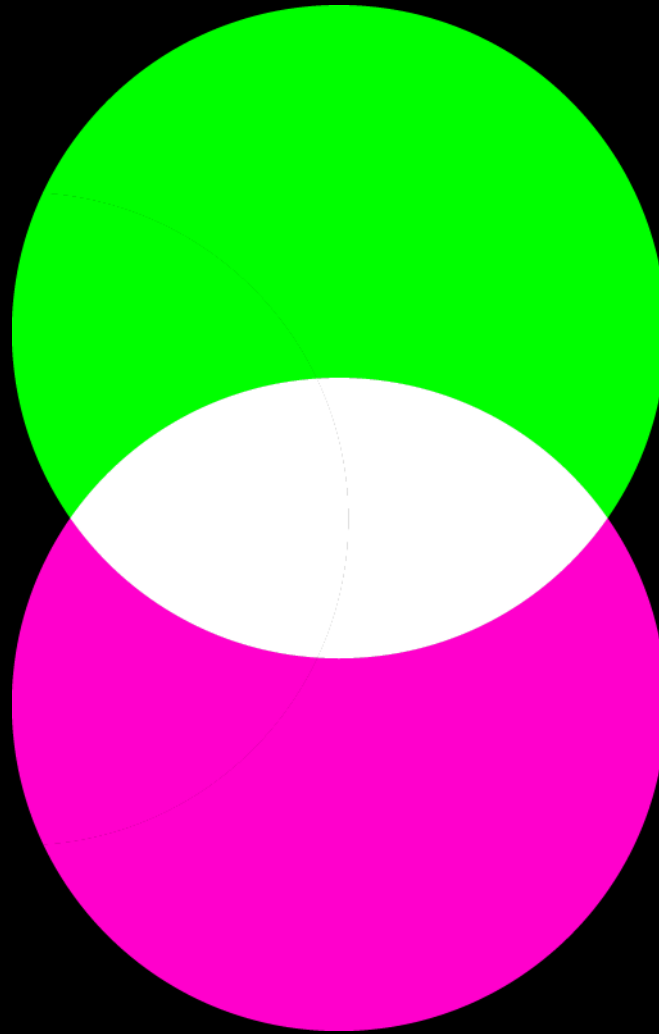
There are many other ways to make white light

Additive Color Mixing



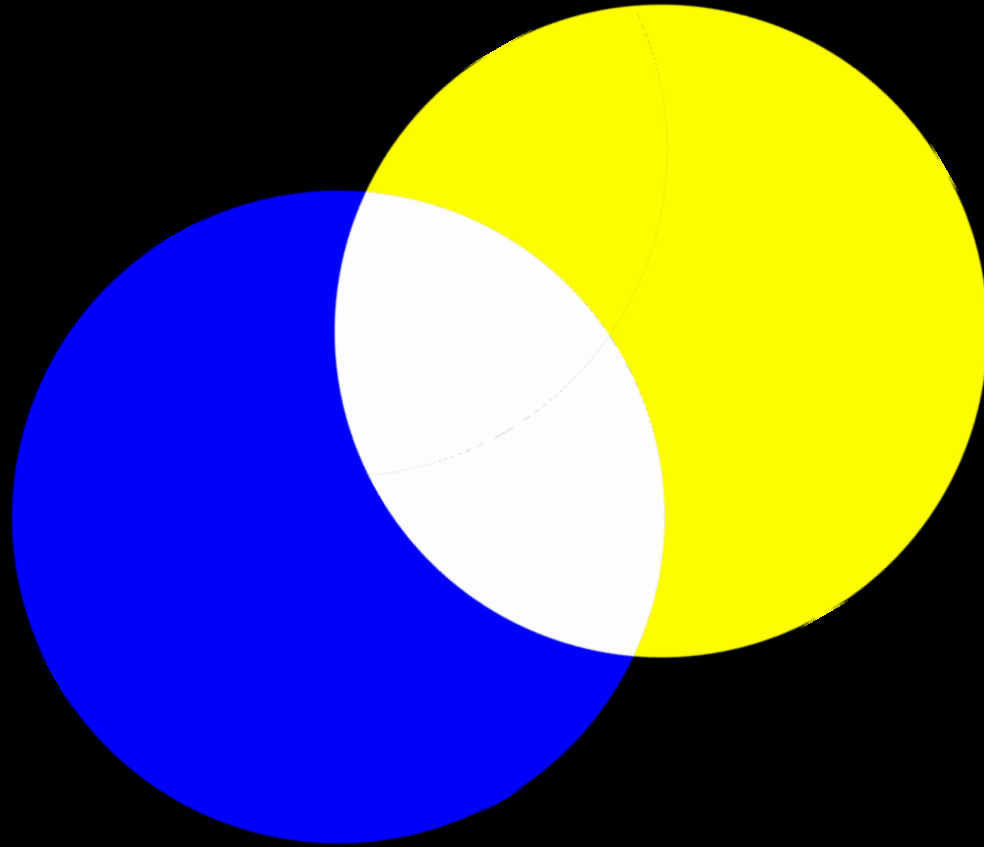
Cyan + Red → White

Additive Color Mixing



Magenta + Green \rightarrow White

Additive Color Mixing

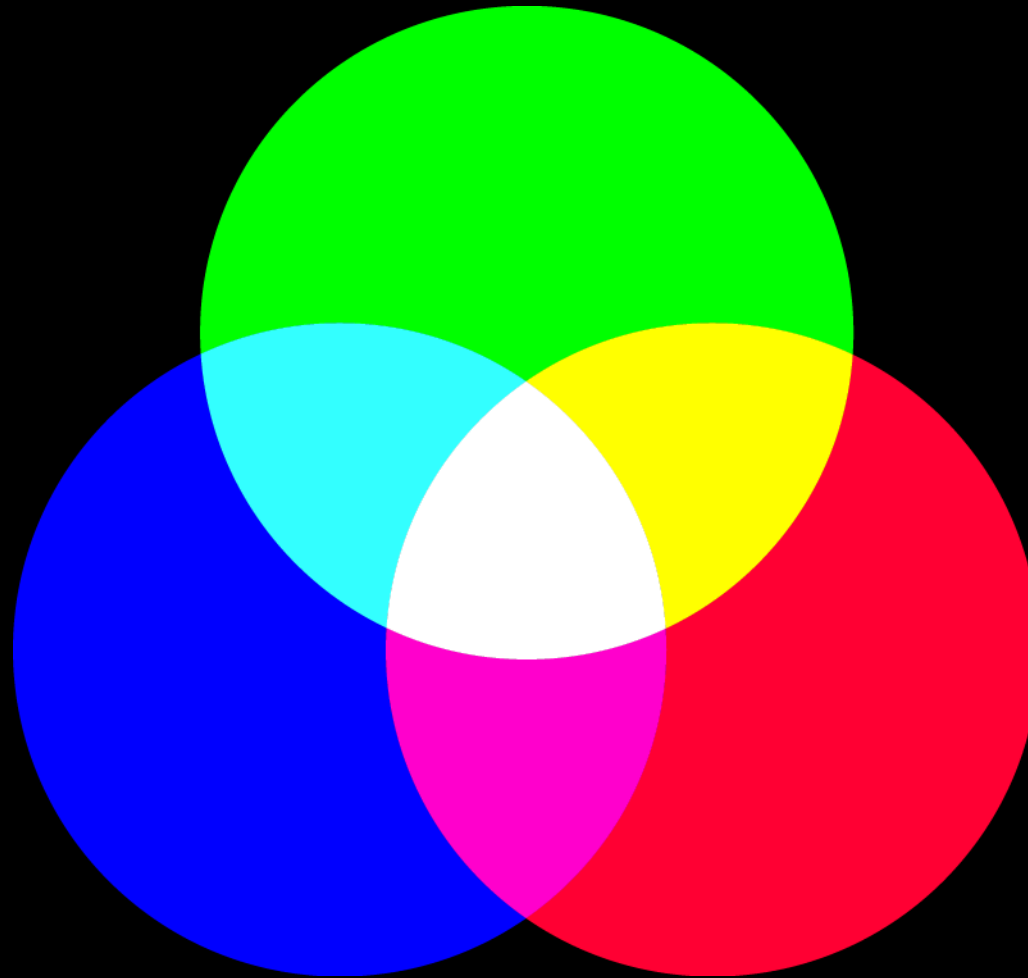


Very poor color rendering LEDs
use mixing of yellow and blue
to make white



Blue + Yellow → White

Additive Color Mixing



We can change the rendering properties of a light source by tuning the saturation and hue of the primaries

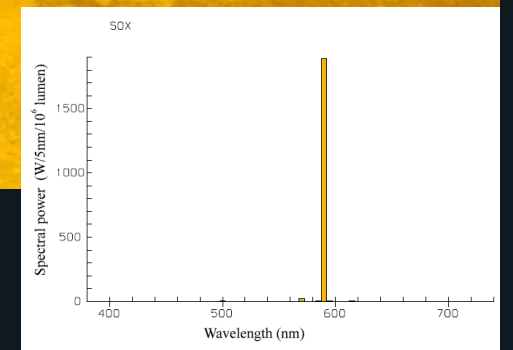
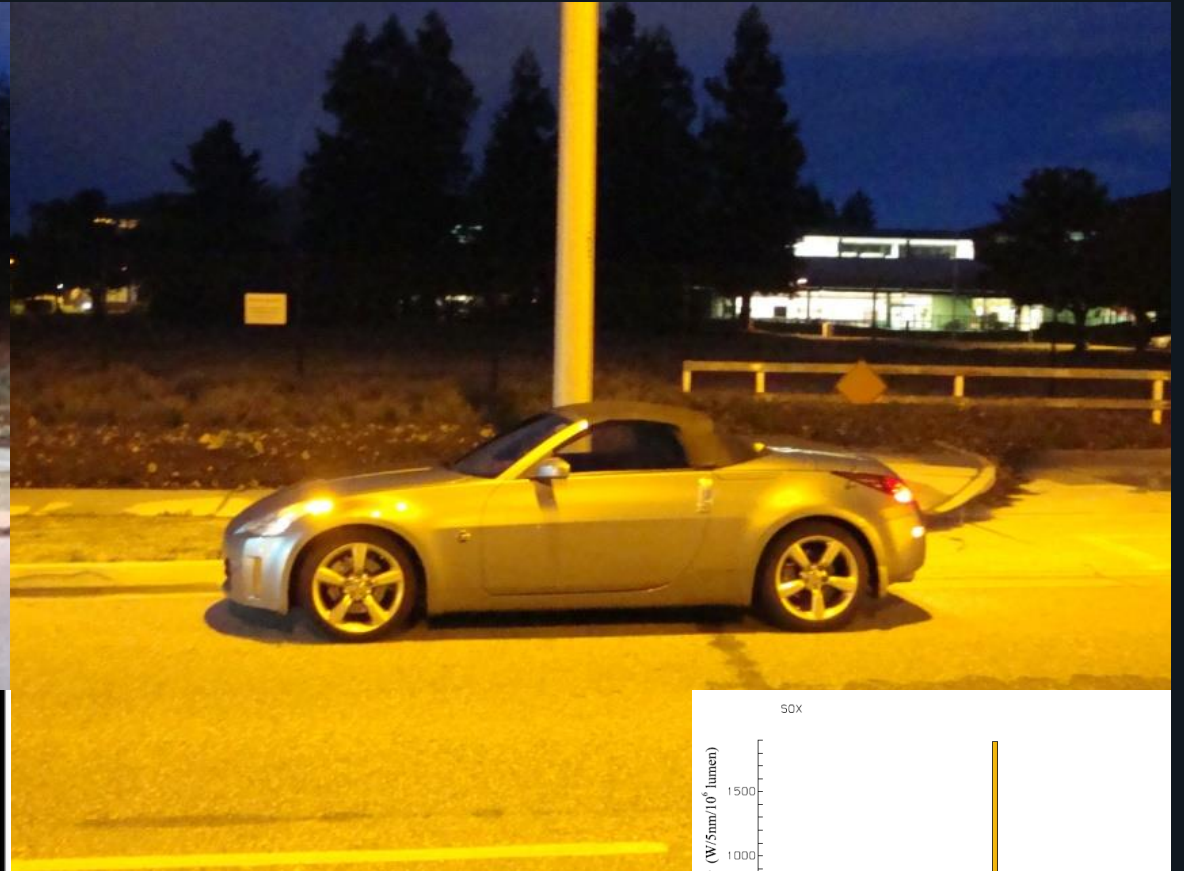
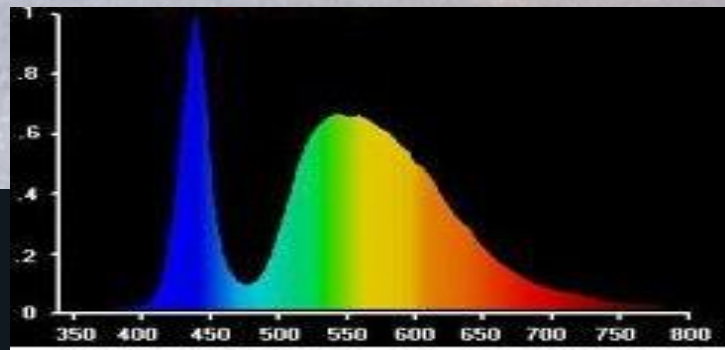
Colour Rendering



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'LIGHT' THE WAY WE SEE THINGS

Effect of SPD on Colour Appearance + Rendering



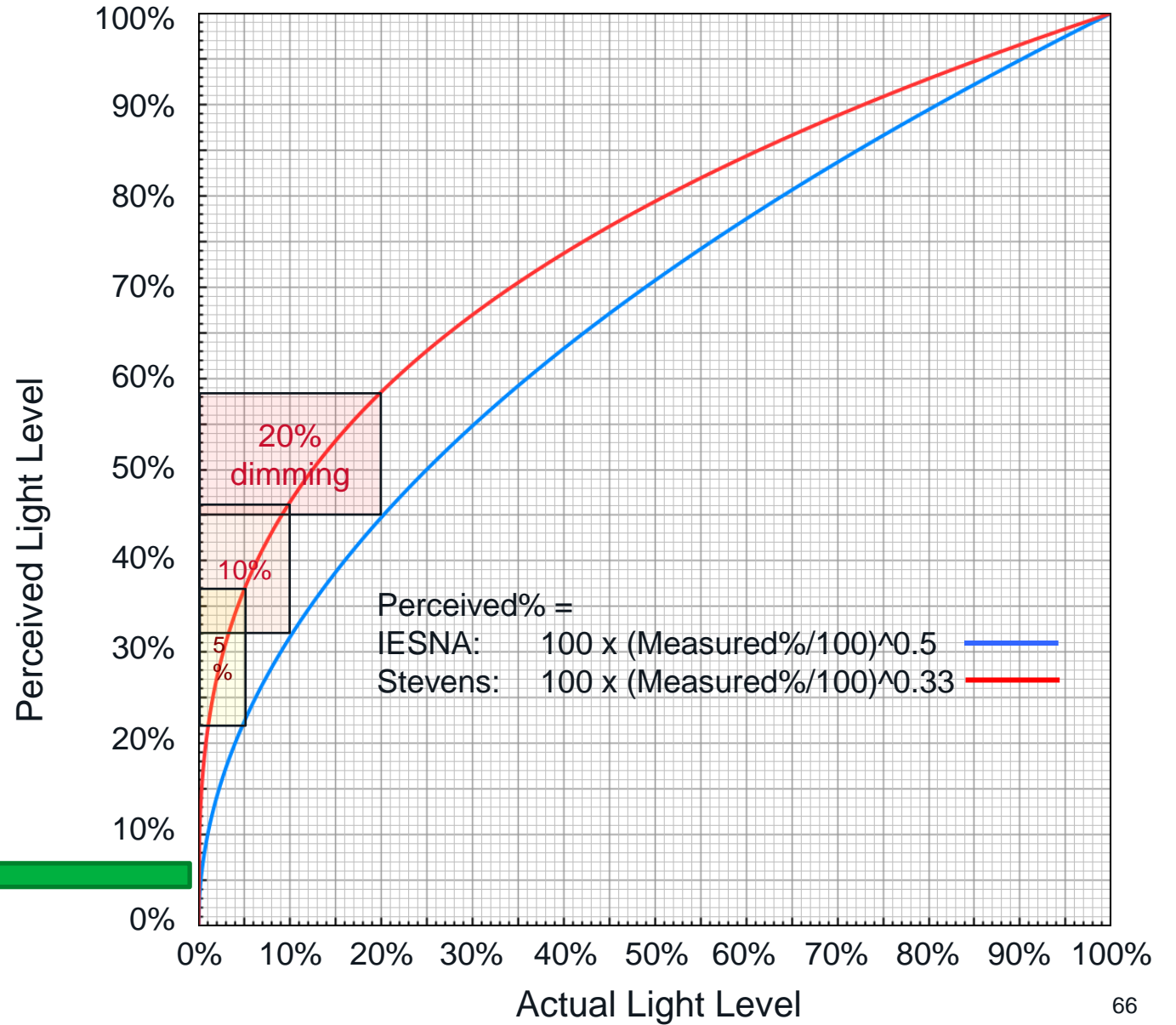
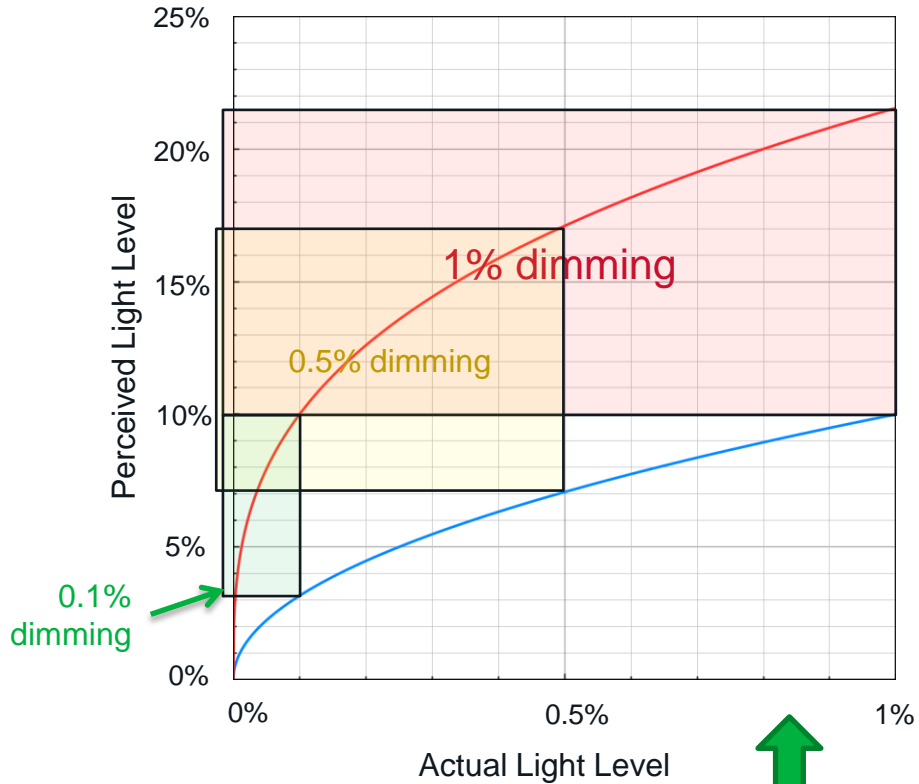
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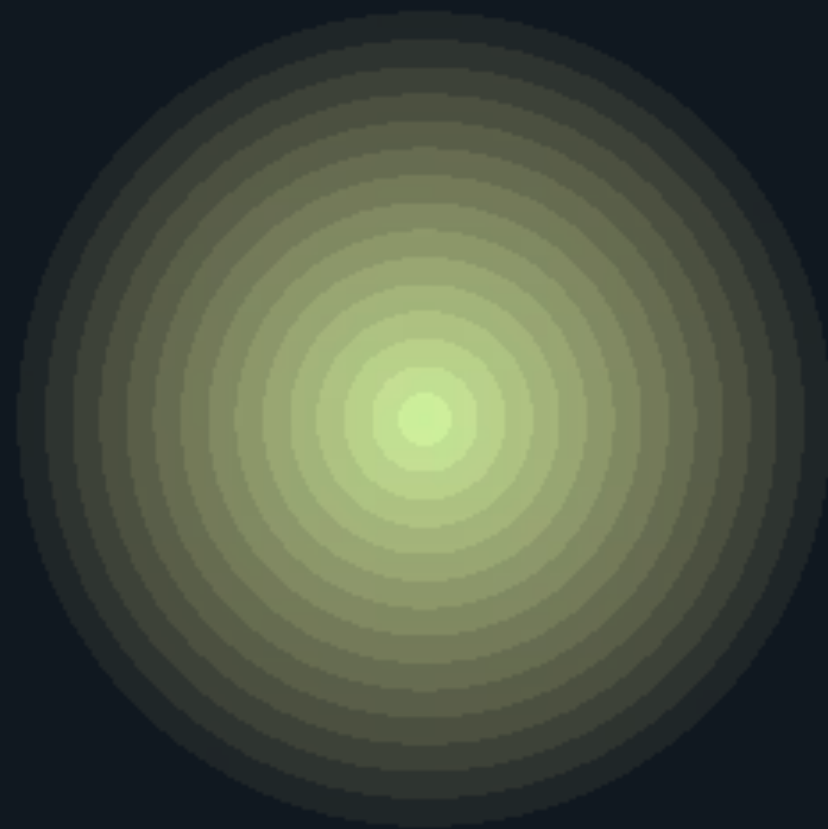
'LIGHT' THE WAY WE SEE THINGS

Electronica

Diepe Dimming

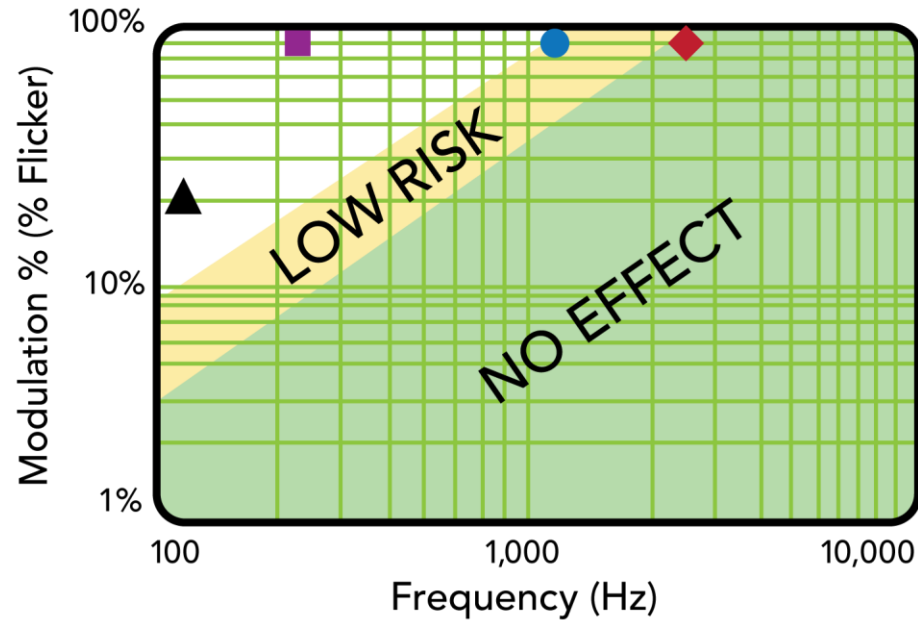
Human Vision is Exponential –
0.1% is required for smooth dim to off.



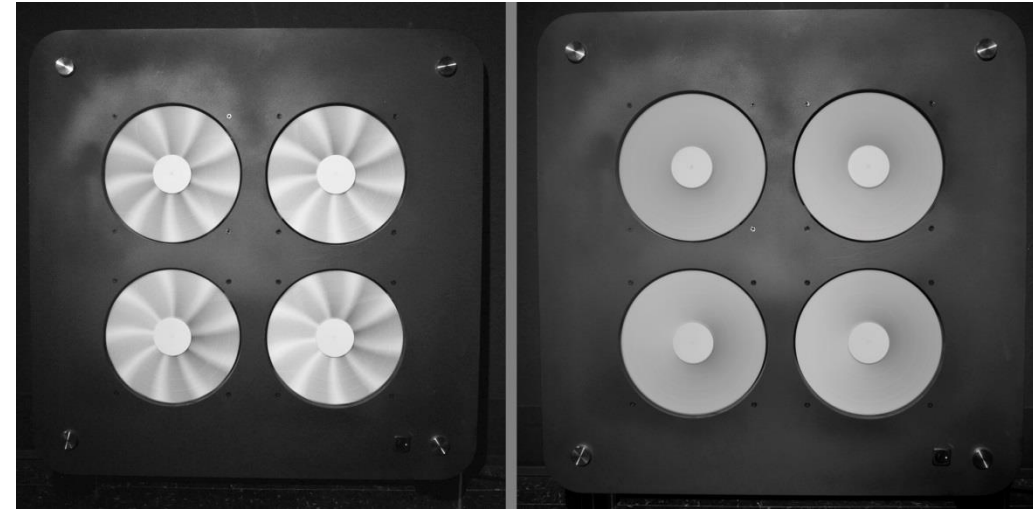


The difference of a good smooth fade
(XIM simulation)

Electronica: Geen gevolgen gezondheid door afwezigheid Flicker



- Recommended Low Risk Minimum (1250Hz)
- ◆ Xicato XIM at 1% Dim Level (2500 Hz)
- "Quality" Dimming Driver at 5% Dim Level
- ▲ "Mainstream" Dimming Driver at 20% Dim Level



Xicato from 100% to 20%: Constant Current
Xicato from 20% to 1.2%: 3000 Hz (No Effect)
Xicato from 1.2% to 0.5%: ≤ 1250 Hz (Low Risk)

Toekomst – Integratie van electronica?

- Ubiquitous support on Smartphones and Tablets
- Native support in iOS, Android, Windows 10, Linux
- Used for iBeacon, Eddystone, Physical Web
- Strong momentum driven by IoT
- Easy integration in embedded devices
- Open and license free standard



BLE communication



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Bedankt

Vragen?



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