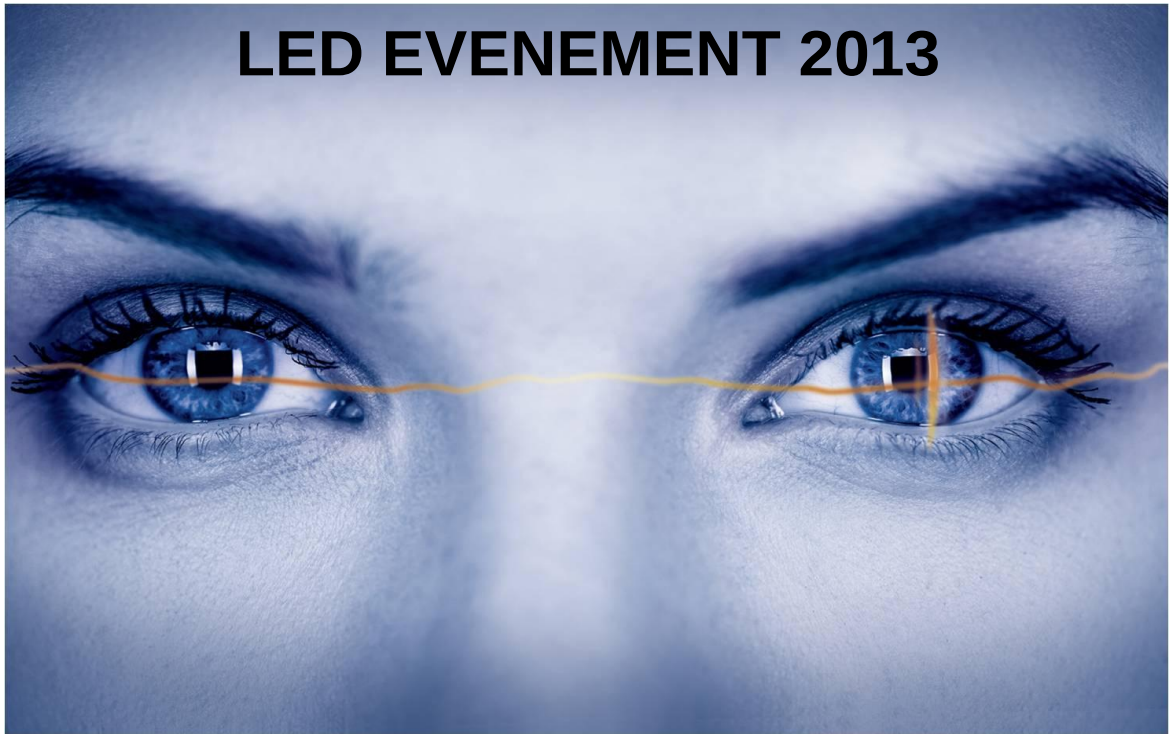

LED Light for you
powered by OSRAM

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AGENDA

LED Light for you
powered by OSRAM

1. Identify the Nature of the Potential Faillure
2. Why do we need to bin LEDs ?
3. Colour binning @ OSRAM Opto Semiconductors
4. Mixing of LEDs – the Brilliant Mix concept
5. Mixing of LEDs – the Mix-To-Match concept
6. Experiment and conclusion

Producing LEDs is like baking a cake ...
... with a quite complicated recipe ...

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USING LEDs:

need to follow essential recipes to get best results

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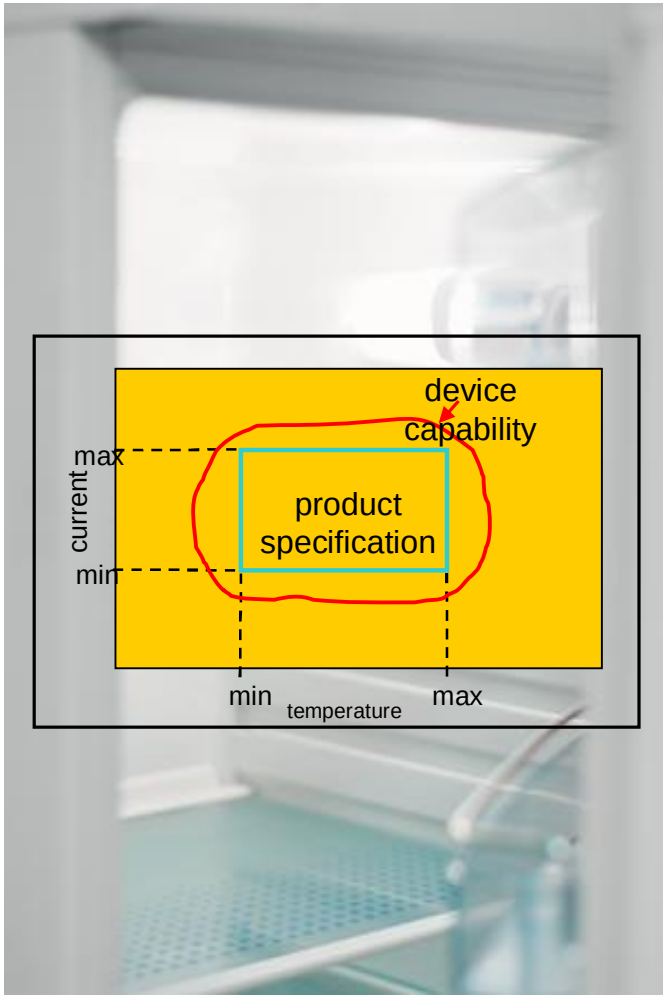
AVOID Undesired Behaviour



Faillure Modes:

Irreversible

Reversible

Producing LEDs is like baking a cake ...
... with a quite complicated recipe ...

USING LEDs:

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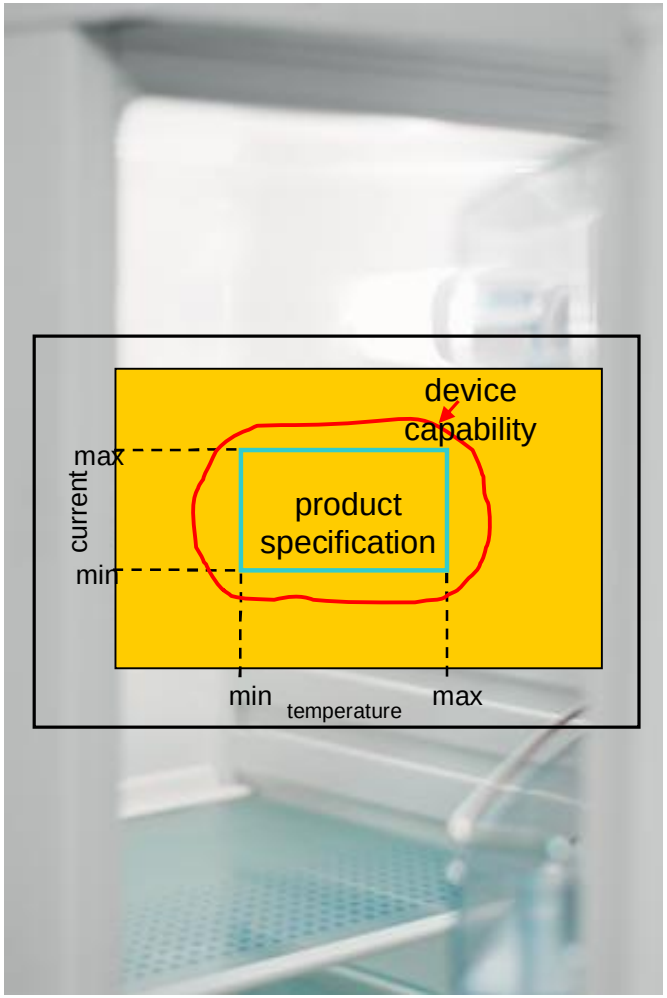
AVOID Undesired Behaviour



Faillure Modes:

Irreversible:

- Aging
- Out of SOA

Corrosion
EOS I > Imax
Accelerated Aging

Reversible:

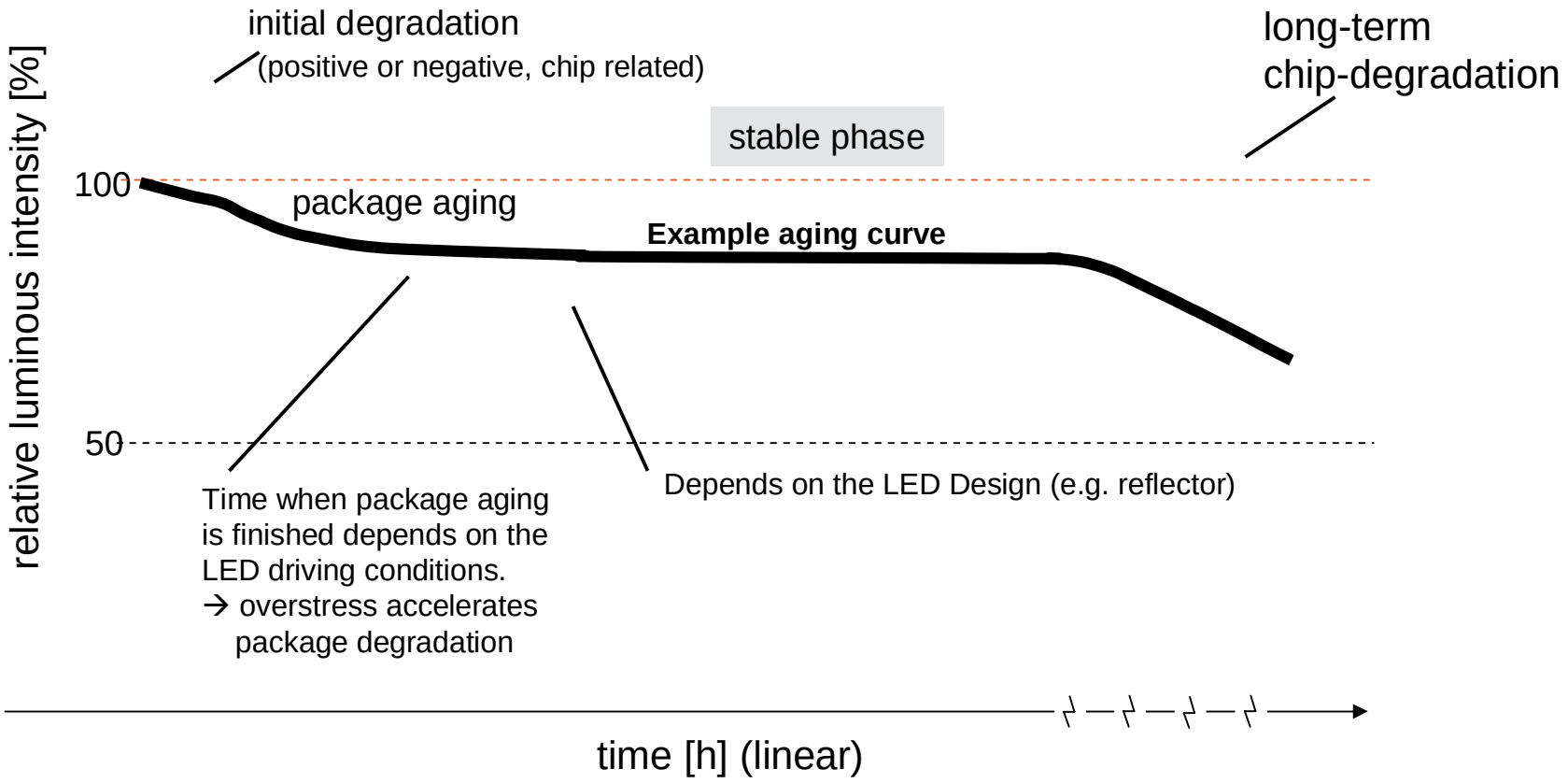
- In SOA

Vf, Colour shift

Colour / Brightness appearance out of spec
Samples => full production

Degradation Mechanisms of LEDs

During the lifetime of an LED we can observe different phases of aging



Degradation Mechanisms of LEDs

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The different phases are influenced by different factors:

Degradation	Influencing Factors
Chip Degradation (Initial and long term)	Temperature Current
Converter degradation	Temperature Current Humidity
Package degradation	Temperature Short wavelength

The production of LEDs is similar to cooking ...

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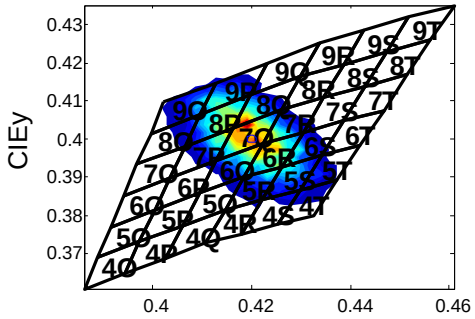
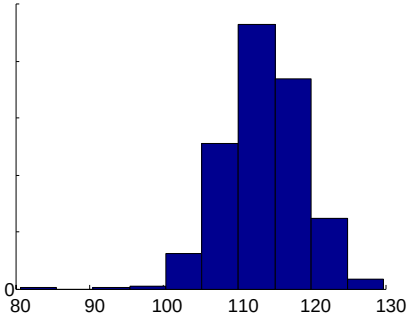
The challenge is to generate only a very small variation in the production.

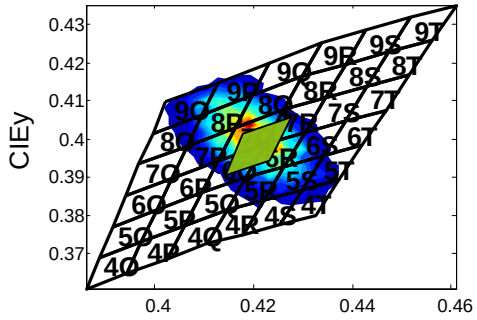
Exemplary production distribution

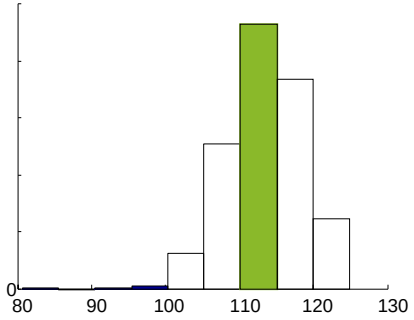




Colour Distribution **Flux Distribution**

Customer's target





Colour Distribution **Flux Distribution**

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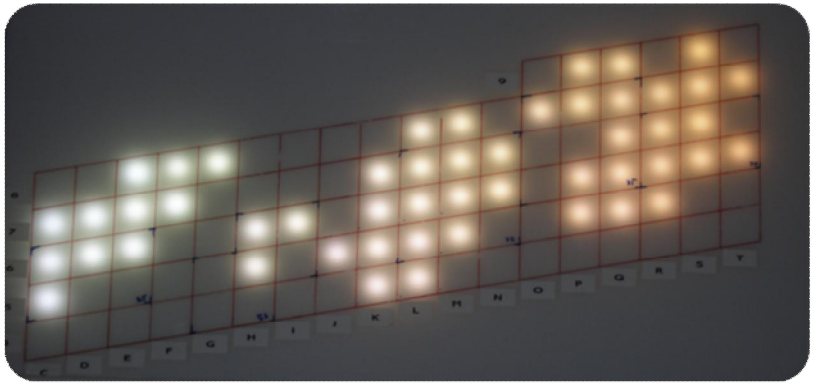
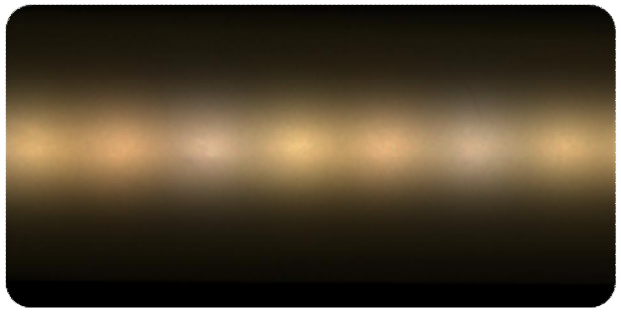
Why do we need a colour binning and a tight selection of colour coordinates for LEDs?

Lamp-to-lamp variation

Applications are very sensitive to small differences in color especially if:

- low (reflected) luminance is involved (like wallwashing)
- large plain surfaces are visible (signage / backlighting)





Background for SSL colour binning: The well known experiment from MacAdam

MacAdam asked the test person at different colour coordinates to vary the colour a little bit until a colour shift is visible.

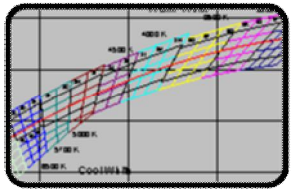
Based on the results he generated a plot of the resulting ellipse parameters g11 g12 g22 and a formula where:

ΔC = 1: standard deviation of colour matching (SDCM)
ΔC = 2: the chromaticity is just noticible different

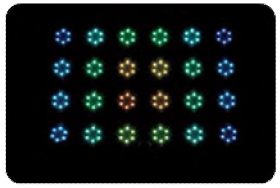
What are the existing solutions in the LED industry to meet tight colour requirements?

LED technology has developed several approaches for a solution of the problem:

- **In-line testing and correction**
  - Additional production steps can reduce color spread



- **Binning and selection**
  - Logistics at LED maker to deliver different bins to different customers
  - Huge stock / No stock / delivery risk / innovation risk



- **Multi-color systems and color steering**
  - RGB or Brilliant Mix steering involves complex electronics and sensors

- **Mixing of LEDs in multi-LED systems**

Option 1: Fine binning
Selection is adaptable to customer requirements

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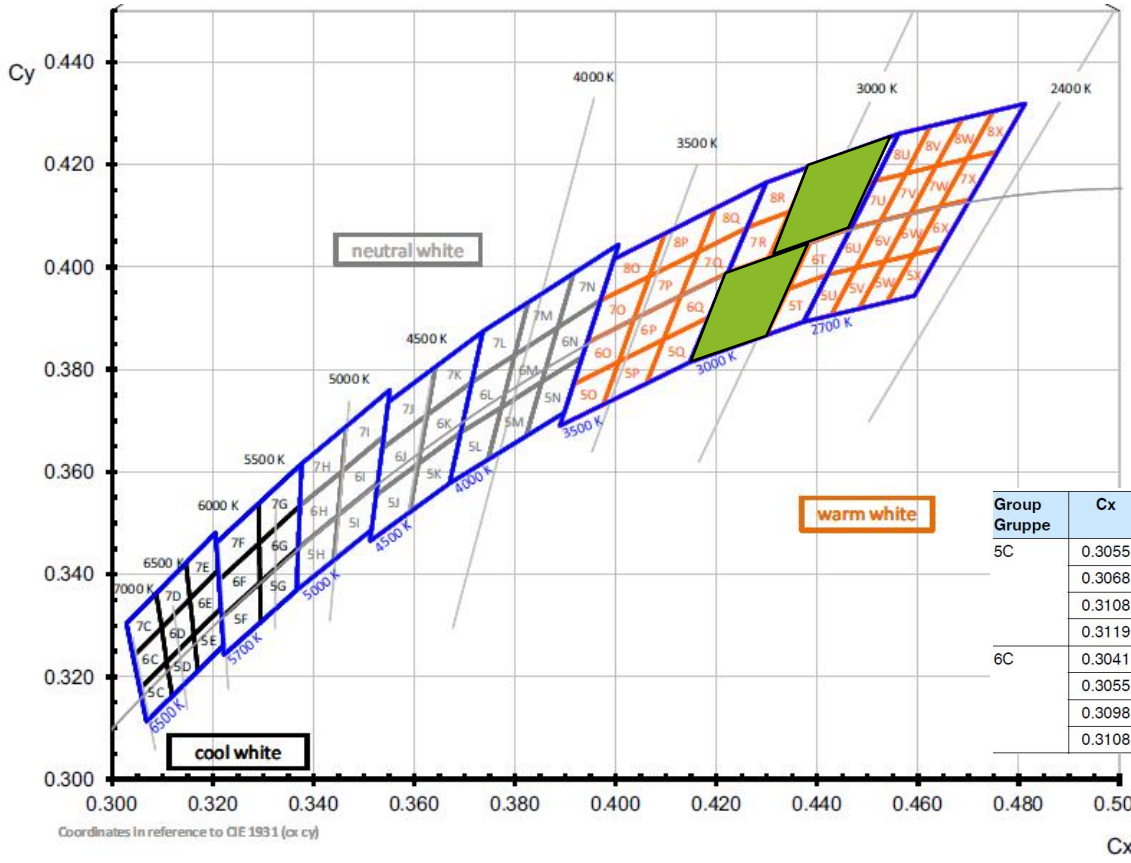
The OSRAM OS fine binning system is using the ANSI colour bins and divides it into smaller bin of a size around 2-3 SDCM.



Group Gruppe	Cx	Cy
5C	0.3055	0.3177
	0.3068	0.3113
	0.3108	0.3229
	0.3119	0.3162
6C	0.3041	0.3240
	0.3055	0.3177
	0.3098	0.3296
	0.3108	0.3229

Group Gruppe	Cx	Cy
7K	0.3625	0.3711
	0.3642	0.3805
	0.3714	0.3775
	0.3736	0.3874
5L	0.3670	0.3578
	0.3692	0.3677
	0.3746	0.3624
	0.3773	0.3726

Group Gruppe	Cx	Cy
5S	0.4222	0.3840
	0.4263	0.3929
	0.4298	0.3867
	0.4342	0.3957
6S	0.4263	0.3929
	0.4305	0.4019
	0.4342	0.3957
	0.4386	0.4048

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Option 2: MacAdam binning
One colour coordinate for all!

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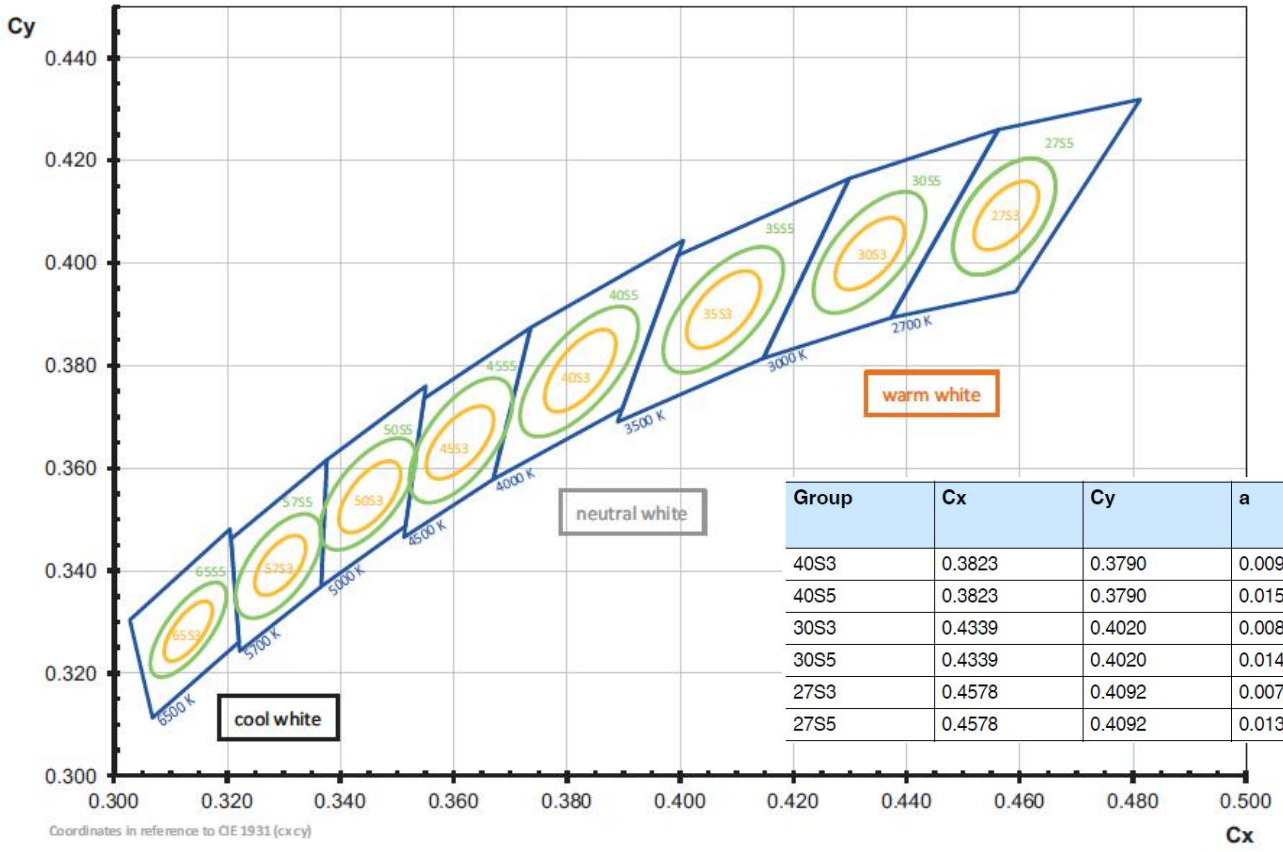
The OSRAM OS Ellipse binning is using the MacAdam ellipses as boundary for the bins.



Group	Cx	Cy	a	b	Θ
40S3	0.3823	0.3790	0.0094	0.0040	53
40S5	0.3823	0.3790	0.0156	0.0067	53
30S3	0.4339	0.4020	0.0085	0.0041	53
30S5	0.4339	0.4020	0.0142	0.0068	53
27S3	0.4578	0.4092	0.0079	0.0041	54
27S5	0.4578	0.4092	0.0132	0.0068	54

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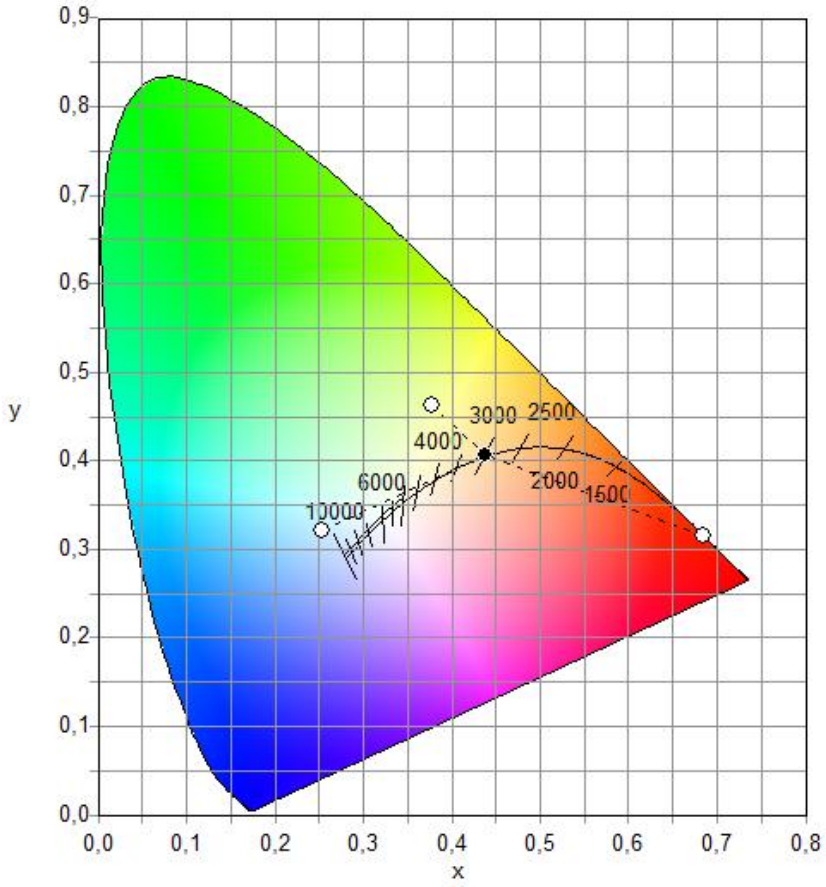
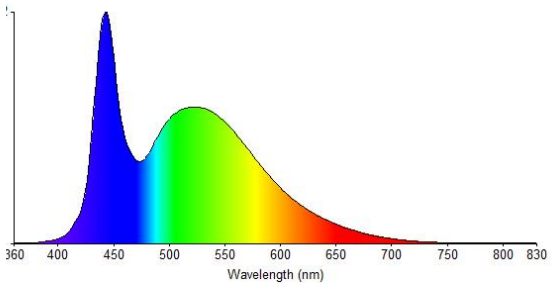
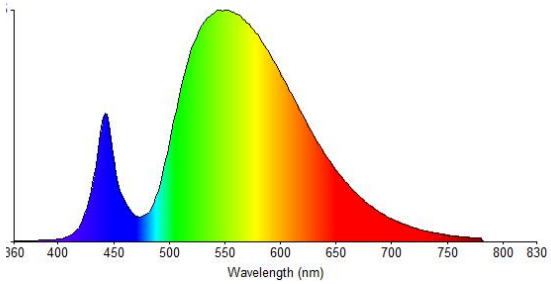
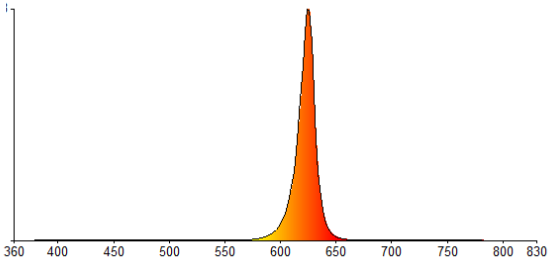
Option 3: Meeting the colour coordinate requirements by mixing 3 “coloured” LEDs



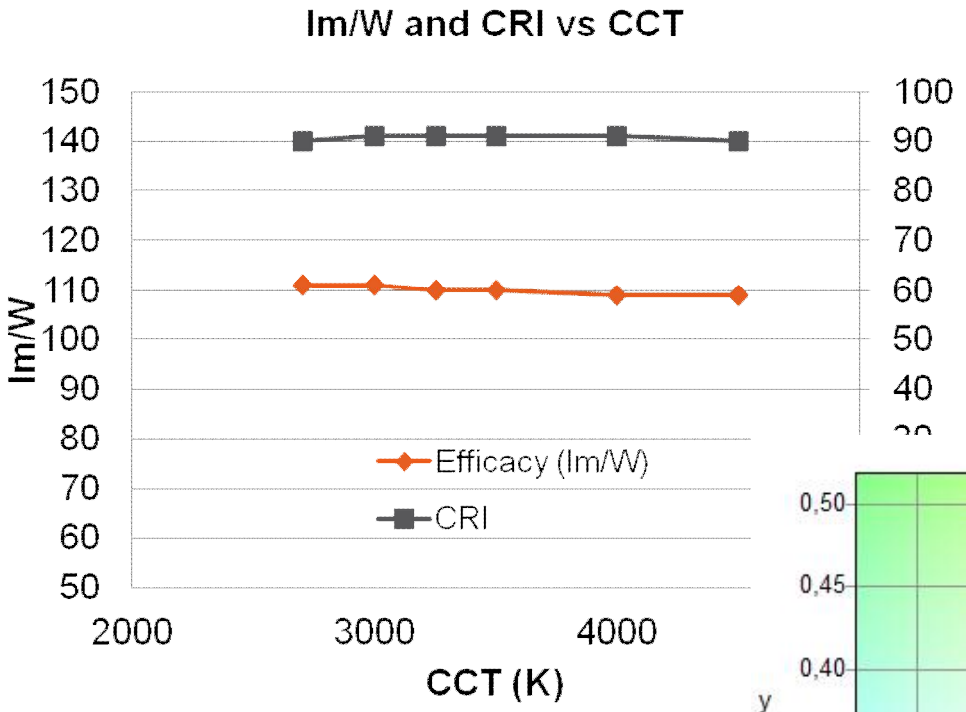


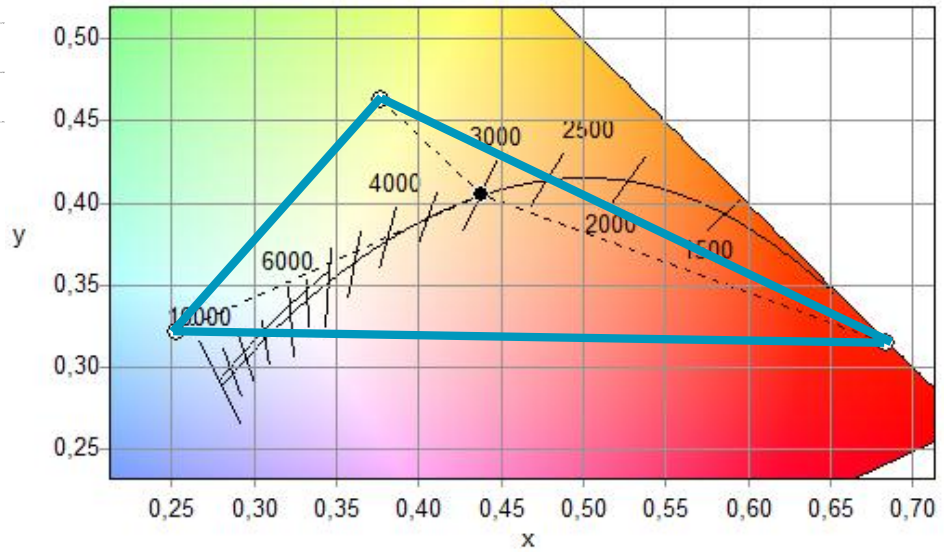




Brilliant Mix: The combination of a greenish white LED, a blue or bluish white LED and a red LED

Benefit of brilliant mix: high efficacy & colour rendering index over a large CCT range

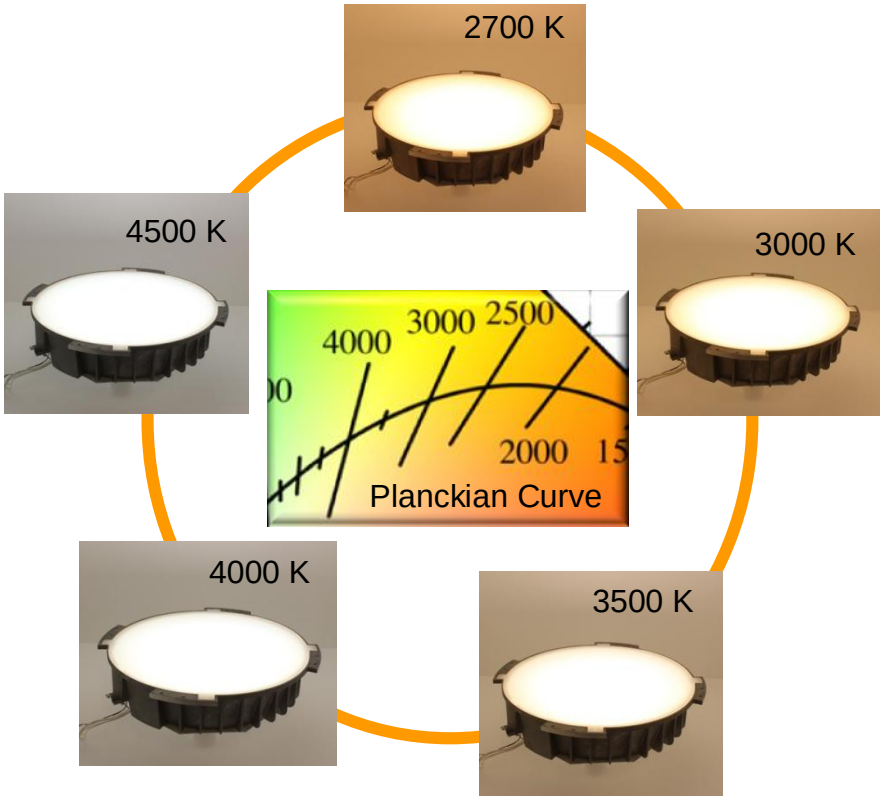




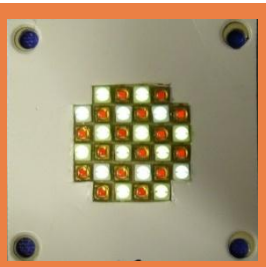
Applications for white tune ability with Brilliant Mix and arctic white

Circadian Rhythm, Simulate Skylight
- Offices
- Schools
- Nursing
- Shift Workers
- Residential, etc

Situative Illumination with the right CCT
- Retail
- Museum
- Theater, etc



Challenges:
- Colour Mixing
- Colour Control



Option 4: The “Mix to Match concept” – mixing different white

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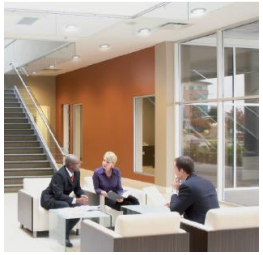
Mix **to** **Match**

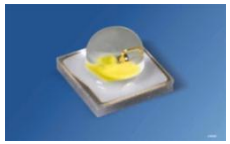
Smart Mixing of Single LEDs

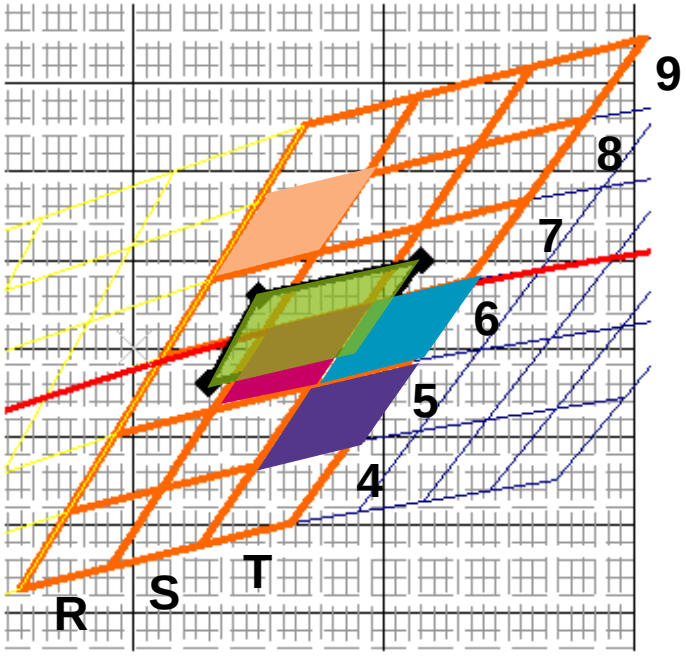
Match the customer‘s requirements



The “Mix to Match concept” – mixing different white LEDs to meet the colour target

Luminaire with OSLON SSL LCW CRDP:
=> Mixing of different bins / e.g. 3000K

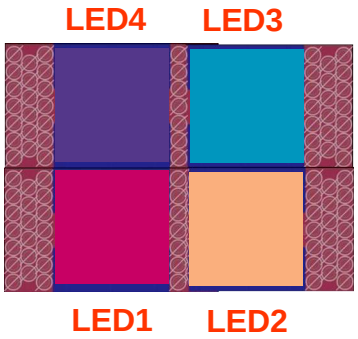




Fixture Colour Specification

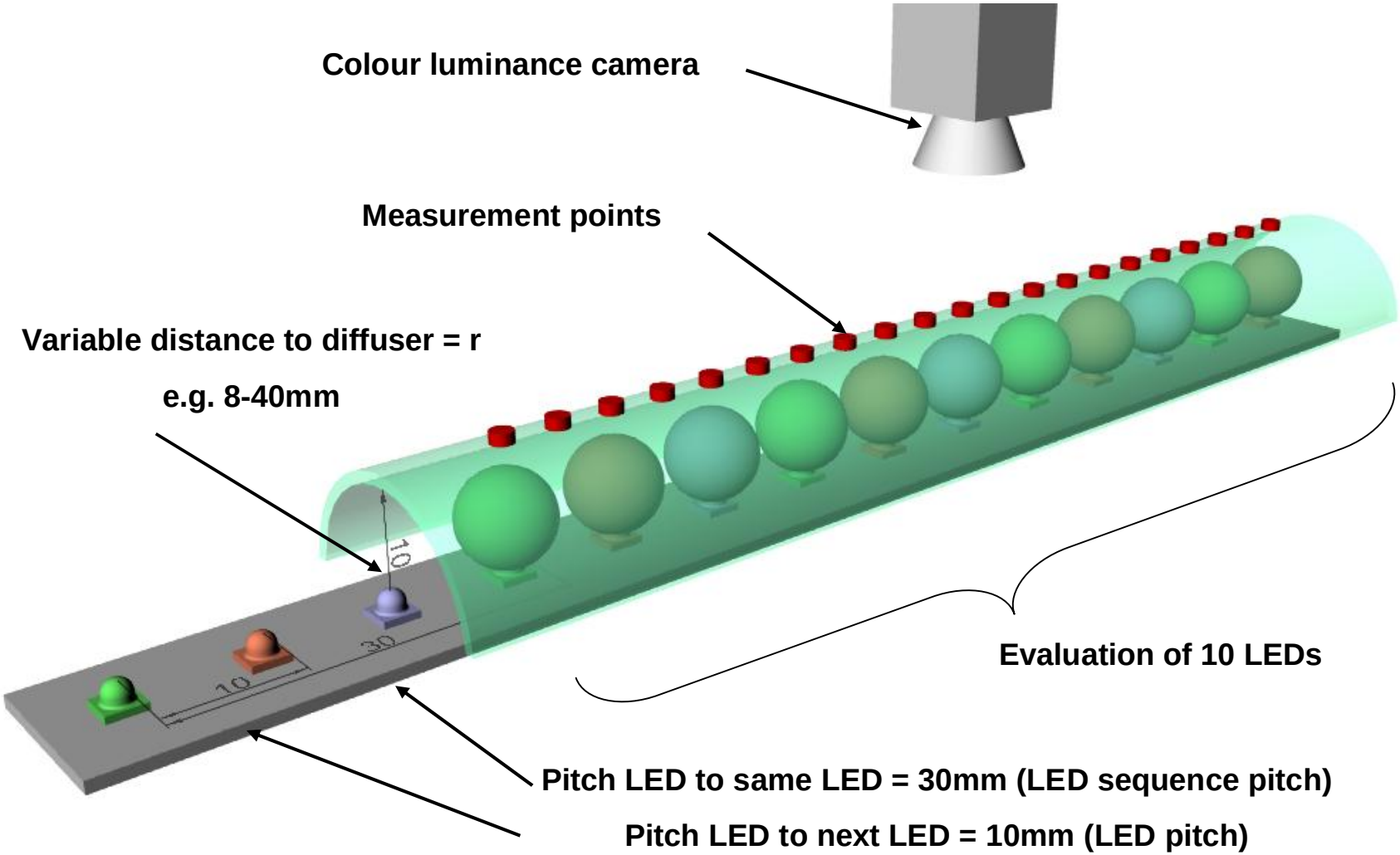
Possible combination:

KS6S-KS8R-KR6T-KR5T



Delivery of right combination within a shipping box to eliminate stock risk

Experiment: Setup of linear luminance and colour homogeneity measurement



Experiment: Visualization of brightness and colour homogeneity

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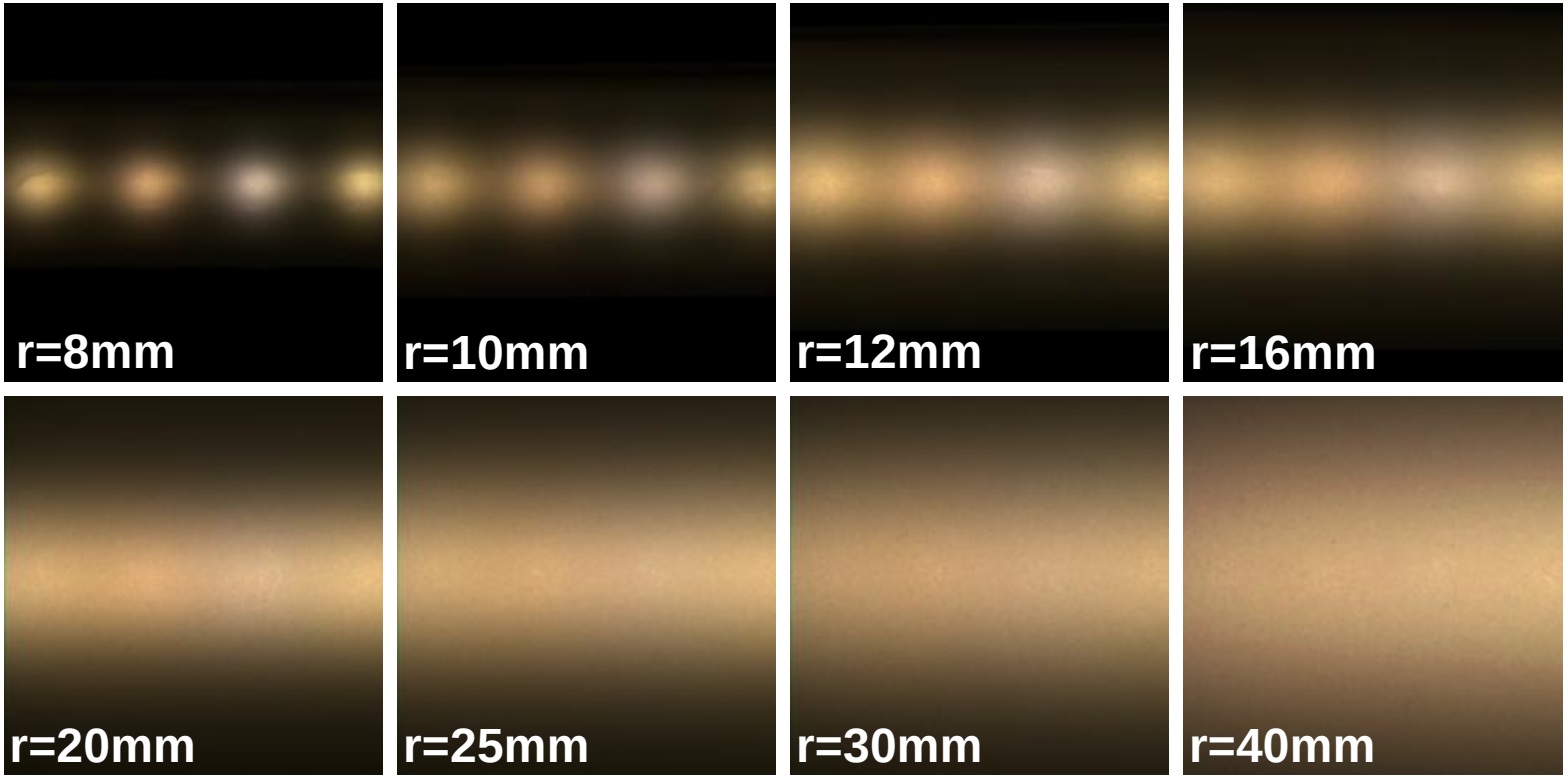
In the beginning, the differences in colour and brightness are clearly visible. With increasing distance between LED and diffuser, homogeneity improves significantly.



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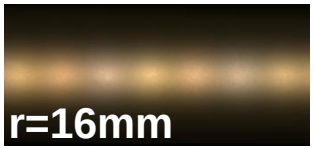

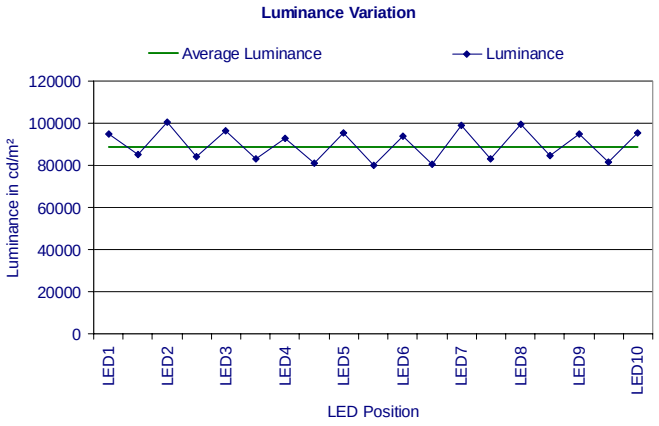

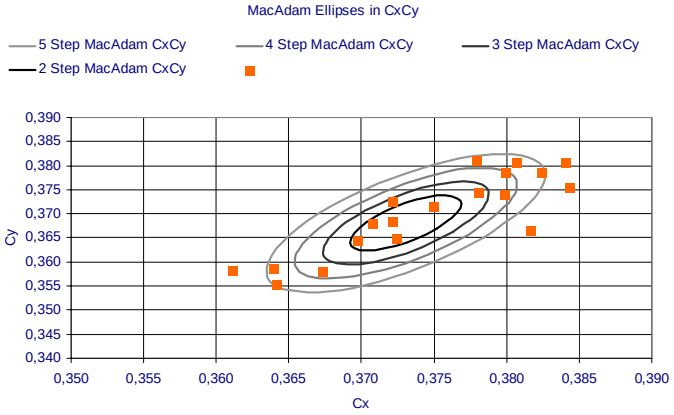

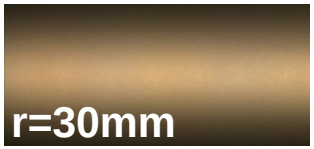

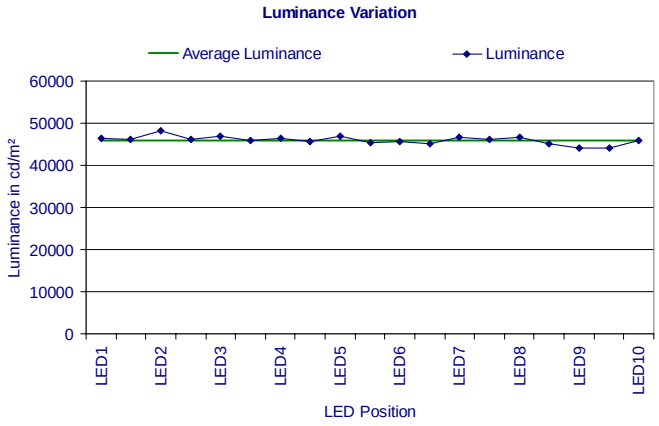

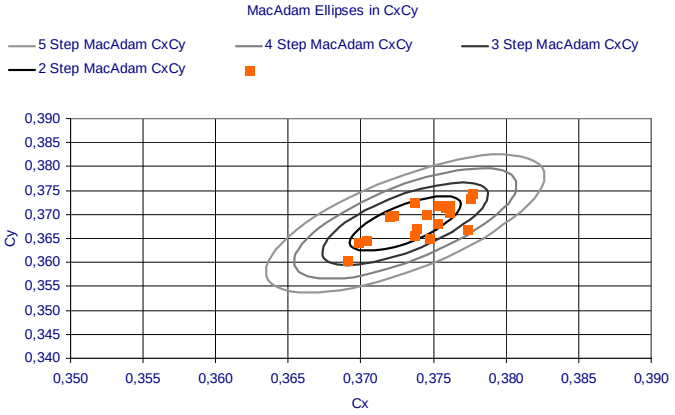

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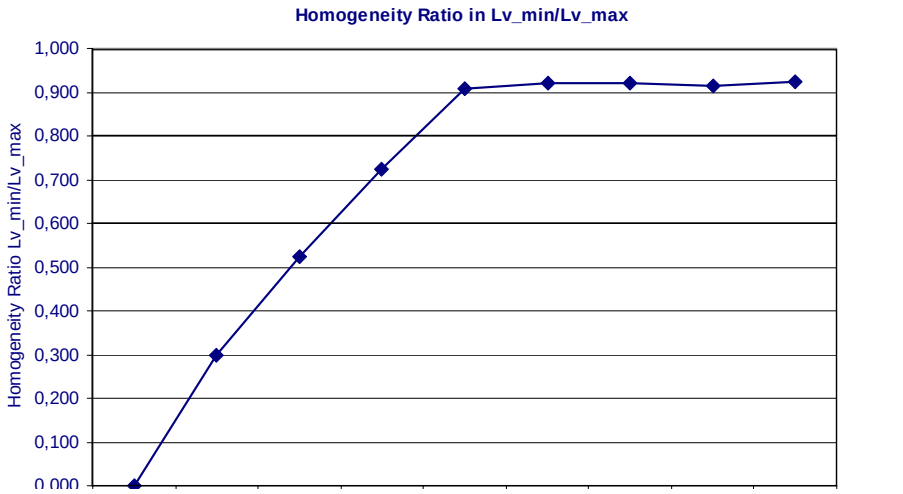

At a distance of approximately **1,5x LED pitch**, the **luminance or illuminance homogeneity** of the system may be sufficient for most applications. The bigger the distance, the better the homogeneity.

At a distance of approximately **1x LED Sequence pitch**, the **white colour homogeneity** of the system may be sufficient for most applications. The bigger the distance, the better the homogeneity.

SUMMARY

- Understand the key influencing factors and nature of potential Faillures
  - Identify and avoid reversible Faillures
  - Minimise influencing factors for irreversible Faillures
- Tight colour requirements are typical for the SSL market
- More and more applications become very sensitive to different colours
- The tight colour requirements can be fulfilled by:
  - OSRAM OS Fine Binning
  - OSRAM OS MacAdam Binning
  - Brilliant Mix – Mixture of 3 “coloured” LEDs
  - Mix-to-Match – Mixture of white LEDs
- In order to achieve a homogeneous appearance in luminance and colour, a distance to the diffuser of 1-1.5 times the LED pitch is necessary.

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Many Thanks From:

RUTRONIK
ELECTRONICS WORLDWIDE

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