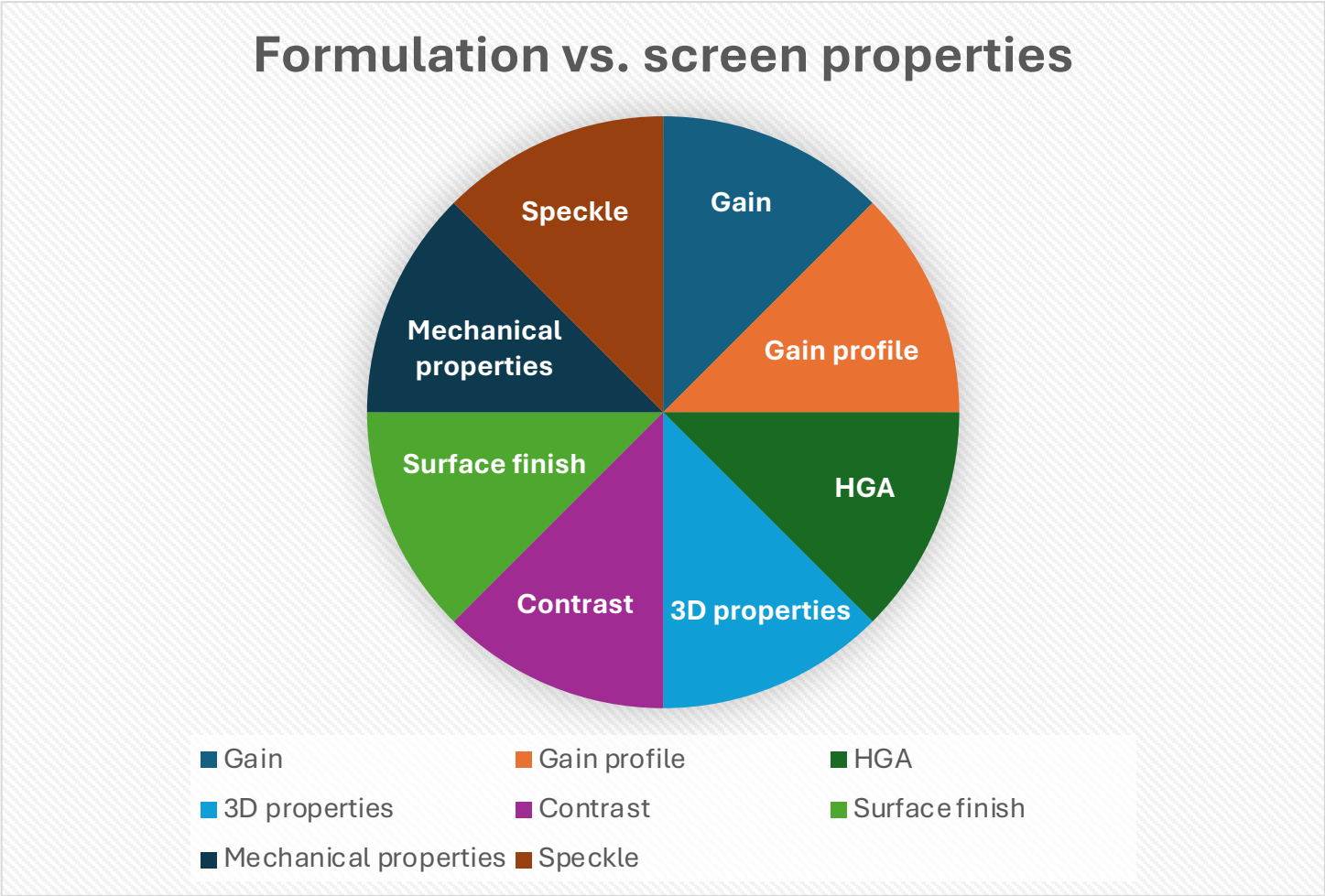# Development and Metrology of Cinema Screens for Laser Illuminated Projectors

Matt Jahans

What is laser speckle in cinema projection?

- Laser speckle is an interference pattern which can affect all laser projectors, and to a different degree. It is more pronounced on RGB projectors. This can cause a subjectively 'disruptive' viewing experience for cinema goers.

- Projector manufacturers mitigate these effects in different ways and to different degrees. This can be done within the projector and sometimes additionally by vibrating the screen.

- Laser speckle is also influenced by the type of screen surface the image is projected on.

- Laser speckle is visually very subjective with certain factors further affecting the visual impact that a movie goer will experience

  - Distance from the screen surface
  - Brightness levels
  - Movie content type and scene
  - Each individual eye and prescription eyewear

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Effect on screens and material selection

Formulation vs. screen properties

Pie chart segments: Speckle, Gain, Gain profile, HGA, 3D properties, Contrast, Surface finish, Mechanical properties

Legend:
- Gain
- Gain profile
- HGA
- 3D properties
- Contrast
- Surface finish
- Mechanical properties
- Speckle

- Customer requirements / expectations must be disclosed and understood for adequate material selection.

- Changing one screen property has effects on other screen properties, it is a balance.

- The formulation process is therefore complex.

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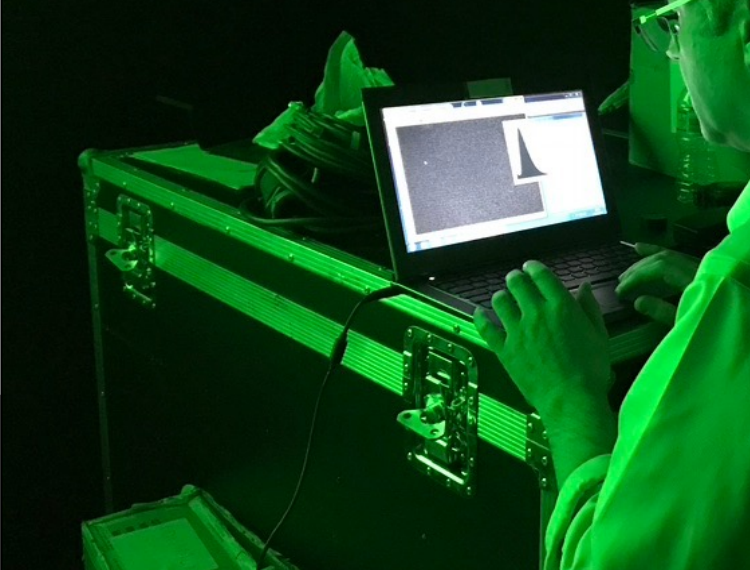
The formulation development process

The complex process involves testing a multitude of parameters over 1000s of samples.

- Coating material selection
- Size of coating particles
- Size of particle distribution

Successful test formulations are then validated in four ways upsizing from A4 samples to full cinema screens.
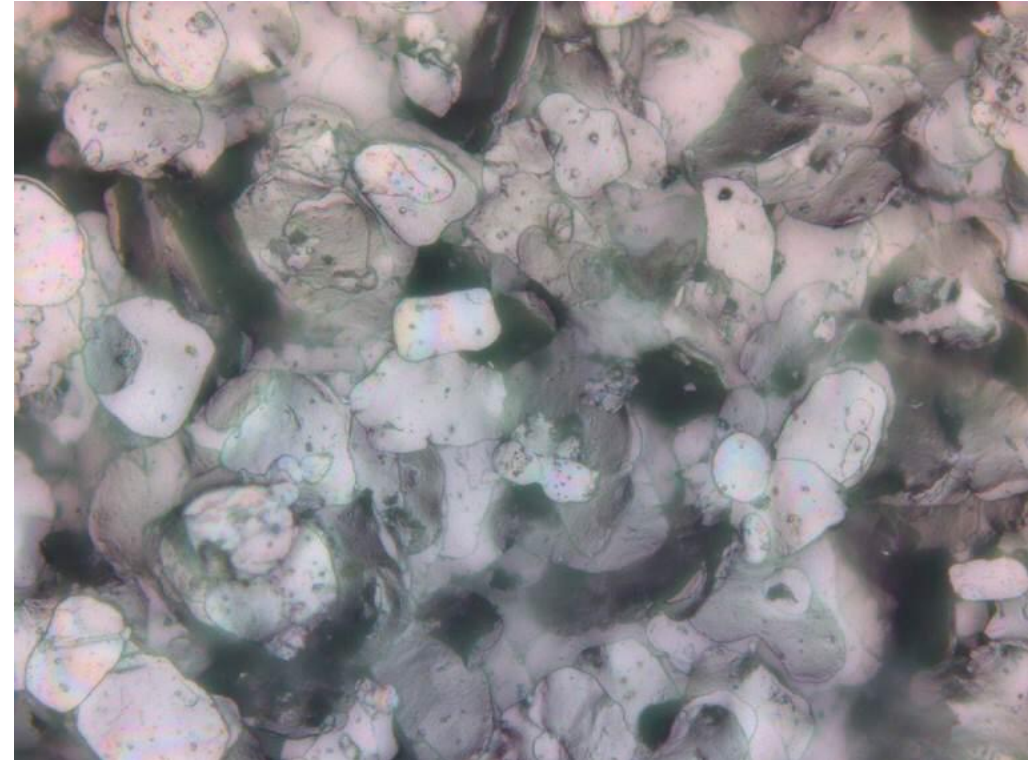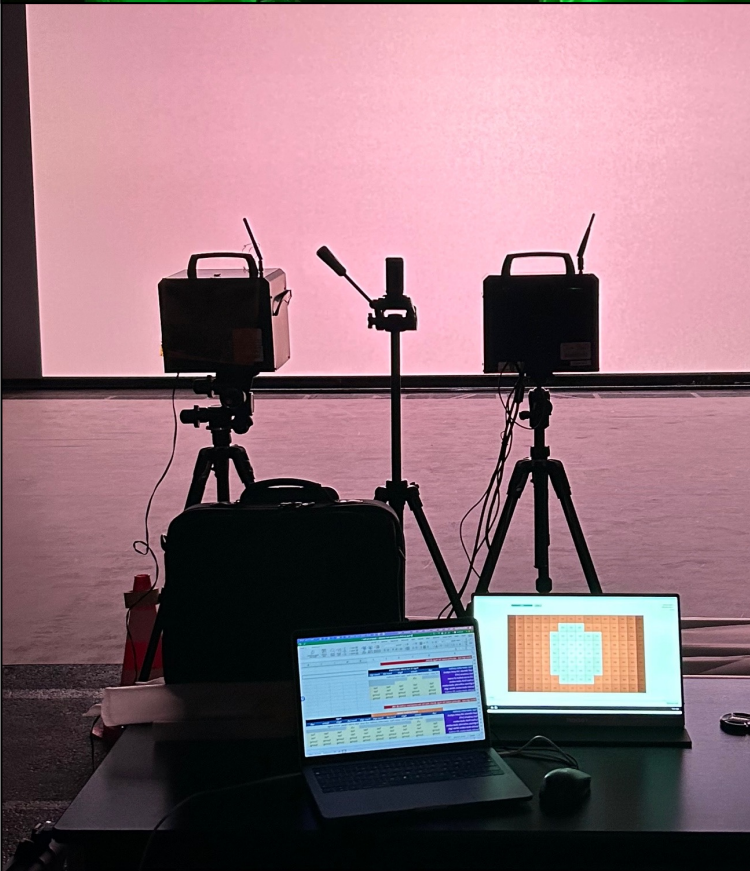
We've developed a methodology, to provide guidance by combining relative laboratory and in-cinema data.

Interpreting that quantitative and qualitative data allows us to best understand screen surface and projection equipment combinations to guide our customers.

1. Laboratory controlled Laser Speckle Contrast Ratio (LSCR) sample measurement (A4)
2. Laboratory subjective laser speckle visual impact (A4)
3. Internal movie content subjective evaluation (5-12m wide)
4. External / customer movie content subjective evaluation (12-20m wide)

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LSCR tells part of the story

LSCR camera measurements determine a relative ratio of laser speckle vs. a screen sample during a fixed conditions trial. Useful for benchmarking a particular projector laser speckle output against screen types in a controlled environment.

However, it is difficult to correlate LSCR to how the human eye might perceive laser speckle during an actual movie

- LSCR camera measurements **cannot** consider the following cinema auditoria movie factors:
    - Viewer distance from the screen
    - Content type and actual movie scene variations e.g. sky, desert
    - Foot Lambert brightness levels
    - Hot spot and position – theatre geometry

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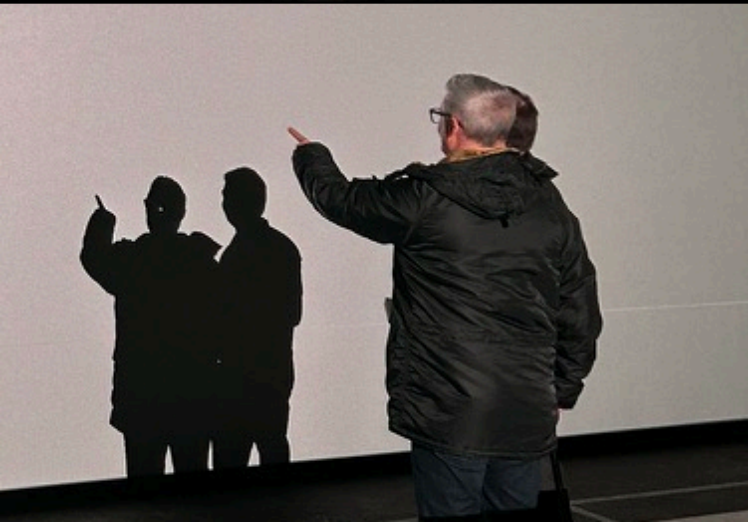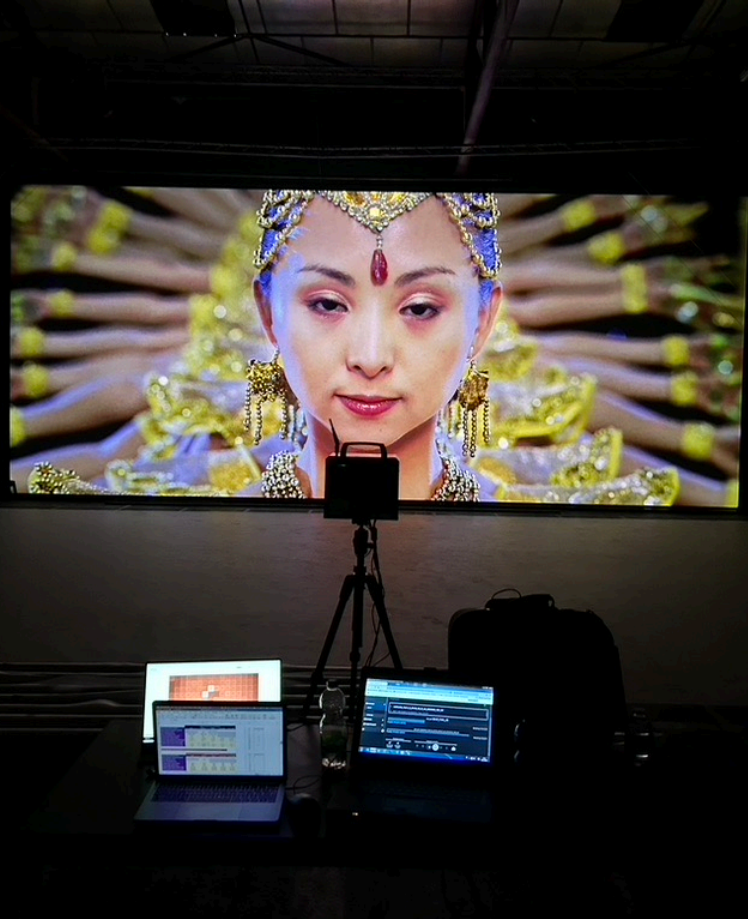
Subjective laser speckle visual impact evaluations use the human eye, not a camera

It is important to understand how the human eye, subjective though that may be, is impacted by laser speckle during movie content and white light as a reference.

A movie goer experiences laser speckle in this way across a large screen not a small sample.

- In-cinema, subjective laser speckle visual impact to movie content & white light evaluation, considers:
    - Speckle Depth Perception (SDP), distance from screen
    - Movie content type and scene variations
    - Foot Lambert brightness levels
    - Hot spot, angles and position – theatre geometry
    - Results relative to equipment, geometry and observers
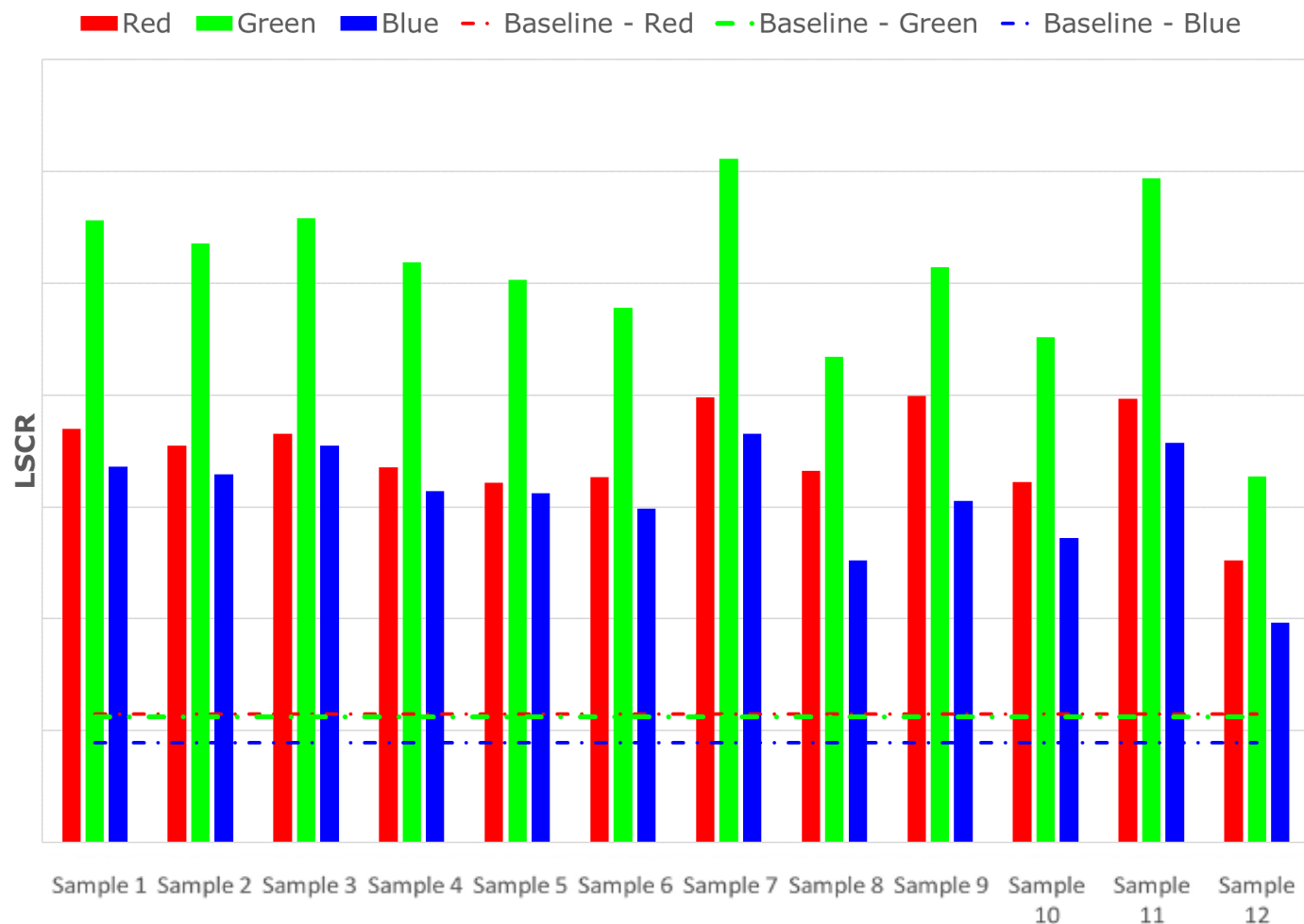
Formulation validation, step 1

A4 samples validated in our photonics laboratory

- Measuring LSCR
- Samples at 1.3 metres from the speckle maker
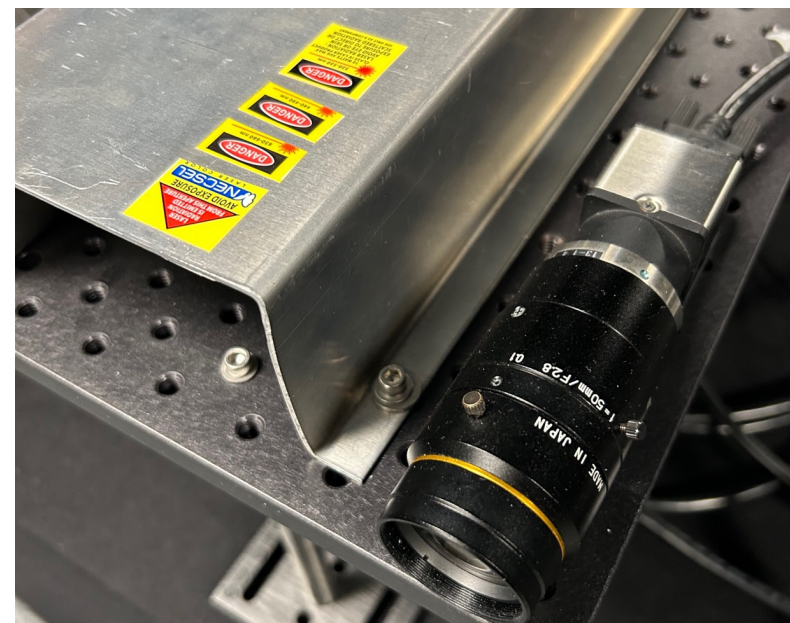- Red, Green, Blue and White laser light
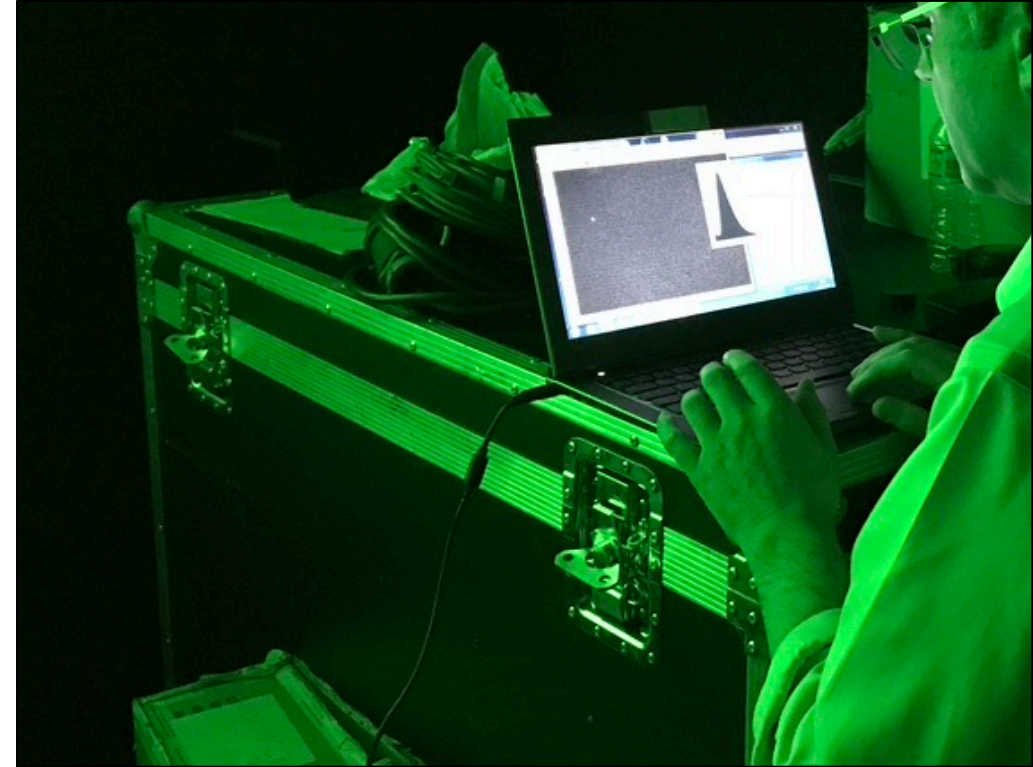- 14fL
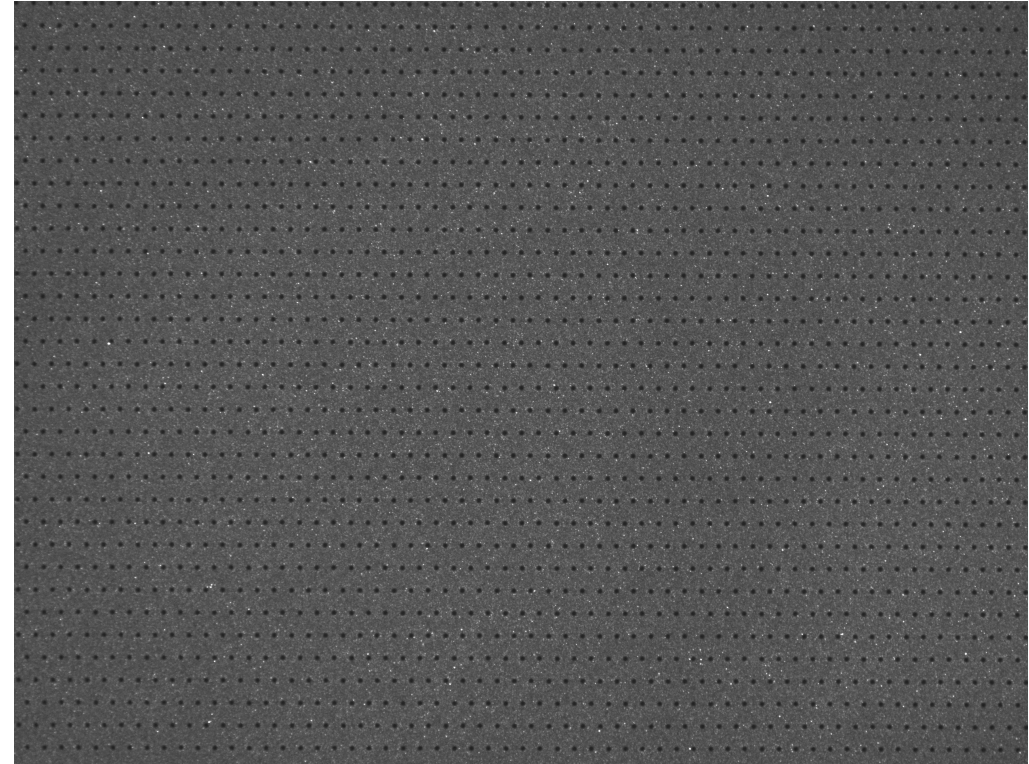
LSCR – For 12 different formulations

- A given laser projector or system
- Relative RGB LSCR camera measurements of small screen surface samples

Formulation validation, step 2

A4 samples validated in our photonics laboratory

- Visual evaluation of laser speckle
- Samples at 1.3 metres from the speckle maker
- Red, Green, Blue and White laser light

Formulation validation, step 3

5-12m cinema screens validated under projection in our R&D theatres

- Visual evaluation with movie content
- Cinema conditions at varied geometries
- Multiple projection types, RGB laser, RB Laser phosphor, Laser phosphor
- Movie content and Red, Green, Blue and White laser light

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Formulation validation, step 4

12-20m cinema screens validated under projection in our partner theatres

- Visual evaluation with movie content
- Actual cinema auditoria covering varied geometries
- Multiple projection types, RGB laser, RB Laser phosphor, Laser phosphor
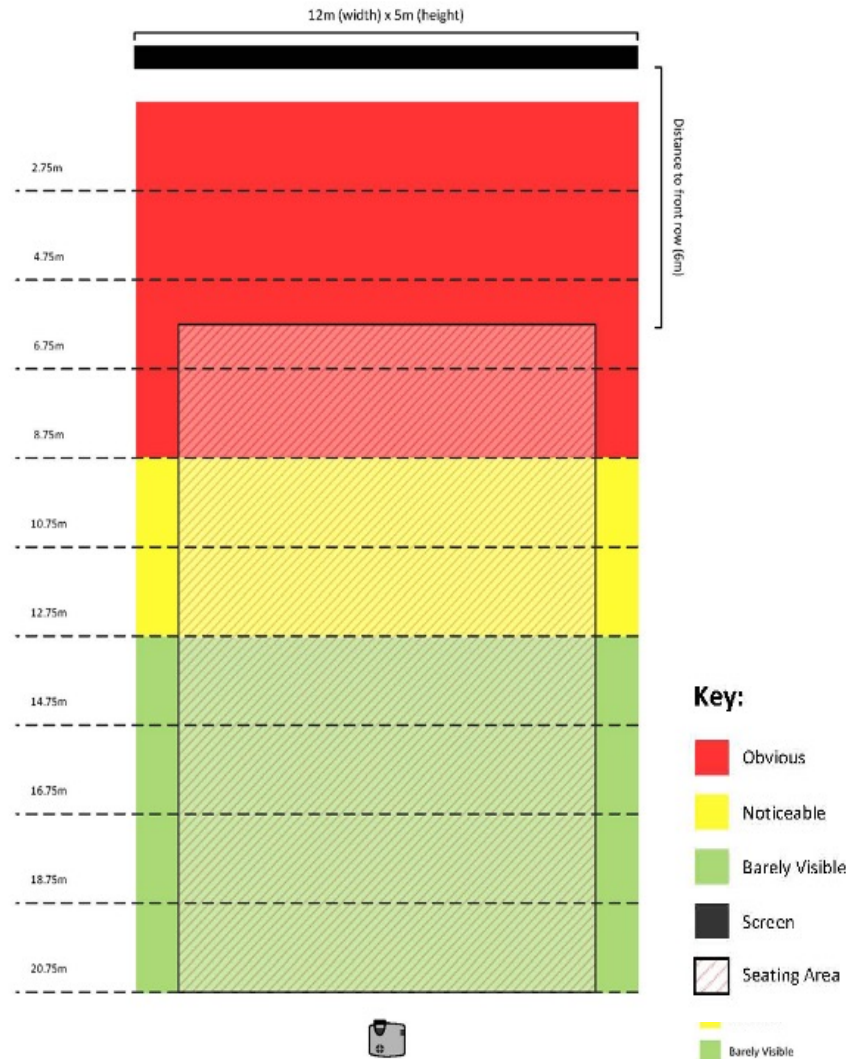- Movie content and Red, Green, Blue and White laser light

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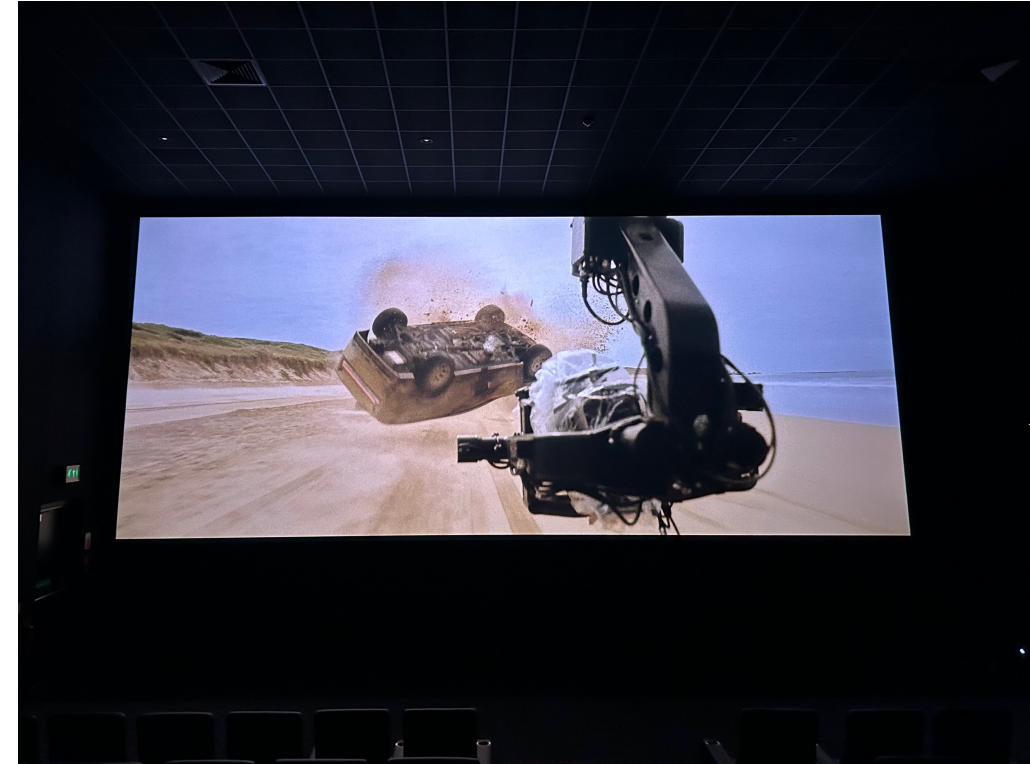
Formulation Feedback gathered during trials

Laser speckle, distance from screen perception
Under movie content

M	Speckle score
2	3
4	
6	
8	2
10	1
12	
14	
16	
18	
20	

LEGEND: Speckle perception score, white test pattern

0	Not visible, even if hunted for
1	Barely visible
2	Noticeable
3	Obvious and distracting

12m (width) x 5m (height)

Distance to front row (6m)

2.75m
4.75m
6.75m
8.75m
10.75m
12.75m
14.75m
16.75m
18.75m
20.75m

Key:
- Obvious
- Noticeable
- Barely Visible
- Screen
- Seating Area
- Barely Visible
- Screen

SDP illustration from a controlled trial
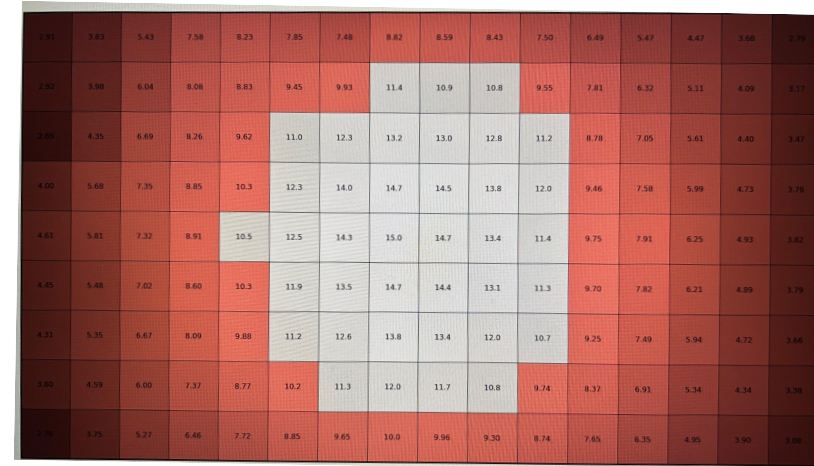
Speckle perception walk back from screen test
Until x meters distance, under white light

Test screen	Obvious speckle	Noticeable speckle	Barely visible speckle
Sample 1	up to 8.75	8.75 to 12.75	12.75+
Sample 2	up to 8.75	8.75 to 18.75	18.75+
Sample 3	up to 10.75	10.75 to 14.75	14.75+
Sample 4	up to 10.75	10.75 to 18.75	18.75+
Sample 5	up to 10.75	10.75 to 14.75	14.75+
Sample 6	None	up to 8.75	8.75+
Sample 7	up to 10.75	10.75 to 16.75	16.75+
Sample 8	None	up to 8.75	8.75+
Sample 9	up to 10.75	10.75 to 18.75	18.75+
	Note that 20.75m was the maximum, end of the test area		

Summary process table

	Formulation validation stages			
	1) LSCR - Lab	2) Visual - Lab	3) Visual - R&D	4) Visual - Cinema
Formulation test units	100s	100s	10+	1 to 2
Sample sizes	A4	A4	5 - 12m	12-20m
Gain, ER, HGA etc.	Yes	Yes	Yes	Yes
Laser light	R,G,B & W	R,G,B & W	R,G,B & W	R,G,B & W + movie content
Movie content	No	No	Mixed scene movie content	Mixed scene movie content
Uniformity fL / hotspot	No	No	Yes	Yes
Mechanical properties	No	No	Yes	Yes
Fire testing	No	No	Yes	Yes

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HSG-Labs Ultimate144 point brightness uniformity vs. 5 or 9 point SMPTE / DCI measurements
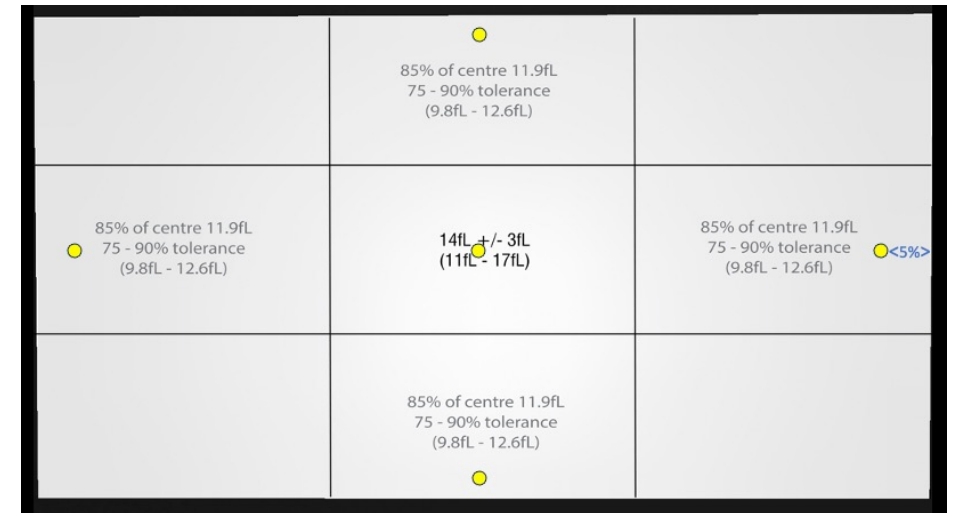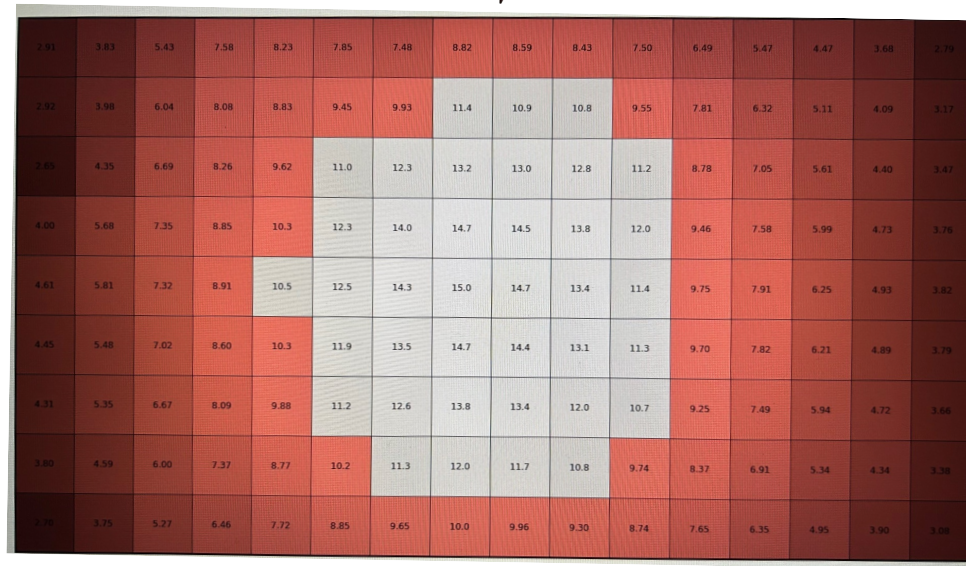
144 points provides a more useful understanding of screen brightness uniformity during product development.

Limitations of laser speckle validation

- LSCR is relative and difficult to correlate to the movie experience

- Movie content subjective visual evaluations are relative to all conditions, and..
  - Half and half screen trials are artificial, potential fL difference due to gain
  - Moving to "one at time" screen evaluation with screen changes
  - Moving to "Coming to screen" instead of walking "from screen"

- Limits of end user understanding
  - Speckle evaluations are relative!
  - Projector technology expectations
  - Screen gain?
  - fL and hotspots?
  - Theatre geometry?

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- The Percepta method combines the relative learnings of lab based *LSCR* and the *subjective laser speckle visual impact to movie content evaluation, a*cquired working with our projector manufacturer partners and technical customers since the early days of laser projection.

- The Percepta method allows us to best understand how screen surfaces behave with the laser speckle produced by different types of laser projector.

- We know that all cinemas are unique, so the Percepta method applies the learnings of the laser speckle visual impact factors captured during SDP. These impact factors such as distance, brightness, theatre geometry, movie content etc. are unique to each cinema auditorium.

Hugo [SR]

- Outstanding 2D and 3D performance
- Ideal for RGB laser illuminated projectors
- Speckle reduction technology
- A visibly whiter appearance, similar to white gain screens on axis
- Improved contrast

Engineered for laser projection

Embedded speckle reduction technology

Laser speckle, most visible with RGB projectors (but also present, although less visible with other projection technologies) is a significant concern for exhibitors looking to leverage laser projection. Hugo has been engineered to significantly reduce visible speckle by up to 30% compared to traditional high gain silver and white screen surfaces.

This dramatic reduction allows exhibitors to deploy higher gain surfaces alongside RGB projectors with greater assurance that laser speckle will not interfere with the viewing experience for the majority of movie-goers in the auditorium.

The result of more than five years of research and development alongside projector manufacturers, leading educational institutes, exhibition and the Hollywood community, Hugo [SR] is the brand new fifth generation screen technology from Harkness designed to support laser projection.

An optically whiter polarised screen, Hugo creates compelling 2D and deep 3D images with additional contrast and speckle reduction, enabling exhibitors to utilise the enhanced capabilities of laser projection to improve presentation quality for movie-goers everywhere.
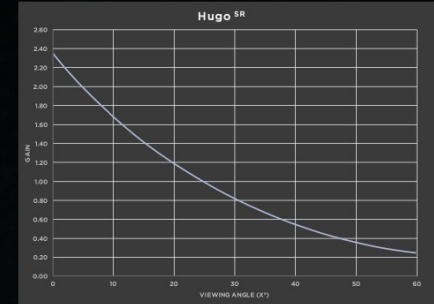
Technical Specifications

Hugo [SR]

Gain: 2.2+
HGA: 22°
ER: 140:1
Max. Size: 44.19 x 18.28m
Packaging: Rolled
Perforation: Digital or Mini-Perf

Gain Curve

Whiter Appearance On Axis

Perlux HiWhite 180   Hugo [SR]
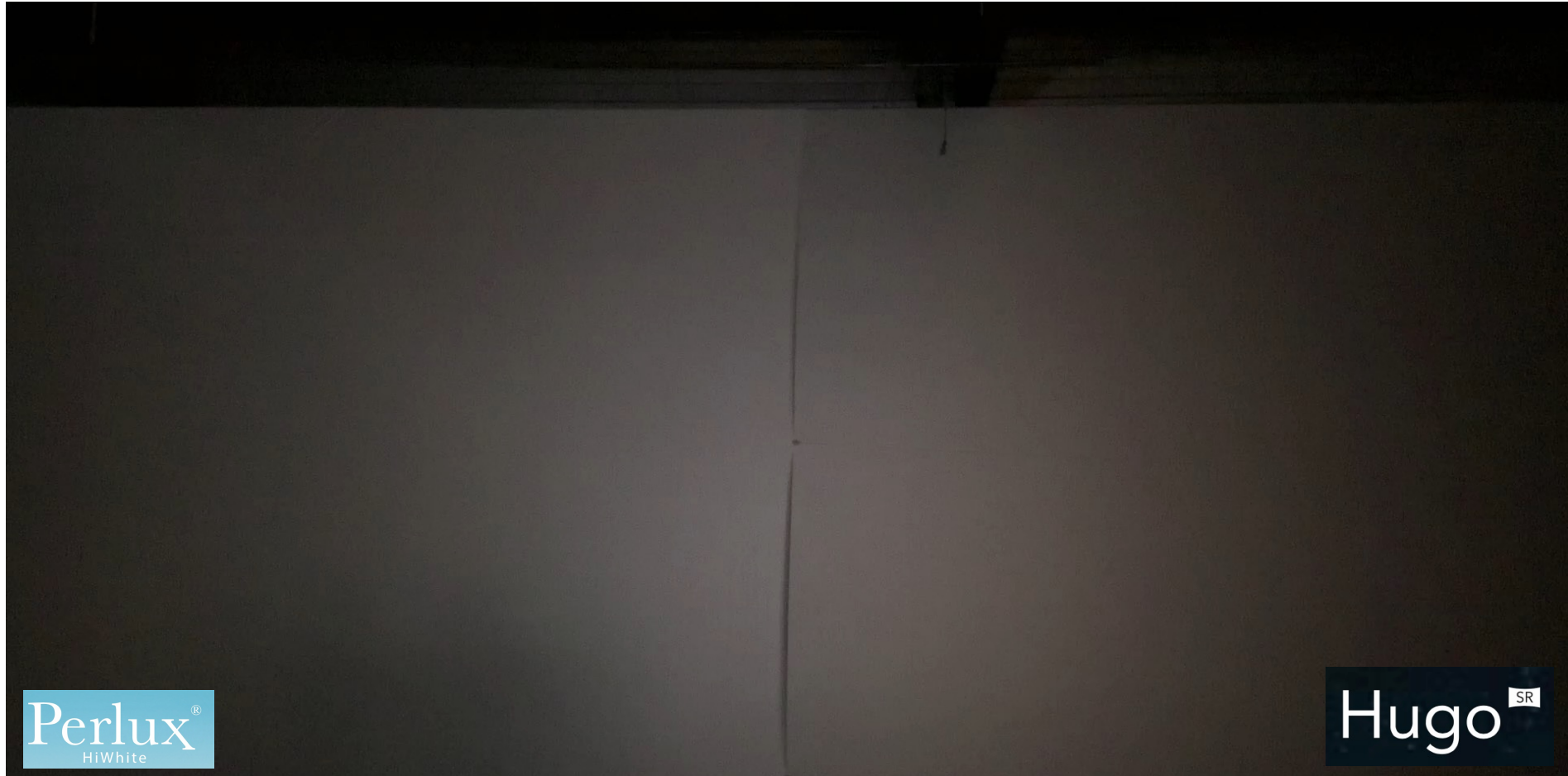
Improved Contrast

Perlux HiWhite 180   Hugo [SR]

Hugo SR vs Perlux HiWhite 1.8 – visual content evaluation

Hugo SR – industry feedback

- US studio trials main, looking at their content on an RGB projector.
  - Reduced speckle
  - Contrast improvements

- Key customer cinema trials
  - RGB and RB laser phosphor projectors
  - Reduced softer speckle and non-discernible speckle respectively
  - The screen light distribution appears favourably like a lower gain than 2.2

- Shown to more than 250 people at trade shows – RGB projector
  - In deliberately unfavourable conditions with noticeable speckle
  - Compared against existing generation silver screen
  - Softer speckle in the hotspot
  - Positive contrast differences

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95 YEARS OF INNOVATION | **Percepta**

Speckle Percepta Method