

# DOE R&D Workshop

## NEW LIGHTING CONCEPTS

Steve Paolini – 4feb16



# Outline

- Introduction
- Products
- Why go beyond RGB?
- What's next
- Summary



- Founded 2007 – Silicon Valley, CA
- Purpose – create any light for human consumption
  - Products/services to create/playback light
- Privately owned
- Current products:
  - Light Replicator (16 color light player)
  - Penta (5 color light player)
  - Light Recorder (spectrometer)
  - LumenScripts (content)
    - Recordings, created, composed digital data

# Target Applications for Researchers

- Consumer/Home – daylight experience indoors, better circadian cycle
- Retail – make products more appealing
- Healthcare – faster healing, wake/sleep
- Workplace – increase productivity
- Sensors – time varying spectrum
- Movie, TV – outdoor scene or filter replication

# Two ways of experiencing light

## Illumination

- Look at people, objects
- Less saturated colors
- Changes slowly
- Low spatial density
- High spectral density
- CRI – important, RGBWA
- Collimated, Diffuse
  
- Electric lights, Daylight
  - RGB is NOT sufficient

## Infotainment

- Look at the light
- Saturated colors
- Changes fast
- High spatial density
- Low spectral density
- CRI – don't care, RGB
- Collimated, Diffuse
  
- Computer Display, TV, Rock Concert
  - RGB is sufficient

The sky is a special case. It fits into both categories.

# Next Generation Light Sources – now

- Remote on/off, dimming
- Fixed custom spectrum (non-blackbody)

- Warm-white, Cool-white “white tunable”
- RGB and beyond

# Warm-white, Cool-white “white tunable”



# Warm-white, Cool-white “white tunable”



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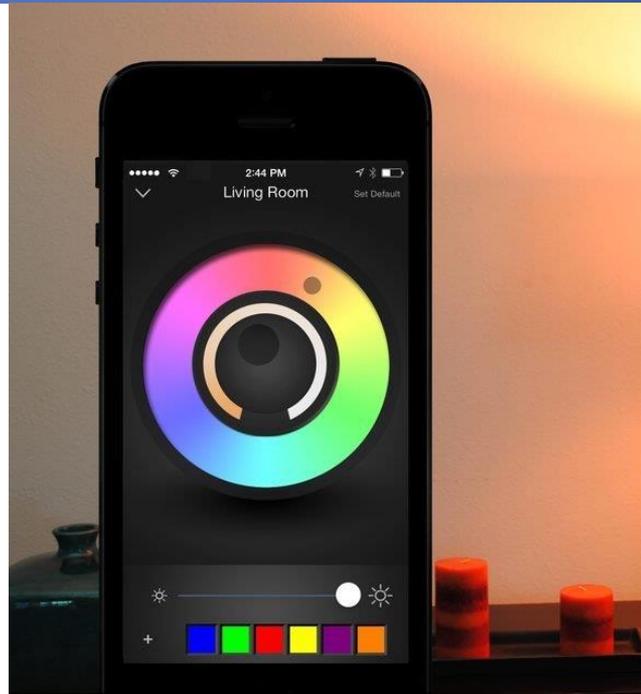
## Beetle

Advanced  
Tunable System

2700K–6500K CCT Control  
Samjin Ultra System Compatible



# RGB and beyond



# RGB and beyond

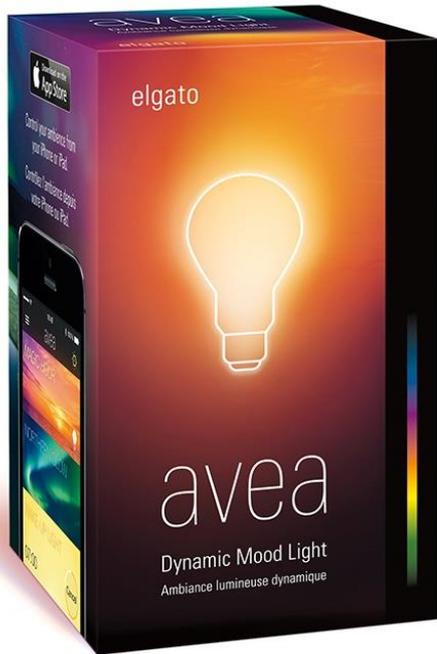
MarSwell® 450LM RGBW Bluetooth Smart LED



Flux Bluetooth Smart LED Light Bulb



# RGB and beyond



# RGB and beyond



# RGB and beyond

 K E T R A™

lumenetix®

Home

araya<sup>5</sup>

Products

iOS App



iOS

 Bluetooth™

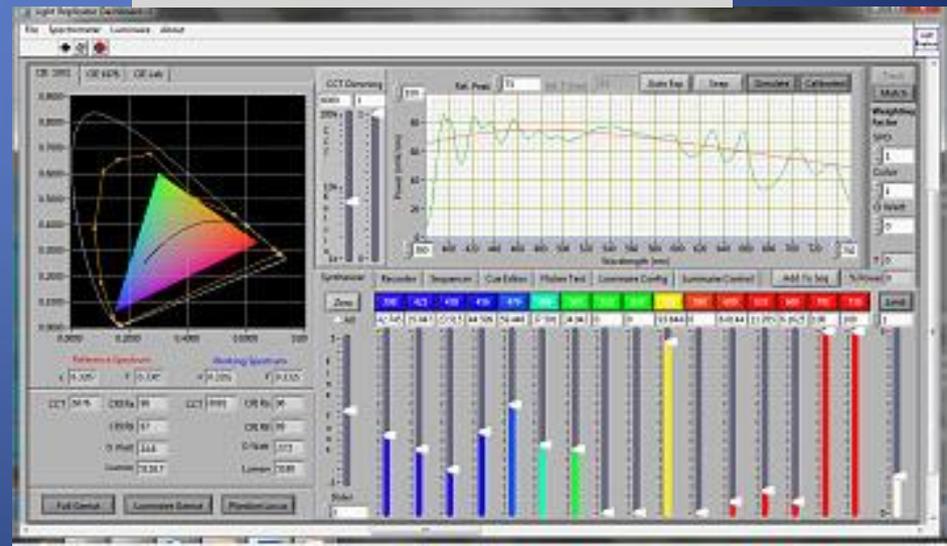
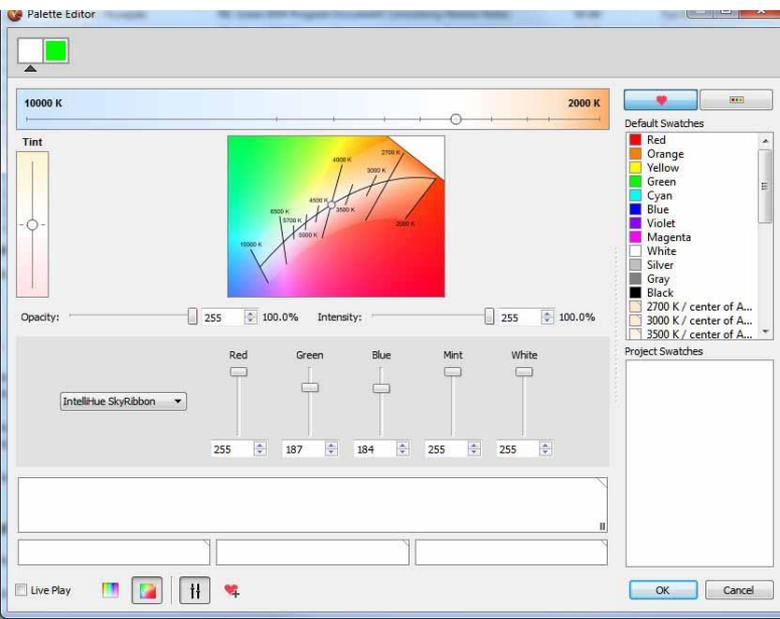
DMX

 EcoSystem.  
Enabled

 AcuityControl  
by ieco

 CRESTRON

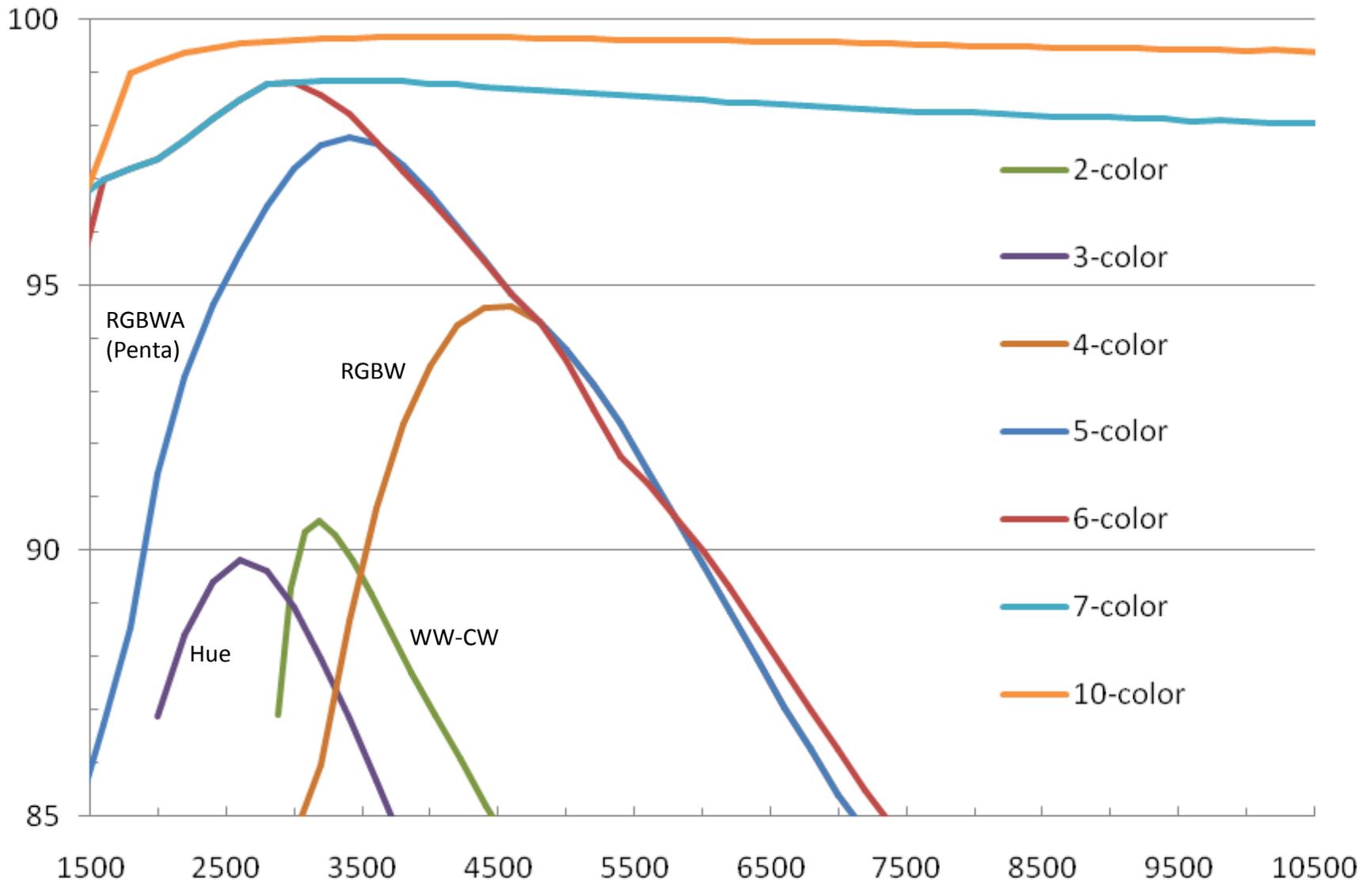
# RGB and beyond



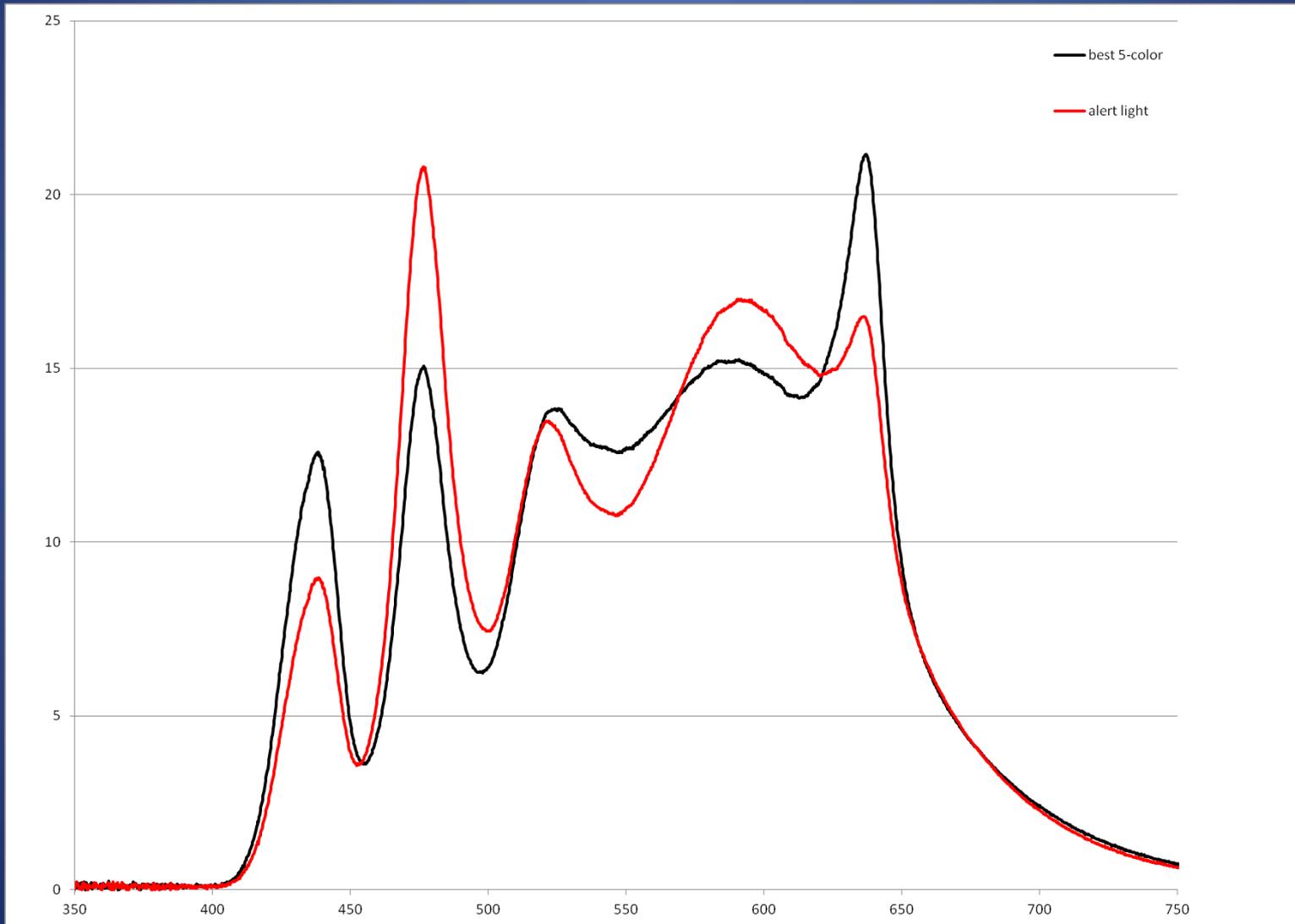
# Why go beyond RGB

- Broader CCT range at higher color quality
- Multiple solutions for a given chromaticity
- Larger gamut area
- Tradeoff between efficacy and color quality

# Multi-color – CQS vs. CCT



# Multiple 4000K solutions – 5-color



# What's Next – Light Players

- Illumination has many dimensions:
  - Intensity, spectrum, direction, beam angle, time
- A light player is to illumination as an MP3 player is to music.
- Record, Compose, Playback
- Some examples

# Claude Monet – “Haystacks”

The series shows differences in perception of light across various times of day, seasons, and types of weather.

1890-1891 series [\[edit\]](#)



*Grainstacks in the Sunlight, Morning Effect*, 1890. Oil on canvas. Private collection.



*Haystacks, (Midday)*, 1890-91, National Gallery of Australia



*Wheatstacks (End of Summer)*, 1890-91. Oil on canvas. Art Institute of Chicago



*Wheatstacks*, 1890-91. Oil on canvas. Art Institute of Chicago.



*Wheatstacks, Snow Effect, Morning*, 1891. Oil on canvas. J. Paul Getty Museum



*Haystacks at the End of Summer, Morning Effect*, 1891. Oil on canvas. Musée d'Orsay, Paris, France.



*Haystacks on a Foggy Morning*, 1891. Oil on canvas. Private collection.



*Haystack, Morning Snow Effect (Meule, Effet de Neige, le Matin)*, 1891. Oil on canvas. Museum of Fine Arts, Boston.



*Grainstacks Snow Effect, (Meules, effet de neige)*, 1891. Oil on canvas. National Gallery of Scotland, Edinburgh, Scotland



*Wheatstacks (Sunset, Snow Effect)*, 1890-91. Oil on canvas. Art Institute of Chicago.



*Wheatstack (Snow Effect, Overcast day) (Meule, effet de neige, temps couvert)*, 1890-91. Oil on canvas. Art Institute of Chicago.



*Wheatstack*, 1890-91. Oil on canvas. Art Institute of Chicago.



*Wheatstack (Thaw, Sunset)*, 1890-91. Oil on canvas. Art Institute of Chicago.



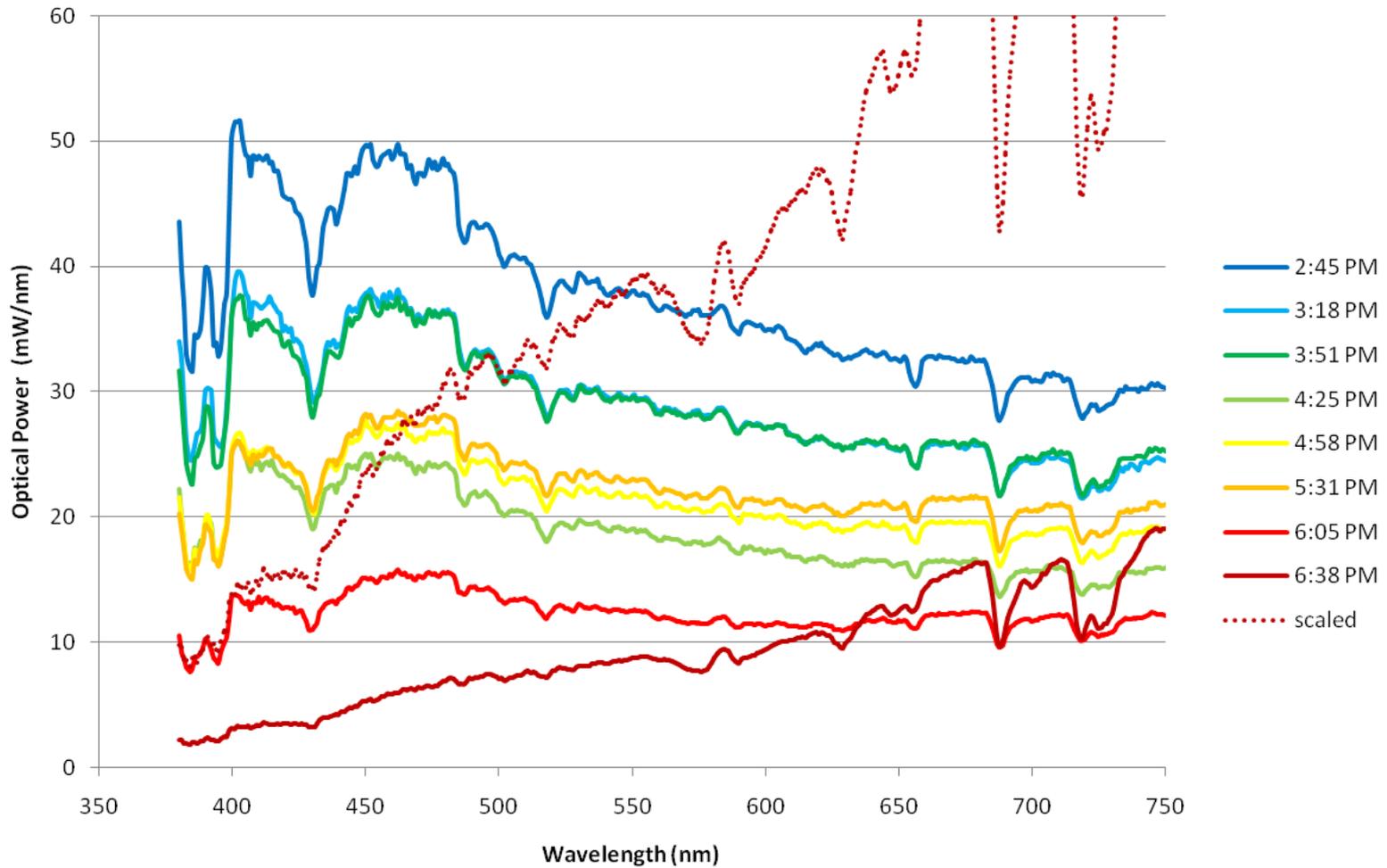
*Wheatstack (Sun in the Mist)*, 1891. Oil on canvas. Minneapolis Institute of Arts.



*Grainstacks. (Snow effects; sunlight)*, 1890-91. Oil on canvas. National Gallery of Scotland, Edinburgh, Scotland.

# Changing Daylight Example

## SPD Snapshots of Daylight Over 4-Hour Period



# Portable Spectrometer for Light Recording

Removable Aluminum case that secures Spectrometer

Bluetooth Technology for remote measurements

Defuser light entry for easy measurements

WiFi  
Lightweight handheld device with Wifi to transfer data

Free APP to analyse many types of data including Spectrum. Continuous measuring compatible

Calibrated with NIST traceable light source

Comes packaged with iPod touch 5

**A SENSE**

Pod 11:02 AM

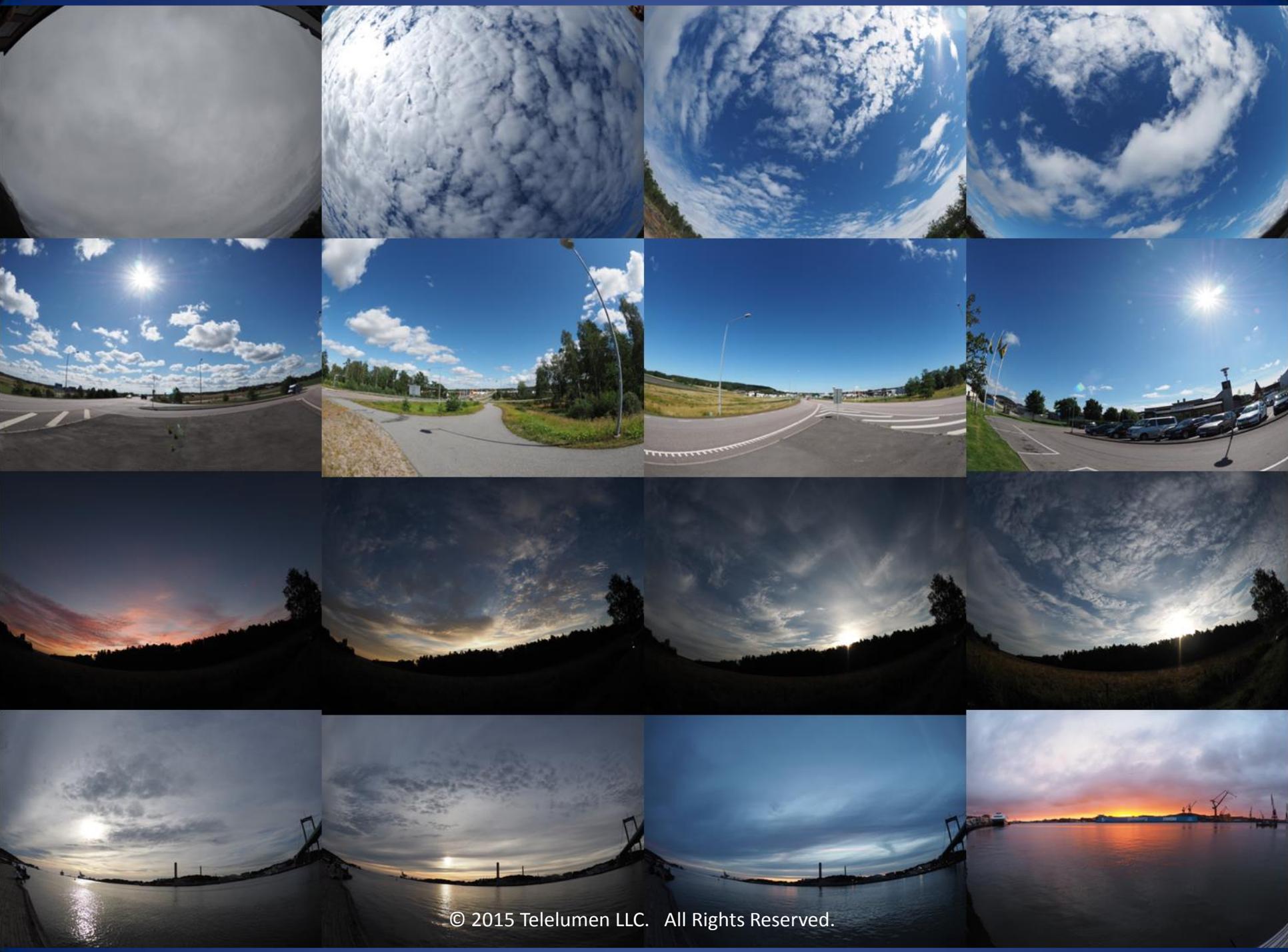
Continuous

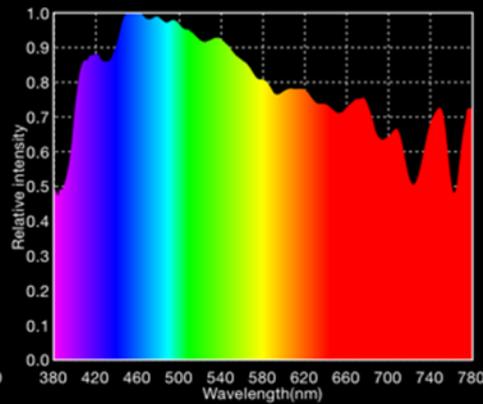
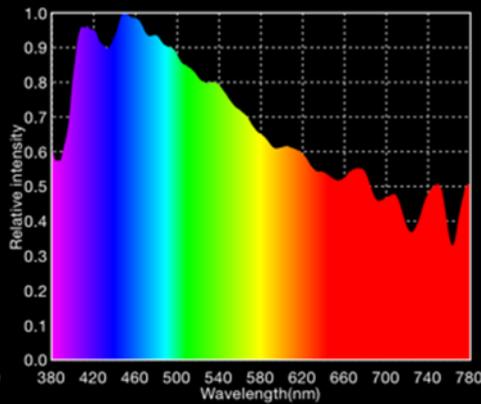
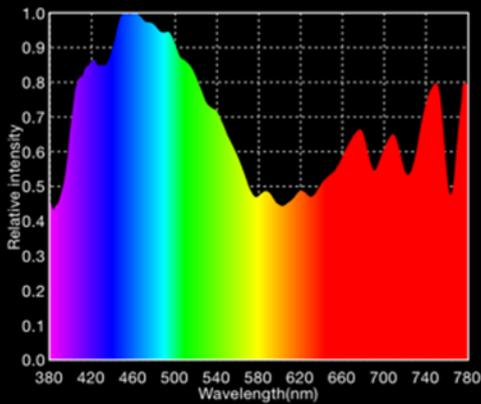
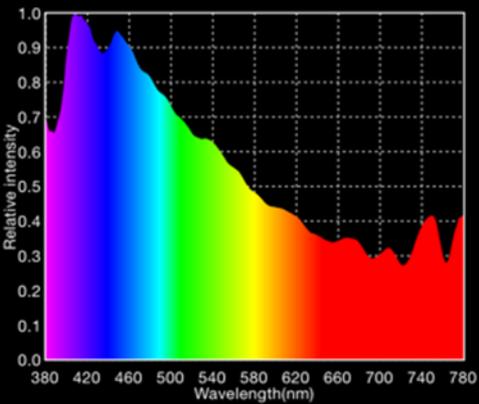
Measure delay 1 min

Total Times 5

Select Parameter(s)

- CCT ✓
- CRI ✓
- COG ✓
- Illuminance ✓
- CIE1901 ✓
- CIE1976 ✓
- Ap ✓



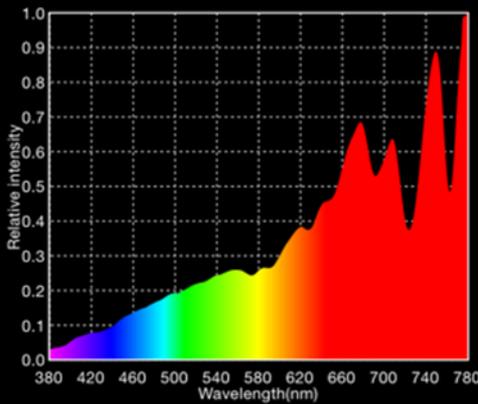
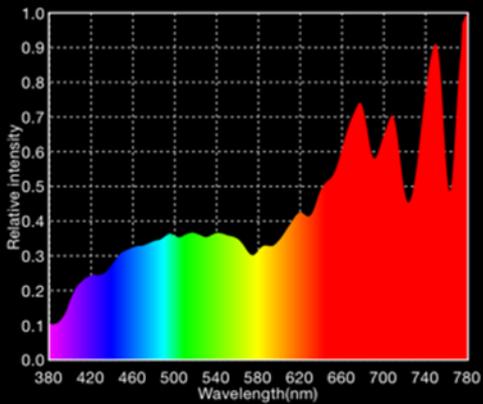
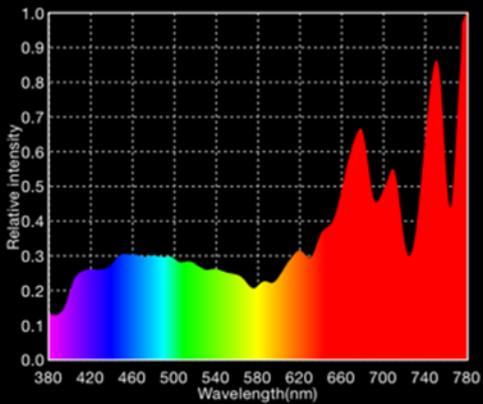
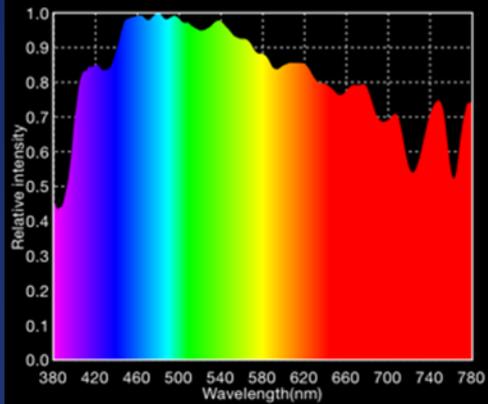


2015/08/12 02:30:12  
 CCT 11745 K  
 CRI(Ra) 97  
 Illuminance 6007 lux  
 CIE1976 u' 0.1848  
 CIE1976 v' 0.4347  
 Duv 0.0036

2015/08/12 08:48:27  
 CCT 10688 K  
 CRI(Ra) 94  
 Illuminance 232 lux  
 CIE1976 u' 0.1823  
 CIE1976 v' 0.4415  
 Duv 0.0077

2015/08/12 09:04:35  
 CCT 8224 K  
 CRI(Ra) 98  
 Illuminance 5789 lux  
 CIE1976 u' 0.1913  
 CIE1976 v' 0.4528  
 Duv 0.0031

2015/08/06 05:54:16  
 CCT 6542 K  
 CRI(Ra) 99  
 Illuminance 3961 lux  
 CIE1976 u' 0.1983  
 CIE1976 v' 0.4672  
 Duv 0.0024



2015/08/11 11:59:07  
 CCT 6049 K  
 CRI(Ra) 99  
 Illuminance 25354 lux  
 CIE1976 u' 0.2012  
 CIE1976 v' 0.4728  
 Duv 0.0023

2015/08/11 09:01:59  
 CCT 5349 K  
 CRI(Ra) 77  
 Illuminance 189 lux  
 CIE1976 u' 0.2182  
 CIE1976 v' 0.4656  
 Duv -0.0138

2015/08/08 08:47:05  
 CCT 4540 K  
 CRI(Ra) 85  
 Illuminance 995 lux  
 CIE1976 u' 0.2204  
 CIE1976 v' 0.4856  
 Duv -0.0056

2015/08/08 08:26:06  
 CCT 3113 K  
 CRI(Ra) 88  
 Illuminance 6279 lux  
 CIE1976 u' 0.2480  
 CIE1976 v' 0.5144  
 Duv -0.0034

# Summary

- Products have moved beyond fixed CCT.
- Control interfaces are often complex.
- Light Players provide a simpler solution.
- Daylight provides a useful roadmap.
- The blackbody locus is a convenience.
- Clock, calendar time are key elements.
- Regular advancements on all fronts continue.



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Thank You