

LIGHTING WITH LED WALLS

# IN VIRTUAL PRODUCTION VOLUMES

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10.03.2023





# JULIA ISABELL LEBER

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Camera & Lighting

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# VIRTUAL PRODUCTION



"Virtual Production is where the physical and digital worlds meet."  
- *Weta Digital*

*Moving Picture Company (MPC):* "Virtual Production combines virtual and augmented reality with Computer Generated Images (CGI) and game-engine technologies to enable production crews to see their scenes unfold as they are composed and captured on set."



# VIRTUAL PRODUCTION



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# VIRTUAL PRODUCTION



Great difference to **green screen** shooting:  
More preparation, less post production

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# LED WALLS AS A LIGHTING TOOL



Additional light sources needed to create

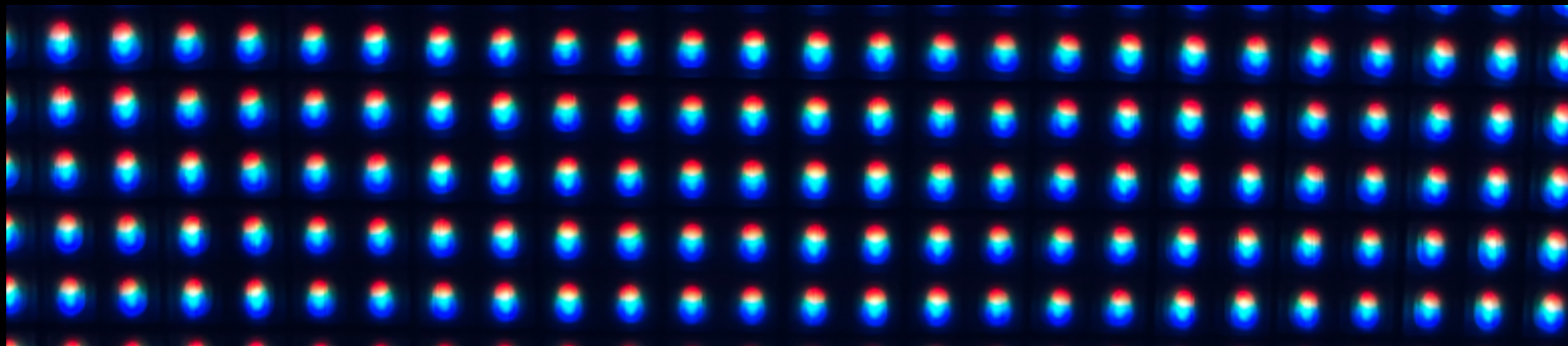
- scene contrast / dynamic range
- long / hard shadows



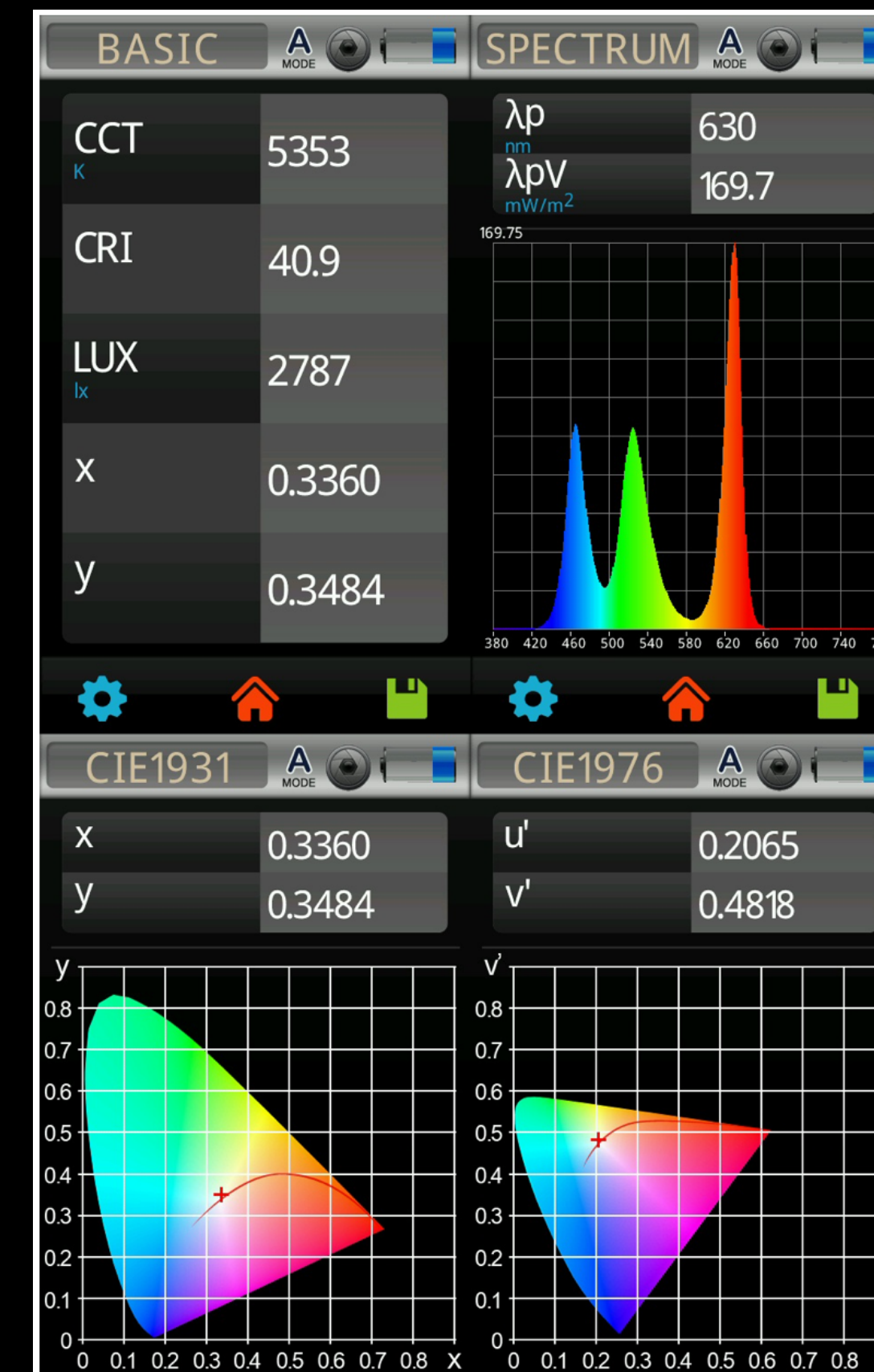
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# LED WALLS AS A LIGHTING TOOL

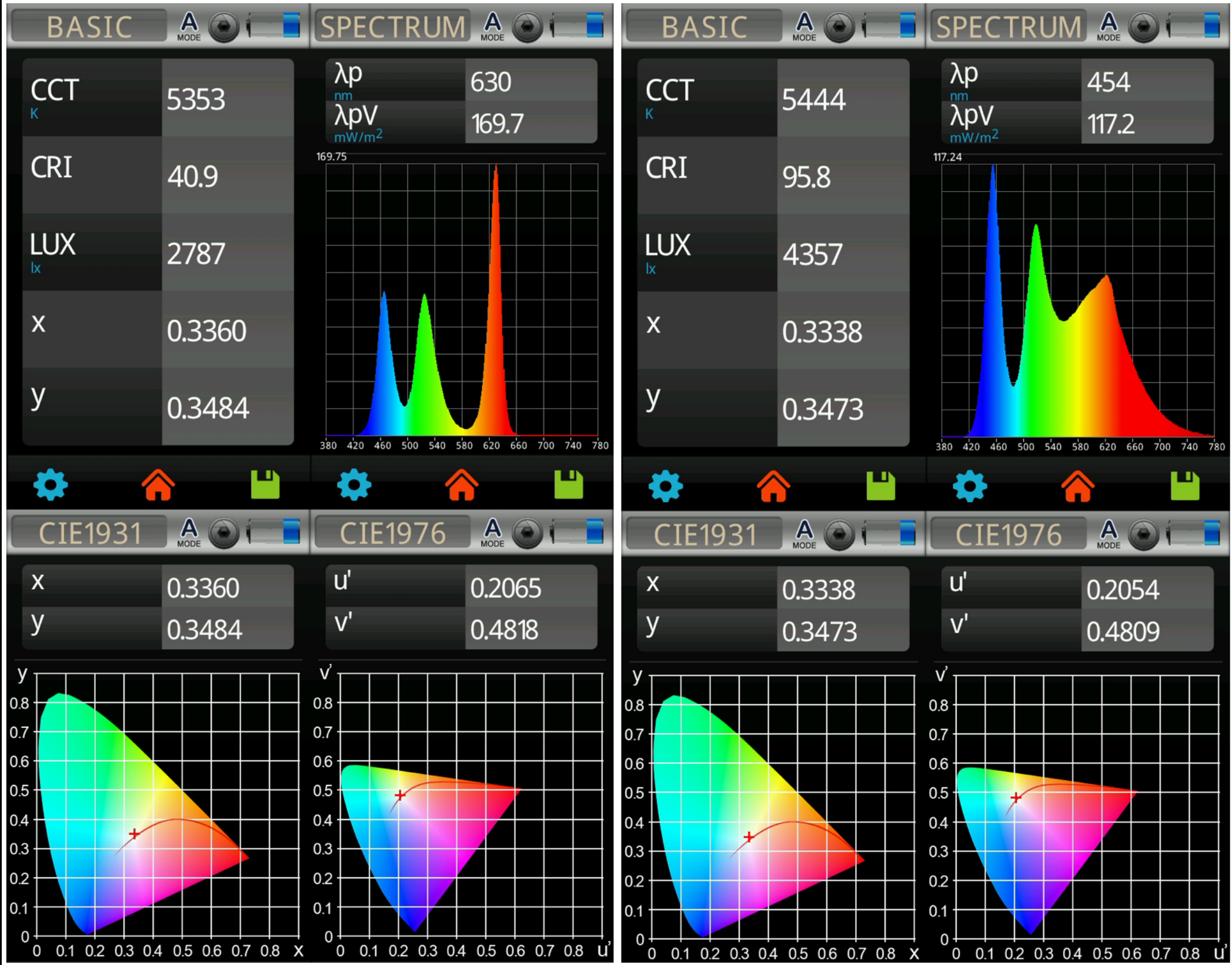
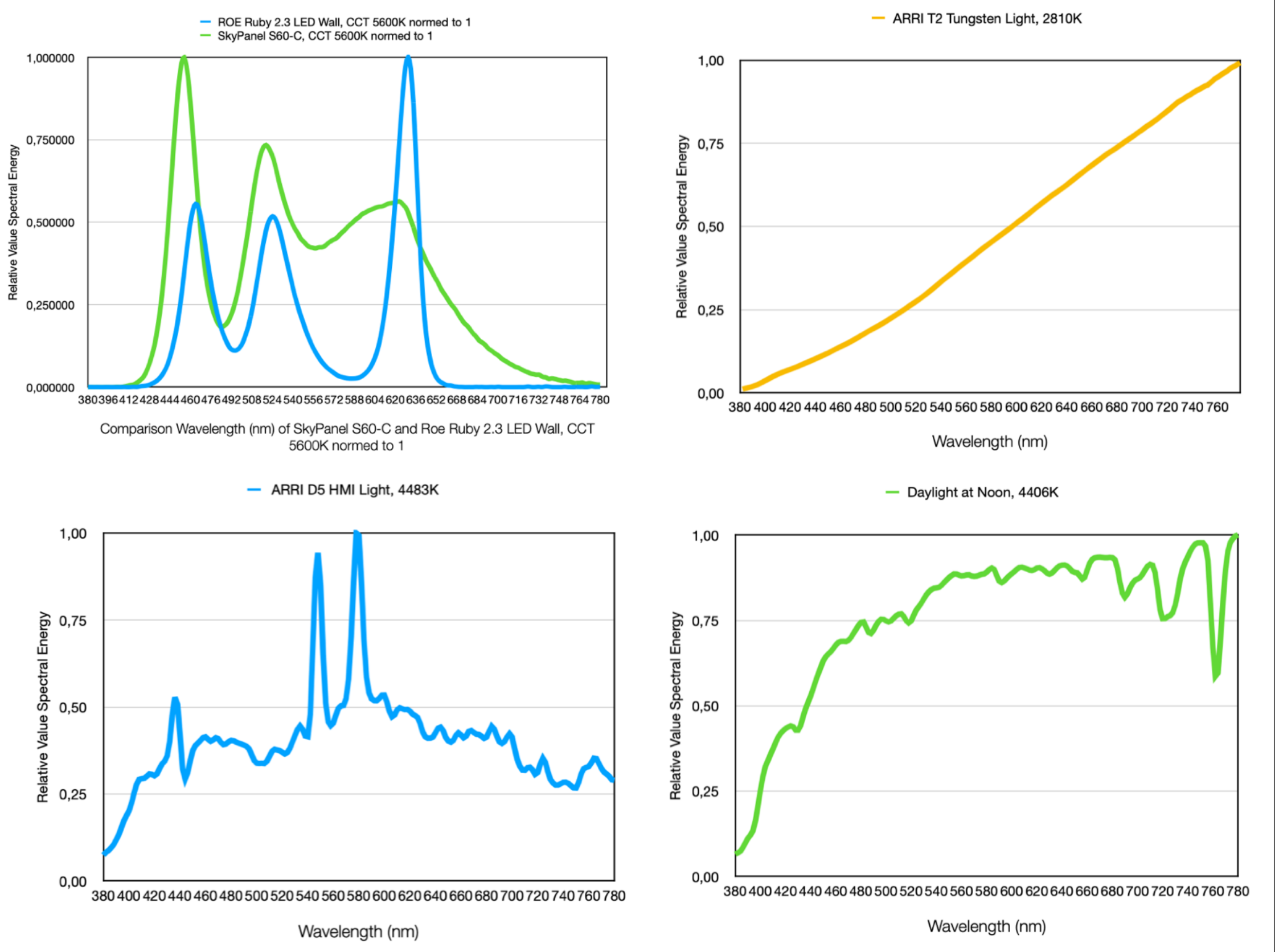


- Red green and blue LED, like LED panel lights around 20 years ago
- Poor color rendition





# LED WALLS AS A LIGHTING TOOL





# APPROACHES



Dr. Paul Debevec

Director of Research, Creative Algorithm and  
Technology at Netflix

Clustering Method



Adding additional LEDs

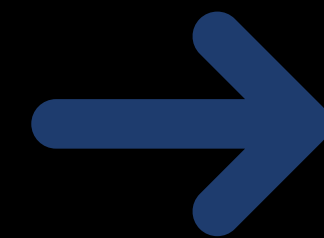




# LED WALLS AS A LIGHTING TOOL



- Not enough angular coverage
- Not enough dynamic range
- Poor color rendition



Use additional lighting kit



# TWO TEST SETUPS



1. Fixed testing setup
2. Skintones scene



# TESTSETUP FIXED SCENE

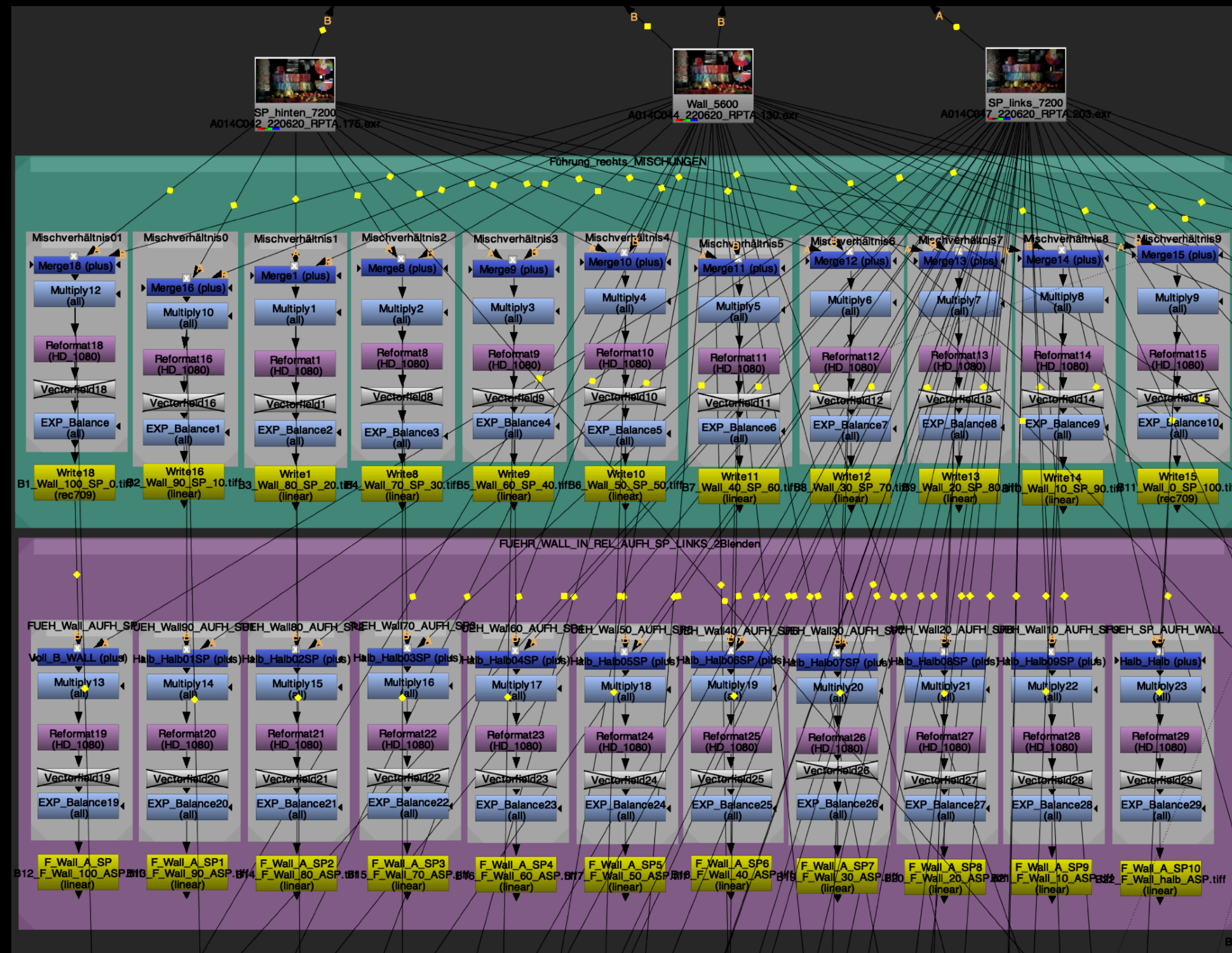


3 recorded sequences:

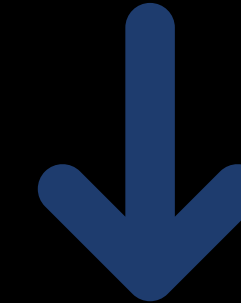
- Lit with SkyPanel S60-C from both sides
- Lit with the LED wall from the right hand side



# TESTSETUP FIXED SCENE



3 linearised EXR. files



Merged files in Nuke



Exported TIFFs of final lighting setups



# TESTSETUP FIXED SCENE



Read into Matlab



Picking average linear RGB values



XYZ values to L\*a\*b color space



Calculation in  $\Delta E_{2000}$



# EVALUATION



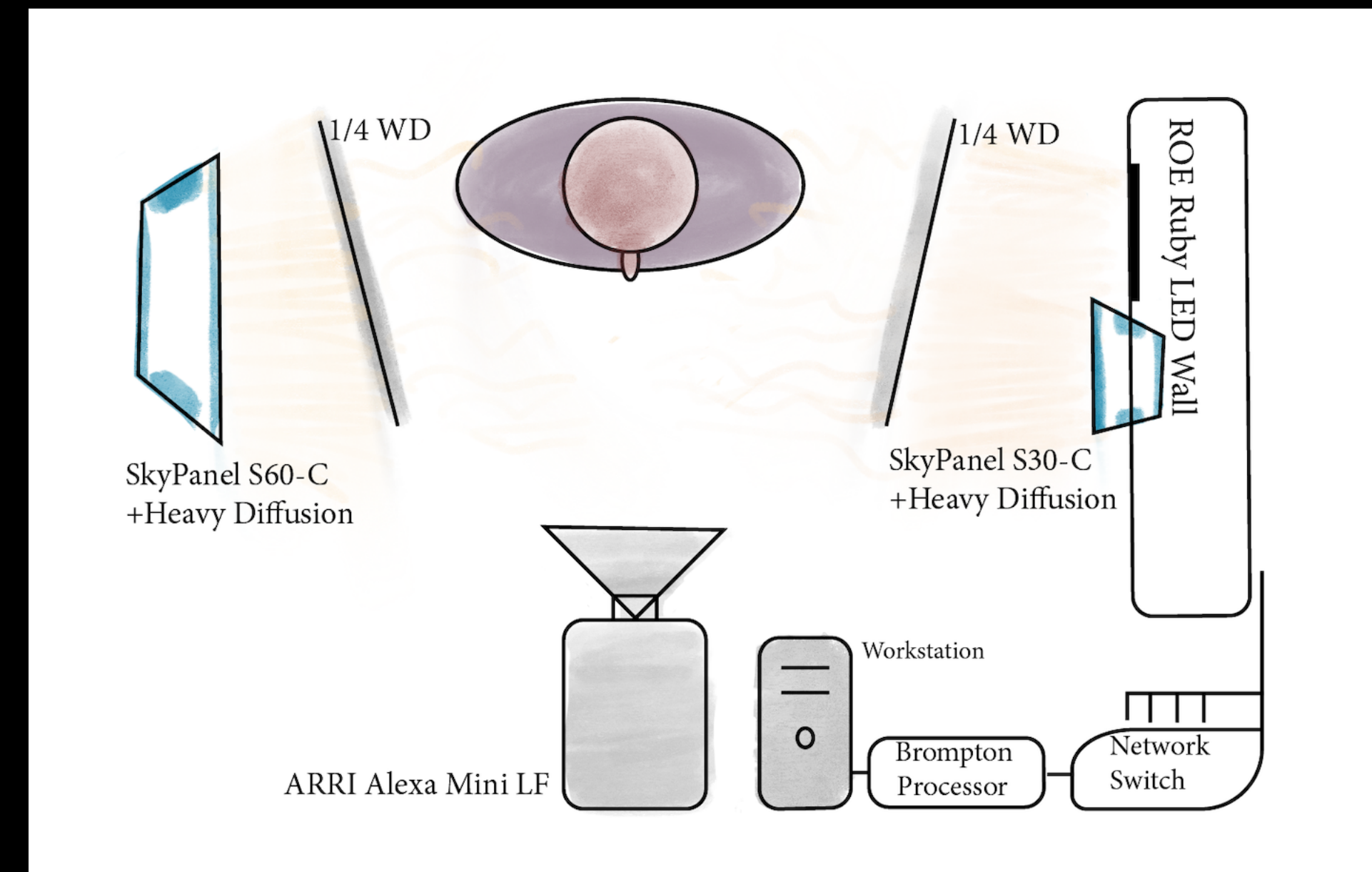
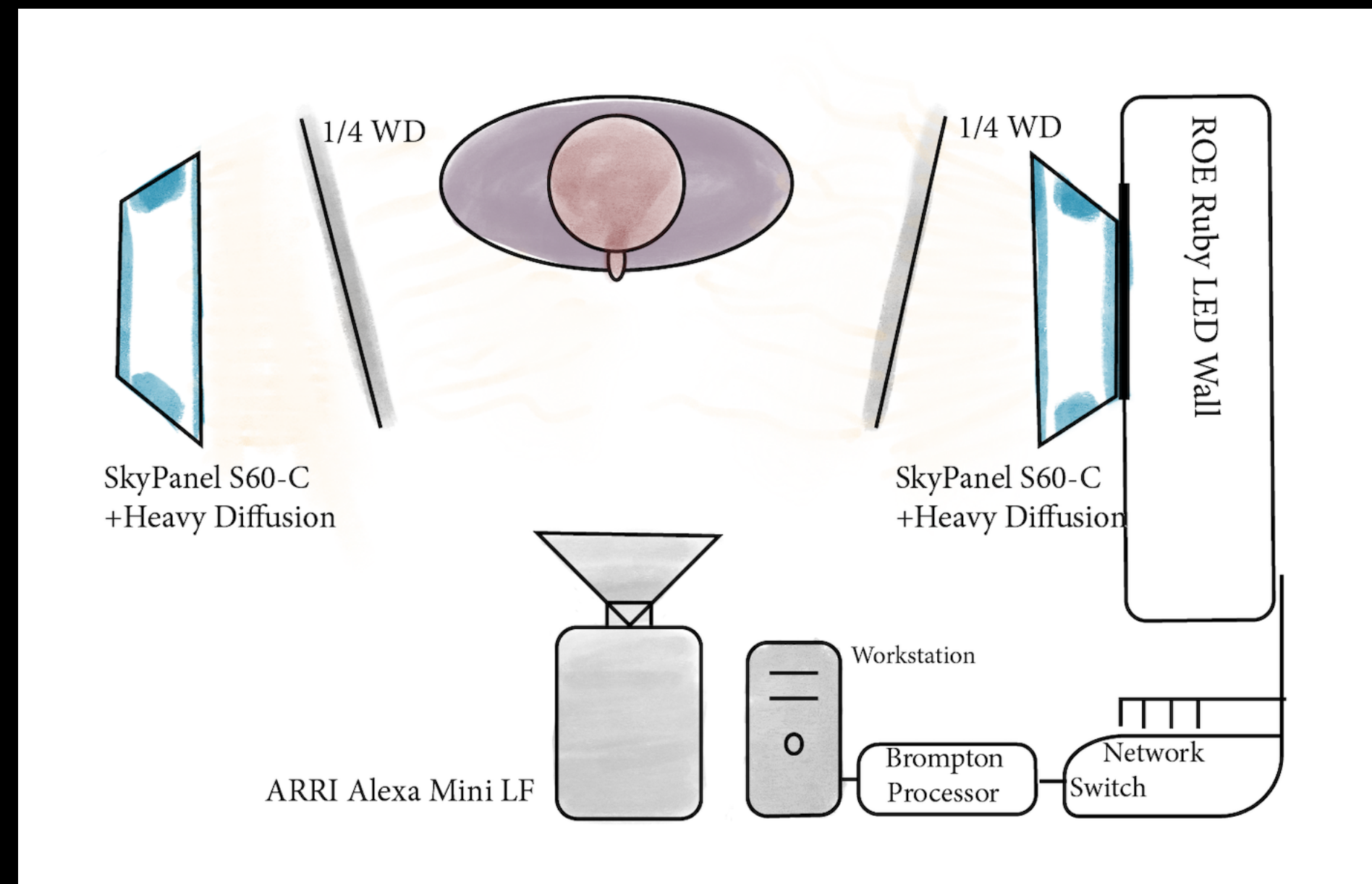
## $\Delta E_{2000}$

- Mathematically expanded
- $\Delta E$  groundwork for accuracy in colors
- Color difference can be quantified
- Best mathematical agreement with human sensation of color differences

|            |                                                    |
|------------|----------------------------------------------------|
| $\leq 1.0$ | Not perceptible by the human eye                   |
| 1-2        | Perceptible through to close observation           |
| 2-3        | Unexperienced observer also notices the difference |
| 3-5        | Perceptible at a glance, clear divergence in color |
| $>5$       | Observer notices two different colors              |
| 11-49      | Colors are more similar than the opposite          |
| 100        | Colors are exactly the opposite                    |



# TEXTSETUP SKIN TONES





# TEXTSETUP SKIN TONES



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# TESTSETUP FIXED SCENE



Skypanel as only light source

//Keylight



# TESTSETUP FIXED SCENE



LED Wall as only light source

//Keylight



# SKIN TONE EVALUATION



Skypanel as only light source





# SKIN TONE EVALUATION



LED Wall as only light source





# SKIN TONE EVALUATION



Skypanel as only light source





# SKIN TONE EVALUATION



LED Wall as only light source





# SKIN TONE EVALUATION



Skypanel as only light source





# SKIN TONE EVALUATION



LED Wall as only light source





# SKIN TONE EVALUATION



SP key light / LED Wall fill / 1 F-Stop

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# SKIN TONE EVALUATION



SP key light / LED Wall + SP as fill

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# SKIN TONE EVALUATION



Skypanel as only light source





# SKIN TONE EVALUATION



LED Wall as only light source





RESULTS



|                                           | 1    | 02   | 03   | 04   | 05   | 06   | 07   | 08   | 09   | 10   | 11   | 12   | 13   | 14   | 15   | 16   | 17   | 18   |      |      |      |      |      |      |
|-------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 'B55_Optimum,tiff'                        | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    |      |
| Keylight Combinations                     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | *    |      |      |      |      |      |      |
| 'B1_Wall_100_SP_0,tiff'                   | 4,27 | 7,20 | 3,76 | 0,90 | 8,10 | 1,71 | 8,29 | 2,70 | 5,16 | 7,37 | 1,29 | 8,31 | 2,70 | 1,36 | 6,65 | 5,00 | 7,78 | 3,33 | 6,43 | 3,90 | 3,25 | 2,74 | 2,53 | 2,10 |
| 'B2_Wall_90_SP_10,tiff'                   | 4,02 | 6,68 | 3,45 | 0,85 | 7,47 | 1,57 | 7,66 | 2,42 | 4,75 | 6,83 | 1,16 | 7,56 | 2,51 | 1,23 | 6,15 | 4,57 | 7,20 | 3,04 | 6,20 | 3,57 | 2,98 | 2,56 | 2,32 | 2,01 |
| 'B3_Wall_80_SP_20,tiff'                   | 3,74 | 6,28 | 3,20 | 0,81 | 6,92 | 1,46 | 7,10 | 2,25 | 4,39 | 6,39 | 1,04 | 6,97 | 2,34 | 1,12 | 5,74 | 4,21 | 6,70 | 2,86 | 6,03 | 3,35 | 2,79 | 2,40 | 2,18 | 1,95 |
| 'B4_Wall_70_SP_30,tiff'                   | 3,54 | 5,86 | 2,98 | 0,79 | 6,43 | 1,36 | 6,63 | 2,08 | 4,08 | 5,98 | 0,95 | 6,45 | 2,21 | 1,06 | 5,38 | 3,89 | 6,27 | 2,69 | 5,87 | 3,10 | 2,61 | 2,29 | 2,06 | 1,81 |
| 'B5_Wall_60_SP_40,tiff'                   | 3,31 | 5,55 | 2,81 | 0,74 | 6,03 | 1,29 | 6,23 | 1,95 | 3,81 | 5,63 | 0,87 | 6,02 | 2,12 | 0,99 | 5,06 | 3,63 | 5,90 | 2,52 | 5,75 | 2,94 | 2,48 | 2,17 | 1,90 | 1,72 |
| 'B6_Wall_50_SP_50,tiff'                   | 3,14 | 5,25 | 2,67 | 0,70 | 5,67 | 1,21 | 5,85 | 1,83 | 3,58 | 5,30 | 0,80 | 5,62 | 2,00 | 0,94 | 4,76 | 3,40 | 5,58 | 2,38 | 5,64 | 2,81 | 2,34 | 2,09 | 1,81 | 1,65 |
| 'B7_Wall_40_SP_60,tiff'                   | 3,03 | 5,00 | 2,54 | 0,70 | 5,34 | 1,16 | 5,50 | 1,74 | 3,37 | 5,01 | 0,73 | 5,31 | 1,90 | 0,88 | 4,50 | 3,20 | 5,29 | 2,25 | 5,56 | 2,71 | 2,24 | 2,02 | 1,73 | 1,54 |
| 'B8_Wall_30_SP_70,tiff'                   | 2,89 | 4,77 | 2,44 | 0,68 | 5,08 | 1,11 | 5,22 | 1,65 | 3,18 | 4,75 | 0,68 | 4,99 | 1,82 | 0,86 | 4,27 | 3,02 | 5,03 | 2,12 | 5,48 | 2,58 | 2,12 | 1,94 | 1,69 | 1,52 |
| 'B9_Wall_20_SP_80,tiff'                   | 2,75 | 4,56 | 2,35 | 0,67 | 4,87 | 1,08 | 4,97 | 1,57 | 3,01 | 4,50 | 0,63 | 4,71 | 1,74 | 0,83 | 4,06 | 2,87 | 4,80 | 2,00 | 5,40 | 2,50 | 2,04 | 1,89 | 1,61 | 1,50 |
| 'B10_Wall_10_SP_90,tiff'                  | 2,61 | 4,37 | 2,26 | 0,65 | 4,62 | 1,04 | 4,73 | 1,50 | 2,86 | 4,30 | 0,58 | 4,47 | 1,67 | 0,81 | 3,87 | 2,73 | 4,59 | 1,90 | 5,34 | 2,41 | 1,96 | 1,84 | 1,57 | 1,44 |
| 'B11_Wall_0_SP_100,tiff'                  | 2,51 | 4,21 | 2,19 | 0,64 | 4,40 | 1,00 | 4,52 | 1,42 | 2,72 | 4,12 | 0,55 | 4,26 | 1,61 | 0,79 | 3,70 | 2,61 | 4,40 | 1,80 | 5,30 | 2,32 | 1,87 | 1,75 | 1,51 | 1,39 |
| Keylight Combinations + Fillight Skypanel |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | *    |      |      |      |      |      |      |
| 'B12_F_Wall_100_ASP,tiff'                 | 3,84 | 6,52 | 3,08 | 0,73 | 7,12 | 1,47 | 7,32 | 2,39 | 4,68 | 6,59 | 1,17 | 7,25 | 2,35 | 1,25 | 6,04 | 4,33 | 6,89 | 2,88 | 5,18 | 3,27 | 2,69 | 2,27 | 2,09 | 1,70 |
| 'B13_F_Wall_90_ASP,tiff'                  | 3,56 | 6,02 | 2,85 | 0,69 | 6,54 | 1,35 | 6,74 | 2,17 | 4,30 | 6,10 | 1,05 | 6,63 | 2,18 | 1,14 | 5,59 | 3,95 | 6,35 | 2,68 | 4,93 | 3,00 | 2,46 | 2,11 | 1,92 | 1,59 |
| 'B14_F_Wall_80_ASP,tiff'                  | 3,30 | 5,58 | 2,62 | 0,66 | 6,05 | 1,24 | 6,26 | 2,00 | 3,98 | 5,70 | 0,95 | 6,09 | 2,05 | 1,03 | 5,20 | 3,62 | 5,92 | 2,48 | 4,71 | 2,79 | 2,31 | 1,97 | 1,82 | 1,53 |
| 'B15_F_Wall_70_ASP,tiff'                  | 3,10 | 5,23 | 2,48 | 0,61 | 5,56 | 1,15 | 5,83 | 1,87 | 3,69 | 5,33 | 0,88 | 5,62 | 1,93 | 0,96 | 4,86 | 3,36 | 5,55 | 2,33 | 4,54 | 2,62 | 2,15 | 1,85 | 1,72 | 1,43 |
| 'B16_F_Wall_60_ASP,tiff'                  | 2,90 | 4,95 | 2,32 | 0,58 | 5,20 | 1,08 | 5,45 | 1,73 | 3,45 | 5,01 | 0,80 | 5,22 | 1,83 | 0,88 | 4,57 | 3,14 | 5,20 | 2,20 | 4,40 | 2,46 | 2,00 | 1,76 | 1,57 | 1,32 |
| 'B17_F_Wall_50_ASP,tiff'                  | 2,71 | 4,68 | 2,21 | 0,55 | 4,89 | 1,01 | 5,13 | 1,65 | 3,24 | 4,72 | 0,74 | 4,88 | 1,73 | 0,82 | 4,30 | 2,94 | 4,91 | 2,06 | 4,29 | 2,35 | 1,89 | 1,67 | 1,48 | 1,26 |
| 'B18_F_Wall_40_ASP,tiff'                  | 2,57 | 4,43 | 2,12 | 0,54 | 4,60 | 0,96 | 4,83 | 1,56 | 3,06 | 4,45 | 0,69 | 4,58 | 1,63 | 0,76 | 4,07 | 2,78 | 4,65 | 1,93 | 4,19 | 2,25 | 1,81 | 1,60 | 1,37 | 1,21 |
| 'B19_F_Wall_30_ASP,tiff'                  | 2,46 | 4,22 | 2,05 | 0,52 | 4,37 | 0,92 | 4,56 | 1,48 | 2,89 | 4,22 | 0,65 | 4,30 | 1,56 | 0,73 | 3,87 | 2,62 | 4,42 | 1,84 | 4,11 | 2,14 | 1,72 | 1,54 | 1,27 | 1,22 |
| 'B20_F_Wall_20_ASP,tiff'                  | 2,34 | 4,01 | 1,95 | 0,50 | 4,13 | 0,87 | 4,33 | 1,40 | 2,73 | 3,99 | 0,61 | 4,06 | 1,48 | 0,69 | 3,68 | 2,48 | 4,21 | 1,74 | 4,03 | 2,05 | 1,67 | 1,49 | 1,24 | 1,15 |
| 'B21_F_Wall_10_ASP,tiff'                  | 2,24 | 3,87 | 1,88 | 0,49 | 3,90 | 0,84 | 4,12 | 1,34 | 2,59 | 3,81 | 0,57 | 3,85 | 1,42 | 0,66 | 3,50 | 2,35 | 4,02 | 1,61 | 3,96 | 1,96 | 1,59 | 1,44 | 1,18 | 1,12 |
| 'B22_F_Wall_half_ASP,tiff'                | 2,15 | 3,68 | 1,80 | 0,47 | 3,72 | 0,80 | 3,93 | 1,28 | 2,46 | 3,63 | 0,53 | 3,67 | 1,36 | 0,63 | 3,34 | 2,24 | 3,85 | 1,53 | 3,91 | 1,89 | 1,52 | 1,39 | 1,12 | 1,11 |
| Keylight Wall _ Fillight SP left 10-100   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | *    |      |      |      |      |      |      |
| 'B23_Wall_100_SP_0,tiff'                  | 4,27 | 7,20 | 3,76 | 0,90 | 8,10 | 1,71 | 8,29 | 2,70 | 5,16 | 7,37 | 1,29 | 8,31 | 2,70 | 1,36 | 6,65 | 5,00 | 7,78 | 3,33 | 6,43 | 3,90 | 3,25 | 2,74 | 2,53 | 2,10 |
| 'B24_Wall_100_SP_10,tiff'                 | 4,07 | 6,89 | 3,47 | 0,84 | 7,68 | 1,60 | 7,88 | 2,56 | 4,94 | 7,03 | 1,24 | 7,84 | 2,57 | 1,30 | 6,39 | 4,70 | 7,39 | 3,14 | 5,90 | 3,61 | 3,02 | 2,53 | 2,34 | 1,92 |
| 'B25_Wall_100_SP_20,tiff'                 | 3,89 | 6,64 | 3,19 | 0,77 | 7,30 | 1,52 | 7,50 | 2,45 | 4,76 | 6,73 | 1,19 | 7,44 | 2,41 | 1,27 | 6,15 | 4,45 | 7,05 | 2,97 | 5,43 | 3,38 | 2,80 | 2,34 | 2,17 | 1,77 |
| 'B26_Wall_100_SP_30,tiff'                 | 3,75 | 6,39 | 2,99 | 0,72 | 6,97 | 1,43 | 7,17 | 2,35 | 4,59 | 6,45 | 1,15 | 7,08 | 2,28 | 1,23 | 5,93 | 4,21 | 6,73 | 2,79 | 4,96 | 3,17 | 2,59 | 2,20 | 2,00 | 1,60 |
| 'B27_Wall_100_SP_40,tiff'                 | 3,58 | 6,17 | 2,85 | 0,64 | 6,62 | 1,36 | 6,88 | 2,24 | 4,43 | 6,20 | 1,11 | 6,74 | 2,21 | 1,21 | 5,73 | 3,99 | 6,44 | 2,68 | 4,53 | 2,98 | 2,44 | 2,09 | 1,88 | 1,50 |
| 'B28_Wall_100_SP_50,tiff'                 | 3,46 | 5,98 | 2,70 | 0,61 | 6,31 | 1,31 | 6,58 | 2,15 | 4,29 | 5,96 | 1,10 | 6,41 | 2,13 | 1,20 | 5,55 | 3,79 | 6,15 | 2,58 | 4,19 | 2,80 | 2,29 | 1,95 | 1,79 | 1,42 |
| 'B29_Wall_100_SP_60,tiff'                 | 3,31 | 5,76 | 2,55 | 0,57 | 6,04 | 1,24 | 6,33 | 2,10 | 4,16 | 5,74 | 1,07 | 6,13 | 2,04 | 1,18 | 5,38 | 3,60 | 5,90 | 2,46 | 3,91 | 2,63 | 2,12 | 1,87 | 1,69 | 1,32 |
| 'B30_Wall_100_SP_70,tiff'                 | 3,22 | 5,56 | 2,41 | 0,55 | 5,78 | 1,18 | 6,08 | 2,05 | 4,03 | 5,54 | 1,06 | 5,90 | 1,95 | 1,19 | 5,21 | 3,44 | 5,69 | 2,37 | 3,63 | 2,50 | 1,99 | 1,77 | 1,59 | 1,25 |
| 'B31_Wall_100_SP_80,tiff'                 | 3,12 | 5,40 | 2,27 | 0,53 | 5,50 | 1,14 | 5,85 | 2,00 | 3,91 | 5,33 | 1,03 | 5,67 | 1,88 | 1,18 | 5,05 | 3,29 | 5,48 | 2,30 | 3,38 | 2,40 | 1,87 | 1,65 | 1,47 | 1,16 |
| 'B32_Wall_100_SP_90,tiff'                 | 3,03 | 5,22 | 2,14 | 0,52 | 5,27 | 1,09 | 5,61 | 1,95 | 3,79 | 5,16 | 1,00 | 5,44 | 1,81 | 1,18 | 4,91 | 3,17 | 5,28 | 2,19 | 3,14 | 2,26 | 1,77 | 1,56 | 1,35 | 1,10 |
| 'B33_Wall_100_SP_100,tiff'                | 2,93 | 5,06 | 2,04 | 0,51 | 5,01 | 1,05 | 5,43 | 1,92 | 3,69 | 5,00 | 0,98 | 5,24 | 1,73 | 1,17 | 4,77 | 3,05 | 5,09 | 2,11 | 3,01 | 2,15 | 1,65 | 1,47 | 1,26 | 1,05 |
| Keylight Wall _ Fillight SP left 0B-3B    |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | *    |      |      |      |      |      |      |
| 'B45_F_Wall_100_A_SP_0B,tiff'             | 2,93 | 5,06 | 2,04 | 0,51 | 5,01 | 1,05 | 5,43 | 1,92 | 3,69 | 5,00 | 0,97 | 5,24 | 1,73 | 1,18 | 4,77 | 3,05 | 5,09 | 2,11 | 3,01 | 2,15 | 1,65 | 1,47 | 1,26 | 1,05 |
| 'B46_F_Wall_100_A_SP_1B,tiff'             | 3,47 | 5,98 | 2,70 | 0,60 | 6,31 | 1,30 | 6,58 | 2,16 | 4,31 | 5,97 | 1,08 | 6,41 | 2,13 | 1,21 | 5,56 | 3,78 | 6,16 | 2,59 | 4,21 | 2,81 | 2,29 | 1,95 | 1,79 | 1,42 |
| 'B47_F_Wall_100_A_SP_2B,tiff'             | 3,84 | 6,52 | 3,08 | 0,73 | 7,12 | 1,47 | 7,32 | 2,39 | 4,68 | 6,59 | 1,17 | 7,25 | 2,35 | 1,25 | 6,04 | 4,33 | 6,89 | 2,88 | 5,18 | 3,27 | 2,69 | 2,27 | 2,09 | 1,70 |
| 'B48_F_Wall_100_A_SP_3B,tiff'             | 4,01 | 6,82 | 3,39 | 0,82 | 7,59 | 1,58 | 7,78 | 2,52 | 4,90 | 6,94 | 1,23 | 7,74 | 2,54 | 1,29 | 6,33 | 4,63 | 7,30 | 3,11 | 5,78 | 3,58 | 2,96 | 2,49 | 2,29 | 1,92 |

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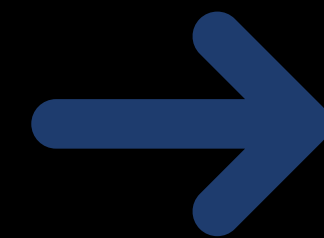
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# RESULTS



LED Wall as key-light



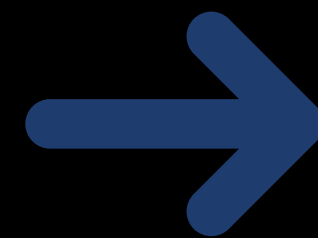
- high color difference values in all color patches
- except foliage, yellow green and green
- $\Delta E_{2000}$  reaching values until 8.31



# RESULTS



Most acceptable  $\Delta E_{2000}$  values



SkyPanel as a key-light, LED wall as a fill-light with a contrast of at least 3 F-Stops

SkyPanel as a key-light, fill-light was mixed by using a minimum 50% output of the SkyPanel together with the LED Wall



# OUTLOOK



Broader spectral LED Walls in future?

...?





THANK YOU  
for your attention

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