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Designers Lighting Forum

Light and health…and energy efficiency?

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CONTINUING EDUCATION AIA

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

At the end of the this course, participants will be able to:

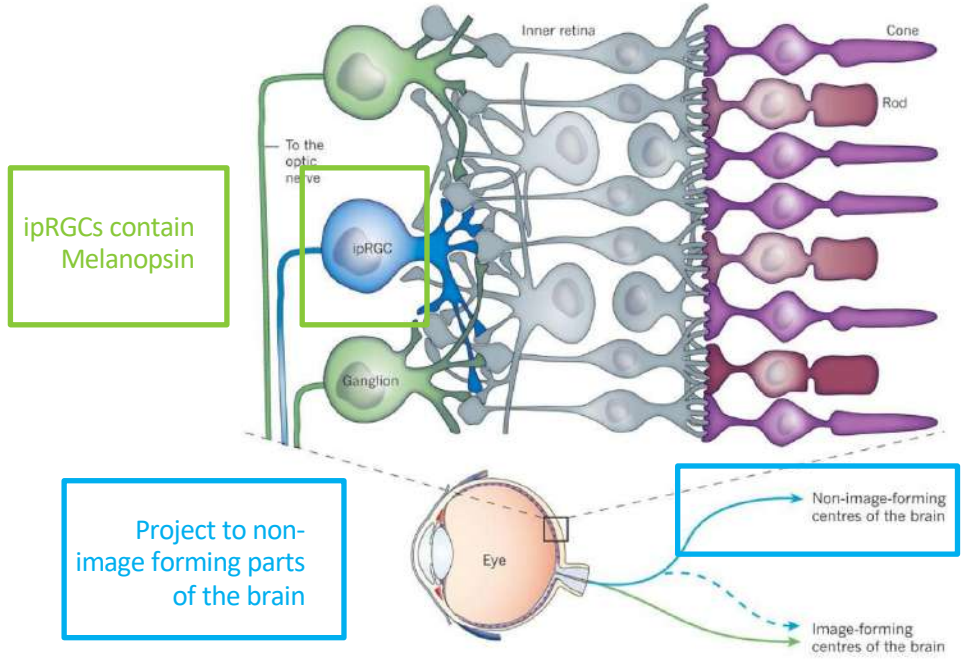
1. Understand the physiological effects of light.
2. Calculate vertical foot-candles in designs
3. Meet criteria for WELL and CS without compromising energy efficiency
4. Employ color constancy in design applications

Agenda

- What do we agree on?
- What we don’t agree on, yet?
- How to do vertical light calculations
- How to meet the WELL criteria without compromising energy efficiency
- How to take this whole thing to the next level

Light and Health: What do we agree on?

- What it is
  - ipRGCs mediate different physiological effects
    - Direct effects
      - Alertness
      - Melatonin secretion
      - Cognition
      - Mood
    - Indirect effects
      - Circadian entrainment
      - Sleep
      - Mood (yup, again)
- Where it should be
  - Vertical not horizontal light
- How much
  - Each physiological effect appears to be greater than what is required for vision
- **Brighter days and darker nights** in the built environment
- Anything we do is better than what we are currently doing



What we don’t agree on

- The exact role of rods and cones
- Which model should be used
  - LRC CS Model Vs. melanopic lux model Vs. CIE model
- Timing
  - First hour of the day?
  - First 4 hours of the day?
  - All day?
- Exactly how much?
  - 150 m-lux? (WELL V2 - 1 point)
  - 200 m-lux?
  - 240 m-lux? (WELL V2 – 3 points)
  - 500 m-lux?
  - CS = 0.3?
- A lot of the “movement” in criteria has been more of an interaction between what’s best for light and health and what’s best for comfort and energy
- Make no mistake, from a light and health standpoint, brighter is better.

CIE S 026 versus Lucas Model (WELL) for melanopsin

- CIE created a Melanopic DER (Daylight Efficiency Ratio)
  - How much melanopsin is stimulated by a light source relative to D65 (Daylight)
    - Melanopic EDI (Similar to melanopic lux)
      - **A high melanopic EDI during the day is usually supportive for alertness, the circadian rhythm and a good night's sleep.**
      - **A low melanopic EDI in the evening and at night facilitates sleep initiation and consolidation. [CIE position statement]**
    - Melanopic Daylight Efficiency Ratio
    - D65 would yield a melanopic DER of 1.
    - **Highest sensitivity at 490nm**
- WELL model (Melanopic Lux)
  - How much melanopsin is stimulated by a light source relative to Equal Energy Spectrum (~5555K)
    - **Highest sensitivity at 490nm**
    - Equal energy would yield an m/p = 1.
    - D65 would yield an m/p = 1.1
      - WELL m/p is about 10% higher than melanopic DER.
- Exact same weighting function!

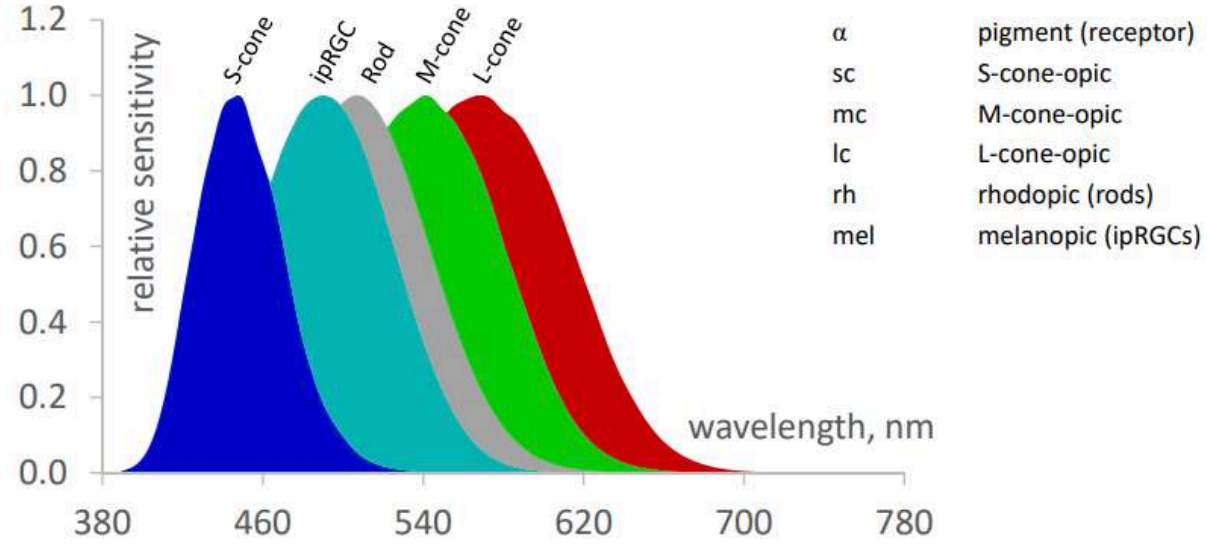
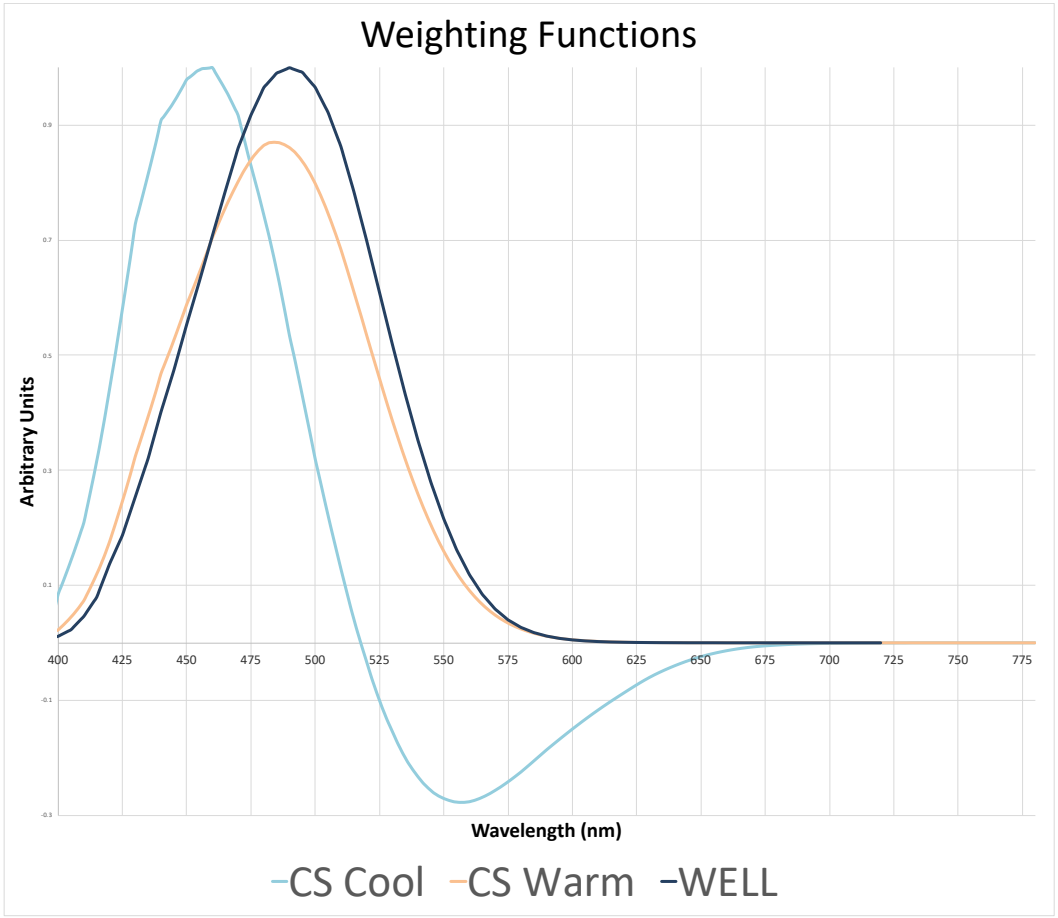


Image credit: CIE S 026 EDI Toolbox userguide
https://www.nsvv.nl/wp-content/uploads/2019/03/CIE-S-026-EDI-Toolbox-Userguide-vE1.05x.pdf

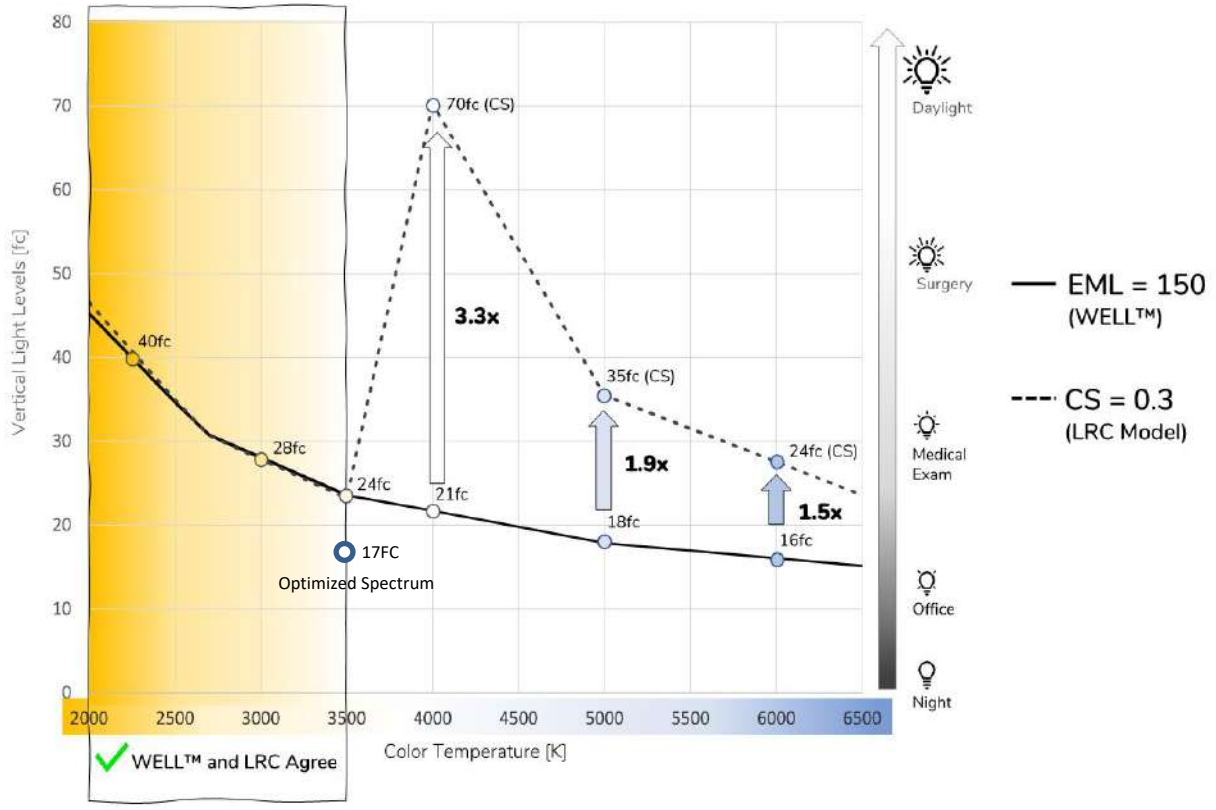
WELL versus CS

- The LRC has two models in one
  - Warm model is almost identical to WELL and CIE DER
    - Peak sensitivity at 485nm instead of 490nm
  - Cool model has this sub-additivity that they always talk about
  - Crossover is around 3500K
    - 3500K and warmer is “warm” model
    - Cooler than 3500K is “cool” model



Application: How much we need for daytime versus color temperature

- *Standard LED at 2200K requires 40FC vertical for* **BOTH** *CS and WELL*
- *Standard LED at 3000K requires 28FC vertical for* **BOTH** *CS and WELL*
- *Standard LED at 3500K requires 24FC vertical for* **BOTH** *CS and WELL*
  - *Spectrally Optimized will drop this down to 17FC*
- **At 3500K and warmer, the two models are the same**
- *Standard LED at 4000K requires 21FC for WELL and 3.3* **times** *that for CS*
- *Standard LED at 5000K requires 18FC for WELL and 1.9* **times** *that for CS*
- *Standard LED at 6000K requires 16FC for WELL and 1.5* **times** *that for CS*
- **When the two models are NOT the same, CS requires significantly more light**



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Which color temperature do we want to use in our everyday daytime spaces?

	Favorite CCT	I would never
6500K	XX%	XX%
5000K	XX%	XX%
4000K	XX%	XX%
3500K	XX%	XX%
3000K	XX%	XX%
2700K	XX%	XX%

Reminder: CIE, LRC, and WELL all agree at 3500K and warmer

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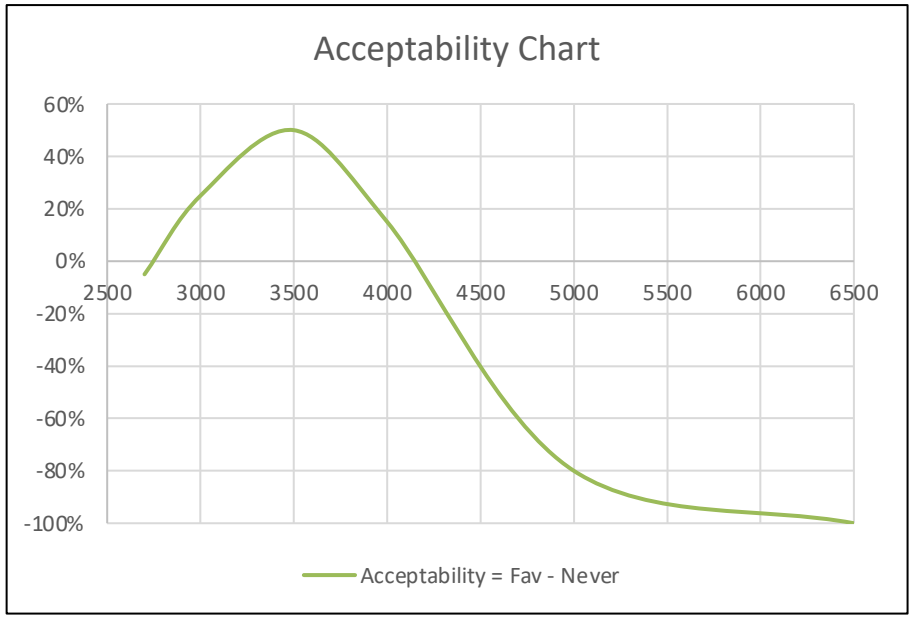
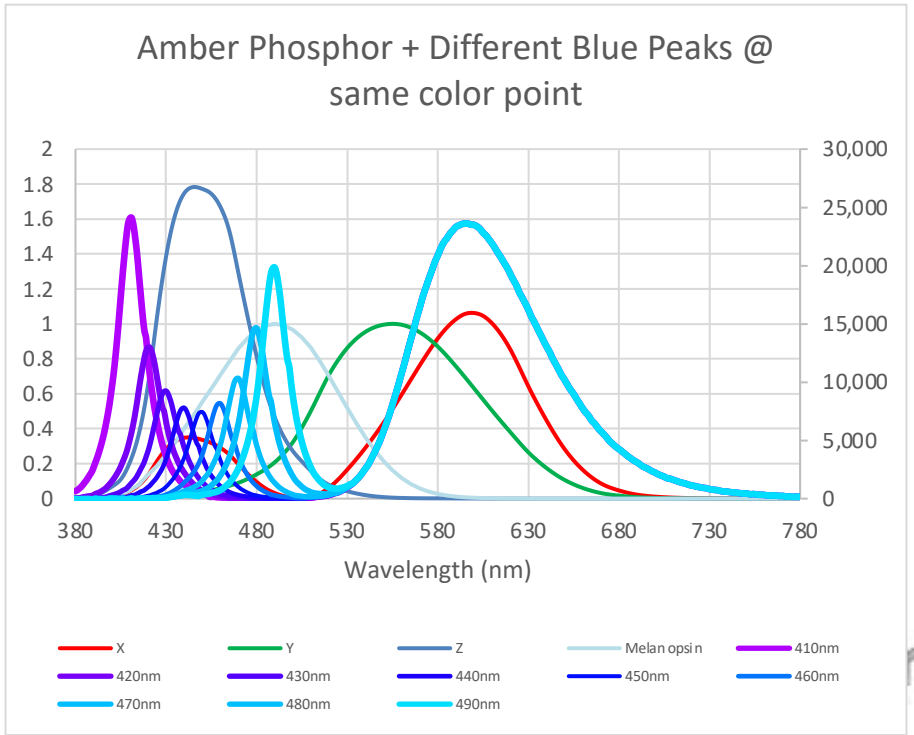
Matching with Preference

- My results from previous questionaires
- In order to maximize melanopic stimulus within the preference range, we have to consider the interaction with color vision

Warm White 2700K-3300K | Daylight White 4200-4500K | Cool White 5500-7000K

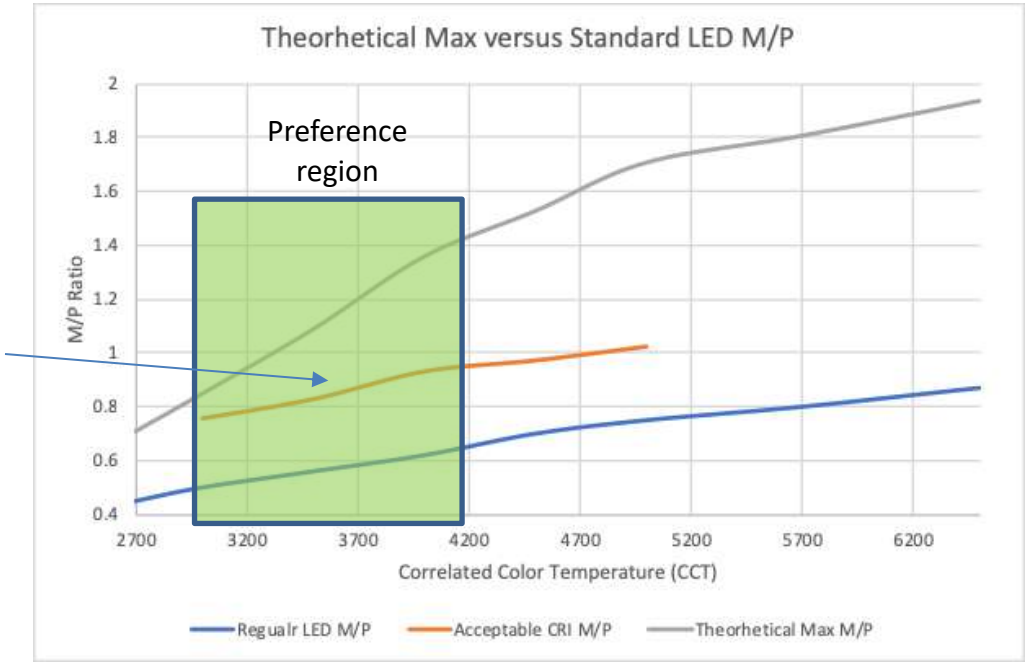


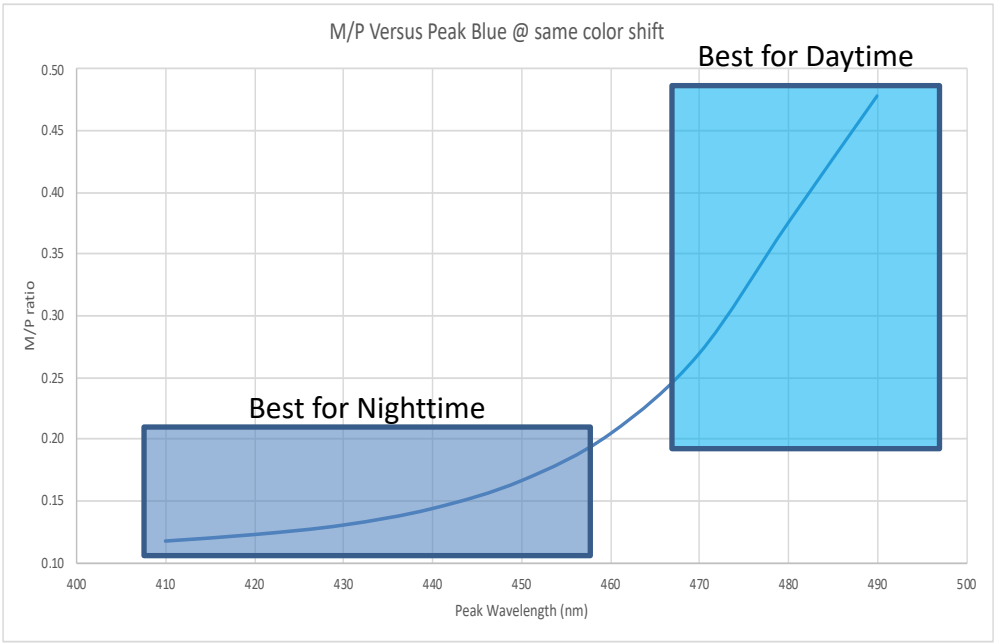


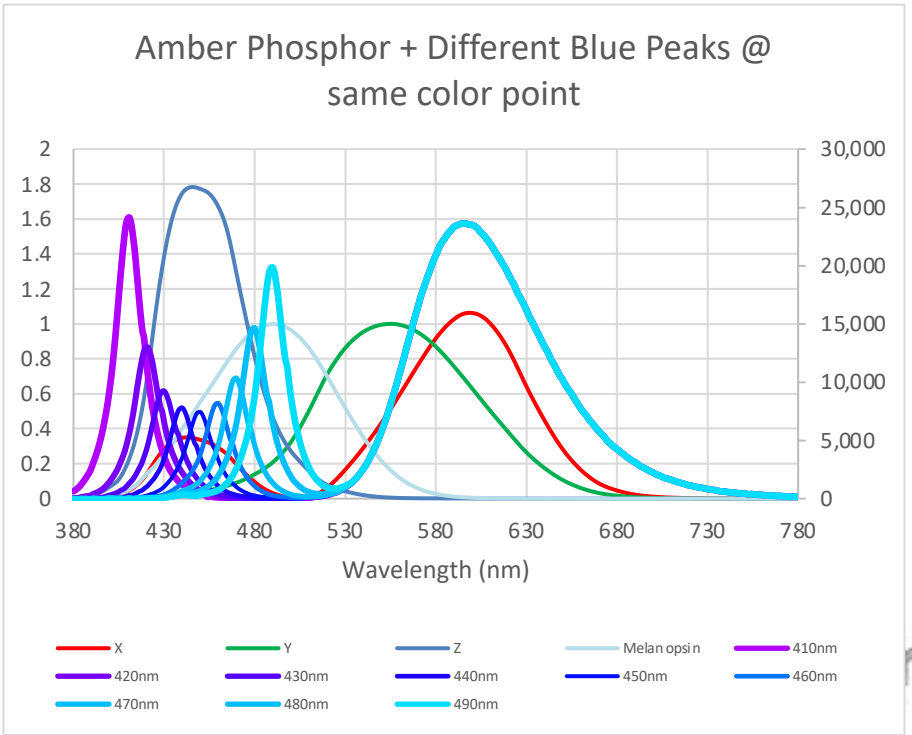
Where should I put my peak?

- Colder color temperatures have the most capacity for melanopic rich spectrum
- We still have to make sure color rendering isn't compromised

Spectrally optimized light engines







Quick how to (WELL):

- Figure out M/P ratio
  - Some manufacturers will provide
  - Or you can calculate yourself
- Plug M/P ratio as a LLF
- Create a vertical calc plane

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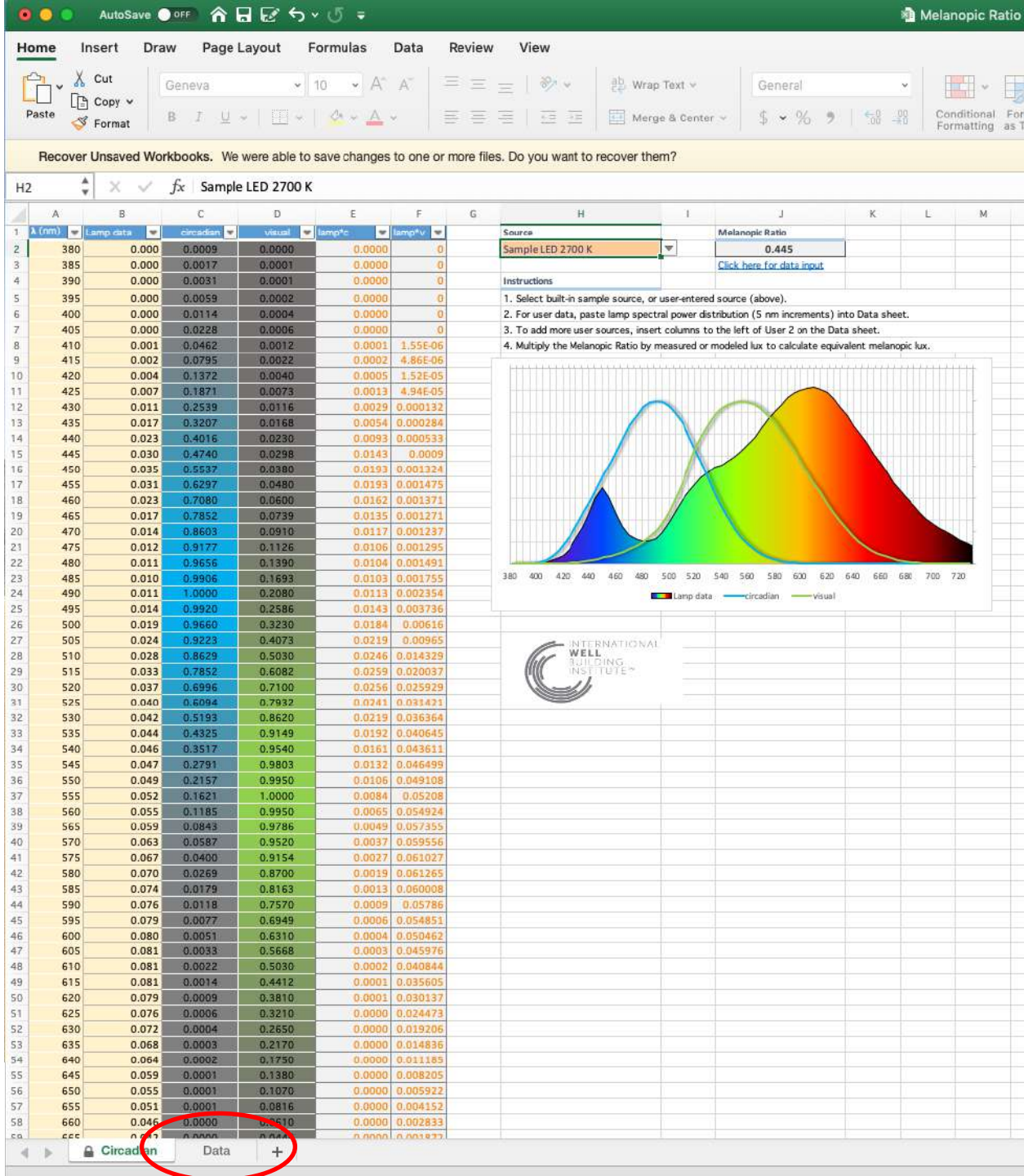
Figuring out the m/p

- Calculator can be found at: https://standard.wellcertified.com/tables#melanopicRatio
- Click data tab to input your own SPD data



AutoSave OFF — Melanopic Ratio

Home Insert Draw Page Layout Formulas Data Review View

Paste Cut Copy Format — Geneva 9 — Wrap Text — General — Conditional Formatting

Recover Unsaved Workbooks. We were able to save changes to one or more files. Do you want to recover them?

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Wavelength	Sample LED 2700 K	Sample LED 4000 K	Sample Fluorescent 2950 K	Sample Fluorescent 4000 K	Sample Fluorescent 6500 K	Sample Overcast	User 2	User 1
380	0	0	1.469086667	0.088942857	1.316893333	10.27834		
385	0	0	1.65856	0.087871429	1.70446	12.70802		
390	0	0	1.87856875	0.086866667	2.20519375	12.03508		
395	0	0	1.928986667	0.808844444	2.598086667	17.4267		
400	0	0	7.646746316	2.477175	10.73393659	22.10276		
405	0	0.001459025	14.32851284	1.068	14.23881	23.82654		
410	0.0012778	0.0026689	4.943801961	0.848142857	4.8469	24.41185		
415	0.002231086	0.004704371	1.92730625	1.448585714	4.9355125	23.8595		
420	0.003787683	0.008960765	1.81836	2.37715	5.644473333	24.52441		
425	0.006768392	0.016133333	1.790826667	11.75395652	6.331693333	23.0354		
430	0.01137806	0.026225	11.25750127	22.86331753	21.26188296	23.28304		
435	0.016858824	0.040314286	40.61630899	6.404441176	44.453268	24.65627		
440	0.02319	0.059346552	19.96685856	4.28675	19.90576394	27.33922		
445	0.030214286	0.080282692	2.28079375	4.121685714	9.580693333	28.90782		
450	0.03485	0.091275	1.960486667	4.23	10.34961333	29.34359		
455	0.030726923	0.078393548	1.9239125	3.900814286	11.0898	30.4925		
460	0.022845	0.060321212	1.92348	3.571657143	11.76982	29.99563		
465	0.017192308	0.048725	2.004453333	3.187814286	12.39346667	29.01958		
470	0.0136	0.039966667	2.0921875	3.132028571	12.94182941	29.2246		
475	0.0115	0.03465	2.256786667	6.116533333	13.35968667	29.58881		
480	0.010728571	0.032333333	2.382973333	10.72654615	13.68372667	29.58318		
485	0.010366667	0.032428571	2.574125	9.566345455	13.97110625	28.33778		
490	0.011316667	0.034471429	2.879453333	6.189957143	14.19598	29.2656		
495	0.014446154	0.0381	3.177446667	3.3182	14.38378667	28.93676		
500	0.019071429	0.04229	3.55624375	1.539942857	14.83723225	28.39326		
505	0.023692308	0.045542857	4.144153333	1.210757143	14.26049333	28.74863		
510	0.028486667	0.0482	4.921406667	0.826914286	14.16479375	27.95267		
515	0.032945455	0.0510625	5.86085	0.8258	14.02823333	27.04093		
520	0.03652	0.053825	6.900866667	0.934114286	13.83470667	26.99912		
525	0.0396125	0.055711111	7.894555625	5.608104545	13.6 913125	27.13098		
530	0.042185714	0.057933333	8.789933333	29.53066796	13.42994	27.00314		
535	0.044428571	0.06026	9.621433333	75.41515328	13.2 275333	26.66868		
540	0.045714286	0.0628375	14.069025	61.27502029	17.8 160549	26.39452		
545	0.047433333	0.064533333	24.65848229	13.64250476	29.567098	26.54004		
550	0.049357143	0.0664	21.1113713	3.532754545	18.45561818	25.79795		
555	0.05208	0.068257143	13.12353684	1.391525	12.6899625	25.03495		
560	0.0552	0.07	13.37198667	1.199028571	12.56653333	24.71014		
565	0.058609091	0.0716	14.07691333	6.377933333	12.54113125	23.8177		
570	0.062558333	0.073133333	14.91957059	15.62201143	12.42783333	24.45848		
575	0.066666667	0.074283333	17.19122333	14.76690909	14.39066977	23.76463		
580	0.07042	0.0753	18.82074	18.47862308	15.01757059	24.4215		
585	0.0735125	0.0761	17.30793125	16.49222903	12.04747333	23.40605		
590	0.076433333	0.0765	17.26683333	7.891206250	12.0537	23.26213		
595	0.078933333	0.0765	17.64614375	4.030433333	12.06013750	22.7122		
600	0.079971429	0.0763	18.06172667	18.64042625	11.93039333	22.6133		
605	0.081114286	0.075271429	18.37778	34.09730719	11.86397333	21.98297		
610	0.0812	0.073816667	18.6537375	9.68624	11.70473125	22.1309		
615	0.0807	0.071871429	18.72960667	7.742375	11.49552	21.97493		
620	0.0791	0.06883	18.77437333	8.486135714	11.33833333	21.01736		
625	0.07624	0.065455556	18.77115625	3.837385714	11.07693125	19.68272		
630	0.072475	0.062044444	18.56556667	1.566871429	10.79736	20.38542		
635	0.068366667	0.05843	18.26672667	1.565833333	10.51950625	20.54702		
640	0.063914286	0.05425	17.794975	1.619557143	10.18376667	20.69576		
645	0.059458333	0.05007	17.28023333	1.618414286	9.790493333	19.5565		
650	0.055341667	0.045891667	16.65584667	1.179928571	9.41503125	20.81234		
655	0.050885714	0.04171	15.962575	1.452228571	8.977146667	19.62564		
660	0.046441667	0.03791	15.28056	1.177771429	8.56572	19.97618		
665	0.041985714	0.0343	14.4866375	0.957957143	8.1318125	19.85317		
670	0.037525	0.030877778	13.69725333	0.792828571	7.670653333	19.36595		
675	0.03375	0.027842857	12.87396	1.229214286	7.231993333	19.70443		
680	0.029991667	0.025185714	12.00995	1.5563	6.806018750	18.74204		
685	0.026575	0.02245	11.16406	1.008457143	6.38232	16.2408		
690	0.023655556	0.0206	10.43118667	0.4059	6.088933333	17.58187		
695	0.0207375	0.018414286	9.5587	1.69665	5.5994	17.34308		
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715	0.012685714	0.011466667	6.558806667	0.4005	4.205153333	15.53248		
720	0.010983333	0.0101247	5.94519375	0.235371429	3.877925	15.03319		
725	0.0094557	0.008942383	5.346246667	0.015571429	3.600626667	15.59816		
730	0.007986586	0.007906314	4.80328	0.014566667	3.325413333	15.56764		

Equal Energy Constant: 1.218

Insert columns to left of User 2 to add additional sources.

Circadian | Data

AutoSave OFF — Melanopic Ratio

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Paste Cut Copy Format — Arial 10 — Wrap Text — Scientific — Conditional Formatting

Recover Unsaved Workbooks. We were able to save changes to one or more files. Do you want to recover them?

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380	0	0	1.469086667	0.088942857	1.316893333	10.27834	6.61E-08	-3.23E-09
385	0	0	1.65856	0.087871429	1.70446	12.70802	6.87E-08	1.49E-08
390	0	0	1.87856875	0.086866667	2.20519375	12.03508	3.85E-08	-2.42E-08
395	0	0	1.928986667	0.808844444	2.598086667	17.4267	3.22E-08	-2.20E-08
400	0	0	7.646746316	2.477175	10.73393659	22.10276	2.81E-08	-2.50E-08
405	0	0.001459025	14.32851284	1.068	14.23881	23.82654	4.31E-08	1.74E-09
410	0.0012778	0.0026689	4.943801961	0.848142857	4.8469	24.41185	7.51E-08	4.12E-08
415	0.002231086	0.004704371	1.92730625	1.448585714	4.9355125	23.8595	1.39E-07	1.05E-07
420	0.003787683	0.008960765	1.81836	2.37715	5.644473333	24.52441	2.96E-07	2.59E-07
425	0.006768392	0.016133333	1.790826667	11.75395652	6.331693333	23.0354	6.39E-07	6.01E-07
430	0.01137806	0.026225	11.25750127	22.86331753	21.26188296	23.28304	1.32E-06	1.32E-06
435	0.016858824	0.040314286	40.61630899	6.404441176	44.453268	24.65627	2.60E-06	2.72E-06
440	0.02319	0.059346552	19.96685856	4.28675	19.90576394	27.33922	4.78E-06	5.19E-06
445	0.030214286	0.080282692	2.28079375	4.121685714	9.580693333	28.90782	7.73E-06	9.25E-06
450	0.03485	0.091275	1.960486667	4.23	10.34961333	29.34359	9.80E-06	1.30E-05
455	0.030726923	0.078393548	1.9239125	3.900814286	11.0898	30.4925	9.26E-06	1.30E-05
460	0.022845	0.060321212	1.92348	3.571657143	11.76982	29.99563	7.39E-06	1.01E-05
465	0.017192308	0.048725	2.004453333	3.187814286	12.39346667	29.01958	6.93E-06	8.48E-06
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475	0.0115	0.03465	2.256786667	6.116533333	13.35968667	29.58881	1.23E-05	1.34E-05
480	0.010728571	0.032333333	2.382973333	10.72654615	13.68372667	29.58318	1.63E-05	1.74E-05
485	0.010366667	0.032428571	2.574125	9.566345455	13.97110625	28.33778	1.77E-05	1.86E-05
490	0.011316667	0.034471429	2.879453333	6.189957143	14.19598	29.2656	1.60E-05	1.65E-05
495	0.014446154	0.0381	3.177446667	3.3182	14.38378667	28.93676	1.35E-05	1.37E-05
500	0.019071429	0.04229	3.55624375	1.539942857	14.83723225	28.39326	1.17E-05	1.21E-05
505	0.023692308	0.045542857	4.144153333	1.210757143	14.26049333	28.74863	1.07E-05	1.13E-05
510	0.028486667	0.0482	4.921406667	0.826914286	14.16479375	27.95267	1.00E-05	1.07E-05
515	0.032945455	0.0510625	5.86085	0.8258	14.02823333	27.04093	9.69E-06	1.04E-05
520	0.03652	0.053825	6.900866667	0.934114286	13.83470667	26.99912	9.49E-06	1.03E-05
525	0.0396125	0.055711111	7.894555625	5.608104545	13.63913125	27.13098	9.40E-06	1.03E-05
530	0.042185714	0.057933333	8.789933333	29.53066796	13.42994	27.00314	9.37E-06	1.02E-05
535	0.044428571	0.06026	9.621433333	75.41515328	13.27275333	26.66868	9.38E-06	1.01E-05
540	0.045714286	0.0628375	14.069025	61.27502029	17.82160549	26.39452	9.51E-06	1.01E-05
545	0.047433333	0.064533333	24.65848229	13.64250476	29.567098	26.54004	9.70E-06	1.02E-05
550	0.049357143	0.0664	21.1113713	3.532754545	18.44561818	25.79795	9.98E-06	1.04E-05
555	0.05208	0.068257143	13.12353684	1.391525	12.6899625	25.03495	1.04E-05	1.06E-05
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565	0.058609091	0.0716	14.07691333	6.377933333	12.54113125	23.8177	1.14E-05	1.15E-05
570	0.062558333	0.073133333	14.91957059	15.62201143	12.42783333	24.45848	1.22E-05	1.20E-05
575	0.066666667	0.074283333	17.19122333	14.76690909	14.39066977	23.76463	1.30E-05	1.27E-05
580	0.07042	0.0753	18.82074	18.47862308	15.01757059	24.4215	1.39E-05	1.35E-05
585	0.0735125	0.0761	17.30793125	16.49222903	12.04747333	23.40605	1.49E-05	1.43E-05
590	0.076433333	0.0765	17.26683333	7.891206250	12.0537	23.26213	1.58E-05	1.50E-05
595	0.078933333	0.0765	17.64614375	4.030433333	12.06013750	22.7122	1.67E-05	1.57E-05
600	0.079971429	0.0763	18.06172667	18.64042625	11.93039333	22.6133	1.74E-05	1.63E-05
605	0.081114286	0.075271429	18.37778	34.09730719	11.86397333	21.98297	1.80E-05	1.68E-05
610	0.0812	0.073816667	18.6537375	9.68624	11.70473125	22.1309	1.85E-05	1.71E-05
615	0.0807	0.071871429	18.72960667	7.742375	11.49552	21.97493	1.88E-05	1.73E-05
620	0.0791	0.06883	18.77437333	8.486135714	11.33833333	21.01736	1.88E-05	1.73E-05
625	0.07624	0.065455556	18.77115625	3.837385714	11.07693125	19.68272	1.87E-05	1.71E-05
630	0.072475	0.062044444	18.56556667	1.566871429	10.79736	20.38542	1.85E-05	1.68E-05
635	0.068366667	0.05843	18.26672667	1.565833333	10.51950625	20.54702	1.81E-05	1.63E-05
640	0.063914286	0.05425	17.794975	1.619557143	10.18376667	20.69576	1.75E-05	1.57E-05
645	0.059458333	0.05007	17.28023333	1.618414286	9.790493333	19.5565	1.67E-05	1.49E-05
650	0.055341667	0.045891667	16.65584667	1.179928571	9.41503125	20.81234	1.59E-05	1.41E-05
655	0.050885714	0.04171	15.962575	1.452228571	8.977146667	19.62564	1.50E-05	1.33E-05
660	0.046441667	0.03791	15.28056	1.177771429	8.56572	19.97618	1.40E-05	1.23E-05
665	0.041985714	0.0343	14.4866375	0.957957143	8.1318125	19.85317	1.30E-05	1.13E-05
670	0.037525	0.030877778	13.69725333	0.792828571	7.670653333	19.36595	1.19E-05	1.03E-05
675	0.03375	0.027842857	12.87396	1.229214286	7.231993333	19.70443	1.08E-05	9.36E-06
680	0.029991667	0.025185714	12.00995	1.5563	6.806018750	18.74204	9.86E-06	8.47E-06
685	0.026575	0.02245	11.16406	1.008457143	6.38232	16.2408	8.90E-06	7.62E-06
690	0.023655556	0.0206	10.43118667	0.4059	6.088933333	17.58187	8.00E-06	6.80E-06
695	0.0207375	0.018414286	9.5587	1.69665	5.5994	17.34308	7.15E-06	6.03E-06
700	0.018171429	0.0164	8.75744	3.933855556	5.2211	17.22972	6.35E-06	5.28E-06
705	0.016028571	0.014557143	8.006453333	2.125175	4.863218750	17.46368	5.62E-06	4.65E-06

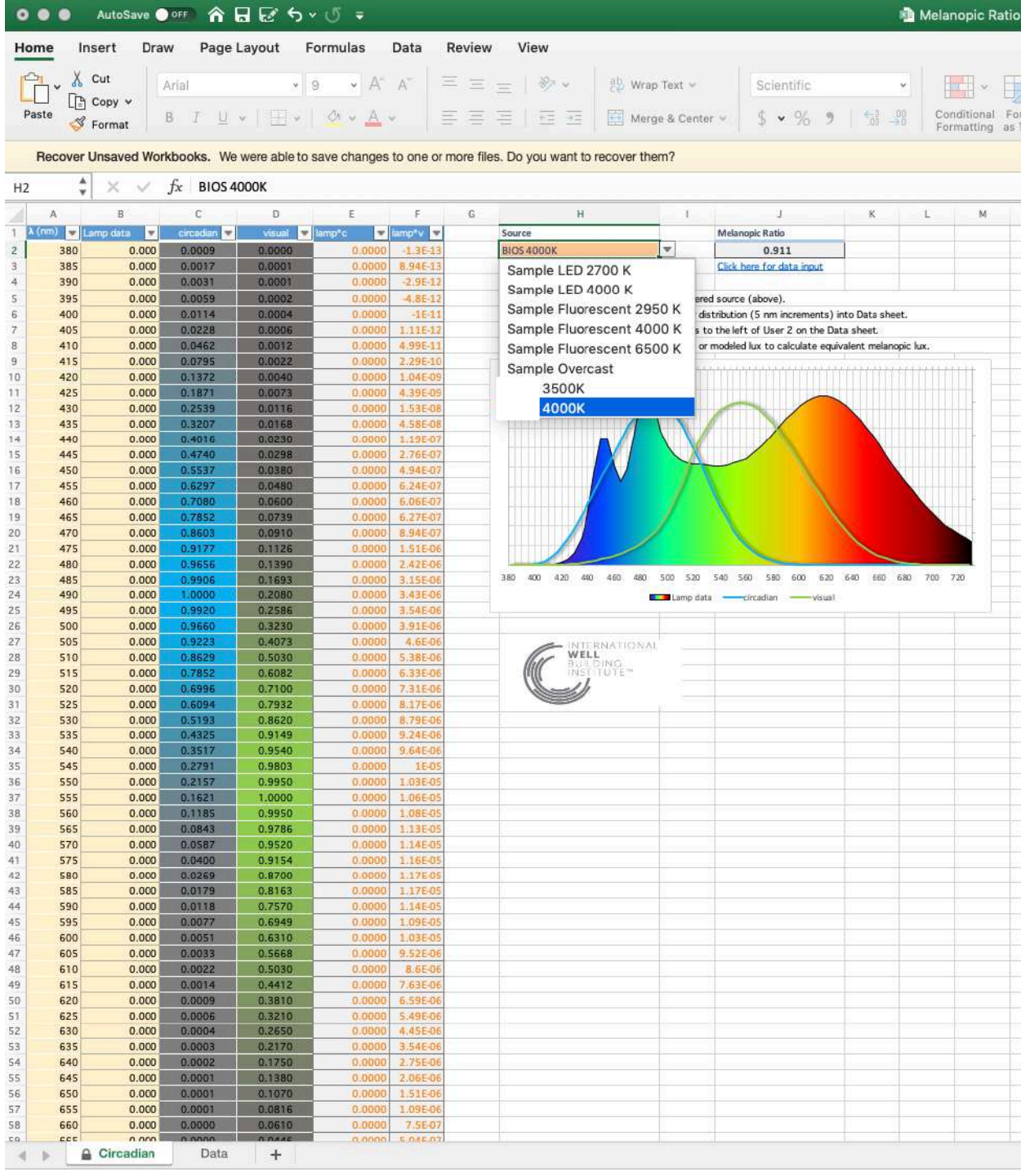
Equal Energy Constant: 1.218

Insert columns to left of User 2 to add additional sources.

Circadian | Data

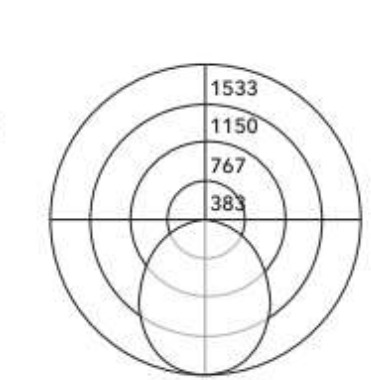
LEDucation

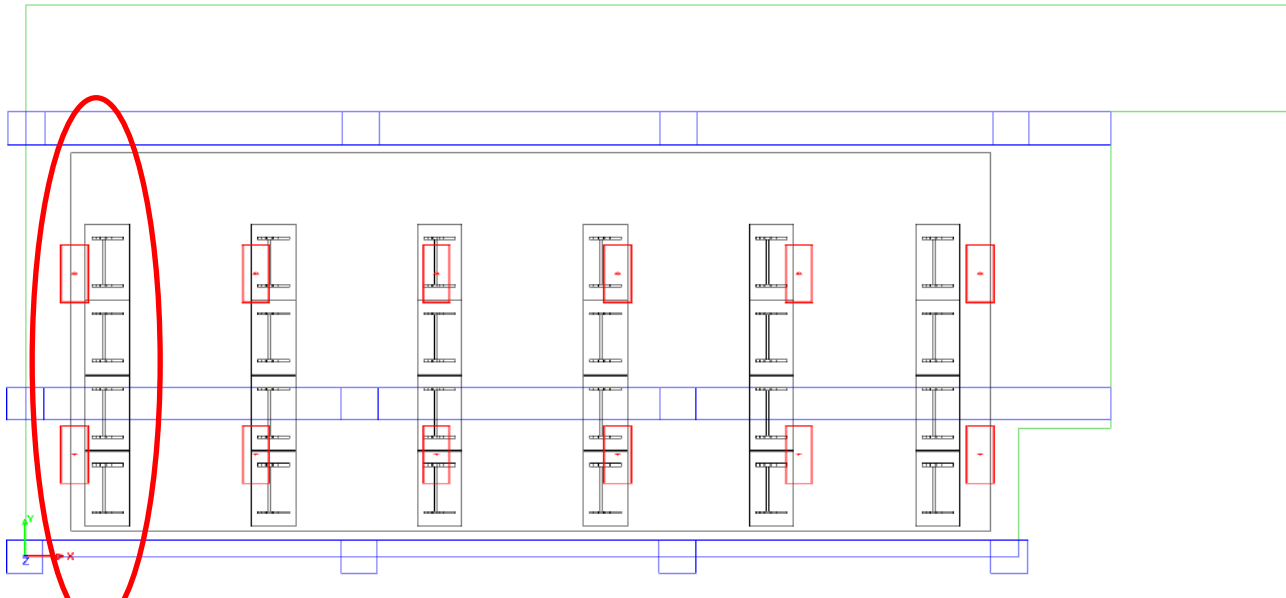
- Calculator can be found at: https://standard.wellcertified.com/tables#melanopicRatio
- Click data tab to input your own SPD data
- In this instance, we see an m/p of 0.911 (We'll use 0.9 for our example)



Open Office with a troffer

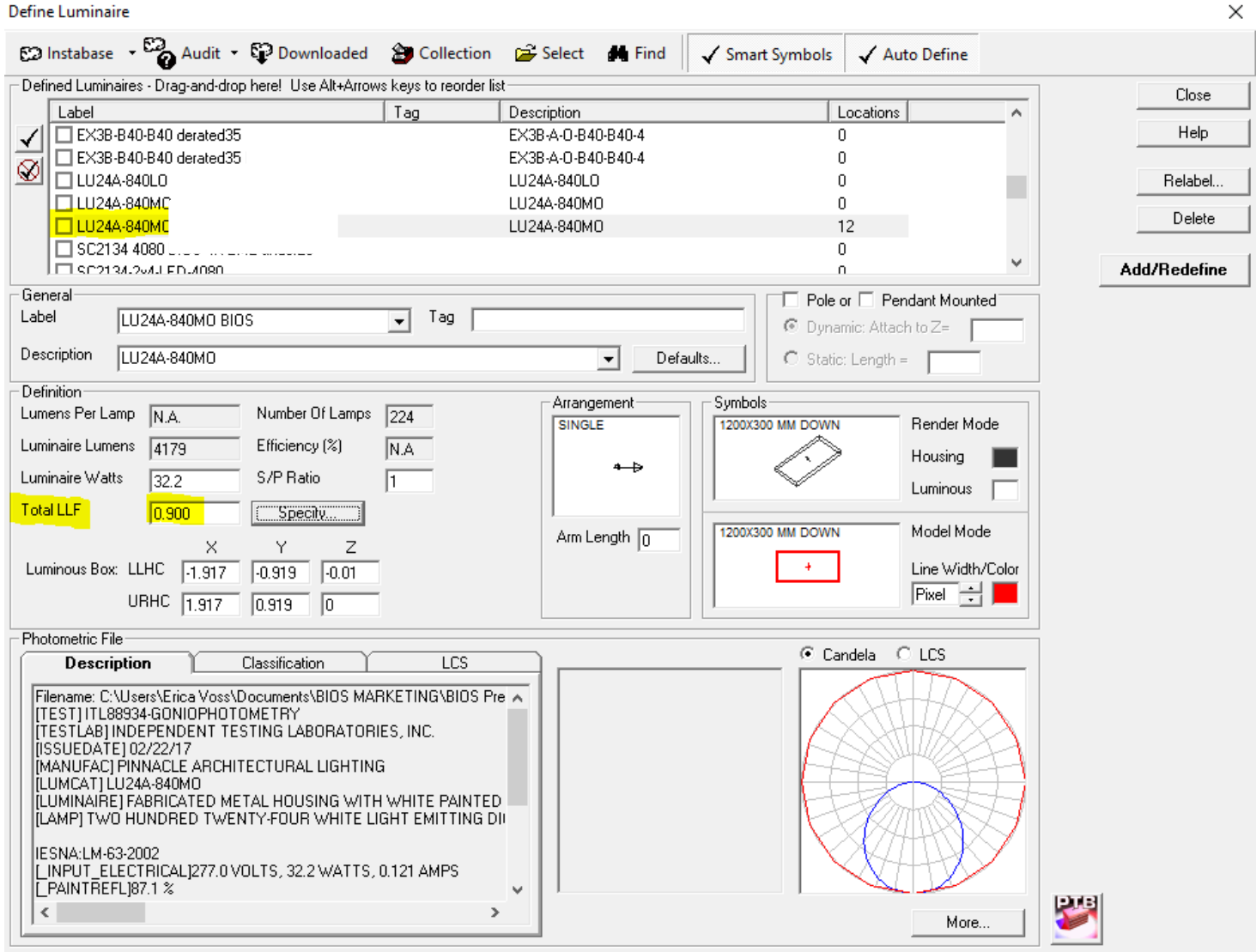
- Open Office 66’ x 31’
- 5 or 6 long tables with workstations
- Notes: tables facing walls are going to suffer on vertical lux





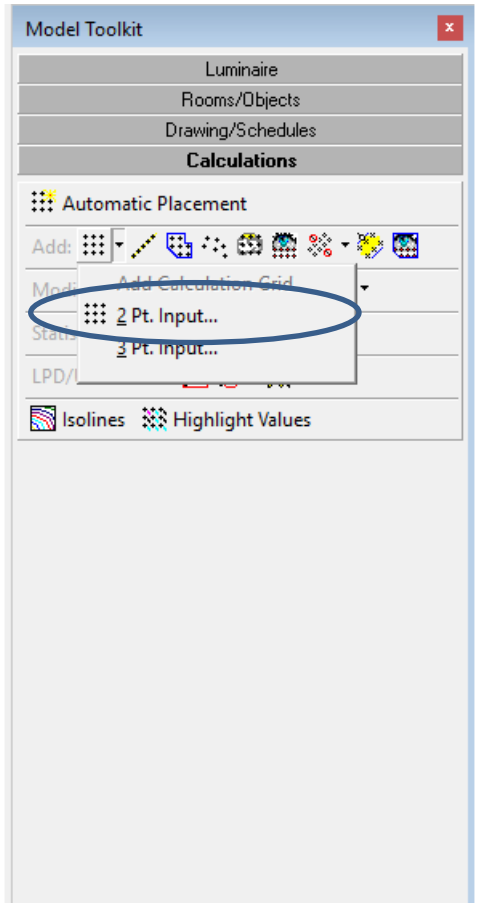
Adding m/p ratio into calcs

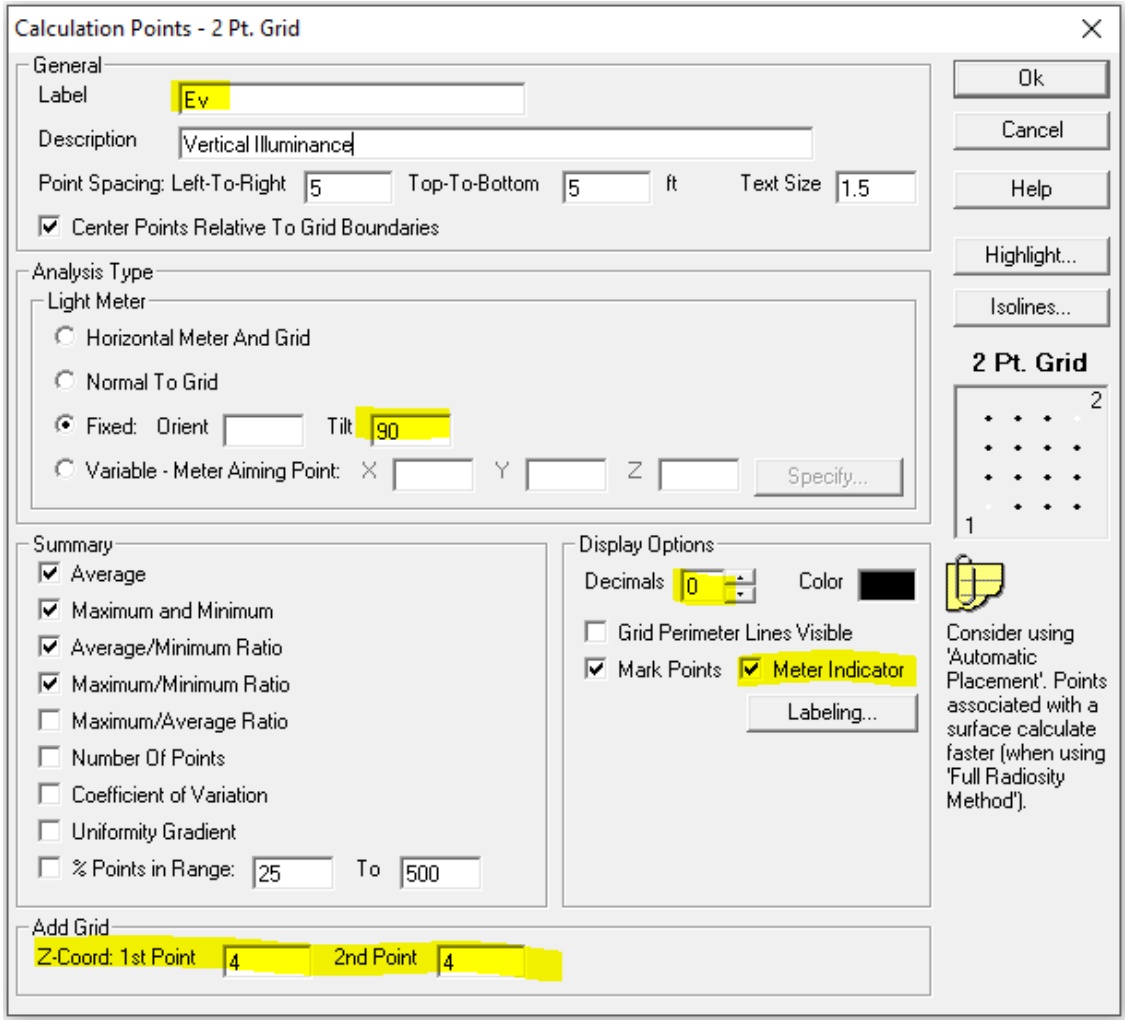
- Uploading m/p (0.9) as a LLF



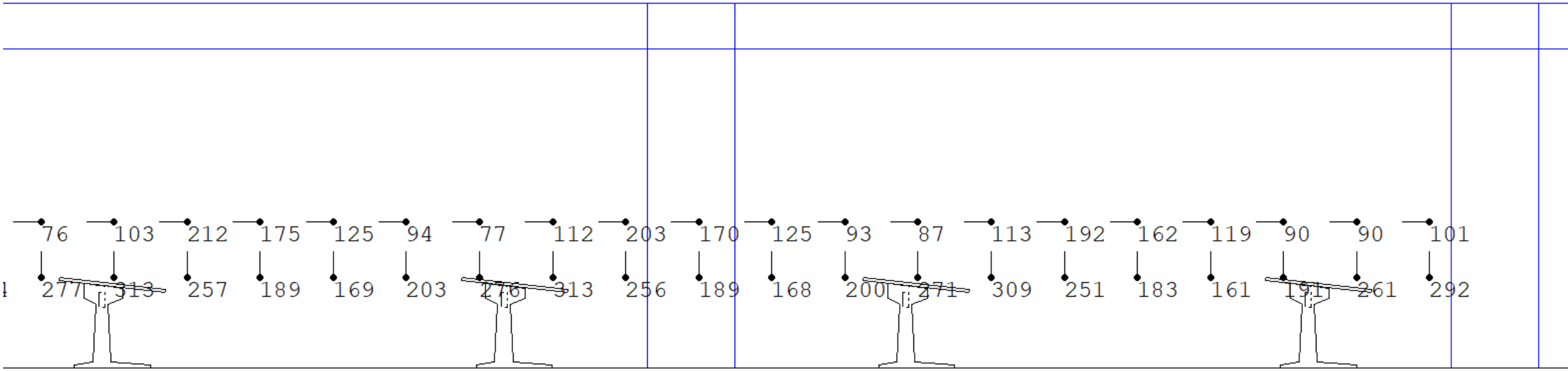
Setting up vertical calcs

- Must use 2 point calculation
- Tilt light meter 90 degrees
  - Orientation dictates which direction looking
  - Turn on meter indicator to see direction
- 4’ above finished floor



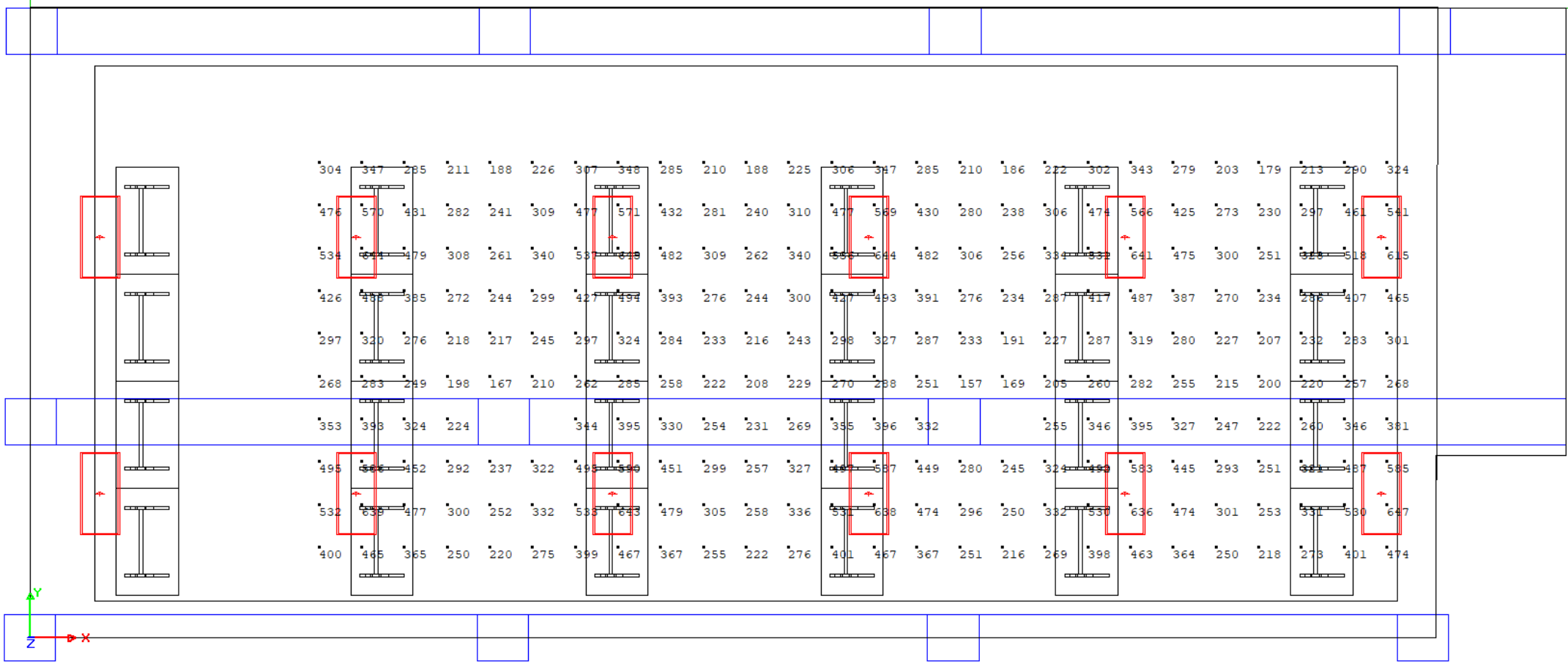


Elevation view of horizontal calc plane and vertical calc plane



LPDArea_1

Area = 2066 Sq.ft
Total Watts = 386.4001
LPD = 0.187 Watts/Sq.ft
UWLR = 0.000

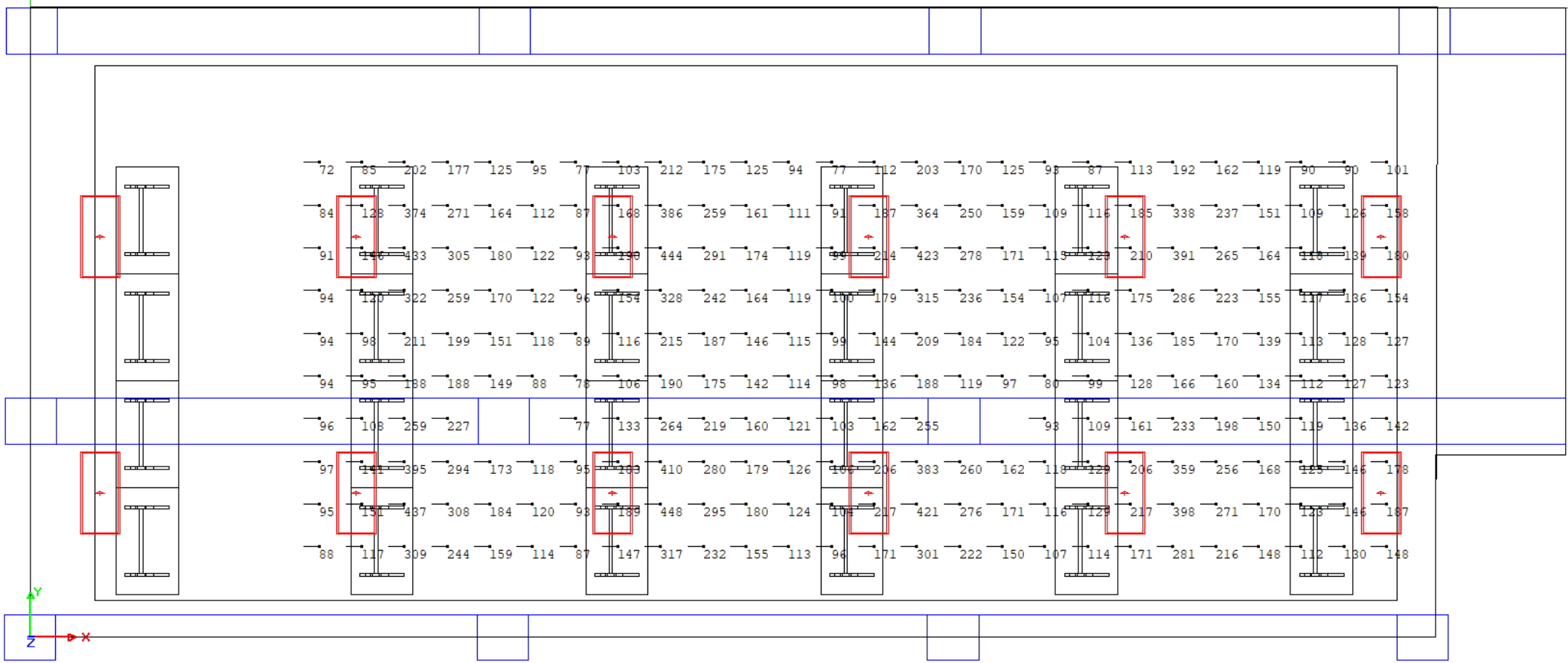


Visual Light Levels - Lux

Illuminance (Lux)
Average = 345.21
Maximum = 647.0
Minimum = 157.0
Avg/Min Ratio = 2.20
Max/Min Ratio = 4.12

LPDArea_1

Area = 2066 Sq.ft
Total Watts = 386.4001
LPD = 0.187 Watts/Sq.ft
UWLR = 0.000



Circadian Light Level - EML

Average = 172.61
Maximum = 448.0
Minimum = 72.0
Avg/Min Ratio = 2.40
Max/Min Ratio = 6.22

LEDucation

Data

	Standard Troffer design w/ Standard 4000K LED	High output design to meet WELL criteria	Troffer (3,950 lm @ 37.4W) – Spectrally optimized 3500K LED
Fixture Output	4,179 lm	5,403 lm	3,950 lm
Fixture Wattage	32.2 W	42.5 W	37.4 W
Fixture efficacy	129 lm/W	129 lm/W	104 lm/W
CCT	4000K	4000K	3500K
m/p	0.61	0.61	0.83
LPD	.187	.246	.215
Horizontal lux	345 [32 FC]	446 [41.5 FC]	326 [30 FC]
Vertical lux	191 [18 FC]	246 [23 FC]	181 [16.8 FC]
Vertical m-lux	116	150	150

Spectrally optimized fixtures may ”under perform” in efficacy, but when do better in total energy consumption when trying to achieve circadian metrics

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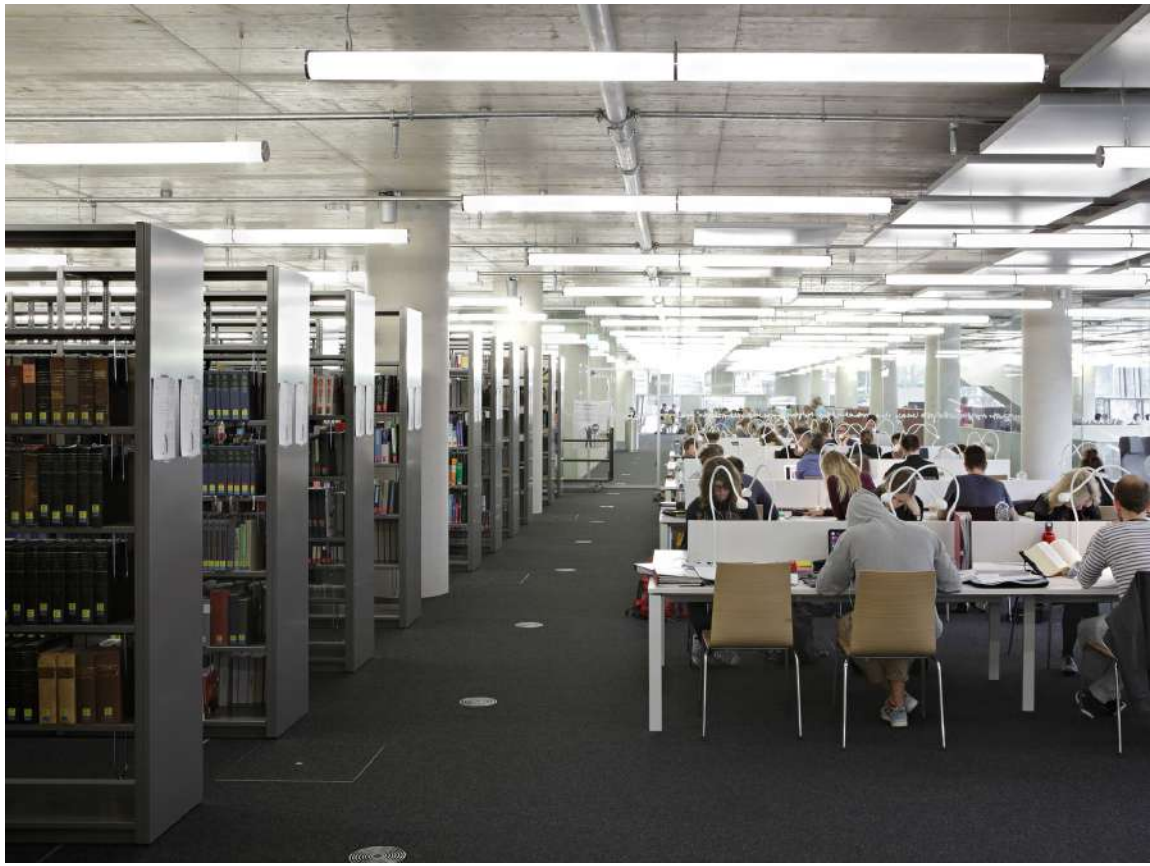
LEDucation

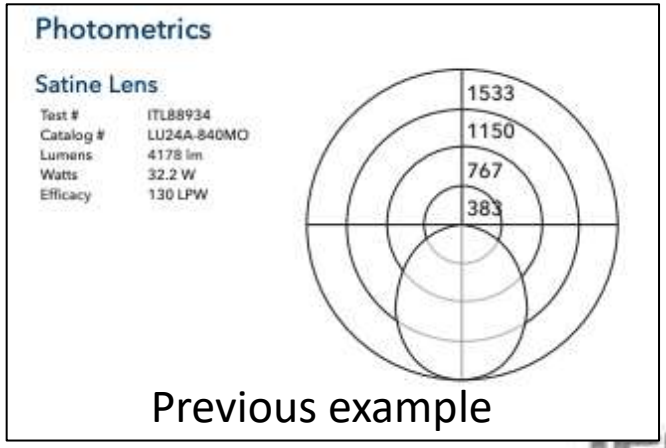
In review

- Brighter days and darker nights is the goal
  - The brighter the day, the better
  - The darker the night, the better (didn't get into this much, but trust me)
- Vertical lux is what we need, not horiztonal
- ALL MODELS AGREE AT 3500K and warmer
- That's GREAT, because we like 3500K and warmer.

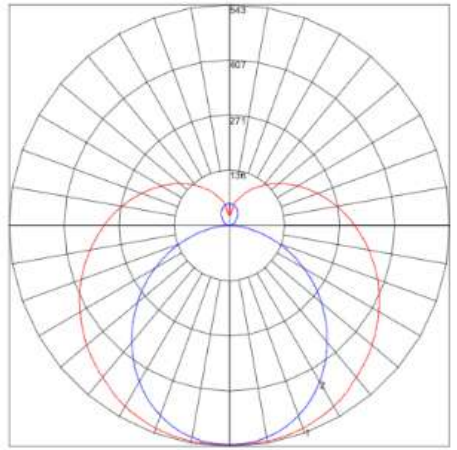
Getting more vertical lux

- More luminous pendants can get more vertical lux





Previous example



Data

	Luminous pendant design w/ Standard 4000K LED	High output design to meet WELL criteria	Luminous pendant design w/ Spectrally optimized 4000K LED
Fixture Output	2,339 lm	2,690 lm	2,339 lm
Fixture Wattage	27.2 W	32.3 W	33.4 W
Fixture efficacy	85 lm/W	85 lm/W	70 lm/W
CCT	4000K	4000K	4000K
m/p	0.61	0.61	0.91
LPD	.384	.44	.45
Horizontal lux	320 [30 FC]	368 [34 FC]	320 [30 FC]
Vertical lux	214 [20 FC]	246 [23 FC]	214 [20 FC]
Vertical m-lux	130	150	194

LEDucation

Putting the light where you need it

- Take a page out of task lighting's handbook
- But now, the "task" has changed

But let’s go a little further

- Why do we dislike 6500K, when it’s 6500K outside
- What if we can change preference?
- What if what you see is not what you get?

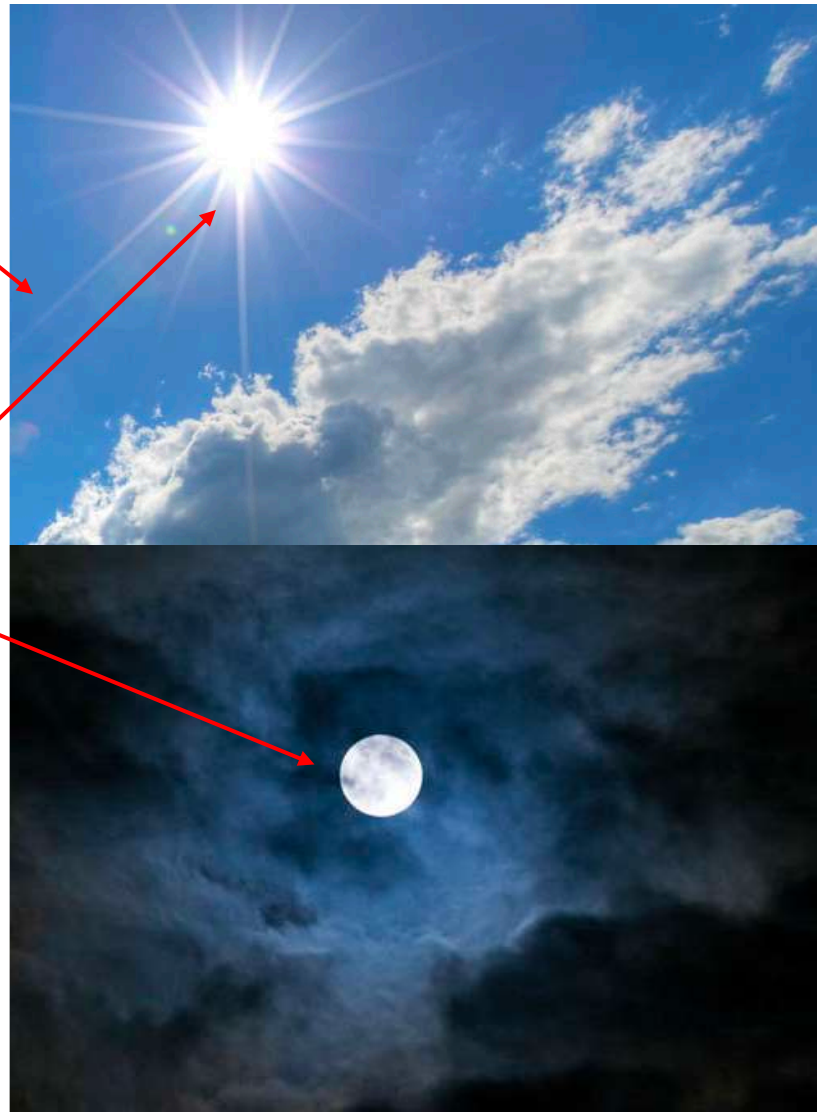
Demonstration 1

Color Constancy (adaptation)

- Our color vision is compromised in the most central field of view
  - Lack of S cones
  - Macular pigment
- We use surrounding information and information about the light source to calculate a perceived color
- Blue colored sky is important to making colder lights appear warmer
- Nature is nominally 6500K
  - Nothing is actually 6500K
  - A gradient of colors warmer than 5000K and colder than 6500K

This is important to shifting the preference curve

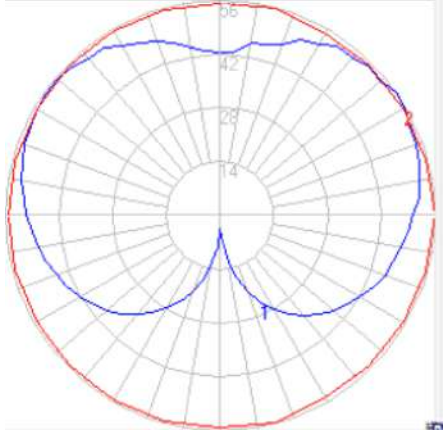
Which is warmer?

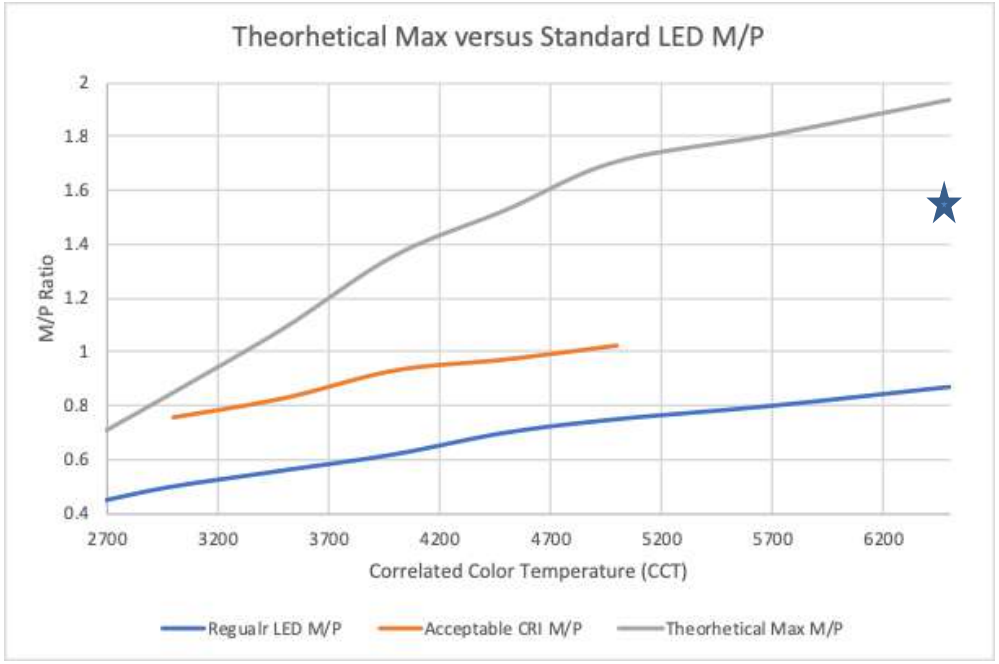


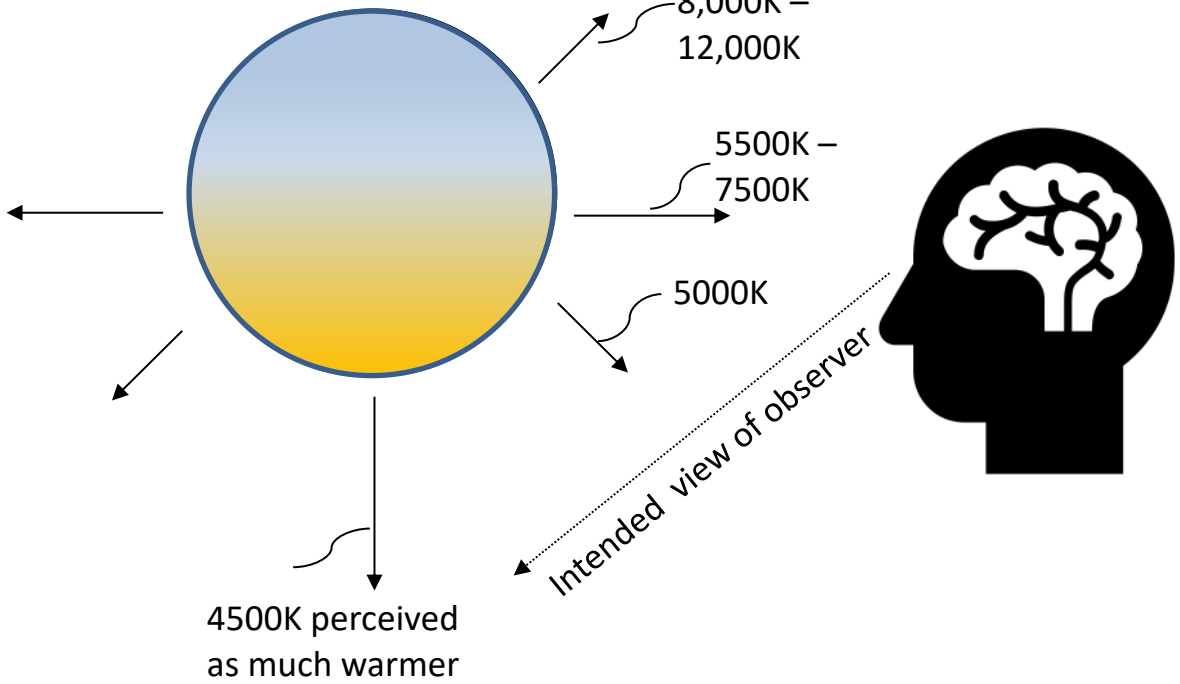
LEDucation

Demonstration that is WAY better in person

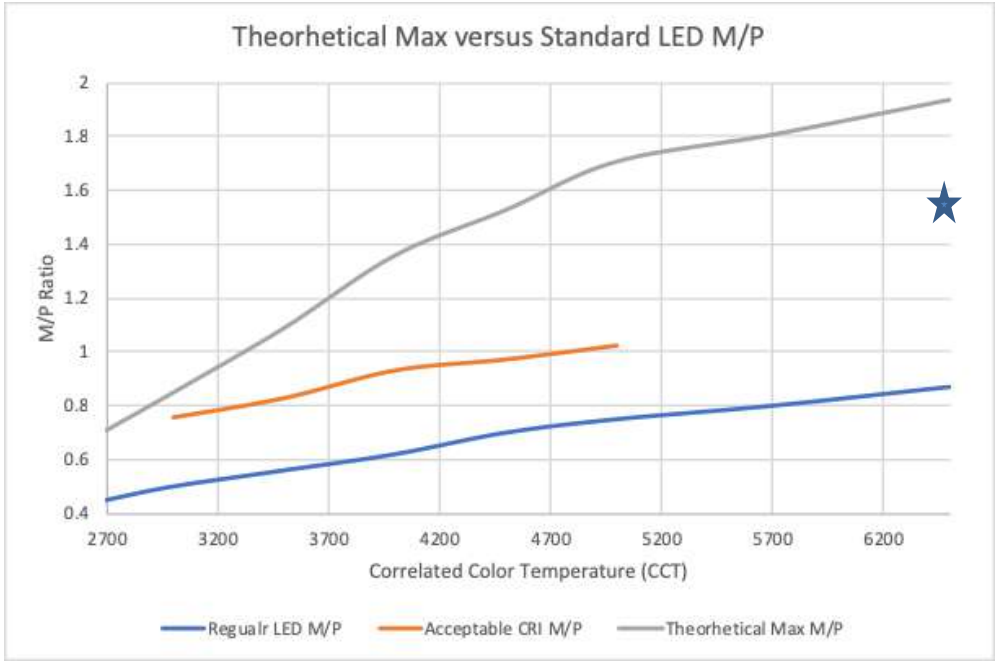
Color gradients (Task Lamp)







Color gradients (Task Lamp)



Color gradients (Task Lamp)

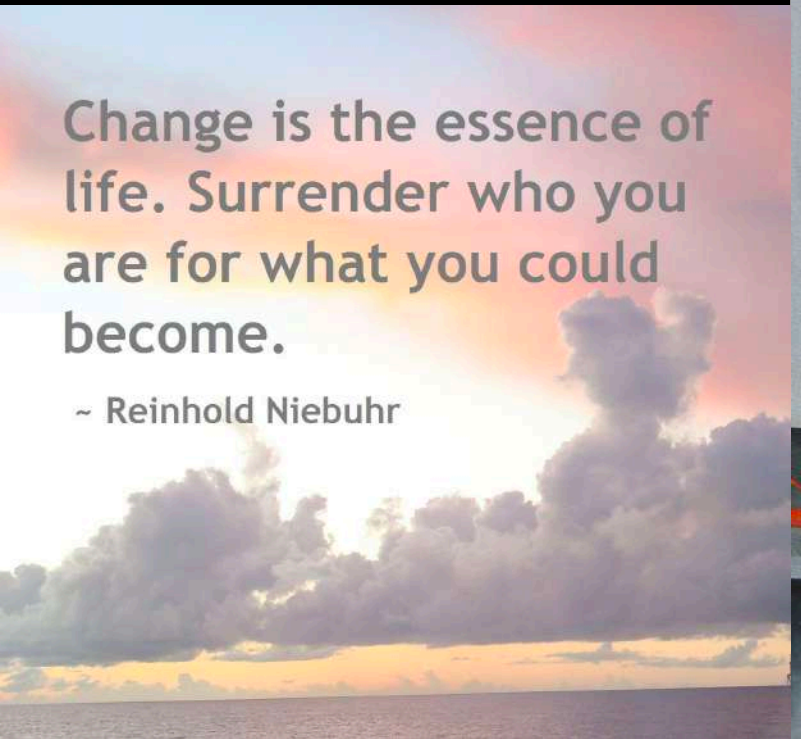
- 6500K directed at the eye (1.5 m/p ratio)
  - 3 vertical lumens for 1 horizontal lumens
- Provides 200 melanopic lux when placed next to a monitor
  - Takes all the design work out of meeting WELL
- Biophilic component
- Individualized control

Final recap

Health and Wellness lighting:

- We’re in enough agreement in order to really get started
- Think about spectrum and color together
  - 490nm peak during the daytime
    - Use coolest acceptable CCT for maximum benefit (note: full agreement at 3500K)
  - 450nm peak at night
    - Use warmest acceptable CCT for maximum benefit
- Standard (not spectrally optimized) LED can achieve daytime requirements, but it will come at the cost of energy and comfort
- Spectrally optimized solutions can provide an energy efficient and comfortable daytime environment
- Luminous pendants can increase the vertical lux compared to traditional light sources
- Color separation can take circadian lighting to the next level
- Task lighting is going to take a new evolution

Catnap Mural
by Michael Sommers
Location: Carlsbad, CA



This concludes The American Institute of Architects Continuing Education Systems Course

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