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Retrofitting Fluorescent Lamp Growth Chambers with Ceramic Metal Halide Lamps

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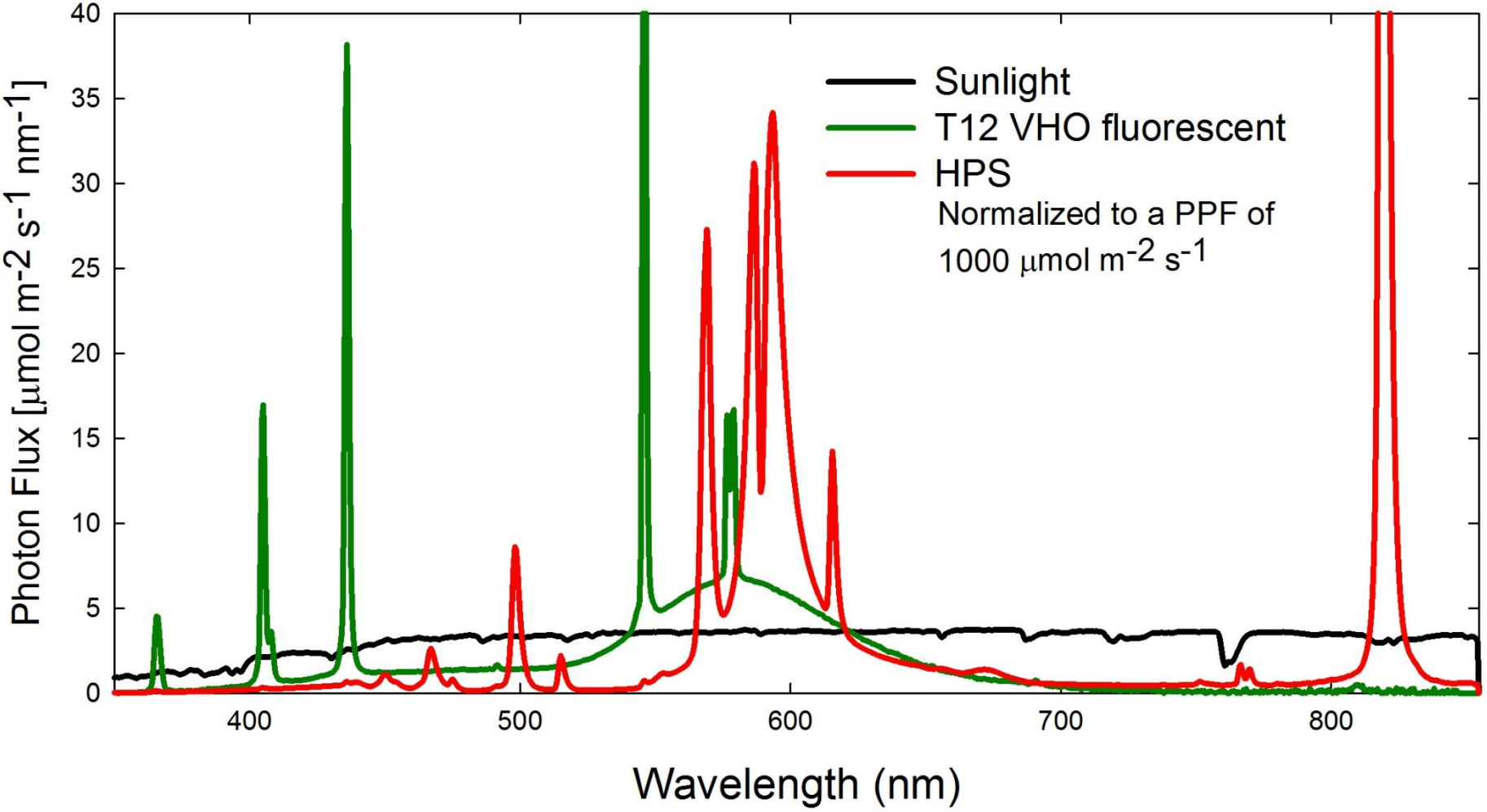
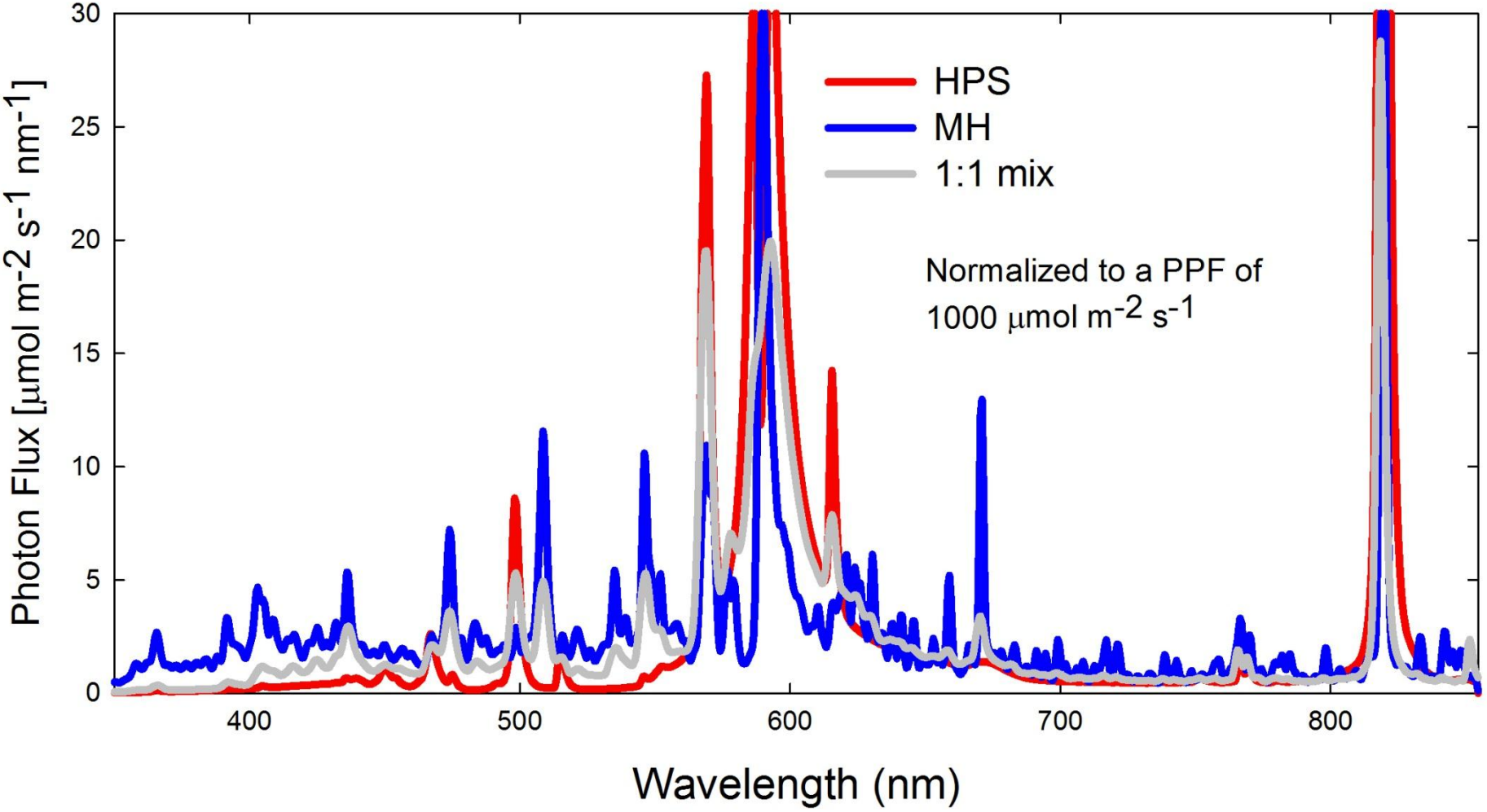
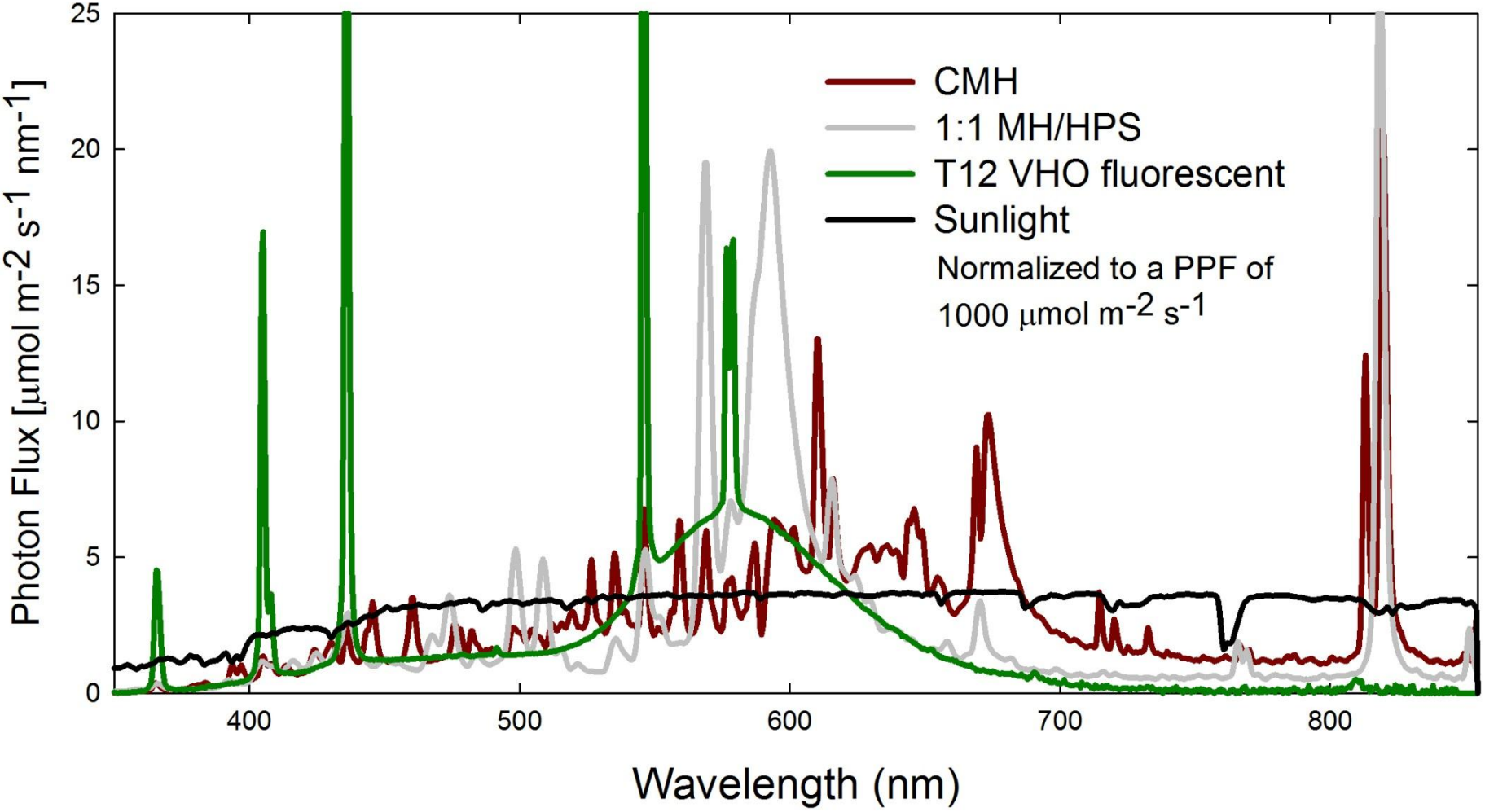
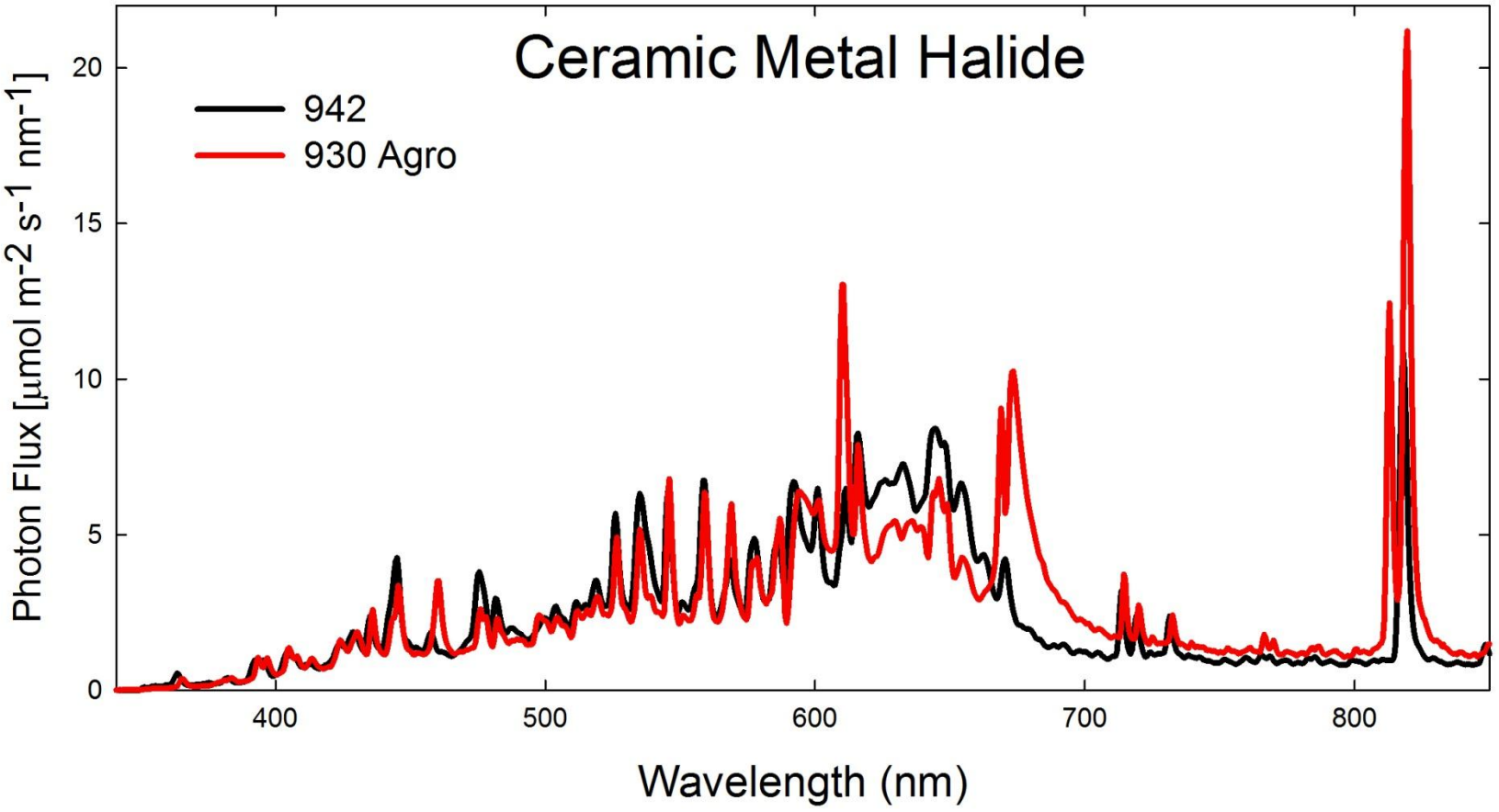
LIGHT QUALITY ANALYSIS


Sunlight
T12 VHO fluorescent
HPS
Normalized to a PPF of
1000 μmol m-2 s-1
Photon Flux [μmol m-2 s-1 nm-1]
Wavelength (nm)
0
5
10
15
20
25
30
35
40
400
500
600
700
800


HPS
MH
1:1 mix
Normalized to a PPF of
1000 μmol m-2 s-1
Photon Flux [μmol m-2 s-1 nm-1]
Wavelength (nm)
0
5
10
15
20
25
30
400
500
600
700
800


CMH
1:1 MH/HPS
T12 VHO fluorescent
Sunlight
Normalized to a PPF of
1000 μmol m-2 s-1
Photon Flux [μmol m-2 s-1 nm-1]
Wavelength (nm)
0
5
10
15
20
25
400
500
600
700
800

A comparison of two Philips ceramic metal halide lamps



Light Quality Analysis of Light Sources

		Radiation distribution (% of PPF)							Ratios important to Photosynthesis		Ratios important to Phytochrome		
					Totals to 100%								
		%UVB (287-320)	%UVA (320-399)	Weighted UV[1]	%Blue (400-500)	%Green (501-600)	%Red (601-700)	%Near IR (701-850)	YPF / PPF	PPF / kLux	PPE[2]	Skye[3] Red/FR	(630-660) / (712-742)[4]
Sunlight-Solar Noon													
18-Mar	Clear	0.39	8.3	3.9	28.3	35.4	36.2	50.4	0.89	16.2	0.72	1.06	1.07
26-May	Clear	0.47	8.5	4.3	28.0	35.5	36.5	50.8	0.90	16.2	0.72	1.03	1.08
11-May	Cloudy	0.51	8.8	4.5	28.0	35.5	36.5	53.7	0.91	16.2	0.71	0.98	1.02
HID 1000 W													
HPS	Philips	0.01	0.8	0.3	7.5[5]	64.6	27.9	56.6	0.88	10.9	0.87	3.3	3.65
Metal Halide	GE	0.13	8.2	2.9	24.2	49.9	25.9	26.5	0.91	13.4	0.80	2.5	2.38
Metal Halide	EYE	0.03	5.0	1.6	20.9	59.7	19.3	22.7	0.95	11.6	0.82	4.2	3.66
1:1 HPS MH Mix		0.06	1.7	0.5	12.4	58.9	28.7	21.1	0.93	11.8	0.83	3.3	3.03
Ceramic Metal Halide													
9420 K	Philips	0.03	1.9	0.5	17.0	43.1	39.9	18.1	0.891*	14.3	0.82	4.1	3.68
9300 K	Philips (Agro)	0.01	0.4	0.1	14.3	37.7	48.0	21.7	0.899	15.8	0.82	2.7	2.72
VHO Fluorescent													
T12	Sylvania	0.55	2.7	3.0	22.4	53.1	24.6	3.4	0.89	12.0	0.83	8.6	7.09
T12	GE	0.43	2.8	2.2	22.4	53.3	24.4	4.0	0.89	11.9	0.83	10.3	6.42
T12	Philips	0.49	2.1	2.7	20.9	54.4	24.8	4.4	0.90	11.7	0.83	6.9	7.33
HO Fluorescent													
T8	Sylvania	0.32	1.7	1.7	21.2	48.0	30.7	3.2	0.91	11.8	0.84	5.8	6.19
T8	GE	0.30	1.6	1.6	18.2	45.2	36.6	4.7	0.91	11.8	0.84	4.0	4.52
T8	Philips	0.40	1.5	1.9	15.0	41.4	43.6	5.1	0.91	11.9	0.85	4.0	4.29
T5	Sylvania	0.10	2.1	1.3	25.8	42.9	31.3	3.6	0.89	12.2	0.83	3.9	4.50
T5	GE	0.11	1.8	1.2	25.1	43.1	31.8	3.4	0.88	12.1	0.83	3.9	4.62
T5	Philips	0.11	1.9	1.3	27.5	40.7	31.8	3.8	0.89	12.7	0.82	3.9	4.37
LED													
Warm		0.00	0.0	0.0	10.2	41.1	48.6	7.3	0.91	14.2	0.84	4.7	5.01
Neutral		0.00	0.0	0.0	18.5	46.2	35.3	4.8	0.88	13.1	0.84	5.5	5.40
Cool		0.00	0.1	0.0	25.7	49.1	25.2	2.8	0.86	12.7	0.83	5.9	6.14
Compact Fluorescent													
30 W	Sylvania	0.10	1.9	1.4	17.9	40.4	41.7	5.5	0.91	12.4	0.84	3.4	4.11
13 W	Black Light	13	756	326	92.8	3.3	3.8	23.6	2.95	105	0.75	0.0	0.08
Incandescent 100 W		0.02	0.7	0.6	8.0	29.1	62.9	167.5	0.94	19.0	0.65	0.6	0.65
Quartz Halogen[6]		0.14	1.9	2.5	11.5	31.6	56.9	128.7	0.95	17.8	0.67	0.7	0.73

LIGHT UNIFORMITY

	Intensity			Efficiency				Uniformity					
	Average PPF			kWatts	Average PPF per kilowatt			Max Min			Coefficient of Variation (%)		
	50	80	Avg		50	80	Avg	50	80	Avg	50	80	Avg
T12 Fluorescent	480	375	428	3.08	156	122	139	1.70	1.48	2	12.7	8.9	11
HPS/MH Mix													
Horizontal Mount	1638	1352	1495	4.66	352	290	321	1.65	1.37	2	11.3	7.1	9
CMH													
Horizontal Mount	1532	1178	1355	2.16	709	545	627	1.27	1.16	1	7.3	4.1	6
Vertical Mount	1608	1201	1405	2.16	744	556	650	1.28	1.26	1	4.9	4.3	5
Vertical Mount w/ Painted Tips	1595	1161	1378	2.16	738	538	638	1.17	1.17	1	3.5	3.7	4

T12 Fluorescent- 16, 6 ft VHO, cool white fluorescent tubes with 2, 18” tubes on each end in a Conviron E15 Chamber. Adjusted to new brightness.

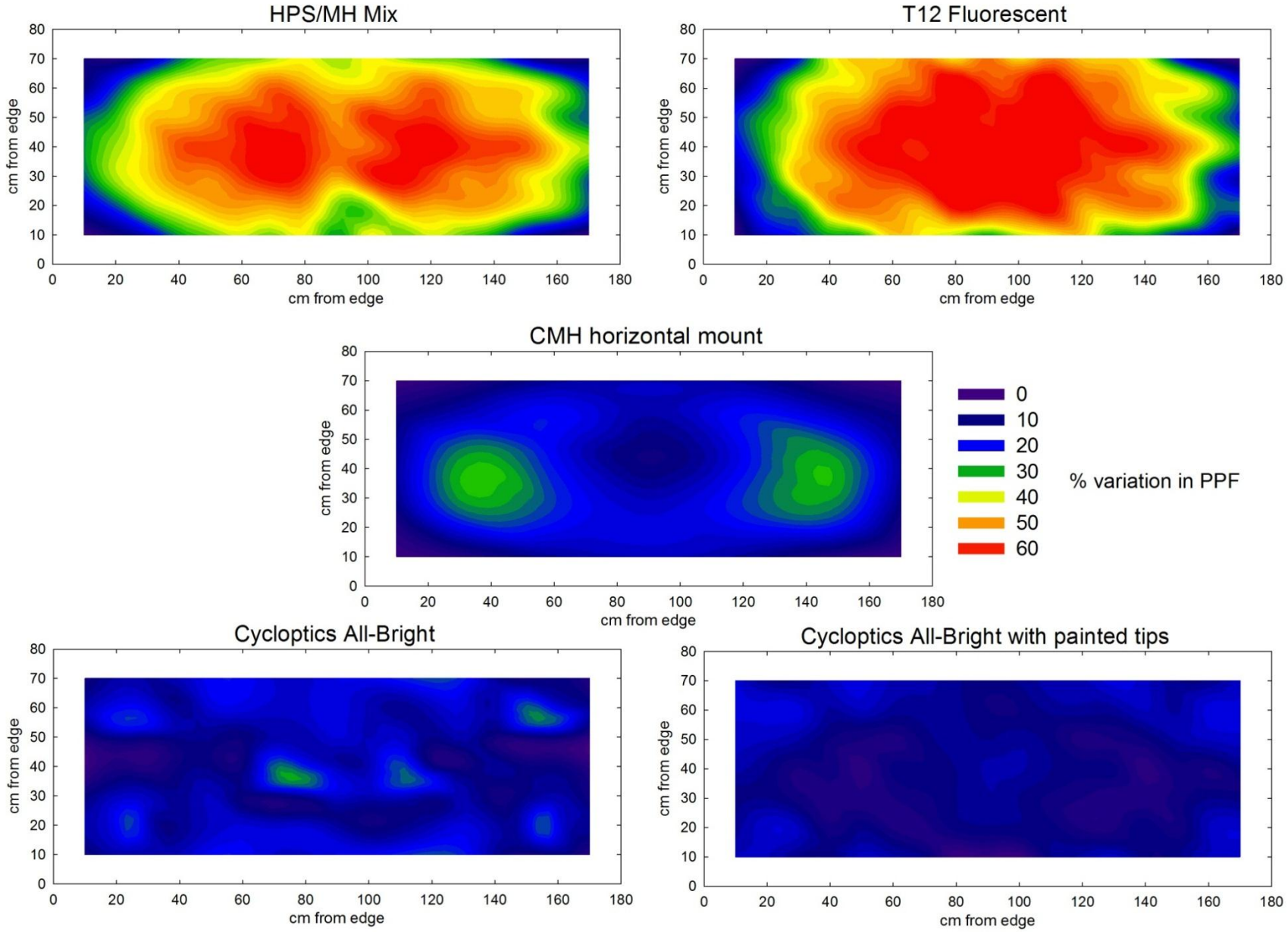
Horizontal Mount HPS/MH- A standard Conviron PGR15 (same dimensions as an E15) chamber with the original mix of 5 High Pressure Sodium and 5 Metal Halide lamps.

Horizontal Mount CMH- 6 Ceramic Metal Halide lamps retrofitted into a Conviron E15 chamber.

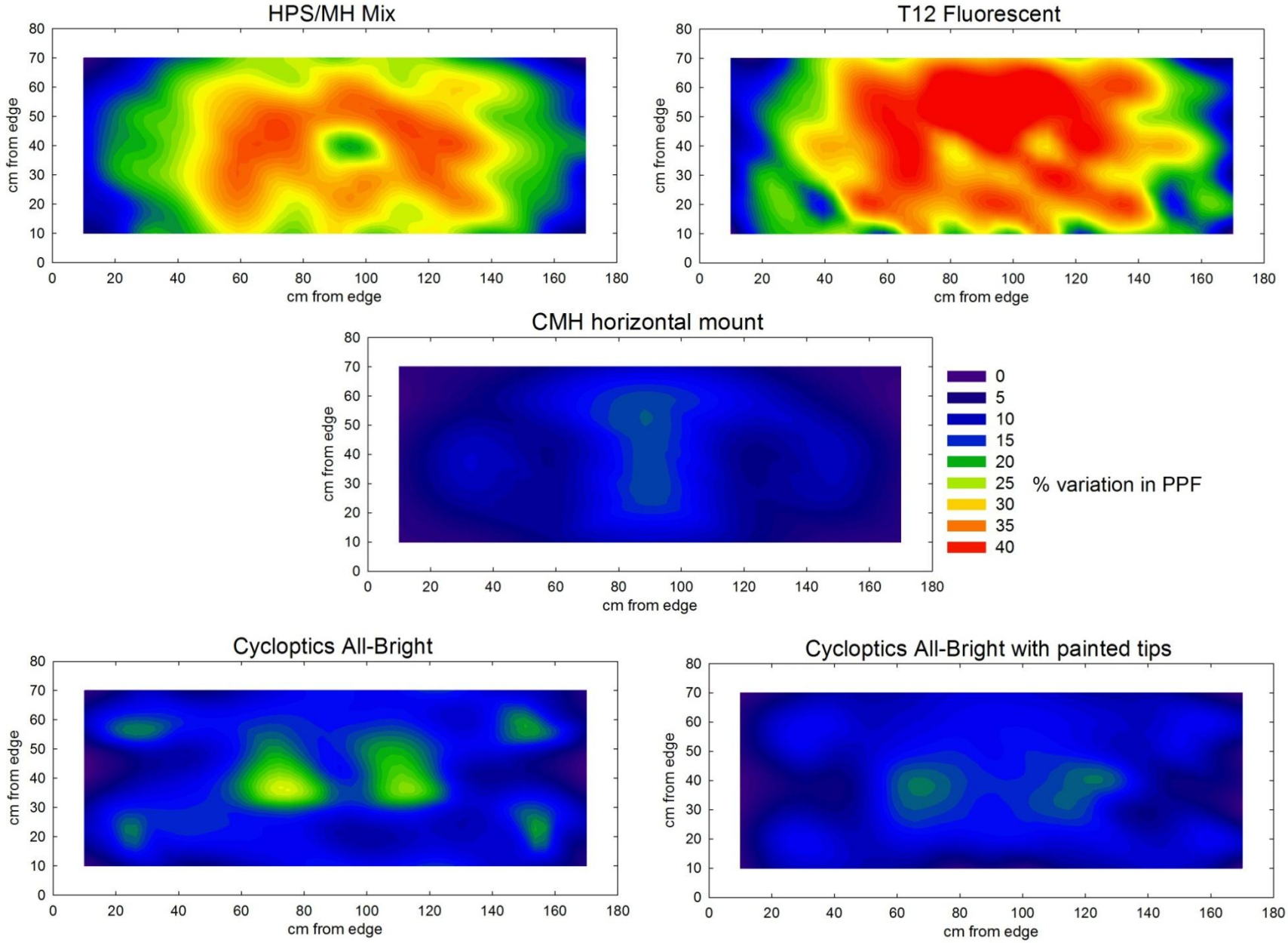
Vertical Mount Mount CMH- 6 Ceramic Metal Halide lamps in Cycloptics All-Bright luminaires, retrofitted into a Conviron E15 chamber.

Vertical Mount CMH with Painted Tips- 6 Ceramic Metal Halide lamps in Cycloptics All-Bright luminaires, incorporating a painted tip to remove bright spots directly below the lamp, retrofitted into a Conviron E15 chamber.

Effect of lamp type and placement on PPF uniformity in a Conviron E15 chamber at 50 cm



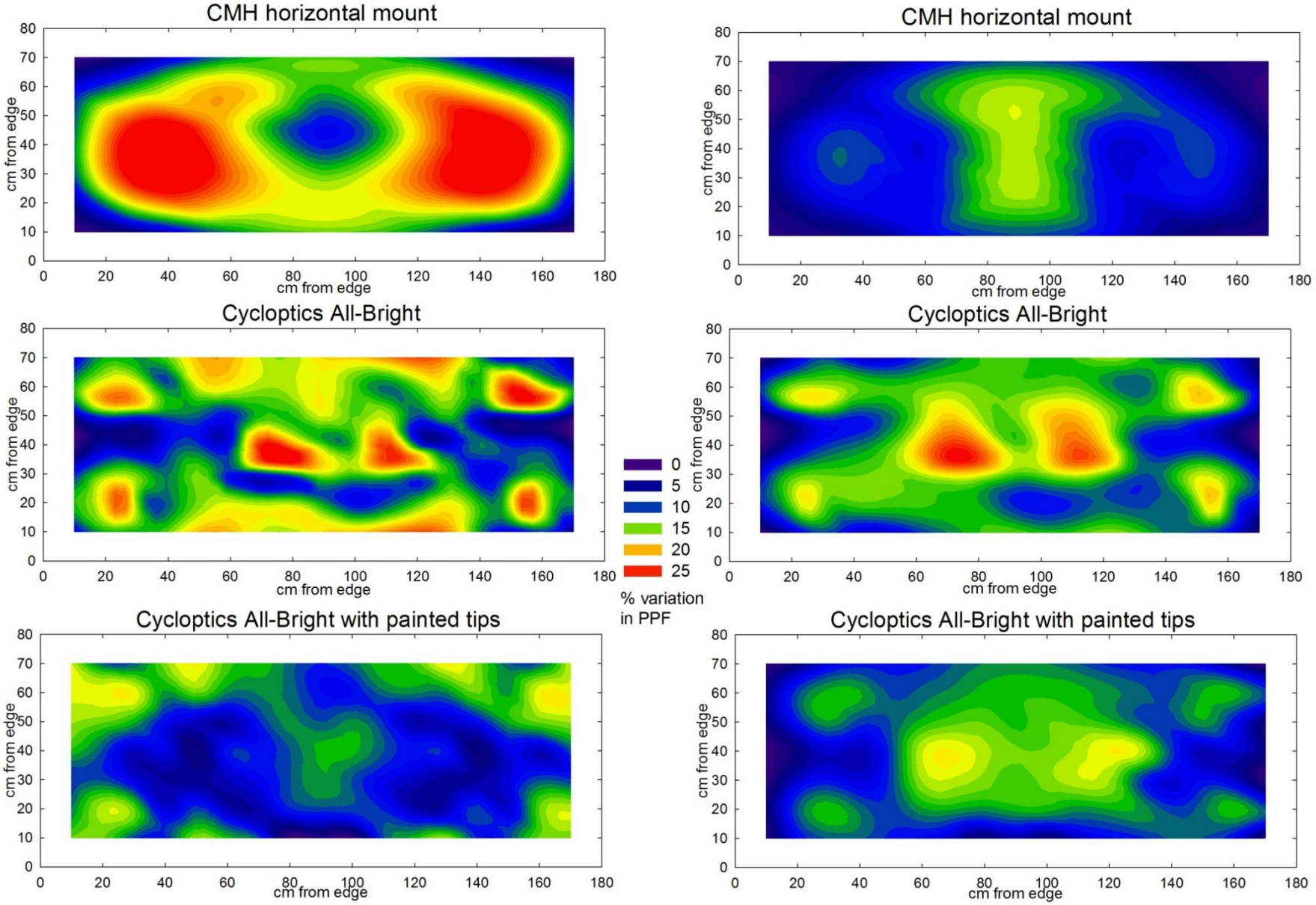
Effect of lamp type and placement on PPF uniformity in a Conviron E15 chamber at 80 cm



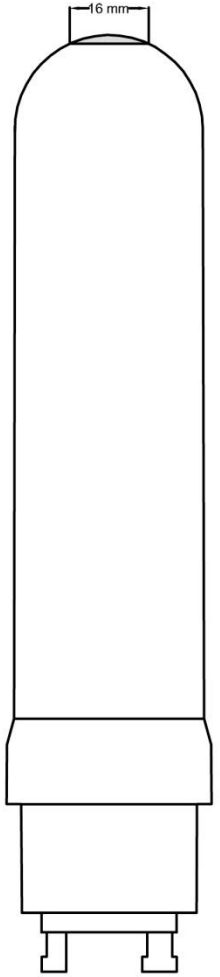
PPF variation of 6 CMH lamps in a Conviron E15 chamber in different arrangements

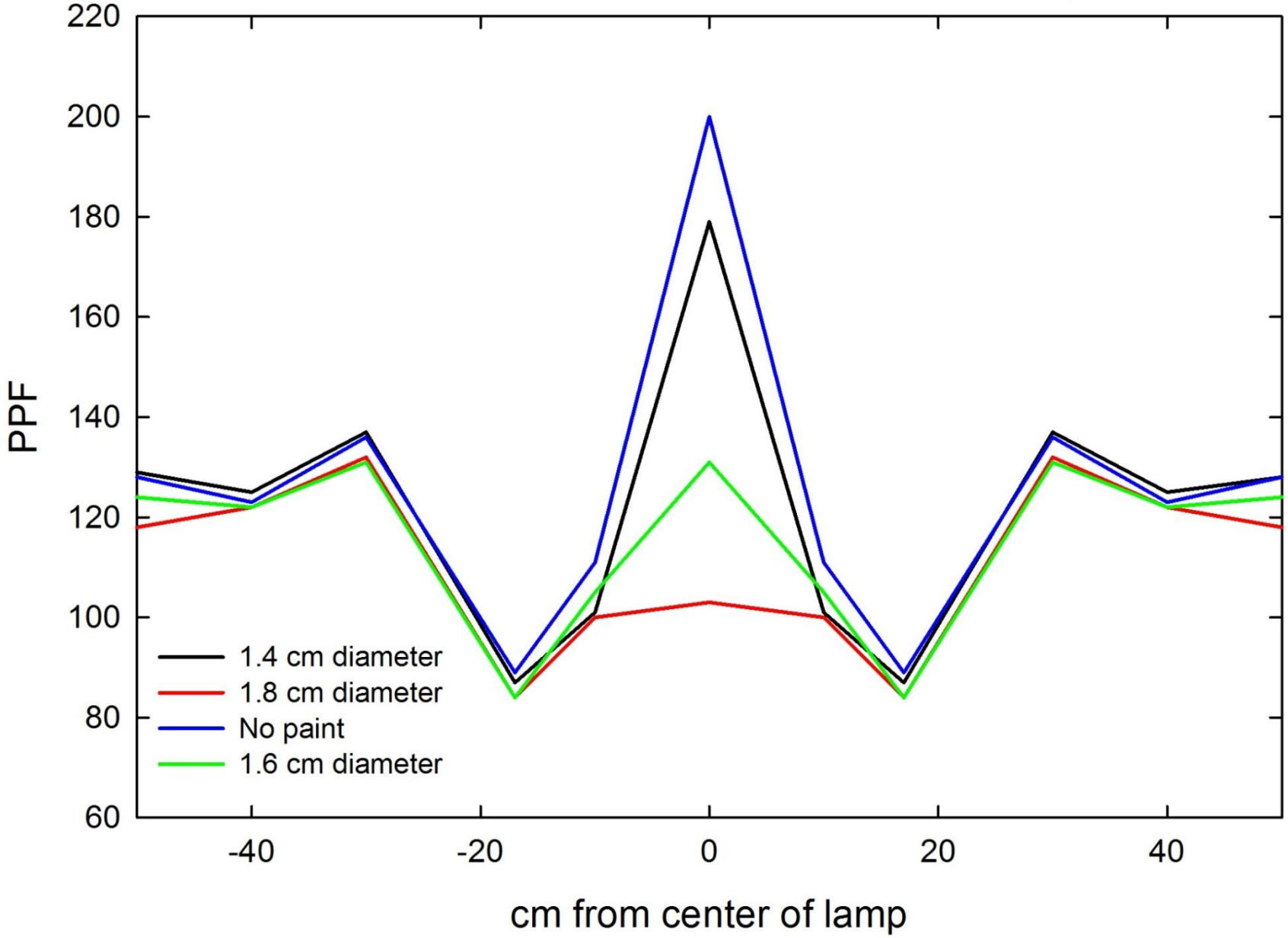
50 cm from lamps

80 cm from lamps



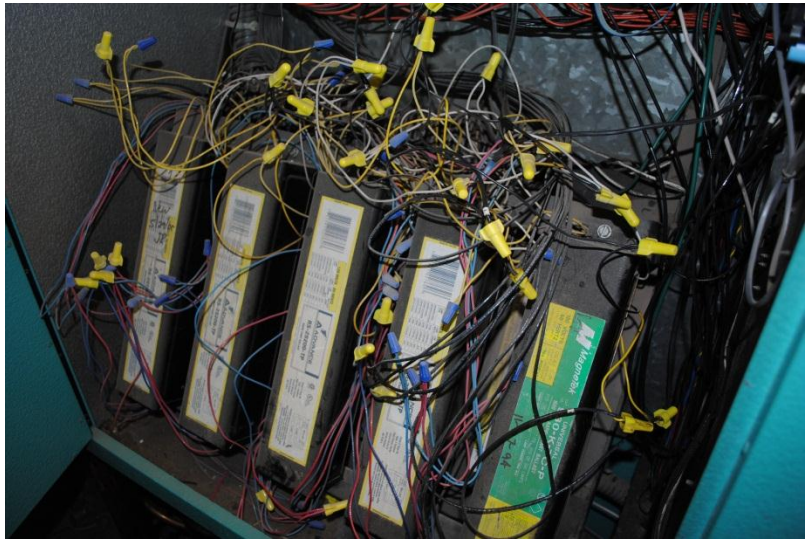
Painting the tip of a Philips CMH lamp improved uniformity




Cycloptics All-Bright lamp with reflective paint on tip of lamp.
Measurements taken 62 cm below lamp.
PPF
220
200
180
160
140
120
100
80
60
-40
-20
0
20
40
cm from center of lamp
1.4 cm diameter
1.8 cm diameter
No paint
1.6 cm diameter

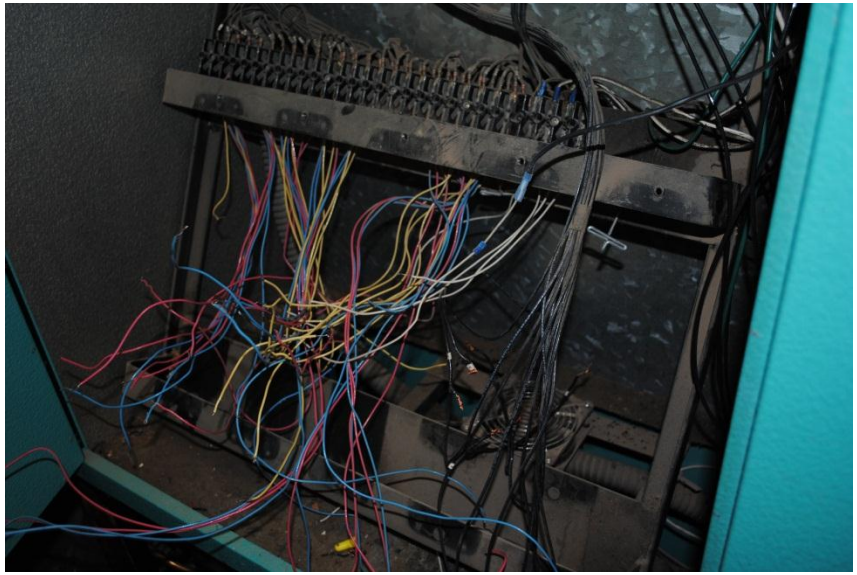
Removal of old lighting system

An E15 chamber before removal



Removal of old lights and ballasts

Once the lights and ballasts have been removed, much of the wiring that runs between them can be removed.



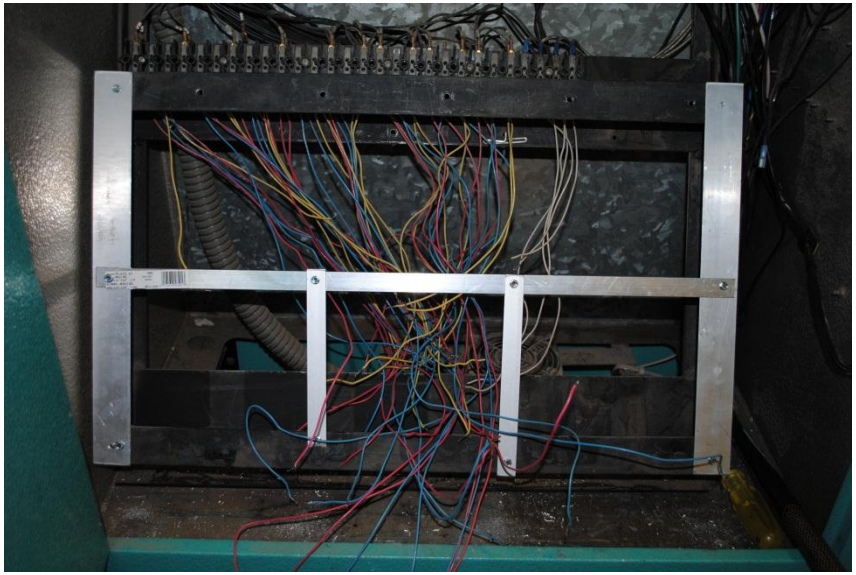
The new lighting system requires only 12 wires to run from the ballasts to the lamps, therefore the majority of the wiring can be removed, leaving only 12 wires of adequate length (generally leave at least 12 of the longest). All other wiring can be cut and/or removed.

Our chamber had 3 wire bundles running from the control cabinet, through the wall, into the growth chamber. Only one is needed all others were removed, being sure that there are 12 adequate wires left in the remaining bundle.

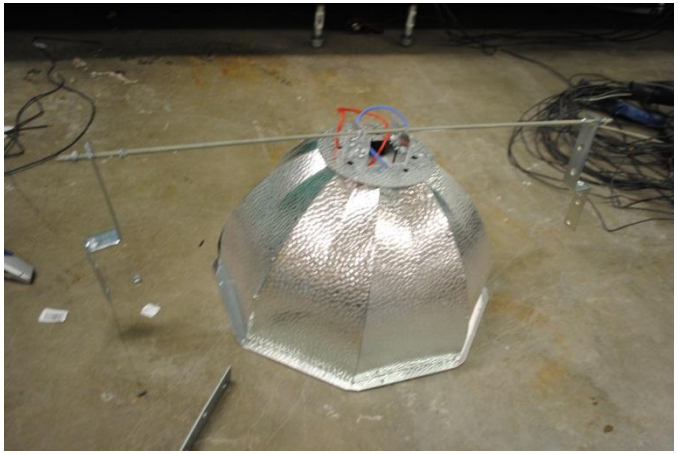
Once the excess wiring has been removed, the two lateral crossbars can be removed. These crossbars must be removed to allow enough room for the Allbright lamp reflectors. The crossbars can be removed by drilling out the rivets. These will be reused so it is best to minimize damage.

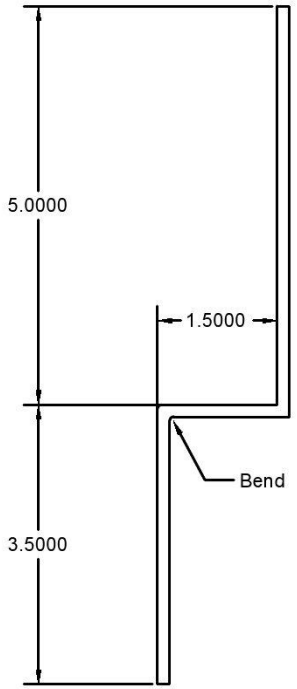
Installation of new lighting system

A frame made of aluminum is then built into the existing steel ballast framework. This allows for existing wiring and cooling systems to be utilized.

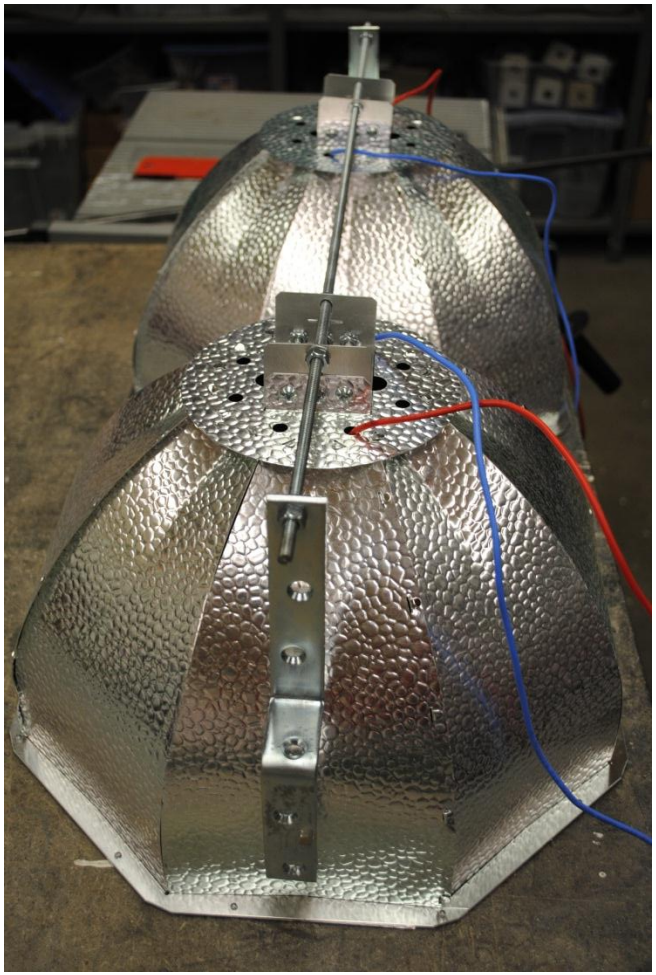


The core components of the mounting system consist of two brackets and a length of allthead. The brackets are modified 5” angle brackets that have been bent as shown in the drawing. The allthread is simply cut short enough so as to not scrape the sides of the chamber.

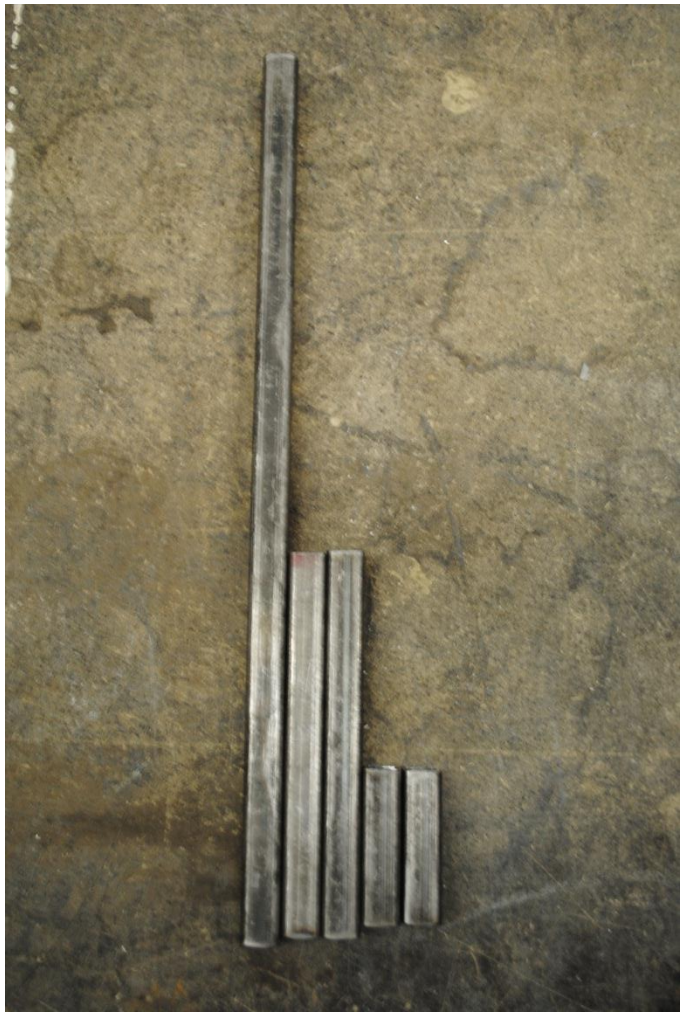


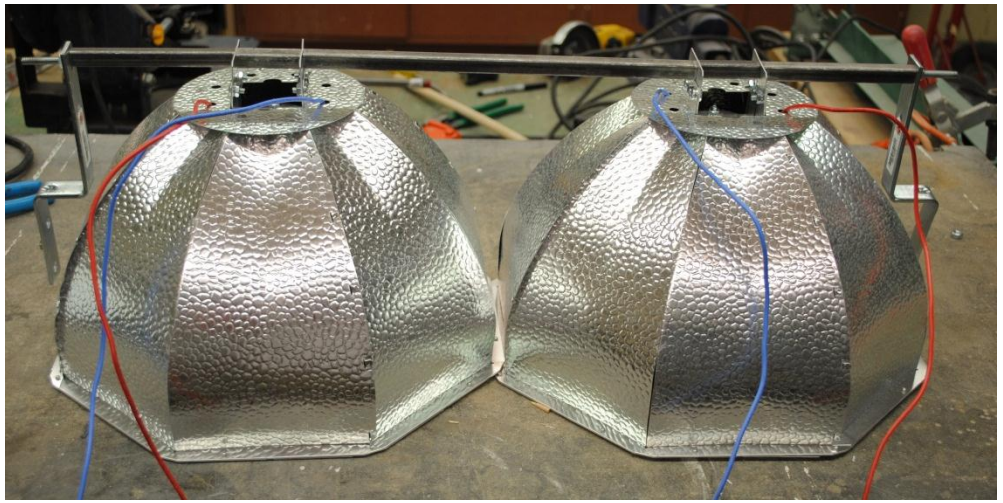


A standard 5” angle bracket was bent at 1.5” from the center pivot to create the light support bracket.



To provide strength and rigidity, ½” square zinc coated steel tube was cut into appropriate sized spacers as shown.





Using the lateral crossbars that were removed, a longitudinal crossbar was constructed. The lateral crossbars were cut to length and the ends were flared to allow a connection point. The remaining wire bundle was then attached to this longitudinal cross bar using the old hardware.

Conviron E15 Growth Chamber

Before

After