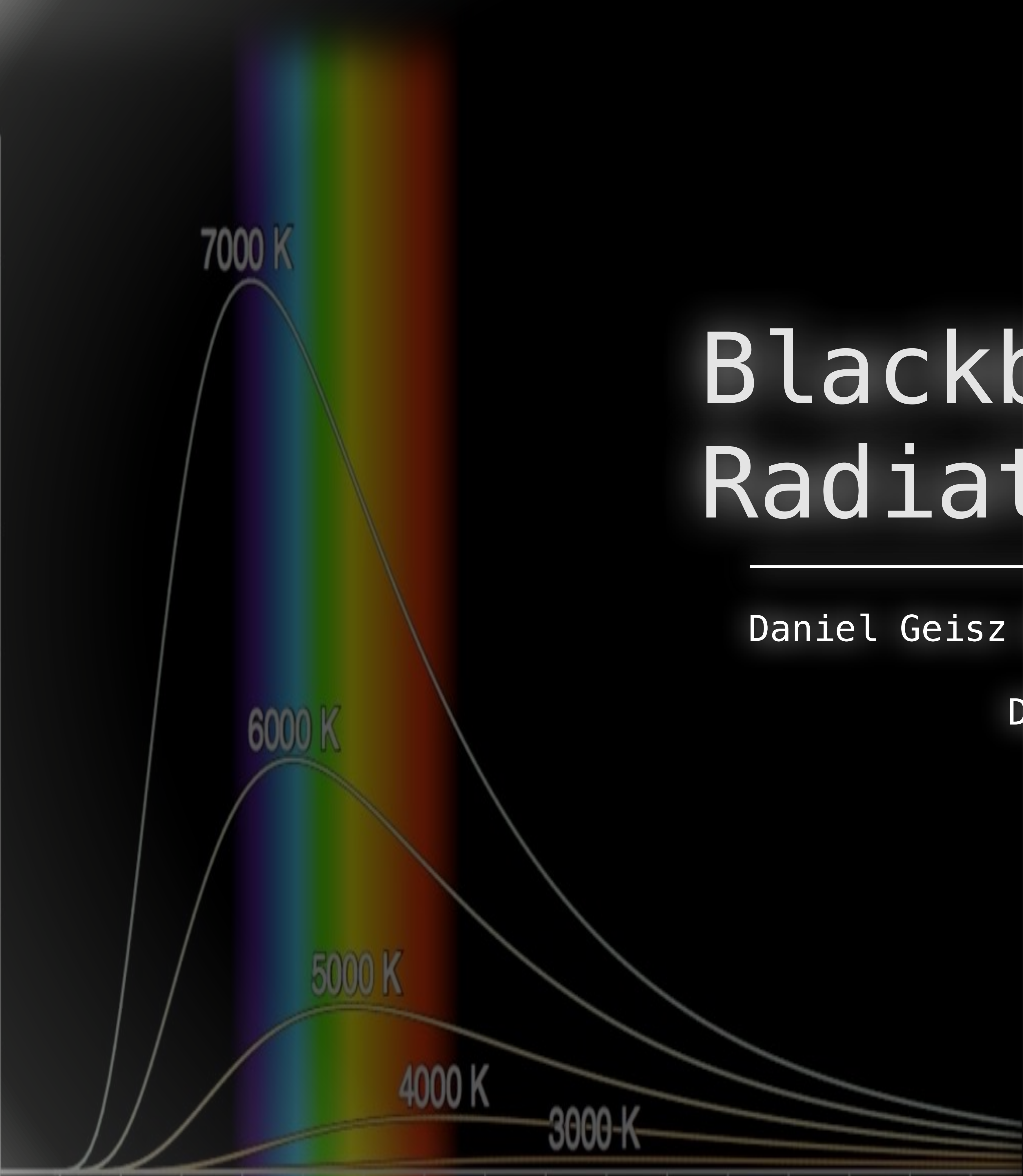

Blackbody Radiation

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- Theory
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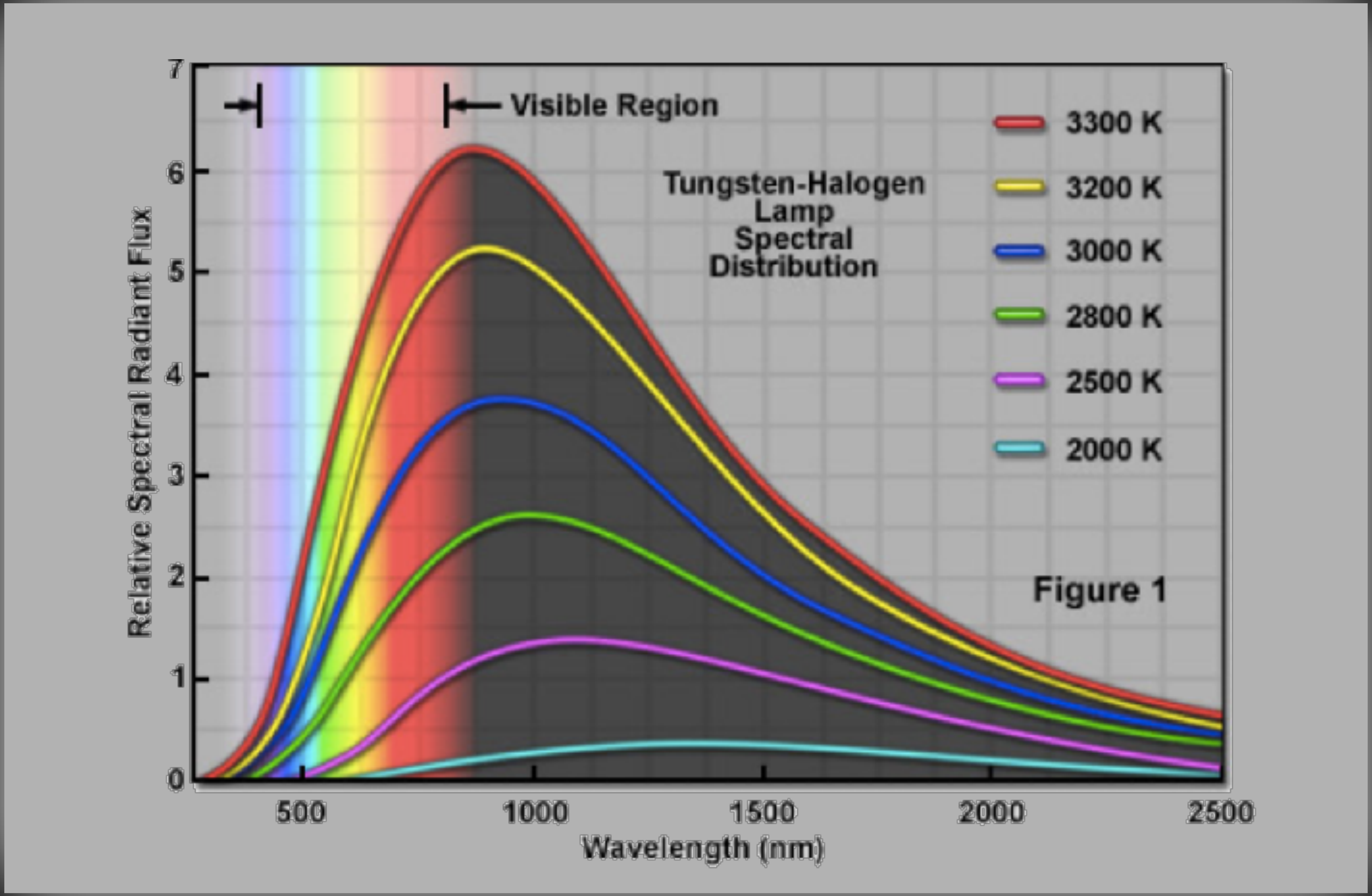
Theory – Planck's Law

$$B_\lambda(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$

Theory



Visible Region
Tungsten-Halogen
Lamp
Spectral
Distribution
3300 K
3200 K
3000 K
2800 K
2500 K
2000 K
Figure 1
Relative Spectral Radiant Flux
Wavelength (nm)
0
1
2
3
4
5
6
7
500
1000
1500
2000
2500

Theory – Wien's Law

$$\lambda_{max} = \frac{b}{T}$$

$$b = \frac{hc}{xk_B} \qquad \frac{xe^x}{e^x - 1} - 5 = 0$$

$$x \approx 4.965114231744276$$

Temperature dependence of resistivity

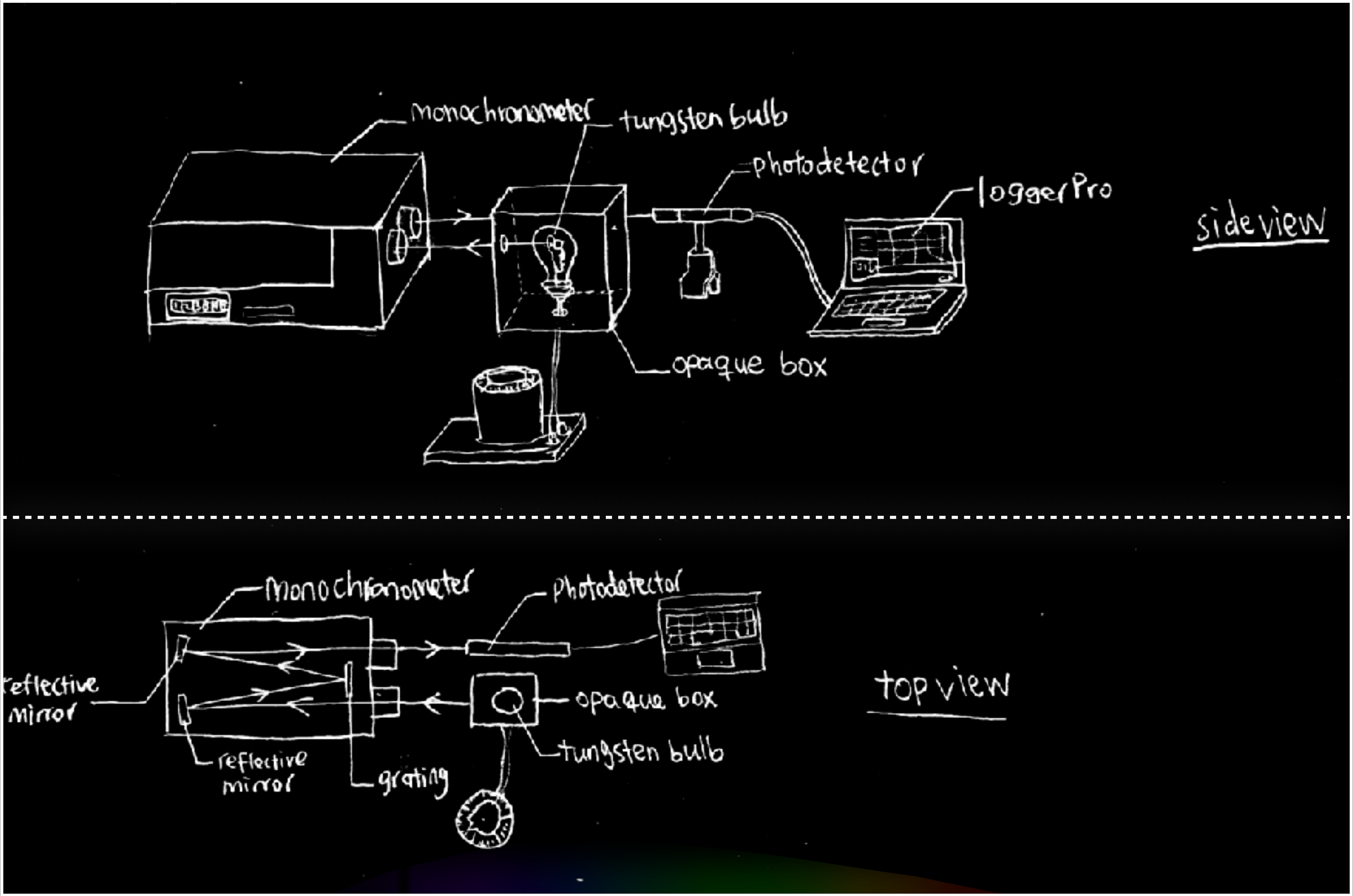
$$T = \left(\frac{R}{R_0} - 1\right)\frac{1}{\alpha} + T_0$$

Equipments

- Tungsten Bulb & Power Supply
- Vernier Photodetector
- Monochromator
- Three Lasers with Known Wavelengths
- Cardboard Box
- Multimeter & Current Clamp

Procedure – Calibration

- 1. Shine the first of the three lasers through the opening to the monochromator.
- 2. Adjust the wavelength dial on the monochromator until the laser light is emitted from the device.
- 3. Record the monochromator's wavelength reading and the actual wavelength of the laser.
- 4. Repeat steps 1–3 with the other two lasers.
- 5. Use the data collected to determine the offset between the monochromator's wavelength reading and the wavelength of light actually being emitted from the device.


monochronometer
tungsten bulb
photodetector
loggerPro
side view
opaque box
Monochronometer
Photodetector
reflective mirror
top view
opaque box
tungsten bulb
reflective mirror
grating

Procedure

- 2. Turn on the Tungsten bulb to a low setting.
- 3. Align the bulb so that the light emitted into the monochromator is incident on both mirrors and the grating inside the monochromator.
- 4. Align the photodetector so that the light emitted from the monochromator is incident on the aperture of the detector.
- 5. Adjust the wavelength dial on the monochromator until the photodetector reads a value just above 2.0 Lux.

Procedure

- 6. By turning the wavelength dial on the monochromator, record the photodetector reading over the range of wavelengths for which the photodetector reads a value greater than 2.0 Lux.

- In our case, we started at the smallest wavelength for which the photodetector read a value greater than 2.0 Lux, and we increased the wavelength by about 100 Angstrom between subsequent data points.

- 7. Repeat steps 5 and 6 four times, but each time change the power supplied to the Tungsten bulb to change its temperature.

Procedure

- 8.Turn off the power supply, and connect the multimeter in parallel to the circuit, and clamp the current clamp onto one of the light bulb wires.
- 9. Turn on the power supply to the lowest setting at which current flows through the bulb. Use the multimeter and the current clamp to find the voltage across the light bulb and the current running through the circuit. Use these values to give an approximate value of the resistance of the bulb at room temperature.
- 11. Turn the power supply to each of the power settings used in steps 1–7, and at each setting, record the voltage across the light bulb and the current in the circuit. Used with equations in the theory section, approximate value for the temperature of the filament.

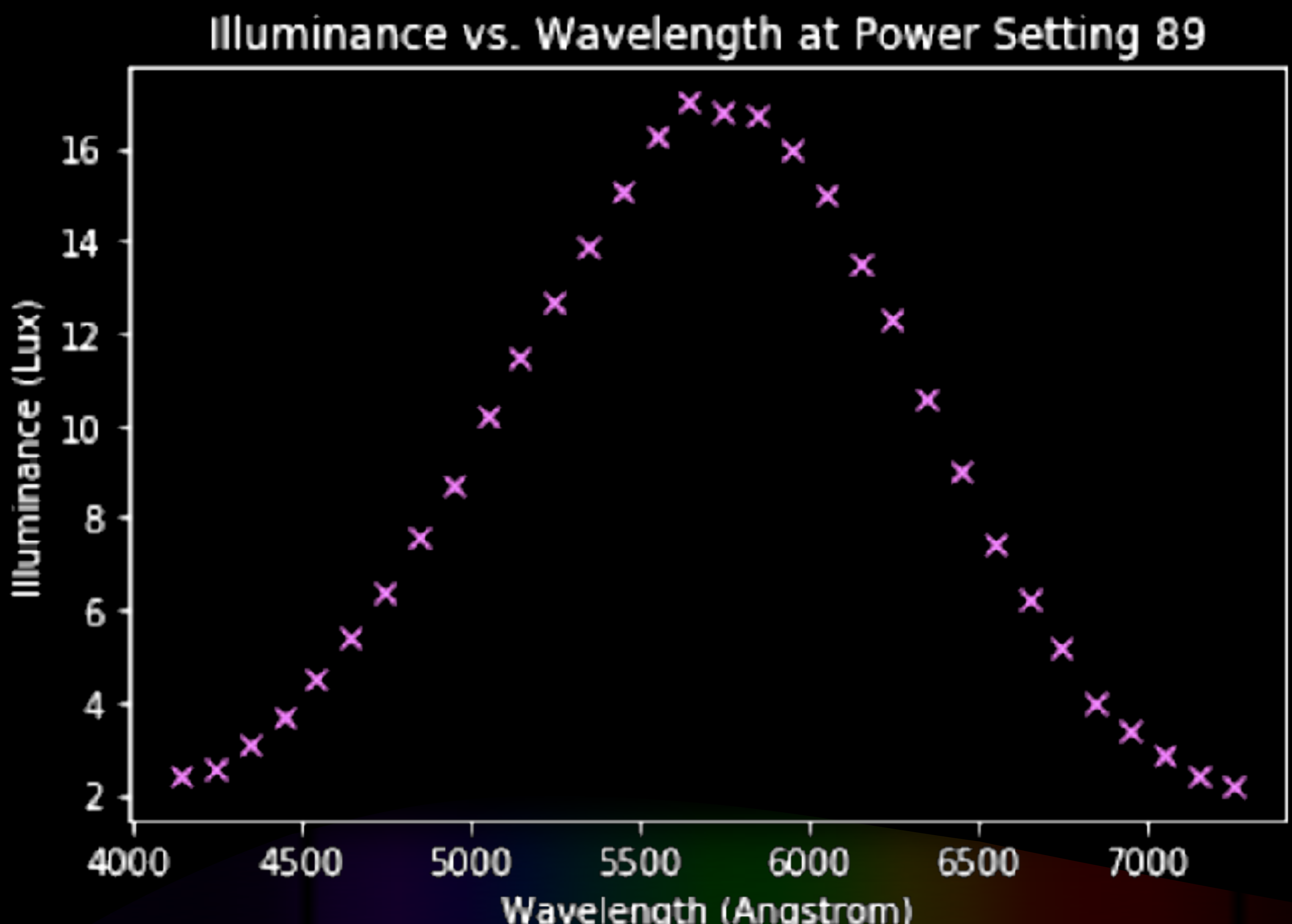
Data – Calibration

	Wavelength Reading	Actual Wavelength
0	3816	6328
1	3332	5320
2	2727	4050

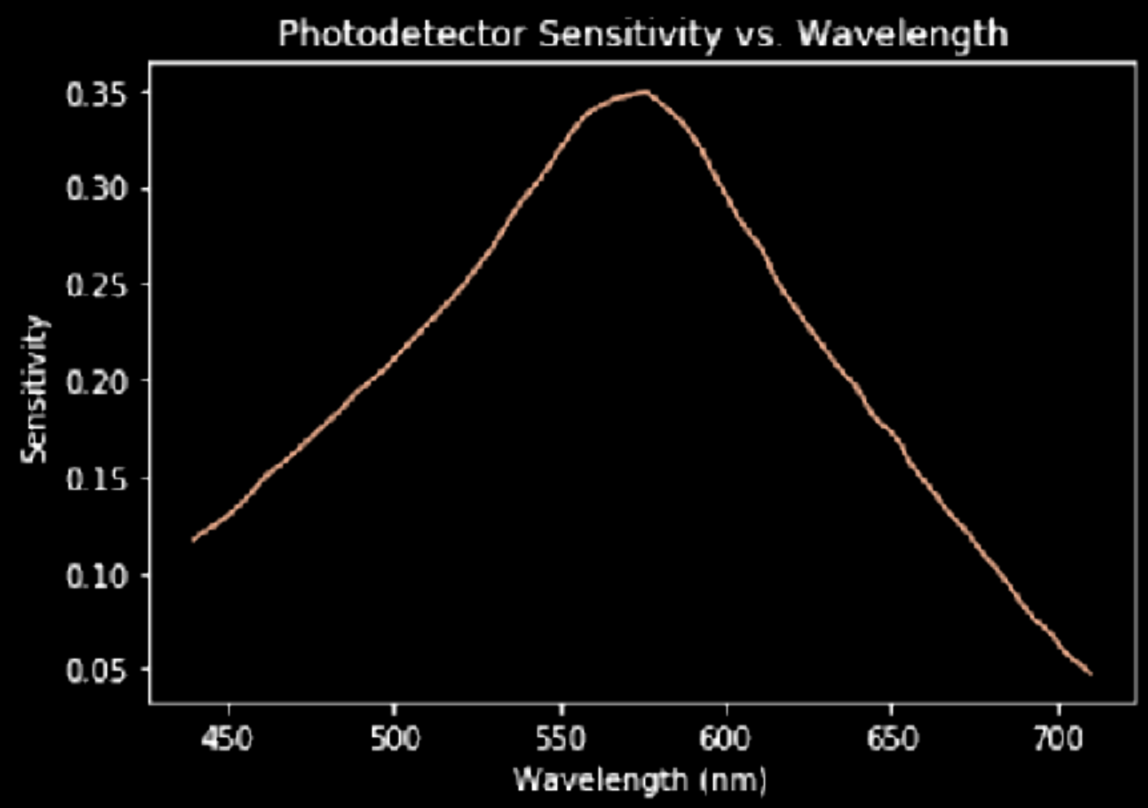
Data – Temperature

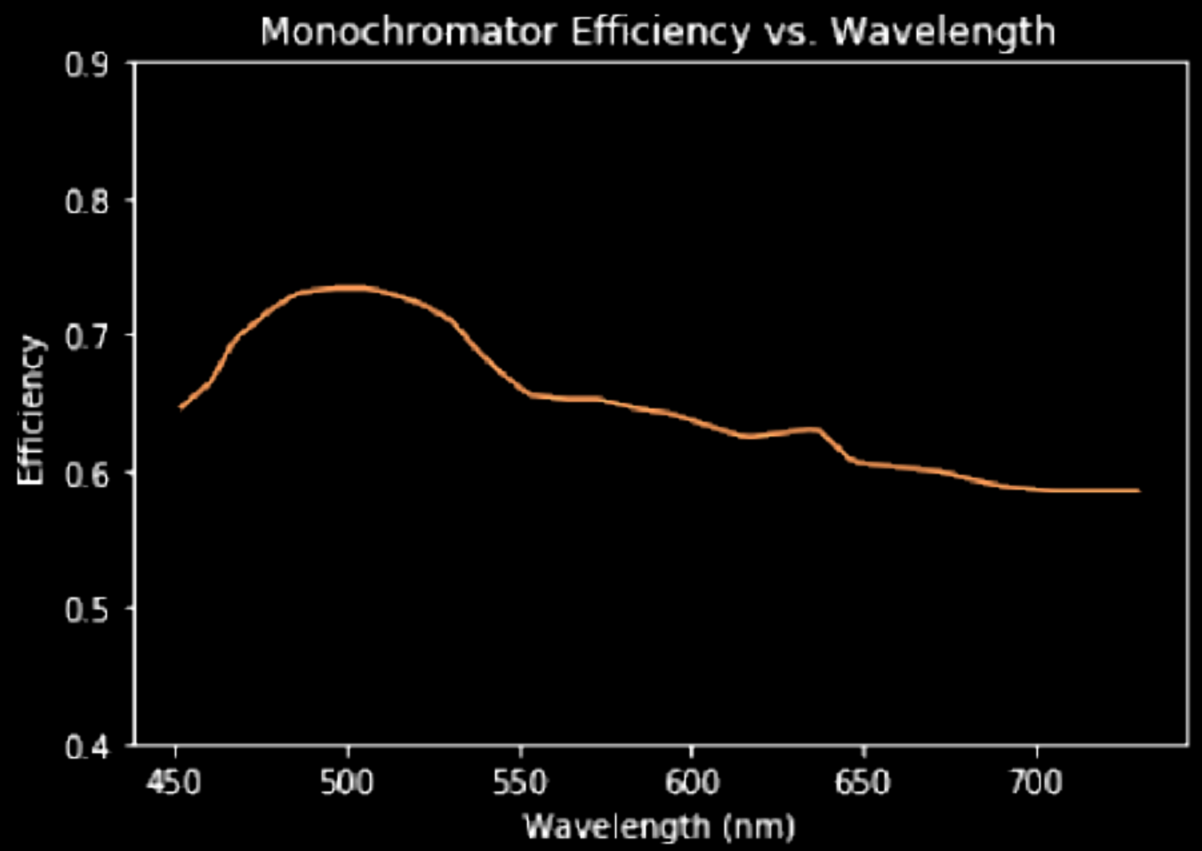
	P	I	V	R	T	δT
0	**1**	0.01	0.072	7.20	25.4	1.0
1	**89**	0.80	55.3	69.1	1936	1826
2	**100**	0.89	67.3	75.6	2137	1997
3	**110**	0.97	77.5	79.9	2269	2110
4	**120**	1.04	88.1	84.7	2417	2237
5	**140**	1.16	107.7	92.8	2668	2452

Raw Data

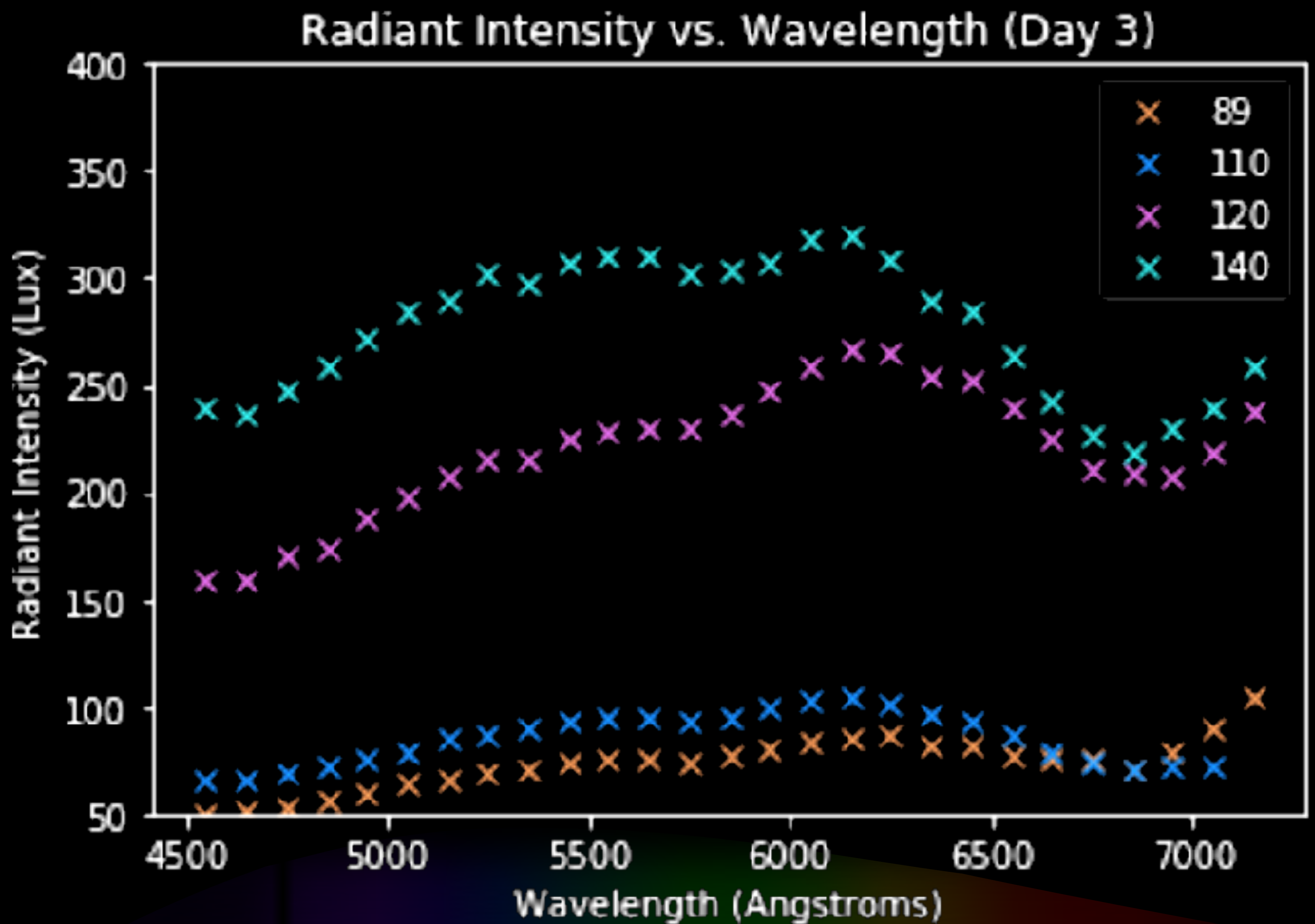

Illuminance vs. Wavelength at Power Setting 89
Illuminance (Lux)
2
4
6
8
10
12
14
16
4000
4500
5000
5500
6000
6500
7000
Wavelength (Angstrom)

Corrections





Processed Data



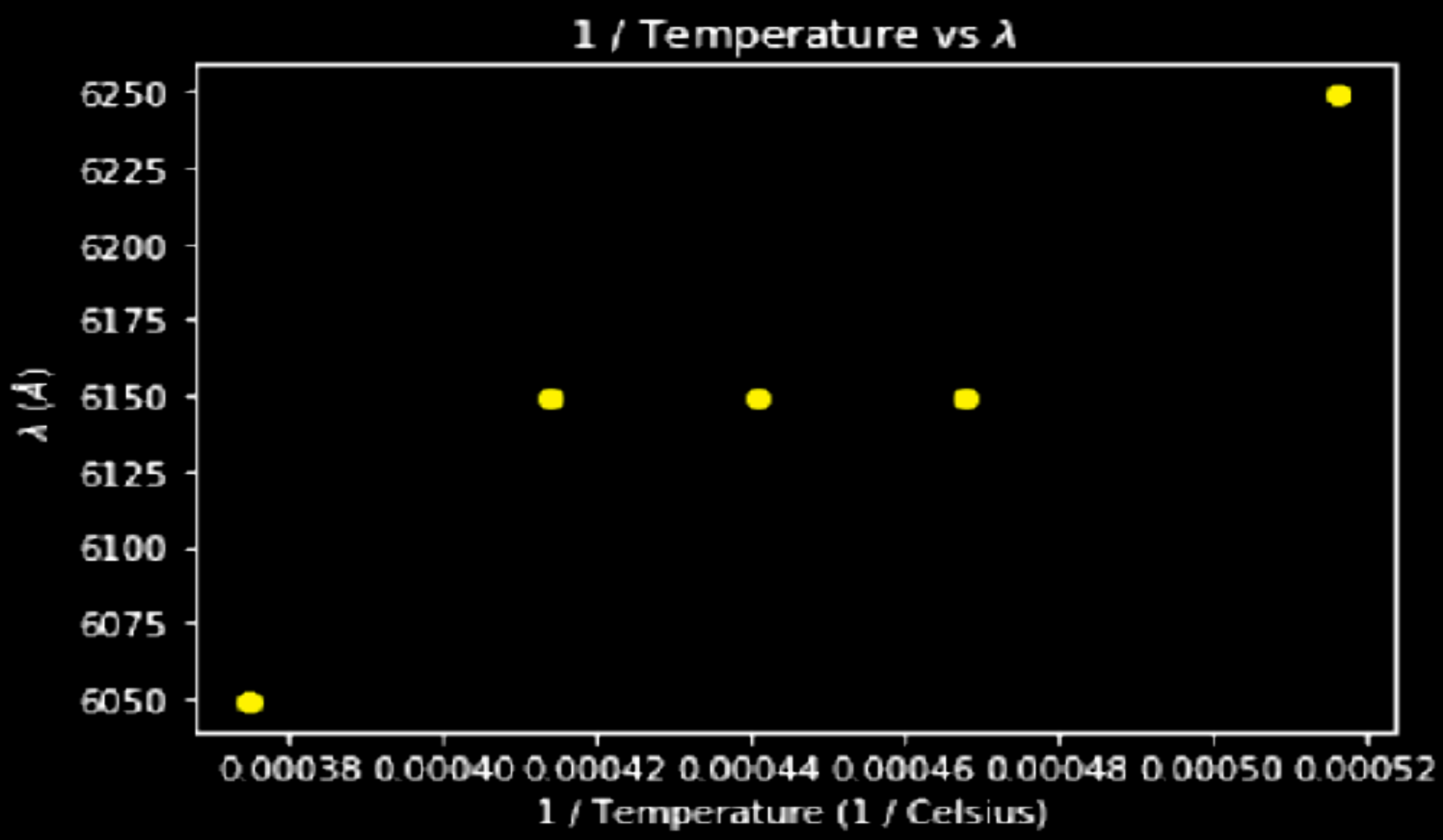
Sources of Error

- Tungsten is not a perfect blackbody
- Not enough lasers used for calibration
- Unclear form of corrective information on photodetector’s sensitivity and mono-chronometer’s efficiency.

Attempting to Verify Wien's Law

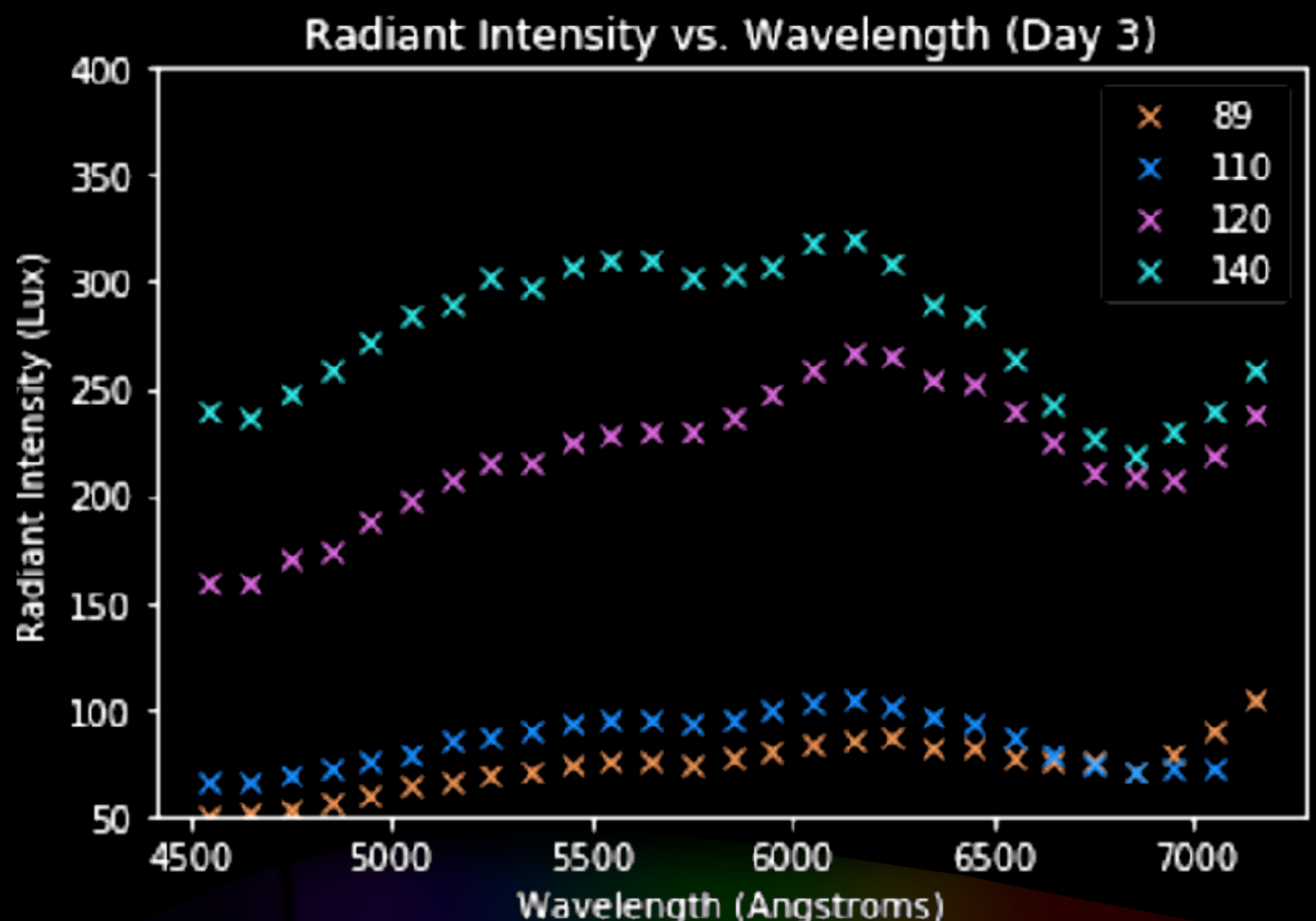
	Power	Temperature	δT	λmax	δλ
0	89	1937	1826	6249	25
1	100	2137	1997	6149	25
2	110	2269	2110	6149	25
3	120	2418	2237	6149	25
4	140	2669	2452	6049	25

Attempting to Verify Wien's Law



$$\hat{m} = 1245757.3116098575 \pm 4742295.84971805\ {}^{o}C \cdot \text{Å}$$
$$\hat{b} = 5597.622005875043 \pm 2058.7735784622555\ \text{Å}$$

Stefan–Boltzmann Law – $j = \sigma T^4$



Conclusion

- 💡 Our spectral data was not consistent with the Planck’s Law
- 💡 Our data did not verify Wien’s Law
- 💡 Our spectral data is qualitatively consistent with the Stefan–Bolzmann Law.