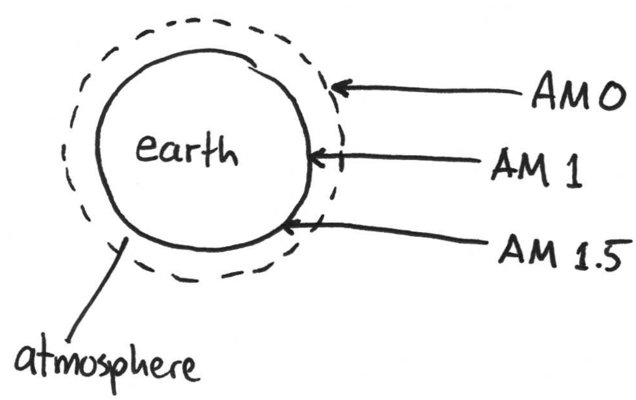
THERMODYNAMIC LIMITS FOR SOLAR CELL EFFICIENCY

Efficiency changes with light intensity.

Need to define standard solar intensities



(1 unit of air mass).

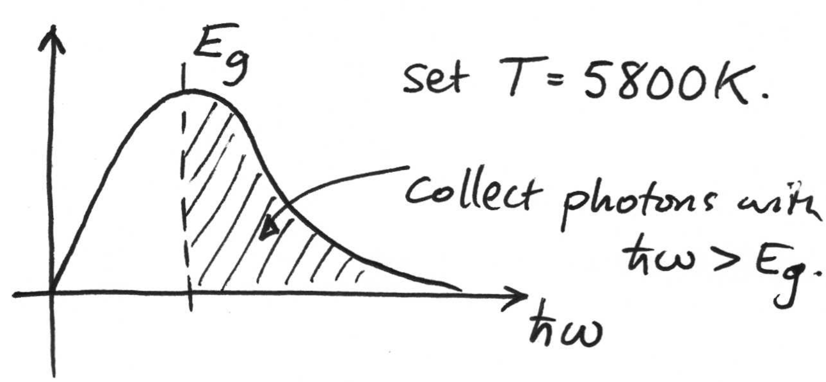
See attached Figure.

Total incident power with AM1.5 is 1000 W/m^2.

First Order Estimate of Efficiency:
(we will later refine the calculation)

# of photons with freq between ω & $\omega + d\omega$

$$\propto \underbrace{\frac{\omega^2}{\pi^2 c^3}}_{\text{counting photon modes}} \underbrace{\frac{1}{e^{\hbar\omega/kT} - 1}}_{\text{Boson statistics}} d\omega$$



set $T = 5800K$.

	Material	J_{sc} theory max @ AM1.5 (mA/cm^2)
Small E_g	Ge	59
↓	CuInSe	48
	Si	42.5
	CIGS	32.5
large E_g	GaAs	31.5

Consider the upper bound for GaAs solar cell efficiency:
if fill factor was 100% (never true)

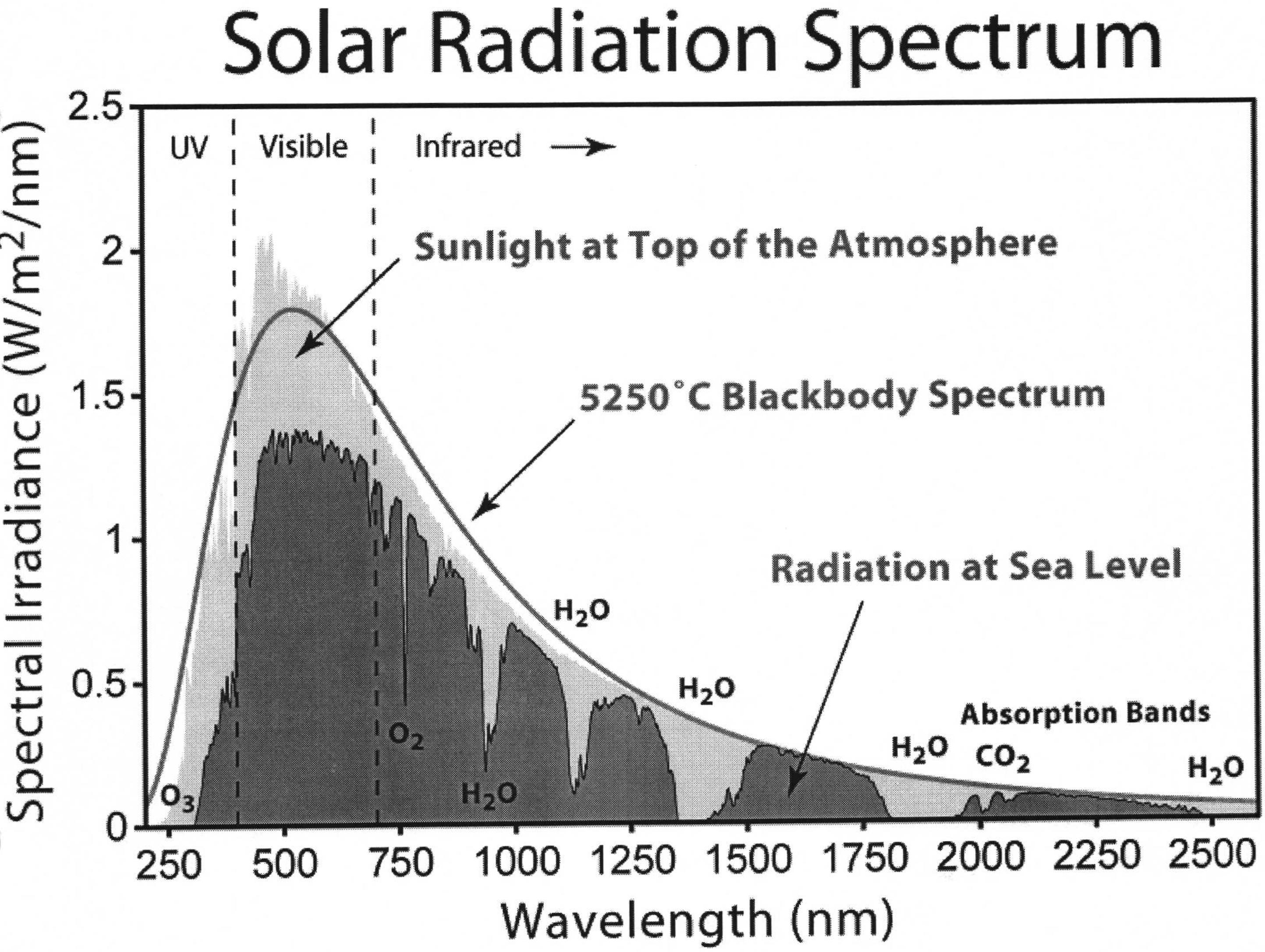
and $V_{oc} \rightarrow \frac{E_g}{e} = 1.4\,V$ (never true)

$$\frac{\text{Max Power}}{\text{Incident Power}} =$$

In reality, the upper bound for a single jn solar cell which converts each photon into one e/h+ pair is 33%. (AM1.5).

This is the Shockley-Queisser (SQ) limit.

Requires a more refined calculation.
(coming up next).



Note: This is not equivalent to a plot of $\frac{\text{photon flux}}{\text{nm}}$.