

The background features a dark blue gradient with a starry space pattern. Overlaid on this are several technical diagrams, including circular gauges with numerical scales (e.g., 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260) and various circular and semi-circular lines, some with arrows indicating direction or flow. The main title is centered in a large, white, sans-serif font.

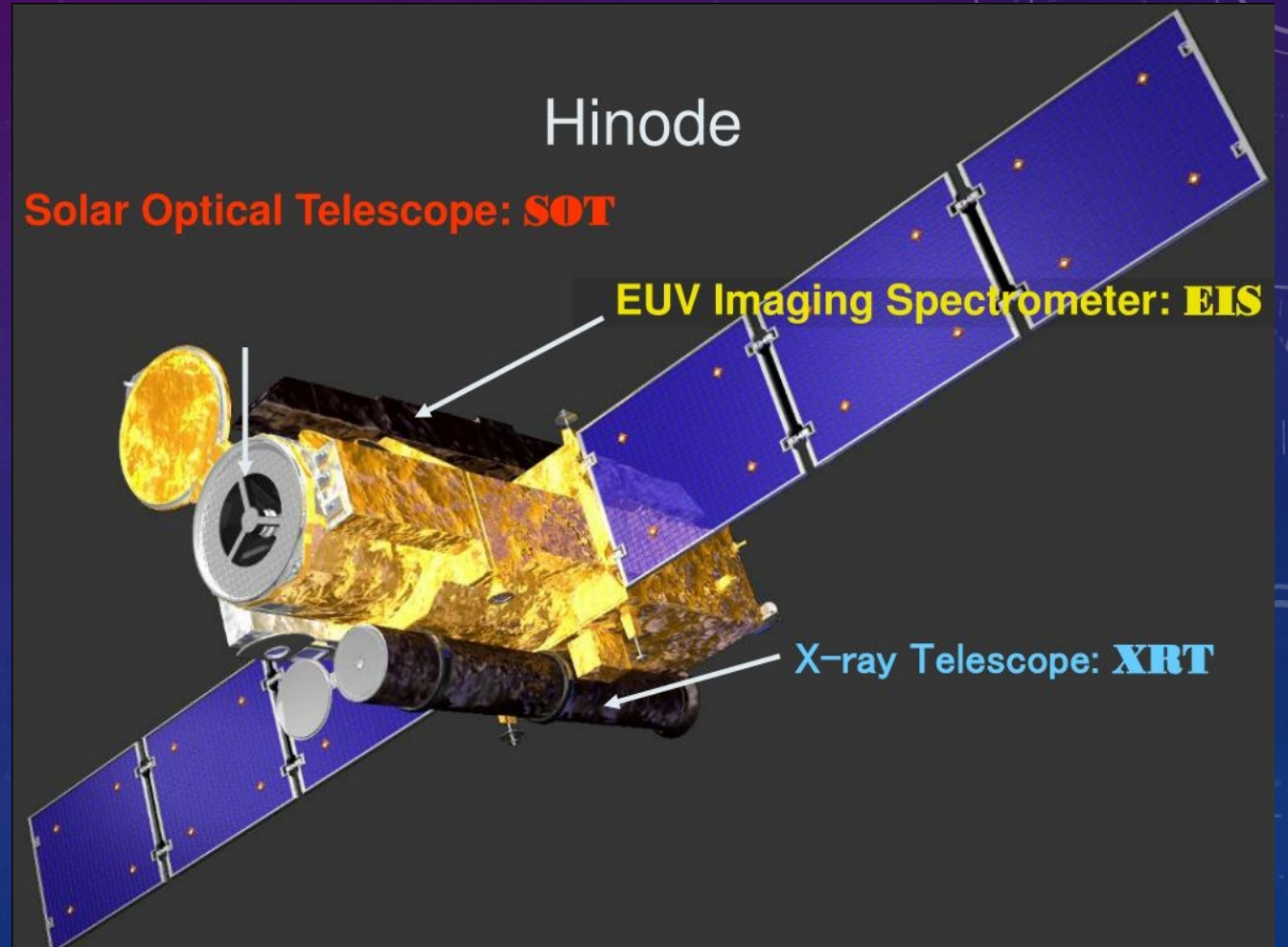
SOLAR SOFT X-RAY IRRADIANCE WITH HINODE/XRT

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MENTOR: AKI TAKEDA

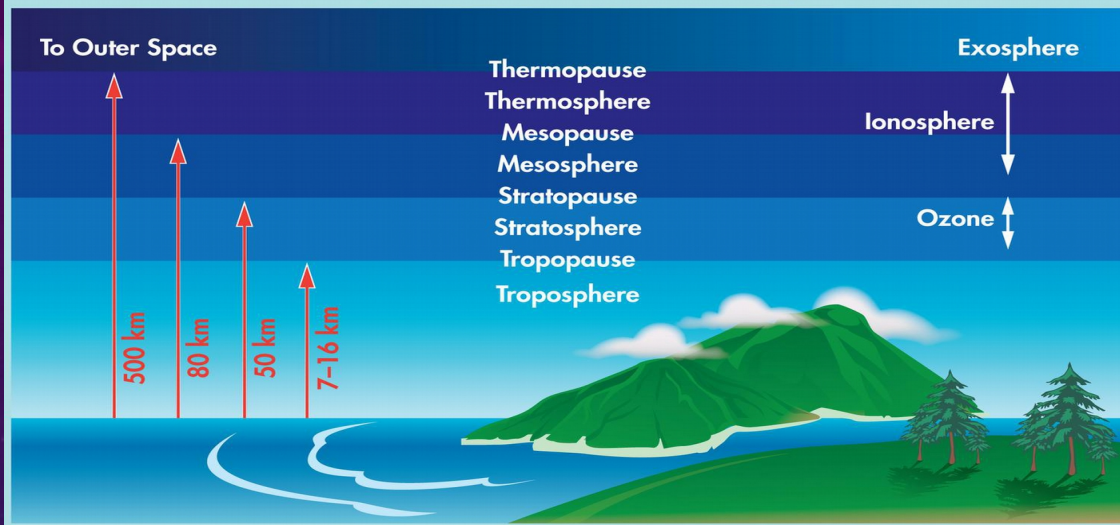
THE HINODE SATELLITE

- Orbits at about 500-600km above the Earth.
- Launched in September, 2006
- Hinode has a polar orbit
- Hinode has the ability to observe the full sun or just a partial region.



THE IMPORTANCE OF OUR PROJECT

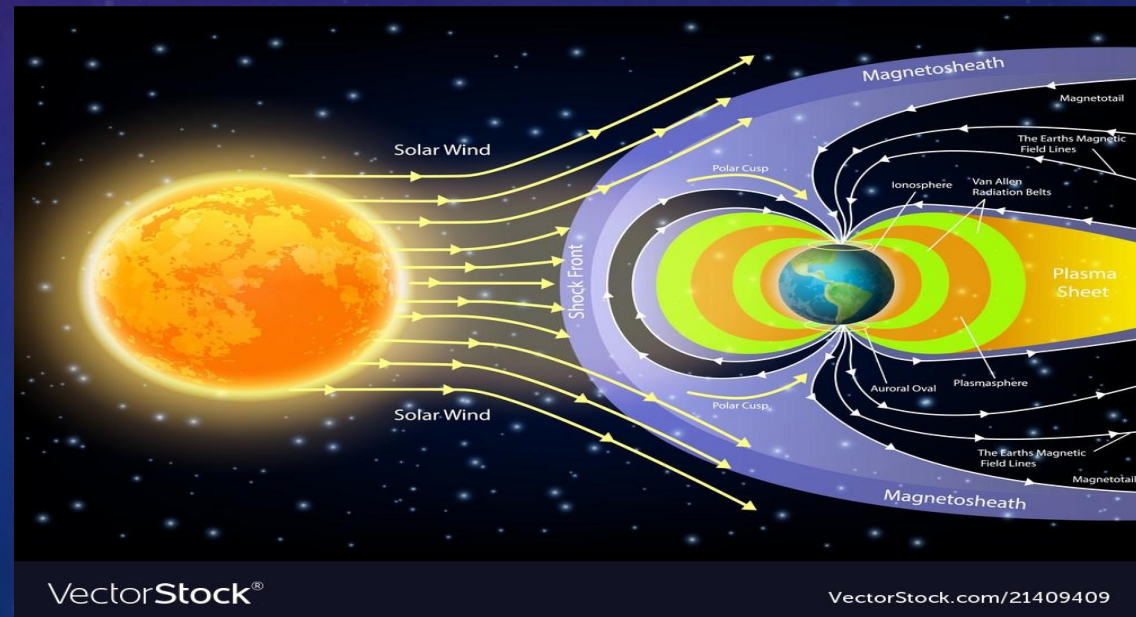
The Layers of the Atmosphere



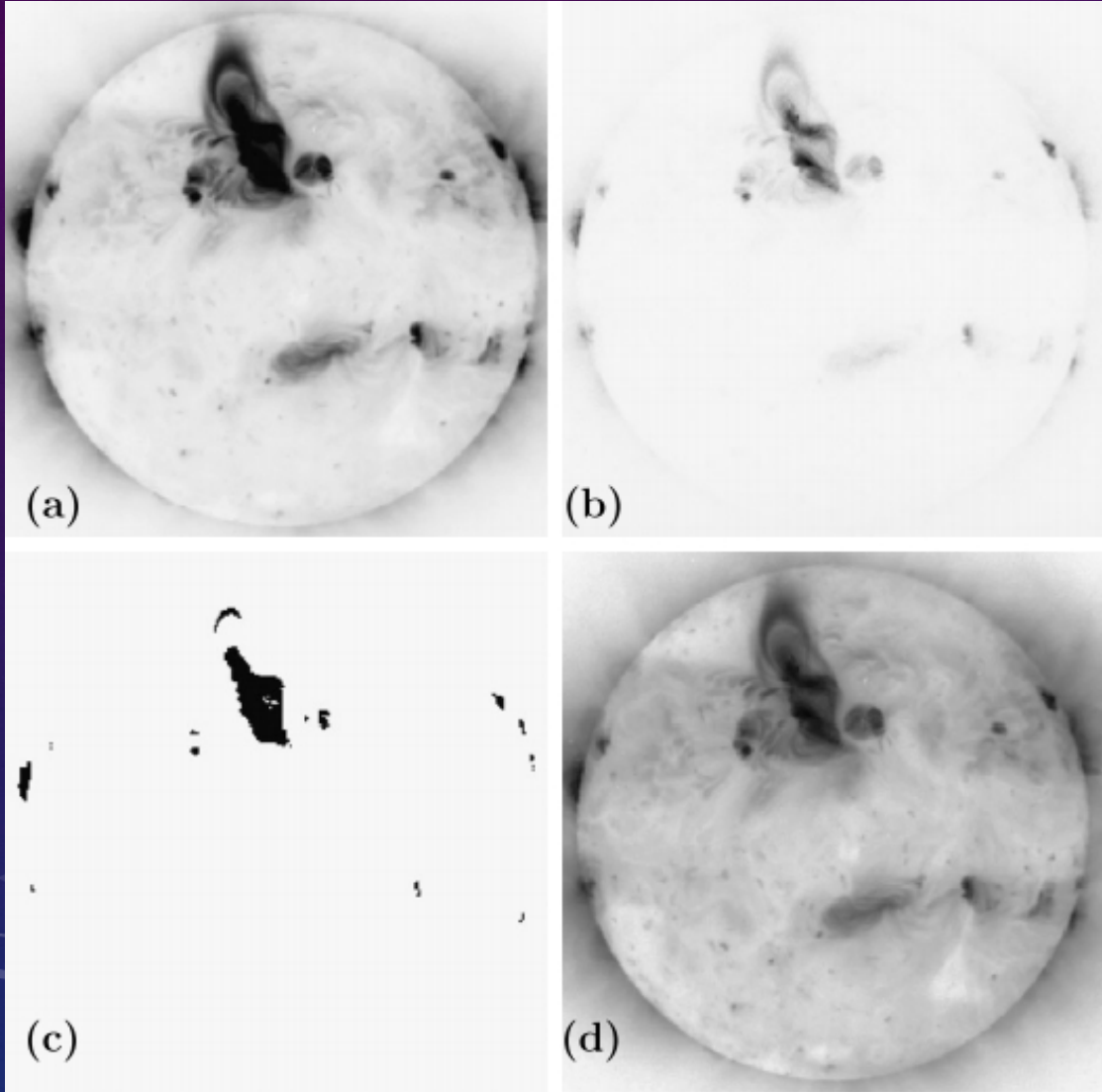
http://data.allenai.org/tqa/layers_of_the_atmosphere_L_0023/

- Soft x-rays are important because they show many magnetic field configurations and have a wide temperature coverage.
- Soft x-rays are absorbed in the ionosphere.

- Solar irradiance is the amount of light energy from the sun that is measured on Earth.
- Space Weather can interfere with Earth communications, overload power grids, and cause geomagnetic storms.

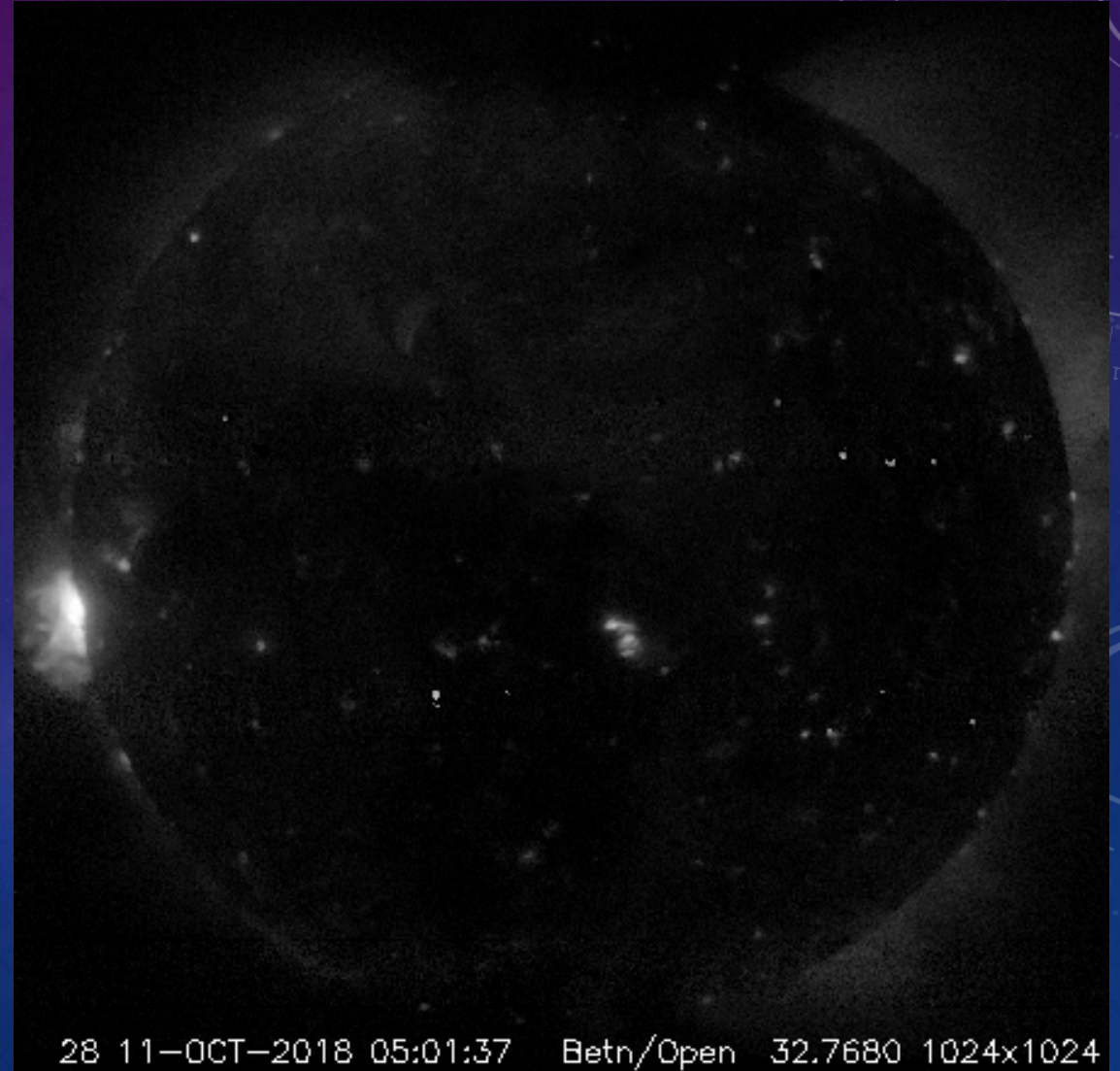
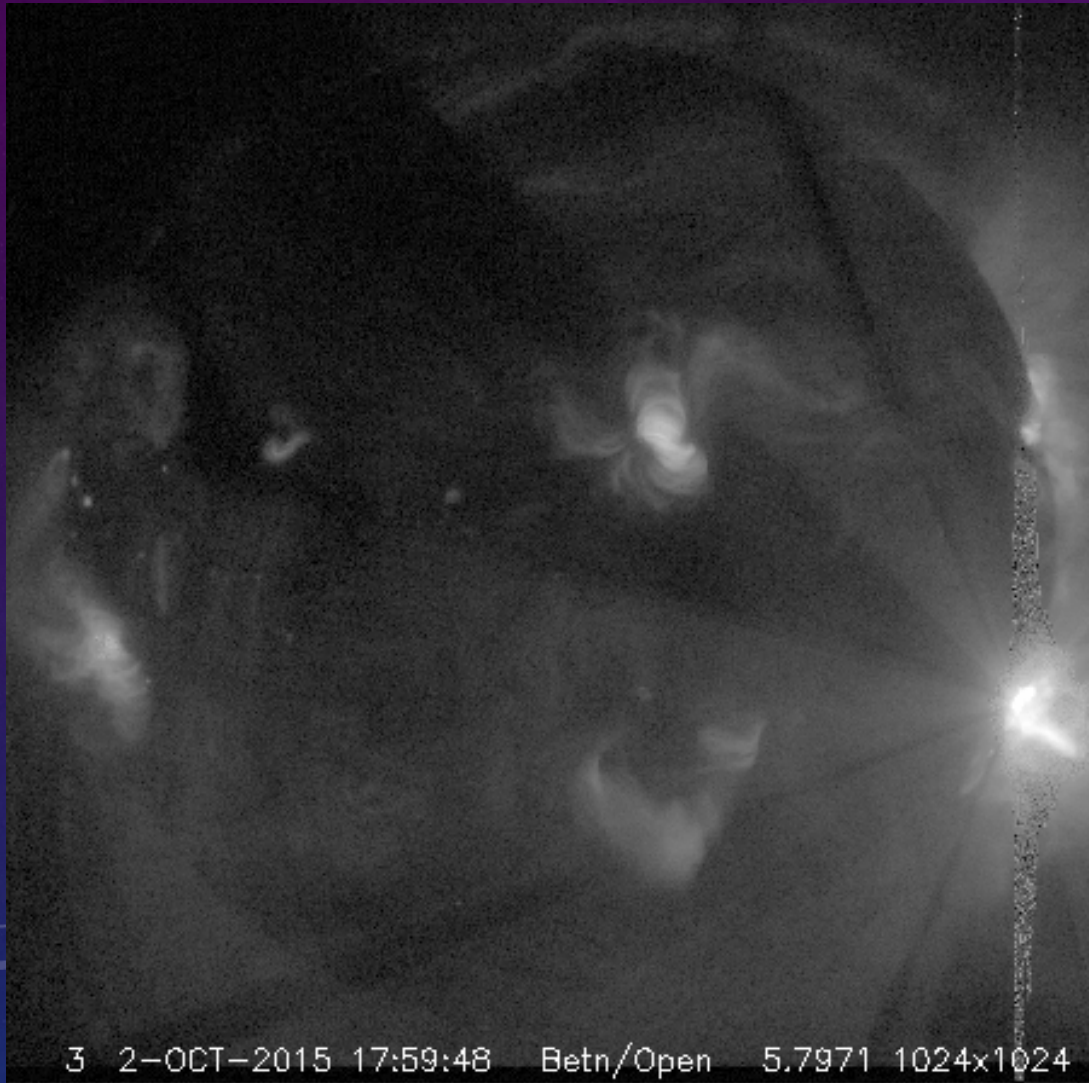


PROJECT OVERVIEW



- Our project was focused on using soft x-rays from the XRT.
- We used the XRT Synoptic Composite Image Archive created by MSU.
- 2008-present day
- Thin-Be filter: measure higher temperatures
- Al-mesh filter: measure lower temperatures
- Our goal was to measure the average temperature and emission measure of the sun and calculate irradiance.

STEP 1: DATA SELECTION

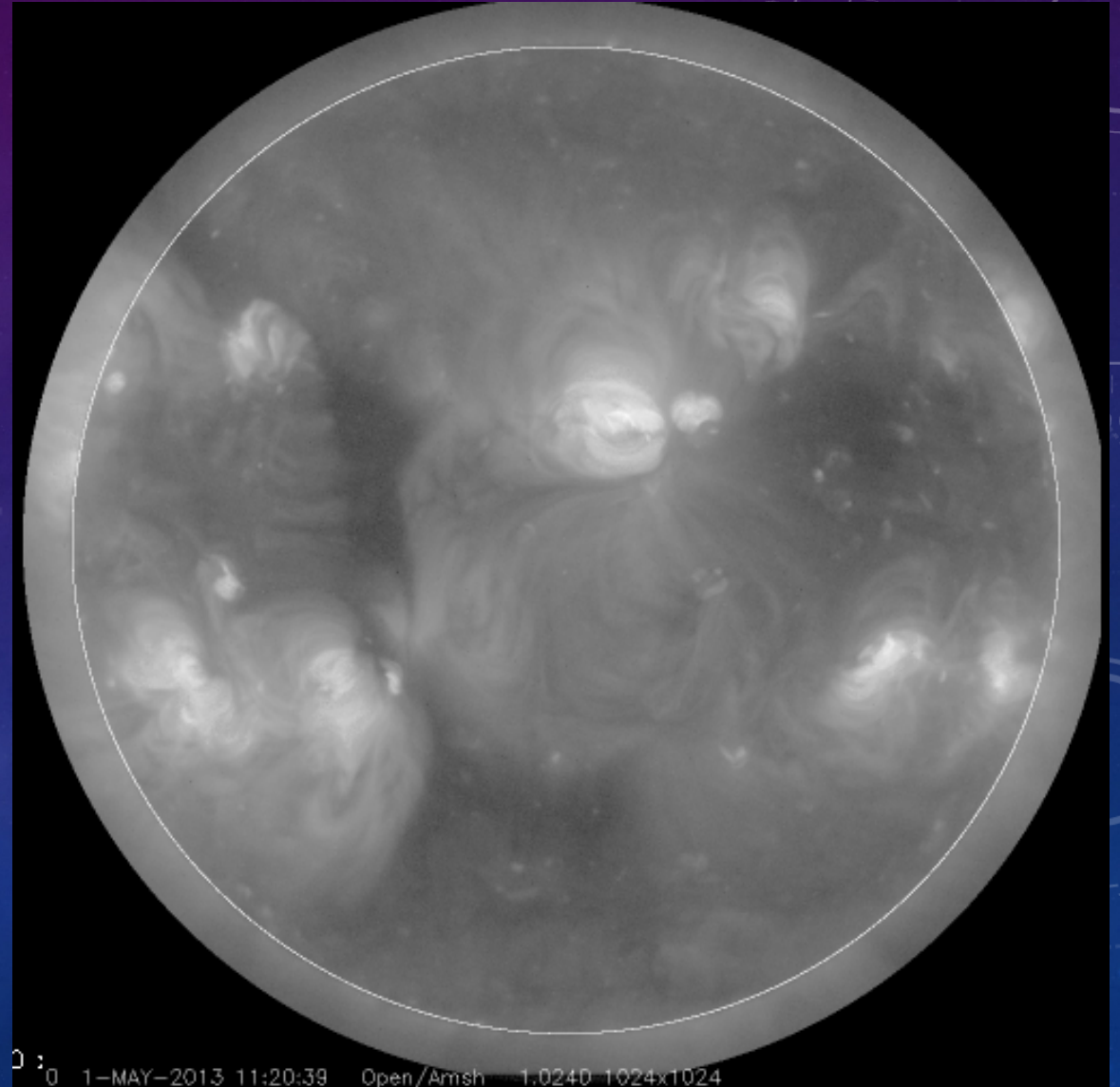


SAVED DATA

Year	# of data
2008	22
2009	43
2010	0
2011	117
2012	108
2013	135
2014	107
2015	351
2016	213
2017	154
2018	557
2019	1287
2020	1054
2021	398
Total	4572

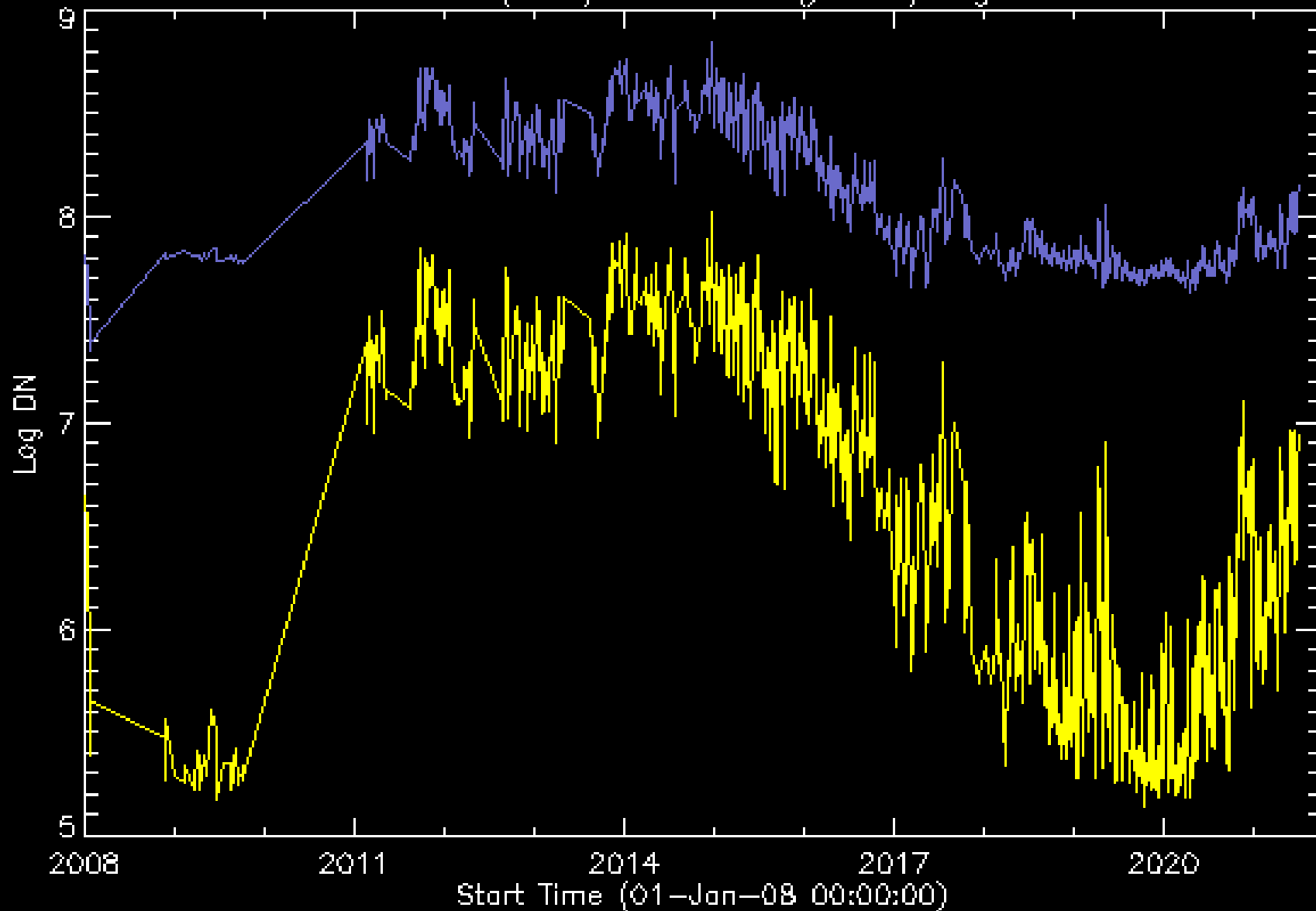
STEP 2: SIGNAL COLLECTION

- My next step was to put masks around the images.
- 1.1 radii of the sun
- Then modified a program to plot the intensities.



FINDING INTENSITY

Al-mesh(blue) & thin_Be(yellow) signals



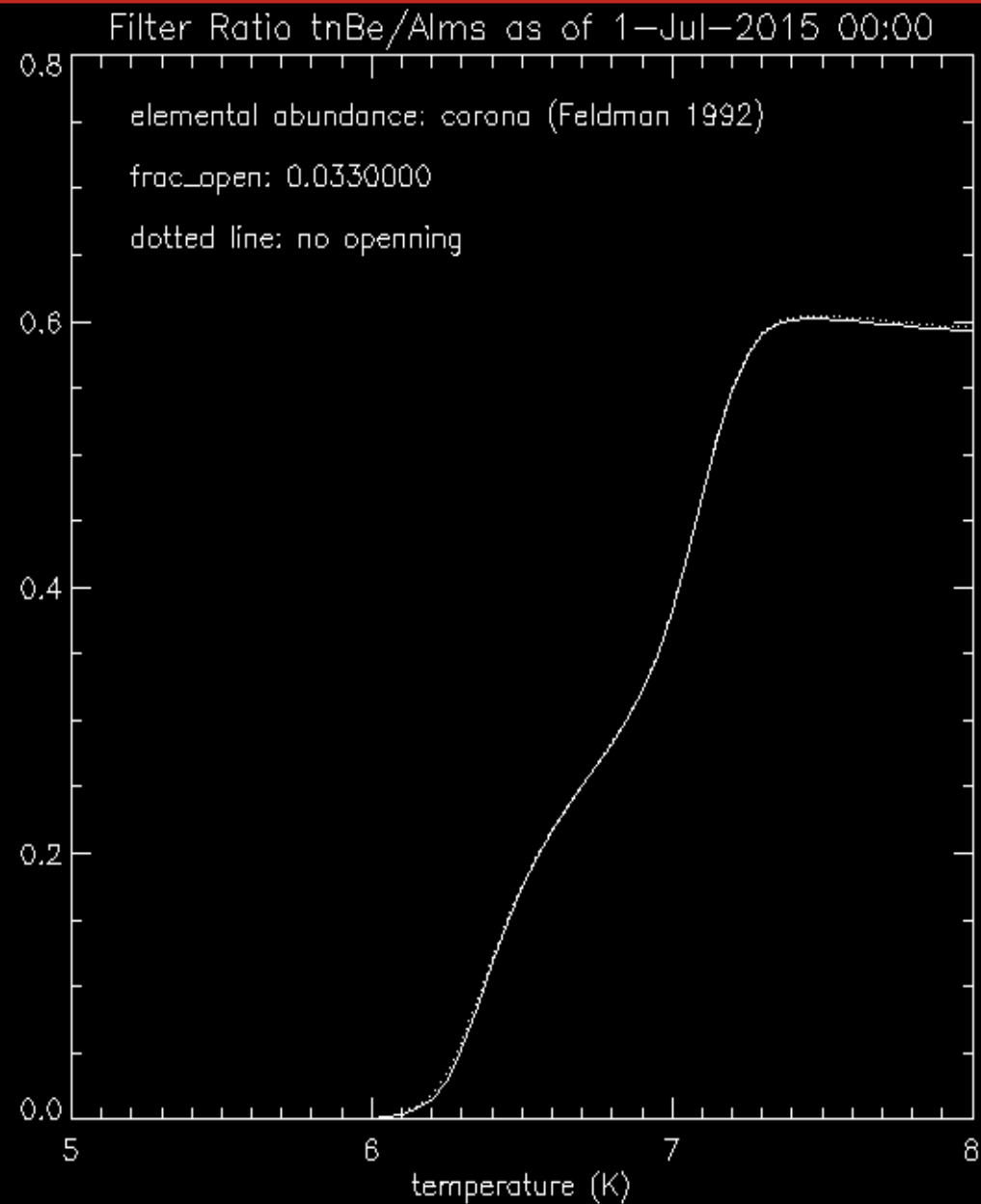
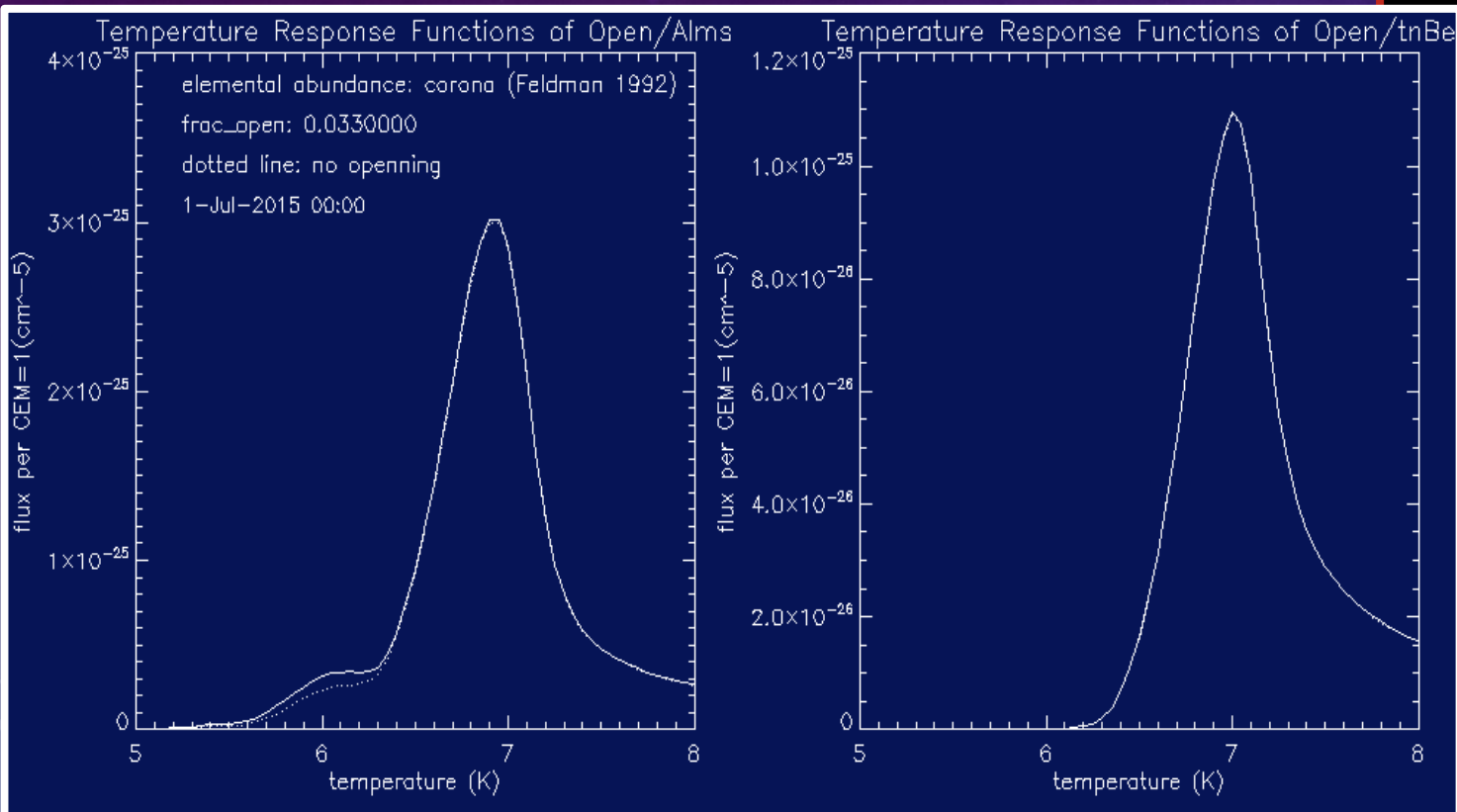
STEP 3: FINDING TEMPERATURE AND EMISSION MEASURE

- The filter-ratio method is the key to finding the average coronal temperature and the average emission measure.
- Using the ratio of two different filters, we are left with the function of temperature. With that we can also go back and find the emission measure.
- I ran a program that used the filter-ratio method to find the temperature and emission measures of the Al-mesh and thin-Be filters.

$$R_{ij} \equiv \frac{DN_i/\delta t_i}{DN_j/\delta t_j} = \frac{F_i(T)}{F_j(T)}.$$

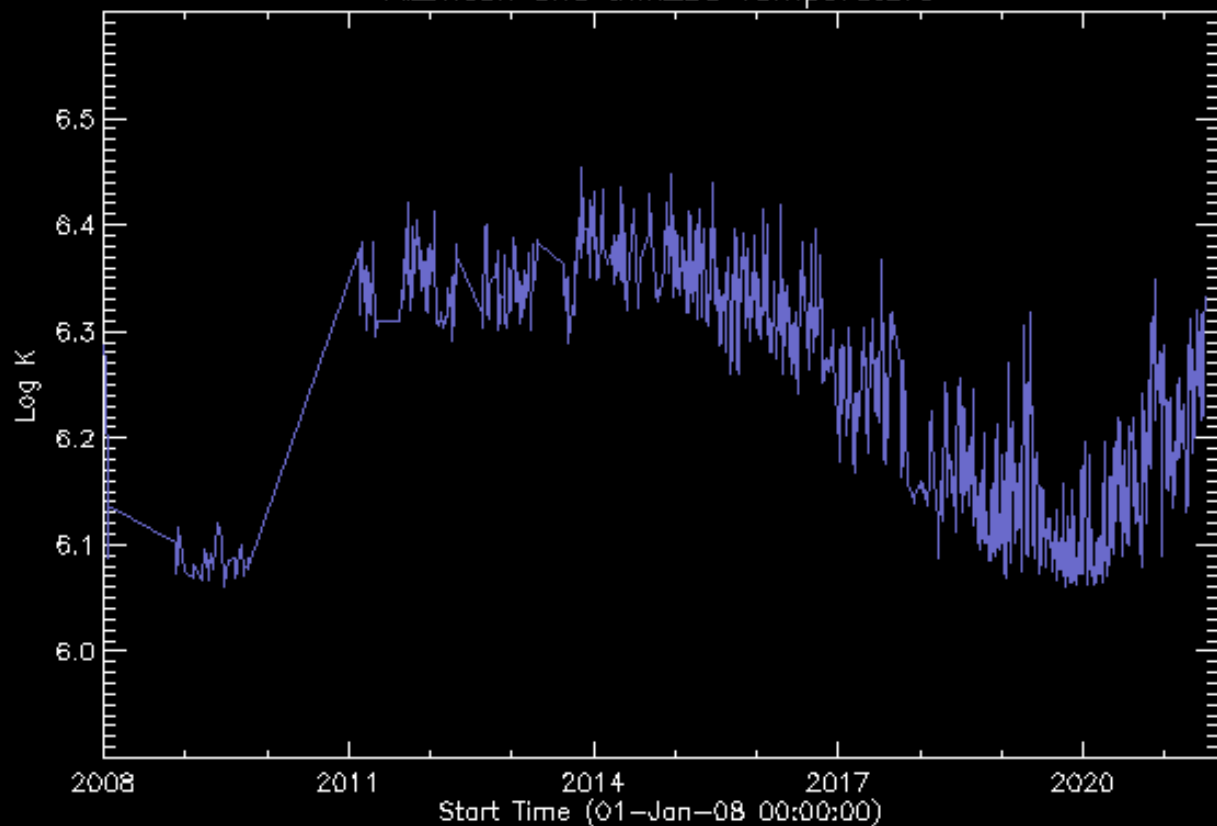
$$\epsilon = \int_0^{\infty} N_e^2(l) dl \cdot d\sigma. \quad (4)$$

TEMPERATURE RESPONSE FUNCTIONS AND FILTER RATIO

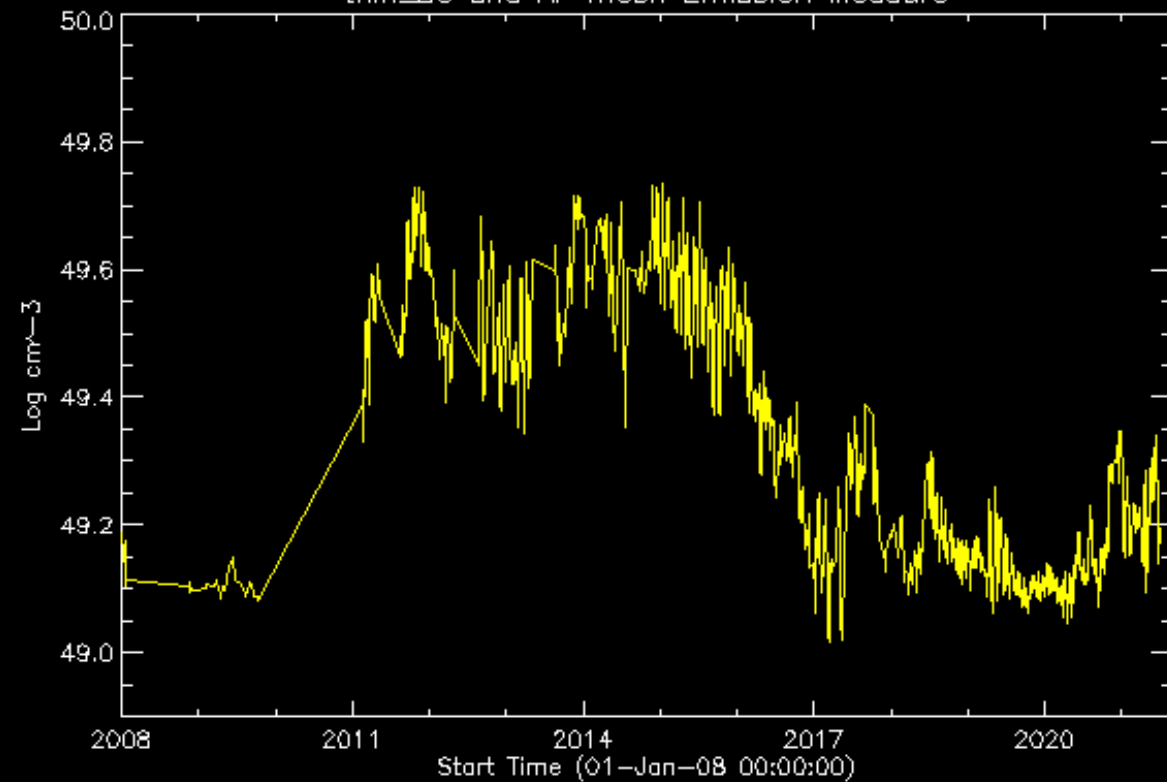


TEMPERATURE AND EMISSION MEASURE

Al_mesh and thin_Be Temperature

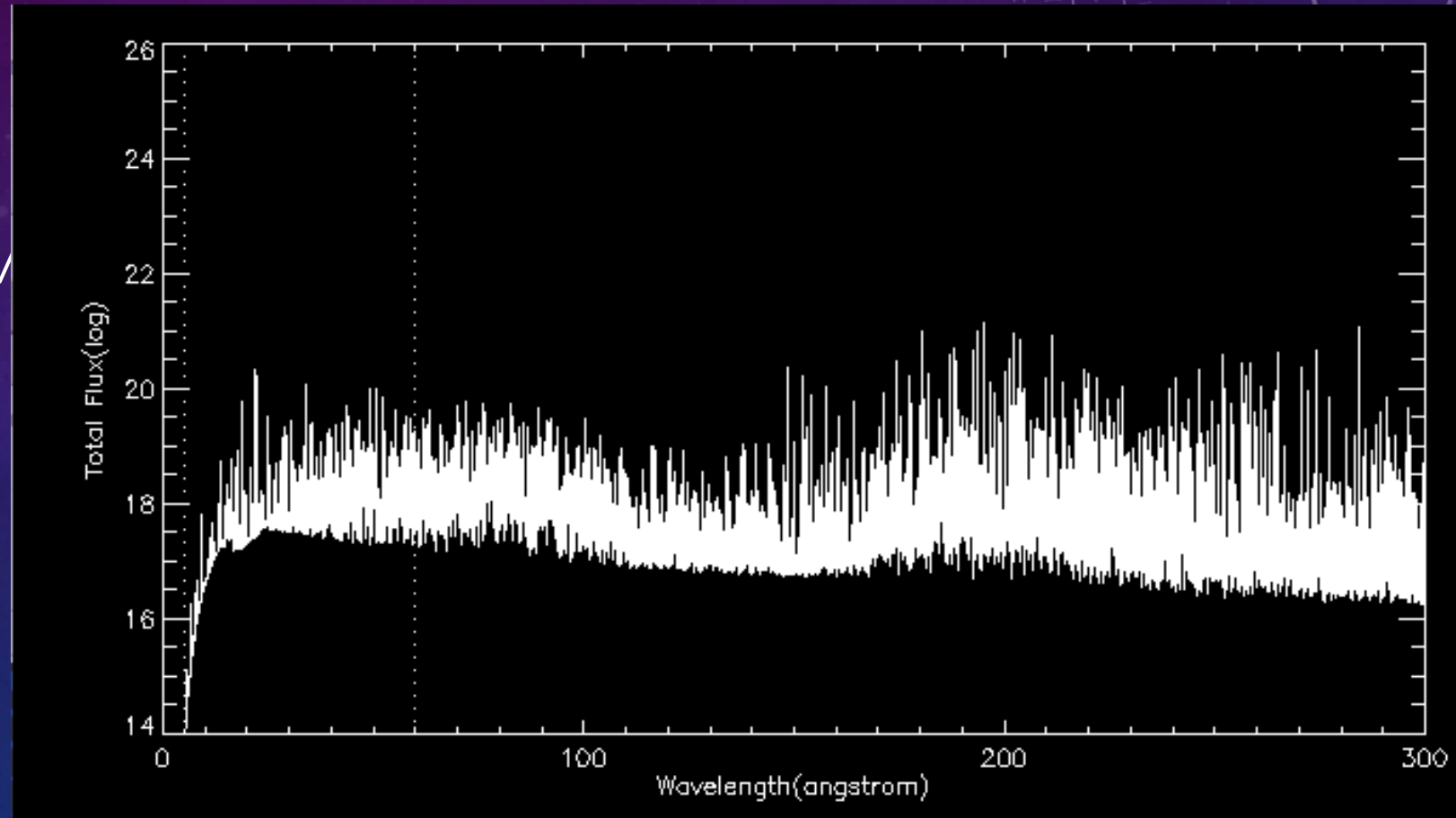


thin_Be and Al-mesh Emission Measure

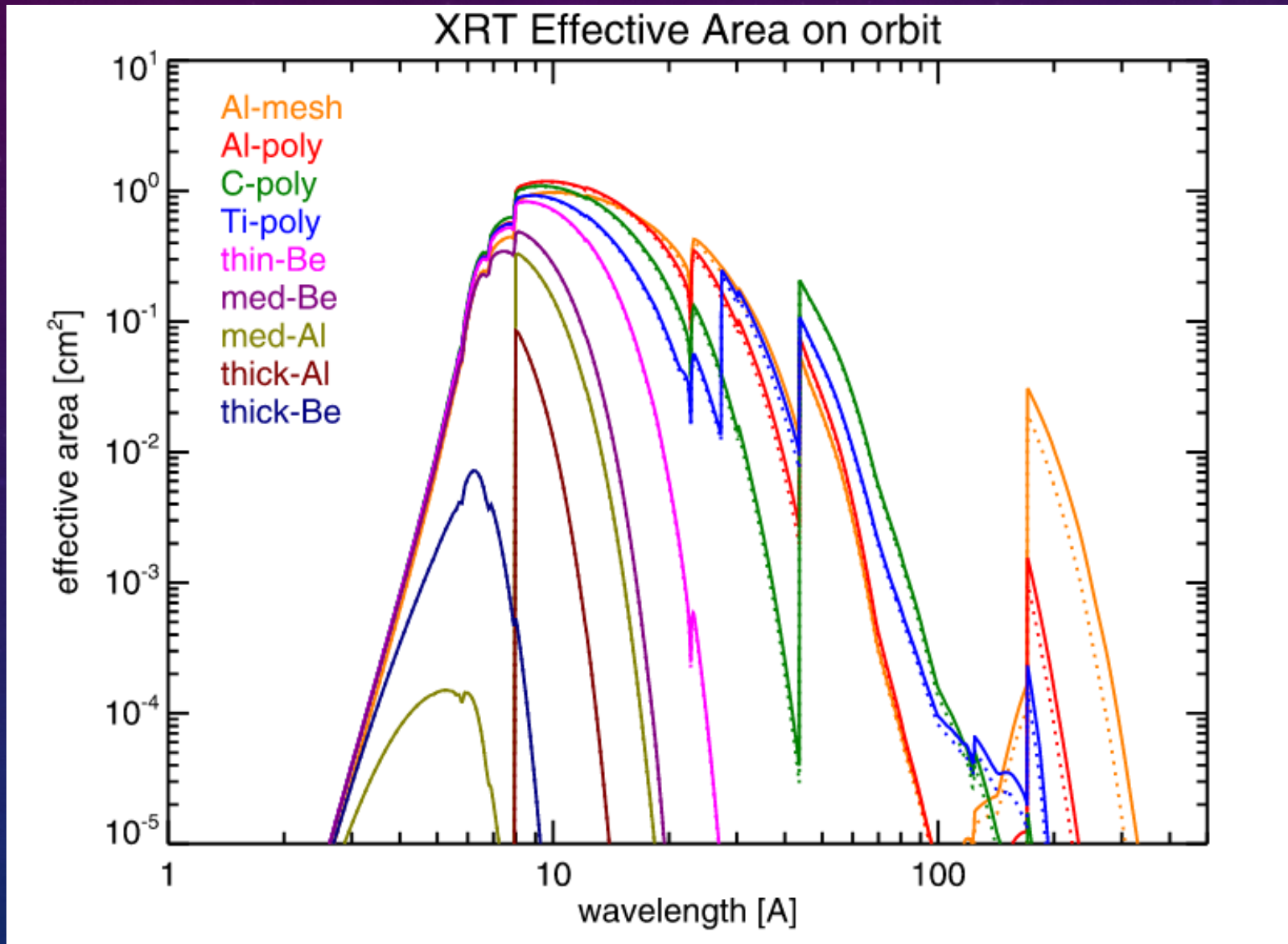


STEP4:FINDING IRRADIANCE

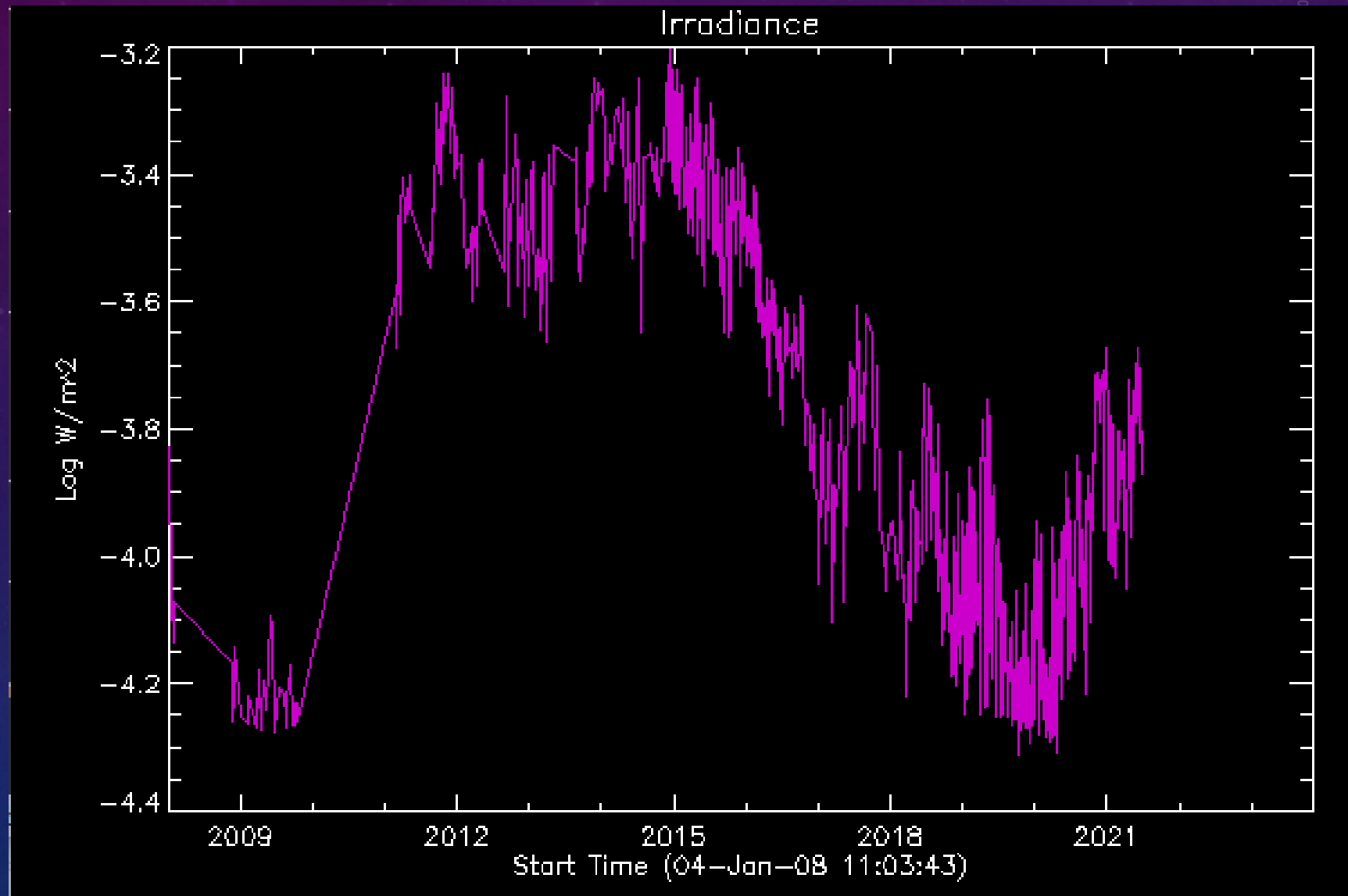
- We converted the temperature and emission measure to solar irradiance in the unit of W/m^2 by using the thermal distribution spectra calculated by CHIANTI database.
- We then integrated over the wavelength range of 5-60 (Å) XRT spectral response



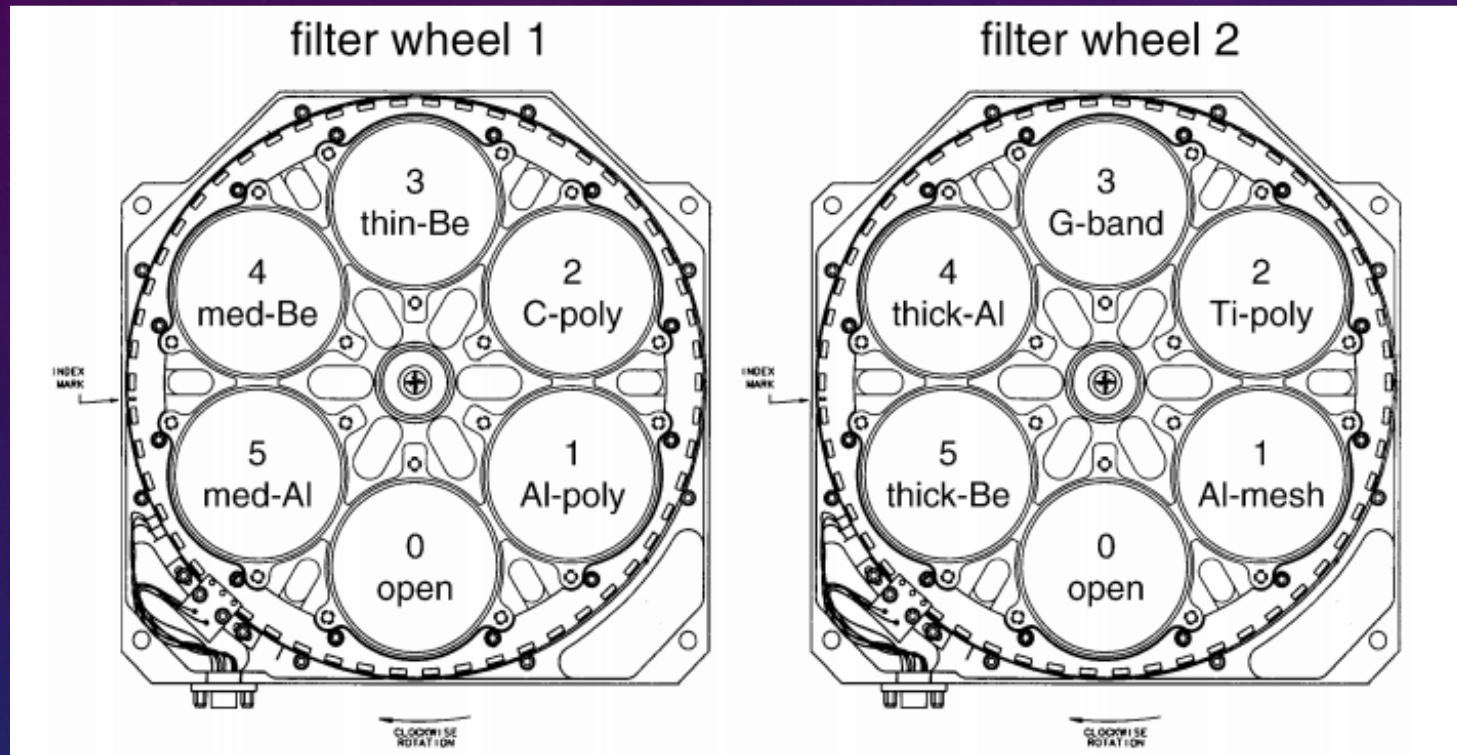
XRT SPECTRAL RESPONSE



IRRADIANCE OF AM/TB



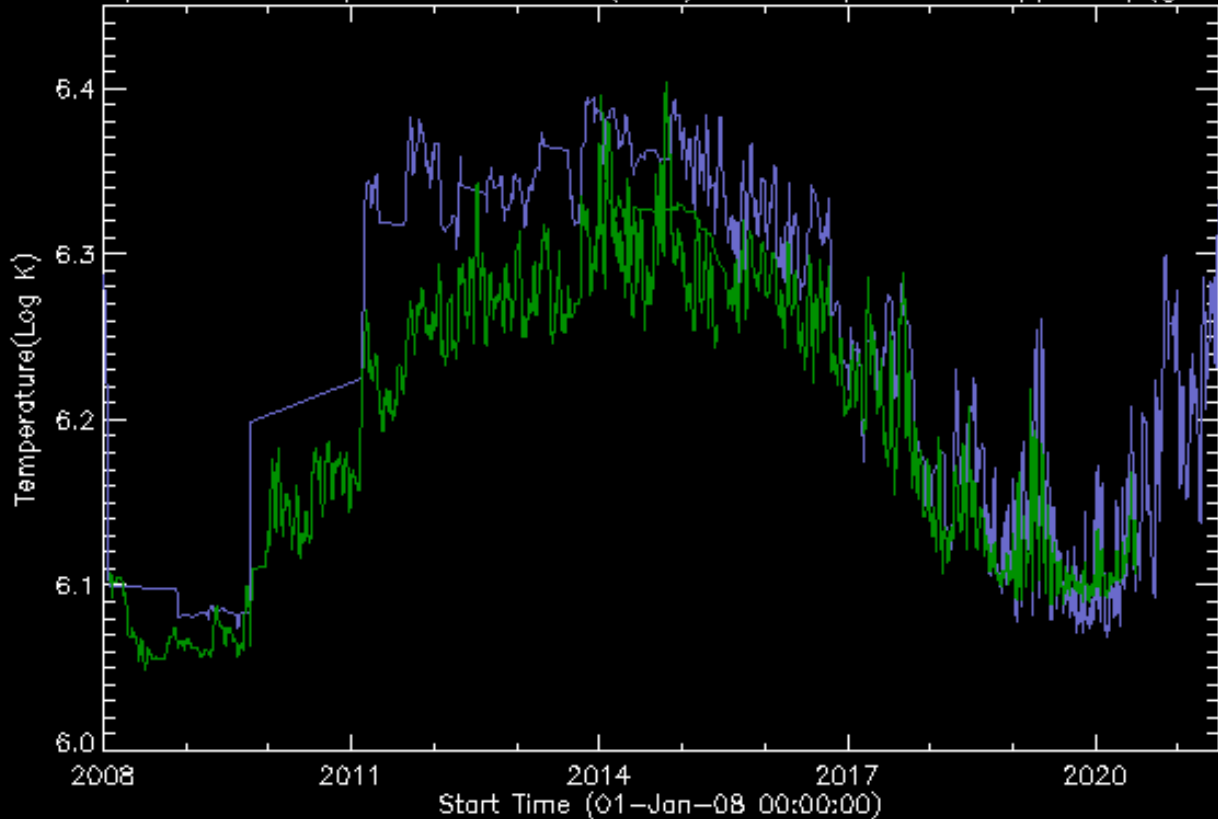
STEP5:COMPARISON



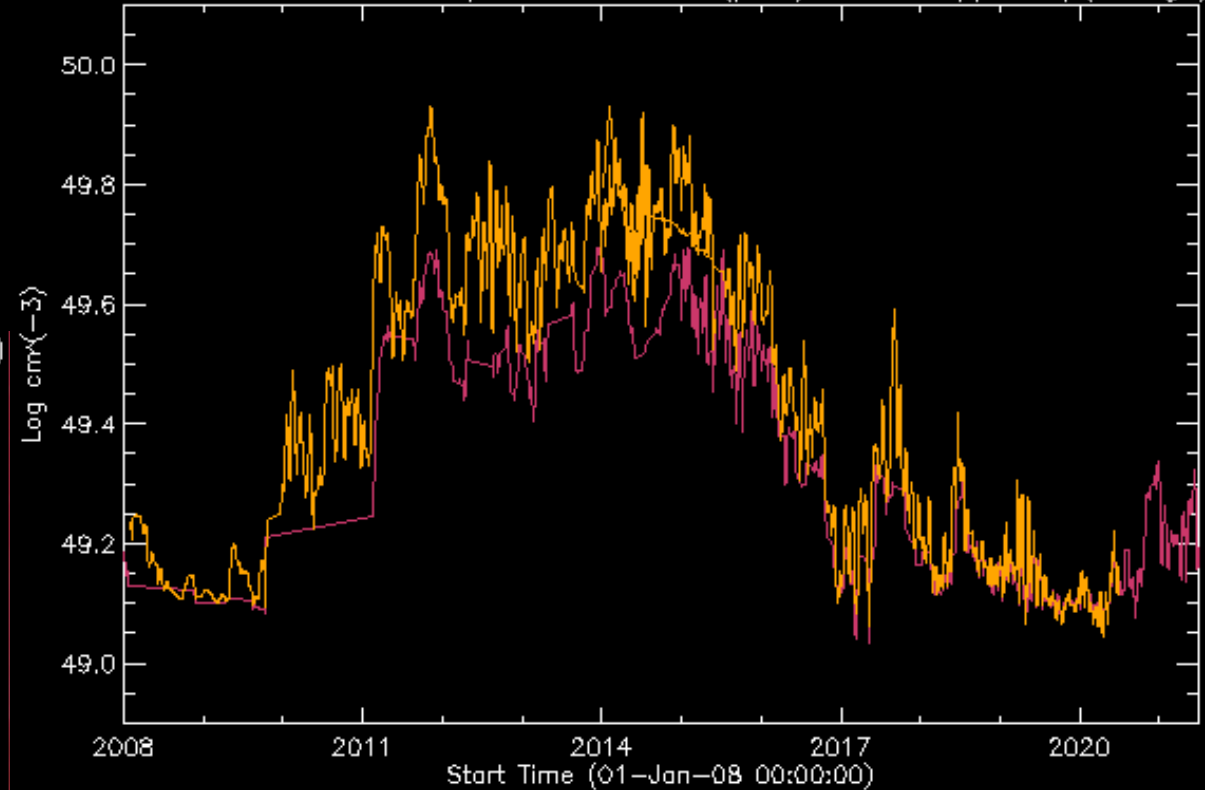
- Previous Study
 - Al-mesh/Ti-poly (2006-2015)
 - Al-mesh/Al-poly (2015-2020)
- Sunspot Numbers
 - Silso
 - <https://wwwbis.sidc.be/silso/>
- The following plots have smoothed data points for easier comparison

TEMPERATURE AND EMISSION MEASURE COMPARISON

Temperature Comparison of AmTb(blue)and Composite AmTp/AmAp(green)

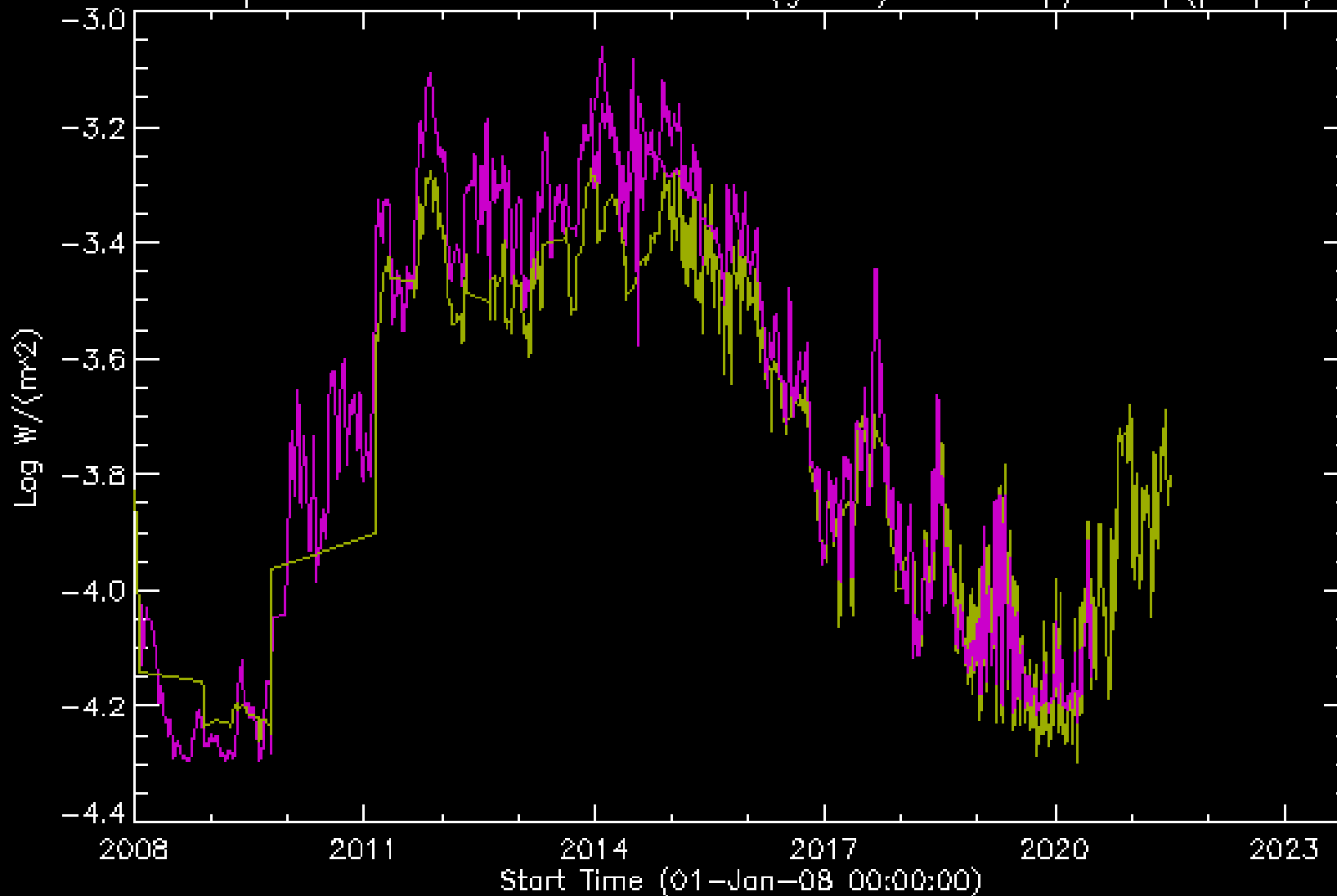


Emission Measure Comparison of AmTb(pink) and AmTp/AmAp(orange)

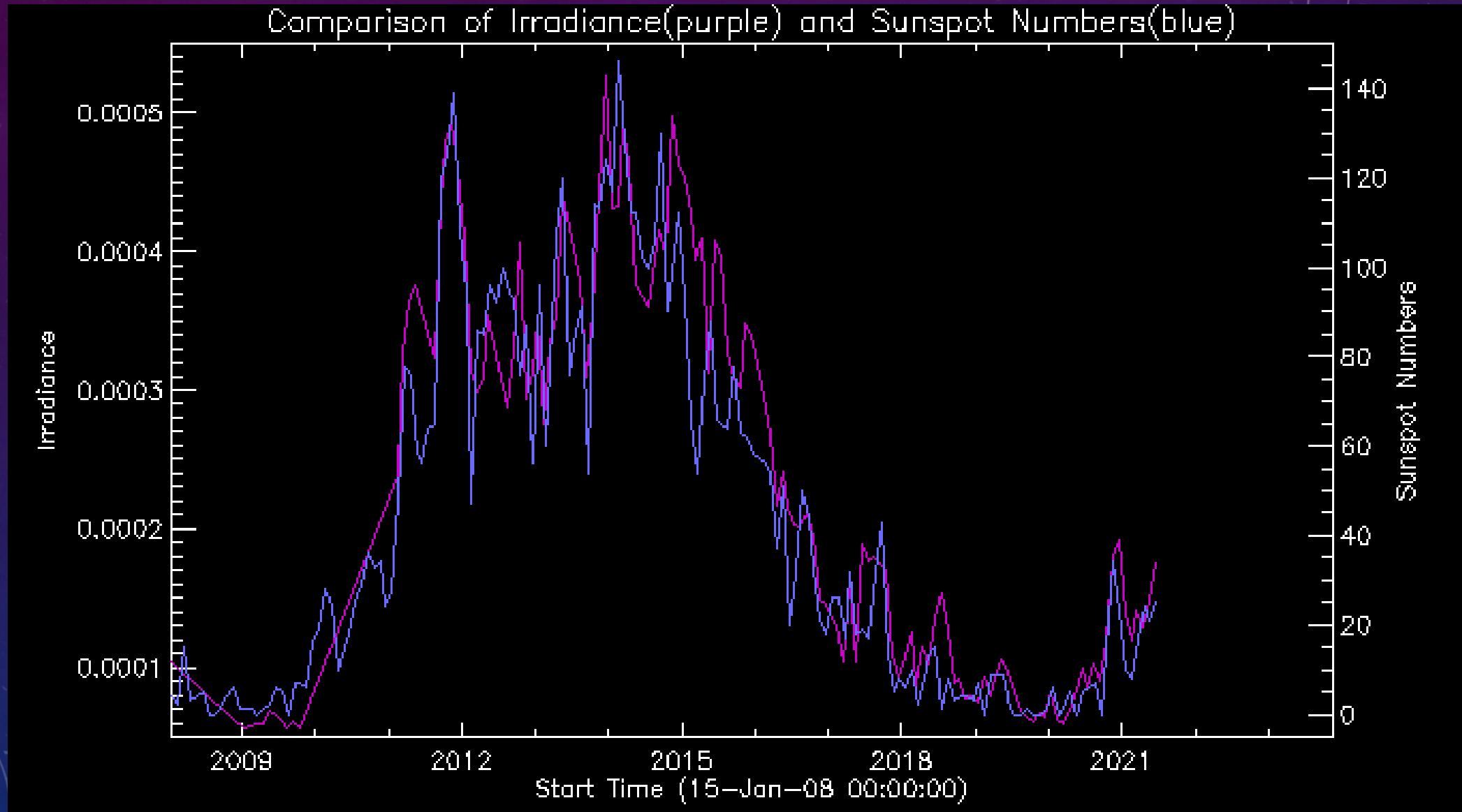


IRRADIANCE COMPARISON

Comparison of Irradiance of AmTb (green) and AmTp/AmAp (purple)



COMPARISON OF SUNSPOT NUMBER AND XRT IRRADIANCE



SUMMARY

- We successfully found the temperature, emission measure, and irradiance of the thin-be and al-mesh filter pair.
- The plots follow the 11 year cycle
- During the comparison with the previous study, we found that our study had a higher temp, but lower emission measure than the other study. We also see the direct correlation between the emission measure and the irradiance.
- Finally, the sunspot number is very similar to the irradiance.

REFERENCES

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THANK YOU

- Special Thanks to Aki Takeda, Suman Panda, and all the mentors for guiding me on this journey.
- Thank you to all my fellow students who supported me along the way.



FILTER RATIO METHOD

$$E_i = \frac{1}{4\pi D^2} \int_0^\infty \int_\lambda N_e^2(l) P[\lambda, T(l)] \eta_i(\lambda) d\lambda dl \cdot d\sigma, \quad (1)$$

$$E_i = \frac{1}{4\pi D^2} F_i(T) \varepsilon, \quad (2)$$

$$F_i = \int_\lambda P(\lambda, T) \eta_i(\lambda) d\lambda \quad (3)$$

$$\varepsilon = \int_0^\infty N_e^2(l) dl \cdot d\sigma. \quad (4)$$

$$DN_i = f_i(T) \varepsilon \delta t_i. \quad (5)$$

$$R_{ij} \equiv \frac{DN_i / \delta t_i}{DN_j / \delta t_j} = \frac{F_i(T)}{F_j(T)}. \quad (6)$$

$$N_i = E_i / 3.65 k_e,$$

$$DN_i = N_i \delta t_i / 100,$$