This document contains notes on how to convert Chandra imaging time to MJD and count/second to flux and luminosity units.

MJD

After processing the Chandra data with MEGA's *Guide to Analyzing Flares,* you are left with an _evt.fits file. This is a table of binned events. In this file there is a Chandra specific TIME column. However, this is reference to some arbitrary starting period.

Table Browser for 1: 28232_sgra_2-8keV_lc300_mjd_l

	TIME_BIN	TIME_MIN	TIME	TIME_MAX
1	1	8.290351e8	8.290353e8	8.290354e8
2	2	8.290354e8	8.290356e8	8.290357e8
3	3	8.290357e8	8.290359e8	8.290360e8
4	4	8.290360e8	8.290362e8	8.290363e8
5	5	8.290363e8	8.290365e8	8.290366e8
6	6	8.290366e8	8.290368e8	8.290369e8
7	7	8.290369e8	8.290371e8	8.290372e8
8	8	8.290372e8	8.290374e8	8.290375e8
9	9	8.290375e8	8.290377e8	8.290378e8
10	10	8.290378e8	8.290380e8	8.290381e8
11	11	8.290381e8	8.290383e8	8.290384e8
12	12	8.290384e8	8.290386e8	8.290387e8
13	13	8.290387e8	8.290389e8	8.290390e8

If we want to convert that to MJD, we can find the "zeropoint time" in the header ('MJDREF') and perform the following calculation.

```
mjdref = f[0].header['mjdref']
timezero = f[0].header['timezero']

time = table['TIME']
utc_time = mjdref + (timezero + time)/86400
```

Where f[0] is the data table above.

Flux and Luminosity

Similarly, Chandra gives data in counts/second and there is likewise a column in the _evt.fits table for binned counts ('NET_RATE'). Unfortunately, there is no simple conversion between the two, and any change is based on a best fit model.

We can use the PIMMS X-Ray astronomy software from the Goddard Spaceflight Center to help us create a model. Installation instructions can be found here https://heasarc.gsfc.nasa.gov/docs/software/tools/pimms_install.html

You can also use the PIMMS web interface if the installation does not work.

https://heasarc.gsfc.nasa.gov/cgi-bin/Tools/w3pimms/w3pimms.pl

In both of these programs, the first step is to specify a model to help us convert between counts and flux. Nowak (2012) suggests a power law with photon index = 2 and hydrogen column density (n_h) = 14.2e+22. Note that these are not set in stone, they are just from literature. Feel free to edit them. Once we have specified the model, set the appropriate instrument your data came from, what you want to convert to and what energy range of the luminosity/flux you want. Recall that the _evt.fits data is binned into time AND energy buckets, likely 2-8keV if you are doing Chandra X-ray analysis of SgrA*. After, enter the counts/s reported in your data, convert it and read off the flux!

Note that PIMMS can output the flux but not the luminosity. If you want L, simple multiply by the distance to the object and 4pi (simple L and F relationship from introductory astrophysics).

The quiescent (uneventful region - no flare) x-ray luminosity should be about 2e+33 erg/s.

The Chandra _evt.fits table should give you the error in counts/s. If you want to find the error in luminosity and flux, simply run the count error through PIMMS and assume that is the flux error. To get luminosity error, we simply use the luminosity formula and propagate the error.

$$u(L) = L\sqrt{(u(F)/F)^2 + (u(r)/r)^2}$$

Where f is flux and u(F) is the error of flux (found by PIMMS). Based on Haggard (2019), r = 7.97kpc with u(r) = 0.07kpc.

There ends up being a linear relationship between counts and flux, and you can find the constant by dividing the counts by the resulting flux. In this way, once you have the constant multiplicative factor, you can just apply that to all counts and get flux without having to type in every datapoint.

Otherwise, if you downloaded PIMMS, you can automate a script to run calls on the command line

Can use the following script to help you automate this entire process.
https://github.com/ZachSumners/SgrA--MSc/blob/main/Chandra/Scripts/pimms.py

Requires local PIMMS installation.