

Python *sso_freeze* User Guide

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Hardwire Locations

- The code is split into 5 sections (labelled and with a brief explanation about each within the script).
- Sections 1), 2), 3) and 5) require a file to be hardwired.
- Section 1) -> **evt_location** -> input the path of the event file to be corrected.
- Section 2) -> **orb_location** -> enter path of the orbit empheris file of the spacecraft.

Hardwire Locations

- Section 3) -> **eph_location** -> enter path of chandra_horizons2000 file needed (from horizons2000 folder).
- Section 5) -> **new_evt_location** -> enter path of the new corrected fits file to be written with corrections.

Using Python *sso_freeze*

- The next few slides will talk about how to use the code in sections.
- Once the files are hardwired, the code basically does all the work without any more input required by the user.
- The code is commented throughout, explaining what each variable is.
- For new Python users, the very first section imports all the relevant modules needed to run the function within the script/Jupyter notebook.

Section 1): Reading in the Chandra event file

- ***Make sure the event file is hardwired before running the code!*** – this is at the beginning of the section.
- The event file pre-correction should look similar the event file below – distinguishable streaks across the detector (as Jupiter moves very fast when viewed from Chandra).



Section 1): Reading in the Chandra event file

- Once the file is read in, the header information and data needed for analysis is extracted:
 - the time of each photon observed,
 - start time and date of the observation,
 - the x and y position of Jupiter with it's corresponding RA and DEC and the start of the observation.
- With the date and time information, the Day of Year (DOY) when Chandra was making the observations is calculated – using a defined function at the beginning of the script, *doy_frac*.

Section 2): Reading in the orbit empheris file

- ***Make sure the orbit empheris file is hardwired before running the code!*** – this is at the beginning of the section.
- When the orbit empheris file is read in, like before, the relevant header information is extracted:
 - Time of observation when the Jovian photons reach the spacecraft
 - Positional coordinates of space craft at the time when the photons were detected
- The start time of obs is subtracted from the time found in the orbit empheris file to allow the DOY of the spacecraft to be calculated.

Section 3): Reading in the *horizons2000* file

- ***Make sure the Chandra_horizons2000 file is hardwired before running the code!*** – this is at the beginning of the section – files found from horizons2000 folder.
- If you are using your own generated file, ensure that the table settings are of the following form:

Table Settings [change] : QUANTITIES=1,13-15,17,20; time digits=FRACSEC; angle format=DEG

- The files **do not** to be edited to account for the time to be read into sections – Python has in built-in modules to carry this out!

Section 3): Reading in the *horizons2000* file

- The code automatically locates the empheris file data needed and reads in the columns needed – again, any size horizons2000 file can be read in!
- The date, time, RA and DEC of Jupiter at each specified interval is read in and the DOY of the horizons2000 file is calculated.
- If the date lies within a leap year, the DOY is corrected and this is used instead.

Section 4): Applying the corrections to the photon position

- The code takes the positional coordinates and DOY from Section 2) and performs a 1D-linear interpolation to the DOY from the horizons file.
- This produces the new orbital positional coordinates within this time range.
- This is used to calculate the positional coordinates of Jupiter during the observation with the corresponding RA and DEC.
- The offset from Jupiter was also calculated (denoted as **cc** in the script/Jupyter notebook).

Section 4): Applying the corrections to the photon position

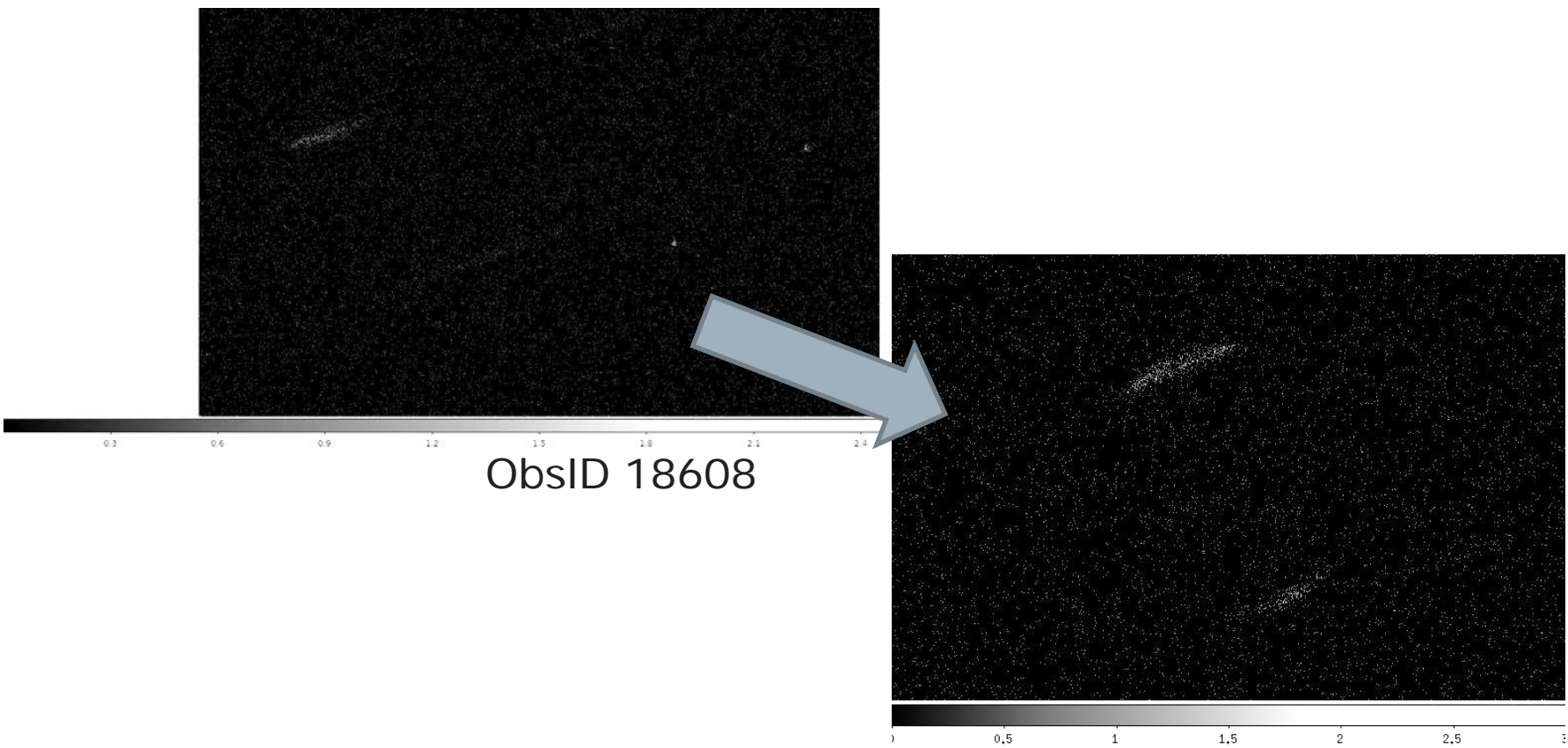
- An interpolated RA and DEC is calculated from interpolating the RA/DEC and DOY from Section 3) to the DOY of Chandra (calculated from Section 1).
- The values are then used to calculate the corrected position of the photons i.e track them back to Jupiter's disk and auroral regions.

Section 5): Creating the new corrected fits file

- ***Make sure the file path of the new fits file is hardwired before running the code!*** – this is at the beginning of the section.
- The code retrieves the data and header information from the original fits file and changes the x and y coordinates to the corrected positional coordinates.
- The corrected fits file is then written as a new file – therefore **the original fits file is not overwritten.**

Section 5): Creating the new corrected fits file

- The final result should look something similar to below – two clear North and South x-ray regions!



Other comments

- The python code was translated from the *stop_hrci* IDL script created by Randy Gladstone.
- The python code produces the same result as the IDL script without having to overwrite the original file and making edits the horizons2000 file.
- The plot at the end was used for a sanity check – to check the data was interpolated correctly.
- The figure can be saved if needed but it is not essential for the code to run.

Other comments

- Future steps:
 - To further optimise the code -> no need to hardwire files and possibly extract the files from a library with the associated ObsID.
 - Translate the other IDL scripts into Python too.
 - Will all be on Github and will be made public.
 - Github repository with the script(s):
<https://github.com/waledeigt/jupiter-python.git>