

# *MOSES* Data Coordinates and Doppler Shifts

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## 1 Introduction

The purpose of this document is to explain the orientation of images obtained by the *MOSES* rocket payload, so that the dispersion direction and the sense of observed doppler shifts can be determined with certainty.

## 2 *MOSES\_READ*

The output of *MOSES\_READ* is an image oriented as if we are facing the detector. Fig. 1 illustrates this orientation in the instrument coordinates  $(x, y, z)$ , with  $x$  pointed toward us, in the sunward direction. Thus, each image has  $z$

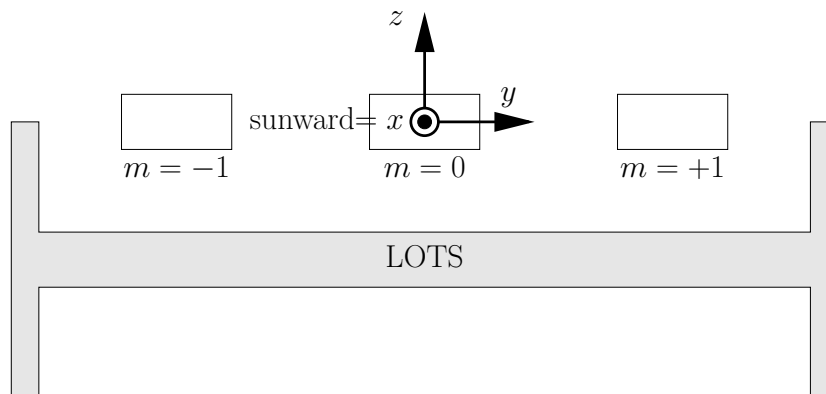


Figure 1: *MOSES\_READ* image orientation, looking into the CCDs. Not to scale.

up and  $y$  to the right. The output of `MOSES_READ` therefore has the dispersion in the  $my$ -direction.

`MOSES_READ` first reads in the raw image and then reorients the image using the IDL command `ROTATE(image, 2)`. This is a  $180^\circ$  rotation, mapping  $X \rightarrow -X$ ,  $Y \rightarrow -Y$ . By the capitalized coordinates  $X$  and  $Y$ , we mean rightward and upward screen coordinates for viewing the image in IDL (see the documentation for `ROTATE`). That this is the correct transformation was determined by Roger Thomas during the flat field exercise at GSFC in 2004. Since the flat field data was obtained using different software than the flight software, it is worth checking that the same transformation from readout order to detector plane coordinates holds (see §4).

### 3 Solar Orientation

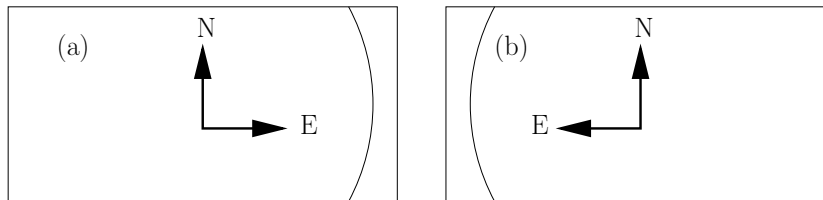


Figure 2: Solar orientation in the 2006-Feb-08 data. The arc represents the solar east limb. (a) Output of `MOSES_READ`. (b) Output of `MOSES_PREP`.

The images obtained with *MOSES* on February 8, 2006, when viewed in the `MOSES_READ` orientation, have north on top and the east limb to the right. The data reduction routine `MOSES_PREP` introduces a reflection, using `ROTATE(image, 5)`, to give proper solar orientation. The transformation is  $X \rightarrow -X$ . This is illustrated in Fig. 2.

### 4 Consistency Test: Flat Fields

The flat fields images generated by Lewis from the 2004 GSFC data are saved in raw (readout) order. Based on the foregoing reasoning, we would expect that the alignment of the flat fields with the solar-oriented data derived by `MOSES_PREP` should require a transformation `ROTATE( ROTATE(image, 2)`,

5 ). This is equivalent to `ROTATE(image, 7)` or  $X \rightarrow X, Y \rightarrow -Y$ , which is exactly the transformation implemented by Charles for *MOSES\_PREP* in June, 2006. At the time, this was determined in a completely independent way, by matching dark pixels in the flats to corresponding dark pixels in the flight images. We are therefore confident that the raw readout is still in the orientation determined in §2.

## 5 Conclusion

Coordinates and dispersion direction for the 2006-Feb-08 *MOSES* launch are summarized in the following table. Everything is referenced to solar E/W and N/S because these are easily determined by comparison of our images with other solar data from the same day (*e.g.* *SOHO/EIT*).

Spectral Order	$m = -1$	$m = 0$	$m = +1$
Redshift	W	n/a	E
Blueshift	E	n/a	W
Focal plane $y$	E	E	E
Focal plane $z$	N	N	N
MOSES_READ $X$	E	E	E
MOSES_READ $Y$	N	N	N
MOSES_PREP $X$	W	W	W
MOSES_PREP $Y$	N	N	N