ANALYSIS OF THE INSTRUMENTAL BACKGROUND OF THE MOS DURING REVOLUTIONS: 14–16

EPIC-MCT-TN-003 **Simona Ghizzardi**

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S. Ghizzardi - Milano Calibration Team - Istituto di Fisica Cosmica - CNR - Milano
e-mail: simona@ifctr.mi.cnr.it

Contents

1 The data

Data concerns all the CCDs of both the MOS cameras. Measurements have been taken during revolutions 14 to 16, before the doors opening. All the CCDs are working in Full Frame Imaging mode. The Calibration Source is OFF, and the EDU threshold is 25. Similar RUNS (same: MOS, CCD, Operating mode, etc.) have been joint together to increase the statistics. Data have been analyzed in IDL.

2 MOS 1

For the MOS 1 there is only one RUN in the revolution 14. The duration of the observation is roughly 3800 sec and so the statistics is not particularly high.

The **pattern distributions** (see figs. 1) are similar for all the CCDs.

The main contribution comes from monopixels, bipixels and pattern 31. It is worth to notice that the contribution of pattern 31 is really important, as it is comparable to the contribution of monopixel events.

The presence of the other kind of pattern configurations is negligible.

So, if the pattern 31 events are rejected, the background noise is significantly reduced.

In figs. 2 we reported the **spectra** for some CCDs. The black line is the total spectrum, the red line is the spectrum for the monopixel events and the blue one is the spectrum of the bipixels configurations.

In these spectra some features appear. At the very low channels there is a lot of noise, where most of the contribution comes from mono and bipixels. For all the CCDs there is a peak at 1.5 keV (probably the Aluminium K_α). Some other peaks are frequently present (especially at about 3.5 keV). For energies higher than about 6 keV, the main contribution is not from monopixel or bipixel events, and looking at the pattern distribution we can conclude that here the contribution is from pattern 31 events. A particular feature is present at energies higher than 12 keV, where an excess of events is registered. This is probably due to a bad reconstruction of the events of energy higher then the upper limit of the energy range (namely 15 keV).

As an example in fig. 3 we report the **light curve** for CCD 1 (number of counts at each frame time). The other light curves are quite similar and in none of them any feature or irregularity is detected.

In fig. 4 there are the **images** of the 7 CCDs. It can be noticed that a large quantity of bright columns and pixels are present and most of them are not included into the bright pixel tables. Nevertheless, they mostly contribute at the very low part of the spectrum, and so they can be easily ruled out.

3 MOS 2

For the MOS 2 there are three RUNs. The first and the last are very long (18000 sec and 42000 sec respectively) runs, the second one took about 3000 sec. The first two runs are taken during the revolution 14 and the last during the revolution 15.

The **pattern distributions** (see figs. 5) are similar for all the CCDs and they display the same behaviour as the MOS 1 CCDs.

Again, the main contribution comes from monopixels, bipixels and pattern 31, with the contribution of pattern 31 comparable to the one of monopixel events.

In figs. 6 we reported the **spectra** for some CCDs. The black line is the total spectrum, the red line is the spectrum for the monopixel events and the blue one is the spectrum of the bipixel configurations. In this case the statistics of the RUNS is higher than the MOS1 RUNs, and the part at higher energies is more detailed. The main contribution in this region is again from pattern 31 configuration.

In these spectra some features appear. Some of them are the same of the MOS 1 spectra, i.e. the peak at very low energies, the Aluminium peak at 1.5 keV, the peak at 3.5 keV and the feature above the 12 keV. Other peaks (different for different CCDs) appear for the MOS2. In particular we note that in the CCD 2 a complex group of peaks is present at 3.5-5 keV. We will see later that all these features are due to some bright columns.

In general the **light curves** do not show any irregularity, except for the CCD2. We report a part of its light curve (in fig. 7) related to the third RUN. At about $1.9 \cdot 10^5$ s, a sudden rise in the light curve is registered. We will study these events later on. At the same times the other CCDs have a regular behavior.

In fig. 8 there are the **images** of the 7 CCDs. Again, large quantity of bright columns and pixels – not included into the bright pixel tables – are present. They most contribute at the very low part of the spectrum, and so they can be easily ruled out.

Apart from the presence of bright pixels and columns, as in the MOS 1, here we can notice that the CCD2 is really very noisy. It is to be noticed that the CCD 2 has irregularities also in the light curve and in the spectrum.

In order to estimate the mean level of noise on the CCDs, it is necessary to "clean" the event list.

4 Cleaning

For all the RUNs the bright pixel tables have been inserted, to discard the bright pixels and columns.

Ruling out such pixels and some of the edges of the CCDs, where often other bright columns are present, the features in the spectra disappear, apart from the aluminium peak, the noise at very low energies and the feature at very high energies. As an example we report here (figs. 9 and 10) the spectrum of fig. 2 and 6 after removing the bright pixels.

In the spectrum of the CCD2 in the MOS 2 there is residual feature around the aluminium peak. For this CCD a more detailed cleaning procedure will be treated in the next section.

In general these bright pixel tables are not enough for ruling out all the bright pixels on the CCDs. In any case, as it can be seen in fig. 11, the bright pixels contribute to the spectrum in the [0-0.2] keV energy range. So, although a complete bright pixel table is not available, such events can be avoided, considering only energies greater than 0.2 keV.

As an of example we report the images for some CCD2 for events which are selected in the [2-10] keV energy range (fig. 12).

It can be noticed that the bright columns and pixels are not present. The noise appears uniform, and some lines can be seen. This suggest that the main contribution to the noise probably comes from cosmic rays hitting the CCDs.

5 CCD 2 in MOS 2

As we already have pointed out previously, CCD2 is particular noisy. The most of the unwanted features in the spectrum have disappeared with the removal of the bright pixels.

The main point which must be investigated further concerns the sudden rise in the light curve (see fig. 7). Selecting the time range [190490-190550] sec (1 minute!), the correspondent events have the image in fig. 13.

We excluded therefore these events. With such a removal, the residual bump around 1-2 keV, disappears. We tried also to remove the second run, whose image (fig. 14-left) appears particularly noisy.

It can be seen that the image corresponding to the first and the last RUN (fig. 14-right), appears less noisy and more similar to all the other images. It could be that, during the second RUN, the CCD 2 was hot (this information can be checked looking at the HouseKeeping files)

When determining the mean noise level of each CCD, for CCD 2 we will report both the value considering all the three RUNS and the value when the second RUN is excluded.

6 Noise evaluation

For each CCD, we can estimate (Tab. 1) the averaged count rate (per pixel and on the whole CCD) when considering only the "cleaned" events. As pointed out in the previous section, for the CCD 2 in MOS 2, we will report both the value considering all the three RUNS and the value when the second RUN is excluded.

Table 1: Averaged noise for each CCD.

		0.2-2 keV		0.2-10 keV		2-10 keV	
		cts/s/pixel	cts/s	cts/s/pixel	cts/s	cts/s/pixel	cts/s
MOS 1	CCD 1	2.879e-07	0.100	1.152e-06	0.402	1.439e-06	0.502
	CCD 2	3.269e-07	0.114	1.033e-06	0.359	1.360e-06	0.472
	CCD 3	2.715e-07	0.097	9.982e-07	0.358	1.270e-06	0.456
	CCD 4	7.622e-07	0.267	1.123e-06	0.393	1.885e-06	0.660
	CCD 5	9.205e-07	0.329	1.097e-06	0.392	2.016e-06	0.720
	CCD 6	3.455e-07	0.122	1.045e-06	0.368	1.391e-06	0.490
	CCD 7	3.022e-07	0.107	1.078e-06	0.382	1.380e-06	0.489
MOS 2	CCD 1	3.938e-07	0.137	1.041e-06	0.363	1.435e-06	0.500
	CCD 2	2.502e-06	0.871	1.051e-06	0.366	3.552e-06	1.236
	CCD 2*	8.167e-07	0.284	1.050e-06	0.366	1.867e-06	0.650
	CCD 3	5.540e-07	0.199	8.706e-07	0.312	1.424e-06	0.511
	CCD 4	6.208e-07	0.217	9.145e-07	0.320	1.535e-06	0.537
	CCD 5	2.693e-07	0.096	9.930e-07	0.355	1.262e-06	0.451
	CCD 6	3.736e-07	0.132	9.005e-07	0.317	1.274e-06	0.449
	CCD 7	3.734e-07	0.131	1.075e-06	0.378	1.449e-06	0.509

*Note**: Averaged values when excluding the second RUN

In general the values of all the CCDs noises are similar, and the value in the range 0.2-10 keV is roughly of 0.5 cts per CCD per second.

The CCD4 and CCD5 in MOS1 are more noisy than the others CCDs but only in the lower range of energies, whereas they are similar to the others in the range [2-10] keV.

The same occurs for CCD2. In fact excluding the second RUN affects only values in the lower ranges of energy.

The same analysis outlined above is repeated considering only monopixels and bipixels. The values are reported in Table 2.

In general the values are significantly reduced for higher energies (a factor 3 or even 4). A somewhat weaker reduction is present in the low energy band.

Table 2: Averaged noise for each CCD. Only monopixels and bipixels have been considered.

		0.2-2 keV		0.2-10 keV		2-10 keV	
		cts/s/pixel	cts/s	cts/s/pixel	cts/s	cts/s/pixel	cts/s
MOS 1	CCD 1	2.296e-07	0.080	2.576e-07	0.090	4.865e-07	0.170
	CCD 2	2.643e-07	0.092	3.277e-07	0.114	5.920e-07	0.206
	CCD 3	2.331e-07	0.084	2.700e-07	0.097	5.032e-07	0.181
	CCD 4	6.416e-07	0.225	2.744e-07	0.096	9.160e-07	0.321
	CCD 5	8.060e-07	0.288	2.811e-07	0.100	1.086e-06	0.388
	CCD 6	2.869e-07	0.101	2.554e-07	0.090	5.423e-07	0.191
	CCD 7	2.403e-07	0.085	2.701e-07	0.096	5.104e-07	0.181
MOS 2	CCD 1	3.205e-07	0.112	2.657e-07	0.093	5.860e-07	0.204
	CCD 2	2.318e-06	0.807	2.944e-07	0.102	2.612e-06	0.909
	CCD 2*	6.578e-07	0.229	2.778e-07	0.097	9.356e-07	0.326
	CCD 3	4.976e-07	0.179	2.512e-07	0.090	7.487e-07	0.269
	CCD 4	5.533e-07	0.194	2.692e-07	0.094	8.225e-07	0.288
	CCD 5	2.173e-07	0.078	2.558e-07	0.091	4.728e-07	0.169
	CCD 6	3.189e-07	0.112	2.528e-07	0.089	5.716e-07	0.201
	CCD 7	3.214e-07	0.113	2.770e-07	0.097	5.982e-07	0.210

*Note**: Averaged values when excluding the second RUN

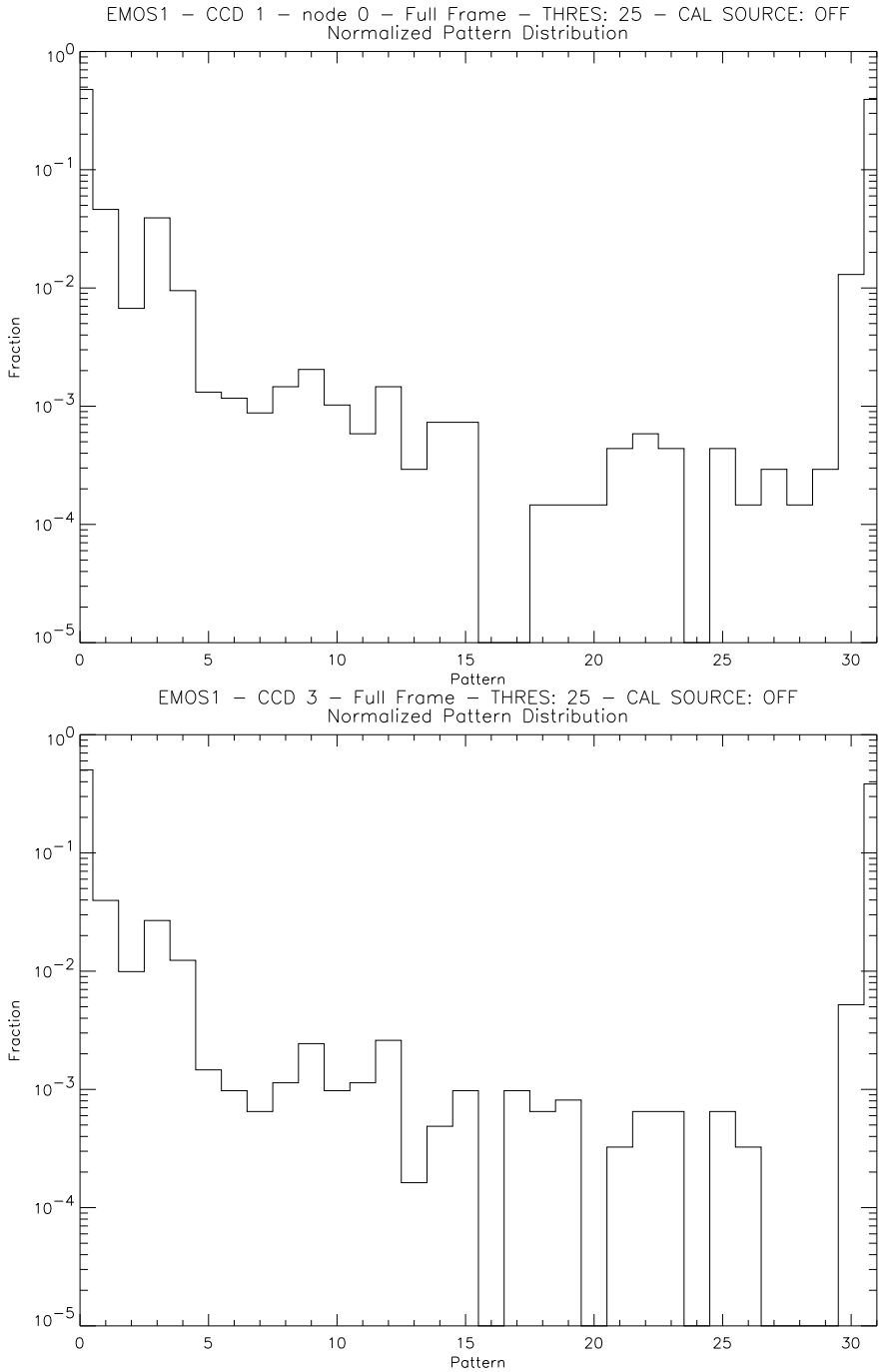

Figure 1: Pattern distribution: major contributors are monopixels and pattern 31

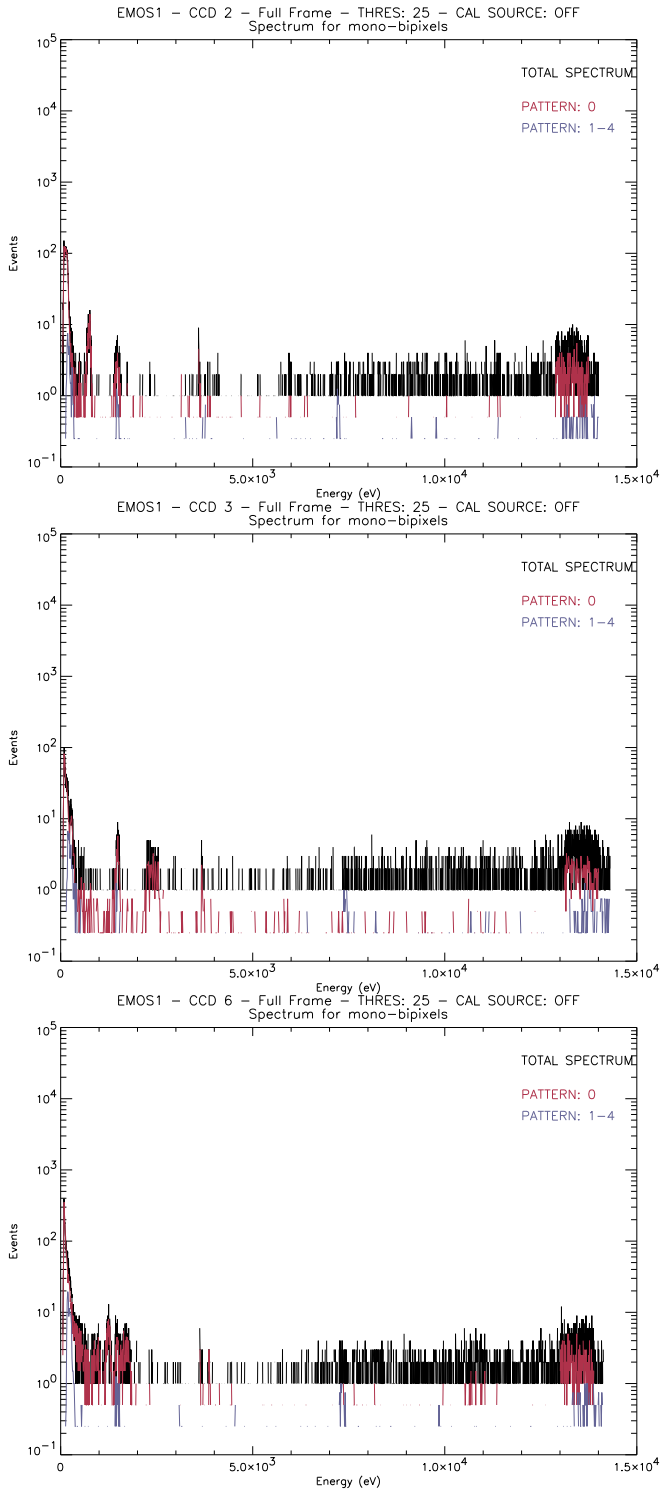

Figure 2: Energy spectrum with contributions from monopixel, bipixel configurations

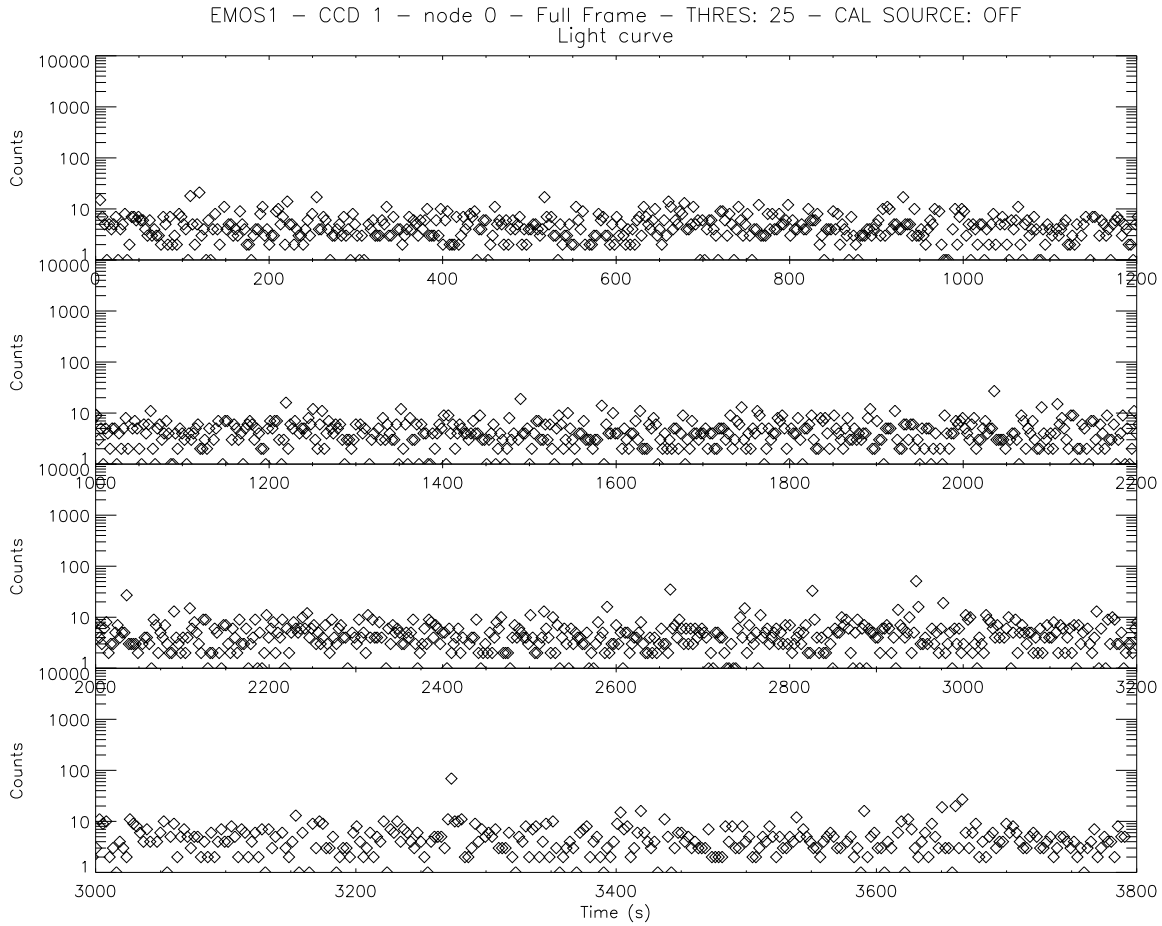

Figure 3: Light curve for CCD 1. The rate is almost constant. No particular irregularity is detected. All the other CCDs have a similar behavior.

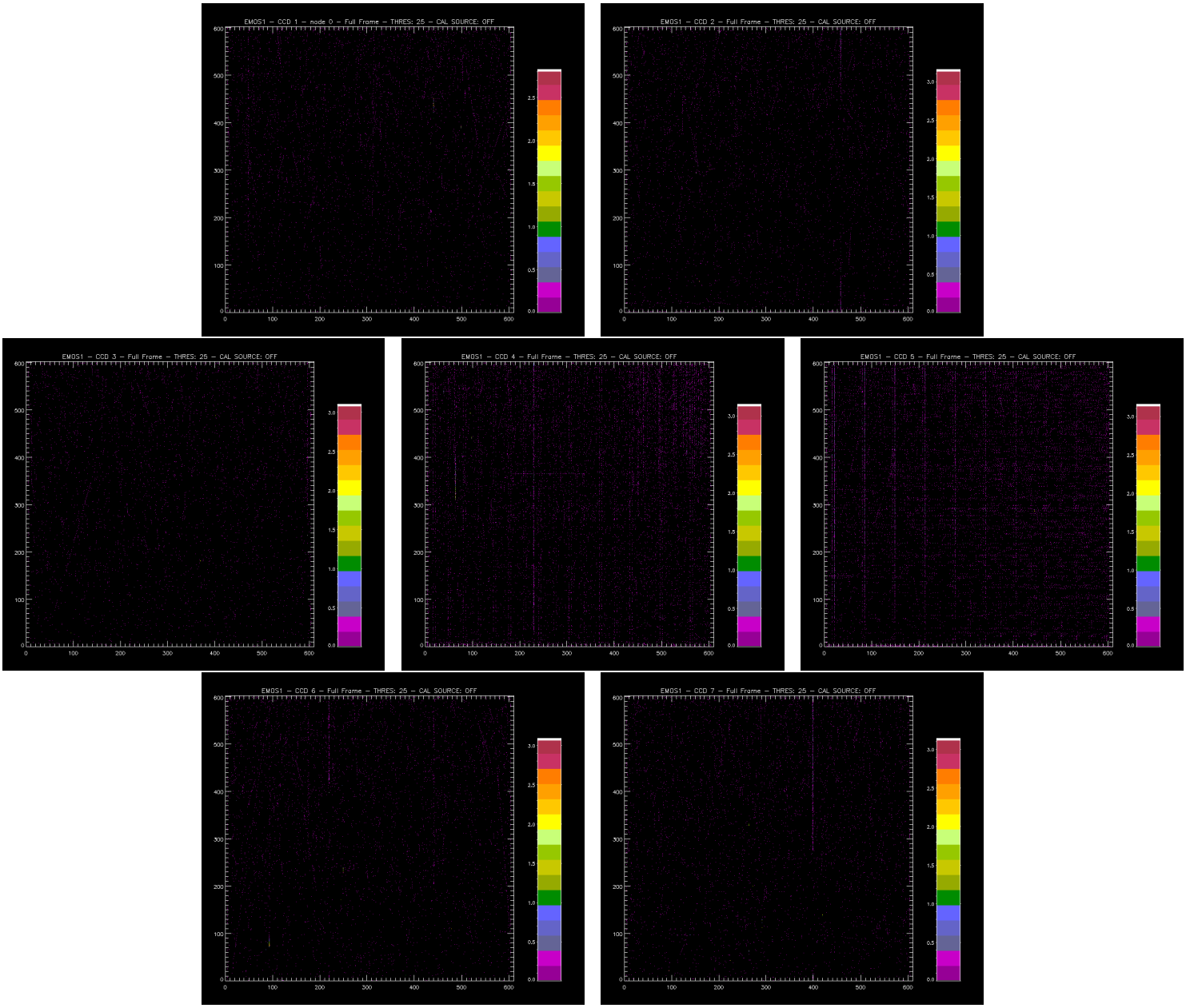

Figure 4: In all the CCDs there are many bright pixels and columns. CCD 4 and CCD 5 appear very noisy.

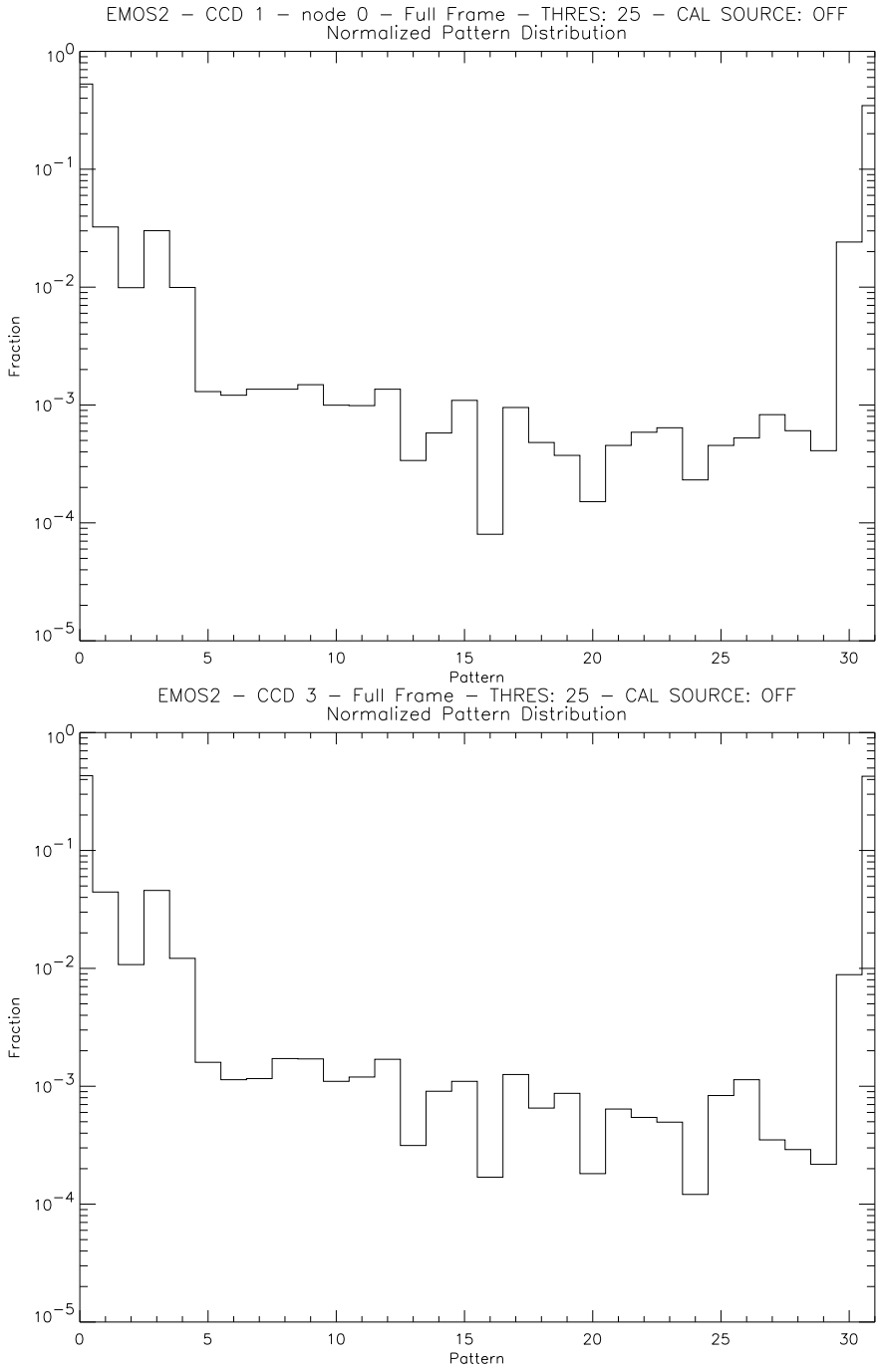

Figure 5: Pattern distribution: major contributors are monopixels and pattern 31

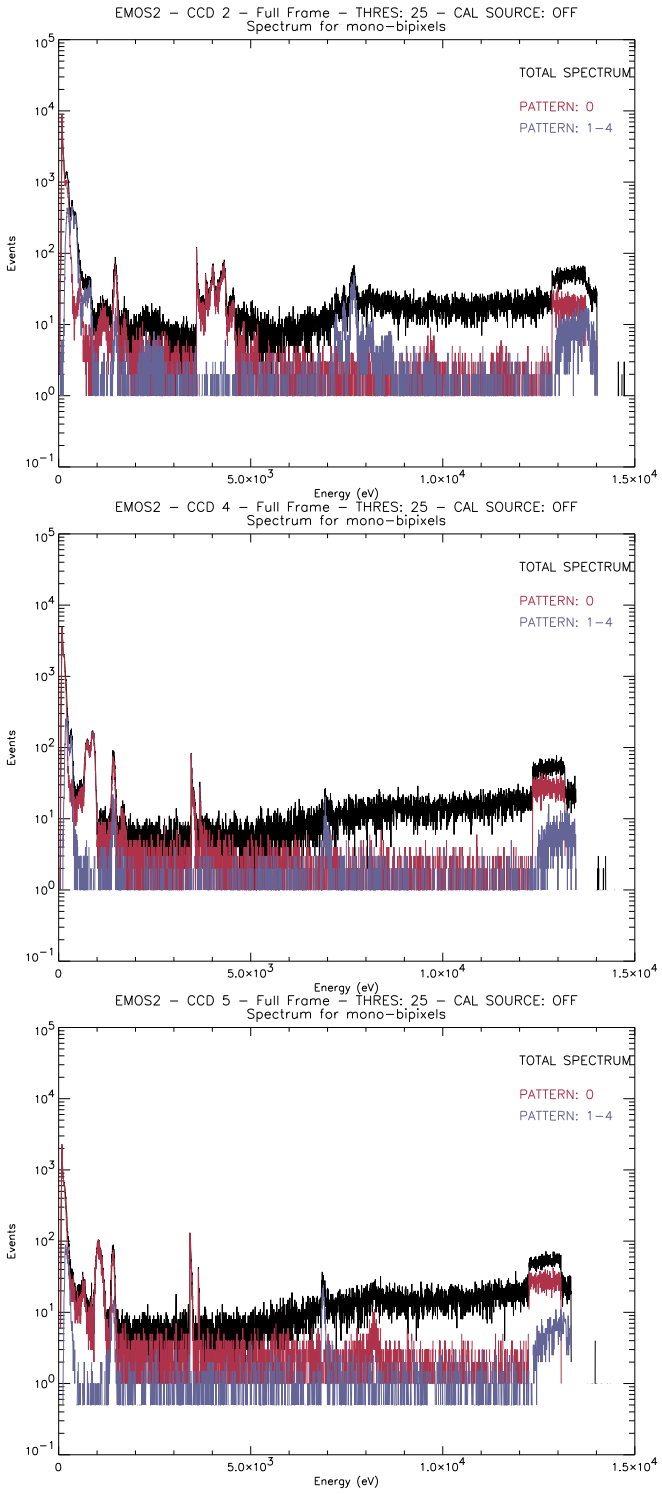

Figure 6: Energy spectrum with contributions from monopixel, bipixel configurations.

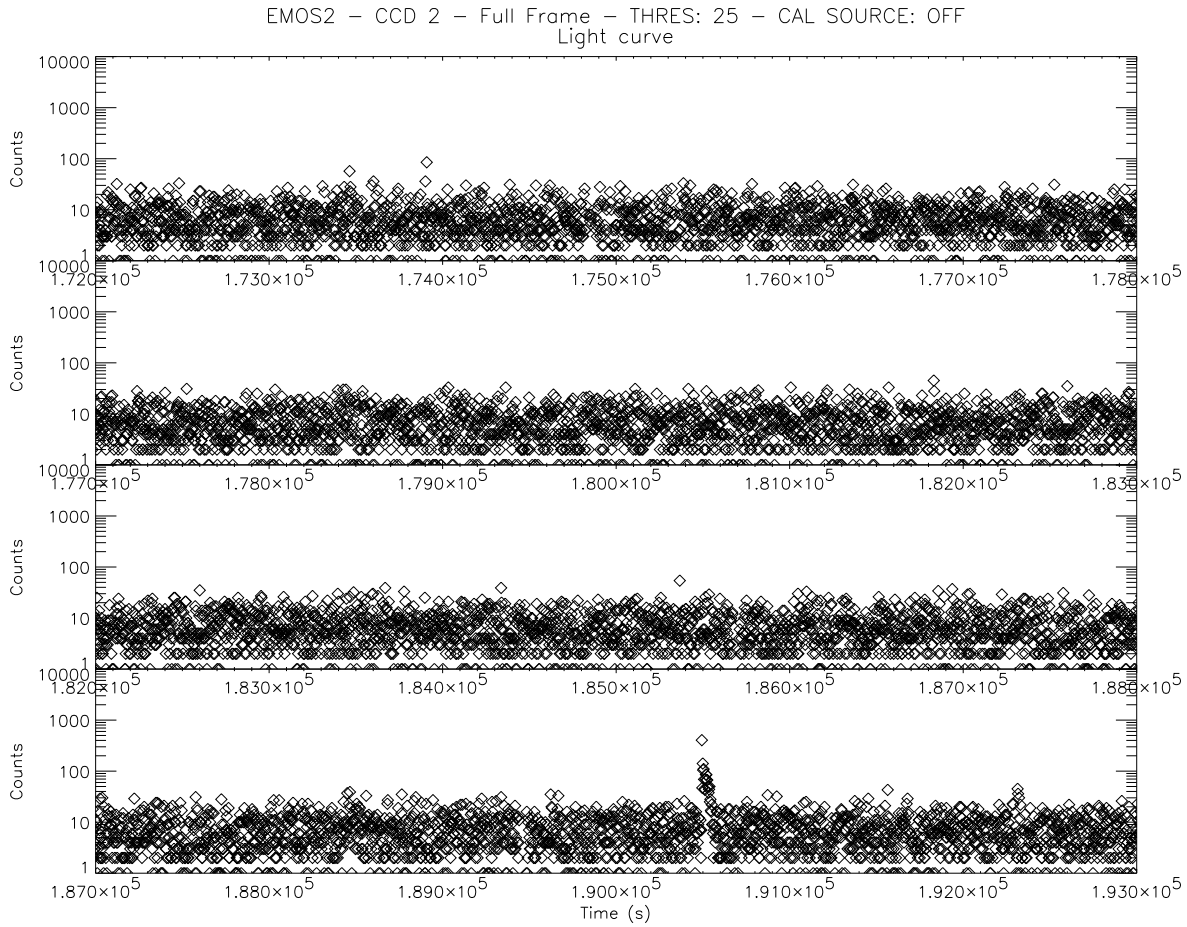

Figure 7: Part of the light curve for CCD 2. The rate is almost constant, but there is a sudden rise at about $1.9 \cdot 10^5$ s. All the other CCDs have a regular behavior.

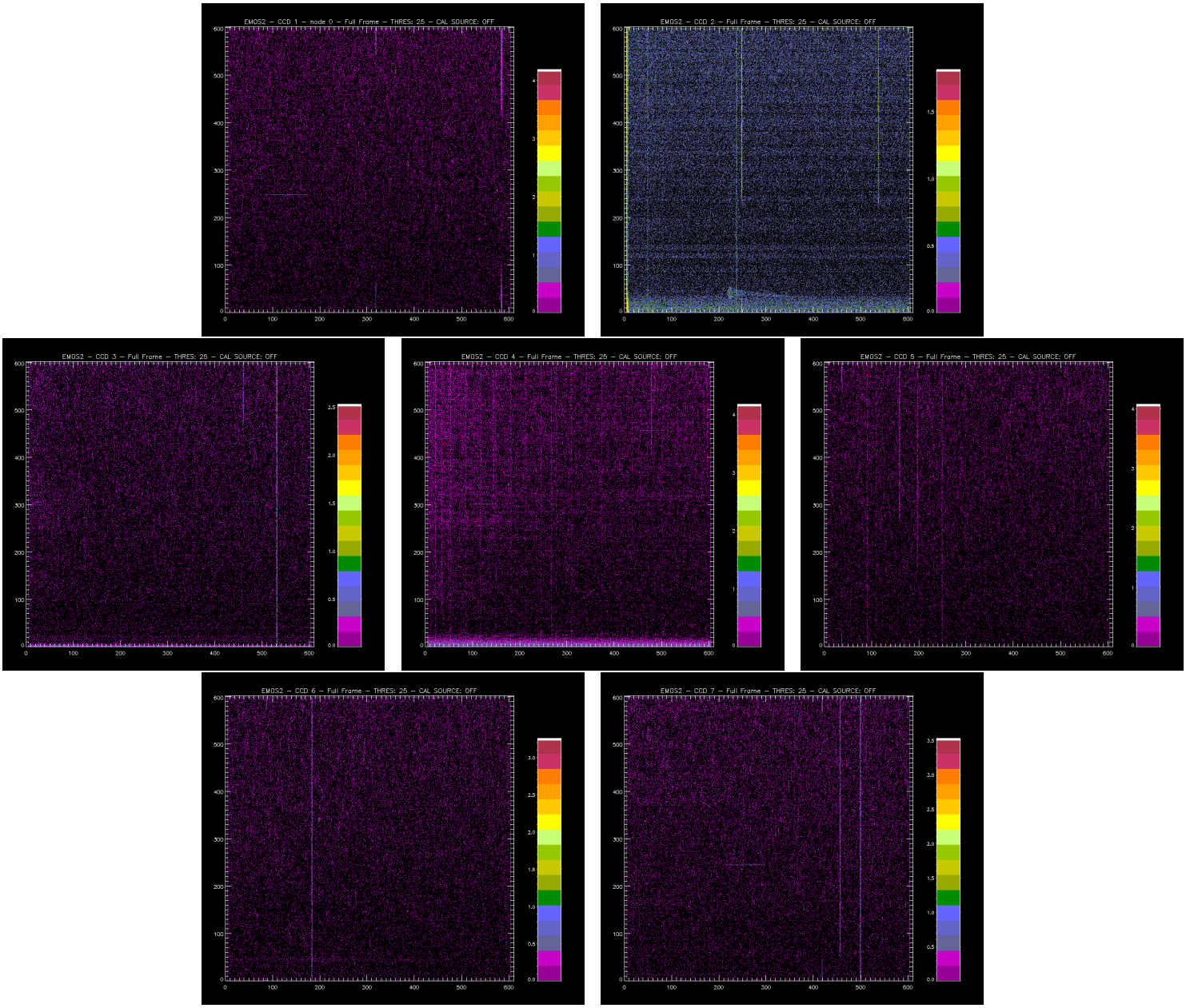

Figure 8: In all the CCDs there are many bright pixels and columns. CCD 2 is really very noisy.

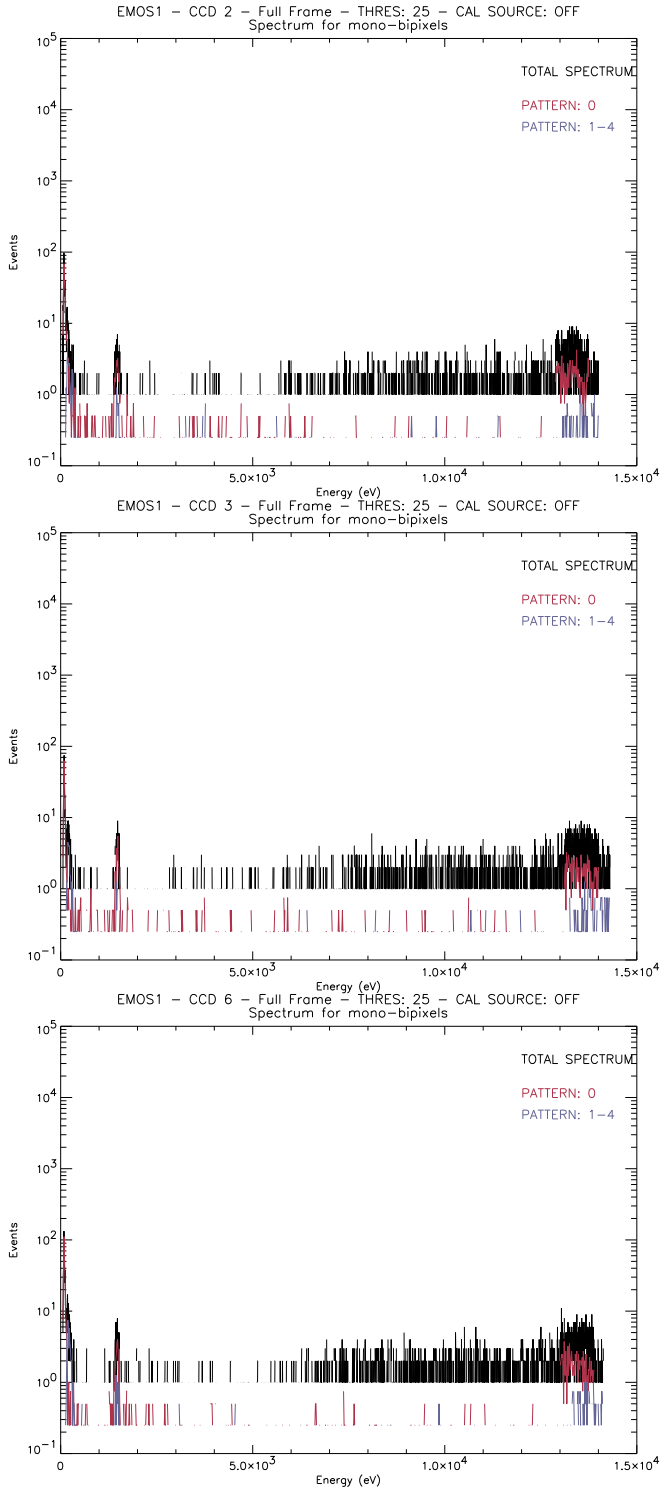

Figure 9: Energy spectrum with contributions from monopixel, bipixel configurations, after removing bright pixels using the bright pixel tables.

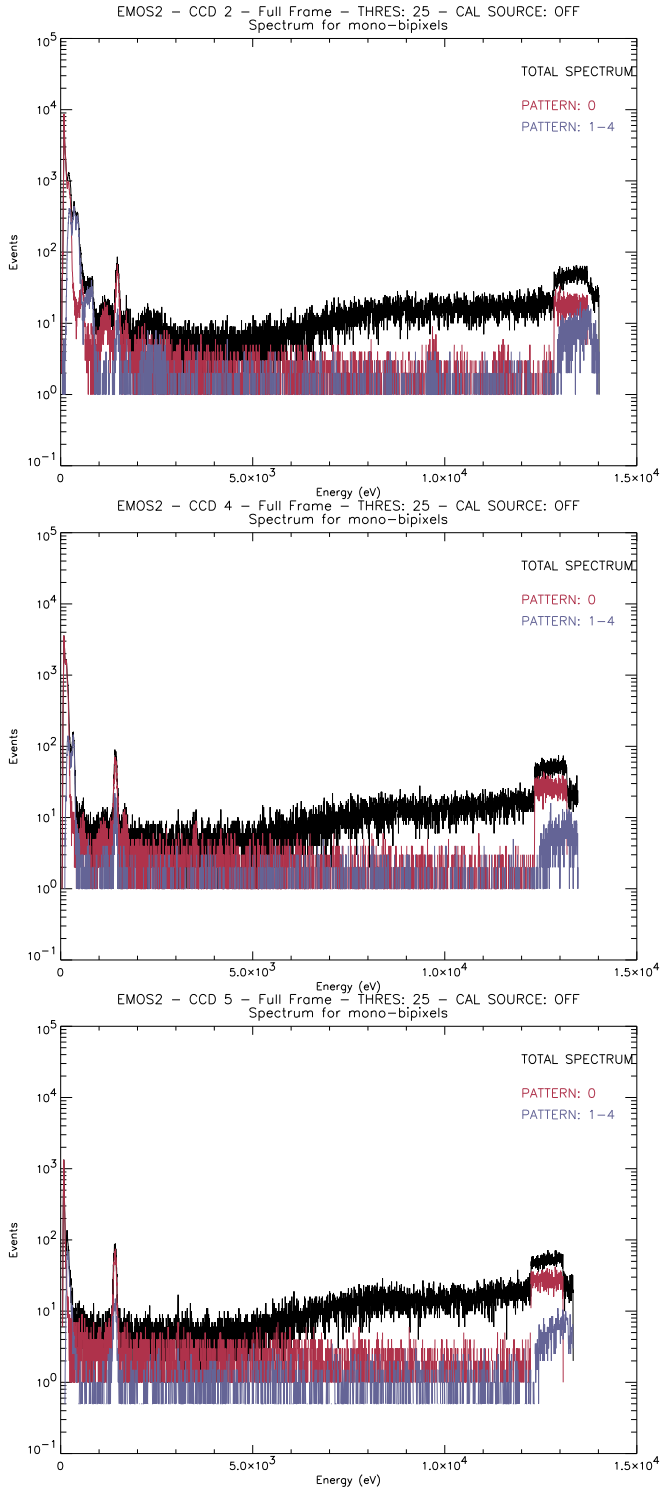

Figure 10: Energy spectrum with contributions from monopixel, bipixel configurations, after removing bright pixels using the bright pixel tables.

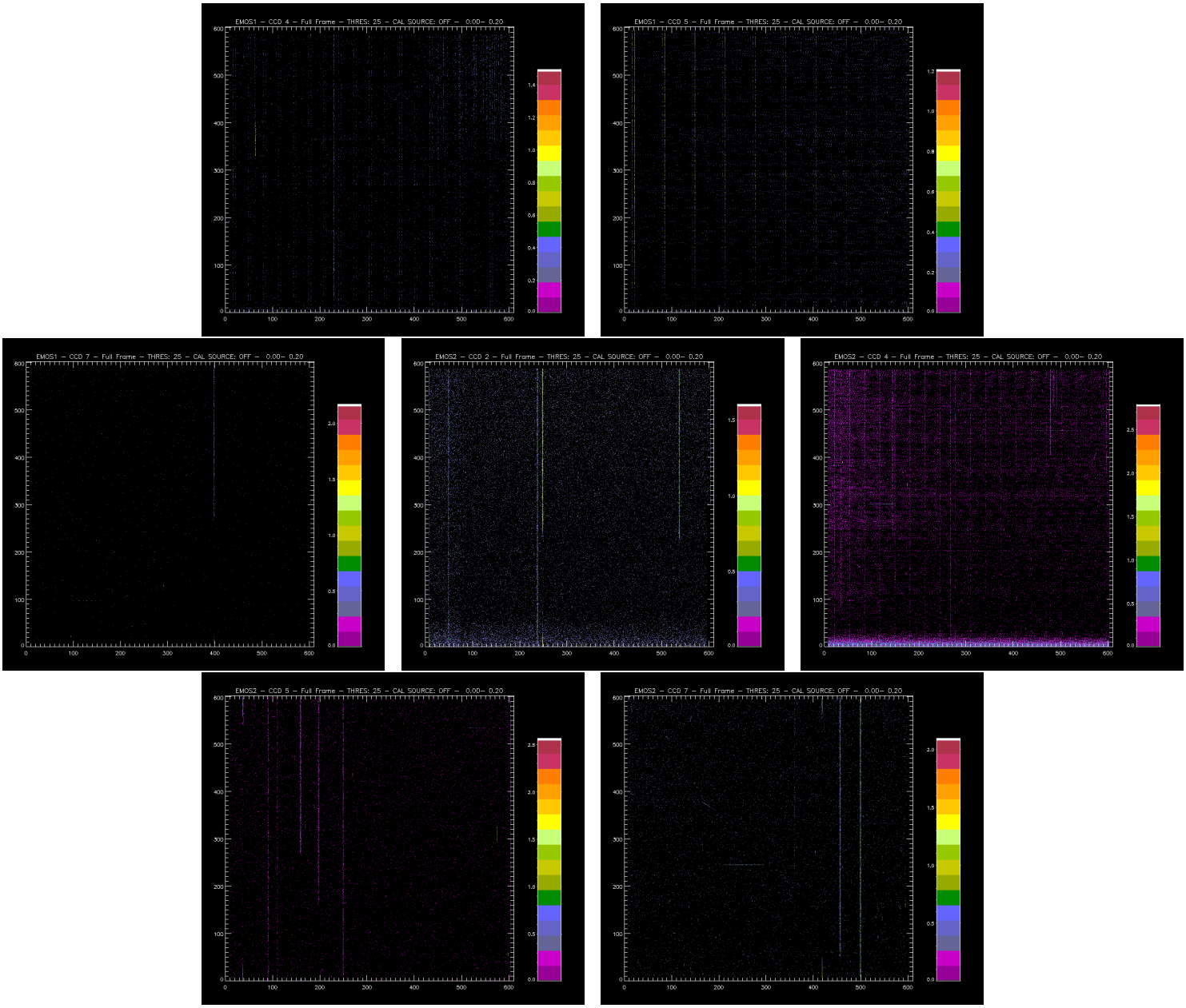

Figure 11: Images for some CCDs for events with energy in the range [0-0.2] keV. Bright pixels and columns lie in this range.

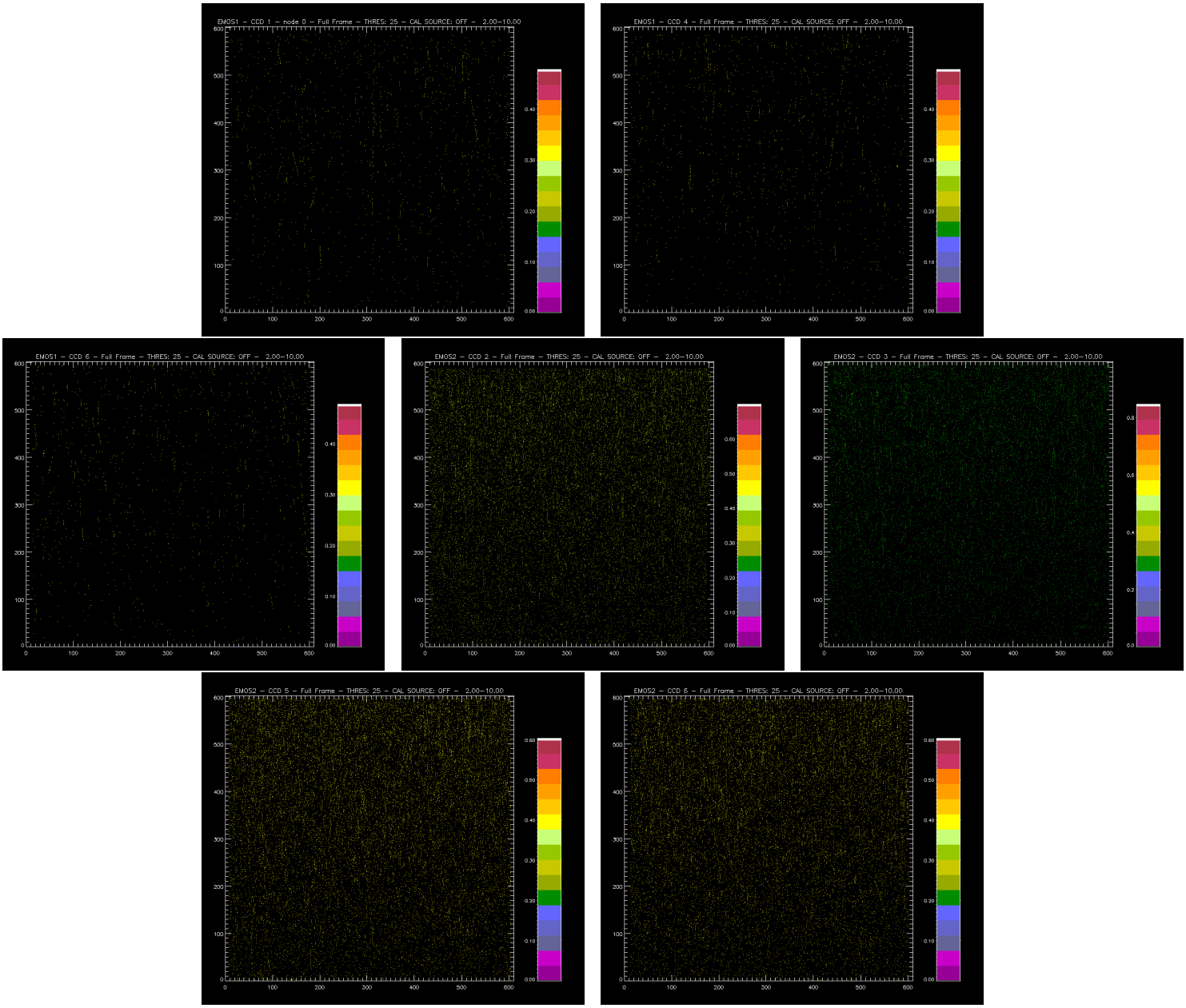

Figure 12: Images for some CCDs for events with energy in the range [2-10] keV. Bright pixels have disappeared.

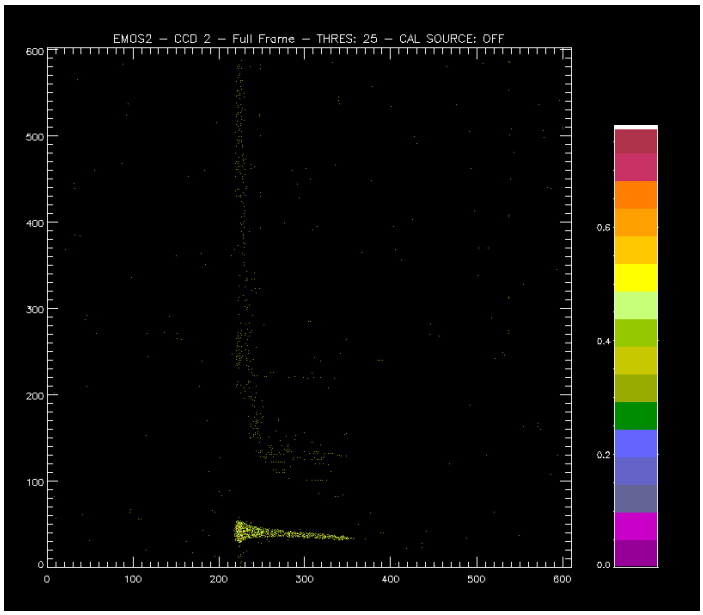

Figure 13: Image for CCD 2 in MOS 2 for events with time in the range [190490-190550] s.

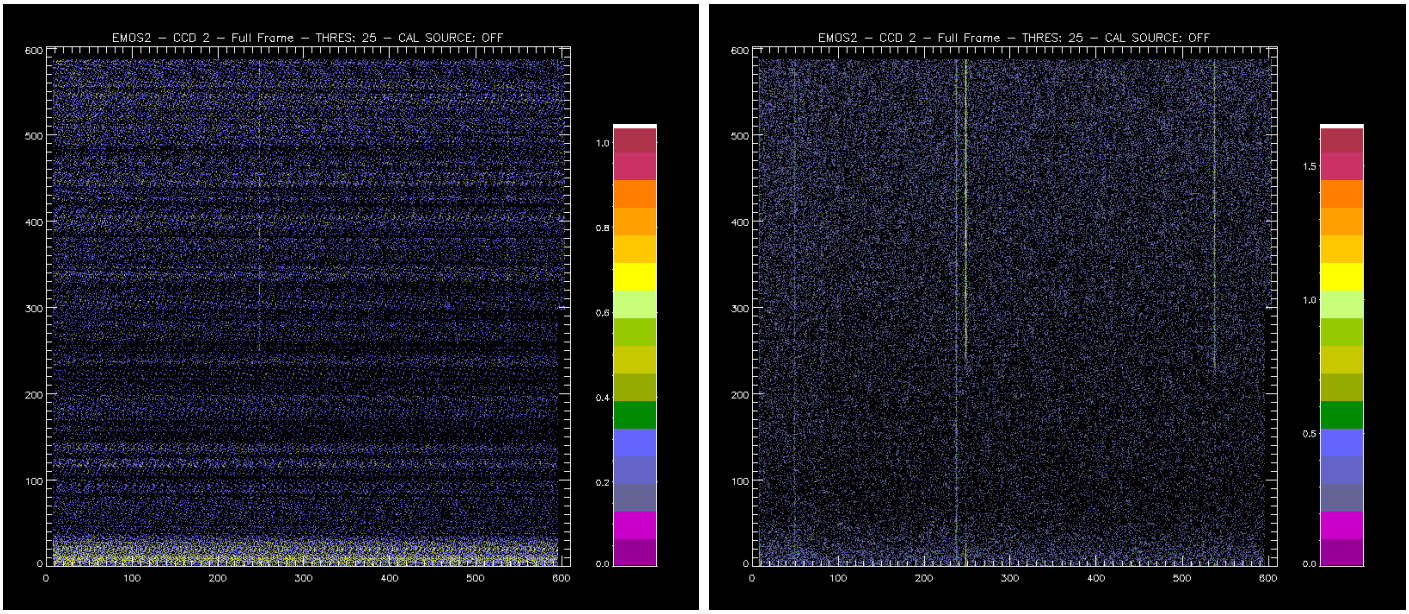

Figure 14: Left panel: Image for CCD 2 in MOS 2 for events with time in the range [71500-75000] s (second RUN). Right panel: Image for CCD 2 in MOS 2 excluding events of the second RUN.