Wavelength control of bad surface features in the RGS

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1 Instrumental features in RGS spectra

The two RGS instruments cover the calibrated wavelength range between 6 and 38 Å with CCDs mounted along the dispersion axis. The resulting spectra are currently calculated by default in 3600 spectral bins of width 10 mÅ. The wavelength coverage is not complete in either RGS1 or RGS2 because of instrumental features of different types, namely

- gaps between CCDs;

- boundaries between the two nodes of a CCD;

- CCD failures;

- hot pixels;

- cool pixels.

Hot pixels, which are very few in number, are reported in the RGS[12]_BADPIX CCFs [1] and the more numerous cool pixels in the RGS[12]_COOLPIX CCFs [2]. For observations taken in routine geometry at the fixed RGS aim point, these surface features fall at fixed wavelengths and it is possible that a spectral feature of particular scientific interest falls directly onto an instrumental blemish of one sort or another. For example, the rest wavelength of the strongest line of N VII at 24.778 Å usually falls on the gap betweens CCDs 3 and 4 in RGS1.

2 Management of the spacecraft pointing

Naturally enough, changes in the spacecraft pointing direction cause events with given wavelengths to move to different parts of the detector because of the change in the incidence angle of the source on the gratings [3]. In the RGS's multi-pointing mode, this effect is used to advantage by programming observations at a standard set of displacements of 0, ±15 and $\pm30''$ along the dispersion axis in order generally to mitigate the effects of detector features. The wavelength scale shifts by about 2.3 mÅ per arcsec. Within operational constraints, it is possible for observers to exercise more detailed control over the spacecraft pointing. In order to take advantage of this possibility, knowledge is required of the wavelengths affected by detector features as a function of pointing displacement from the normal aim point. For each RGS and each CCD, Figures 1-18 show how the wavelengths affected by detector features change according to pointing displacements along the dispersion axis in the particular range $\pm90''$ within which targets remain in the EPIC-pn small window: the effects of pointing adjustments

on the whole set of XMM instruments need to be borne in mind. On each CCD, the wavelength locus of the set of bad surface features is shown. The two permanent hot columns disabled on-board, one on each of the RGS instruments, are shown by the red lines in Figure 1 in RGS1 CCD1 at long wavelengths and Figure 18 in RGS2 CCD9 at short wavelengths. Advisory hot surface assessed during data processing is shown in magenta. This mechanism is used to signal hot spots in a limited area near the edges of RGS1 CCD1 at long wavelengths [4] that does not affect the spectrum of on-axis sources. Advisory cool pixels appear on most CCDs and are shown in cyan. Chip gaps and node boundaries are shown in black.

3 A simple worked example

Considering again the N VII line at 24.778 Å, Figures 3 and 4 confirm that at the regular zero dispersion shift, the line falls squarely on the gap between CCDs 3 and 4 in RGS1. Displacements of either $\pm 90''$ look viable choices to move the line away from the gap onto CCD4 for a negative shift or onto CCD3 for a positive shift. Pointing adjustments affect both RGS instruments and all wavelengths. Considering Figure 12 shows that the negative shift might be preferable because of a cool pixel on RGS2 CCD3.

4 The RGS spectrum in its entirety

As pointing adjustments affect the whole spectrum, the consequences of a displacement that works well at one wavelength need to be considered over the whole spectrum in RGS1 and RGS2 as well as the other instruments aboard XMM. Although this would preclude use of the EPIC-pn small window, Figures 19 and 20 show where bad surface features would be found on the RGS1 and RGS2 spectra of the line-rich O-star ζ Puppis for a large example pointing displacement of $+3'$, emphasising the potential complexity of the task.

References

[1] RGS bad pixels `http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0292-1-0.pdf`

[2] RGS cool pixels `http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0218-1-0.ps.gz`

[3] SAS `rgslinepos` task `http://xmm.esac.esa.int/sas/current/doc/rgslinepos.pdf`

[4] RGS bad pixels `http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0239-1-0.ps.gz`

Figure 1: Wavelengths affected by instrumental features on RGS1 CCD1 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Hot, advisory hot and cool pixels are plotted in red, magenta and cyan respectively.
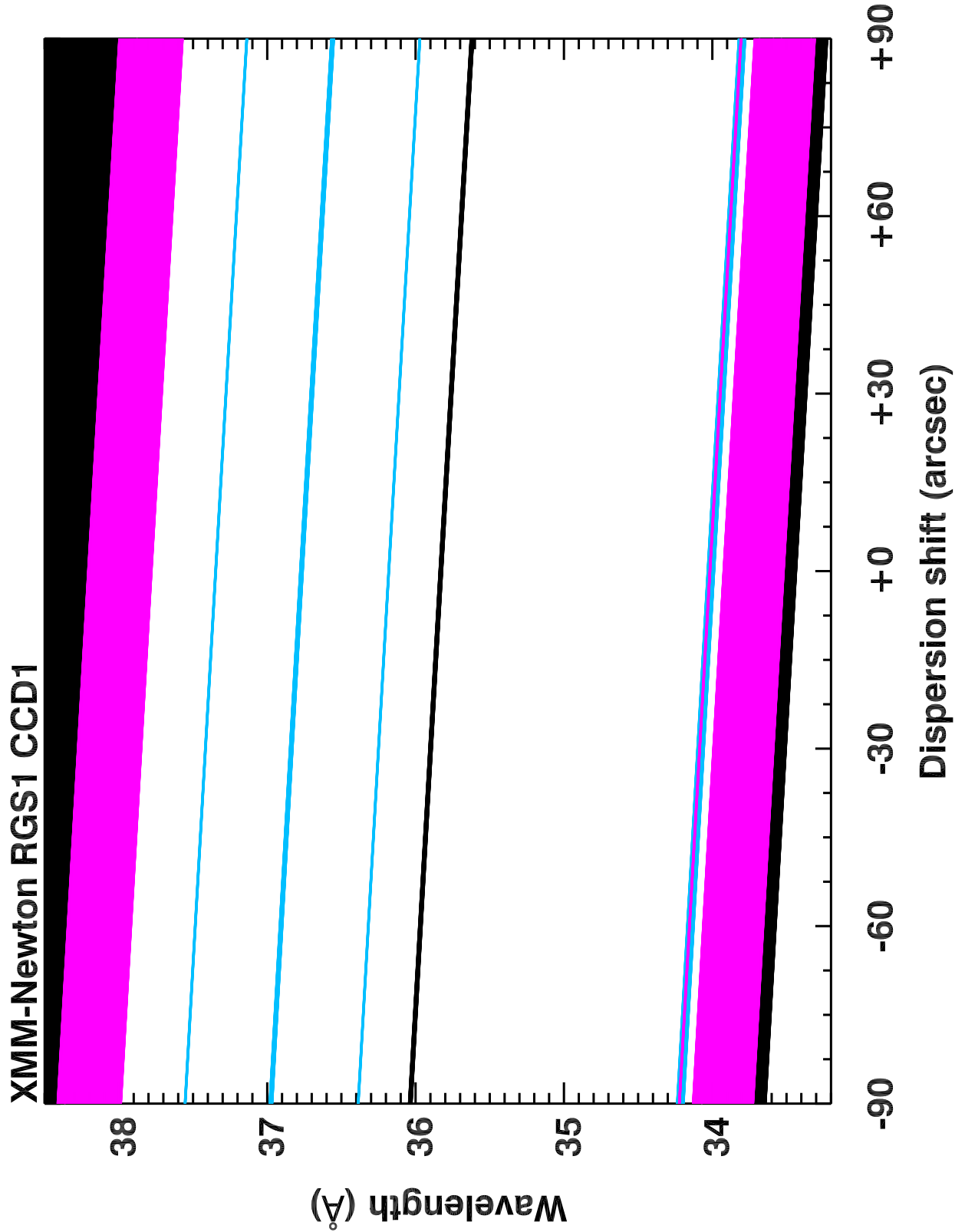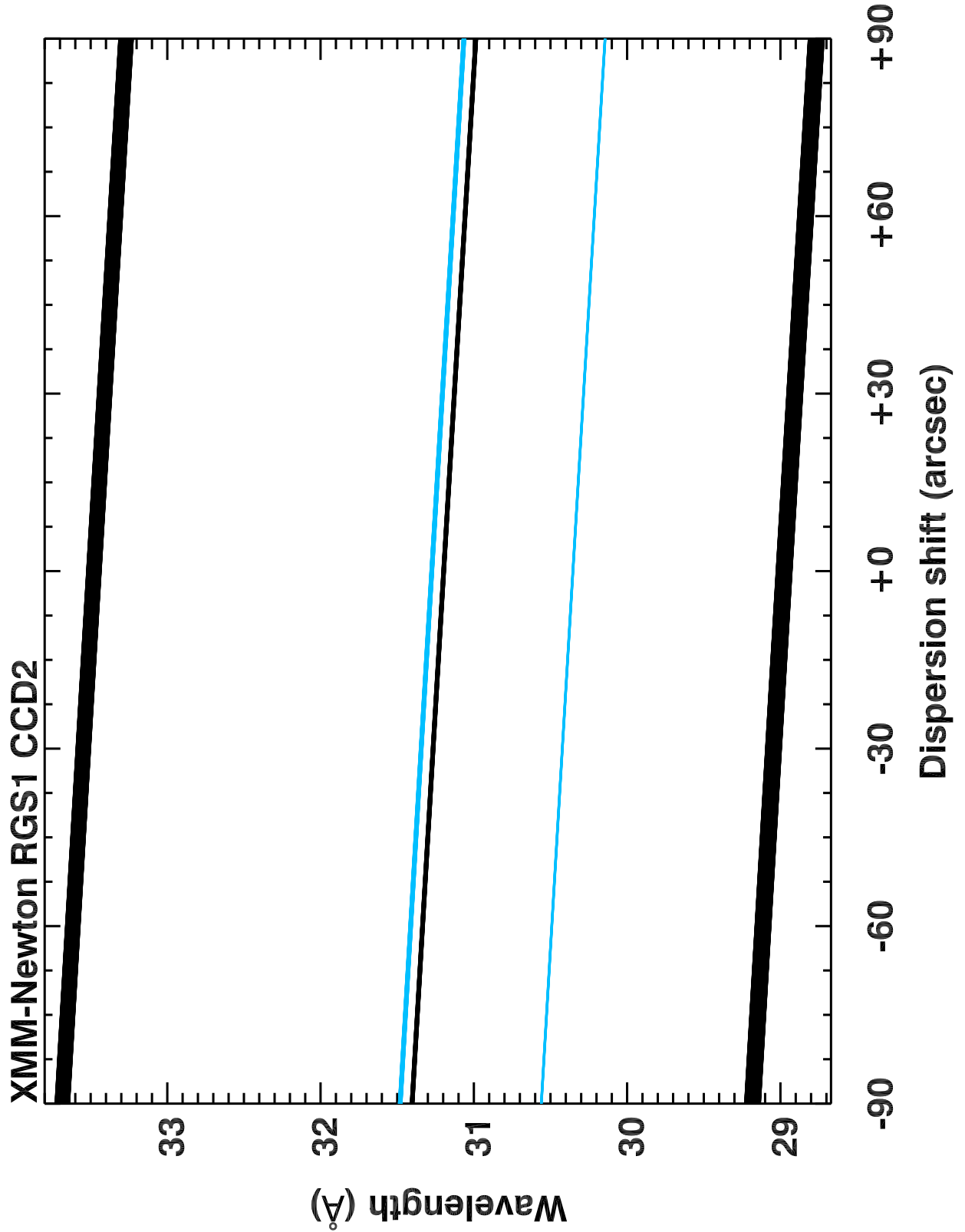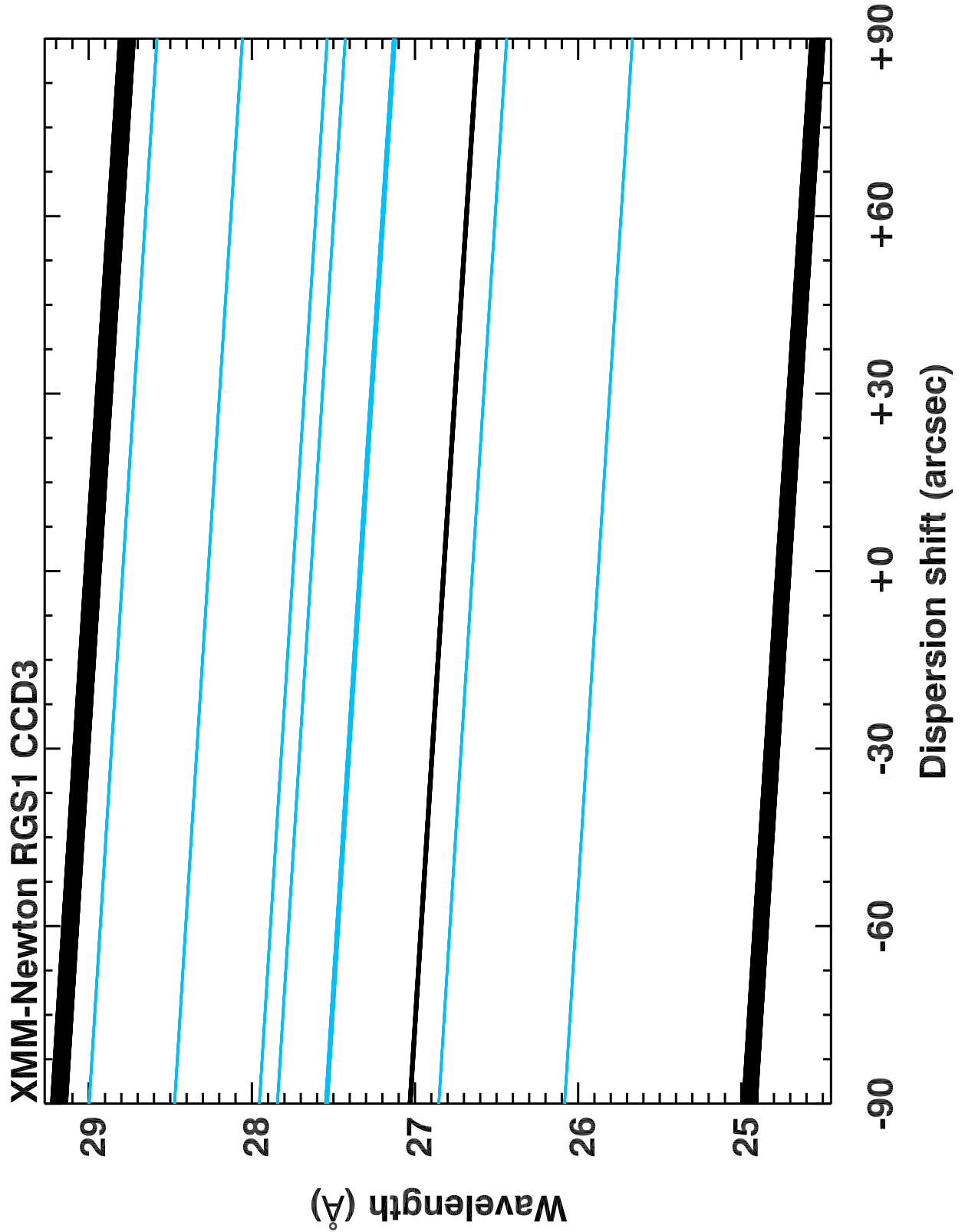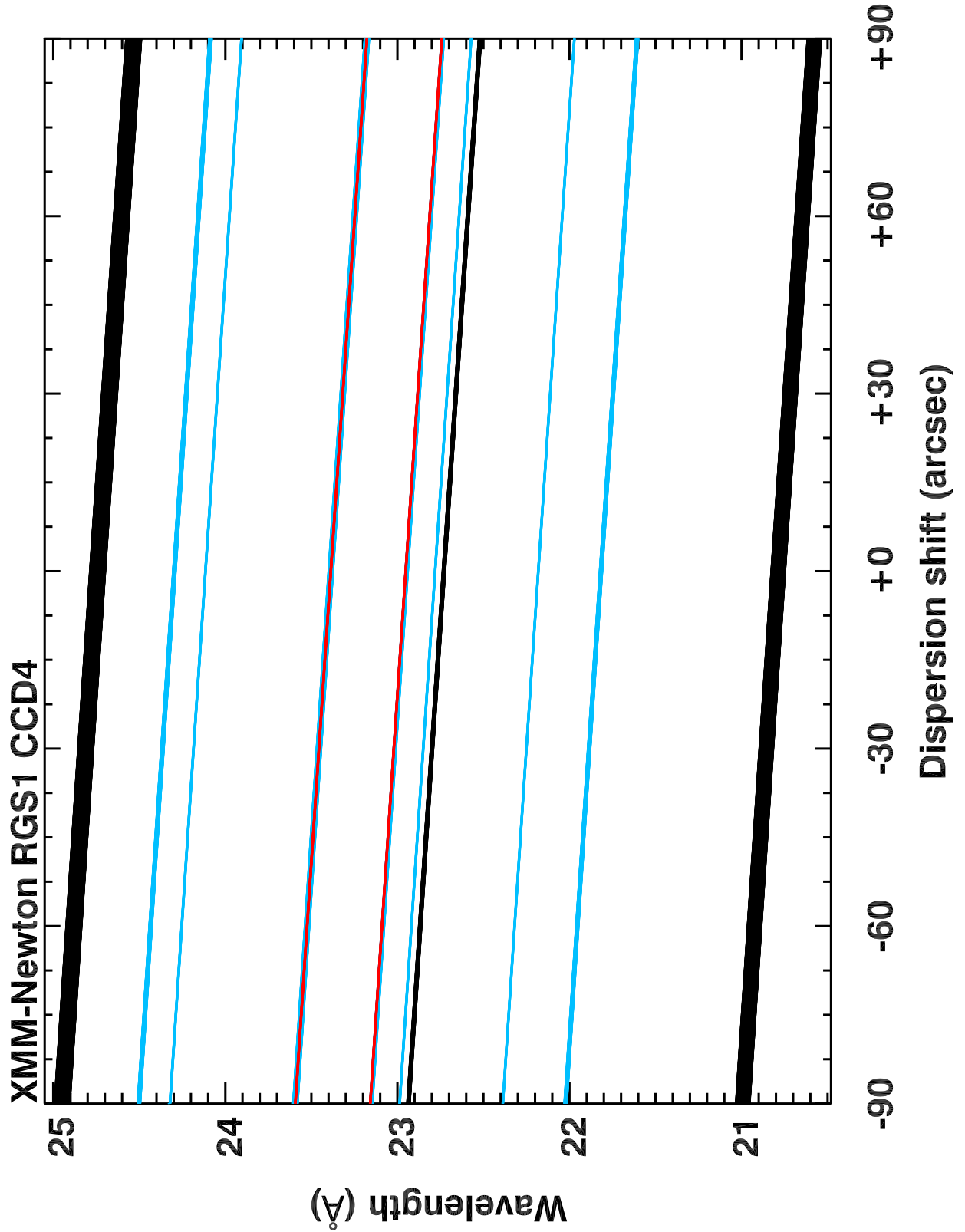
Figure 2: Wavelengths affected by instrumental features on RGS1 CCD2 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Cool pixels are plotted in cyan.

Figure 3: Wavelengths affected by instrumental features on RGS1 CCD3 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Cool pixels are plotted in cyan.
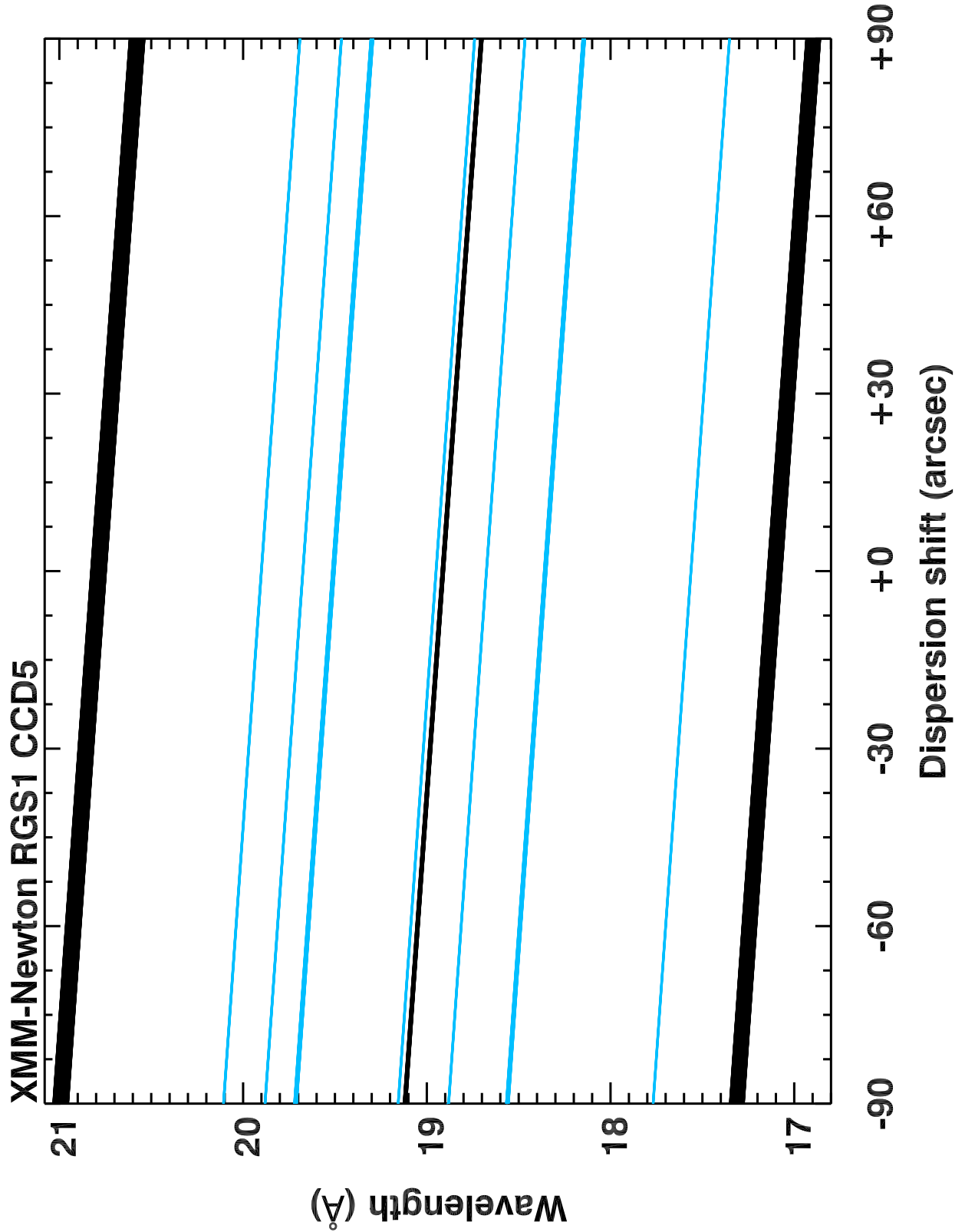
Figure 4: Wavelengths affected by instrumental features on RGS1 CCD4 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Advisory hot and cool pixels are plotted in magenta and cyan respectively.
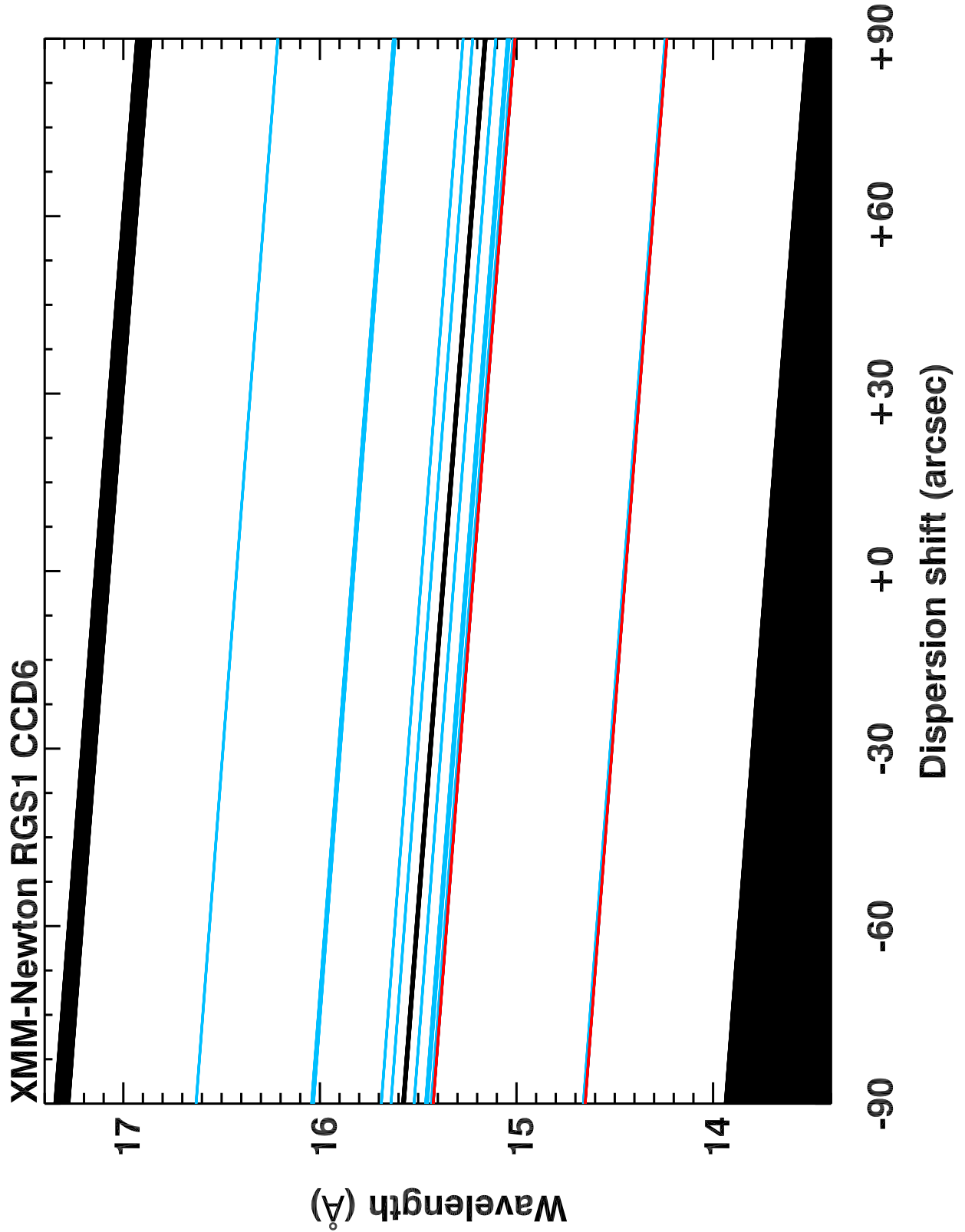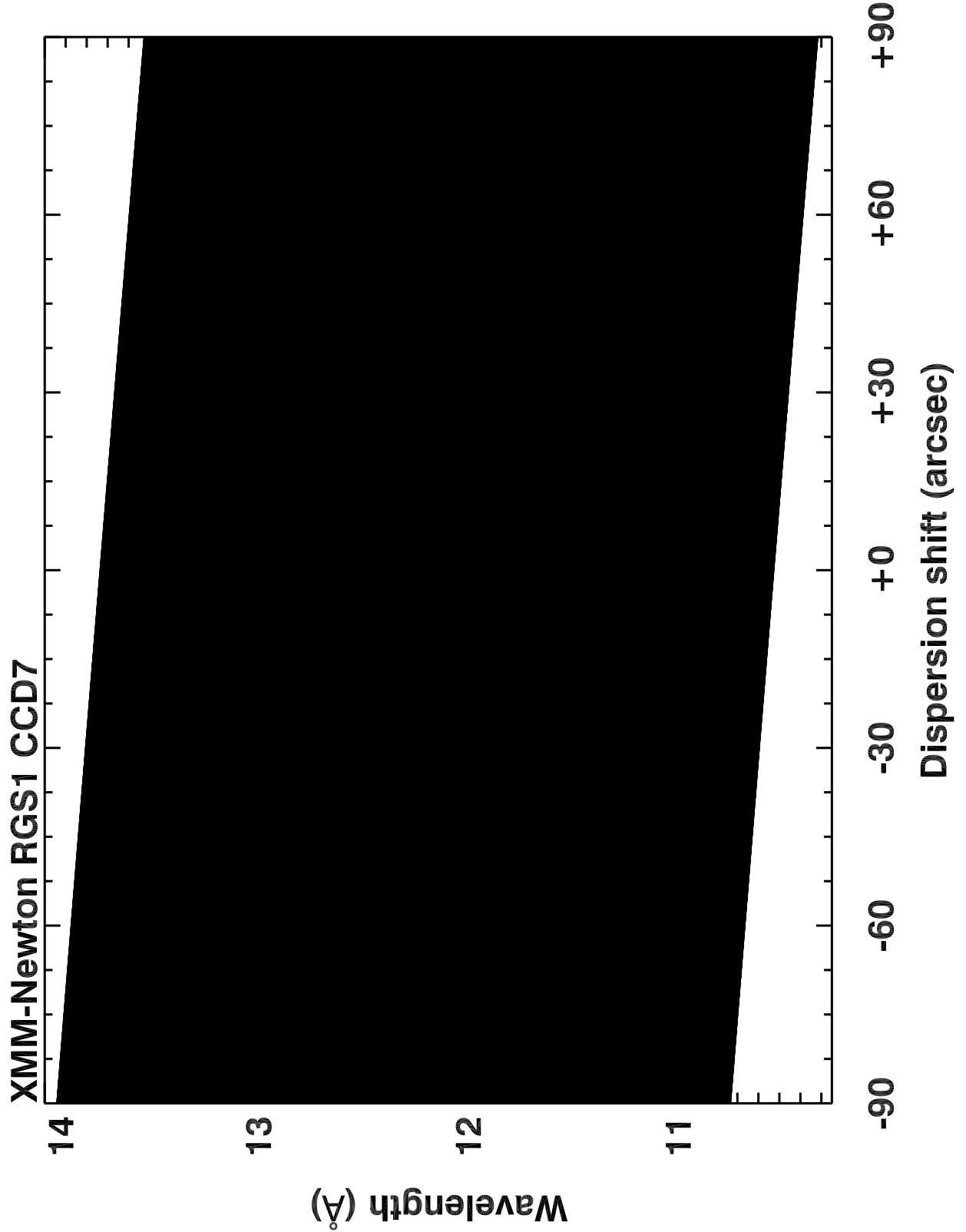
Figure 5: Wavelengths affected by instrumental features on RGS1 CCD5 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Cool pixels are plotted in cyan.

Figure 6: Wavelengths affected by instrumental features on RGS1 CCD6 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Advisory hot and cool pixels are plotted in magenta and cyan respectively.

Figure 7: Wavelengths on the failed RGS1 CCD7 depending on pointing offset in the dispersion direction. This CCD failed early in the mission and is no longer in operation.
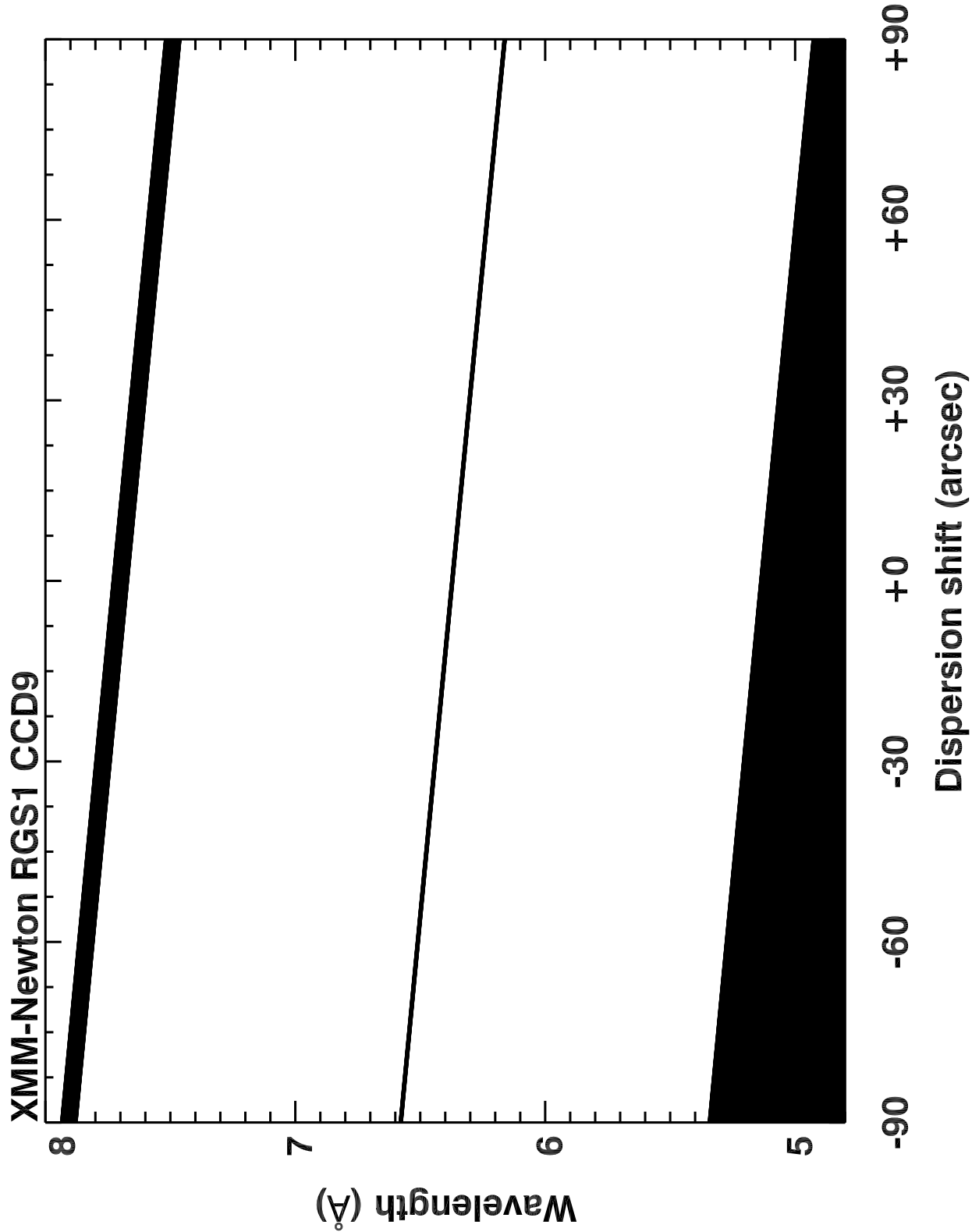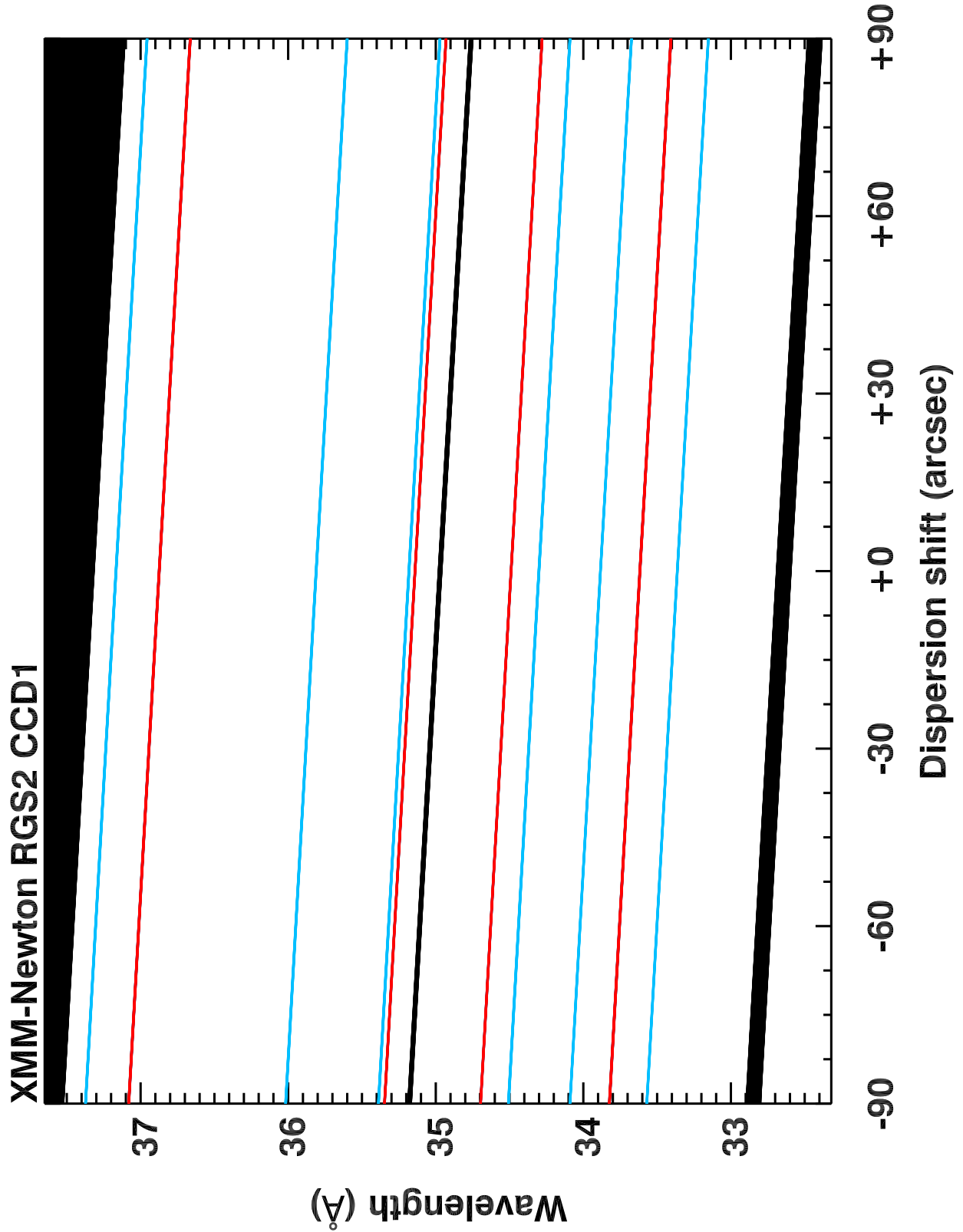
Figure 8: Wavelengths affected by instrumental features on RGS1 CCD8 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Cool pixels are plotted in cyan.
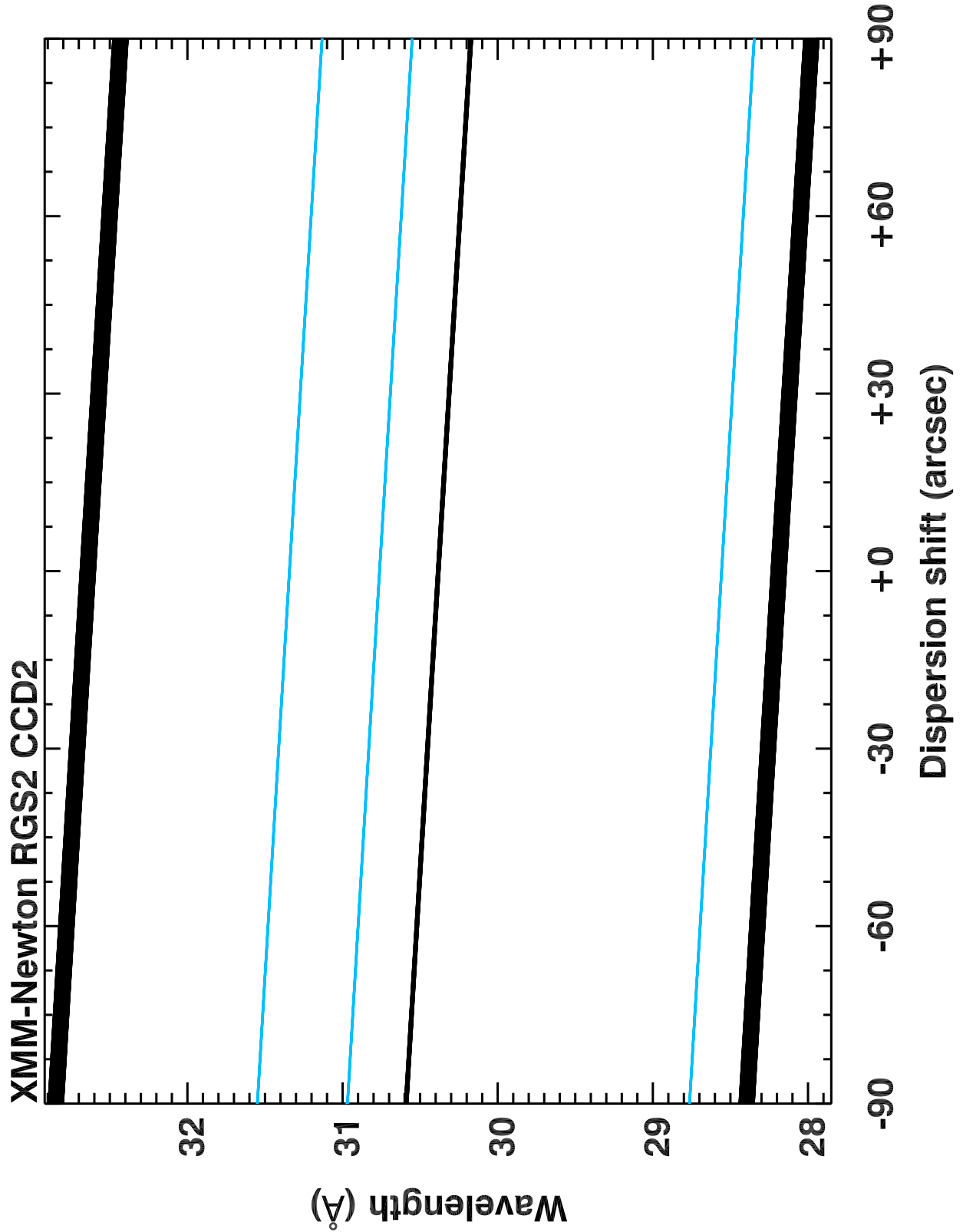
Figure 9: Wavelengths affected by instrumental features on RGS1 CCD9 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. This CCD is currently free from defects.

Figure 10: Wavelengths affected by instrumental features on RGS2 CCD1 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Advisory hot and cool pixels are plotted in magenta and cyan respectively.
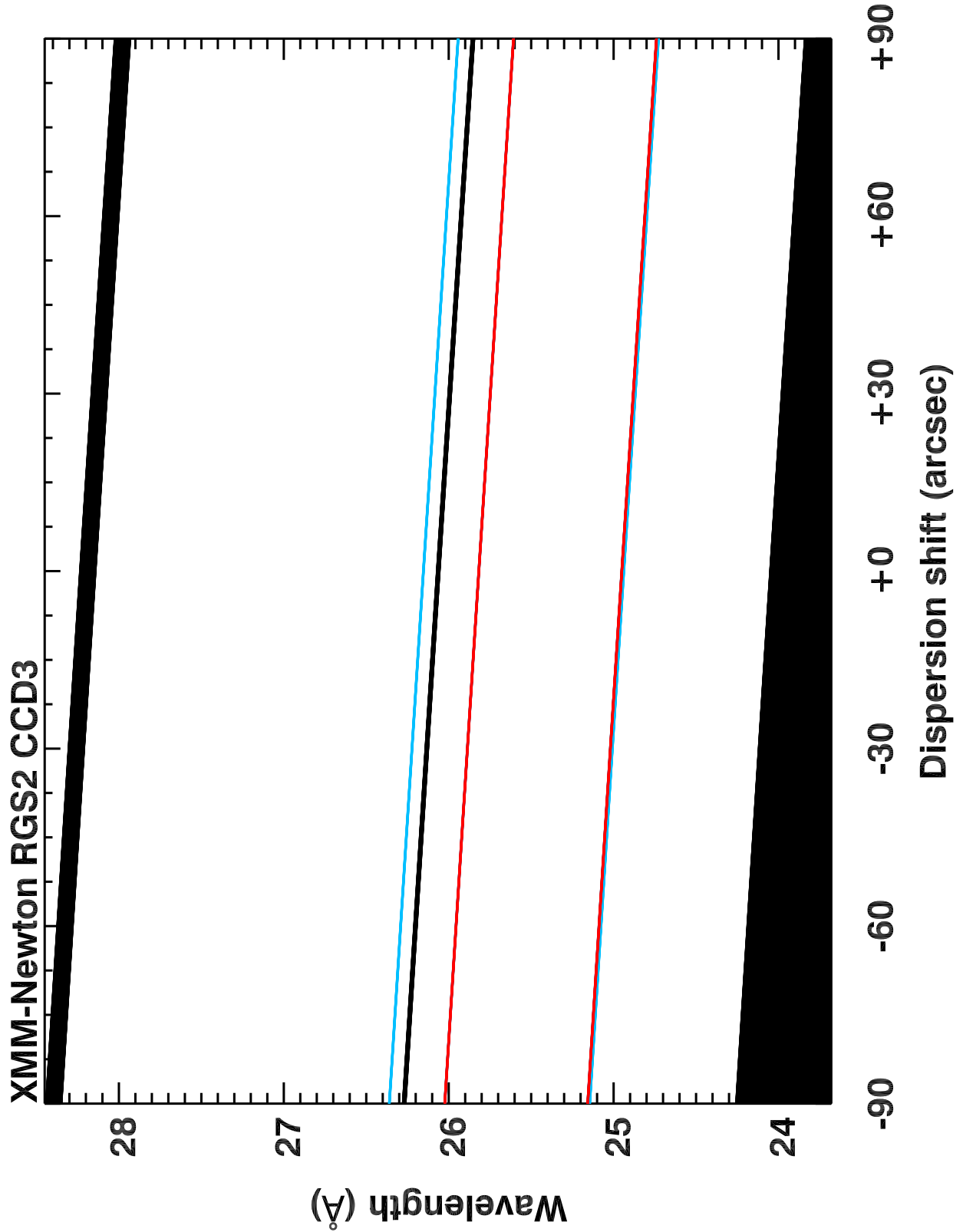
Figure 11: Wavelengths affected by instrumental features on RGS2 CCD2 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Cool pixels are plotted in cyan.

Figure 12: Wavelengths affected by instrumental features on RGS2 CCD3 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Advisory hot and cool pixels are plotted in magenta and cyan respectively.

Figure 13: Wavelengths on the failed RGS2 CCD4 depending on pointing offset in the dispersion direction. This CCD failed early in the mission and is no longer in operation.
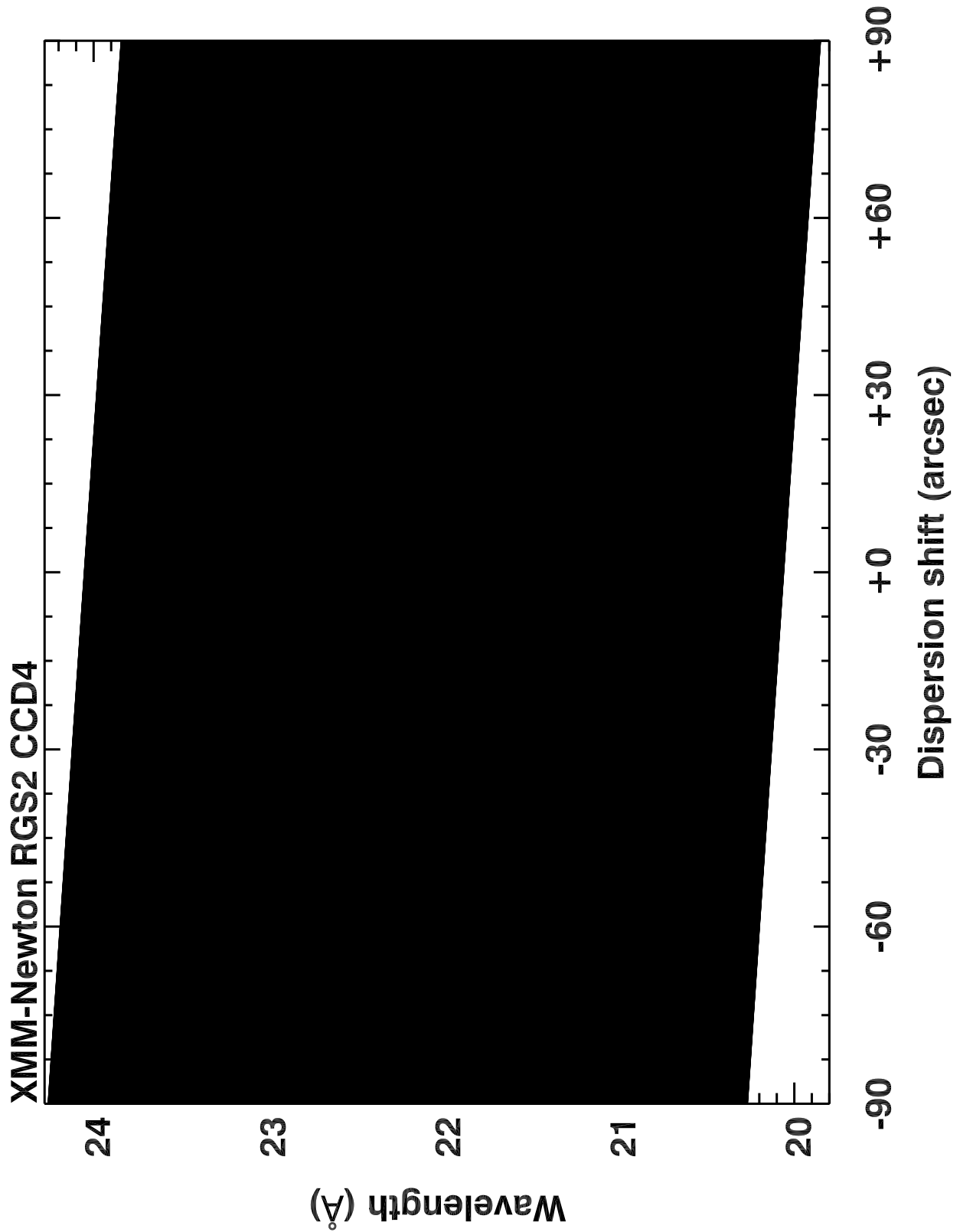
Figure 14: Wavelengths affected by instrumental features on RGS2 CCD5 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Cool pixels are plotted in cyan.
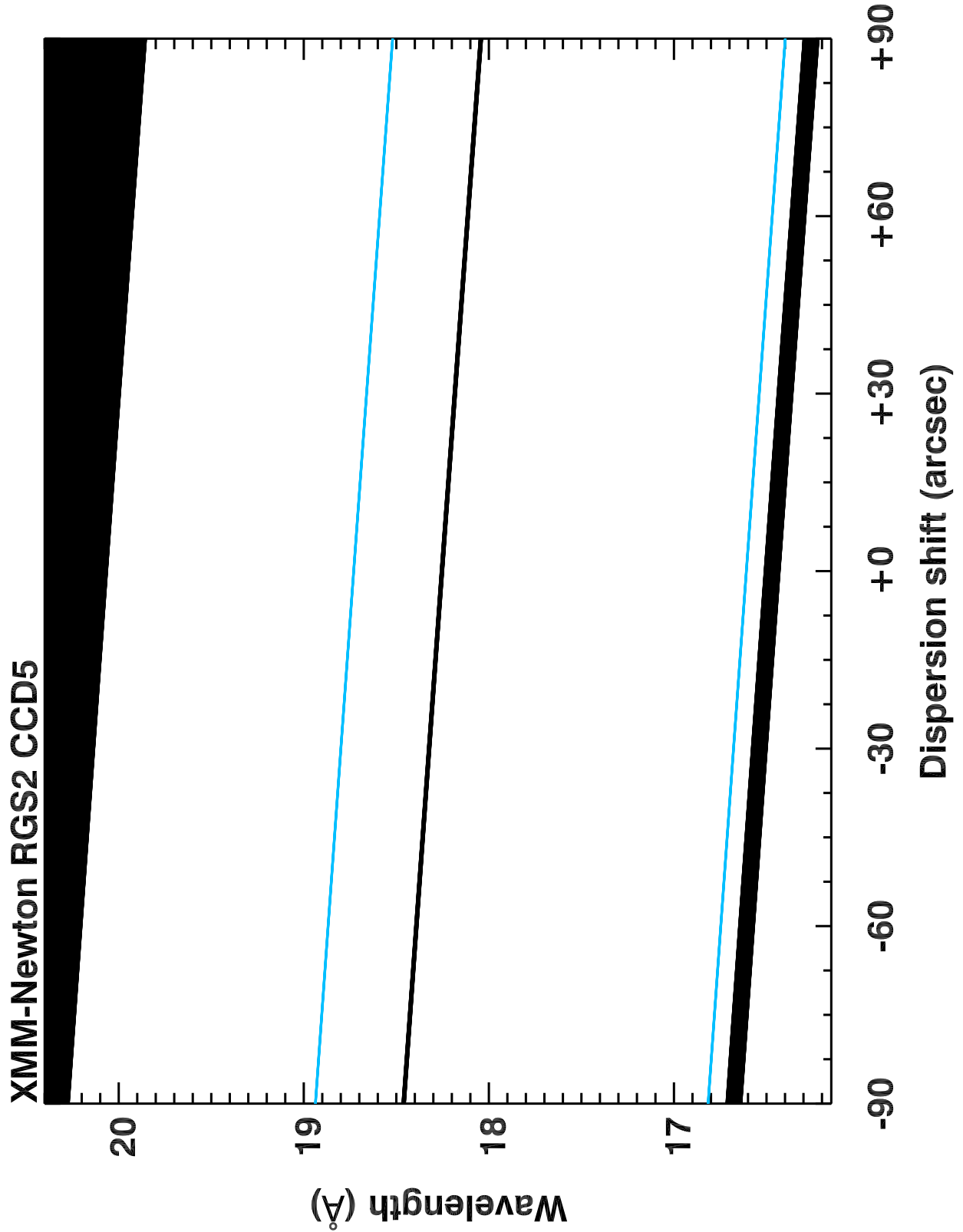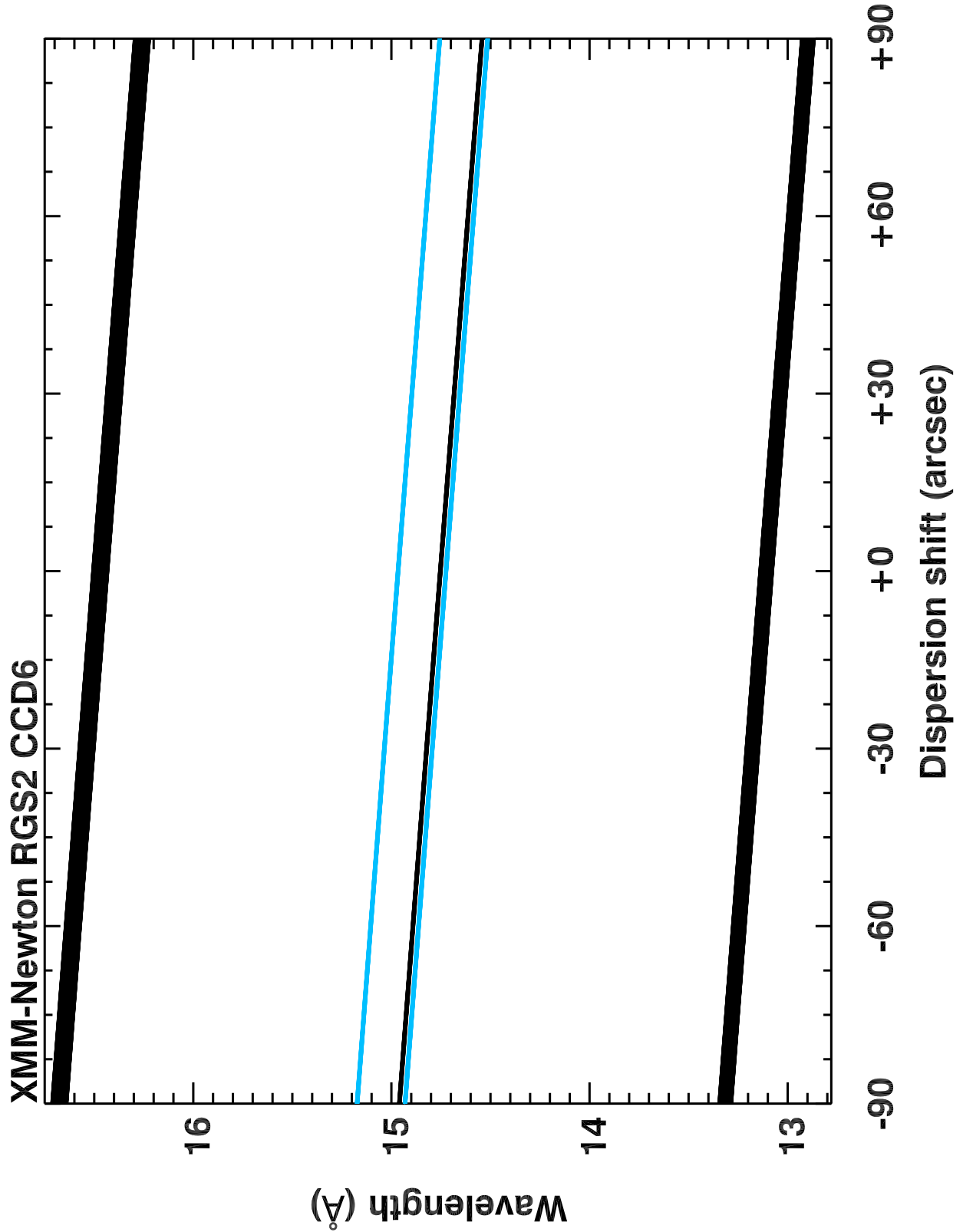
Figure 15: Wavelengths affected by instrumental features on RGS2 CCD6 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Cool pixels are plotted in cyan.

Figure 16: Wavelengths affected by instrumental features on RGS2 CCD7 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. This CCD is currently free from defects.
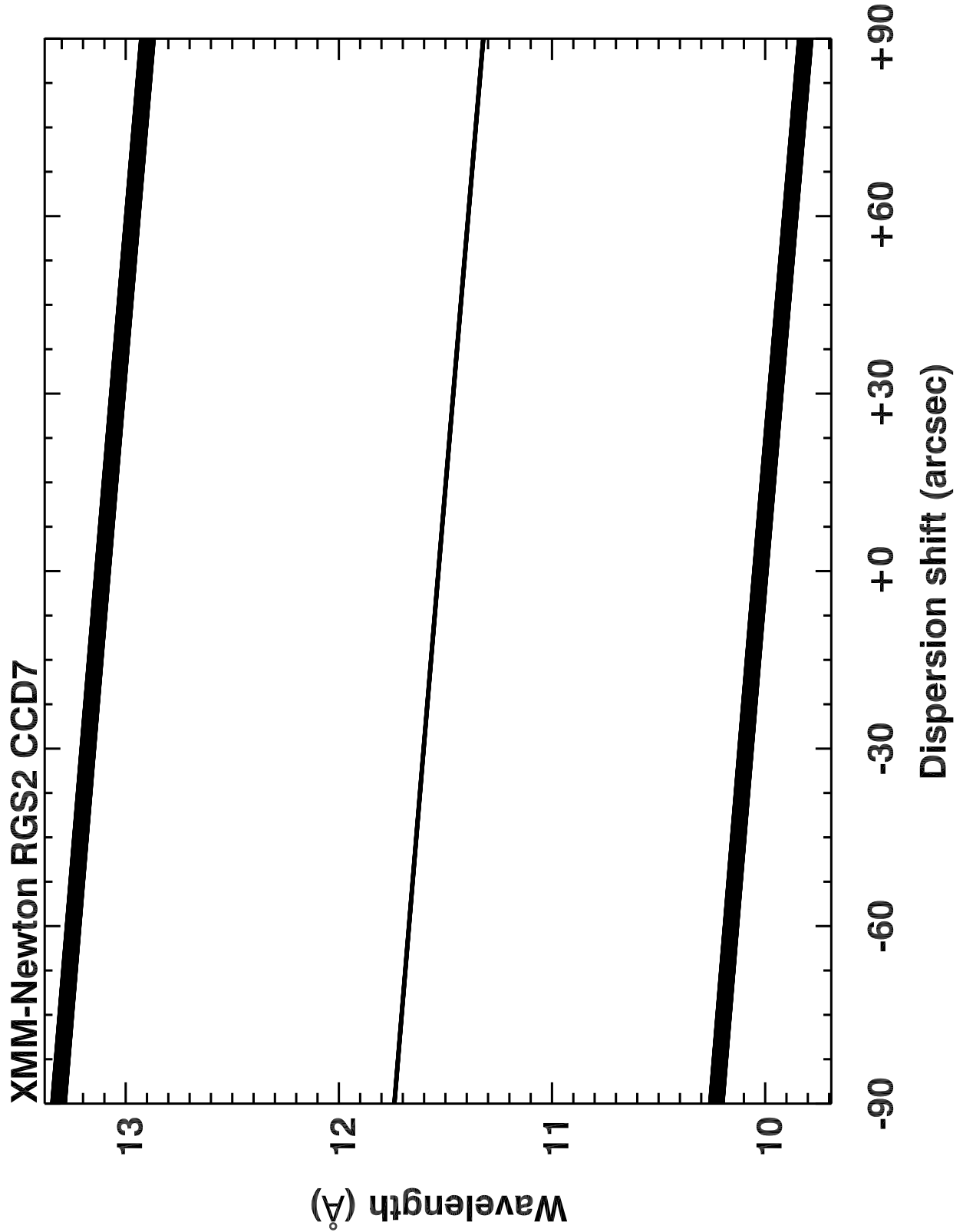
Figure 17: Wavelengths affected by instrumental features on RGS2 CCD8 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Cool pixels are plotted in cyan.
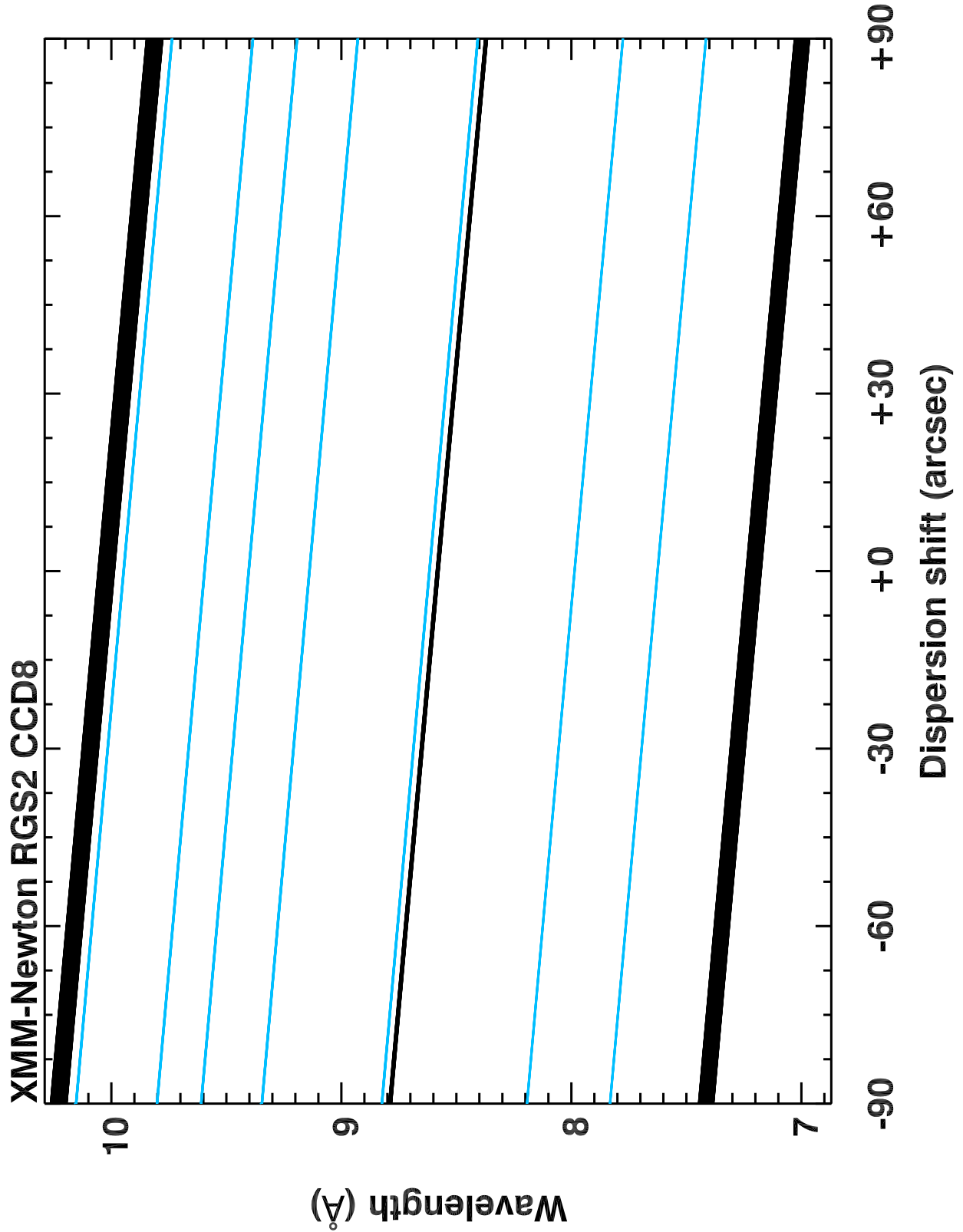
Figure 18: Wavelengths affected by instrumental features on RGS2 CCD9 depending on pointing offset in the dispersion direction. Gaps between chips and the boundary between the two chip nodes are shown in black. Hot and cool pixels are plotted in red and cyan respectively.
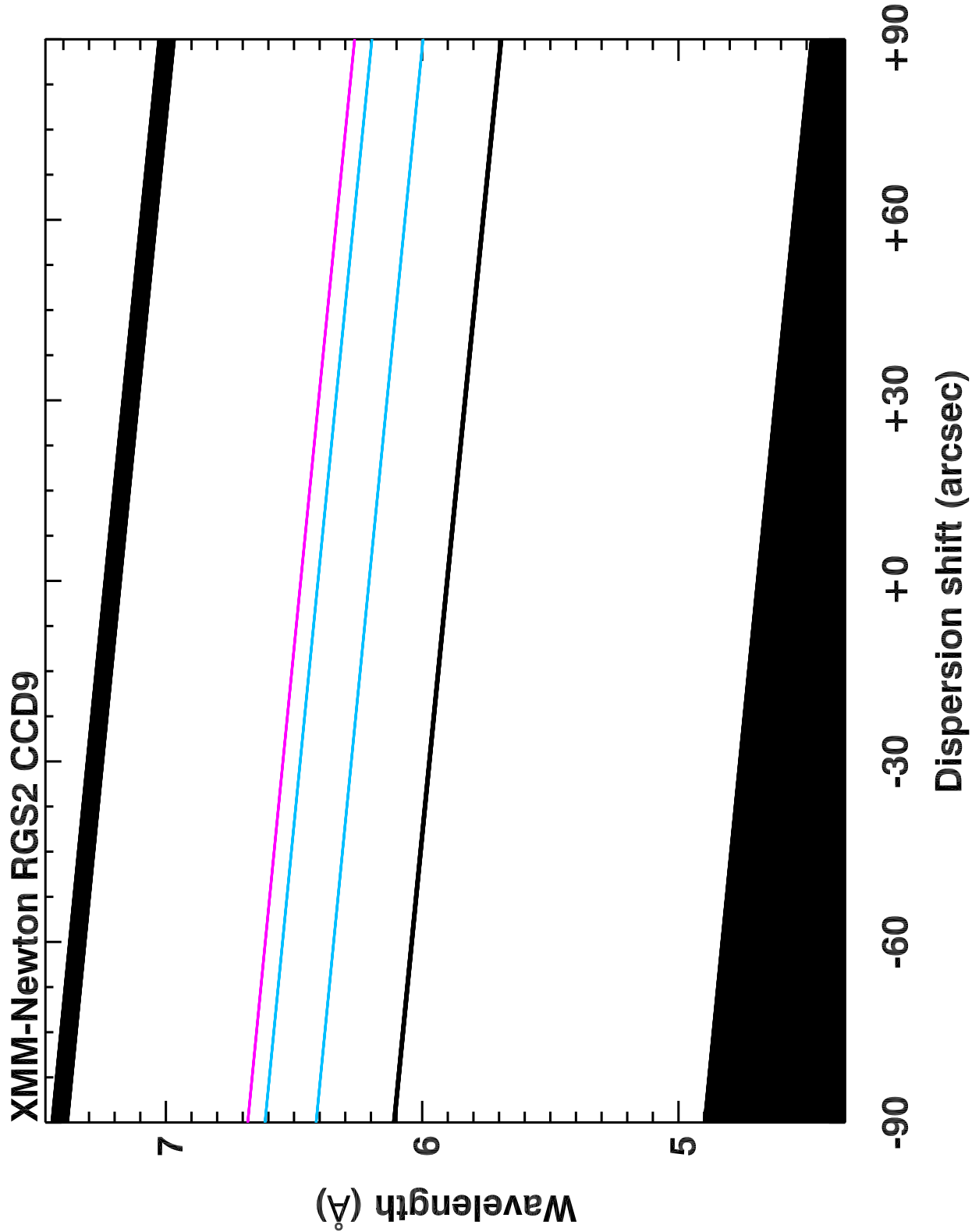
Figure 19: The X-ray spectrum of the O star zeta Puppis overlaid with the locations of bad surface features in RGS1. Gaps between chips and the boundary between the two chip nodes are shown in grey with the variety of other types of bad surface in assorted colours.
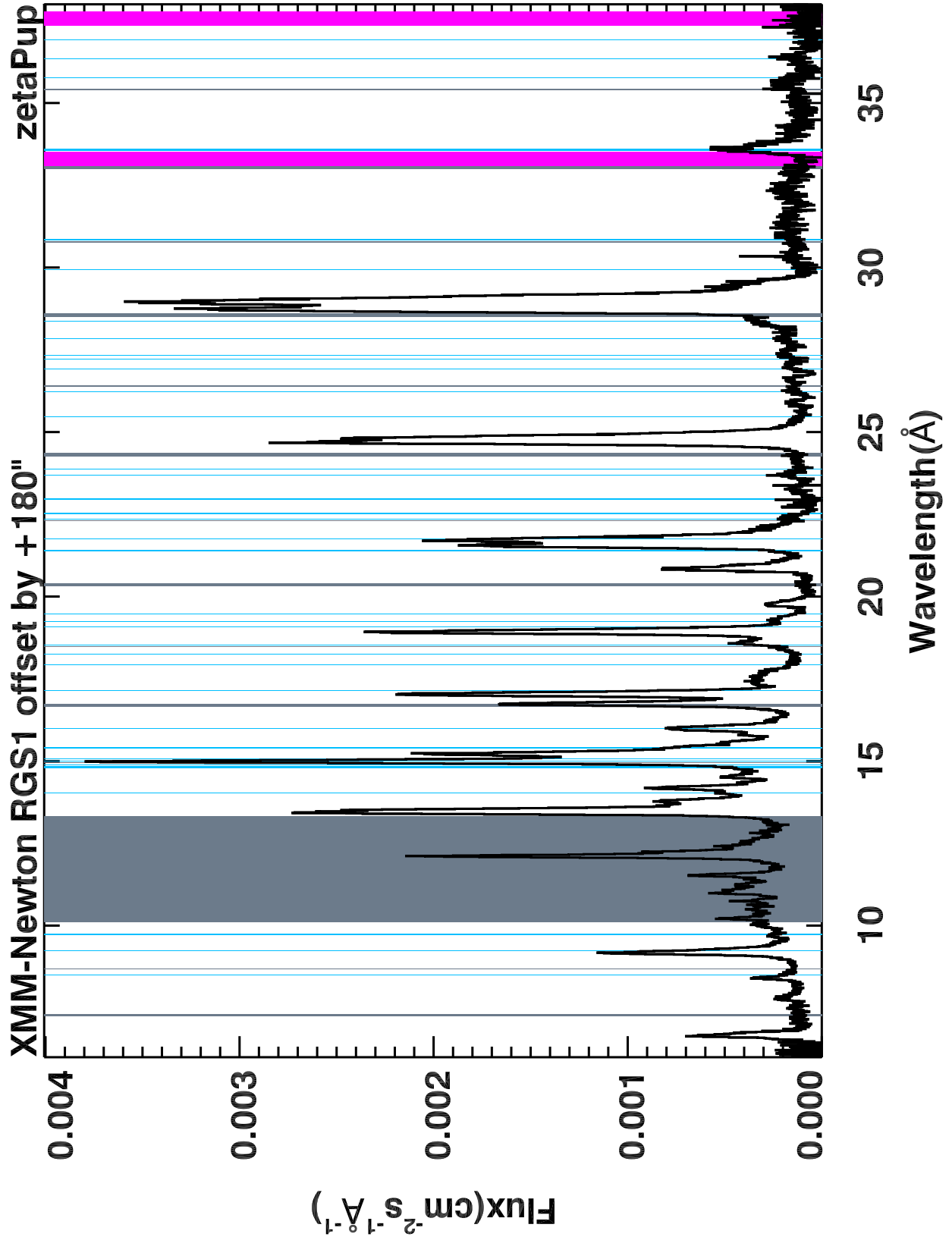
Figure 20: The X-ray spectrum of the O star zeta Puppis overlaid with the locations of bad surface features in RGS2. Gaps between chips and the boundary between the two chip nodes are shown in grey with the variety of other types of bad surface in assorted colours.