

**PACS homogeneous SED and
 Nyquist spectral sampling**
PICC-KL-TN-040

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1 Summary

The grating step sizes currently used in PACS SED mode and Nyquist sampling range spectroscopy are not optimal. On average these step sizes provide 3 samples per resolution element, but in practice when rebinning a PACS SED spectrum or Nyquist sampled range spectroscopy measurement, a significant number of wavelength bins are not sampled.

2 Undersampling

When rebinning a PACS spectrum a wavelength grid is constructed that follows the PACS spectral resolution as a function of wavelength. In order to save all spectral information when rebinning the spectrum, we rebin to a grid that is Nyquist sampling a resolution element, i.e., we construct a wavelength grid with every bin spanning half a resolution element ($\frac{1}{2}$ FWHM), or oversampling 2.

When rebinning an SED or Nyquist range spectroscopy with the current SED step sizes (2400 for bands B2A and B3A, 2500 for band B2B) not every wavelength bin is sampled. The problem is illustrated in Figure 1

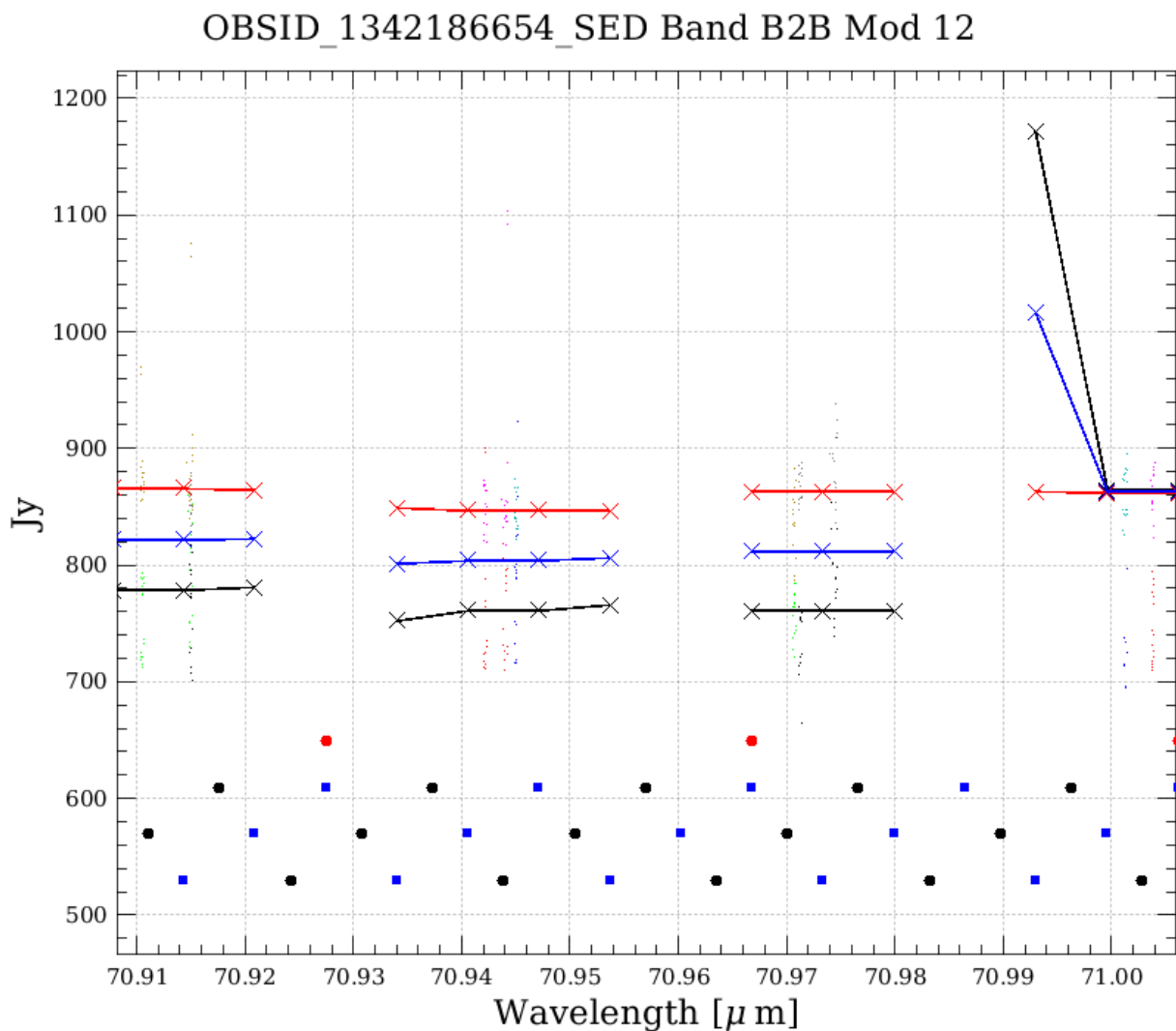


Figure 1: band B2B, rebinned with oversampling 2. Blue dots show bin centers. Black dots show bin borders. Red dots show the width of one resolution element. The faint dots are PACS detector signals.

3 Grating step size versus number of samples

We have simulated the number of samples in every $\frac{1}{2}$ resolution element wavelength bin for different grating step sizes between 2000 and 3000. Figures 2,3,4 show this for the blue bands. Especially for band B2B we are currently using a grating step size that yields a very unhomogeneous sampling. From these figures, we suggest the following changes to SED and Nyquist range grating step size:

B2A: 2300 (old step size: 2400)

B3A: 2220 (old step size: 2400)

B2B: 2400 (old step size: 2500)

Figure 5 shows that these step sizes are all acceptable for the parallel red ranges too.

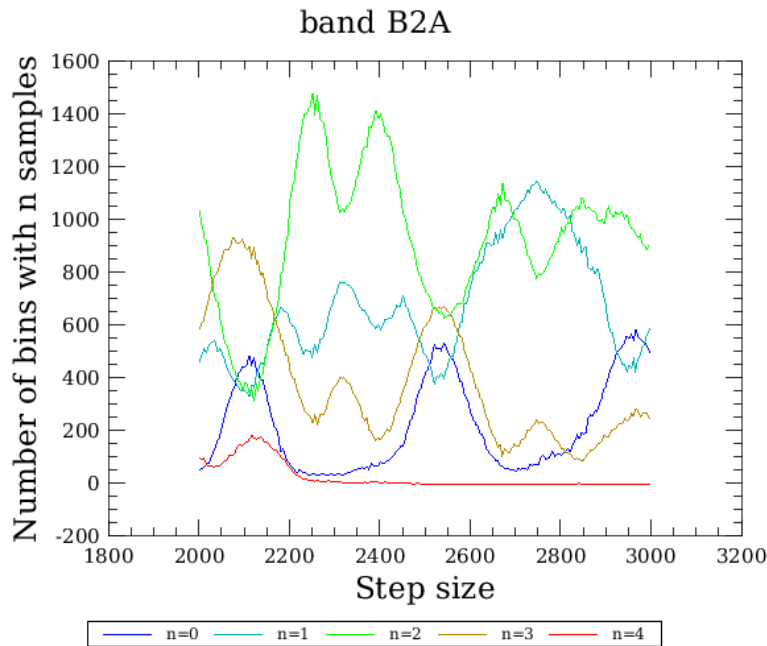


Figure 2: Number of $\frac{1}{2}$ resolution wavelength bins that have 0, 1, 2, 3 and 4 samples in a PACS SED scan in band B2A. The current grating step size is 2400.

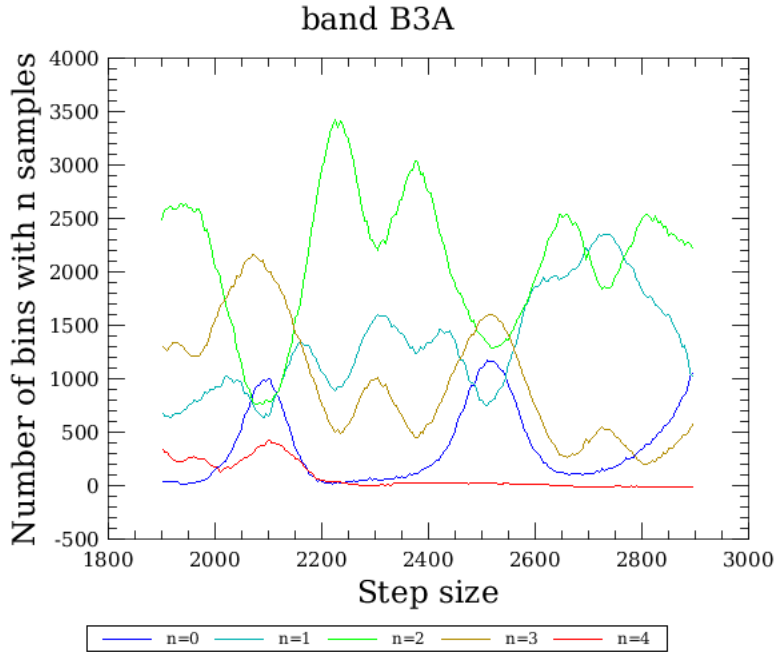


Figure 3: Number of 1/2 resolution wavelength bins that have 0, 1, 2, 3 and 4 samples in a PACS SED scan in band B3A. The current grating step size is 2400

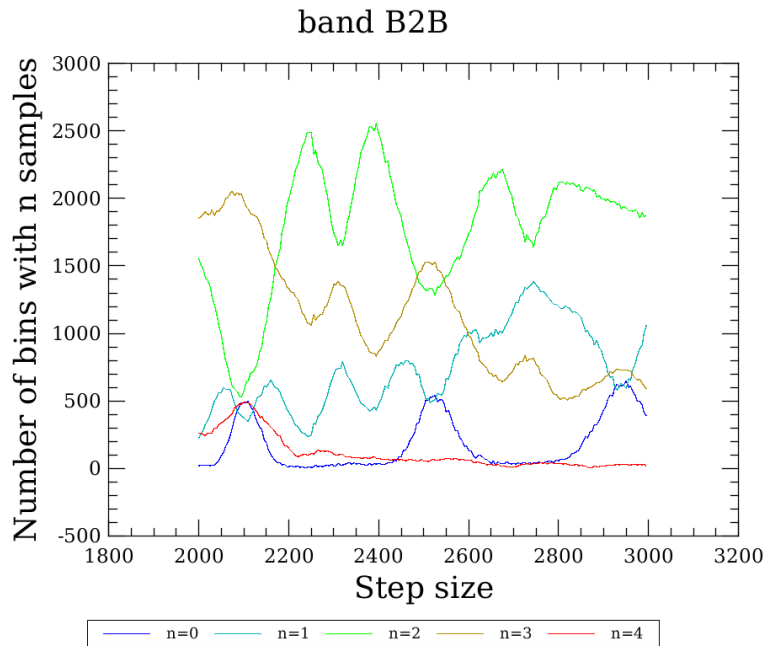


Figure 4: Number of 1/2 resolution wavelength bins that have 0, 1, 2, 3 and 4 samples in a PACS SED scan in band B2B. The current grating step size is 2500

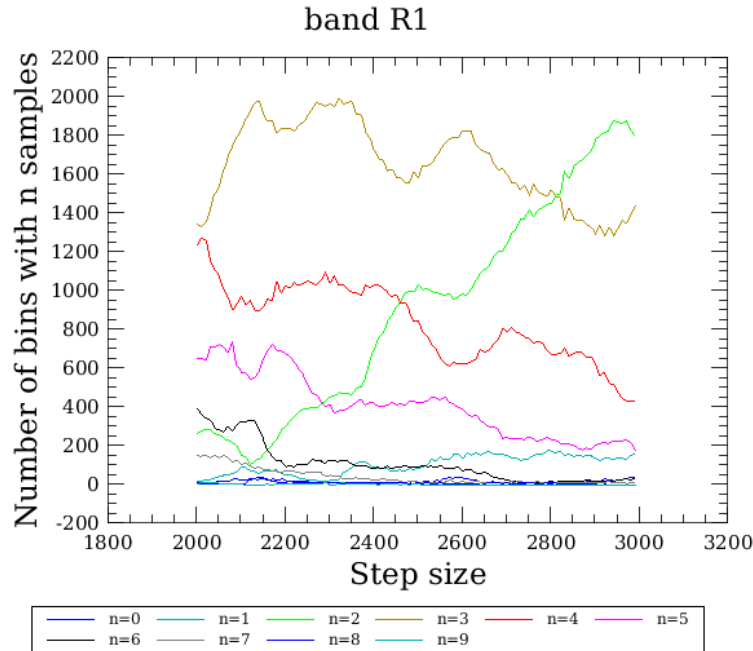


Figure 5: Number of $1/2$ resolution wavelength bins that have 0, 1, 2, 3 and 4 samples in a PACS SED scan in band R1.

4 Distribution of $1/2$ resolution bins without samples

In figures 6 to 12 we show for every $1/2$ resolution bin how many samples it contains for the present and proposed SED grating step size.

5 Impact on AOT duration

If we decrease the grating step size, more steps are needed to cover the same wavelength range. Therefore the AOT durations will increase. The impact however is marginal with respect to the original durations:

B2a: from 124 steps to 130 steps; 1266 sec + 28 sec

B2B: from 251 steps to 261 steps; 2344 sec + 46 sec

B3A: from 276 steps to 298 steps; 2888 sec + 100 sec;

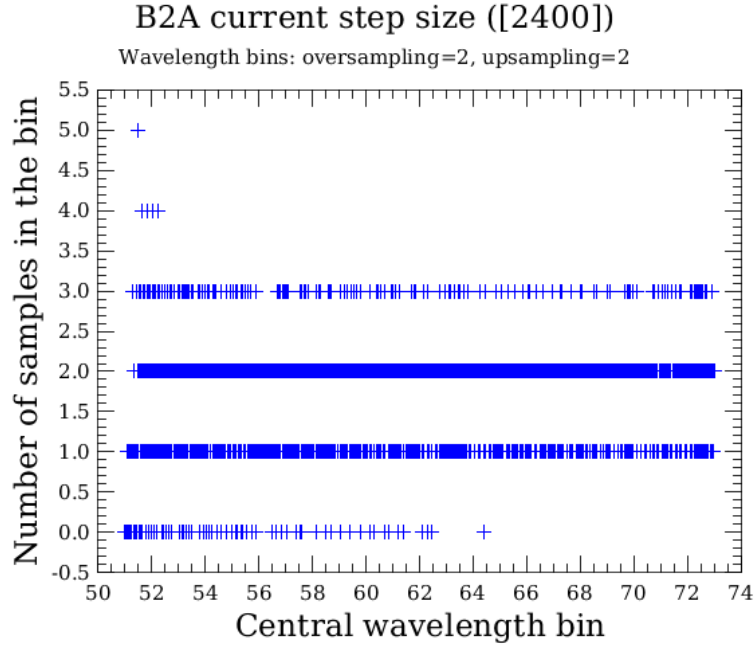


Figure 6: Number of samples in every $\frac{1}{2}$ resolution bin for band B2A with the current step size (2400)

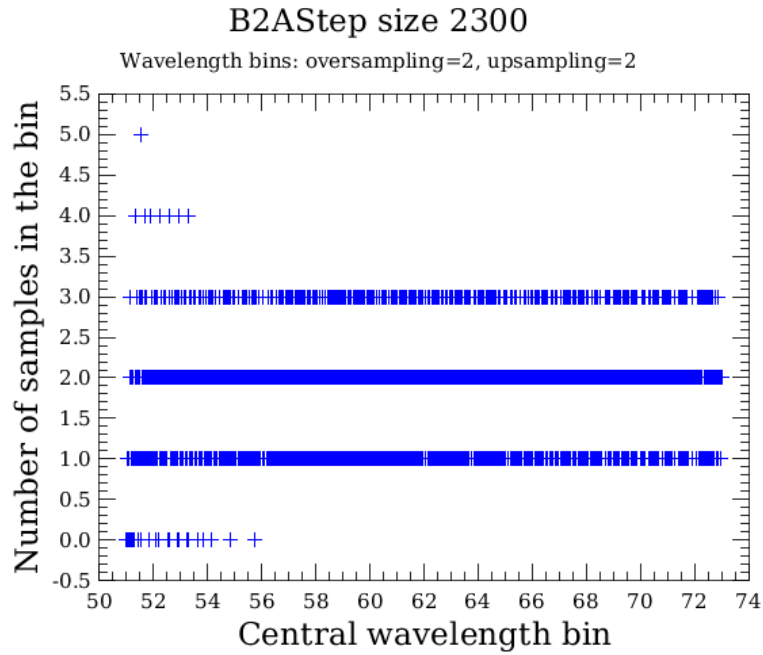


Figure 7: Number of samples in every $\frac{1}{2}$ resolution bin for band B2A with the proposed new step size (2300)

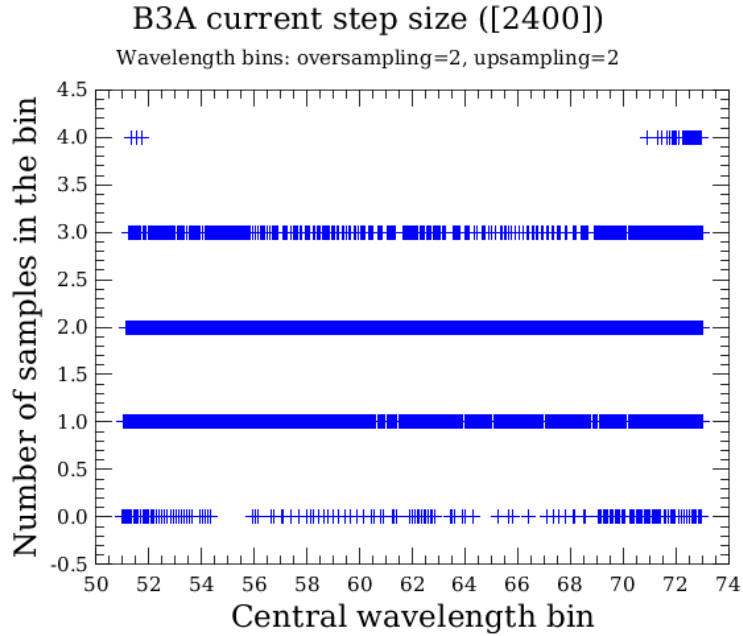


Figure 8: Number of samples in every $\frac{1}{2}$ resolution bin for band B3A with the current step size (2400)

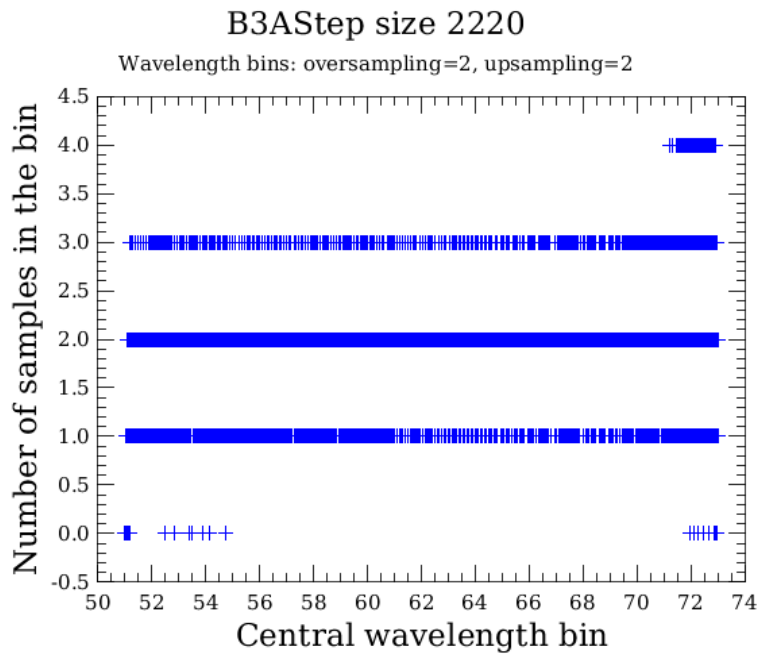


Figure 9: Number of samples in every $\frac{1}{2}$ resolution bin for band B3A with the proposed new step size (2220)

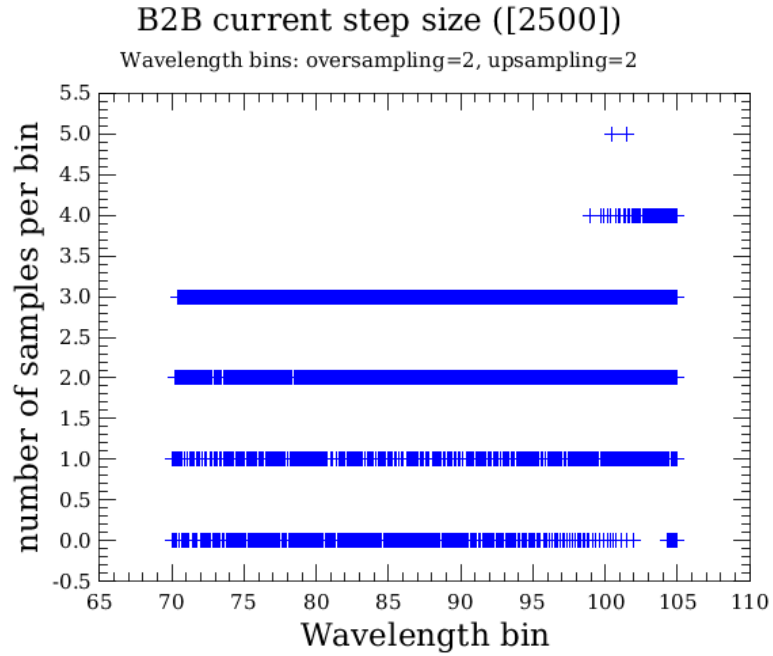


Figure 10: Number of samples in every $\frac{1}{2}$ resolution bin for band B2B with the current step size (2500)

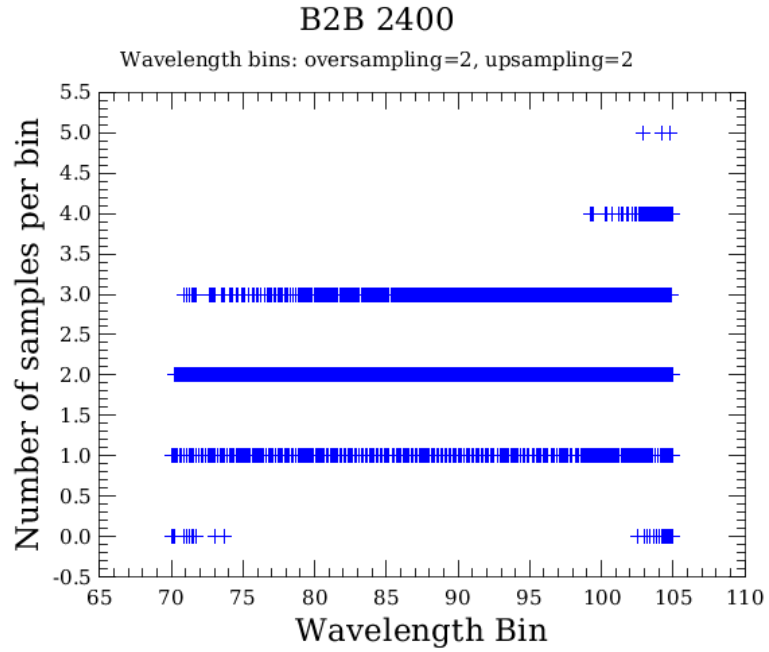


Figure 11: Number of samples in every $\frac{1}{2}$ resolution bin for band B2B with the proposed new step size (2400)

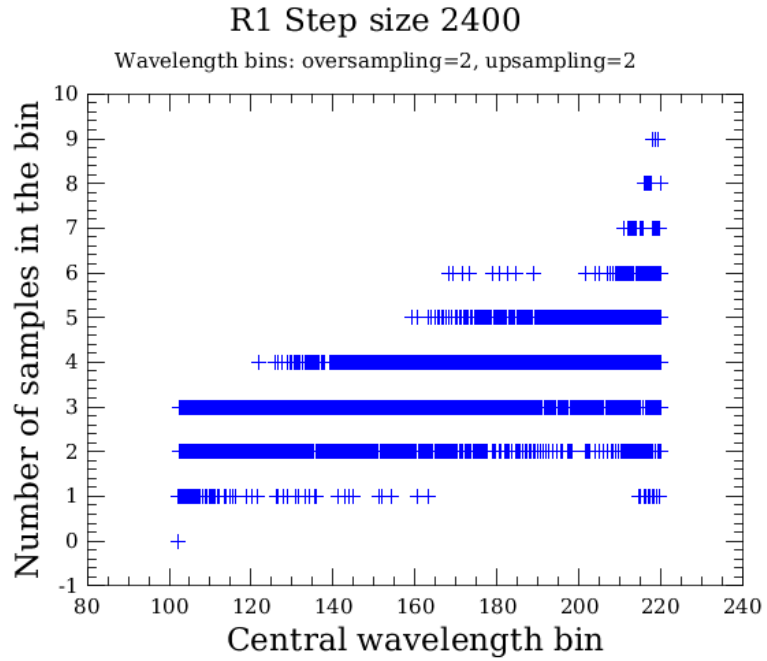


Figure 12: Number of samples in every $\frac{1}{2}$ resolution bin for band R1 with step size 2400