New evidence for the 3.5-keV feature in clusters is inconsistent with a dark matter origin

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Introduction

- Galaxy clusters are the largest dark matter dominated, gravitationally collapsed objects
- Hypothetical *sterile neutrino* dark matter may be the origin for a recent feature observed in the X-ray spectrum of galaxy clusters at ~3.5 keV.
- Results from Bulbul+2014 reported an excess of emission in the stacked spectrum of 73 galaxy clusters.
- Counter evidence has also emerged against the line, in individual clusters (Perseus), galaxies, dwarf spheroidals, and blank sky observations. **Currently, an inconclusive picture remains as to the status and origin of the 3.5 keV line.**
- We pursue a new angle: to search for whether a temperature dependence exists in the appearance of the 3.5 keV feature, given that X-ray temperature is a reliable tracer of dark matter halo mass.

The cluster sample

- We use the largest sample thus far for such a study: **117 optically and X-ray confirmed galaxy clusters**, in the redshift range: **0.1 < z < 0.6**.
- Photometric redshifts for the clusters have been measured using the red-sequence based redMaPPer cluster finder (Rykoff+2014)
- X-ray temperatures using only XMM-PN data have been extracted. Only clusters with a reliable temperature measurement are used in the study.
- The sample contains clusters with temperatures between **1 and 11 keV.**

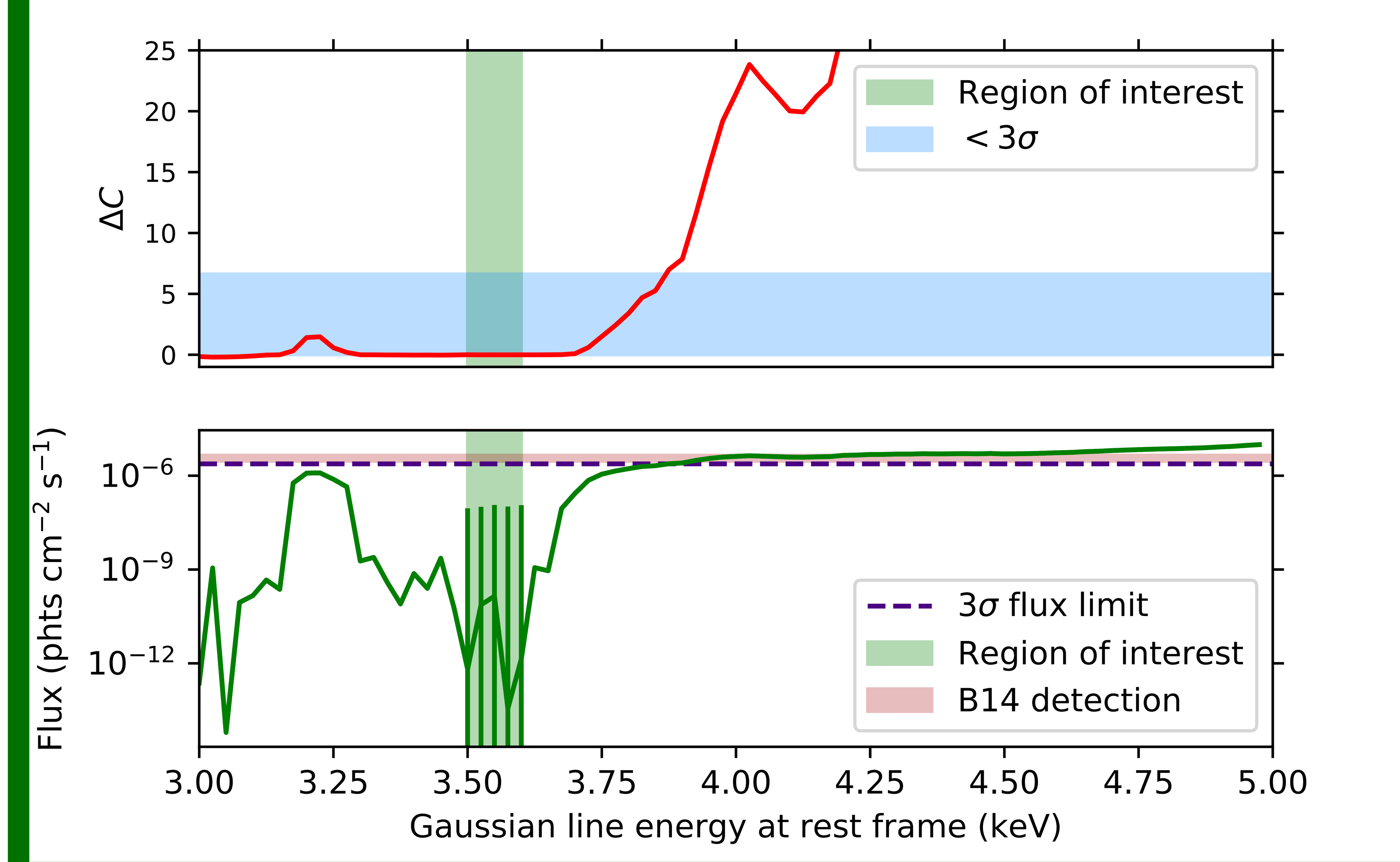
Methodology

- We *blueshift* each cluster spectrum to the rest frame to smear out redshift-independent artefacts
- We then conduct **three separate and related spectral fitting procedures**.
  1. Each cluster individually
  2. Clusters binned according to temperature
  3. All the clusters in our sample

Results

We find **no evidence of a 3.5 keV feature as a function of X-ray temperature in 117 galaxy clusters**. We jointly fit the spectra of 114 clusters (3 are removed; see below) to recover **an upper limit on the flux of an undetected line at 3.5 keV**; the most precise constraint on the allowed mixing angle from sterile neutrino dark matter from cluster studies so far.

Fig. 7 in paper.



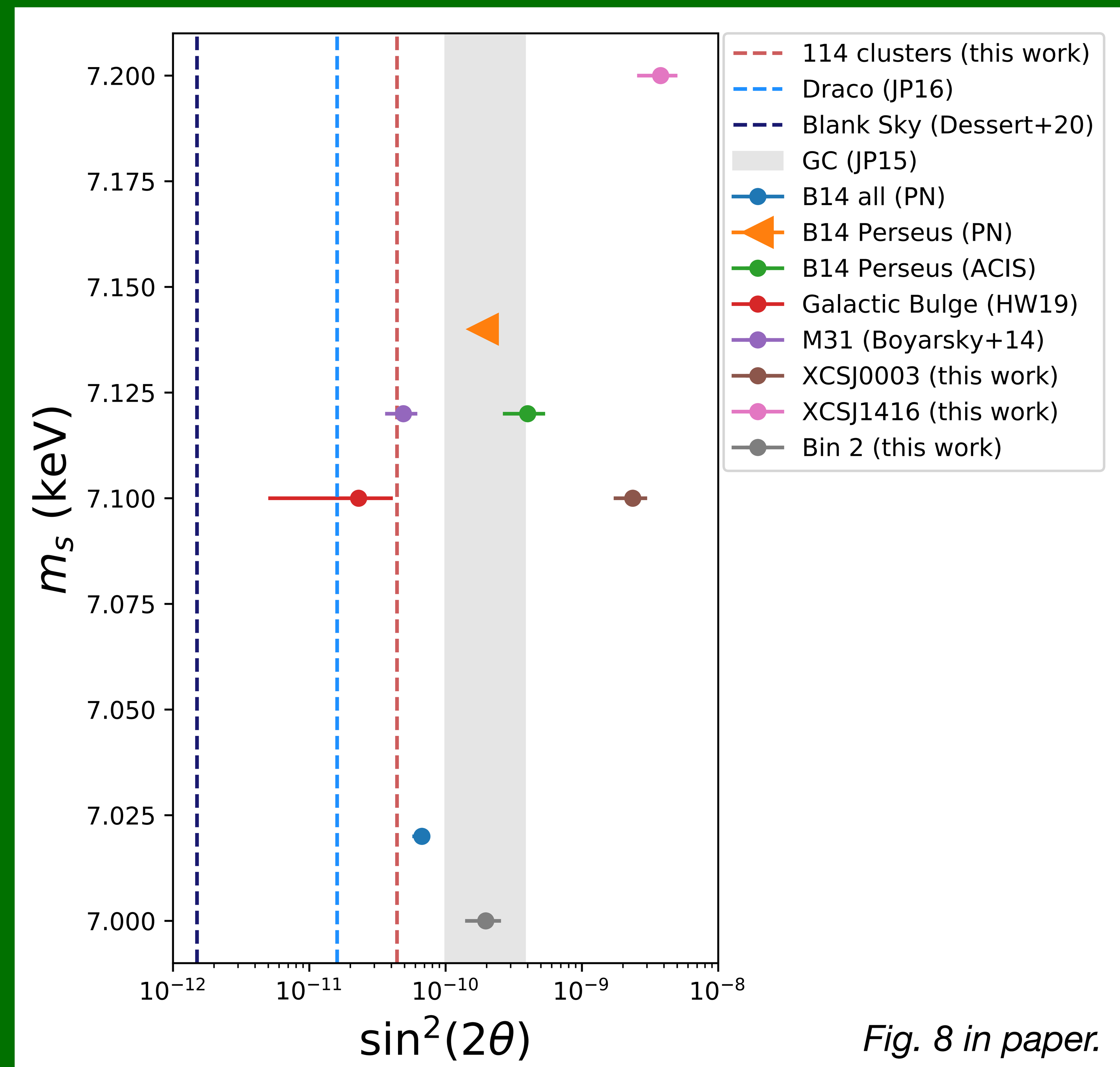


Fig. 8 in paper.

- We use the **XSPEC implementation of the *apec* model** to fit the baseline cluster spectrum.
- We then iterate a Gaussian line between 3.5 and 3.6 keV, searching for a fit improvement relative to the baseline model.

In departure from previous studies, we favour a simultaneous fitting approach across all our clusters over a stacking method.

Discussion

- Clusters XCS J0003.3+0204 (1) and XCS J1416.7+2315 (2) both display 3.5 keV line-like features. Cluster XCS J2223.0-0.137 (3) also shows a 3.5 keV excess but is likely to be the result of a poor fitting to the continuum emission due the merging cluster's complex morphology.
- **We find that in the two cases of genuine line-like features, the excess shown is insensitive to:**
  - Photometric vs spectroscopic redshifts
  - Core-excluded vs core-included spectra
  - Alternative observations where available
  - Different cluster abundance tables
- The fact the 3.5 keV excess is not a ubiquitous feature in the clusters in the sample **disfavours a dark matter origin.**
- **Other line searches should be aware that a feature in individual clusters may contaminate a signal from a stacked spectrum** (see Fig 5.b in the paper).

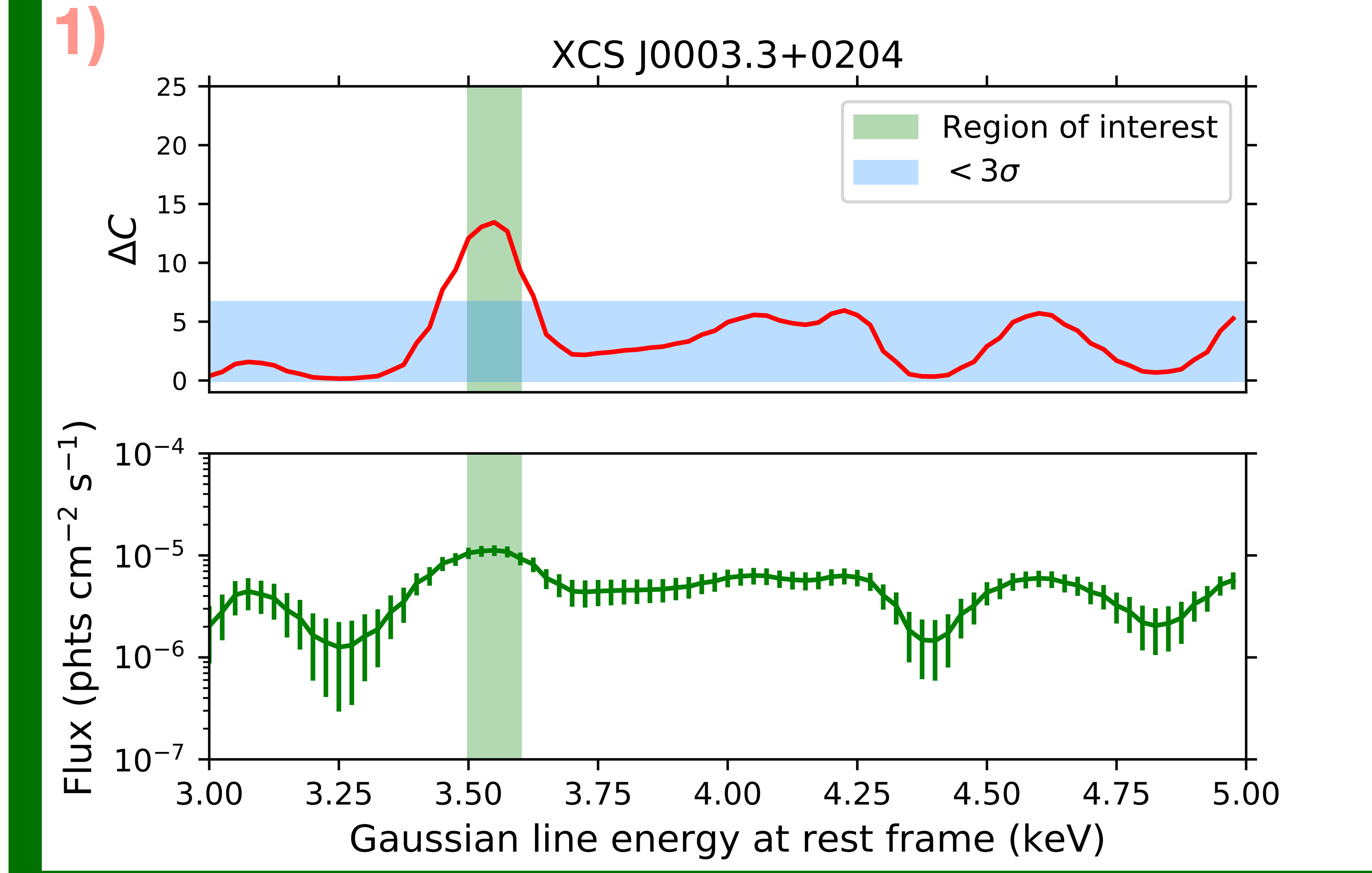
Summary

We used the largest sample of confirmed clusters (117) to investigate the potential dark matter origin of the '3.5 keV line,' placing a new upper limit on its flux and mixing angle. We find no evidence of a X-ray temperature dependence. More observations and higher resolution data will be required to assess the origin of the excess in the three individual clusters.

References

Bulbul E., Markevitch M., Foster A., Smith R. K., Loewenstein, M., Randall S. W., 2014, ApJ, 789, 13
Rykoff E. S., et al., 2014, ApJ, 785, 104

Three individual clusters in our sample do produce significant detections at 3.5 keV. Out of these, one is most plausibly the result of a discrete emission line. However, none of clusters are the most dark matter dominated within the sample.



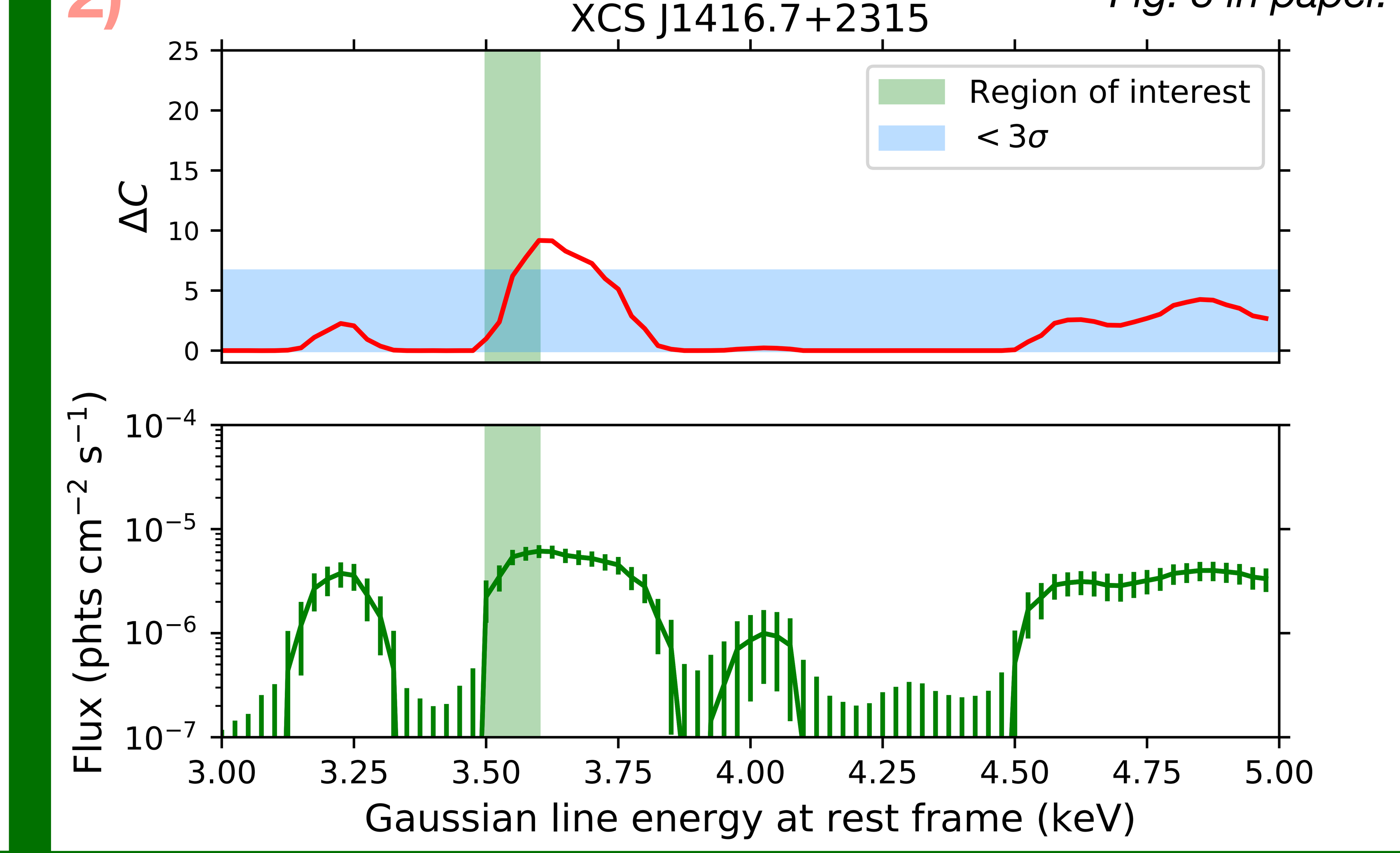
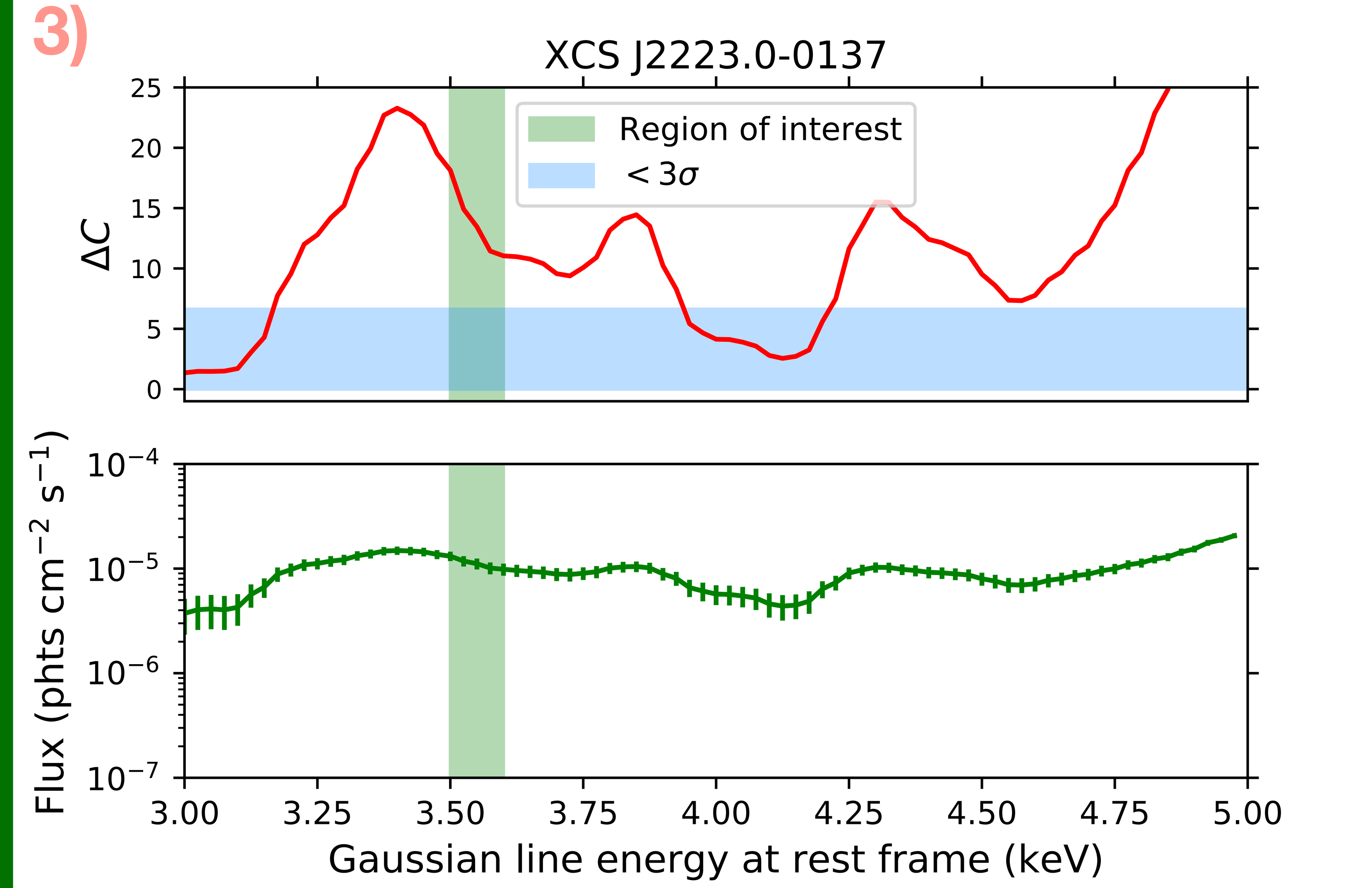


Fig. 3 in paper.



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