



eROSITA Background

Filter-Wheel-Closed Observations

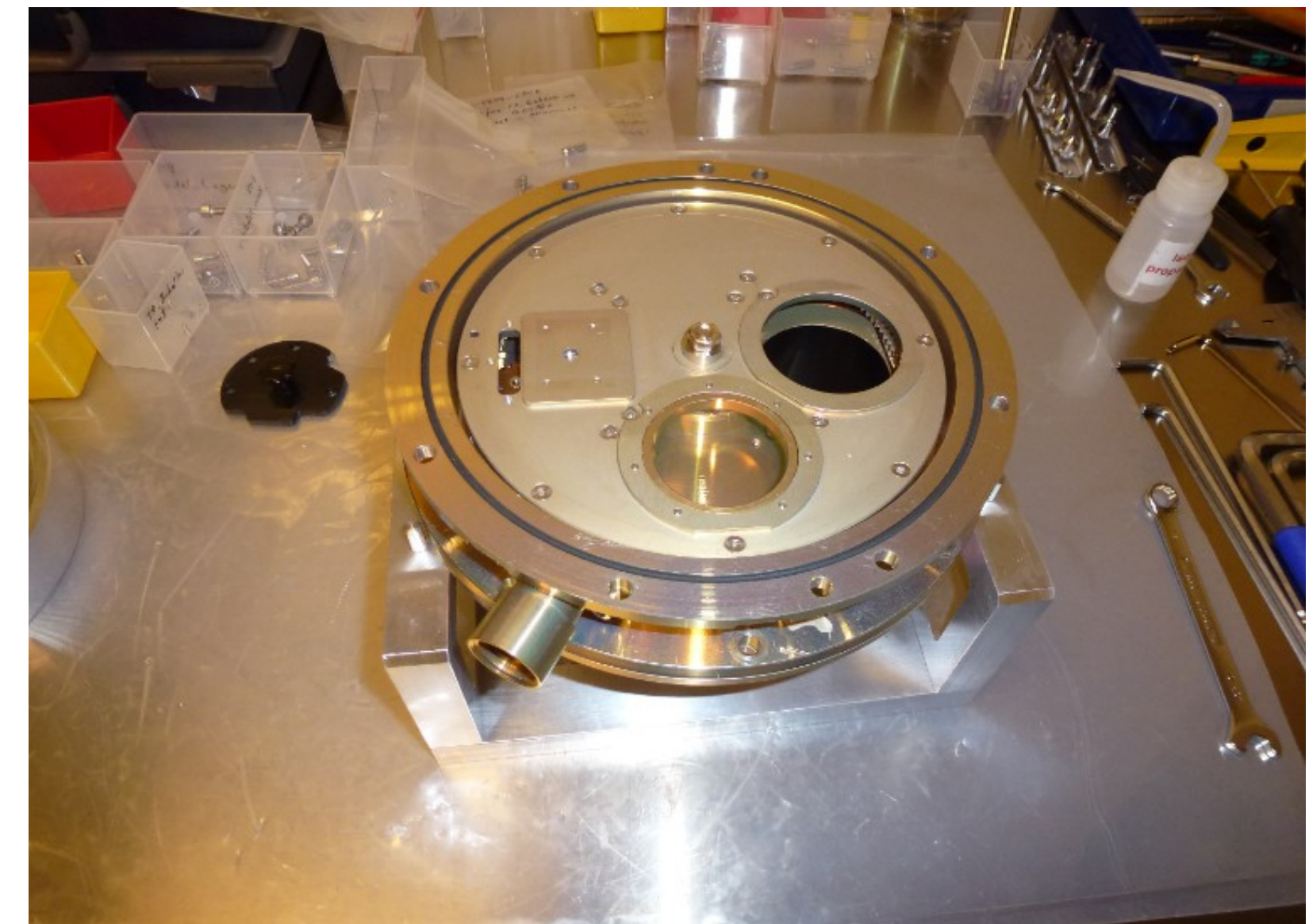
Michael Yeung

25.04.2023 IACHEC meeting
Pelham, Bad Endorf

Filter Wheel Closed (FWC) Observations

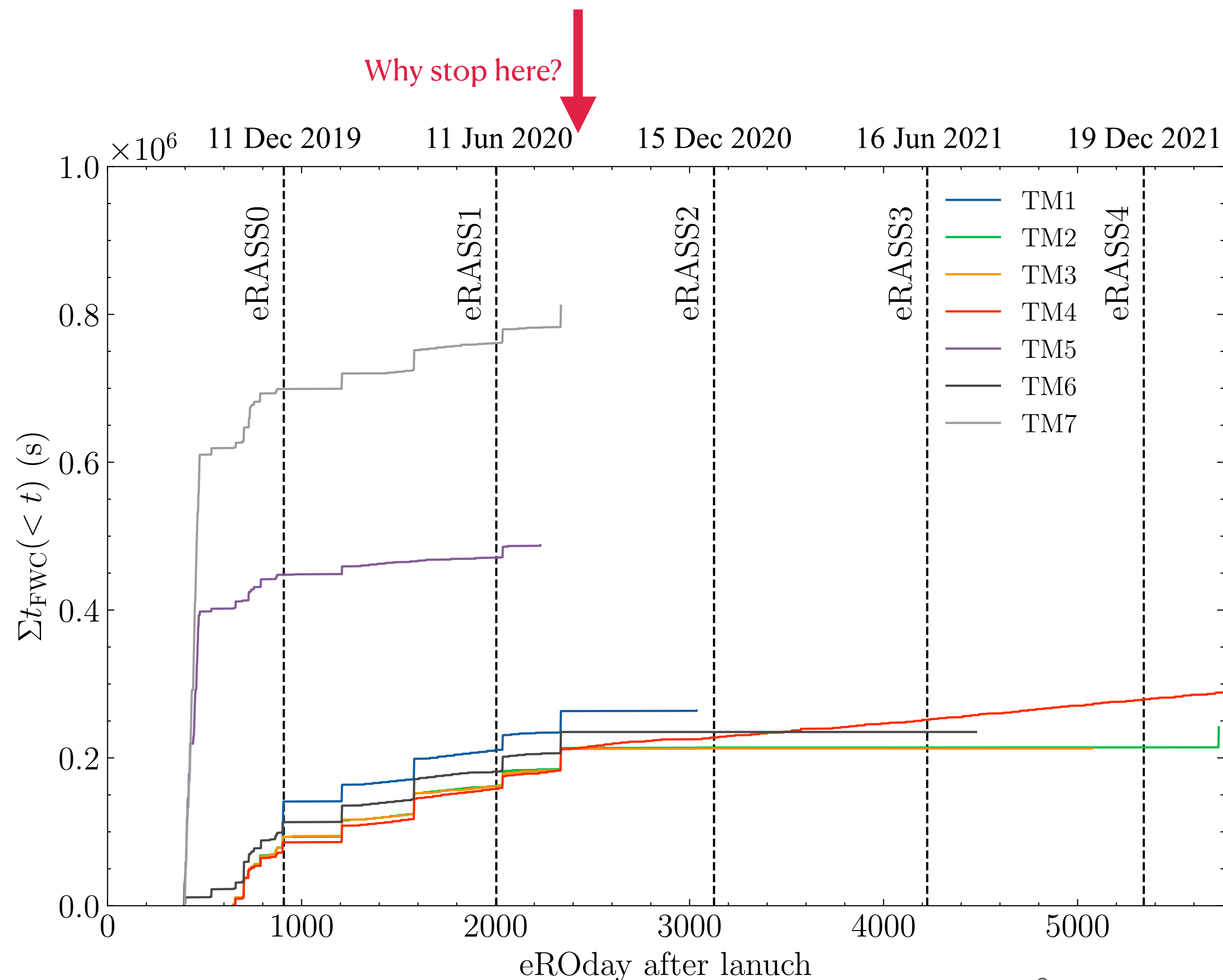


- Four positions in eROSITA's filter wheels (one per telescope module (TM))
 - **CLOSED (instrumental background)**
 - CALIB (radioactive ^{55}Fe source with Al/Ti target for calibration)
 - FILTER (observation)
 - OPEN (for outgassing)
- FWC observations
 - Measure & monitor the in-orbit background of eROSITA
 - Useful for analysis of extended sources/diffuse emissions
 - when instrumental background contributes significantly to the source counts



Courtesy of S. Friedrich

Filter Wheel Closed Observations



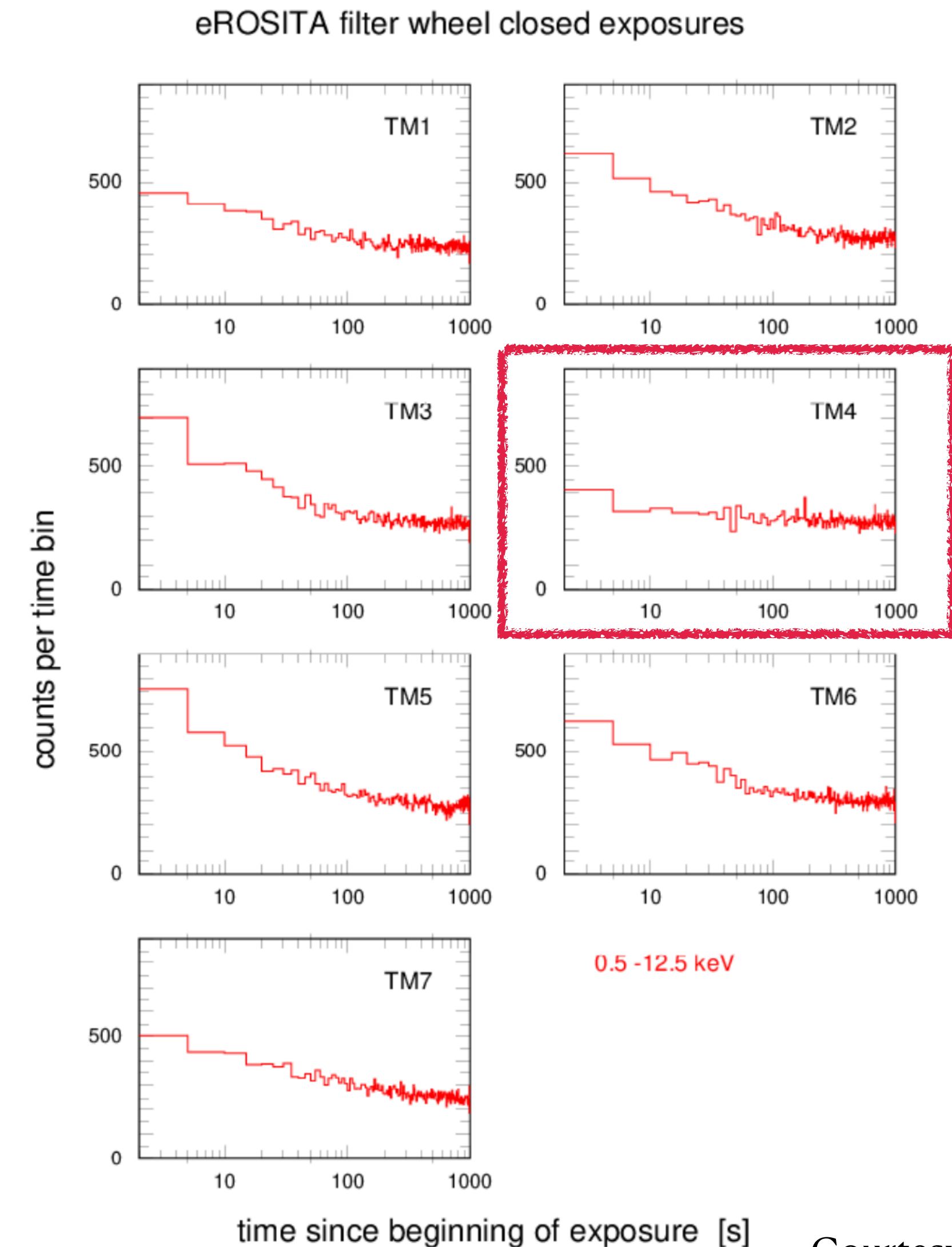
- Long exposures from orbit corrections
- eRASS1: ~20 half-hour exposures
- eRASS2: ~10 half-hour exposures
- Afterwards: TM4 ~50 half-hour exposures; TM2: 8 hours

TM	Live time (ks)
1	268.3
2	246.5
3	216.7
4	294.2
5	487.1
6	246.1
7	811.8

Enhancement Following Filter Wheel Rotation



- Decay to constant level after ~10 min
- Different intensity depending on TM
- Affect both Closed and astrophysical observations
 - But more so for Closed
- TM₄ least affected
 - TM₄ FWC observations continued after July 2020
- Will be documented in Freyberg+23 (in prep.)



Possible Source of Enhancement

- Most likely the contact between the Stepper motor and the inner ring of the filter disc
- Discovered in ground calibration in 2015
- Motor originally made of Al, ring Vespel
- No longer detected on ground after interchanging the materials
- Probably generate X-ray via tribo-electric effect

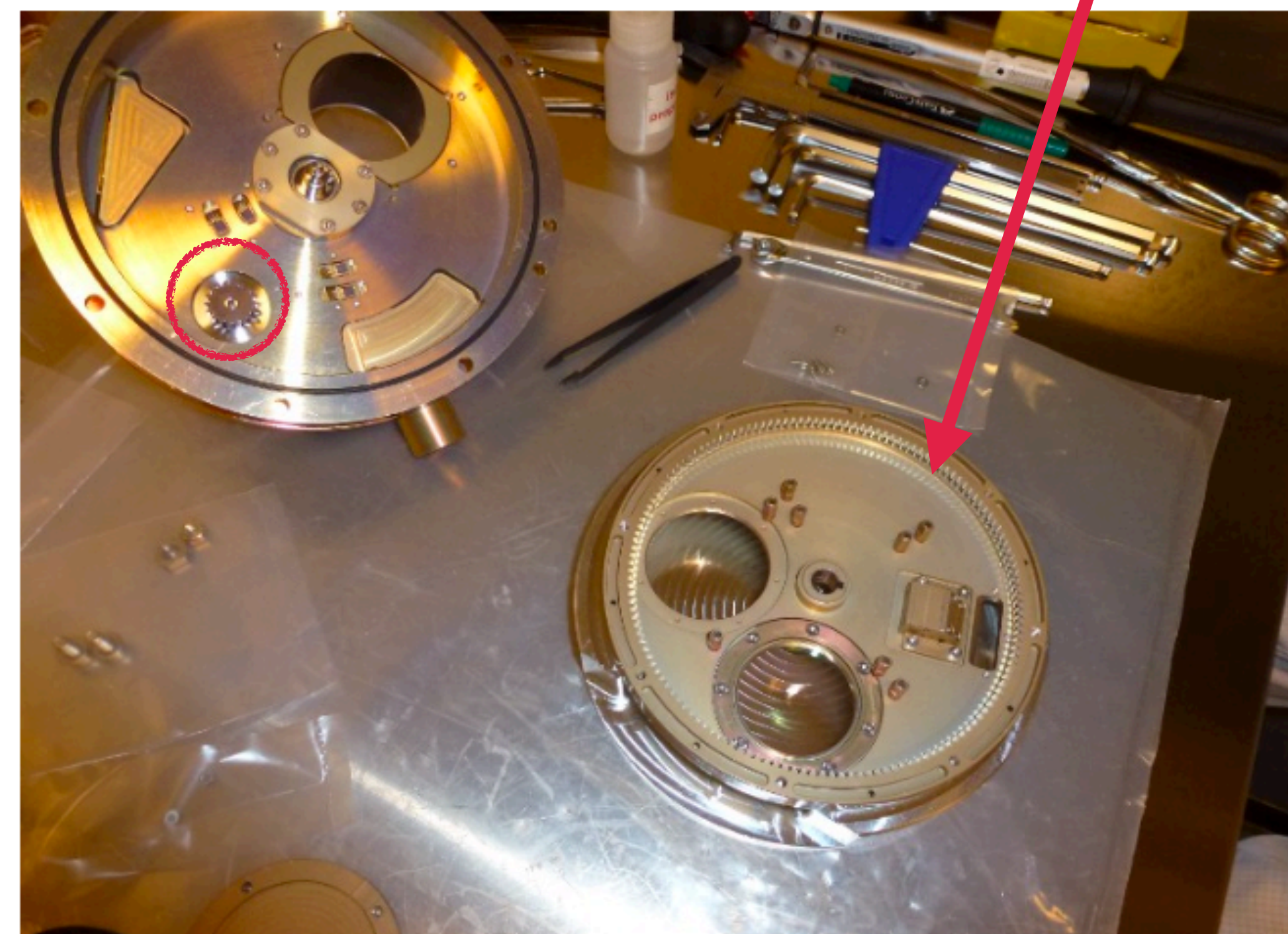


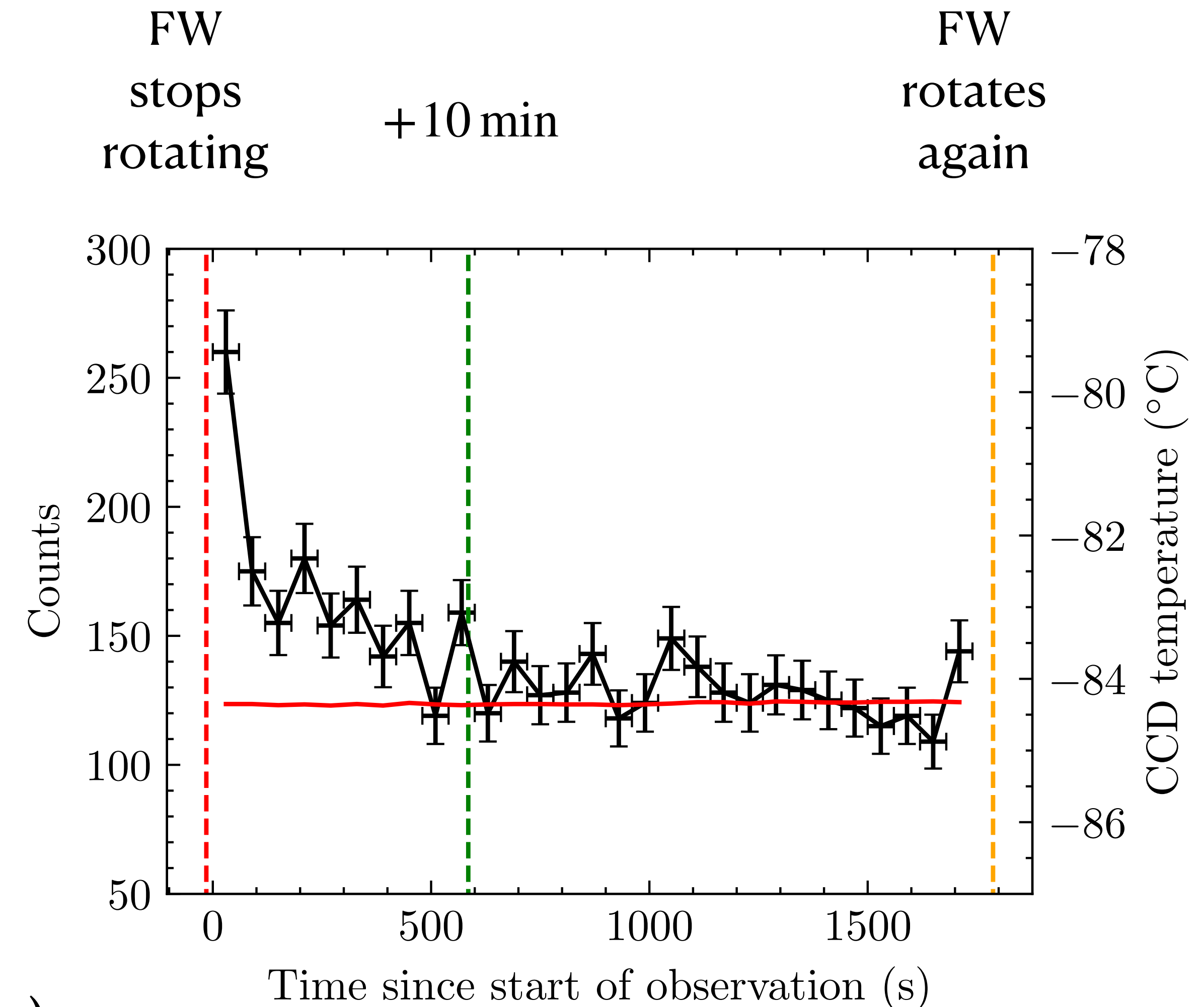
Figure 1 Filter wheel with Hall sensors, small wheel (Vespel), magnets for position coding (left) and filter disk (right).

Enhancement Cleaning



1. Light curves in 60 s bins
 - a. remove time periods with no events
 - b. correct for chopper settings
2. Remove time intervals with $90 \text{ cts/min} \leq \text{count rate} \leq 170 \text{ cts/min}$
3. Identify and remove $\sim 10 \text{ min}$ after FW rotations using house-keeping record
4. Remove remaining enhancement instances manually
5. Apply standard eROSITA EventList flagging

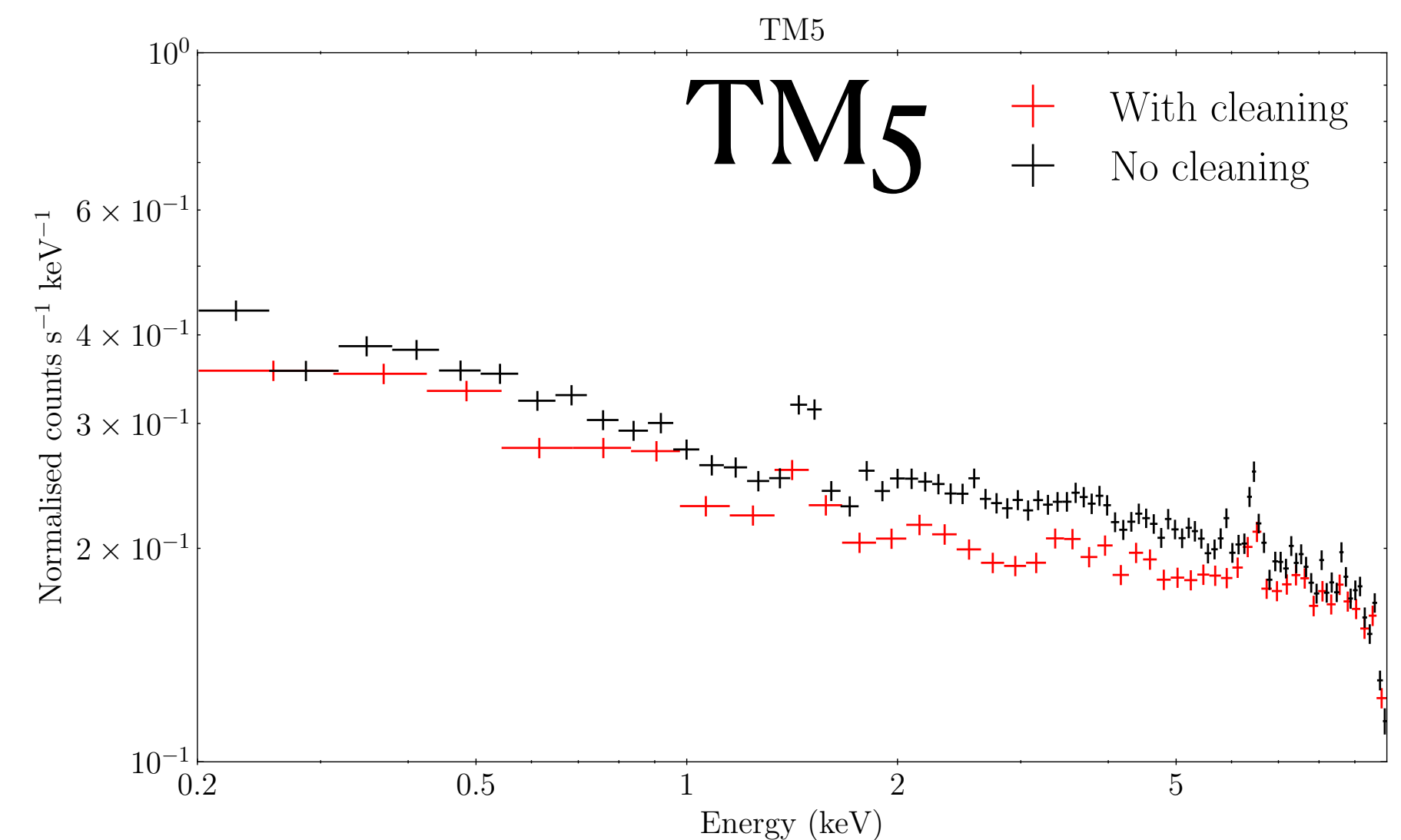
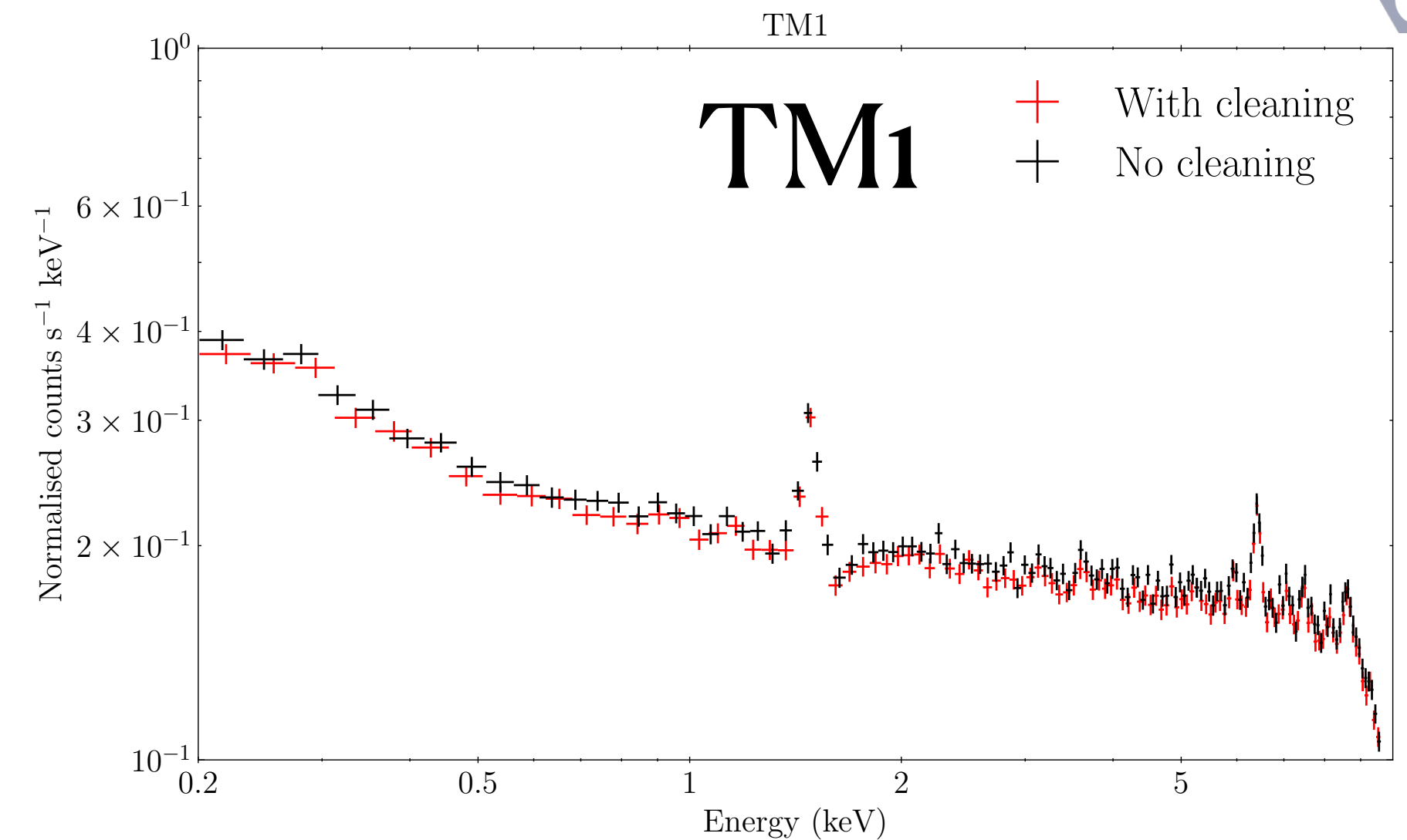
(Out of FOV , bad pixels, invalid patterns)



How much difference does it make?



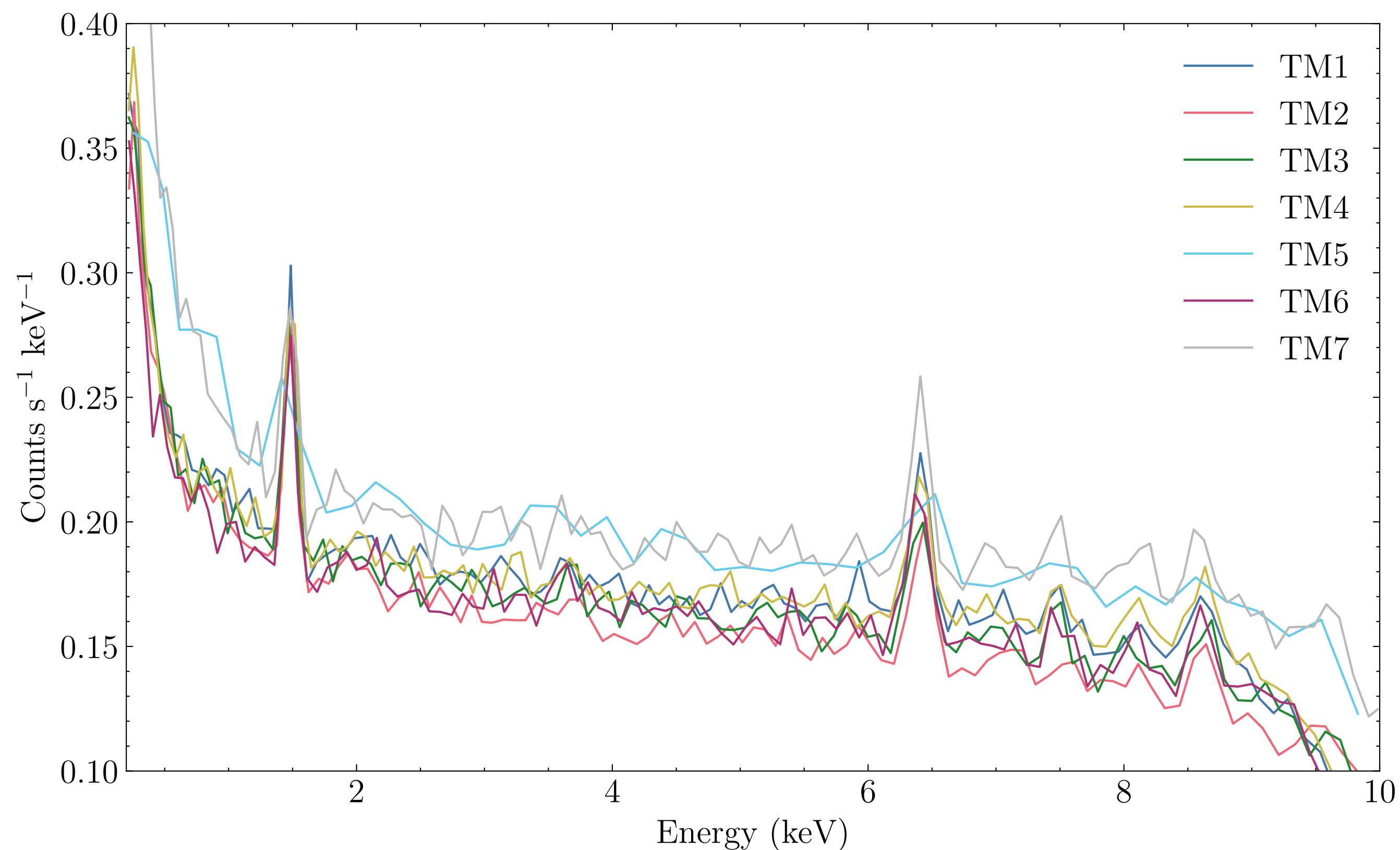
- eRASS1:
 - Non-light-leak TMs:
 - 3-4% (0.2-9 keV) in general for TM1-3 and 6
 - For TM4, only 1%
 - Light-leak cameras:
 - ▶ without 200nm Al on-chip filter
 - ▶ enhancement from light leak partially removed from light curve
 - 13% for TM5
 - 5% for TM7



Cleaned FWC Spectra

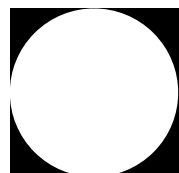


- Small difference between TMs
 - TM2 slightly lower
 - TM5, 7 (without on-chip filter) higher
- High-energy cut-off is different in every TM in energy space (gain of each TM is different)
- Cut-off depends on minimum ionising particles (MIPs) threshold (12288 adu; 13568 adu after 16 Feb 21)



Cleaned FWC Spectra



- Empirical spectral model for all TMs
- Models can be scaled to observations with the header “BACKSCAL” keyword
- BACKSCAL of FWC model = 0.8235 deg^2 (FOV of each TM) 

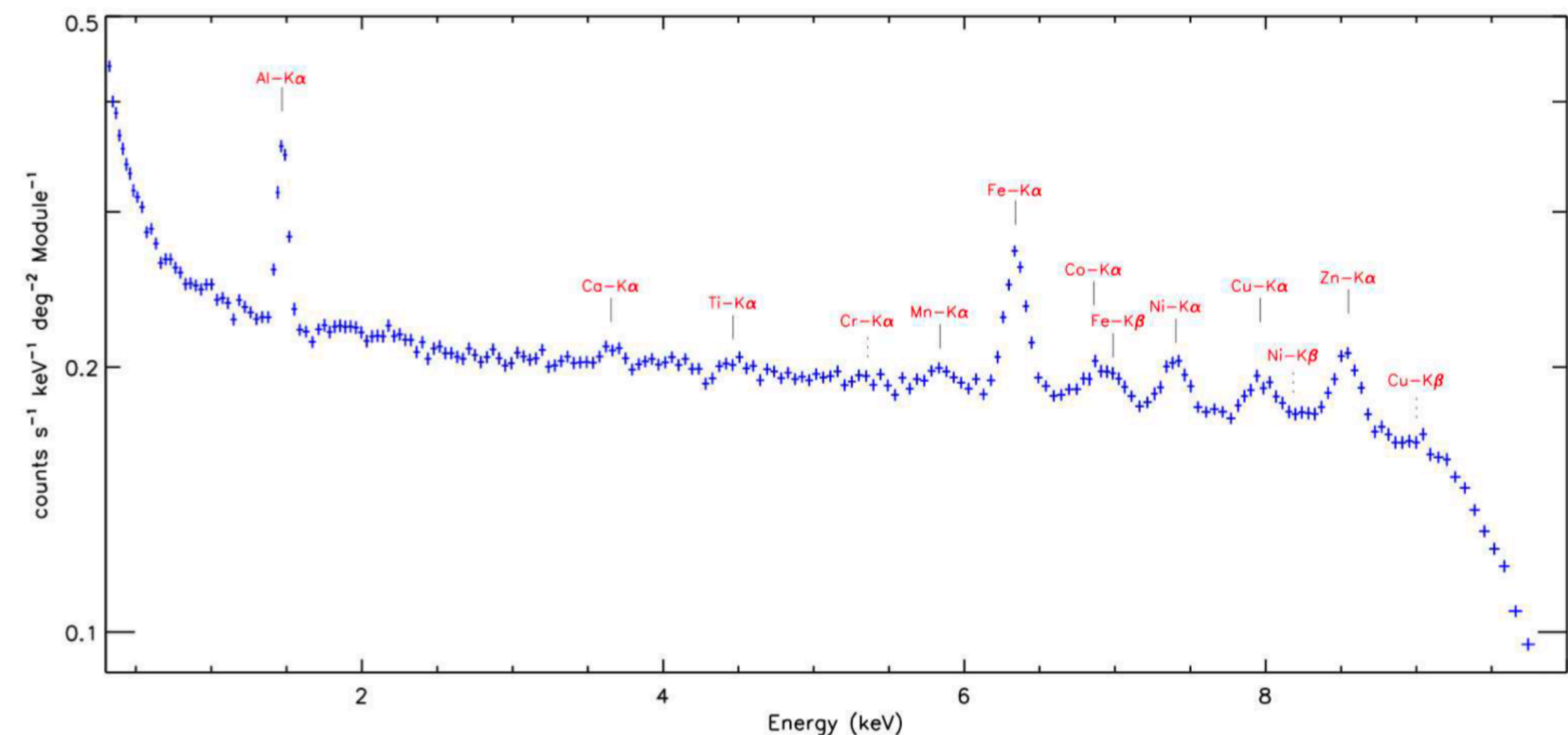
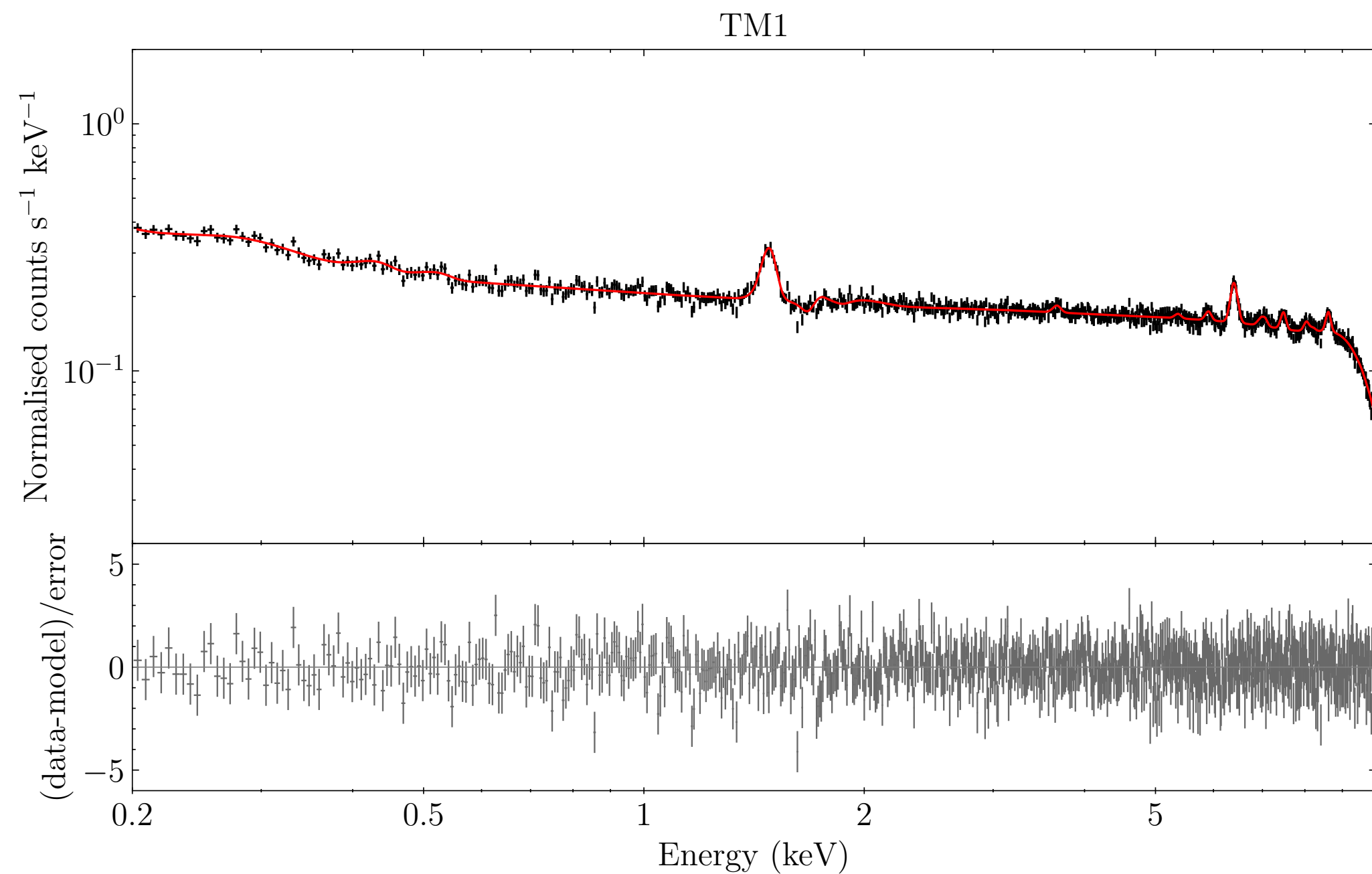
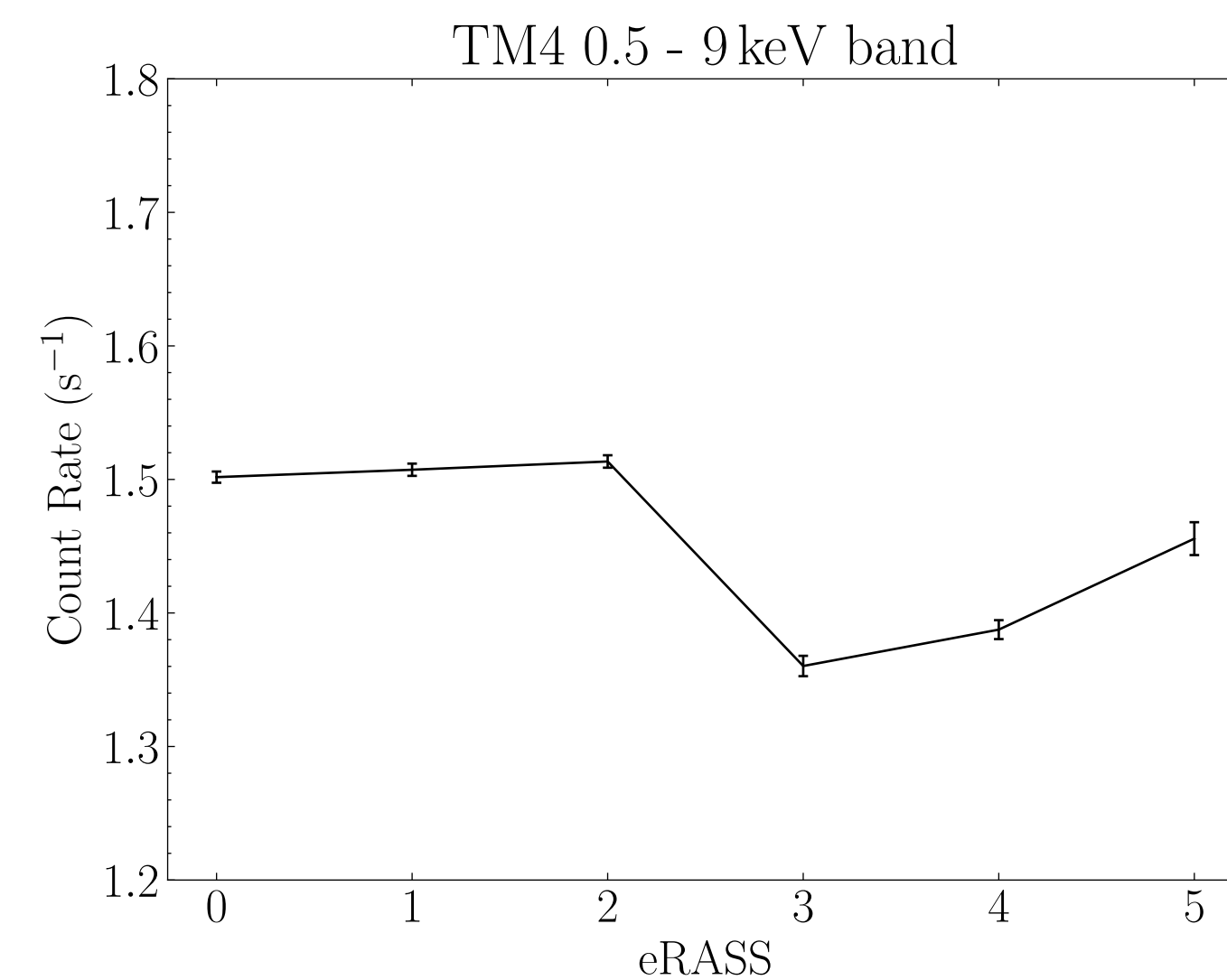
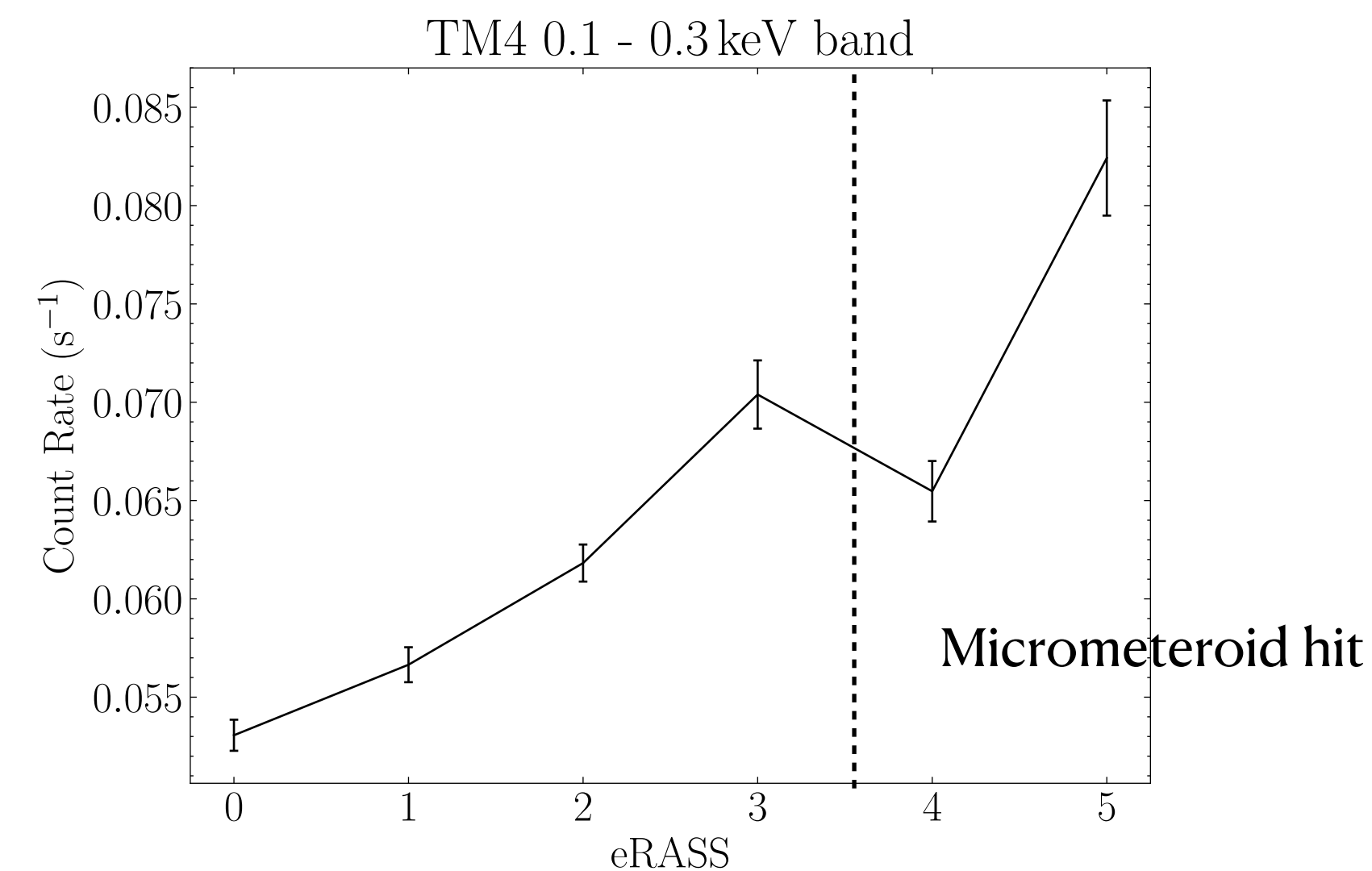
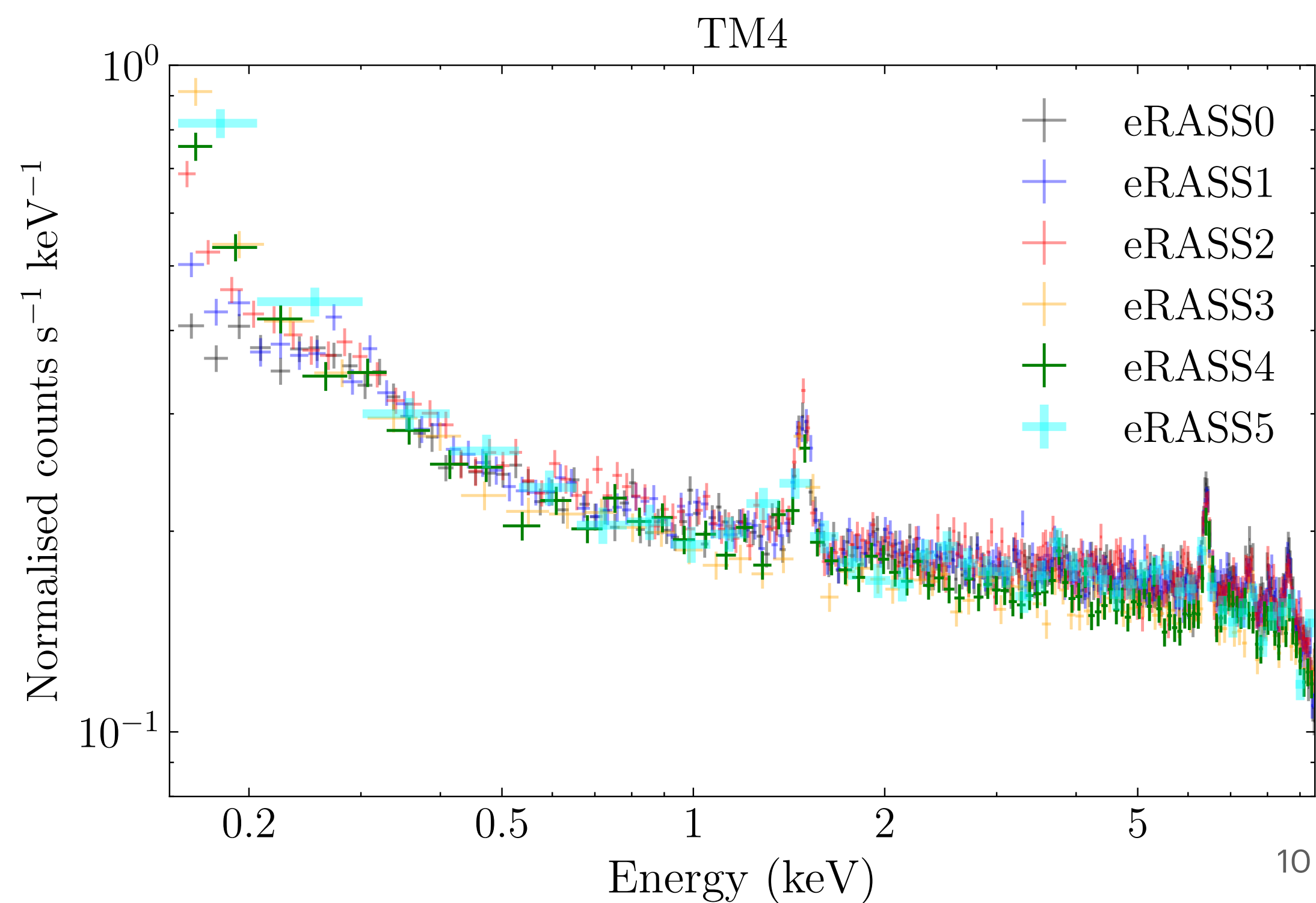


Figure 4. Average eROSITA spectrum in CLOSED filter position.

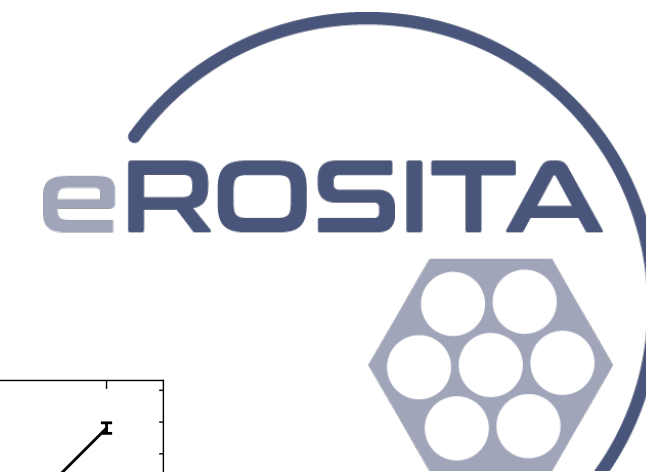
Time Variability



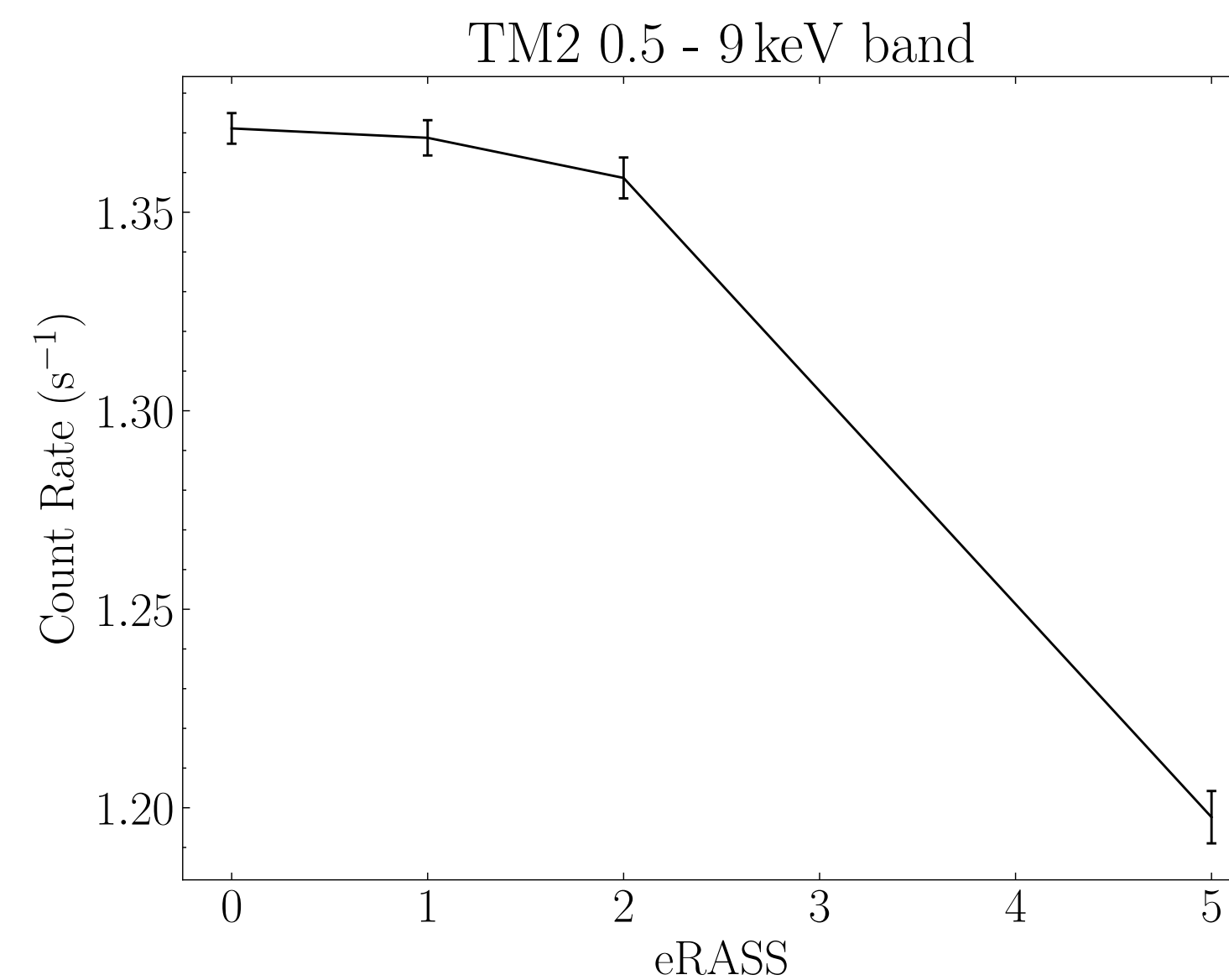
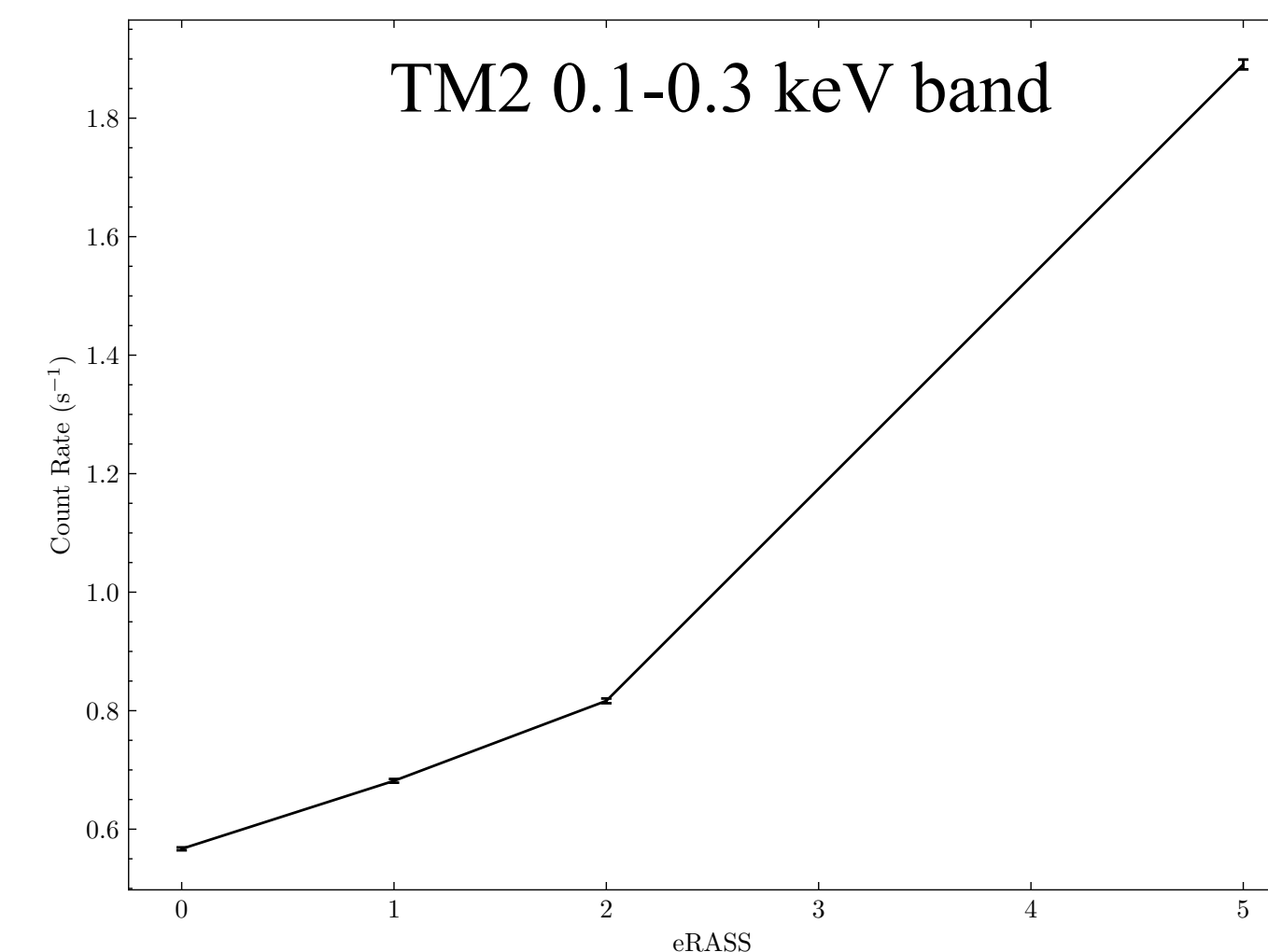
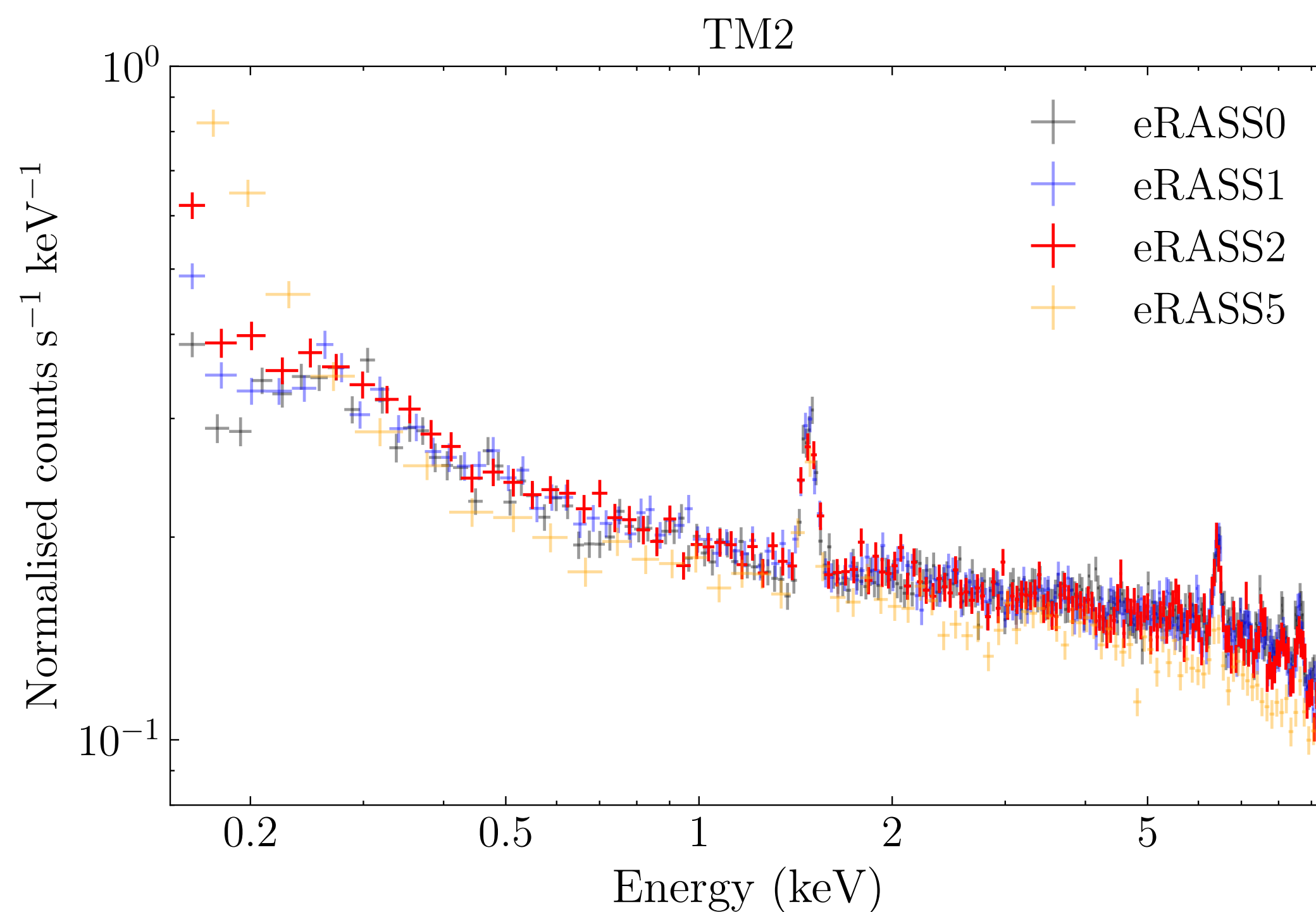
- Low-energy background increases with time below ~ 0.3 keV
 - electronic noise
- Particle background decreases due to solar activity



Time Variability

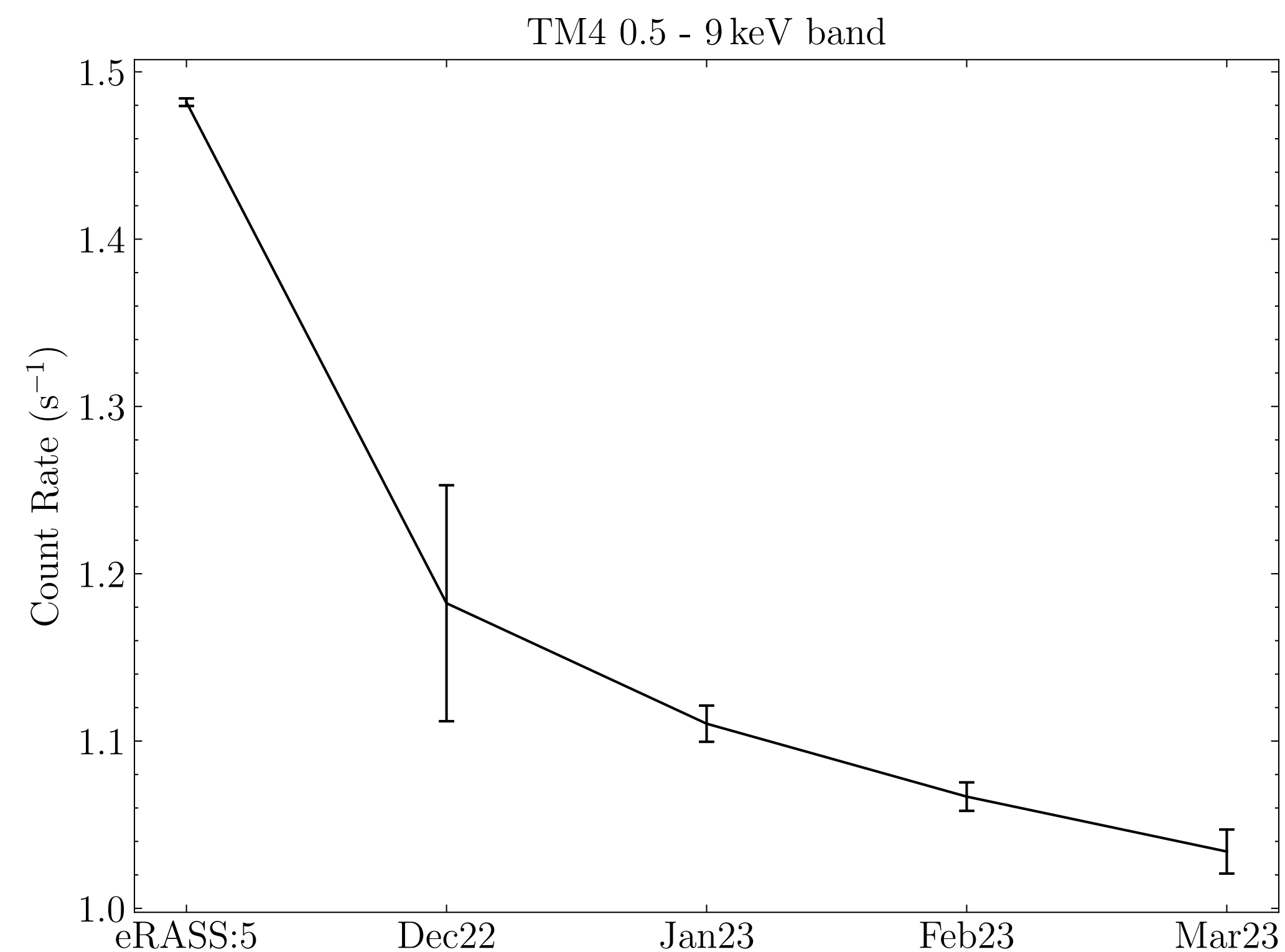
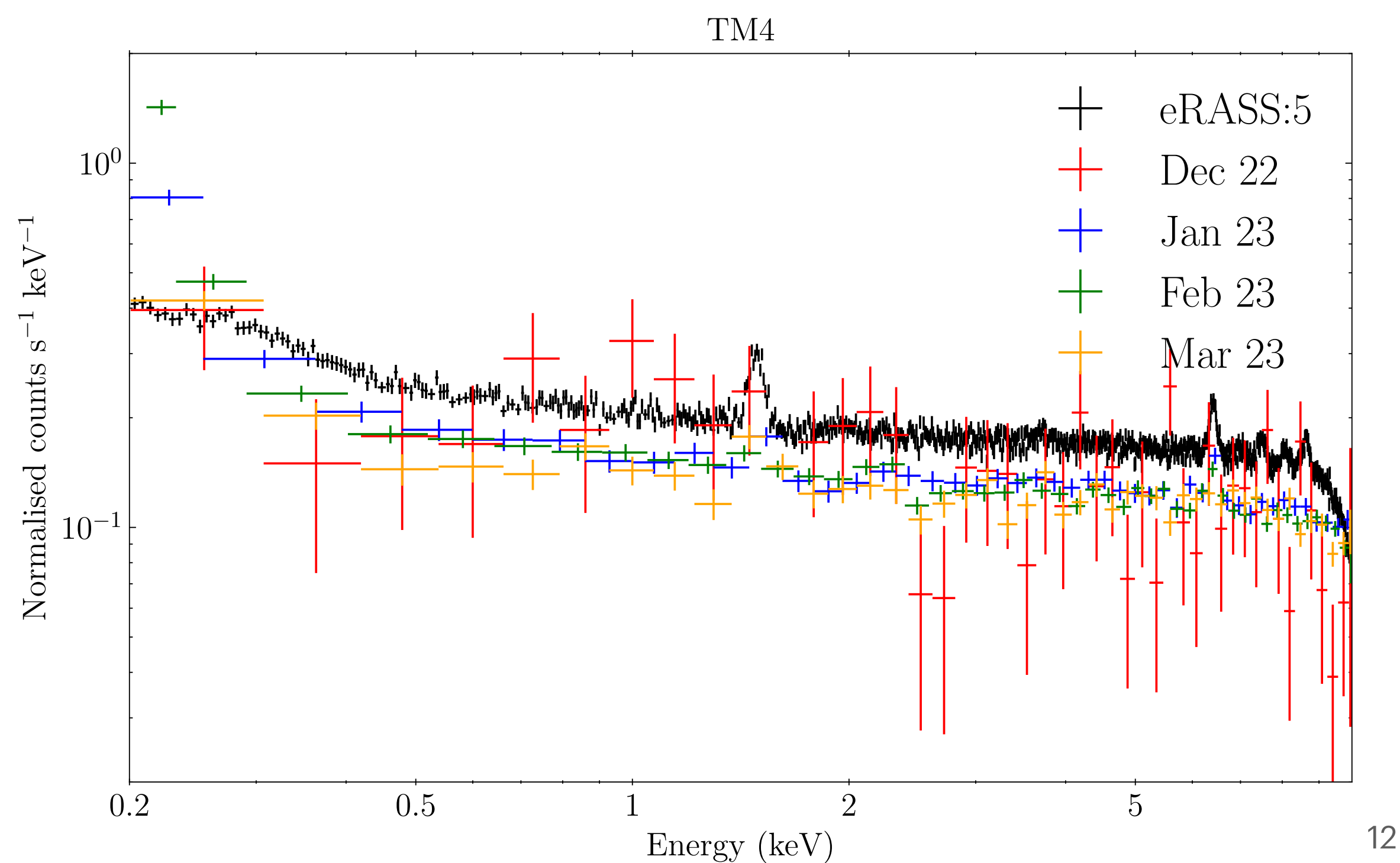


- Low-energy background (electronic noise) increases with time below ~ 0.3 keV
- Particle background decreases due to solar activity



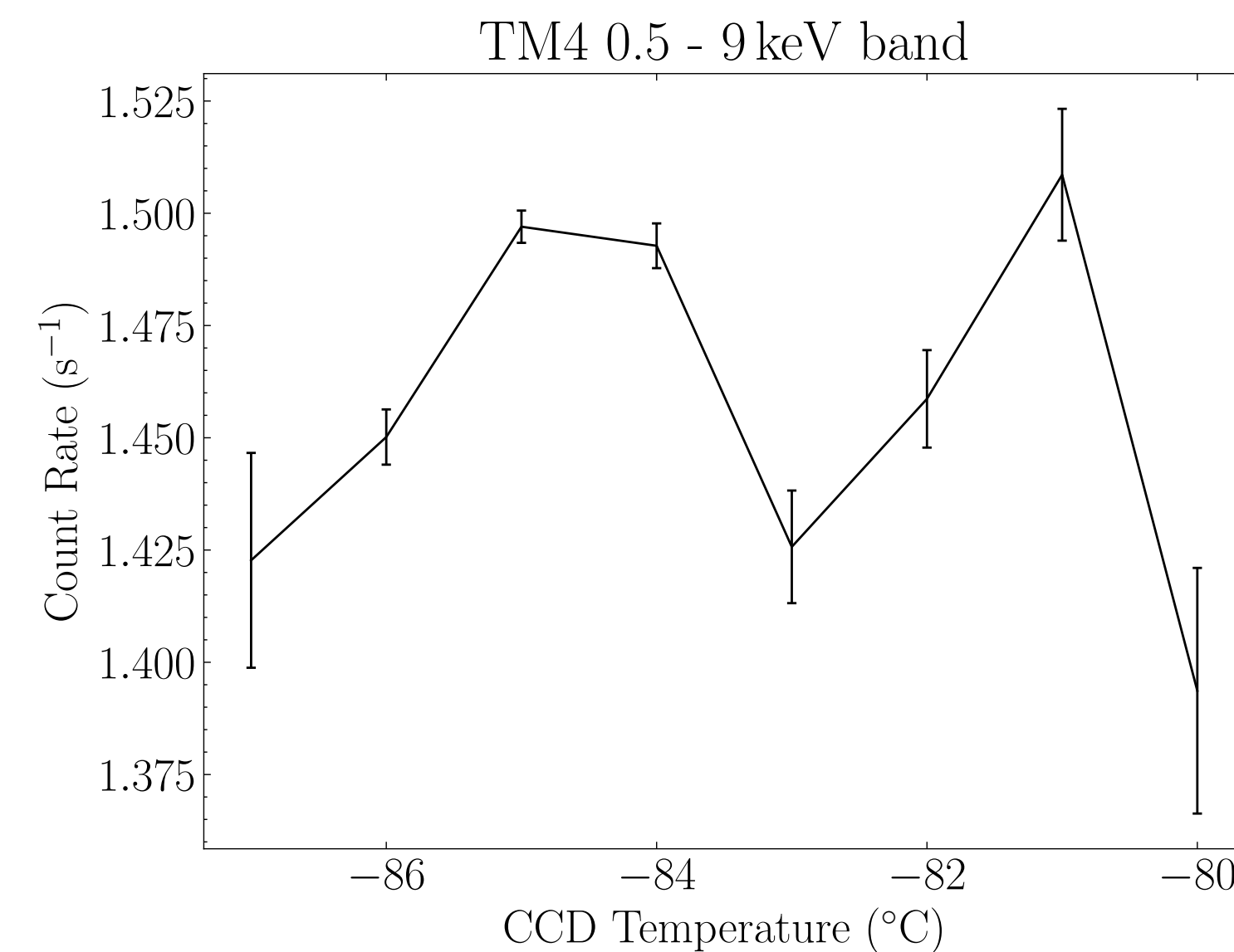
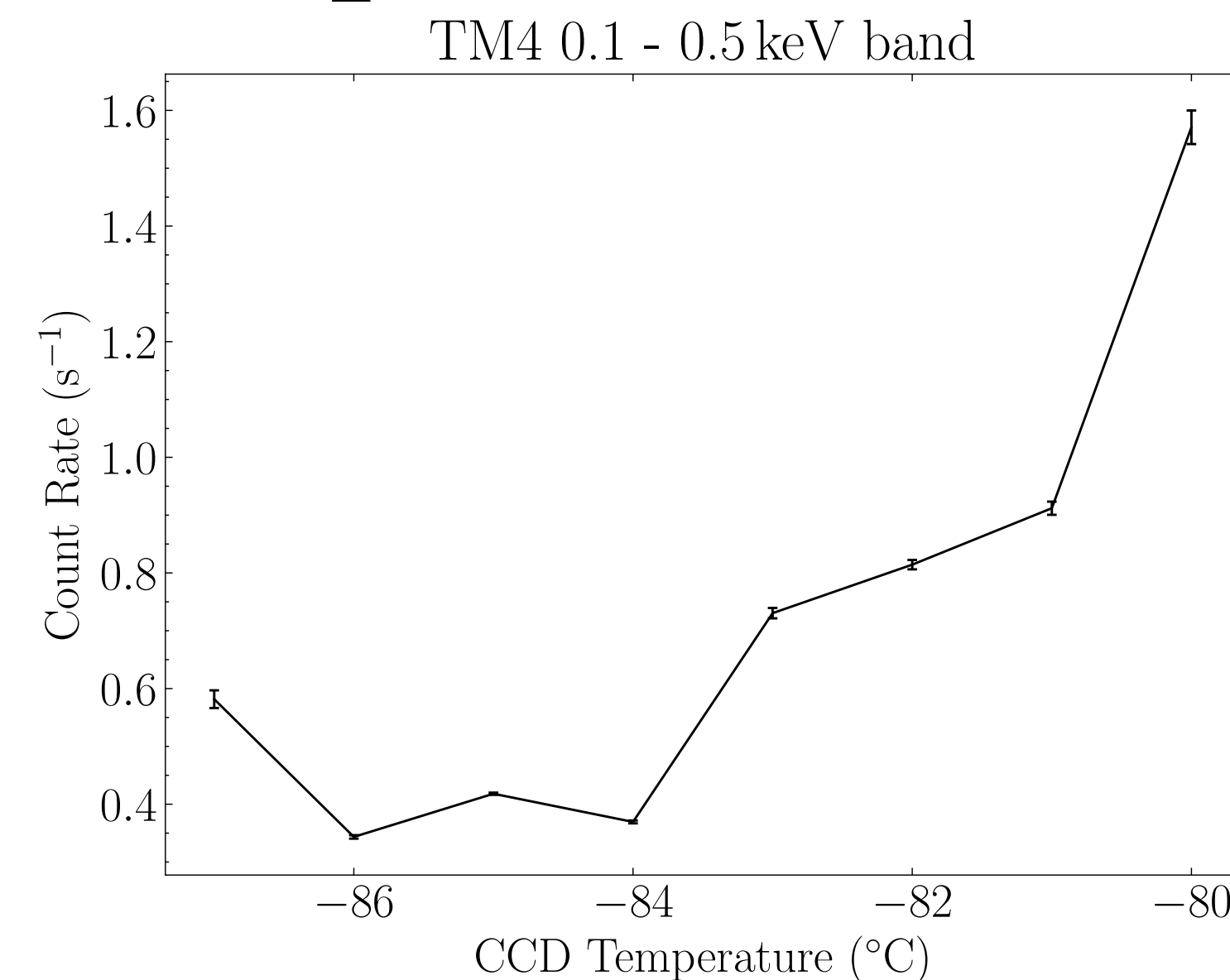
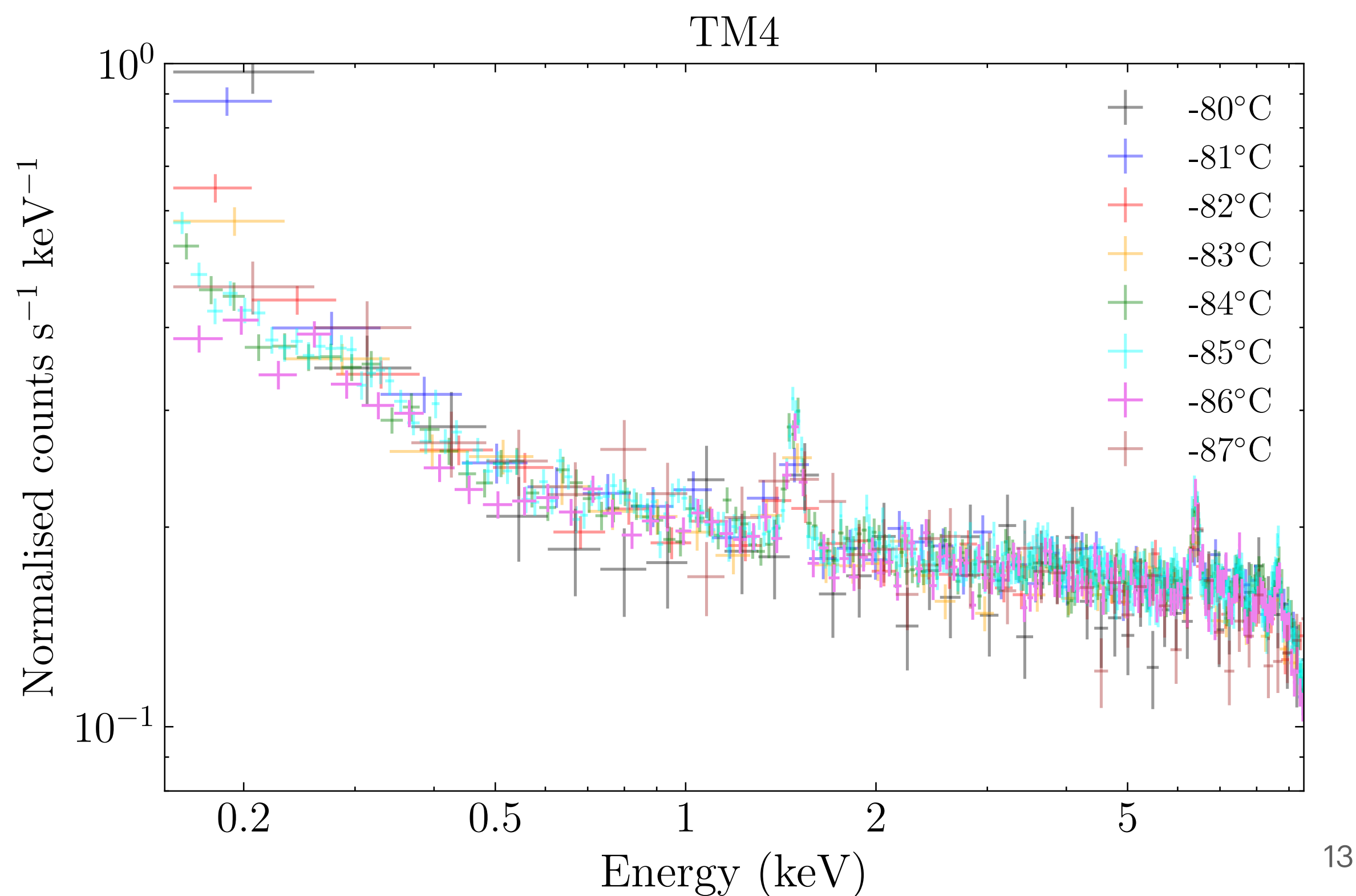
Recent Measurements

- eROSITA in stand-by mode between Dec 2022- Mar 2023
 - 5 min FWC data ~ daily
 - All TMs simultaneously
 - Filter wheel stayed in CLOSED position -> no enhancement



Variability from CCD temperature

- Hint of higher background $\lesssim 0.5$ keV
- Difficult to decouple from time dependence (vice versa)

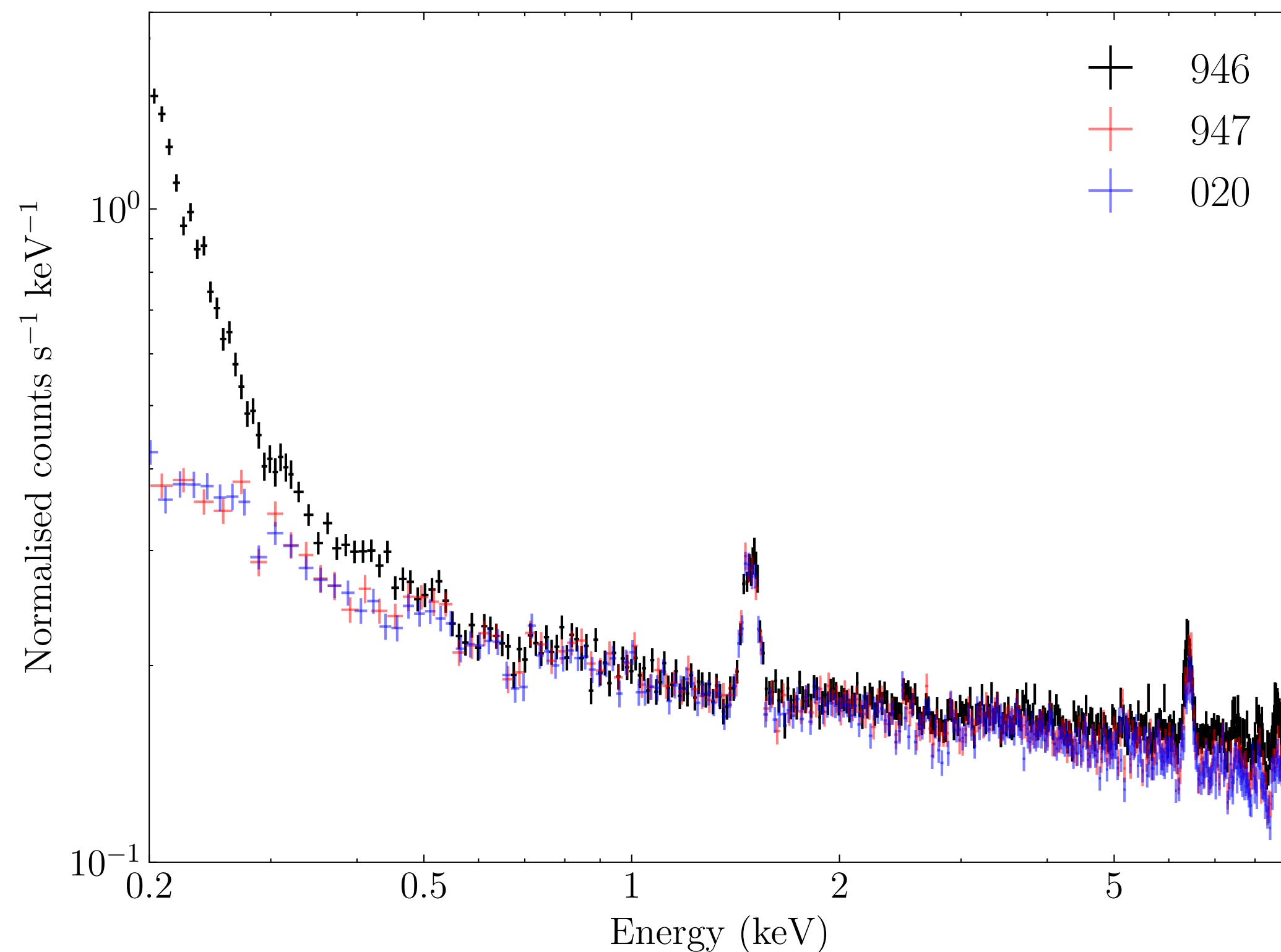


Effect of Software Changes

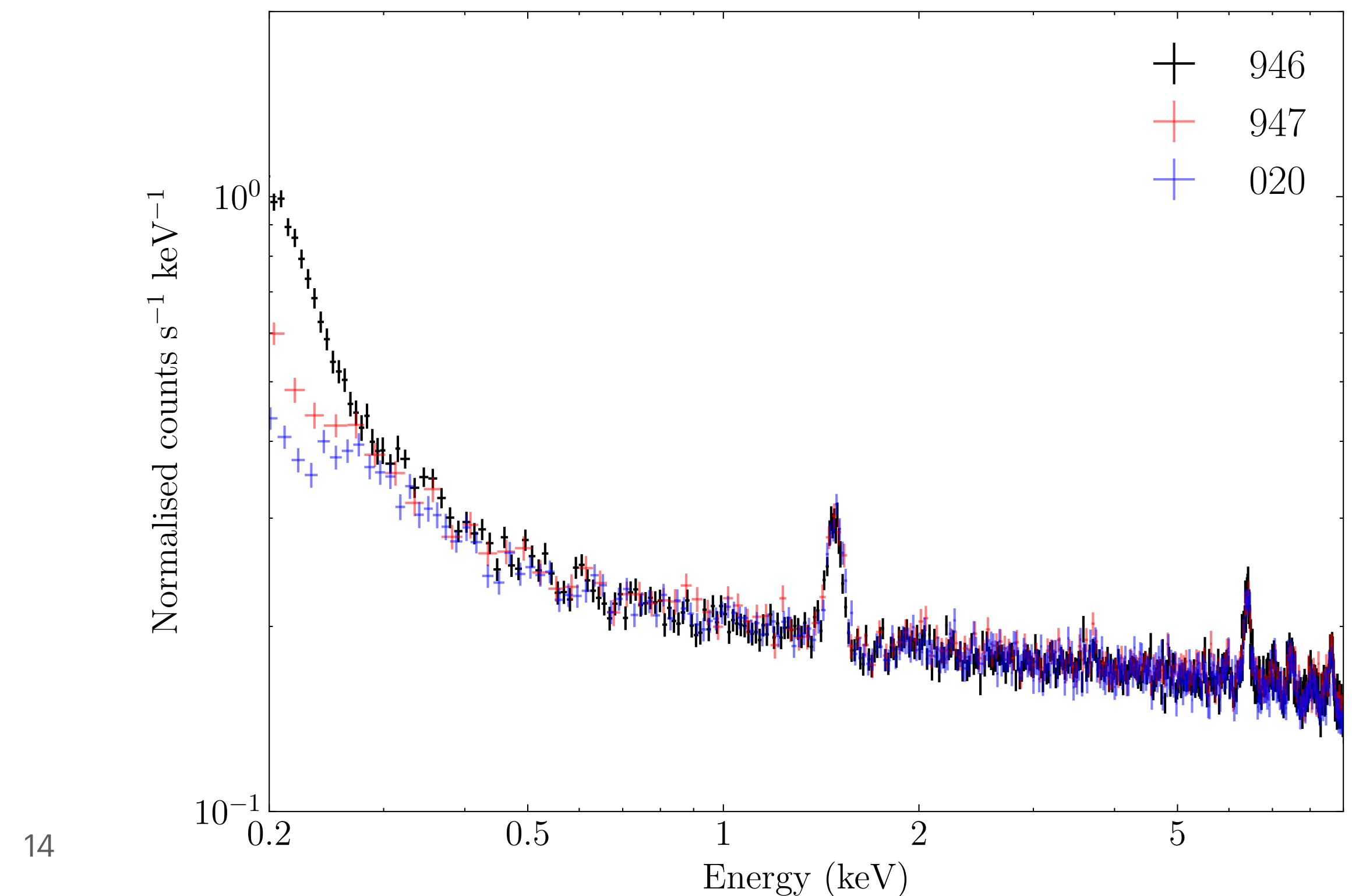


- Big jump between 946 and 947 due to software change
 - enhanced probability of asymmetric double events
- Small (but not negligible) difference between 947 and 020 for TM4 (micrometeoroid hit after eRASS1)

TM2



TM4



Summary

- ~ 70 h of FWC observations per TM
 - Most FWC observations were made in the first 1.5 yr after the launch
- **Enhancement** observed following **filter wheel rotations**
 - **Removed** in EDR and DR1 (later this year)
- Particle background correlates well with solar activity
- **Time** and **CCD temperature** dependence at $\lesssim 0.3$ keV
- **Software updates** suppressed the electronic noise at low energies
- FWC data seem to **agree well** with the **simulation** after cleaning