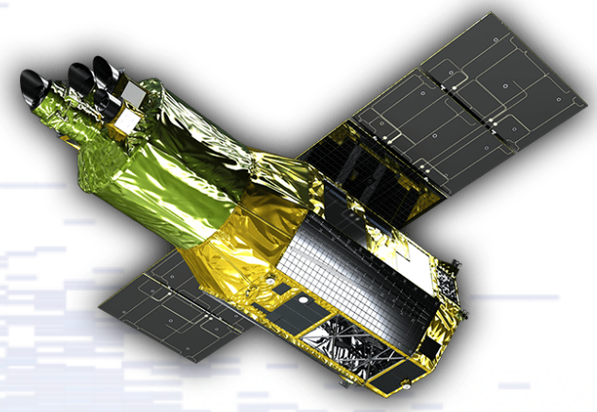
XRISM

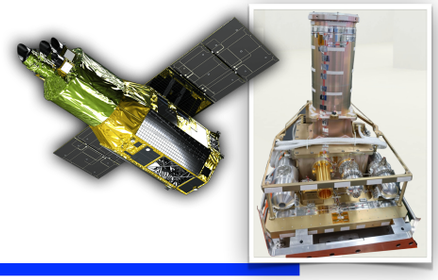
X-Ray Imaging and Spectroscopy Mission



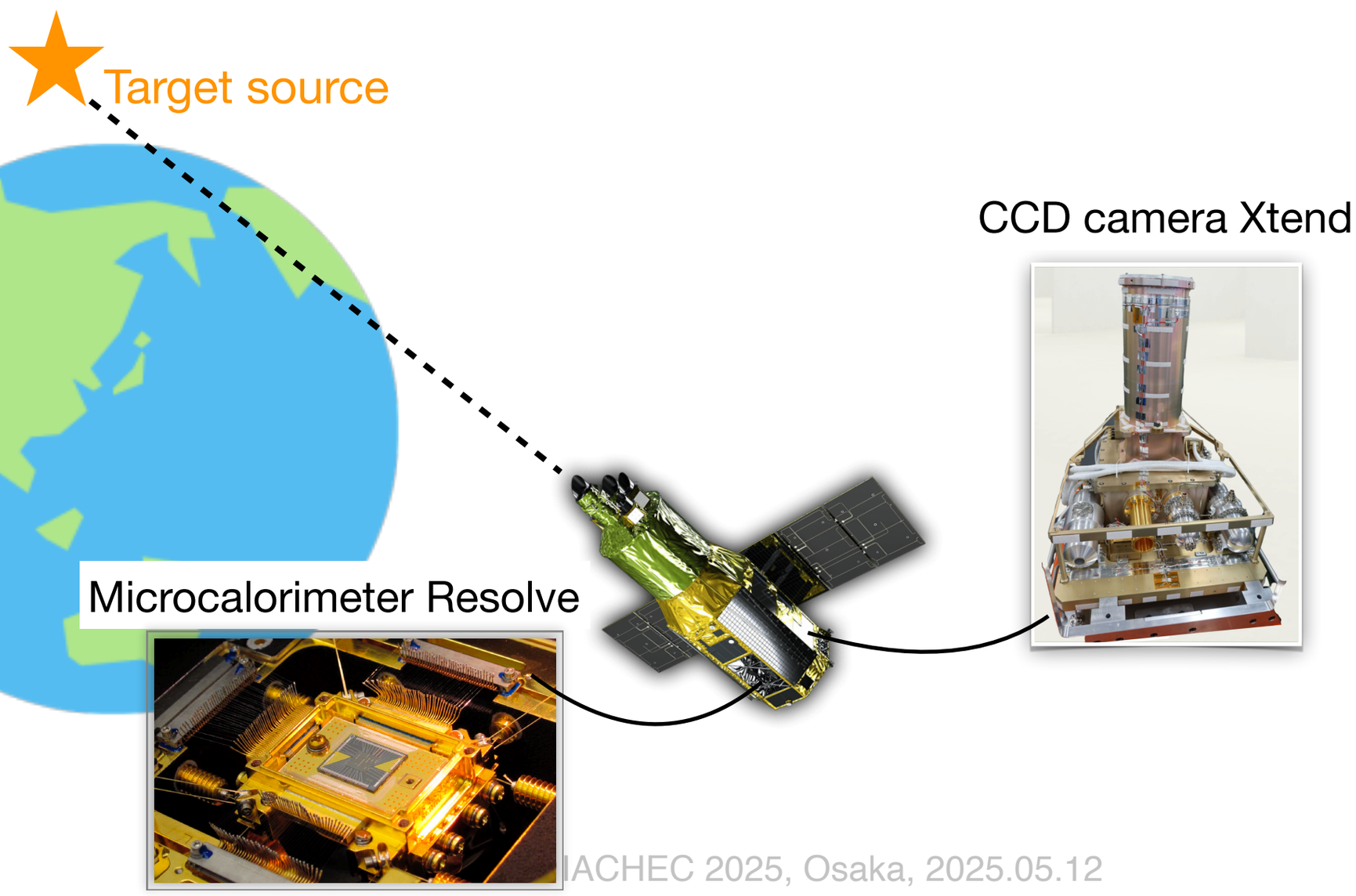
Particle-induced background of XRISM Resolve and Xtend

Hiromasa Suzuki (University of Miyazaki),
Caroline Kilbourne (NASA/GSFC),
on behalf of the XRISM Cal-IP BGD team

Particle-induced background of XRISM



- XRISM is in low-Earth orbit. The "night-Earth occultation" data (~1.5 yr) represent pure particle-induced background (NXB)
- Particle-induced background is normally low and stable
- Current high solar activity sometimes affects background spectra significantly



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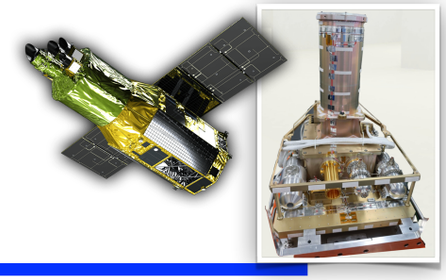
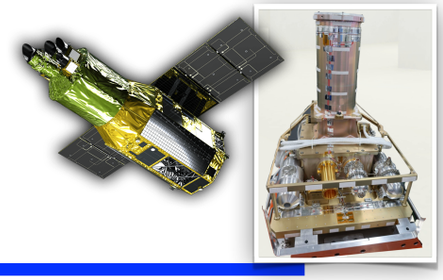
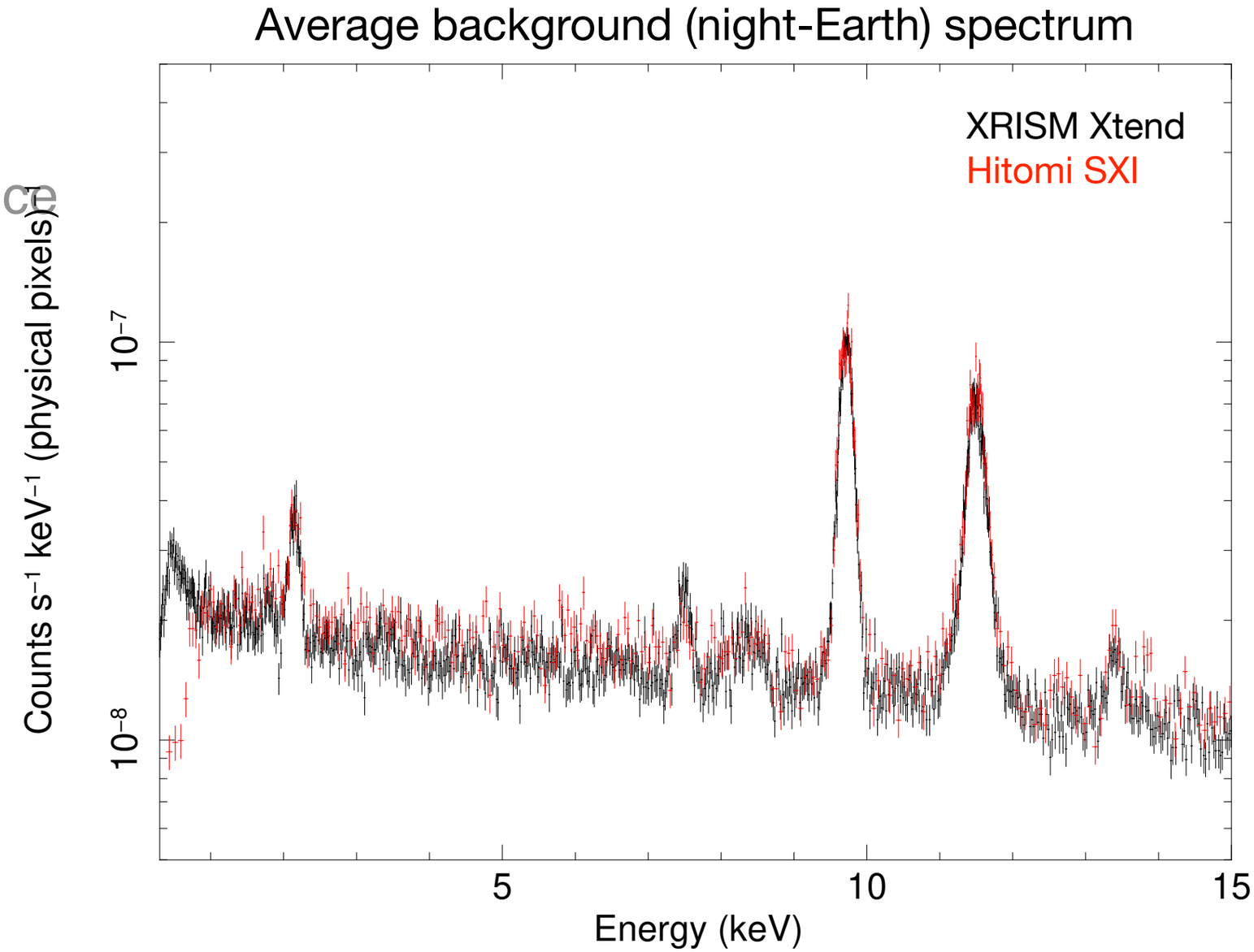
Report on Xtend



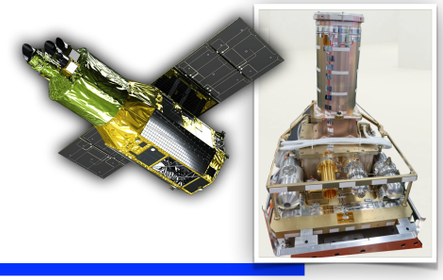
Particle-induced background of Xtend



- Average spectrum
  - Very similar to Hitomi SXI
  - Confirmed very low level
- Cut-off rigidity dependence
- Other parameter dependence
- Effect of high solar activity



Particle-induced background of Xtend



- Average spectrum
  - Very similar to Hitomi SXI
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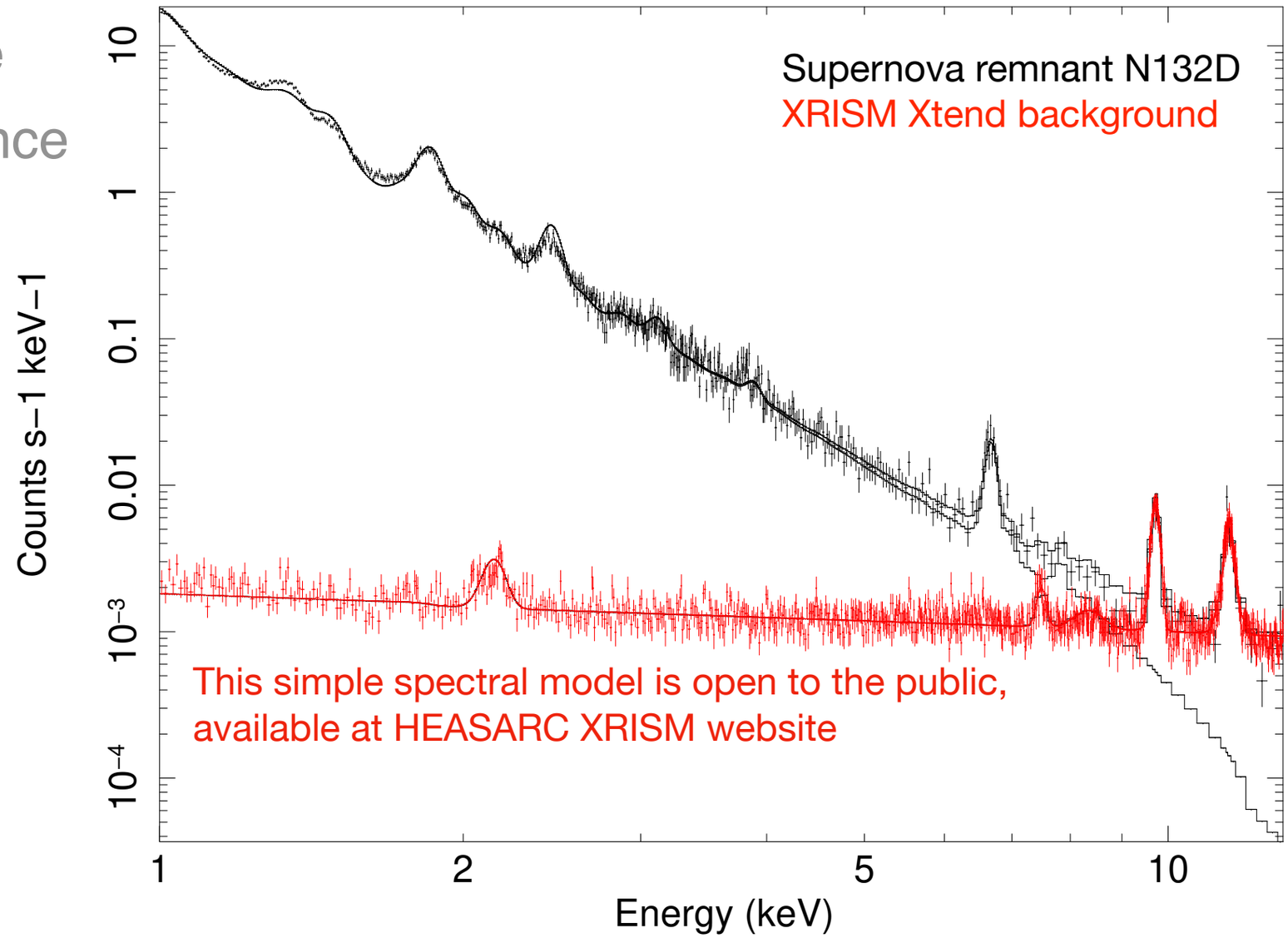
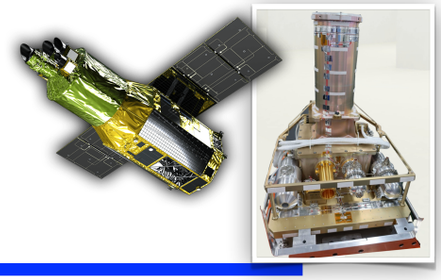
- Cut-off rigidity dependence
- Other parameter dependence
- Effect of high solar activity

Average background (night-Earth) spectrum

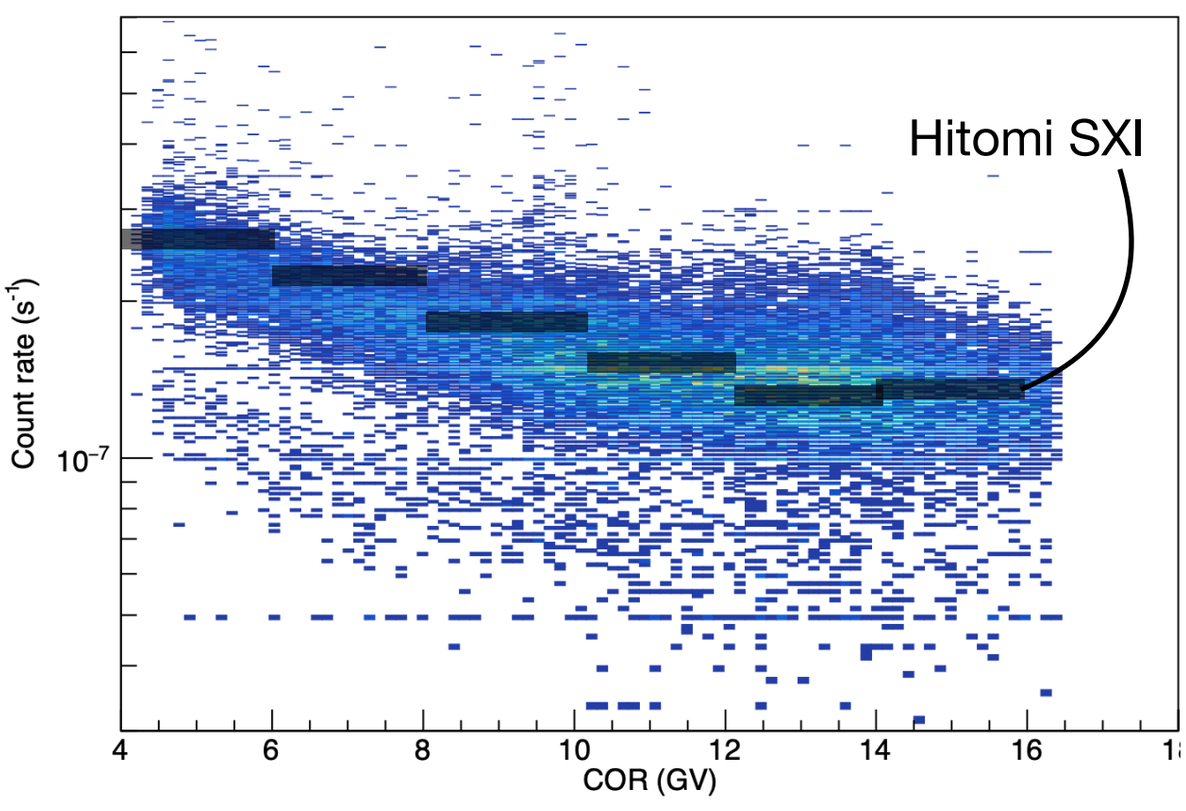


Particle-induced background of Xtend

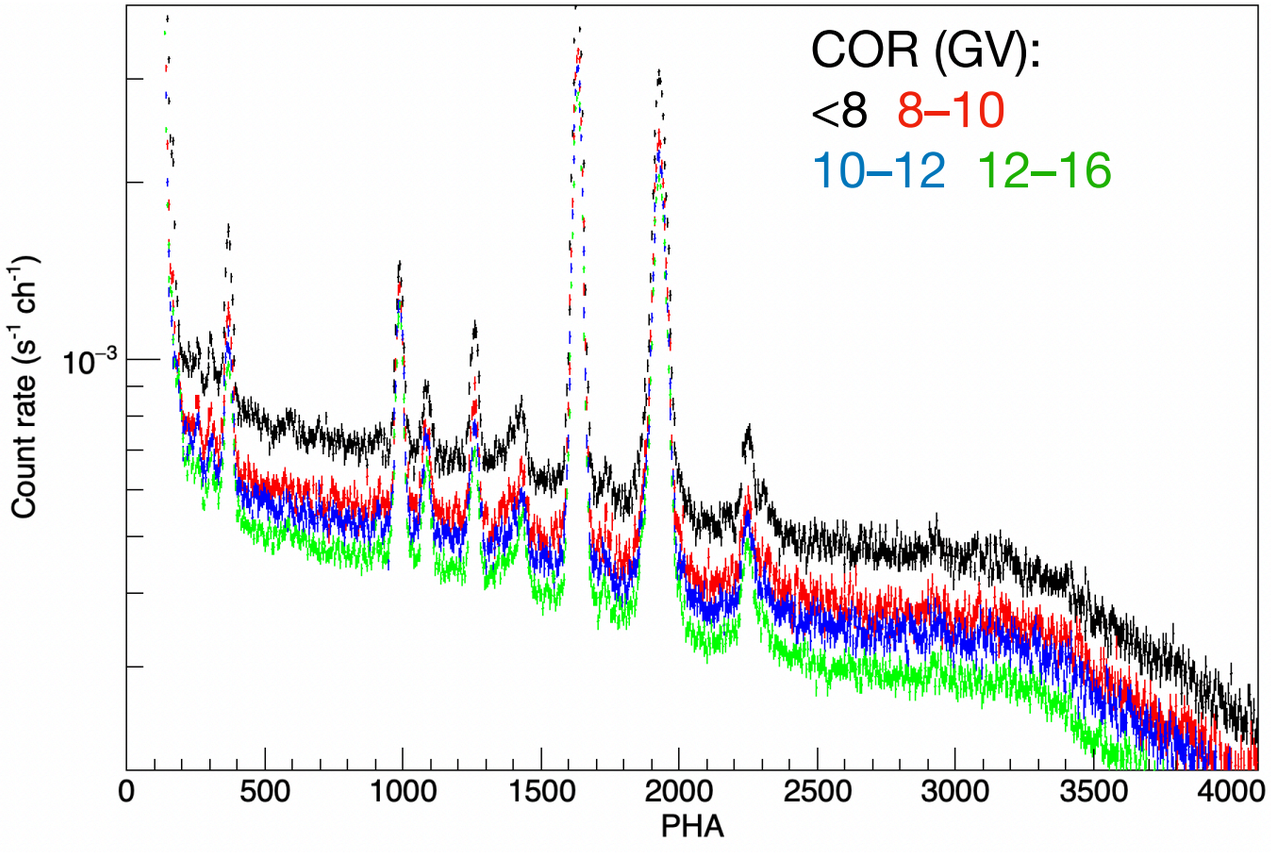


- Average spectrum
- Cut-off rigidity dependence
  - Factor of ~3 change in flux
  - No significant changes in spectral shape

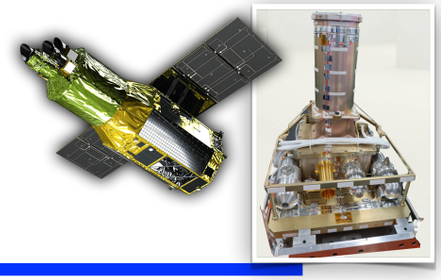
COR dependence of Xtend background rate



… and spectra

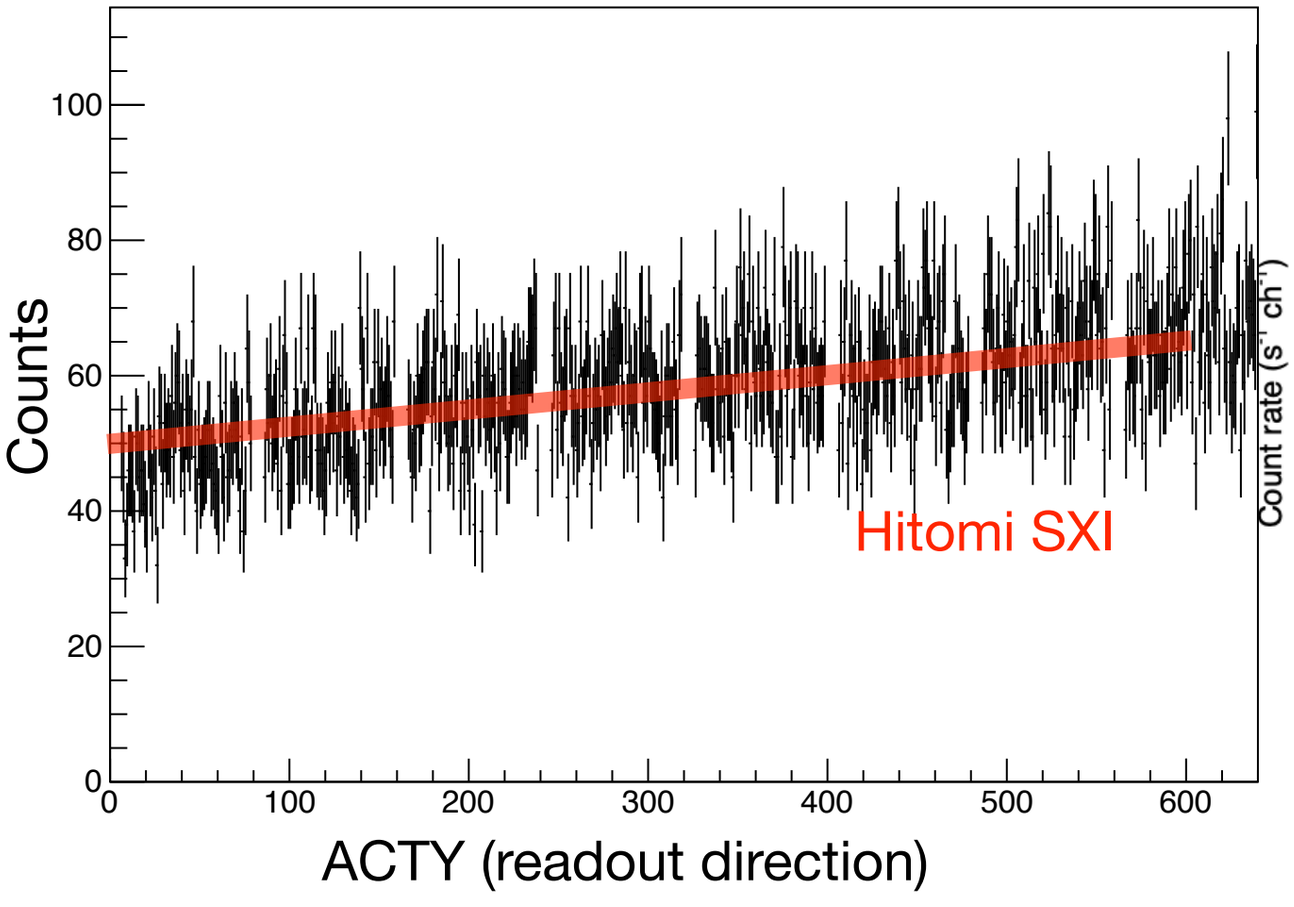


Particle-induced background of Xtend

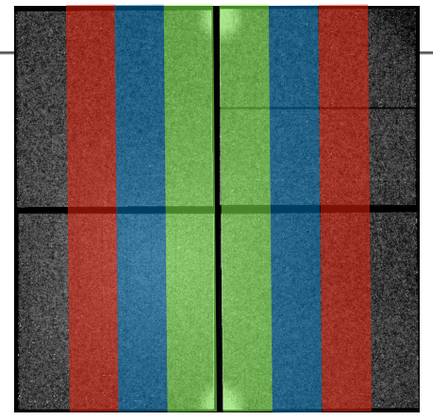


- Average spectrum
- Cut-off rigidity dependence
- Other parameter dependences
  - ~30% along readout, no significant changes in spectral shape

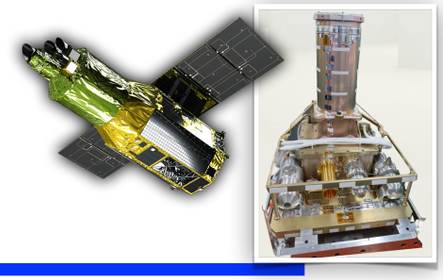
Spatial dependence of Xtend background rate



… and spectra

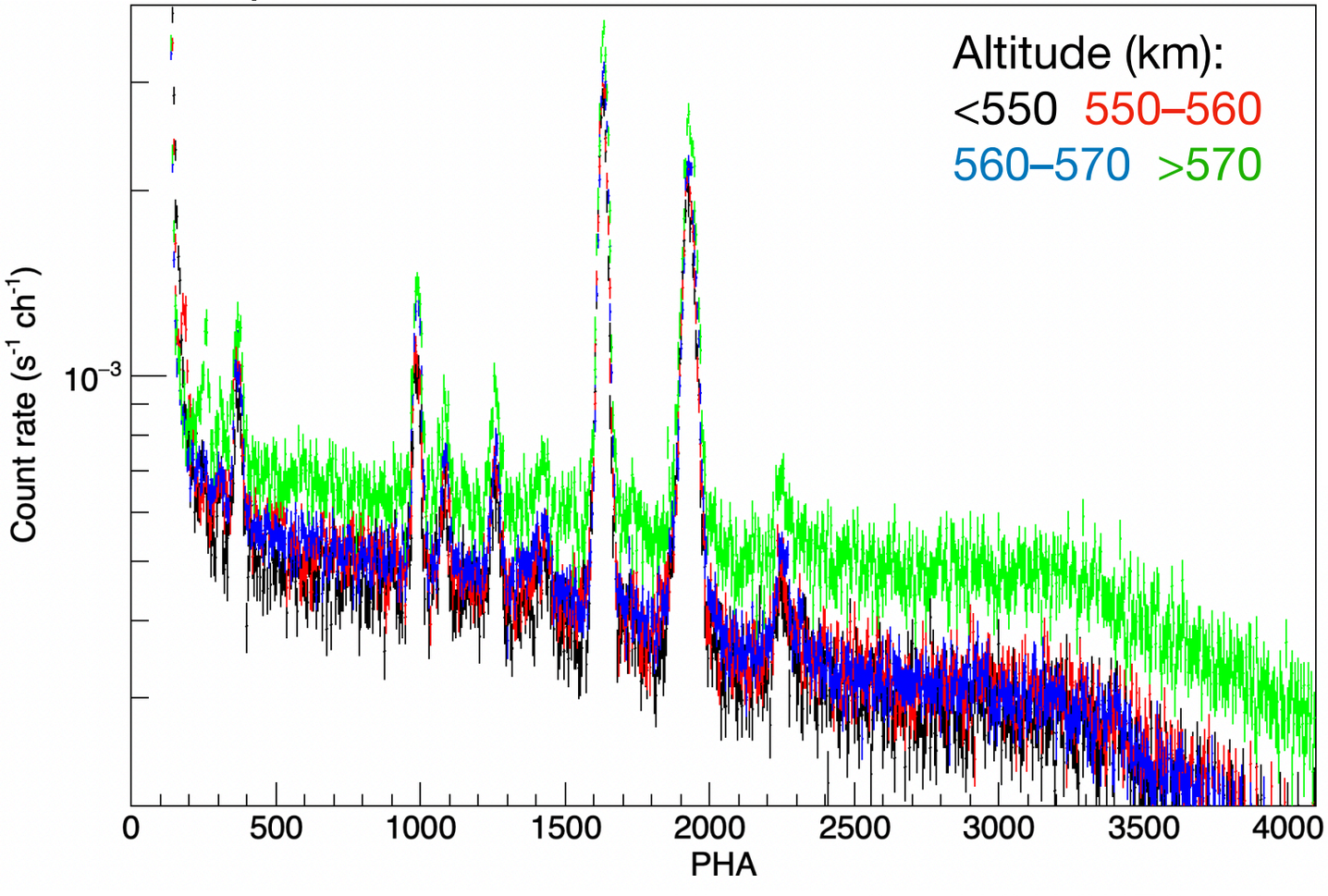


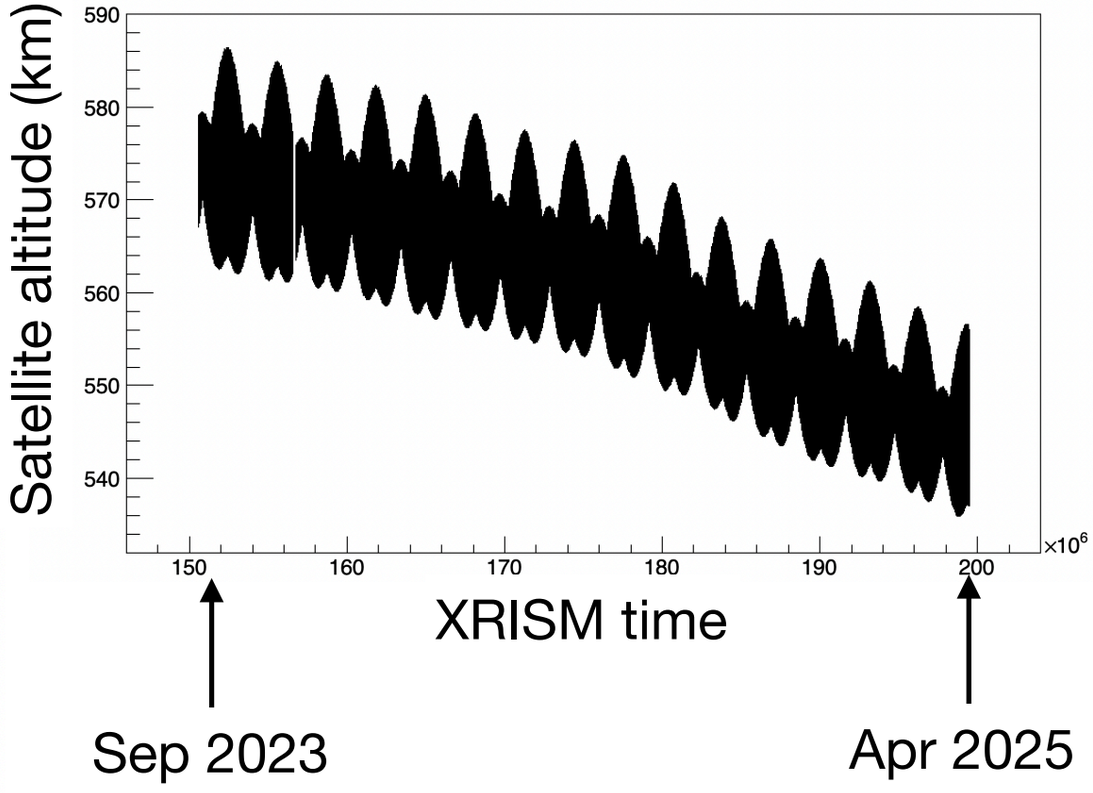
Particle-induced background of Xtend



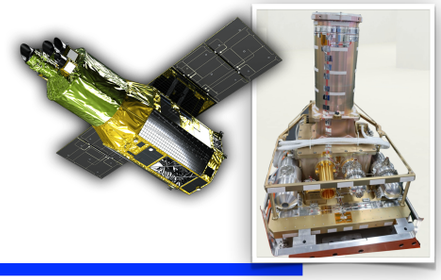
- Average spectrum
- Cut-off rigidity dependence
- Other parameter dependences
  - Weak dependence on satellite altitude, only significant when >570 km

Spectra from different satellite altitudes

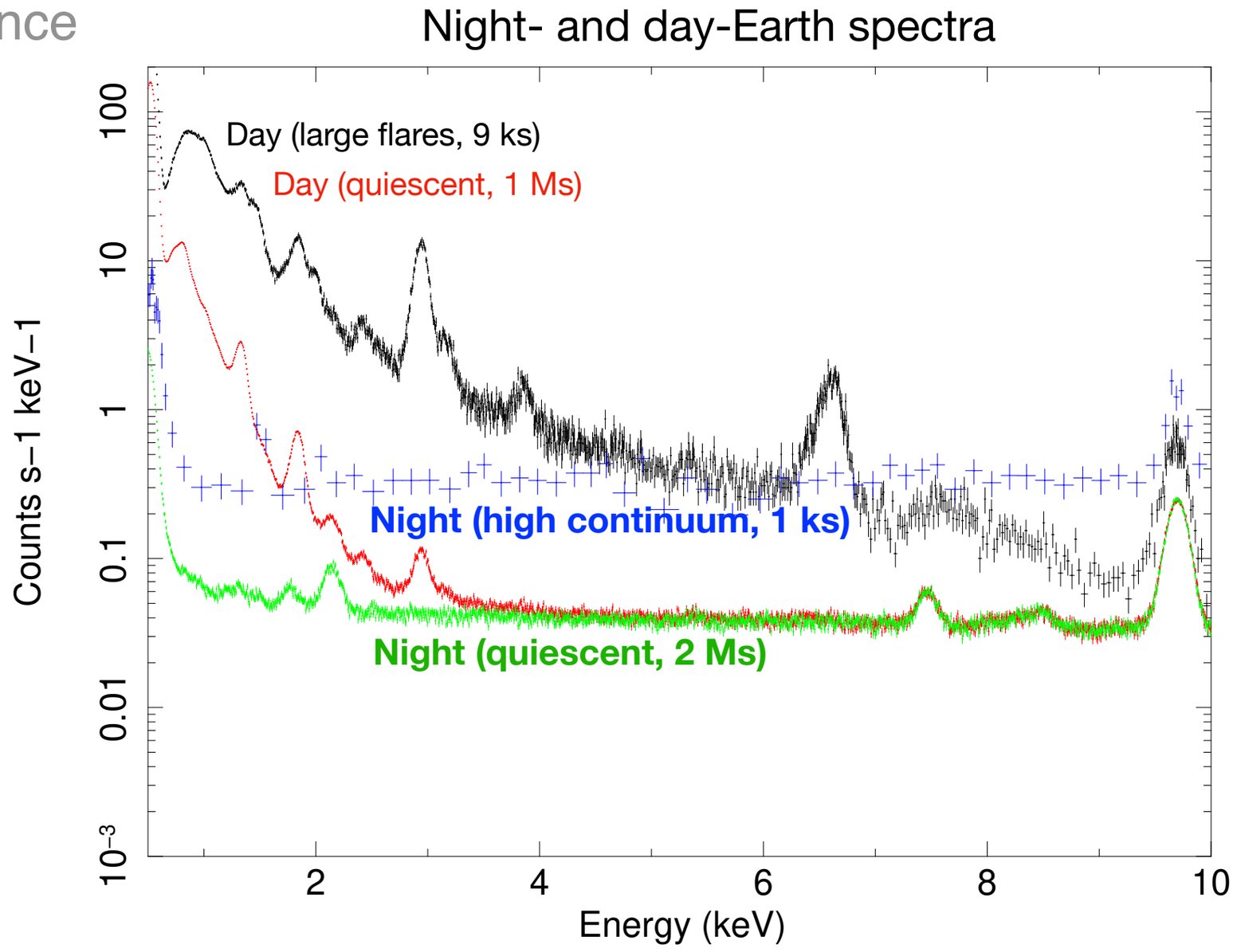




Particle-induced background of Xtend



- Average spectrum
- Cut-off rigidity dependence
- Other parameter dependence
- Effect of high solar activity
  - Night-Earth data are sometimes affected by solar flares/CMEs (day-Earth data are always affected)



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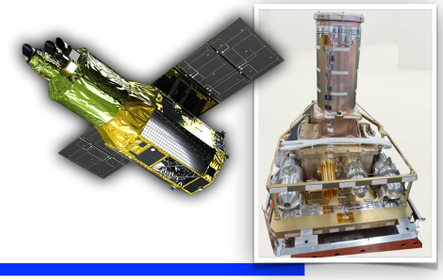
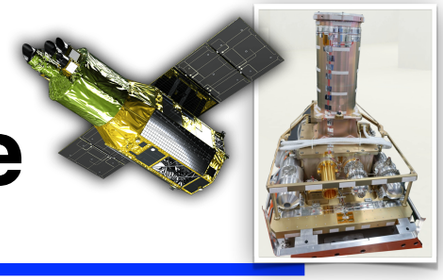
Report on Resolve



Particle-induced background of Resolve



Resolve NXB provisional database v2 : to allow users to evaluate NXB in their data

- hand assembled from NXB event files in trend archive, as done for v1
- dates: December 25, 2023 through February 27, 2025
- Excluded entire OBSIDS:
  - that occurred prior to standard gain tracking
  - experienced hardware anomalies
  - were taken in forced-midres mode
  - were taken with the MXS on
  - experienced gain jumps
  - were missing essential gain fiducials
- Merged clean, NTE, non-SAA event data and applied recommended screening for RISE_TIME and pixel-to-pixel coincidence
- Checked for obvious-by-eye contamination from solar activity but identified no further cuts to be needed.
- **EXPOSURE = 2.67 Ms (compared with 0.78 Ms of v1)**

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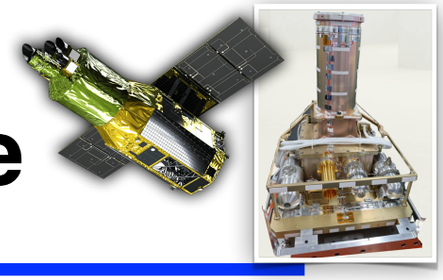
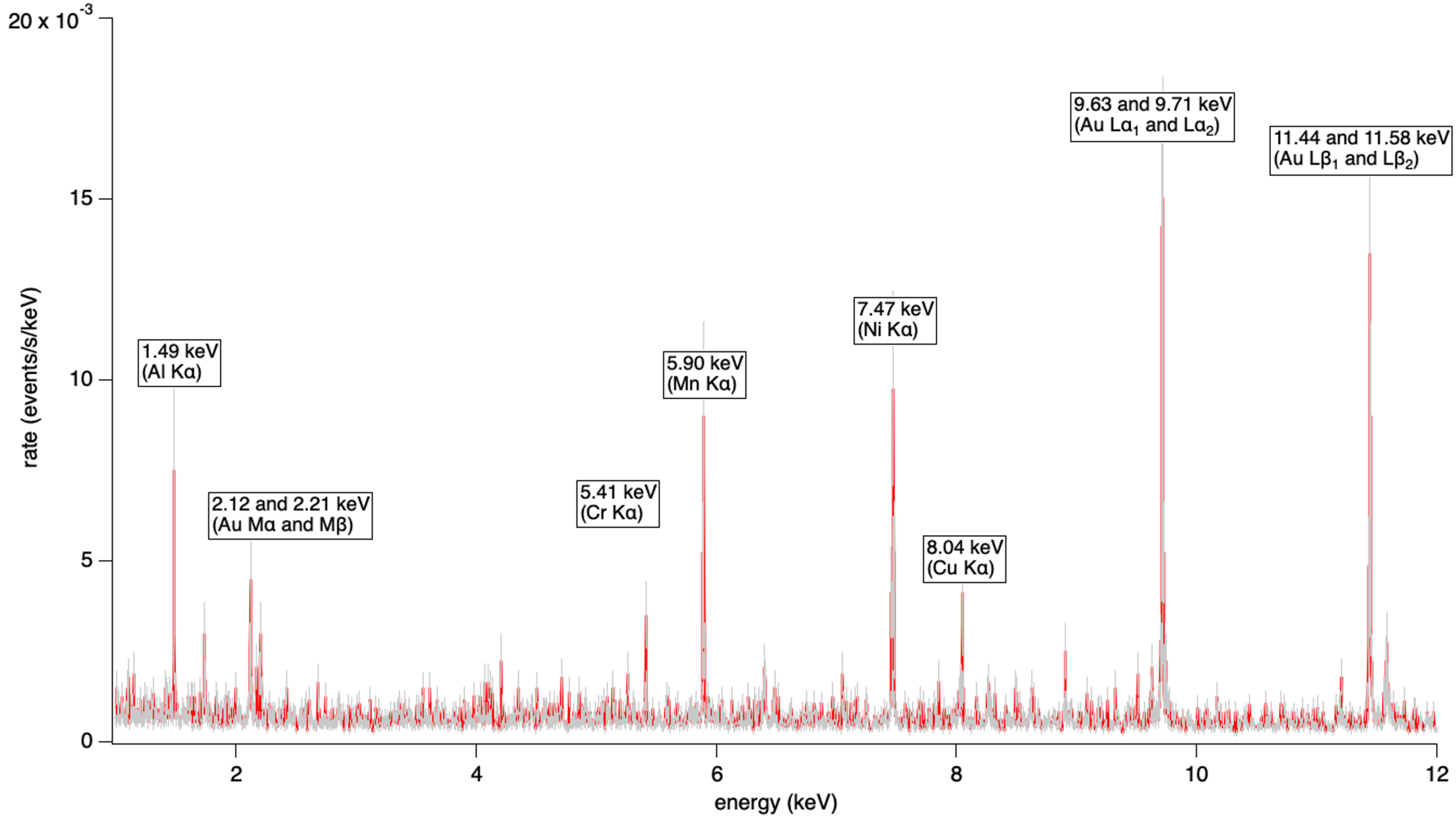
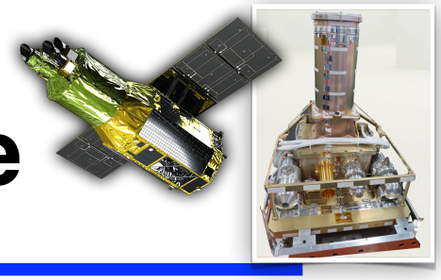
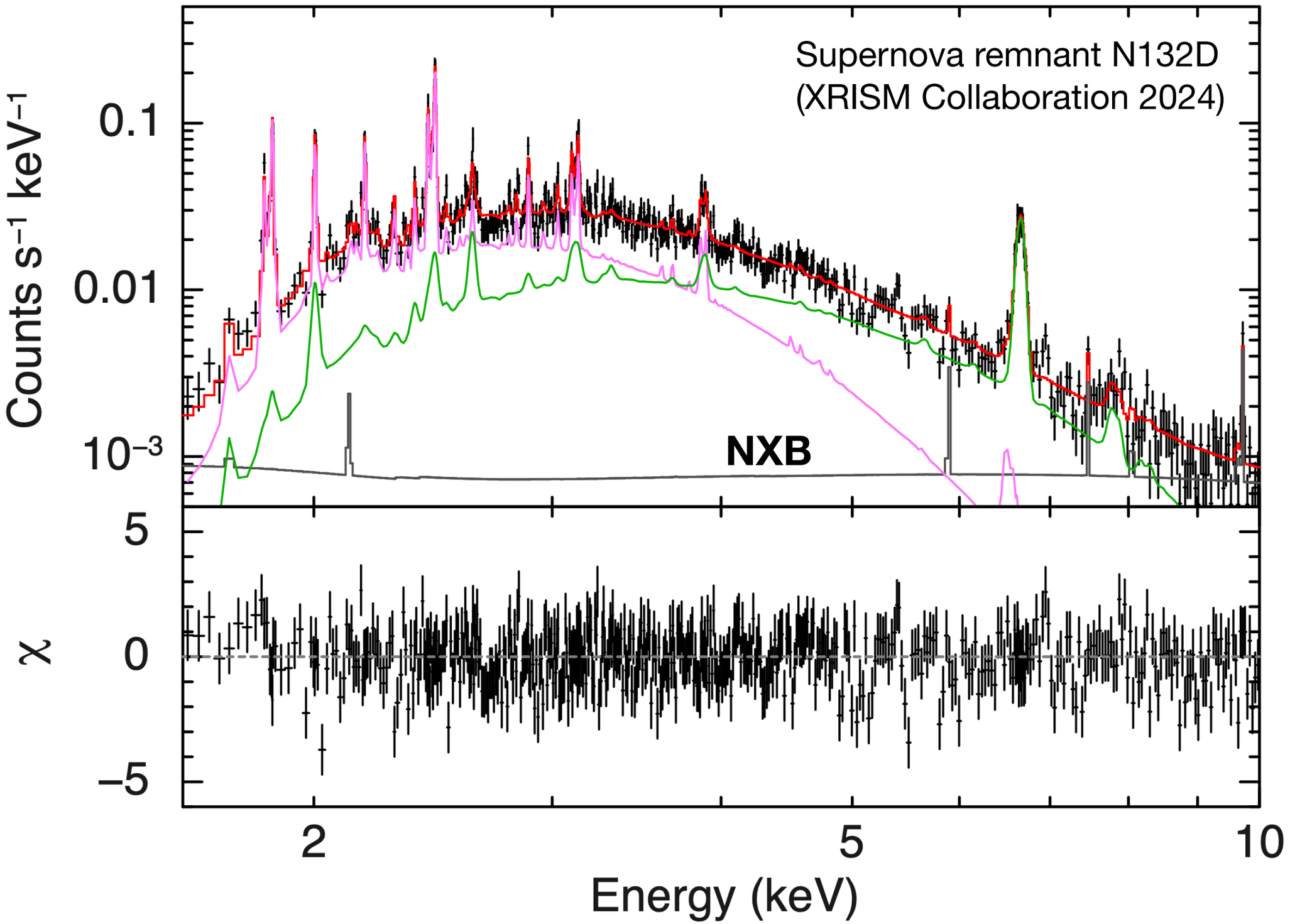
Particle-induced background of Resolve



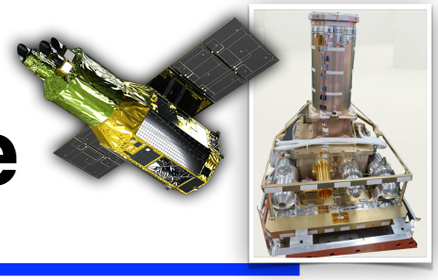


Particle-induced background of Resolve





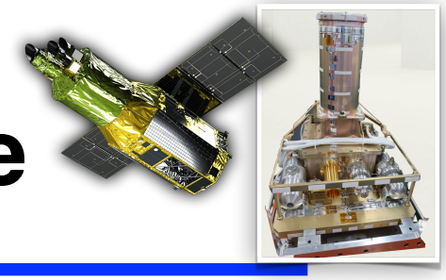
Particle-induced background of Resolve



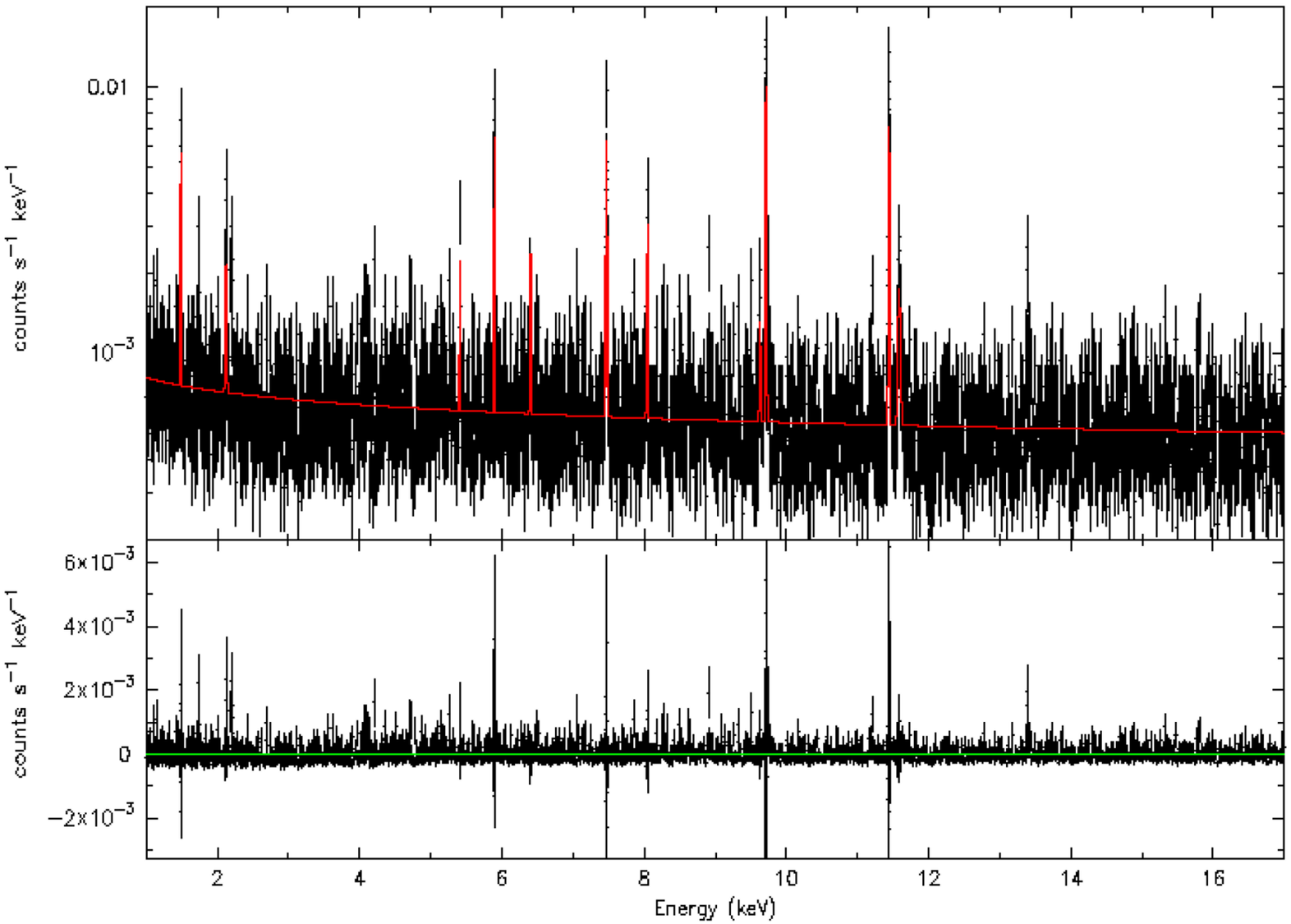
Model developed for v1 of the database

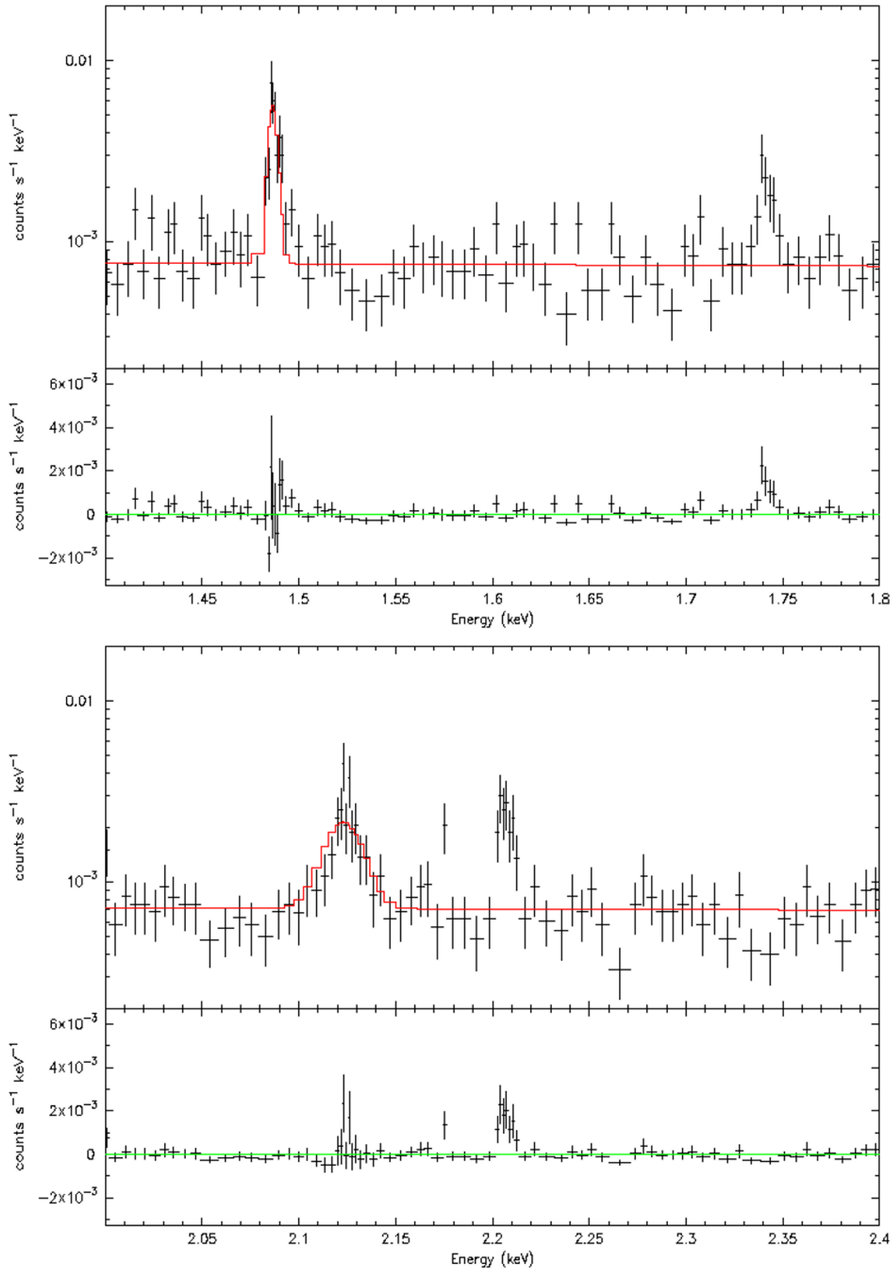
- **Empirical model intended simply to describe the background we measure, and not some fundamental spectrum that is altered by the instrument response.**
  - A diagonal response matrix must be used.
  - Because of this, the instrumental broadening of the lines is included in the model.
- power law + 17 Gaussians: Al-Kα_1/Kα_2, Au-Mα_1, Cr-Kα_1/Kα_2, Mn-Kα_1/Kα_2, Fe-Kα_1/Kα_2, Ni-Kα_1/Kα_2, Cu-Kα_1/Kα_2, Au-Lα_1/Lα_2, Au-Lβ_1/Lβ_2
  - Approximated as Gaussians because the statistics of the background did not justify specifying the known detailed descriptions of each line complex
  - For Al, Cr, Mn, Fe, Ni, and Cu lines, we fixed the sigma parameter of the Gaussians at values consistent with fits of Gaussians to the same lines in high-statistics, ground-calibration data.
  - The shapes of the Au lines were not available in the literature; they are entirely described by the fits to the background data file.
  - Central energies of the lines were fixed to the values in *X-RAY DATA BOOKLET*
  - Sigmas of Gaussian models of Kα_1/Kα_2 lines for each element are tied and fixed.
  - Line intensity ratio of Kα_1/Kα_2 is set to be 2:1 for each element.
- **Applying same model to v2 database:**
  - Normalization and index of power law changed 4-5%.
  - Normalizations of several lines changed more than this.
  - The statistics clearly show the doublet structure of the strongest K lines, and the residuals show the next lines we should add.

Particle-induced background of Resolve

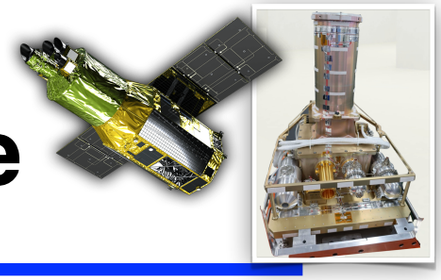


Model made from v1 database vs. data from v2 database

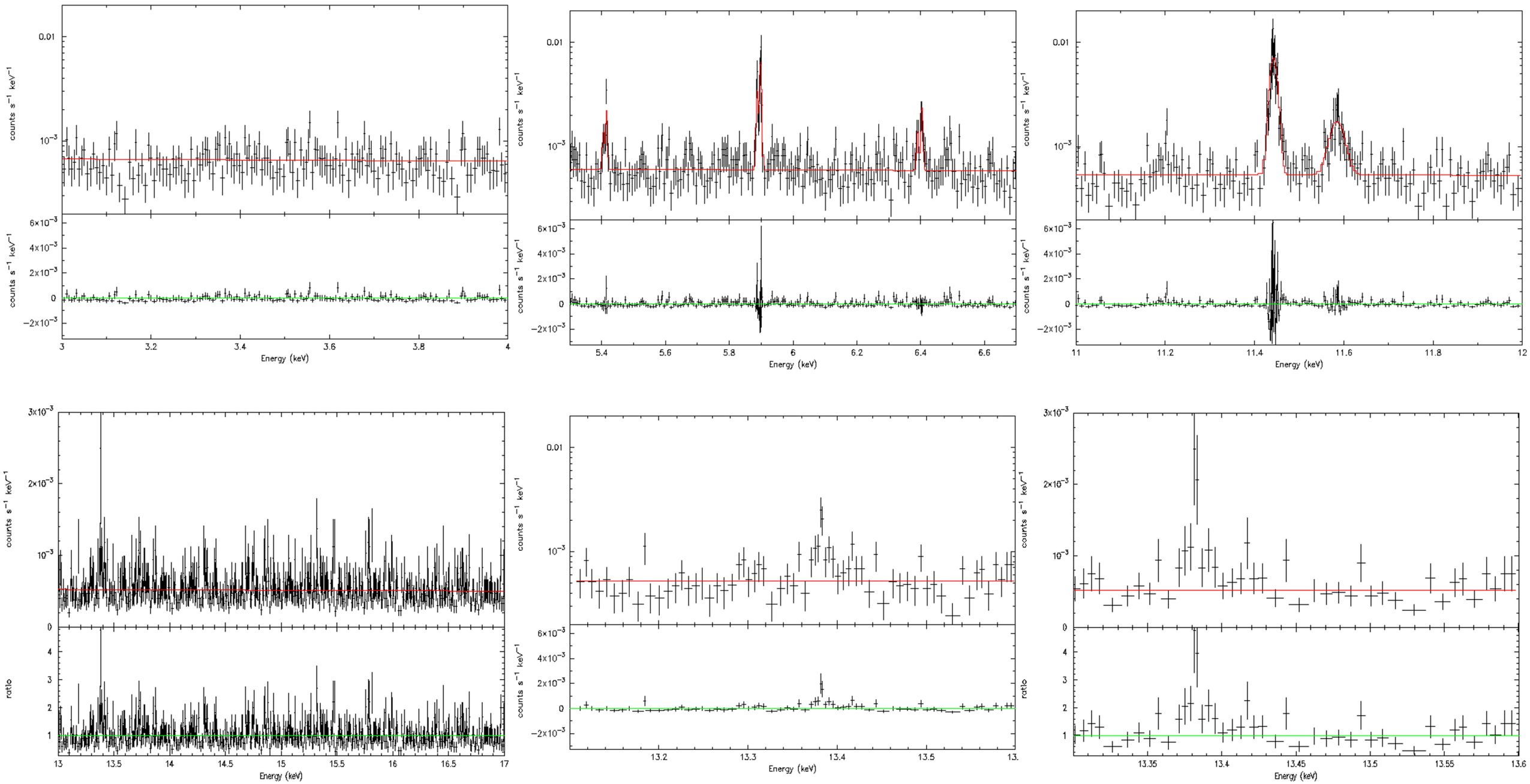




Particle-induced background of Resolve



Model made from v1 database vs. data from v2 database



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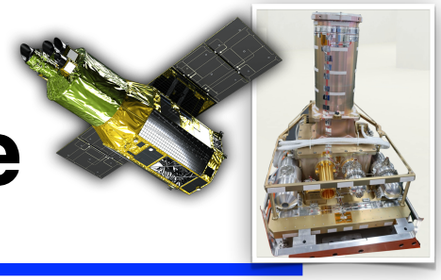
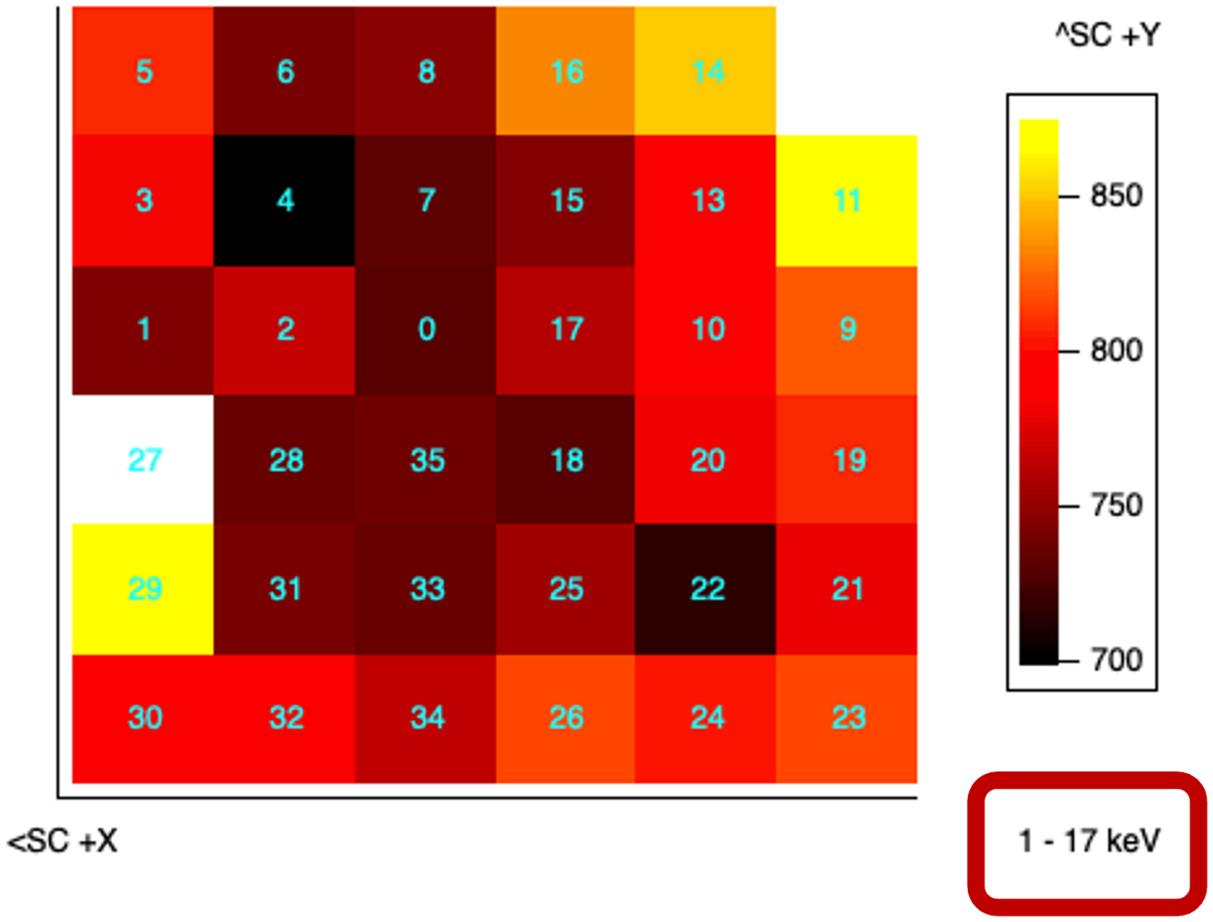
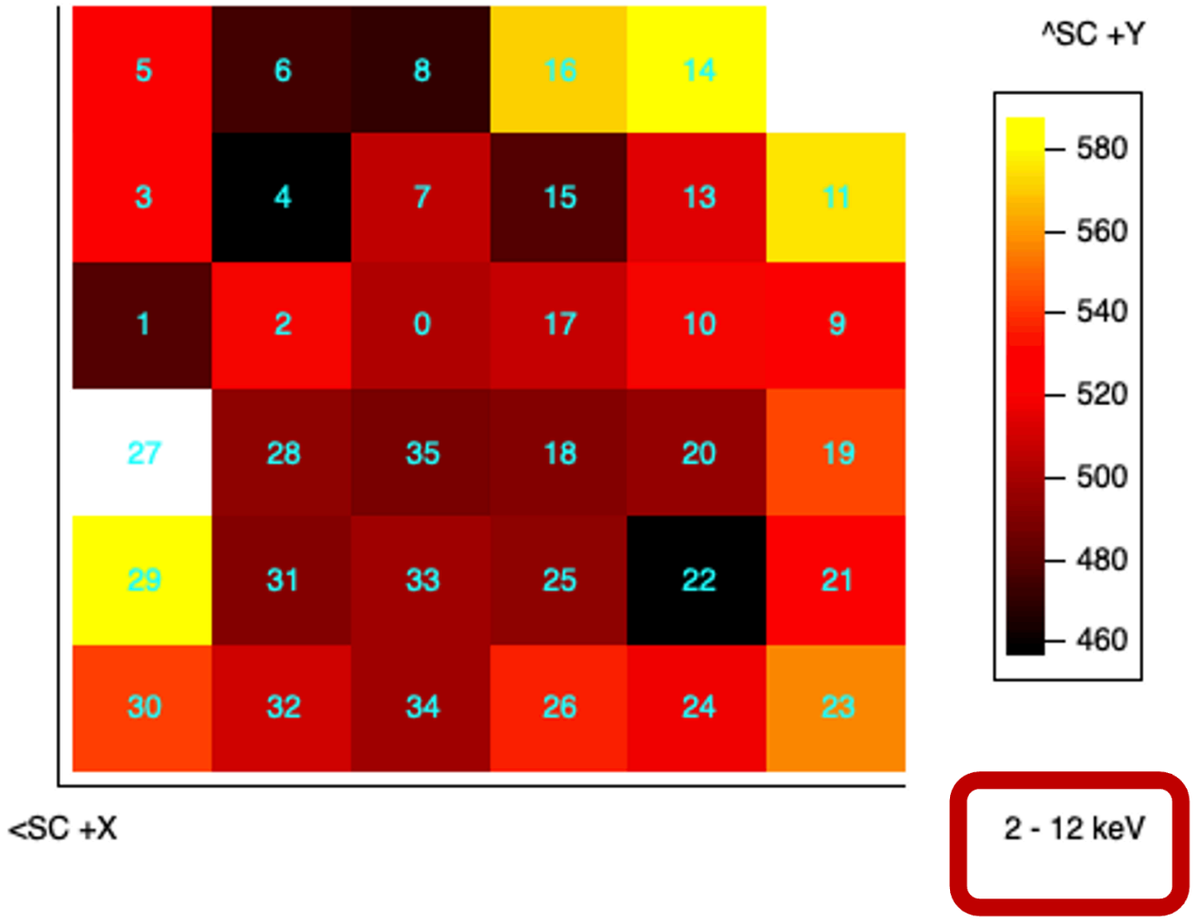


Looking for spatial non-uniformity:



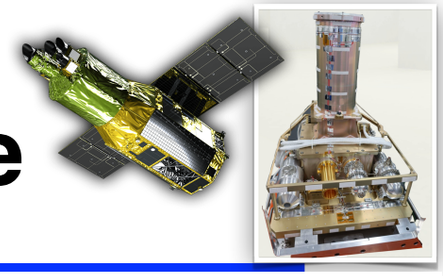
mean: 775.235
sqrt(mean): 27.843
std dev: 43.3639



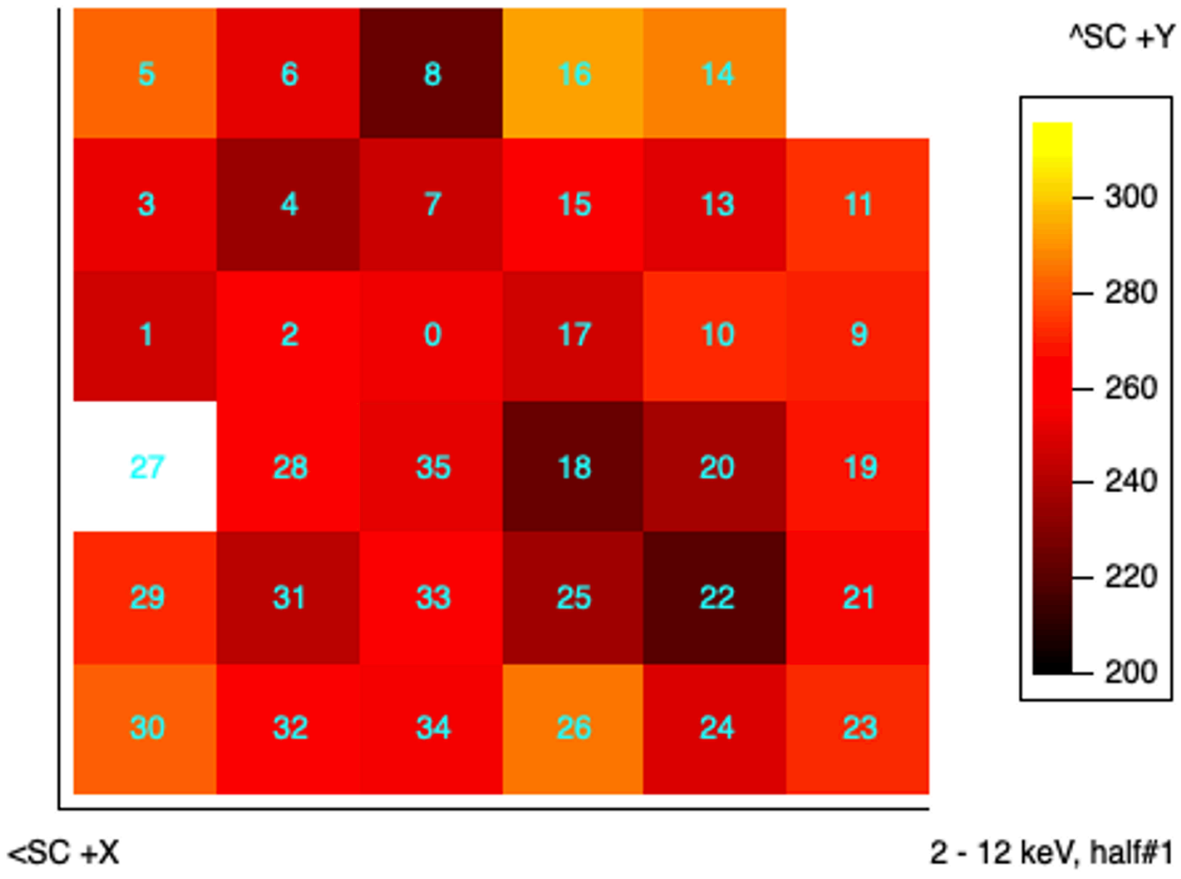
mean: 513.647
sqrt(mean): 22.6638
std dev: 33.7647

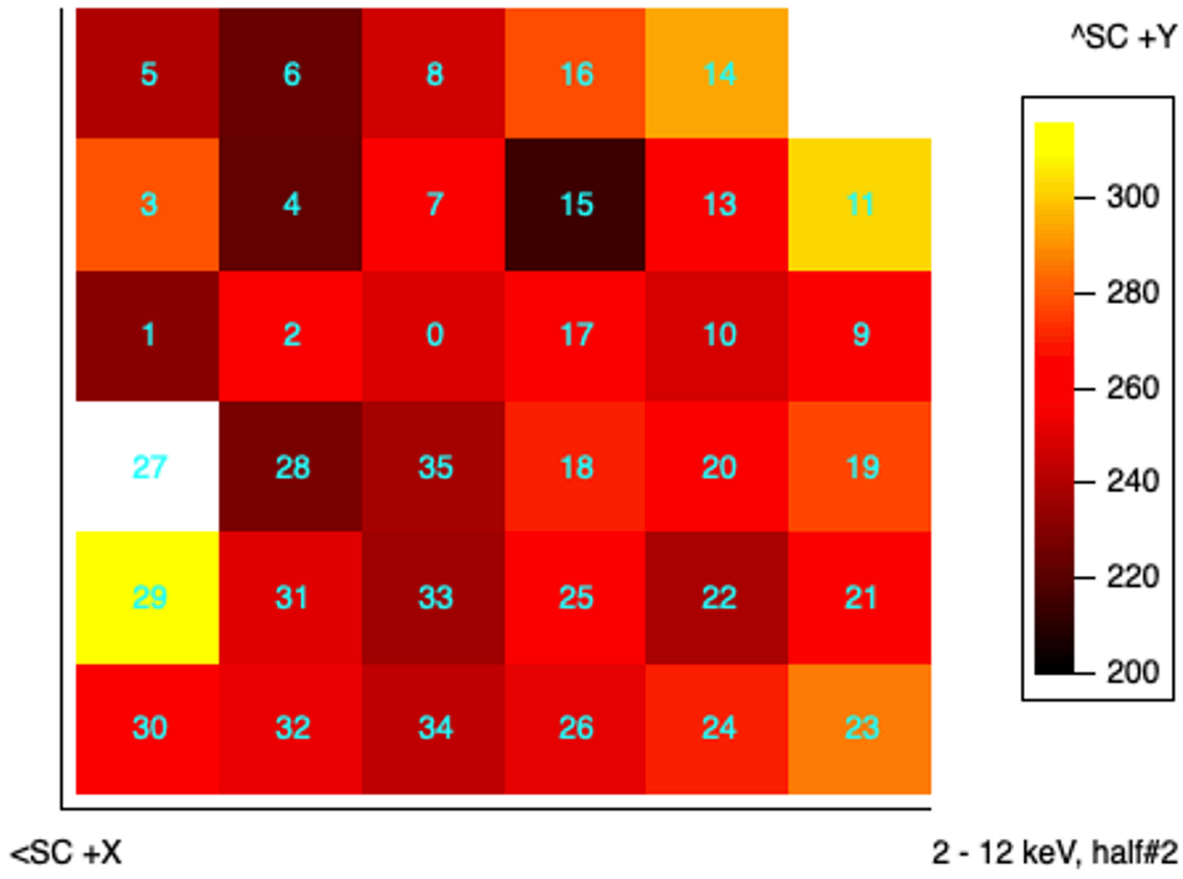
Seems worse than expected from Poisson statistics, but...

Particle-induced background of Resolve

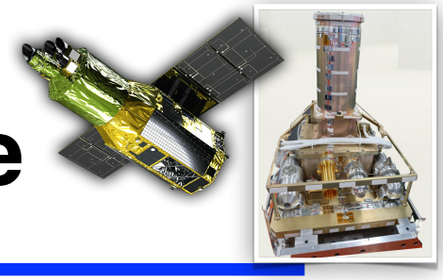


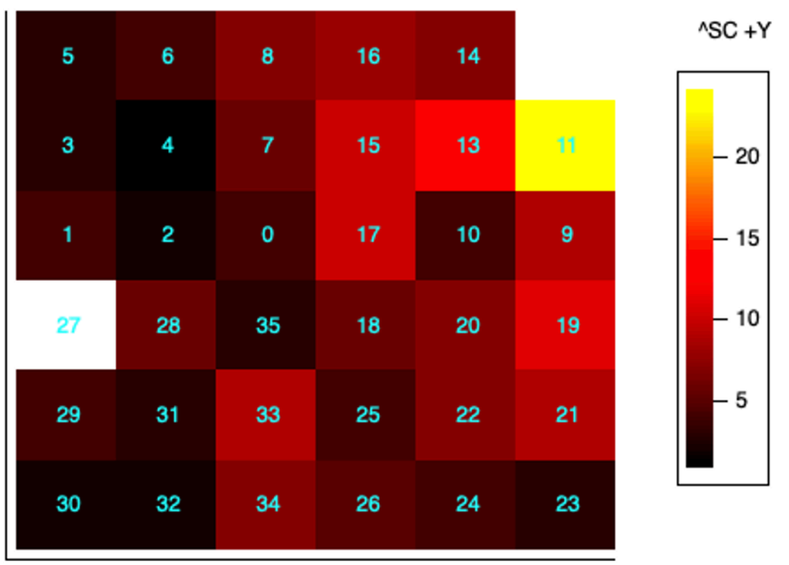
splitting 2-12 keV data into halves, patterns don't persist

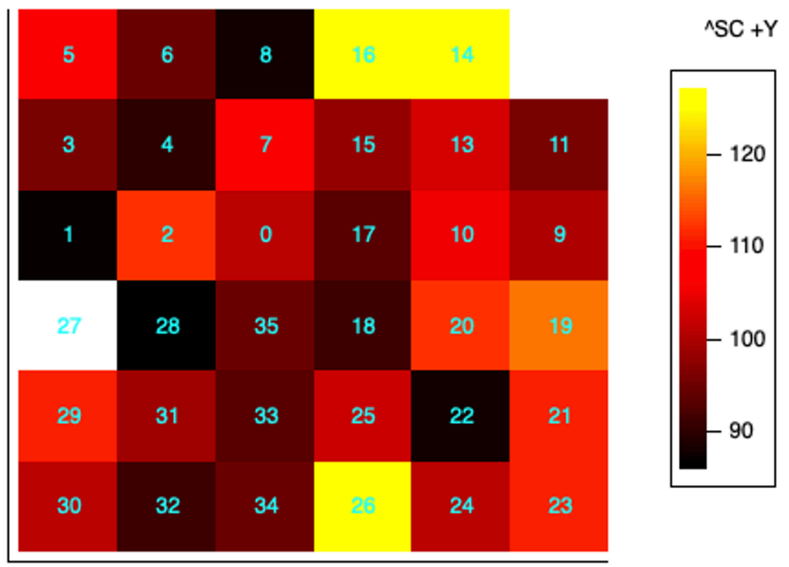


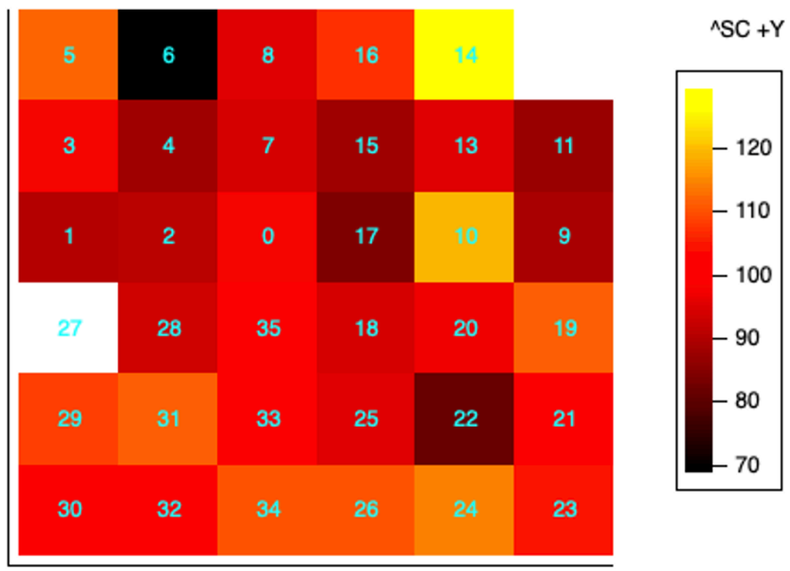


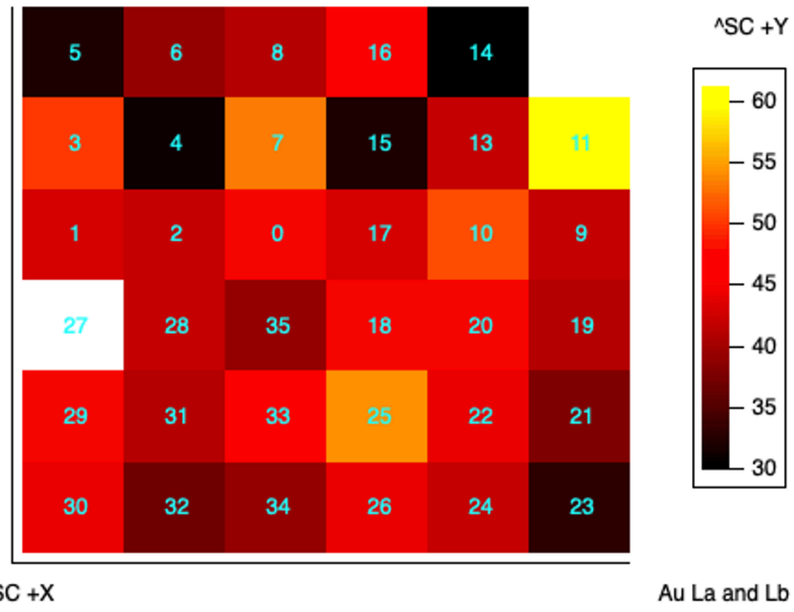
Particle-induced background of Resolve

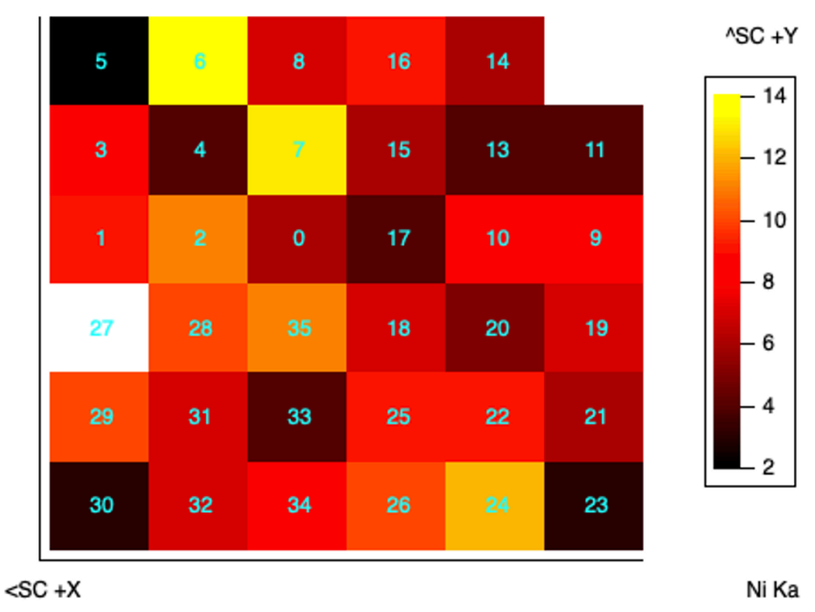






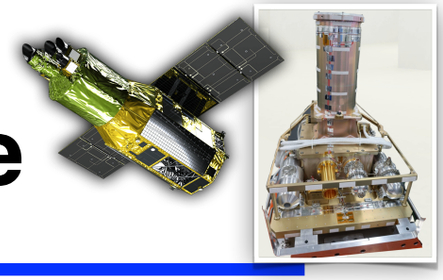






Narrow-band images:
No common patterns.
Only clear gradient is for MnKa (from scattered light from the collimated internal calibration source)

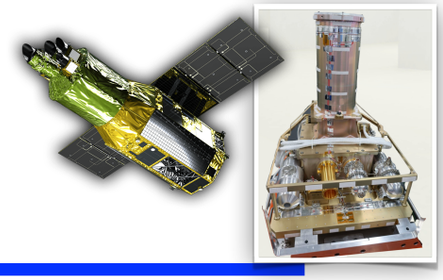
Particle-induced background of Resolve



Plans:

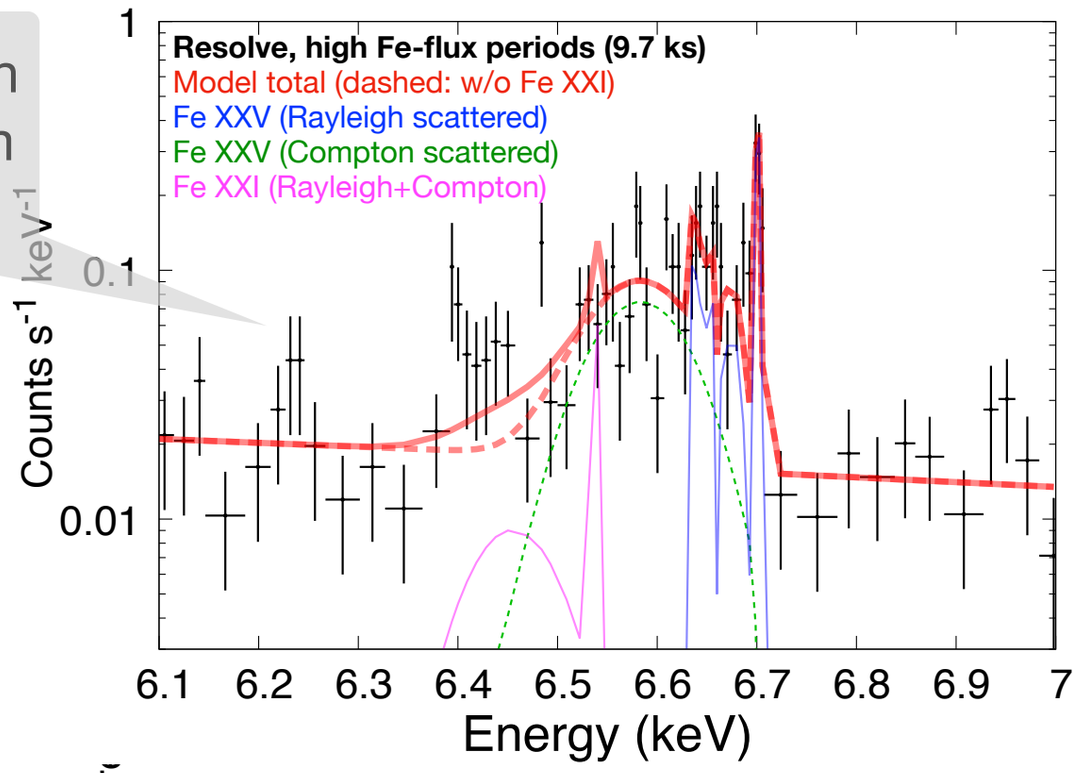
- update NXB model
- map COR and NXB spectrum to anti-co rate
    - can integrated anti-co counts for an observation predict the NXB as well as (or better than) rslnxbgen?

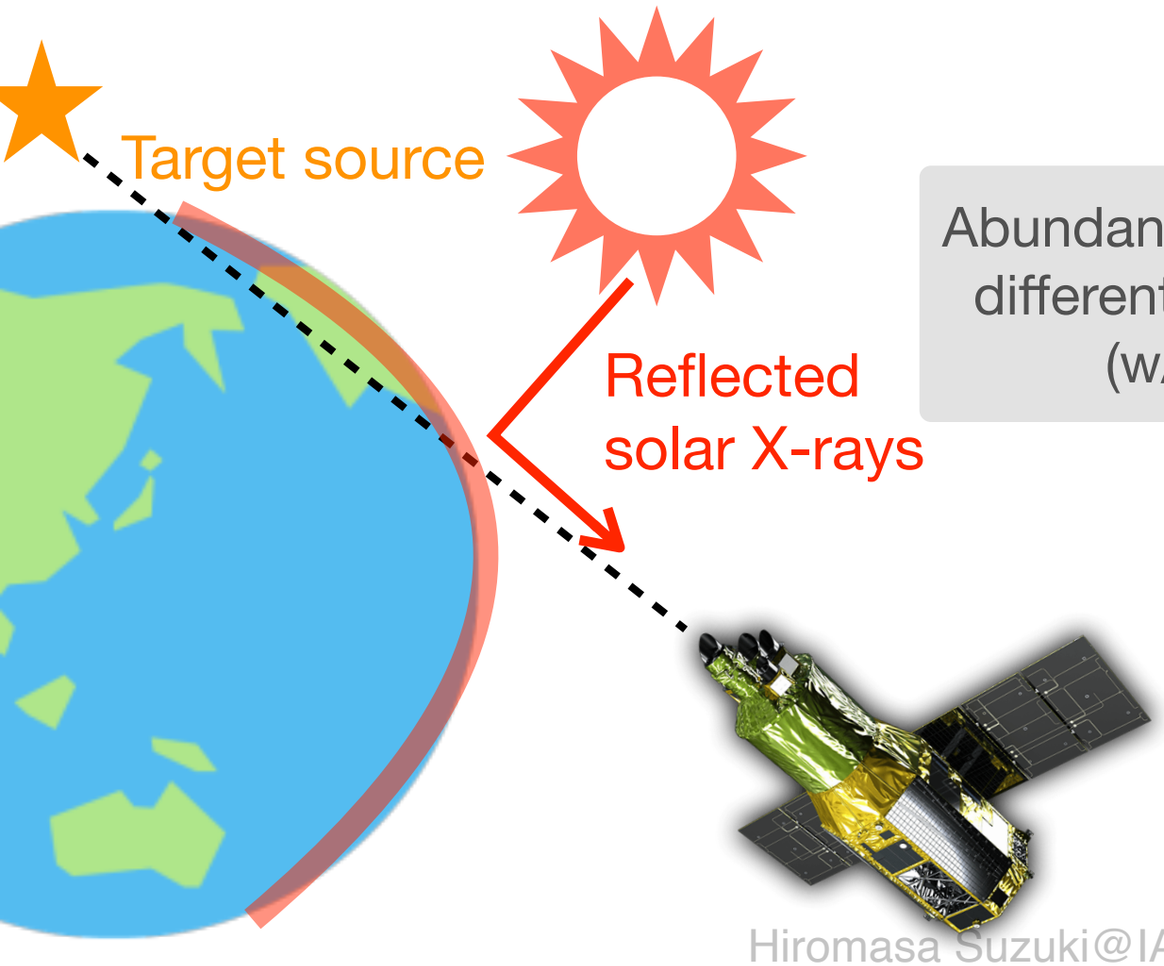
Appendix: solar flare study using day-Earth observations



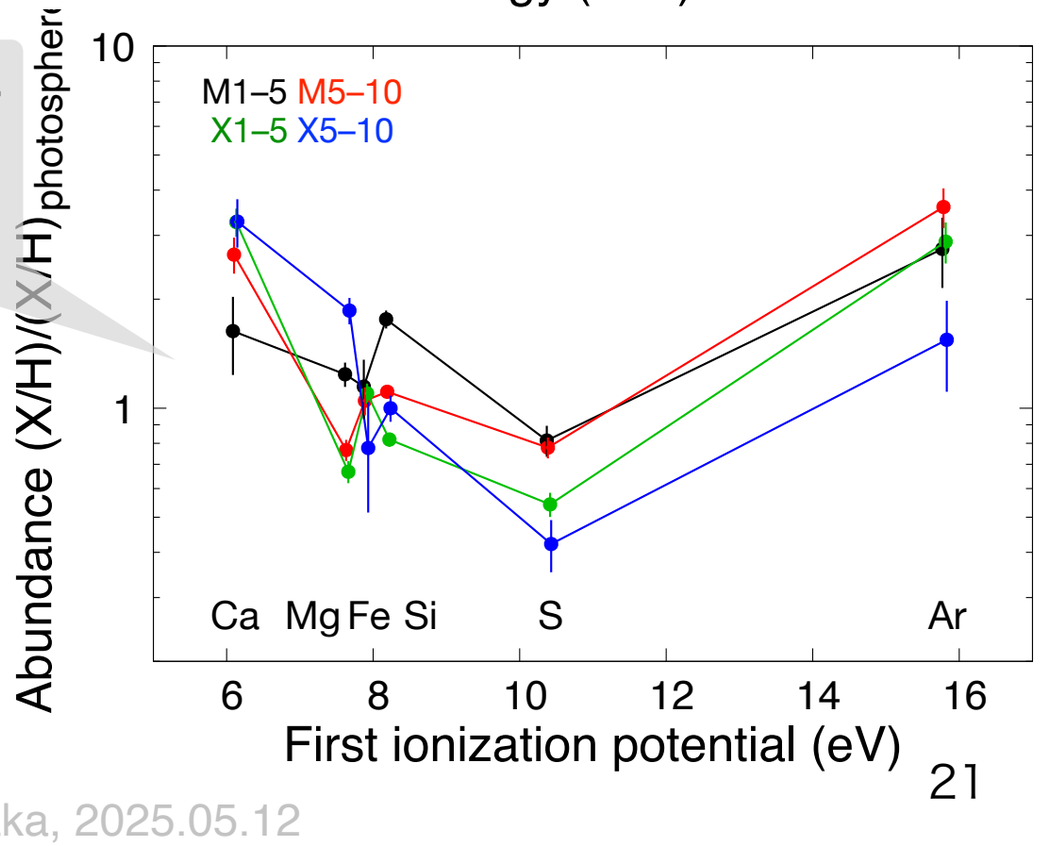
- Using the day-Earth data set, we have also been working on solar flare physics (paper submitted!)

High-resolution Fe-K spectrum (w/ **Resolve**)

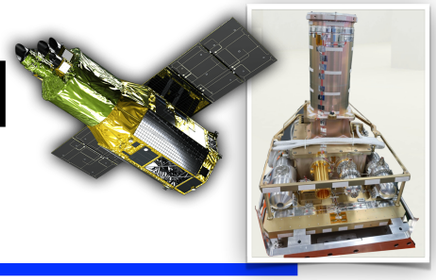




Abundance patterns for different flare classes (w/ **Xtend**)

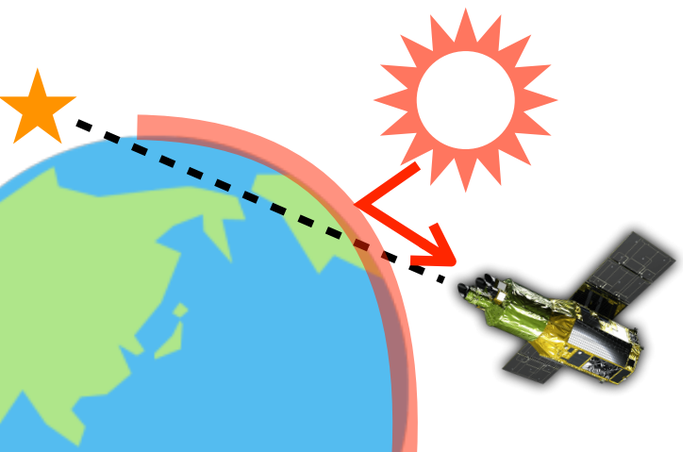


Summary: Particle-induced background of XRISM Resolve & Xtend



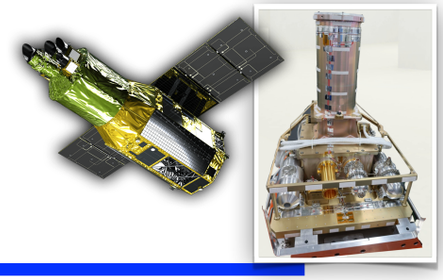
- **Xtend**
  - Low level confirmed, bright sources observable up to ~10 keV
  - COR dependence: flux changes by ~3x w/o spectral changes
  - Spatial dependence: ~30% along readout w/o spectral changes
  - Little dependence on satellite altitude
- **Resolve**
  - Improving spectral model using updated NXB database
  - Significant pixel-by-pixel variation present
  - Will investigate how well anti-co rate can predict NXB

- Night-Earth spectra are sometimes affected by solar flares/CMEs (day-Earth and science data are much more affected)
- Rather we can study solar physics using day-Earth observations (!)

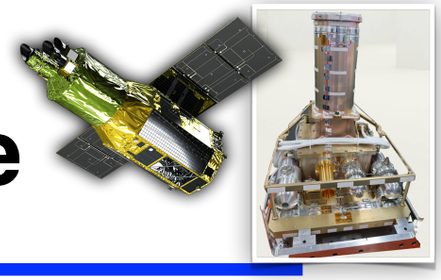


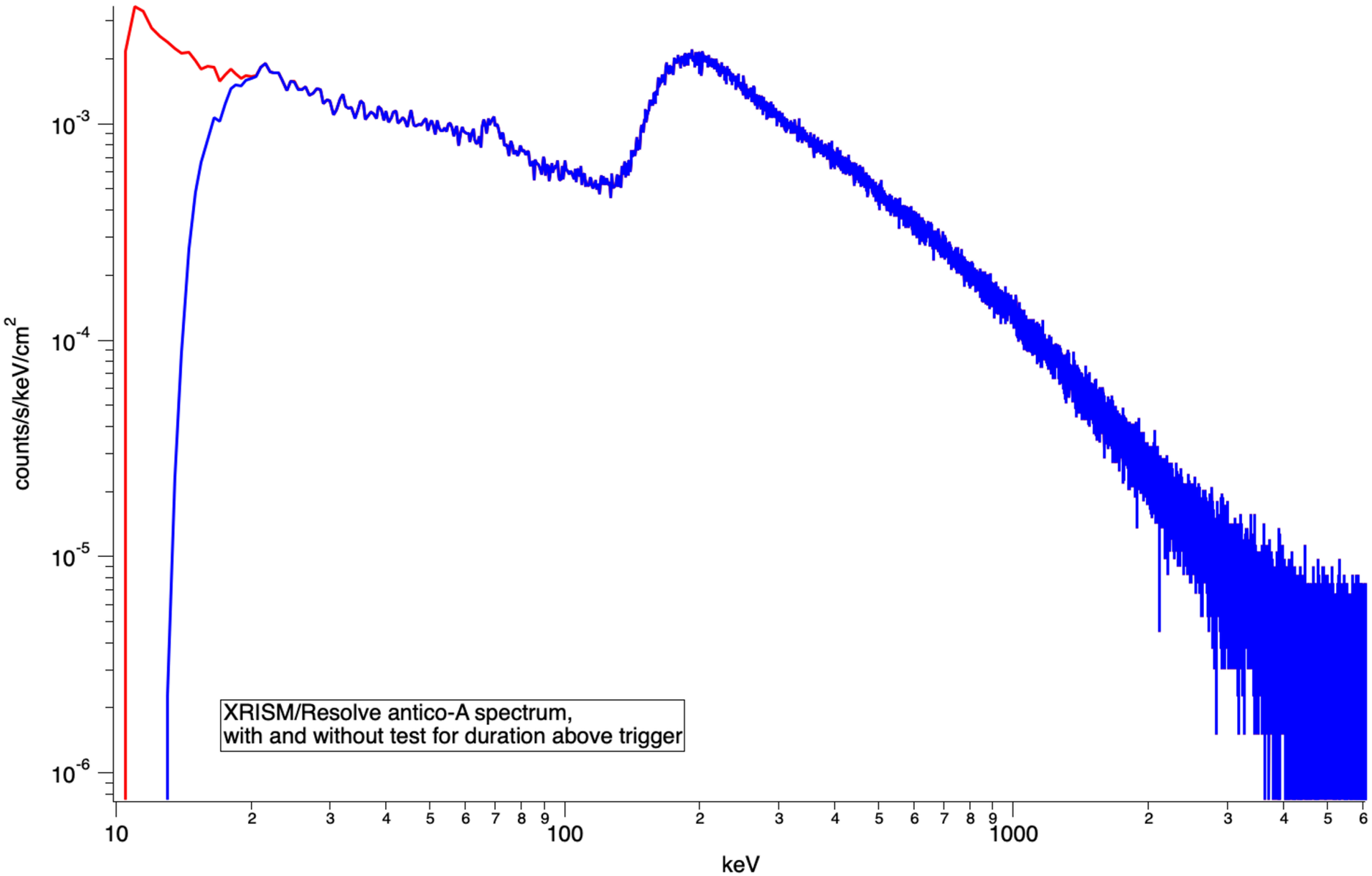
XRISM
X-Ray Imaging and Spectroscopy Mission

Backup



Particle-induced background of Resolve





- anti-co spectrum corresponding to time intervals included in the full NXB database of Resolve
- only events > 30 keV and with more than 2 samples above the trigger are used for coincidence screening of Resolve
  - above 30 keV, the duration test only removes a few events