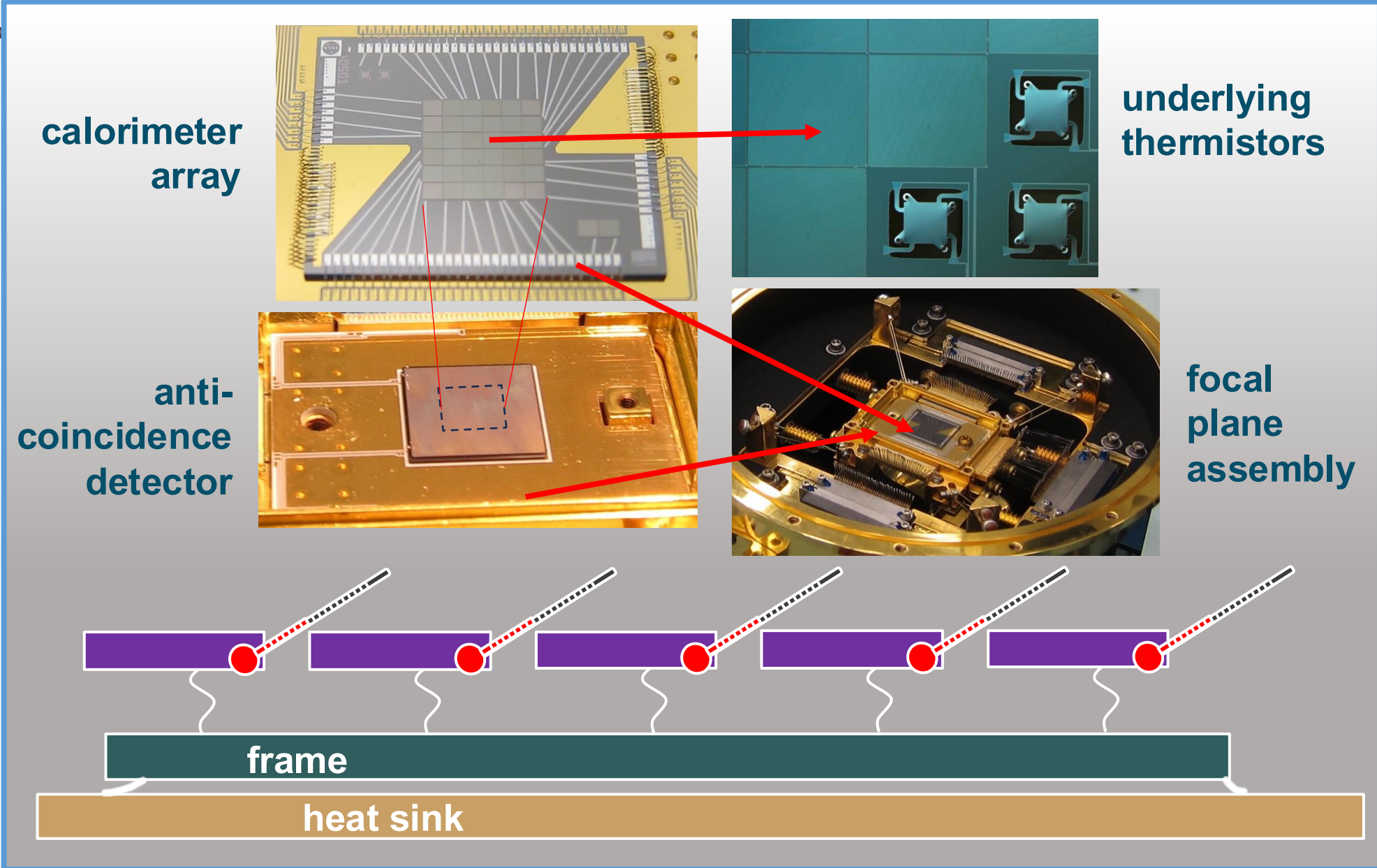




The In-Orbit Instrumental Background of the Resolve X-ray Spectrometer on the XRISM Observatory

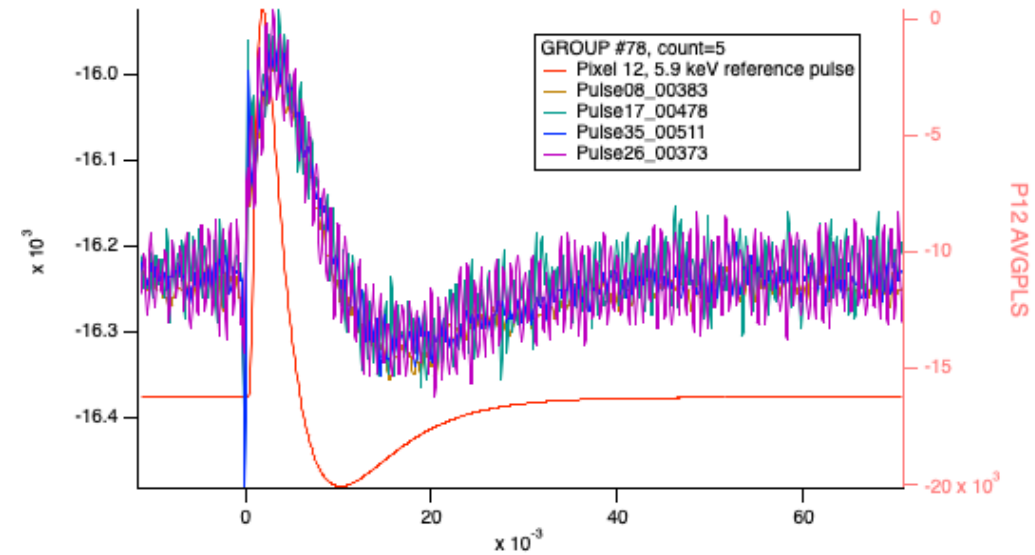
Caroline Kilbourne (GSFC)
on behalf of the Resolve Instrument Team
and the XRISM Background Working Group

Resolve focal-plane basics

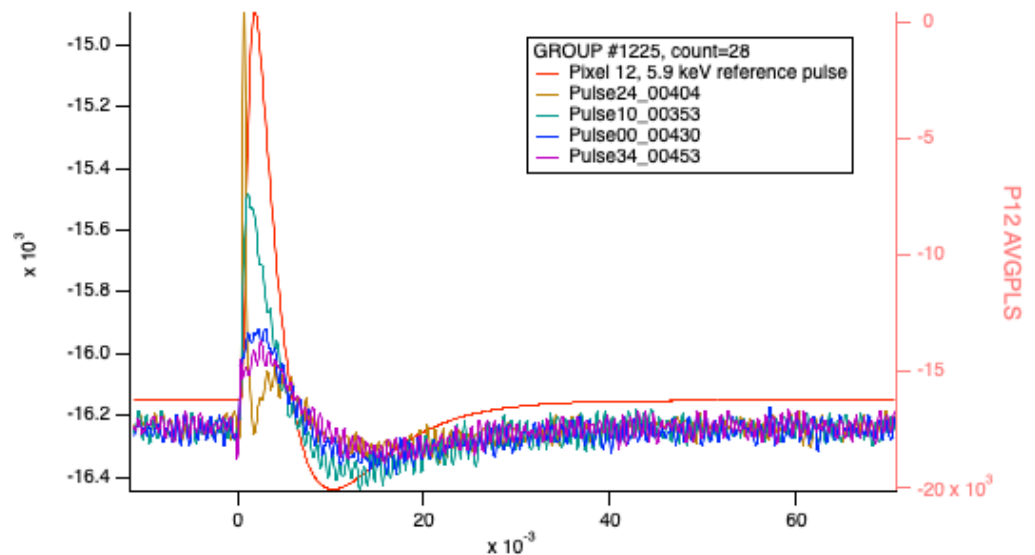


Screenable background events

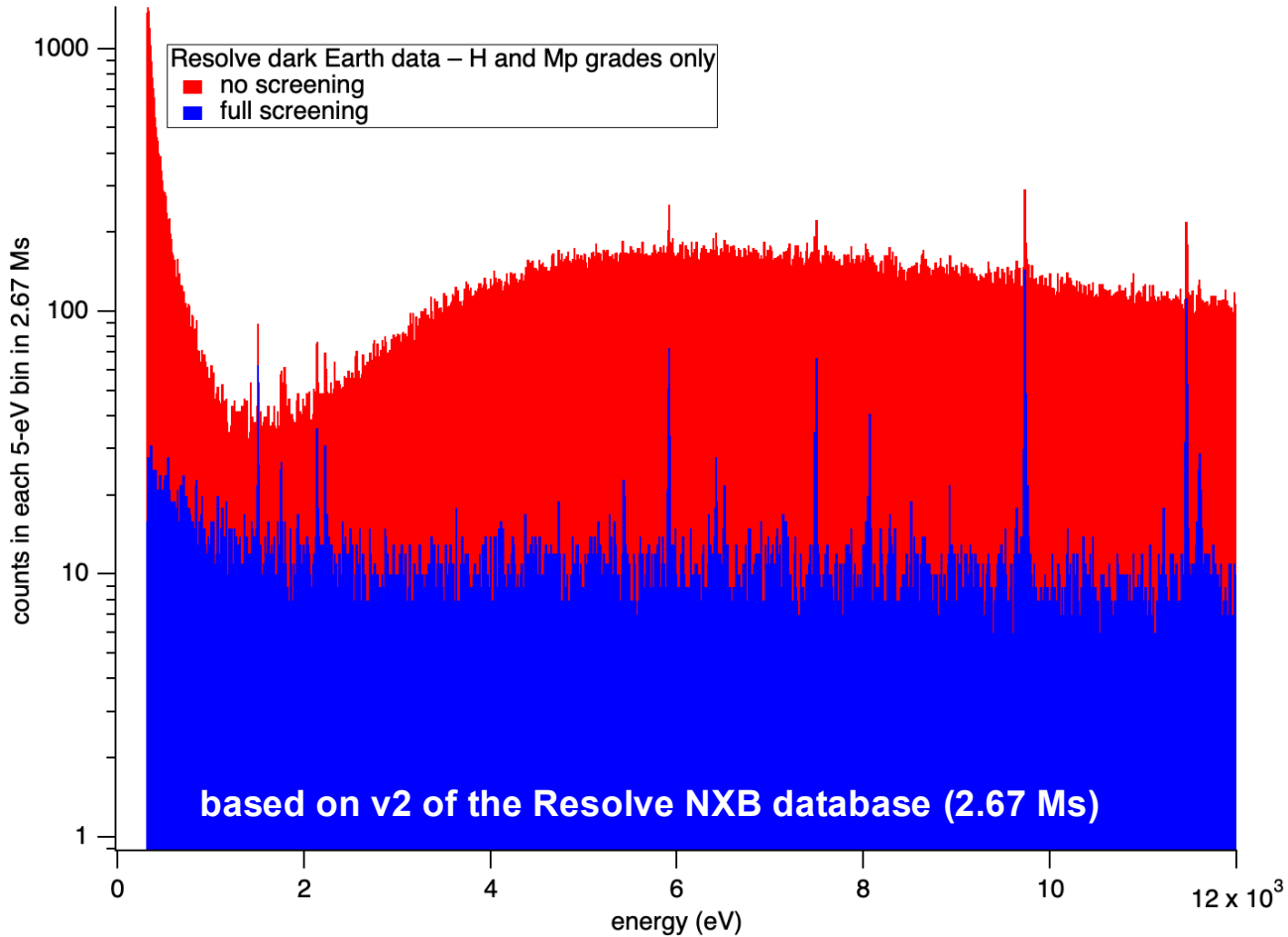
- Energy into the absorber of a pixel other than from a source X-ray
 - Same pulse shape for a given energy deposition, whether from a sky photon, a cosmic-ray proton, or a secondary electron or photon
 - Can only identify by coincidence
 - With the anti-coincidence detector
 - Pixel-to-pixel (at rate higher than expected from false coincidence)
- Pulses originating outside of the absorber of the triggered channel
 - Electrical crosstalk from large pulse on electrical nearest neighbor
 - Currently “screened” by ignoring events with $E < 300$ eV
 - Slow thermal pulses on multiple pixels when a large amount of energy is deposited into the silicon frame around the array
 - Screened on pixel-to-pixel coincidence and/or rise time



examples of frame events

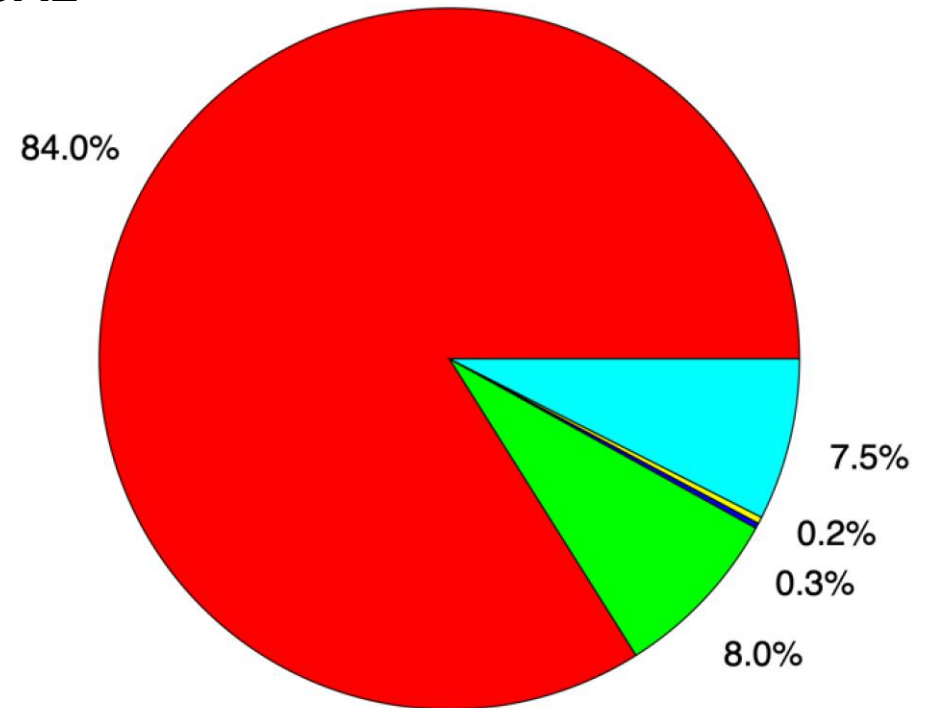


Efficacy of screening



Screening efficacy if done in following order:

- ▲ anti-co
- ▲ pixel-pixel coincidence
- ▲ rise time
- ▲ other
- ▲ RESIDUAL

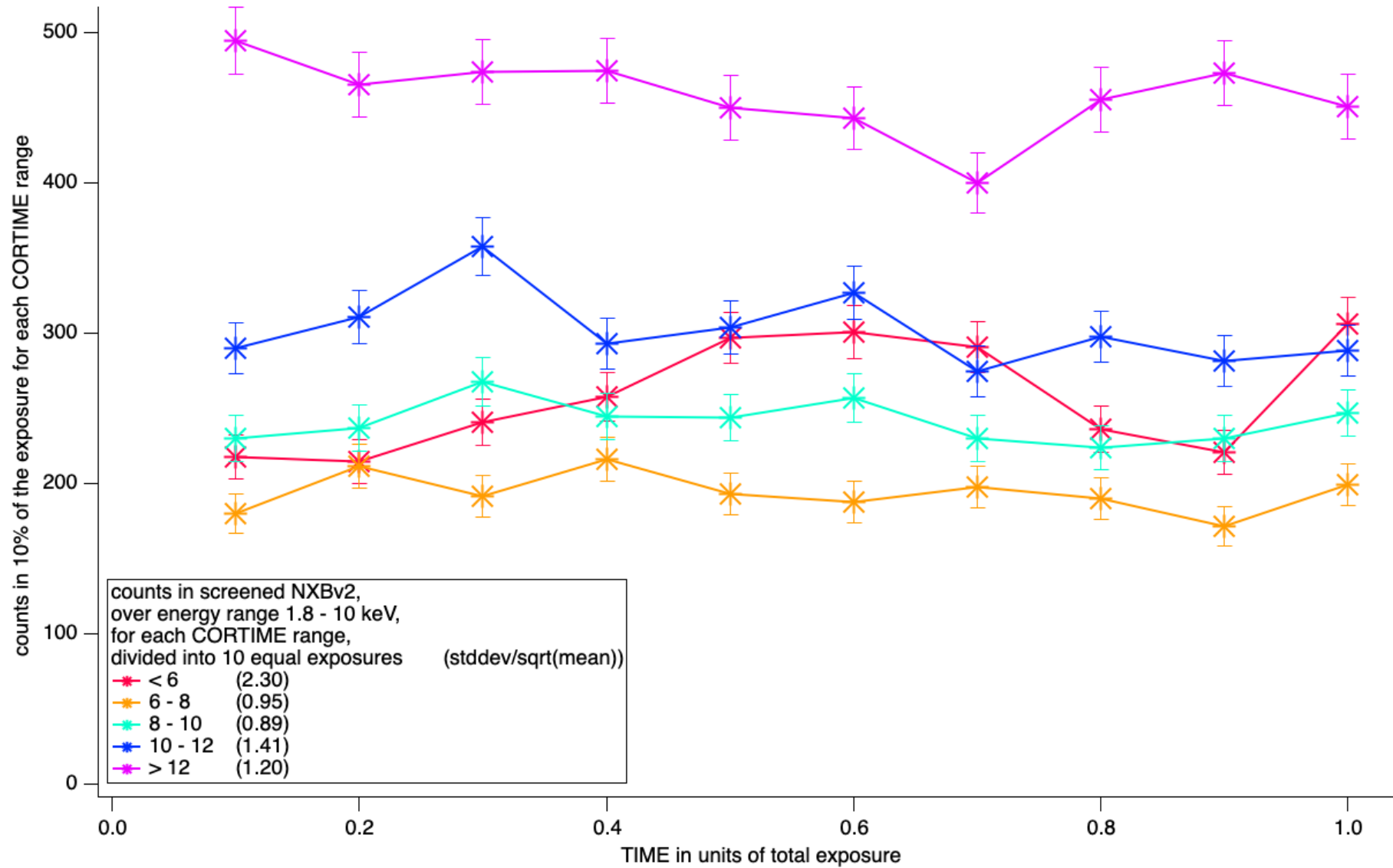


Average 2.0 – 12.0 keV array rate (34 pixels): 6.37×10^{-4} counts s^{-1} keV⁻¹
Per 5-eV resolution element, that's 1 count in 4 days!

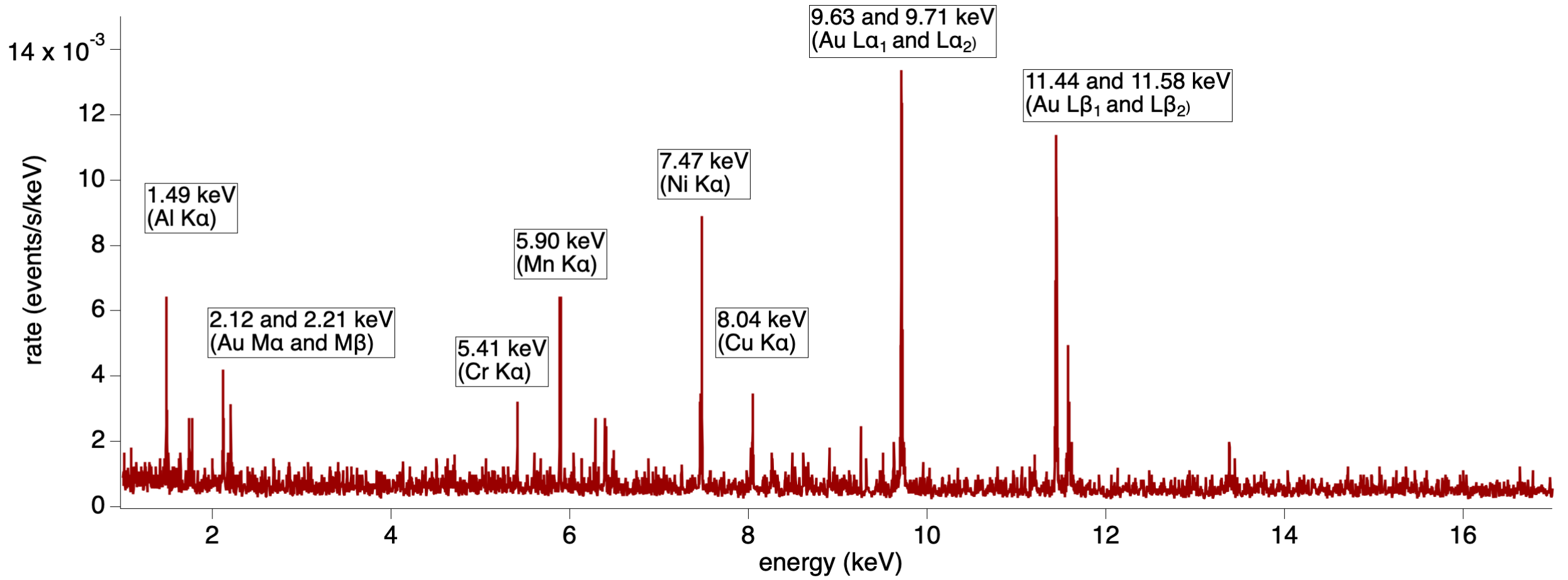
- Resolve NXB databases
 - sourced from the cleaned NXB event files in the trend archive (from periods of Earth occultation)
 - aggregated by hand
 - OBSIDs with calibration-source usage, anomalies, or periods with bad gain solutions omitted
 - NTE (dark Earth) data extracted
 - standard additional screening applied
 - v1: December 25, 2023 – April 15, 2024, 0.8 Ms (released to XRISM team and public)
 - v2: December 25, 2023 – February 27, 2025, 2.7 Ms (released to XRISM team)
 - v3: December 25, 2023 – January 30, 2026, 4.0 Ms (can be released soon)
- HEASARC pages for Resolve NXB database and model will soon be updated
 - https://heasarc.gsfc.nasa.gov/docs/xrism/analysis/nxb/resolve_nxb_db.html
 - https://heasarc.gsfc.nasa.gov/docs/xrism/analysis/nxb/nxb_spectral_models.html
 - currently use v1 of the NXB database and original version of the model
- v3 expected to be last manually aggregated version of the database

- Times of SAA crossings must be excluded
 - Definition of SAA boundary is important!
 - Resolve's anti-co makes great SAA maps
- Galactic cosmic-ray (GCR) flux is substantially shielded
 - NXB reduction somewhat offset by Earth albedo
 - The shielding changes over the orbit, thus NXB flux oscillates
 - max/min ~ 2 for XRISM's orbit (~ 550 km, $\sim 30^\circ$ inclination)
 - No significant dependence of the spectrum on magnetic cut-off rigidity (COR) has yet been determined
 - except that the Mn line doesn't oscillate, since it originates from an internal ^{55}Fe source
 - Resolve team now recommends excluding times of $\text{COR} < 6$
 - In the v3 database, 9.5% of exposure at $\text{COR} < 6$
 - Recommendation to exclude it based on its variability more than its average rate
 - variability could be related to the spikes in rate that occur preferentially at the southern extreme of the orbit

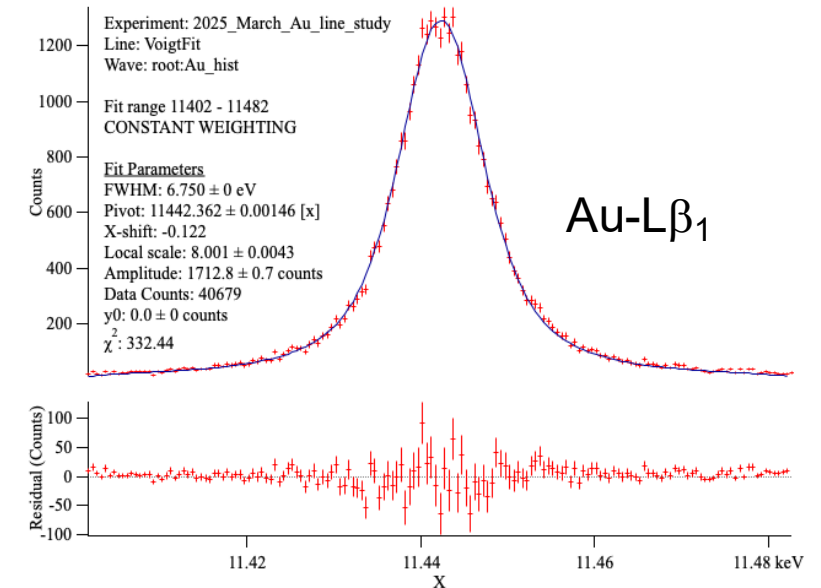
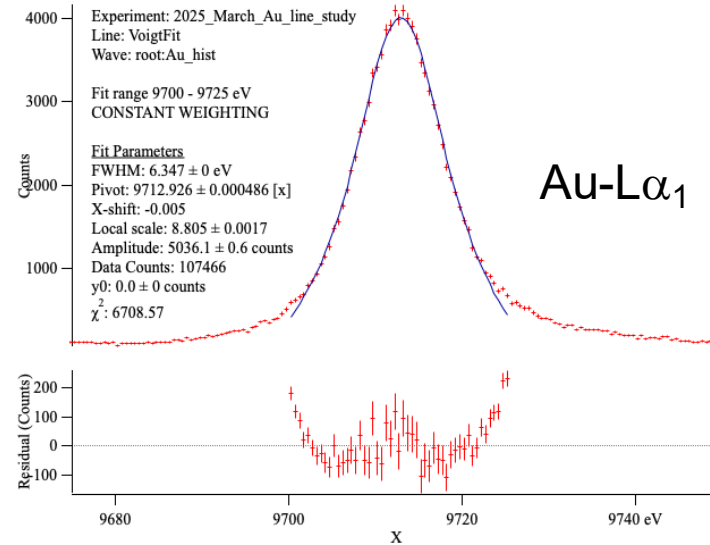
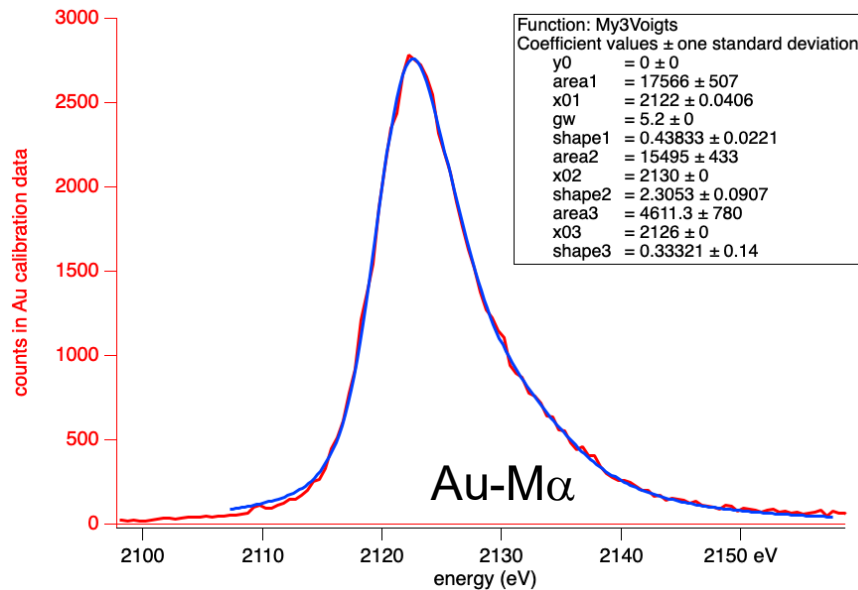
COR-dependence of NXB flux variability



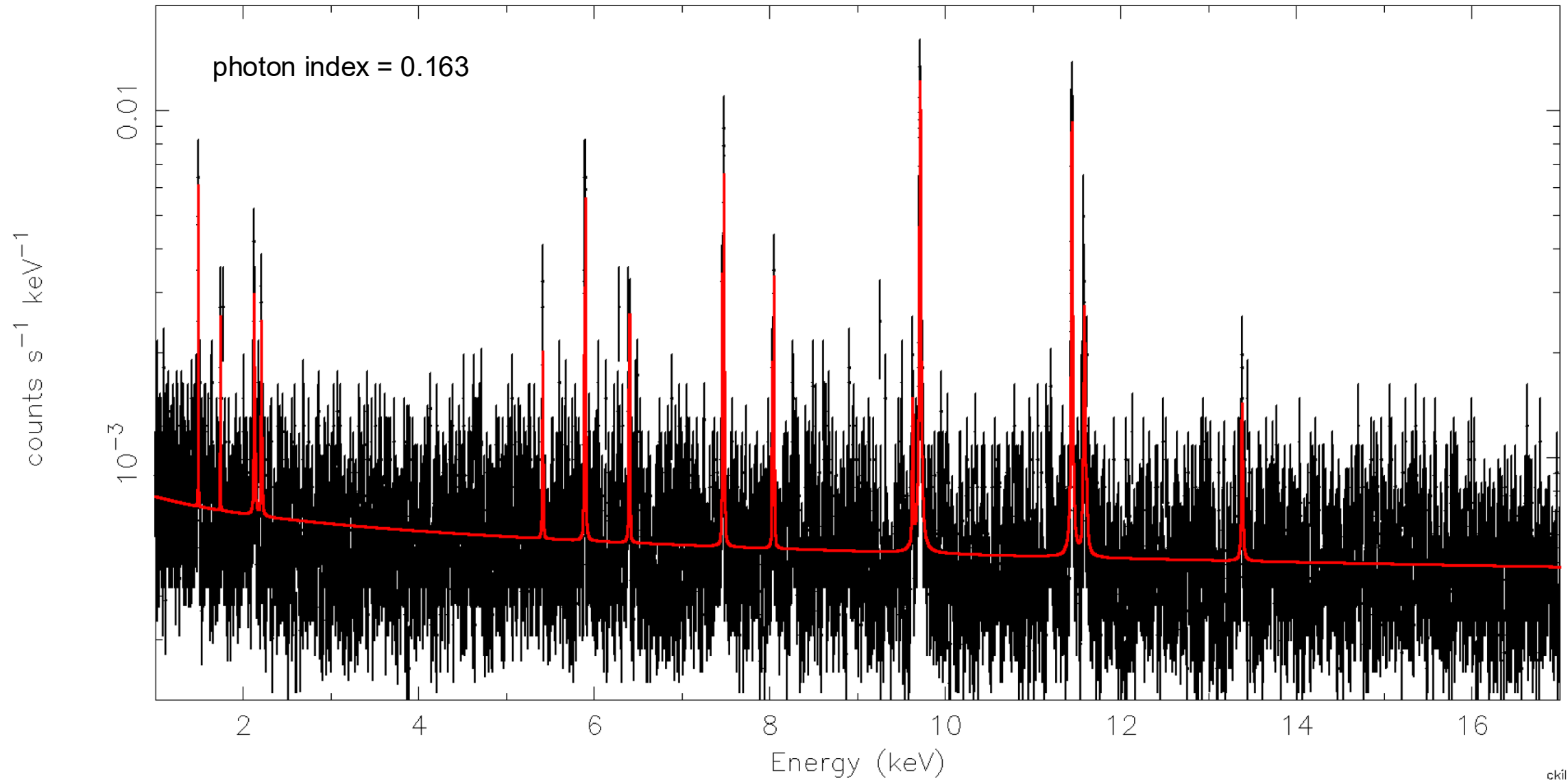
Resolve NXB spectrum (database v3)



- The strongest line in the Resolve NXB is Au $L\alpha$; there are numerous other Au lines
- We could not find any high-resolution profiles for these lines in the literature
- Thus we used a microcalorimeter spectrometer at LLNL to obtain a Au fluorescence spectrum with high statistics and characterized the line shapes empirically

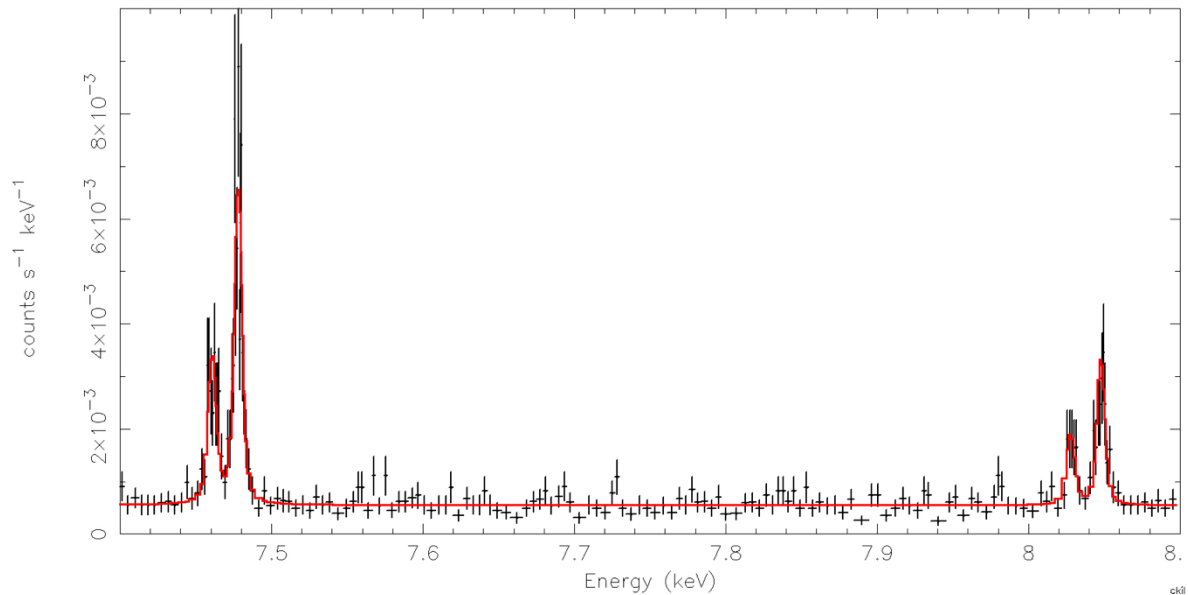
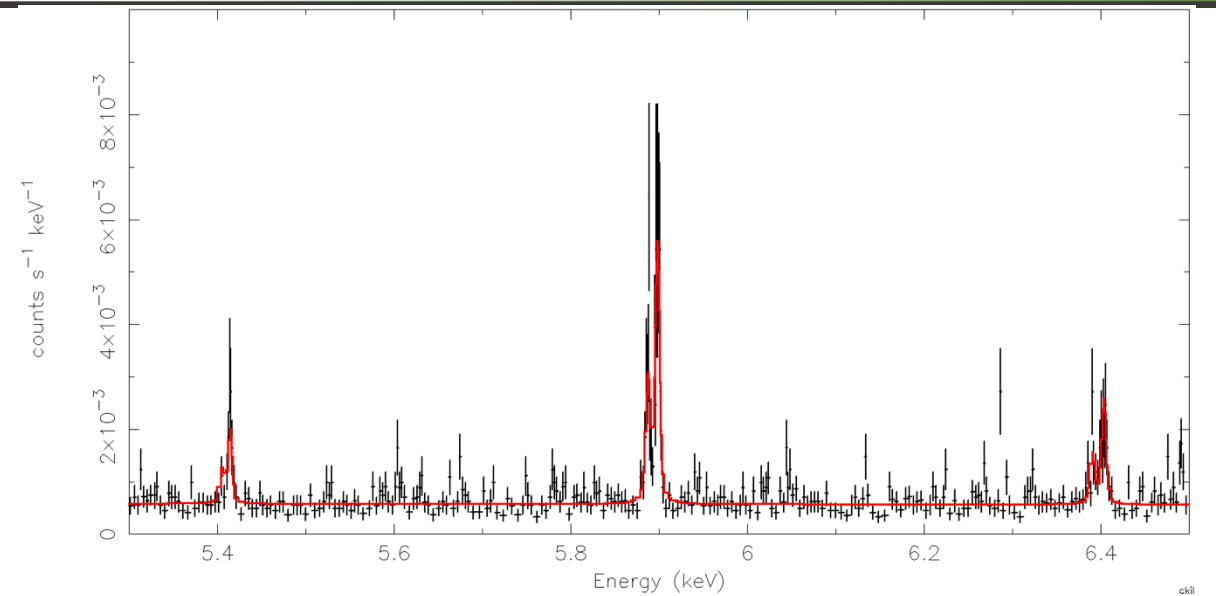
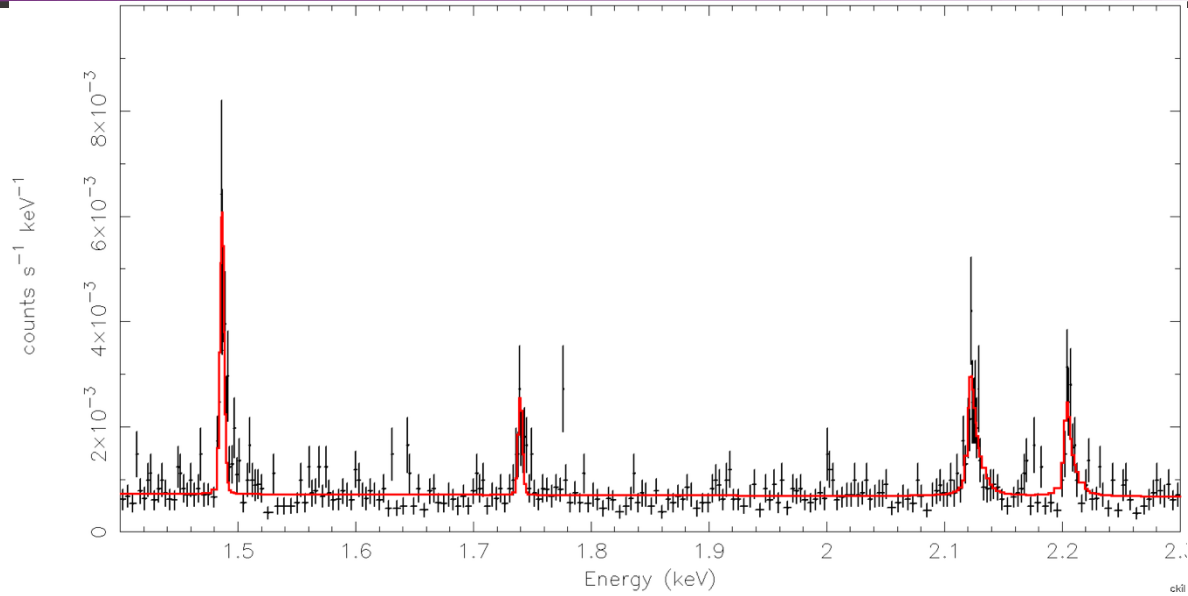


Power law and lines



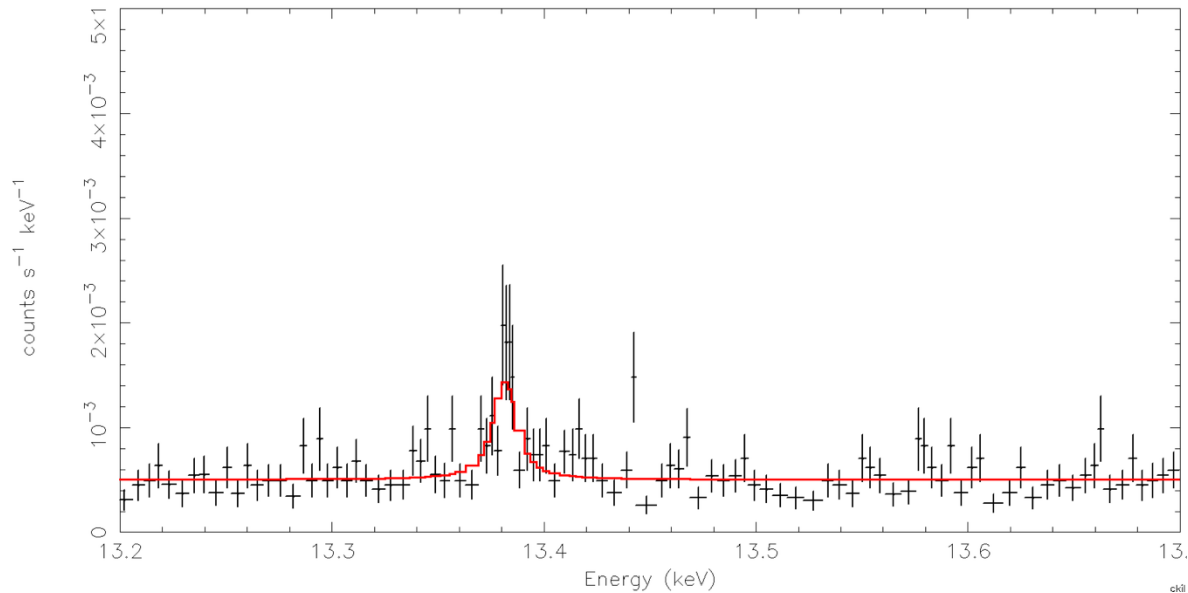
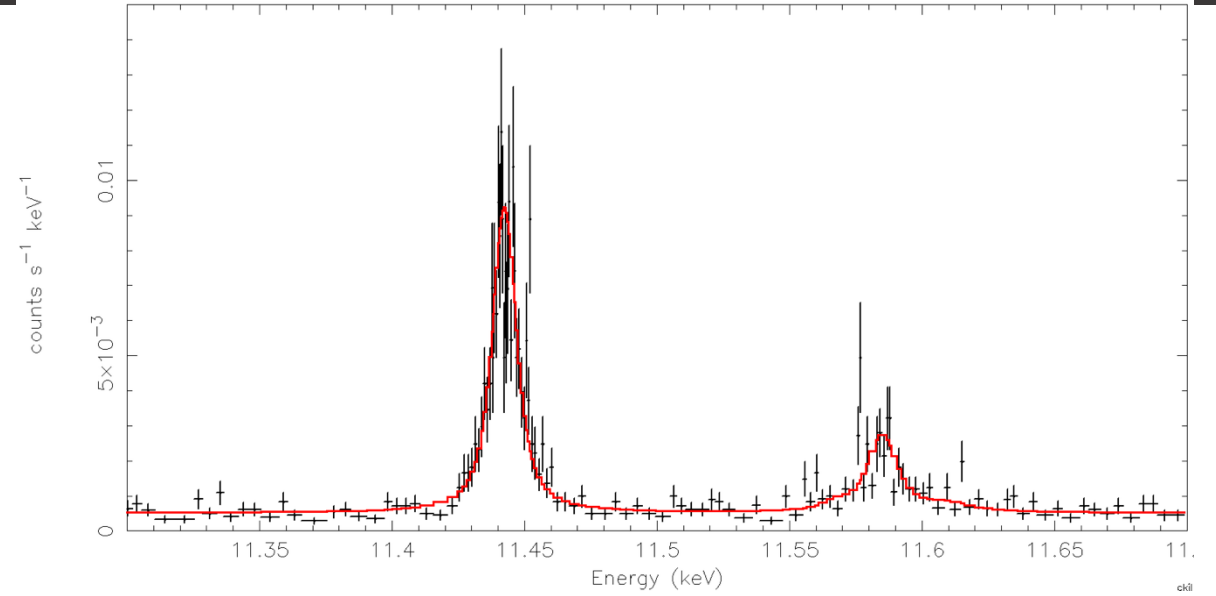
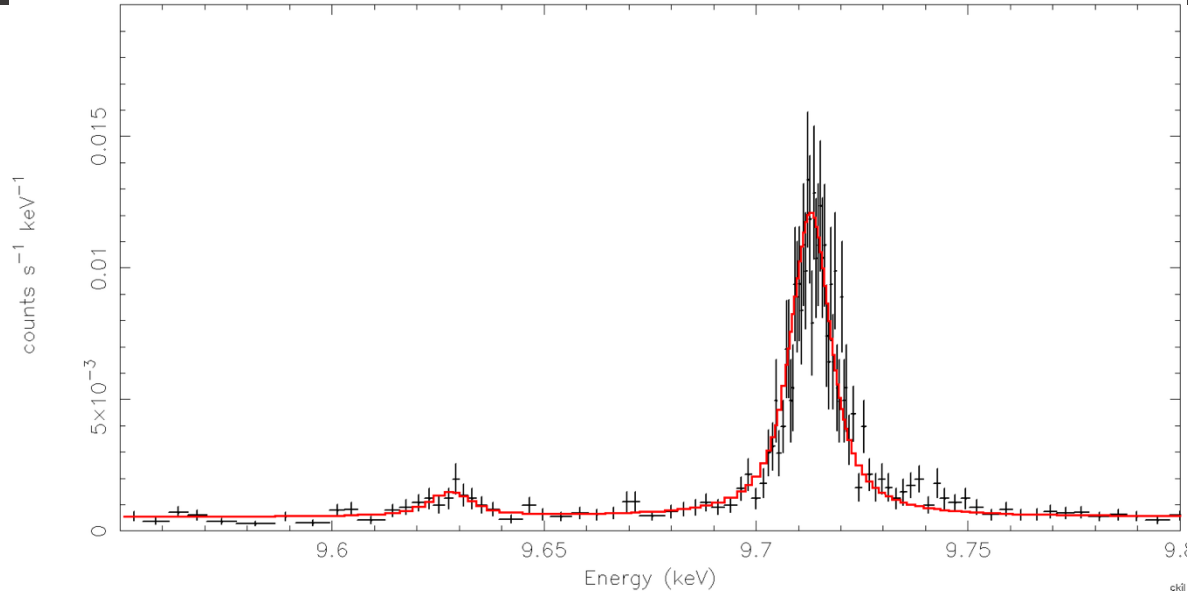
ckilt

Line fits



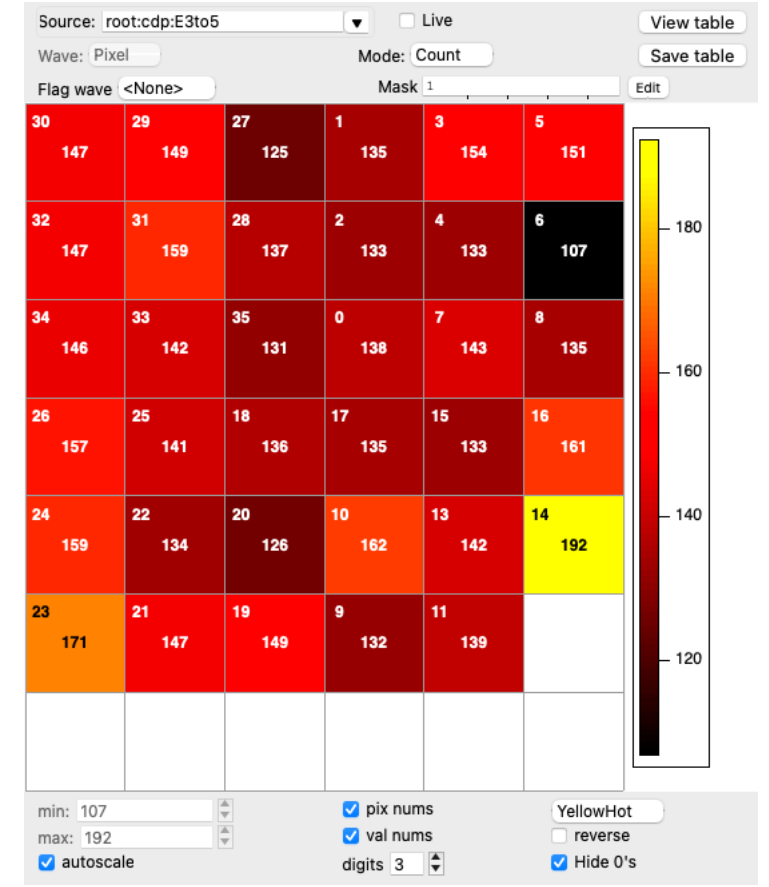
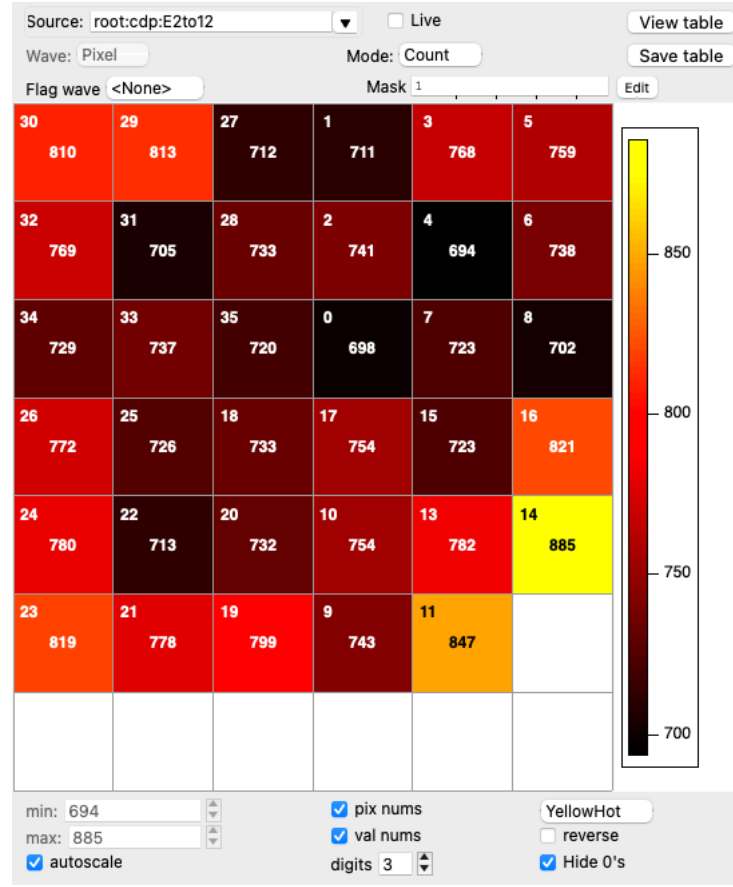
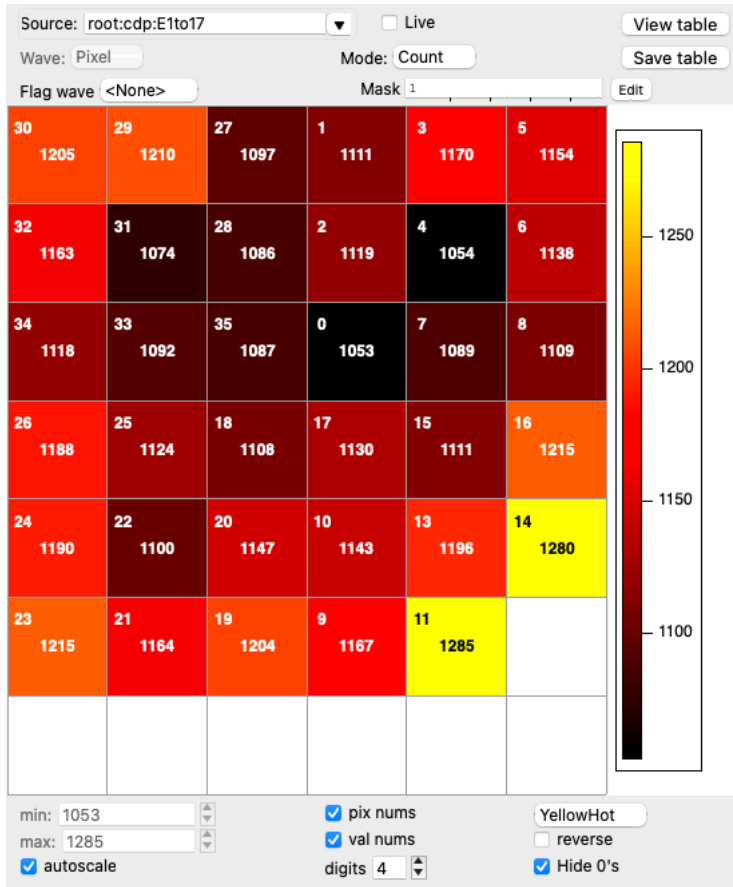
Al-K α , Si-K α , Au-M α , Au-M β
Cr-K α_1 /K α_2 , Mn-K α_1 /K α_2 , Fe-K α_1 /K α_2
Ni-K α_1 /K α_2 , Cu-K α_1 /K α_2

Line fits



Au-L α_1 , Au-L α_2
Au-L β_1 , Au-L β_2
Au-L γ_1

Non-uniformity

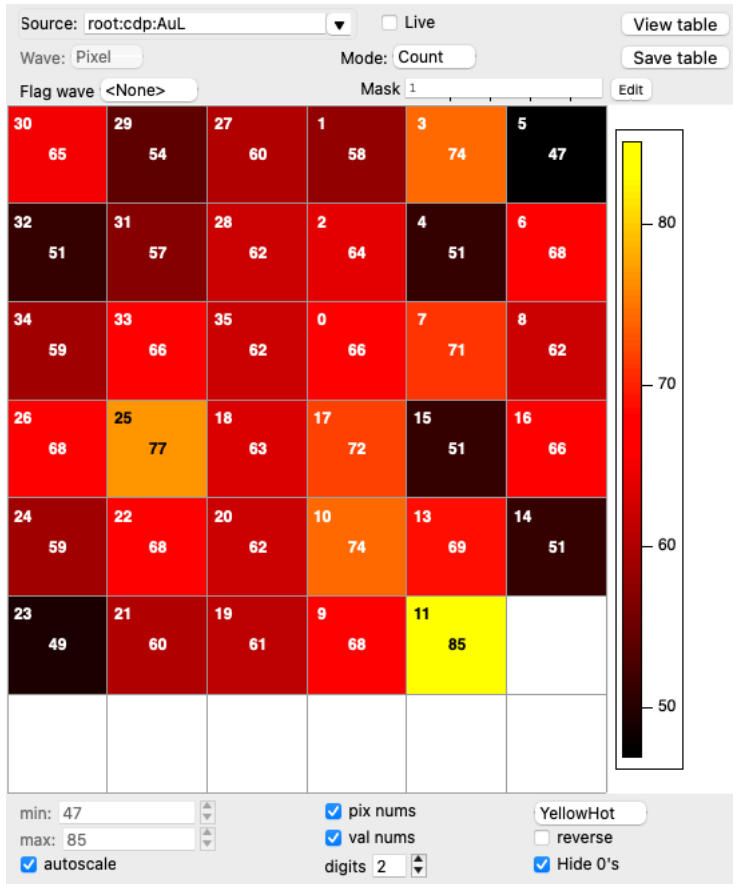


1 – 17 keV

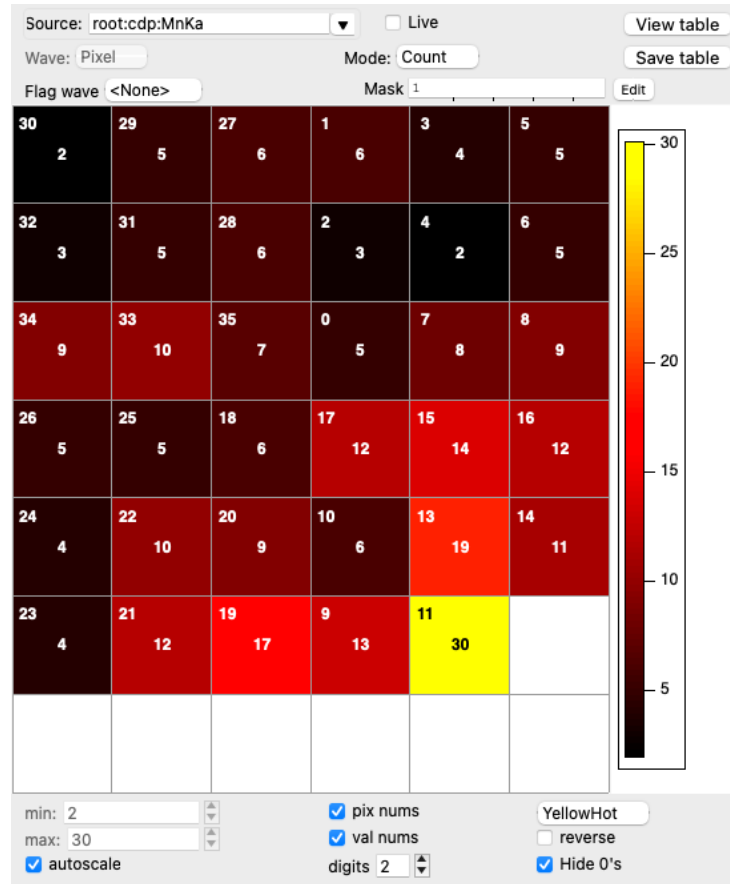
2 – 12 keV

3 – 5 keV (band w/o lines)

Non-uniformity



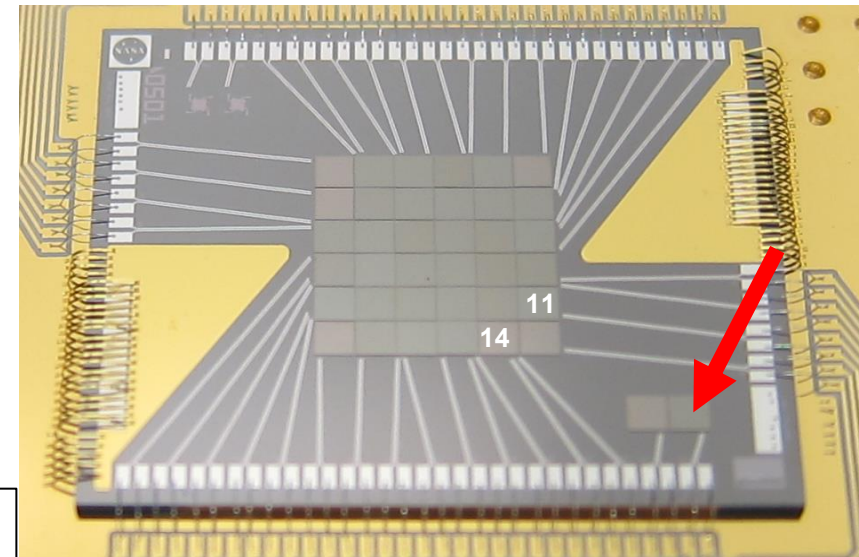
Au-L α , L β



5.88 – 5.91 keV (Mn K α)

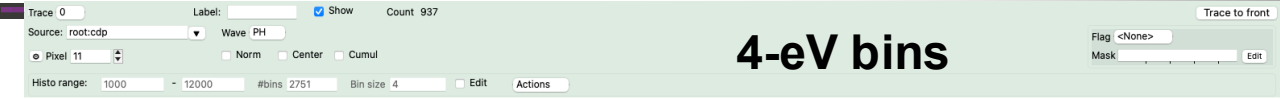
Mn non-uniformity significant despite the small number of counts.

Consider the pixels that only got 2 counts in a 30 eV bin in 4 Ms!

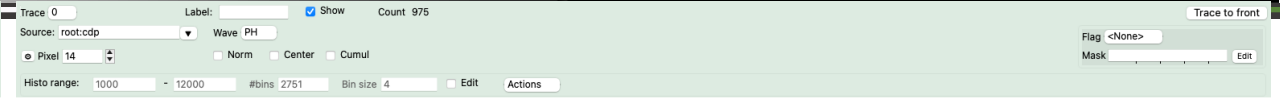
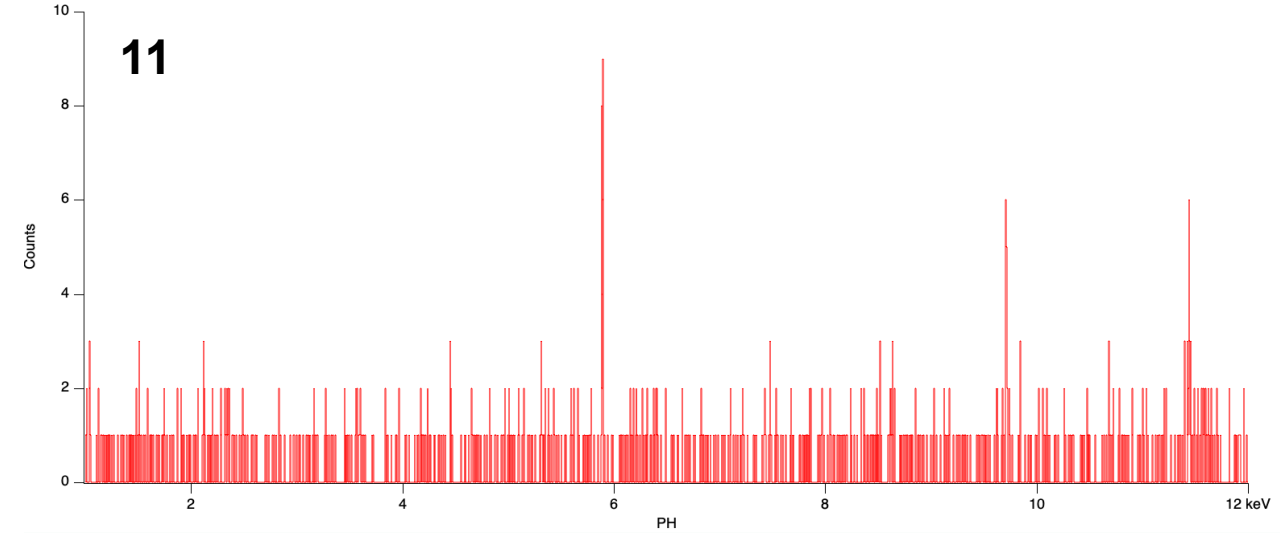


Spectra of outlier pixels

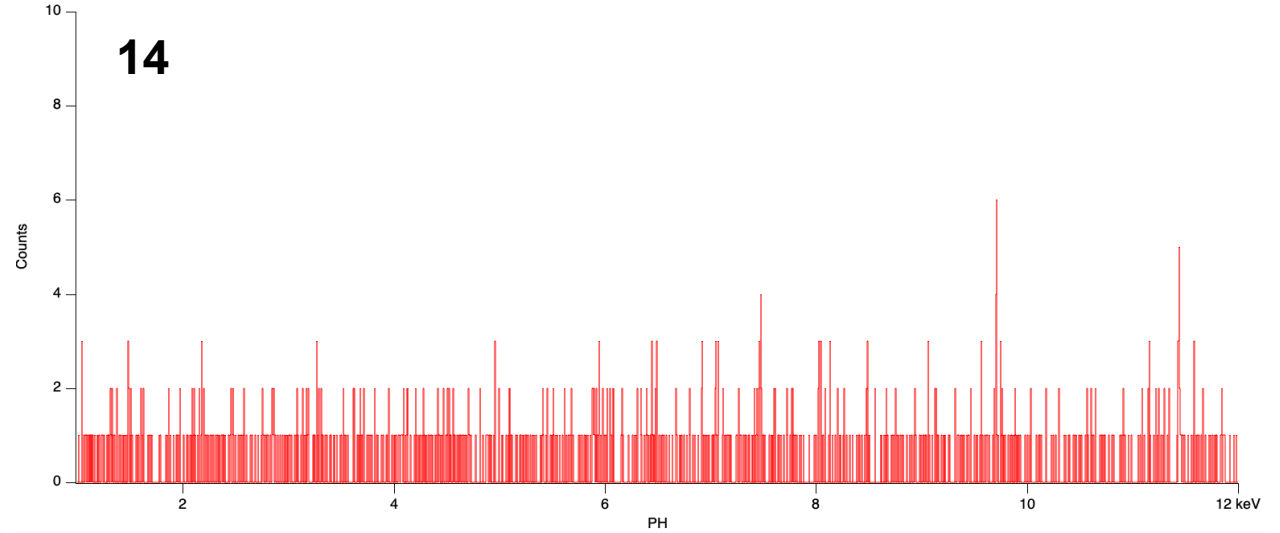
4-eV bins



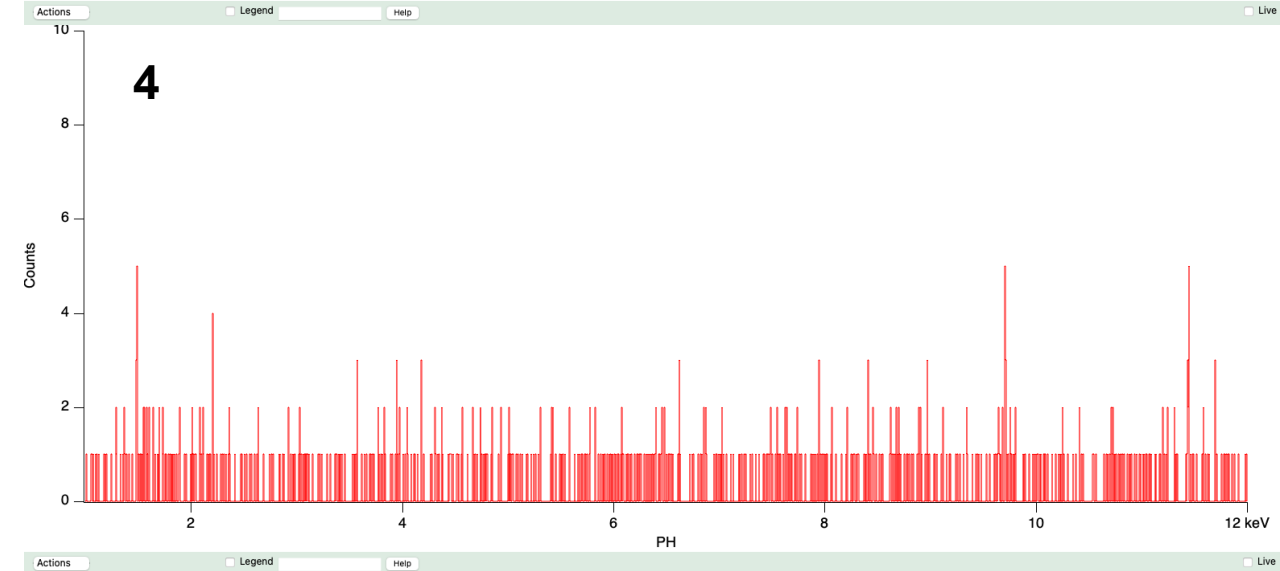
11



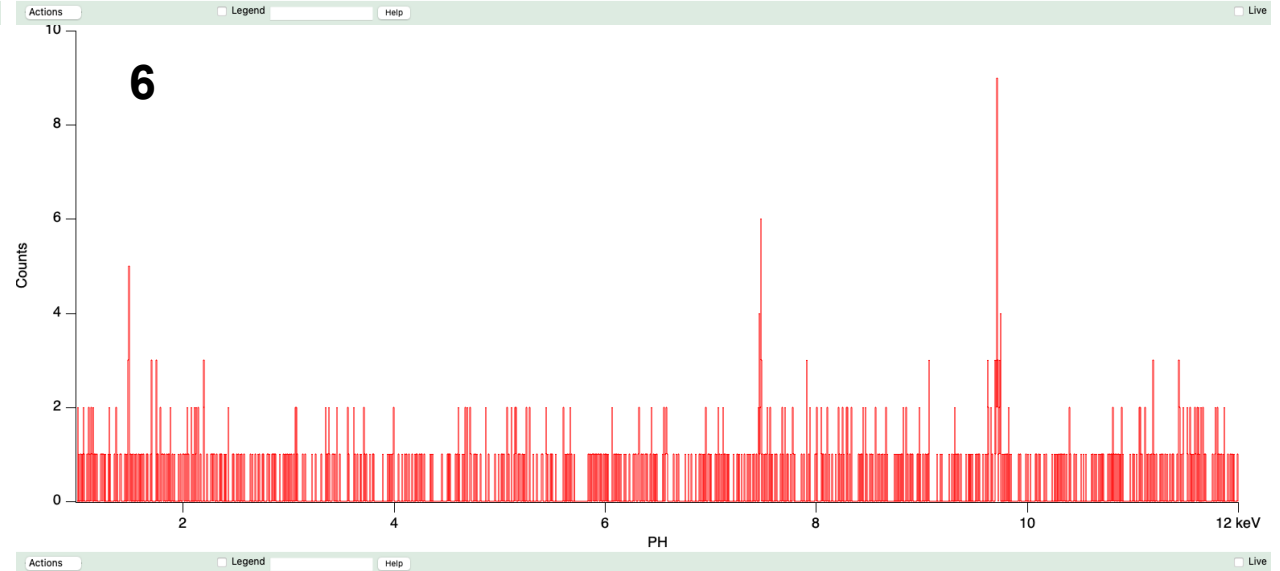
14



4



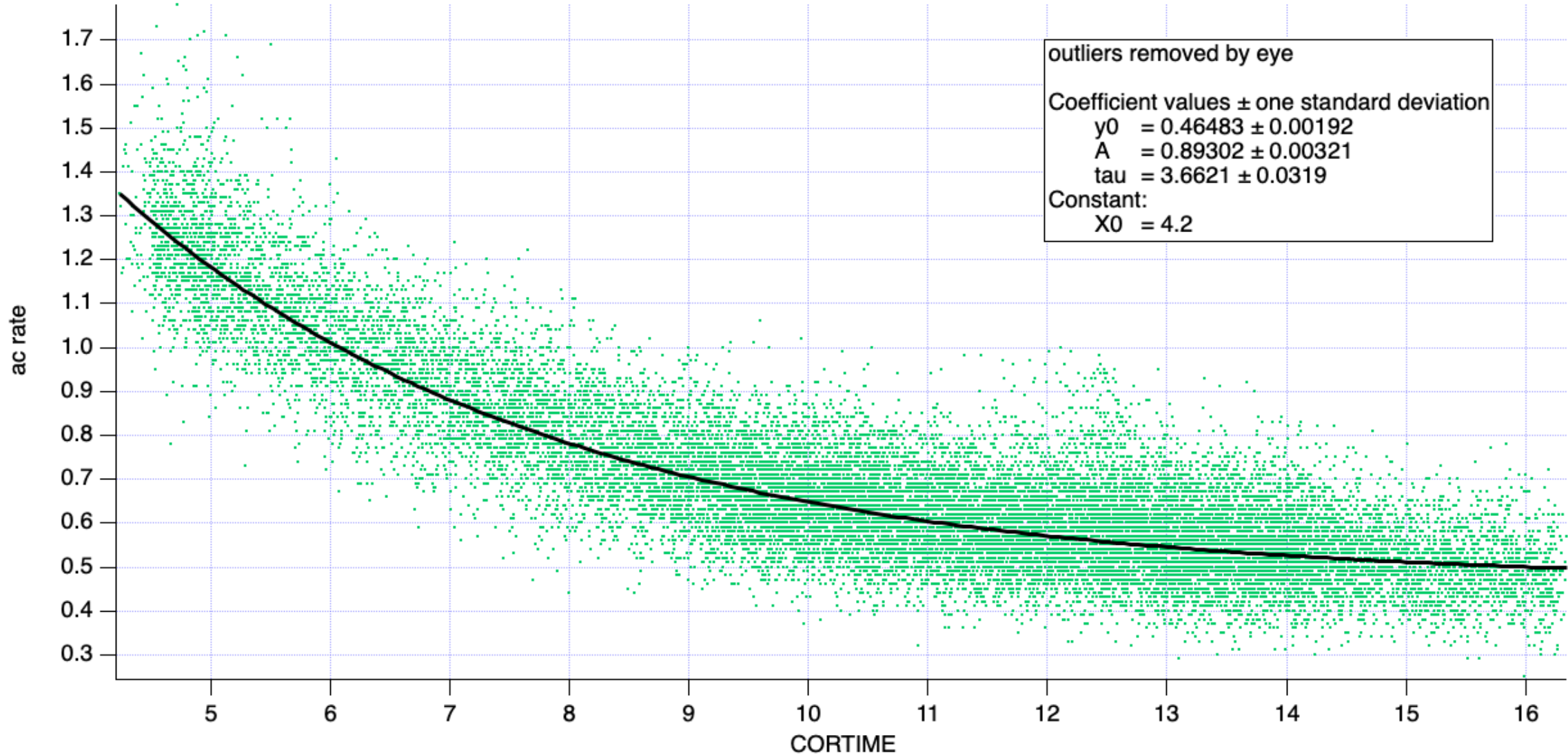
6



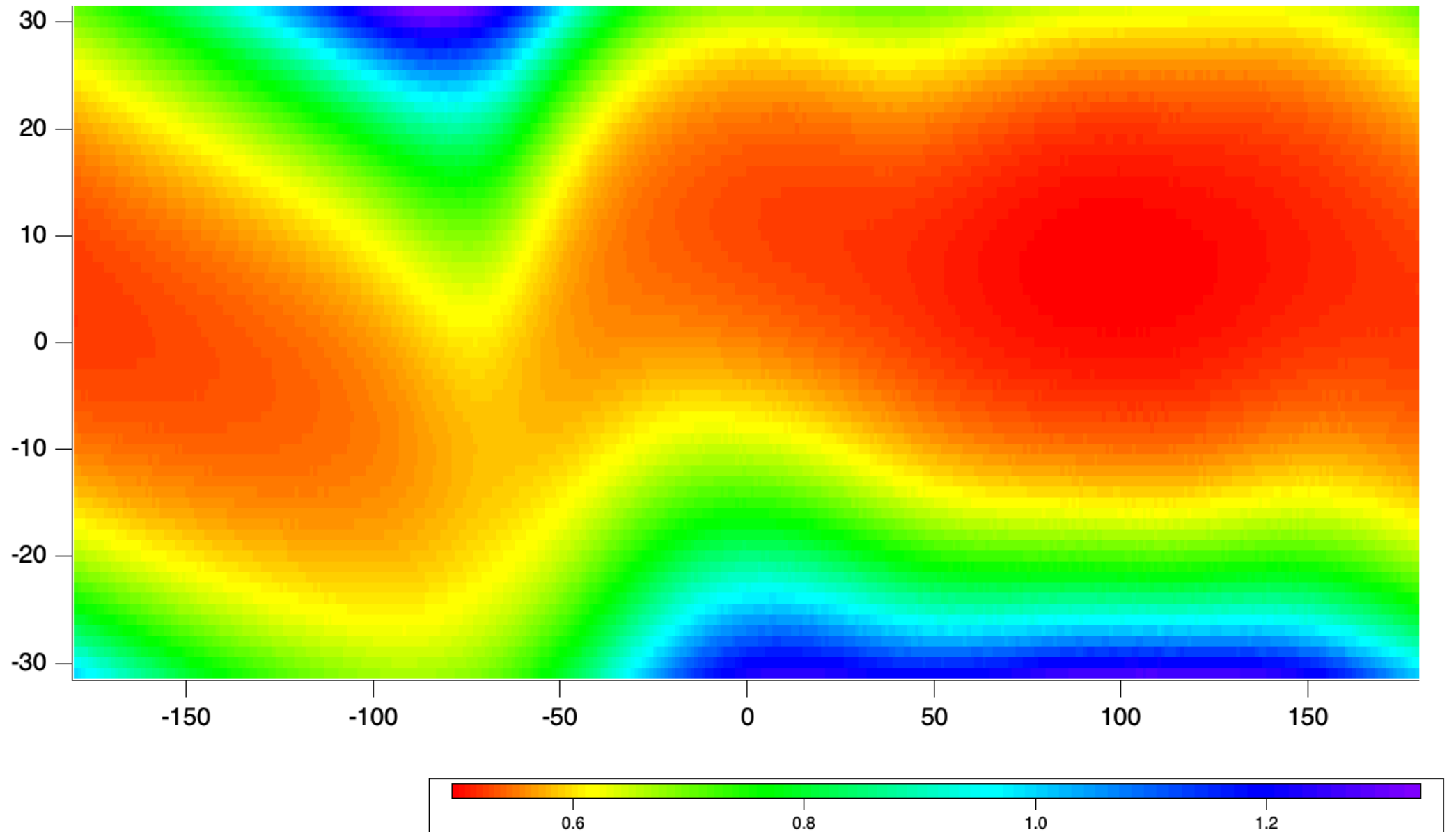
- Next steps
 - Plan to fit model to pixel groupings
 - inner/outer
 - quadrants
 - Continue correlation studies of array rate, anti-co rate, and COR done on v2 database
 - Look for time evolution
- Basic “problem” of low background rate and very high spectral resolution
 - Impossible to study dependence of high-resolution spectrum on time, COR, and pixel separately in a meaningful way, even with 4 Ms of data.
 - But we will continue to investigate parsing the Resolve NXB database into subsets useful for analysis of sources that are approaching background-limited.

bonus slides

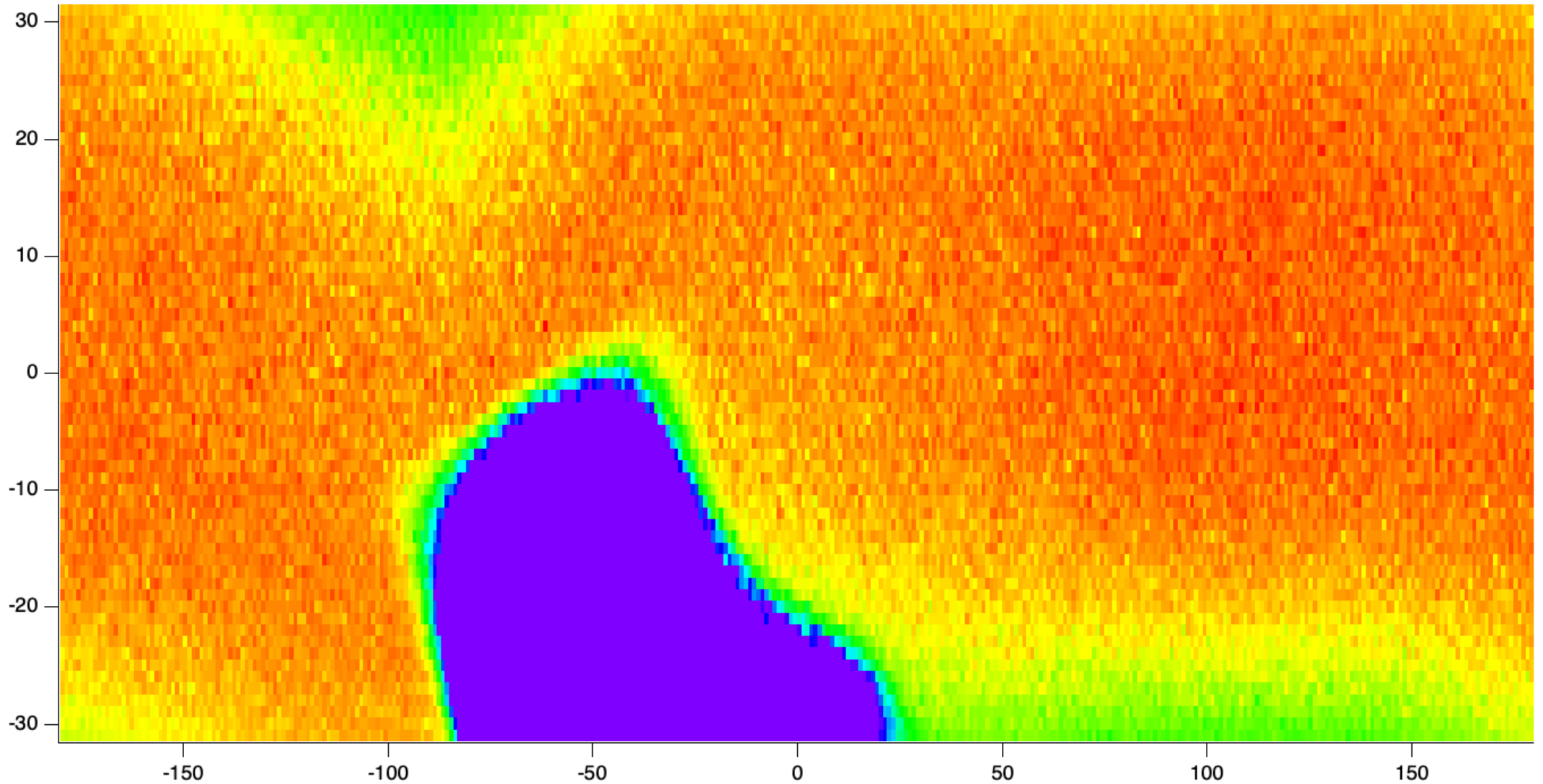
Anti-co rate vs COR (Resolve NXB v2)



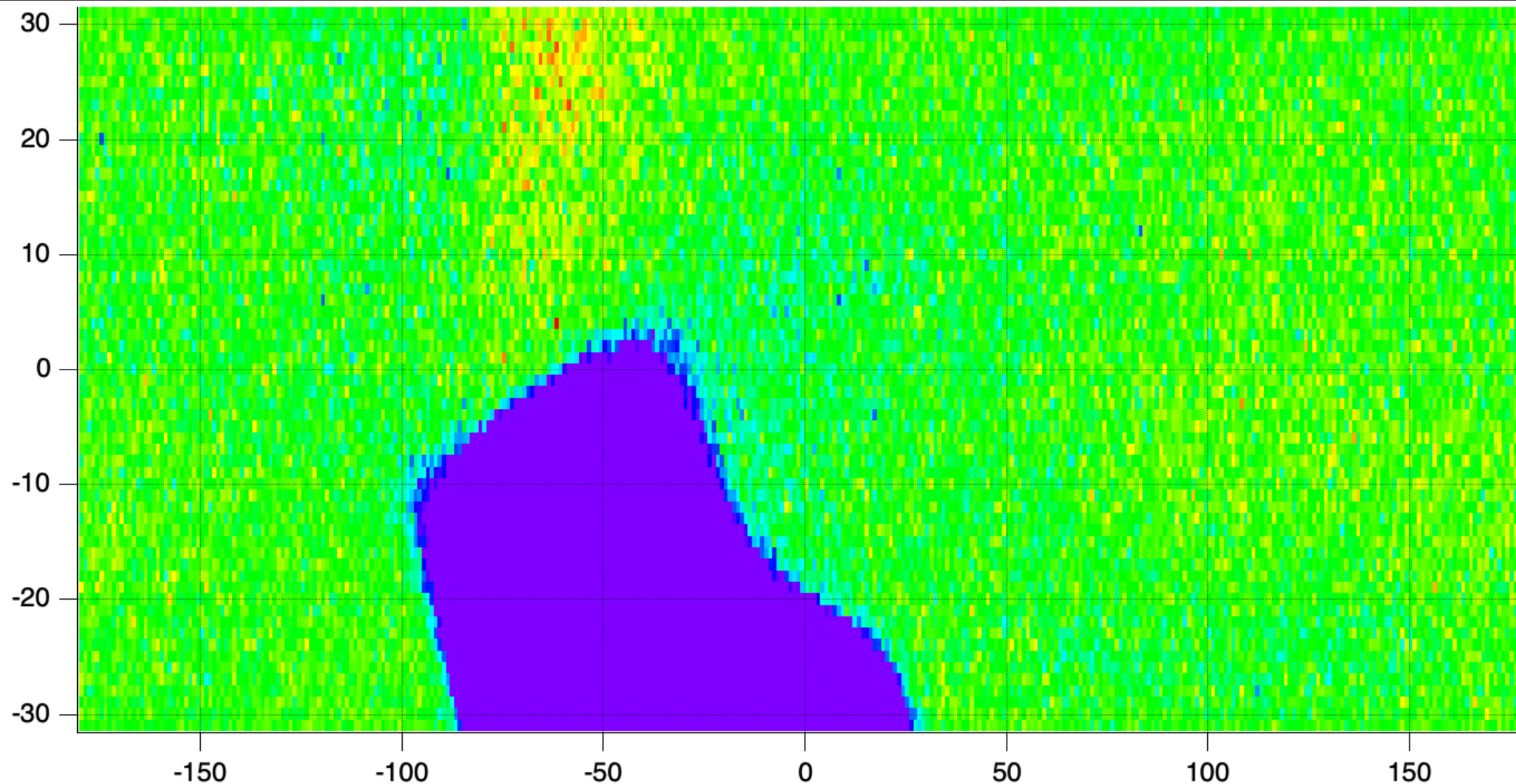
anti-co rate map if no SAA



real map of anti-co rate (linear, max at 3)



real anti-co rate – COR-derived anti-co rate



anti-co rate (from averaging EHK ANTRATE) - acrate(CORTIME) (from fit outside of SAA)
upper limit of scale = 5x standard deviation outside of SAA