XMM-Newton EPIC-pn

Updates to the Long-Term CTI corrections

XMM-EPIC CAL & OPS meeting, 3-4 June 2024

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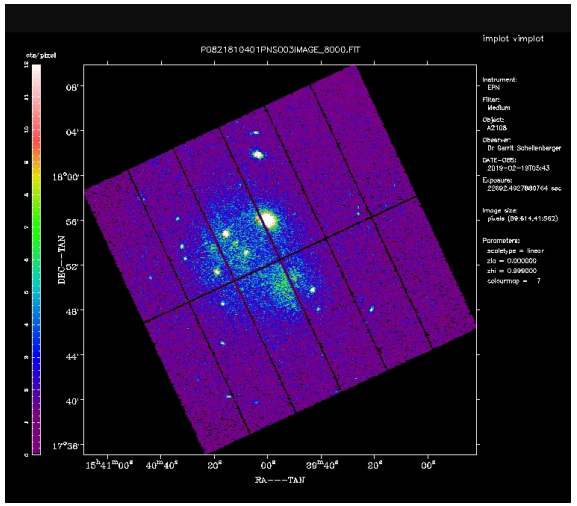
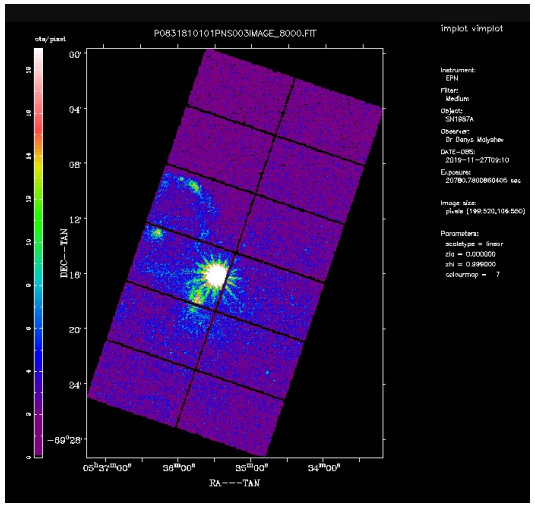
- CCF Release note XMM-SOC-CAL-SRN-0407
  - CCF file EPN_CTI_0058 already available
  - Bulk reprocessing

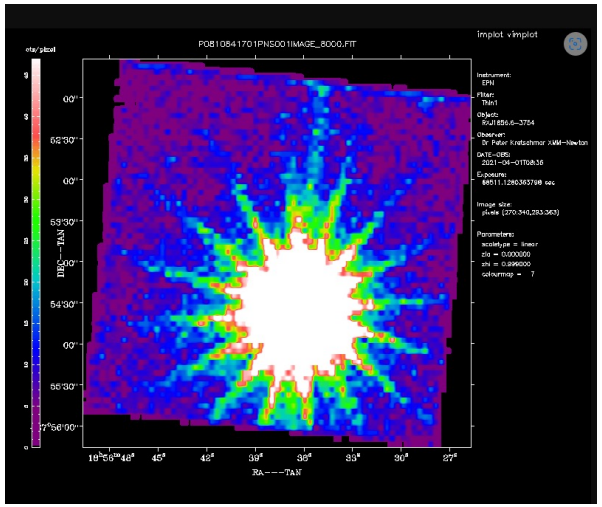
Full Frame and extended



Large Window

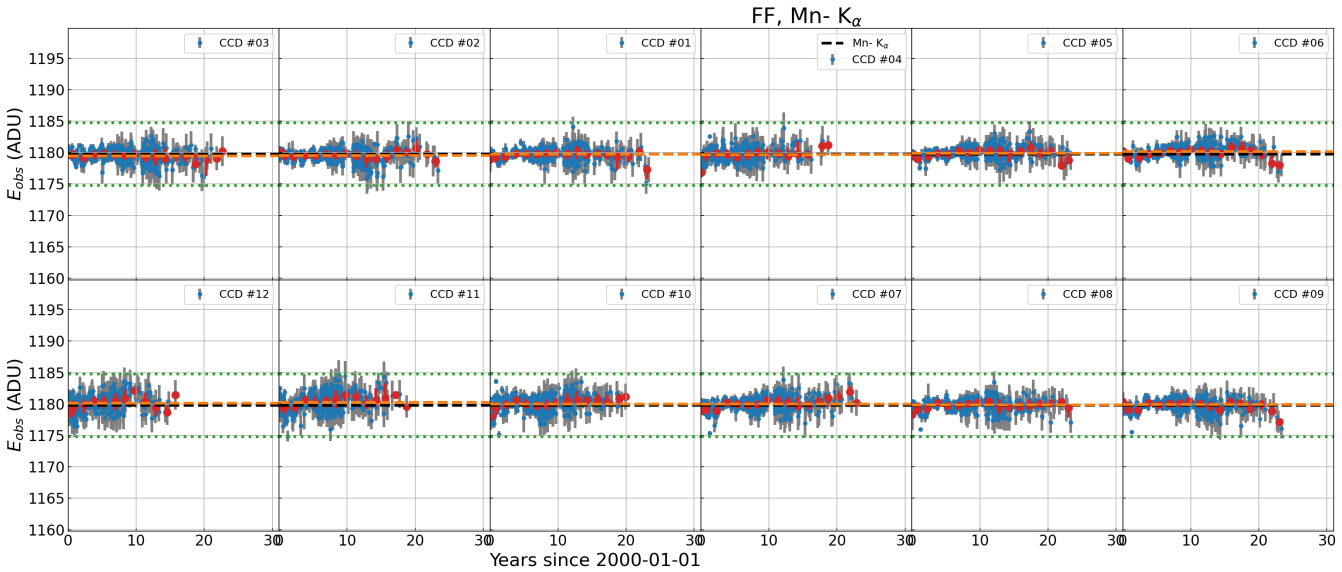


Small Window

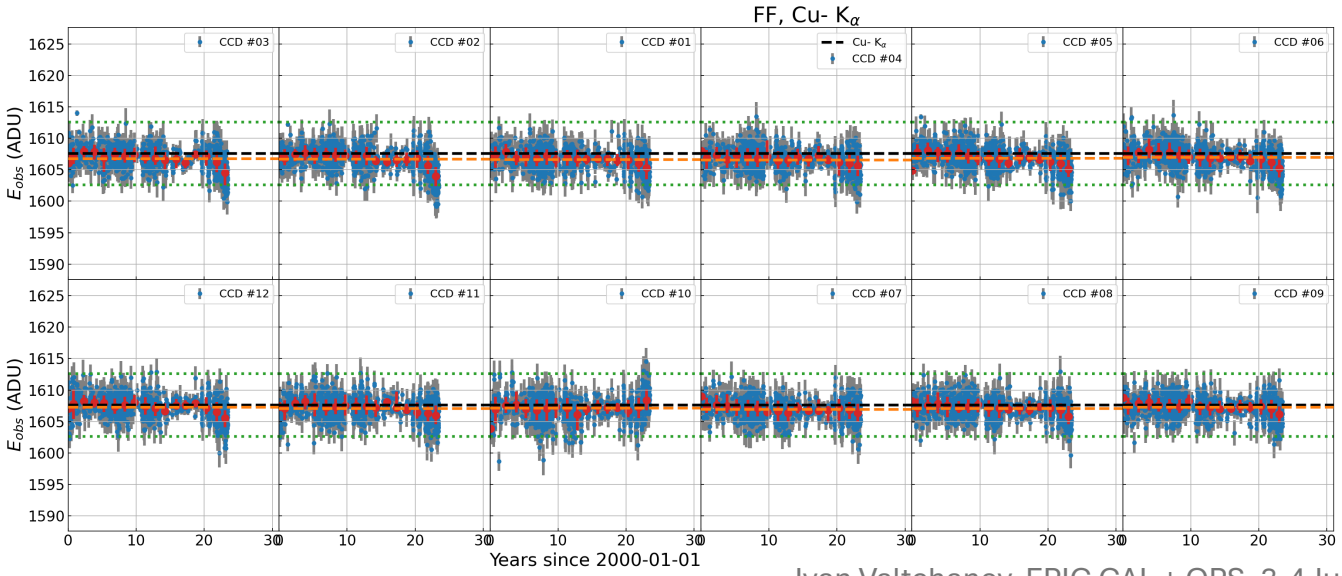


+ Timing and Burst modes

Need of an update



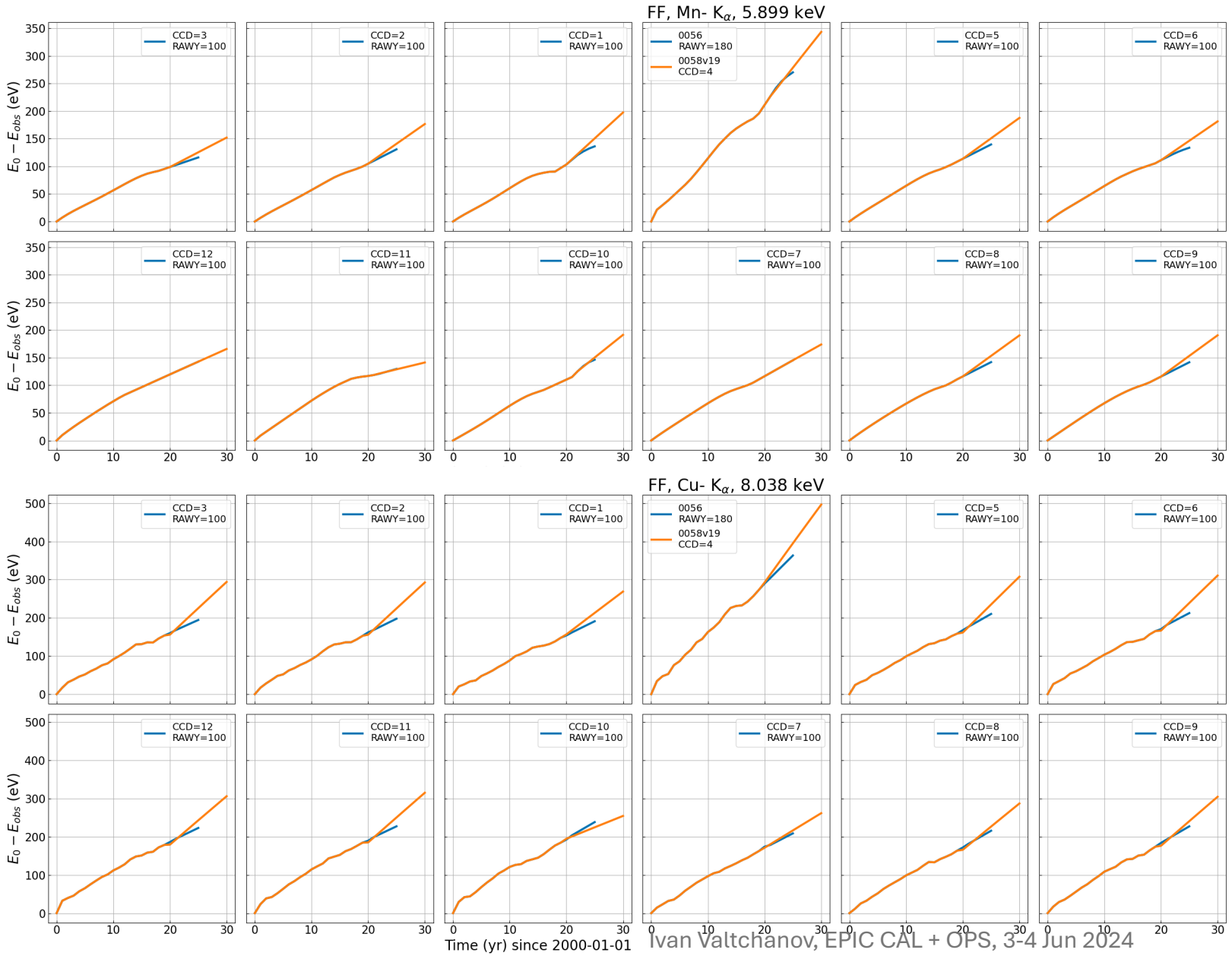
FF, Mn Kα



FF, Cu Kα, CalClosed only

0056 correction curves used data up to t=18 yr
➔ Obvious under-correction at t > 21 yr.

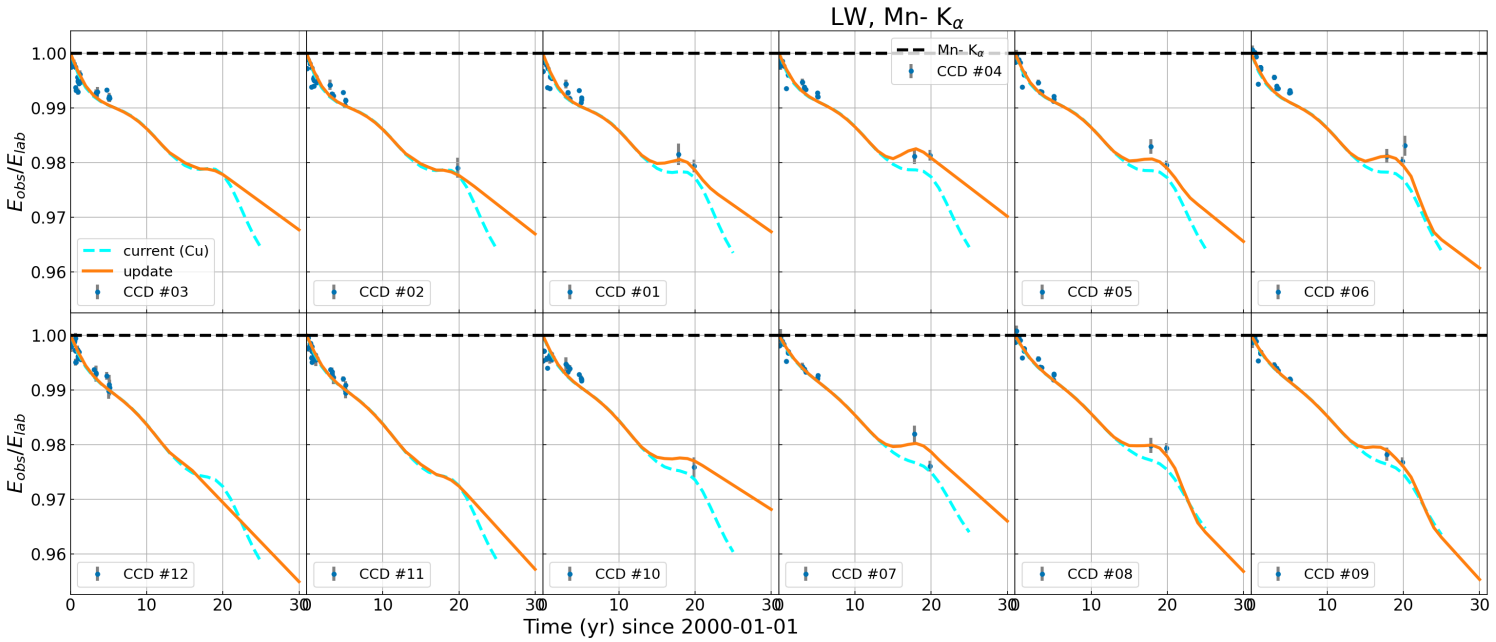
Empirical updates for t>18 yr, FF mode

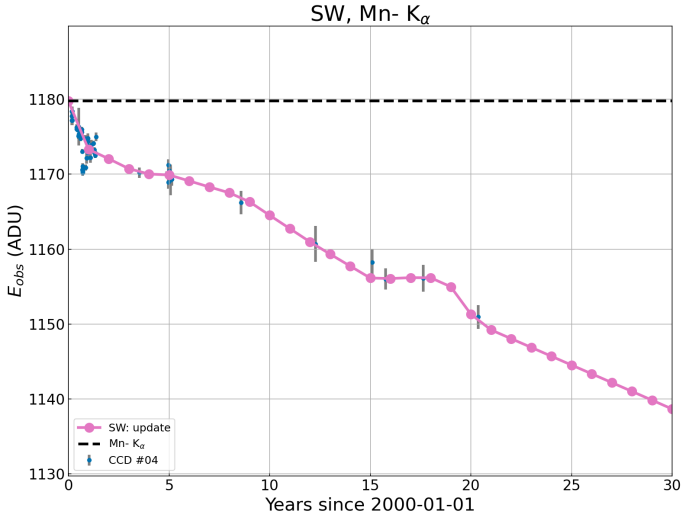


FF, Mn Kα

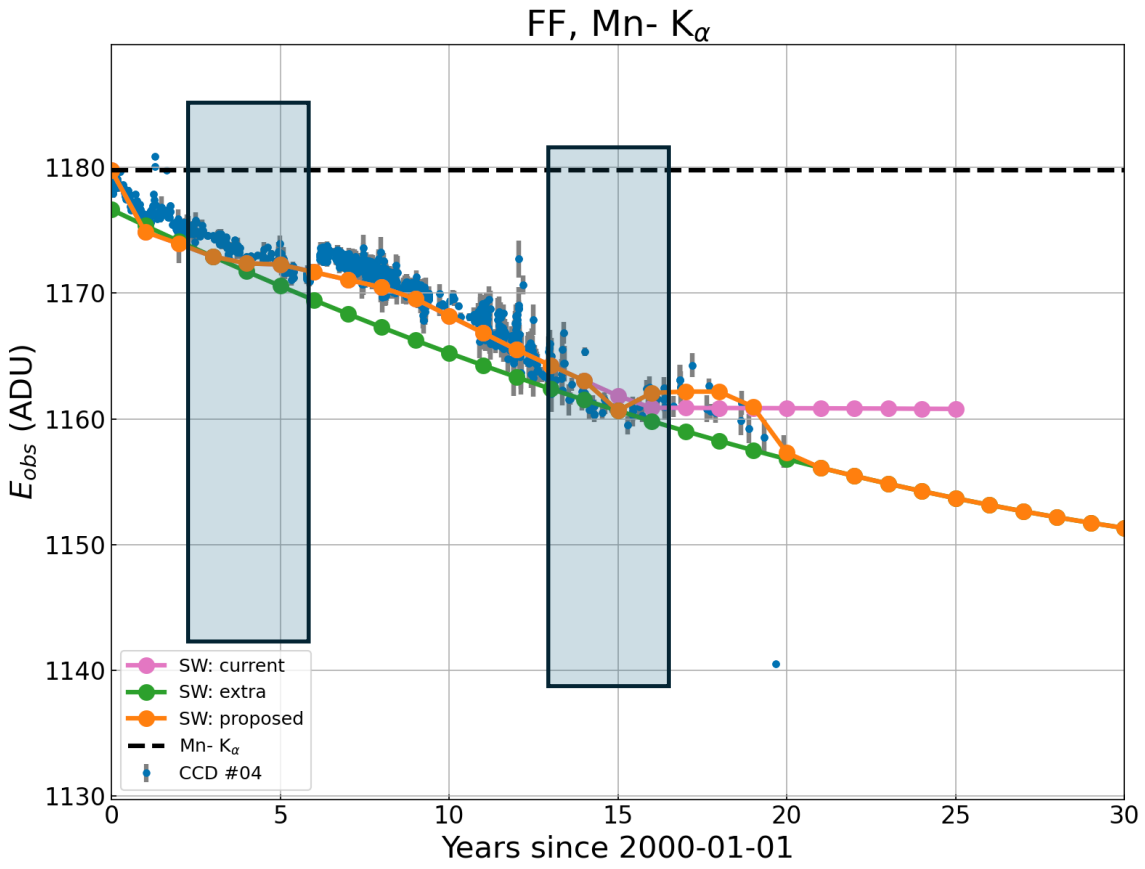
FF, Cu Kα

Large and Small Window modes





For SW and LW mode



No QPB correction available in LW and SW mode (see action EPIC-TTD-031/1)

Using FF CalClosed with no LTCTI and no QPB

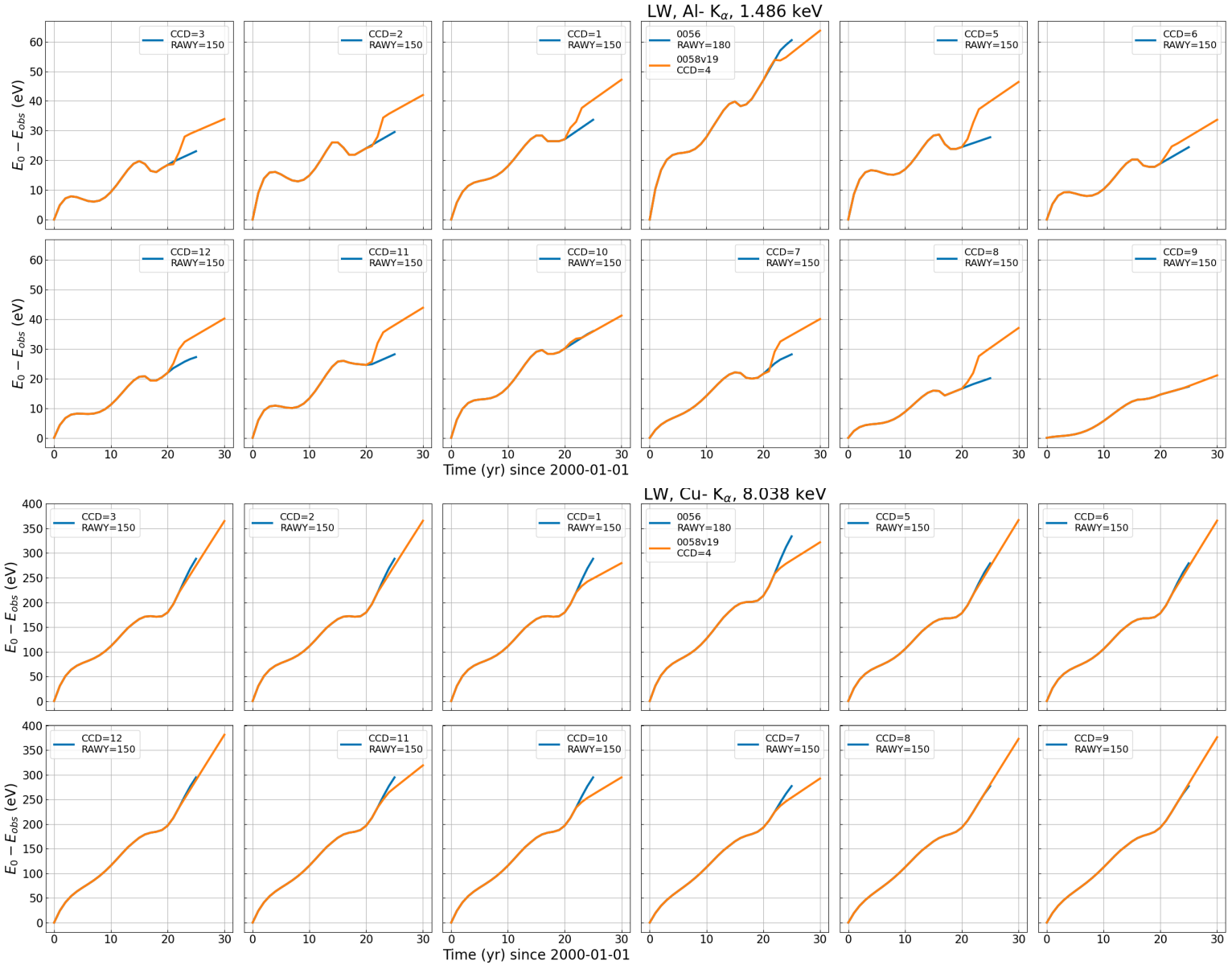
Poly(2) on solar minima

Residual as smooth spline

Keep the residual for each CCD and line

- Will use the residual shape for LW and SW mode
- Applicable to Al Kα, Mn Kα and Cu Kα
- Update for t>18 yr (in general)

Updated curves for LW mode



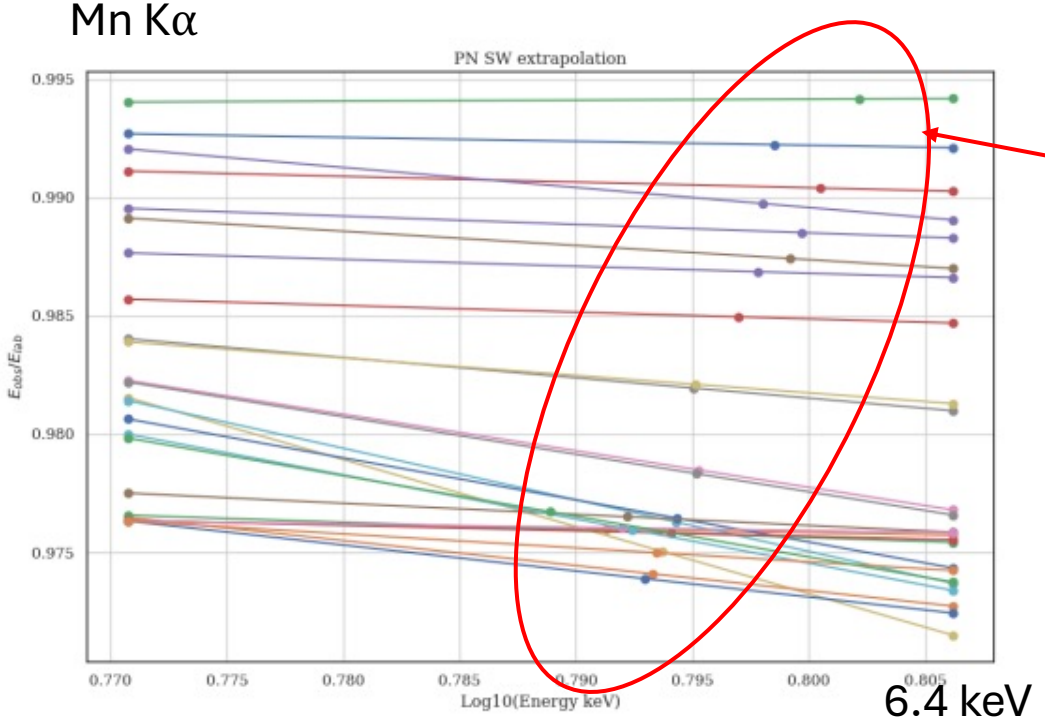
LW, Al Kα

LW, Cu Kα

Small Window (SW) change of strategy for Fe Kα

- Previously in CCF 0056, using ~10 AGNs with narrow Fe Kα lines
  - Extrapolation to a common reference energy 6.4 keV, sources at different redshifts ➔ lines at different energies

Mn Kα



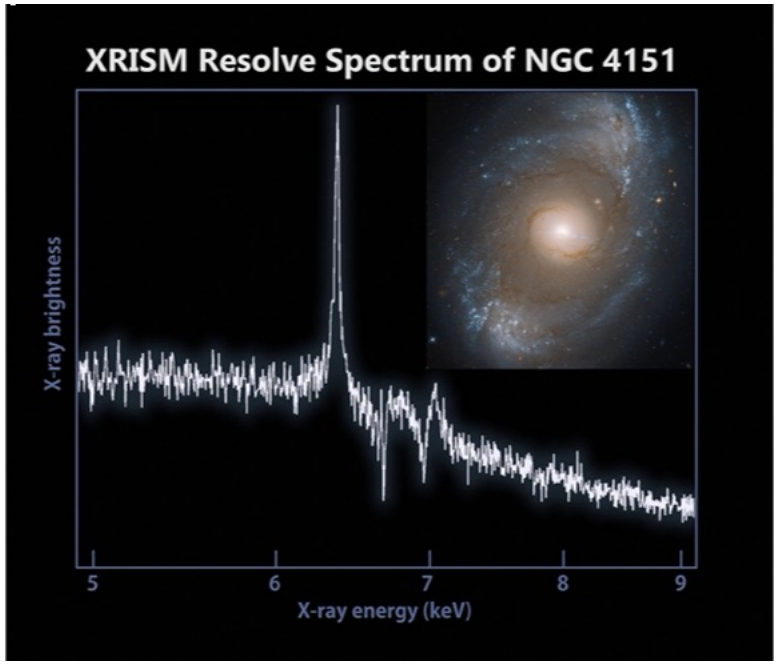
Redshifted Fe Kα lines

6 keV

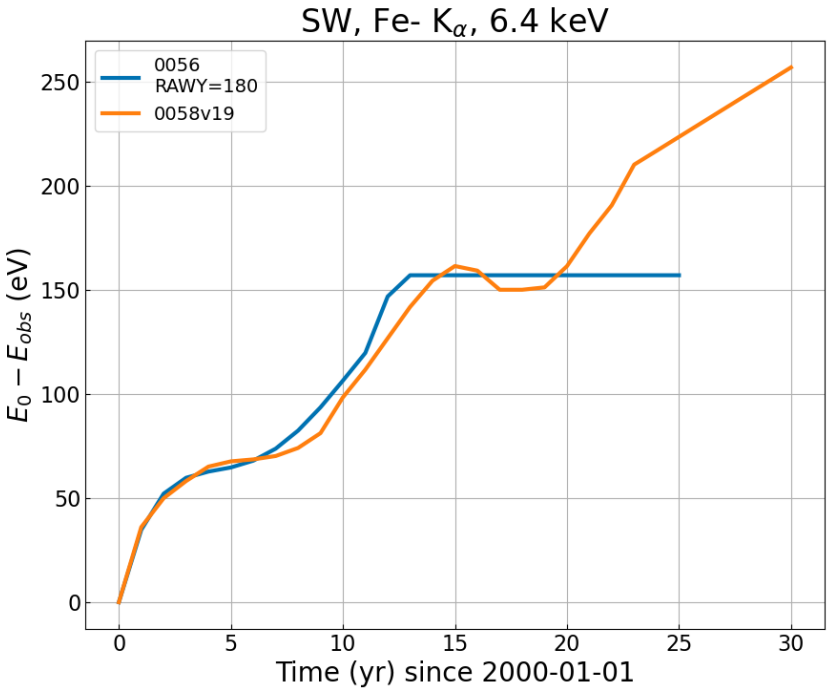
6.4 keV

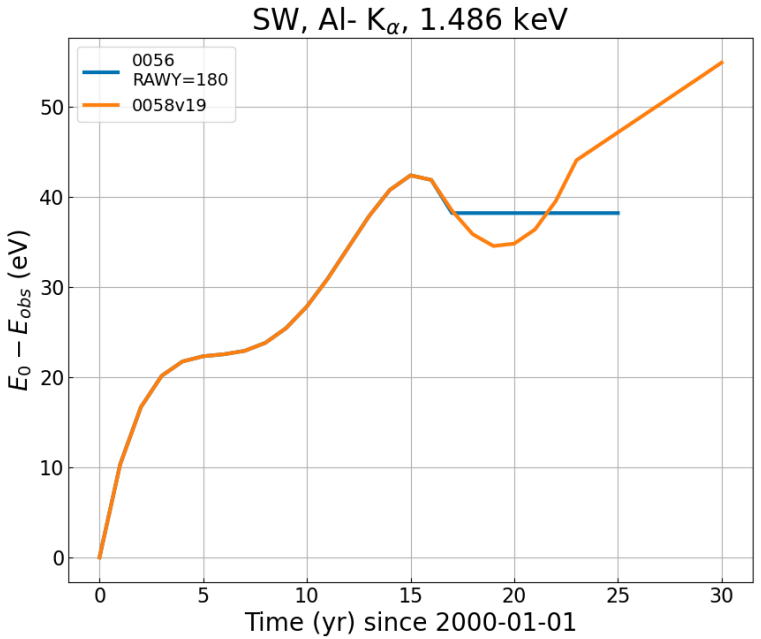
SW at 6.4 keV, using NGC 4151

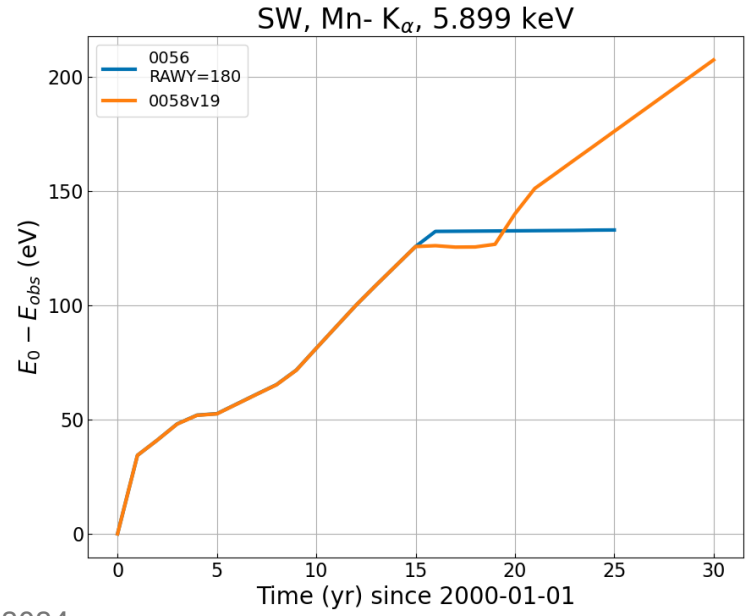
- In this update: using only NGC4151, to avoid extrapolation
  - Several observations, most recent one at t=22.96 yr
  - + some with Chandra HETG (XRISM too)
  - **Reference energy** = best-fit line centroid from HETG at t=0.1 yr,
    ➔ E = 6.3752 keV
- Using the Mn Kα, SW curve and adjust to NGC4151 data
- Validate with other AGN sources: NGC3516, MCG05-23-16,…



SW curve at 6.4 keV

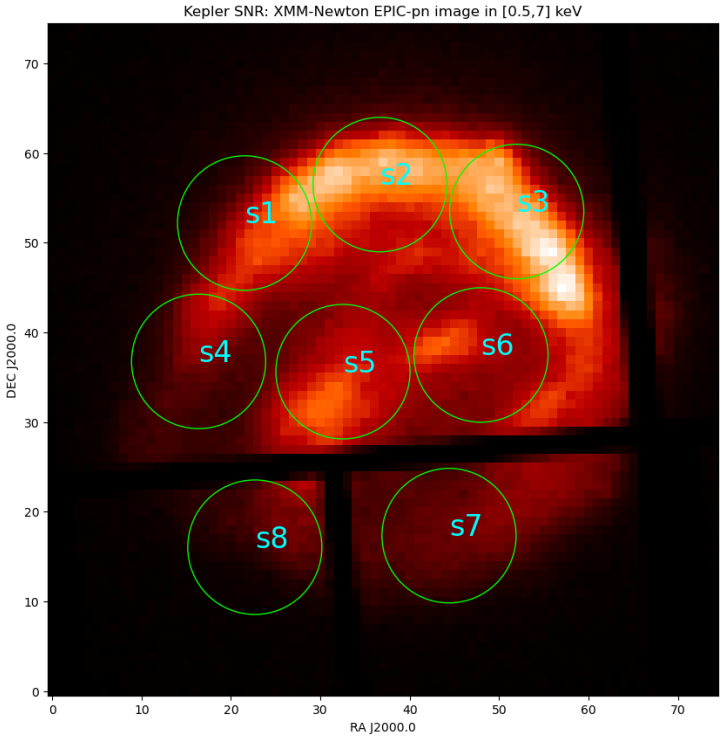




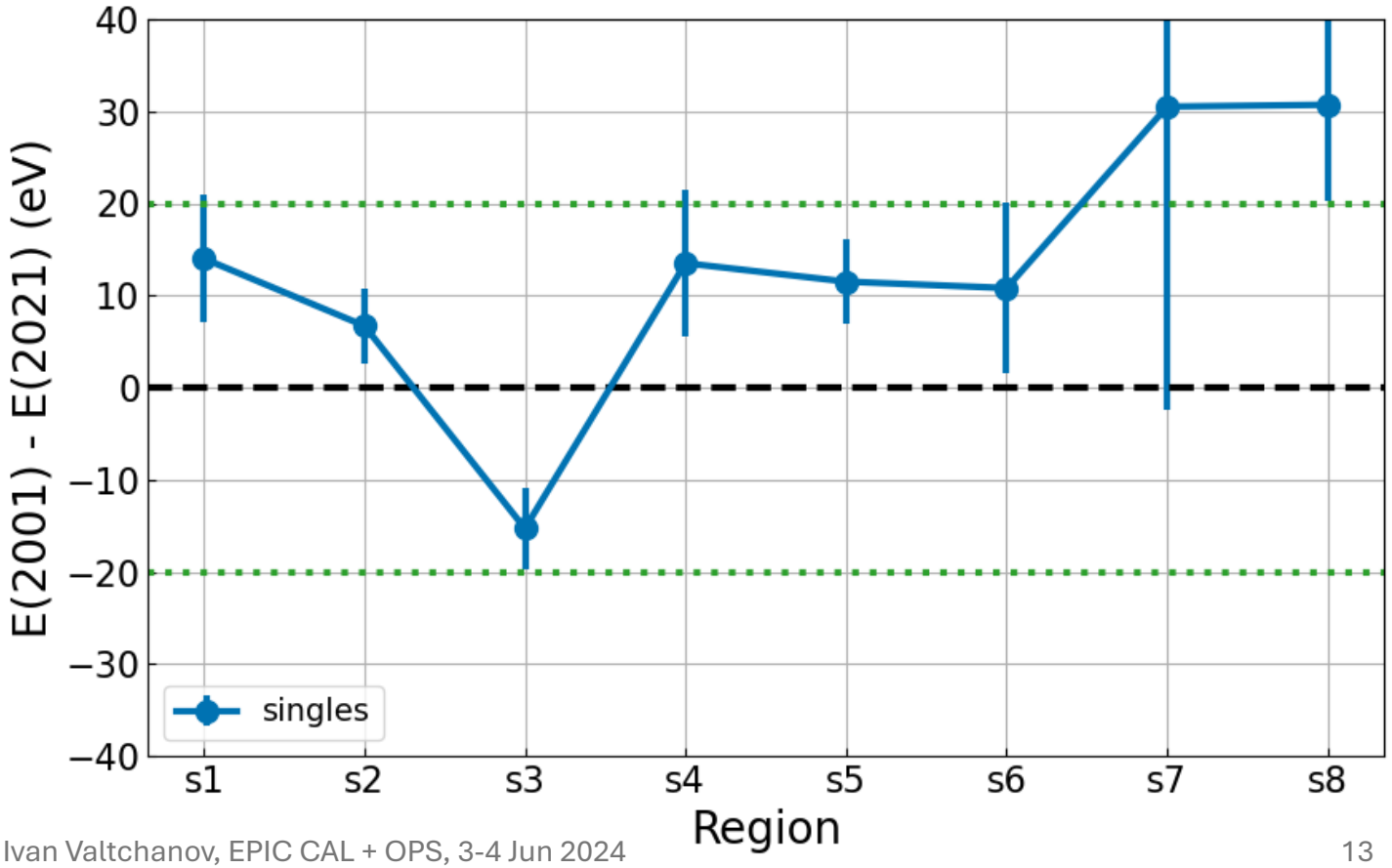


Validation

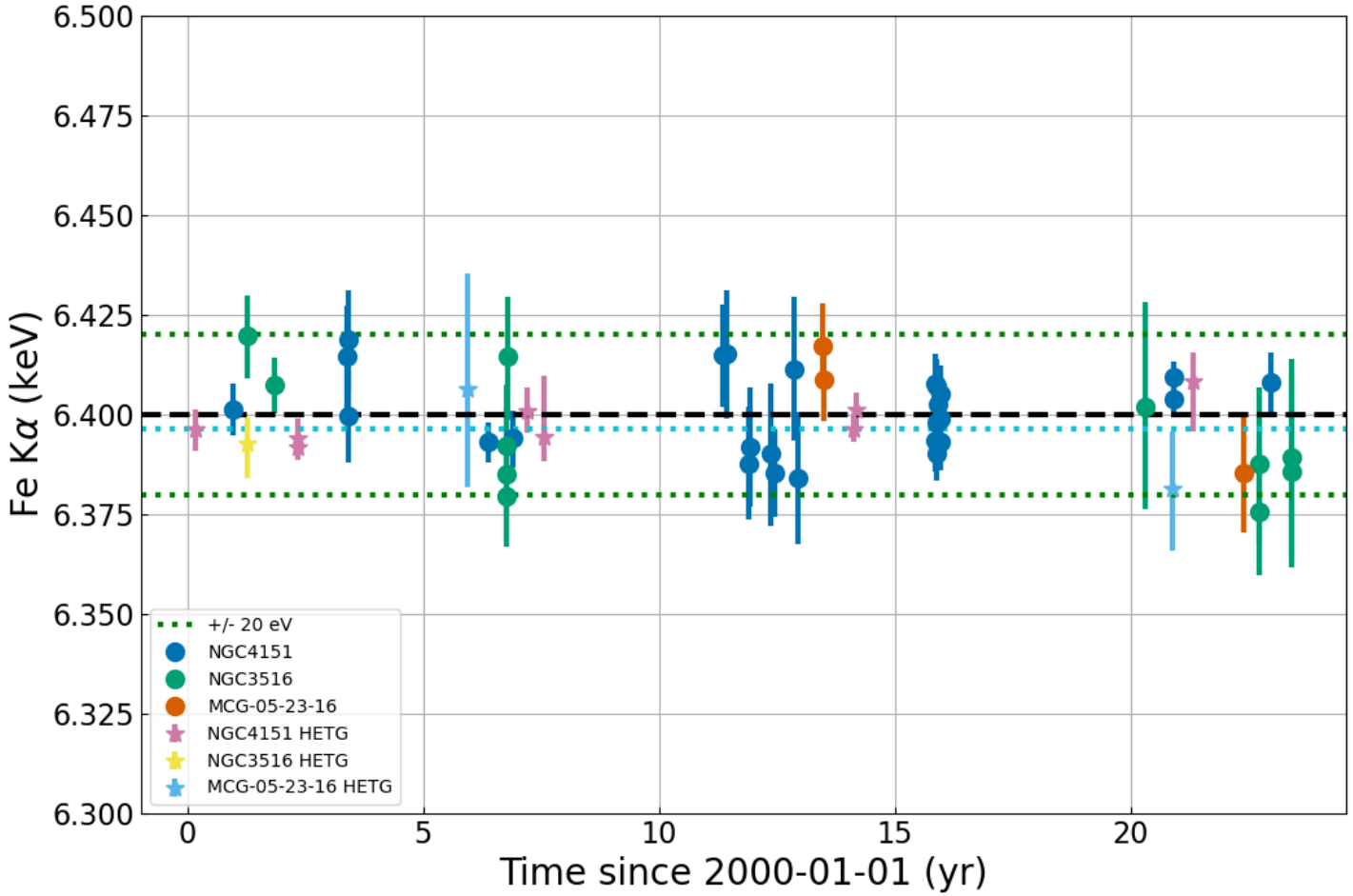
Validate LW at 6.4 keV with Kepler SNR



Fe Kα line, per region



SW at 6.4 keV



Best-fit Fe Kα lines for AGN sources

EPIC-pn in SW and Chandra HETG

Conclusions

- Incremental update to all EPIC-pn modes (including TI + BU)
  - Extrapolation to t=30 yr
  - Change in SW modelling at 6.4 keV (using only NGC4151)
    - Change of reference energy to 6.3752 keV
  - Used in the bulk reprocessing of the XMM archive.

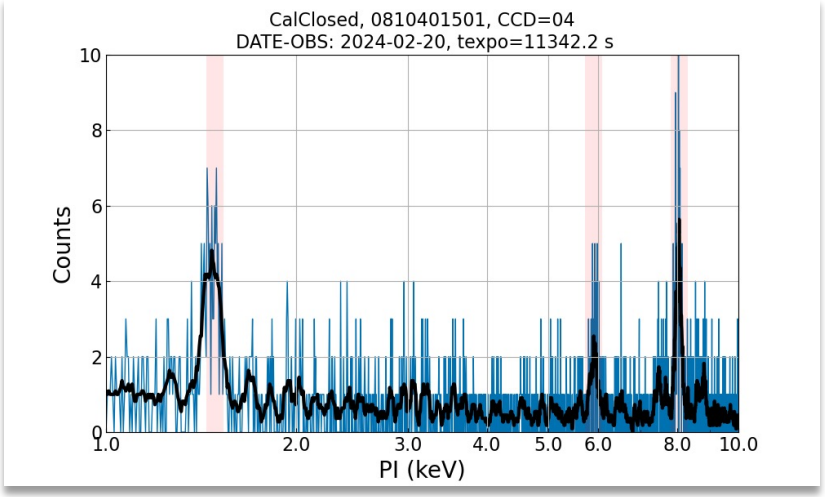
Future work

- Proposal to stop serendipitous CalClosed (CC) observations (to save filter wheel movements)

  ➔ challenging for energy scale calibration

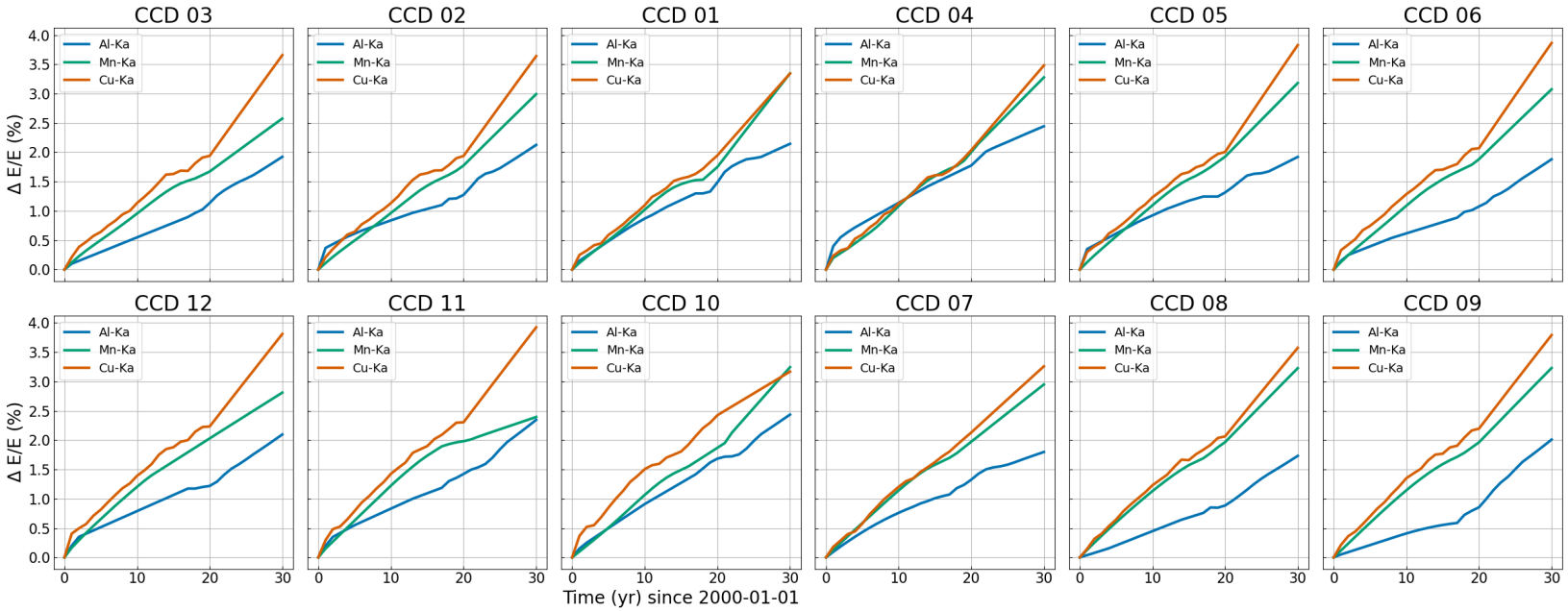
  ➔ + the weaker Fe-55 source

  ➔ planning of cal observation with long CCs once or twice per year? Under analysis.



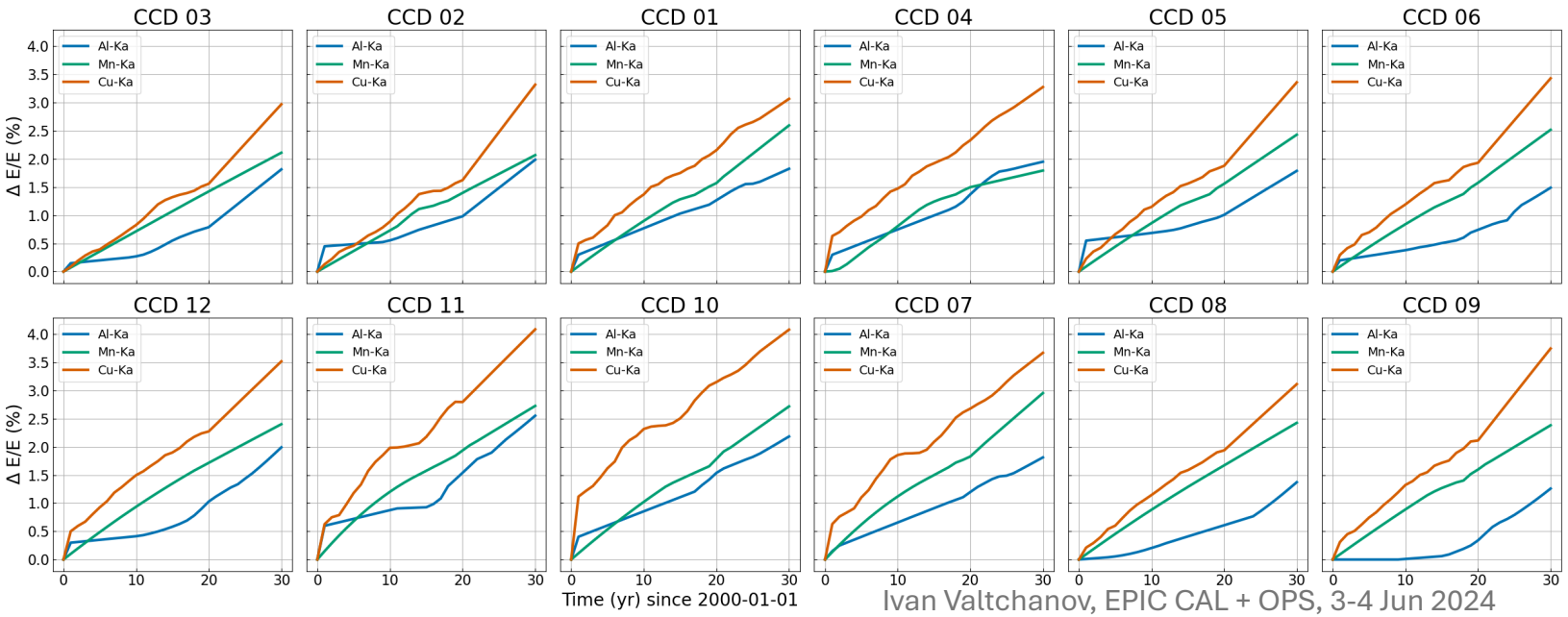
- Simultaneous QPB & LTCTI correction for future updates
  - Using the number of discarded lines as proxy for QPB (will be available for window modes)
  - Using Cu Kα to predict Al Kα and Mn Kα (low S/N for Cal source)

- Update the spatial CTI ?

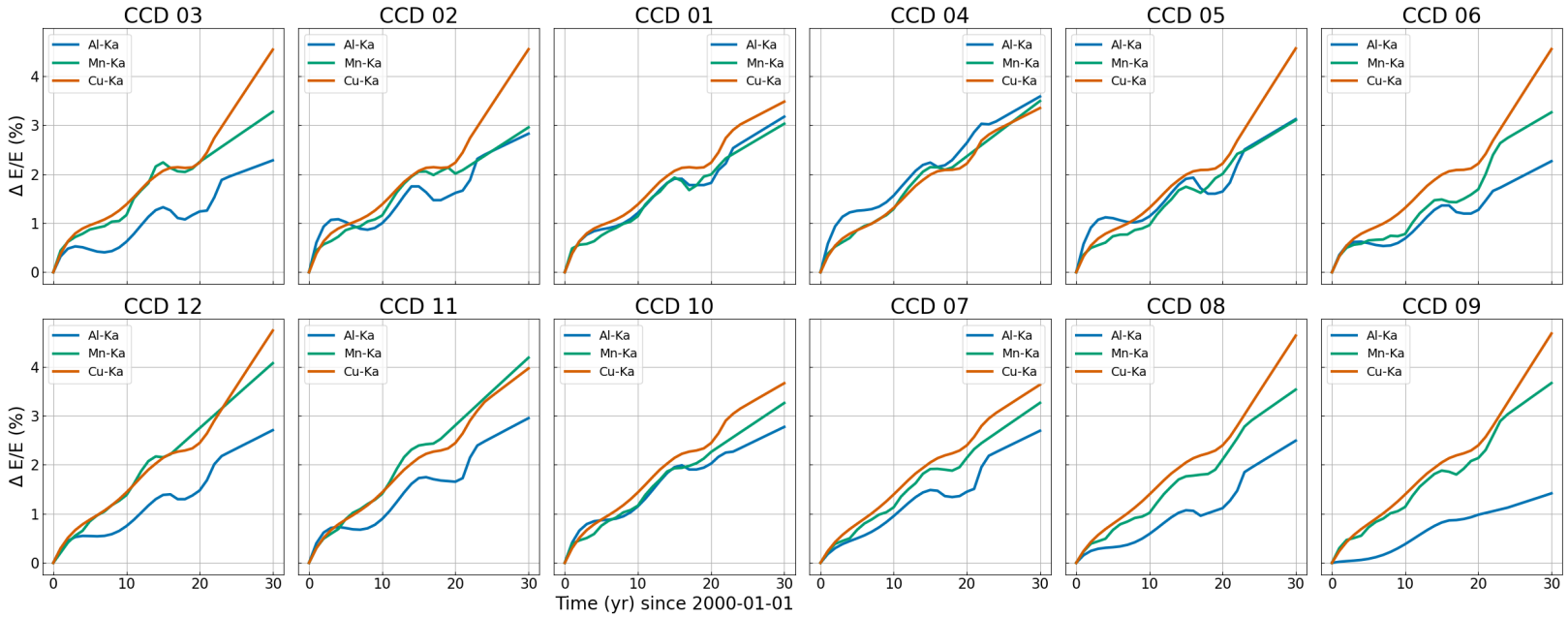


Predicted LTCTI **Δ**E/E in %

FF mode

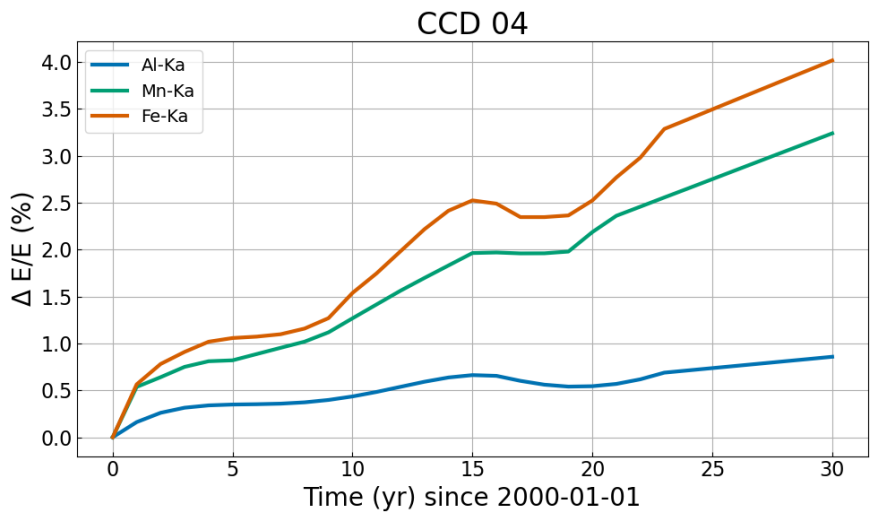


EFF mode



LW mode

SW mode



The End

Comparing the curves

$$\Delta E(t, y, E_0) = E_0 \times \left[1 - \left(\frac{1 - g(t)}{1 - a_0}\right)^y\right],$$

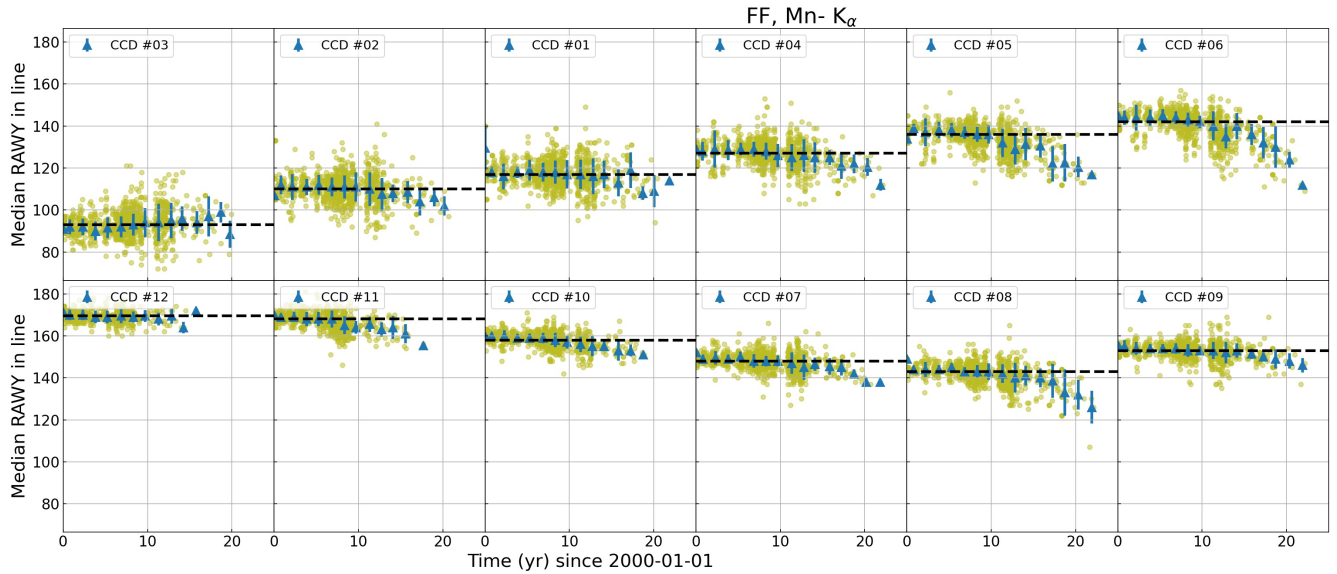
E_0 is the correct line energy,
g(t) is the T_COEFF curve in CCF,
a_0=T_COEFF(0),
y= Distance from read-out node in RAWY in pixels.

Discussion

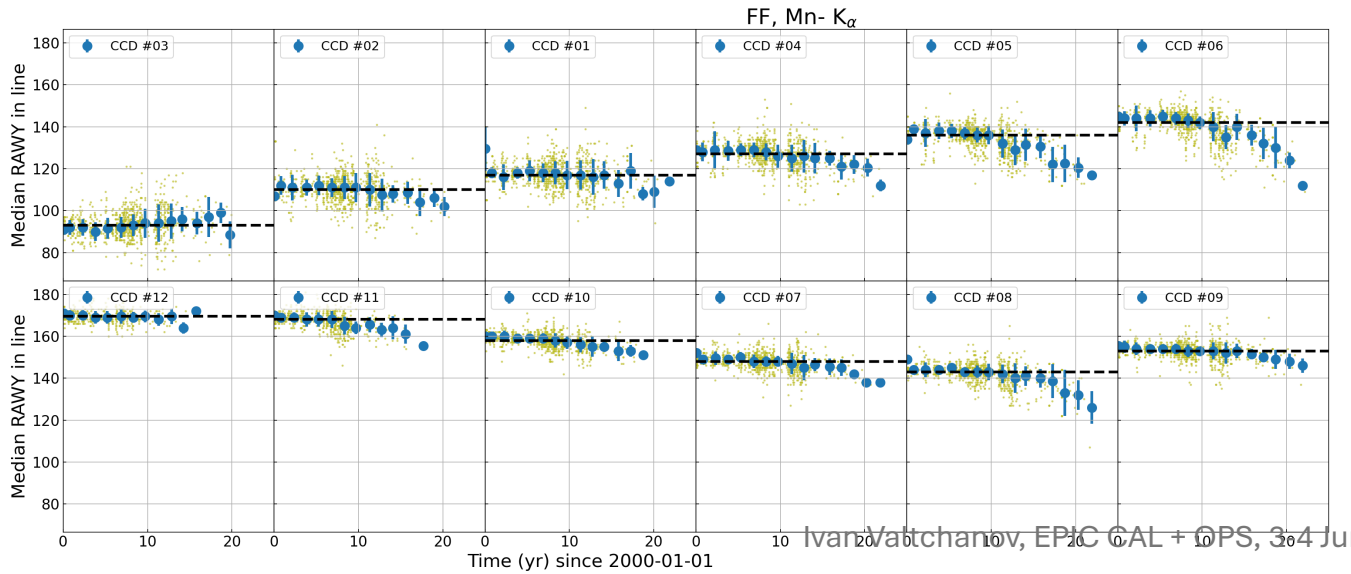
- Incremental update: CCF needed for bulk reprocessing
- Modelling E_{obs}/E_0 and using median RAWY in line core ➔ 😟
- Modelling T_COEFF (median RAWY per observation) ➔ 😟
- Need to understand why:
  - Median RAWY in line core (±1σ) as function of time
  - Normalisation a_0 ➔ in some cases it needs changing

- Work in progress + simultaneous QPB & LTCTI correction for future updates

Median RAWY evolution



Time dependence



Exponential function on RAWY !

Linked to decreasing S/N?