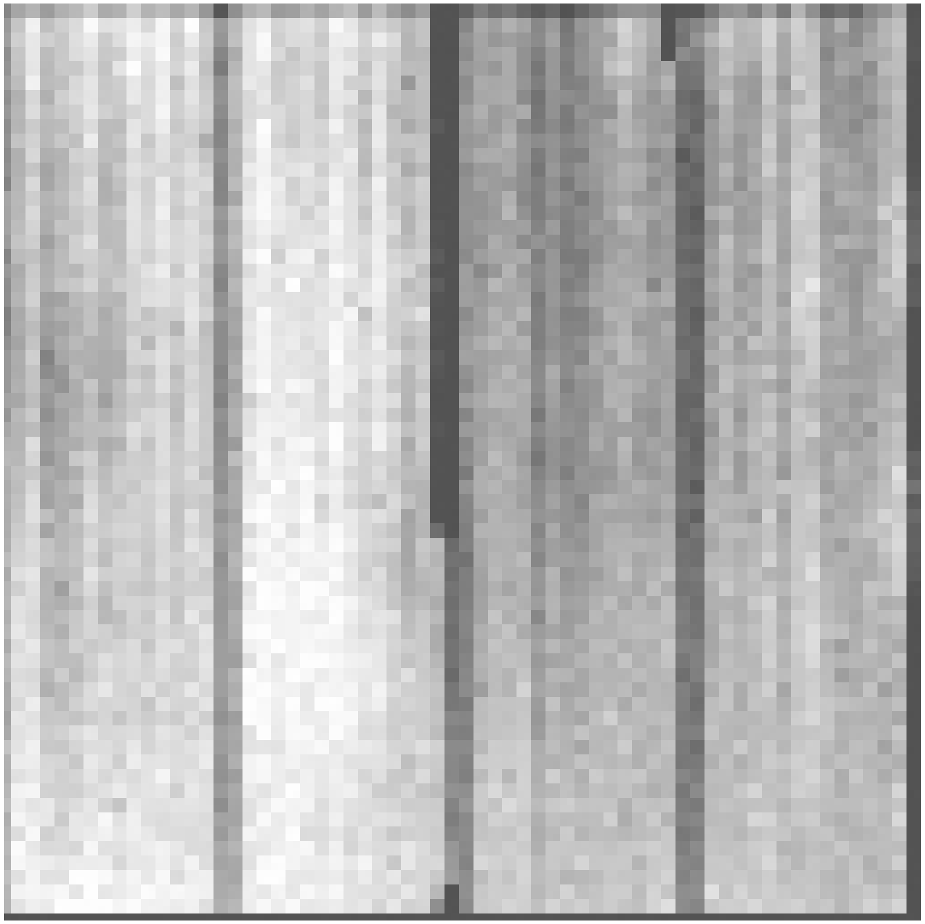
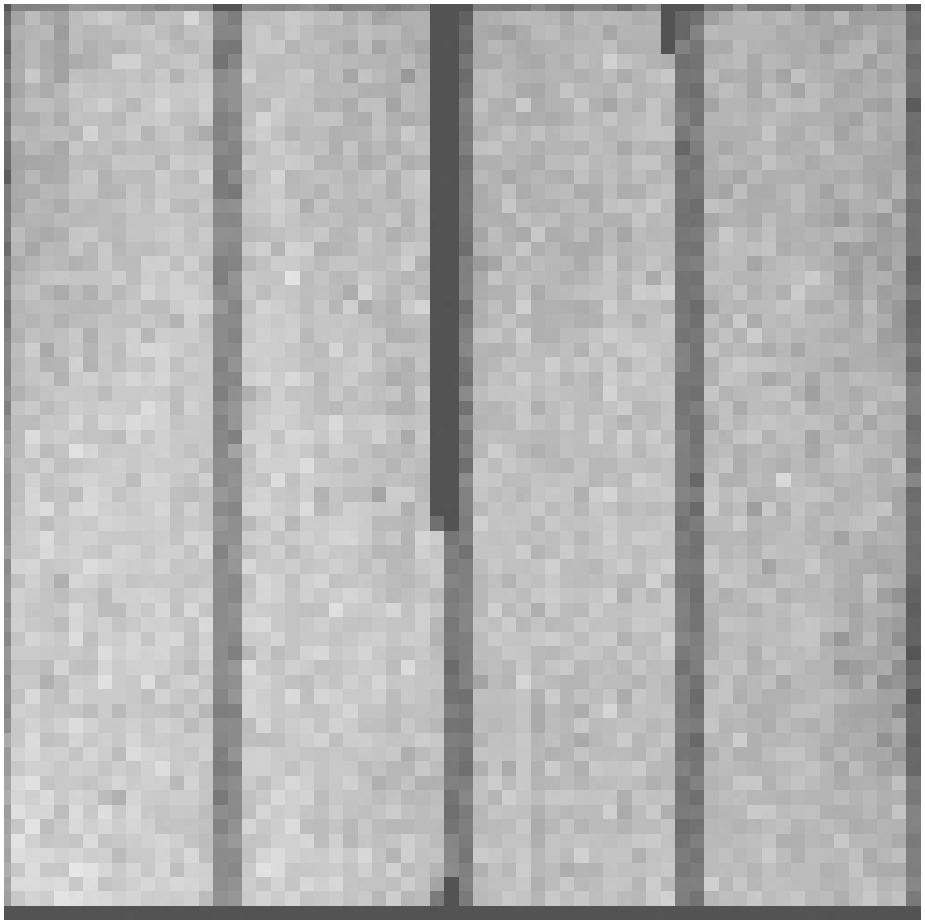
HIGH-RESOLUTION ACIS QEU MAPS:

Improve QEU(CTI) from 7%



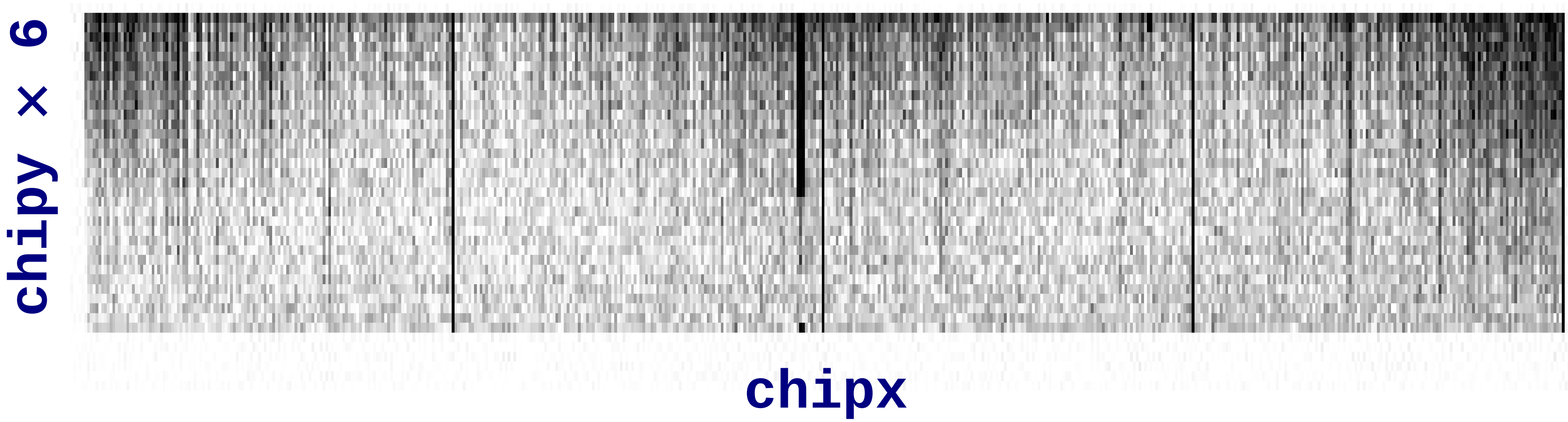
to 1% residuals



HISTORY

- **Previous QEU calibration was derived from ground data and in-flight ECS exposures over $\approx 1 - 2$ months.**
- **4 years worth of ECS measurements accumulated by 2004 revealed deficiencies:**
  - **5–7% residuals (both FI and BI)**
  - **strong column-to-column variations in the BI chips.**

S3, Mn-Ka   (5.9 keV)



HOW TO MEASURE QEU FROM FLIGHT DATA?

- $$\mathrm{QEU}(E_i) = \frac{\text{flux after CTI}}{\text{flux before CTI}} = \frac{\mathrm{cnt}(Y, E_i)/\mathrm{Illum}(Y, E_i)}{\mathrm{cnt}(0, E_i)/\mathrm{Illum}(0, E_i)}$$

- **Illum(X, Y, E_i) can be derived from the ground ECS dataset because FI CCDs were “flat”**

- **Problems:**
  - **Flight data available only for $E_i = 5.9, 4.5, 1.5$ keV**

    — how to determine QEU(E)?

  - **Effects are small: 15–20% at 6 keV, $\lesssim$ 5% at 1.5 keV**

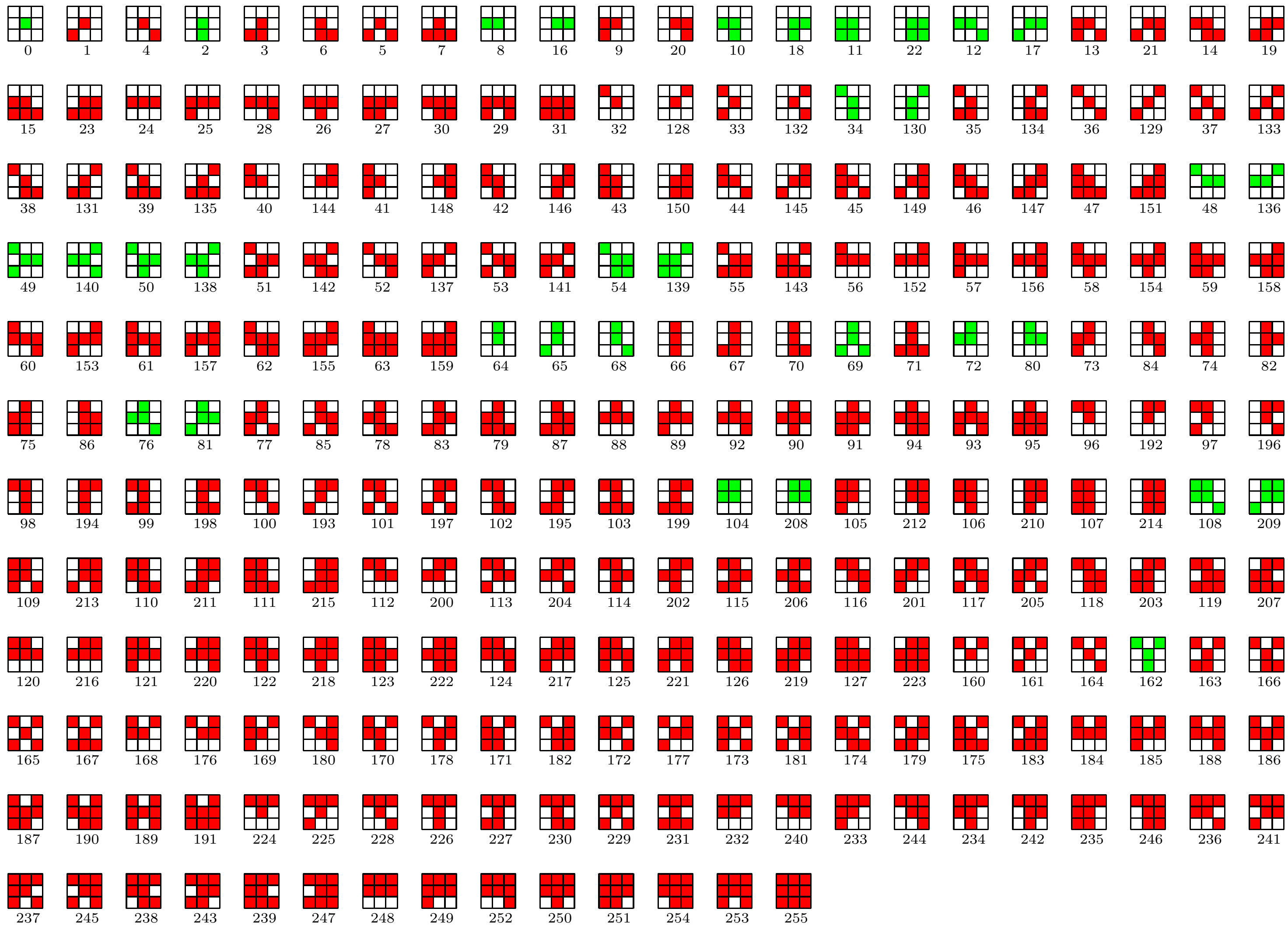
    — accurate measurements are hard

- **Linear interpolation/extrapolation over E was used before; accuracy insufficient for 1% calibration.**

HOW TO ENHANCE QEU?

- **CTI effect on QE is due to grade migration**

- **We need to enhance the QEU "signal".** ***Idea*****:**
  Only a subset of ACIS flight grades can migrate into bad grades

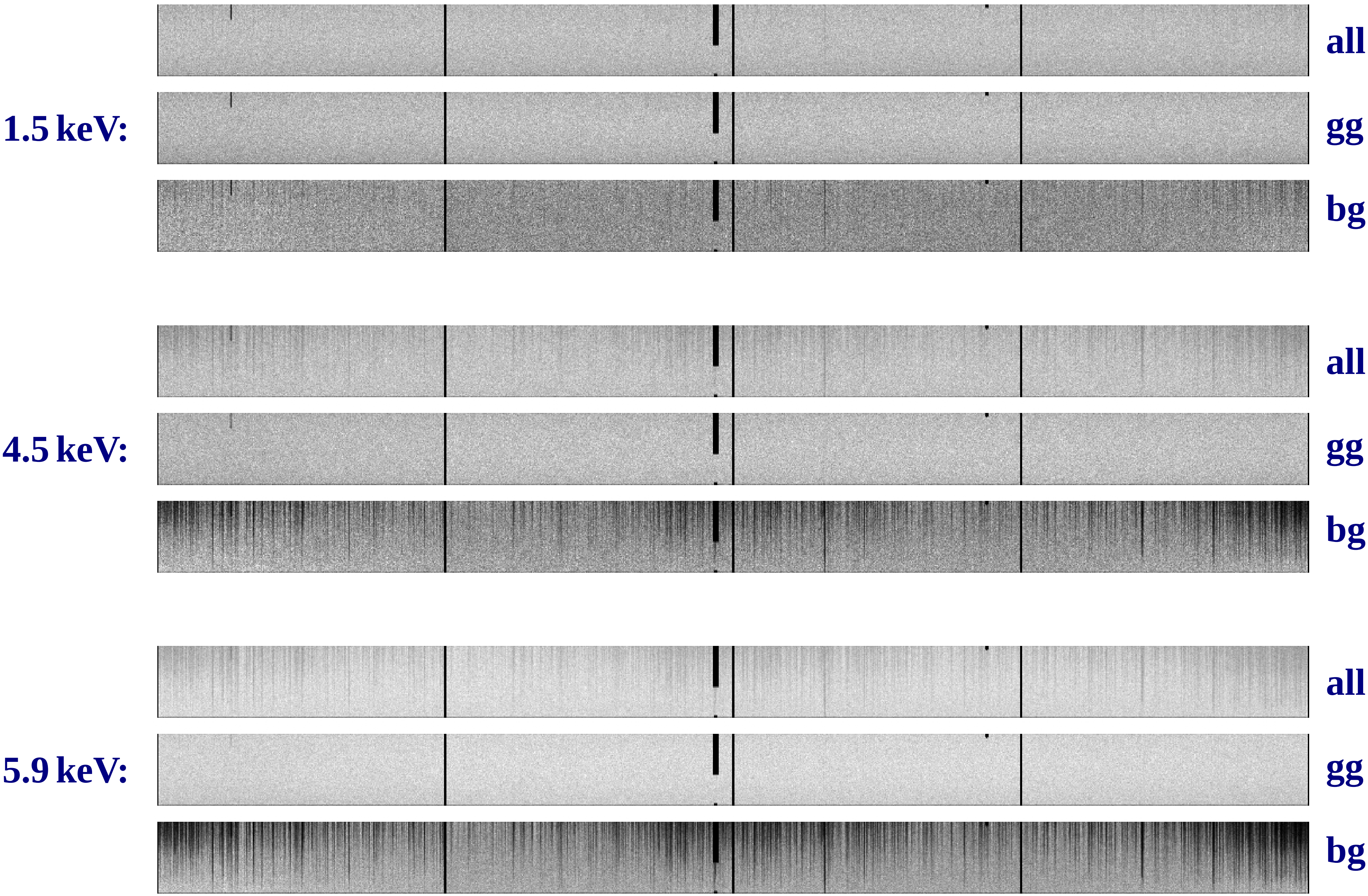


0, 8, 16, 64, 72, 80, 104, 208 migrate into each other — "Good" good set (GG)

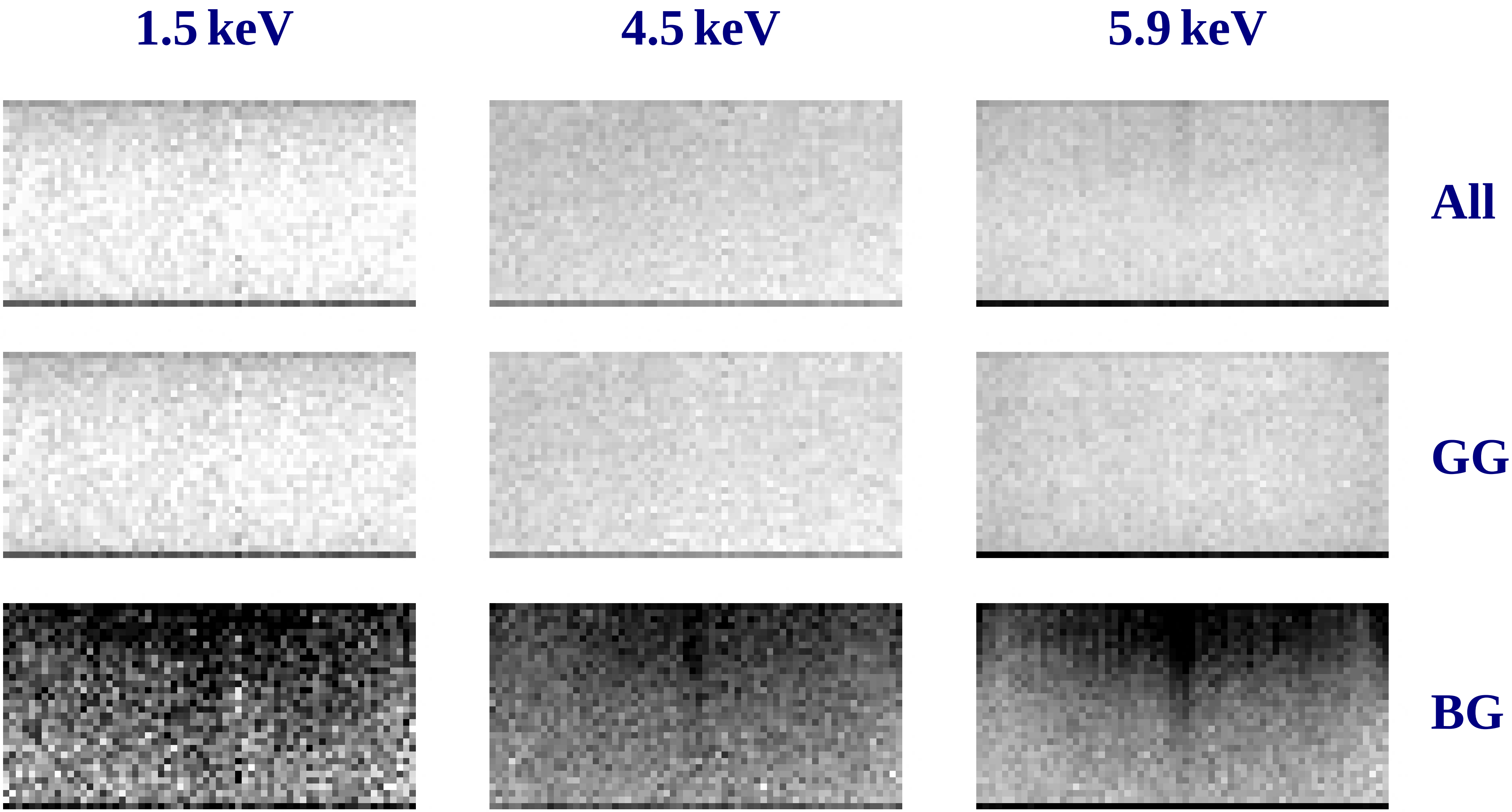
2, 10, 18, 11, 22 migrate into bad grades — "Bad" good set (BG)

Prediction: QEU is strong for BG, absent for GG

ACIS-S3



ACIS-S2

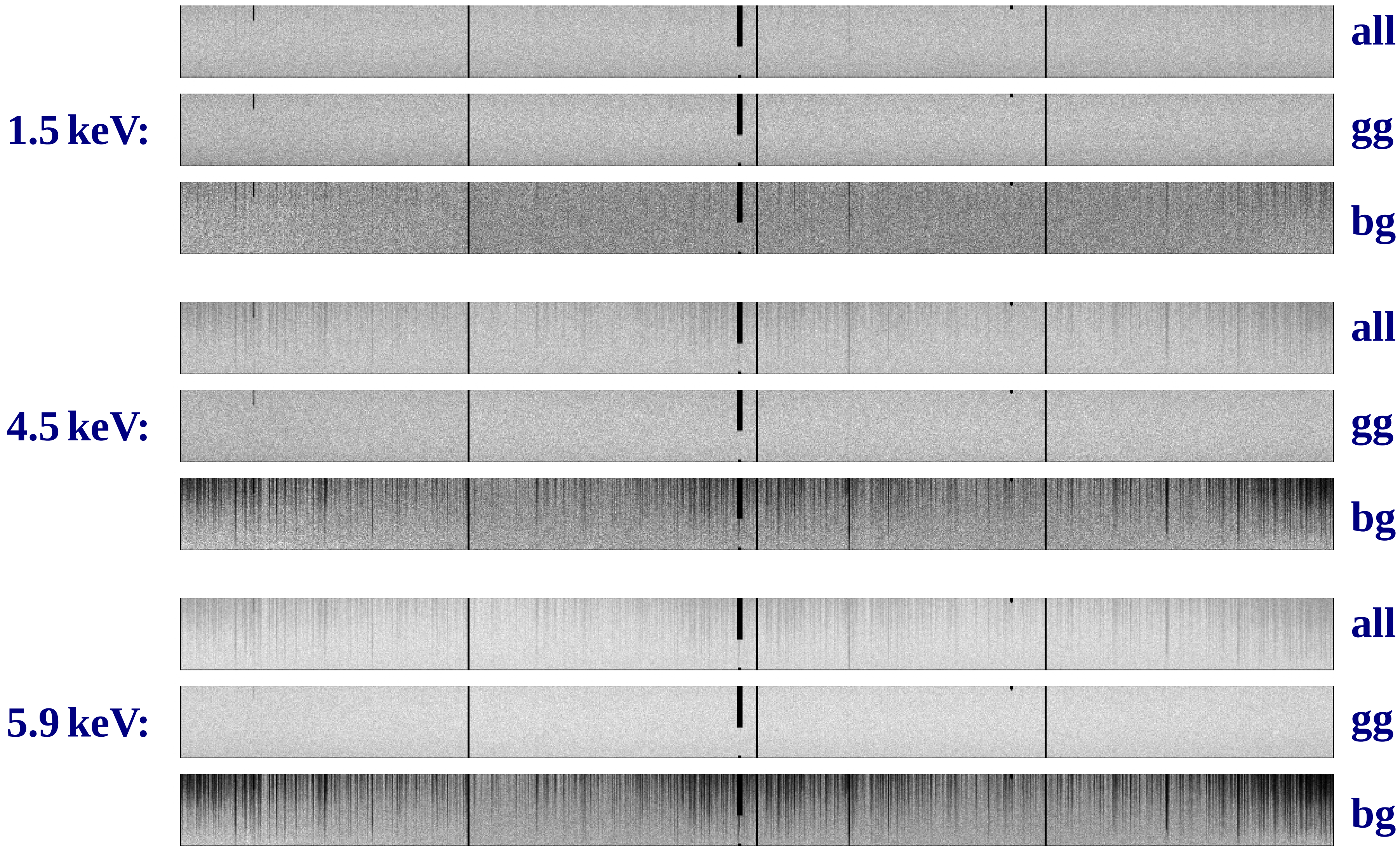


PLAN:

1. **Derive QEU for BG set, $QEU_{BG}(X, Y, E)$,**
2. **derive fractional flux in BG set, $f_{BG}(E)$,**
3. **and then**

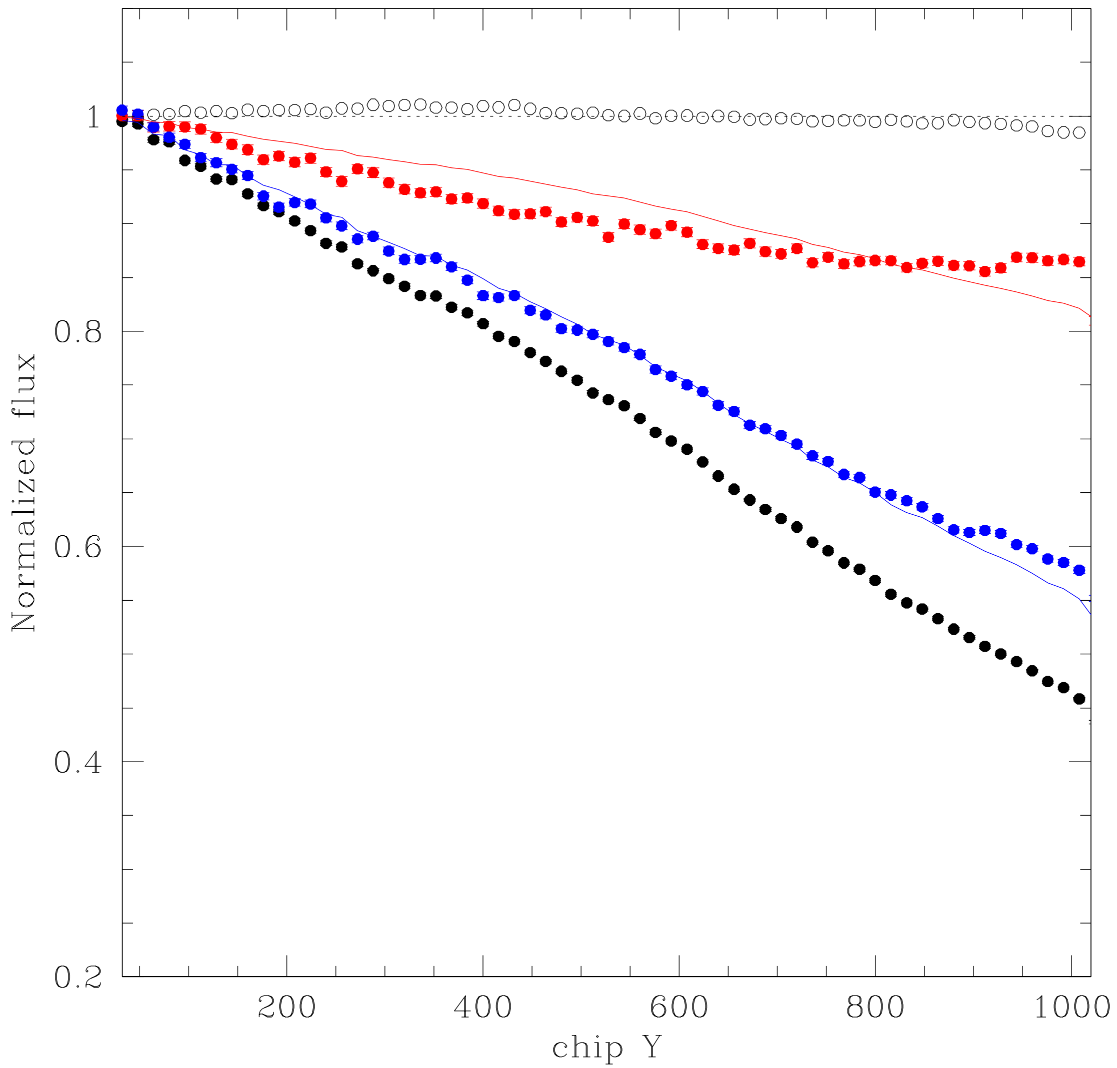
$$QEU(X, Y, E) = 1 + f_{BG}(E) \times (QEU_{BG}(X, Y, E) - 1)$$

QEU(E) for BG



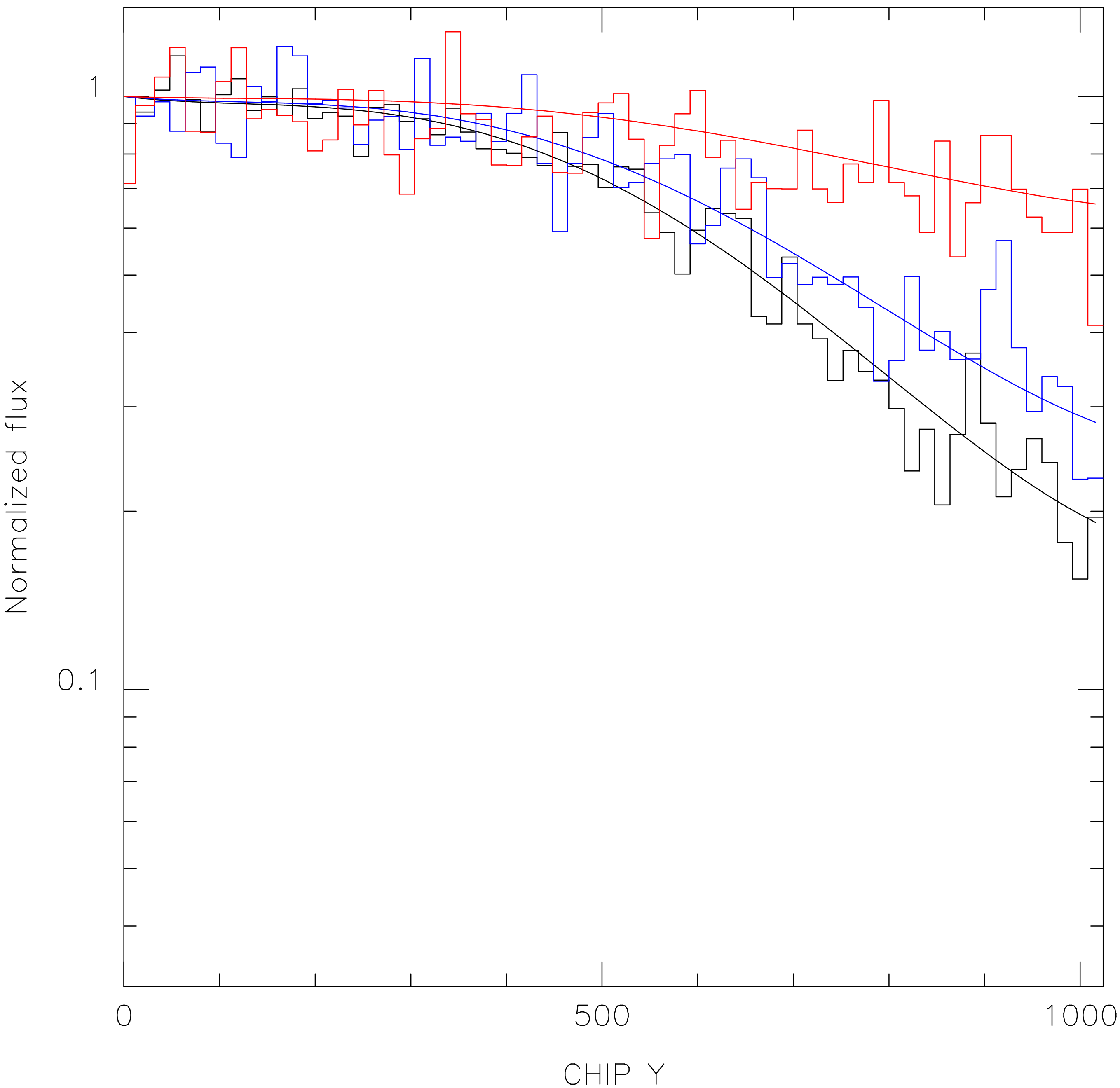
$$\mathrm{QEU_{BG}}(X, Y, E) = f(X, Y) \times g(E)$$

QEU(E) for BG

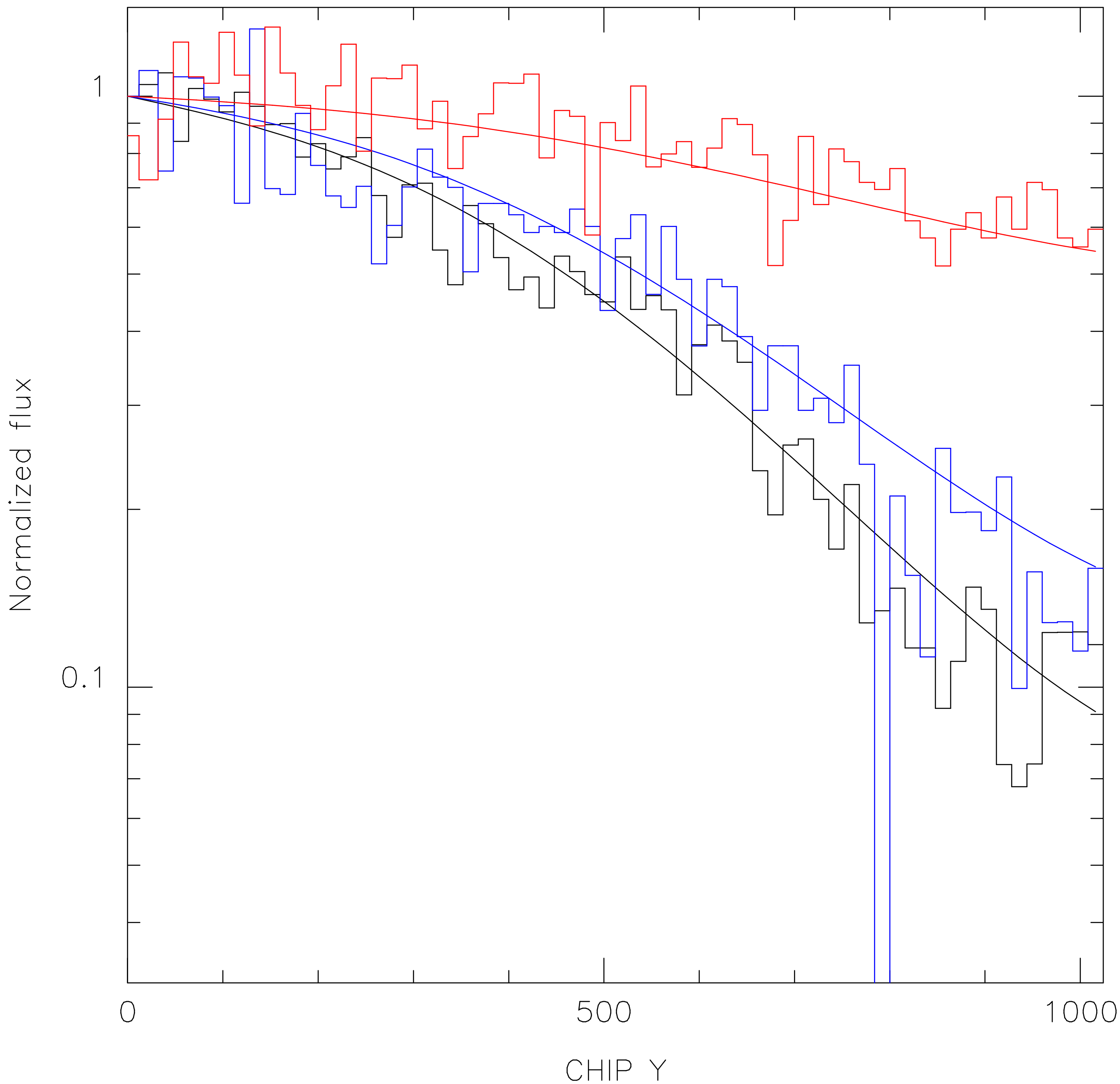


- **flux loss ∝ log *E* — verified at 0.5, 0.7, 1.7, 2.2, 6.4, 8.0 keV (XRCF)**
- **spatial dependence can be derived using the brightest line, Mn-K**

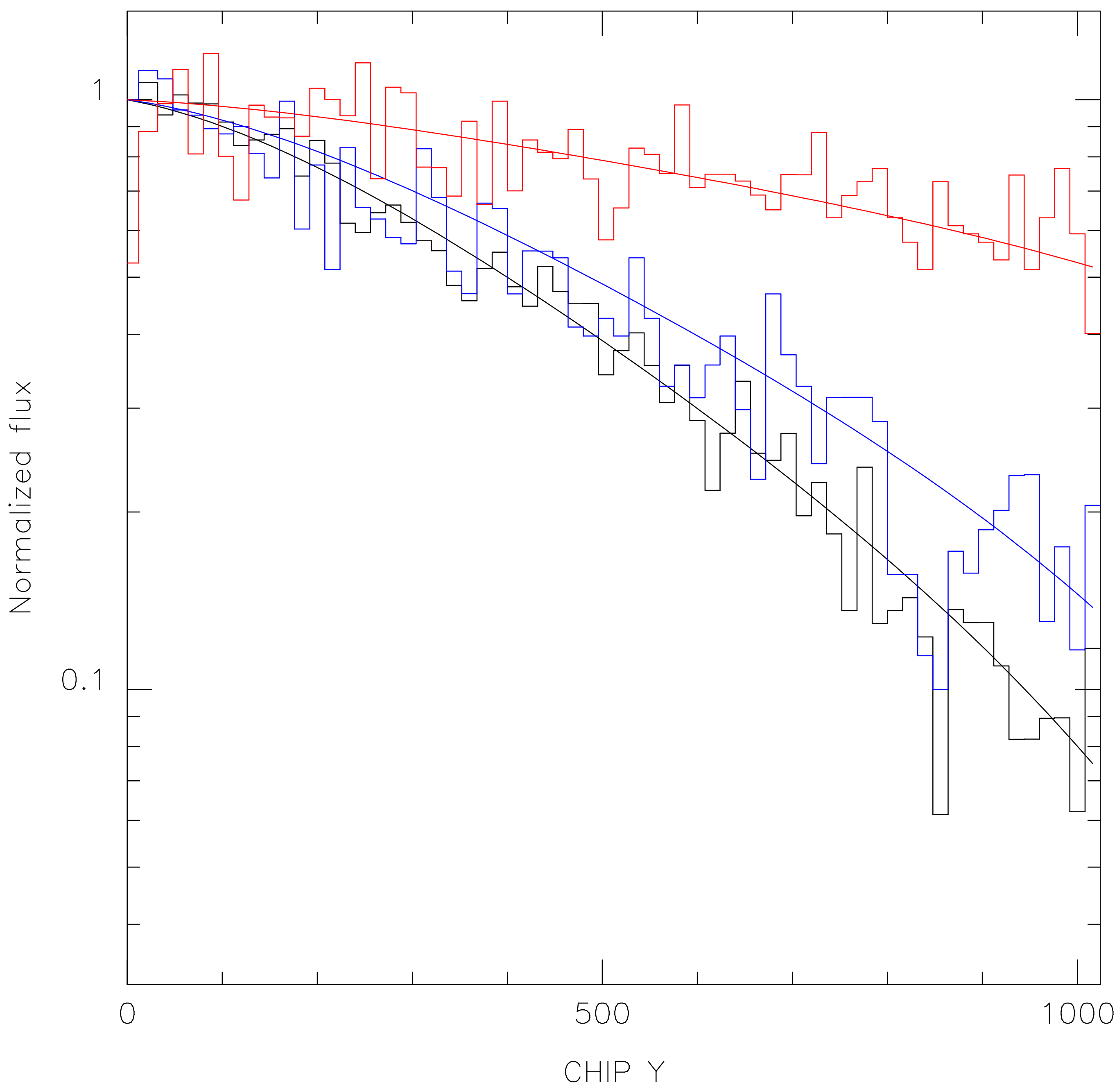
QEU(X,Y) for BG



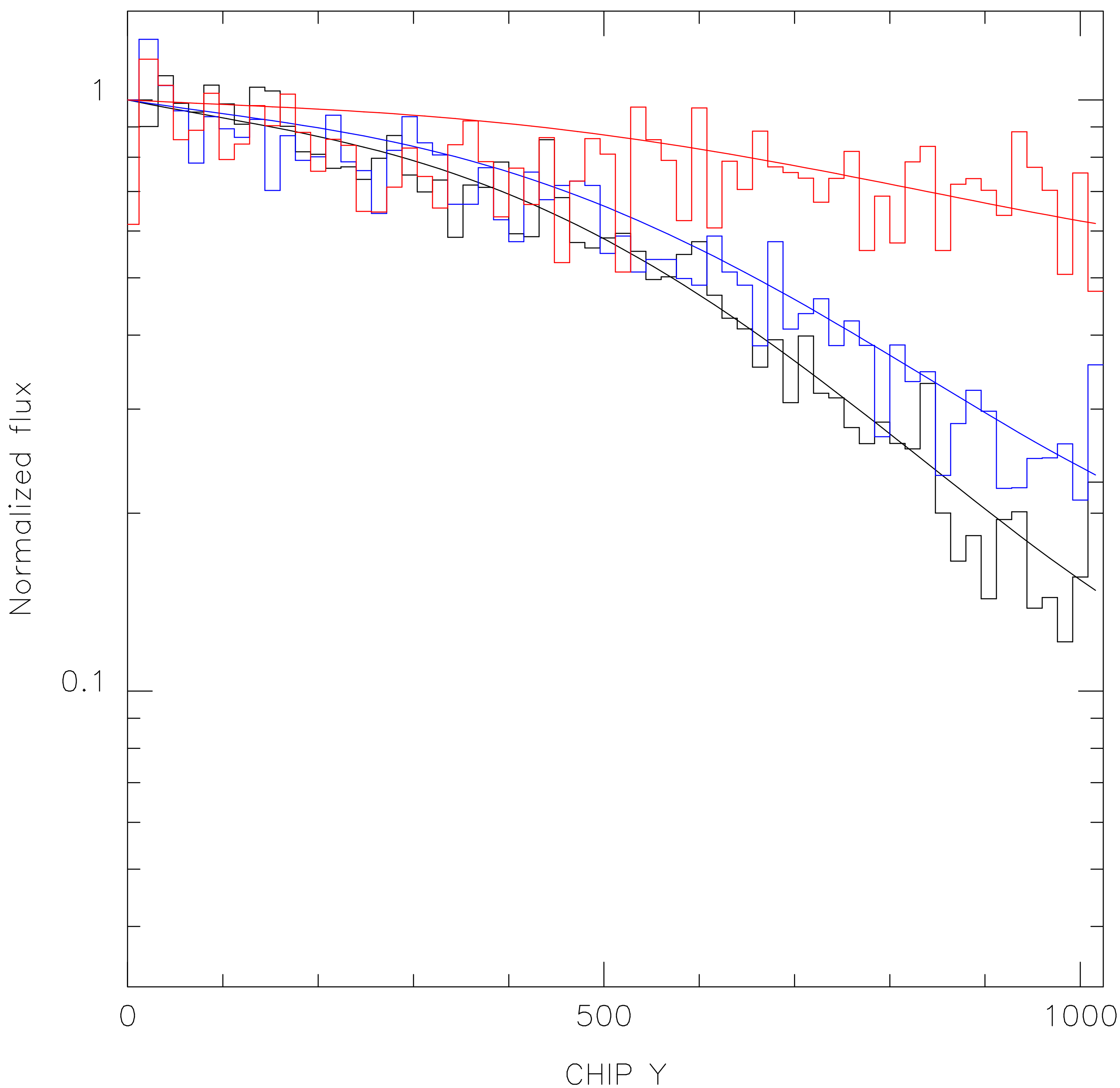
QEU(X,Y) for BG



QEU(X,Y) for BG



QEU(X,Y) for BG



QEU(X,Y) for BG

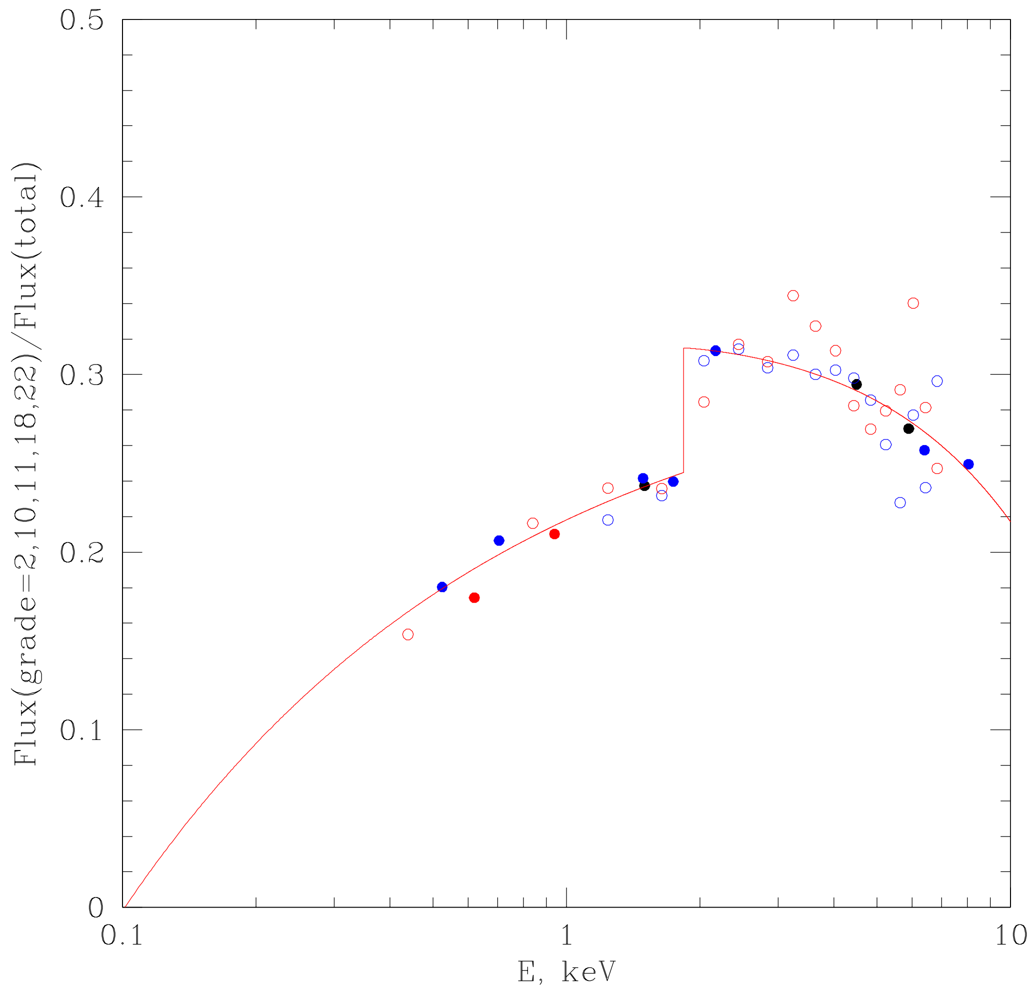
- **Correction (Y) measured in *each column* from Mn-K**

  — strong effect, high flux $\Longrightarrow$ accurate measurement

- **Correction (X, Y, E) = Correction (X, Y, Mn) $\times \dfrac{\log E}{\log 5.9}$**

- **Last step: derive $f_{\mathrm{BG}}(E)$**

$f_{BG}(E)$



- **$f_{BG}(E)$ can be measured accurately from calibration data: ECS, XRCF, E0102**
- **... less accurately with G21.5 and A1795 at intermediate energies**

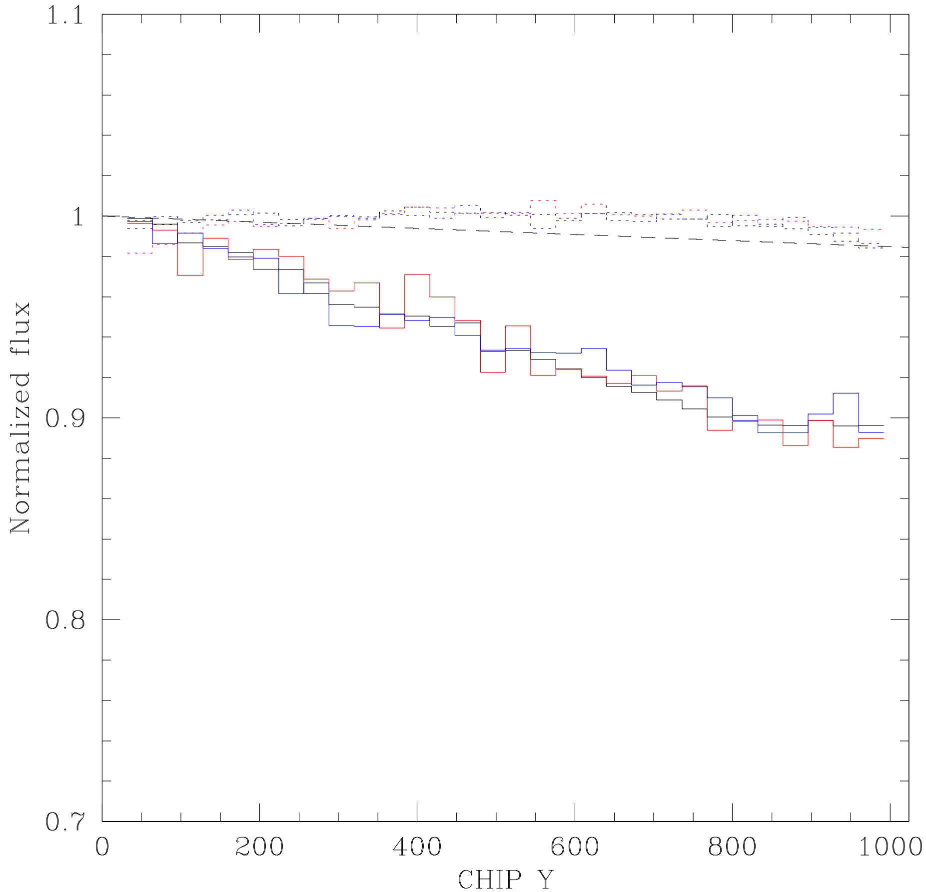
➢ **Jump between 1918 and 2004 eV**

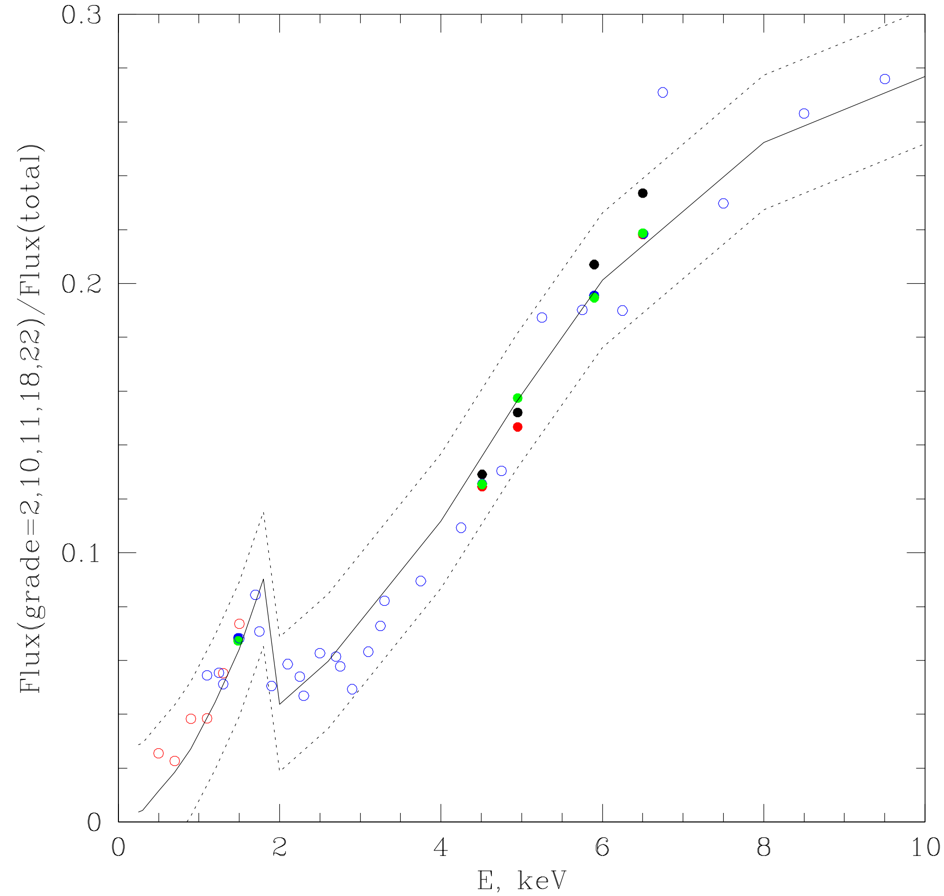
➢ **Empirical fit:**

$$f(E) = 0.32 \times \left(1 - 0.45\,(0.5/E)^{0.5}\right) \quad \text{for } E < 1.837 \text{ keV}$$

$$f(E) = 0.315 \times \left(1 - 0.0225\,(E - 1.837)^{1.25}\right) \quad \text{for } E > 1.837 \text{ keV}$$

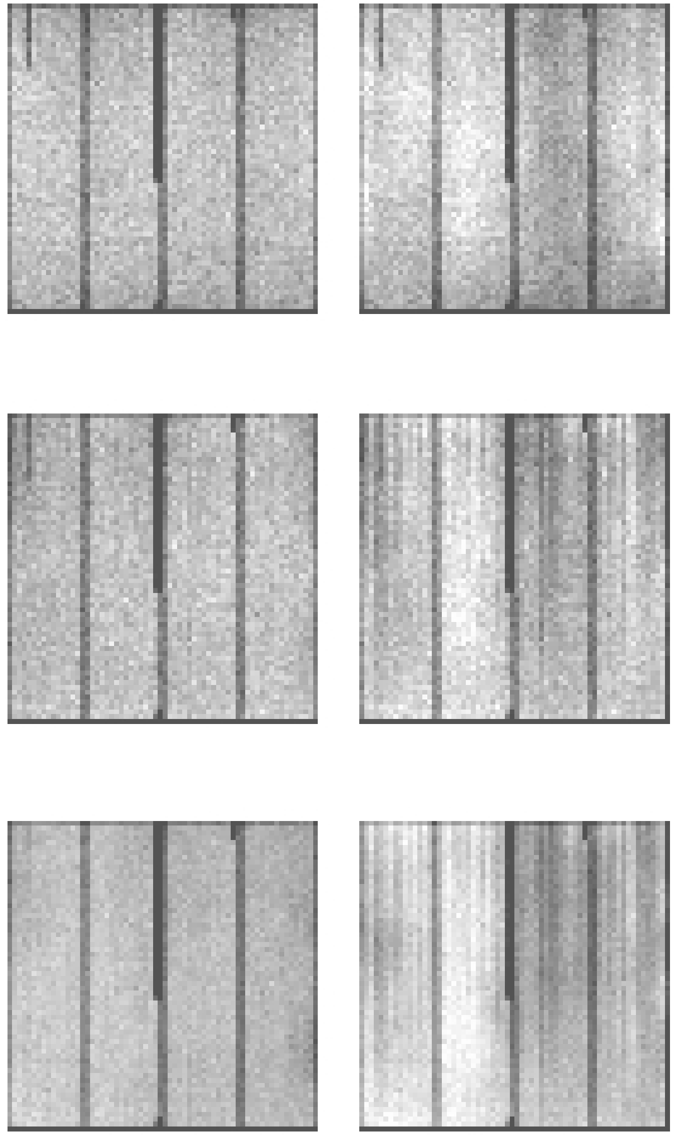
FI chips





- **Identical procedure for FI chips**
  - ➢ **No detectable column-to-column variation, bin `chipx` by 4**
  - ➢ **Correction in BG set independent of energy**
  - ➢ **Different $f_{\mathrm{BG}}(E)$**

Test: S3



1.5 keV

4.5 keV

5.9 keV

new old

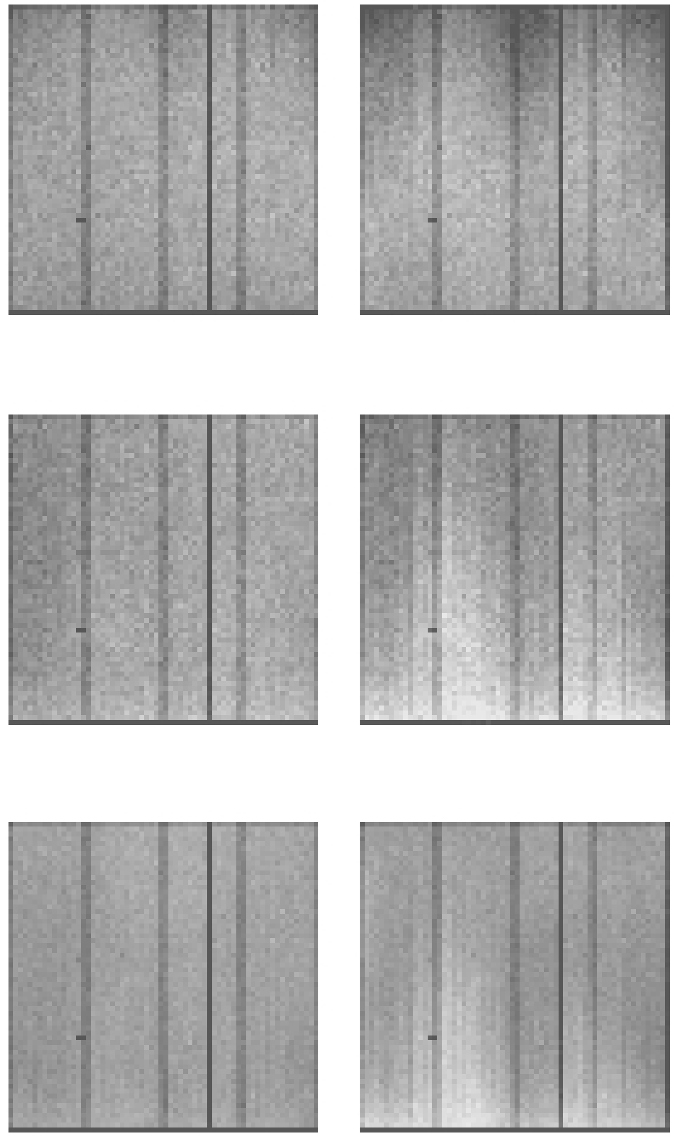
±7% residuals (rms) ⟶ ±1% (rms), ±3% (max)

Test: S1

1.5 keV

4.5 keV

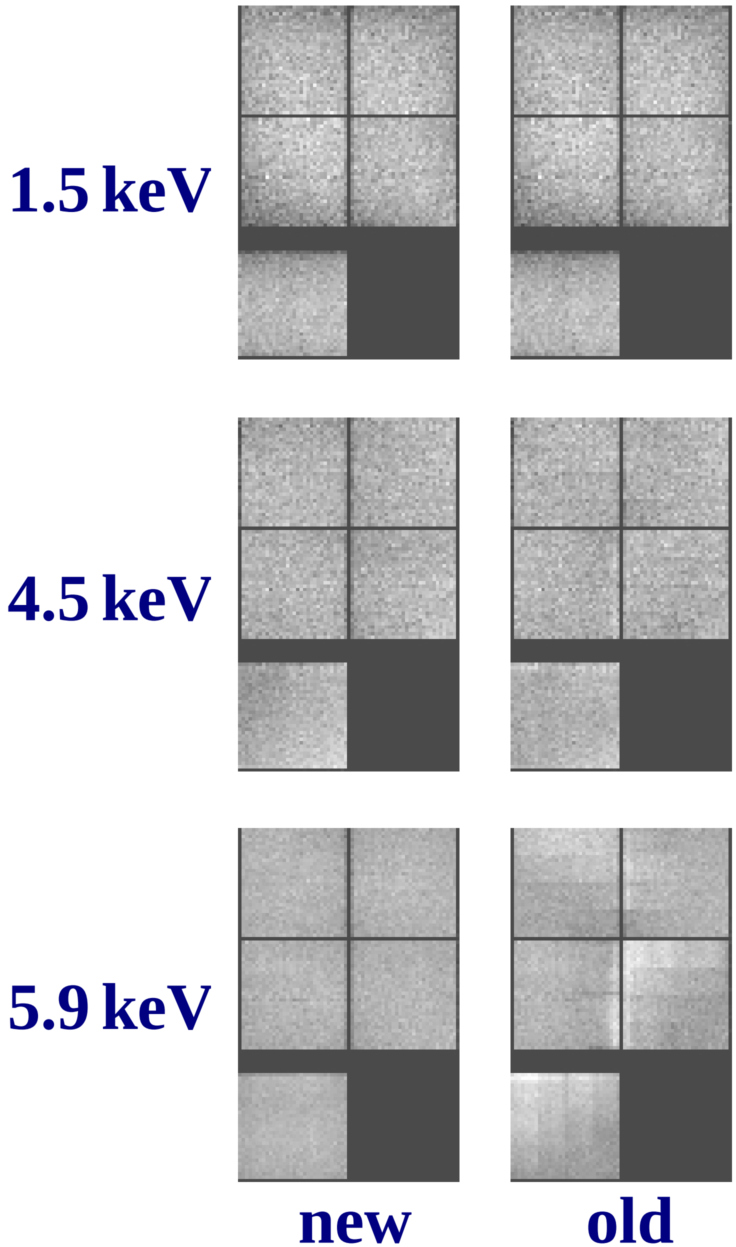
5.9 keV



new old

±10% residuals (rms) ⟶ ±3% (rms, max),

Test: FI chips



+7%, –3% at high energies ⟶ < ±1% (rms), < ±2% (max)