Effects of a Warm ACIS Focal Plane on HETGS Spectroscopy

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Warm ACIS: Non-Issues

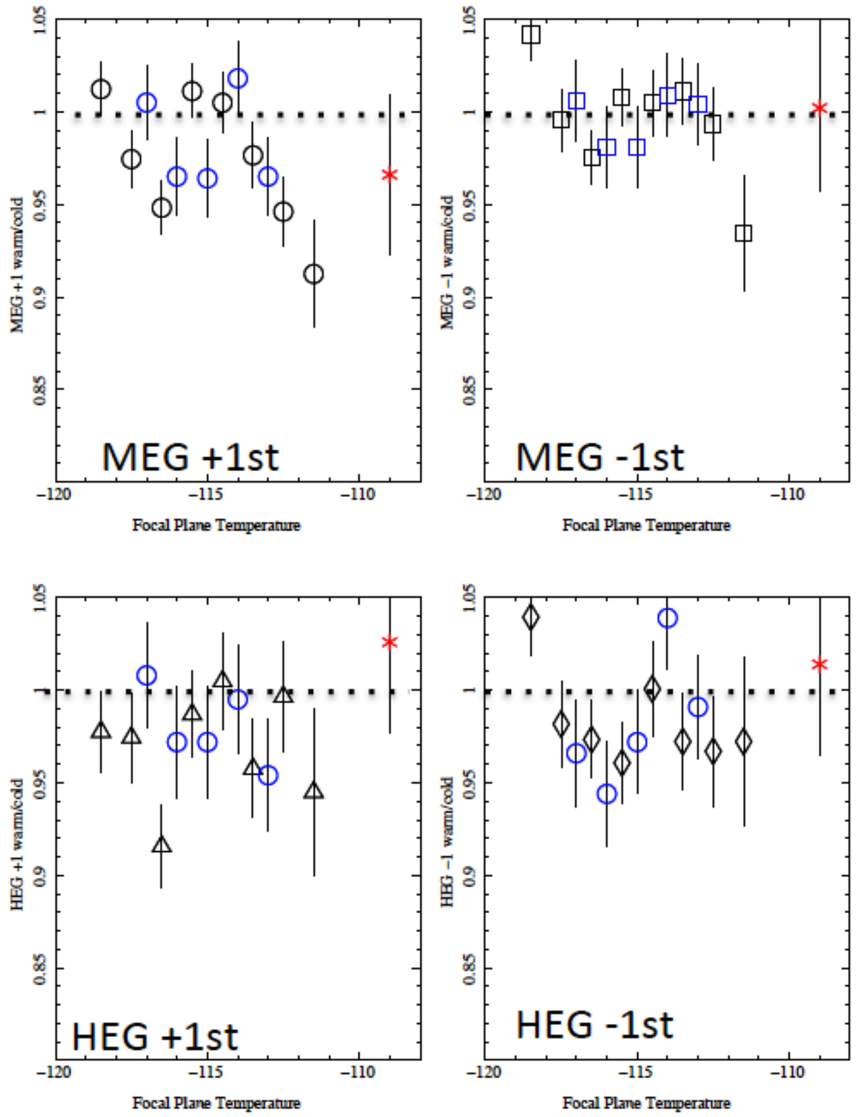
- Dispersion relation
  - Only depends on grating P, Rowland distance, ACIS scale
  - Effect on ACIS scale is negligible
- Line response function
  - Only depends on grating dP/P, HRMA PSF, ACIS pixel size
  - ACIS T does not affect these noticeably
- Grating efficiencies or HRMA area
- Cross dispersion profile
  - Determines aperture correction
  - Depends on HRMA PSF and Rowland geometry

Effects on HETGS EA

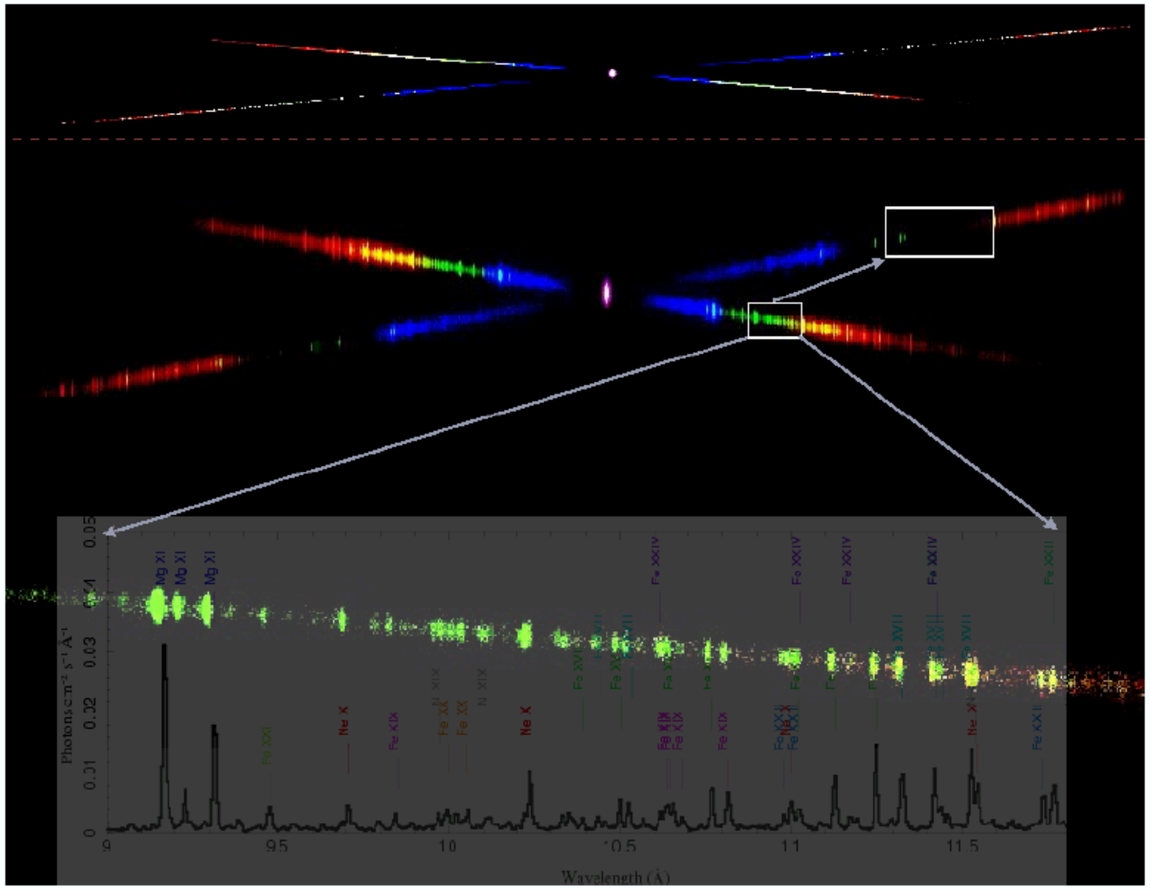
- Increased detector hot pixels
  - Impact mitigated by dithering
  - HEG/MEG and +1/-1 provide complementary data
- **Reduced detector QE**
- Order selection
  - Separating orders — no problem due to wide order separation
  - Accounting for PH selection fraction
    - **Gain changes centroid of selection**
    - **RMF may be broader when warm**

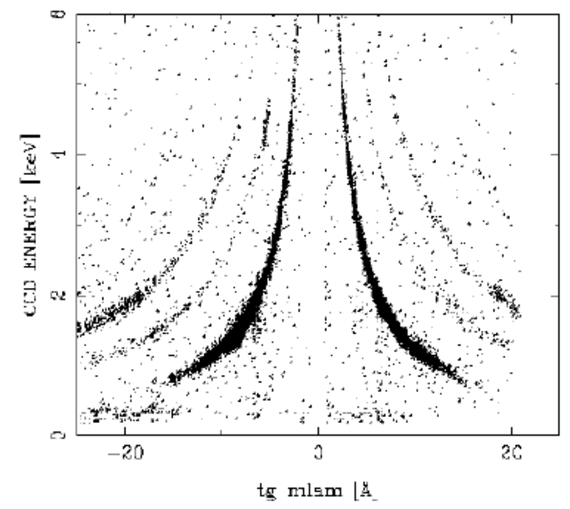
QE Effects (from NSS)

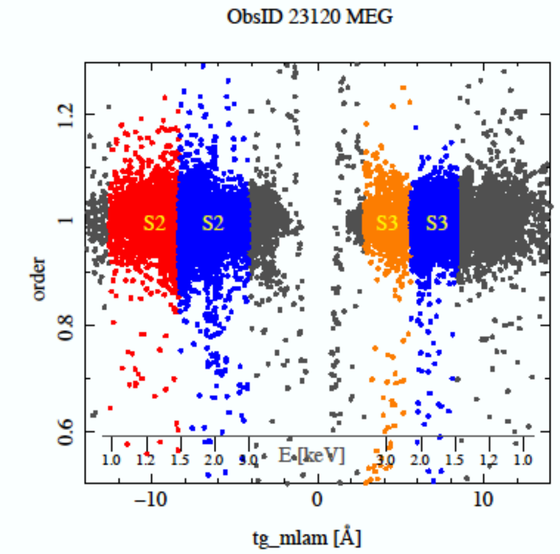
- Data:
  - θ^1 Ori C: 1999, 2002
  - θ^1 Ori C: 2019-2020
  - 4U 1626-67: 2018
- Result
  - No temperature dependence
  - Losses < 3% at -109°C



RMF Effects (from DPH)

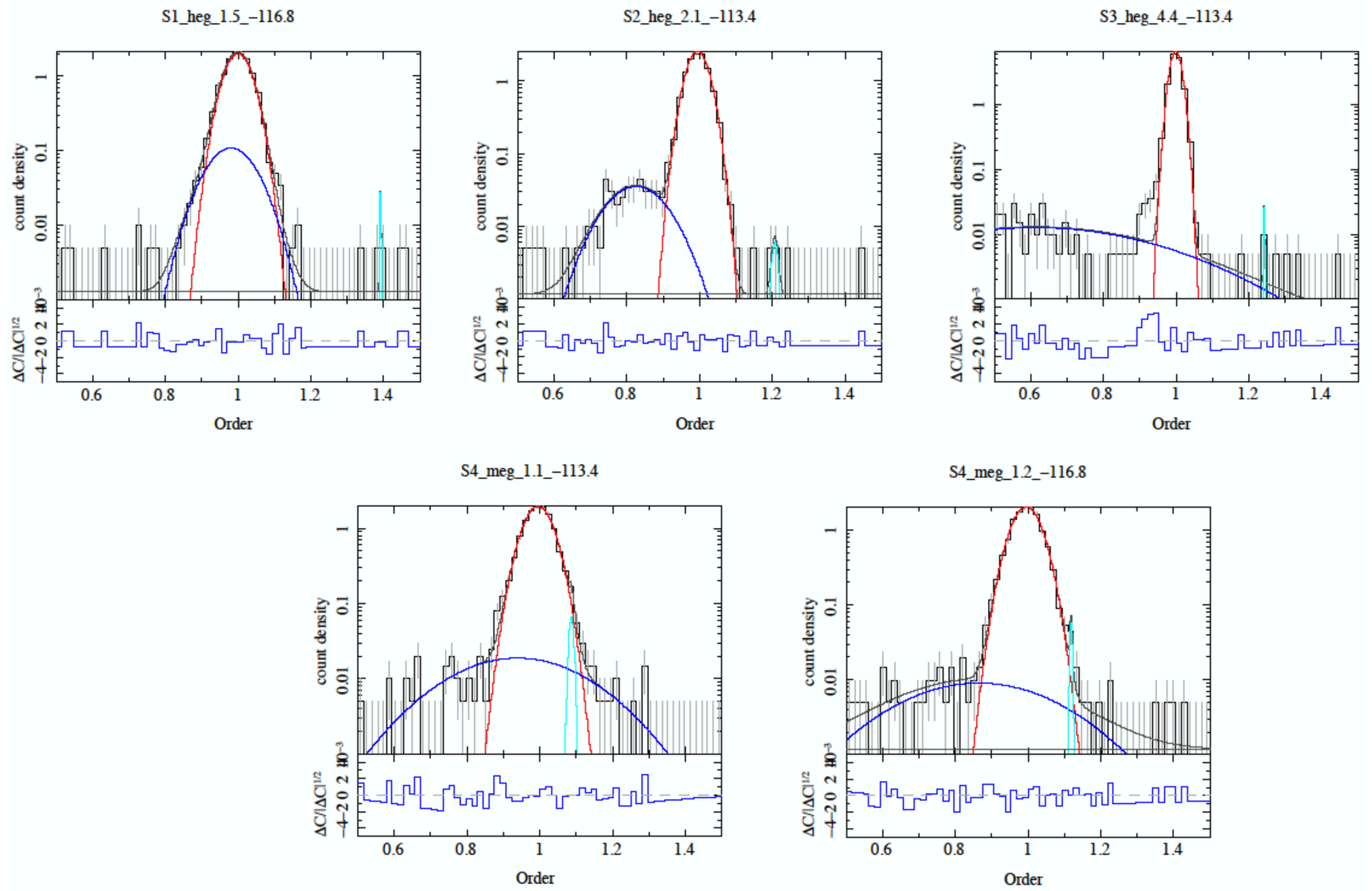






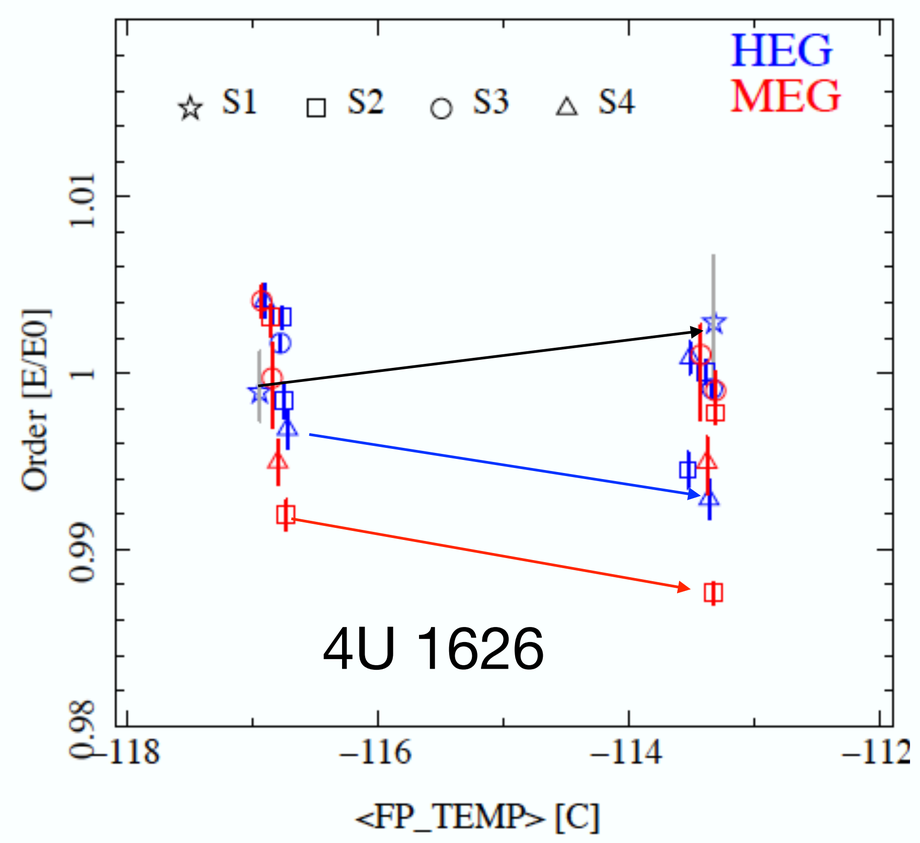
RMF Effects 2

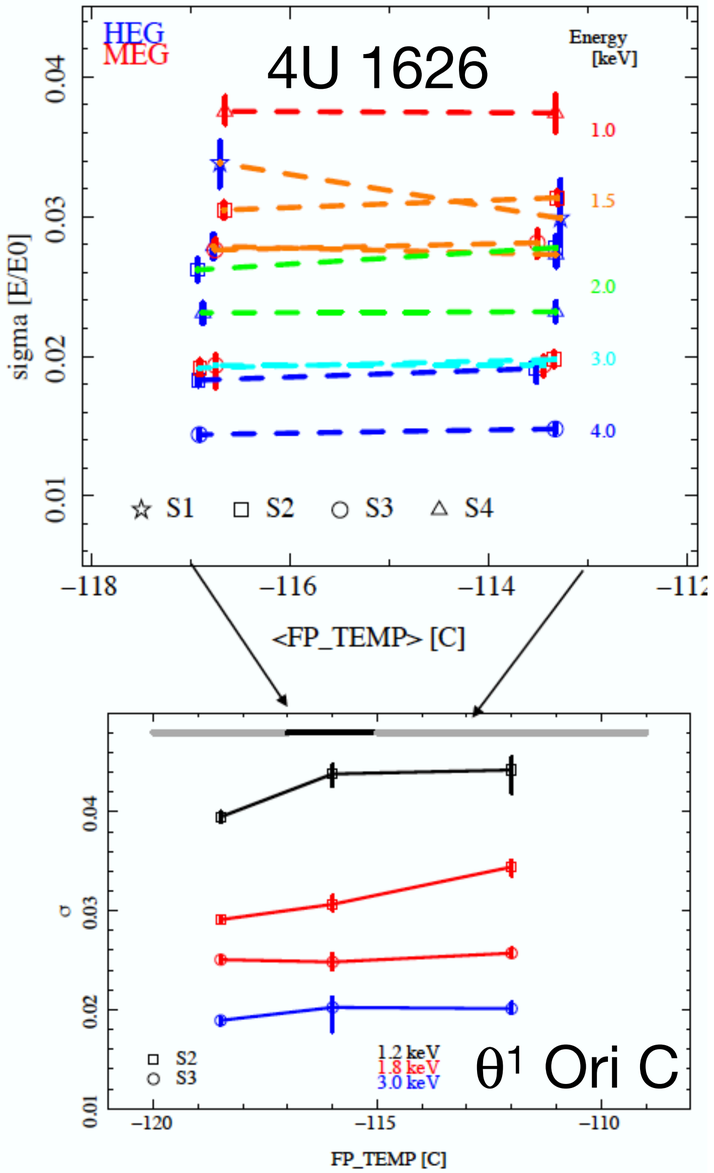
- Data sets
  - 4U 1626 (2018)
  - θ^1 Ori C: 2019-2020
  - Capella had poor gain correction
- Processing
  - Accumulate PH distributions
  - Fit Gaussians
  - Separate by T



RMF Effects 3

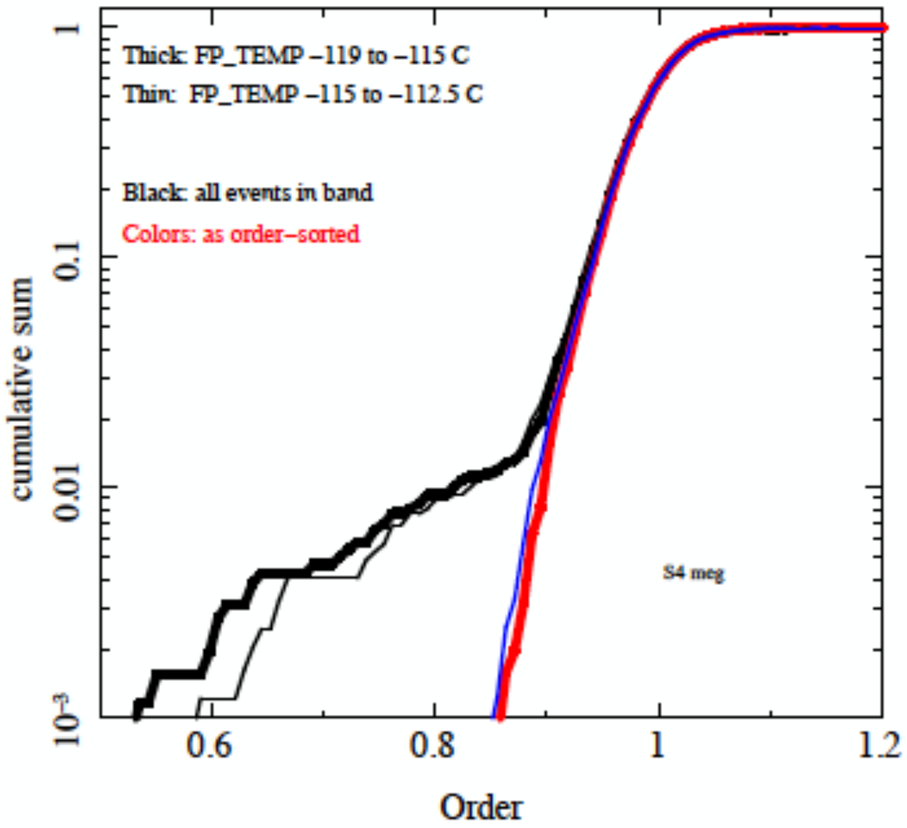
- Centroids
  - Slight variations in <E/E$_0$>
  - Assume < 0.4% shift
- Widths
  - σ/E$_0$ changes inconsistent
  - -1.6 ± 0.8% for 4U 1626
  - -9.6 ± 1.2% for θ^1 Ori C
  - Assume < 5% smaller

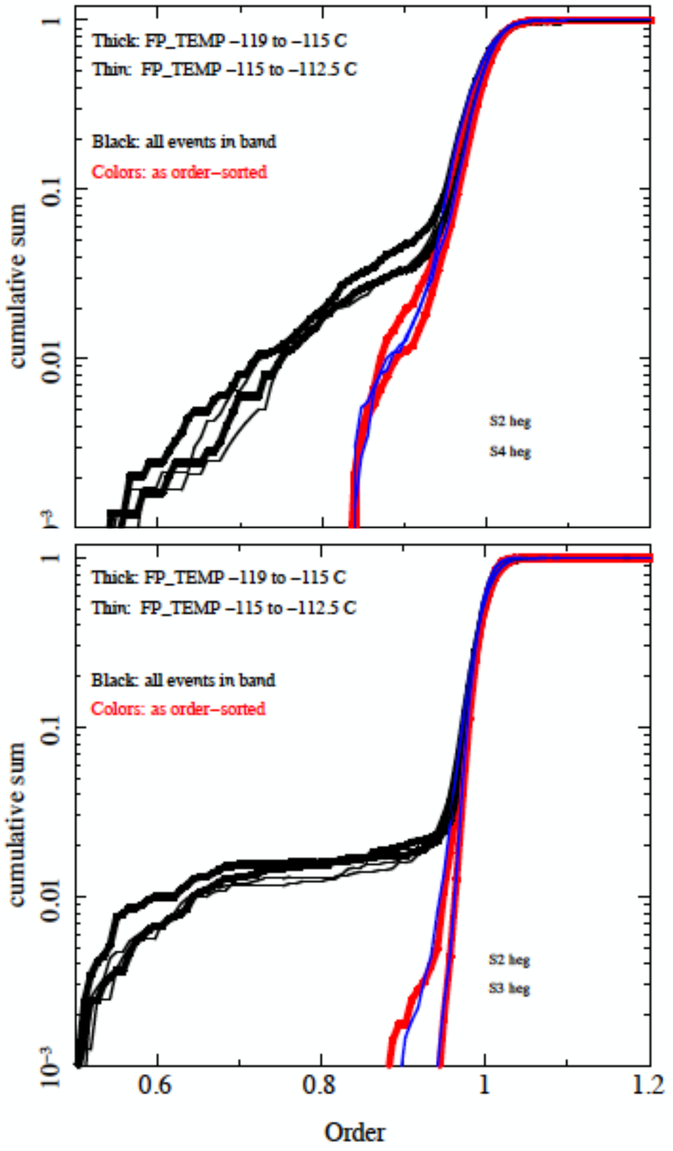




RMF Effects Analysis

- RMF Center: Gaussian
  - dominates OSIP
  - **possible** weak change with FP_TEMP
- RMF tail
  - escape peak at 2 keV
  - otherwise < 2% of total
  - no change with FP_TEMP
- → Concentrate on Gaussian





Effect of Centroid Shift

- Shifting RMF reduces power in OSIP region
- Model:

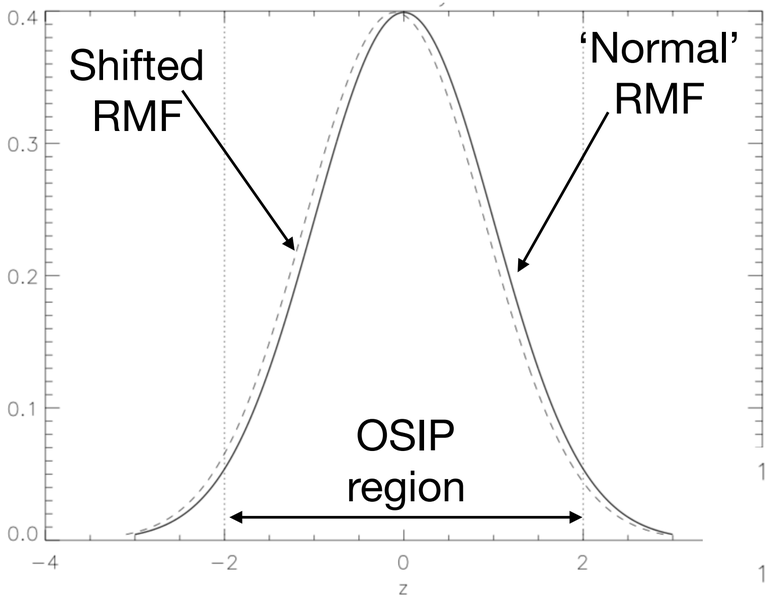
$$f = \int_{-a}^{a} \phi(x)dx, \quad \phi(x) = \frac{1}{(2\pi)^{1/2}\sigma} e^{(x-\mu)^2/2\sigma^2}$$

$$x = E/E_0, \qquad \mu = \bar{E}/E_0$$

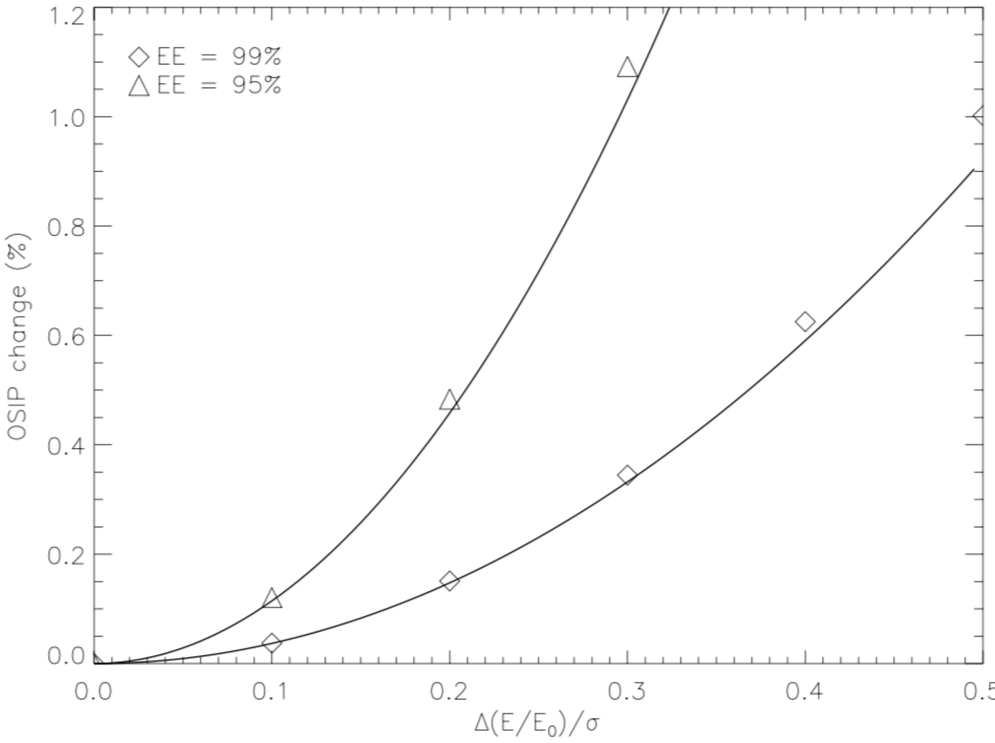
- Let $\mu = \mu_0 + \Delta\mu$

Then $\delta f \approx \frac{a\Delta\mu}{(2\pi)^{1/2}\sigma} e^{-\frac{a^2}{2}}$

- Verified approximation with simulation



- From DPH: $\Delta\mu$ = 0.004, σ/E_0 = 0.038-0.014 (1-4 keV) → $\Delta\mu/\sigma = \Delta(E/E_0)/\sigma$ = 0.1-0.3
- Gaussian model: δf = 0.05 - 0.35% for 99% OSIP (a = 2.58); 0.1-1.1% for 95%
- → **Expect < 1% OSIP loss**

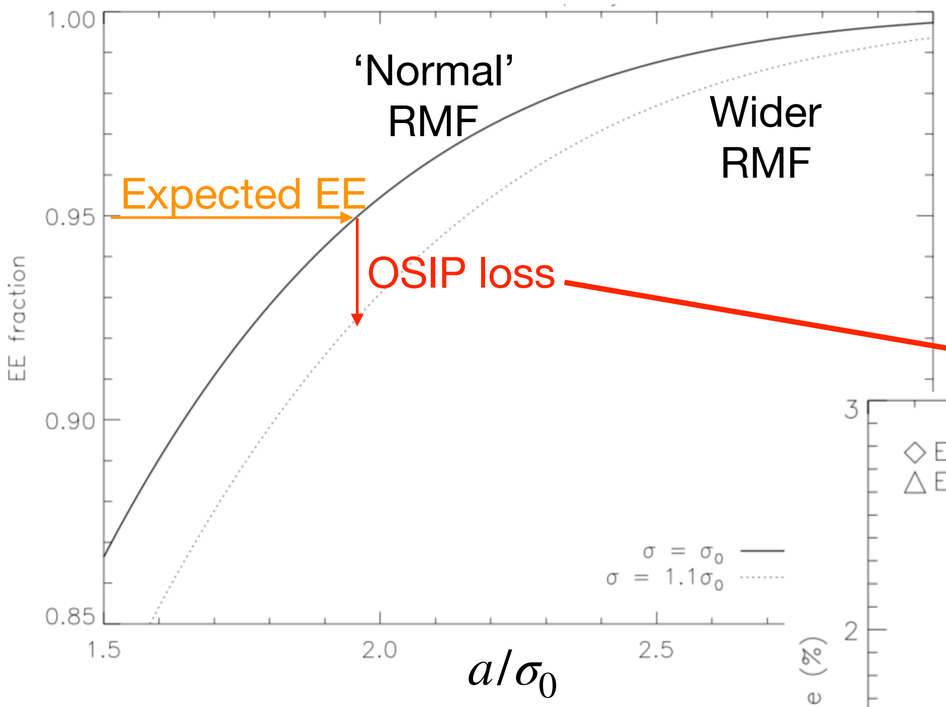


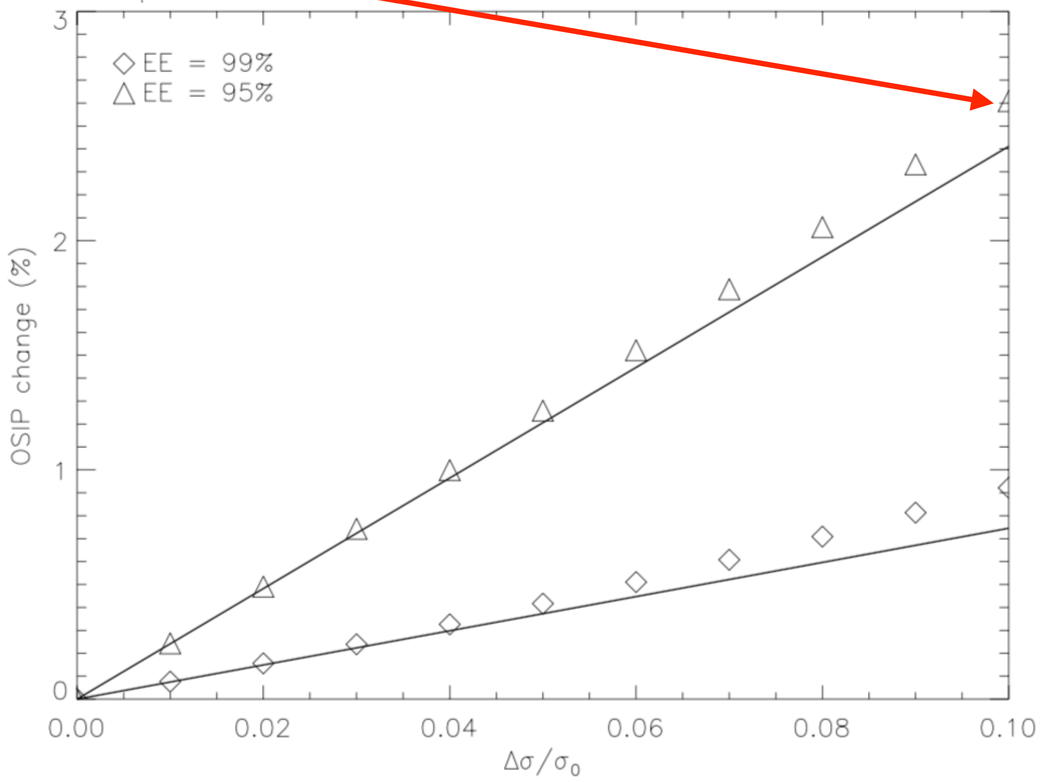
Effect of Wider RMF

- Wider RMF reduces power in OSIP region
- Same Gaussian model
- Let $\sigma = \sigma_0 + \Delta\sigma$

Then $\delta f \approx \frac{2\Delta\sigma}{(2\pi)^{1/2}\sigma} e^{-\frac{a^2}{2}}$

- Verified approximation with simulation





- From DPH: $\Delta\sigma$ <0.05
- Gaussian model: δf = 0.5% for 99% OSIP; 1.3% for 95% (worst case)
- $\rightarrow$ **Expect < ~1% OSIP loss**

Conclusions

- Effect of higher T on QE looks negligible
- < 1% effect on OSIP due to possible shift of RMF centroid
- <~ 1% effect on OSIP due to possibly wider RMF
- Caveats:
  - Small RMF effects need more data
  - Some inconsistencies between data sets
- Impression: **OK to use HETGS with warmer ACIS**