

# Status of EPIC calibration related to the Users' Group recommendations

Michael Smith, on behalf of XMM-SOC and Instrument Teams

20<sup>th</sup> XMM-Newton Users' Group Meeting, ESAC, 7 May 2019

**Recommendation 2015-05-22/02:** The UG identifies the following tasks in order of priority;

1. Cross-calibration of the responses of the XMM-Newton X-ray cameras and spectrometers. This is a longstanding issue, and it should be resolved as far as is possible in the near future.
2. Evidence for a shift in gain of the PN detectors, which is dependent on the quiescent background. This should be investigated and quantified, and a correction implemented.
3. Calibrated spectra from NuSTAR and XMM-Newton sometimes show a significant mismatch in spectral slope and offset above 3keV. This is a matter which the IACHEC should be encouraged to investigate.
4. Complete the calibration of the PN Burst Mode, RDPHA correction.

**Recommendation 2016-06-08/02:**

- The time and energy reconstruction of the pn Timing mode should be studied with respect to recently observed discrepancies.

**Recommendation 2017-05-11/05:**

- The NuSTAR off-axis observation of the Crab has the potential to serve as a “standard candle” [...] study the implications of this observation [...].

# Update of the CORRAREA Correction



The **CORRAREA** tool was implemented in SAS 14 (autumn 2014):

- Applies an empirical correction to the EPIC effective areas
- Can be used to evaluate the impact that the current relative EPIC  $A_{\text{eff}}$  uncertainties have on astrophysical parameters derived from spectral fitting
- Derived from a sample of 47 sources (FF + EFF modes, Thin + Medium filters)
- Currently, a non-default SAS option (`arfgen applyxcaladjustment=no`)

A recalibration of the **CORRAREA** correction has been on-going:

- Combined effort of IAAT and SOC
- Larger source sample (163 observations)
- Additional instrument modes (LW, SW) and filters (Thick)
- Revised screening: background selections, pile-up evaluation
- Largely automated pipeline from data reduction to spectral and residual modelling
- Outlook is:
  - Mode-dependent MOS/pn comparison (FF, LW, SW)
  - MOS/pn comparison at higher energies ( $> 8$  keV)
  - Further extend automation
- Aim is to make **CORRAREA** a default empirical correction

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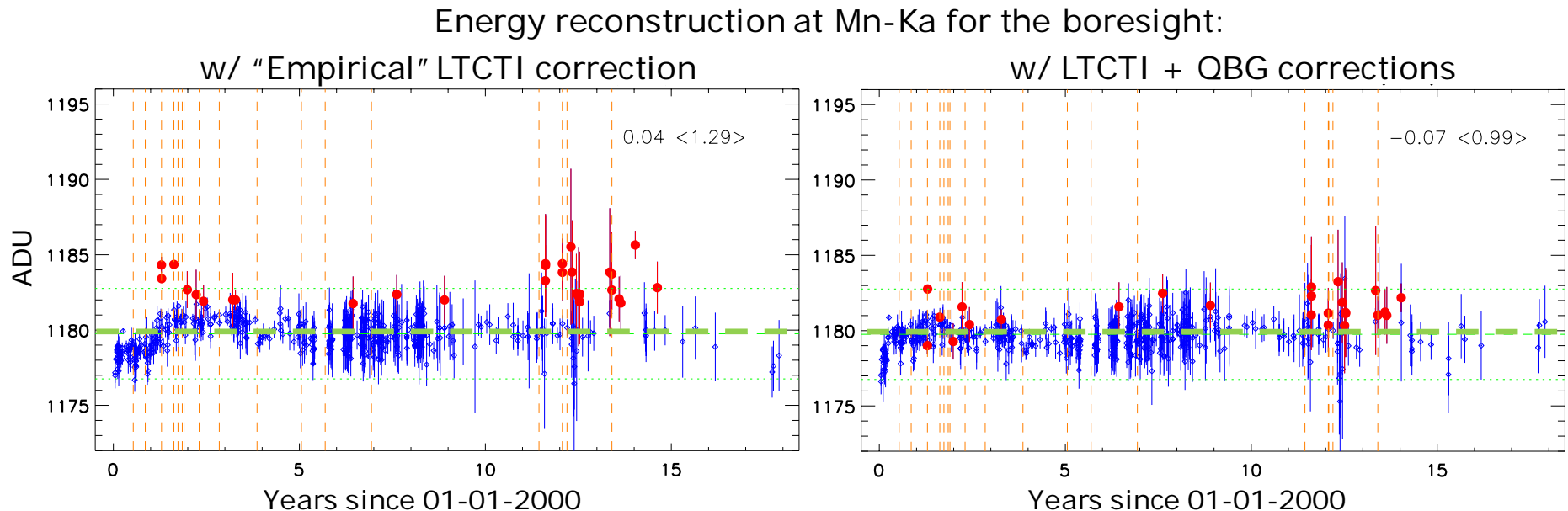
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# PN: Quiescent Background Gain Correction

- Dependency of the EPIC-pn energy scale on the quiescent particle background rate: quiescent background dependent gain (QBG)
- Time-dependent QBG correction implemented in SAS 17 (June 2018)
- QBG correction decoupled from the long-term CTI correction → XMM-CCF-REL-358 (Oct 2018). Calibrated for FF and EFF modes.



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# EPI C-pn / NuSTAR comparison

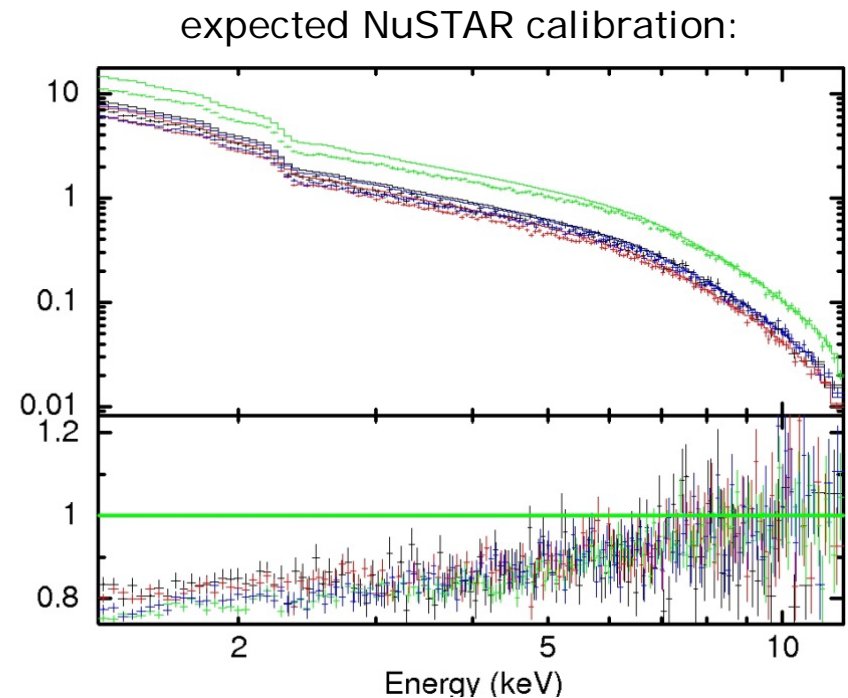
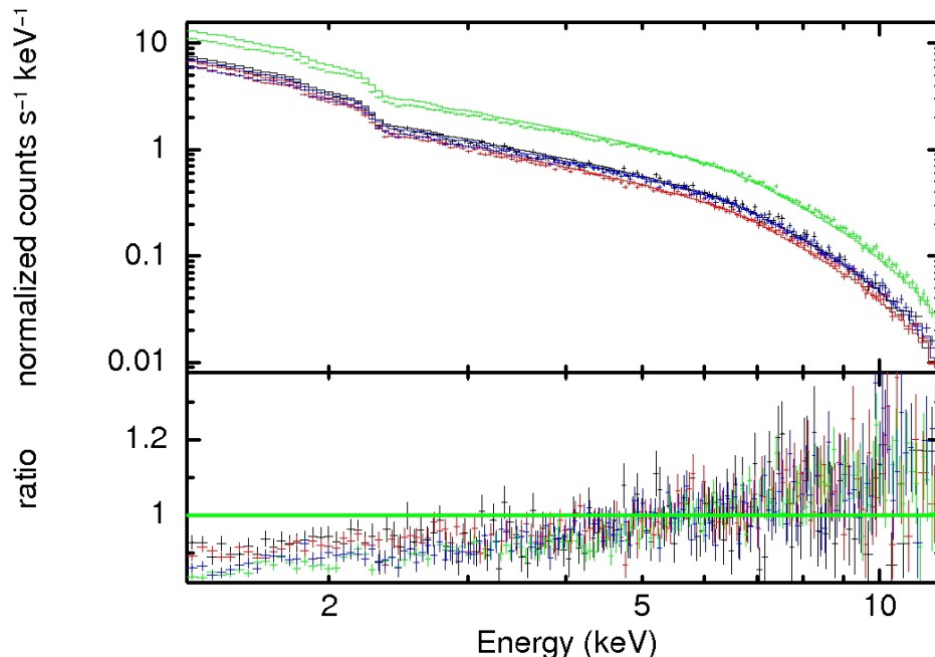
Comparison of 4 observations of 3C 273:

- PN imaging modes
- Strictly simultaneous PN-NuSTAR data
- Models fit to NuSTAR (extrapolated below 3 keV)

⇒ Systematic PN residuals: flux and spectral shape

- NuSTAR results comparing focused with stray-light measurements of the Crab confirm NuSTAR normalisation underestimated by  $\sim 12\%$  (Madsen et al. 2017)

⇒ 15 – 20% PN flux deficit ( $> 3$  keV)



- ❑ The 3C 273 results were confirmed with a sample of simultaneous XMM / NuSTAR observations ~ 18 AGN (currently undergoing re-analysis with latest calibration)
  
- ❑ Dedicated simultaneous XMM / NuSTAR observation of the Crab was performed in Sept 2018:
  - PN observing in Burst mode (in Medium and Thick filter)
  - XMM pointing was adjusted in order to contain full nebula
  - NuSTAR observing on- and off-axis

Analysis still ongoing

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## PN Timing Mode:

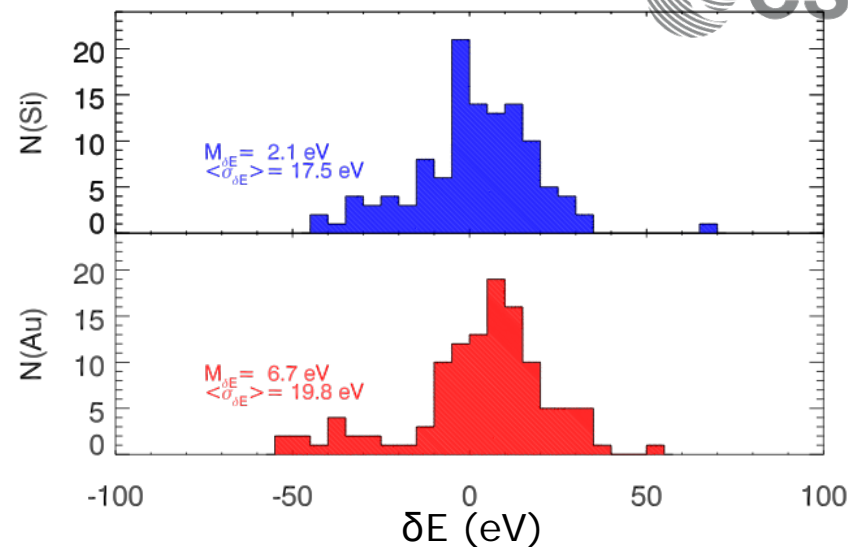
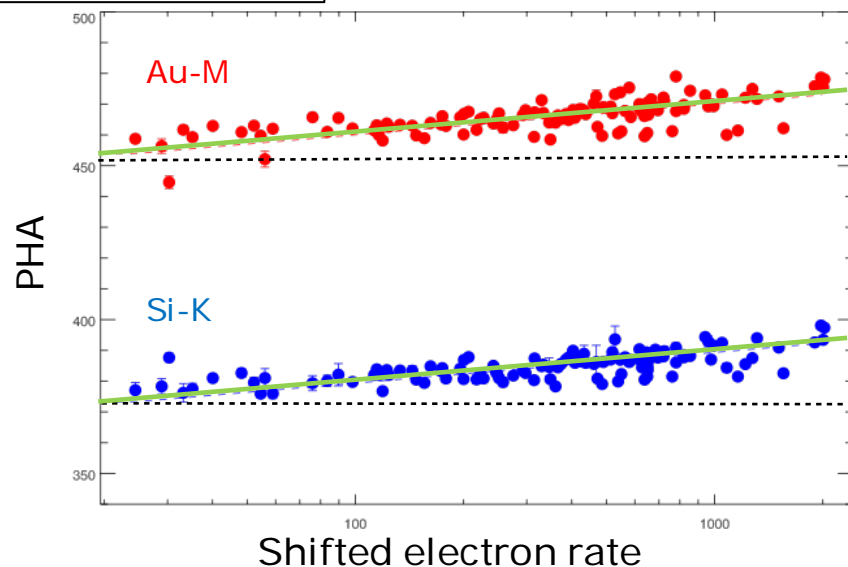
Calibration update to the rate-dependent PHA correction for PN Timing Mode

This new correction improves on that of Guainazzi et al. (2013, 2014):

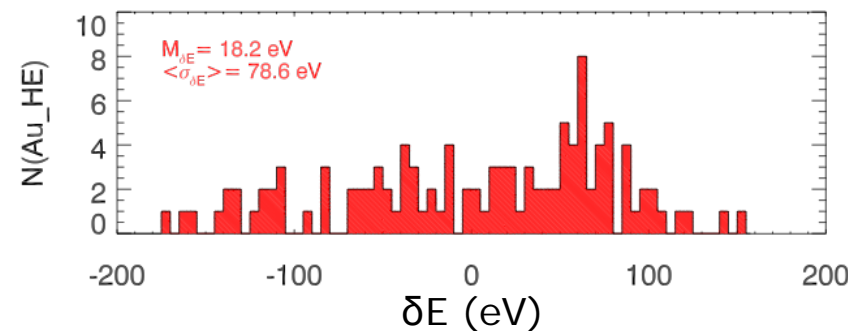
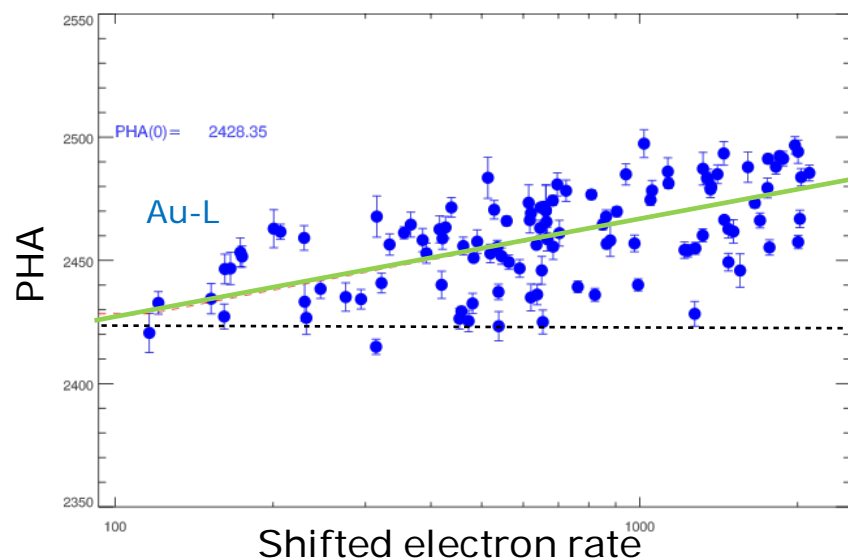
- Derived from a significantly larger sample (~ 150 sources)
- In addition to the instrumental edges at Si-K (1.8 keV) and Au-M (2.2 keV) now includes high energy data point at Au-L (11.9 keV)
- Details in XMM-CCF-REL-369 (Migliari et al., 2019)

## PN Burst Mode:

- Newly derived RDPHA calibration (will replace current RDCTI correction)
- Derived similarly as for Timing Mode (although smaller source sample)
- Implementation requires a SAS S/W update



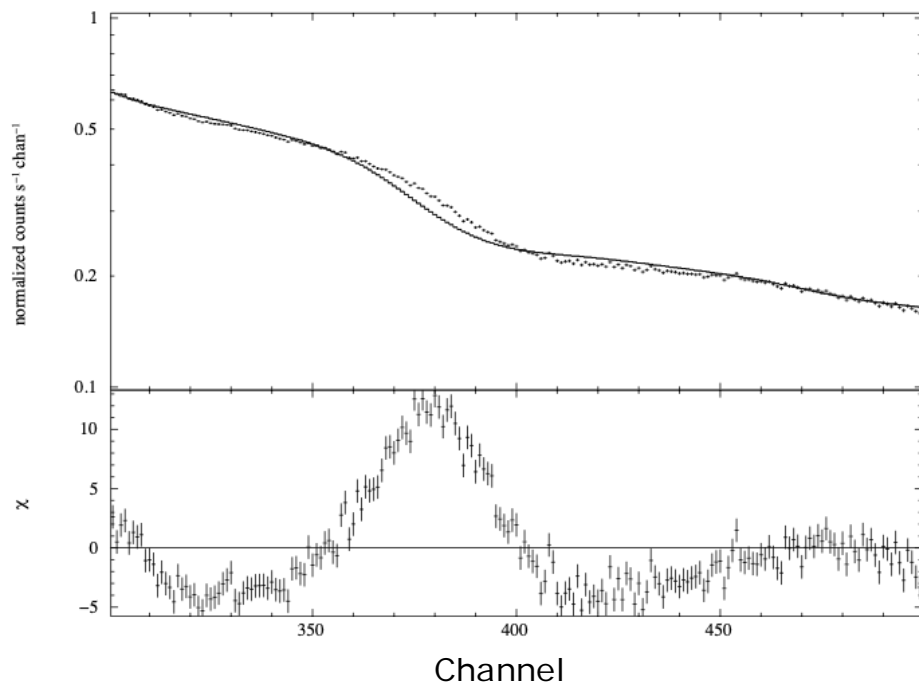
at ~2 keV: average systematics ~1%,  
tail to 70 eV (3.5%)



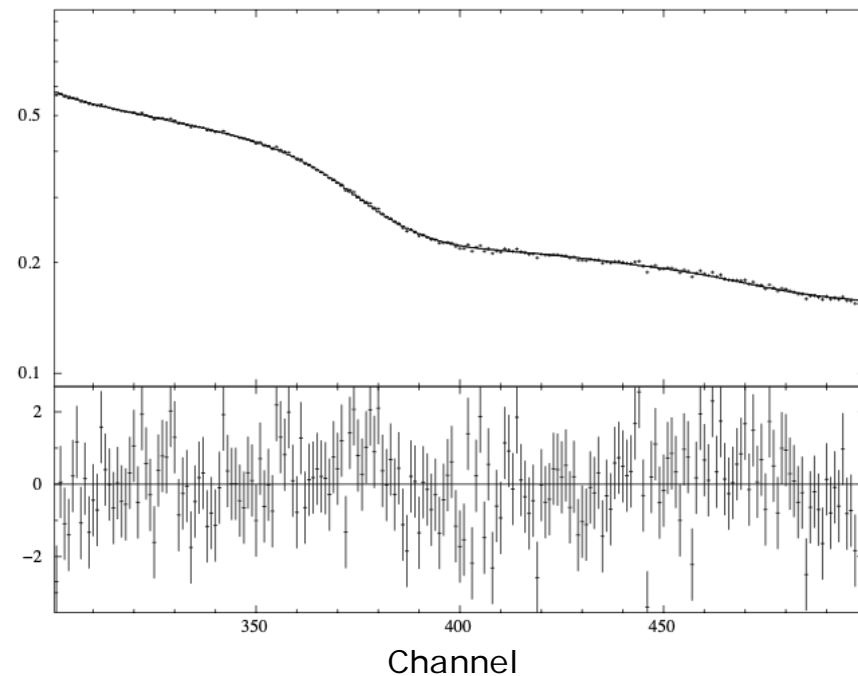
at ~12 keV: average systematics ~0.7%,  
tail to 180 eV (1.5%)

## Timing Mode

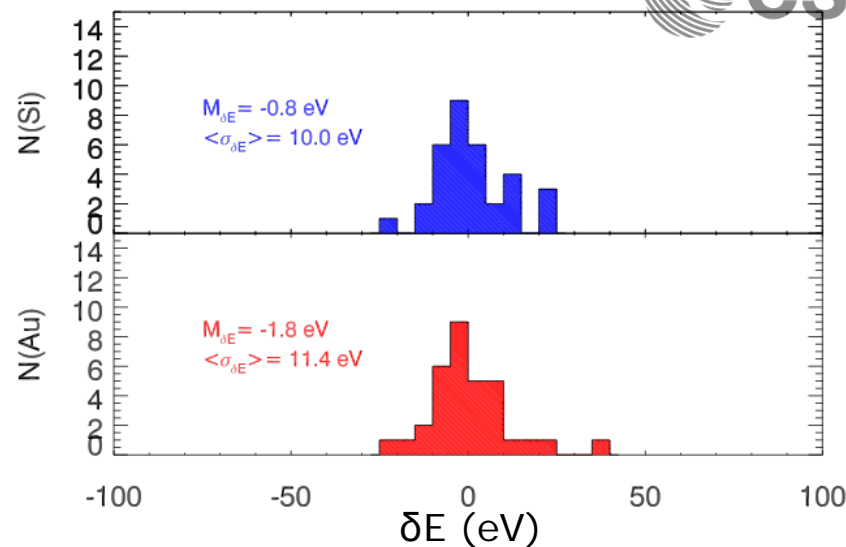
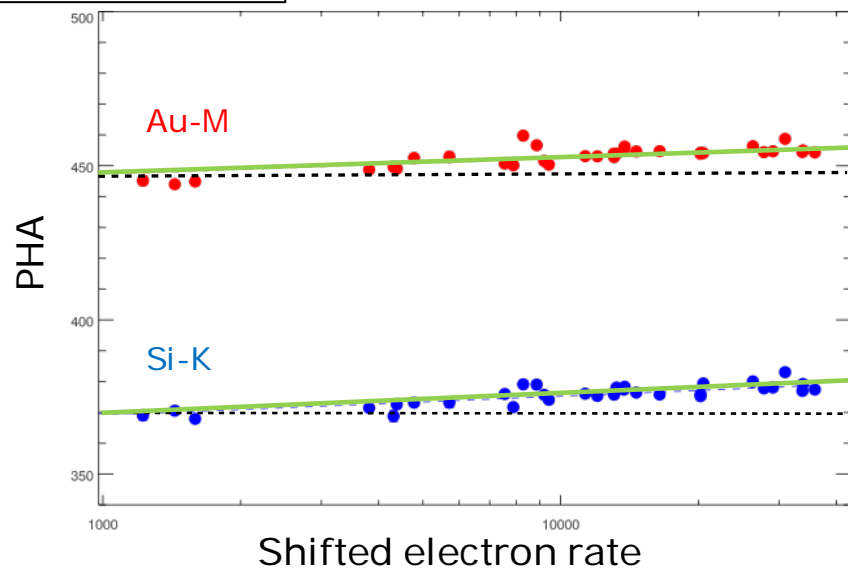
No RDPHA correction



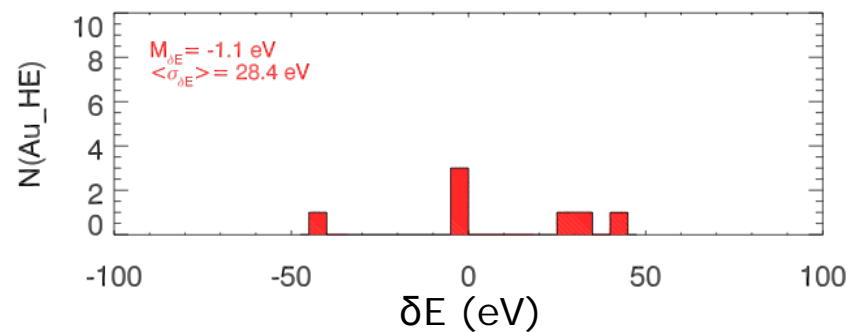
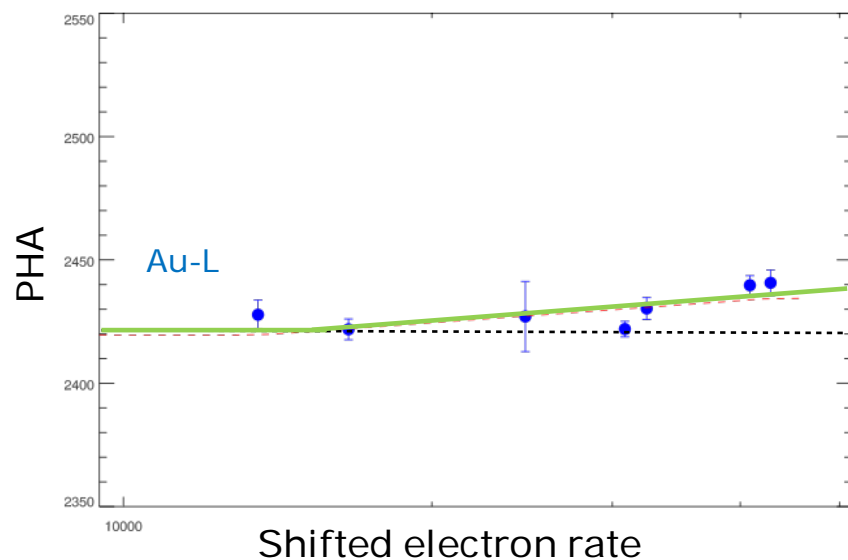
With RDPHA correction



S. Migliari



at ~2 keV: average systematics ~0.6%,  
tail to 40 eV (2%)



at ~12 keV: average systematics ~0.2%,  
tail to 50 eV (0.4%)

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2. Evidence for a shift in gain of the PN detectors, which is dependent on the quiescent background. This should be investigated and quantified, and a correction implemented. → **Done: SAS 17 + calibration release**
3. Calibrated spectra from NuSTAR and XMM-Newton sometimes show a significant mismatch in spectral slope and offset above 3keV. This is a matter which the IACHEC should be encouraged to investigate. → **On-going**
4. Complete the calibration of the PN Burst Mode, RDPHA correction. → **In validation**

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- The time and energy reconstruction of the pn Timing mode should be studied with respect to recently observed discrepancies. → **Done: calibration release**

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