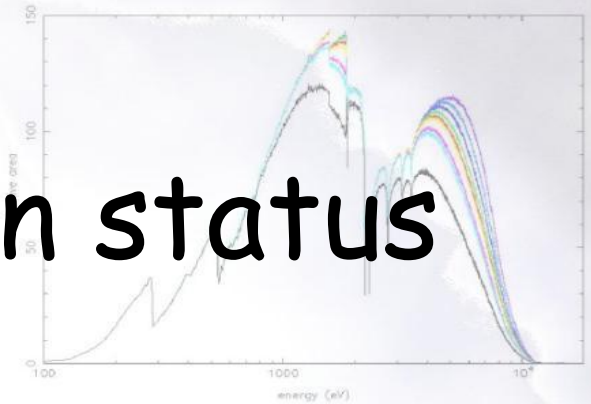
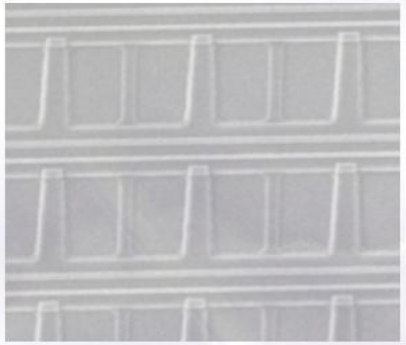
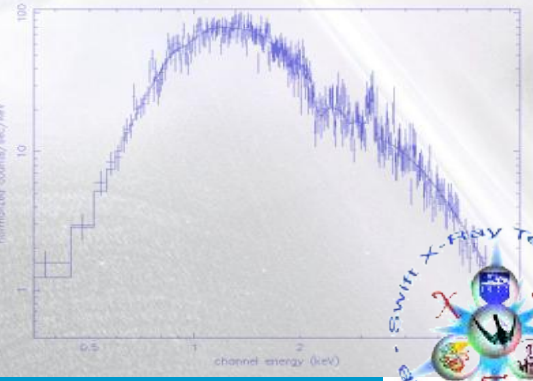
Swift-XRT calibration status update

Andy Beardmore
on behalf of the
Swift-XRT team







Swift-XRT status

Changes since IACHEC 2007

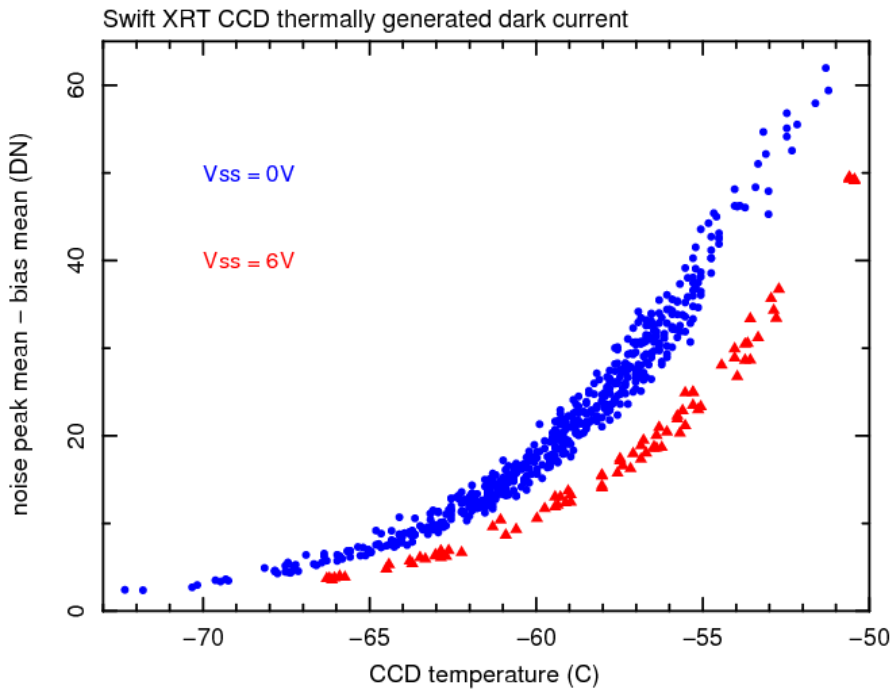
- CCD Substrate Voltage Change : 0V→6V (2008/08/30)
- Improved on-board temperature dependent event threshold tables (2007/09/14)
  - Reduces dark current, allowing the CCD to operate at higher T before pixels become `hot'
- On-board flight s/w efficiency enhancements (2008/06) → continuous Fe-55 cal source data
  - CTI estimate improvements
- Charge Trap mapping using Cas A
- Broadened RMFs

Substrate Voltage Change

- XRT CCD operates at temperatures from -75C to -48C (ideally -50C) because of a failure of the TEC shortly after launch.
- In 2005, a lab programme (led by Tony Abbey at LU) showed that by raising the substrate voltage the noise performance properties of a flight spare CCD operating at high T were improved.
  - Tests suggested SSV = 6V would be optimal

Substrate Voltage Change (cont)

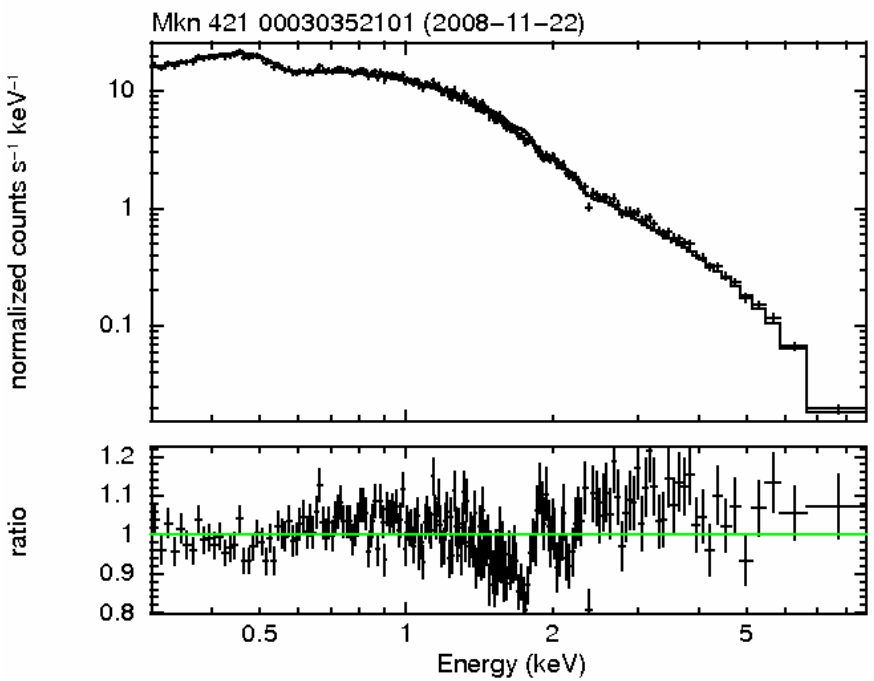
- Substrate voltage changed to 6V on 2007/08/30
- Raw-frame analysis



- Around same time (2007/09/14), Jamie uploaded new temperature dependent event threshold tables
  - Significant reduction in the on-board count rate → less hot pixels and mode switching when CCD is warmed up to -50C.

Substrate Voltage Change (cont)

- Downside - 10% QE changes at high energies (above 5 keV) and around the Si K-edge

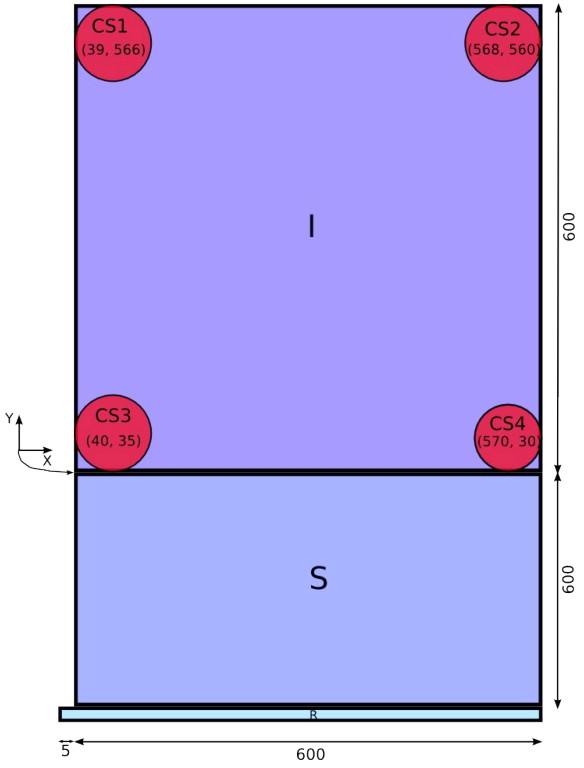


- To be fixed in next release of RMF/ARF
- Also different operating voltages caused a gain change

Gain / CTI

- In 2008-June, flight software improvements were uploaded which allowed the CCD to be read out more efficiently.
- This meant continuous collection of full-frame CCD data, which includes Fe-55 "corner sources" used for gain/CTI estimates.
- Prior to this we were limited to a few frames of data near midnight (part of `Daily Ops proc')

Corner sources



cs1 to cs4 : Fe-55 corner sources

Measured PHA value (DN) :

$$D = \frac{E}{A}(1 - CTI_{p,i})^{Y}(1 - CTI_{p,f})^{Y_S}(1 - CTI_s)^{(X+5)}$$

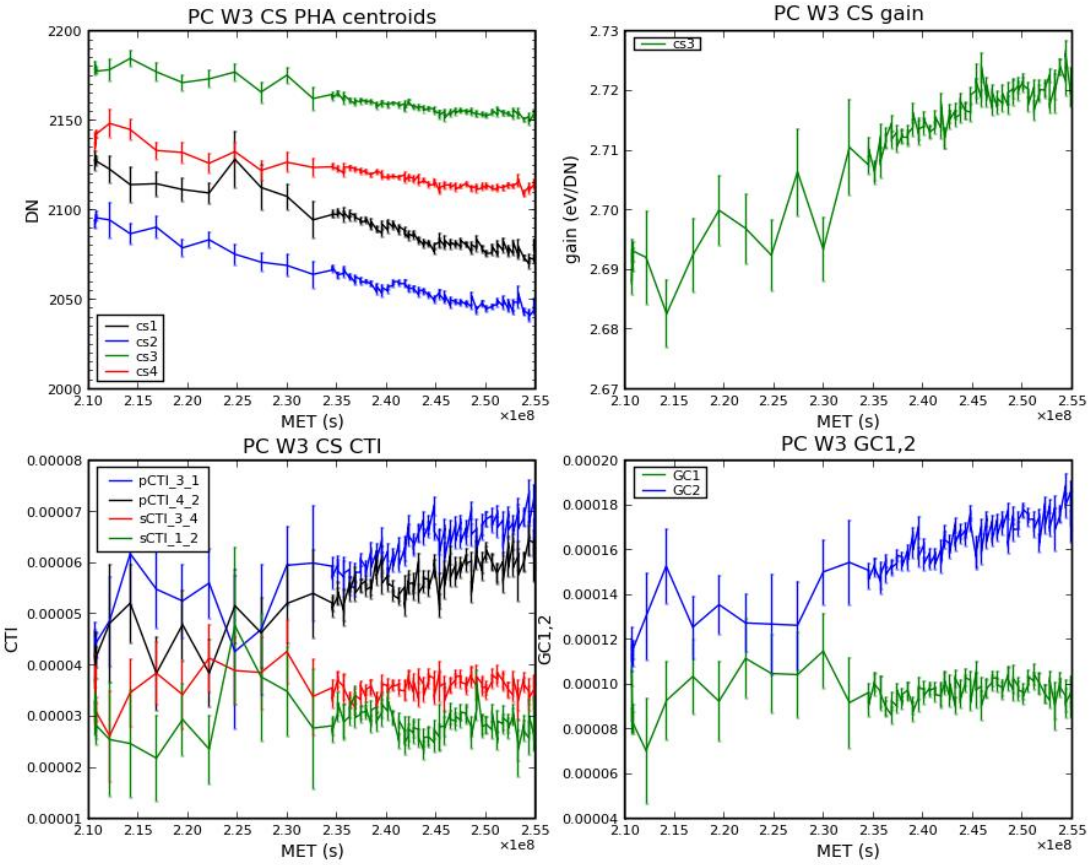
cs3 → gain coefficient evolves with time

cs3-cs4 → serial CTI

cs3-cs1 & cs4-cs2 → parallel CTI

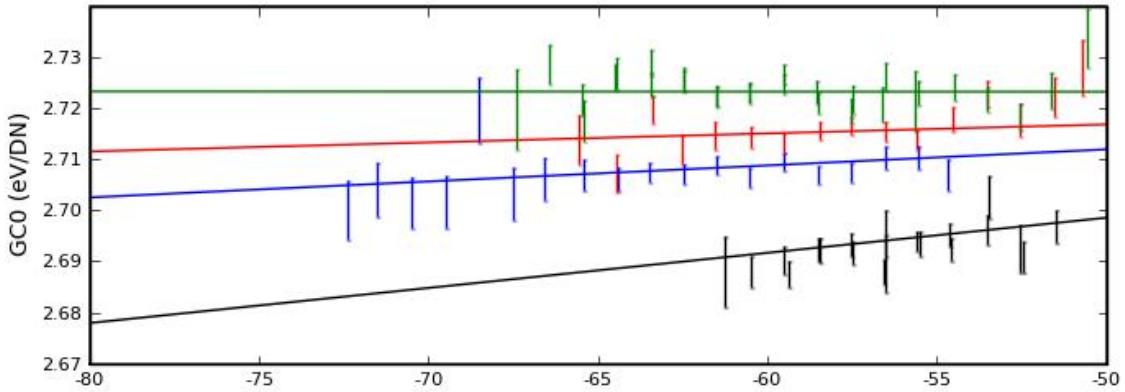
Gain/CTI history for SSV 6 data

- Corner source data from 2007-09 to 2009-01 at -57C



Gain/CTI v CCD temperature

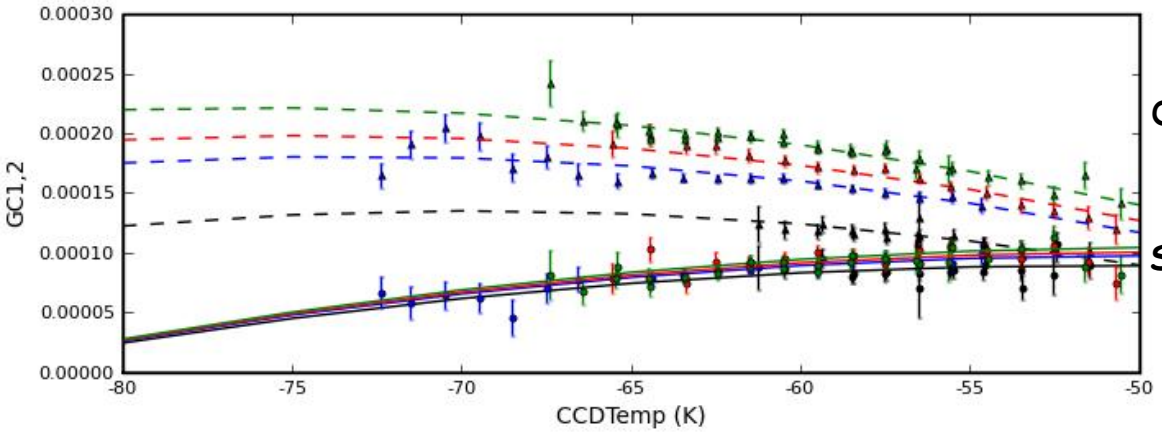
Gain



2009-01

2007-09

CTI



dashed – parallel

solid - serial

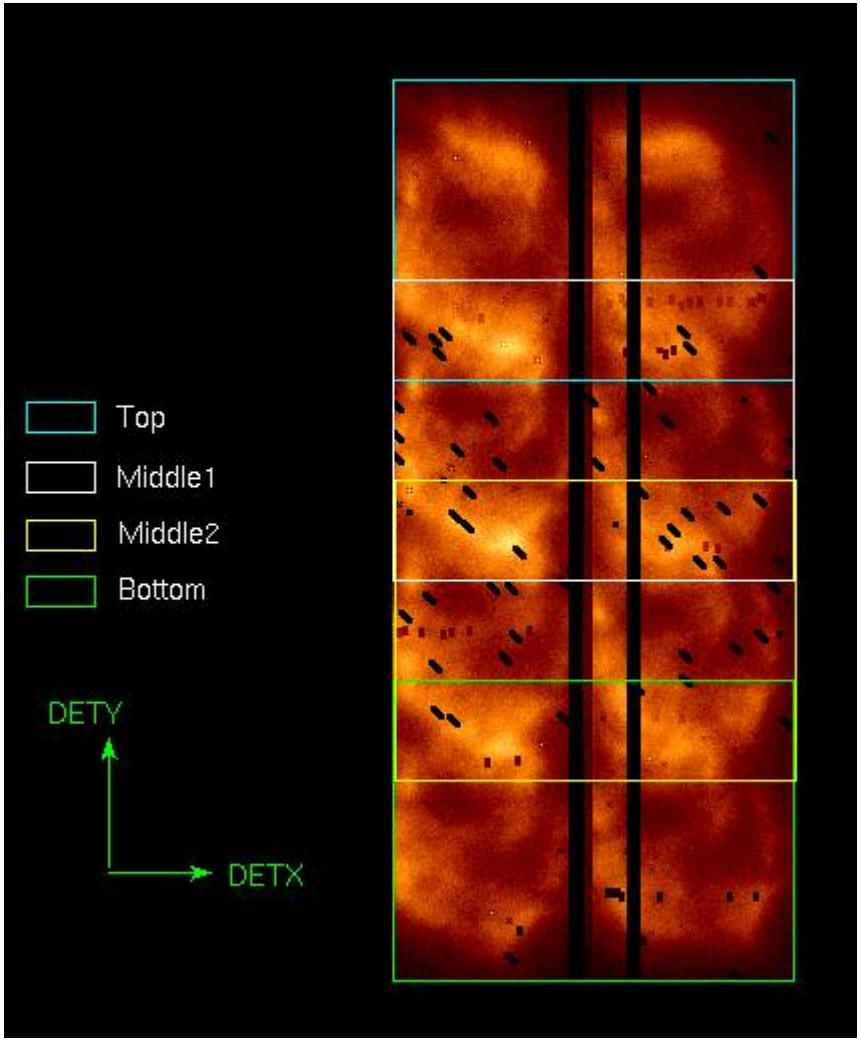
Gain / CTI (fin)

- Much improved characterisation of the XRT photon counting mode gain / CTI behaviour as a function of time and temperature
- Difficult to get an accurate estimate of the CTI energy dependence: CTI(E) ~ E^(-0.5)
- No direct measure of gain/CTI in windowed timing mode (1.8 ms readout mode).
  - Cas A offset observations hint CTI is worse in WT mode
- Started theoretical modelling of the gain/CTI using code developed by Ian Hutchinson (LU)

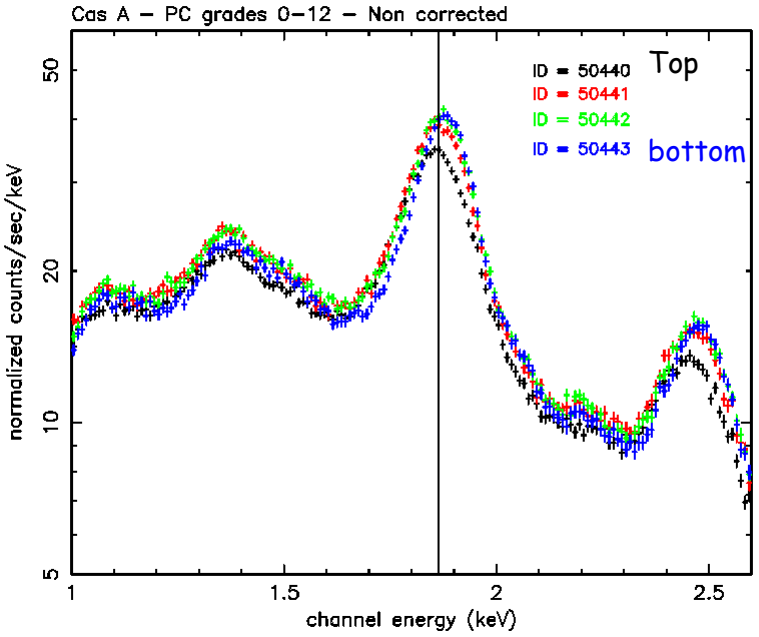
Charge Trap Mapping

- Significant charge traps have been developing on CCD for some time
- No fully-illuminated CCD calibration data to investigate traps with
- While charge injection is possible on CCD22, it can't be controlled accurately enough.
  - Column-column variations
- What can we do?
  - Cas A...

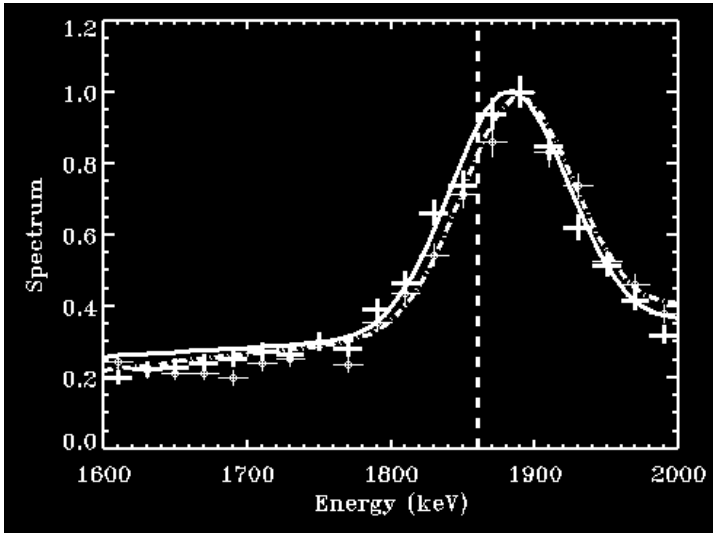
Trap mapping – Cas A



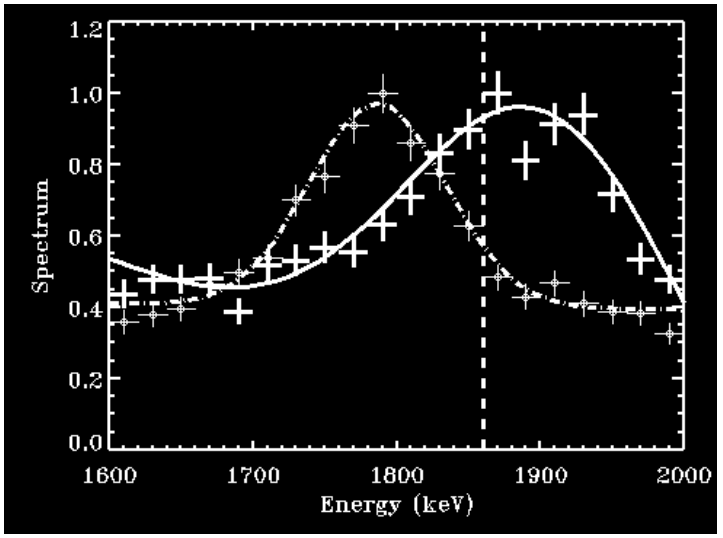
129 ks of data taken in 8 offset pointings covering the central 200



Trap example



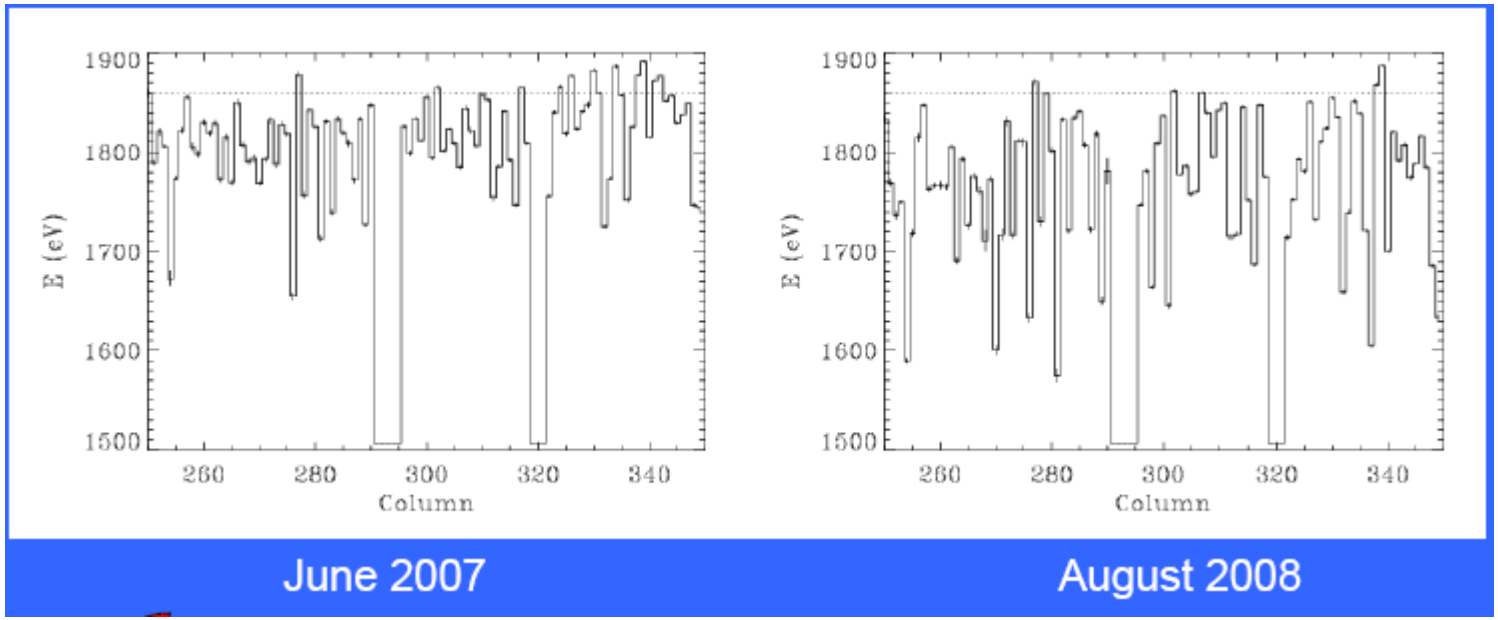
Column 202: no trap



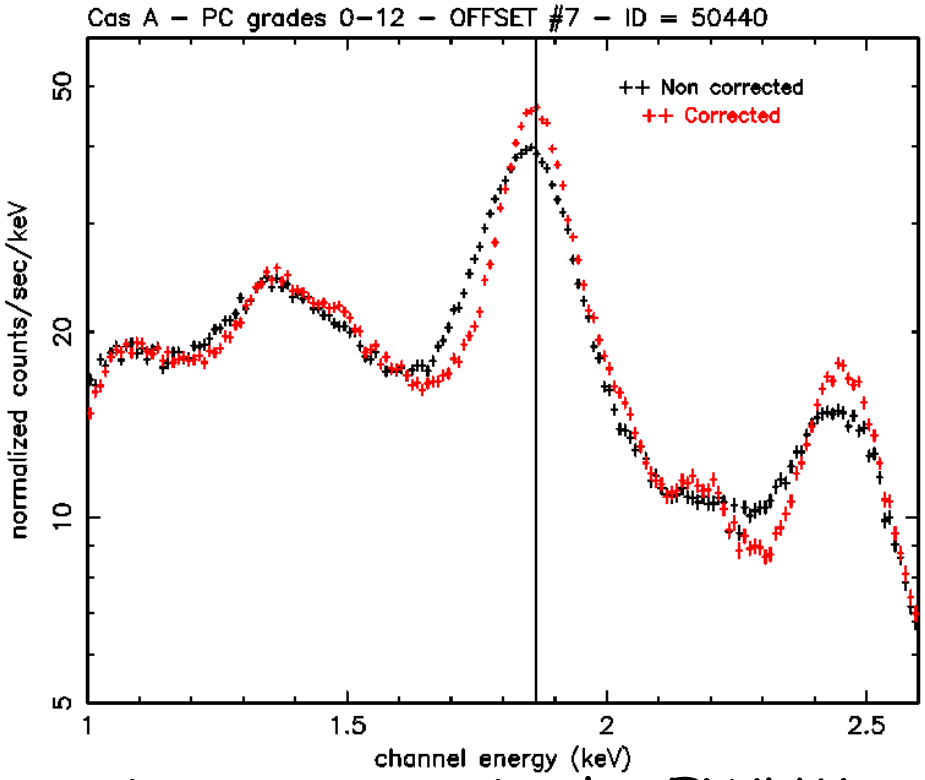
Column 343: trap ~100eV

- Using an "iterative" process can refine the trap location to ~20-30 pixels in DETY
- Spectral variation across the remnant limits minimum trap depth to ~20 eV

- Mean column-by-column Si- Kalpha centroid



Cas A - trap corrected

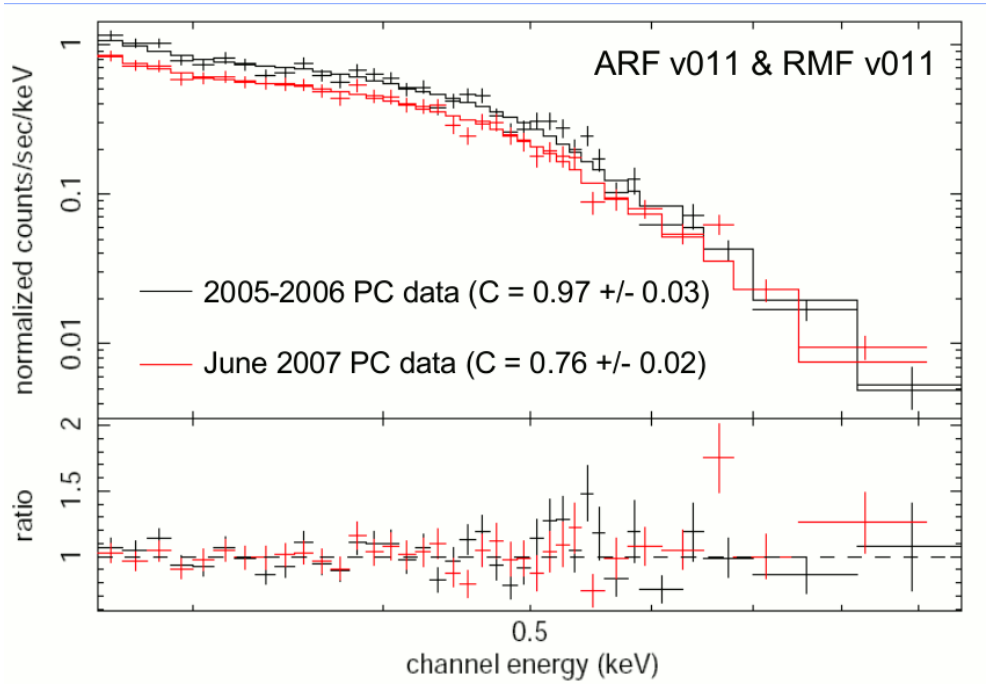


- Significant improvement in the FWHM
- New ground s/w under development to perform the trap correction
- Need to take cal data every ~6 months to monitor traps

Broadened RMFs

- Worsening CTE is increasing the response kernel FWHM
- Trap build up is also responsible for reducing QE at low E as good events are lost below threshold

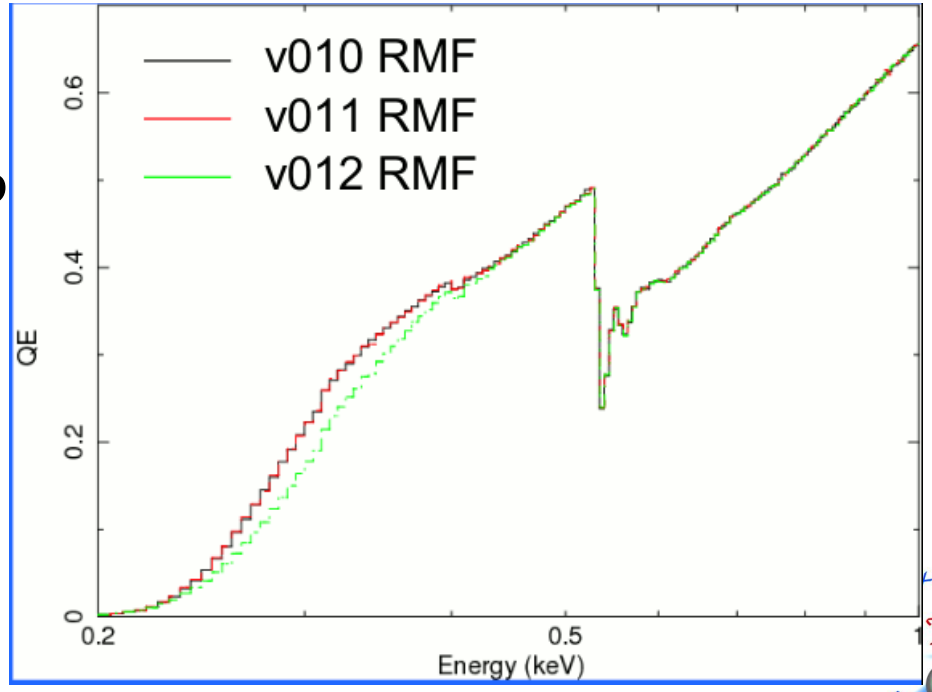
RXJ1856



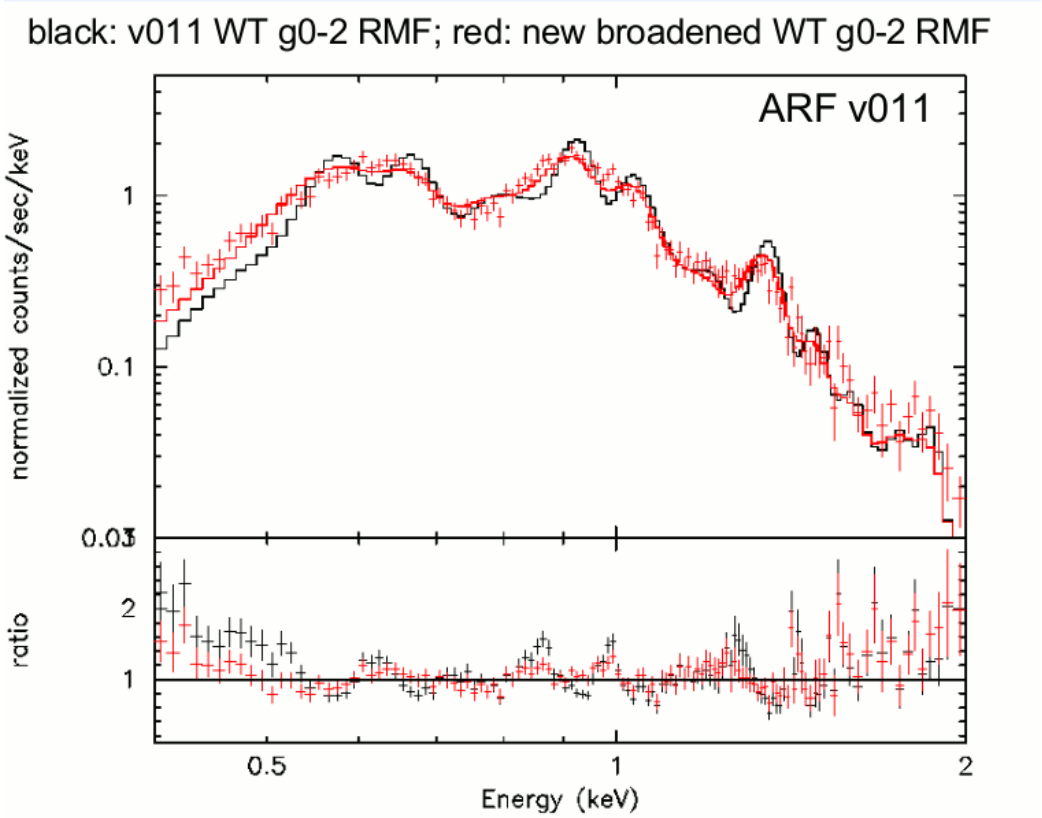
Burwitz et al bbody model

Broadened RMFs (cont)

- Olivier Godet developed a RMF kernel convolution function (2 gaussians) with CTI dependent FWHM
- Carefully tuned on line source E0102, and on continuum sources below the O – edge
- Reduces QE at low E
- Account for RXJ1856



Broadened RMFs (cont)



E0102 with IACHEC model

broadened RMF in RED

- Fixed epoch RMFs released for data from 2007-03 (pre-SSV) and 2007-09 (post-SSV) for WT mode. PC to follow
- ToDo – need a s/w tool to automatically compute the broadening