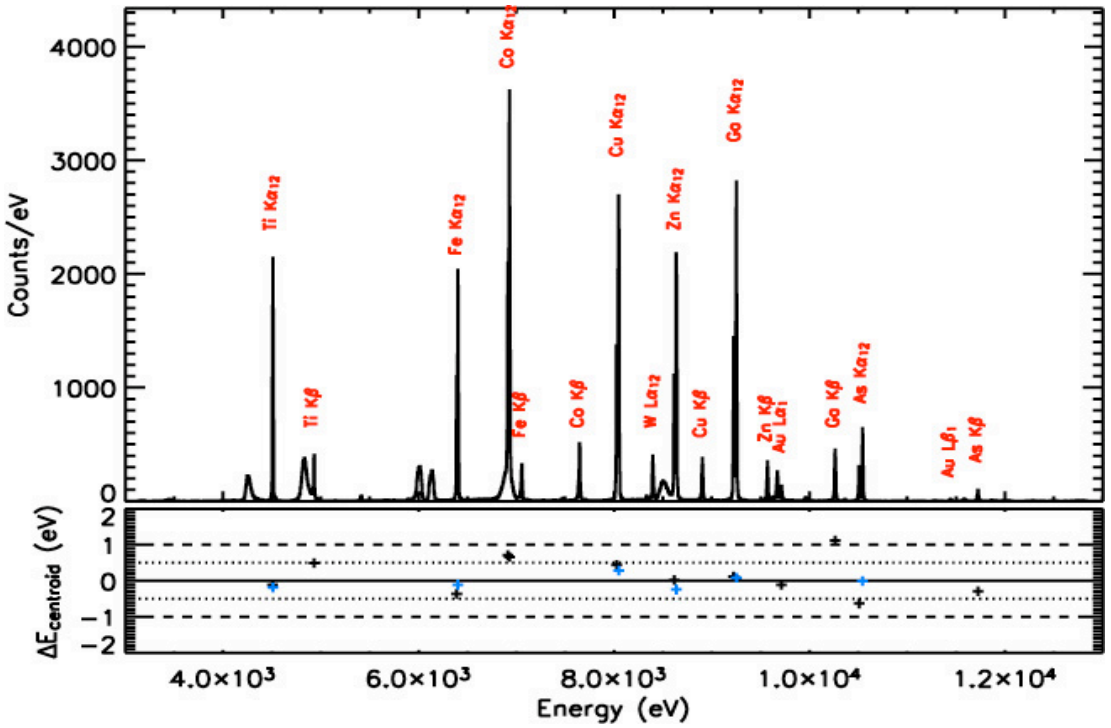
# XRS Calibration

## Status & In-Flight Plan

- **Energy Scale**
- **Line Spread Function**
- **Effective Area**
- **Background**

# Energy Scale

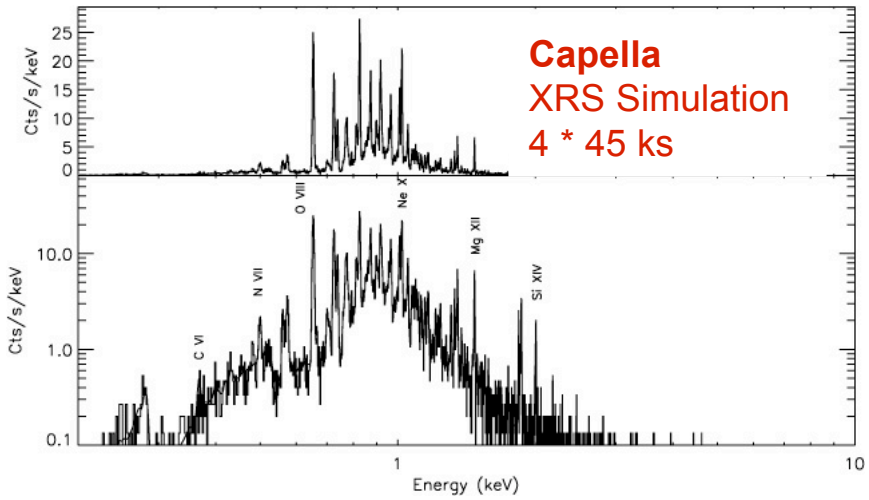
The energy scale is a complicated, non-analytic function. Using a physical model for the pulses, we find that E(V) can be well characterized by a 4th order polynomial. For ground calibration data this gives an energy scale that is accurate to $\Delta E \lesssim 0.5$ eV

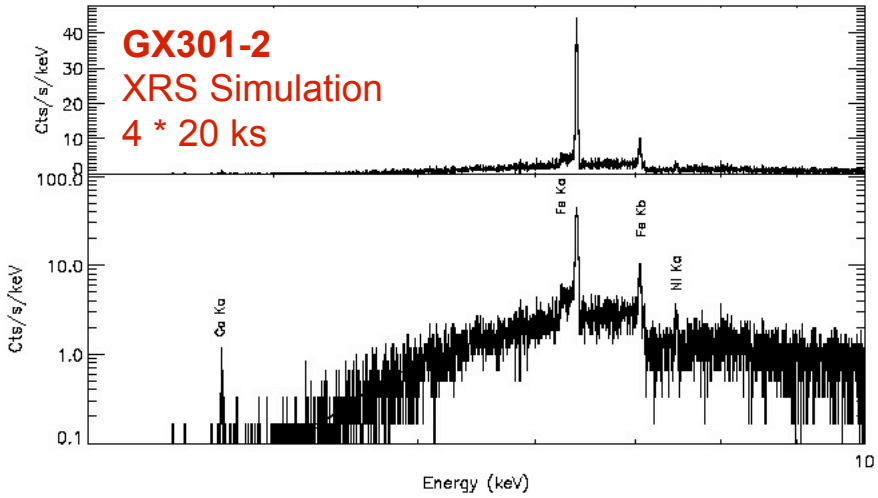


# Energy Scale: In-Flight

The energy scale must be re-established in-flight. We will use offset pointings of Capella and GX301-2 to illuminate all pixels.

| Line | Energy (keV) | Inner Pixel | Outer Pixel |
|---|---|---|---|
| N VII Lyα | 0.500 | 105 | 58 |
| O VIII Lyα | 0.654 | 1045 | 404 |
| Ne X Lyα | 1.022 | 1051 | 407 |
| Mg XII Lyα | 1.473 | 279 | 108 |
| Si XIV Lyα | 2.006 | 70 | 27 |
| K Kα | 3.314 | 186 | 186 |
| Mn Kα | 5.894 | 6200 | 6200 |
| Fe Kα | 6.400 | 3320 | 1262 |
| Ni Kα | 7.461 | 105 | 40 |



# Energy Scale: Drift Correction

Changes in the energy scale will be tracked using an offset pixel.

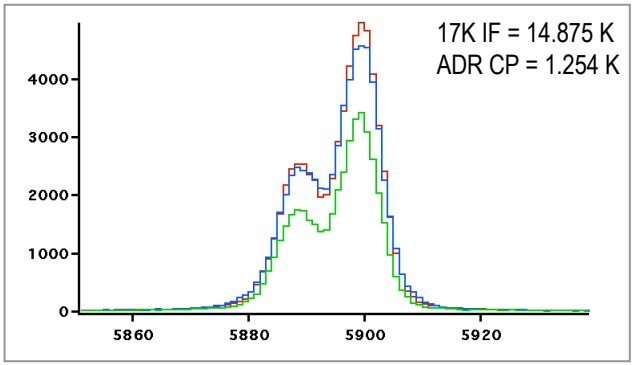
During ground calibration we discovered that the calibration pixel and the array pixels respond differently to changes in the thermal environment.

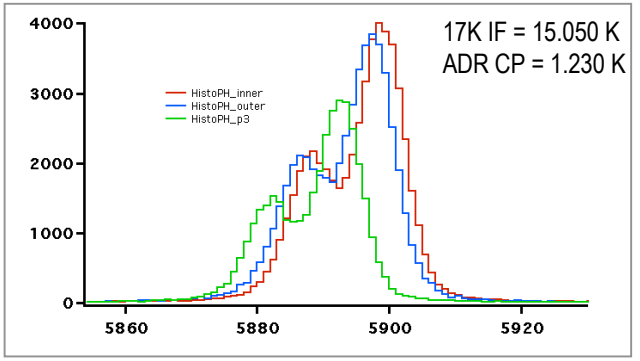
This is very difficult to characterize. For small changes in temperature, the drift is linear.

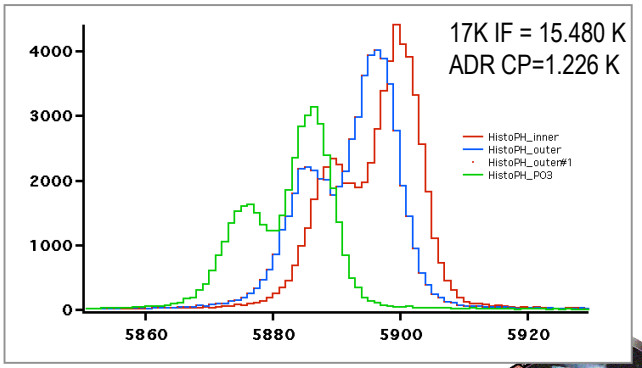
Cal Pixel:

$\Delta T_{Ne}$ ~ 40 eV/K

$\Delta T_{He}$ ~ 130 eV/K



# Line Spread Function

The line spread function is well characterized by a Gaussian function.

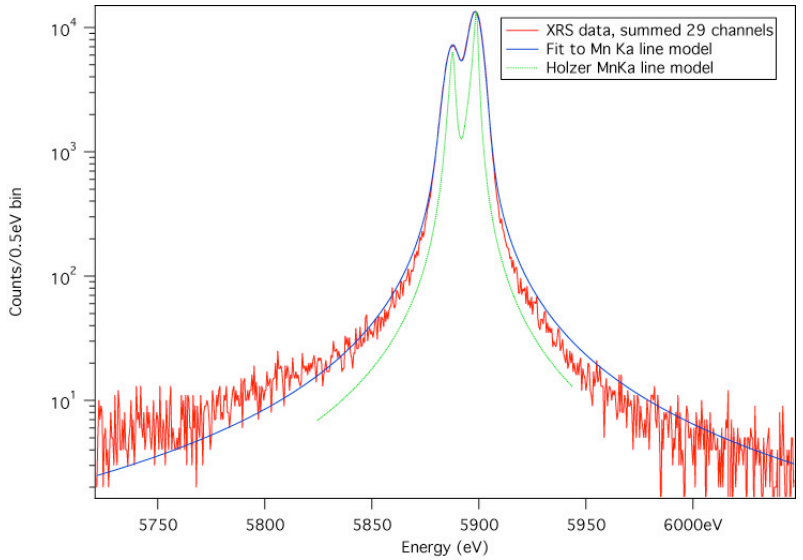
This resolution kernel is measured using a $^{55}$Fe source. For the most flight-like conditions we find:

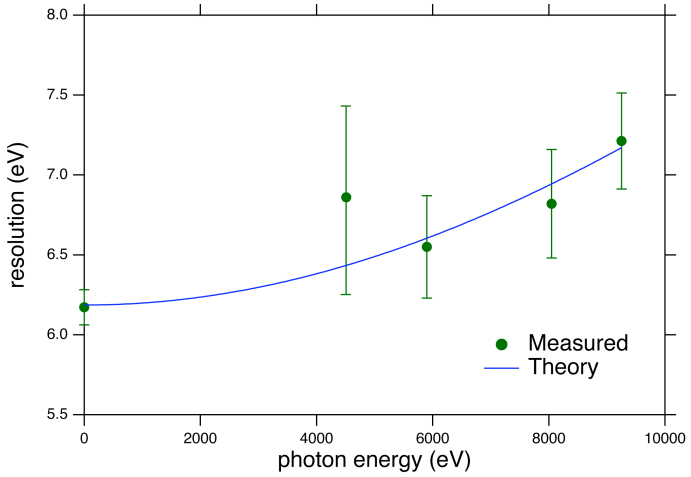
Composite: $\Delta E_{FWHM} \sim 5.6$ eV

Pix mean: $\Delta E_{FWHM} \sim 5.3$ eV

Std dev: $\sigma \sim 0.2$ eV

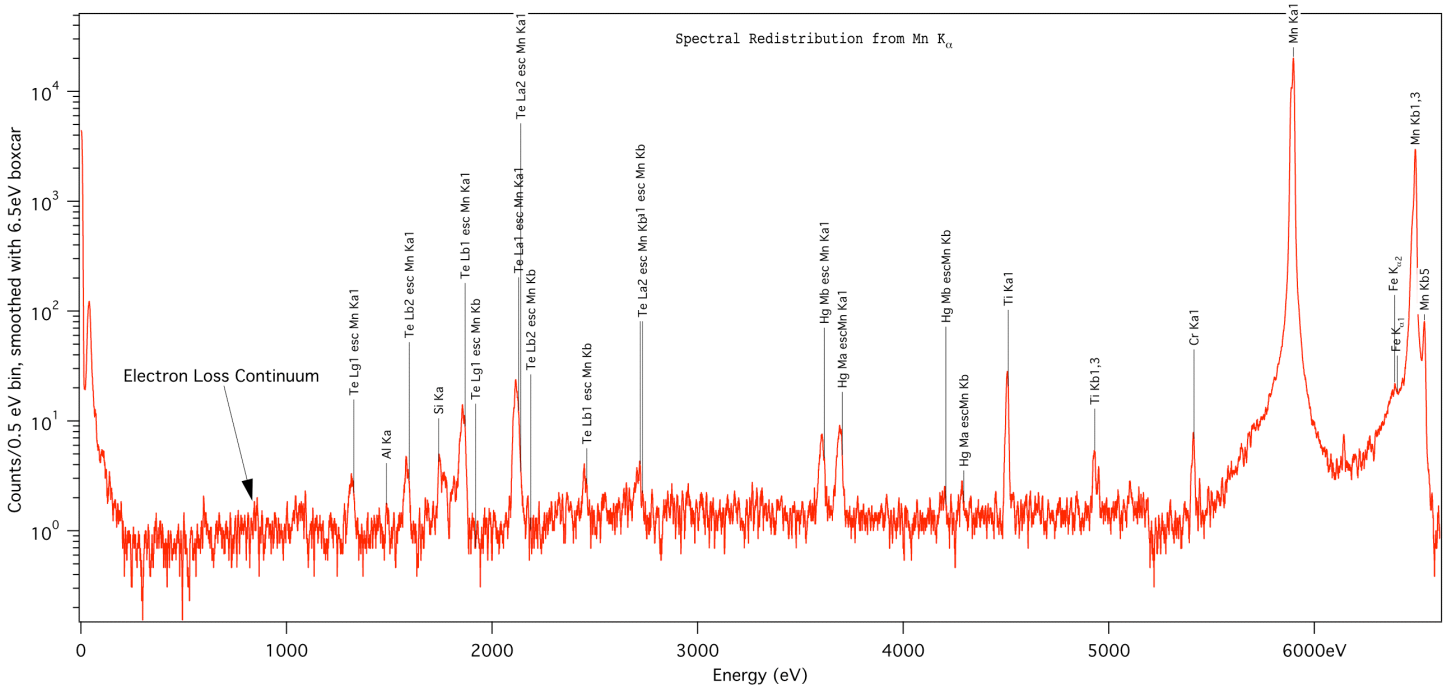
The energy dependence appears to follow the predictions of the pulse model.



# Line Spread Function: Low Energy Shoulder

There is a low energy shoulder due to photo- and electron-escape events. A monte-carlo is being developed. It depends on both the photoelectric absorption cross-sections and the electron interaction with the solid state HgTe absorber.



# Effective Area

$$A_{eff} = A_{tel} * \eta_{tel} * \Pi\eta_{filters} * \eta_{intercept} * \eta_{QE} * \eta_{electonics}$$

Telescope: Described by Kai-Wing Chan

Blocking Filters: Aluminum and oxides in the filters produce absorption structure at low energies. This is measured on the ground.

Pixel Intercept: This will depend on the boresight, the telescope PSF and the alignment of the pixels.

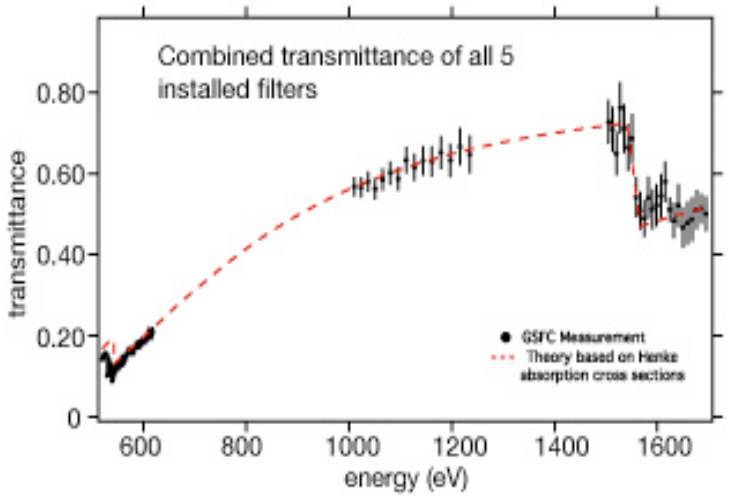
Absorber Quantum Efficiency: This depends on the column density of the HgTe absorbers. The absorbers have been measured and weighed, and the Hg L absorption edges have been measured.

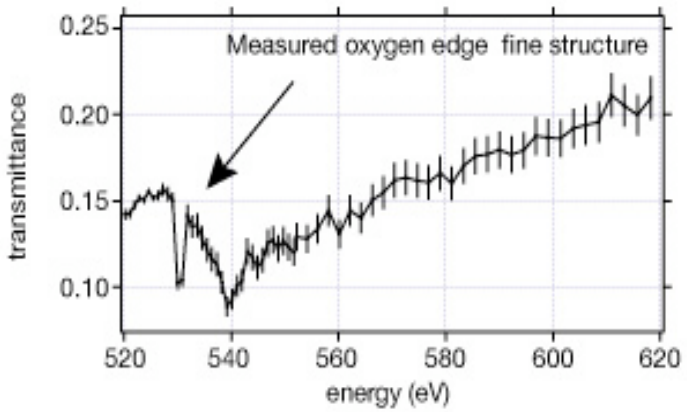
Electronics: At high count rates some events will not be identified by the pulse detection algorithms. This 'pile up' will decrease the effective area by a few percent.



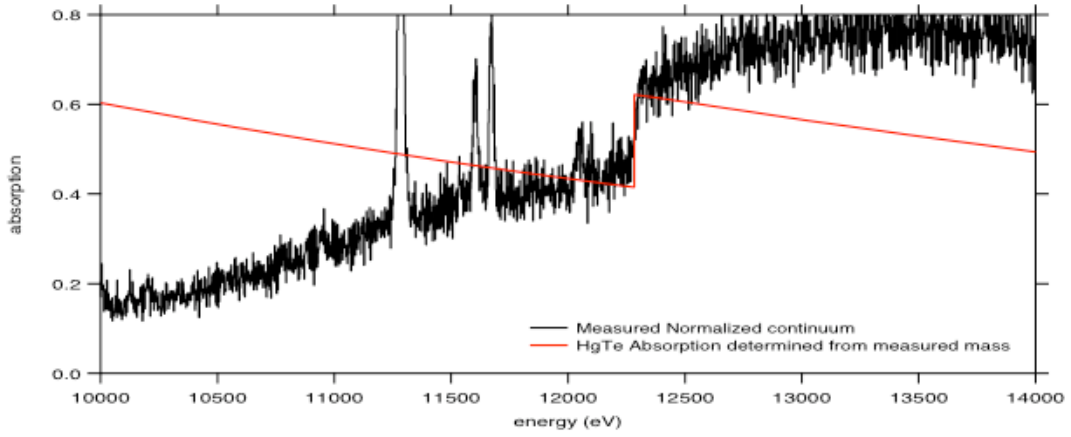

# Effective Area: Components

## Filter Transmission



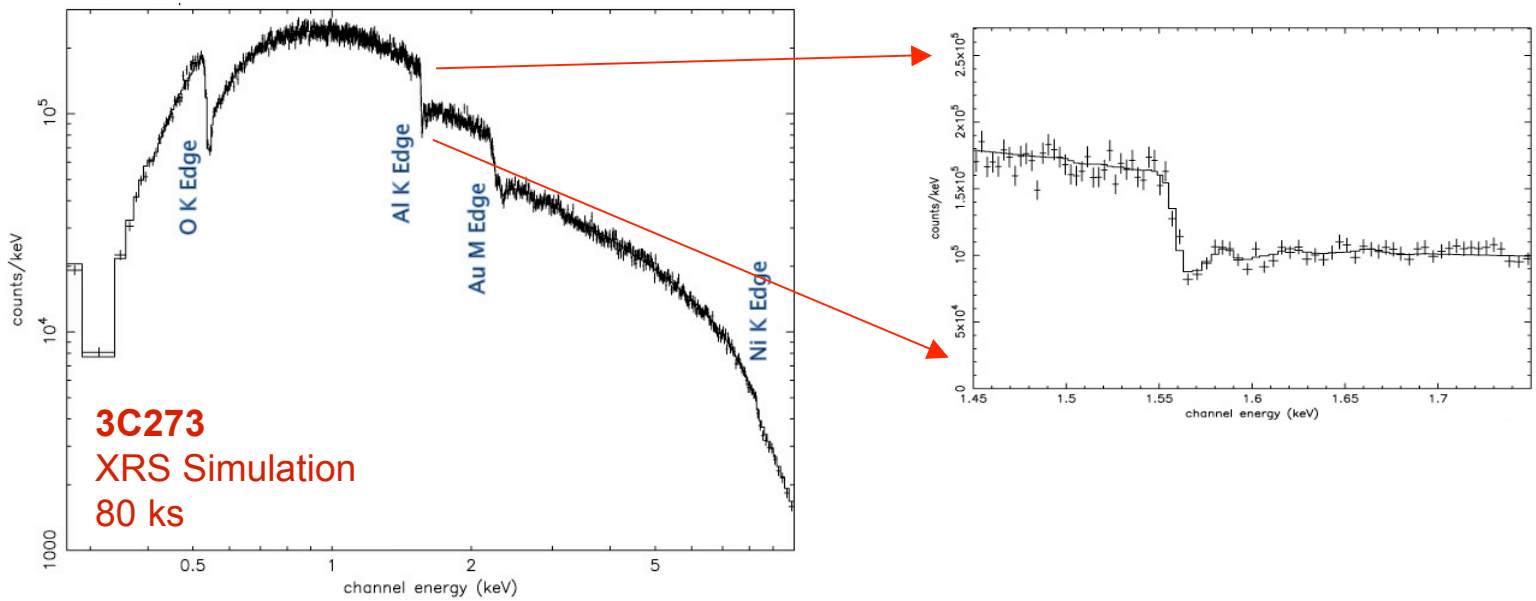




## Quantum Efficiency

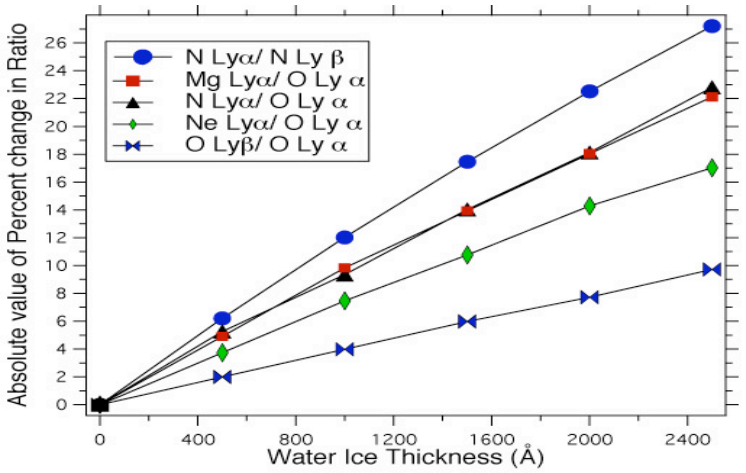


# Effective Area: In-Flight

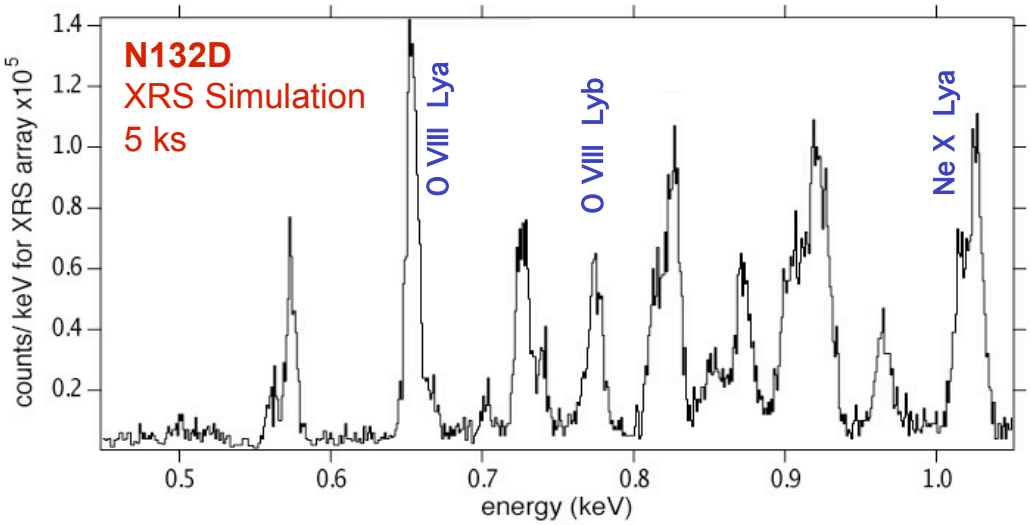
The goal of the in-flight calibration is to verify the discrete structure and characterize the global effective area. We will use the bright, featureless BL Lac 3C273 as a backlight. Simultaneous observations and cross-calibration with XMM-Newton/Chandra are required.



# Effective Area: In-Flight




To monitor the presence of ice contamination on the blocking filters we will observe line-rich SNRs N132D and 1E0102-72 repeatedly during the early phases of the mission.




**N132D**

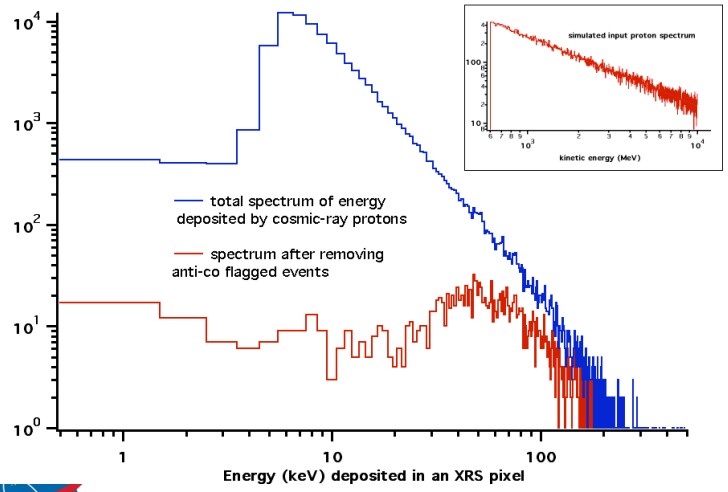
| Line | E (keV) | Cts |
|---|---|---|
| N VII Lyα | 0.500 | 65 |
| O VIII Lyα | 0.654 | 1900 |
| O VIII Lyβ | 0.775 | 850 |
| Ne Lyα | 1.022 | 2500 |
| Mg Lyα | 1.472 | 500 |

# Background

Primary cosmic ray protons: The anticoincidence detector identifies all but ~0.1% of events due to primary protons. Protons that hit the frame cause simultaneous pulses on multiple pixels that can be rejected by the processing software.

Secondary electrons and photons: To estimate the unrejected background due to secondary events, we scale the ASCA rate → 7 x $10^{-4}$ events/s.

**Anti-Coincidence Detector Rejection**




**Simultaneous 'clustered' events**