ROSAT PSPC Calibration

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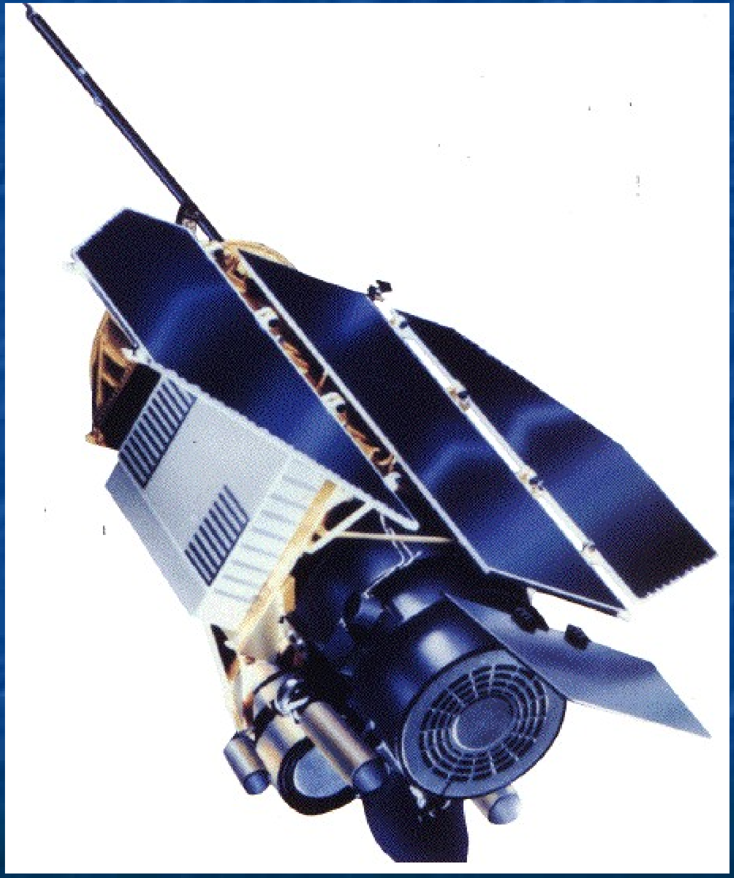
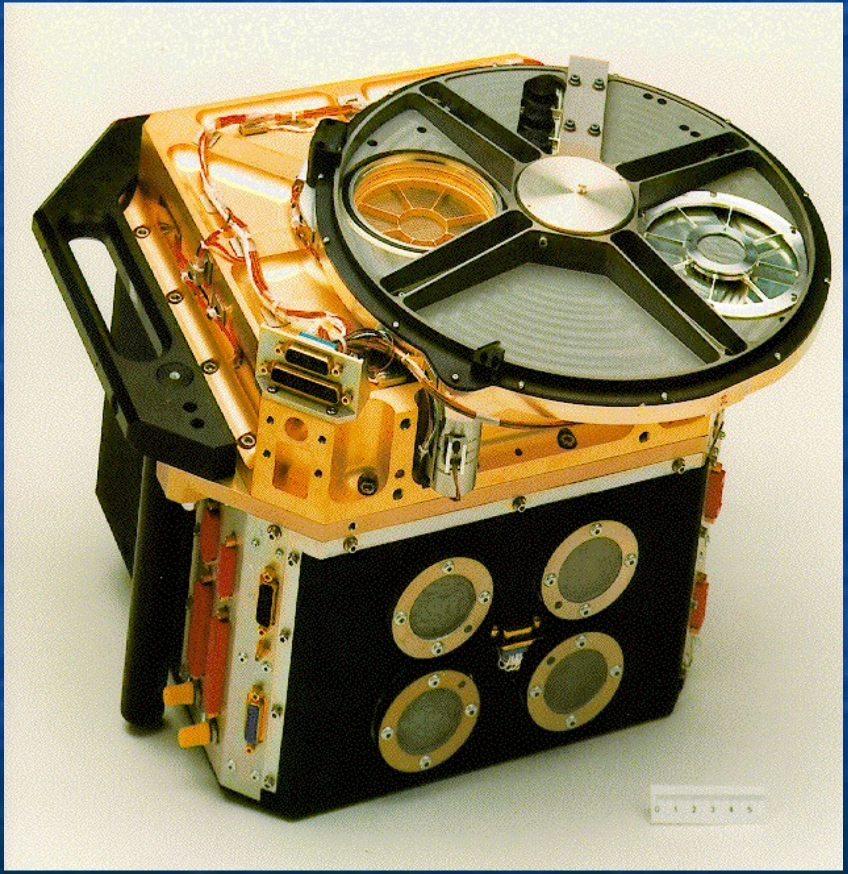
IACHEC #8 Hothorpe Hall

Theddingworth, UK   25-28 October 2007

ROSAT and the PSPC

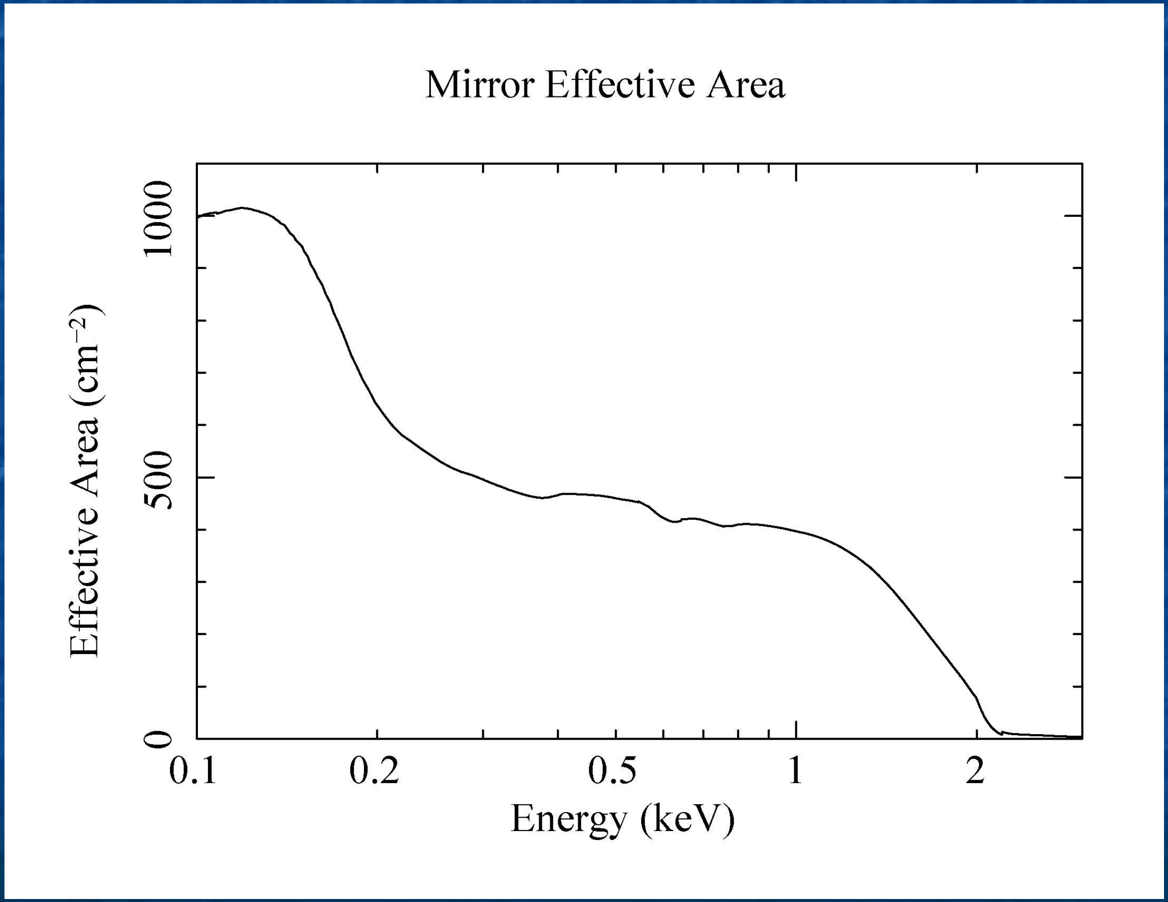




Spectral Response Calibration

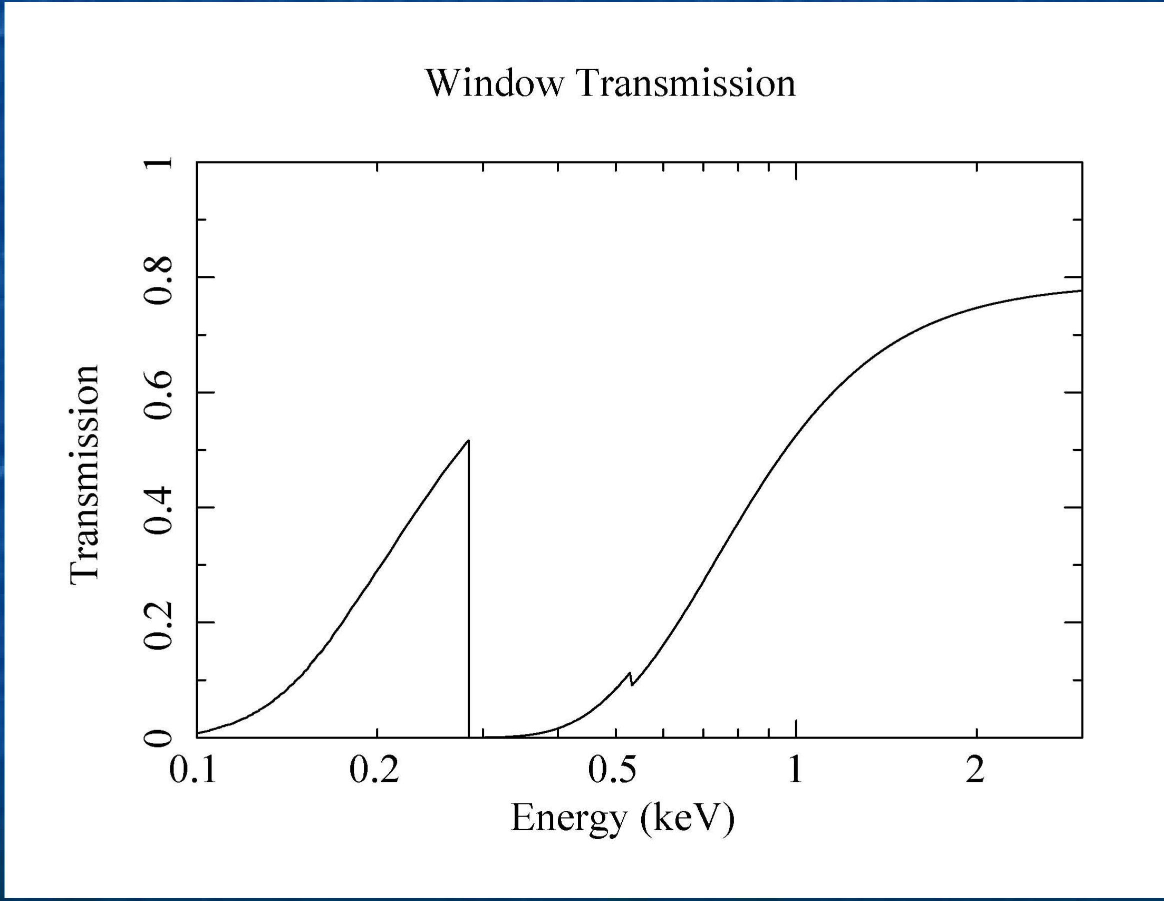
- Several simple and separable components
  - Mirror Effective Area
  - Window Transmission
  - Counter Gas absorption efficiency
  - Counter Vignetting
  - Detector Response Matrix – not so simple
- Physical models with calibrated parameters

Mirror Effective Area



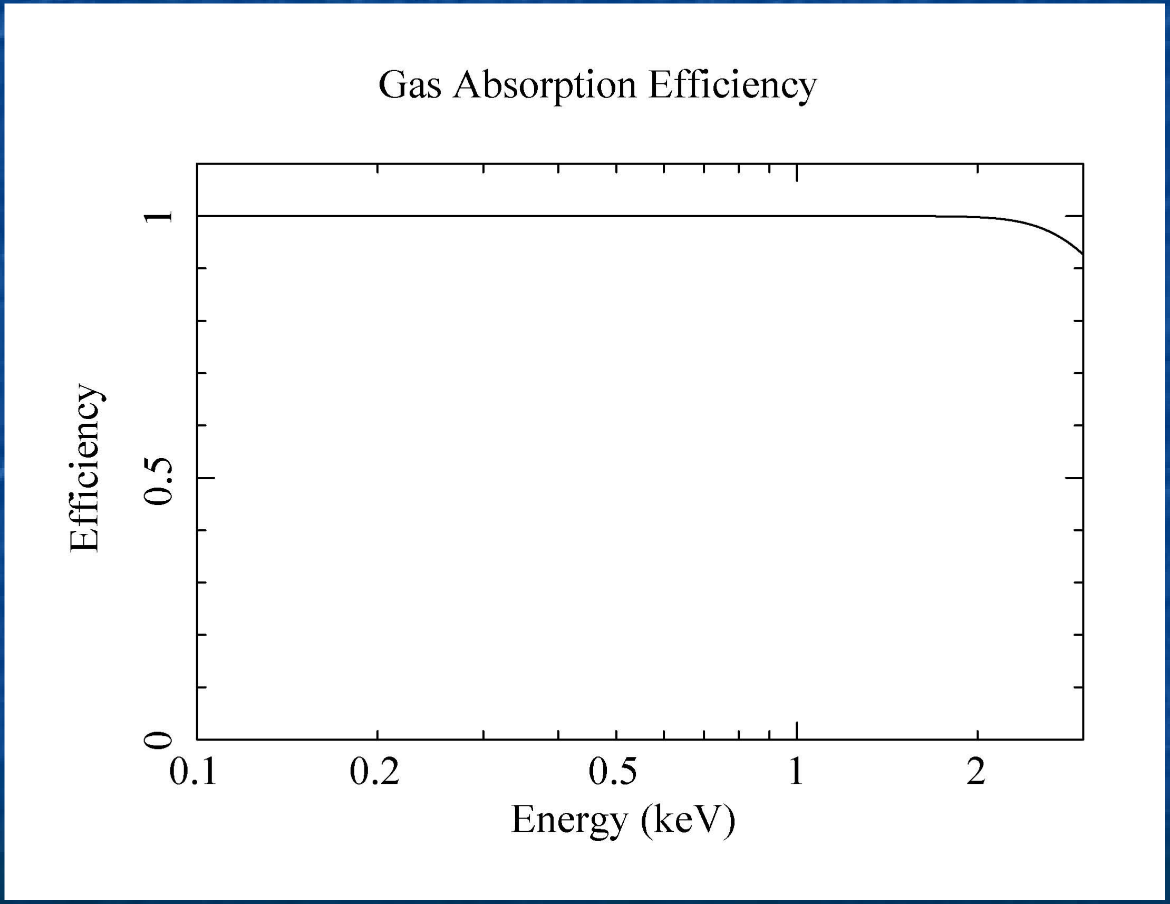
- Henke (1987) scattering/reflection coefficients
- Should have been recalculated using newer parameters generated for Chandra
- Some resistance for doing so – maybe I just got too irritating
- No idea how the new parameters would have affected the effective area

Window Transmission



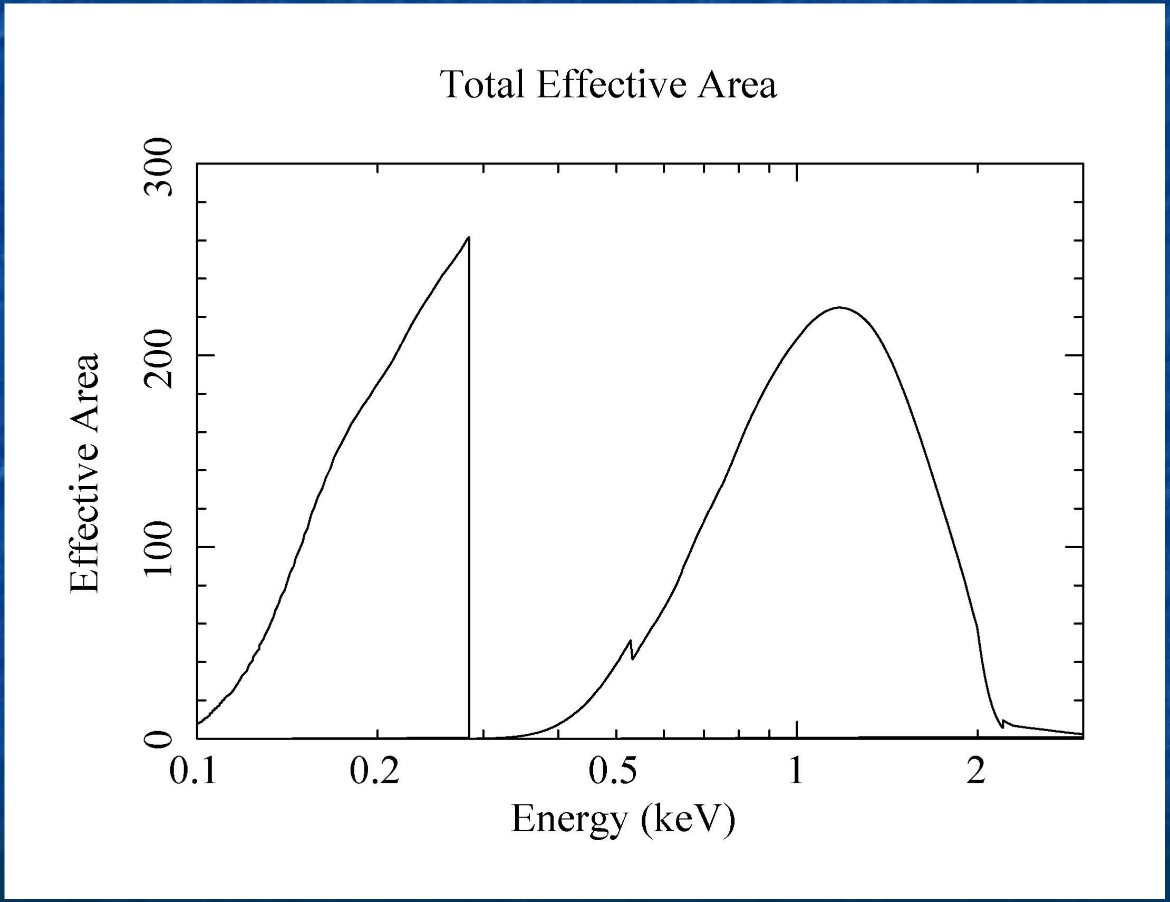
- Henke (1987) absorption cross sections
- Known formula for the window components
- Transmission measurements at various energies provided constraint on window thickness
- Final values were adjusted by 1σ based on Martin Barstow's work on white dwarfs
  - Small effect at higher energies

Counter Gas Absorption



- Henke (1987) absorption cross sections
- Counters operated at constant gas density so fixed curve
  - Any residual variation would have only a minimal effect
  - Compare the absorption efficiency with the mirror effective area – there is little area at energies where the gas is not completely opaque.

Total Effective Area



- Simple product of the previous three components.

Vignetting

- Not sure how the vignetting correction was done for point-source analysis
- For image processing and spectral extraction of extended objects this was probably the easiest calibration element
  - Vignetting is the fall-off of mirror effective area with distance from the optical axis
  - For flat-fielding observations, create energy band detector maps using ROSAT All-Sky Survey data.
  - Includes not just the vignetting but also the obscuration of the detectors by the window support structure and variations in the window thickness, as well as other artifacts

Detector Response Matrix

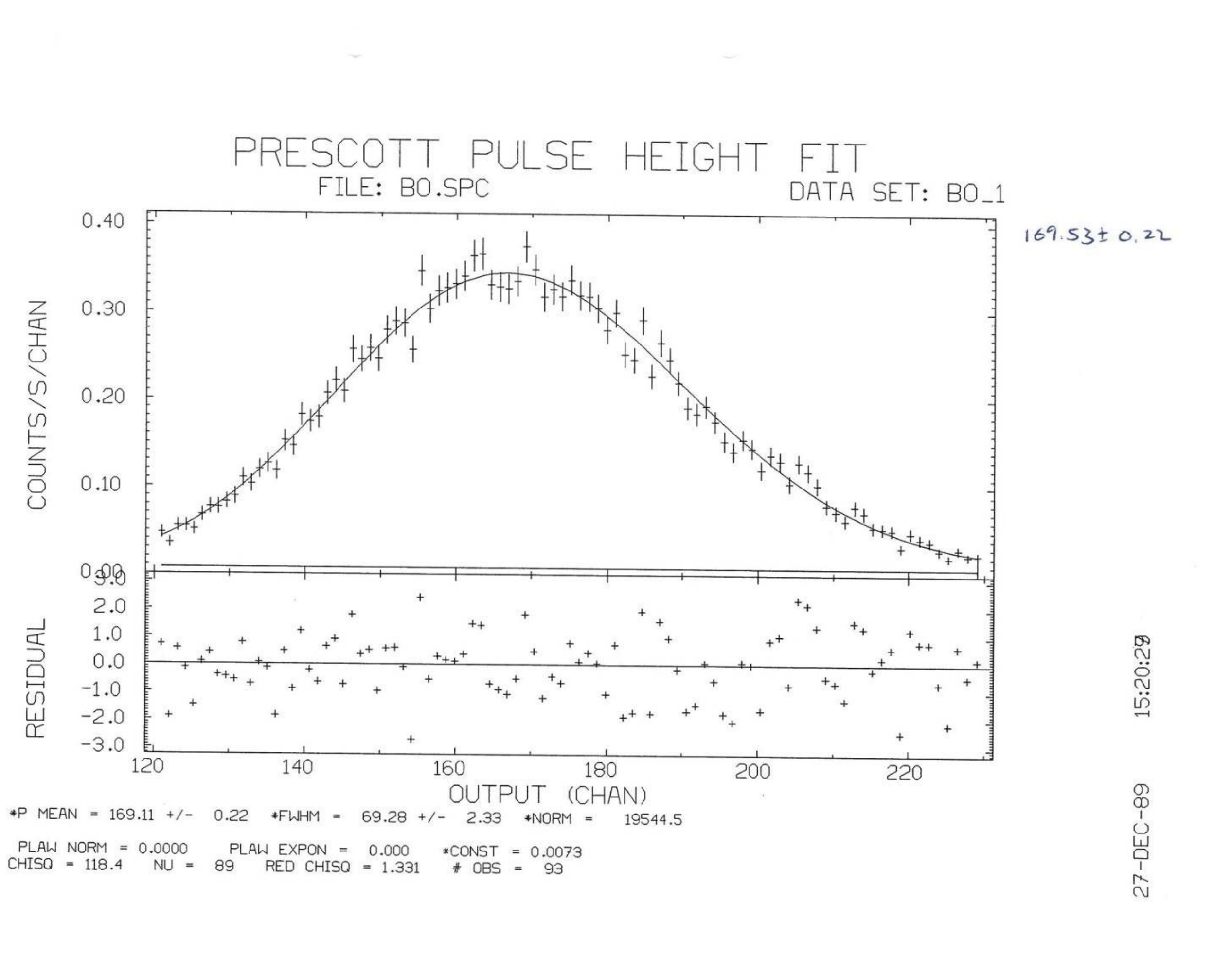
se a physical model for the response of the

proportional counter to monochromatic X-rays

- Prescott function works well at higher energies
- Empirical model uses a Polya function to model the single electron spectrum – full spectrum made up of multiple Polyas
- Accounts for loss of initial electrons to the window for events converting near the window and various other physical effects
- Final response matrix is built energy by energy from the best fit parameters

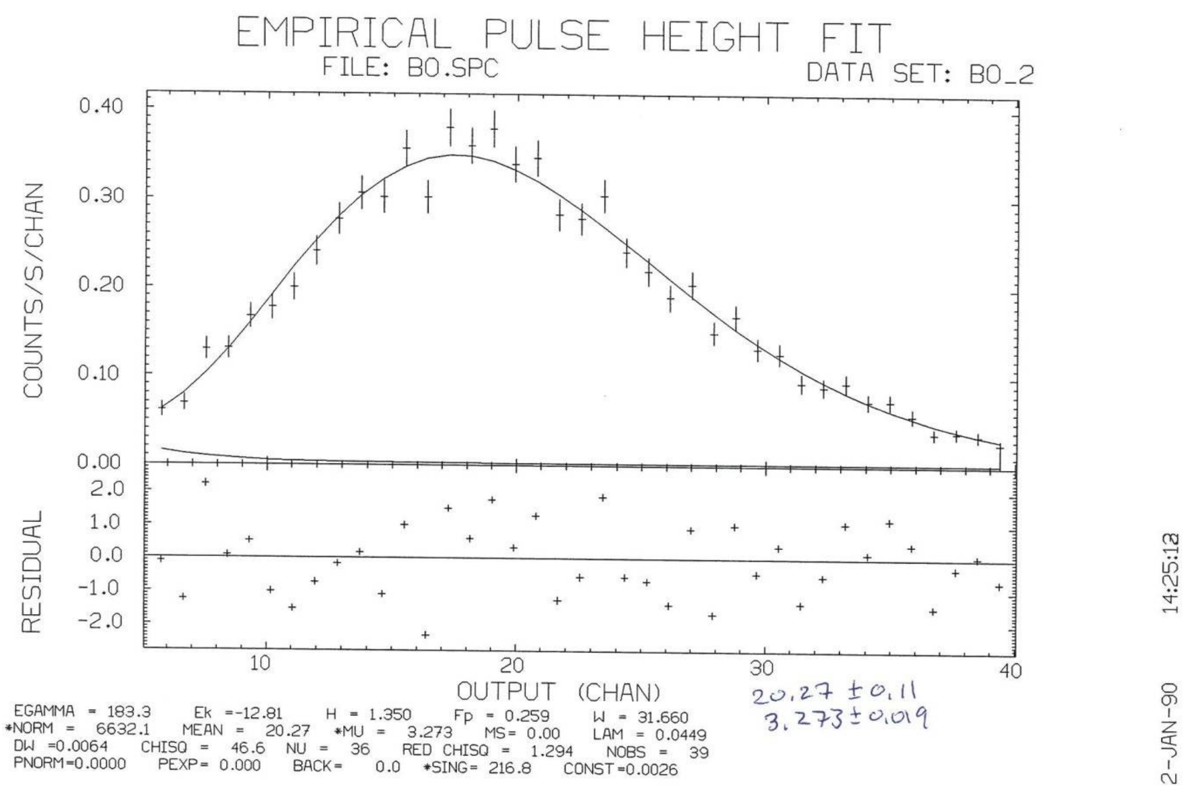
asically a very difficult problem to get right

Sample Calibration Lines



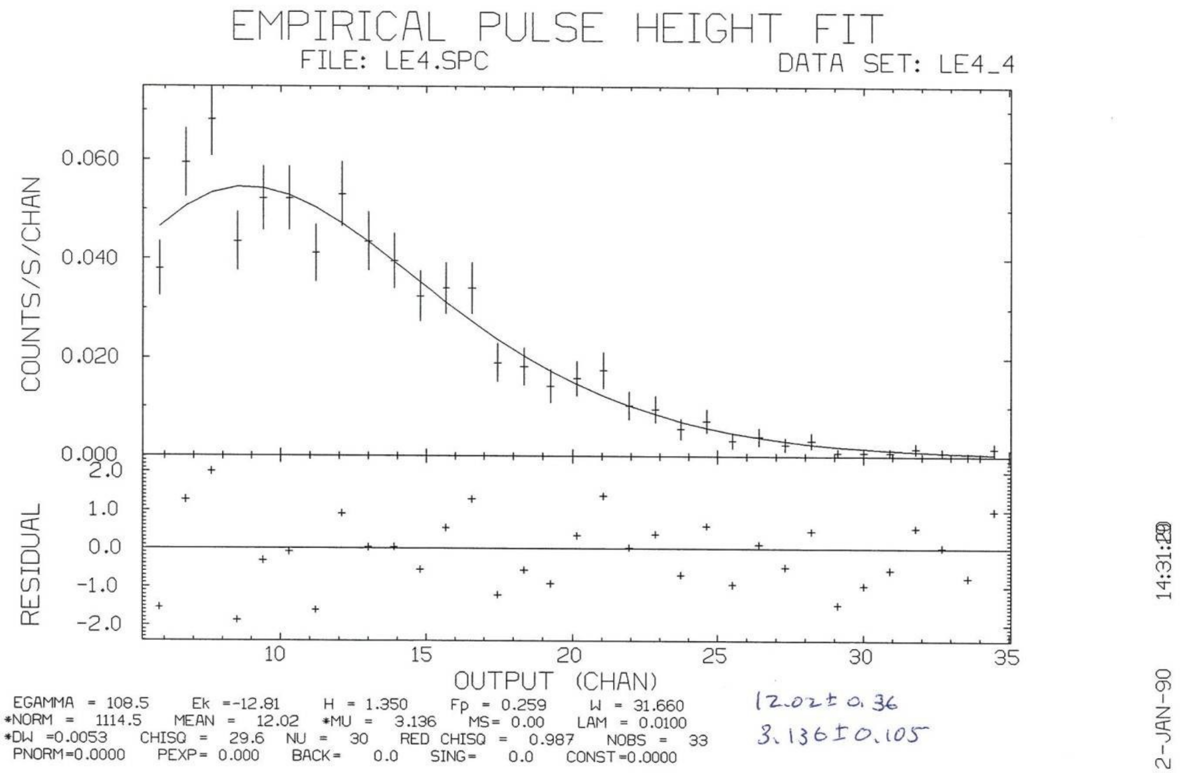
- Prescott function works reasonably well at higher energies.
- This is probably is a Si Kα line at ~1.75 keV

Sample Calibration Lines



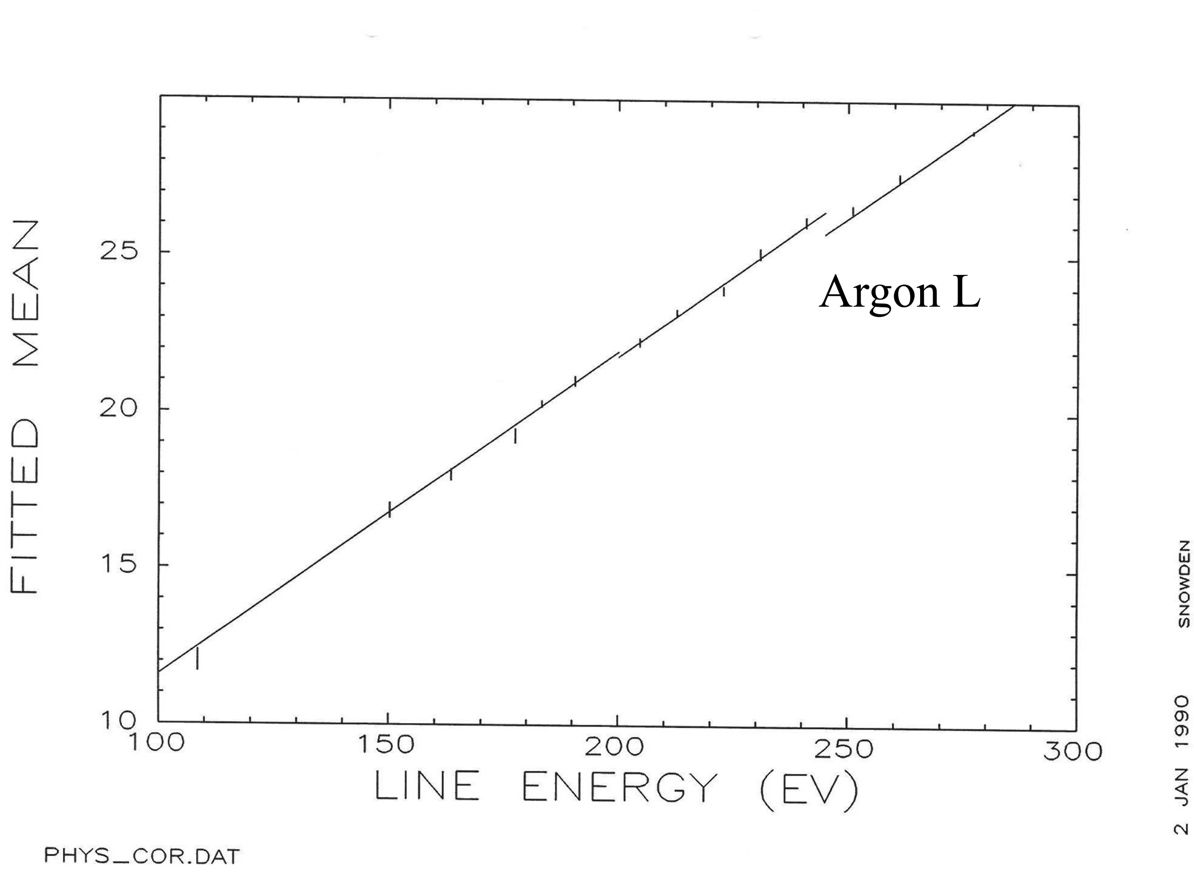
- At lower energies the pulse-height distribution gets more skewed and the empirical model is
- This is a B Kα line at ~183.3 eV

Sample Calibration Lines



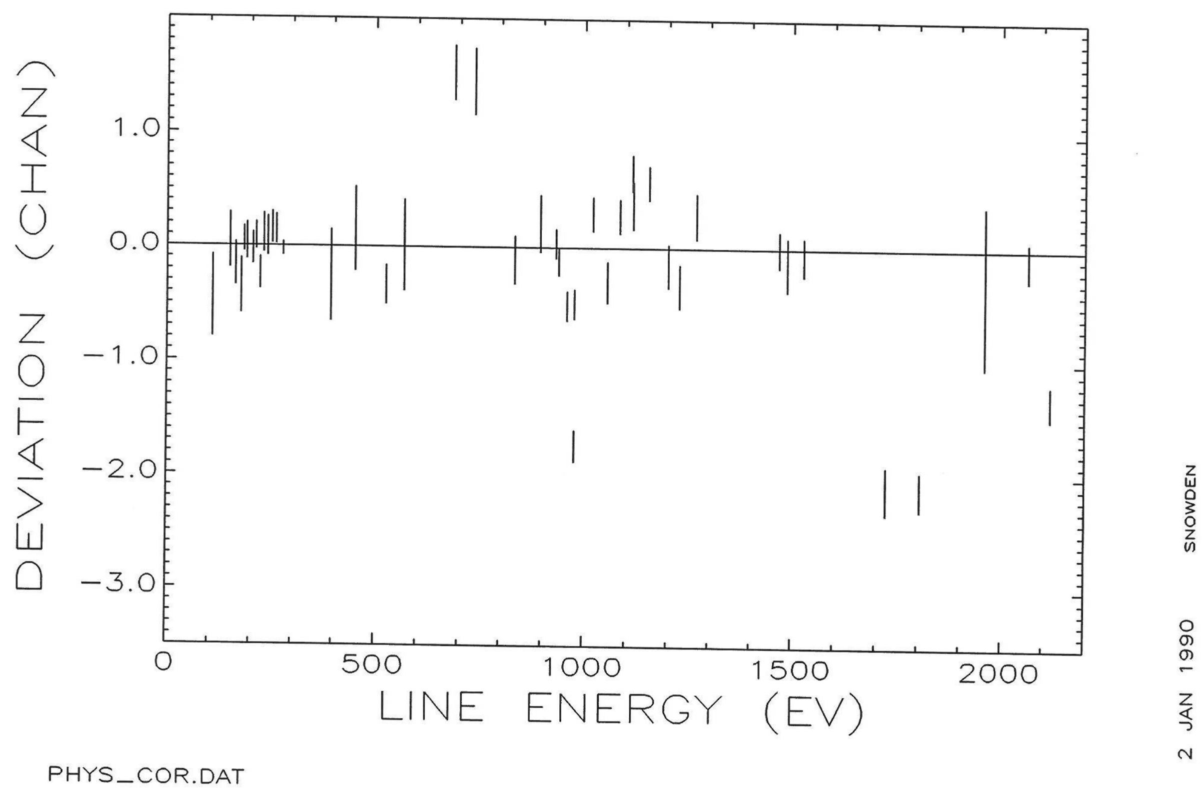
- At lower energies the pulse-height distribution gets more skewed and the empirical model is required
- This is a Be Kα line at ~108.5 eV
- Must span the entire range of detected energies

Calibration Results – Fitted Mean



- If the proportional counter response is linear, the expected pattern is to have fitted mean channels lie on straight lines with offsets at counter gas absorption edges
- The PSPC counter gas was 65% argon, 20% xenon, and 15% methane

Calibration Results – Fitted Mean



- Residuals of the fitted means

Detector Response Matrix

- The detector response matrix is then assembled using the fitted parameters from the calibration data
  - Assumes that there are no changes between ground calibration and flight
  - Assumes that any gain variation of the proportional counter has been corrected

Detector Response Matrix

- Empirical Model Parameters
  - Ek – Energy of the calibration line
  - W – Mean energy required for electron/ion pair
    - Related to the intrinsic energy resolution
  - F – Fano factor
    - Shape parameter
  - H – Polya parameter
    - Another shape parameter
  - D/W – Ratio of diffusion rate to drift velocity
    - Loss of secondary electrons to window
  - Mean – Gain of instrument