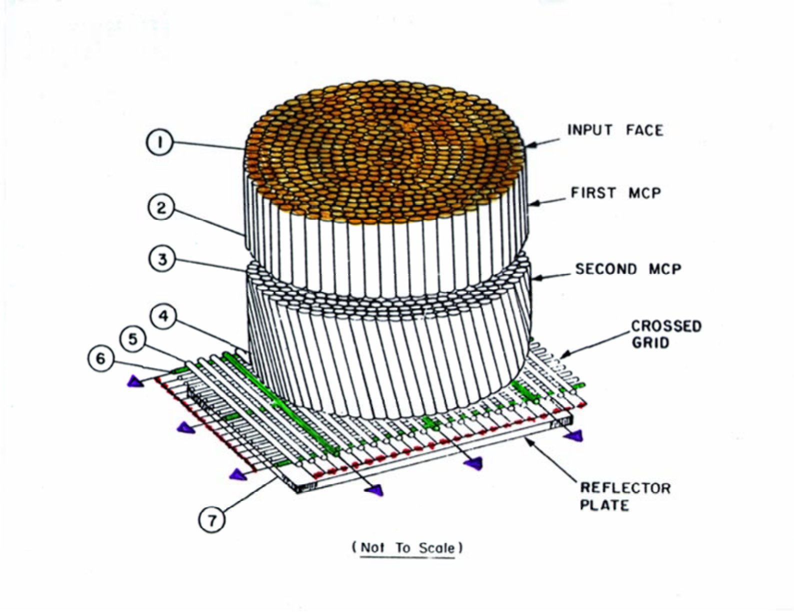
Calibration – Why Bother?

SCIENCE!!!

Steve Murray

Review of the HRC

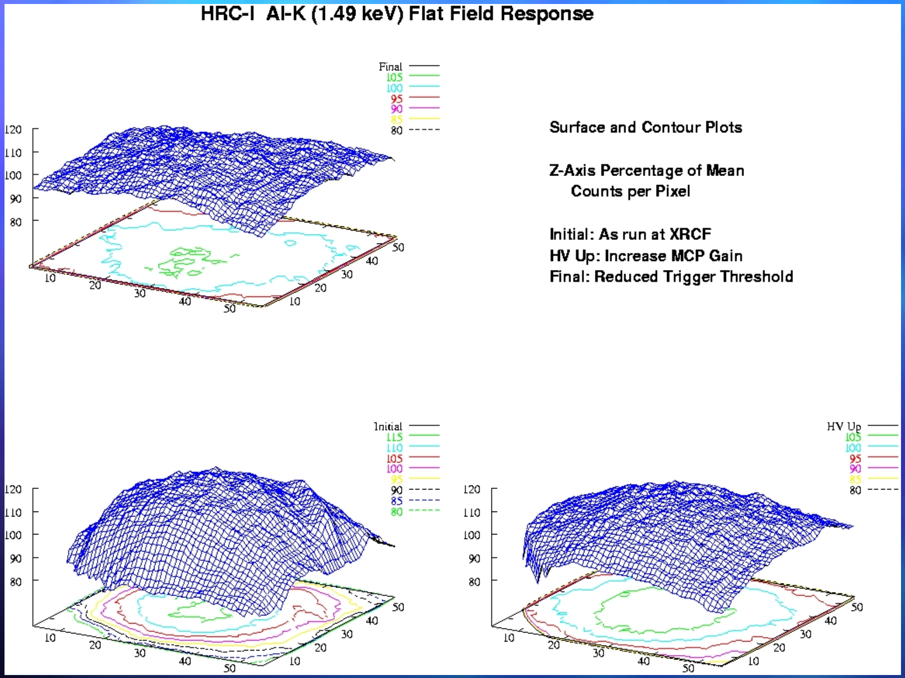
- Event driven MCP detector with CGCD readout
  - XY coordinates: 20 micron FWHM (6.25 micron digitization)
  - Event time: 15.625 microseconds (S/C clock 1 pt in 10^9)
- CsI Photocathode on MCP
  - CsI + MCP Glass => Quantum Efficency vs. Energy
  - MCP gain uniformity => low energy threshold and noise
- CGCD and Readout Electronics
  - Uniformity
  - Spatial non-linearity (large and small scales)

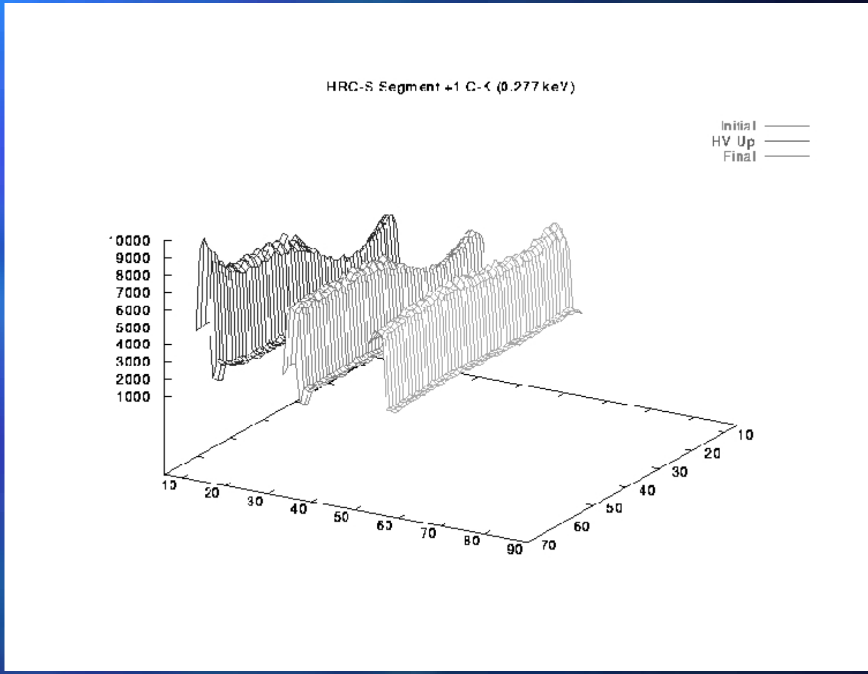


Some Post Launch Issues

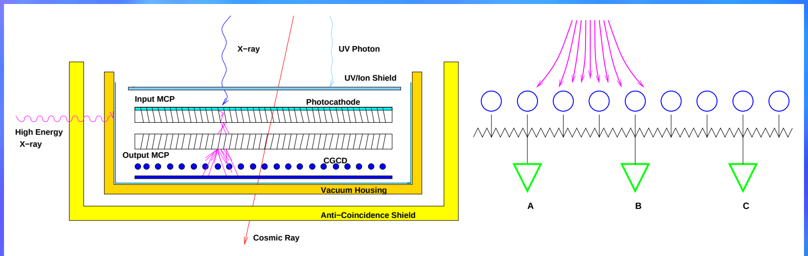
- Particle Background
  - Almost 100% efficient telemetry saturation
  - Anti-co timing error for HRC-S
- Gain Saturation
  - MCP gain too high
  - Errors in event positions
- Time Tagging
  - HRC-S timing mode
- Image Blur from Ringing
  - Large amplitude events only
- Double Counting
  - HRC-S event trigger ringing
- Degap Map
  - Tap dependent map
- Low Energy QE
  - Effective area
  - Asymmetric LETGS
- Spatial Non-Linearity
  - Energy scale

HRC Flat Fields





Background Screening



Zone of Acceptance

Based on the fine position as a function of the shape factor

Fine Position Algorithm

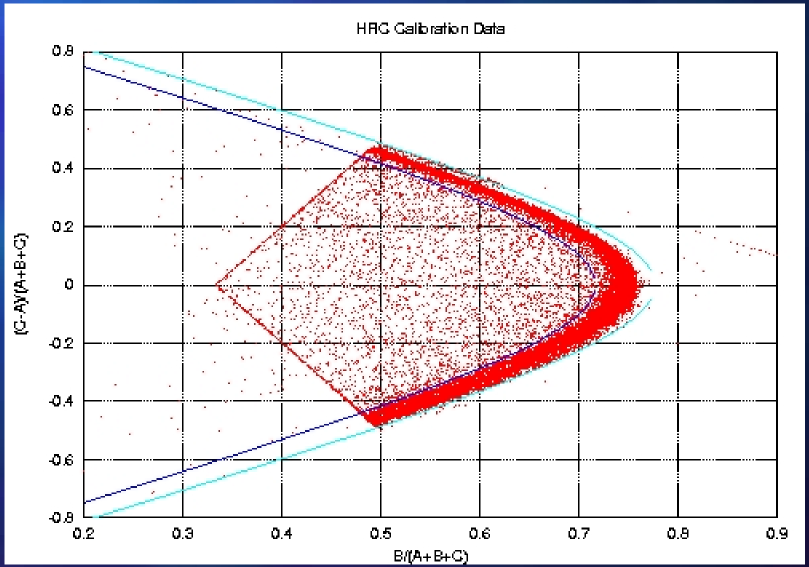
$f_p = (C-A)/(A+B+C)$

Degap Correction

$f_c = af_p + bf_p^2 + \ldots$

Shape Factor

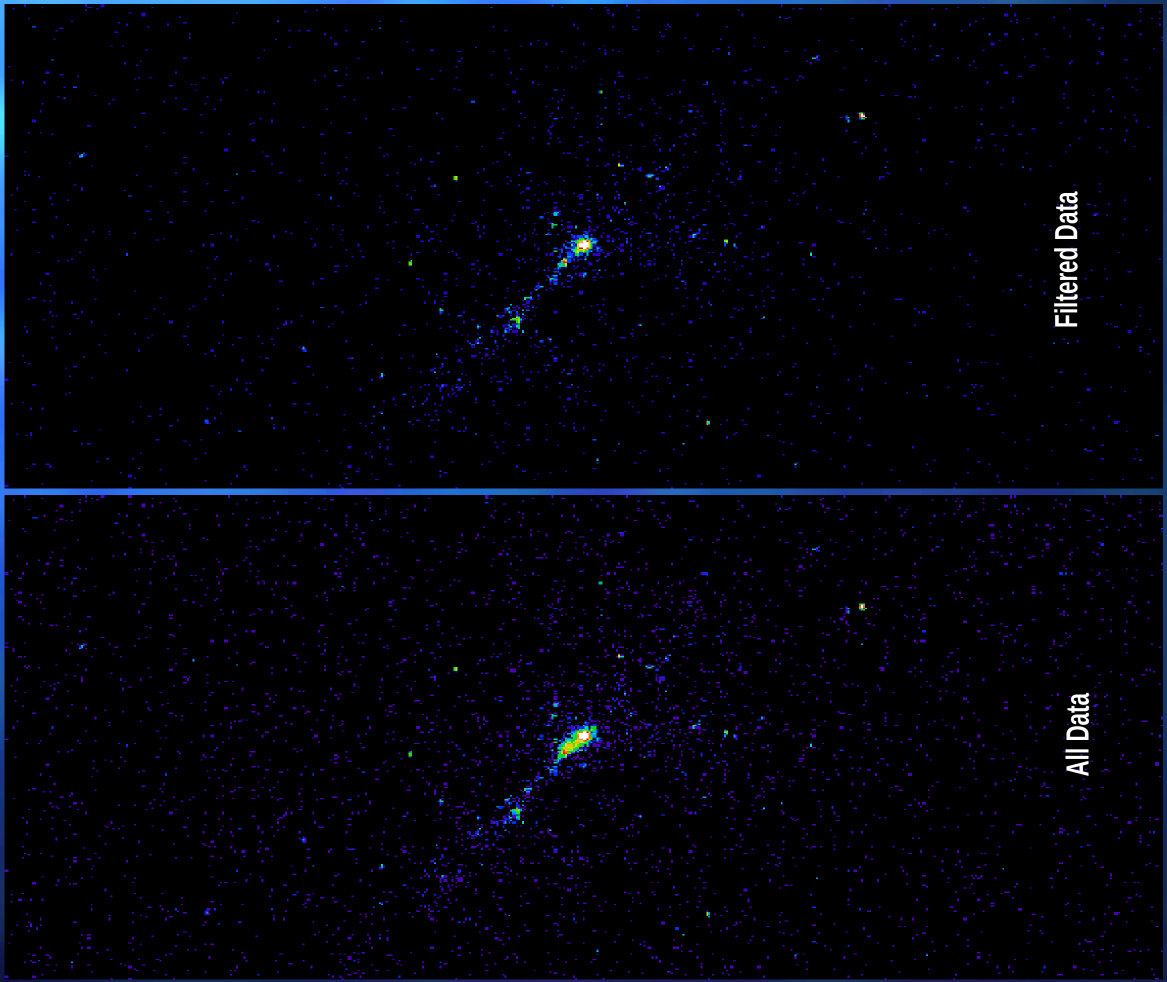
$s = B/(A+B+C)$



Impact on Science - Background

- HRC-I few times greater than anticipated.
  - Reduced sensitivity for extended sources, and for off-axis serendipitous sources (large area)
- HRC-S significantly higher (lack of anti-co)
  - Serious reduction in sensitivity for weak spectral features with grating.
- Calibration effort
  - Find ways to identify and reduce background events.
    - Hyperbolic screening (effective for HRC-I)
    - PHA screening (effective for HRC-S)

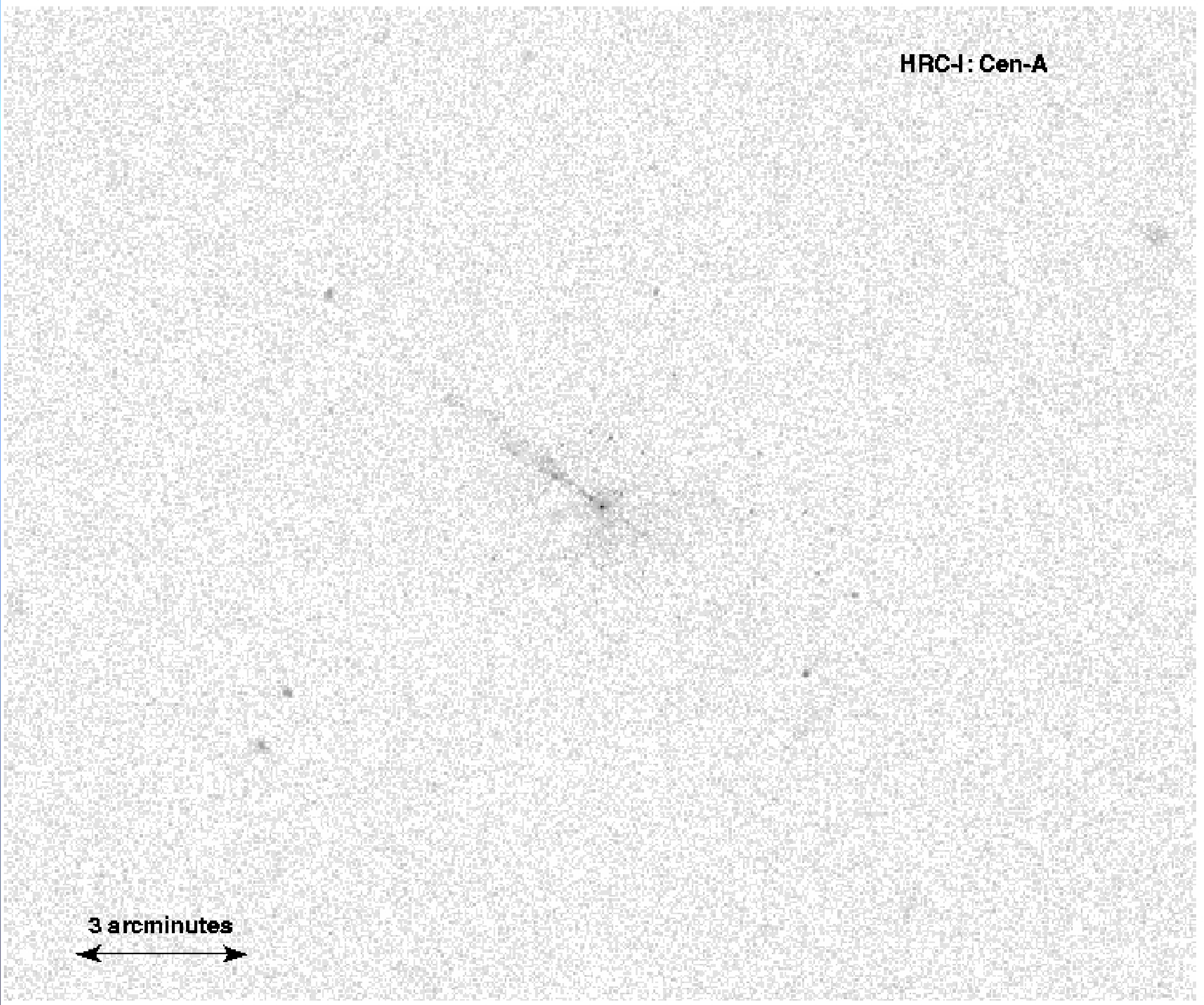
Example of a Cleaned Image



Impact on Science - Blurring

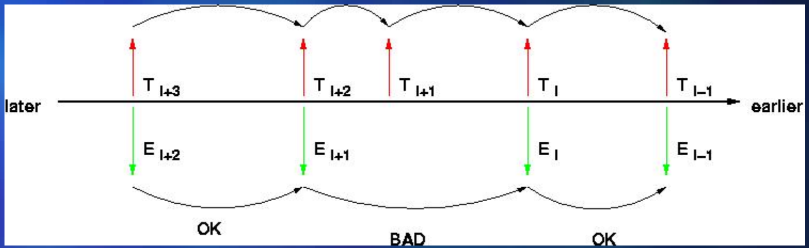
- Prevents full spatial (angular) resolution
  - Worse for HRC-I than HRC-S due to gain differences.
  - More blurred events in HRC-I
    - Can be recognized as potentially blurred.
    - Ad-hoc algorithm developed to correct positions based on some understanding of the root cause.

Example of Blur Correction

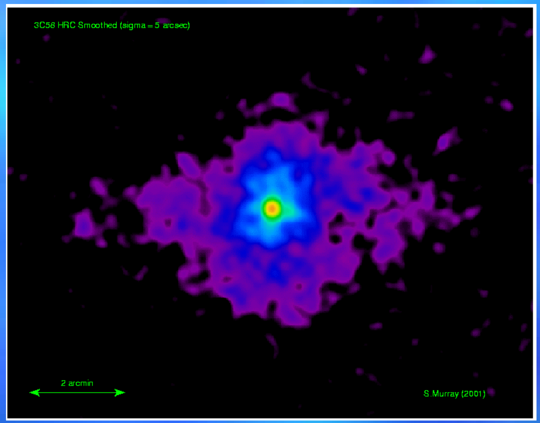


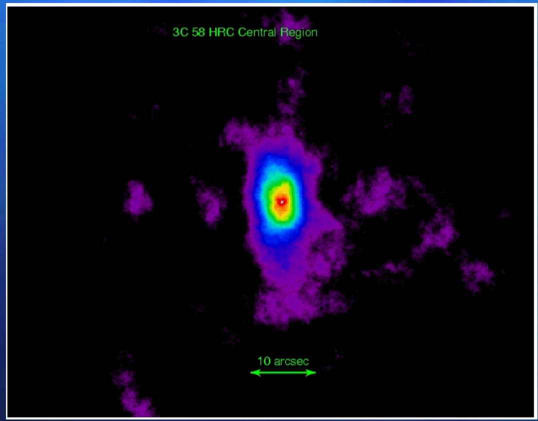
Impact on Science - Timing

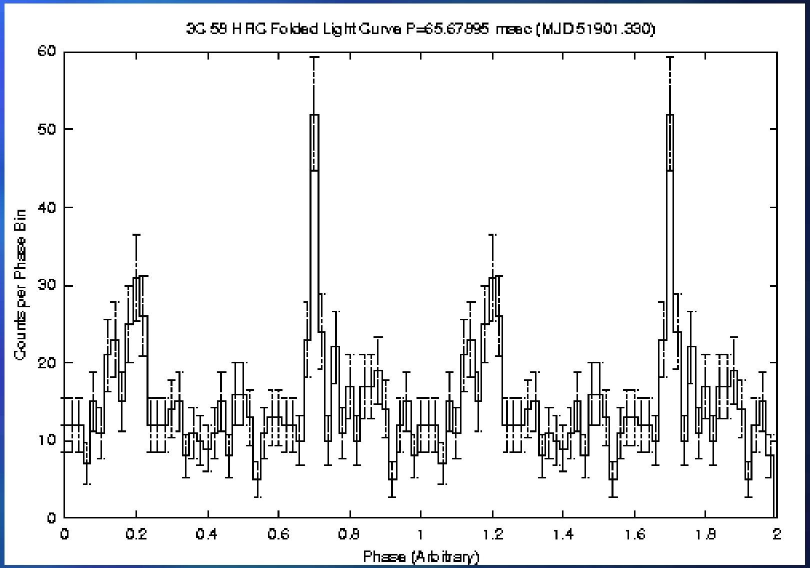
- Telemetry saturation complicates timing correction due to wiring error.
- High rate reduces the timing uncertainty and mitigates effect for certain variability
- Calibration effort
  - Invent new operating mode with no lost events
  - Permits complete recovery of proper event times
  - Limited field of view (HRC-S center segment)



Example of Timing







Impact on Science - QE

- Uncertainty in the low energy quantum efficiency (and effective area) adds uncertainty to flux conversion and sensitivity.
- Non-uniformities complicate data analysis and add potential systematic uncertainties.
- Good news is that the relative efficiency appears constant.

Future Issues

- Can the spatial resolution for HRC be improved to take full advantage of the telescope PSF?
  - Better degap maps already have helped.
  - Better charge division algorithm. The current linear model with degap may be too simple.
  - Better background recognition and rejection improves signal to noise.

Future Issues (cont)

- Can the timing mode be improved?
  - As long as HRC-S Timing mode is not telemetry saturated, we achieve the design time resolution. Depends on total event rate (background dominated)
  - Double counting in secondary science depends on MCP gain. Lower could be better, but impacts gain uniformity and perhaps low energy QE.

Future Issues (cont)

- Can the low energy QE be better determined?
  - Continued cross calibration of HRC and ACIS will help.
  - More grating observations extend the relative low energy calibration precision.

Future Science Enabled via Calibration Efforts

- With better understanding of the imaging performance of the HRC and Telescope (PSF), it should be possible to make more use of image deconvolution.
- Improved background rejection will improve low surface brightness feature detection (e.g., Cen A Arcs), and increase sensitivity.
- More accurate QE and Effective Area will improve flux estimates and comparisons with other instruments (and missions).

Cen A