# An Improved HRC-I Degap

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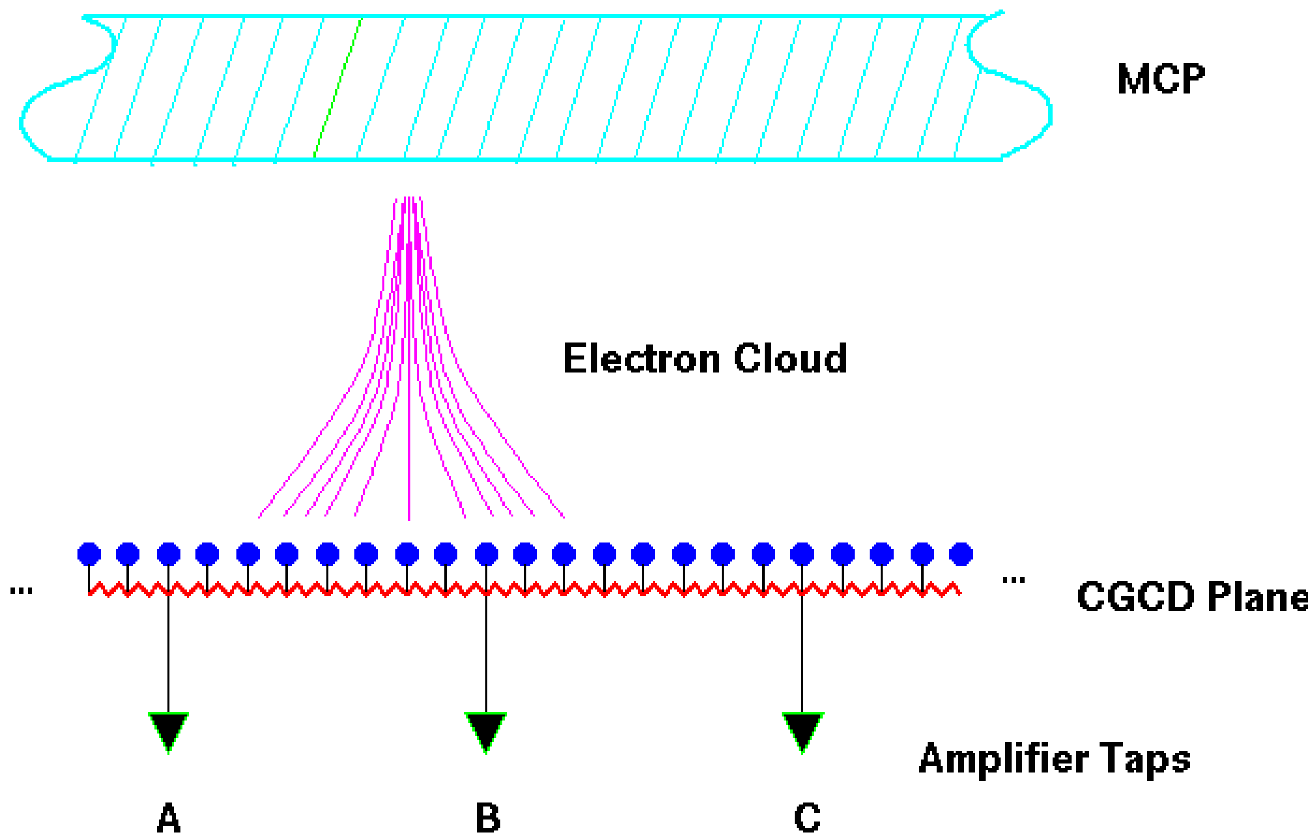
# Outline

1. HRC Position Reconstruction and “Gaps”
2. Aspect Solution to Detector Location
3. Deriving Look-up Corrections
4. Improved Degap Look-up Example
5. Future Improvements

# Crossed-Grid Charge Detector Readout

## HRC Fine Position Algorithm




$$fp = \frac{C - A}{A + B + C}$$

Fine Position

- HRC does not have fixed pixels
- Coarse position (amplifier with “largest”signal) and signal size of this and amplifier to either side is telemetered
  - 60 coarse positions per HRC-I axis
  - Coarse positions are at fixed points in the detector
- Event position on an axis is determined by centroid of charge distribution among three amplifiers
  - Centroid gives a fine position relative to the location of the coarse position of the center amplifier of the triplet
- “ RAW” position is given by:

$$\mathrm{RAW} = 256 \times (\mathrm{CRS} + 0.5 + \mathrm{fp})$$

# Origin of Gaps

- Fine position is biased toward center tap
  - Three signals lose information as charge cloud moves to the half-way point between coarse positions
  - Loss of information produces gaps in image produced in RAW coordinates
  - Gaps are not due to missing events but due to a systematic mis-location of events
- Mis-match of amplification gains and offsets will also lead to distortions in the RAW coordinates

- Degap correction implemented to remove the bias
  - Old-style correction

    $X_{fine} = \mathrm{sign}(fp)\times(a_1\times|fp| + a_2\times|fp|^2 + a_3\times|fp|^3 + a_4\times|fp|^4 + a_5\times|fp|^5)$

    $\text{Degapped RAW} = 256\times(\text{CRS} + 0.5 + X_{fine})$
  - New-style correction

    $\text{Degapped RAW} = \text{RAW} + \Delta$

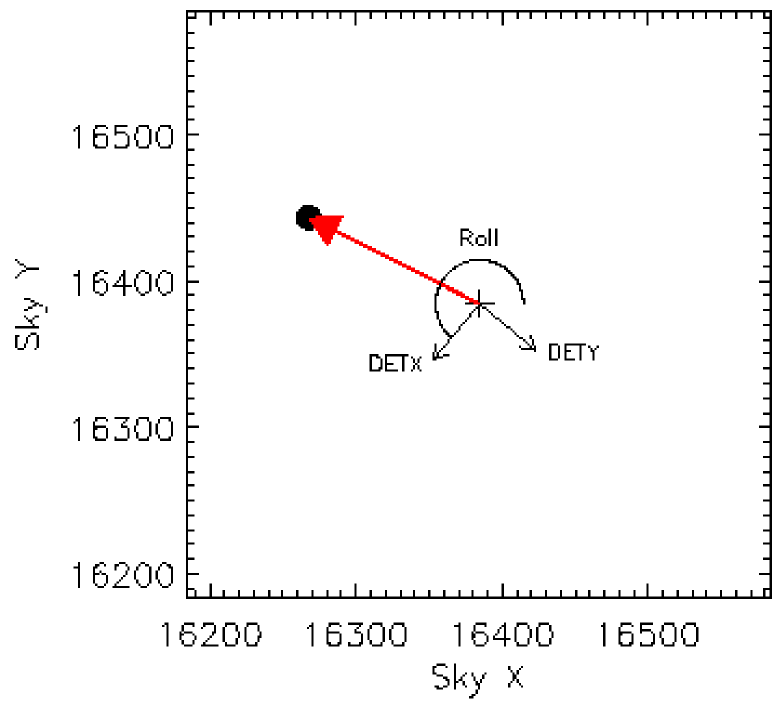
    $\Delta$ = value look-up based on RAW

    Current Δ's based on values from old-style correction
- Old-style correction assumes amplifiers are well-matched:

  $fp = 0$ is at the center of the coarse position
- New-style correction can account for amplifier mis-match

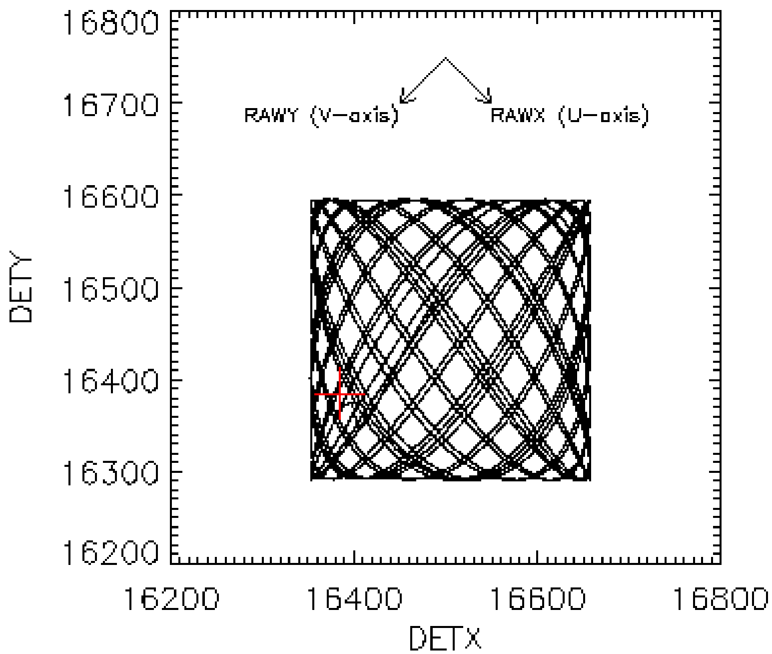
- Aspect solution used in pipeline to determine sky position for all events
  - Remove spacecraft dither
  - Determine absolute pointing
- Work backward with aspect solution to determine the path a near-on-axis source traces on the detector
  - Assume dither averages away small scale deviations

- Point source location determined relative to nominal "on-axis" position
- Combine with nominal roll to get radial offset and position angle relative to on-axis in "detector" coordinates



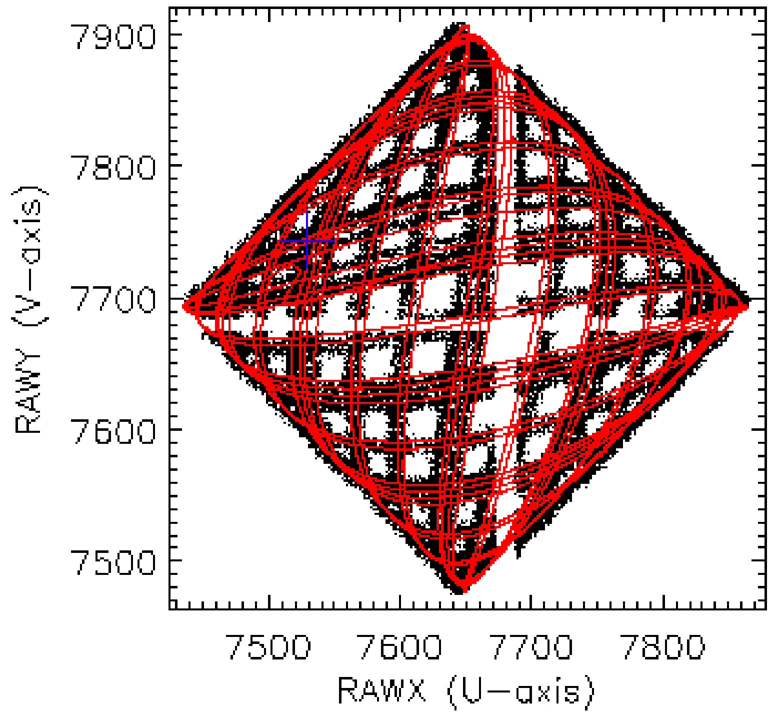
# Dithered Source Location

- From aspect solution get RA & Dec offsets relative to nominal pointing *vs* time
- Combined with source position offset gives dither path of source in “detector” coordinates



# Source Path on HRC-I

- HRC-I is rotated relative to the DET coordinate system
- SIM-Z position offset will move nominal aim-point on HRC-I, as will "bending" of the optical bench
- Dither path can be rotated and translated into HRC-I coordinates
- Source position modeled for each event time



- Point sources within 3 arcmin of on-axis
  - Bright enough/long enough for good statistics
- Select source events in a ~1 arcsec radius
- For each event use aspect to model location of source on HRC-I
- For all events at a given modeled location along an axis determine the mean RAW coordinate for each of the three AMP_SF values

# Deviations of Modeled and RAW

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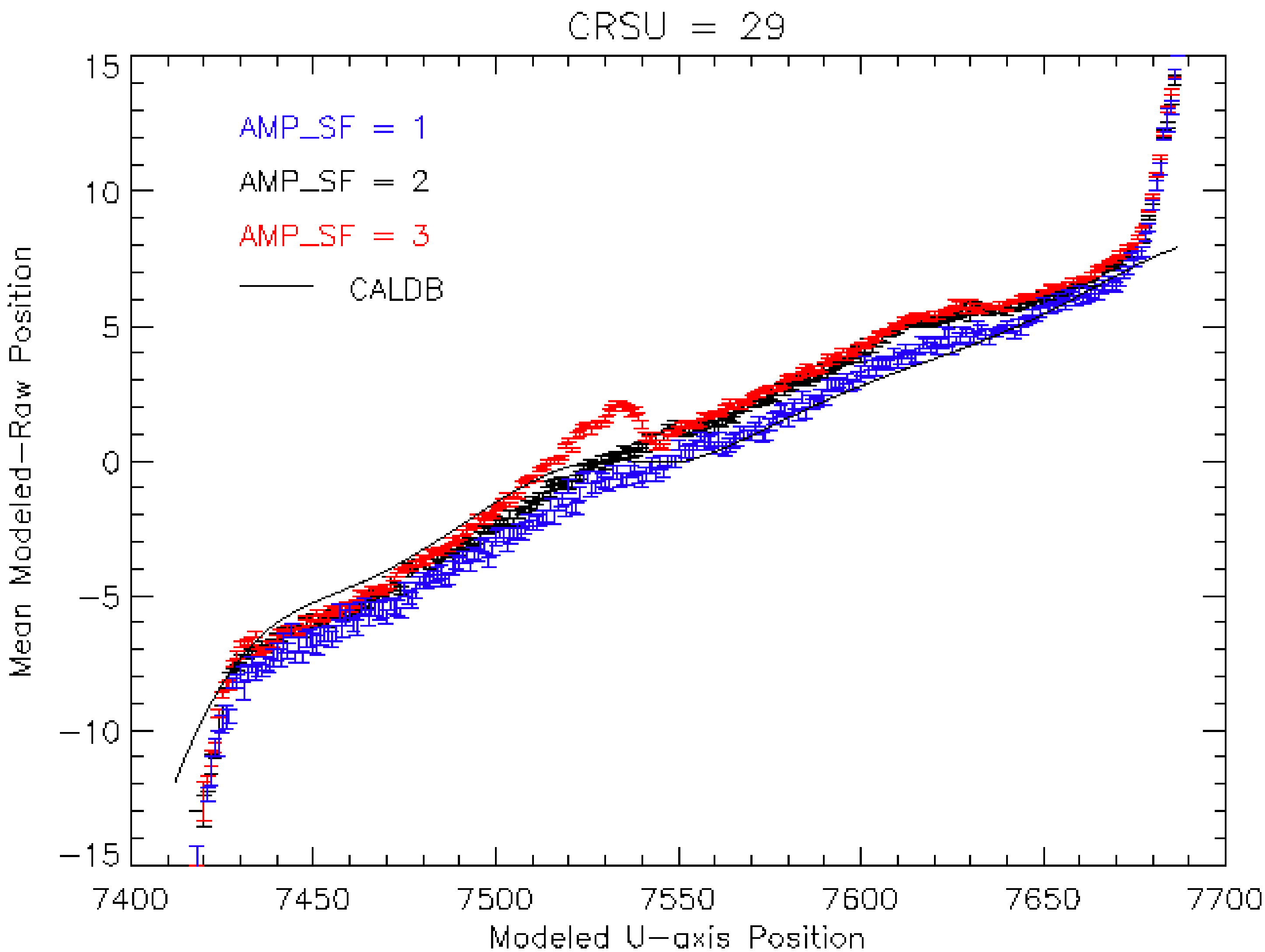

- Deviation between Mean RAW position for a given Modeled position and the Modeled position provides the basis for the look-up correction
  – Degap correction must be referenced to the RAW position rather than the Modeled position to allow for look-up
  – (Modeled position-deviation, deviation) pairs are interpolated into (RAW, degap correction) pairs for the look-up table

# Derived Degap Example

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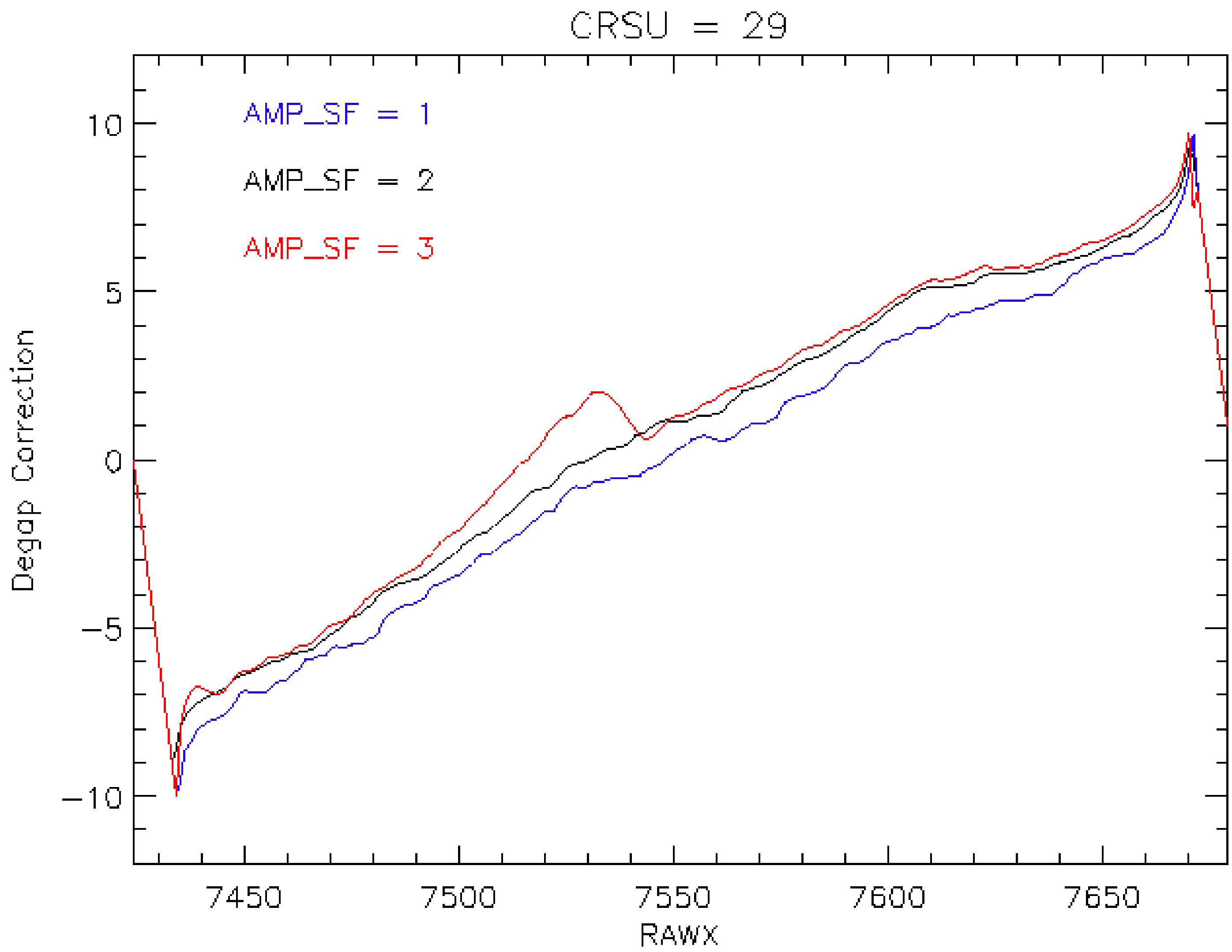
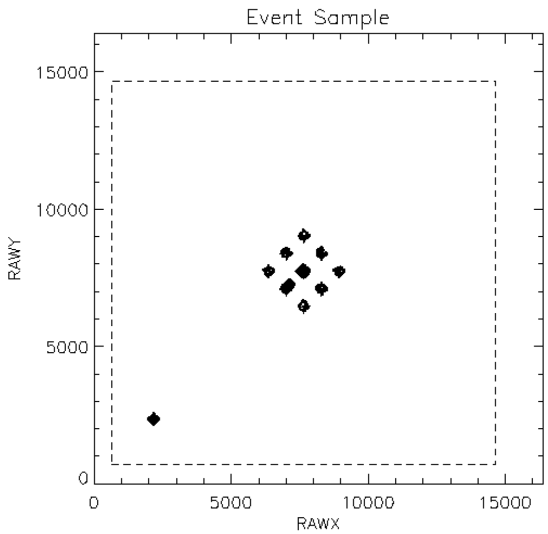
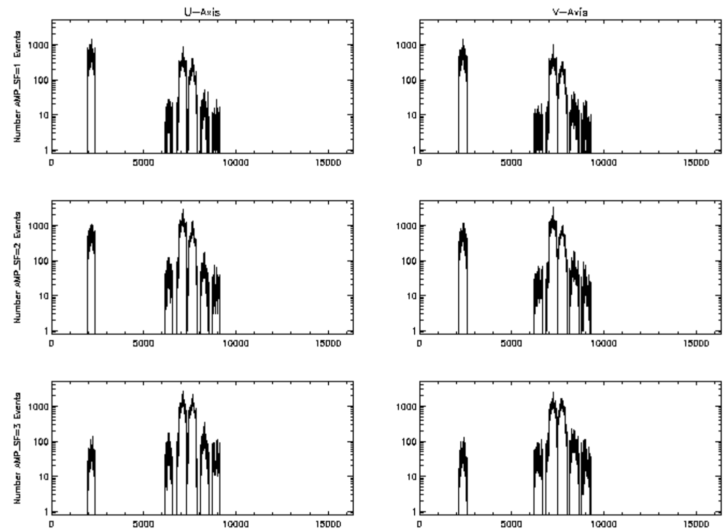


# Events for Example Degap Lookup

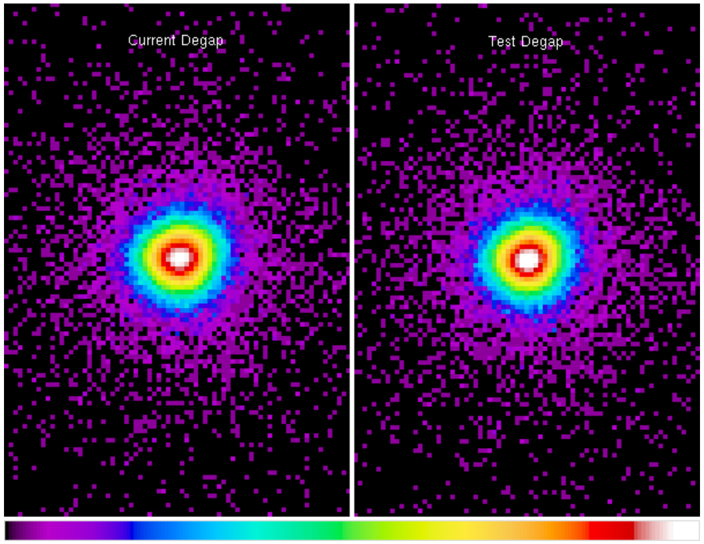


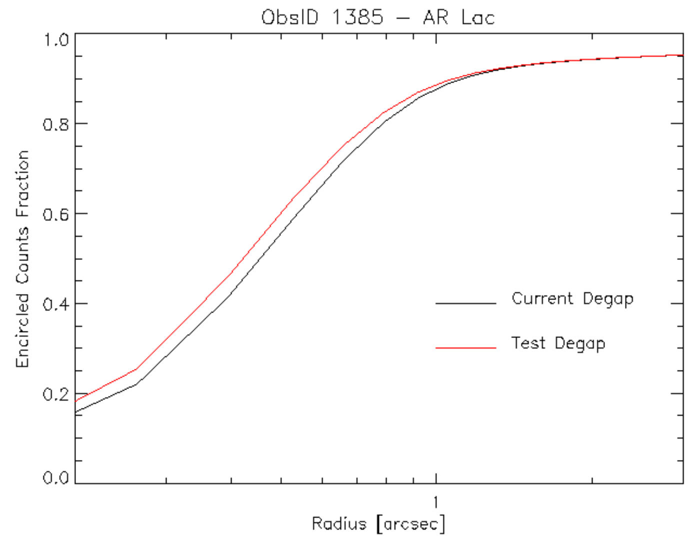



- Events taken from several bright on-axis sources
  - Some used zero-order from LETG (HZ 43, Cyg X-2)
  - Some used non-zero SIM-Z offset (GX13+1, Cyg X-2)
- Events taken from AR Lac offset scans for gain variation
- Counts over portions of ~15 coarse positions per axis
  - Coverage gaps due to available sample of sources
  - Count statistics quite variable in covered regions

# Effect on PSF




- Derive values for lookup table of degapping corrections via described method where adequate statistics are available
  - Use corrections derived from old-style polynomial in all other places
  - AMP_SF columns may be updated for only one or two of the values over some ranges
- Reprocess using CIAO tool `hrc_process_events` and apply standard filtering
- Standard deviation of source events decreases by ~5%
- No obvious distortions introduced in the limited number of ObsIDs tested

- Dedicated set of observations to map deviations across the span of the HRC-I
  - Capella as source - expect ~15 counts/s
  - Total of ~40 observations with SIM at different translation offsets
  - 3 mm translation step to provide overlap in dither pattern
  - With planned overlap 5ks per observation will provide good statistics for all three AMP_SF
  - First set of 20 observations in the next year cover central region of HRC-I and large SIM-Z offset region used for GX13+1