Present Degap Procedure for the HRC detectors

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The HRC "Gaps" are spatial non-linearities in the HRC detectors that are due to the fact that the X-ray position algorithm does not collect all the charge that exits the rear of the output HRC Microchannnel plate (MCP). These non-linearities occur between the taps of the HRC crossed grid charge readout. The tap to tap distance is $\approx 1.6mm$.

These non-linearities can be examined and algorithms for their correction can be determined in a straight forward way using pinholes masks. However, time constraints and hardware constraints made this approach unworkable.

The present procedure for degapping the HRC detectors uses flat field illuminations that were taken for the purpose of determining the uniformity of the Quantum Efficiency. The technique uses the distortions of the flat-field distributions and the theory of probability transformations to determine the function that corrects the non-linearity.

For further details describing the HRC detectors and the degapping see:
See `http://hea-www.harvard.edu/HRC/HomePage.html` and associated links.

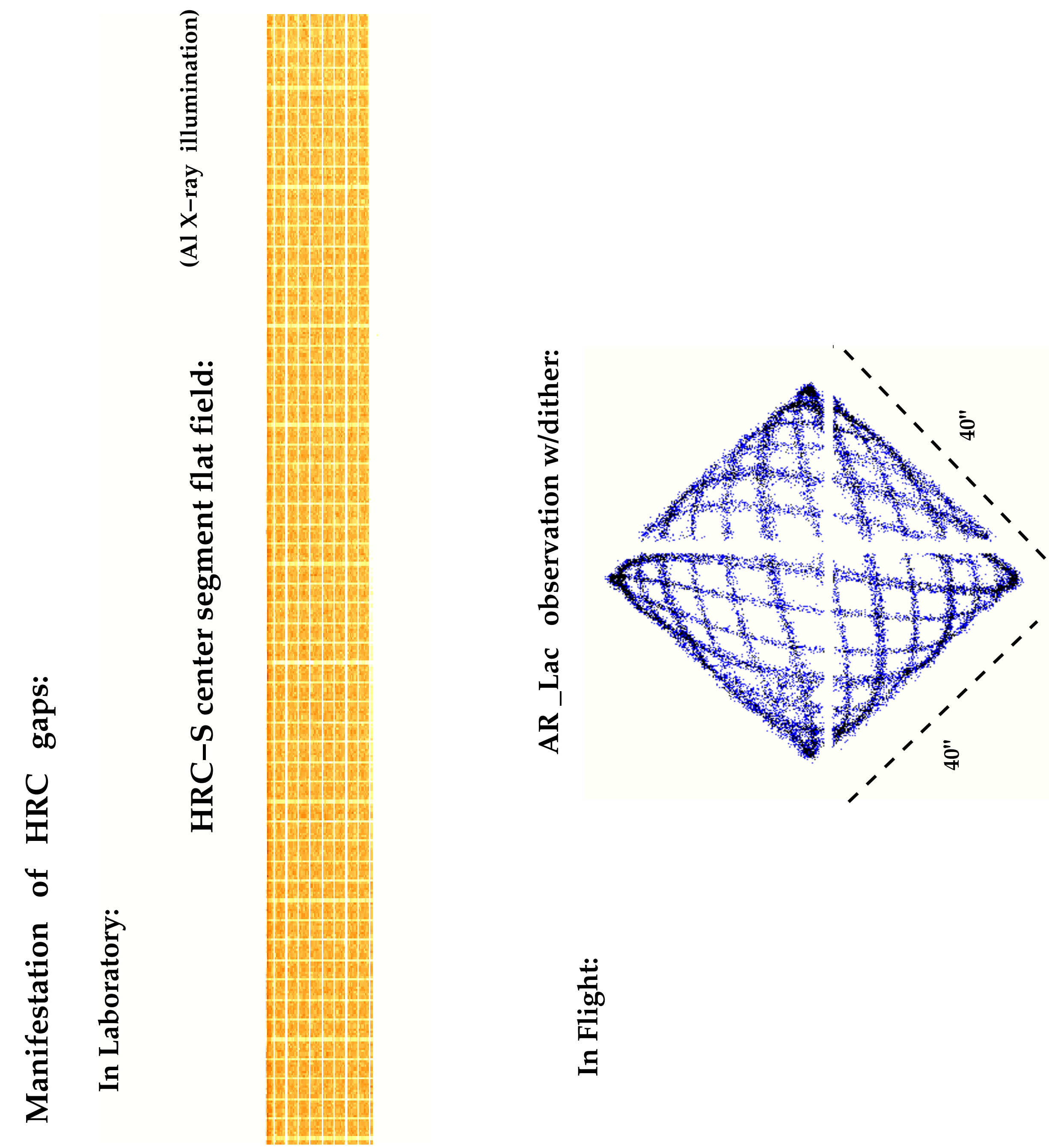


Fig. 1.— Gaps are non-linearities visible in laboratory data and in flight detector coordinate data. The “gaps” or non-linearities are corrected for in post processing of data

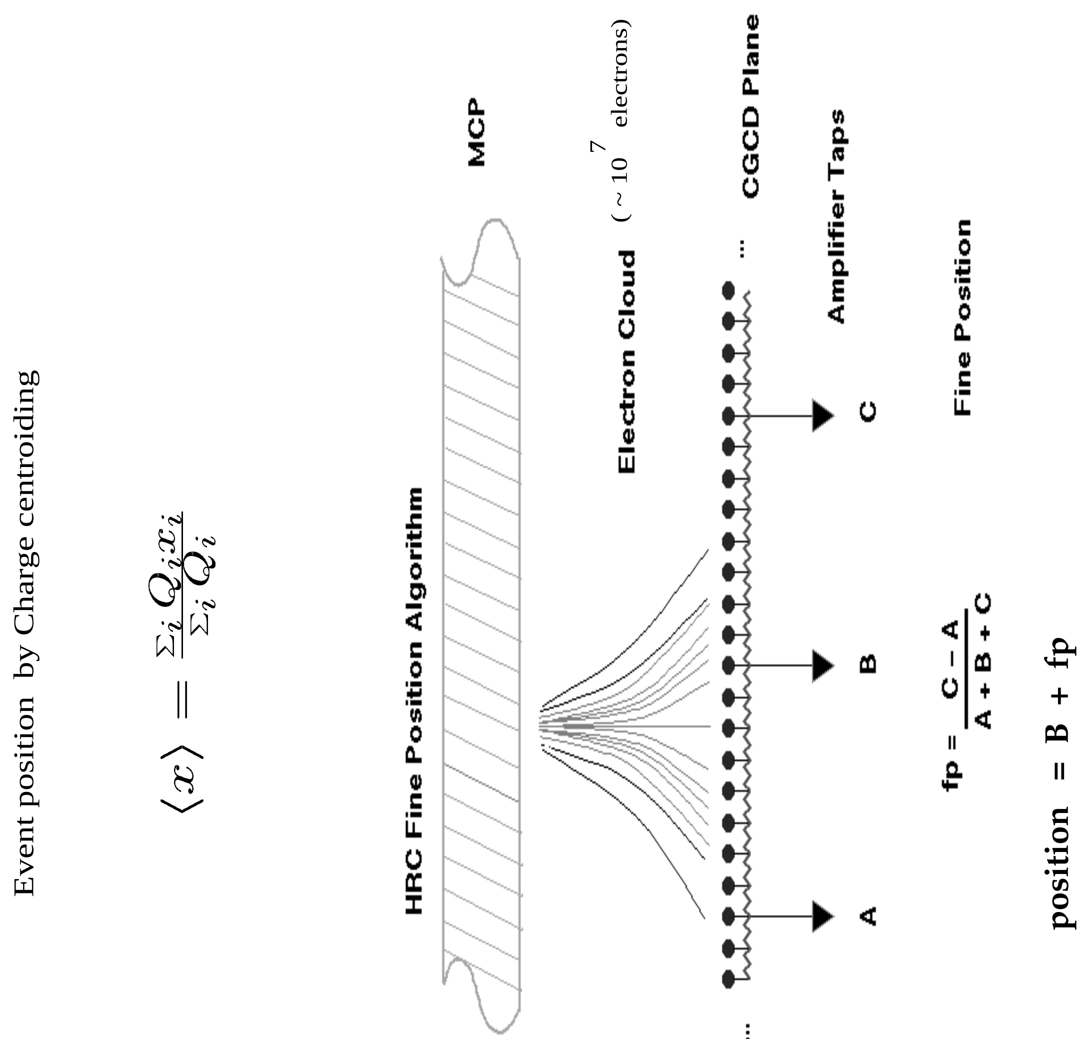


Fig. 2.— X-ray position is determined by charge centroiding process.

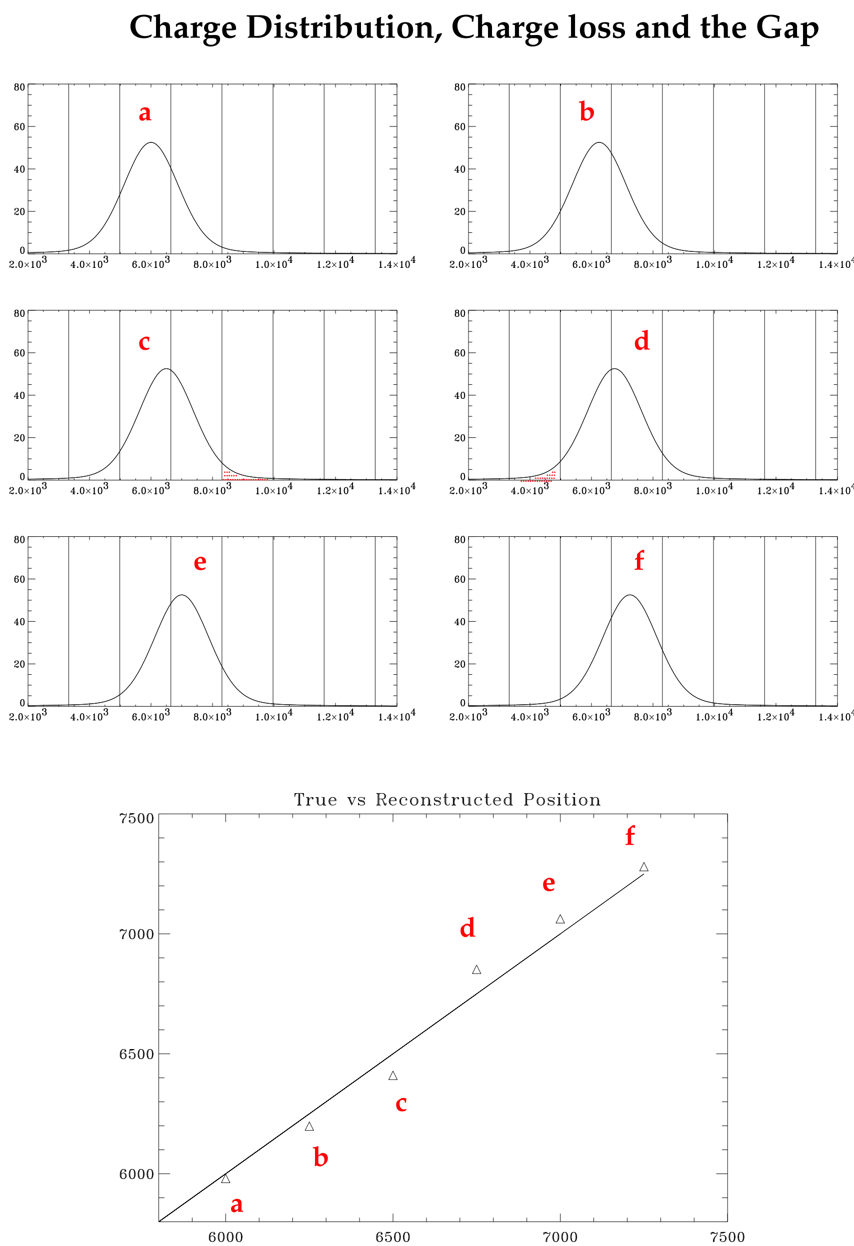


Fig. 3.— Charge cloud is combination of Lorentizian and Gaussian. As position of event moves across detector it crosses gap boundaries and region of maximum charge loss moves from right side of position to left. This jump causes gap.

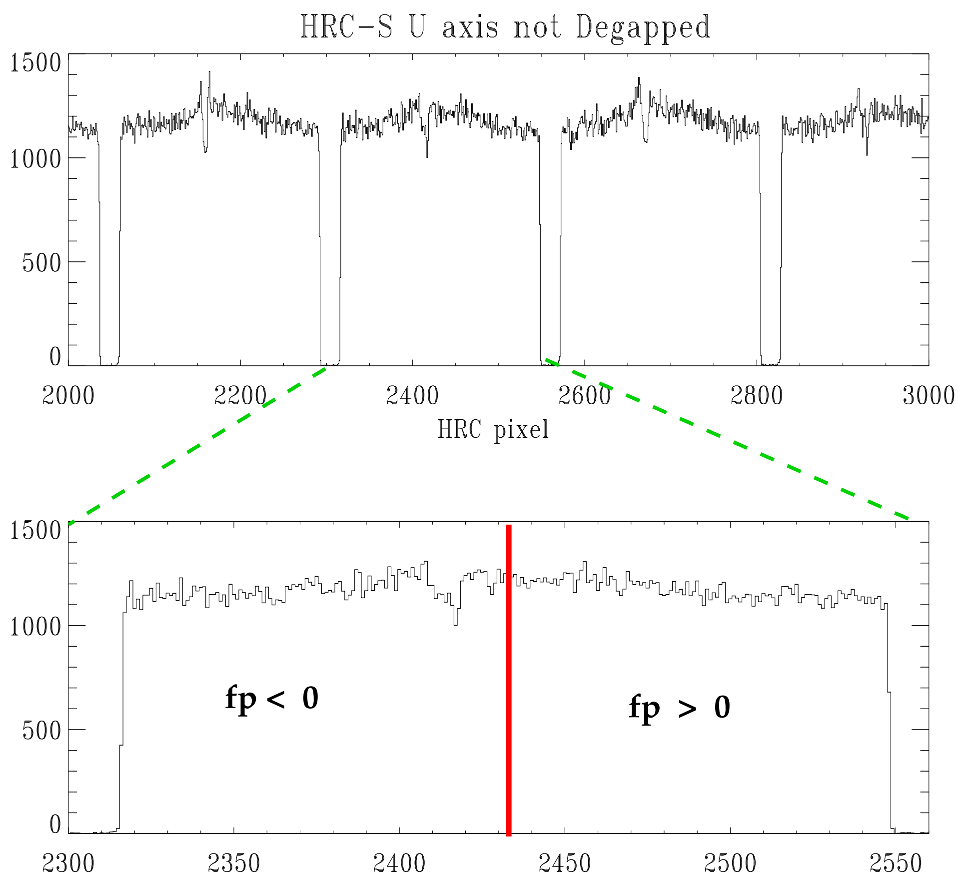


Fig. 4.— For projection of flat field we look at region between gaps. Each is broken into fine position > and < 0. The derivative of the fit to the distribution gives the function that corrects the non-linearity

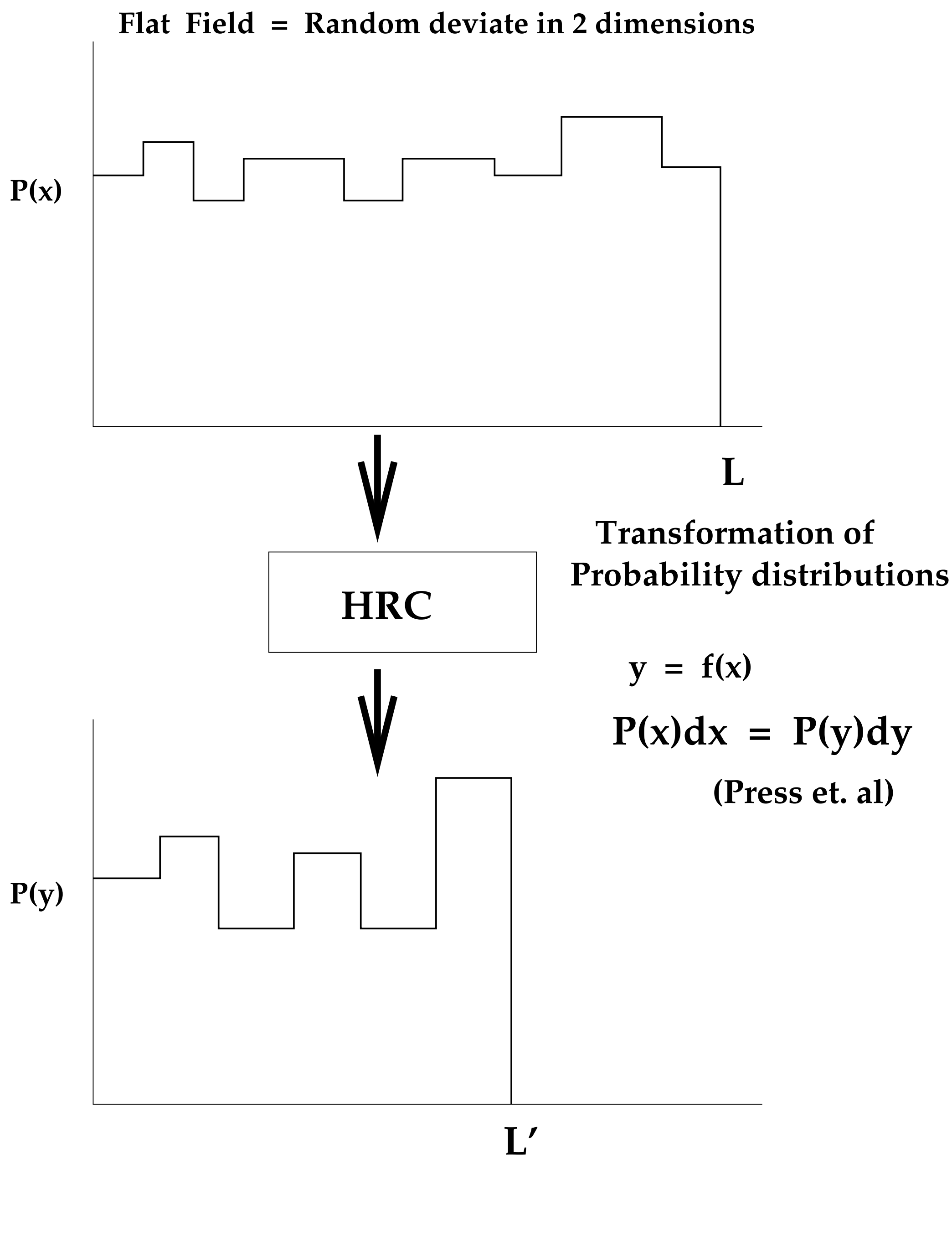
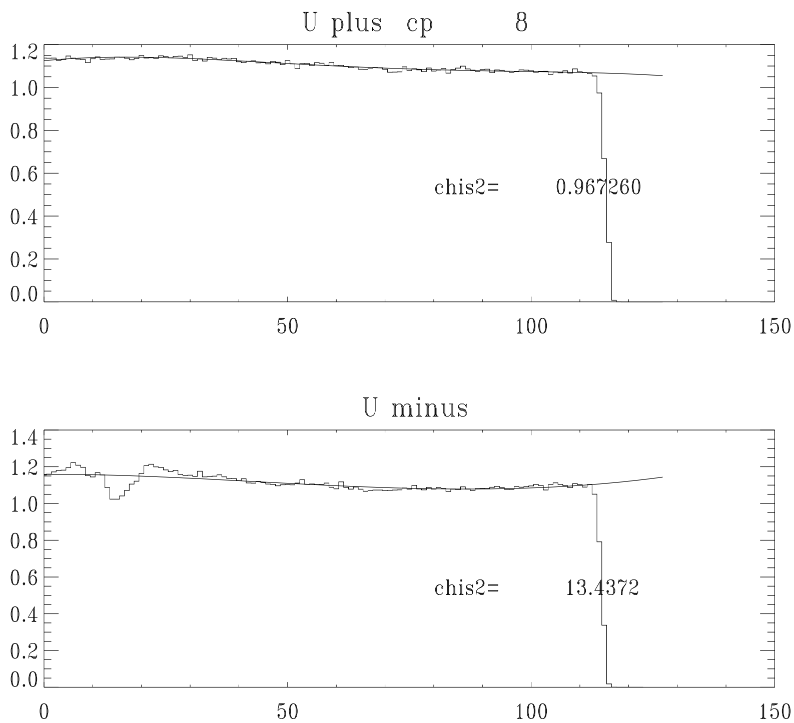


Fig. 5.— Proof of statement for previous figure can be derived by considering transformation of probability distributions. Input flat field is a random uniform deviate in two dimensions. HRC non-linearity transforms the simple input probability distribution



Transformation of Probability:

$P(x)dx = P(y)dy$

$P(x)dx = \frac{N}{L}dx$

$P(y) = \frac{N}{L} \times \frac{dx}{dy}$

If one assumes a correction of the form:

$x = ay^5 + by^4 + cy^3 + dy^2 + ey$

$P(y) = \frac{N}{L}(5ay^4 + 4by^3 + 3cy^2 + 2dy + e)$

Fig. 6.— Fitting to the non-degapped distribution provides the function that linearizes and removes gap. Process is limited by statistics and QE variations.

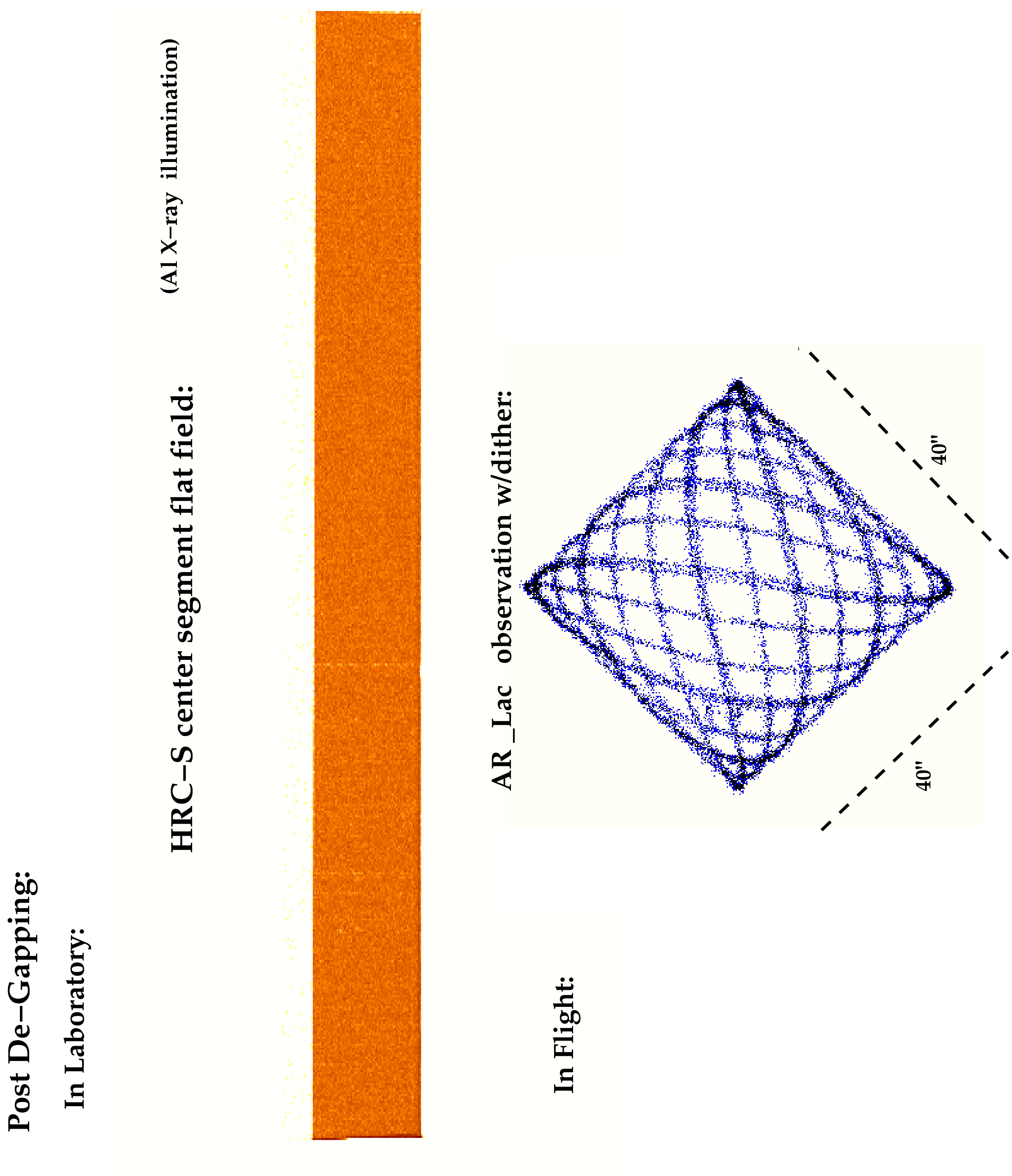


Fig. 7.— Post degapping of flat field and detector coordinate flight data.

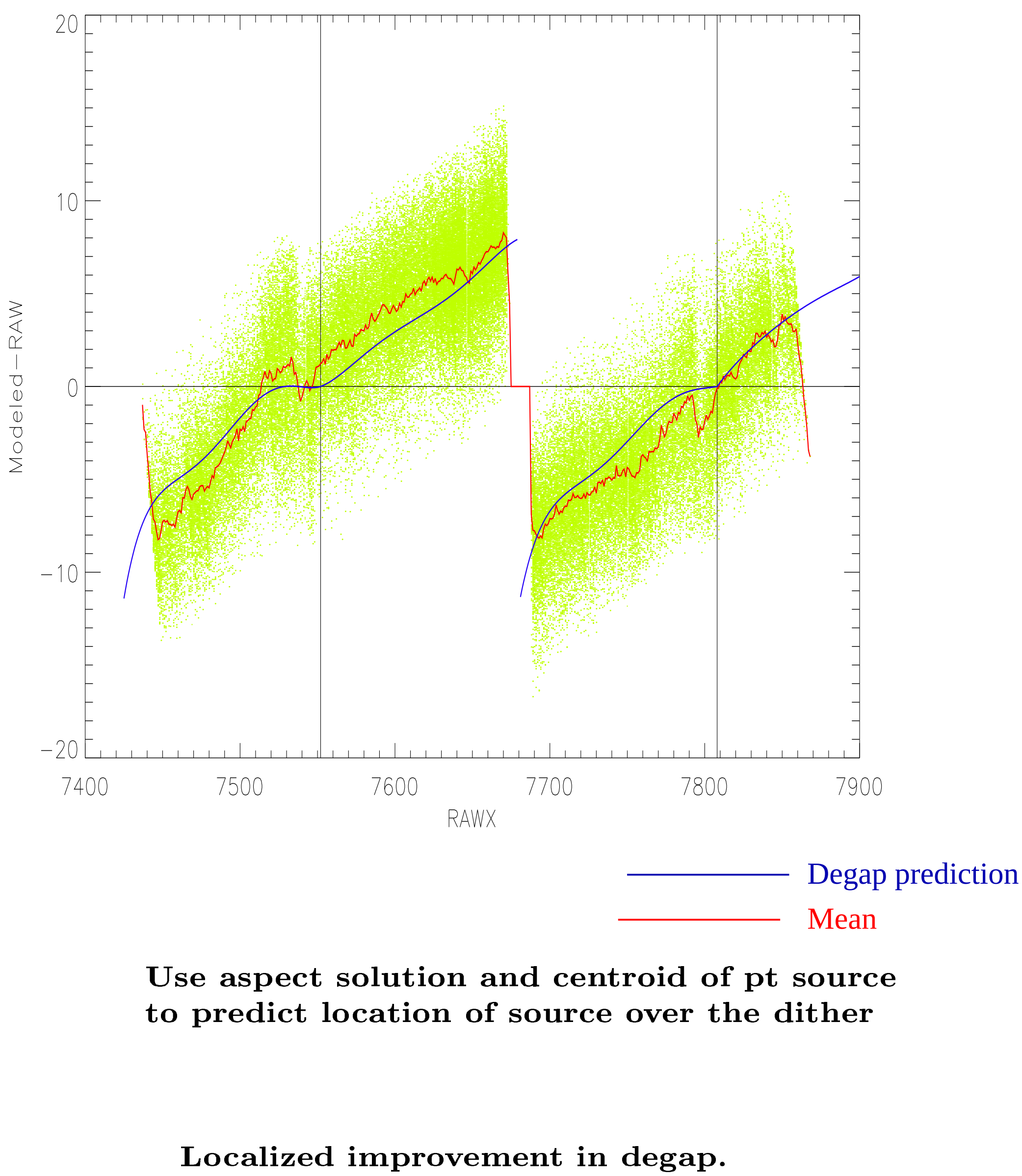


Fig. 8.— It is possible to locally correct degap by looking at bright sources during the dither pattern. This technique is limited to size of dither pattern.

Conclusions and Shortcomings:

Technique works well down to several HRC "pixels".
Assume all events are from same distribution:
(ignores ringing, pulse height...)

Assume distribution shape is due to imaging non-linearity:
(ignores QE variations, UVIS structure features...)

Statistics.
We are limited in statistics; particularly in the HRCS wings where we only exposed to soft Xrays. Localized Improvements:

We need feedback from users to correct degap parameters.
HRC-S line locations, aspect "type" solutions. But these are local corrections only valid for the particular taps.
Perhaps we should have large scale calibration dither??