

# COS Acquisition Strategies

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## Abstract

With its small aperture NUV and FUV dispersed-light target acquisition modes, and NUV imaging target acquisition, COS presents unique challenges in successfully acquiring targets for science observations. We present a number of tips for optimizing a COS target acquisition, along with potential pitfalls which might compromise the resulting science.

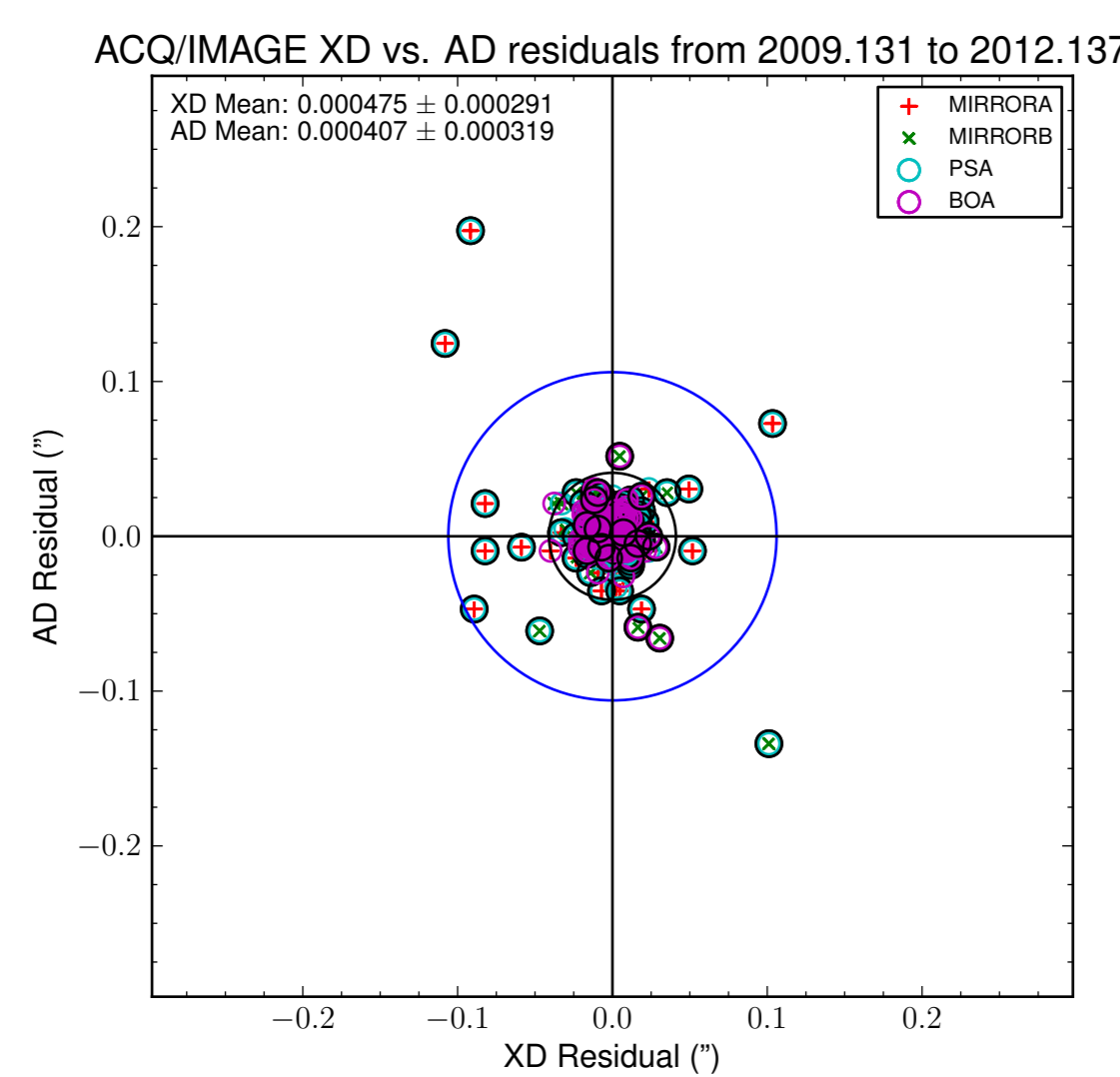
## Introduction

The Cosmic Origins Spectrograph (COS) has four different target acquisition modes – NUV Imaging (ACQ/IMAGE), NUV or FUV search (ACQ/SEARCH), and NUV or FUV dispersed-light (ACQ/PEAKD and ACQ/PEAKXD). Any of these modes may be used with either the Primary Science Aperture (PSA) or the Bright Object Aperture (BOA), with the BOA including a neutral density filter.

- **ACQ/IMAGE** Takes a lamp exposure (to determine the aperture center) followed by an NUV image of the target and, after a centering slew, a final check image. In addition to PSA or BOA, the ACQ may use either MIRRORA (normal) or MIRRORB (reduced throughput).
- **ACQ/SEARCH** The ACQ/SEARCH takes a series of exposures spiraling out from the centre (with a default step between exposures of 1.767" to provide full coverage), and records the number of counts at each dwell position, before slewing to the calculated centroid. This allows targets outside the COS aperture to be found.
- **ACQ/PEAKD** The ACQ/PEAKD takes a series of exposures along the dispersion direction (similar to a dispersion-only SEARCH).
- **ACQ/PEAKXD** The ACQ/PEAKXD takes a lamp exposure (to determine the aperture centre) followed by a target exposure, and then slews to bring the target to the center of the aperture in the cross-dispersion direction.

## 1. Use ACQ/IMAGE Whenever Possible

The ACQ/IMAGE is exceptionally accurate, achieving the strictest centering requirement (0.041") in every case with S/N > 20, and regularly achieving the strictest FUV centering requirement (0.106") even with S/N < 20 (see Figure 1). In addition, the ACQ/IMAGE provides a check image, which allows the final target centering to be determined in case any issues are found with the final exposure.

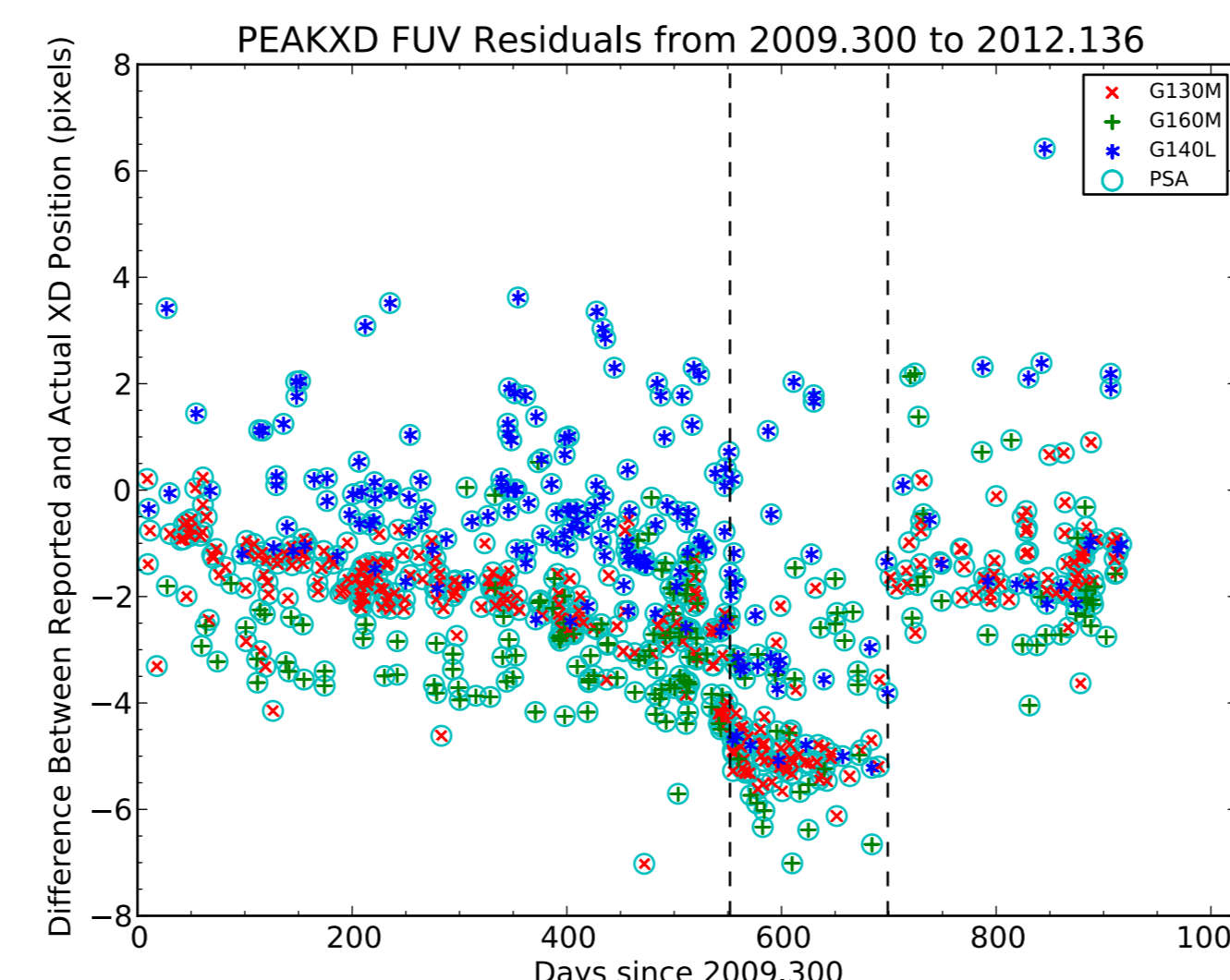


**Figure 1:** Residual error from ACQ/IMAGE exposures. The black circle shows the strictest NUV centering requirement, and the blue circle the strictest FUV centering requirement. Points highlighted in black have SNR < 20.

## 2. Use ACQ/SEARCH Only to Bring Target Into Aperture

The ACQ/SEARCH is intended to bring a target into the COS aperture if there is a significant chance that the blind pointing would leave the target outside the aperture. It is neither designed nor expected to bring a target sufficiently close to the aperture centre to provide an accurate wavelength scale (only 23% meet the FUV centering requirement, and only 6% the NUV centering requirement).

As Figure 2 shows, the ACQ/SEARCH is unbiased (i.e. it does not have a systematic tendency to offset the target in either the dispersion or cross-dispersion directions), and it will almost always succeed in moving the target into the aperture, and usually into the non-vignetted region.



**Figure 3:** Offset between perfectly centered exposure and position registered by FUV PEAKXD exposure as a function of time. The vertical black dashed lines indicate updates to the WCA-PSA offset distance.

## 3. Consider Y-walk for FUV ACQ/PEAKXD

The COS FUV detector is subject to Y-walk (the Y position of counts being mis-registered on the detector) as a result of gain sag (a loss in XDL detector efficiency as a result of prolonged exposure to light). This will effectively modify the distance between the wavecal lamp and the aperture center as perceived by the ACQ/PEAKXD (which does not perform co-ordinate correction or Y-walk correction). As a result, the offset must be updated periodically. For programs that may be affected by even small offsets in the cross-dispersion direction, the use of the FUV ACQ/PEAKXD may cause issues.

The only mitigation strategy for this issue is to avoid the use of FUV ACQ/PEAKXD exposures. This can be accomplished through the use of NUV ACQ/IMAGE (preferred), or NUV dispersed-light target acquisitions, which are not subject to gain sag.

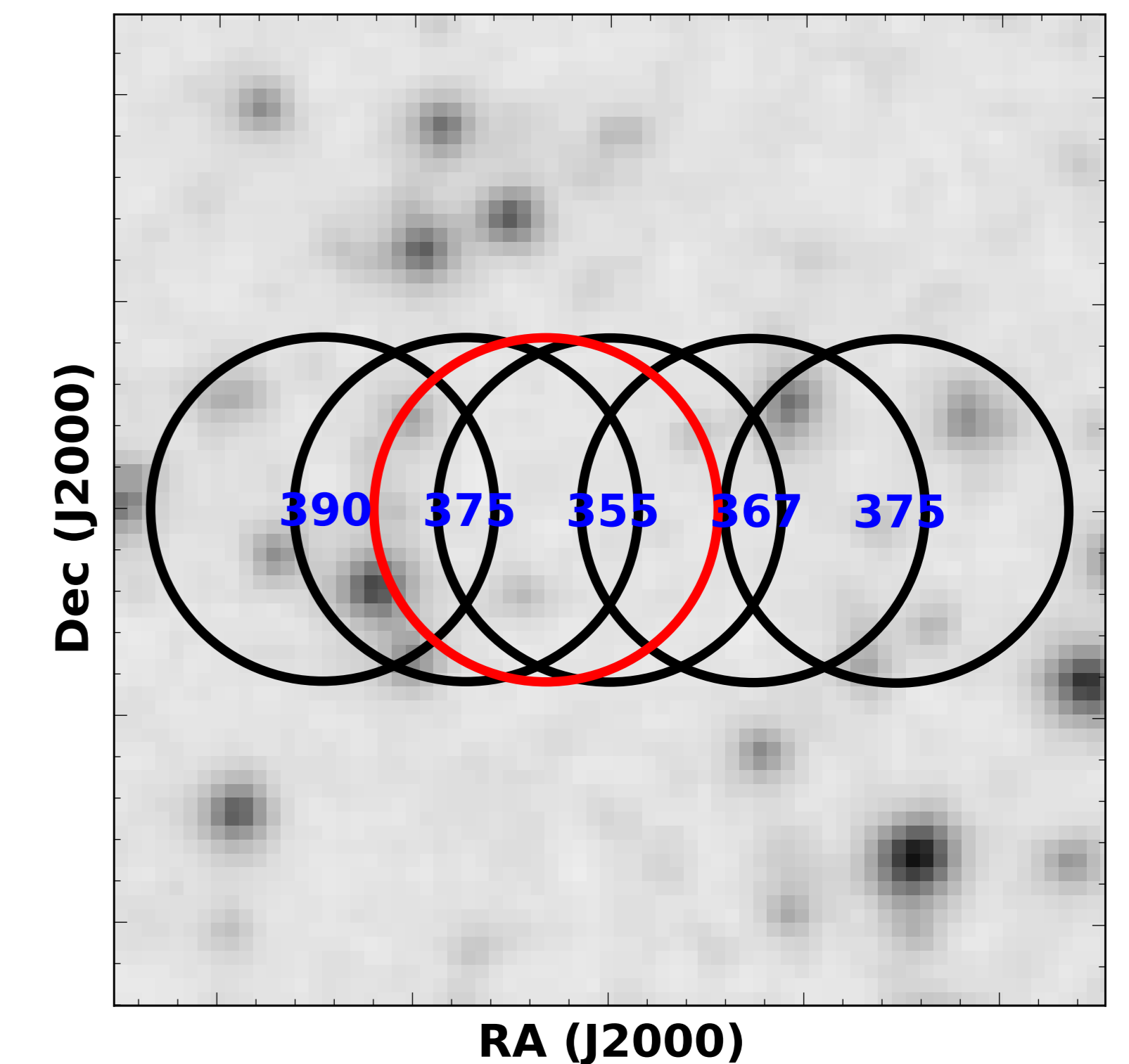
## 4. Be Careful in Crowded Fields with non-Imaging ACQs

The COS non-imaging ACQs, rather than centering on a checkbox, center based on either the mean count location (ACQ/PEAKXD), or a centroid of the total counts in each dwell position (ACQ/SEARCH and ACQ/PEAKD). This can result in inaccurate centering and missed targets, especially in crowded fields (see Figure 4 for an example ACQ/SEARCH, Figure 5 for an example ACQ/PEAKD).

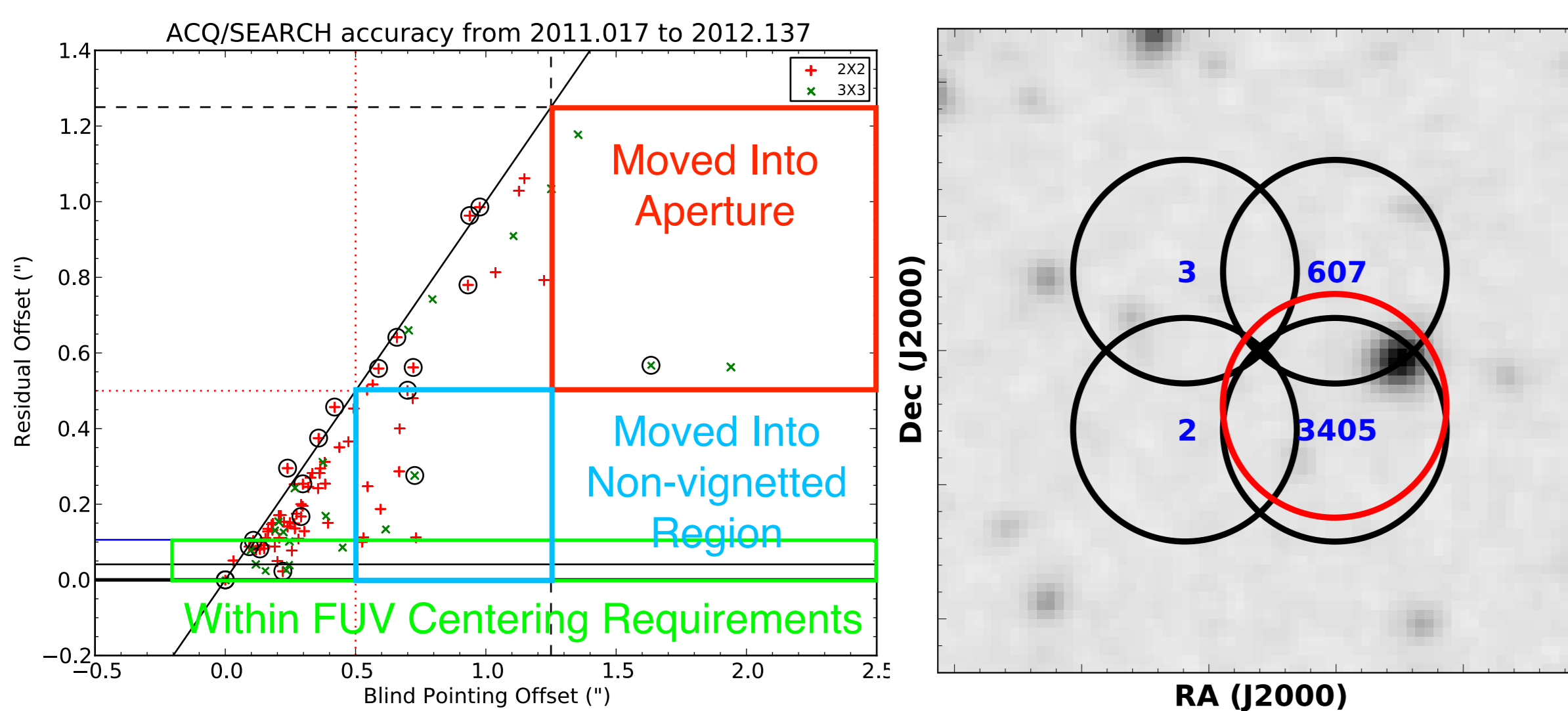
In the case of ACQ/PEAKXD exposures, the brightest source in the aperture is unlikely to be moved entirely out of the aperture, but if multiple sources are present then the detector will center on the mean Y position of all counts, which may be between several sources (Figure 6).

## Mitigation Strategies

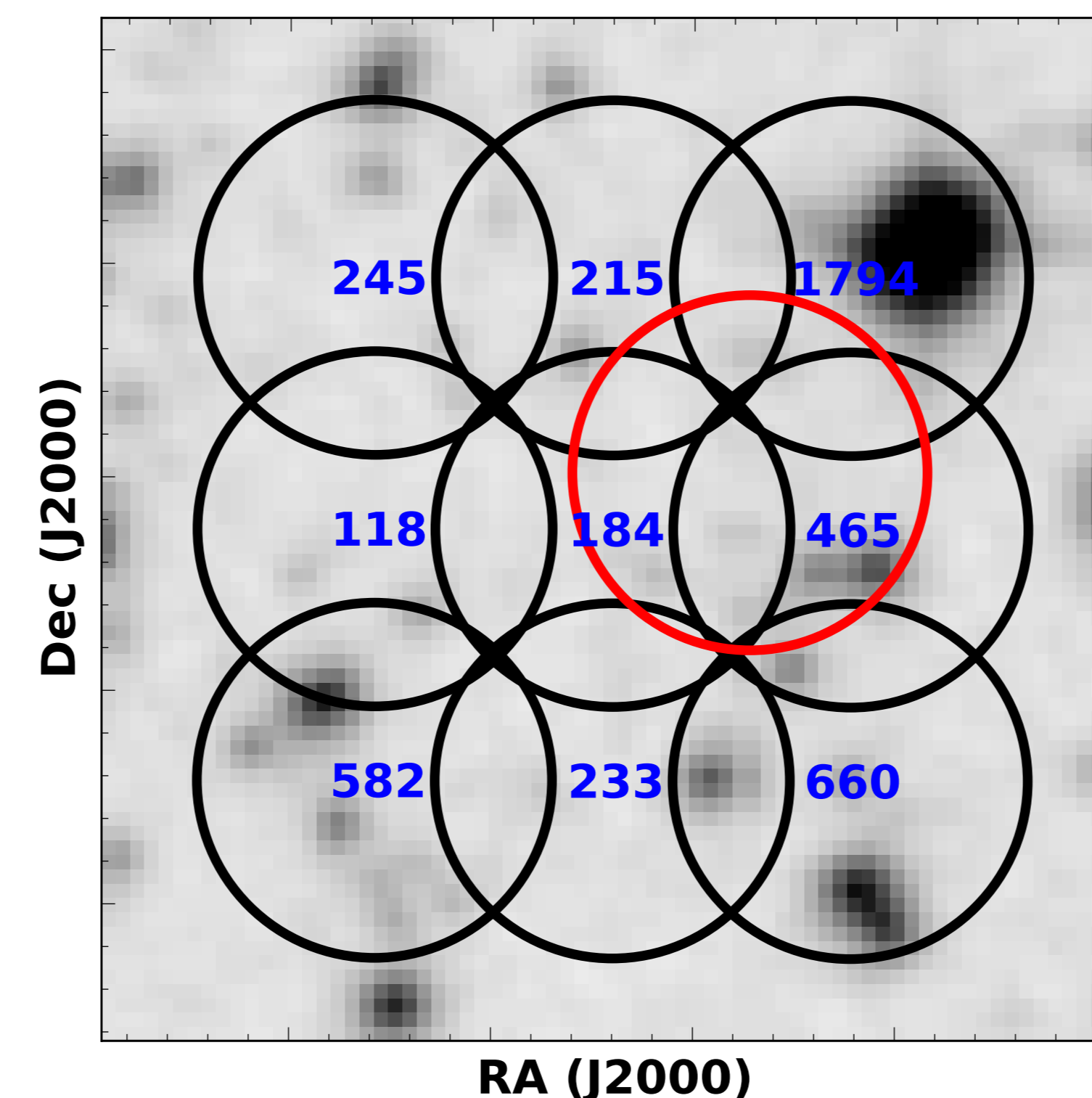
- **Use CENTER='BRIGHTEST'** for ACQ/SEARCH Since the main purpose of the ACQ/SEARCH is to bring the target into the aperture, centering on the brightest dwell point can accomplish this purpose in a crowded field.
- **Repeat the ACQ/SEARCH with a smaller step size** The 1.767" default step size is the largest possible step size that ensures no gaps in coverage. Smaller step sizes can achieve better accuracy once a larger search has found the general centering.
- **Get UV Images of the target field in advance** This allows for testing of ACQ strategies as well as finding potential issues in advance.



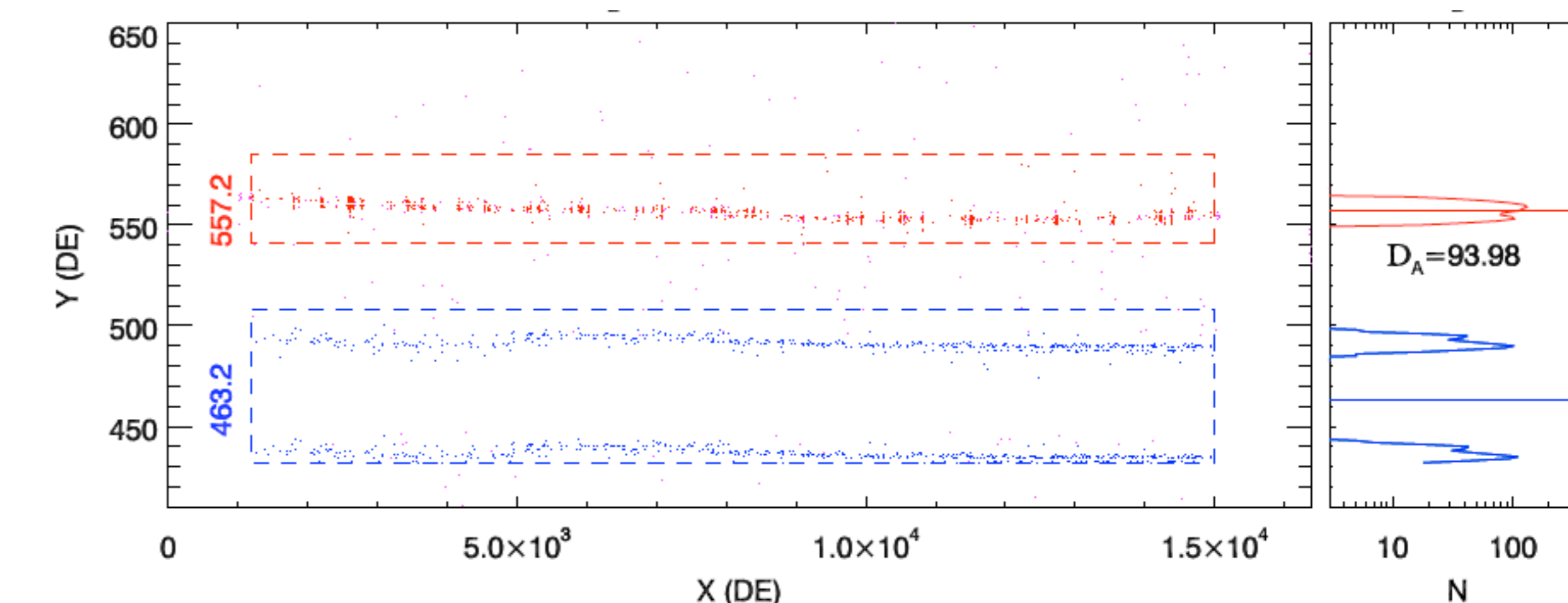
**Figure 5:** Simulated 5-dwell ACQ/PEAKD with a step size of 1.1 arcsec. The blue numbers show the count at each dwell point, the black circles the aperture at each dwell point, and the red circle the final position of the COS aperture.



**Figure 2:** Residual offset vs. initial pointing (left) and a sample search (right). In the left plot, the solid black diagonal line represents Y=X (points above the line are worse after the search), the black dashed line the aperture, the red dotted line the non-vignetted region, and the inner solid blue and black horizontal lines the FUV and NUV strict centering requirements as in Figure 1. Black circles around individual data points represent S/N < 40. In the right figure, blue numbers show the counts at each dwell, black circles the COS aperture, and the red circle the final center.



**Figure 4:** Simulated COS 3X3 ACQ/SEARCH in a crowded field. Black circles show dwell positions, blue numbers show the counts at each dwell, and the red circle shows the final commanded pointing.



**Figure 6:** Simulated ACQ/PEAKXD with 2 sources on the detector. The left panel shows the 2D detector subarrays (with the lamp in red and the target in blue), whilst the right panel shows the detector profiles after collapse along the X axis. The horizontal red line shows the detected position of the lamp, and the blue line the detected position of the target.