Angular Differential Imaging with Microwave Kinetic Inductance Detectors

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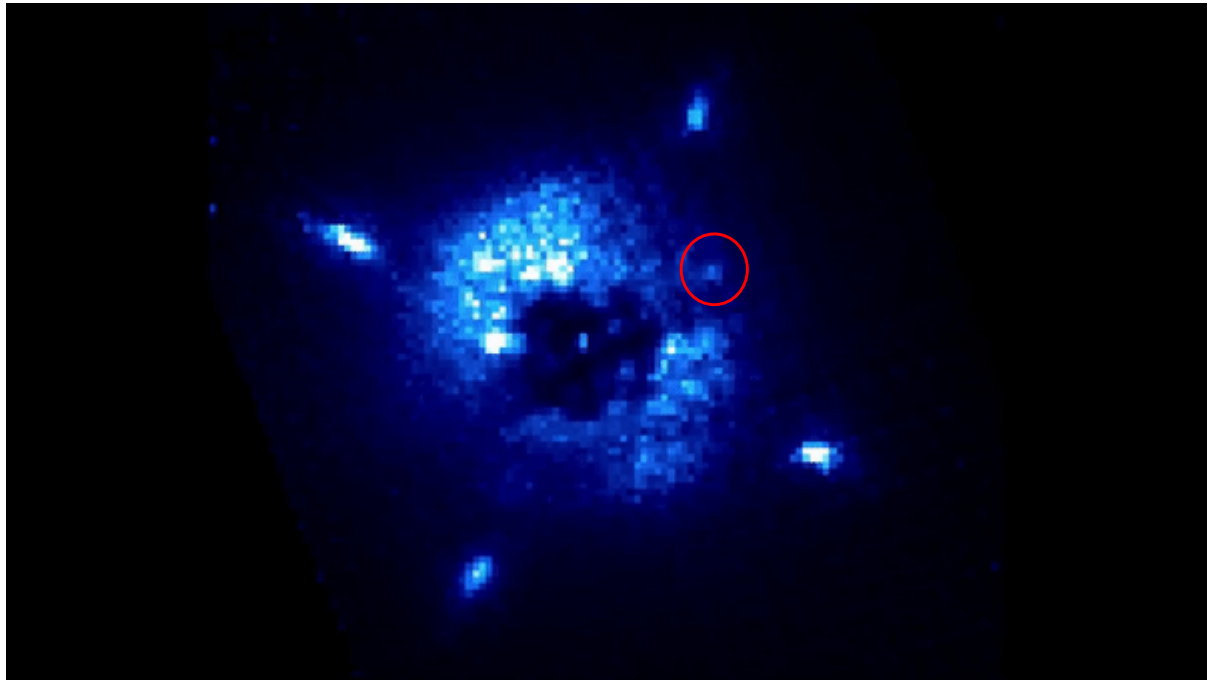
Outline

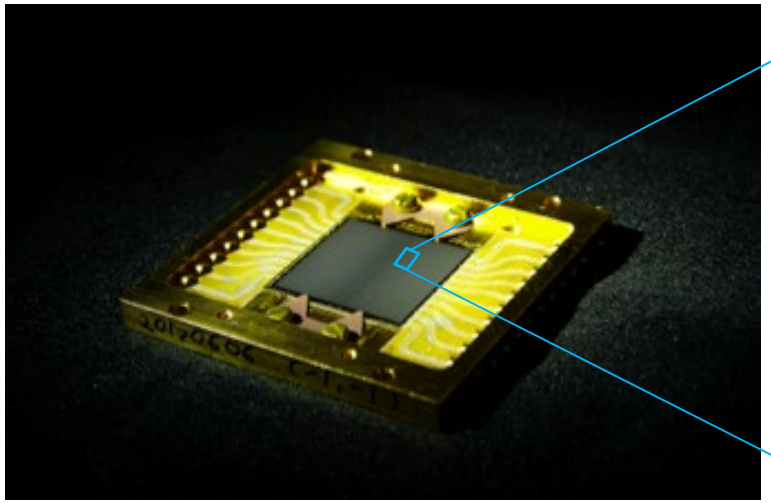
- Emergence of Exoplanet Astronomy
- What is an MKID?
- MKID Pipeline
- Angular Differential Imaging
- Results
- Future Work

Are we alone?



Wavelength scan of star (behind coronagraph) and companion (circled) from MEC

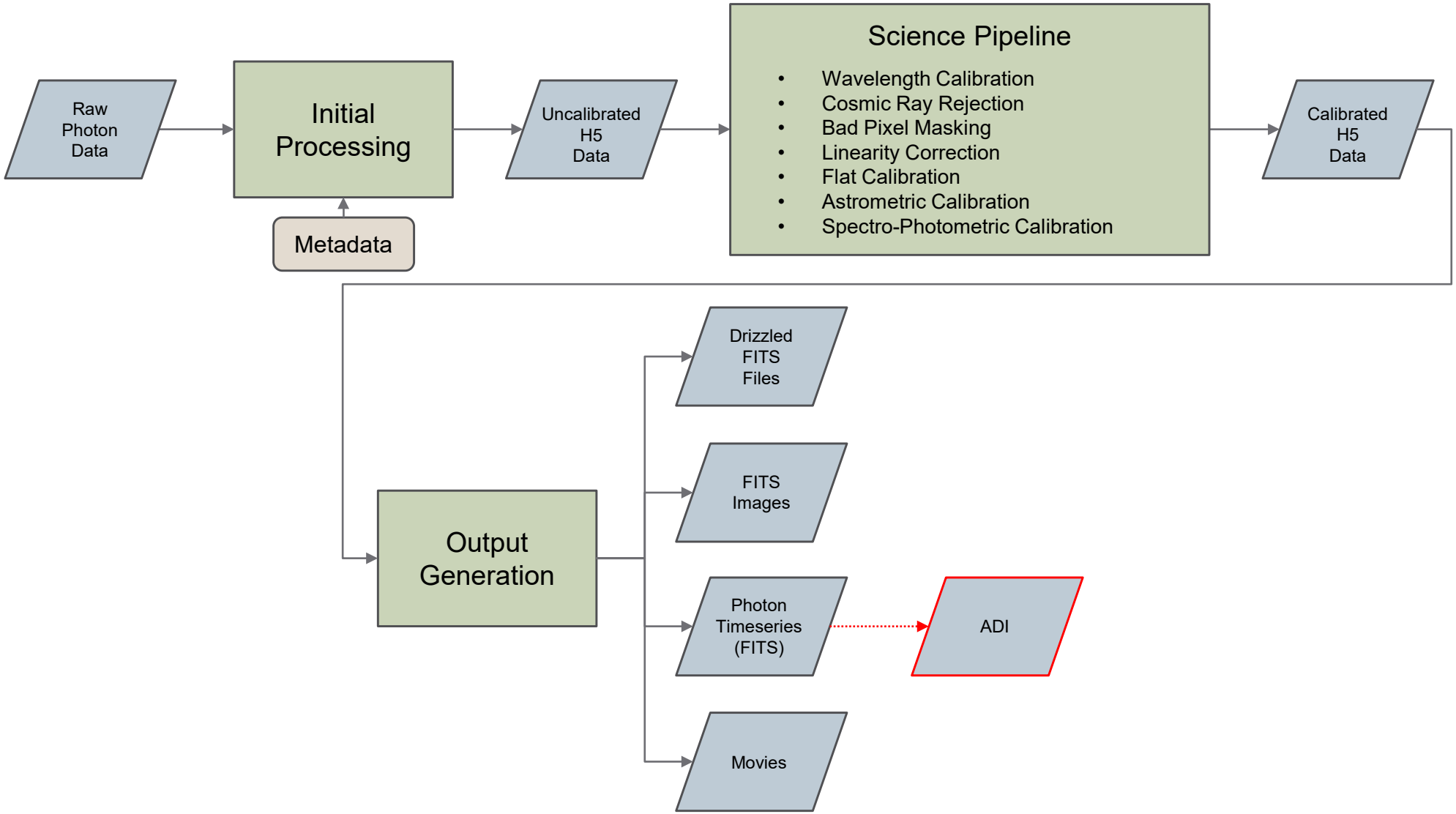
What is an MKID?



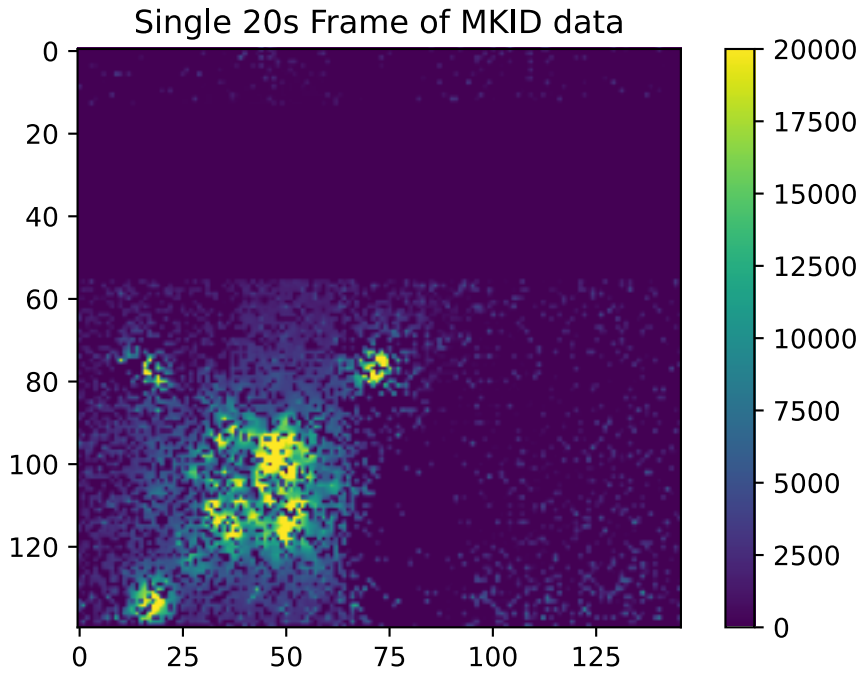
~20,000 pixel MKID array used in MEC

Microscopic view of individual MKIDs (pixels)

MKID Pipeline



Angular Differential Imaging (ADI)



Typical reduced image of a target with speckle halo and satellite spots

Classical ADI Algorithm

First phase: Find a reference PSF image from all frames in the set and subsequently subtract that reference from all frames.

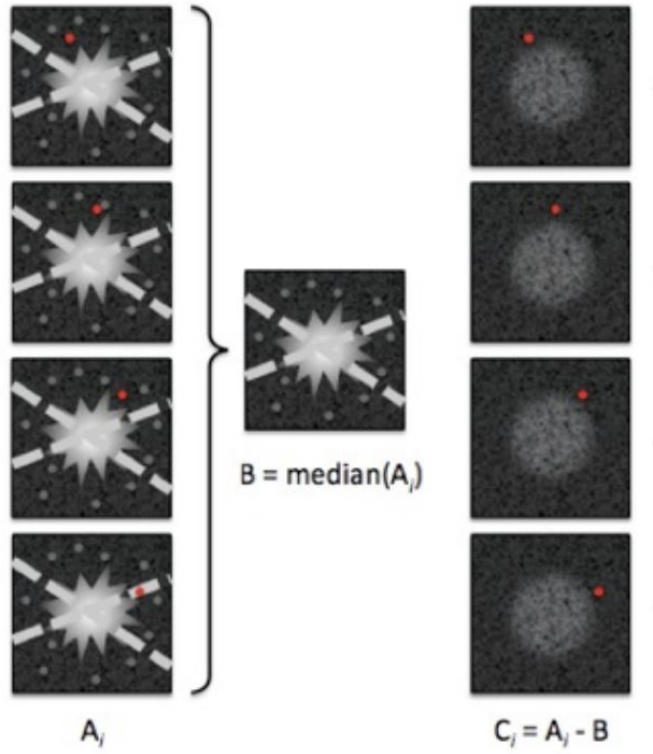
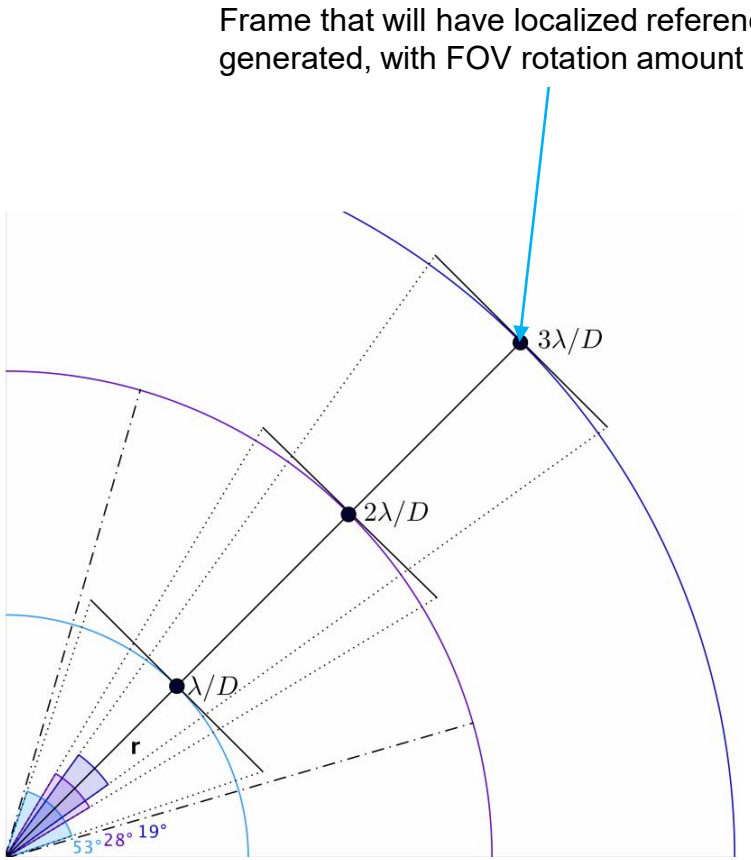


Image Source: https://www.s.utokyo.ac.jp/en/utrip/archive/2014/pdf/09TaweewatSoomboonpanyakul.pdf

Classical ADI Algorithm

Second phase: Find a **localized, annular** reference PSF image for **each** frame in the set and subsequently subtract that reference from it's related frame.



Reference frame exclusion zones, as a function of annulus separation. Excludes frames that have less than 1.5 FWHM displacement.

Image Credit:Carlos Alberto Gomez Gonzalez, Olivier Wertz et al.

Classical ADI Algorithm

Final phase: De-rotate all frames in the set such that their orientations align with the initial frame and then perform median combination

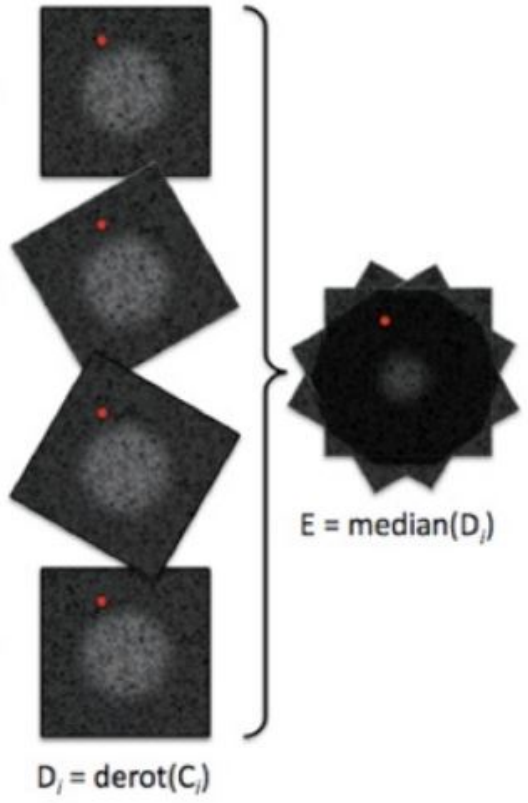
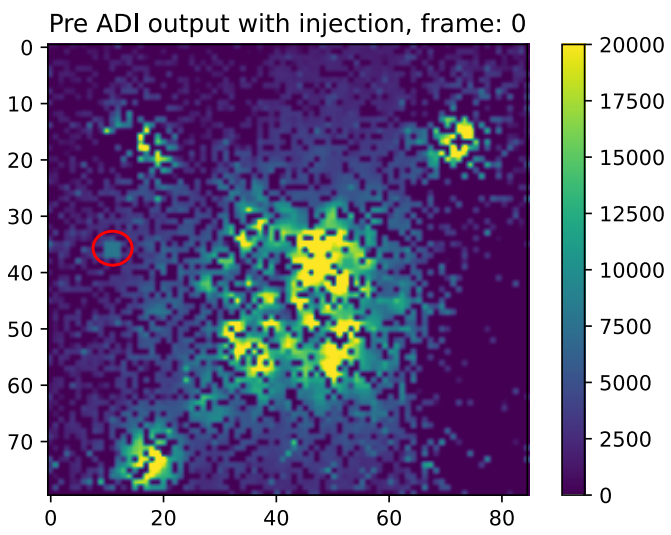
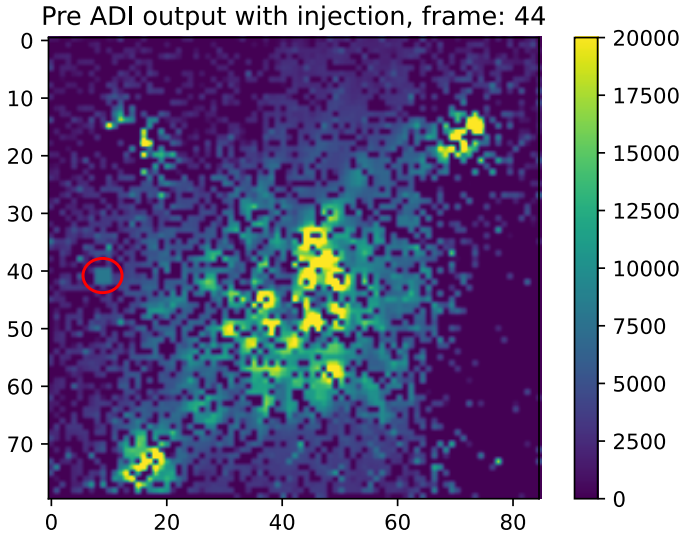
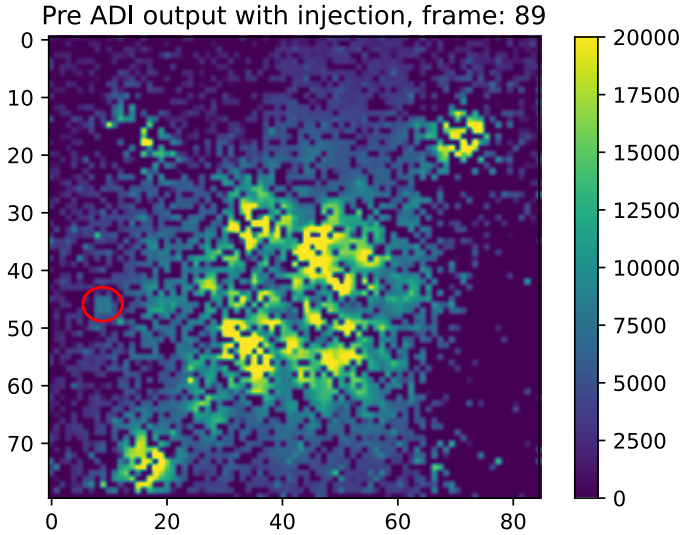


Image Source: https://www.s.utokyo.ac.jp/en/utrip/archive/2014/pdf/09TaweewatSoomboonpanyakul.pdf

Companion Injection: Pre-ADI

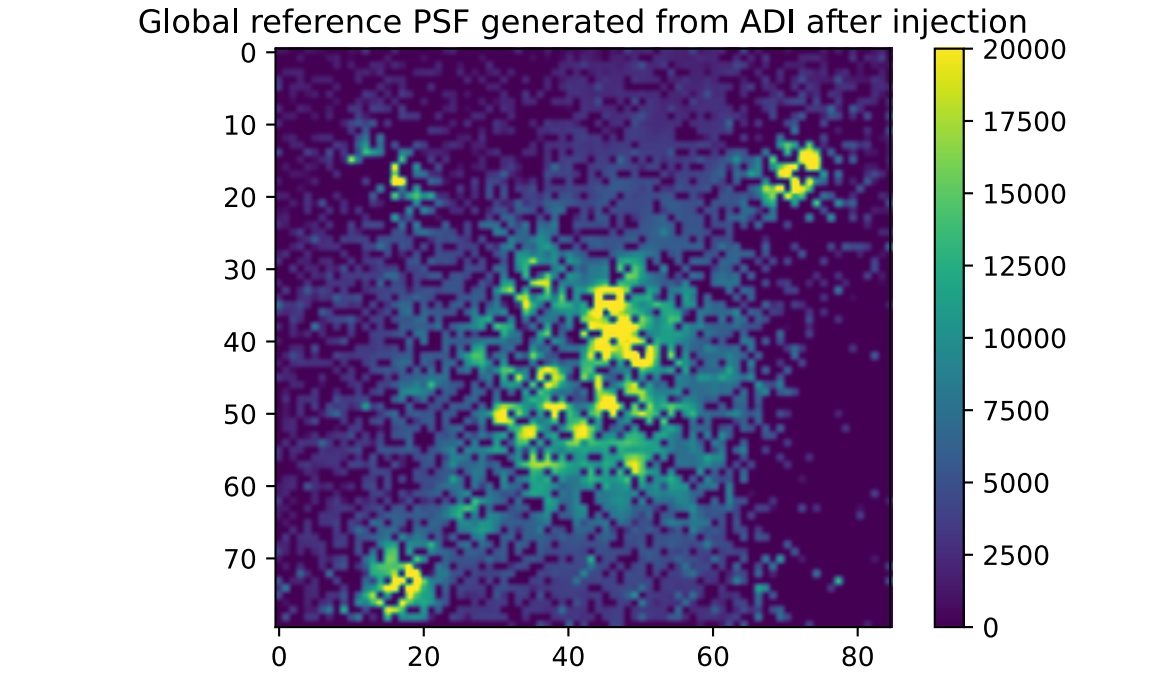






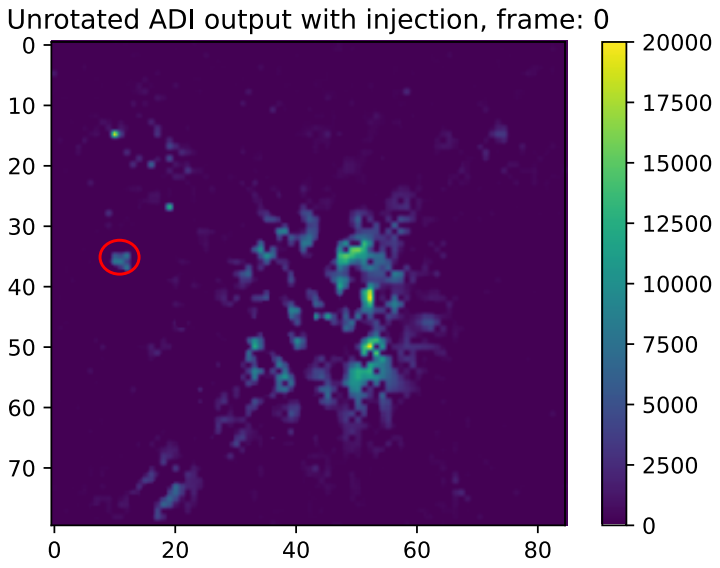
- Companion injected at 0.25” separation
- ~20 degrees of total FOV rotation

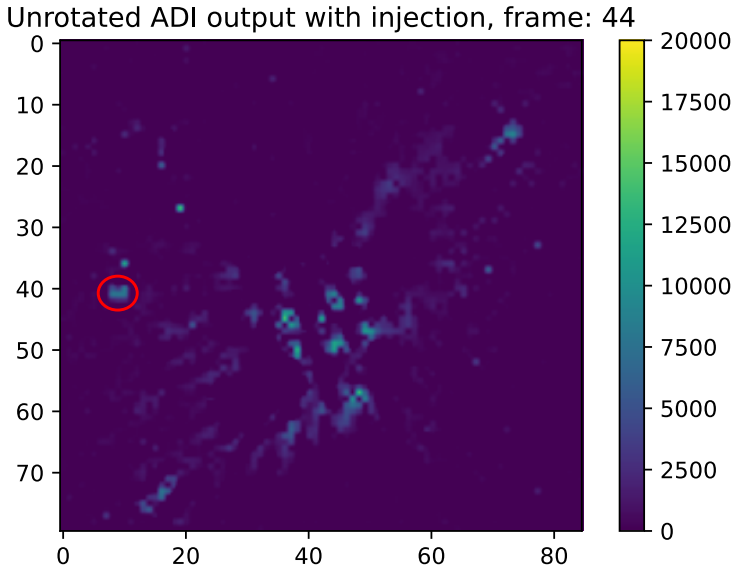
Global Reference PSF

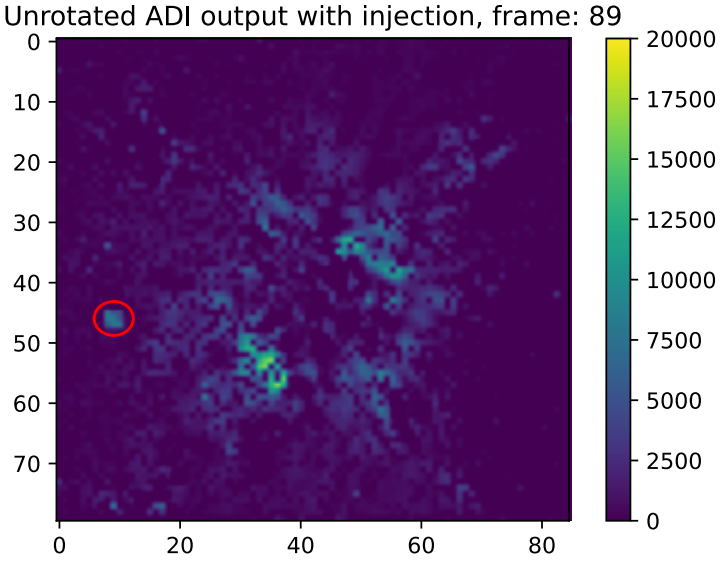


Signature of the injected companion is missing from the reference PSF

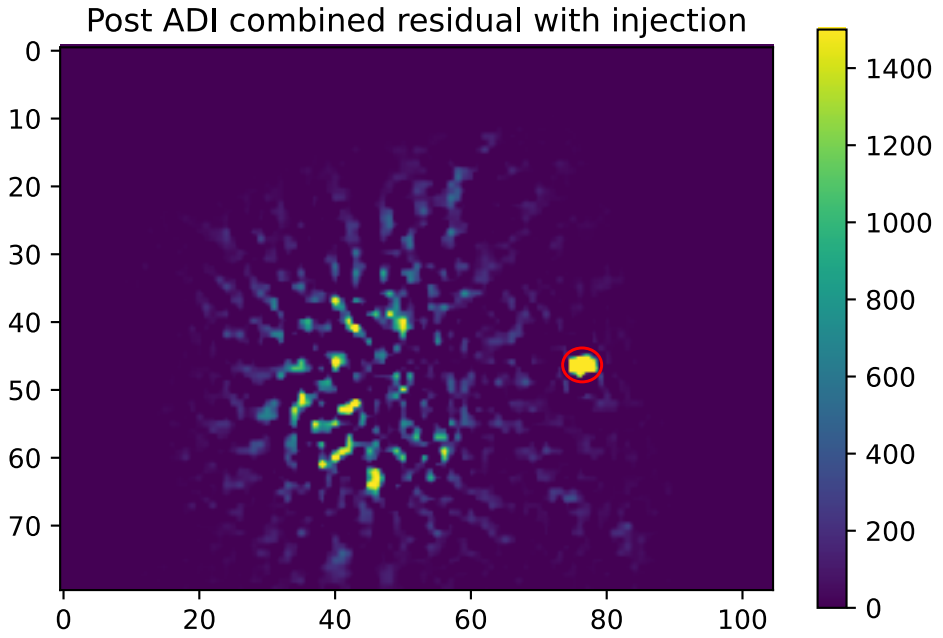
Companion Injection: Post-ADI







Final Result



Future Work

- Engineer tighter integration with the MKID Pipeline
- Use the implementation to hunt for real companions in this dataset and datasets from other candidate targets!

Acknowledgments

- Ben Mazin
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- Jeb Bailey and Sarah Steiger
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