High resolution near-infrared deep fields with MCAO

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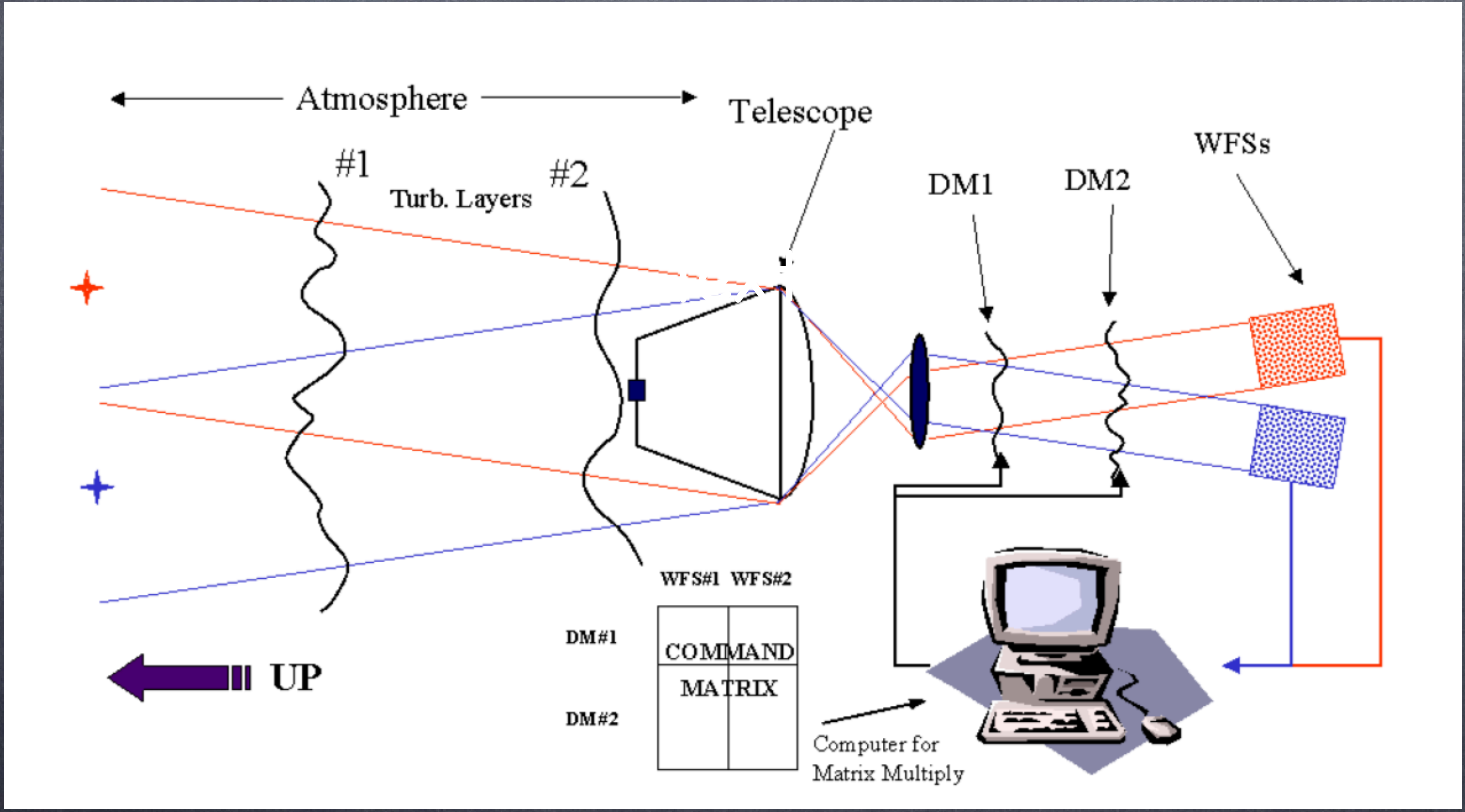
“Wide”-field AO corrections

- Conventional AO systems only provide good correction <0.5′-1′ from the field center, and the PSF quality falls off as a function of distance from the guide star.
- Systems using multiple guide stars and laser constellations are conjugate to multiple layers of turbulence (MCAO), allowing a wide-field correction.
- Promise of these systems for TMT is huge - better resolution than JWST. Already Gemini better than HST in K-band.
- AO turns TMT from just a bigger light bucket to a qualitatively more powerful telescope.

System diagram (Rigaut et al.)



Tomographic - each GS samples all layers

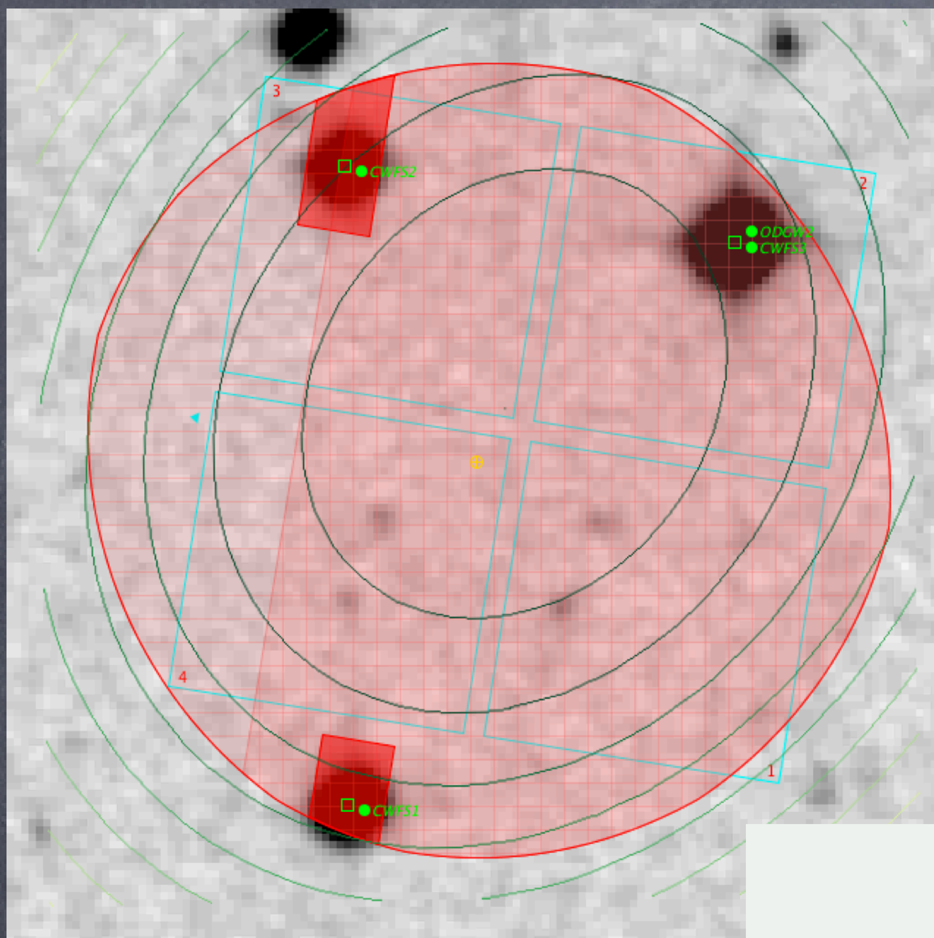
Gemini GeMs/GSAOI

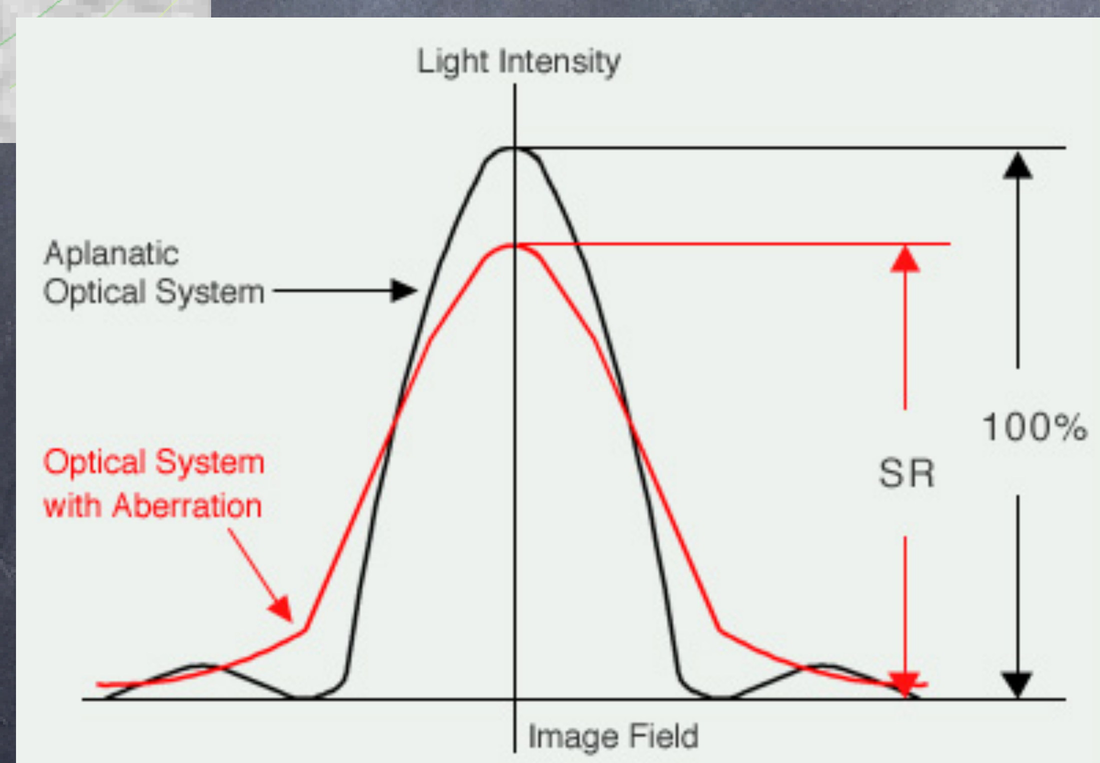
- Currently the only MCAO system with a laser constellation.
- Natural guide stars also needed though to perform low-order corrections.
- Right now restricted to R<15.5. One star can be used, but 3-star asterisms ideal to get uniform PSF across the field. Problem is only ~1/deg^2 in extragalactic sky.

SERVS

- The 18deg^2 Spitzer Extragalactic Representative Volume Survey (SERVS; Mauduit et al. 2012) reaches deep enough to find galaxies out to z~5, and covers 18deg^2. Multiwavelength data from radio, Herschel (FIR), SWIRE (IR), VIDEO (near-IR), optical.
- It is thus ideal for finding the rare asterisms that allow full exploitation of the current GeMS/GSAOI system.
- We have obtained Gemini time to observe 5 fields to 90min depth (GS-2013B-Q-14). (Also some complementary VLA X-band A-array in the equatorial fields.)

Asterisms





- ES1c - contours are Strehl 0.35+/-0.5. Max 35.4.
- Other 4 similar
- Not all asterisms are created equal - need near equilateral triangle

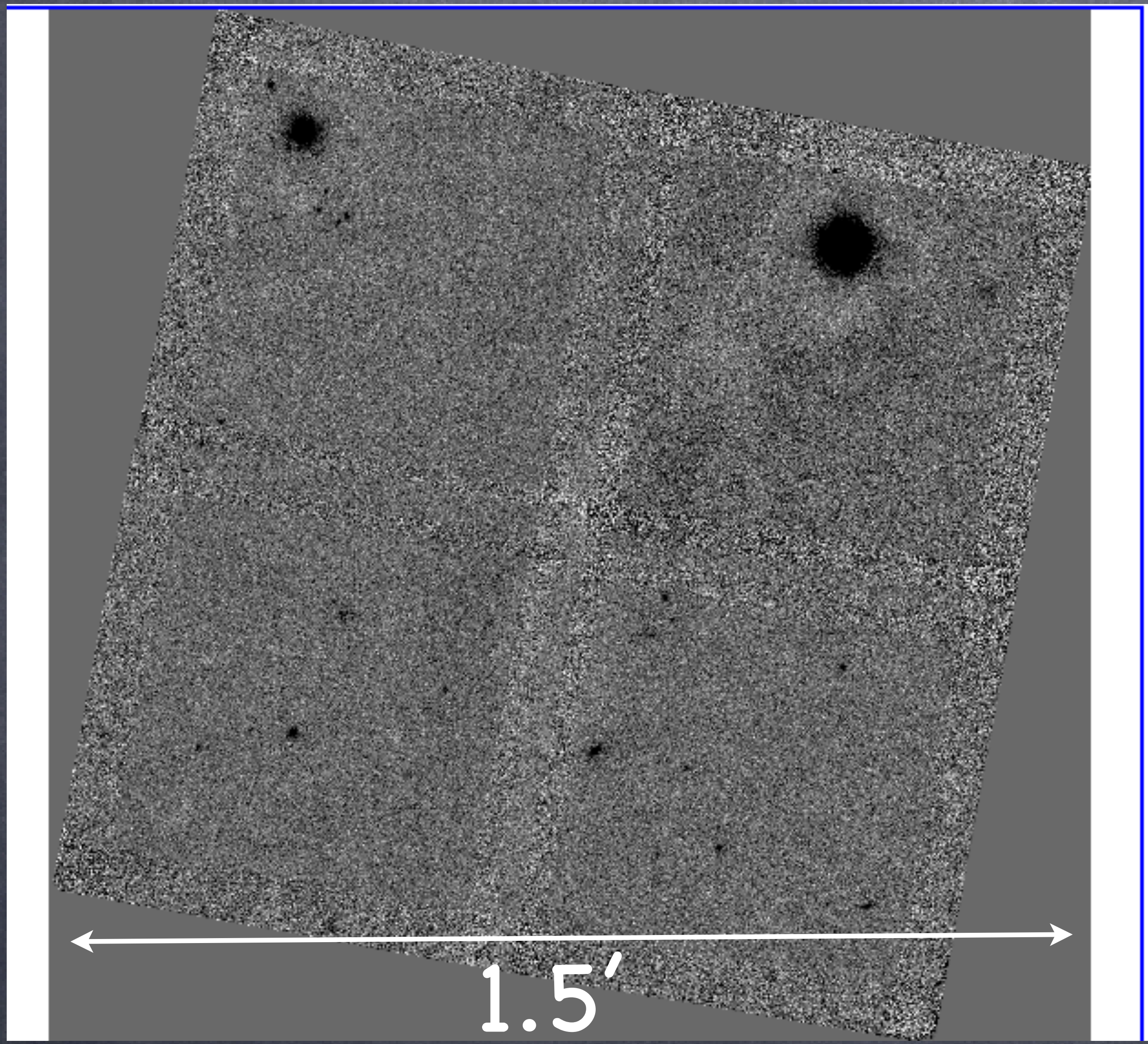
First results

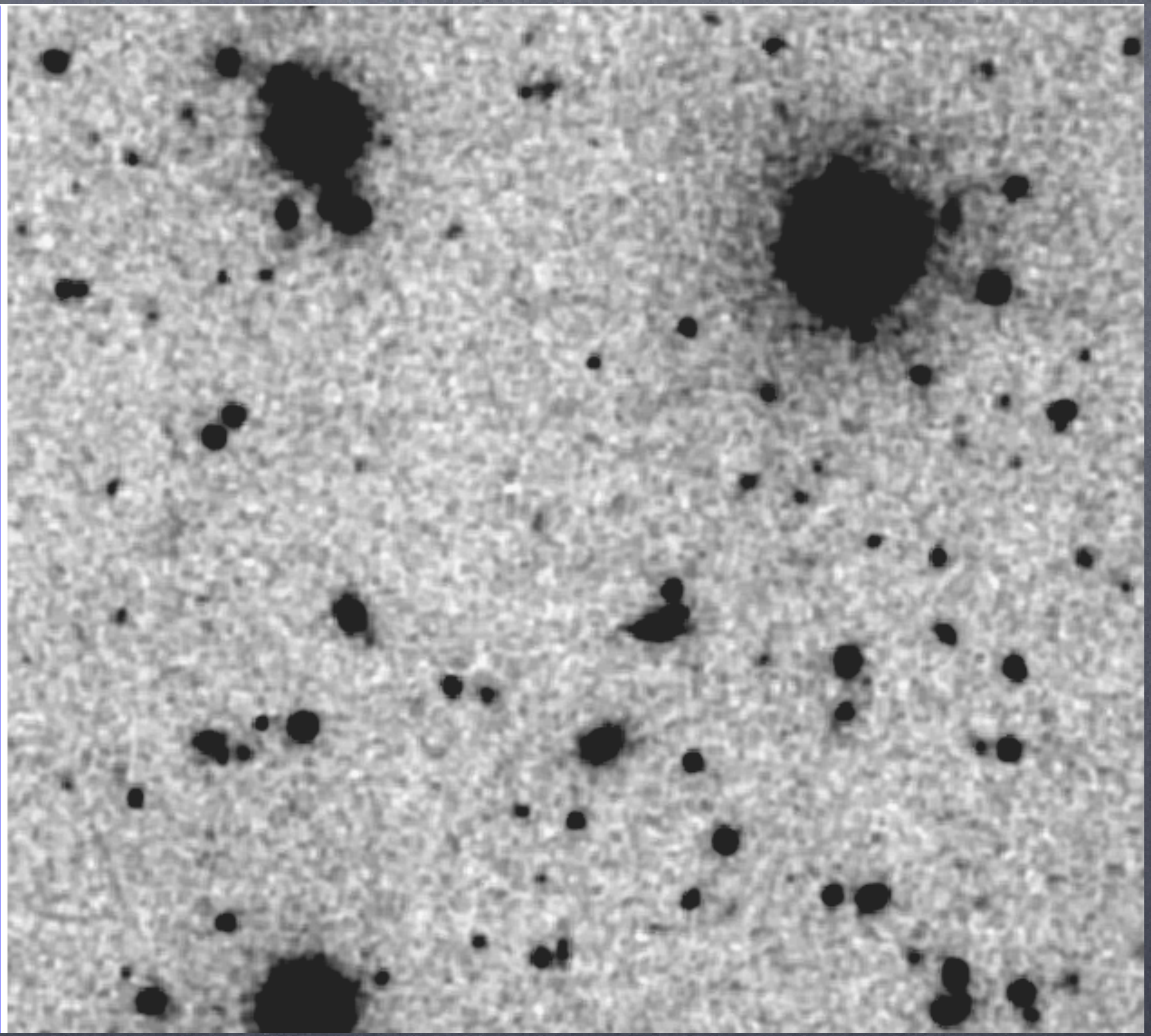
- Weather and instrument issues meant only one field was observed in 2013B, and for only 10/90min. (Program has carryover though.)
- Nevertheless, enough data to check quality, test data reduction algorithms and whet our appetites with some "instant science".
- (Note also GSAOI data on HFF MACS0416 in GS-2013B-DD-1 using a single guide star.)

ES1c

GSAOI K

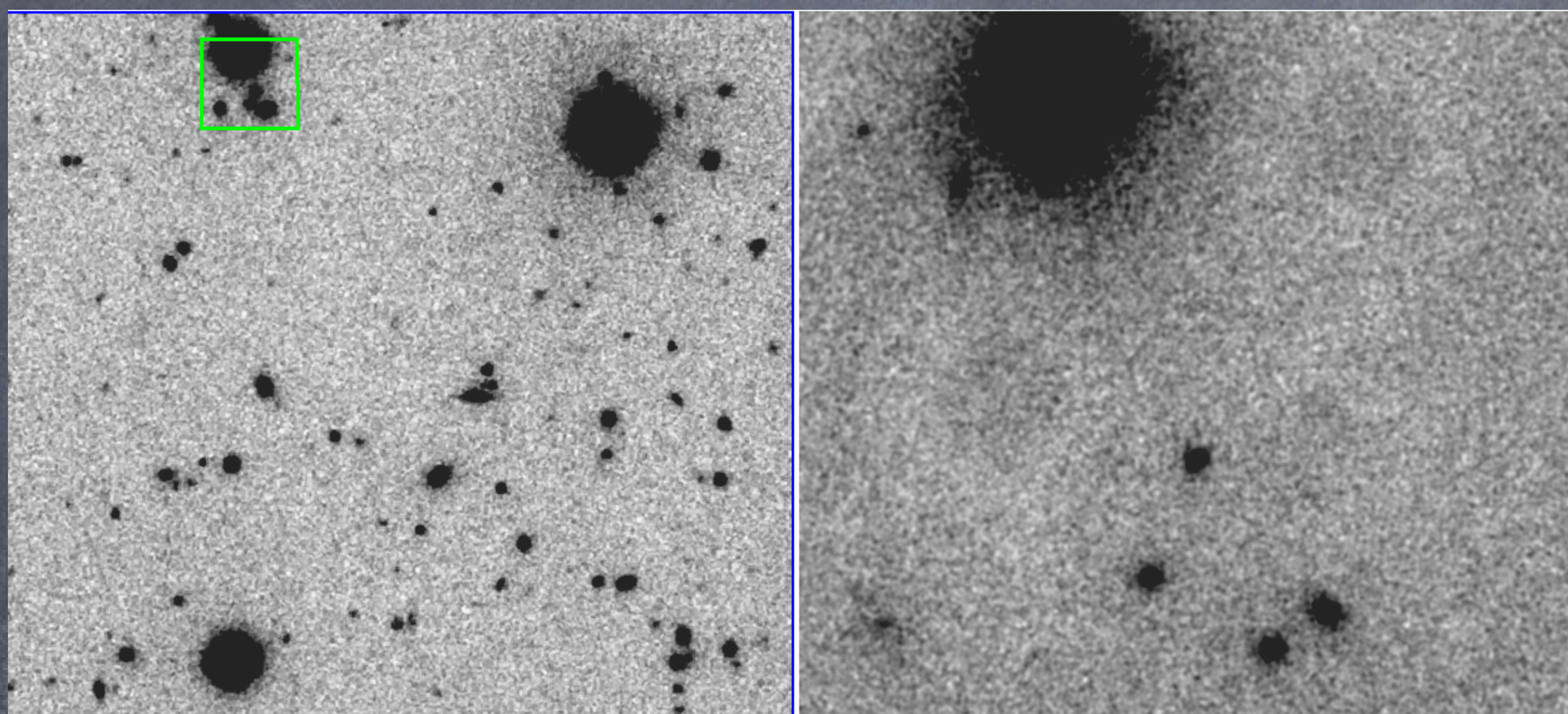
VIDEO K





Distortion a major issue in data reduction - good to have a deep survey image for astrometry.

Zooms



GSAOI

VIDEO

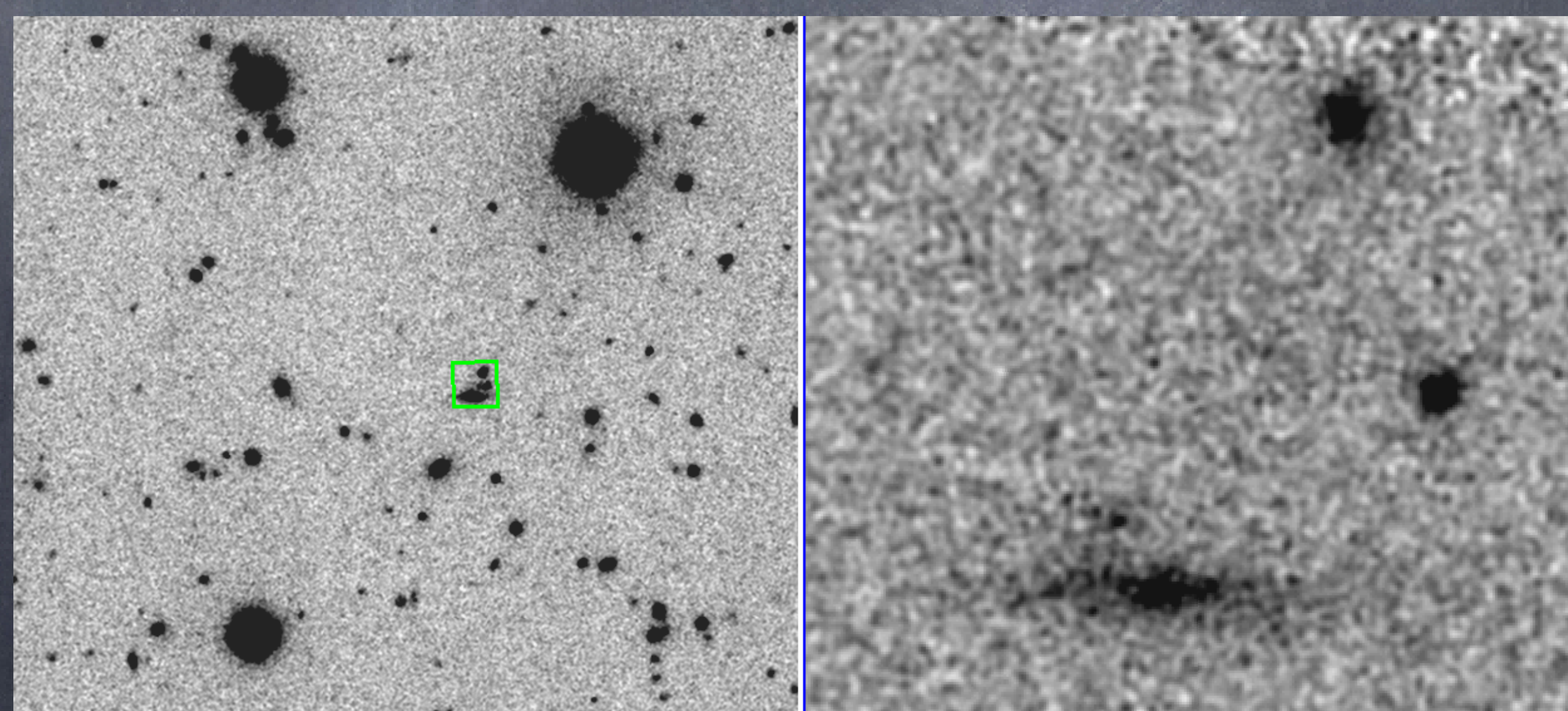
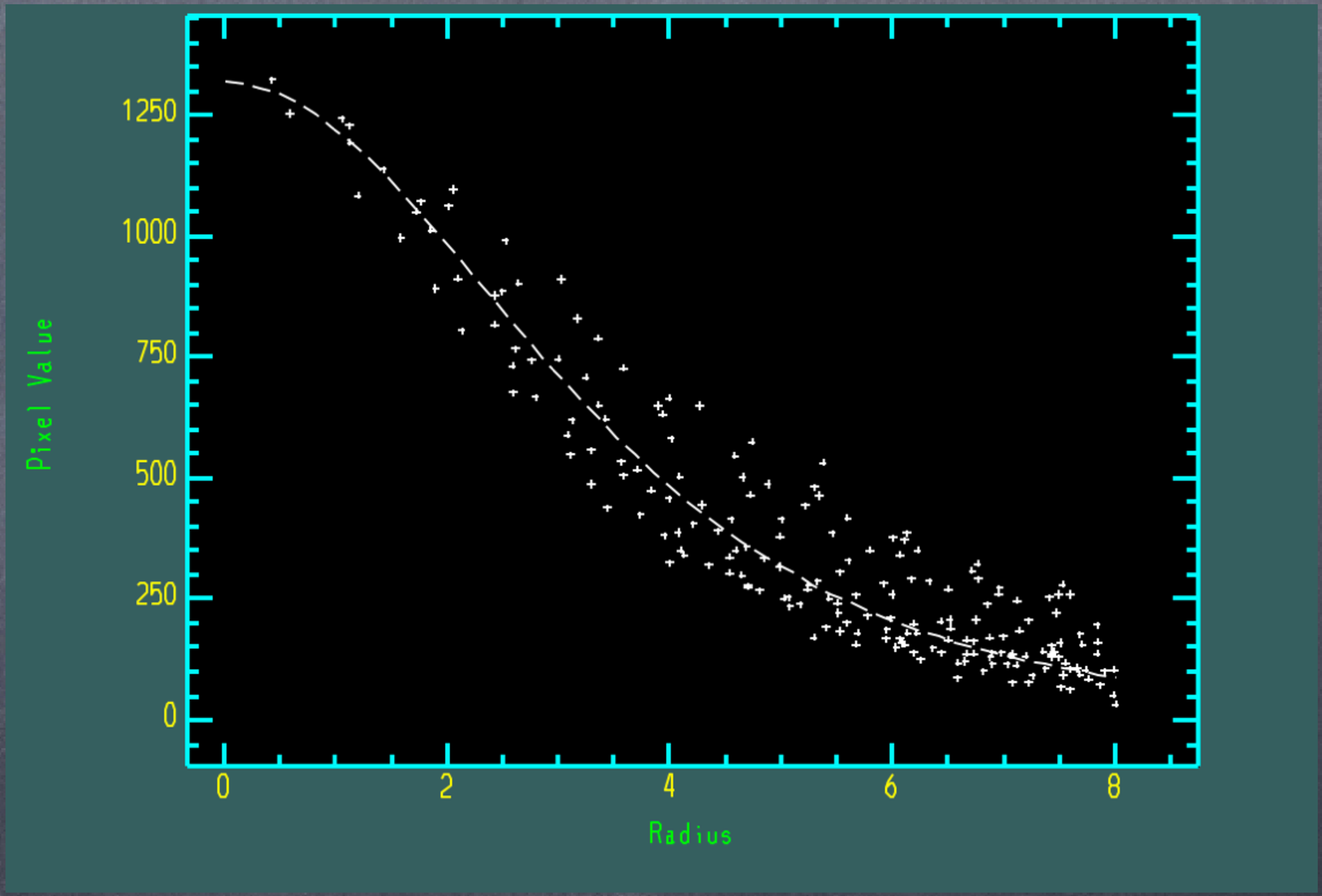
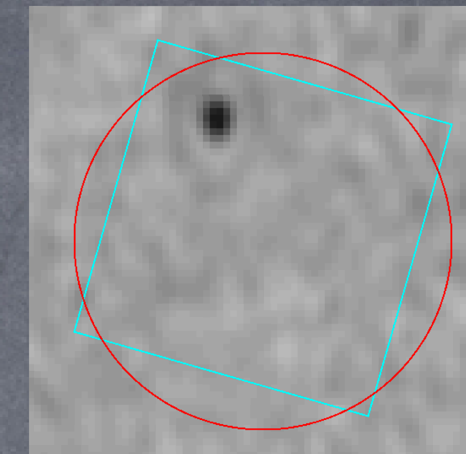


Image quality

- 0.14″ FWHM (compare to HST diffraction limit in K-band ~0.22″)
- No "core+halo" as seen in some AO systems - photometry easier.



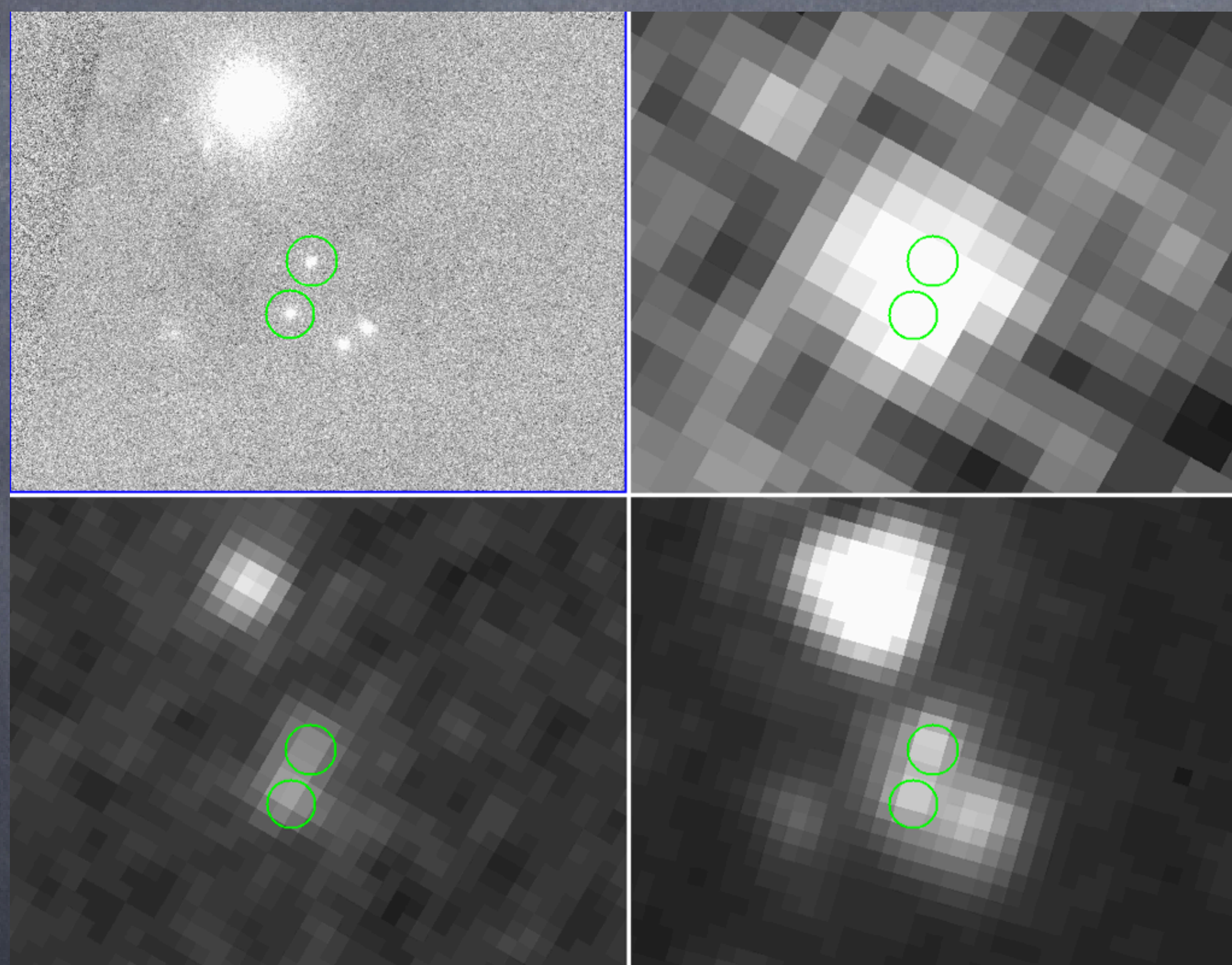
Quick science: I- Candidate multiple AGN



ATNF/ATLAS
1.4GHz

GSAOI-K

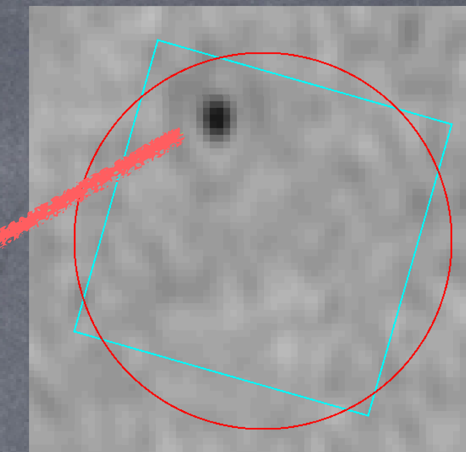
SWIRE
24mu



SWIRE
8mu

SERVS
4.5mu

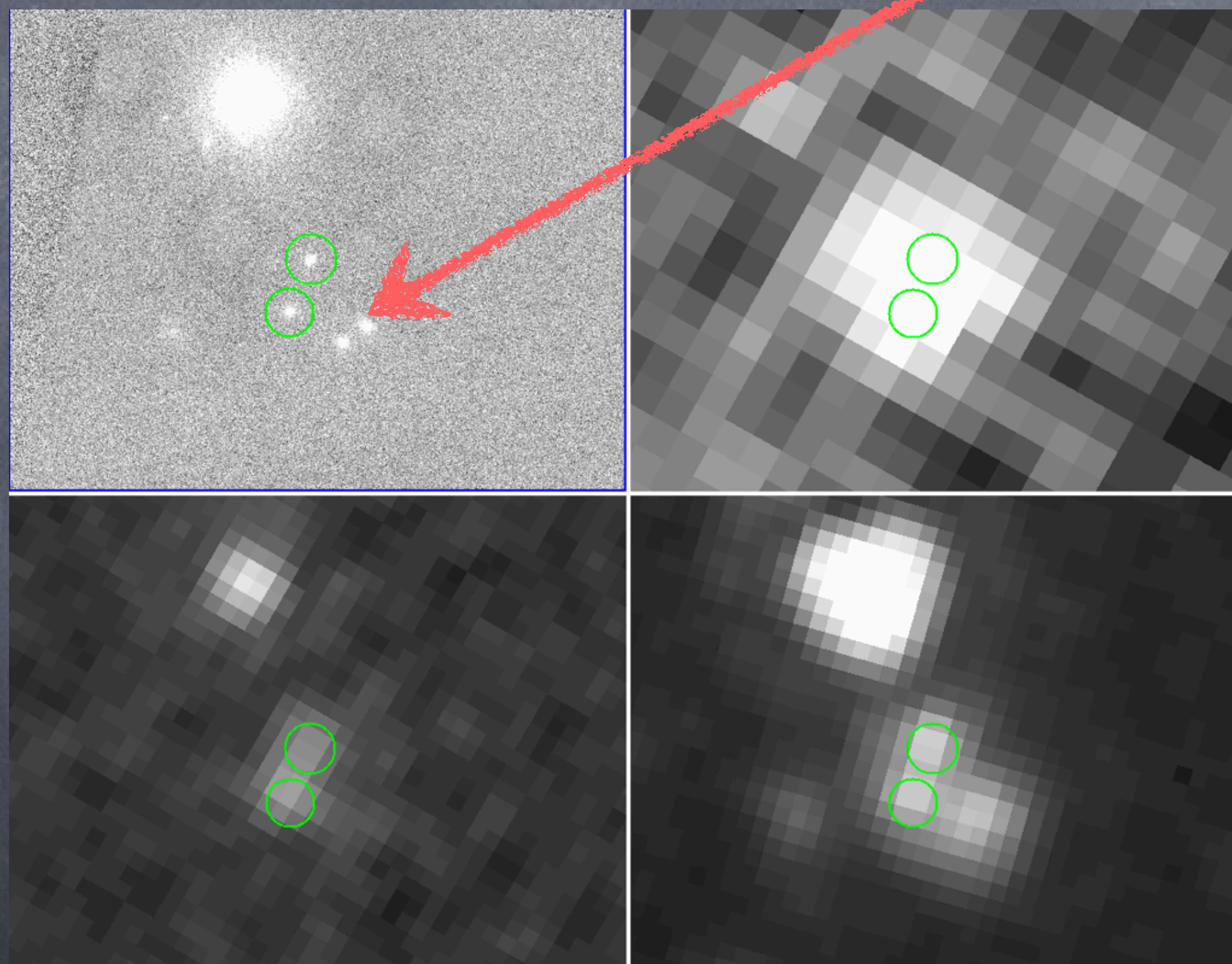
Quick science: I- Candidate multiple AGN



ATNF/ATLAS
1.4GHz

GSAOI-K

SWIRE
24mu



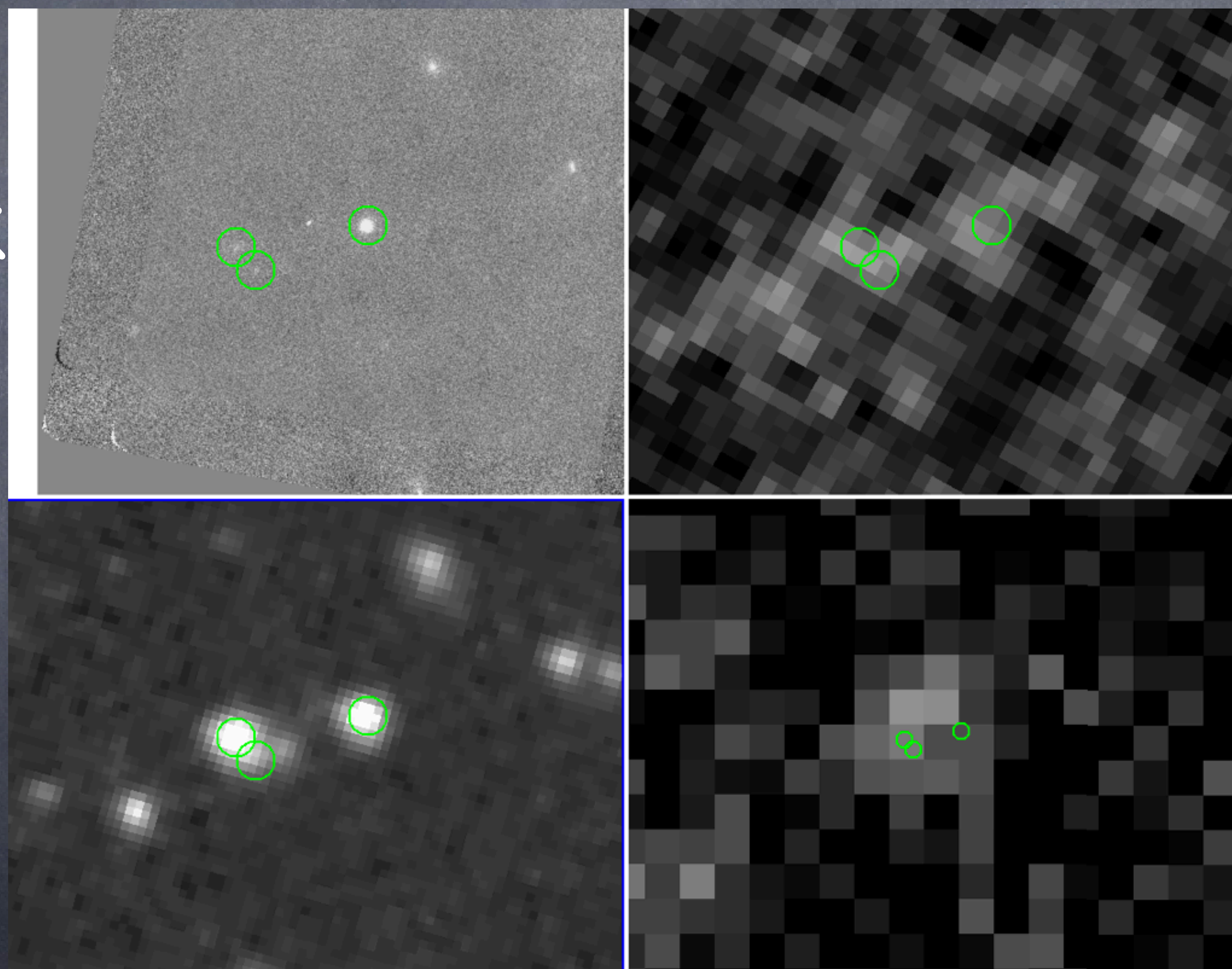
SWIRE
8mu

SERVS
4.5mu

Quick science II - Herschel source ID

GSAOI-K

SWIRE 24mu



SERVS 4.5mu

HerMES 250mu

Summary

- TMT MCAO instruments will allow high spatial resolution studies of high-z galaxies in NIR with resolution better than JWST, just as Gemini GeMS/GSAOI now allows higher resolution than HST.
- Morphologies of high-z AGN hosts and ULIRGs in particular benefit from high resolution near-infrared images (and IFU data) - importance of dusty merging systems will become clearer. Strong links with ALMA, VLA and even GW detectors.
- Key is to pick fields with good asterisms, a good reference image and good multi-wavelength data.
- Also need guide star selection tools and data pipelines to move AO observations from "experts only" into the mainstream.