IO:I - A new(ish) NIR imager for the Liverpool Telescope

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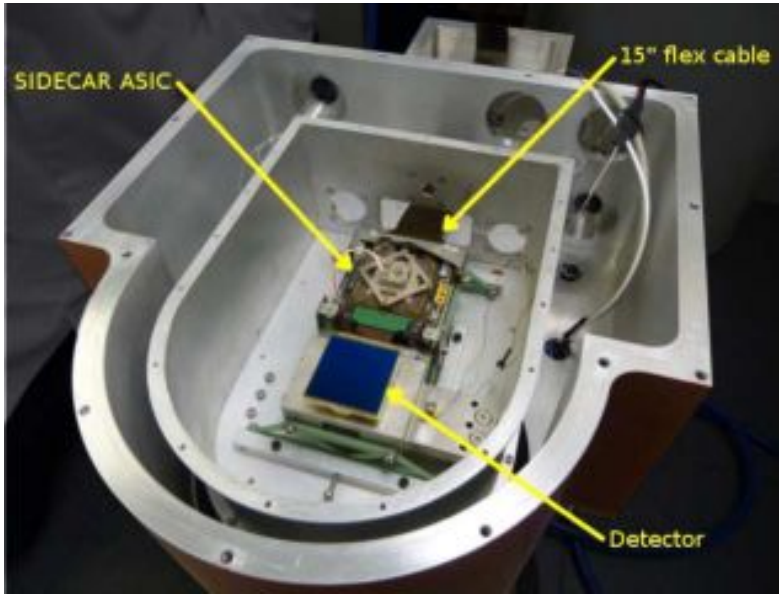
Why?

- Extend capabilities of LT beyond optical
- Measurement of NIR light curves for SNe Ia
- Early time follow up of high-z GRBs
- Many more..

Instrument Overview

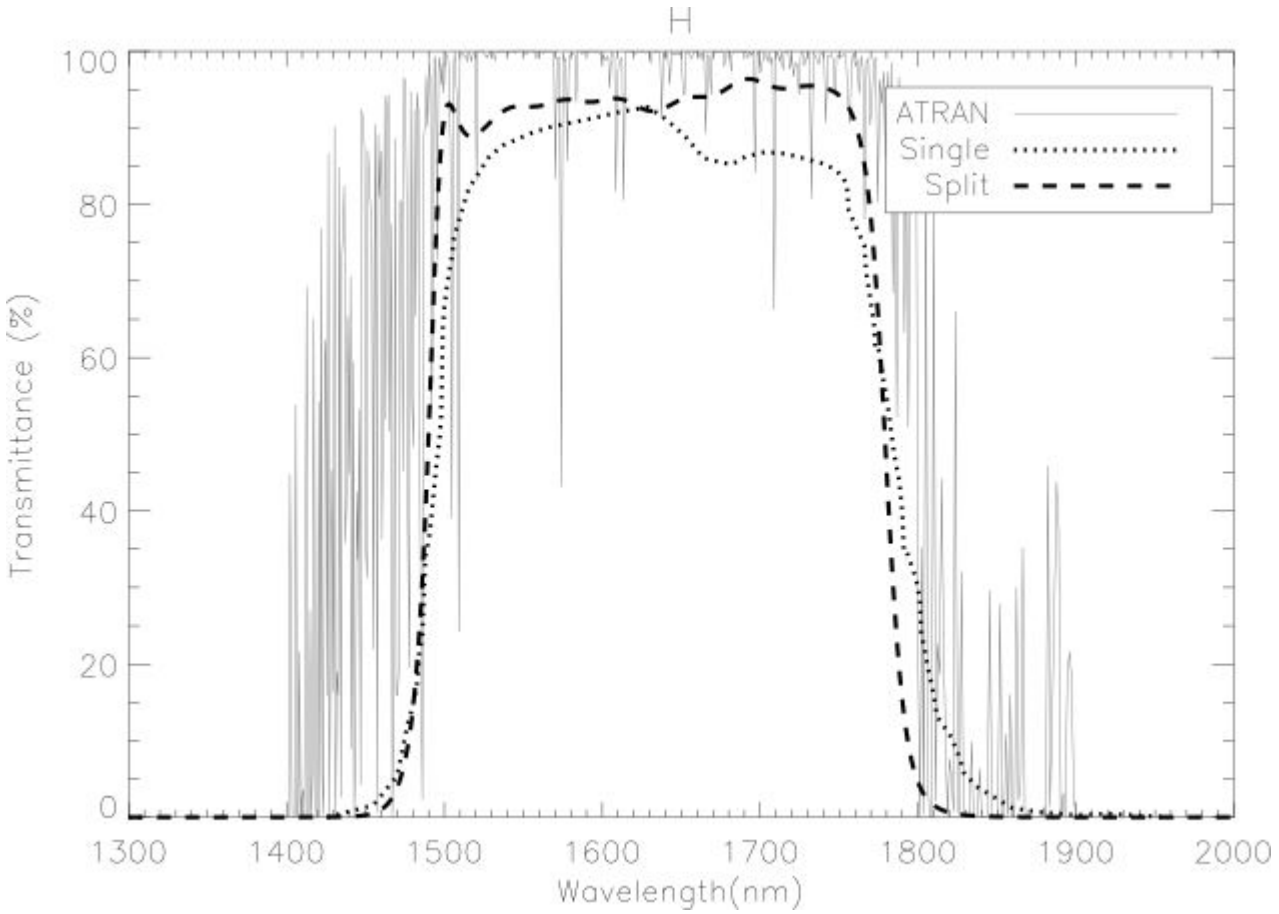
- Hawaii-2RG (H2RG), SIDECAR and JADE2 from Teledyne
- Old SupIRCam dewar
- 1.7µm cutoff
- FOV of 6'x6'
- Single fixed filter (H)
- Minimum exposure time of 6s (w/ 1.4s RO)



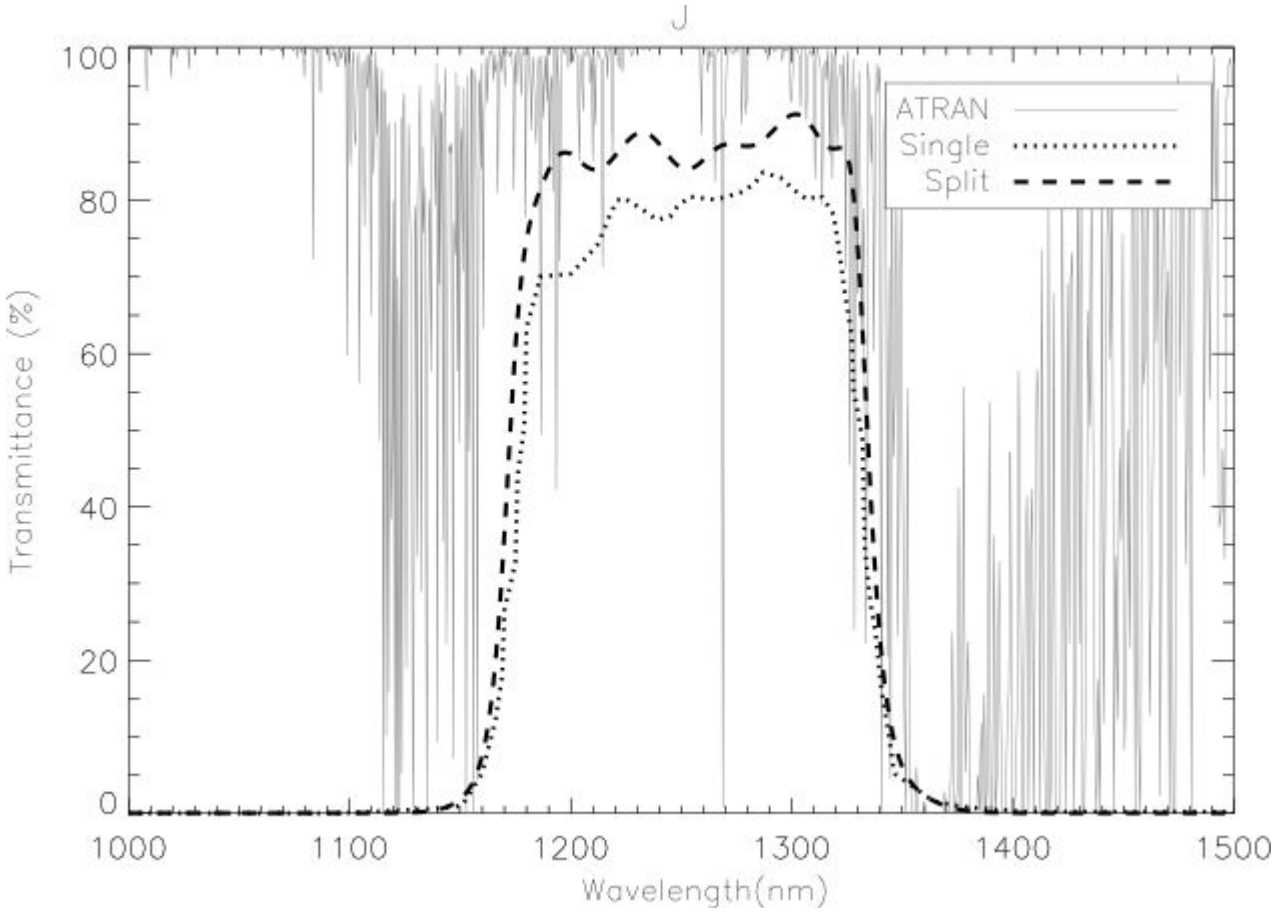
Splitting the FOV

- Possibility, strength of science case permitting, of splitting the FOV between J&H
- Filters for this configuration already procured
- Changing filters requires instrument to be warmed up, taken off telescope temporarily, and cooled back down again with downtime of a few days

H Band (Single vs Split)



J Band (Single vs Split)



Measured Instrument Specification

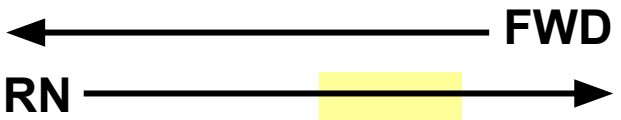
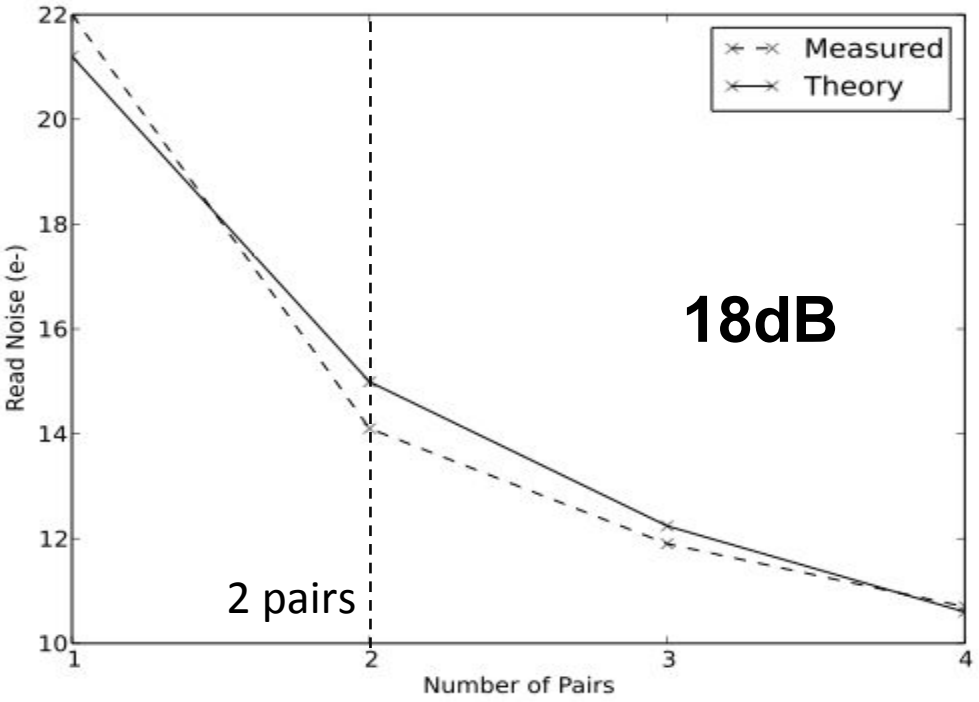


Table 1 A summary of IO:I's characterisation tests.

Preamp Gain	12	15	18	21
Conversion Gain (e-/ADU)	3.05	2.12	1.50	1.06
CDS Read Noise (e-)	32.4	26.5	21.8	19
Uncorrected FWD 5% (ke-)	102	72	69	57
Corrected FWD 5% (ke-)	–	–	93	–
Vrefmain (V)	1.71	1.26	1.16	1.09

Fowler Sampling

- Number of fowler pairs chosen is compromise between read noise and quantity of data needing to be transferred from site



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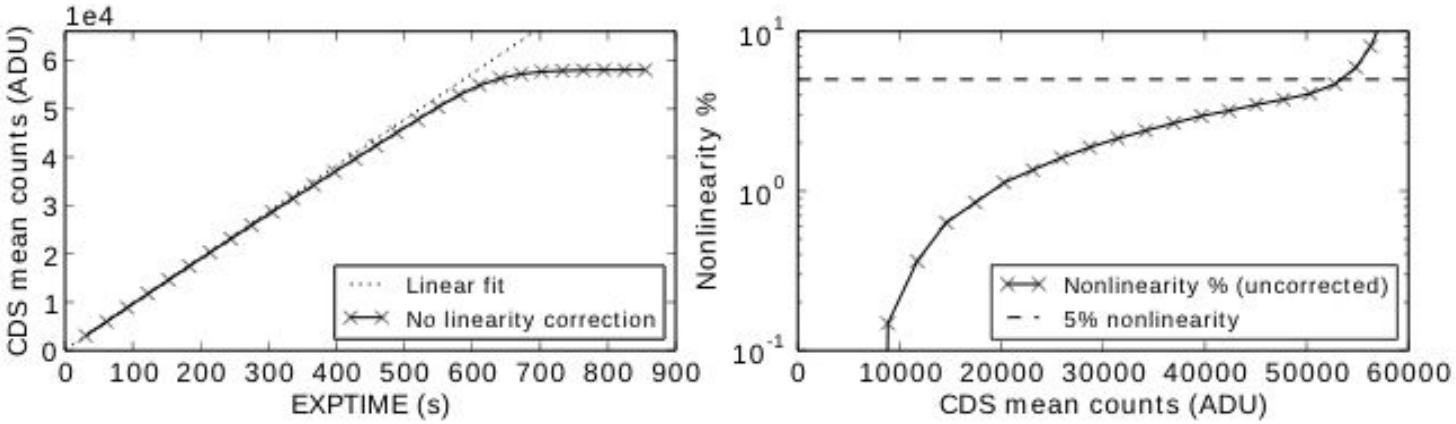
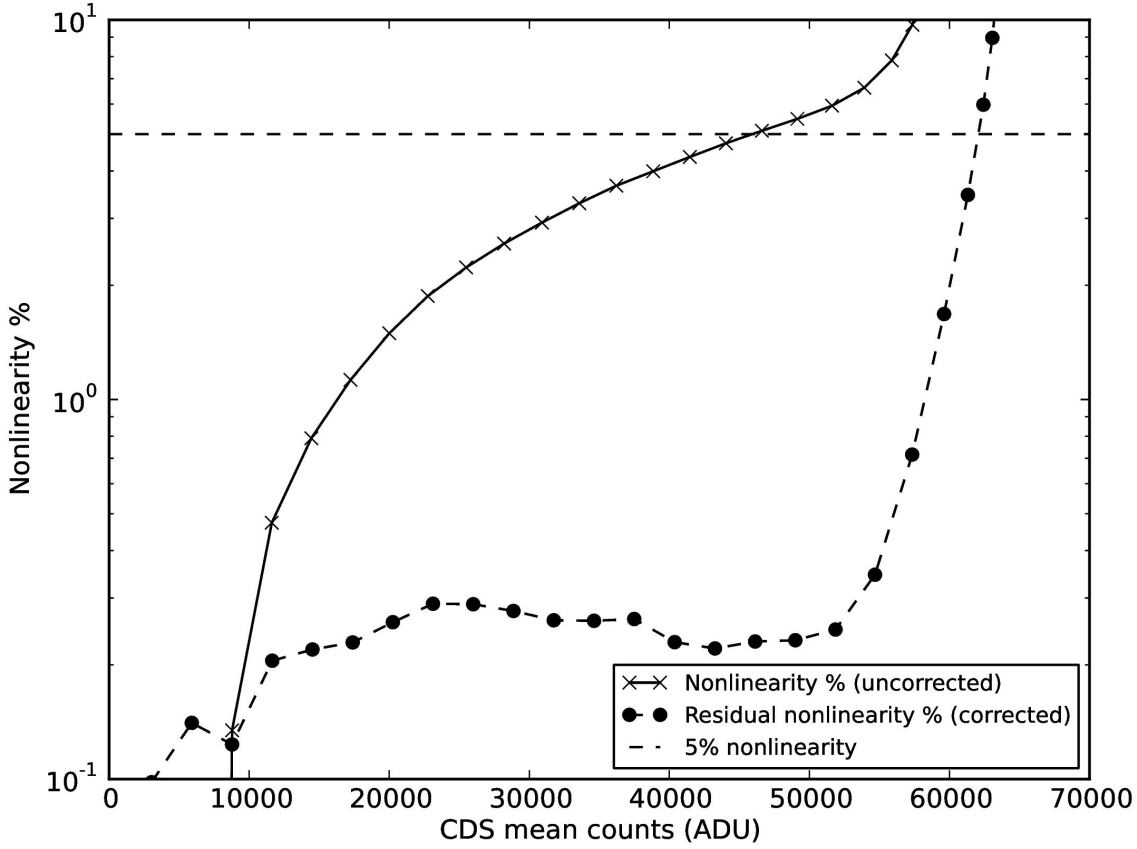
Nonlinearity Correction

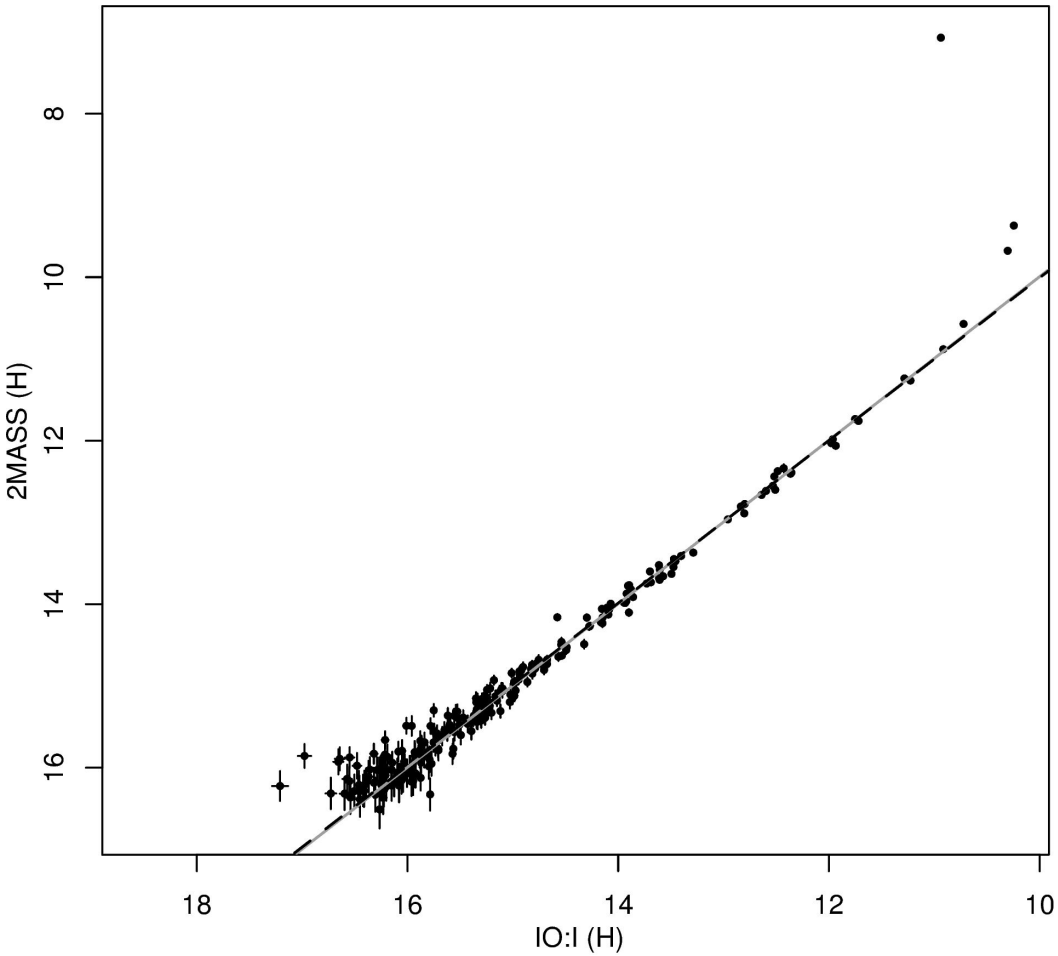


- Intrinsic nonlinearity expected given architecture of pixel unit cell
- Corrected by creating a mapping between the observed and expected counts, the latter of which is derived by extrapolation of the integration slope at early times

Nonlinearity Correction



Nonlinearity Correction (On Sky)



Sensitivity and Sky Background

- Measured sky bg of 12.45 mags/arcsec^2
- Depends on observing strategy, but as an example, a 30s single dither of a 14th magnitude target yields a SNR of 100

IMAGING Exposure Time Calculator

Instrument: IO:I ▼ Magnitude: 14

Binning: 1x1 ▼ SNR: 100

Filter: H (IO:I) ▼ Calculate

Sky Brightness	1.0 arcsec	1.5 arcsec	2.0 arcsec	3.0 arcsec	4.0 arcsec	per sqr arcsec
Dark	27	59	103	229	406	8

http://telescope.astro.ljmu.ac.uk/TelInst/calc/

Pipelining

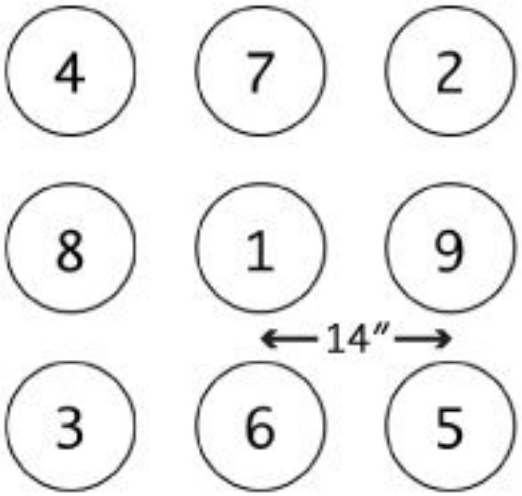
- Pipeline performs autonomous:

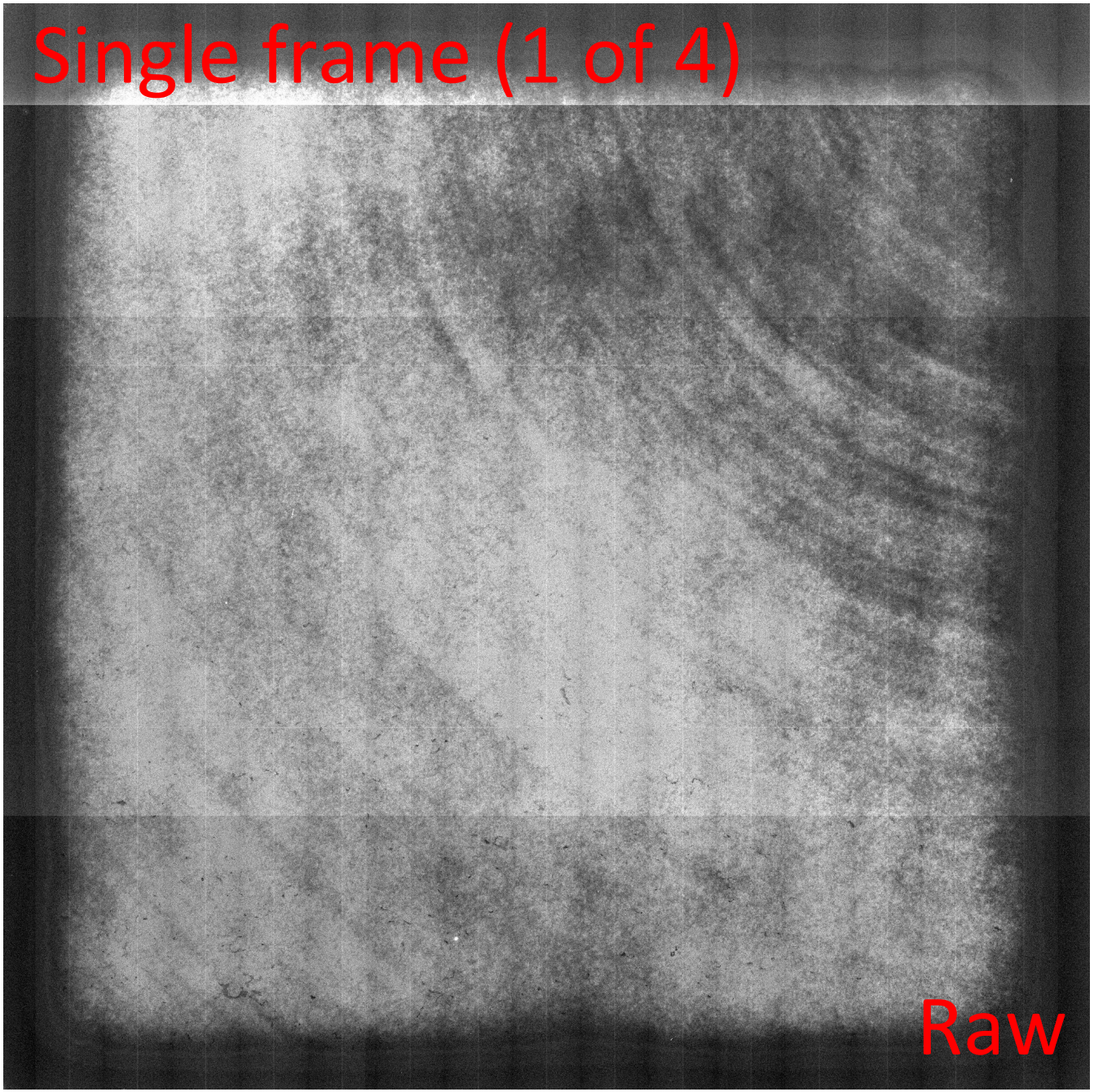
  i) reference subtraction
  ii) frame combination (Fowler)
  iii) nonlinearity correction
  iv) flatfielding
  v) bad pixel masking
  vi) sky subtraction (watch for extended objs / crowded fields!)
  vii) registration
  viii) stacking

Sky Subtraction

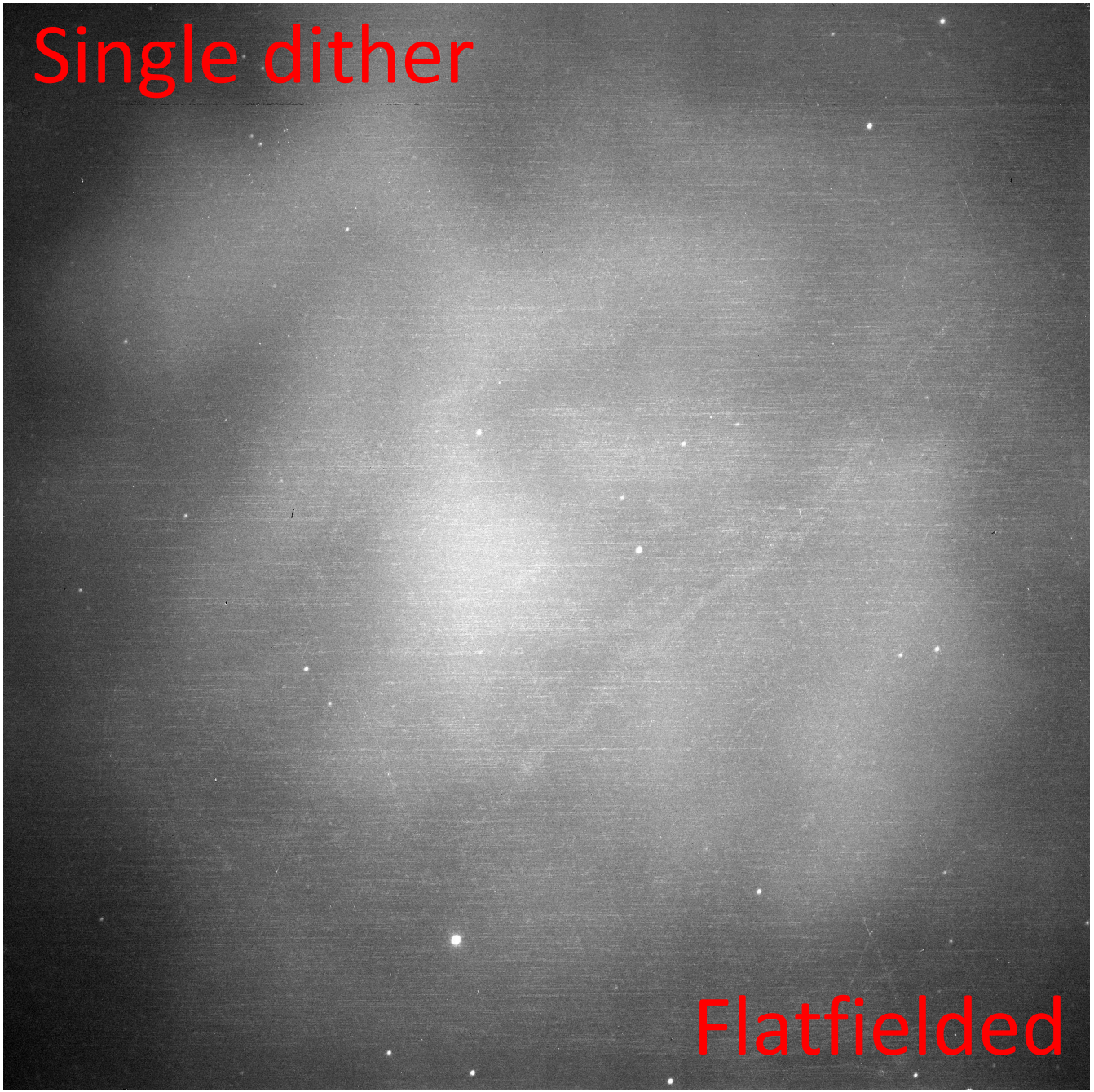
- Currently median-of-peers (all dither positions except current frame being subtracted) used to generate sky frame
- A variety of more robust M-Estimators were investigated (HuberT, Tukey's Biweight) but found to either give an incorrect estimate of the sky value, or produce artefacts in the extraction that were not "user friendly", even though they may have yielded a more statistically favourable result

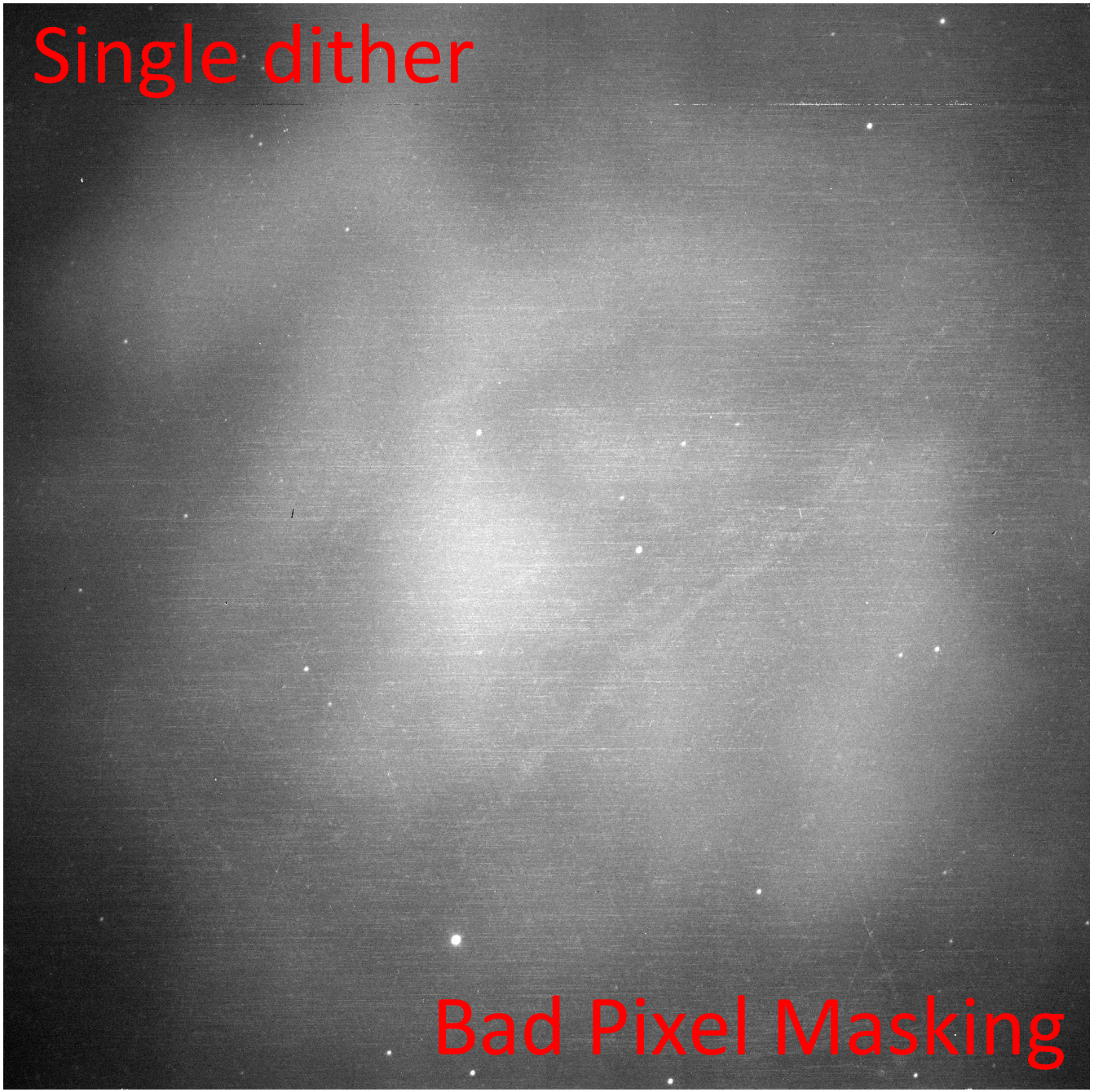
Dither Pattern

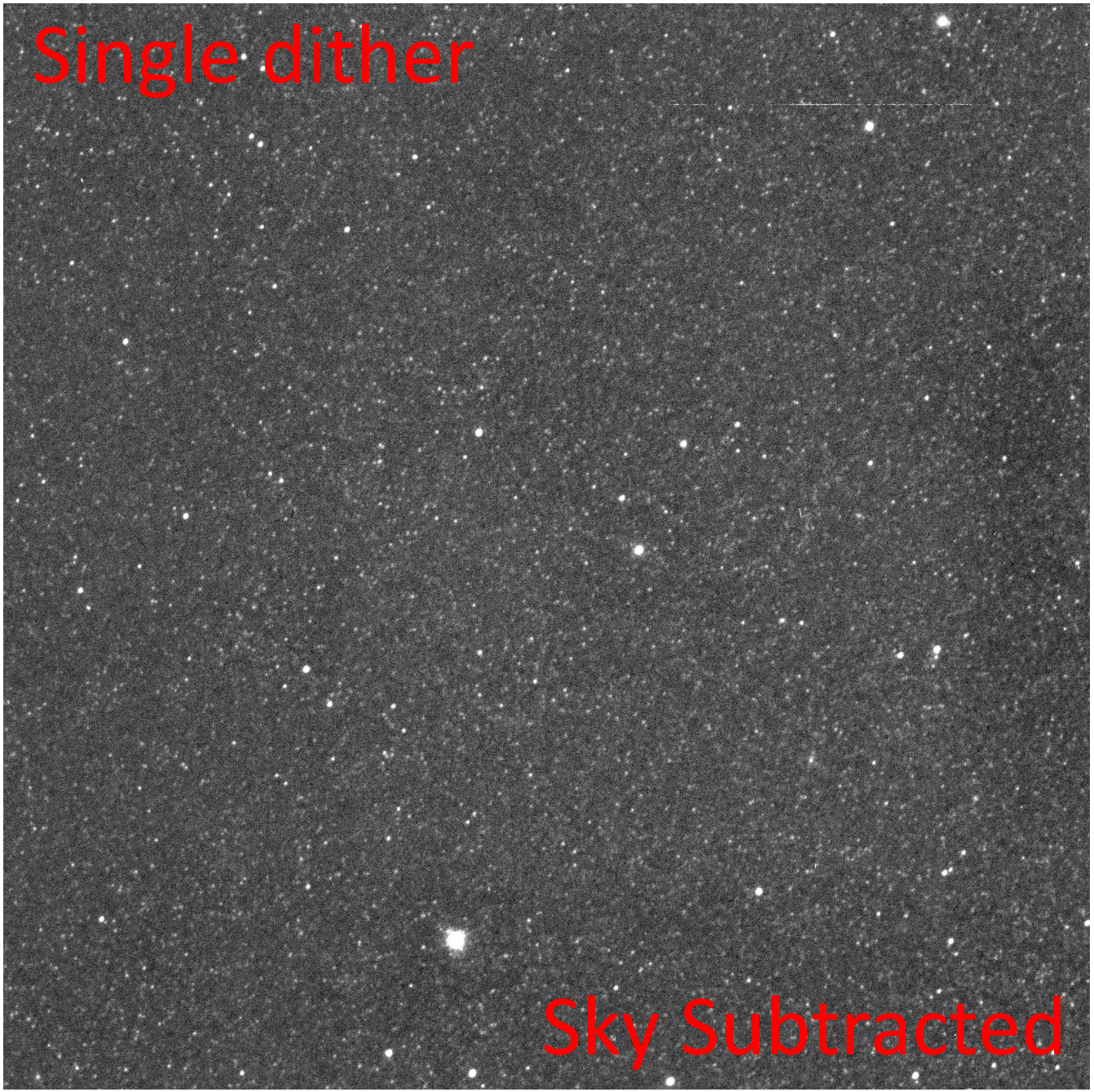


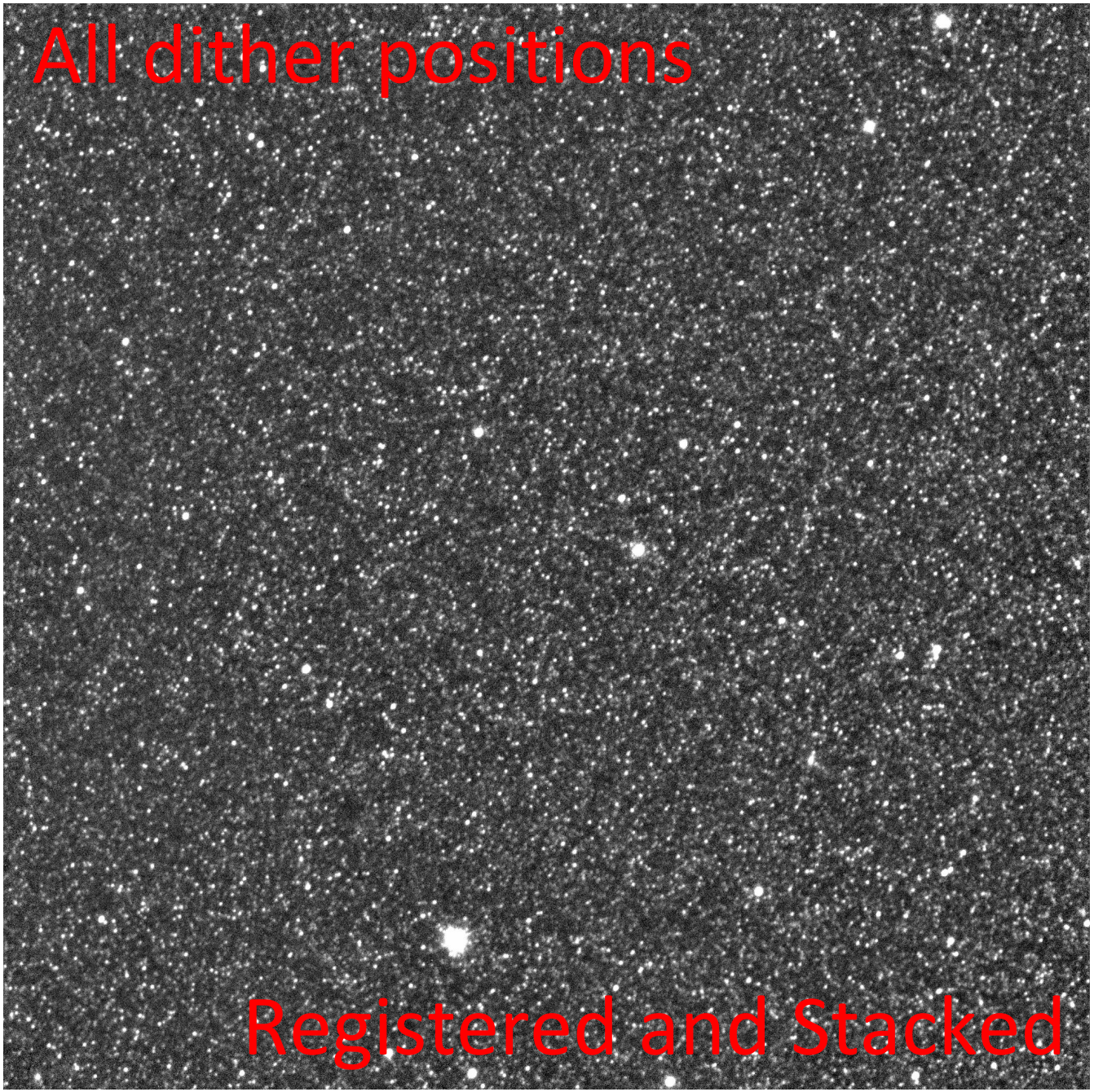

Single frame (1 of 4)
Raw


Single dither
Linearity Corrected
Fowler 2-pair


Single dither
Flatfielded


Single dither
Bad Pixel Masking


Single dither
Sky Subtracted


All dither positions
Registered and Stacked