SIMPLE
Imaging and Mosaicking PipeLinE

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Outline

- A brief introduction to SIMPLE

- Reduction flowchart for near-IR mosaic camera images

- More on distortion correction

- Current SIMPLE distributions

What is SIMPLE?

- SIMPLE =
  SIMPLE Imaging and Mosaicking PipeLinE

- An IDL-based data reduction package.

- More optimized for optical and near-IR extragalactic deep imaging.

- Can process data from large mosaic cameras.

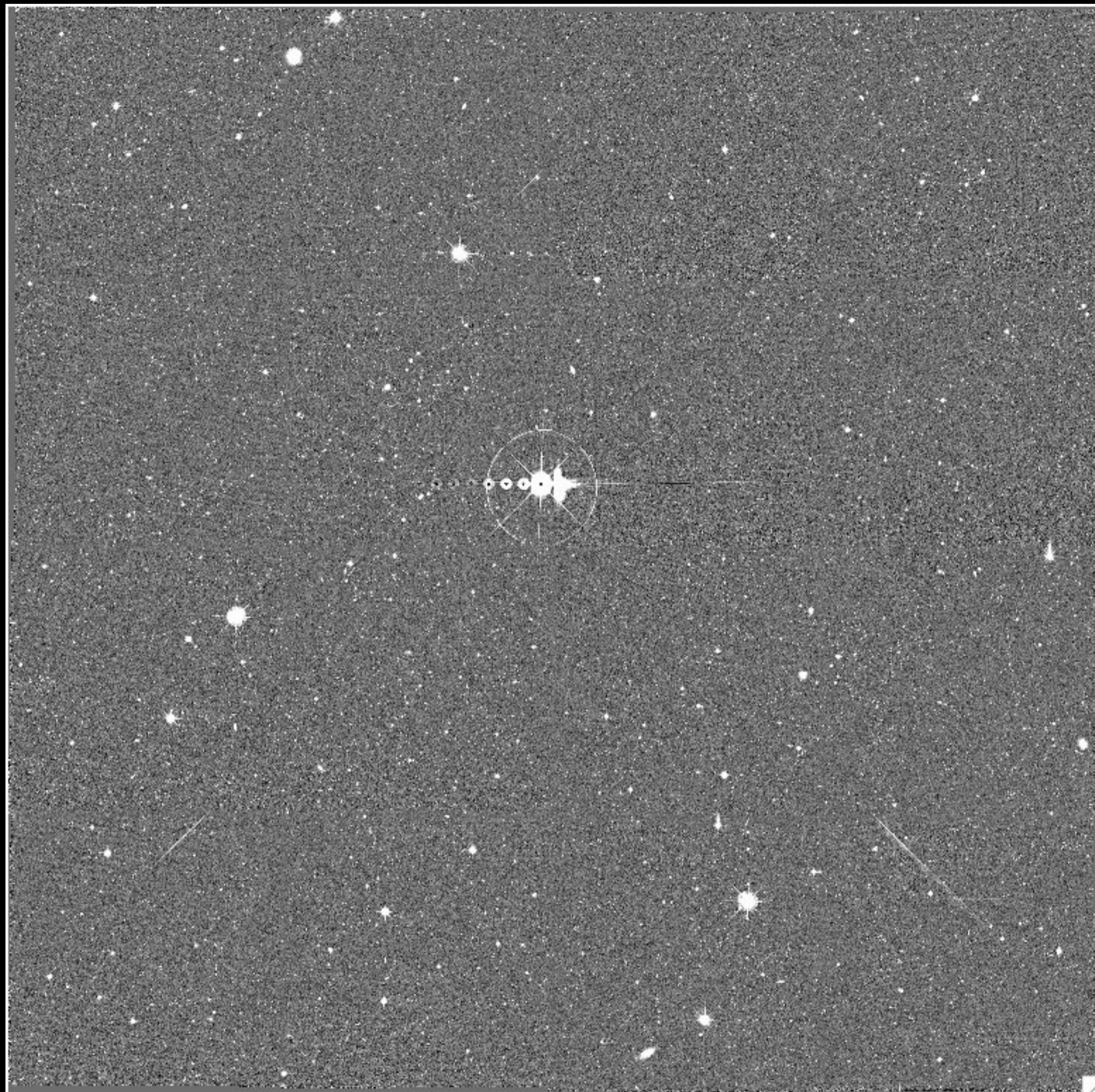- Data reduction is quite automatic.

Showcase Images
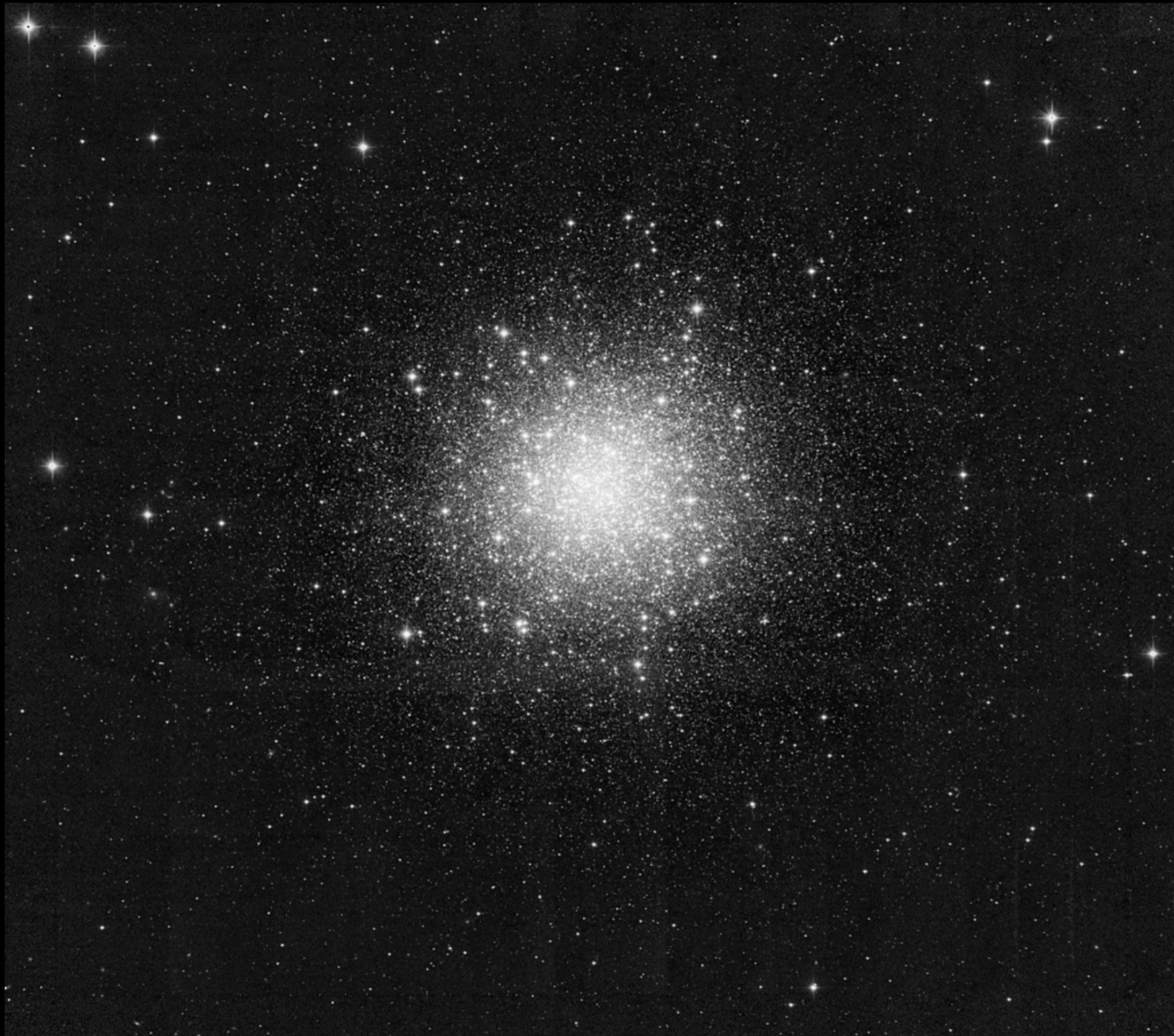
M13 at H band, by UH2.2m and ULBCAM (HAWAII2 × 4)
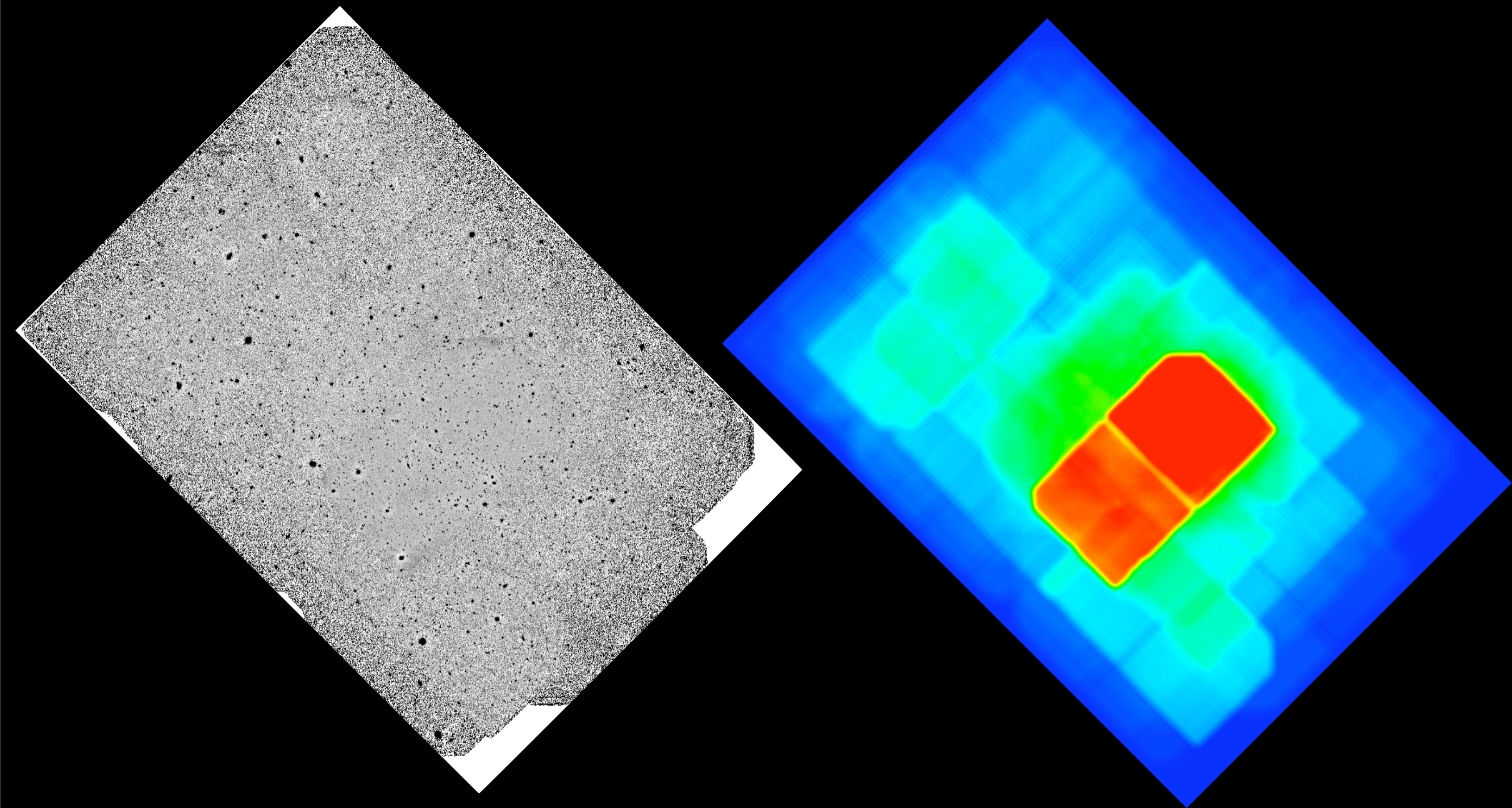Reduced by SIMPLE v.-1.0
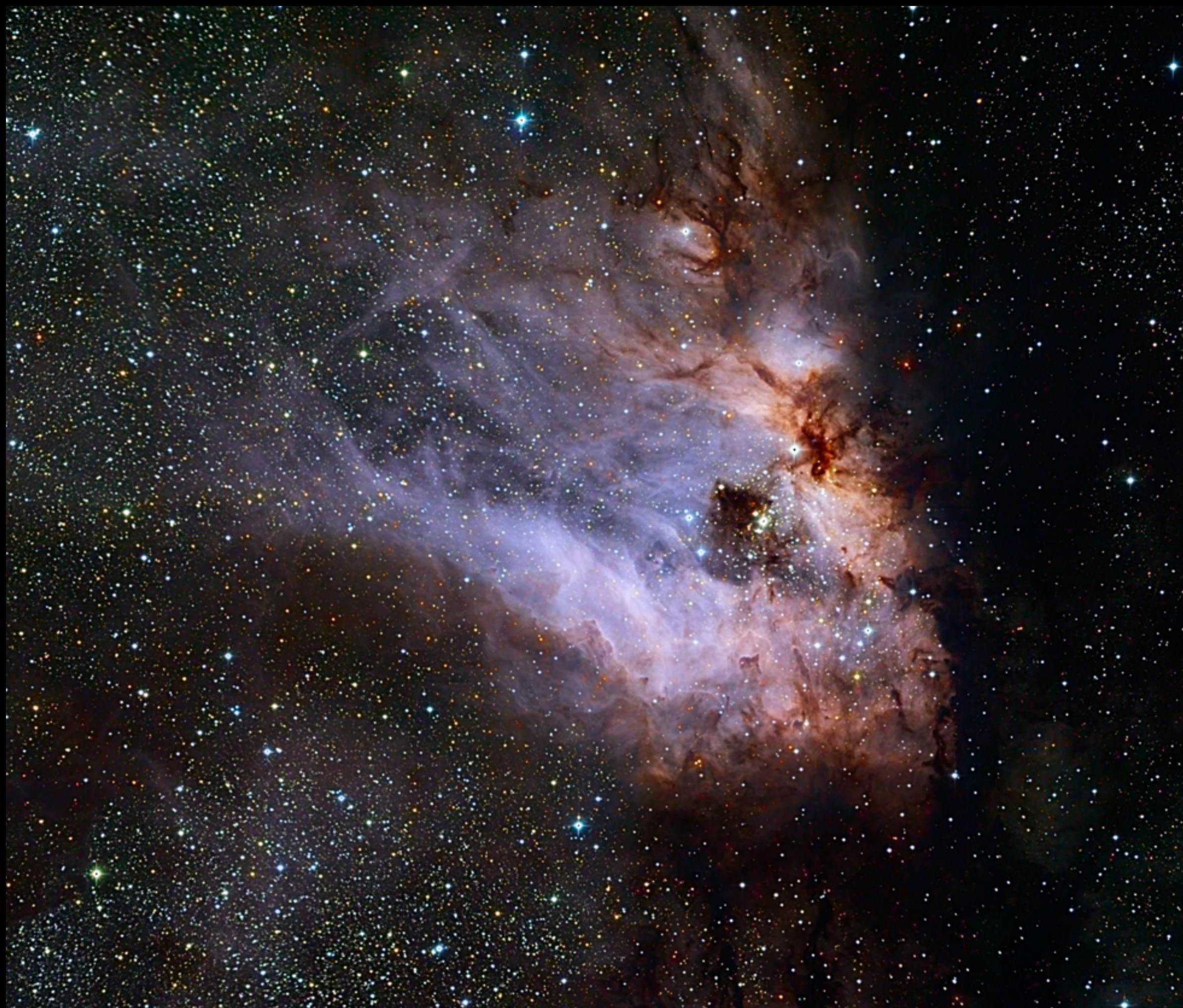
M17 at J band, by UH2.2m and ULBCAM
A showcase image for ULBCAM on Physics Today Magazine (2004).
Reduced by SIMPLE v.-1.0 and assembled in Photoshop.
RGB color coded by 2MASS JHK low-resolution images.

SWIRE Lockman Hole at H band, by UKIRT and WFCAM (HAWAII2 × 4)
Initial reduction by UKIRT pipeline. Mosaicked by SIMPLE v.1.0
Image size = 12400^2 pixels = 53.8^2 arcmin^2
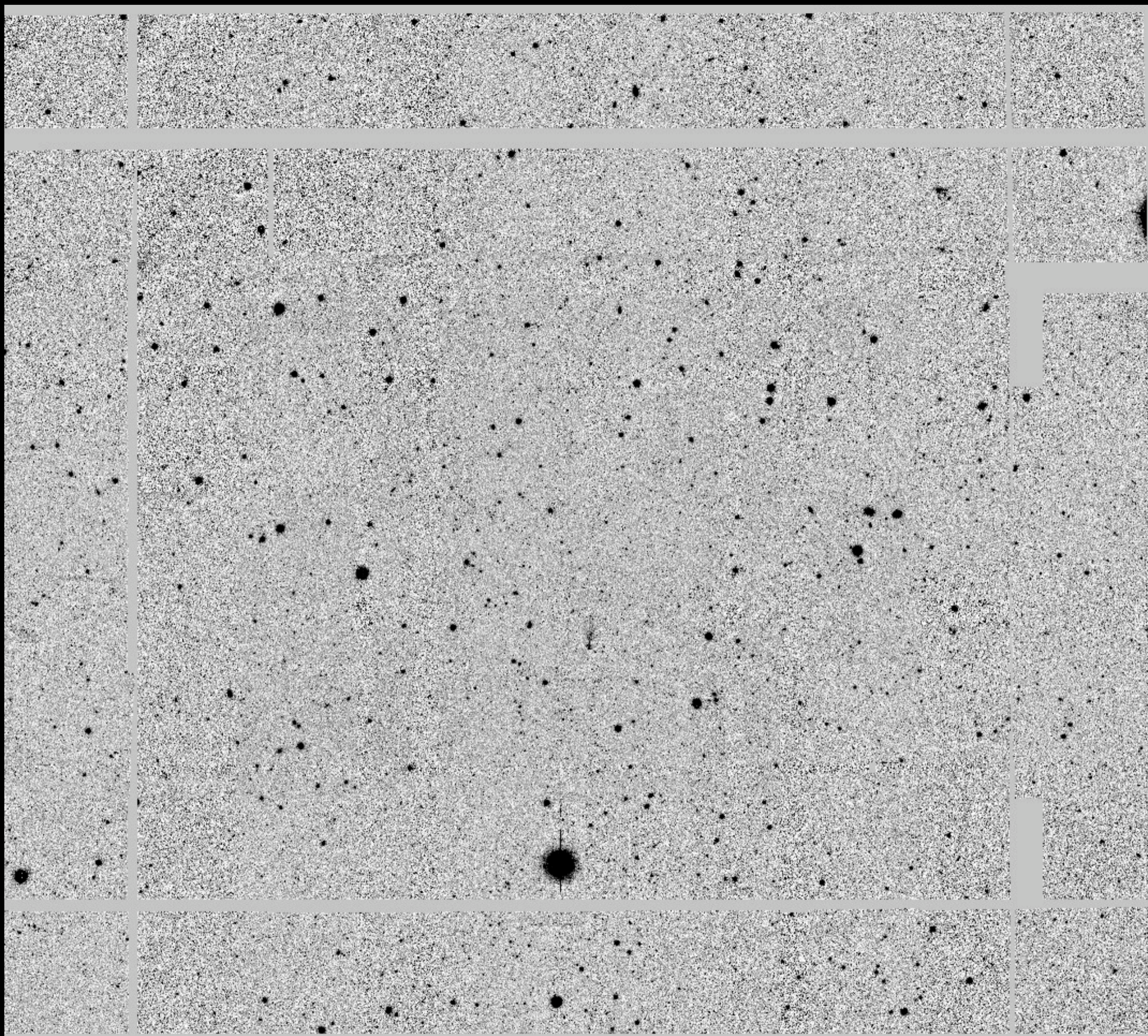
Groth Strip at NB921 by Subaru SuprimeCam
Mosaicked with SIMPLE v.1.0 by L. Trouille (UW-Madison)
Image size = 18000 × 16000 pixels = 0.74 deg^2

GOODS-N at Ks by Subaru MOIRCS (HAWAII2 × 2)
Image size = 10400×7280 pixels = 19.8×13.8 arcmin^2
Max integration time = 22 hr
Reduced by SIMPLE-MOIRCS v.1.0

Barger, Cowie, & Wang (2008)
Wang, Barger, & Cowie (2009)
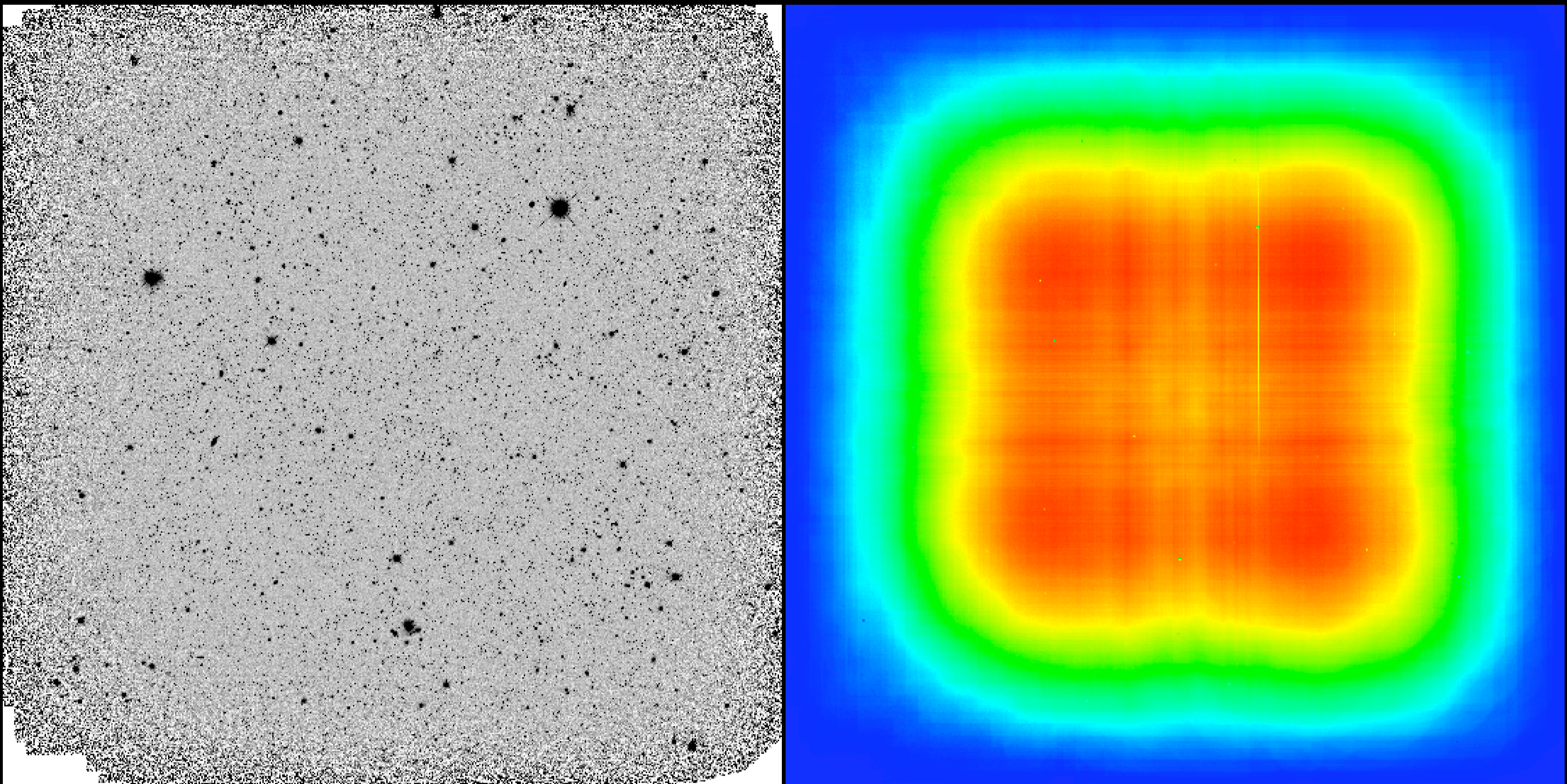
GOODS-N at Ks by CFHT WIRCAM (HAWAII2 × 4)
Image size = 6530^2 pixels = 32.7^2 arcmin^2
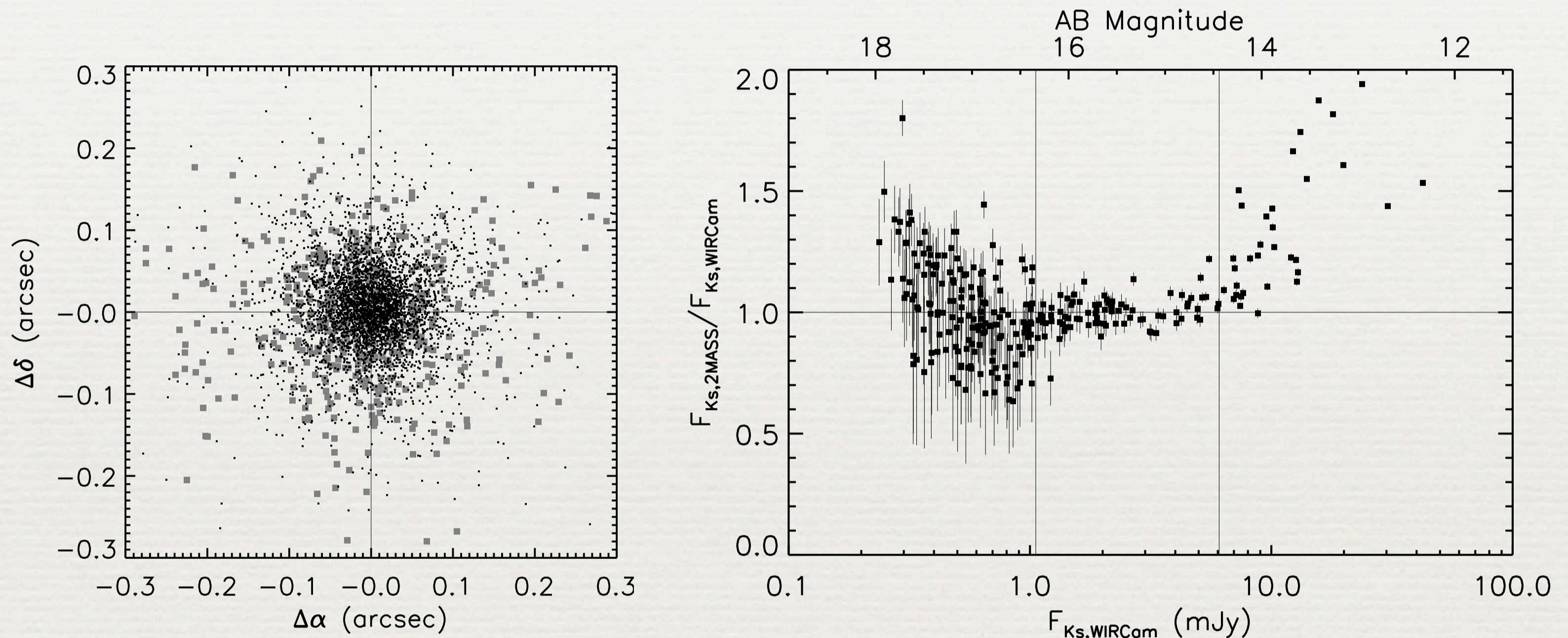Integration time = 39 hr
Reduced by SIMPLE-WIRCAM v.0.9

Wang, Cowie, & Barger (2007)
Barger, Cowie, & Wang (2009)
Full data release: Wang et al. (2009, in preparation)

SIMPLE Reduction of the WIRCam GOODS-N Images

- RMS astrometric offset relative to the HST ACS catalog is 0".03 (both RA and Dec) on high S/N sources.

- Photometry (calibrated with 2MASS) is uniform in a ~0°.2 scale within 1.3%.

The SIMPLE Reduction

Basic Reduction

Dithered Raw Exposures

- Median Stack to Derive Flat Field

Flattened Images

- Detect and Mask Objects

Object Masked Raw Images

- Median Stack to Derive Flat Field

Second Flat Field

- Flat Fielding
- Background Subtraction
- Spatial σ Filter for Cosmic Ray Removal
- Removal of Instrumental Features

Geometric Correction
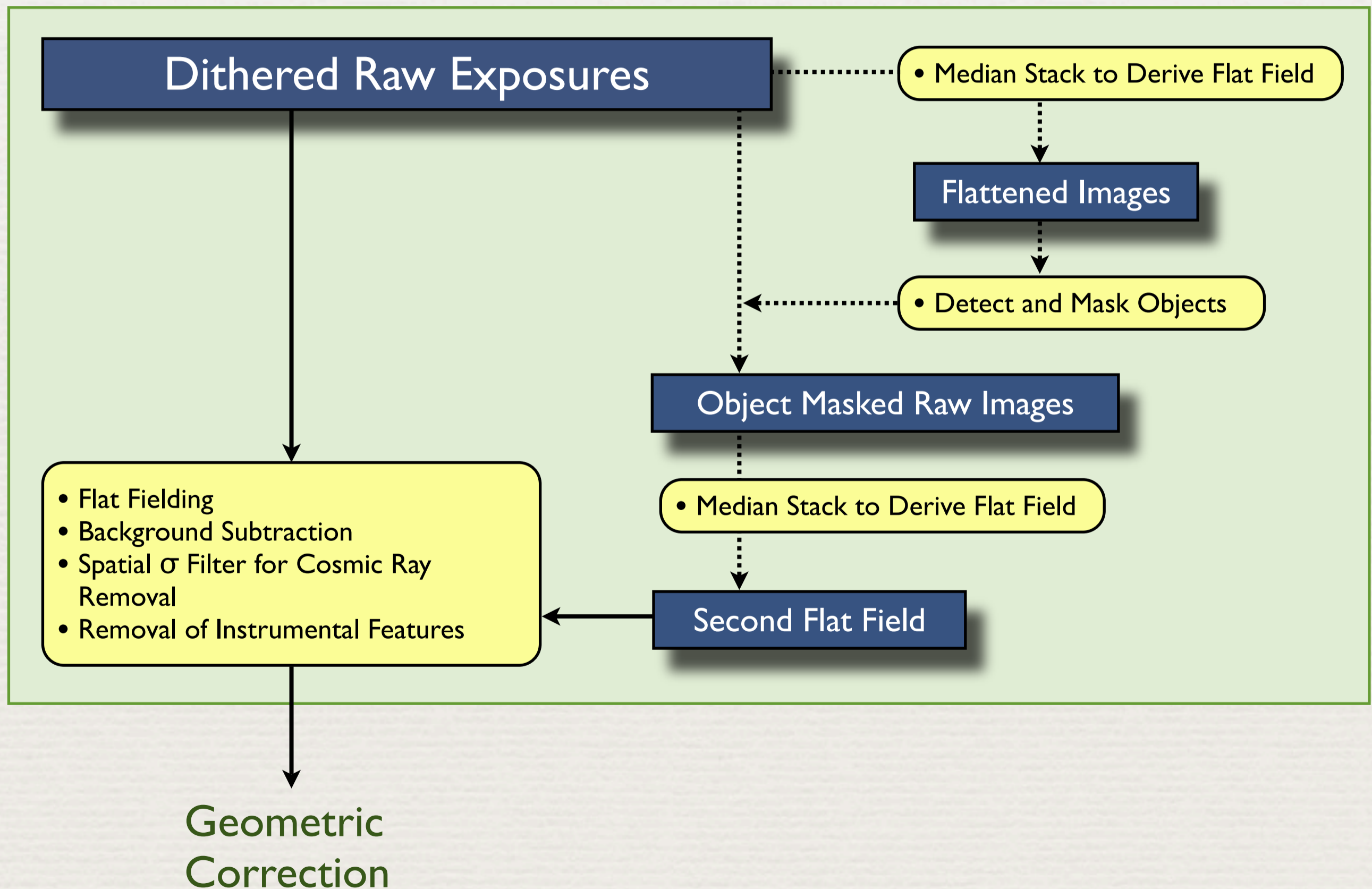
The SIMPLE Reduction
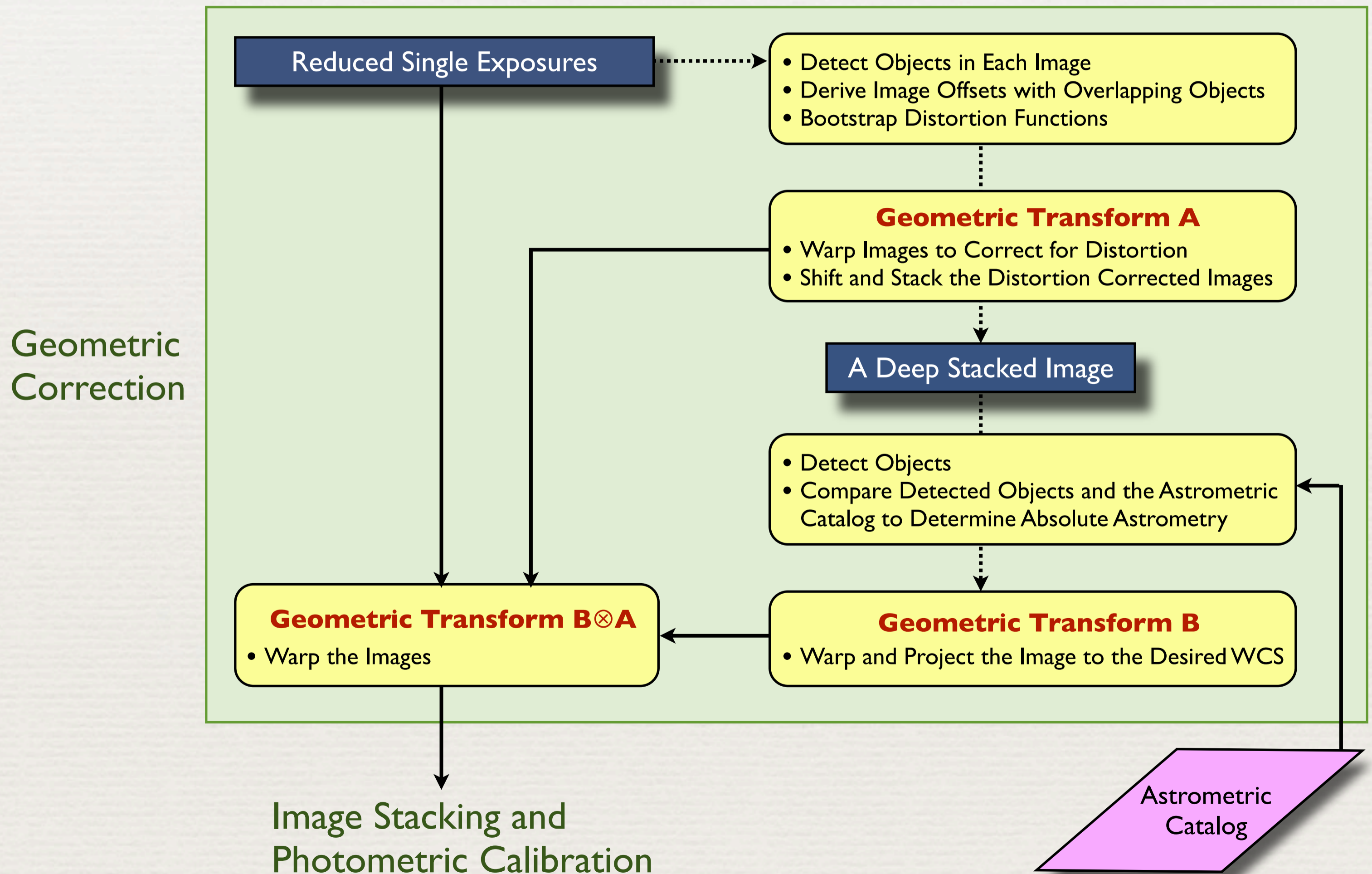
The SIMPLE Reduction

Image Stacking and Photometric Calibration

Distortion Corrected and WCS Projected Single Exposures

- Detect Objects in Each Image
- Derive and Correct for Photometric Offsets with Overlapping Objects

Photometrically Matched Single Exposures

- Align the Images
- Temporal σ Filter for Cosmic Ray Removal
- Mean Stack the Images

A Deep Wide-Field Mosaic

- Photmetric Calibration with a Standard Star or with a Phometric Catalog

Photometric Catalog

Final Image

SIMPLE Distortion Correction

The optical distortion functions:
$$x' = F(x,y),\ y' = G(x,y),$$
x, y = object position in the undistorted frame
x', y' = object position in the distorted frame

The displacement of a star in two dithered images:
$$\Delta x' \approx \partial_x F\ \Delta x + \partial_y F\ \Delta y$$
$$\Delta y' \approx \partial_x G\ \Delta x + \partial_y G\ \Delta y.$$
$\Delta x, \Delta y$ = dither offset of the telescope (same for all stars)
$\Delta x', \Delta y'$ = displacements of star in the images (different for all stars)

With N stars and M dithered images, we can solve for $\partial_x F, \partial_y F, \partial_x G, \partial_y G$ with a system of 2×N×(M-1) linear equations.

The solutions are the 1st-order derivatives of the distortion functions.

Based on the method described by Anderson & King (2003) for WFPC2.

SIMPLE Distortion Correction

✦ Only requires a few (>5) dithered images and >10 compact objects in the images to obtain good solutions. Usually much more are available.

✦ No need for any external information.

✦ Can handle time-dependent distortion (e.g., that caused by telescope flexure).

✦ Quality of the image registration is not limited by the quality of the astrometric catalog.

✦ Still need an external catalog for projection and absolute astrometry.

Current SIMPLE Distributions

✦ Best optimized for extragalactic deep field observations.

✦ Basic tools are available for general processing:

   flat-fielding, background subtraction, distortion related functions, image warping, mosaicking, etc.

✦ Two highly optimized automatic pipelines for Subaru MOIRCS and CFHT WIRCam are available.

✦ An optimized version for SuprimeCam is considered, and will be released if implemented.

✦ http://www.asiaa.sinica.edu.tw/~whwang/idl/SIMPLE/

✦ We would like to hire a postdoc to work on SIMPLE stuffs. Please contact me if you are interested.