The Blanco DECam Bulge Survey: status and challenges

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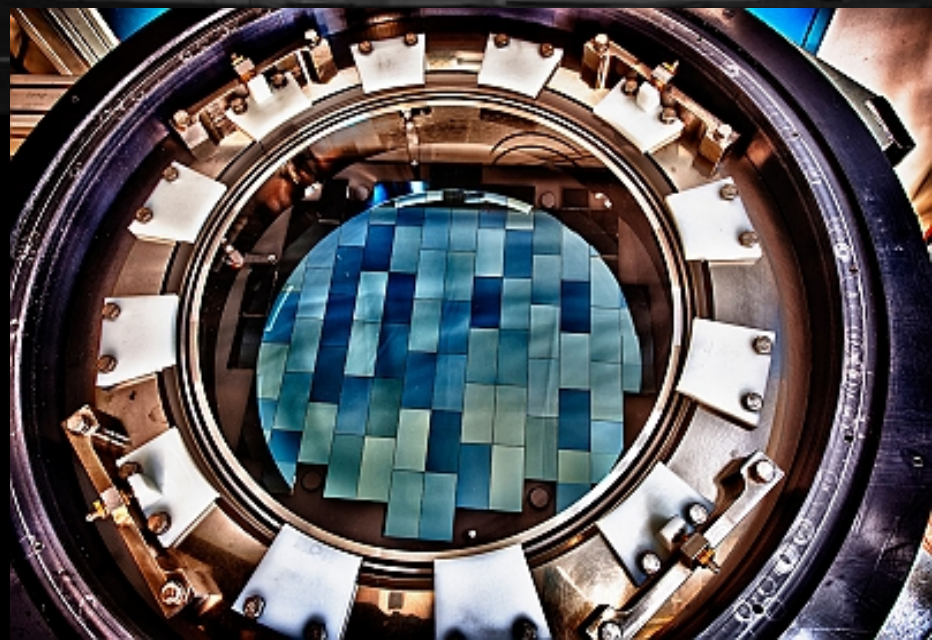
Lizzy Clyne, UM-Dearborn
Zach Belanger, UM-Dearborn
Michael Young, IUB
Zeljko Ivezic, University of Washington
Annie Robin, Besancon Observatory
Rodrigo Ibata, Strasbourg
Mike Irwin, IoA Cambridge
Kathy Vivas, CTIO

Talk Outline

- The Blanco DECam Bulge Survey
- Pointing DECam at highly crowded fields
- BDBS, DECam and LSST
- Interesting challenges / issues

DECam – the Dark Energy Camera

- CTIO 4m + DECam
  - ~36% the collecting area of LSST
  - 3 sq deg field of view
    - ~31% the field of view of LSST
  - Seeing-limited
  - 520 MPix
    - ~16% the pixel-count of LSST



The Blanco DECam Bulge Survey (BDBS)

- A multi-year ugrizY photometric survey of the Southern Bulge with DECam
  - 2013A: about half the survey area observed.
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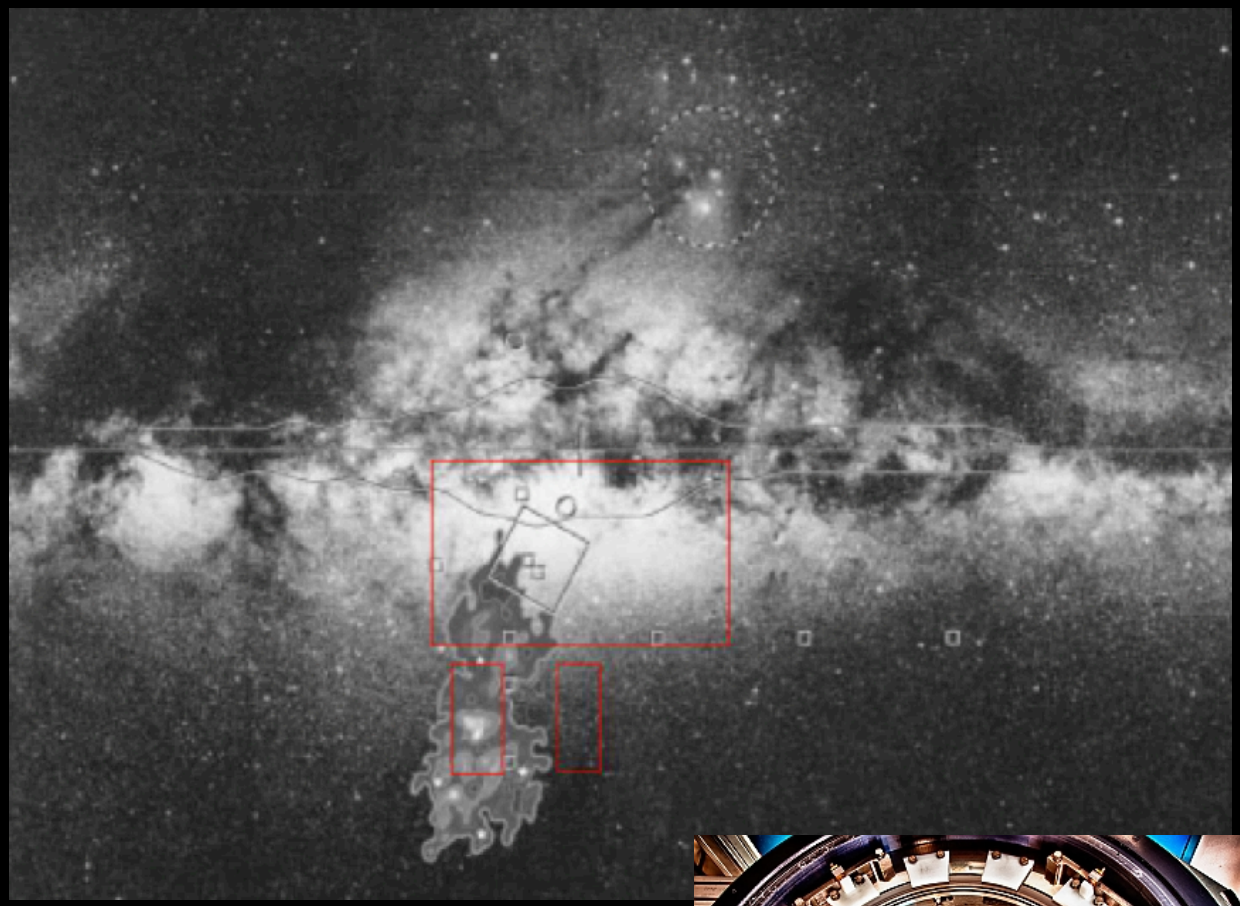
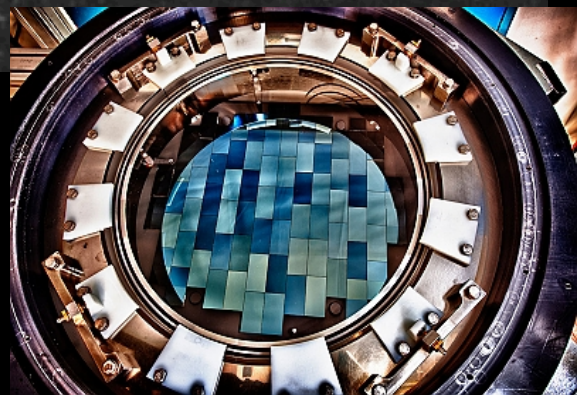
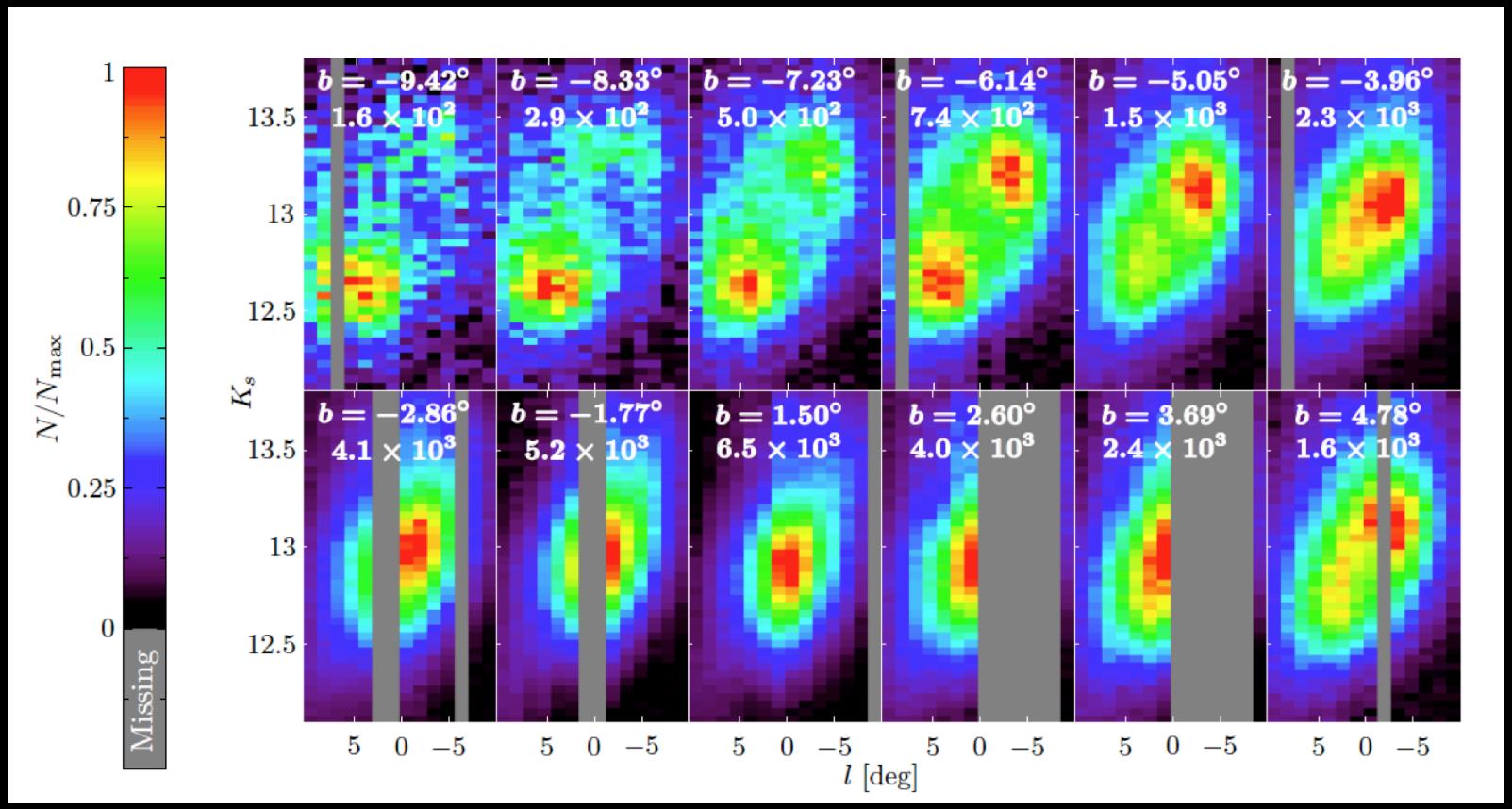




Ultimate aim: better understand the formation history of the Milky Way bulge

- We will spatially map the distributions and motions* of Bulge, Bar, old-disk and halo populations as a function of metallicity.



From Wegg & Gerhard (2013)

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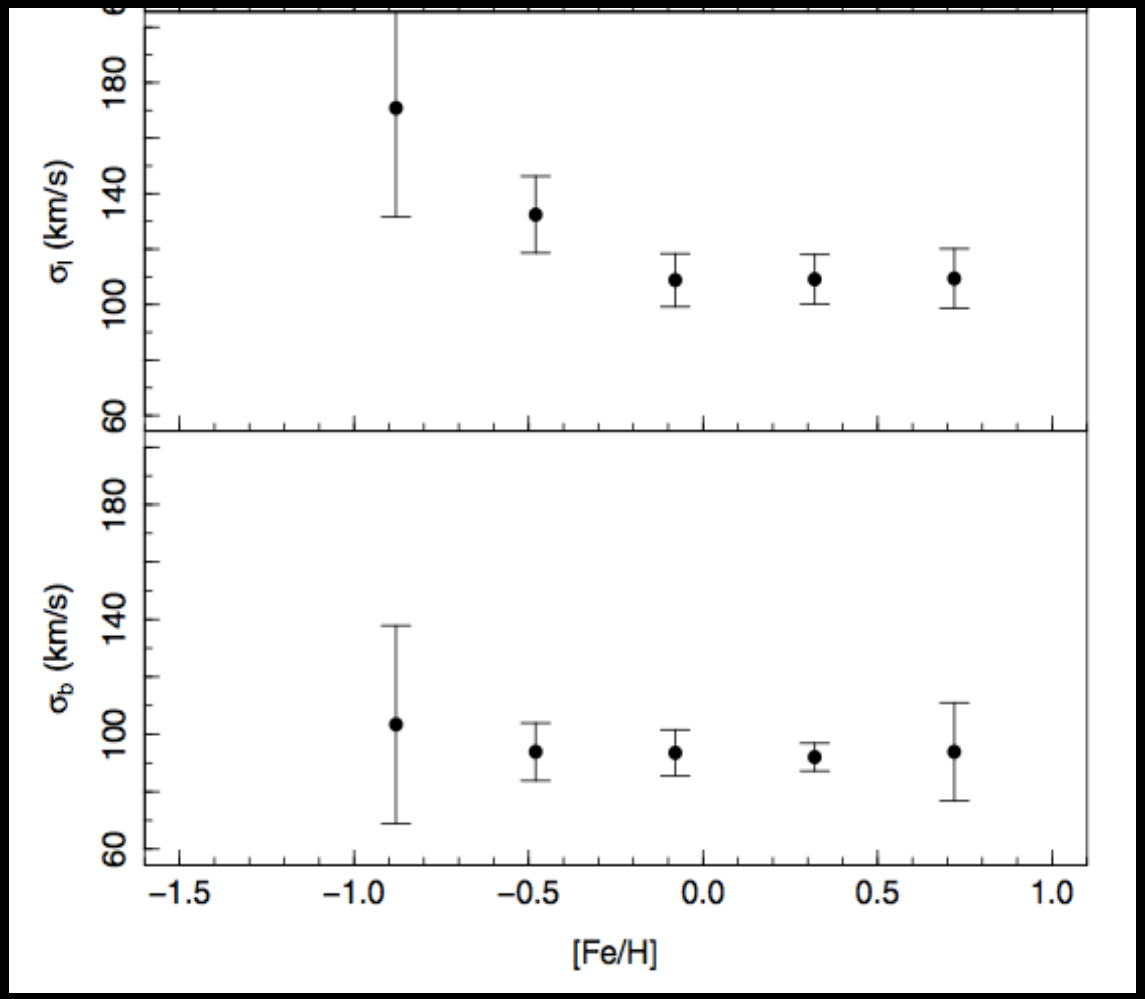

From Babusiaux et al. (2012): Transverse velocity dispersion as a function of metallicity

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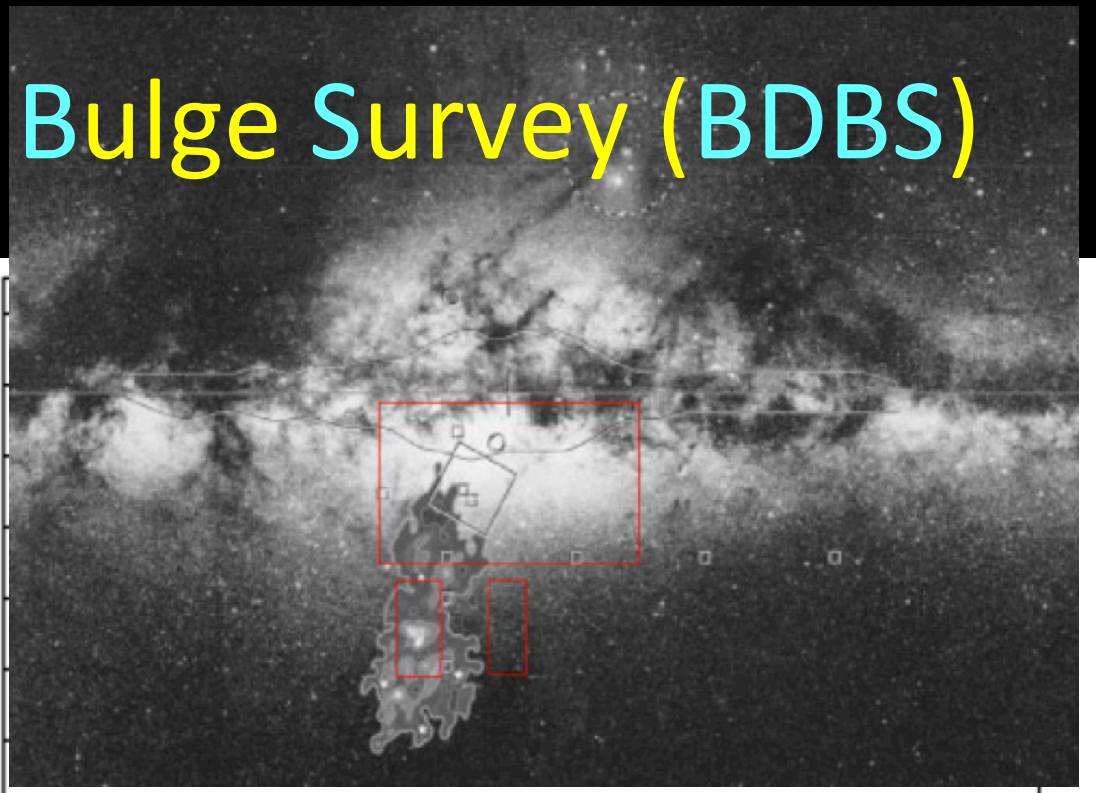
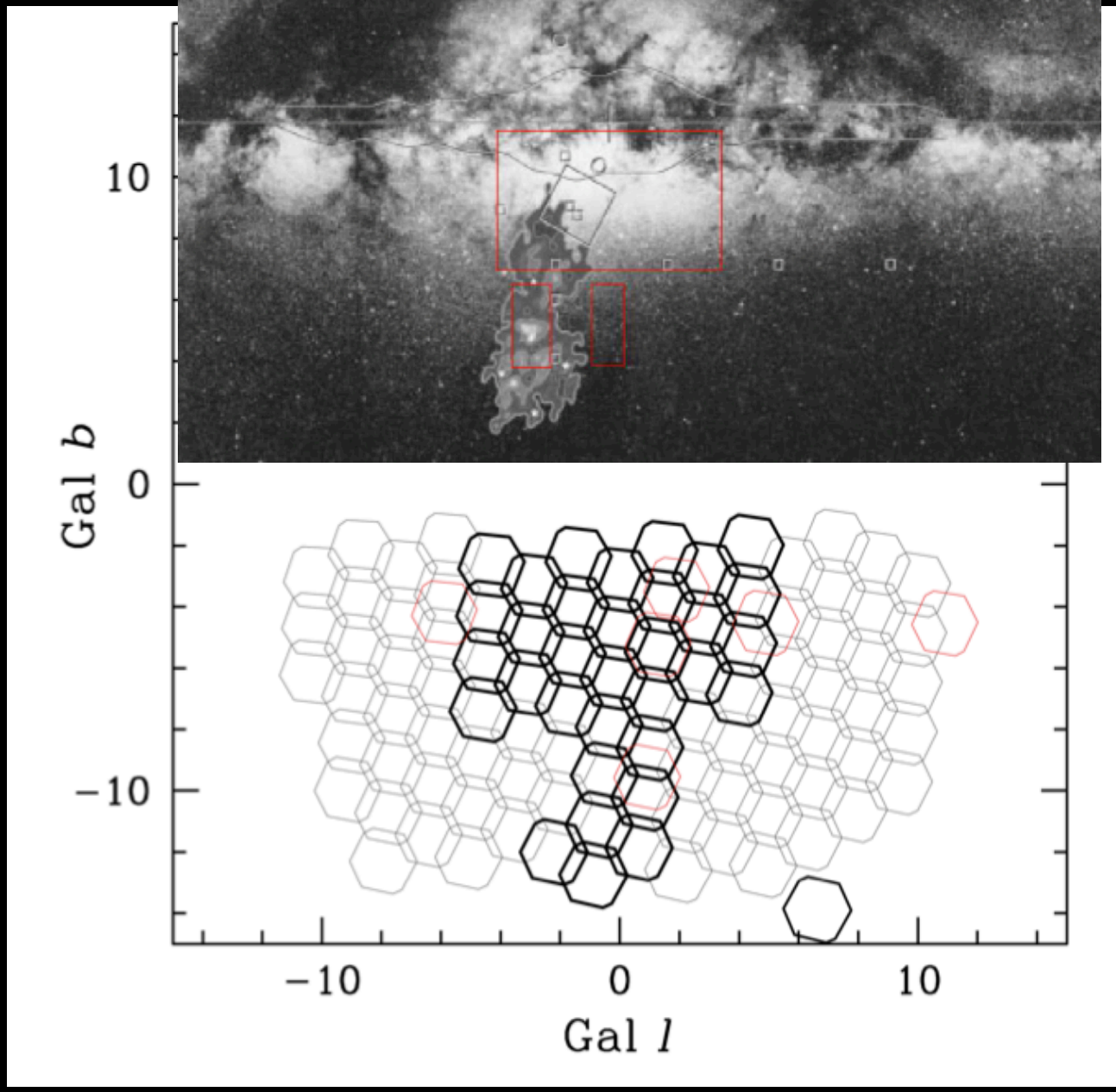
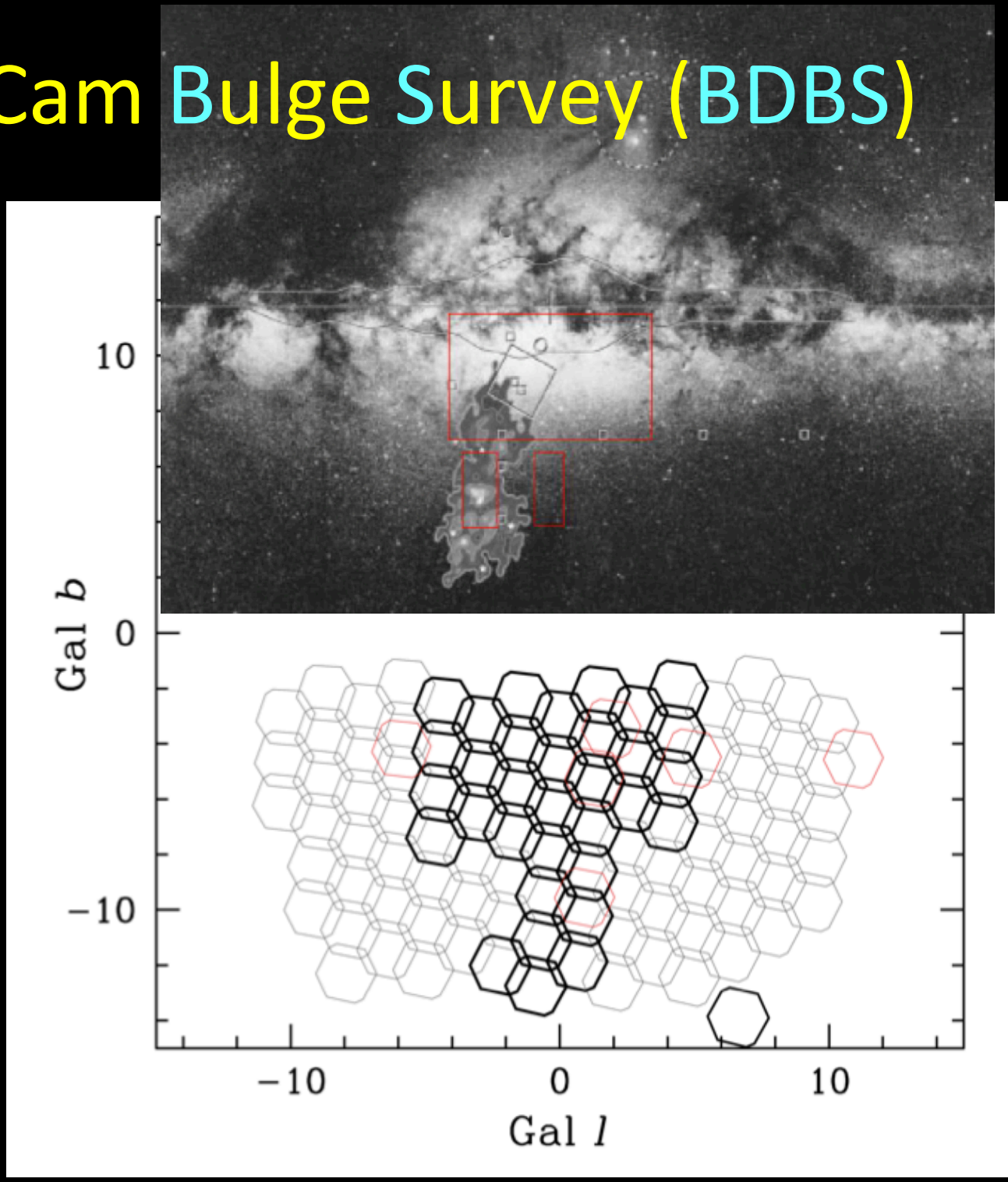




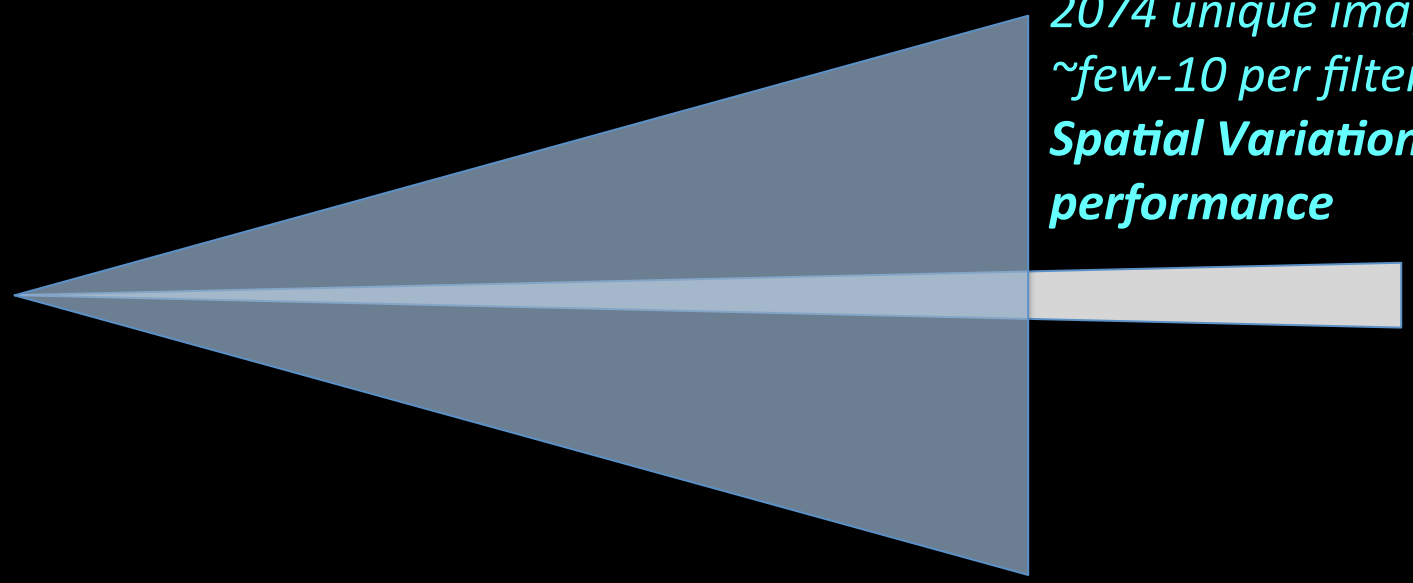
The Blanco DECam Bulge Survey (BDBS)

- Broad spatial coverage, quite deep:
  - (75s + few s)
  - ~few-10 exposures per field per filter
  - 2074 unique images
  - Broad dithers
  - Additional "astrometric dithers" in r-band



The Blanco DECam Bulge Survey (BDBS)

BDBS is one of at least three ongoing DECam surveys towards the bulge, e.g.:



BDBS: Ultimately, 240 sq. deg
2074 unique images in 2013A
~few-10 per filter per field
Spatial Variation of photometric performance

RR Lyraes in the bulge
With DECam –
Time-variability in deep fields

All highly complementary to each other

The Blanco DECam Bulge Survey (BDBS)

- Processing the full dataset:
- 2013A: 126,514 chip-images
  - ~5 TB uncompressed
- Full area: DOPHOT
  - Developing initial catalog
- Other approaches tested on select fields.

Images processed on the Quarry-II infrastructure at Indiana University.

With hundreds of cores, takes about 1 week for the entire dataset.

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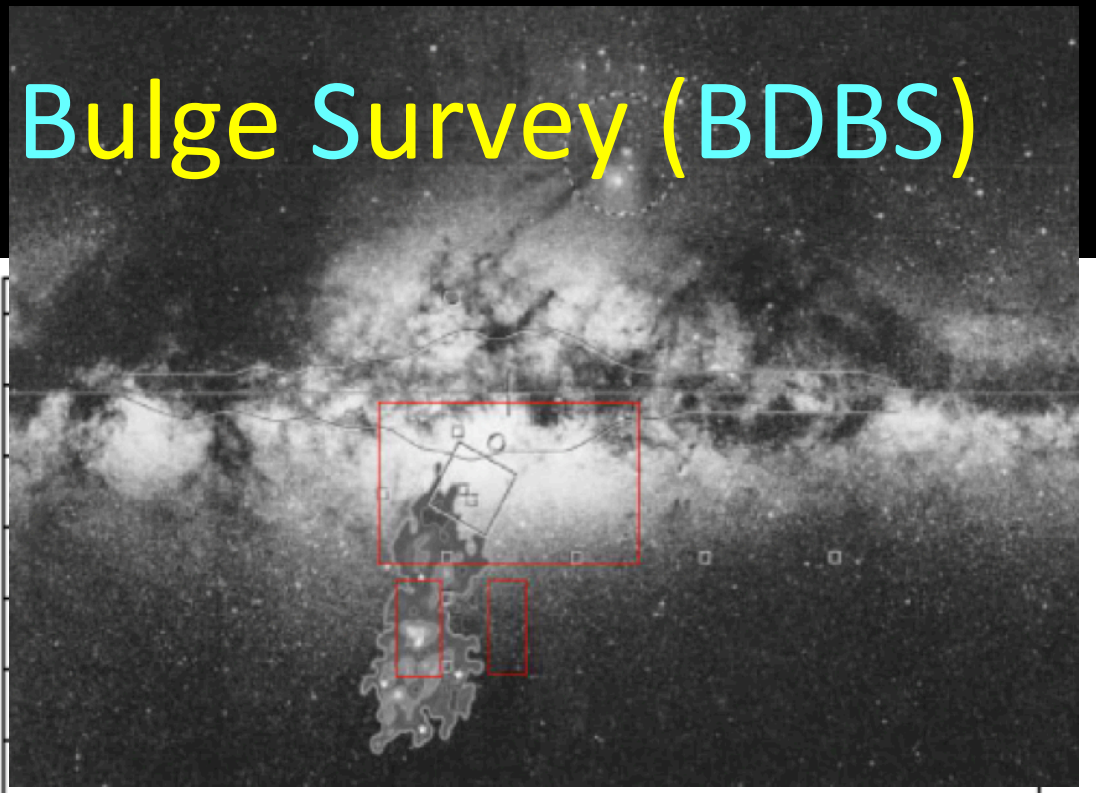

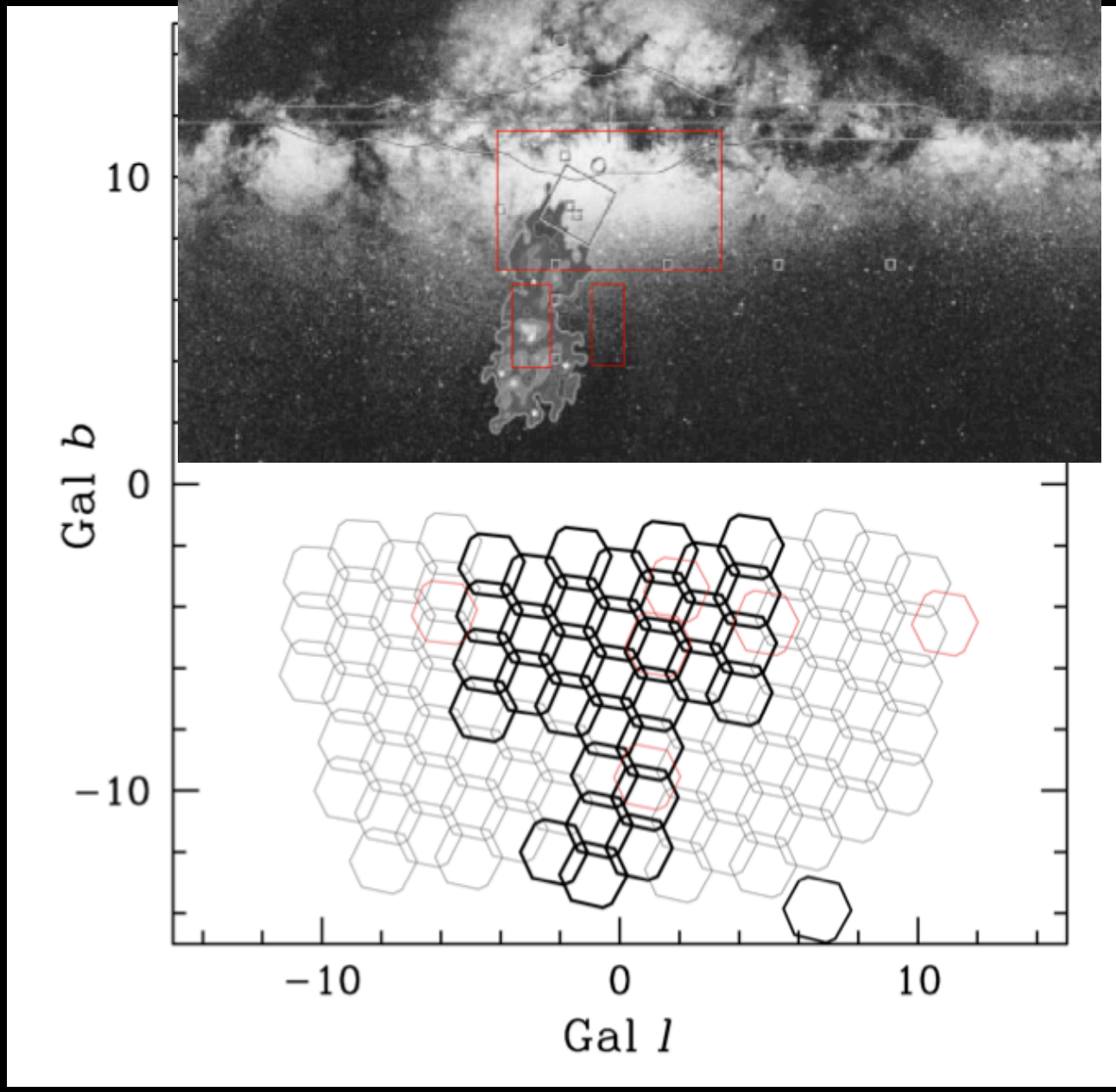

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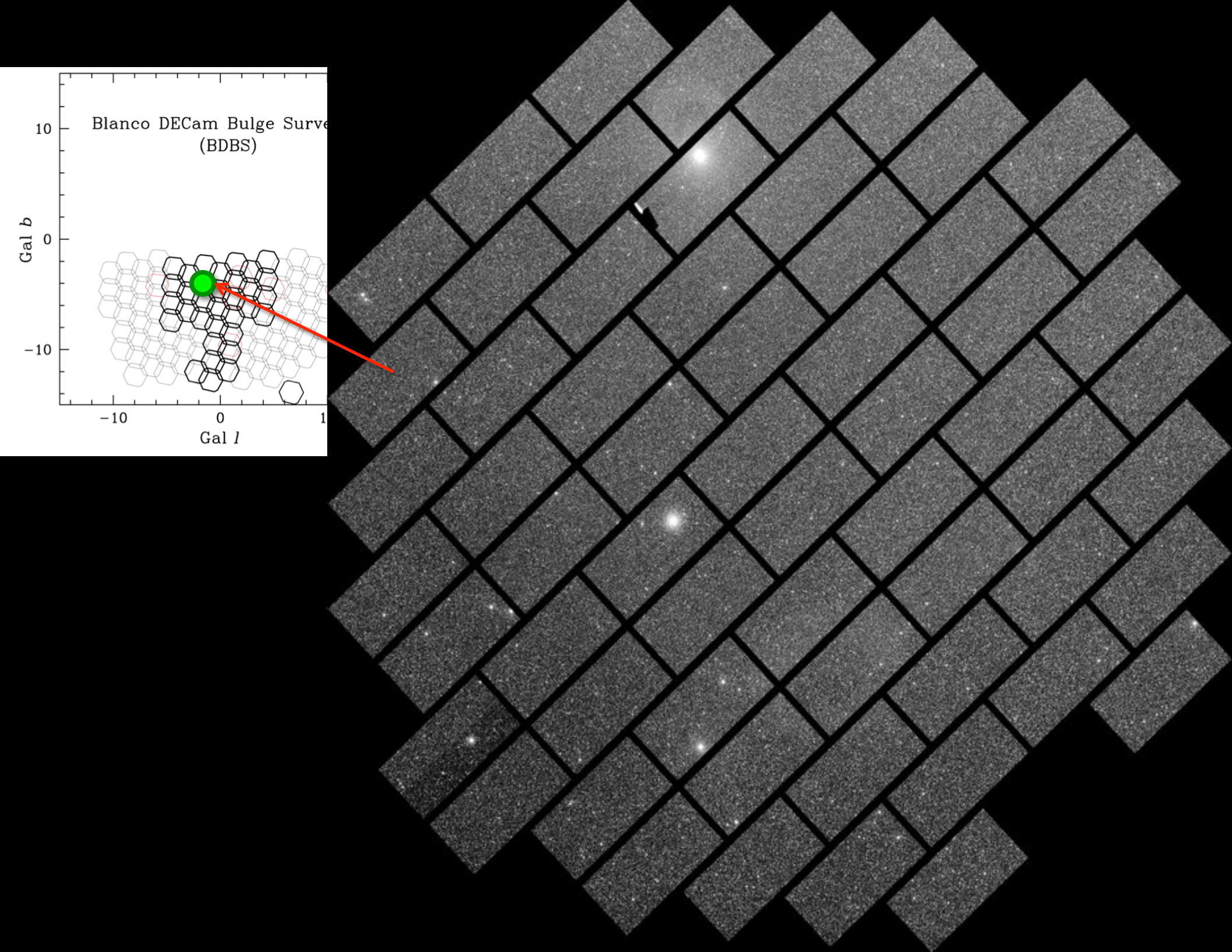
Blanco DECam Bulge Surve
(BDBS)
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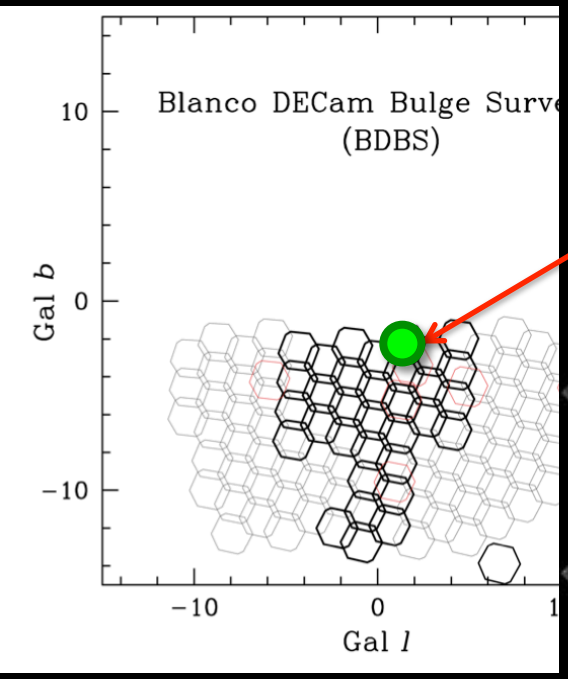
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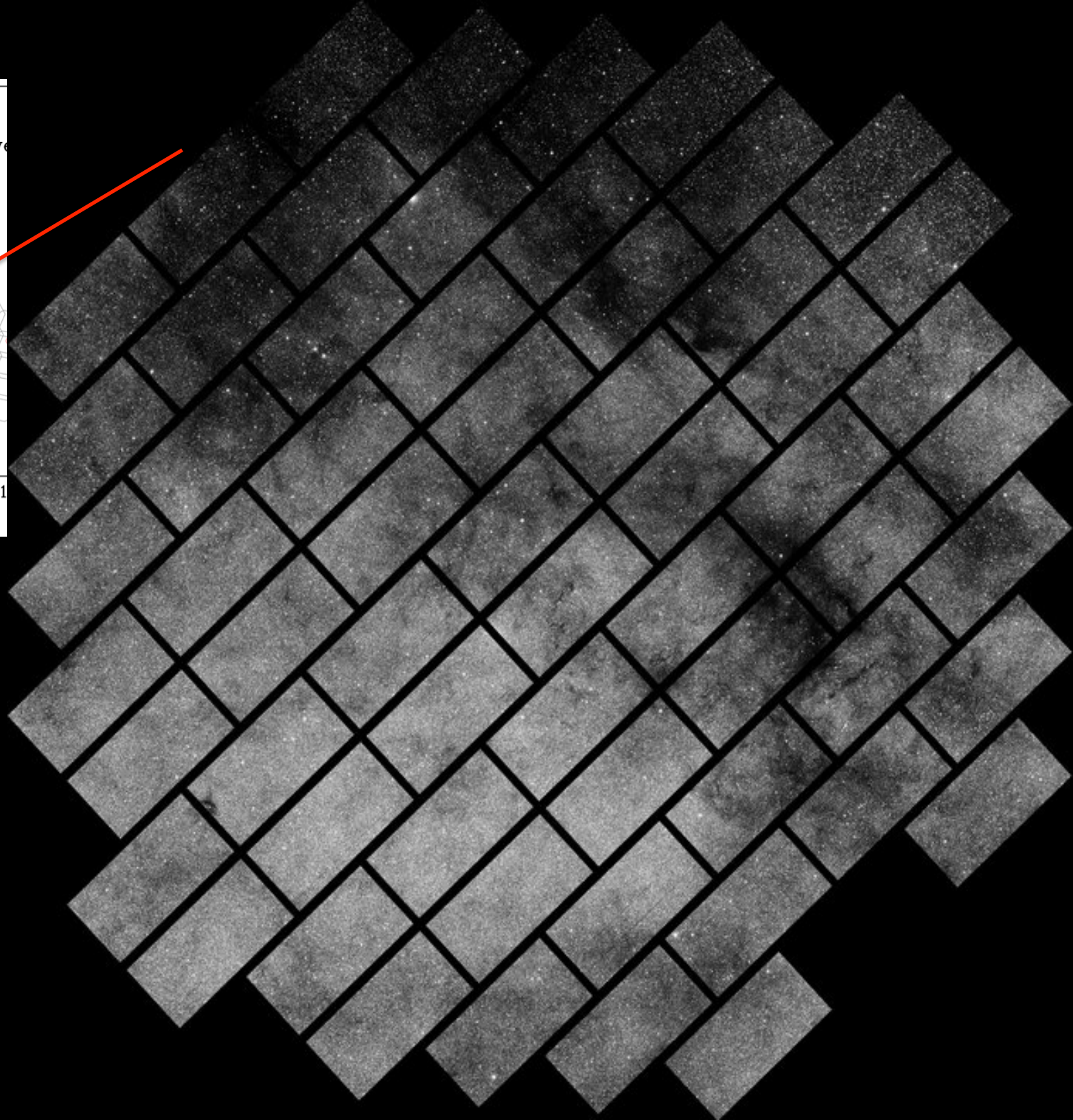

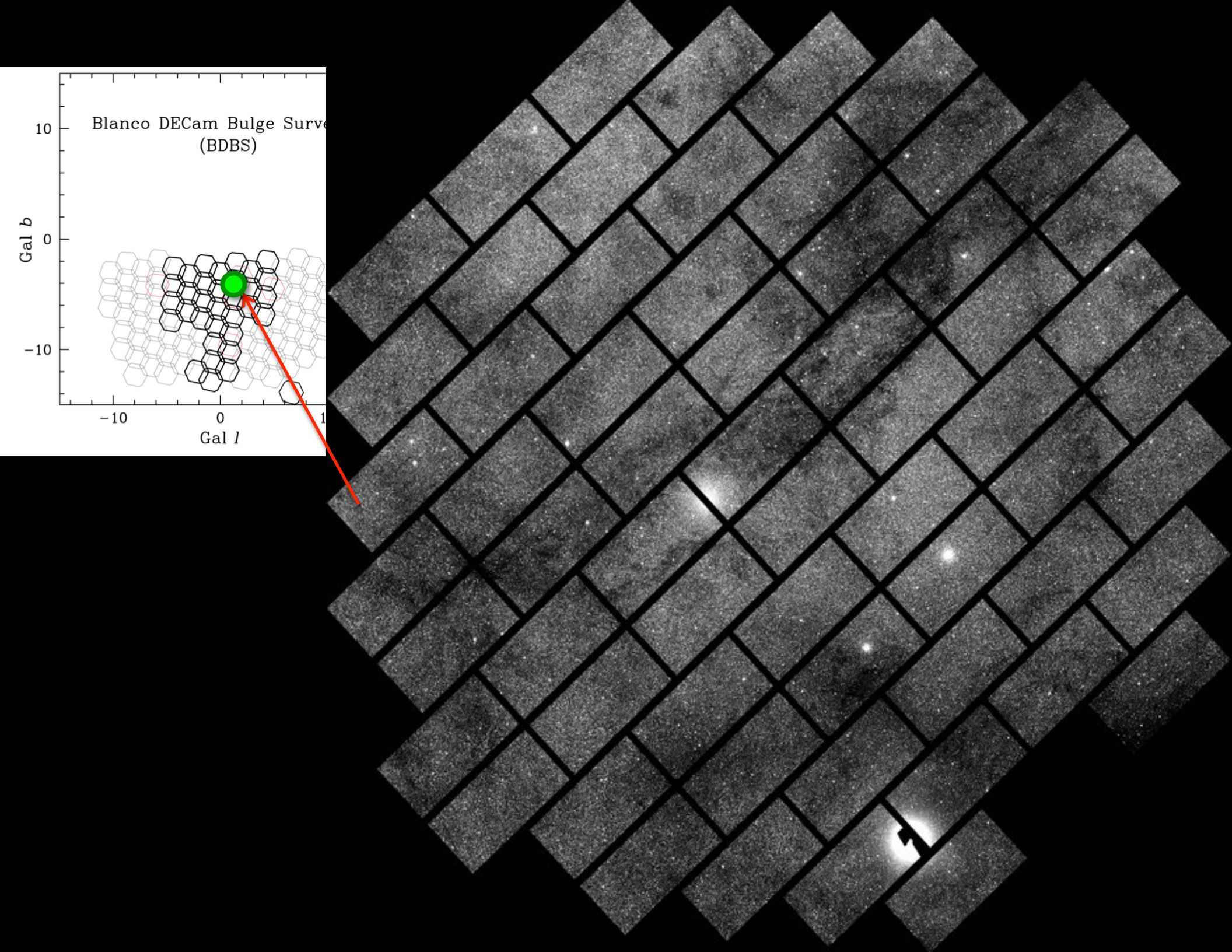
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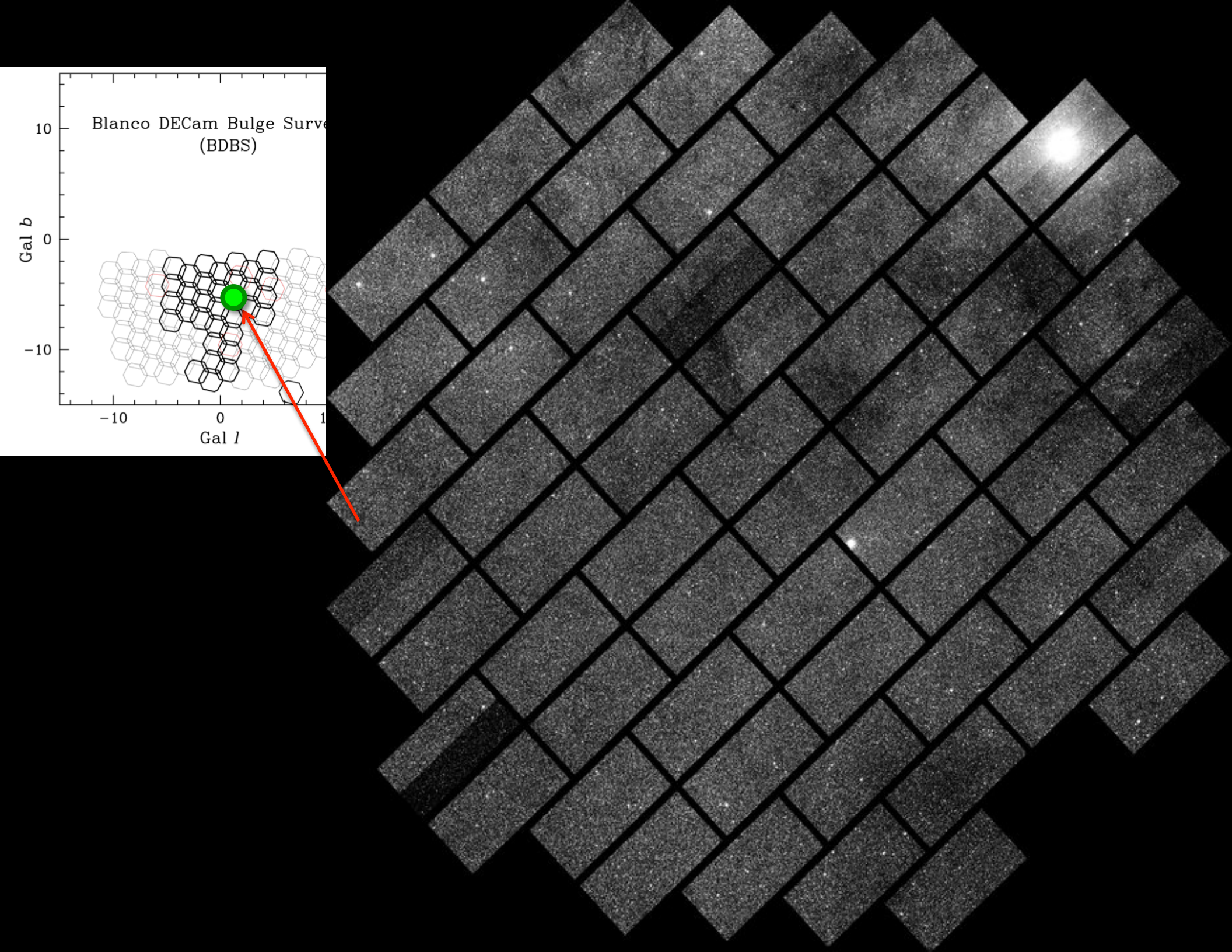
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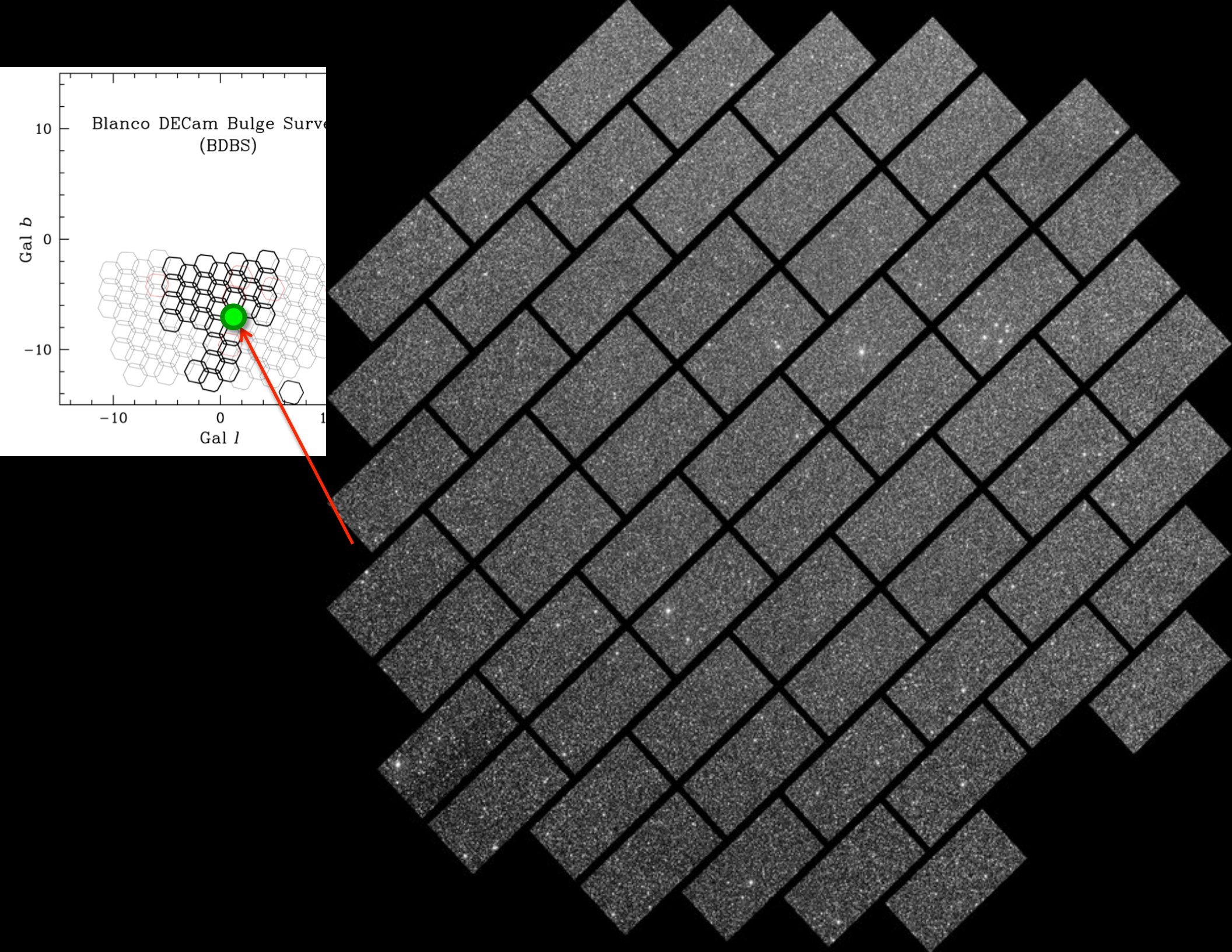
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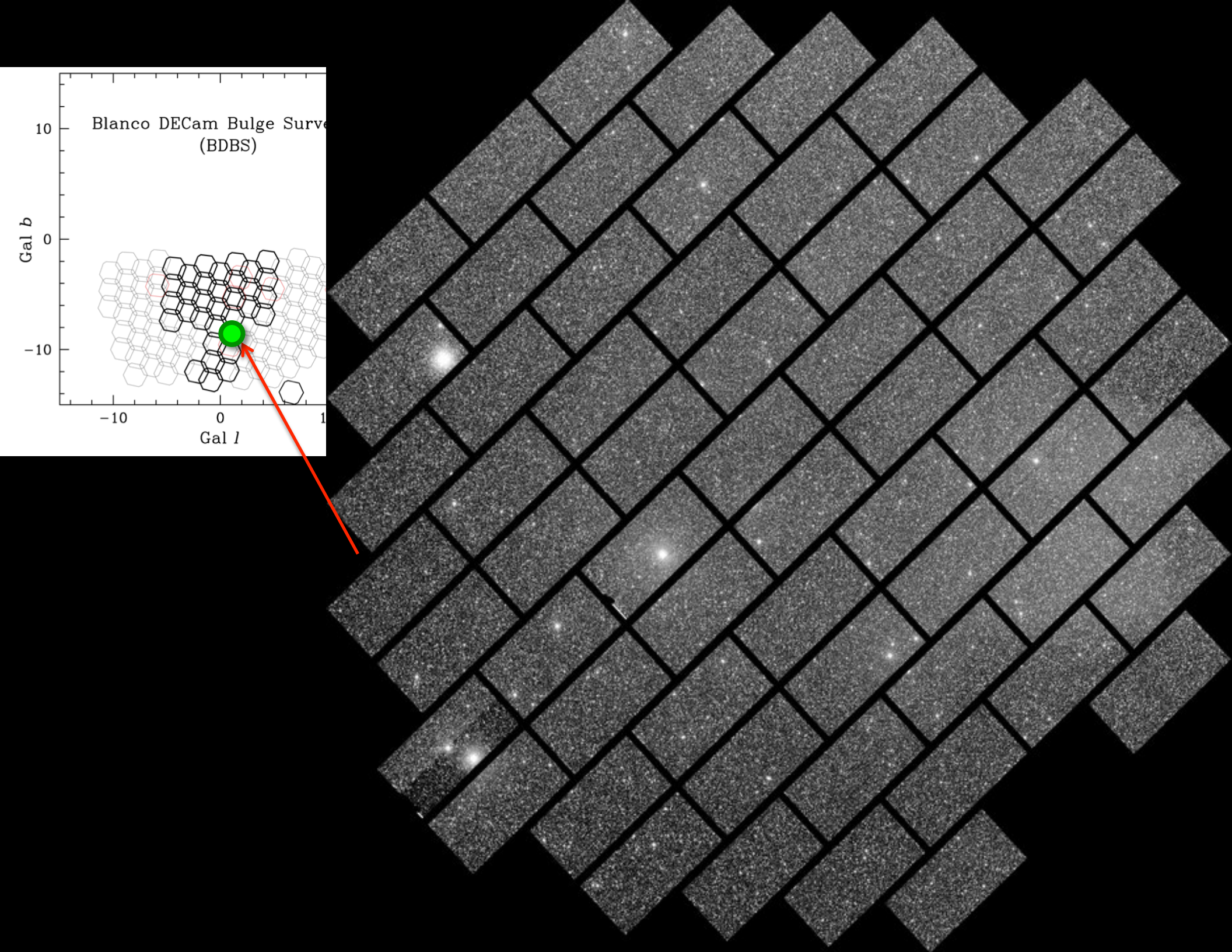
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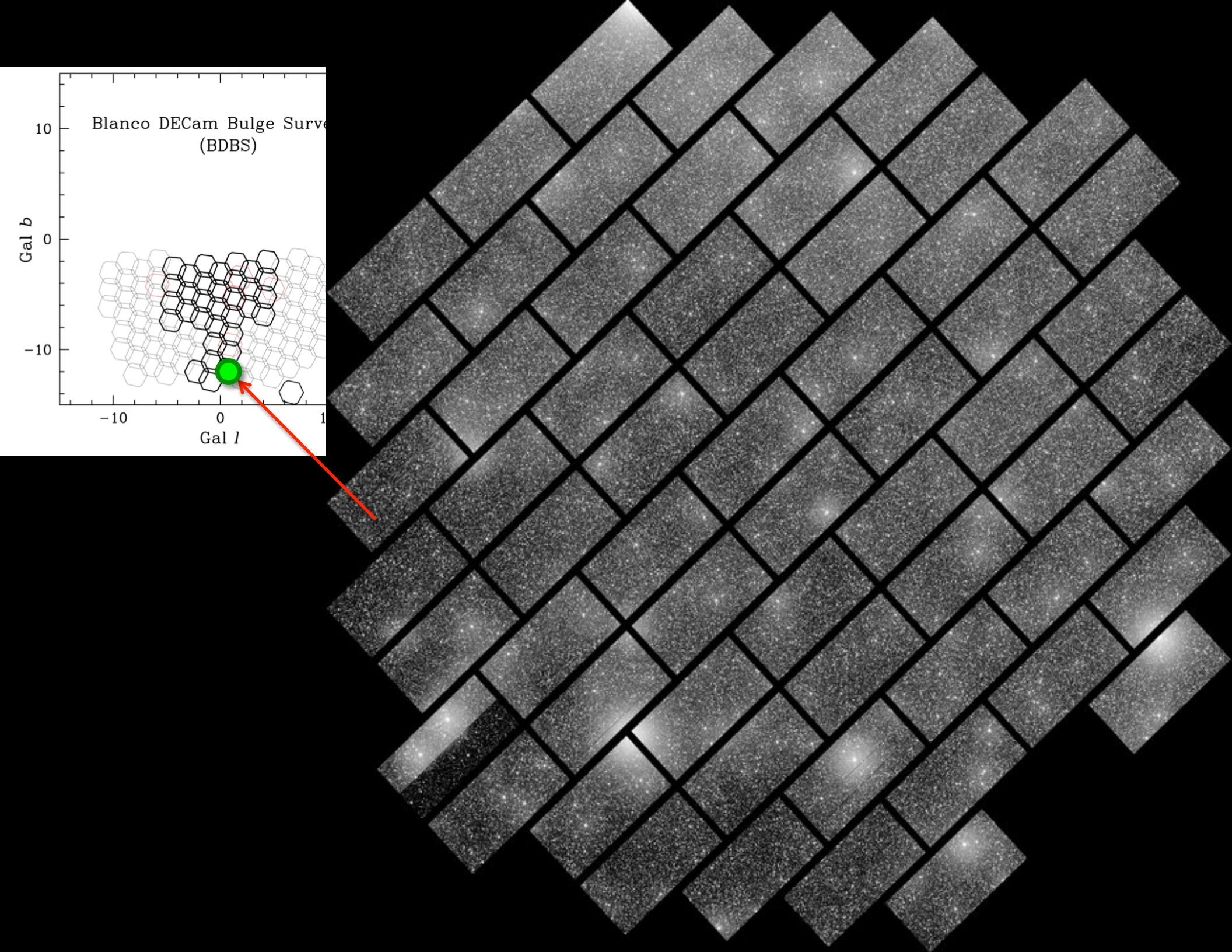
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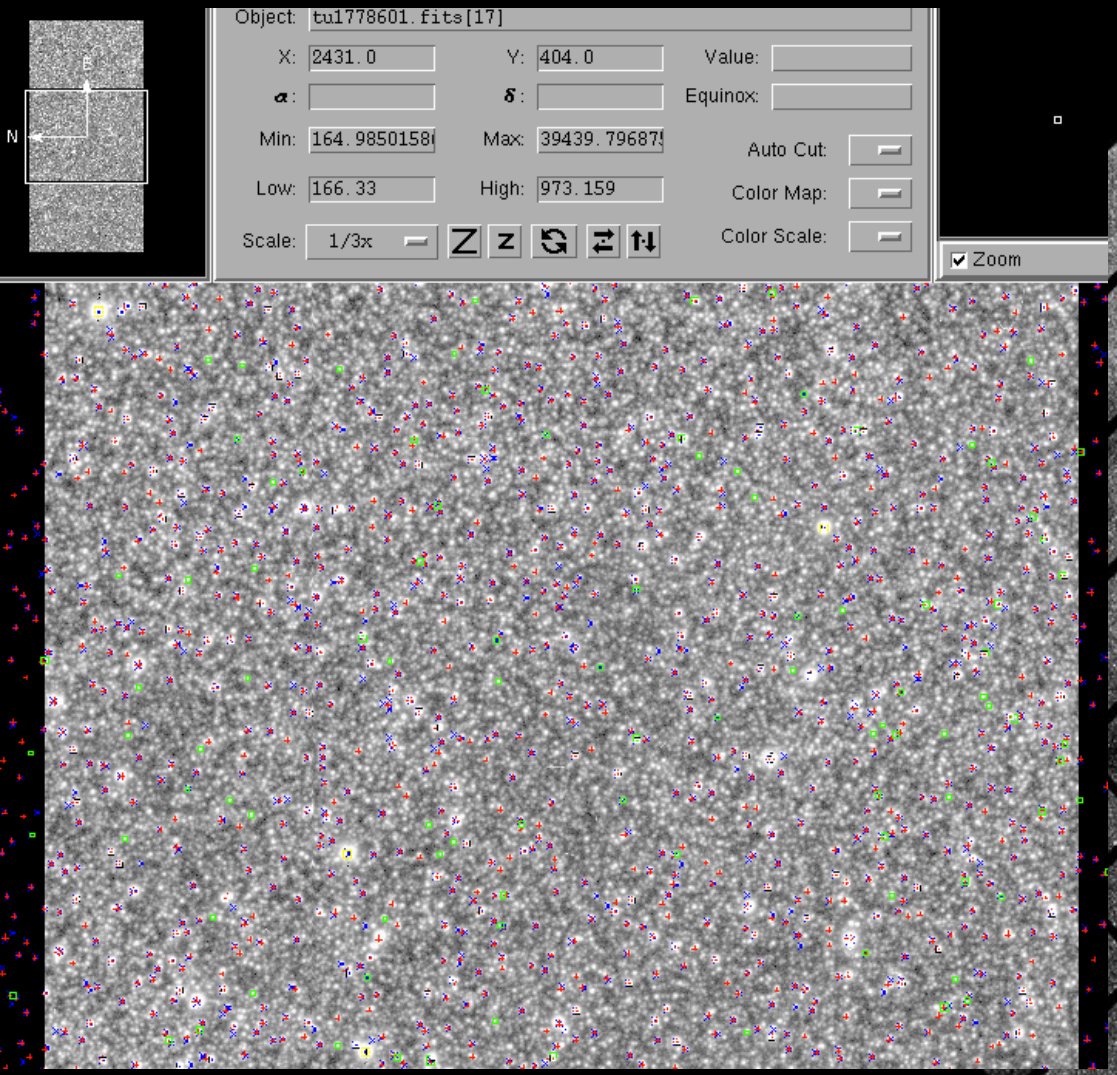
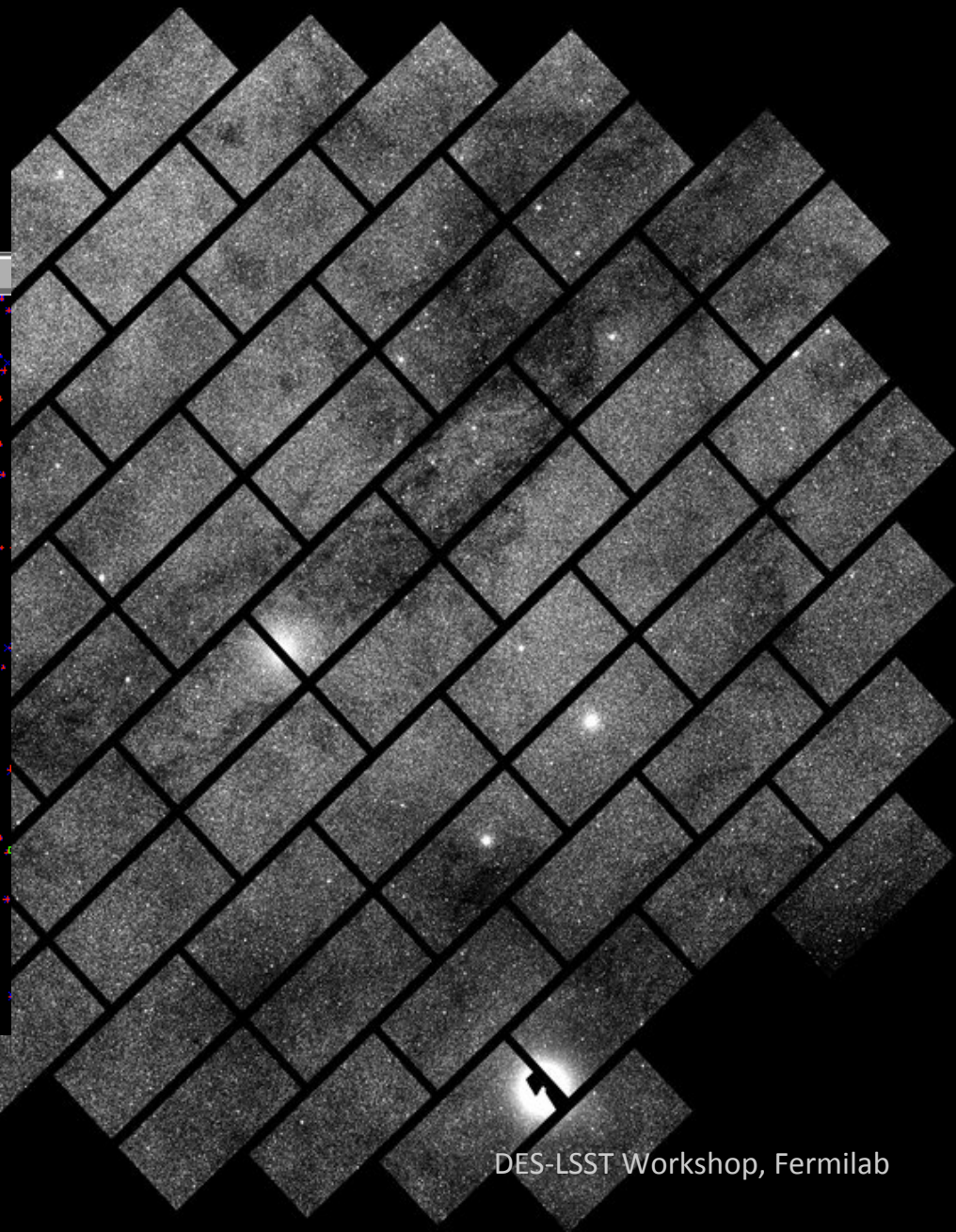
BDBS operates in quite a crowded regime:





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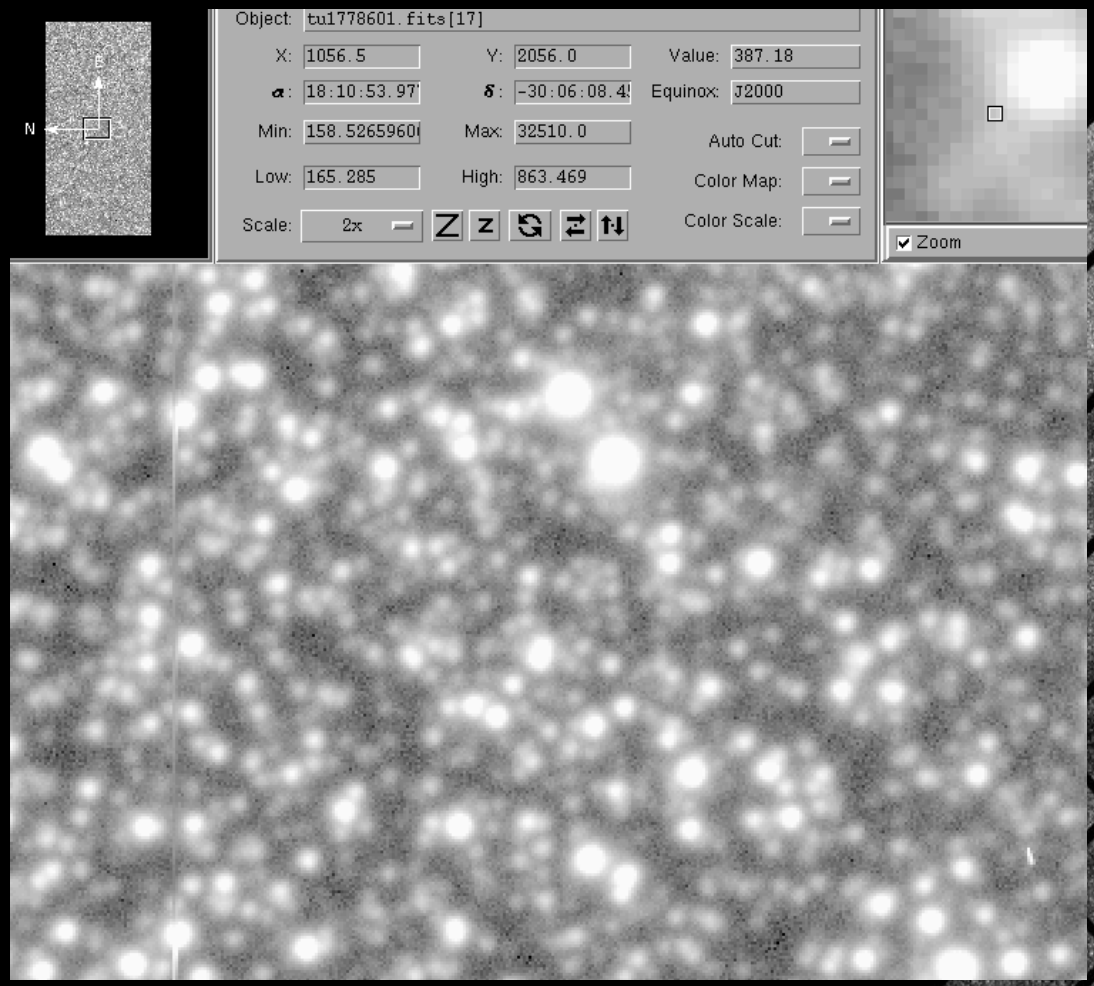

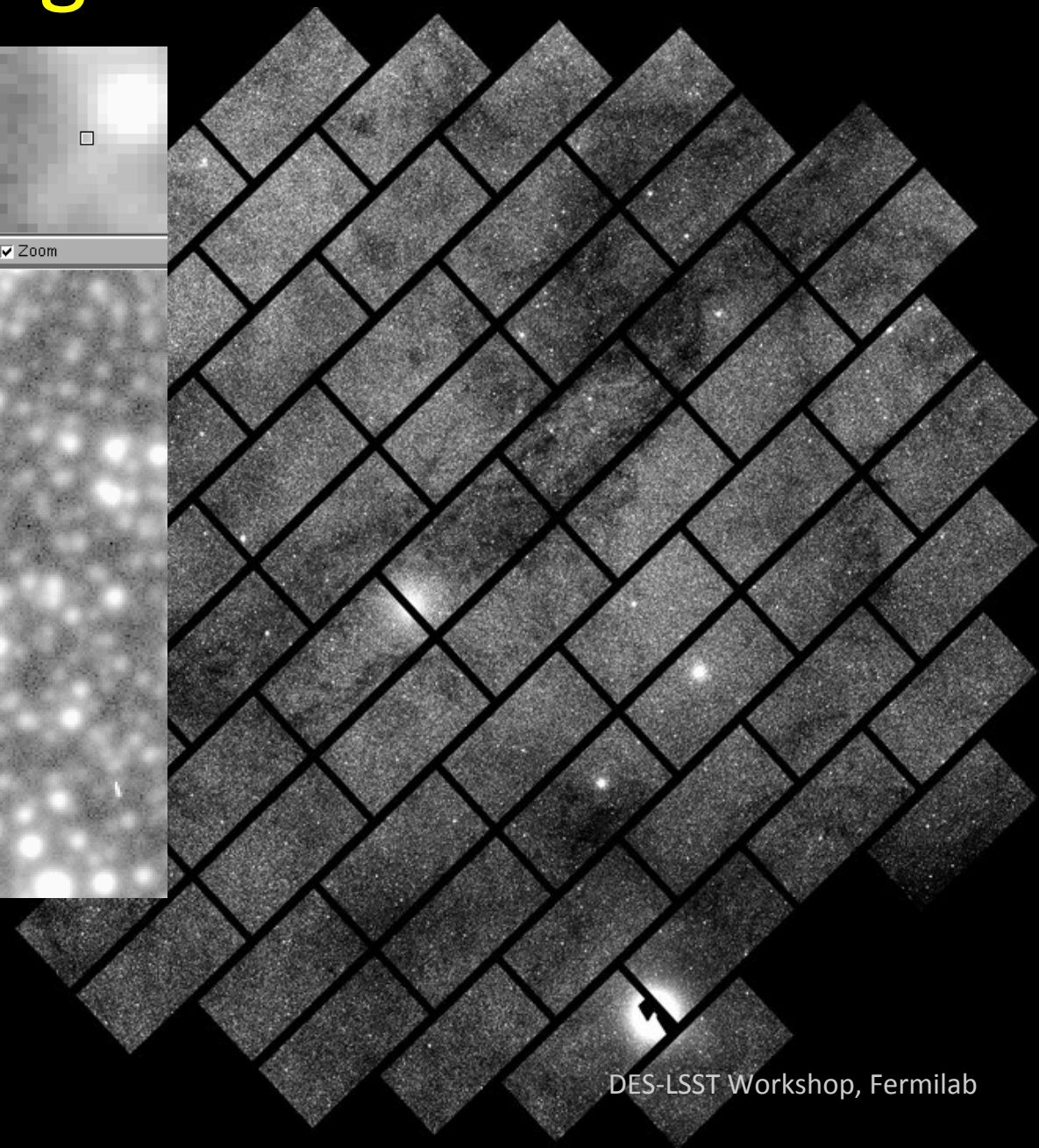

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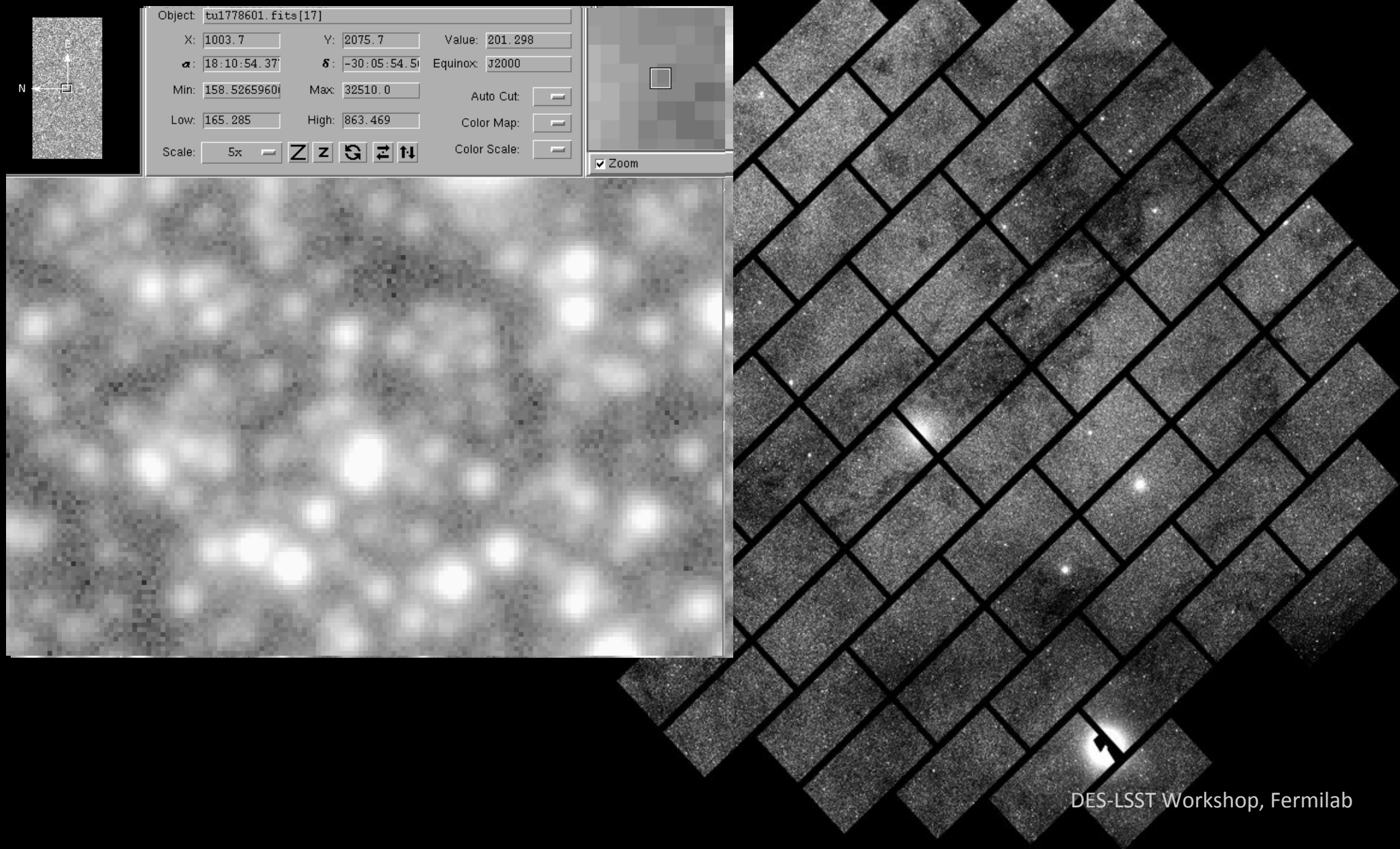

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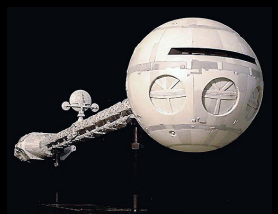
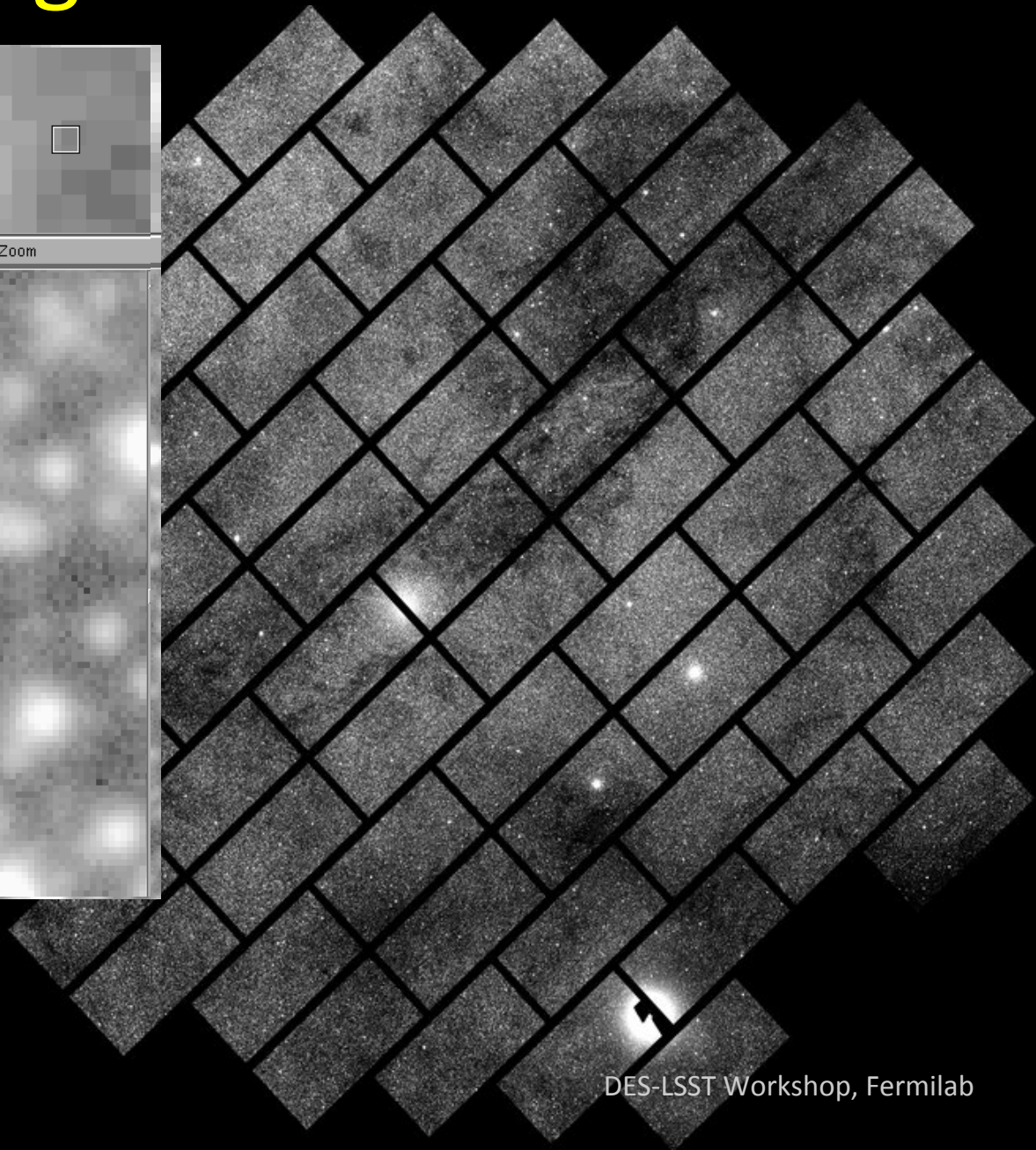
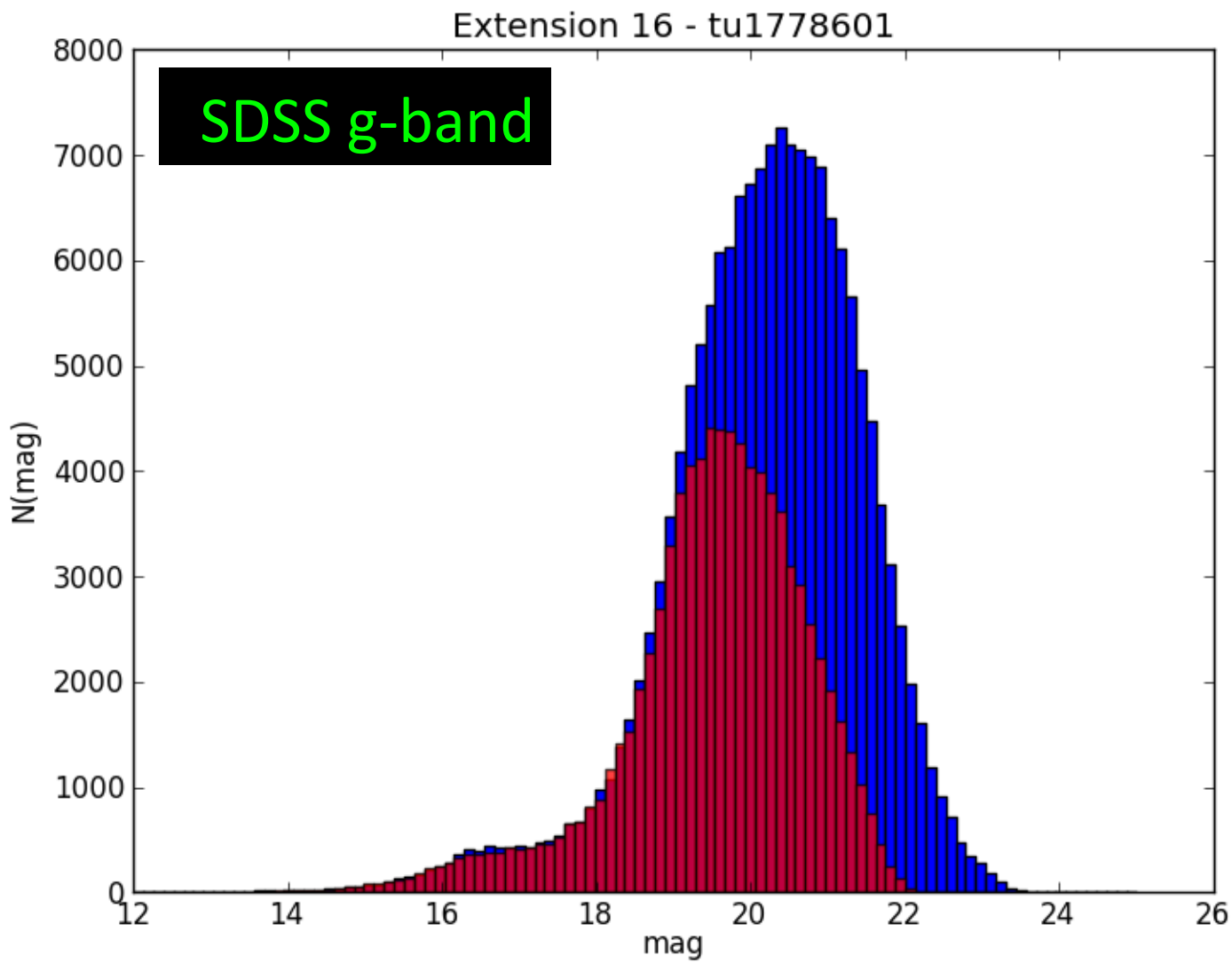




In a single 75-second image, we detect just under 10 million stars in the full-frame (in SDSS g and r)



ALLSTAR with three passes: 164,100 stars in chip 16

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DOPHOT: 86,652 stars in chip 16 (SDSS g)

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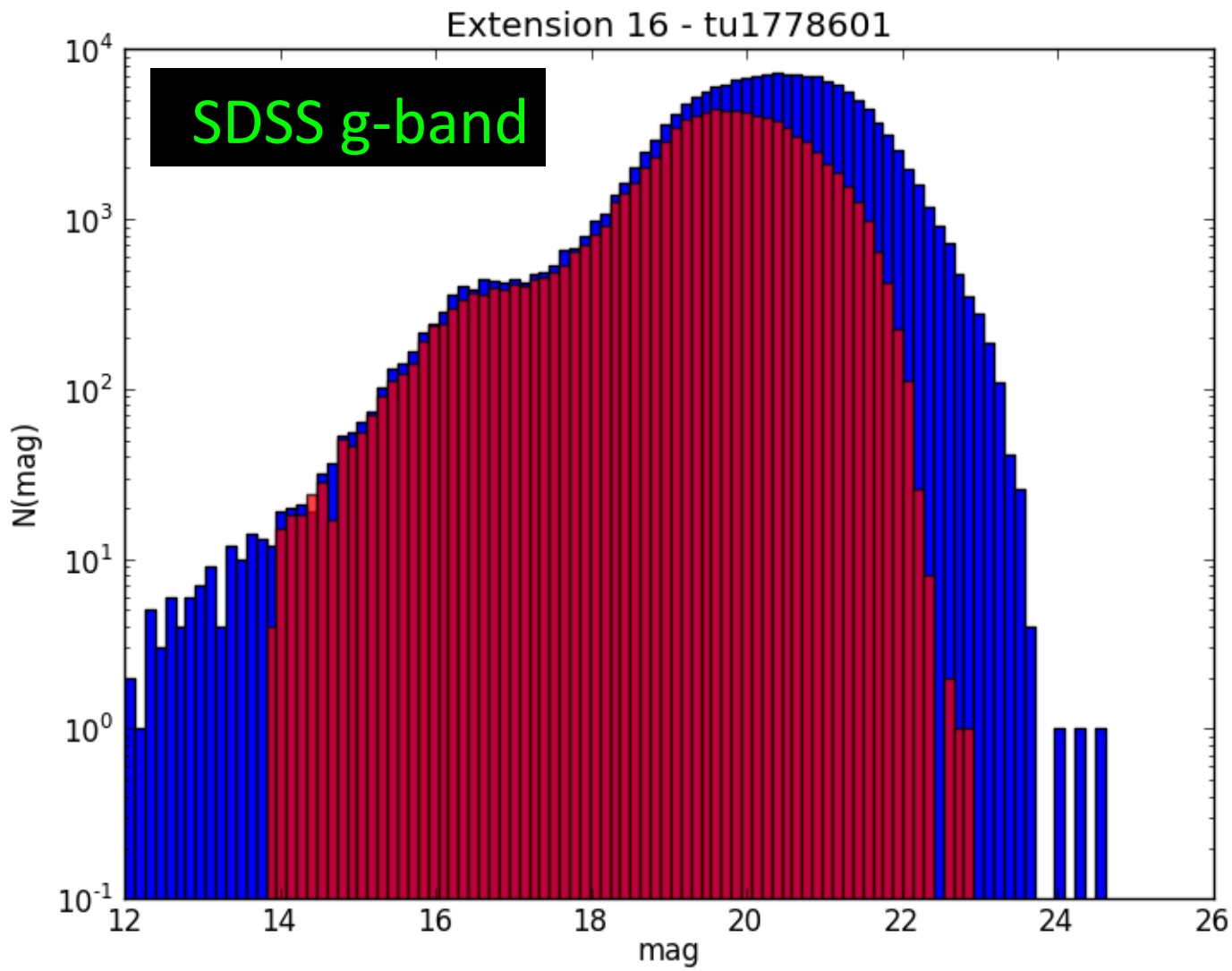

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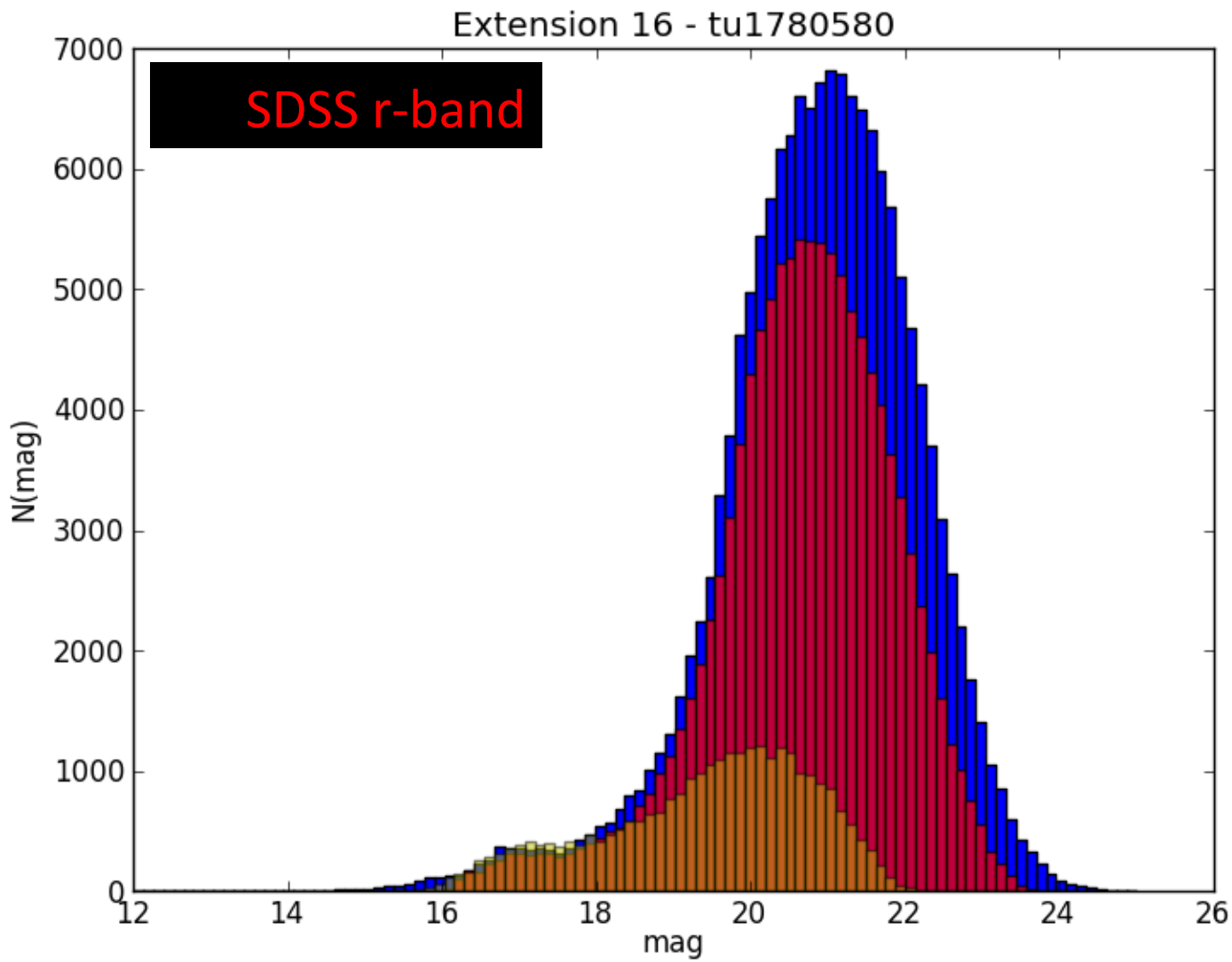

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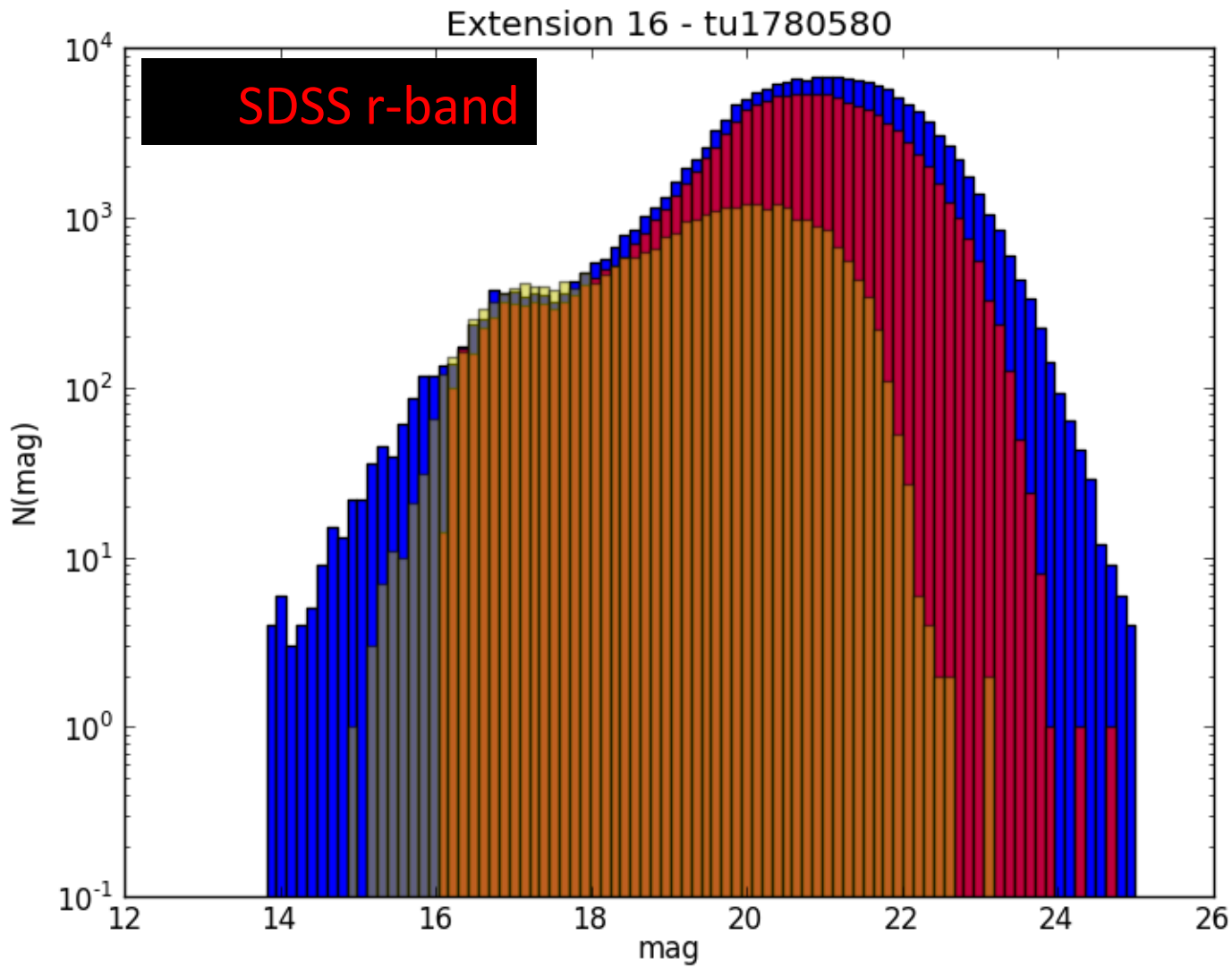

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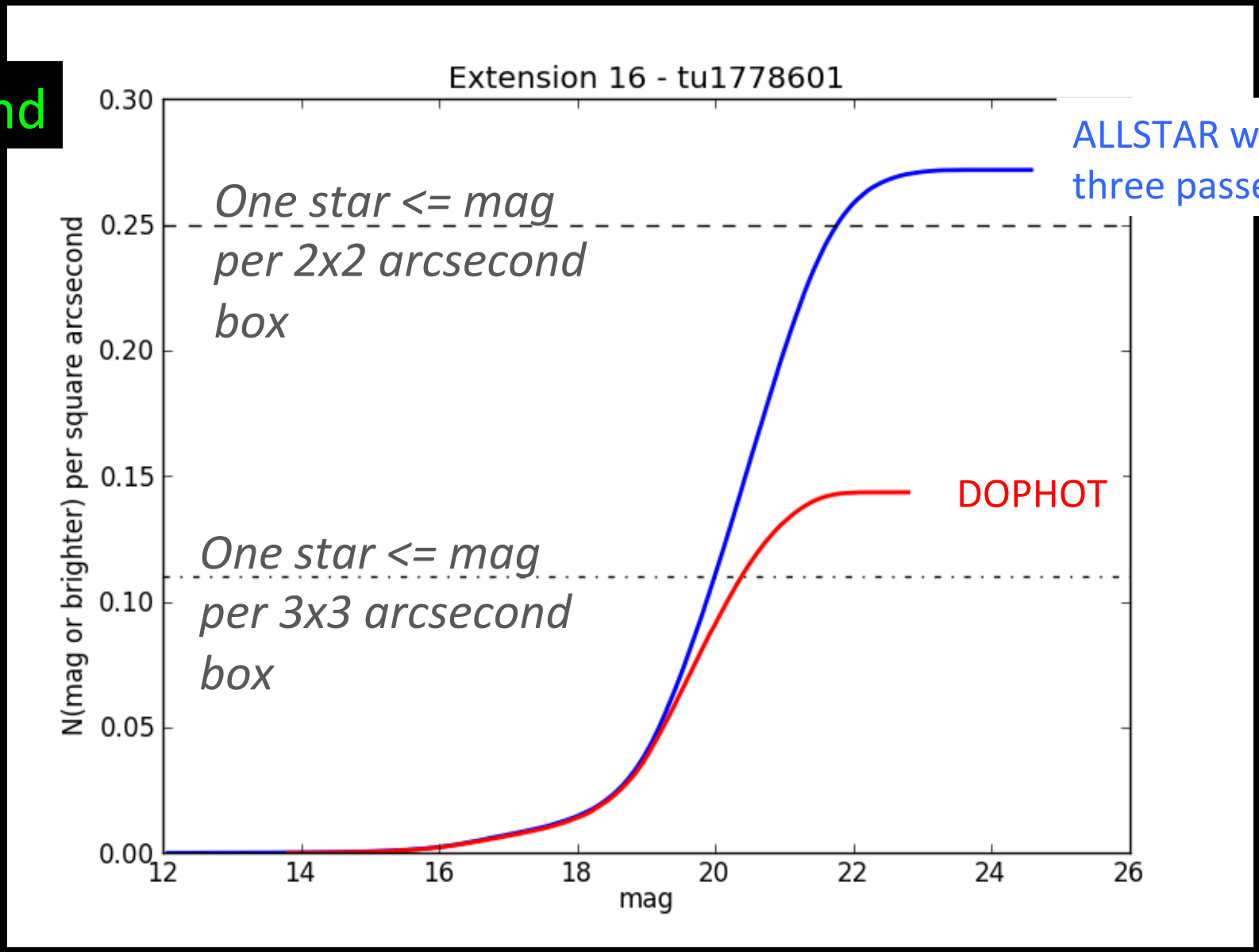
How “crowded” is this?

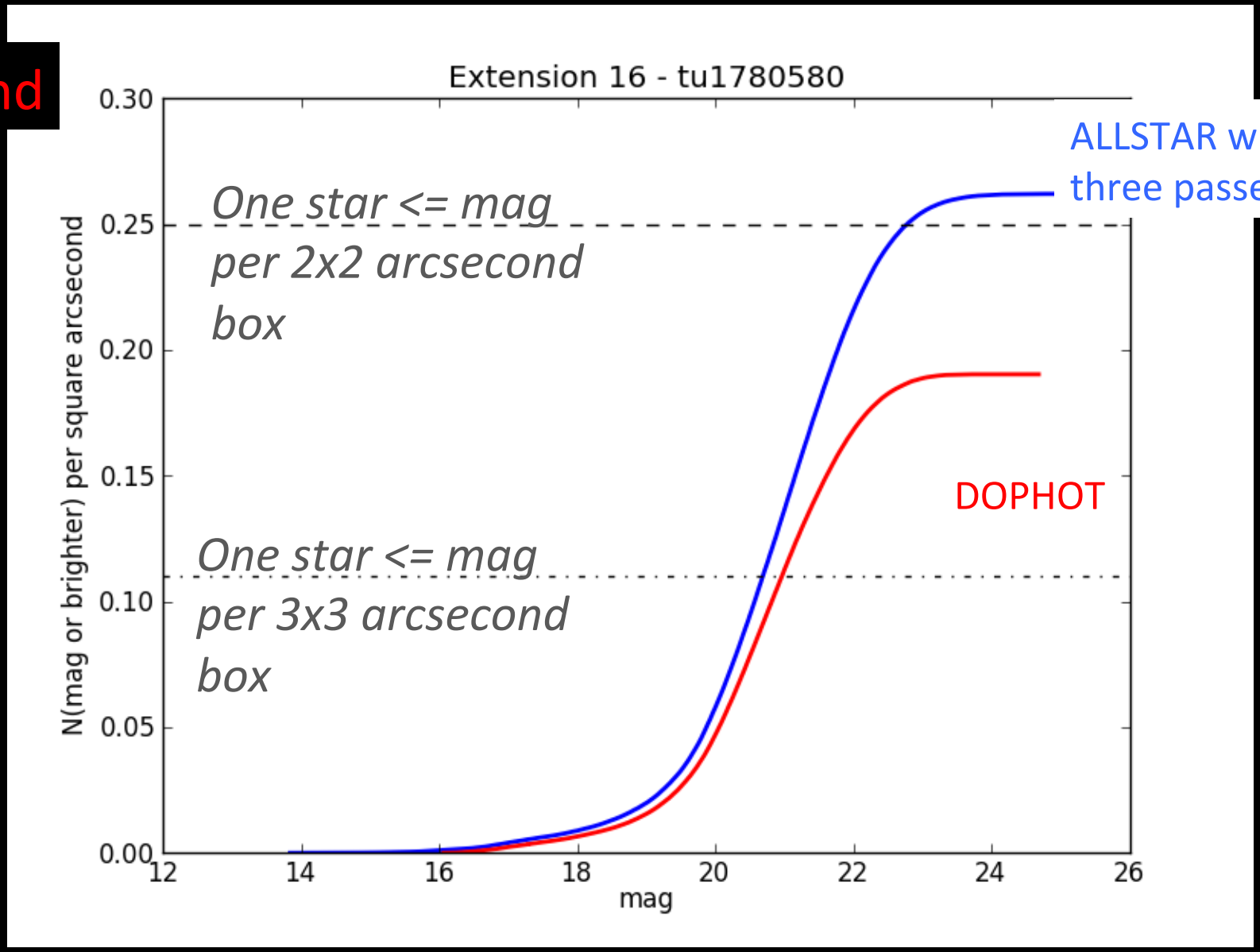
SDSS g-band



Stars per square arcsecond at least as bright as “mag”

How “crowded” is this?

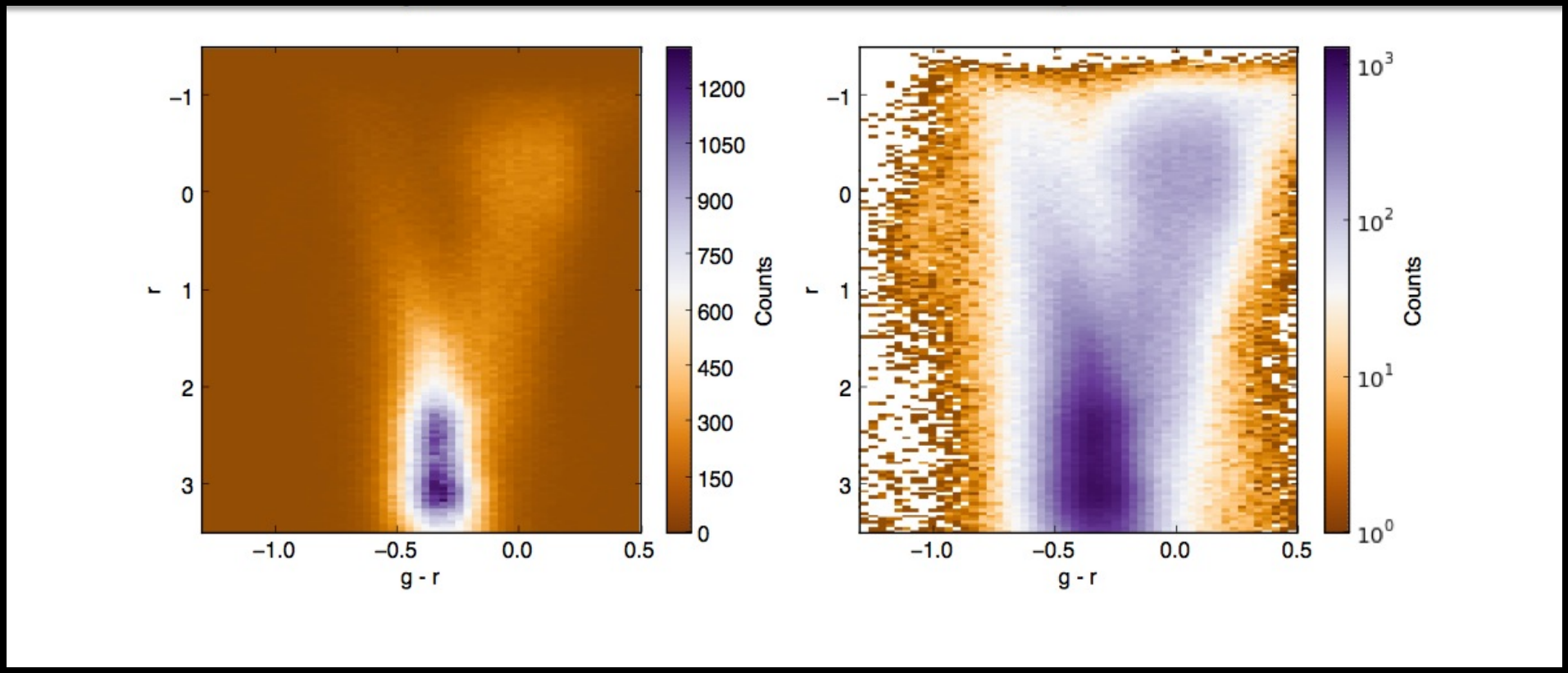
SDSS r-band



Stars per square arcsecond at least as bright as “mag”

Based on a single image-pair, DECam reaches sufficiently deep to well-sample the turn-off population.

- (l,b) = (1.2, -5.04)
- This CMD is based on our DOPHOT photometry over the full survey; we expect to go ~1 mag or so deeper



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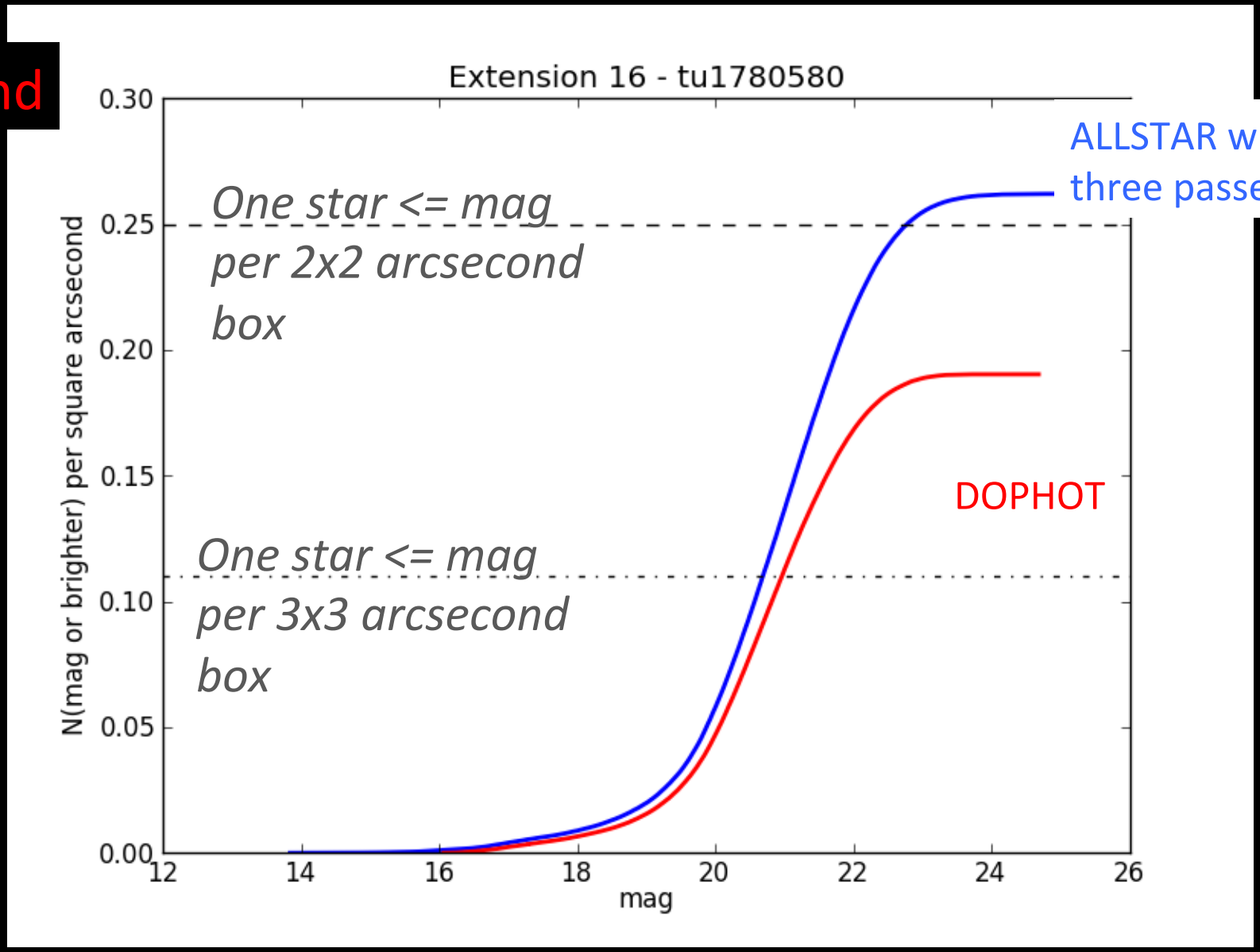
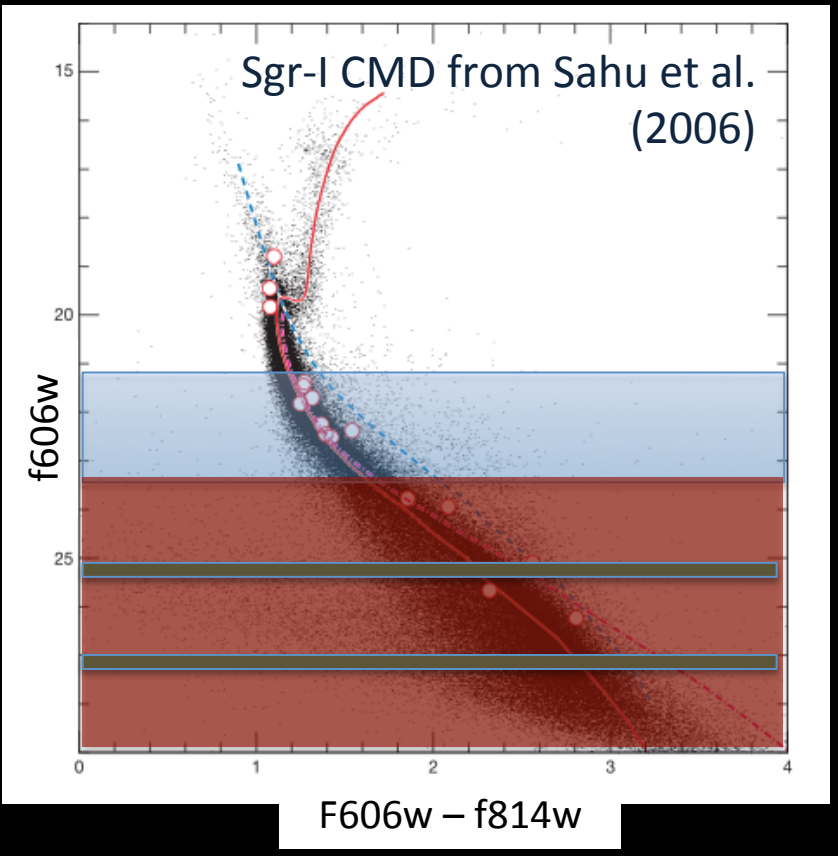
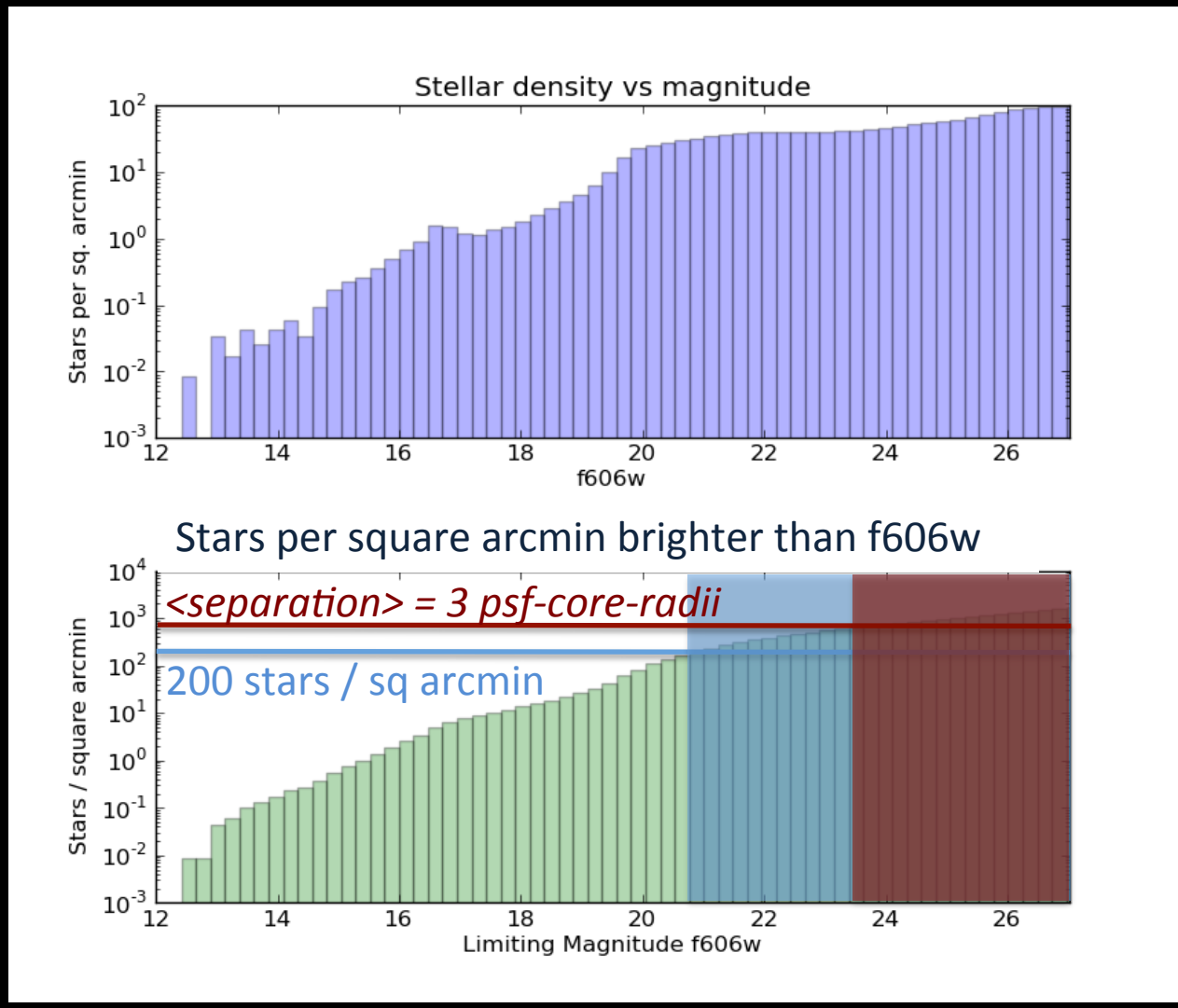


Stars per square arcsecond at least as bright as “mag”

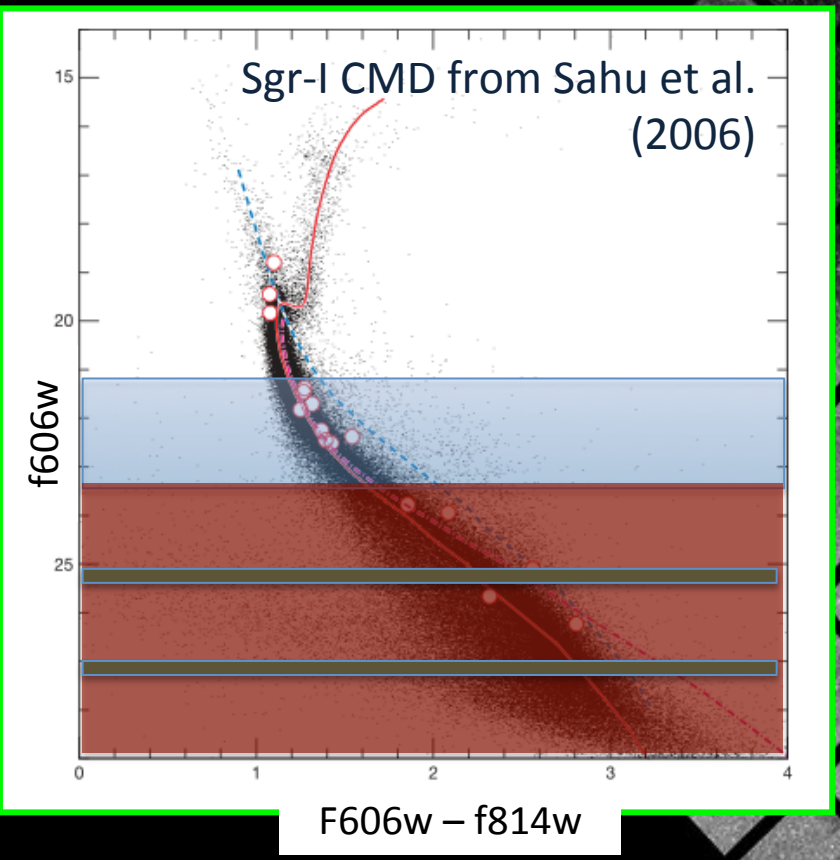
Existing deep photometry gives some indication for what to expect from LSST:

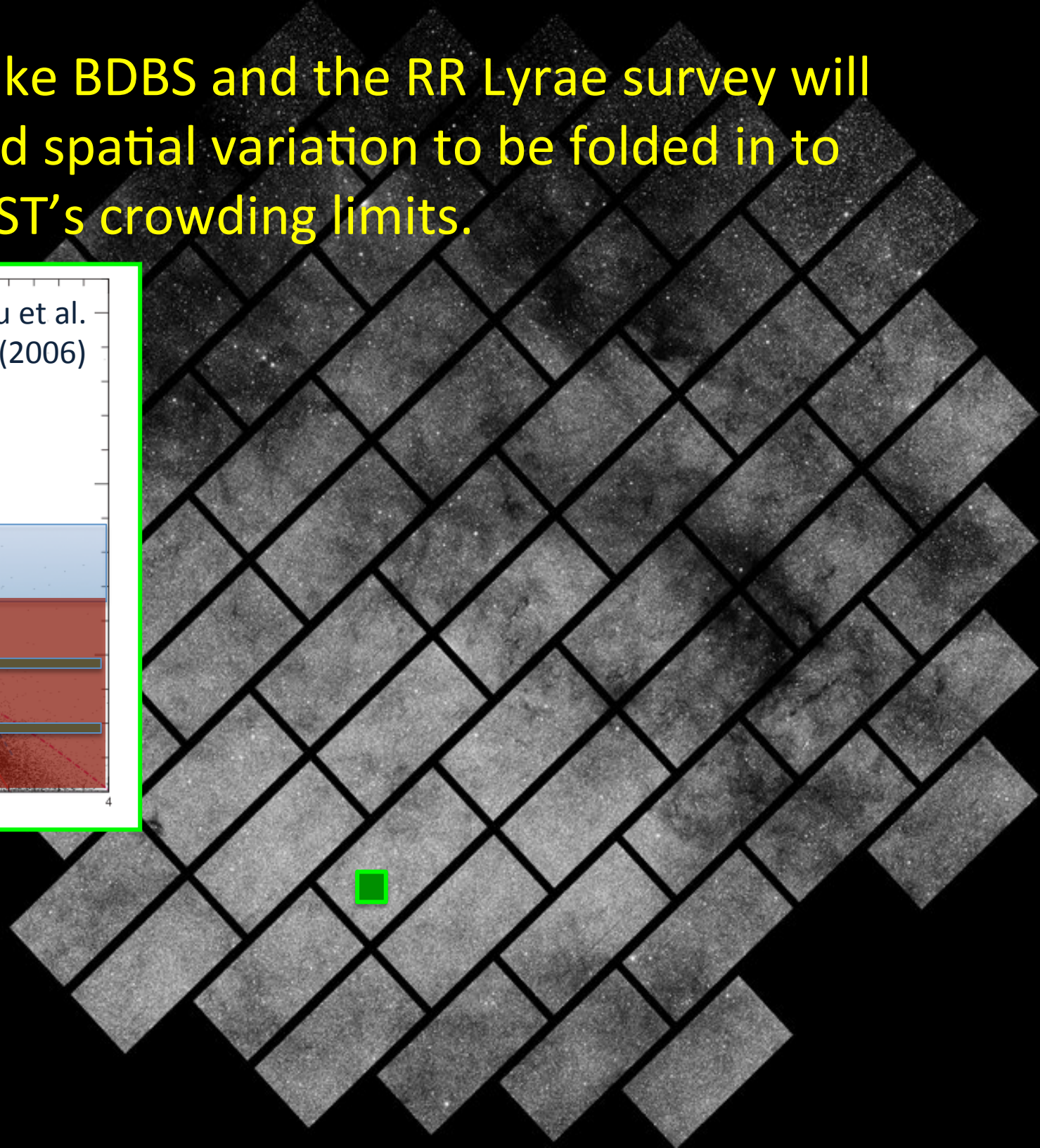




– Stars per square arcmin brighter than f606w, as a function of f606w

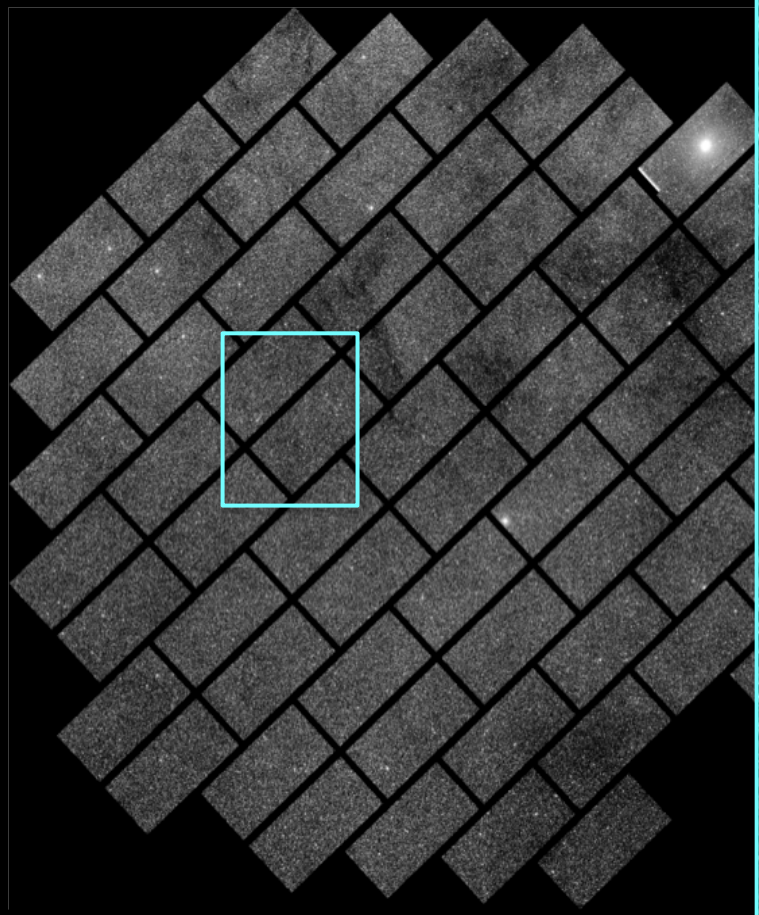
DECam surveys like BDBS and the RR Lyrae survey will allow fine-grained spatial variation to be folded in to predictions of LSST's crowding limits.

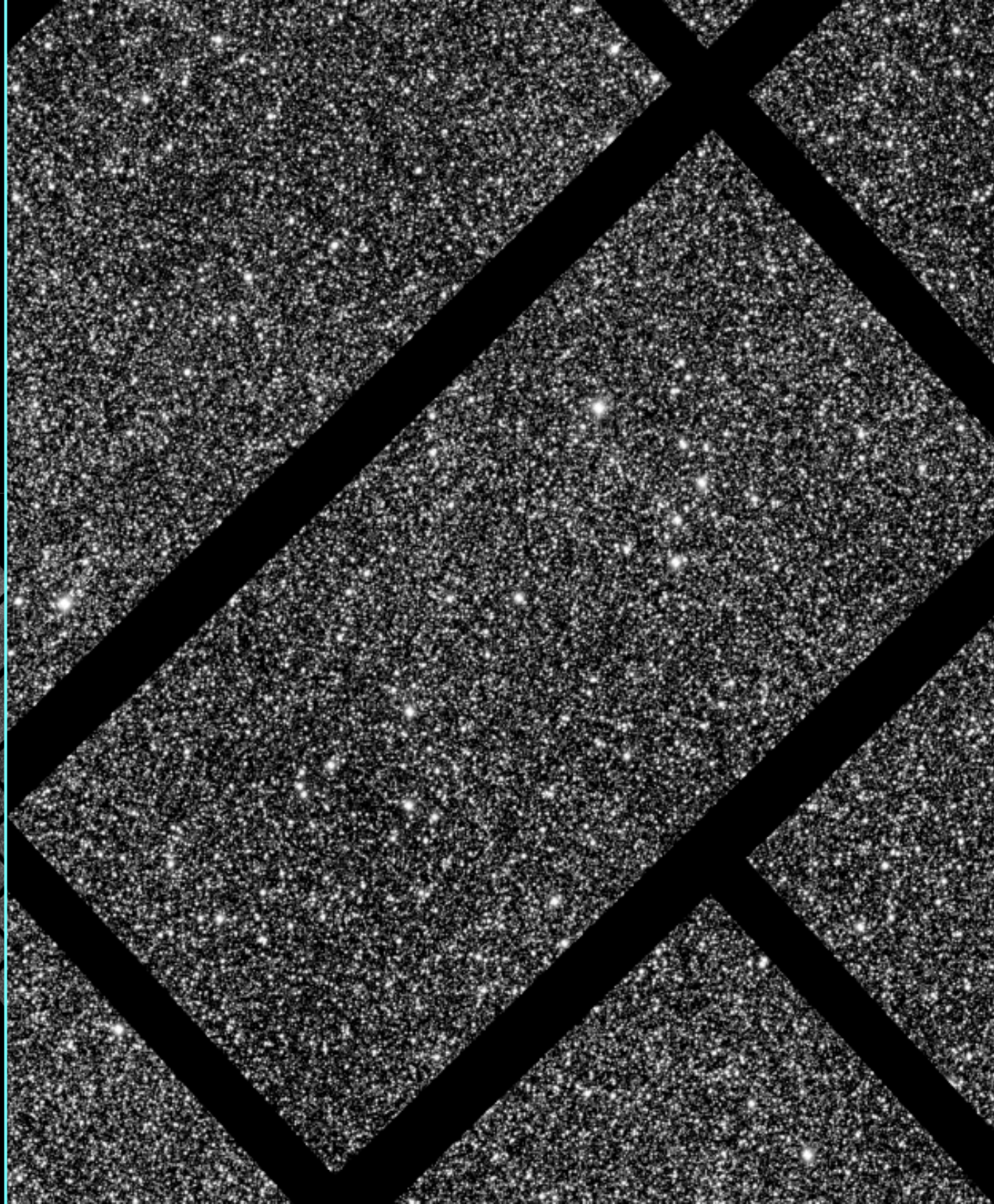




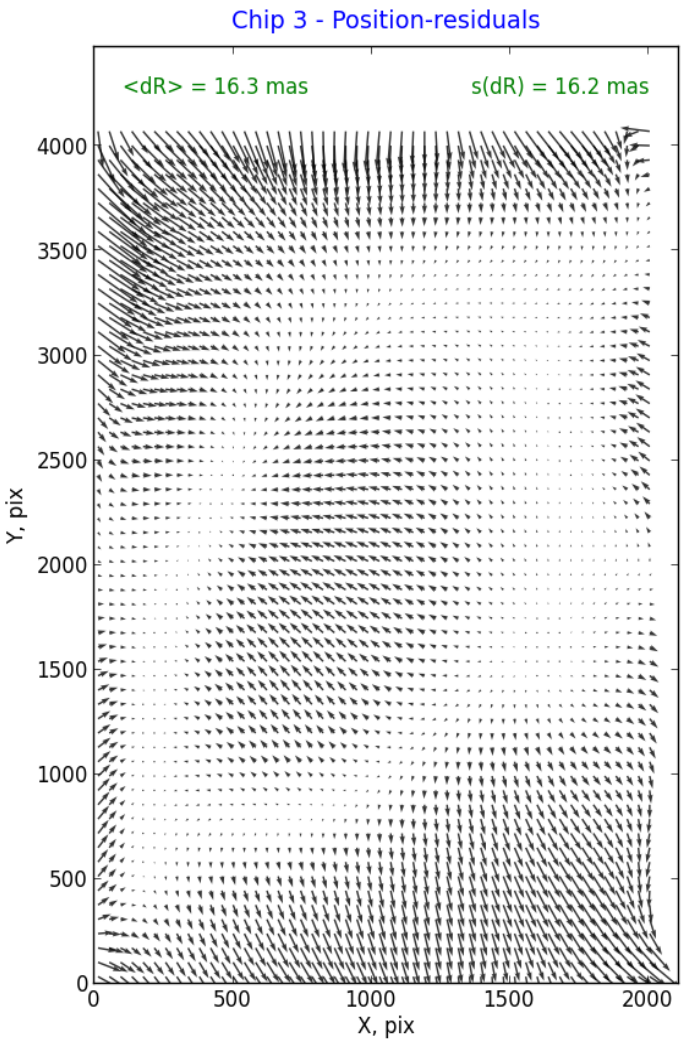
HST's ACS-WFC field of view superimposed on a typical DECam field at (l, b) ~ (1.0, -2.5)

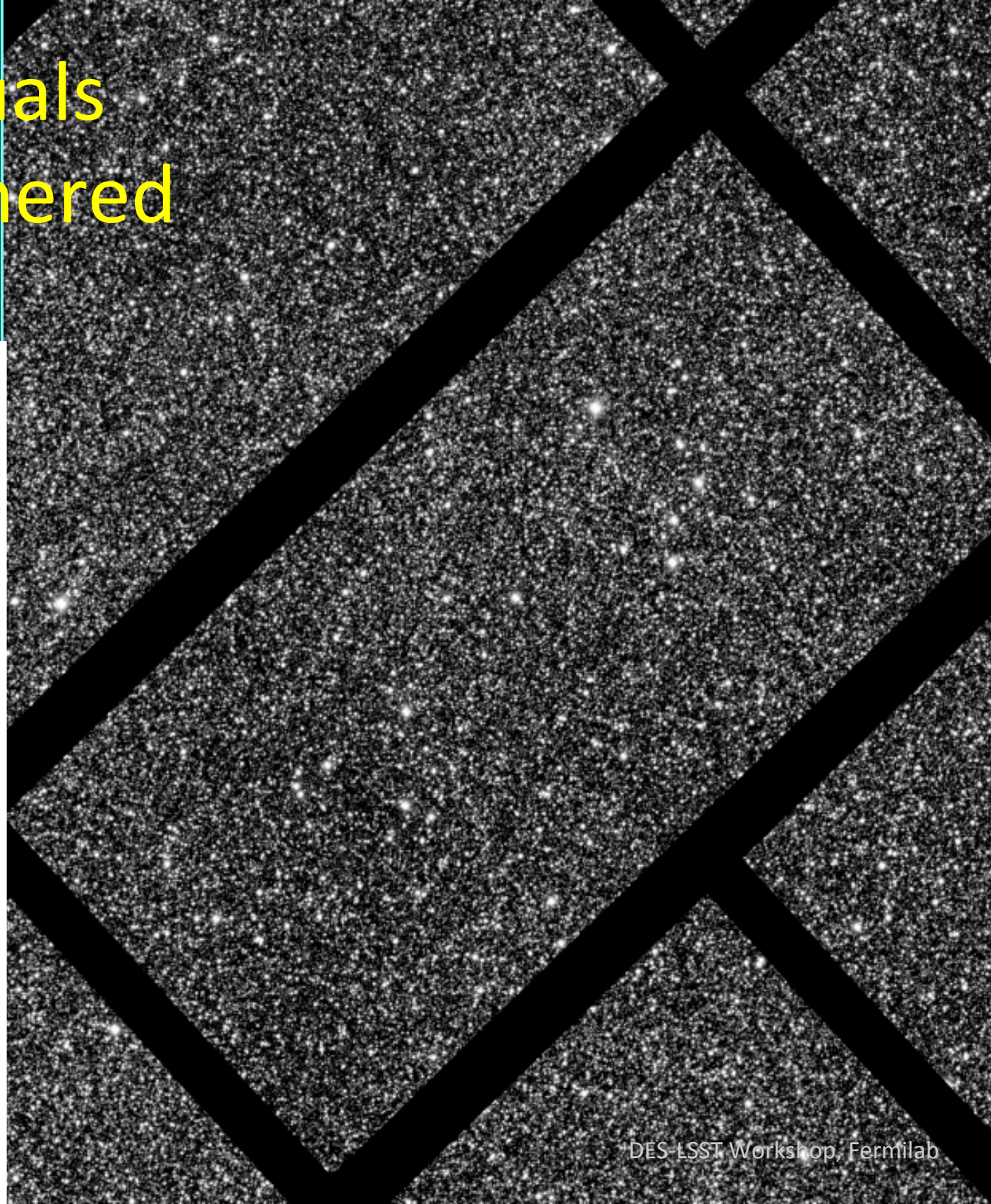
The Bulge should provide excellent calibrator fields for relative astrometry:





Position-residuals between a dithered image pair:





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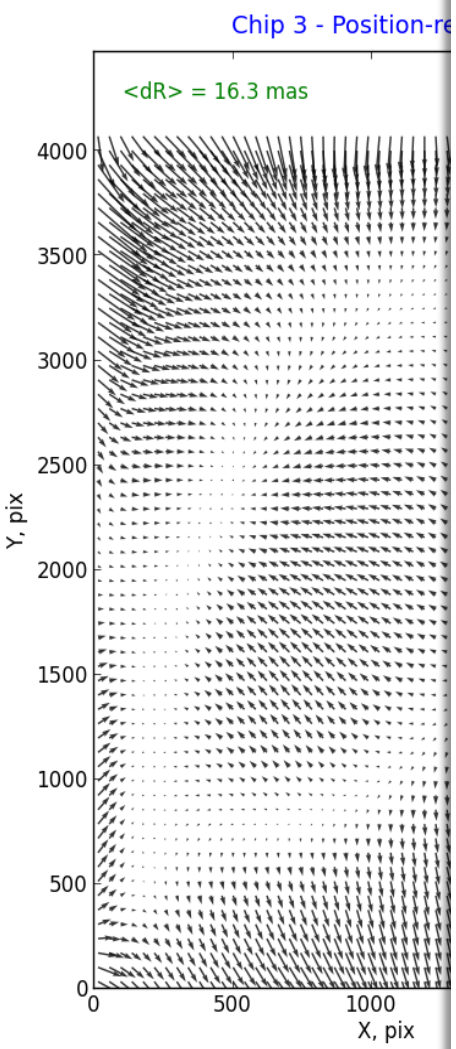

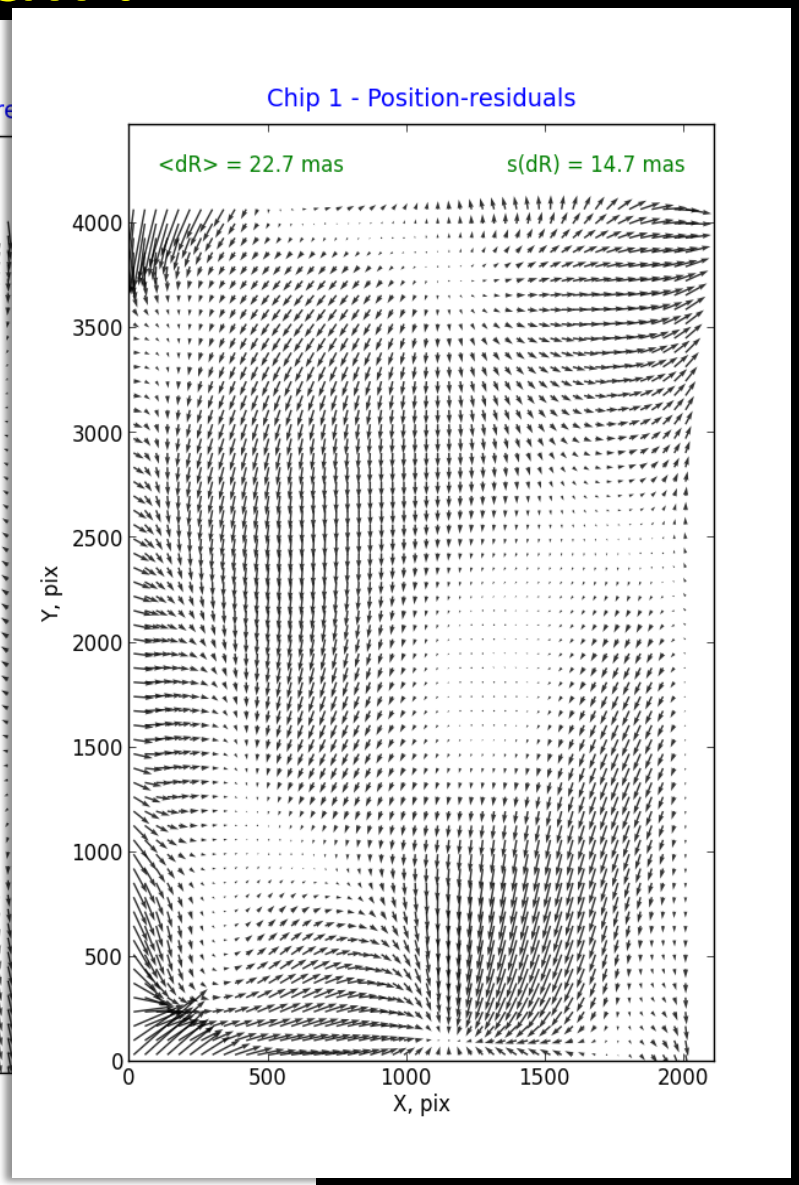

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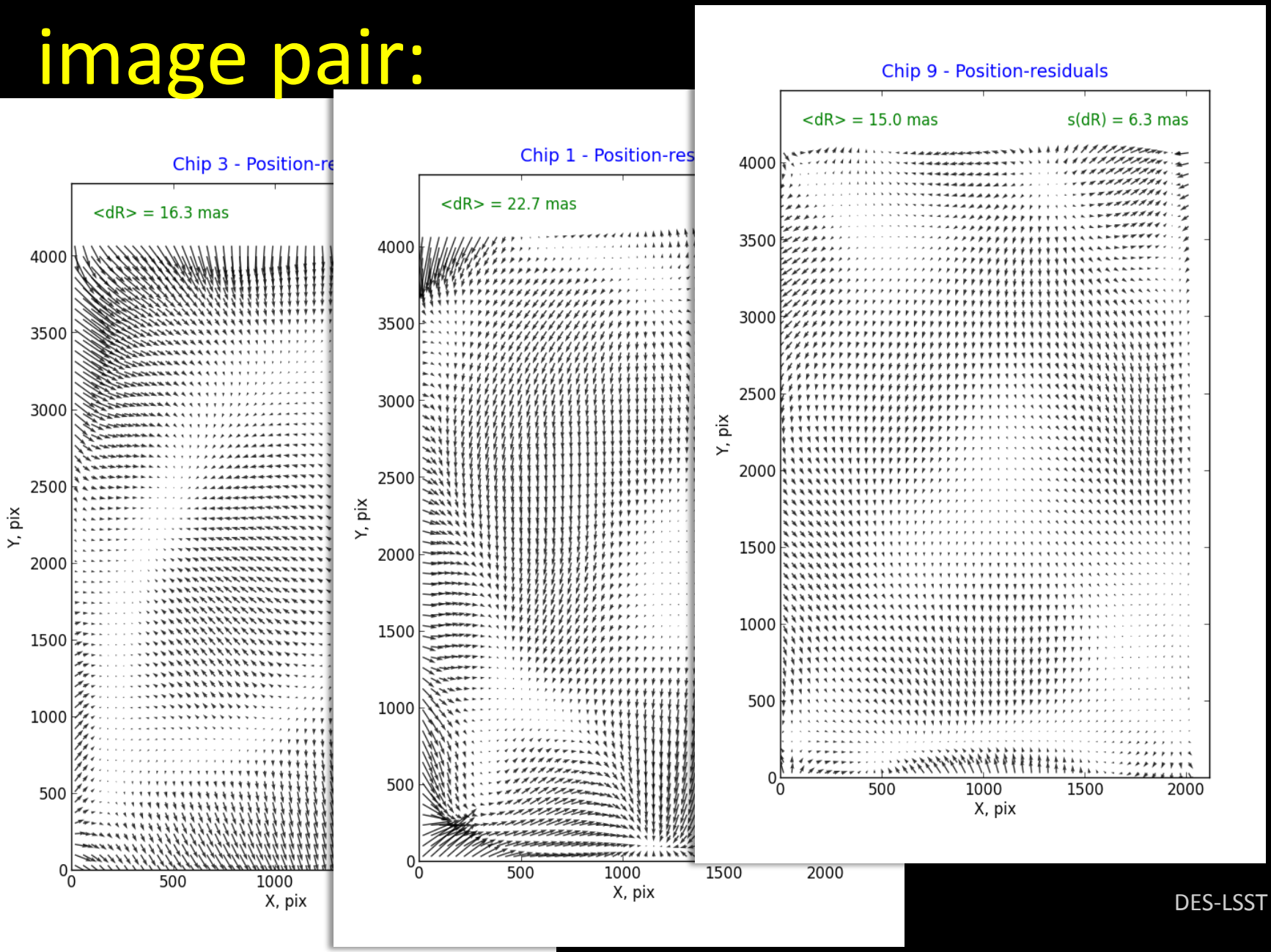

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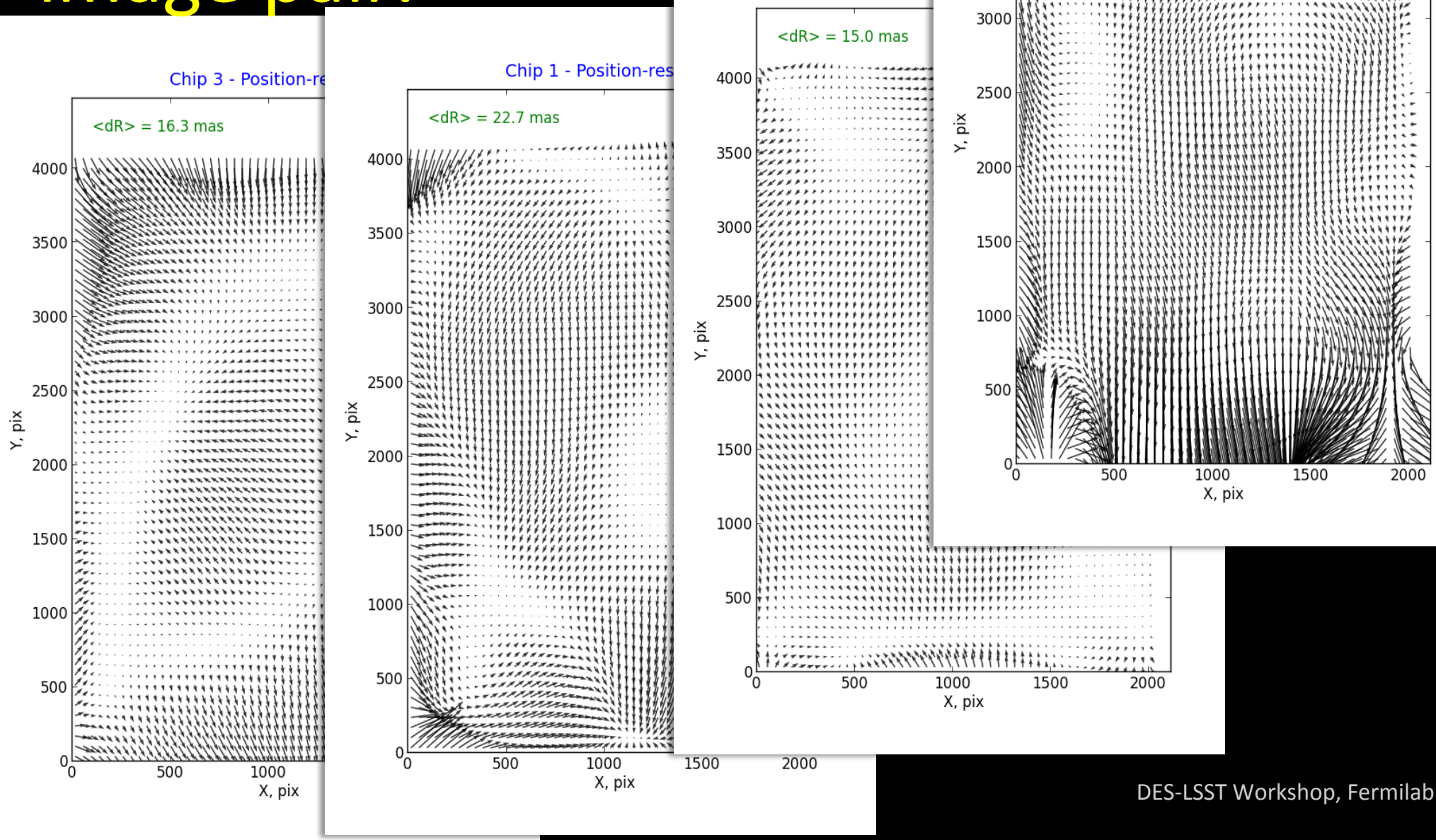
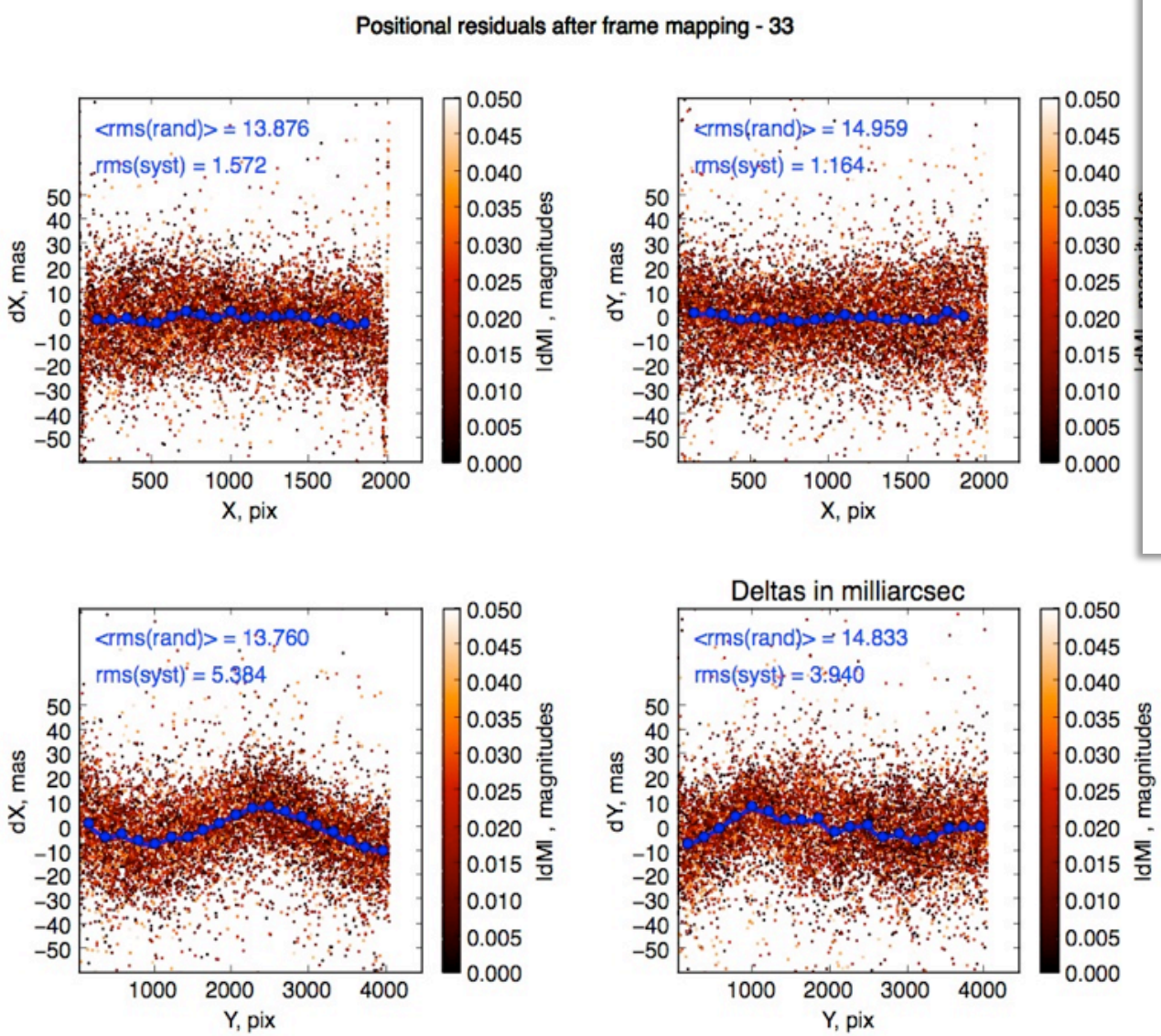
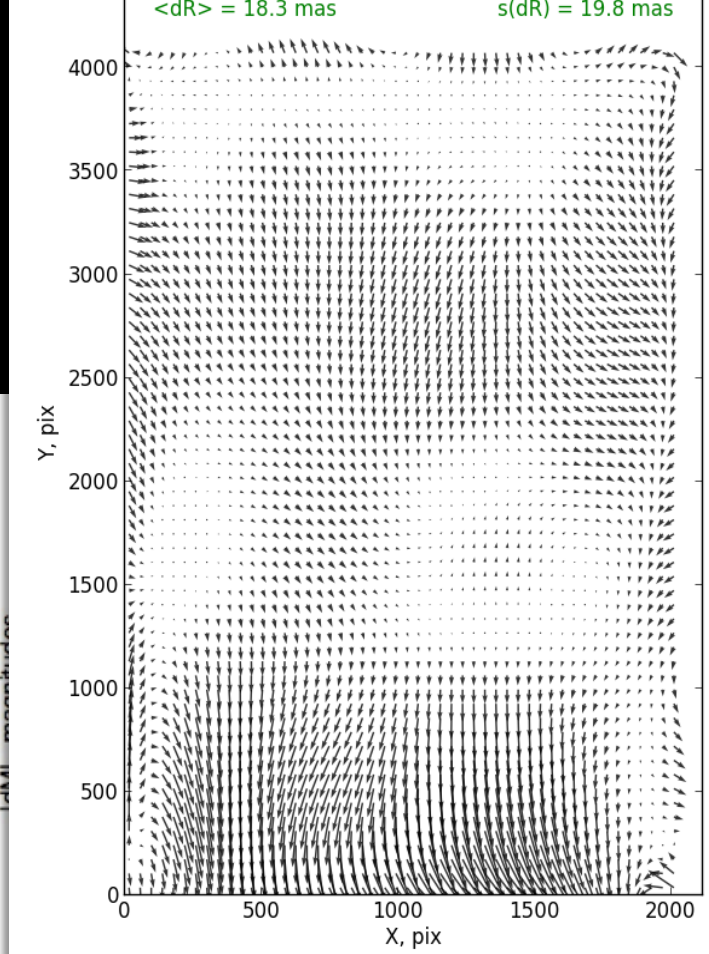
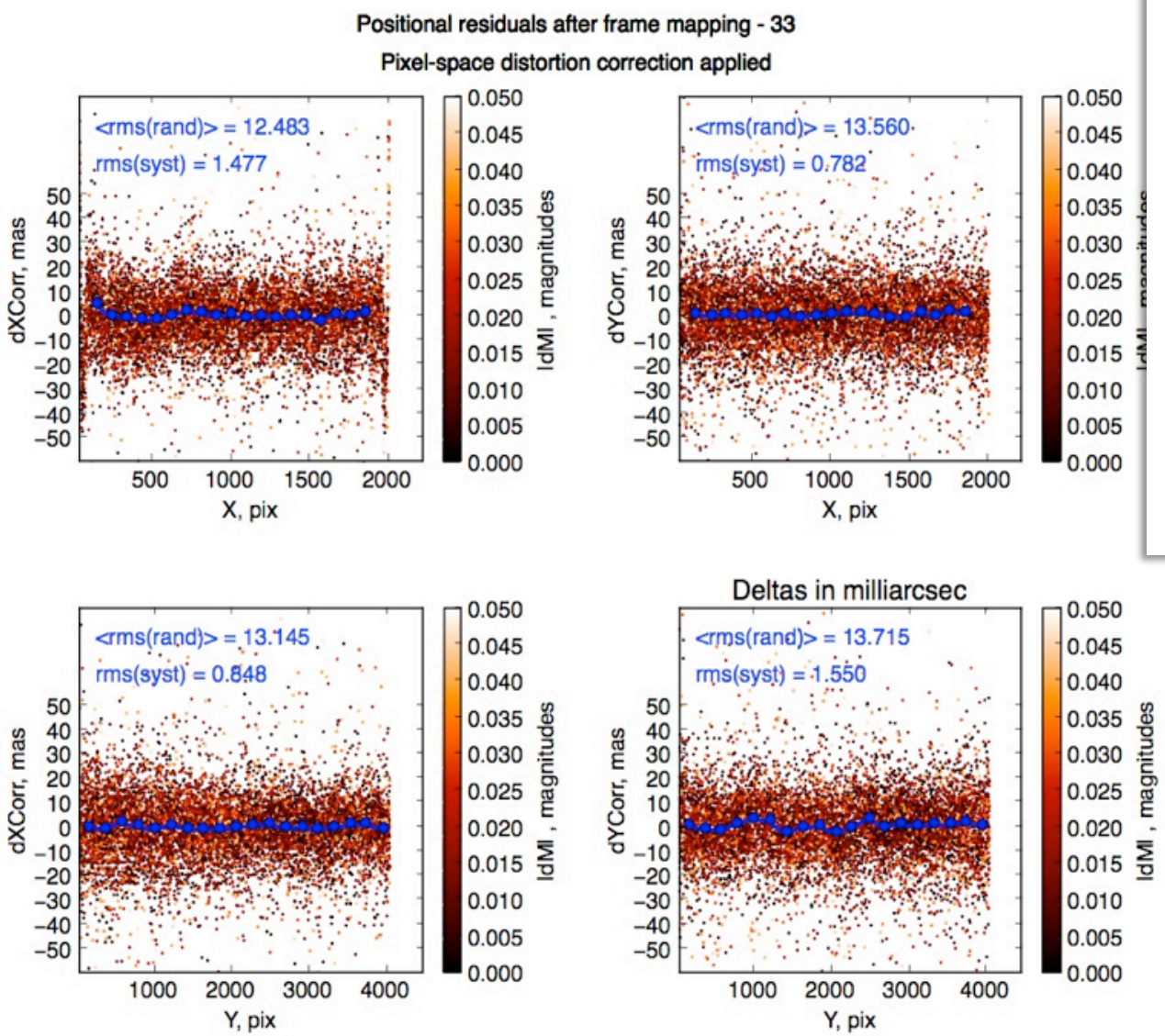


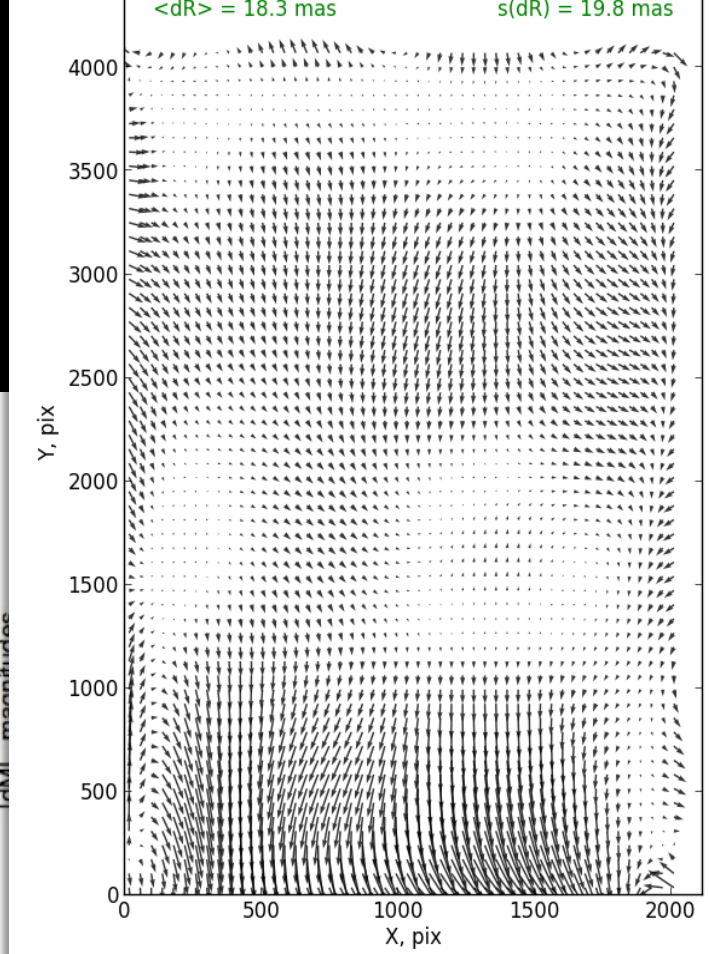
BDBS as a legacy dataset for proper motions:





BDBS as a legacy dataset for proper motions:





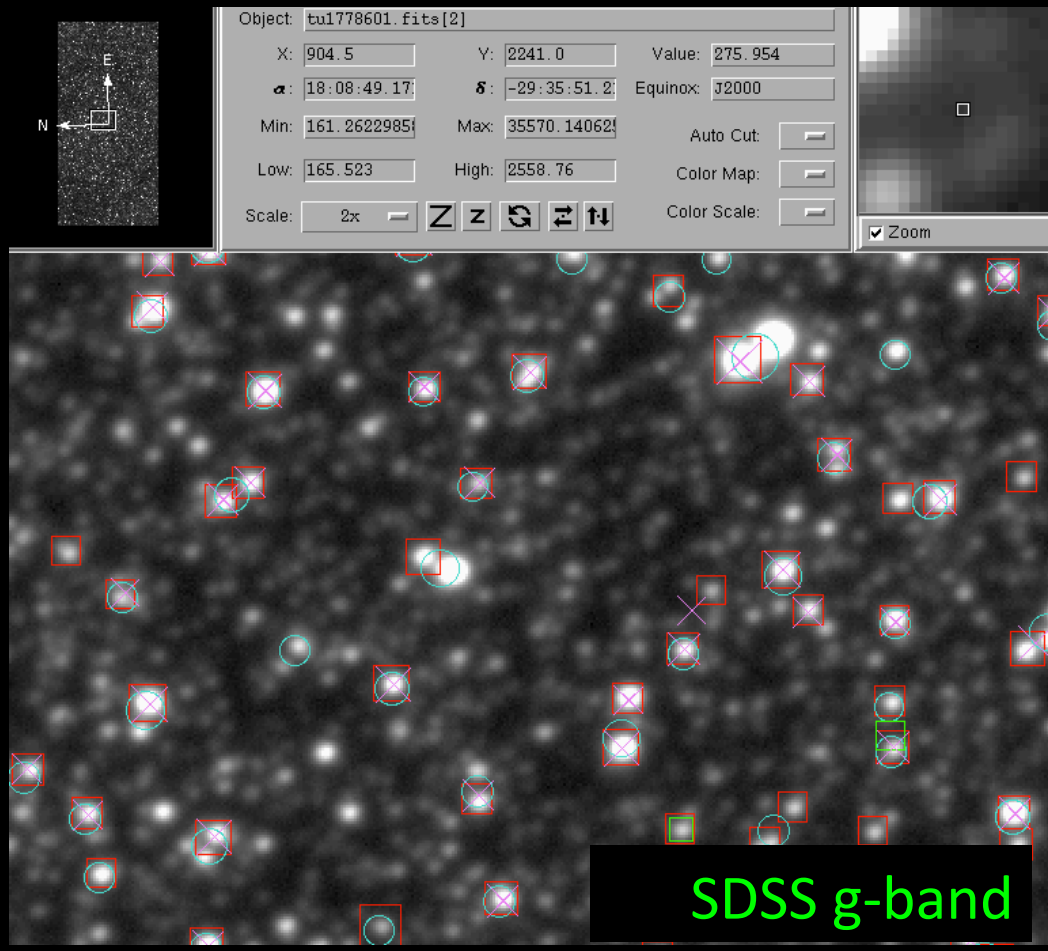
Talk Outline

- The Blanco DECam Bulge Survey
- Pointing DECam at highly crowded fields
- BDBS, DECam and LSST
- Interesting challenges / issues

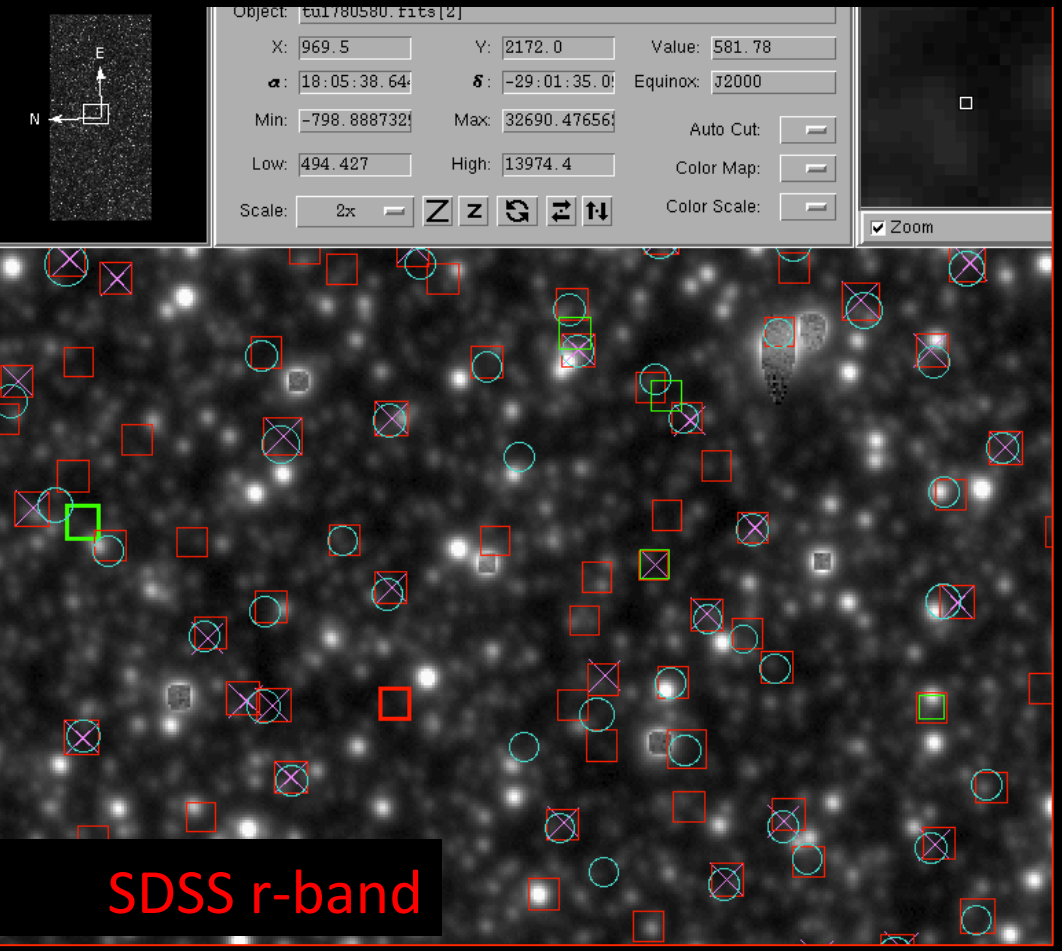
Absolute astrometric solution is challenging for our deeper exposures…

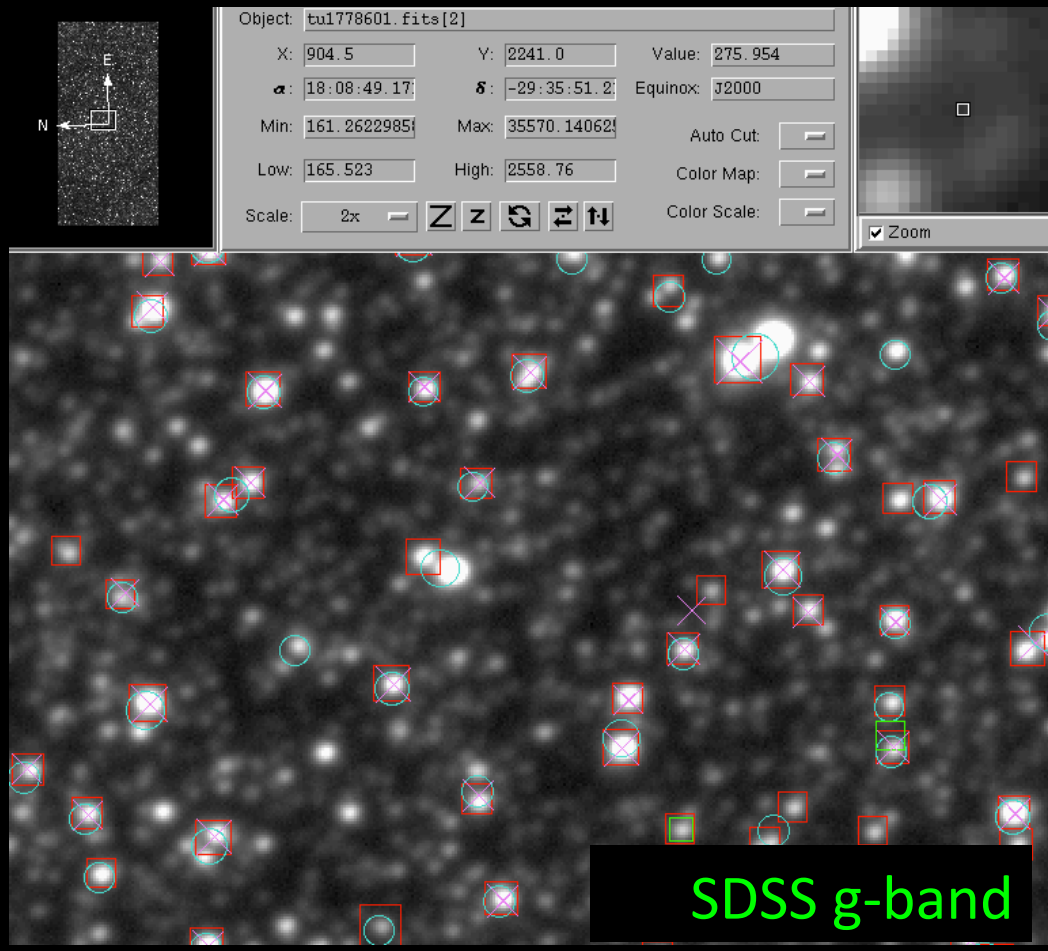
We want to use WCS mapped onto a trustable catalog, to accumulate our master-database of measurements.

Solving for the WCS in deep exposures is probably the most critical bottleneck currently faced by BDBS.



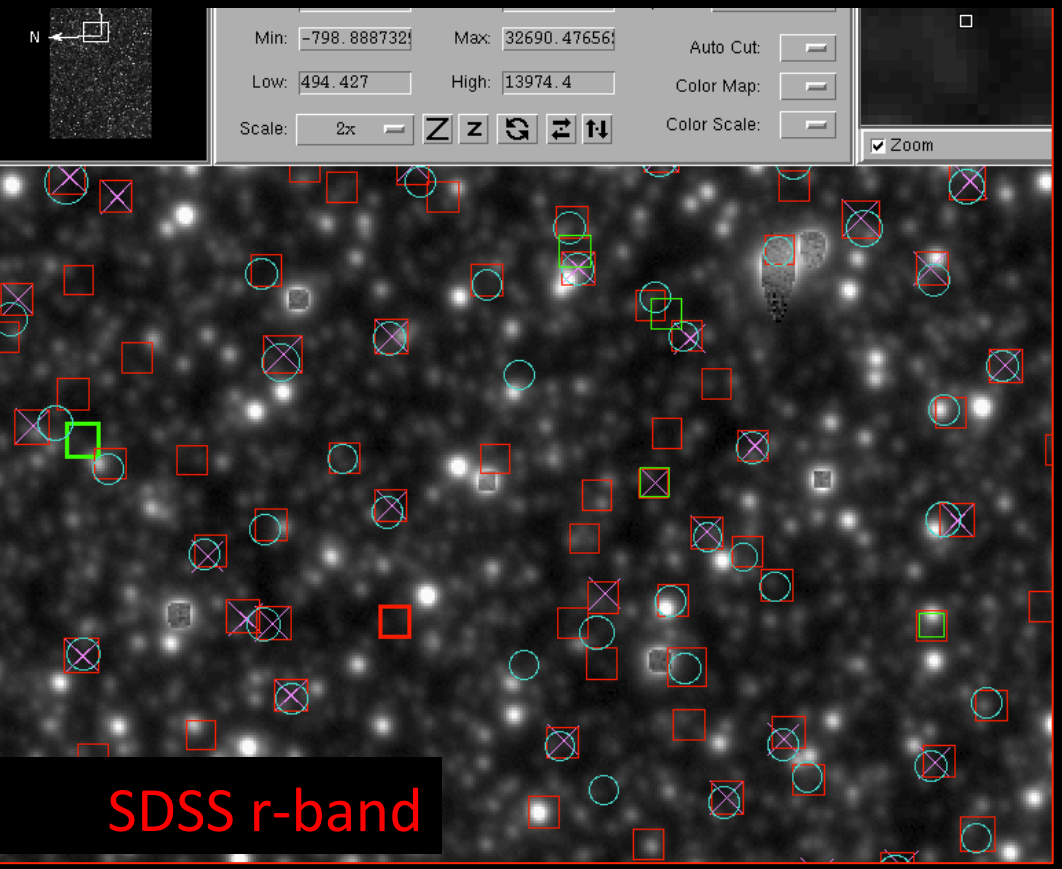
Absolute astrometric solution is challenging for our deeper exposures…

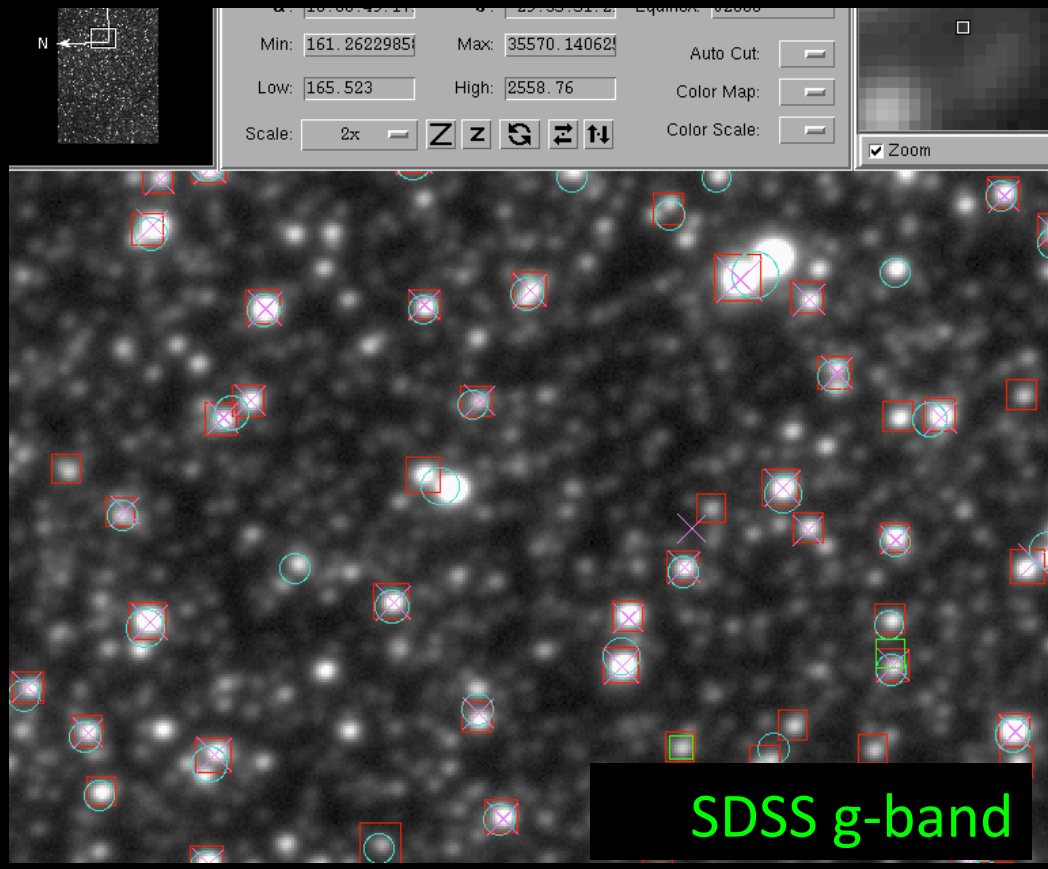




- … e.g. scamp fails on r-band in crowded regions whether 2MASS, GSC, UCAC-4 is used as reference…

Assigning WCS by mapping onto successful matches (different filter or the shorter exposures) may be the best approach.

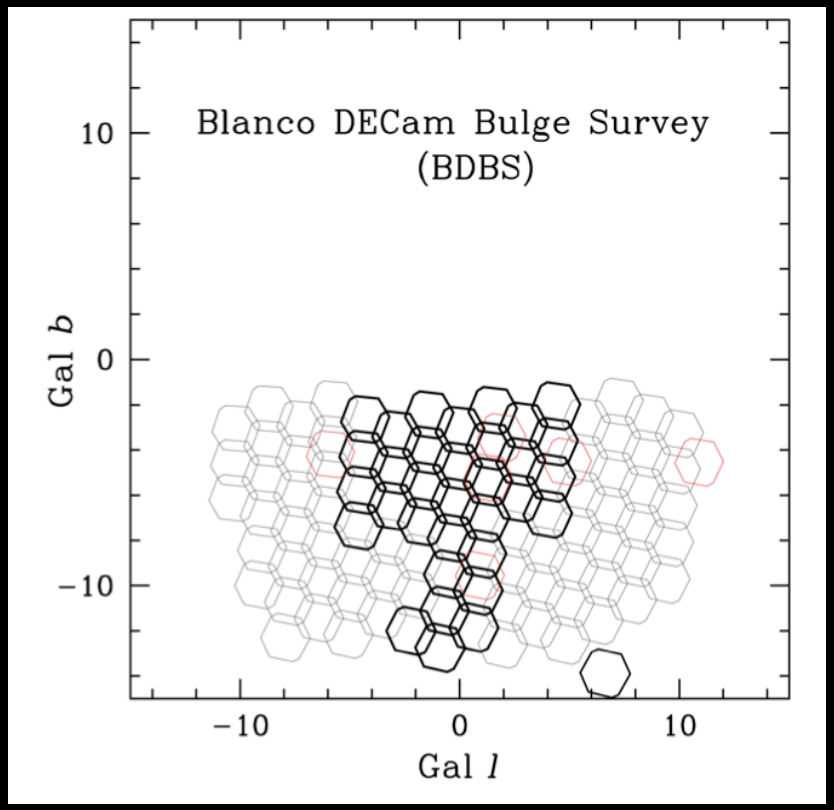


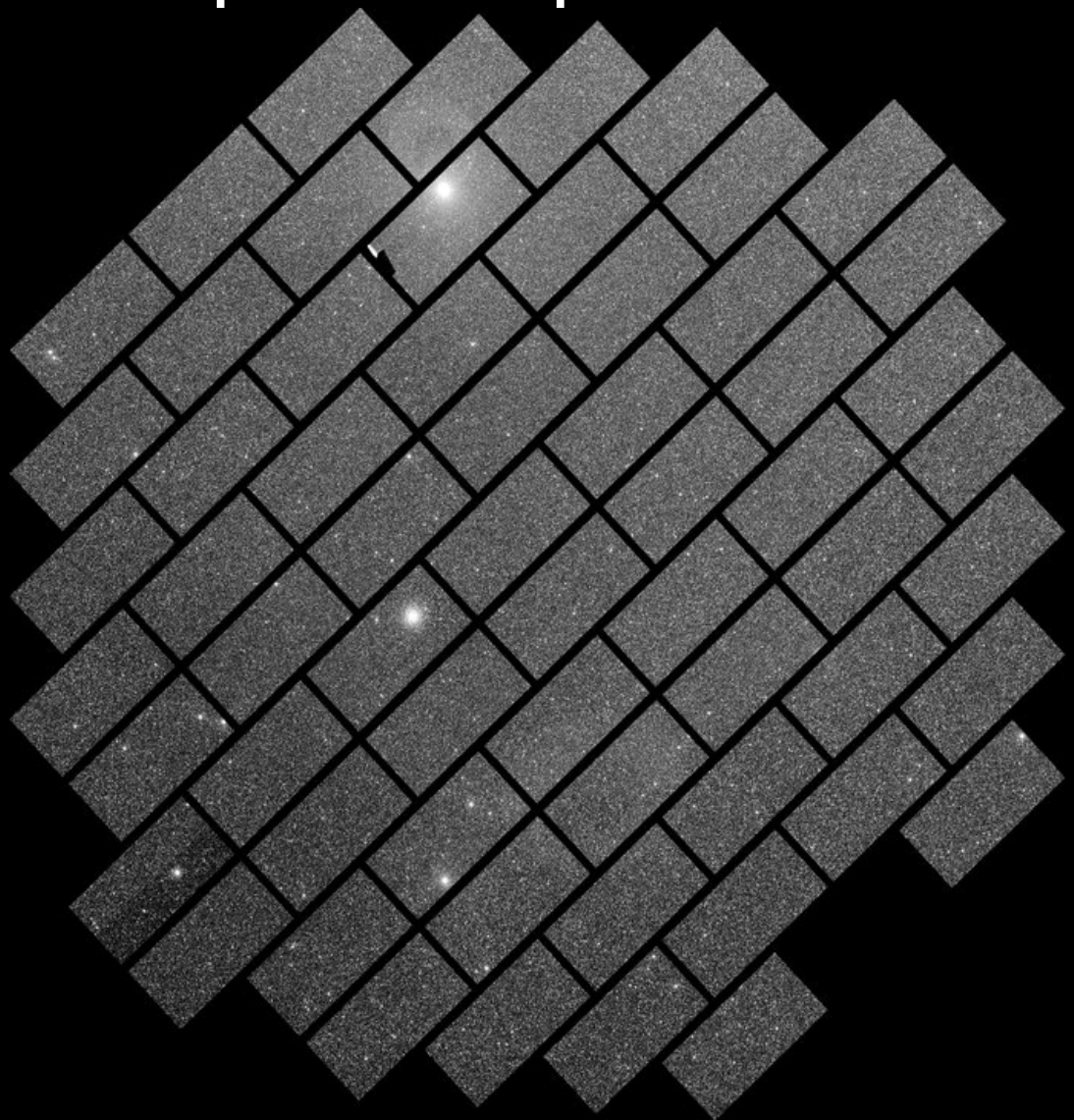


- Most of the BDBS short exposures have good astrometric solutions via SCAMP

The sheer number of measurements makes accumulating the catalog, non-trivial…

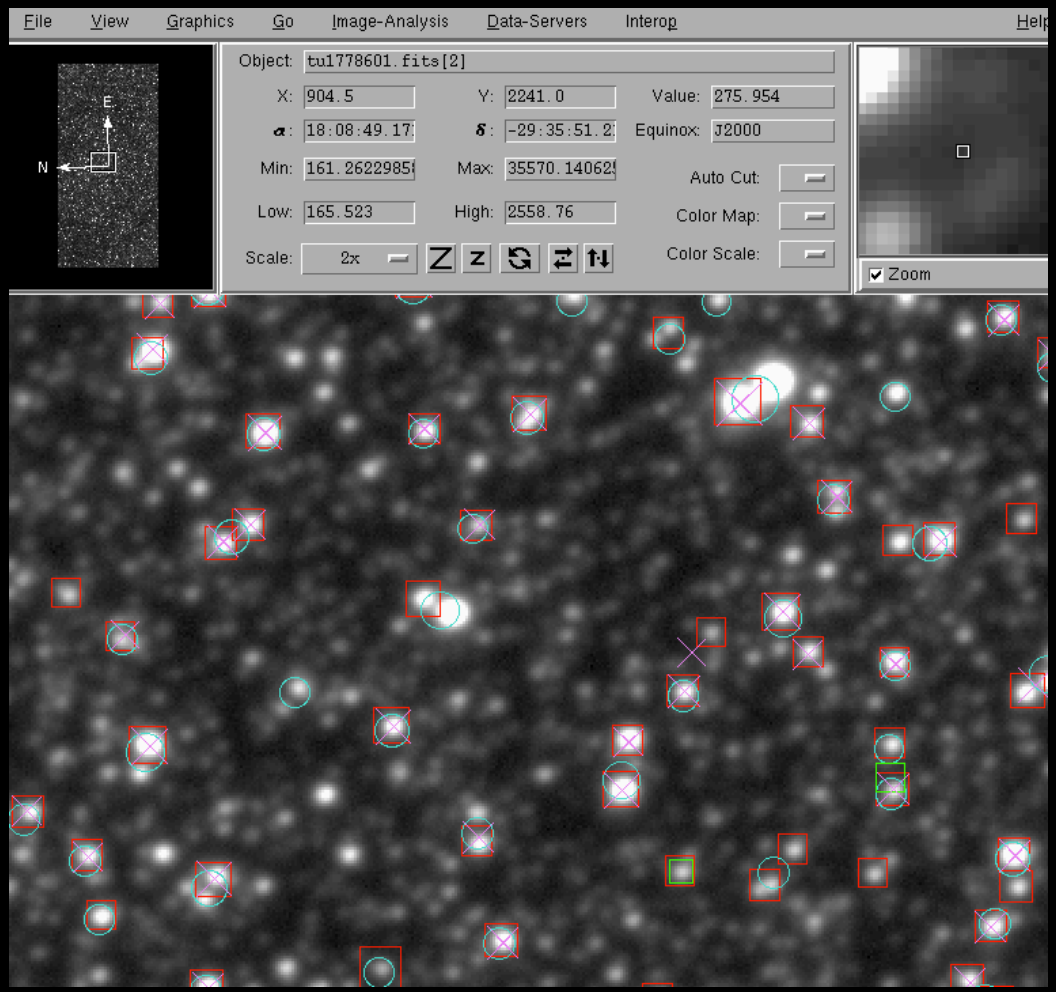
- Of order 5-10 million stars per field per exposure





Photometric calibration is an important challenge for this dataset

- Even for *griz* filters, standard catalogs are limited in depth over most of the BDBS survey area
  - Selected pencil-beams may help
- Y-band will be an interesting challenge to calibrate in its own right
- SDSS-stripe 82



Indications at this stage:

- DECam is already providing early epochs for LSST-era surveys of crowded regions like the bulge.
  - About 3.5 mag below the red-clump using single-pass photometry
  - Depending on the filter, about 1.3-1.7 times as many detections using more sophisticated treatments.
  - Already we are not far off the crowding limit.
- Crowding will likely not defeat LSST photometry at the MSTO.
  - (Although LSST's standard exposure time may yet be too deep)
- Some bulge fields provide excellent astrometric flat-fields to calibrate instantaneous distortion

Main challenges at this stage:

- WCS solution in moderately deep, highly crowded regions
  - Would be nice to have distortion represented as both TPV and SIP in the FITS headers!
- Accumulation and self-calibration of catalog of 0.1-1 billion stars
- Photometric calibration