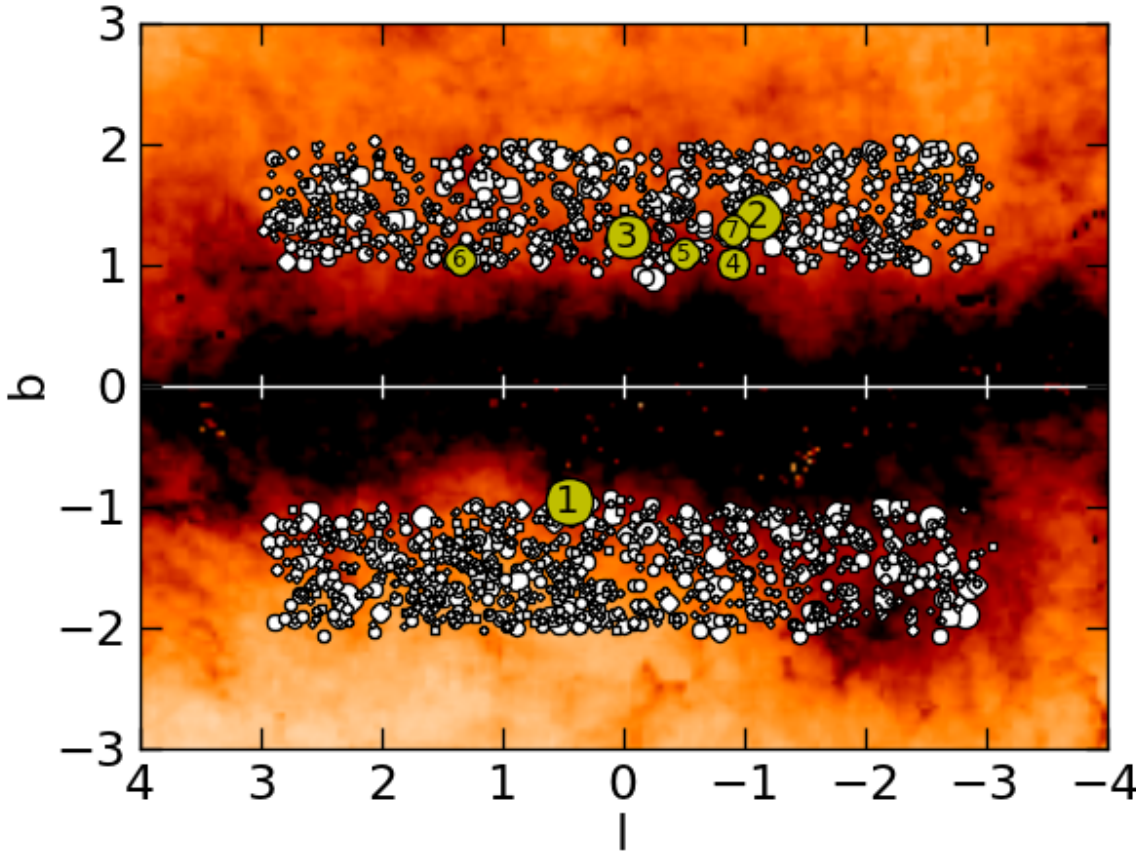
DECam Variability Surveys of the Galactic Bulge Survey Fields



Robert Hynes, Chris Johnson, Louisiana State University

Peter Jonker, Manuel Torres, Tom Maccarone, Chris Britt, Danny Steeghs, Sandra Greiss, Gijs Nelemans, and the wider GBS Collaboration

The Galactic Bulge Survey

Flux-limited X-ray survey

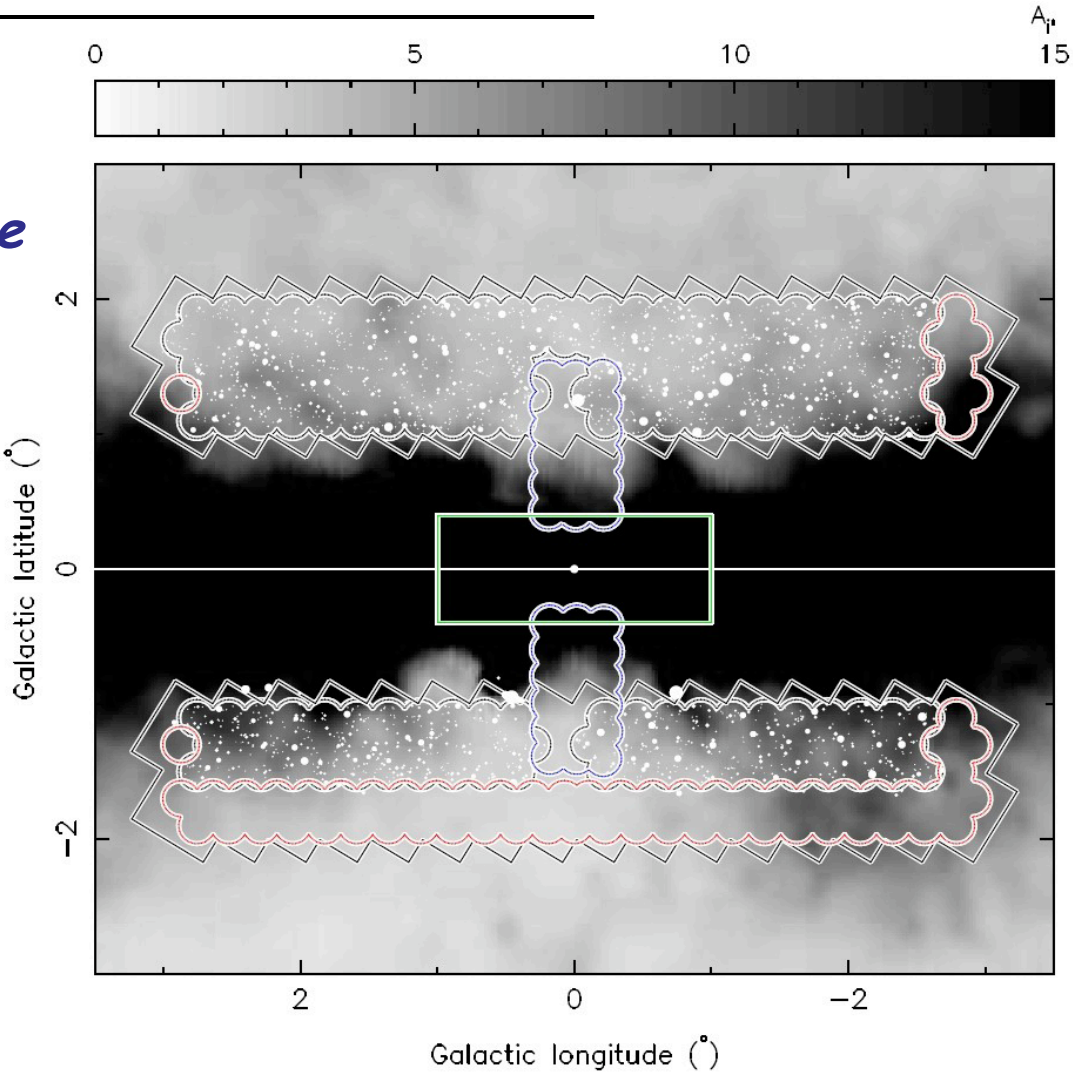
Galactic Bulge but off-plane

- Accessible optical counterparts

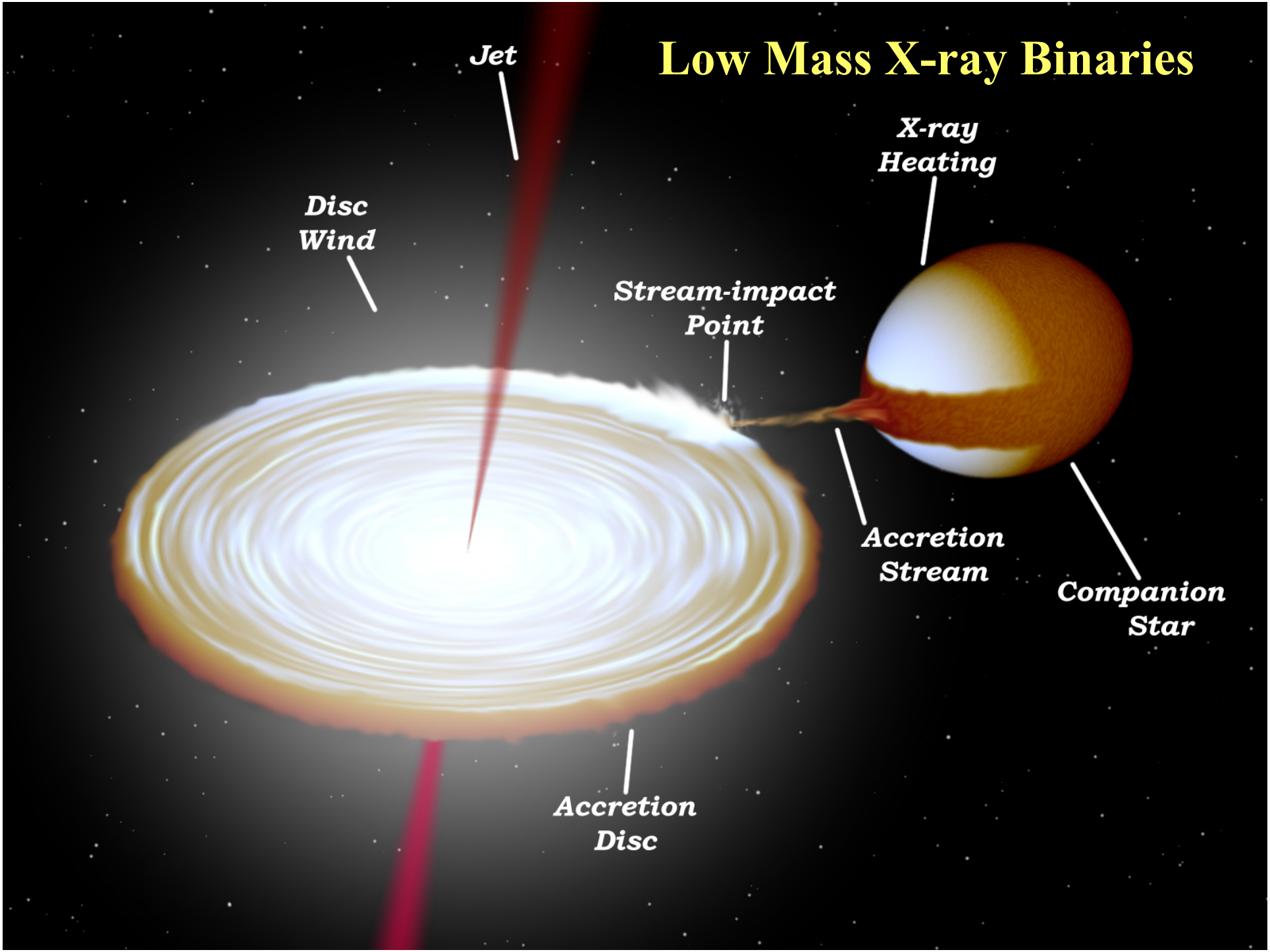
Wide but shallow

- Maximize numbers of intermediate luminosity sources

1640 X-ray sources



Jonker et al. (2011, ApJS, 194, 18); Jonker et al. (2014, ApJS, 210, 18)


Low Mass X-ray Binaries
Jet
X-ray Heating
Disc Wind
Stream-impact Point
Accretion Stream
Companion Star
Accretion Disc

Big Questions

How many low-mass X-ray binaries are in the Galaxy?

- Persistent vs. transient

What are the black hole and neutron star mass distributions?

- Eclipsing systems give most precise results

Where are the eclipsing black holes?

- Can they be found in quiescence?

Can we find more _____ systems*

** Insert your favorite cool objects here!*

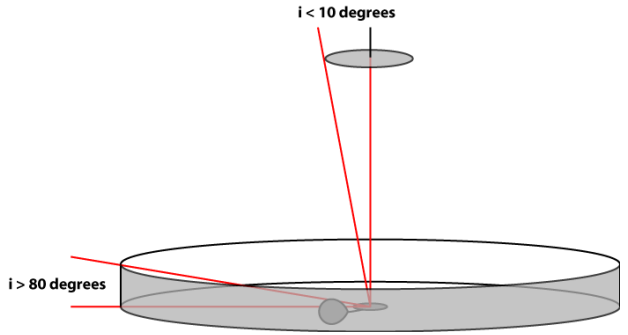
Active galactic nuclei, Algols, Be stars, Be X-ray binaries, Dwarf novae, Intermediate polars, Flare stars, Low mass X-ray binaries, Normal FGKM stars, Nova-likes, O stars, Pre-main sequence stars, Quiescent black hole binaries, RS CVns, Slowly pulsating B stars, Symbiotic stars, Symbiotic X-ray binaries, Ultracompact X-ray binaries, W UMas

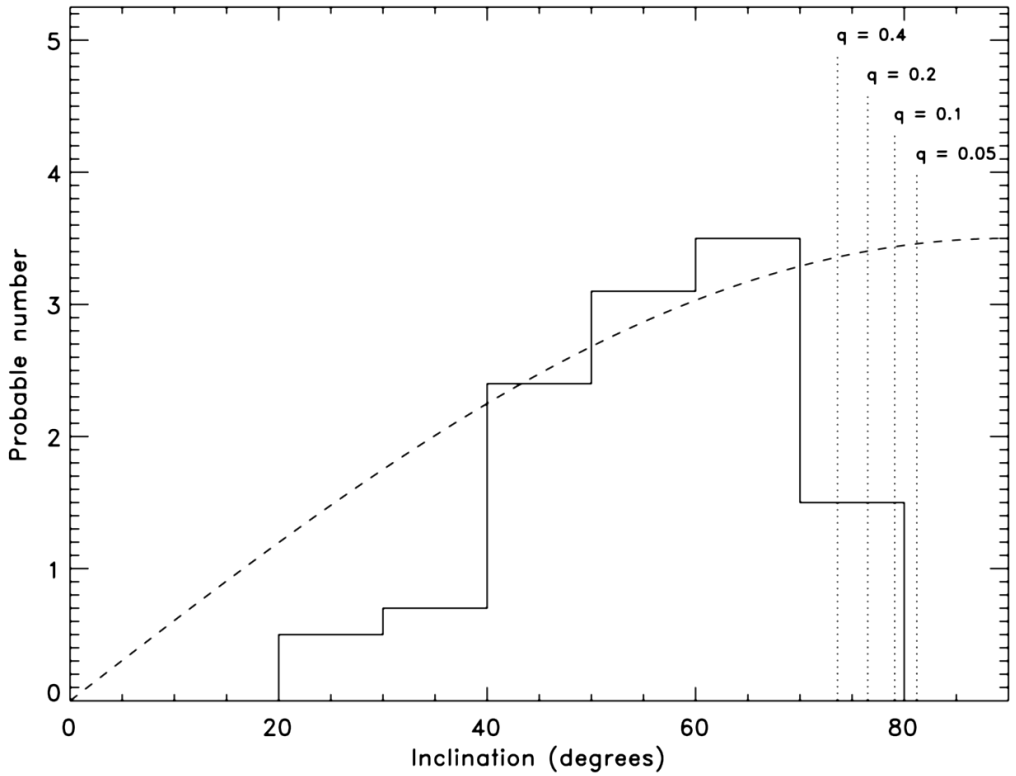
Where are the Eclipsing Black Holes?

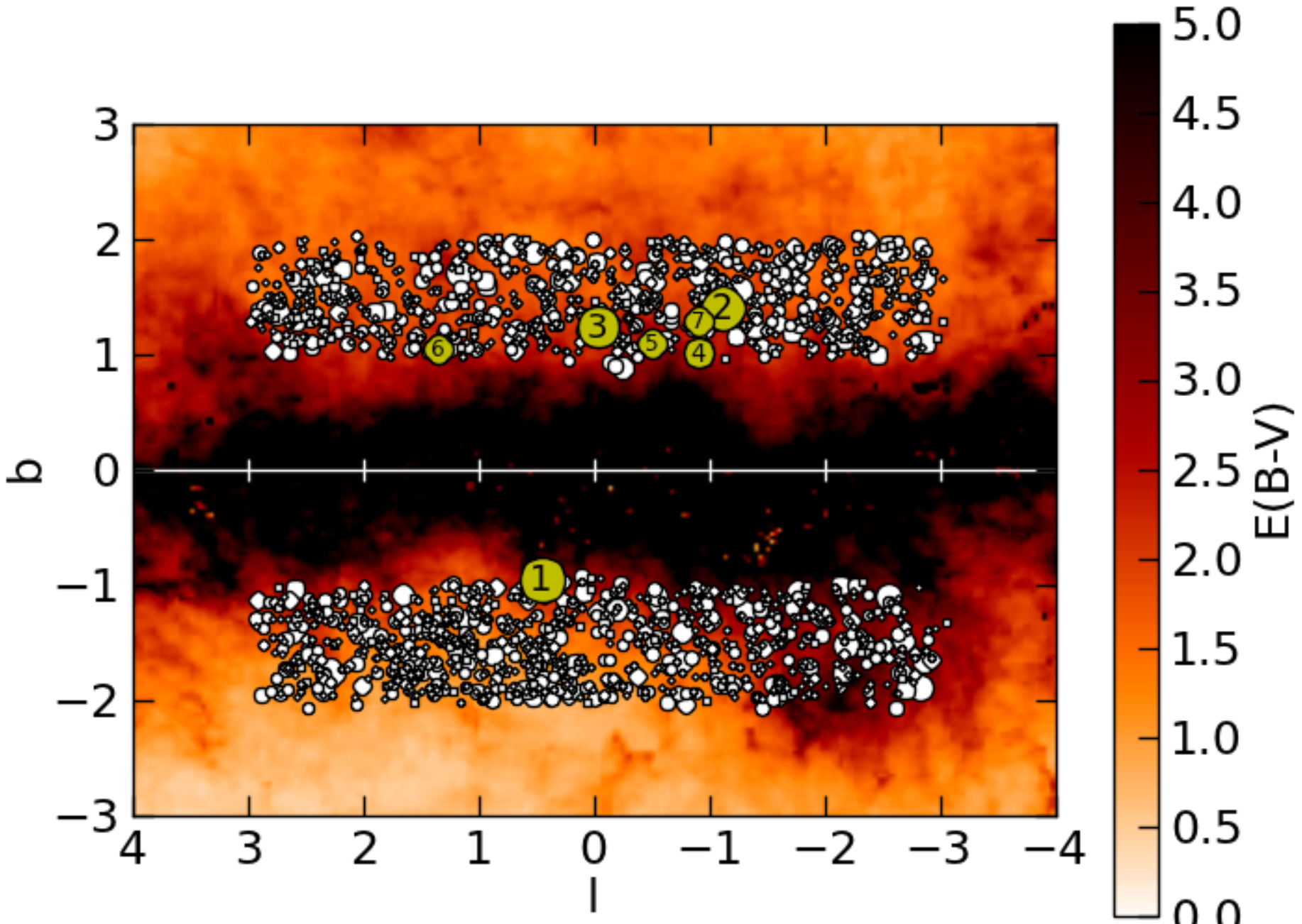
Binary inclination distributions

- Edge-on more likely than pole-on

  Probability (i) ∝ sin i



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Optical Variability Timescales

Minutes (DECam)

- Ultracompact X-ray binary orbital period
- Intermediate polar spin period
- CV and X-ray binary flickering

Hours (Mosaic II, DECam)

- CV and X-ray binary orbital period
- CV and X-ray binary flickering

Days (ASAS, OGLE, Mosaic II)

- Long period X-ray binary orbital period
- Dwarf novae outbursts

Years (ASAS, OGLE)

- X-ray binary outbursts

Mosaic II Variability Survey

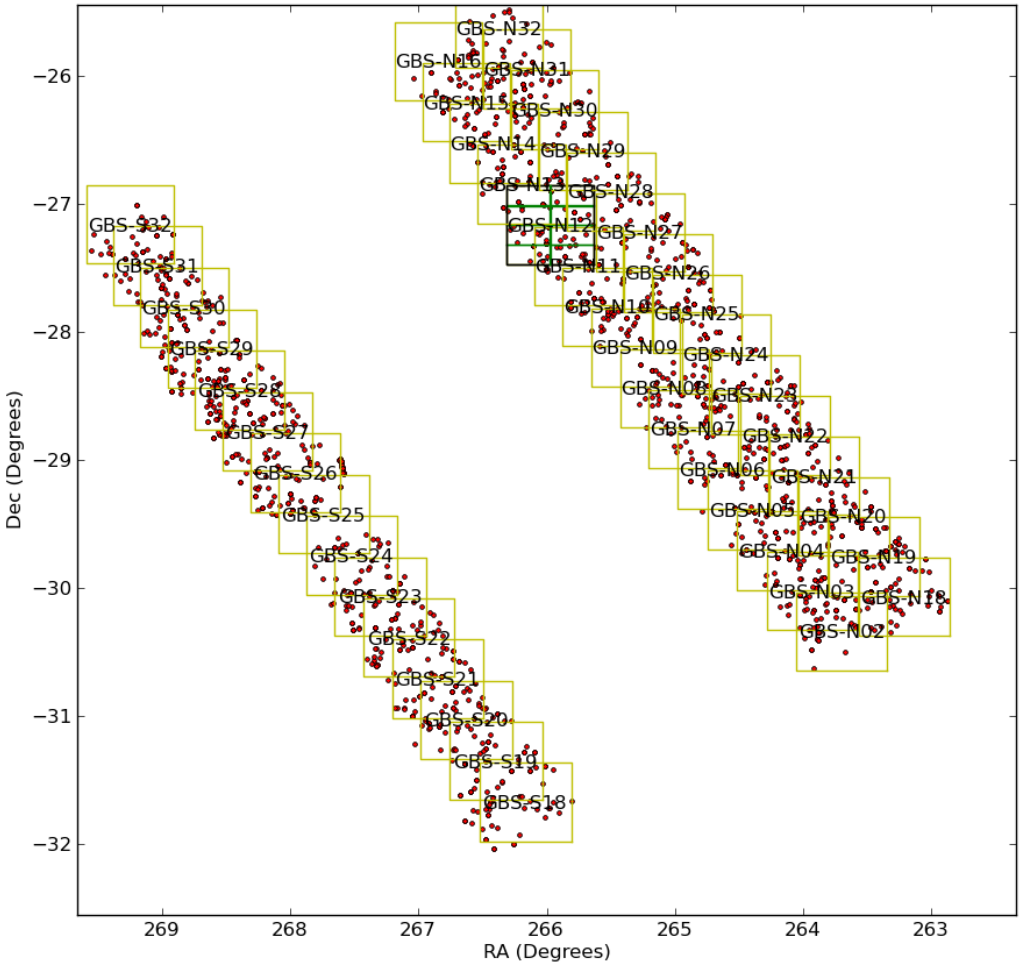
CTIO 4m Blanco / Mosaic II

- 8 nights in 2010 June
- 45 fields, repeated 2-3 times per night
- Random sequence to break aliases

Variable counterparts

- 165 variables

- Eclipses
- Ellipsoidal
- Outbursts
- Irregular/flickering
- Long period variable
- …



Britt et al. (2014, ApJS, 214, 10)

DECam Coverage of the GBS

Southern GBS, r

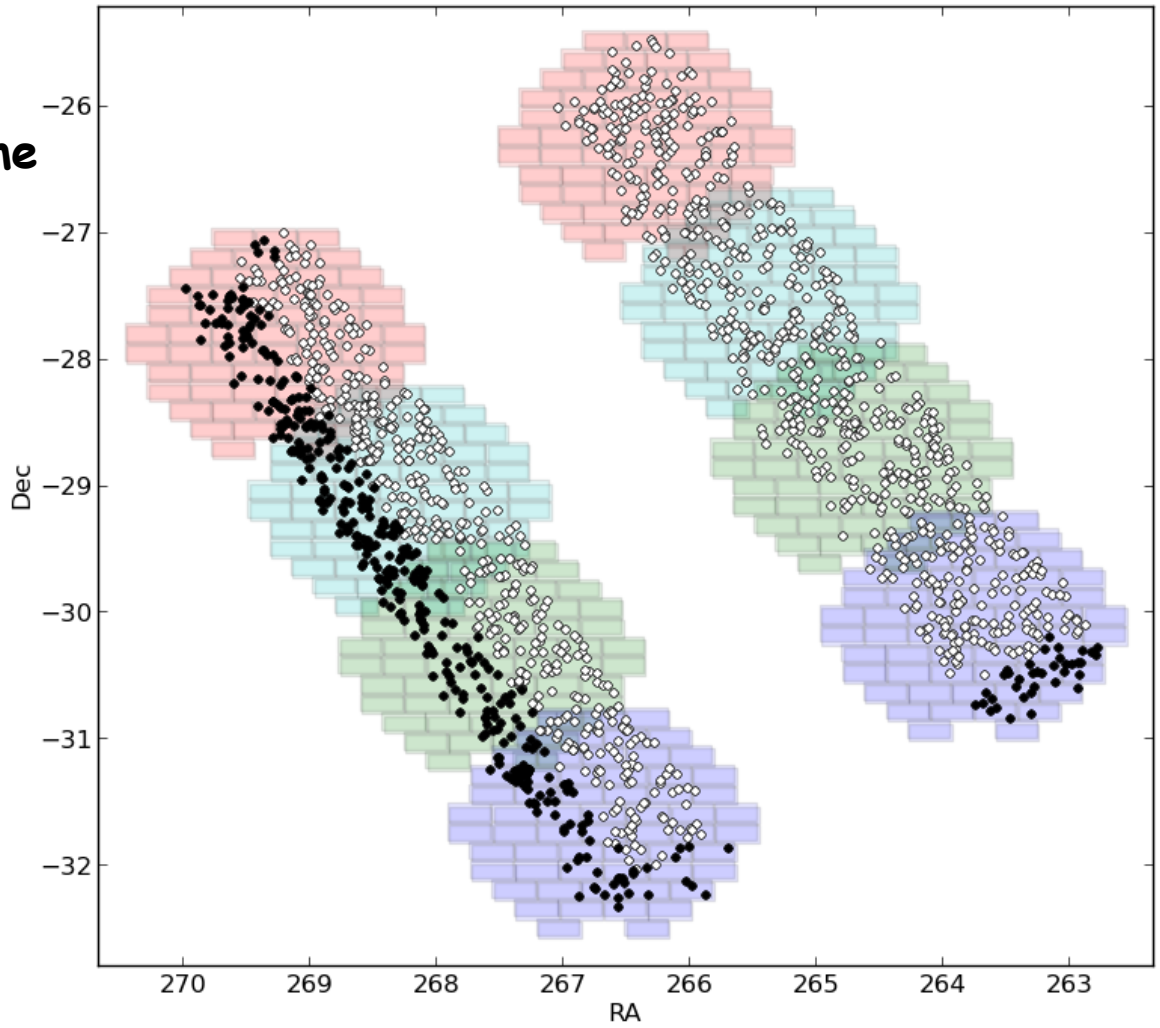
- Summer 2013
- Chandra AR Joint Time

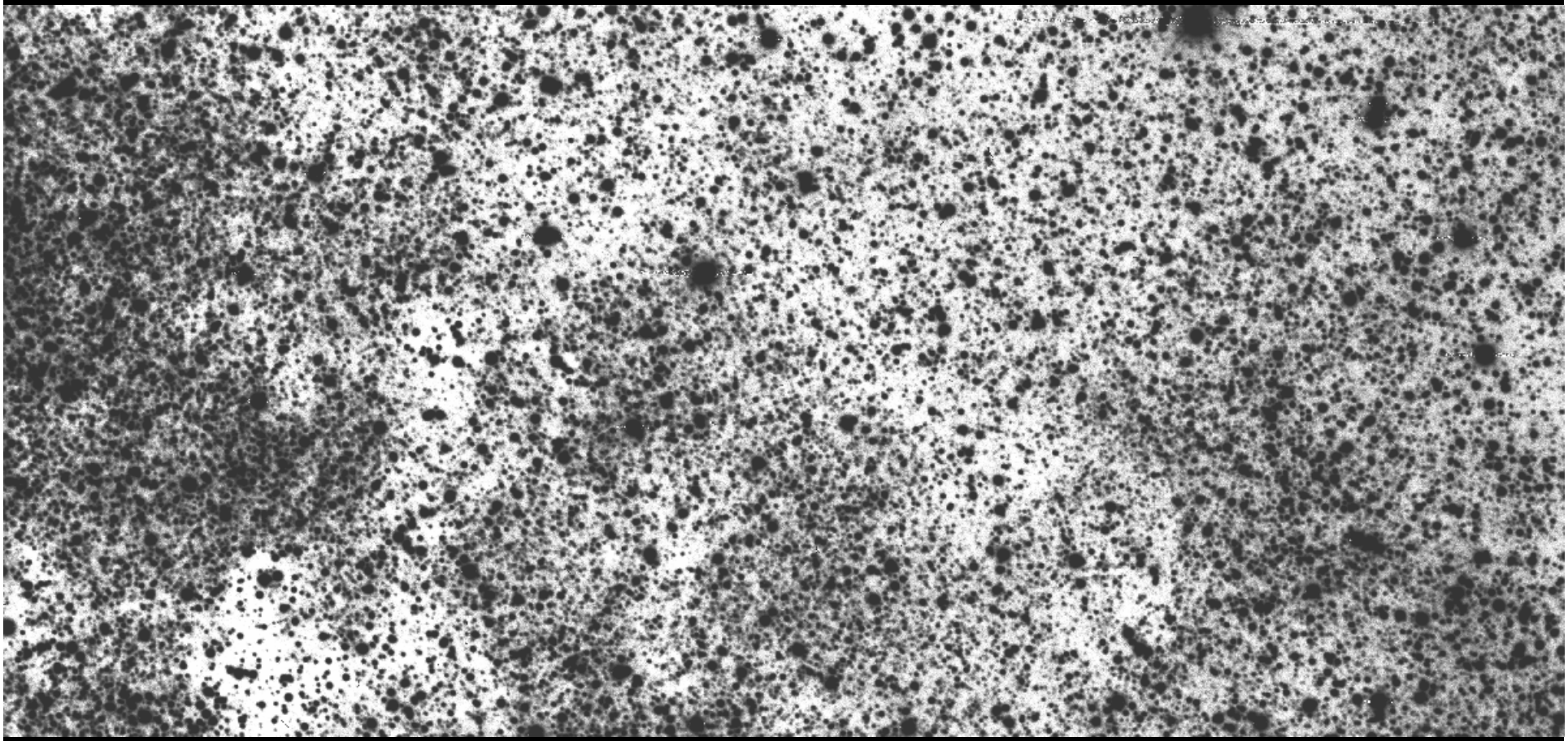
Northern GBS, i

- Summer 2014
- NOAO

Strategy

- 4 fields repeated 25-30 times per night
- Typical 5-10 min cadence





Data Analysis

Begin with pipeline processed images

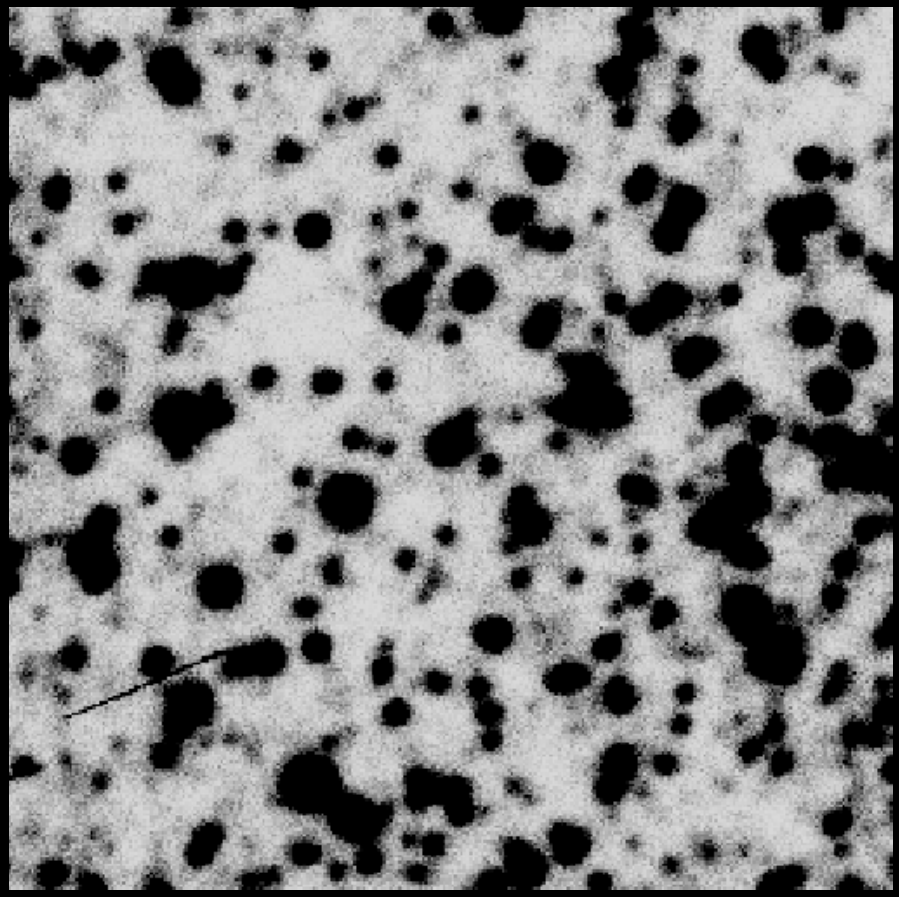
Aperture photometry

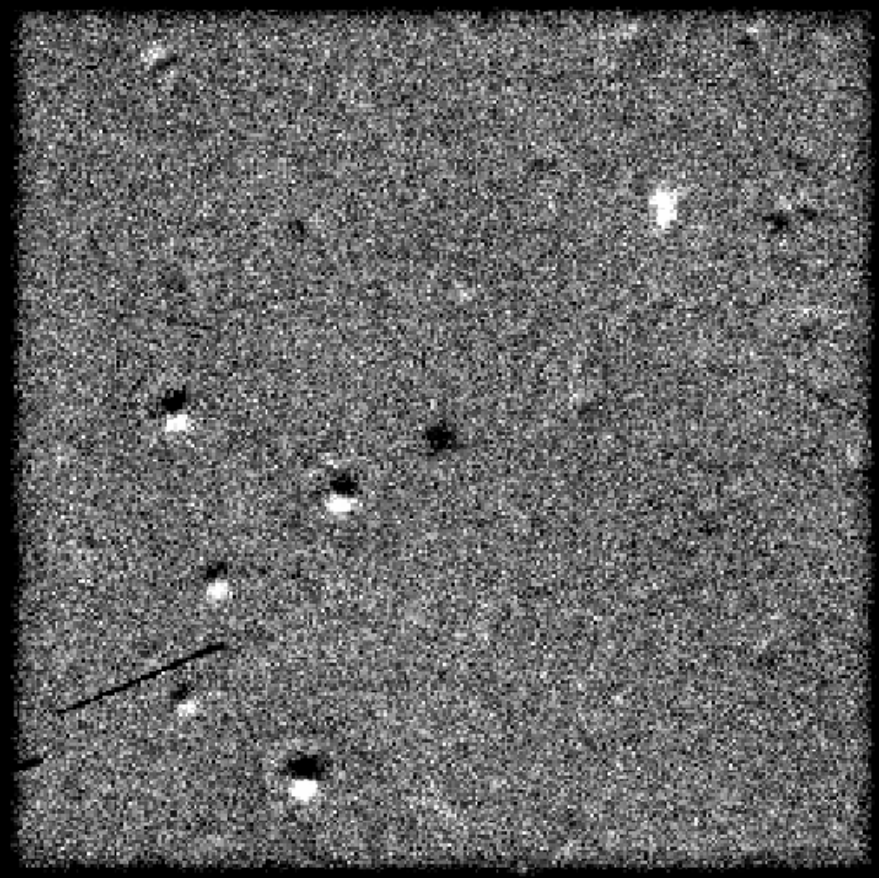
- Only useful for uncrowded objects
- Best for 1 sec exposures

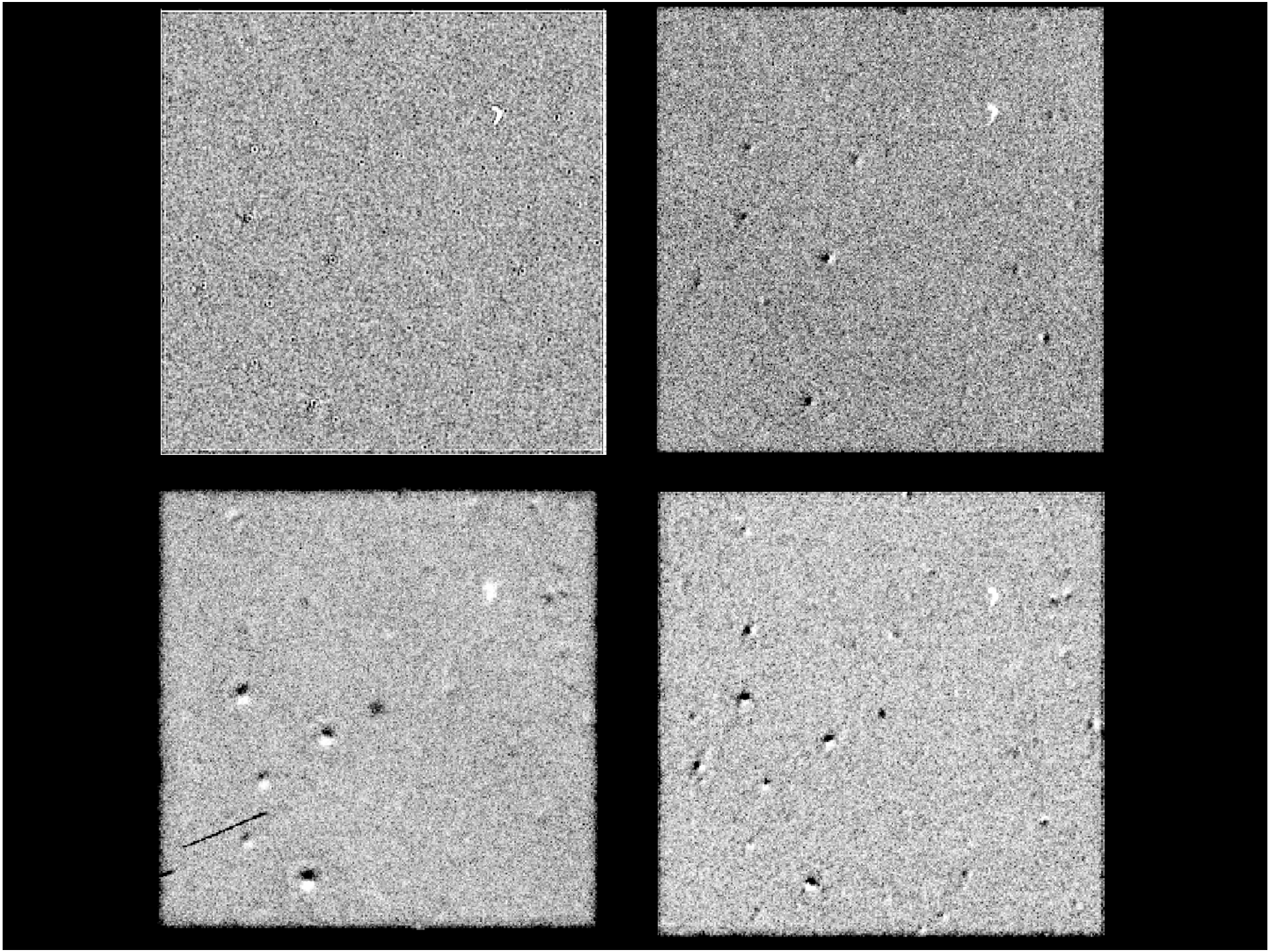
Image subtraction

- Python code based on Bramich et al. (2013, MNRAS, 428, 2275) algorithm
- Pixelated PSF allows miscentering
- Allows independent control of background, transparency, and PSF variation
- Still ironing out some issues

Careful source-by-source approach to optimize reduction and filter false variables.







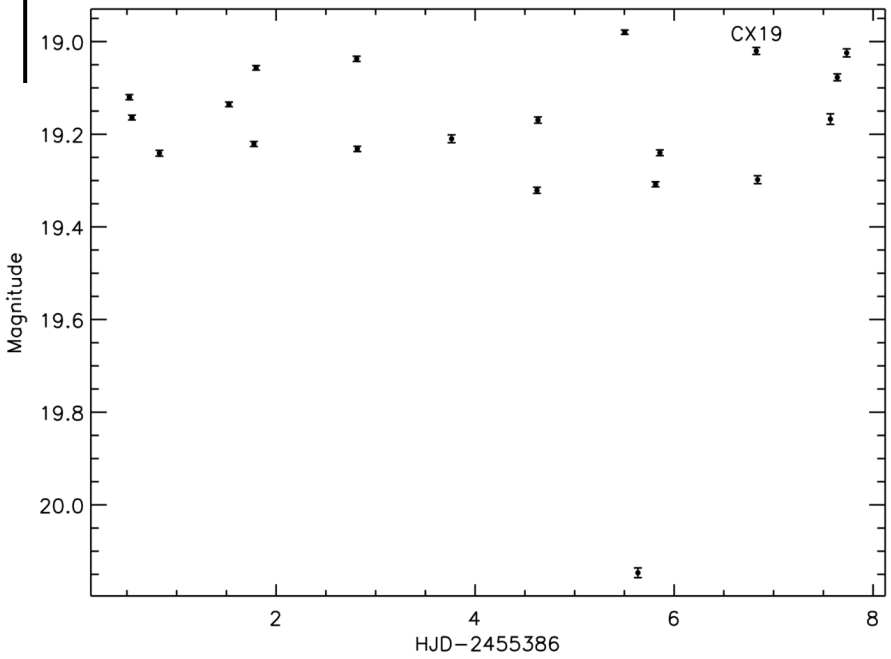
From Mosaic II to DECam…

Mosaic II Survey

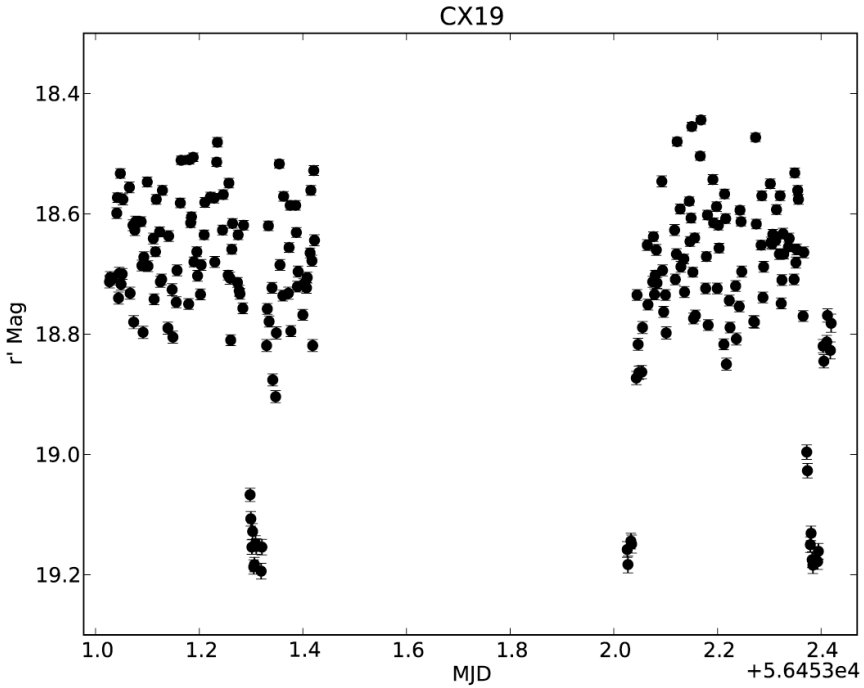
- 2-3 observations per night without overlaps

DECam Surveys

- 25-30 observations per night without overlaps

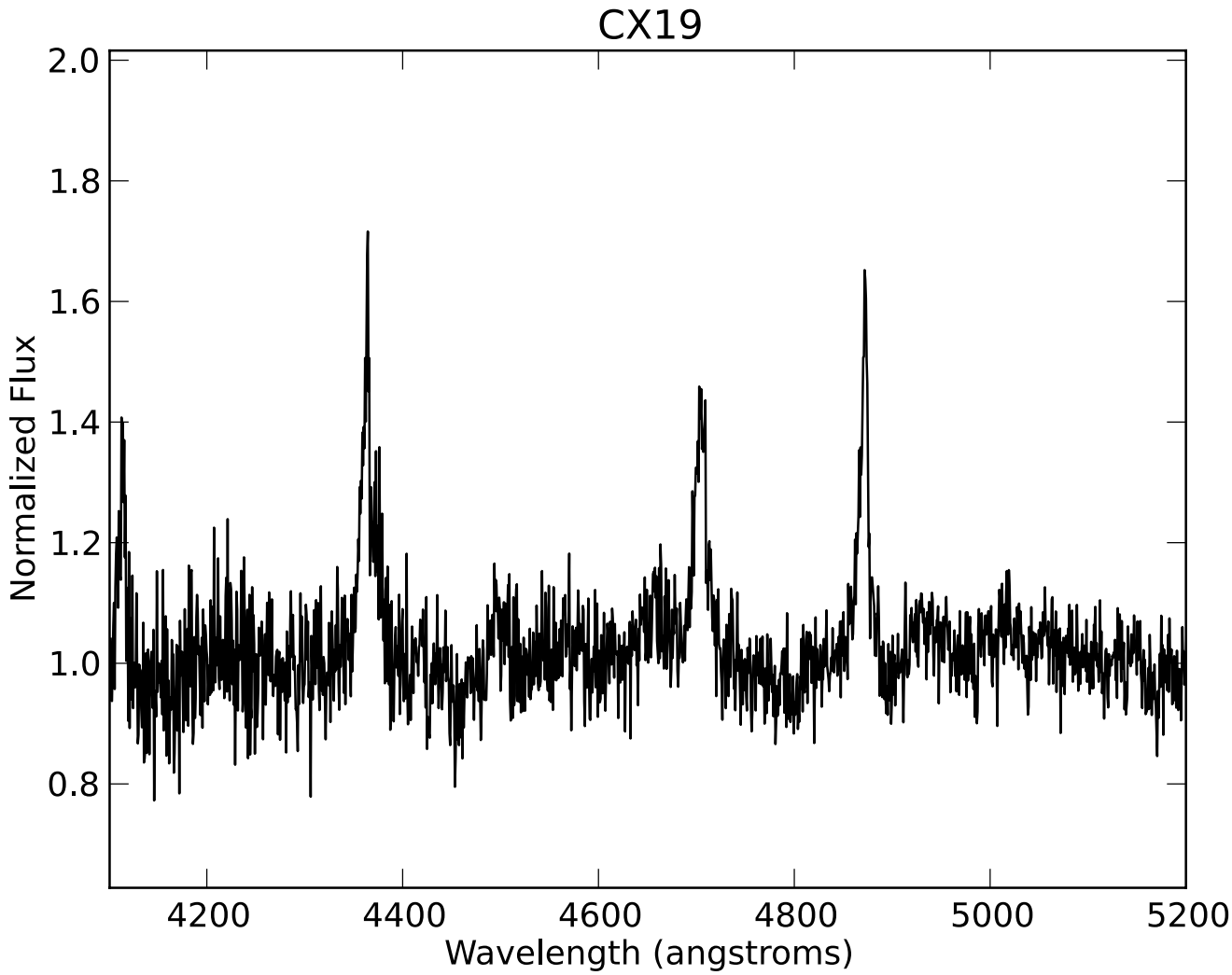


Britt et al. (2014)



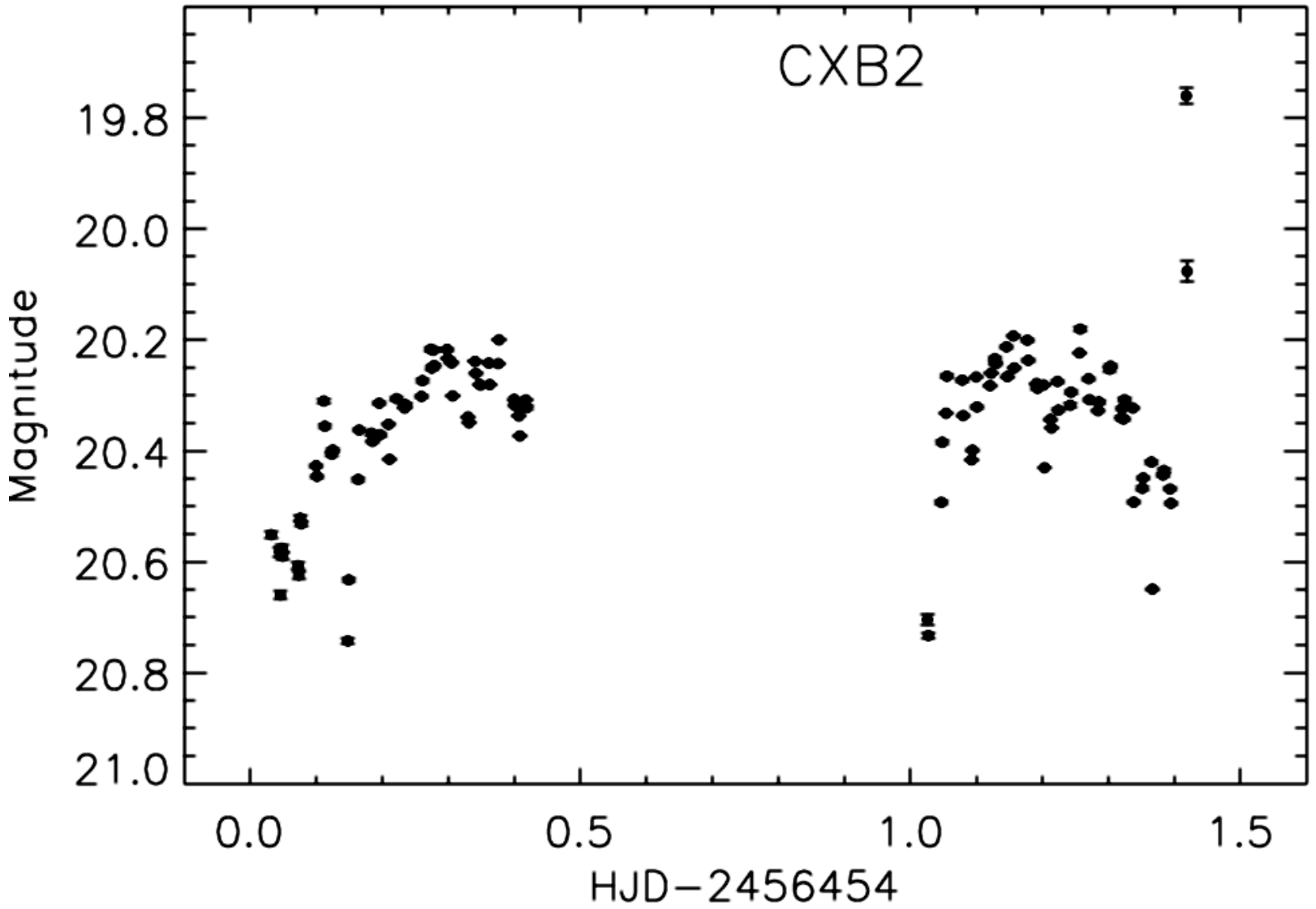
Johnson et al. (in prep.)

CX19 Spectrum – Eclipsing Magnetic Cataclysmic Variable



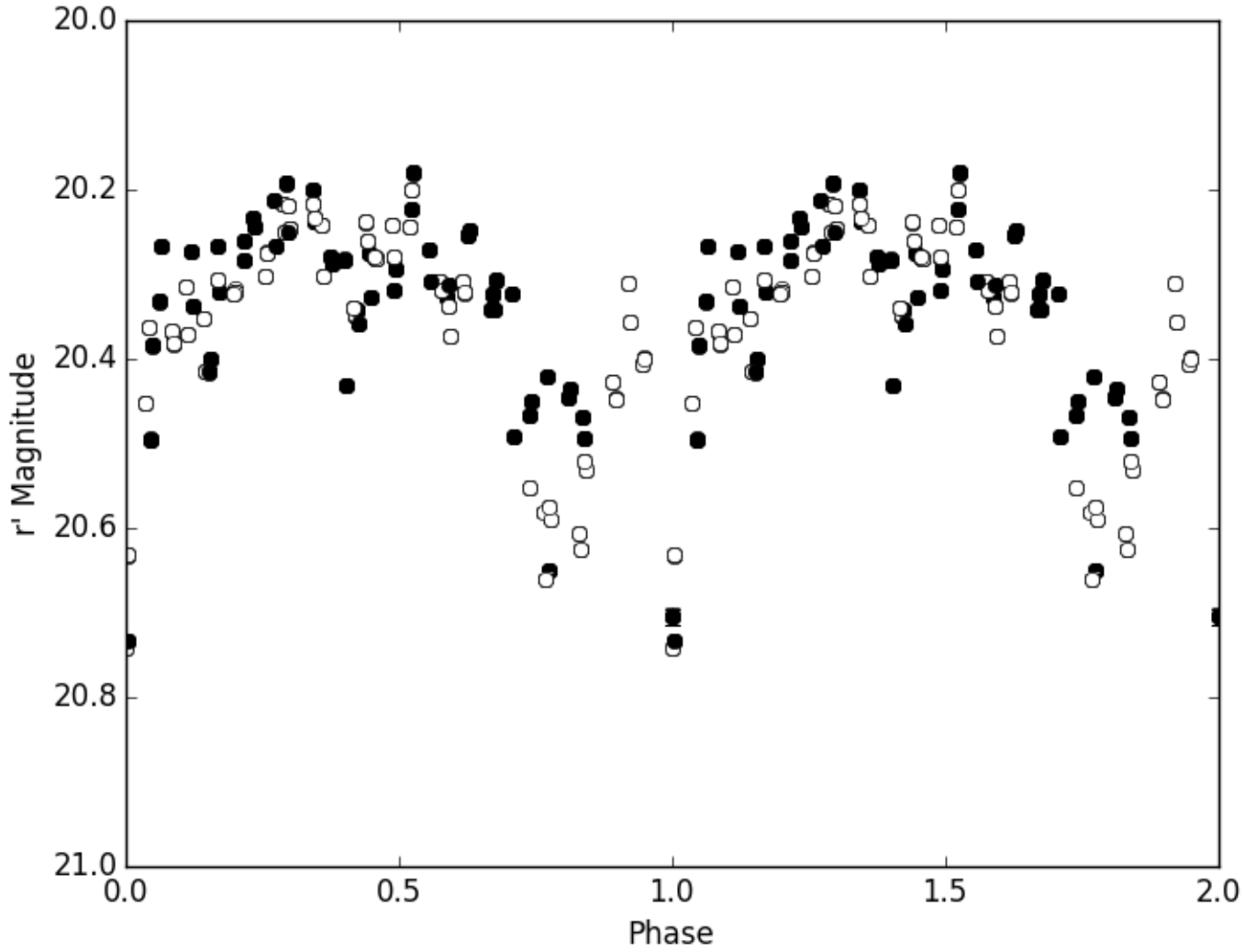
Johnson et al. (in prep.)

CXB2 Lightcurve – Eclipsing LMXB?

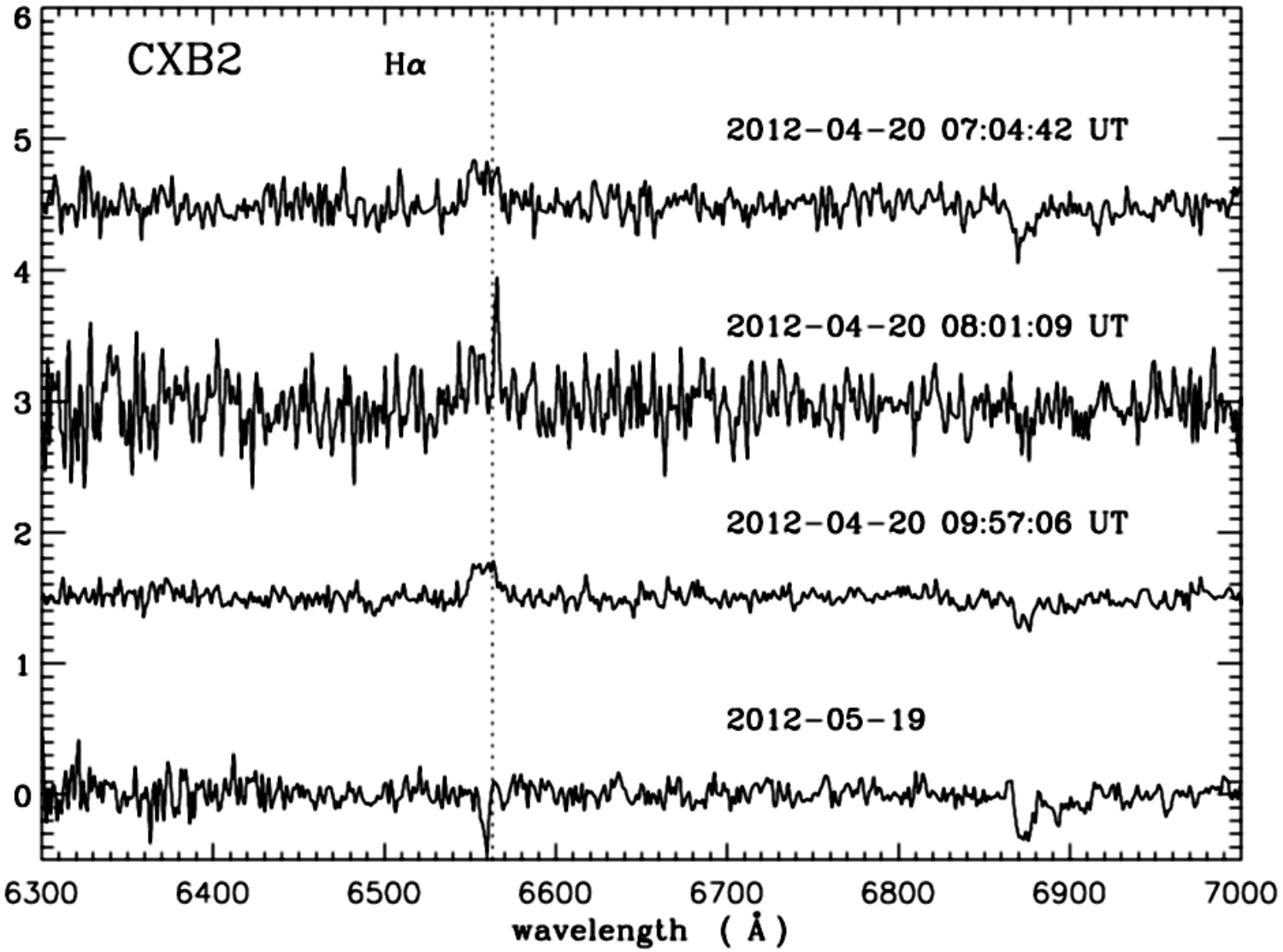


Wu et al. (2015, MNRAS, 448, 1900)

CXB2 Lightcurve – Eclipsing LMXB?



CXB2 Spectra



Wu et al. (2015, MNRAS, 448, 1900)

Summary

DECam is a GREAT multi-channel photometer!

- Observe ~800 X-ray sources simultaneously
- Time resolution greatly improved over Mosaic II

Galactic Bulge Survey

- 1640 X-ray sources
- Many have variable optical counterparts
- We are finding eclipsing interacting binaries

Next step

- Dynamical study of candidate X-ray binaries
  - ➔Compact object masses