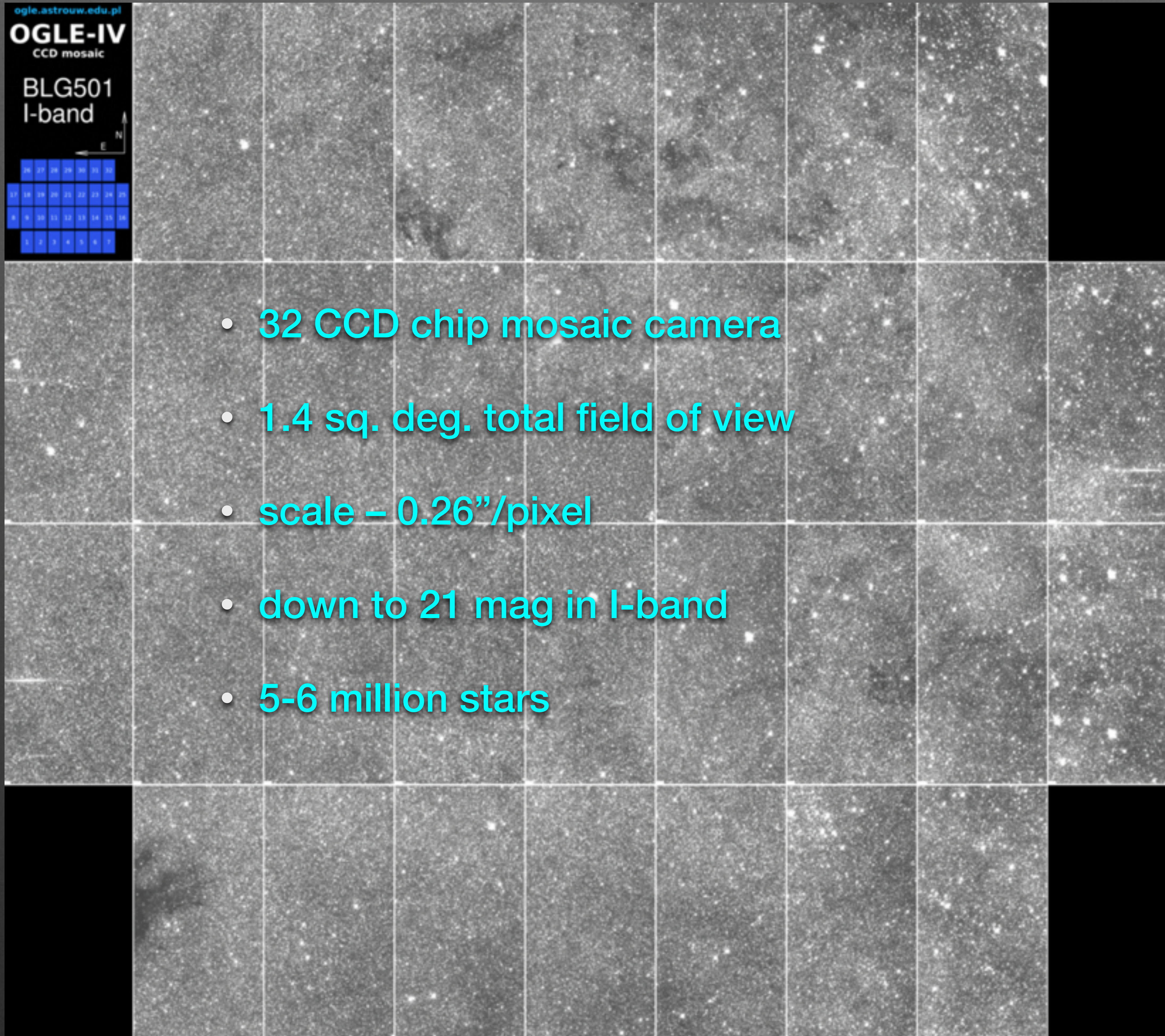
Search for lensed QSOs in the OGLE -IV survey

Zuzanna Kostrzewa-Rutkowska
Szymon Kozłowski, Łukasz Wyrzykowski & OGLE Team
Warsaw University Astronomical Observatory

OGLE

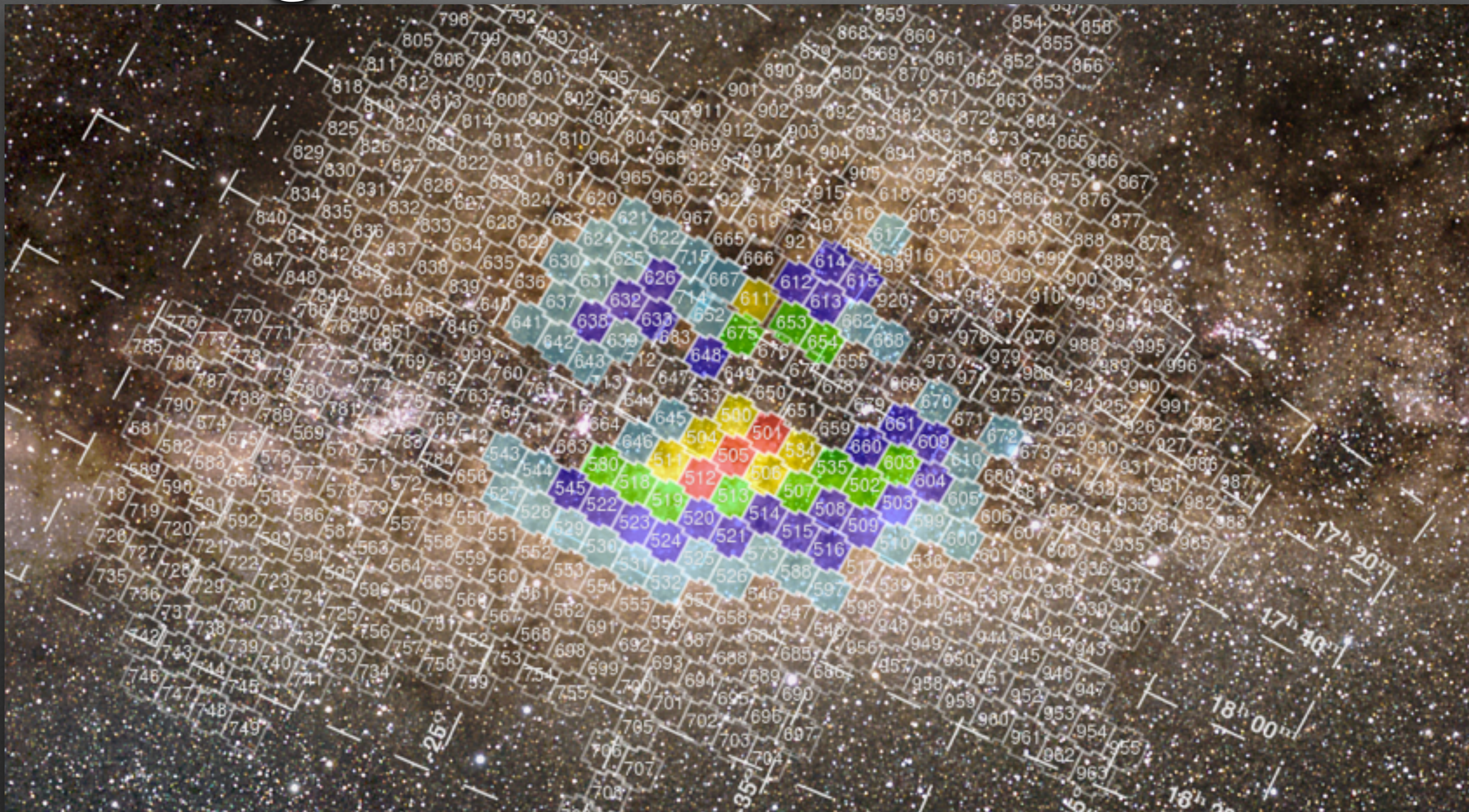
Optical Gravitational Lensing Experiment

- operated since 1992
- OGLE-IV from 2010-now (Udalski et al. 2015)
- OGLE-IV - a billion stars
- 1.3-m Warsaw Telescope at Las Campanas
- http://ogle.astrouw.edu.pl



- 32 CCD chip mosaic camera
- 1.4 sq. deg. total field of view
- scale – 0.26”/pixel
- down to 21 mag in I-band
- 5-6 million stars

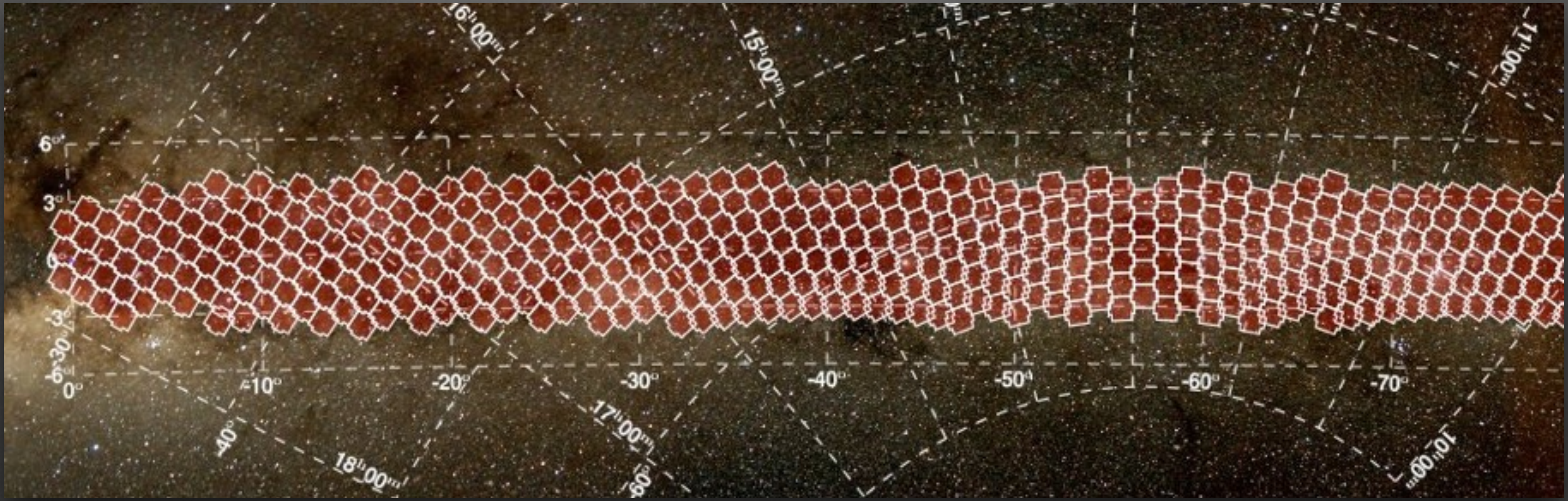
Bulge



- half a billion stars
- some fields observed since 1992
- aims: microlensing and variable stars

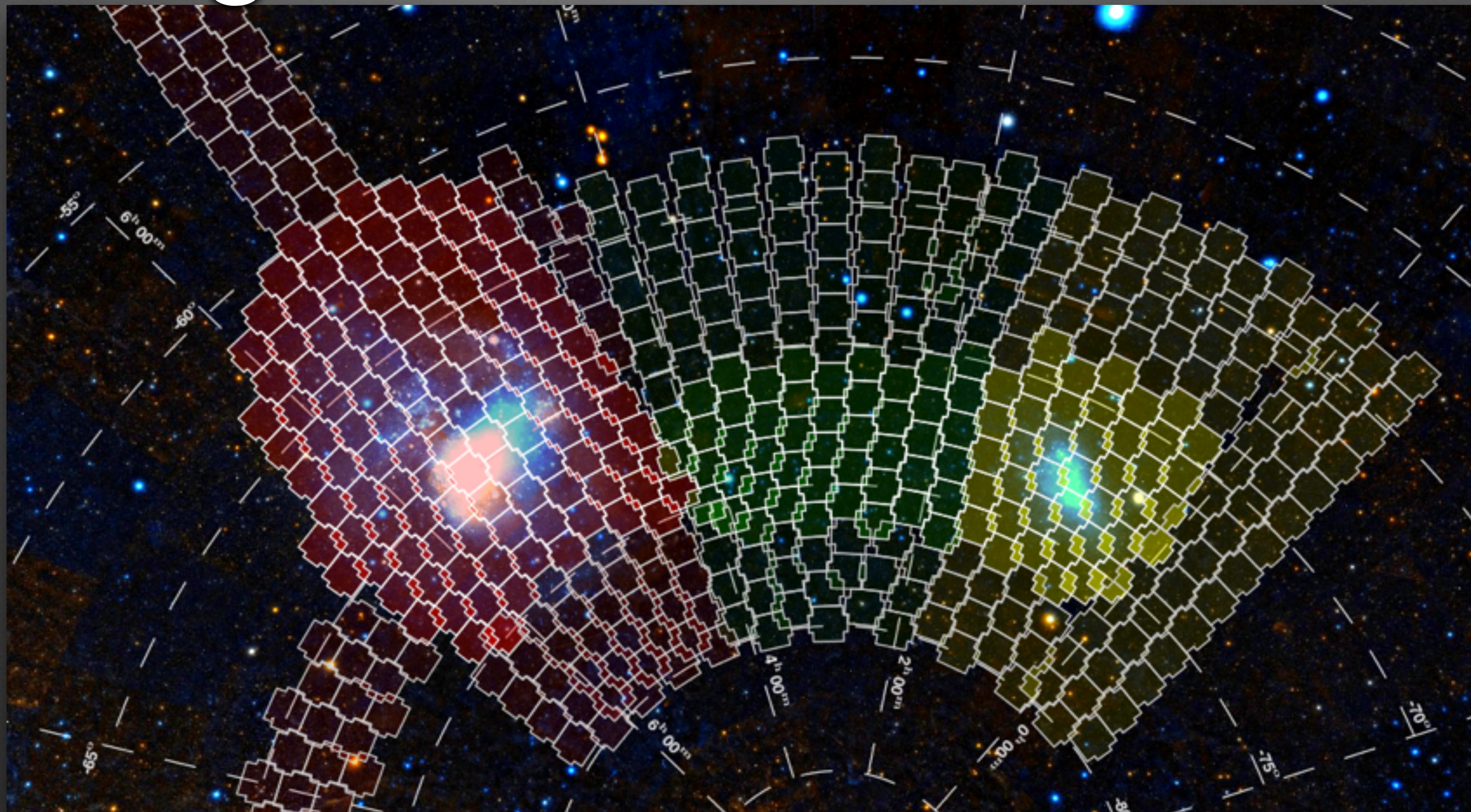
field cadence:
red: 10-30 per night
yellow: 3-10 per night
green: 1-3 per night
blue: 0.5-1 per night
cyan: less than 0.5 per night
transparent: observed occasionally

Galactic Disk



- 1700 sq deg down to 19 mag
- monitored already for 3 years
- aims: variable stars

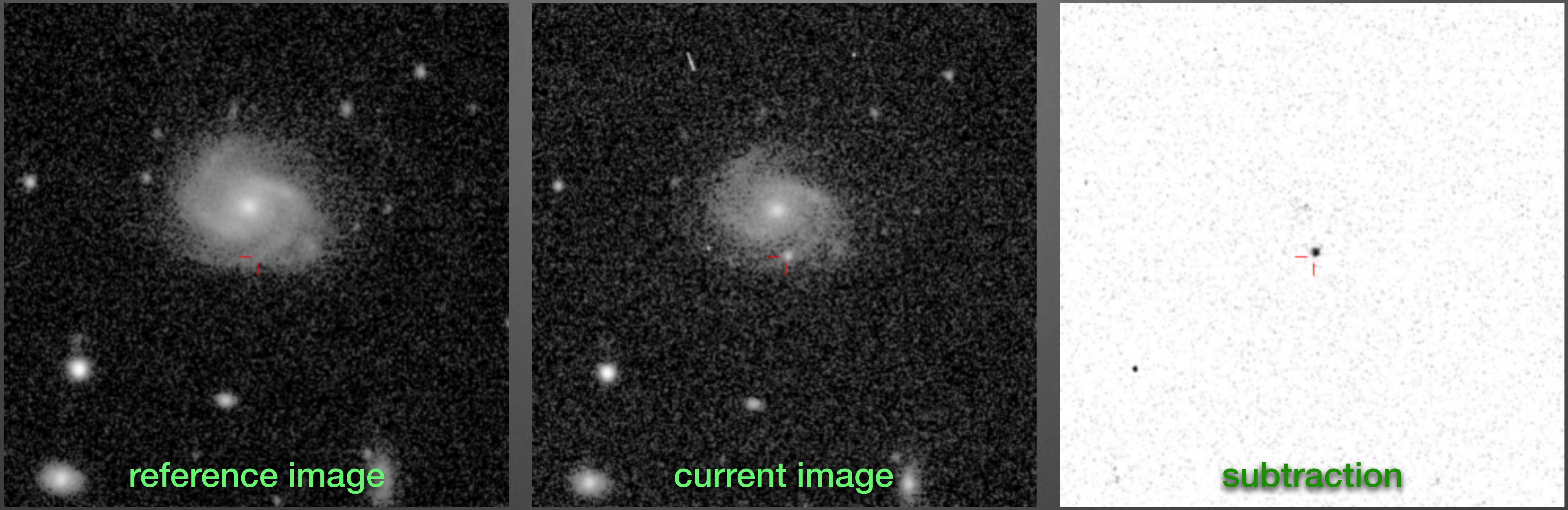
Magellanic Clouds



- LMC+MBR+SMC - 670 sq. deg
- some fields observed since 1997
- aims: transients and variable stars

field cadence:
2-6 days

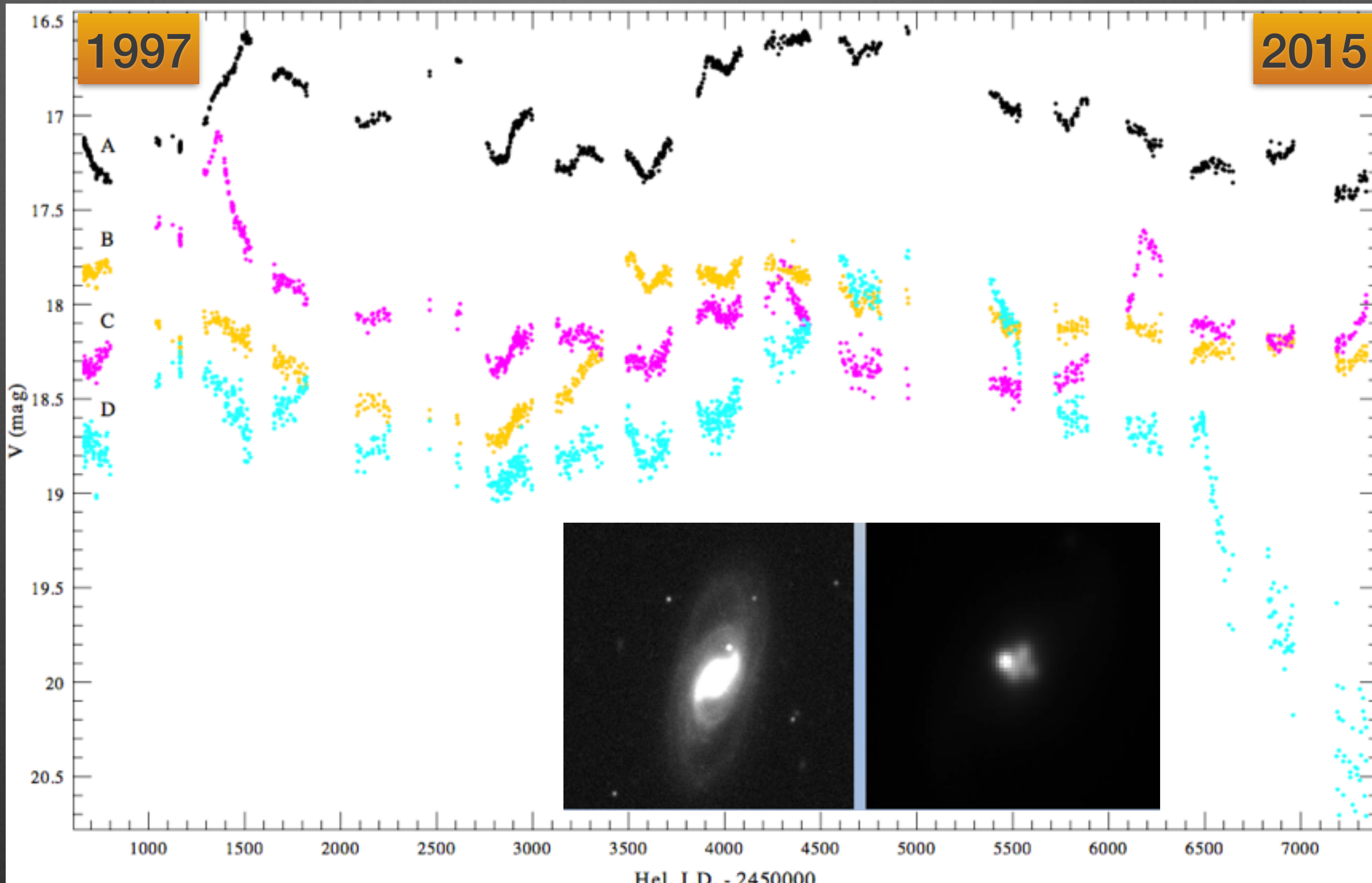
Difference Imaging Analysis



supernova OGLE13-148

DIA accuracy - better than a fraction of a pixel
pixelsize ~0.26”

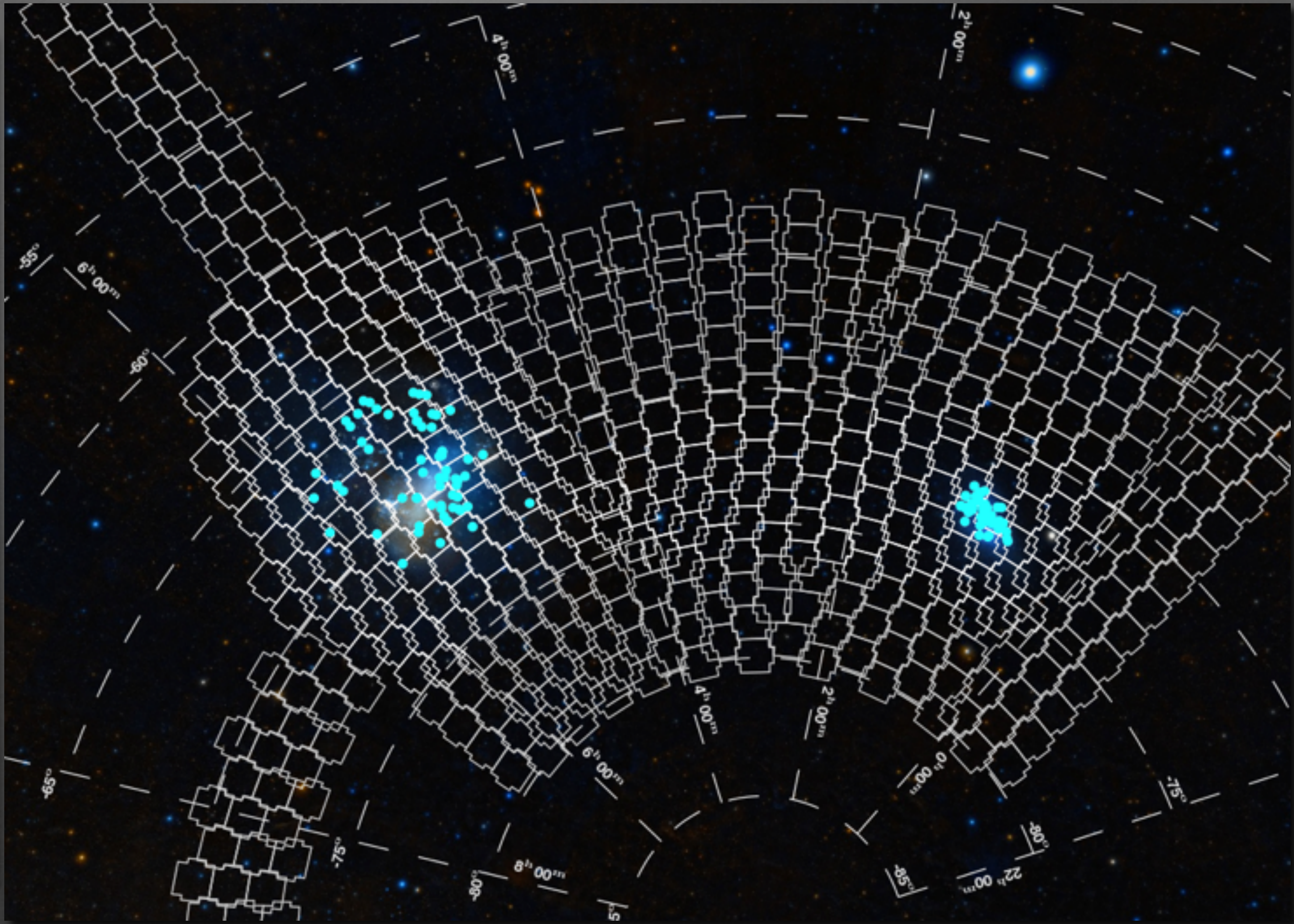
Einstein cross (QSO 2237+0305)



Huchra lens: homogeneous data set starting in 1997

Magellanic Quasars Survey

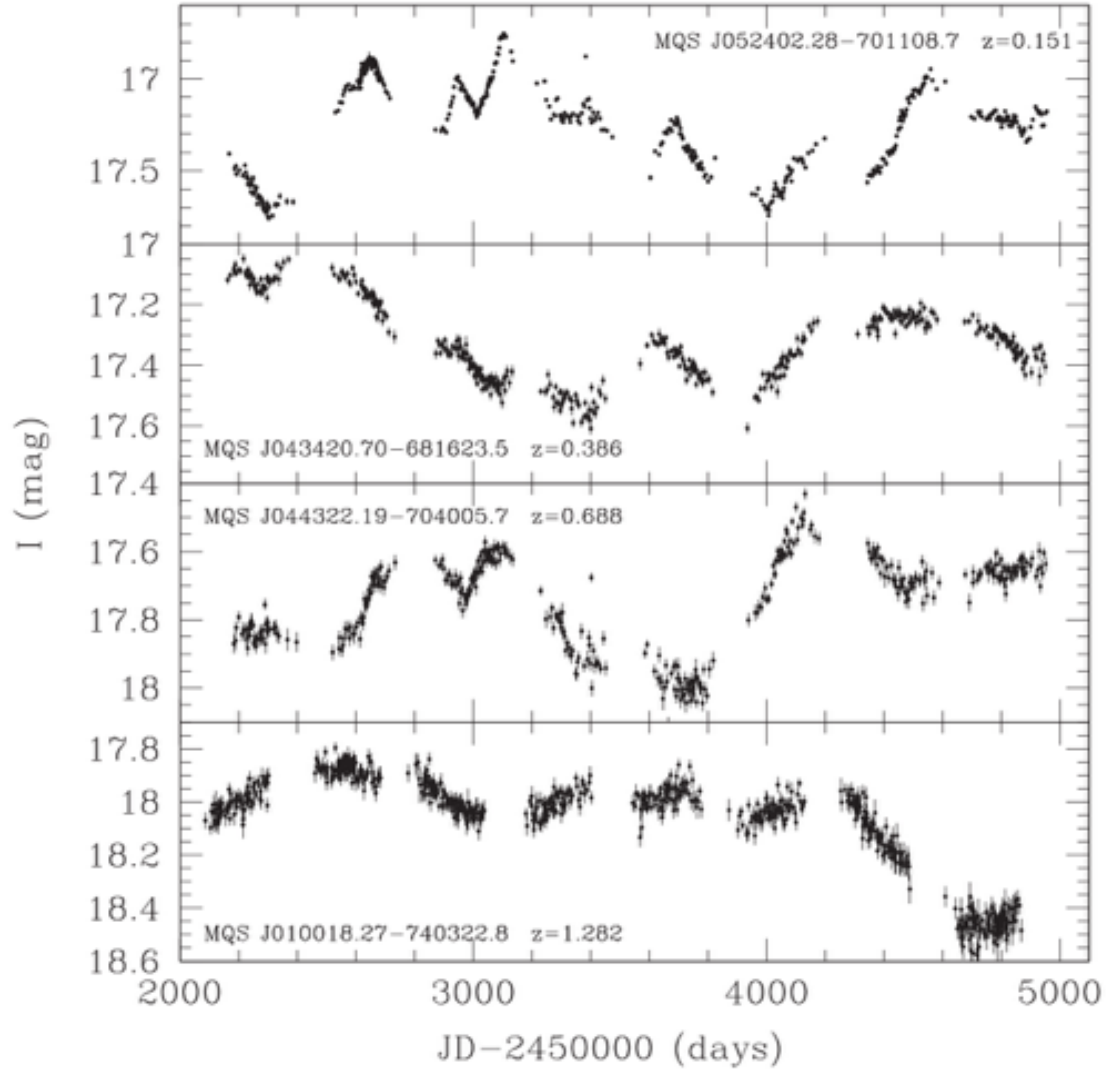
The Magellanic Quasars Survey (MQS) has now increased the number of known quasars behind the Magellanic Clouds by almost an order of magnitude using OGLE-III data (Kozłowski et al. 2011, 2013)



OGLE-IV phase: plan to perform a similar, extensive search behind the Magellanic System (Kozłowski in prep.)

Magellanic Quasars Survey

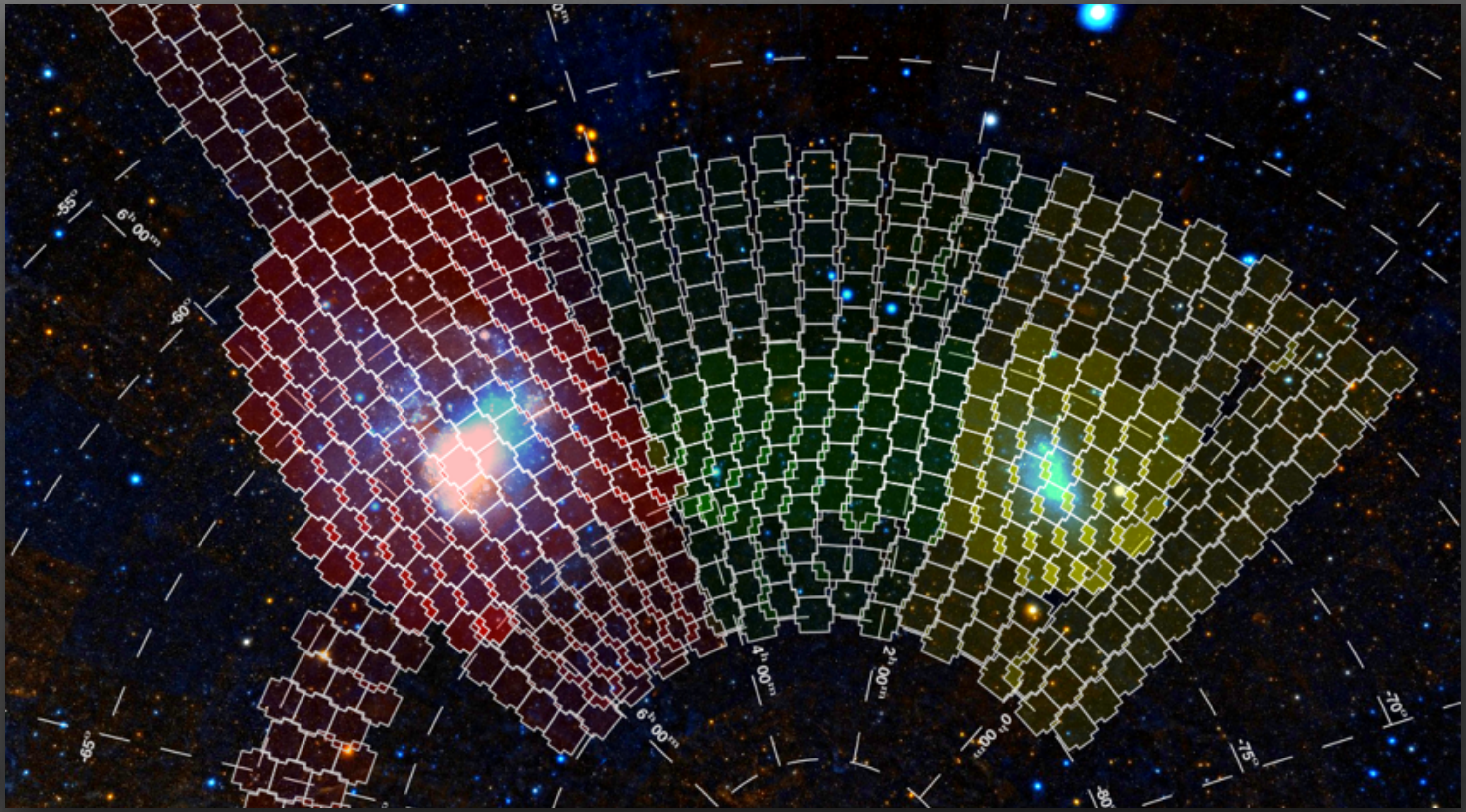
QSOs search:
- locating all objects in the WISE survey fulfilling the mid-IR colours criteria for quasars (Stern et al. (2005) and Assef et al. (2010));
- crossmatching the selected WISE objects with the OGLE database;
- performing a variability analysis of the OGLE objects and isolating the final sample.



Kozłowski+2011,2013

Search for lensed QSOs

- 670 sq. deg behind the Magellanic System
- prediction: about 10 lensed QSOs (doubles and quads) - Oguri & Marshall 2010

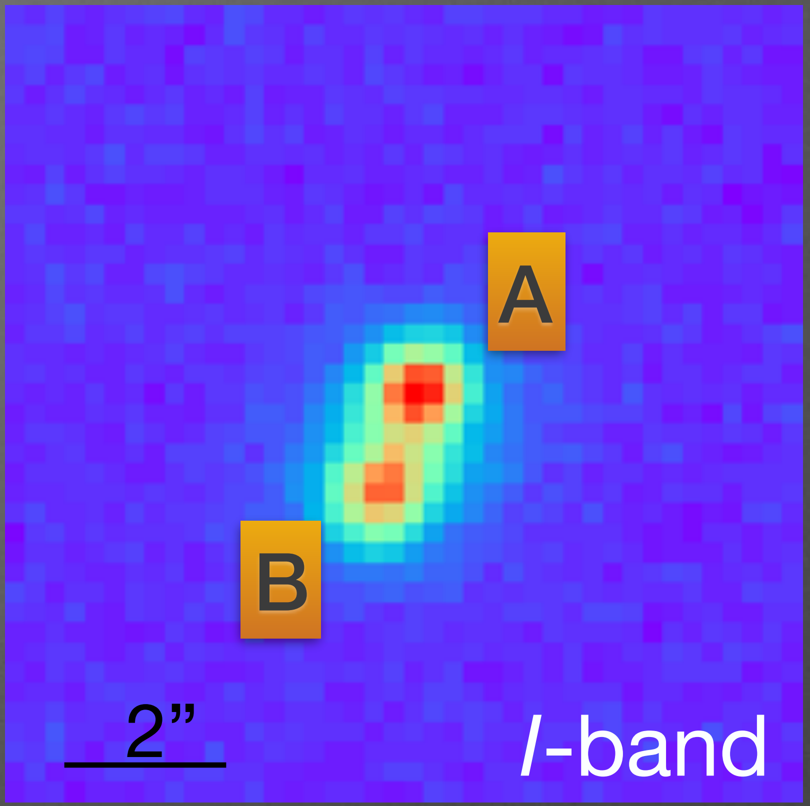


How to find lensed QSOs?

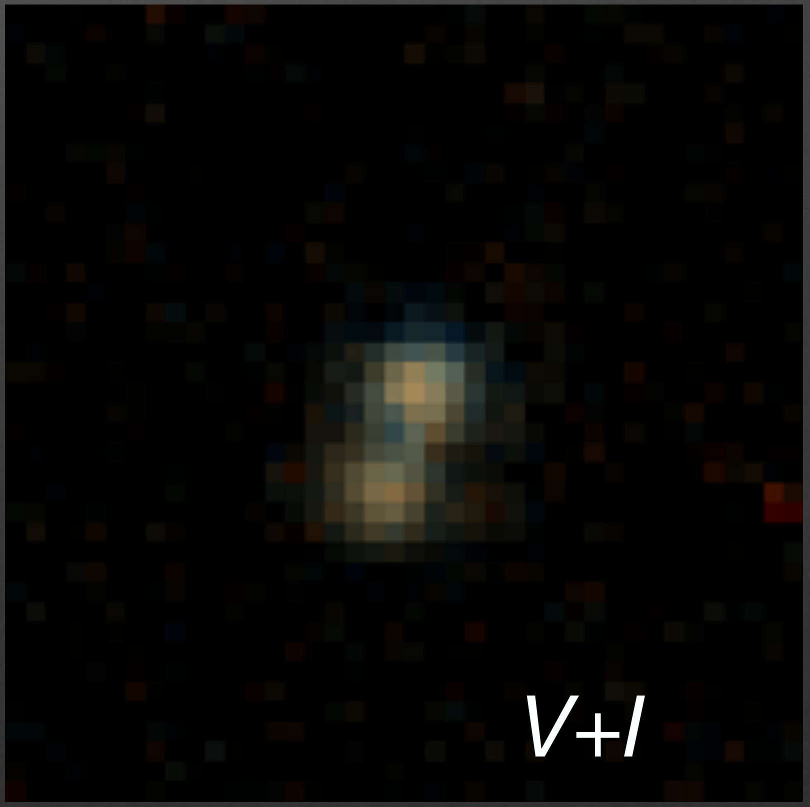
- search for another object around quasar candidates (search radius < 6 arcsec)
- main criteria: similar variability and V-I colour
- exclude the false positive objects with difference image analysis

First candidate

- image A: 19.74 mag
- image B: 19.96 mag

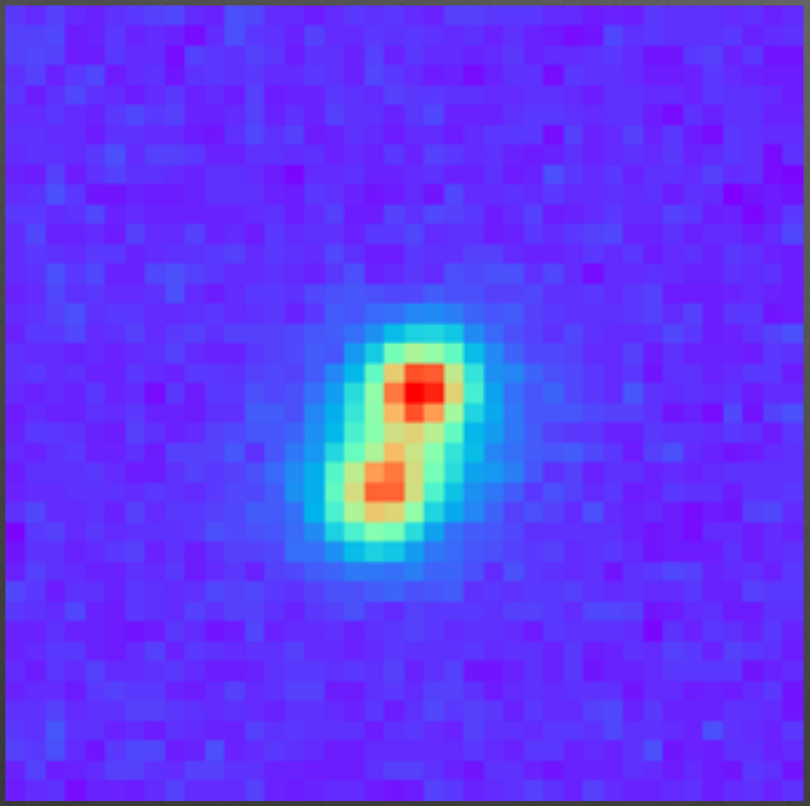


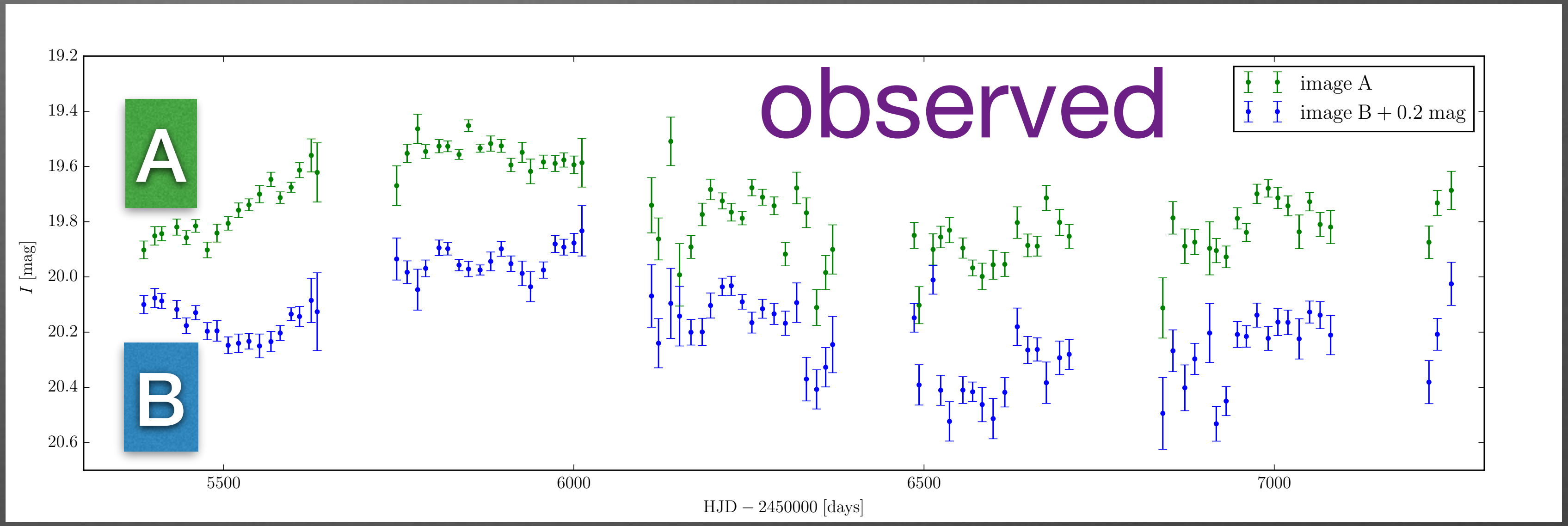
- SED fitting
  (OGLE I+V, 2mass, WISE): z~2.2
- lens: z~0.8
- galaxy brightness outside OGLE limits

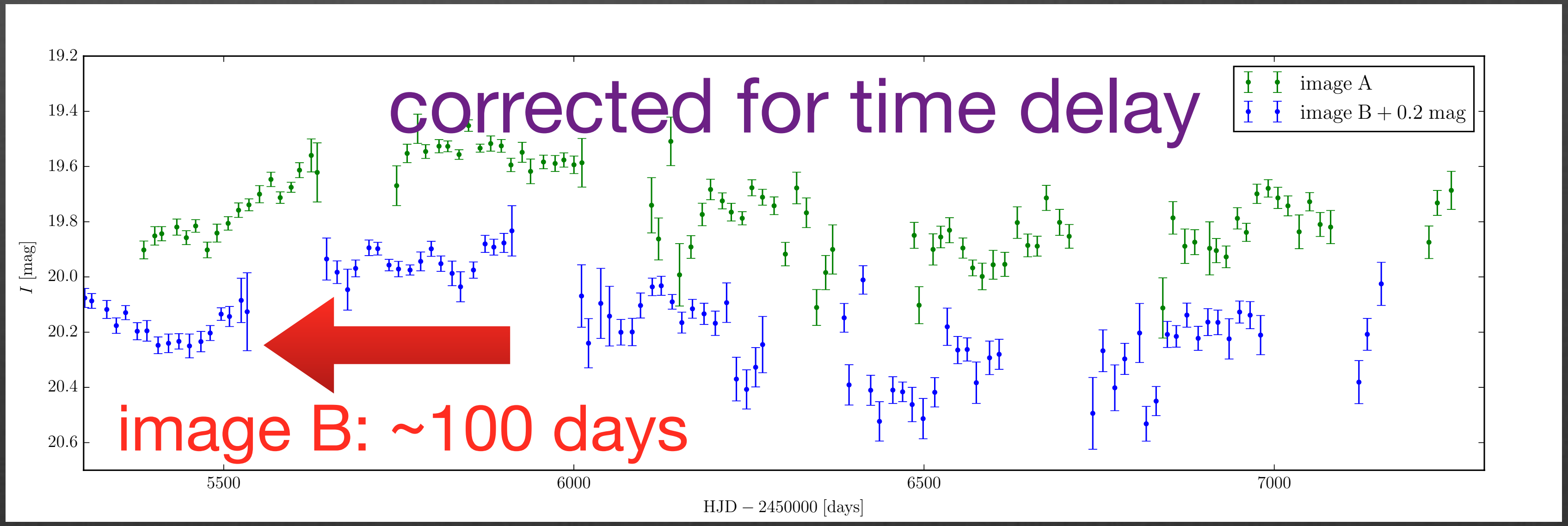


Lens model & Time delay

- SIS model
- Einstein radius: $\theta_E \sim 0.68$ arcsec







- JAVELIN code - damped random walk model (Zu et al. 2013)
- time delay ~ 100 days in observer frame

What next?

- more candidates
- machine learning techniques
- spectroscopic confirmation

References:

Assef R. et al. 2010, ApJ, 713, 970
Kozłowski S. et al. 2011, ApJS, 194, 22
Kozłowski S. et al. 2013, ApJ, 775, 92
Oguri M. & Marshall P. 2010, MNRAS, 405, 2579
Stern D. et al. 2005, ApJ, 631, 163
Udalski A. et al. 2015, AcA, 65, 1
Zu Y. et al. 2013, ApJ, 765, 106

This work has been supported
by the Polish National Science Centre grant No. 2014/15/B/ST9/00093.
The OGLE project has received funding from the National Science Center, Poland,
grant MAESTRO 2014/14/A/ST9/00121.