Study of the Sagittarius Dwarf Galaxy

Aleksandra Hamanowicz

Warsaw University Observatory

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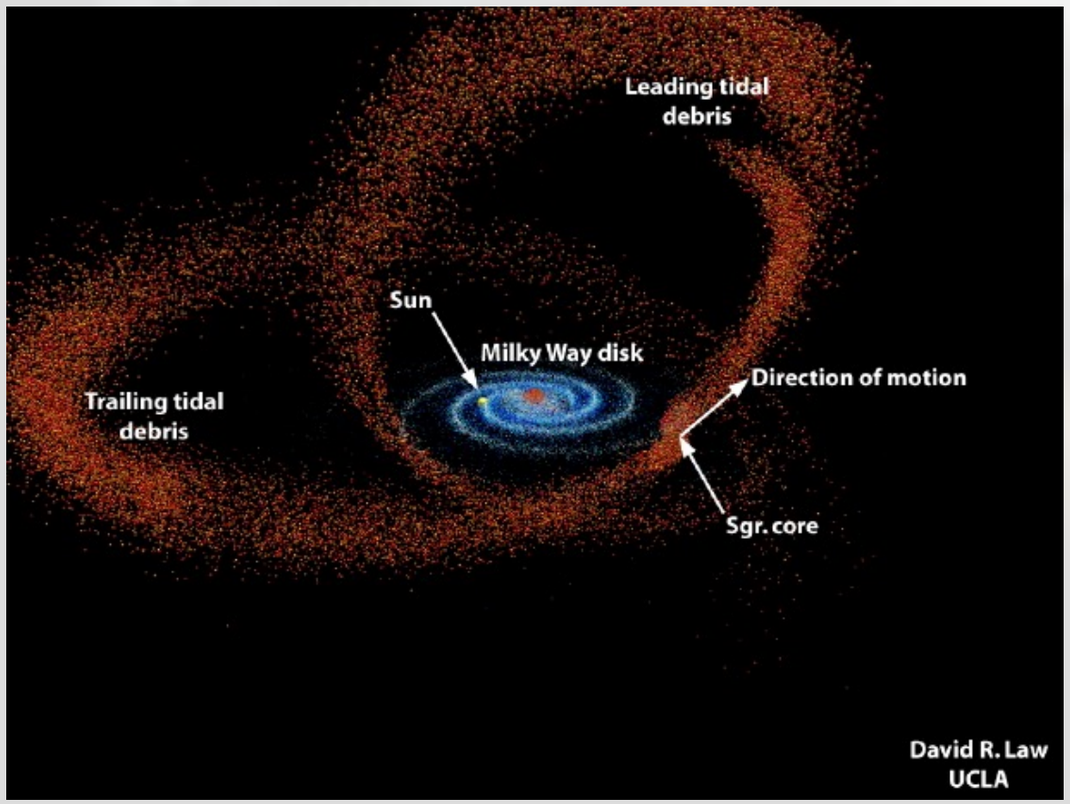
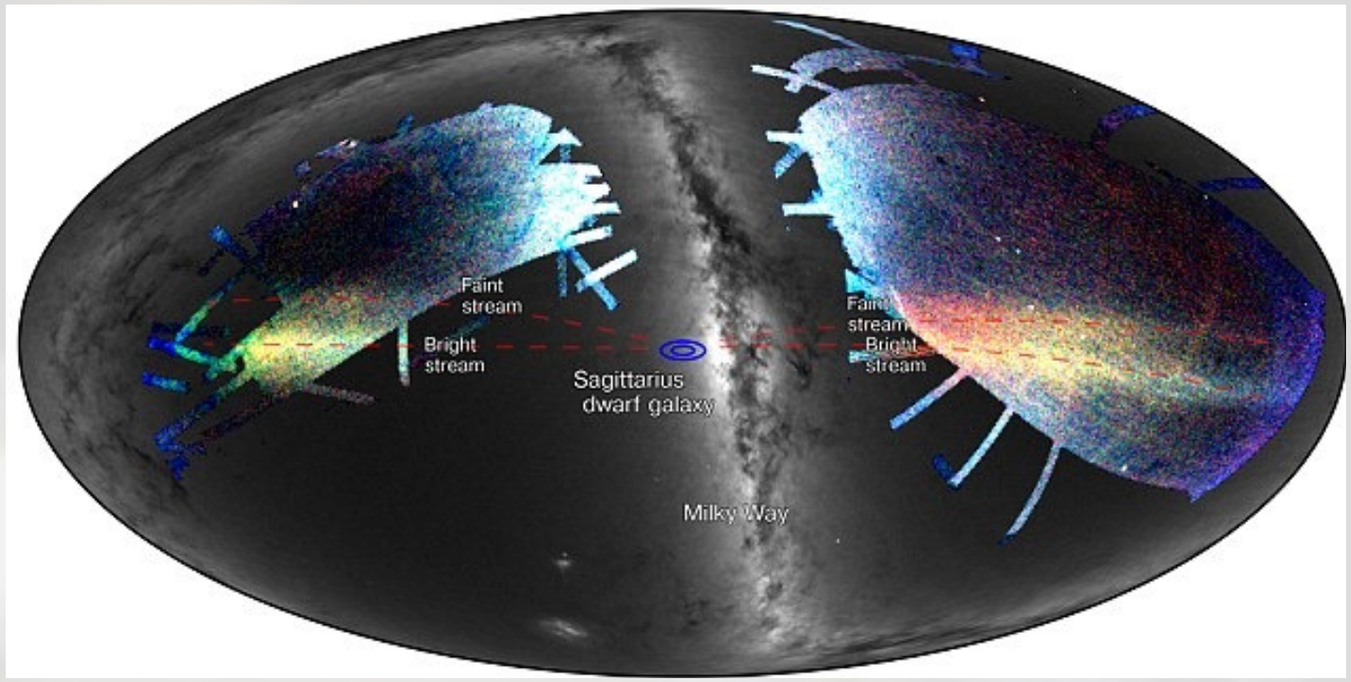
SAGITTARIUS DWARF SPHEROIDAL GALAXY

Sgr dSph galaxy was discovered by Ibata et al.(1994).
It is disrupted by tidal forces of the Milky Way.



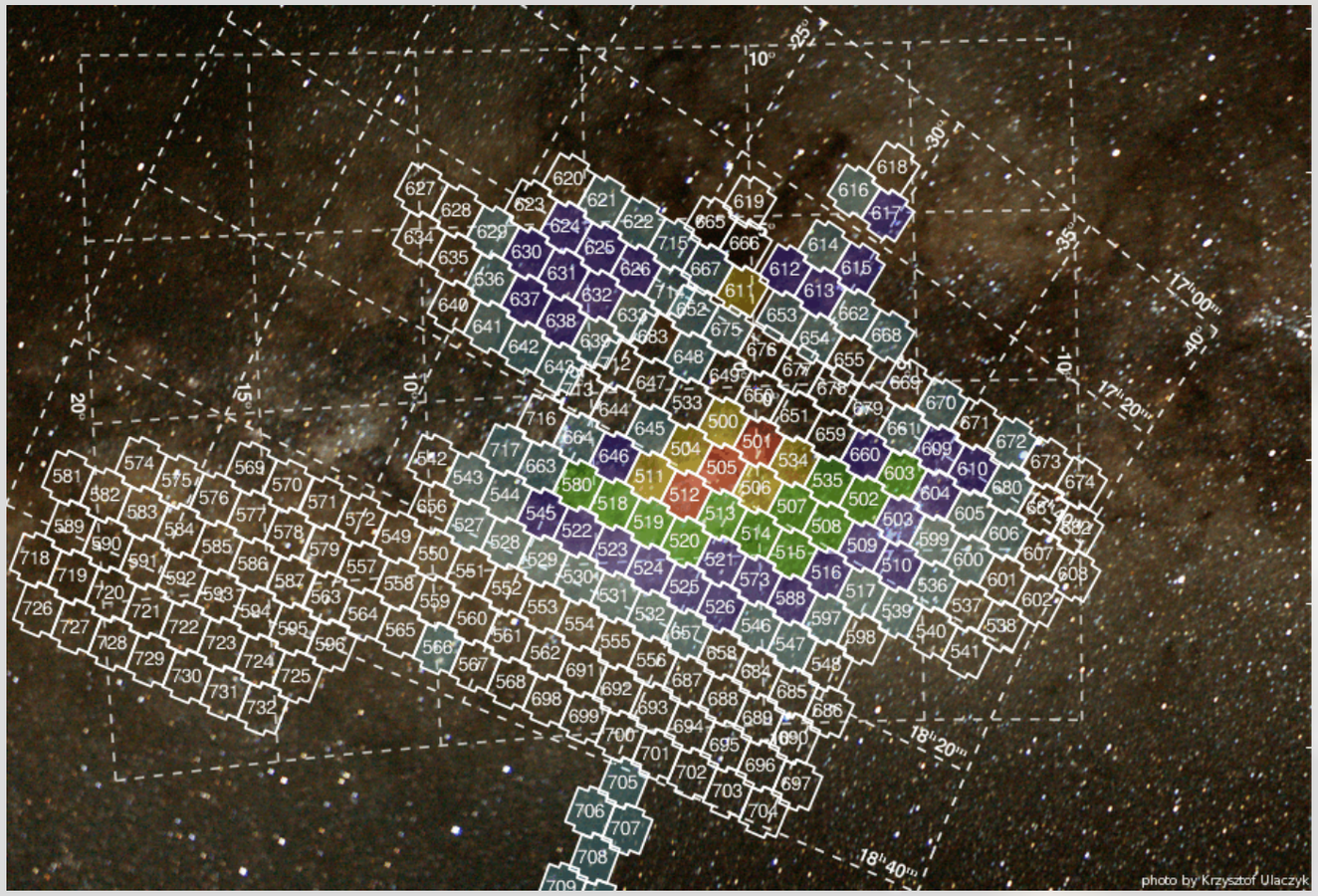
Credit: David R. Law, UCLA



Credit: S. Koposov and the SDSS-III collaboration

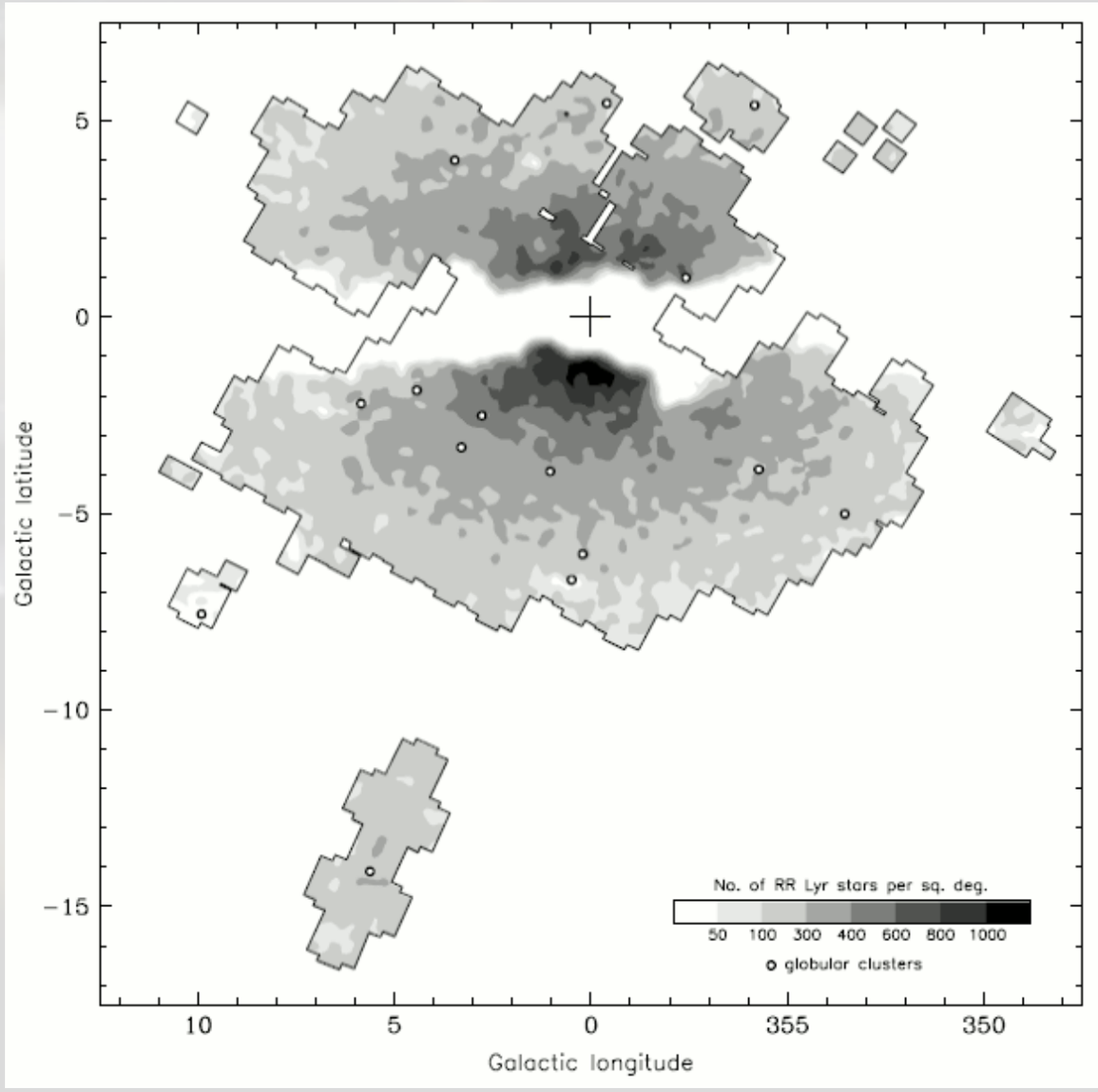
Sgr dSph stars form tidal streams orbiting our Galaxy. The dwarf galaxy is an old object with population II stars and no neutral hydrogen.

OGLE fields toward Sgr dSph and the Galactic Bulge



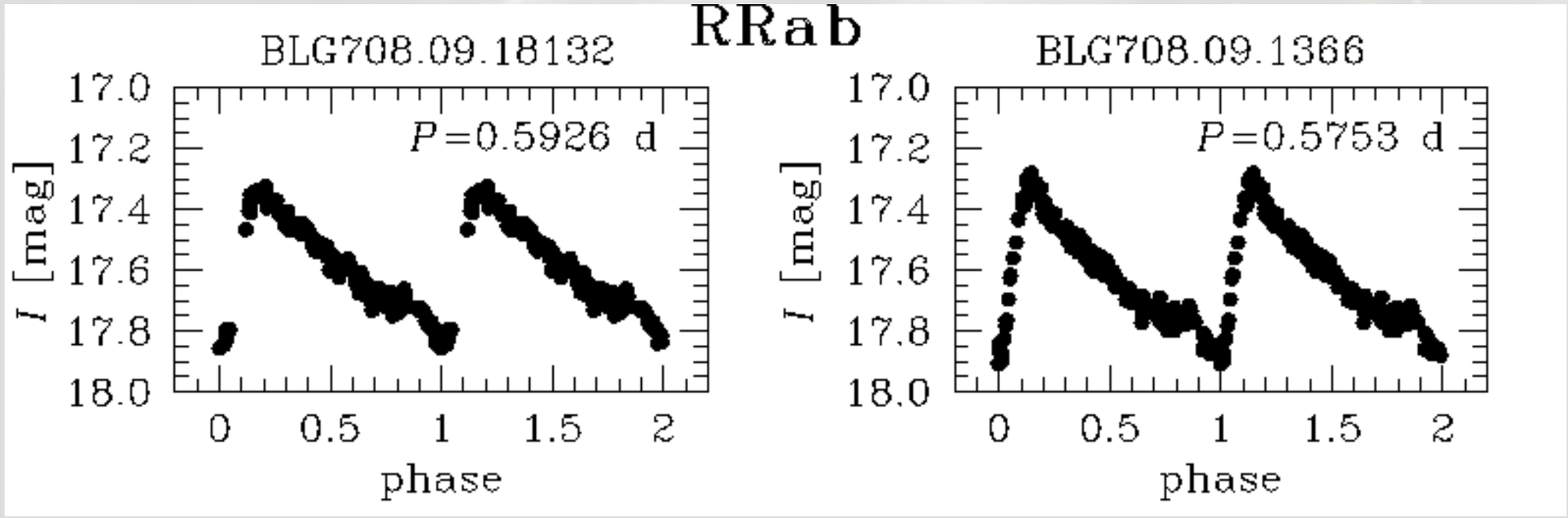
Sky coverage in OGLE-IV around the Galactic bulge and Sgr dSph.

Density of RR Lyrae stars found in OGLE-IV Galactic bulge fields (Soszyński et al. 2014).



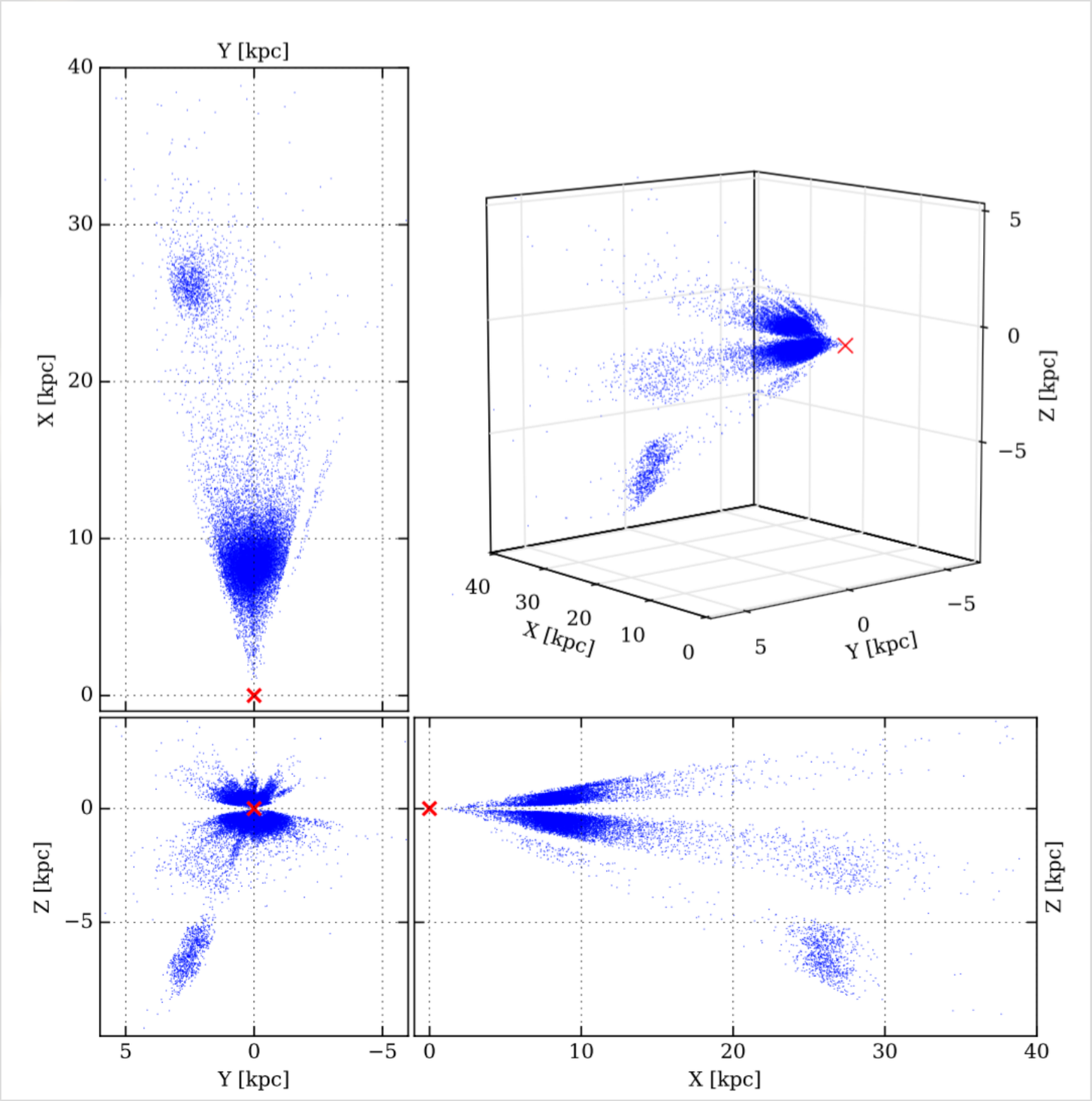
THE RR LYRAE STARS – DISTANCE DETERMINATION

* old (> 10 Gyr), evolved stars burning helium in their cores
* stellar masses 0.55 – 0.80 $M_\odot$
* pulsation periods 0.2 < P < 1 day
* absolute magnitudes +0.3 < M_V < +0.9 mag
* RRab – fundamental mode, RRc – first overtone, RRd – double mode stars
* serve as distance indicators within the Local Group

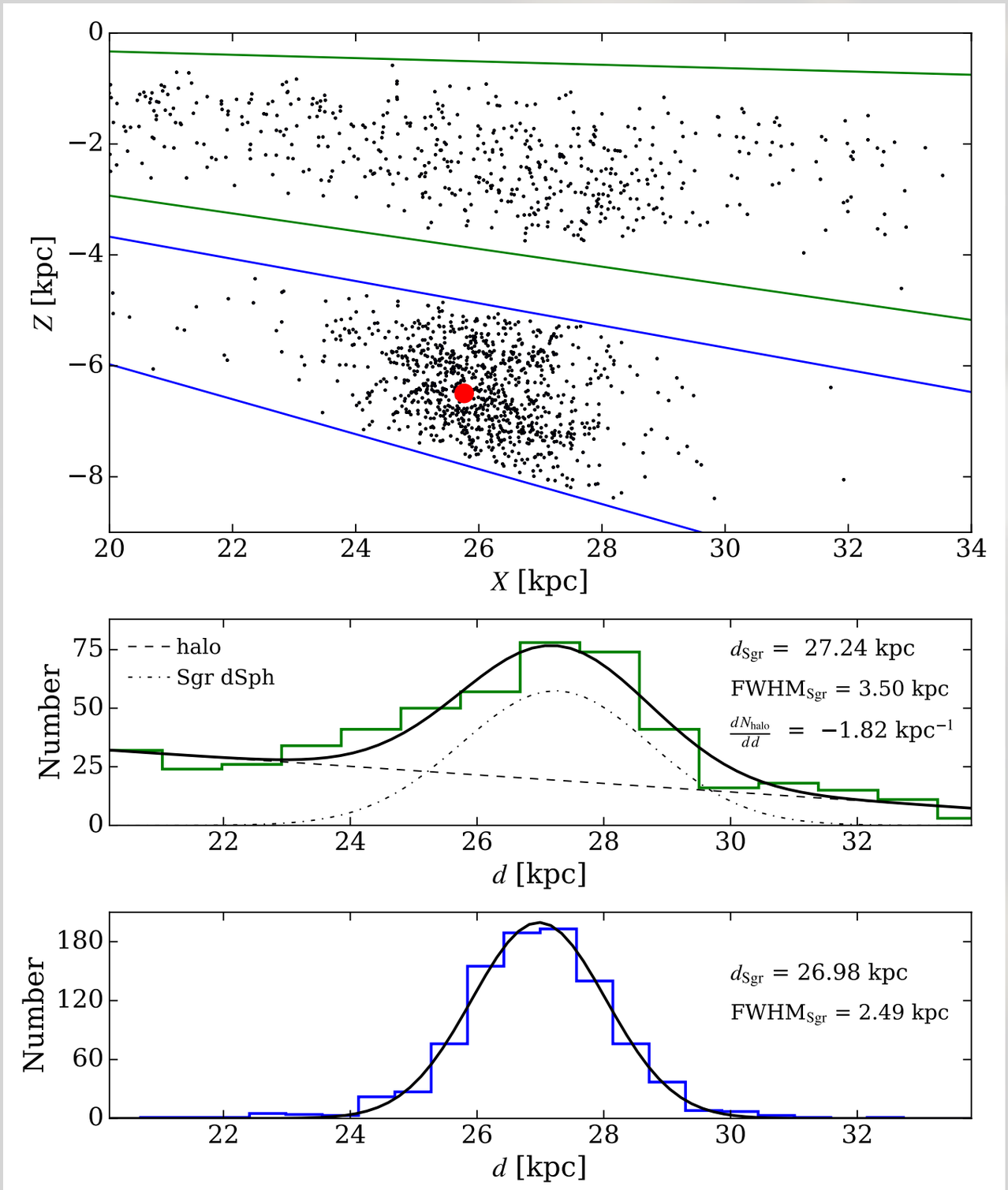


3D VIEW OF THE SGR DSPH BEHIND THE BULGE

Distribution of all observed OGLE-IV RRab stars in 3D – space with the origin in the Sun (marked with the red cross). The Sagittarius stream goes roughly along the Z axis.



THICKNESS OF THE SGR DSPH STREAM



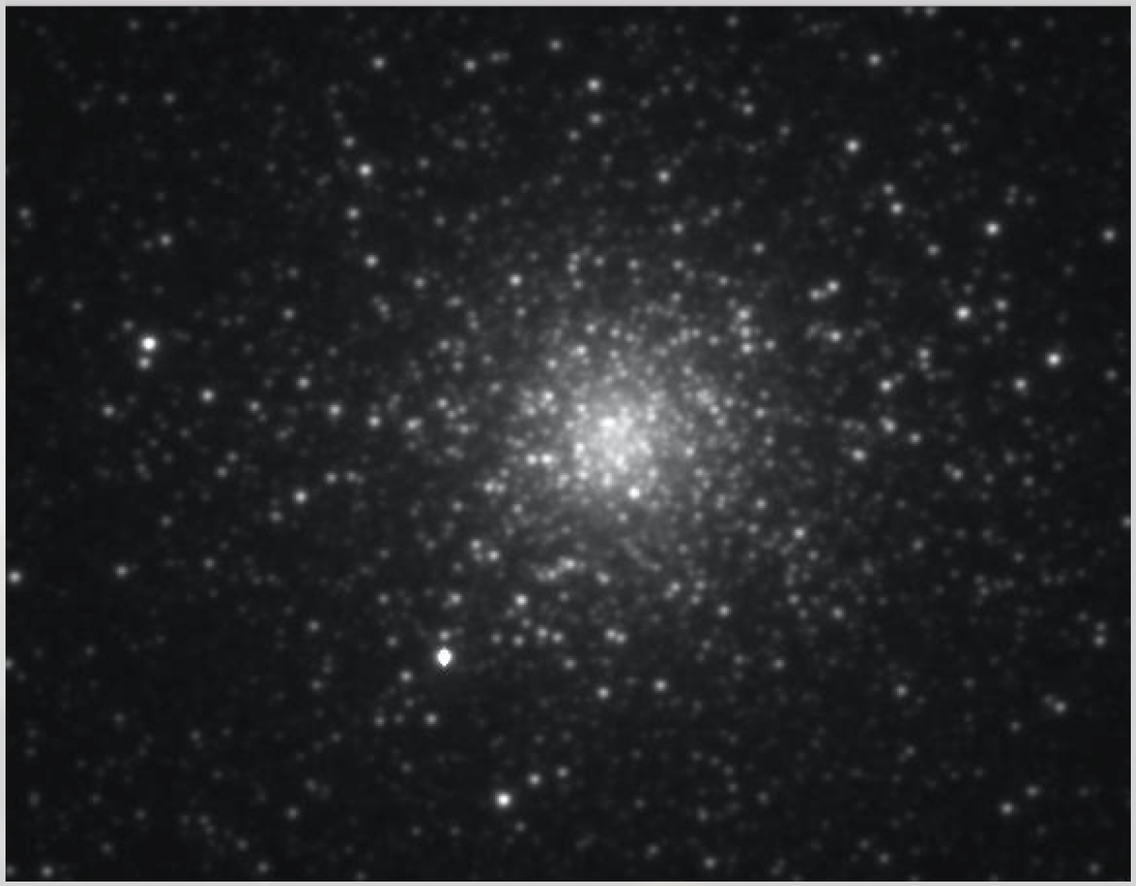
RRab stars in the projection onto the XZ plane. Red circle marks the position of the globular cluster M54.

FWHM$_{Sgr}$ = 2.42 kpc

M54 – GLOBULAR CLUSTER IN THE CORE OF SGR DSPH

Previous searches for variable stars in M54:

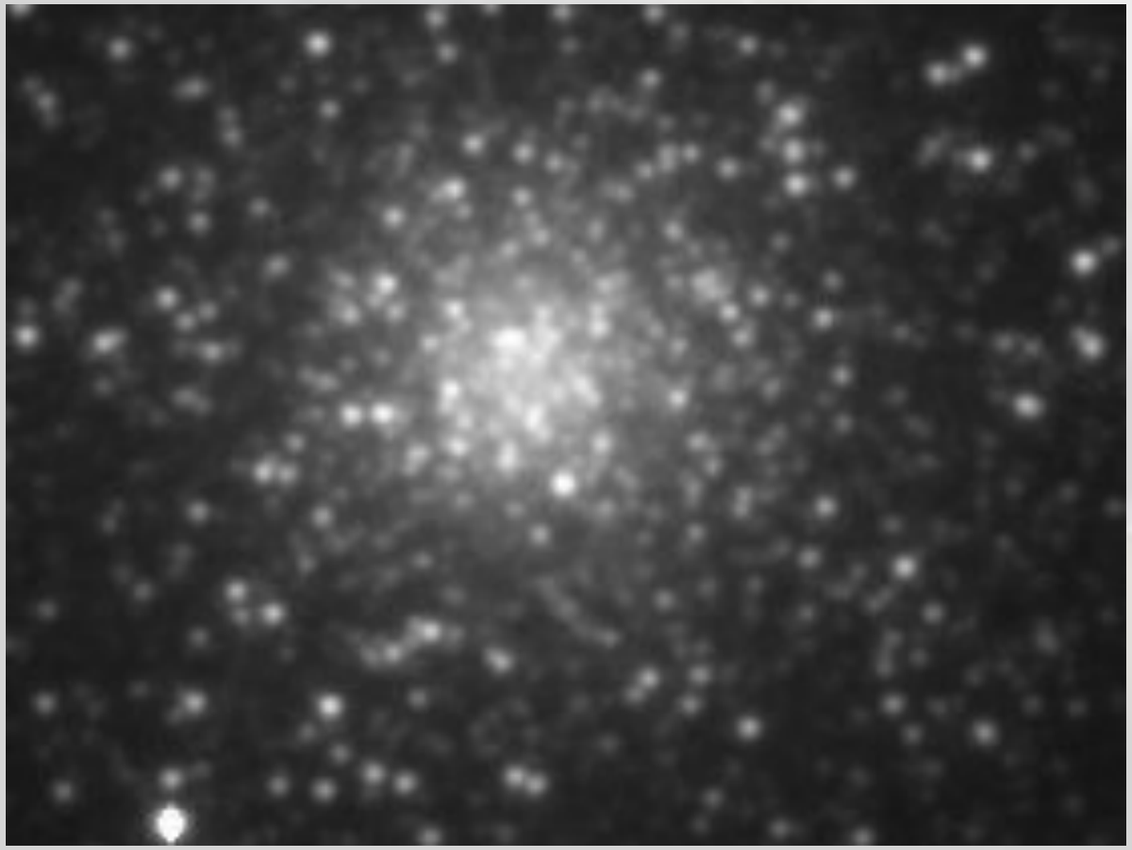
* Rosino (1952) – 28 objects
* Rosino & Nobili (1958) – 54 stars
* Layden & Sarajedini (2000) – 35 new stars
* Sollima et al. (2010) – 94 new variables
* Montiel & Mighell (2010) – 50 candidates for RR Lyr from HST
* Figuera Jaimes et al. (2016) – 67 new variables – parallel work to our project by MiNDSTEp



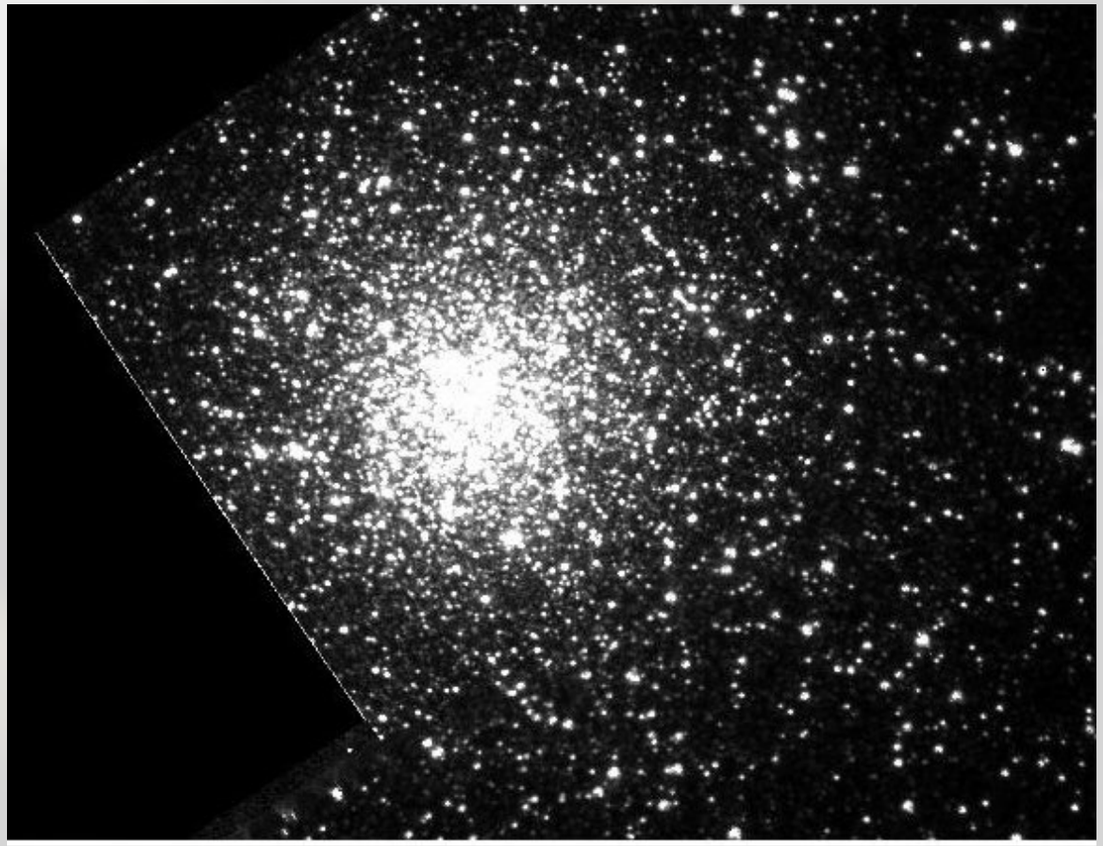
GLOBULAR CLUSTERS – DIFFICULTIES IN THE ANALYSIS

Crowing in the center of cluster:

* high level of background (faint stars), problematic calibrations
* individual stars are hard to resolve (blending)
* variables affect light of their neighbors – false variables

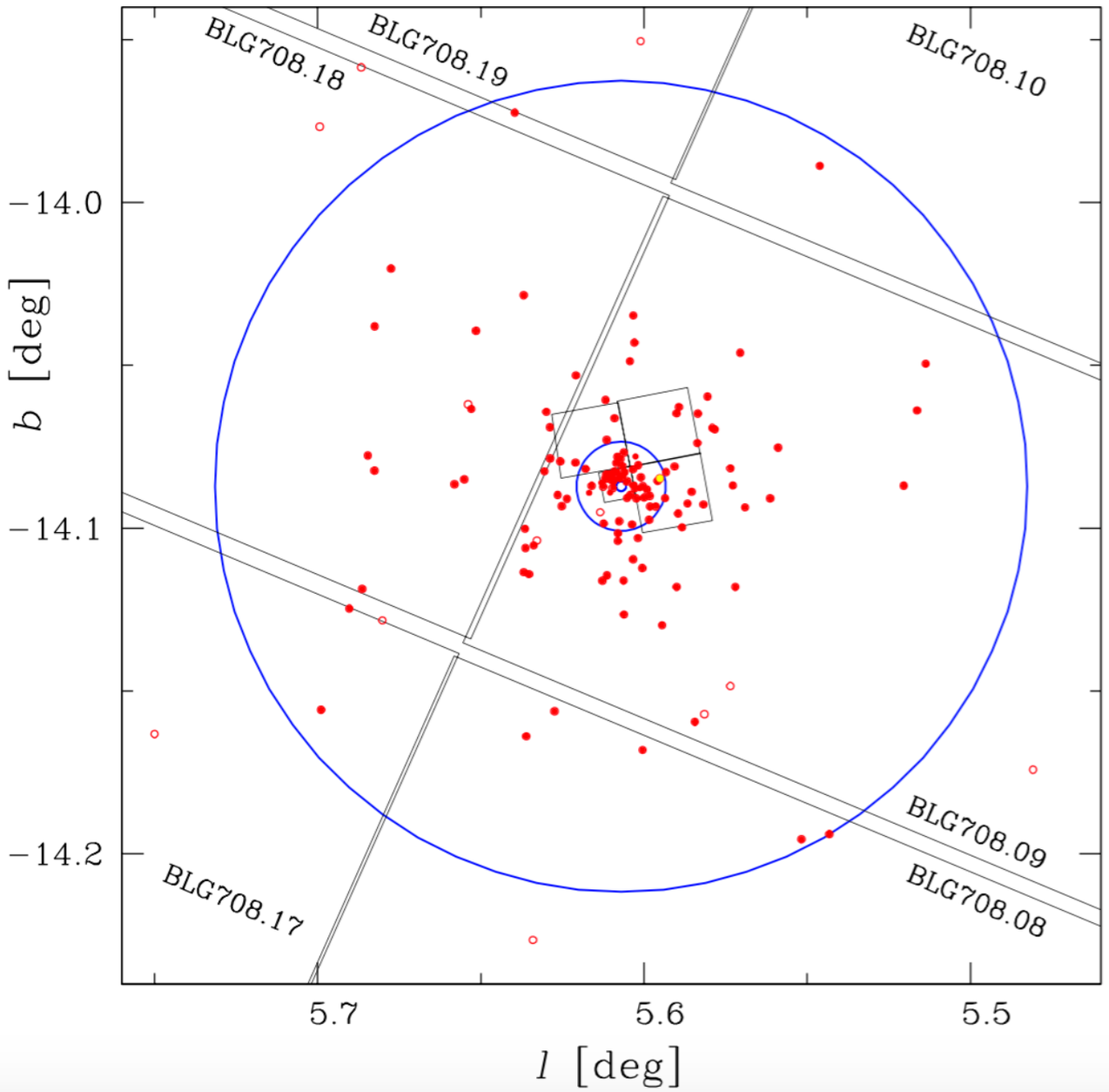


OGLE ground-based image



Hubble Space Telescope image

RRAB STARS IN M54



M54 significant radii:
core radius – 0.09’
half-light radius – 0.82’
tidal radius – the boundary of cluster’s gravity 7.5’

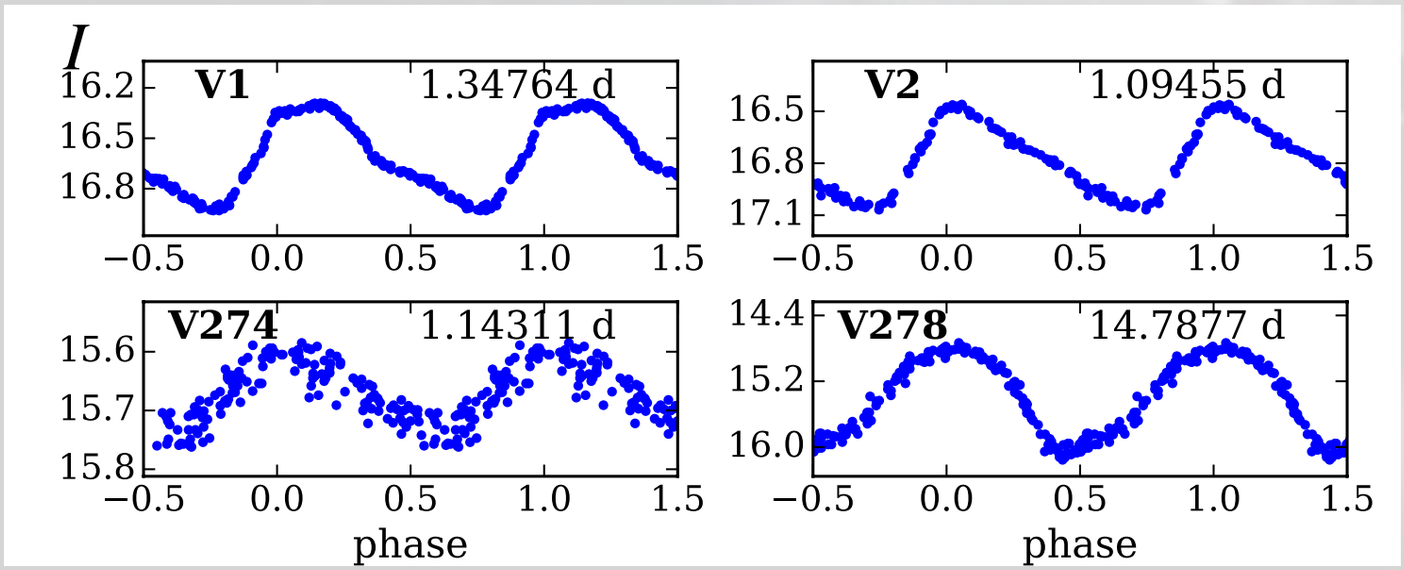
We considered all objects laying within the tidal radius.

Our exploration of M54

Distance determined from 70 RRab stars ($r_c < r < r_t$)

$$d_{M54} = 26.7 \pm 0.03_{stat} \pm 1.3_{sys}$$

Total number of detected variables: 268 (83 new discoveries).

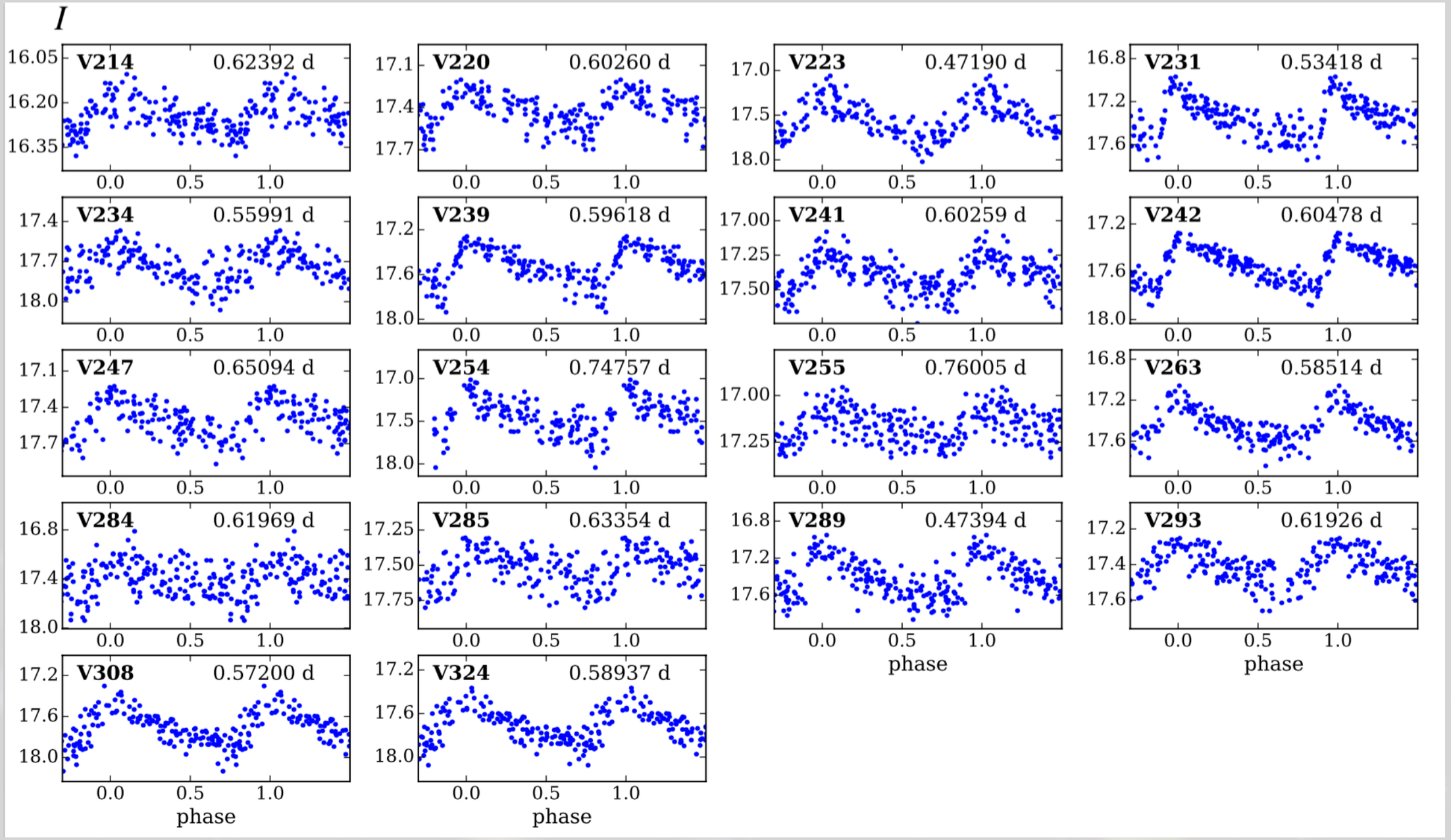


Type II Cepheids found in M54

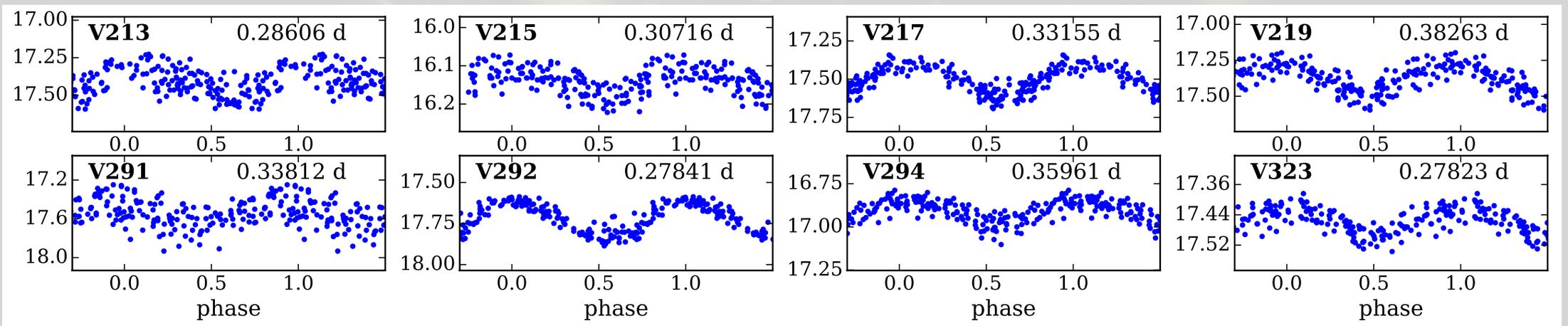
Census after our work:

- 174 RR Lyr stars
- 4 Type II Cepheids
- 51 semi-regular variable red giants
- 3 SX Phe-type stars
- 18 eclipsing binary systems
- 18 other

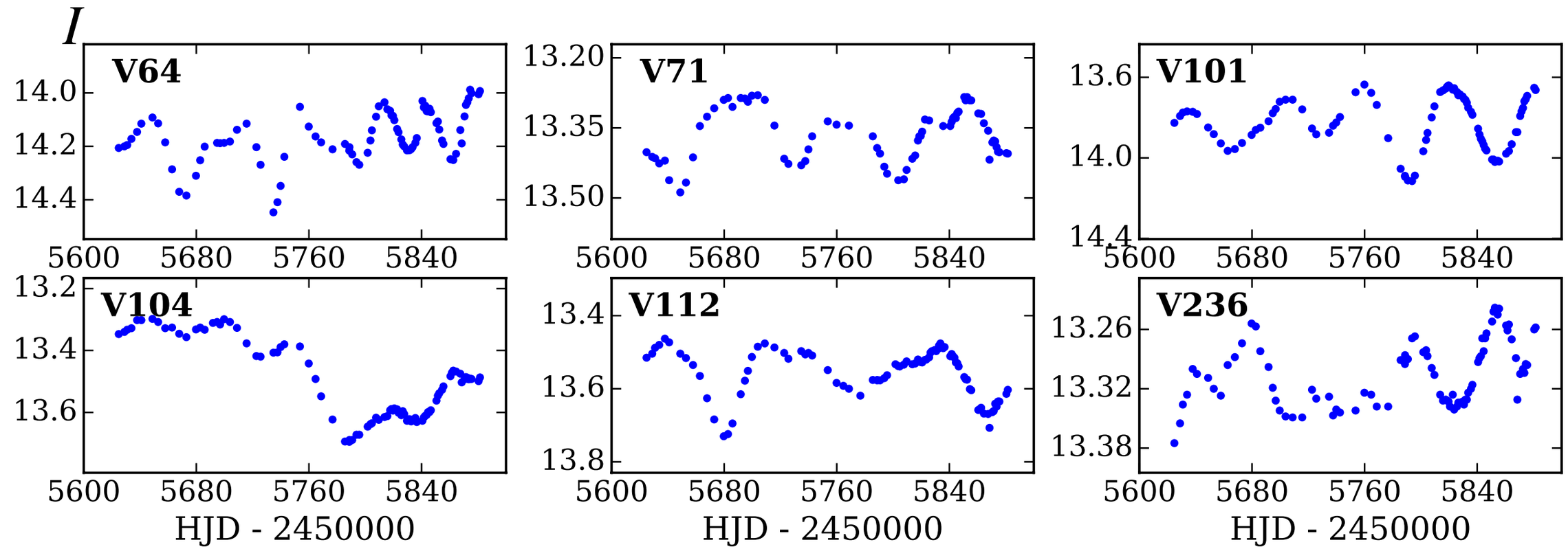
RRab


I
V214 0.62392 d
V220 0.60260 d
V223 0.47190 d
V231 0.53418 d
V234 0.55991 d
V239 0.59618 d
V241 0.60259 d
V242 0.60478 d
V247 0.65094 d
V254 0.74757 d
V255 0.76005 d
V263 0.58514 d
V284 0.61969 d
V285 0.63354 d
V289 0.47394 d
V293 0.61926 d
V308 0.57200 d
V324 0.58937 d
phase

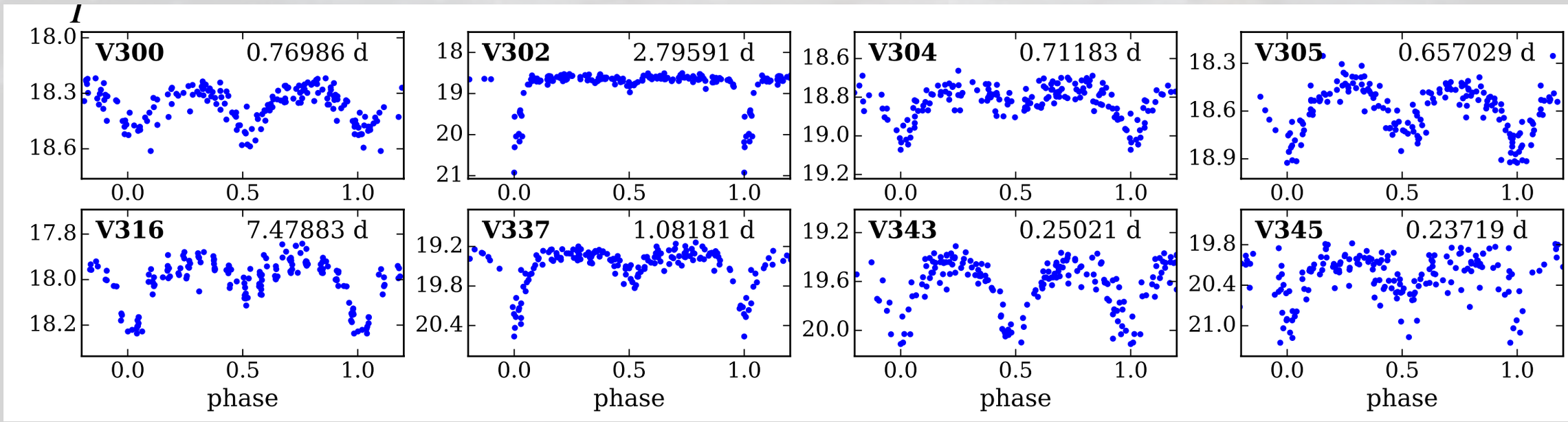
RRc


V213 0.28606 d
V215 0.30716 d
V217 0.33155 d
V219 0.38263 d
V291 0.33812 d
V292 0.27841 d
V294 0.35961 d
V323 0.27823 d
phase

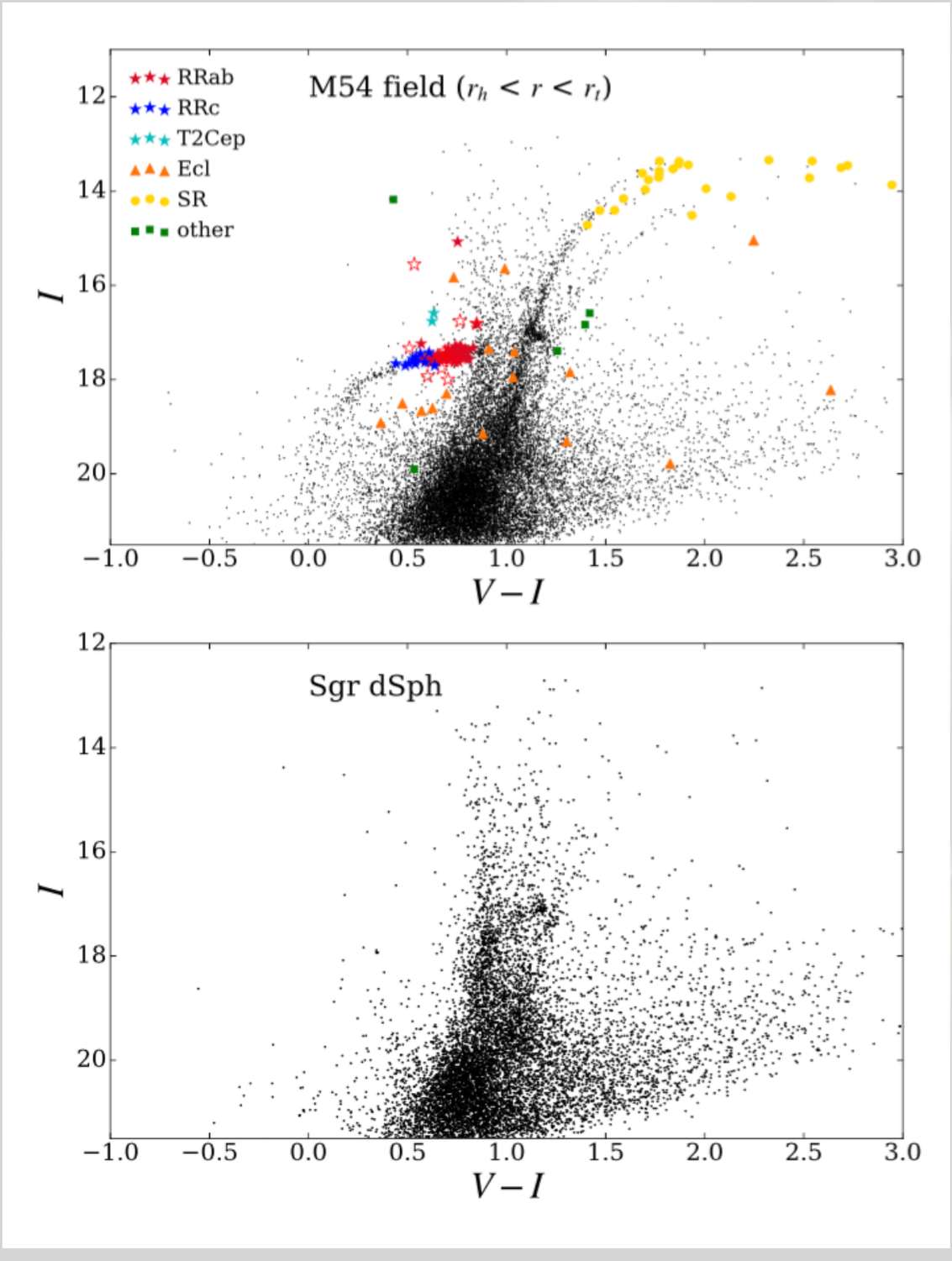
SR


I
V64
V71
V101
V104
V112
V236
HJD - 2450000
HJD - 2450000
HJD - 2450000

Ecl


I
V300 0.76986 d
V302 2.79591 d
V304 0.71183 d
V305 0.657029 d
V316 7.47883 d
V337 1.08181 d
V343 0.25021 d
V345 0.23719 d
phase
phase
phase
phase

COLOR–MAGNITUDE DIAGRAMS

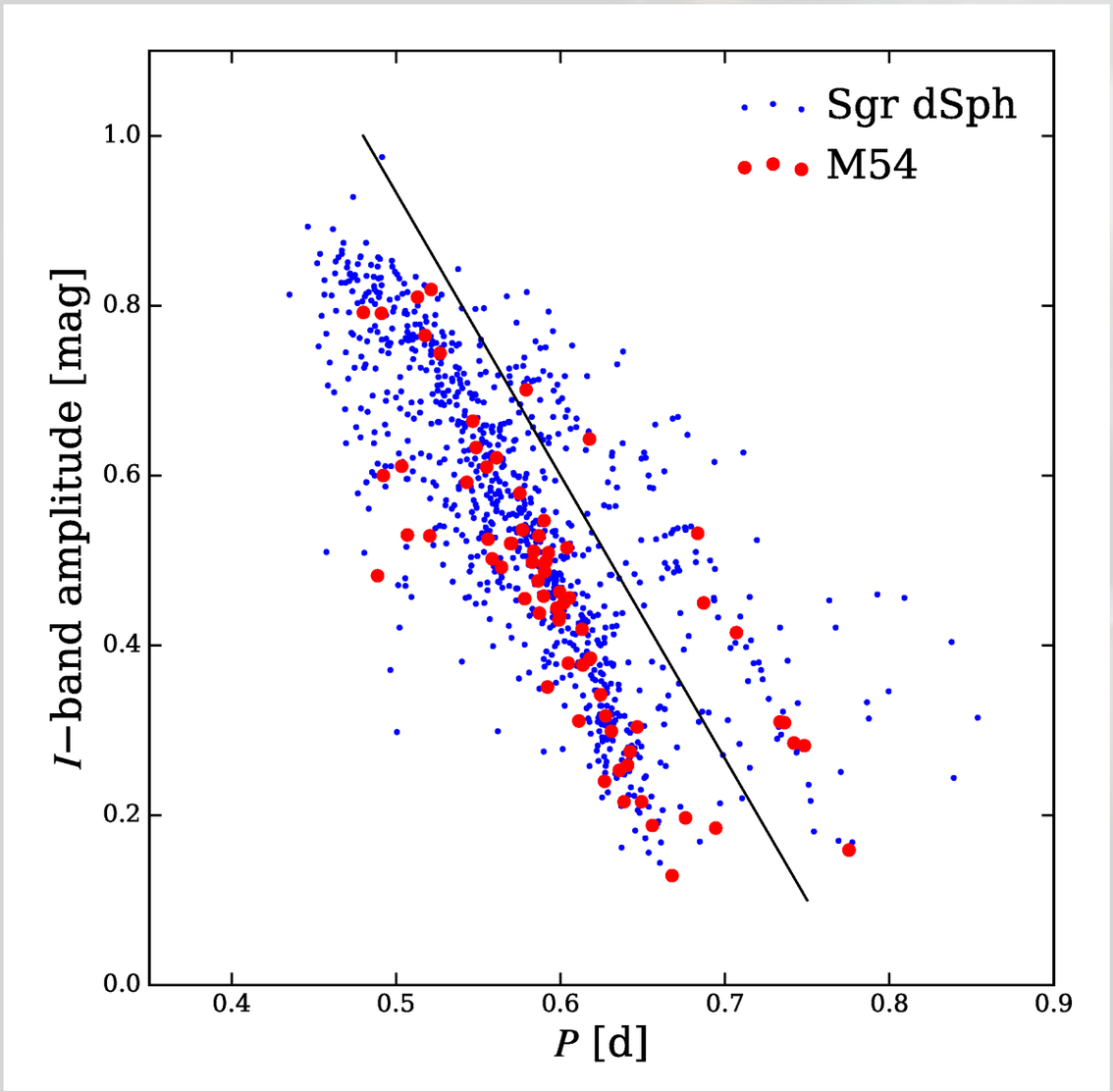


CMDs of M54 and off-cluster Sgr dSph region.

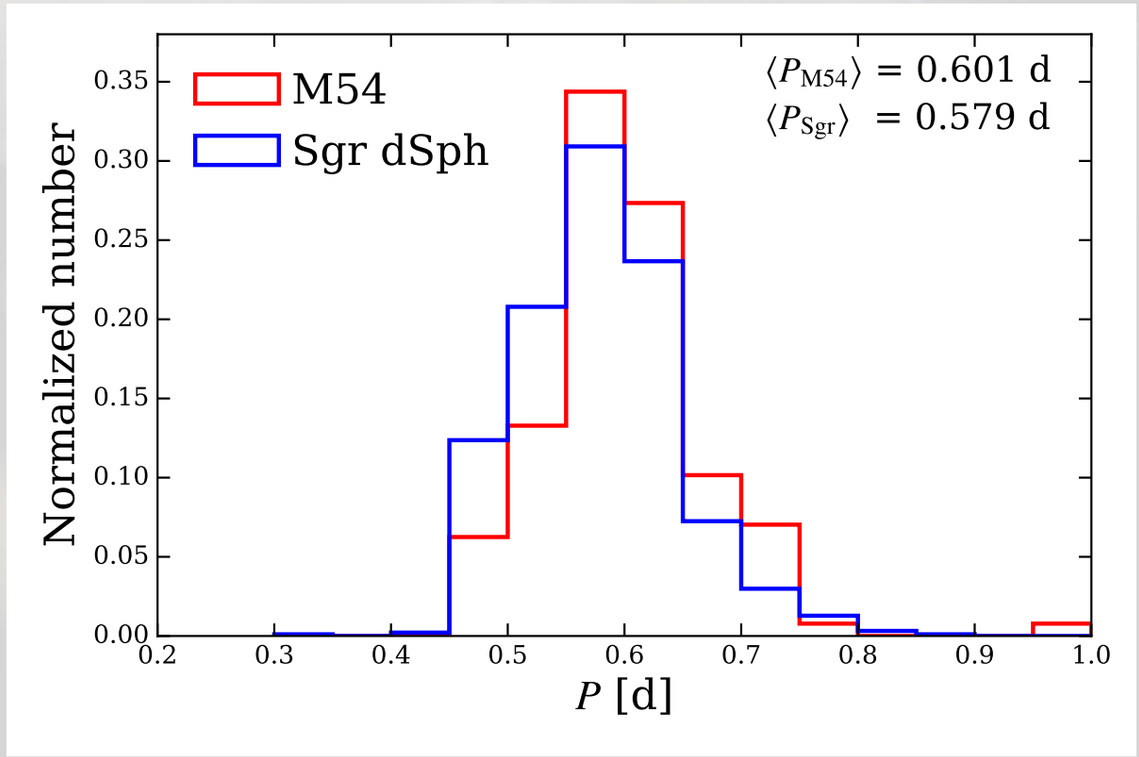
Note a shift between red clumps in M54 and Sgr dSph: the cluster is more metal poor than the remaining body of the dwarf galaxy.

BAILEY DIAGRAM – CONFIRMATION OF TWO POPULATIONS

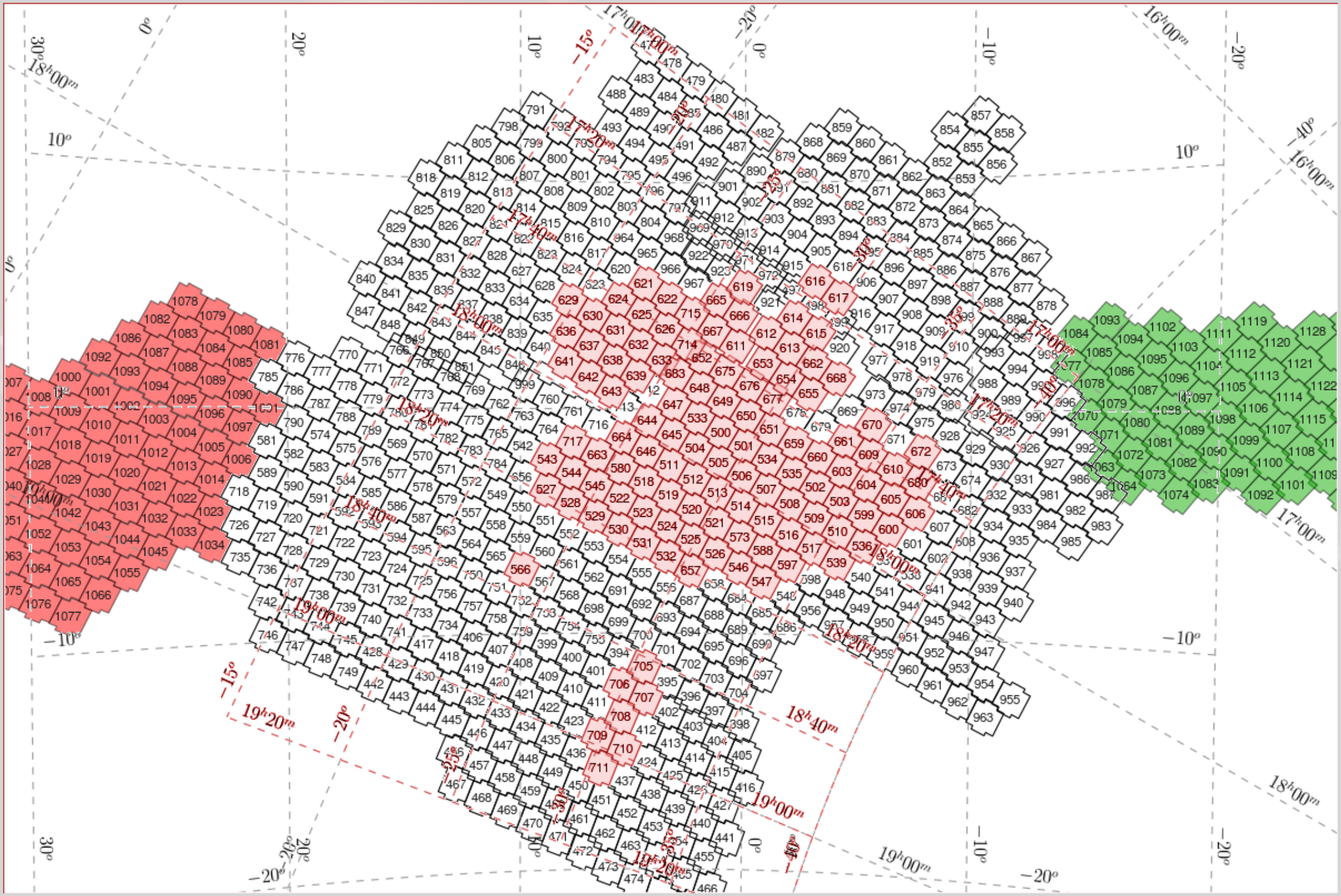
Both in the cluster and surrounding dwarf galaxy there are stars representing two populations.



According to other studies M54 consists of multiple stellar populations with different chemical abundances, and intrinsic iron dispersion (Caretta et al. 2010, Milone 2015, Piotto et al. 2015).



FUTURE WORK – OGLE-IV OUTER BULGE FIELDS

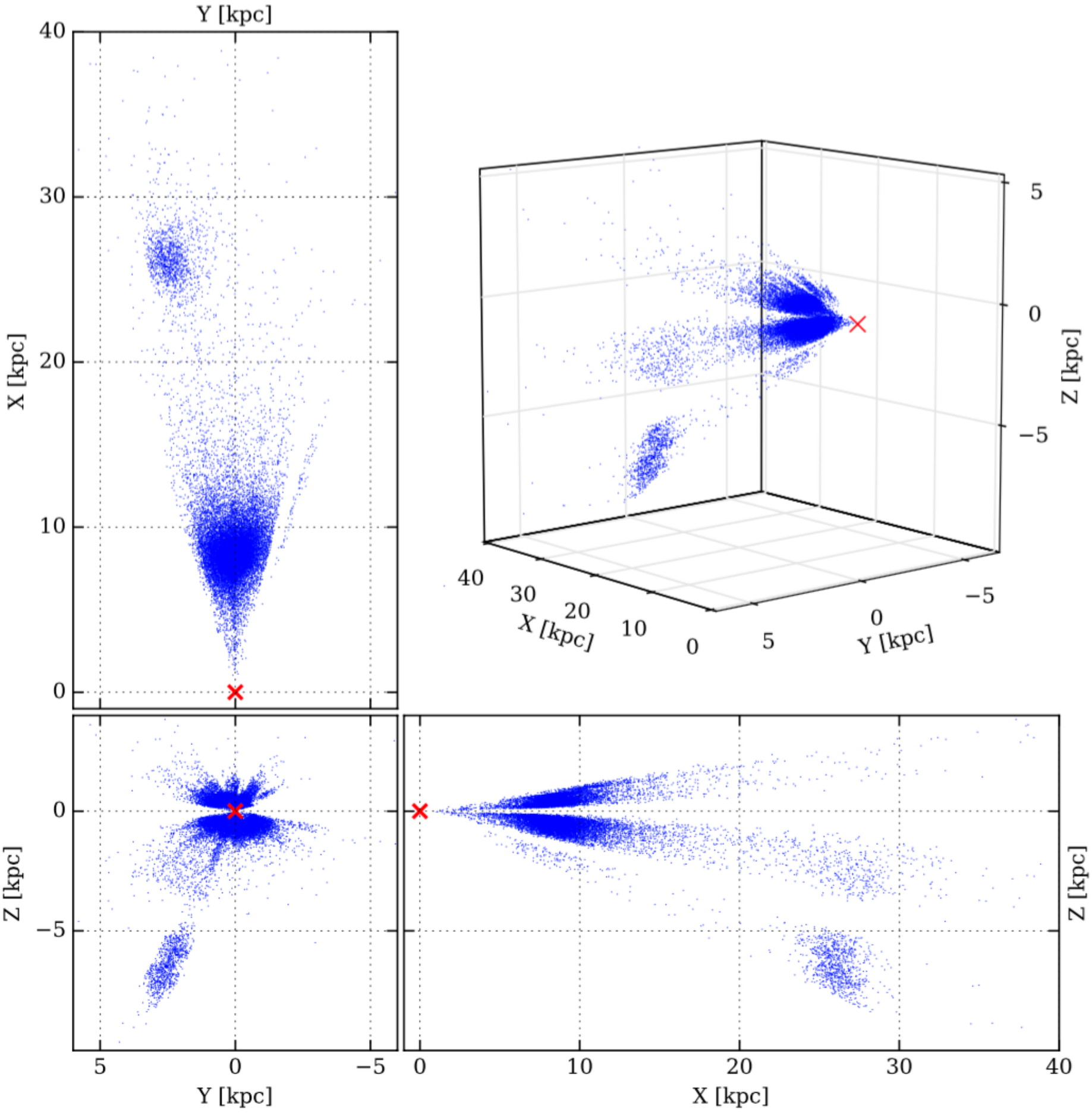


Conclusions

- Our search for variable stars in the field of the globular cluster M54 residing in the core of the Sgr dSph galaxy yielded 83 new objects.
- We found 26 new RR Lyr stars (18 RRab + 8 RRc).
- Distance to M54 based on 70 RRab stars:

$$d_{M54} = 26.7 \pm 0.03_{stat} \pm 1.3_{sys}$$

- Thickness of the observed central fragment of the Sgr dSph stream: FWHM = 2.42 kpc.
- Work published in
  Hamanowicz et al. 2016, Acta Astronomica, 66, 197.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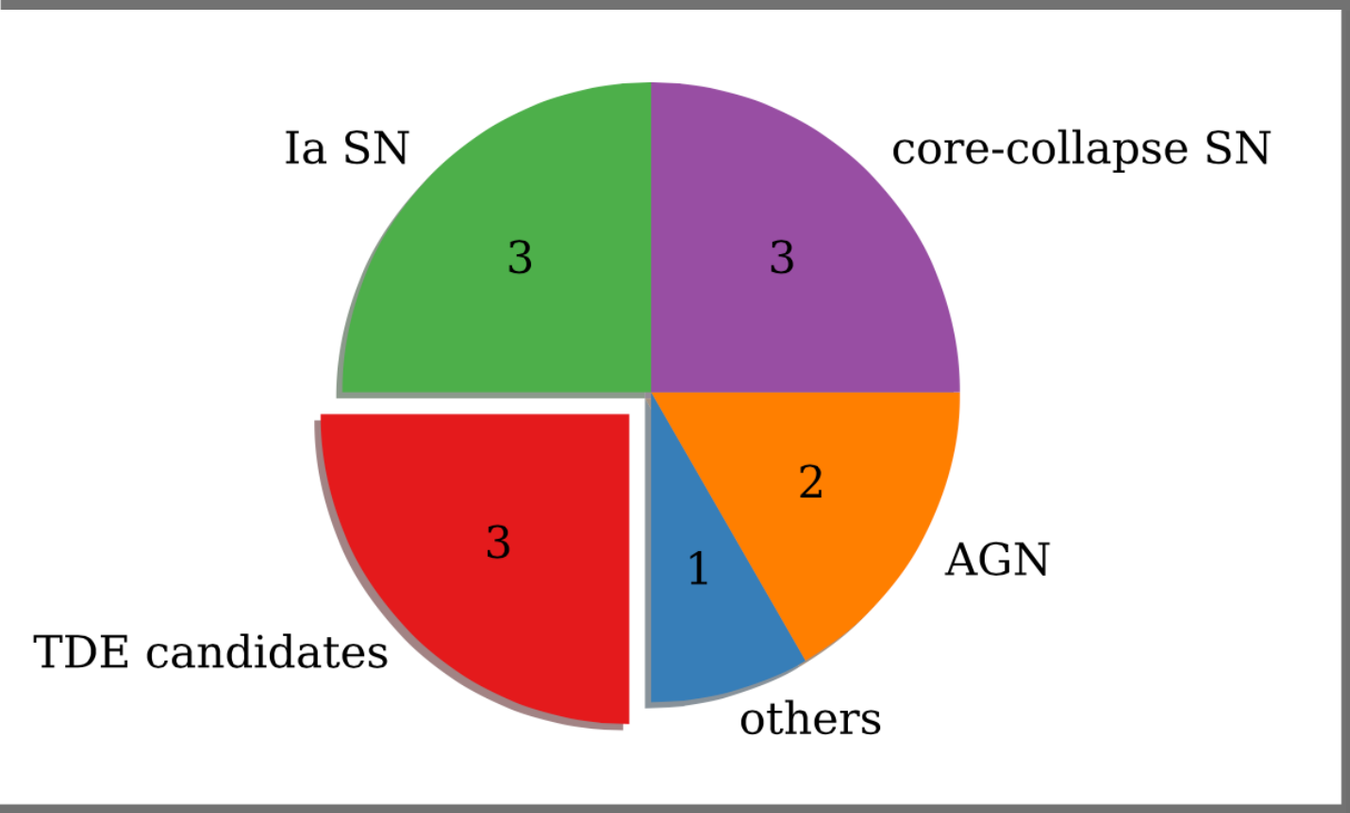
Nuclear transients in OGLE

Aleksandra Hamanowicz **Łukasz Wyrzykowski** **Mariusz Gromadzki**
ahamanowicz@astrouw.edu.pl
Warsaw University Astronomical Observatory, Poland



12 nuclear transients

search for Tidal Disruption Events (TDE)