THE MILKY WAY GALAXY AS SEEN BY LSST

N.W. Evans (Cambridge)

LSST DATASETS

LSST will permit:

• the mapping of stellar number density with observations of ~ 10 billion main sequence stars to (unextincted) distances of 100 kpc over 20,000 deg^2 of sky. The near IR *y* band allows mapping in regions of high extinction.

• the mapping of stellar metallicity over the same volume, using *u* band observations of photometric metallicity indicators in ~ 200 million near turn-off main sequence (F/G) stars.

• the construction of maps of other more luminous tracers, such as RR Lyrae variables, to as far as 400 kpc – the approximate virial radius of the Milky Way.

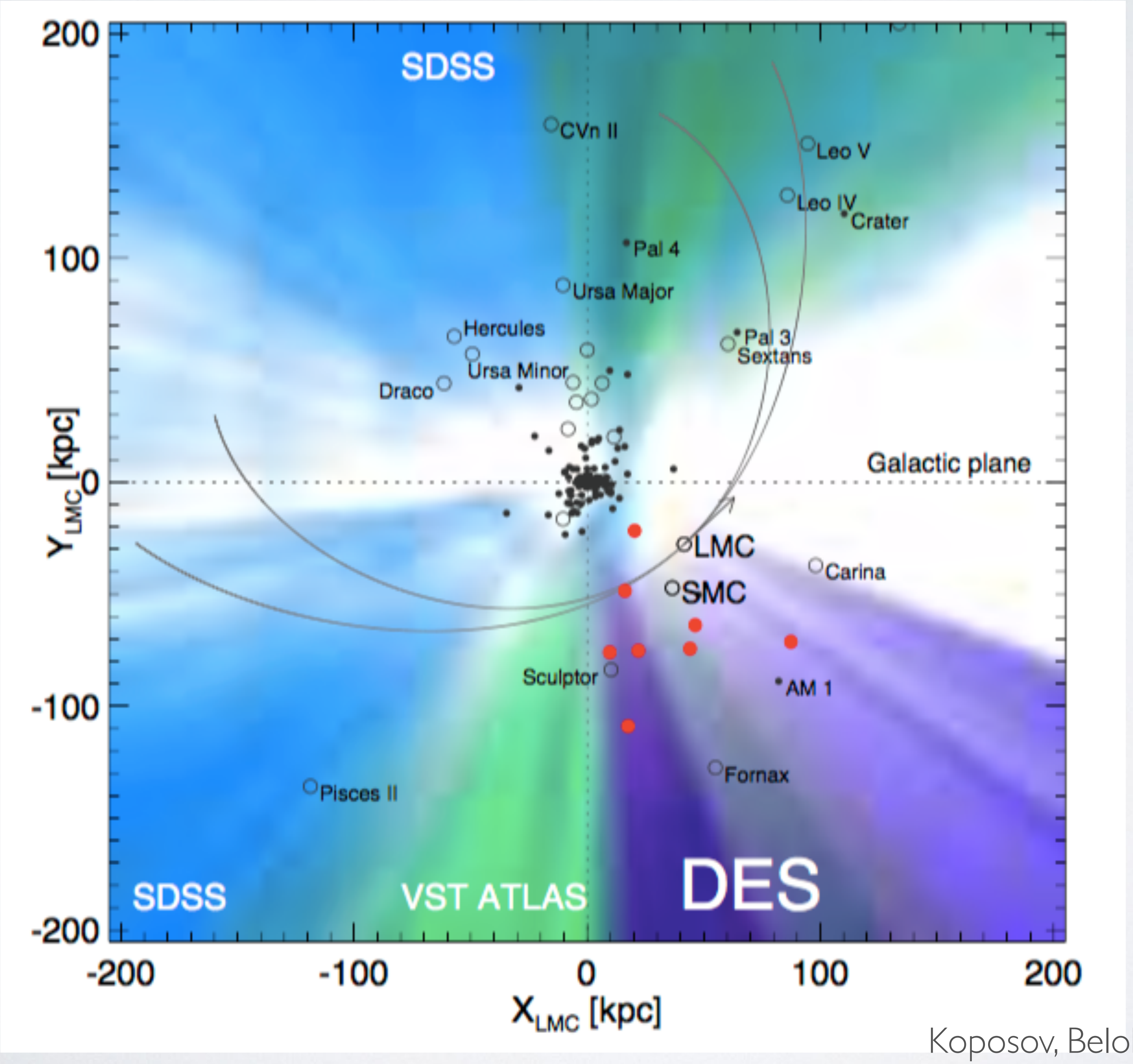
• high fidelity maps of tangential velocity field to at least 10 kpc (at 10 km/s precision) and as far as as 25 kpc (at 60 km/s precision).

LSST DATA

The typical resolution of LSST Galactic maps will be on order of ~ 10 − 15% in distance and 0.2 − 0.3 dex in metallicity.

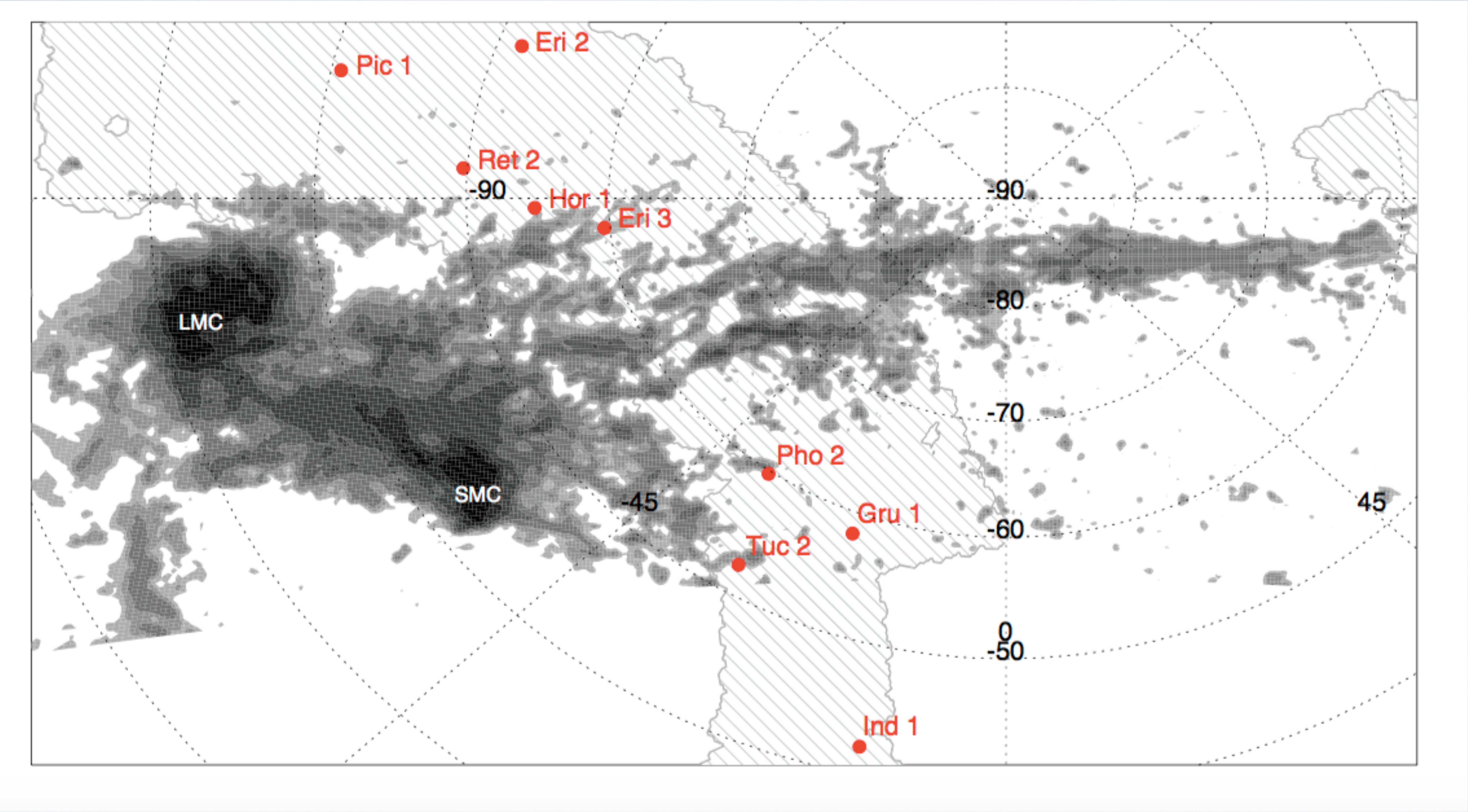
The former is fundamentally limited by unresolved multiple systems, while the latter is limited by calibration and accuracy of u band photometry.

DISCOVERY OF ULTRAFAINTS



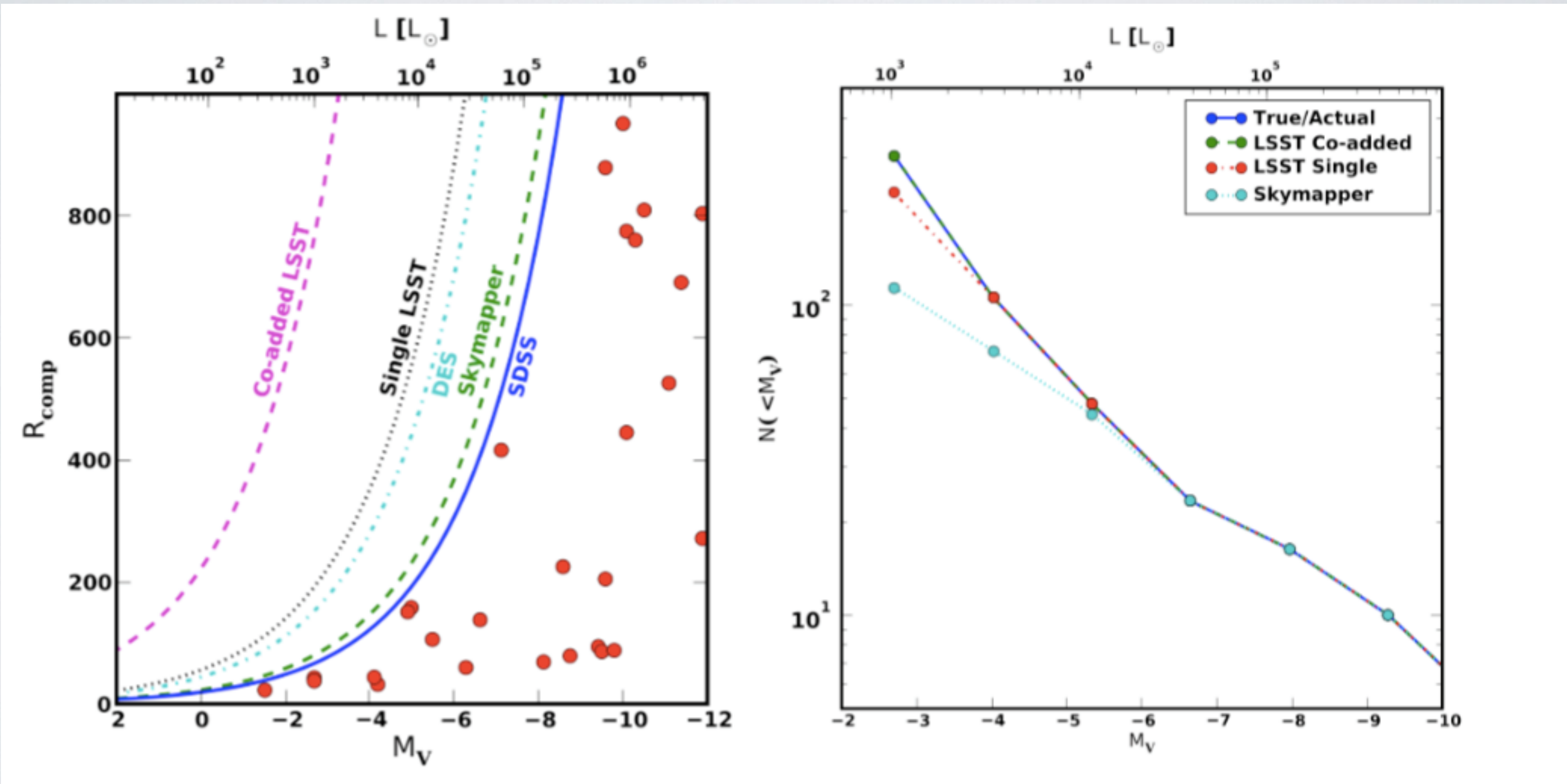
Koposov, Belokurov, Torrealba, Evans 2016;

DISCOVERY OF ULTRA-FAINTS



Koposov, Belokurov, Torrealba, Evans 2016; see also Drlica-Wagner et al. 2015, 2016

DISCOVERY OF ULTRA-FAINTS

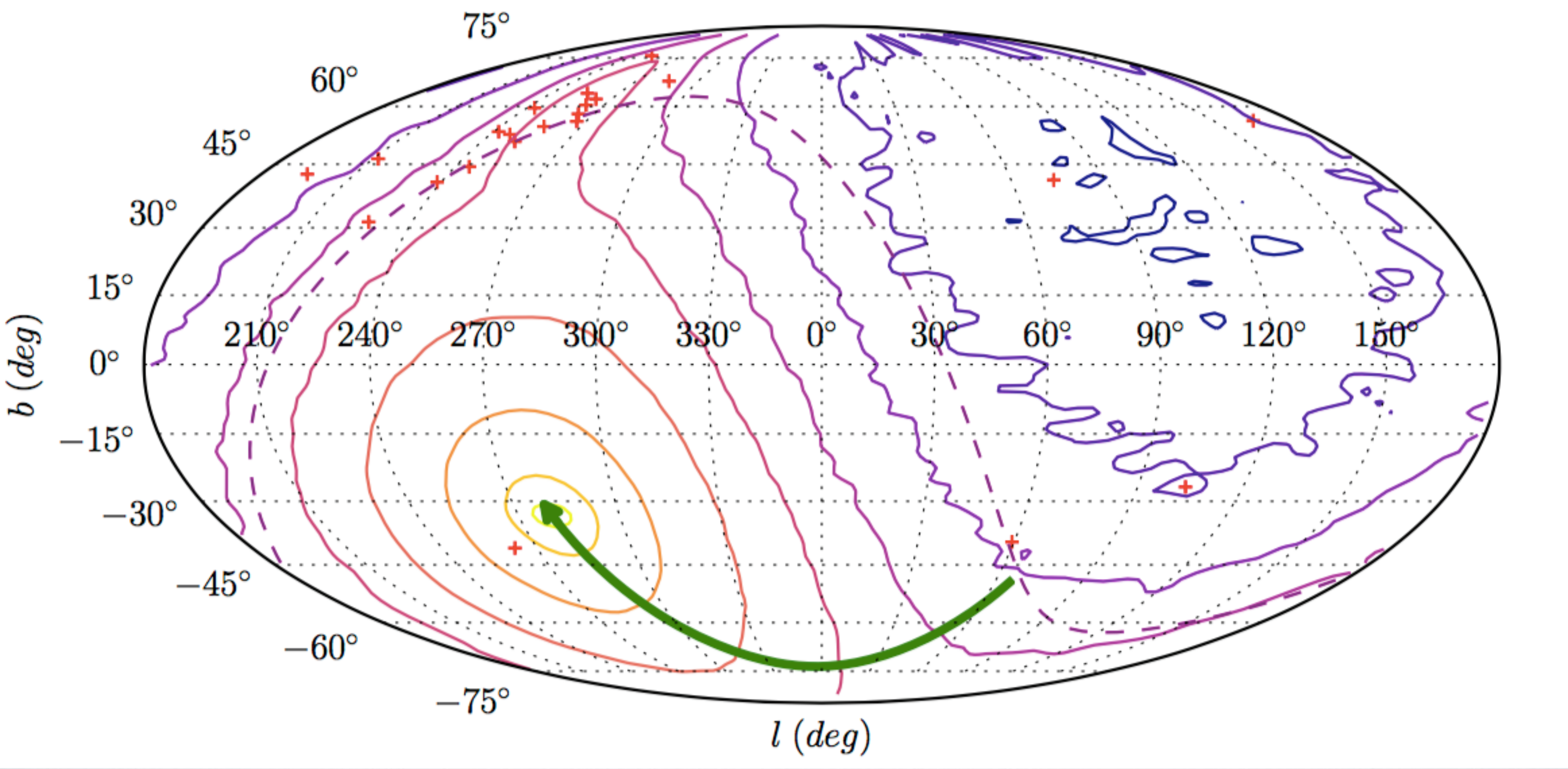


Tollerud et al. 2008

DISCOVERY OF ULTRAFAINTS

The depth of the co-added LSST survey could reveal objects, like the very least luminous now known ($M_V \sim -2$) to distances of 600 kpc – several thousand times the volume searchable by SDSS. A straightforward luminosity bias correction suggests there may be as many as 500 ultra-faint dwarf galaxies within the virial radius of the Milky Way (Tollerud et al. 2008).

HYPERVELOCITY STARS



Boubert & Evans 2016

HYPERVELOCITY STARS

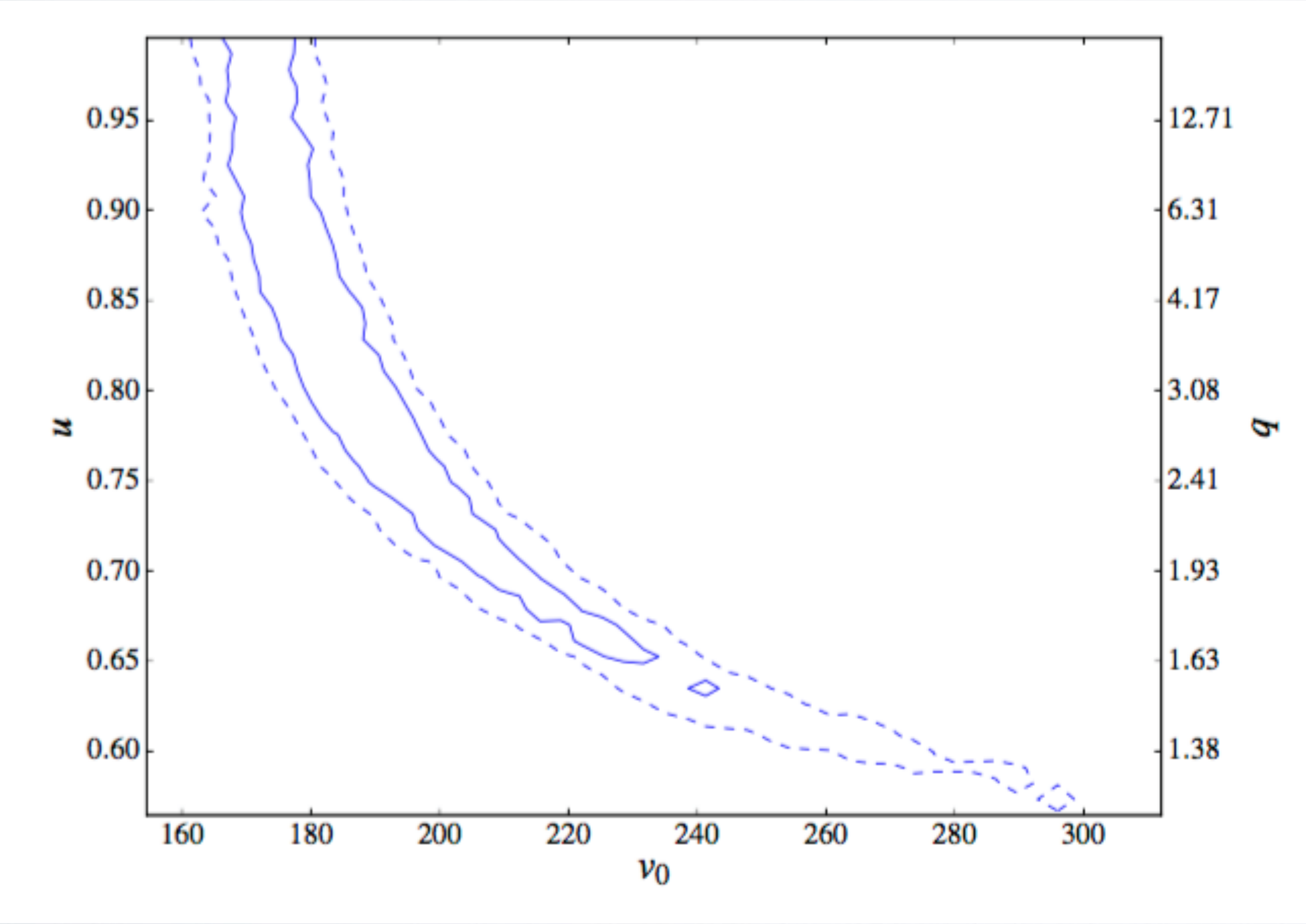
- Gaia will obtain more accurate proper motions than LSST for stars brighter than $r = 20$. For $V > 20$, then LSST will dominate with a proper motion accuracy of 10 km/s at 10 kpc.

- As an example, an HVS 10 kpc from the Sun with a transverse velocity of 500 km/s will have a proper motion of 10 mas/yr. The proper motion error at the single-visit limit (2 15s exposures) of the survey ($r = 24$) is ~1 mas/yr, so HVS with absolute magnitudes as faint as $M_r = 9$ (mass ~ $0.4M_\odot$) will be identified. Such stars are too faint to be studied by Gaia, and are too rare to be selected by any radial velocity survey.

SHAPE OF THE HALO

- Dark halo is oblate, as judged from modelling of the GD1-stellar stream (Koposov et al 2010, Bowden et al. 2015).
- Dark halo is nearly spherical, as judged from Sagittarius stream modelling (Fellhauer et al. 2010) or stellar kinematics (Smith et al. 2009) or the HI gas flare (Olling & Merrifield 2000).
- Dark halo is prolate, as judged from Sagittarius stream (Helmi 2004) or HI gas flare (Banerjee & Jog 2011).

SHAPE OF THE HALO



Bowden, Evans, Williams 2016

Bowden et al. (2016) used a sample of ~ 10000 SDSS/SEGUE stellar halo stars with proper motions to solve the axisymmetric Jeans equations and find a halo flattening of $1.5 < q < 2$ (prolate !) if the circular speed lies between 200 km/s and 250 km/s.

SHAPE OF THE HALO

LSST will provide 0.2 mas/yr (1 mas/yr) proper motion accuracy for objects as bright as r = 21 (24) over its 10-year baseline. For main sequence stars at a distance of ~ 15 kpc (60 kpc), this proper motion accuracy corresponds to approximately ~ 15 km/s (300 km/s) velocity accuracy per star.

Measurements at these levels for more than 200 million stars will enable high-precision mass models of the Milky Way halo. By the end of the survey, tangential velocities with accuracies better than 100 km/s will be available for every red giant star within 100 kpc.

CONCLUSIONS

A triumph of the last decade was that the broad consistency of hierarchical models of structure formation with the Milky Way (e.g. substructure, ultra faints).

The LSST will extend this work by providing maps of the stellar distribution throughout the Local Volume. This will provide an inventory of streams & substructure, telling us how their properties (e.g., morphology, extent) vary as a function of location, allowing us to make connections with the local environment and early Universe influences.

Combining this with stellar population studies will give chemo-dynamical spatial maps of substructure. This will provide insight into the assembly history and star formation unrivalled by any studies that rely on integrated light at higher redshift.

LSST will provide a significant test for our theories of galaxy formation.

LSST DATASETS

- The existence of the *u* band allows the measurement of stellar metallicities of near turn-off stars and its mapping throughout the observed disk and halo volume.
- The existence of the near-IR *y* band allows the mapping of stellar number densities and proper motions even in regions of high extinction.
- Well sampled time domain information allows for the unambiguous identification and characterization of variable stars (RR Lyrae), facilitating their use as density and kinematic tracers to large distances.
- Multi-epoch data allows proper motion measurements for stars 4 mags fainter than obtained by Gaia.
- The depth and wide-area nature of the survey permits a uniquely uniform, comprehensive, and global view of all luminous Galactic components.