The Ghosts of Galaxy Formation

KITP, 1st October, 2008

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with
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and
Wyn Evans, Paul Hewett, Gerry Gilmore, Mike Irwin, Dan Zucker, Matt Walker, Dan Faria,
Mike Fellhauer, Martin Niederste-Ostholt, Laura Watkins, Hannah Whiteoak

Talk Outline

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- Kittens in Leo
  - Leo V
  - Leo T
- SEGUE-1

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- Kittens in Leo
  - Leo V
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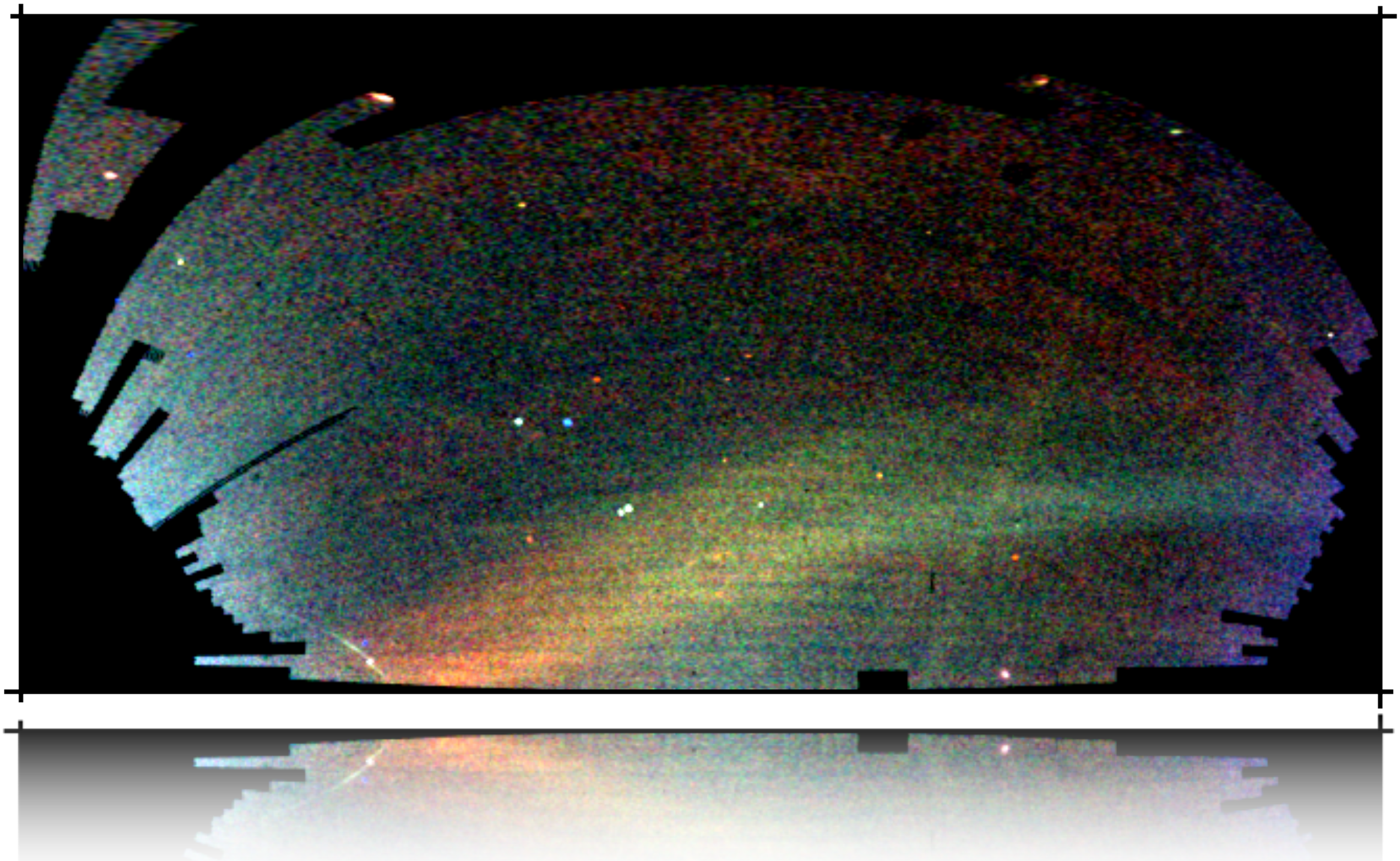
    - SEGUE-1
- Stripe Mining
  - Disc Heating
  - Constraining Halo Profile
  - Accretion Remnants

Kittens in Leo

Field of Streams

Belokurov et al. (2006)



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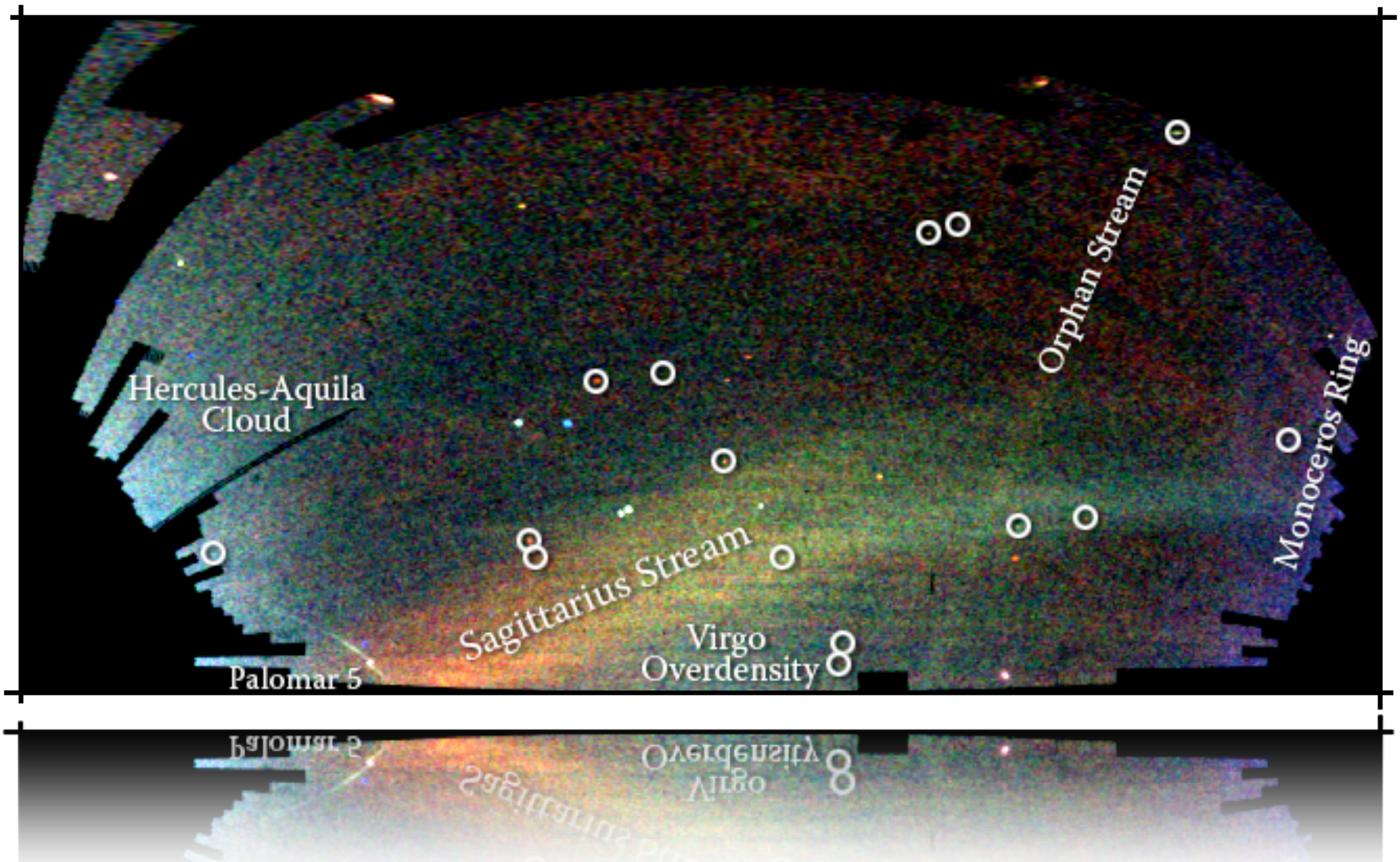
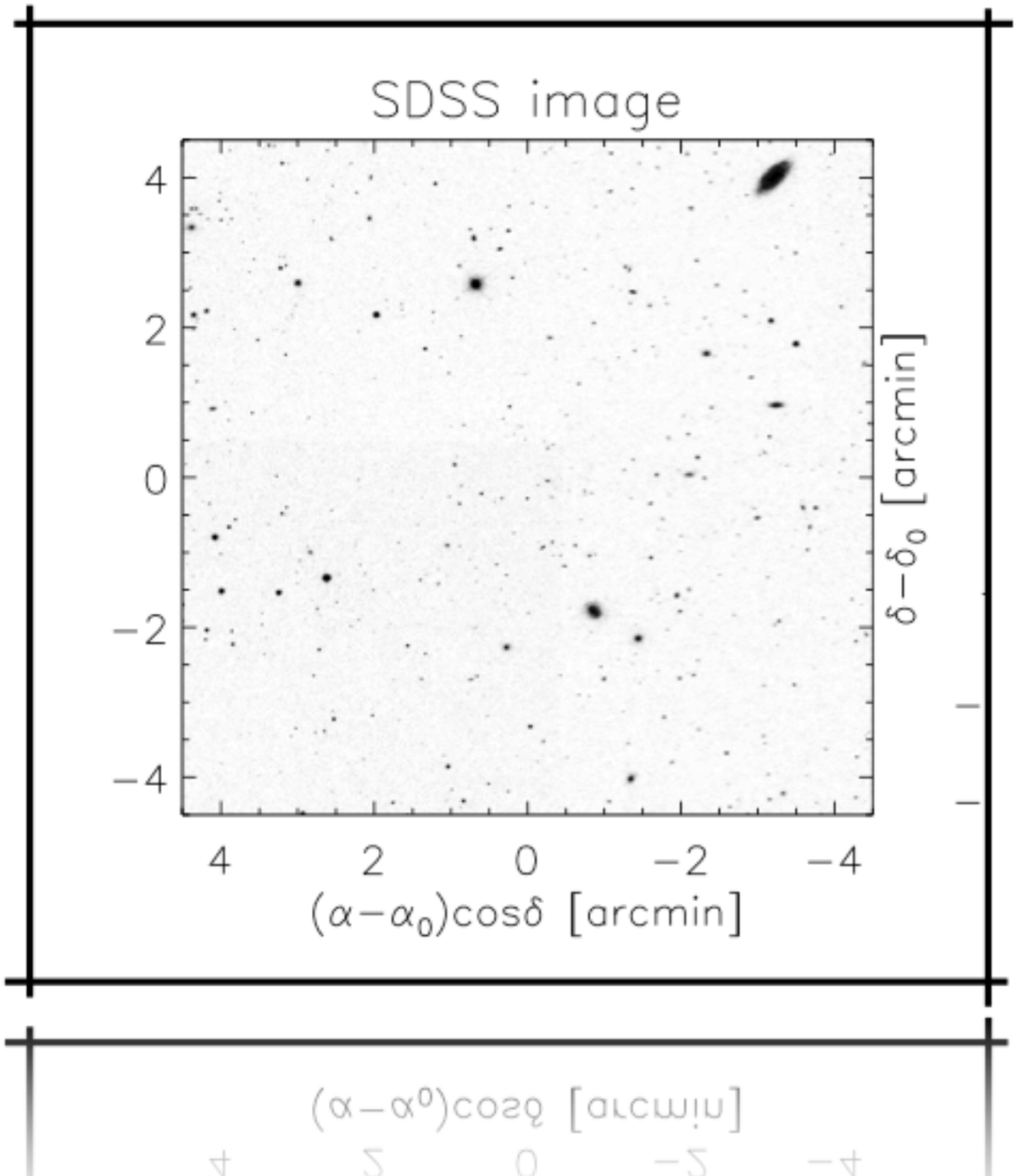


Leo V

Belokurov et al. (2008)



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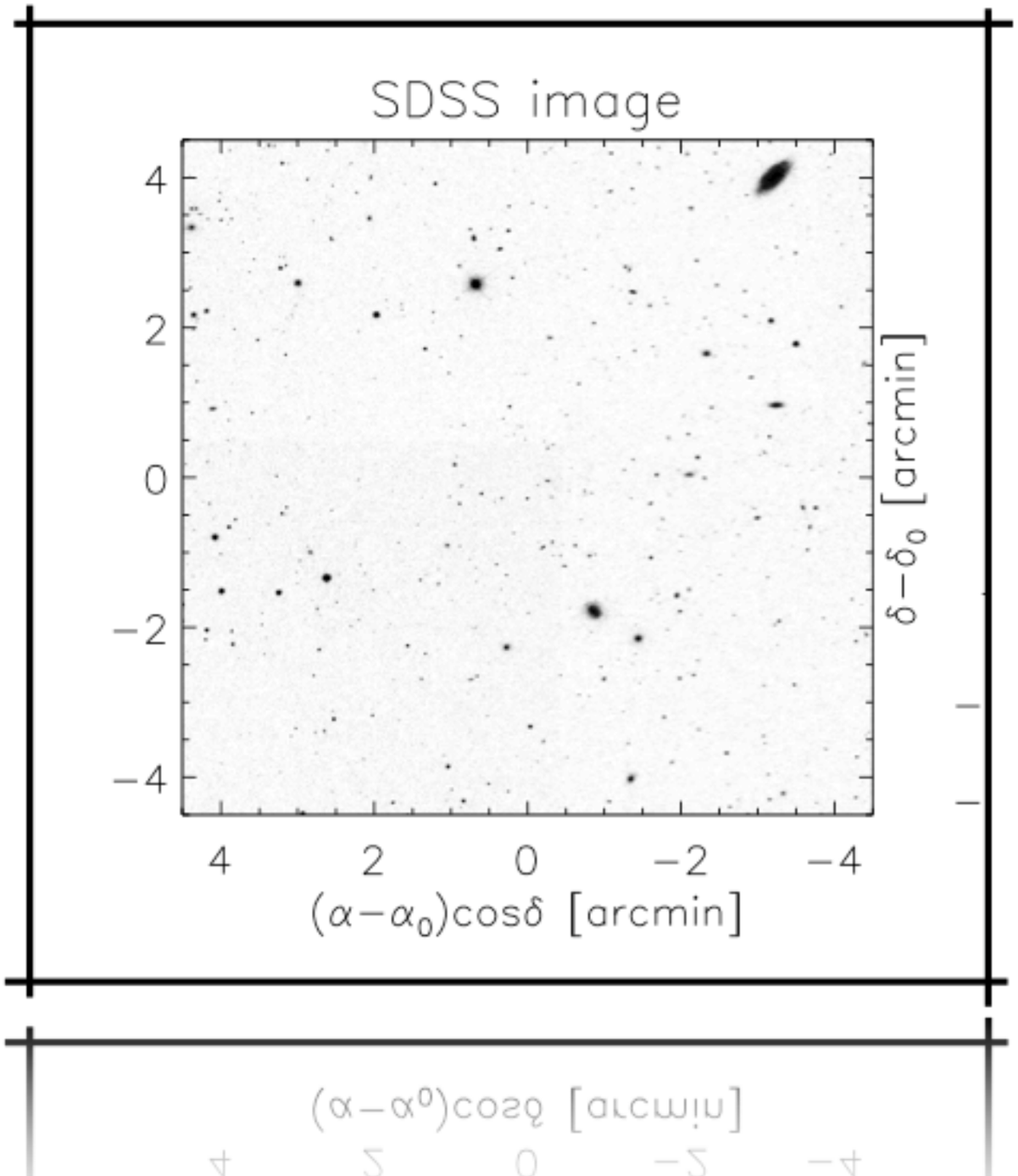
Belokurov et al. (2008)

- Ultra-faint dwarf at ~180kpc



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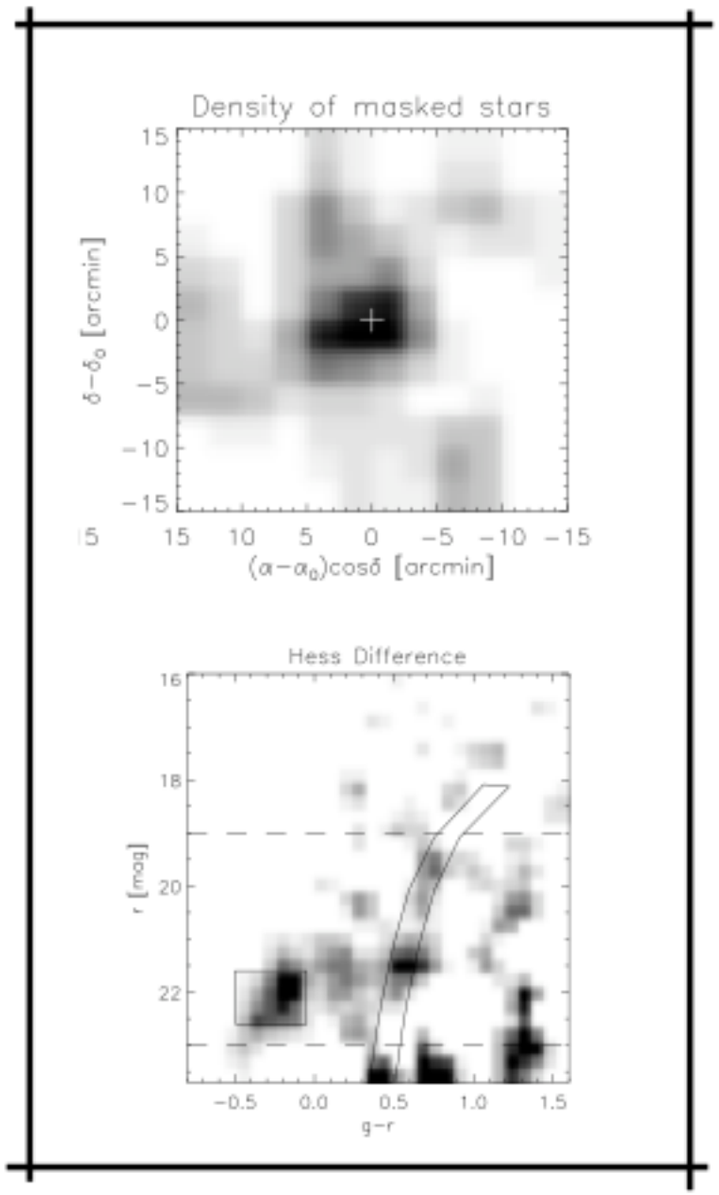

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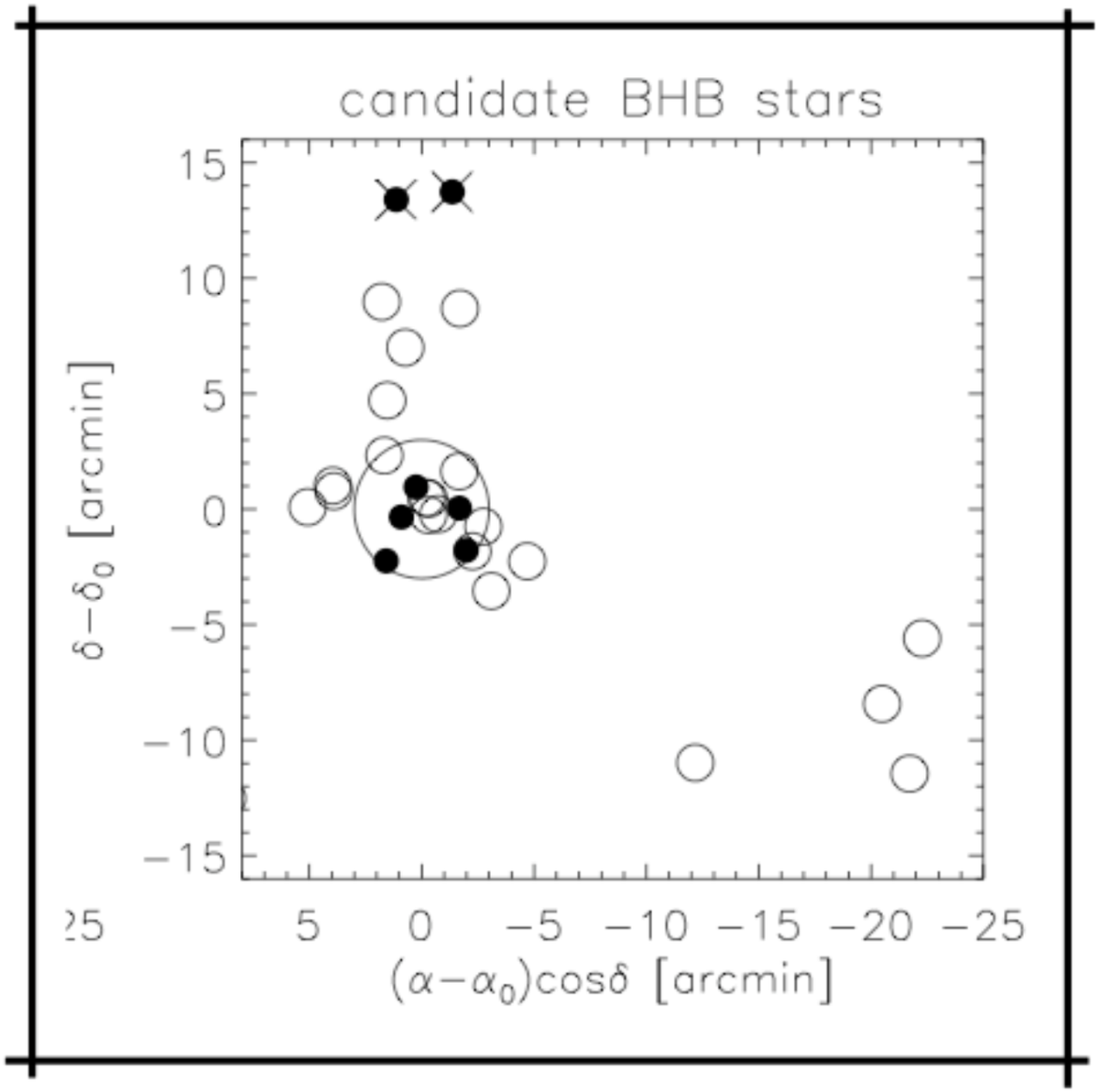
- BHBs shows extended profile
- Similar extension seen in other dwarfs such as Hercules and Leo IV

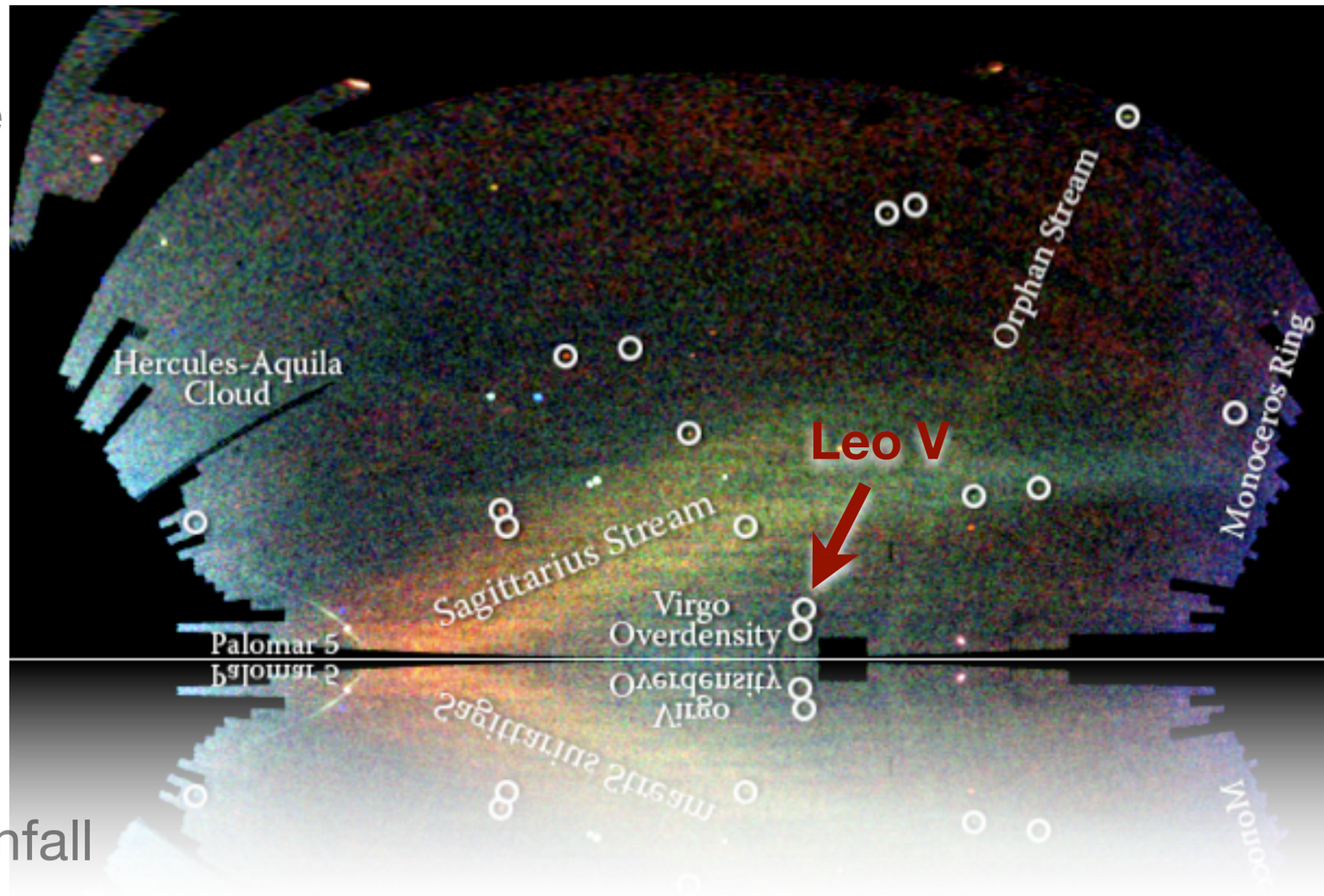


RGBs
BHBs

Leo V

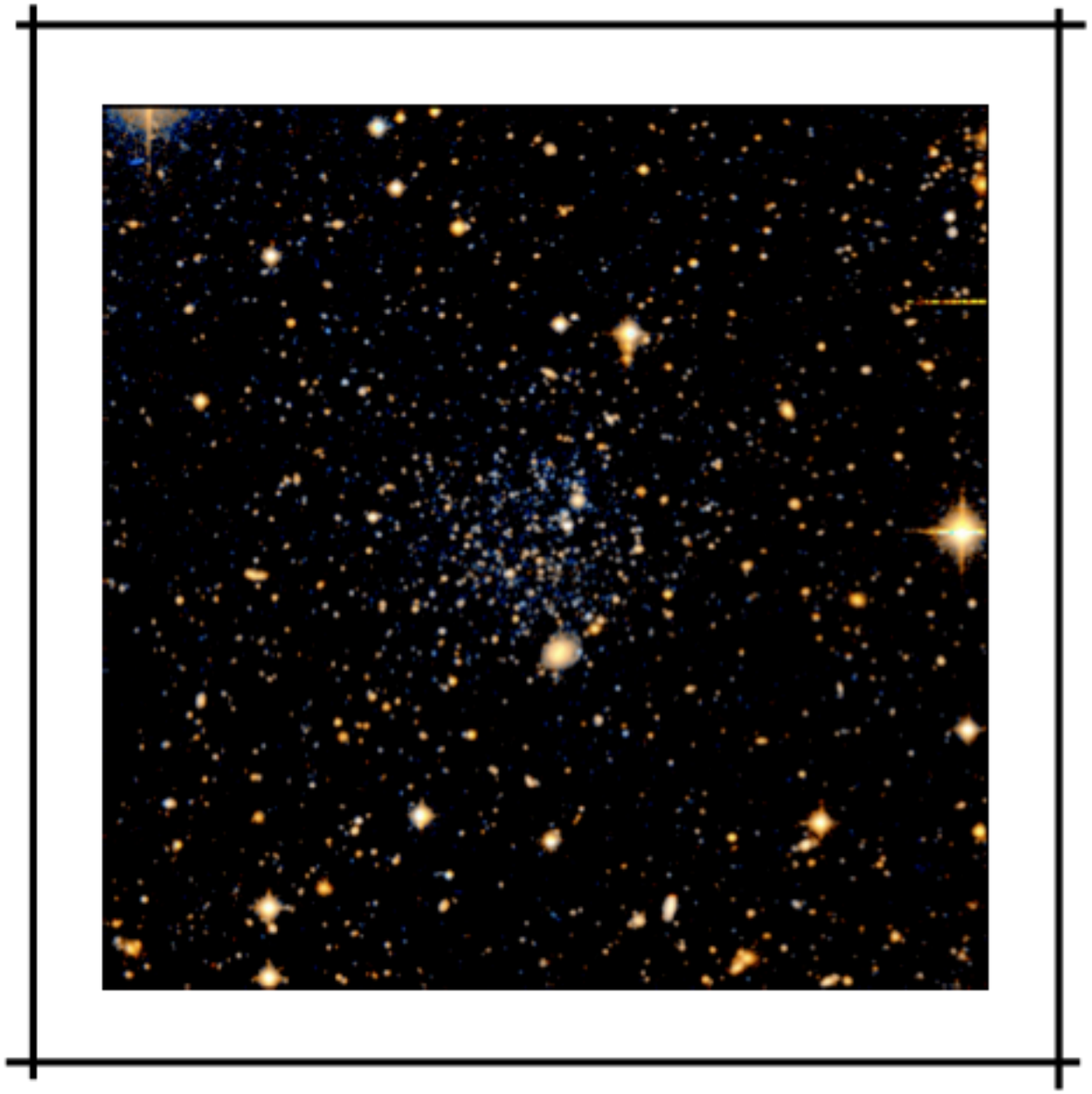
Belokurov et al. (2008)

- Ultra-faint dwarf at ~180kpc
- CMD mask shows overdensity
- BHBs shows extended profile
  - Similar extension seen in other dwarfs such as Hercules and Leo IV
- But is this a companion of a companion?
  - Is this part of a stream, i.e. direct evidence for group infall



Leo T

Irwin et al. (2007)
Ryan-Weber et al. (2008)



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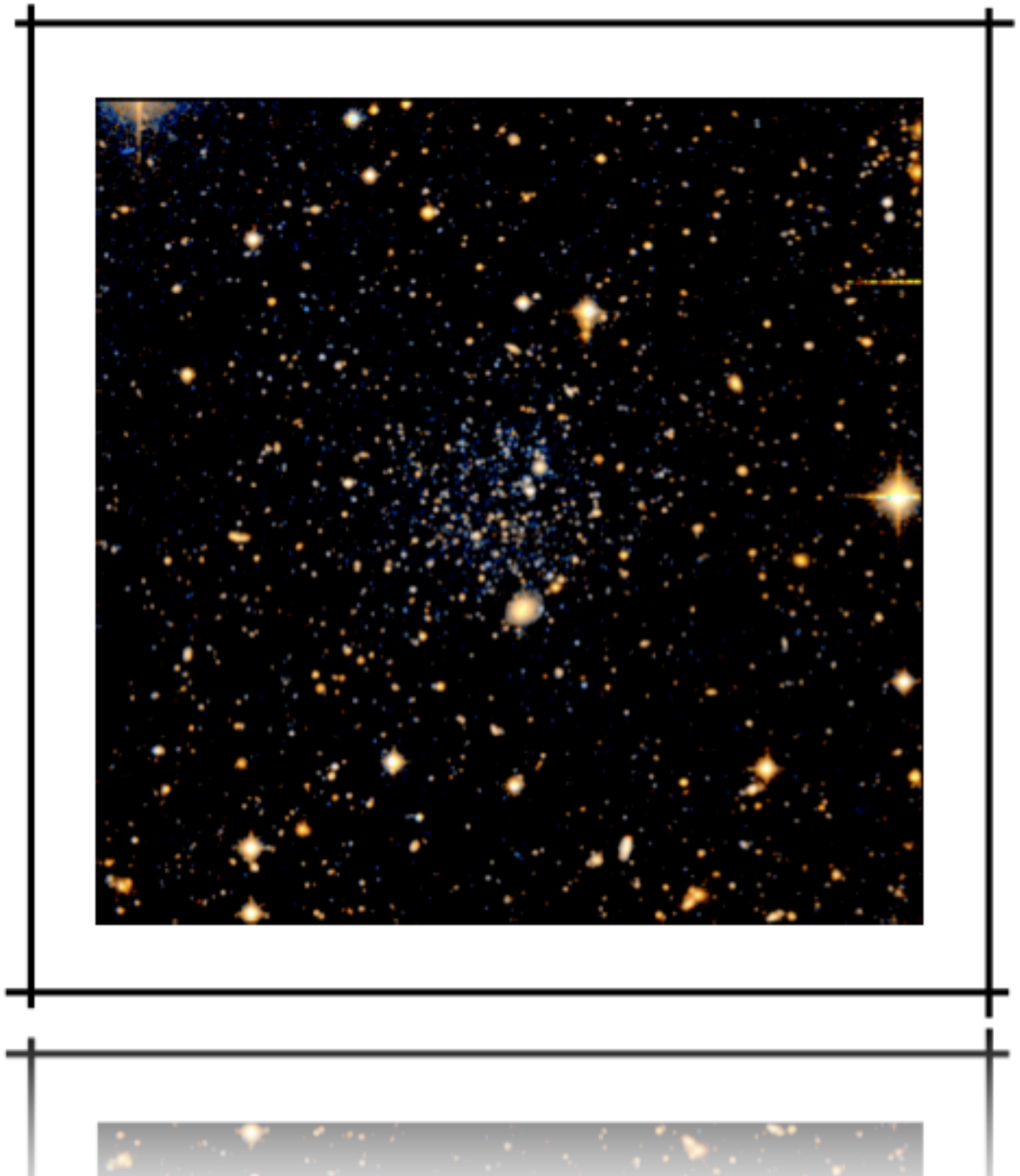
- ~420 kpc and ~3.3x10^6 $M_\odot$



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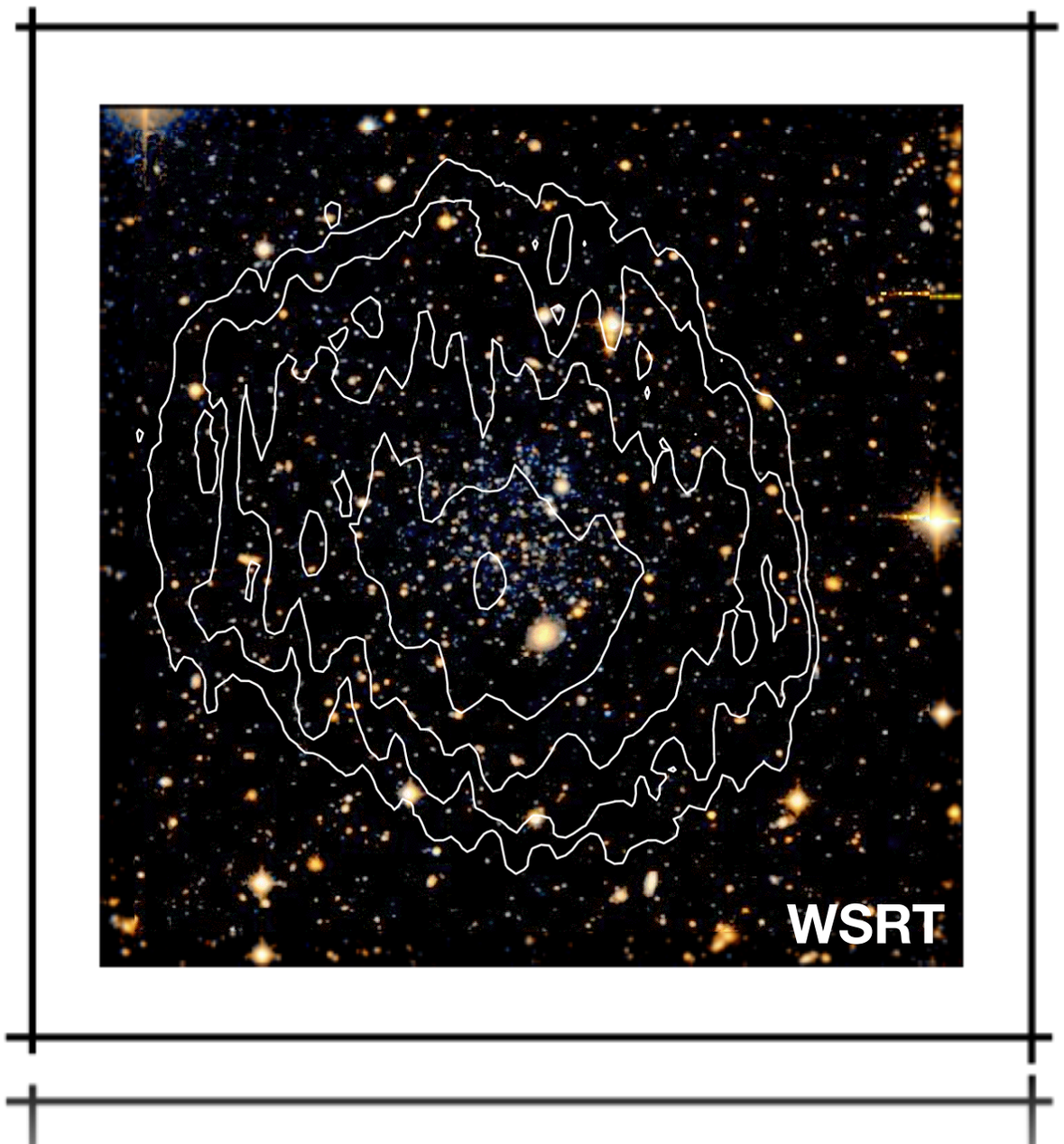

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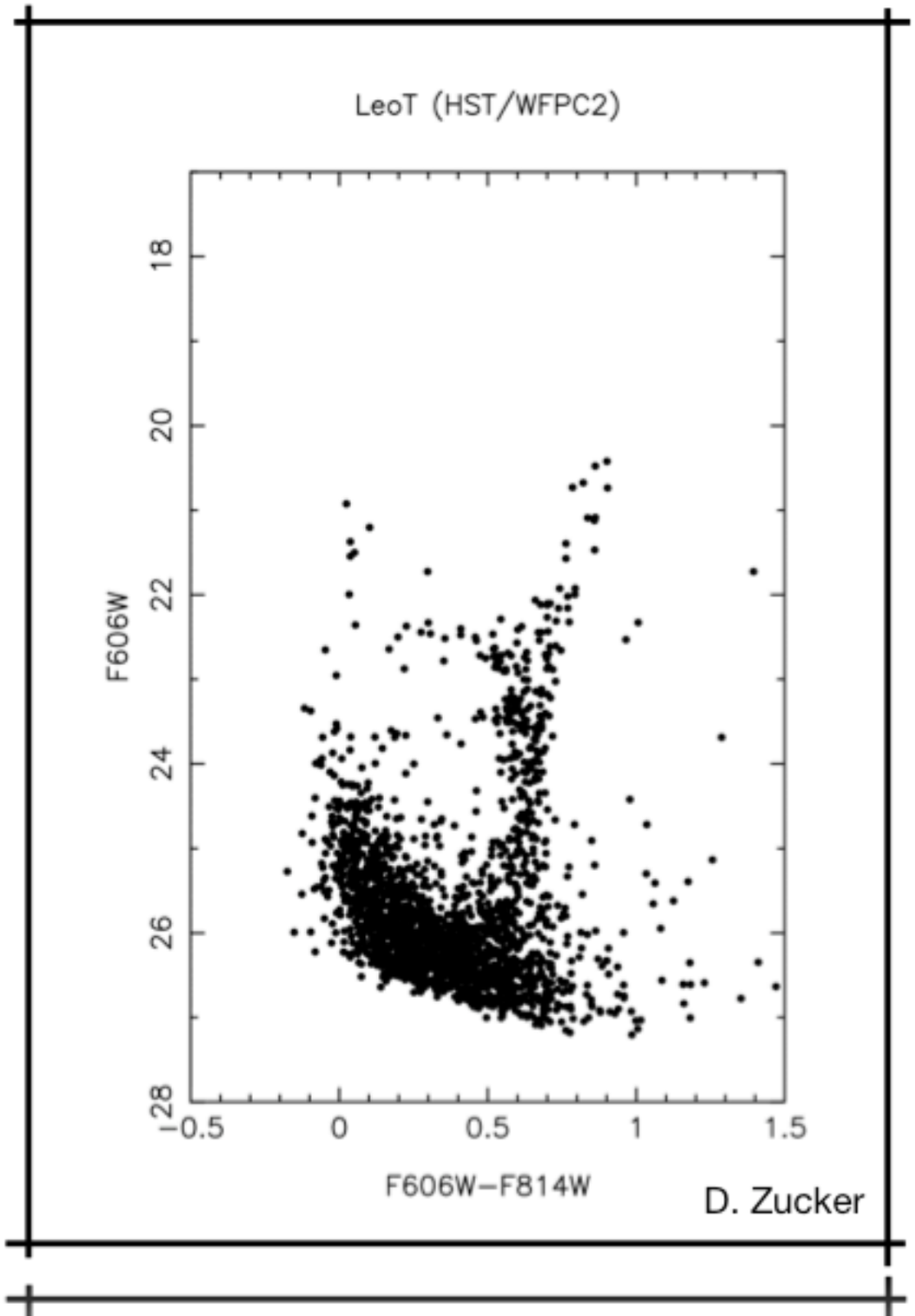
- "H_I on the brink of star formation": ~3x10^5 $M_\odot$ of H_I

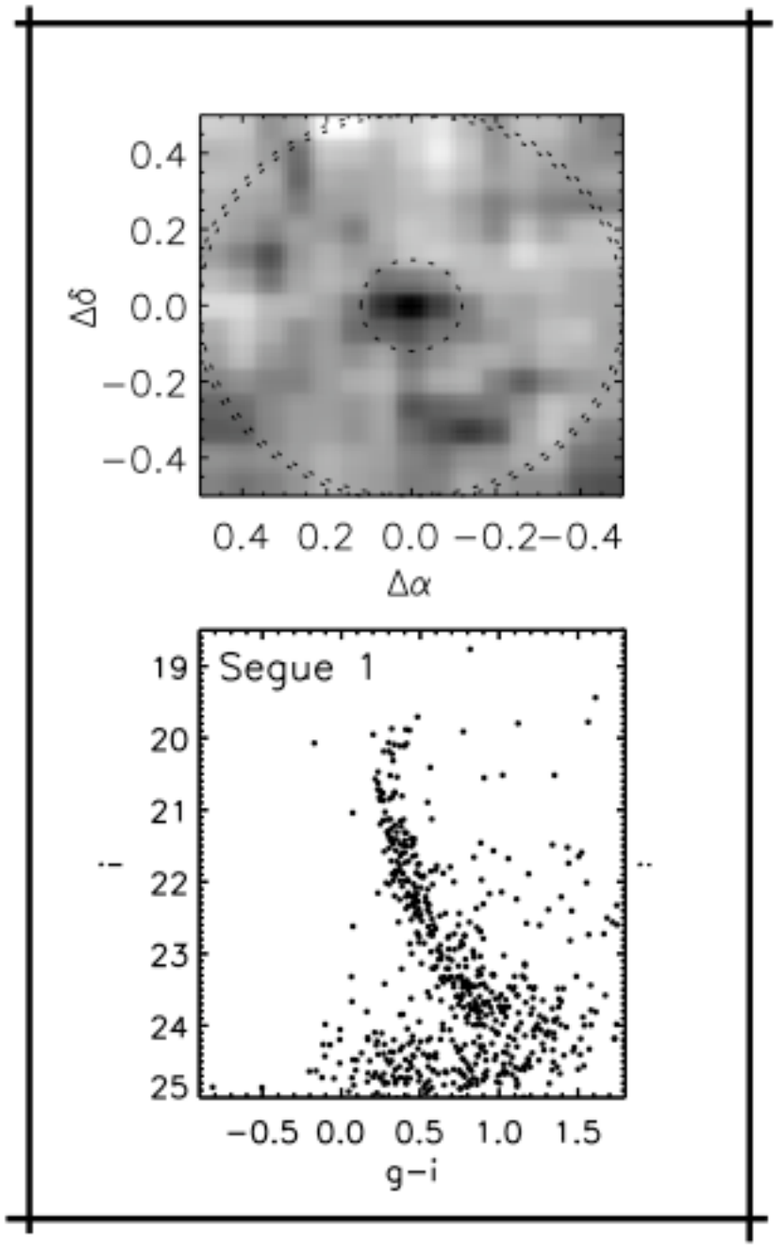
- Both intermediate age (~6-8 Gyr) and young (~200 Myr) stellar populations

- But given the low mass, it's surprising that it can retain gas and form stars



Segue-1

Belokurov et al. (2007)
Niederste-Ostholt et al. (in prep)



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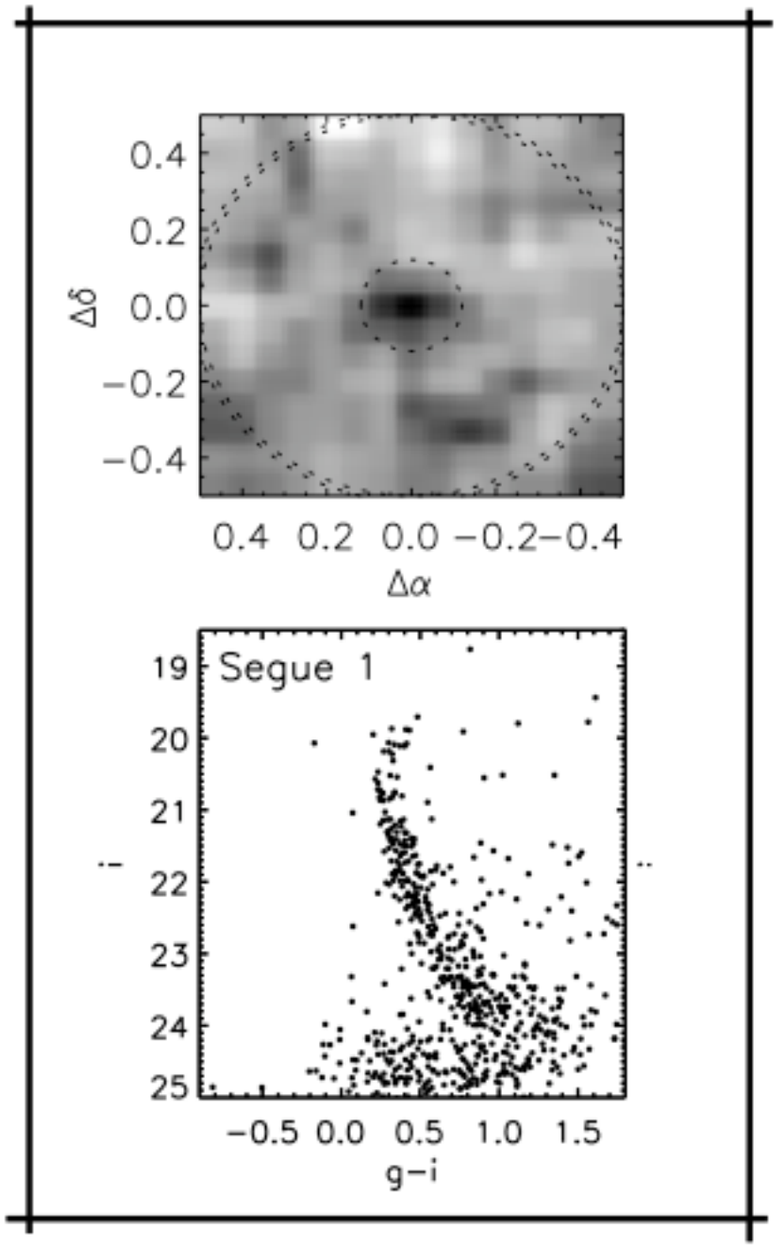
- Originally classified as “an unusually extended globular cluster”, but this is subject of on-going debate



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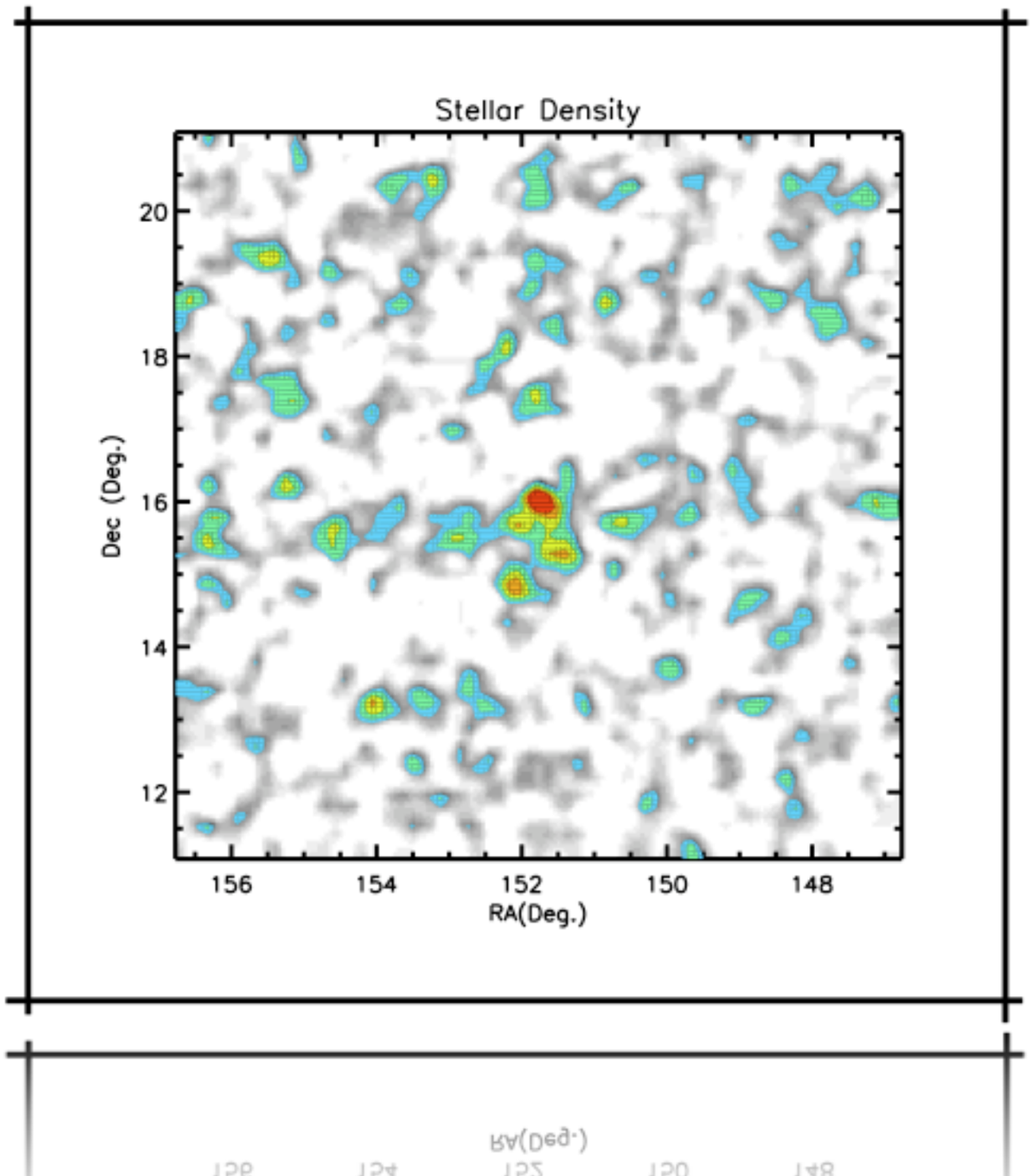

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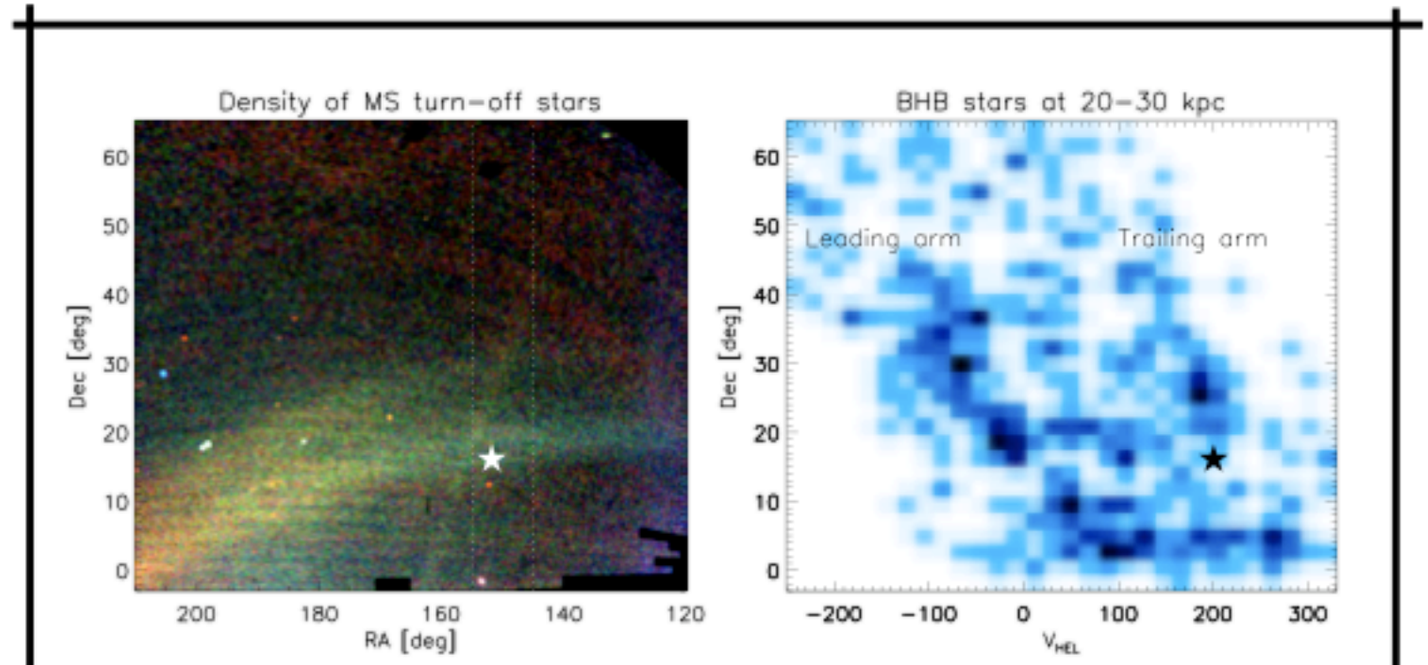
- Optimal Filter Technique (e.g. Odenkirchen) uncovers extended features out to as much as a degree

- For the first time, BHBs reveal kinematic sigature of trailing arm



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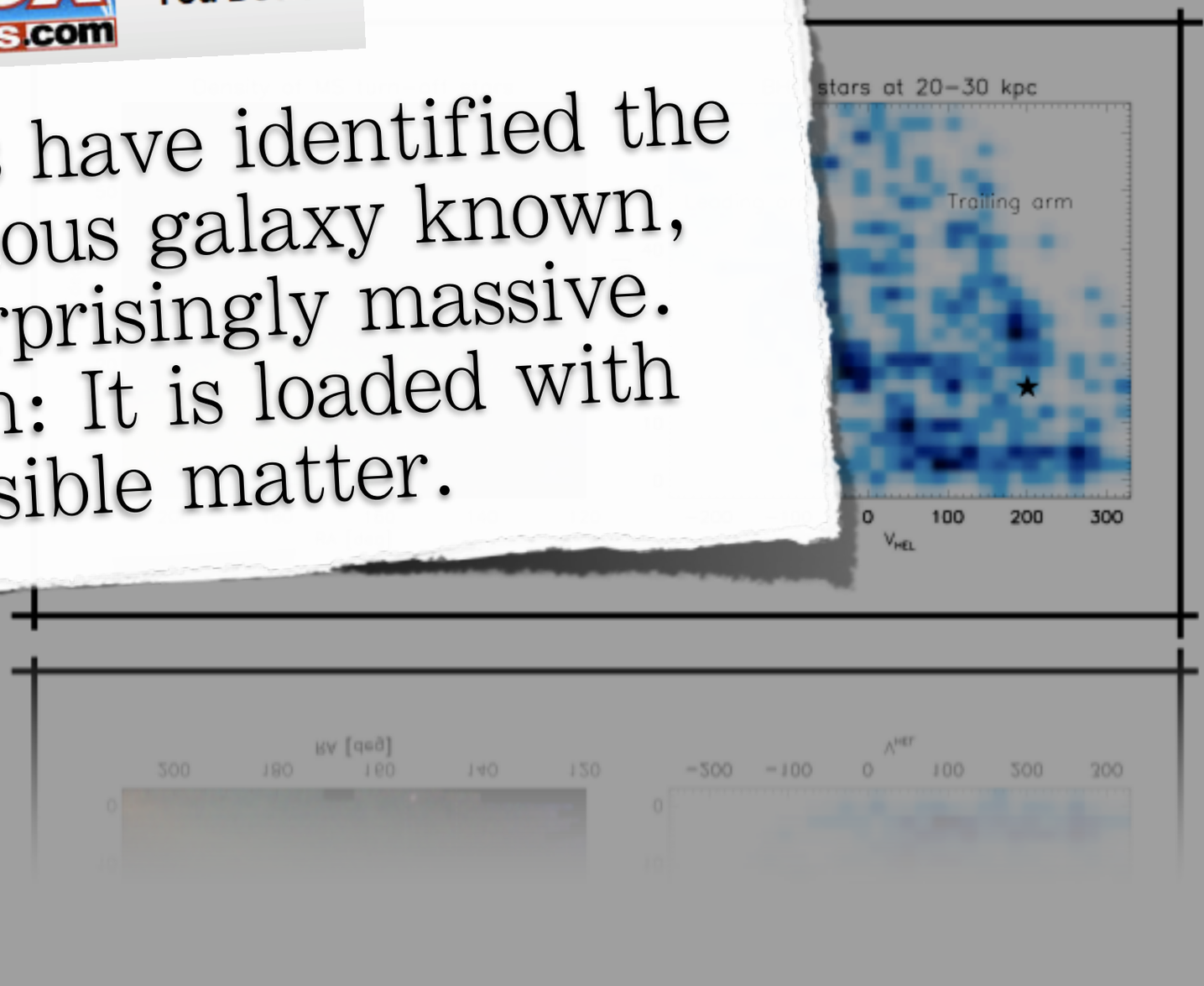
- Optimal F… Odenkirc… extended … much as a …

- For the fir… time, there is … kinematic signature of tidal arm

FOX NEWS.com
We Report. You Decide.

Astronomers have identified the least luminous galaxy known, but it's surprisingly massive. The reason: It is loaded with invisible matter.

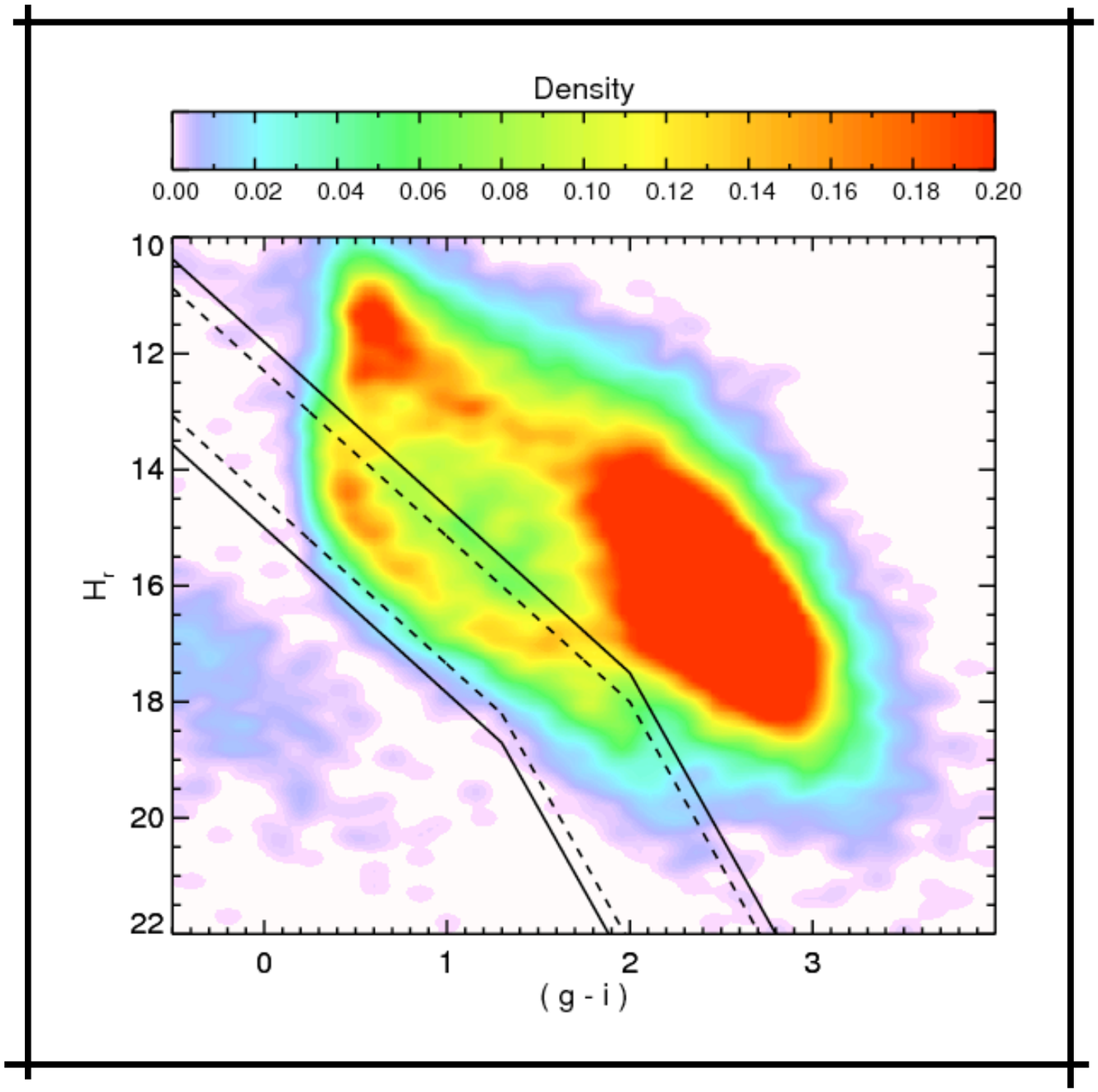


Stripe Mining

Stripe-82

Bramich et al. (2007)

- ~250 square degrees in SDSS equatorial stripe
- up to ~80 epochs over 8 years
- ~1 million stars with photometric and astrometric information
- We have ~7x10^5 objects with $\delta\mu < 5$ mas/yr
- Ultra-cool white-dwarfs analysed by Vidrih et al. (2006)



Stellar Kinematics: The Disc

Whiteoak & Smith (in prep)

- Cross-match with SEGUE spectra to get ~12,000 disc & halo dwarfs out to 5 kpc

- Distances to ~10% and velocities to ~25 km/s

- Use this sample to investigate disc heating

- Obtain trends with [Fe/H] & height from the plane

- Interpretation underway

-0.5 < [Fe/H] < 0.2
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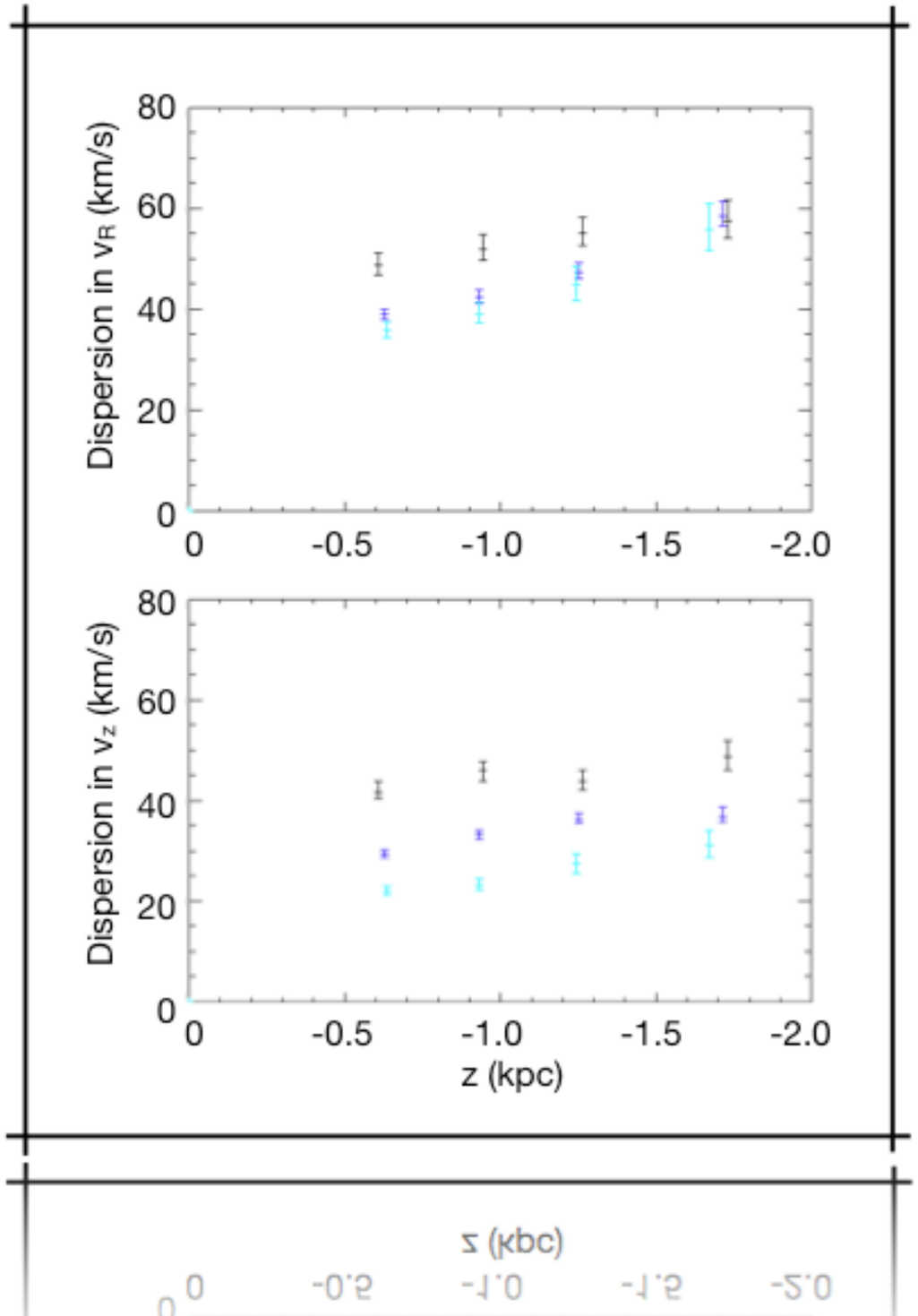

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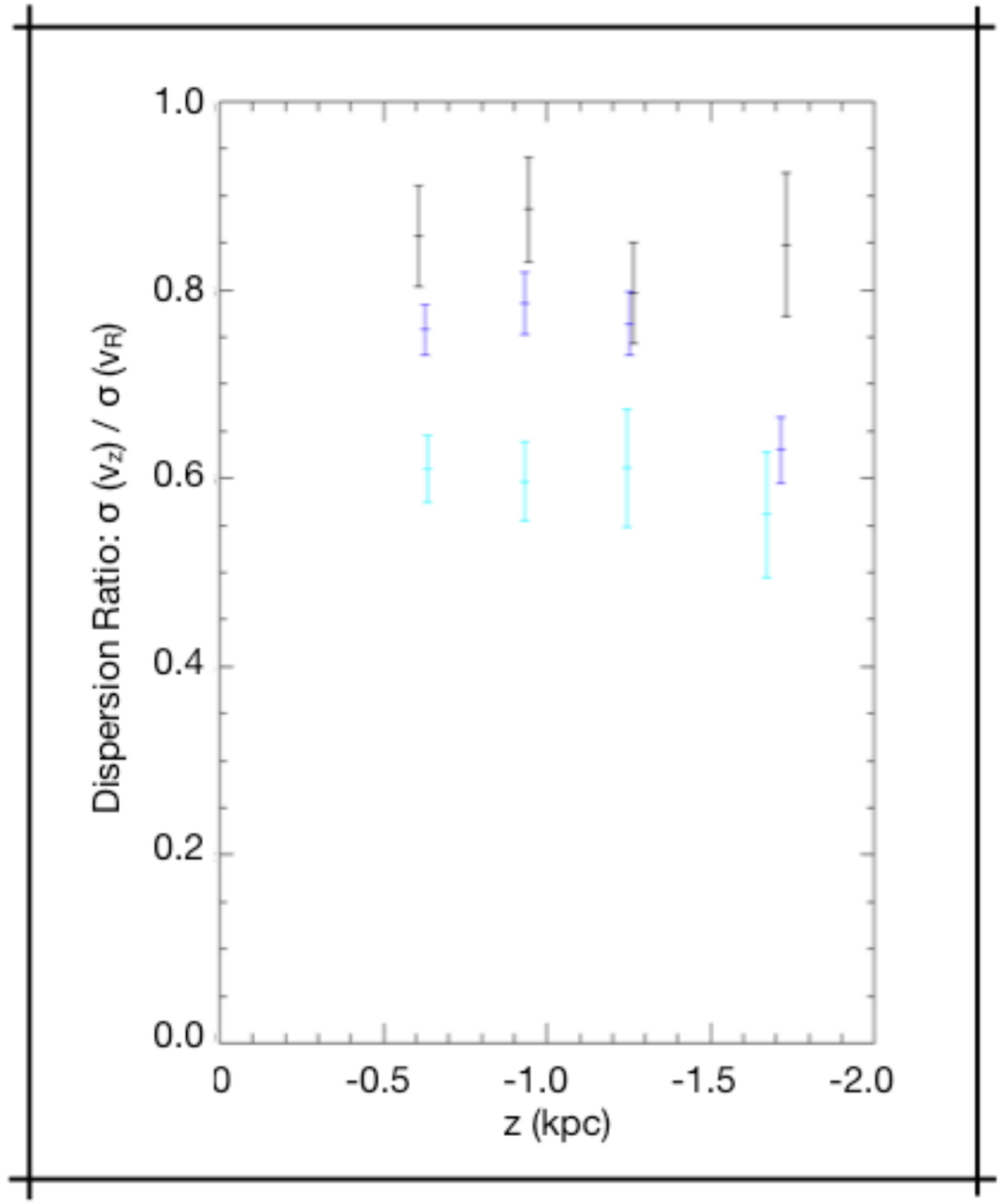

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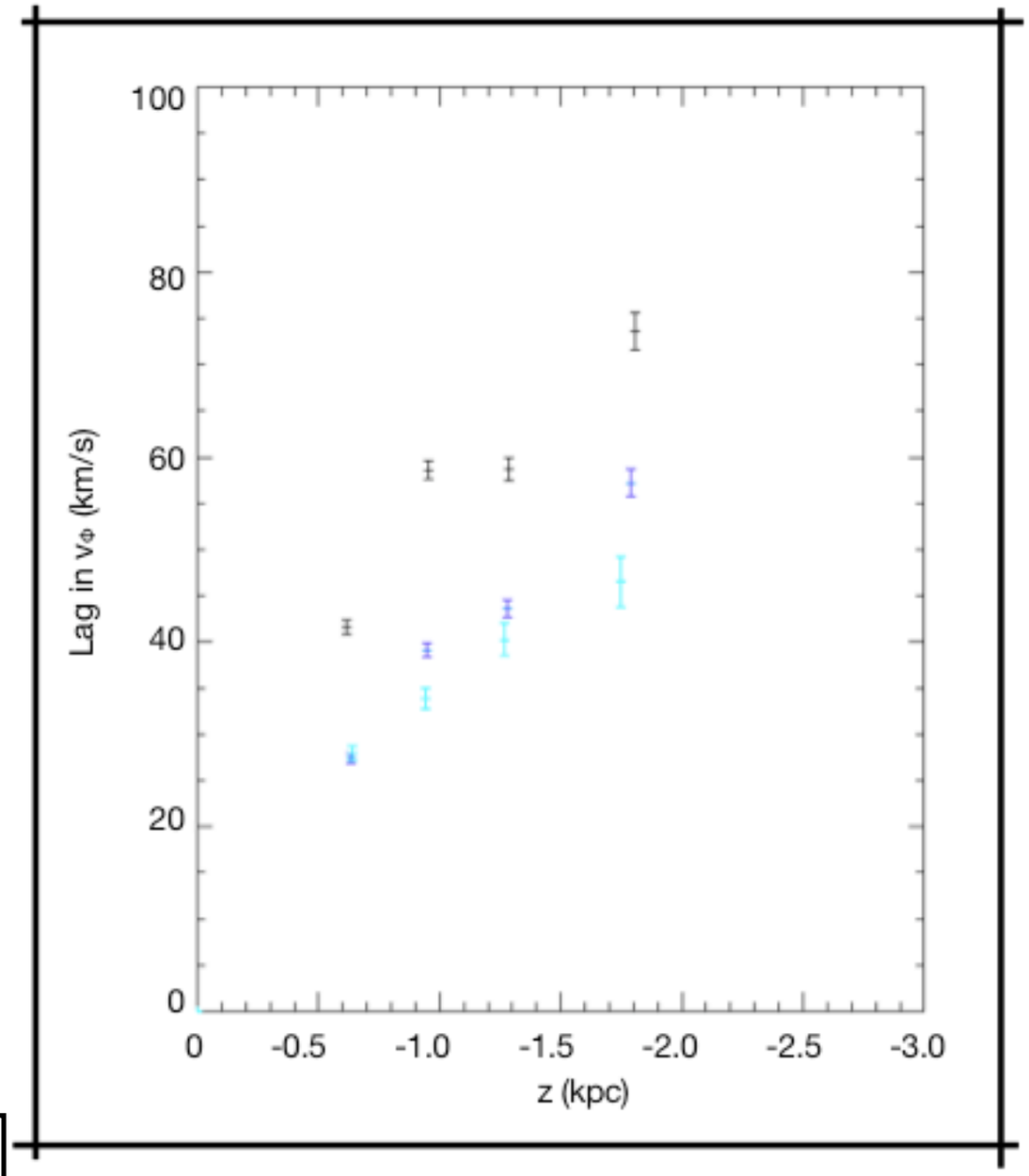

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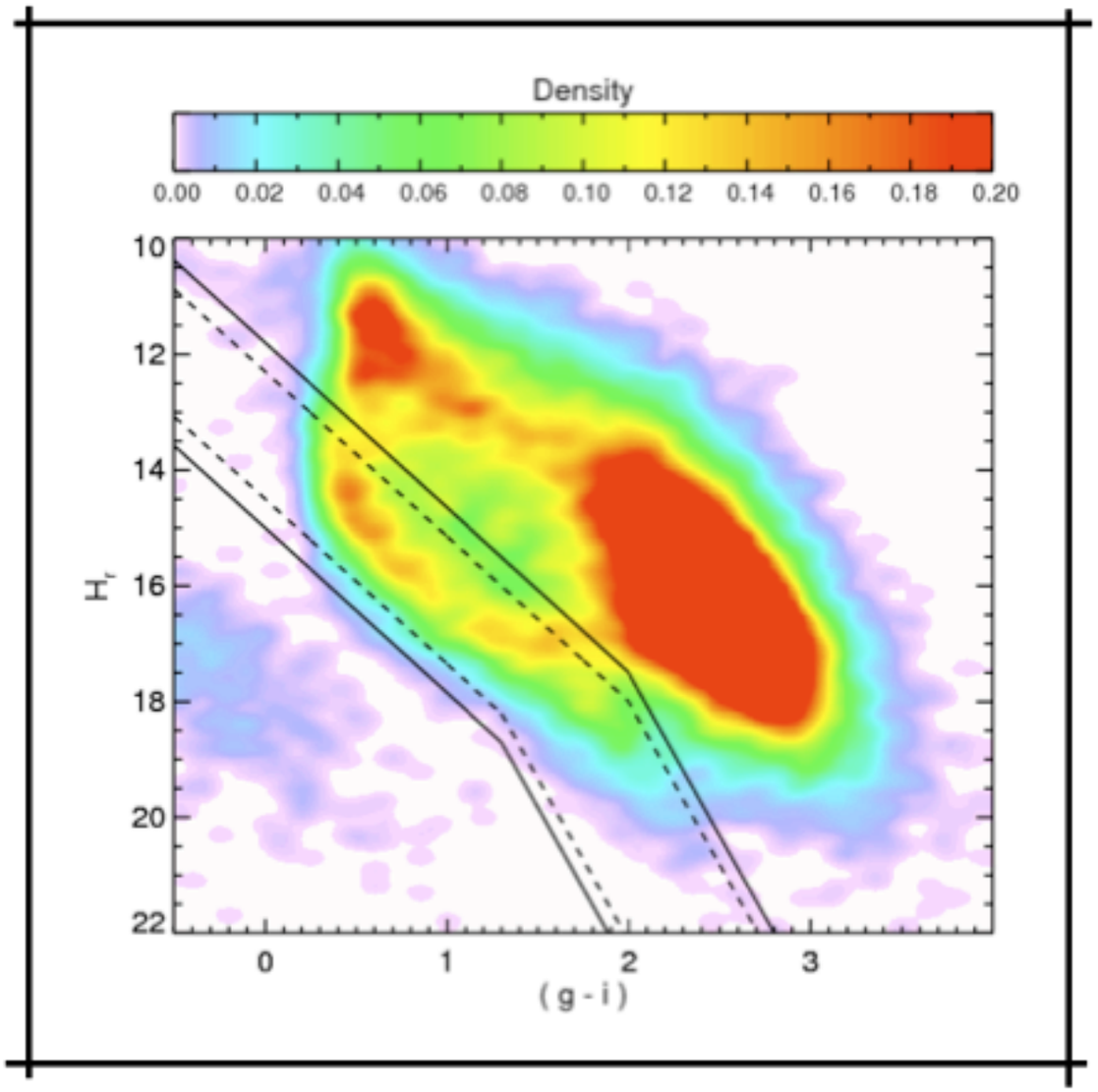

Stellar Kinematics: The Halo

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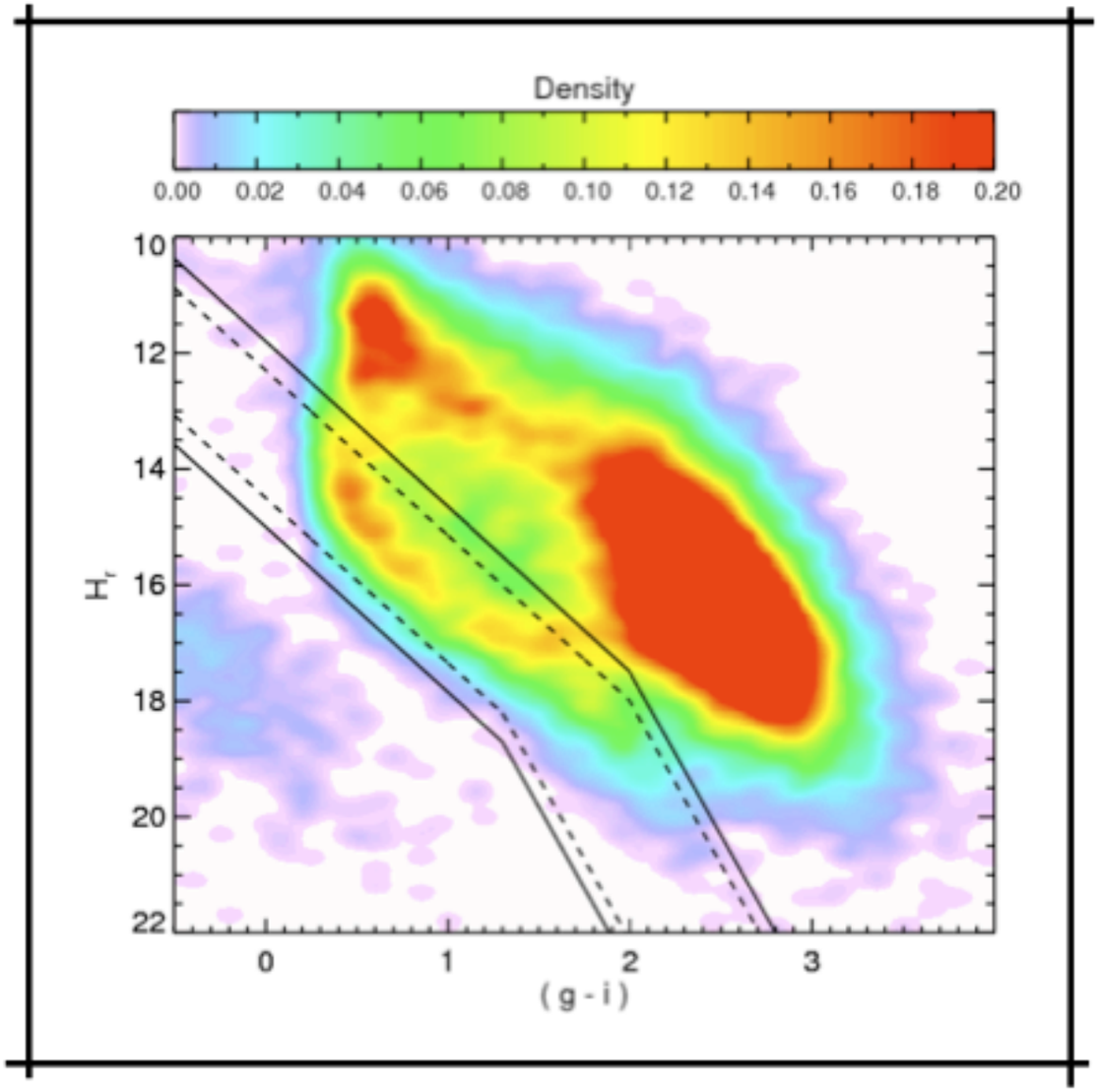
- ~2000 halo stars out to 5 kpc
- Small dispersions:
  $(\sigma_r, \sigma_\Phi, \sigma_\theta) = (143, 93, 82)$ km/s
- No net rotation (or rotation gradient)



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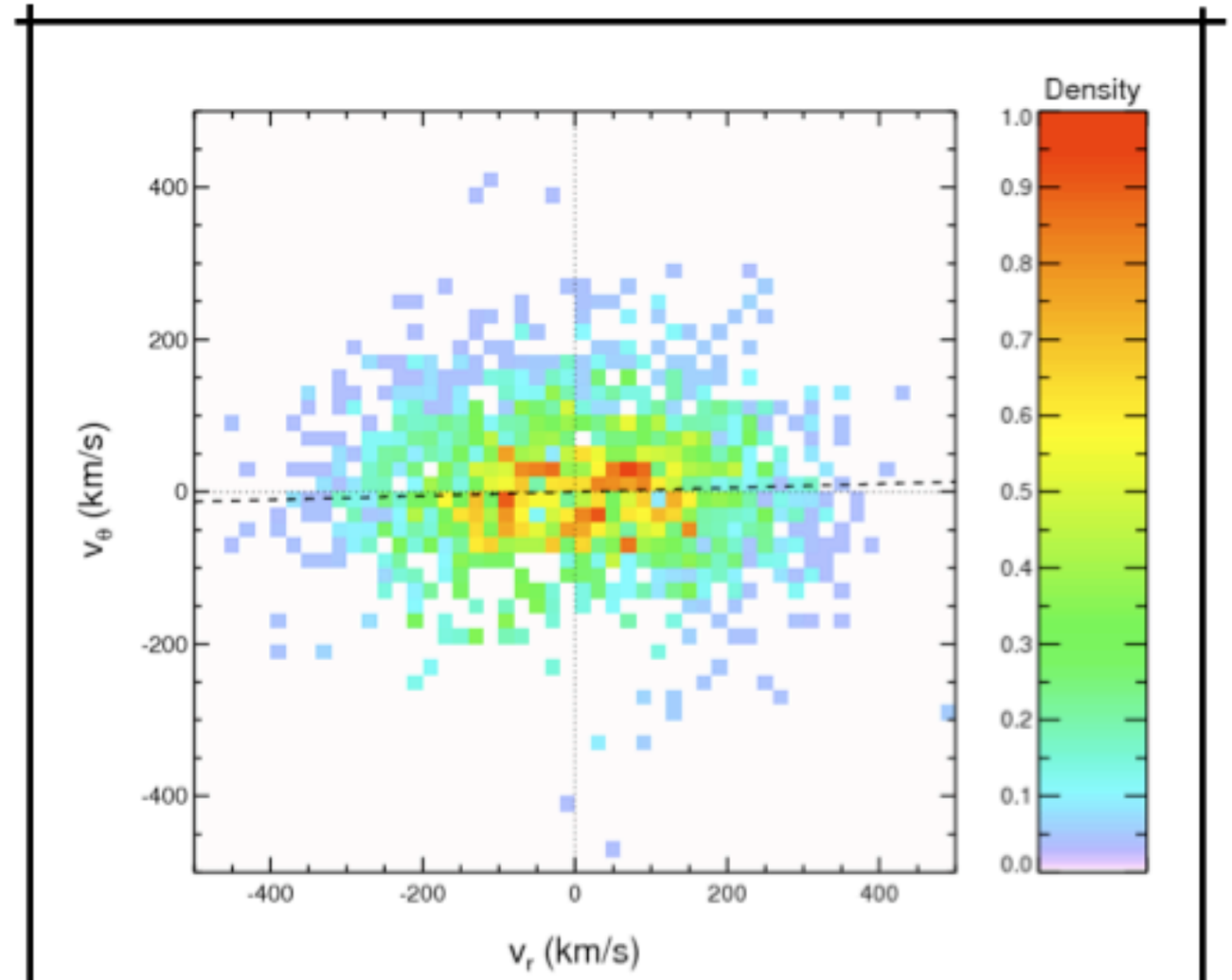

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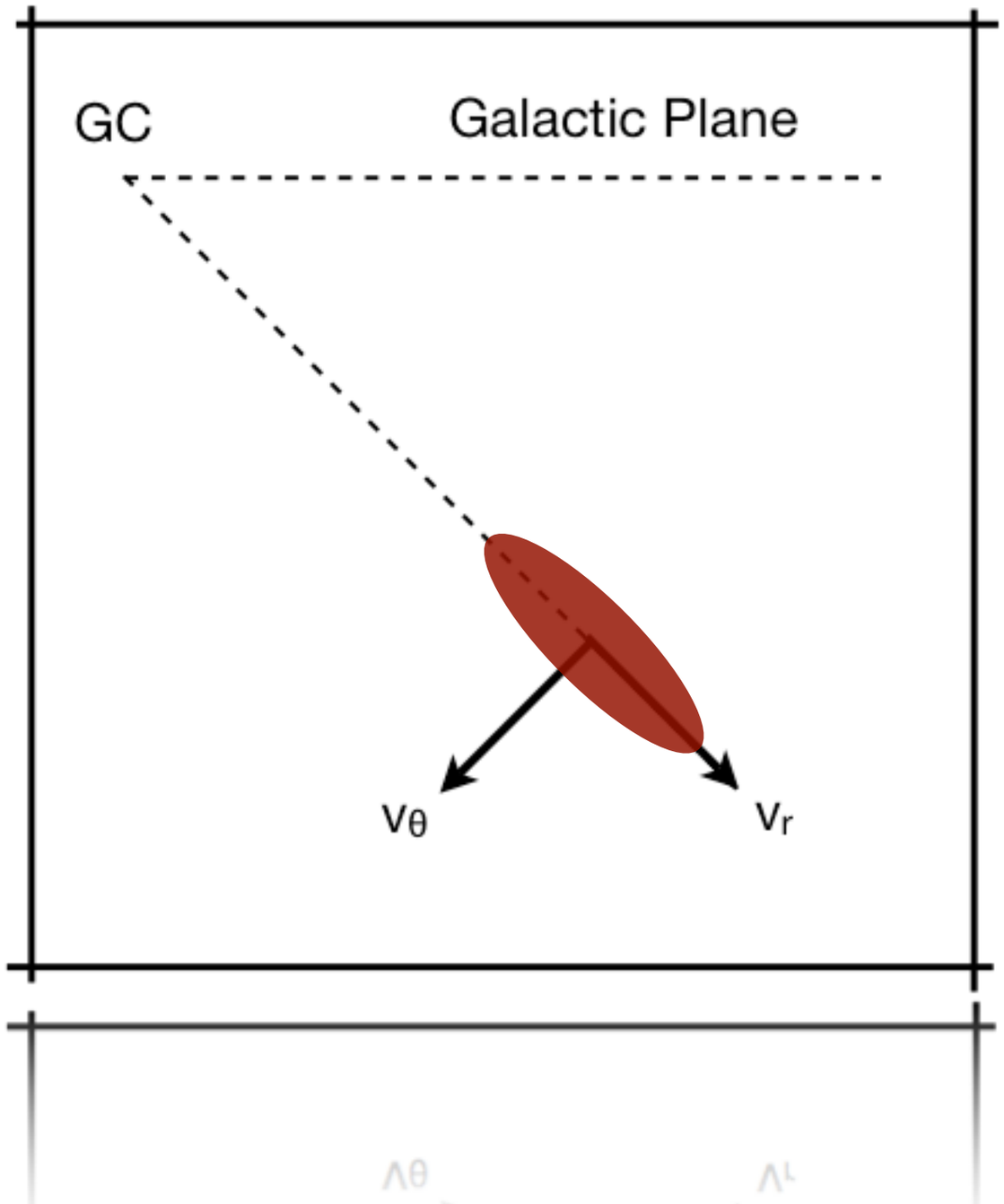

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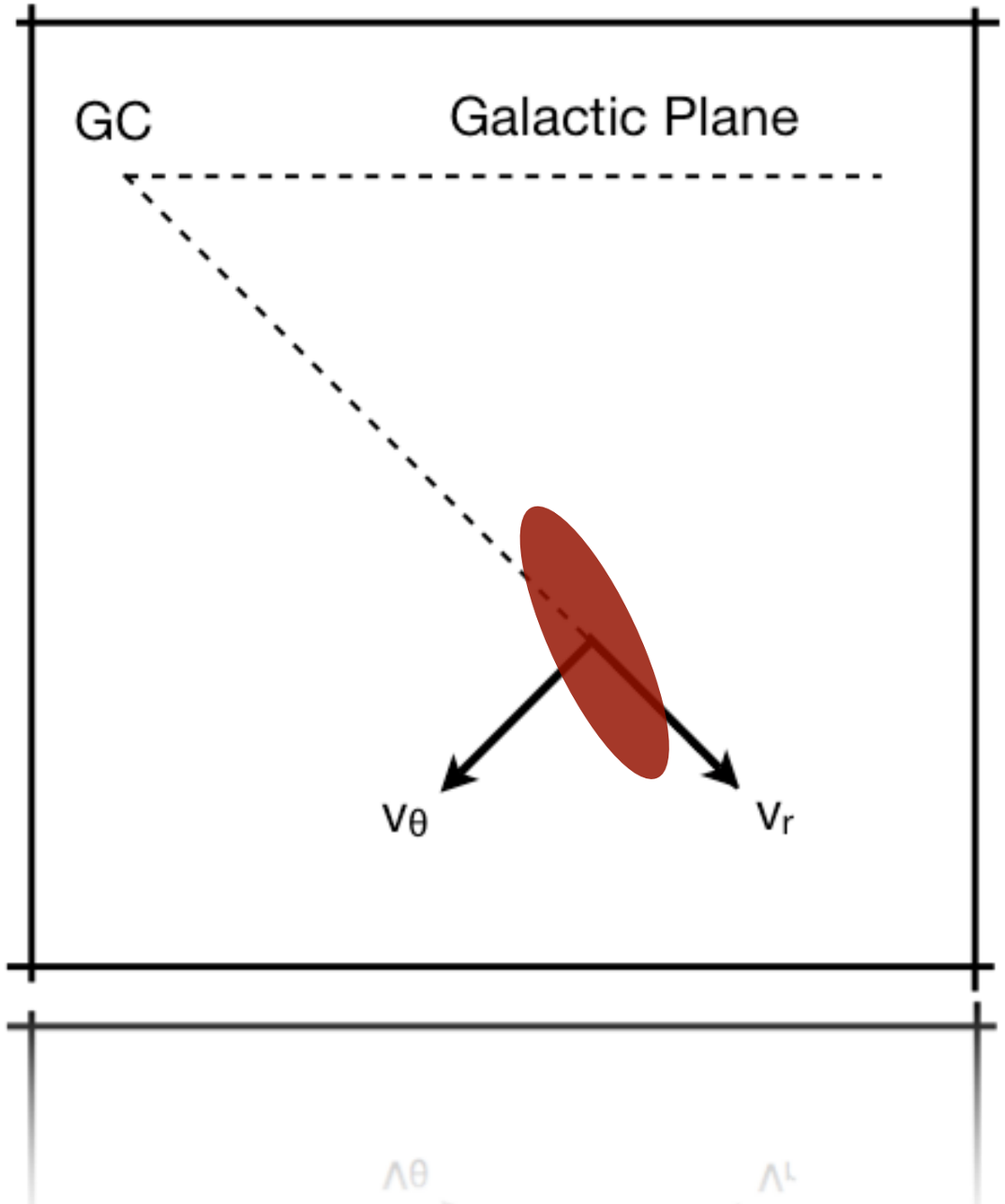

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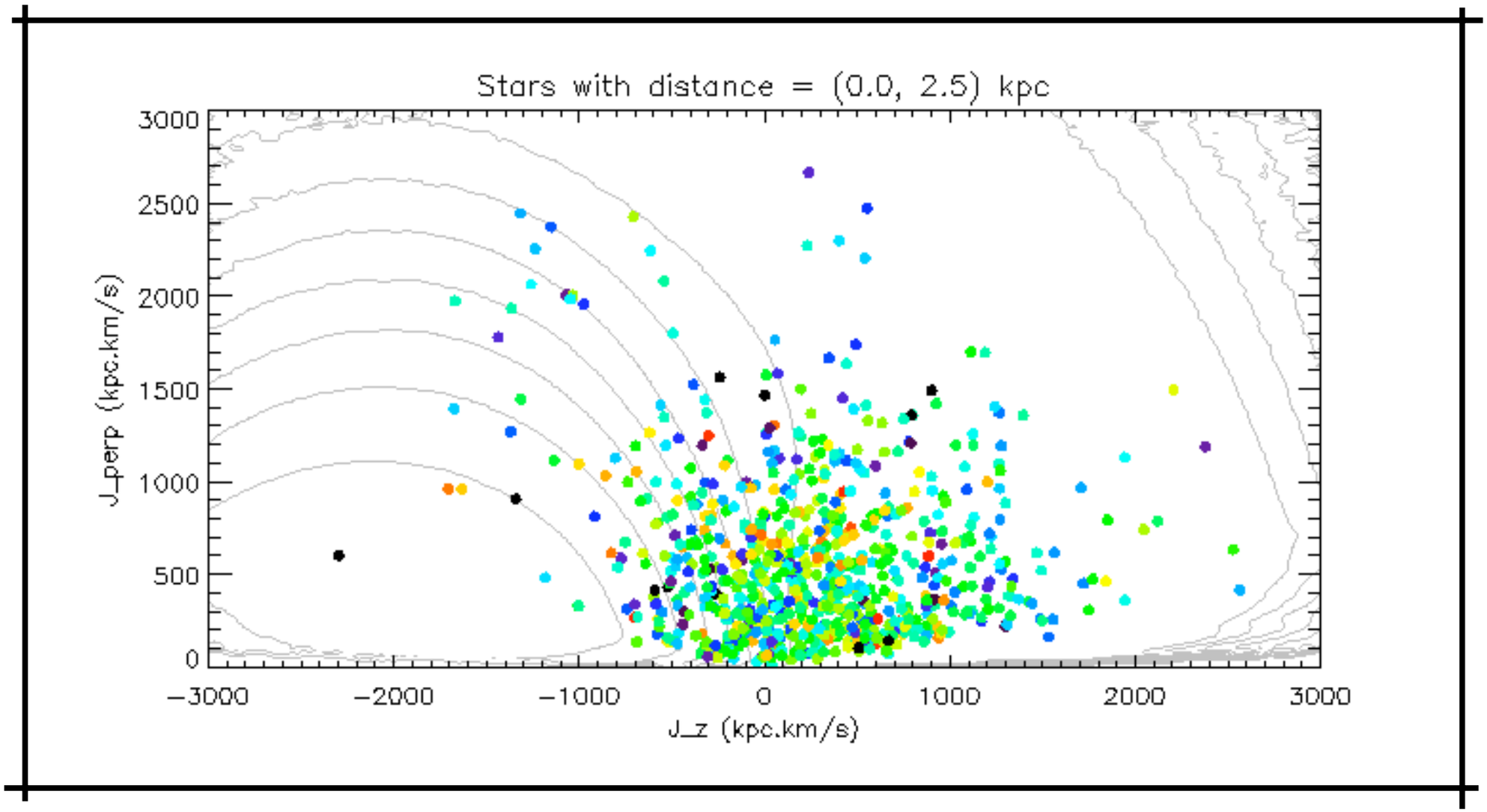
Stellar Kinematics: Overdensities in the Halo



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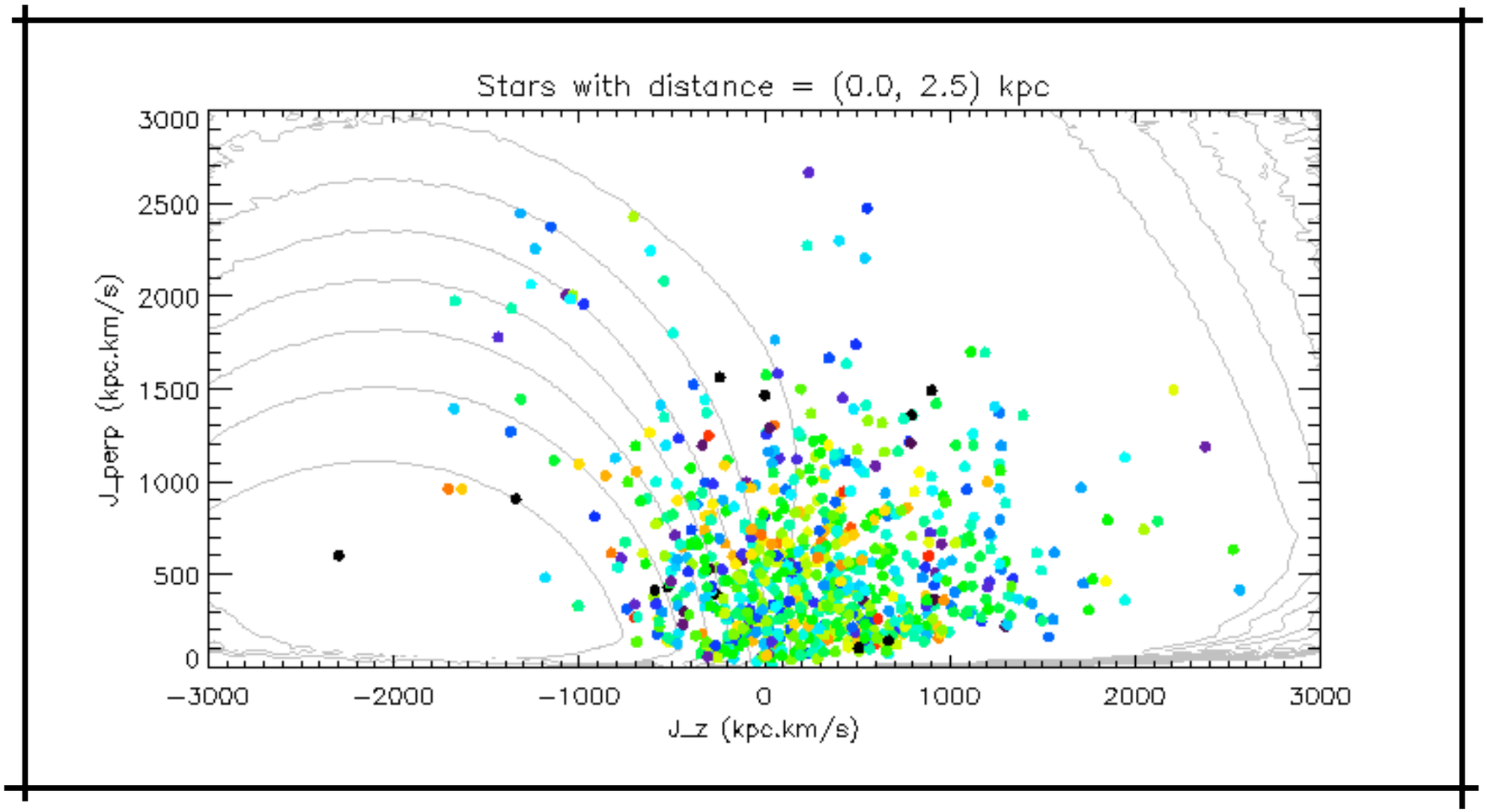
Stellar Kinematics: Overdensities in the Halo

- Use angular momentum to hunt for accretion remnants



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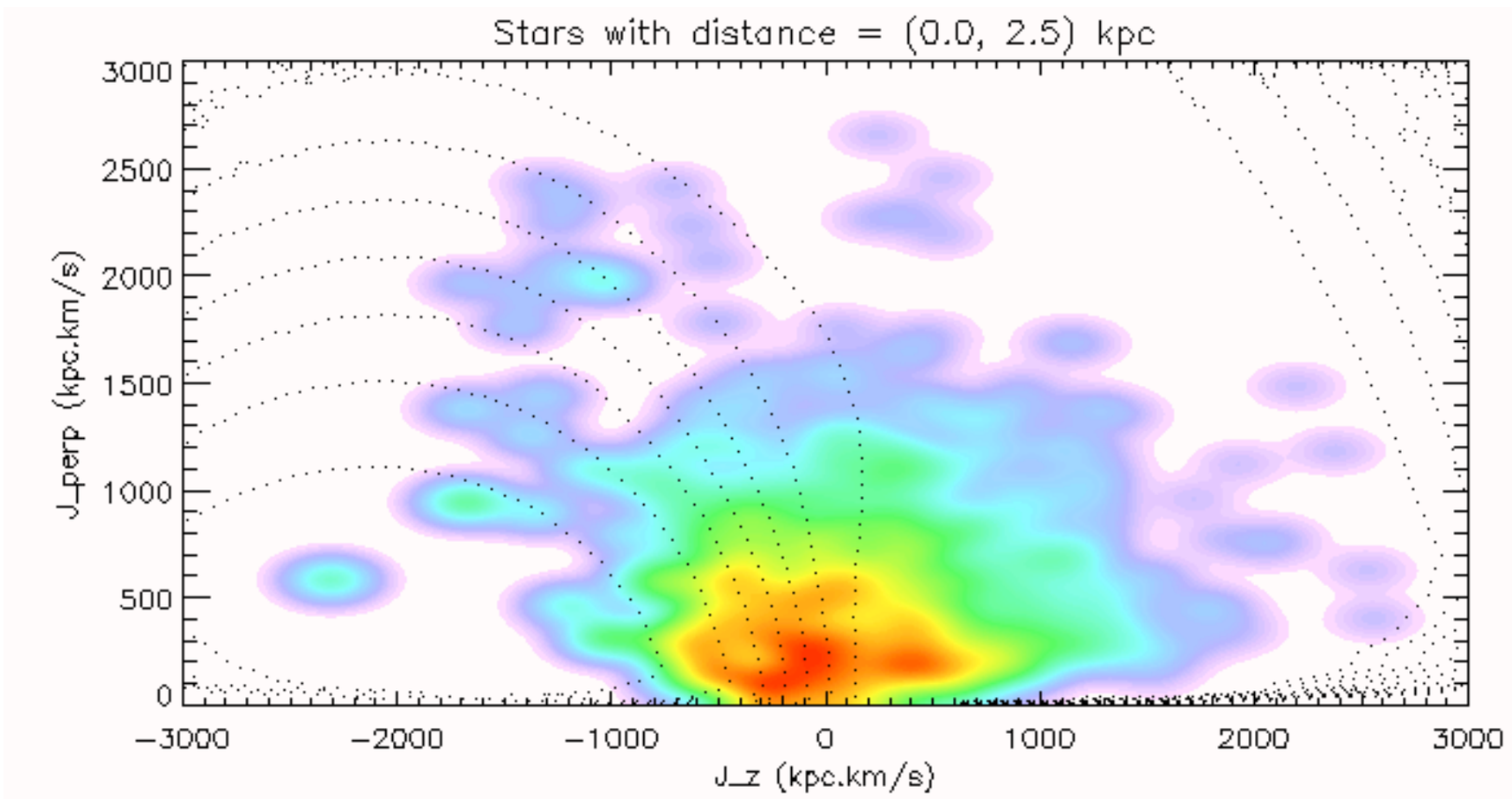
Stellar Kinematics: Overdensities in the Halo

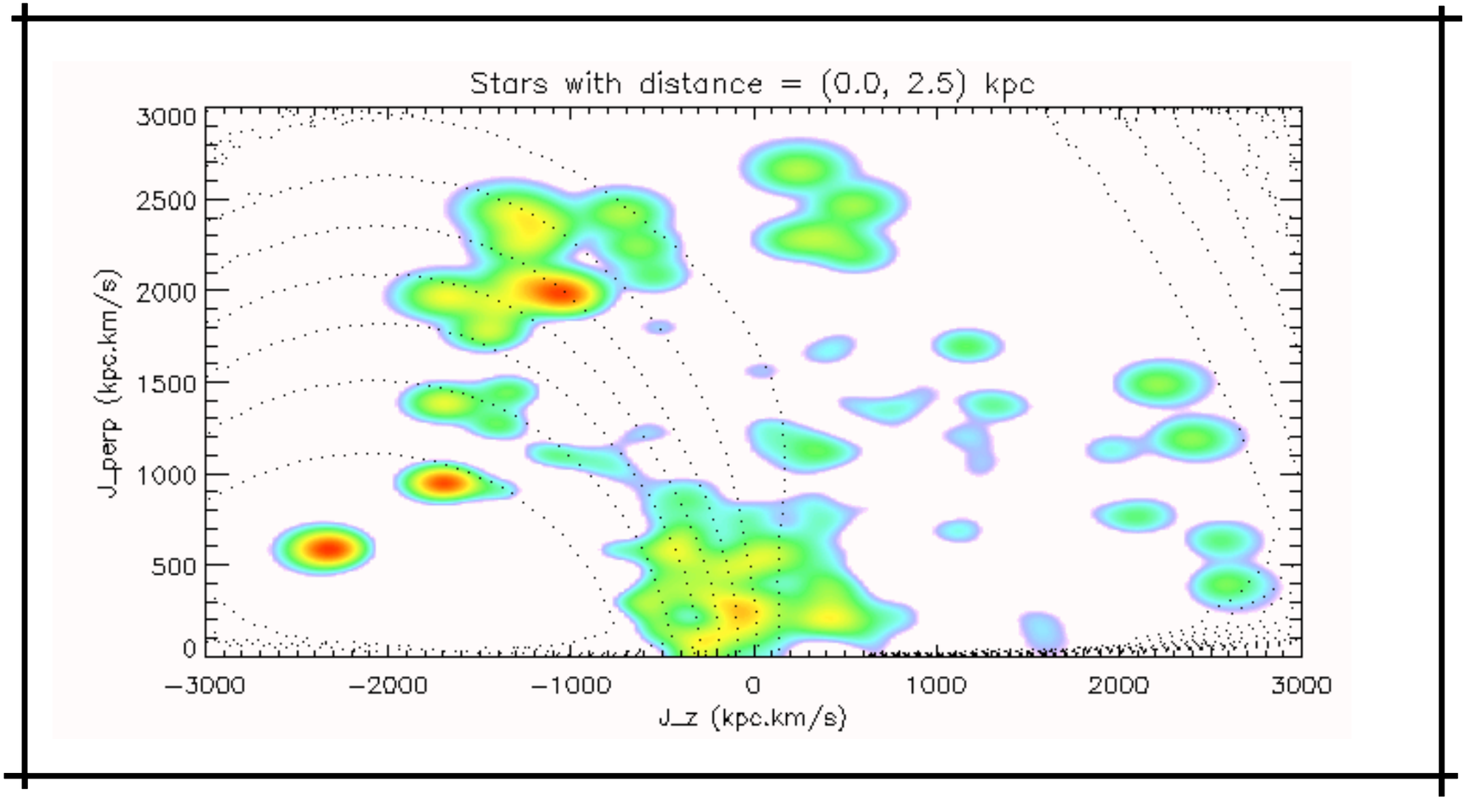
- Use angular momentum to hunt for accretion remnants
- Smooth & correct for bias



Smith et al. (in prep)

Stellar Kinematics: Overdensities in the Halo

- Use angular momentum to hunt for accretion remnants
- Smooth & correct for bias
- Clear overdensities, such as Helmi et al. (1999) stream



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Stellar Kinematics: Overdensities in the Halo

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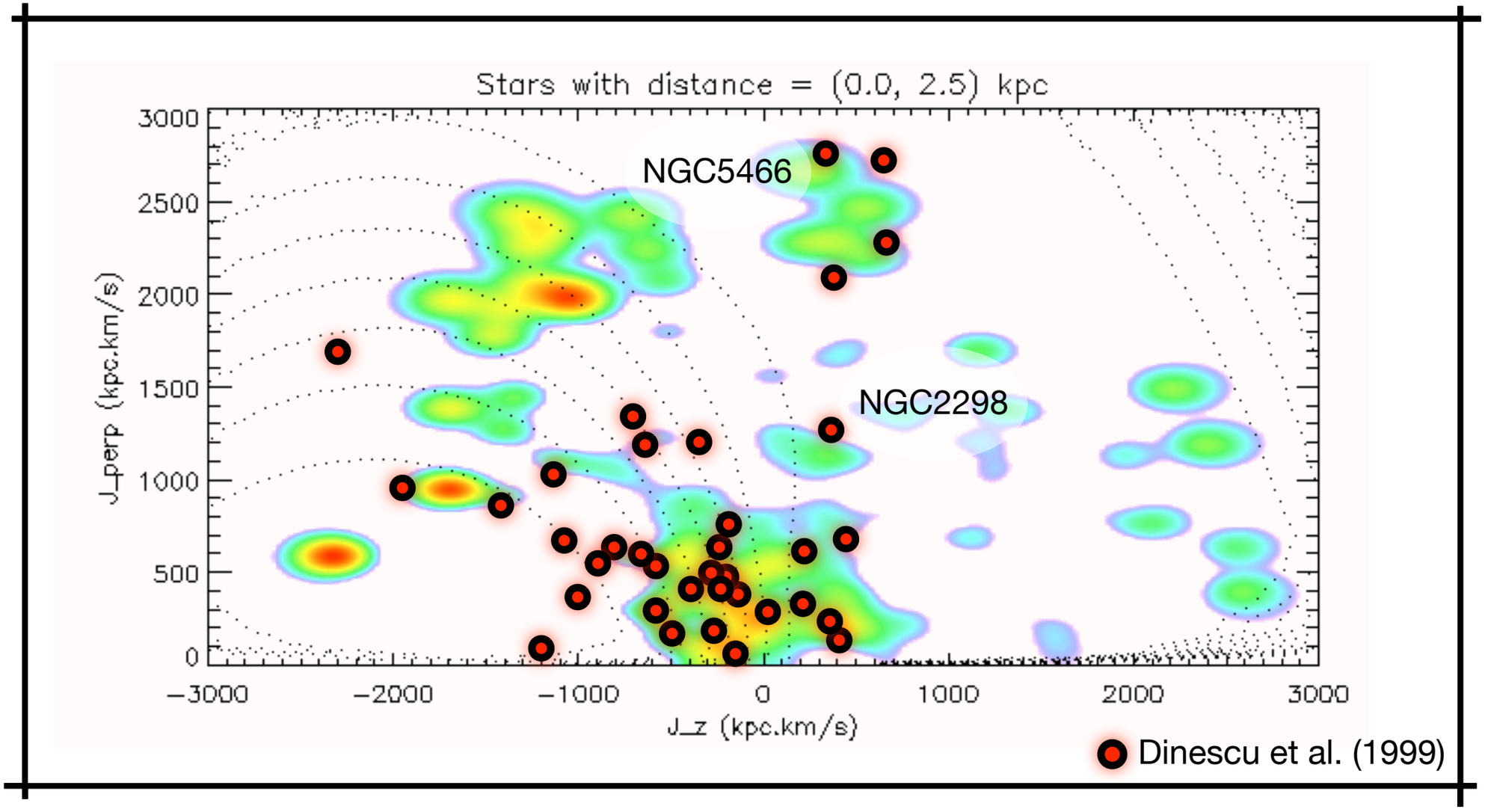
- Clear overdensities, such as Helmi et al. (1999) stream
- Associated to Globular Clusters?



Conclusions

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- New and interesting satellites still being found
    - Stamps that can tell us about underlying physical processes
    - Important to know whether a stamp is indeed a stamp
- Utilise large numbers of SEGUE spectra to investigate kinematics of disc and halo populations
    - Probe disc kinematics out beyond RAVE, producing complimentary analysis
    - Probe halo to find and classify accretion remnants
    - Future prospects from short-baseline high-cadence proper motion work

Fin