Morphology of the GD-1 stream

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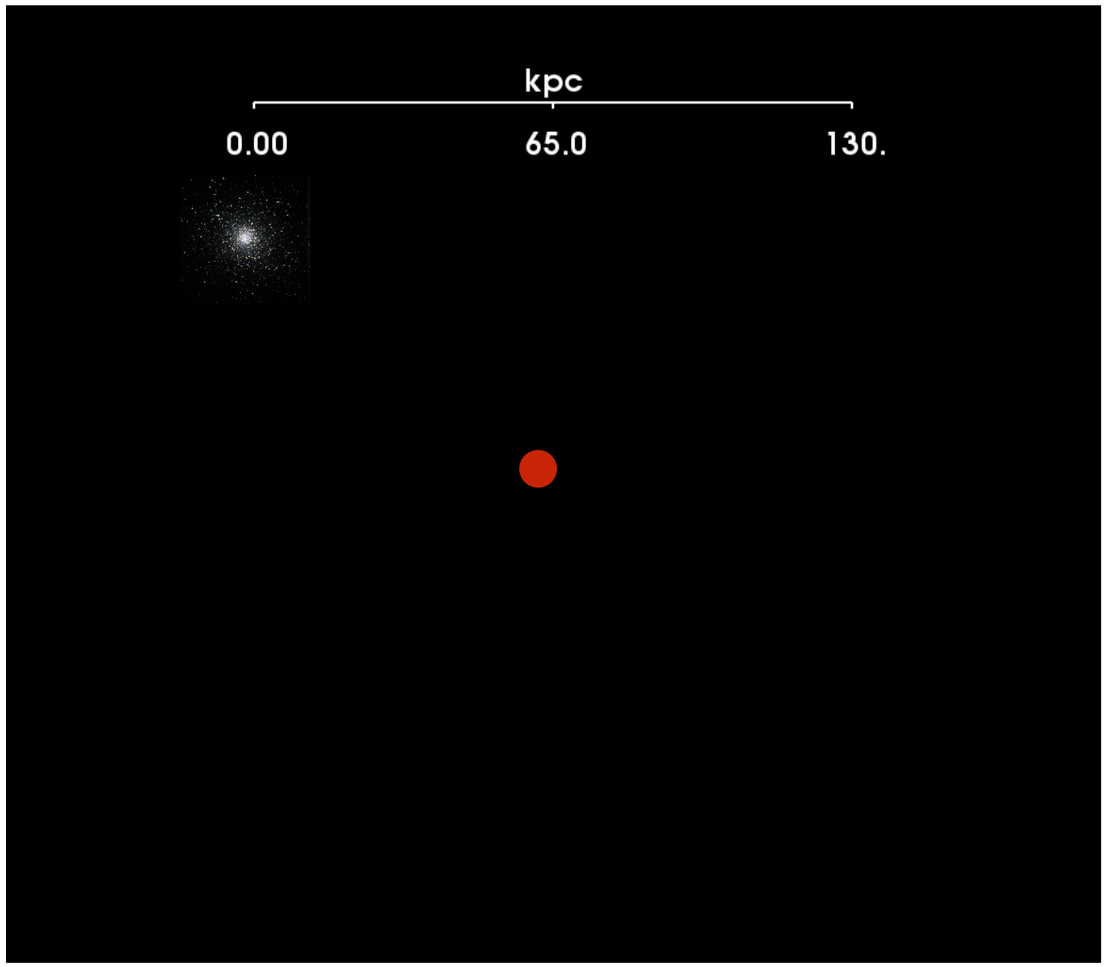
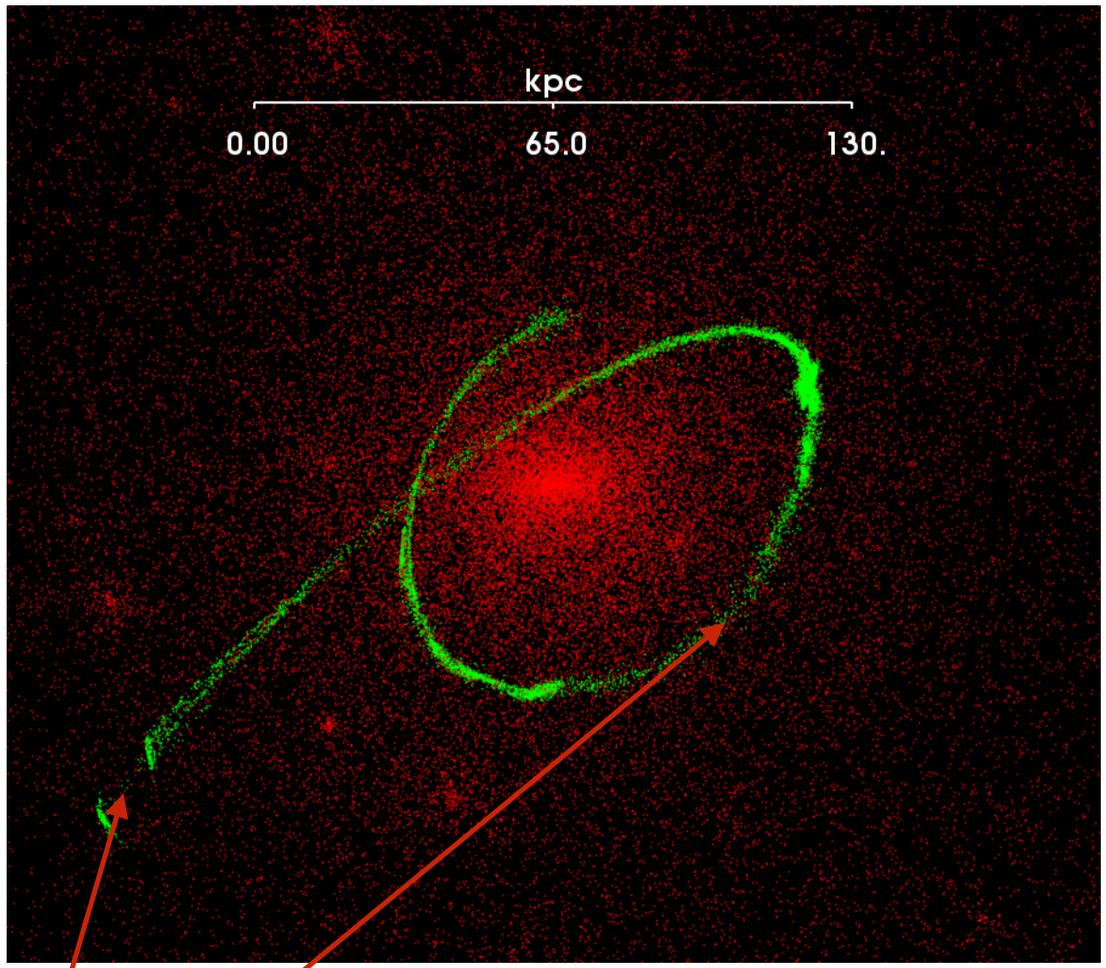
University of Surrey

Small Galaxies, Cosmic Questions, Durham

Tidal Streams from Globular Clusters





Smooth Potential

Lumpy Potential

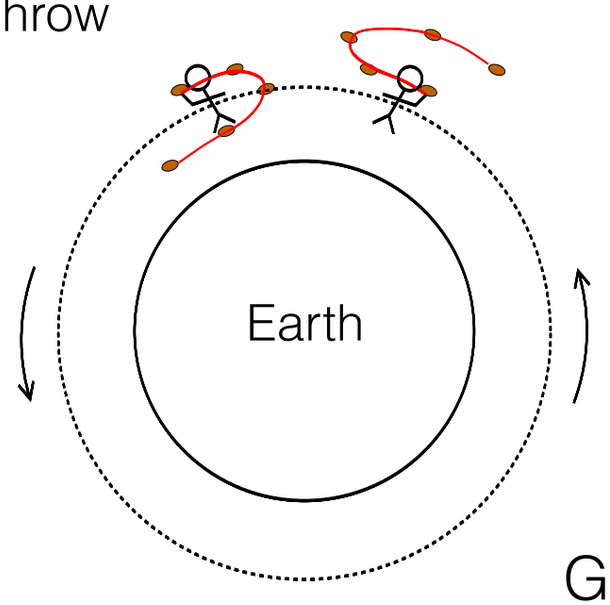
Interaction with substructure

Ibata et al. 2002, Johnston et al. 2002

Cartoon of Gap Formation

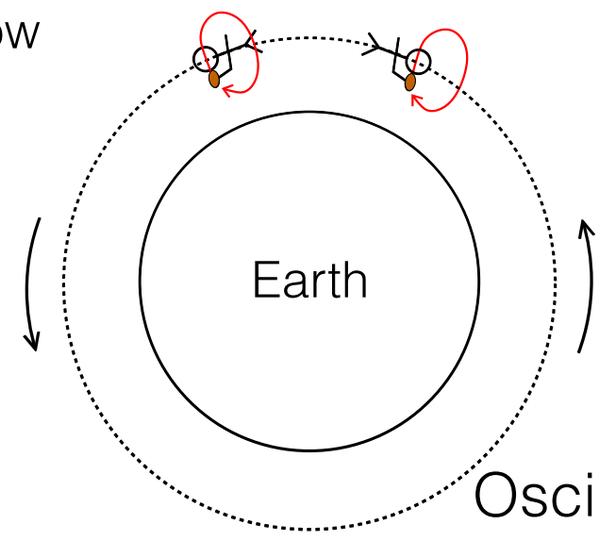
Orbital Mechanics 101
aka Football in Space

Tangential Throw



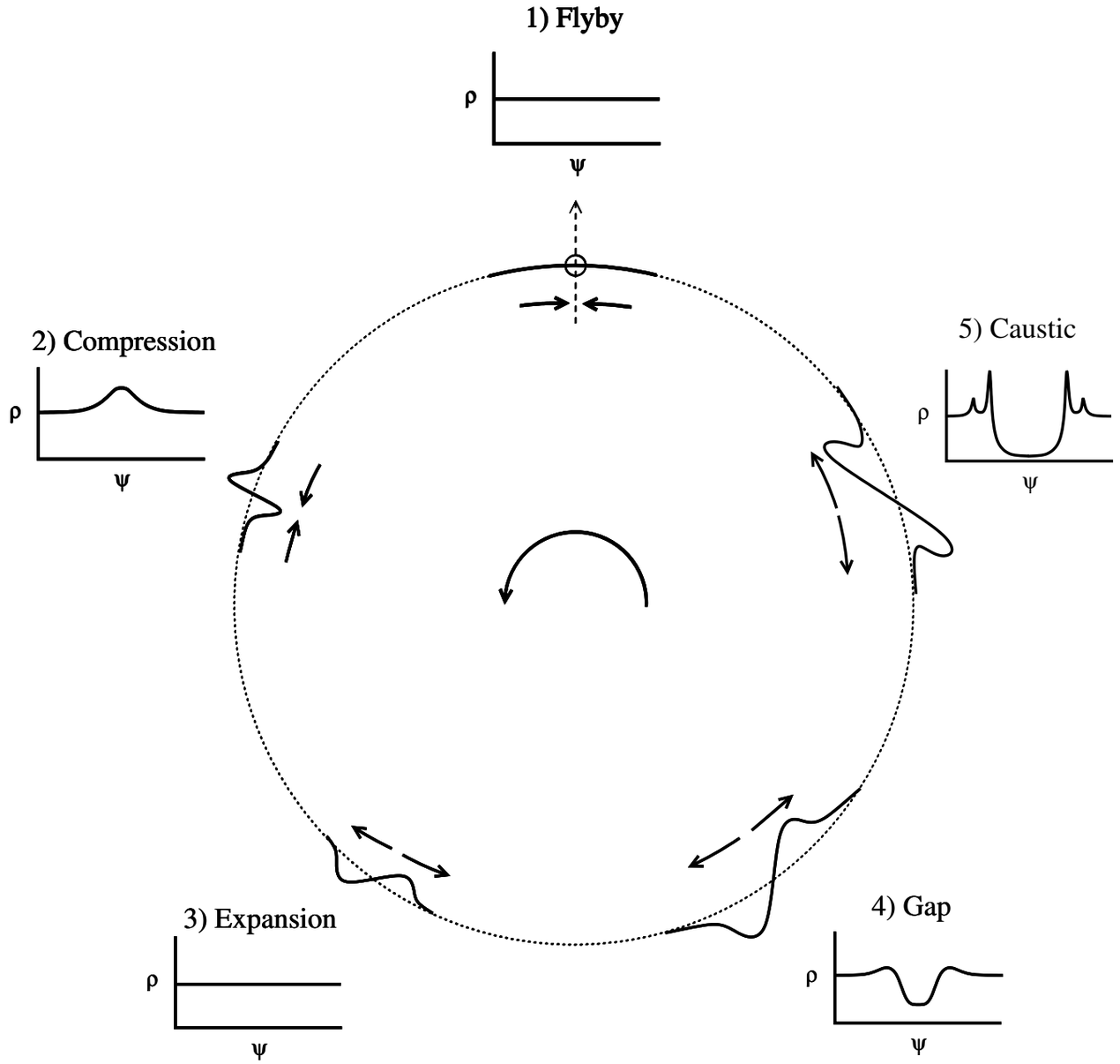
Gap!

Radial Throw



Oscillations!

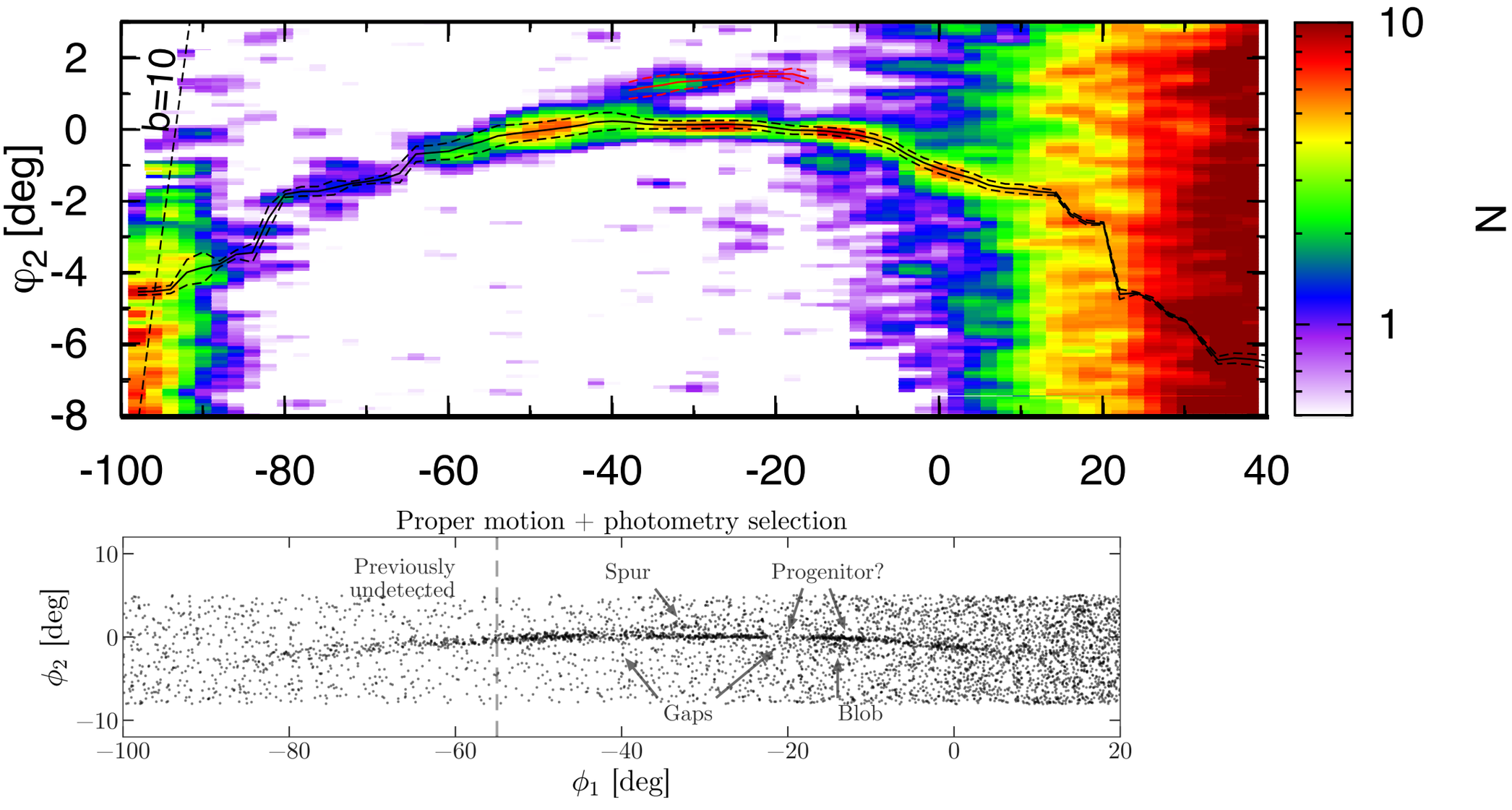
Gap Formation (also in Space)



Erkal, Belokurov 2015a

Spur, blob, wiggles in GD-1

de Boer, Erkal, Gieles in prep.



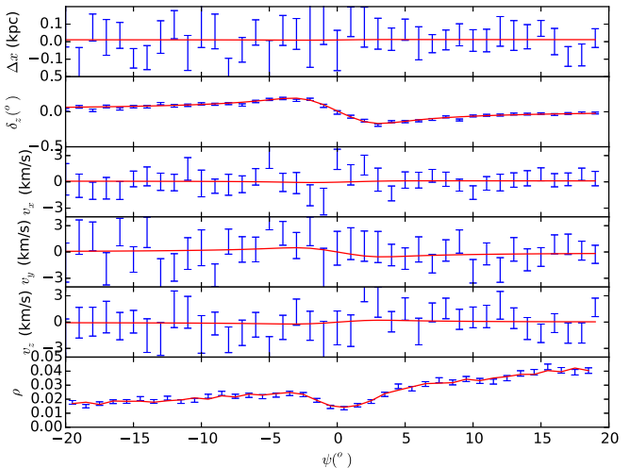
Price-Whelan & Bonaca 2018

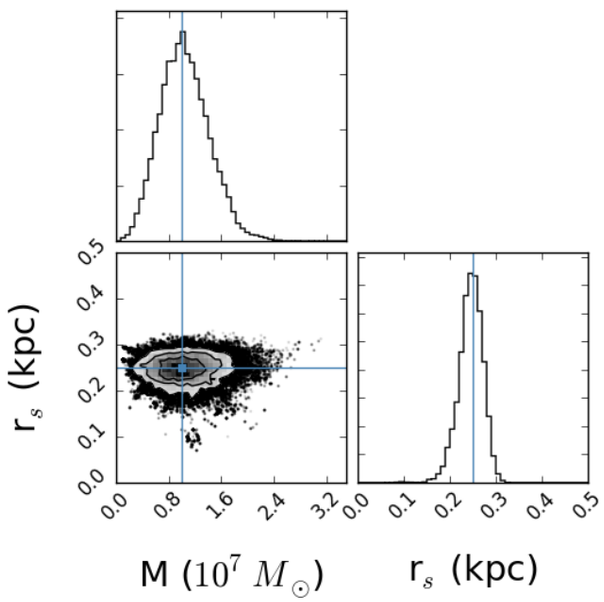
(see also Malhan et al. 2019)

Extracting subhalo properties

Fit individual gaps

Stream observables



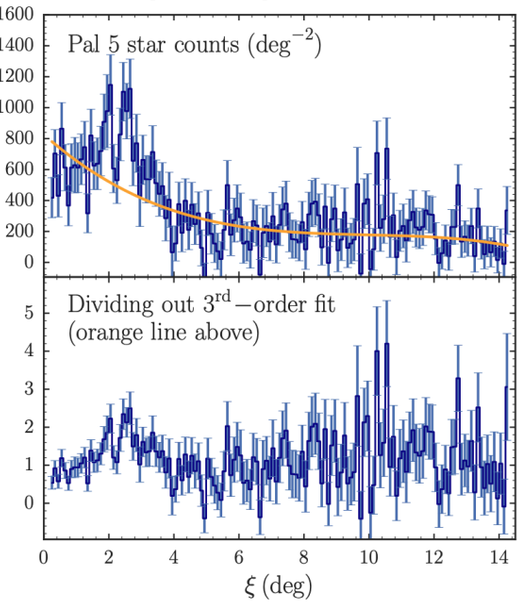


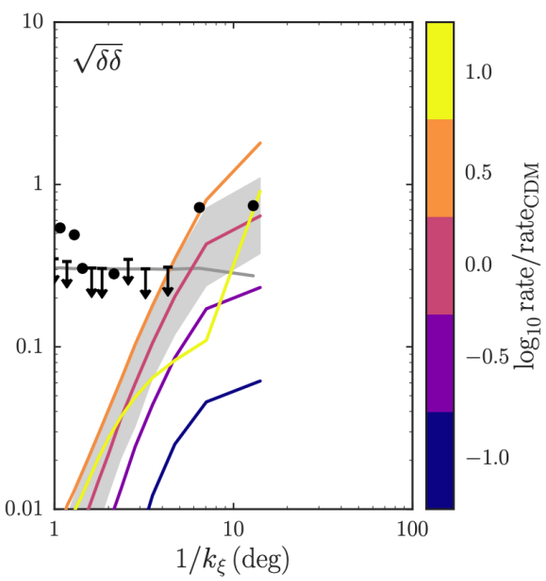
Erkal, Belokurov 2015b
Bonaca et al. 2019, Erkal + in prep.

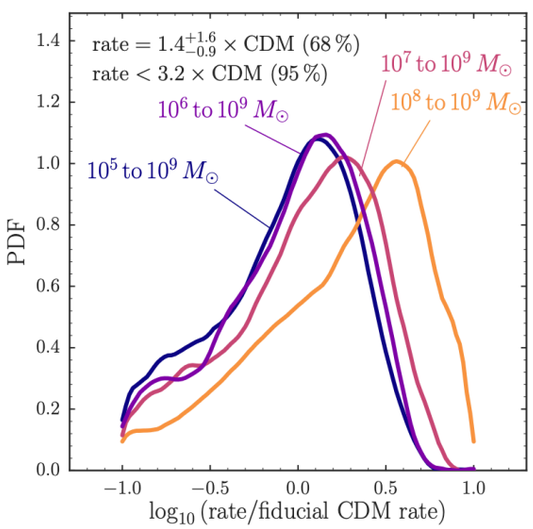
Fit statistical properties of stream

Density

Normalized density



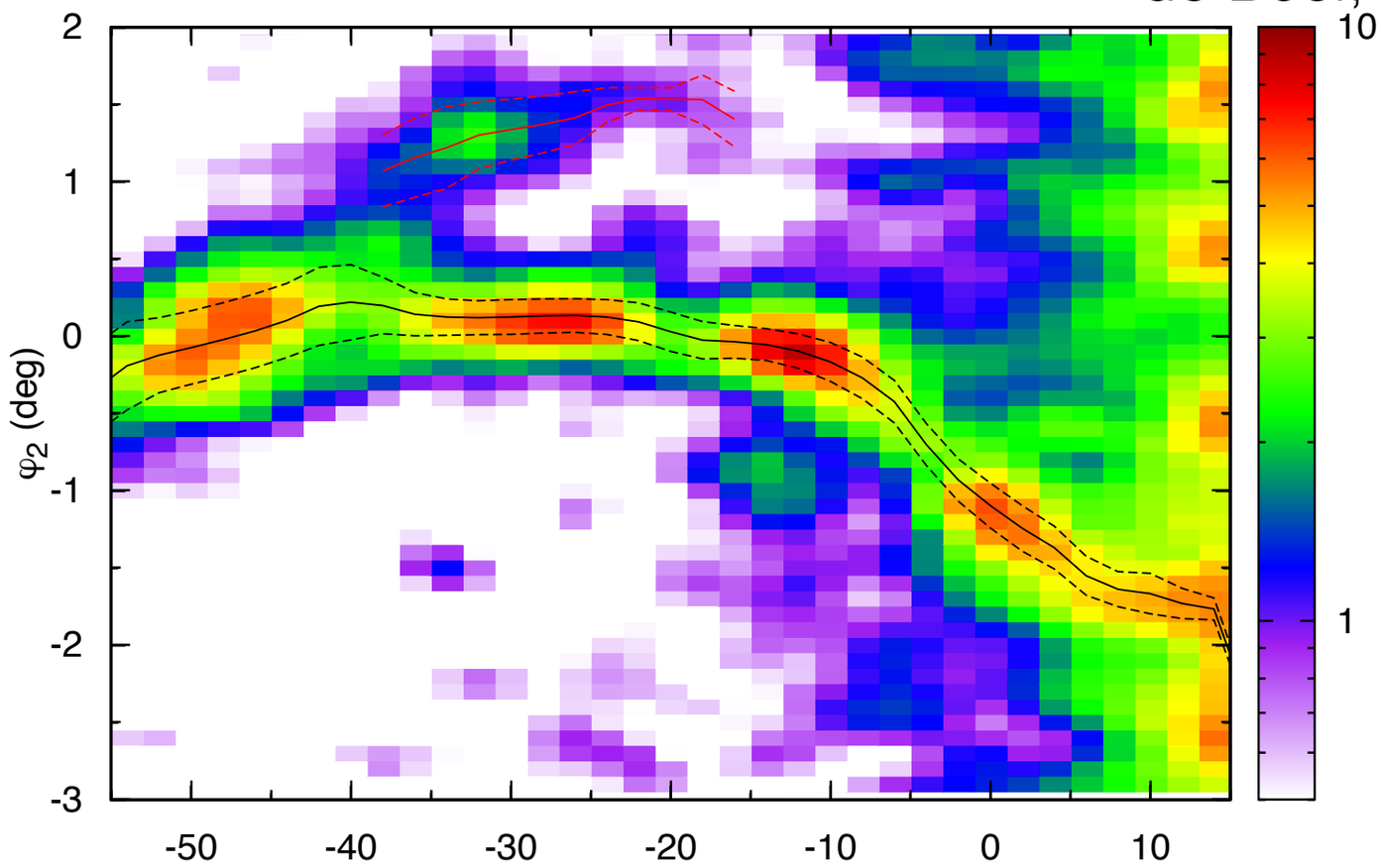




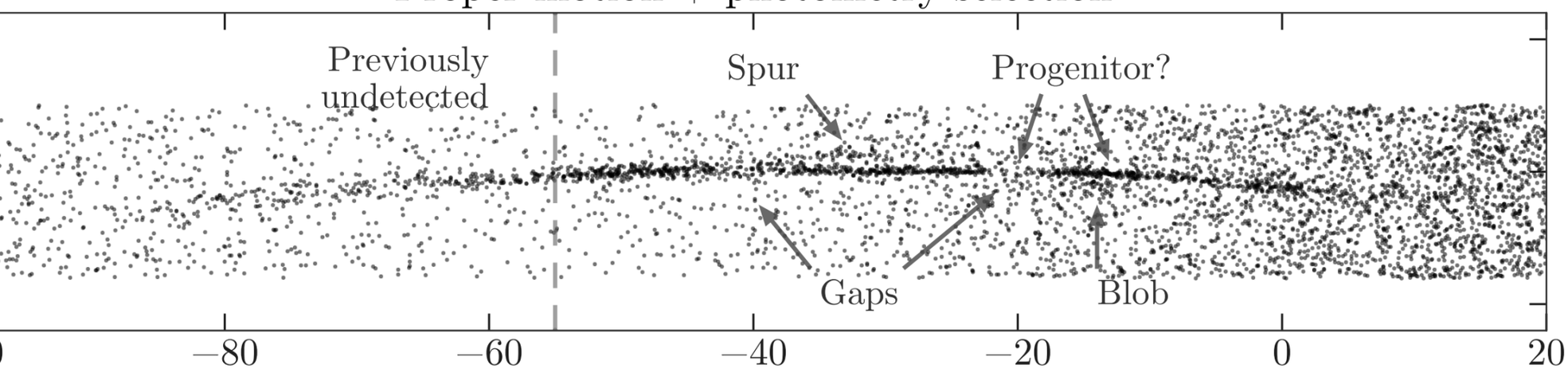
Bovy, Erkal, Sanders 2017
Banik, Bovy, Erkal et al. In prep

Spur, blob, wiggles in GD-1

de Boer, Erkal, Gieles in prep.

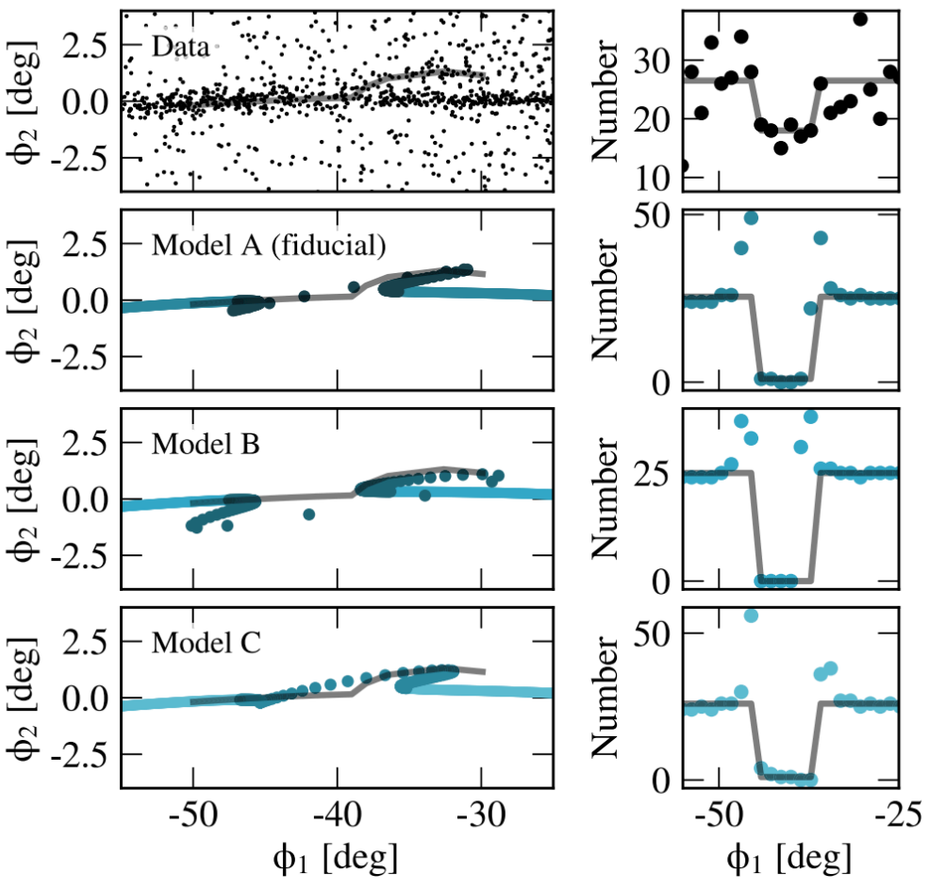


Proper motion + photometry selection

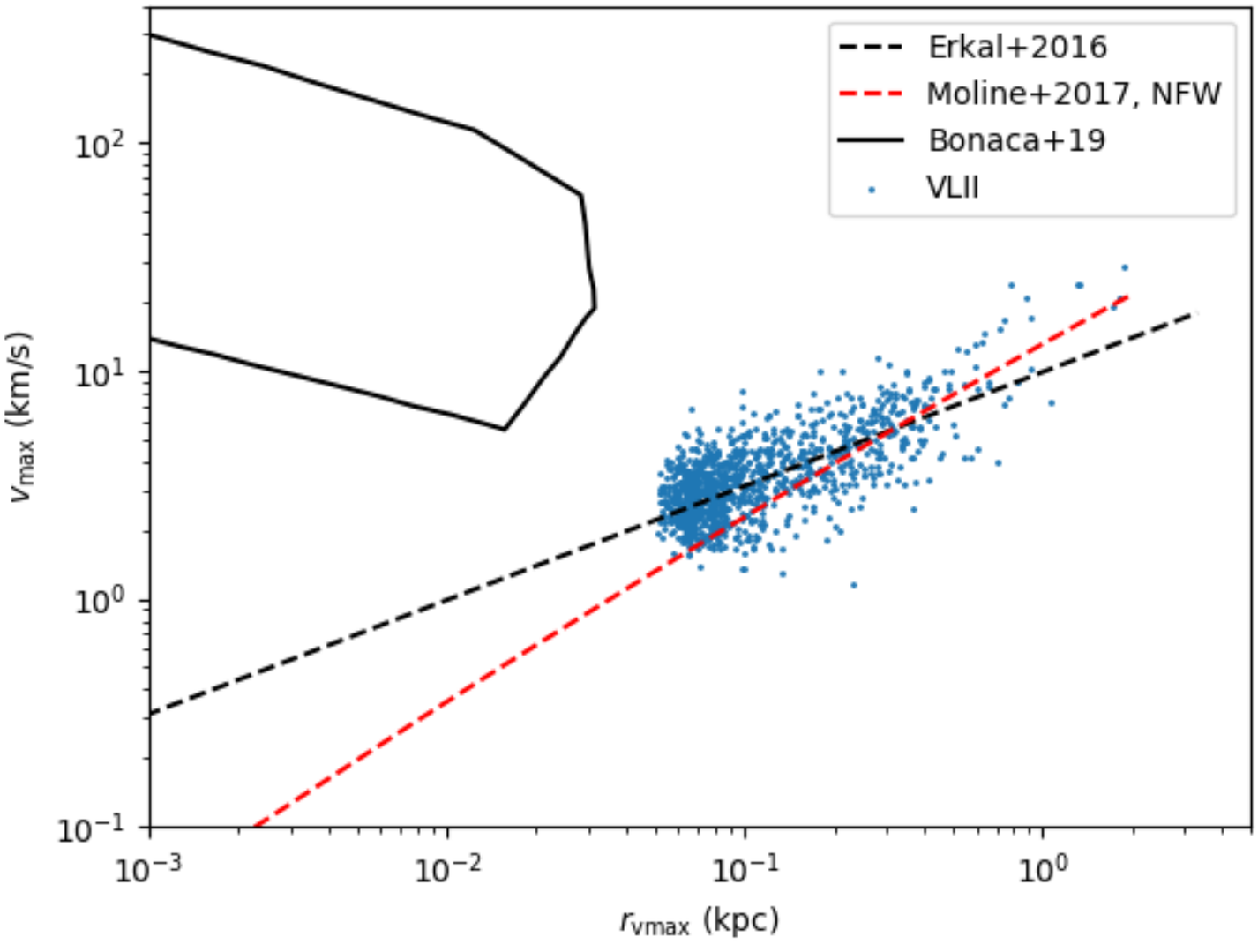


Price-Whelan & Bonaca 2018

Spur models



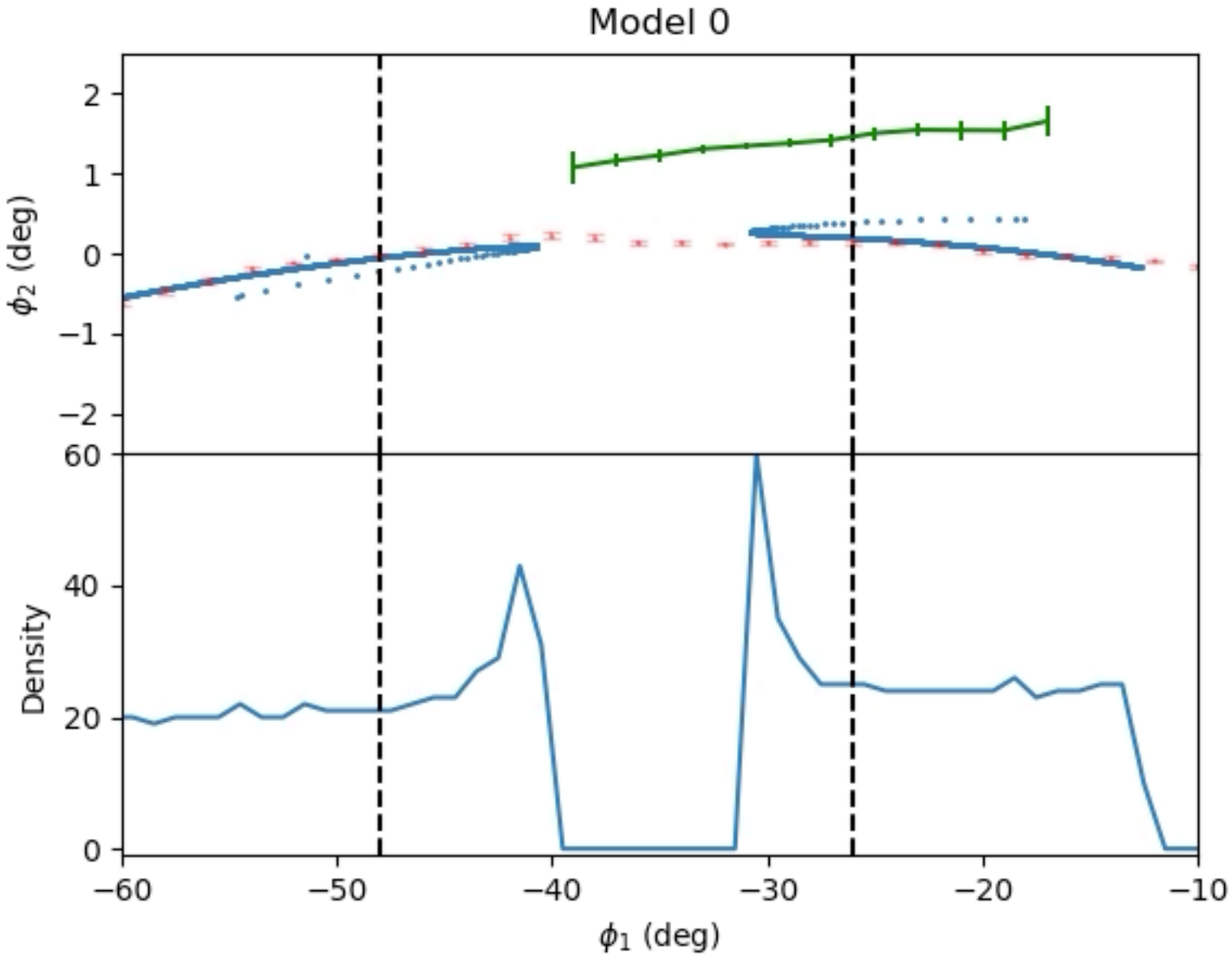
Bonaca et al. 2019



Much denser than LCDM subhaloes

Spur models

- 3×10^7 $M_\odot$, r_s=10 pc Hernquist profile

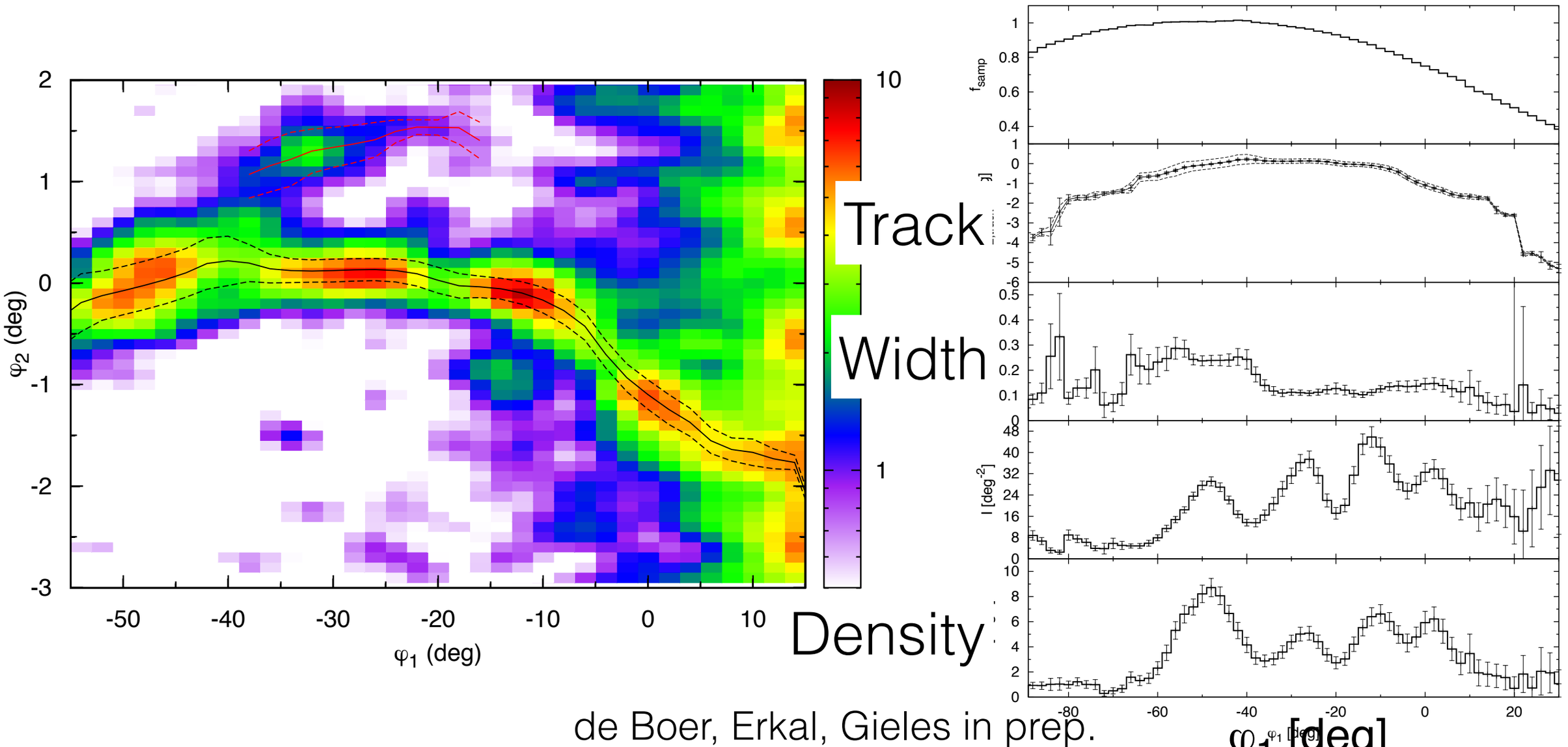


de Boer, Erkal, Gieles in prep.

Dense part of spur always connects to near side of the gap

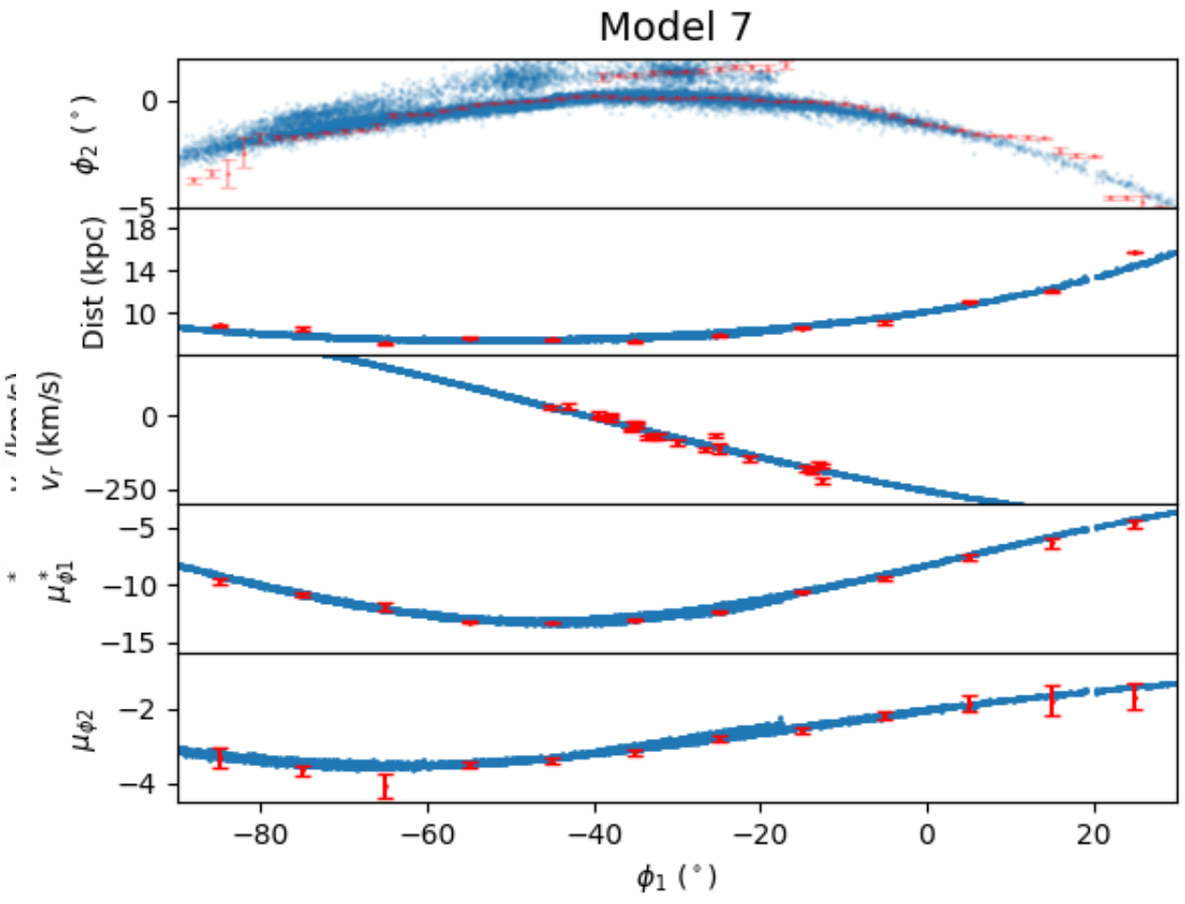
Spur models

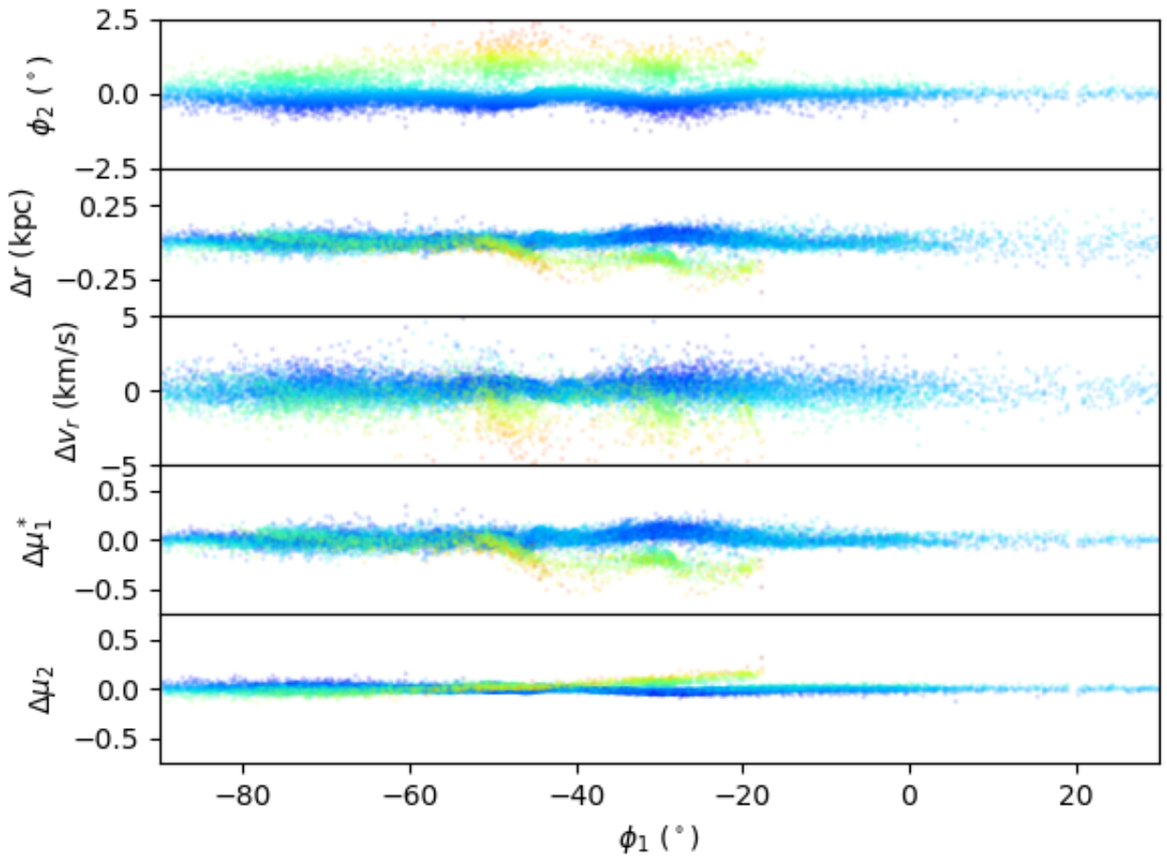
- Spur in GD-1 passes over the gap
- Width doubles to the left of the spur connection



de Boer, Erkal, Gieles in prep.

Effect of Sagittarius

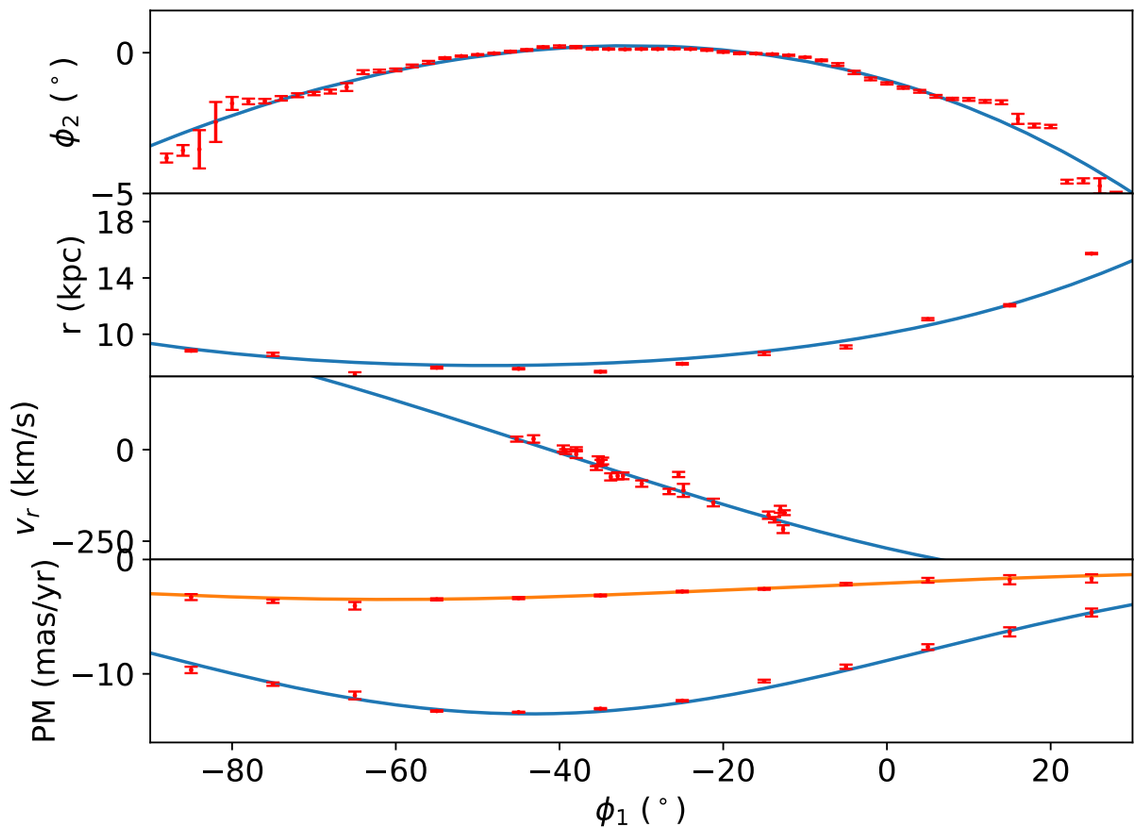




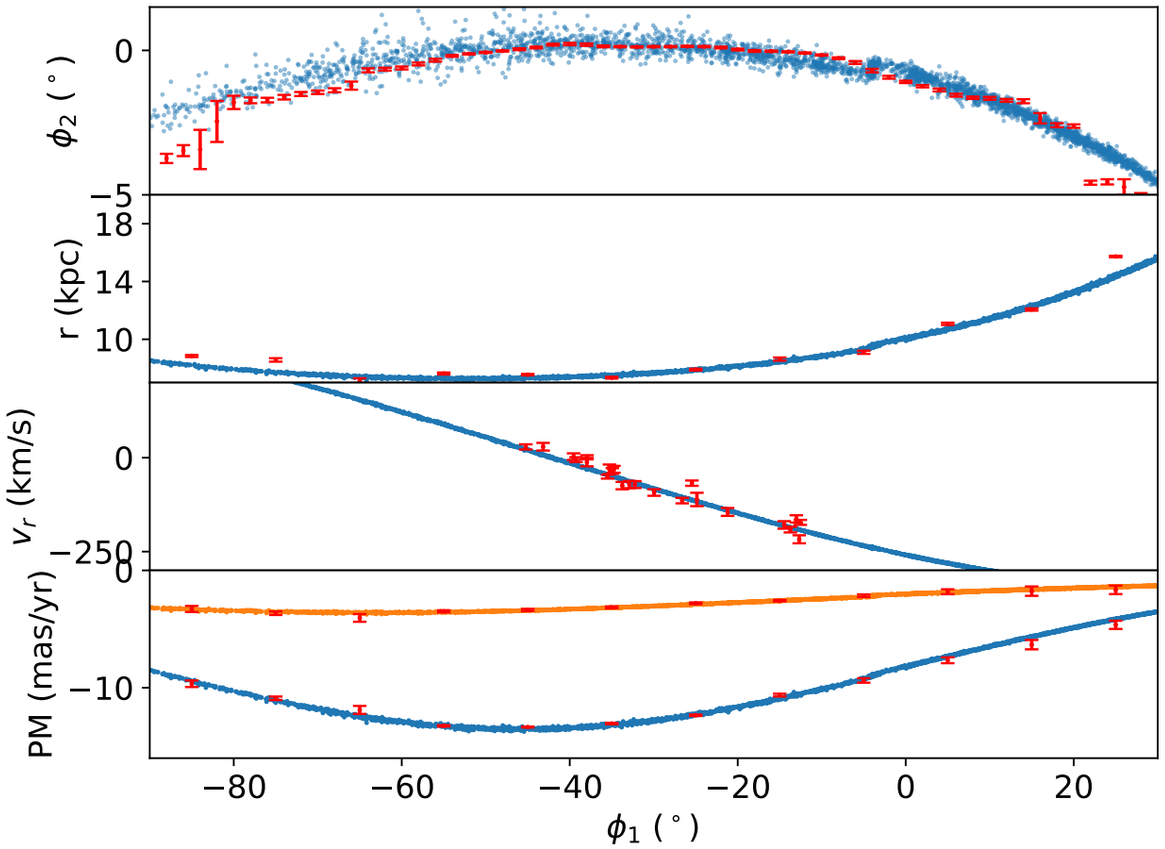
de Boer, Erkal, Gieles in prep.

Gap at -3 deg

Orbit fit



Progenitor at -3? No



de Boer, Erkal, Gieles in prep.

Fit gap at -3 deg

- Need 3 observables to get unique gap fit (Erkal & Belokurov 2015b)
  - e.g. track on sky, density, radial velocities, or PMs

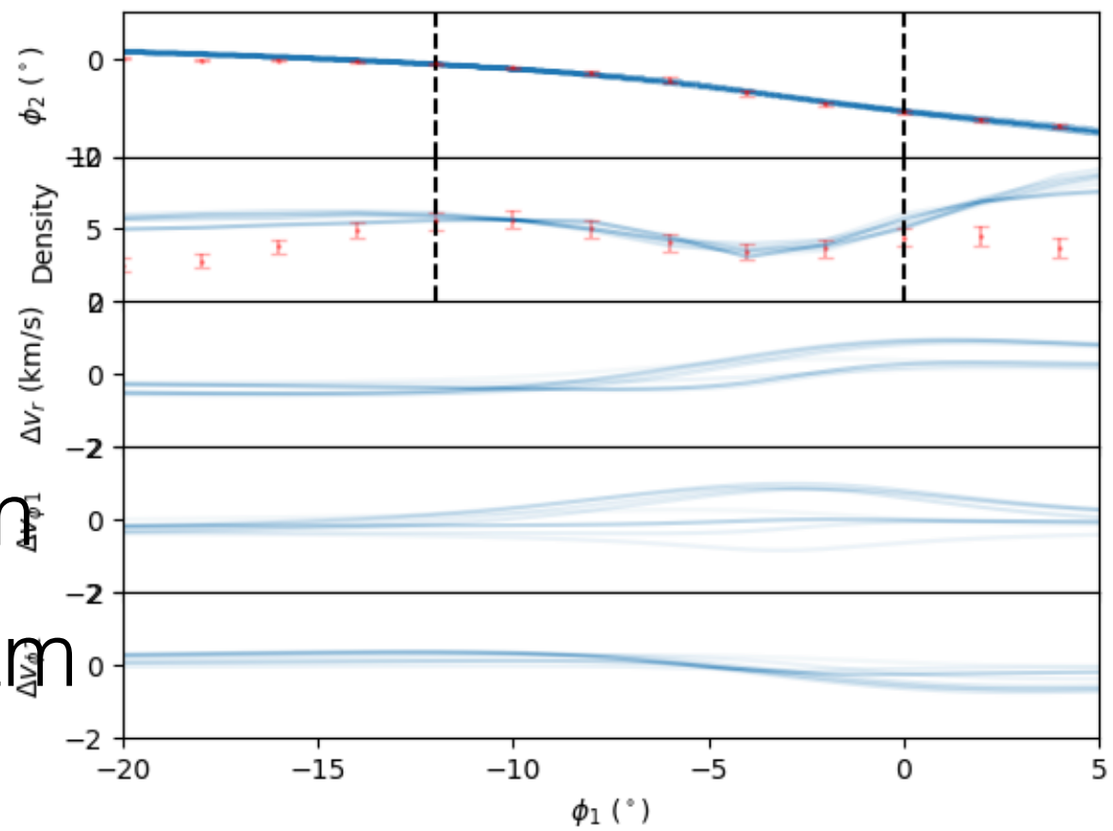
Track

Density

Radial velocity

Vel along stream

Vel perp. to stream



10^7-10^8 $M_\odot$

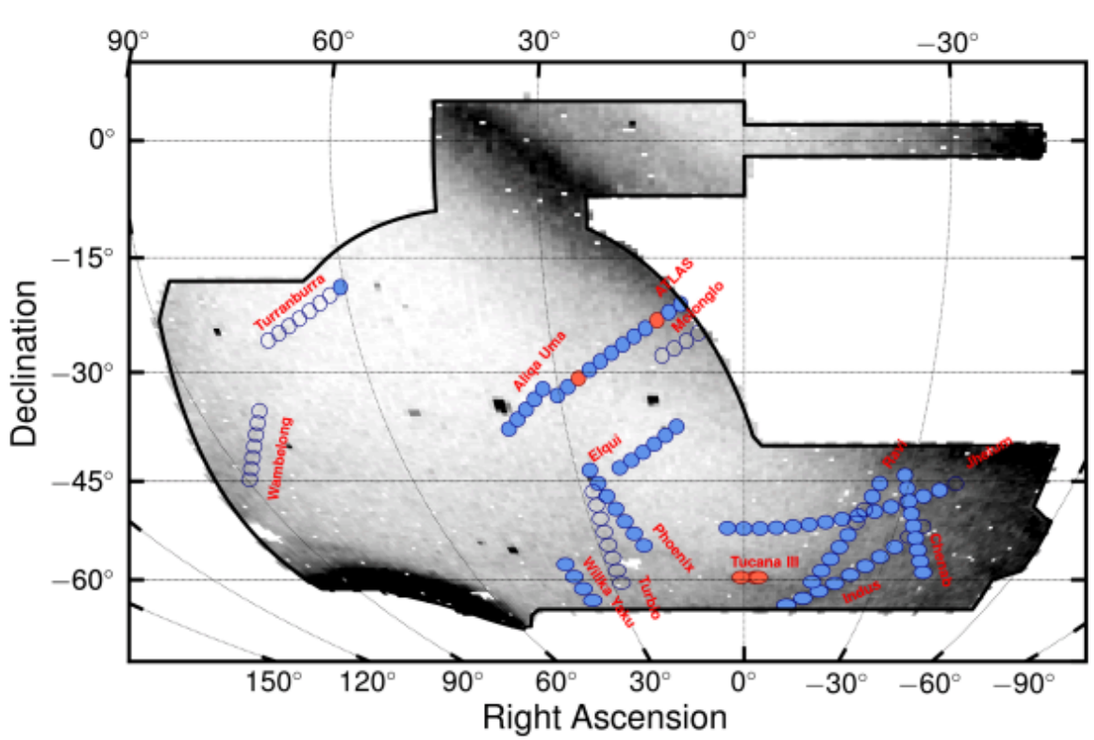
Similar density

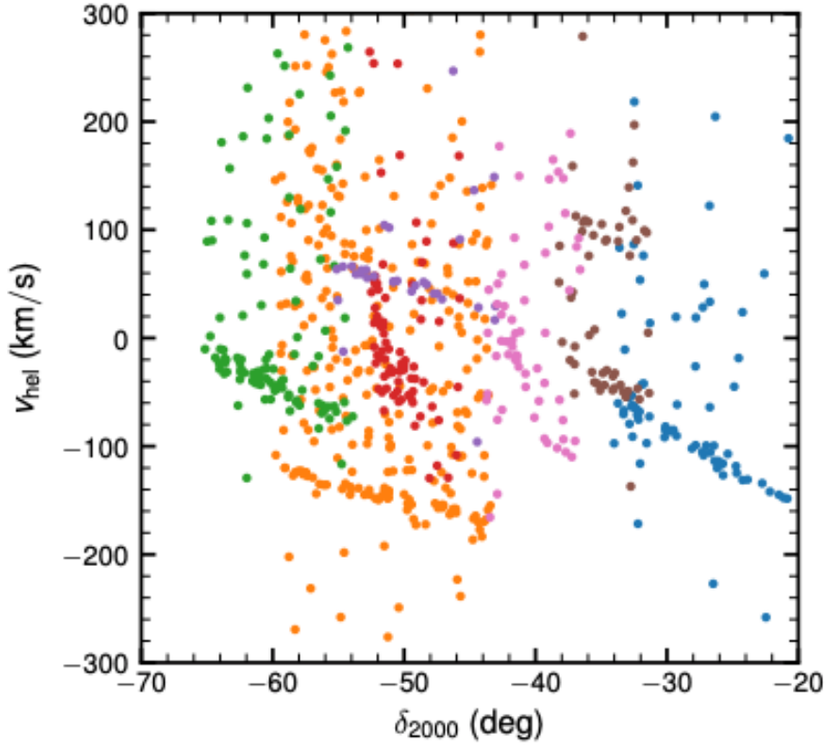
To LCDM

Erkal et al. in prep.

S^5 - Southern Stellar Stream Spectroscopic Survey

- Leadership: Ting Li, Daniel Zucker, **Geraint Lewis**, Kyler Kuehn
- Builders: **Denis Erkal**, **Alex Ji**, Sergey Koposov, Dougal Mackey, **Nora Shipp**, Jeffrey Simpson, Zhen Wan
- Members: Sahar Allam, Josh Bland-Hawthorn, Eduardo Balbinot, Keith Bechtol, **Vasily Belokurov**, Andrew Casey, Lara Cullinane, Gary Da Costa, Gayandhi De Silva, Alex Drlica-Wagner, **Marla Geha**, Sarah Martell, Jeremy Mould, Andrew Pace, Sanjib Sharma, **Josh Simon**, Douglas Tucker, Kathy Vivas, Zhen Wan, **Risa Wechsler**, Brian Yanny

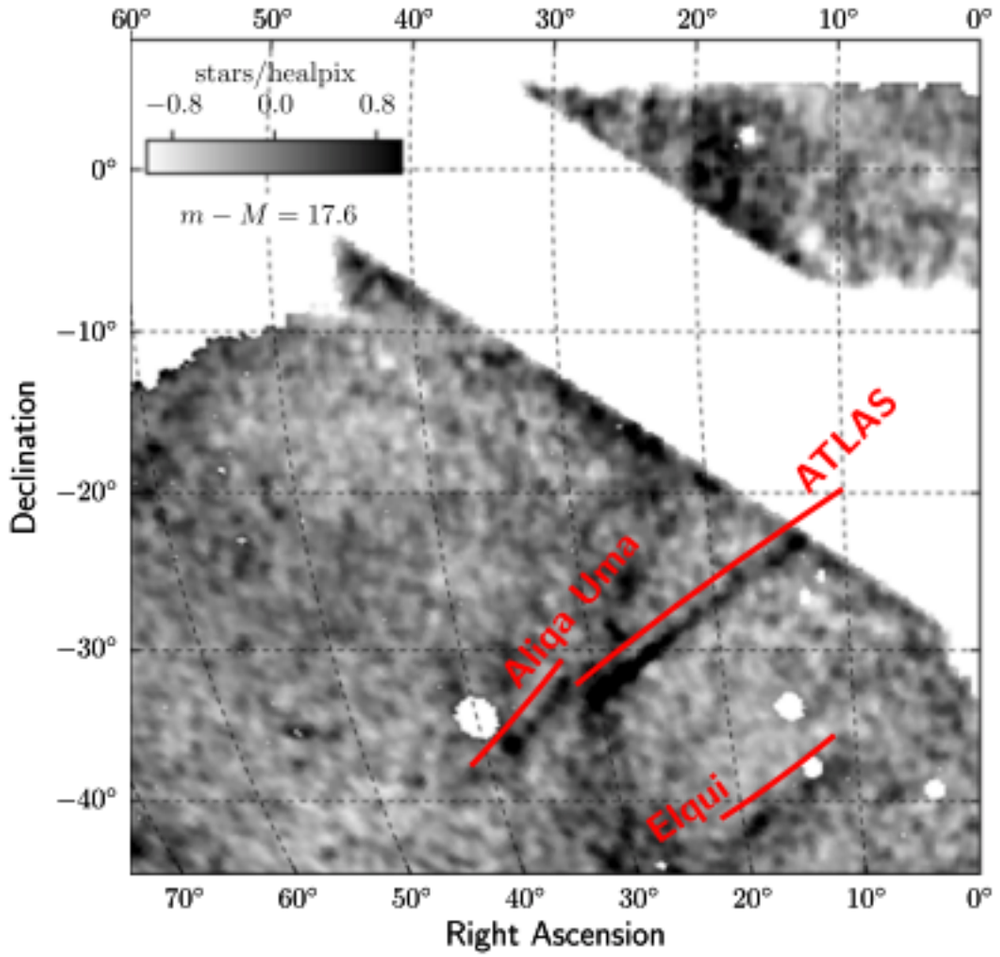




https://s5collab.github.io/

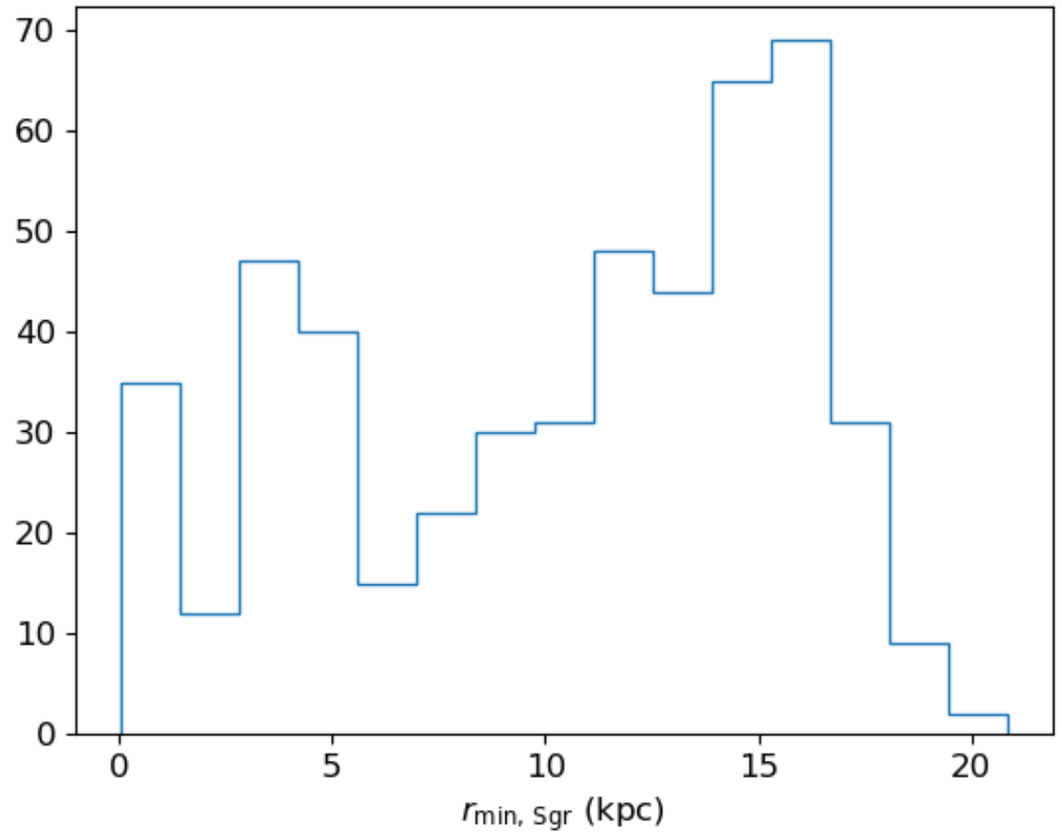
Li+2019, arXiv:1907.09481

ATLAS & Aliqa Uma



Shipp et al. 2018

Sgr can pass close to ATLAS



S5 et al. in prep

Conclusions

- Precise morphology of streams tells us about perturbers
- Spur may not connect on to the gap next to the spur
- Sagittarius can create similar features in GD-1
- Wiggle at -3 degrees looks interesting
- S^5 reveals that ATLAS has a large perturbation (Sgr?)
- We need follow-up of the streams (photometric, rv, PM)
- We need to understand Sgr better

My favourite streams