

Ana Bonaca
Carnegie Observatories

From Dozens to Thousands: Stellar Streams with the Roman Space Telescope

Galaxy interactions as evidence of hierarchical growth of structure

Atlas of Peculiar Galaxies, Arp (1966)



The Mice (Arp 242)



The Antennae (Arp 244)

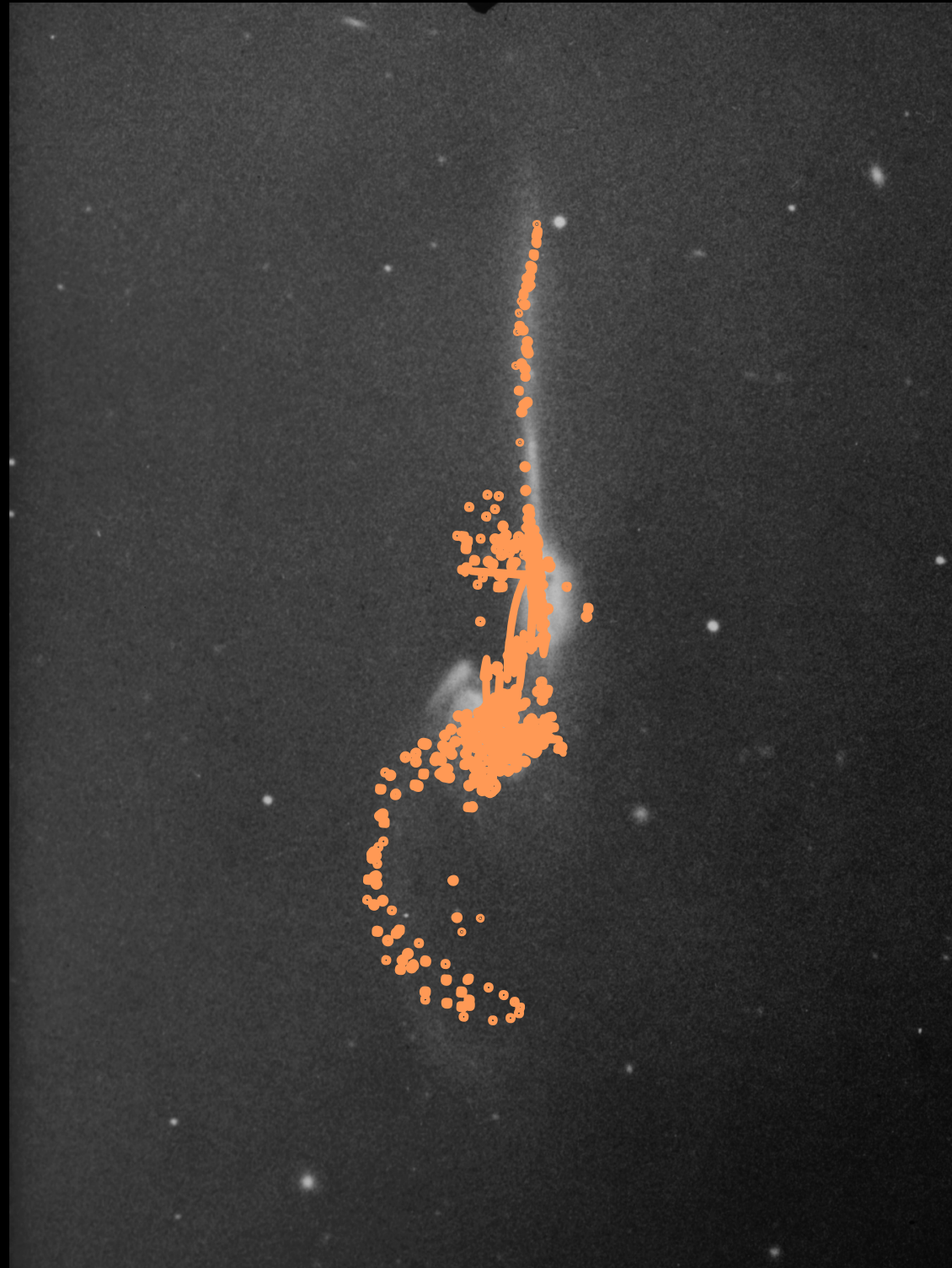


(Arp 295)

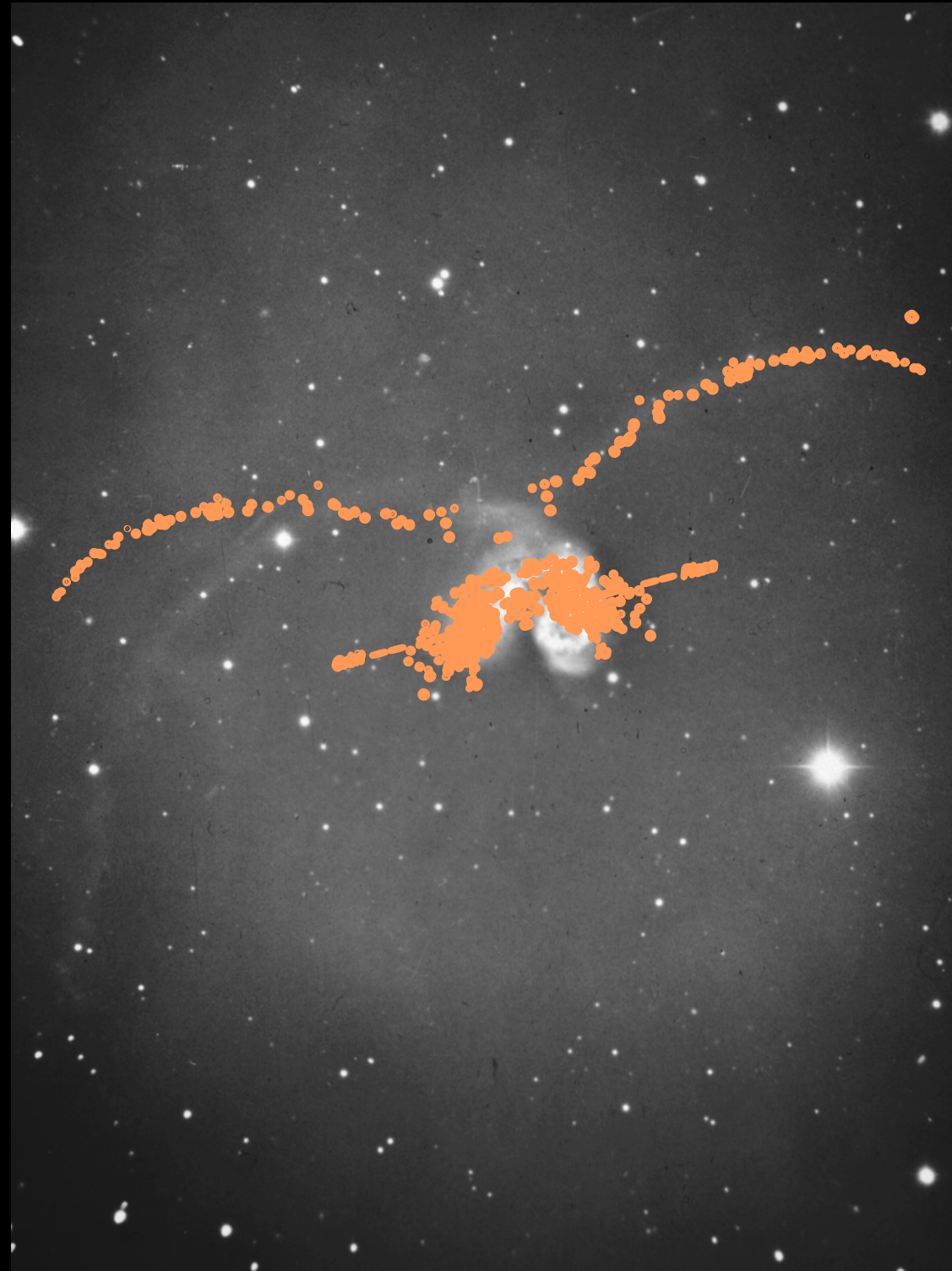
Galaxy interactions as evidence of hierarchical growth of structure

Atlas of Peculiar Galaxies, Arp (1966)

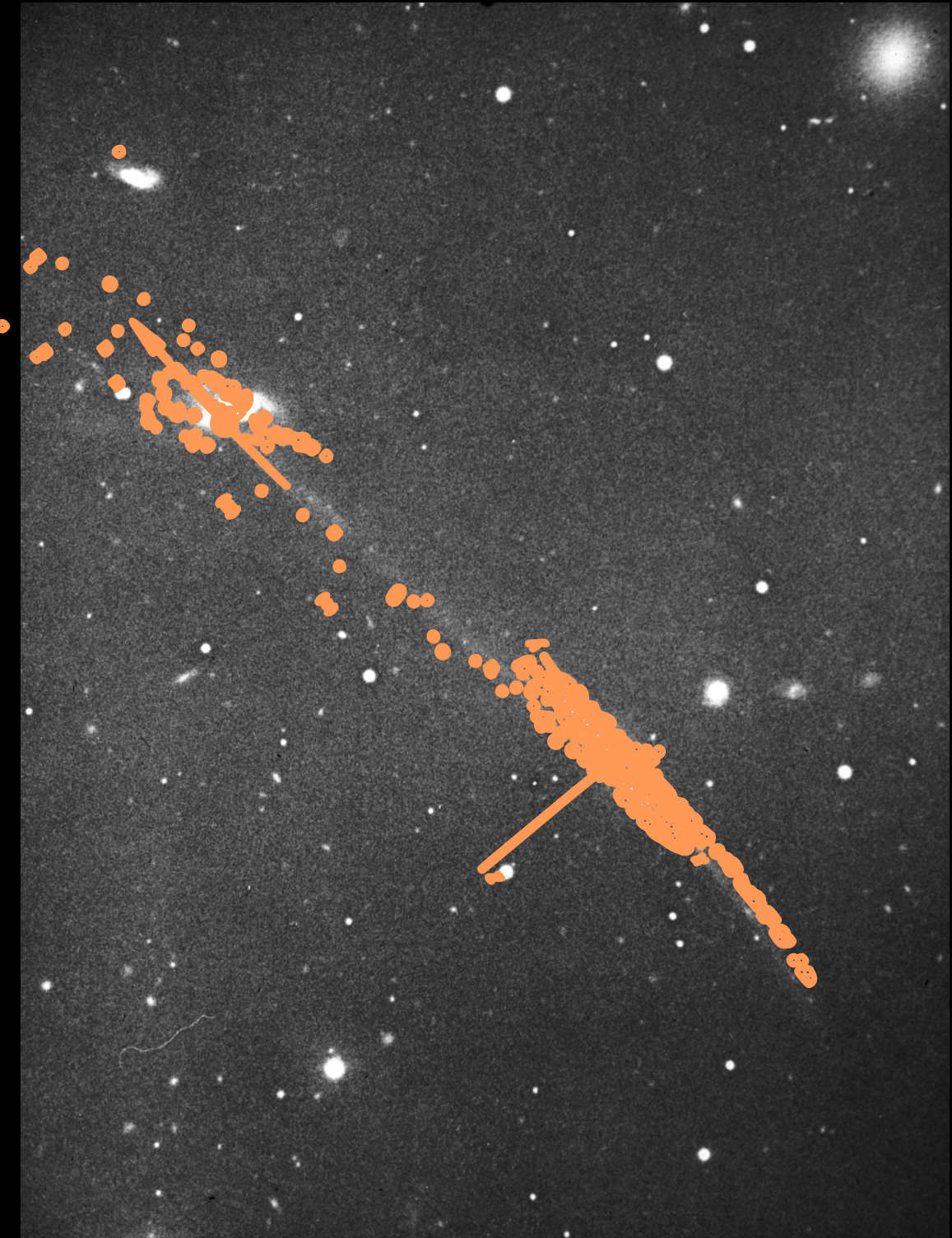
Toomre & Toomre (1972)



The Mice (Arp 242)



The Antennae (Arp 244)



(Arp 295)

WDM

SIDM

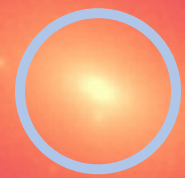
CDM

Particle nature of dark matter is encoded in its spatial distribution on small scales

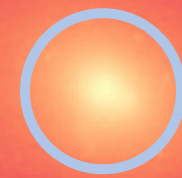
WDM

SIDM

CDM



most triaxial



more spherical



more triaxial

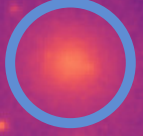
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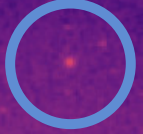
WDM

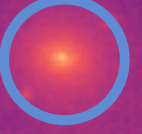
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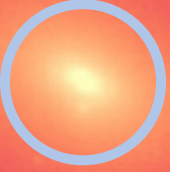
CDM

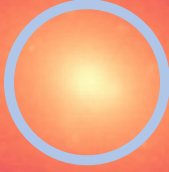
less 
substructure

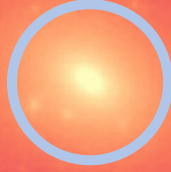

diffuse


compact

 similar
concentration

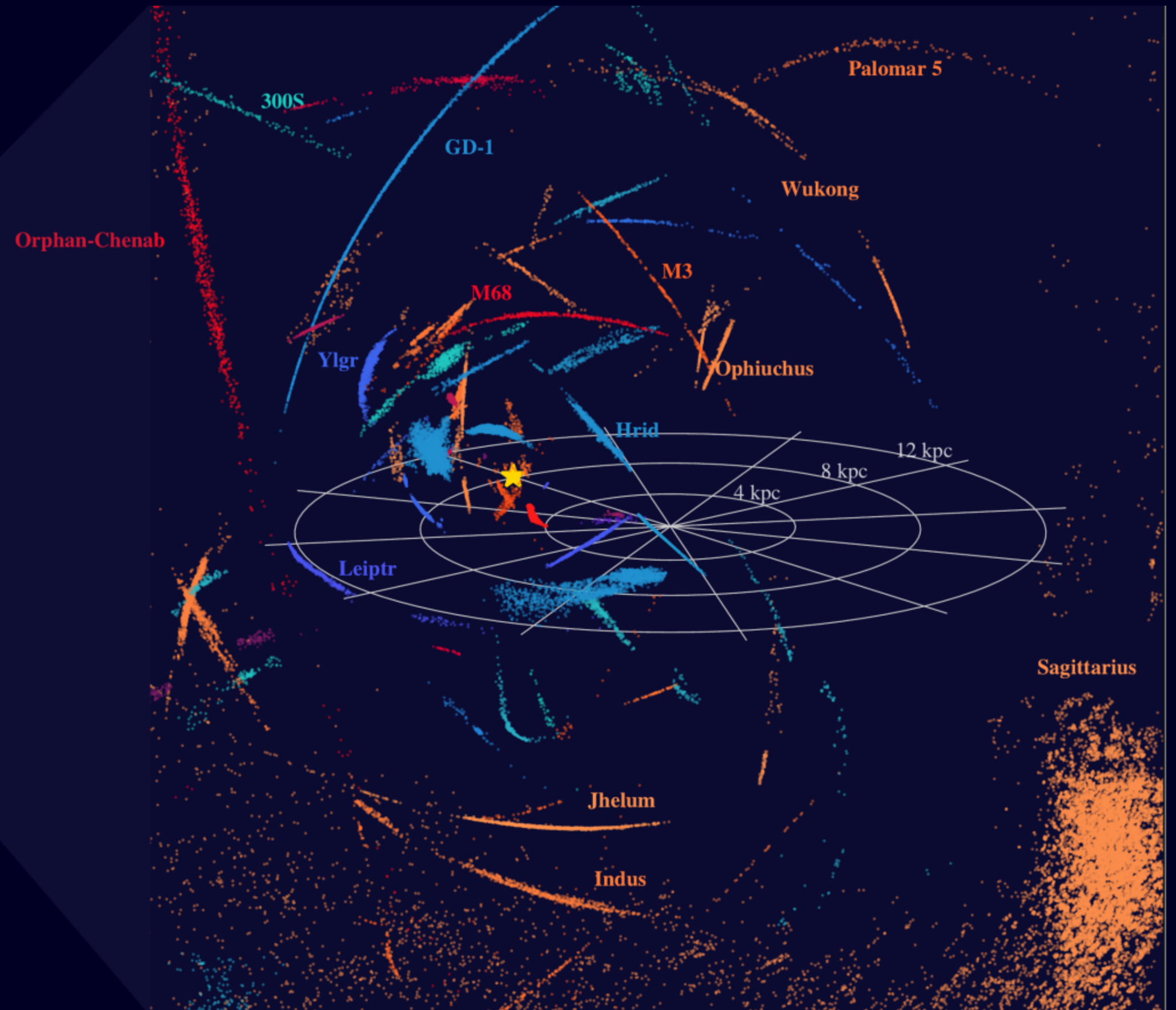
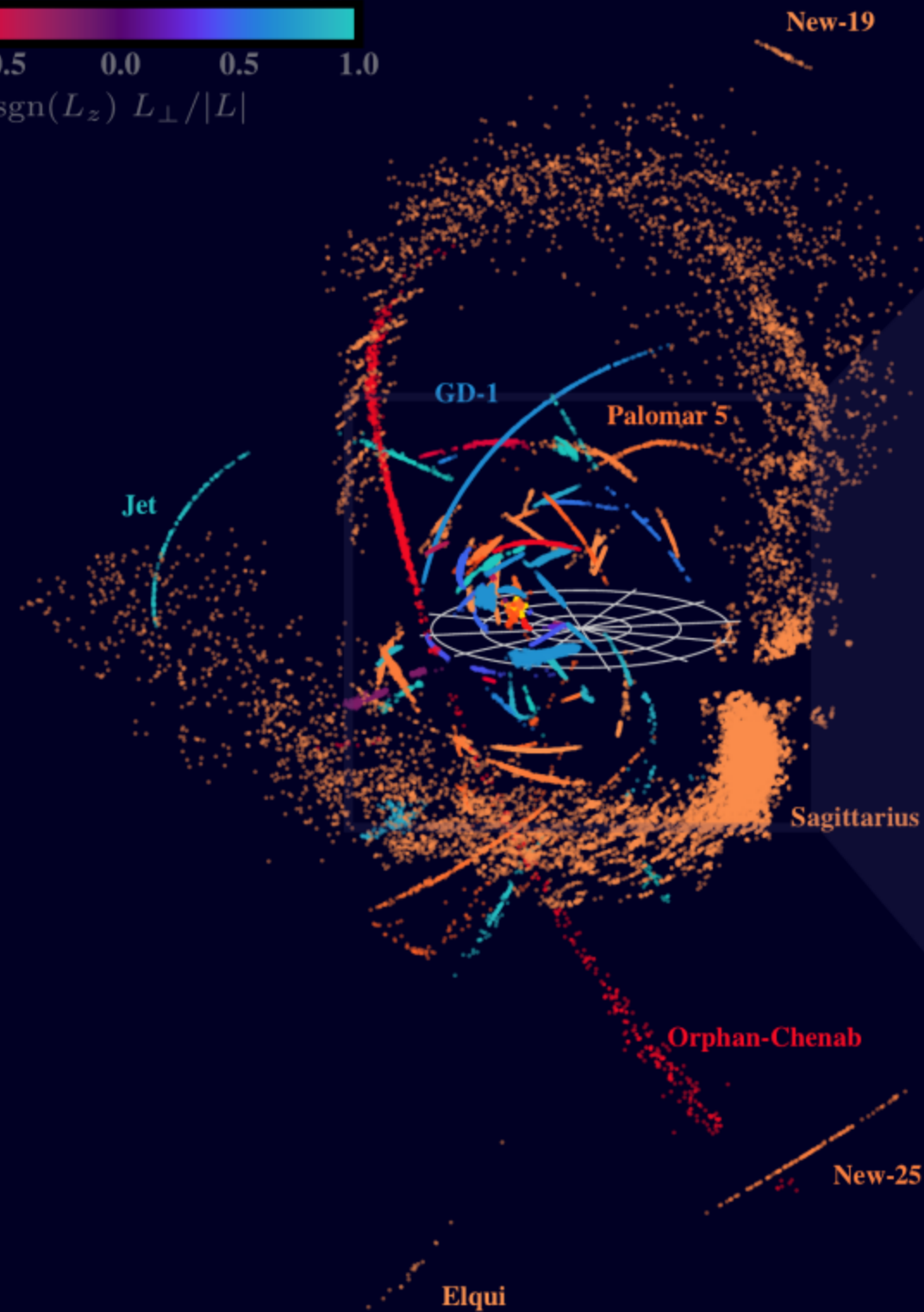
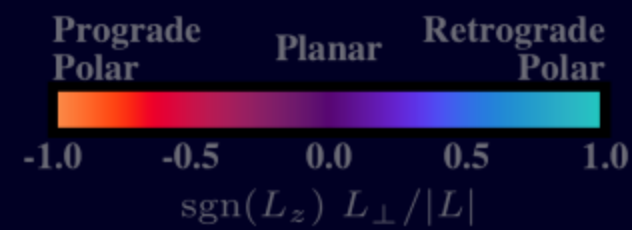

most triaxial


more spherical


more triaxial

Particle nature of dark matter is encoded in its spatial distribution on small scales

>130 streams have been discovered in the Milky Way



Stream trajectories measure the acceleration field

Numerical integration: $(x_i, v_i) + \Phi(x_i) \rightarrow (x_{i+1}, v_{i+1})$



Stream trajectories measure the acceleration field



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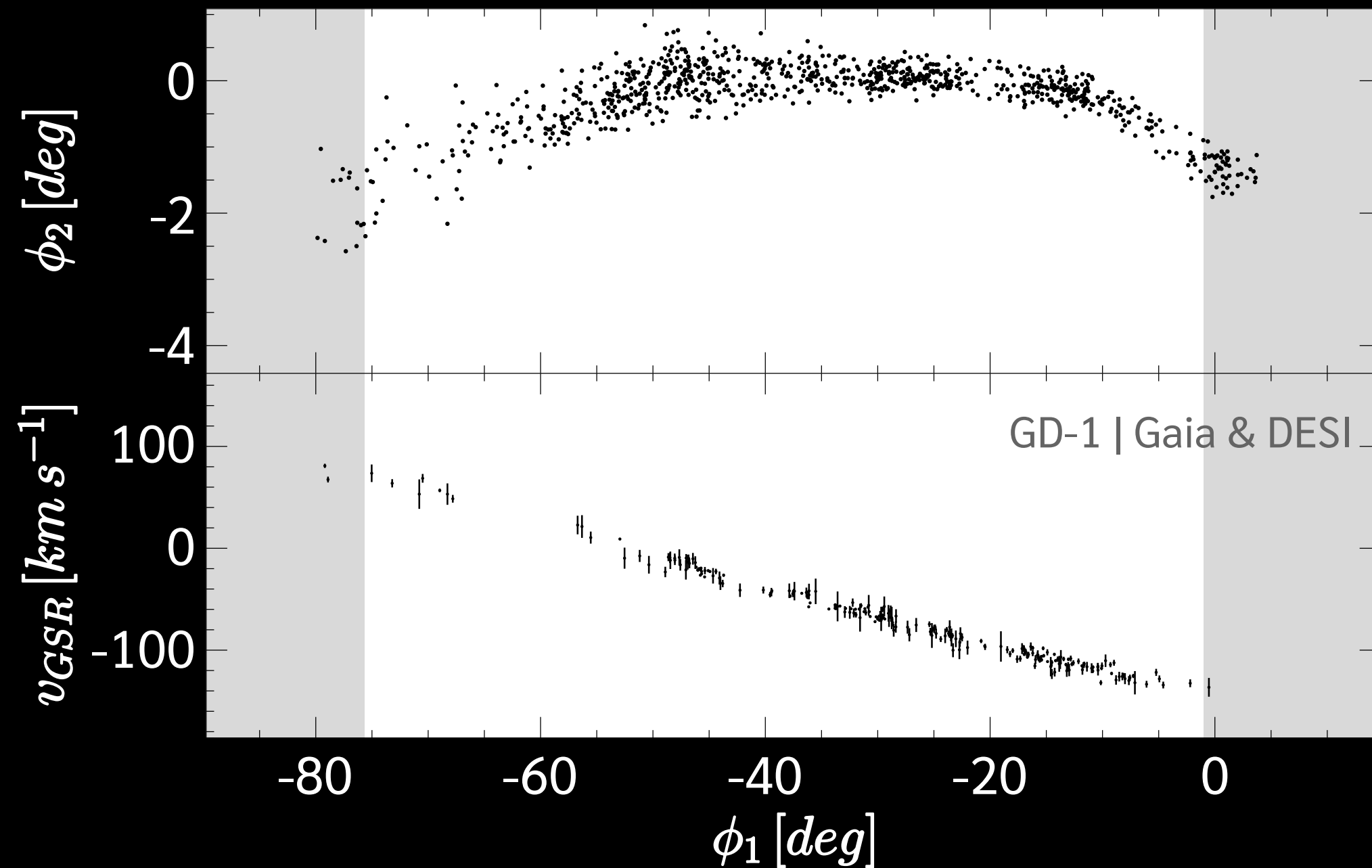
Streams*: $(x_i, v_i) + (x_{i+1}, v_{i+1}) \rightarrow \Phi(x_i)$

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* without large-scale perturbations

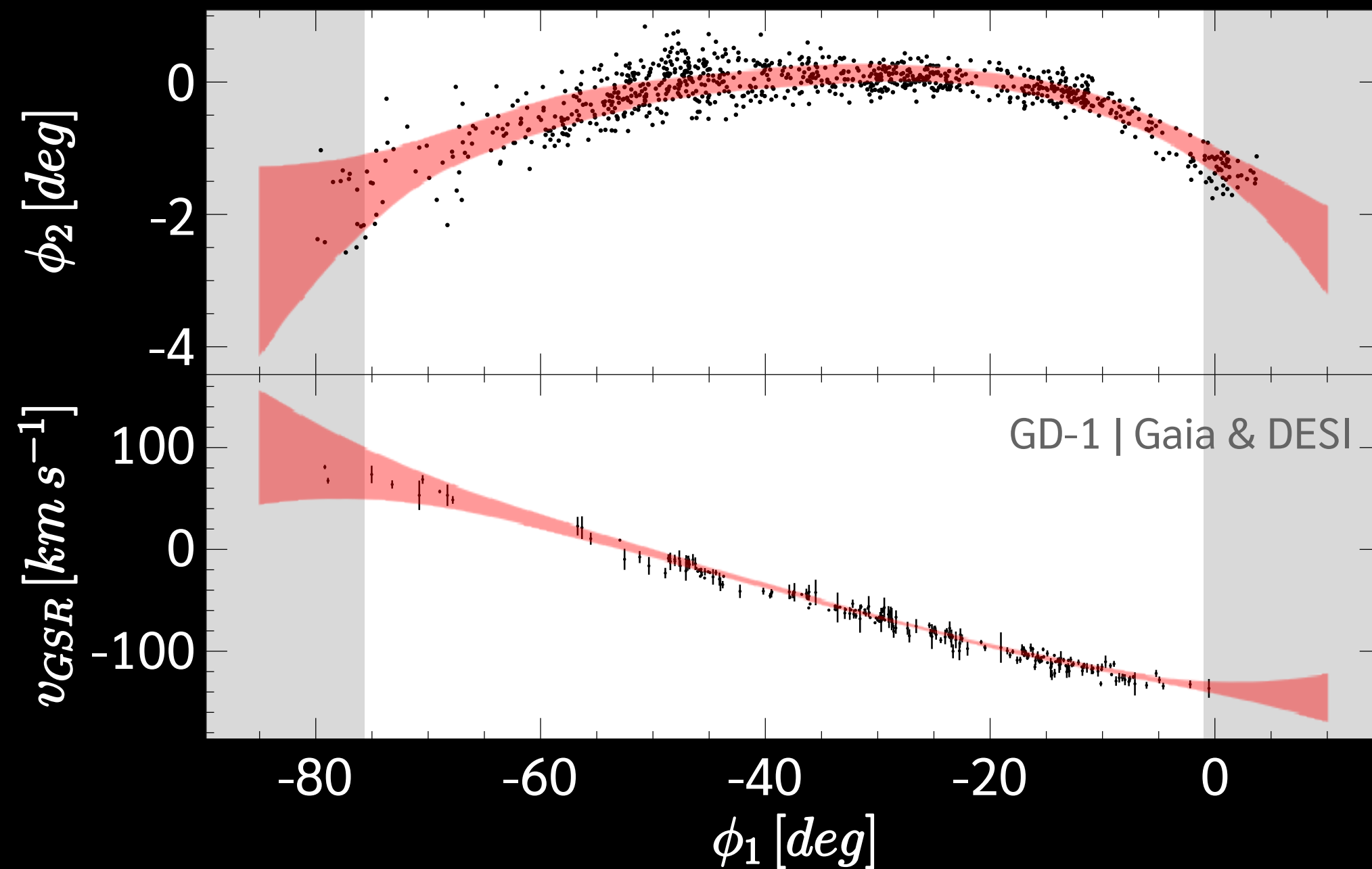
Nibauer et al. (2022), Nibauer & Bonaca (2025)

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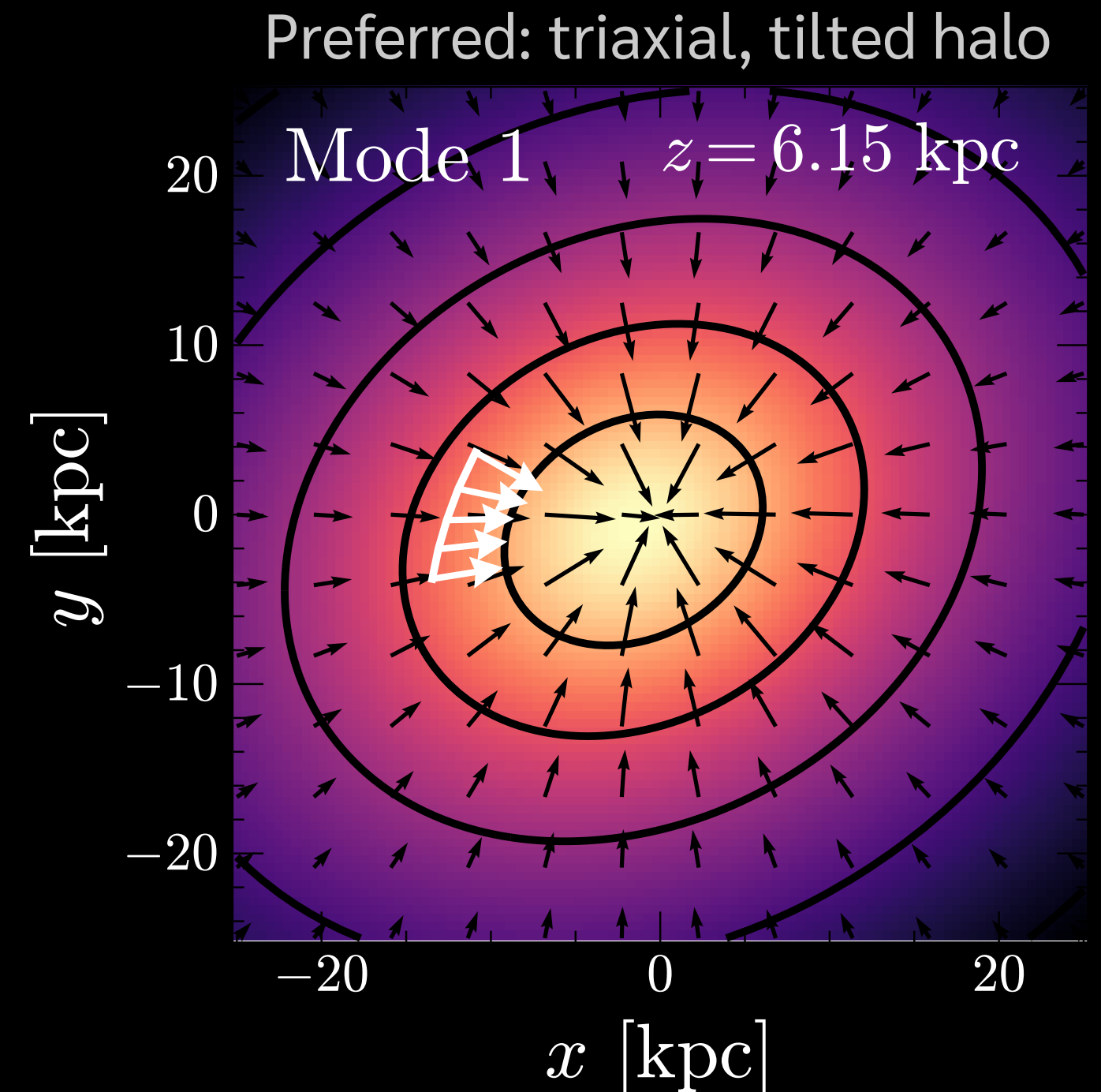
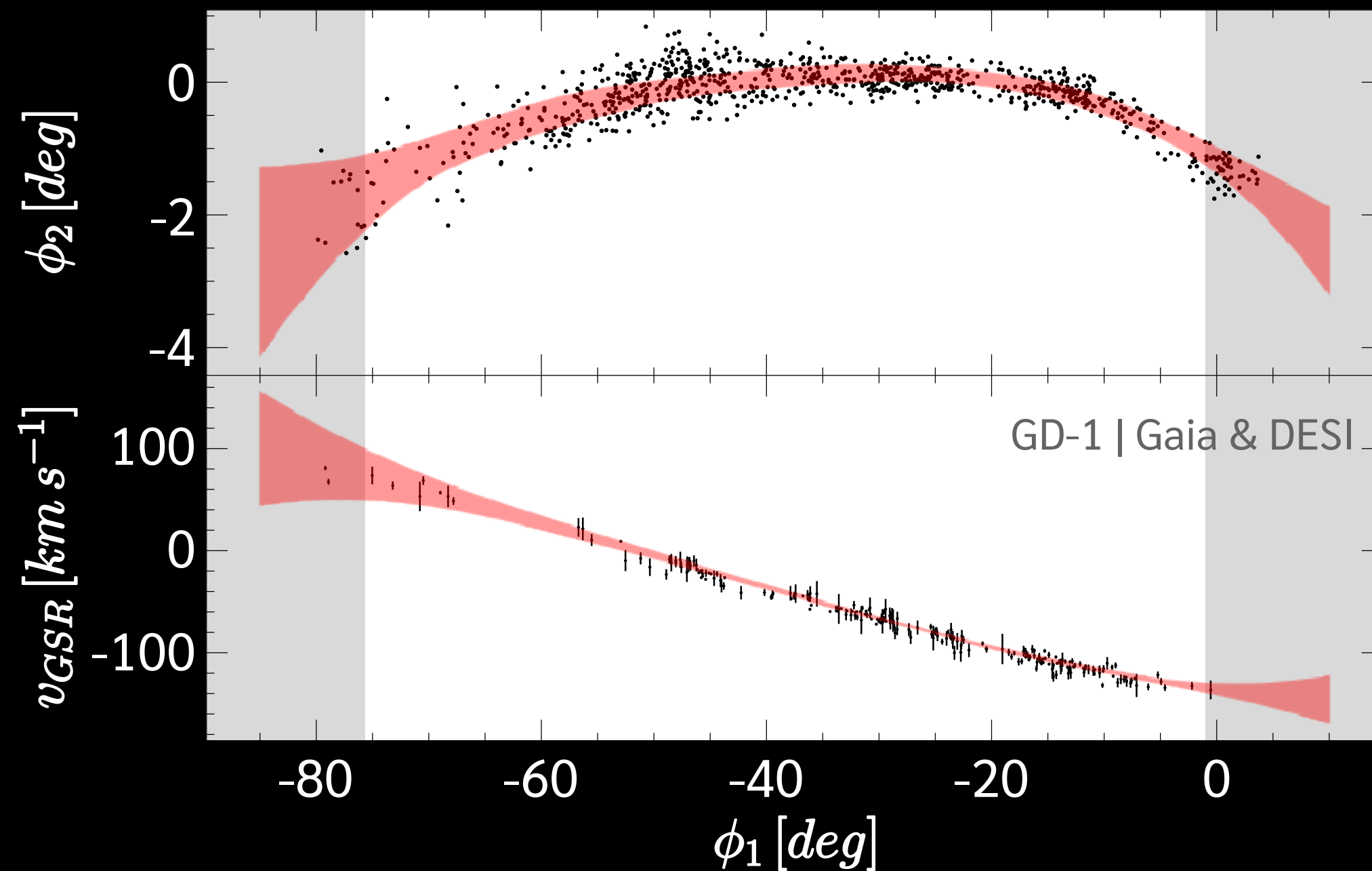
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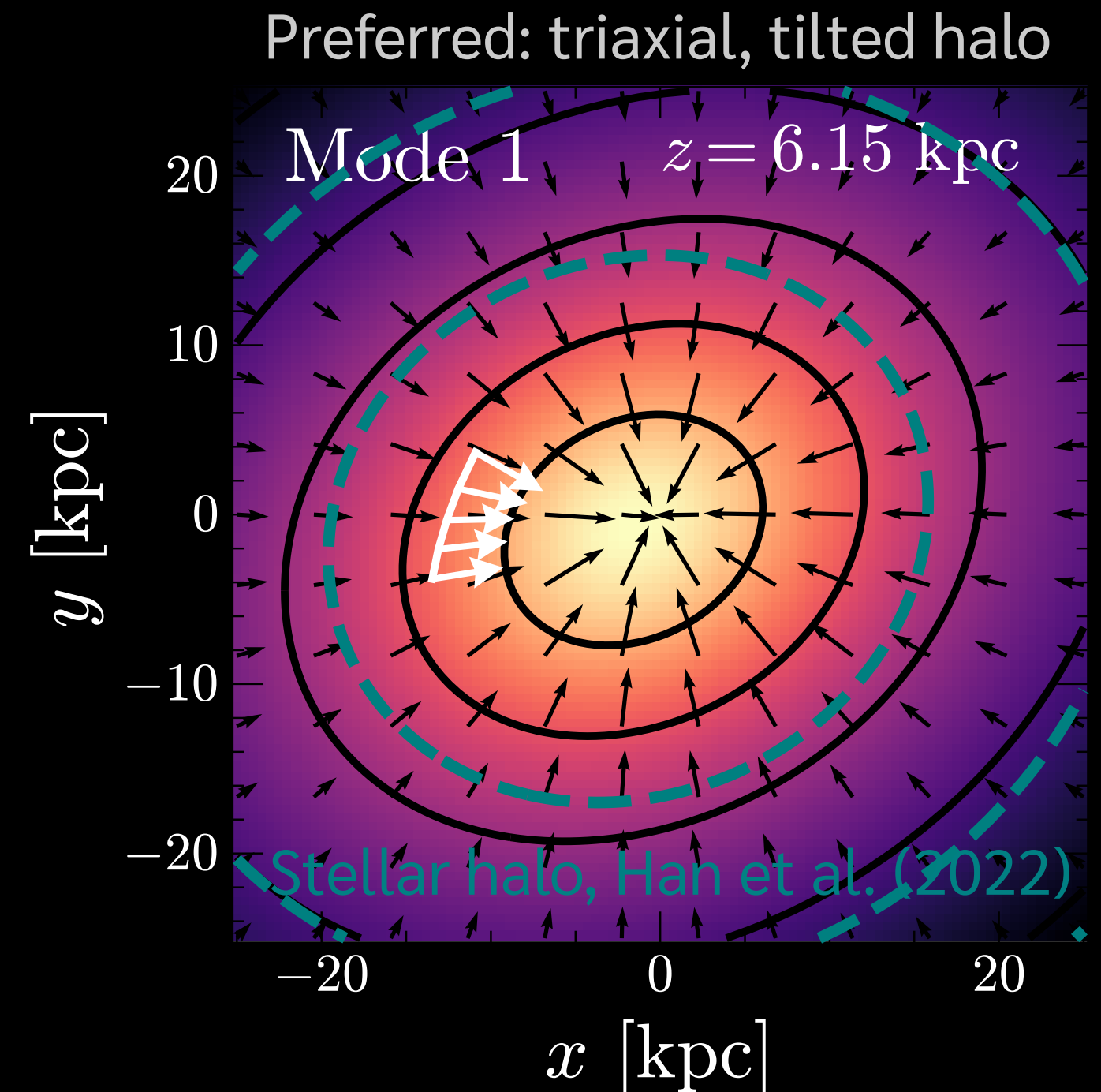
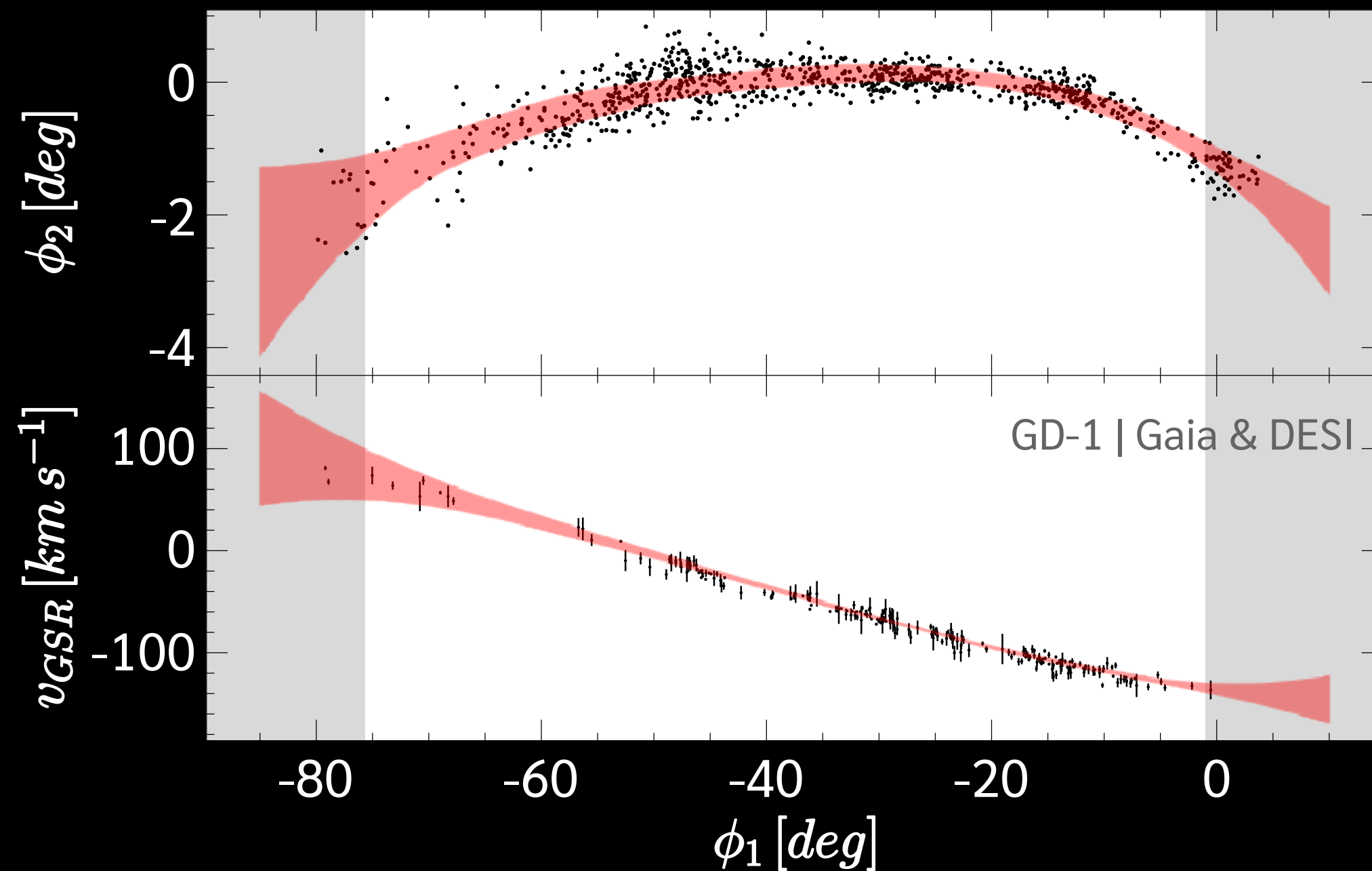
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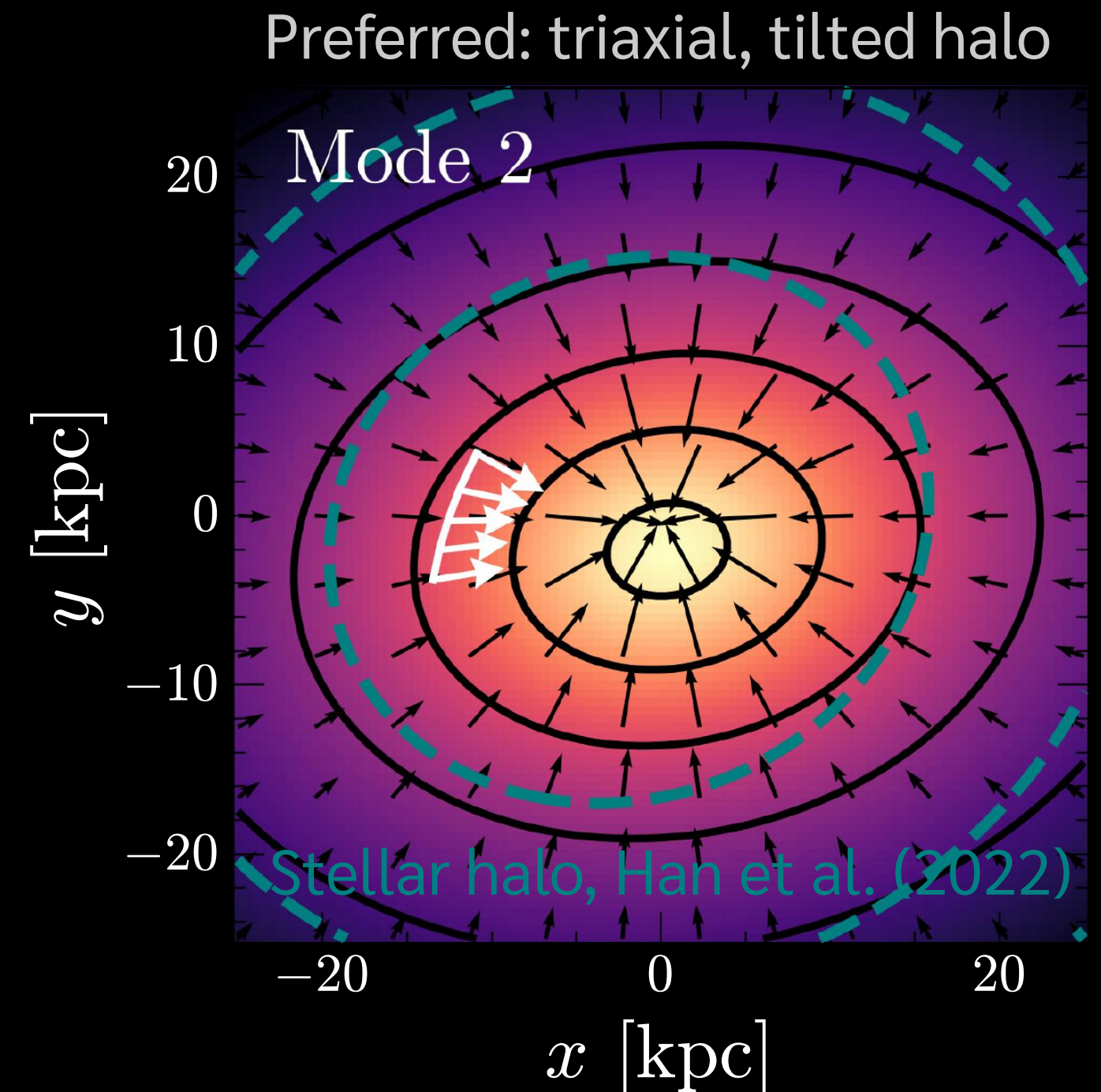
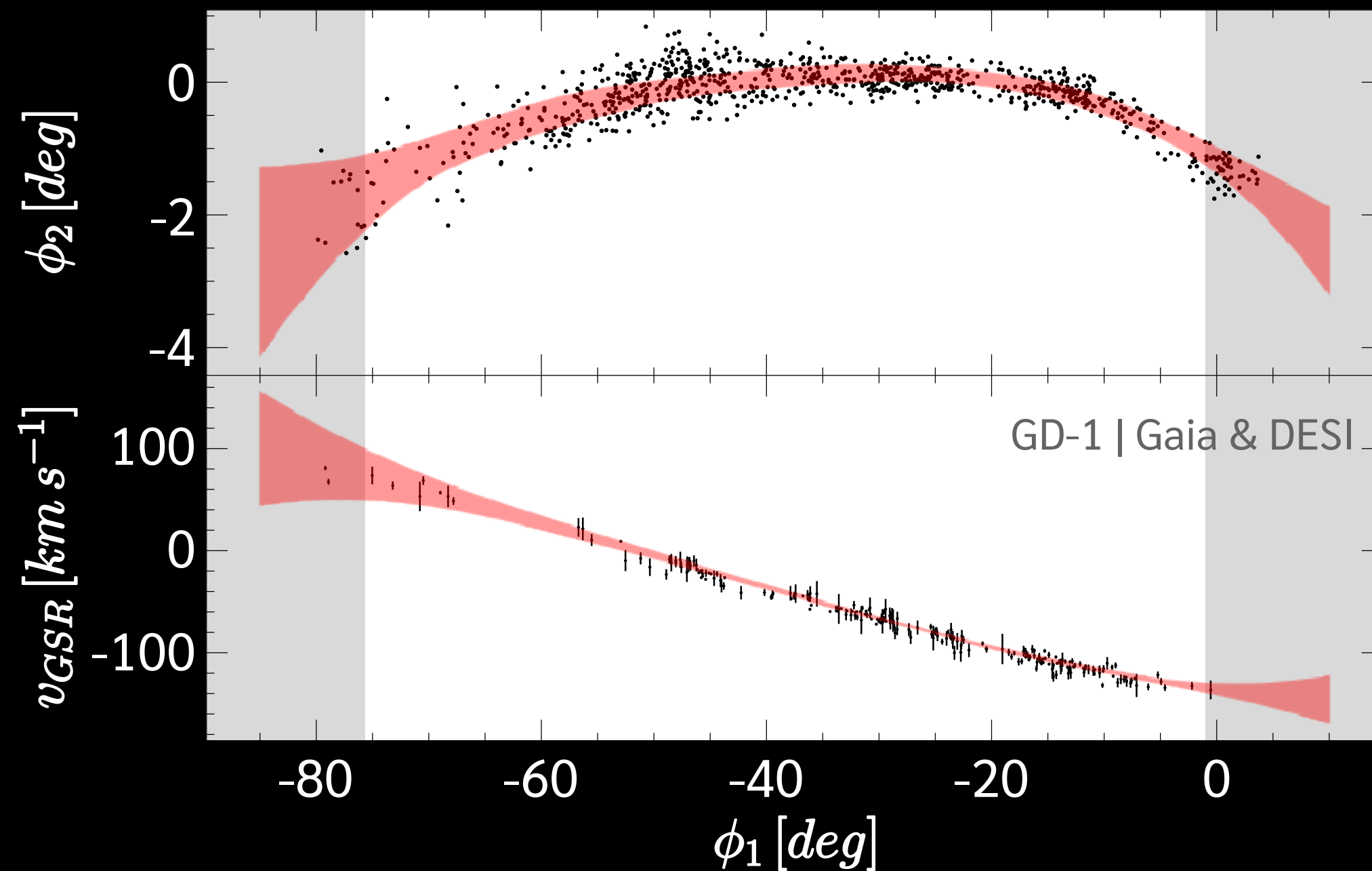
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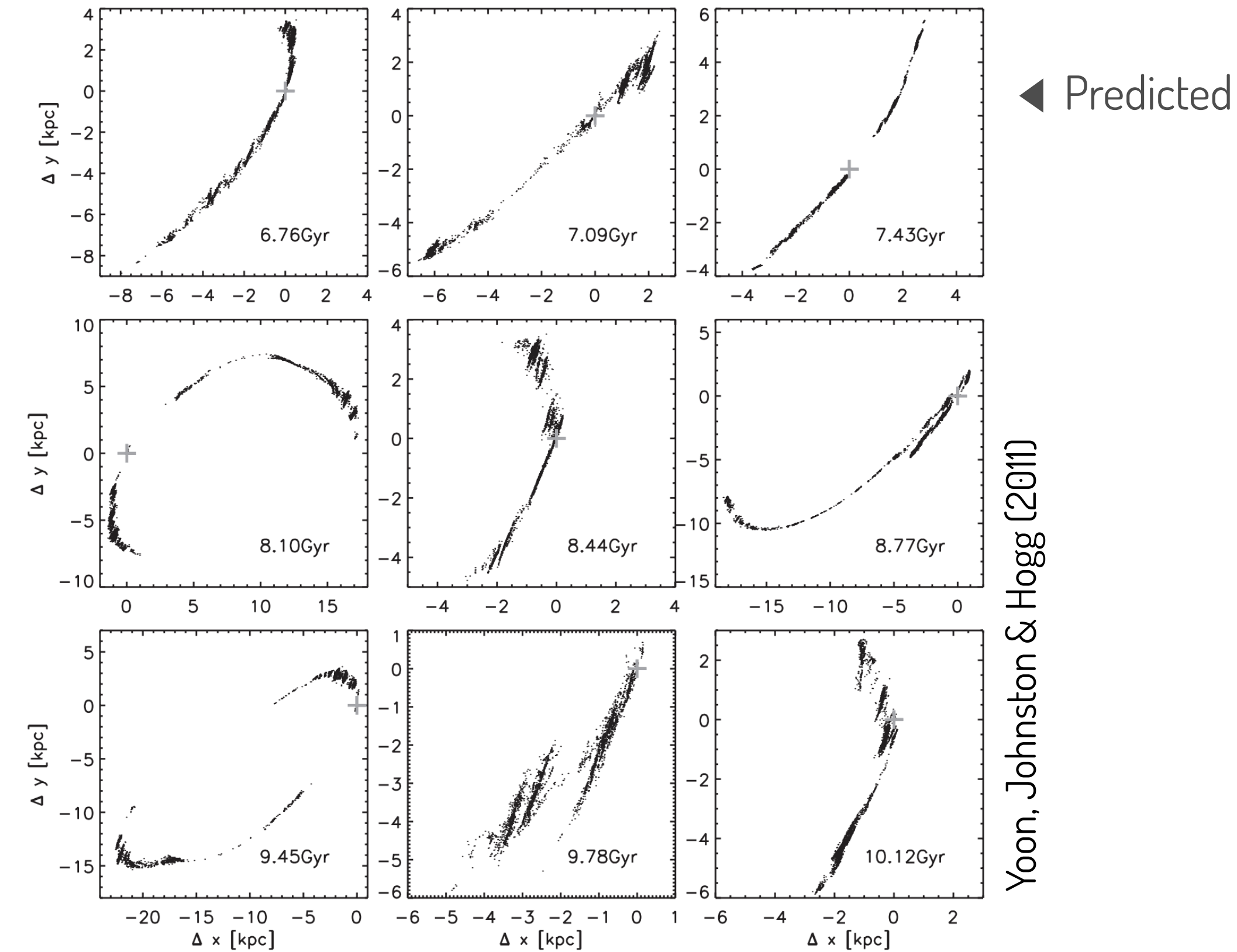
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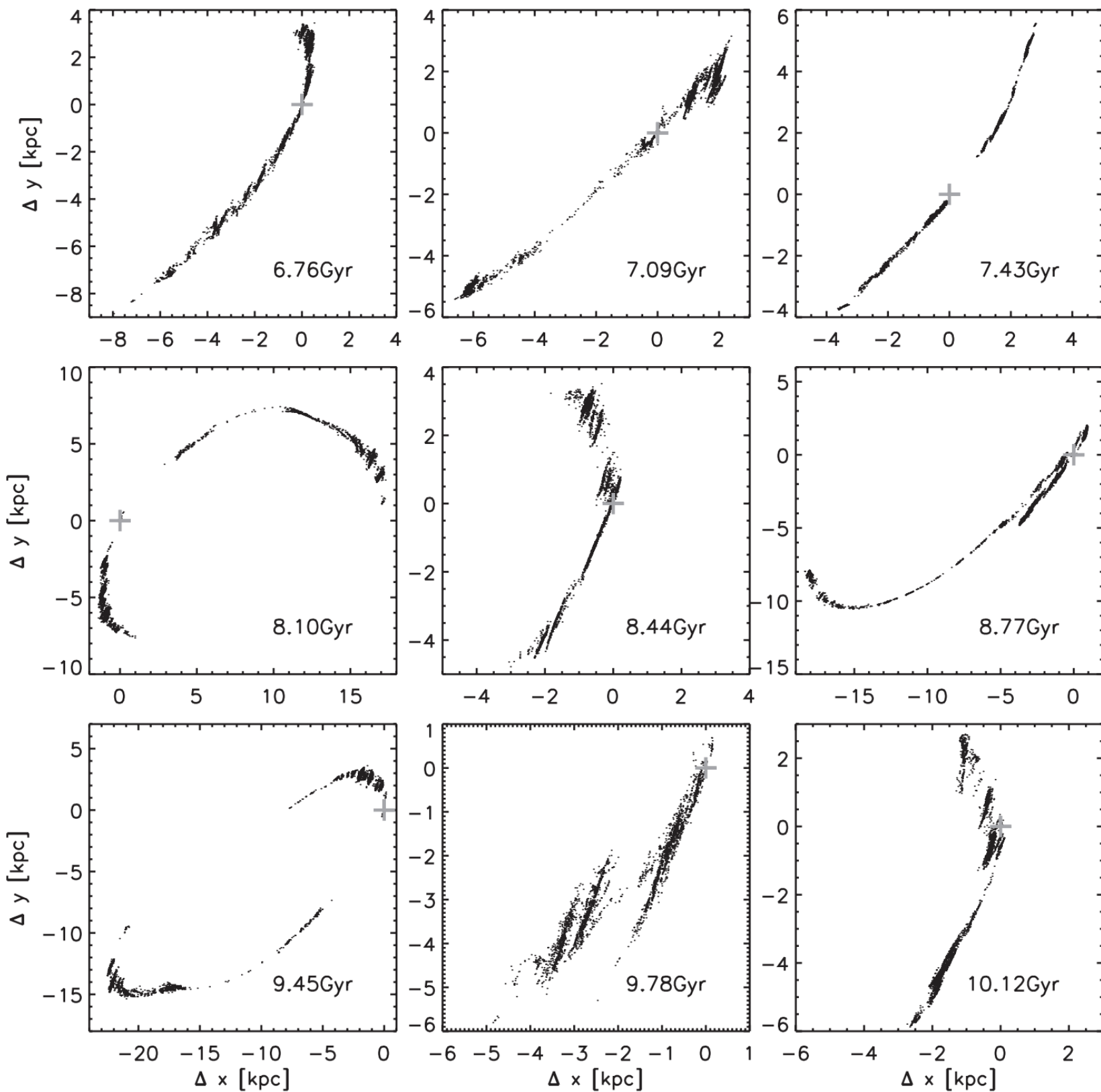
Dynamically perturbed stellar streams are common



Yoon, Johnston & Hogg (2011)

See also: Johnston et al. (2002), Ibata et al. (2002),
Carlberg (2009, 2012), Erkal & Belokurov (2015), Bovy et al. (2016)

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◀ Predicted
Observed ▶

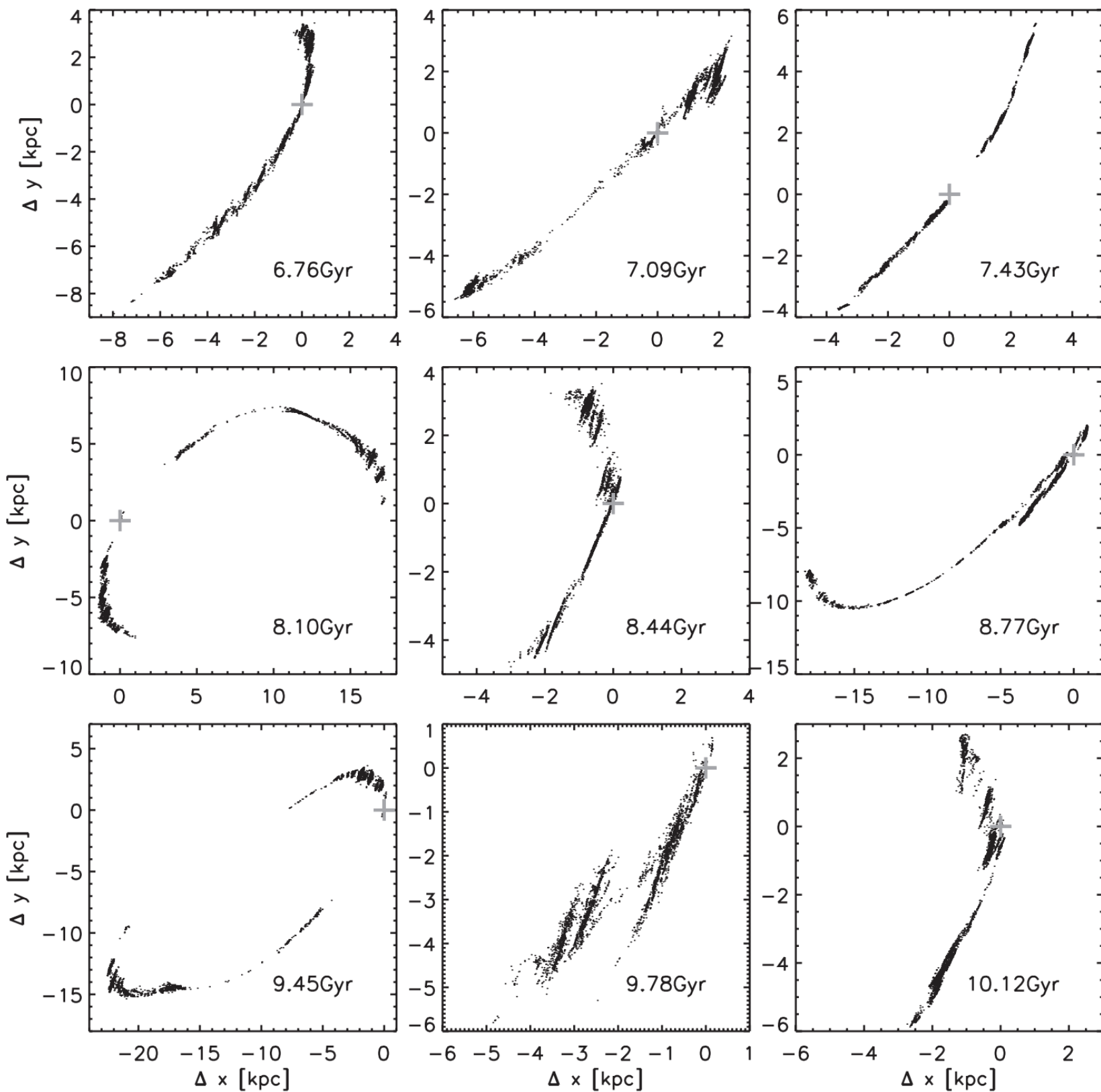
GD-1

Price-Whelan & Bonaca (2018)

Yoon, Johnston & Hogg (2011)

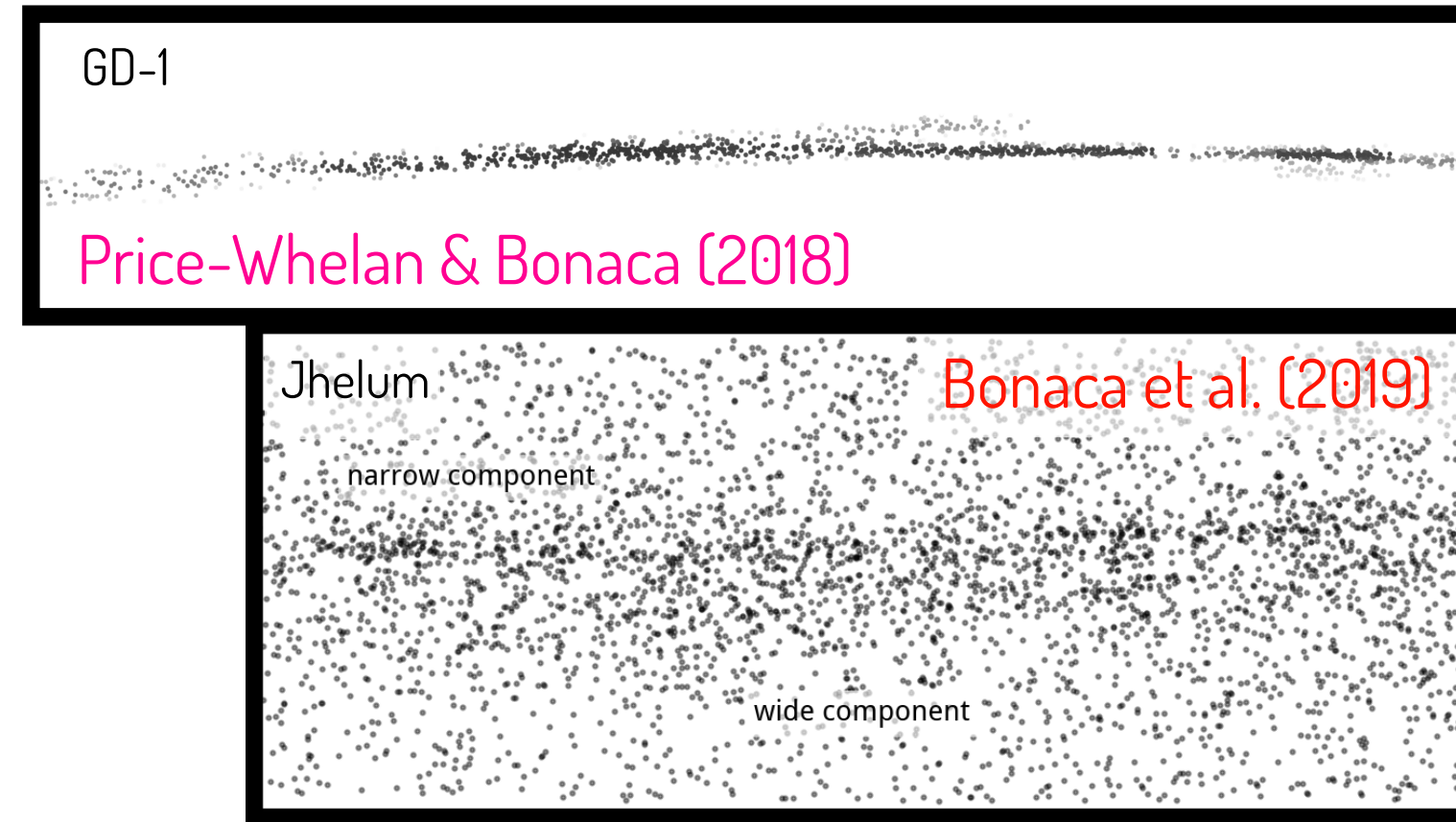
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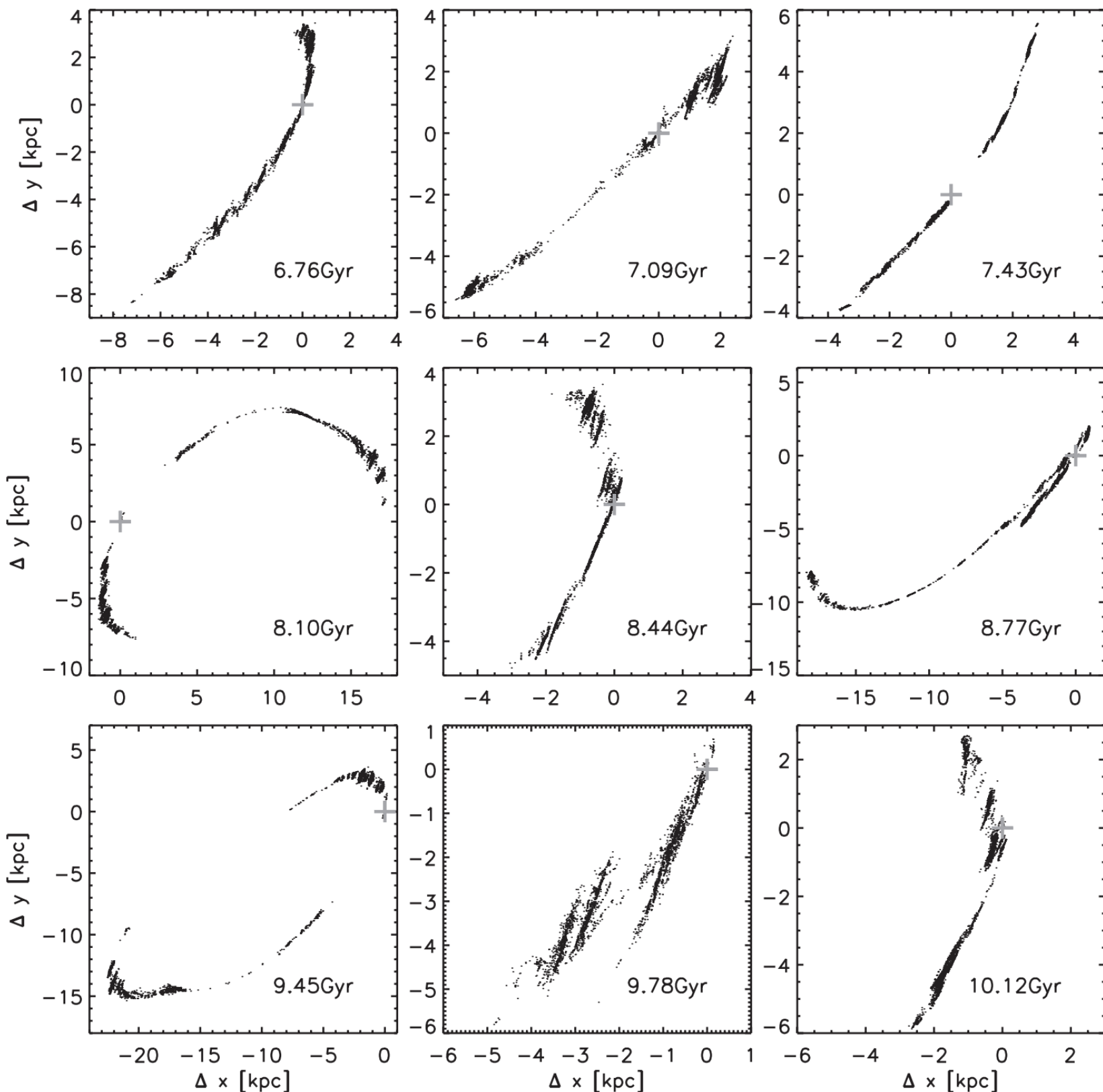
◀ Predicted
Observed ▶

Yoon, Johnston & Hogg (2011)



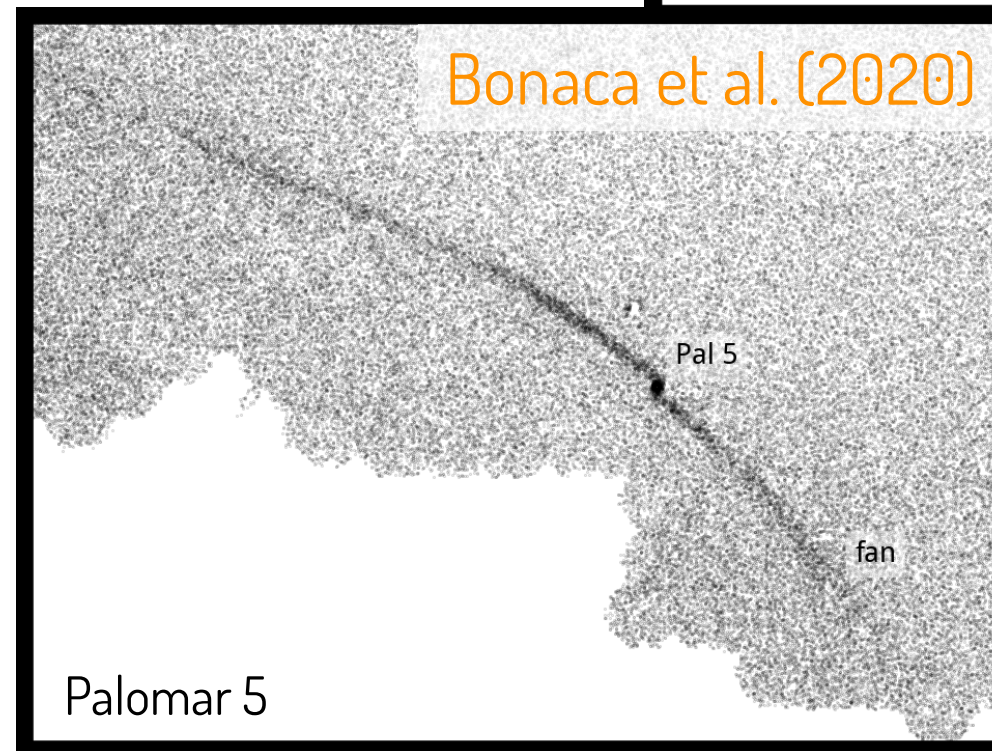
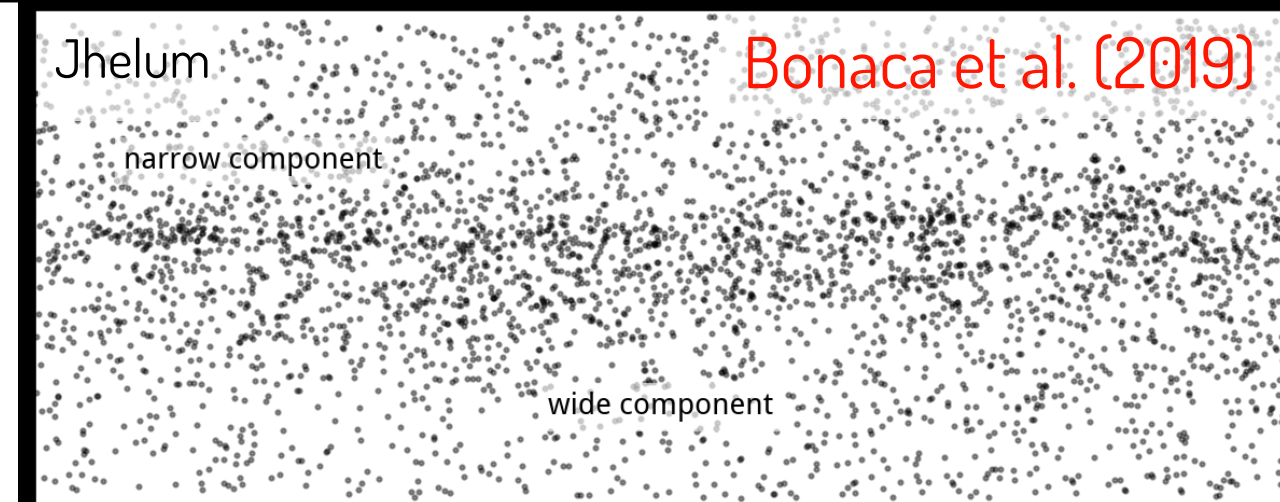
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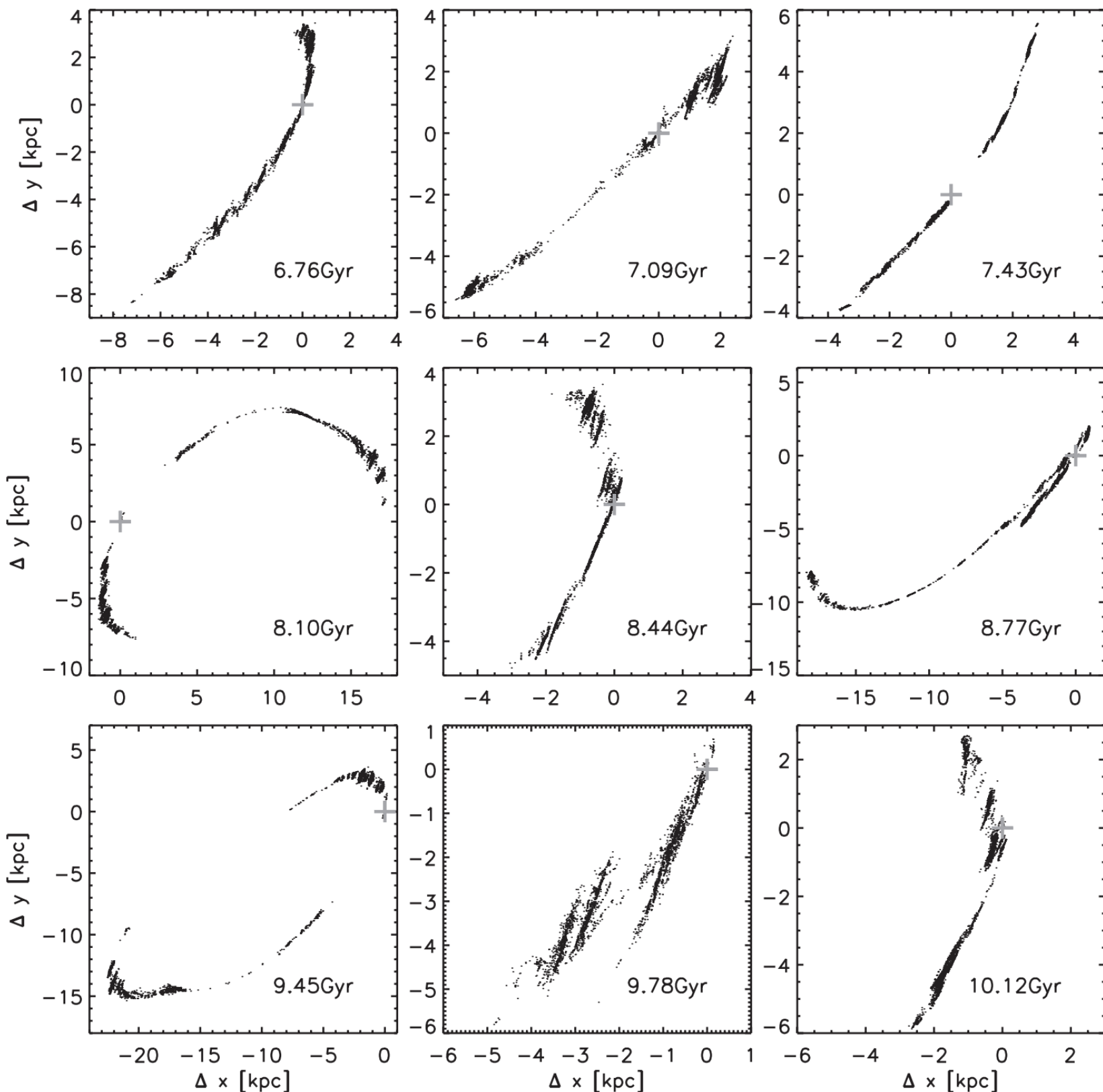
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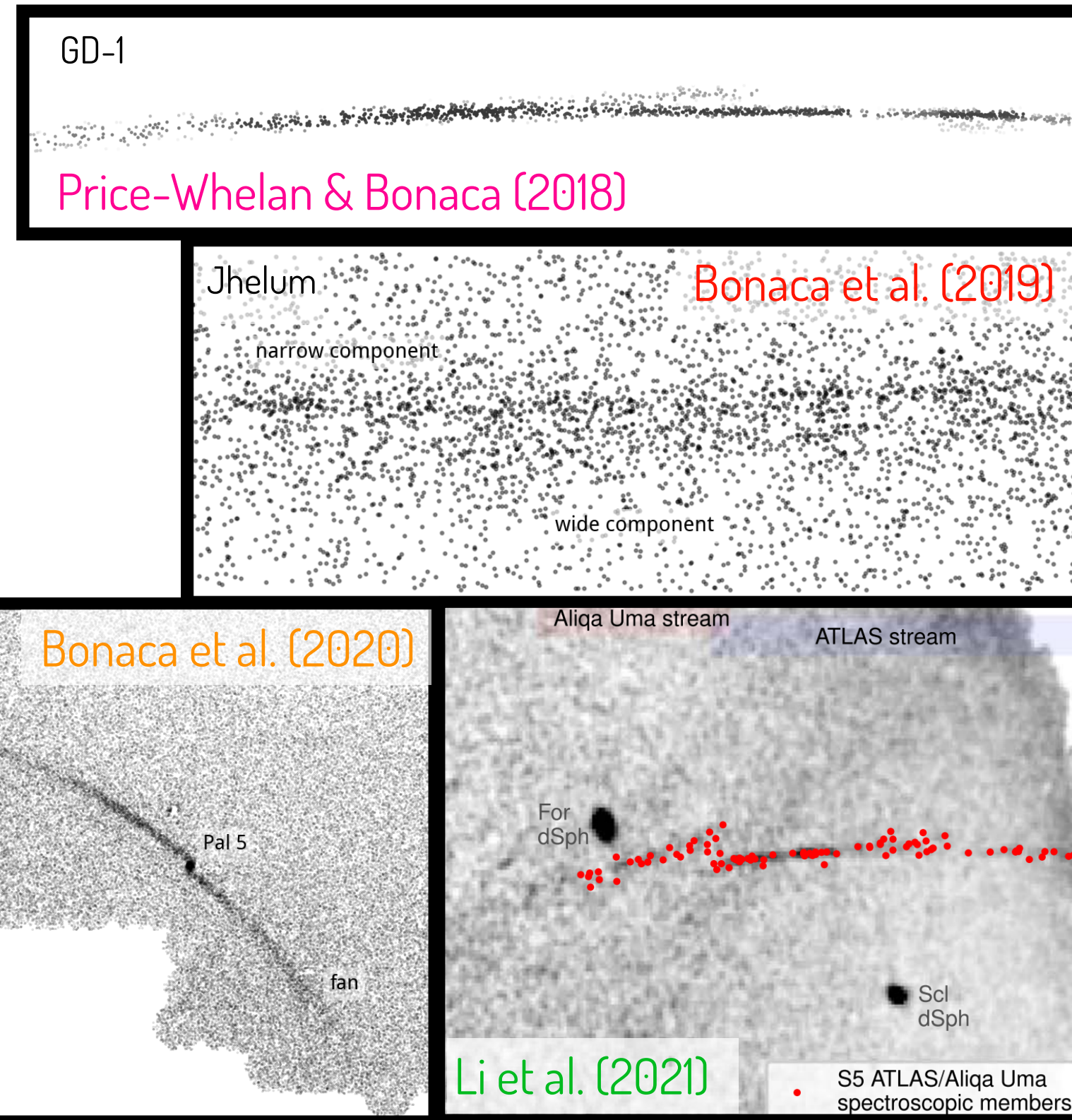
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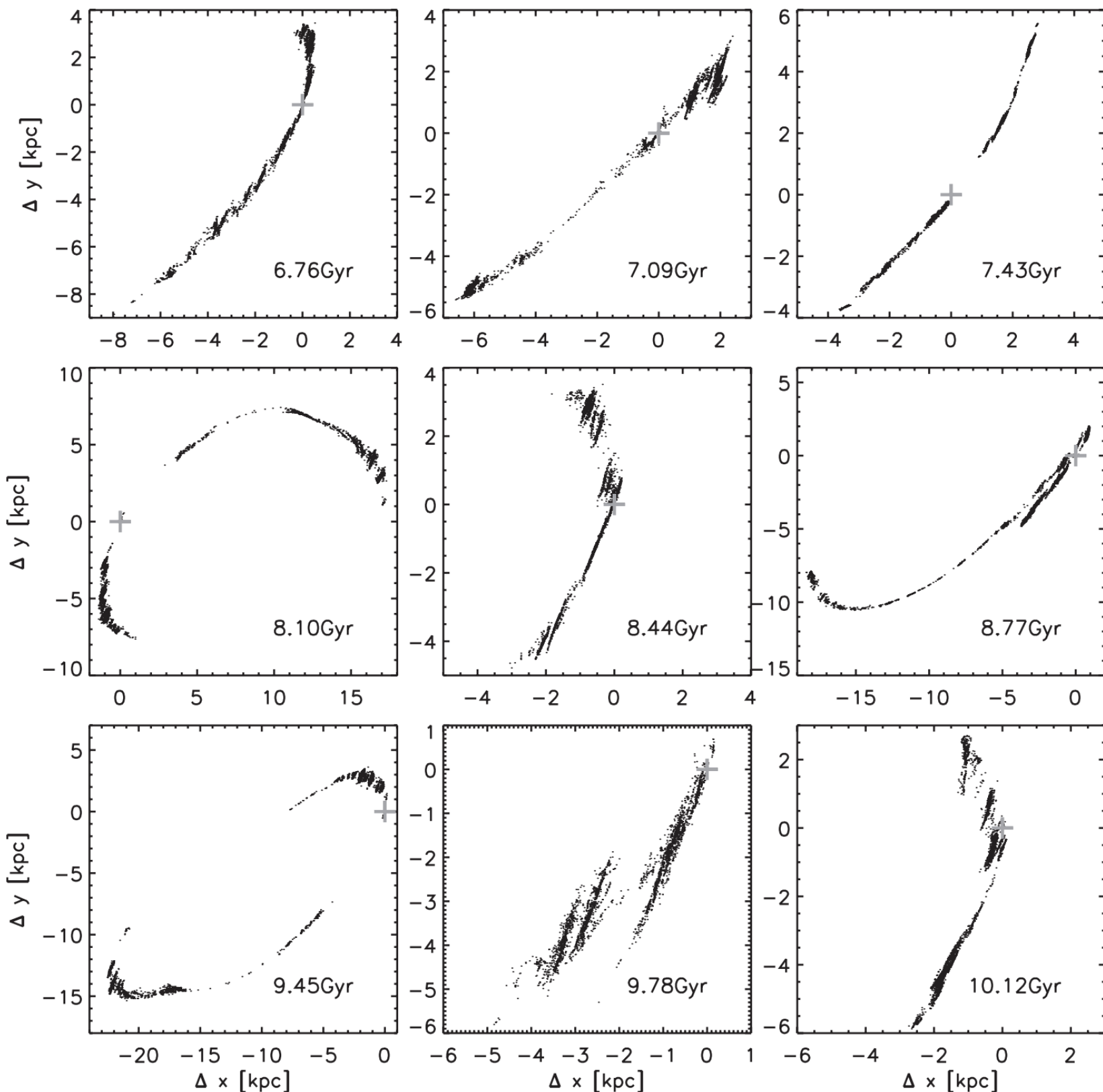
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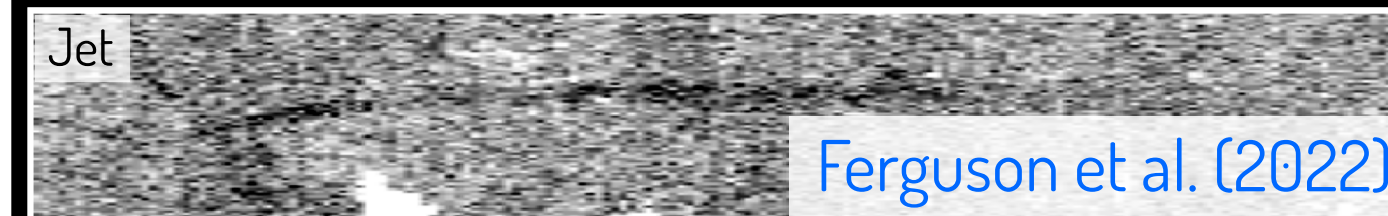
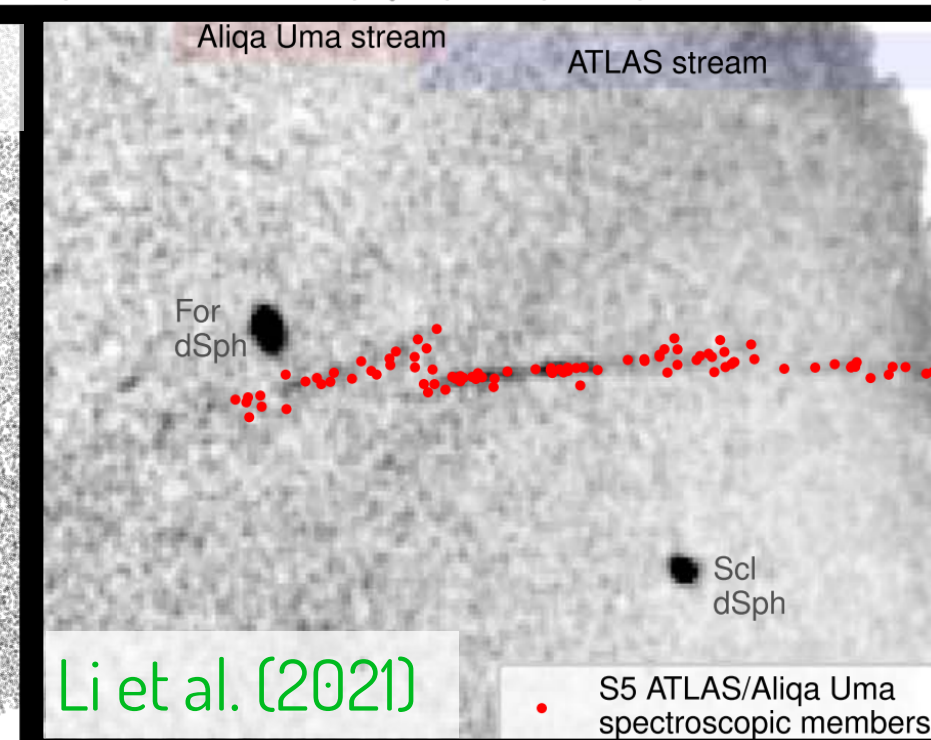
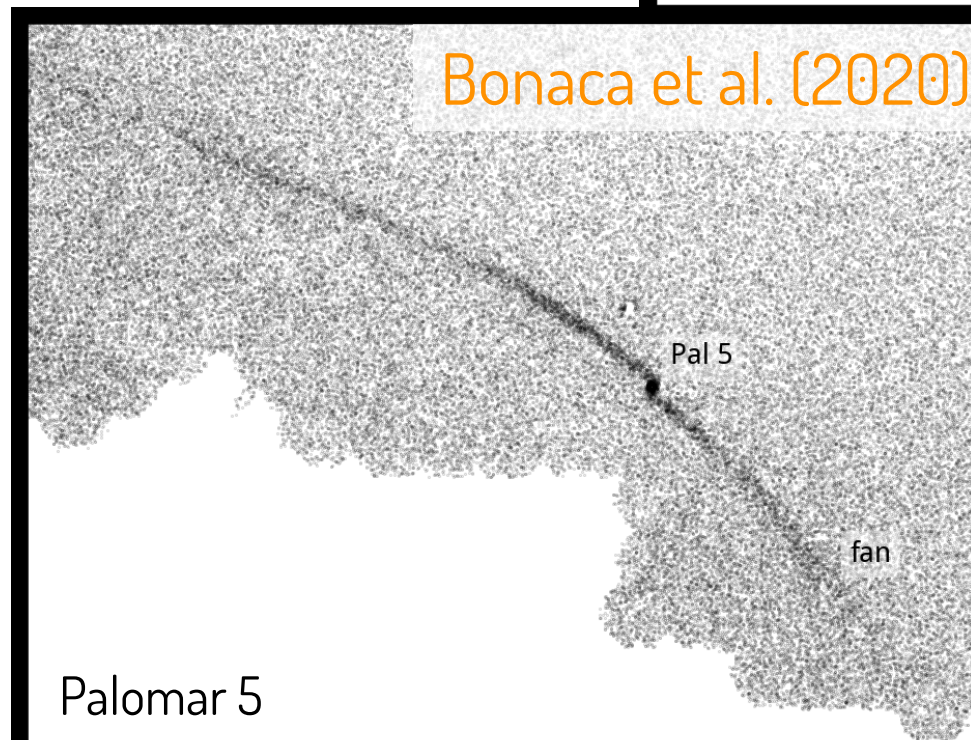
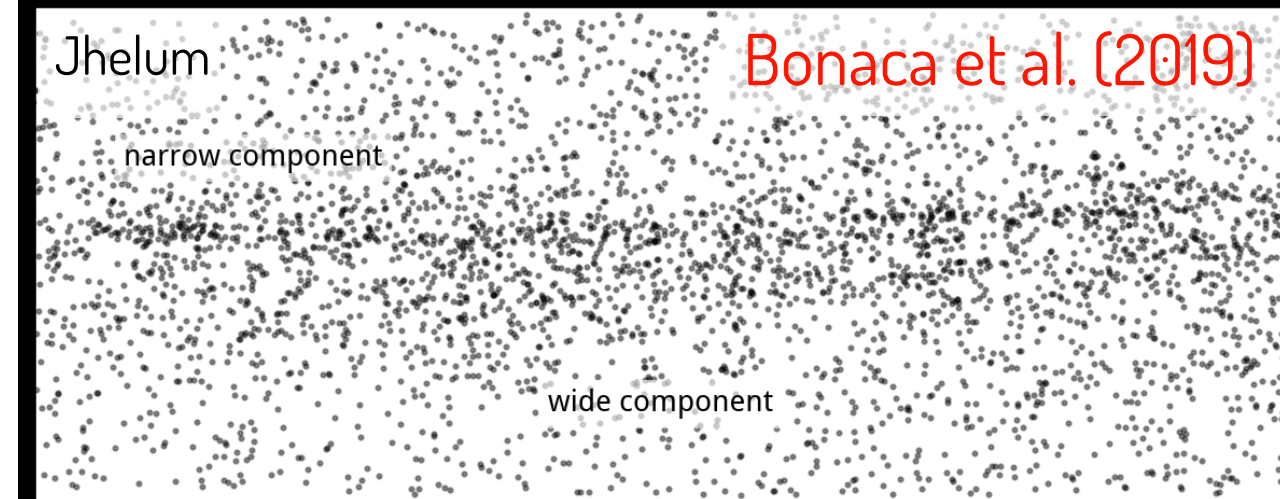


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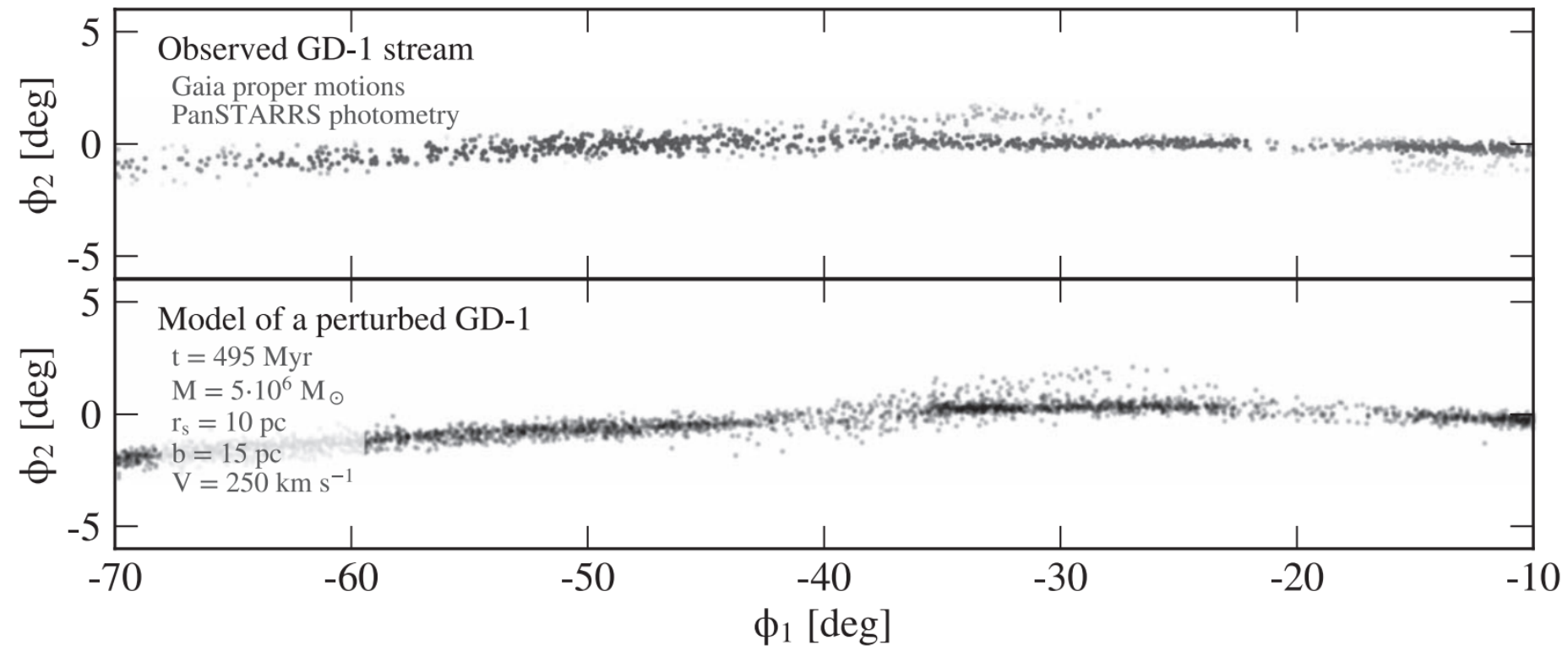
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Stream modeling: phase-space reconstruction

GD-1



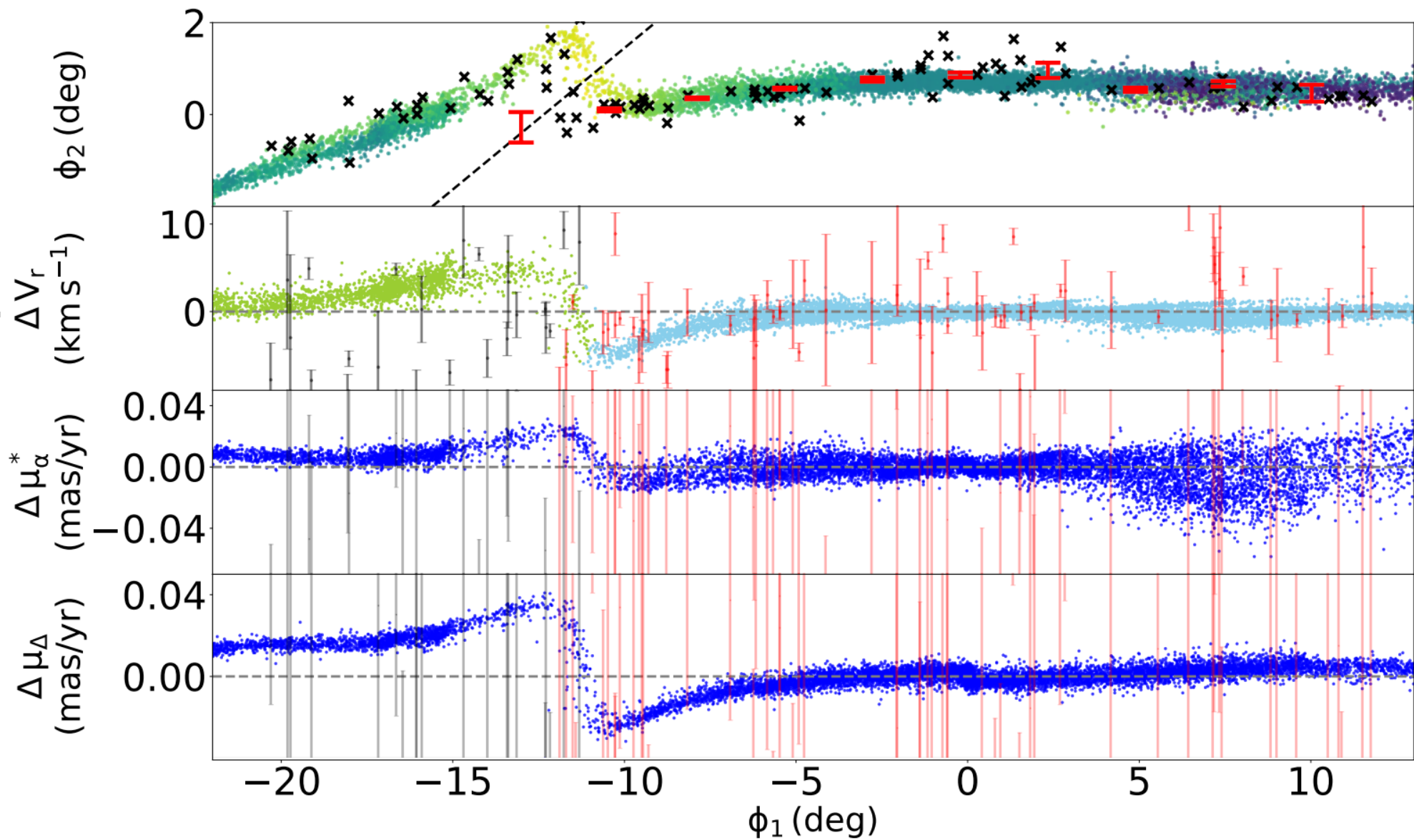
Bonaca et al. (2019)

Conclusion: $5 \cdot 10^6 M_{\odot}$
subhalo plausible, too
dense for CDM (3σ outlier)

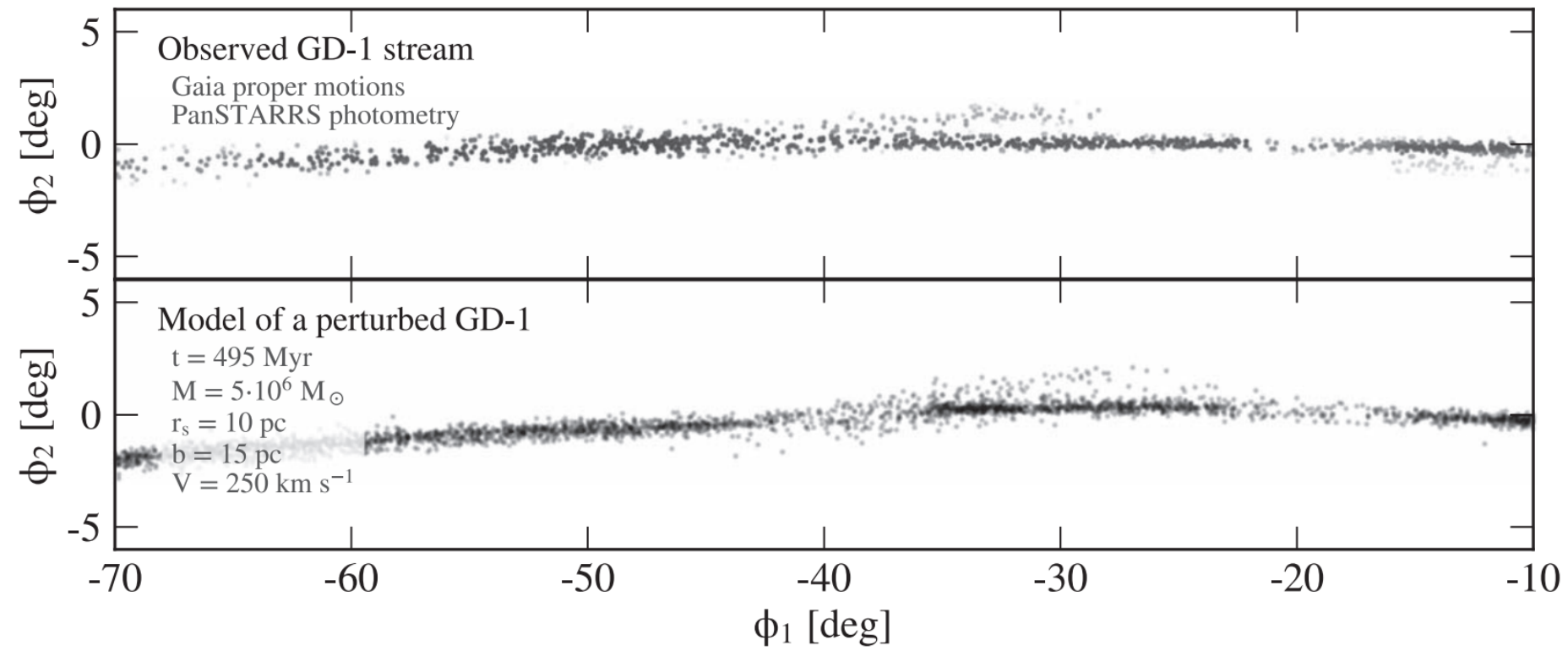
Zhang et al. (2025):
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Stream modeling: phase-space reconstruction

ATLAS - Aliqa Uma



GD-1



Bonaca et al. (2019)

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Hilmi et al., arXiv:240402953

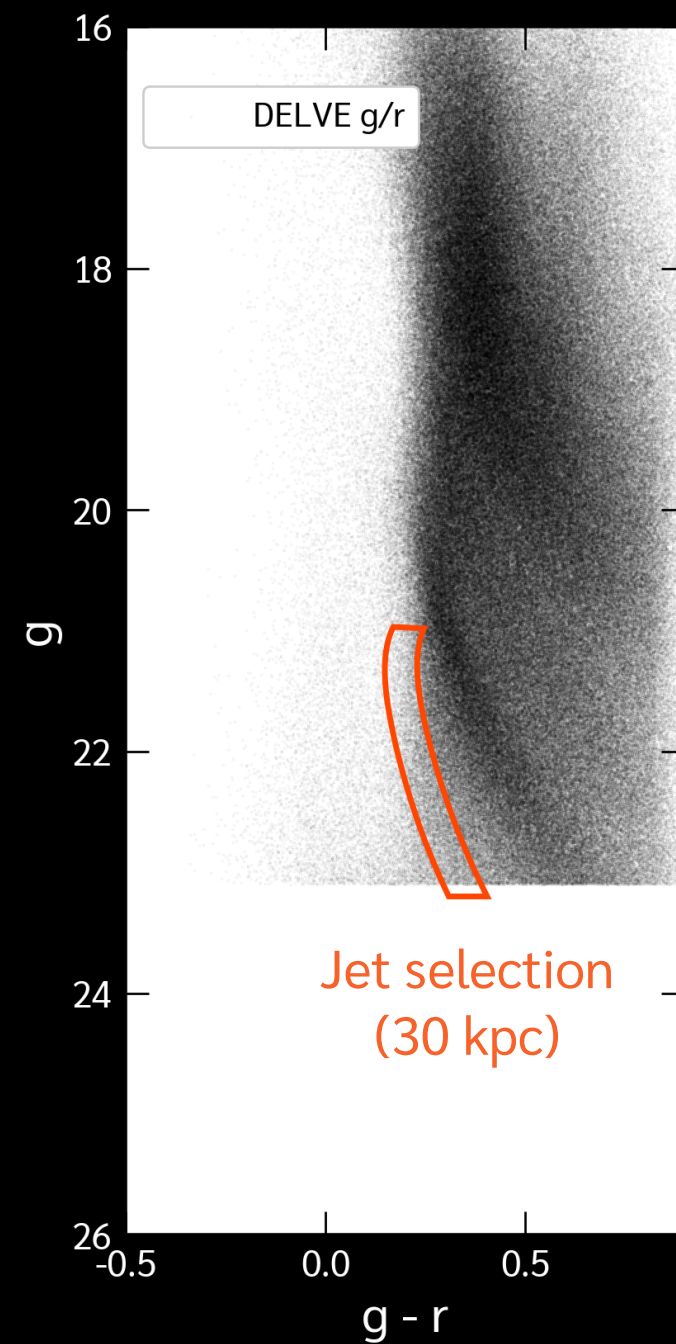
Conclusion: $10^7 M_\odot$ CDM
subhalo plausible, better
kinematics needed

➔ might allow us to
recover the subhalo orbit
and present-day location!

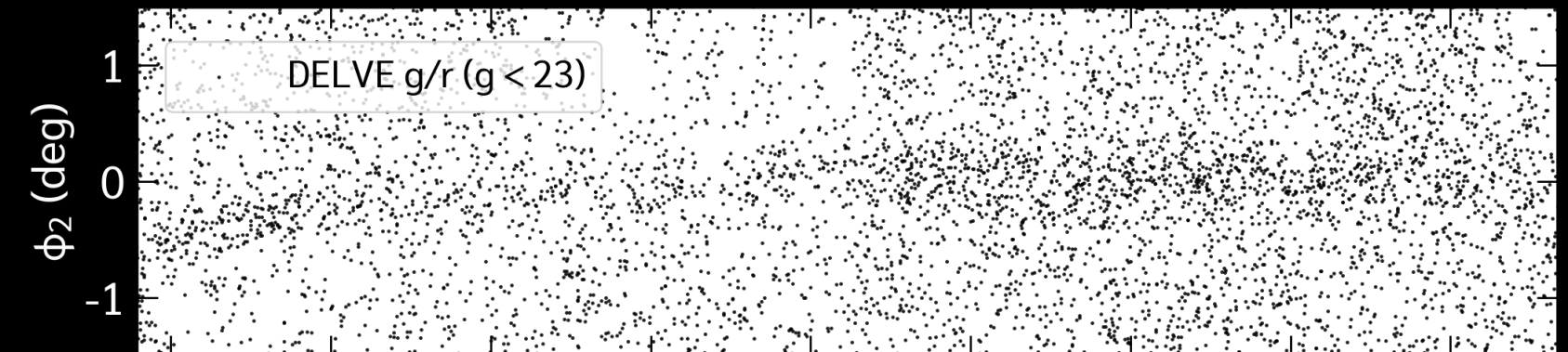
Deep photometry improves stream membership



Color-magnitude selection



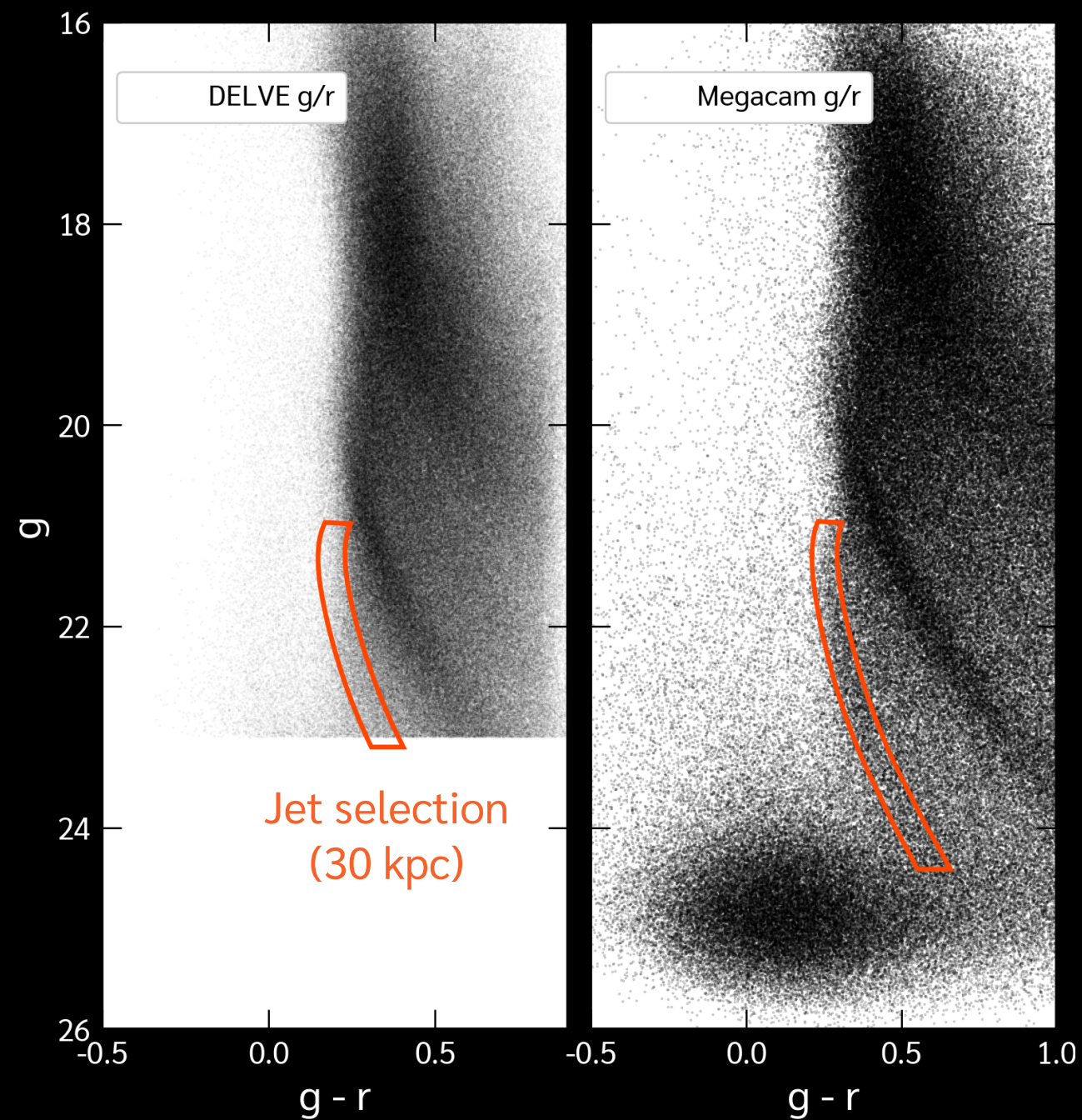
Jet stellar stream sky positions



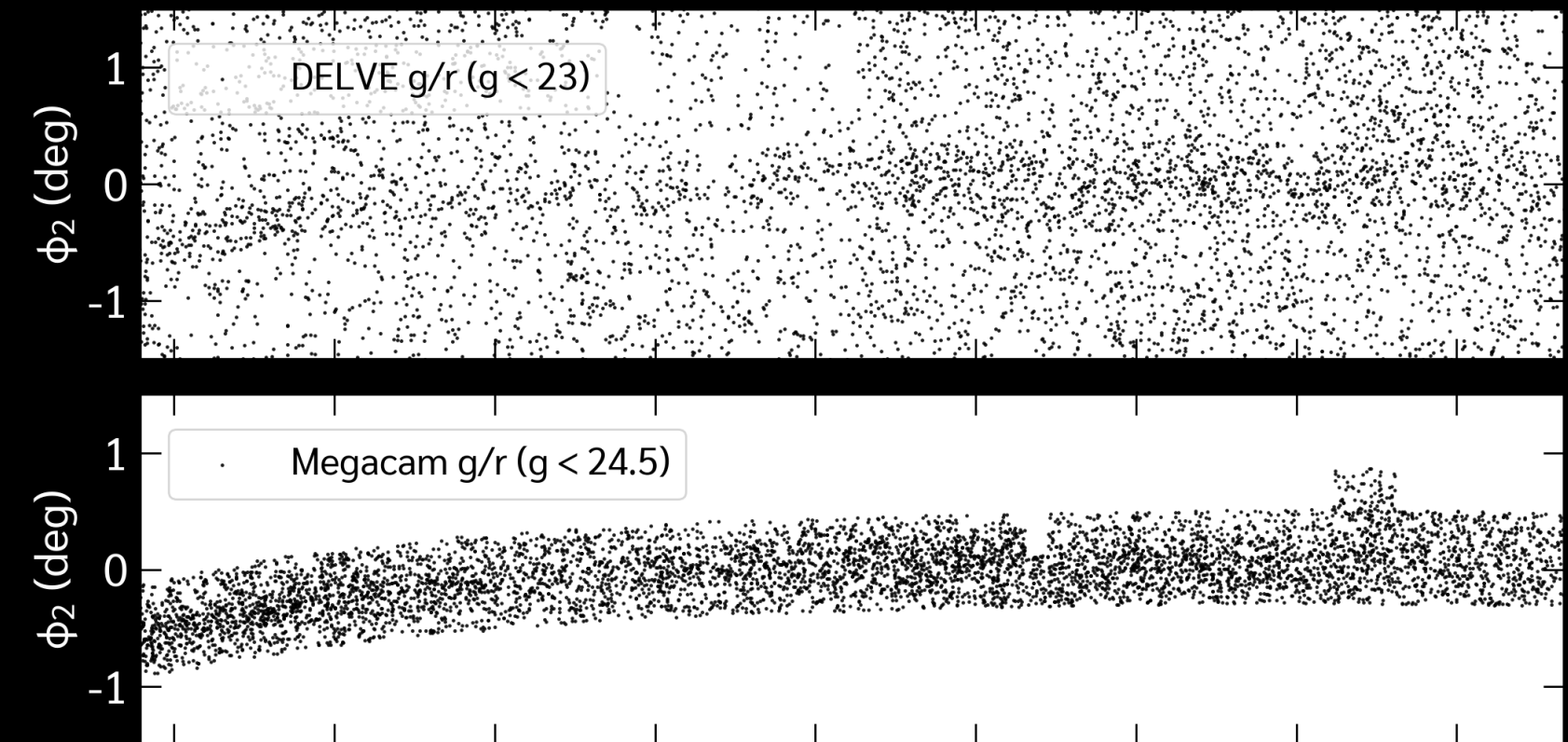
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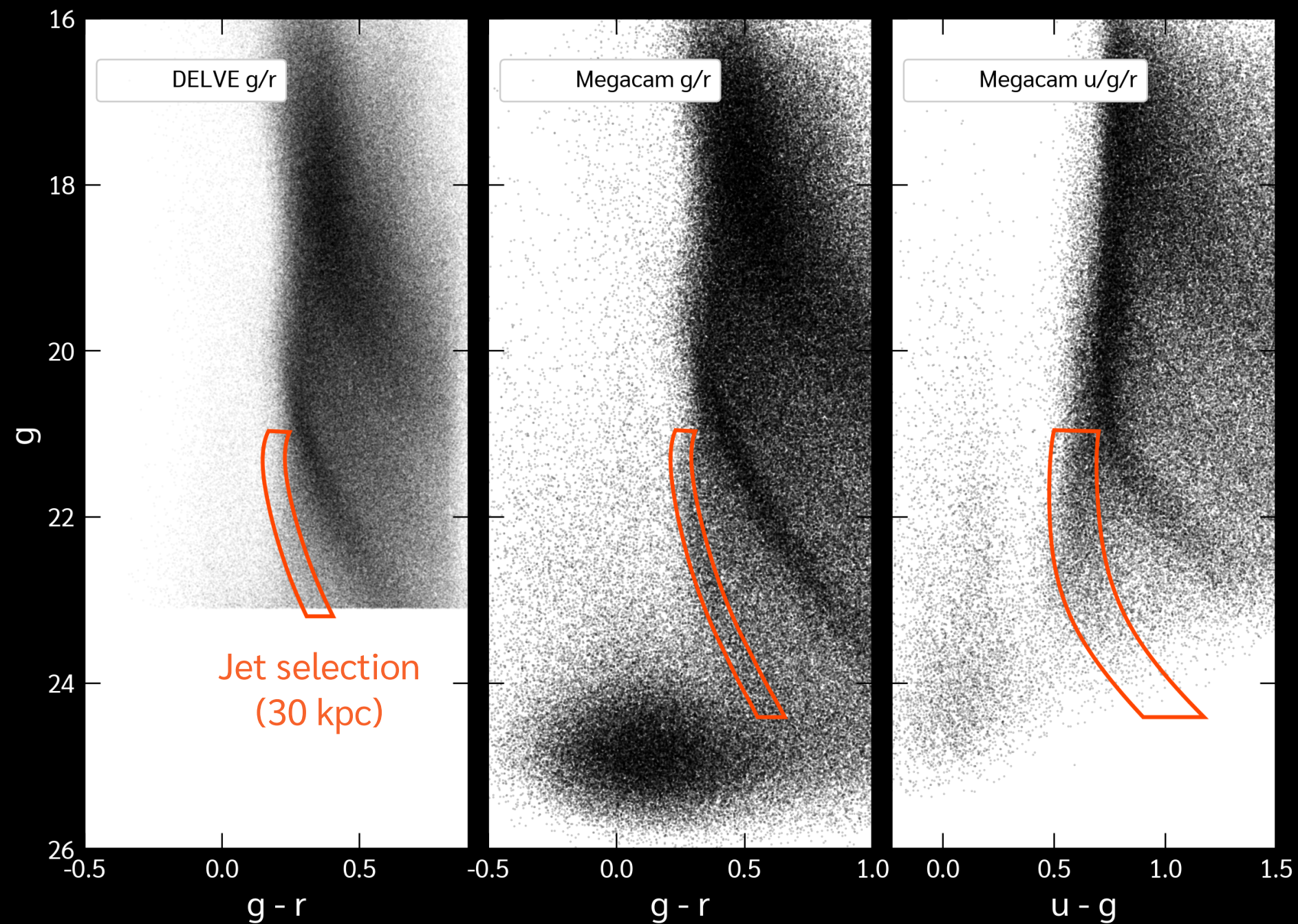
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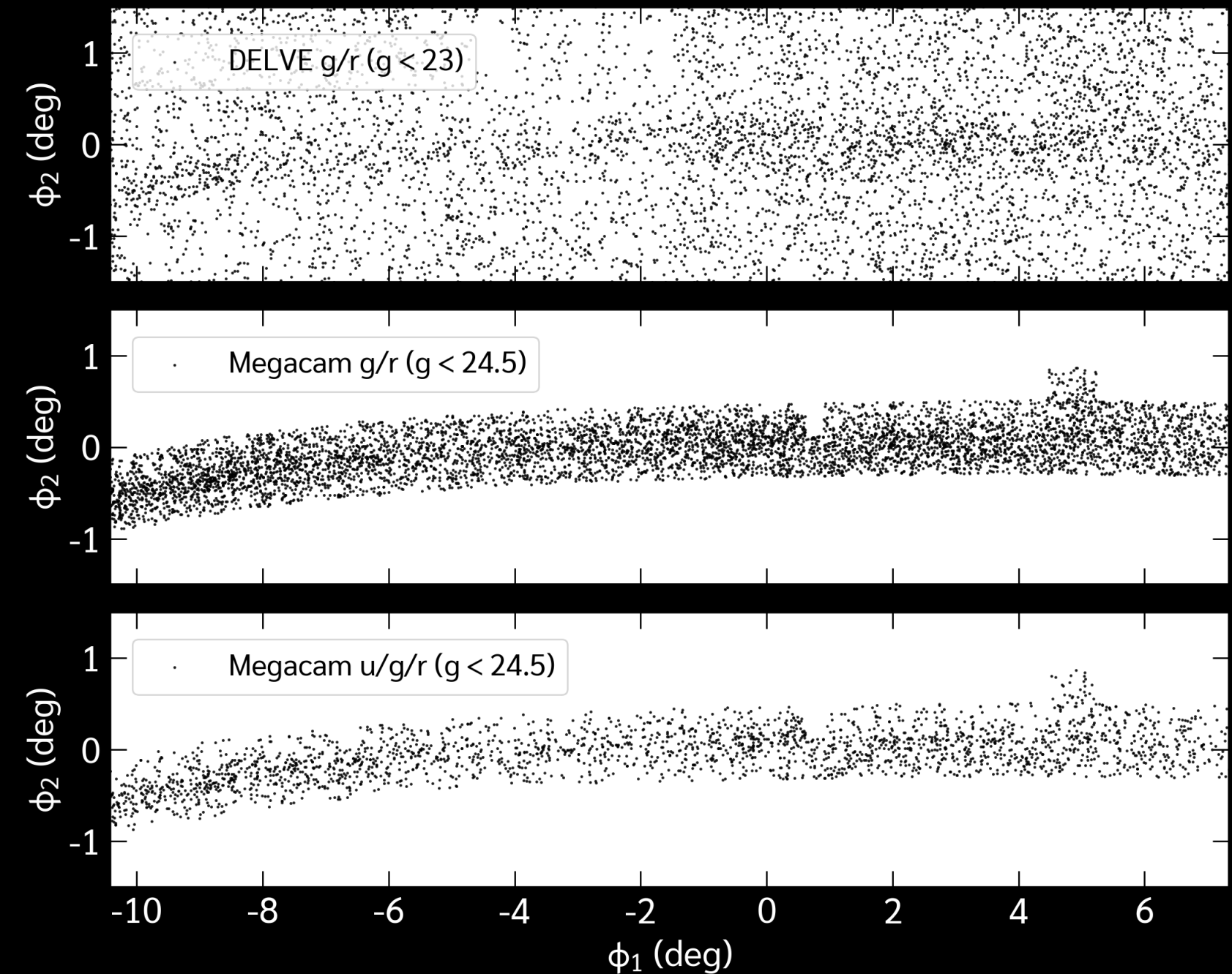
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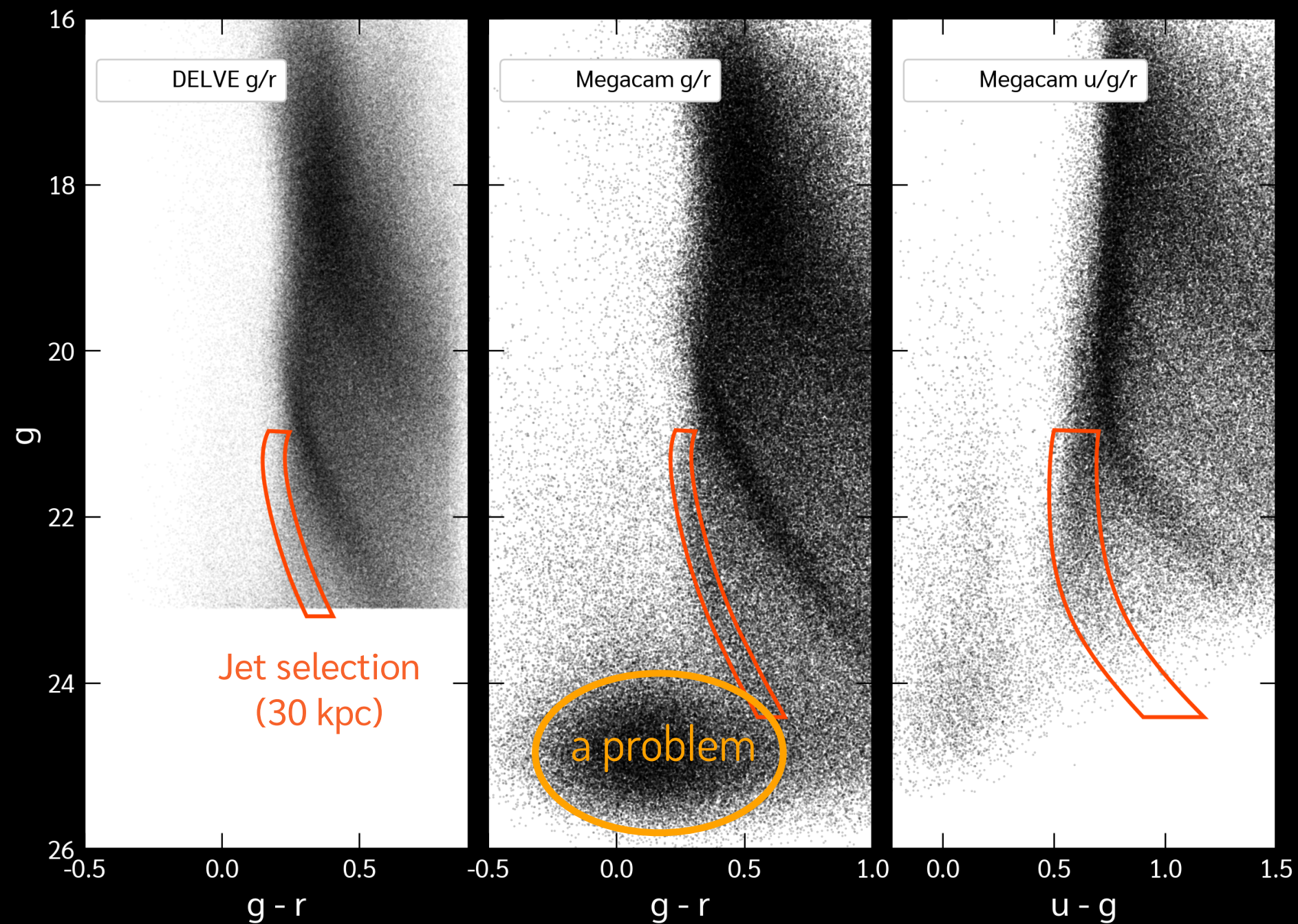
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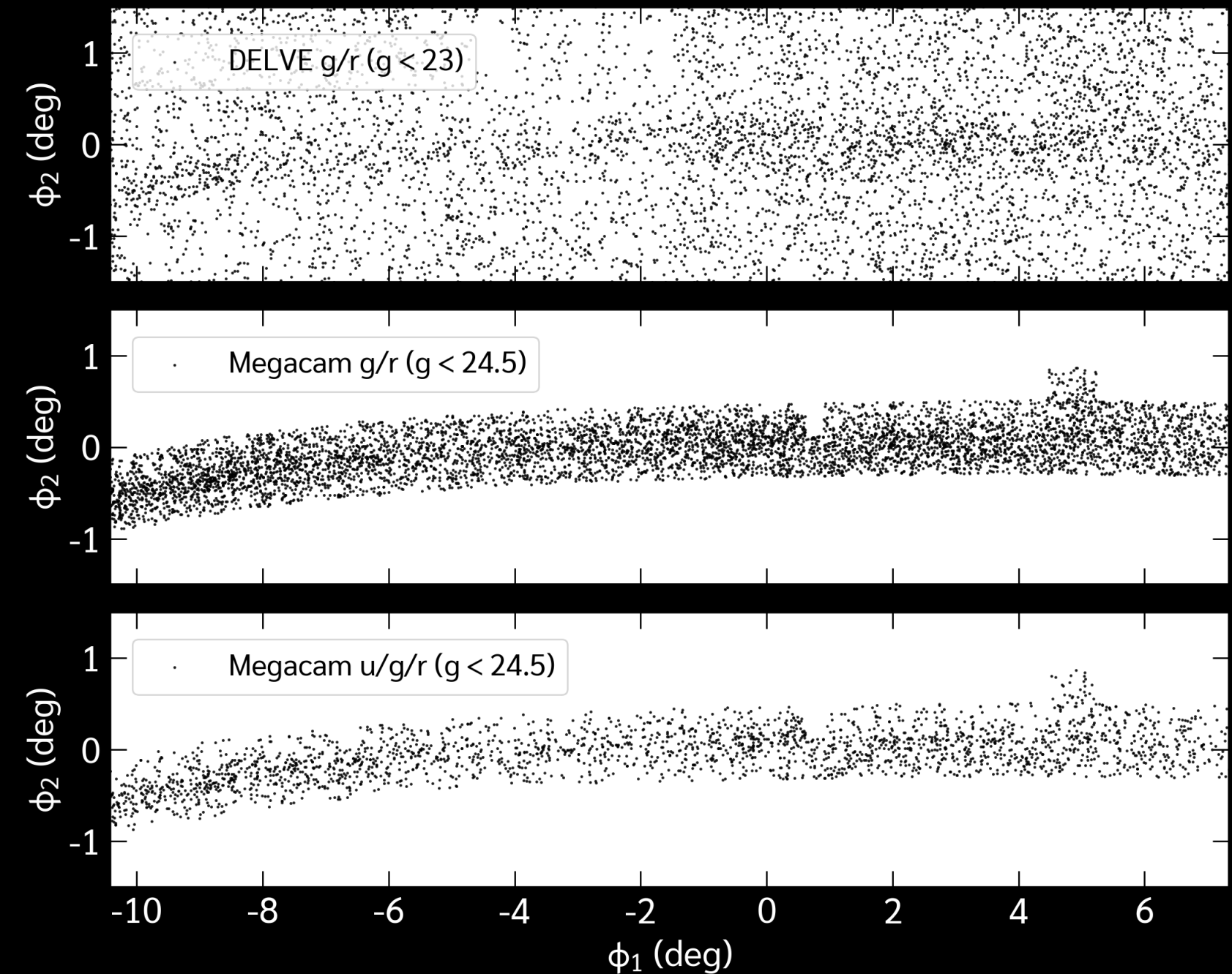
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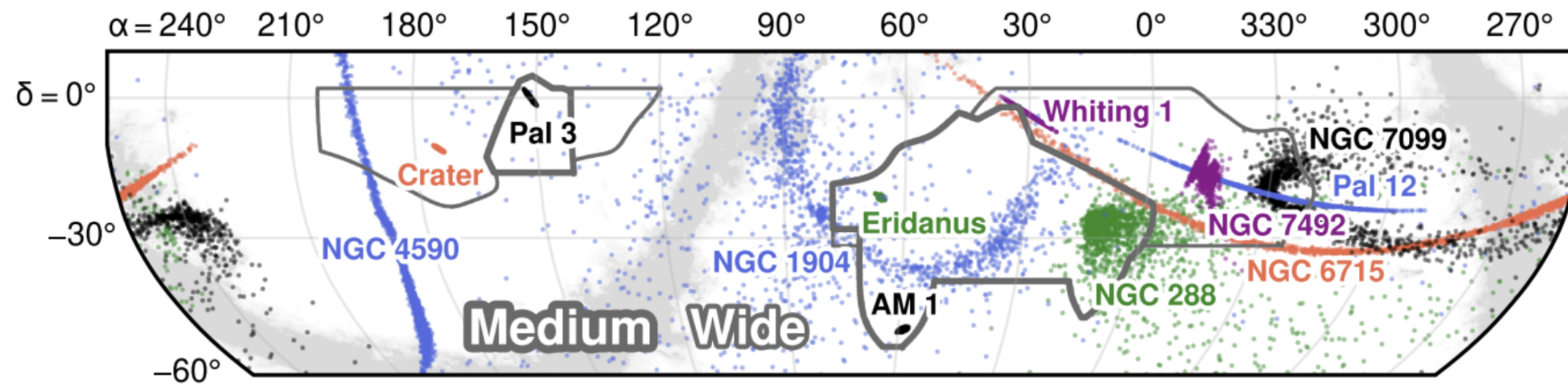
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Revealing Missing Globular Cluster Streams: Mapping the Milky Way Halo with Roman HLWAS

Roman Cycle 1, ID 19072 (PI Yingtian Chen)

Globular clusters in HLWAS footprint



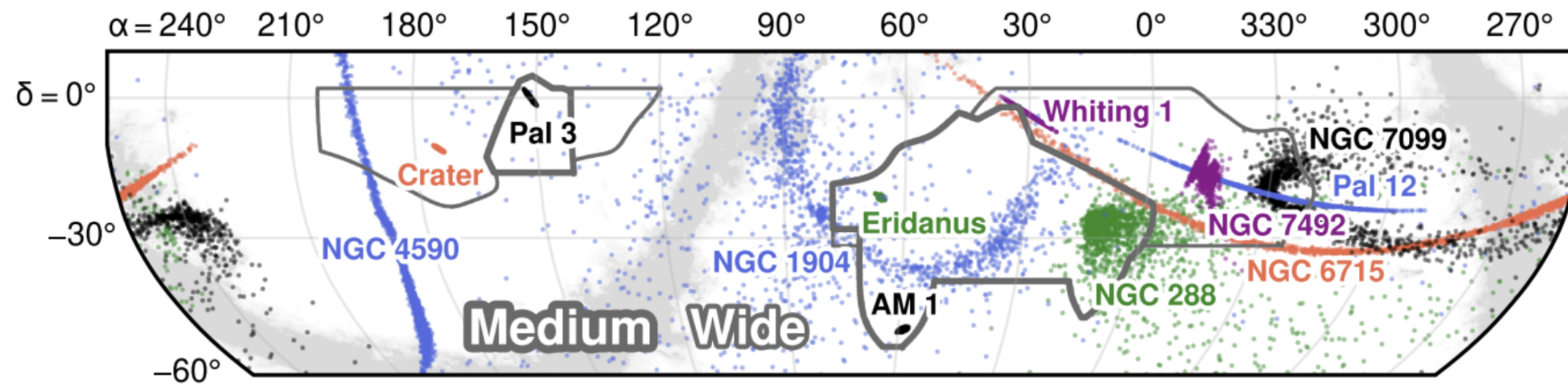
Goals:

- Perform morphological star/galaxy classification
- Discover if streams exist at 100 kpc
- Resolve the density structure of streams

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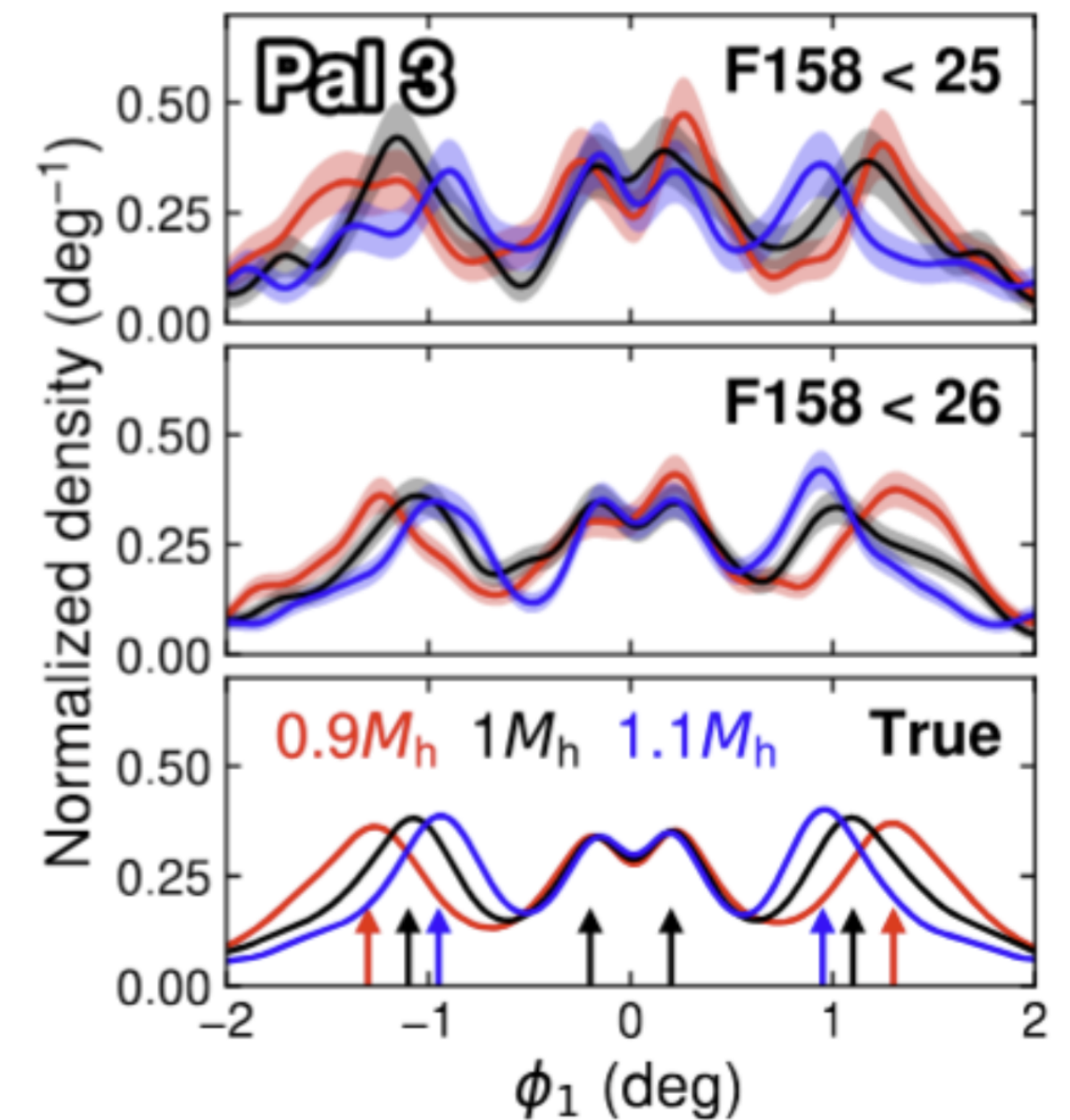
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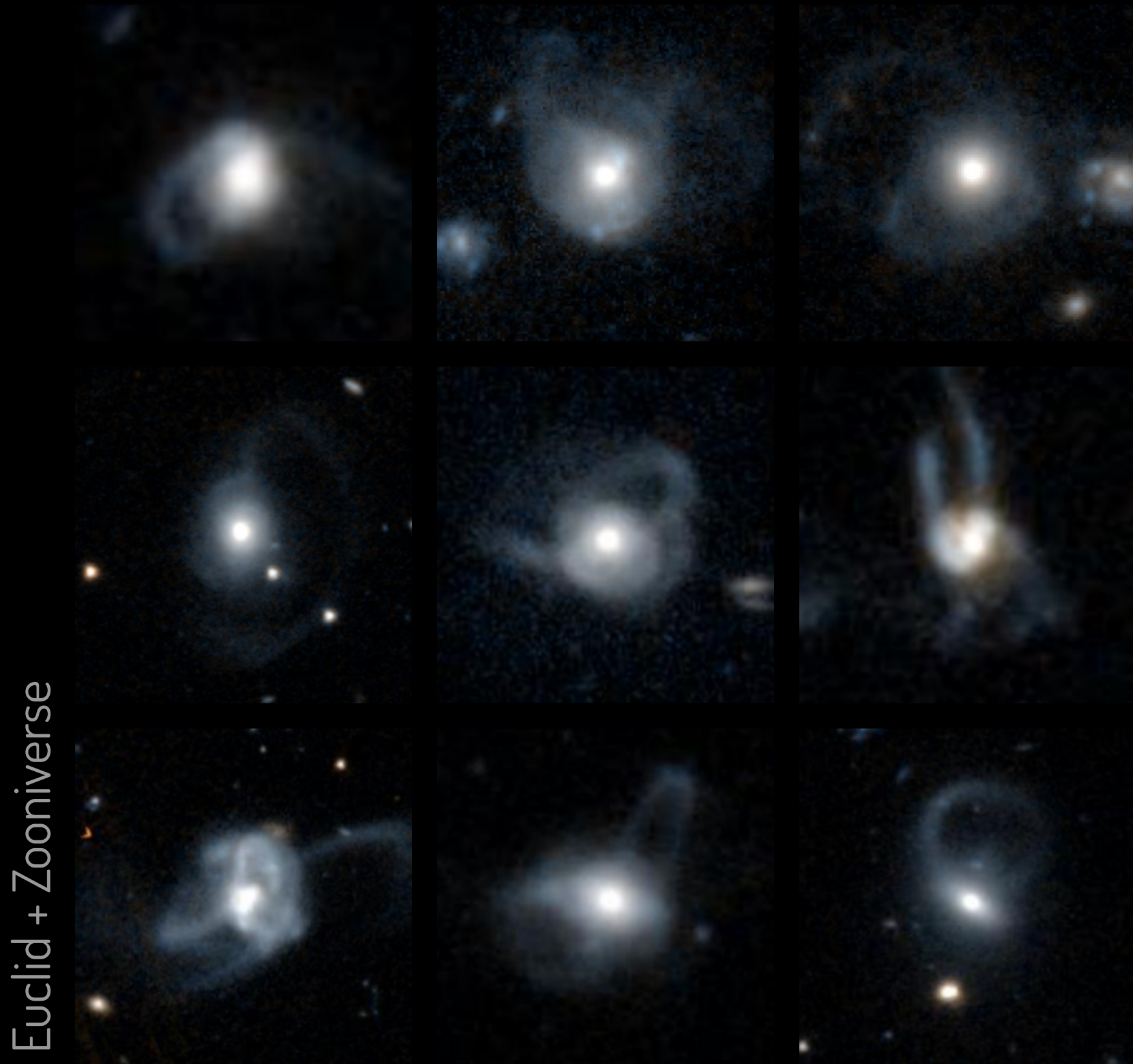
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Milky Way mass at 100kpc



Extragalactic streams measure halo shapes in numerous galaxies



Euclid Collaboration, Starkman, et al., arXiv:2606.21774

Extragalactic streams measure halo shapes in numerous galaxies

Euclid + Zooniverse



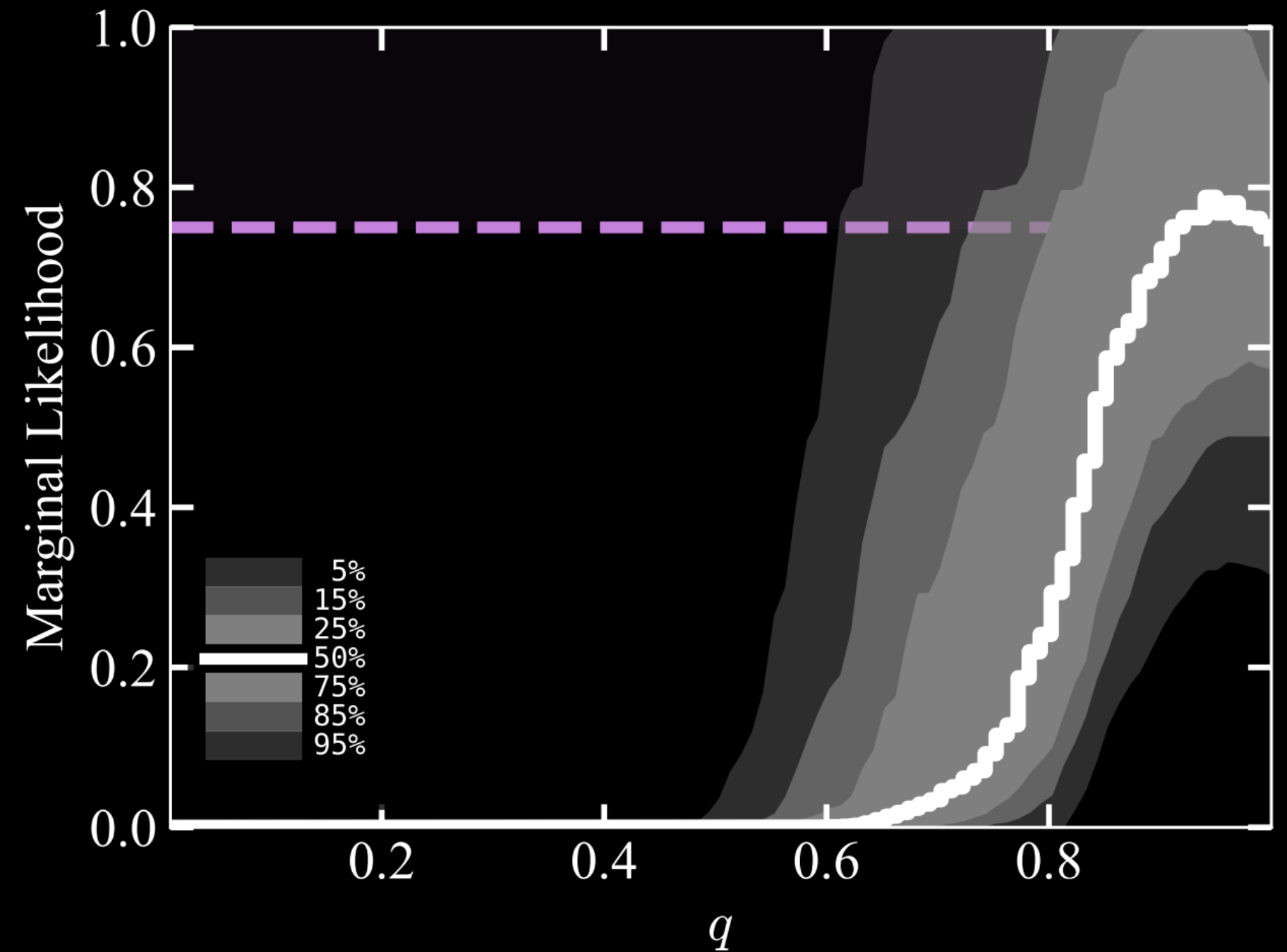
Euclid Collaboration, Starkman, et al., arXiv:2606.21774

Extragalactic streams measure halo shapes in numerous galaxies

Euclid + Zooniverse



Cumulative constraints on halo flattening



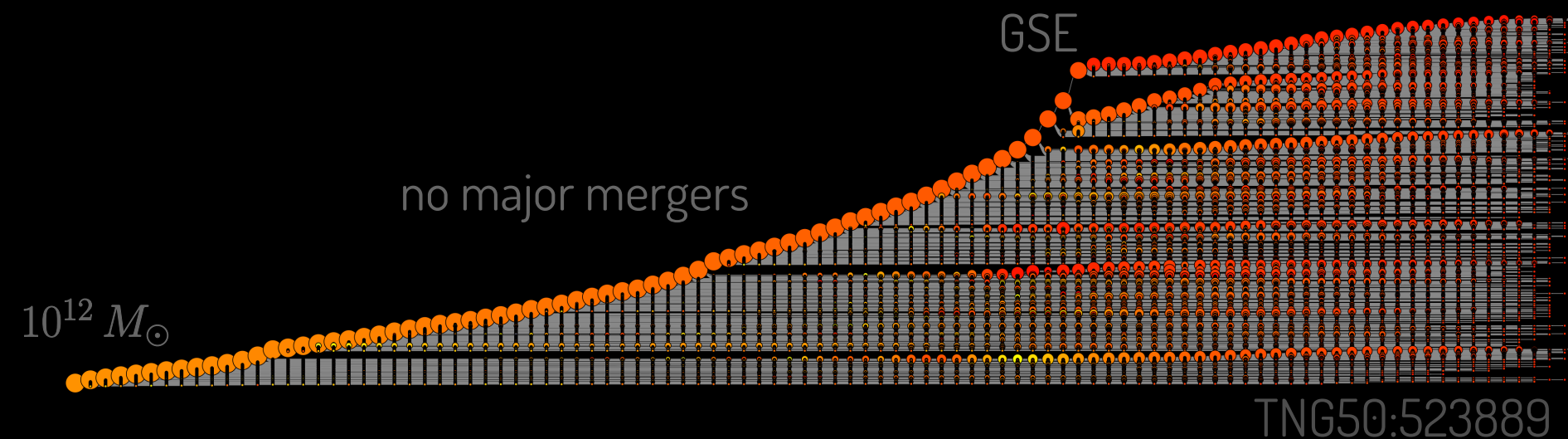
Euclid Collaboration, Starkman, et al., arXiv:2606.21774

based on Nibauer et al. (2023)

Milky Way may host thousands of dissolved globular clusters

Forecasting the globular cluster population

1) Milky Way-like host galaxy in Illustris TNG-50



2) Trigger cluster formation on high mass-accretion rate

3) Draw cluster masses ($>10^4$ Msun) + assign particles

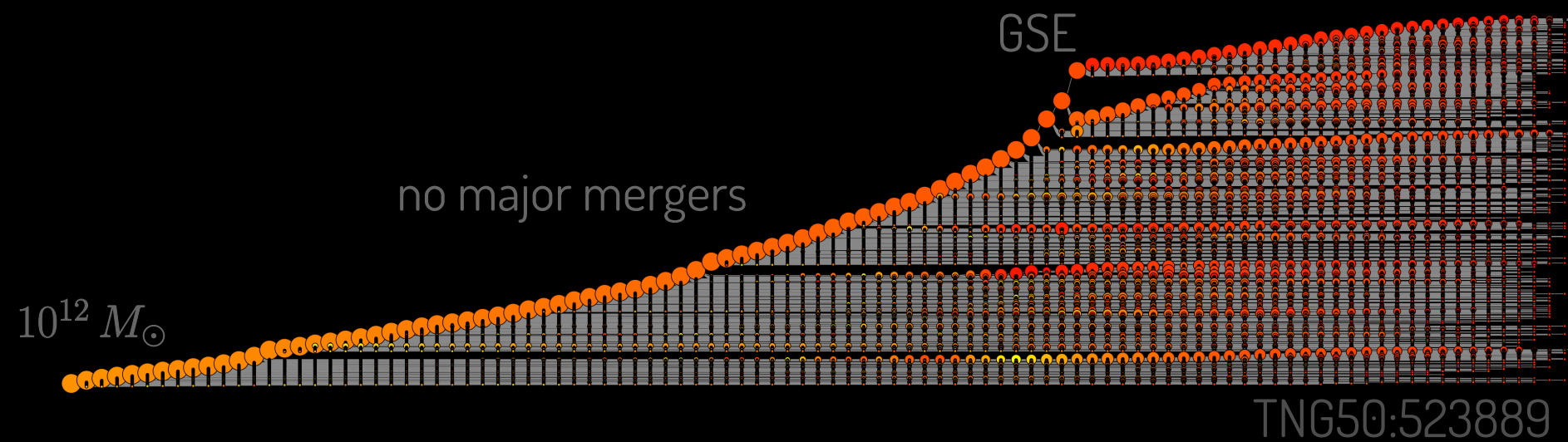
4) Estimate mass-loss rate from local tidal tensor

Pearson, et al. (2024), Chen & Gnedin (2022, 2023)

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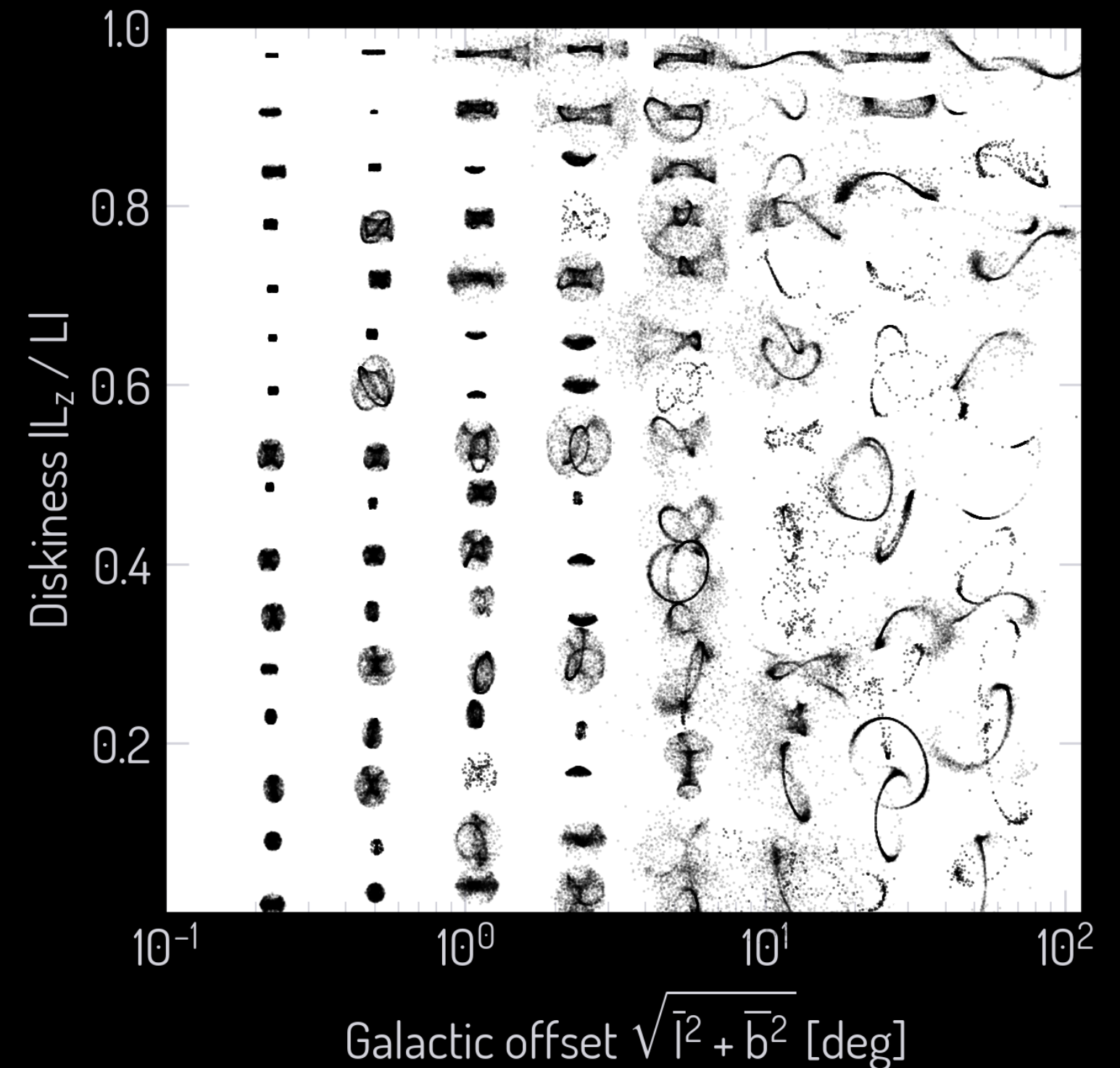
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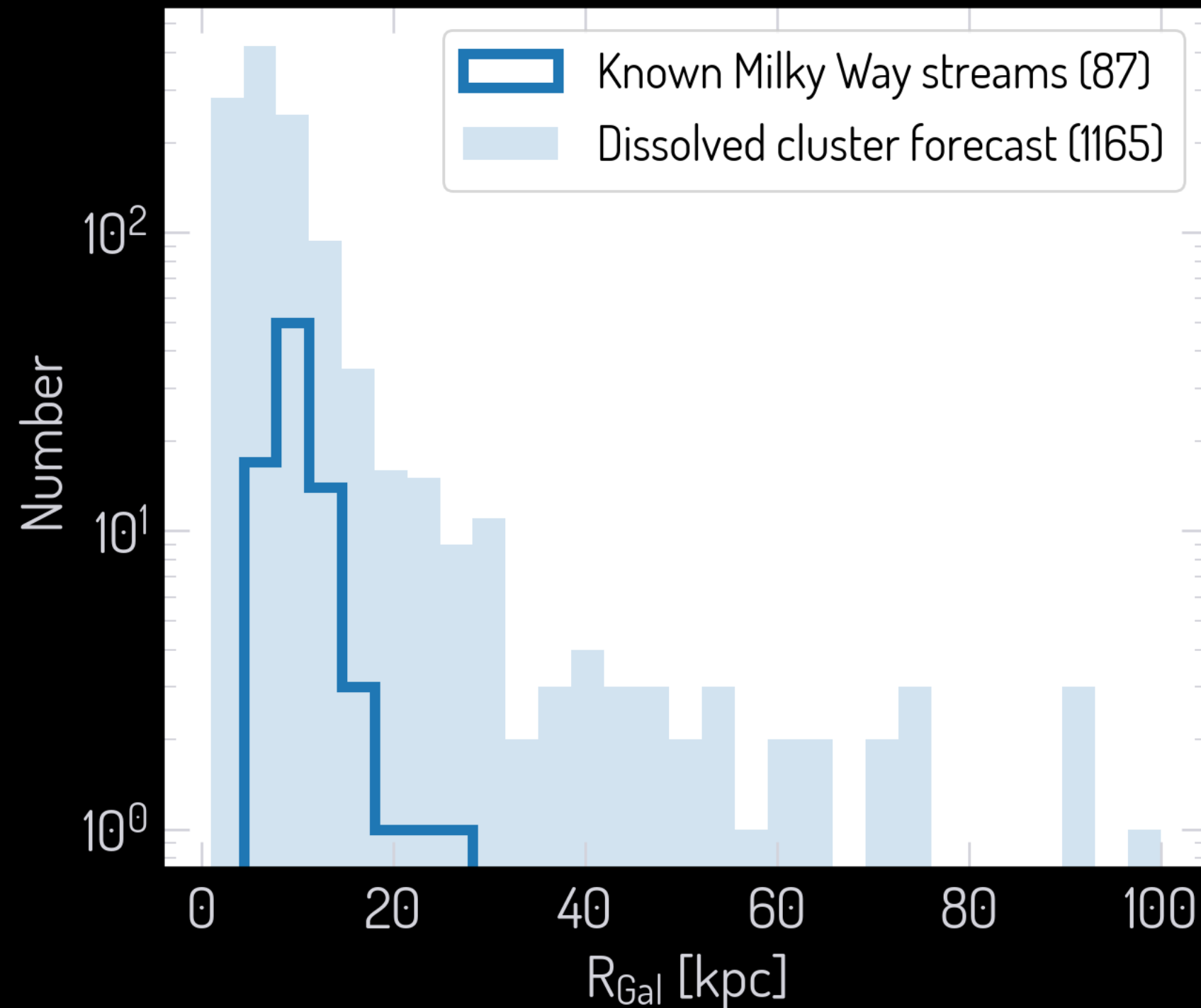
Identifying surviving stellar streams*



* integrated in static $z=0$ potential, see Panithanpaisal et al., (2026) for GC streams in a live potential

A Roman all-sky survey could detect all Milky Way streams

New globular cluster streams expected at all radii

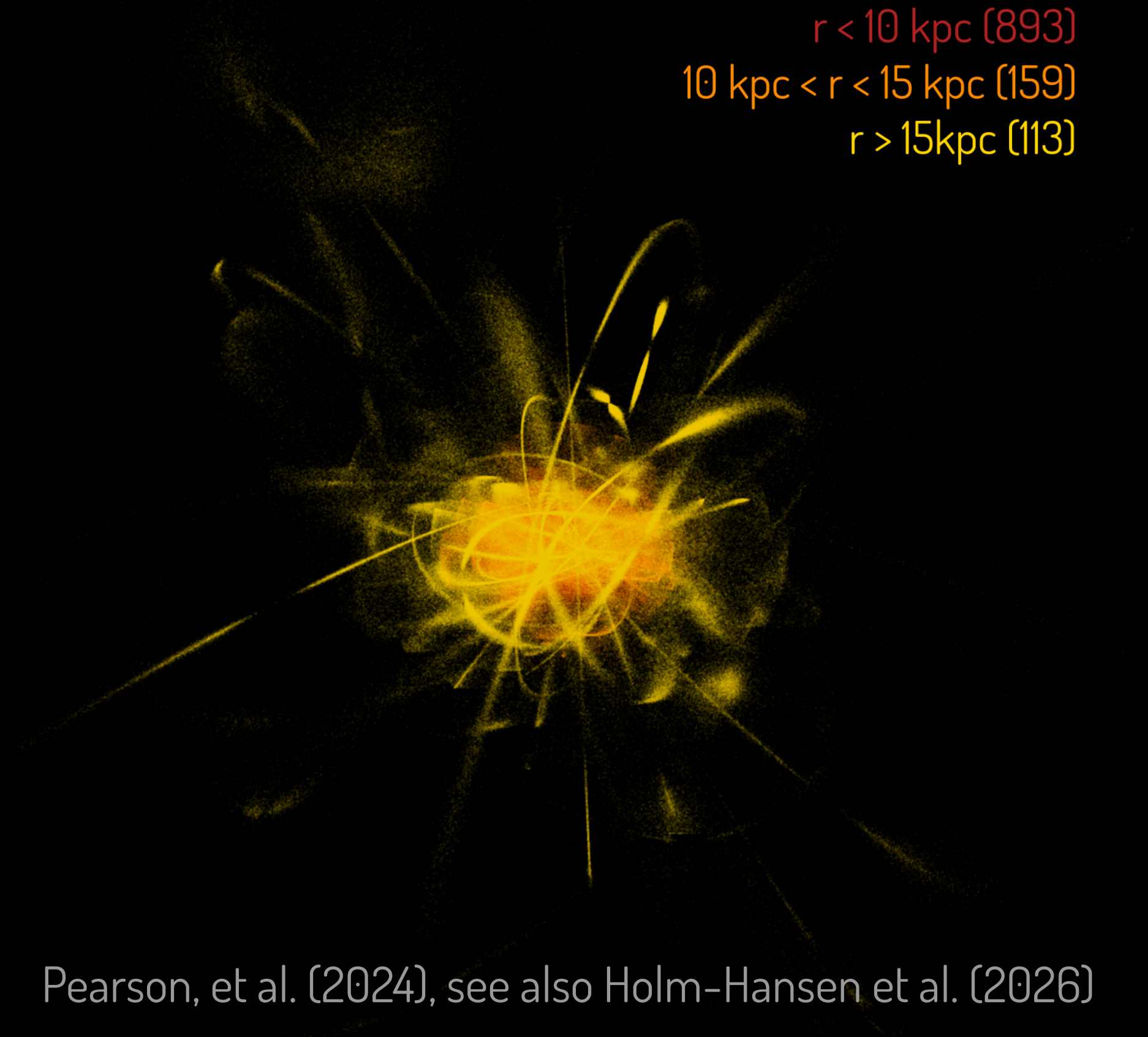
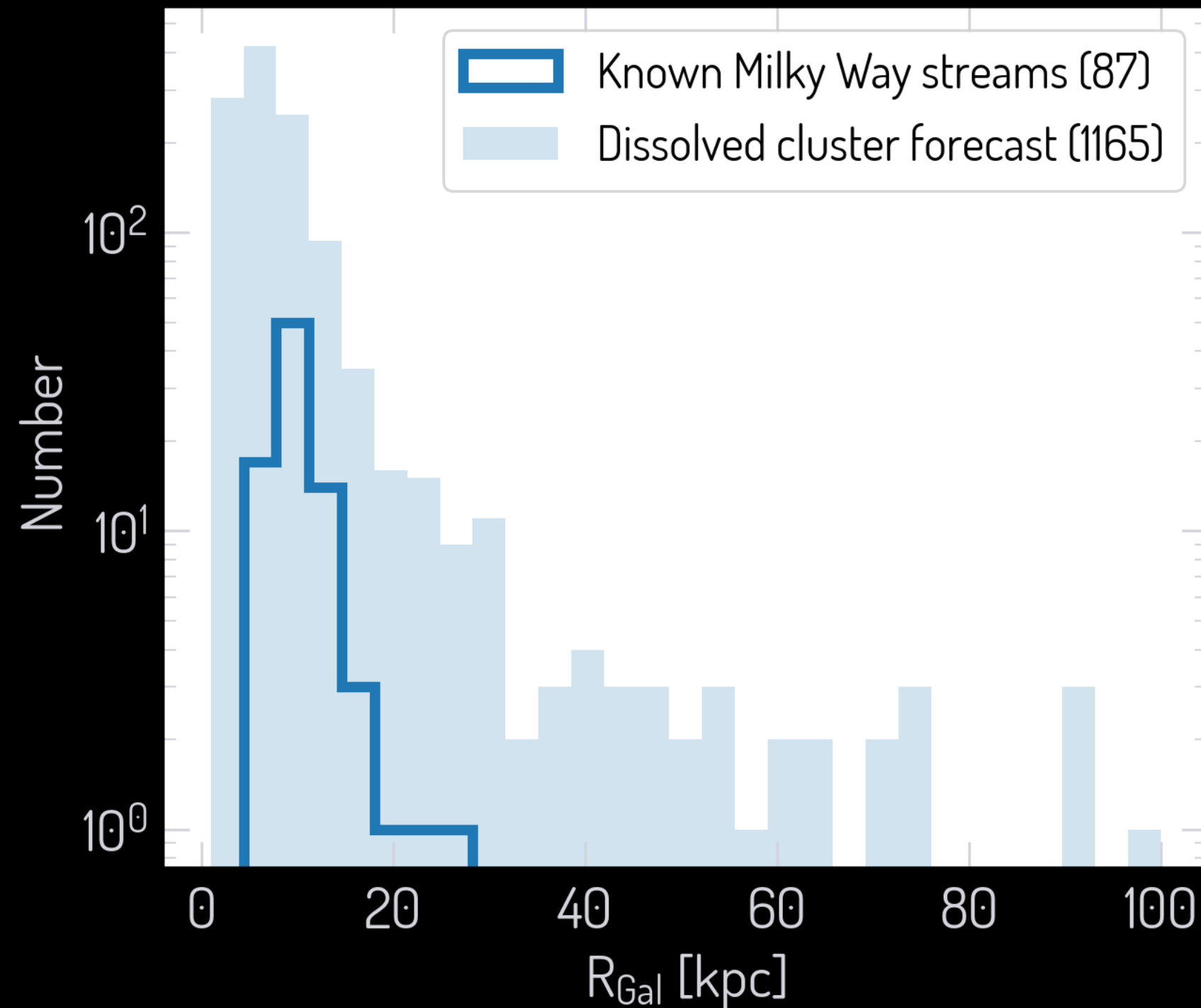


Pearson, et al. (2024), see also Holm-Hansen et al. (2026)

A Roman all-sky survey could detect all Milky Way streams

New globular cluster streams expected at all radii

Forecast streams at $g < 27$



Pearson, et al. (2024), see also Holm-Hansen et al. (2026)