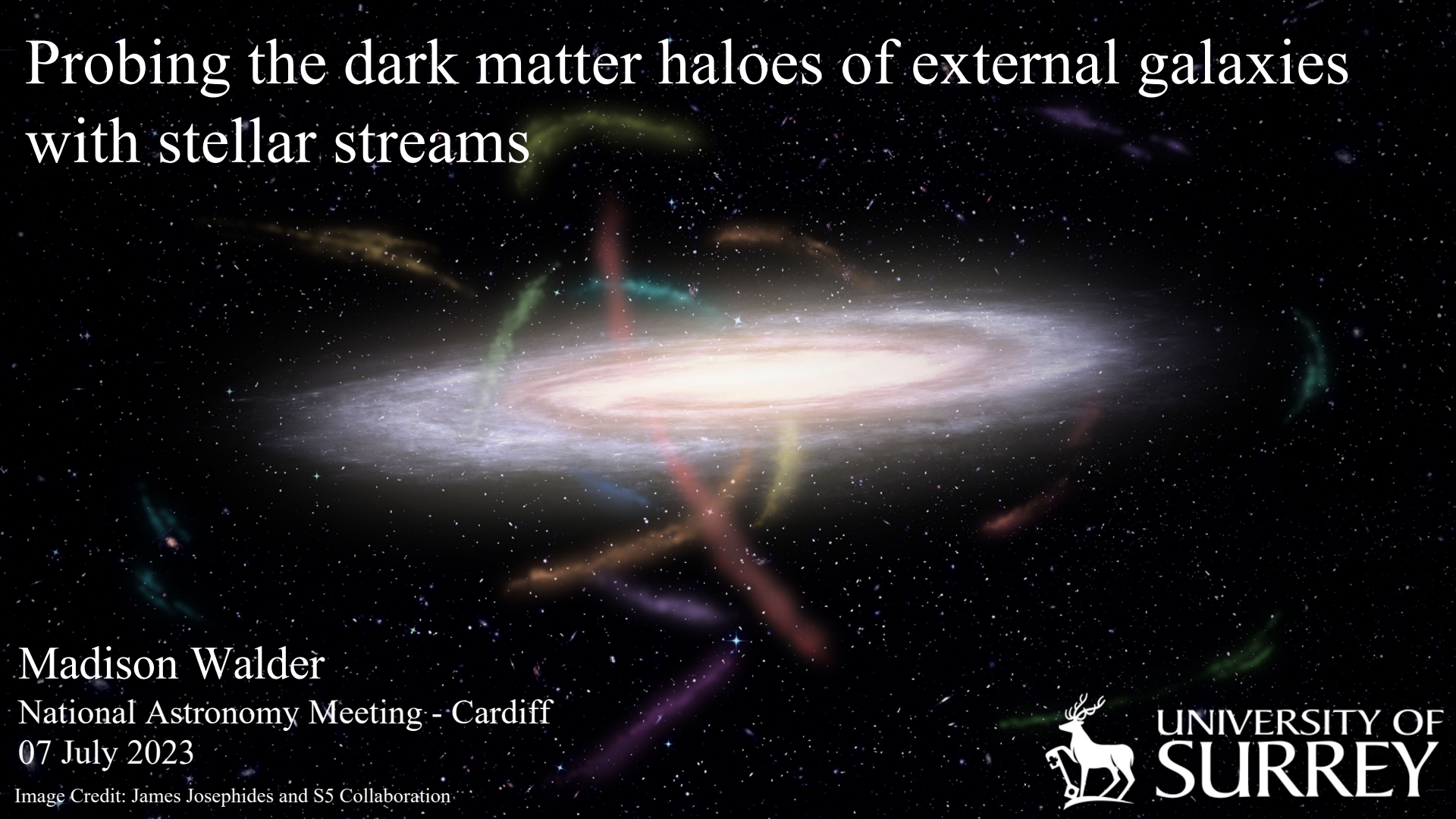
Probing the dark matter haloes of external galaxies with stellar streams



Madison Walder

National Astronomy Meeting - Cardiff
07 July 2023

Image Credit: James Josephides and S5 Collaboration

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Motivation: Dark Matter Models

Dark matter (DM) halo characteristics are sensitive to the properties of the DM particle:

ΛCDM | WDM | SIDM | FDM

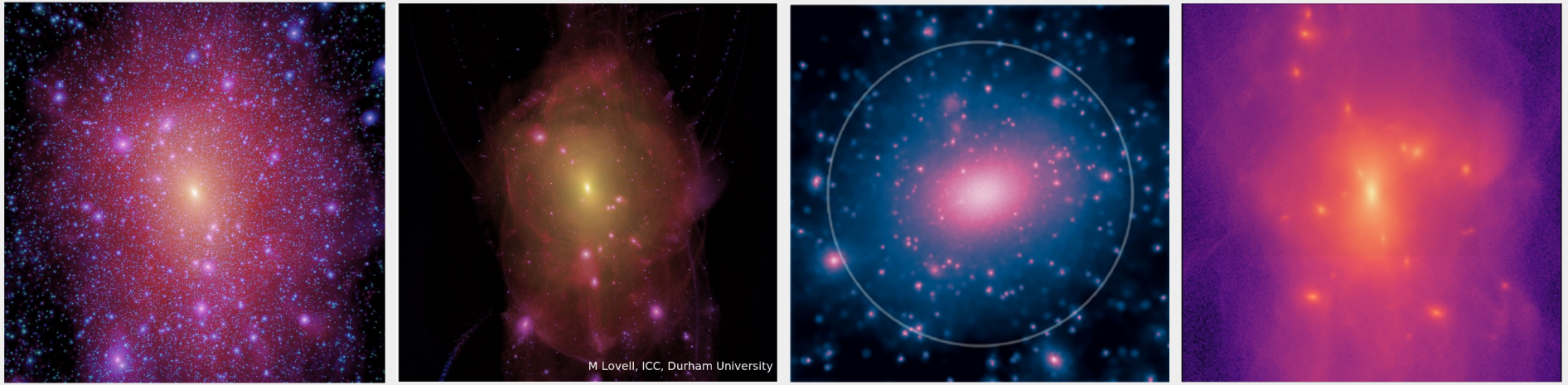


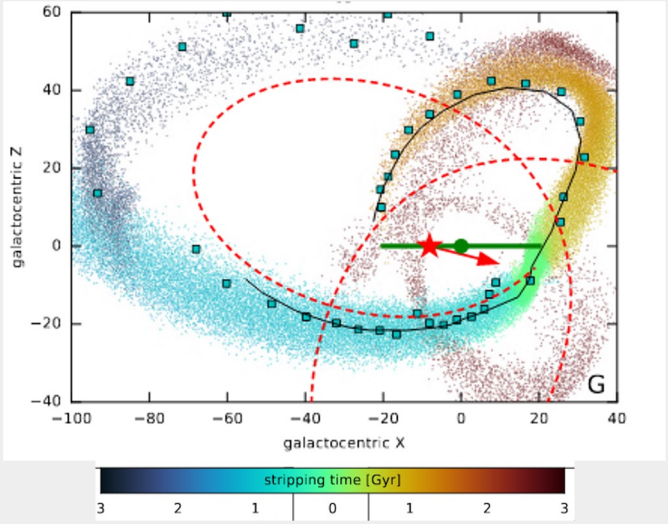
Image Credit: Aquarius/Virgo/ICC Durham University; SIDM halo image from Brinckmann et al. (2017)

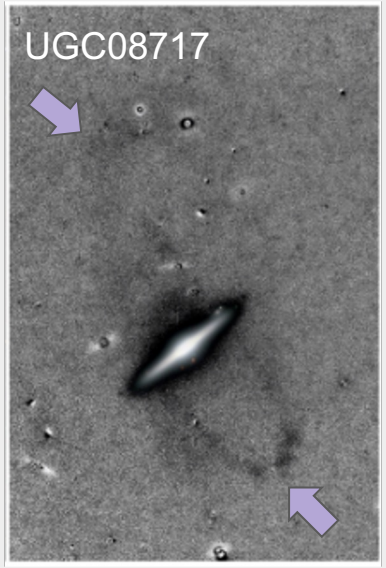
Motivation: Streams as probes of DM haloes

Streams are excellent probes of dark matter! ⇨ constrained DM halo of MW with 6D stream data

Need a statistical sample of galaxies to test our DM models ⇨ streams around external galaxies!

LSST, Euclid, and NGRST will uncover 1000s of extragalactic streams ⇨ lower data quality





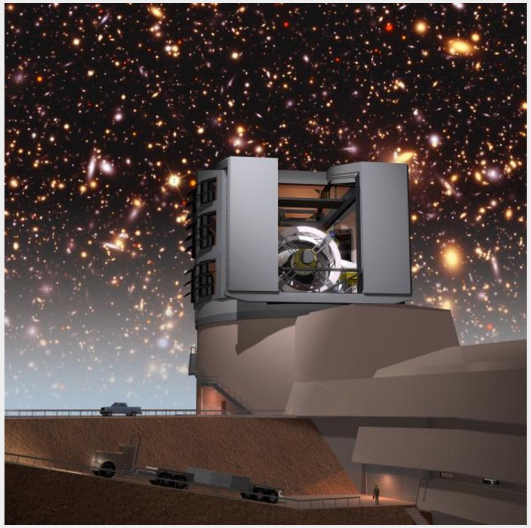


Image Credit: Eugene Vasiliev, Vasily Belokurov and Denis Erkal (2021); David Martínez-Delgado et al. (2021); Todd Mason, Mason Productions Inc. / LSST Corporation

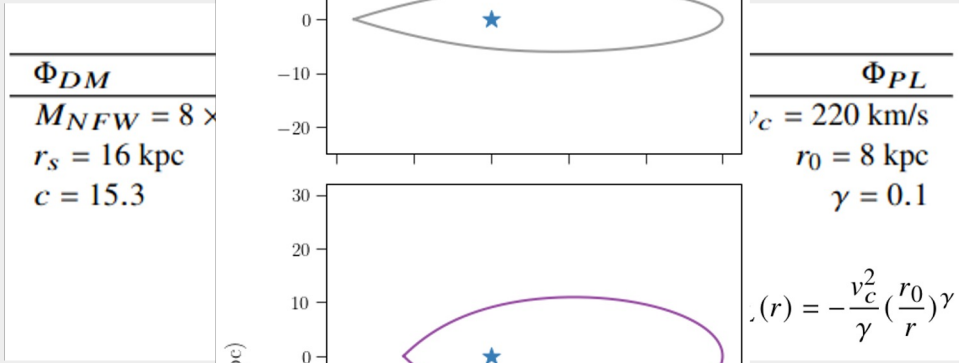
Gauging information content ns

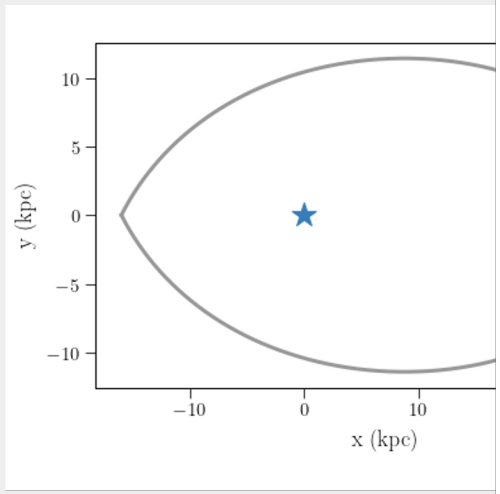
Generate orbits in 3 MW-like potentials:

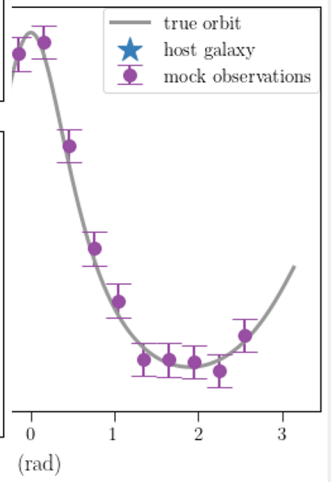
Take mock observations

Fit stream track for:

- Initial pos. & $v_{x, y, z}$
- M_{NFW} & r_s
- v_c & γ







Gauging info. content: vary data quality and stream properties

Fit streams in 4 data quality scenarios:

- Stream track only w/ current uncertainties ⇨ $\sigma_{track} = 1$ kpc
- Stream track w/ 1 radial velocity (RV) ⇨ $\sigma_{track} = 1$ kpc; $\sigma_{RV} = 10$ km/s
- Track only w/ improved uncertainties ⇨ $\sigma_{track} = 0.2$ kpc
- Track w/ improved uncertainties + 1RV ⇨ $\sigma_{track} = 0.2$ kpc; $\sigma_{RV} = 10$ km/s

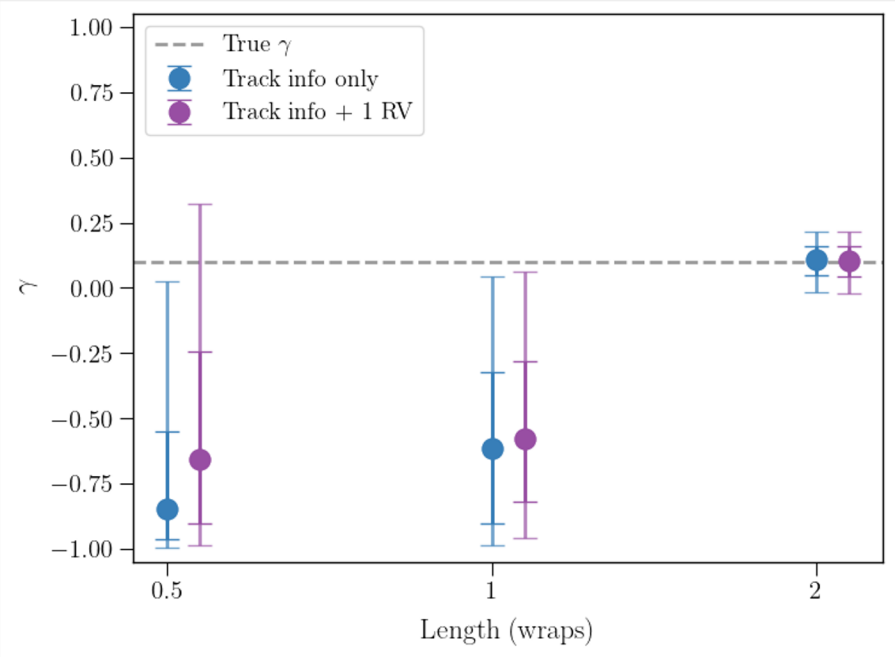
Repeat for streams with varying lengths, inclination angles, apocenters, and eccentricities

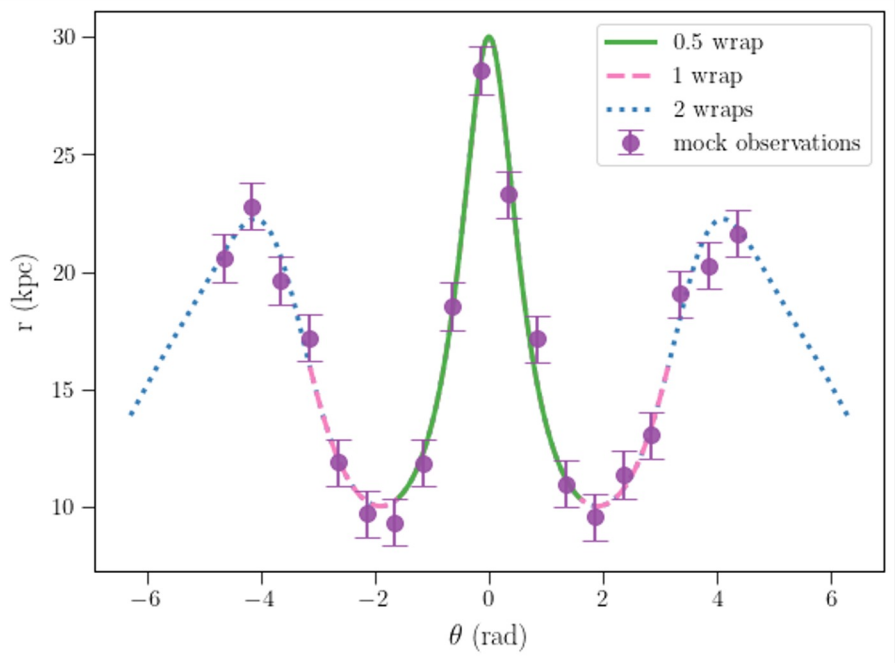
Stream Properties

L	ϕ	r_{apo}	e
0.5 wrap	0°	15 kpc	0.2
1 wrap	**45°**	**30 kpc**	**0.4**
2 wraps	70°	60 kpc	0.8

Results: Radial Profile Constraints

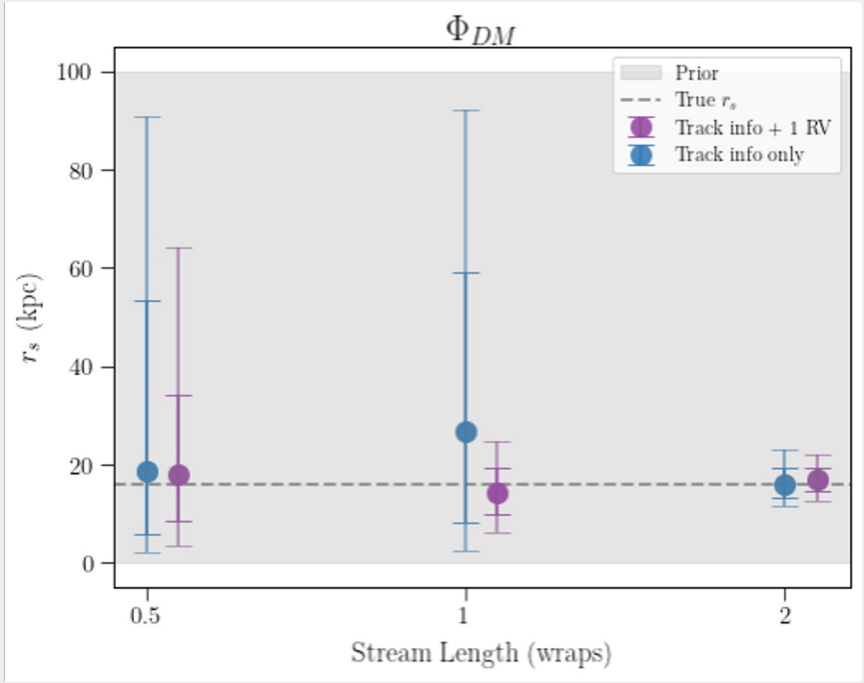
Key point: γ constrained using **only stream track** for stream with 2 wraps

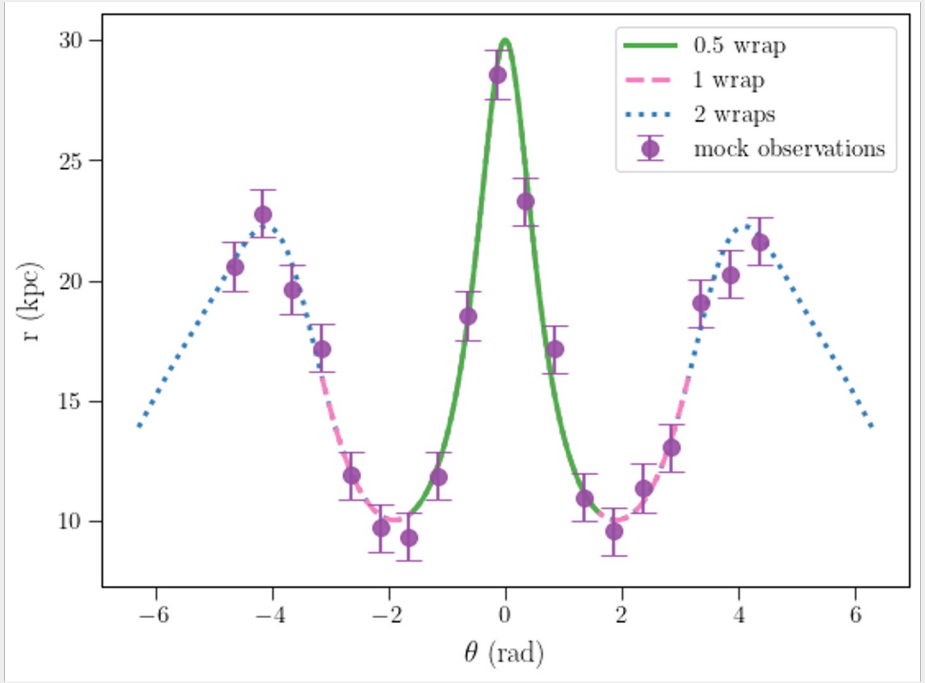




Results: Scale Radius Constraints

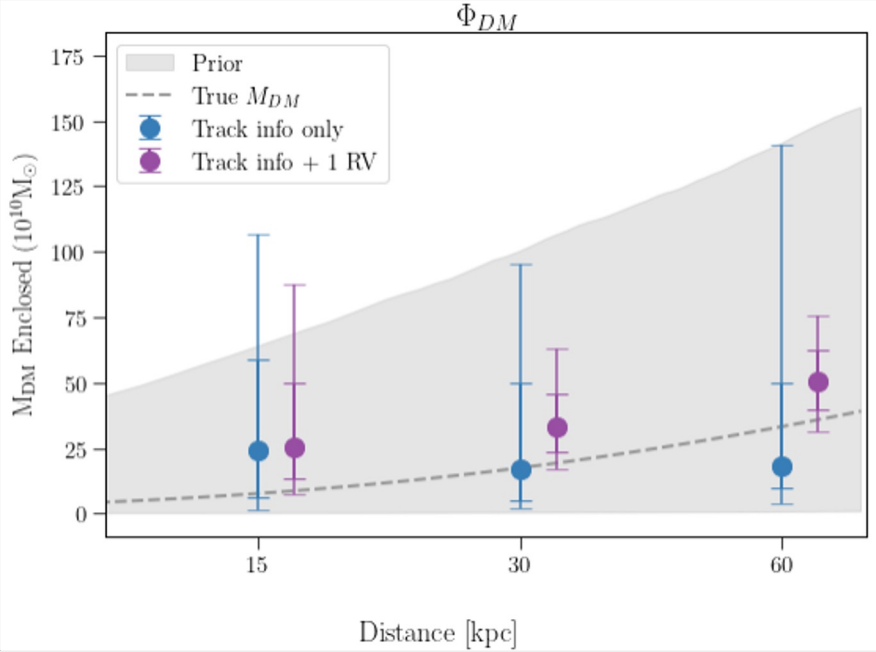
Key point: r_s constrained using **only stream track** for stream with 2 wraps

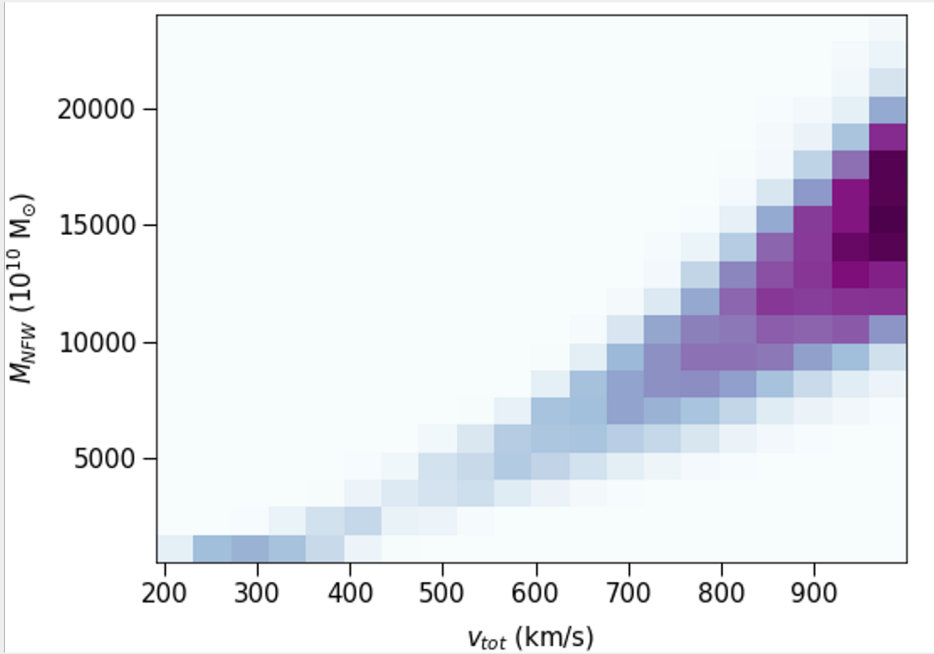




Results: Enclosed Mass Constraints

Key point: M_{DM} best constrained **only with RV** for streams with $r_{apo} > r_s$





Conclusions

Streams are useful tools for measuring dark matter in galaxies

LSST/Euclid/NGRST will reveal 1000s of extragalactic streams

Thus allowing us to probe the DM halo properties of thousands of galaxies!

With **only** the stream track on the sky, we can measure the radial profile of a galaxy!

However, need **at least 1 RV** to measure the halo mass.

Longer streams provide the **most** information on a galaxy's halo

Thanks for listening!

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