Astrometric lensing searches for dark matter substructure with Roman

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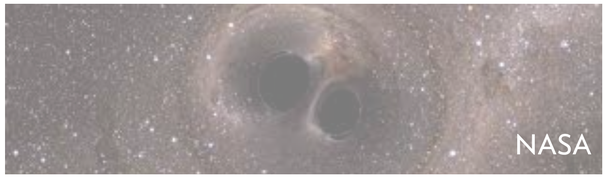
Roman Cosmology Seminar

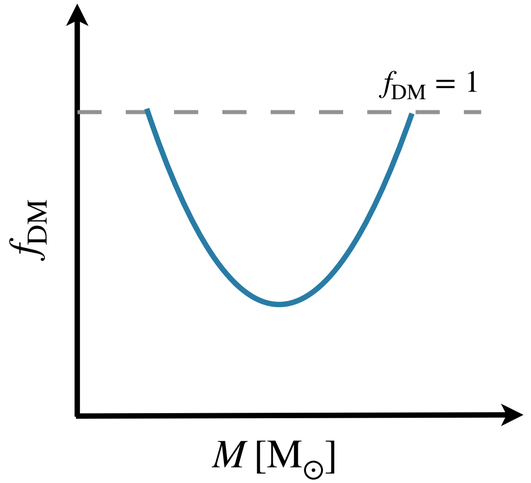
January 27, 2021

The science case: lensing probes of (Galactic) dark matter substructure

More compact ⟷ *More "diffuse"*

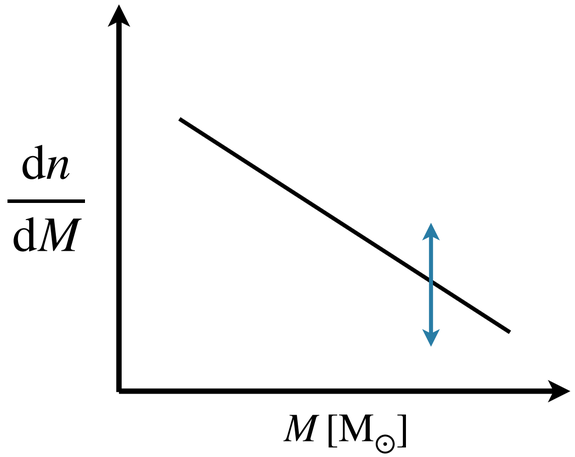
- Point-like objects
- e.g., primordial black holes





microlensing (photometry)
…

~ Cold dark matter



strong gravitational lensing, dwarf galaxies, …

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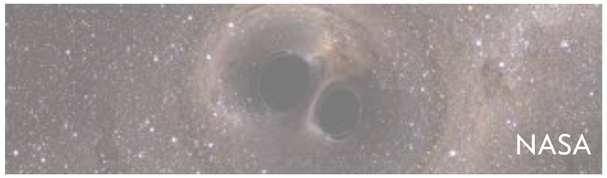
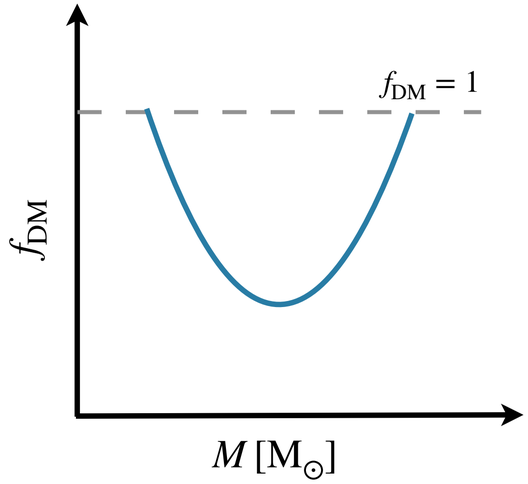




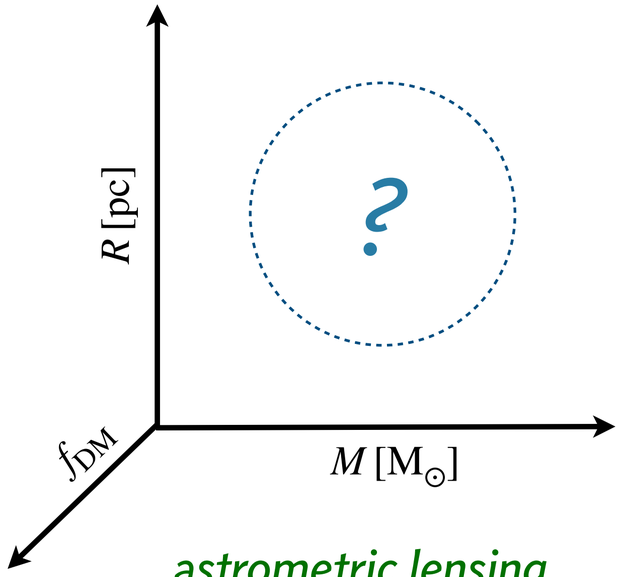
microlensing (photometry)

…

- Extended, compact halos

Dissipative dark matter
(Axion) miniclusters/minihalos
Modified expansion histories
Enhanced primordial power

…



astrometric lensing,
stellar streams, …

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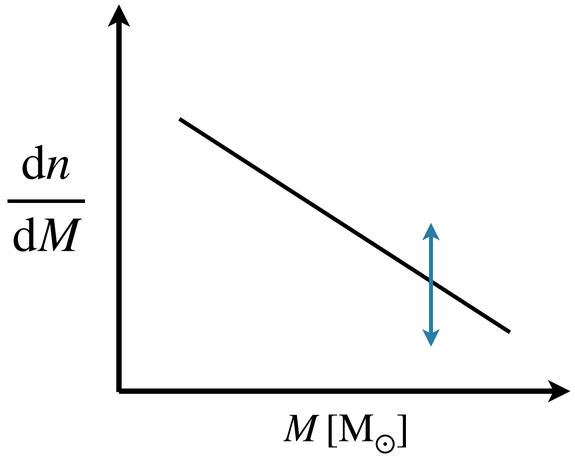

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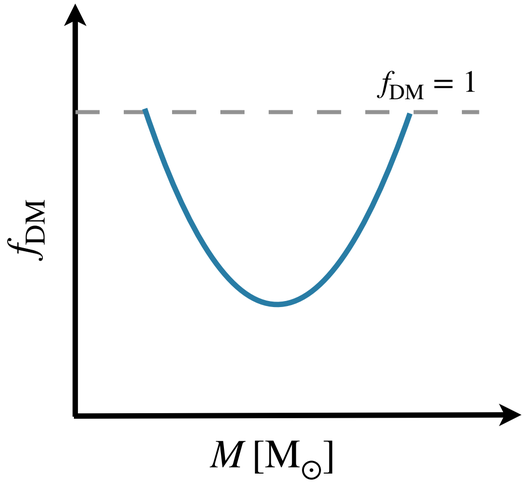

microlensing (photometry)

…

Astrometry with the Wide-Field InfraRed Space Telescope

The WFIRST Astrometry Working Group[†], Robyn E. Sanderson[a,b,c,*], Andrea Bellini[d], Stefano Casertano[d], Jessica R. Lu[e], Peter Melchior[f], Mattia Libralato[d], David Bennett[g], Michael Shao[h], Jason Rhodes[h], Sangmo Tony Sohn[d], Sangeeta Malhotra[g], Scott Gaudi[i], S. Michael Fall[d], Ed Nelan[d], Puragra Guhathakurta[j], Jay Anderson[d], Shirley Ho[b]

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[b]Center for Computational Astrophysics, Flatiron Institute, 162 Fifth Avenue, New York, New York 10010. USA
[c]TAPIR, California Institute of Technology, 1200 E California Blvd, Pasadena, CA 91125, USA
[d]Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
[e]Department of Astronomy, University of California, Berkeley, 501 Campbell Hall, Berkeley, CA 94720, USA
[f]Department of Astrophysical Sciences, Princeton University, Peyton Hall, Princeton, NJ 08544, USA
[g]Astrophysics Science Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
[h]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA
[i]Department of Astronomy, Ohio State University, 140 W. 18th Ave., Columbus, OH 43210, USA
[j]University of California Santa Cruz, 1156 High Street, Santa Cruz, CA 95060, USA

Abstract. The Wide-Field InfraRed Space Telescope (WFIRST) will be capable of delivering precise astrometry for faint sources over the enormous field of view of its main camera, the Wide-Field Imager (WFI). This unprecedented combination will be transformative for the many scientific questions that require precise positions, distances, and velocities of stars. We describe the expectations for the astrometric precision of the WFIRST WFI in different scenarios, illustrate how a broad range of science cases will see significant advances with such data, and identify aspects of WFIRST's design where small adjustments could greatly improve its power as an astrometric instrument.

astrometric lensing,
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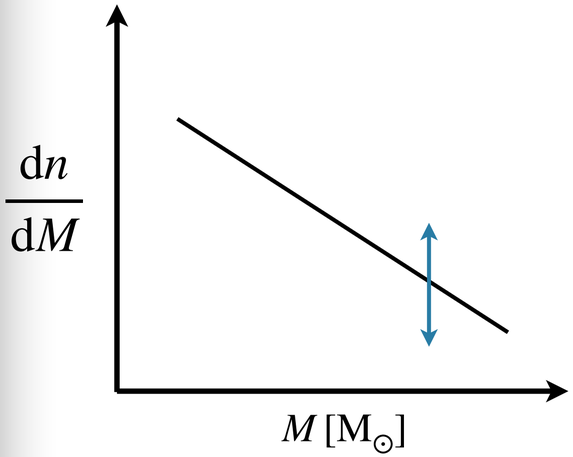

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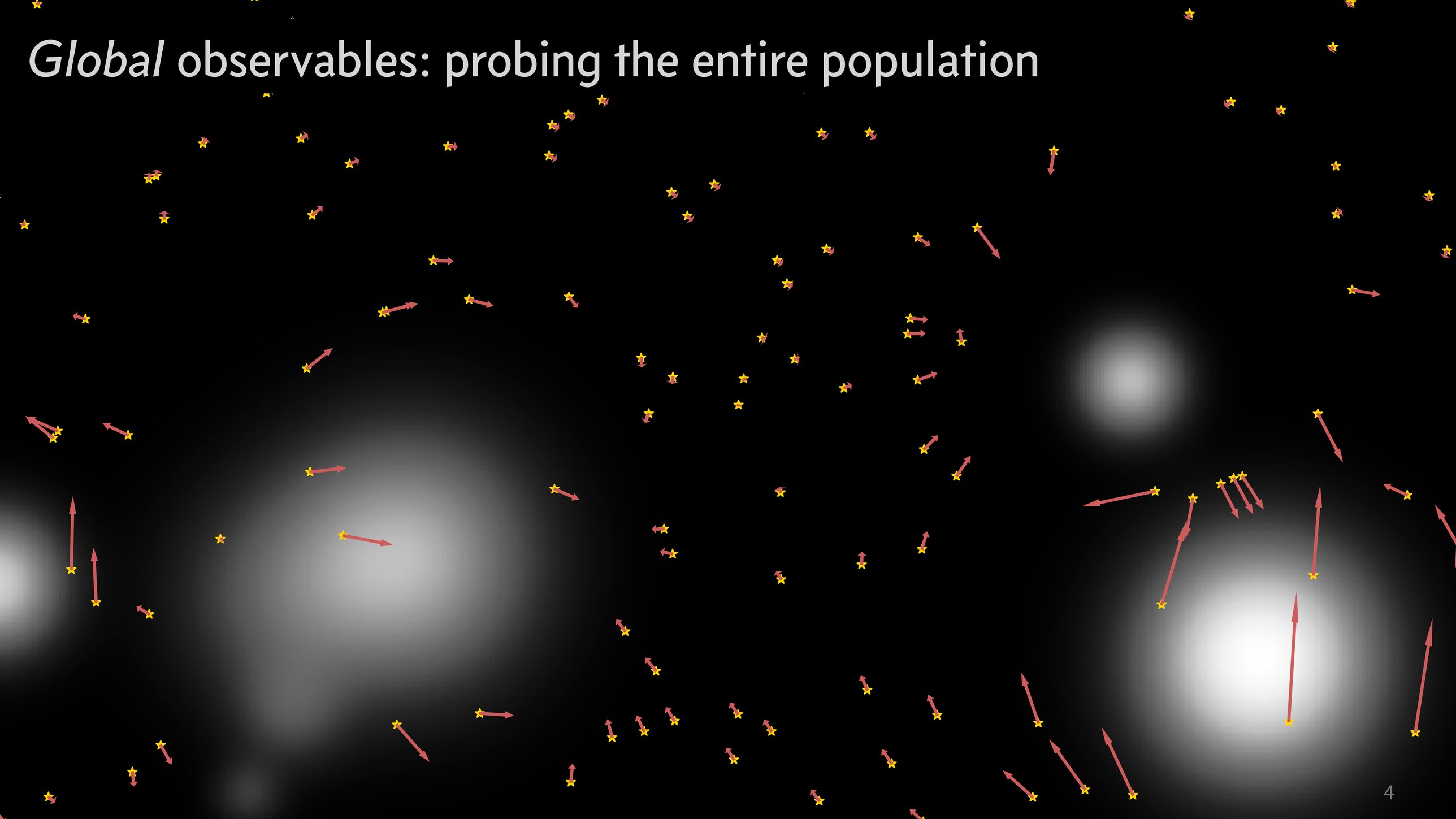
Observables systematically studied in
Van Tilburg, Taki, Weiner [JCAP 2018]
Mondino, Taki, Van Tilburg, Weiner [PRL 2020]

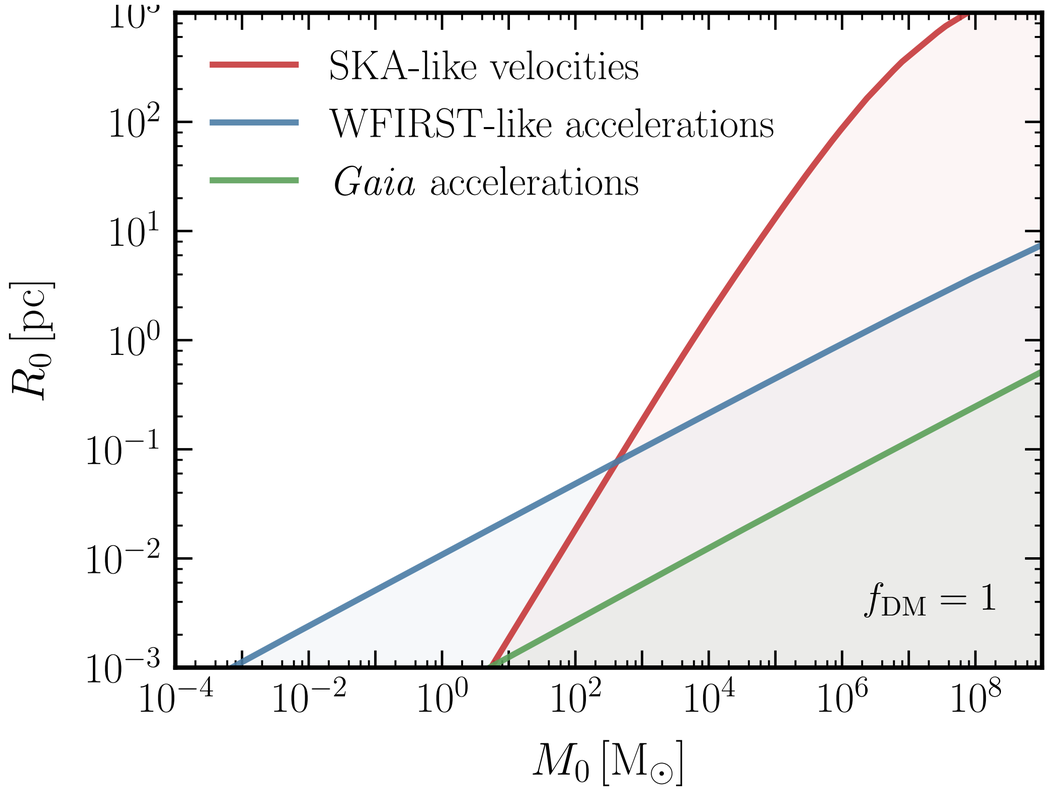
Global observables: probing the entire population



Compact objects in the Milky Way: sensitivity projections

Vector power spectrum decomposition

Mishra-Sharma et al [PRD 2020]



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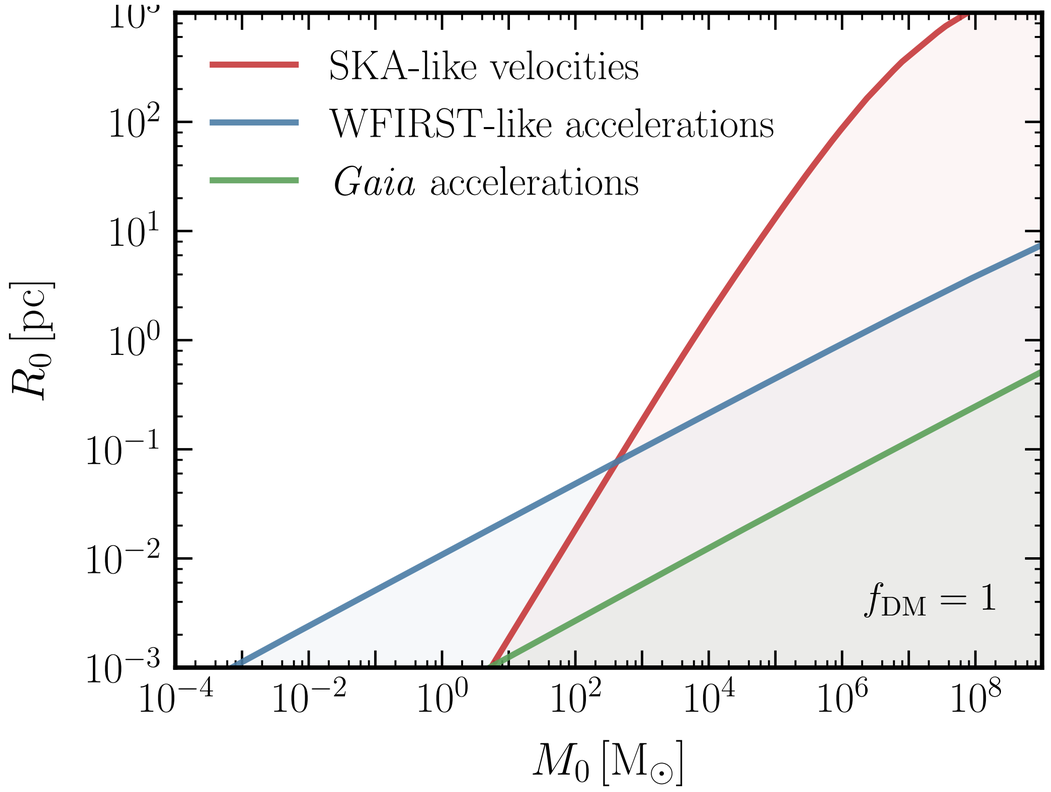
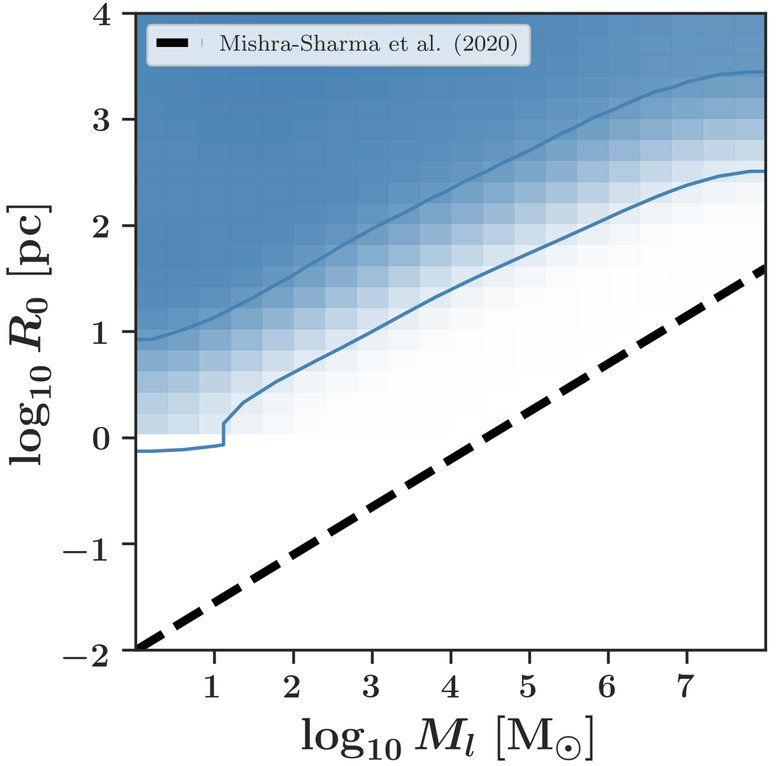


Forward modeling

Pardo & Doré [PRD 2021]



Machine learning & likelihood-free inference approach

Mishra-Sharma [MLST 2022]

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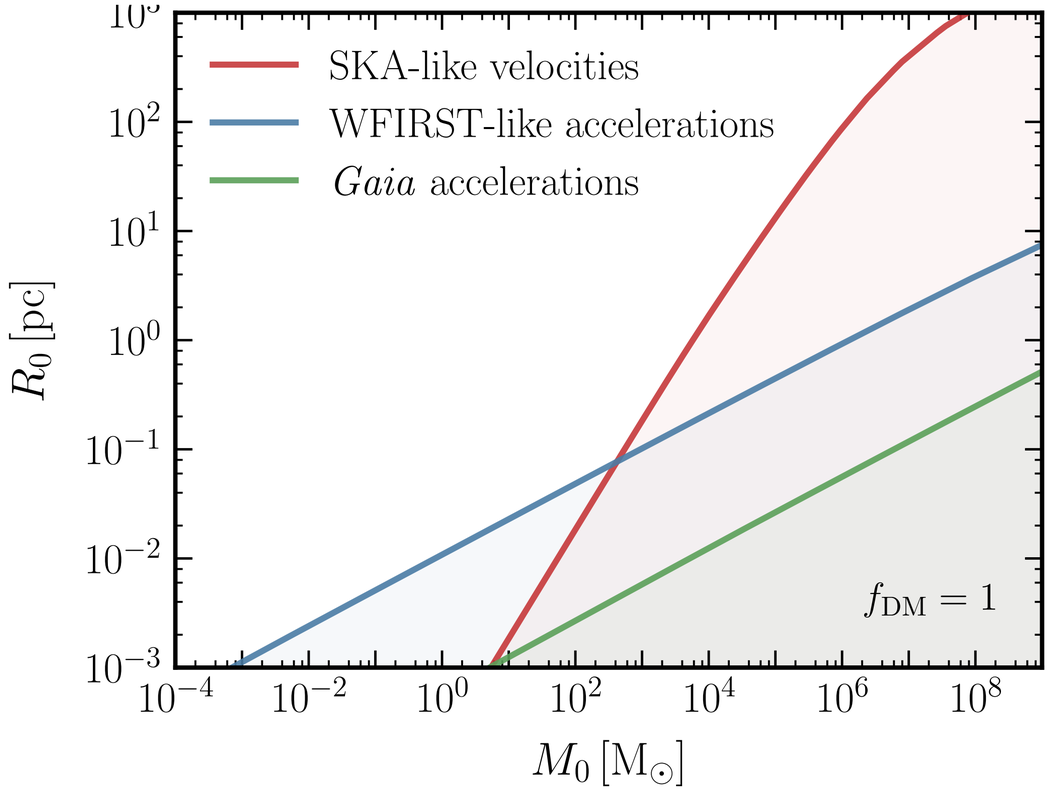

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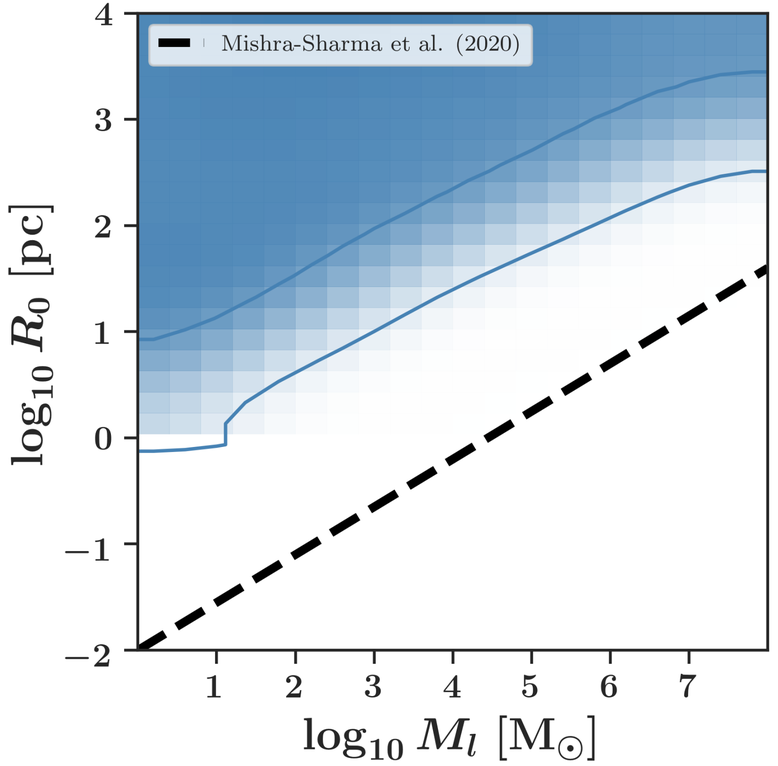

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Relatively extended subhalo populations can be probed

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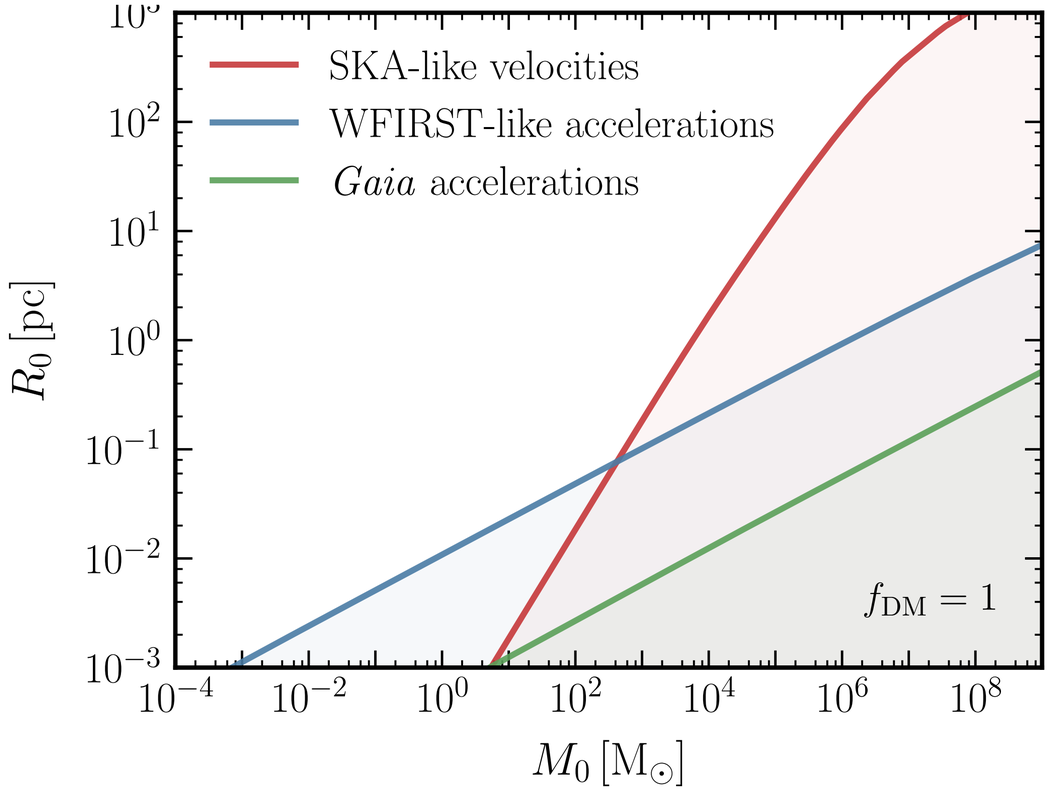

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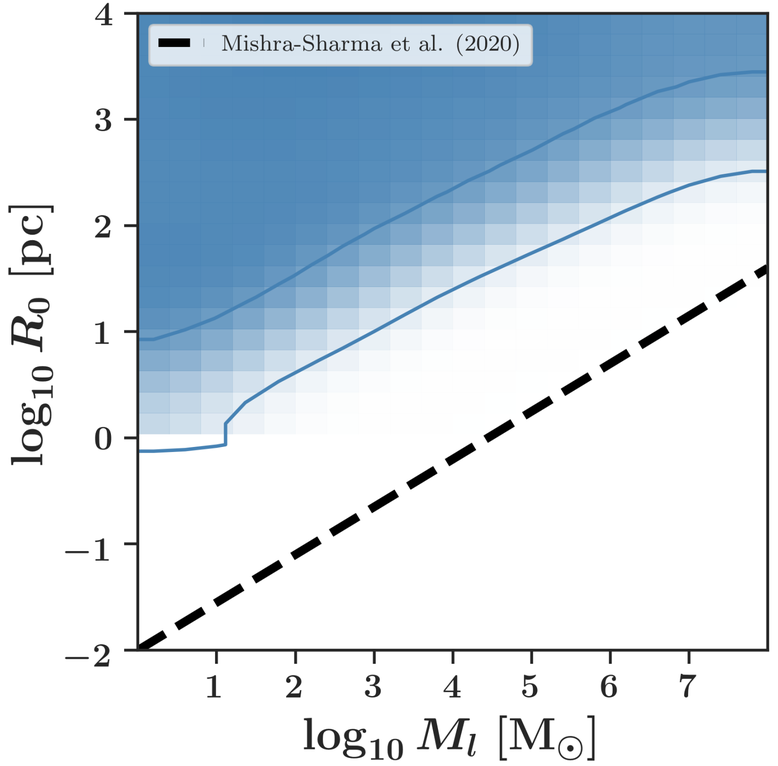

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Lots of interesting dark matter science with Roman!