Dark Matter on small scales: Precise dynamical analysis of dwarf spheroidal galaxies with Roman and Subaru-PFS

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Subaru Instrument: Prime Focus Spectrograph

Observation requirement (Number of nights, condition, time critical):
The PFS observations for the Galactic dwarf spheroidal galaxies are planned for the Subaru Strategic Program (SSP) survey, which will start from the next semester (25A).
We have planed 72 hours for six of the Galactic dwarf spheroidal galaxies (Boötes I, Draco, Ursa Minor, Sextans, Sculptor, and Fornax).

Relevant CCS/other Roman program: Relevant to one of the CCS science pitch lead by Ting Li

Category: galaxies

Key words: dark matter, dwarf spheroidal galaxies, proper motions, dynamical analysis

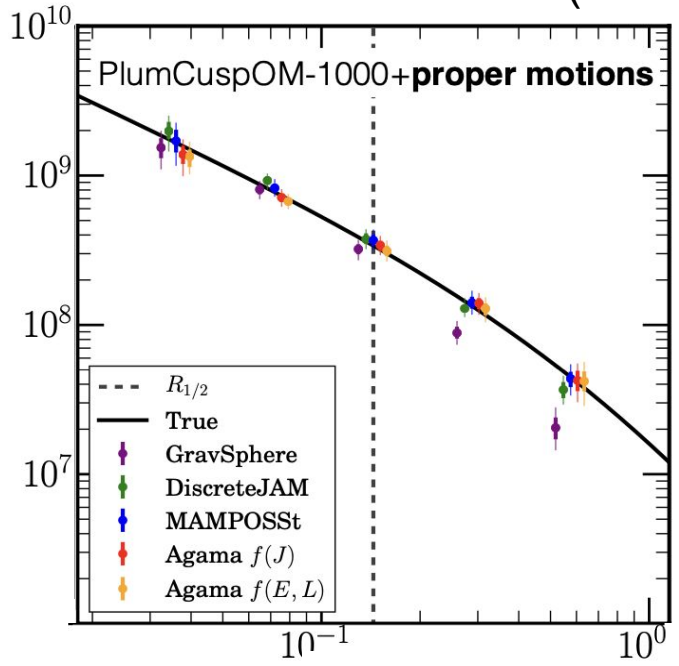
Dark matter density profiles of dSphs

$$(\gamma = 0 \ : \text{core}, \ \gamma = 1 \ : \text{NFW cusp})$$

- The DM density profile of each dSph is estimated by stellar kinematics (***sky positions and line-of-sight velocities***, so far) of member stars in the dSph.
- There are still **large uncertainties** on the DM density estimations due to insafficient data volume.

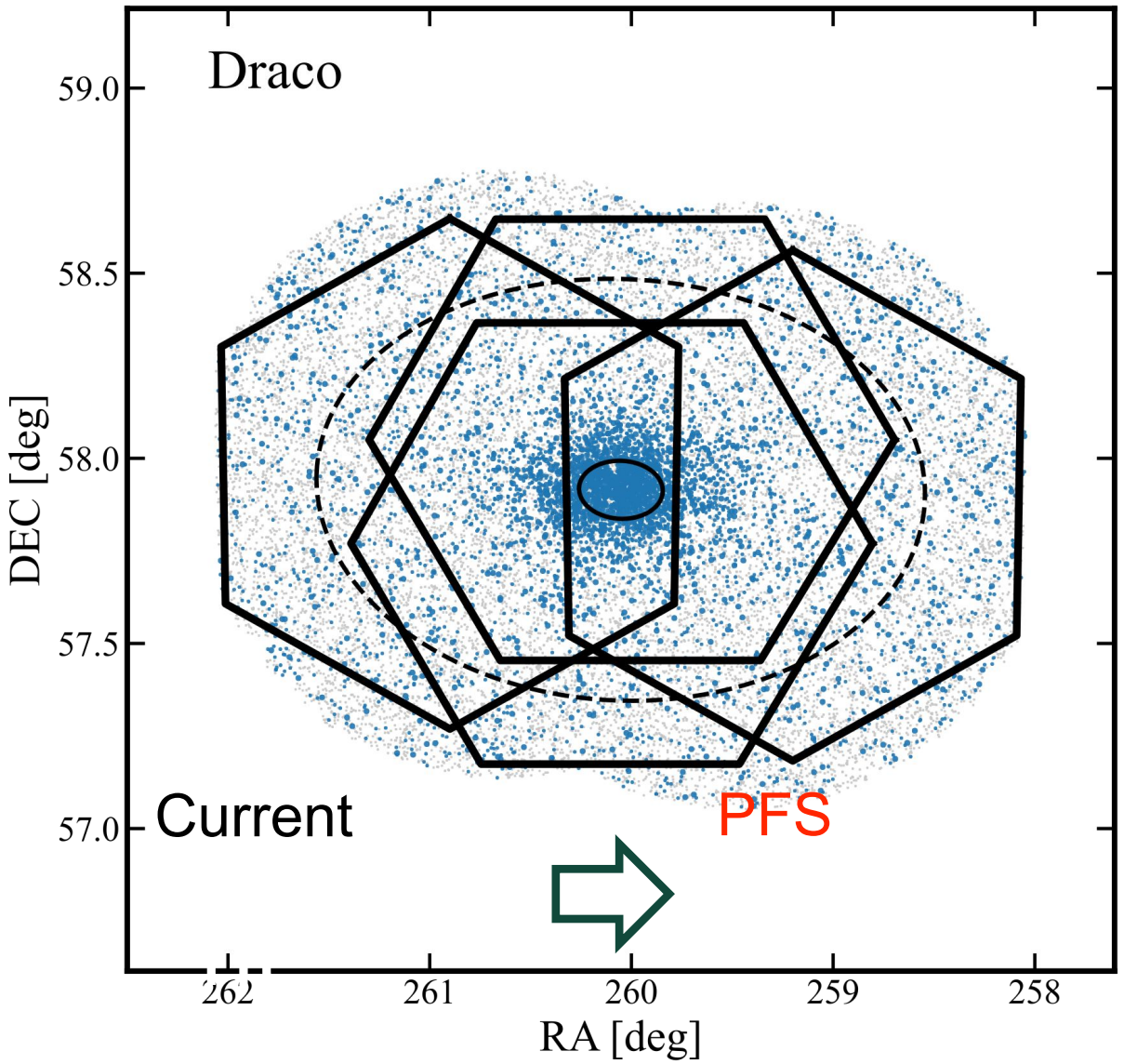
Hayashi, Chiba, Ishiyama (2020)

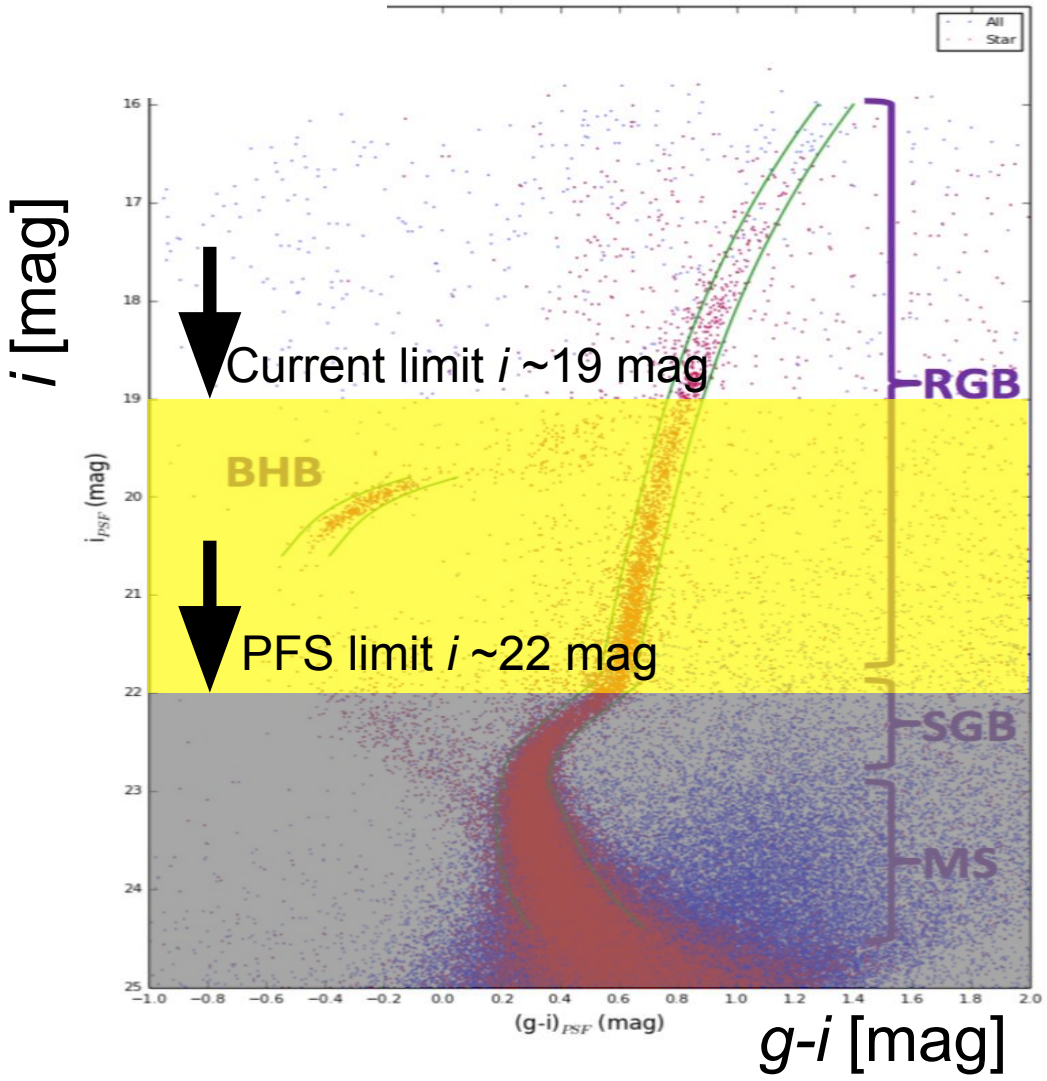
Read et al. (2021)



- Mock analysis for DM density profile in a dSph with several dynamical models.
- This work indicates that to estimated DM density precisely, over 1000 l-o-s velocity data *plus* ***their proper motions***.

PFS

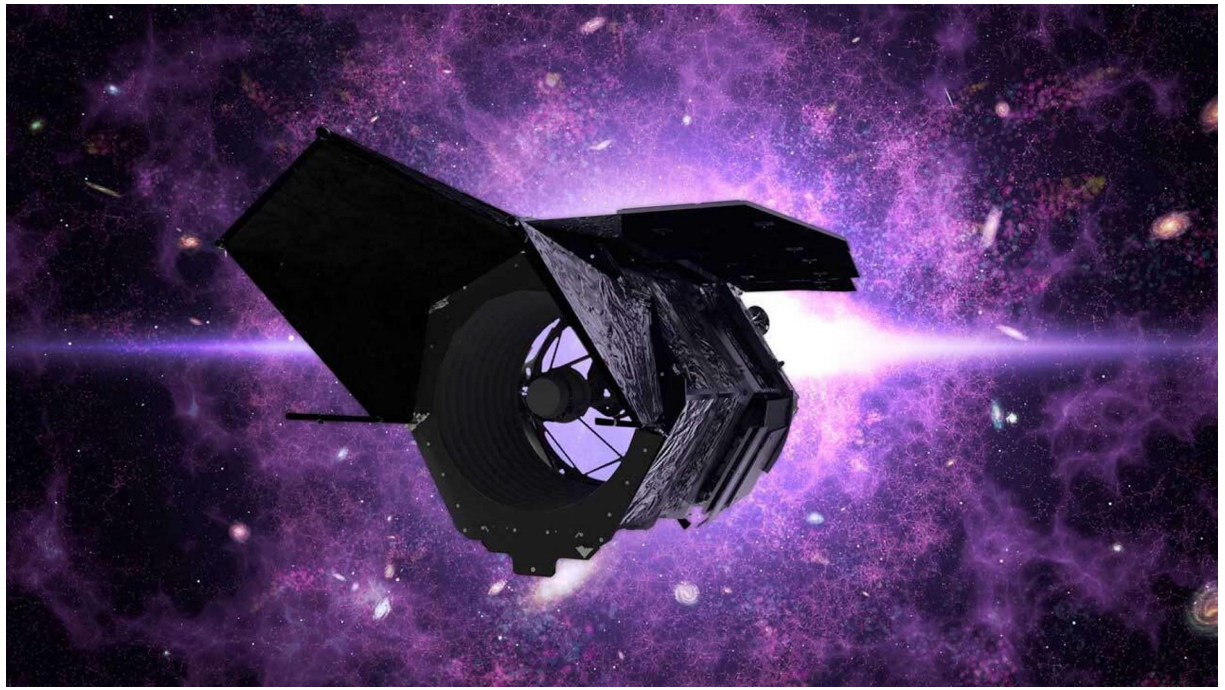




PFS wide (2400 fibers within 1.3 diameter hexagon) and deep (the limiting mag is i ~22 mag) survey will enable us to obtain the huge number of stellar kinematics out to the outskirts of the Galactic dSphs.

PFS

- Because of its large field of view and high precision photometry of the star, **Roman will enable us to measure proper motions of individual stars in the dSphs**.
- Provided typical internal velocities of their stars are ~10 km/s, we expect **proper motions of ~0.03 mas/yr in dSphs at distance of 70 kpc from the Sun**, which can be achievable with **Roman astrometry over 5 years coordinated observations** of stellar positions.
- Long baseline in combination with previous measurements such as HST and Gaia to get more precise proper motions.
- The combination between PFS and Roman will get 3D stellar motions of individual stars in the dSphs.



This synergy will allow us to construct more realistic mass models of dSphs than previously made and thus to set important constraints on ***not only the DM density profiles but the non-spherical structures of dark matter halos*** .

Summary

- The Galactic dwarf spheroidal galaxies are ideal sites for studying dark matter because they are dark matter rich systems.
- To shed light on their dark matter density profiles, stellar kinematics of individual stars in the dSphs should be required. However, we have an insufficient number of line-of-sight velocities and a tiny amount of proper motion data.
- Subaru-PFS will enable us to hunt the huge number of line-of-sight velocities out to outskirts of the dSphs.
- Roman will also enable us to measure the proper motions of their individual stars precisely.
- **The synergy with Roman and Subaru-PFS will provide 3D stellar motions of individual stars in the dSph and it will allow us to place strong constraint on dark matter density profiles.**
- This constraint should be critical to keV-TeV dark matter searches by Japan-flagship projects such as XRISM and CTA.