HST Proper Motions of Satellites and Streams

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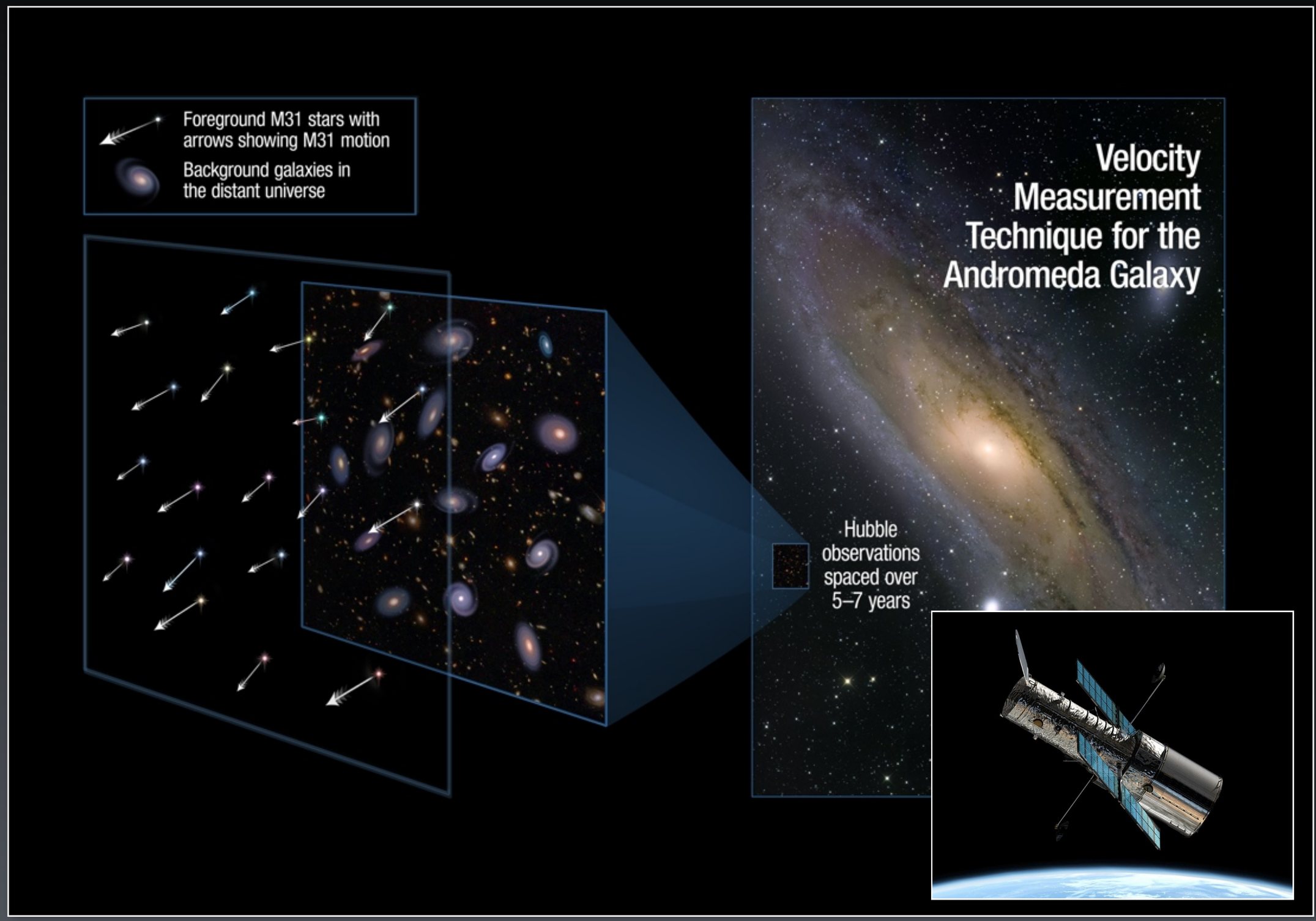
“HSTPROMO Collaboration”

HST Proper Motions of Satellites and Streams

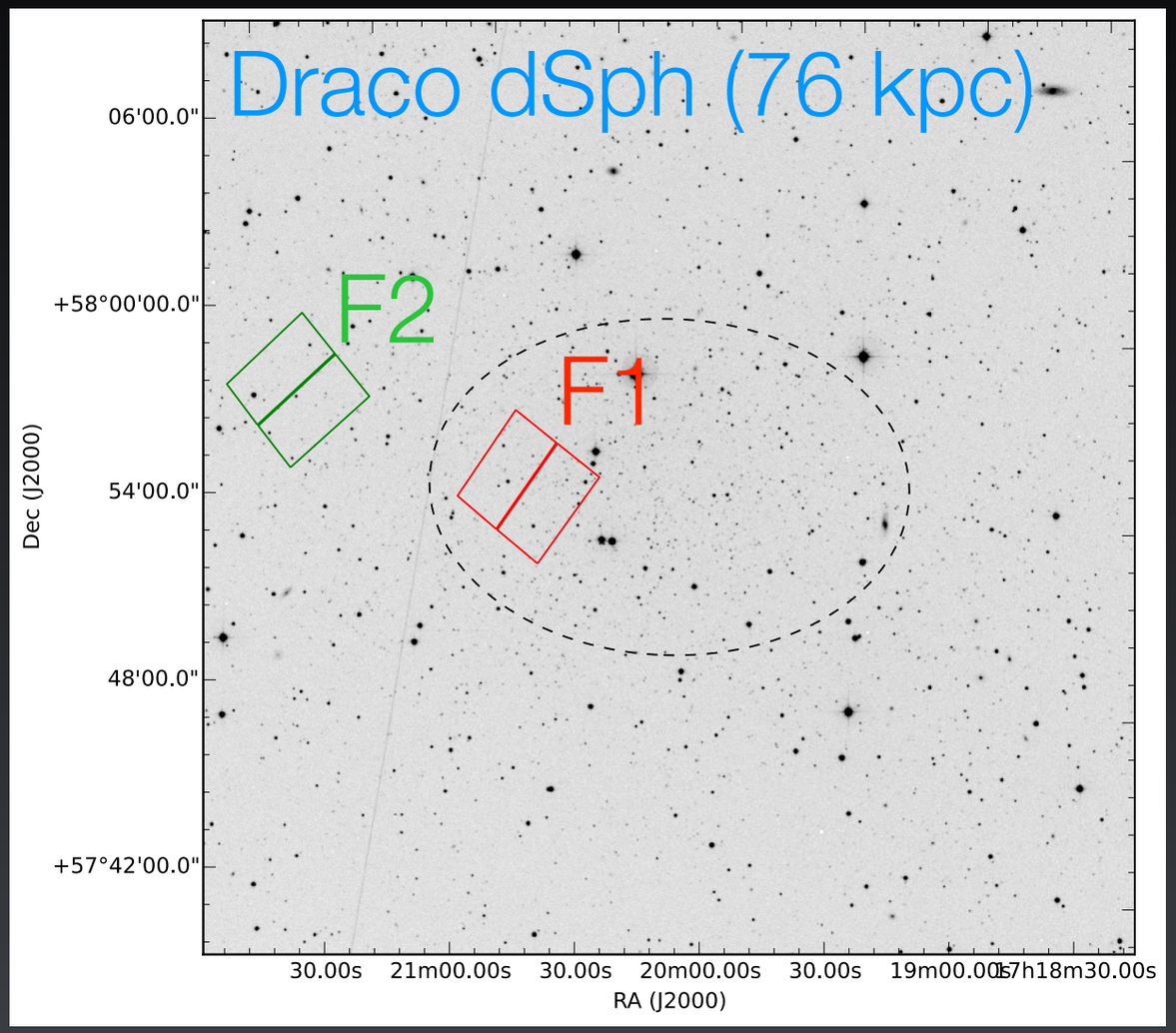
- Draco dSph (76 kpc)
- Sculptor dSph (86 kpc)
- Leo I dSph (254 kpc)

- Sagittarius stream
- Orphan stream

Proper Motion Measurements



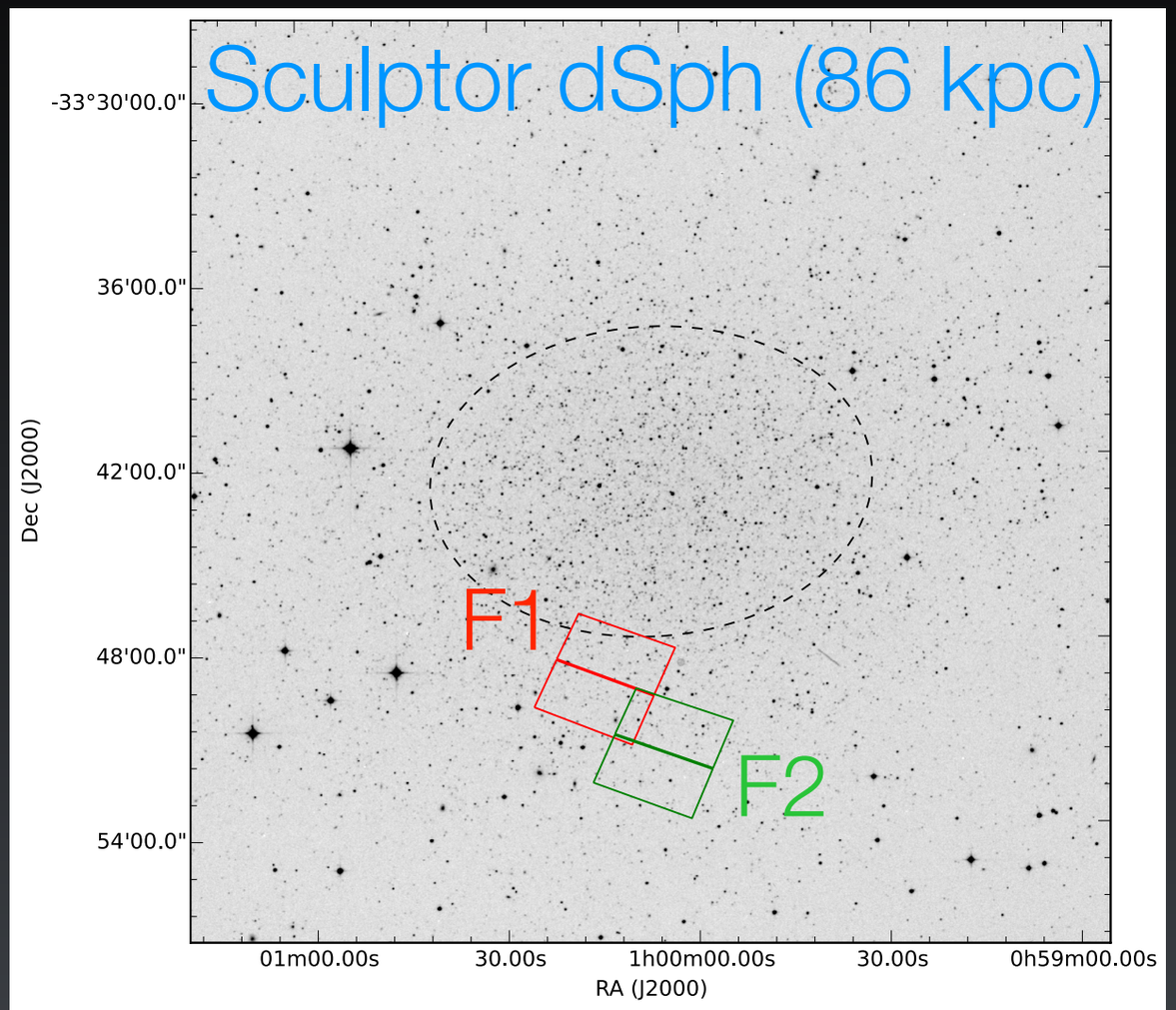
Draco dSph (Sohn+2015 in prep)



- ACS/WFC F606W
- ΔT = 9-10 yrs
- QSOs + b.g. galaxies

- 1-D σ_μ = 0.008 mas/yr
- $(V_{rad}, V_{tan})_{GC}$ = (-87, 161) ± (4, 5) km/s
- V_{tan} error ~ V_{rad} error

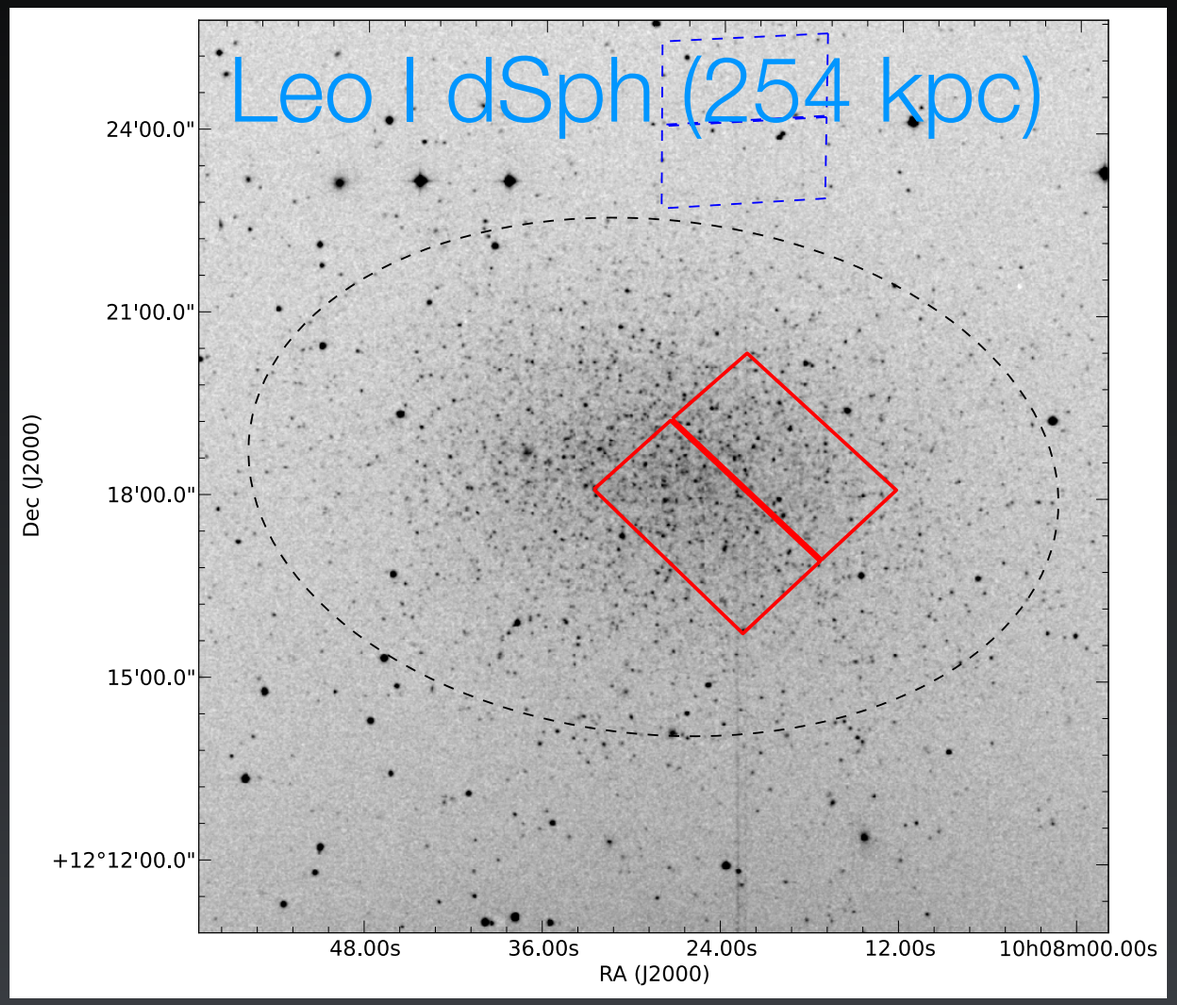
Sculptor dSph (Sohn+2015 in prep)

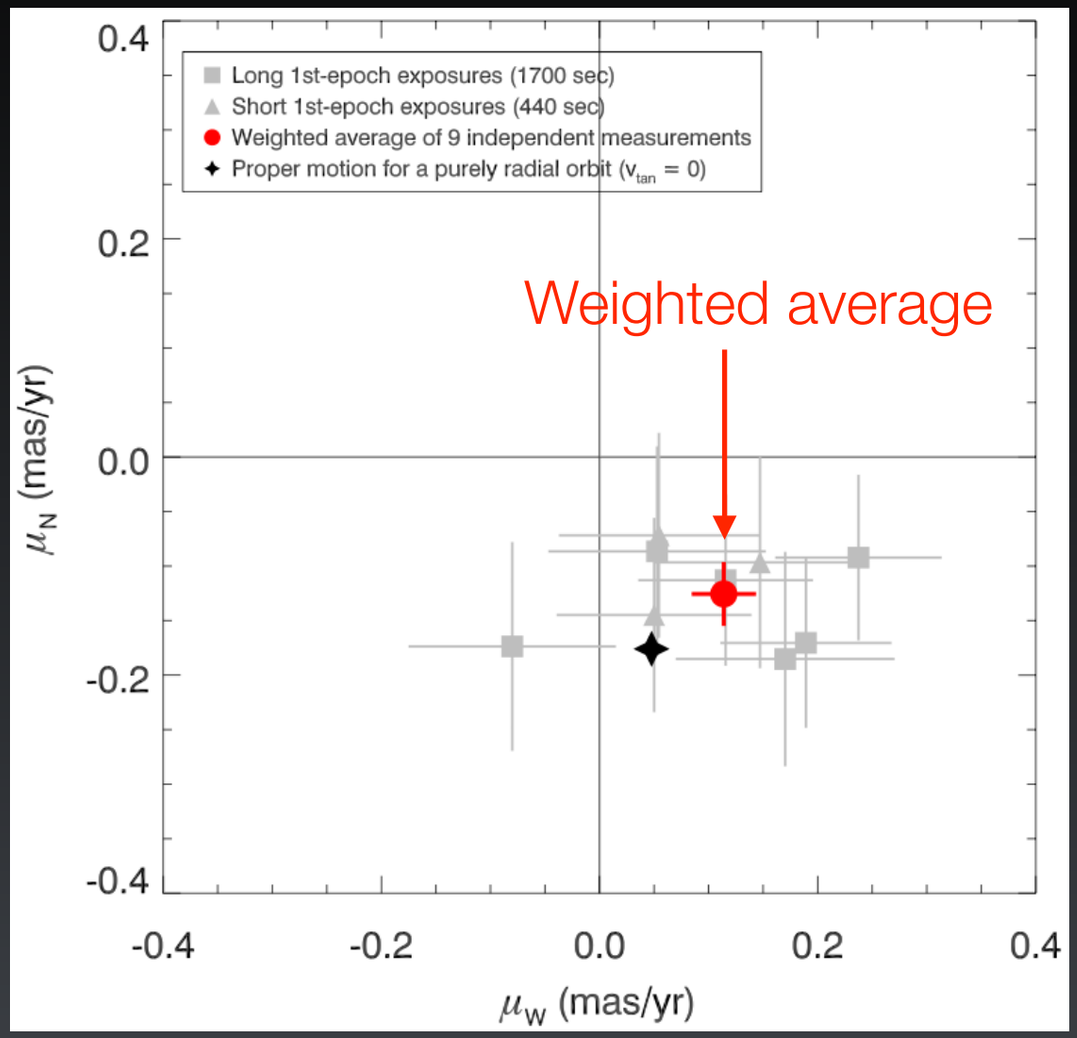


- ACS/WFC F606W
- ΔT = 11 yrs
- Only b.g. galaxies

- 1-D σ_μ = 0.021 mas/yr
- $(V_{rad}, V_{tan})_{GC}$ = (73, 200) ± (1, 11) km/s

Leo I dSph (Sohn+2013)





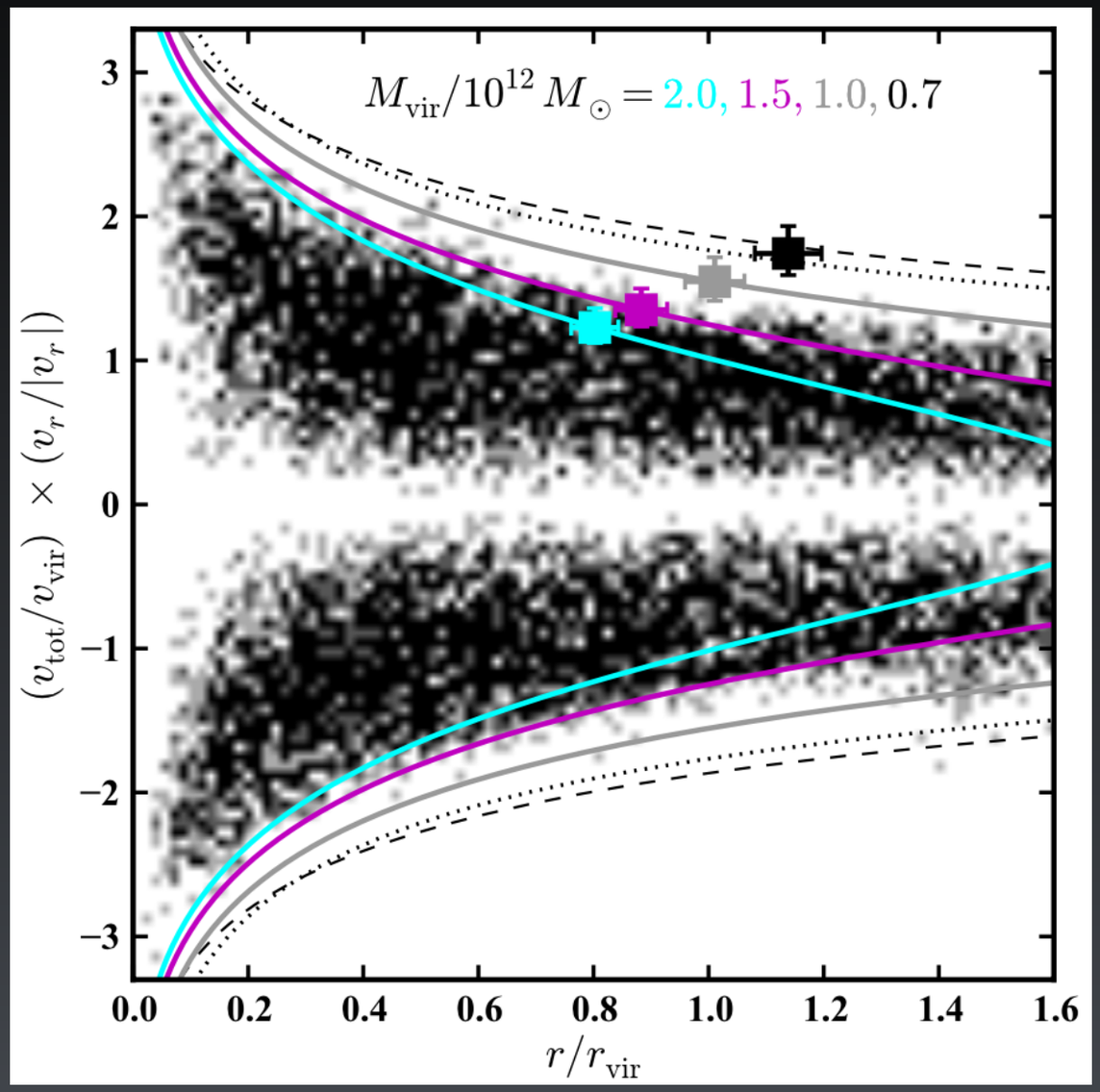
- ACS/WFC F814W
- ΔT = 5 yrs (2006-2011)
- Only b.g. galaxies

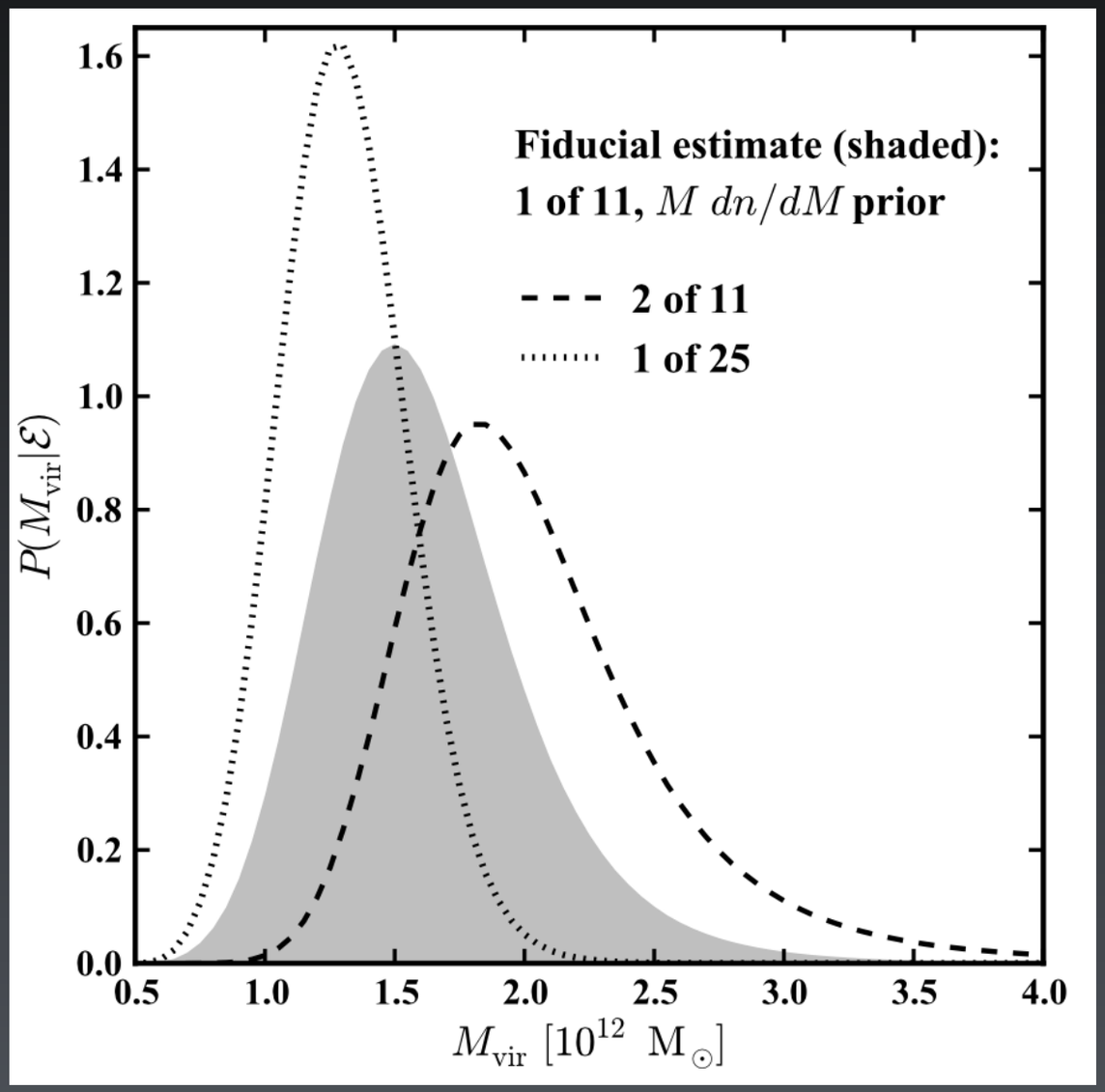
- 1-D σ_μ = 0.030 mas/yr
- $(V_{rad}, V_{tan})_{GC}$ = (168, 101) ± (1, 34) km/s

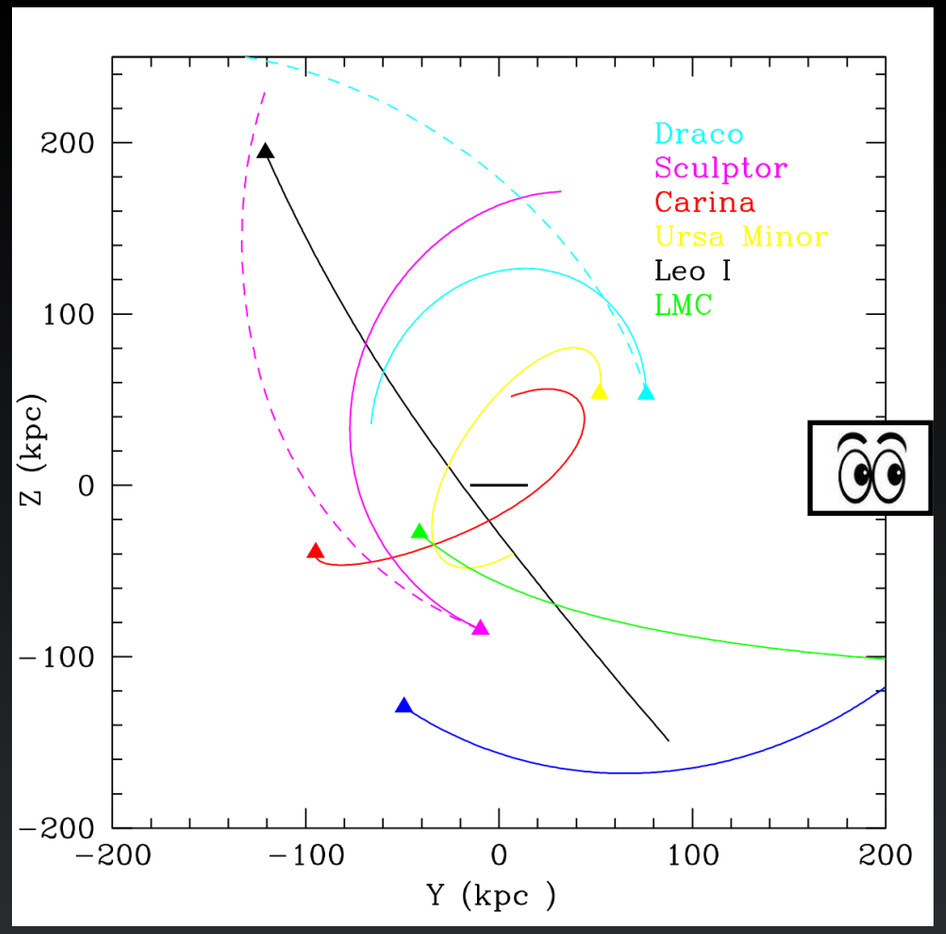
Leo I dSph (Boylan-Kolchin+2013)

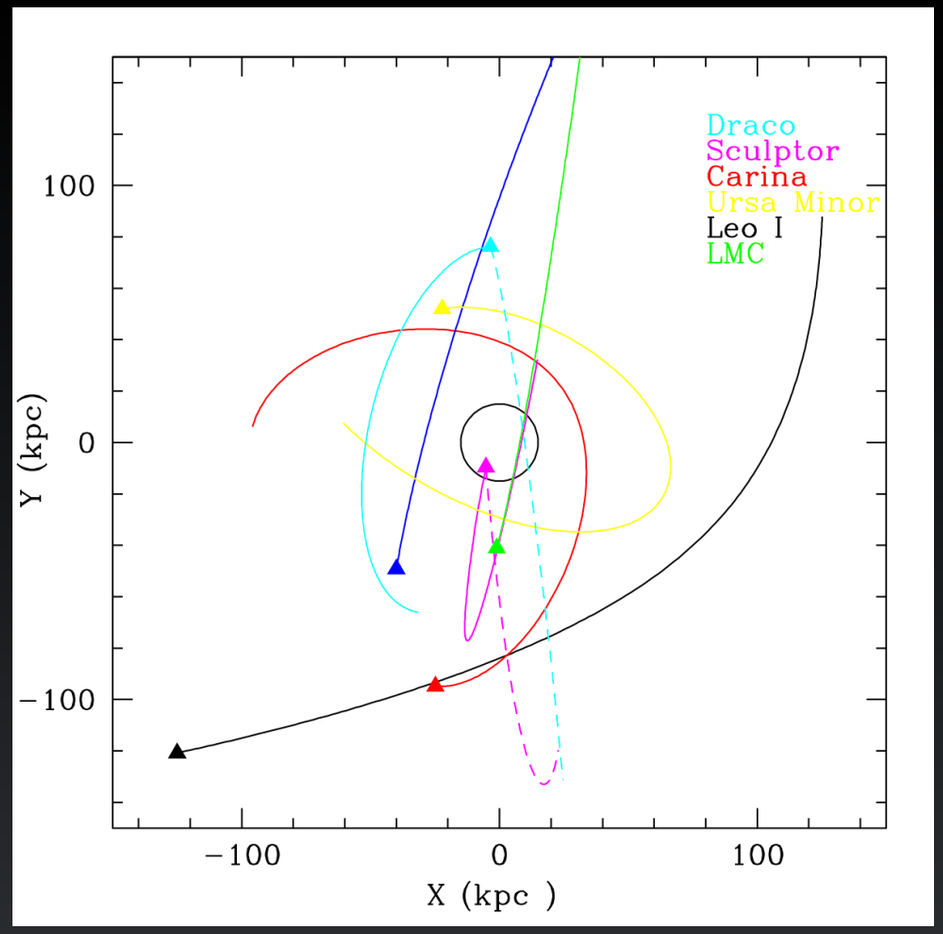
$M_{vir,MW} = 1.6 \times 10^{12}\ M_\odot$

$[1.0 - 2.4] \times 10^{12}\ M_\odot$

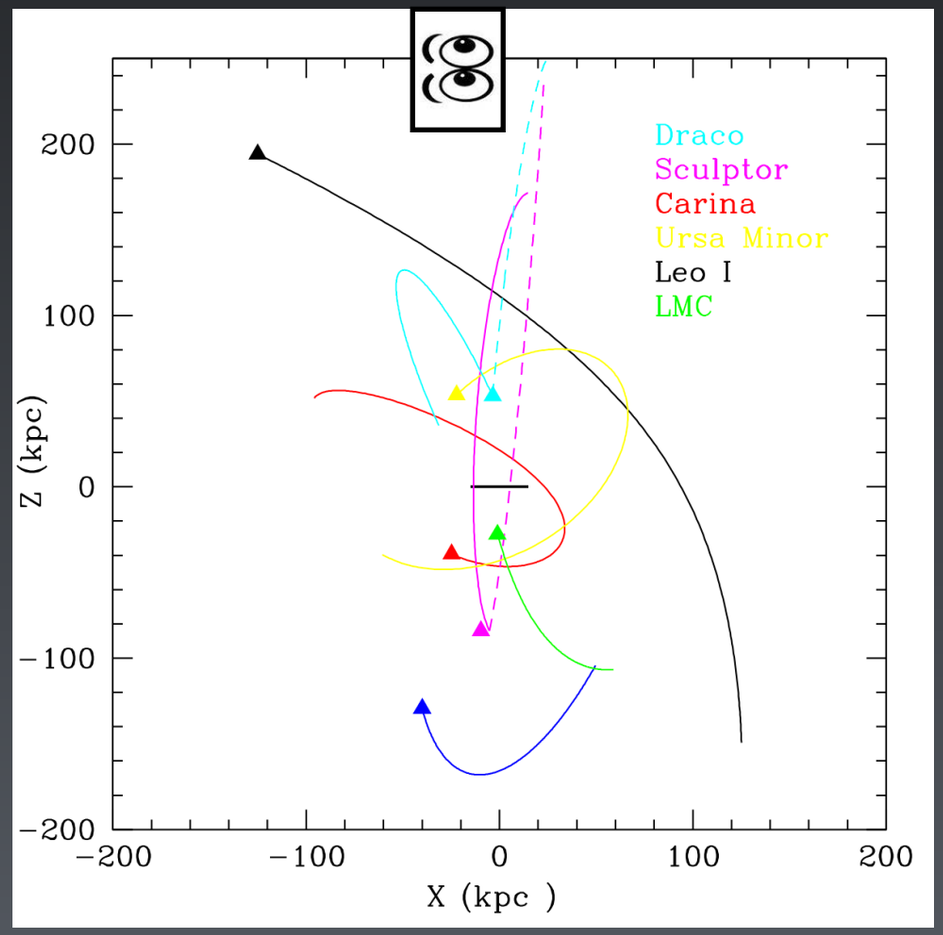


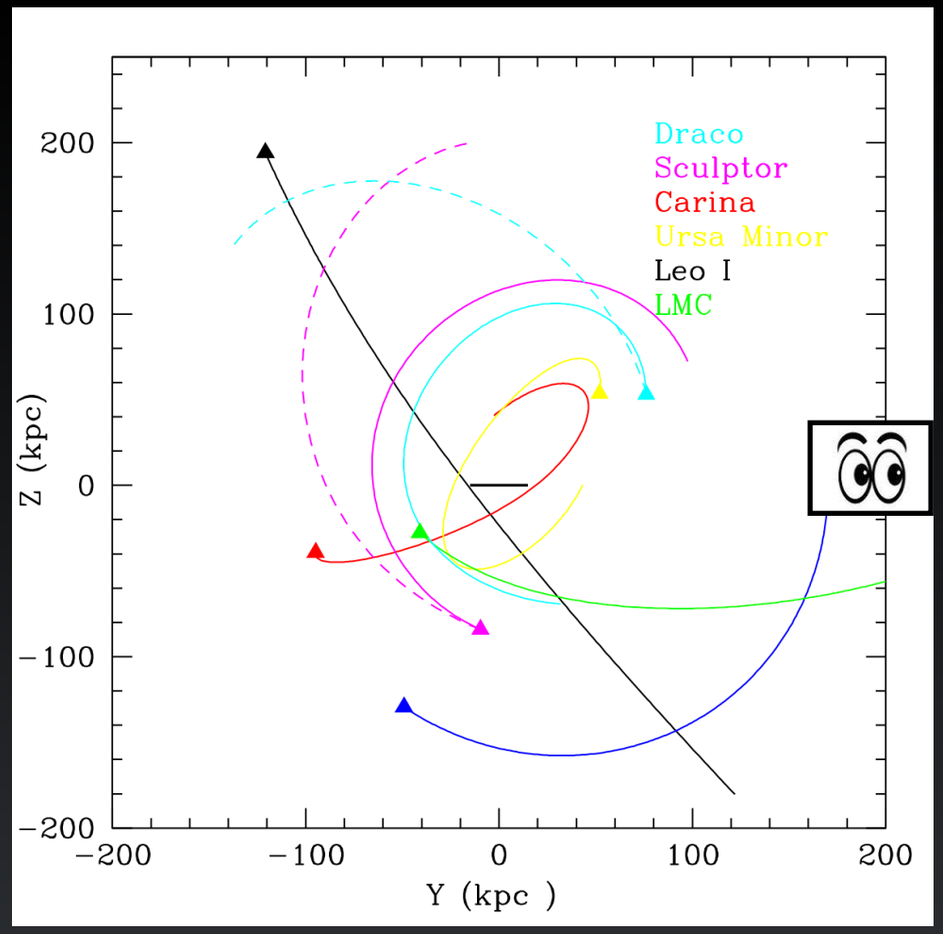


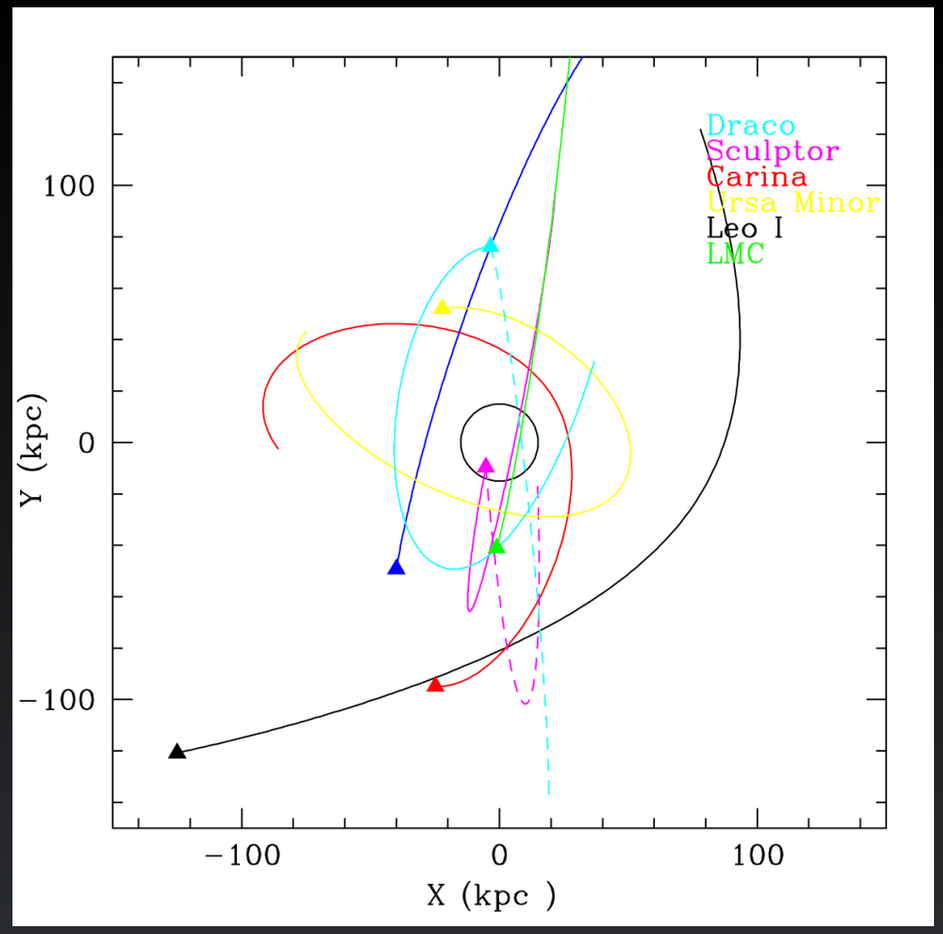




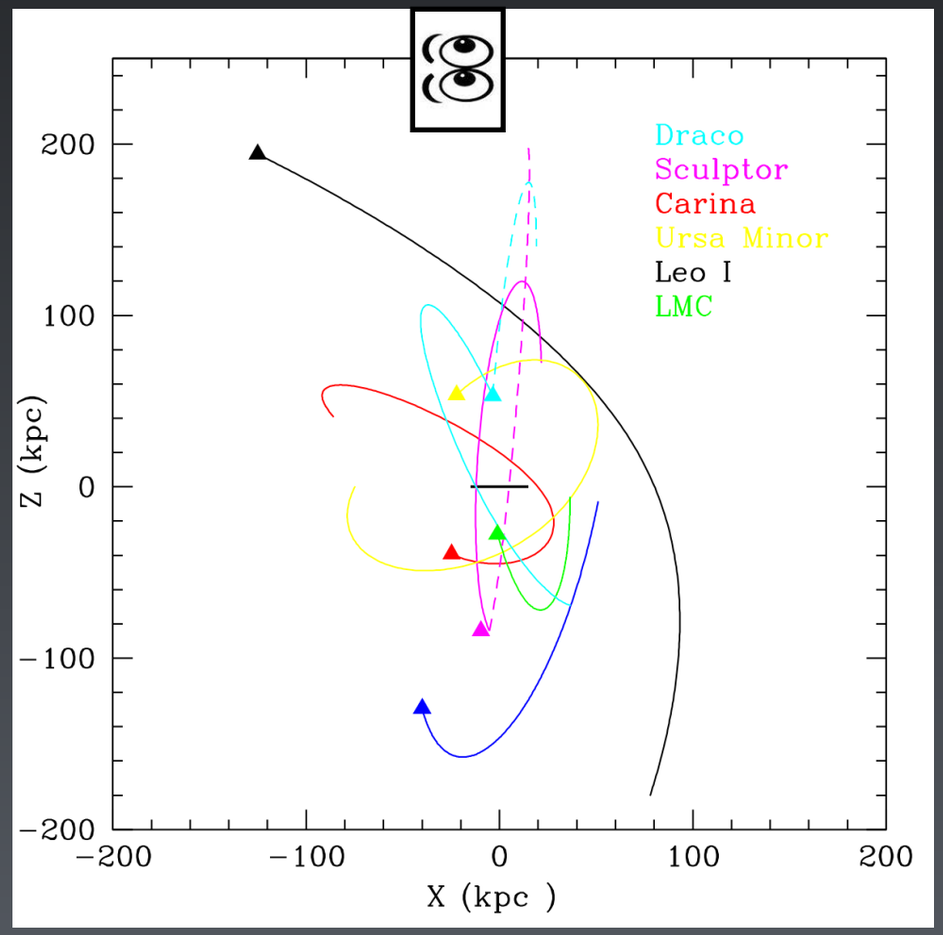
$M_{MW} = 1.0 \times 10^{12}\ M_{\odot}$

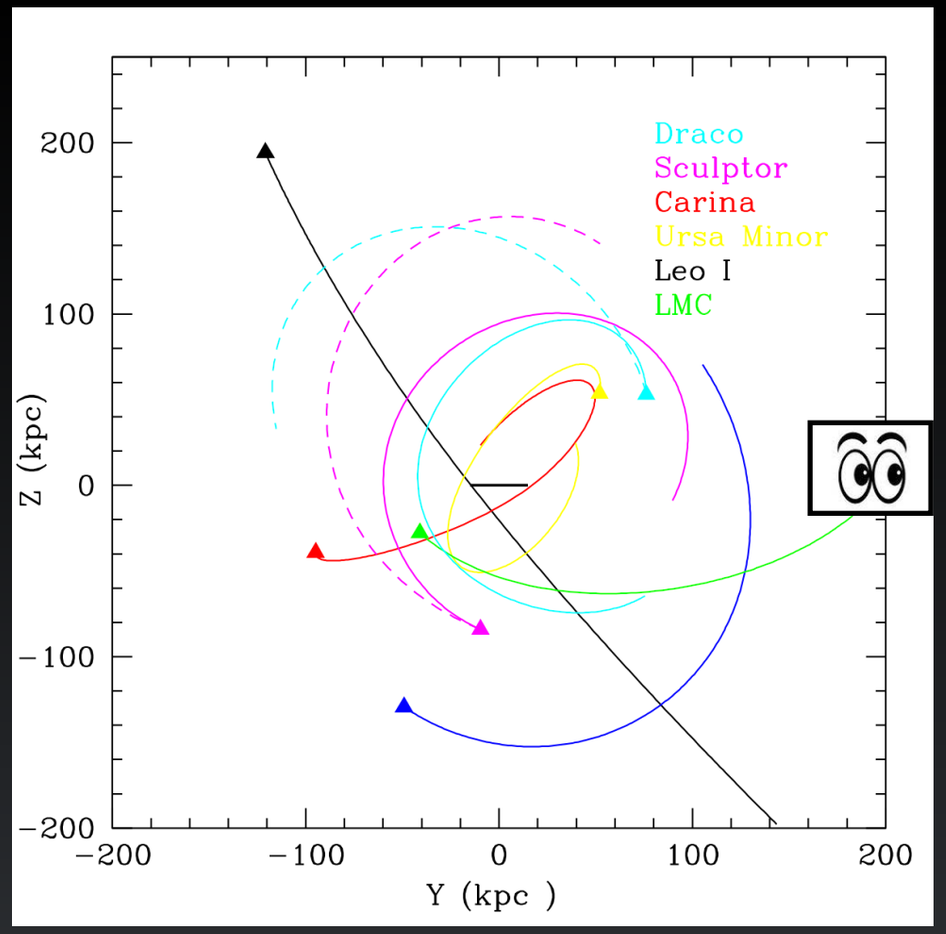


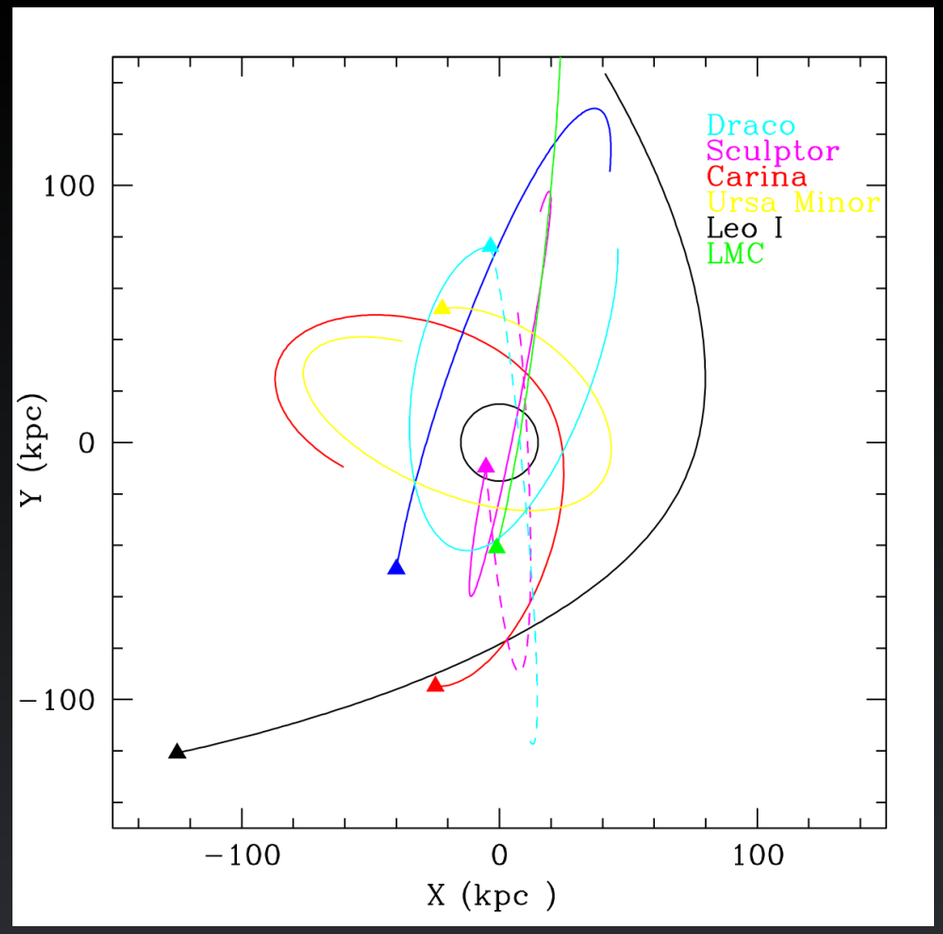




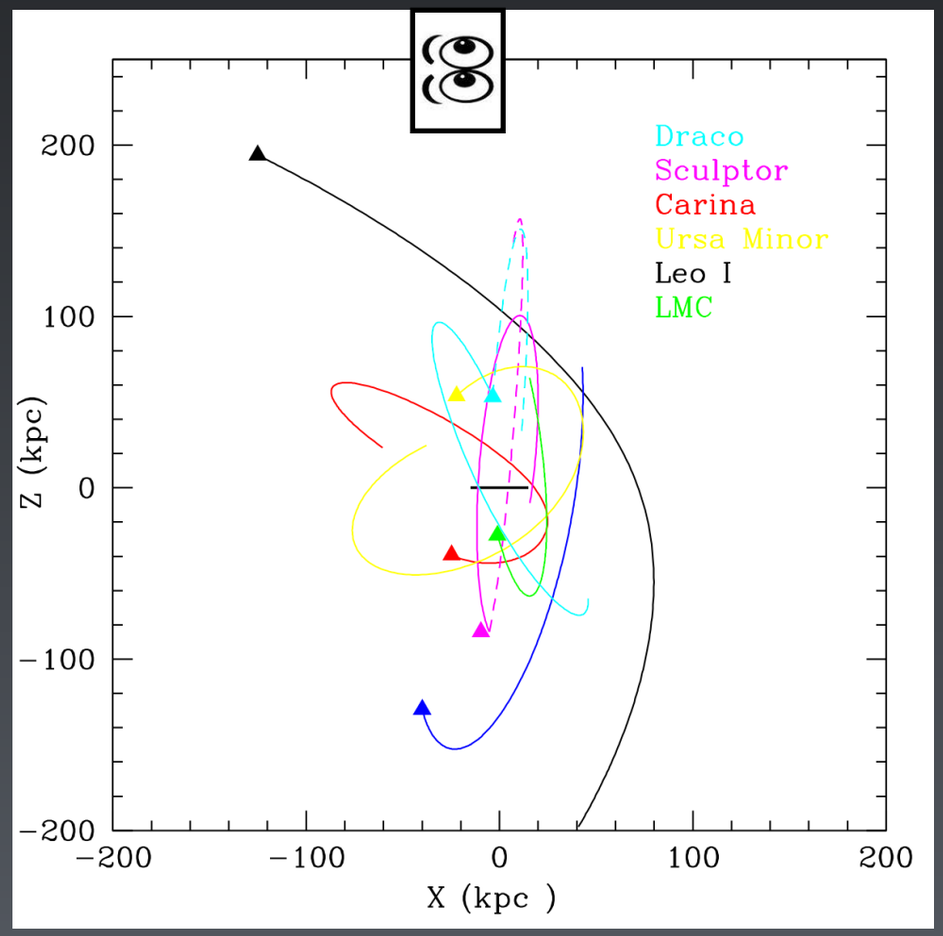
$M_{MW} = 1.5 \times 10^{12}\ M_{\odot}$







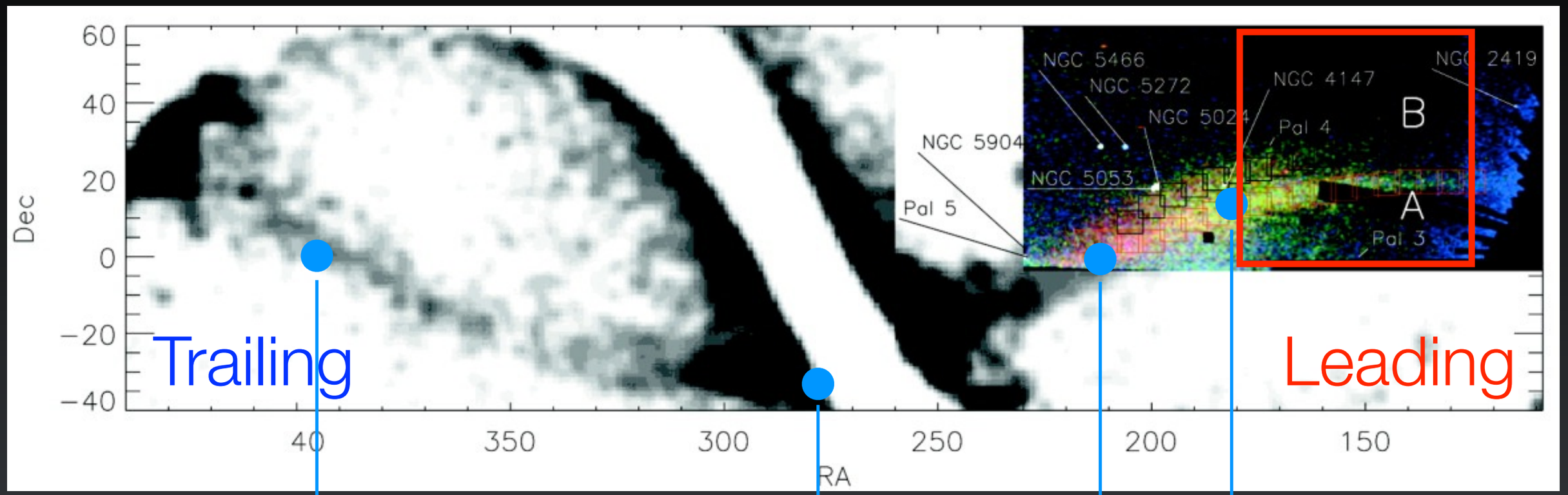
$M_{MW} = 2.0 \times 10^{12}\ M_{\odot}$



With PM-based orbits we can:

- Link orbital evolutions with their SFHs.
- Constrain the MW mass.
- Look for possible interactions between satellites.
- Test the dynamical stability of the satellite plane.
- And more…

Sgr Stream (Sohn+2015)



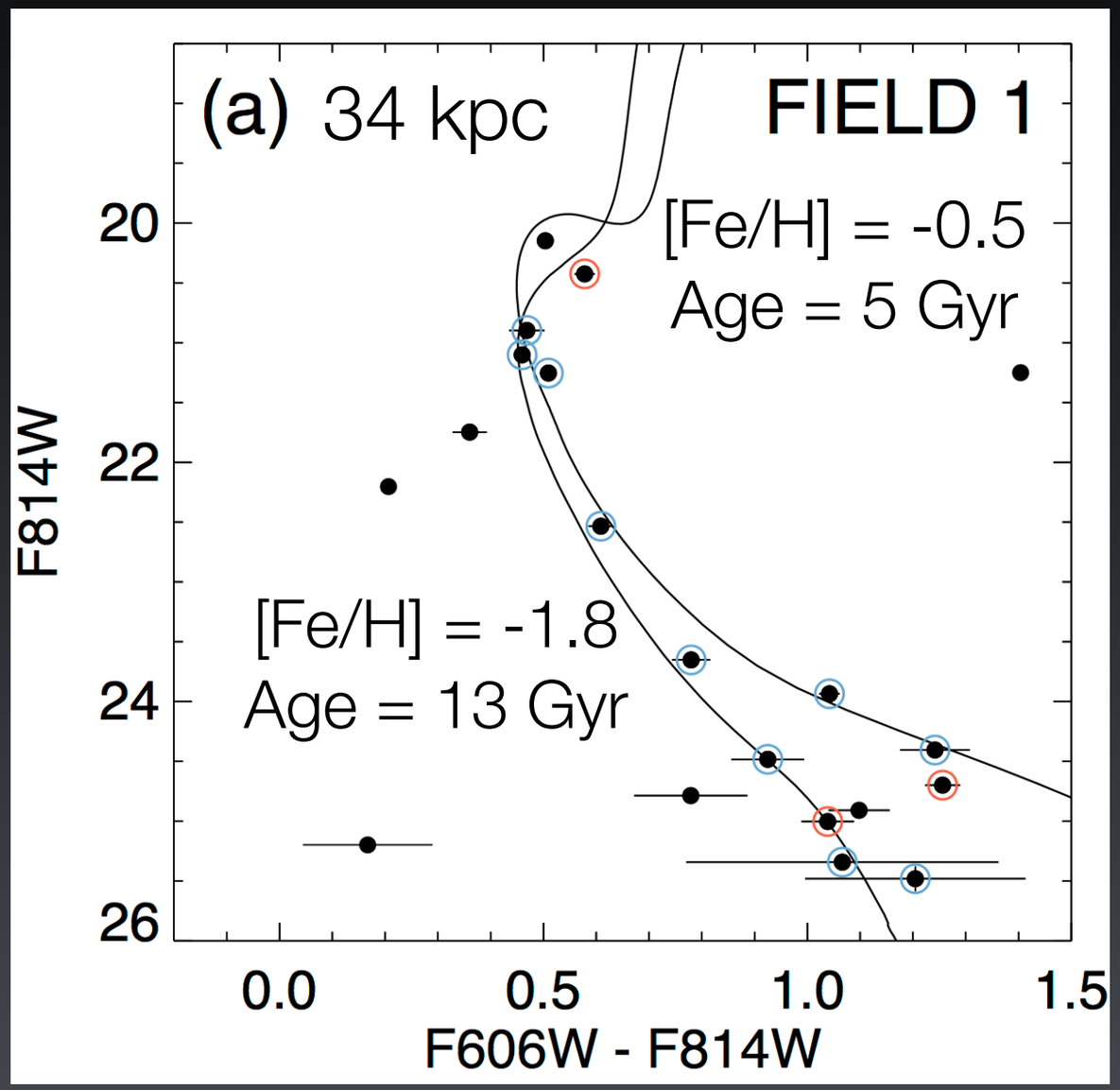
2MASS (Majewski et al. 2003) + SDSS (Belokurov et al. 2006)

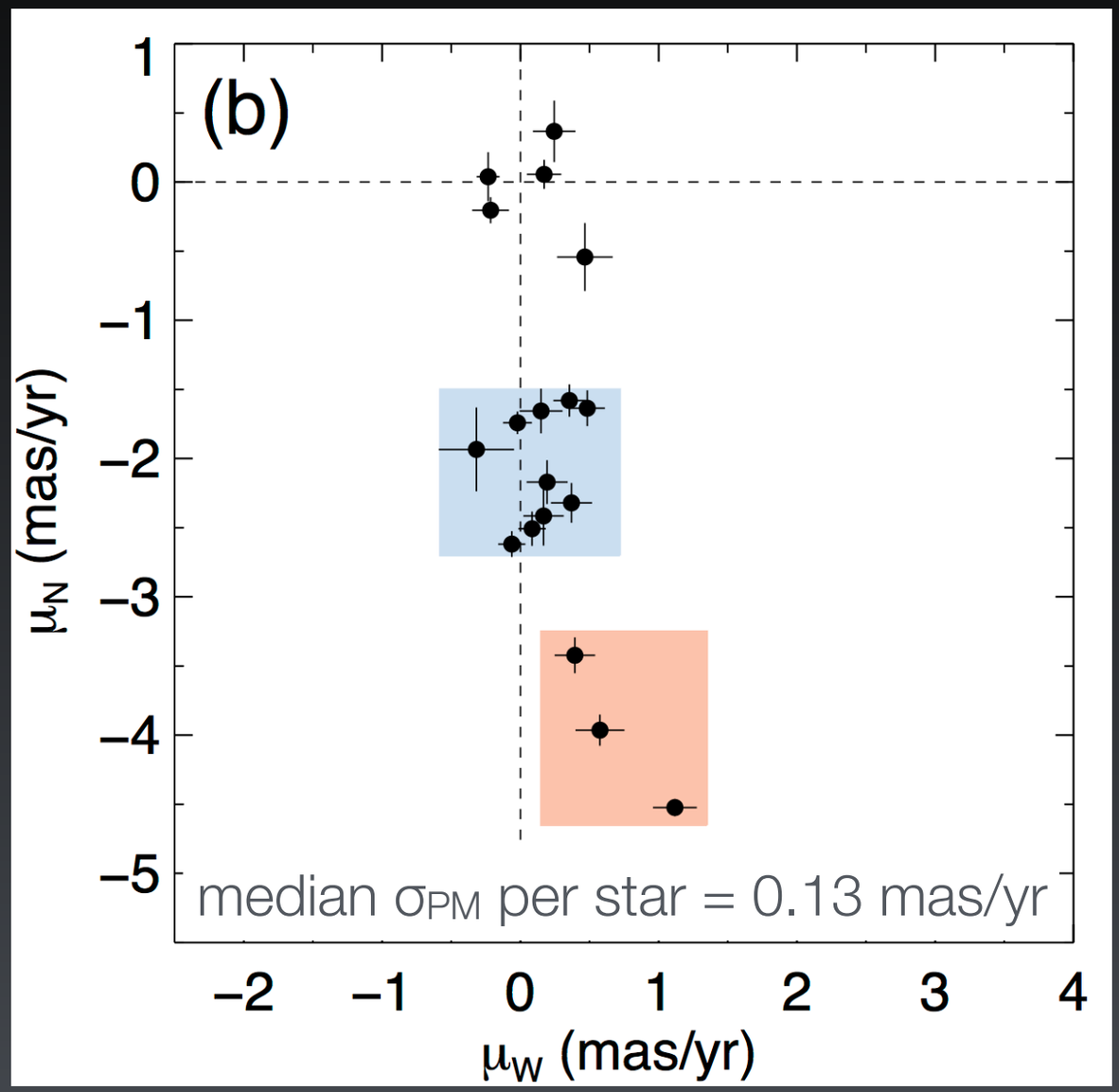
FIELD1 FIELD2 FIELD3 FIELD4

GDDS field GC (NGC 6652) QSOs (z ~ 4)

- 2 epochs per field, ΔT = 6~9 years
- ACS/WFC F775W or F814W (+F606W for CMDs)

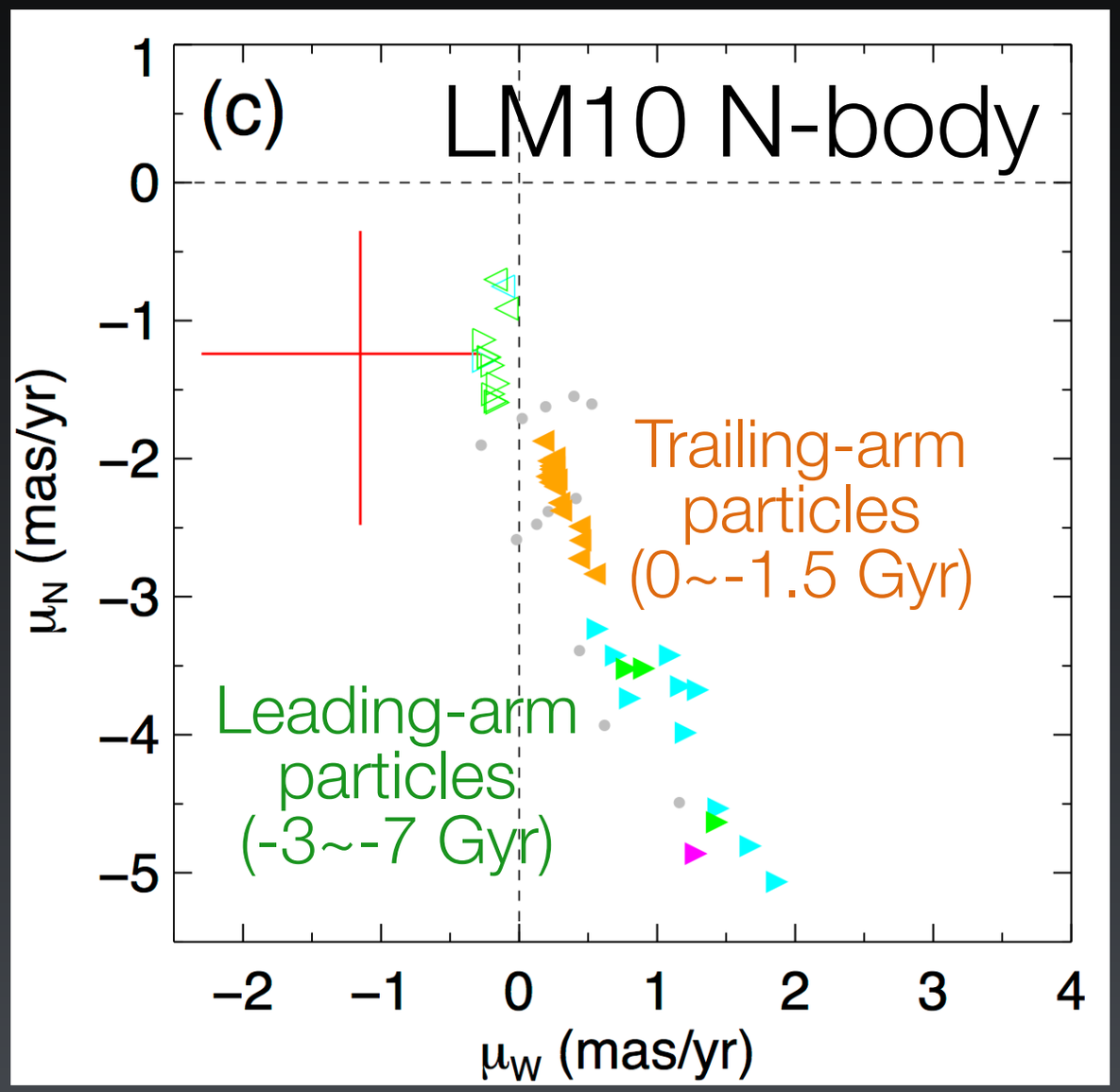
Sagittarius Stream: FIELD 1

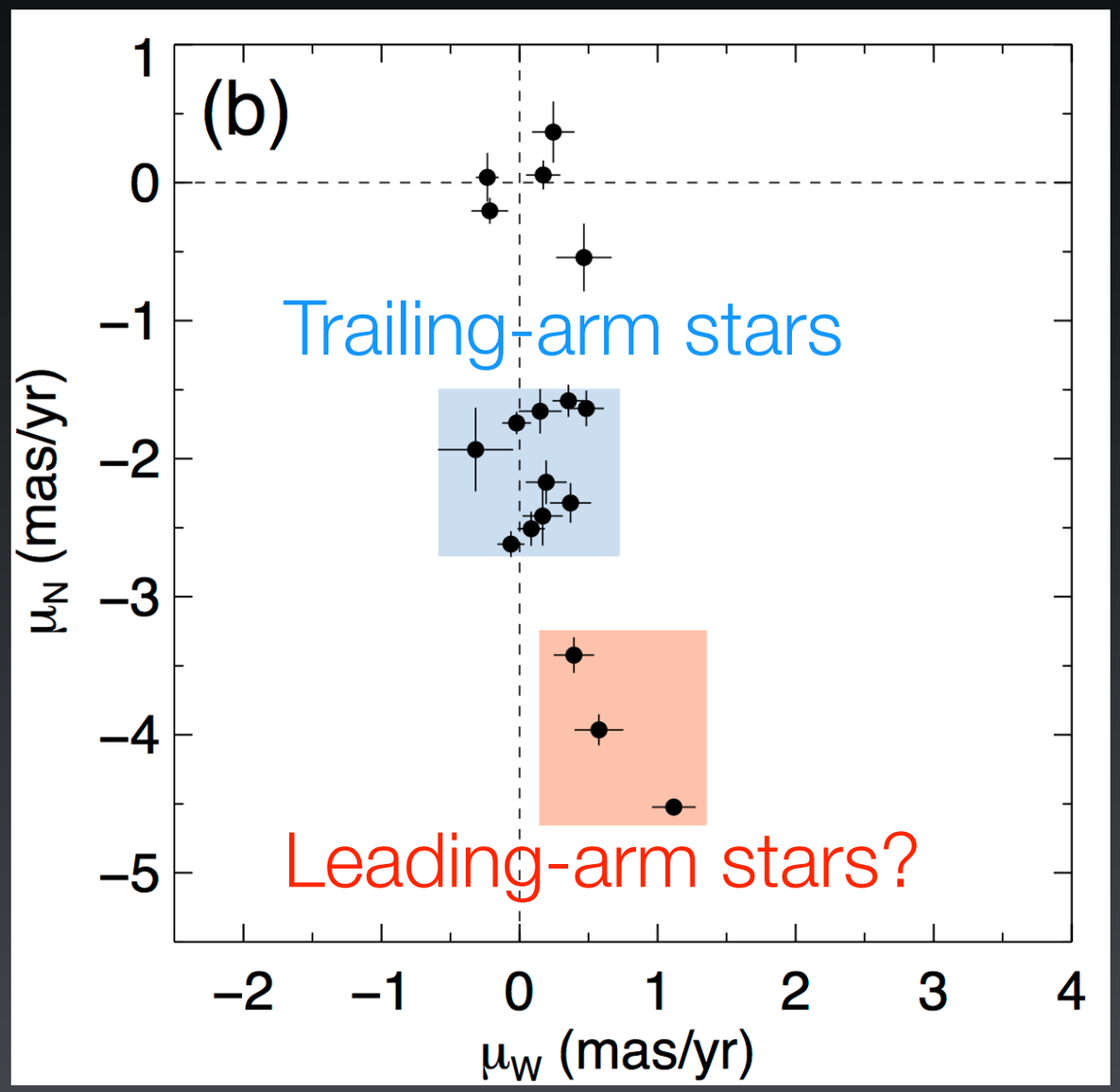




Trailing-arm Field

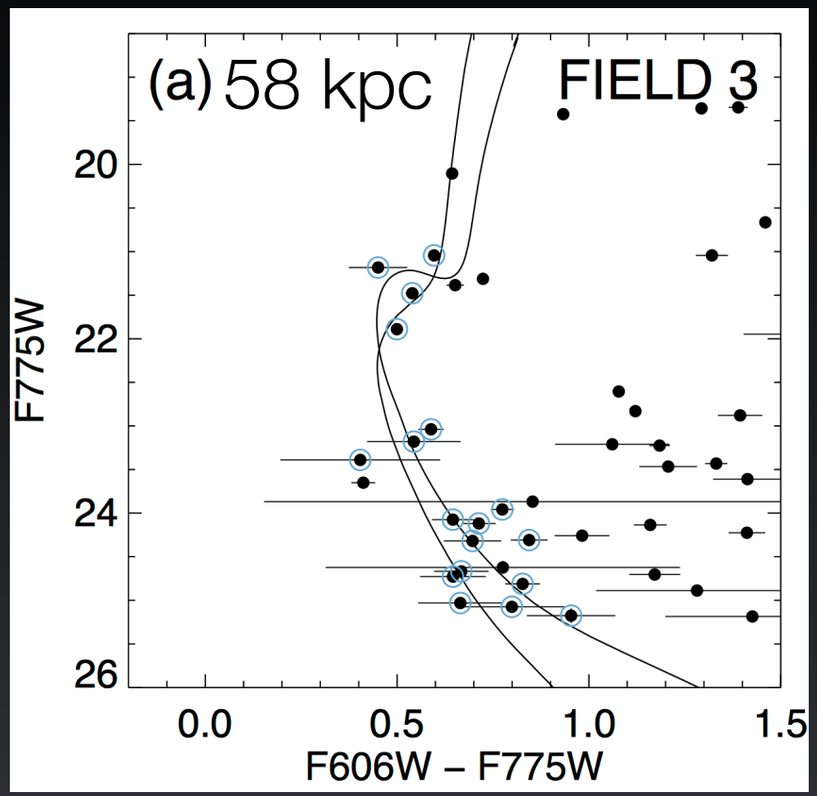
Sagittarius Stream: FIELD 1

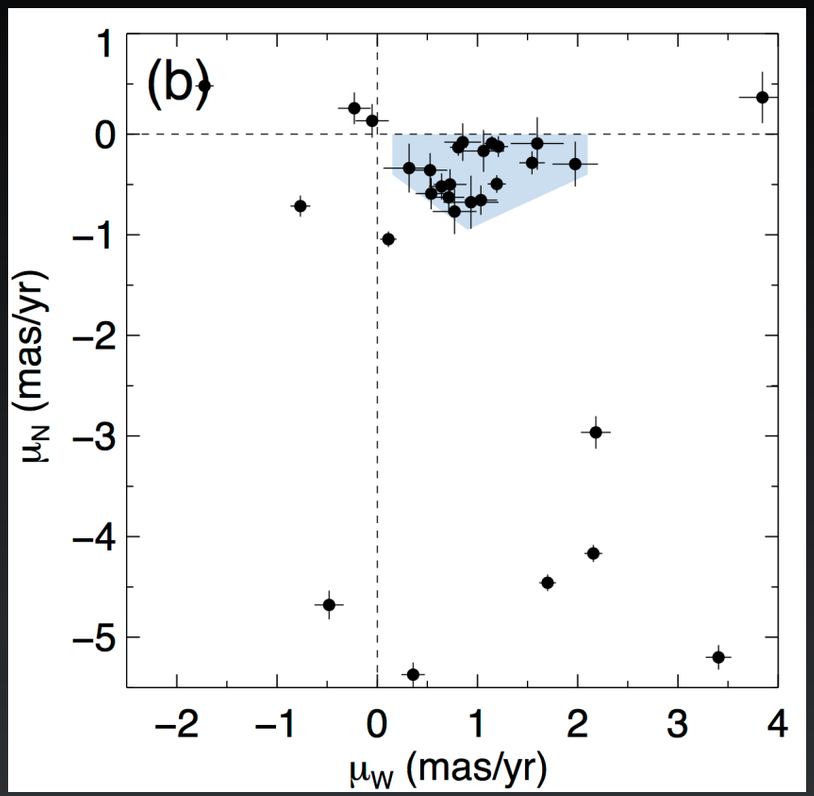


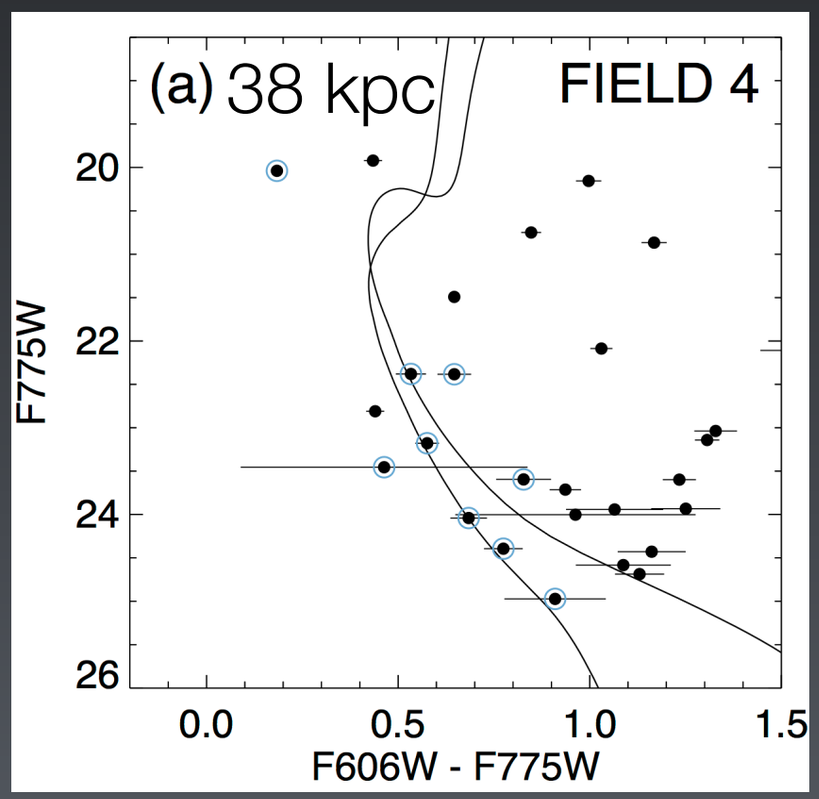


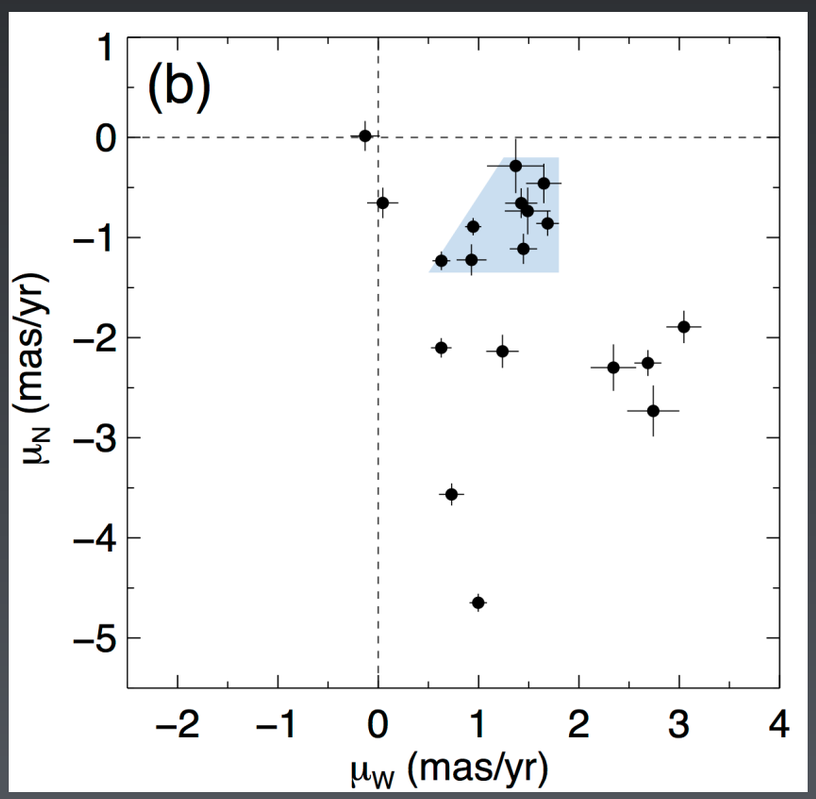
Trailing-arm Field

Sgr Stream: Leading-arm Fields

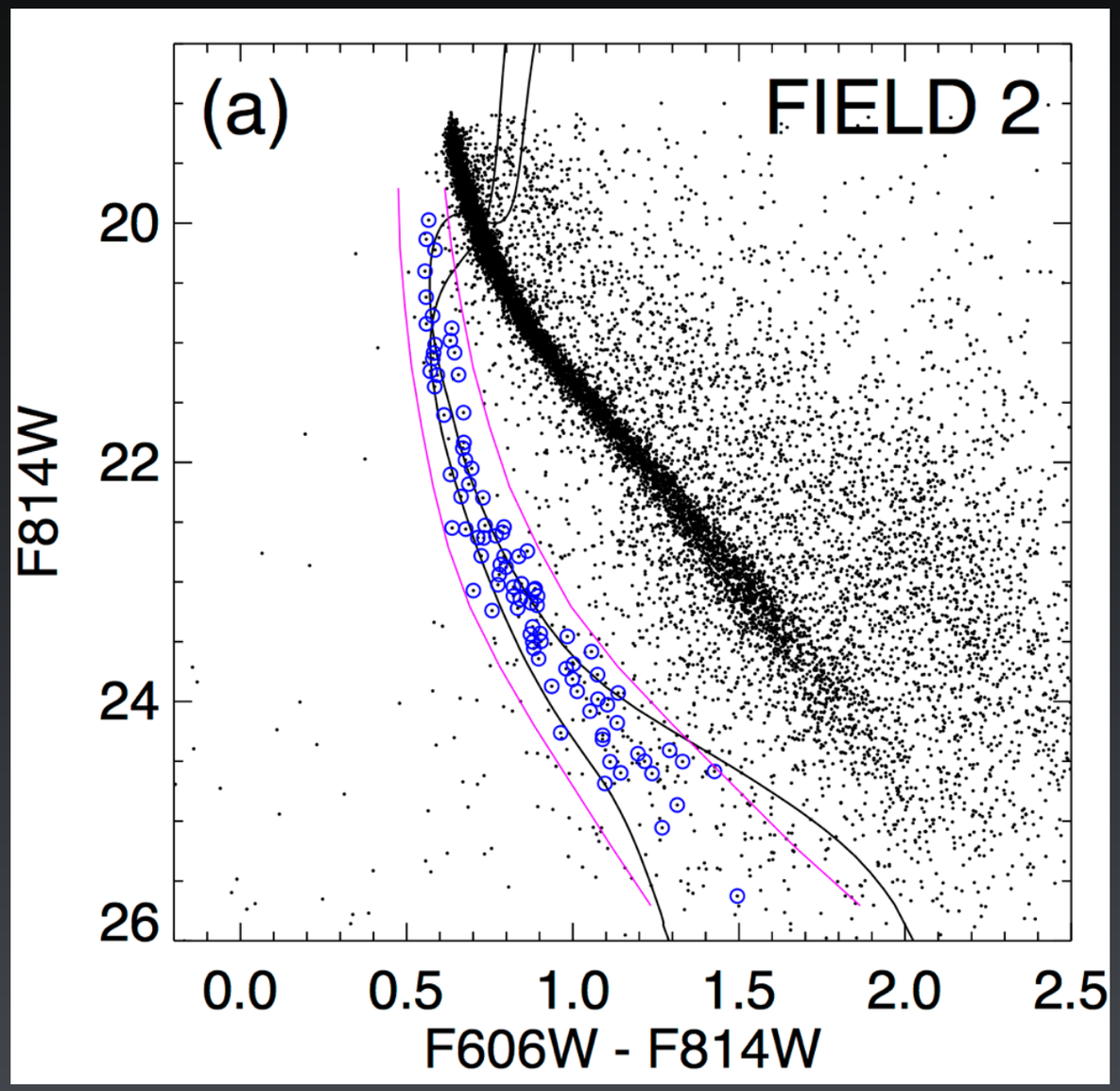


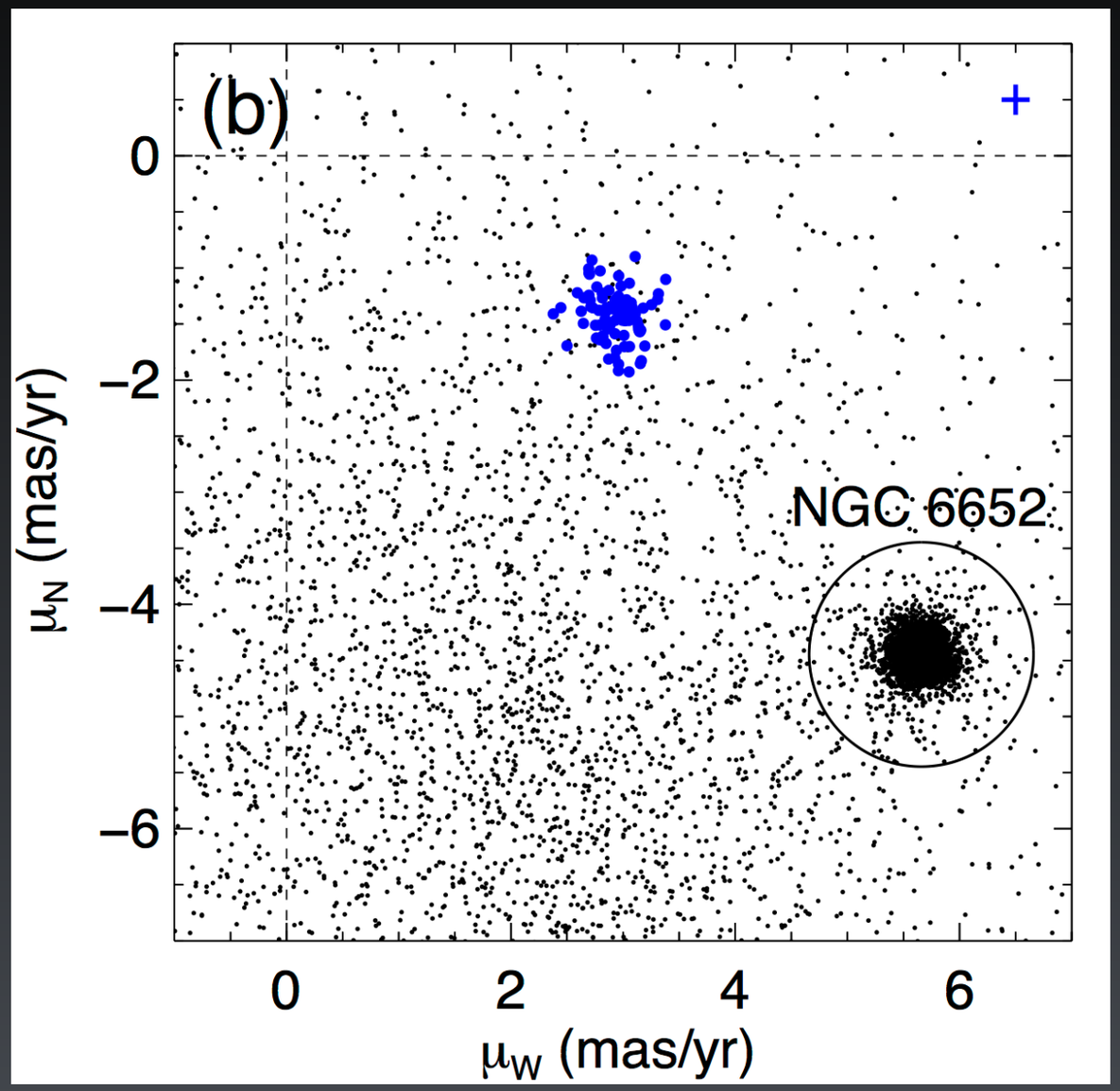






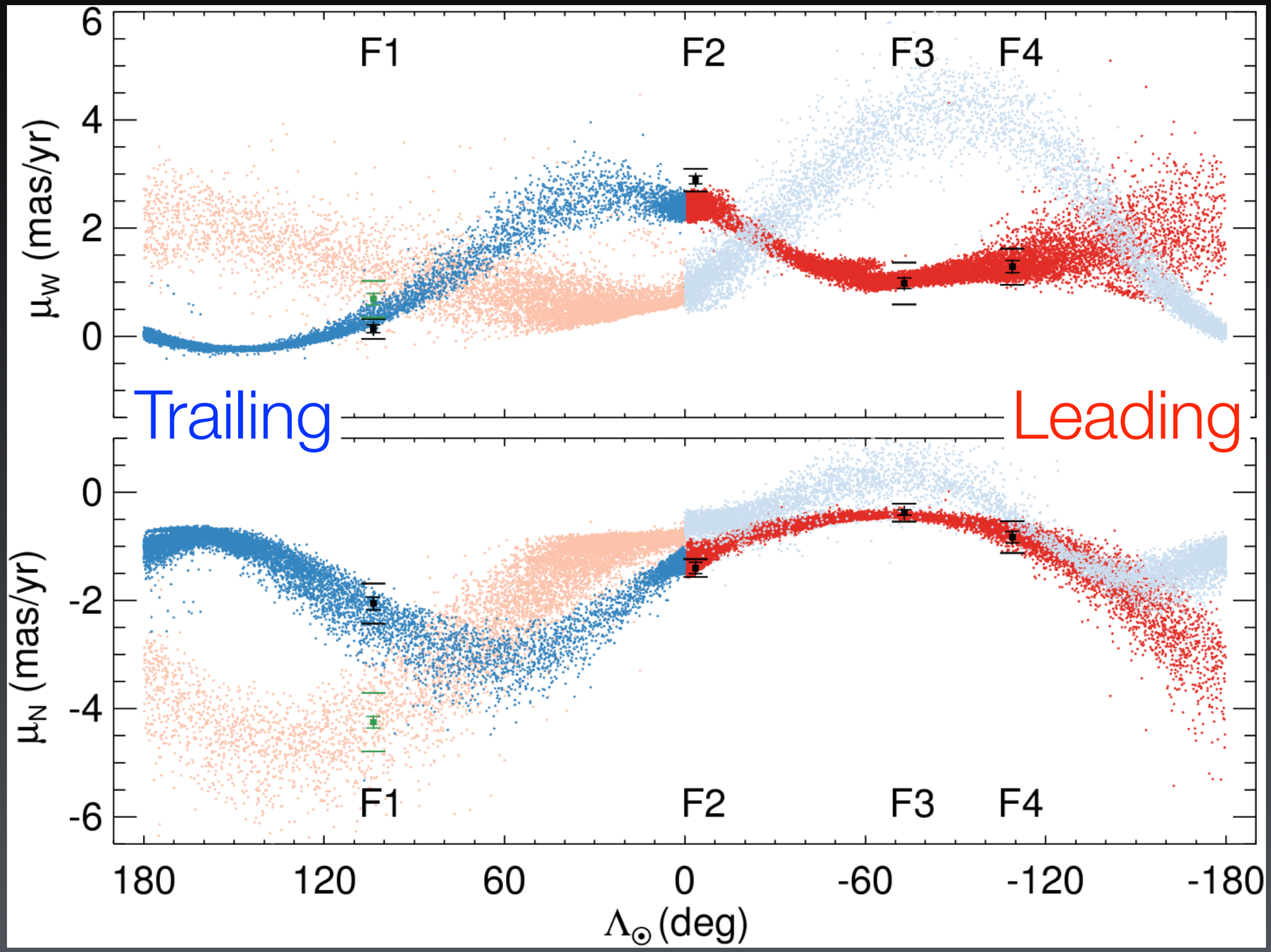
Sagittarius Stream: FIELD 2



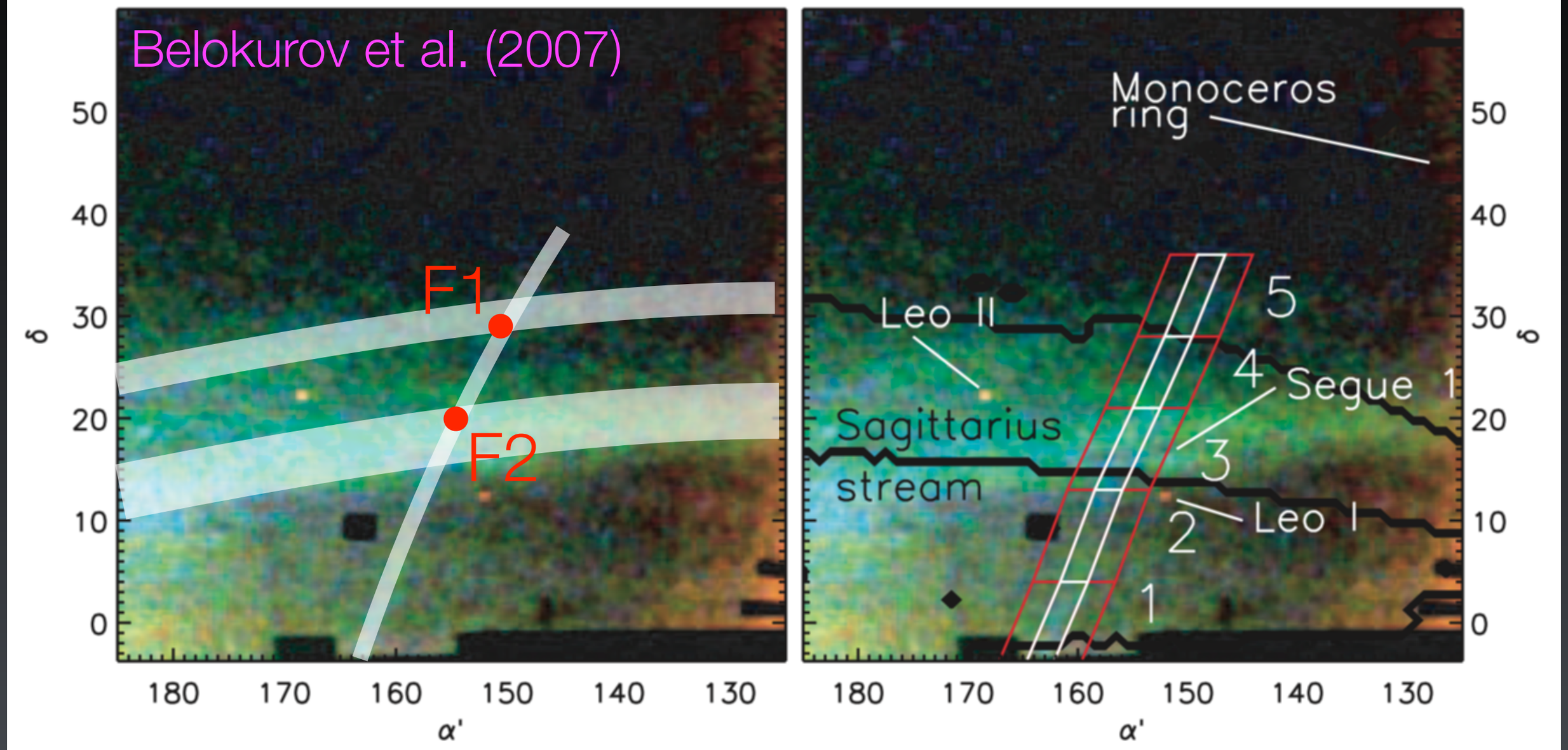


Central Field

Comparison to LM10 Model

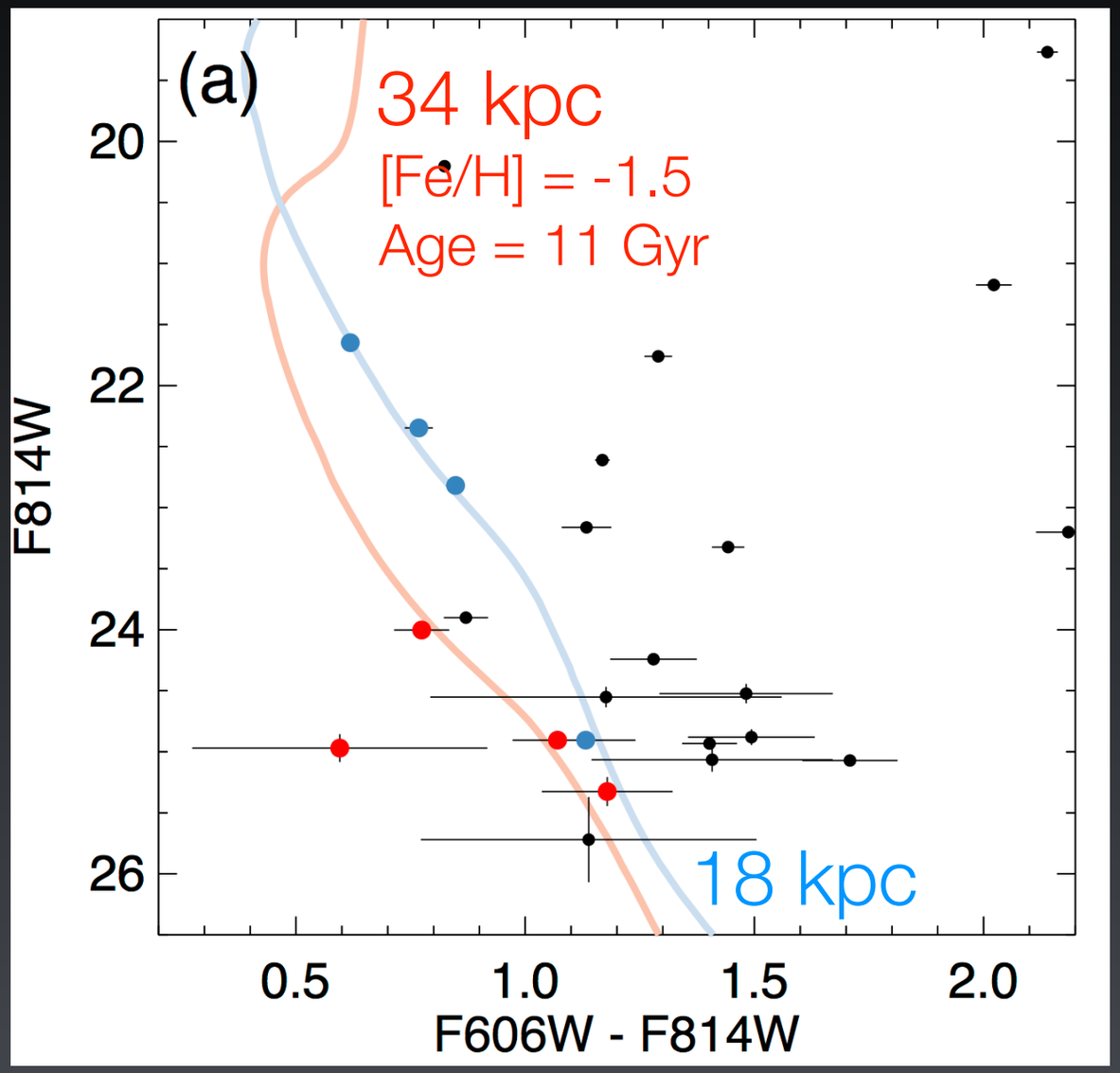


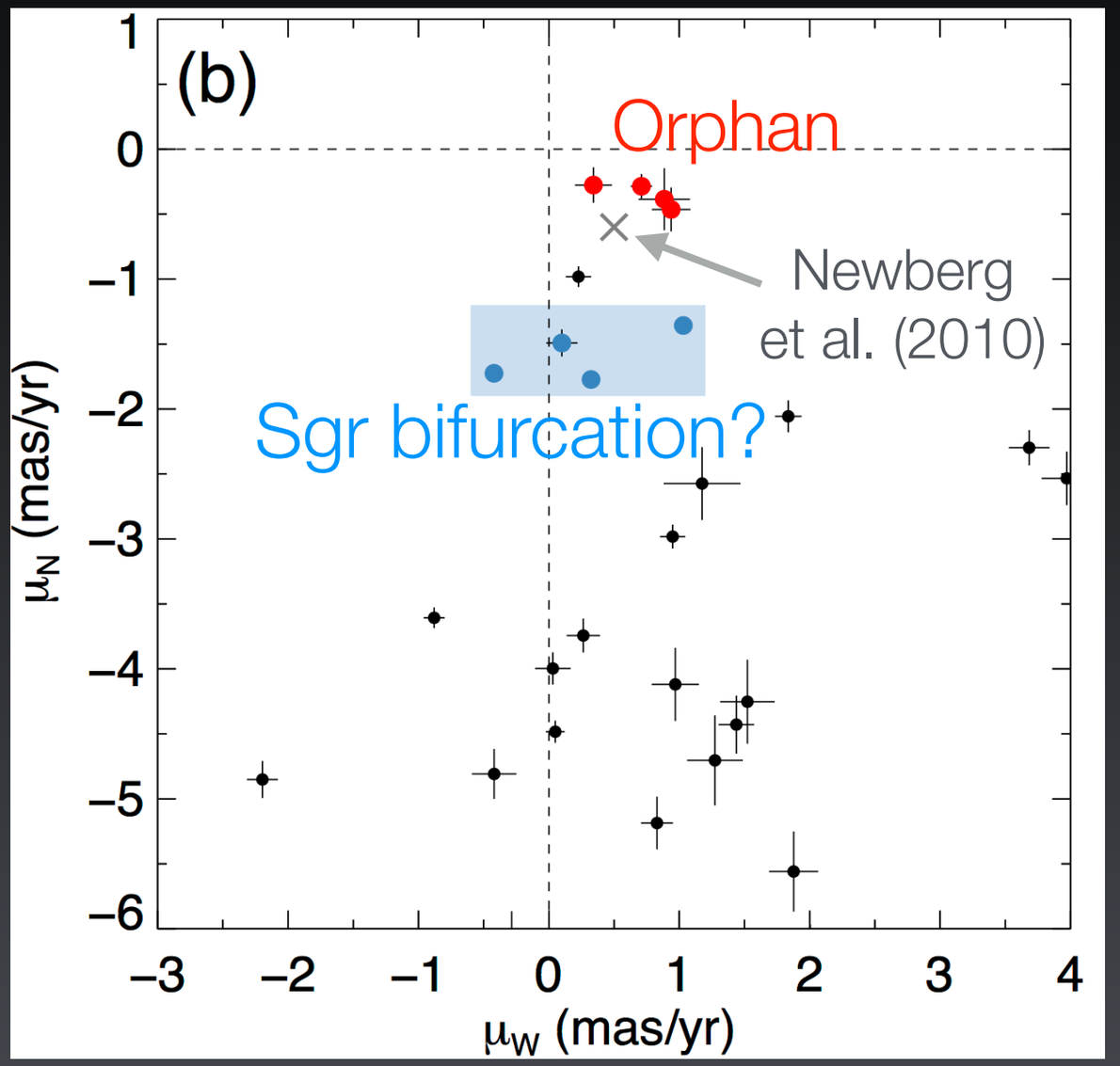
Orphan Stream (Sohn+, in prep)



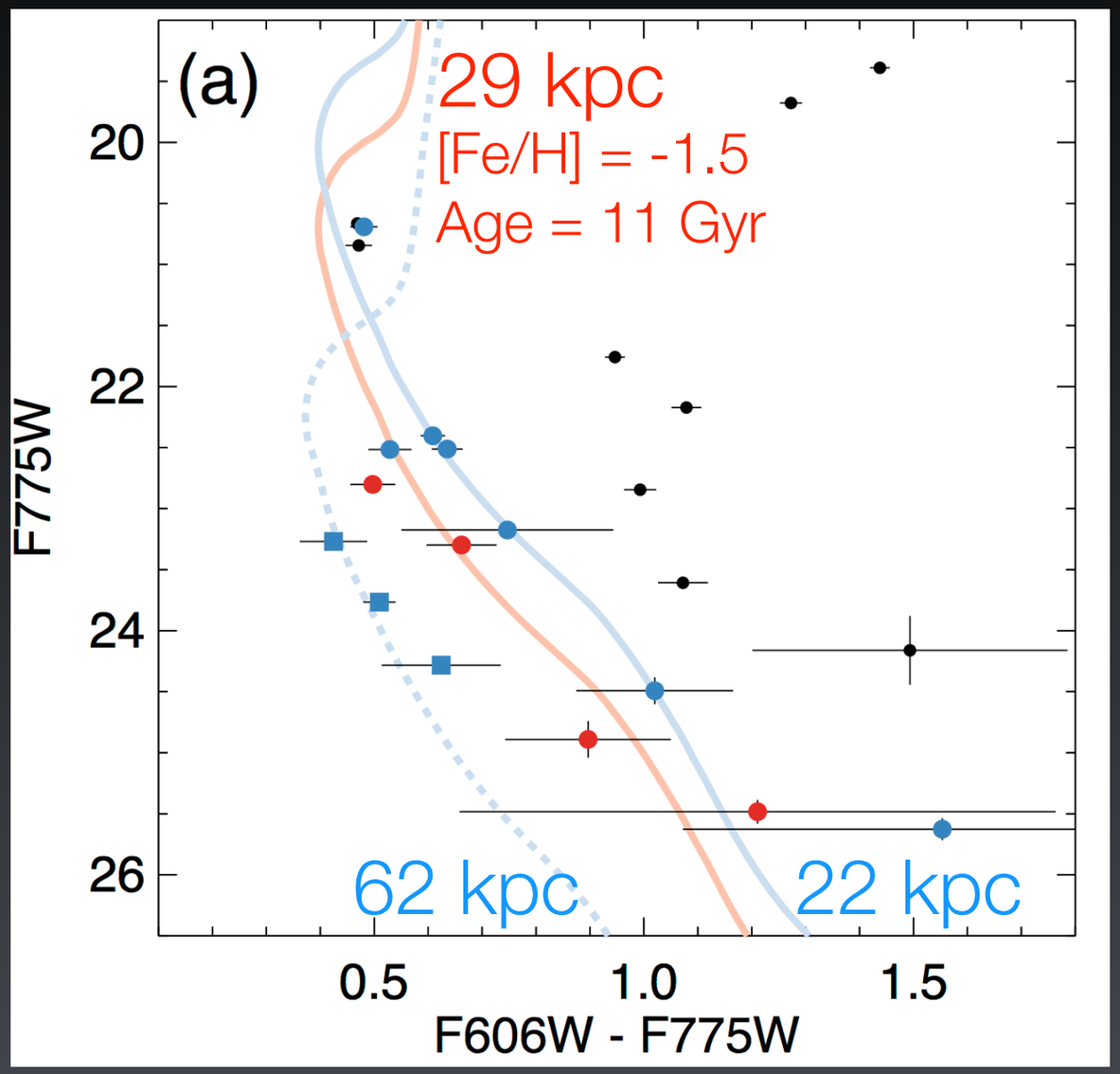
- 2 epochs per field, ΔT = 11~12 years
- ACS/WFC F814W/F775W (+F606W for CMDs)

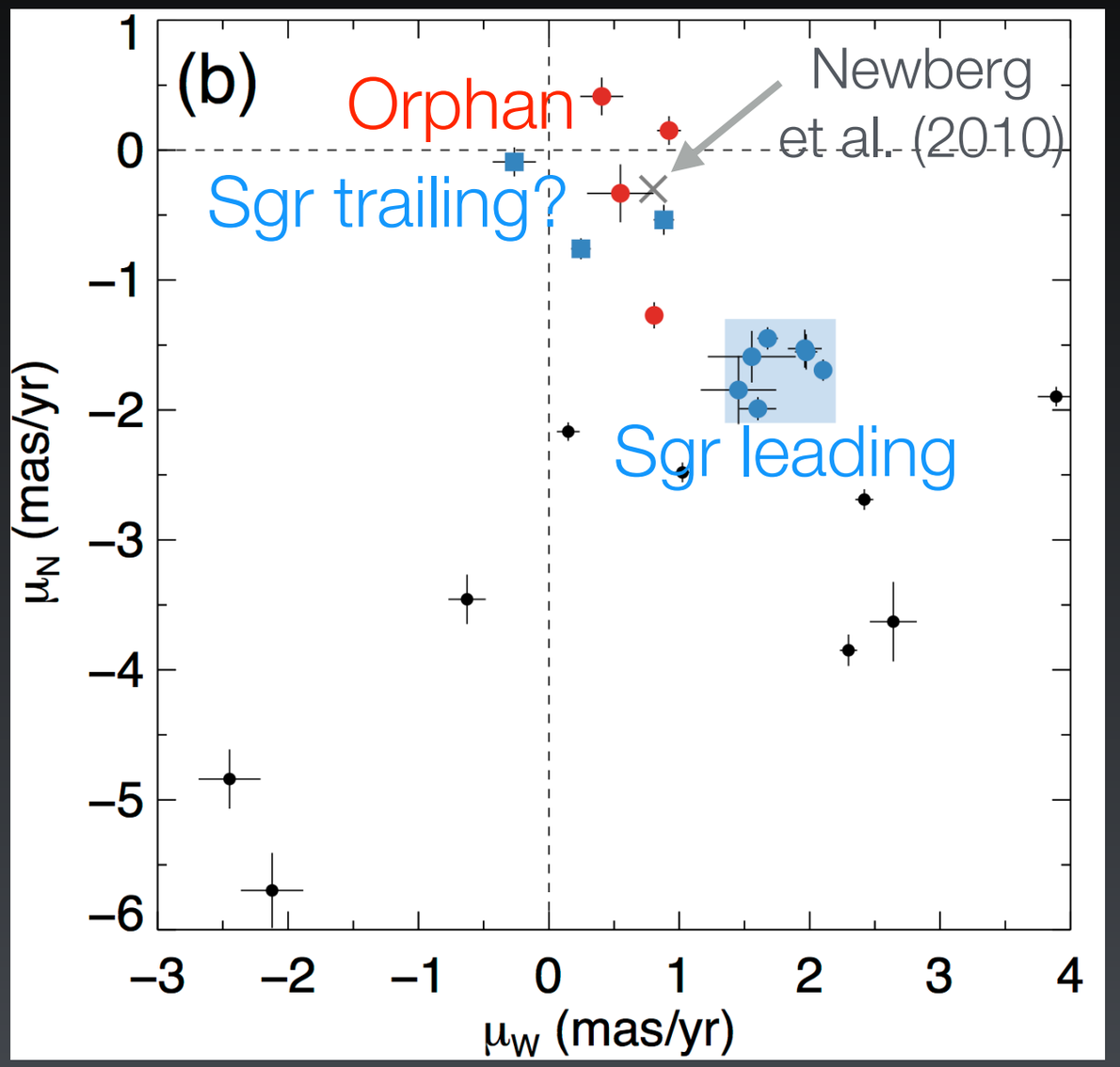
Orphan Stream: FIELD 1



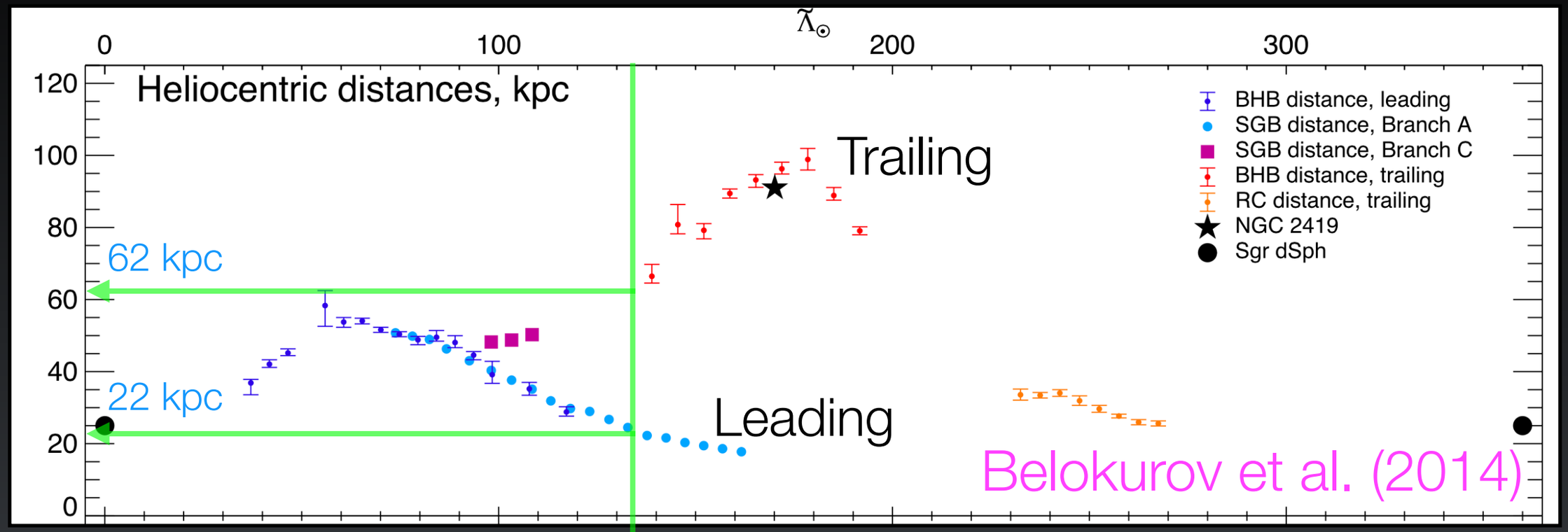


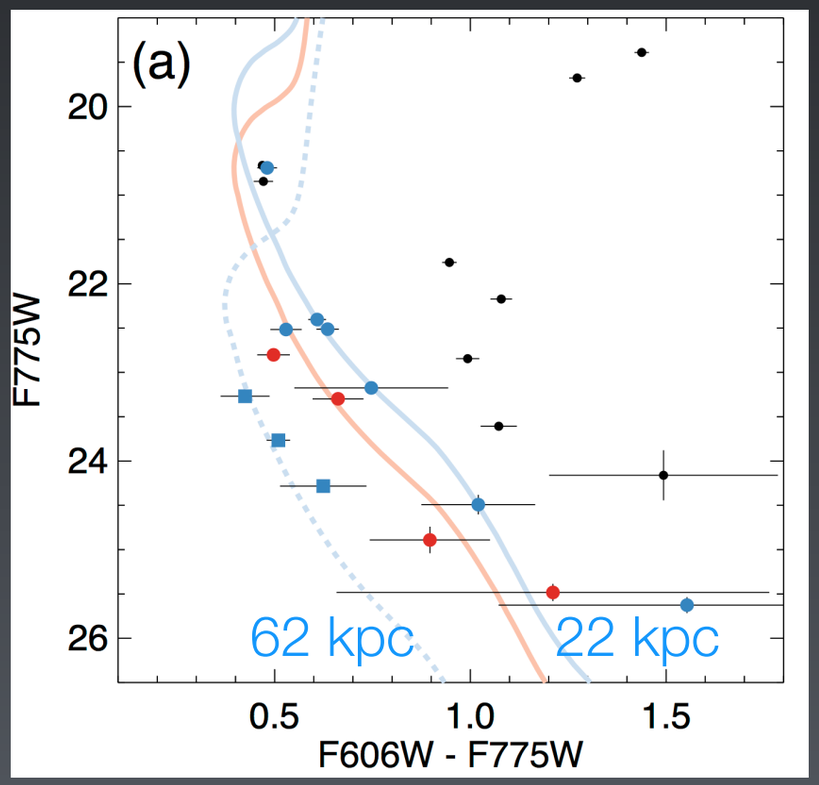
Orphan Stream: FIELD 2



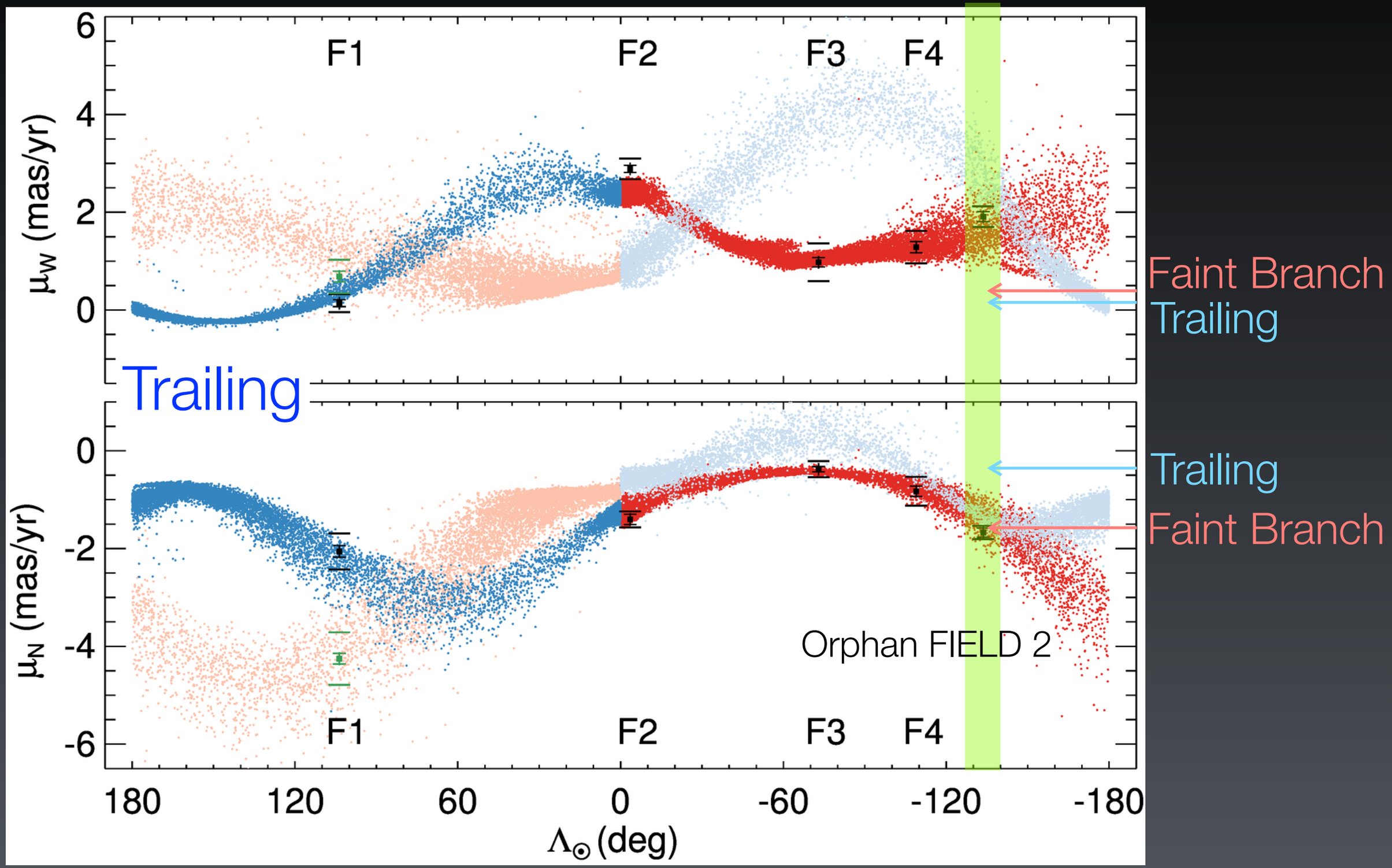


Orphan Stream: FIELD 2





Comparison to LM10 Model



Conclusions

- ≲10 km/s V_{tan} errors for dSphs are now a reality!
- Accurate orbital calculations in progress.
  ➥ M_{MW} profile / SFH-orbits / Interactions / VPOS?
- Successfully ID-ed Sgr / Orphan stars & PM measured.
  ➥ HST works well on MW halo streams.
- PM results broadly consistent with existing models.
  ➥ Detailed data-model comparison possible.
- HST allows star-by-star PM analysis.
- Multiple kinematical components found in some fields.