

Constraints on LMC Internal Kinematics from HST+JWST Proper Motions

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(STScI)

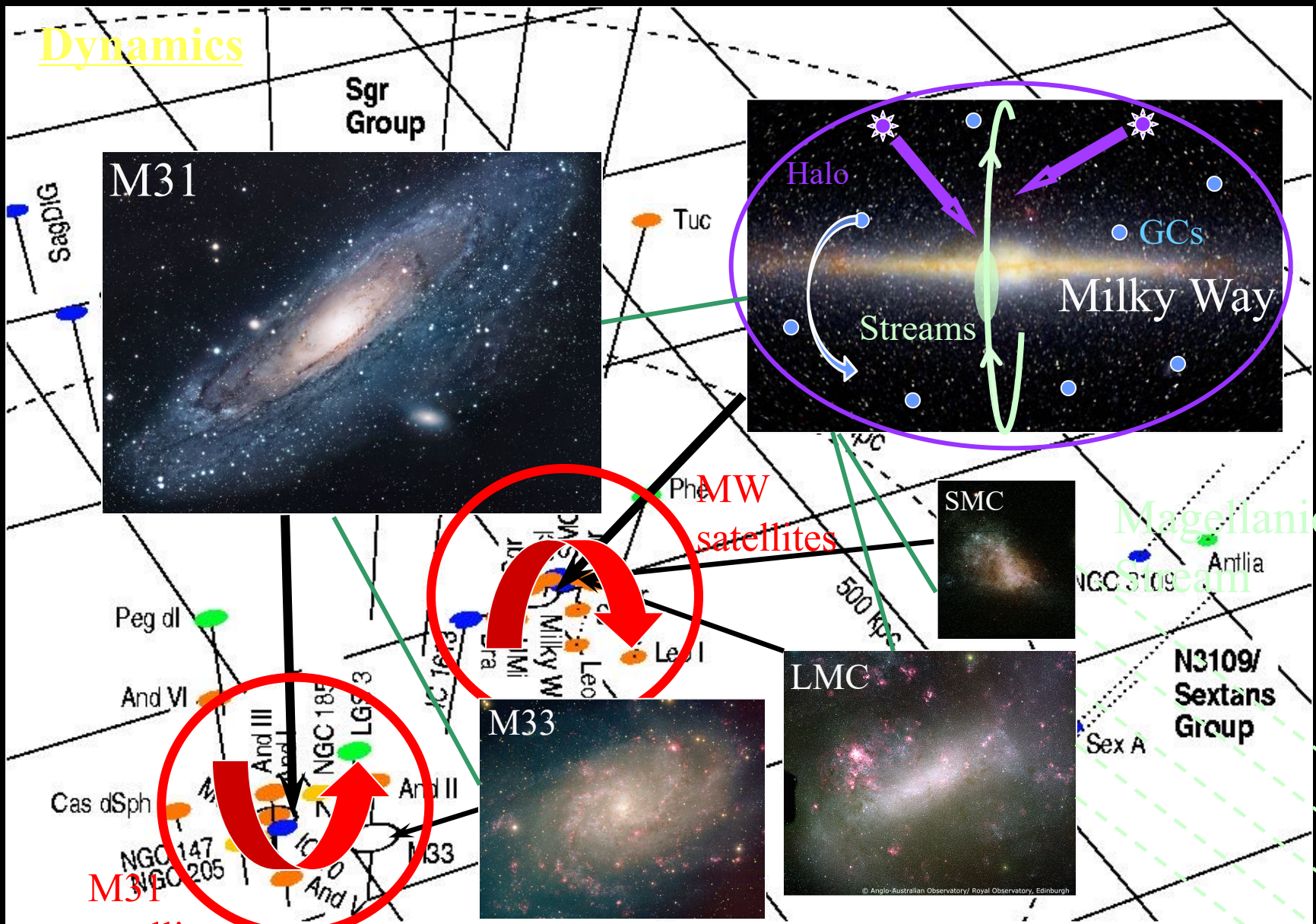
HSTPROMO: High-Resolution Space Telescope Proper Motion Collaboration

(<http://www.stsci.edu/~marel/hstpromo.html>)

- Set of many different HST, Gaia, JWST investigations, with detailed theory components
 - Lead coordinators:
van der Marel & Anderson
 - Current key members:
Bellini, Bennet, Besla, del Pino, Fardal, Guhathakurta, Kallivayalil, Libralato, McKinnon, Patel, Pawlowski, Sohn, Vitral, Watkins
 - Many other (former) associates
- Status/Achievements
 - 20 years of work
 - 61 HST, 21 Gaia, 1 JWST papers

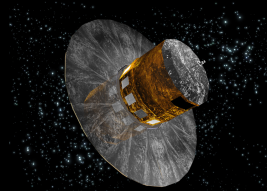


Dynamics

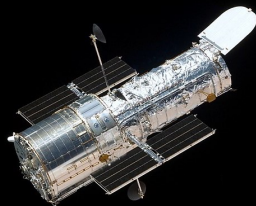


[Grebel 2000]

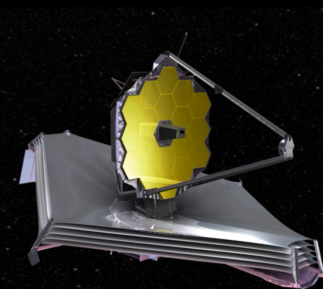
Current PM Capabilities from Space



- **GAIA:**
 - Fantastic for innumerable things + full sky coverage
 - Limited to $G < 20$ (and hence, “nearby” distances)



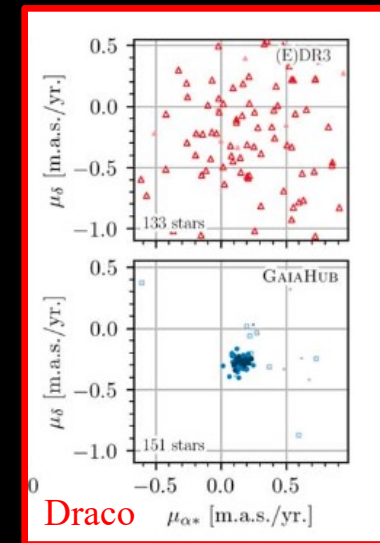
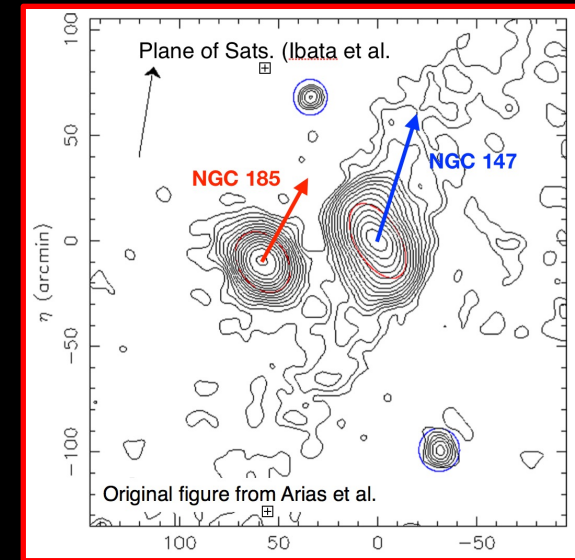
- **HST:**
 - Long time baselines with small FOV
 - High Accuracies to much fainter limits ($V \sim 25$)



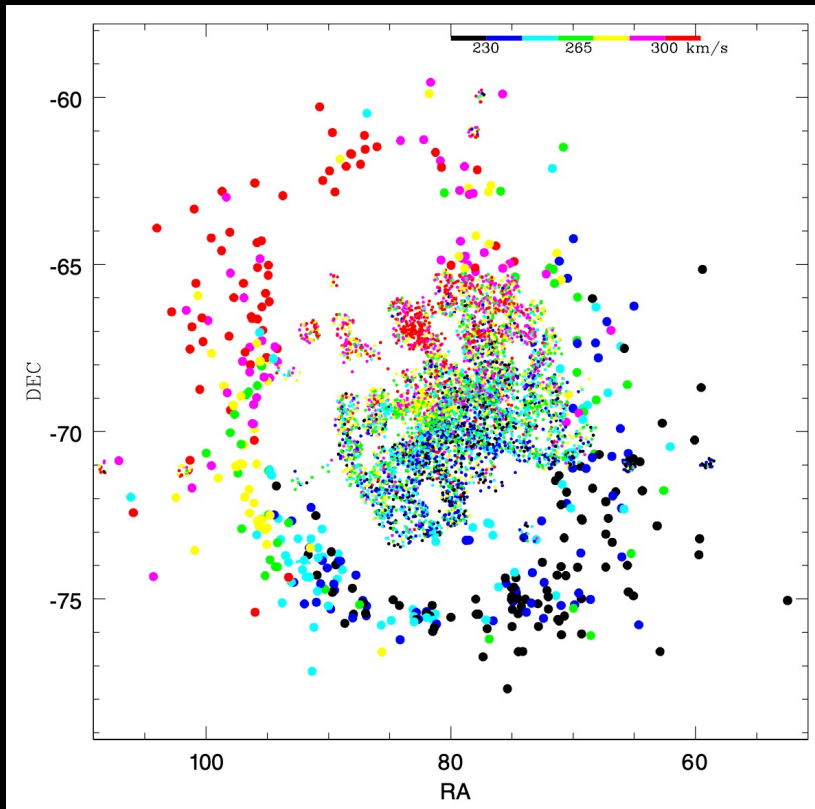
- **JWST:**
 - Similar spatial resolution and FOV to HST
 - Large mirror enables deeper studies
 - Infrared opens up extincted regions

Going beyond Gaia with Hubble+Webb

- Bulk PMs of distant galaxies
 - Andromeda satellites (e.g., Sohn+ 2020)
 - Distant Isolated Local Group Dwarfs (e.g., Bennet+ 2024)
 - Galaxies beyond the Local group (Cycle 31: Leo P, M81 group)
- Internal Dynamics of nearby dSphs
 - Draco (Vitril+ in prep.), Sculptor, Ursa Minor
- Galactic Center
 - Nuclear cluster, young clusters, fast stars (Libralato+ 2021; Anderson+/Lu+ in prep.)
- Improved PM accuracies from HST+Gaia
 - GaiaHub (del Pino+ 2022)
 - BP3M (McKinnon+ 2024)

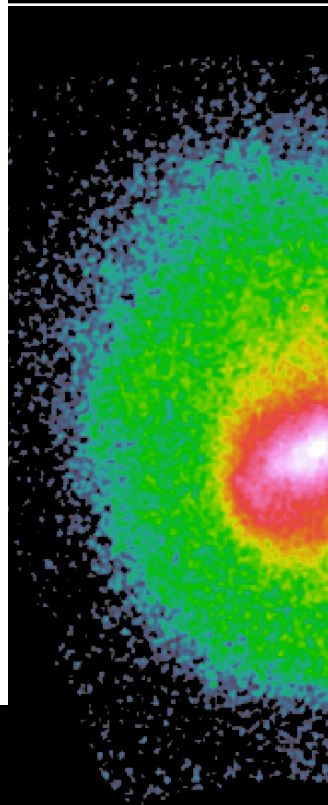


Evolution in Mapping LMC Kinematics



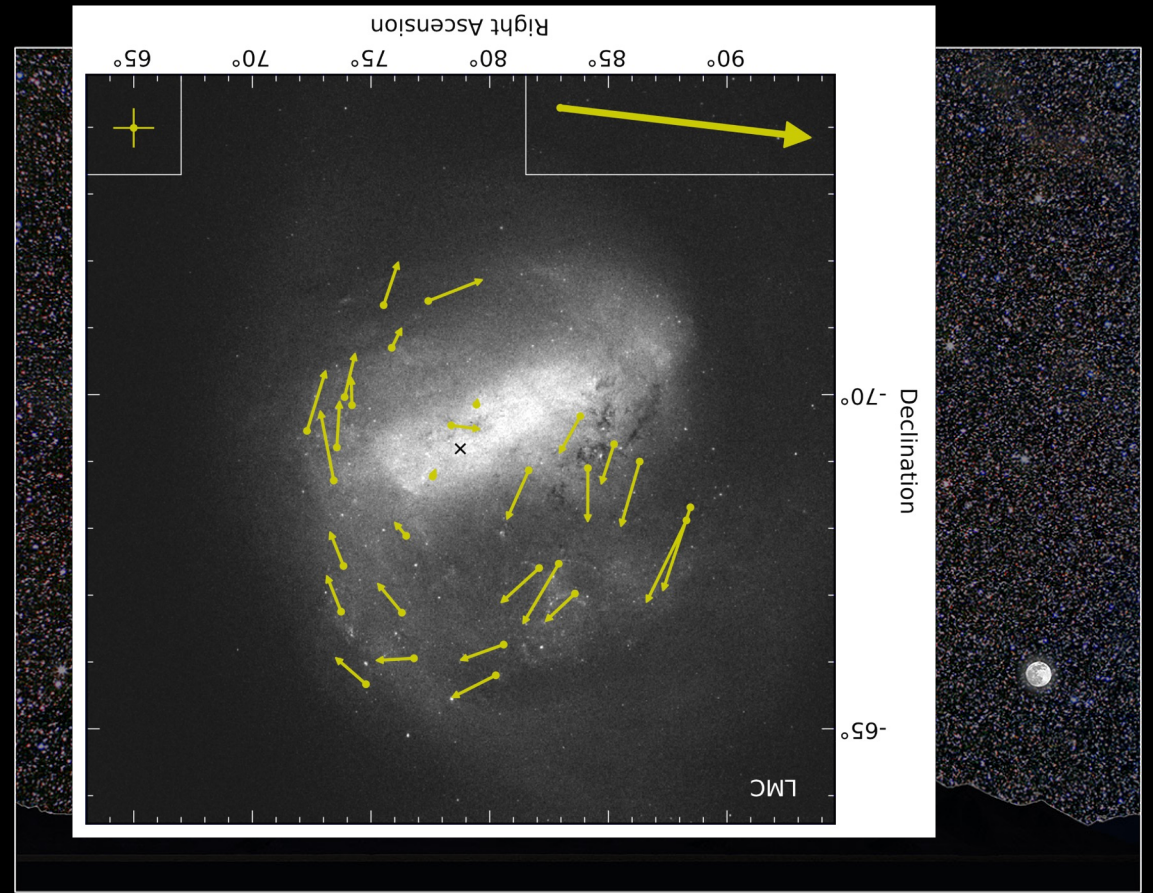
Line of Sight Velocity Fields

van der Marel+ (2002)
van der Marel & Kallivayalil (2014)



Structure & Viewing Angles

van der Marel & Cioni (2001a)
van der Marel (2001b)



Hubble Measures Rotation of the Large Magellanic Cloud • Photo Illustration

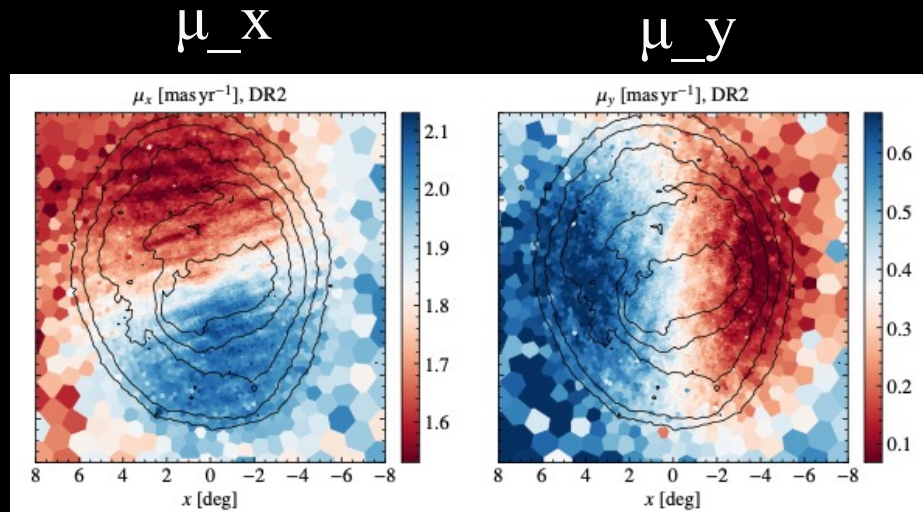
NASA and ESA • STScI-PRC14-11a

Proper Motion Rotation

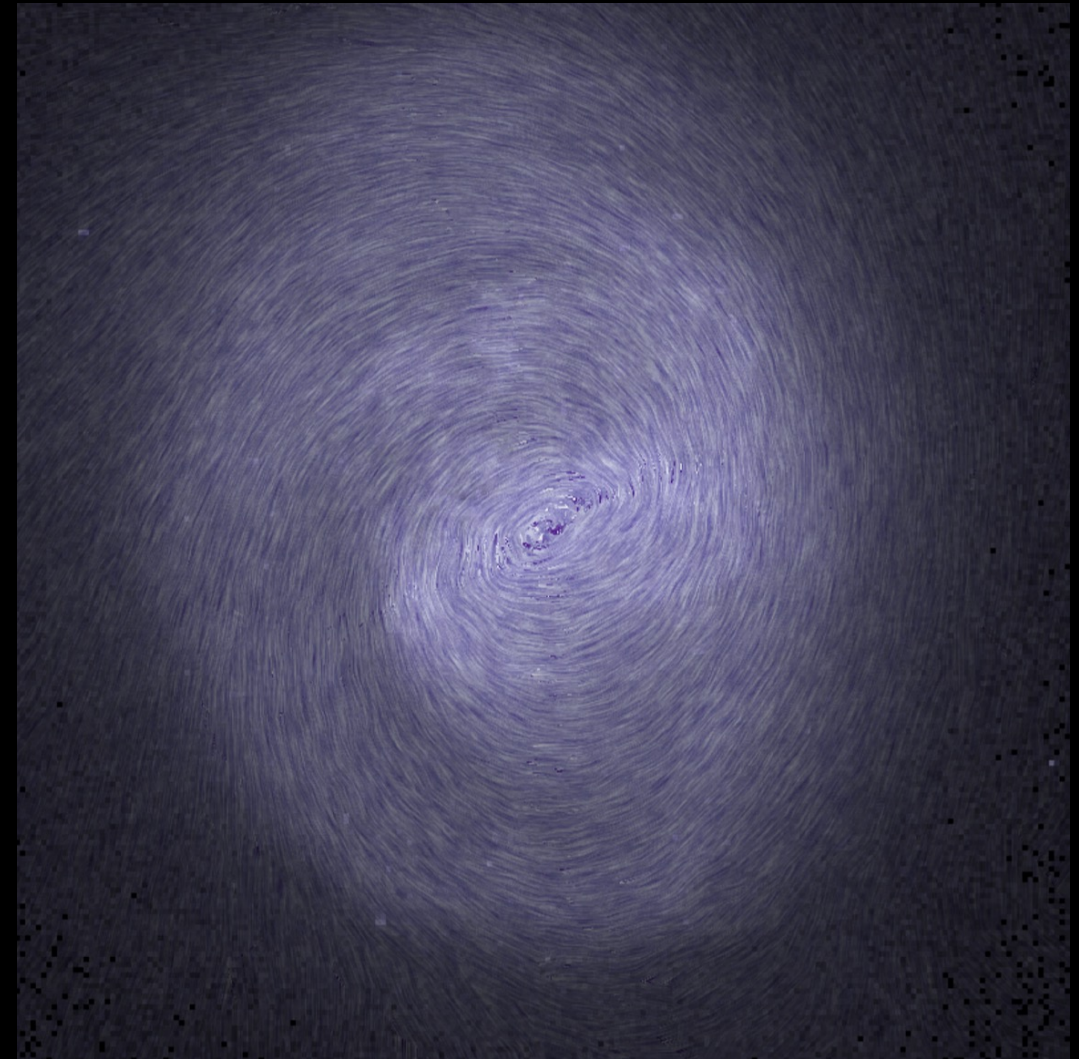
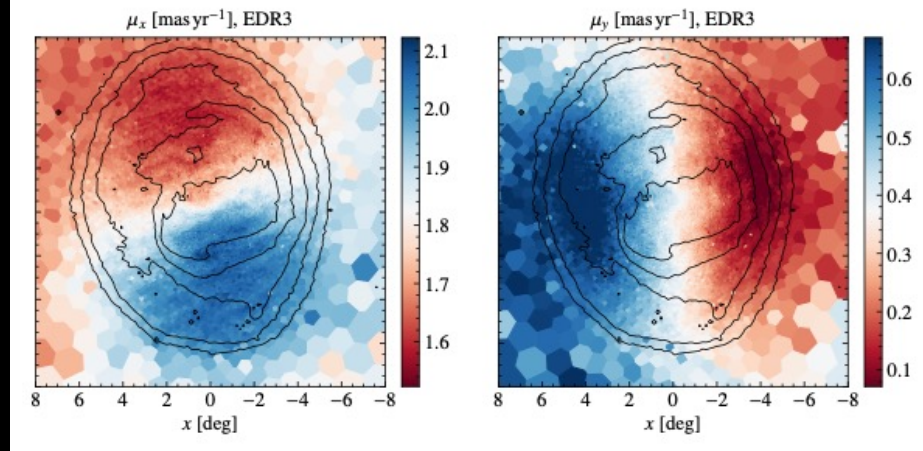
van der Marel & Kallivayalil (2014)
van der Marel & Sahlmann (2016)

Evolution in Mapping LMC Kinematics

DR2



eDR3



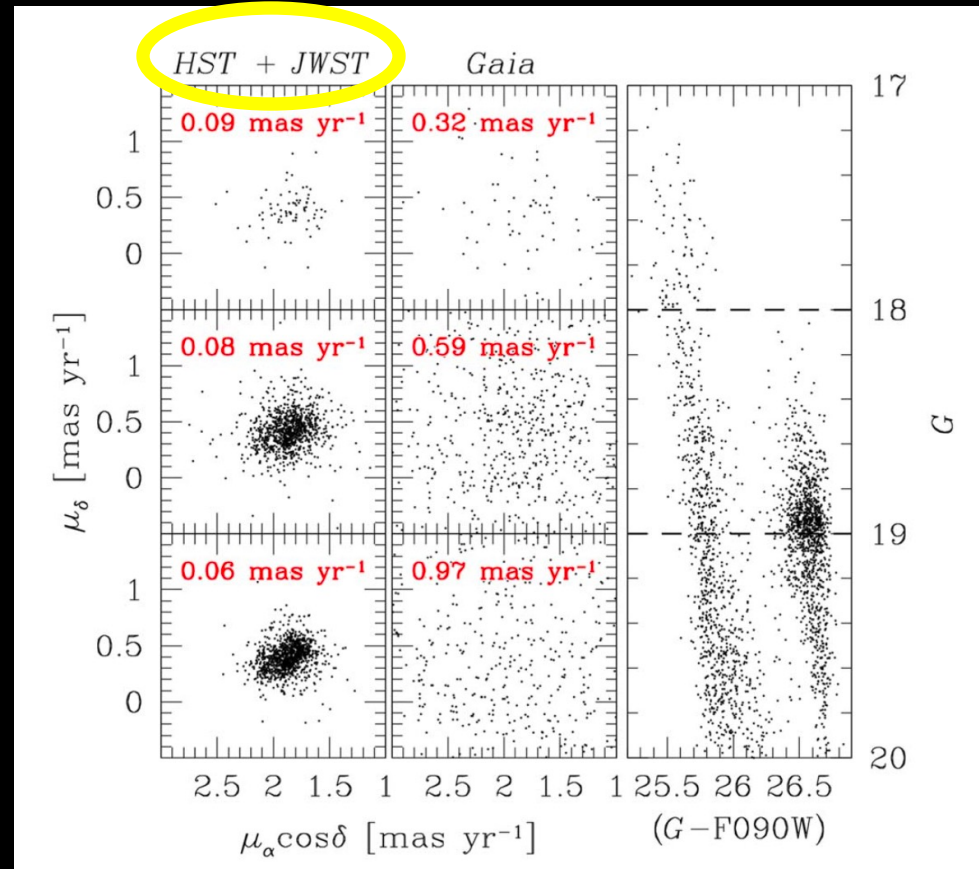
Gaia Collaboration (Luri+ 2021)

HST vs. JWST PMs

(Libralato+ 2023; JWST Telescope Scientist GTO Team)

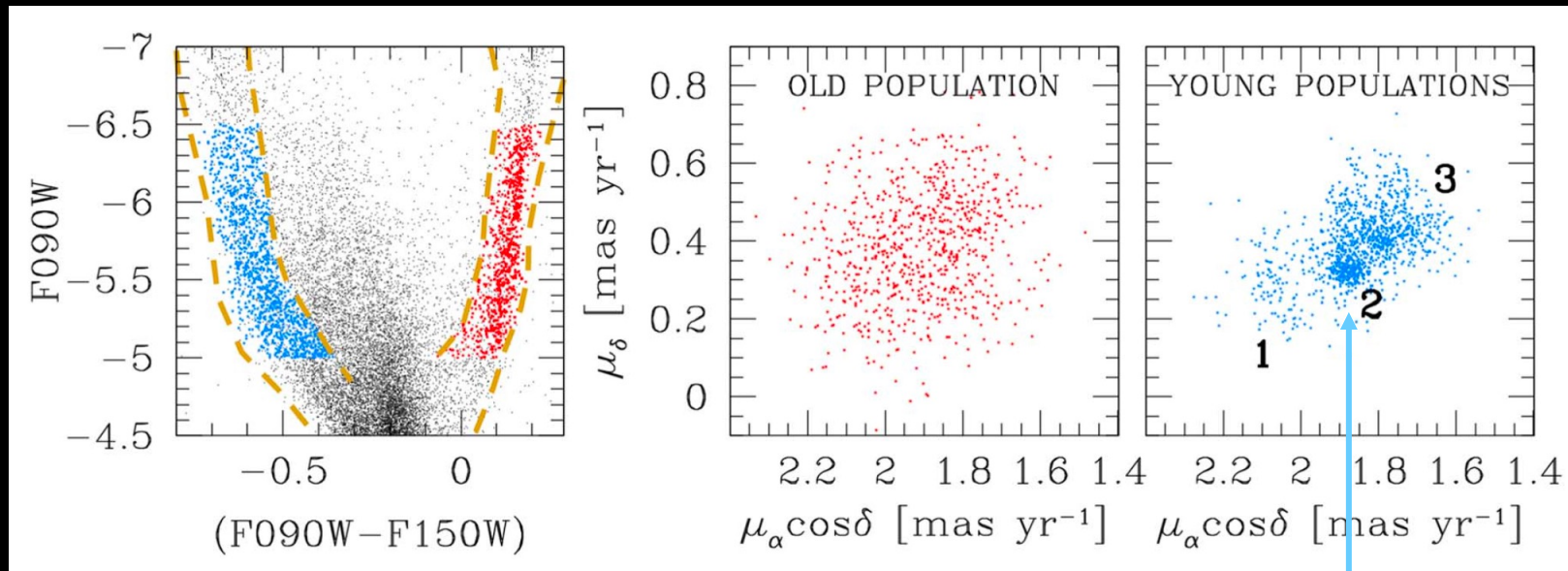
- Field in LMC bar
~0.4 deg from center
- Observed by HST and JWST in many filters 16 years apart (used for JWST geometric distortion calibrations)
- median PM error at $G \sim 20$ is $13 \mu\text{as/yr} \sim 3 \text{ km/s}$ (better than median Gaia eDR3 error at $G \sim 9-12$!!)

Observed PM RMS indicated in red



(Left: PM diagrams Right: CMD)

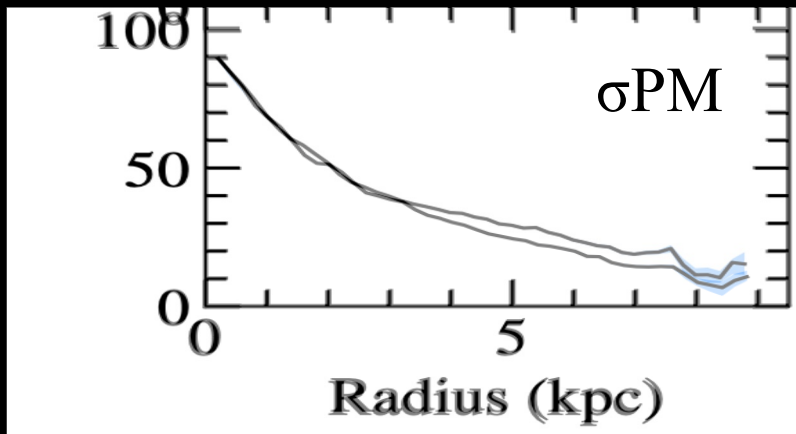
HST vs. JWST PMs



- **Young Population:**
 - Narrow distribution but with significant substructure
 - Kinematical detection of 120 Myr-old cluster OGLE-CL LMC 407, with PM dispersion $\sigma = 5.6 \pm 0.4$ km/s \rightarrow limit on PM systematics
- **Old Population:**
 - Broader smooth distribution
 - $\sigma = 33.8 \pm 0.6$ km/s

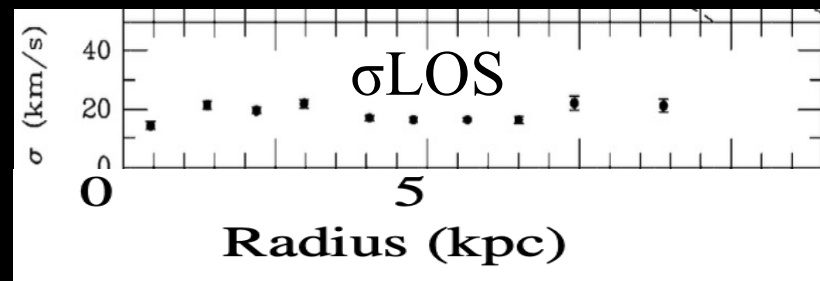
HST+JWST Velocity Dispersion

- Similar to results from many LOS velocity studies ($\sim 20\text{-}40$ km/s depending on population age)
- Consistent with lower mass of LMC relative to MW+M31
- Much lower than Gaia eDR3 inferred dispersions



(Gaia Collaboration, all populations; Luri+ 2021)

(Note: Figures stretched to similar scales)



(carbon stars; van der Marel+ 2002)

- Likely Explanation: Even after all quality cuts, GAIA PMs have significant added scatter from crowding/blending
 - Consistent with similar findings from analyses of Gaia star cluster data (Lennon+ 2018; Vasiliev & Baumgardt 2021)

Conclusions

- HST, and now JWST, continue to enable unique dynamical studies of the Local Group and beyond
 - Very high accuracy to very faint magnitudes, but over small fields of view
- GAIA PMs of the LMC should be interpreted with care, since uncharacterized sources of scatter are present that depend on local density
 - Should not affected bulk/mean PMs of samples in which many stellar PMs are averaged

