# The power of teaming-up HST and Gaia

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# Dynamical tracers to investigate dark matter haloes

Dynamical tracers
(radial valocities)

- Mass

- Shape

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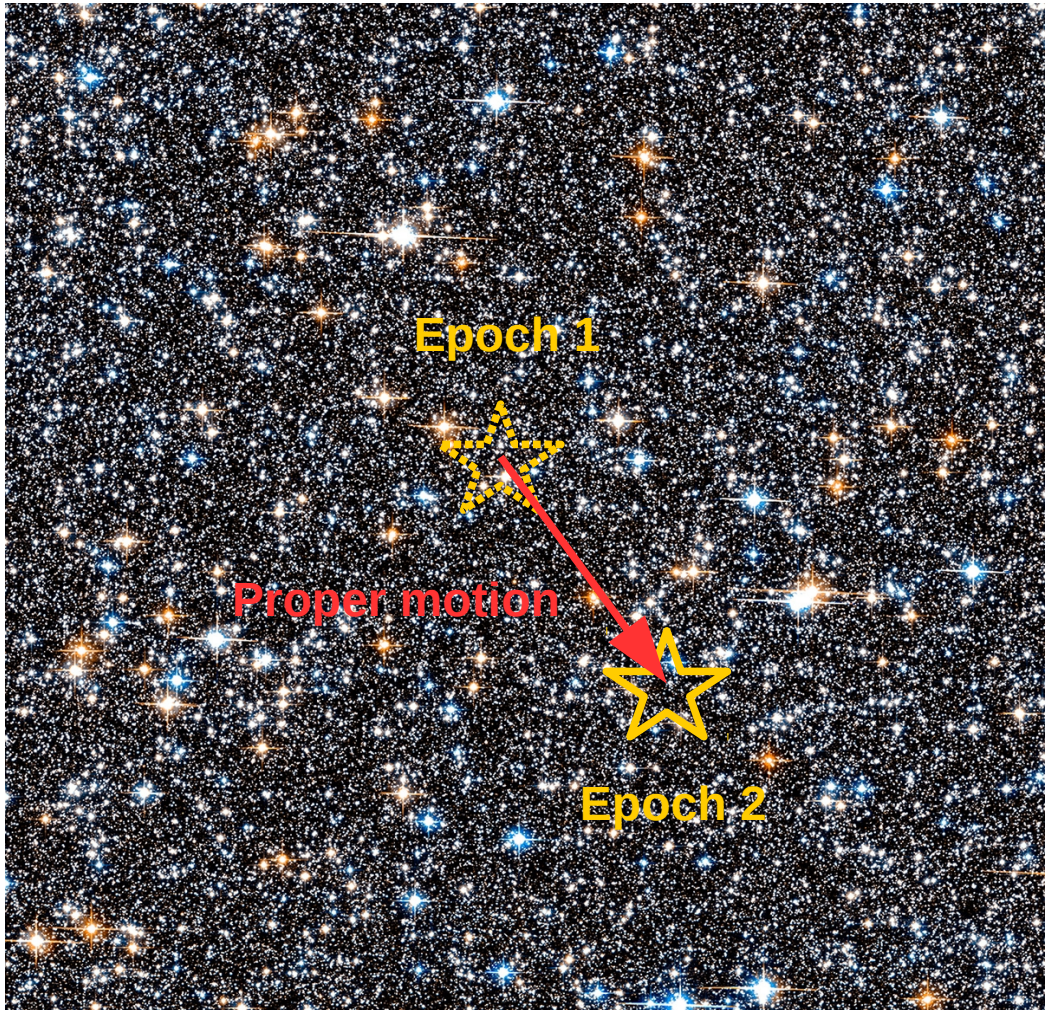
# Proper Motions




**Very complex measurement!**

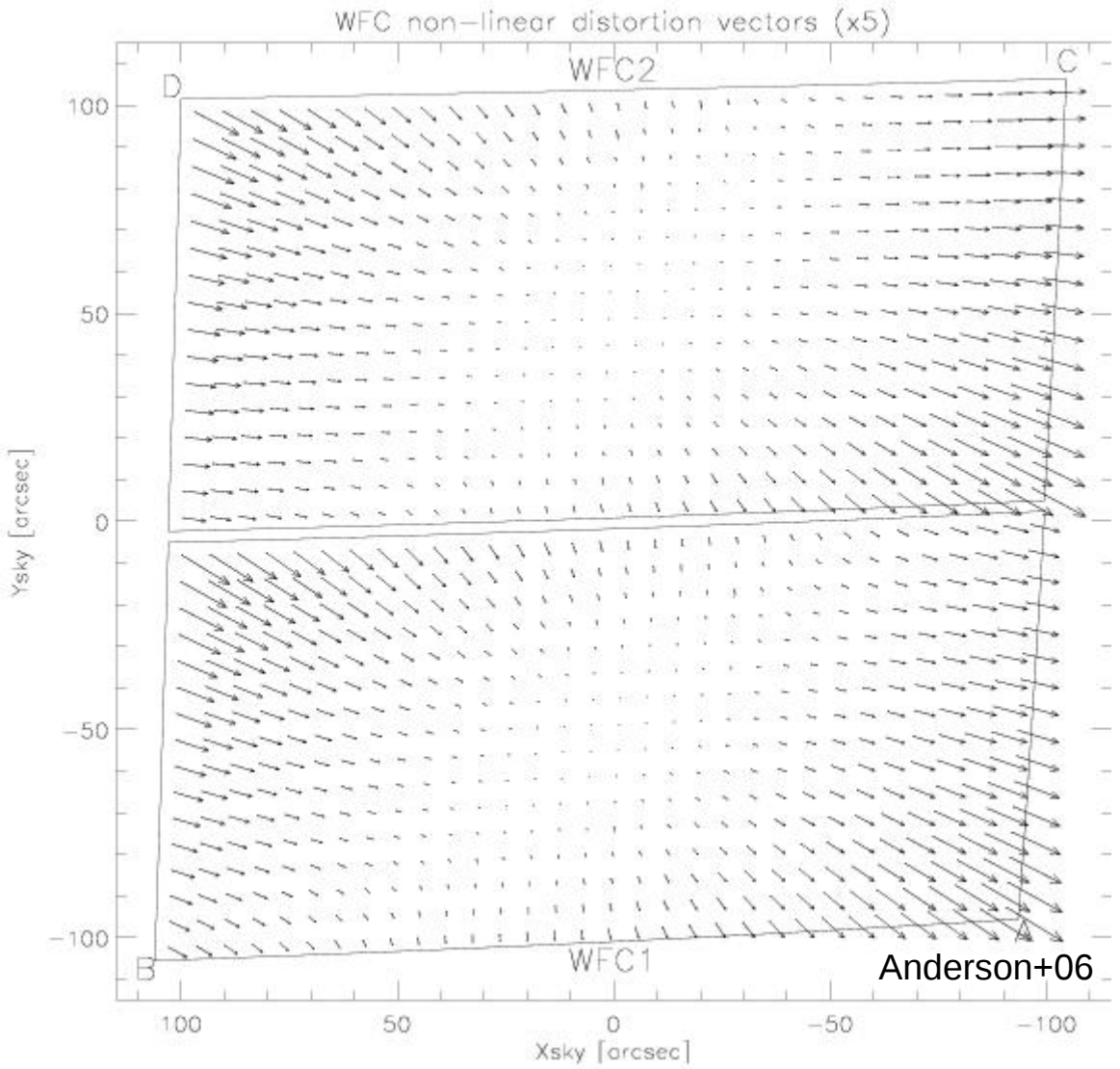
1- At least two observations

2- Short separation=small the proper motion

3- Large distance=small the proper motion

4- Instrumental effects >>> proper motions

# Proper Motions: HST




PSF knowledge 0.01 pixels

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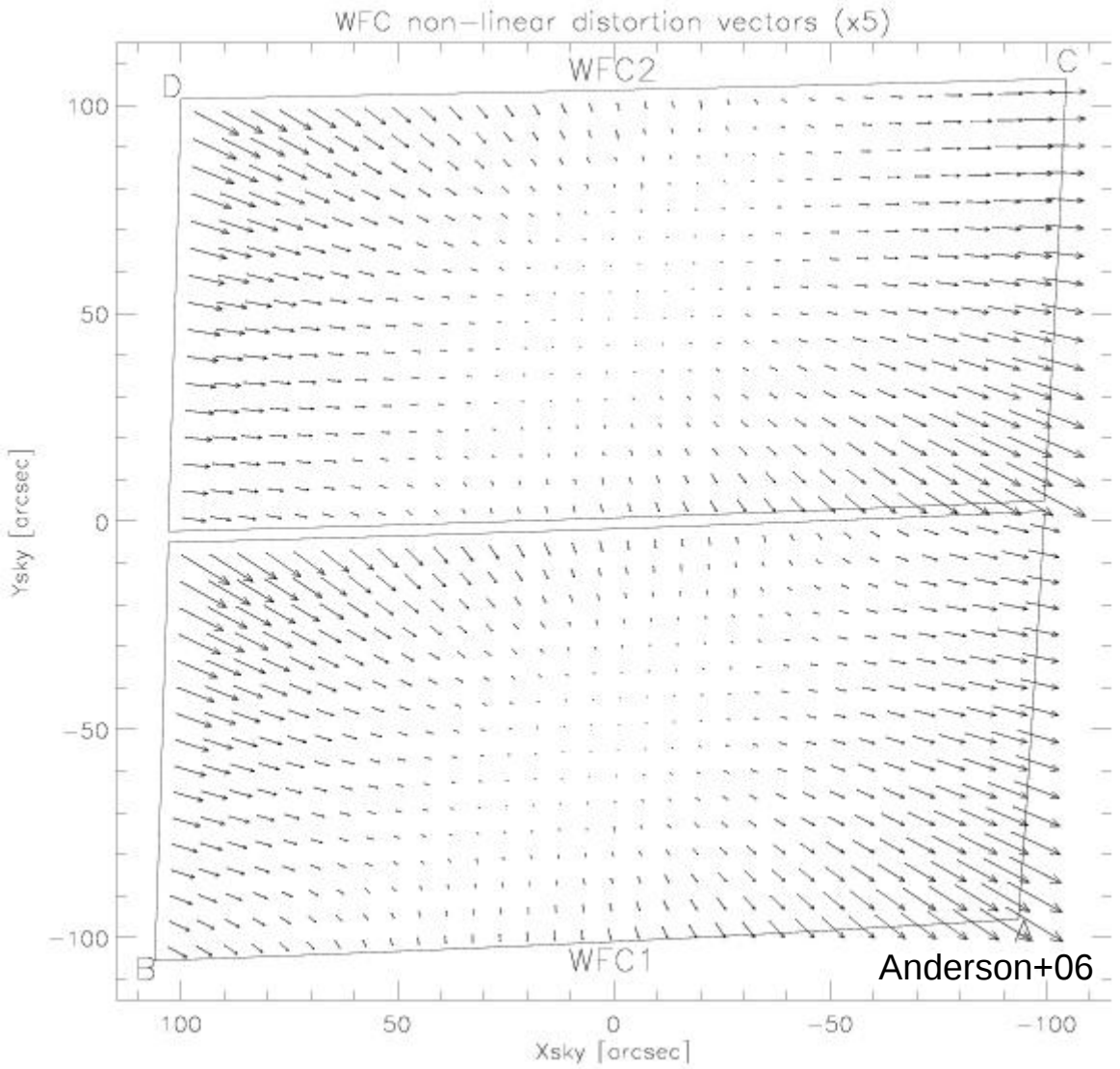
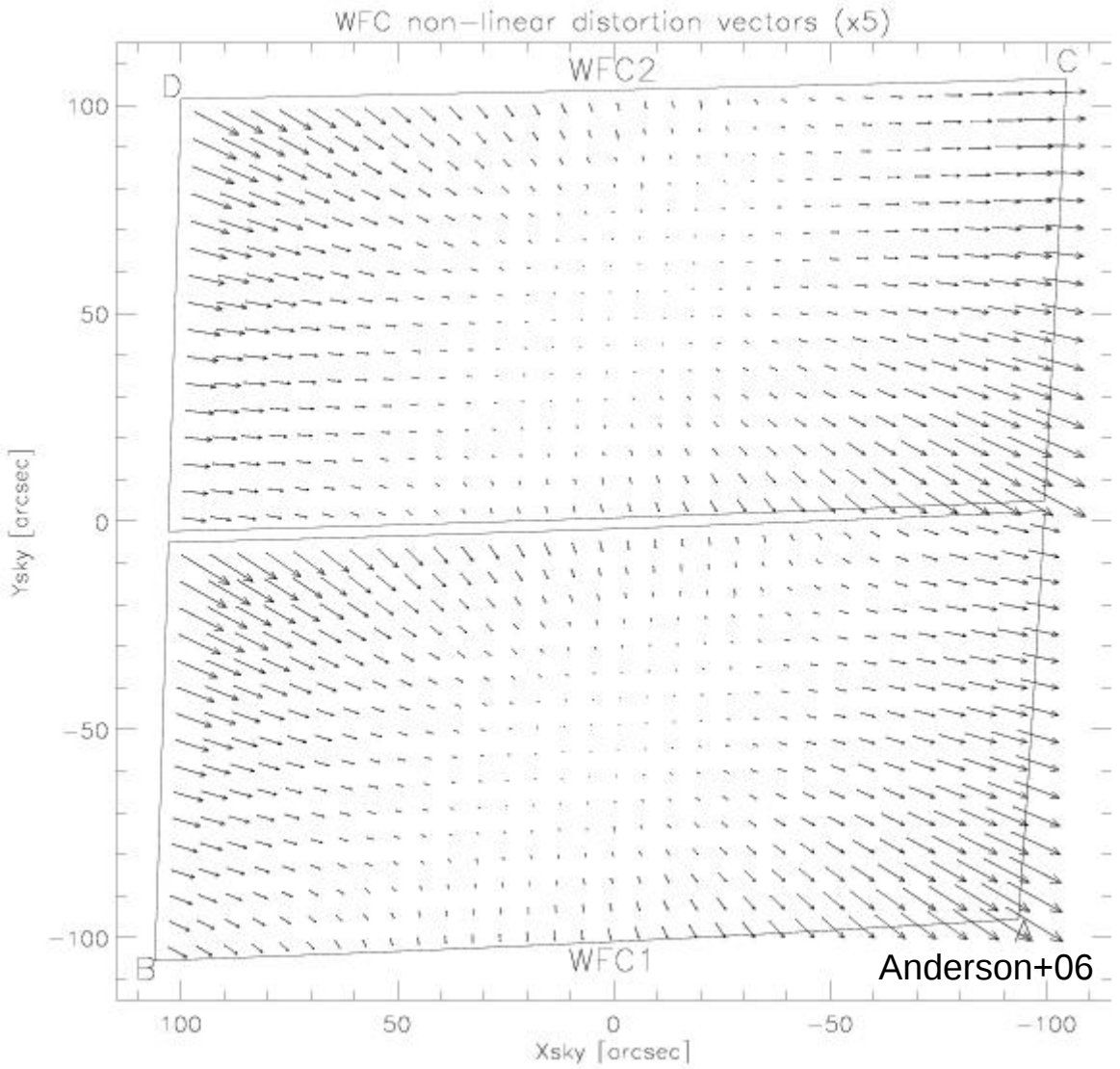



| | |
|---|---|
| PSF knowledge | 0.01 pixels |
| + | + |
| Geometric distortion corrections | 0.01 pixels |

# Proper Motions: HST




| | |
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| PSF knowledge | 0.01 pixels |
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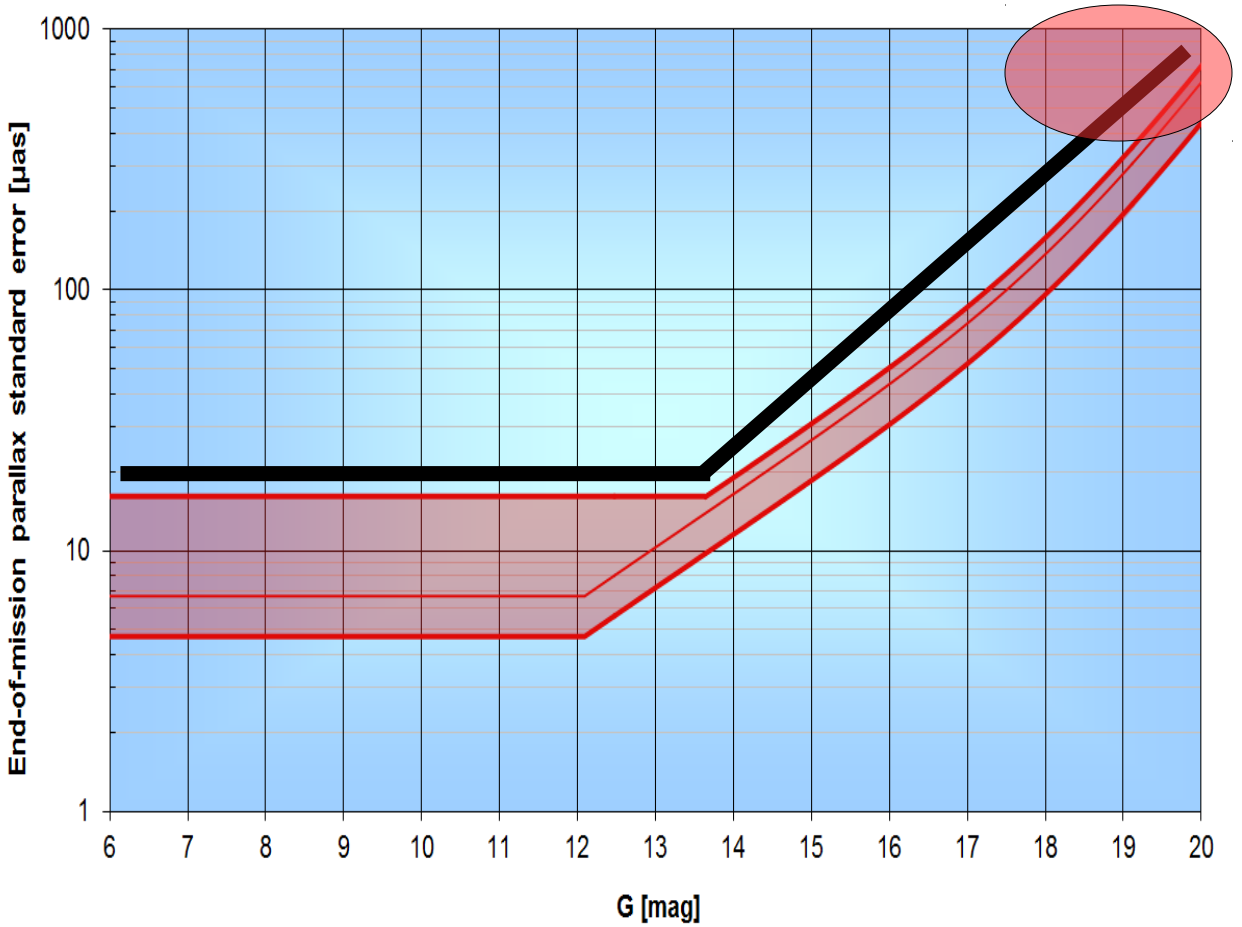
Absolute positional precision
=
0.7 mas

# Proper Motions: *Gaia*

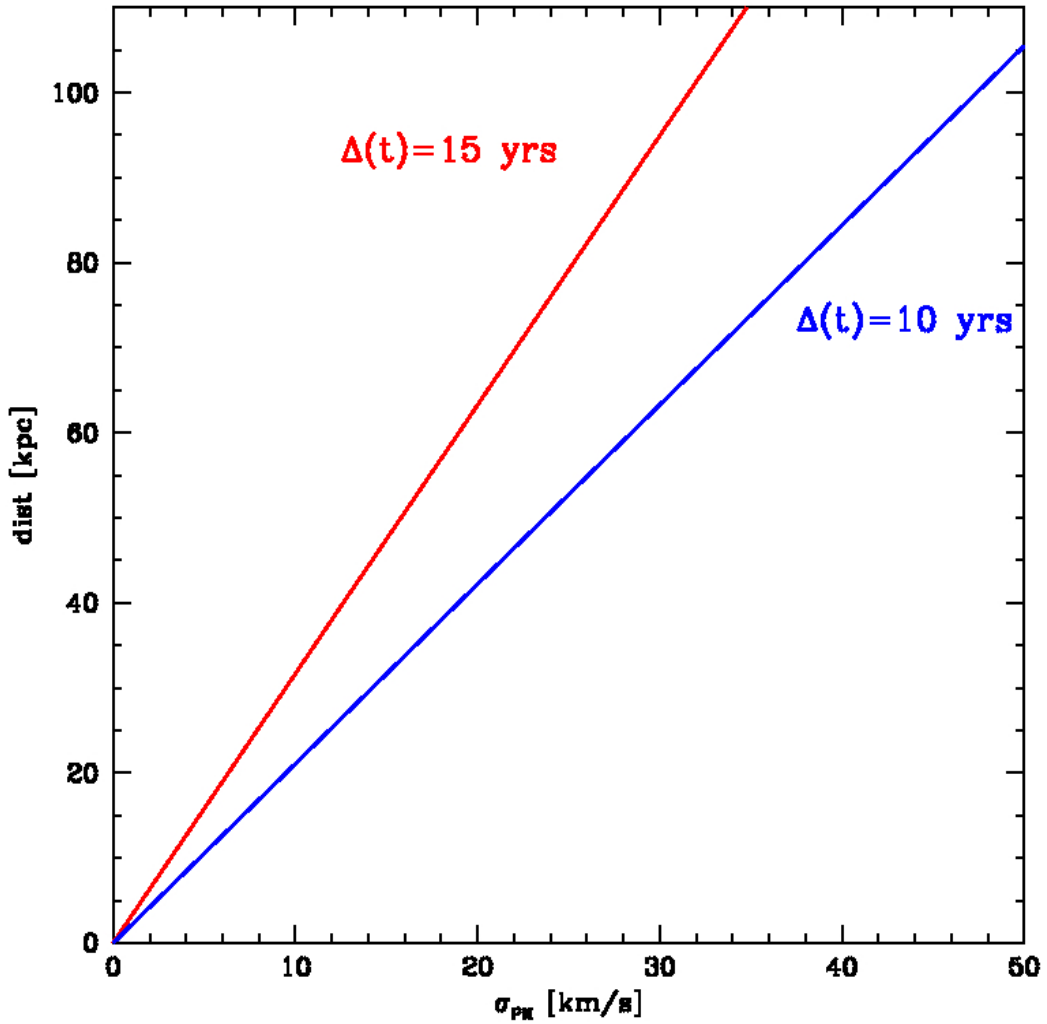



At the typical magnitude of HB for 100 kpc distant stellar population

=

Precision similar to HST!

# Proper Motions: HST + *Gaia*



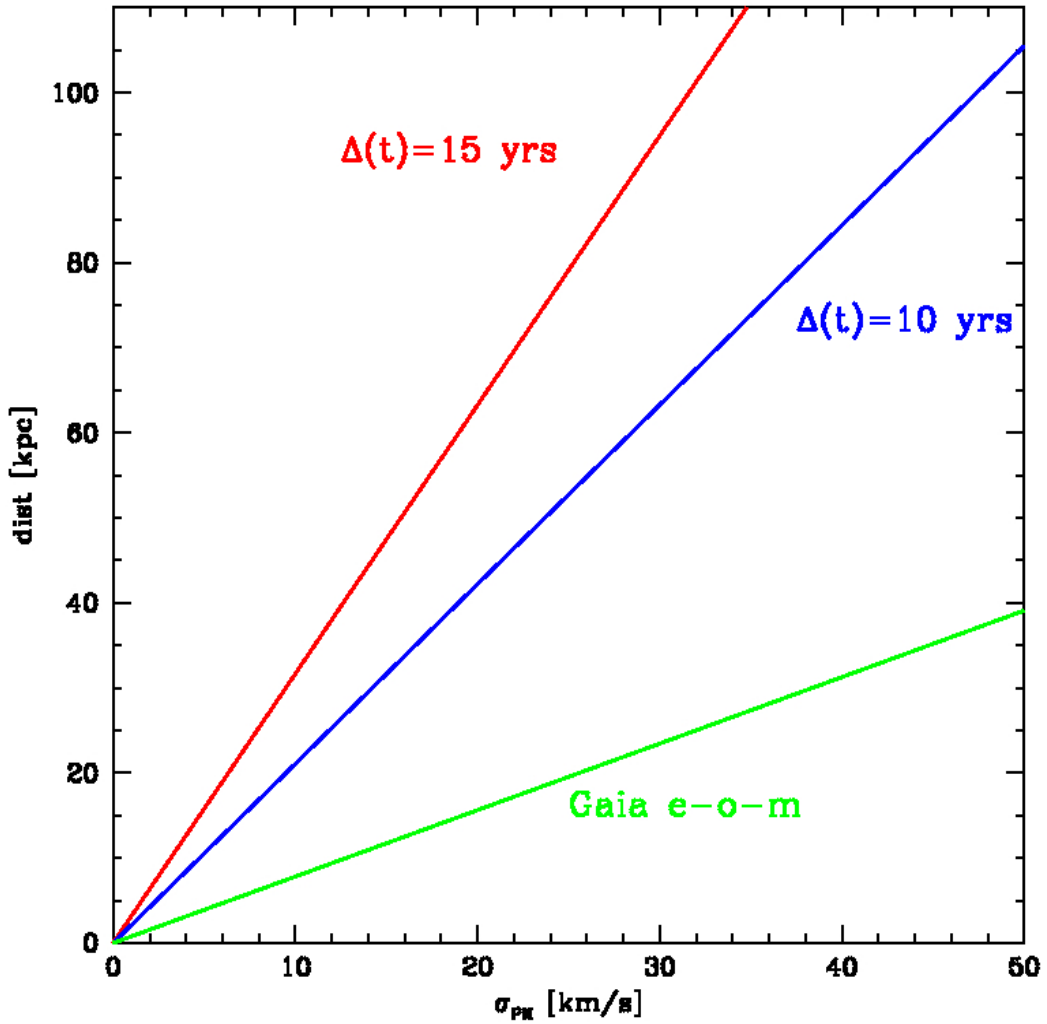

Absolute proper motion precision

< 50 km/s

*Gaia* end of mission: 120 km/s!

Gain coming from Δt

# Proper Motions: HST + *Gaia*

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# Proof of concept: NGC 2419

- Distance = 87.5 kpc
(Di Criscienzo+11)

- Brightest halo GC
(Harris+96)

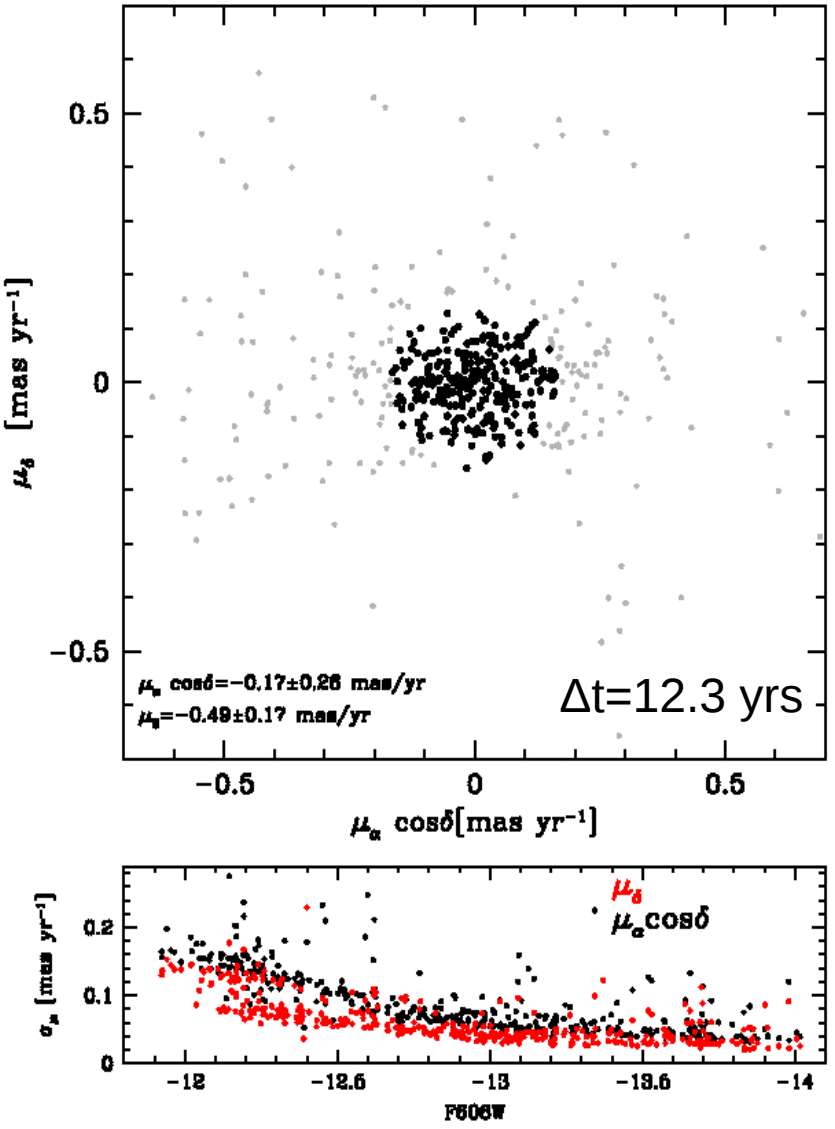
- Very extended
(Harris+96)

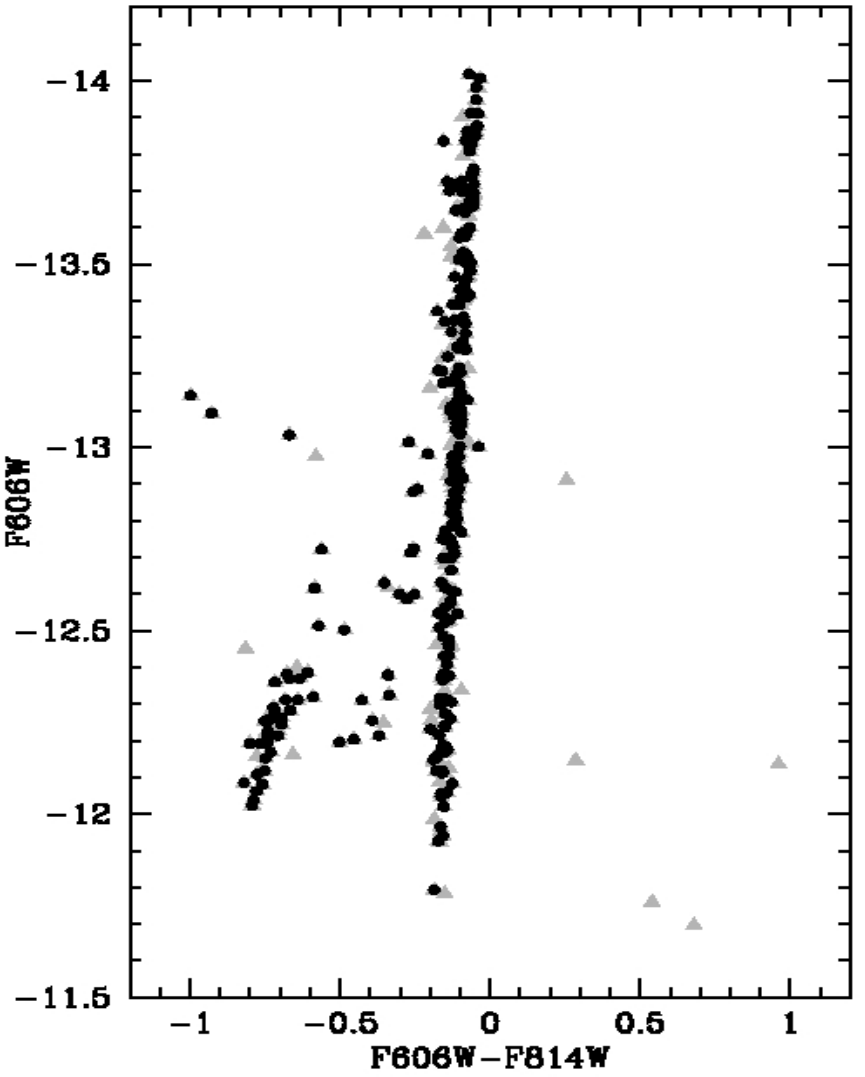
- Ca, K spread
(Mucciarelli+12, Lee+13)

**EXTERNAL ORIGIN?**
(Irwin+99, Belokurov+14)

# Proof of concept: NGC 2419

CataPack code for geometric transformations



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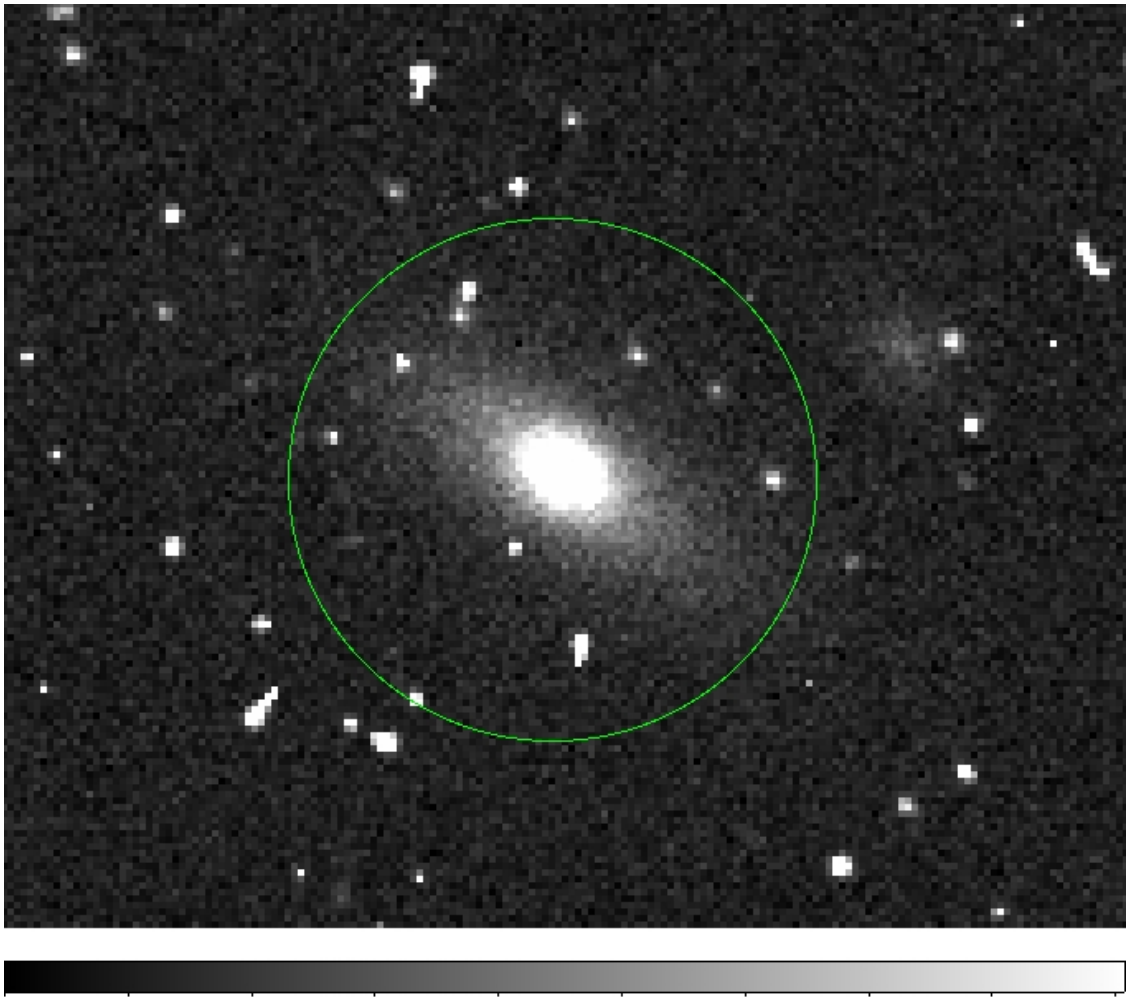

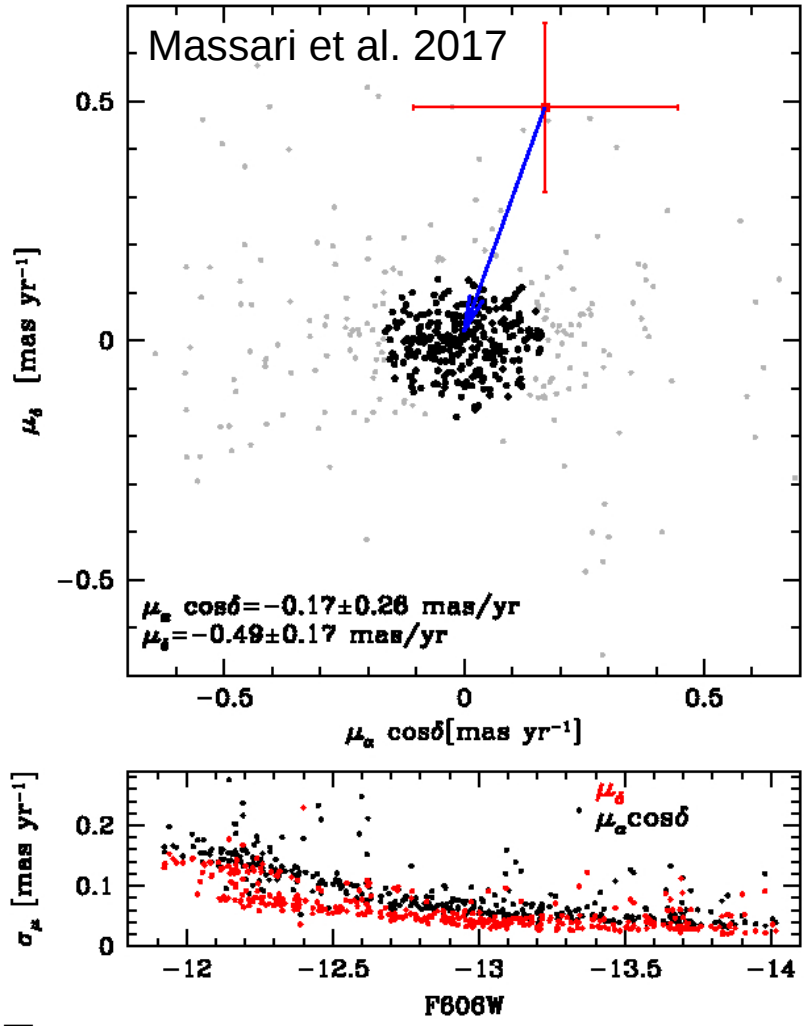


($\mu_\alpha \cos(\delta)$, $\mu_\delta$)=(-0.17±0.26, -0.49±0.17) mas/yr

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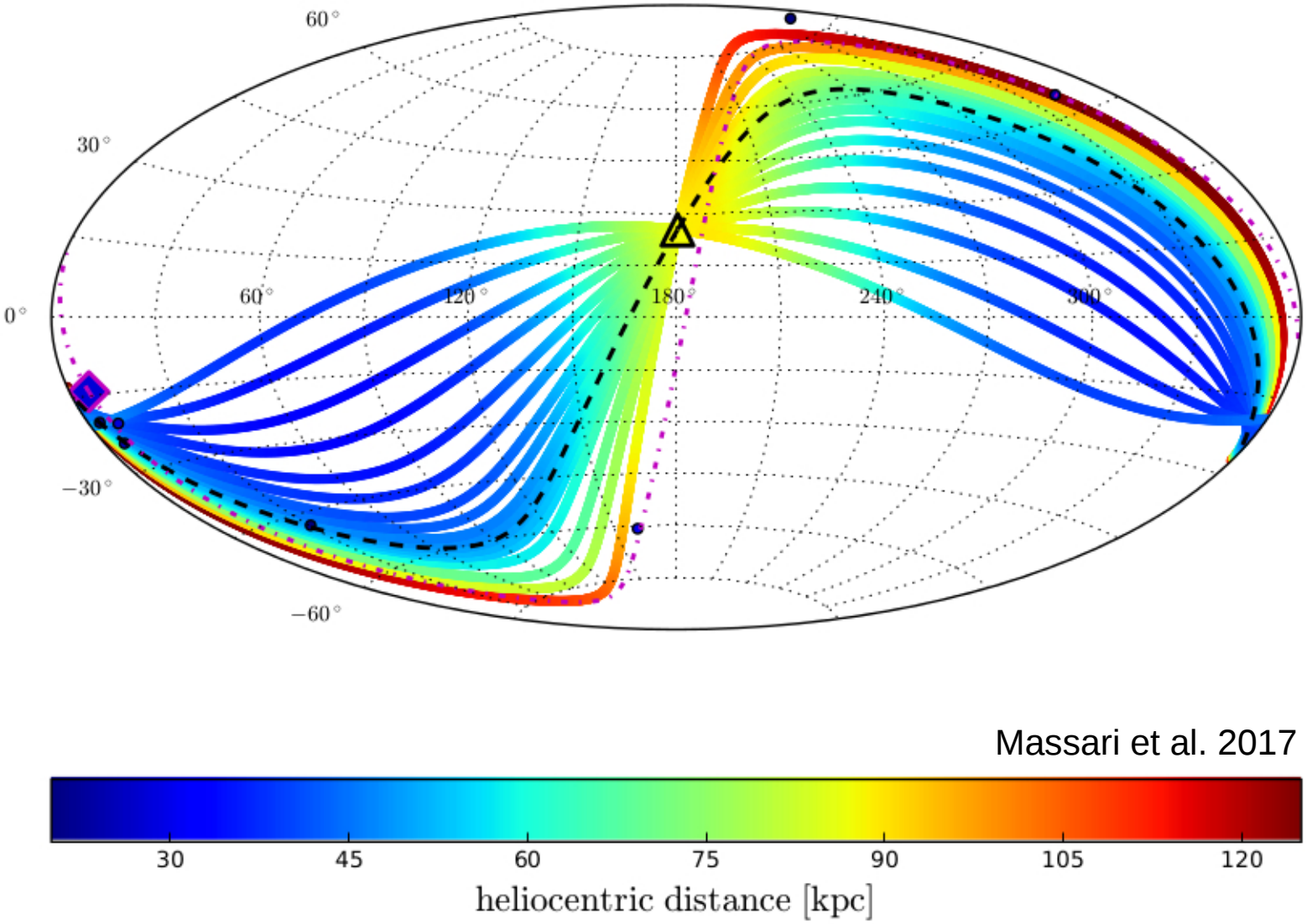


Massari et al. 2017

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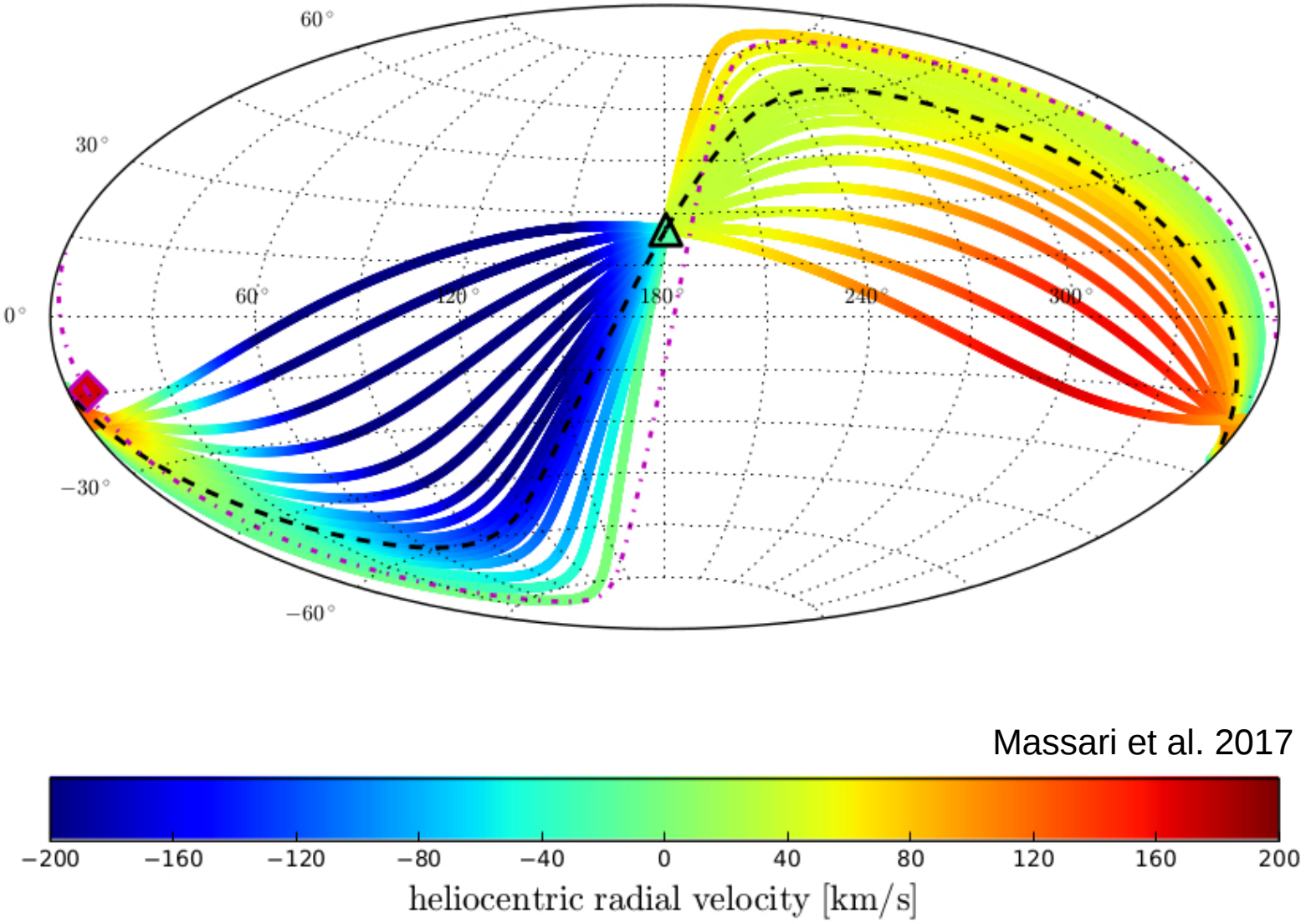


Massari et al. 2017

# NGC 2419 and Sgr dSph

Features of the orbit:

- close to polar 

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- BHB tidal stream overlapping in position and l.o.s velocity: part of Sgr trailing stream (Belokurov+2014)
- Model by Vera-Ciro+13, Sgr trailing stream with tangential velocity similar to NGC2419!

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**Likely association!**

# Summary

- HST + Gaia: high accuracy down to mag 20 → HB of stellar populations 100 kpc distant

- Test on the distant GC NGC2419 (no PM so far)

- Presence of 1 background galaxy →$(\mu_\alpha \cos(\delta), \mu_\delta)=(-0.17\pm0.26, -0.49\pm0.17)$ mas/yr

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**Next steps**

- Try this strategy on dwarf galaxies

- First target: Sculptor dwarf spheroidal (debated PM measurement)