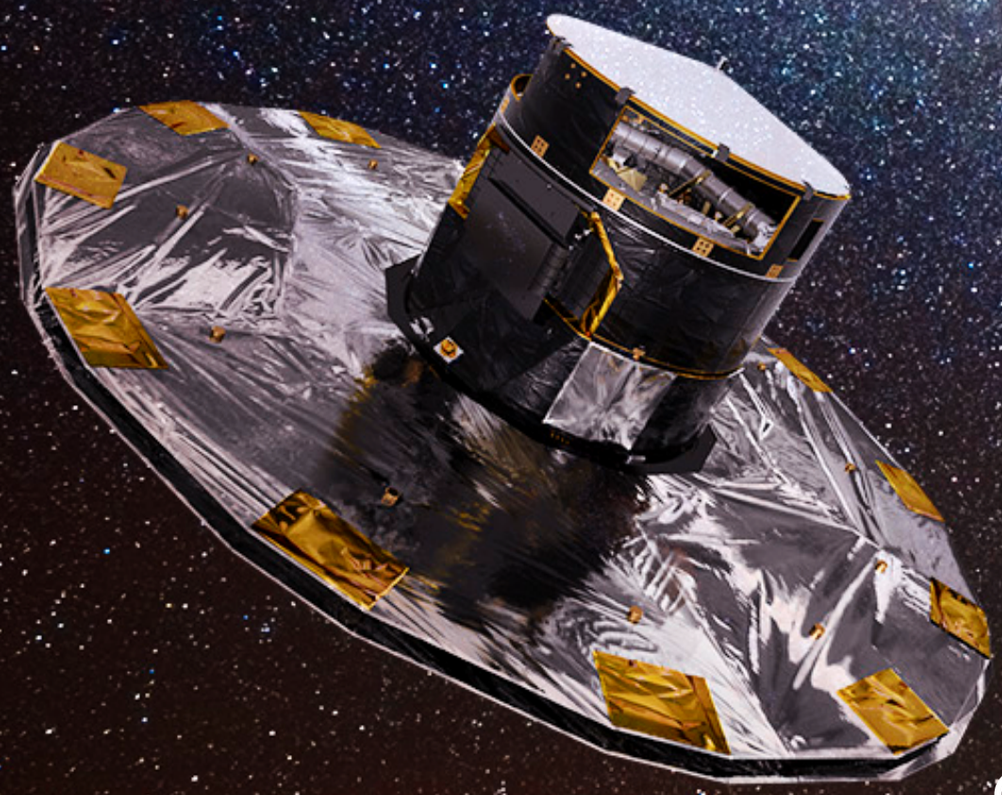
Gaia & Ultra-Cool Dwarfs: What will we learn?



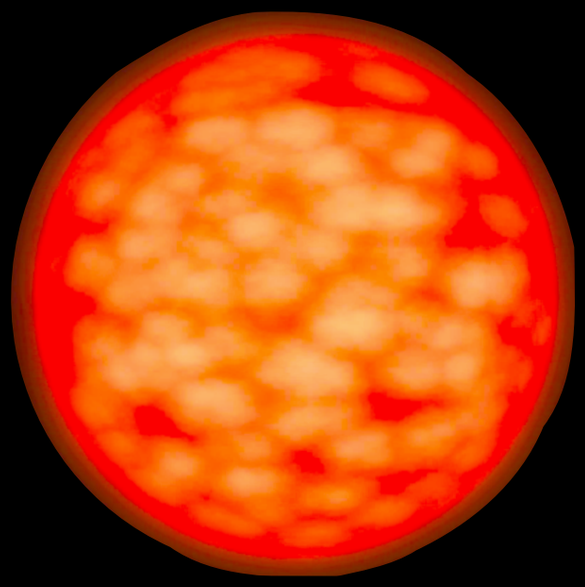
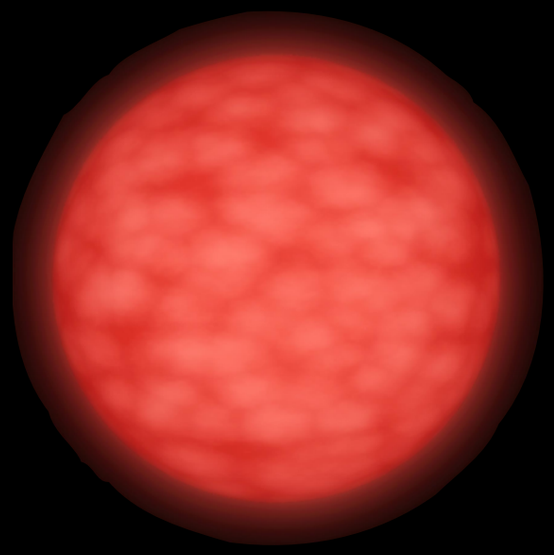
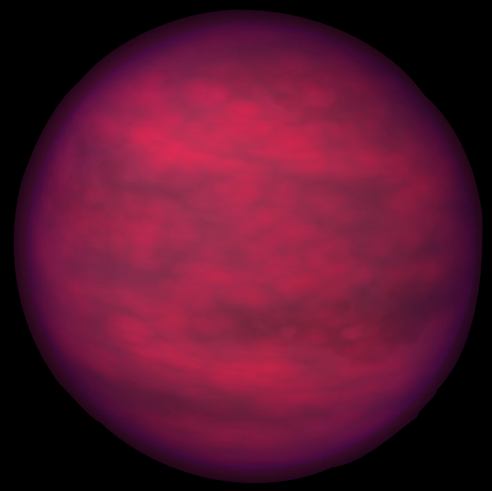
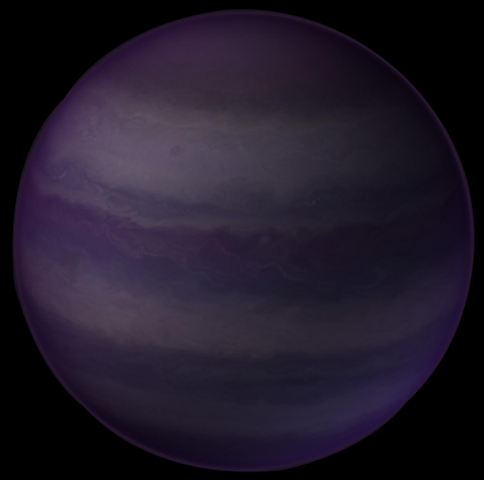
John Bochanski (Haverford College)

Gaia & The Unseen: The Brown Dwarf Question

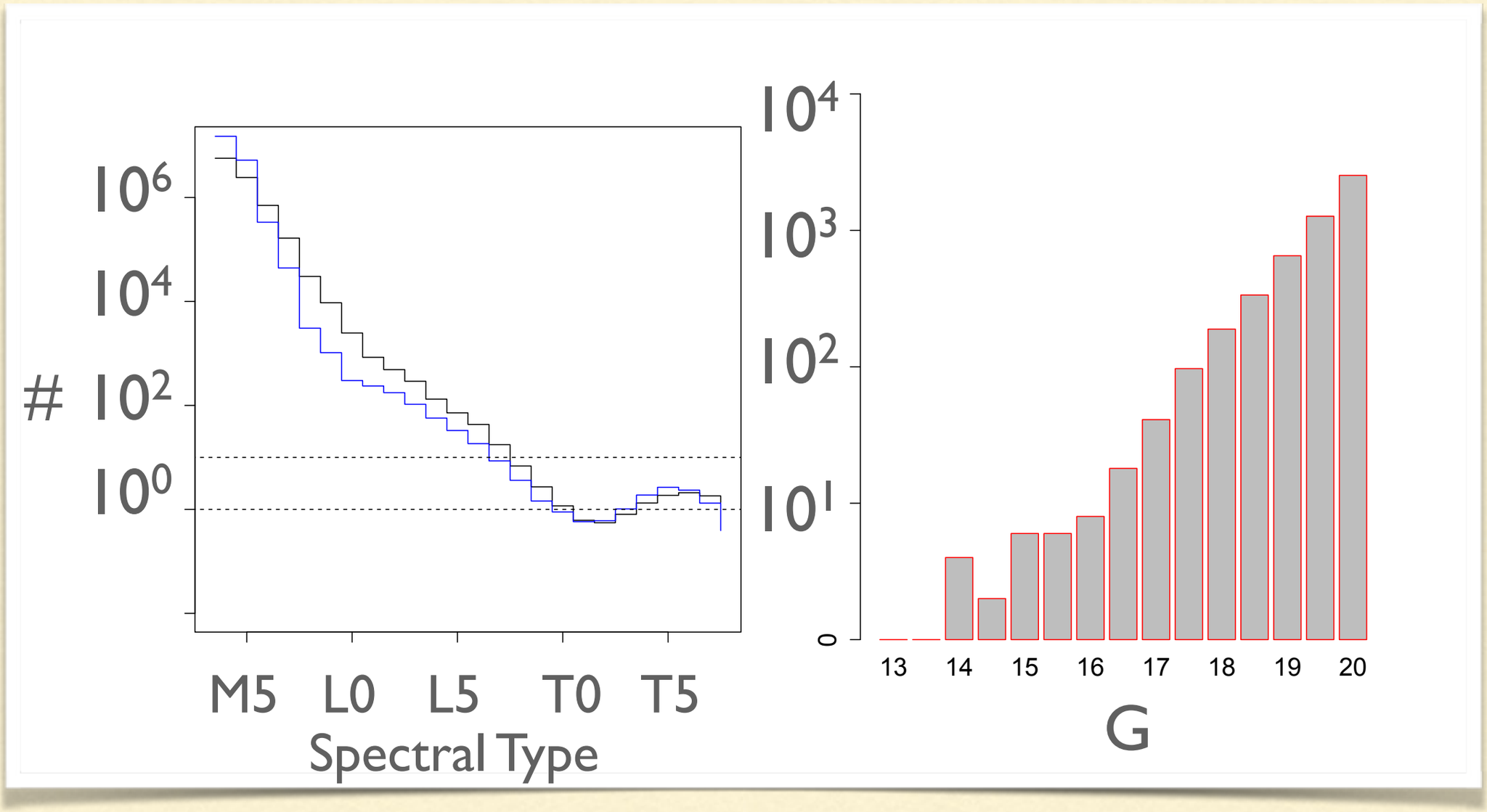
March 25th, 2014

My original title:
1% astrometry +10 m/s velocities
on 1000's of UCDs,
what can we learn?

UCDs include all MLTY dwarfs for this talk.

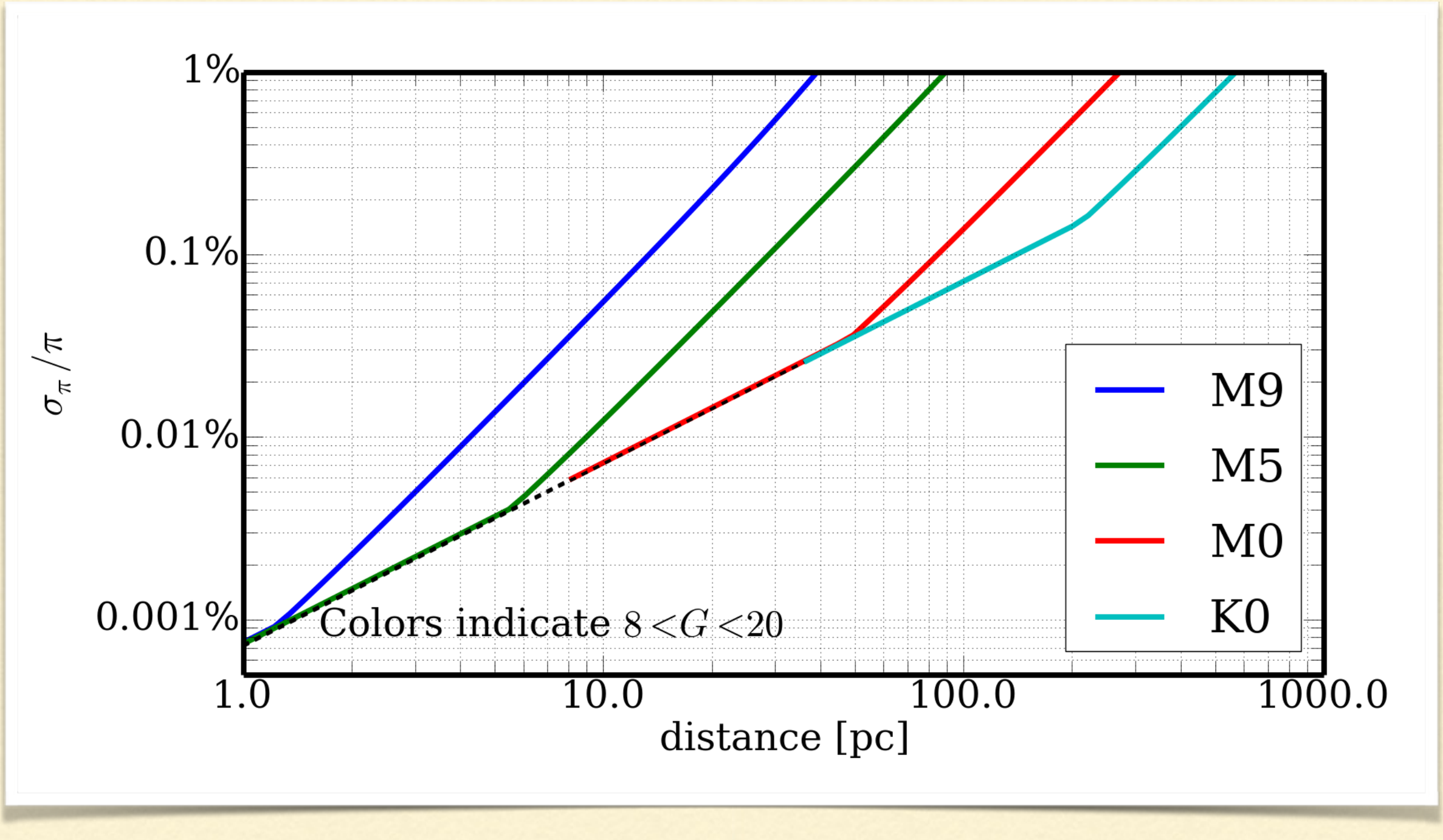
< 3800 K	< 2000 K	< 1000 K	< ~ 400 K
			
M dwarf	L dwarf	T dwarf	Y dwarf

Gaia will observe hundreds of thousands of MLTY dwarfs within 300 pc with $G < 20$.



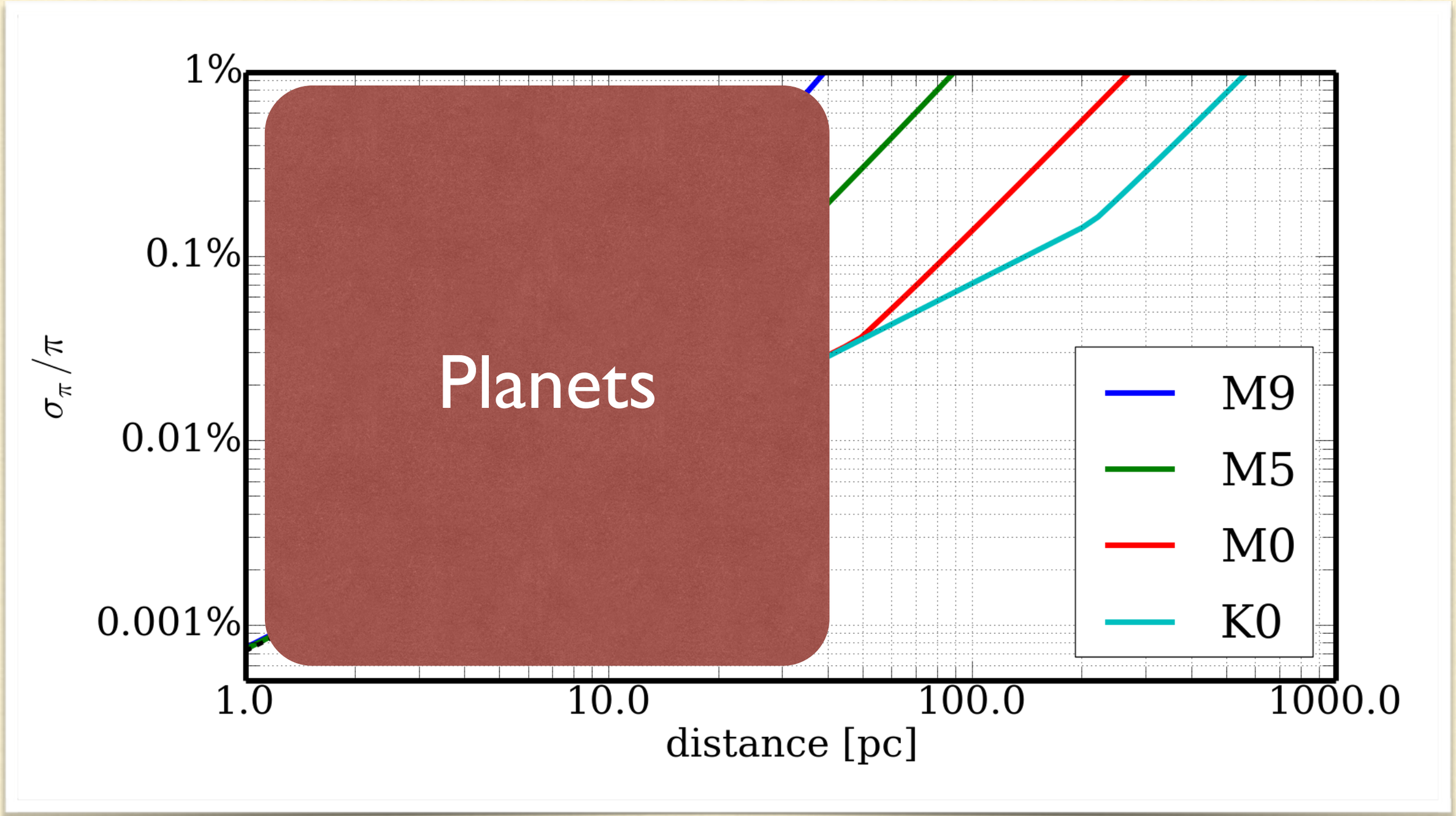
Sarro et al., 2013

Where will GAIA deliver 1% astrometry?



github.com/agabrown/PyGaia

Where will GAIA deliver 1% astrometry?



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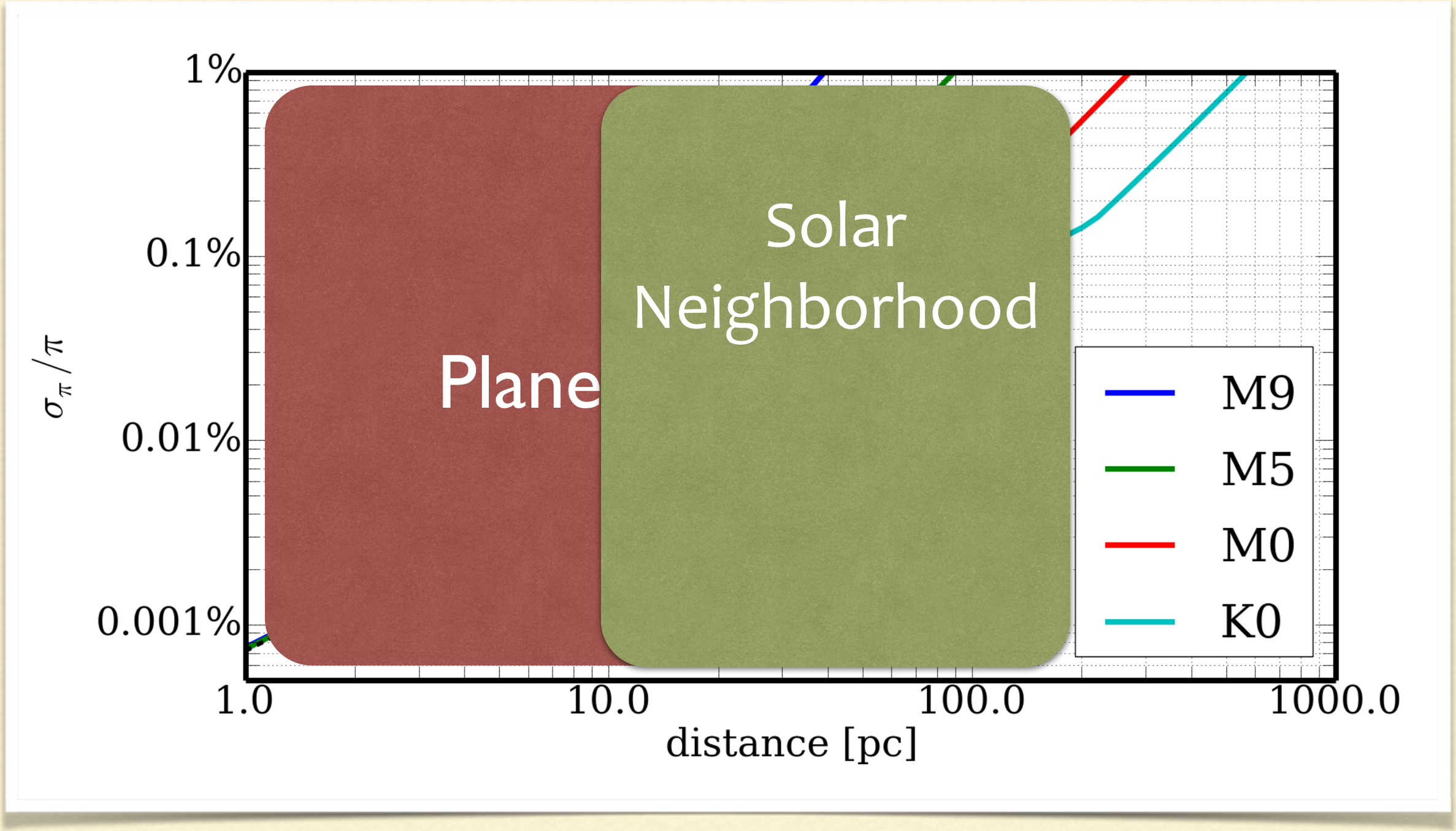
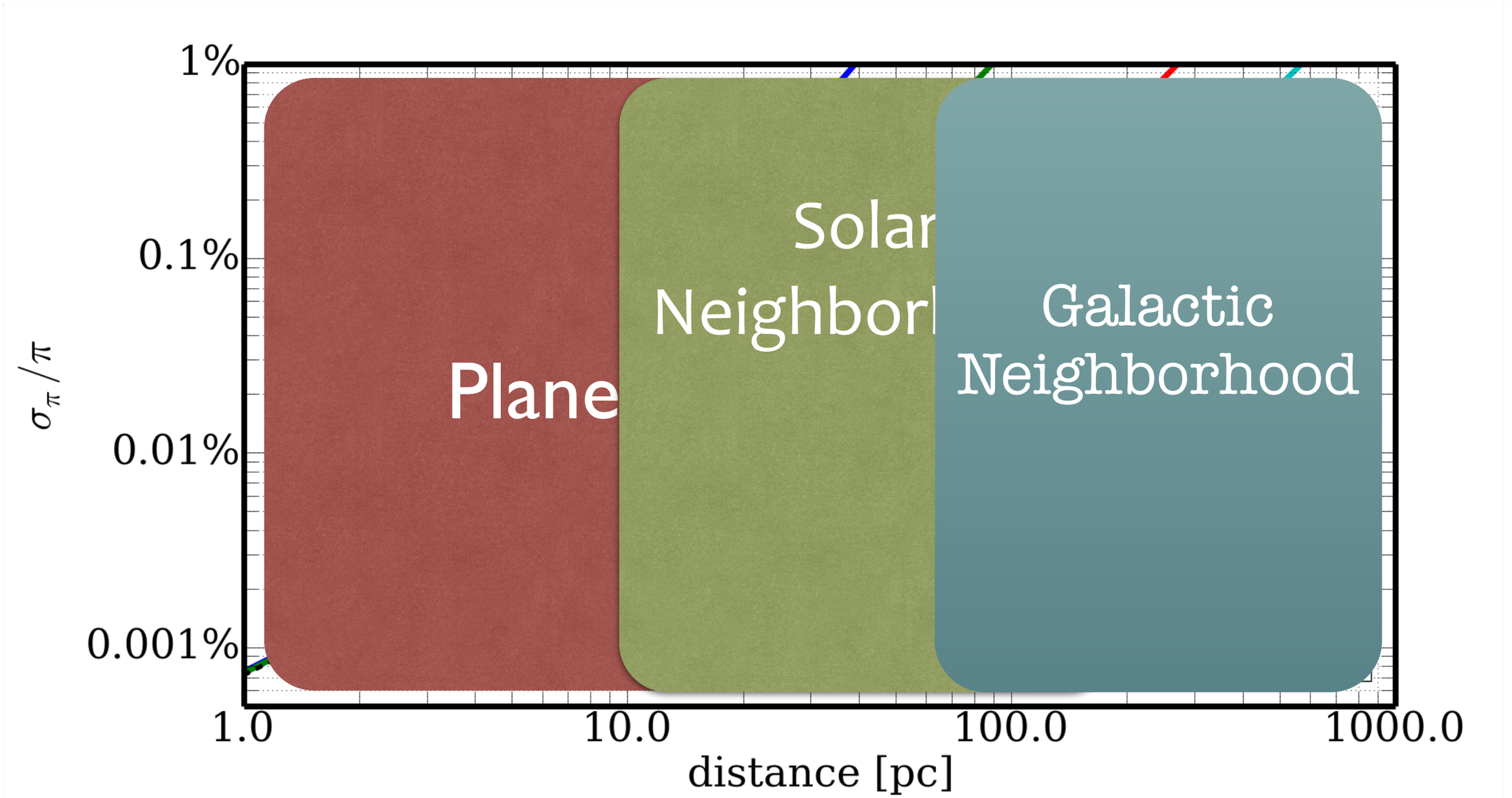
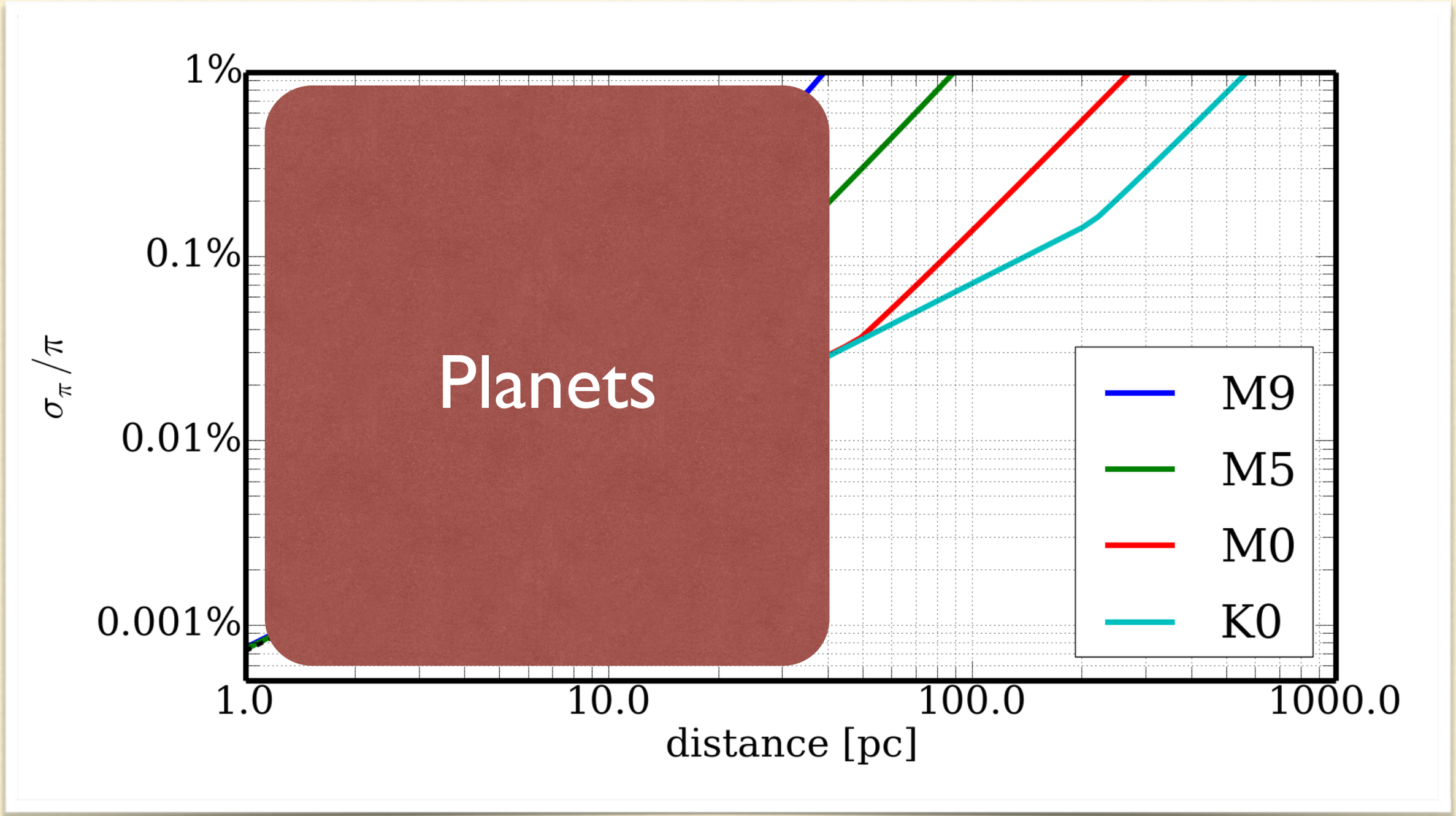


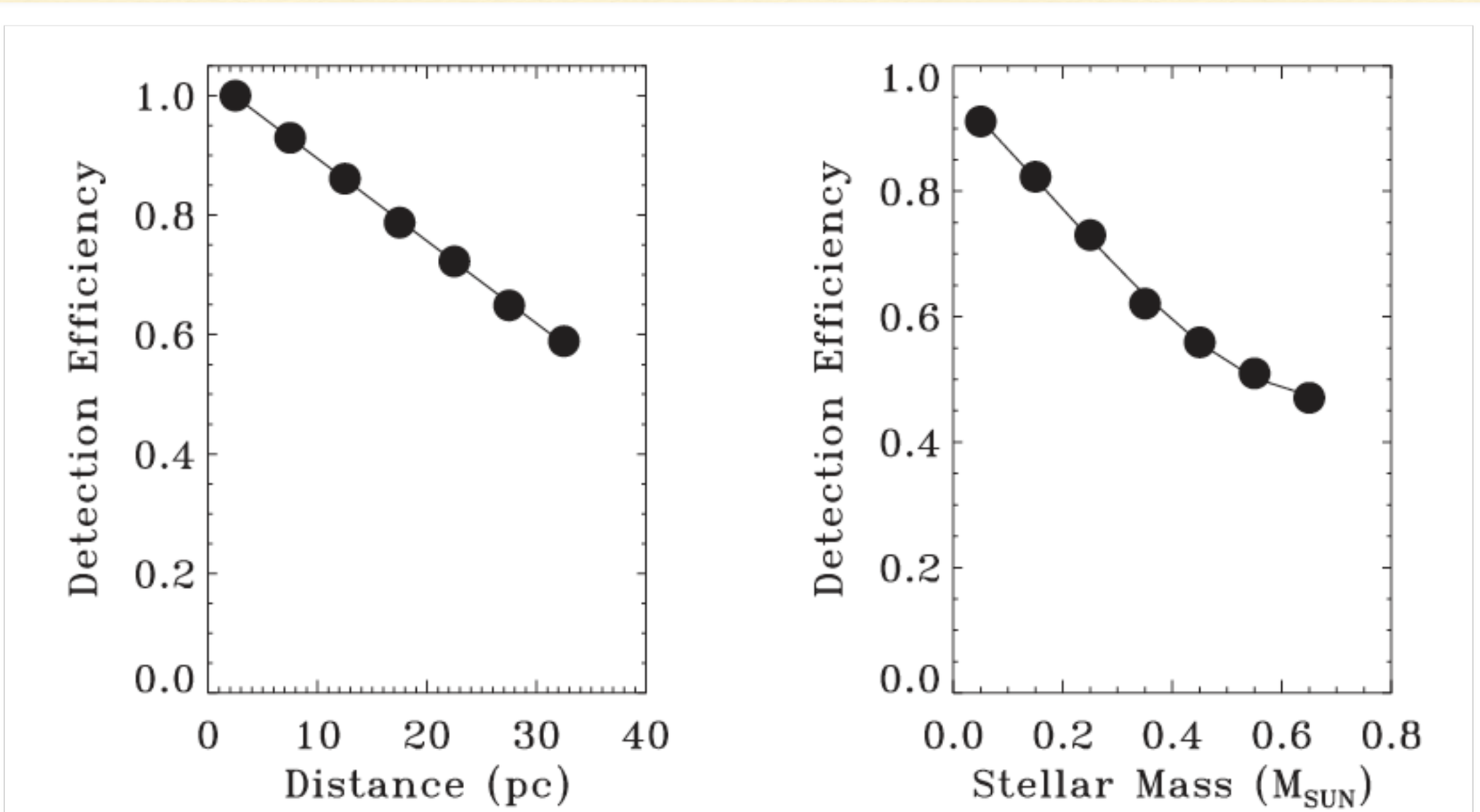
Where will GAIA deliver 1% astrometry?



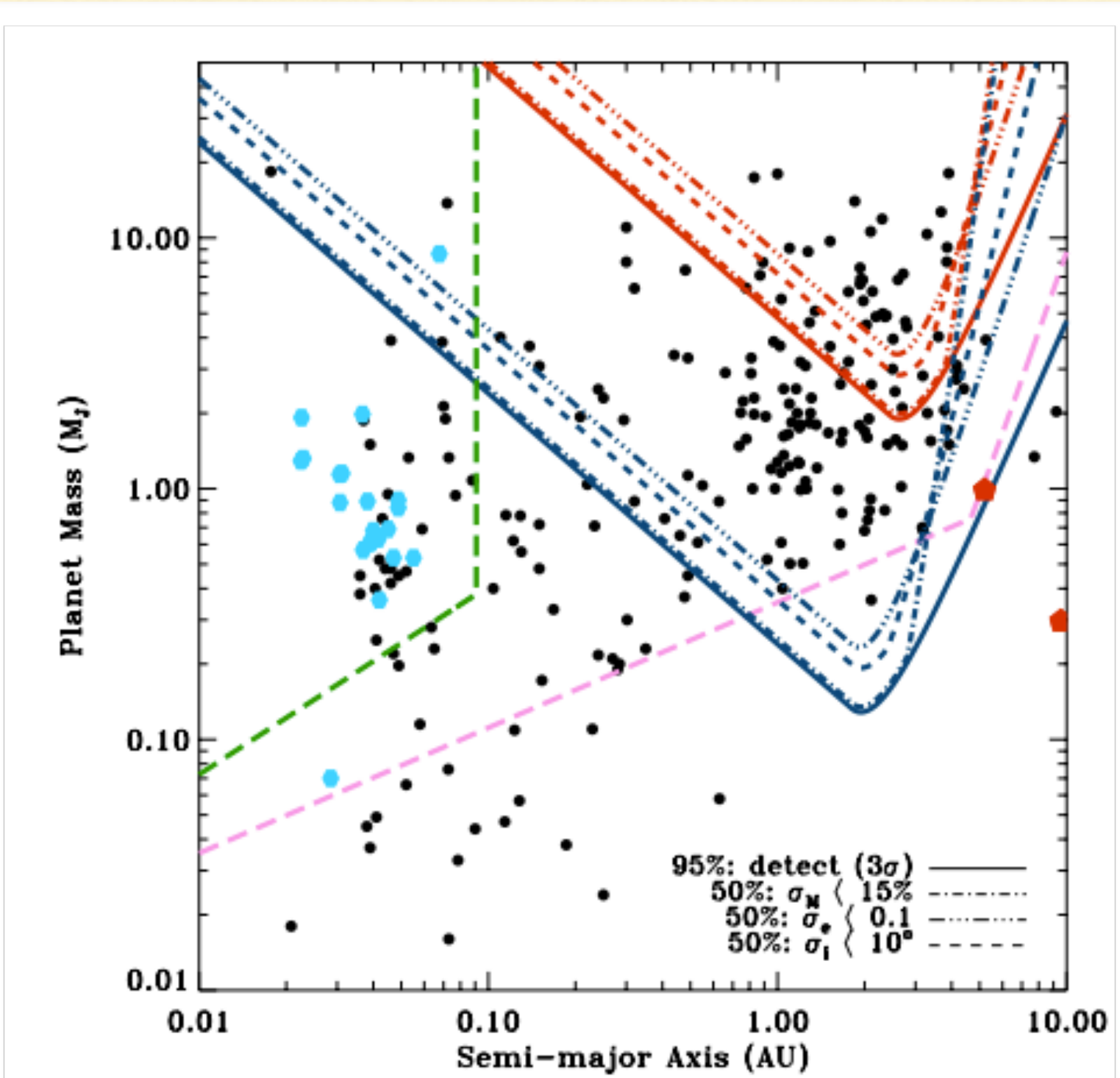
Where will GAIA deliver 1% astrometry?



Gaia will be the first efficient astrometric giant planet detector.



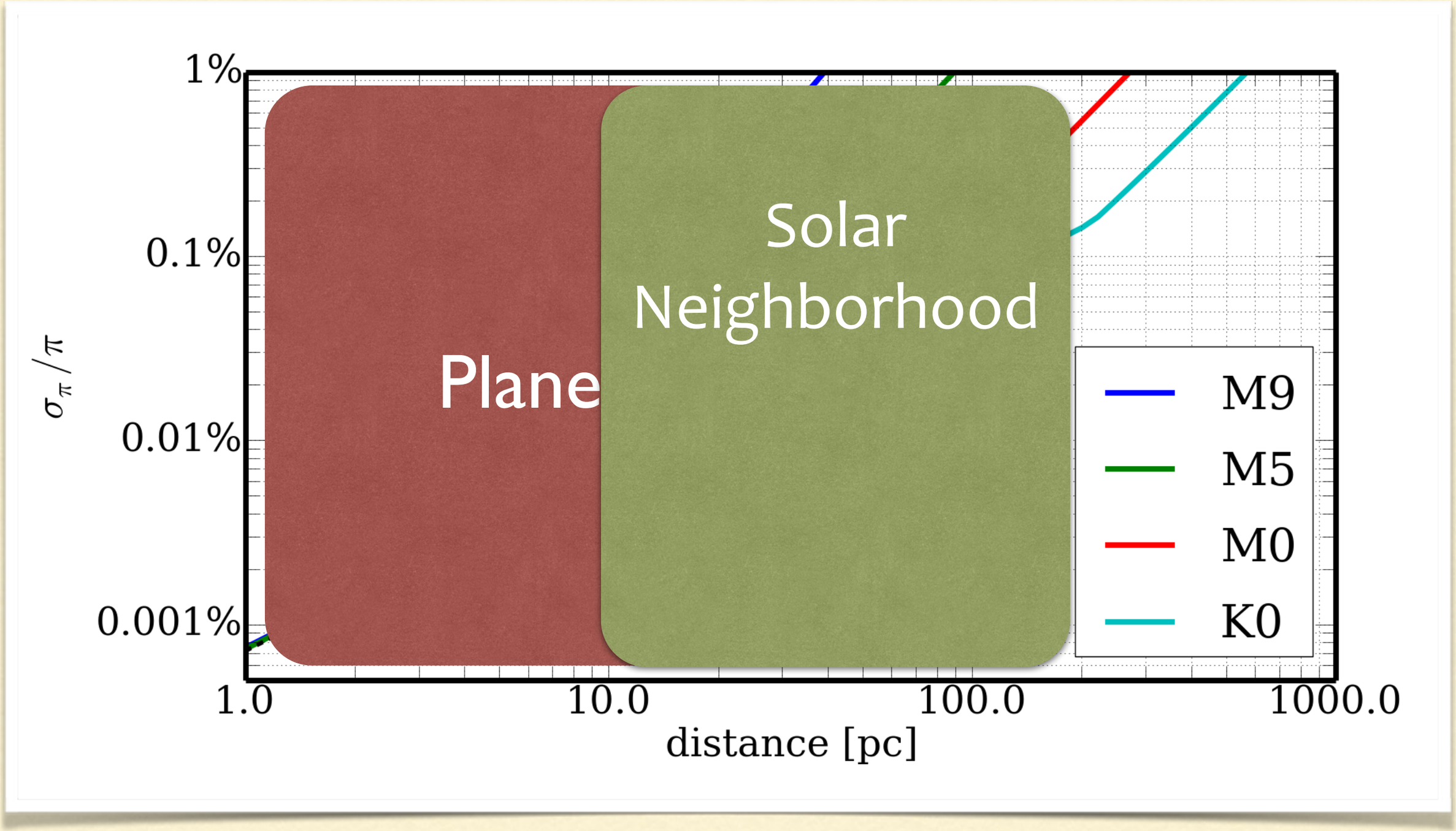
Sozzetti et al., 2013



Gaia's observations of planets around M dwarfs could fill in some gaps in discovery phase space.

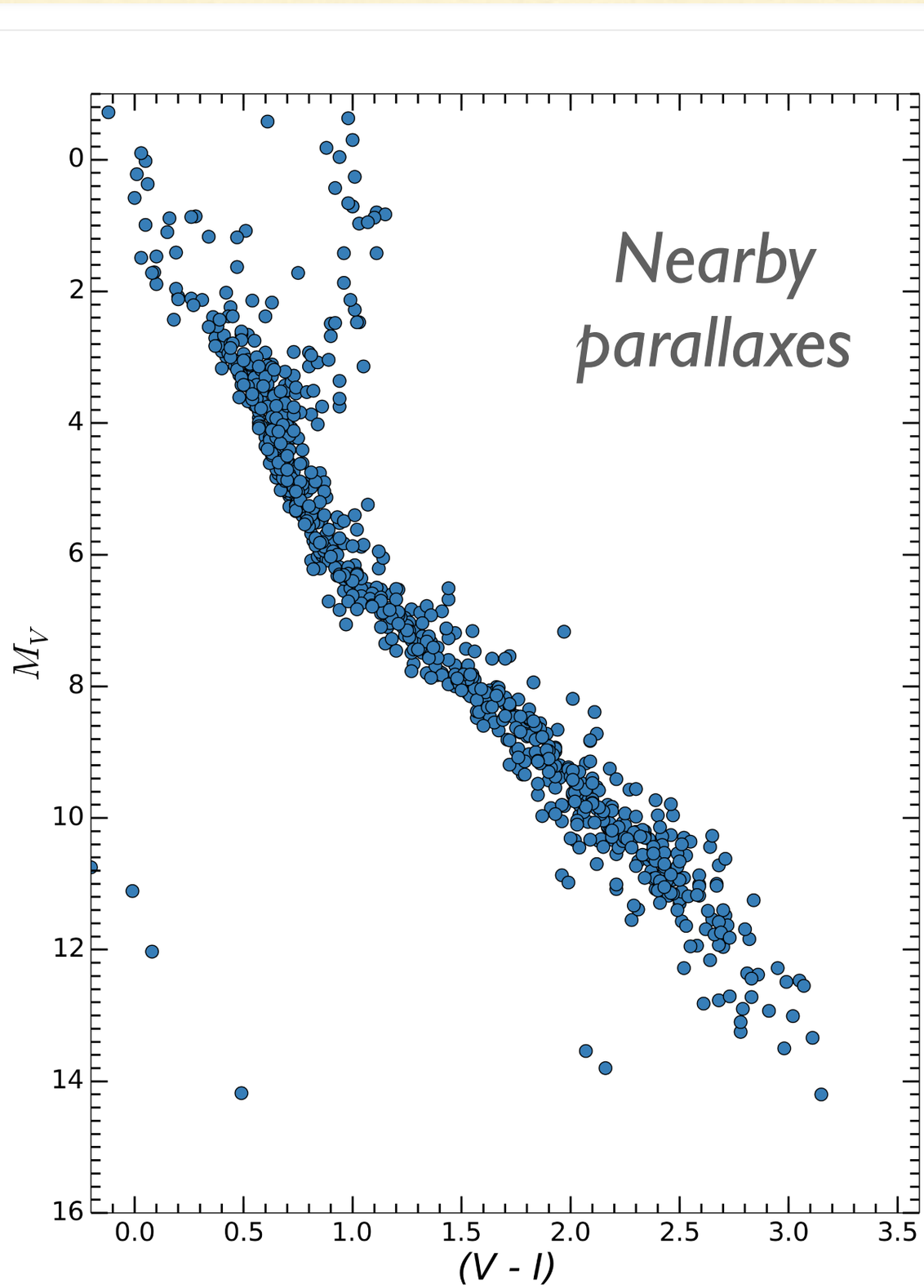
Casertano et al., 2008

Where will GAIA deliver 1% astrometry?



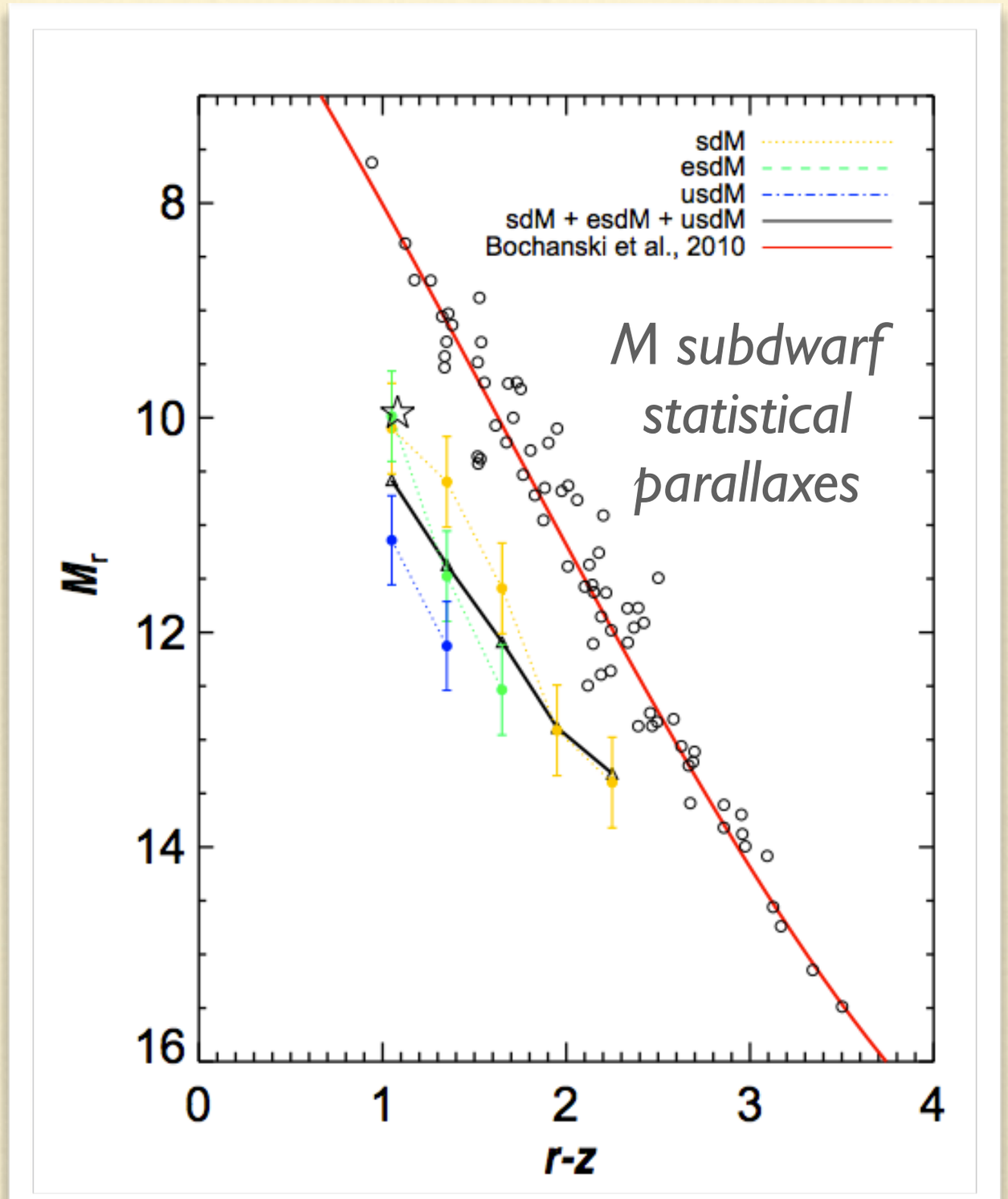
Surveys (i.e., SDSS and RAVE) have paved the way for GAIA.

The Solar Neighborhood is ideal for parallax and detailed kinematic studies.

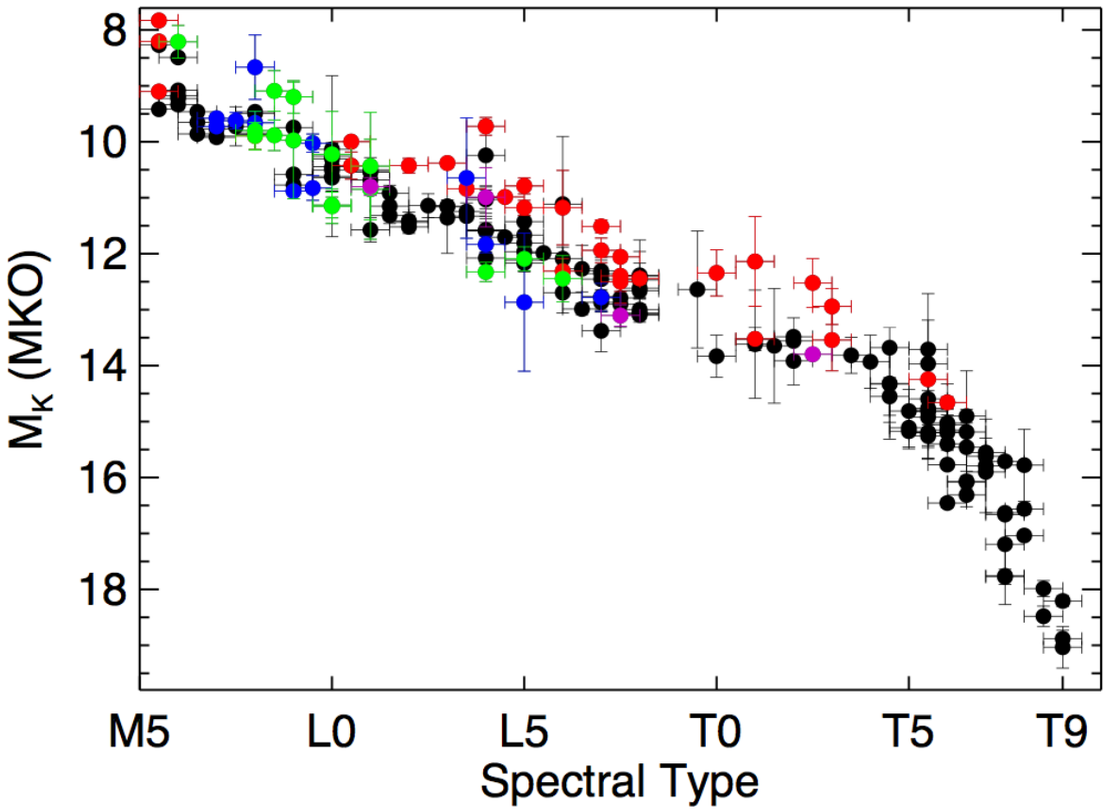


Reid et al.

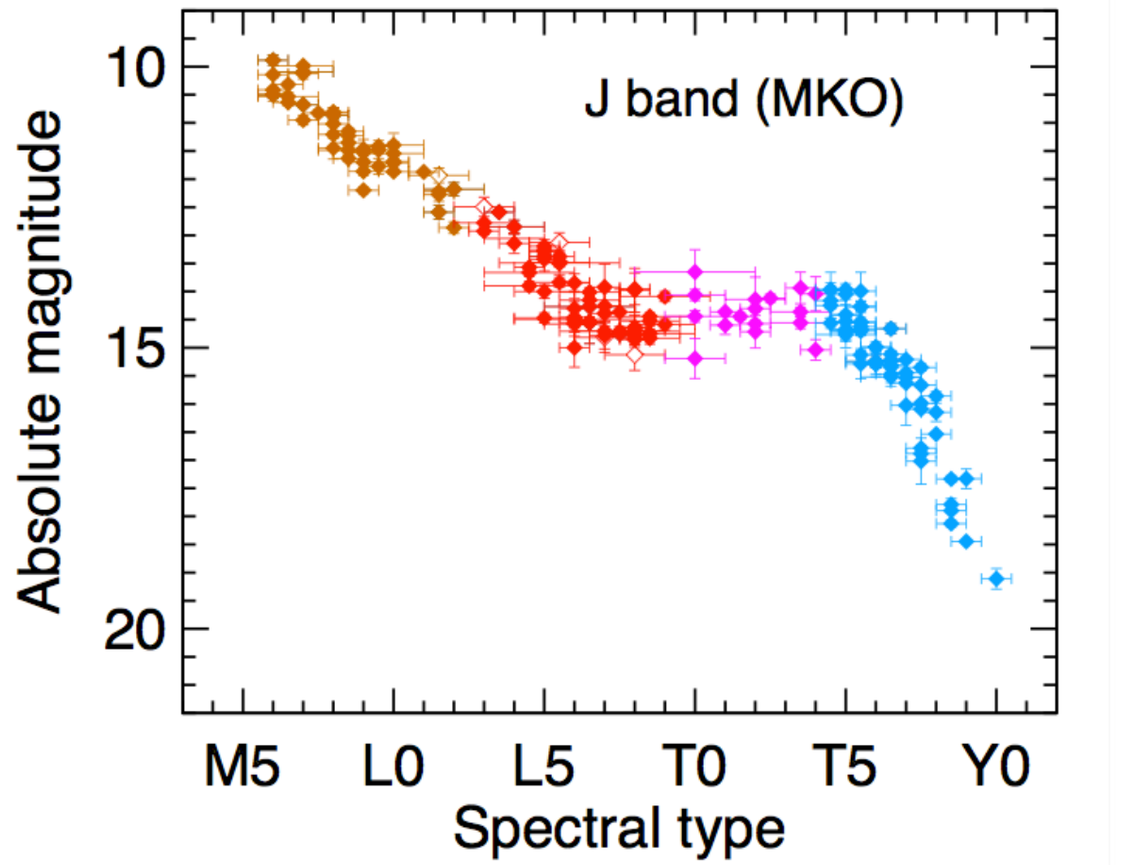
M dwarf and subdwarf statistical parallaxes have revealed a complex relation between color, absolute magnitude, activity, and <u>metallicity.</u>



Bochanski et al., 2013



Faherty et al., 2012

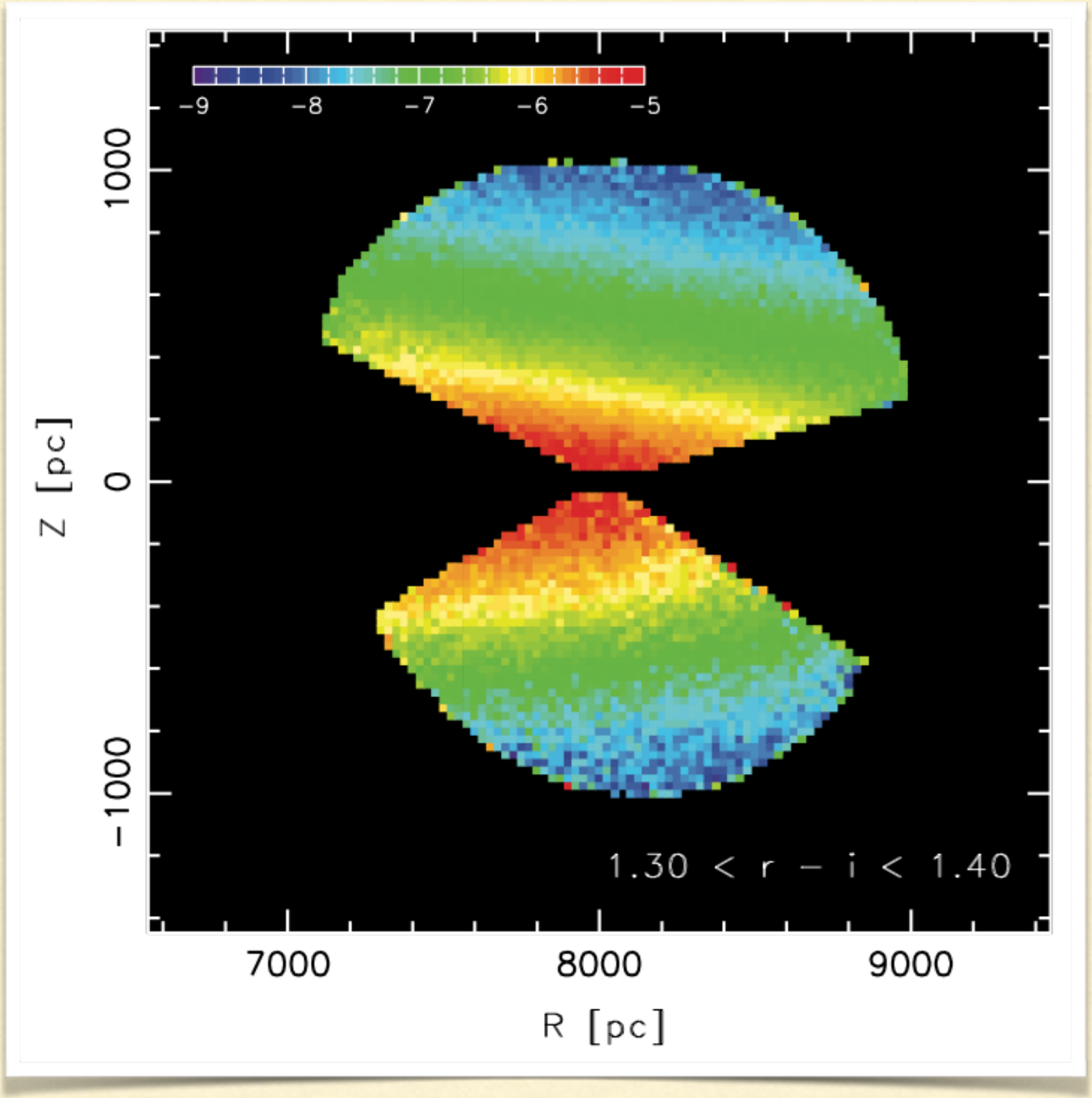


Dupuy et al.

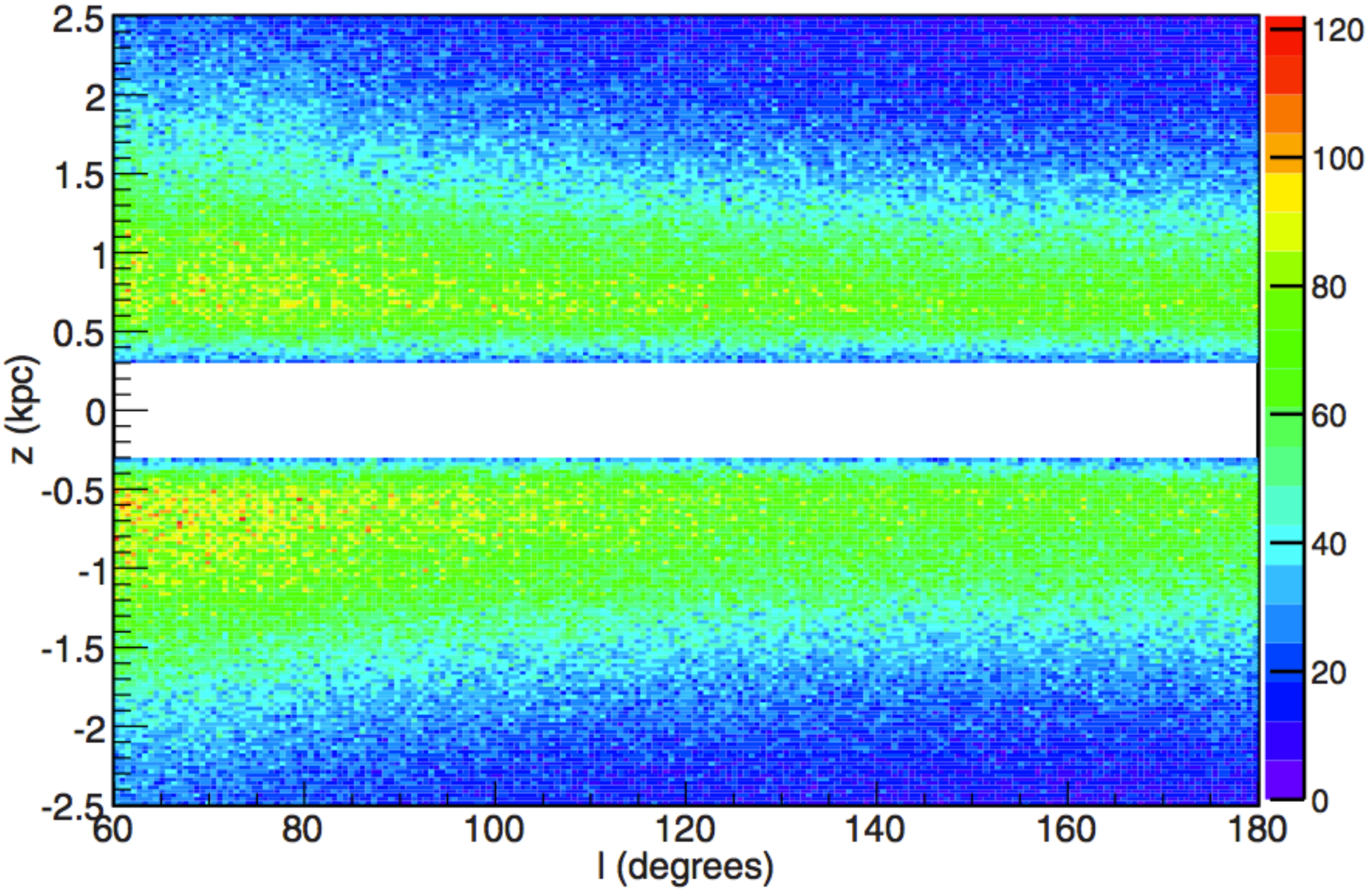
Brown dwarf parallaxes have revealed significant scatter in absolute magnitude for each spectral type.

	CURRENT NUMBER WITH PARALLAXES	PROJECTED NUMBER AFTER GAIA
EARLY M	~1000 (Henry, Reid, Lepine, Golimowski, Upgren, Dahn, Tinney, Gizis, Vrba et al.)	1,000,000s
MID TO LATE M	~1500 (Dittman et al.)	100,000s
L & T DWARFS	~ 400 (Faherty, Beichman, Smart, Manjavacas, Marocco, Dupuy, Shkolnik, Marsh, Dahn, Tinney, Vrba et al.)	~1,000

Precise distances from *Gaia* will permit the mapping of the MW from deeper photometry.

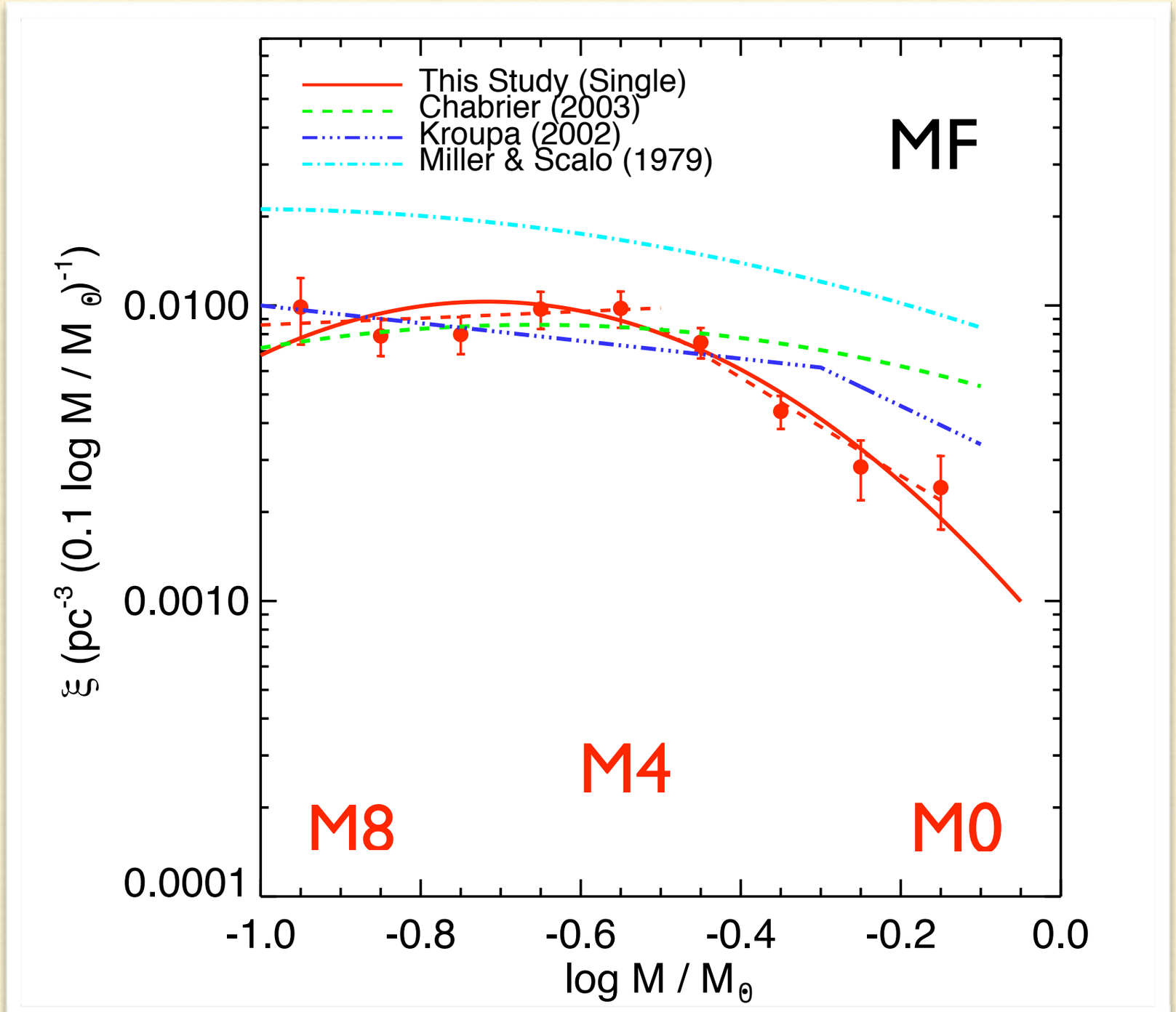


Juric et al., 2008

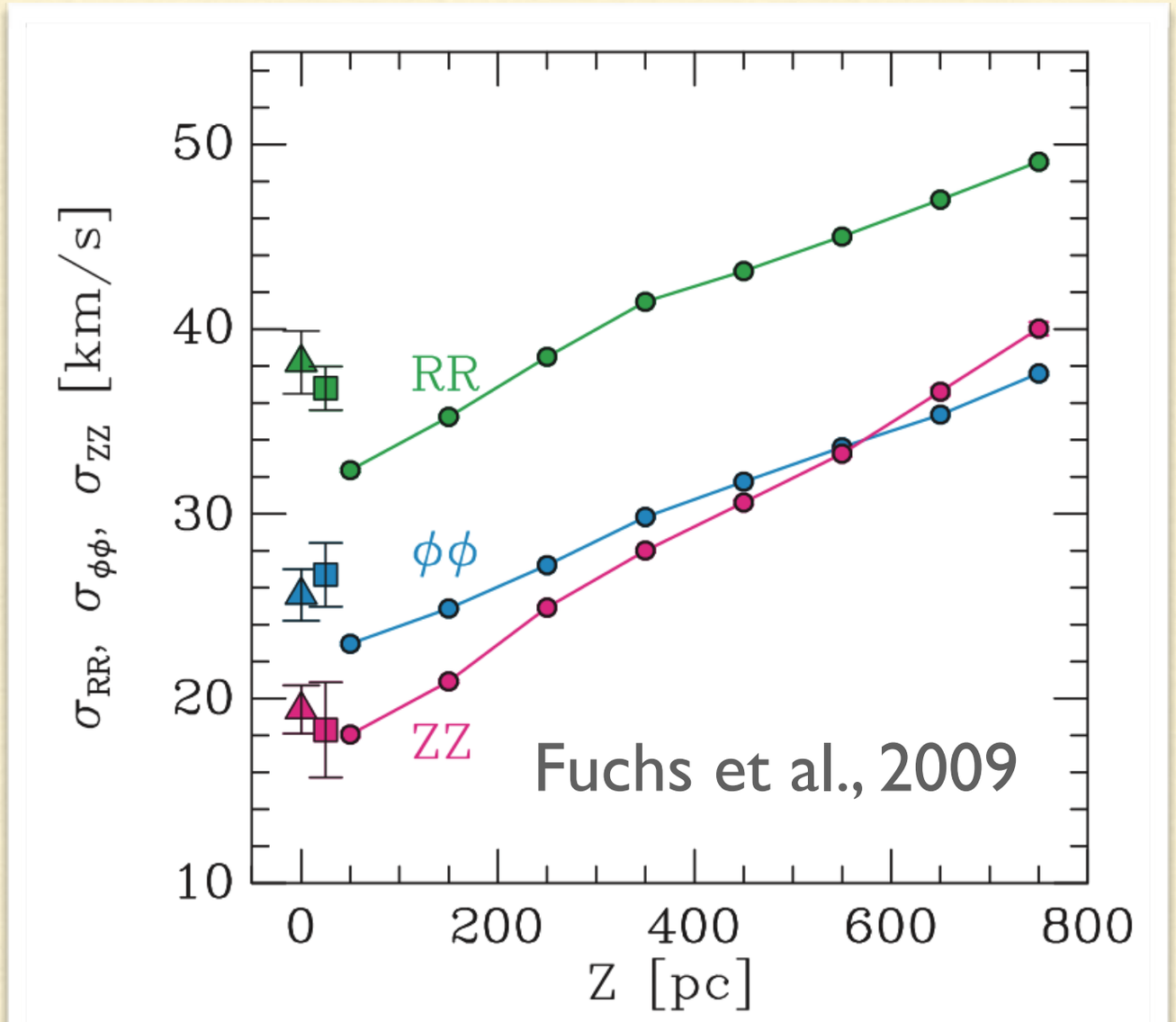


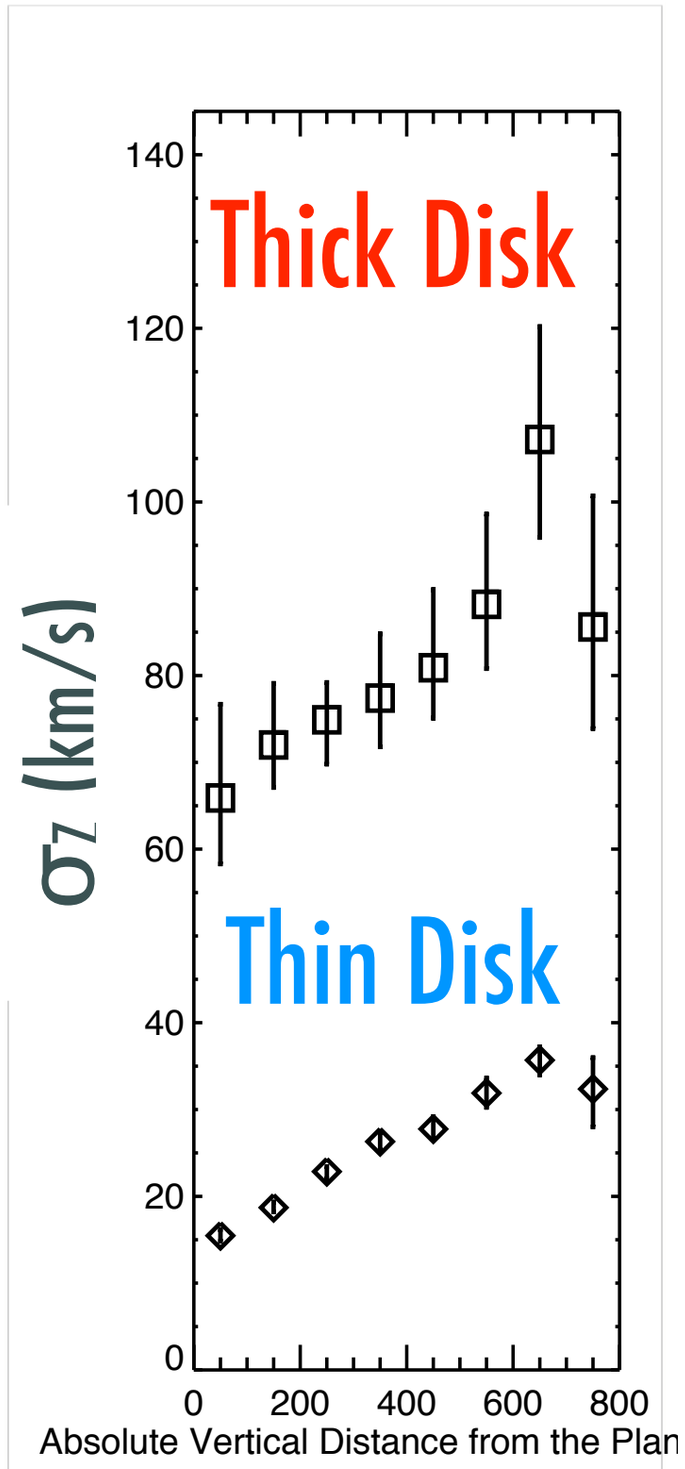
Yanny & Gardner, 2013

Gaia parallaxes will lead to the definitive measure of the Milky Way LF & IMF.



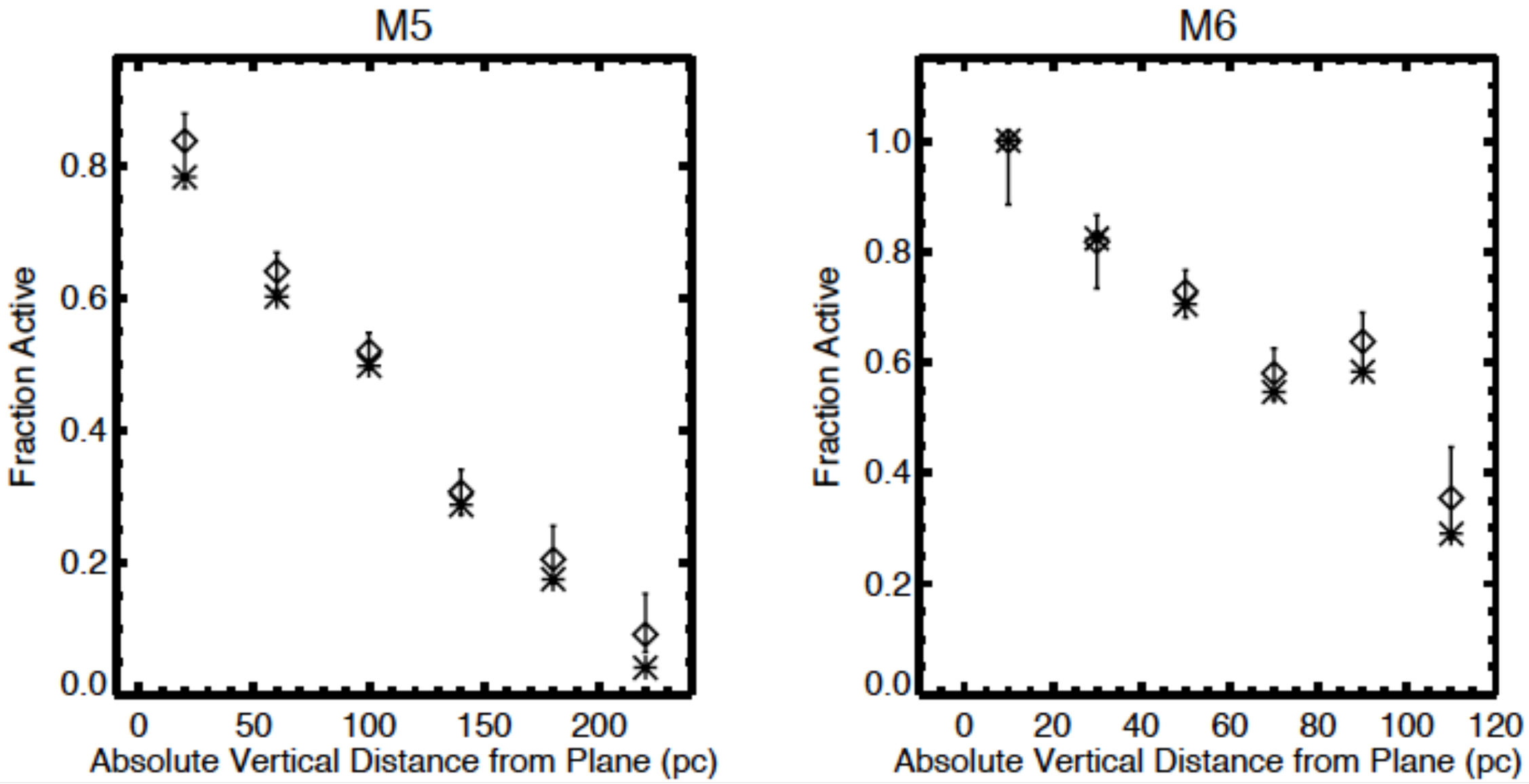
Bochanski et al., 2010





Pineda et al, in prep

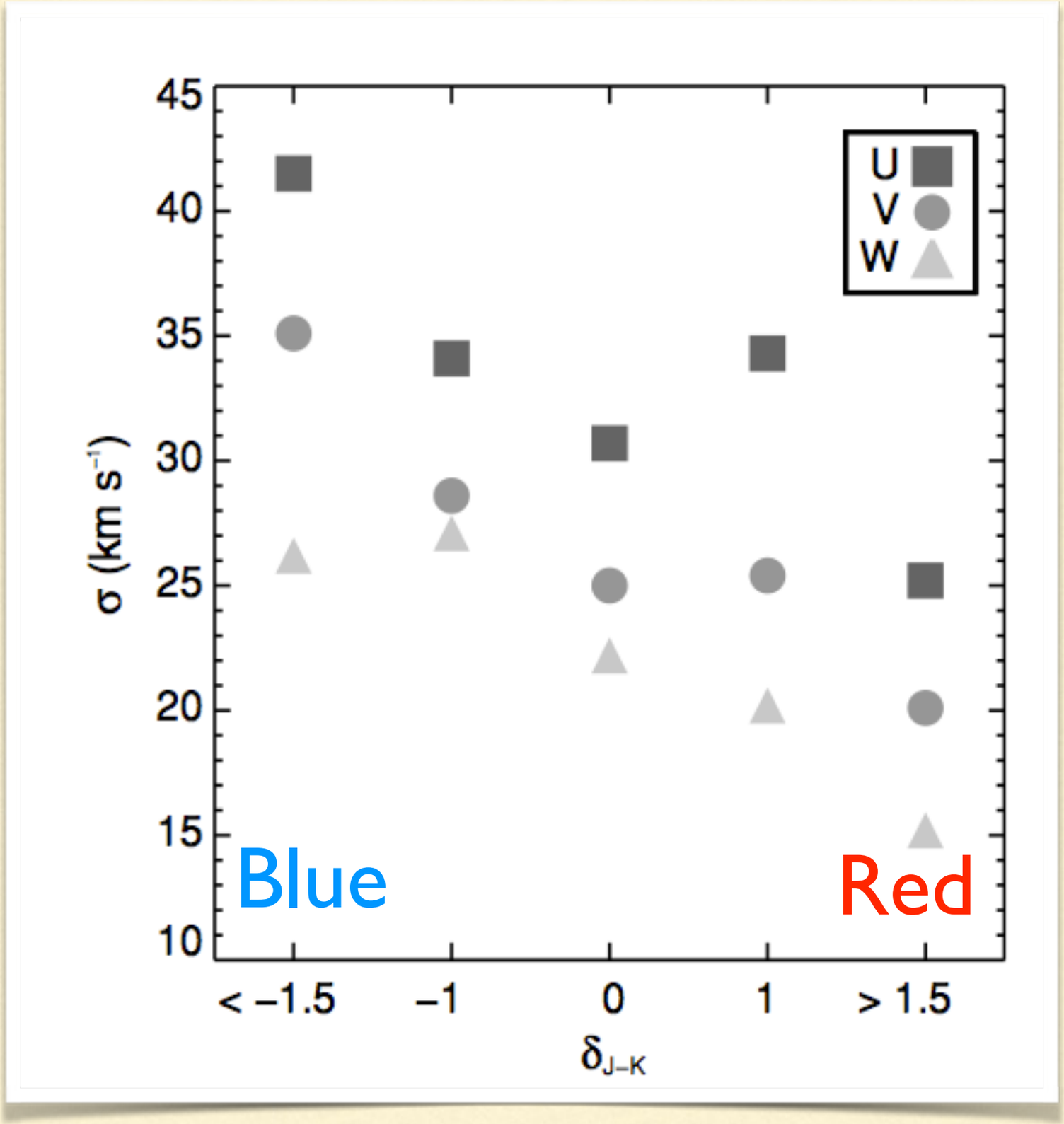
Using SDSS, low-mass stars have been used to map out kinematic structure to ~ 1 kpc.



This kinematic work has informed our knowledge of intrinsic stellar properties, such as chromospheric activity.

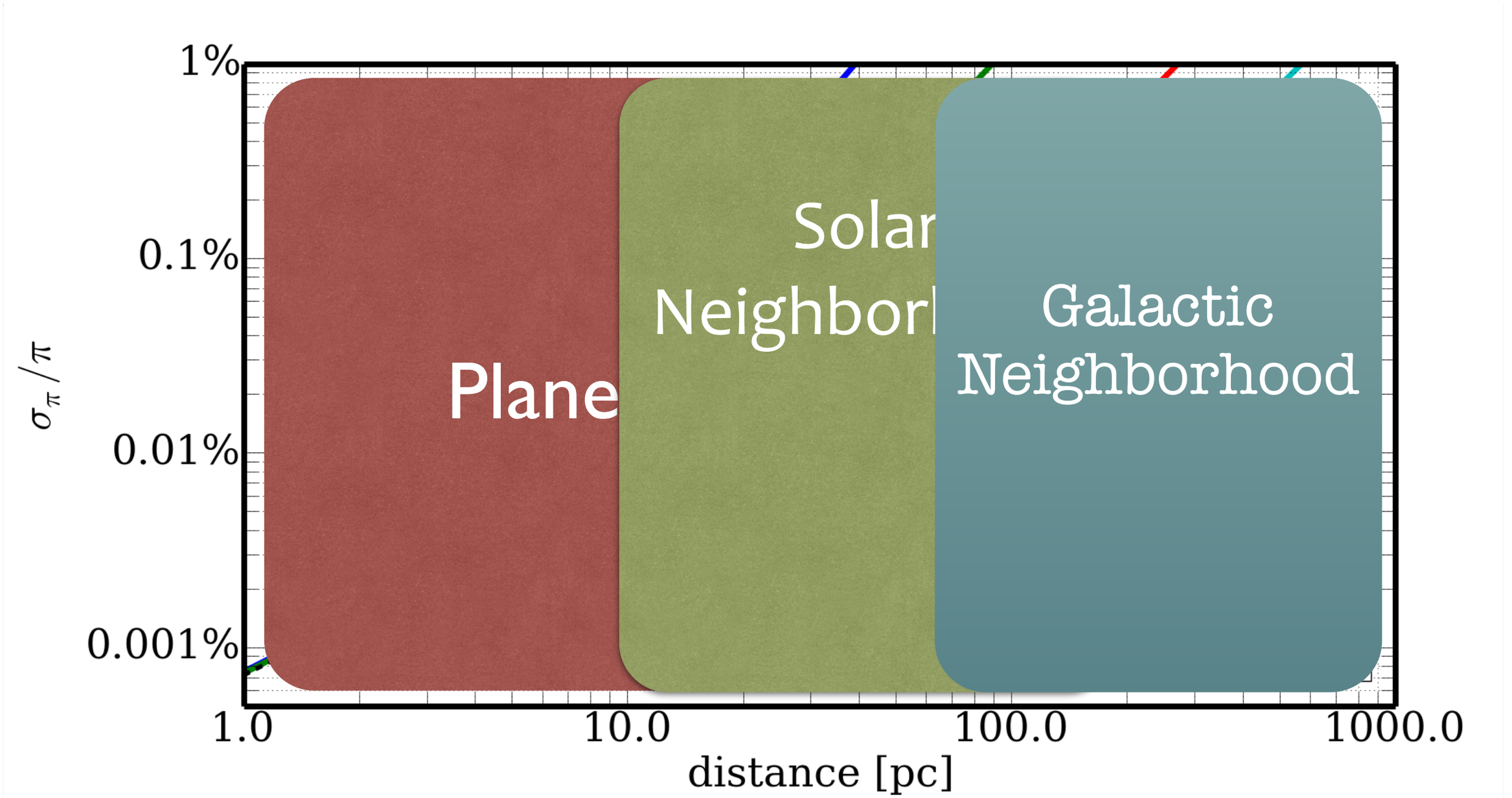
West et al., 2008

Kinematic studies of brown dwarfs have also revealed intrinsic differences.



Schmidt et al, 2010, Faherty et al., 2009

Where will GAIA deliver 1% astrometry?



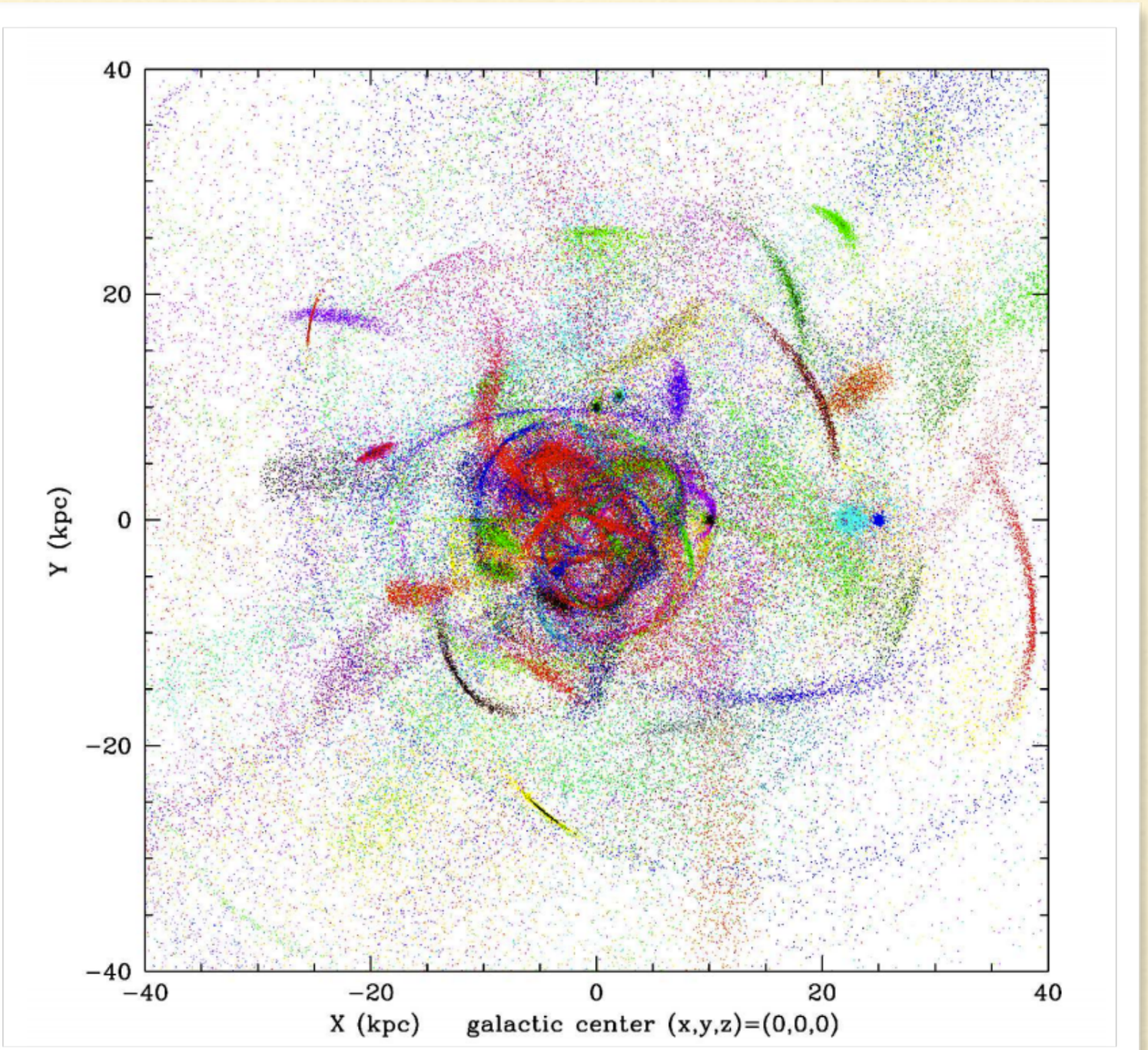
Gaia will record 6D phase space for *millions* of MLTY dwarfs…

What can we do?

- Measure kinematic substructure
- Measure the local mass density
- and much, much more!

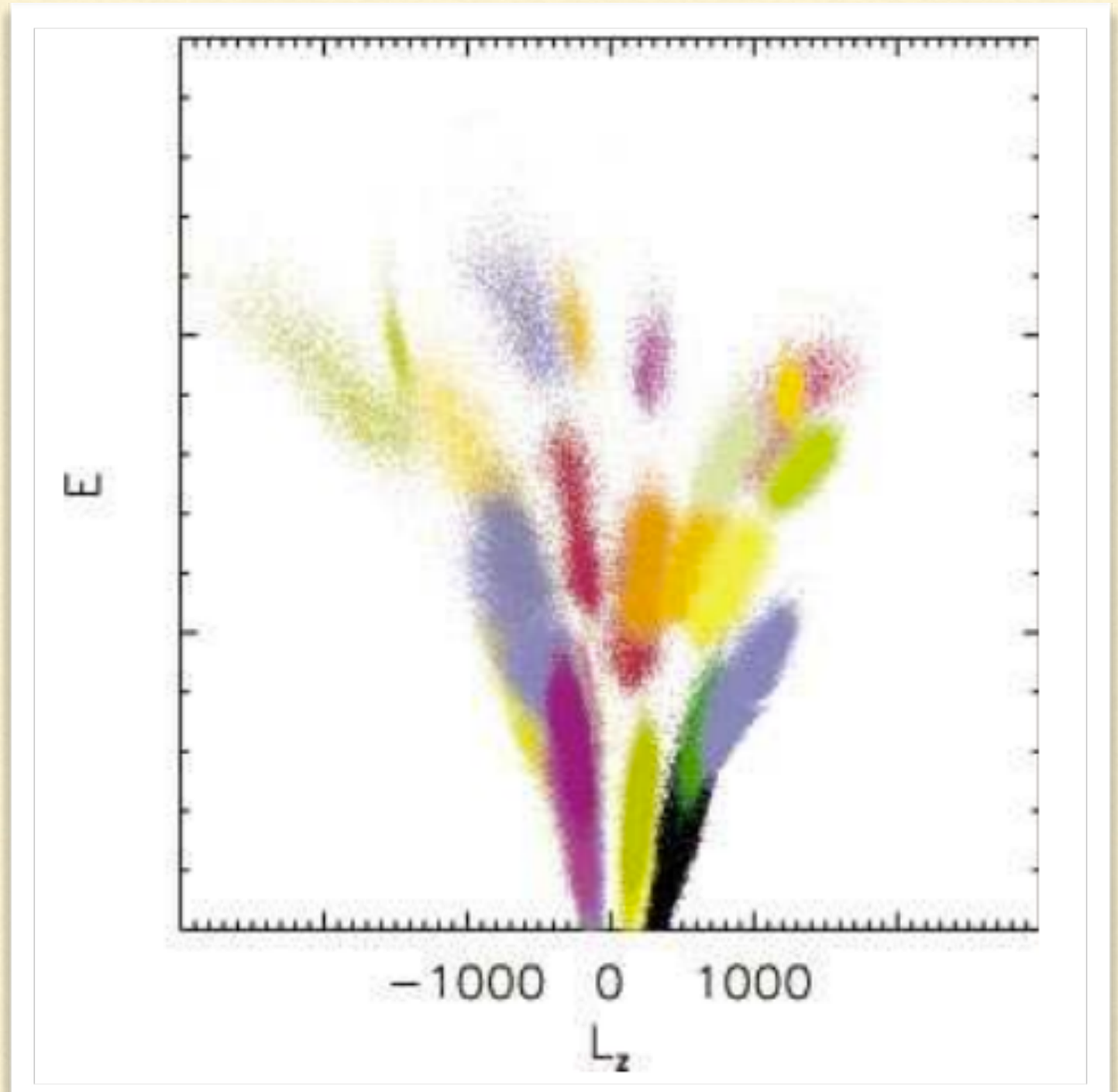
The "Galactic neighborhood" should contain 100s of nearby stellar streams.

Robustly identifying them will allow us to determine how energy and angular momentum are transferred in the Galaxy.



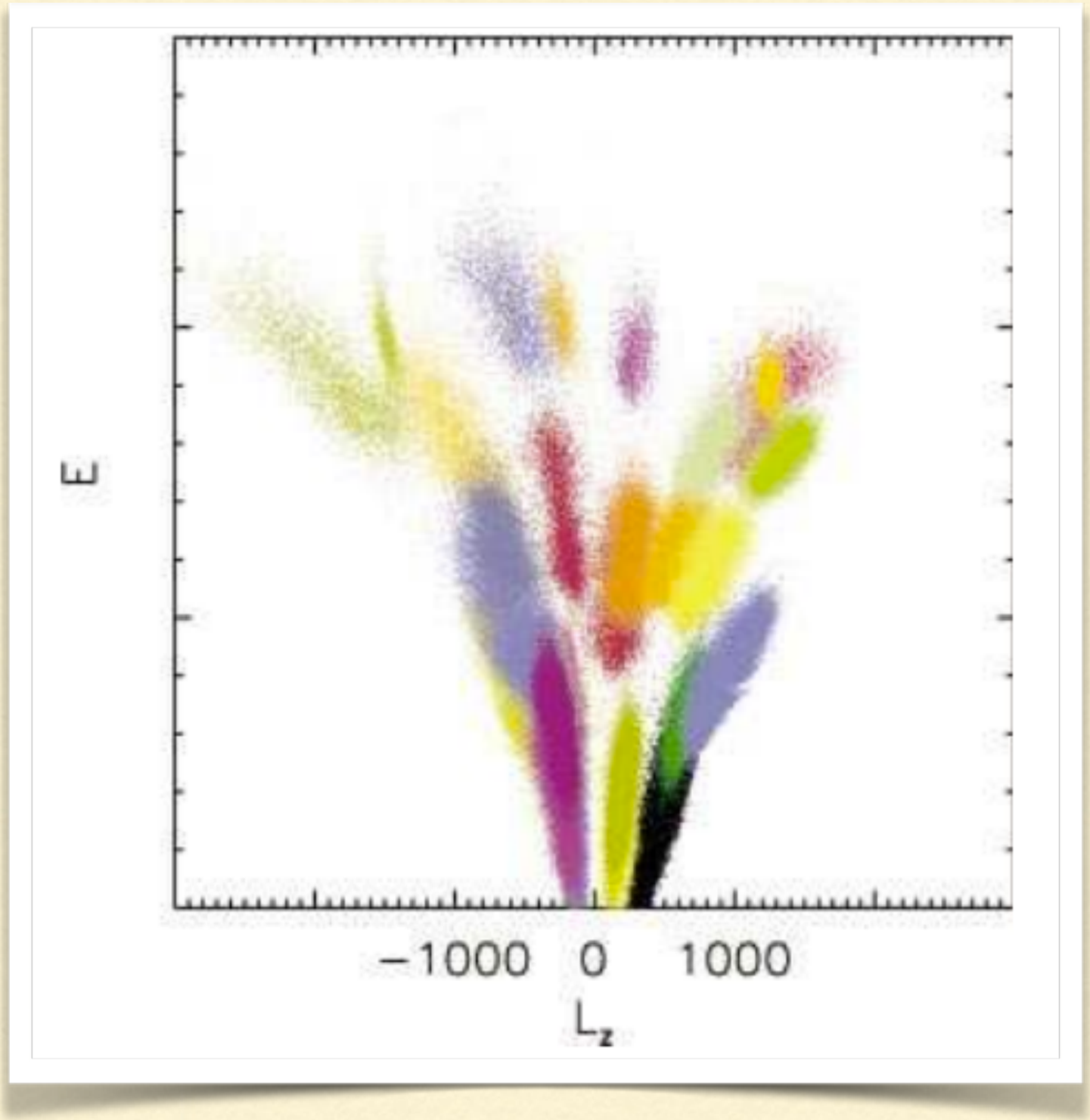
Helmi & Spaghetti Project Survey

Different disk evolution mechanisms (heating from molecular clouds, spiral arm resonances, and minor mergers) all have different age-velocity relations.

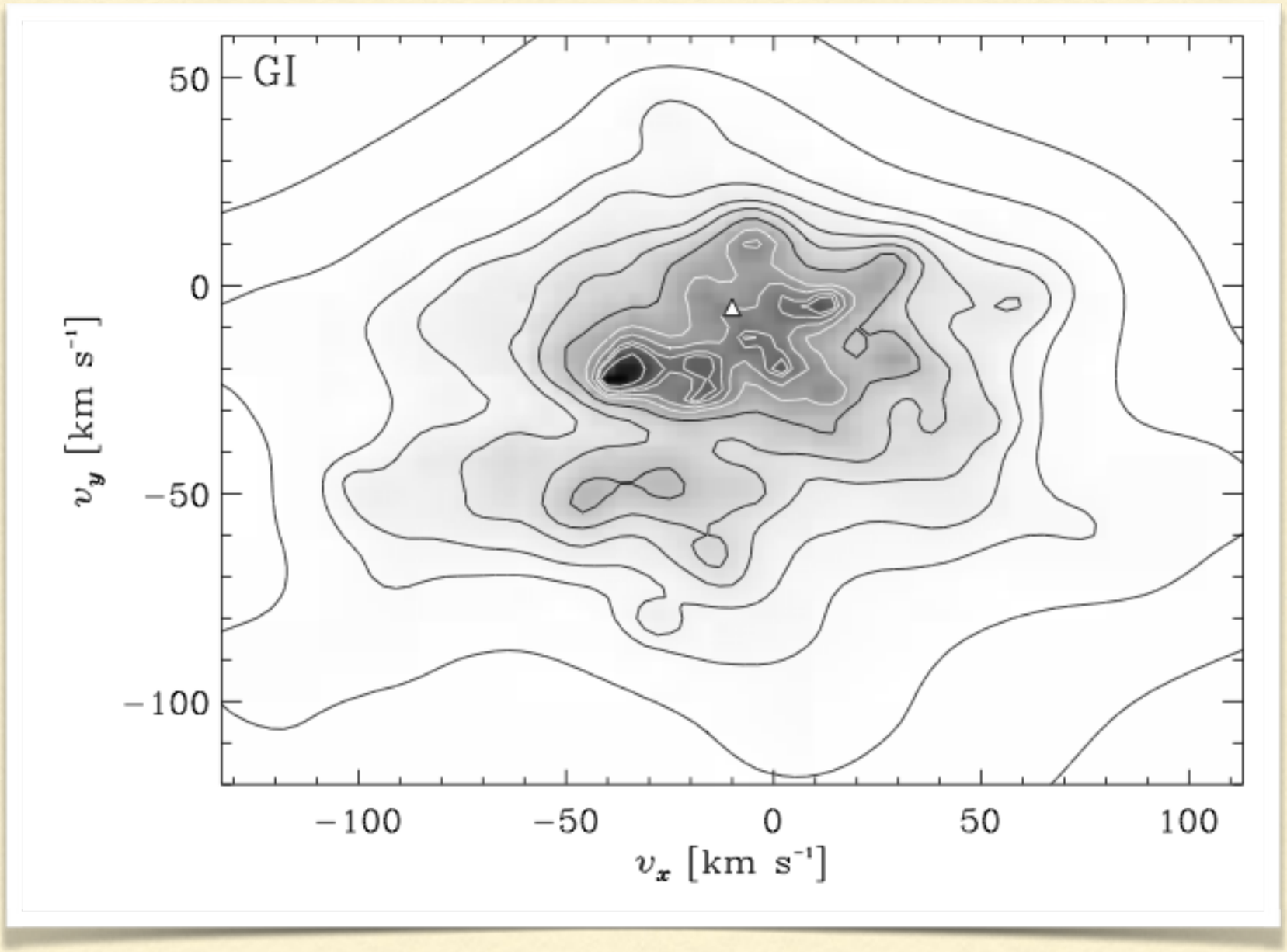


Helmi & de Zeeuw, 2000

Gaia will robustly identify groups and determine which mechanism(s) are the most important.

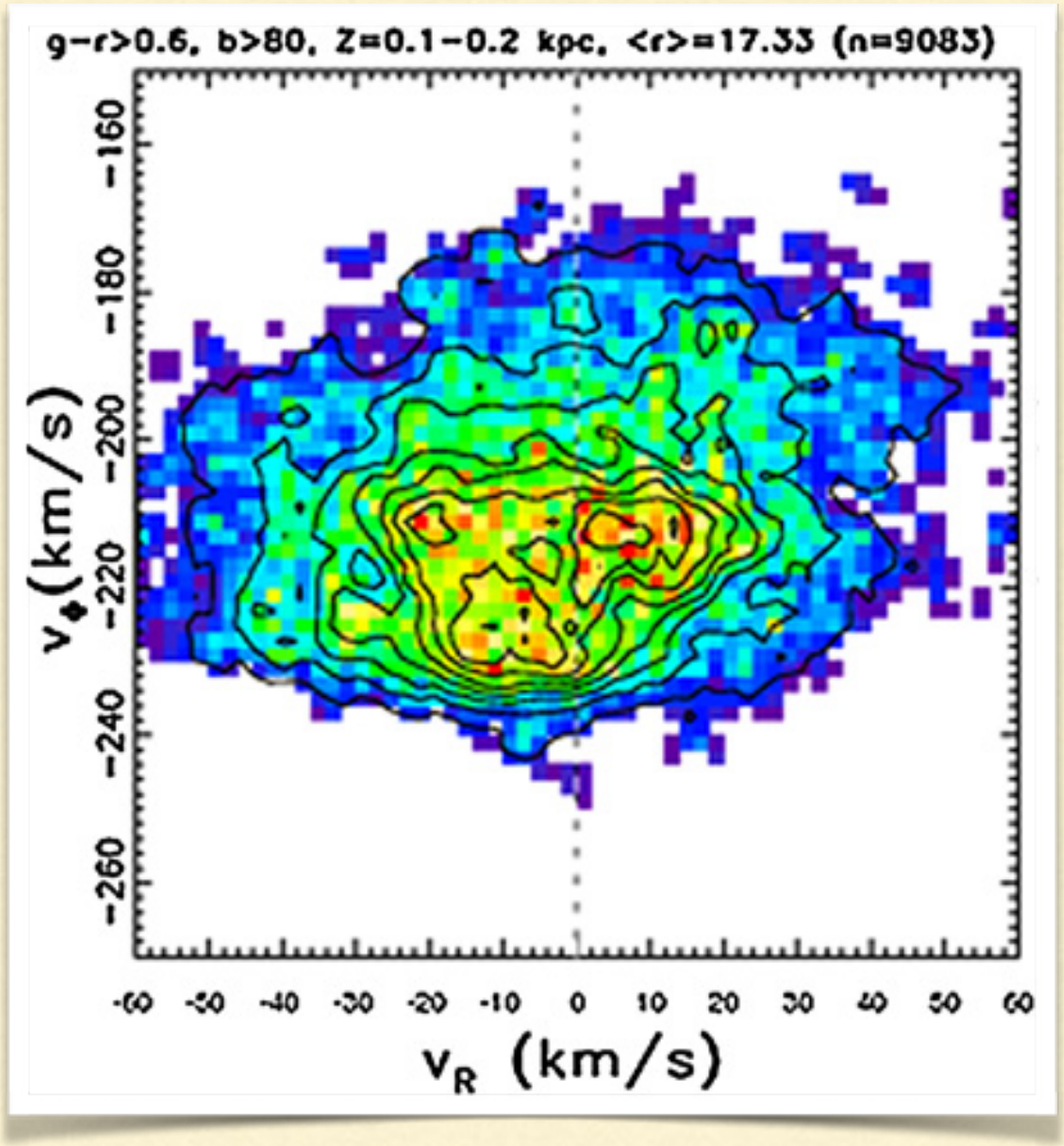


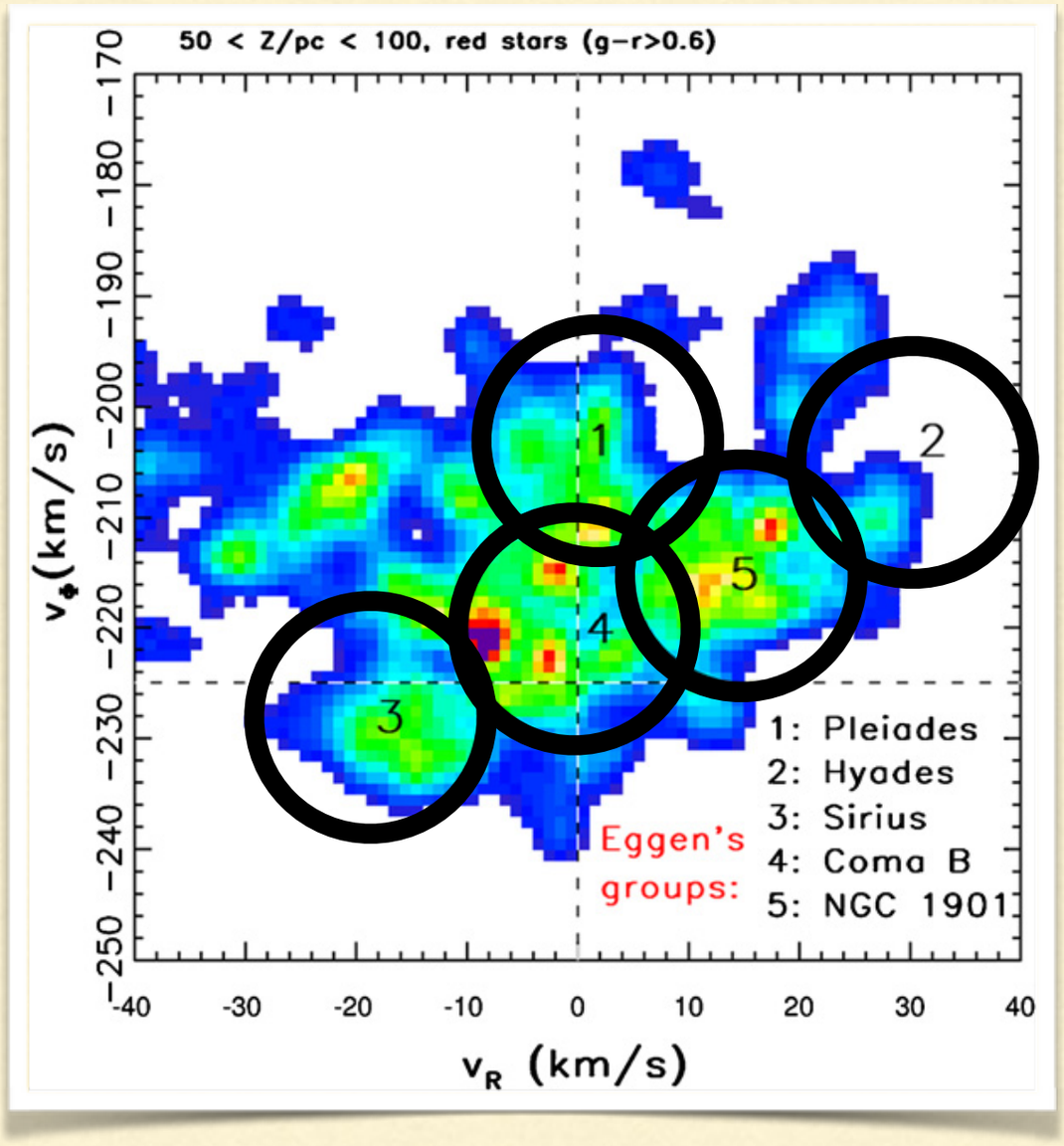
Kinematic substructure has been known in the solar neighborhood for ~50 years.



Dehnen 1998

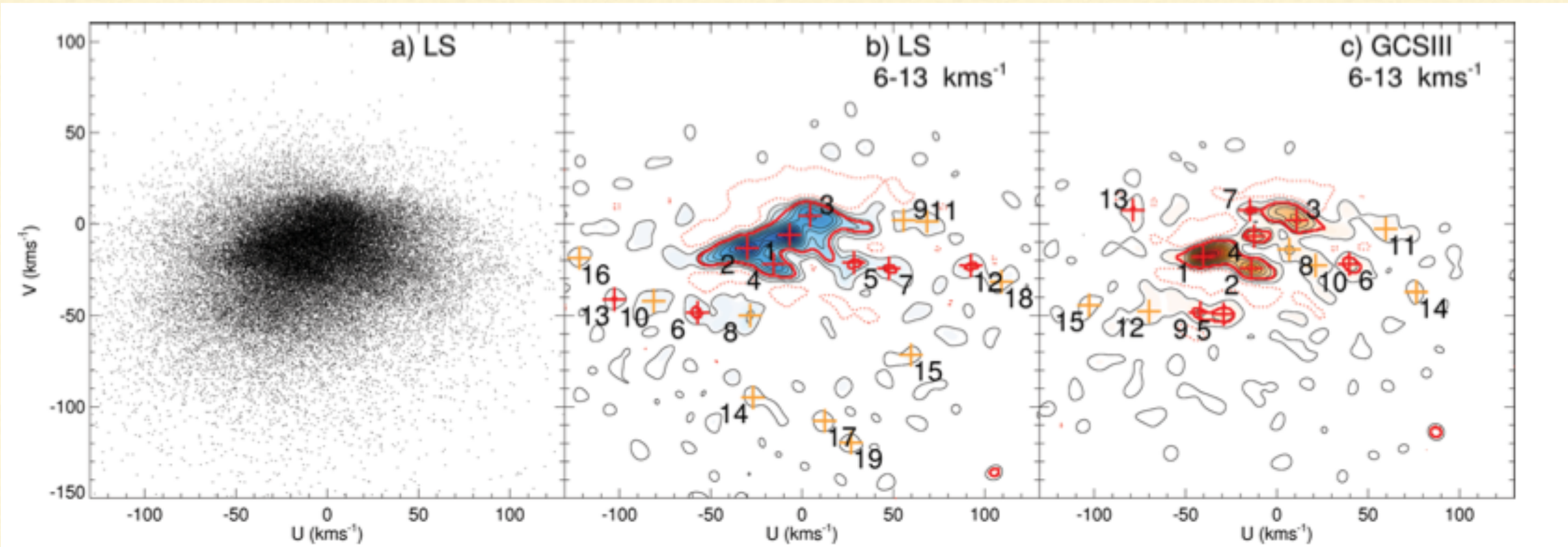
SDSS and RAVE studies have recovered complex substructure in the Solar Neighborhood.





Eggen, 1959; Bond et al., 2010

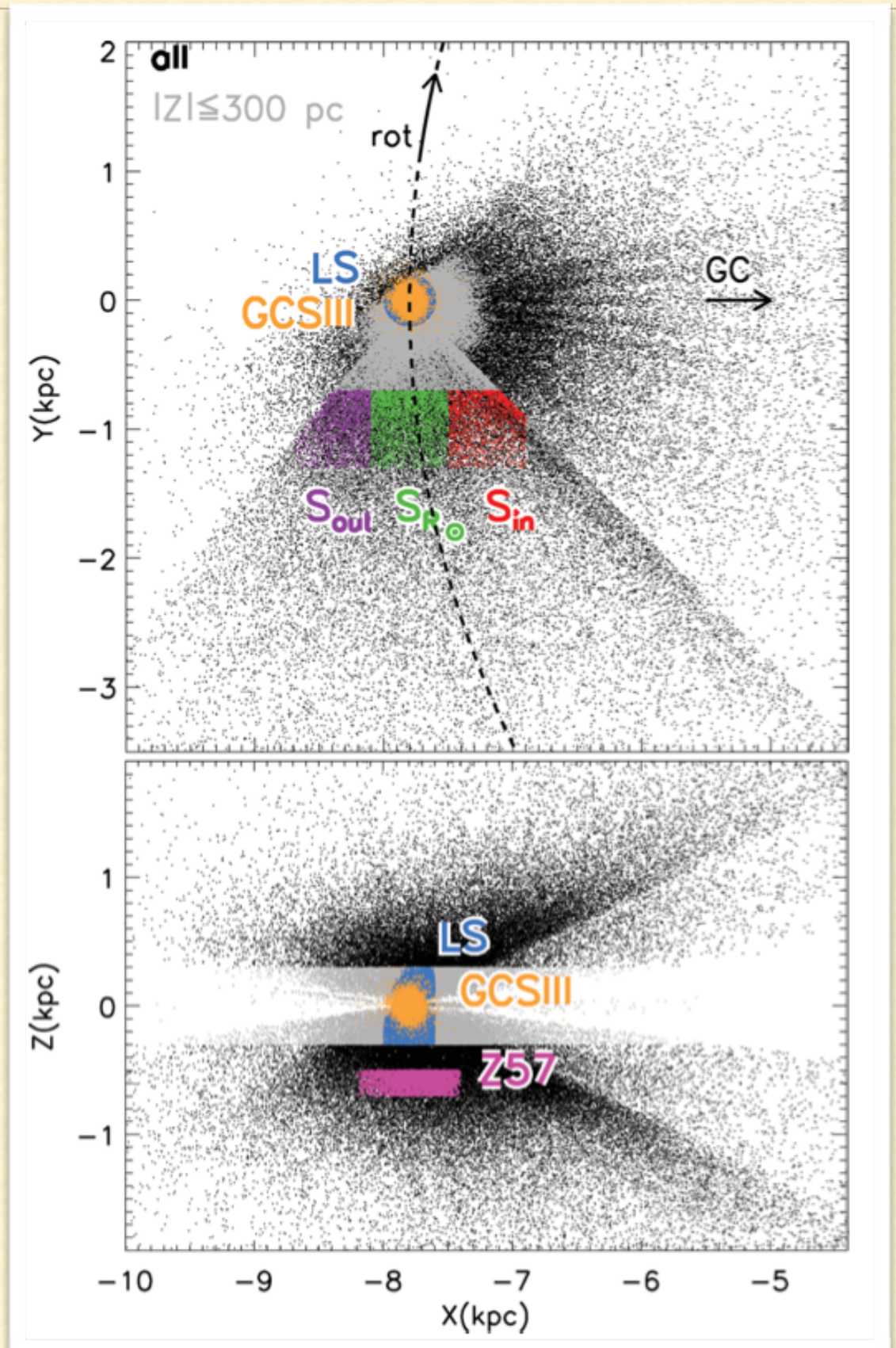
Our analysis must be optimal for the data (drawing circles is no longer good enough!)



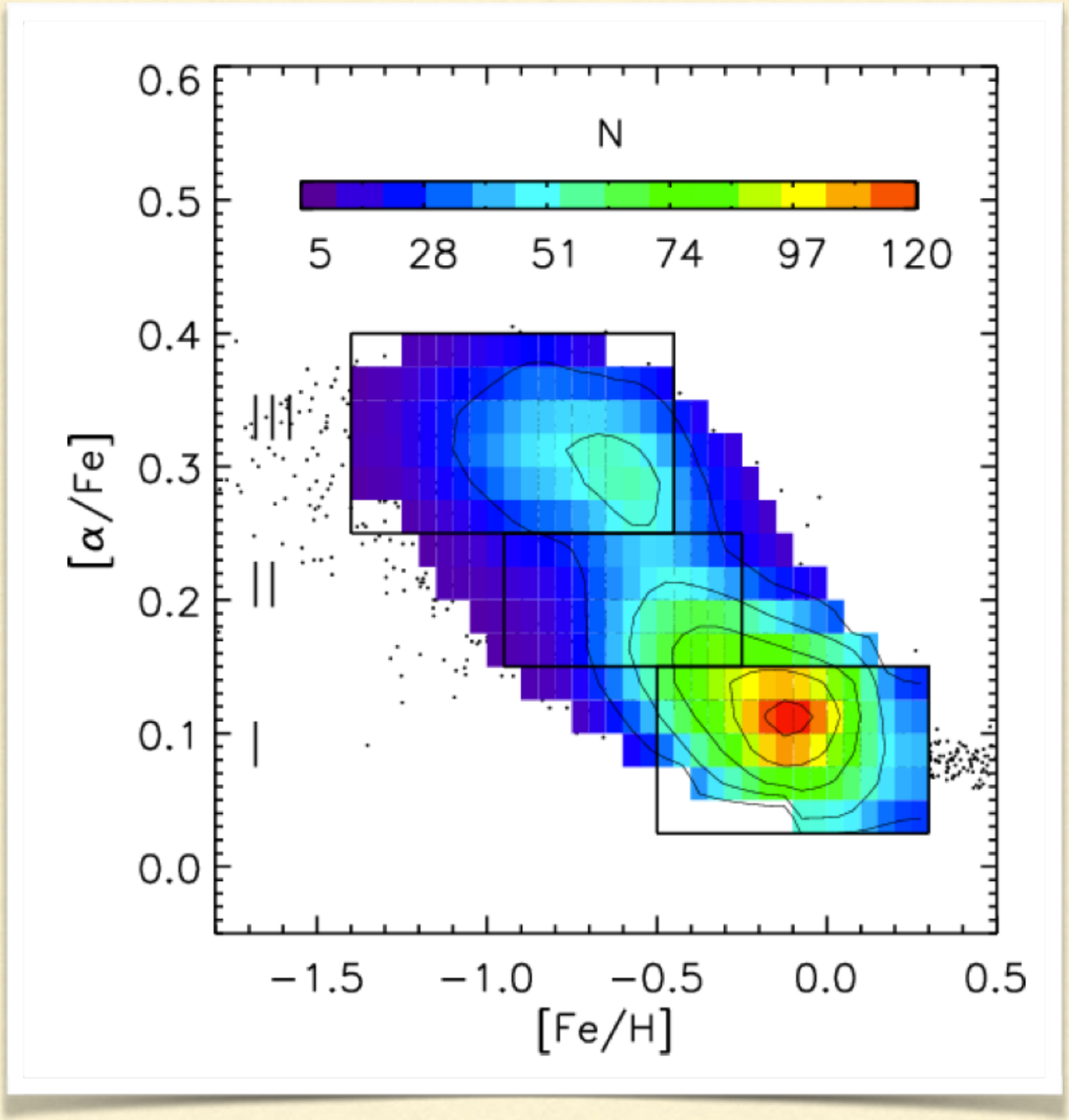
Antoja et al., 2012

Soon we will have precise 6D motions for multiple locations in the Galaxy!

Antoja et al., 2012

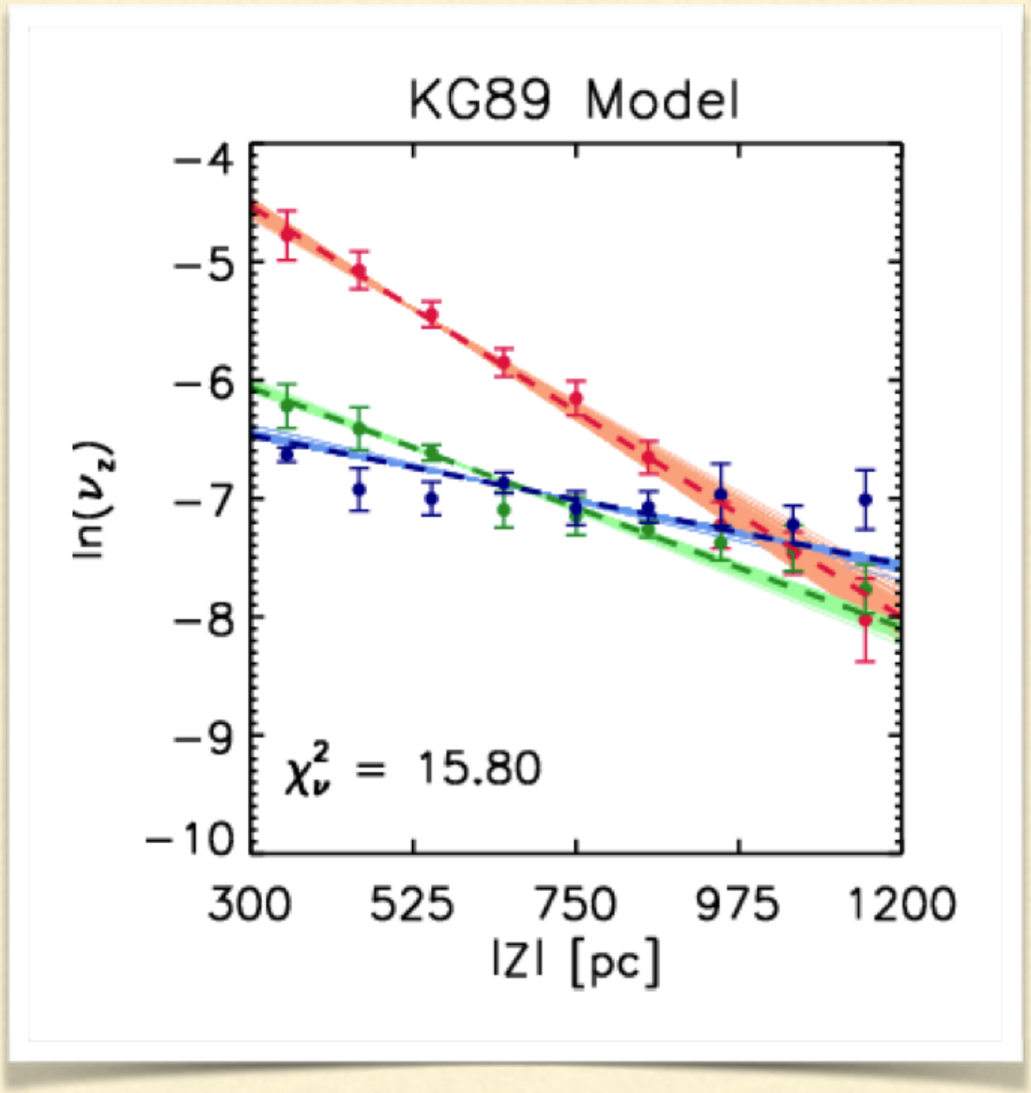


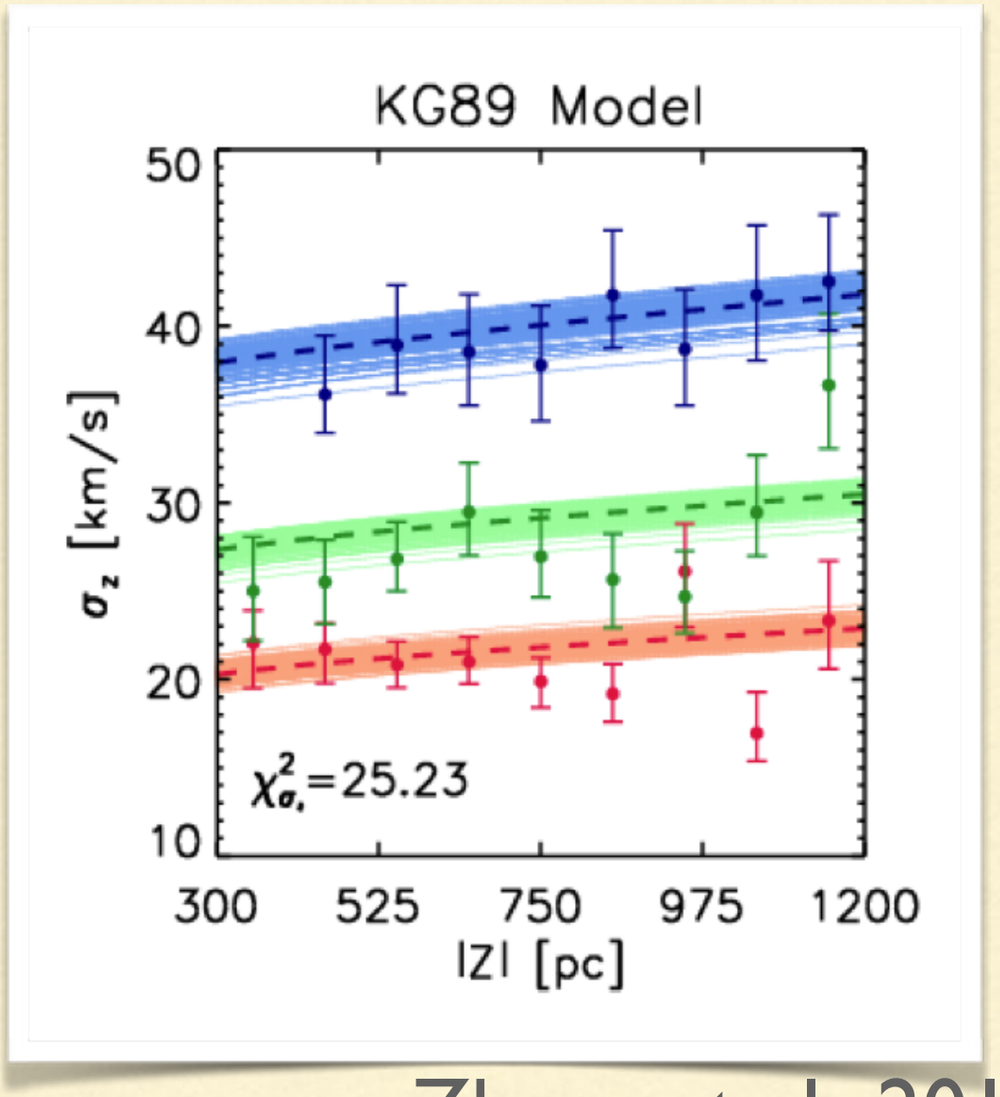
The local mass density is directly related to the velocities and distances of nearby stars.



Zhang et al., 2012

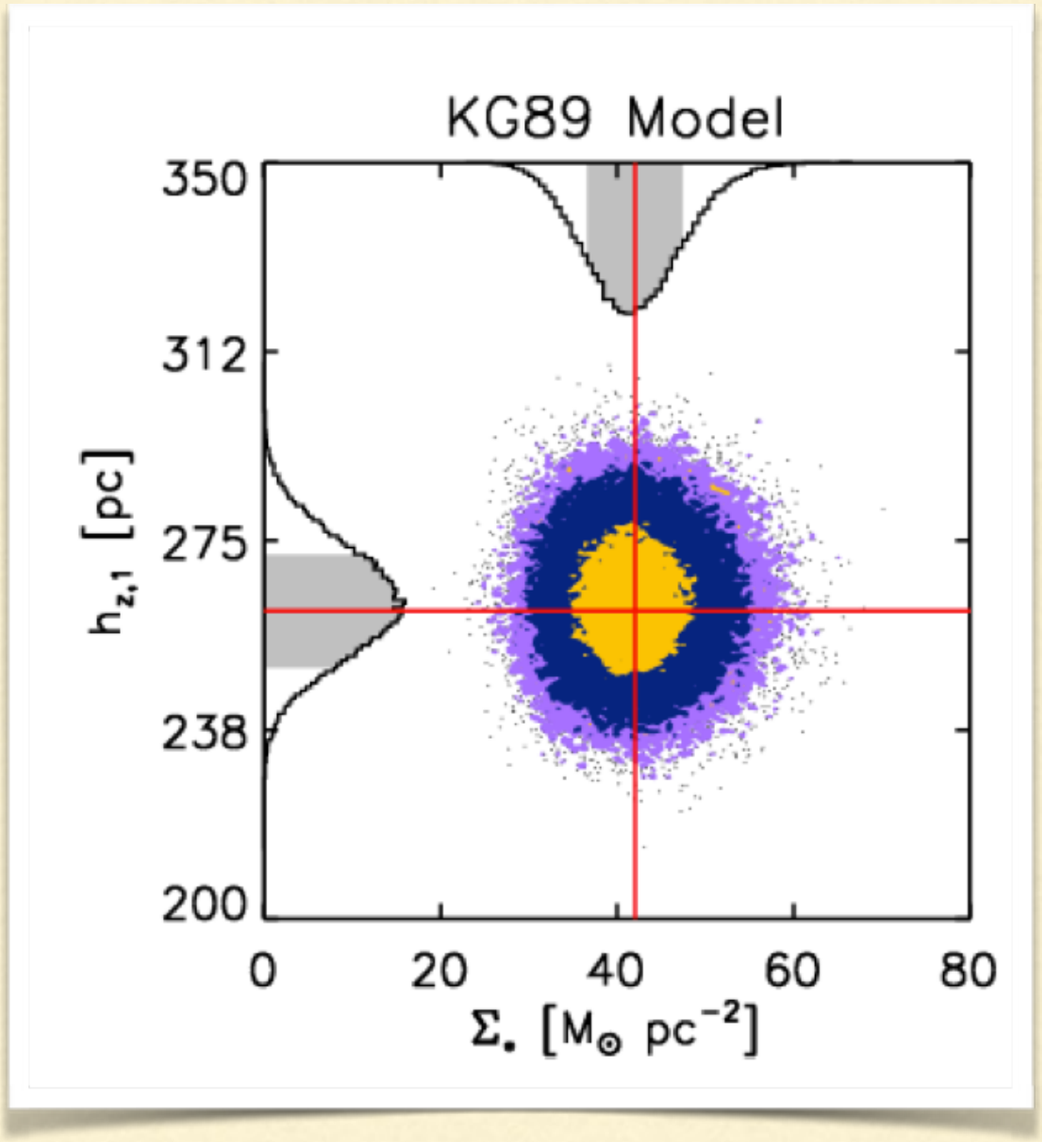
SDSS/SEGUE observations have revealed that different disk populations have different kinematic and structural properties.

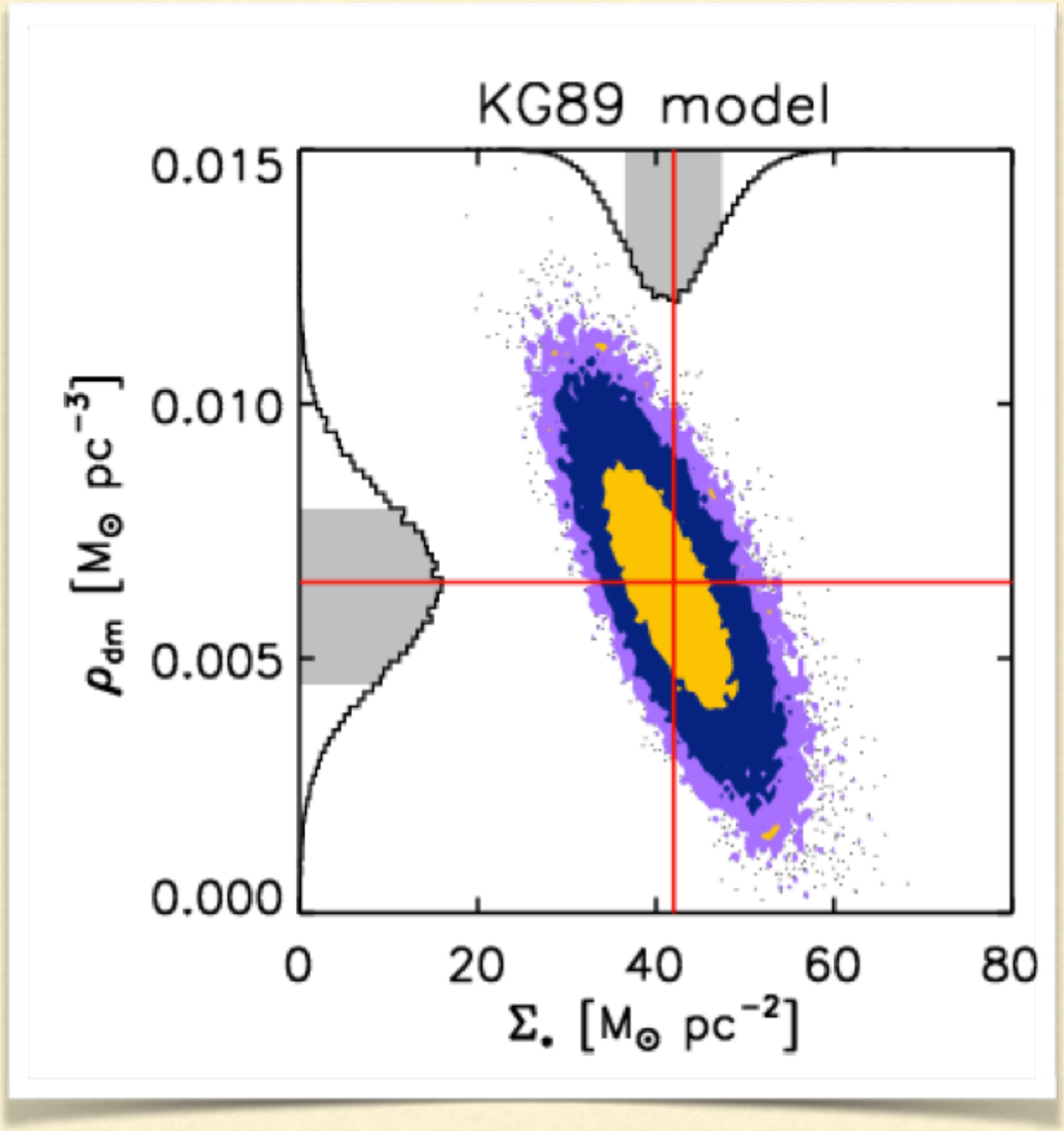




Zhang et al., 2012

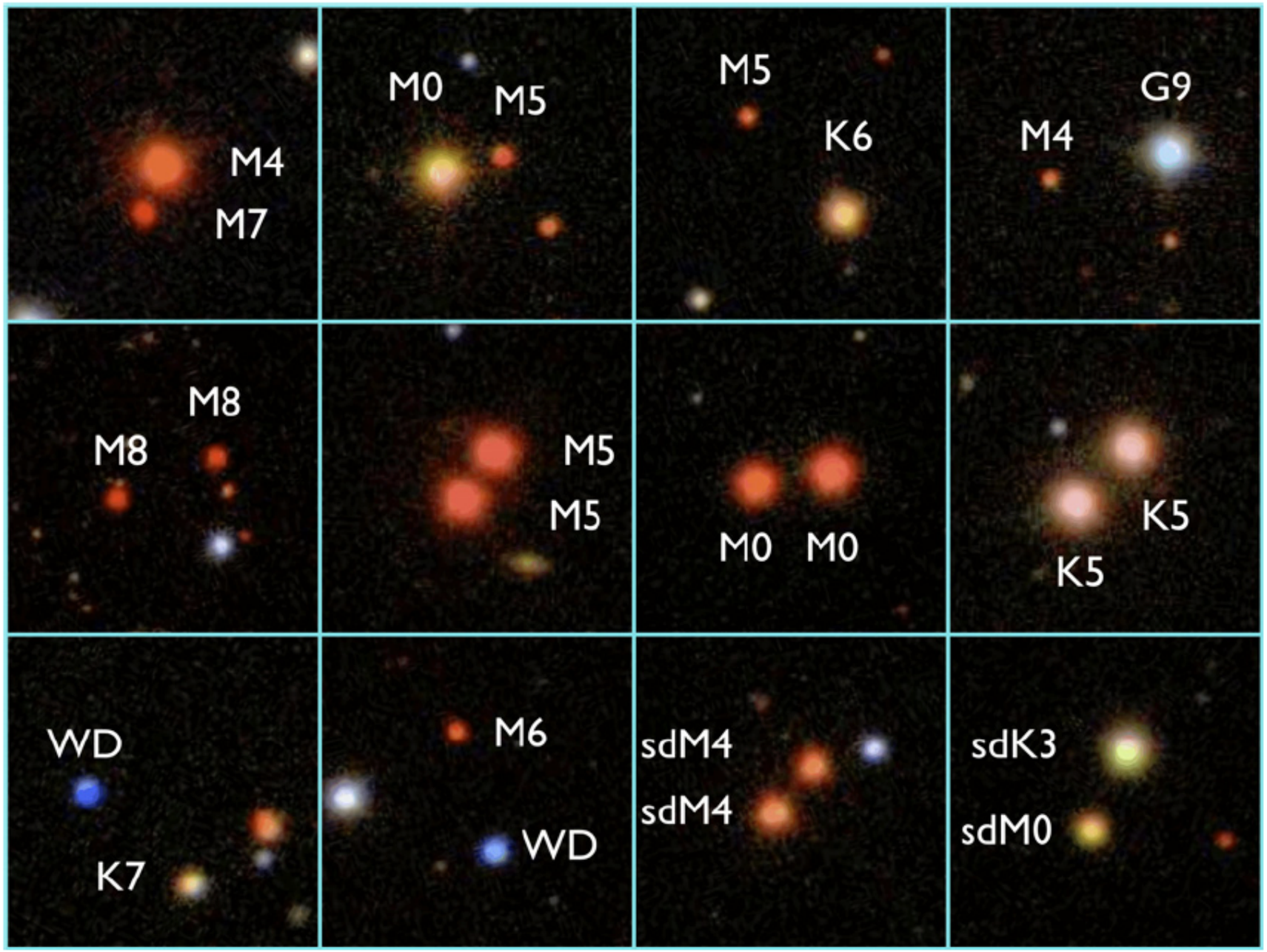
The disk scale length and amount of dark matter near the Sun both influence the local mass density.





Zhang et al., 2012

Gaia will discover thousands of wide binaries, which are testbeds for stellar and Galactic evolution.



Dhital et al, 2010

Gaia will provide an unprecedented view of our low-mass stars in our Galaxy, including :

- The distribution of Jupiters around low-mass stars
- Structure and kinematics of the Milky Way's disk
- Intrinsic stellar properties
- Fundamentals: IMF and gravitational potential
- Binaries, open clusters, and so much more!

Thank You!