Stars in formation in motion

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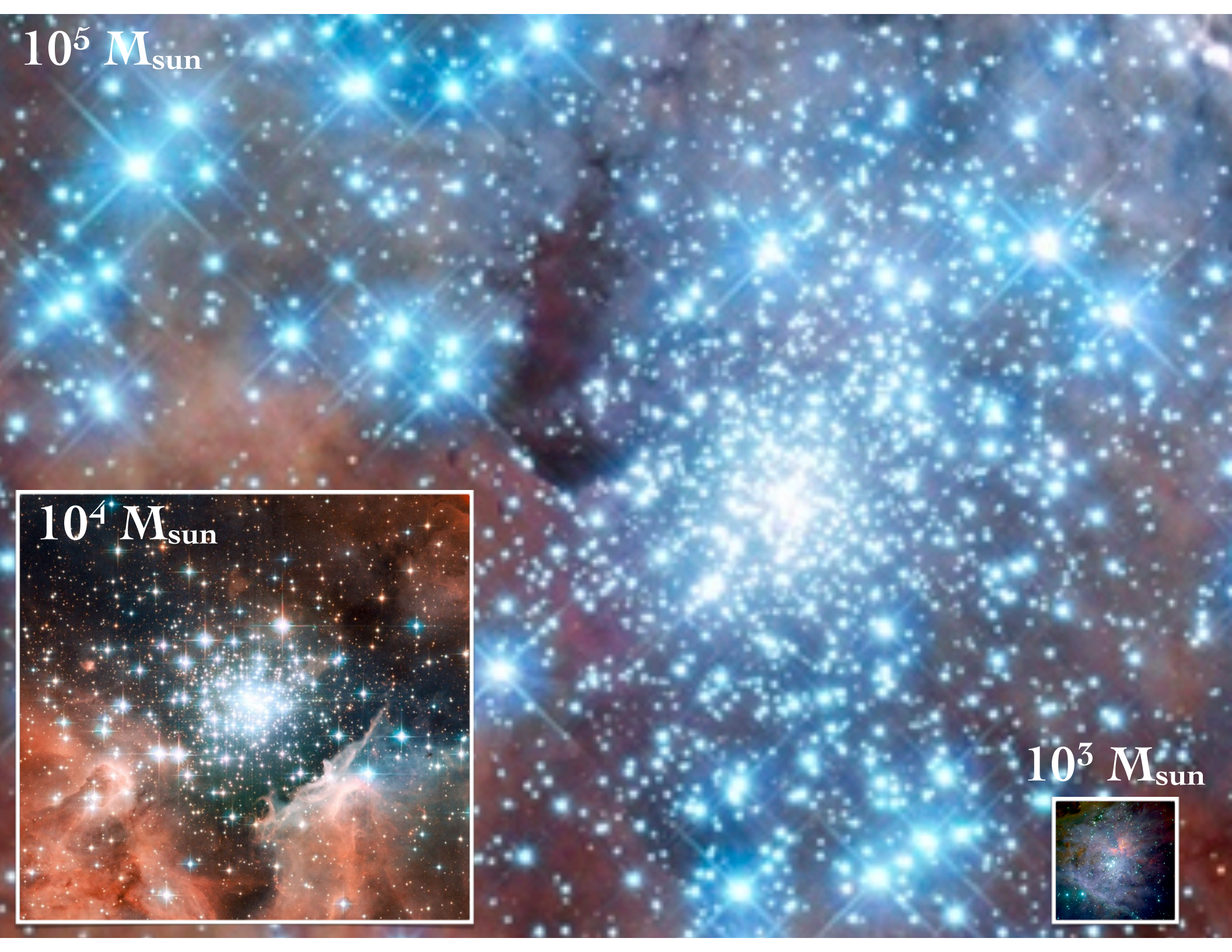
Stars

in formation

in motion


10^5 M_{sun}
10^4 M_{sun}
10^3 M_{sun}

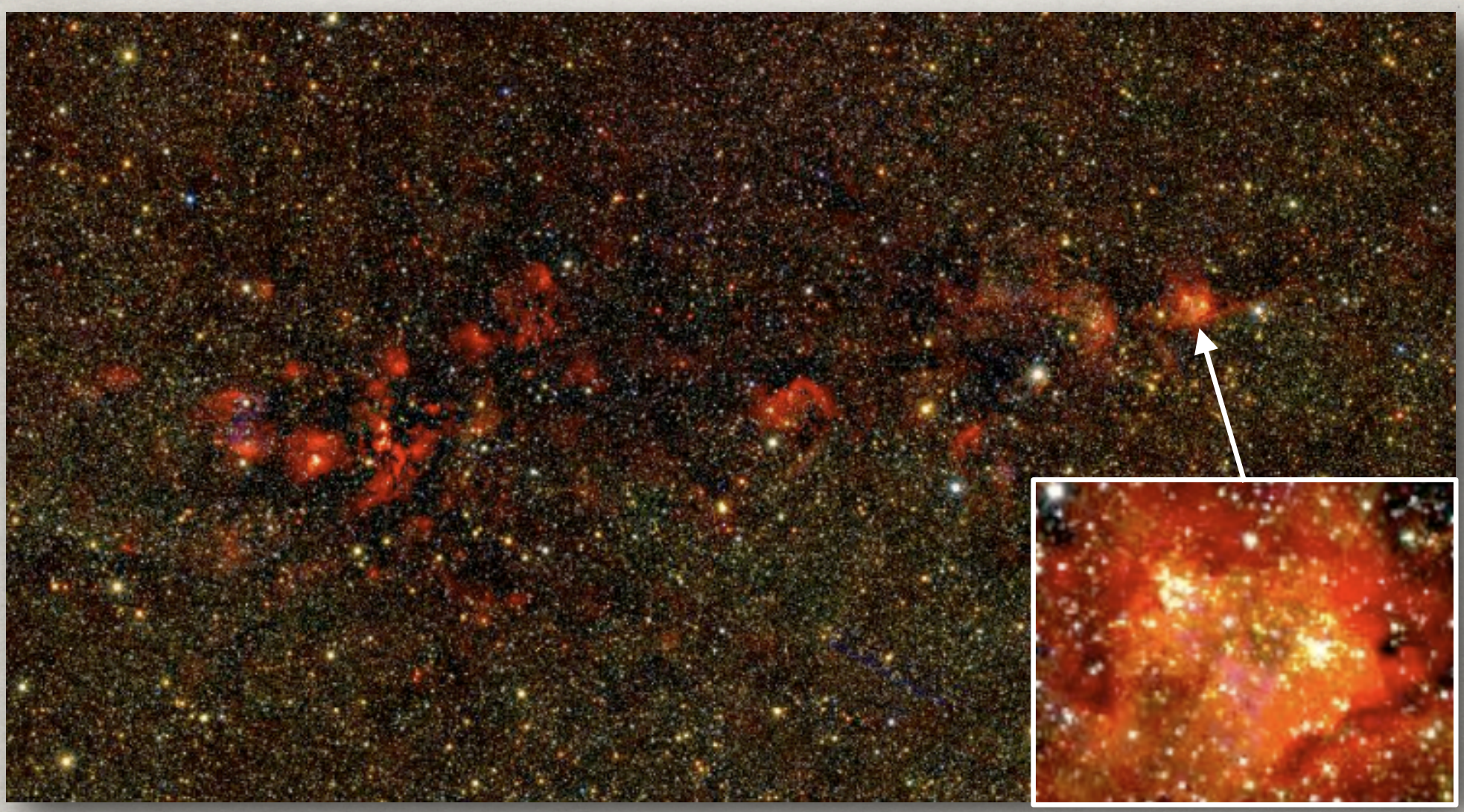
Frontiers in star formation include massive young clusters in a range of environments.

- stellar initial mass function vs. environment
- cluster structure and dynamics
  - as probe of star formation process
  - as probe of cluster evolution/fate
- cluster mass function vs. galaxy properties

Massive young clusters are difficult to find and observe in detail.

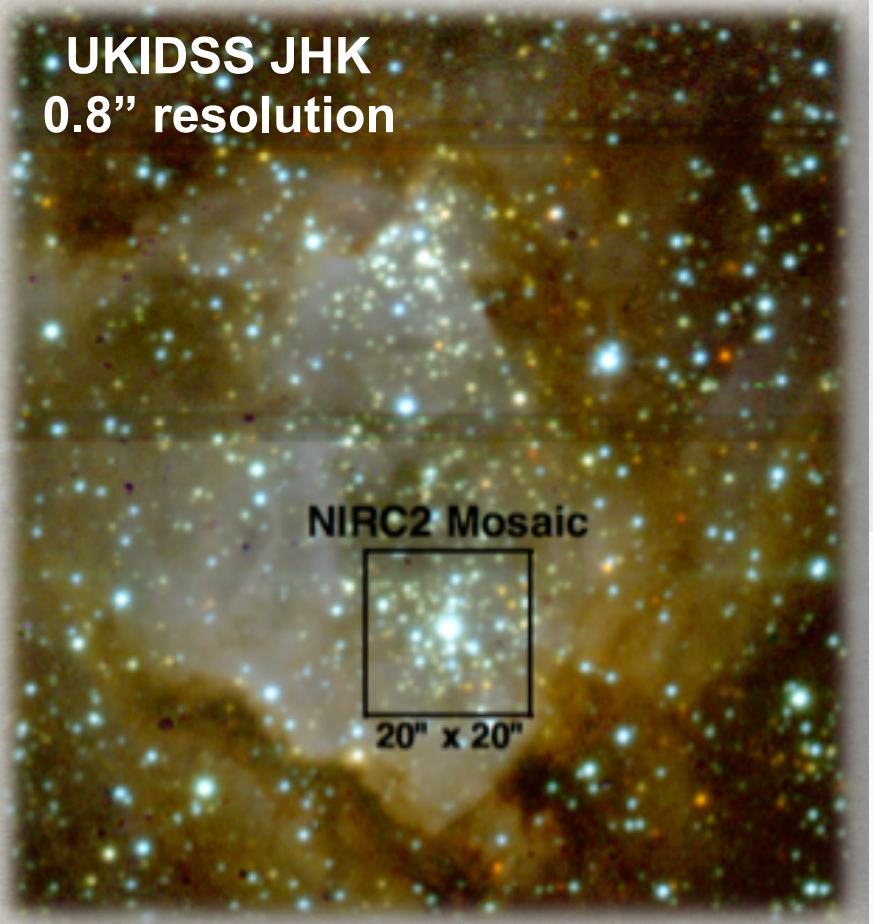
- crowded (5-100 stars/arcsec^2) > high resolution
- deeply embedded (A_V = 10-30) > infrared
- large on the sky > > 2' FOV
- membership is difficult > astrometry
- distance is uncertain > spectroscopy

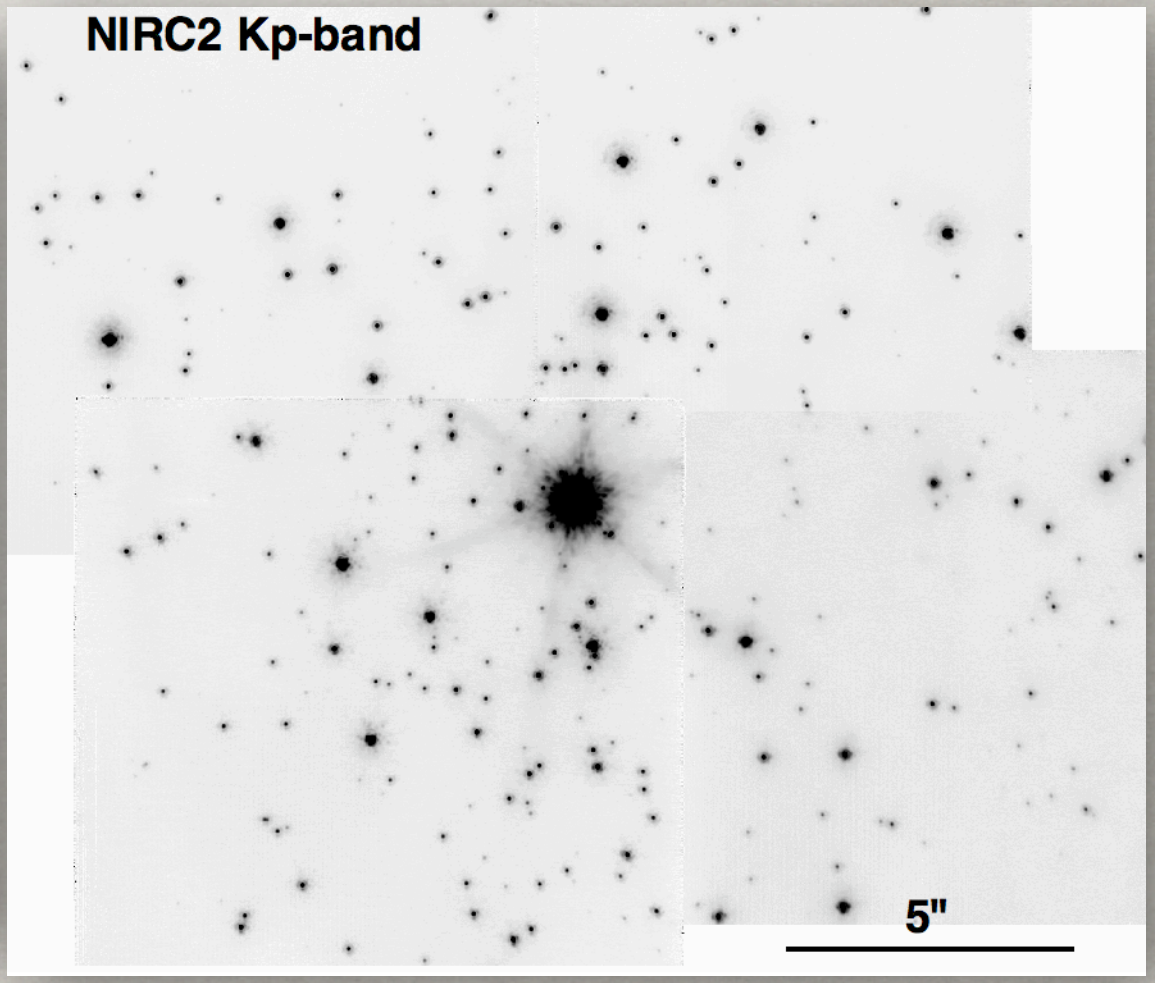
W51 - one of the most luminous star forming complexes in the Galaxy.



JHK Mosaic from UKIDSS Galactic Plane Survey
1 degree wide

Current AO systems have too small FOV to properly characterize W51 and other GMCs.





Current AO systems have too small FOV.

- Gemini MCAO - ideal system for clusters at 3 - 10 kpc
- JWST - ideal for characterizing unresolved clusters in other galaxies
- need bigger FOV for nearby massive clusters (especially lower metallicity outer Galaxy clusters)
- still need good resolution for precise astrometry
- moderate resolution spectroscopy for many objects

IN FORMATION

Stars

in motion

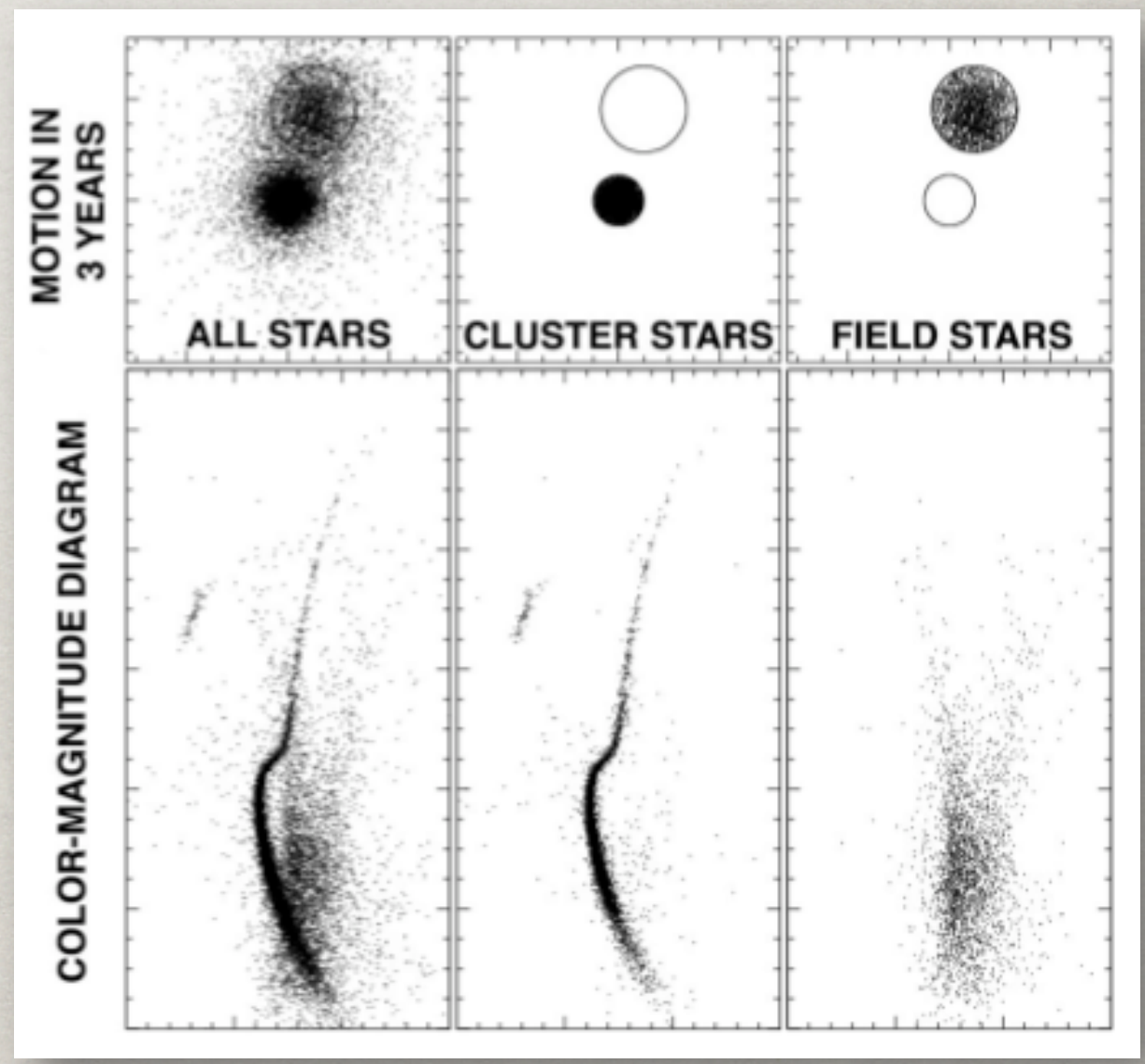
Proper motions are a powerful tool for identifying cluster members.

Commonly used in globular clusters.

High spatial resolution optical capabilities of HST.

Massive young clusters require better astrometric precision.

Massive young clusters require infrared astrometry.



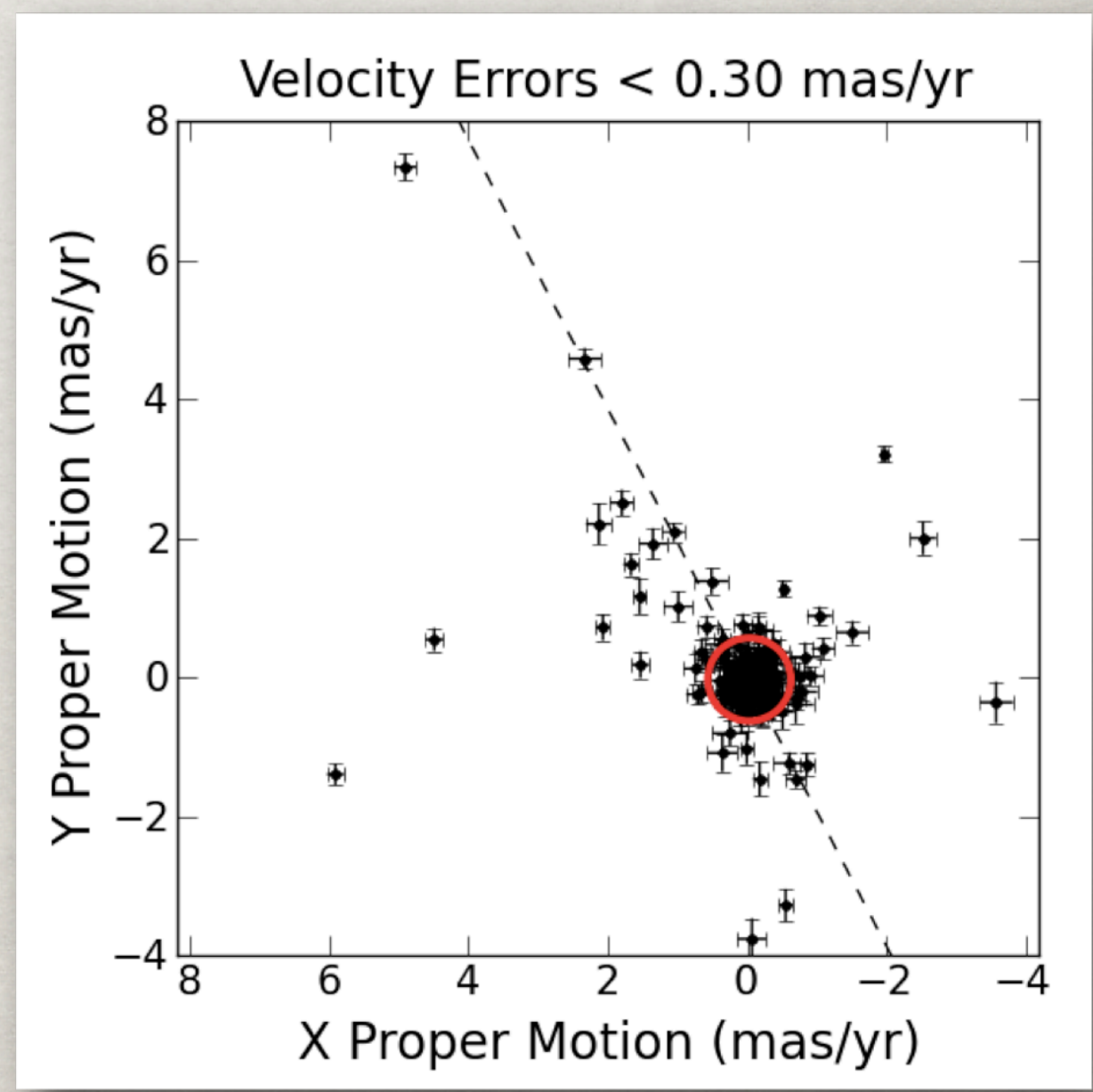
Anderson+ 2006

Successful pilot project for W51.

Done in 1 year with Keck OA (55 mas resolution).

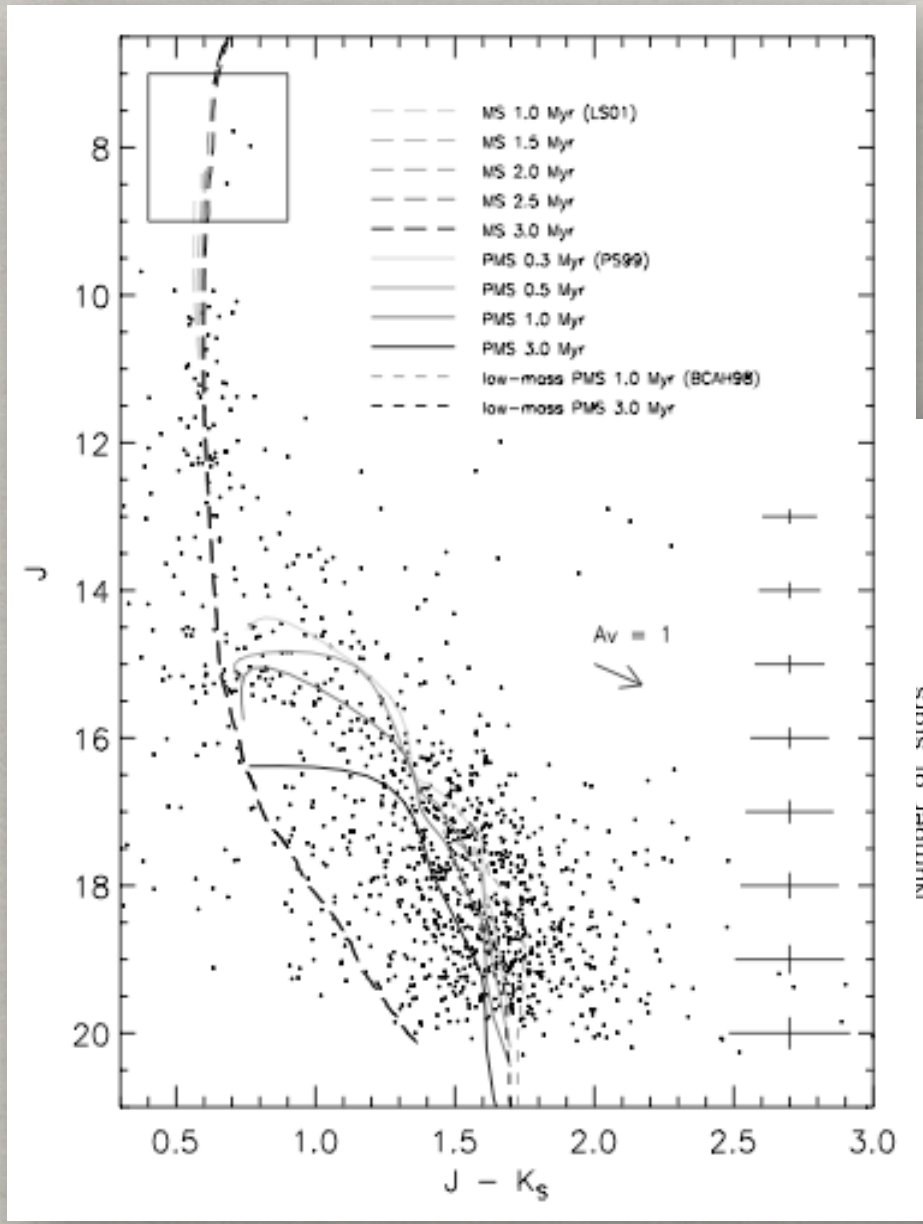
Need bigger FOV to cover whole cluster/GMC.

Need spectroscopy to calibrate masses.

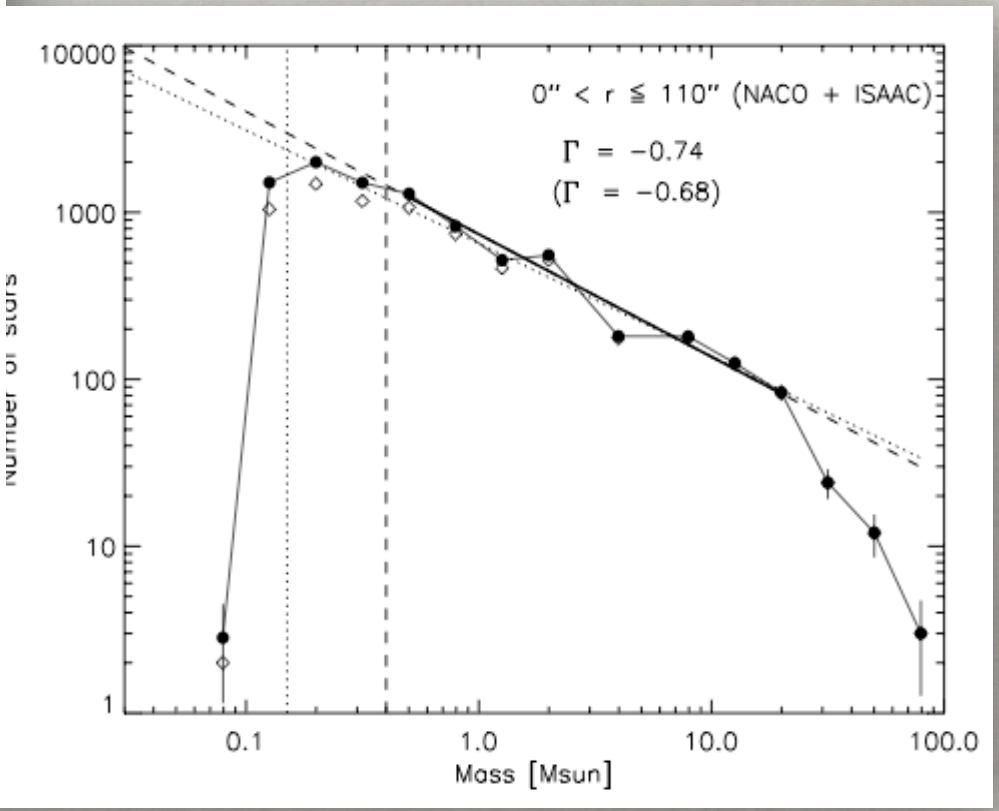


Lu et al. in prep

Membership gives precise IMF and test bed for stellar and cluster evolution.



NGC 3603
Harayama+ 2008
no membership info



Currently, relative astrometry is precise; but reference frames are a problem (FOV).

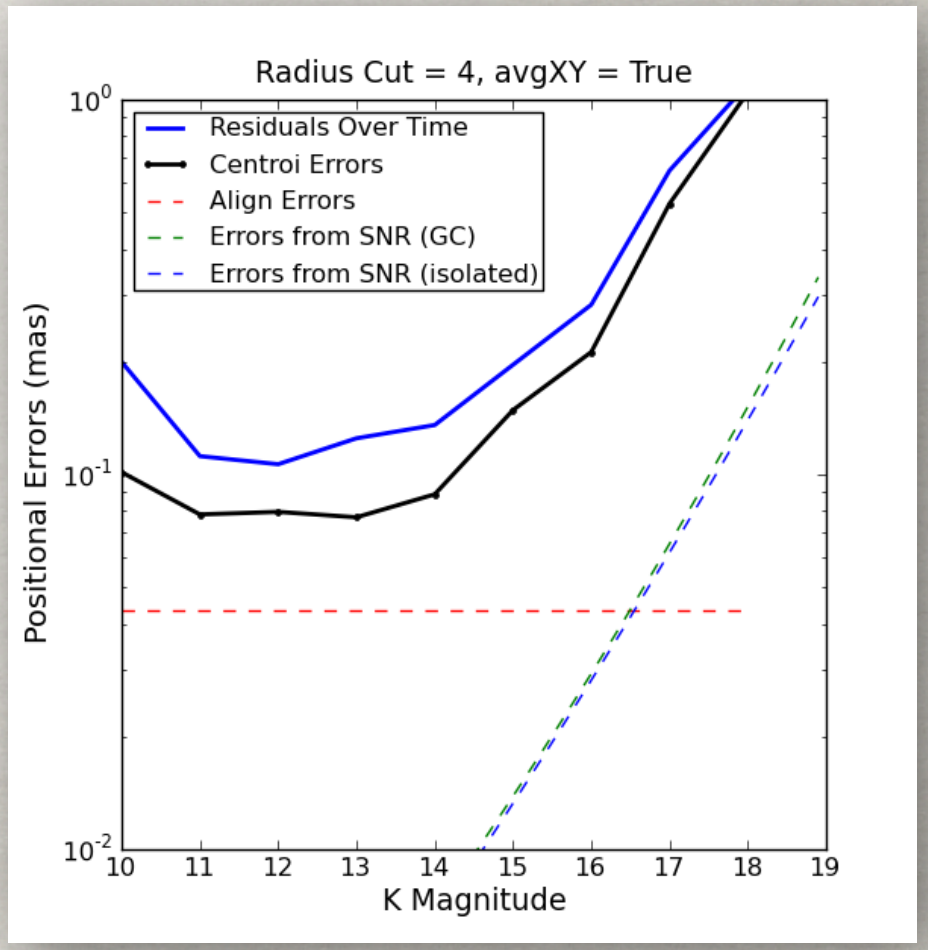
Existing Telescopes with AO

Crowded Fields: 170 μas

Sparse Fields: 500 - 5000 μas

Absolute Astrometry: ??

MCAO ??



Astrometry is relevant to many additional science cases.

Massive young star clusters

Galactic Center - stellar populations, dynamics, structure

Astrometric microlensing from isolated black holes

Parallaxes - faint, red, crowded objects

Binary/planetary companion orbits

Gravitational lensing of galaxies

Intermediate mass black holes

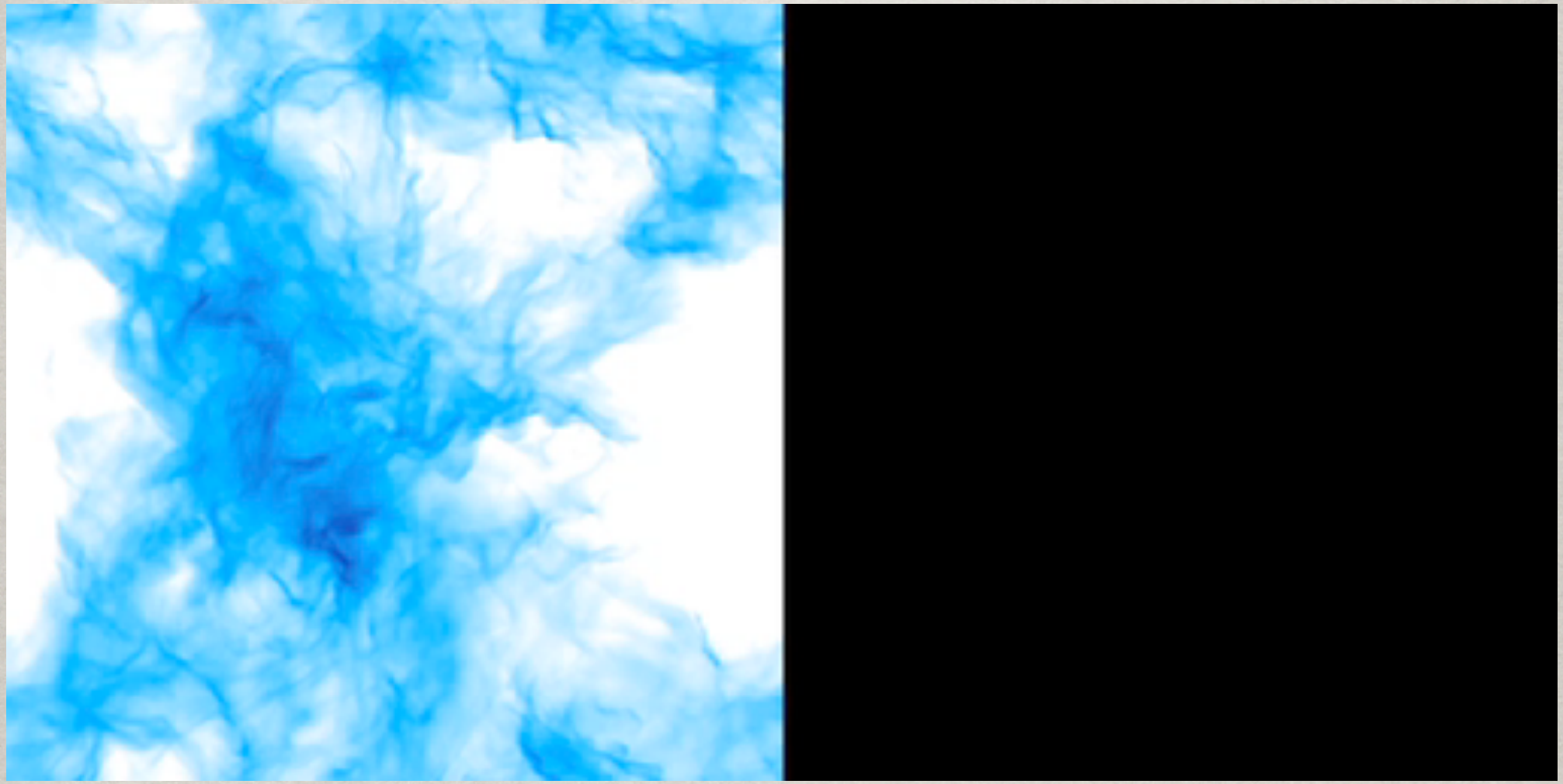
Local group galaxies: orbits and internal kinematics for dark matter

Jet proper motions

Astrometric wobble from planets: crowded, faint, red = what Gaia won't do.

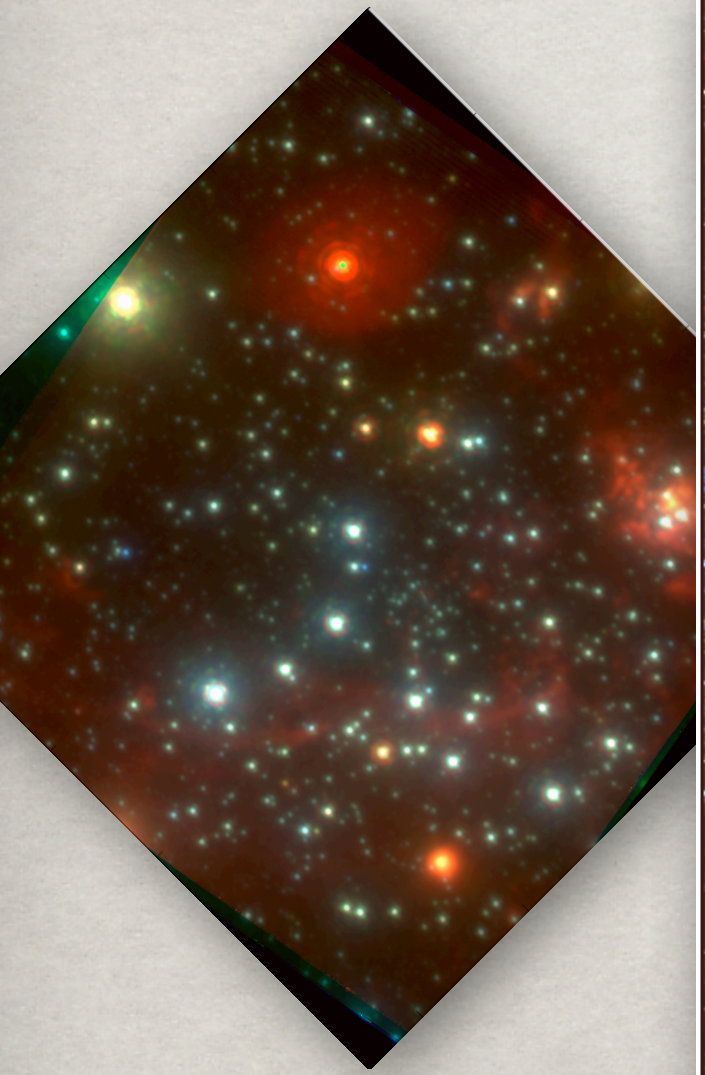
Hypervelocity stars, runaway stars from other galaxies

Internal dynamics are a powerful test of star formation theories.

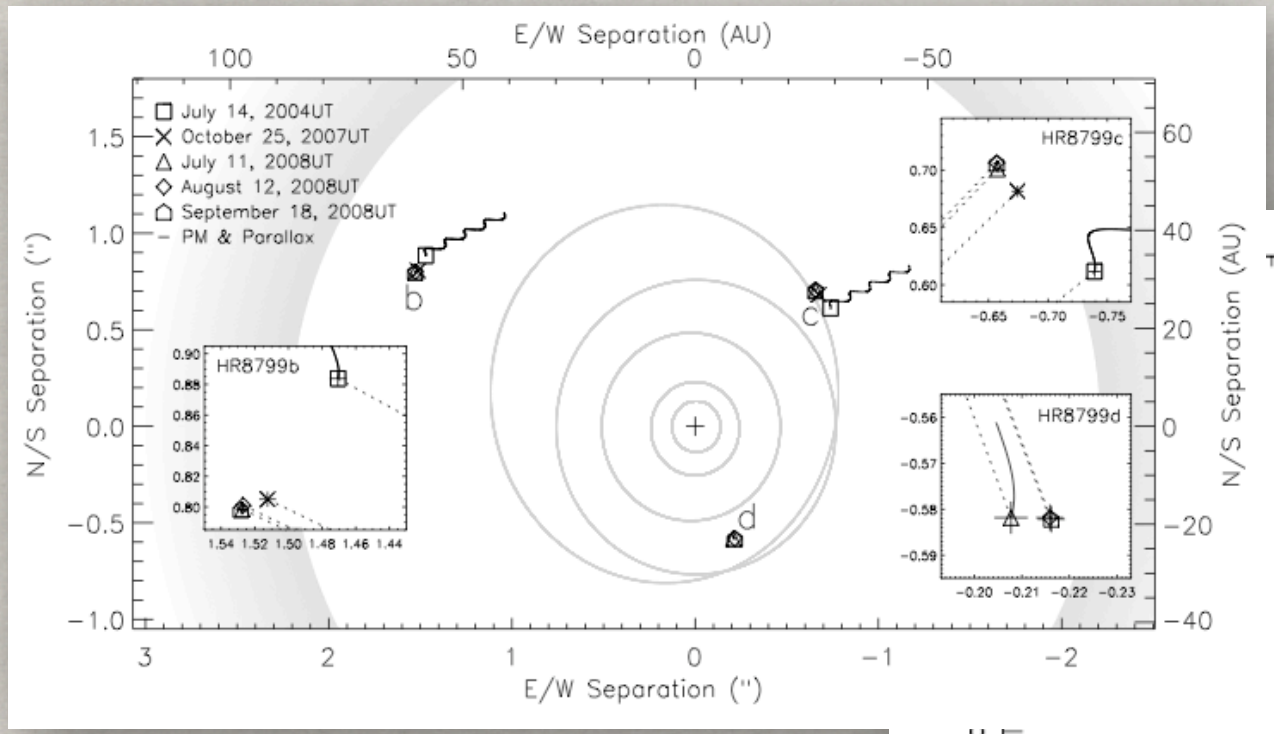


Krumholz+

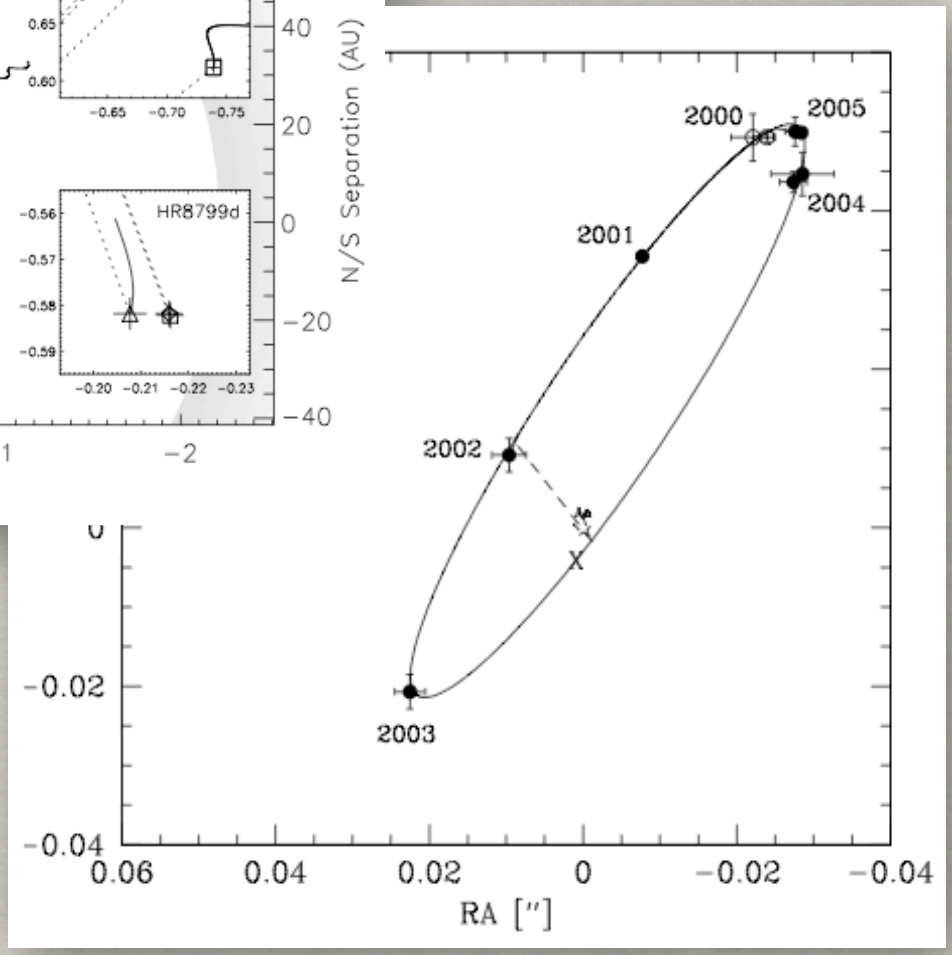
Galactic center stellar population studies require high resolution imaging/spectroscopy.



Masses of stars, brown dwarfs, and remnants can be measured with orbits.

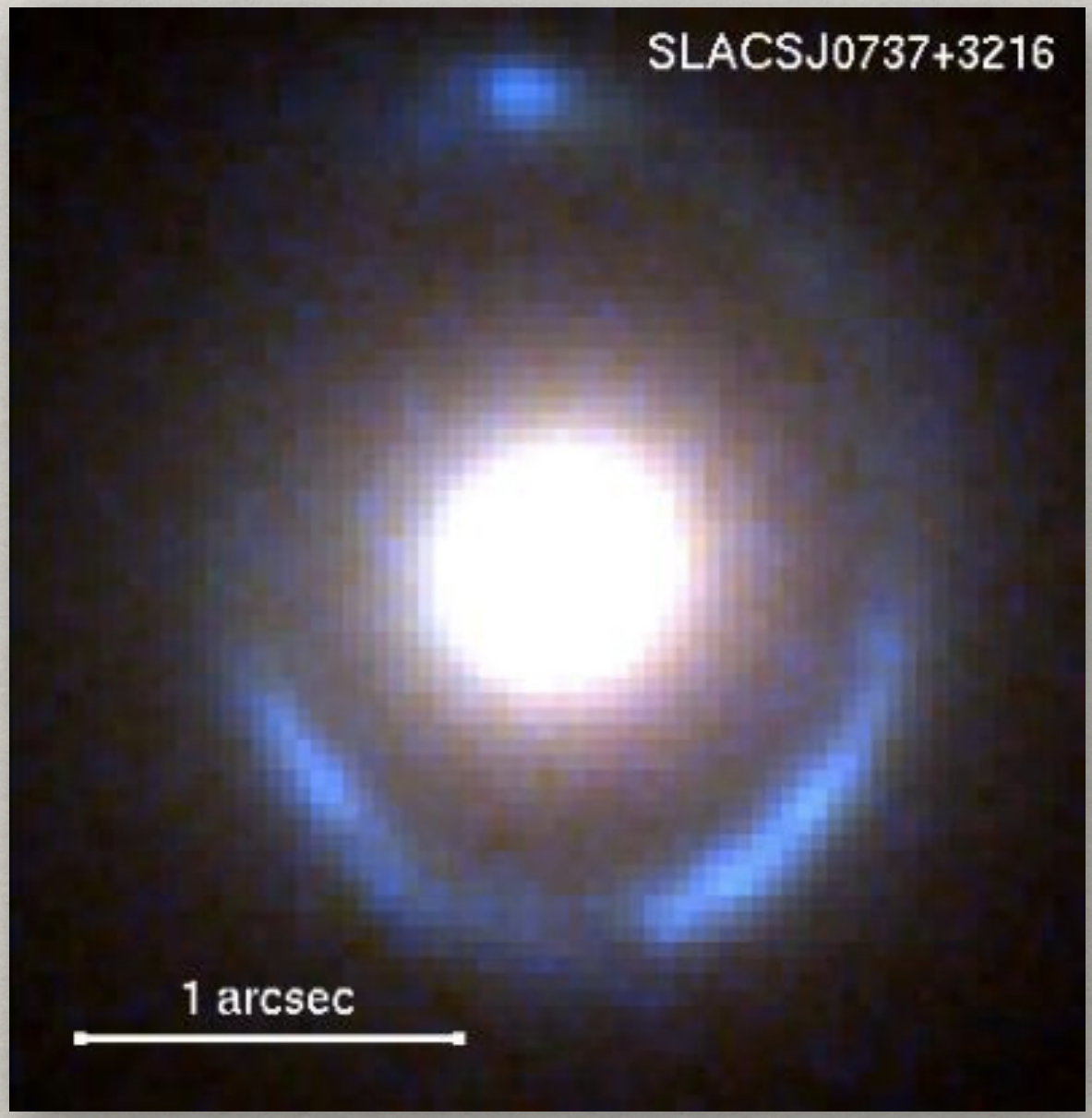


Marois+ 2008



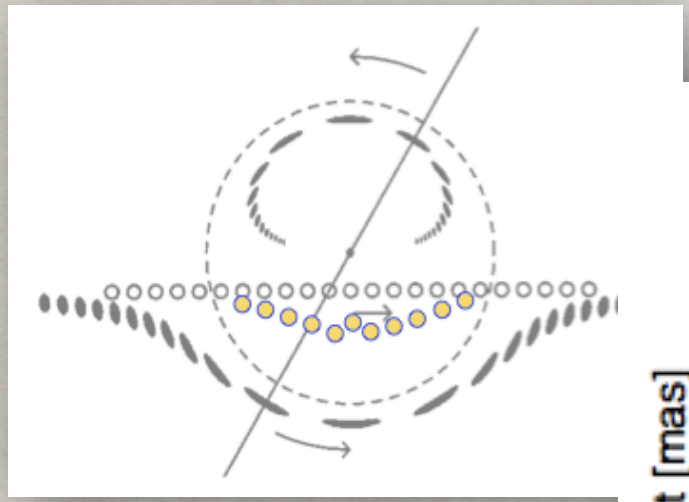
Konopacky+ 2008

Gravitational lensing requires good astrometry (~mas) to constrain mass distributions of the lens.

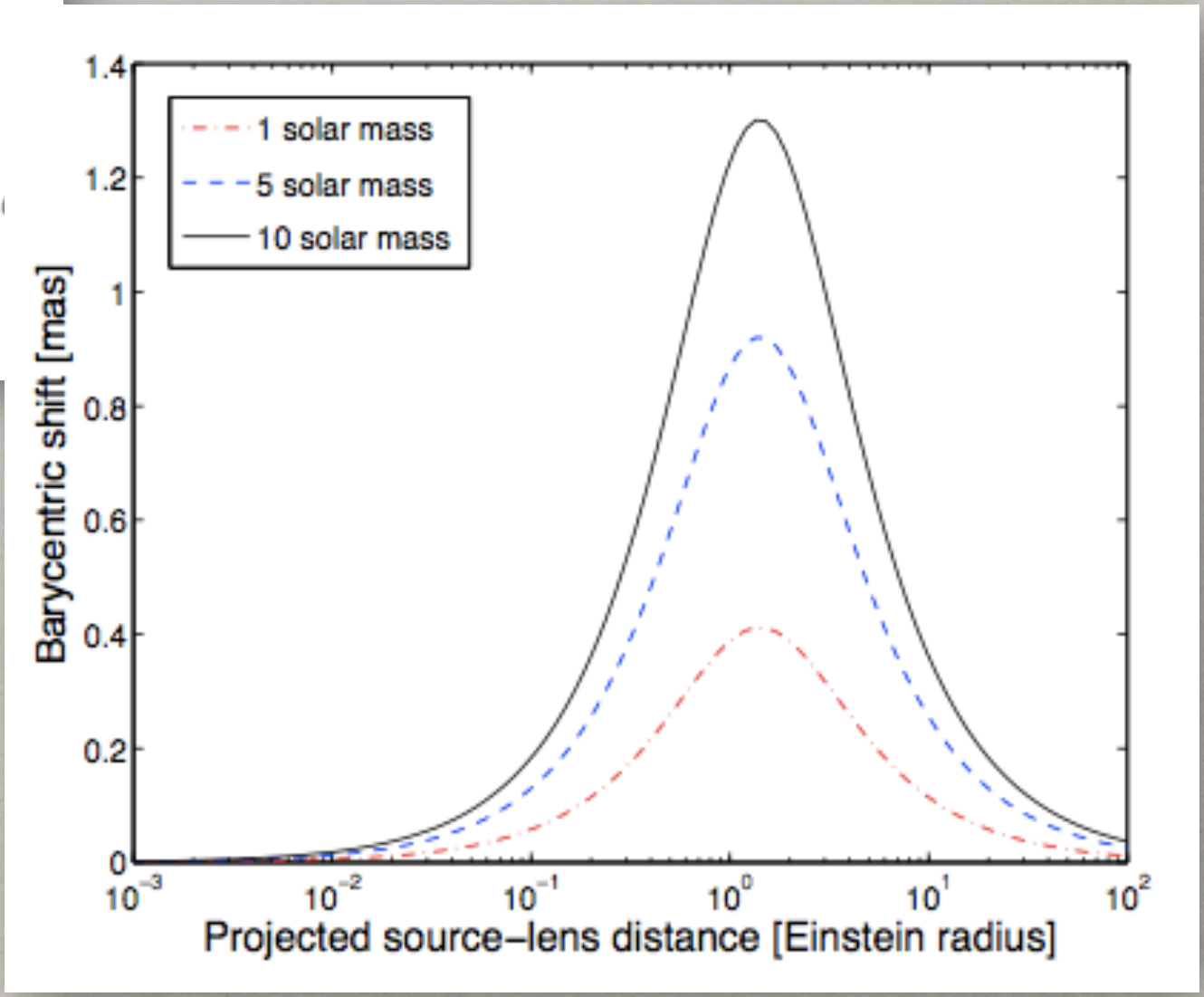


Marshall &
Treu 2008

Astrometric microlensing can probe isolated stellar mass black holes.



Sahu STScI talk 2011



Ofek & Lu (in prep.)

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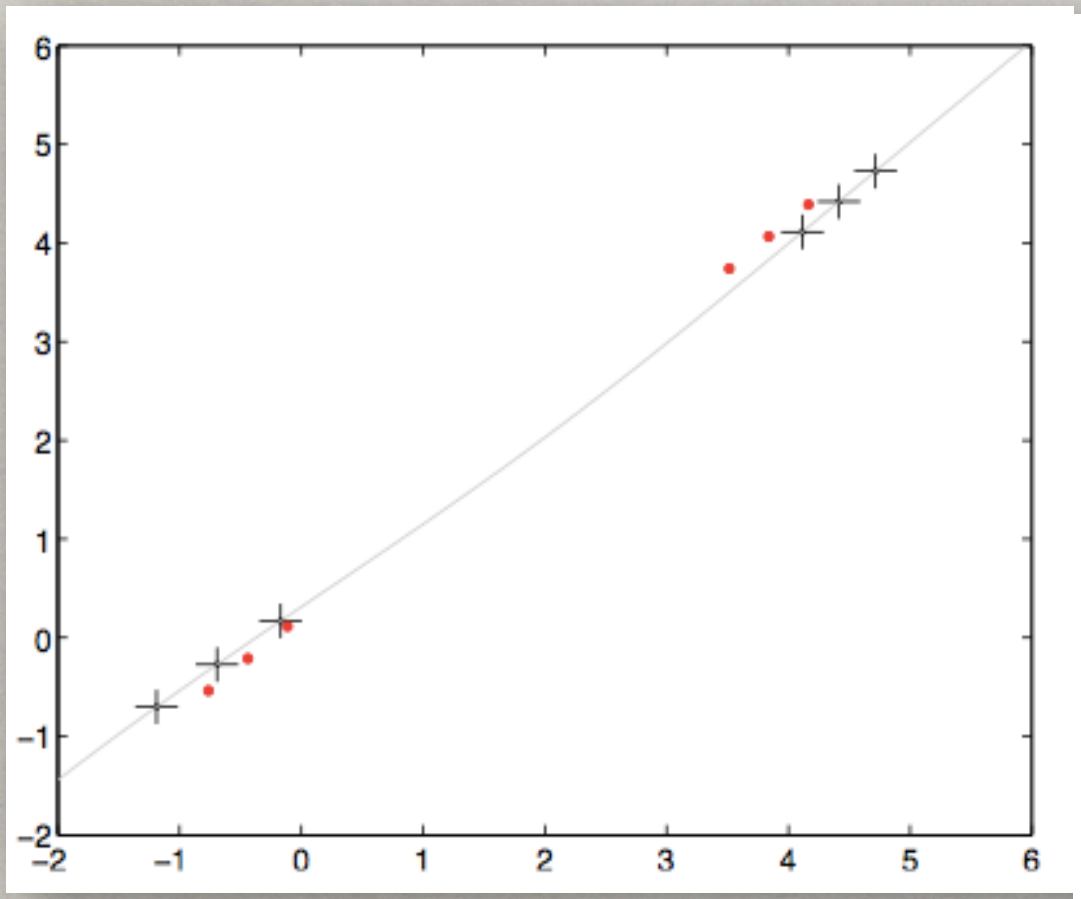

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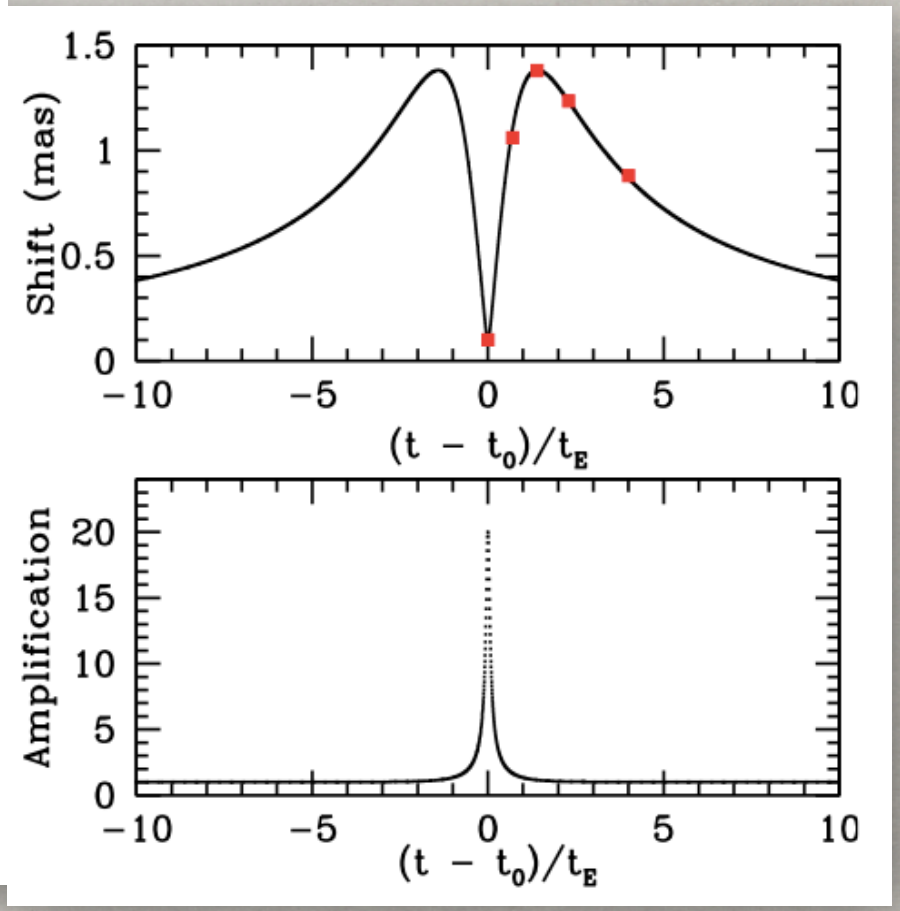

Sahu Talk STScI 2011

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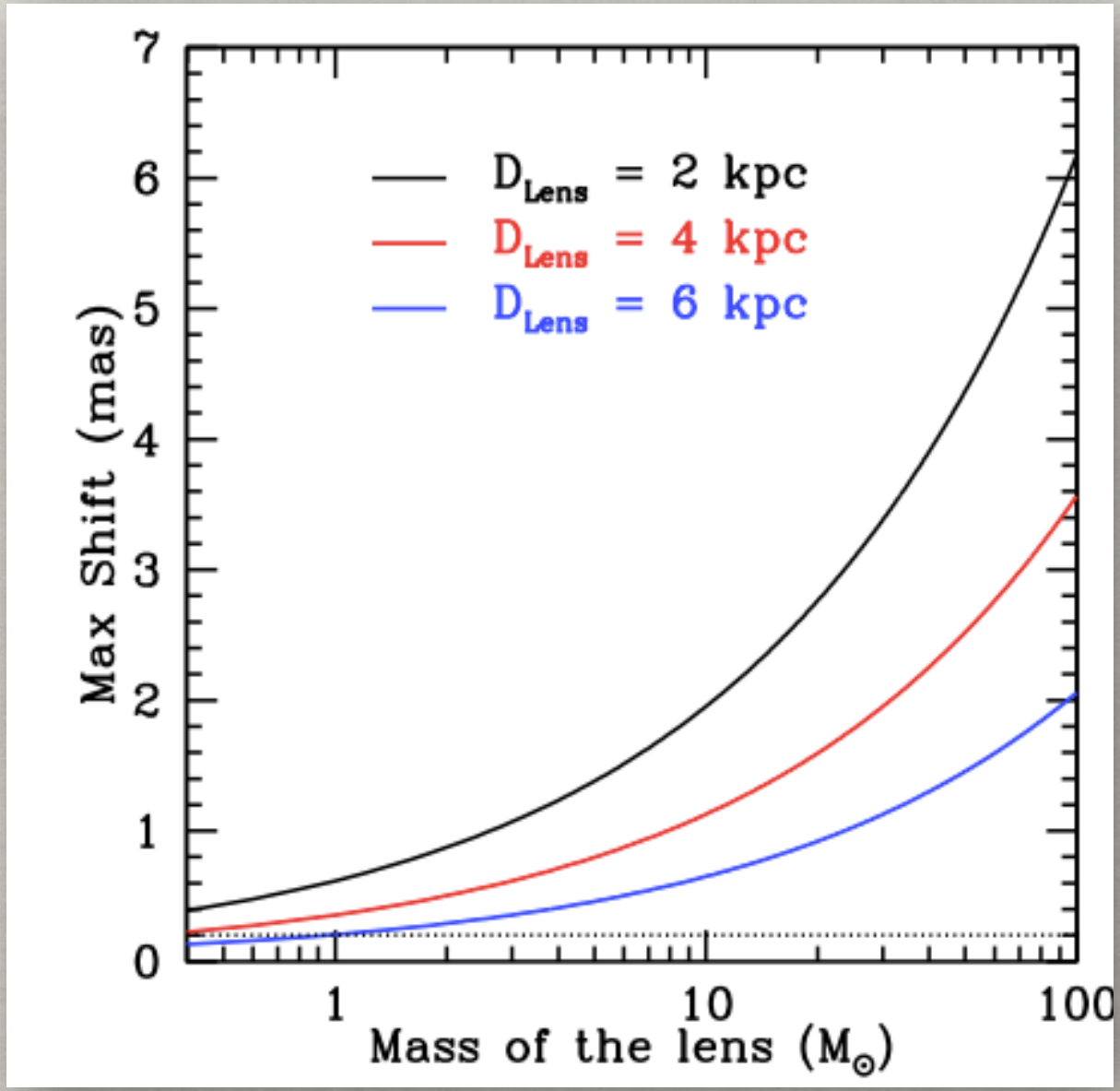
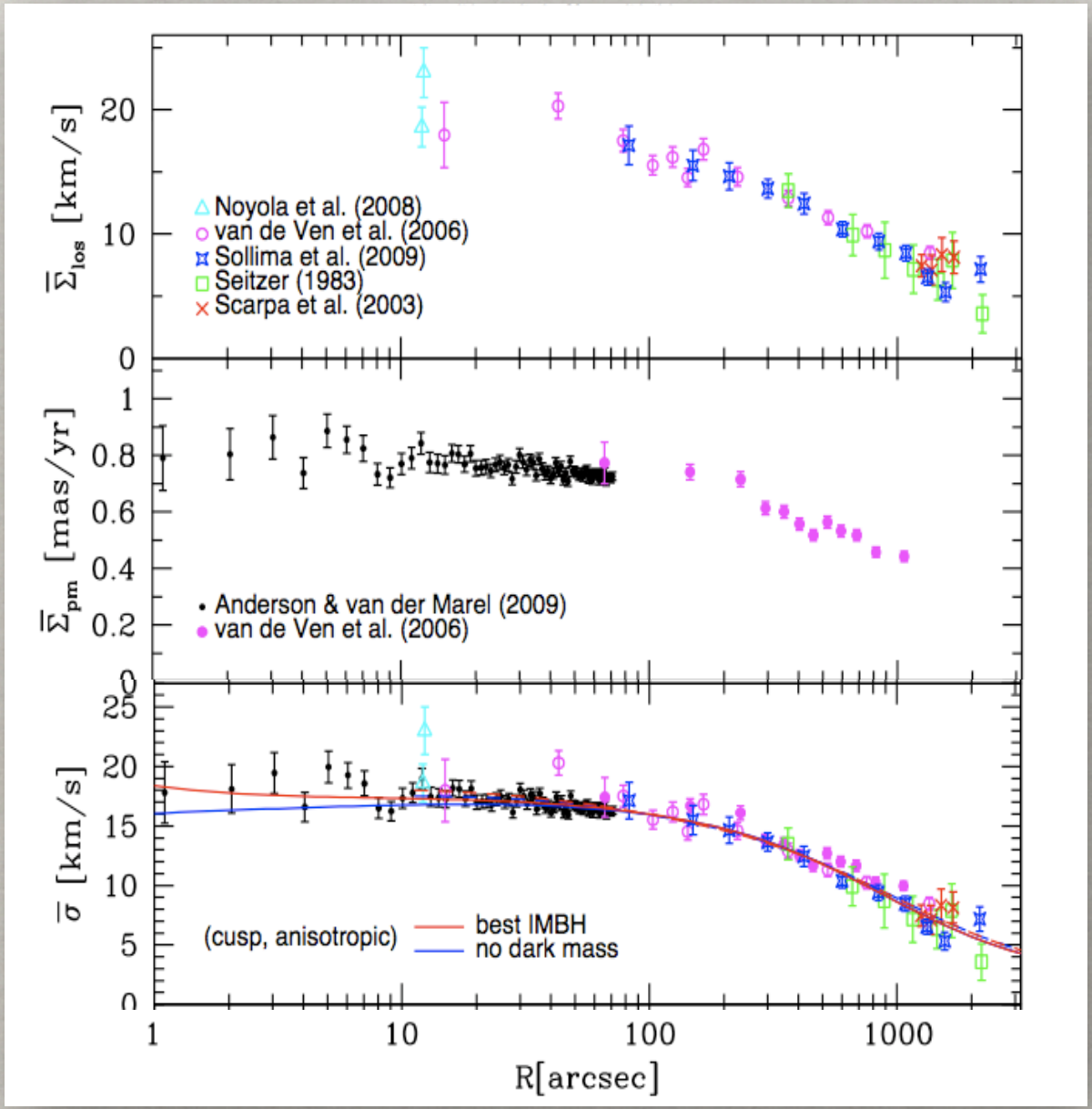


Sahu Talk
STScI 2011

Intermediate mass black holes in globular clusters.



van der Marel+ 2009

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