Accurate and deep near IR CMDs with GeMS

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ASPIDE
Accurate Stellar Photometry In Dense Environments
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ADONI2016, Aprile 2016, Firenze

Why Globular Clusters?

Dense as a **Globular cluster...**

Scientific interests

- Fossils of galaxy archaeology
- Chronology of the Galactic halo and bulge assembly
- Testing ground for stellar evolutionary theory
- Tracers of chemical evolution
- Laboratory for dynamical stellar interaction
- The place to study *exotica* objects as Blue Stragglers and Black holes
- Basis for our understanding of any stellar system in the Universe
- Lower limit to the age of the Universe

Technological interest

VERY DENSE -- The perfect Gym to test new technology that will allow future Extremely Large Telescopes to work at their diffraction limit: real-time Adaptive Optics.

Why Globular Clusters?

Dense as a Globular cluster...

Scientific interests

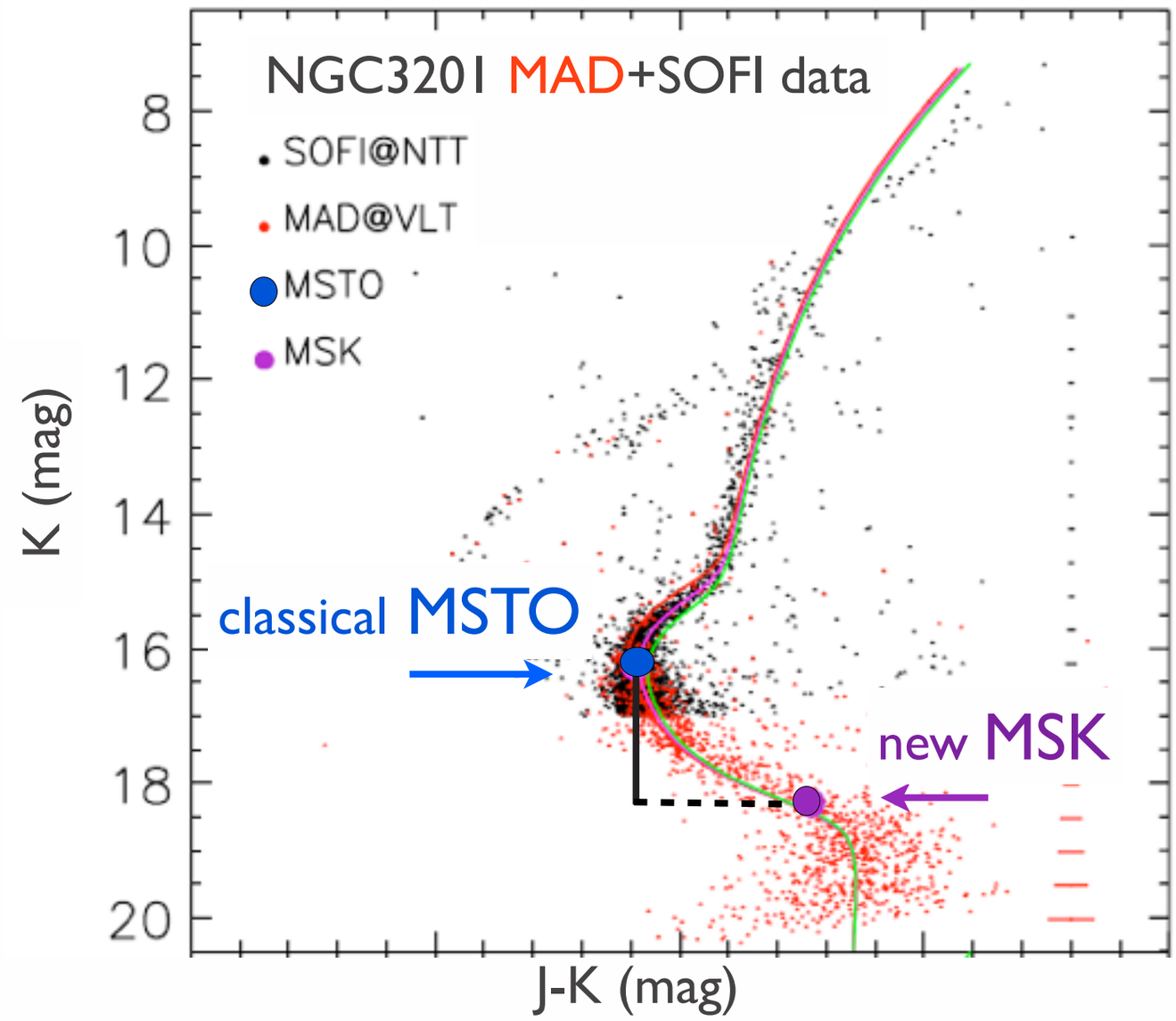
Globular cluster studies,
and more **generally Resolved Stellar Population studies**,
need very high accuracy in measuring positions and luminosities of **individual** stars, including the fainter ones!!

Technological interest

VERY DENSE -- The perfect Gym to test new technology that will allow future Extremely Large Telescopes to work at their diffraction limit: real-time Adaptive Optics.

Stellar Populations and ages

NGC3201 as seen by MAD



NGC3201
d~5Kpc
E(B-V)~0.25-0.30

1) MSK better shows-up in NIR-filters

2) the MSK is almost independent on age

3) Based on a different physics: in low mass star (≤0.4Mo), due to absorption of hydrogen molecules via collisions

4) Independent of Reddening and Distance:
σ(MSTO-MSK)~σ(MSTO)/2

NIR CMD of NGC3201 as provided by the combination of MAD (red dots) and SOFI (black dots). The blue and purple points highlight the Main Sequence Turn Off (MSTO) and the Main Sequence Knee (MSK) locations.

Bono et al. 2010, ApJL

In the SKY with GeMS

Canadian time, collaborators: A. McConnachie, P.B. Stetson, P. Turri, D. Massari, G. Bono, D. Anderson, J.P. Veran

The Targets...

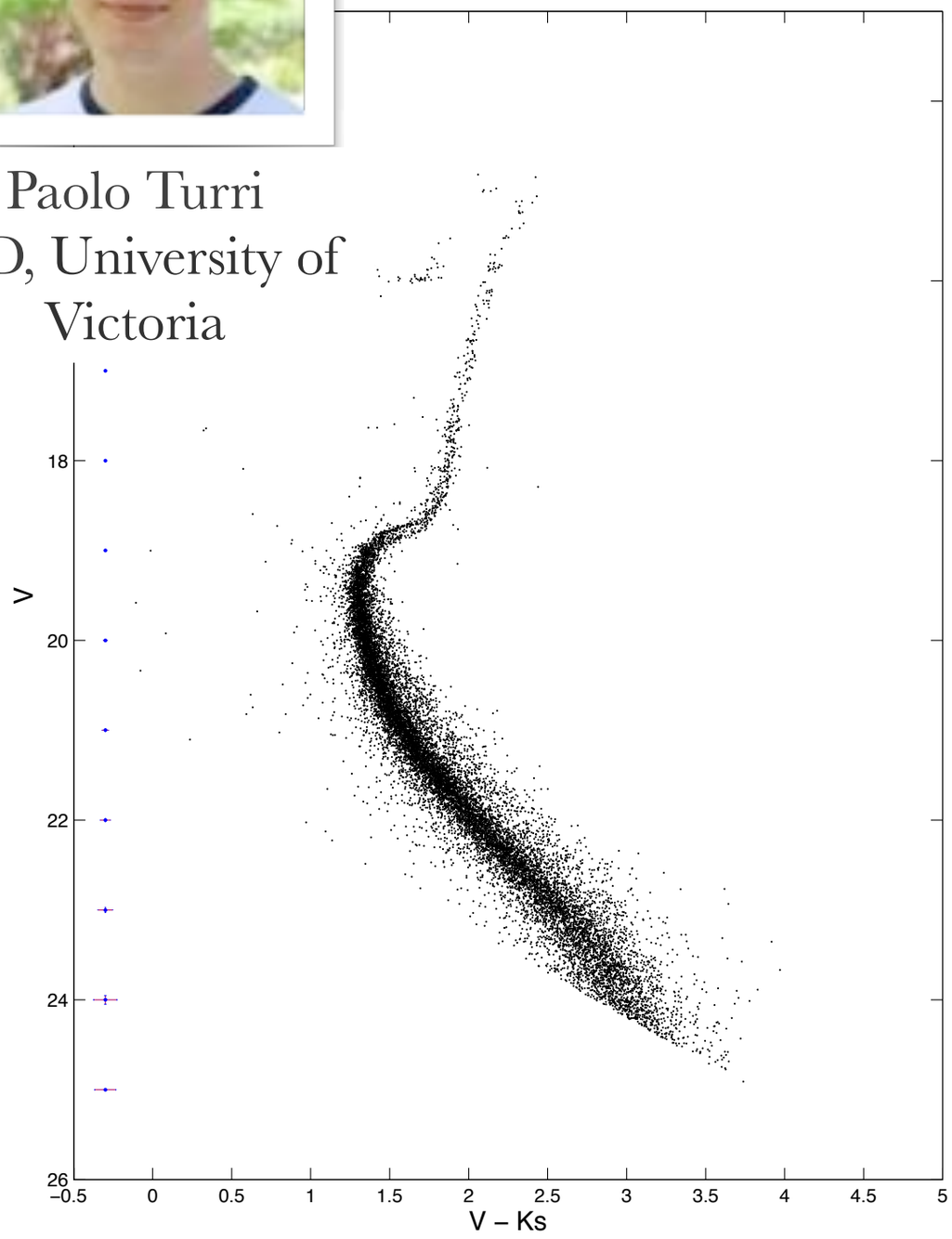
ID	distance (Kpc)	[Fe/H]	E(B-V)
NGC1851	12.1	-1.18	0.02
NGC2808	11.1	-1.12	0.22
NGC5904 (M5)	7.5	-1.29	0.03
NGC6681(M70)	9.0	-1.62	0.07
NGC7078 (M15)	10.4	-2.37	0.10
NGC6723	8.7	-1.10	0.05
NGC6652	10.0	-0.81	0.09

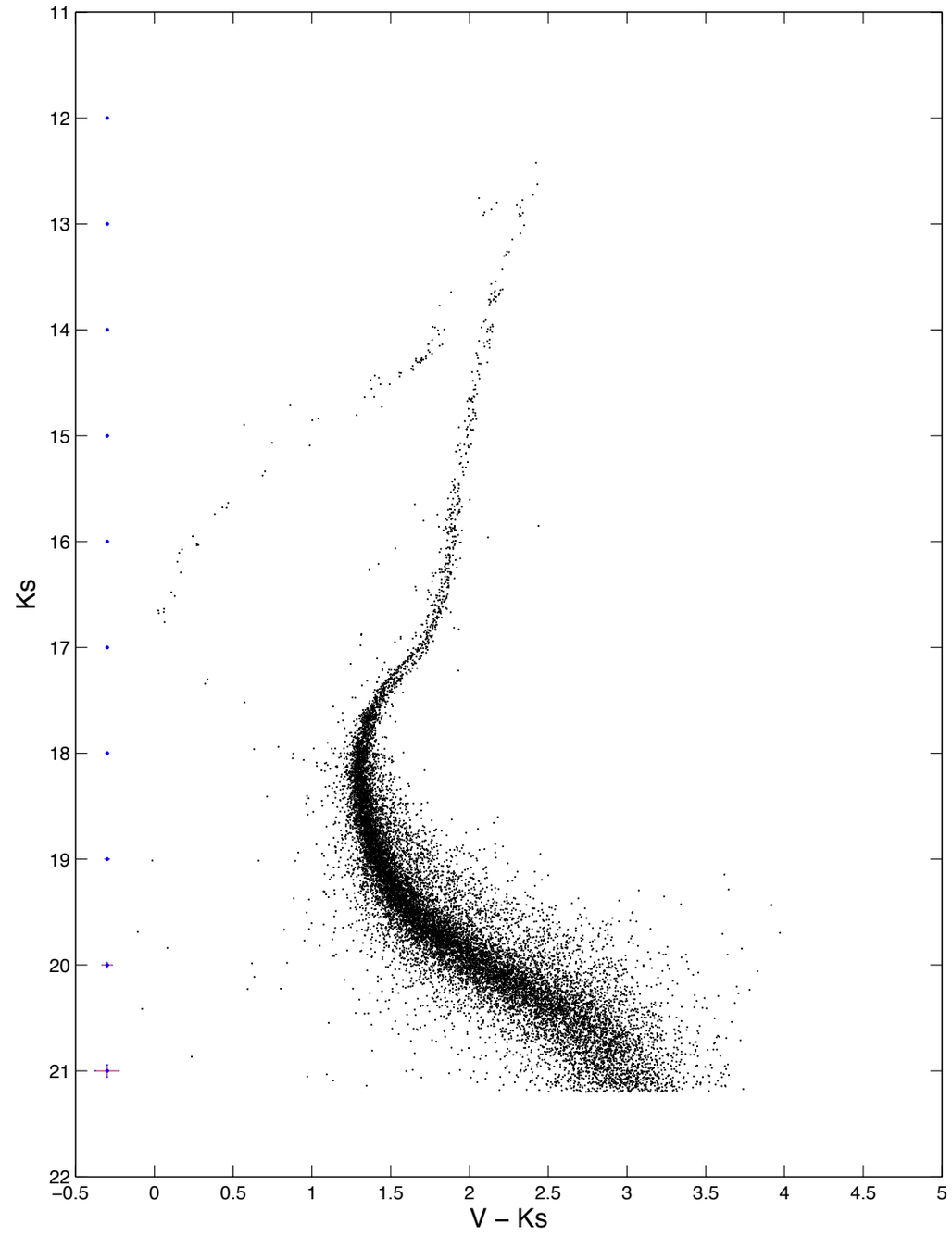
Overall performance

ID	Strehl J--Ks	<FWHM> J--Ks	seeing
NGC1851	10--27	0.07-0.07”/pix	0.75”
NGC2808	15-40	0.16-0.1”/pix	1.2-0.6”
NGC5904 (M5)	14--40	0.07-0.07”/pix	0.5”
NGC6681(M70)	tbd	tbd	0.6”

Photometric precision, NGC1851

Paolo Turri
PhD, University of Victoria





NGC 1851, with DAOPHOT/ALLSTAR/ALLFRAME
(P. Turri et al., 2015 ApJLetter, 2015ApJ...811L..15T)

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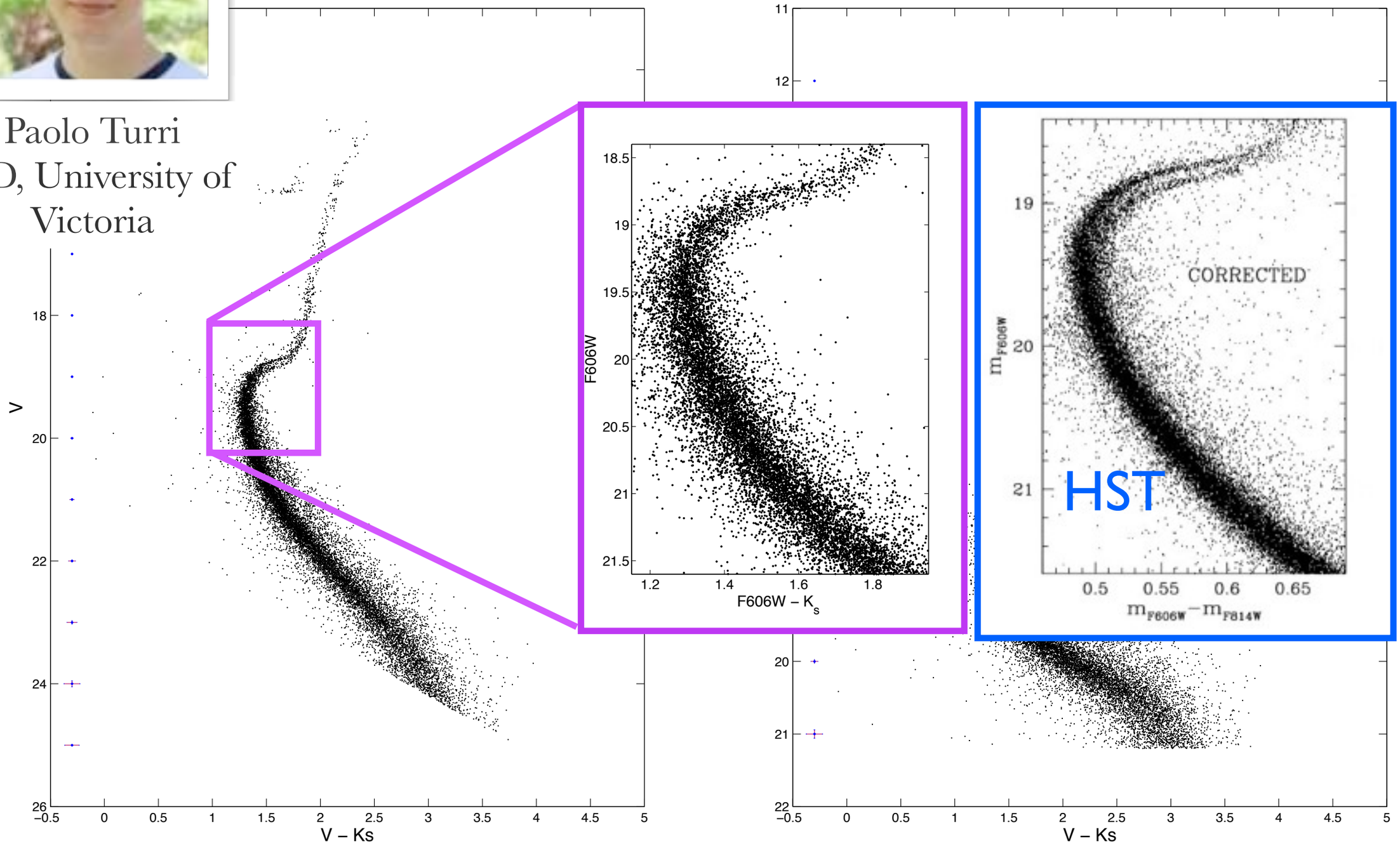

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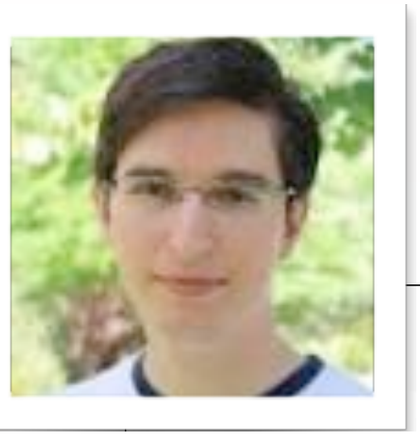
ADONI2016, Aprile 2016, Firenze



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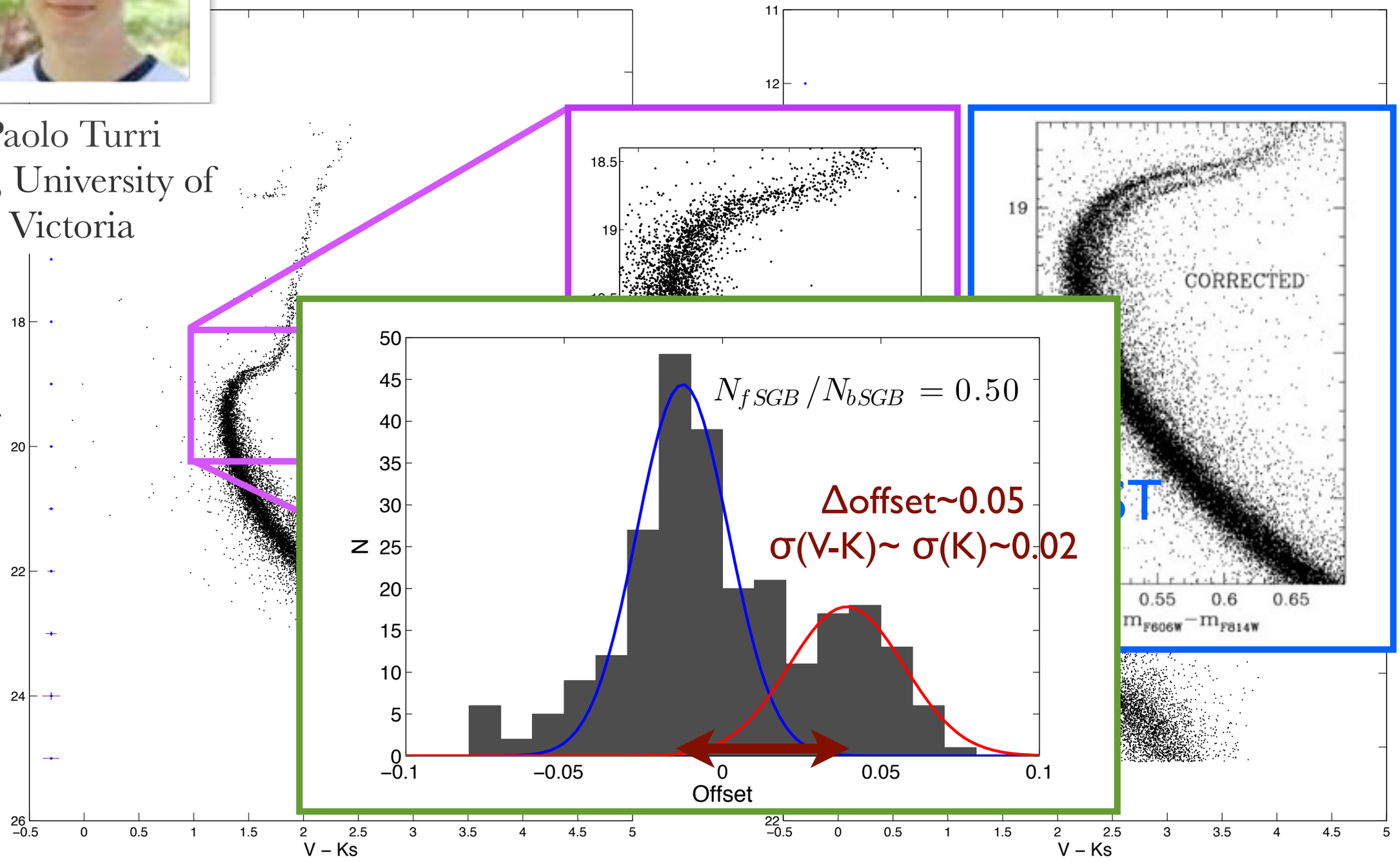

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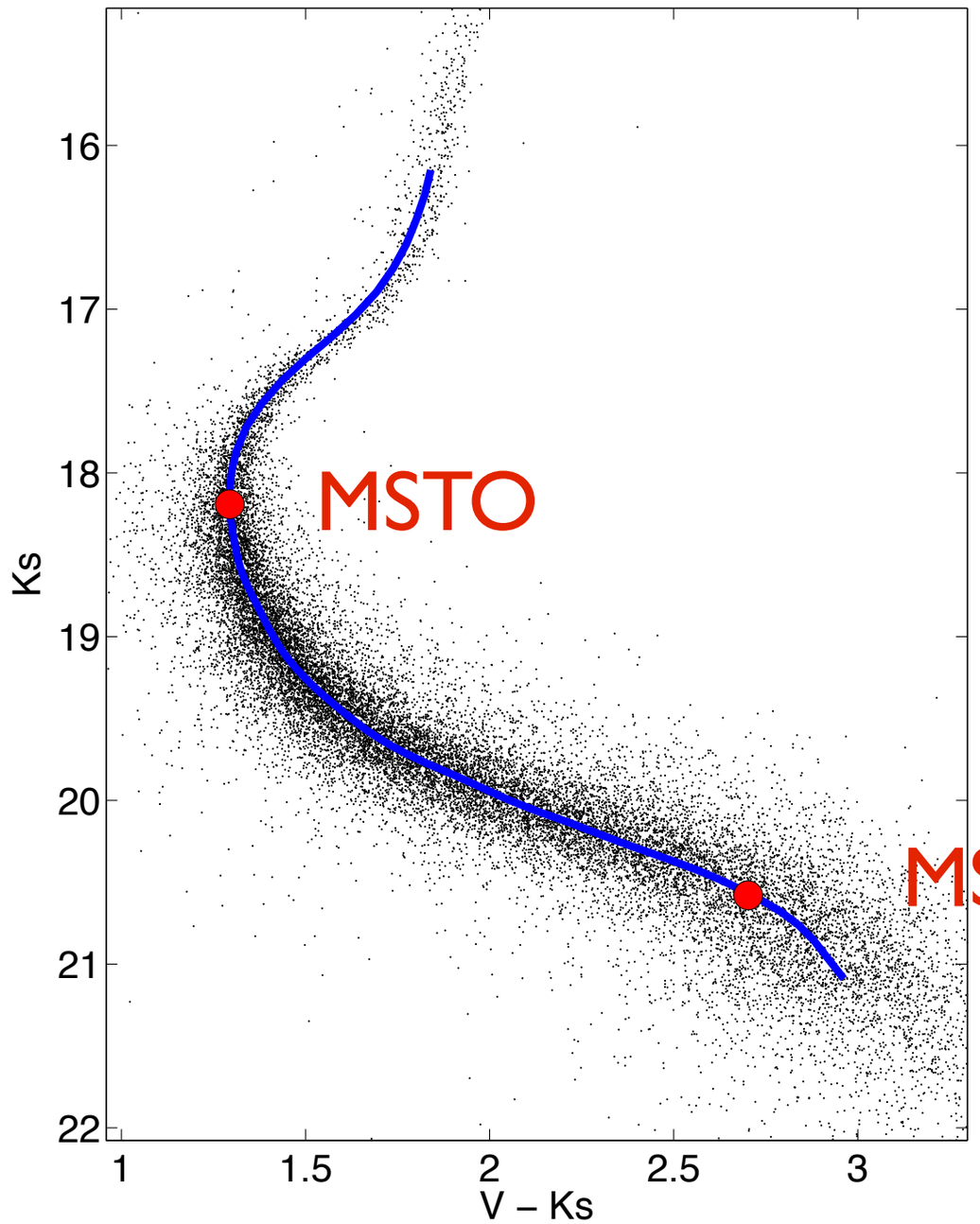
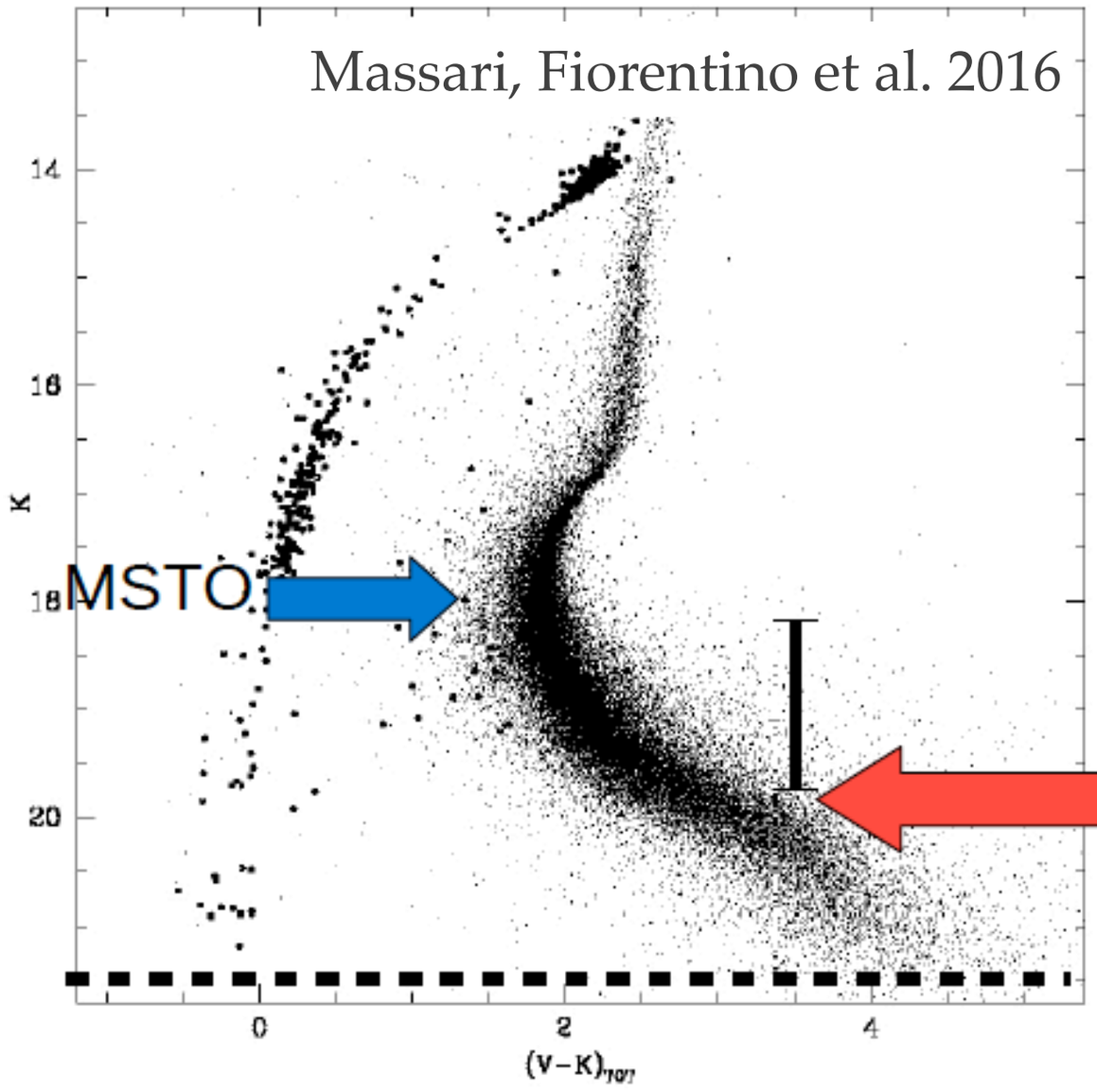
NGC1851, the MSK



work in progress:
Analysis of the MSK!
Turri et al. in prep.

NGC 1851, with DAOPHOT/ALLSTAR/ALLFRAME
(P. Turri et al., 2015 ApJLetter, 2015ApJ...811L..15T)

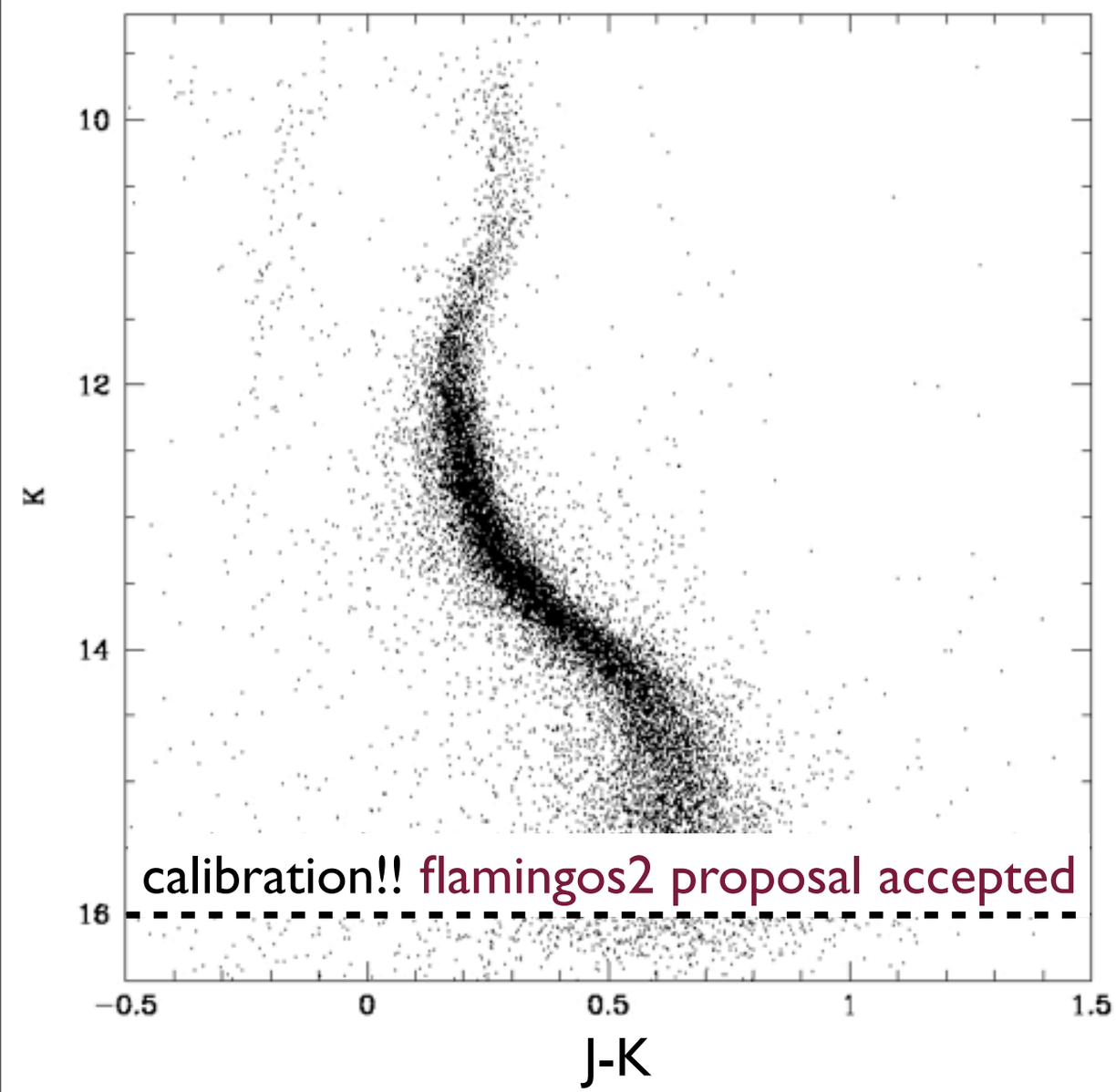
Photometric precision, NGC2808

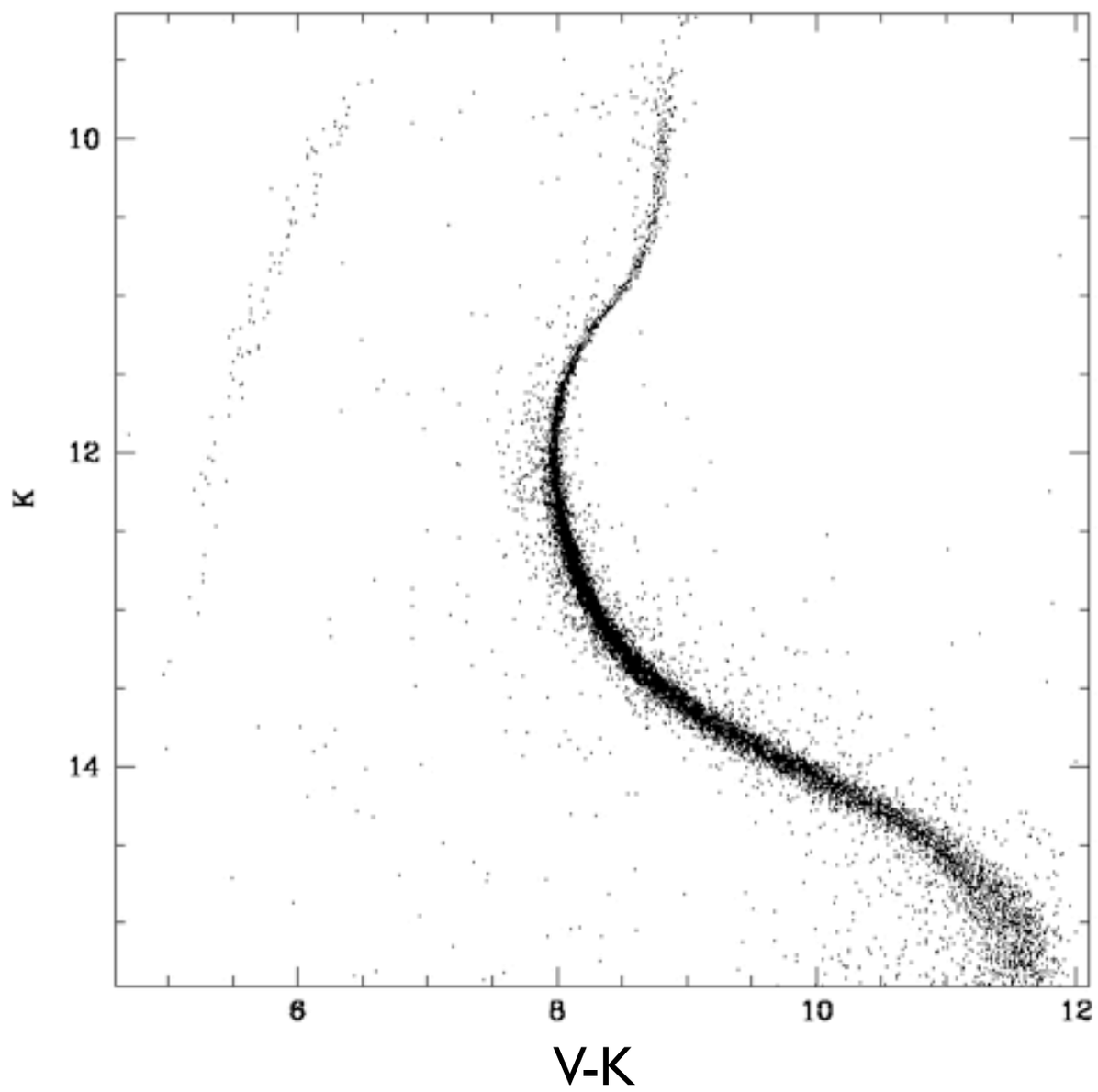


Davide Massari
Post-Doc OABo

age(MSK-MSTO)=10.9 Gyr±0.6(intrinsic)
±0.45(metallicity uncertainty)
+0.25 Gyr (contamination from Helium enhanced pop.)
age(MSTO)=11Gyr±2.7(intrinsic)
±0.05(metallicity uncertainty)

NGC6681





Seeing~0.6” → σ(K)~0.02 mag, σ(J)~0.03 mag at K=SGB

What have we learnt?

✓- Complex calibration: 2MASS too shallow and with too low spatial resolution. An intermediate step is necessary (HAWK-I, FLAMINGOS-II

✓- Achievable photometric precision σ(K)~0.03 mag at K=17 with seeing~0.8”. J requires very good seeing

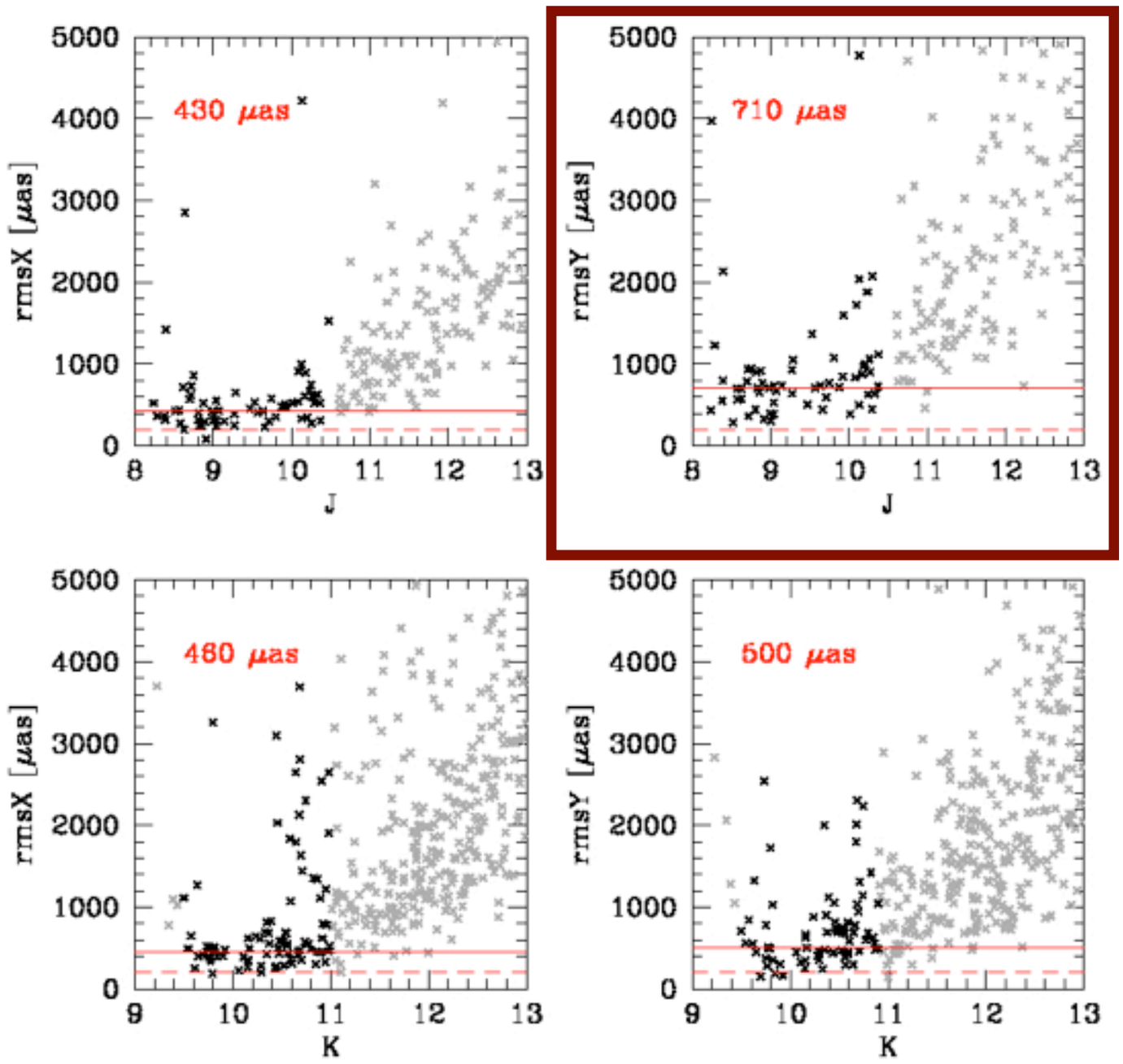
✓- Performance worse than what predicted by the ITC by a factor of 2-3. Room for improvement. News from the magazine Gemini Focus, more PSF modeling?

✓- MAORY will be able to use quite faint stars as NGS (H<22 mag). These studies important to provide them in GC fields (pre-imaging with 8-10m telescopes?)

Astrometry precision

For the best measured stars, r.m.s floor of 0.2 mas--> the same as that found in Neichel+14

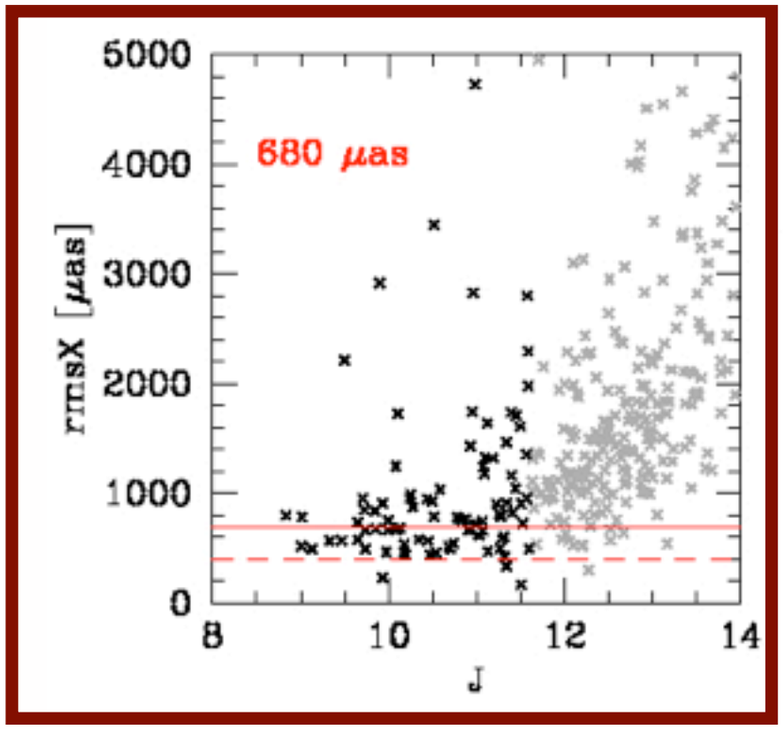
Median r.ms.=0.4 mas
NOT in the X component of J-band exposures

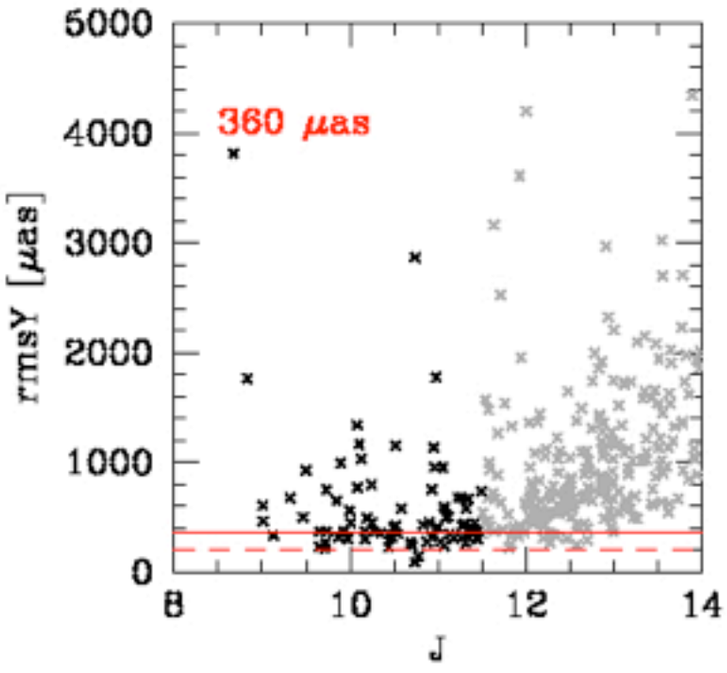


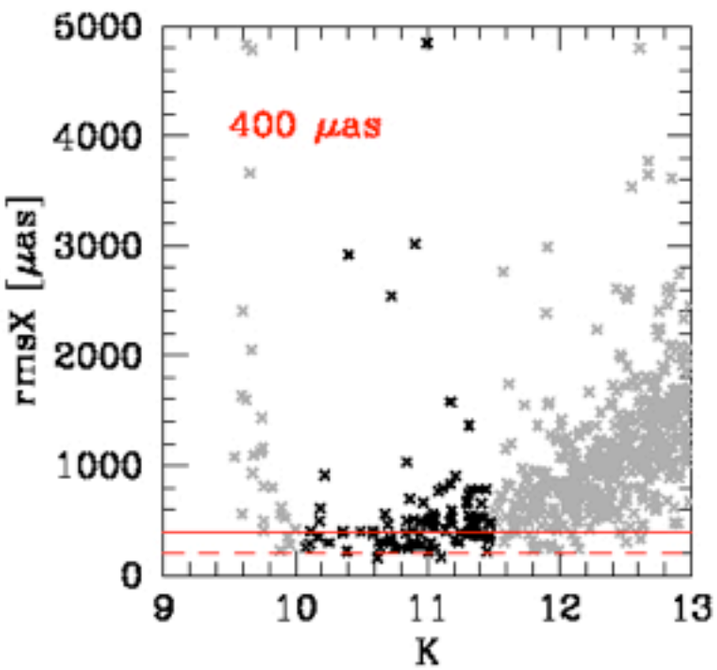
NGC2808

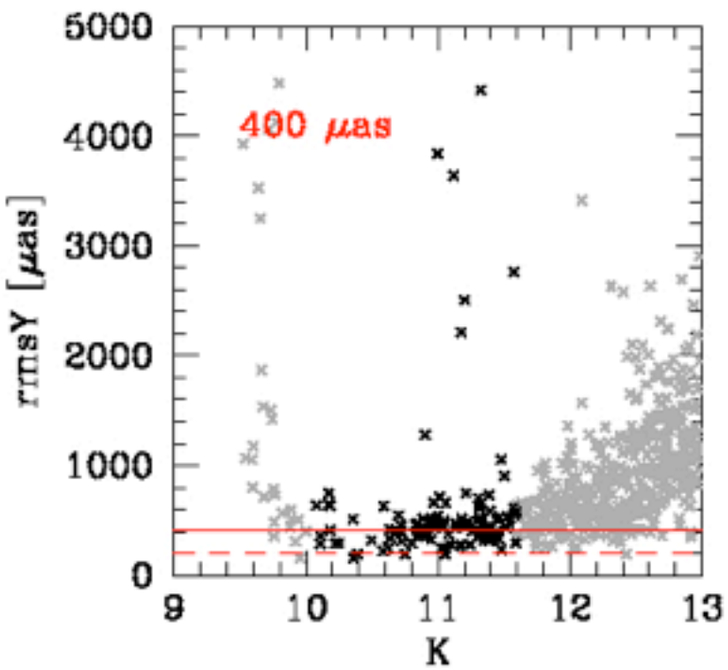
Astrometry precision

This time the worst performance in the Y component of J-band exposures!



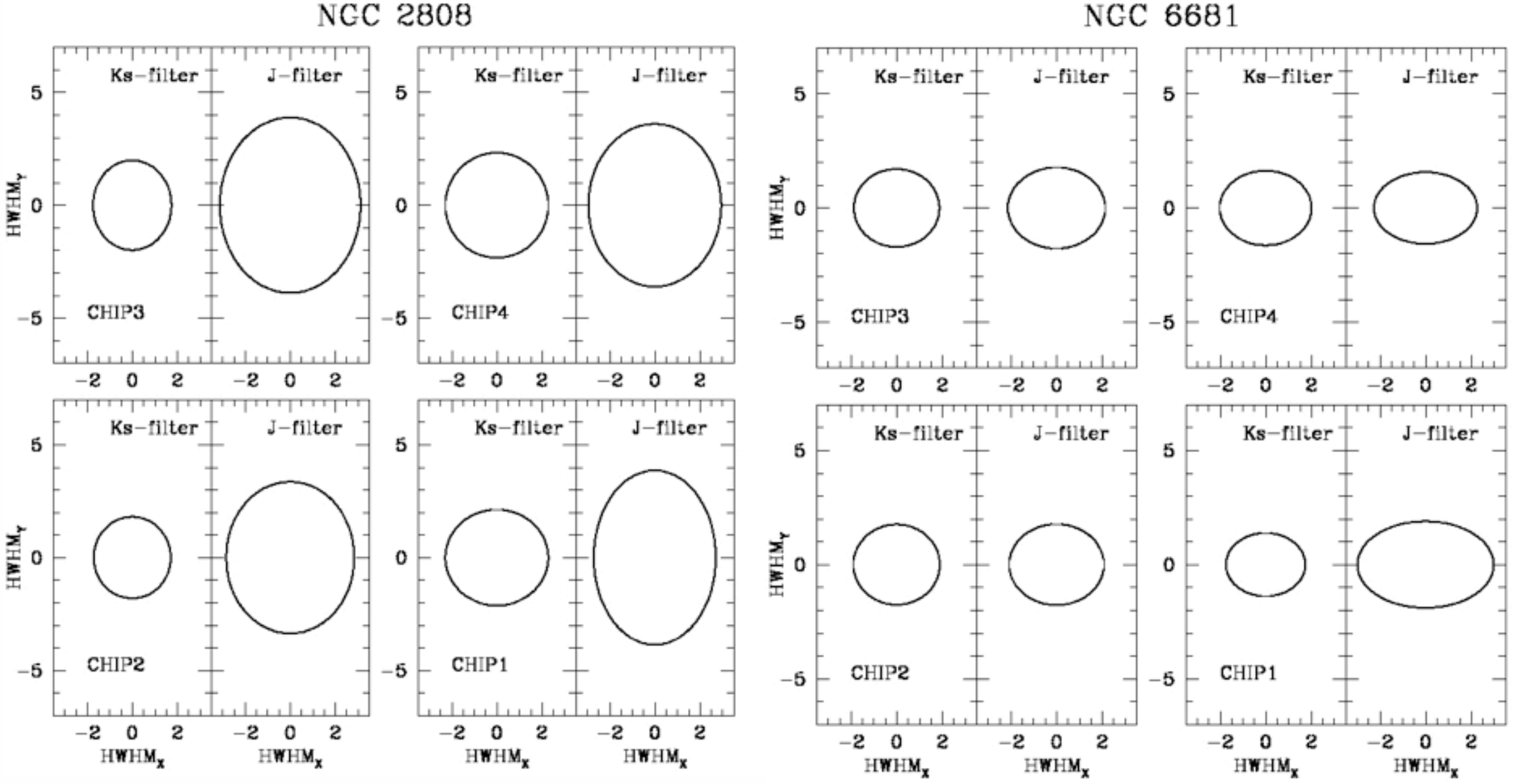






NGC6881

Astrometry
PSF shape



Astrometry
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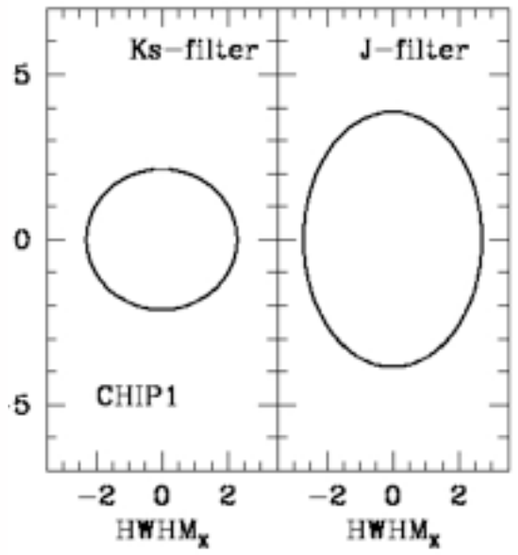
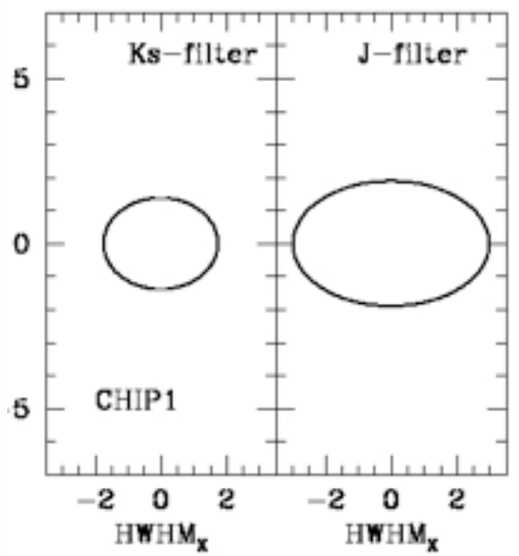
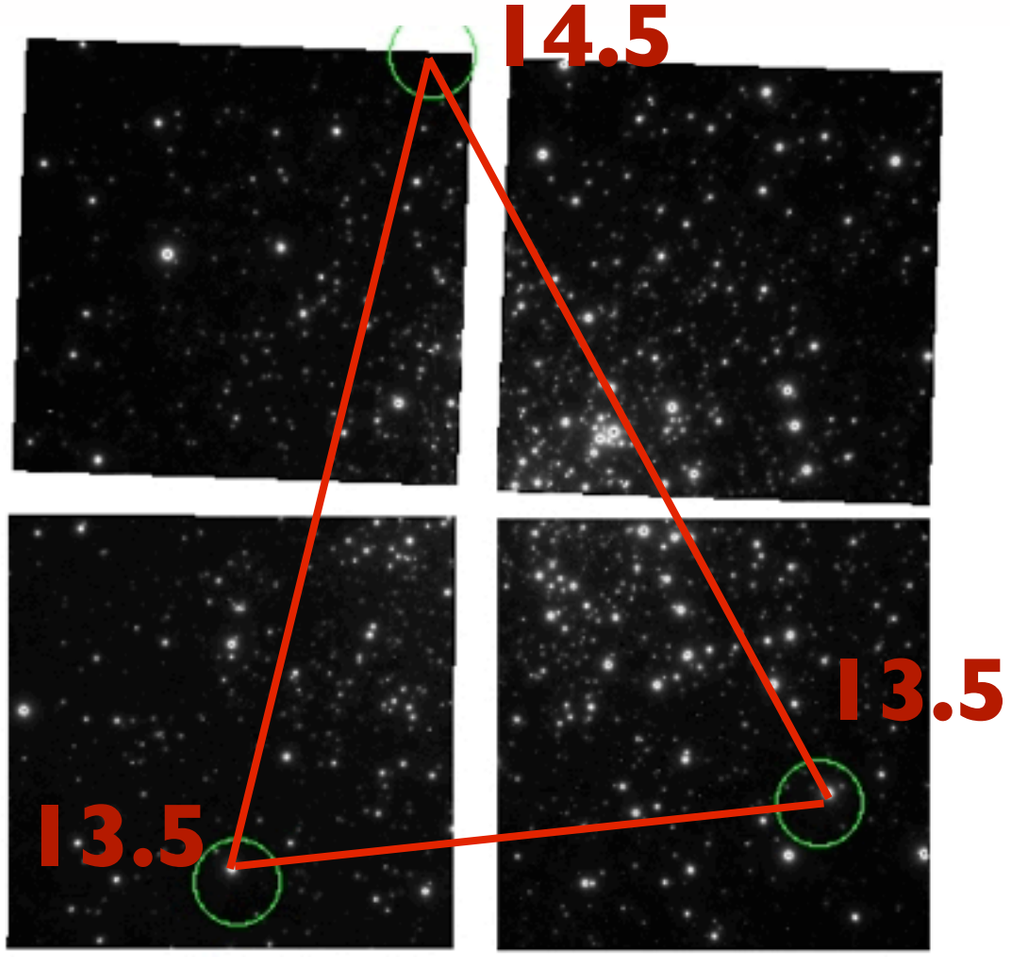
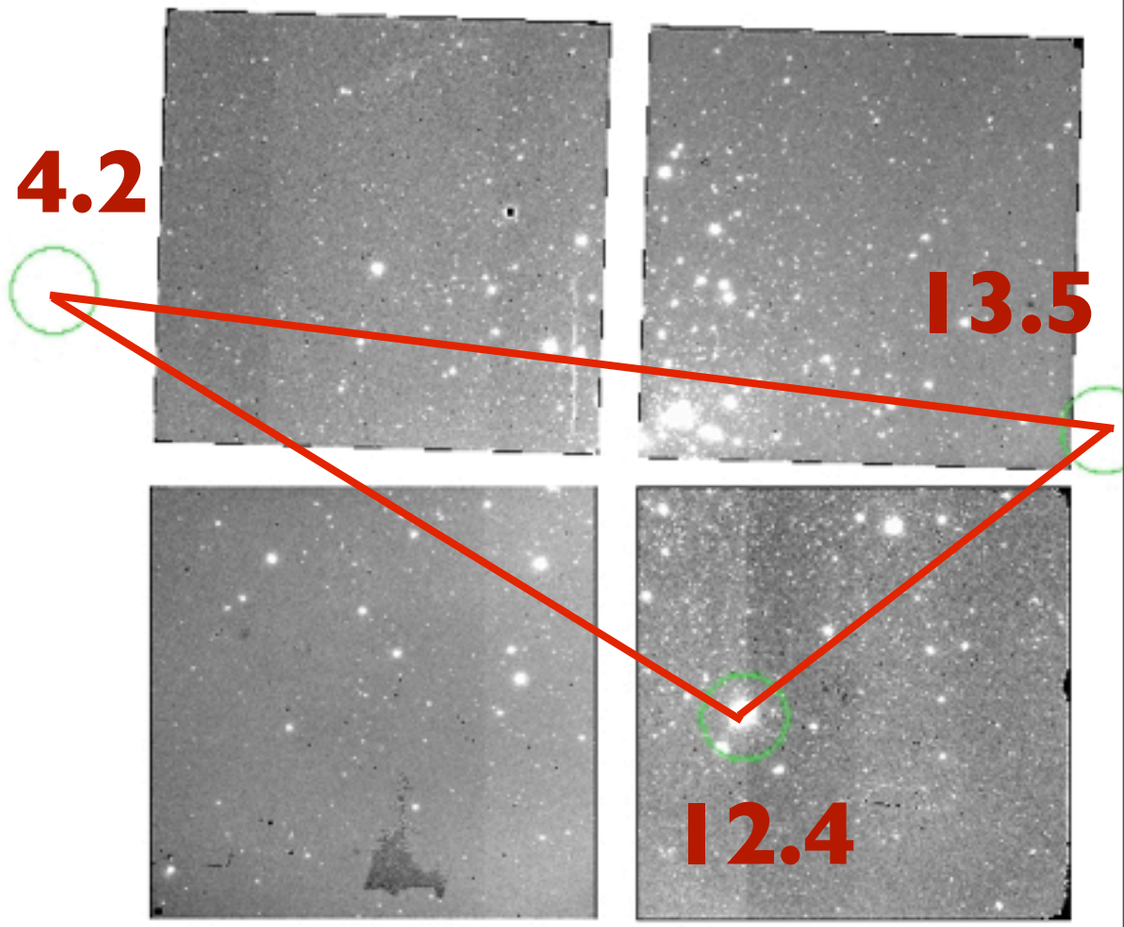




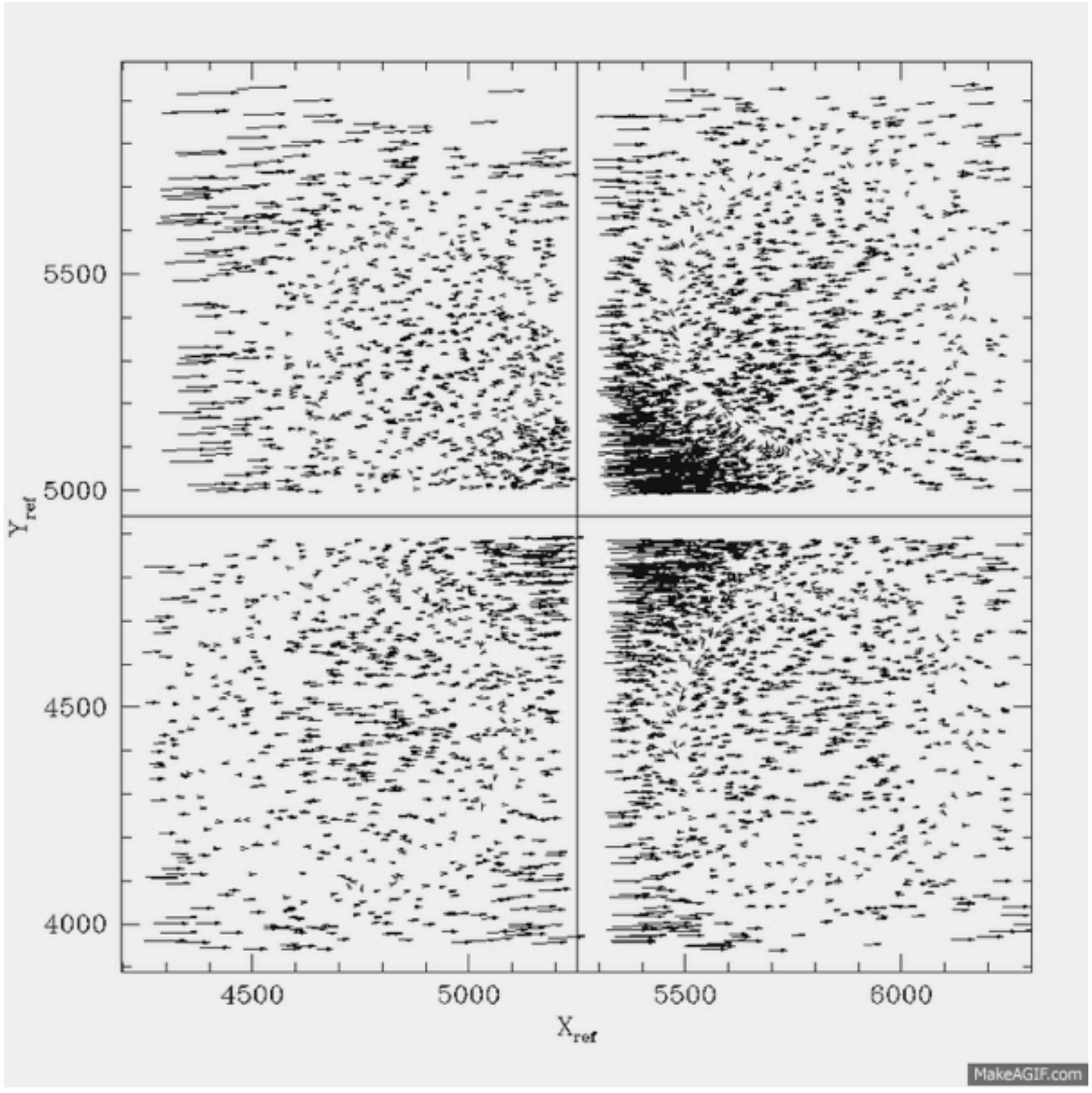




NGC2808

NGC6681

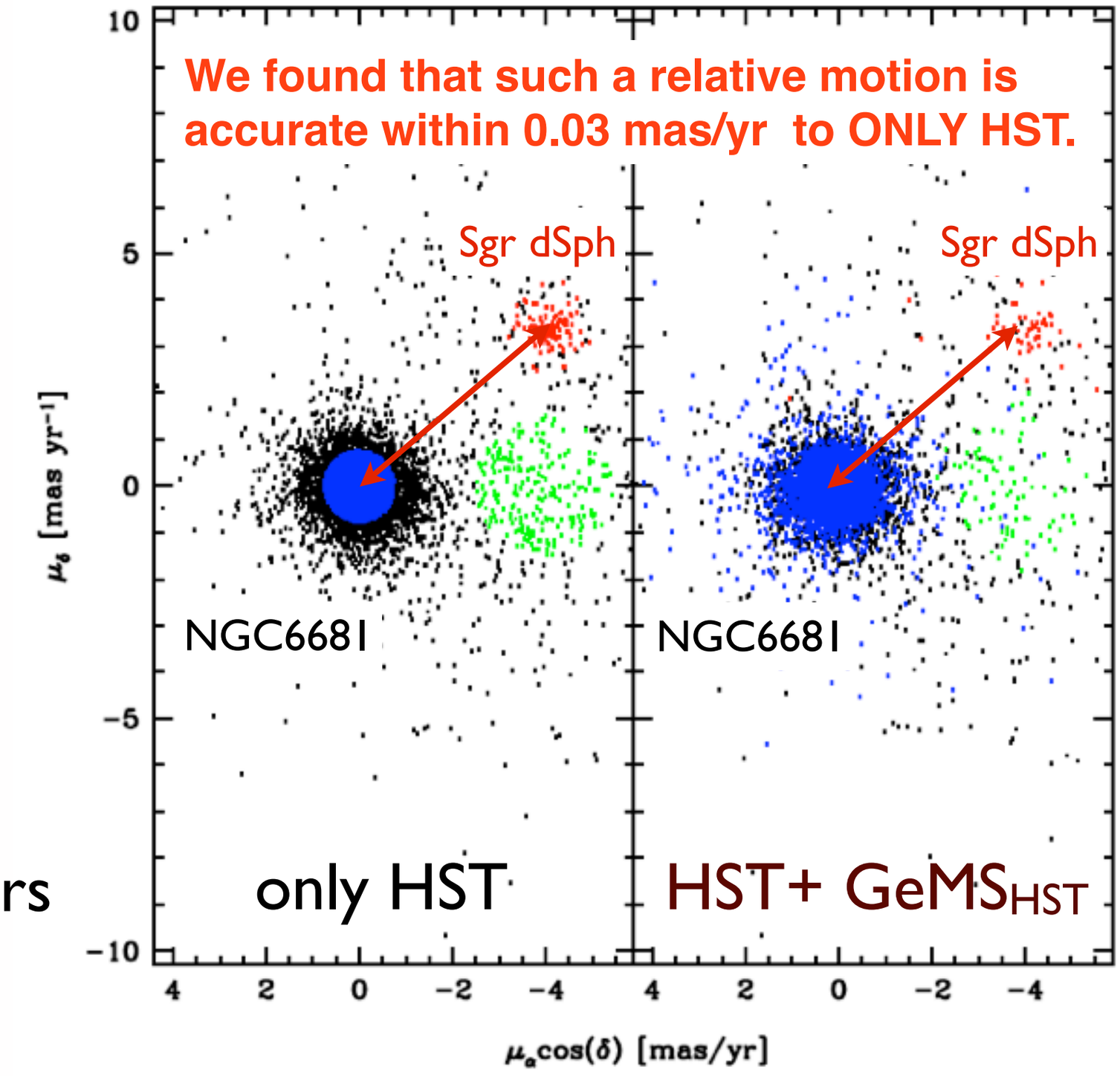
Need of Geometric Distortion maps



Δx=7 pix

Δy=1.5 pix

Relative proper motions HST-GeMS



Δt~5.5 years

Δt~7 years

What have we learnt?

✓- Good PMs accuracy **(within 0.03 mas/yr) to those from HST**

✓- Achievable astrometric precision (repeatability) **σ(K)~0.2** mas for bright stars

✓- Symmetry of NGSs constellation important in J-band

✓-Theoretical performance ~0.05 mas: room for a lot of improvement (**PSF modelling, static+dynamic GDs...**)

Conclusions

TODAY science:

The MSK method looks very promising to build a new Galactic Halo time-scale. The empirical calibration will be extended to old-open clusters in the Galactic disk (down to 6-10 Gyr).

Deep and accurate CMDs are a feasible but not trivial targets, we will expand these studies using all the AO systems planned to work on sky (Linc-Nirvana, SOUL@LBT, Eris@VLT)

Calibration of GeMS Geometric distortion maps (proposal to be submitted)

Preparing the era for ELTs:

Normal packages do prefer to work with uniform correction even with a lower Strehl ratio. (DAOPHOT, Stetson et al 1994).

We need to optimize software in order to account for strong PSF variations when NGSs do not allow a uniform correction. (STARFINDER, Diolaiti et al. 2000, Schreiber et al. in prep, PATCH, blind-deconvolution, La Camera et al. 2015**)**

Stability of the correction in the full wavelength range: reproducibility of the images to increase the S/N ratio.