

MAD observations in crowded and reddened fields: the case of NGC 6441

Elena Valenti ESO - Chile

- G. Fiorentino** - Kapteyn Institute (Netherlands)
- E. Tolstoy** - Kapteyn Institute (Netherlands)
- E. Diolaiti** - INAF, Bologna Observatory (Italy)
- L. Origlia** - INAF, Bologna Observatory (Italy)

Astrophysical context

- ❖ The study of GCs SP address fundamental questions ranging from **stellar structure, evolution and dynamics** to **Galaxy formation**
- ❖ **Astro-Archeology**: “fossil” from the remote and violent epoch of Galaxy formation
- ❖ **Astro-Dynamics**: test particles for studying Galaxy dynamics and stellar dynamical model
- ❖ **Astro-Templates**: largest aggregates, spanning a large metallicity range, in which all post-MS stars can be individually observed and thus they serve as fiducial templates for understanding the integrated light from distance stellar systems.

in particular...

- ❖ **GCs Absolute Age scale**: tracing the epoch of the early Galaxy formation
- ❖ **GCs Relative Age scale**: tracing the timescale of the formation and the overall processes that yielded to the actual GC system.

however...

- ❖ **Halo GC system**: (Rosenberg et al. 1999, Salaris & Weiss 2002, De Angeli et al. 2005)

- ❖ **Bulge GC system**:

NGC6828, NGC6853, NGC6824, NGC6837, Ter5: NICMOS, WFPC2 (Ortolani et al.1995, Heasley et al. 2001, Ortolani et al. 2001, Zoccali et al. 2001, Cohn et al. 2002, Feltzing & Johnson 2001)

NGC6440: NACO (Origlia et al.2008)

NGC6588: MAD (Moretti et al.2009)

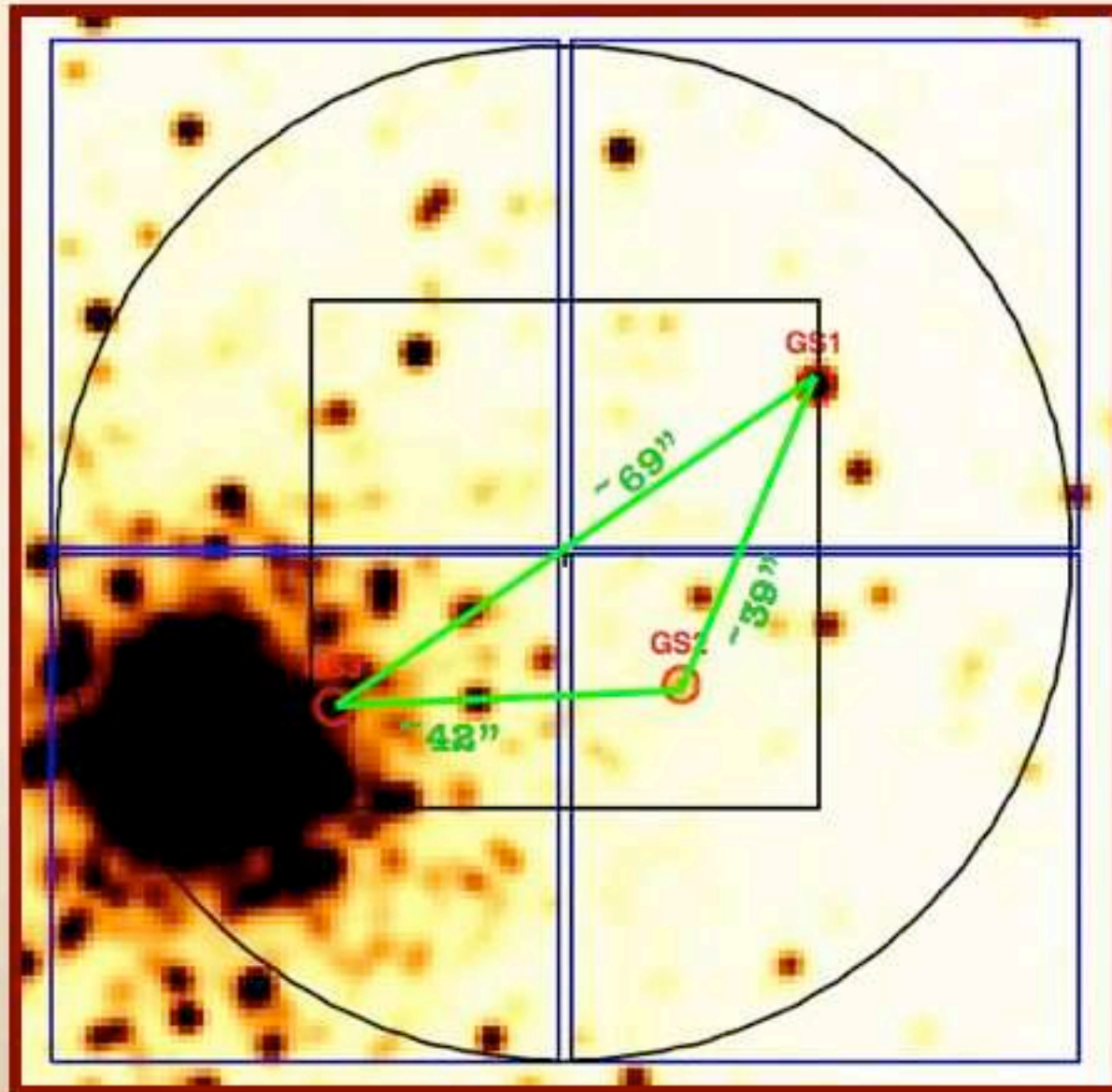
NGC 6441: a bit of history

- ❖ High density $\log \rho = 5.8$ (Djorgovski 1993)
- ❖ Massive $M_V = -9.64$ (Harris 1996)
- ❖ Moderately reddened $E(B-V) = 0.52$ (Valenti, Ferraro & Origlia 2007)
- ❖ From the HST-based CMD ==> extended blue HB (Rich et al 1997)
- ❖ Extensive studies on its HB (Moehler et al. 1999, Plotto et al. 2002, Busso et al. 2007)
- ❖ $[Fe/H] = -0.50$ (Valenti, Ferraro & Origlia 2007)
- ❖ None of the available photometries explored the cluster MS-TO

Our goals:

- ❖ Deriving the age of NGC 6441 from the direct measurement of the cluster MS-TO level
- ❖ Performing a multi-wavelength study of the cluster peculiar HB (combining UV-optical HST data with near-IR MAD photometry)
- ❖ Performing a study of the RR-Lyrae variables cluster population to derive accurate distance (P-L relation in the K-band)
- ❖ Testing the capabilities of ground-based MCAO system in the near-IR and comparing them with HST performances

MAD Observations of NGC 6441



GS1 V=10.2

GS2 V=12.5

GS3 V=13.3

Long exp DIT=10s

Ks: 12 x DIT x 20

J: 6 x DIT x 20

1 point. FoV=1'x1'

Short exp DIT=2s

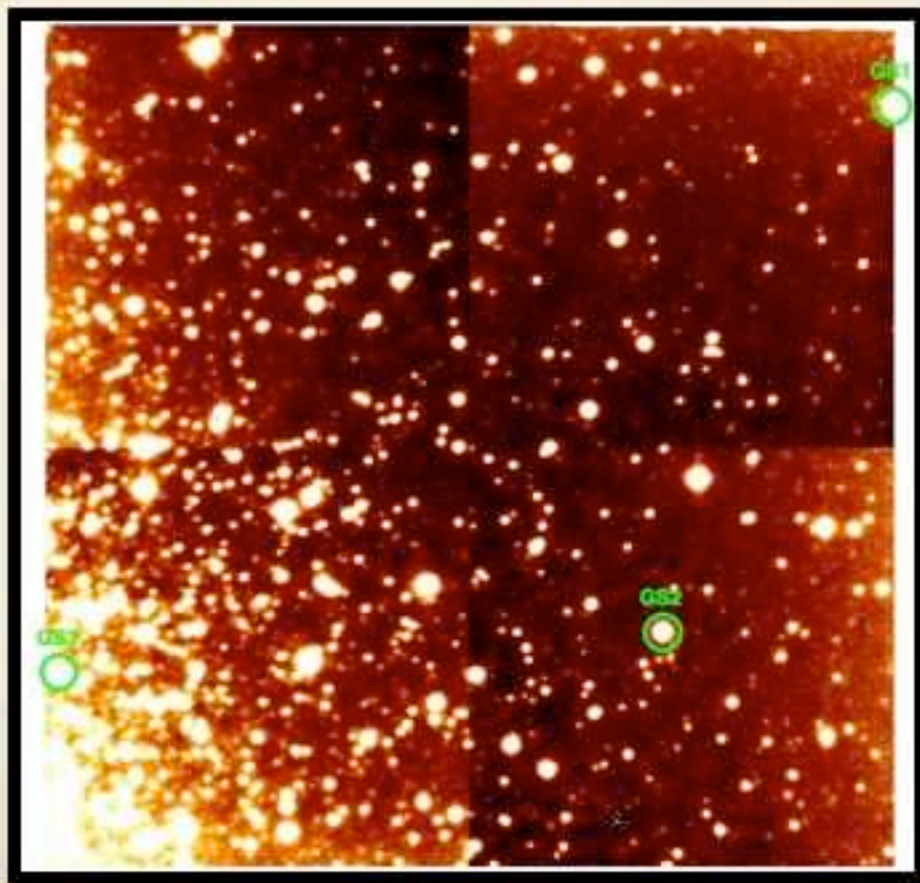
Ks: 3 x DIT x 10

J: 3 x DIT x 10

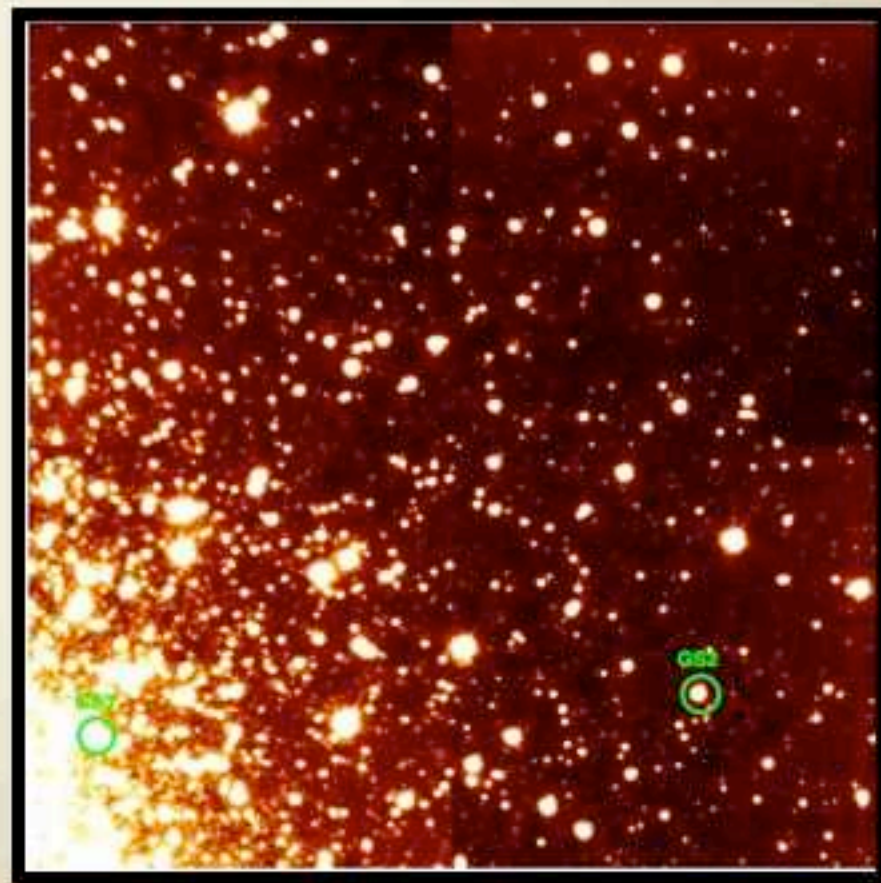
5 point. FoV=2'x2'

MAD single images - LONG EXPOSURES

J-band 60 sec



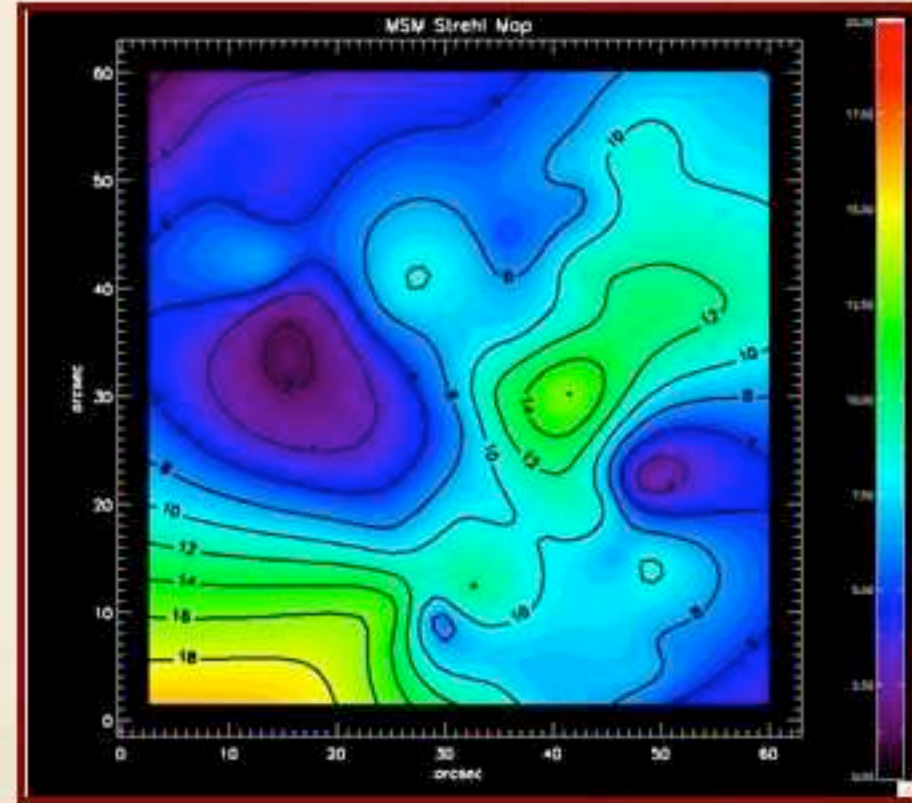
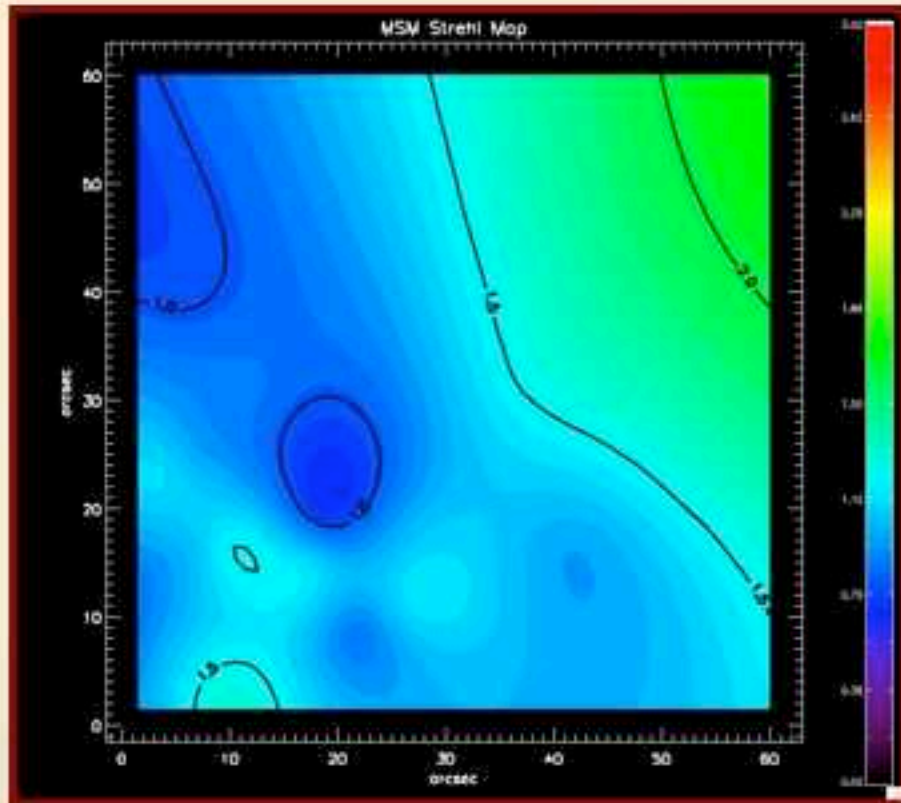
KS-band 120 sec



Strehl on MAD single images - LONG EXPOSURES

J-band 60 sec

Ks-band 120 sec

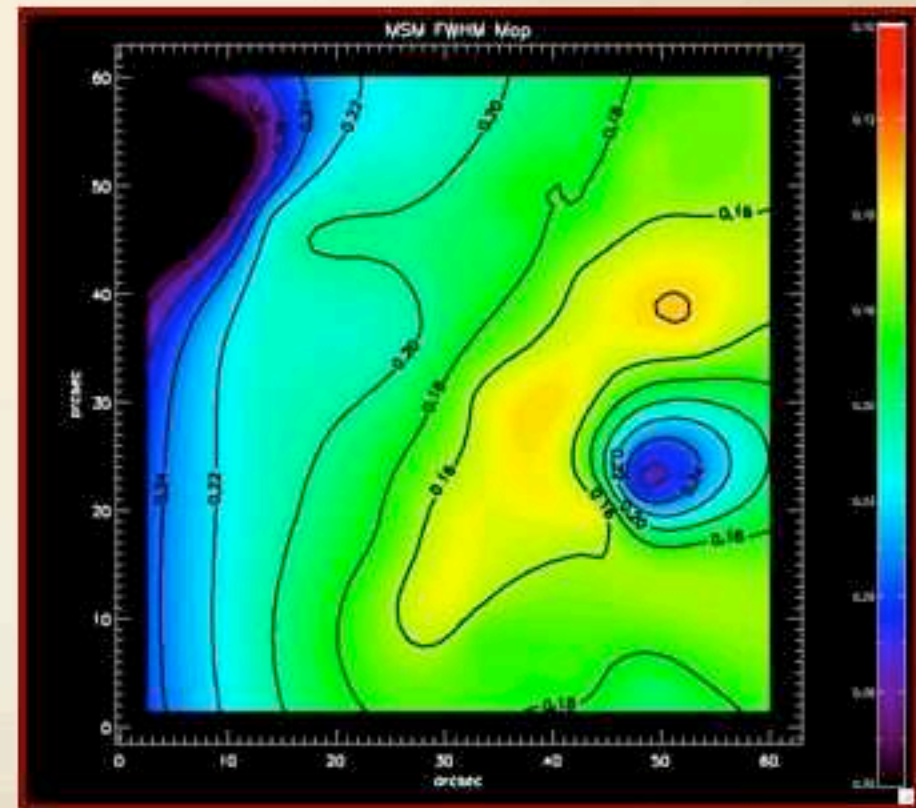
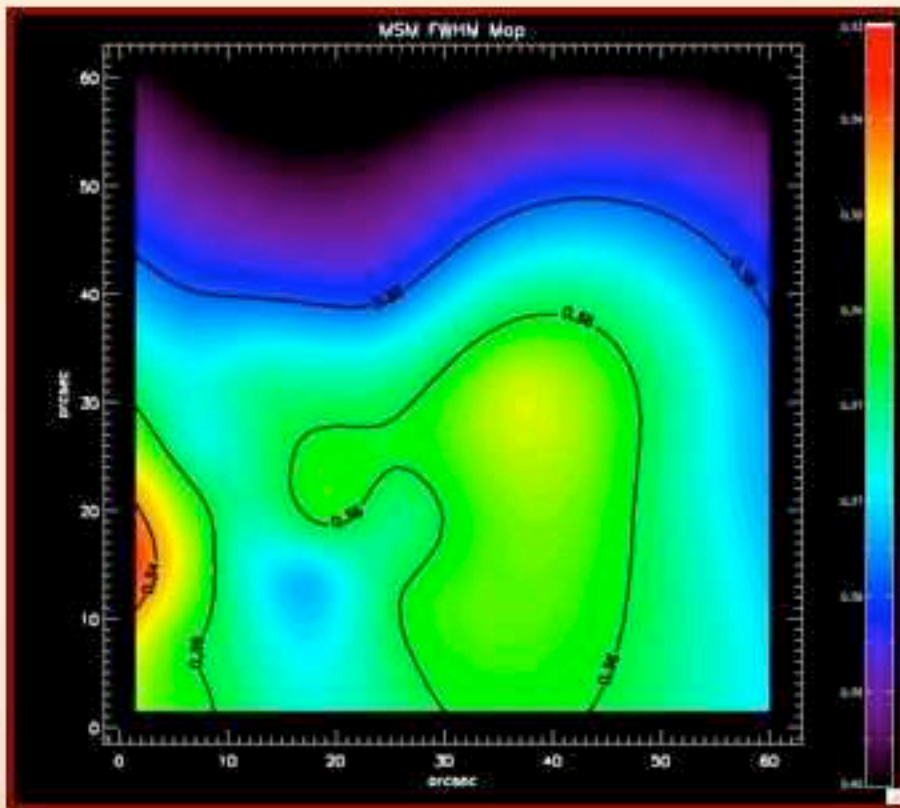


Max Strehl measured across the FoV is **3%** and **18%** in **J** and **Ks**, respectively

FWHM on MAD single images - LONG EXPOSURES

J-band 60 sec

Ks-band 120 sec



Natural seeing measured in open loop **0.5"**, **0.4"** in **J** and **Ks**, respectively
Correction factor ~ 2

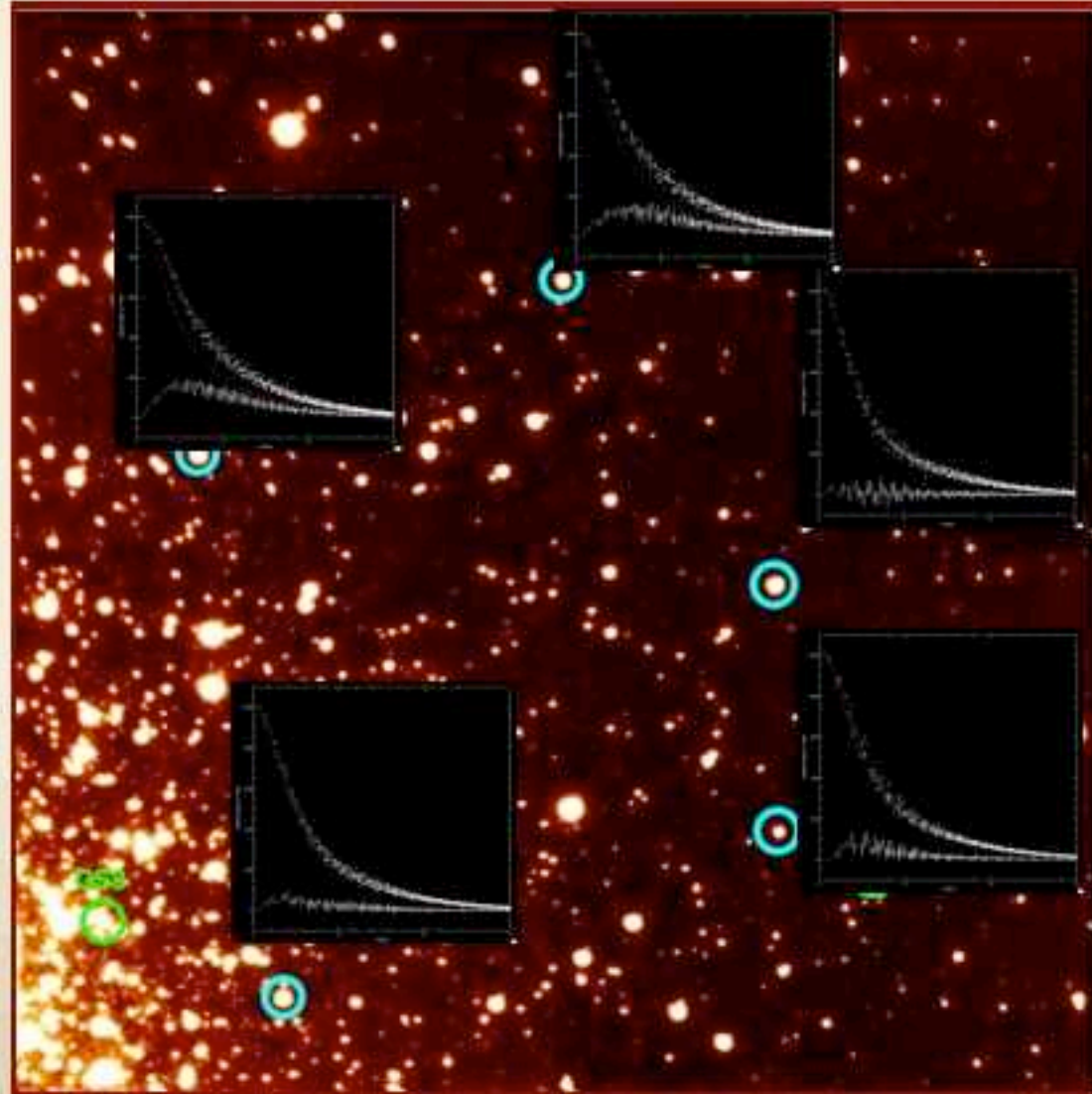
PSF photometry on MAD single images - LONG EXPOSURES

DAOPHOT/ALLSTAR

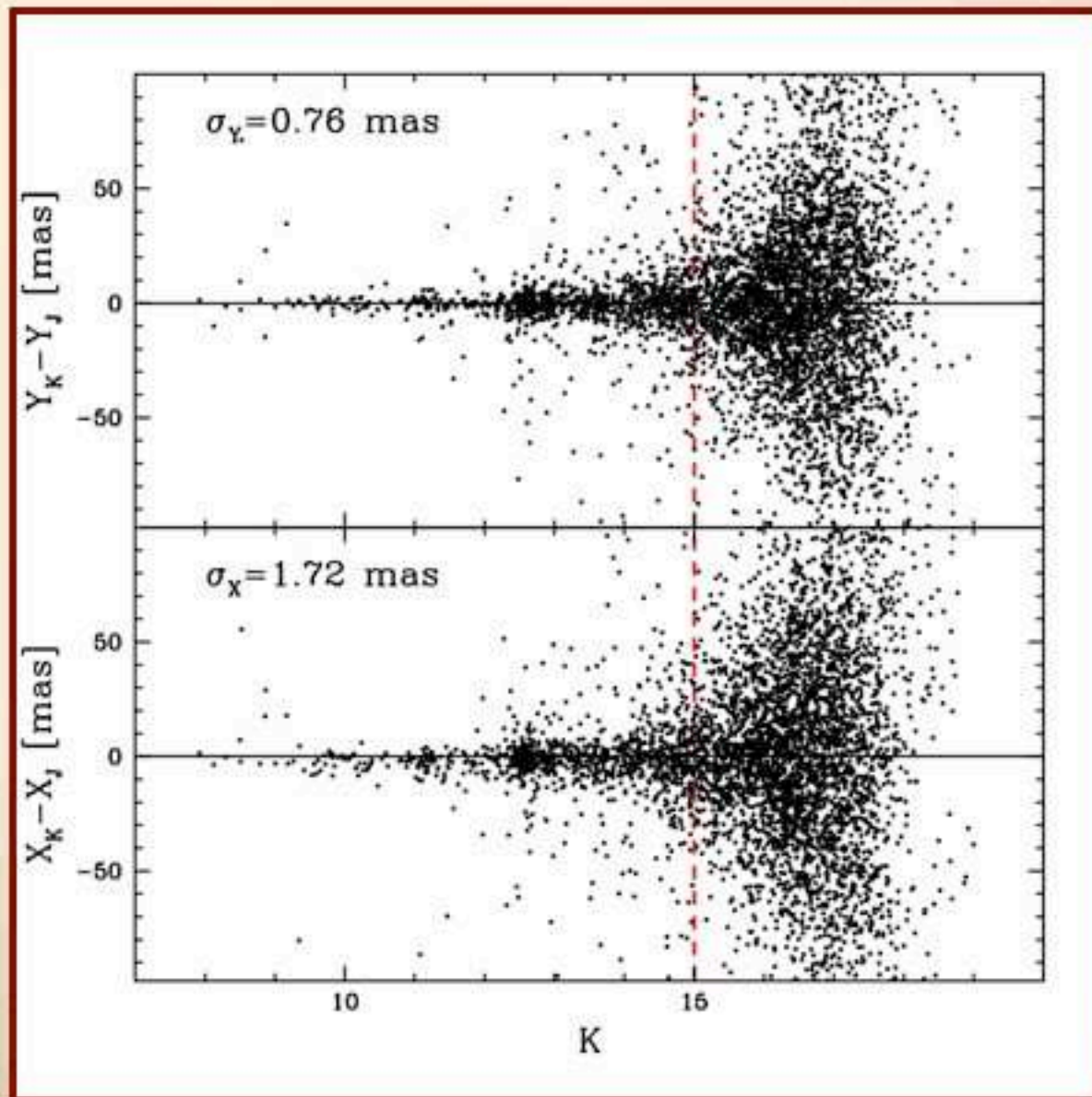
(P.Stetson)

Quadratic variable PSF
(MOFFAT15)

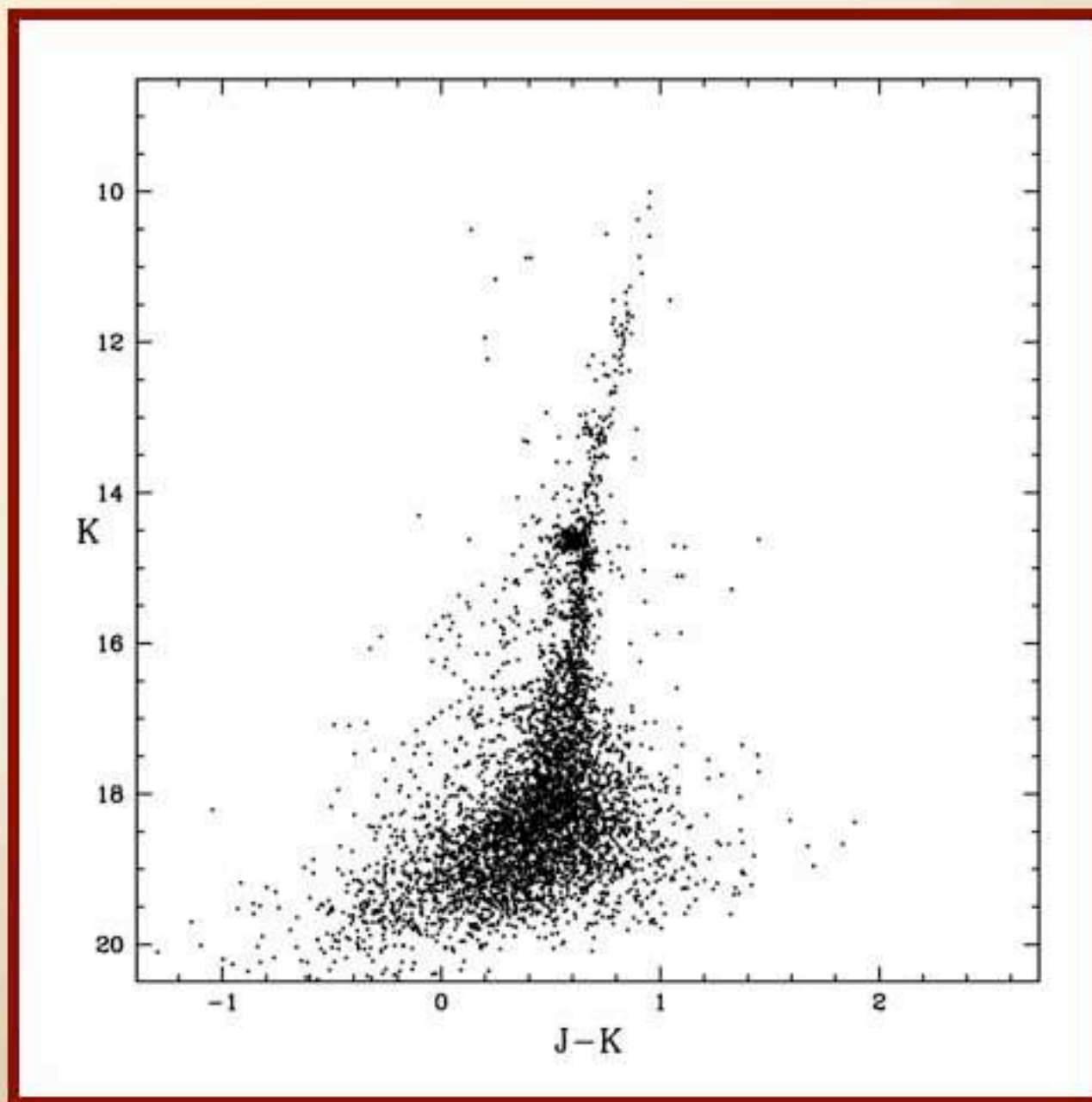
J and Ks MAD catalog
onto 2MASS
photometric and
astrometric system



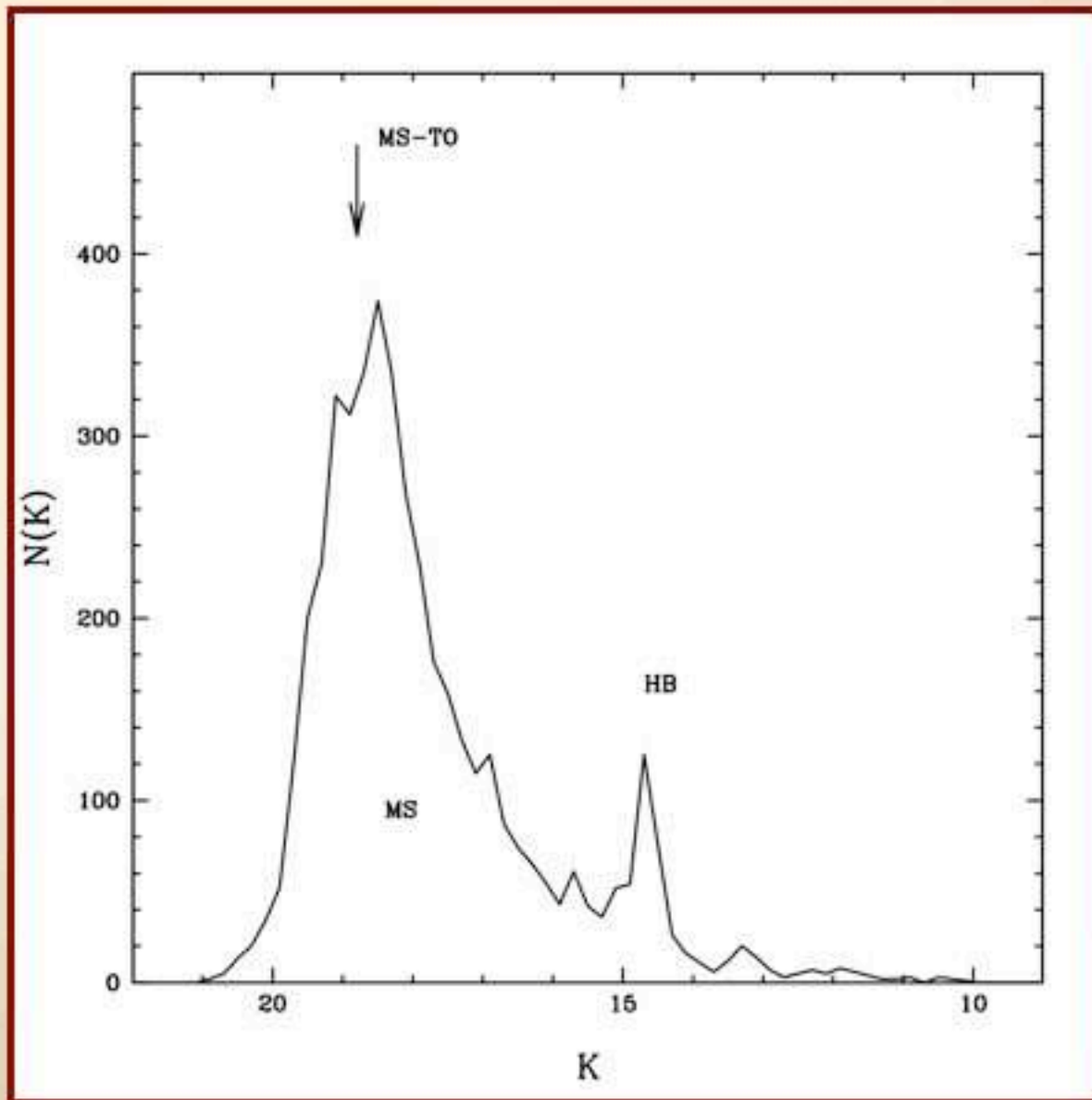
MAD single images - LONG EXPOSURES - ASTROMETRY STABILITY



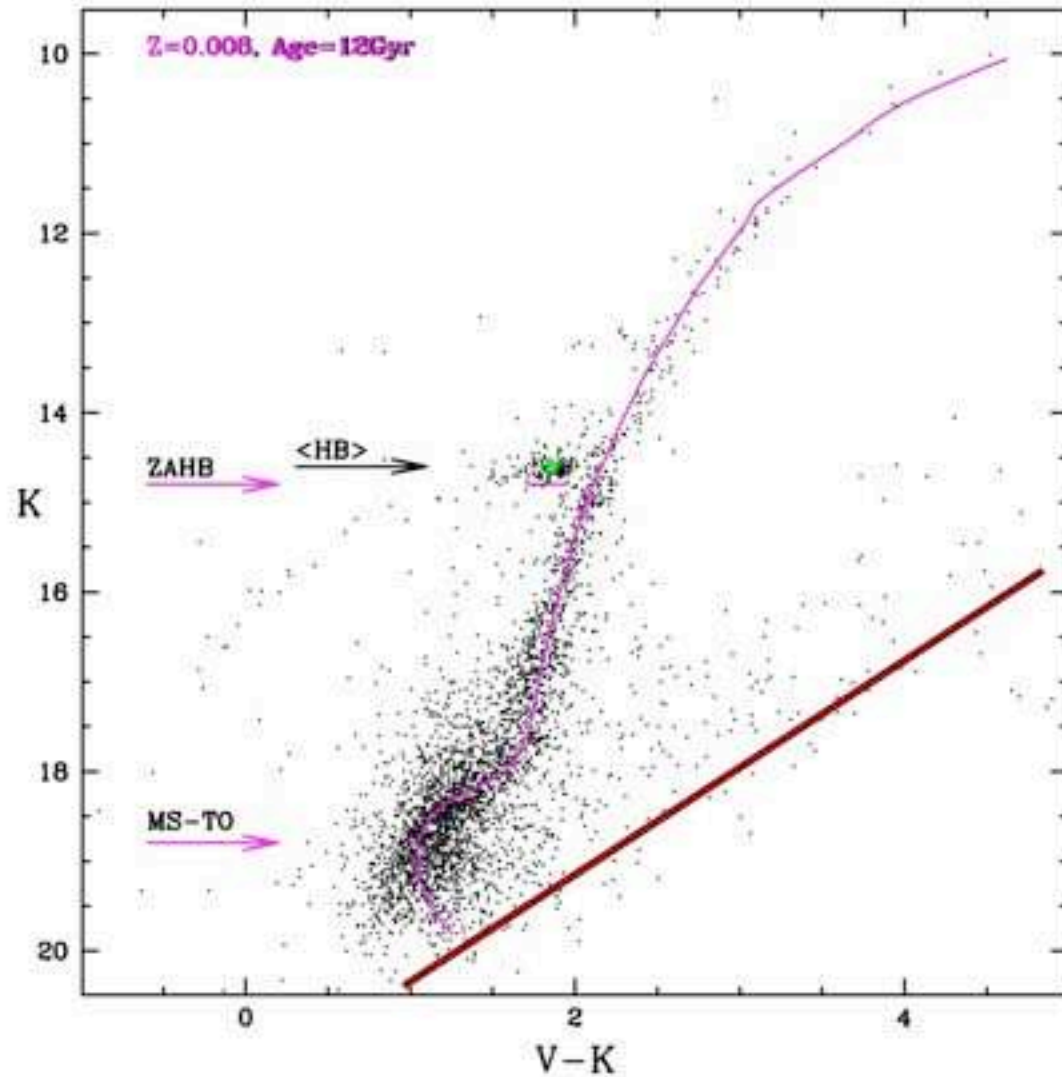
MAD single images - LONG EXPOSURES - K, J-K CMD



MAD single image - LONG EXPOSURES - K LF



Combined MAD-HST photometry



K (120s) MAD@VLT
combined
V (50s) WFPC2@HST

$$(m-M)_0 = 15.65$$

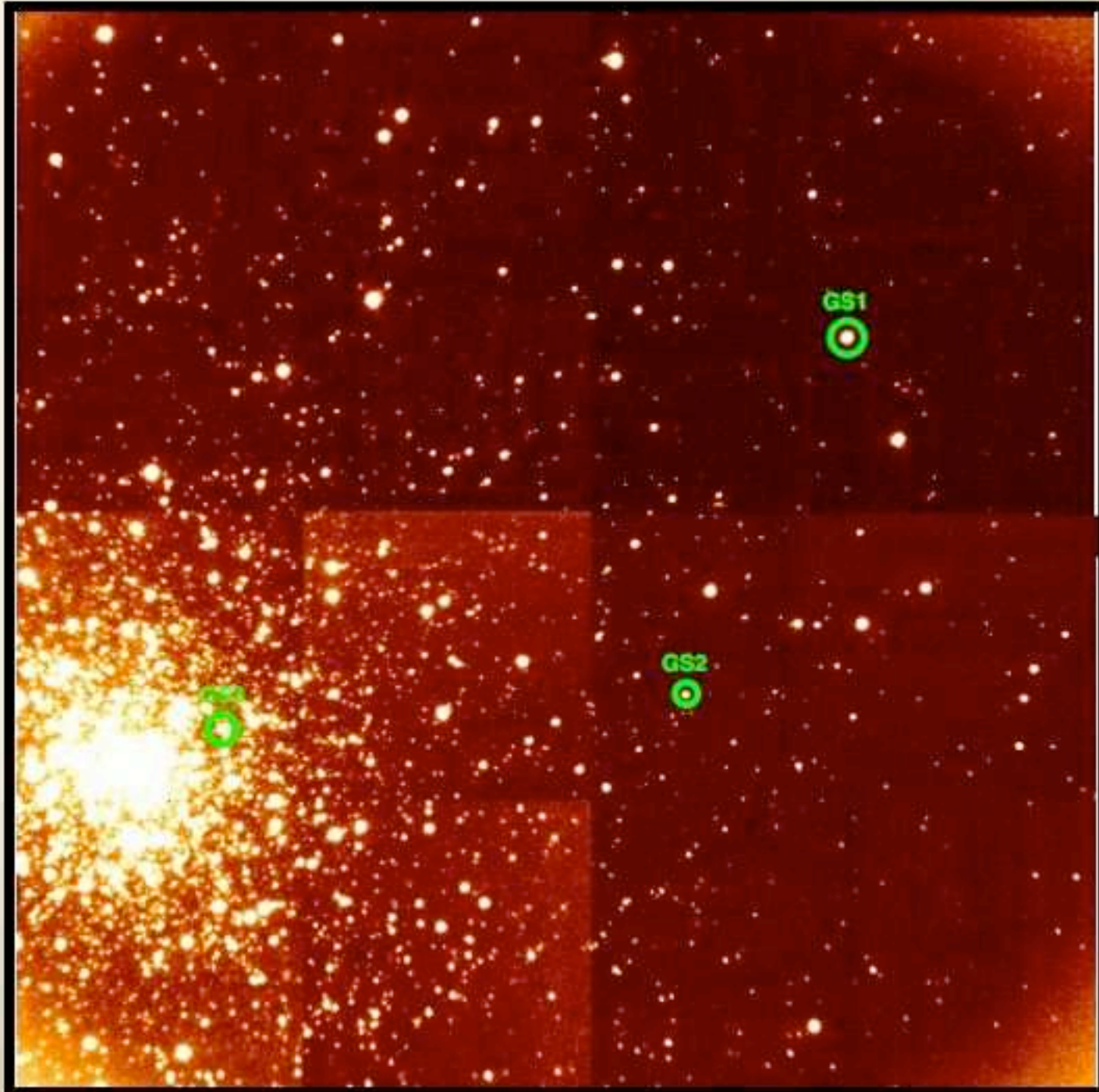
$$A_V = 1.61$$

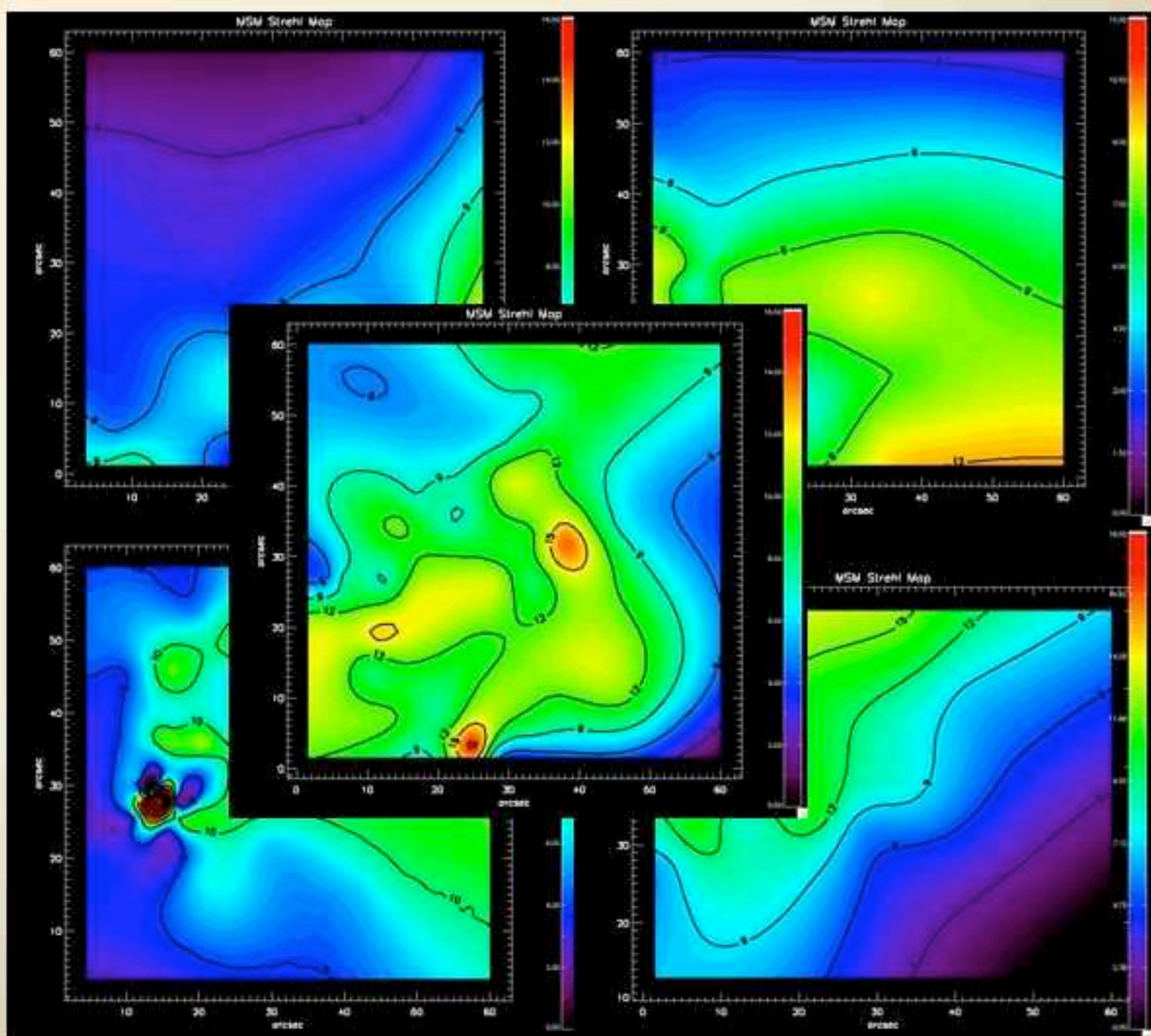
$$A_K = 0.2$$

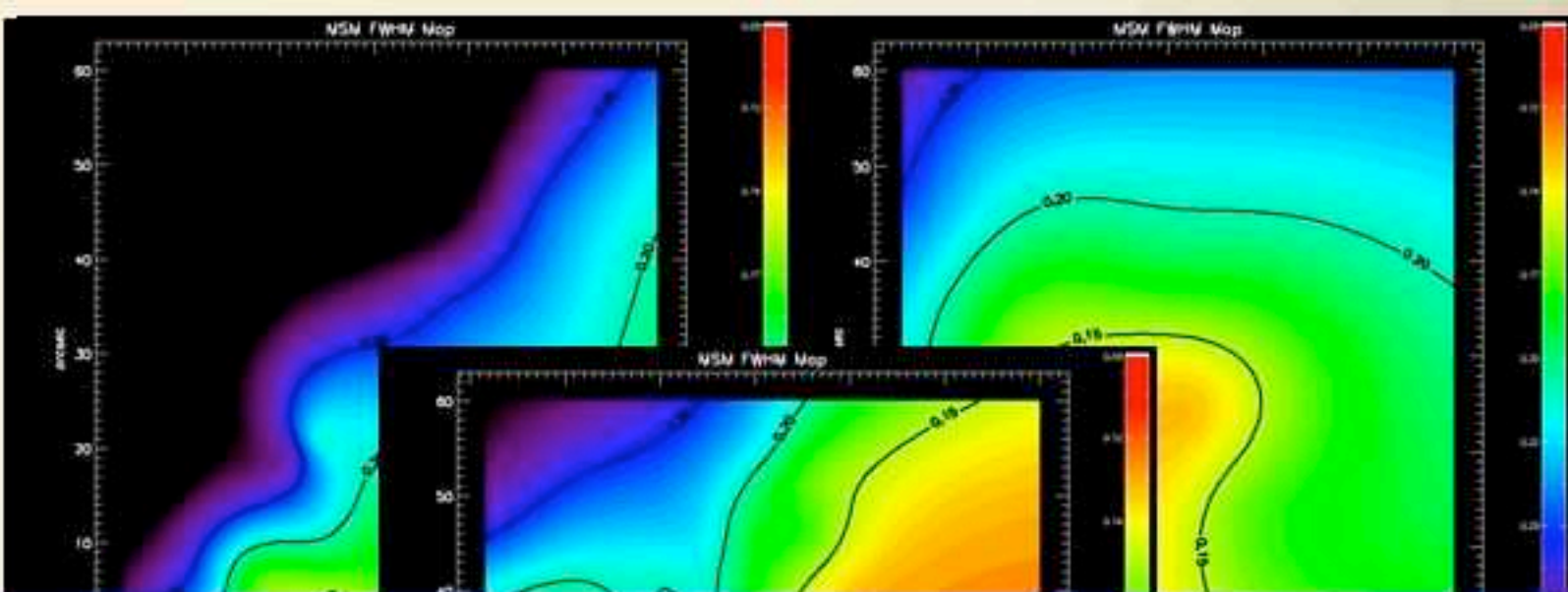
SHORT EXP.

Mosaic of 5
pointings

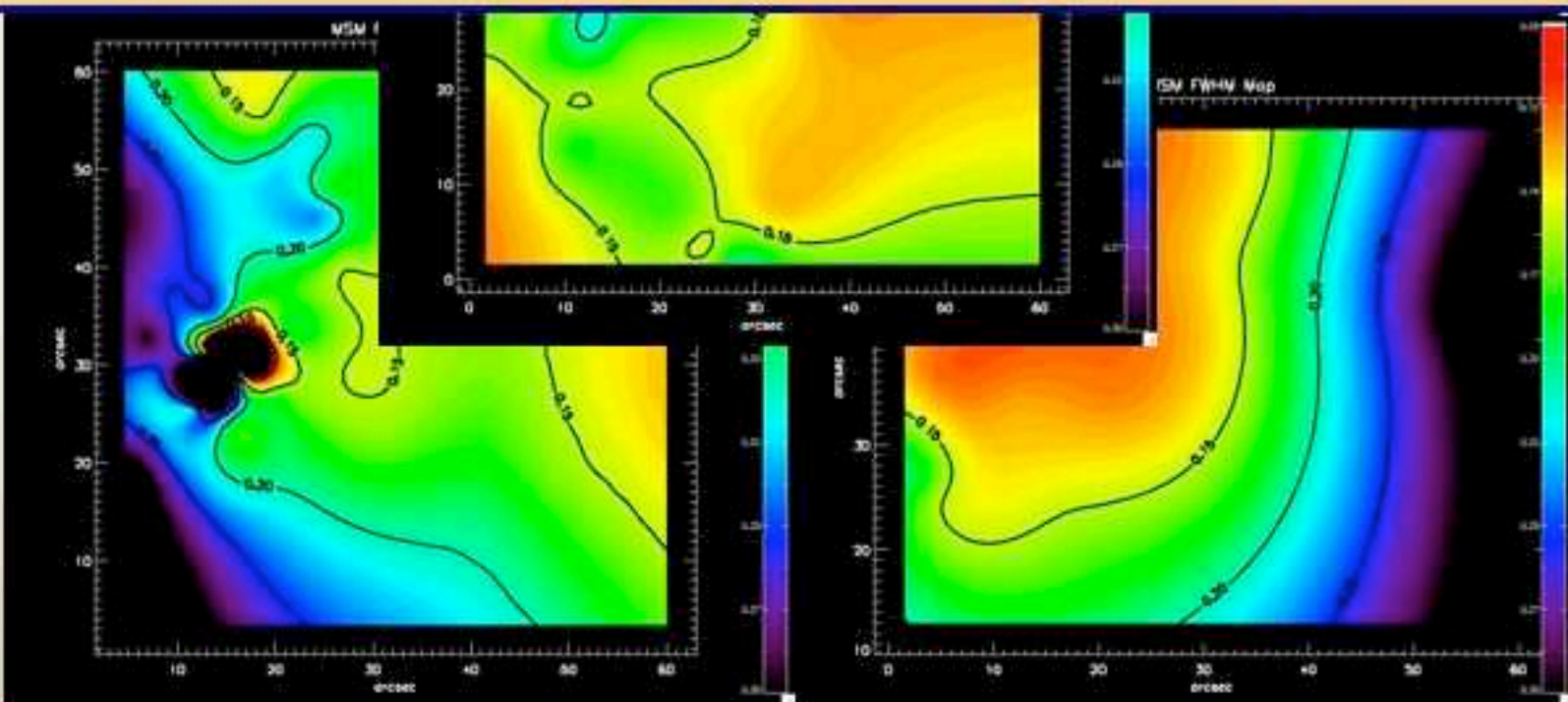
FoV=2'x2'





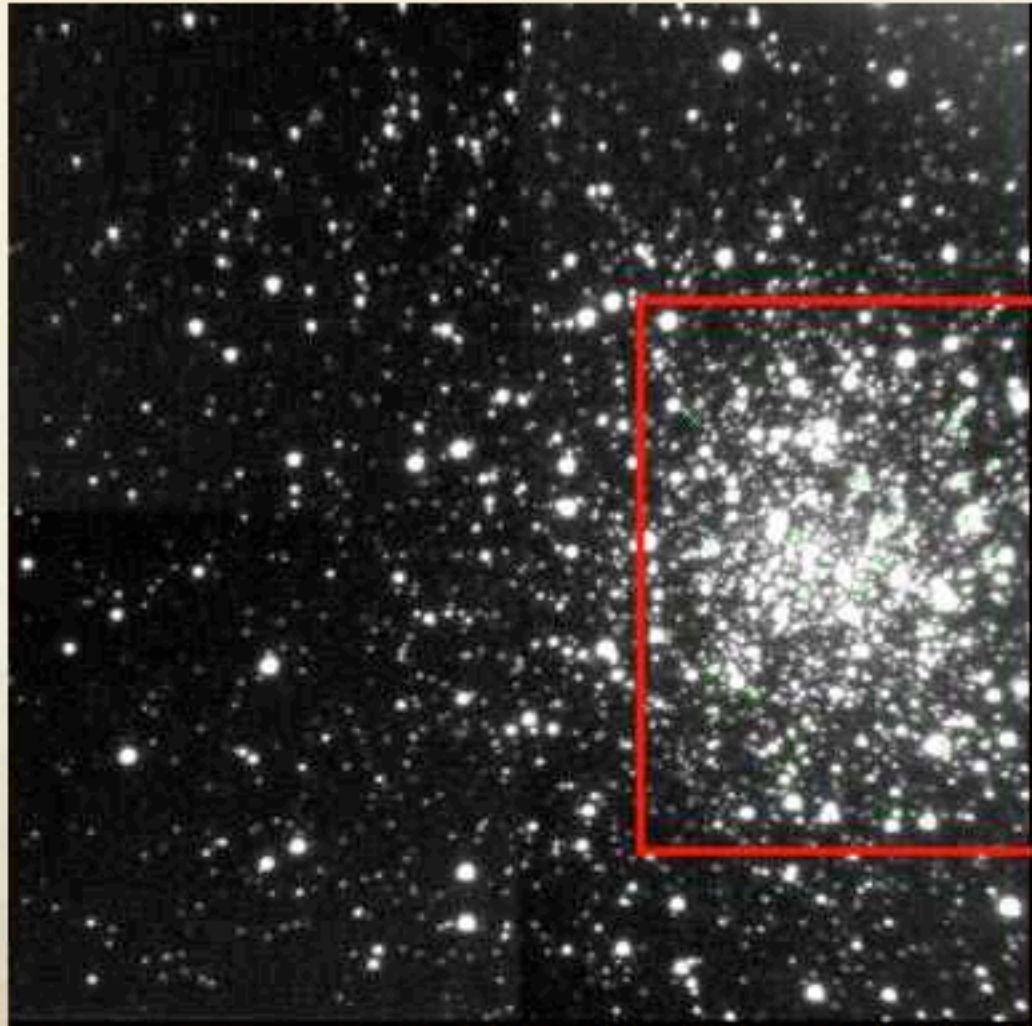


$\langle \text{FWHM} \rangle_k = 0.2''$ in closed loop vs $\langle \text{FWHM} \rangle_k = 0.4''$ in opened loop



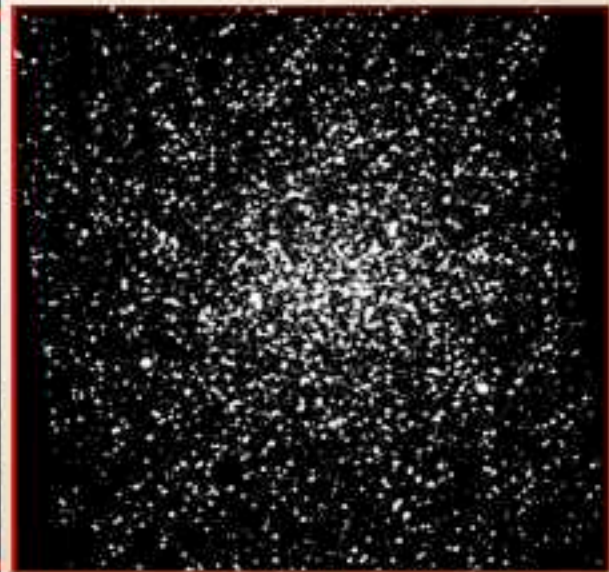
MAD vs HRC/ACS

MAD (1min)

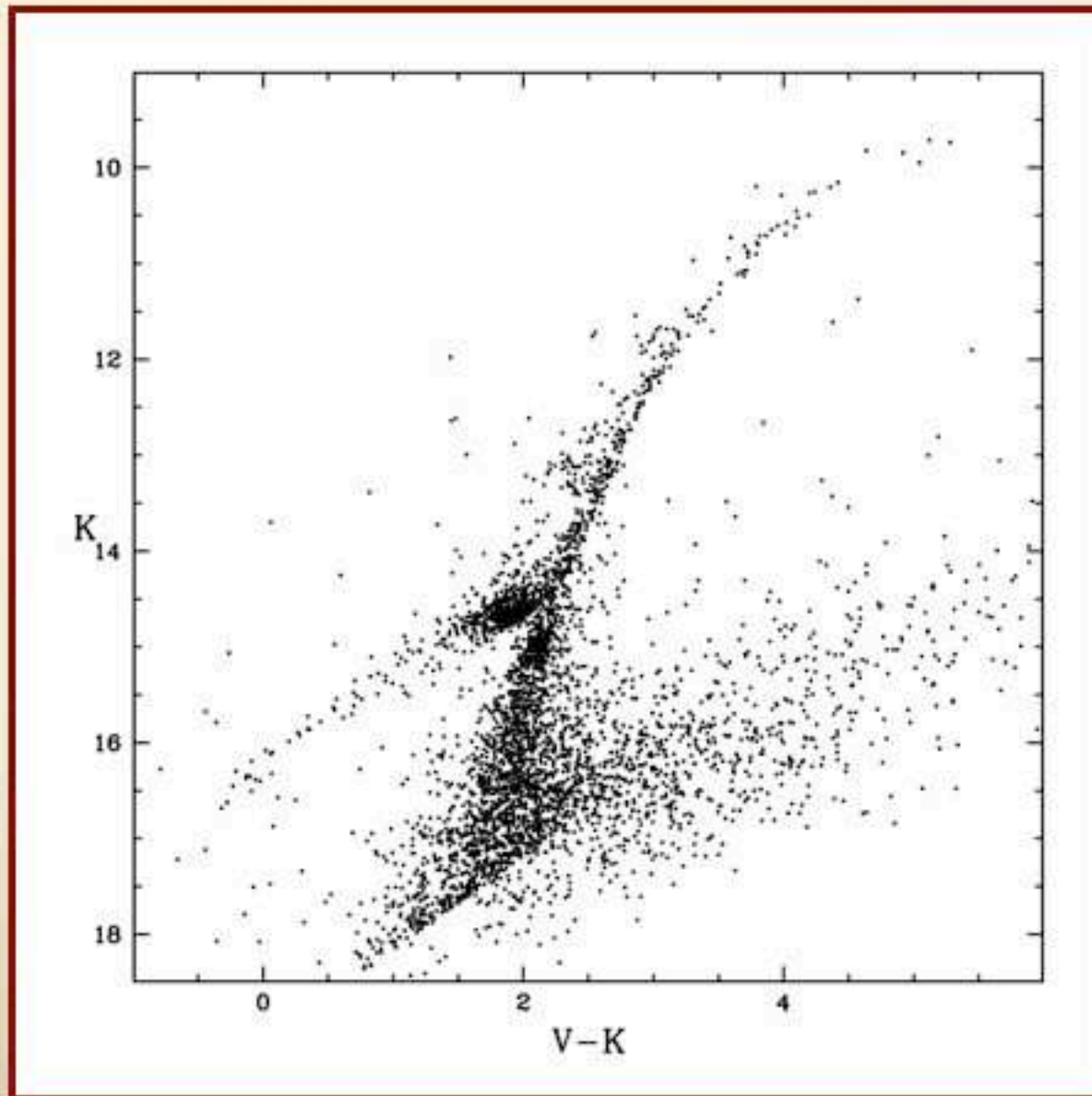


HRC/ACS (12min)

From the HST archive
PI: Druiker



Combined MAD short exp - HST photometry



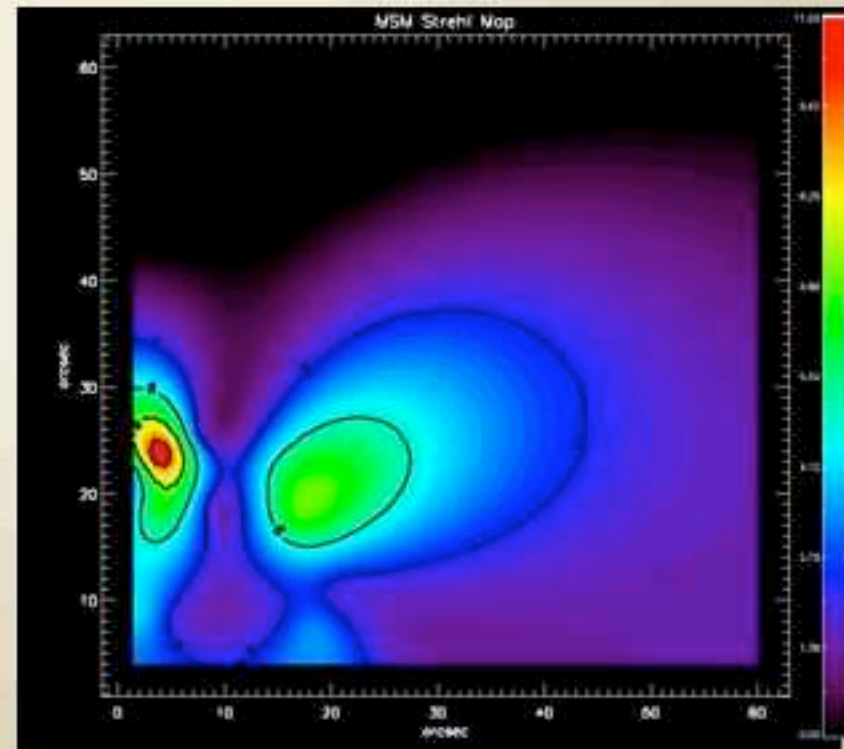
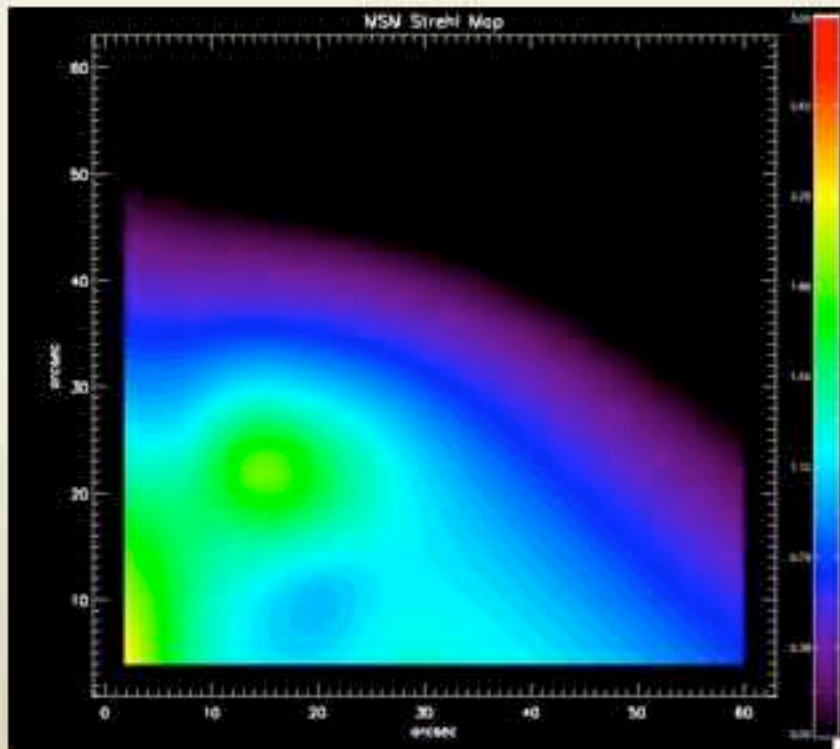
K (60s) MAD@VLT
combined
V (50s) HRC/ACS@HST

SCAO vs MCAO

J,H photometry of the Bulge GCs NGC 6539 ($A_V=3.34$) with **NACO**
(S13, IR-WFS, Dic. K, AO ref K=8.5)

J: DIT x NDIT x NEXP
4s x 22 x 25 ==> 2200sec

H: DIT x NDIT x NEXP
10s x 9 x 25 ==> 2250sec



SCAO vs MCAO

