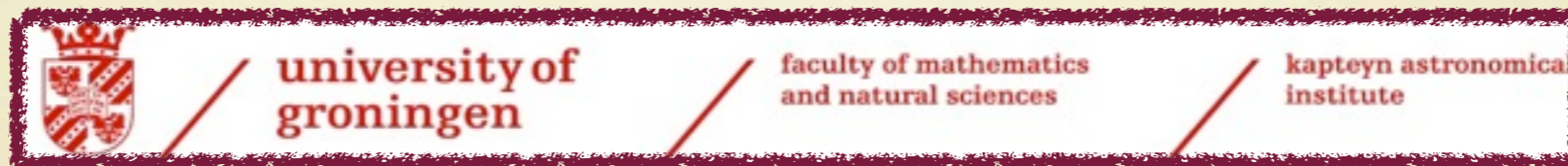




Resolved Stellar populations from MAD:

LMC field

Giuliana Fiorentino¹



E. Tolstoy¹, E. Valenti², E. Diolaiti³

¹ Kapteyn Institute (The Netherlands), ² ESO (Chile), ³ INAF OABo (Italy)



Outline

- Introduction & Motivation
- Data set: LMC field & NGC 6441
- Seeing conditions & Image Quality
- Data Reduction & CMDs
- Conclusions



Outline

- **Introduction & Motivation**
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Why MAD ?



Future large telescopes will be infrared!

An useful experience for planning scientific goals for E-ELT and to understand how to work with MCAO-images

Near IR for new and detailed stellar population analysis:

Cold Stellar evolution phases:

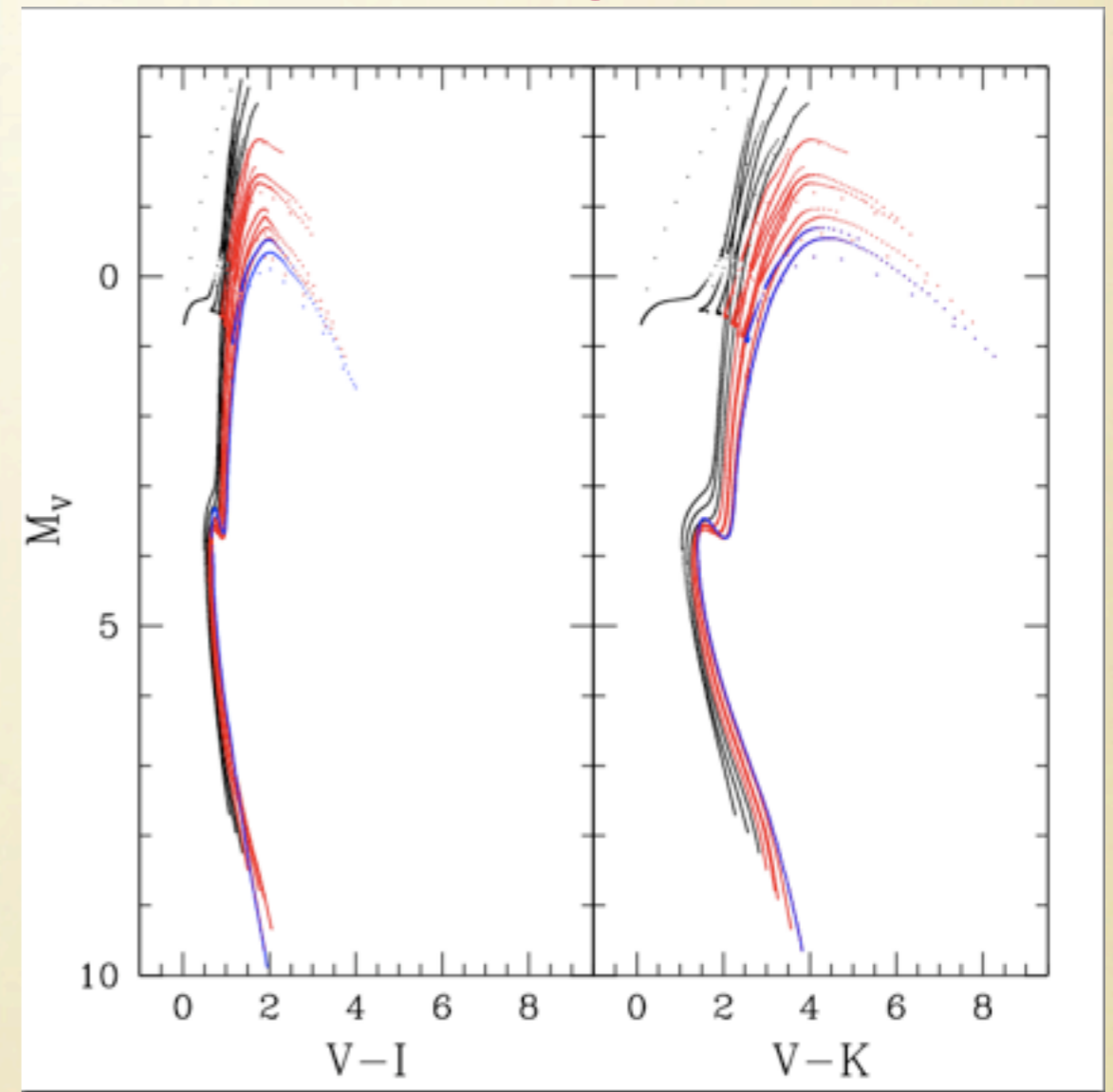
RGB, AGB, Helium Clump...etc.

HIGH Extinction Regions:

Galactic bulge or star forming regions (see Blue compact dwarf galaxies).

Large range of wavelengths:

More sensitivity to the effective temperature (Multiple features in the CMDs, Piotto's talk this morning).



11-13 Gyrs $[\text{Fe}/\text{H}] = -2.3$ to -0.95

10-6 Gyrs $[\text{Fe}/\text{H}] = -0.65$ to 0.25

5 Gyrs $[\text{Fe}/\text{H}] = 0.4$

from BASTI

Why MAD ?

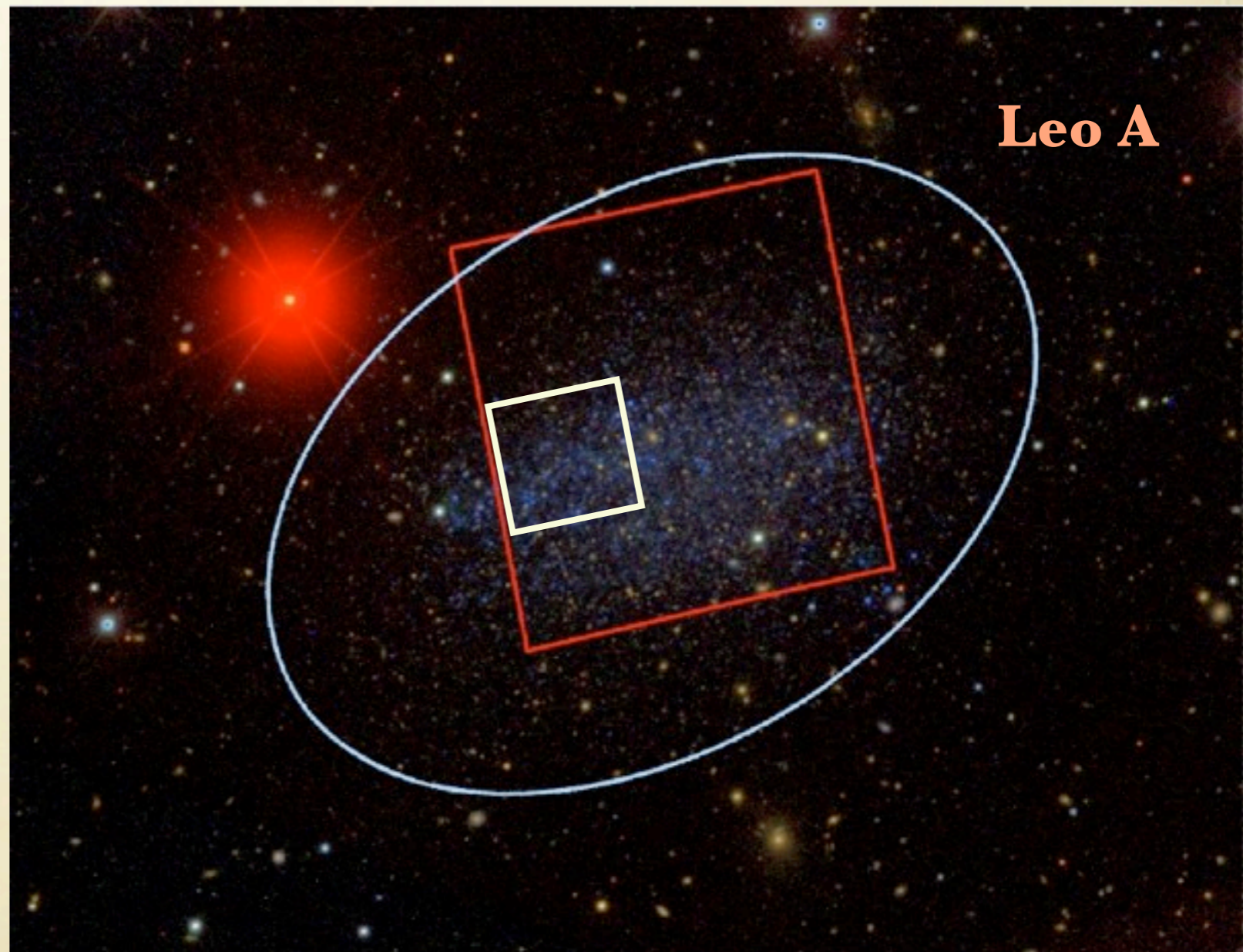


Future large telescopes will be infrared!

**An useful experience for planning scientific goals for E-ELT
and to understand how to work with MCAO-images**

**MAIN improvement to
previous AO near IR imager:**

**The Mad FoV is a square of
1'x1'** that can cover the entire field
of 2'x2' **& High Resolution**
overcoming some of the limitations
of previous AO instruments (e.g.
NACO FoV= from 13-27-54").





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Stellar population targets



pushing MAD capabilities on “difficult targets”

Faint and “crowded” target

LMC Field close to NGC1928

Scientific goal  **SFH of LMC**

Reddened and crowded target

The Bulge Globular cluster **NGC6441**

Scientific goals  **AGE (MSTO), Distance (RRLyrae)
& HB**

Multi-wavelength analysis of the peculiar HB.

Stellar population targets



pushing MAD capabilities on “difficult targets”

Faint and “crowded” target

LMC Field close to NGC1928

Scientific goal



SFH of LMC

Reddened and crowded target

The Bulge Globular cluster **NGC6441**

Scientific goals



AC (M
& HB

Elena just talked
about NGC 6441
before lunch!!

Multi-wavelength analysis

LMC GCs and field



What can we expect to see at the LMC distance (48 Kpc)?
Near IR from ground vs **Optical from space**

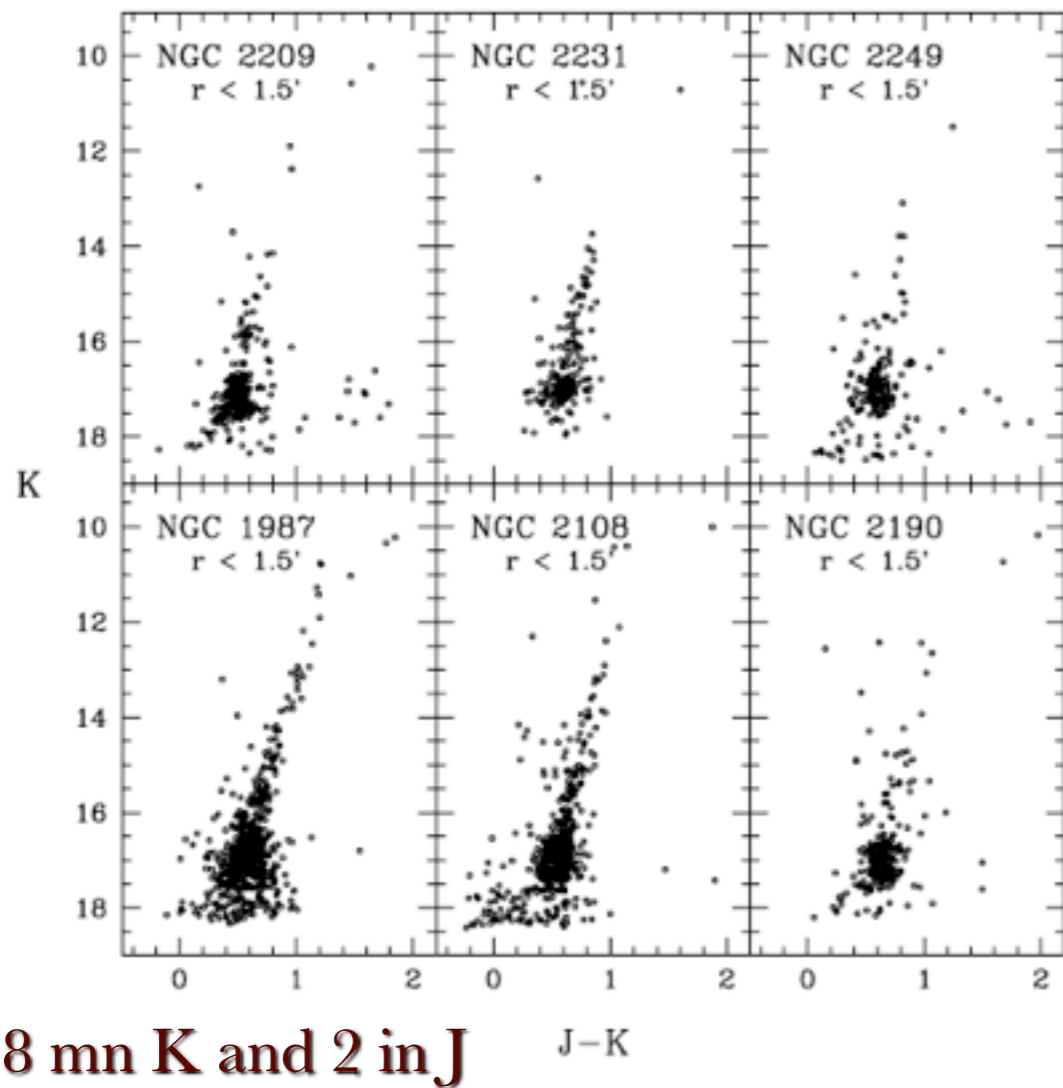
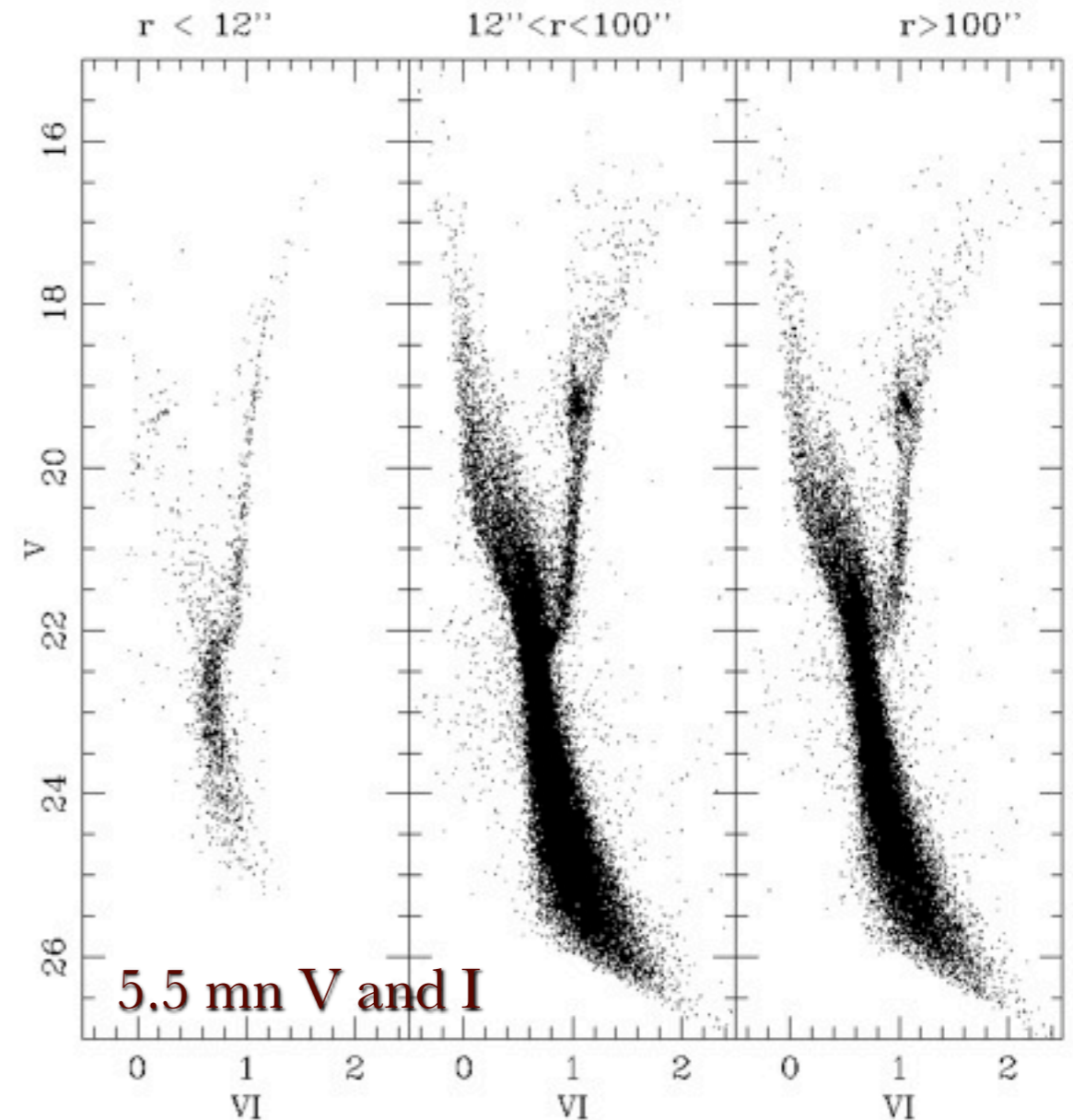


FIG. 2.—Observed (K , $J-K$) CMDs of the six observed LMC clusters. Only stars at $r < 1.5'$ from the cluster center are plotted, sampling a total area of ≈ 7 arcmin².



SOFI@NTT (ESO)
 from Ferraro et al. 2004

WFC/ACS@HST
 from Mackey & Gilmore 2006

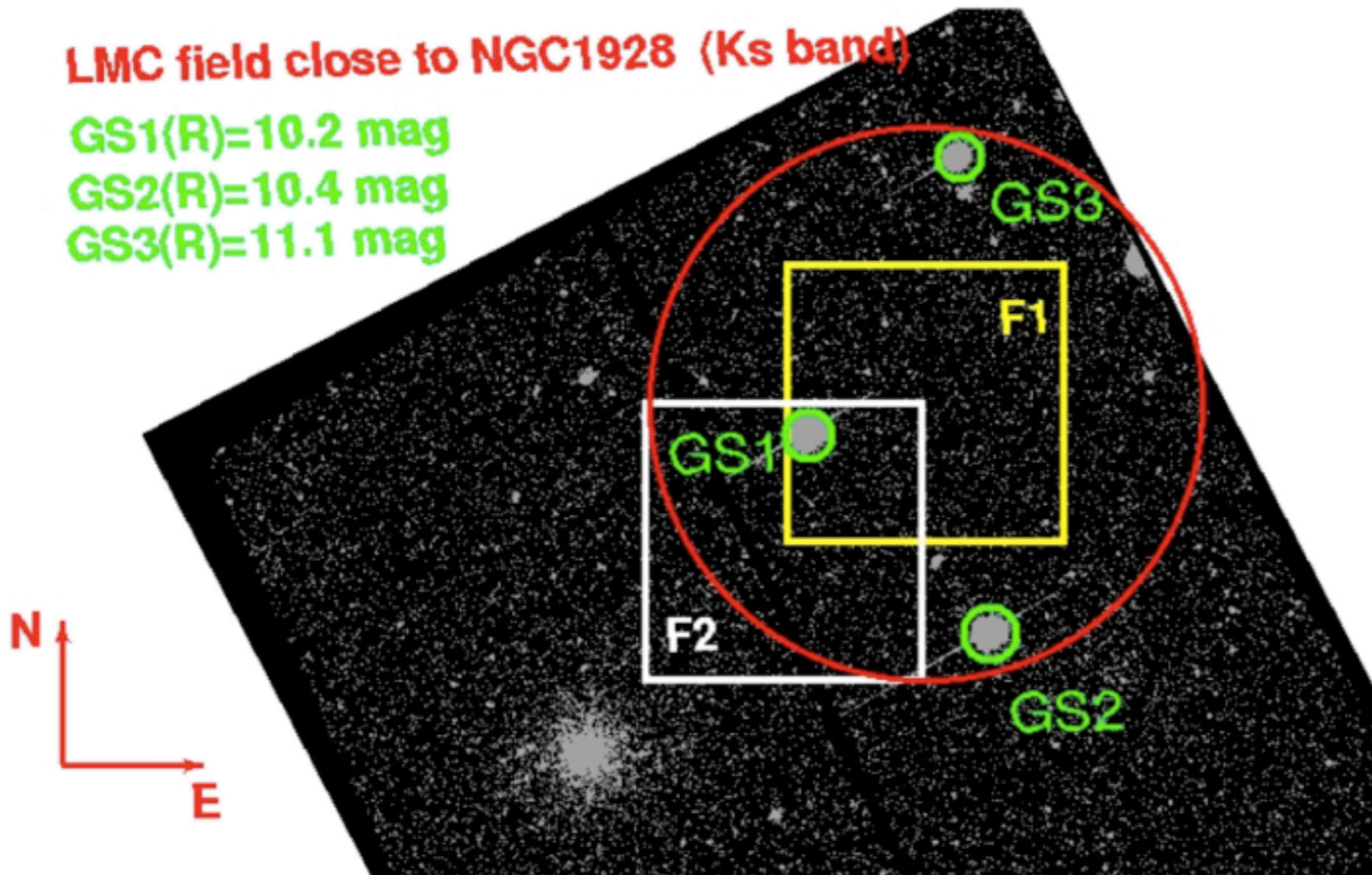
LMC field



Visible FINDING CHARTS from ACS

LMC field close to NGC1928 (Ks band)

GS1(R)=10.2 mag
GS2(R)=10.4 mag
GS3(R)=11.1 mag



Nov 2007-Jan2008

on F2

J-H = 6x7mn

K = 6x10mn

Aug 2008

on F1 & F2

K = 60x1mn

ACS

F555W = 5.5 mn

WFC/ACS@HST from Mackey & Gilmore 2006

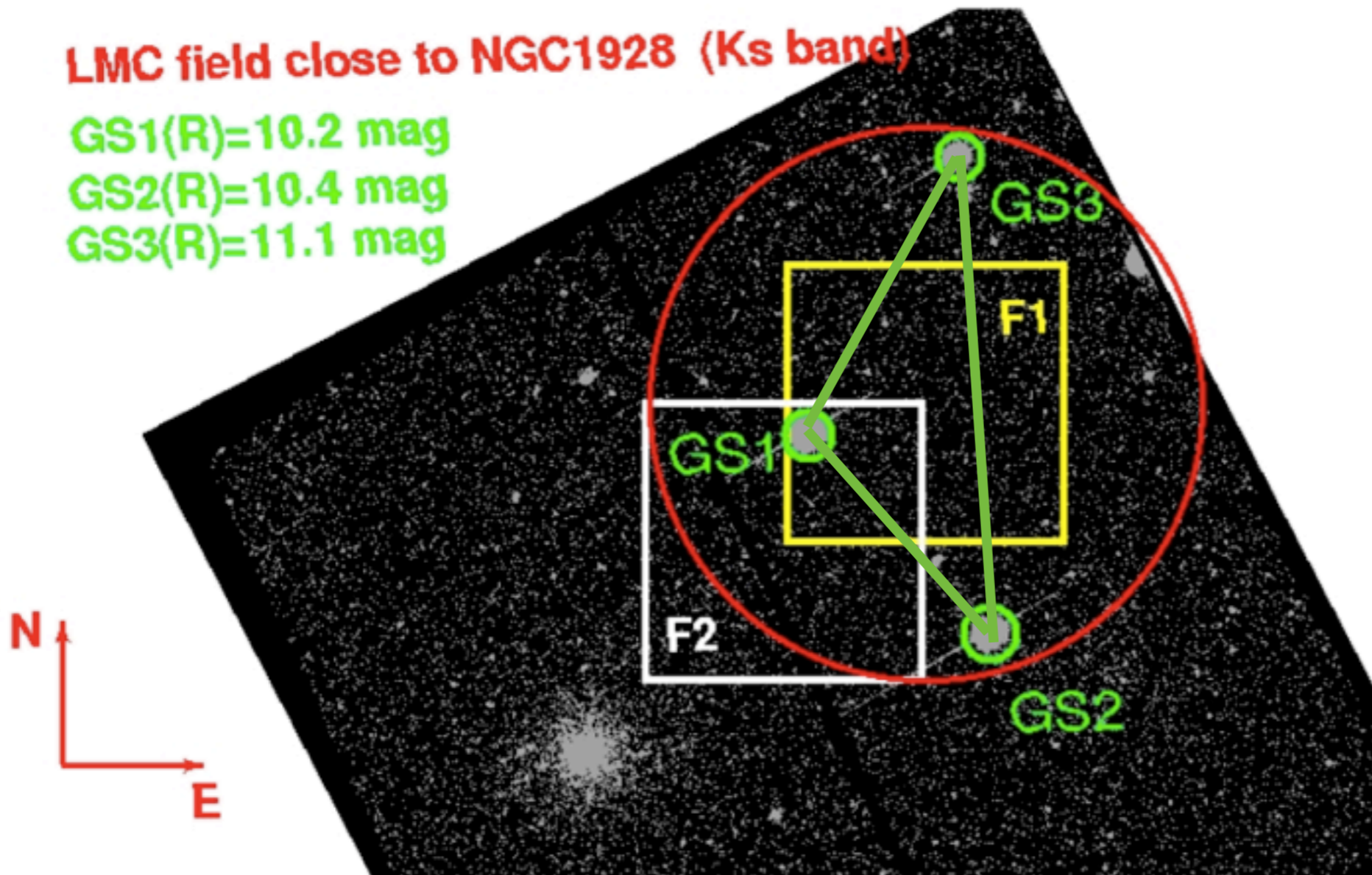
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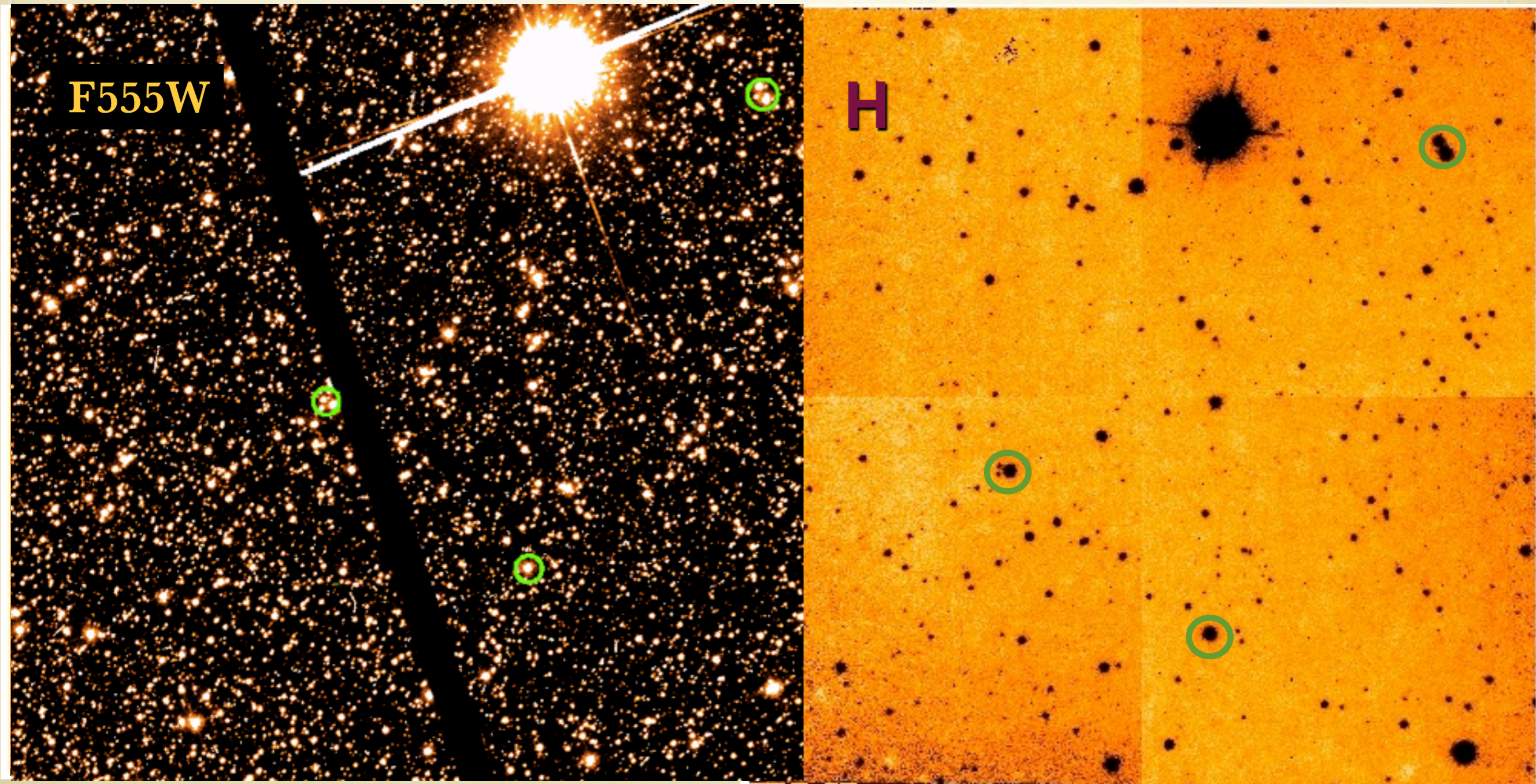
- Introduction & Motivation
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MAD: LMC field

Nov 2008-Jan 2009: T02

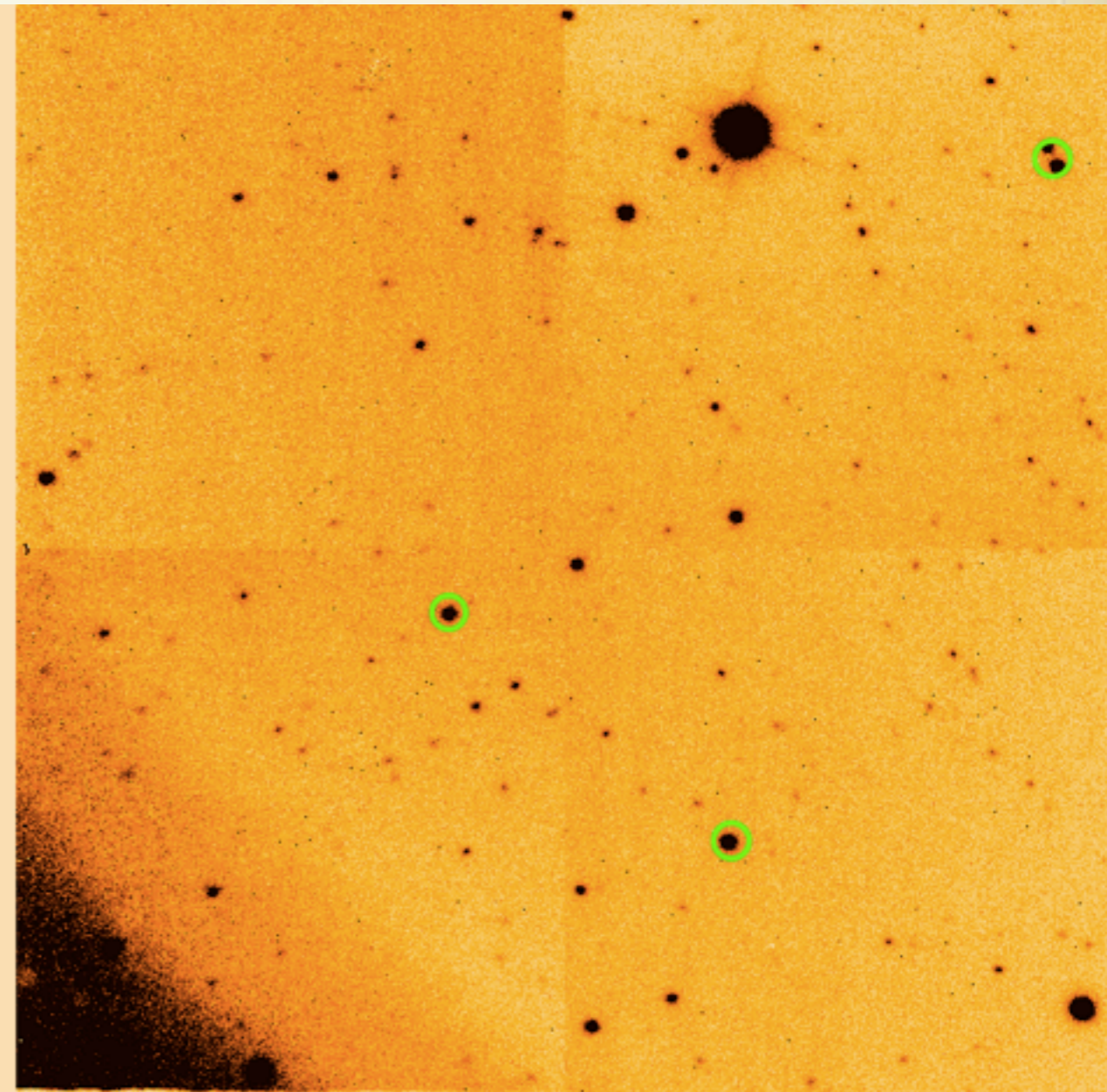
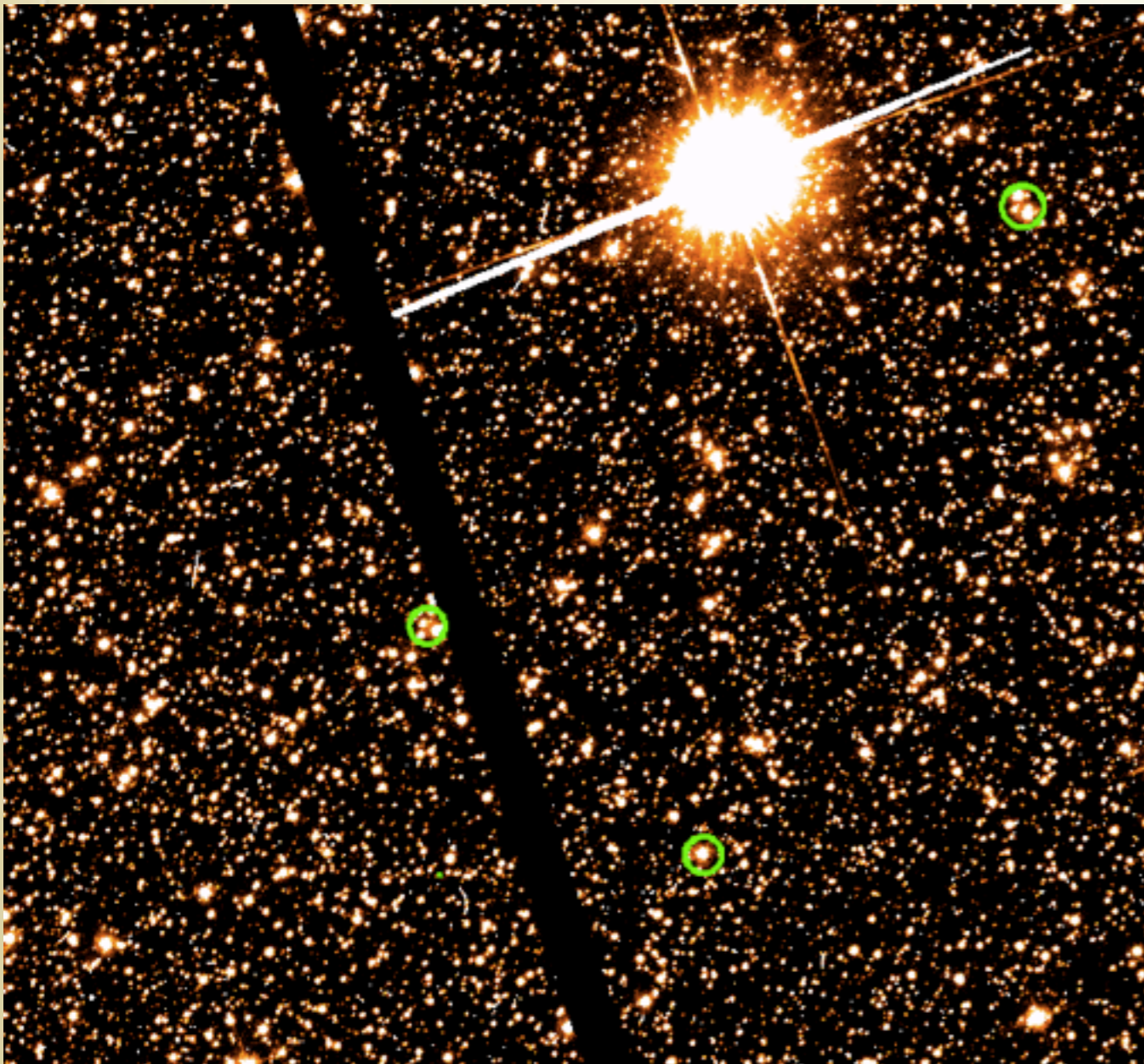


Very crowded in Optical but not in near IR



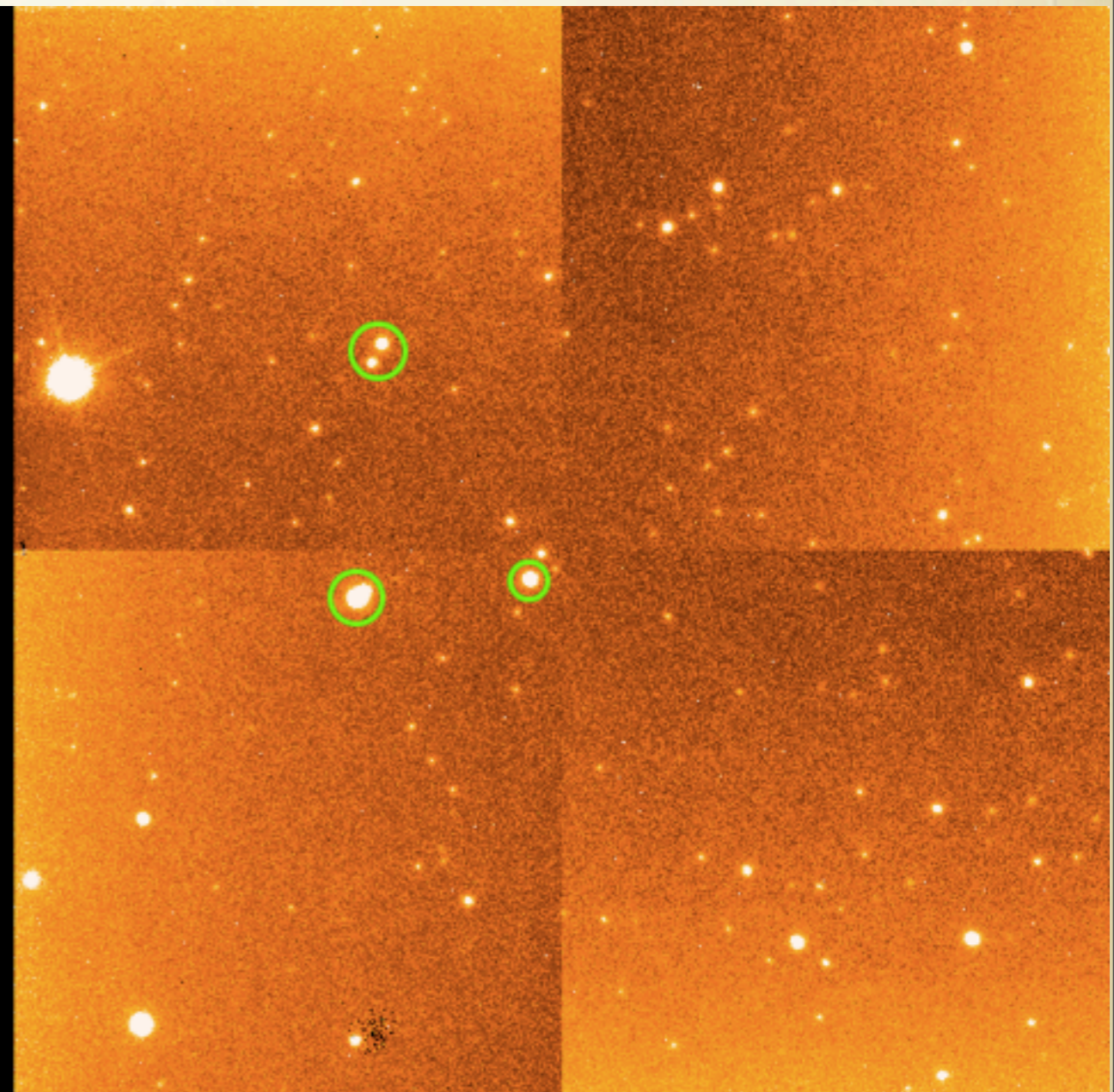
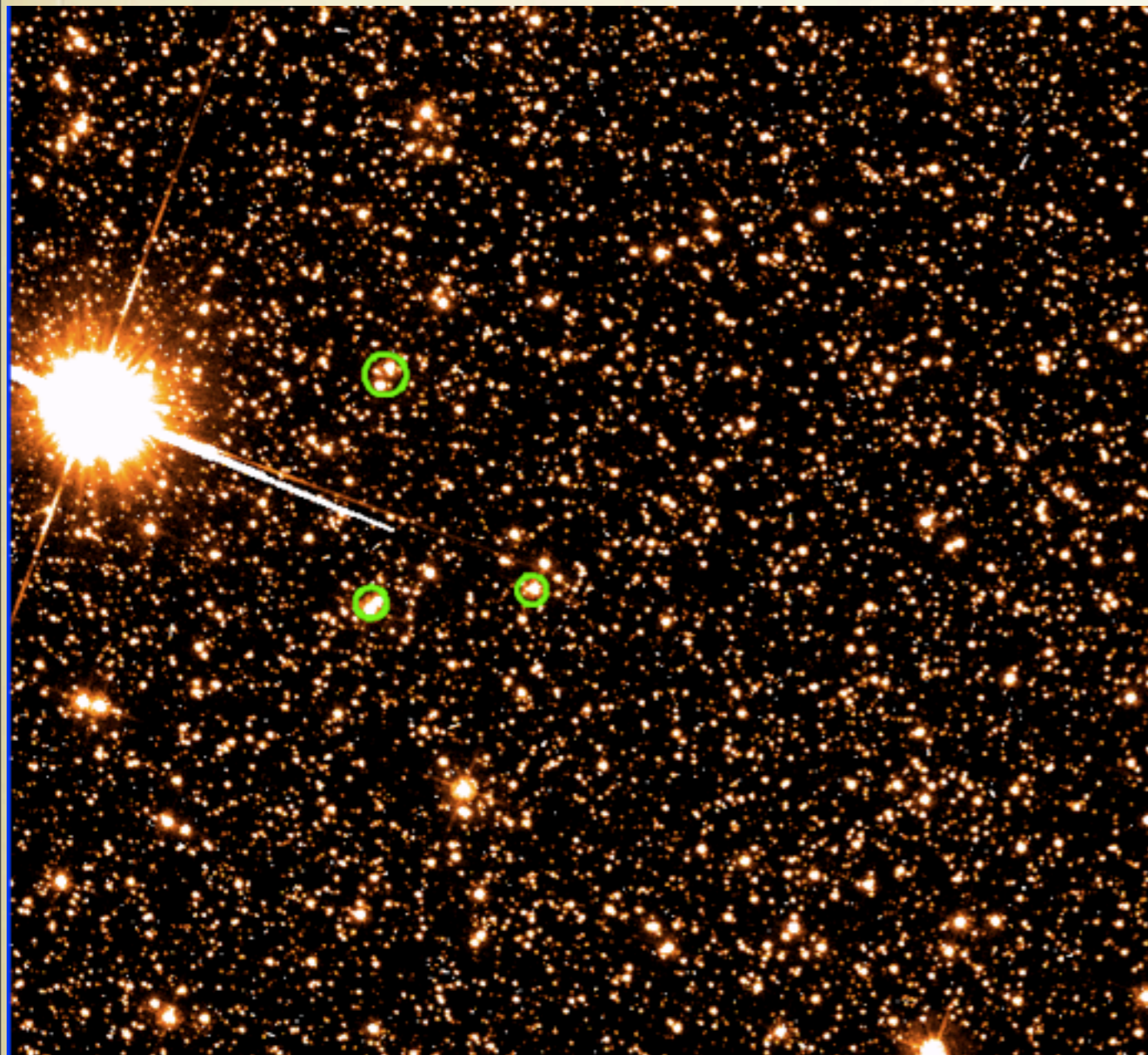
MAD: LMC field

Aug 2008: **K**- T02



MAD: LMC field

Aug 2008: **K**- T01



Seeing Conditions for LMC

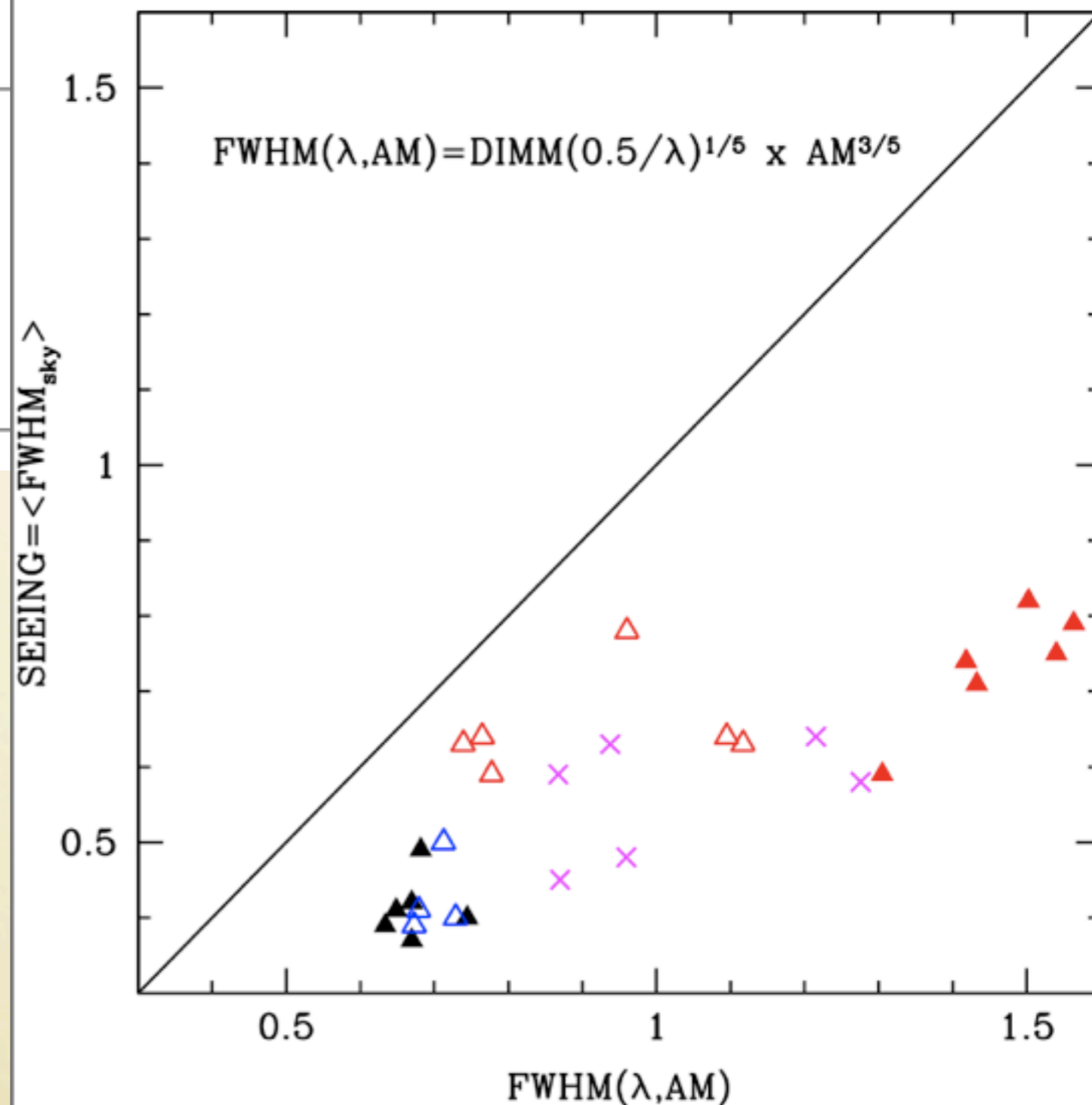
LMC

- ▲ K-T02 26 November 2007
- × H-T02 10 January 2008
- ▲ J-T02 13 January 2008
- △ K-T02 16 August 2008
- △ K-T01 3 September 2008

$\langle \text{FWHM}_{\text{sky}} \rangle$ from the closest (in time) SKY images to scientific images.

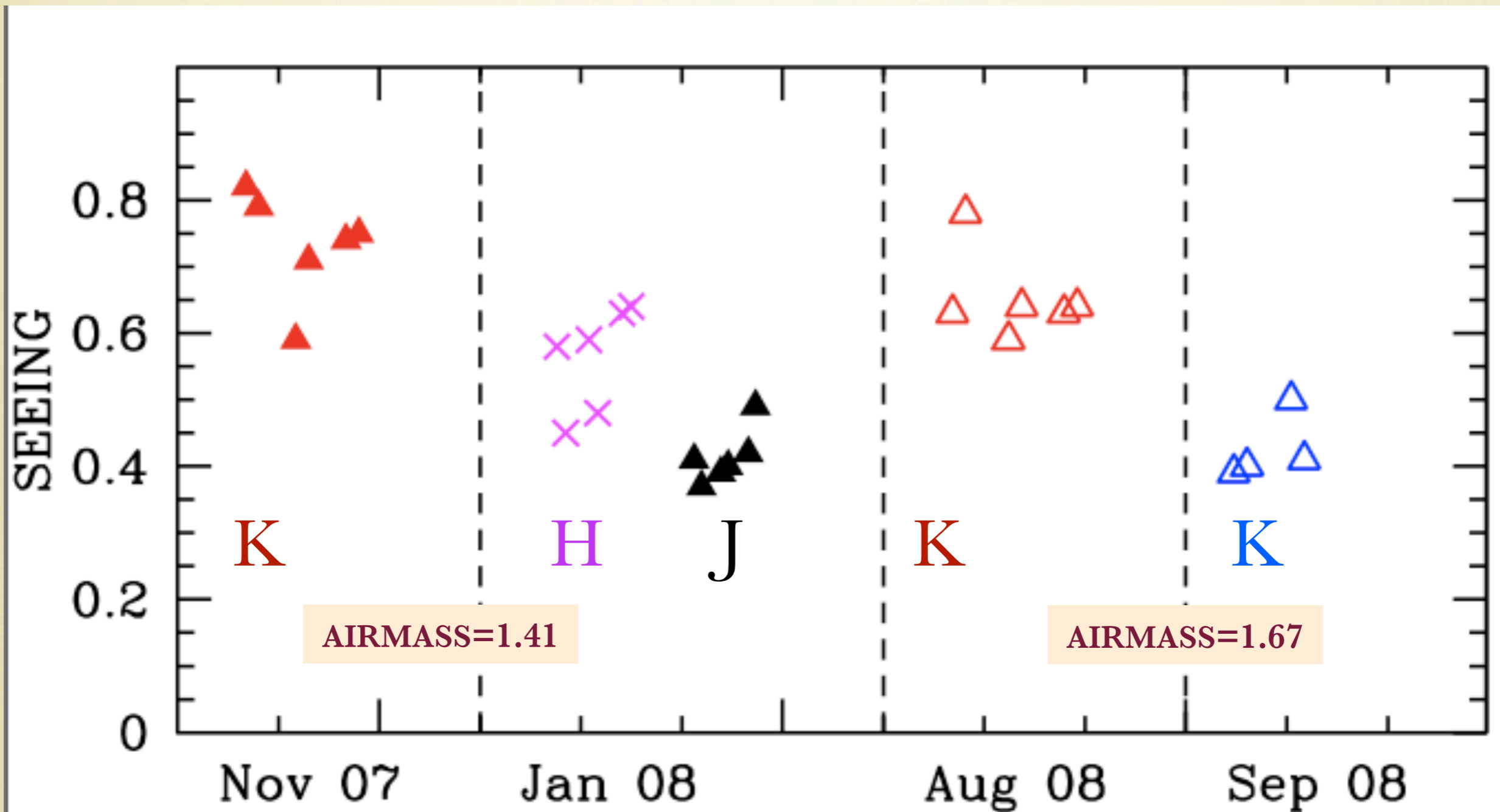
DIMM value from the header.

NO linear trend!!

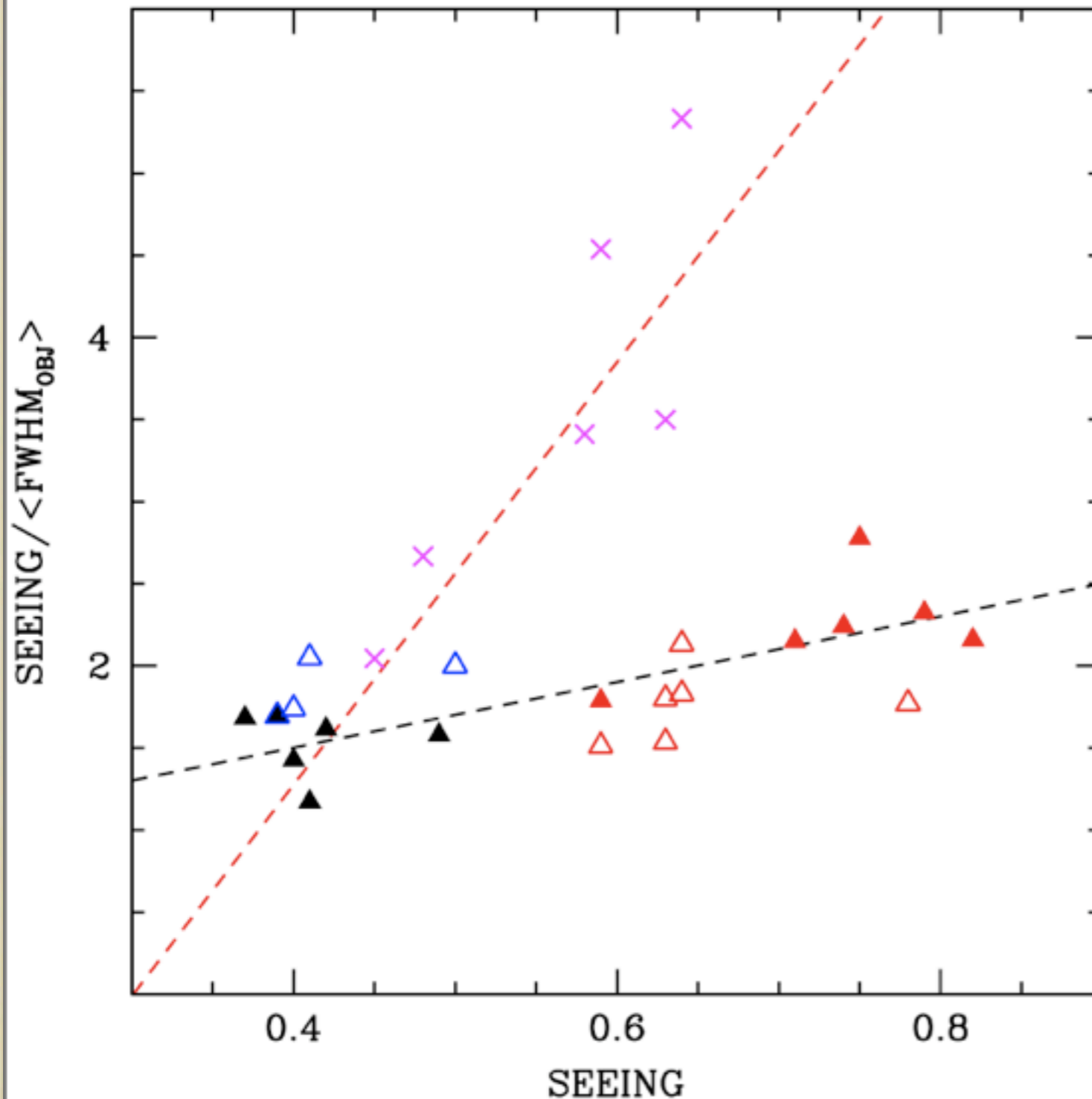


Seeing Conditions for LMC

Best seeing conditions for J, H for T02
and in K only for T01!



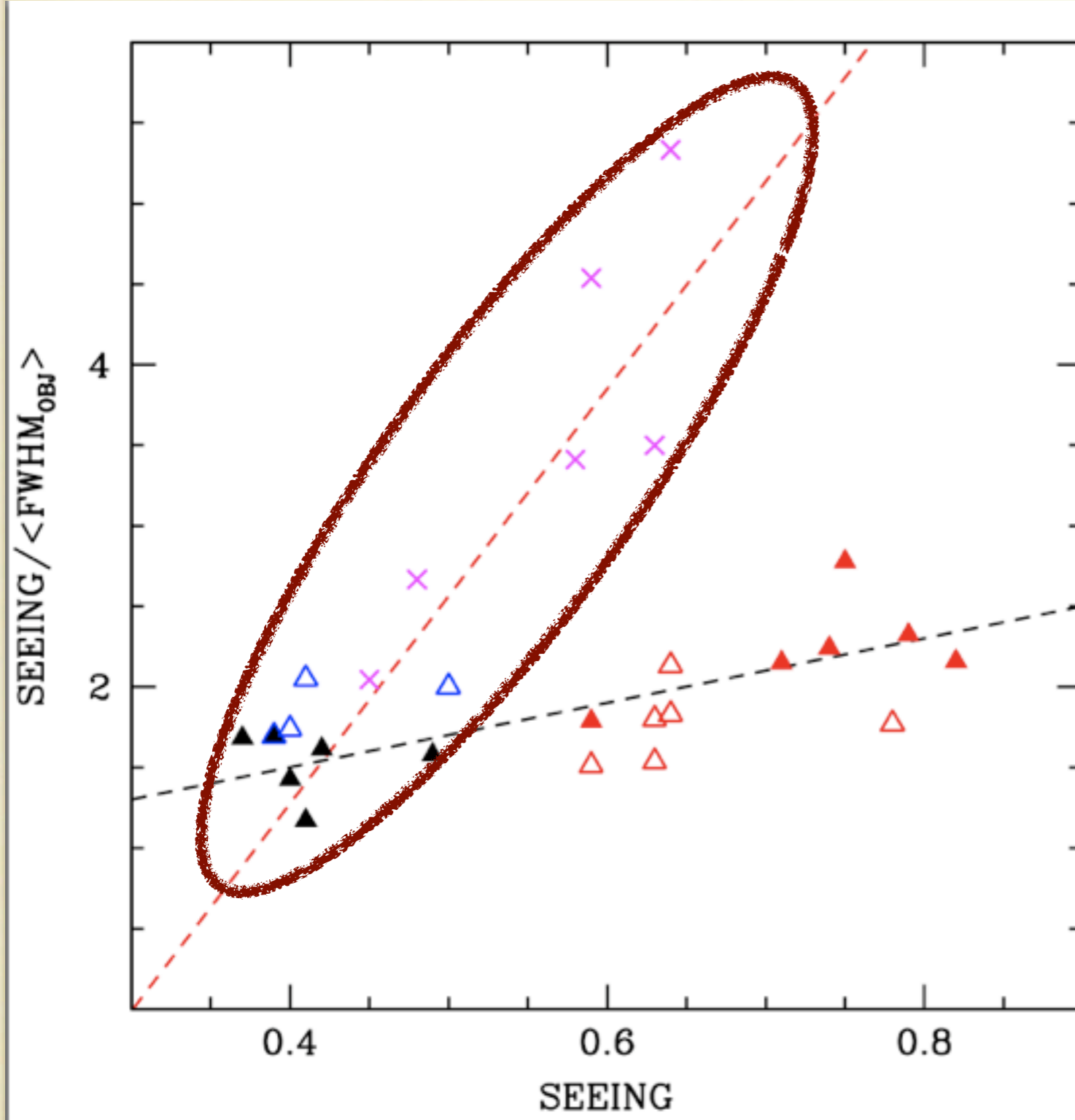
Seeing Conditions for LMC



LMC

- ▲ K-T02 26 November 2007
- × H-T02 10 January 2008
- ▲ J-T02 13 January 2008
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Seeing Conditions for LMC

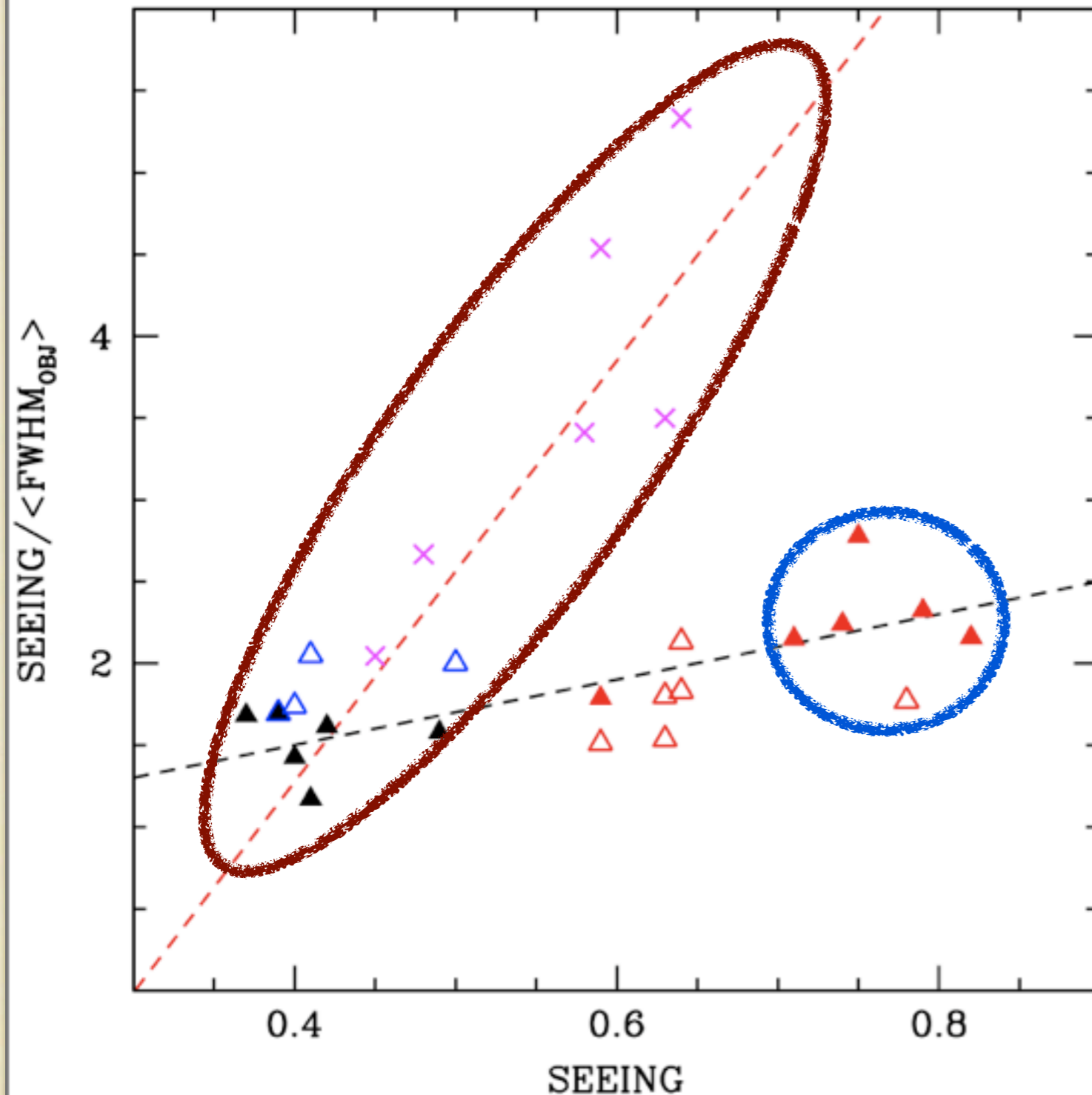


LMC

- ▲ K-T02 26 November 2007
- × H-T02 10 January 2008
- ▲ J-T02 13 January 2008
- △ K-T02 16 August 2008
- △ K-T01 3 September 2008

GOOD seeing conditions.

Seeing Conditions for LMC



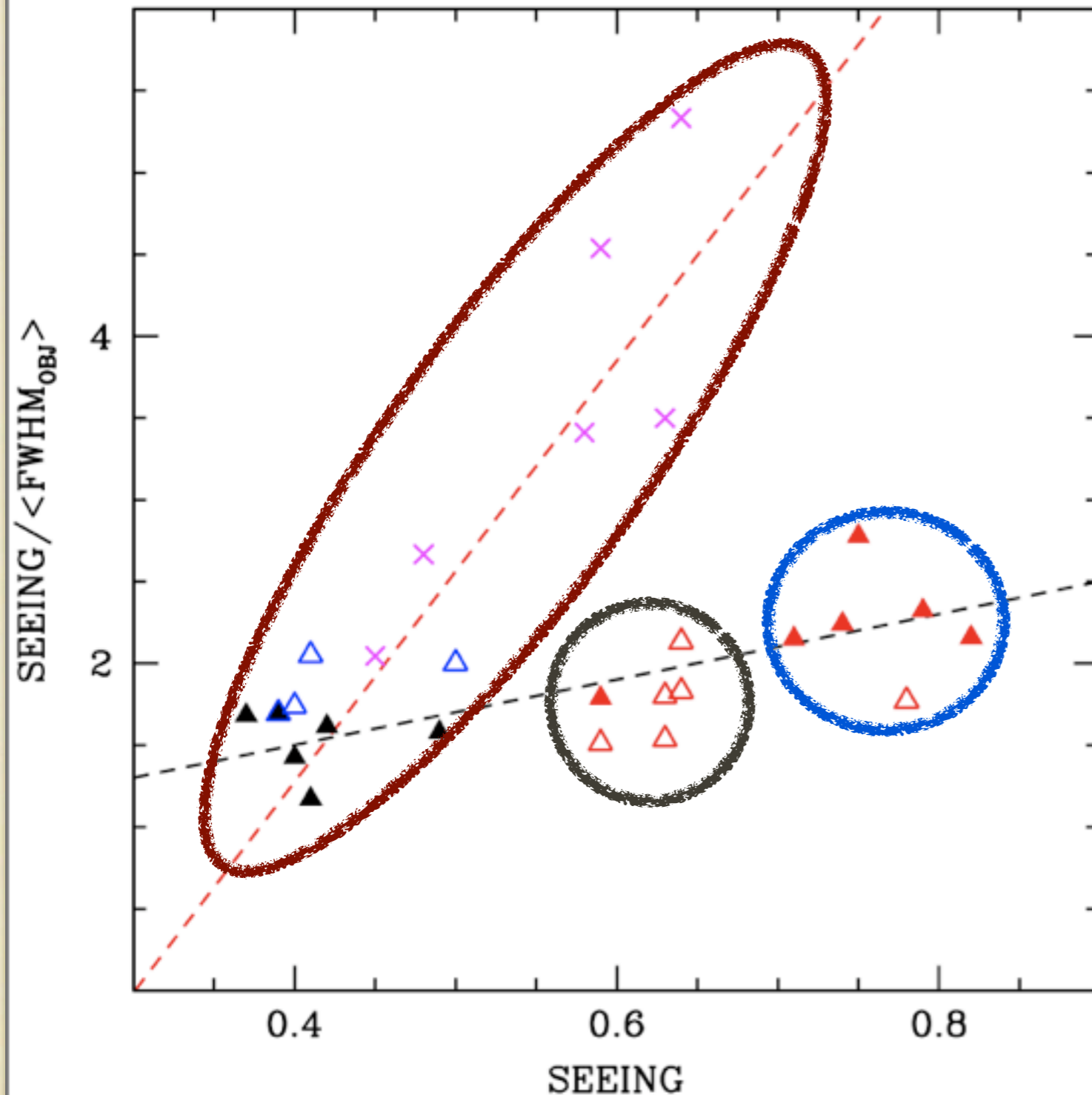
LMC

- ▲ K-T02 26 November 2007
- × H-T02 10 January 2008
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- △ K-T02 16 August 2008
- △ K-T01 3 September 2008

GOOD seeing conditions.

BAD seeing conditions.

Seeing Conditions for LMC



LMC

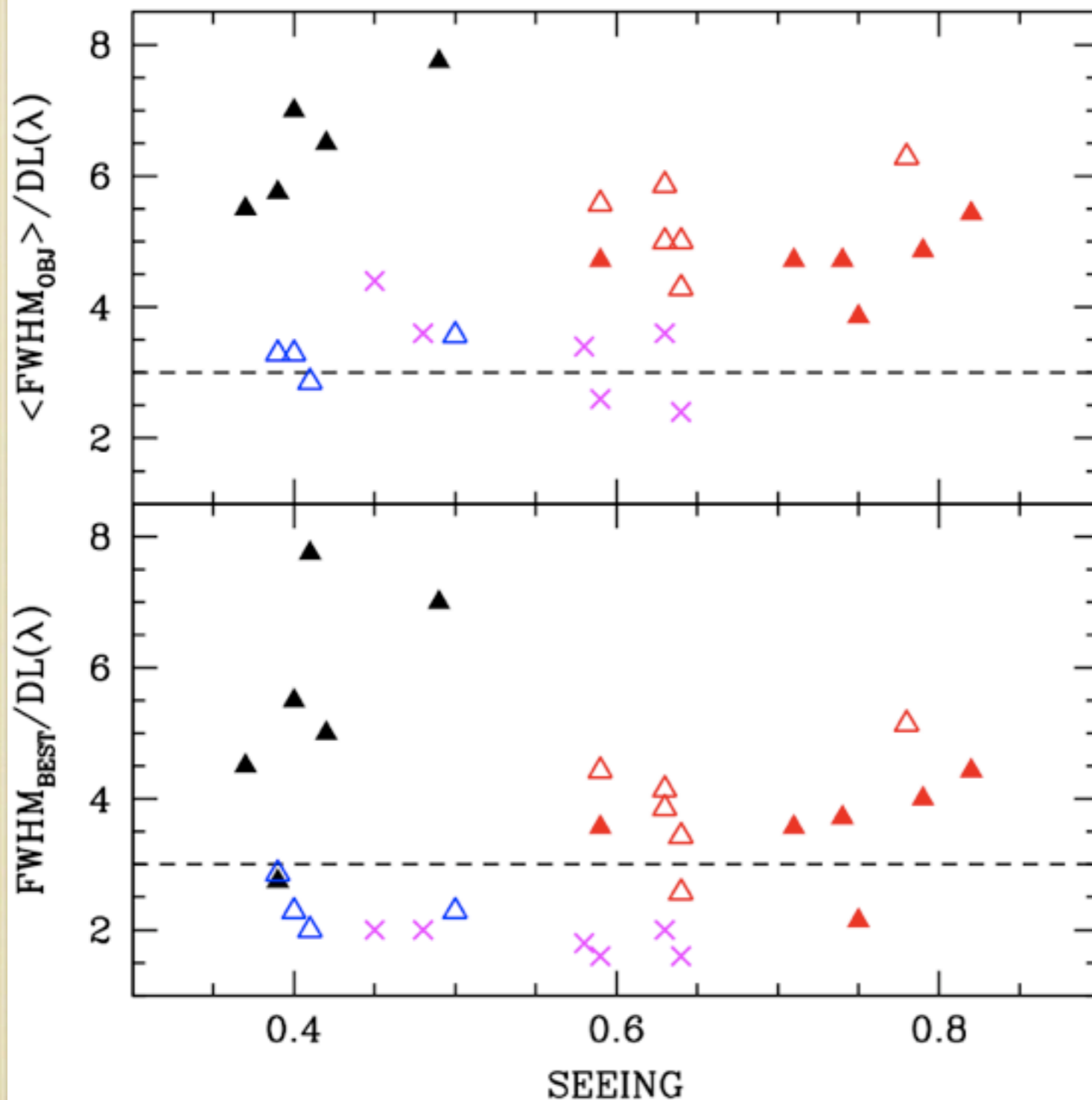
- ▲ K-T02 26 November 2007
- × H-T02 10 January 2008
- ▲ J-T02 13 January 2008
- △ K-T02 16 August 2008
- △ K-T01 3 September 2008

GOOD seeing conditions.

BAD seeing conditions.

Better seeing BUT
higher AIRMASS value
AM=1.67 instead of 1.41!

Seeing Conditions for LMC



LMC

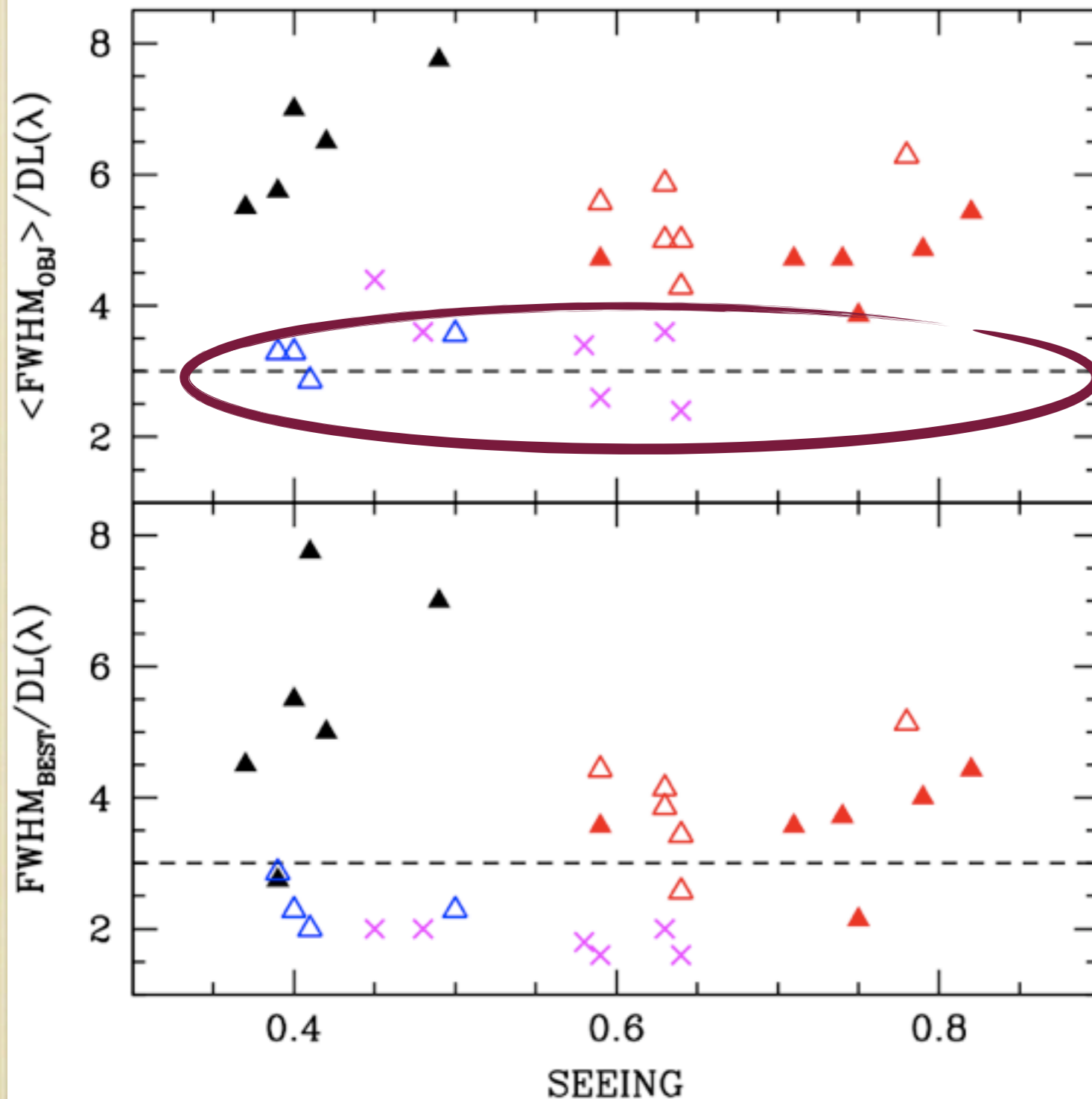
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LMC

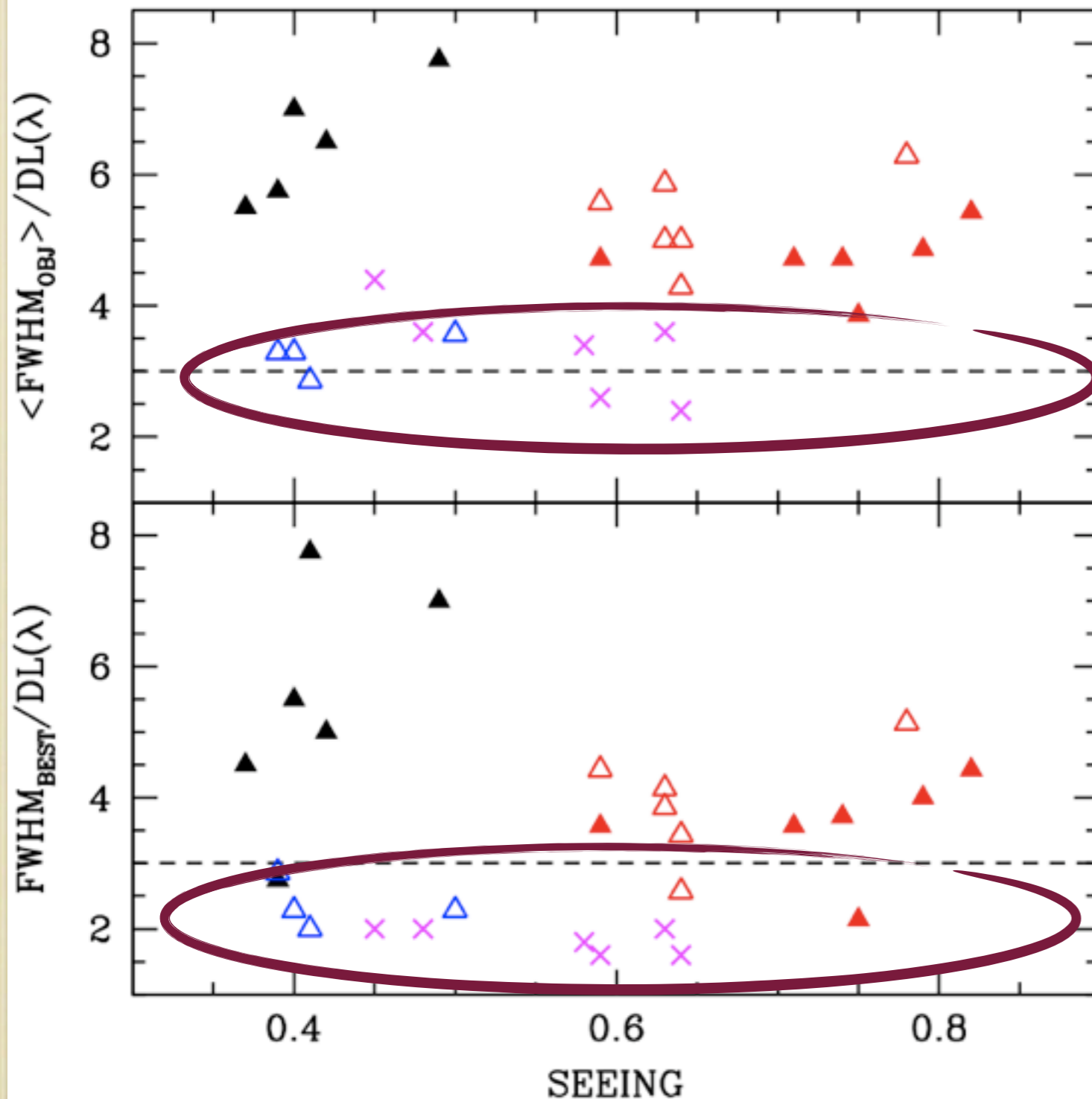
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- △ K-T02 16 August 2008
- △ K-T01 3 September 2008

GOOD seeing conditions.

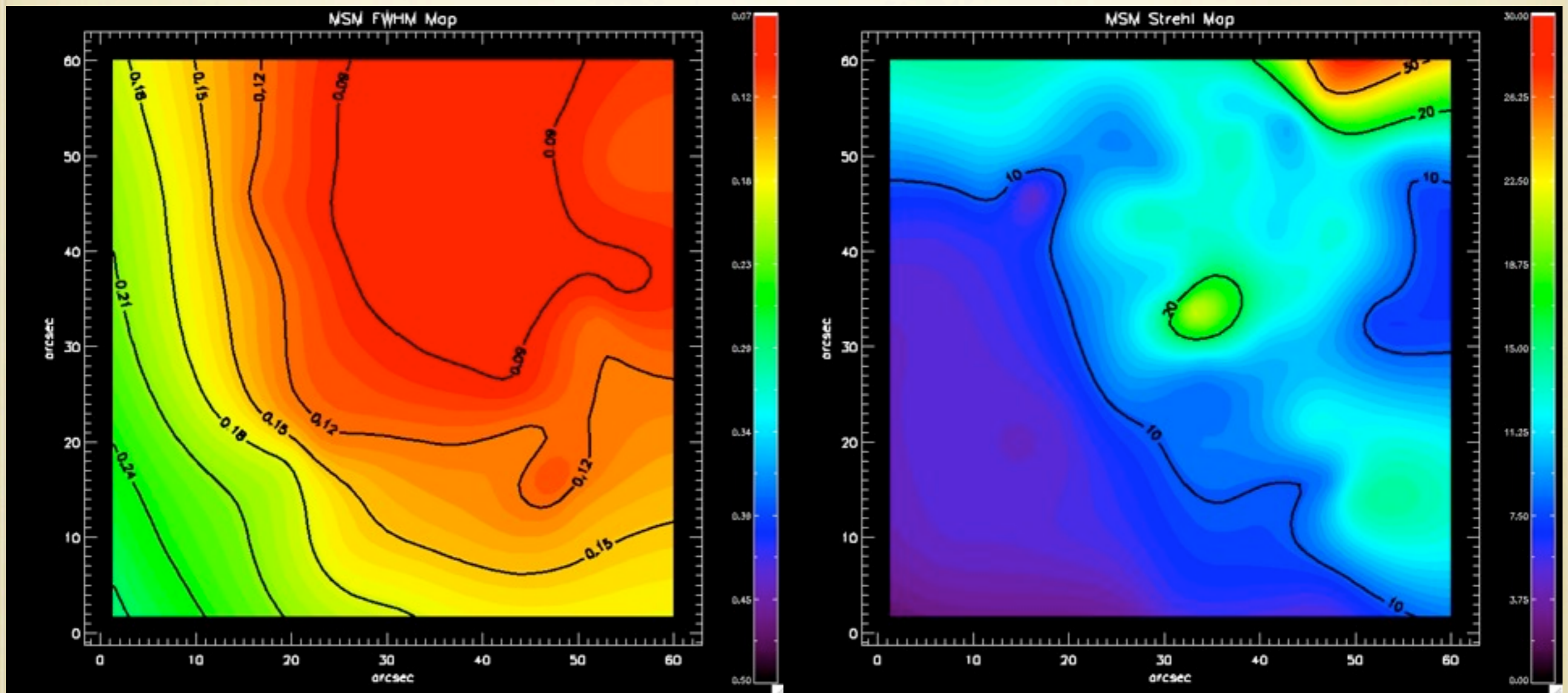
BAD seeing conditions.

Better seeing BUT
higher AIRMASS value
AM=1.67 instead of 1.41!

H band - LMC field



T02 (Jan 2009)
FWHM & Strehl map

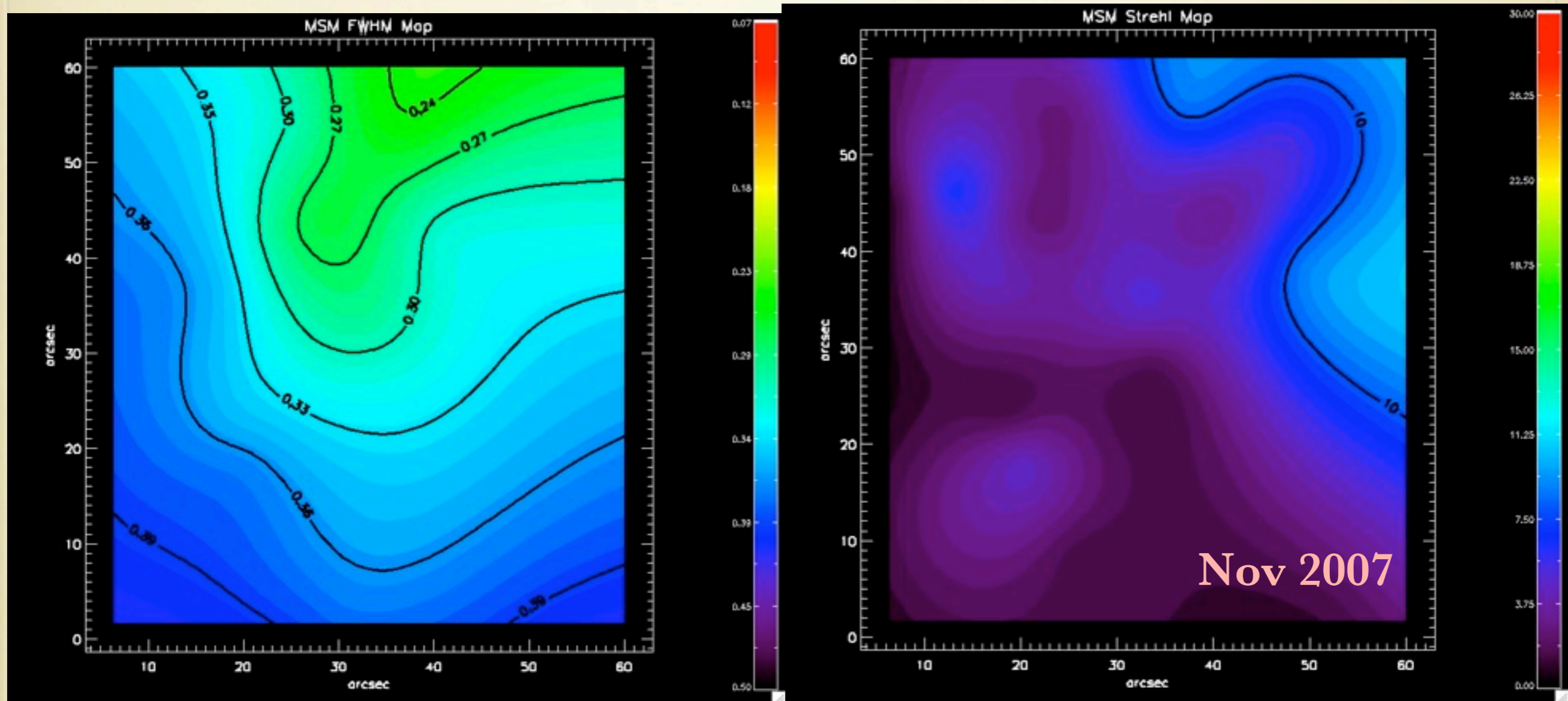


Software provided by ESO (credits E. Marchetti)

K band - LMC field



K-band T02 FWHM & Strehl map

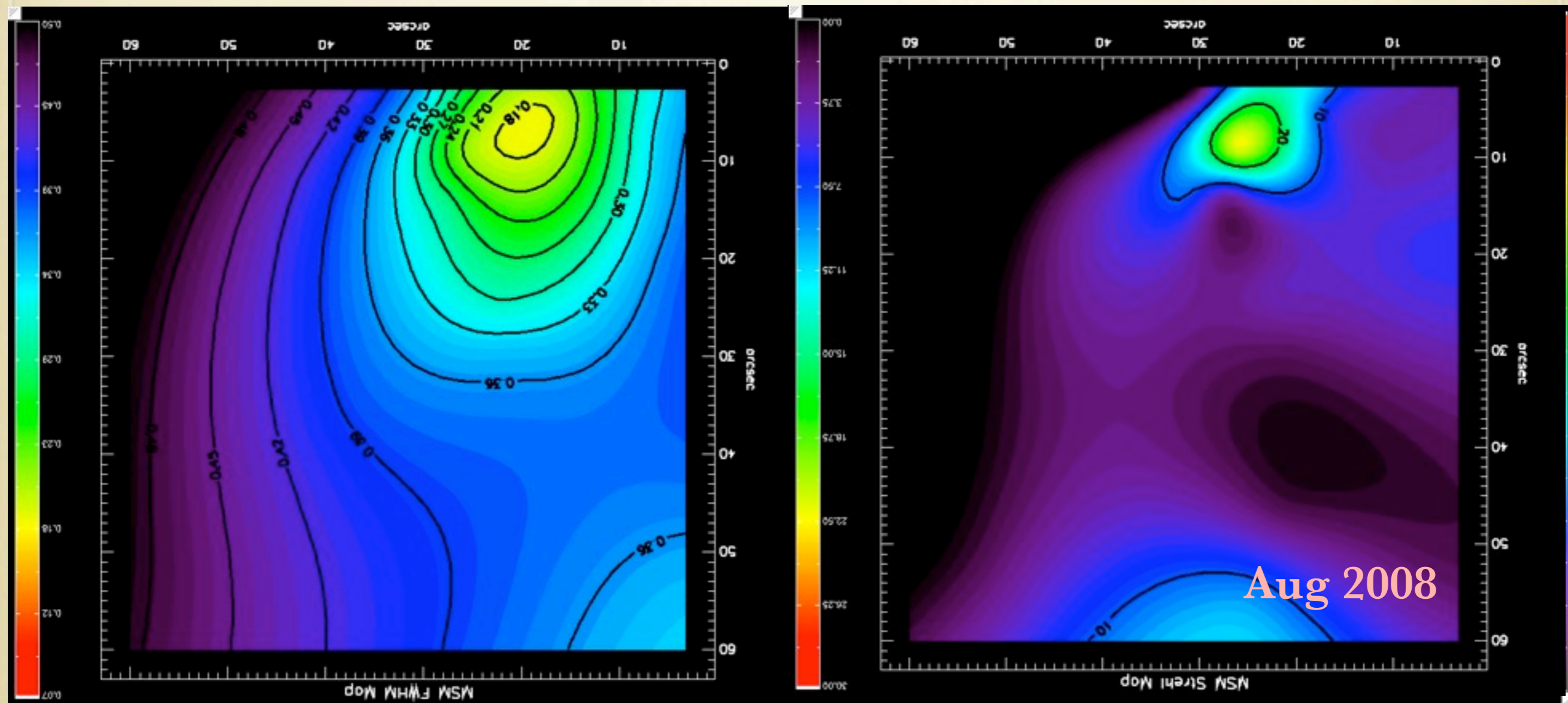


Software provided by ESO (credits E. Marchetti)

K band - LMC field



K-band T02 FWHM & Strehl map



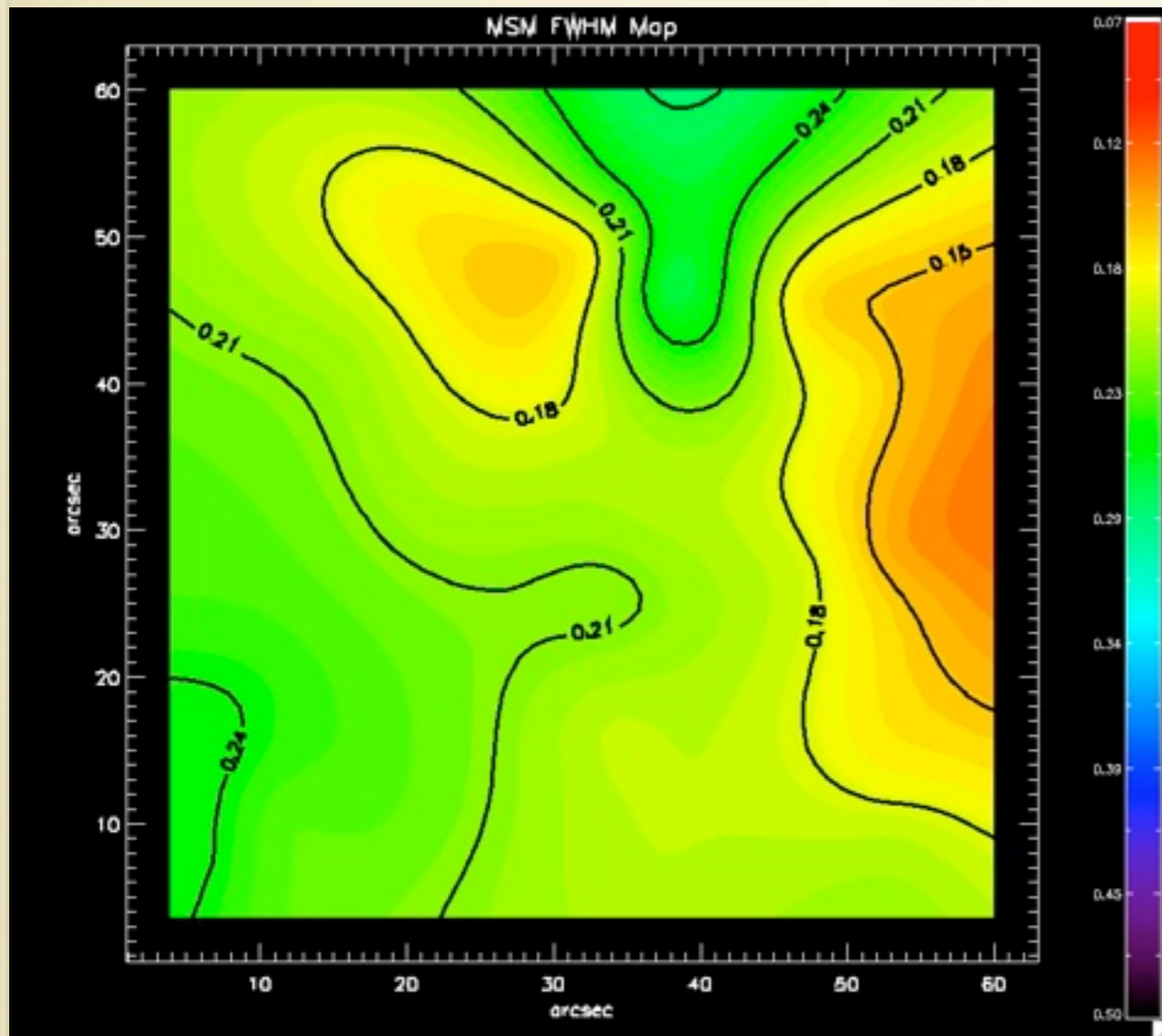
Software provided by ESO (credits E. Marchetti)

K band- LMC field

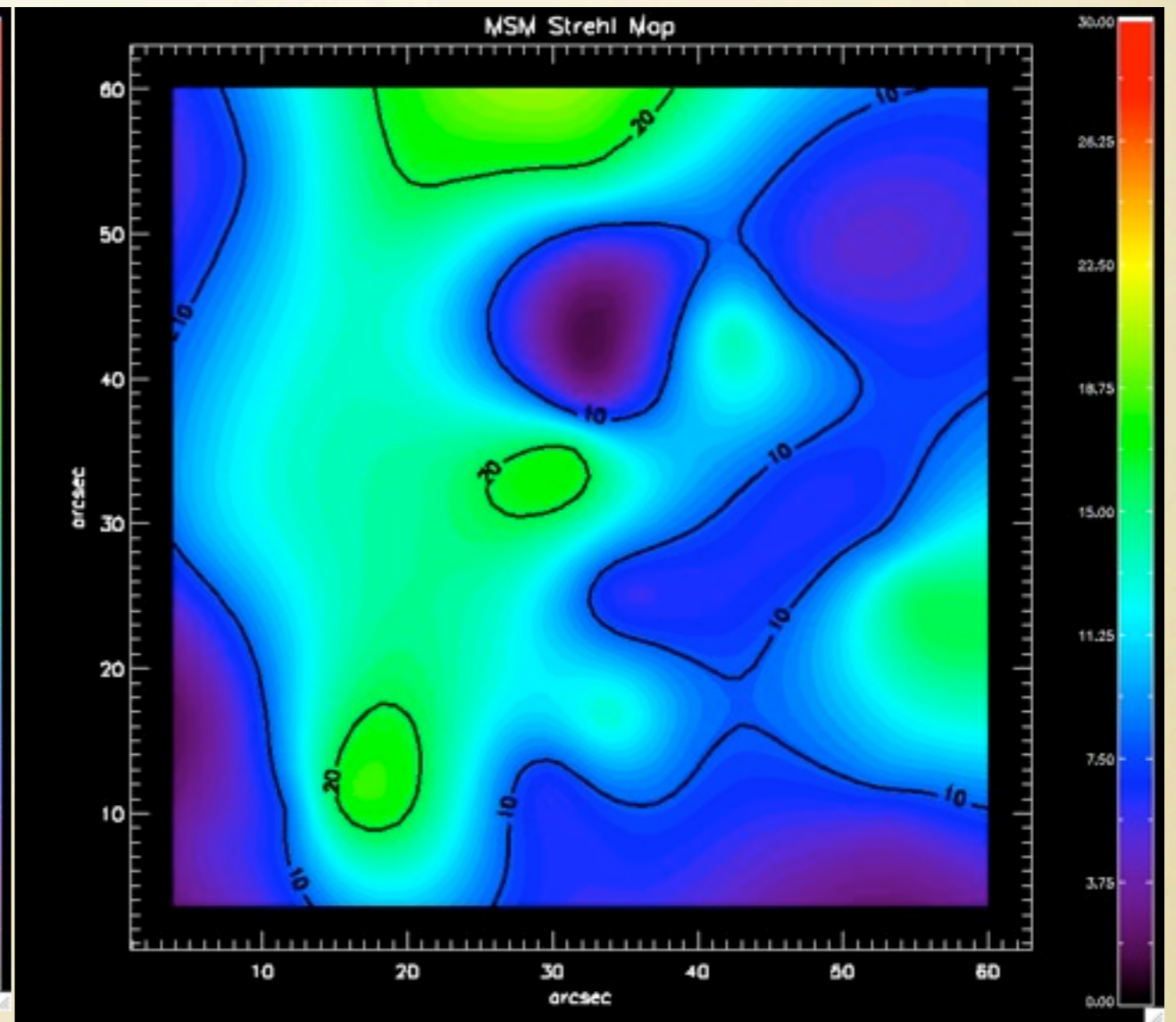


T01(Aug 2008)

FWHM



STREHL ratio



Software provided by ESO (credits E. Marchetti)



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CMDs: LMC field



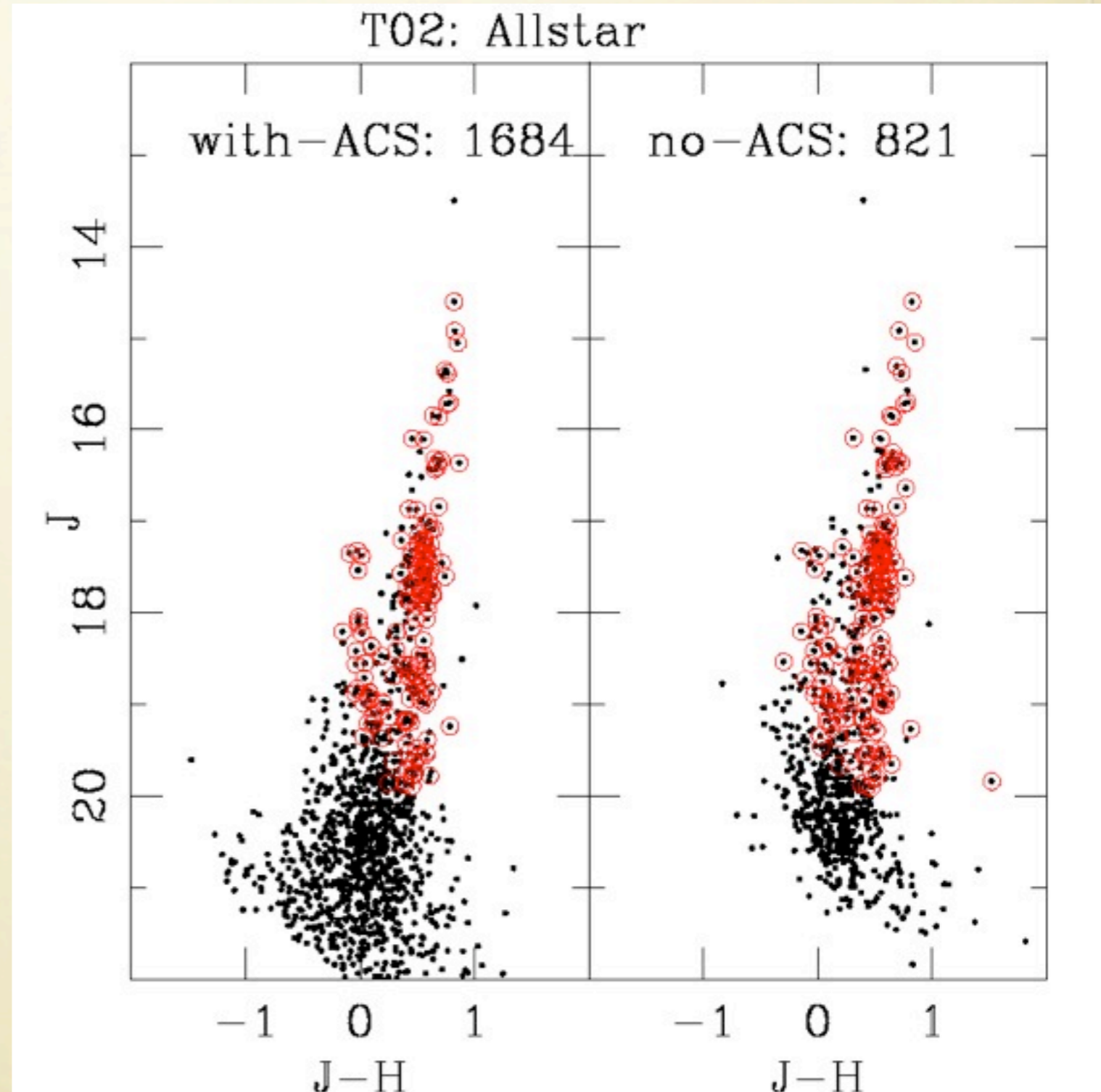
DAOPHOT/ALLSTAR/ALLFRAME
(P. Stetson)

The PSF fitting with a
quadratic variable PSF

TO2 (Nov 2007-Jan 2008)- J/H/K:
Moffat15 PSF

TO1-TO2 (Aug 2008)- K:
mostly Moffat15 PSF sometimes
Lorentz PSF

Calibrated on 2mass survey



CMDs: LMC field



DAOPHOT/ALLSTAR/ALLFRAME
(P. Stetson)

The PSF fitting with a
quadratic variable PSF

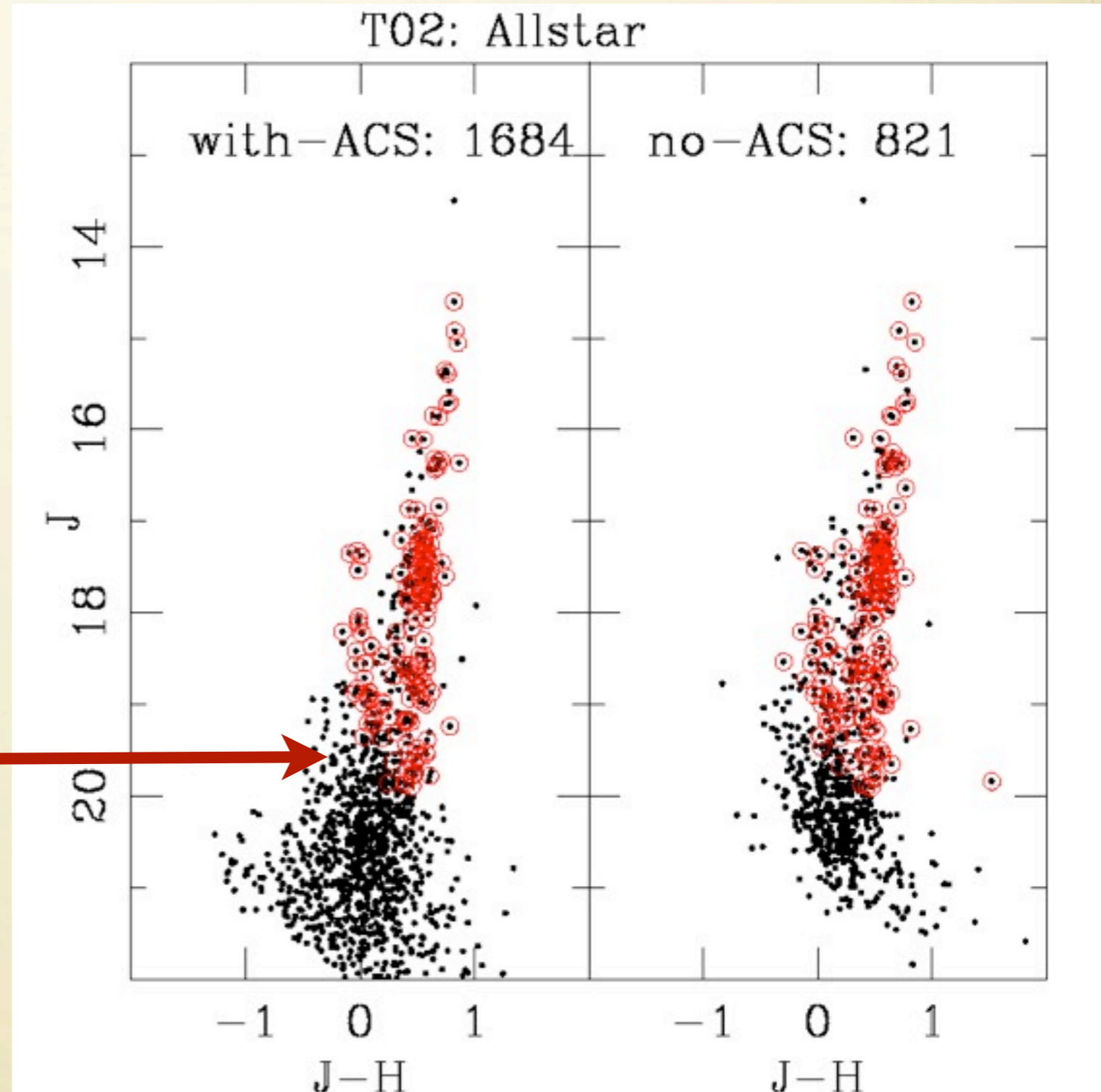
TO2 (Nov 2007-Jan 2008)- J/H/K:
Moffat15 PSF

TO1-TO2 (Aug 2008)- K:
mostly Moffat15 PSF sometimes
Lorentz PSF

Calibrated on 2mass survey

with “standard” near IR-
photometry on co-added
images, we reach:

J~19.5 mag
with $\sigma \leq 0.05$

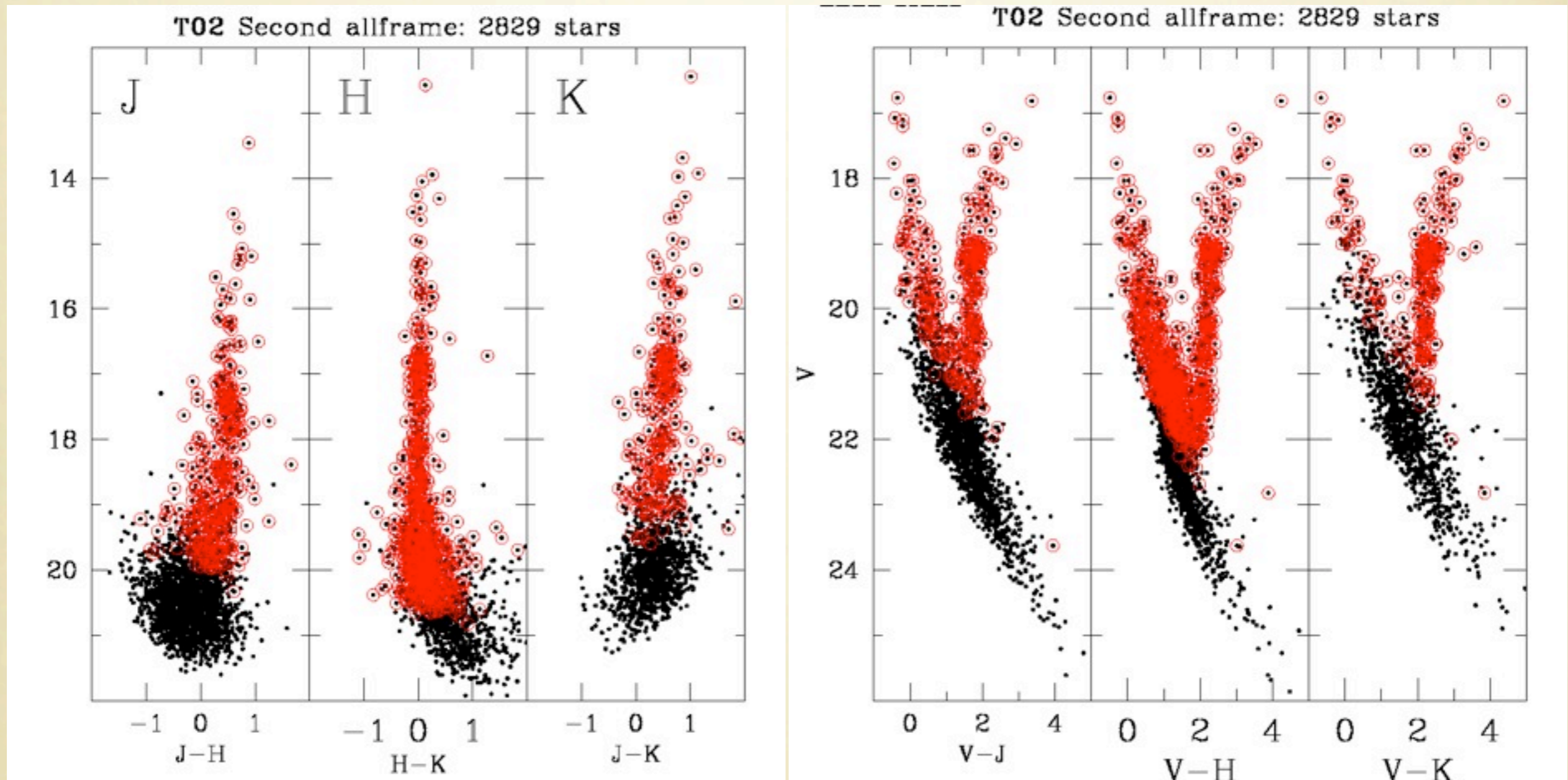


CMDs: LMC field

T02 Nov (2007)-Jan-(2008)



ALLFRAME with ACS information on all the single images

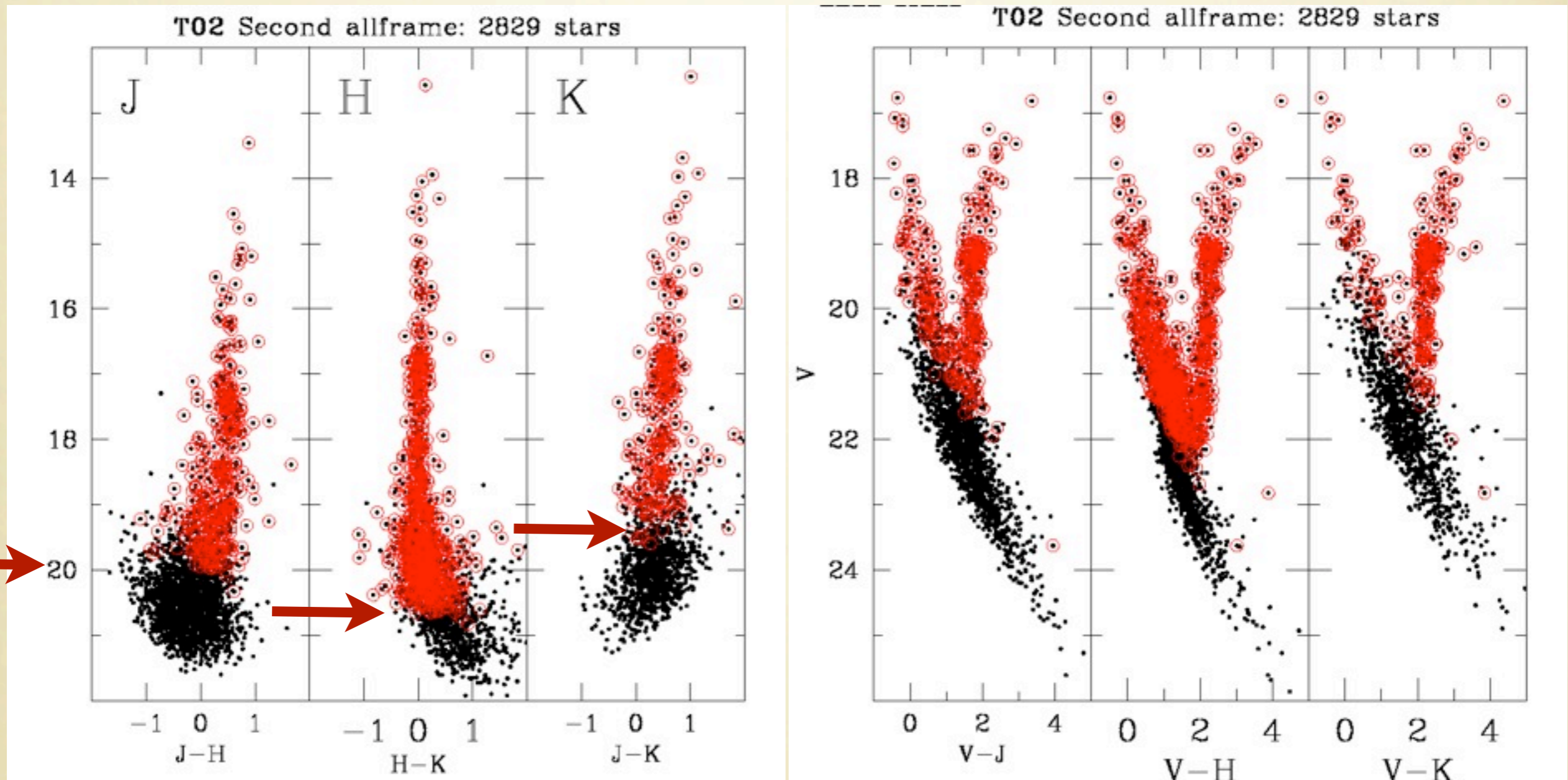


CMDs: LMC field

T02 Nov (2007)-Jan-(2008)



ALLFRAME with ACS information on all the single images

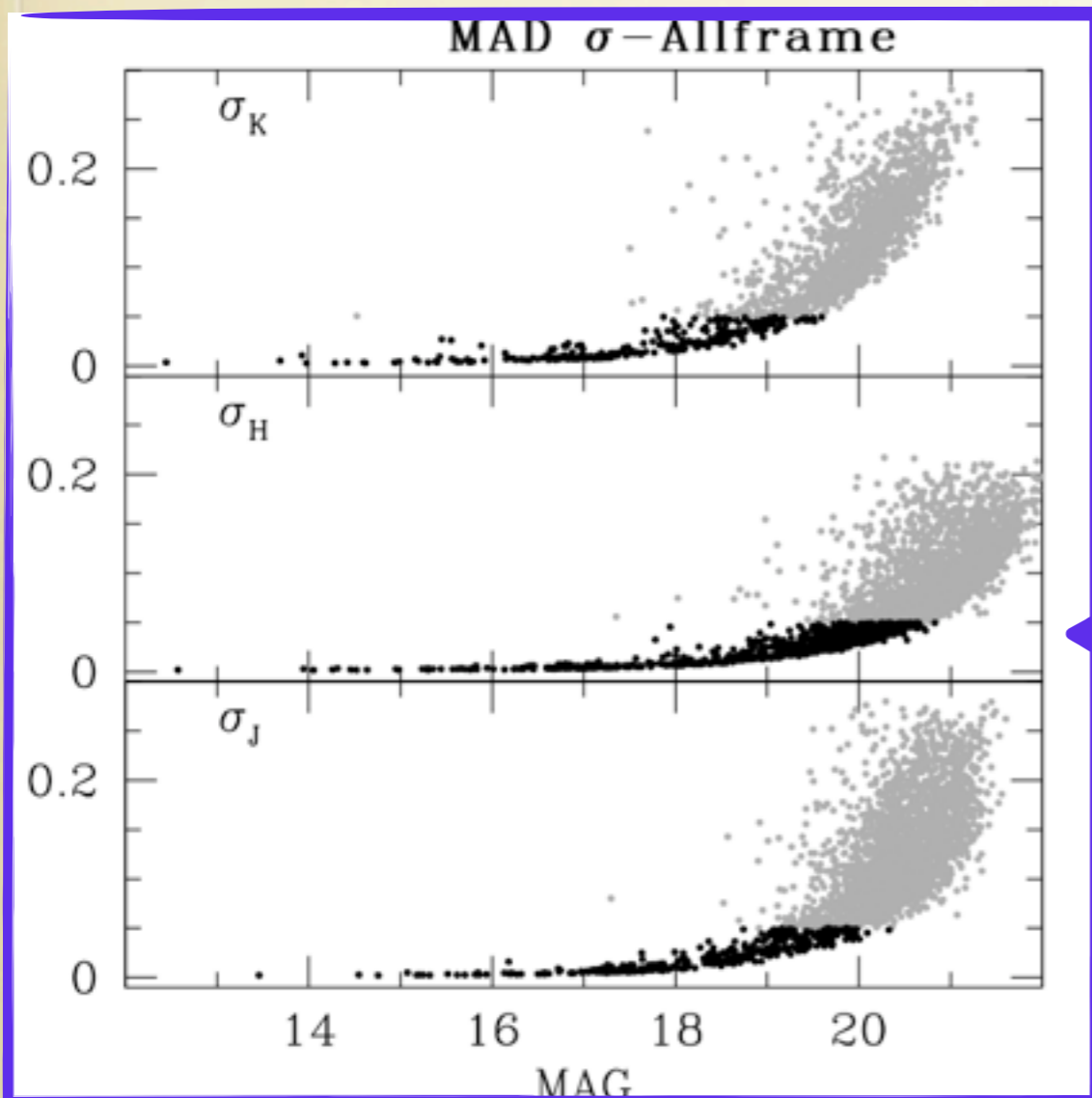
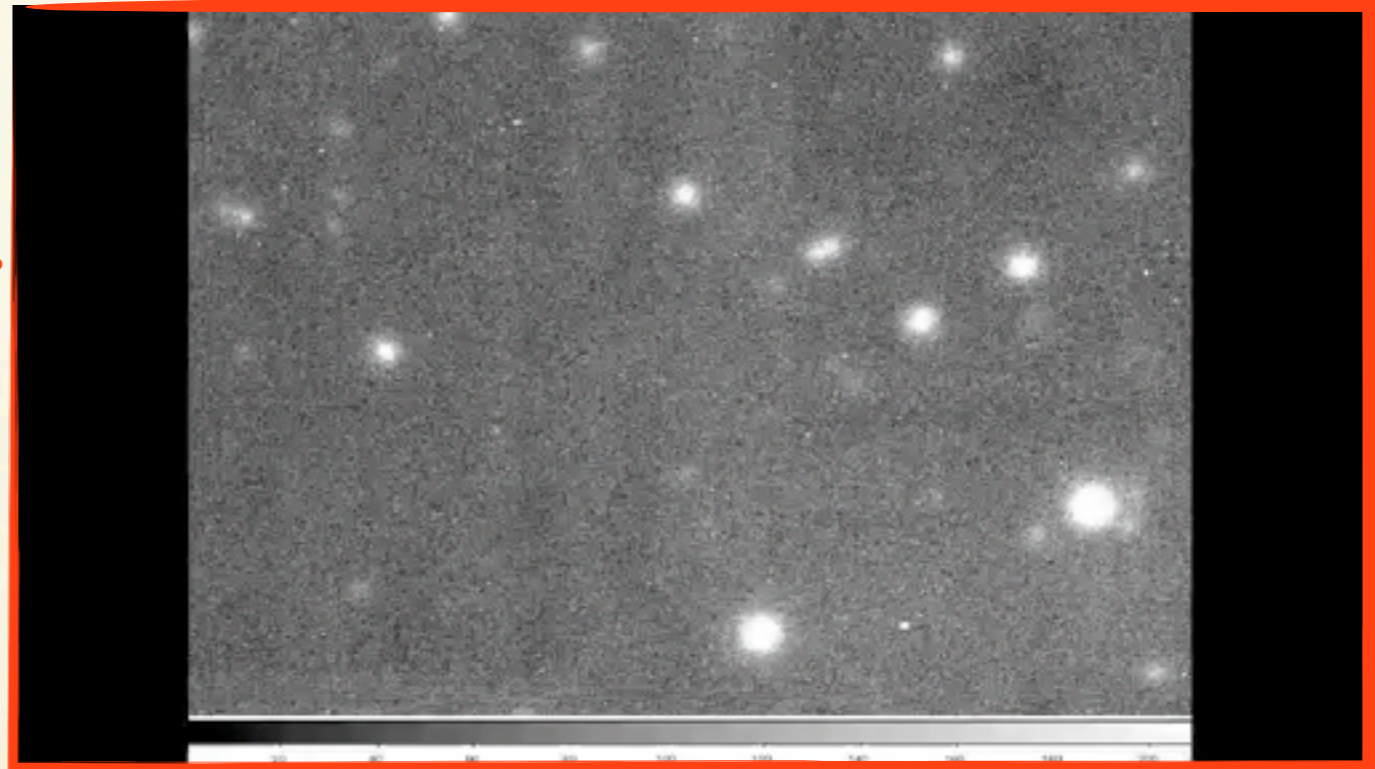


Calibrated on 2mass survey **J~20**, **H~20.5** and **K~19.5** mag
with $\sigma \leq 0.05$ mag

Photometric errors: LMC field



New T02 K-band data are really challenging due to the high Airmass and seeing variation!!

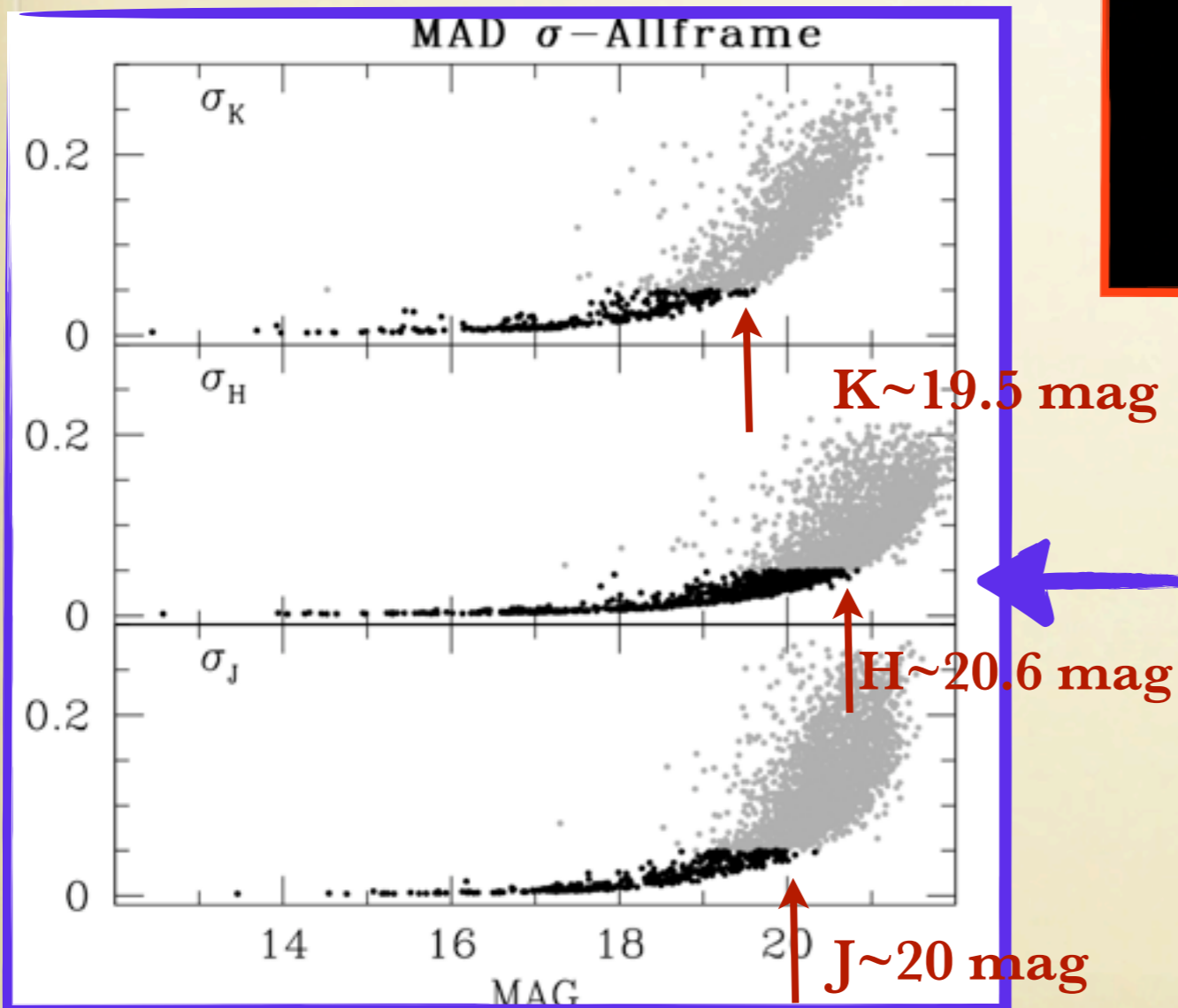
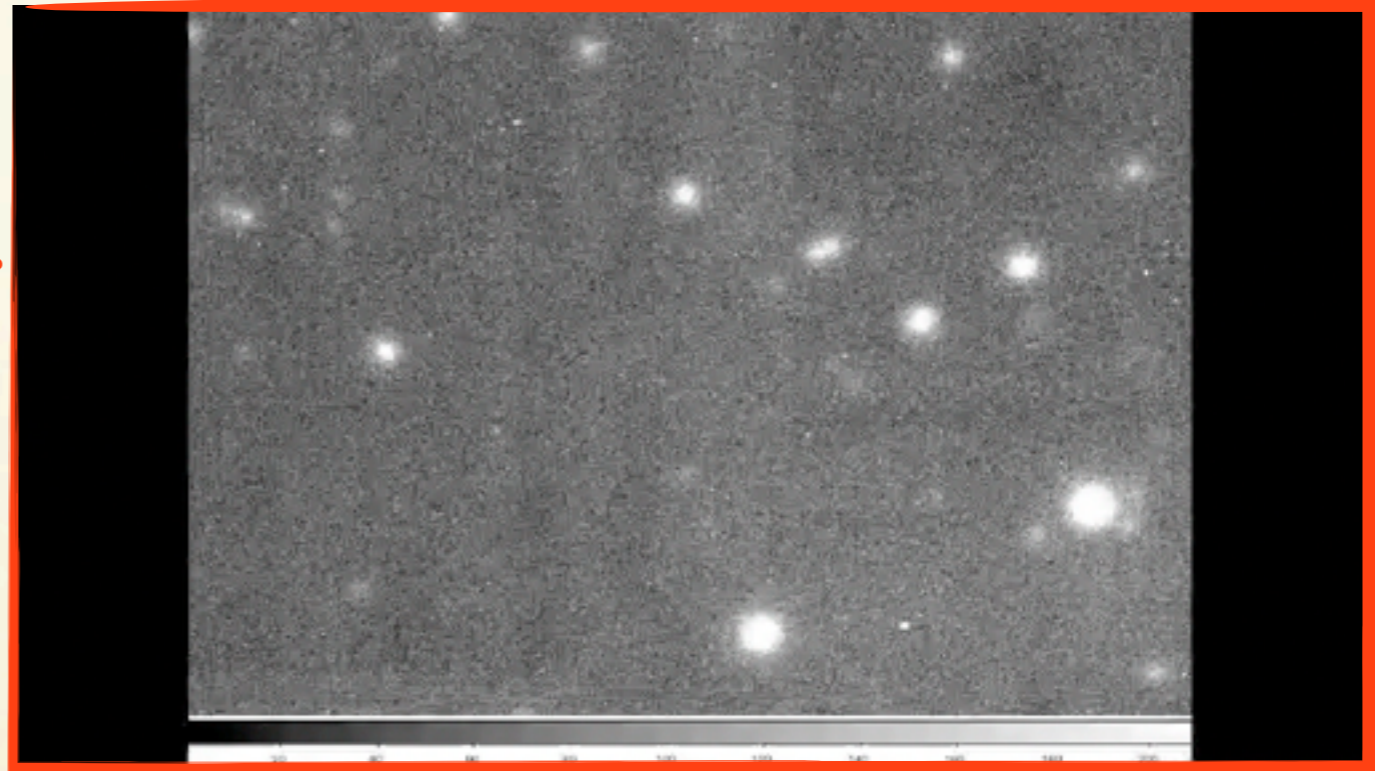


The errors seem to drastically reflect both the seeing conditions and the dependence on the wavelength of the correction.

Photometric errors: LMC field



New T02 K-band data are really challenging due to the high Airmass and seeing variation!!



The errors seem to drastically reflect both the seeing conditions and the dependence on the wavelength of the correction.

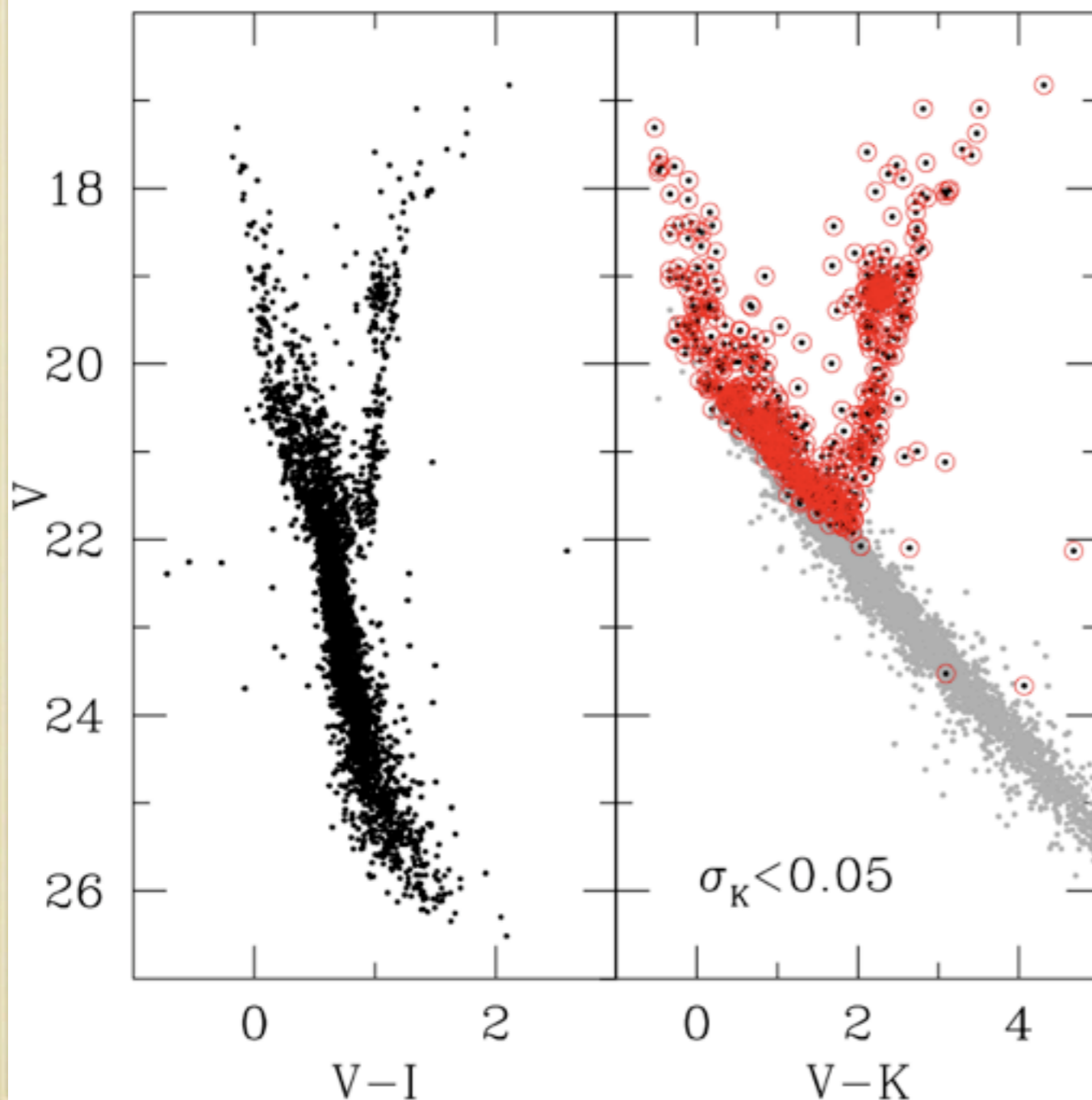
CMDs: LMC field

T01 Aug-(2008)

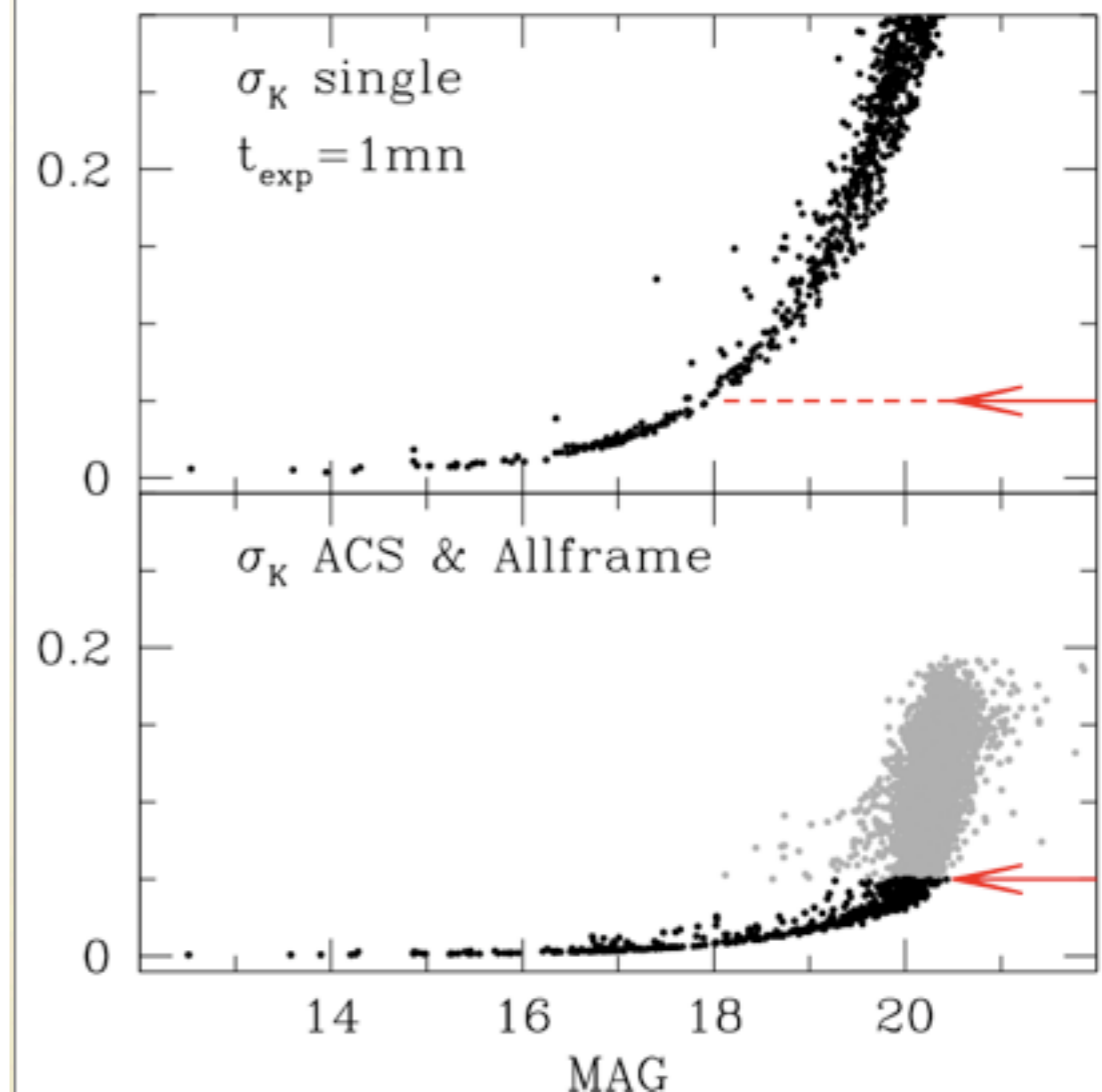


ALLFRAME with ACS information on all the single images

T01: allframe HST vs MAD

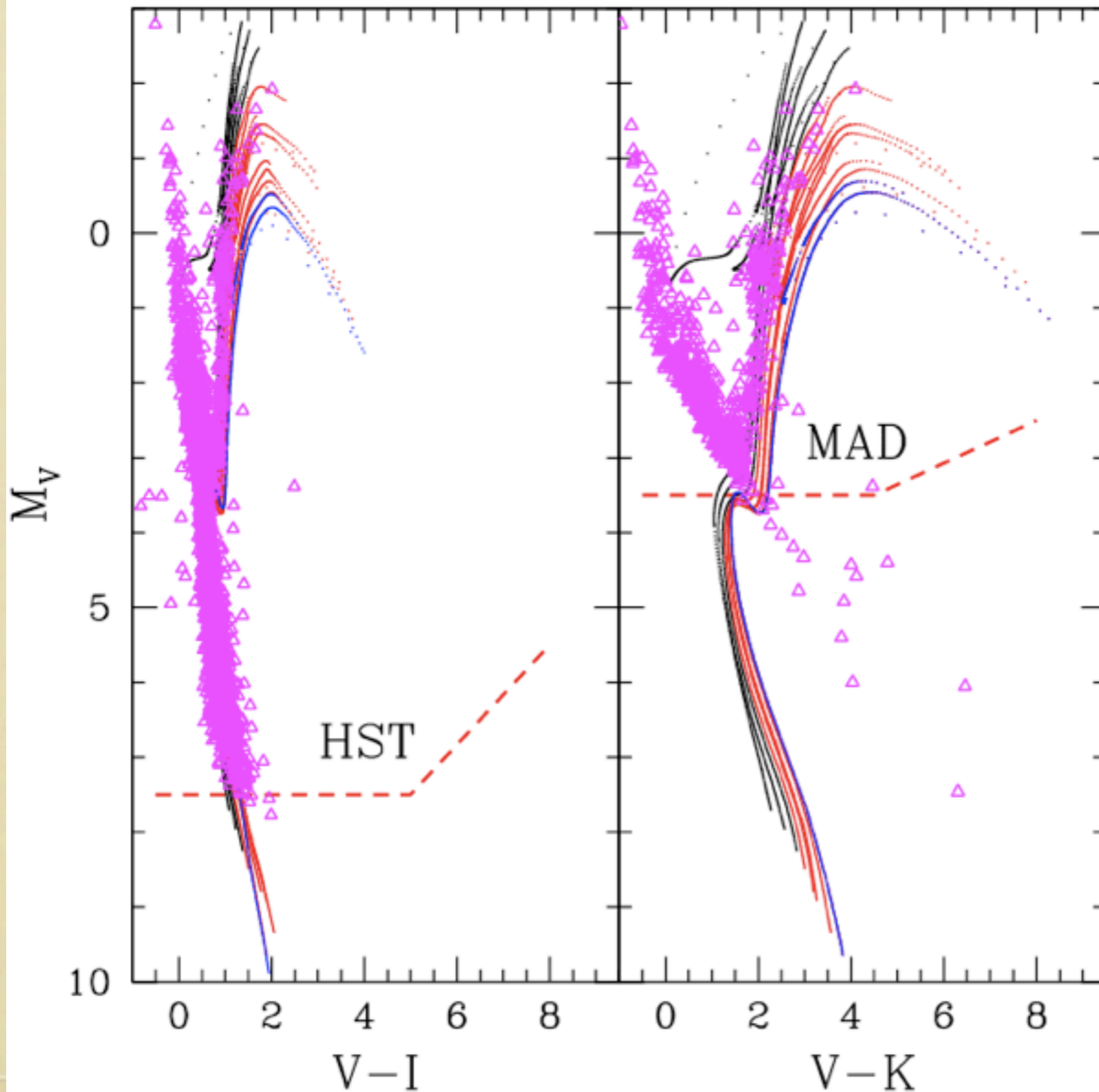


MAD - T01



K ~ 20.5 mag
with sigma ≤ 0.05

Theory vs Observation



By adopting
 $\mu_V = 18.5$ mag
 $E(B-V) = 0.08$
 $[Fe/H]_{LMC} \sim -1.5$

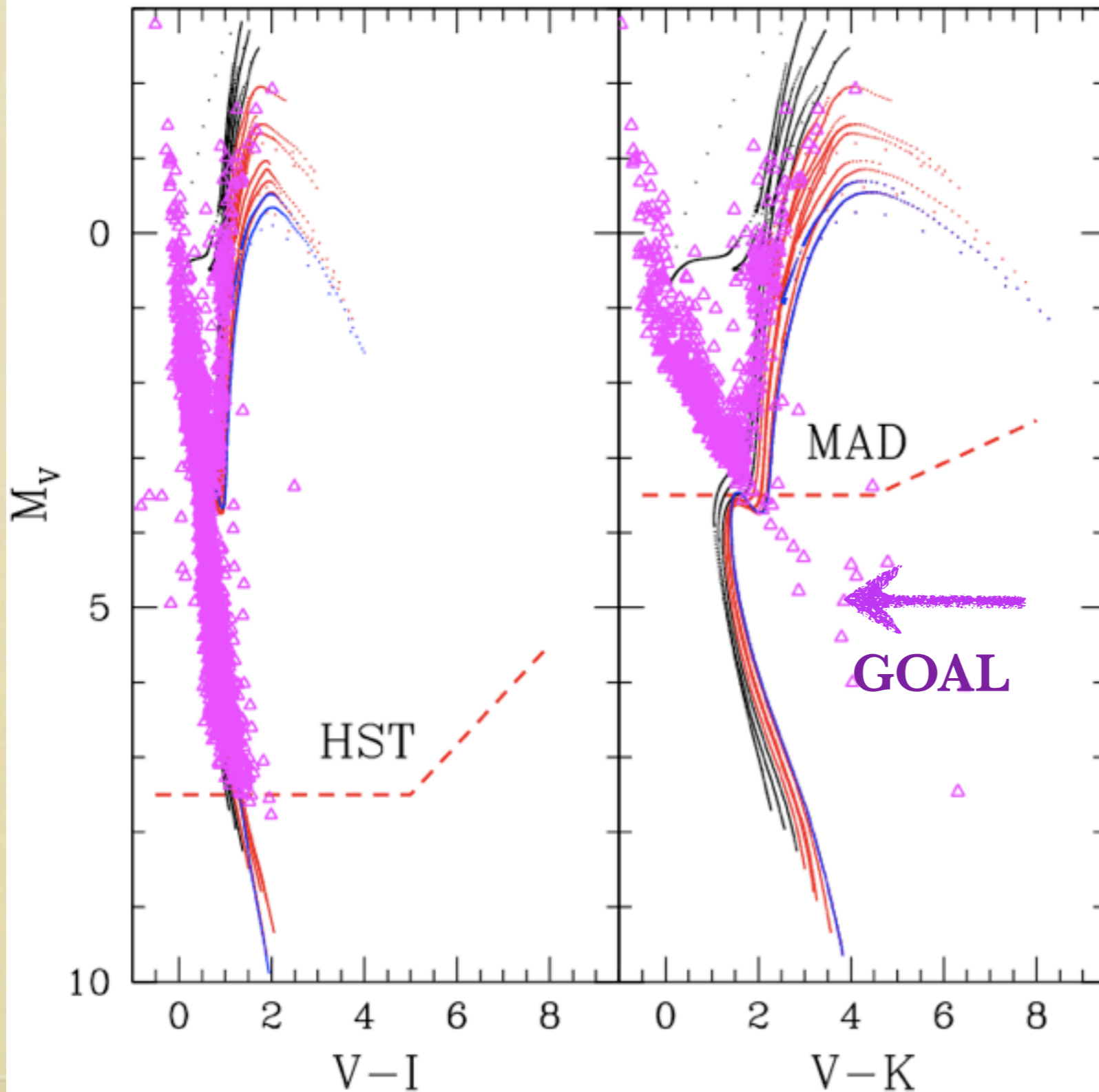
BASTI Isochrones

11-13 Gyrs &
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 $[Fe/H] = -0.65$ to 0.25

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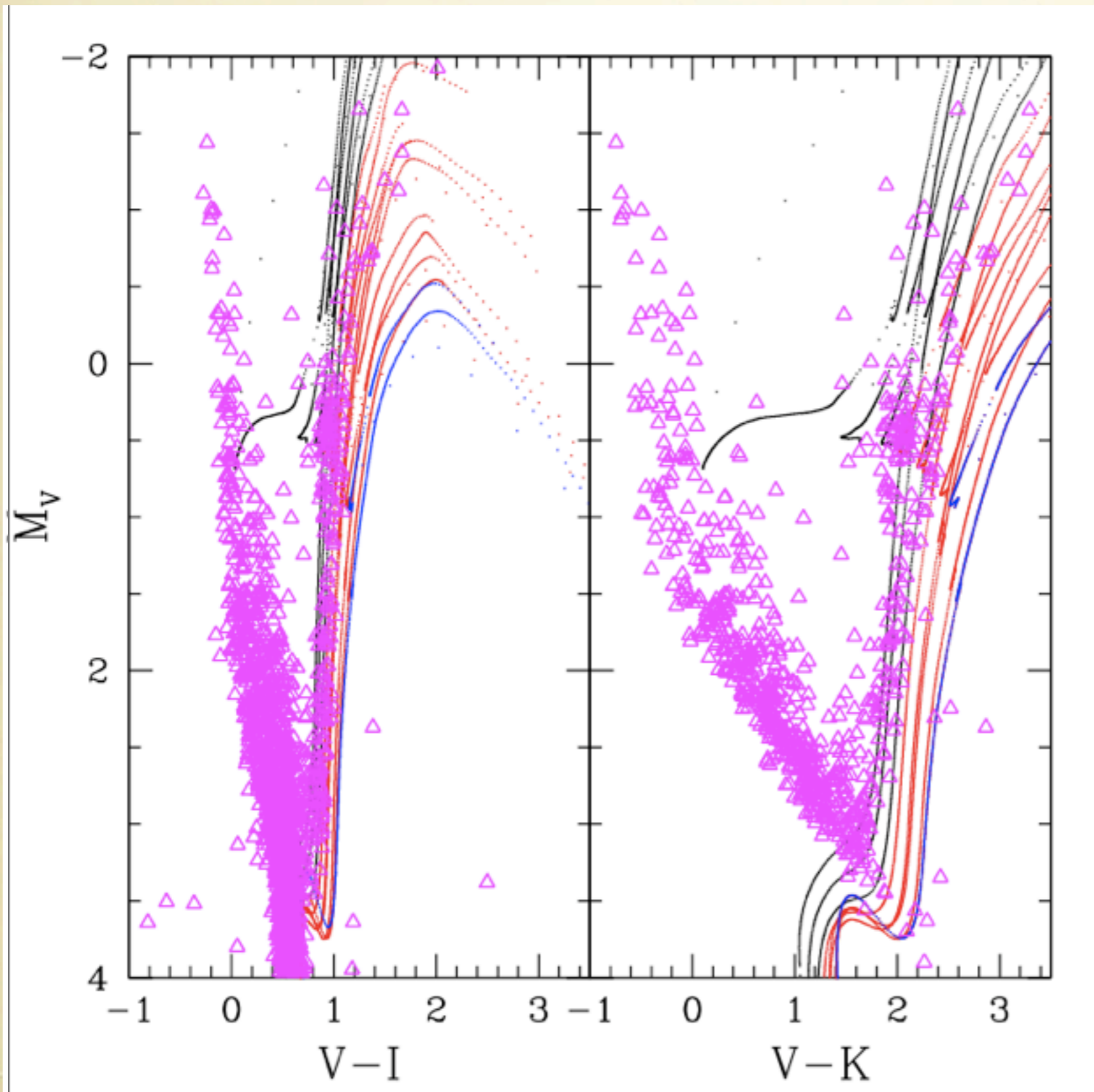
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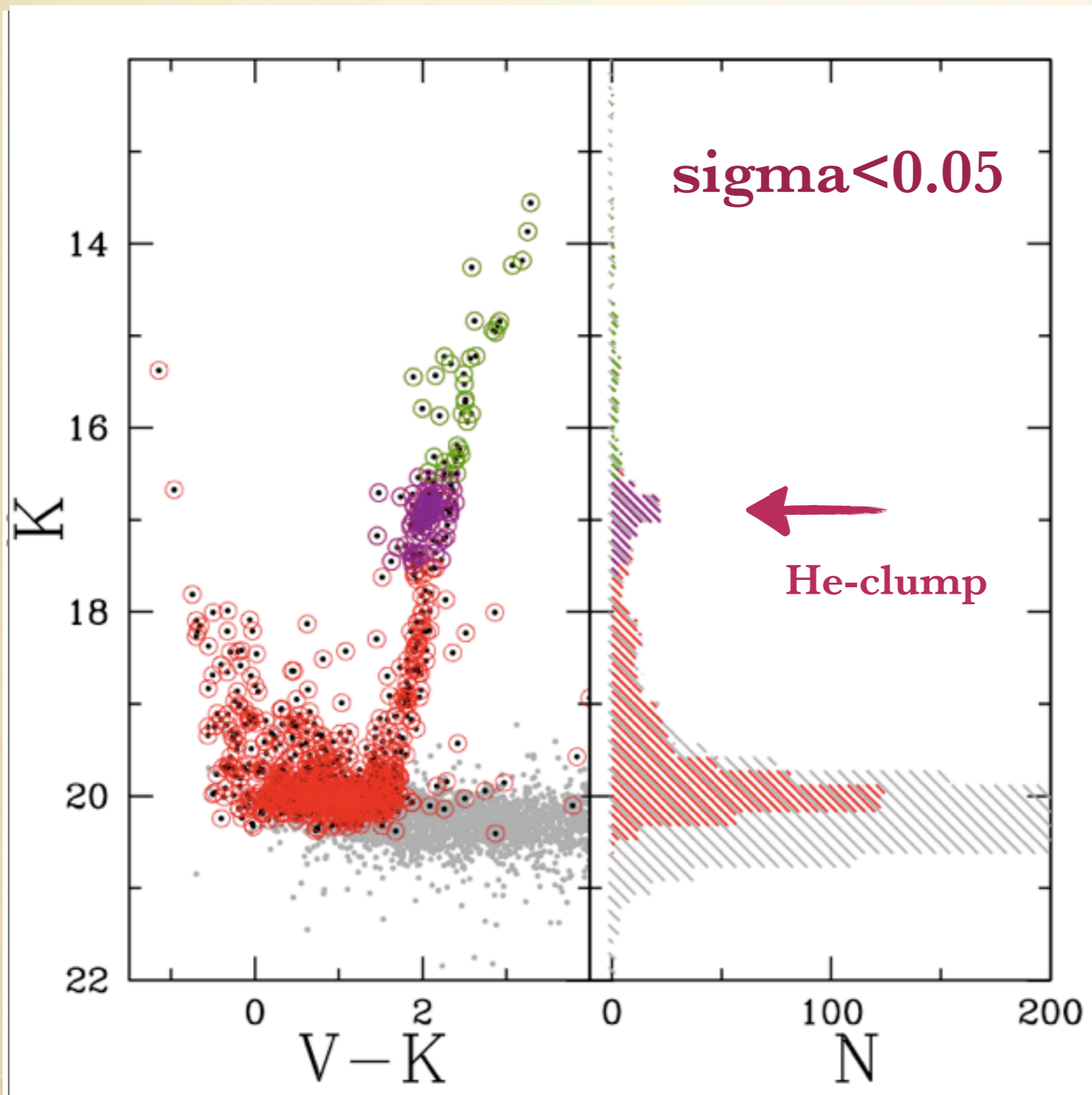
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Deepest photometry
obtained so far in
near IR band for
LMC field!!!



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Conclusions



Conclusions



What can we can learn from this and other studies?

The MSTO in near IR bands of resolved stellar populations in faint (LMC) and crowded (NGC6441) fields is a suitable **BUT not a trivial target!**

Conclusions



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The NEXT Steps:

STARFINDER (Diolaiti et al. 2000): adapting photometric packages to be able to simulate properly the variable and complex PSF function obtained from MCAO systems.

MAD MAX: More and detailed observations of both fields and GCs of the LMC in near-IR bands are needed to add details to our knowledge of this galaxy.

Conclusions



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For E-ELT these efforts need to be made!

The Future Steps:

LASER GUIDE STARS to increase the sky coverage.

OPTICAL AO correction (e.g. I-band).

Conclusions



What can we learn from this and other studies?

The MSTO in near IR bands of resolved stellar populations in faint fields (LMC) and crowded (NGC6441) fields is not as clear as expected, but is still suitable **BUT not a trivial task**

The NEXT Steps:

STARFINDER

be able to

obtain

MAD

More and detailed observations of both fields and GCs of the LMC in near-IR bands are needed to add details to our knowledge of this galaxy.

For E-ELT these efforts need to be made!

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Thanks for your attention!!