Micado observations of resolved galaxies: first simulations of stellar fields

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for the MICADO Consortium

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MICADO

*M*CAO *I*maging *Ca*mera for *D*eep *O*bservations

Phase A Study

consortium

MPE	Garching, Germany
MPIA	Heidelberg, Germany
USM	Munich, Germany
OADP	Padova Astronomical Observatory (INAF), Italy
NOVA	Leiden, Gronigen, Dwingeloo (ASTRON), Netherlands

Aim: design a simple & robust near-IR imaging camera, ready early on, primarily for MCAO but also compatible with GLAO, LTAO, etc.

Board of Directors

R. Genzel, H.-W. Rix, K. Kuijken, A. Renzini, R. Bender

Key Roles

Principal Investigator	R. Genzel (R. Davies)
Project Manager	R. Davies
Project Scientist	A. Renzini (R. Falomo)
Instrument Scientist	T. Herbst
Systems Engineer	M. Thiel (L. Barl)
Optics	R. Ragazzoni, F. Eisenhauer
Mechanics	G. Kroes
Electronics	A. Hess
Software	B. Muschielok (M. Wegner)
Data Flow	E. Valentijn

Also involved:

L. Tacconi, D. Lutz, F. Eisenhauer, N. Forster Schreiber, M. Feldt, K. Jahnke, L. Greggio, E. V. Held, L. Bedin, G. Piotto, R. Saglia

Science Cases

building on science cases from E-ELT Science Working Group

• Galactic Center	R. Genzel
• YSOs, outflows, disks	M. Feldt, T. Herbst
• High mass star formation	T. Herbst, M. Feldt
• Globular cluster astrometry	G. Piotto
• Globular cluster photometry	G. Piotto
• Star formation histories	L. Greggio, E. Held
• Deep, faint, photometry	E. Tolstoy
• Galaxy Cores	R. Bender, R. Saglia
• Dwarf Spheroidal Kinematics	K. Kuijken
• QSO environments	R. Falomo
• QSO host galaxies at high z	H.-W. Rix, K. Jahnke
• Structure of high z galaxies	M. Franx
• High-z resolved colour mapping	N. Forster Schreiber
• High-z emission line mapping	N. Forster Schreiber

Science Trade-Off

- Spatial/Spectral properties – pixel size, field of view, wavelength coverage, etc.
- Filter sets
- Importance of photometry, astrometry, sensitivity, spatial resolution, image fidelity
- PSF calibration
- Impact of scientific results for different AO performance
- Impact with other AO techniques (GLAO, LTAO)
- Impact of other operational telescopes

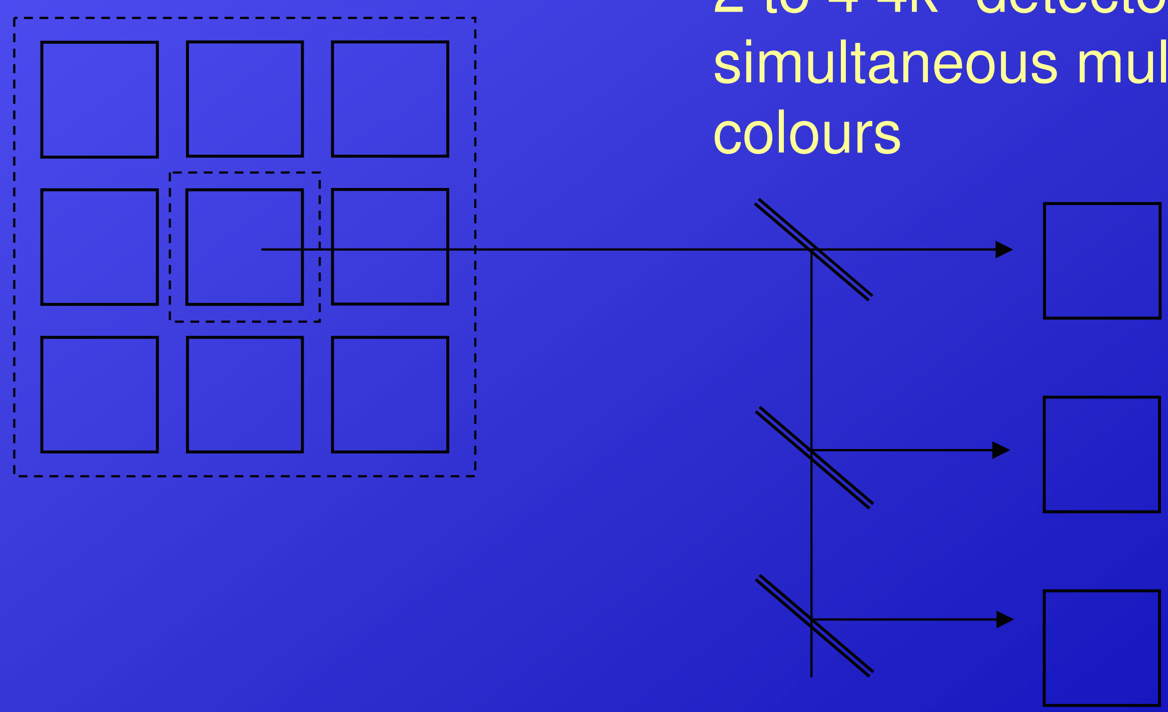
the results of this trade-off will be used to drive the camera design via Top Level Requirements

One possible MICADO concept

basic configuration:
3x3 4k2 detectors, ~4mas pixels, covering 48”×48”
or ~3mas pixels, covering 36”×36”

inner channel:
removable dichroics with 2 to 4 4k^2 detectors for simultaneous multi-colours

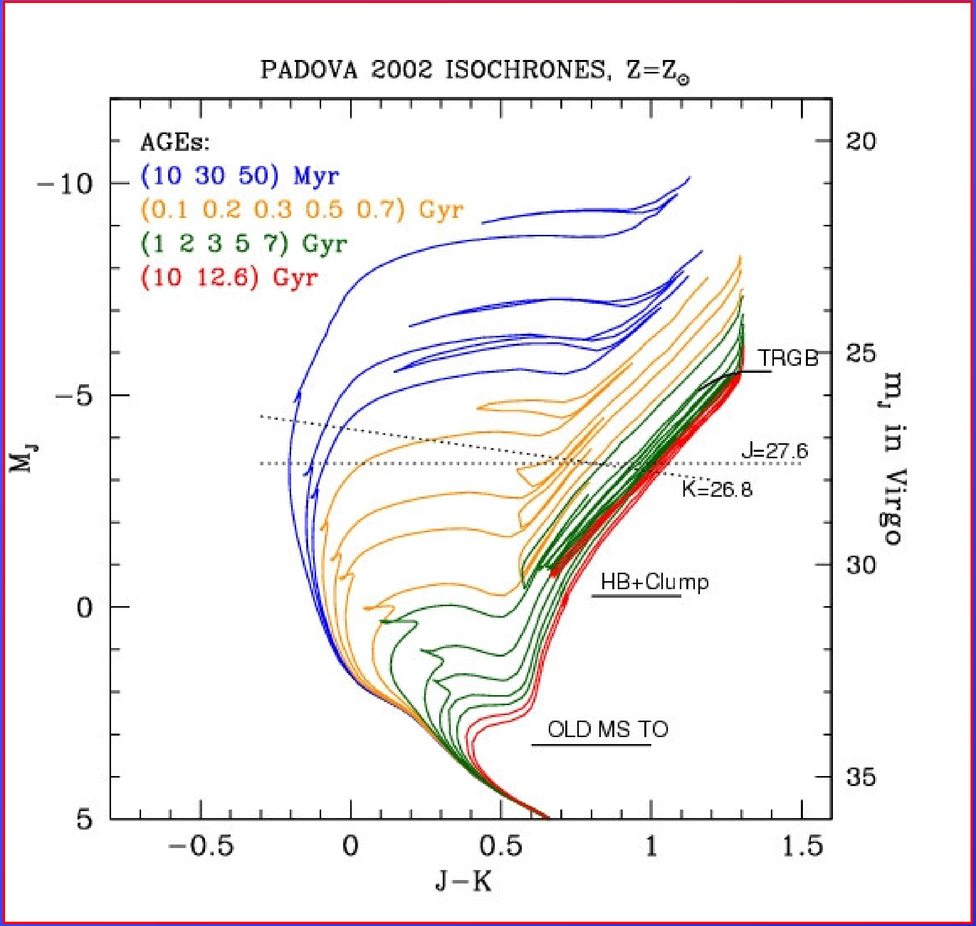
zoom optics over some or all of field:
e.g. 1, 2, & 4 mas/pix



The resolution of MICADO and the E-ELT will allow us to apply the techniques used so far in the Local Group to galaxies of all morphological types, as far as the Virgo cluster of galaxies

Science Case 1: Resolved Stellar Populations in Virgo late-type Galaxies

SCIENCE CASE FOCUSSES ON DERIVING SFHs FROM THE INTRINSIC BRIGHTEST PORTION OF THE CMD

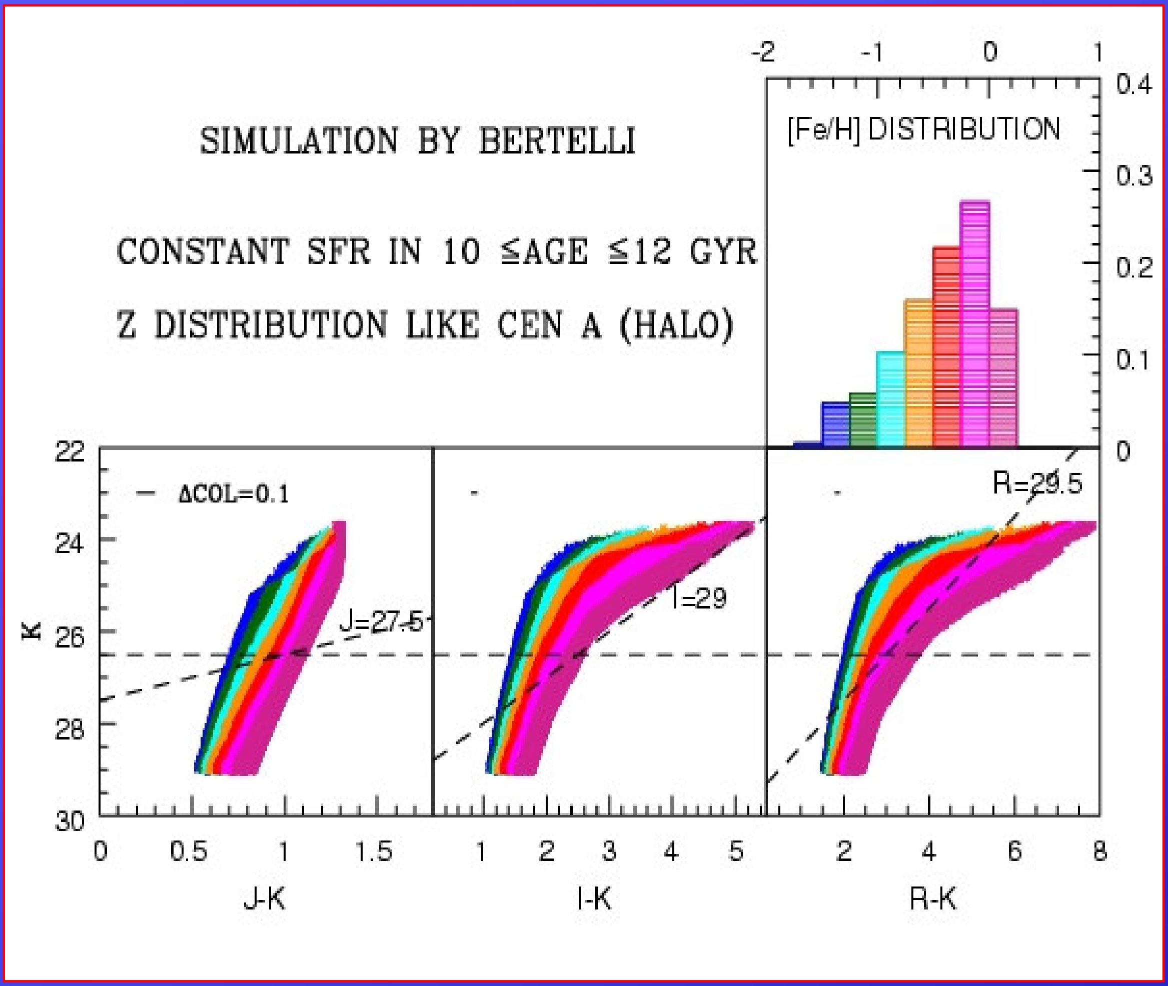


SFH from analysis of stellar distribution on the CMD using stellar evolution theory

Best diagnostic from MS TOs where different luminosities sample different stellar ages, but old TOs are faint

Old SPs can be sampled on the bright RGB, at ~ 7 mags brighter, a gain in volume of a factor of ~ 15 10^6

Science case 2: metallicity distribution in early-type galaxies

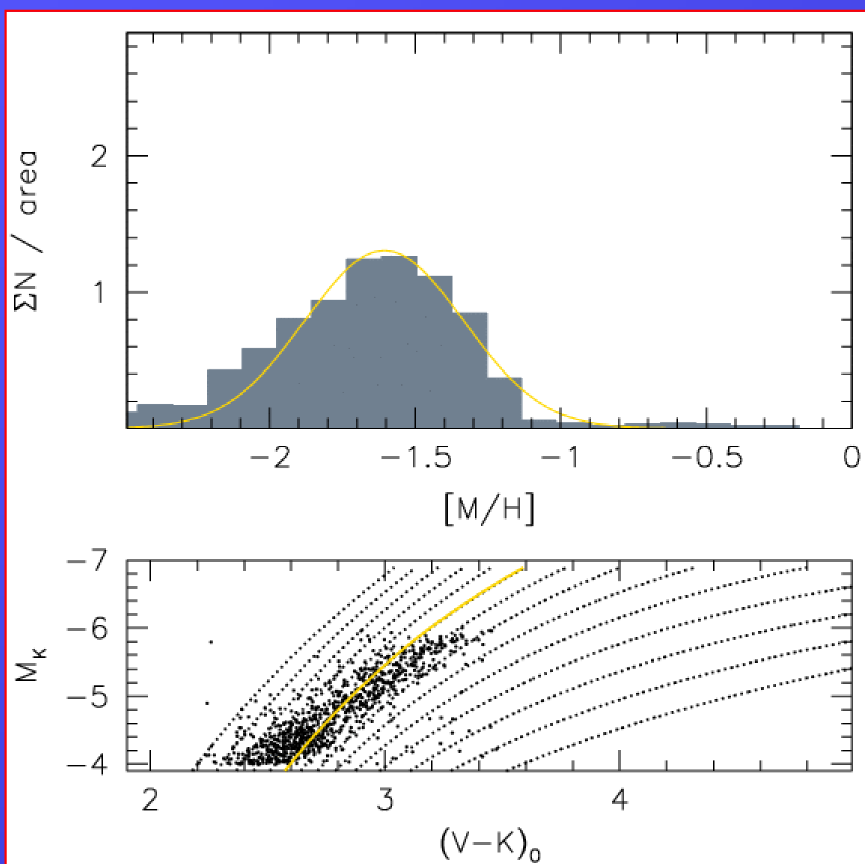


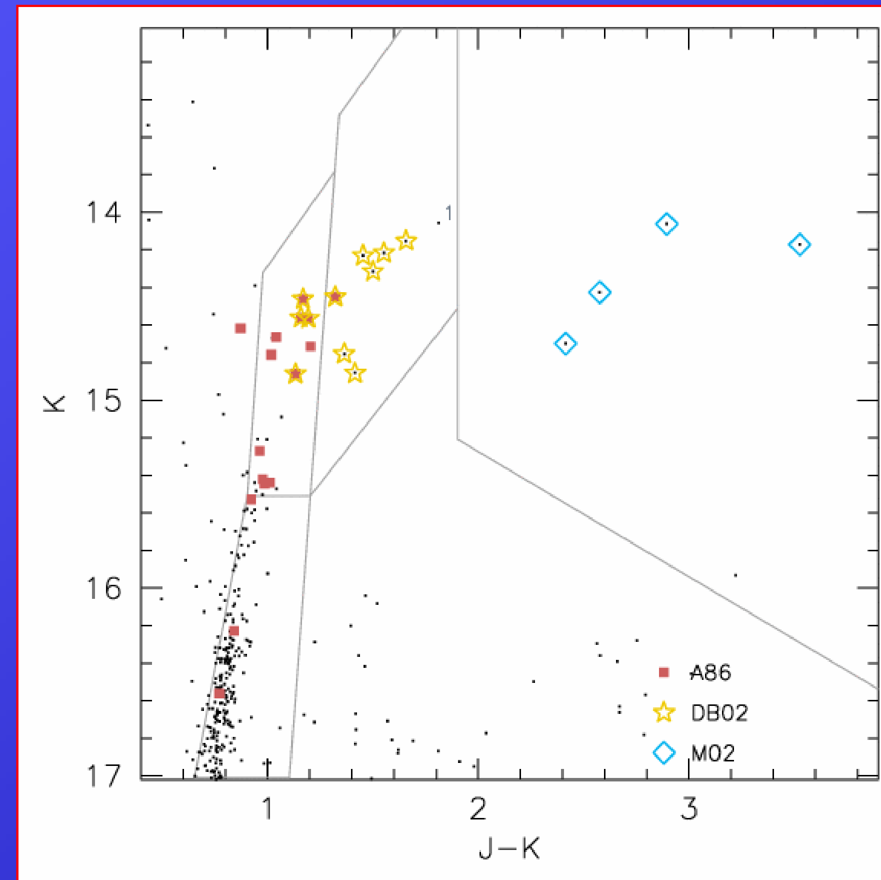
Wide Color baseline allows us to recover the Z distribution in more detail, at given photometric precision

For an application in Virgo the I-K combination could be the best

Is NIR a good choice ?

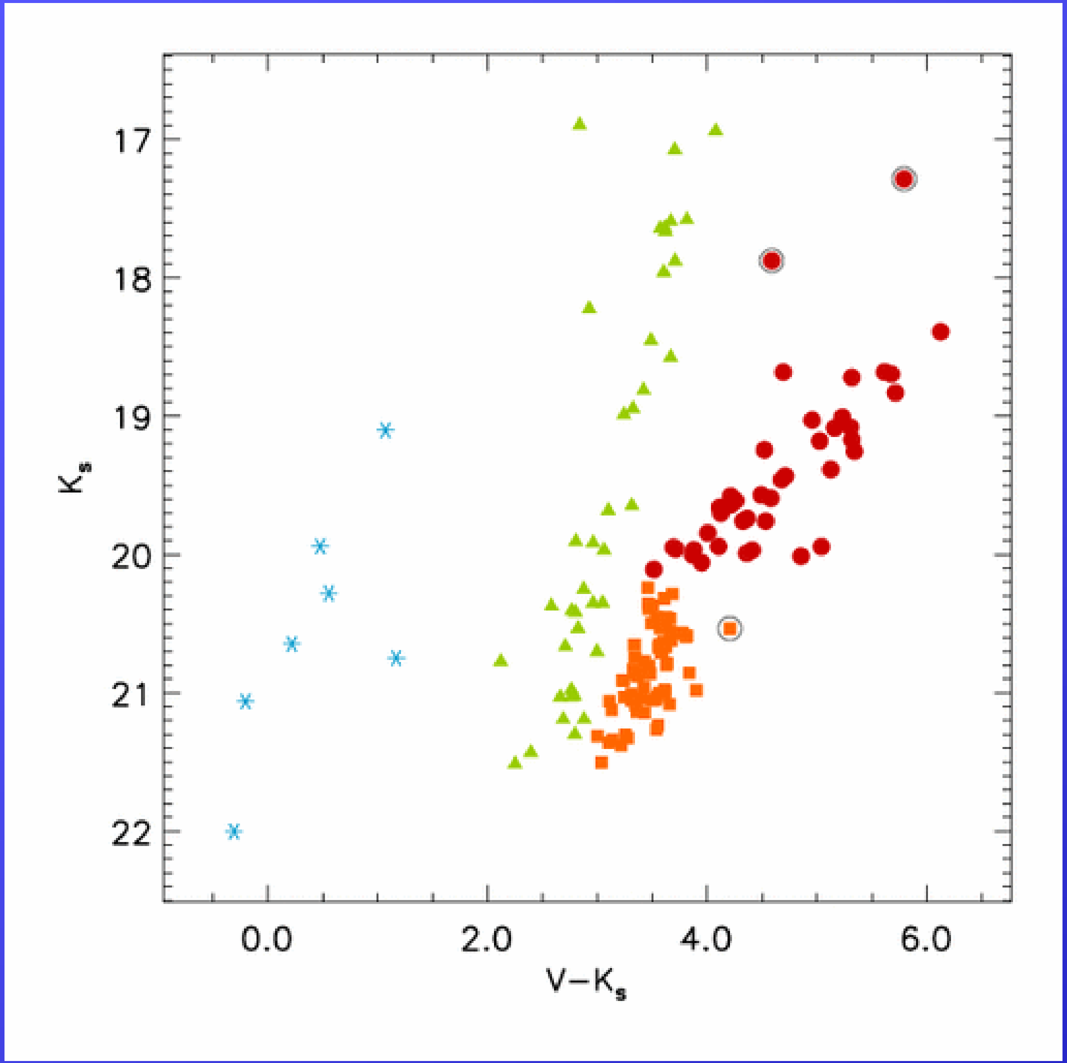
A combination of optical – NIR colors is most effective for estimating metallicities of red giant stars beyond the limit of spectroscopy





Carbon- and oxygen-rich AGB stars, bearing information on the star-formation history of the systems in the last few Gyr, are best observed in the NIR

AO for resolved stellar populations: MAD results

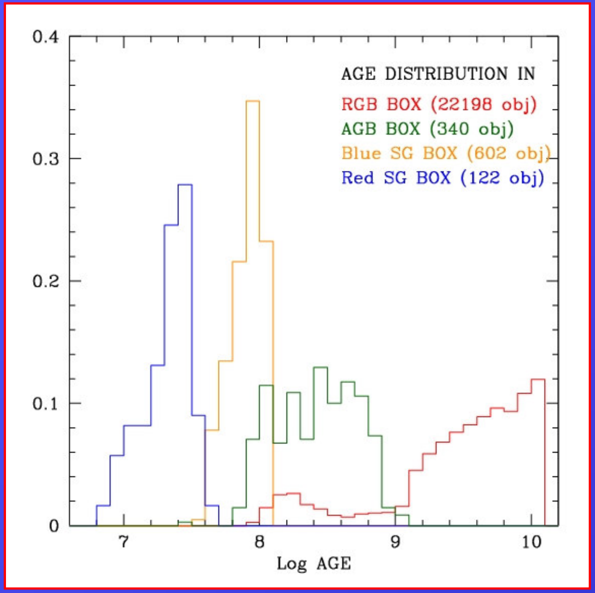


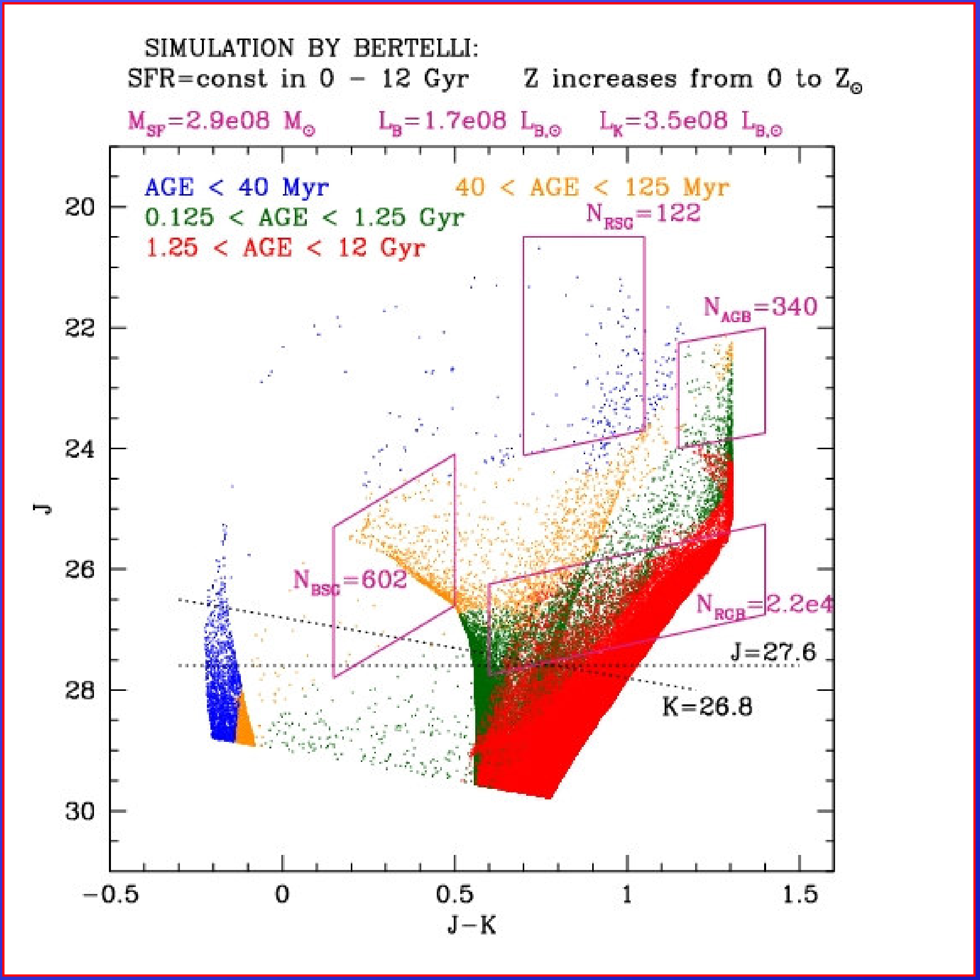
MAD observations of UKS 2323-326 (Gullieuszik et al. 2008)

AO observations at the VLT allowed us to reach the RGB, AGB, and red supergiant population in the nearby Sculptor group (DM ~ 26.5)

Simulations: theoretical input

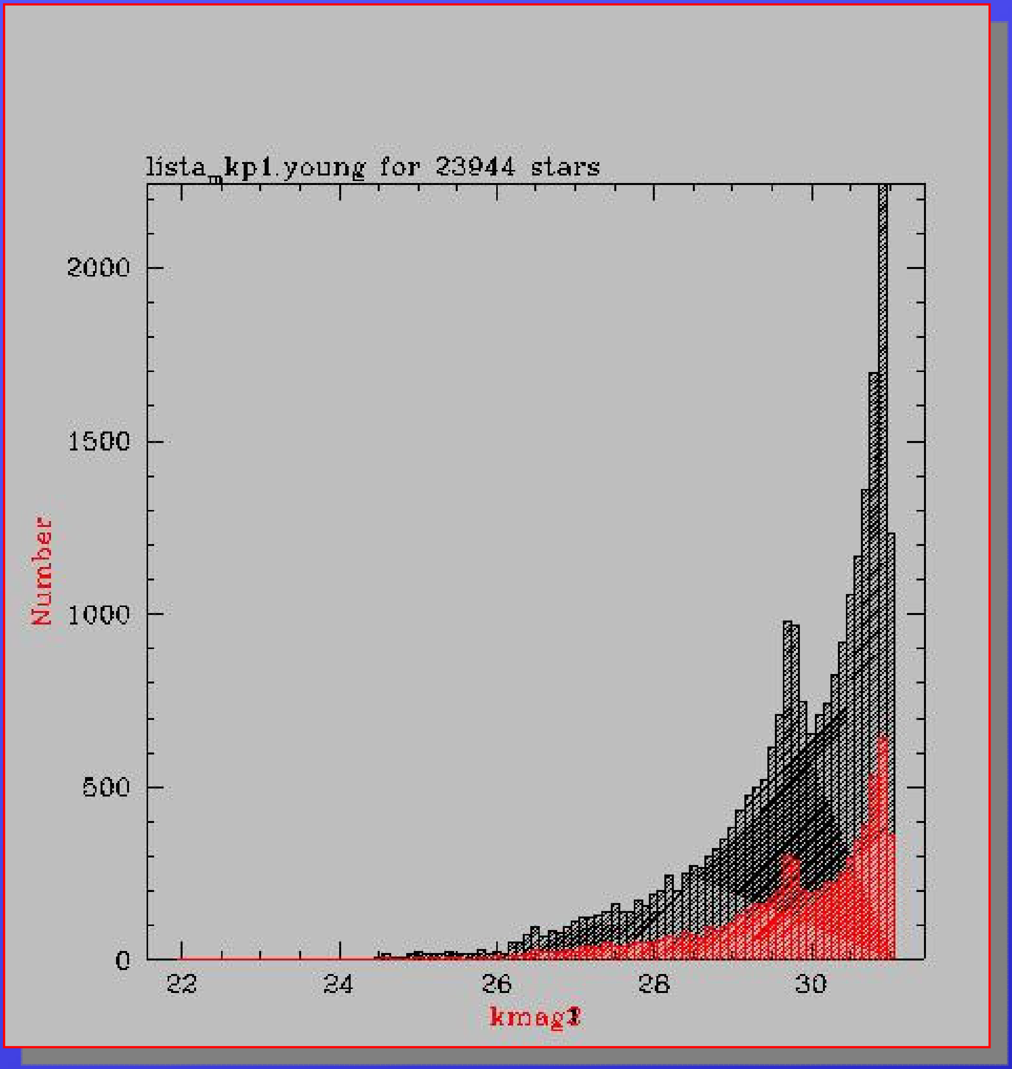
Simple star counts in diagnostic boxes are used to sketch the SFH





- Padova isochrones (Girardi et al. 2000)
- ZVAR simulator by G. Bertelli (since 1992)
- flat SFH over the last few Gyr

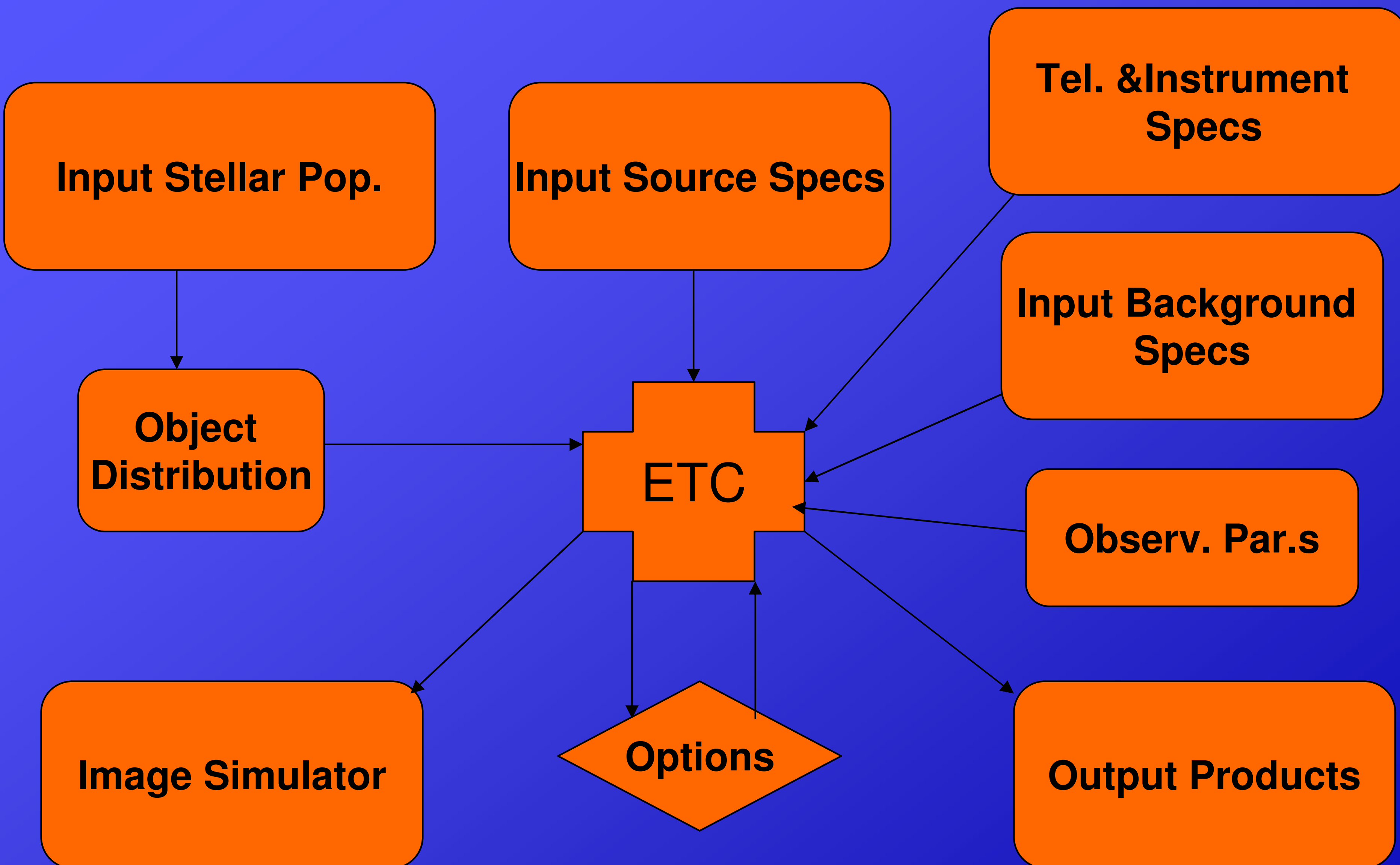
Simulated frames in J and K



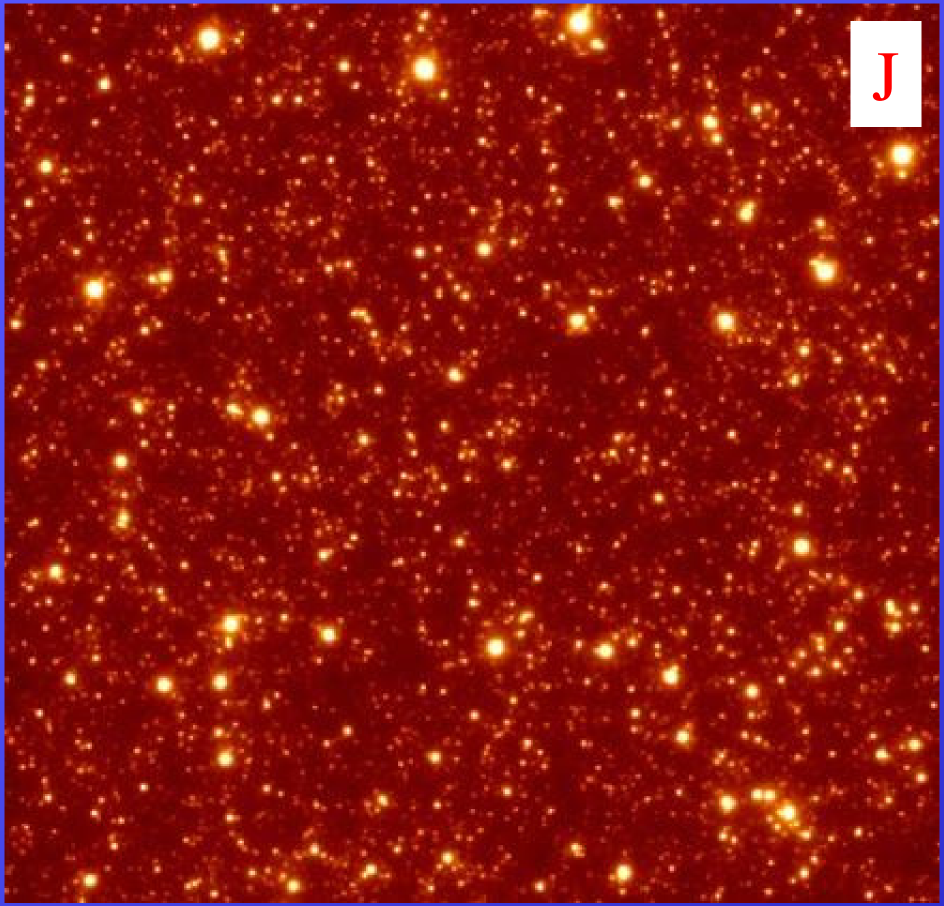
- 17000 stars down to K=30 simulated in a 3” x 3” field
- faint, unresolved stars contribute to the diffuse background
- realistic LF is an important ingredient

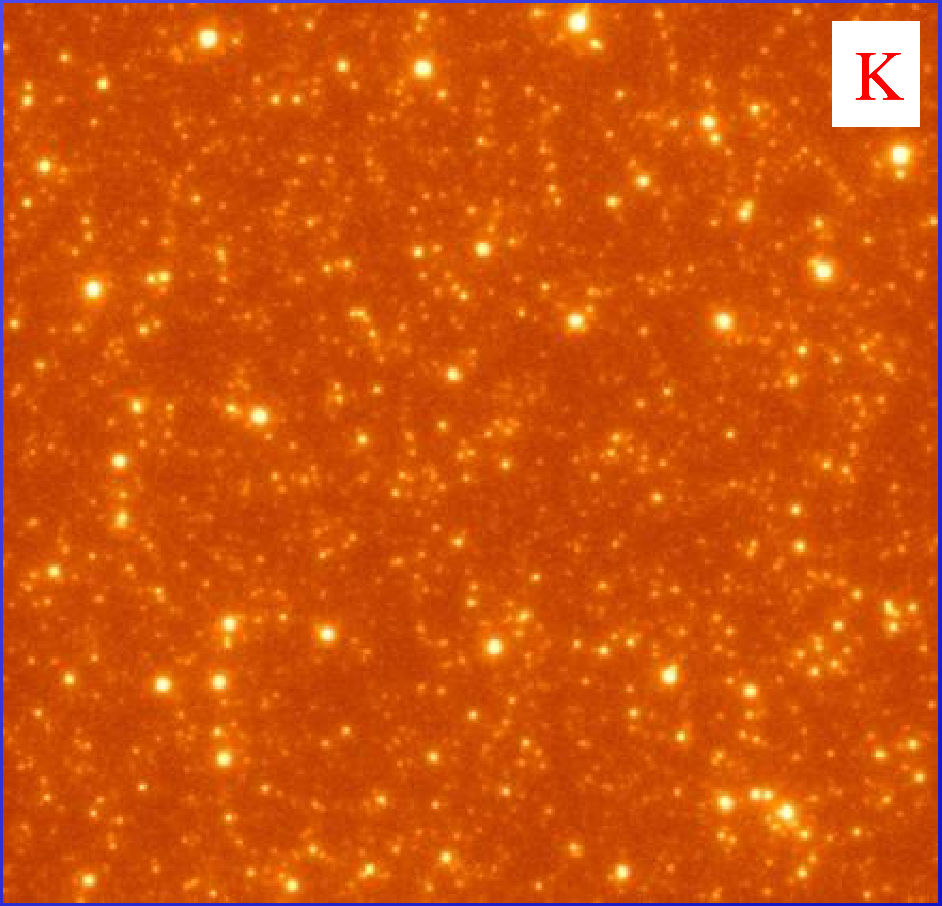
Advanced Exposure Time Calculator

by R. Falomo, M.Uslenghi, D. Fantinel, L.Greggio



Simulated frames in J and K



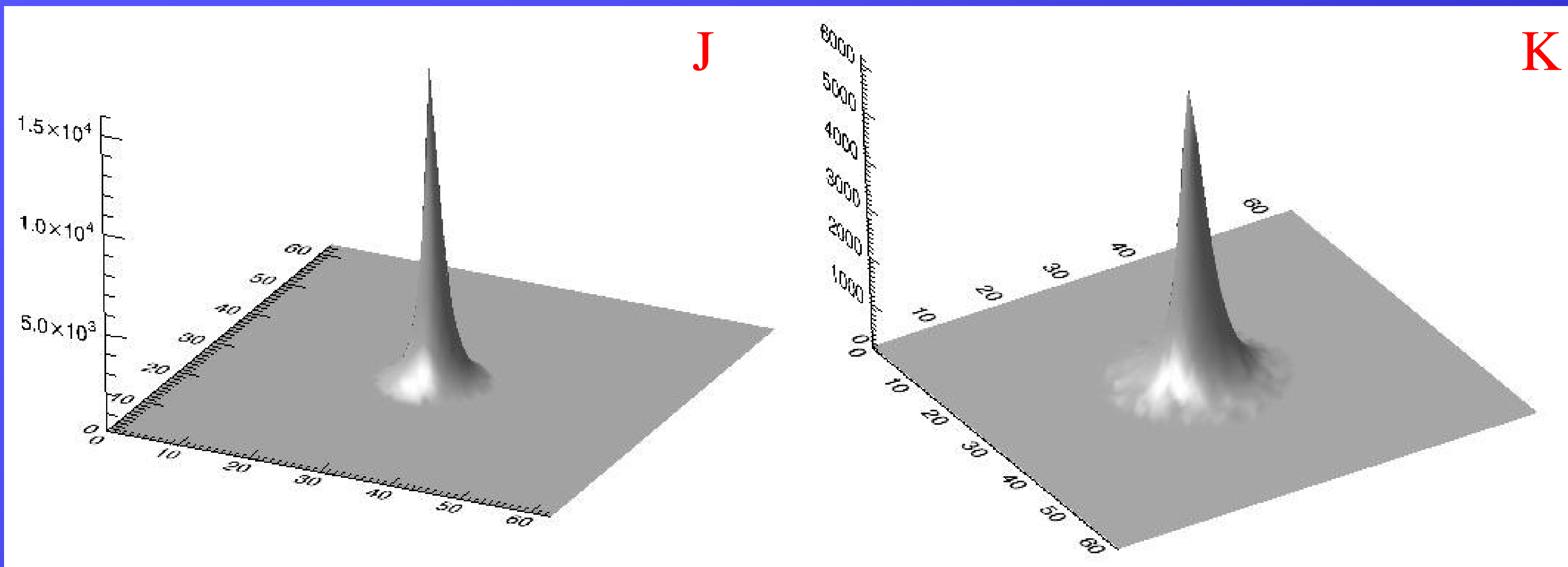


simulation recipe

- Simulation of a 3x3” field observed with MICADO
- 5 x 3600 exposure time, R.O.N. = 1 e-, DIT=120s
- 1000 x 1000 pixel image, pixel scale 3 mas
- very preliminary PSF different in J and K, close to diffraction limit => representative of the best observing conditions: Gaussian core according to the MICADO specifications + halo representative of the PSF under a ~0.5” seeing. This simplistic model roughly reproduces the Strehl ratio in the specs.
- The background and throughput are calibrated on the E-ELT model ETC.

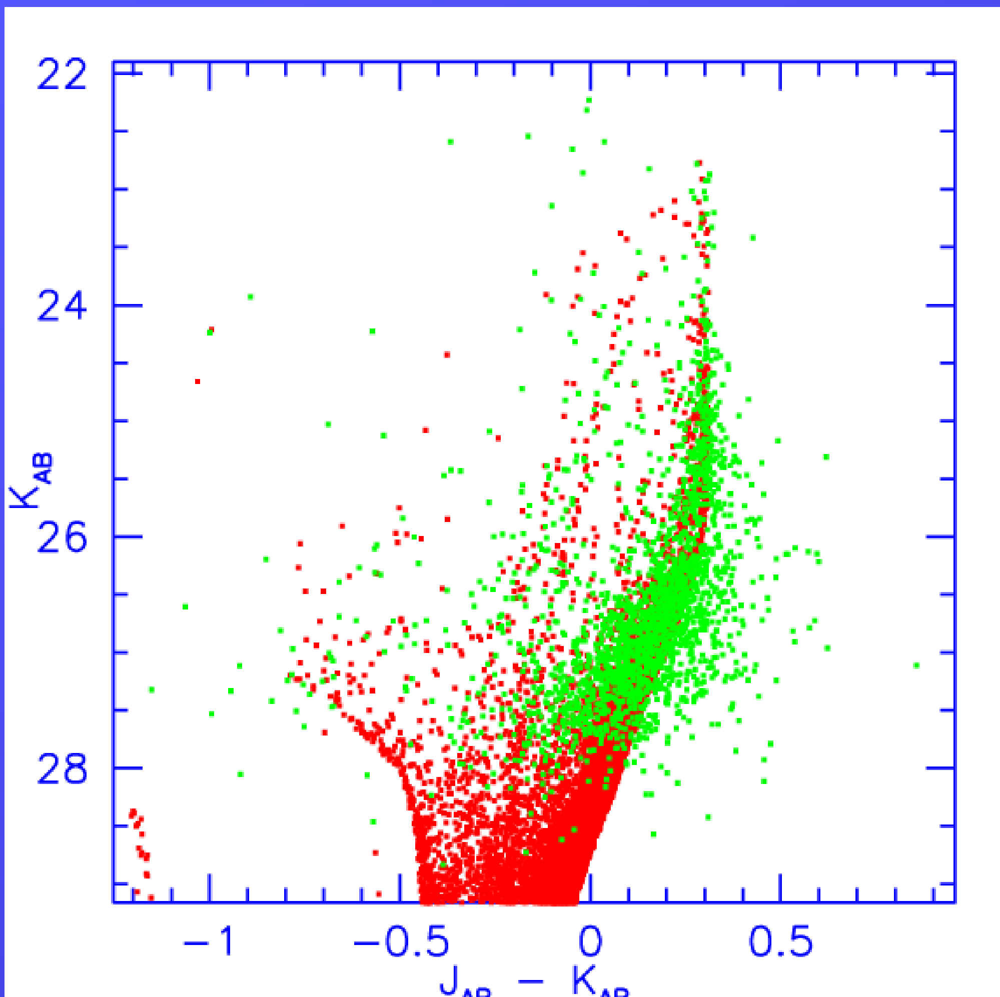
Reduction recipe

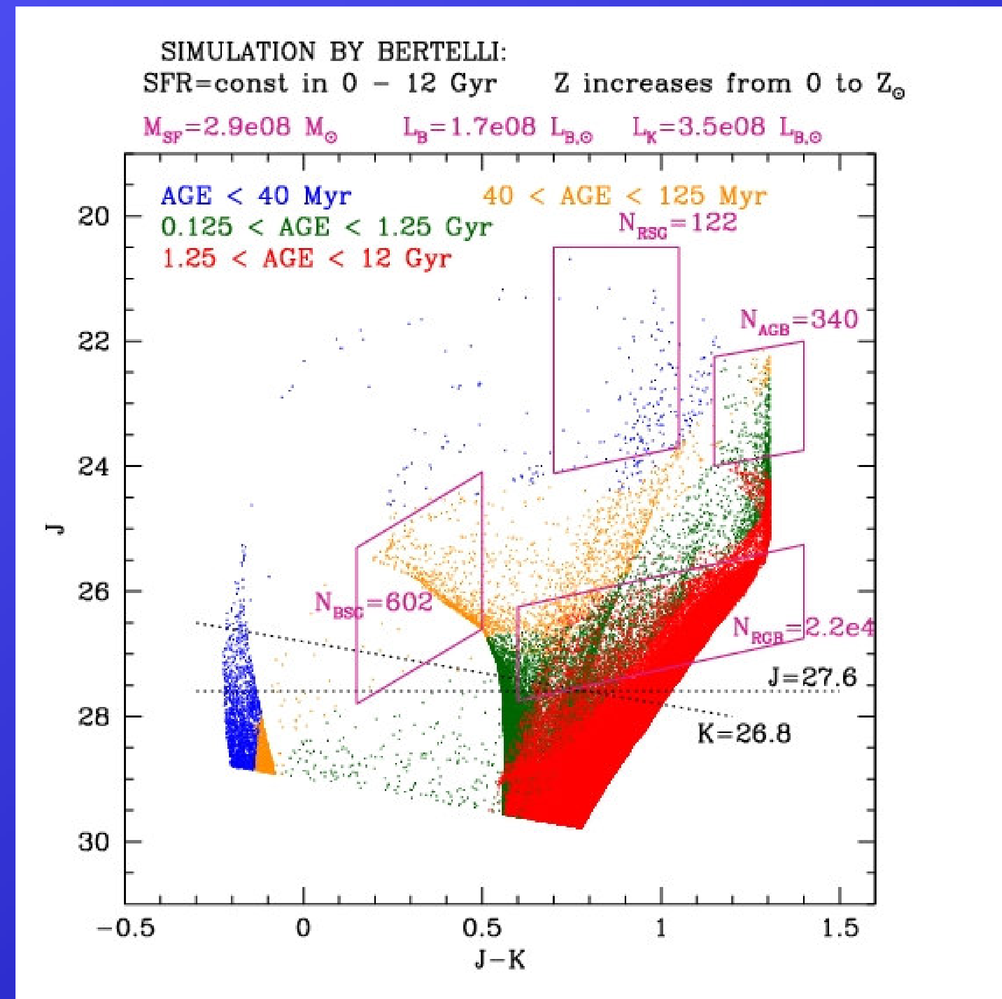
The simulated frames have been reduced with DAOPHOT/ALLSTAR (Stetson 1987)



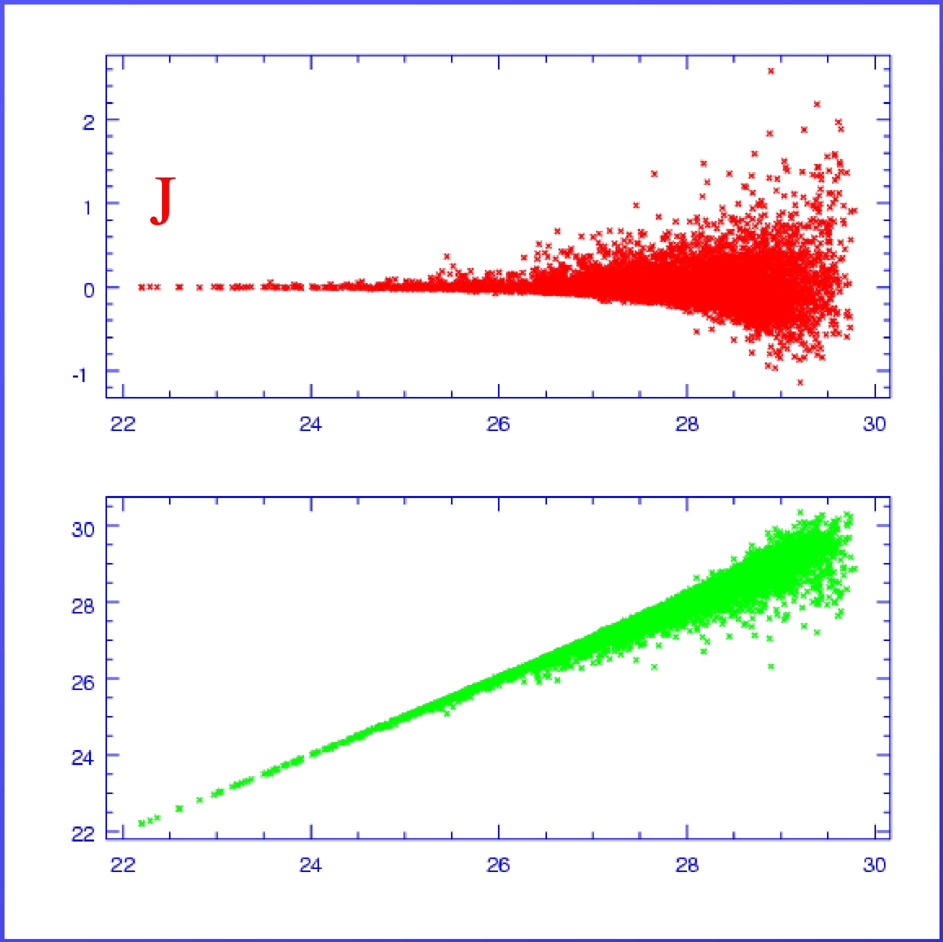
- the PSF is modeled with a Gaussian nucleus and an outer halo represented by a Lorentz function; the ellipticity and position angle of the PSF (core and halo) fixed across the field
- The DAOPHOT-reconstructed PSF is shown in the figures
- 5 σ detection threshold both in J and K

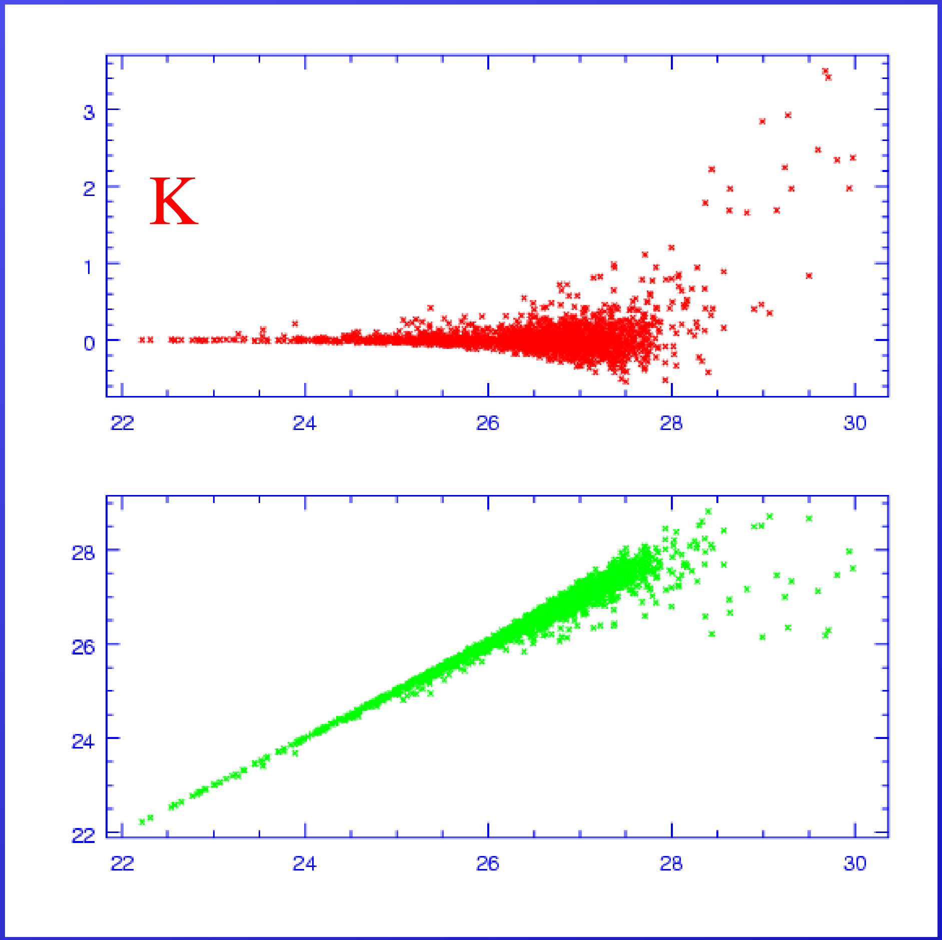
Results of simulations





Results of simulations: color-magnitude diagram





- magnitude difference between input and retrieved magnitudes (zero point empirically matched)

Conclusions …

- our first simulations indicates that deep MICADO exposure with optimum AO performance can reach below the RGB tip in Virgo cluster galaxies; the brightest stars are measured reasonably well

… much work TBD

- test different PSF with dependence on various observing conditions, using more realistic PSFs provided by ESO DRM and/or MAORY teams

- test different stellar populations and star-formation histories typical of the early- and late-type galaxies in the MICADO Science Cases

- test a range of crowding conditions at different SB's

- test alternative PSF-fitting software such as Starfinder (Diolaiti+2000)