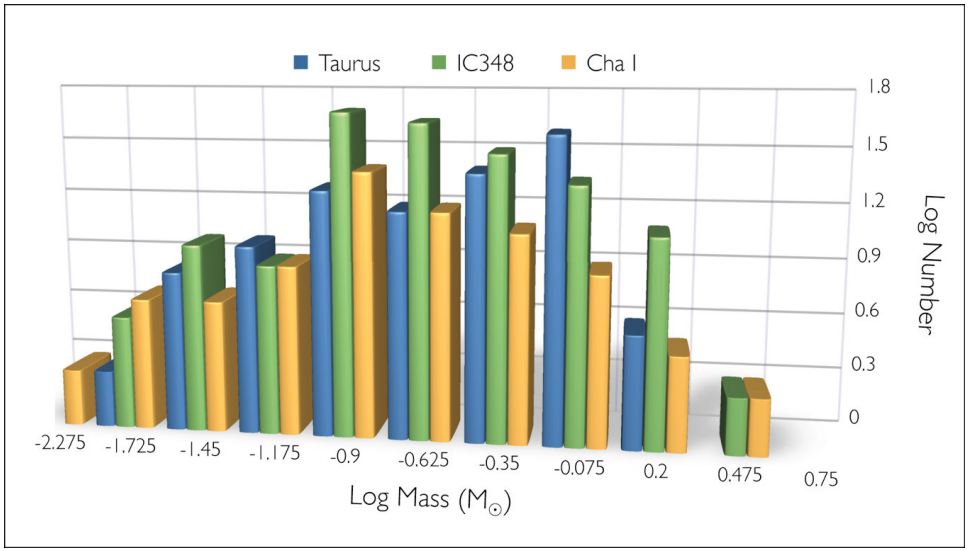
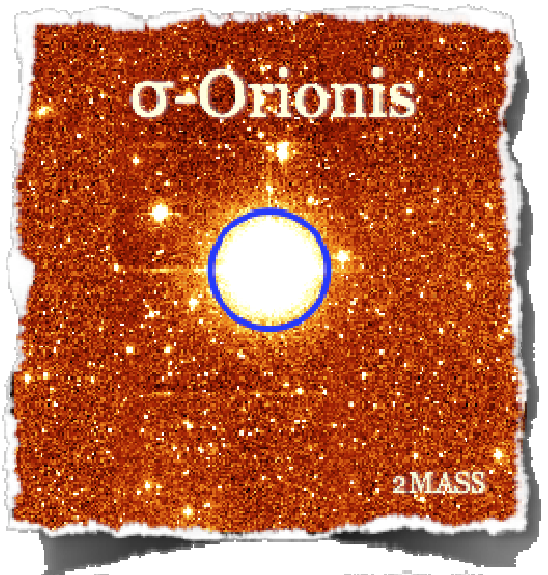
MAD observations of Young Clusters

N. Huélamo, D. Barrado, E.L. Martín, M. Morales-Calderón, A. Bayo (LAEX-CAB, Madrid)
H. Bouy (IAC, Tenerife)
J. Kolb, E. Marchetti, M. Petr-Gotzens (ESO, Garching)
M. Sterzik, V. Ivanov (ESO, Chile)

The Mass Function





- Mas functon: important outcome of stellar formation. It holds clues on the origin of stars and BDs

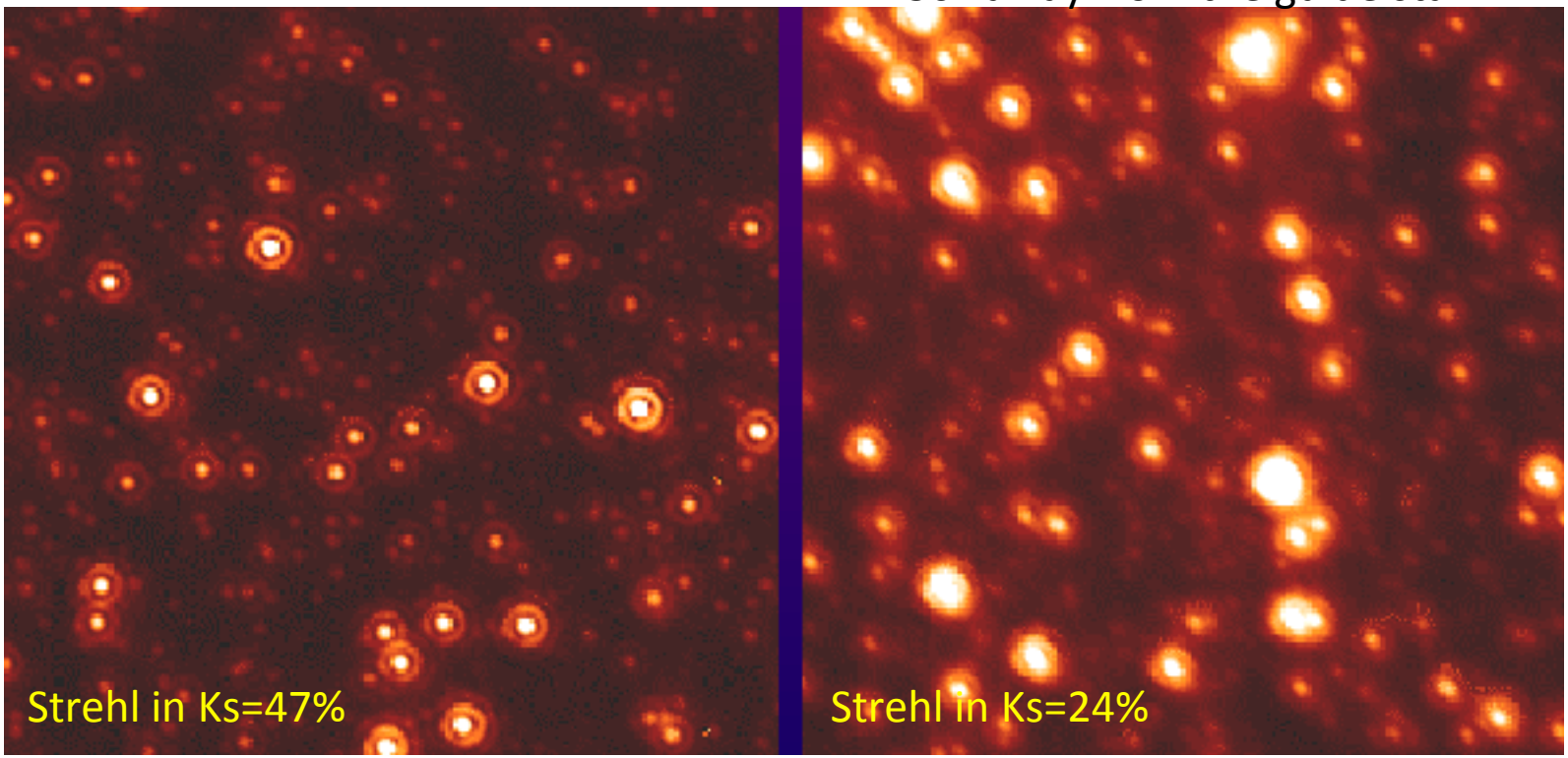
- Mass function is `well-known´ in a variety of environments but not so much in the cores of stellar clusters

Classical Adaptive Optics

The problem of anisoplanatism

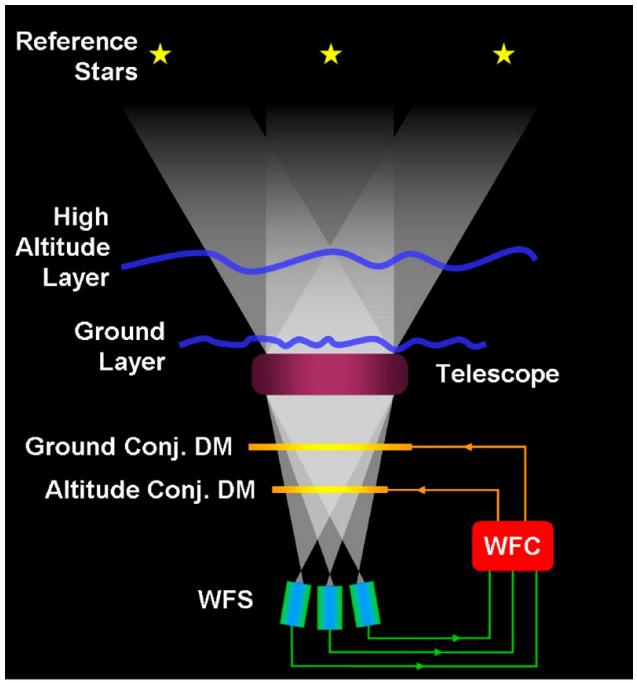
Center

30” away from the guide star



- AO works well within ~15” radius from the guide star
- Clusters are highly affected by anisoplanatism

Multi Conjugate Adaptive Optics (MCAO)



The MCAO Concept

ESO Press Photo 19c/07 (30 March 2007)

- Several reference stars (NGS or LGS)
- Several deformable mirrors
- 'Uniform' correction accross a wider FOV

What is MAD?

Multi conjugate Adaptive optics Demonstrator

- It is a prototype MCAO system in the framework of the E-ELT and the 2nd generation VLT instruments

- MAD is designed to perform wide Field of View (FoV) AO correction over 2 arcmin on the sky by using relatively bright (mv < 14) Natural Guide Stars (NGS).

- It is equipped with a 1x1 arcmin IR camera, CAMCAO

MAD observations

MAD was offered to the general community for 23 nights spread over three Science Demonstration runs between November 2007 and August 2008

- Clusters: prime targets for MAD

  Lambda Ori, Sigma Ori, NGC2362, Trapezium, Lupus

- Requirements

- 3 bright stars V < 12-13 mag within 1' radius FOV

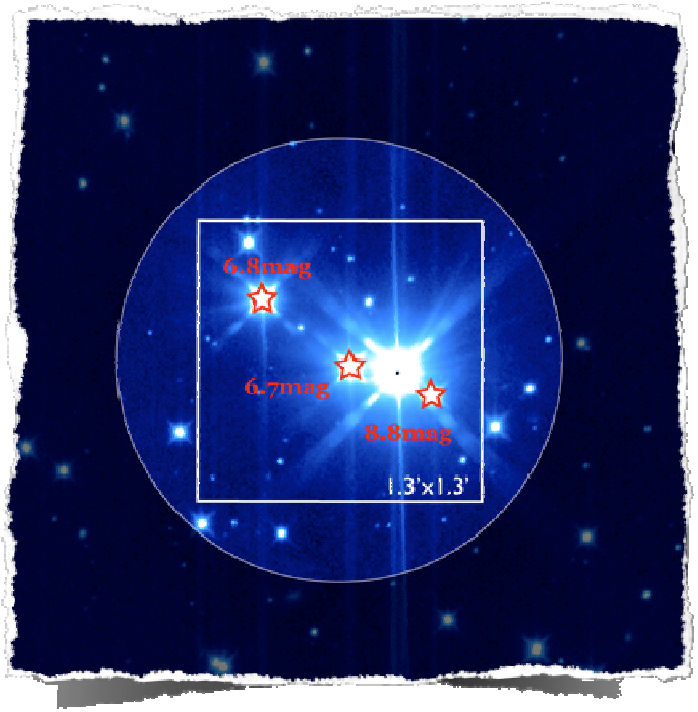
Sigma Ori

- Age: 3~5Myr
- Distance: 350pc
- 5 massives stars
- Several **isolated planetary mass objects**
- Extensively studied **except in its core**

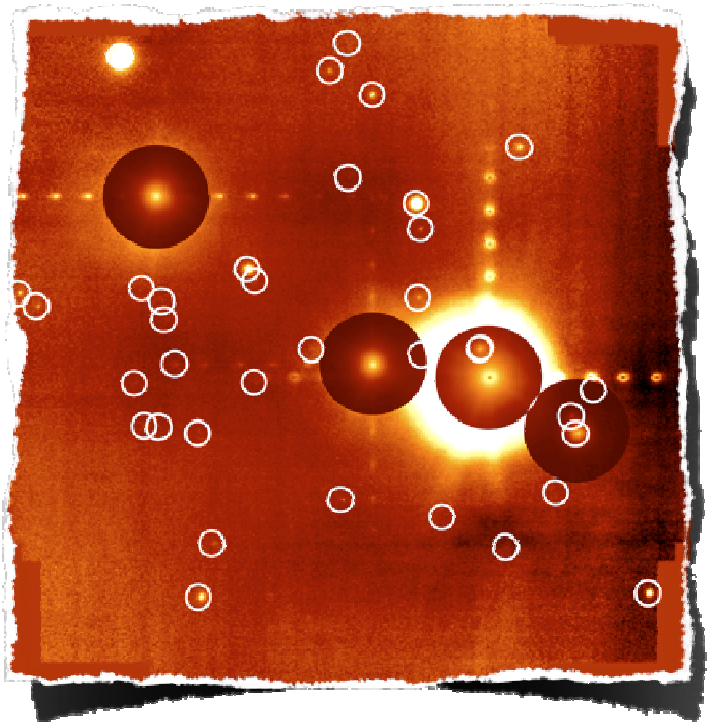
(e.g. Bejar et al. 2001, Zapatero-Osorio et al. 2002, 2008; Caballero et al. 2007, Lodieu et al. 2009)

MAD performance

MCAO field and ref. stars
(NTT/Sofi Ks-image)



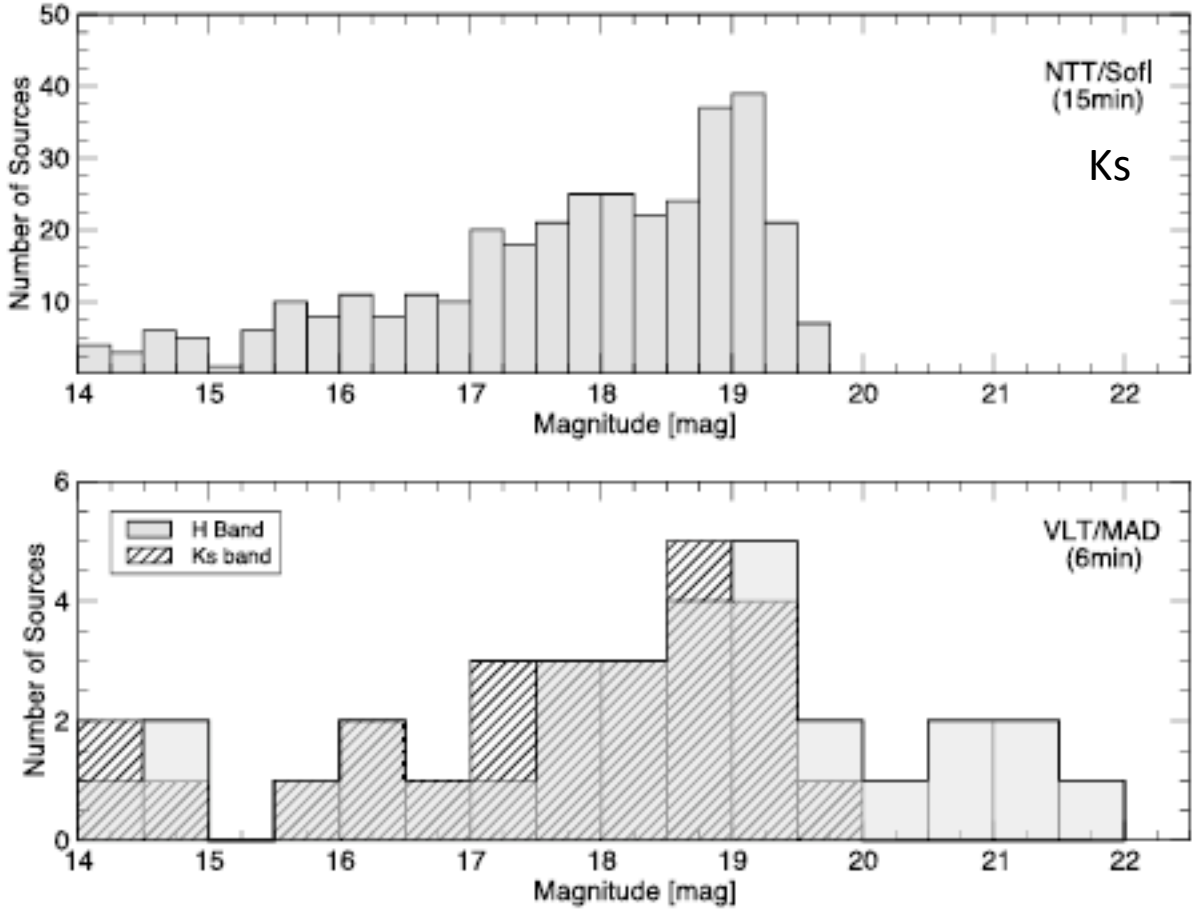
MAD Ks-image



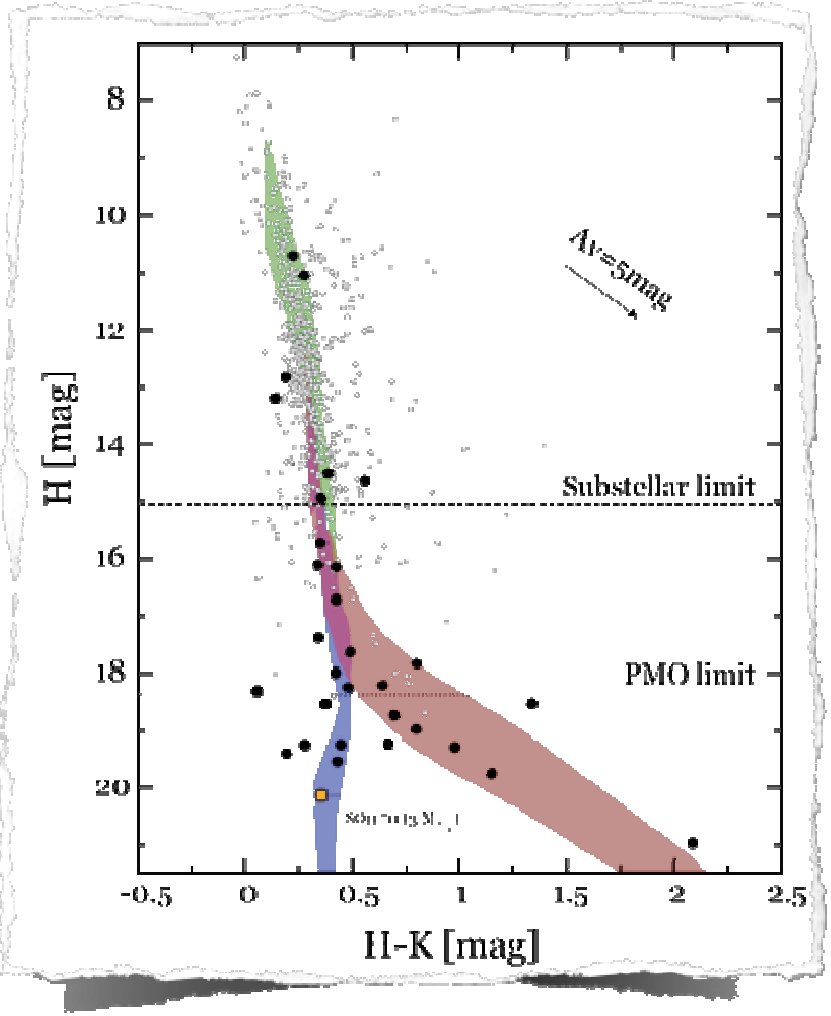
- Very bright reference stars
- Not optimal configuration (almost aligned)

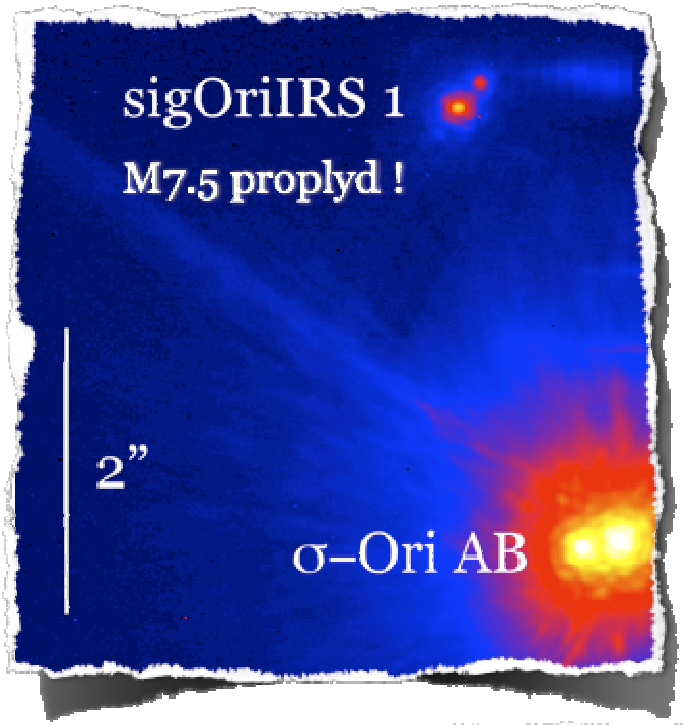
- Strehl ratios 30-45 %
- 36 detections including 30 new sources

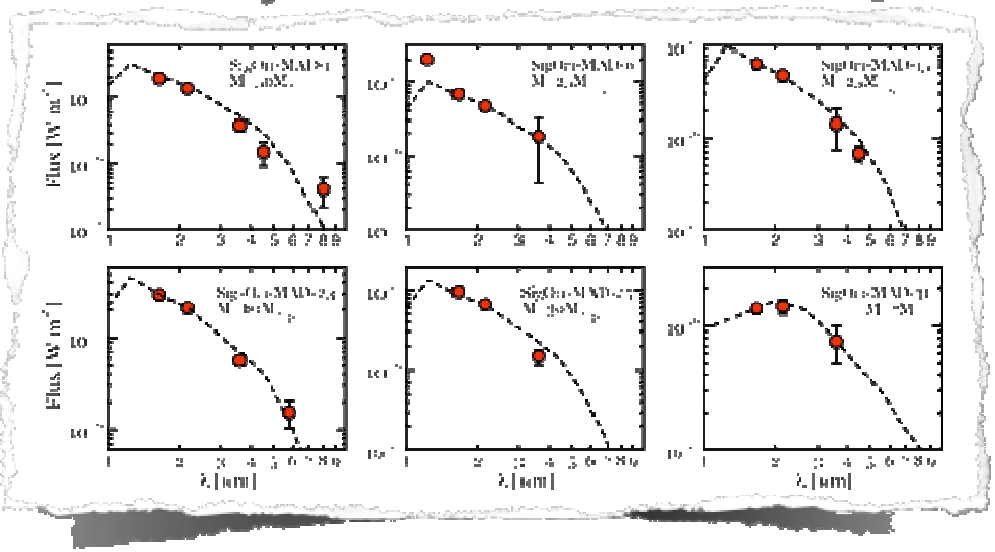
MAD performance



a few scientific highlights ...







Bouy, Huélamo, Martín et al. 2009

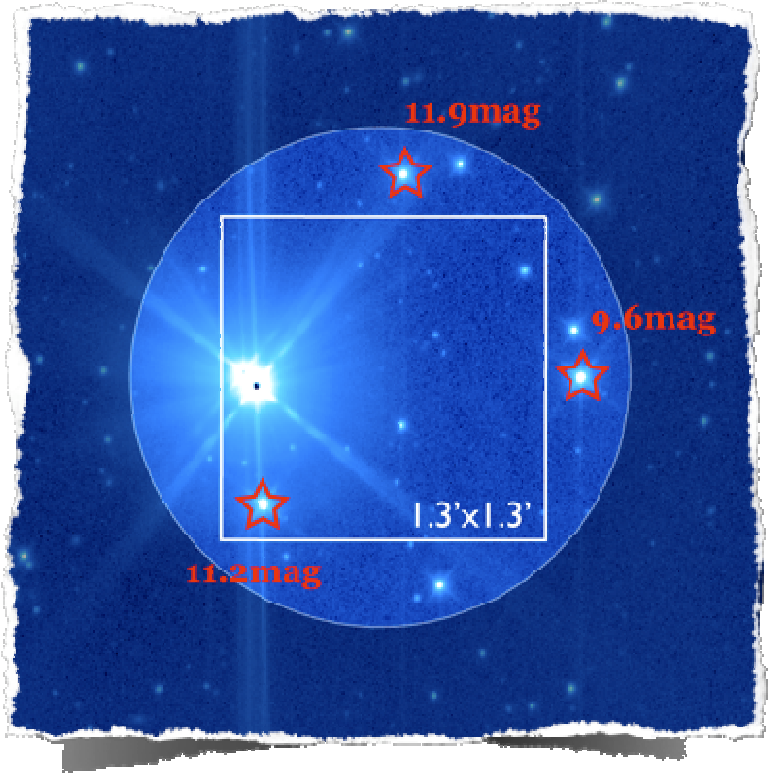
Collinder 69

- Age: 2~5Myr
- Distance: 400pc
- Located in the λ-Orionis star forming region
- Only 2 massive stars
- Numerous very low mass stars, brown dwarfs and planetary mass members

(e.g. Dolan & Mathieu 1994, Sacco et al. 2008, Barrado y Navascués et al. 2004, 2007)

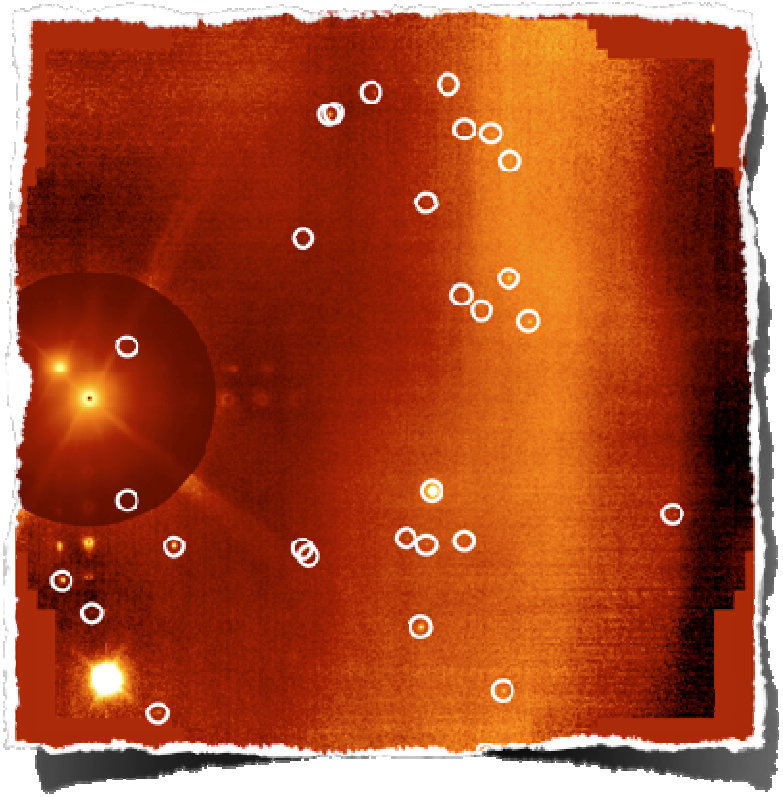
Collinder 69

MCAO field and ref. stars(NTT/SofI Ks-image)



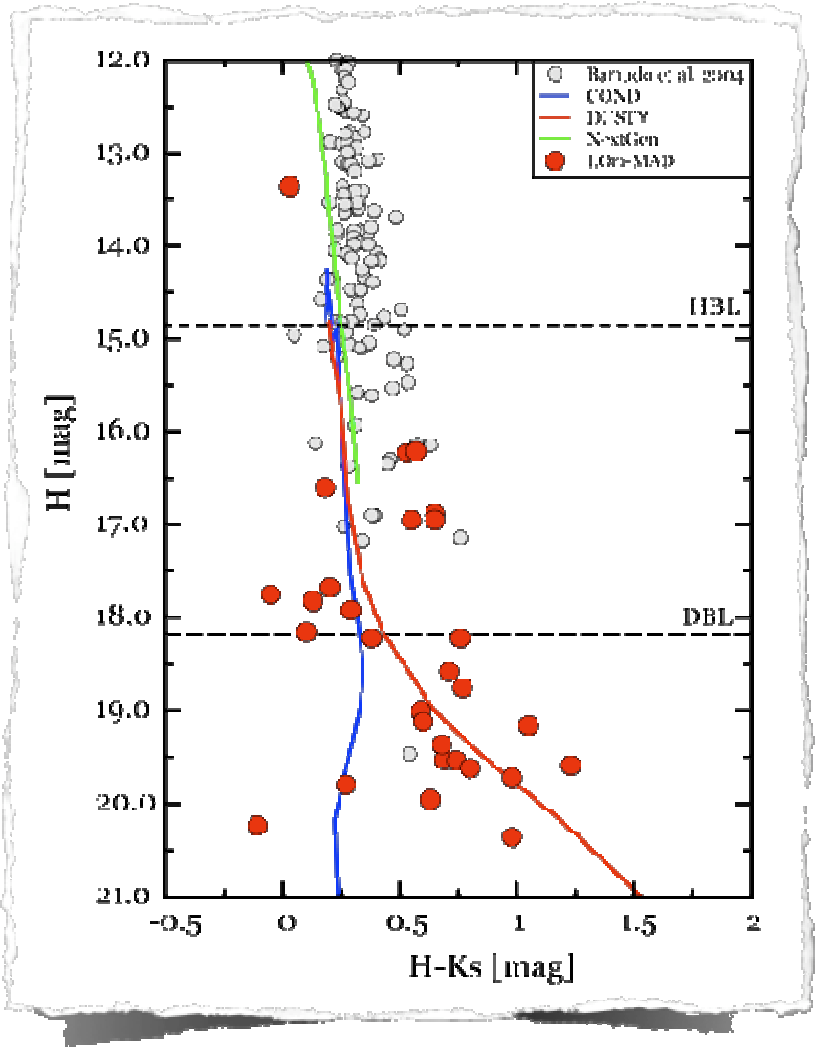
- Nice regular geometry
- but faint AO ref. stars

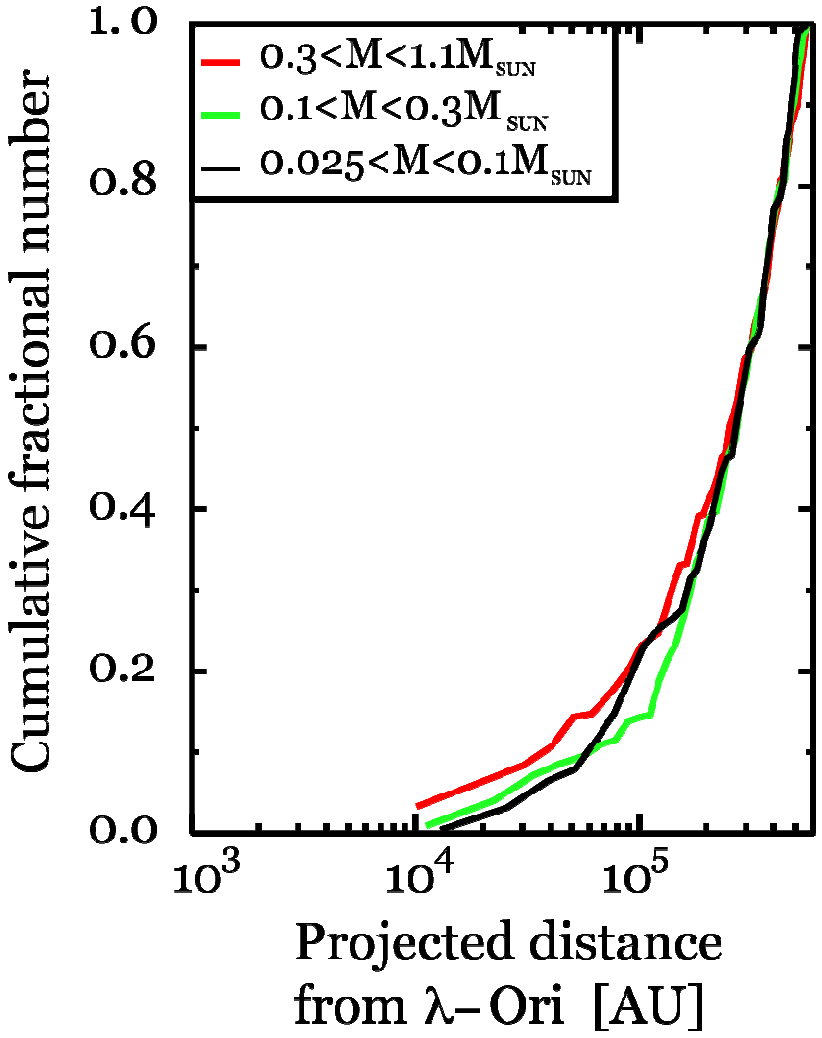
MAD Ks image



- Strehl ratio 5~25%
- FWIIM 0.09~0.12"
- 32 detections including 30 new sources

Collinder 69





Bouy, Huélamo, Barrado y Navascués et al. 2009

NGC 2362

- Age ~5 Myr

- d ~1.5 kpc

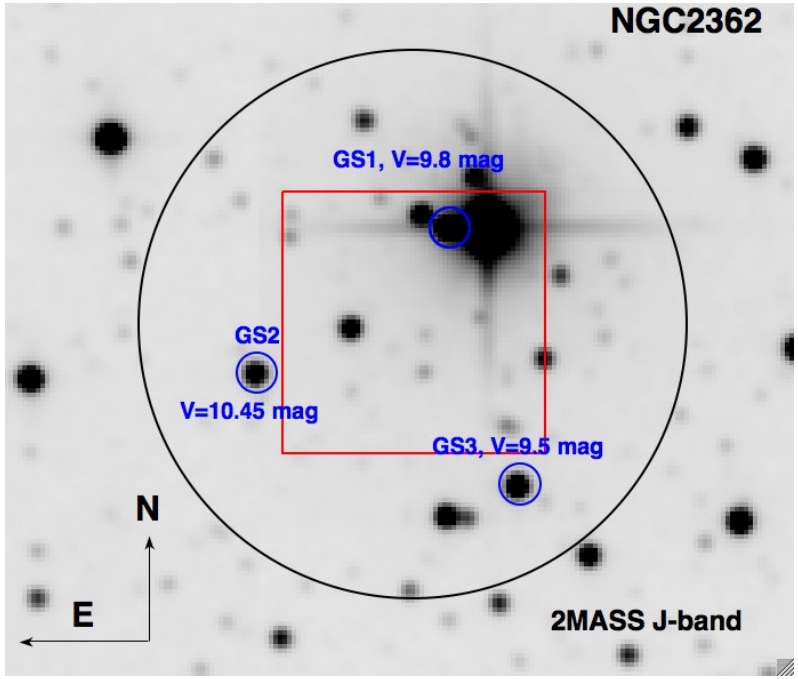
- Negligible extinction (no rest of the parental cloud)

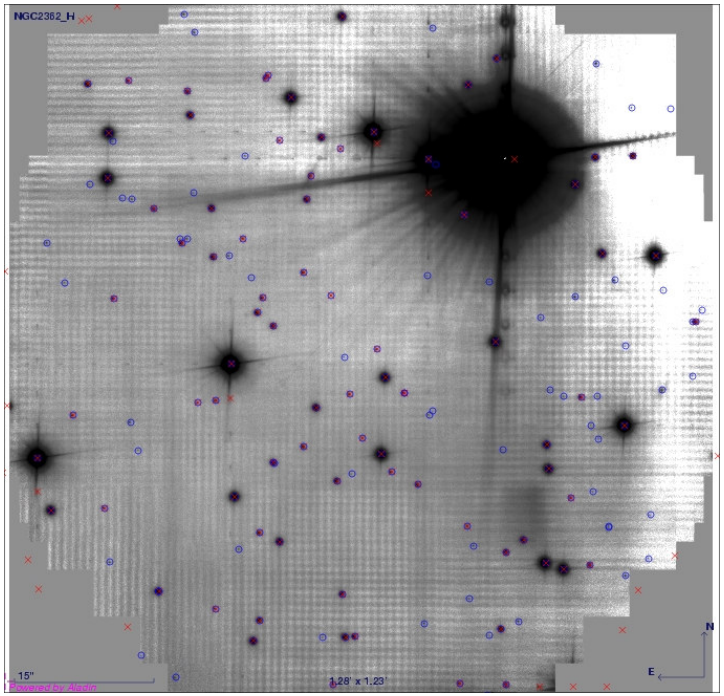
- Lack of circumstellar disks

- Strong X-ray emission

(e.g. Moitinho et al. 2001, Damiani et al. 2006, Dahm et al. 2007, Currie et al. 2009)

NGC2362

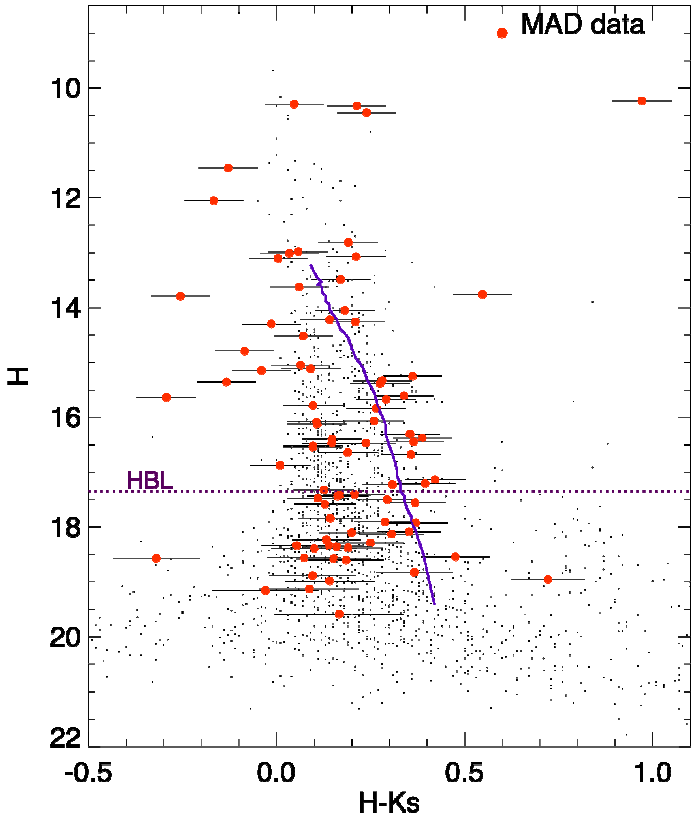




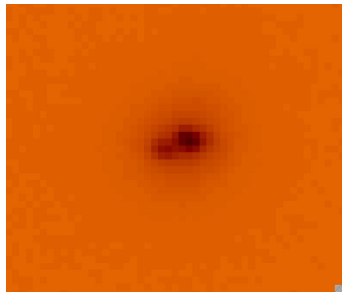
- Relatively faint objects
- Optimal configuration

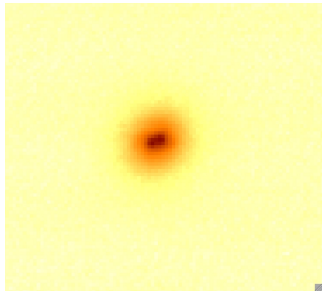
More than 150 sources detected

NGC2362



- Several substellar candidates





Several resolved binaries close to the central source

Huélamo, Moitinho, Bouy et al, in prep.

MCAO?

SOUTH

- ESO: GLAO (2013)
- Gemini MCAO system (GeMS): first light 2010

NORTH

- NO MCAO at the GTC
- NGAO/Keck will be ready at 2015 at best

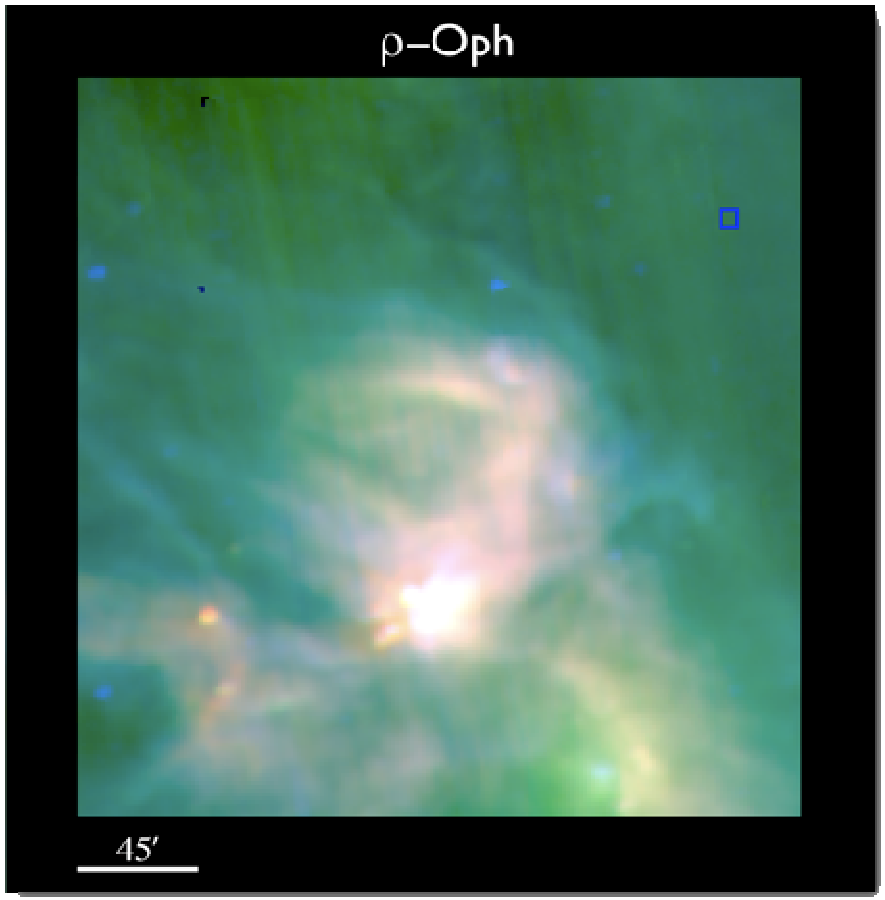
What can we do until 2015?

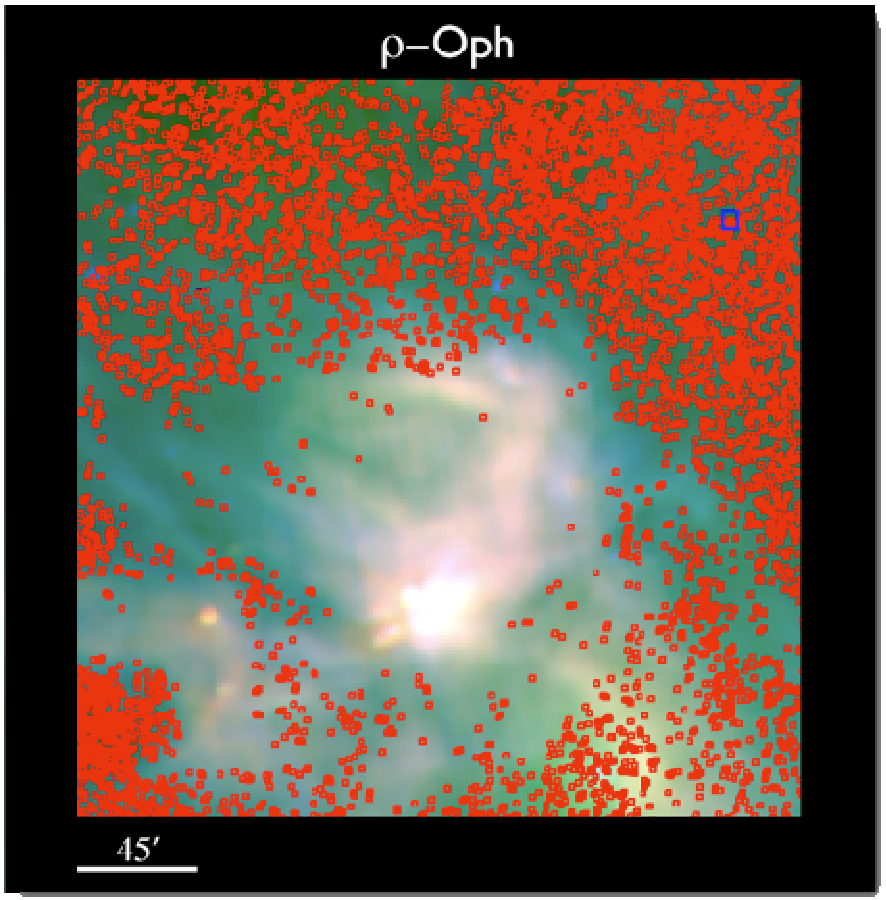
What about mounting MAD at the GTC?

- MAD is built, commisioned and ready to use
- GTC Visitor Instrument program

MAD/GTC will allow MCAO studies until the Keck system is ready.
It will the the first MCAO system to explore the Northern hemisphere.

MAD vs MAD-MAX





V=17 mag (MAD-MAX)