KU LEUVEN

MULTIPLICITY CONSTRAINTS FROM DIRECT IMAGING OF MASSIVE BINARIES

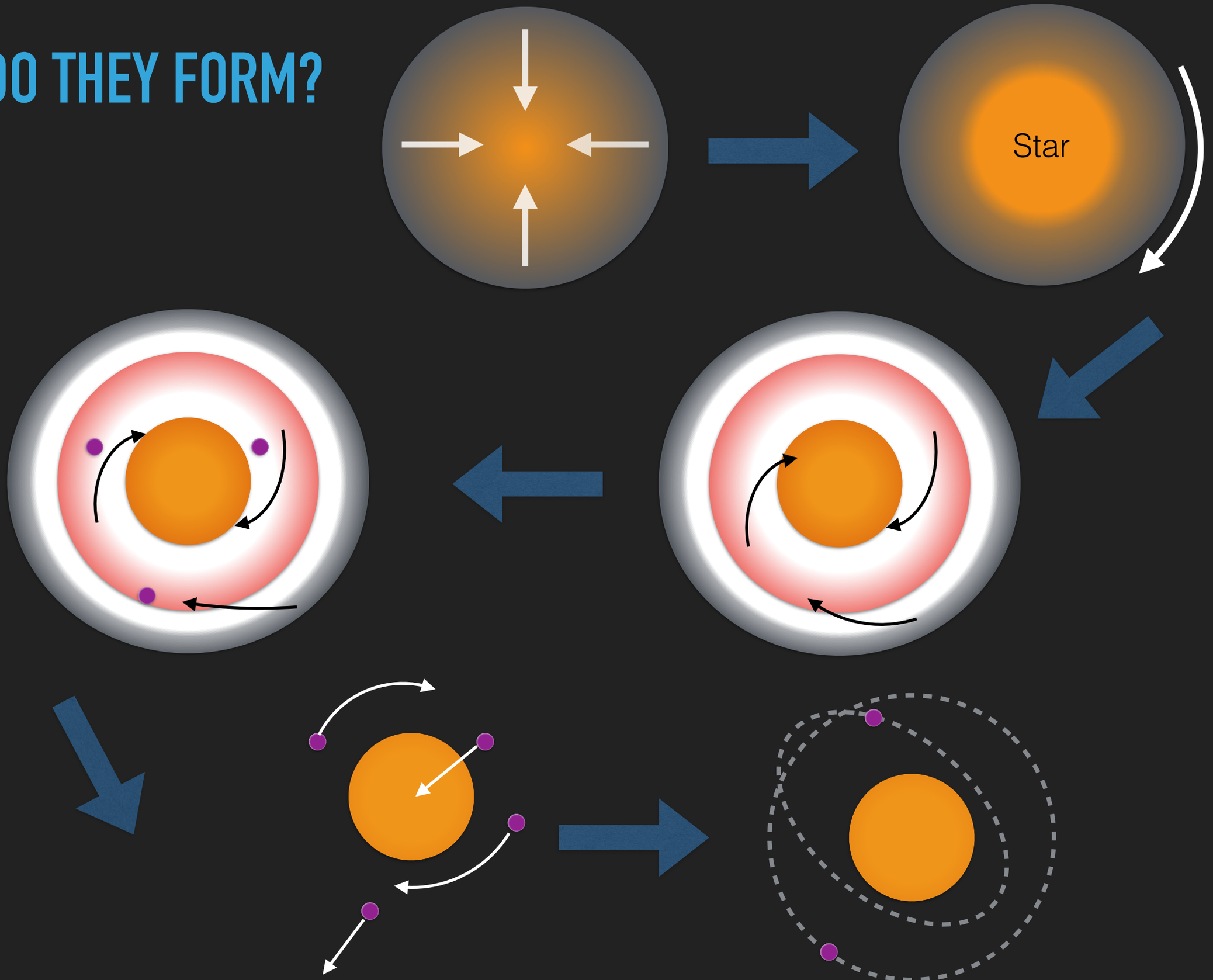
MADDALENA REGGIANI, ALAIN RAINOT, HUGUES SANA ET AL.

MULTIPLICITY CONSTRAINTS FROM DIRECT IMAGING OF MASSIVE BINARIES

WHY?

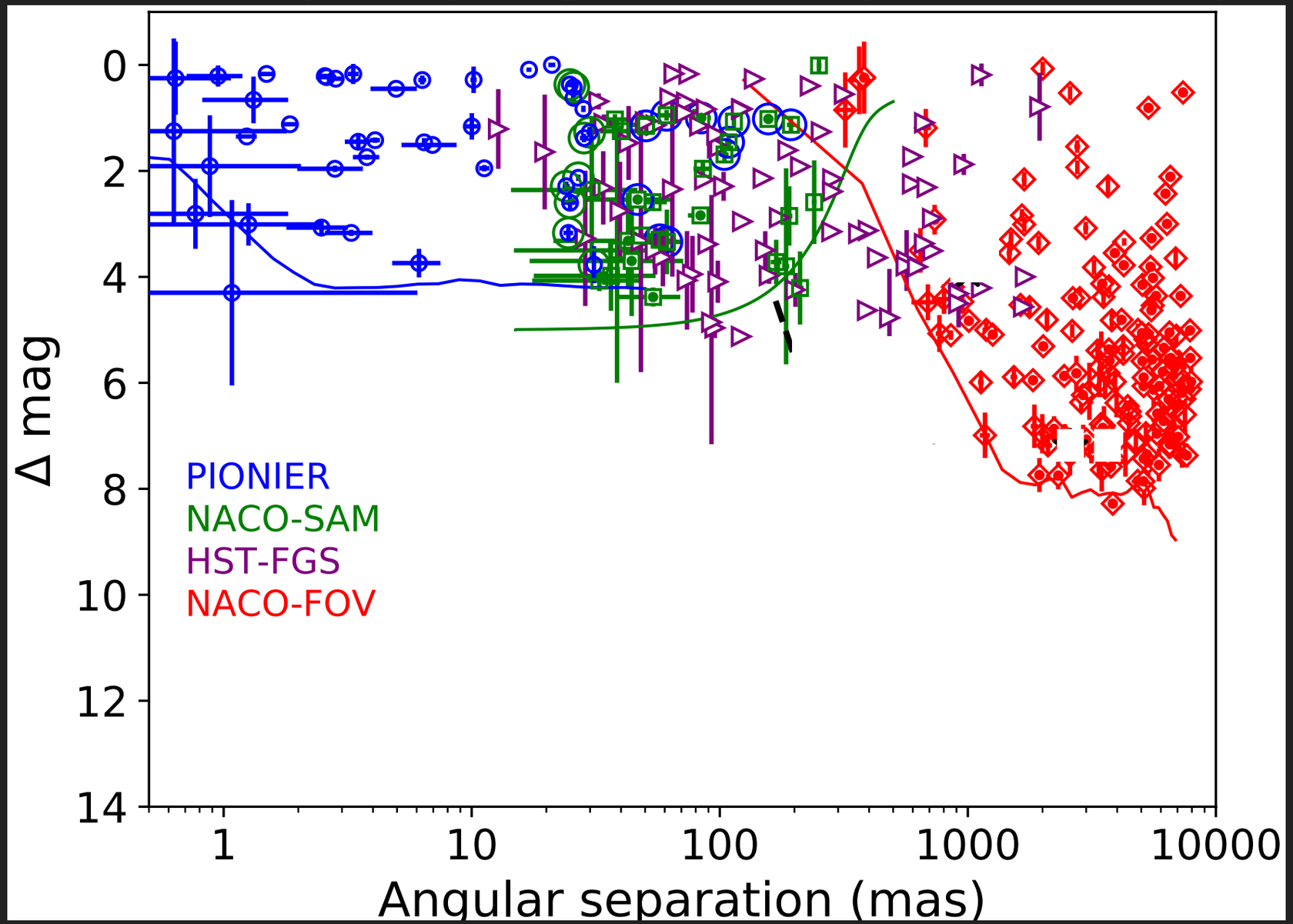
- Why binaries?
- Why massive stars?
- Why massive binaries?

HOW DO THEY FORM?

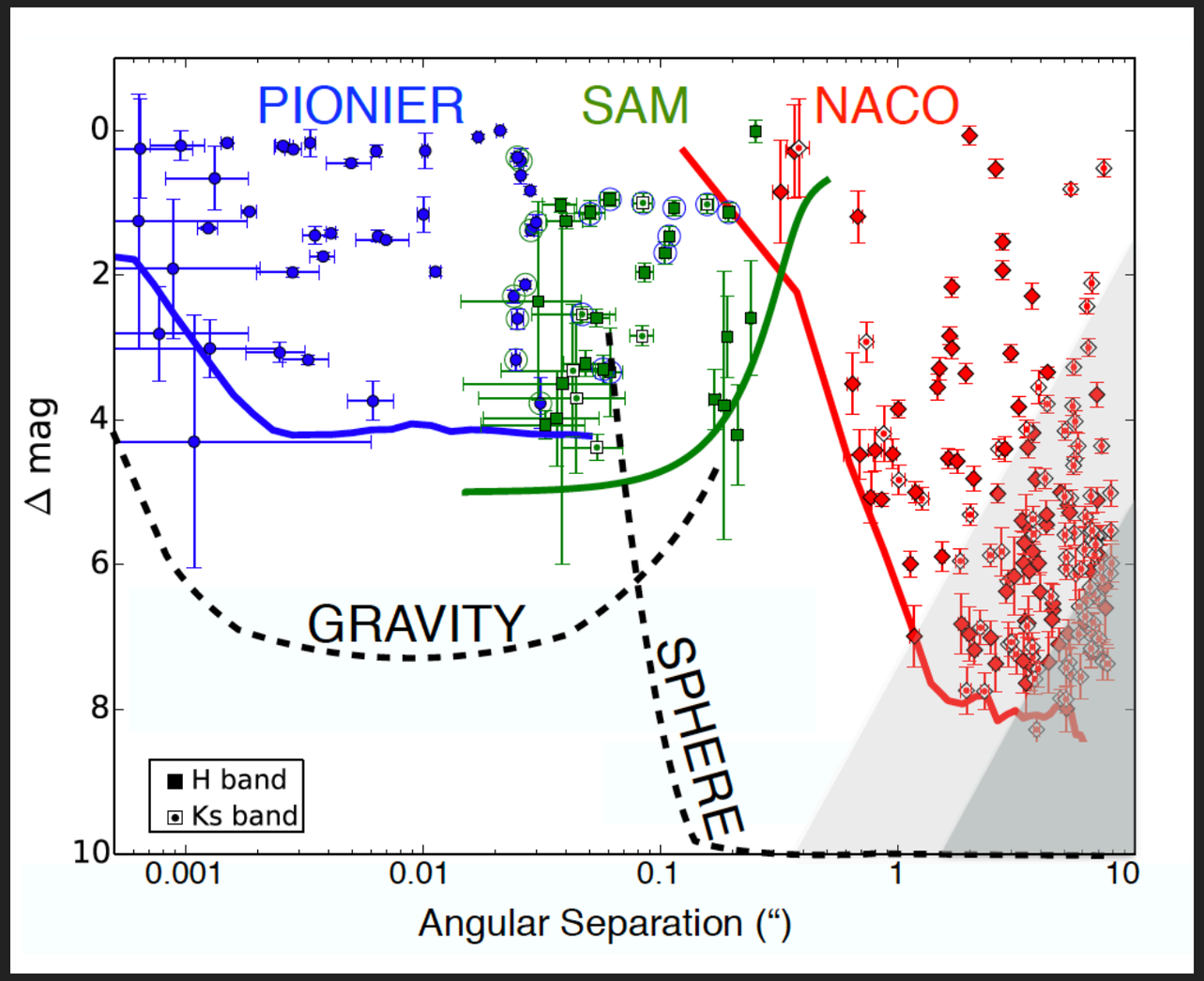


MASSIVE STARS LIKE COMPANY

SMaSH+ (Sana+,2014) & HST-FGS (Aldoretta+,2015)



HIGH-CONTRAST IMAGING OF MASSIVE BINARIES



SMaSH+ (Sana et al.,2014)

VLT/SPHERE with IRDIS (K1+K2, 0.95-2.32 μm) & IFS (YJK, 0.95-1.75 μm)

Beuzit et al. 2008

+

Observing strategy: Angular Differential Imaging mode

Marois et al. 2006

+

Adeguate Image post-processing techniques e.g. VIP (Vortex Image Processing Package)

Gomez Gonzalez et al. 2017

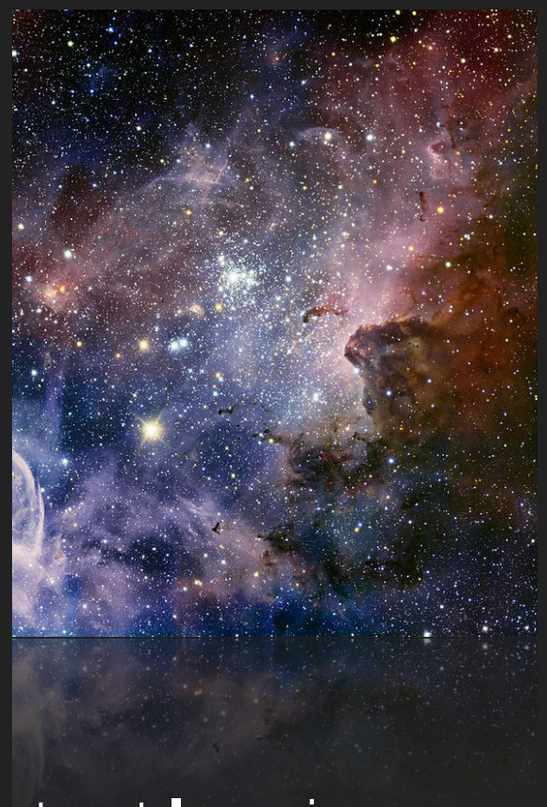
CHIPS AND THE OTHER SURVEYS

- CHIPS:

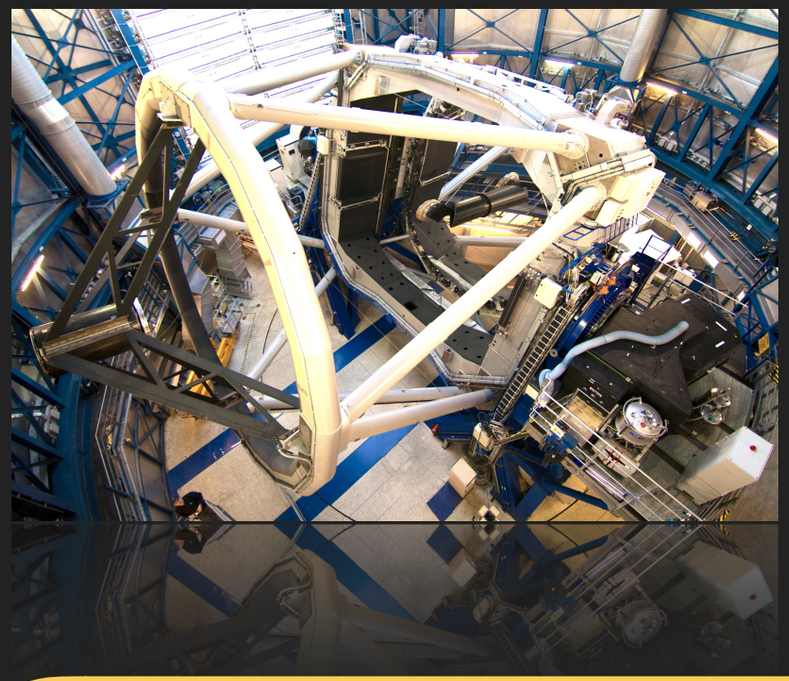
Carina

High-contrast **I**maging

Project of massive **S**tars



close massive star region



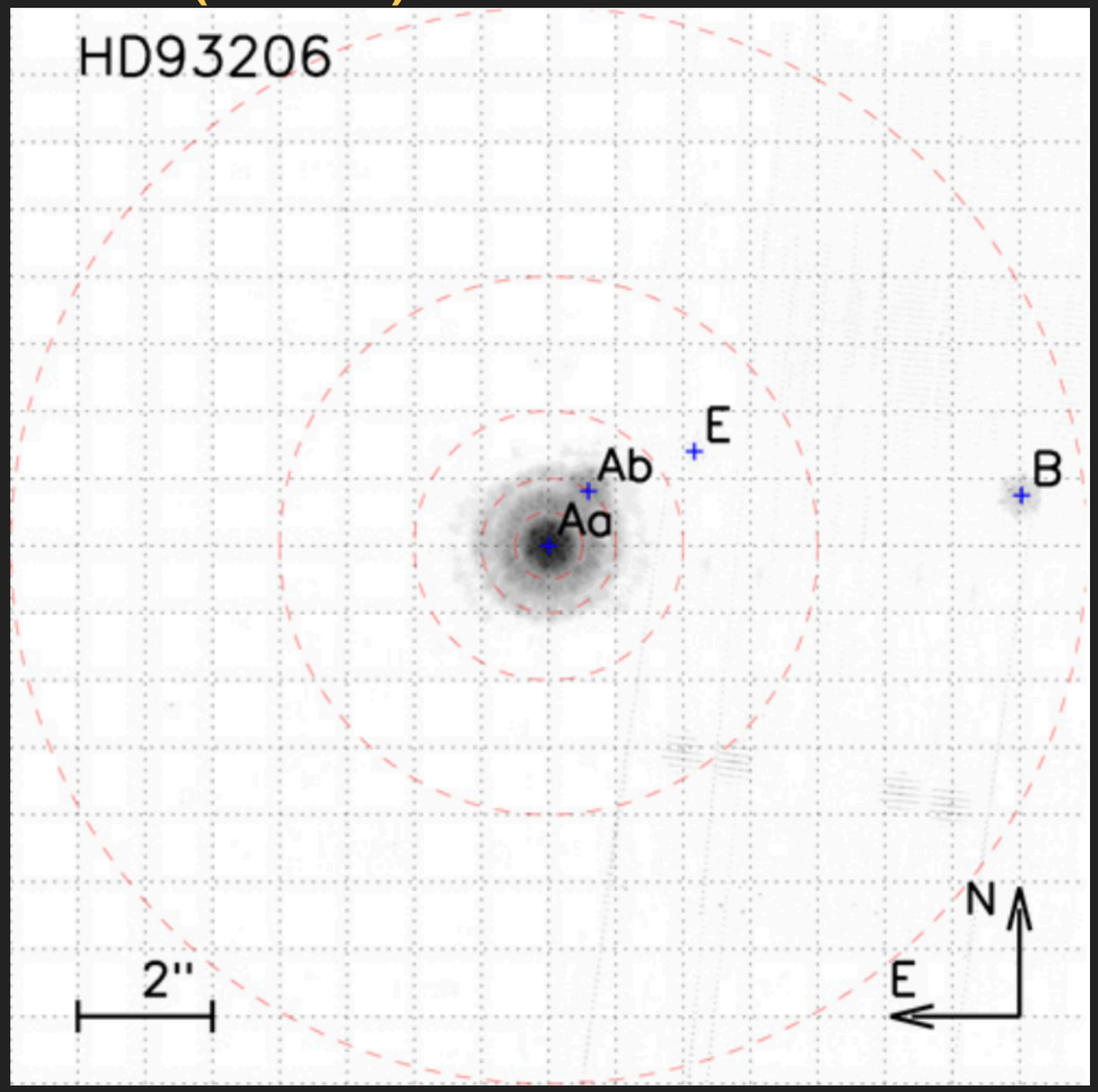
VLT/ SPHERE in IRDIFS mode

Multiplicity properties of 93 massive O-type and WR stars

faint and low-mass companions

QZ CAR: SMASH – VLT/NACO

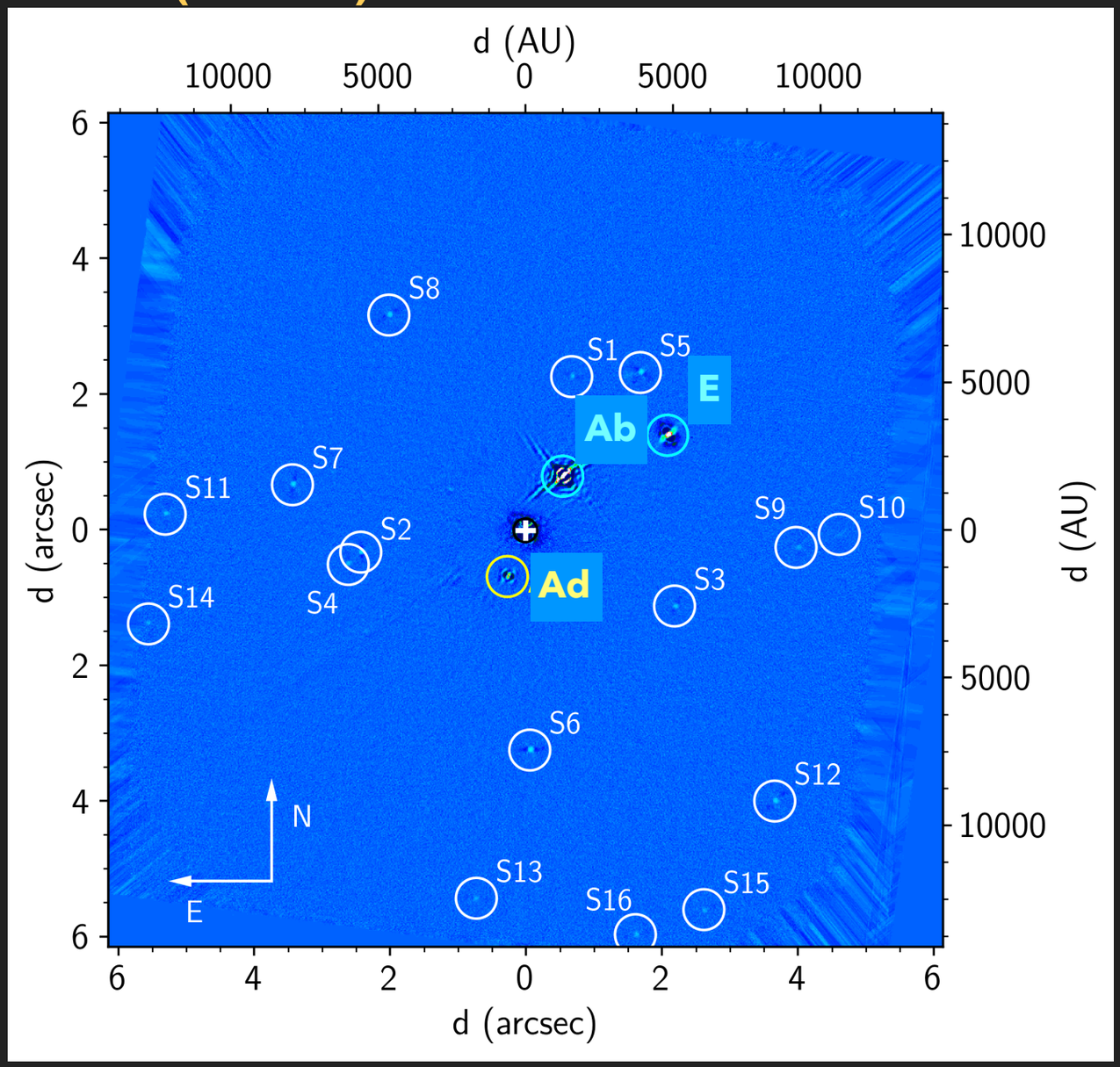
NACO (H band)



SMaSH+ (Sana et al.,2014)

QZ CAR: IRDIS & IFS FINAL REDUCED IMAGES

IRDIS (K1+K2)



(Rainot, Reggiani et al., submitted)

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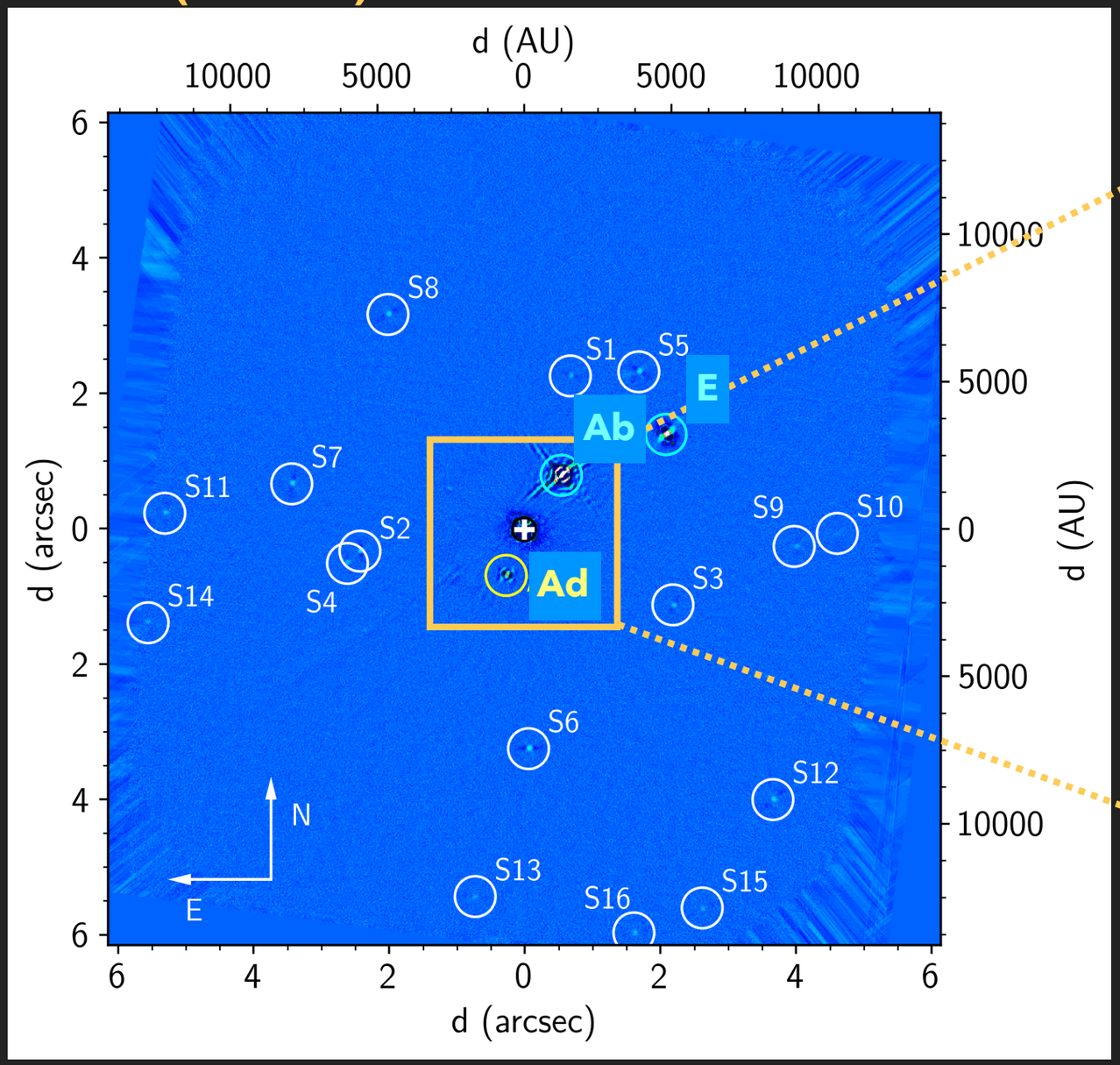
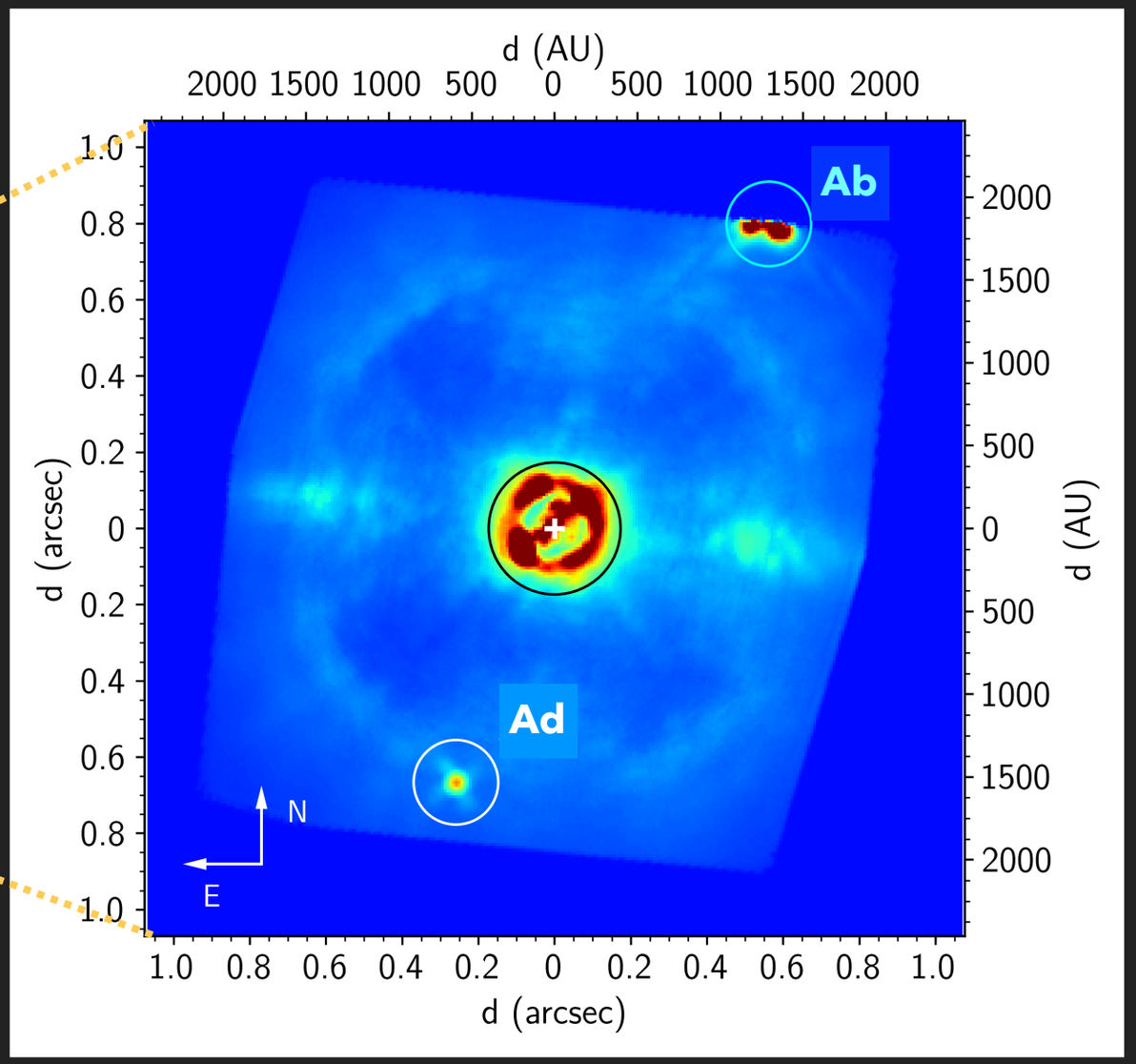
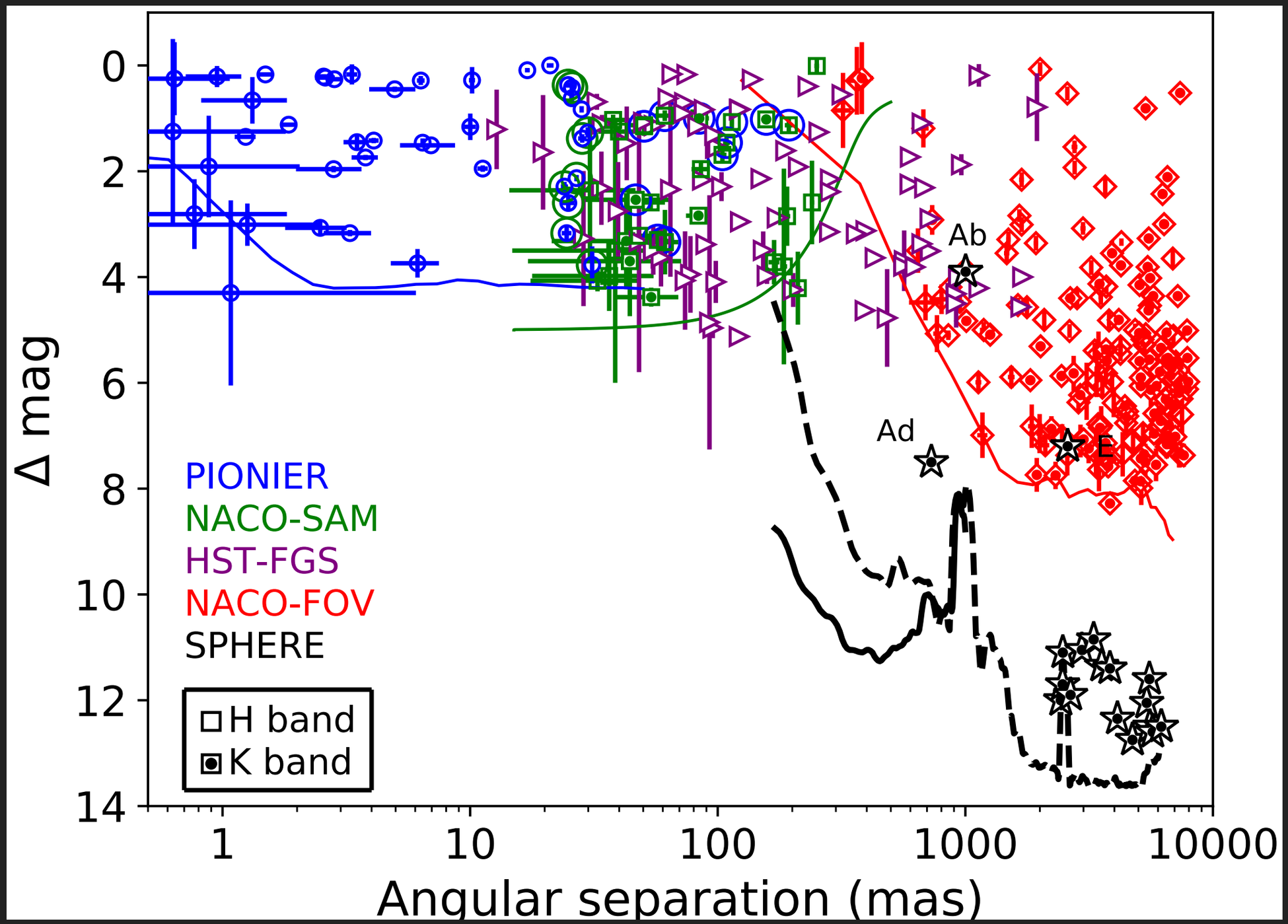


IFS



(Rainot, Reggiani et al., submitted)

VLT/SPHERE DISCOVERY SPACE



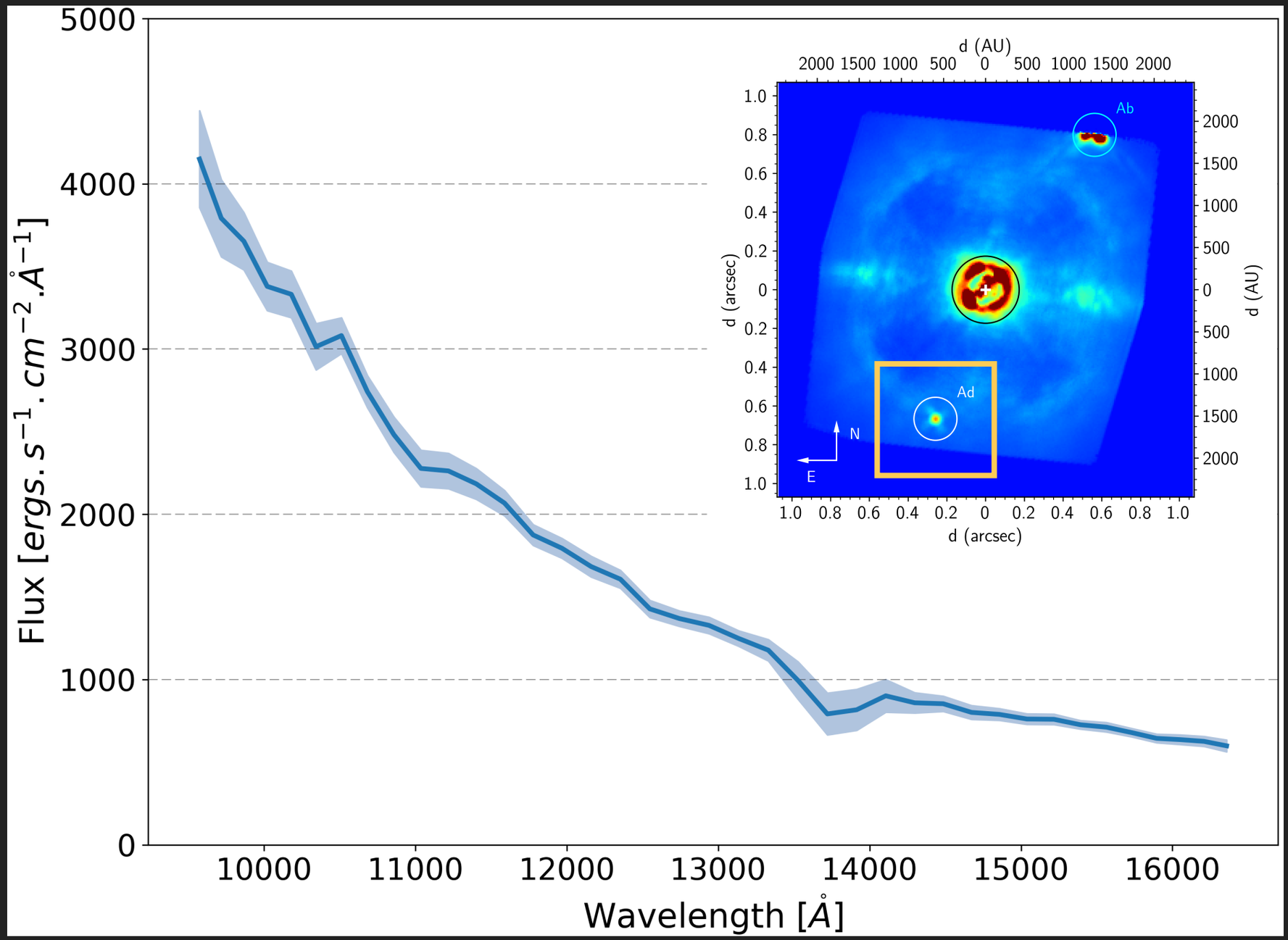
We would be sensitive to sub-solar companions

(Rainot, Reggiani et al., submitted)

FLUX-CALIBRATED SPECTRUM OF QZ CAR AD

We modeled the spectrum of the central 4 stars with FASTWIND

(Puls et al. 2005; Rivero-González et al. 2011)



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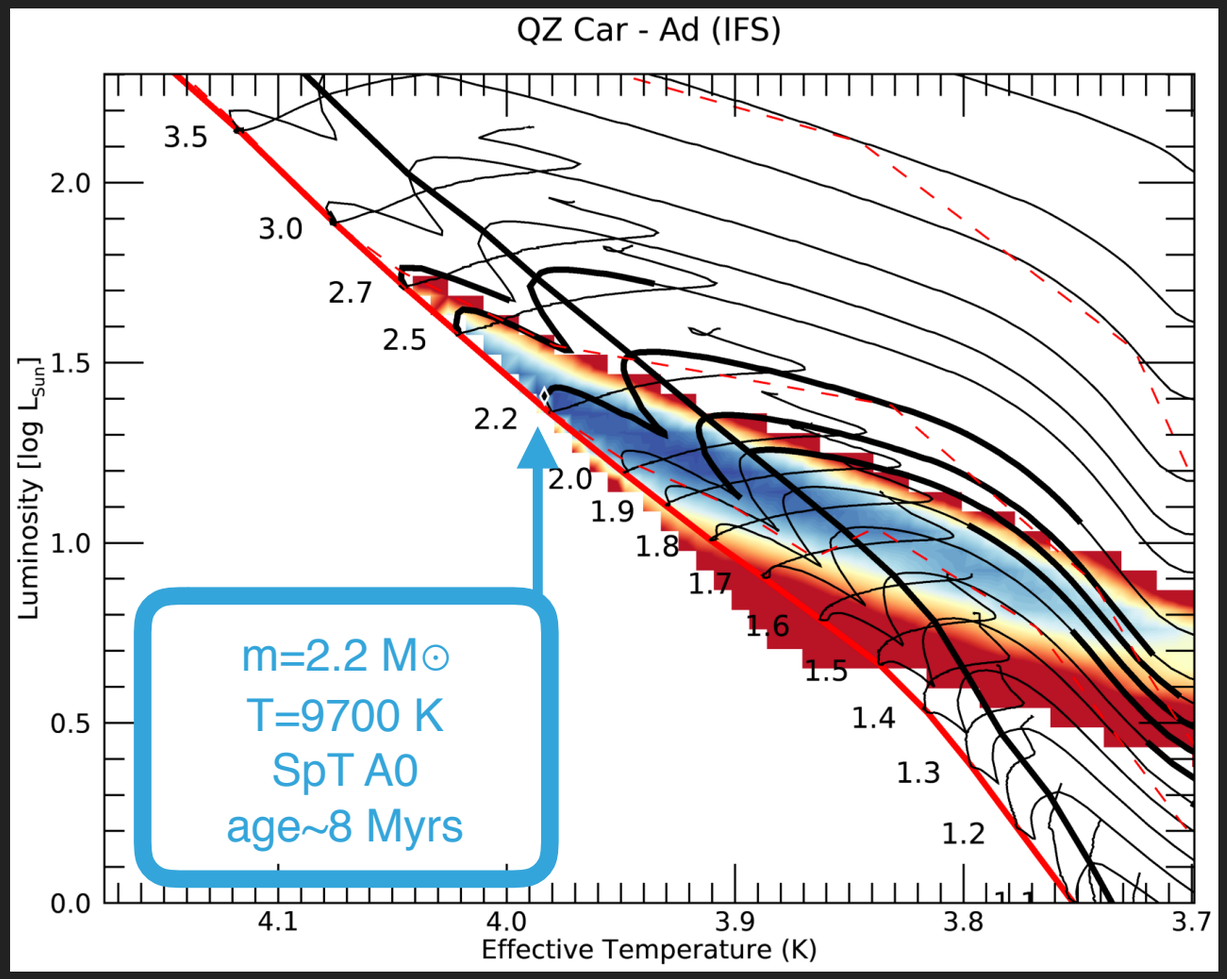
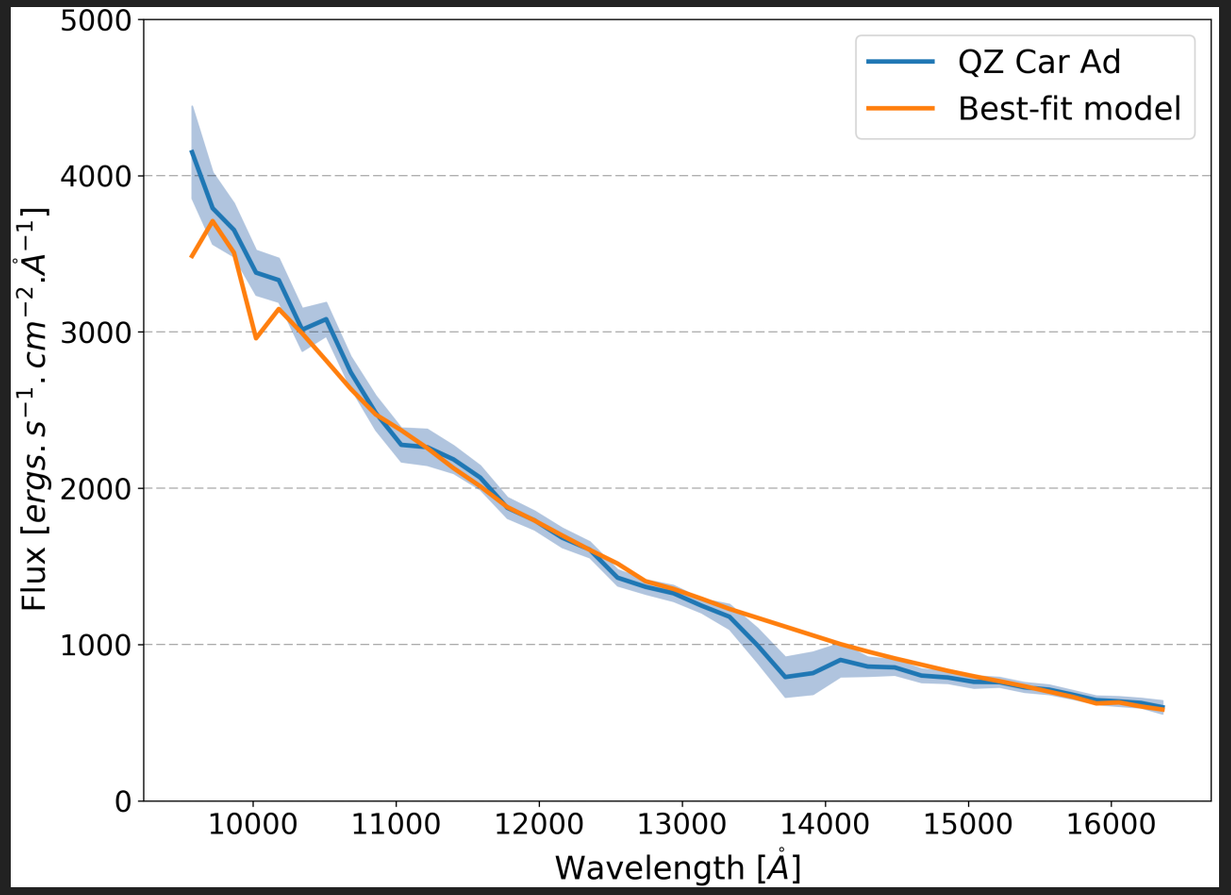
BEST FIT MODEL FOR QZ CAR AD



ATLAS9 atmosphere models (Castelli & Kurucz 2004)

+

Siess et al. 2000 PMS isochrones/ evolutionary tracks



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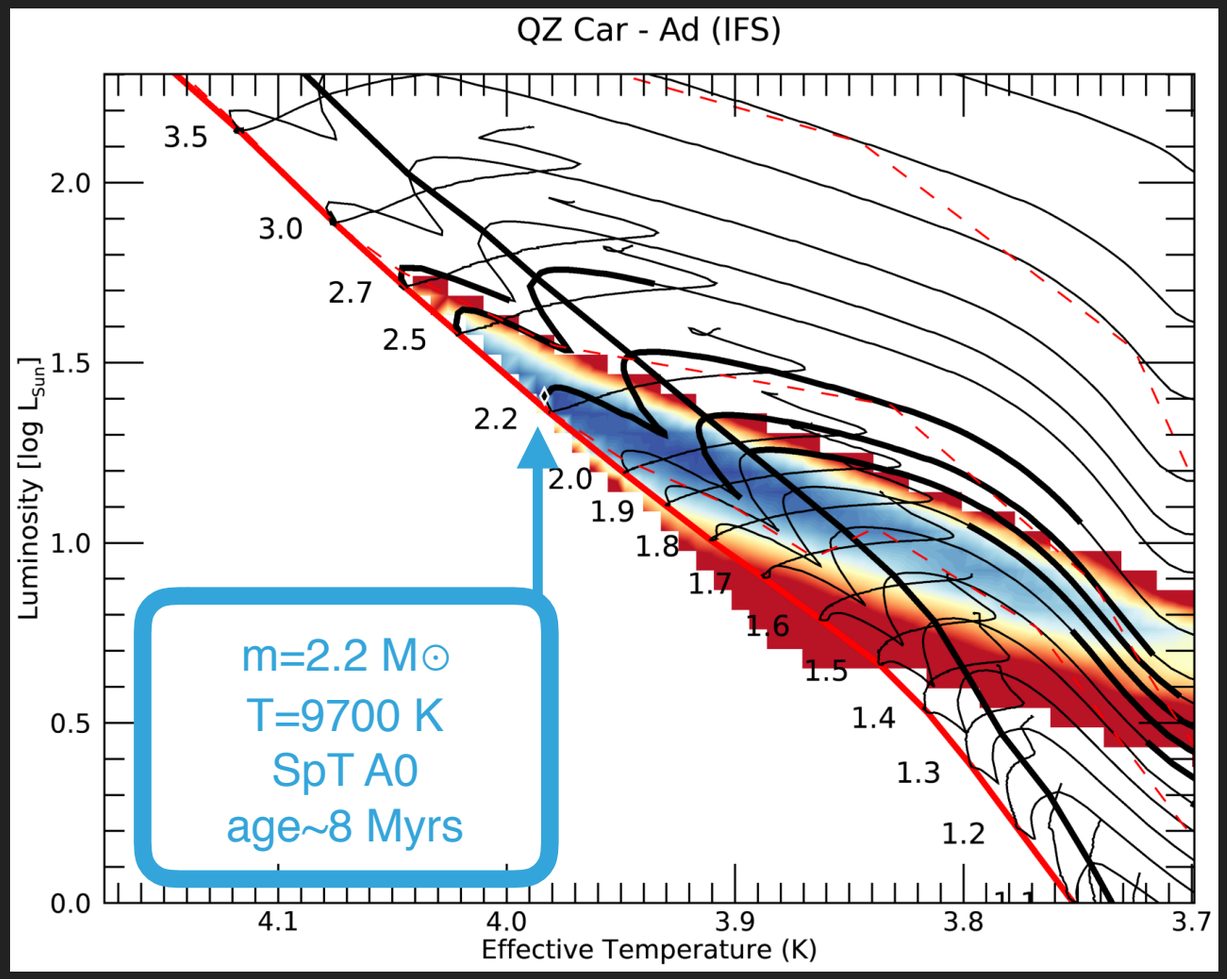

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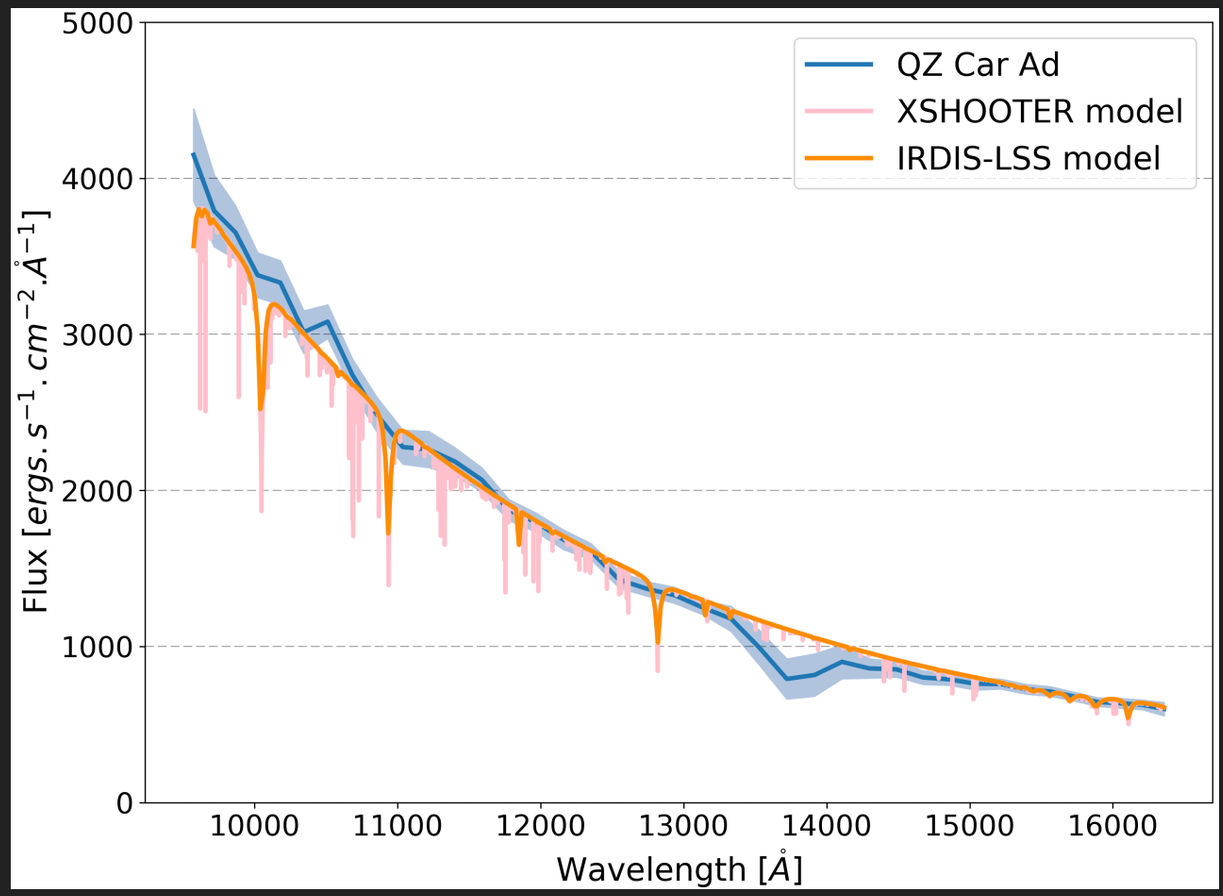
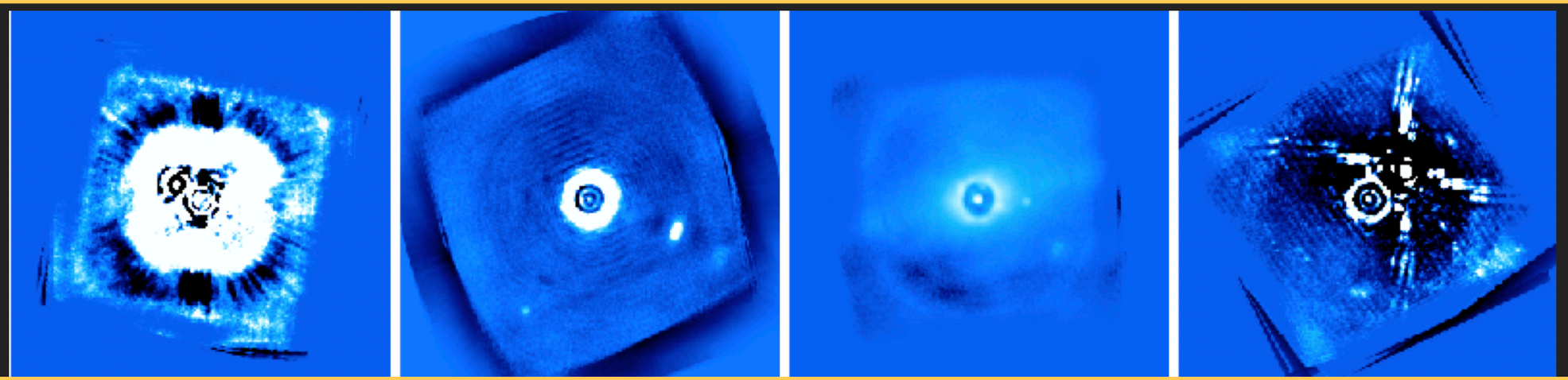


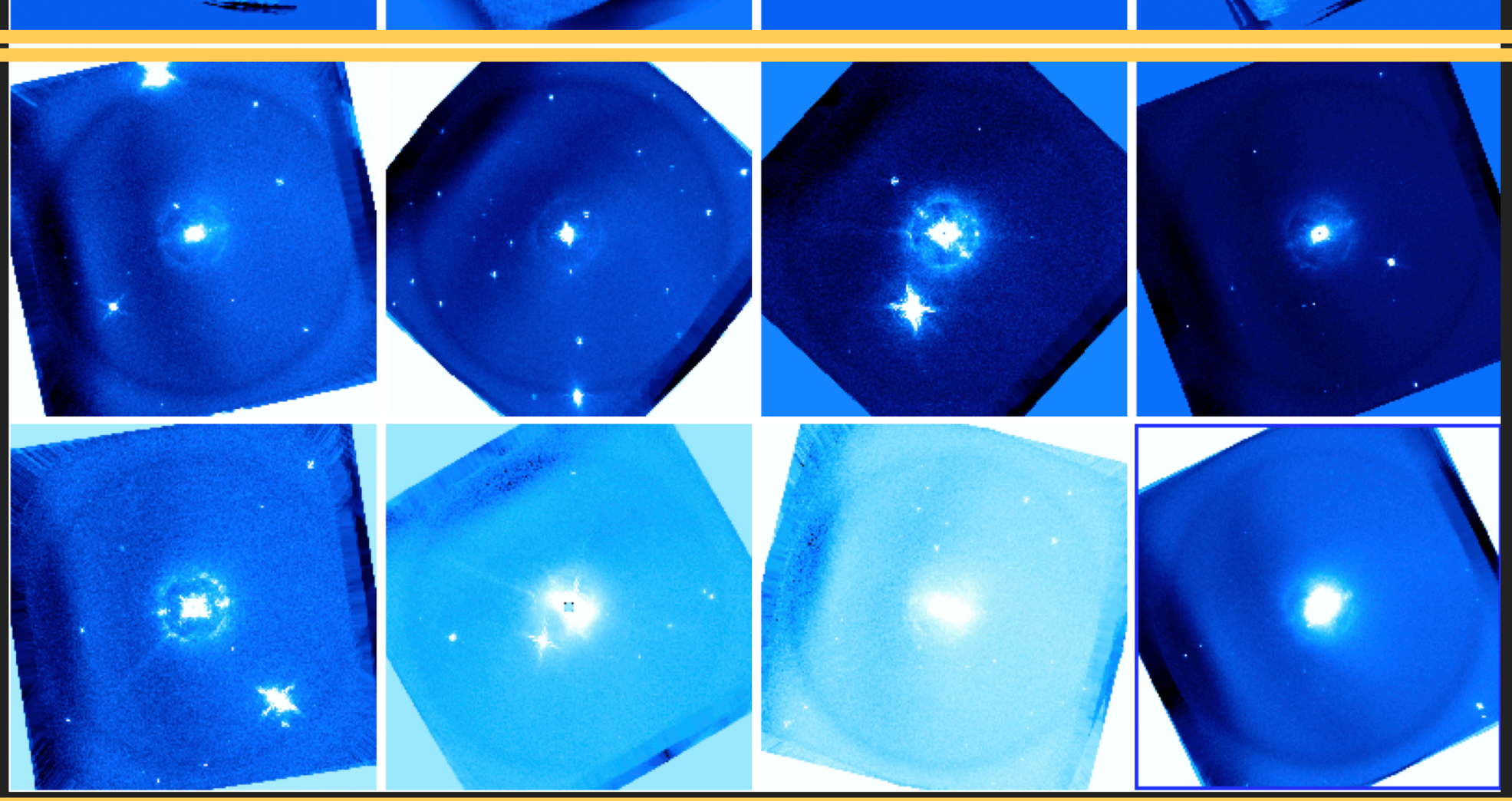
(Rainot, Reggiani et al., submitted)

THIS IS JUST THE BEGINNING...

IFS



IRDIS



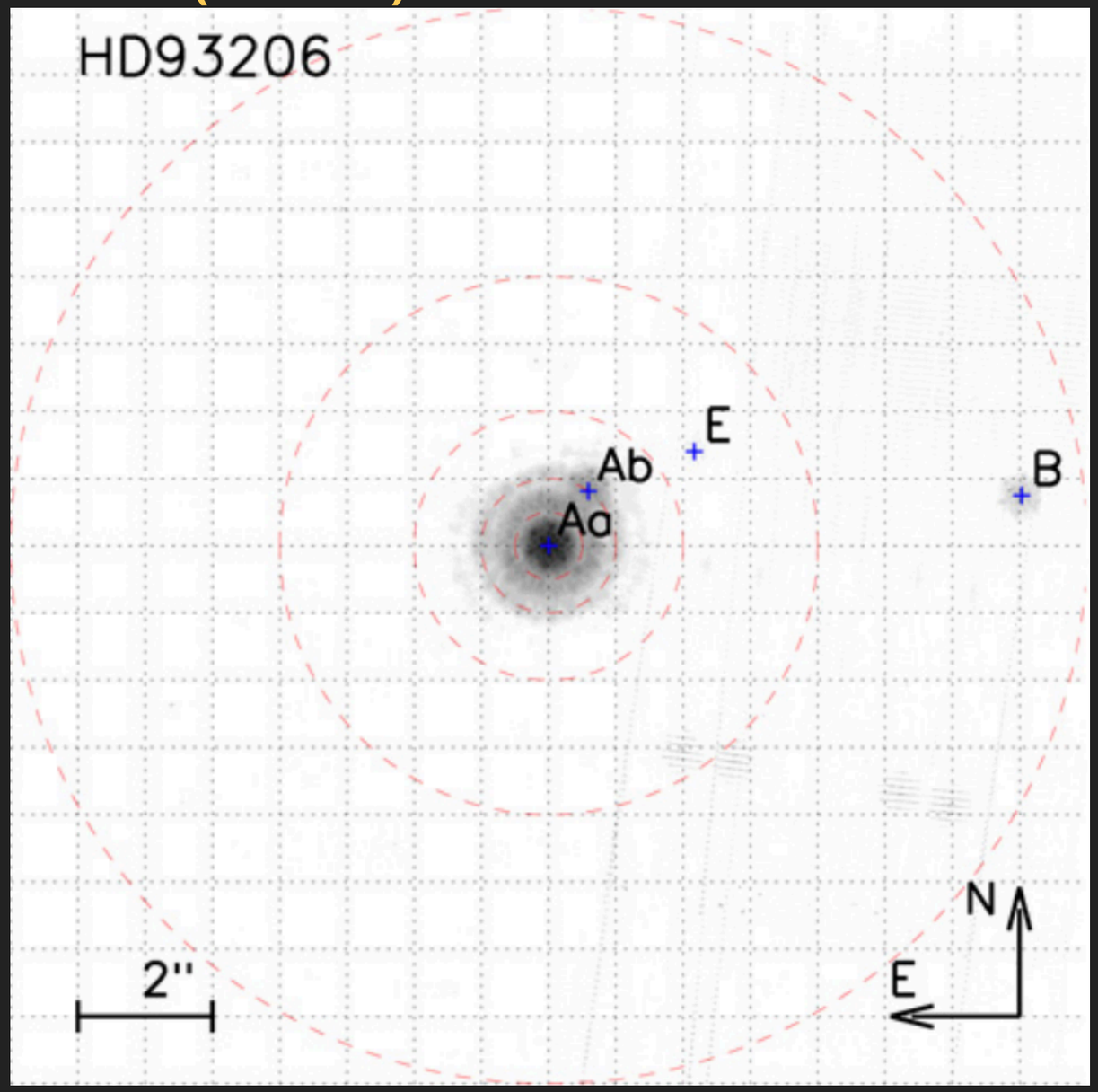
CONCLUSIONS AND FUTURE PERSPECTIVES

- SPHERE is opening a new parameter space to investigate the presence and physical properties of faint companions
- QZ car: it likely has 3 physical companions (Ab, Ad and E), that can be fitted with ages of 4 to 8 Myr, i.e. their formation is potentially contemporaneous to that of the inner quadruple
- Multiplicity constraints for O-type stars in the Carina regions will soon be available…
- We have ongoing campaigns to study the multiplicity of O-type stars in older clusters, loose associations and field stars…

THANK YOU!

QZ CAR: SMASH – VLT/NACO

NACO (H band)



Aa1,Aa2
(O9.7 I + B2 V)
P = 20.7 days

Aa3, Aa4
(O8 III + O9 V)
P = 6.0 days

visual companions at 7”.3 (A,B) and 8”.8 (A,C)

1” separation companion (Aa,Ab)

SMaSH+ (Sana et al.,2014)