Optical Interferometry, Current and Future capabilities

J.-P. Berger

VLTI Programme Scientist

Three facilities in operation

VLTI

4 x 8 m UT
4 x 1.m AT
Bmax = 160m

Instruments:

PIONIER: 4T (H, R~40)
AMBER: 3T (H,K, R ~12000)
MIDI: 2T (N R~ 300)

Midi decommissioned
Closed for P95

CHARA

6 x 1 m Telescopes

Bmax = 330m

Instruments:

CLIMB: 3T (H, K, R~5)
MIRC: 4-6T (H,K, R ~40)
PAVO: 3T (R R~ 100)
VEGA: 3T (B,V,R ~1500 - 30000)

NPOI

6 x 0.12 Siderostats
(+ 4 1x1.8 Keck O?)
Bmax = 79m (437m)

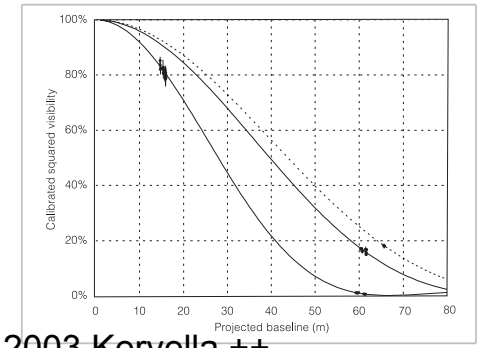
Instruments:

V,R: 4-6T, R ~ 80

ACHIEVEMENTS

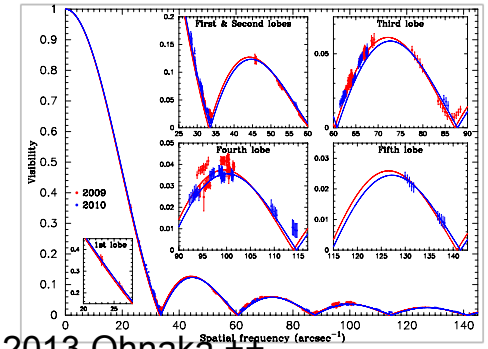
Exquisite constraints on stellar surfaces

VINCI



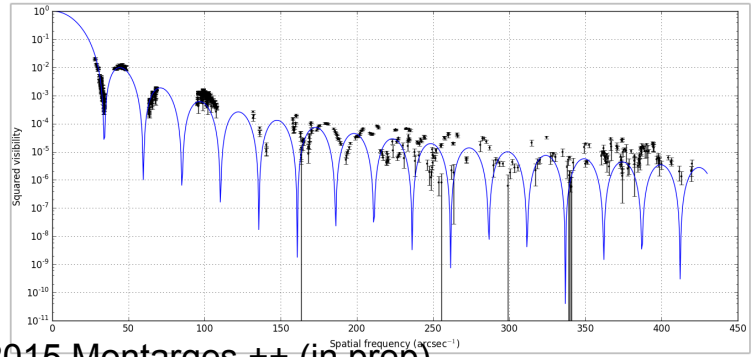
2003 Kervella ++

AMBER



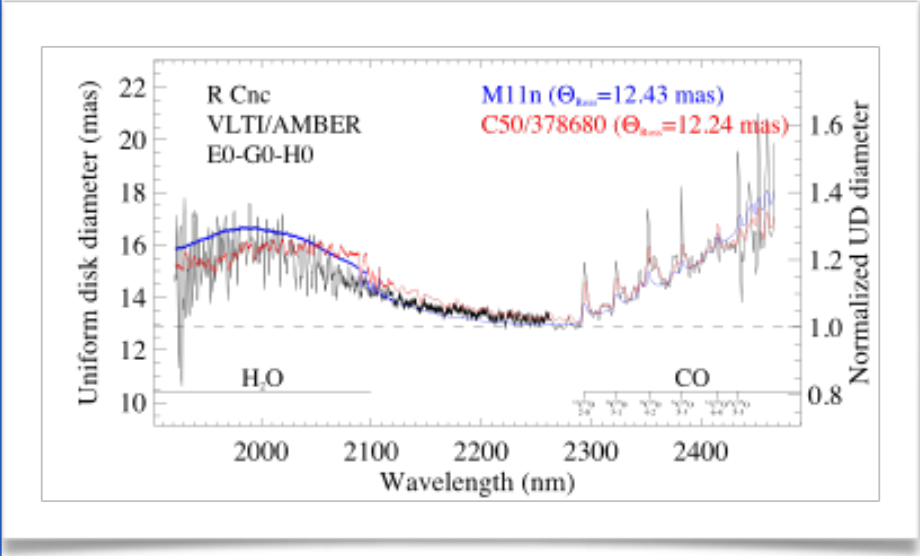
2013 Ohnaka ++

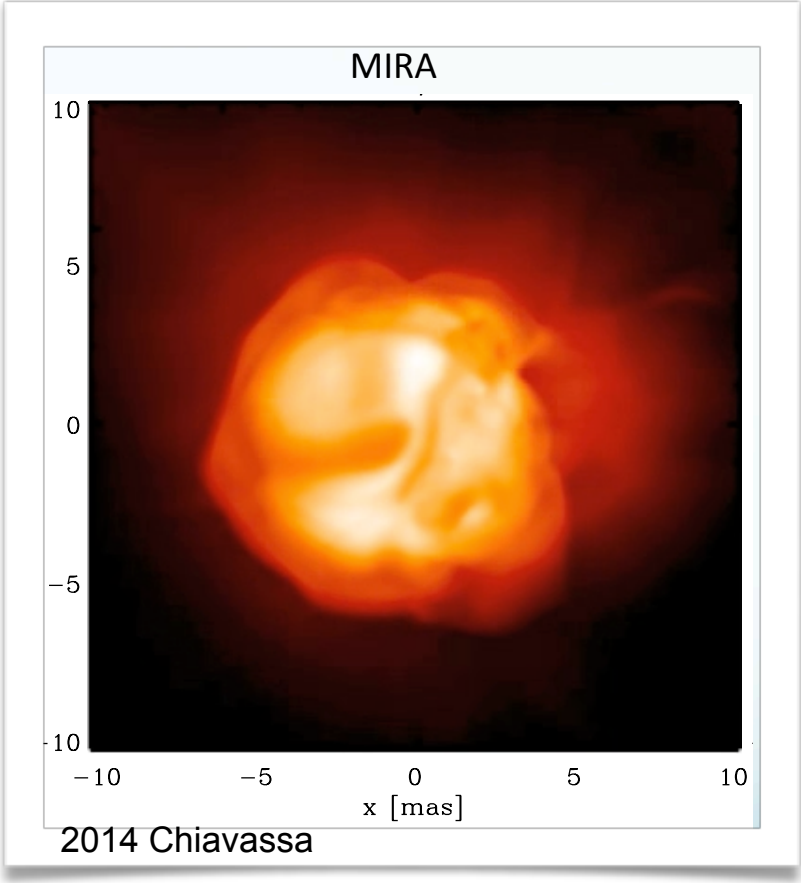
PIONIER



2015 Montarges ++ (in prep)

Spectro interferometry was enabled

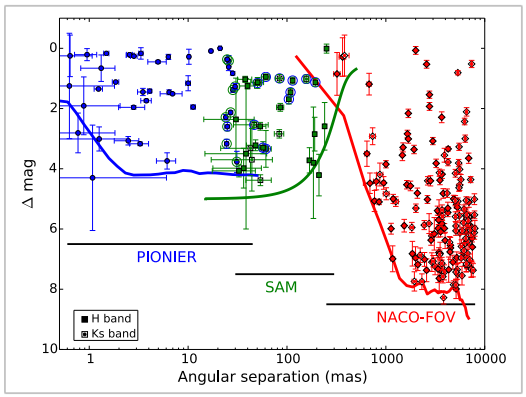




Molecular layer spatio-temporal structure exposed

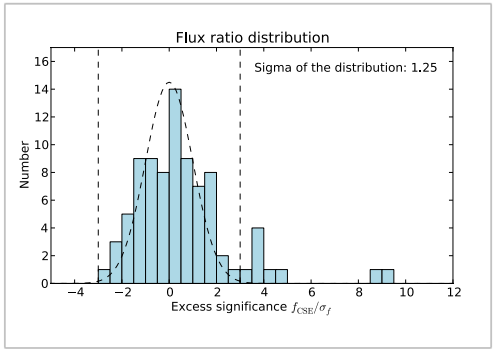
Efficiency has enabled surveys with N>100 objects

Binarity among massive stars



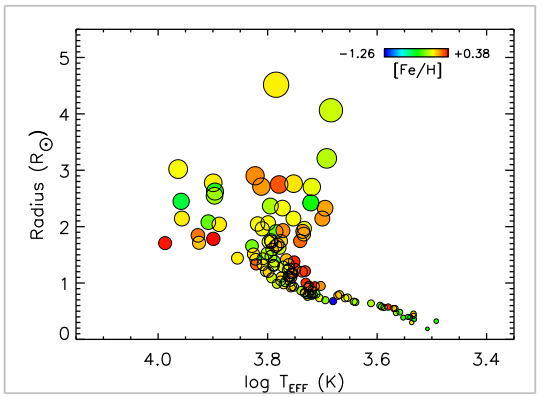
2014 Sana ++

2014 Ertel ++



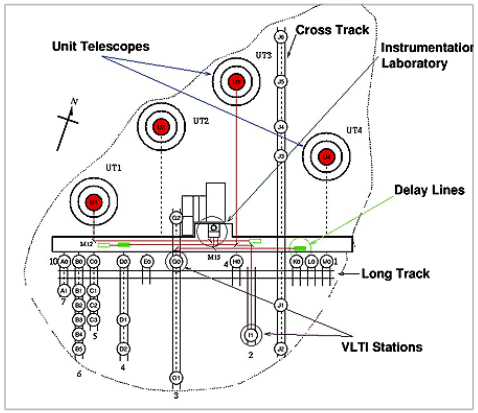
Exozodiacal dust

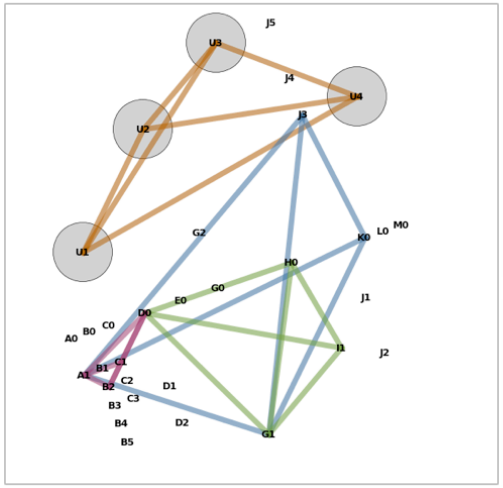
Surface brightness relations among MS , F, G, K stars

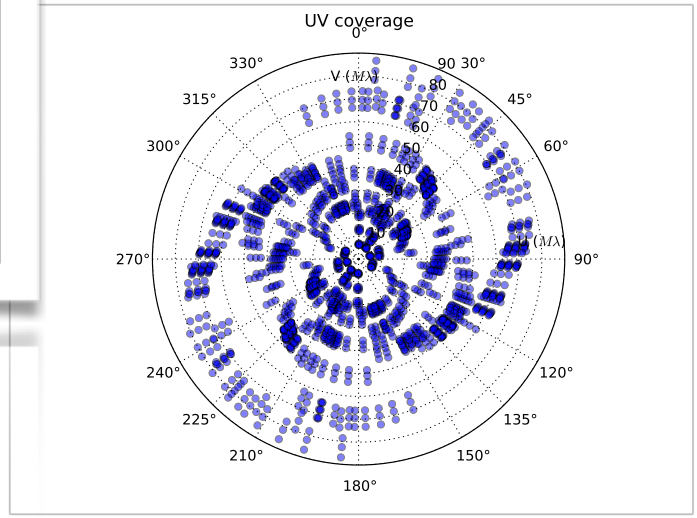


2013 Boyajian ++

Optical interferometry went from snapshot to imaging

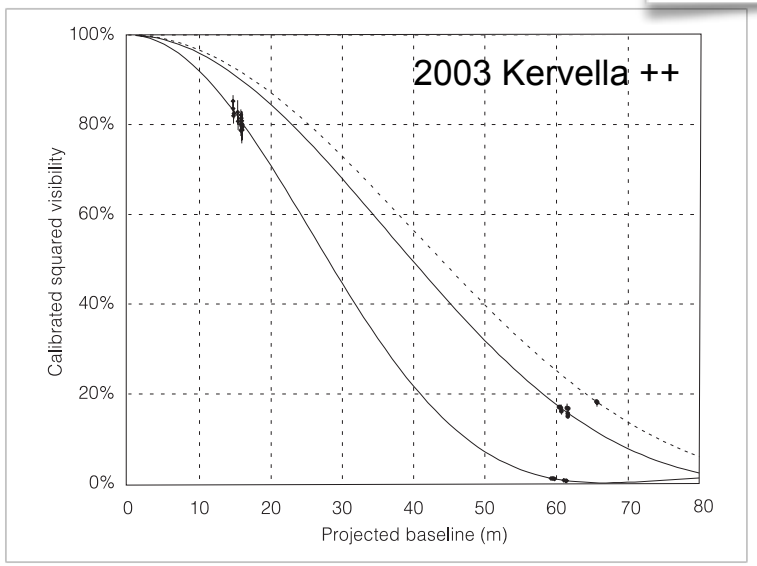




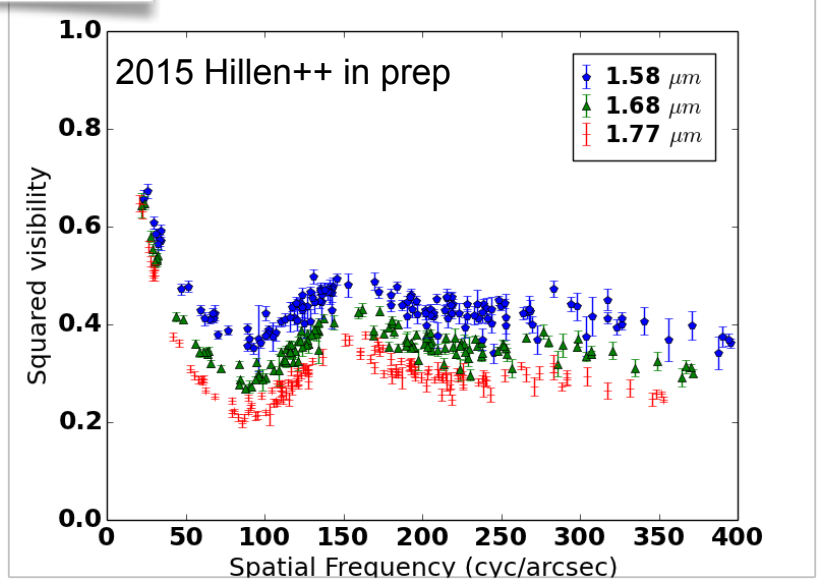


Optical interferometry went from snapshot to imaging

SNAPSHOT

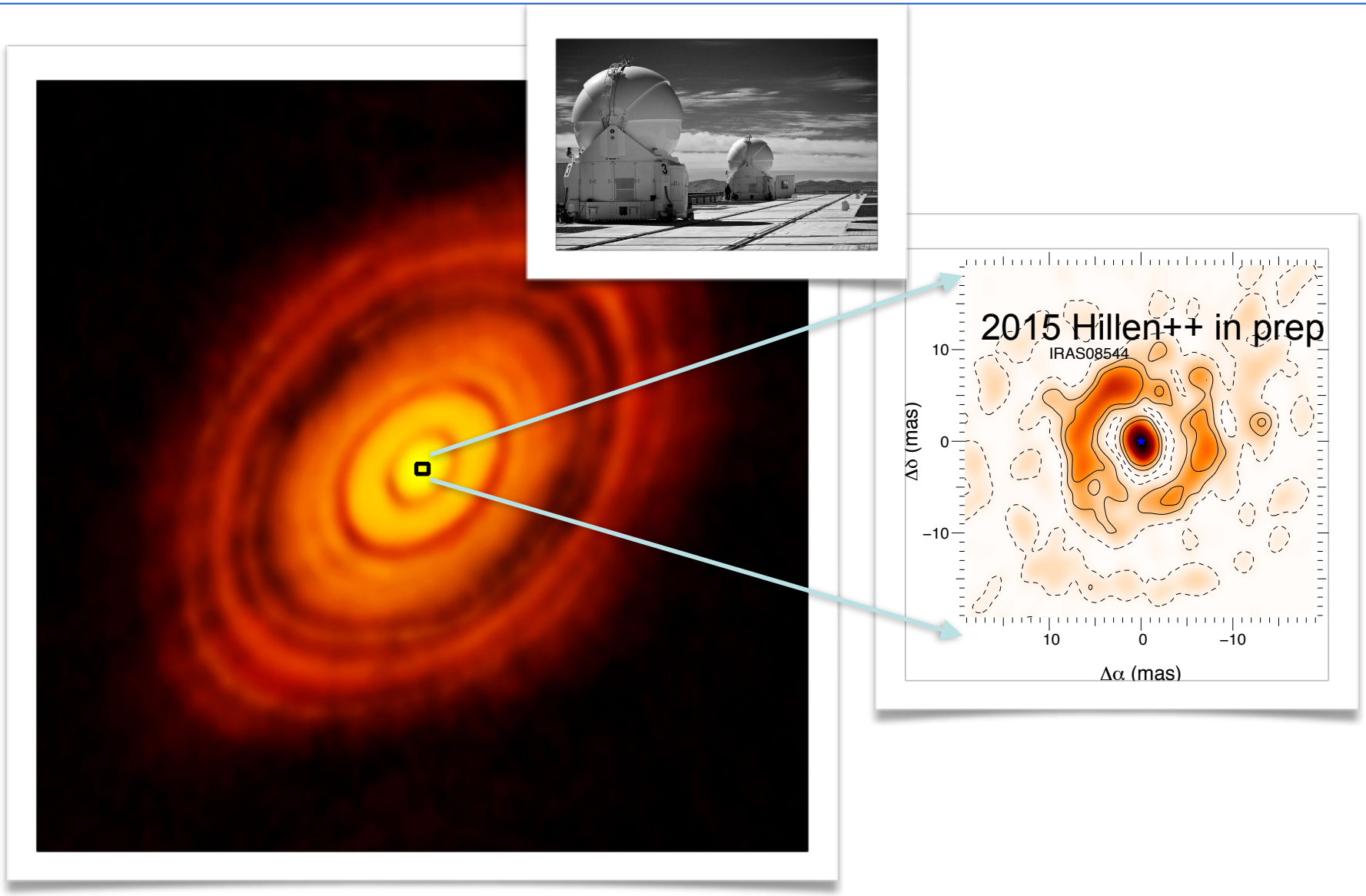


IMAGING



BUT … uv coverage still a limitation

Optical interferometry went from snapshot to imaging

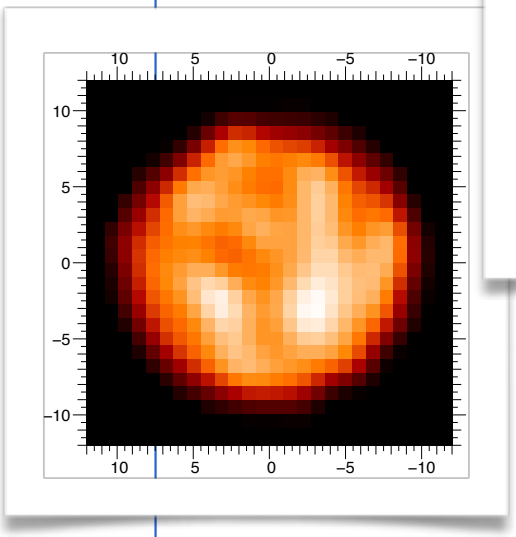


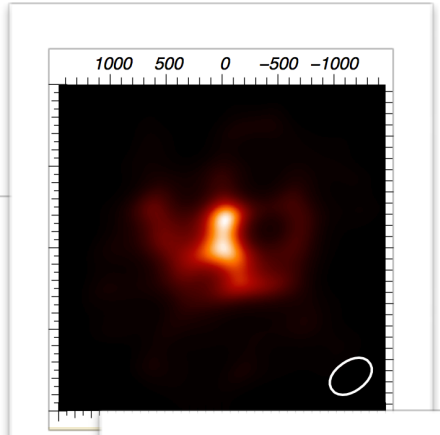
CAUTION: not the same object

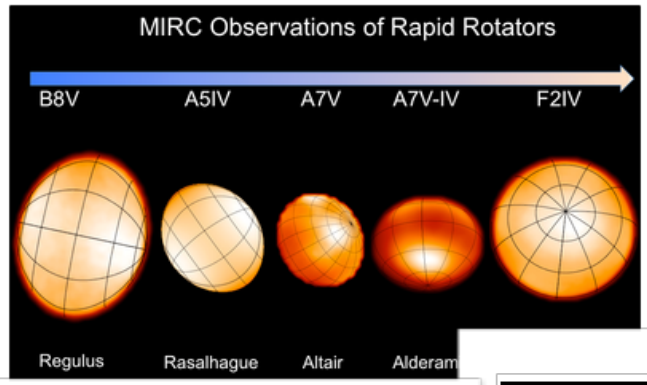
Optical interferometry went from snapshot to imaging

2015 Paladini ++

MIRAs

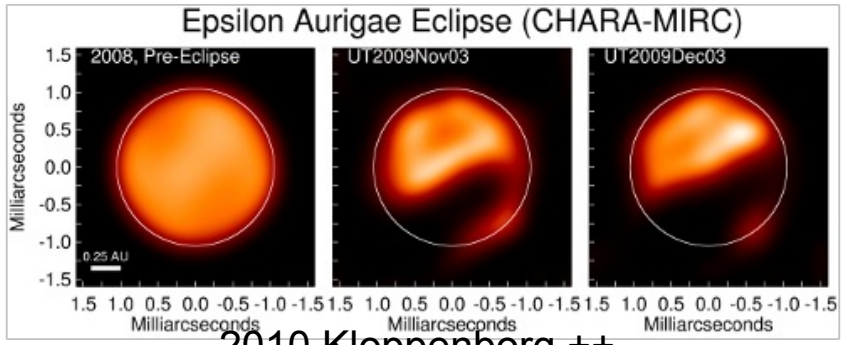




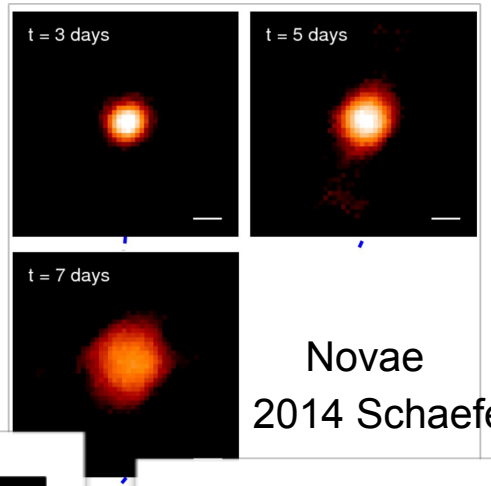


Rapid rotators

2007 Monnier ++
2009 Zhao ++
20111 Che ++



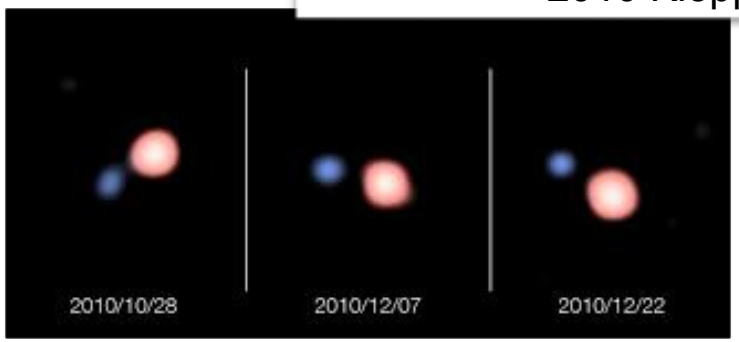
2010 Kloppenborg ++



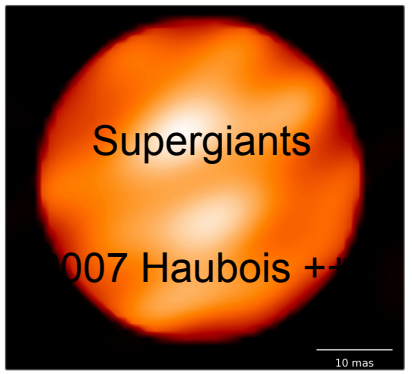
Novae

2014 Schaefer ++

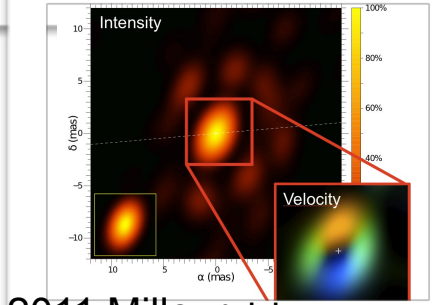
Symbiotics



2011 Blind ++



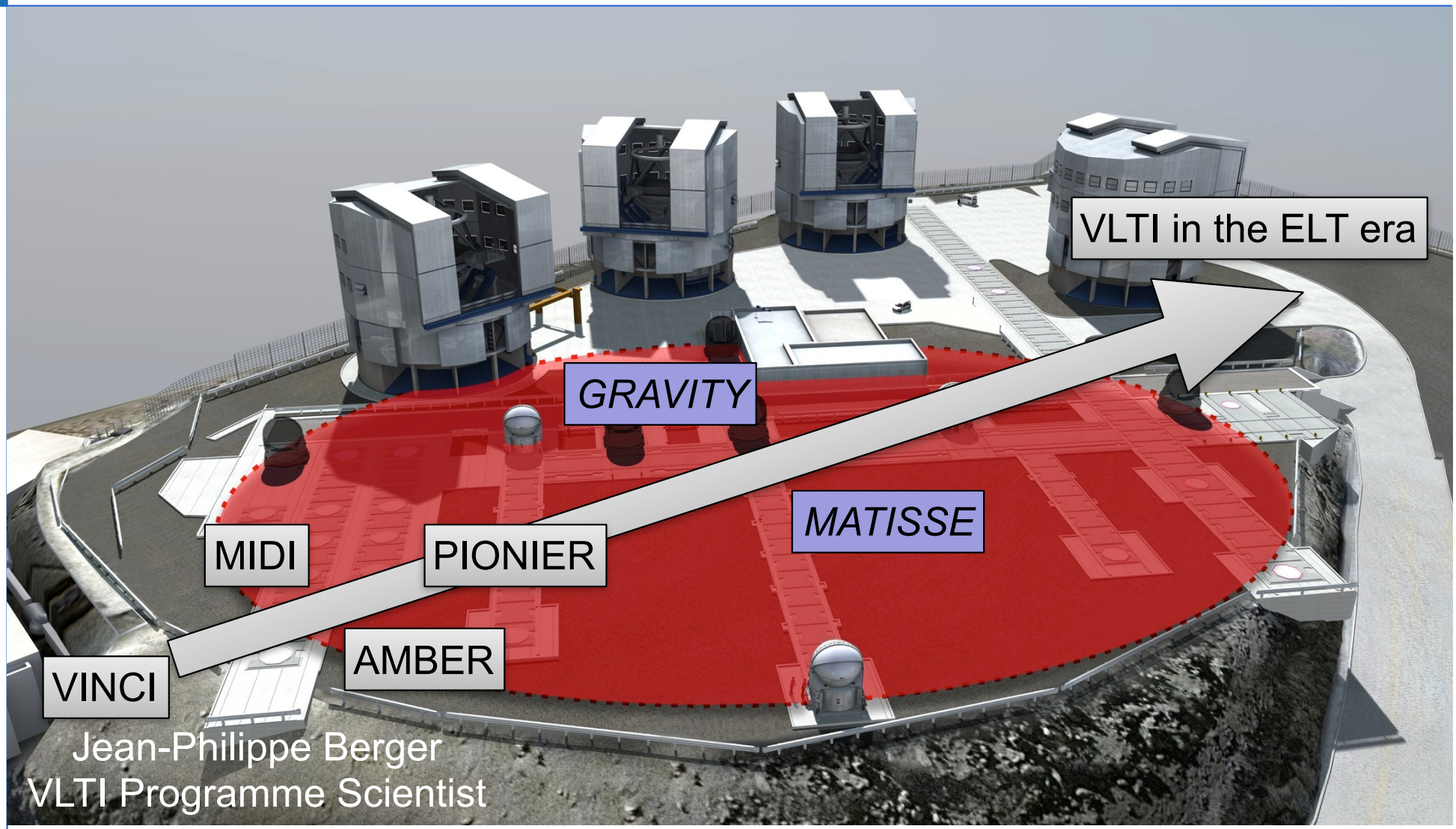
007 Haubois ++



2011 Millour ++

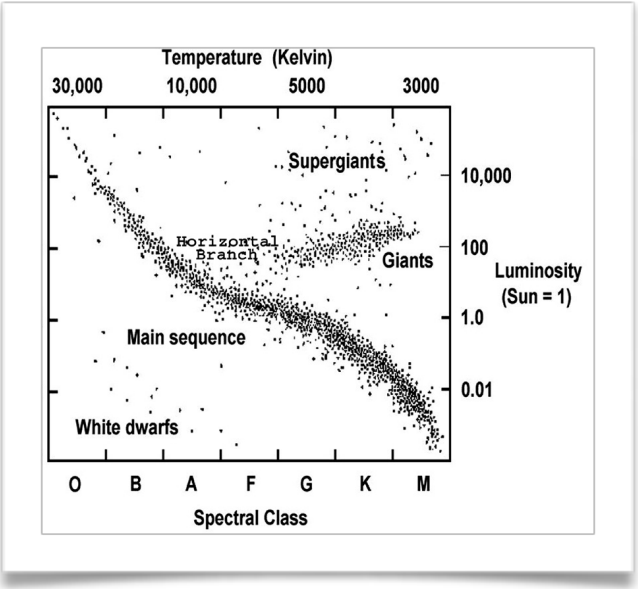
CHALLENGES FOR THE NEXT DECADE

VLTI in the next decade

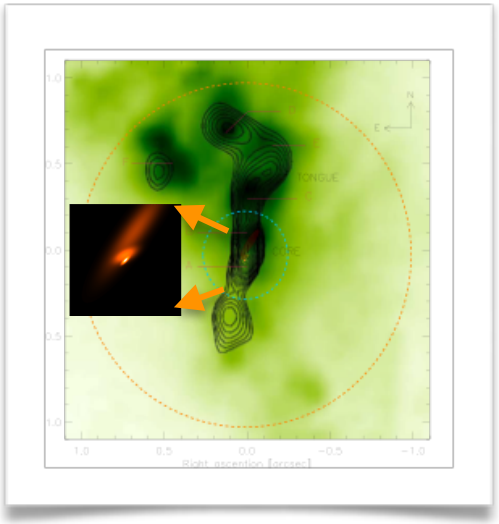


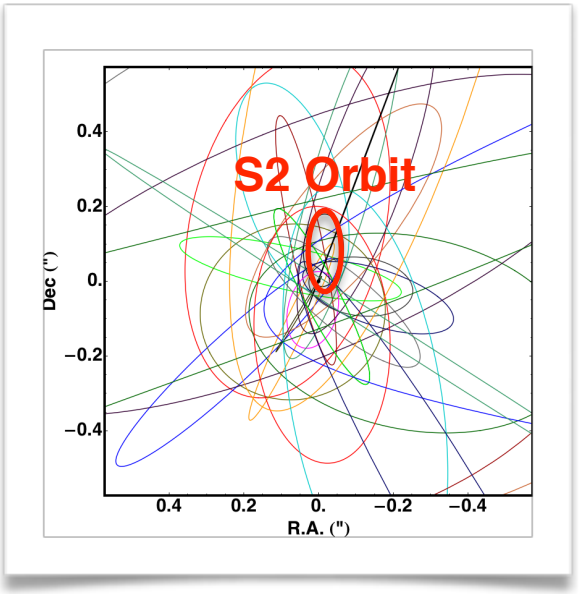
The scientific ambition is multiple

Understand the structure of AGN nuclei



Understand how stars (single or binary) evolve and interact with their environment



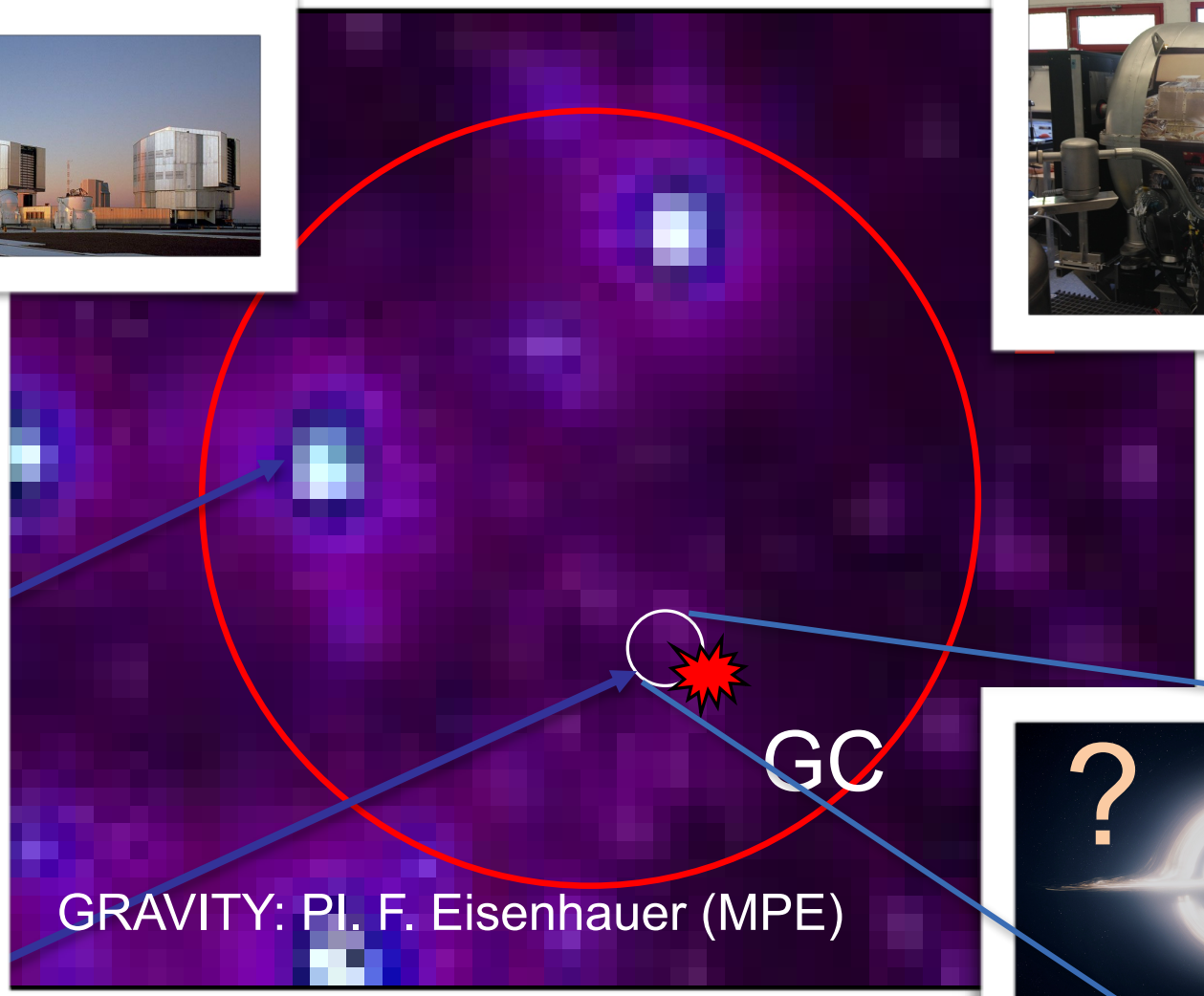


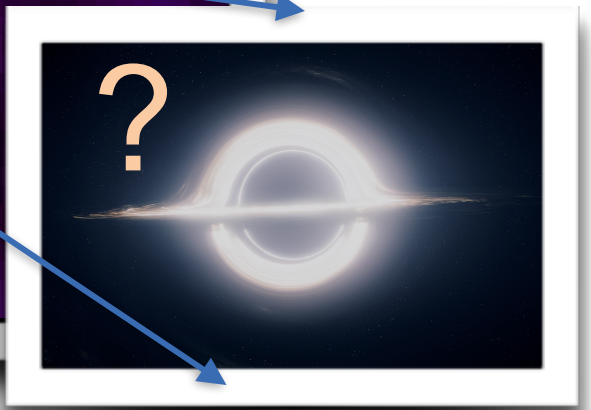
Understand GRAVITY

Combination of surveys, detailed imaging & astrometric campaigns

GRAVITY:
pushing the frontiers of our knowledge in black-holes and fundamental physics.

In operation:
2017





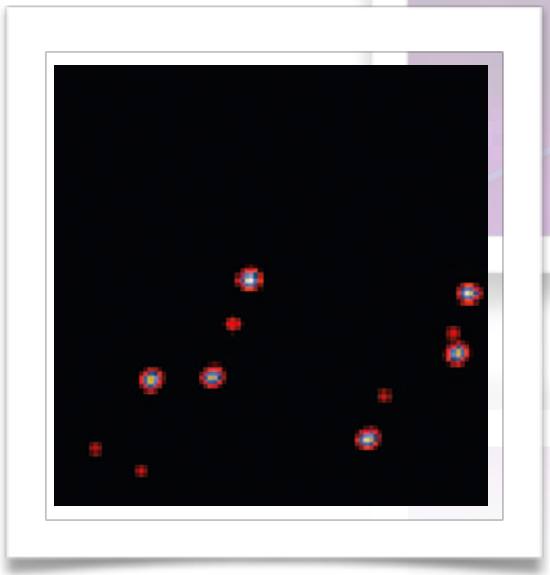
A VLT-end-to end metrology allows astrometry between two objects

Metrology

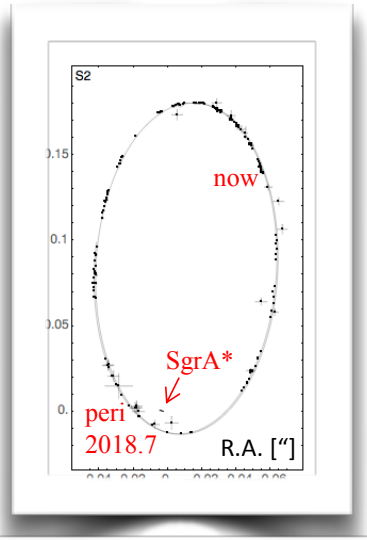
2”

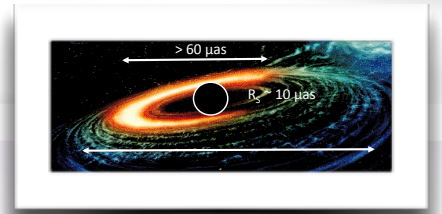
GC

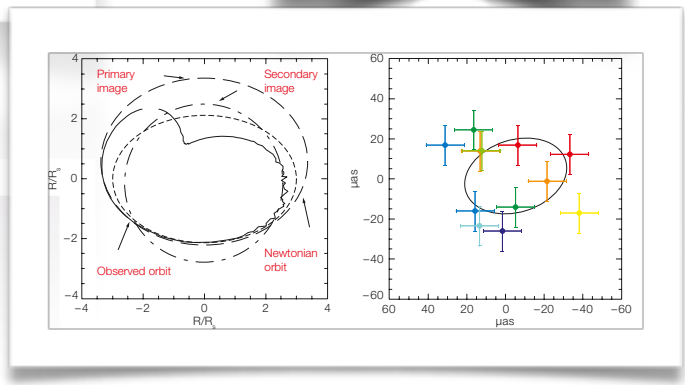
Imaging: K, R ~ 4000



Astrometry







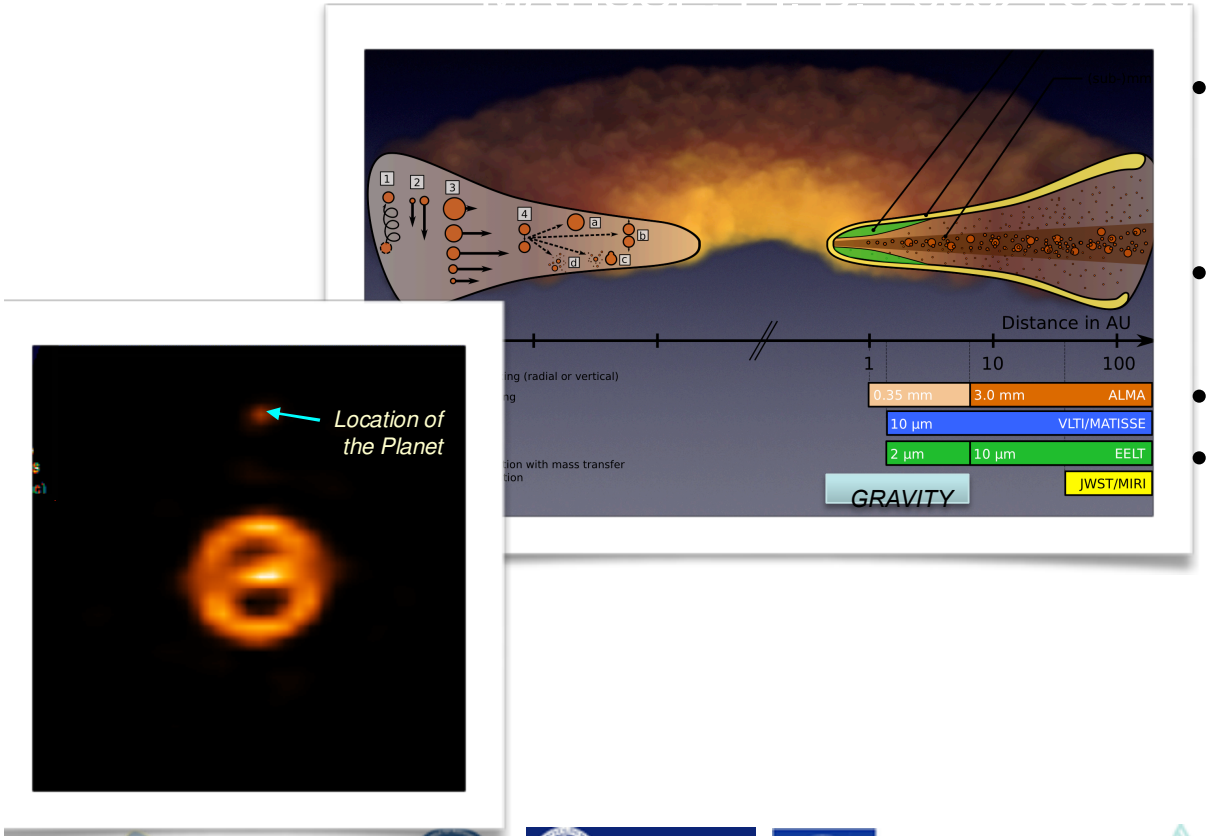
Words at the bottom

MATISSE:

4 Telescopes: L, M, N
R ~ 4000

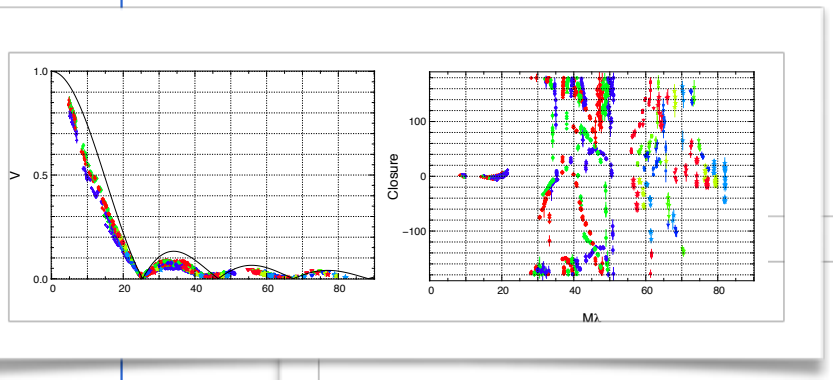
PI: B. Lopez (OCA)
2018

In operation:
2018

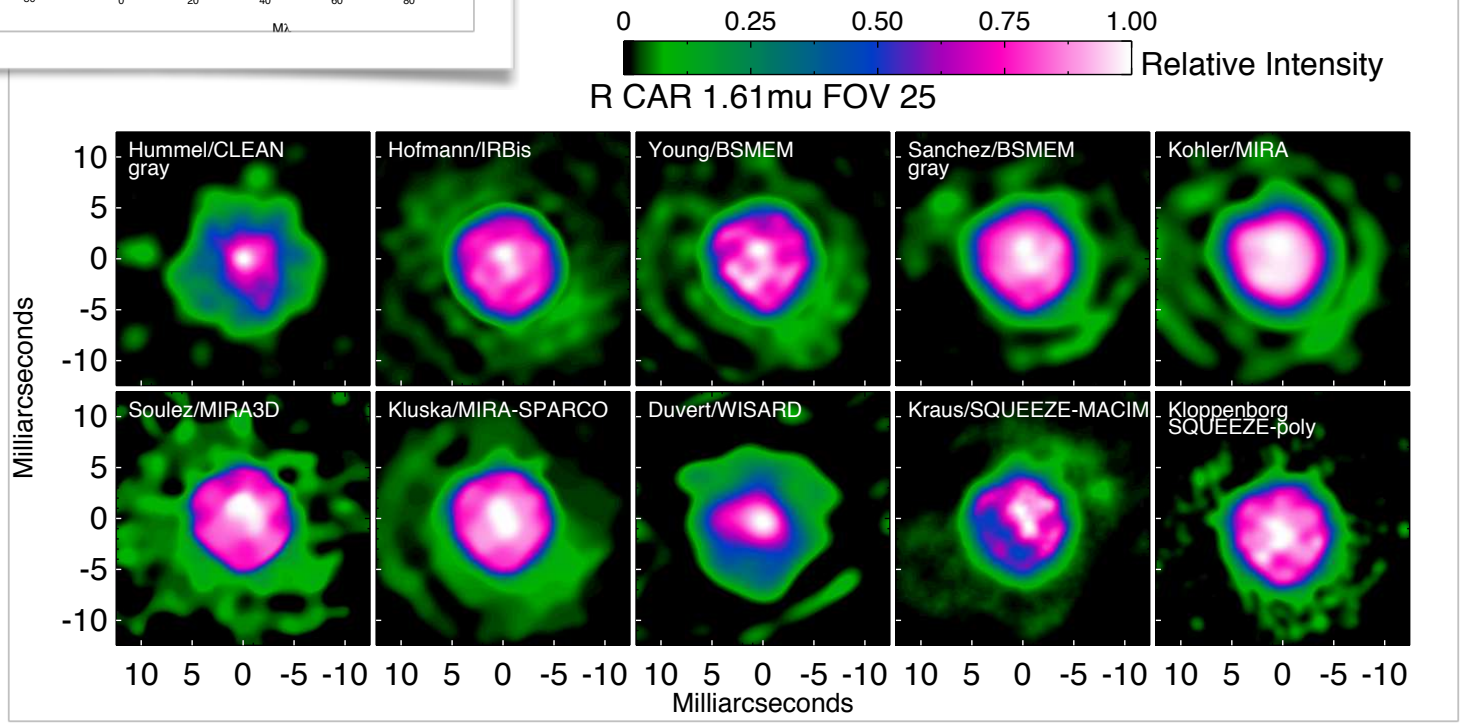


- Observing planet formation processes at the astronomical unit scale
- Mapping Active Galactic Nuclei central parsecs
- The formation of massive stars
- Dust and winds from evolved stars

Consolidate image reconstruction

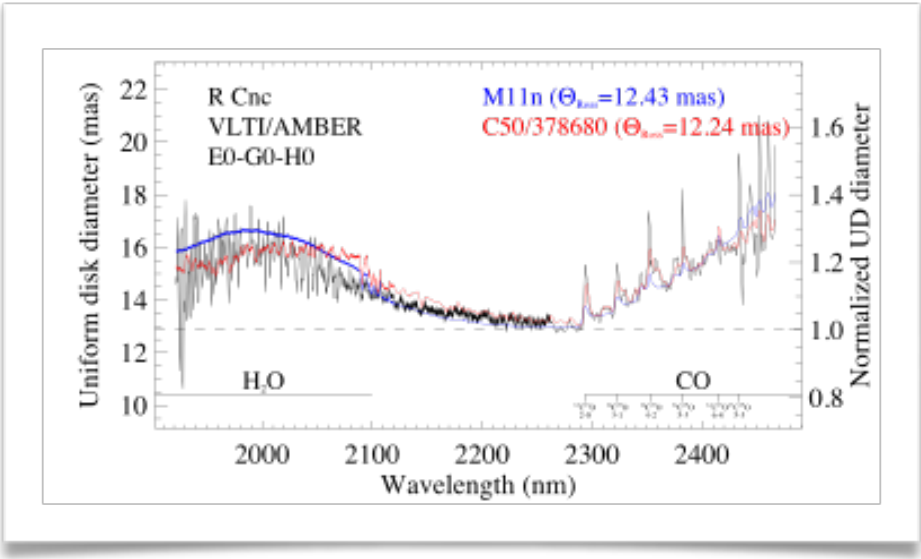


Beauty contest

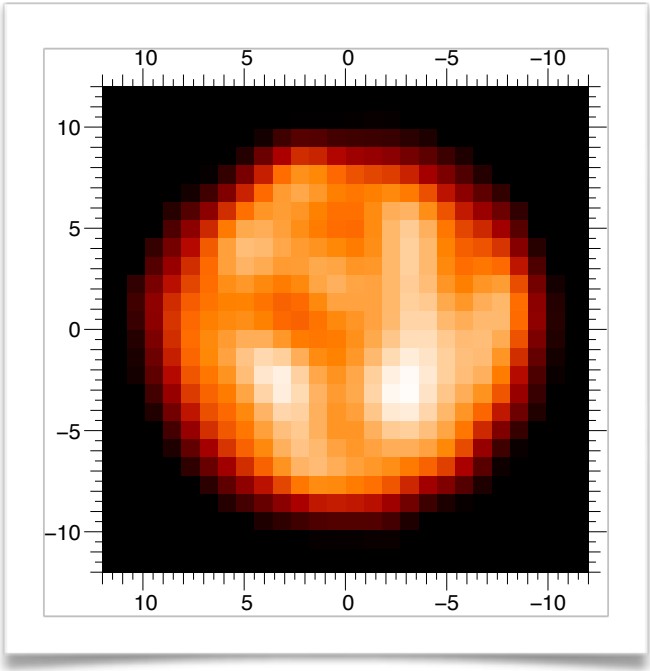


Monnier++ 2014

Combine spectral resolution and imaging

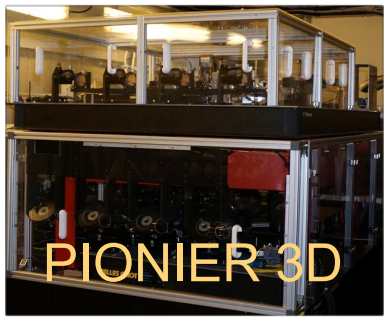


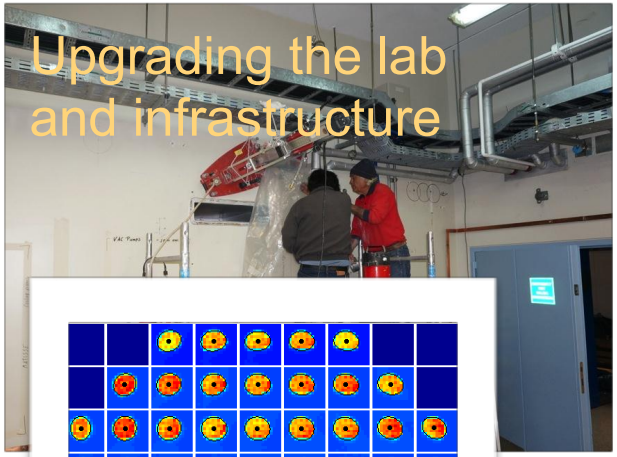
Wittkowski++ 2011

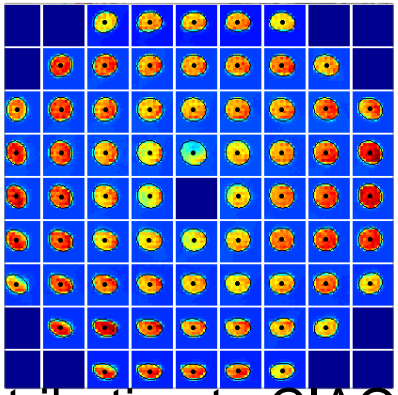


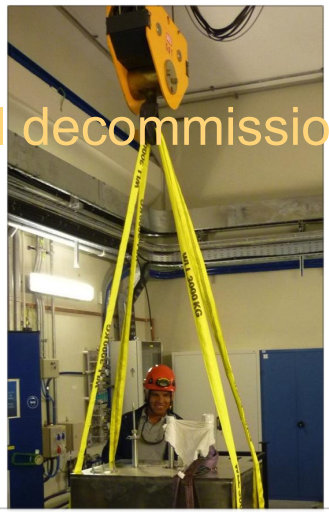
Paladini in prep

Upgrade the infrastructure
Make it performant (AO + phasing)





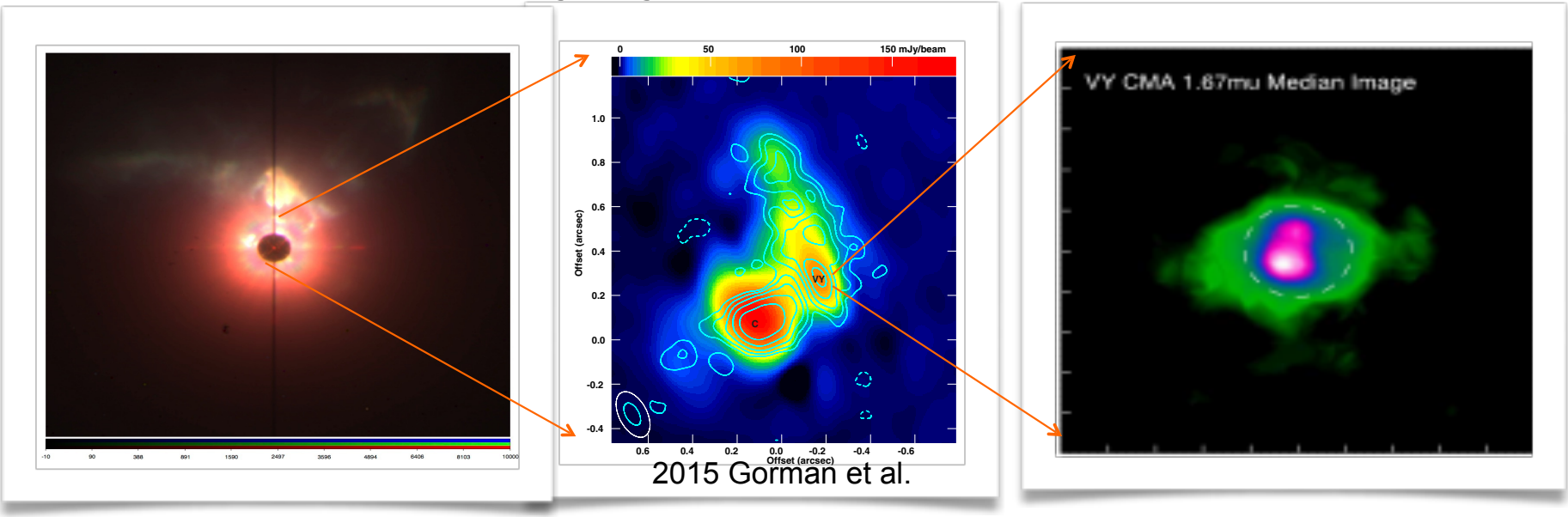

Contribution to CIAO



Expand the user base and join synergies

Develop VLTI expertise centers: Provide VLTI users with support in preparing their proposals, reducing their data and reconstructing images

Ongoing discussion with JMMC

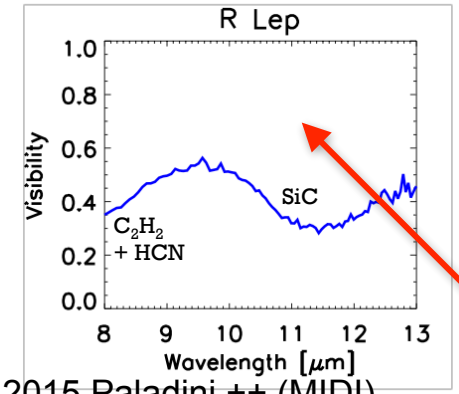


SPHERE

ALMA

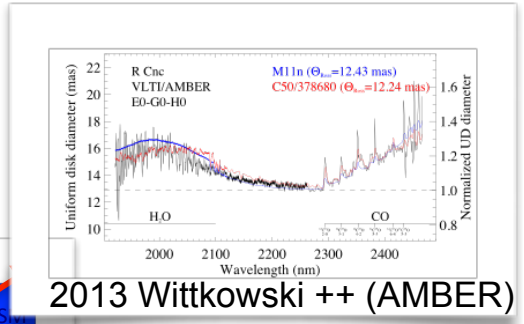
PIONIER

Couple imaging and spectroscopy and use simultaneously the VLTI instruments

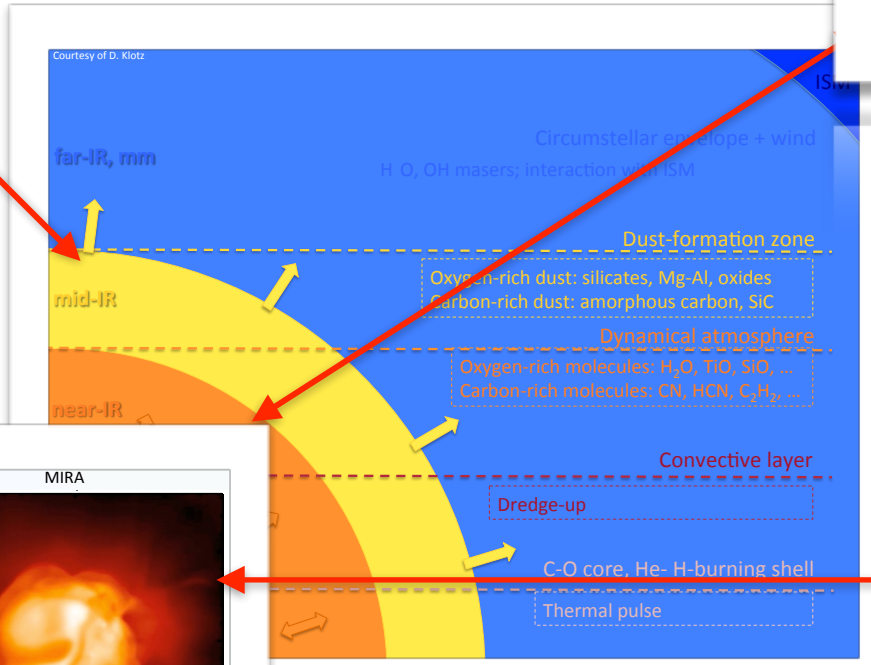


2015 Paladini ++ (MIDI)

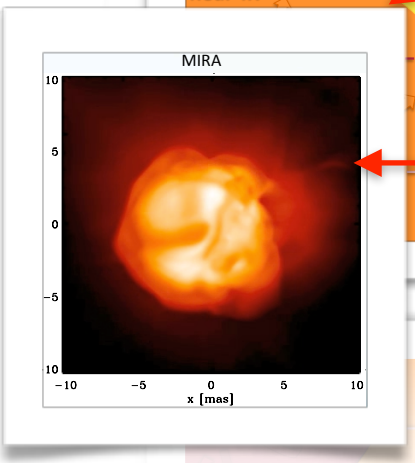
GRAVITY



2013 Wittkowski ++ (AMBER)



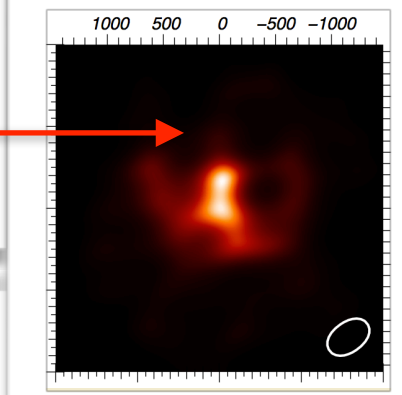
MATISSE



Chiavassa 2013

iShooter ??

PIONIER



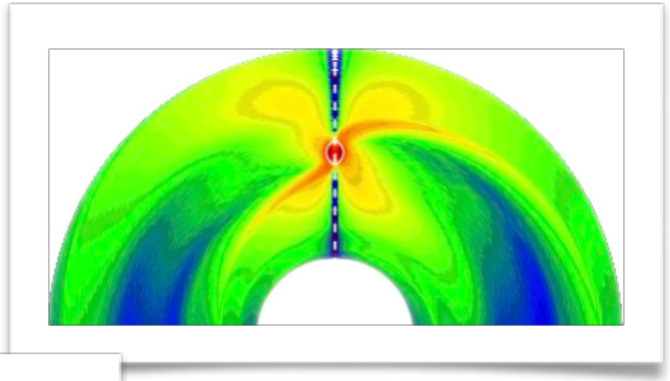
Paladini in Prep

THE FUTURE OF OPTICAL INTERFEROMETRY

STEPS 2015

Upgrades / new facilities

MROI



VLTI beyond GRAVITY and Matisse

Planet Formation Imager
PI: J. Monnier
PS: S. Kraus
http://www.planetformationimager.org

Key areas of scientific strength for VLTI

AREAS of strength

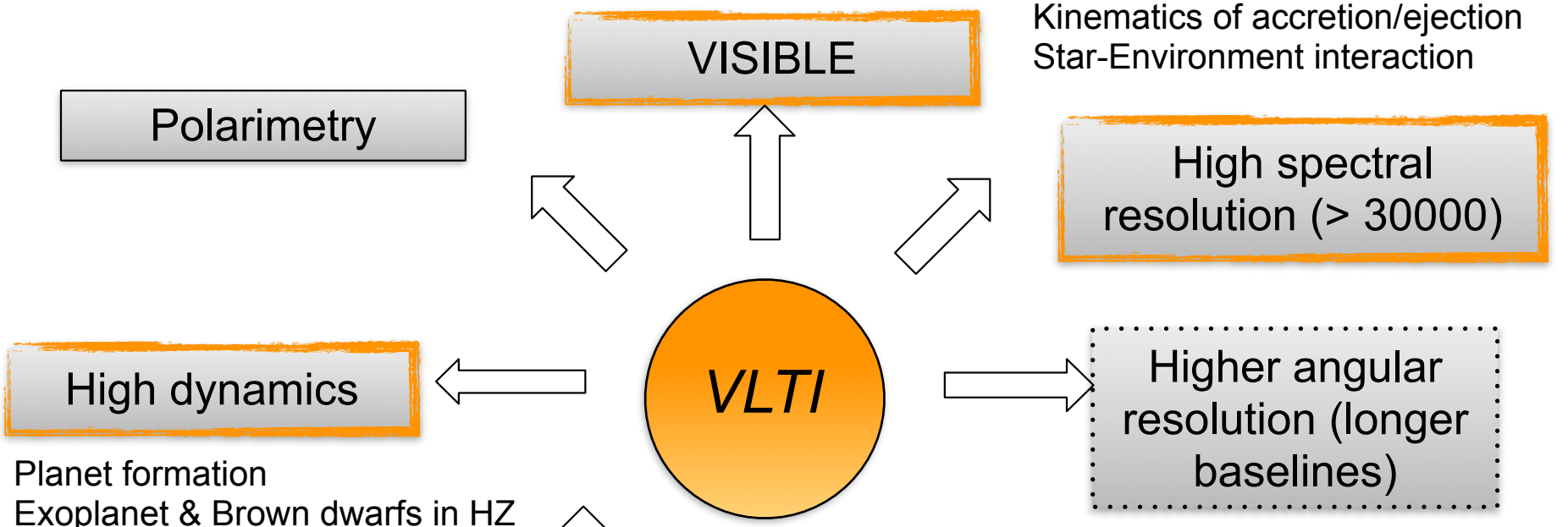
- Fundamental stellar physics including rotation, pulsation …
- How do stars and planetary systems form?
- How do stars enrich galaxies?
- How do massive stars form and interact with their environment?
- How do SN progenitors work?
- Binaries from birth to death.
- Do we understand SMBH interaction with host galaxy
- The galactic center

Global approach vs single object approach

AREAS to investigate

- Improvement of the cosmological distance scale;
- Ground based astrometric follow-up of exoplanet detections (post-GAIA);
- Characterisation of host stars in the context of exoplanet and asteroseismology transit missions (e.g PLATO);
- Constraints on strong lensing.
- Microlensing

Establish the instrumental roadmap in 2016



Fundamental stellar physics (PLATO)
Asteroseismology synergy
Kinematics of accretion/ejection
Star-Environment interaction

Planet formation
Exoplanet & Brown dwarfs in HZ

All science - PLATO

EXO Planet:GAIA and EXAO follow-up

Strong lensing
SMBH mass measurements

All science
Enable time resolved imaging
(Novae, hydrodynamics, convection)

Visitor vs. Facility ?

WRAP UP

WRAP UP

- Optical interferometry is now a reliable technique
- … but still needs user support to reach wider community
- Image reconstruction has considerably progressed but work still remains
- Some performance issues remain to be addressed (spectro-interferometry)
- PIONIER, GRAVITY and MATISSE will provide unique angular resolution spectro-imaging capability: we are OK for the next decade !
- Evolved star community expected to be a strong contributor to the VLTI prospective effort

VLTI SCHOOL

COLOGNE 6-13 SEPT

DEADLINE: JULY 15TH