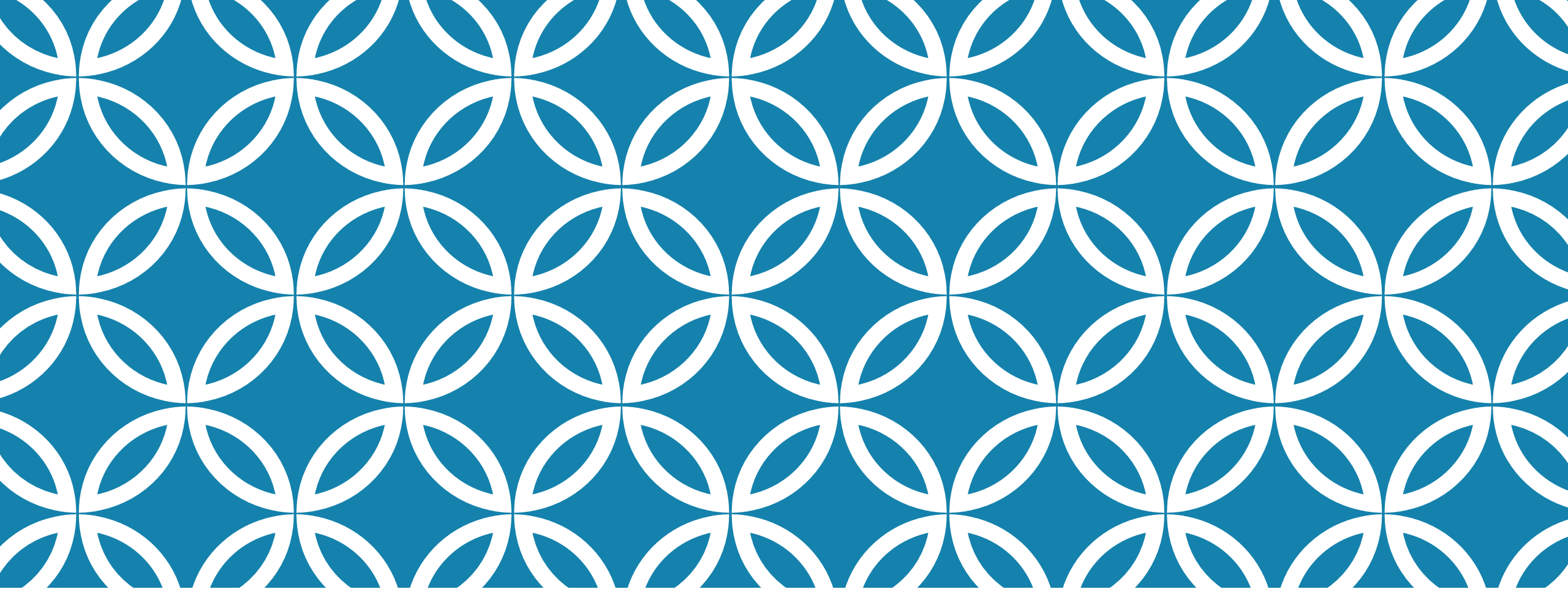




THE EUROPEAN INTERFEROMETRY INITIATIVE

Paulo Garcia, Porto University,
on behalf of the EII Bureau
(views are my own and not of
the Bureau)

THE EUROPEAN INTERFEROMETRY INITIATIVE

In 1998 the first VLT achieves first light (compare with Keck I in 1990).

The VLTI (Very Large Telescope Interferometer) had a difficult birth (delays and over cost of the VLT as well as technological challenges).

In the beginnings the VLTI was pushed (e.g. AT telescopes) by a BE, CNRS, MPG and ESO partnership, i.e. strong community involvement.

In 2001 the VLTI achieves first fringes with a guided optics system VINCI and two siderostats (compare with Keck Interferometer first light the same year).

In 2002 CNRS (JMMC), MPIA (FrinGe) and NOVA (NEVEC) first meet with the goal to create the EII by building a stronger community around long baseline optical interferometry at ground and space (e.g. Darwin) and seek support from FP6.

First generation instruments: MIDI 10 μ m @2002 and AMBER NIR @2004.



THE EUROPEAN INTERFEROMETRY INITIATIVE

The EII joins the OPTICON FP6 project obtaining significant funding towards technology development, second generation instrumentation concepts studies and networking activities.

In parallel FP6 funding is obtained for Marie Curie Training Schools.

FP6 and OPTICON were critical in

- Training a new generation of astronomers in optical long baseline interferometry
- Consolidating science cases in several key areas
- Developing software tools still in use (and mandatory) for observational preparation
- Technology development in guided optics & instrumentation concepts that fed and launched the second generation VLT instrumentation programme



THE EUROPEAN INTERFEROMETRY INITIATIVE

In 2010s ESO launches the 2nd generation VLTi programme with the selection of GRAVITY (K-band) and MATISSE (L to N-band) four telescope beam combiners.

In parallel OPTICON FP7 (I and II) continues to feed EI activities, these now consist on

- Training schools and exchanges of researchers widening knowledge in the community
- Software development consolidating tools widely used in the community, including interferometric imaging tools that will feed the 2nd generation instrument data outputs

In 2016 GRAVITY reaches first light with Afs, and after the UTs. A revolution in optical long baseline interferometry.

For comparison IRAM Plateau de Bure Interferometer combined four antennas in the early 1990s → two decades in technology development to reach 1e3 higher frequencies.

THE GRAVITY REVOLUTION

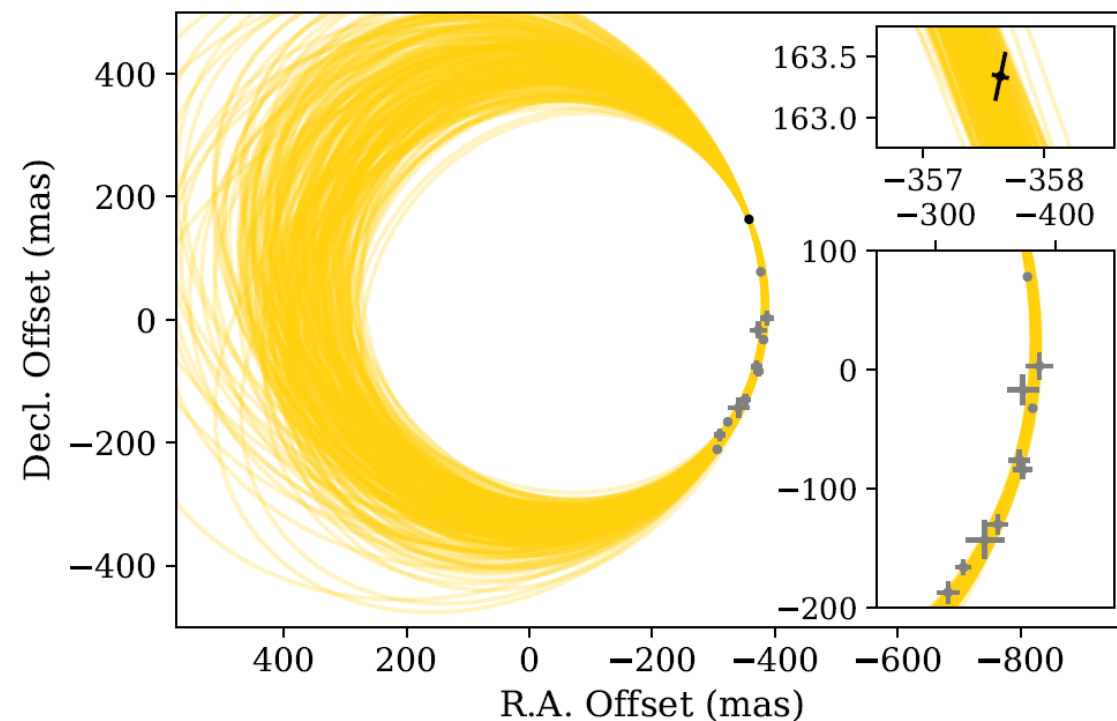
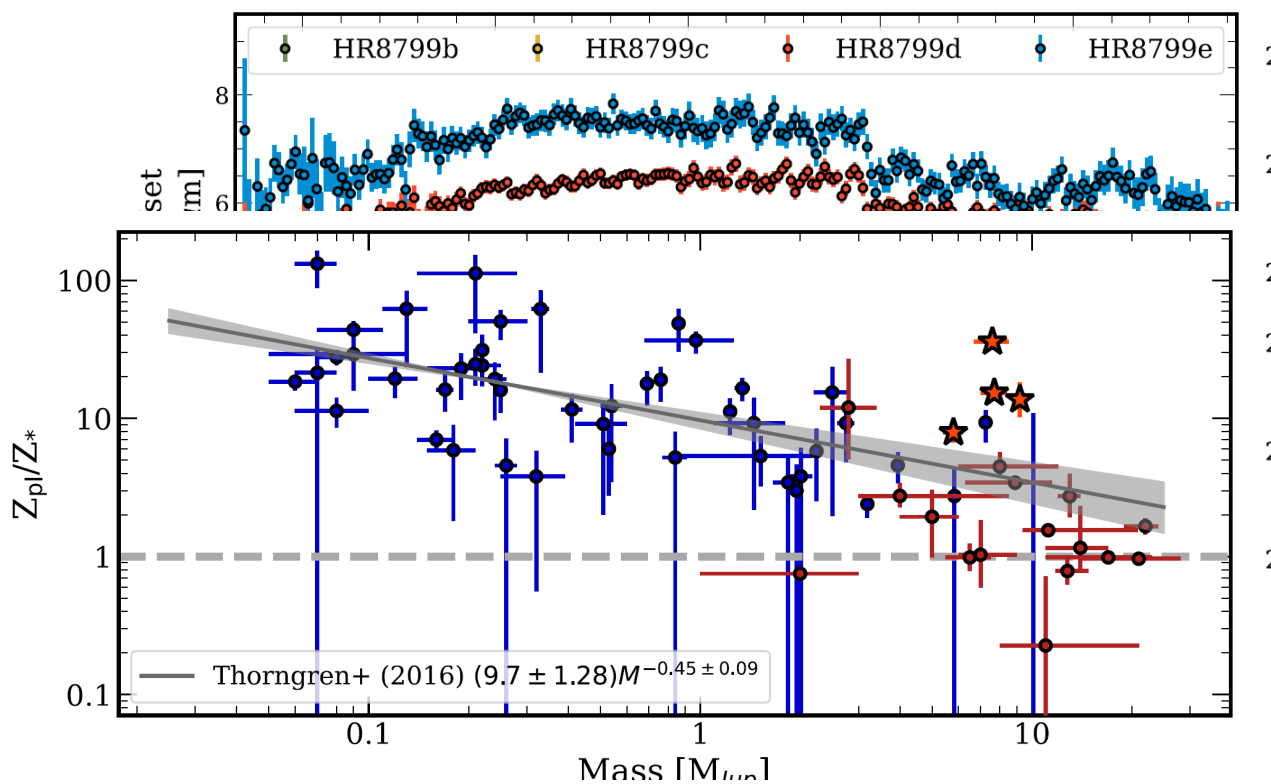
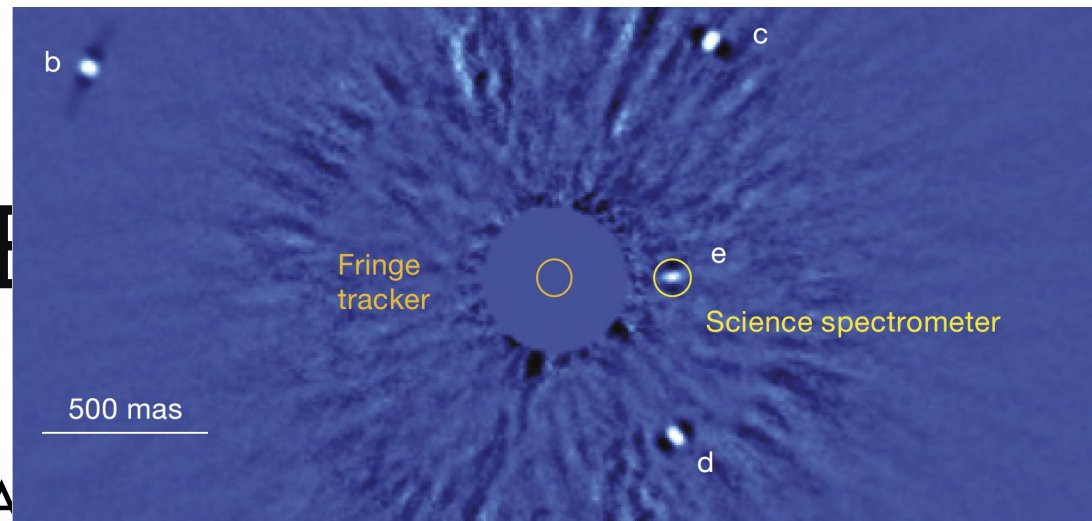
The goal is sensitivity and not imaging (in contrast with mainstream ideas in 2010s, and still today...)

Focused top level science case defines full instrument design (as for ALMA), but still a wide range of science (some unexpected) was enabled.



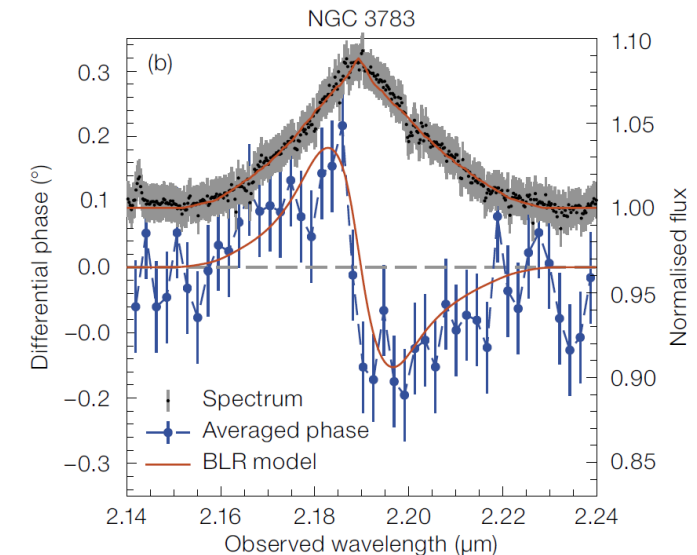
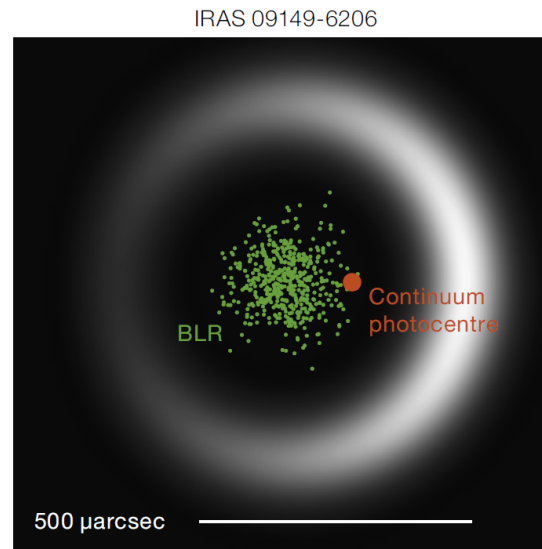
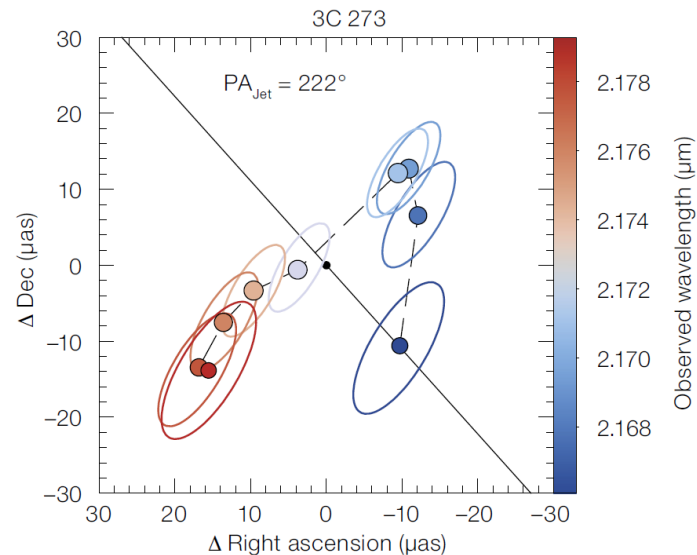
THE GRAVITY REVOLUTION | E

HR 8799 e (2019, A&A 623, L11 + 2024, A&A



THE GRAVITY REVOLUTION | AGNS

2018, Nature, 563, 657 + 2020, A&A, 643, A154 + 2021, A&A, 648, A117 + ...



Ongoing 2-4 redshift programme. Just last week we observed a $z=3.9$ quasar...

THE GRAVITY REVOLUTION | TIME DOMAIN

Resolving microlens events (e.g. Mroz+2024 in press)

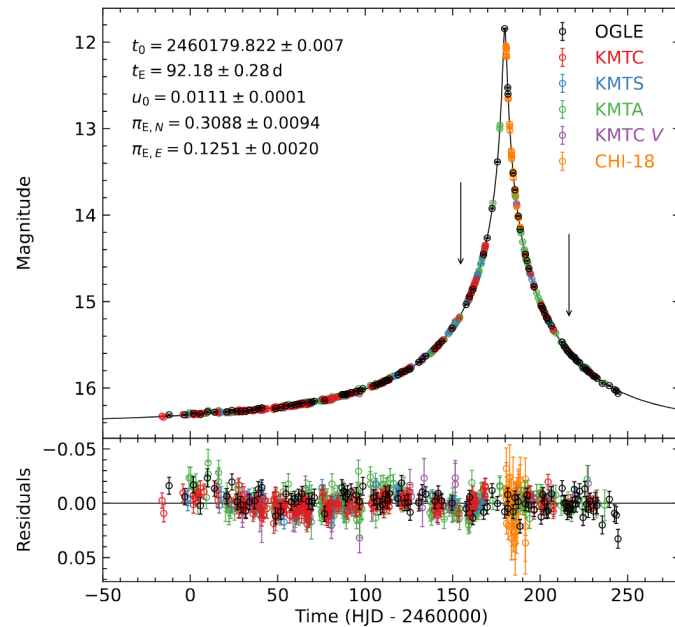


Figure 2. Light curve of OGLE-2023-BLG-0061/KMT-2023-BLG-0496. The black line marks the best-fit model with $u_0 > 0$. Arrows mark the two epochs of VLTI observations.

has made it possible to reach out to significantly fainter objects, and increase the pool of microlensing events amenable to interferometric observations by two orders of magnitude. Here, we present the first successful observation of a microlensing event with GRAVITY Wide and the resolution of microlensed images in the event OGLE-2023-BLG-0061/KMT-2023-BLG-0496. We measure the angular Einstein radius of the lens with a sub-percent precision, $\theta_E = 1.280 \pm 0.009 \text{ mas}$. Combined with the microlensing parallax detected from the event light curve, the mass and distance to the lens are found to be $0.472 \pm 0.012 M_\odot$ and $1.81 \pm 0.05 \text{ kpc}$, respectively. We present the procedure for the selection of targets for interferometric observations, and discuss possible systematic effects affecting GRAVITY Wide data. This detection demonstrates the capabilities of the new instrument and it opens up completely new possibilities for the follow-up of microlensing events, and future routine discoveries of isolated neutron stars and black holes.

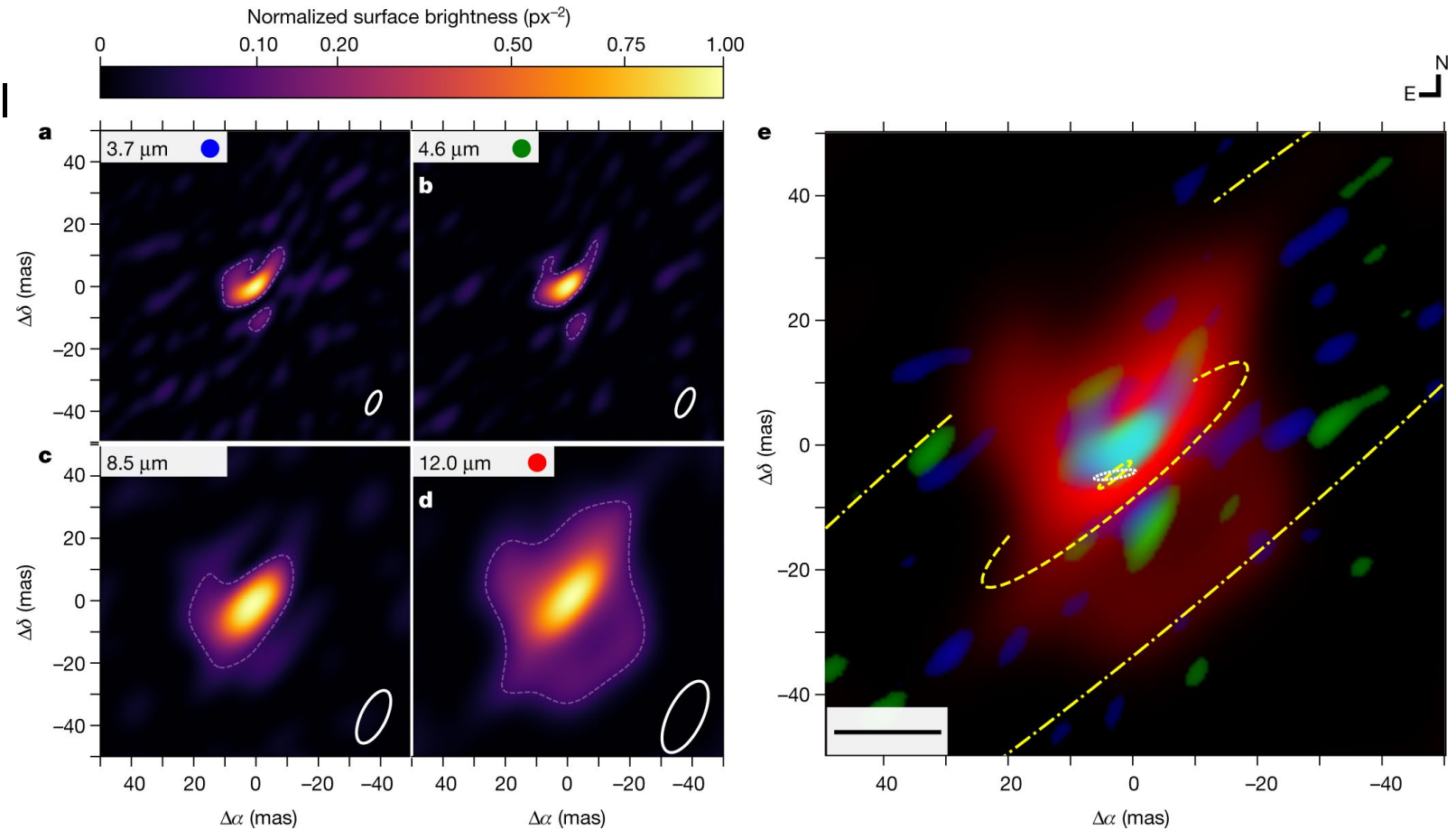
THE VLTI IS ALSO MATISSE



MATISSE probes the thermal infrared from the L to N bands.

Thermal imaging of dust hiding the black hole in NGC 1068

(2022, Nature, 602, 403)



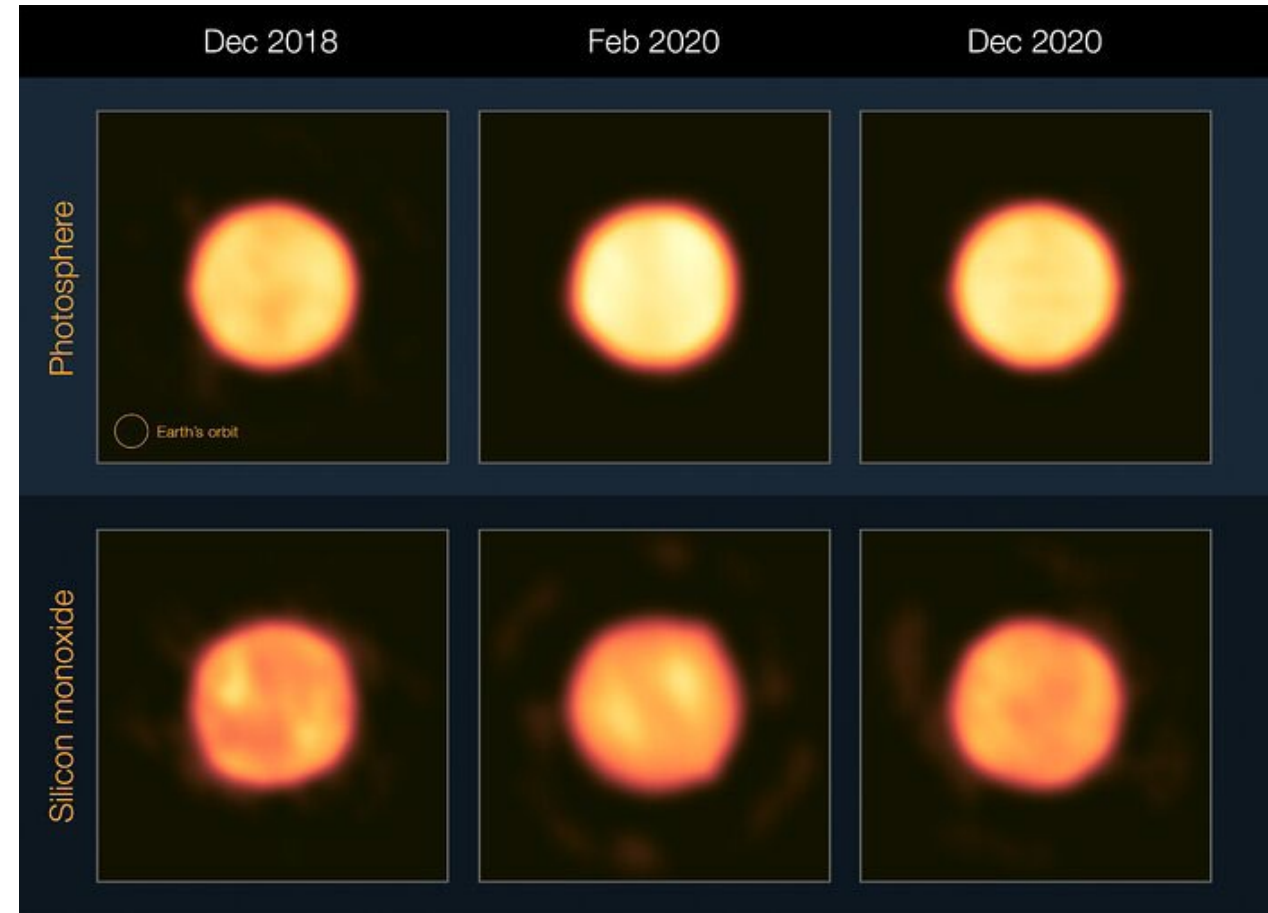
THE VLTI IS ALSO MATISSE



A recent striking result is the imaging of the great dimming of Betelgeuse (2024, MNRAS, 527, L88).

Where atmosphere changes are observed across the stellar surface and time.

MATISSE has also obtained many more results

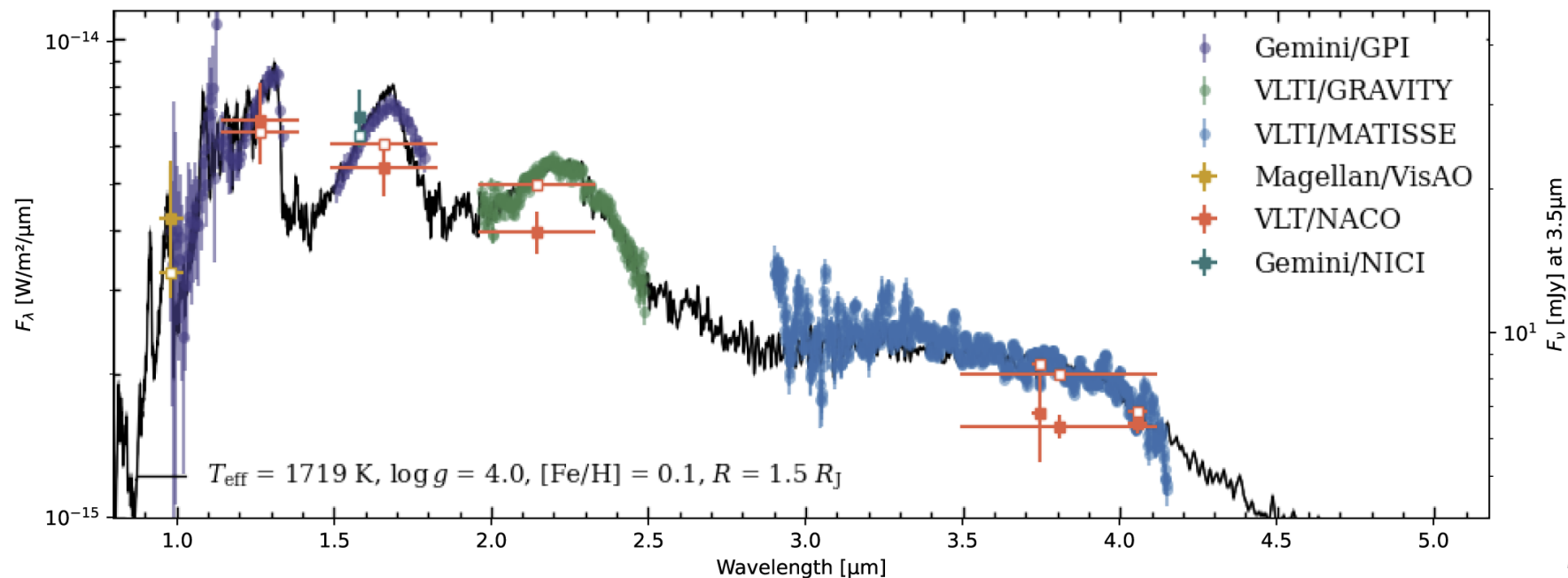


THE VLTI IS ALSO MATISSE



Using the GRAV4MAT fringe tracker faint science is now possible using the off-axis GRAVITY fringe tracker as well as simultaneous L and M band exposures

2024, A&A, 688, A190 → β Pic exoplanet spectroscopy



THE EUROPEAN INTERFEROMETRY INITIATIVE

In FP8 the EII follows OPTICON into the ORP project

- Enabling access to the GRAVITY wide upgrade (a subset of GRAVITY+)
- Extending the VLTI access to shorter NIR wavelengths
- Training and exchange of knowledge across Europe
- User support via a distributed network of expertise centres
- Change in paradigm in data access with enabling science grade data products of GRAVITY
- Interface and synergies with radio/mm interferometry

VLTI EXPERTISE CENTRE'S NETWORK

ESO USD (not a formal expertise centre, nor funded by the Opticon Radionet Pilot)

- ESO user support for VLTI | <https://support.eso.org>

Exeter

- http://emps.exeter.ac.uk/physics-astronomy/research/astrophysics/facilitiesandresources/uk_vlti/

JMMC (Paris, Lyon, Grenoble, Nice)

- <http://www.jmmc.fr/suv>

Konkoly

- <https://vlti-ec.konkoly.hu/>

KU Leuven

- <https://fys.kuleuven.be/ster/projects/belgian-vlti-expertise-centre>

Leiden

- <http://vlti.strw.leidenuniv.nl>

Porto

- <https://centra.tecnico.ulisboa.pt/news/?id=4719>



PARANAL IN 2025 (OPTICON AO + OPTICON / ORP INTERFEROMETRY)

The GRAVITY revolution opens way faint MATISSE science and to the GRAVITY+ instrument in 2020

Currently GRAVITY+ (October) has commissioned the NGS AO in all four UTs, next year the laser guide stars will be commissioned.

Plans for higher spectral resolution capacity underway.

GRAVITY+ brings together decades of technology development in detectors, AO, integrated optics to which OPTICON contributed.



THE EUROPEAN INTERFEROMETRY INITIATIVE

Post-ORP brings **significant risk** to the future of the EI and its services to the community as no funding is currently foreseen.

Training of the next generation of VLTI users with schools?

Support VLTI users via expertise centres?

Plan the future of long baseline optical interferometry (including ground and space)?

In parallel, it is not clear that ESO has the capacity to deliver on these in the future, given the ELT budget pressure.

We need to find ways to support the community in the long term.

MSCA STAFF EXCHANGES 2024

<https://marie-sklodowska-curie-actions.ec.europa.eu/calls/msca-staff-exchanges-2024>

19 September 2024: Launch of the call for proposals

5 February 2025: Deadline for submitting proposals

Can we setup an OPTICON project with $\sim 1\text{M€}$ of staff exchange?

Funds 1 month exchanges (e.g. observer travel to observatories, PhD students, etc)

Provides also funding for research, training and networking activities

We fulfill interdisciplinarity requirement: astronomy, data science, space communications and space situational awareness

These exchanges can be worldwide

LONG TERM EU PERSPECTIVES

Access to EU funding now requires “labelling”

ESFRI research infrastructure classification currently misses OPTICON Alliance medium and small size facilities

OPTICON Alliance infrastructures are a class of ESFRI “distributed infrastructures” and should pursue this label

OPTICON Alliance infrastructures shouldn’t be approached as classical “astronomy” facilities. The world has changed and they are now ground-space passive/active “ports” with interdisciplinary applications

The legal aspects should be considered. Short term solutions involving major funding agencies should be pursued.

Long term ERIC status should be evaluated. We are a large and diverse team and have the capacity to work on several fronts.