GRAVITY+
and upgrades to the VLTI infrastructure

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GRAVITY+ upgrade

Improve sensitivity and sky coverage of GRAVITY to reach K=22 in 1h

Several upgrades

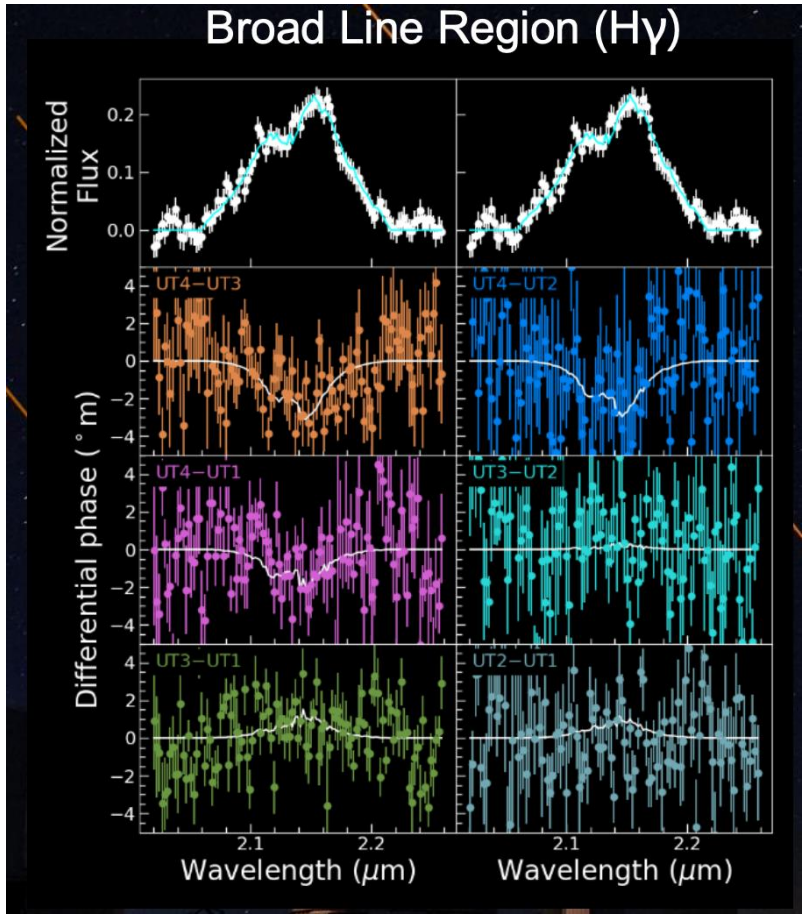
- Off-axis fringe tracking (GRAVITY Wide, BCDDL) -> Done
- Improved vibrations mitigation (“Manhattan 2”) -> On Going
- New Adaptive Optics (GPAO) -> Commissioning ongoing, See Florentin’s presentations
- Laser Guide Stars (LGS) -> LGS UT1,2,3 are being integrated in Garching, transport to Paranal planned mid-2025 and integration late-2025

Pending options (pending Oct2024 STC recommendation):

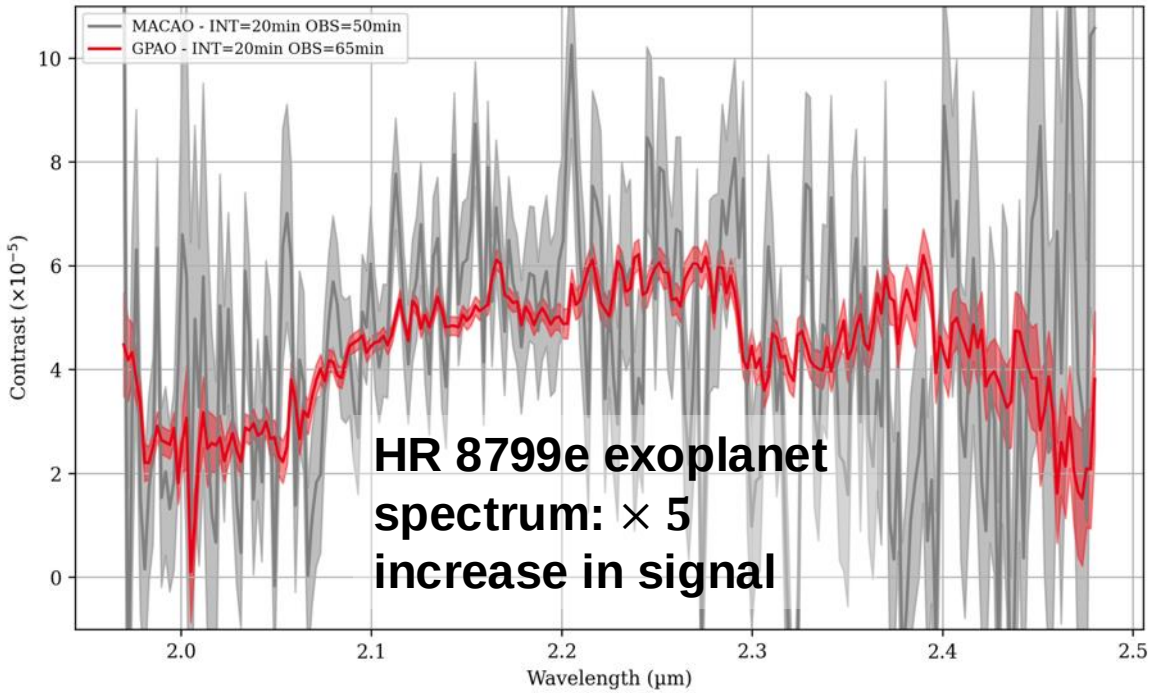
- New injection optics to minimise astrometric bias
- New R~15000 grism around Brackett gamma

GPAO first light (Sept2024)

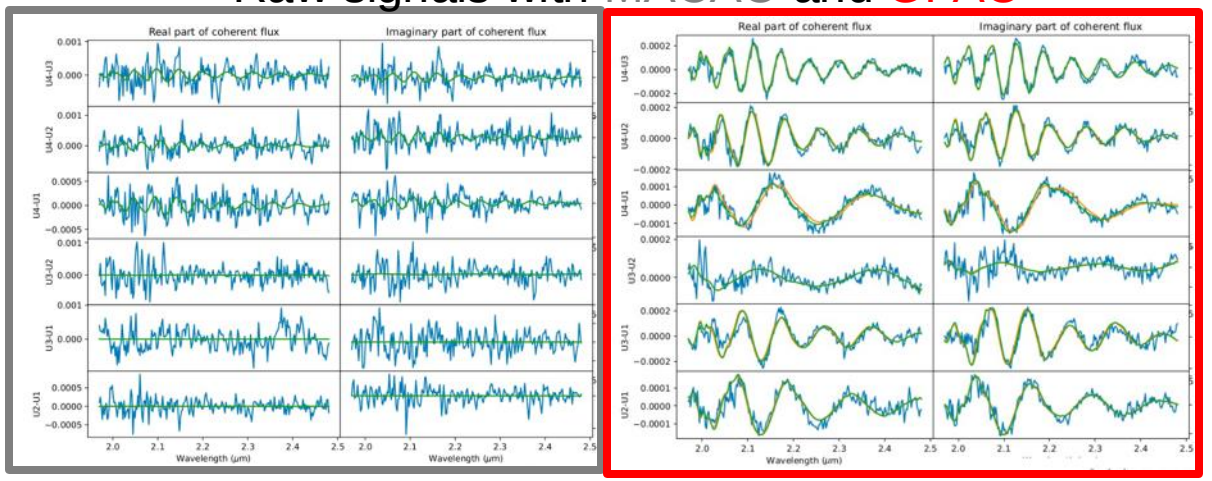
Observations of BLR of a Quasar at z~3.8



MACAO **SNR=2.2** per spectral channel /// GPAO **SNR=15** per spectral channel

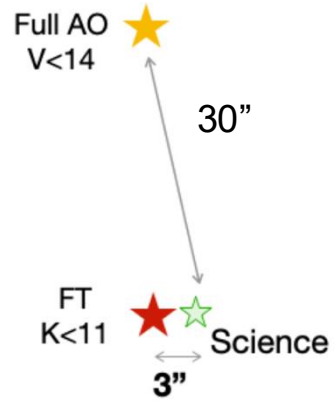


Raw signals with MACAO and GPAO



GRAVITY Science Cases greatly enhanced

Higher sensitivity and better sky coverage from V,K <14,11 to <18,14



GRAVITY

From dozen to thousands of AGNs

- SMBH masses at redshifts from 0 to 4

From dozen to hundreds YSO

- A lot more MYSO and T Tauri

Improved dynamic range for exoplanets

- Reinforce uniqueness of VLTI vs monolithic pupil

From a few/year microlensing to hundreds/year

- Prospects to detect stellar mass holes

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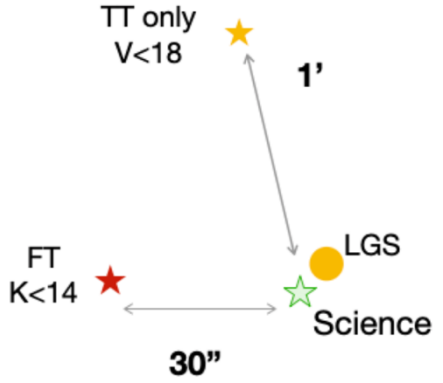
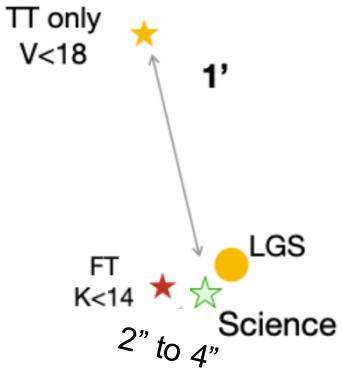


GRAVITY+
(Goals)



GRA4MAT

Check https://searchftt.jmmc.fr/ to check if AO/FT stars are available for your favourite targets!

Benefits for MATISSE

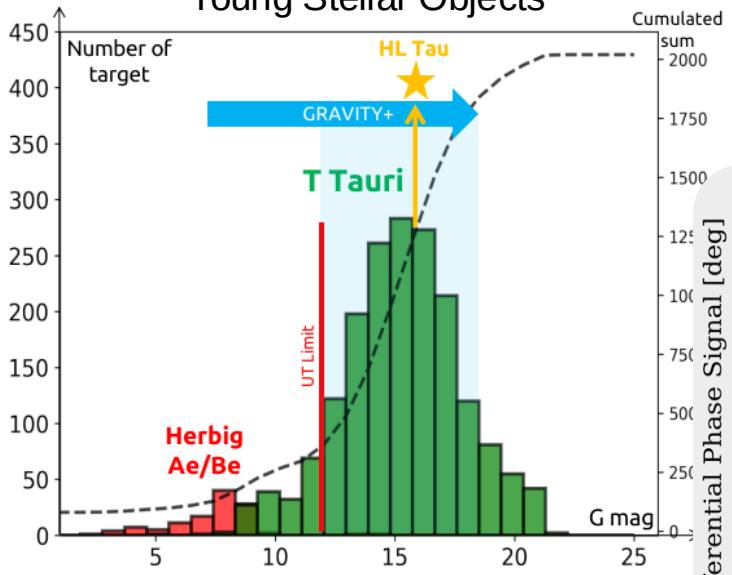
GRAVITY+ benefits all VLTI instruments, including MATISSE

- UTs: Better AO correction and less vibrations means better GRA4MAT, more flux in MATISSE, more stable transfer function
- UTs: Access to redder object thanks to LGS
- ATs/UTs: BCDDL provide a faster OPD actuator, hence inter-band (K-L) fringe tracking performances will improve (less jumps)
- Improved sensitivity means also more targets / new science cases for MATISSE

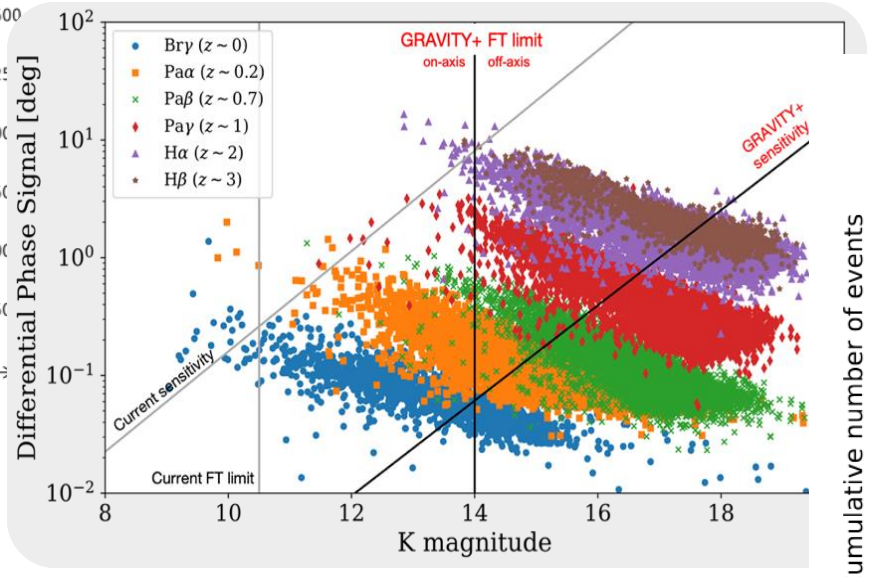
Improvement of sensitivity: get ready!

From a dozen of targets to hundreds (or even thousands)

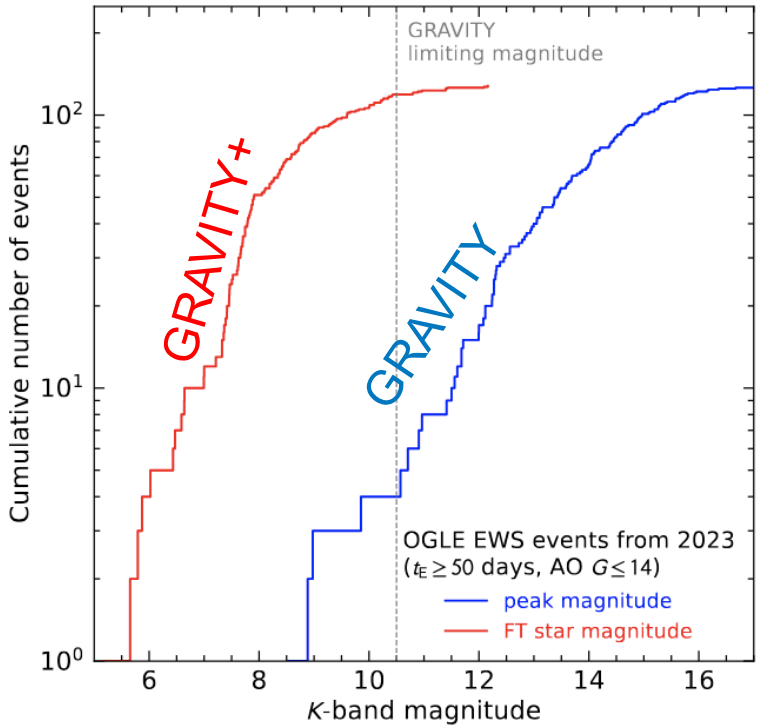
Young Stellar Objects



Black Holes at Cosmic Noon



Microlensing events
(Mroz et al. in prep)



Opportunities and challenges

How do we realise the scientific potential of VLTI?

- New science cases are becoming feasible & number of targets is exploding
- The “interferometrists” community is too small / too busy / not expert to lead all of them. But community can grow rapidly, e.g. exoGRAVITY large programme (15+ published papers):
  - Interferometry experts take and reduce data / Exoplanet experts analyse data and write papers
  - Cross-training over time: exoplanets experts come lead their own proposals!
- Multi-bands studies are still limited, in particular for the GTO fields (AGNs, YSOs)
- Data analysis becomes more challenging (e.g. polychromatic images, spectro-interferometry) and large scale (papers with dozens of targets)

Short- and long-term VLTI future

A bit of history of GRAVITY+

a highly competitive process at ESO for VLT/I new instruments

- **June 2019**: Proposed at the “VLT2030” workshop, along many other projects
- **October 2019**: Selected by STC* for whitepaper, along with BlueMUSE and SPHERE+
- **October 2020**: STC* recommendation
  - GRAVITY+ to start phase A (ran for 6mo)
  - BlueMUSE to follow (eventually delayed to 2024 by ESO because of lack of resources)
  - SPHERE+ as technology development, for AO only
- **October 2021:** STC* recommendation
  - Based on Phase A, GRAVITY+ should be implemented
- **January 2022**: Implementation of GRAVITY+ started
  - GRAVITY+ consortium is funding GRAVITY and VLTI upgrade at ~15Meur level (as of 2024)

* https://www.eso.org/public/about-eso/committees.html

Anatomy of a success:

GRAVITY leads VLTI in quantity and citations of publications

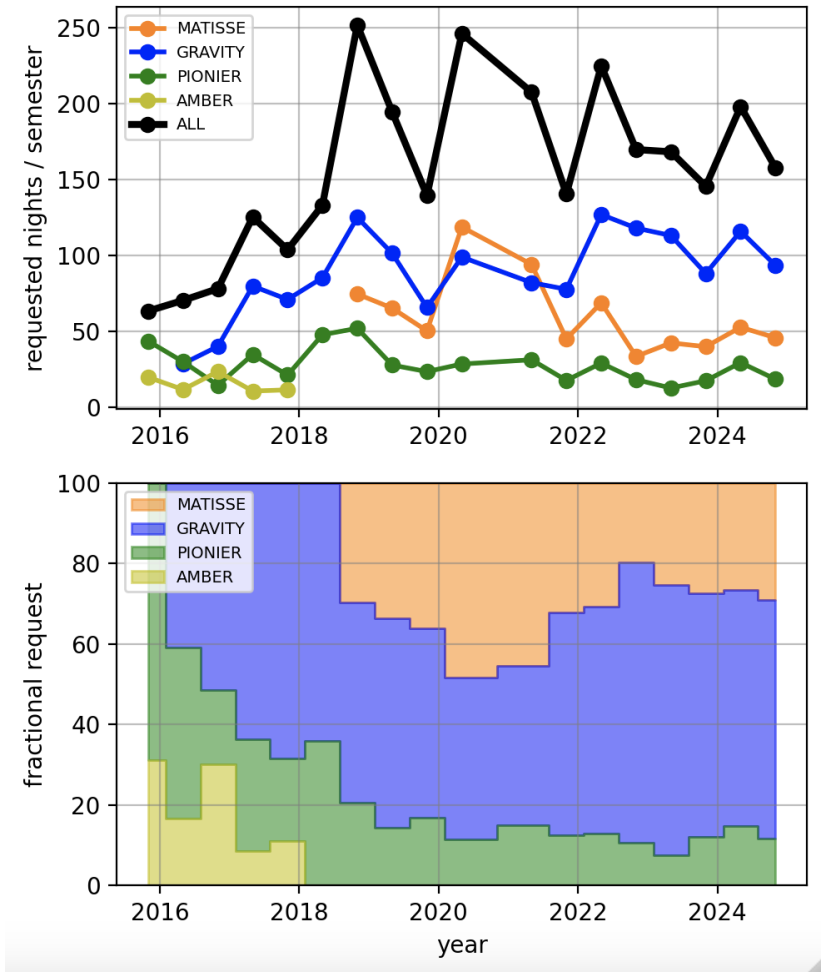
GRAVITY is the workhorse of VLTI:

- 60/30/10% of requested time for GRA/MAT/PIO (allocated time is comparable)
- 67/18/27% of publications for GRA/MAT/PIO

GRAVITY publishes high impact results: 2 out of the top 5 VLT result on the past 5 years

Top 30 VLTI publications:

- Sorted by citations: MIDI 40%, VINCI 23%, GRAVITY 20%, AMBER 17%, PIONIER 10%, MATISSE 0%
- Sorted by Citations/year: GRAVITY 70%, MIDI 20%, PIONIER 10%, VINCI 3%, AMBER 3%, MATISSE 3%



VLTI in the ESO landscape

ESO is committed to maintain the VLT/I competitiveness, while ELT is priority

Instrumentation programme for La Silla / Paranal (now-2030's):

- Just brought to the telescope: NIRPS, ERIS
- Ongoing: GRAVITY+, MOONS, 4MOST, SOXS, FORSup, CUBES, MAVIS
- Visitor / TechDev: HIRISE, ASGARD, SPHERE+
- Ongoing Phase A: BlueMUSE, 2GDSM

GRAVITY+
ASGARD

Continuous developments in Paranal

- Small dev. within the Instrument Operation Team (<~1FTE, few nights)

MATISSE Wide?

Phase 2 of VLT2030 should start next year:

- Conference to identify science cases, possible projects, evolution of operations for VLT/I in 2035+

New instrument?
Instrument upgrade?

Post ELT process is starting at ESO:

- New/upgraded facility for transformative science for 2040+

VLTI upgrade?
New interferometer?

What is next?

Top priority is to do realise the science potential of VLTI

VLTI ESO Priorities on approved developments:

1. Deliver GRAVITY+ (GPAO, LGS, vibrations)
2. Support ASGARD visitor instrument installation

Lots of great improvements are coming via GRAVITY+: sensitivity and performances

- New science cases, orders of magnitudes more targets
- These improvements will benefit MATISSE as well

How do we realise this new scientific potential of an upgraded facility?

- Produce robust reduced/calibrated data
- Develop data analysis tools
- Make it easy for non-experts to write papers!
- Publish backlog of data