VLTI ORP activities

WP4/JA3.2 and WP16

Denis Defrère – KU Leuven, on behalf of European Interferometry Initiative (EII)

This presentation includes

WP4/JA3.2 "Enhancing the Capabilities of the VLTI"

Partners: MPE, Leiden Observatory (NOVA), KU Leuven

WP16 "TA10 VLTI New-instrument TA Support"

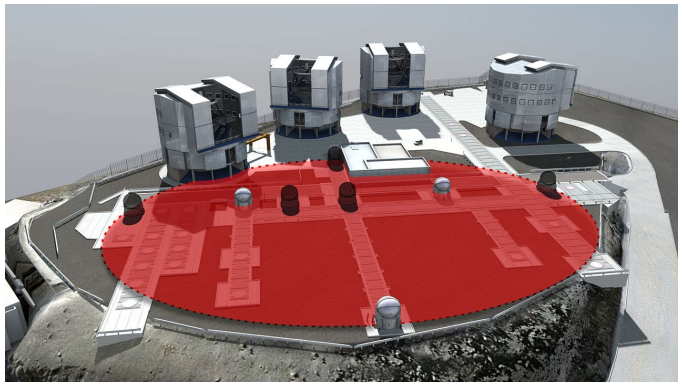
Partners: LESIA (CNRS), KU Leuven

European Interferometry Initiative

Funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004719.

VLTI: Very Large Telescope Interferometer

- Cerro Paranal (2635m), Chile
- Unique facility with four 8-m or four 2-m class telescopes
- Baselines up to 200m
- Three instruments
  - PIONIER (H-band, 1.6 μm)
  - GRAVITY (K-band, 2.2 μm, LR, MR, and HR, now GRAVITY+)
  - MATISSE (L to N band, 3 to 13 μm, LR to HR)
  - Visitor instrument: Asgard (J to L band, HR, high contrast)



VLTI activities in ORP

- Activities disseminated in three WPs:
  - **WP4**: JA3.2 – Enhancing the Capabilities of VLTI (coordinator: Denis Defrère, this talk)
  - **WP16**: TA10 VLTI New-instrument TA Support (coordinator: Denis Defrère, this talk)
  - **WP17** TA11 VLTI Expertise Centres, schools and community days (coordinator: Paulo Garcia, next talk)
- Activities overseen by EII https://european-interferometry.eu

OPTICON RadioNet Pilot

European Interferometry Initiative


ORP
Enhancing VLTI capabilities
JRA 3.2 – WP4
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Enhancing the VLTI Capabilities

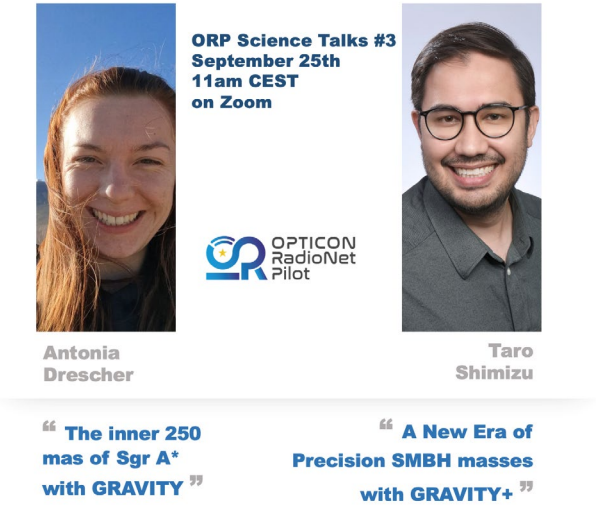
- Three main activities:
  - JA3.2.1: development and commissioning of an off-axis tracking mode for GRAVITY (MPE) => increased sky coverage
  - JA3.2.2: Preparation and integration of Asgard/NOTT into the VLTI for high-contrast imaging (Leuven) => increased contrast
  - JA3.2.3: A correlated flux mode for MATISSE to reach faint targets (Leiden) => better limiting magnitudes

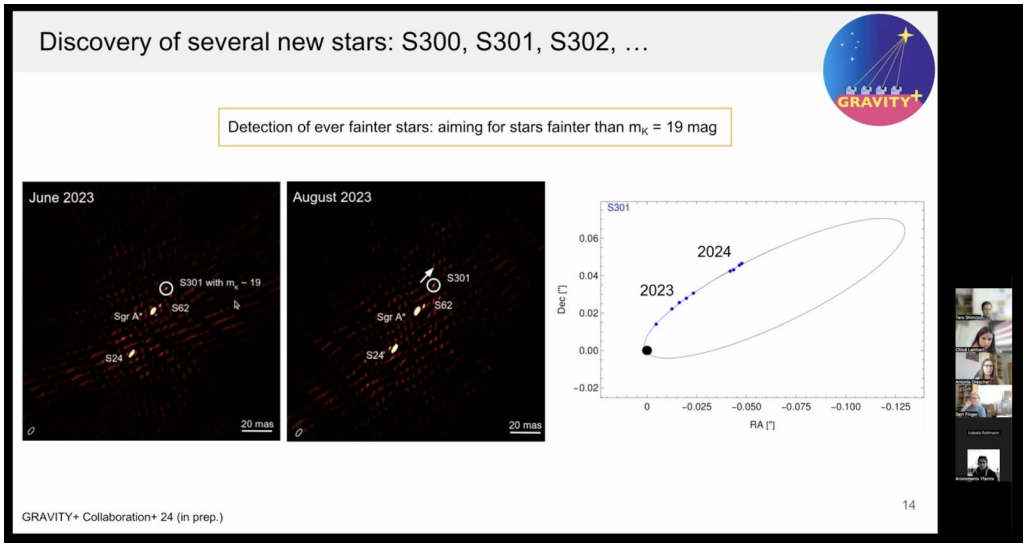
JA3.2.1: GRAVITY new mode

- **Objective**: new GRAVITY mode: off-axis fringe tracking up to 30” (called “GRAVITY wide”)
- **Lead**: F. Eisenhauer (MPE), work carried out by F. Widmann
- **Timeline and main milestones**:
  - Dec. 2021: ORP-funded postdoc hired (F. Widmann) for technical work.
  - Oct. 2022: new mode offered to the community (deliverable D4.3)
  - Commissioning description and first results published (see e.g., GRAVITY+ collaboration 2022).
  - 2023: designs for further improvements and upgrades continue (new faster differential delay lines, DDLs)
  - 2024: on-sky commissioning of DDLs
  - Several technical and peer-reviewed papers, including one in Nature (GRAVITY+ collaboration, 2024)

JA3.2.1: GRAVITY new mode

•**#3 ORP Science talk – September: Antonia Drescher** made a presentation on the galactic center, which harbours the closest **supermassive black hole, Sgr A*** and **Taro Shimizu** on the New Era of **Precision SMBH masses with GRAVITY+**





JA3.2.2 – Asgard

- **Objective**: Preparation and integration of Asgard/NOTT into the VLTI for high-contrast imaging
- **Lead**: Denis Defrère (Leuven), work carried out by M.-A. Martinod
- **Timeline and main milestones**:
  - Feb 2022: new postdoc (M-A Martinod) hired
  - March 2022: Asgard' science case submitted to OPC
  - August 2022: technical feasibility document submitted to ESO, first technical overview paper (Martinod et al. 2022)
  - March 2023: commissioning plan submitted to ESO
  - July 2024: revised technical feasibility document submitted to ESO;
  - October 2024: submitted full Interface Control Document (ICD, deliverable D4.4) to ESO
  - Several technical and peer-reviewed papers, including one on the full Asgard instrument (Martinod et al. 2024)

JA3.2.2 – Asgard

- **Workshops and publications supported by ORP**:
  - March 2023: Asgard workshop organized in Leuven in the presence of ESO
  - Presentation of the instrument at SPIE conference (2022, 2024) and VLTI summer school (June 2023)
  - Science and technology of Asgard presented in a peer-reviewed paper (Martinod et al. 2023) and conference proceedings (Martinod et al. 2022, 2024)

JA3.2.3: MATISSE new mode

- **Objective**: Develop a mode that yields calibrated correlated-flux output. This is especially valuable for faint targets, where (normalised) visibilities produce low S/N results by propagating errors on the photometry.

- **Lead**: Michiel Hogerheijde (Leiden University), work carried out by Violeta Gamez Rosas

- **Timeline and main milestones**:
  - Correlated flux mode offered by ESO since CfP March 2023 (deliverable D4.5)
  - Aug 2023: new hire (Violeta Gamez Rosas)
  - Sep 2024: work completed
  - Standard MATISSE observing mode produces correlated-flux products
  - Python scripts (matisse_tools) carry out calibration for suitable calibrator sources
  - Calibrator database with accurate flux values produced and publicly available (link)
  - Documentation in proof-reading stage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VLTI new instrument TA support (WP16)
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VLTI new-instrument TA support

Provides software for user services and user access for the new VLTI instruments JA3.2 Work Package.

- Support access and observations with GRAVITY+ (LESIA)
  - Model of performances vs mode, separation, condition, and magnitudes
  - Include model in Aspro2 software

- Support access and observations with Asgard/NOTT (KU Leuven)
  - Data reduction/calibration software package
  - Software tool to predict the best configuration and observing time for NOTT

GRAVITY+ software support

- **Lead**: Thibaut Paumard (LESIA)

- **Goals**: (1) Build a simplified model of performances to define the best observing strategy. Include, this model will be embedded inside the Aspro2 software. (2) Calibration and reduction software with documentation for GRAVITY

- **Timeline and main milestones**:
  - September 2022: new postdoc hired at LESIA (Anthony Berdeu)
  - 2022-2023: different modes of GRAVITY+ AO (GPAO) deployed on the LESIA bench to define the performance model and understand its limitations
  - 2022-2023: model implementation discussed with Aspro2 team
  - 2024: Analytical model be validated in AO simulator and implemented in Aspro2 (see link, deliverable D16.1)
  - GRAVITY pipeline and python tools updated (see link, deliverable D16.2)
  - Several technical and peer-reviewed publications (see e.g., Berdeu et al. 2024)

GRAVITY+ software support

- **Main publications**:
  - Poster at SPIE 2024 : “Simplified model(s) of the GRAVITY+ adaptive optics system(s) for performance prediction” - https://doi.org/10.1117/12.3019865
  - Poster at SF2A 2024 : “Simplified model(s) of the GRAVITY+ adaptive optics system(s) for performance prediction” - https://journees.sf2a.eu/ateliers/s05/

- **Other publications**:
  - Paper A&A : “Estimation of the lateral mis-registrations of the GRAVITY+ adaptive optics system – Perturbative method with open loop modal correlation and non-pertubative method with temporal correlation of closed loop telemetry” - https://doi.org/10.1051/0004-6361/202449311
  - Paper A&A : “Blind and robust estimation of adaptive optics point spread function and diffuse halo with sharp-edged objects – Application for asteroid deconvolution and moon detection” -https://doi.org/10.1051/0004-6361/202347636
  - Paper A&A : “Analytical modelling of adaptive optics systems – Role of the influence function” - https://doi.org/10.1051/0004-6361/202245327
  - Proceedings SPIE 2024 : “Open loop calibration and closed loop non-perturbative estimation of the lateral errors of an adaptive optics system: examples with GRAVITY+ and CHARA experimental data” https://doi.org/10.1117/12.3019843
  - Proceedings at SPIE 2024 : “Blind and robust reconstruction of adaptive optics point spread functions for asteroid deconvolution and moon detection” - https://doi.org/10.1117/12.3019874

Support for Asgard access

- **Lead**: Denis Defrère (KU Leuven)
- **Goals**: (1) Release and curate a data reduction/calibration software package with associated documentation. (2) Software tool to predict the best configuration and observing time for NOTT.
- **Timeline and main milestones**:
  - Feb 2024: work carried by M.-A. Martinod (postdoc hired in WP4, JA3.2.2)
  - Sep 2024: Data reduction software and documentation released (deliverable D16.3, Martinod et al. 2025, current version on GitHub: link).
  - Feb 2025: Final version of the observing tool released (deliverable 16.4, current version on GitHub: link)

Summary and contact

- ORP successfully enabled:
  - Two new VLTI observing modes and integration support for one new visitor instrument to be offered in 2025 (WP4, JA3.2)
  - New community tools and documentation to support observation planning and data reduction (WP16, TA10)
  - Several publications, conference presentations, and workshop
- All deliverables have been completed
- Questions? denis.defrere@kuleuven.be


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Questions?
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