STATUS of the VLTI

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VLTI in the ELT era

VINCI

MIDI

PIONIER

GRAVITY

AMBER

MATISSE
ON THE INSTRUMENTS & INFRASTRUCTURE SIDE
The Galactic Center

Measuring the mass through orbits

Fatal cloud disruption

Detection of a mysterious flare

Detection of a mysterious flare
The closest we get the stronger the influence of the black hole.

Figure 1. Finding chart of the S-star cluster. This figure is based on a natural guide star adaptive optics image obtained as part of this study, using NACO at UT4 (Yepun) of the VLT on 2007 July 20 in the \( H \) band. The original image with a FWHM of \( \approx 75 \) mas was deconvolved with the Lucy–Richardson algorithm and beam restored with a Gaussian beam with FWHM = 26.5 mas. Stars as faint as \( m_H = 19.2 \) (corresponding to \( m_K = 17.7 \)) are detected at the 5 \( \sigma \) level. Only stars that are unambiguously identified in several images have designated names, ranging from S1 to S112. Blue labels indicate early-type stars, red labels late-type stars. Stars with unknown spectral type are labelled in black. At the position of Sgr A* some light is seen, which could be either due to Sgr A* itself or due to a faint, so far unrecognized star being confused with Sgr A*.

1. Obtain high-quality, astrometrically unbiased maps of the S-stars. Obtain high-quality spectra for these stars.
2. Extract pixel positions from the maps and radial velocities from the spectra.
3. Transform the pixel positions to a common astrometric coordinate system; transform the radial velocities to the local standard of rest (LSR). For the astrometric data, several steps are needed.
   a. Relate the fainter S-stars positions to those of the brighter S-stars (Speckle data only).
   b. Relate the S-stars positions to a set of selected reference stars.
   c. Relate the reference stars to a set of SiO maser stars, of which the positions relative to Sgr A* are known with good accuracy from radio (VLA) observations (Reid et al. 2007).
4. Fit the data with a model for the potential and gather in that way orbital parameters as well as information about the potential.

We organize this paper according to these steps.

2. DATABASE
   The present work relies on data obtained over many years with different instruments. In this section, we briefly describe the different data sets.

2.1. SHARP
   The first high-resolution imaging data of the GC region were obtained in 1992 with the SHARP camera built at the Max–Planck-Institut für Extraterrestrische Physik (MPE; Hofmann et al. 1992; Eckart et al. 1994). SHARP was used by MPE scientists until 2002 at ESO’s 3.5 m NTT in Chile. The data led to the detection of high proper motions close to Sgr A* (Eckart & Genzel 1996). The camera was operating in speckle mode with exposure times of 0.3 s, 0.5 s, and 1.0 s, which was the optimum compromise between sufficient signal-to-noise ratio (S/N) and fast sampling of the atmospheric turbulence. The data are described in Schödel et al. (2003); a summary is given in Table 1. We used the simple shift-and-add (ssa) technique (Chistou 1991) in order to obtain diffraction limited images from the raw frames. Compared to our previous...
GRAVITY: pushing the frontiers of our knowledge in black-holes and fundamental physics.

The young stars paradox

Explaining the origin of the flare
GRAVITY at the VLTI: a challenge for the infrastructure

AT: recoating of optical train

STAR Separators

UT: CIAO (IR WFS)

AT: NAOMI

Challenges:

- Astrometry
- Acceptance of “experimental mode”
- Sensitivity
**MATISSE**

4T, L, M, N: (R 30 - 4000)
In operation: 2017

**Star and Planet formation**
(“Alma counterpart)

- Dust processing and evolution (mineralogy)
- Gas kinematics/Ice lines
- Planet signposts detection
- Gaps
- Spirals
- Young forming planets

**Challenges:**
- L band uncharted
- Concept
- Pupil control
- Fringe tracking
- Imaging (uv coverage)

**AGN:**
- Challenging the unification scenario
Upgrade the infrastructure:
The VLTI Facility Project (new structuration)

- MIDI decommissioning
- Upgrading the lab
- Prepare GRAVITY and MATISSE spots

1.2
- Heidelberg ‘test bench’ and prototype
- An alignment campaign (Heidelberg + Eric Gendron, Fanny Chemla, Françoise Delplancke)
- took place during Calendar Week 18. The CIAO warm optics were aligned to the input beam of the test bench and output beam of the cryostat, without the derotator.

The following problems were identified:
1. the 2 flat mirrors at the exit of the test bench bring the beam to the height of the AOMS, which are undersized.
2. the AOMS mirrors, on the off-axis side have the exact dimensions needed to transfer the 2 arcsec FOV when the system is aligned to prescription.

The first one creates difficulties for the system testing in Heidelberg. The effective field of view is now roughly elliptical with size 1.3 x 2.0 arcsec² and makes the testing conditions difficult. Yet, ray tracing simulation suggests that vignetting at the best alignment should not be as large as actually observed (Figure 1). I recommend therefore:

- a4 optimizing the alignment with the current mirrors. With the alignment campaign of CW18, this may now be the case. Yet, we may lose this condition after realigning the derotator if, in this process, some field is transferred between the parabola and the TTM.

b4 planning to change these 2 mirrors with larger ones.

The second problem will hit us in Paranal. It removes the flexibility to transfer field or pupil lateral errors between CIAO and the STS. This will constrain the operations (another argument to stop the derotator and make the internal alignment in CIAO static).

Contribution to CIAO
- AT service station: I2
- It is in service:
  - The reference plates are integrated and aligned
  - The ATs control axis have been validated
  - The M12 tower is implemented and aligned
  - The first part of the upgrade of the STS AT3 and AT4 has been made in it.

- Auxiliary telescopes
  - New AT alignment station
  - AT obsolescence and adaptation to astrometry
  - UT adaptation to astrometry

- NAOMI
- GRA4MAT (FT for MATISSE)
- PIONIER 3D
- Eight star separators
- AT train recoating
News from Gravity

- Imaging on-axis is operational on ATs
  - FT-enabled cience integration ~ 10 minutes
  - CfP 98 + **Science verification**
- Imaging off axis in good shape (K ~7, delta K ~3)
- Star separators commissioned
- Astrometry currently being tested on ATs
- CIAO1 aligned and ready for sky
ON THE OPERATIONS SIDE
The Imaging vs. Monitoring challenge

Hillen et al. 2016

Montargès et al. 2015
A crisis to come:

Scheduling VLTI in the VLT science operations paradigm model is a night-mare challenge
PREPARING THE FUTURE
Reasons for Optimism

VLTI is the future of high angular resolution at ESO. *ESO Visiting committee 2013*

"Perhaps the most important development regarding AGN unification is the significant improvements in long baseline interferometry and the ability to resolve the central structure on a milli-arcsecond scale. [...]" Hagai Netzer, ARAA 2014

Thanks to Hönig et al., we may now have to consider whether some of our resources should soon be put into building a next generation of optical interferometers. *Martin Elvis (CfA) Nature 2014*
The VLTI should reach its full potential in the next decade: a success is mandatory

Develop surveys and large programs to answer questions with statistical significance

Develop spectro-imaging capability with robust fringe tracking (iShooter: PIONIER-GRAVITY-MATISSE (J band?))

Expand the user base with VLTI expertise centers and develop synergies (European Interferometry Initiative) JMC

CHARA science meeting (March 2015)
There are several possible directions: all of them will require a strong science case.

- High spectral resolution (> 30000)
- High dynamics
- Increased imaging capability (more tel)
- Polarimetry
- "Wide" field astrometry
- Sensitivity
- Strong lensing SMBH mass measurements
- Fundamental stellar physics (PLATO)
- Asteroseismology synergy
- Kinematics of accretion/ejection
- Star-Environment interaction
- Visitor vs. Facility?
- Planet formation
- Exoplanet & Brown dwarfs in HZ
- All science
  - Enable time resolved imaging (Novae, hydrodynamics, convection)
- Preparing the future

A conference in ~ 2020??

CHARA science meeting (march 2015)