WP 4: Optical Interferometry

Partners: ESO, CNRS, NOVA, MPIA, FEUP

WP 4: Key Objectives

- **Enhancing the scientific output of interferometry**
  - 4.1.1: Evaluation of Paranal atmospheric parameters. *(ESO-F)*
  - 4.1.2: MIDI and AMBER *(1st generation instruments)* with PRIMA *(new generation fringe sensors, astrometry and phase reference imaging)* *(ESO-F-P-NL-D)*
  - 4.1.3: VLTI for the 2nd generation instruments *(D-F-ESO)*

- **Reaching the fundamental limits**
  - Contribution to the development of an optimum cophaser for the VLTI
  - 4.2.1: Analysis of FINITO *(1st gen. Fringe sensor)* and PRIMA commissioning data *(ESO-F)*
  - *Other points have been cut during the negotiation process*
    - *Development of fringe detection and tracking algorithms*
    - *Integration and testing of the new cophaser for the VLTI*

- **WP4 budget: 425k€**
- **Work Packages Leader:**

  Pierre Kervella (CNRS), Françoise Delplancke (ESO)

Progress report - Summary

- WP4.1.1: *Paranal atmospheric parameters*
  - Position started on jan. 1st 2011 (P. Schuller) and stopped on august 31th 2011
  - "Atmospheric properties for optical interferometry": Observatoire de Paris and ESO
  - Review of literature and work on FINITO+AMBER data
  - Participation in 2012 of CNRS/Nice in // to the work on 2GFT/POPS/multiaxial

- WP4.1.2: *MIDI and AMBER with PRIMA*
  - MPIA + ESO (Andre Mueller) for MIDI+PRIMA
  - FAUp (Nuno Gomes) on astrometry and phase reference imaging
  - ESO: improvement of AMBER data reduction using fringe tracking data

- WP4.1.3: *VLTI for the 2nd generation instruments*
  - Connected to WP4.2.1 in fact
  - Funds from CNRS/WP4.1.1 used at CNRS/Nice for multiaxial fringe tracking studies

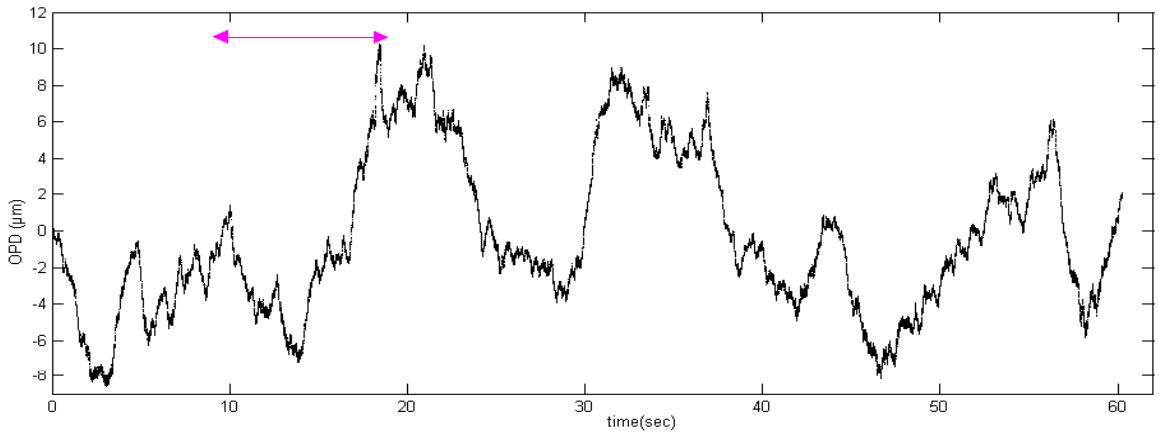
- WP4.2.1: *Reaching the fundamental limits*
  - position started on February 14 2011 (B. Justen)
  - FINITO and PRIMA commissioning data analysis (ESO+CNRS)
  - Other short positions at ESO in 2012 (see later)

Work in progress (1)

CNRS/Nice

- Analytical description of the Chromatic Phase Diversity Algorithm
- Improvement of the testbench (piston mask, chromatism)
- Implementation of full coherencing+cophasing algorithm
- State machine description, criteria
- Possibly, follow-up of work engaged at LESIA about Paranal atmospheric parameters (TBC)
- Anthony MEILLAND(6m postdoc), Wassila DALI-ALI(6m postdoc), DM.
- Partial funding for phase masks

Pistons generator masks



VLTI site (Paranal)

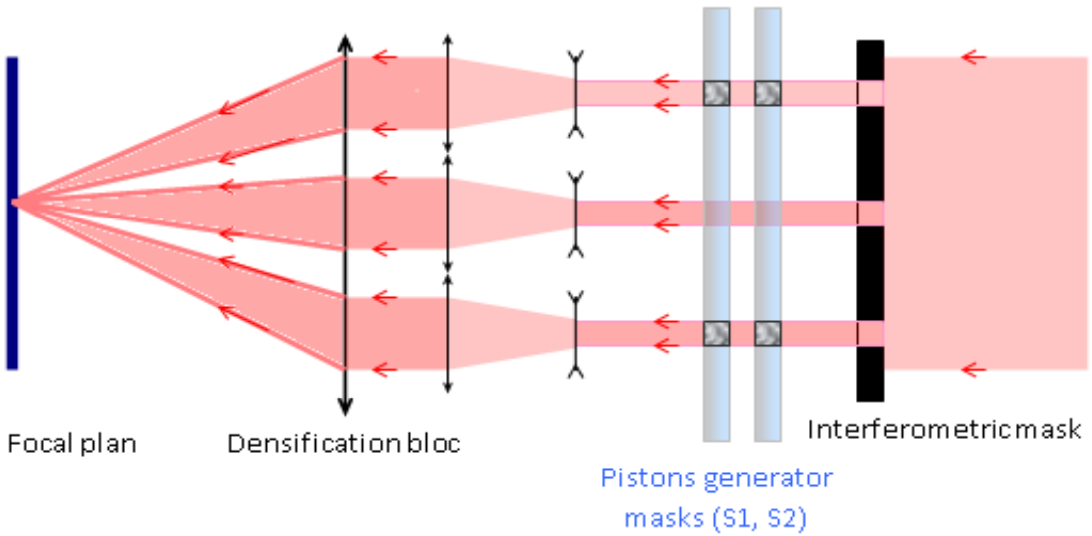
Turbulence conditions:

$\varepsilon 0 \sim 0{,}9$ arc-sec , $\tau 0 \sim 6$ms

Pistons RMS (open loop):

10-15µm (AMBER)

8µm (FINITO)



Tow masks

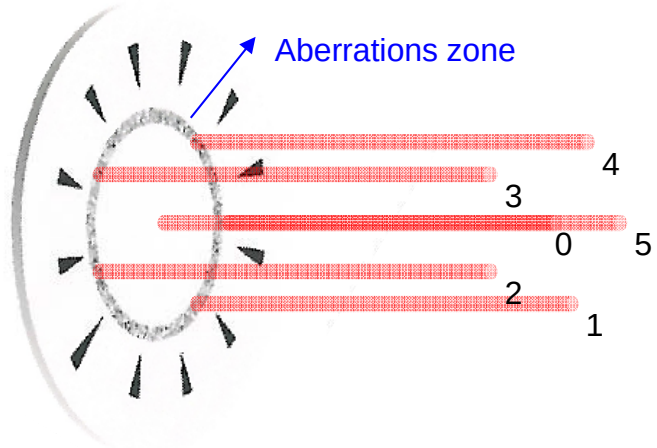
S1: Small amplitude, fast rotation

S2: large amplitude , low rotation

S1+S2 => ±8µm

• Configuration & Spec

Phase masks	Ecran 1	Ecran 2
Diameter (mm)	100 ±0.1	100 ±0.1
Thick (mm)	1,0±0,05	1,0±0,05
OPD amplitude (Min to Max) for λ=0.6µm OPD (amplitude, resolution) (µm) Phase resolution (levels)	9λ (5.5, 0.085) 64	18λ (11, 0.17) 64
Pixels number in the aberrations corona (D=49mm)	1540	1540
Pixel size (mm)	2.7 ×0.1	2.7 ×0.1
Transmittance Chromatic dispersion Parallelism	> 80% < 2% < 15arc-sec	> 80% < 2% < 15arc-sec

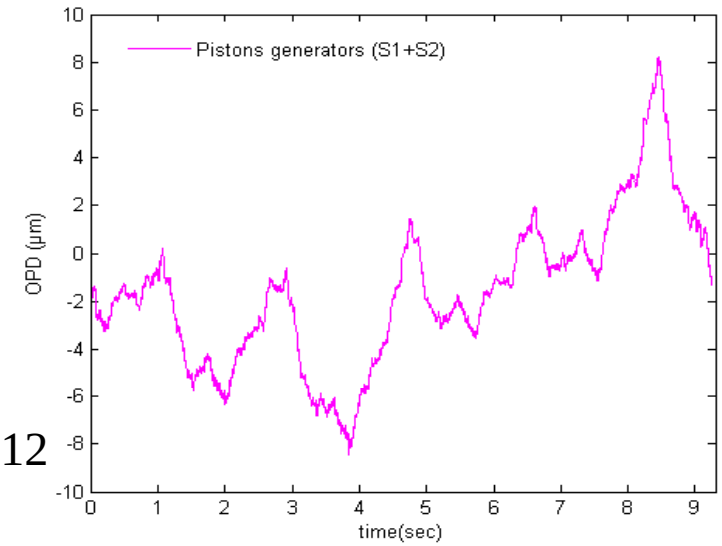


Aberrations profile S1+S2

S1: rotates with 1,2ms/pixel

S2: 6ms/pixel

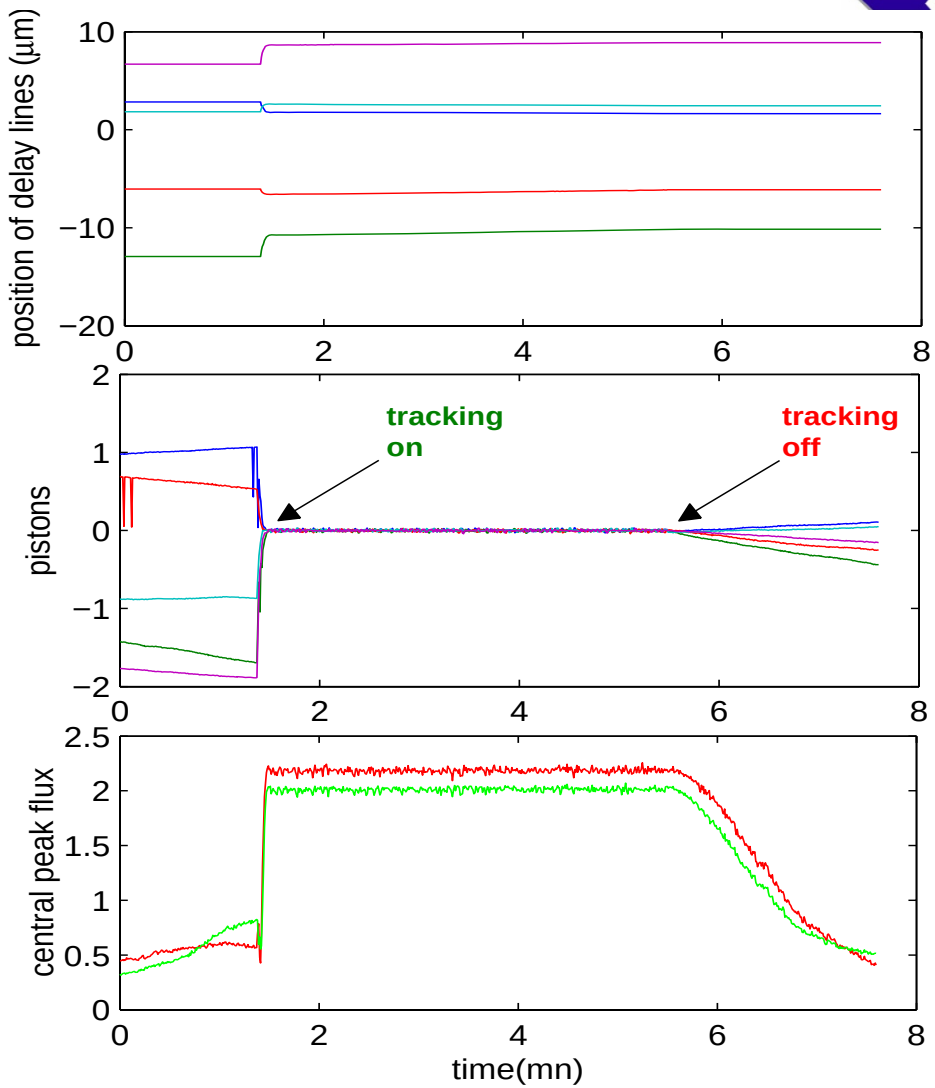
OPD Profile with S1+S2 # Real OPD profile FINITO



Opticon Board, Como, Oct. 2012

Recent results

6-beam closed loop
Top: position of delay lines
Middle: residual piston
Bottom: Intensity of the central pixel in the
'red' and 'green' images



SIRIUS/CPD testbed
OCA/Lagrange
D. Mourard, A. Meilland, W. Dali-Ali

Next step: with piston perturbations (masks)

Work in progress (2)

- ESO hired one post-graduate student (Benedikt JUSTEN) during ~10 months in 2011.
- There are also now 5 undergraduate students: Lester DAVID, Benoit SERRA, Maxime FOLLIN, Beatriz BENAVIDES-BLANCO and Luci METENIER for 4 to 6 months each.

- And finally ESO hired a post-doctoral fellow for one year, Fatme ALLOUCHE.

Work in progress (3)

- Benedikt Justen collaborated with OCA for performing tests on the SIRIUS testbed in Nice in order to understand the **features, advantages and limitations of the multi-axial combination and Chromatic Phase Diversity method** in view of the 2nd generation fringe tracker. Benedikt worked also on the **characterization and calibration of the PRIMA Fringe Sensor Unit**

- Lester David is working on evaluating the enhancement of the science that could be performed by **Gravity and Matisse thanks to off-axis fringe tracking**. For each type of scientific target (YSOs, AGN ...) and as a function of the fringe tracking and tip-tilt tracking performance (limiting magnitude), he evaluates the **number of new objects** that could be observed. He develops an interactive **Java tool** using the Aladin database to display these results.

Work in progress (4)

- Benoit Serra and Fatme Allouche are working on comparing various algorithms that can be used for the **calibration of the Fringe Sensor Units of PRIMA**. The goal is to evaluate as precisely as possible the wavelengths and phases of each detection pixel of the FSU using data recorded during an OPD scan either on an internal calibration source or on a star. The sensitivity of the various methods **to atmospheric and electronic noise** is evaluated. The results will be extrapolated to the concepts envisaged for the 2nd generation fringe tracker.

- Maxime Follin is studying the sensitivity of a potential **integrated optics sensor using multi-axial combination and the Chromatic Phase Diversity method** to optical alignment defects. The defects can be at the entrance of the component (injection into the fibers) or at its output (misalignment of the corld camera). Flux, physical parasitic phase and estimator errors will be evaluated.

Master thesis
PRIMA FSU Scan Data Processing : Evaluation of a new method for data process.

Benoît SERRA
M2 – OSAE 2011/2012
Promotion Galiléo

The VLT array on the Paranal mountain. Credit : MPIfR (Gerd Weigelt)

Internship from March, 5th to August, 31th 2012
ESO Supervisor : Ms. Françoise Delplancke-Stroebele
Paris Observatory's Tutor : Mr. Guy Perrin
Location : European Southern Observatory (ESO) – Garching / Germany

Rapport de Stage

Etudes des observations scientifiques des instruments GRAVITY et MATISSE du VLTI

Lester DAVID

11/09/2012

Pour l'Observatoire de Paris : M. Guy PERRIN
Pour l'Observatoire Européen Austral : Mme. Françoise DELPLANCKE-STROEBEL

Work in progress (5)

- Beatriz Benavides-Blanco and Lucie Metenier are working on the **algorithms for data reduction of AMBER and MIDI data** (respectively) when doing **off-axis fringe tracking:**
  - how to use the fringe tracker data optimally in post-processing to realize a coherent integration of the frames
  - for AMBER, what would be the optimum AMBER integration time depending on the fringe tracking performance
  - for MIDI, how to handle the water vapor dispersion
  - what is the influence of the anisoplanatism, is a frequency filtering of the corrections applied to the scientific object useful or not (in order to avoid propagation of the non-common piston)

Key FP-7 Achievements

Understanding the limitations and pushing the performances of interferometric instruments

- Good improvement of **the limiting magnitude of MIDI** instrument thanks to PRIMA Fringe Sensor (*new device installed on VLTI*)
- Important improvement of the **quality of the AMBER measurements** and removal of many bias using fringe tracking with FINITO (*1st generation of fringe sensor*)
- Steps towards the **future cophasing systems**
  - Development of NFT/NOVA
  - Prolongation of studies on POPS multiaxial.
  - Lab demonstration of the Chromatic Phase Diversity Algorithm
  - Impact on MIDI/AMBER and GRAVITY/MATISSE