FINITO:
Three-Way Interferometric Fringe Sensor for VLTI

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A Collaboration between

European Southern Observatory

INAF – Osservatorio Astronomico di Torino

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ABSTRACT

The Very Large Telescope Interferometer is described in this workshop (Paresce 2002).

The FINITO project is a collaboration between ESO and the Osservatorio Astronomico di Torino for implementation of a two / three beam Fringe Sensor Unit for VLTI. FINITO (**F**ringe-tracking **I**nstrument of **NI**ce and **TO**rino) measures the optical path difference (OPD) variation, induced by atmospheric turbulence, on three telescopes, measured pair-wise, providing the information required by the Delay Line control loop to compensate the perturbation.

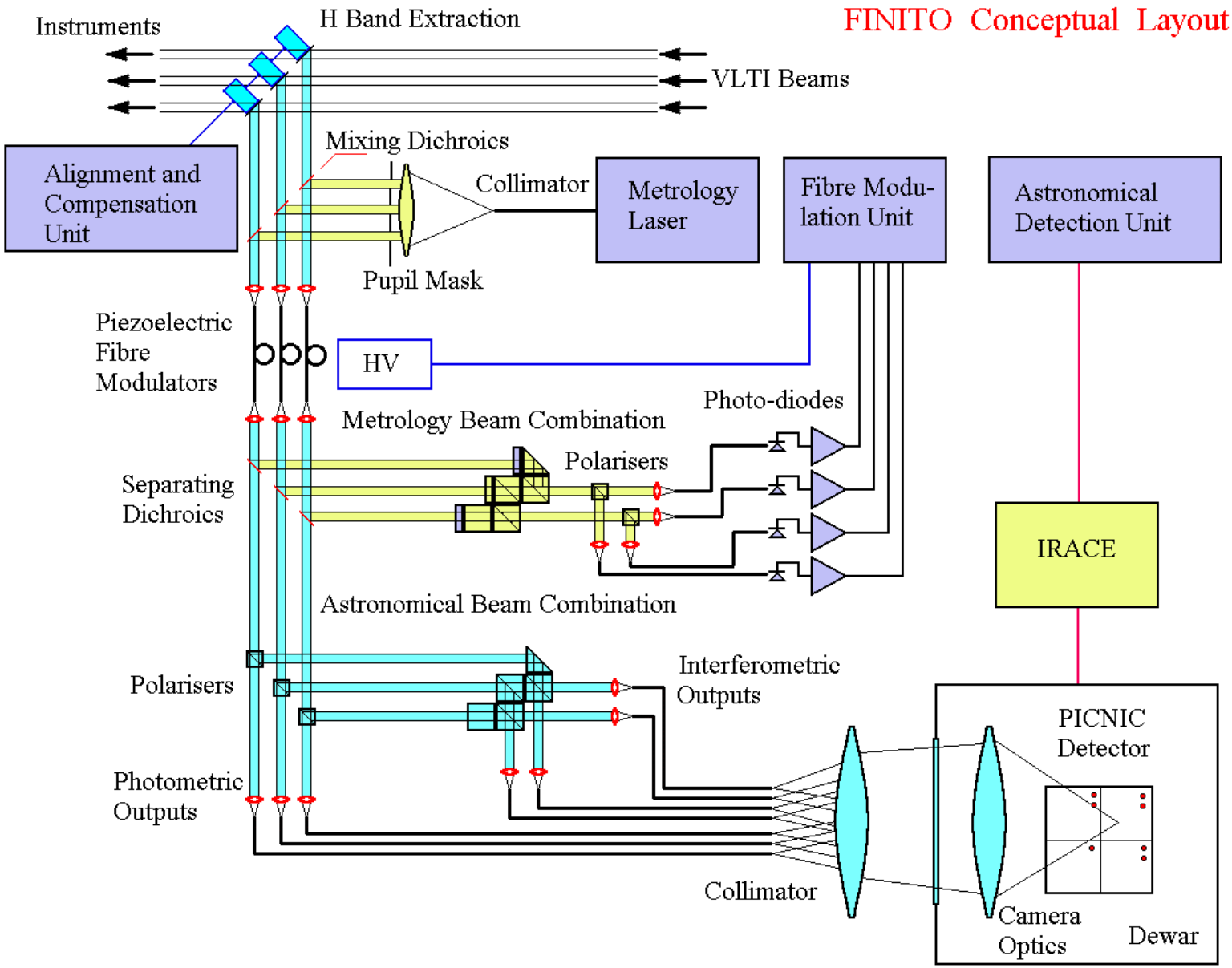
FINITO supports the closure phase measurement capability and significantly improves on accuracy and sensitivity of each VLTI instrument (AMBER, MIDI), increasing their coherent exposure time from few milliseconds to several minutes. We present the instrument concept and its development status, the expected performance, and a few examples of the astrophysical subjects which may benefit from the VLTI resolution complemented by FINITO, as well as the limiting magnitude of the reference source, which promises a coverage up to several percentual parts of the southern sky.

Current status:

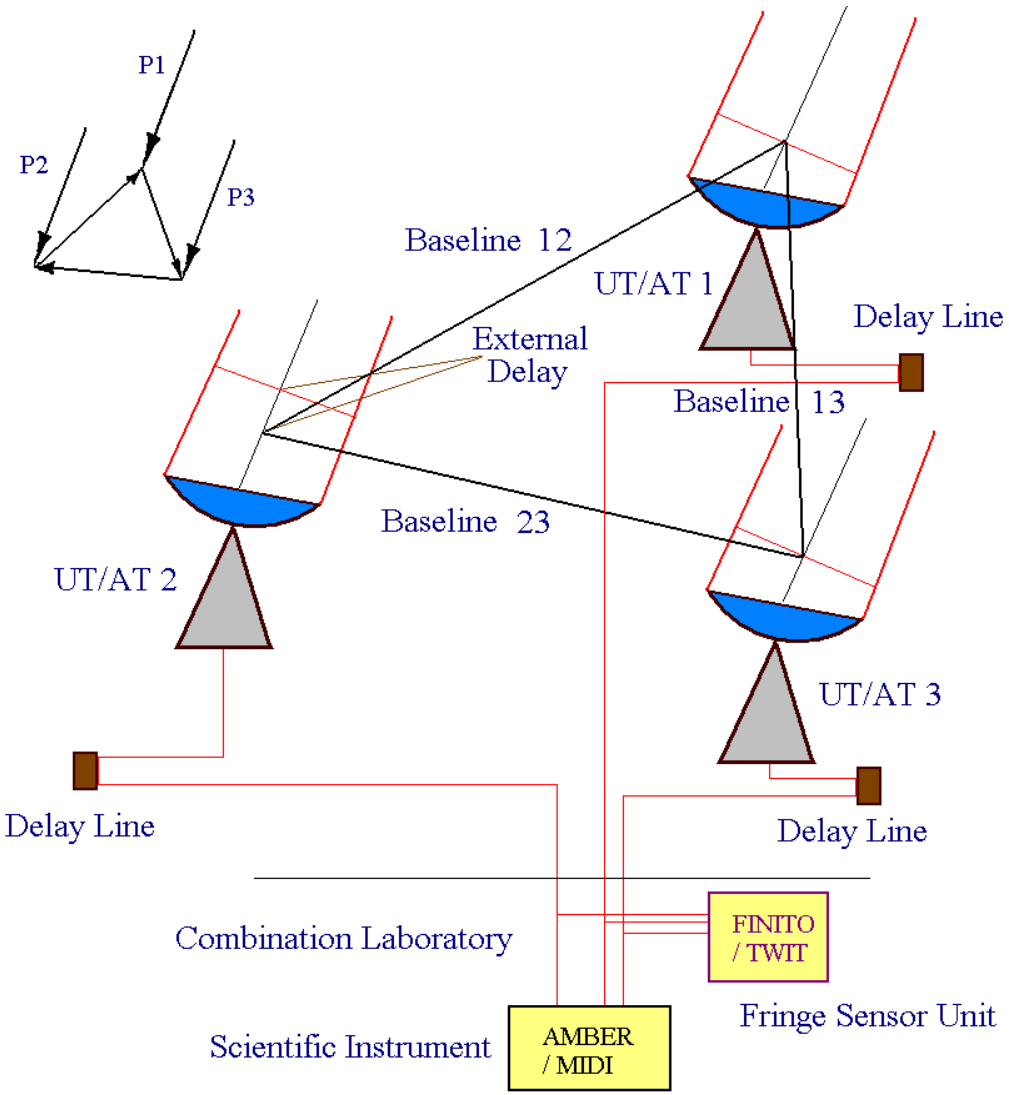
- Component procurement in progress
- Opto-mechanical assembly in Torino: June – September 2002
- System Integration (ESO – Garching): September – December 2002
- Installation at Paranal: January – March 2003

Basic instrument concepts:

- Amplitude combination of 2 or 3 beams, in H band ($\lambda\lambda$=1.5-1.8 μm);
- Temporal modulation of OPD for cophasing / coherencing;
- Spatial filtering to reduce random phase terms (wavefront errors);
- Off-axis fringe sensing, over a field of ~1” diameter on UT;
- 1’ field of view achieved upon availability of the Star Separators;
- Compensation of longitudinal / transversal differential atmospheric refraction.


FINITO Conceptual Layout
Instruments
H Band Extraction
VLTI Beams
Alignment and Compensation Unit
Mixing Dichroics
Collimator
Metrology Laser
Fibre Modu-lation Unit
Astronomical Detection Unit
Pupil Mask
Piezoelectric Fibre Modulators
HV
Photo-diodes
Metrology Beam Combination
Polarisers
Separating Dichroics
IRACE
Astronomical Beam Combination
Interferometric Outputs
Polarisers
PICNIC Detector
Photometric Outputs
Collimator
Camera Optics
Dewar

Phase Closure



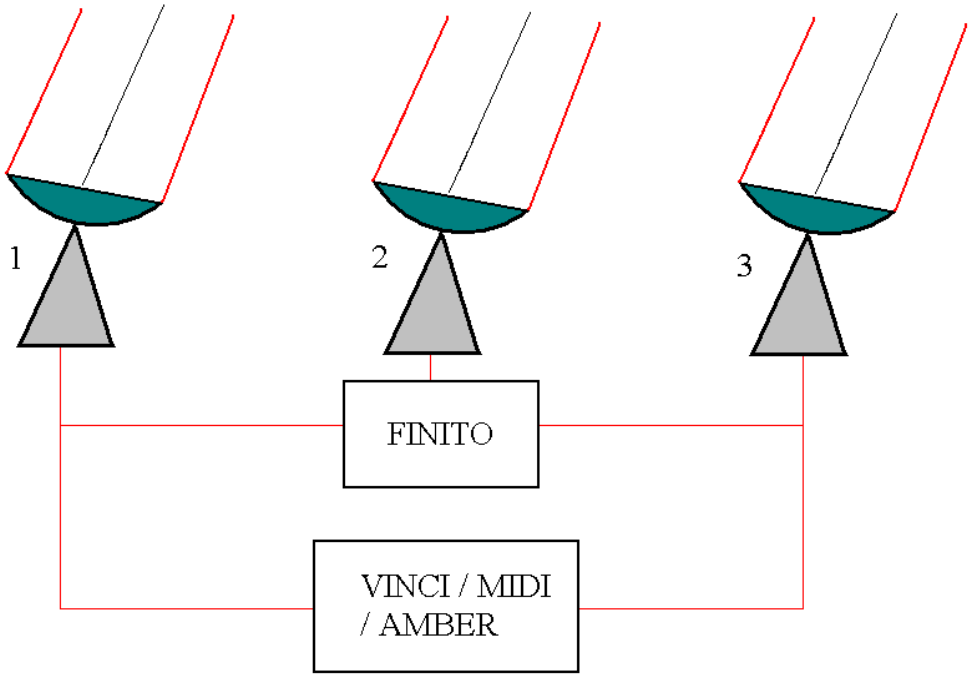
P1, P2, P3: piston contributions to telescopes 1, 2, 3

Measurement and stabilisation of optical path perturbations
P1-P2 and P1-P3:
P2-P3 is also stabilised

Measurement of visibility along baselines 12, 13 and 23 provides information on the target structure
[Jennison 1958]

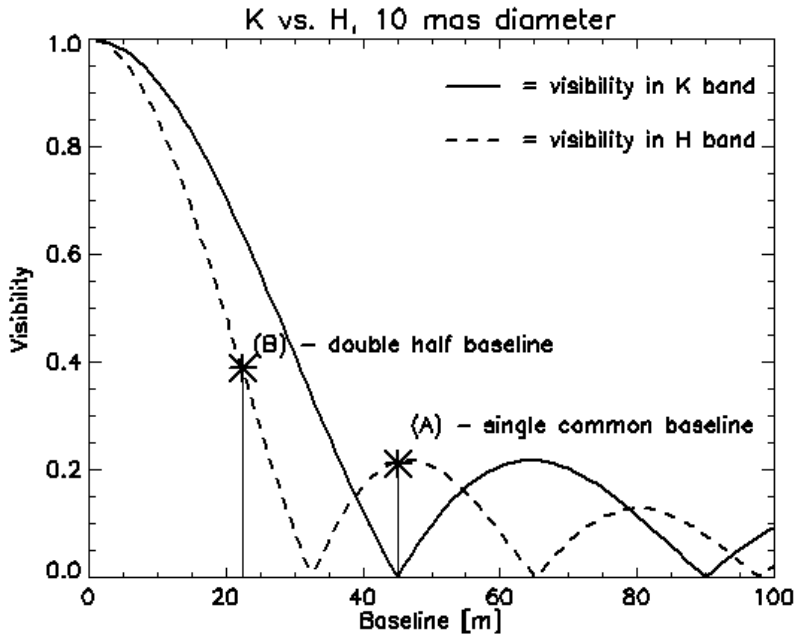
Baseline and wavelength bootstrapping

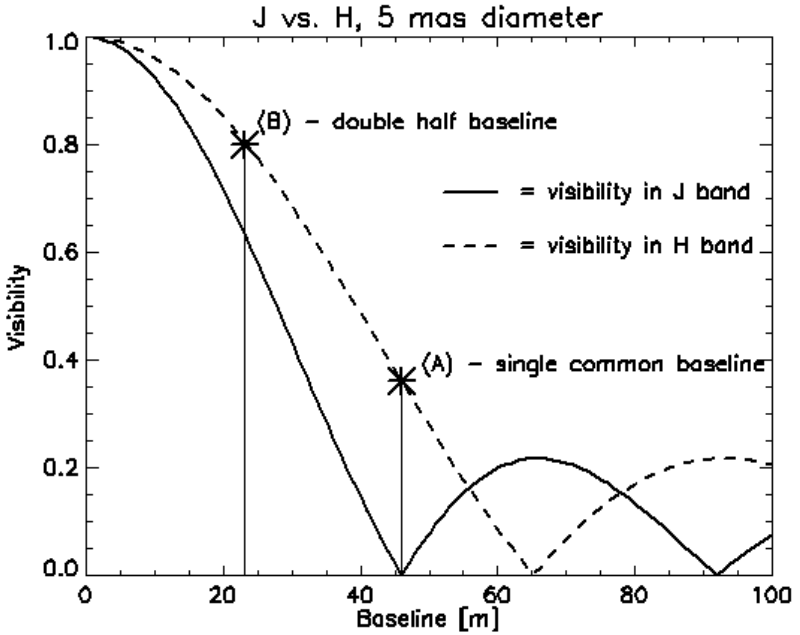
The target structure is mostly evidenced close to the minimum of visibility, where OPD measurement performance is most degraded.



B12 = B23, B13 = 2xB12

Taking advantage of the different observing band between the scientific instrument and FINITO, and operating the latter on two baselines simultaneously, it is possible to achieve high stabilisation efficiency, comparable with point-like source performance, although observing in the most sensitive region.





Cases considered: uniform disc model, wavelength independent

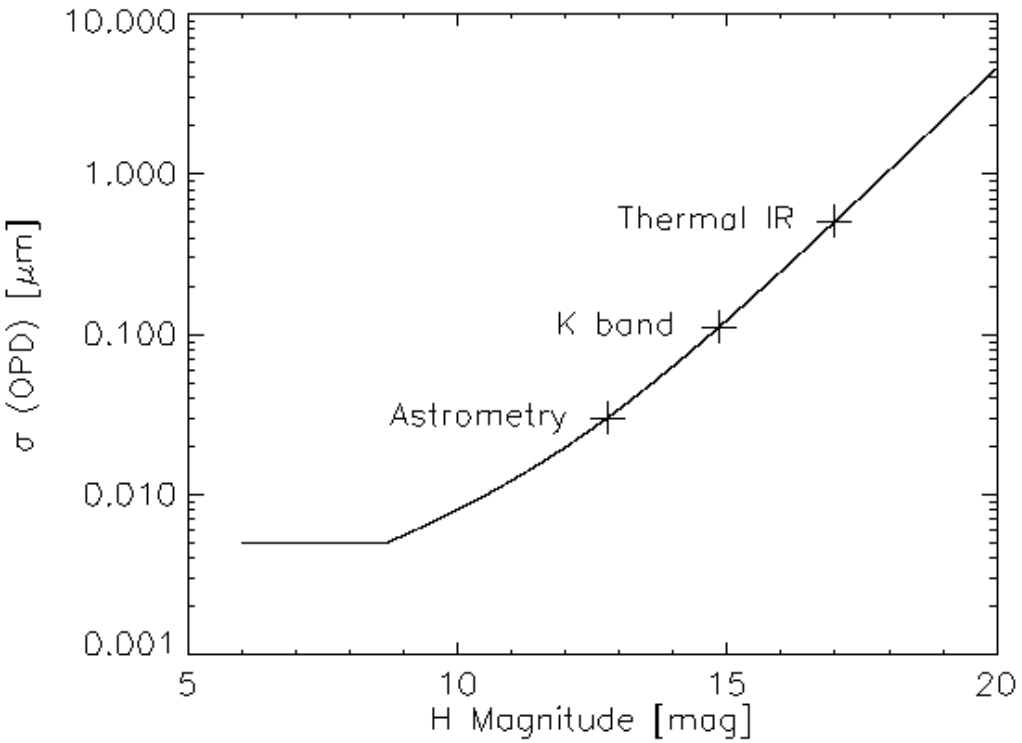
10 mas source observed in K band and tracked in H band

The K minimum is reached for a 45 m baseline, where the FSU has ~20% visibility. Using the two half-baselines of 22.5 m, the FSU visibility reaches 40%.

5 mas source observed in J band and tracked in H band

The J minimum is reached for a 46 m baseline, where the FSU has ~35% visibility. Using the two half-baselines of 23 m, the FSU visibility reaches 80%.

Expected Performance



OPD noise estimate depends upon brightness and visibility of the selected reference source; acceptable thresholds defined by observing mode.

Limiting H magnitude defined for unresolved reference source, on 8 m telescopes; equivalent value for Auxiliary Telescopes reduced by ~3 mag

10 μas Astrometry:	σ (OPD) < 30 nm	H = 12.77 mag
K band Imaging at λ/20:	σ (OPD) < 110 nm	H = 14.83 mag
10 μm Imaging at λ/20:	σ (OPD) < 500 nm	H = 16.98 mag

A few possible applications... (FINITO + VINCI / MIDI / AMBER)

Imaging of several resolved stellar (and a few extra-galactic) sources

Stellar astrophysics and astrometry:

- (Re-)Calibration of the effective temperature scale by diameter determination (~2%)
- High resolution characterization of exo-planet candidates for space interferometric missions (SIM, GAIA, TPF)
- Revision of the radius-mass relation (visual binaries) and stellar masses
- Distance calibration of double-lined spectroscopic binaries up to 2.5 kpc (also single-lined SB with PRIMA)
- Pulsation of Mira (Cepheid, ...) variables

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