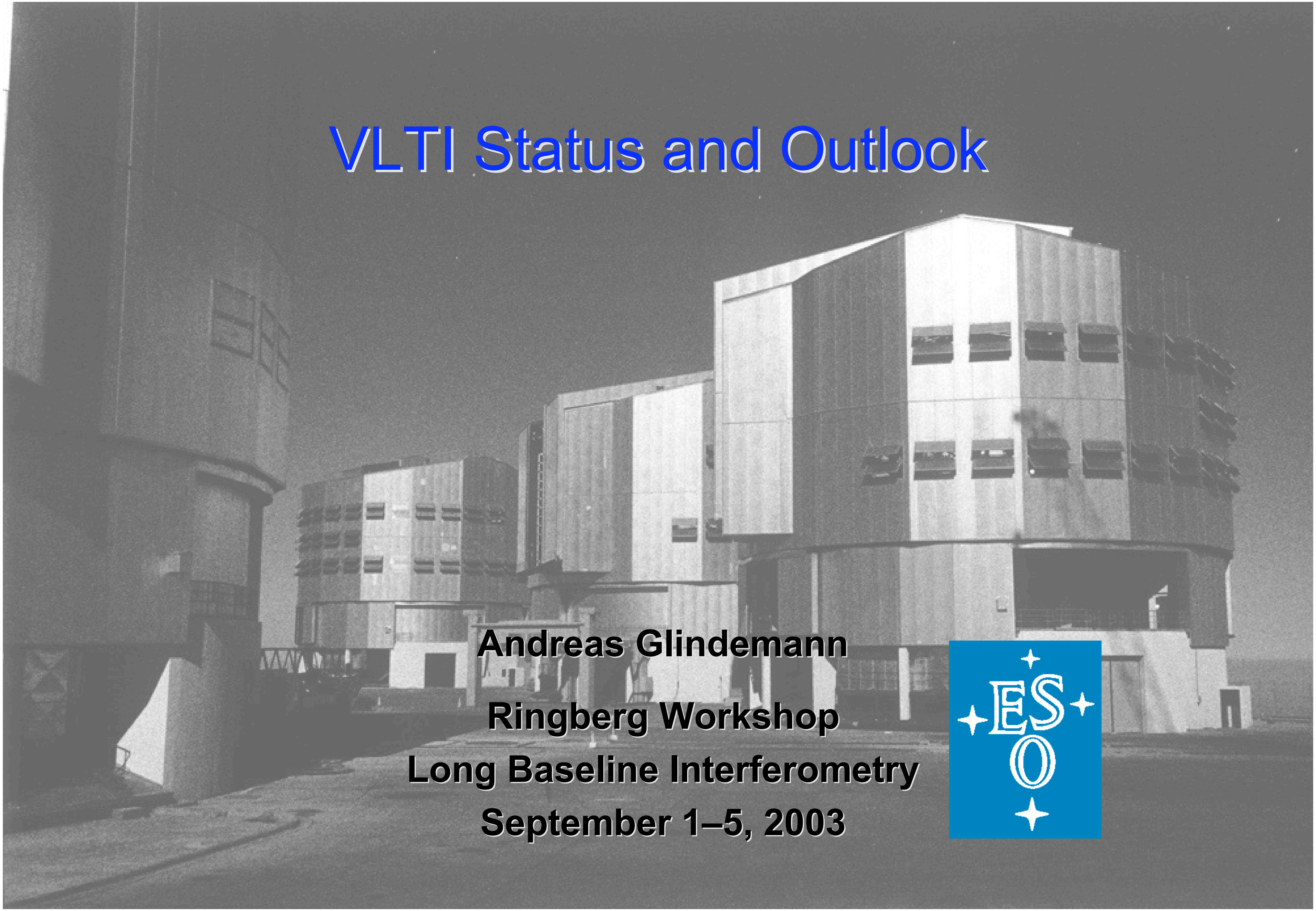
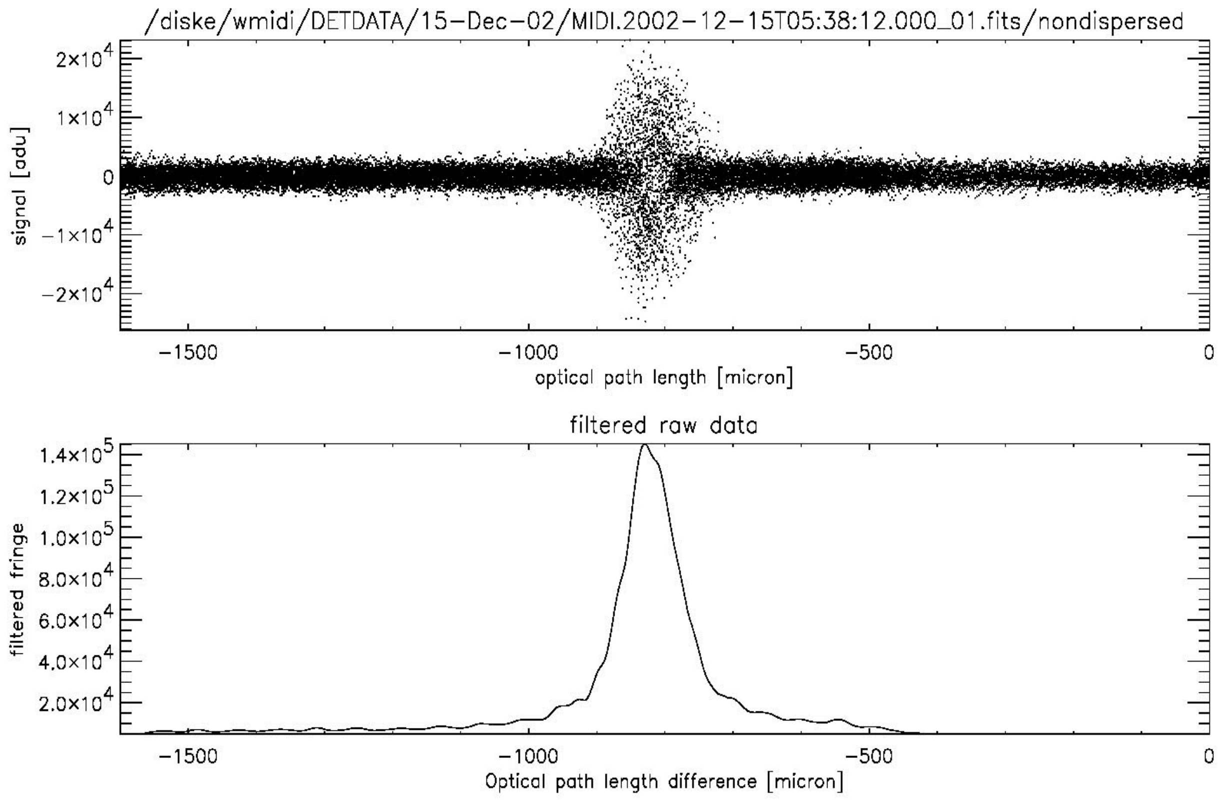
VLTI Status and Outlook

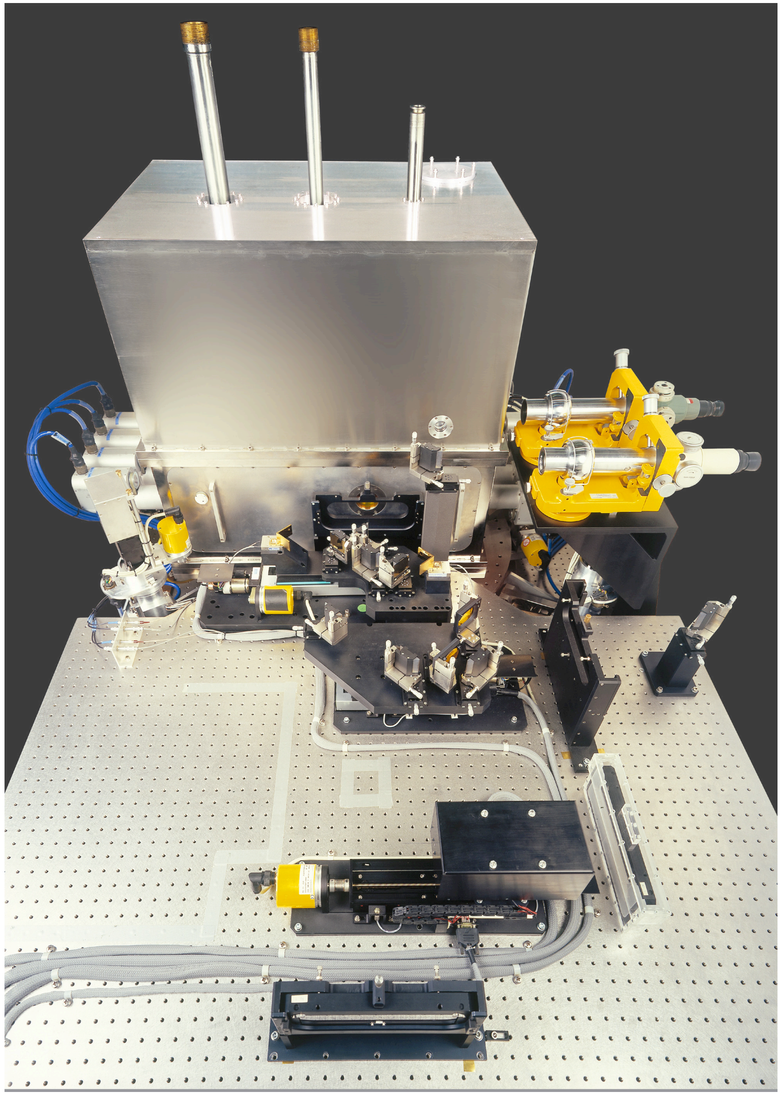


Andreas Glindemann

Ringberg Workshop
Long Baseline Interferometry
September 1–5, 2003

First Fringes with MIDI
Dec 15, 2002





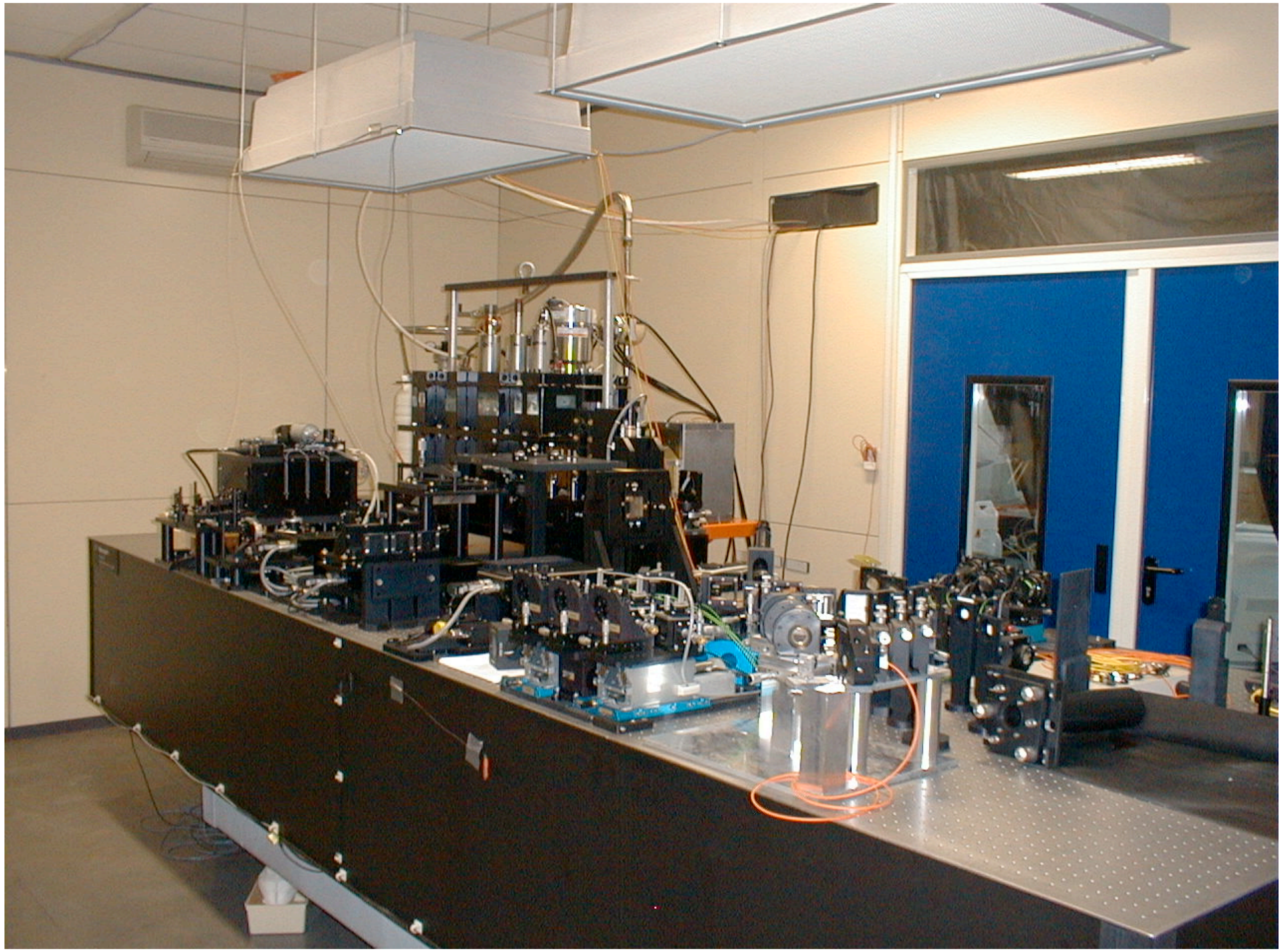
AMBER in Grenoble

Three bands (JHK)

Three beams

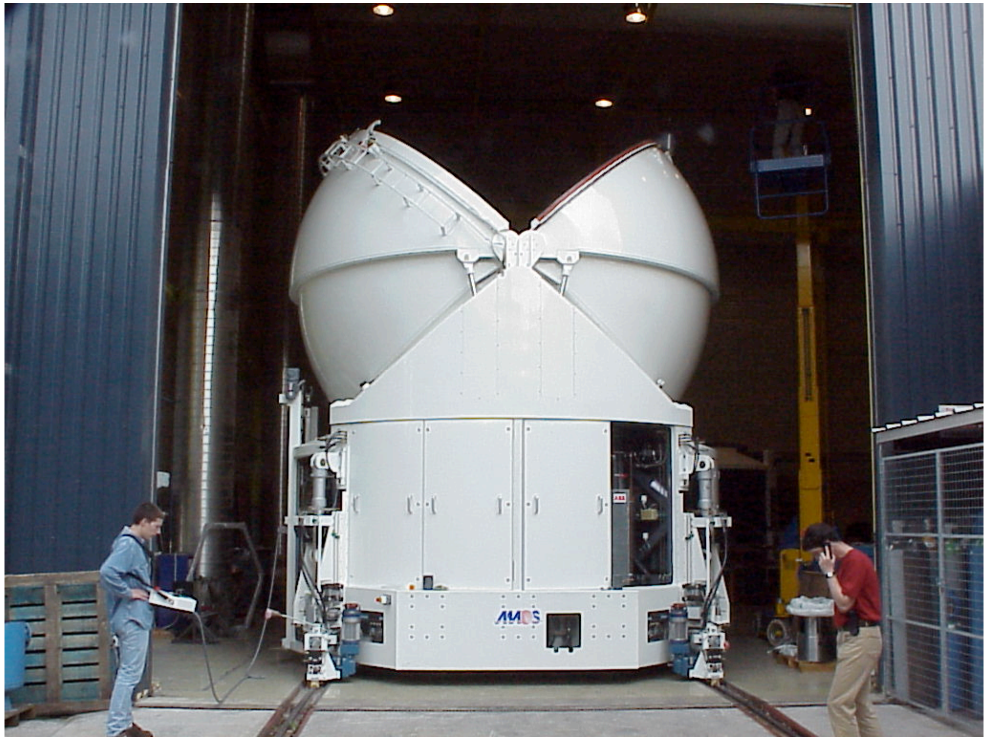
Spectroscopy (10000)

K = 11 – 19



Auxiliary Telescopes

- Status of AT1-3:
  - Tech. Accept. AT1 April 03
    ESO test period April-July
  - Delivery Europe:
    AT1 July 2003
    AT2 Dec. 2003
    AT3 Q2 2004
  - First Fringes:
    AT1-2 Q2 2004
    AT1-2-3 Q3 2004
- AT4 ordered in Sep. 2002, delivery date: Nov. 2004



FINITO

Fringe tracking Instrument of NIce TOrino,
collaboration between ESO and
Osservatorio Astronomico di Torino

- On-axis fringe tracker
- H-band, three beams, H = 12

- First Fringes at Paranal in July 2003 – open loop
- Next run in Sep./Oct. 2003

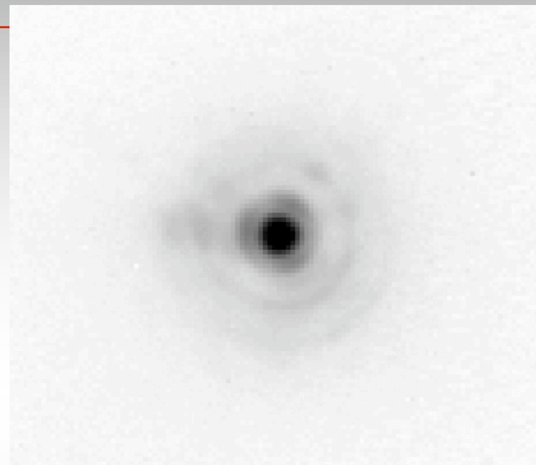
MACAO-VLTI: Status

AO Dept/Instrumentation Division

MACAO #1:

- **First Light on UT2 on April 18**

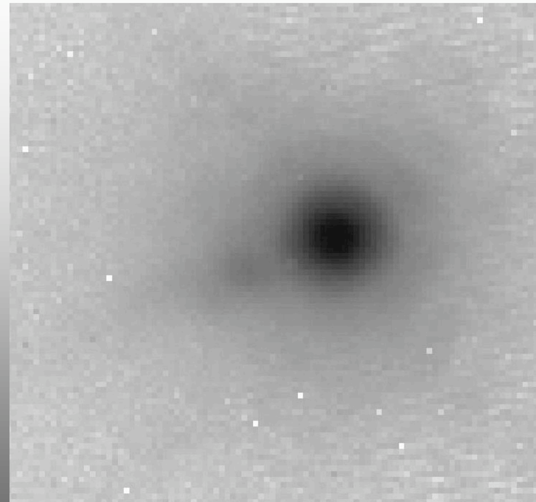
  m_V = 9.9, Strehl = 55%
  FWHM = 60 mas
  (diffr. limit 57 mas)



MACAO #2

- **First Light on UT3 on Aug.12**

  m_V= 15.5, Strehl = 26%
  FWHM = 89mas



MACAO meets VLTI

- **First Fringes on August 16**

PRIMA – The VLTI Dual Feed Facility

- Observations of faint objects (K ~ 19) with MIDI and AMBER
- Imaging of faint objects (UTs and ATs) with MIDI and AMBER
- Astrometry on ATs (10 μarcsec)

Requirement: K ~ 12–15 guide star within 1 arcmin

Start of installation at Paranal 2004/5

Science Instruments:

- MIDI and AMBER with PRIMA
- Two Fringe Sensor Units for astrometry

PRIMA – Phased Approach

1. 2002-2005, 2 ATs:

   Faint object imaging with ATs (K~16, N~8) and 100 □arcsec astrometry

   Required hardware:

   – 2 star separator systems (STS) for the ATs (TNO/TPD, Netherlands)

   – 2 Fringe Sensor Units (ALENIA Spazio, Italy)

   – Laser metrology (ESO+IMT, Switzerland)

2. 2005-2008, 2 UTs:

   Faint object imaging with UTs (K~19, N~11) and 10 □arcsec astrometry

   Required hardware:

   – 2 STS for the UTs

   – Upgrade of laser metrology (5 nm accuracy)

   – Differential Delay Lines (dutch/swiss/german consortium)

3. 2008-2010, any two UTs:

   Faint object imaging in closure phase with all UTs in K and H band

First Generation Instrumentation – Summary

- Mid Infrared: MIDI, First Fringes Dec. 2002
  - N band, 2 beams, N = 4–9*, moderate spectroscopy
  - Included in Call for Proposals for Period 73 (May 2004)
- Near Infrared: AMBER, First Fringes Q1 2004
  - J, H, K bands, 3 beams (closure phase), K = 11–19, spectroscopy with R = 10000

- Adaptive optics on UTs: MACAO First Light April/Aug 2003
  - Strehl ratio >60% on V = 12 (30% on V = 16)
- On-axis fringe tracker: FINITO First Fringes Sep. 2003
  - H band, 3 beams, H = 12
- Dual-feed facility PRIMA First Fringes 2005
  - Off-axis fringe tracker for MIDI and AMBER, K (H) = 12–15 within 1arcmin

*All limiting magnitudes for UTs

GENIE – The DARWIN Ground demonstrator

- ESO/ESA letter of agreement for Phase A signed
- Kick-off for two Phase A studies planned for Q3 2003
- Likely schedule: Phase A study finished in Q3 2004
  Call for Tender for GENIE ready in 2005
  GENIE at Paranal 2007
- Joint (ESA/ESO) Science Team for Phase A nominated

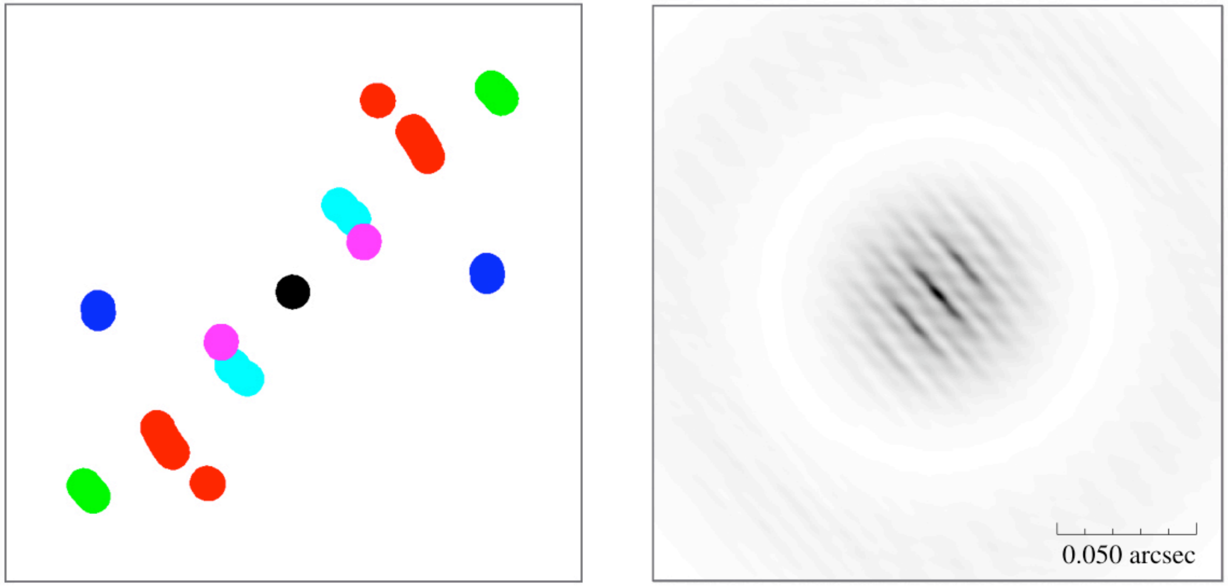
The VLTI at Paranal

- Markus Schöller is ‘Interferometer Scientist’.
  Responsible for core VLTI: Delay Lines, VINCI, FINITO, ARAL (artificial light source), and VLTI activities.
- Jason Spyromilio ‘Telescope Scientist’ responsible for ATs
- Jean-Gabriel Cuby ‘Instrument Scientist’ responsible for VLTI instruments
- Engineering Department supports VLTI like UTs
- VLTI Astronomers part of Science Operations, exchangeable with VLT Astronomers
- Interferometer operators and TIOs exchangeable

The VLTI has actually arrived at Paranal

Interferometry with four 8-m Telescopes

- VLTI combined all 4 UTs in Sep. 2002
- PSF of Achernar gives an idea of resolving power
- Note: UTs combined in pairs with VINCI



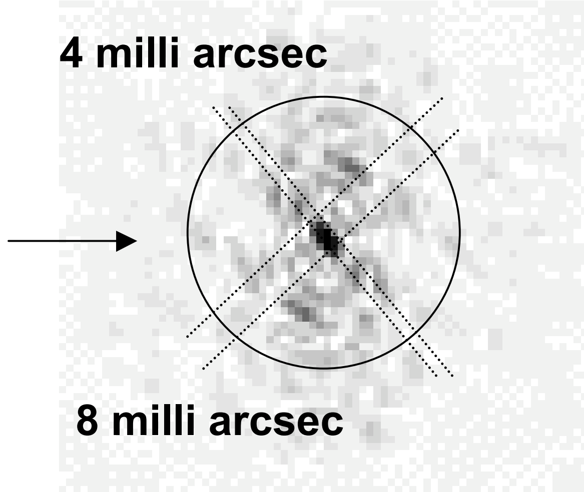
UV Plane Coverage

Fringe Pattern of Achernar

First Steps towards a 2D Interferometric Image
(VLT ANTU/KUEYEN/MELIPAL/YEPUN + VINCI)

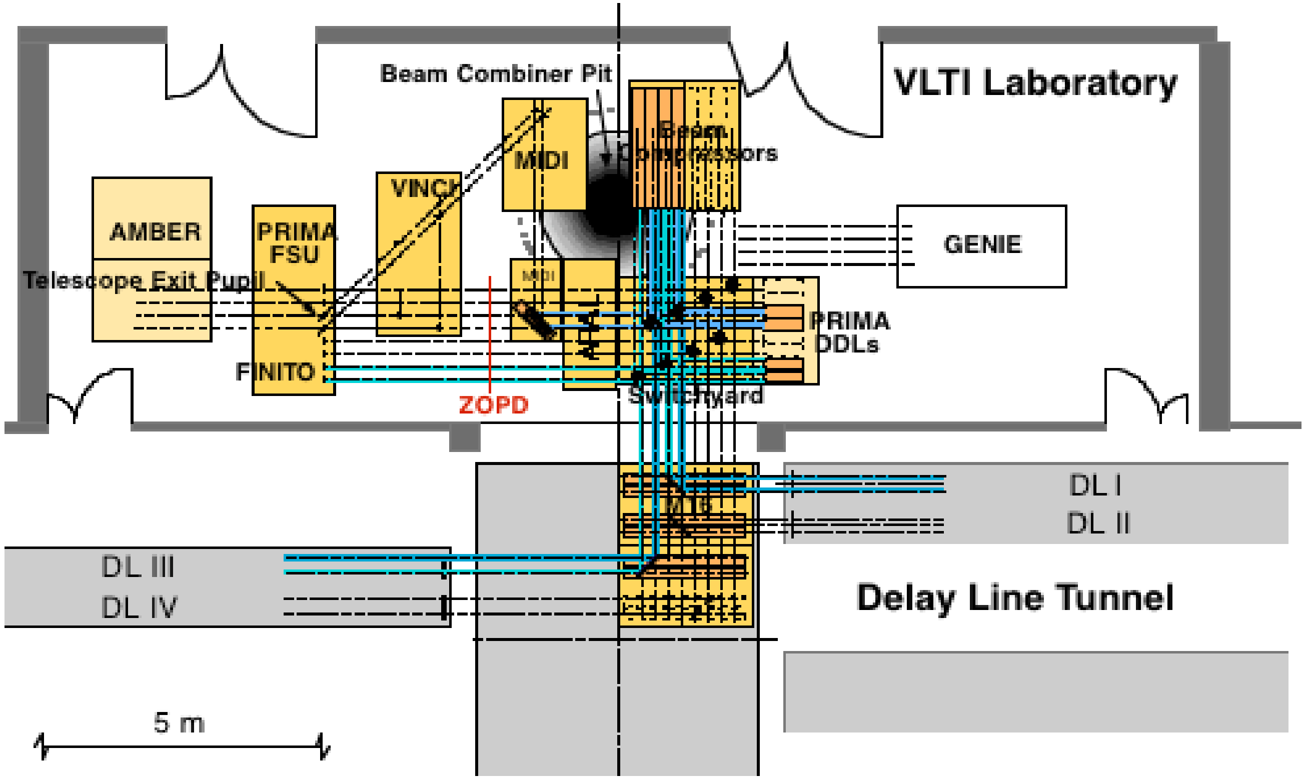
ESO PR Photo 22b/02 (26 September 2002)

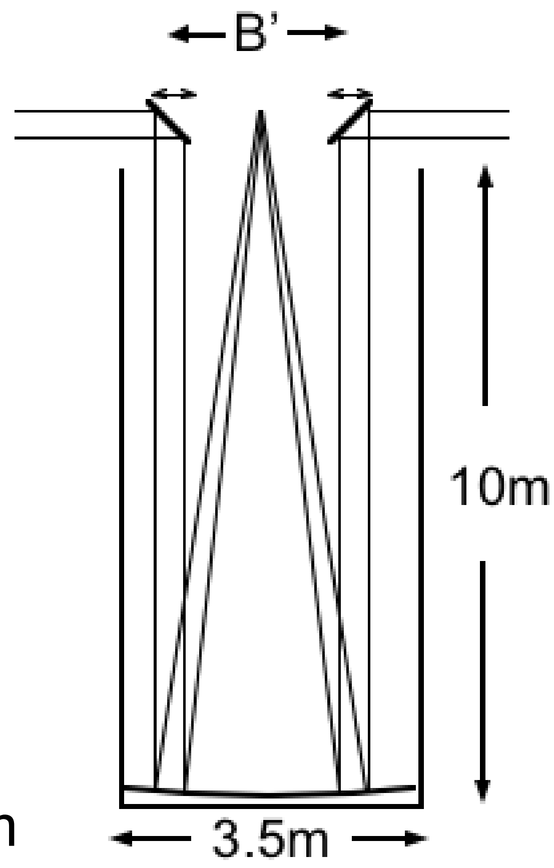
Second generation instruments



- Main limitations of 1st generation instruments:
  - Small field of view of one Airy disk (250 resp. 57 mas in the K-band)
  - Restriction to two (MIDI) resp three (AMBER) beams
    ⇒ cumbersome imaging
- Thus, 4–6 way beam combiner for 2nd generation
- Enlarged field of view, choice between
  - Homothetic mapping
  - Mosaicing

Homothetic mapping with the VLTI

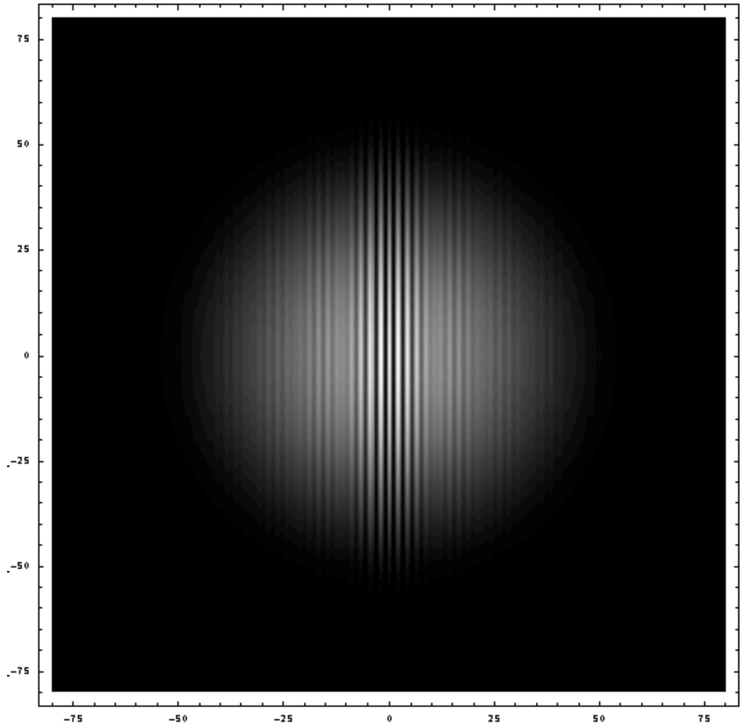




- Cylindric hole with parabolic mirror on the bottom
  - reimaged telescope pupils in front focal plane,
  - spatial fringe pattern in the focus

Homothetic mapping

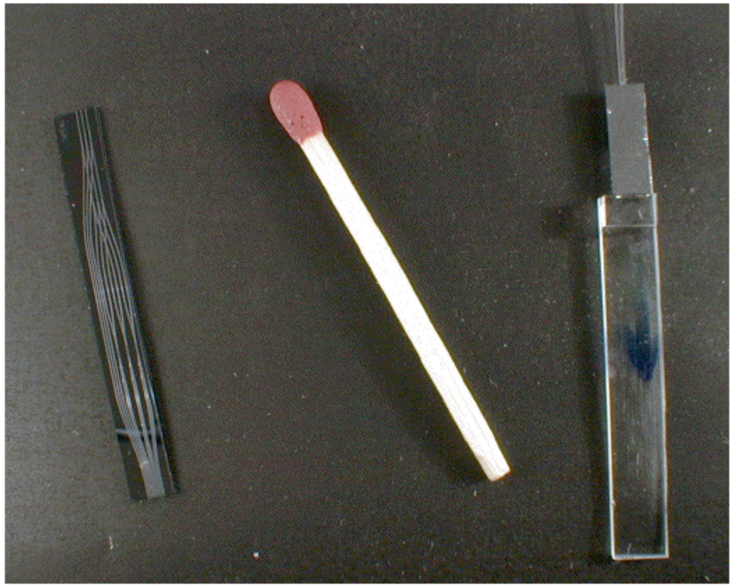
Baseline 50 resp. 200 m
K-band spectrum



- 2x2 arcsec with 1 milli arcsec fringes requires 0.5 milli arcsec pixel
- Loss of sensitivity due to limited coherence length in the K-band
- OPD stability λ/10 over full field
- According accuracy requirements for homothetic pupil mapping and for differential scale factor(s)
- Isoplanatic angle not an issue

Mosaicing with optical fibers

- Fibers and integrated optics for
  - Beam transport with coherent amplification (!)
  - Beam combination with integrated optics components (IONIC very promising)
  - Fringe detection with integrated optics and STJs
- Simple multi baseline beam combination
- Bulk opto-mechanics only for Delay Lines
- Instruments in ‘shoeboxes’



Paranal fully furnished

VLTI can host 8 Delay Lines combining 8 telescopes simultaneously

- Using 4 UTs + 4 ATs possible but not optimal
- Two extra ATs for a total of six most efficient ~11 M€
- Equipping all UTs and all ATs with PRIMA star separators:
  better uv coverage for faint imaging ~ 5 M€
- AO on ATs, opening the visible
  IR wave front sensors, improving sky coverage
  PRIMA FSU for 4 beams ~16 M€

The Overwhelmingly Large Array - La OLA

In times of OWL, interferometers with baselines of km will be required

- Angular resolution for imaging ~100□arcsec
- Limiting magnitude K~20
- *e.g.* observation of AGN cores, origin of stellar jets

Options:

- Delay Line Tunnels of km or
  integrated optics for fast beam switching
  => short(ish) Delay Lines for tracking
- >8 m telescopes or
  OWL production line to produce a ‘few’ more 8m telescopes?
- Go to ALMA site or
  La OLA in VLTI style (2 OWLs + a dozen ATs of 8m)?