



# **The Very Large Telescope Interferometer**

**EuroSummer School**

*Astrometry and Imaging with the Very Large Telescope Interferometer*

**Keszthely, Hungary**  
**June 02-13, 2008**

Markus Schöller  
European Southern Observatory  
June 05, 2008

# ESO - The “European Southern Observatory”



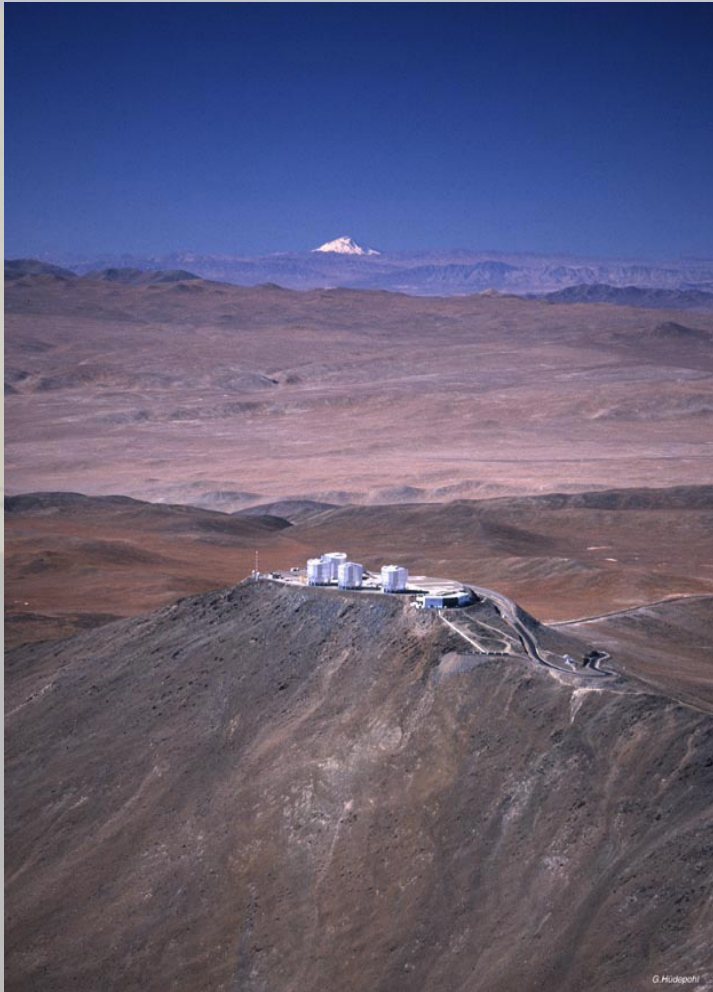
European Organisation for Astronomical Research  
in the Southern Hemisphere



# A brief history of VLTI

- 1980s - Interferometry integral part of the VLT project, early linear array design for UTs goes to trapezium structure
- Early 1990s - engineering of the general layout
- 1993 - council stalls the VLTI, infrastructure implementation (light ducts, tunnel, lab) continues
- 1996 - MPG/CNRS/ESO tri-partite agreement for third AT
- 1997 - MIDI and AMBER proposed by community
- 1998 - contracts for ATs and Delay Lines awarded, MIDI and AMBER instruments started
- 2000 - start of implementation on Paranal (siderostats and delay lines)
- March 2001 - first fringes with VINCI on siderostats

# VLTI

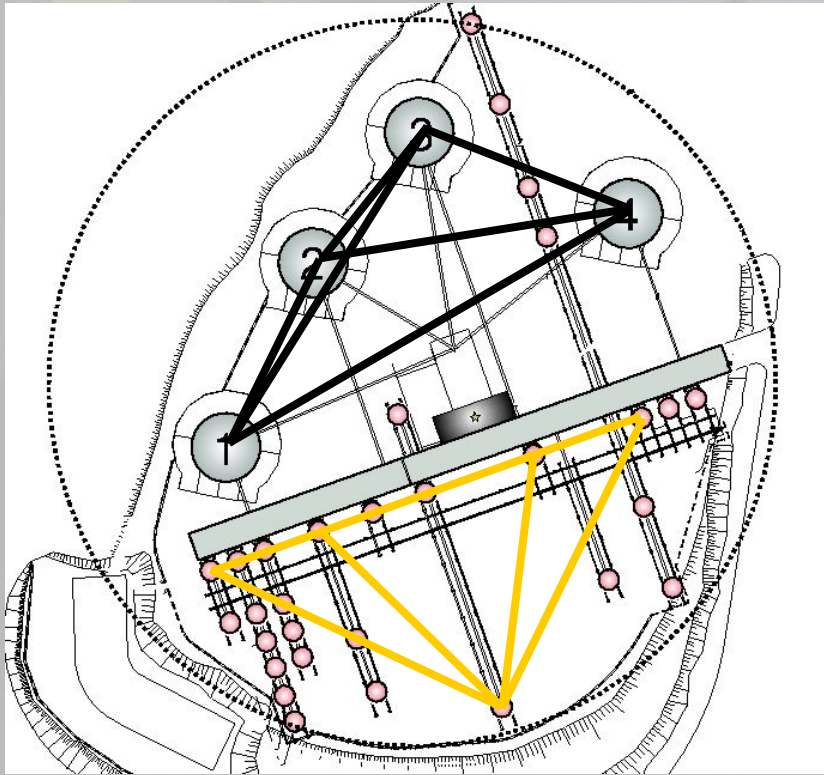


Four 8.2m telescopes (UTs)  
All equipped with AO (MACAO)  
Six Baselines 47m-130m

Four 1.8m telescopes (ATs)  
Movable to 30 stations  
Baselines 8m-202m

Six delay lines  
**PRIMA dual feed facility**  
IRIS lab tip/tilt tracker  
FINITO fringe tracker  
MIDI/AMBER/VINCI

# Status



All UTs operational with full AO, all six baselines and all four baseline closures used for science

AT1-4 in operations on four baseline triples

4 Delay Lines in operations for UTs,  
3 Delay Lines for ATs (all 6 with VCM)

MIDI offered since April 2004 on UTs and  
October 2005 on ATs

AMBER offered on UTs since October  
2005 and ATs since April 2007

~50% of nights used for VLTI science  
operations

Five operations astronomers, three fellows,  
numerous TIOs to run VLTI

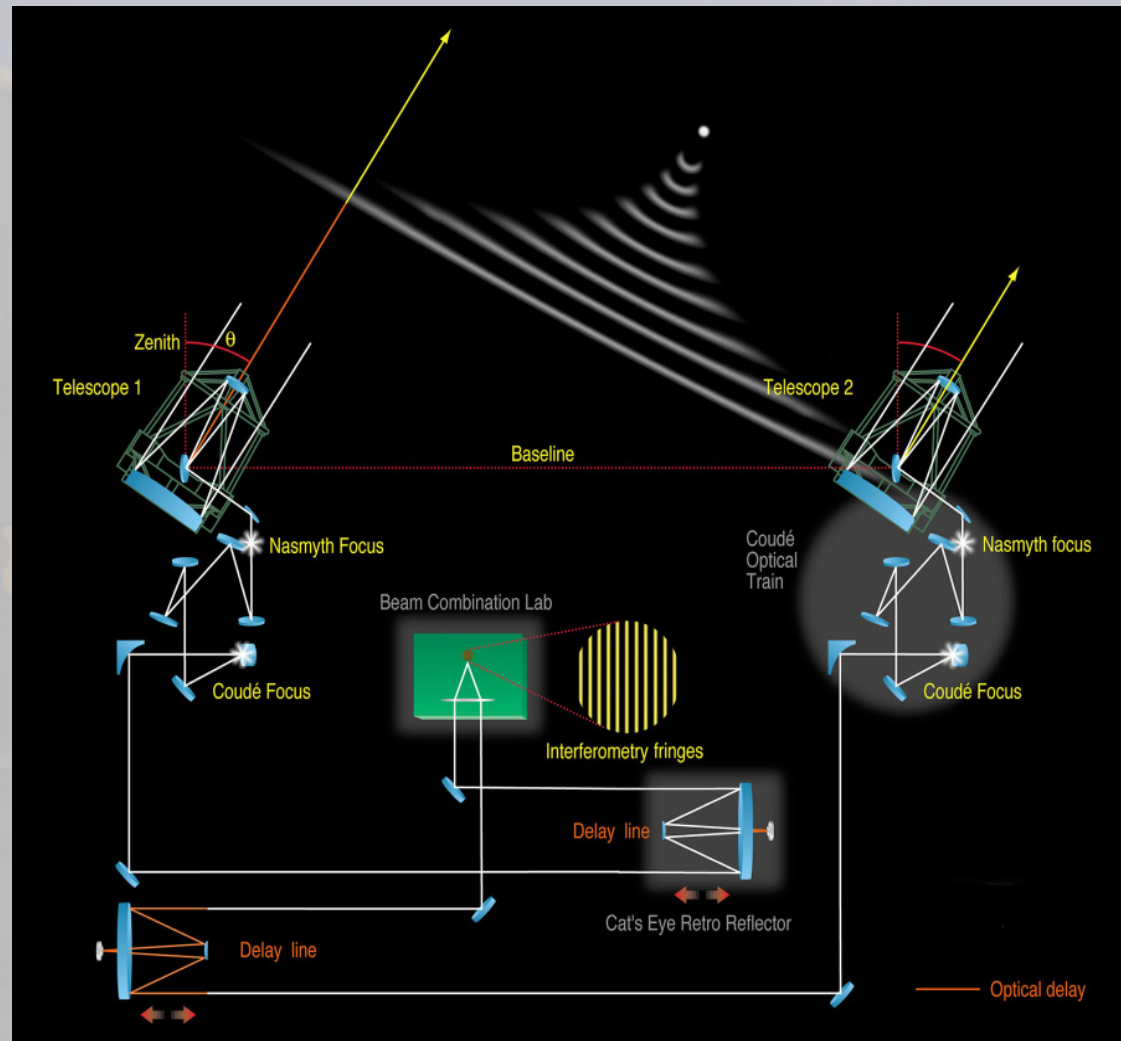
90+ refereed papers

# Some acronyms

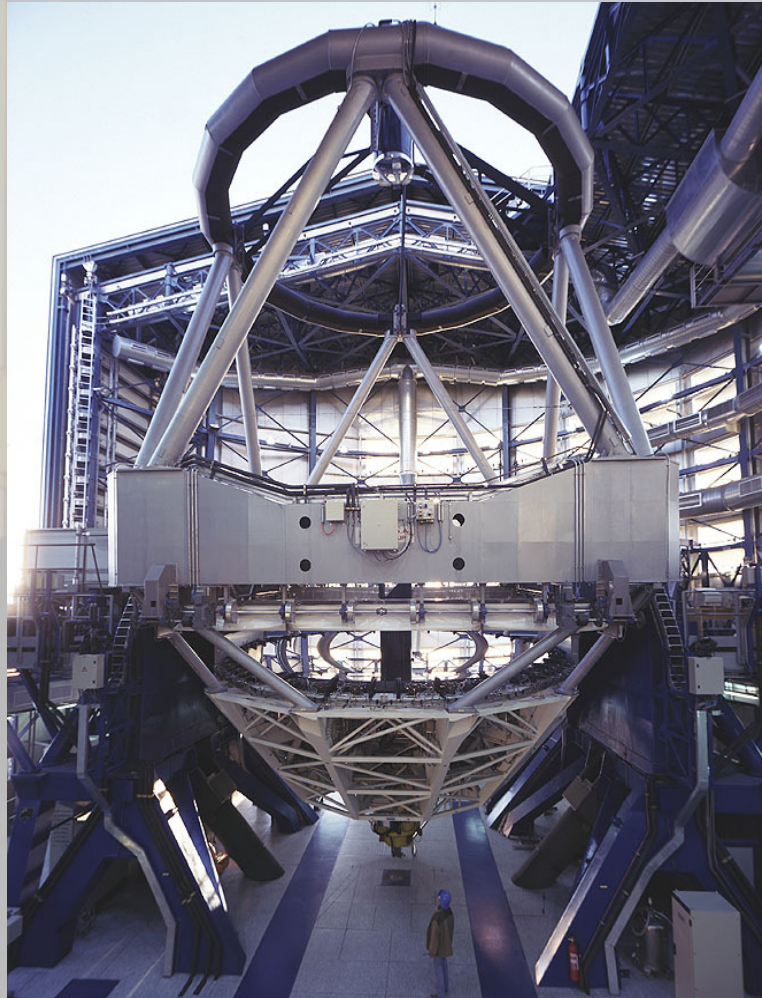
[mschoell@eso.org](mailto:mschoell@eso.org)

- OPL - optical path length
- OPD - optical path difference
- ZOPD - zero optical path difference
- UT - Unit Telescope (8.2m)
- AT - Auxiliary Telescope (1.8m)
- MACAO - Multi Application Curvature Adaptive Optics
- STRAP - System for Tip-tilt Removal with Avalanche Photo diodes
- VINCI - VLT INterferometer Commissioning Instrument
- AMBER - Astronomical Multiple BEam Recombiner
- MIDI - MID Infrared interferometric instrument
- FINITO - Fringe sensing Instrument NICE TORino
- IRIS - InfraRed Image Sensor
- ISS - Interferometer Supervisor Software
- VCM - Variable Curvature Mirror

# VLTI Scheme - Subsystems

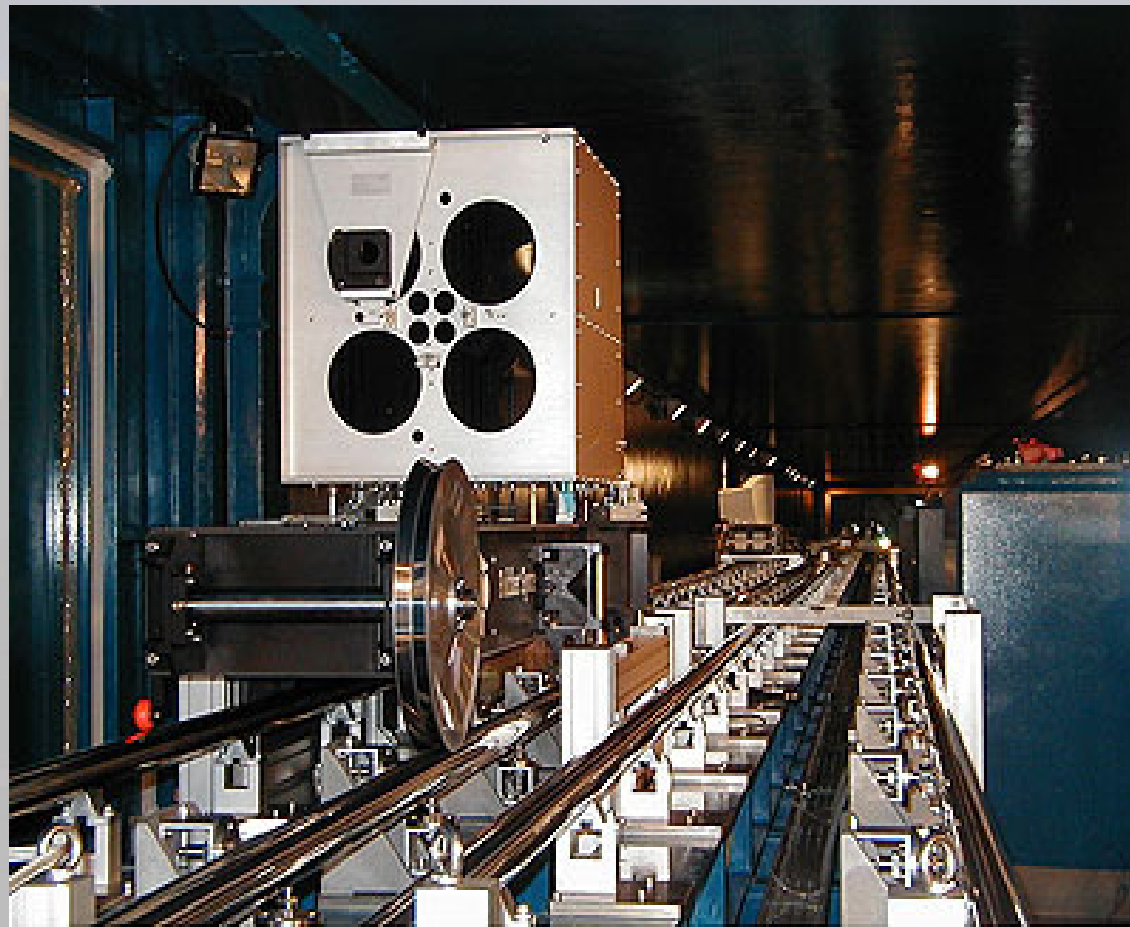


# The VLTI Telescopes





# Delay Lines



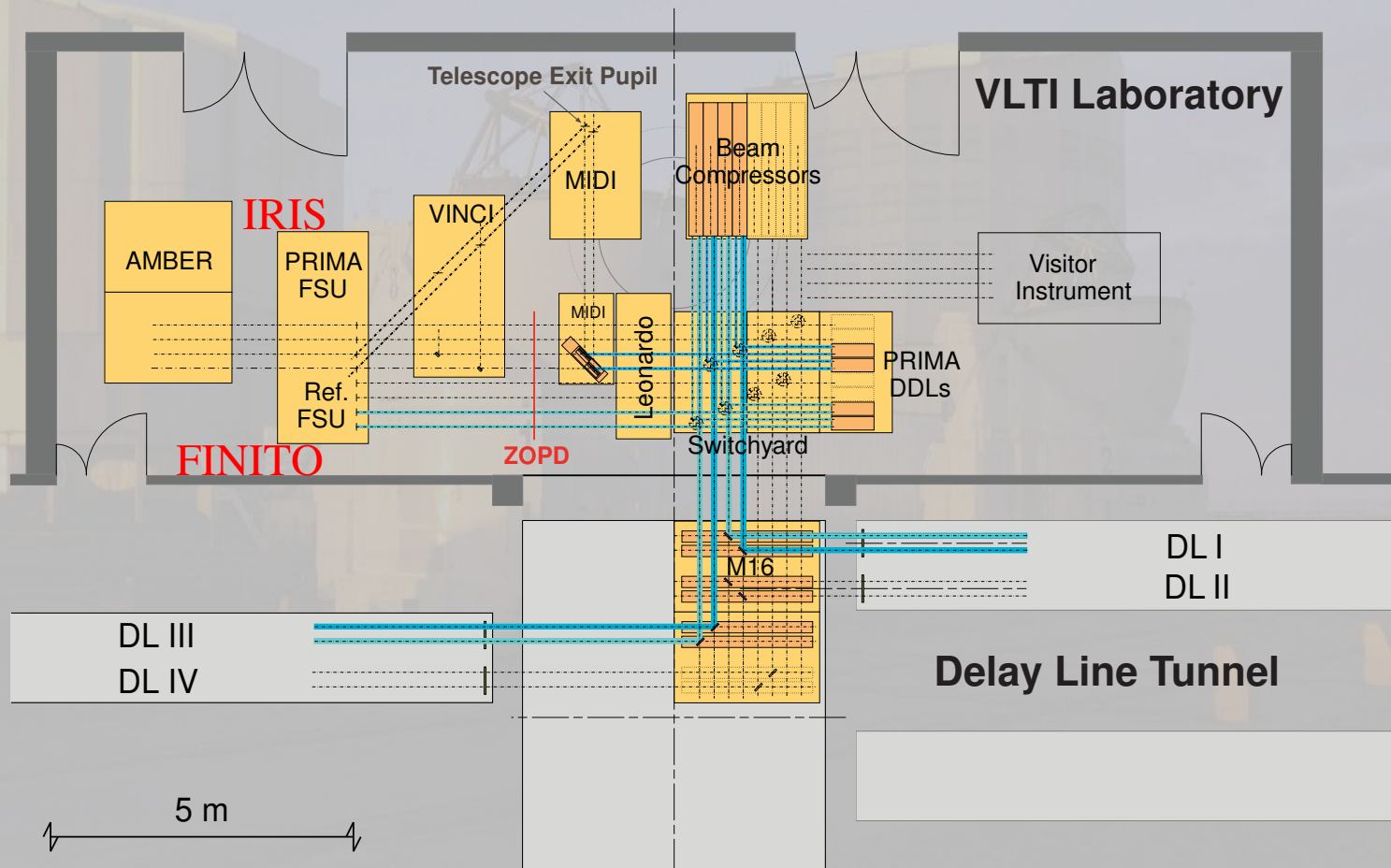
VLT Delay Line Retroreflector Carriage

ESO PR Photo 26c/00 (11 October 2000)

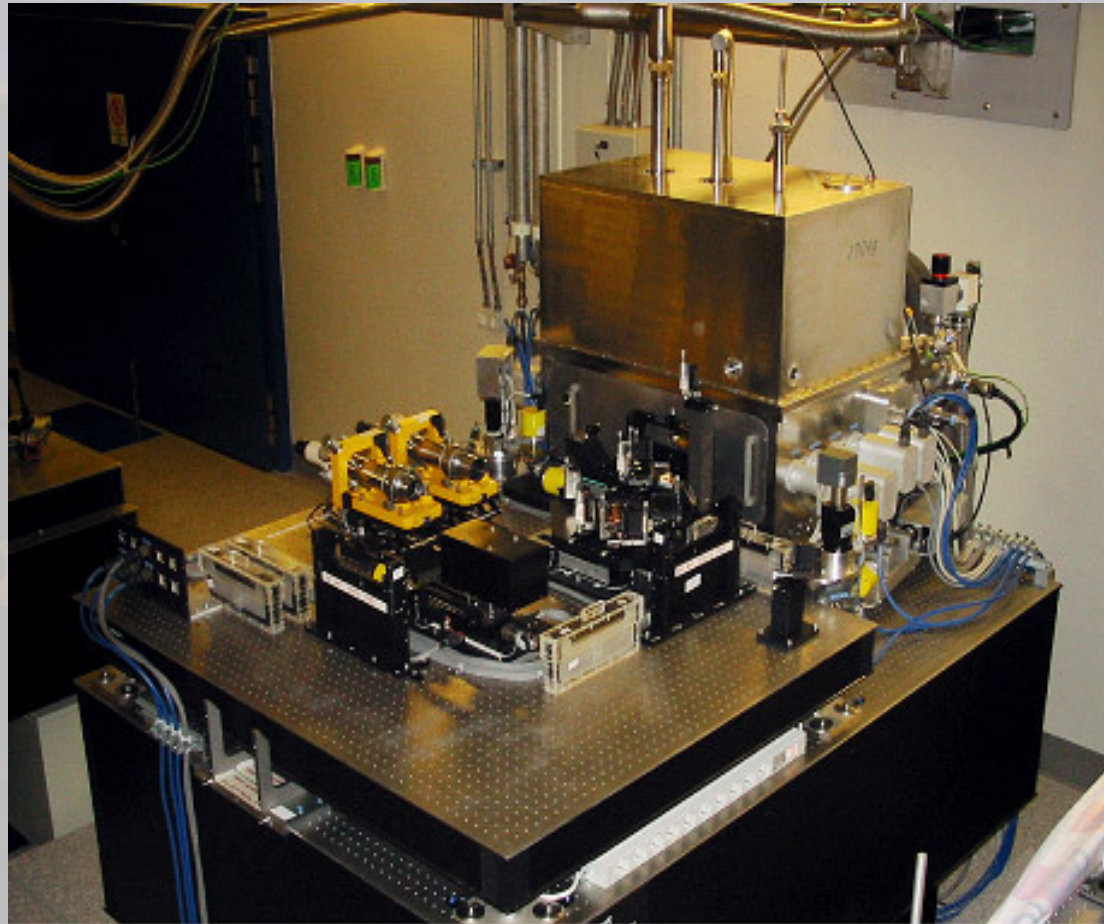
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# The interferometric laboratory



# MIDI in the VLTI lab



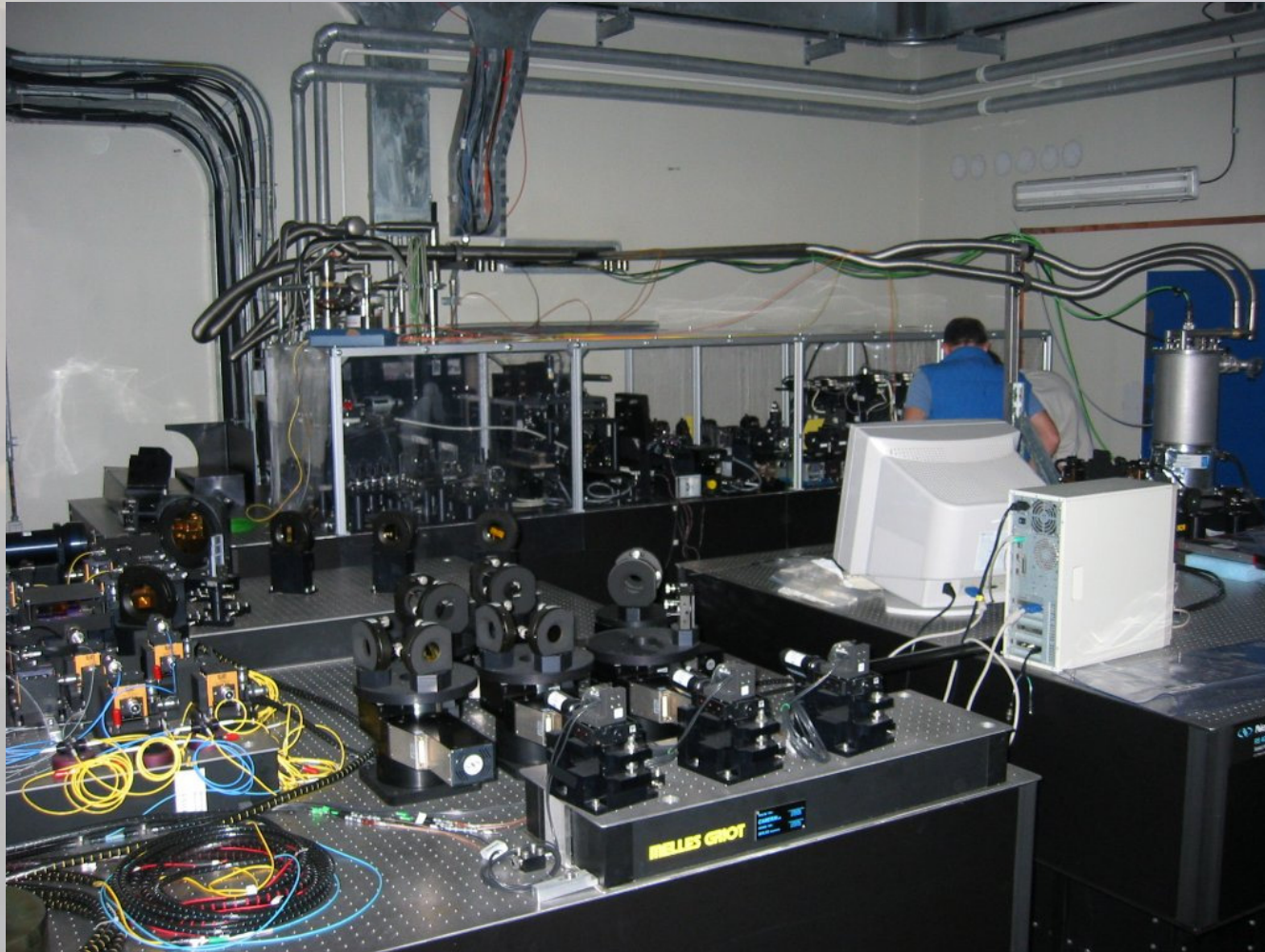
The MIDI Instrument at the VLT Interferometric Laboratory on Paranal

ESO PR Photo 310c/02 (18 December 2002)

© European Southern Observatory



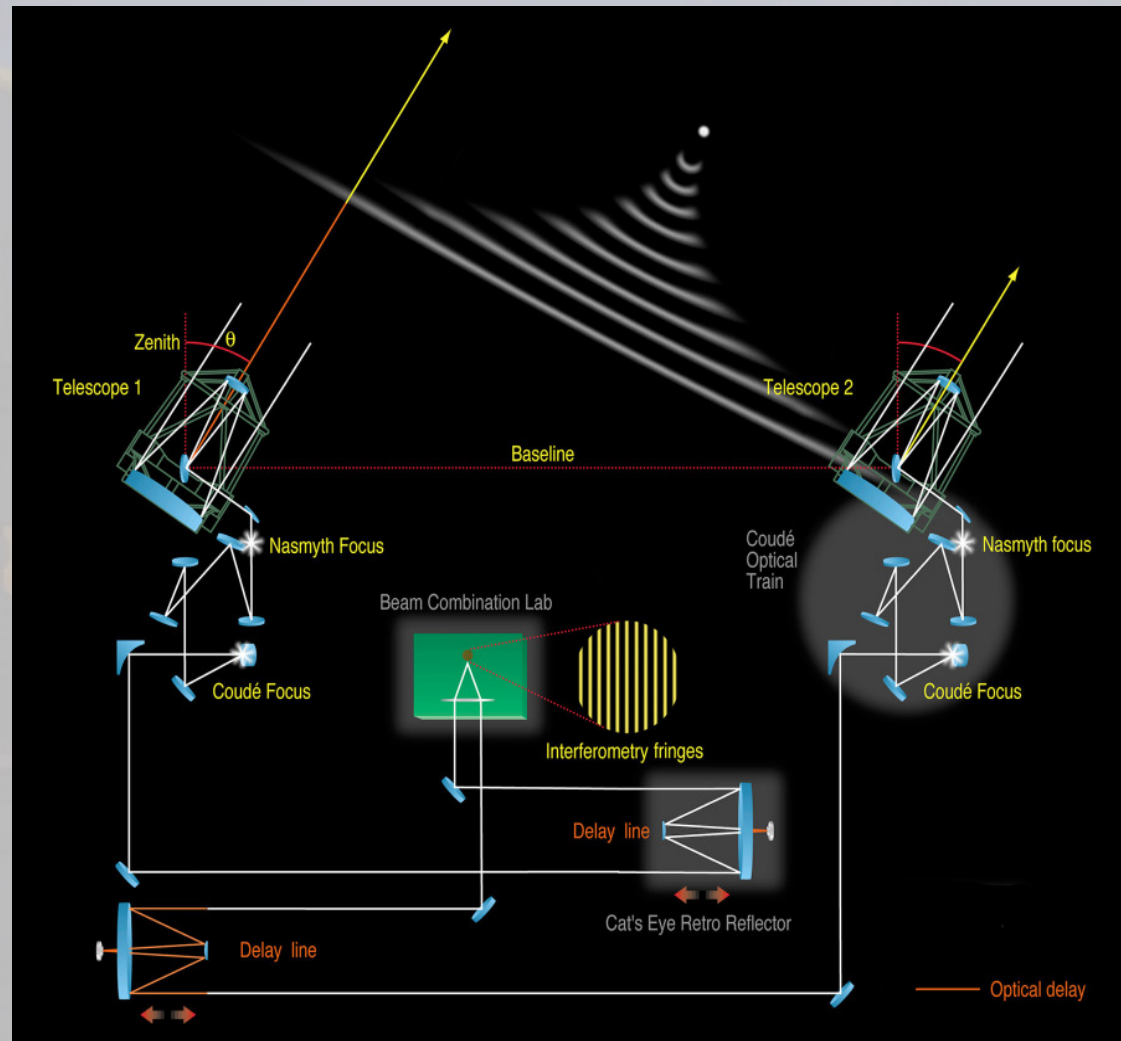
# AMBER in the VLTI Lab



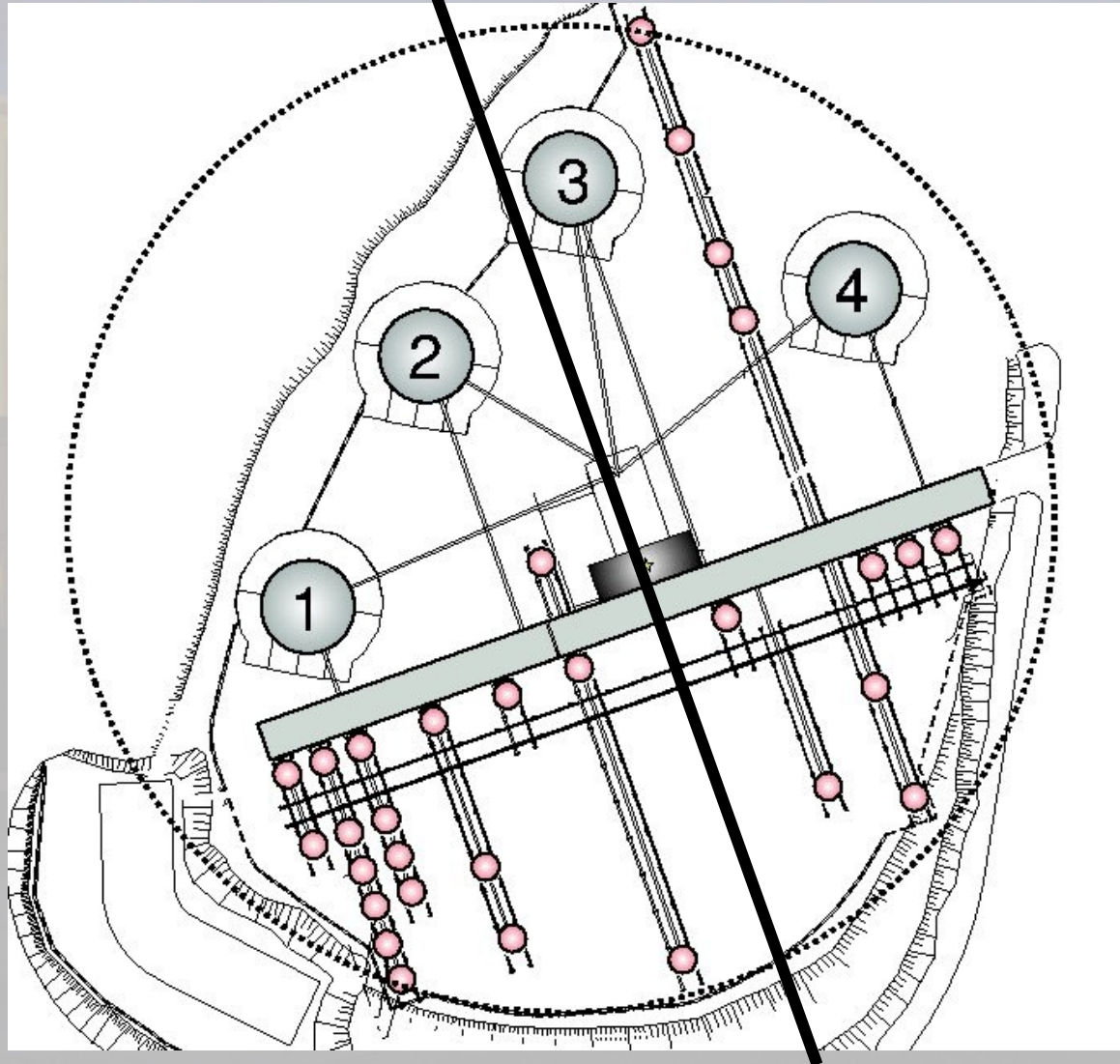
# VLTI Science Instrumentation

	Bands	# telescopes	spectral resolution	limiting magnitude (UTs/ATs)
AMBER	J,H,K	3	35, 1500, 12,000	7,4,1.5/ 5.1,1.6,-
MIDI	N	2	30, 230	4 (1Jy), 2.8/ 0.7,0.3

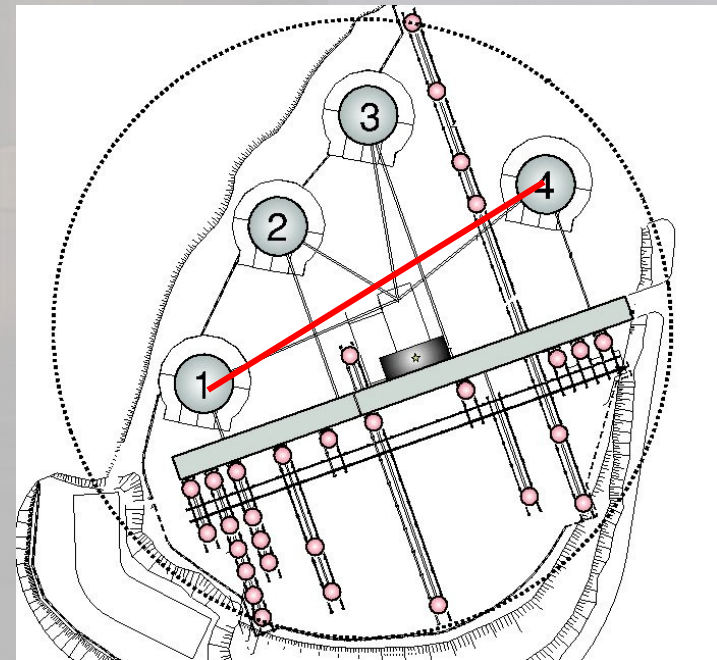
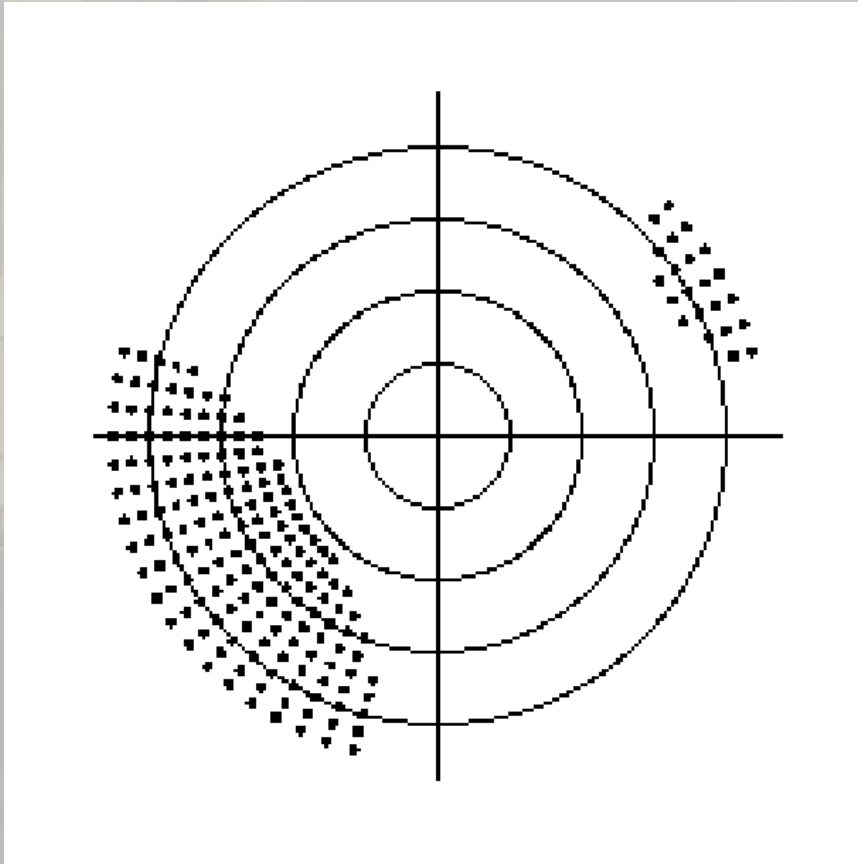
# VLTI Scheme - Constraints



# Restrictions

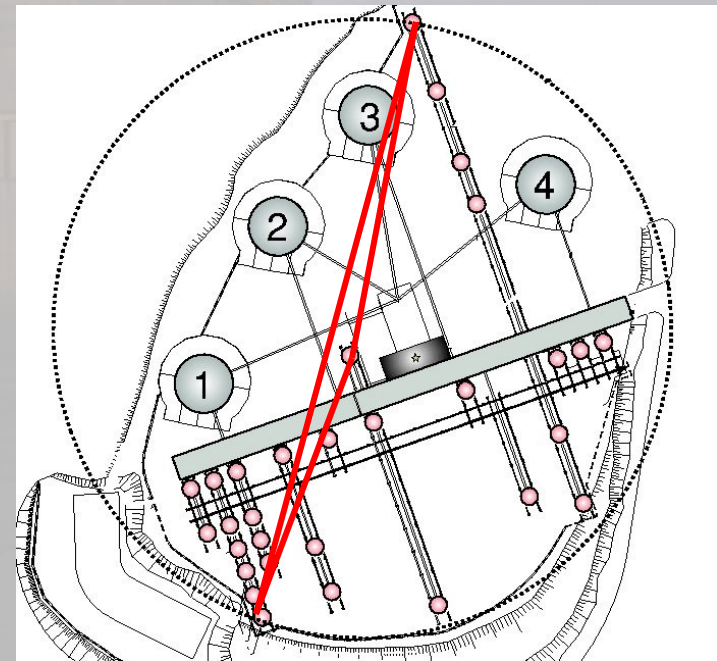
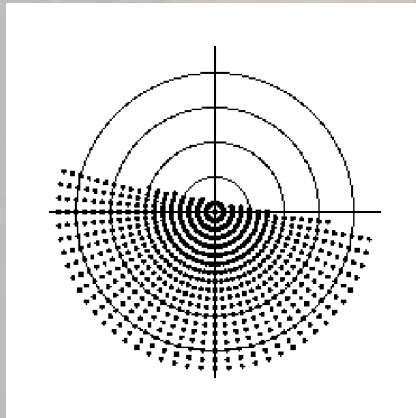
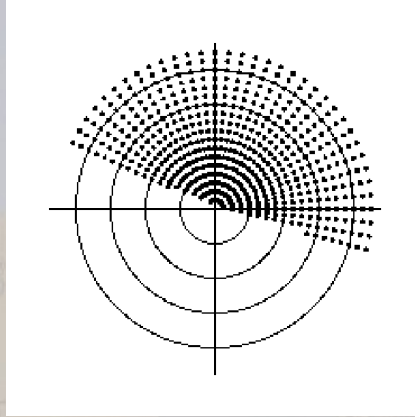
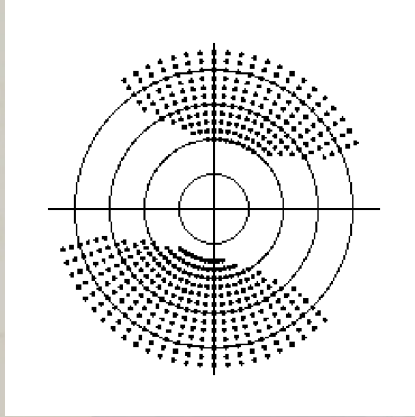


# DL restrictions on UT1/4

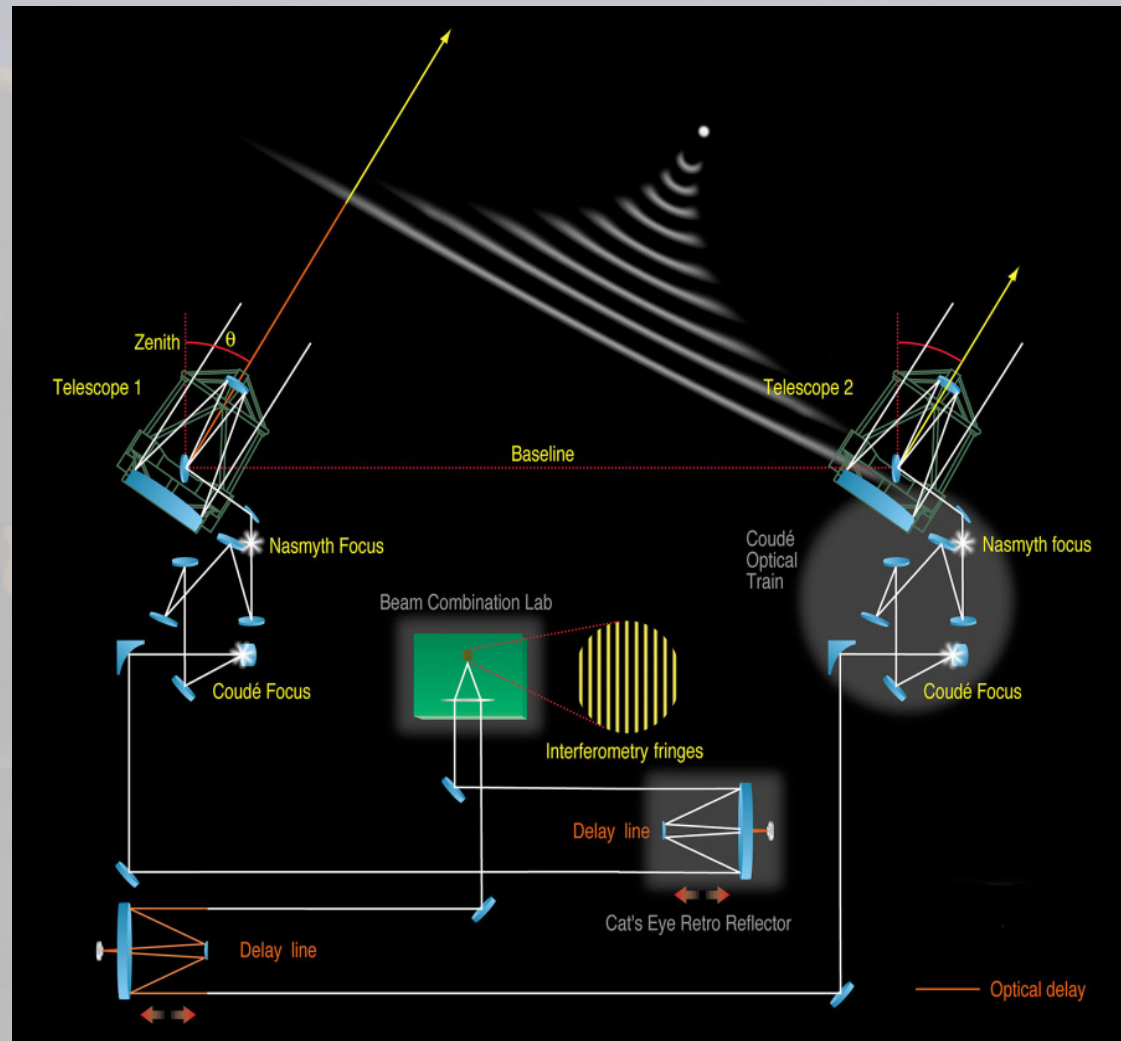




# DL restriction on ATs



# VLTI Scheme - How does it work?



## What does the VLTI infrastructure do?

“Put the light in the one place at the one time.”

- Inject the image plane into the lab
- Make the pupils coincide
- OPD variations should only be atmospheric or their residuals

# How does VLTI do it?

Each UT has a MACAO system that concentrates the bulk of the photons within the Airy ring.

The beam is propagated via the relay optics to the delay lines

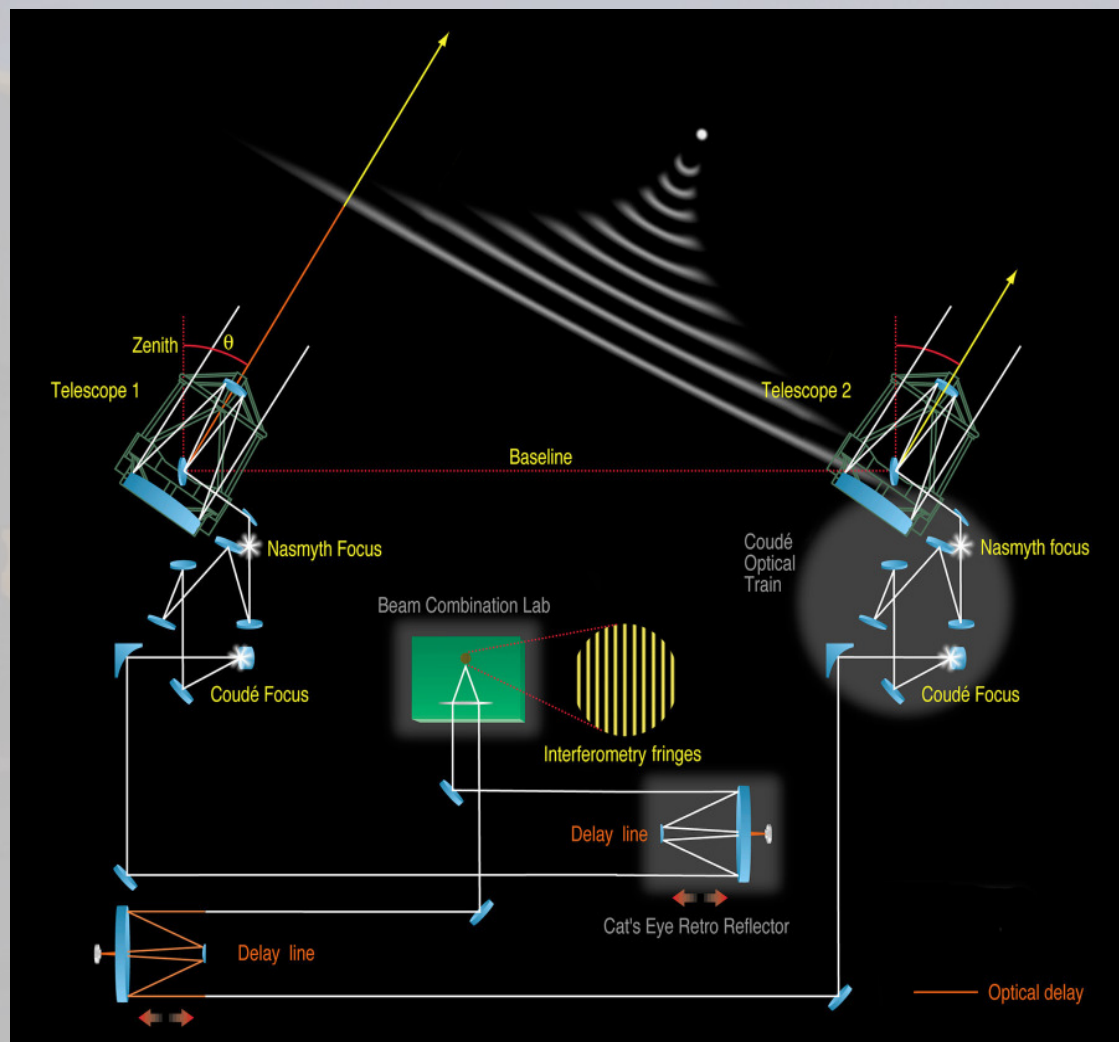
The delay lines correct in 'open loop' geometric OPD (telescope and star locations)

The VCMs on the delay lines move the pupil in the 'axial' direction.

IRIS corrects for drifts in the conjugation between the MACAO reference and the lab reference

FINITO corrects for atmospheric OPD variations through the delay lines

# VLTI Scheme - Issues



# The stable beam challenge on the UTs

MACAO although meeting specs for long term Strehl performance did suffer from saturation of the mirror creating PSF explosions and flux dropouts.

Long and frequent flux Dropouts are FINITO killers.

The ITF developed the SMA (saturation management) and AW (anti-windup) algorithms and deployed them in the RTC of MACAO

- SMA manages the expensive aberrations without loss of Strehl.

# Beam injection

Beacon from Nasmyth A to IRIS

QuickTime™ and a  
decompressor  
are needed to see this picture.

# Beam injection

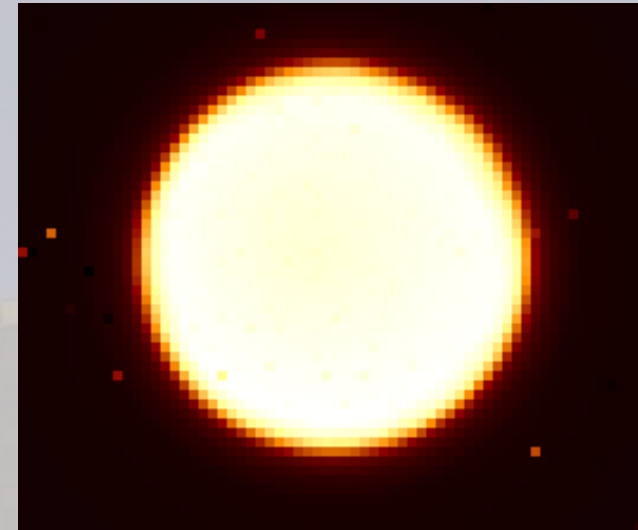
Star to IRIS

QuickTime™ and a  
decompressor  
are needed to see this picture.

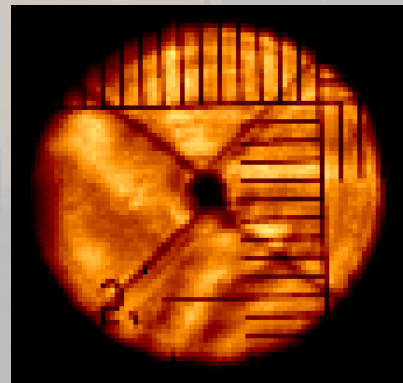


# VCMs

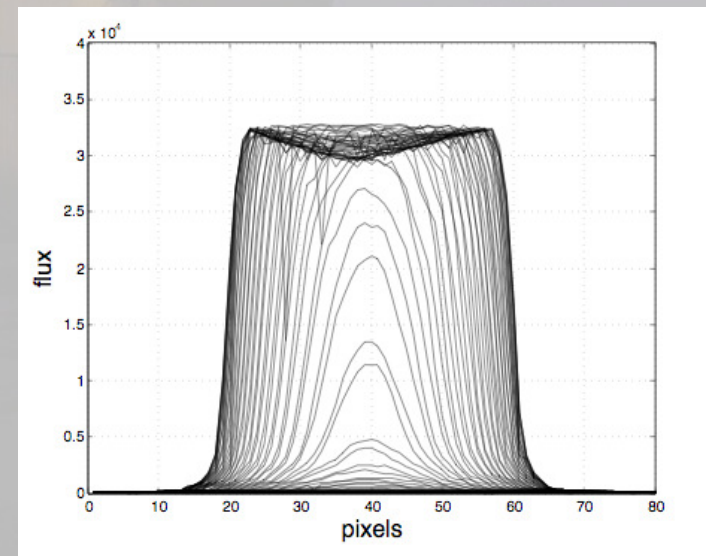
Without the VCMs functioning the field of view of the ATs is limited to about an arcsecond (approx the diffraction limit of a 1.8-m telescope at 10 microns).



J moon in IRIS

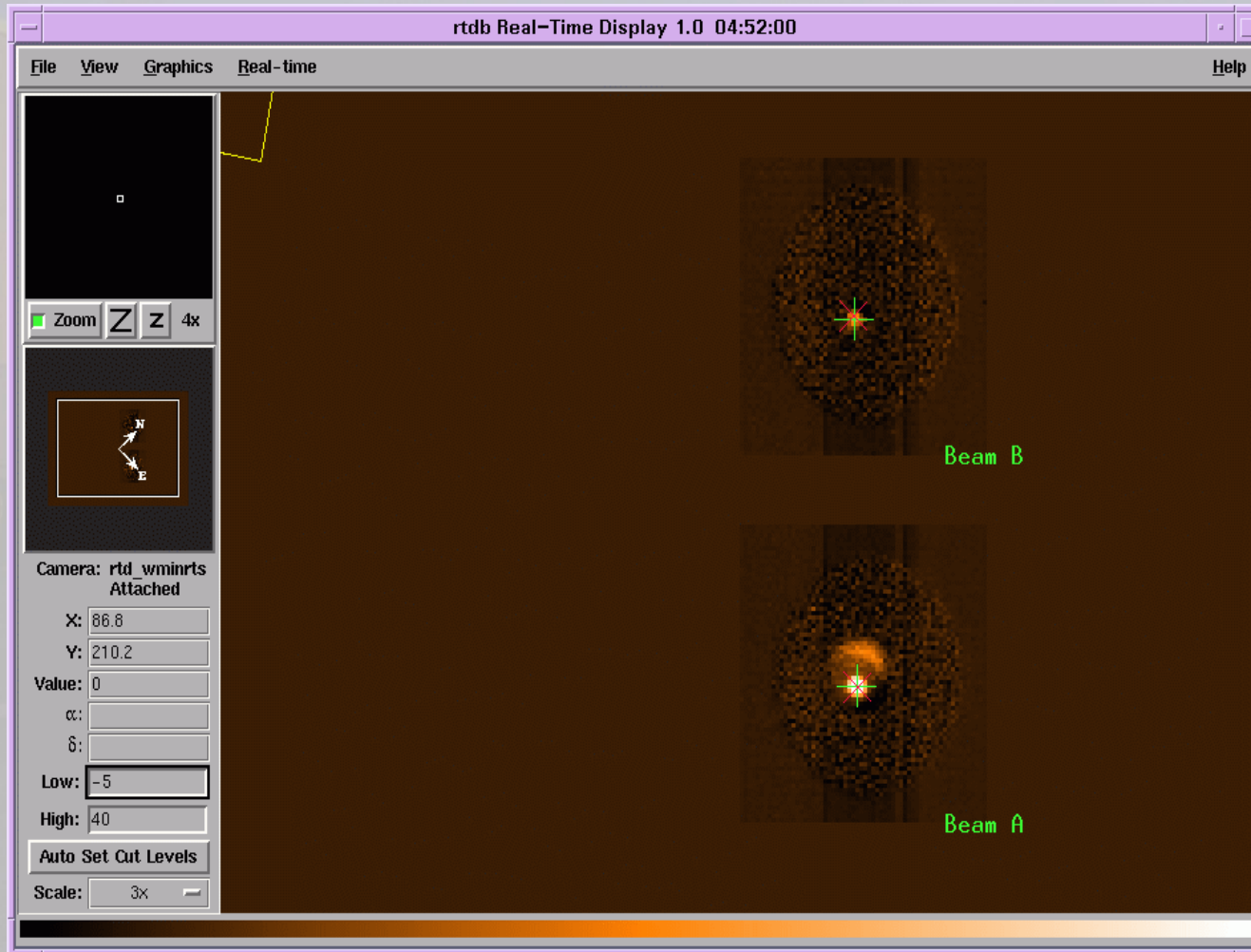


AT2 pupil on ARAL  
through DL6

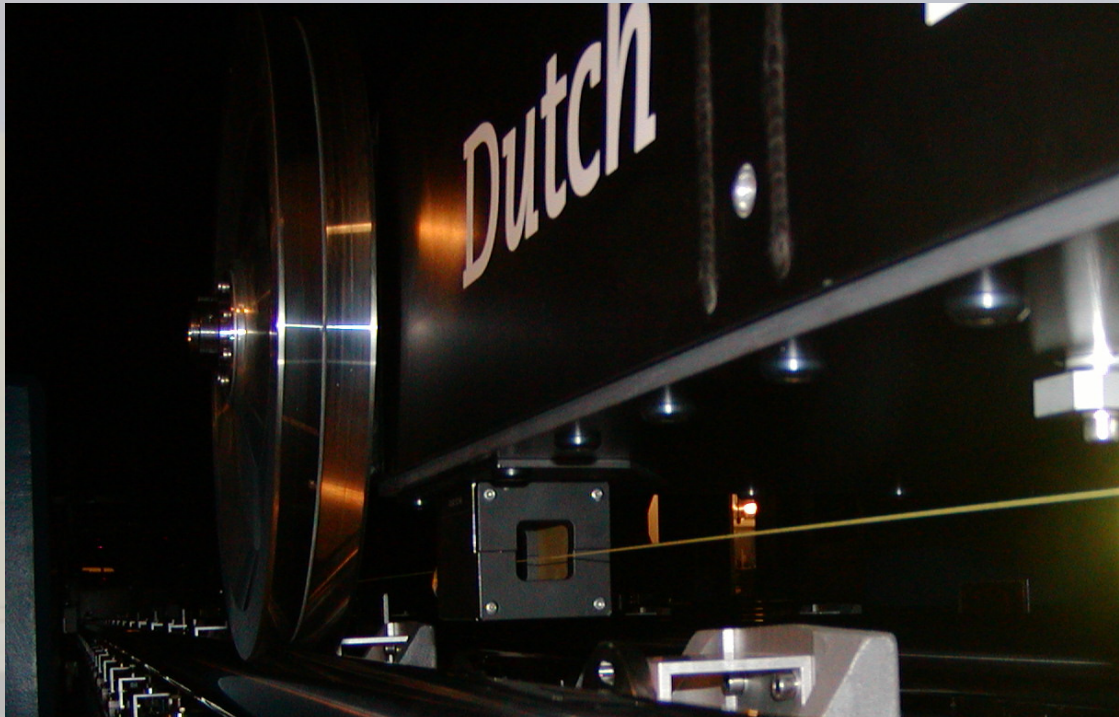


Fwhm = 7.6 arcsec

# AT field of view on MIDI



# Delay Lines : DELIRIUM



Two 2D capacitive sensors (*+water pods for earth horizon referencing*)

One inclinometer for roll measurement

Metrology (laser or coarse)

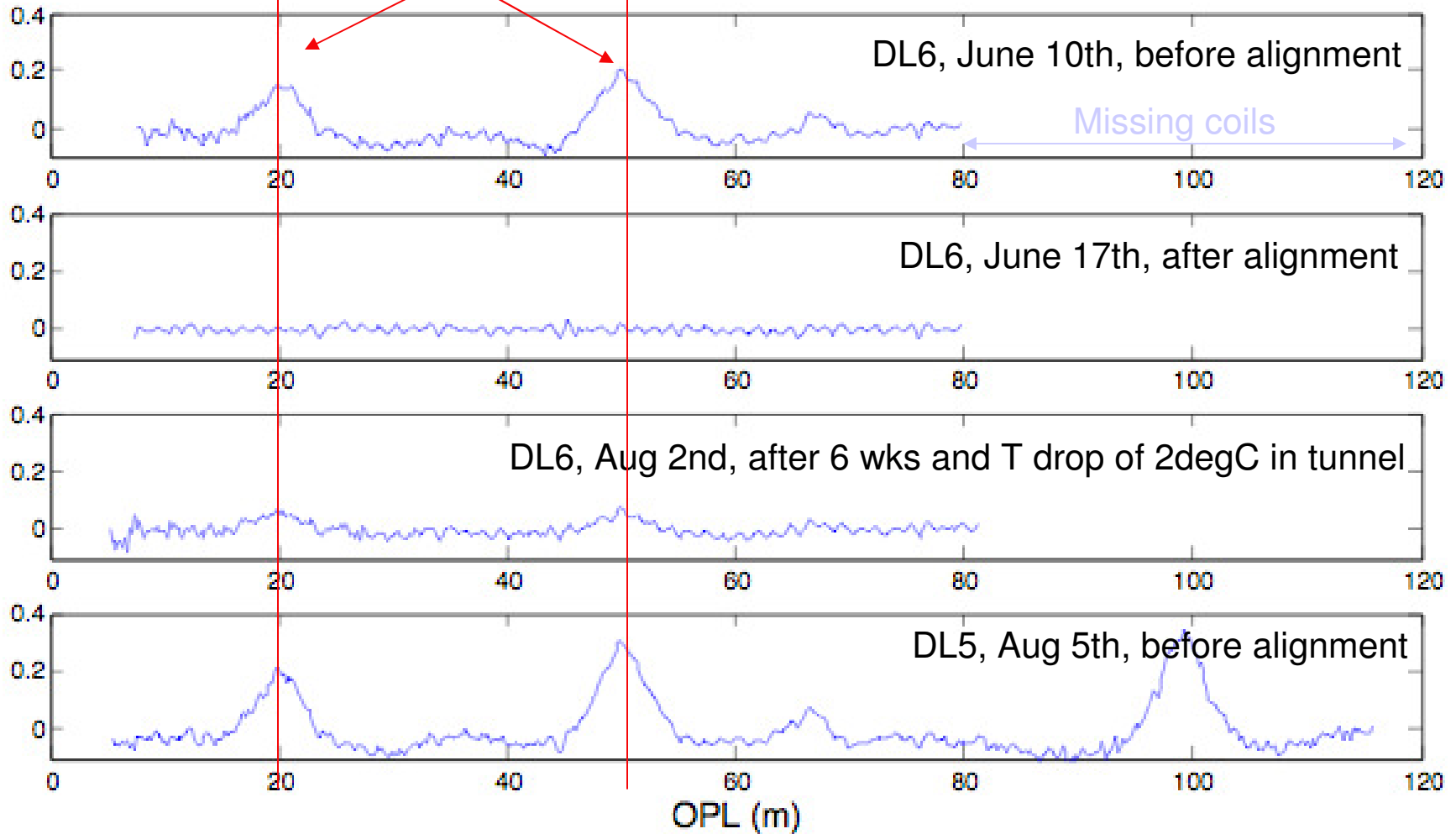
Complete trajectory reconstruction

**Aim:  $7\mu\text{m}$  accuracy  
over 60m**

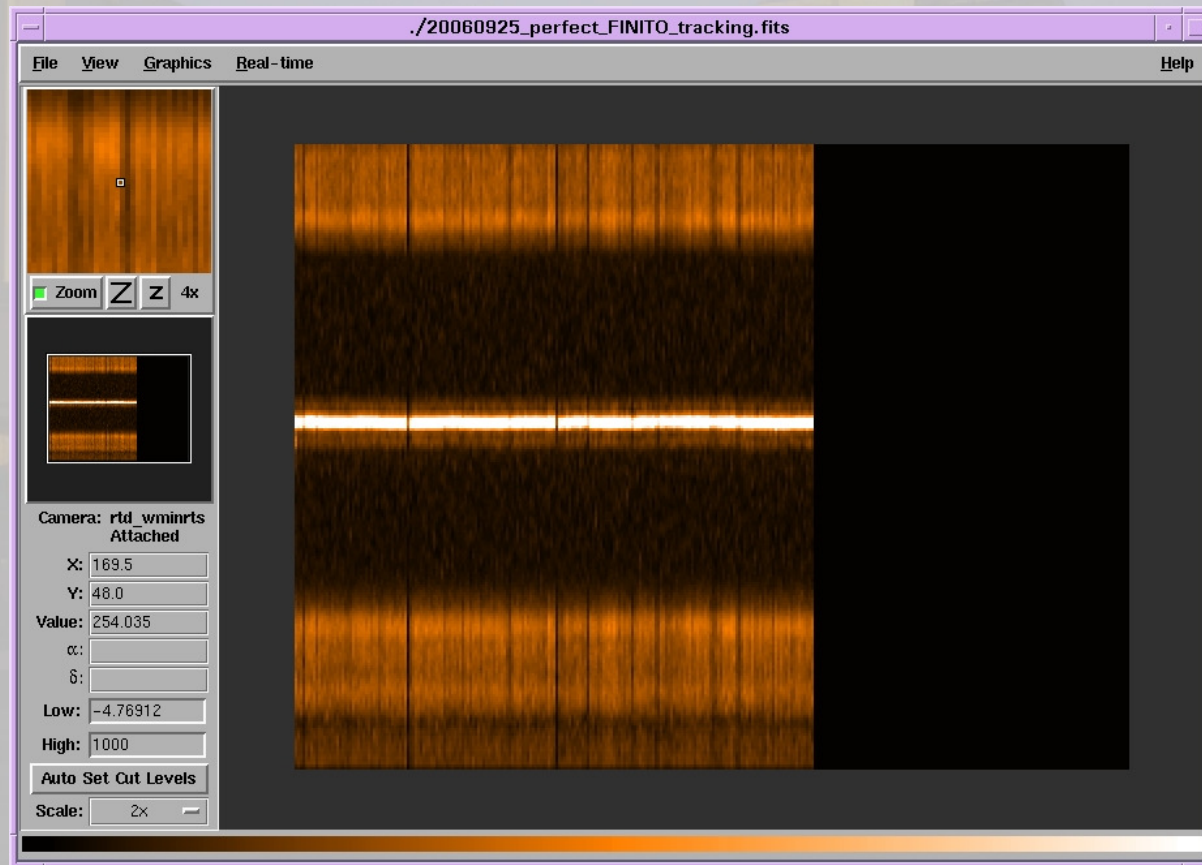
# DL rail drift


DL6 was aligned in Dec 2004 (summer time)

Concrete  
junctions



# Stabilized fringes on MIDI (Sep 06) - Running from template





QuickTime™ and a  
YUV420 codec decompressor  
are needed to see this picture.

Nov 06

QuickTime™ and a  
YUV420 codec decompressor  
are needed to see this picture.

Jan 07

QuickTime™ and a  
YUV420 codec decompressor  
are needed to see this picture.

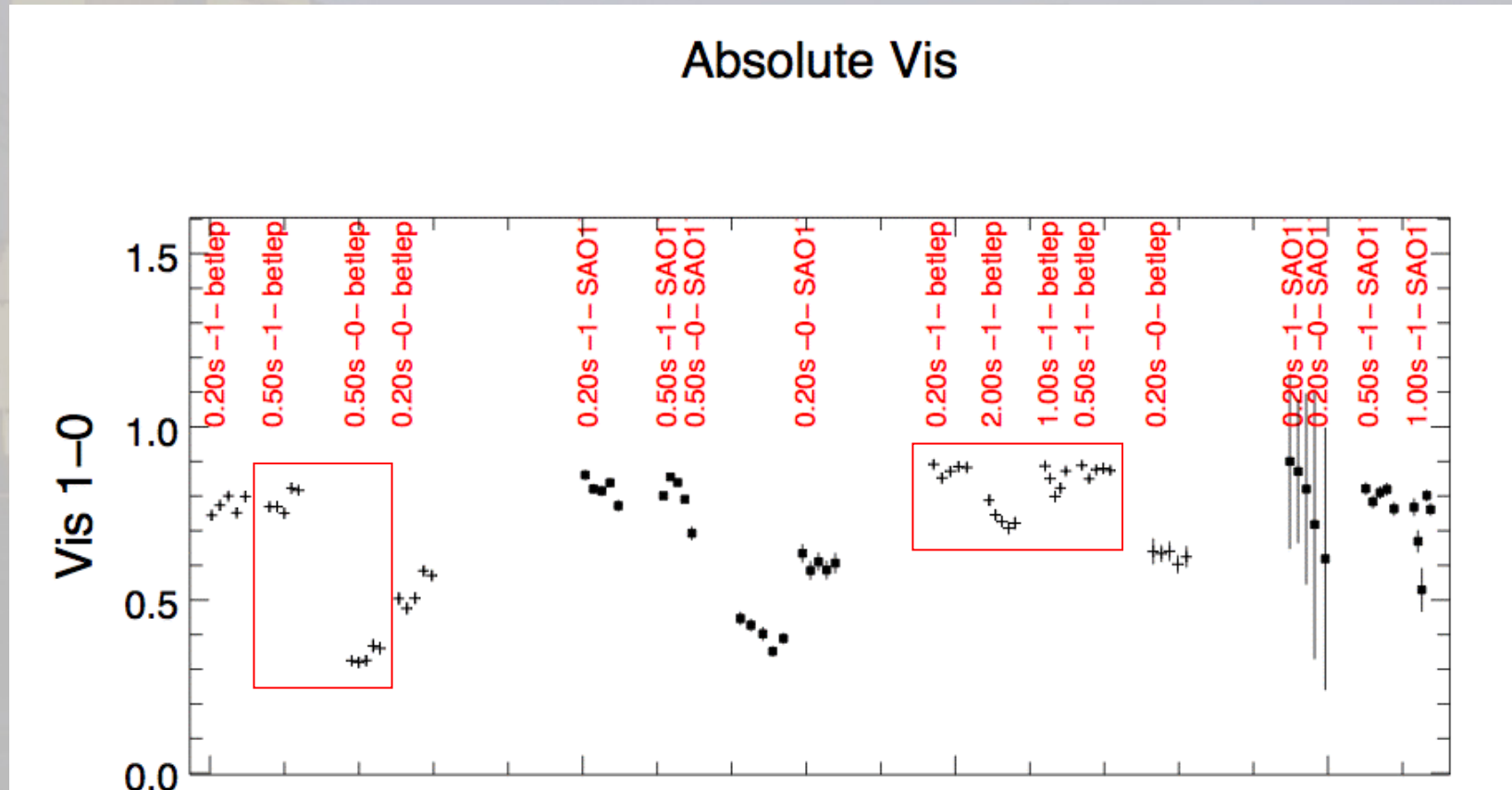
AMBER MRK



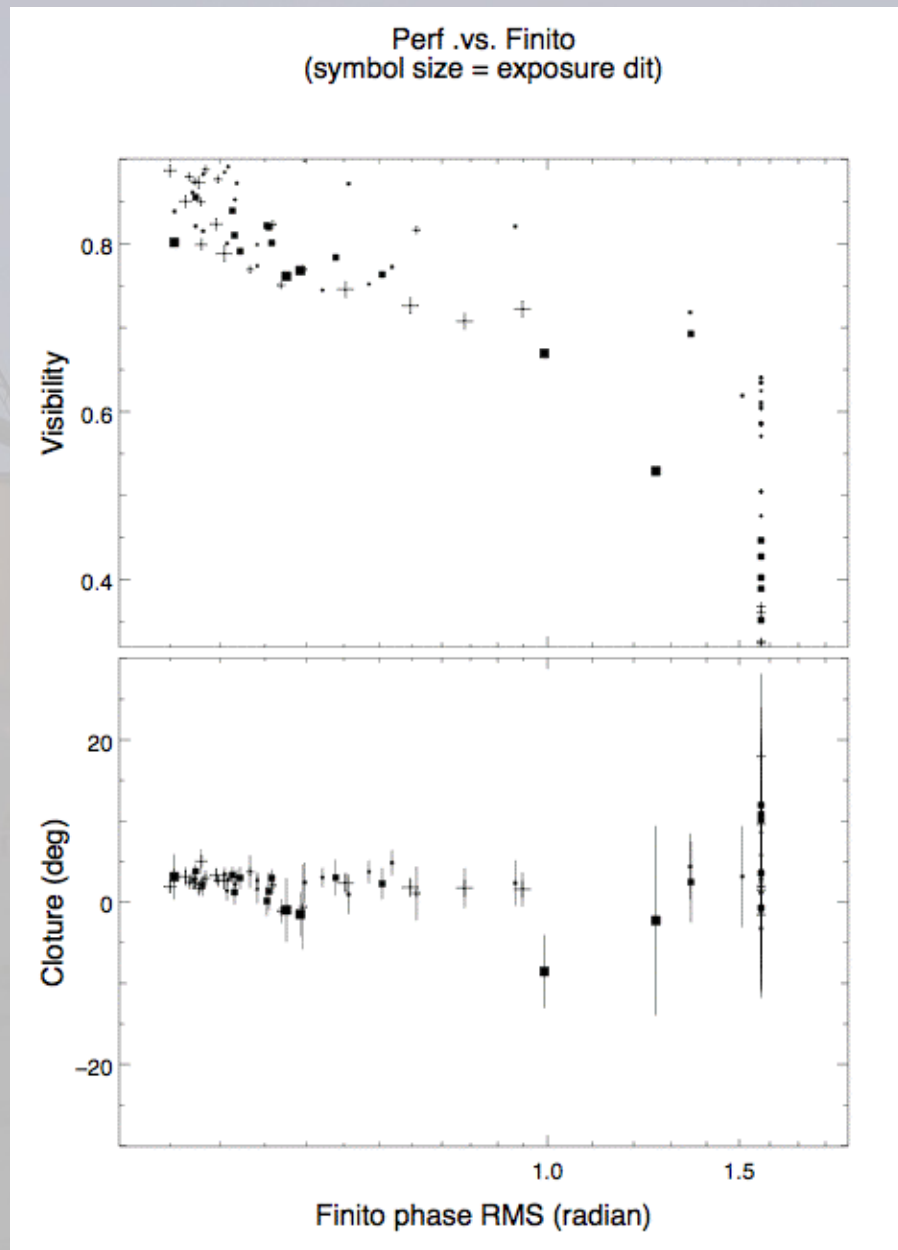
Apr 2007

QuickTime™ and a  
MPEG-4 Video decompressor  
are needed to see this picture.

# AMBER visibilities improved by FINITO



# FINITO performance



# VLTI Science Instrumentation

	Bands	# telescopes	spectral resolution	limiting magnitude (UTs/ATs/ UTs+FINITO/ ATs+FINITO)
AMBER	J,H,K	3	35, 1500, 12,000	7,4,1.5/ 5.1,1.6,-/ 7,7,6/ 5,5,5
MIDI	N	2	30, 230	4 (1Jy), 2.8/ 0.7,0.3

# Further prospects



- **Installation of PRIMA in July/August 2008**
- **2<sup>nd</sup> gen instruments (MATISSE and Gravity) kicking off in 2008**