The Very Large Telescope Interferometer

Neon School, Garching
29 August, 2008

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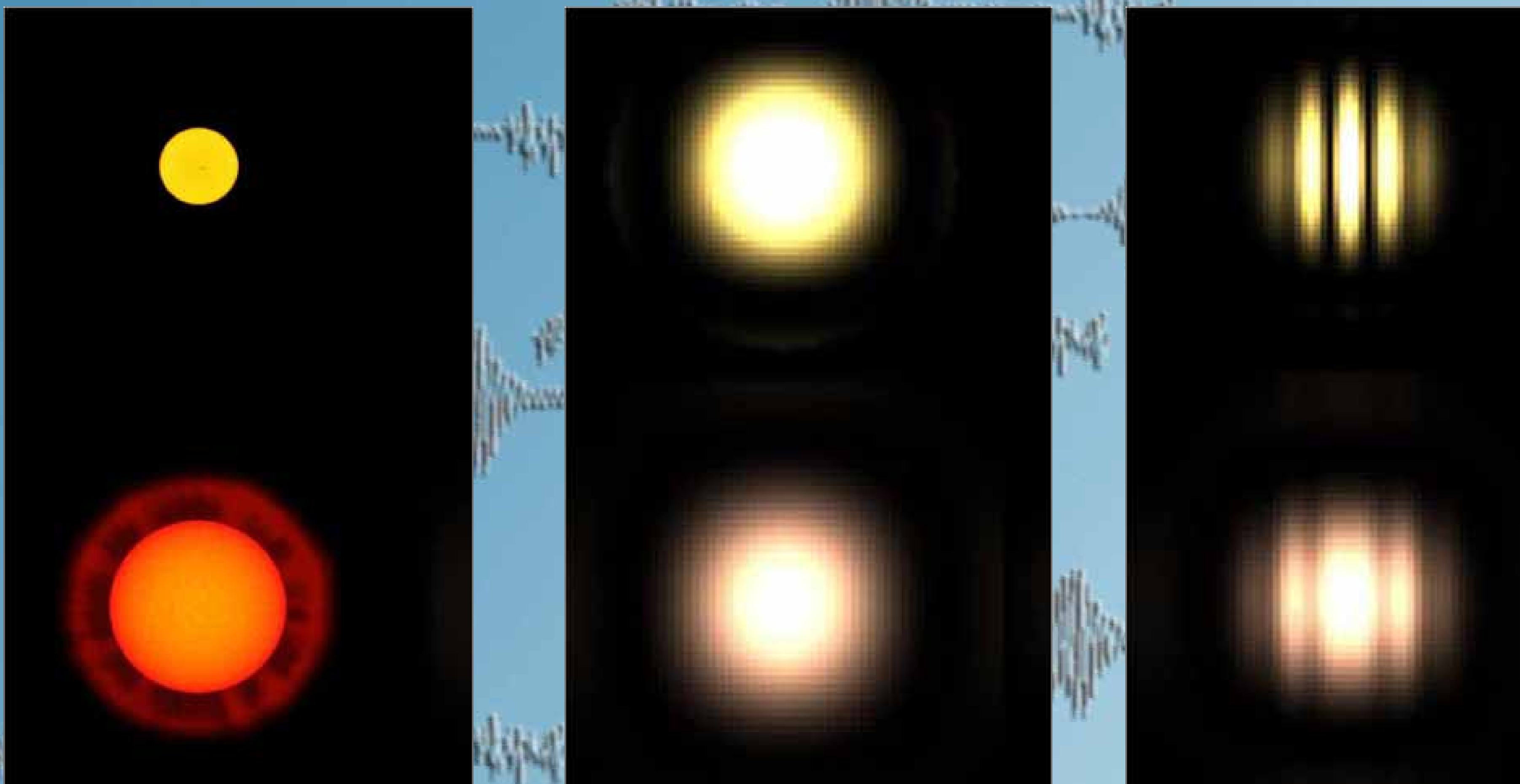
European Southern Observatory

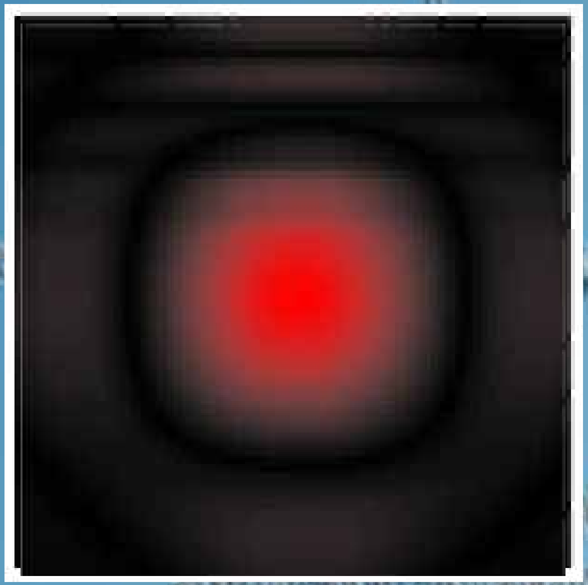
Why is Interferometry useful?

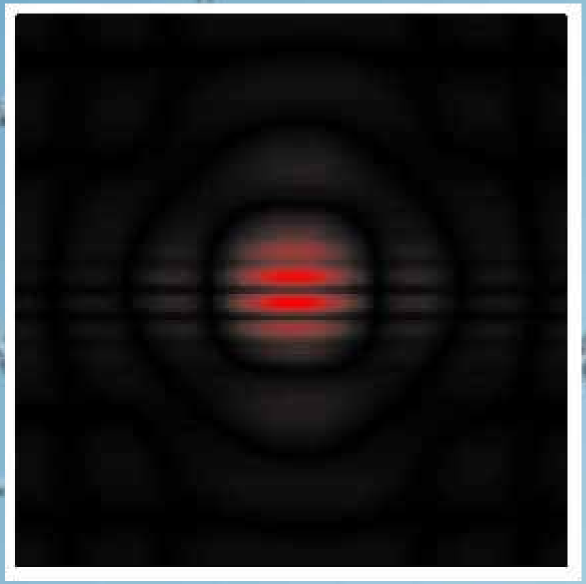


Objects **Single Telescope** **Interf. Fringes**

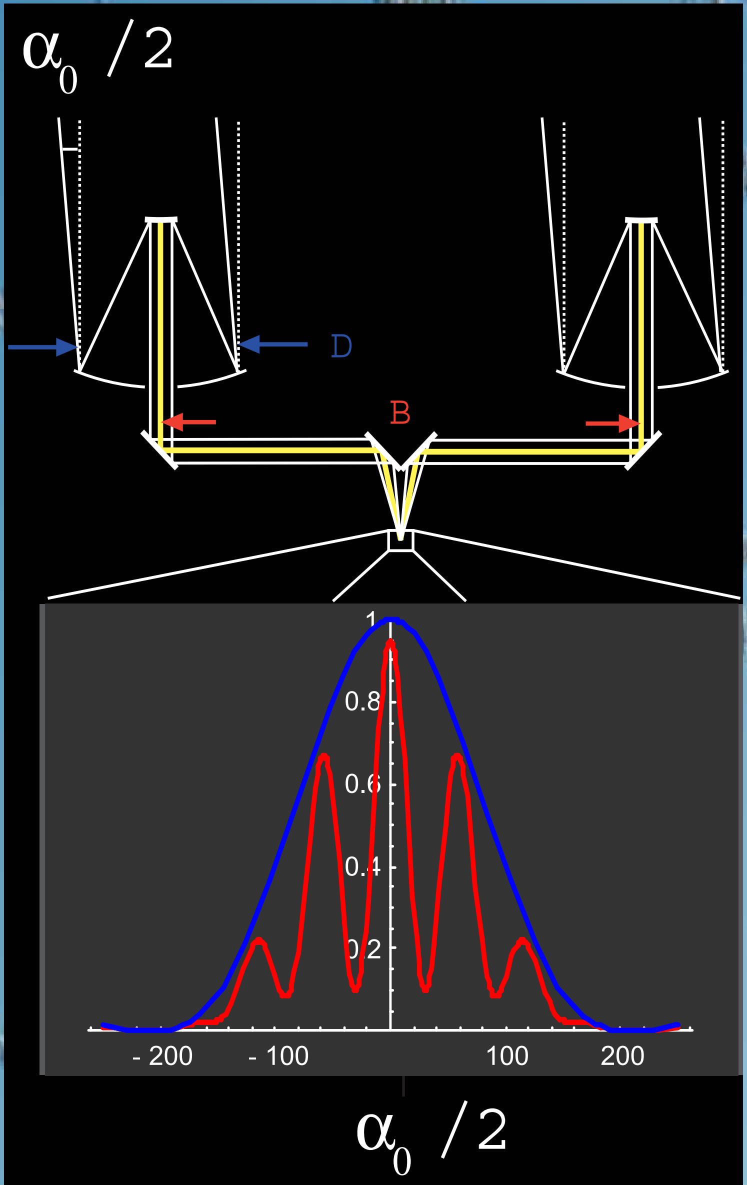
Interferometry at your fingertips

Why is Interferometry difficult?

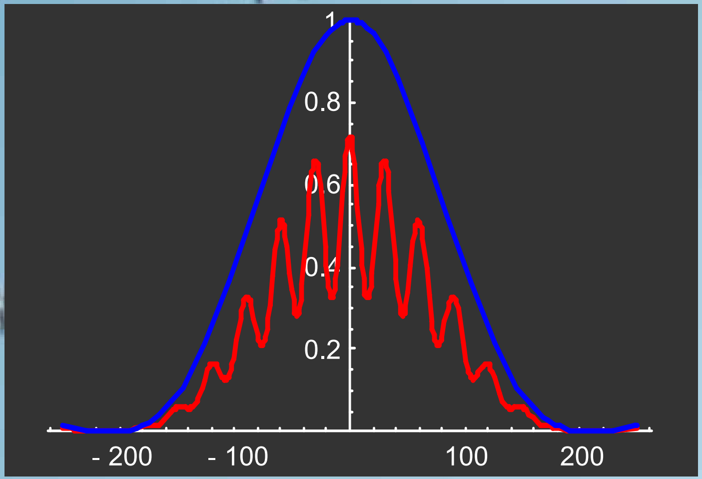




Michelson Stellar Interferometer

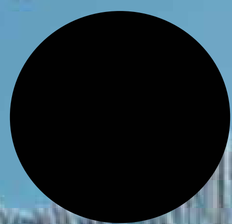


- Stellar source with angular size α_0
- Add fringe patterns (i.e. intensities) between $\pm \alpha_0/2$
- Resulting fringe pattern shows reduced contrast.
- Reduced contrast depends on B – and on α_0.



movies courtesy of A. Glindemann

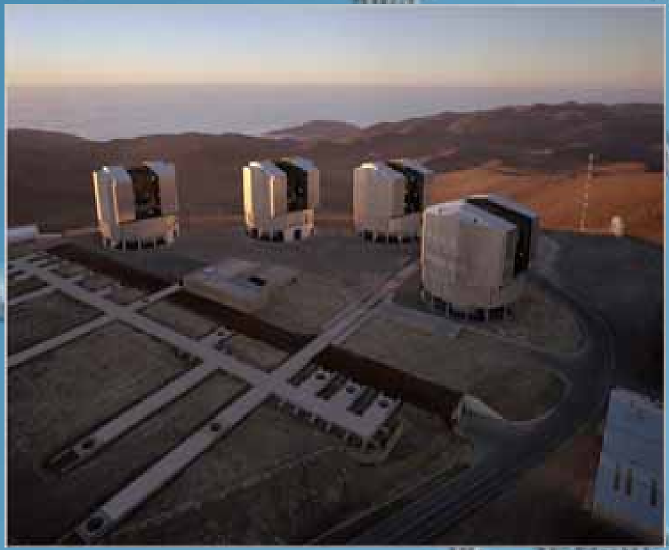
Single telescope imaging vs. interferometry



Sensitivity

Diffraction limit

Optical vs Radio Interferometry

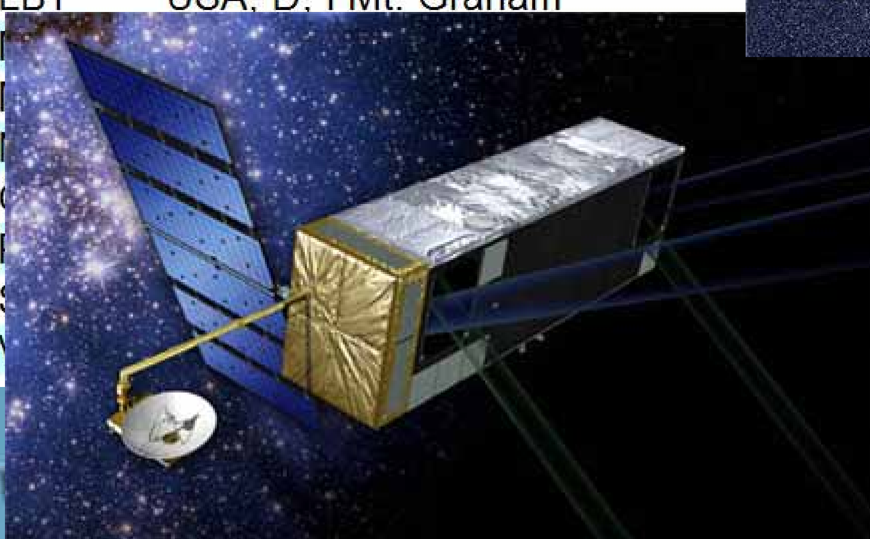


In common: Visibilities, Closure Phases, Angular Resolution (λ/B)

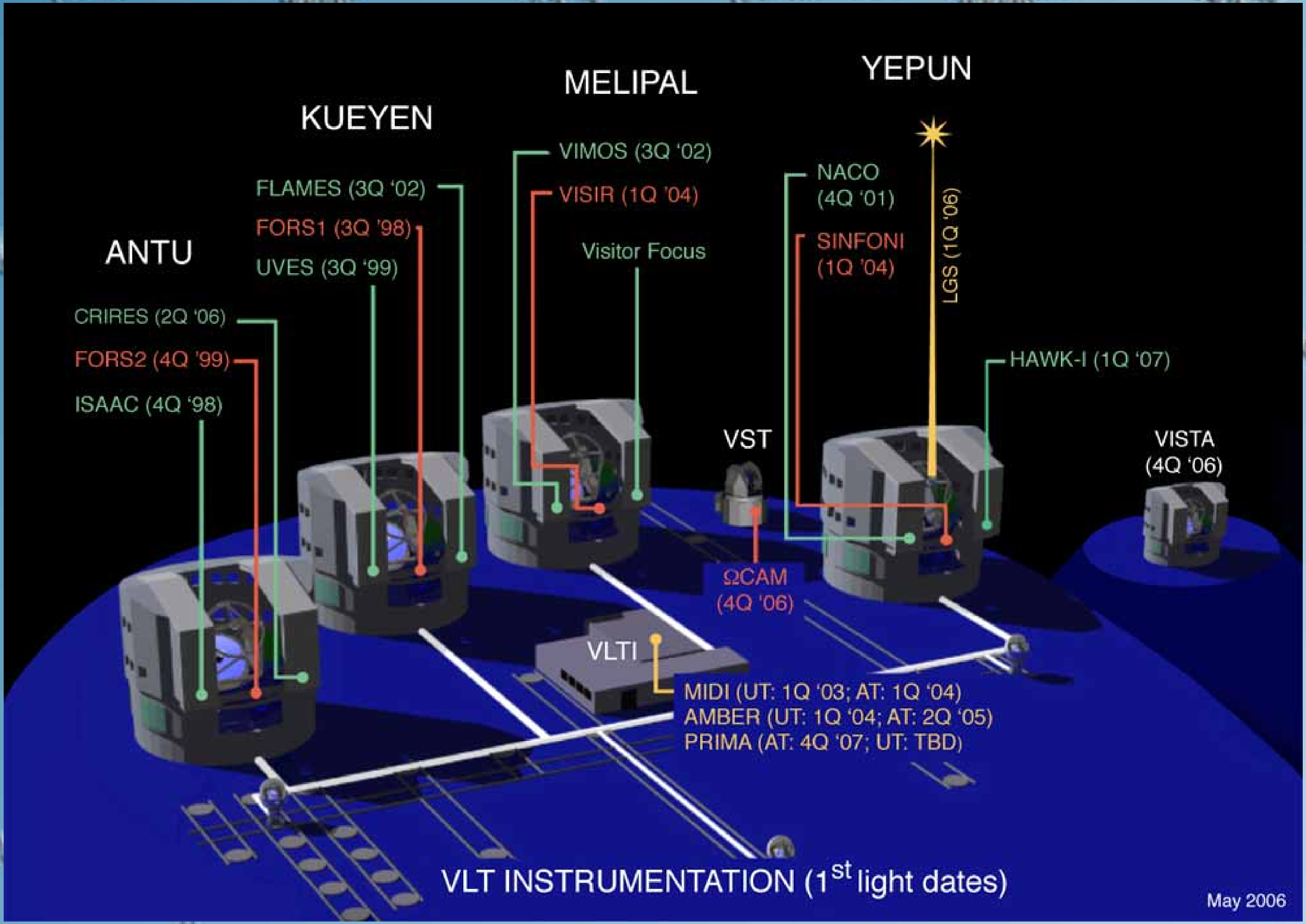
Radio: more baselines, phases, “true” imaging

Overview of current Interferometers

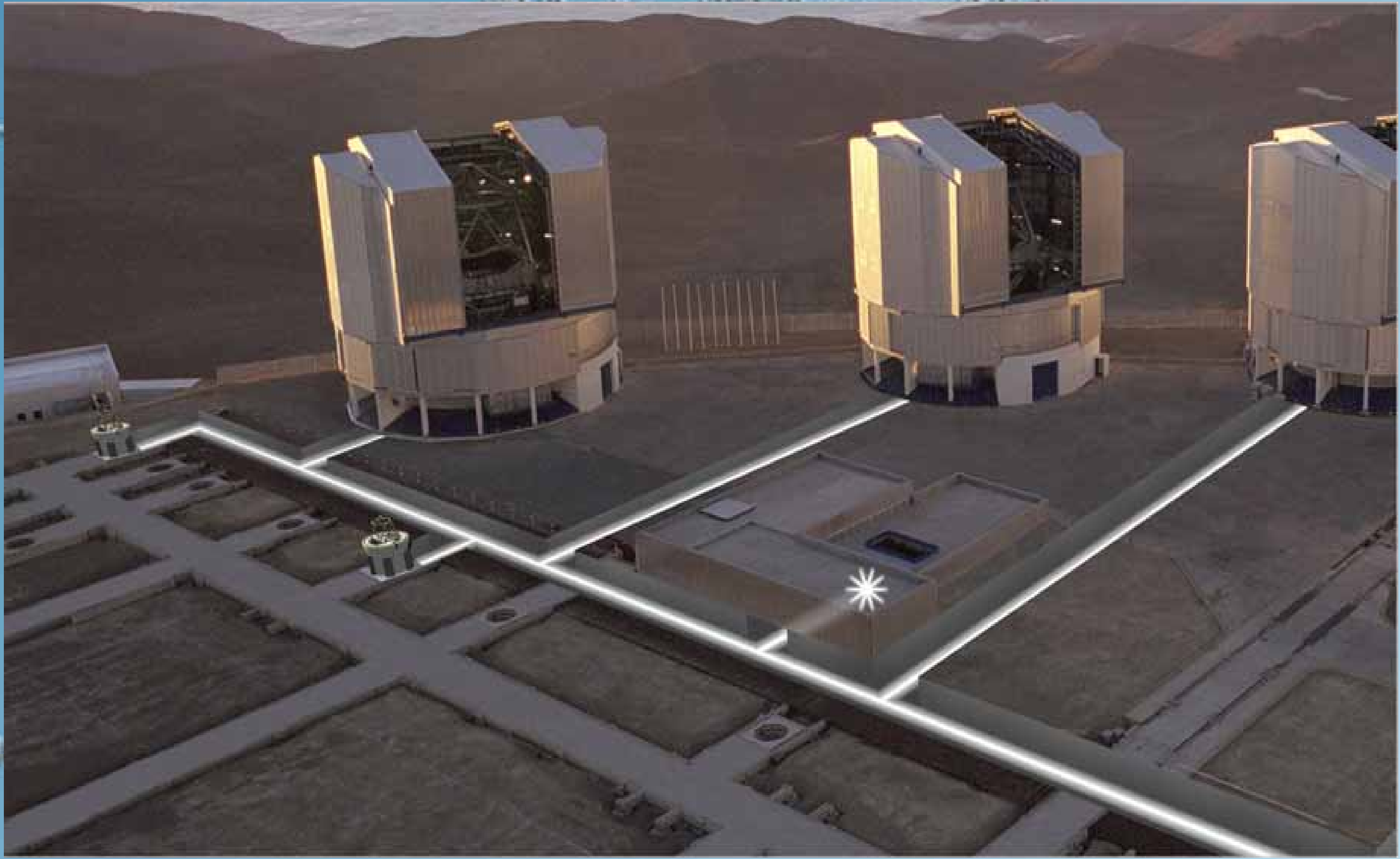
facility	funding	location					
CHARA	USA	Mt. Wilson					
COAST	UK	Cambridge					
GI2T	F	Calern					
IOTA	USA, F	Mt. Hopkins					
ISI	USA	Mt. Wilson					
KECK	USA	Mauna Kea					
LBT	USA, D, I	Mt. Graham					
			1.4		400?	funded	vis, NIR
			0.35		64	1994	vis, NIR
			3-10		85-800	2004	NIR
			0.40		110	1995	(J)HK
			0.14		100(640)	1993	B, R
			8.2	1.8	130-205	2001	JHK, NQ



Paranal Telescopes and Instruments



The VLTI - close up

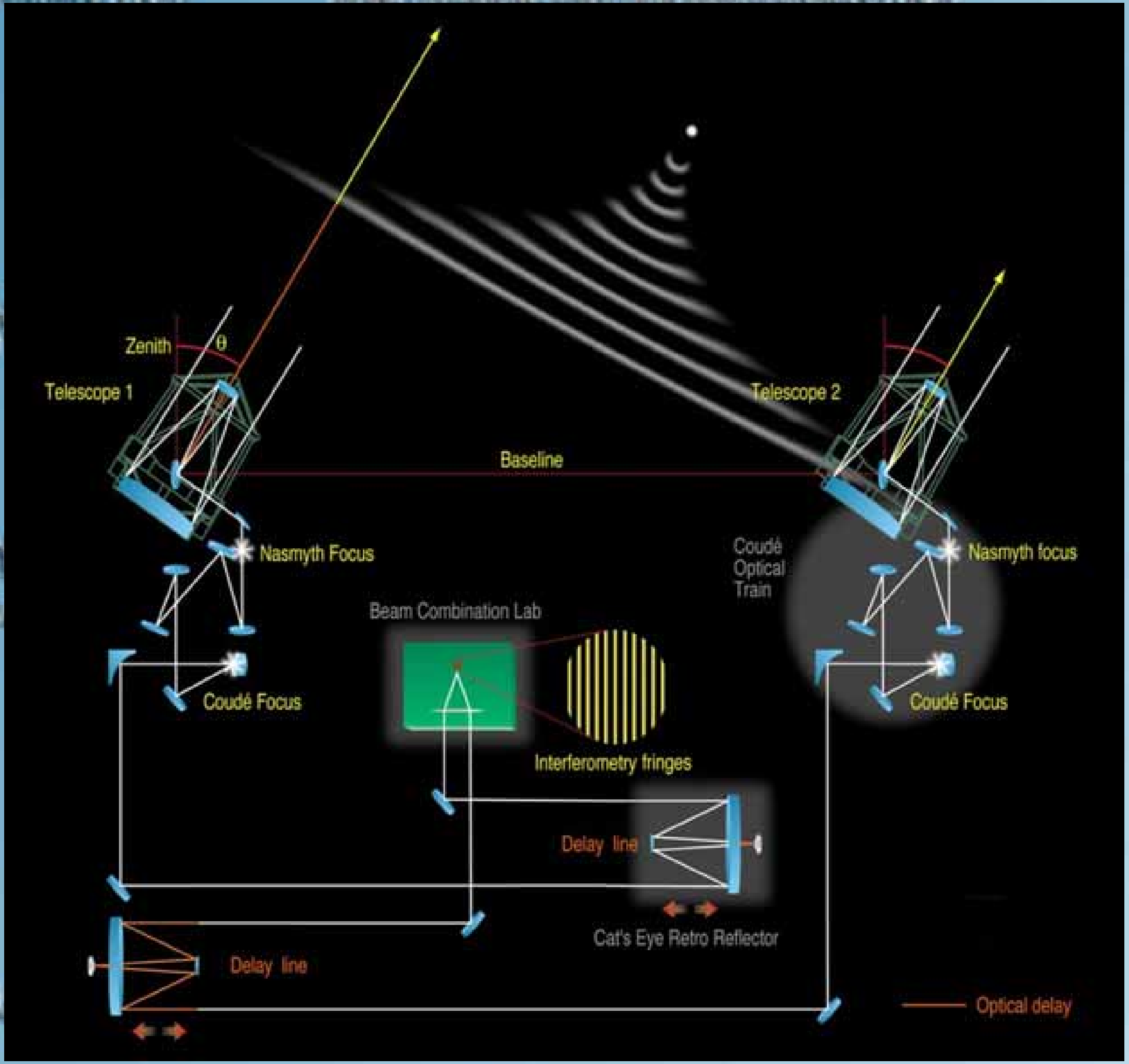


VLTI Scheme

The wavefronts must be "clean", i.e. adaptive optics needed for large telescopes.

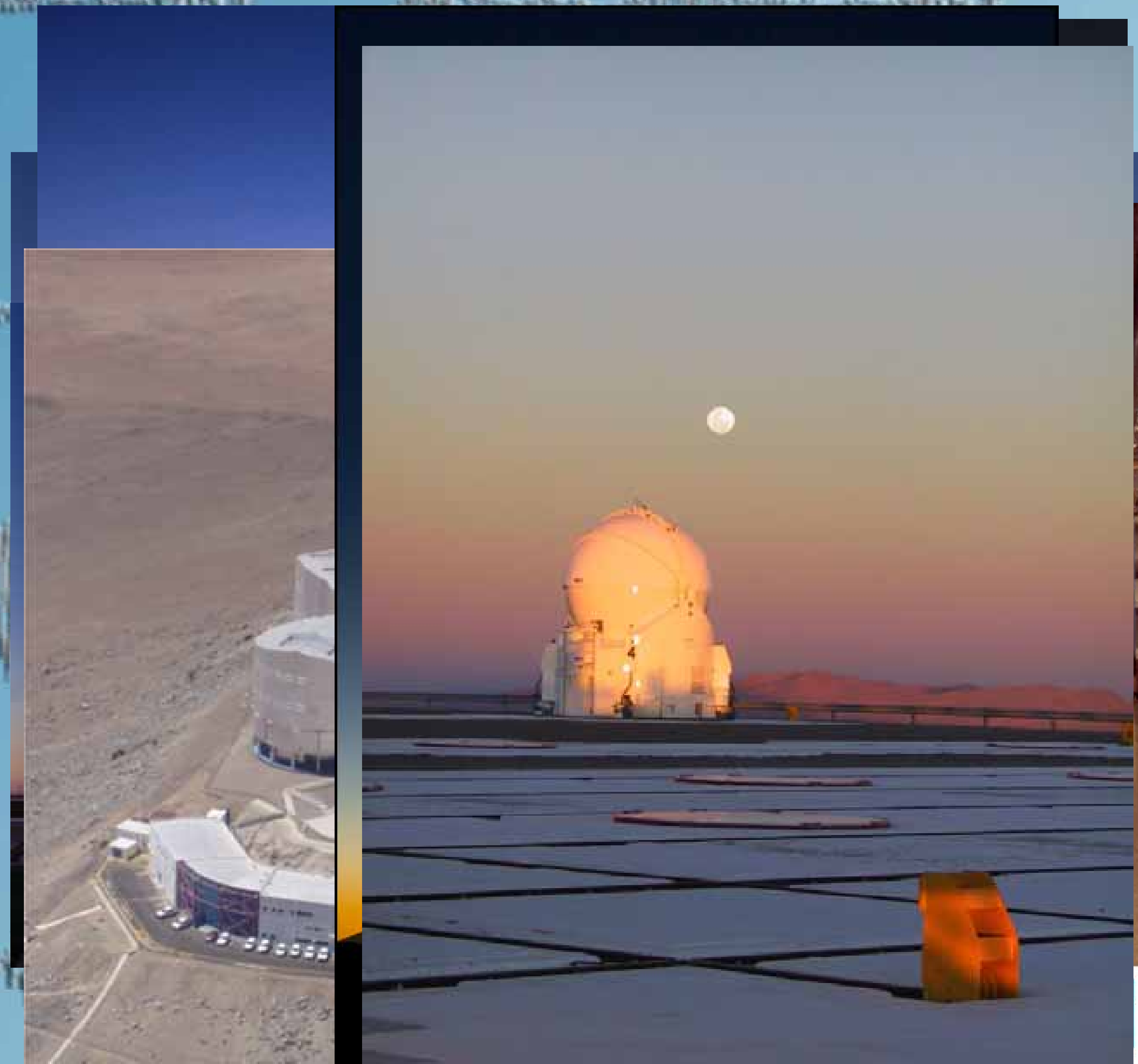
The optical path difference must be continuously compensated by the delay lines.

Atmospheric turbulence causes rapid fringe motion which must be "frozen" by a so-called fringe tracker.

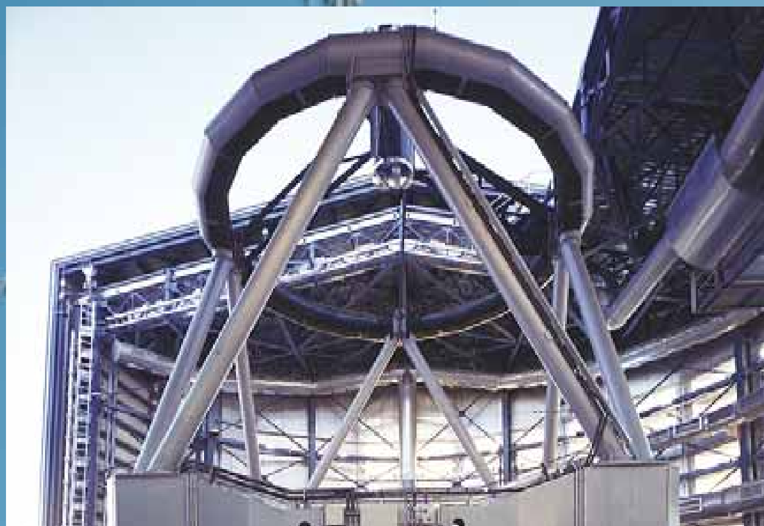


- Four 8.2-m Unit Telescopes (Baselines up to 130m)
- Four 1.8-m Auxiliary Telescopes (Baselines up to 200m)
- 6 Delay Lines
- near-IR to MIR (angular resolution 1-20 mas)
- Excellent uv coverage
- 1st Gen Instruments
- IR tip-tilt in lab
- Adaptive optics
- Fringe Tracker

- Dual-Feed facility (PRIMA)
- 2nd Gen Instruments



The VLTI Telescopes



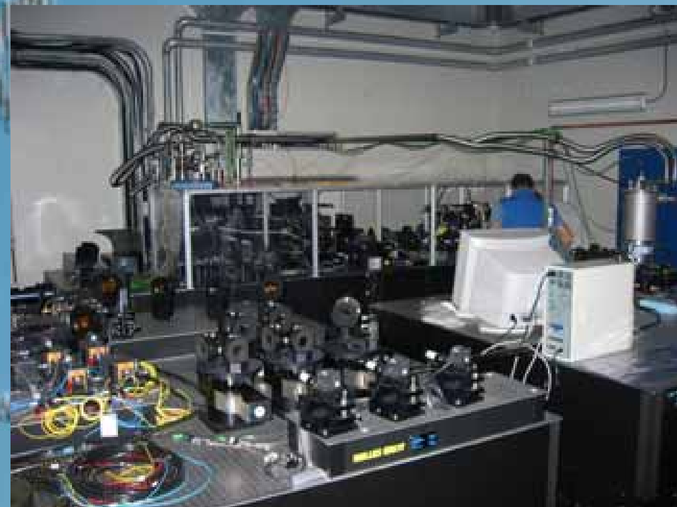
The “Paranal Express”

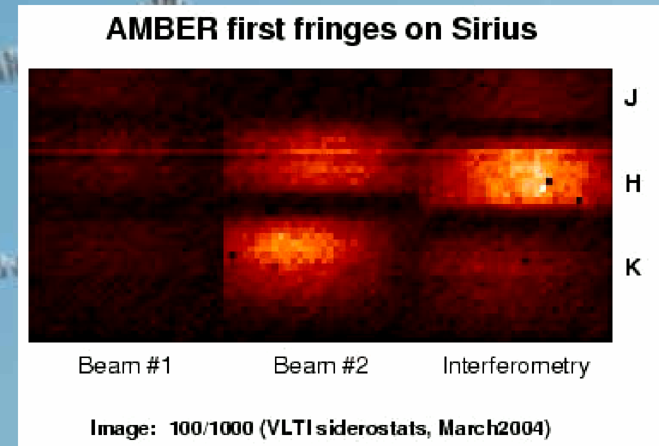
- correct sidereal path difference
- six delay lines
- combine all UT baselines
- combine almost all AT baselines
- laser metrology

VLTI Laboratory

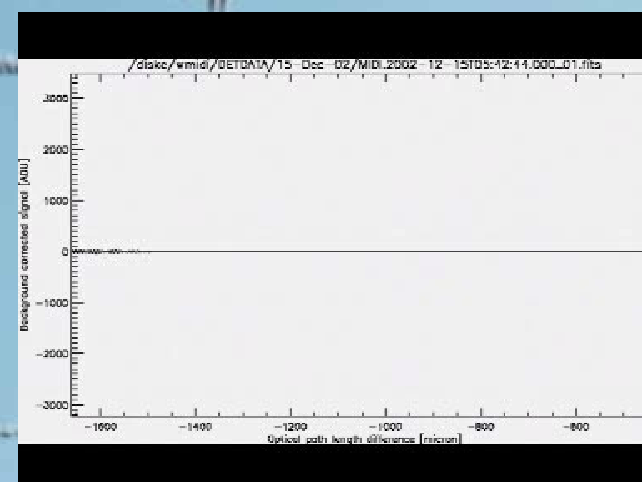
The VLTI Today

AMBER
2-3 beam, JHK R=35, 10^3, 10^4
Paranal 2004/Q1



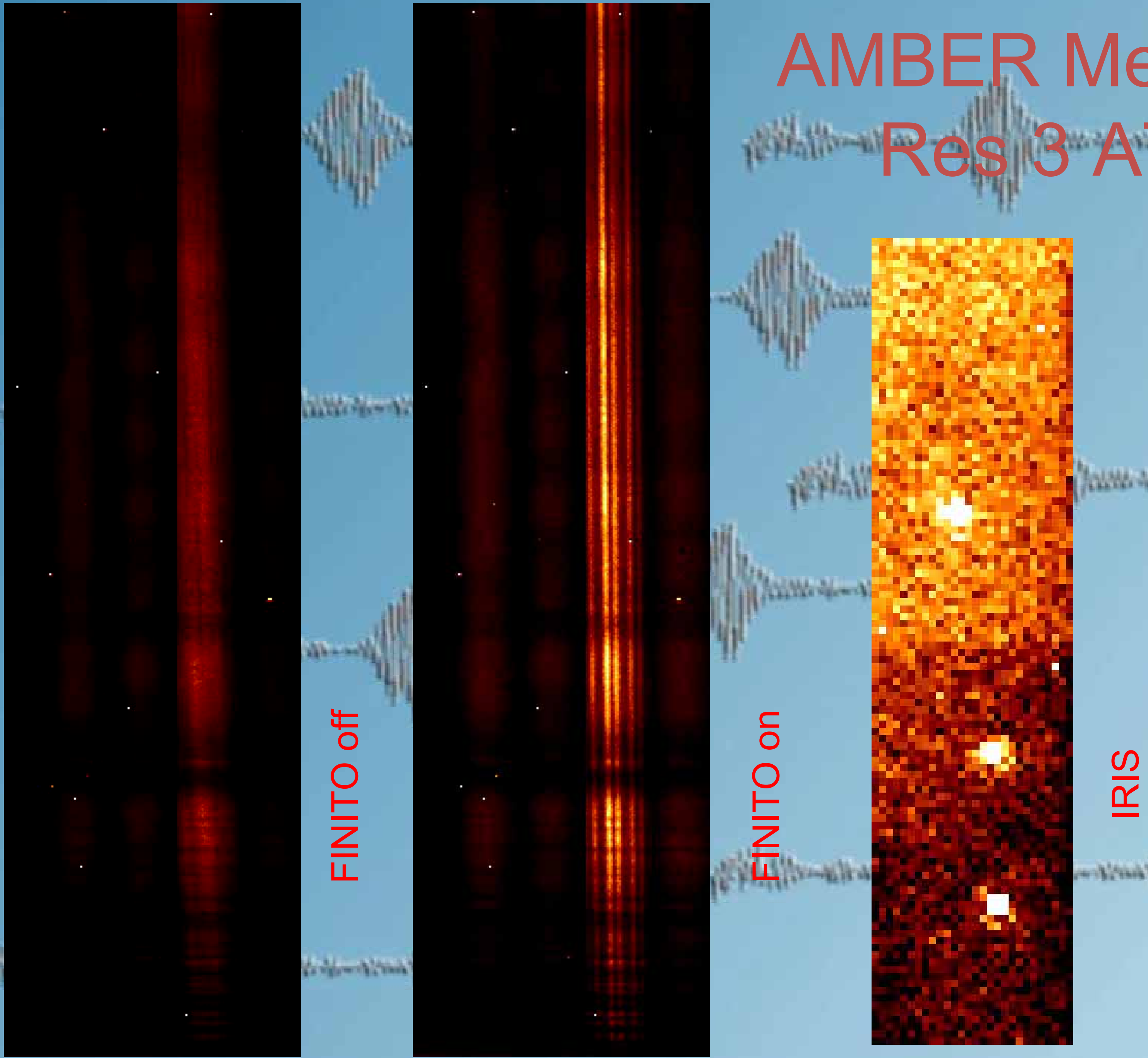


MIDI
2 beam, N-band R=30, 230
Paranal 2002/Q4



+ FINITO, IRIS, Differential Delay Lines, ARAL, vibration correction, ...

AMBER Medium Res 3 ATs



How to obtain and use VLTI data

- Public Archive (VINCI~20000 OBs, SDT, MIDI, AMBER): register as an Archive user
  - VINCI: pipeline
  - MIDI: MIA/EWS software (IDL)
  - AMBER: Ammyorick, Reflex

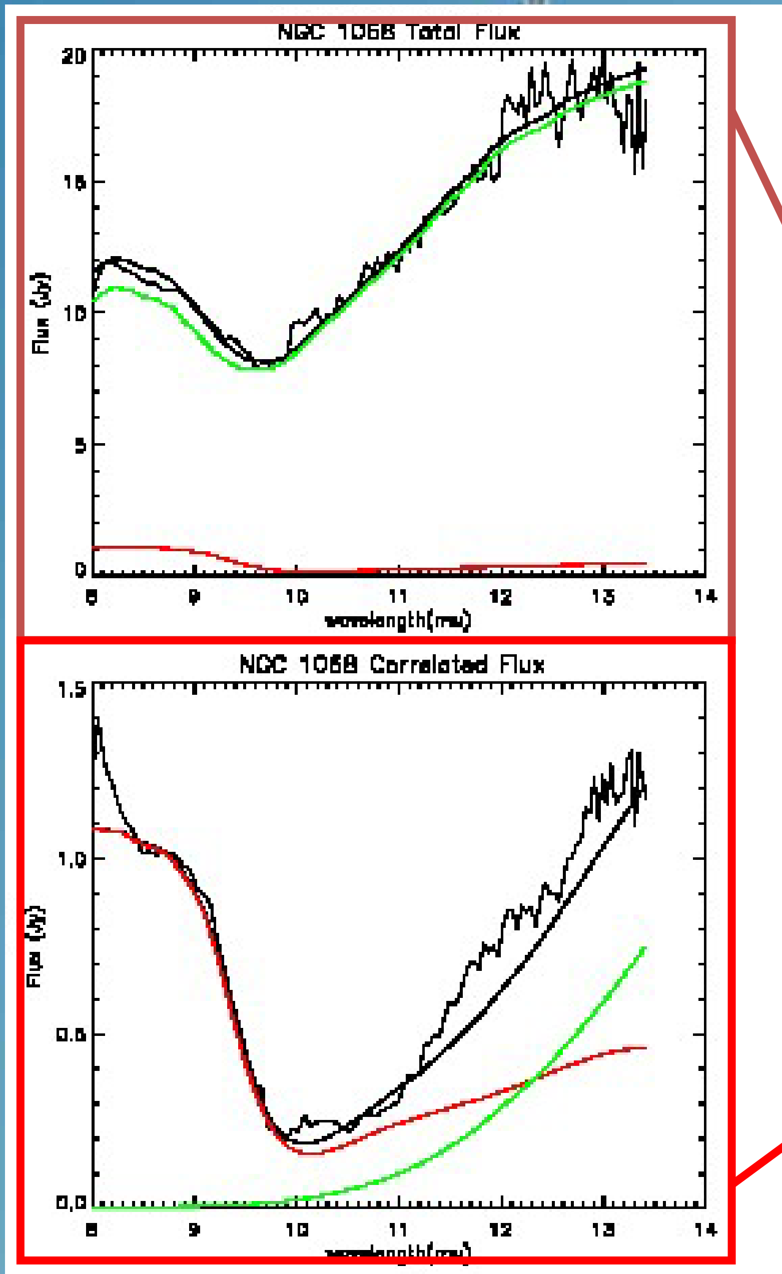
- Write your own proposal

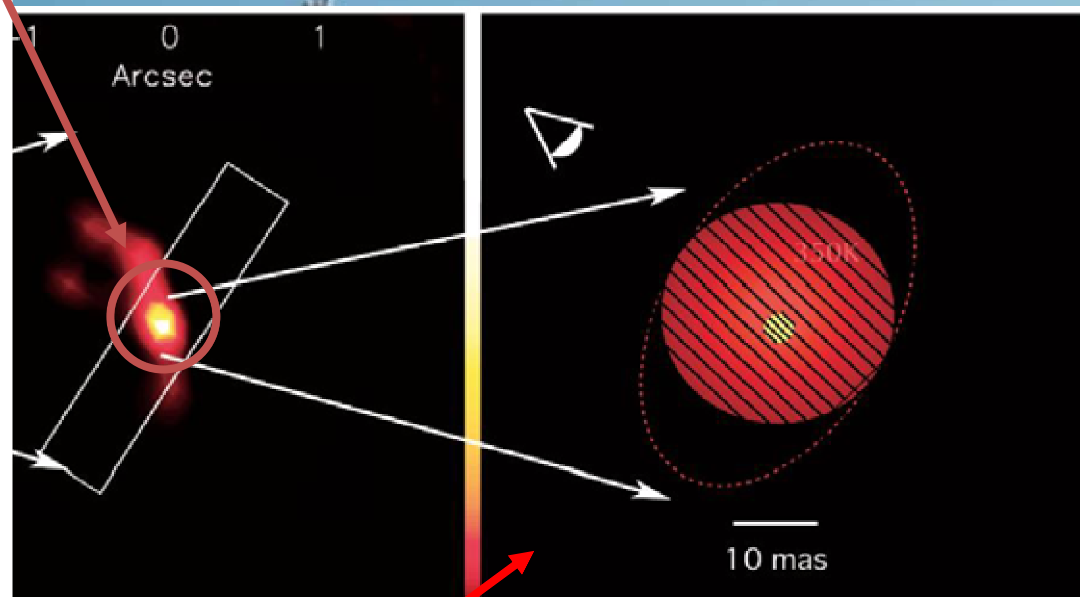
Interferometric Science Highlights

- AGNs (dust tori)
- Hot stars; massive stars; star formation
- Evolved stars; dust in giants; AGBs
- Stellar pulsation
- Binary stars
- MS stars and fundamental parameters
- Search for exoplanets (direct detection)
- Solar system (asteroids)
- Black holes and relativity

NGC 1068

Incoherent combination





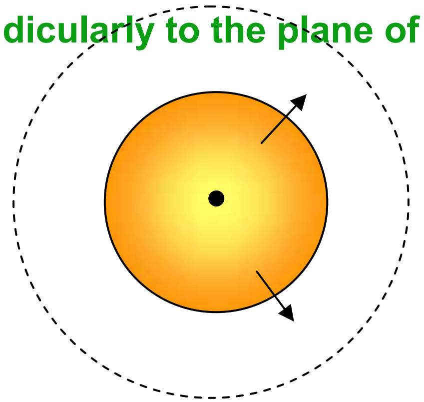
68, (NOAO/AURA/NSF). Centre: non-interferometric acquisition image of NGC 1068
es on arcsec scales. Also shown are the position of the spectroscopic slit used in the
oward top left) and East (toward bottom left) on the sky. The projected baseline was
tion was 26.3 mas at 10 micron wavelength. Right: sketch of the dust structure in the
observations. It contains a central hot component (T > 800 K, yellow) which is signif-
-larger well-resolved warm component (T=330 K, red) of diameter 33±5 mas, corre-
fe et al (2003).

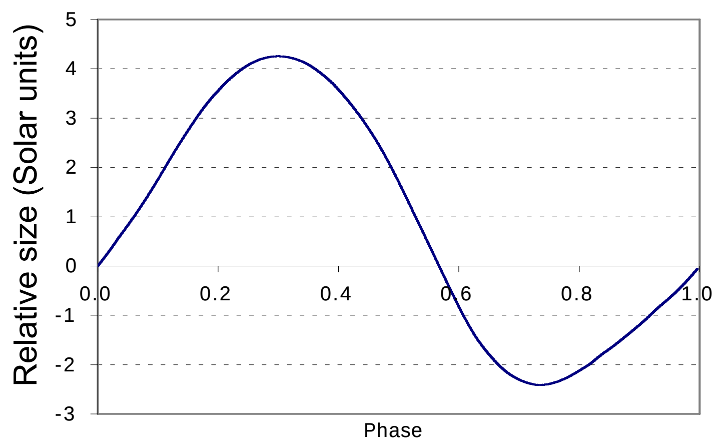
2 Tel coherent combination

Cepheid Stars

- **Radial velocity data (spectroscopy)**

Perpendicularly to the plane of the sky

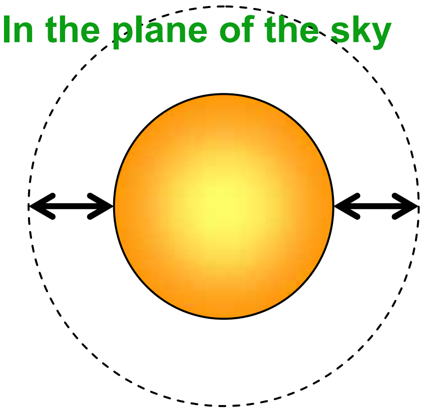


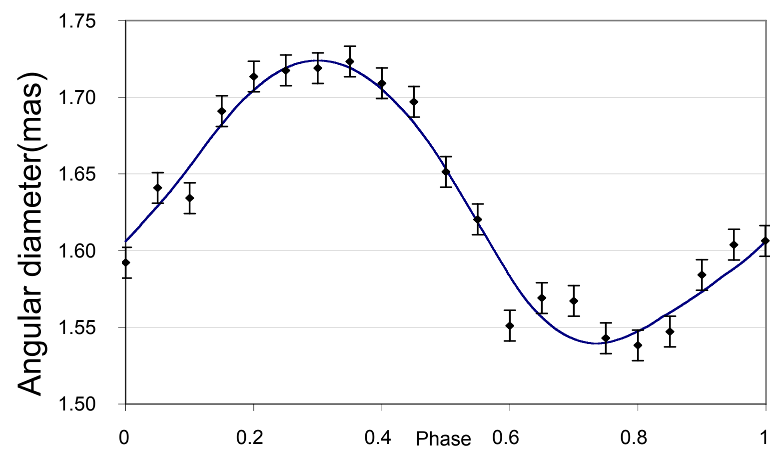


Distance

- **Angular diameter (interferometry)**

In the plane of the sky

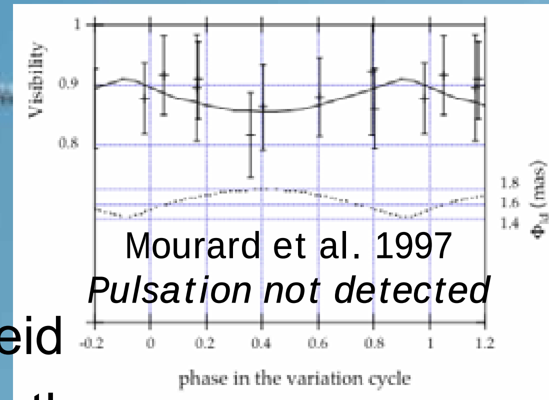


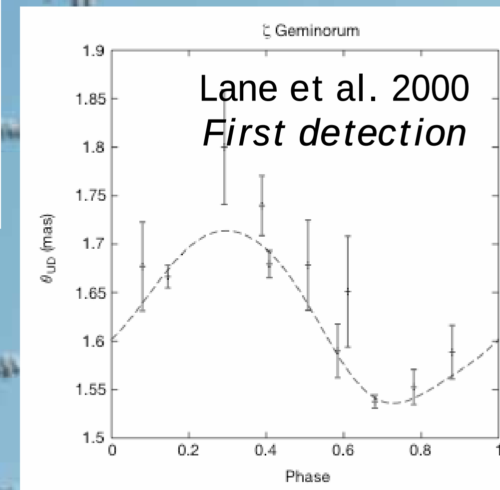


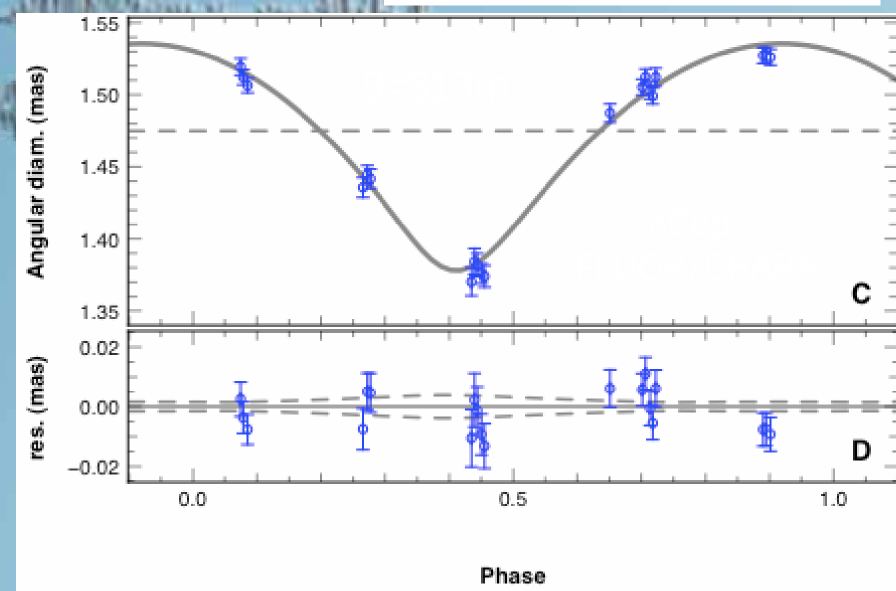
From P. Kervella (2005)

δ Cep

Evolution of the IBW method at a glance:





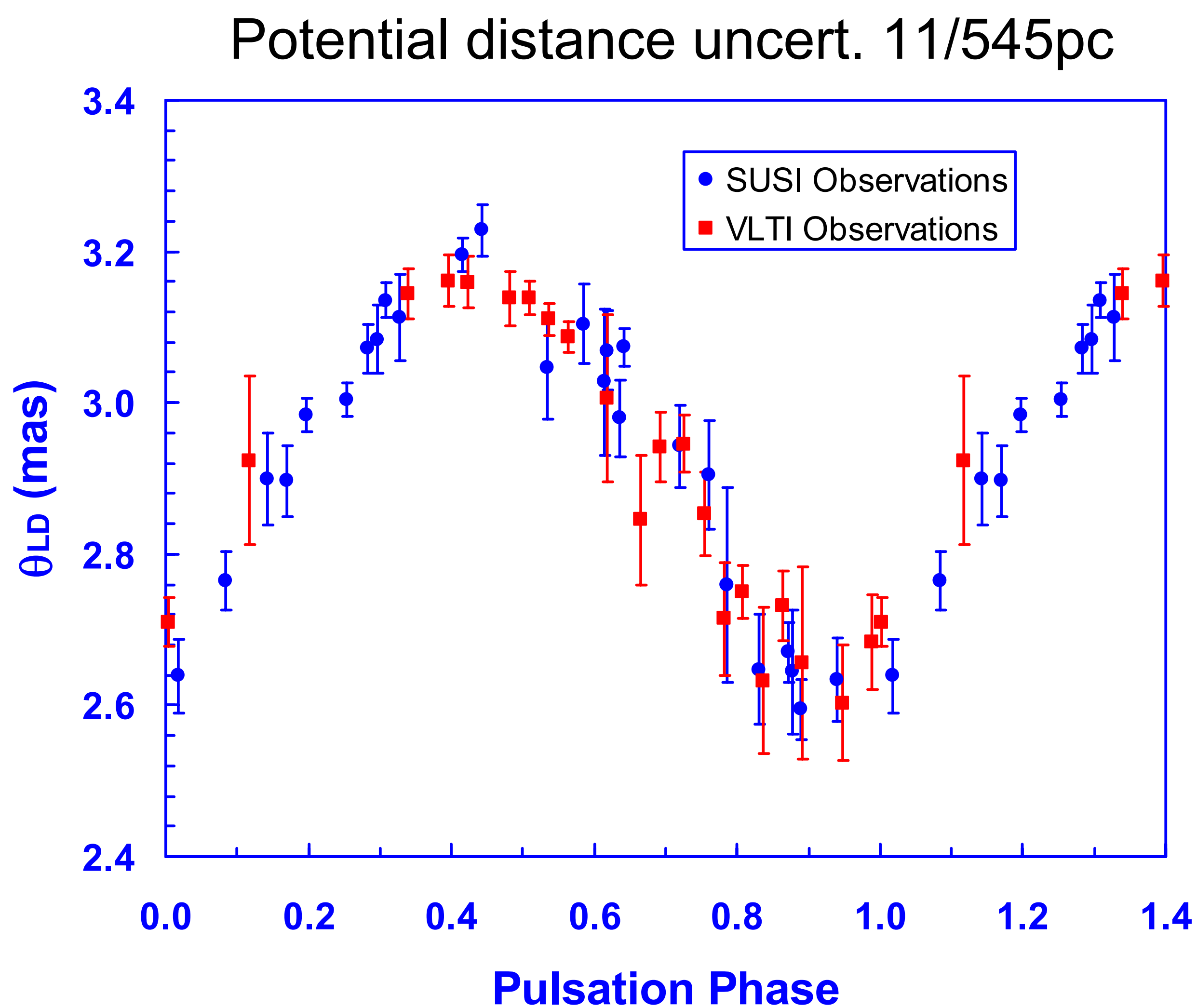


- Prototype Classical Cepheid
- Interferometry is no longer the limitation to the IBW method
- Individual V2 lead to $\sigma\theta/\theta$ < 0.5%
- Potentially*, the distance is determined at the 2% level

* *How well do we trust LD & p-factor models ???*

From A. Mérand (2005)

l Car



From J. Davis (2005)

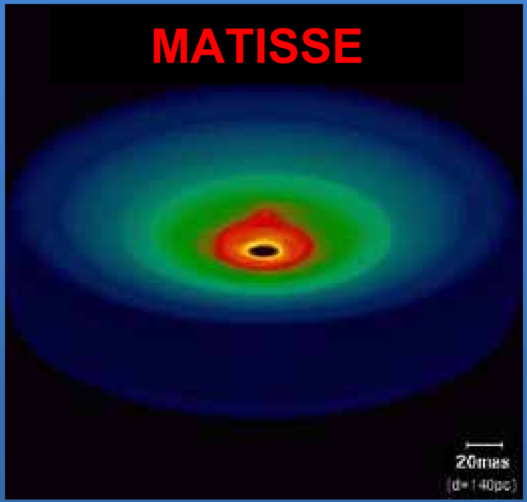
The VLTI Tomorrow

PRIMA

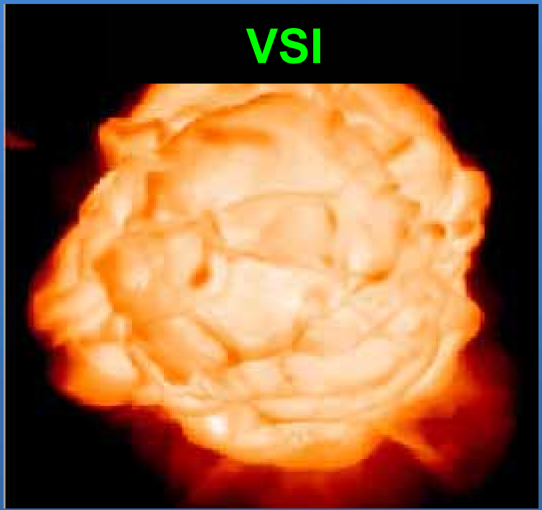
Dual-feed facility
Start of integration in Paranal in 2008
First scientific use in 2009 TBC

Phase A studies concluded (Sep'07) for 2nd Generation Instruments

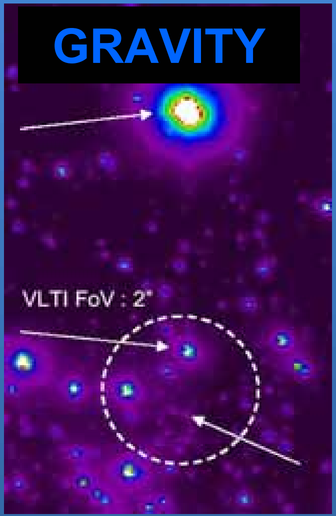
3-20μm, 4 beams



1-2.5μm, 4-6 beams



2.2μm, 4x2 beams



Conclusions

- VLTI is well-developed, open, user-friendly facility
- Flexible baseline system gives wide *uv* coverage
- Most powerful combination of long baselines and large telescopes
- Standard system of observation, data quality and data analysis
- Diverse scientific issues at 0.001” resolution
- Lively future