VLTI update

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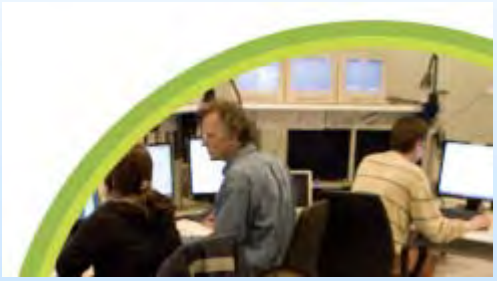

Christian Hummel (USD)
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Francoise Delplancke (INS)

Overview

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- Infrastructure
  - 4 UTs, 4 ATs
  - 6 delay lines
  - FINITO and FSUA fringe trackers
  - PRIMA (dual feed fringe tracker)
- Instruments
  - MIDI, AMBER, PIONIER
  - Commissioning: PACMAN
- 2nd generation instruments
  - MATISSE, GRAVITY
- Operations
  - OPC, SM/VM, USD, SciOps, Archive

Infrastructure

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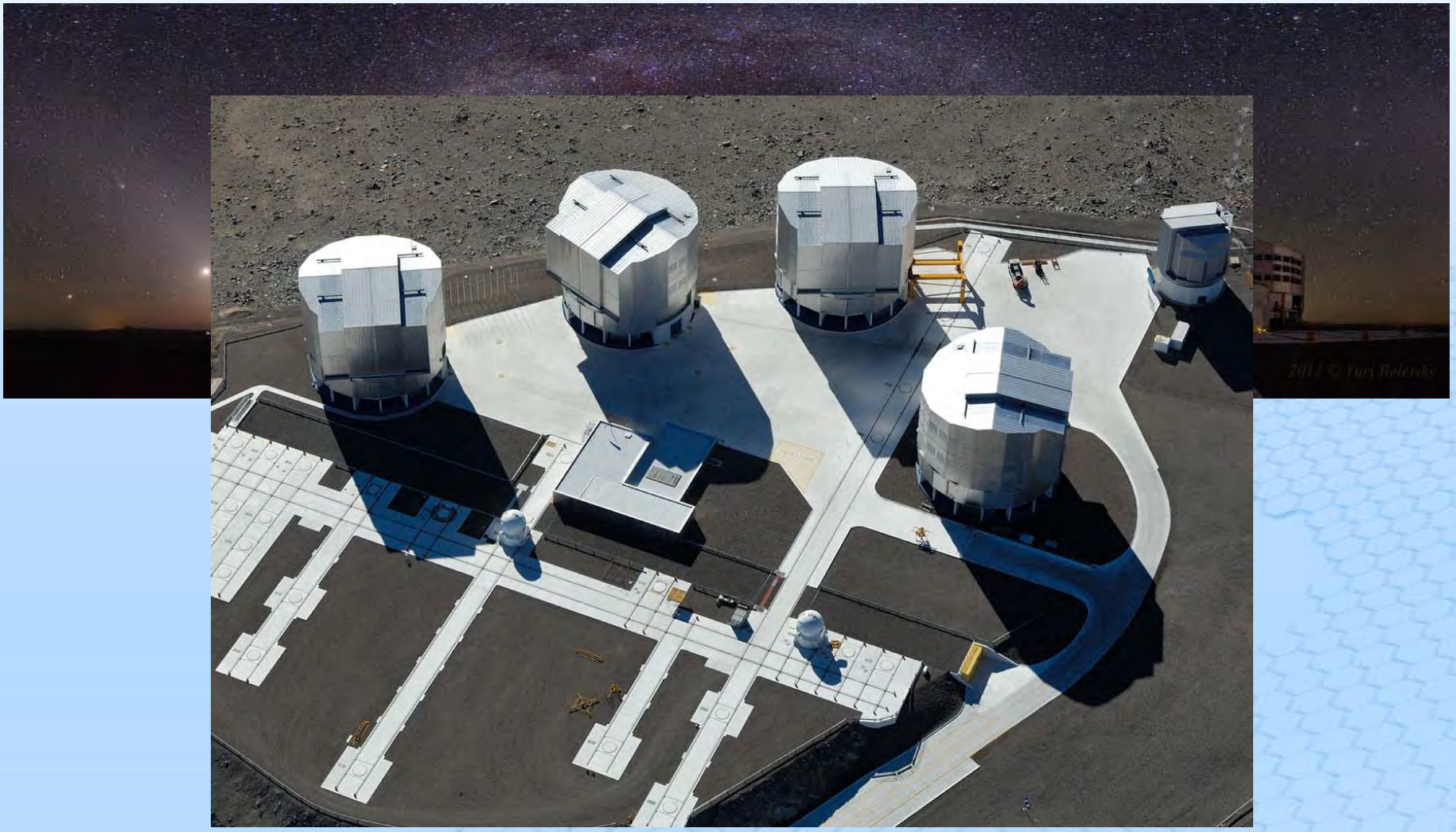

Infrastructure

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- 4 Unit Telescopes (8m ø)
  - with Adaptive Optics (60 element curvature systems)
  - used on average 3-4 nights per month (bright time)
  - baselines: 47m to 130m
- 4 Auxiliary Telescopes (1.8m ø)
  - with tip-tilt field stabilisation at telescope
  - movable (max. 2 movements per day, daytime) on many stations (9 offered or 4 different quadruplets)
  - baselines: from 8m to 128m
  - used 50% of the time (rest = UT nights and technical time / commissioning of new systems)

Infrastructure

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- 6 Delay Lines
  - range: OPD from 0 to 120m, resolution: 5nm
  - pupil relay (continuous) through Variable Curvature Mirror
  - compatible wit dual-feed
- Infra-red tip-tilt sensor IRIS
  - J, H or K-band, up to 4 beams
  - fast tip-tilt guiding
- 3 telescope fringe tracker FINITO
  - H-band, used with AMBER
- Alignment tools (pupil viewer, calibration source…)

Current Instruments: AMBER

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- Bands: (J) H and K (1.5 to 2.5µm)
- Spectral resolution: up to 12000 – Spatial res.: 3mas
- 3 telescopes => phase closure => some imaging
- Limiting magnitudes:
  - low resolution => H_{corr}, K_{corr} = 7.5 (UT) and 5.5 (AT)
  - high resolution => H_{corr}, K_{corr} = 6 (UT) and 5 (AT) with fringe tracking

Current instruments: MIDI

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- Band: N (8-13µm)
- Spectral resolution: 30 or 230 – Spatial res.= 15mas
- 2 telescopes => squared visibilities + differential phase (as a function of the wavelength)
- Limiting magnitudes:
  - high-sensitivity mode (prism) => N=4 =1Jy (UT) and N=0.74 =20Jy (AT)
  - new correlated flux mode => N=5.7 =0.2Jy (UT)

Current instrument: PIONIER

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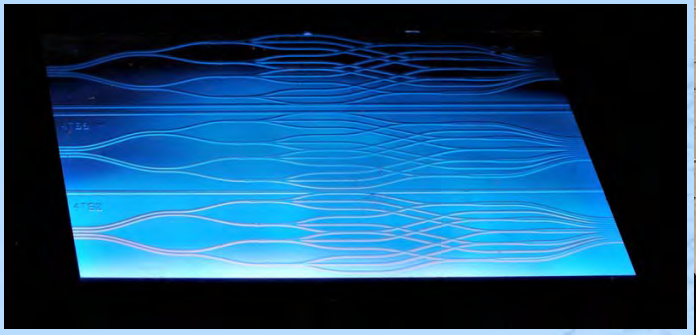
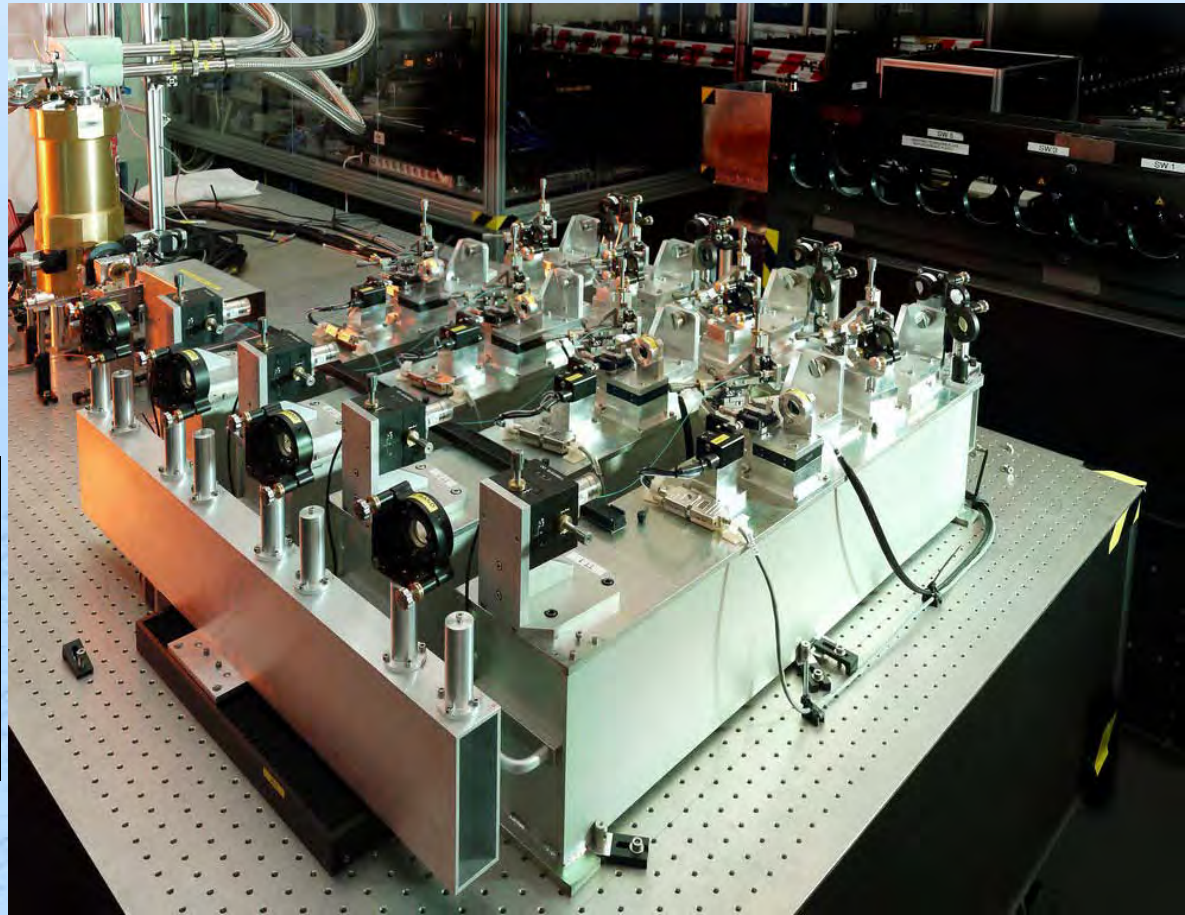
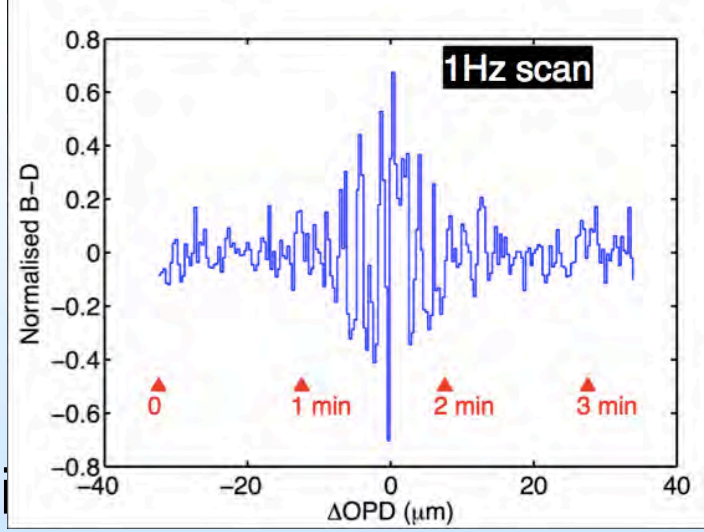
- Band: H (1.5-1.8 μm)
- Low spectral resolution (up to R~ 40)
- 4 telescopes – 6 baselines
- lim. mag. H>7
- Visitor instrument





PRIMA



- PACMAN: Differential astrometry
  - under test / commissioning
  - goal: 50-100 μas accuracy for Jupi
    detection => gives the mass and orbit inclination
  - follow-up of radial velocity + access to more active stars
  - current problem with baseline stability / definition
- Off-axis fringe tracking to push the limiting magnitude of AMBER and MIDI (at the cost of sky coverage)
  - increase of limiting magnitude by 4-5 magnitudes
- Phase-referenced imaging with AMBER & MIDI
  - for some imaging … if implemented

PRIMA – astrometry status

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- New IS: Julien Woillez
- Problem: metrology only for part of stellar light path
  - Path does not contain de-rotator and does not go out to telescope.
  - Flexure problems
- Tiger Team proposed solutions and evaluate potential performance => moving metrology reference point up (M2), measuring its position…
- Work on polarization control (affects quality of return beam from retro-reflector)
- …

2nd generation instruments

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- GRAVITY (2014+) under manufacturing
  - 2 to 2.5 µm (K-band), R= 22 to 4000
  - 4 telescopes simultaneously
  - astrometry (30µas) and faint imaging (K>15)
  - Galactic Center, AGNs, stellar environment & dynamics…
- MATISSE (2015+comm.) at final design stage
  - 3 to 13 µm (L, M & N-bands), R= 30 to 1000
  - 4 telescopes simultaneously
  - star & planet formation (dust), evolved stars, AGNs, minor solar system bodies, Galactic center, extra-solar planets …

Long Range Plan

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- Responsibility of Jean-Philippe Berger (new VLTI Programme Scientist)

AMBER top requirements

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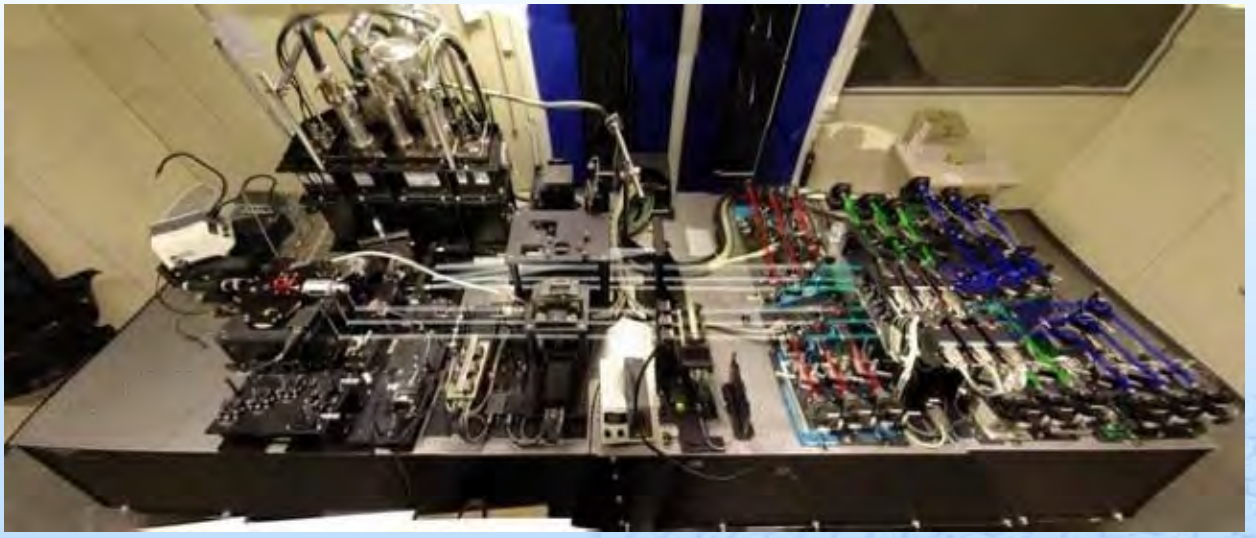
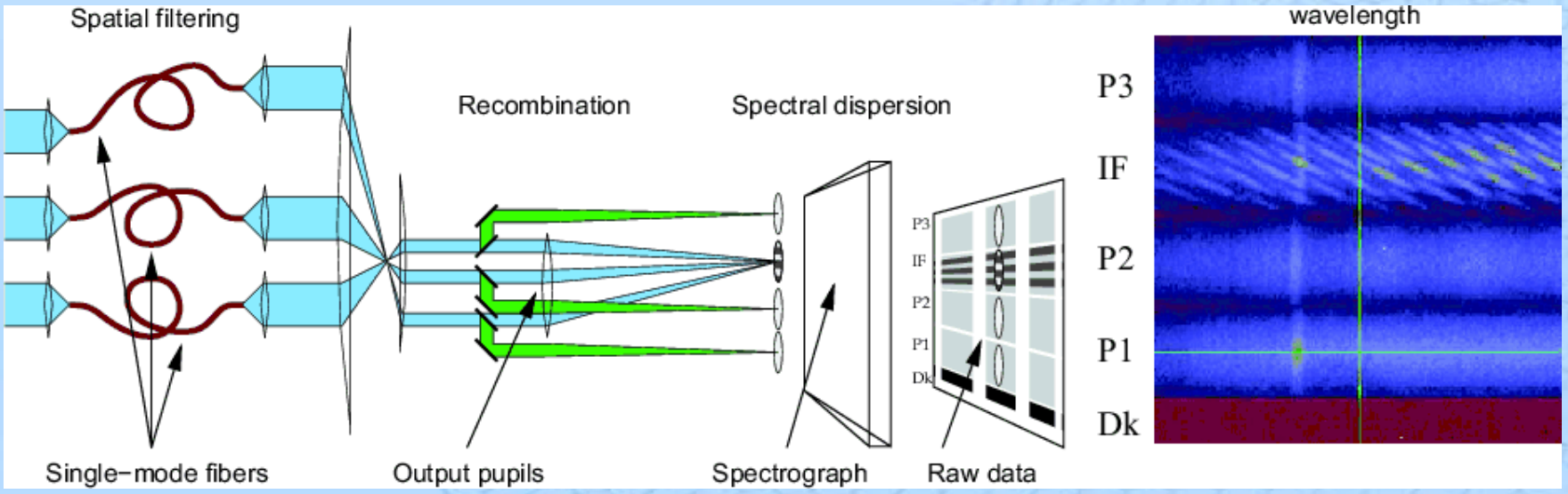
- Sensitivity
- Precision
- High spectral resolution

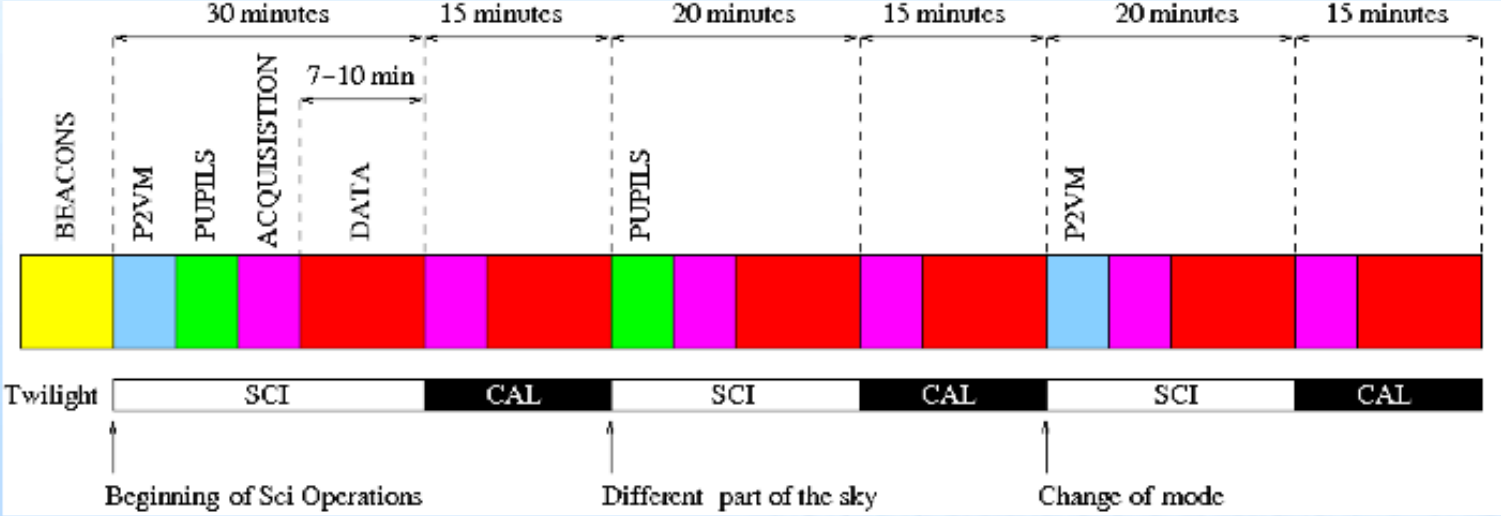
- AMBER offers three beam combination at the VLTI
- (J),H,K bands available
- Observables: visibilities, closure phase (CP), differential vis, phases, CP
- VLTI+AMBER offers 4x3 possible telescope triplets in single night
- R:40,1200,10000





Standard operation

- Typical observation sequence: CAL-SCI-CAL



- Offered: LR: 60 minutes + MR/HR: 75 minutes:
- AMBER+FINITO used “almost” smoothly but performance limitation
- 3T AT triplet can be choosen out of 4 positions (redundancy would avoid idle time)
- AMBER acquisition of faint sources cumbersome (PlayStation-like)

Performance

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Offered

Initial planned

Precision

mode	FINITO	calibrated V	diff. ϕ	CP
low HK	not used	10%	NG	5^{o1}
	coherencing	5%	NG	3^{o1}
	cophasing	7%	NG	3^{o1}
medium K	coherencing	5%	2^{o}	4^{o}
	cophasing	5%	1^{o}	2^{o}
medium H	any mode[3]	5%	2^{o2}	4^{o2}
high K	cophasing	5%	1^{o}	2^{o}

Visibility	Closure phase	Diff. phase
0.1%	0.05deg	0.01deg

Sensitivity

	AMBER	FINITO	Kcorr	Hcorr
UT	LR-HK	no	<7*	<7*
	LR-HK	group tracking	<7.5*	<7.5*
	LR-HK MR-K	fringe tracking	<7	<7
	MR-H	fringe tracking	-	<5
	HR-K	fringe tracking	<6	<6
AT	LR-HK	no	<5.5 (4.1, 3.1)**	<5.5 (4.1, 3.1)**
	LR-HK	group tracking	<5.5 (4.5, 3.5)**	<5.5 (4.5, 3.5)**
	MR-H	fringe tracking	-	<4 (3, 2)
	LR-HK MR-K HR-K	fringe tracking	<5 (4, 3)	<5 (4, 3)

Average seeing conditions (< 60% of time)

	3 UTs			3 ATs		
Observing modes	J	H	K	J	H	K
High Sensitivity	8.8	10.5	**11.6**	6.6	7.5	**8.6**
High Precision Visibility	7.1	8.8	**9.9**	5.1	5.9	**6.9**

AMBER limits

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	Spectral mode	Fringe Tracking[1]	Kcorr limit	Hcorr limit	Vis K	Vis H	Air Mass	Guid. Vmag	Guid. Dist
UT	LR-HK	group	8.5, 7.5*	8.5, 7.5*	>10%	>10%	<2.0	1...17	<55"
	LR-HK, MR-K	phase	8.0, 7.0	8.0, 7.0			<1.5	1...15	<13"
	MR-H	phase	-	6.5, 5.5					
	HR-K	phase	7.0, 6.0	7.0, 6.0					
AT	LR-HK	group	6.0, 5.0, 4.0**	6.0, 5.0, 4.0 **	>5%	>5%	<2.0	-1.7...13.5	<60"
	MR-H	phase	-	4.5, 3.5, 2.5			<1.5	-1.7...11	<15"
	LR-HK, MR-K, HR-K	phase	5.5, 4.5, 3.5	5.0, 4.0, 3.0					

[1]: "Phase" tracking is performed by FINITO, "Group" tracking is performed by AMBER self-coherencing.

The table above assumes seeing<0.6" with CLR conditions, seeing<0.8" with CLR conditions, for the UTs. For the ATs, the conditions are supposed to be seeing<0.6" with CLR conditions, seeing<0.8" with CLR conditions and seeing<1.2" and THN conditions. **THK** conditions should not be used for AMBER observations. **PHO** conditions are not applicable because AMBER does not provide a photometric calibration to a high level of accuracy even under optimum conditions.

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- AMBER is a productive instrument
- VLTI is a robust interferometer
- but .. degraded combined FINITO+AMBER+vibration control performances only give a hint of what could be achieved in particular in stellar physics
- there is hope ...
  - VLTI has demonstrated sensitivity (K~10.5 with VINCI-UT)
  - VLTI has demonstrated good quality fringe tracking (K~9 on ATs)
  - VLTI has demonstrated precision (VINCI, PIONIER):0.5%, 0.5 deg

MIDI in the VLTI lab

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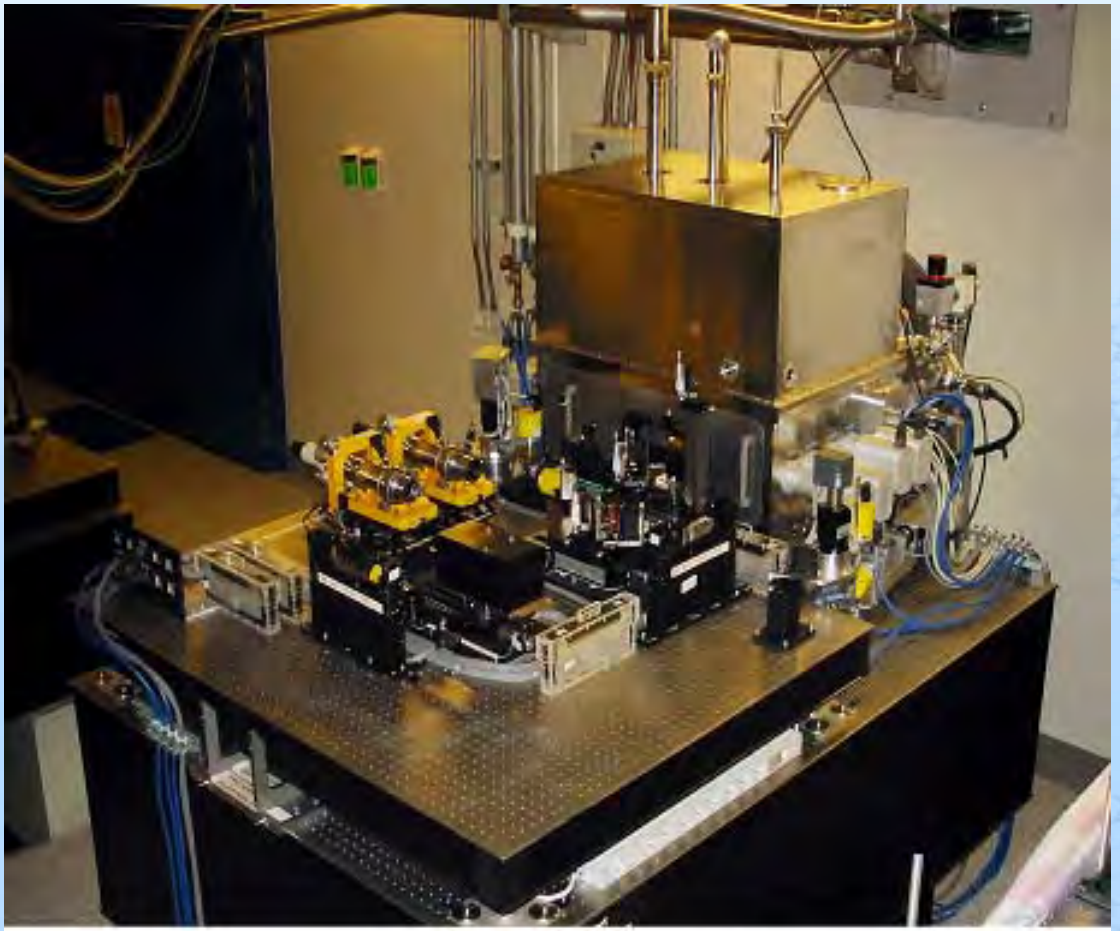
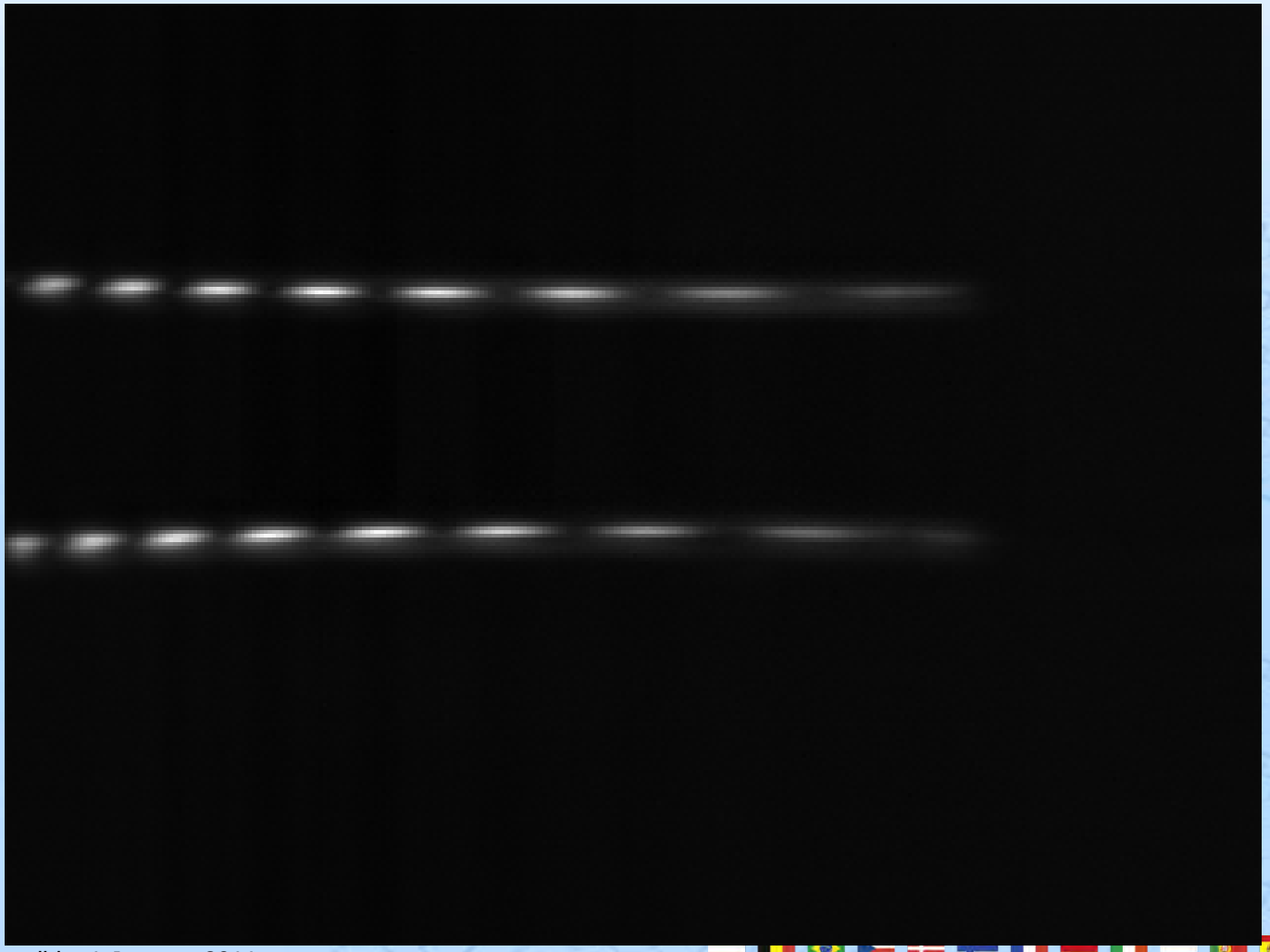


The MIDI Instrument at the VLT Interferometric Laboratory on Paranal

ESO PR Photo 30c/02 (18 December 2002) ©European Southern Observatory

MIDI lab fringes



MIDI limits

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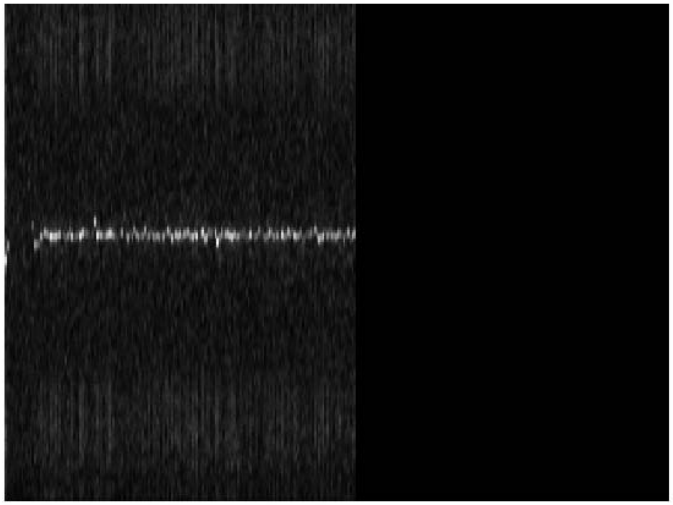
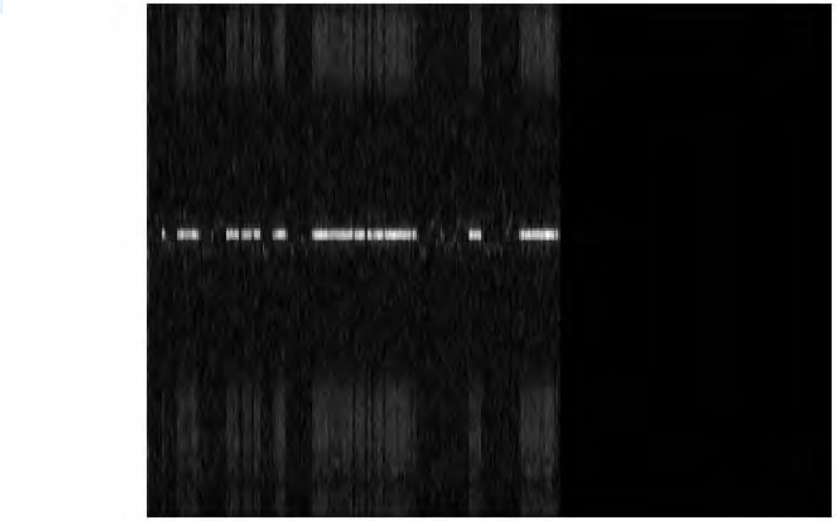
Telescopes	Beam combiner	Spectrograph	Limit (N mag)	Limit (Jy @ 12 µm)
UTs	HIGH_SENS	PRISM	4	1
UTs	HIGH_SENS	GRISM	2.8	3
ATs	HIGH_SENS	PRISM	0.74	20
ATs	HIGH_SENS	GRISM	0.31	30
UTs	SCI_PHOT	PRISM	3.2	2
UTs	SCI_PHOT	GRISM	2	6
ATs	SCI_PHOT	PRISM	0.0	40
ATs	SCI_PHOT	GRISM	-0.44	60

- Limiting correlated magnitudes (flux*visibility).

MIDI+FSUA





MIDI tracking fringe

FSUA tracking fringe

User support

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Phase 2 Instrument Overview Table

For information, please follow the links in this table. If one instrument has special requirements, this is visualized in the relevant row of the table. A summary table of the main characteristics of all instruments is available here.

Instrument	Policies		Change Requests	FC/README	Documentation	Tools	FAQ
General information valid for all instruments							
Paranal instruments	SM specifics OB naming	Constraints Calibrations	Waivers / Change Requests	Finding Charts README	P2PP version 3 Manual Generic P2PP3 tutorials	Exposure Time Calculators Observability	FAQ
Instrument-specific information							
AMBER	SM specifics OB Naming	Constraints Calibrations	N/A	Finding Charts README	User Manual P2PP Tutorial	-	FAQ
CRIRES	SM specifics OB Naming	Constraints Calibrations	Waivers	Finding Charts README	User Manual P2PP Tutorial	-	FAQ
FLAMES	SM specifics N/A	N/A Calibrations	Waivers	Finding Charts N/A	User Manual P2PP Tutorial	FPOSS	FAQ

Service mode

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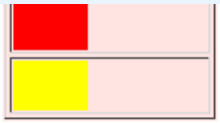
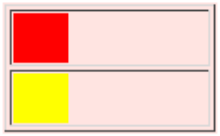
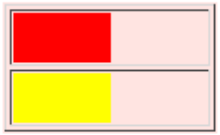
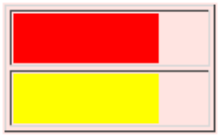
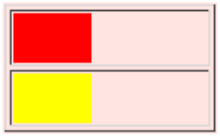
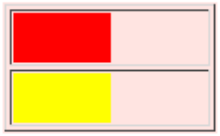
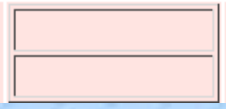
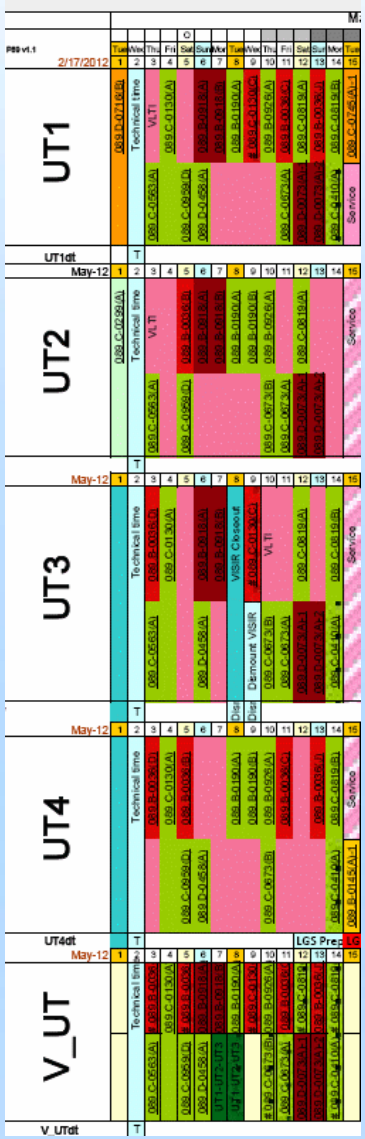
D0-G1-I1	090.D-0136(B) Wittkowski			Special Calibs				Special Remarks		15 done (of 39 OBs) 6.25 hrs done (of 16.25 hrs)
A1-K0-G1	090.D-0136(C) Wittkowski			Special Calibs				Special Remarks		12 done (of 42 OBs) 5.00 hrs done (of 17.50 hrs)
UT1-UT2-UT4	090.C-0954(A) Menu									3 done (of 6 OBs) 1.00 hrs done (of 2.00 hrs)
* Rank class B:										
UT1-UT3-UT4	090.D-0011(A) Chesneau									0 done (of 8 OBs) 0.00 hrs done (of 2.67 hrs)
UT2-UT3-UT4	090.D-0011(B) Chesneau									6 done (of 8 OBs) 2.00 hrs done (of 2.67 hrs)
UT2-UT3-UT4	090.C-0318(A) Wang									6 done (of 15 OBs) 2.50 hrs done (of 6.25 hrs)
UT1-UT3-UT4	090.D-0689(A) Sanchez									3 done (of 6 OBs) 1.00 hrs done (of 2.00 hrs)
K0-G1-J3	090.D-0757(A) Groh									0 done (of 2 OBs) 0.00 hrs done (of 1.33 hrs)

Science Operations



- VLTI UT scheduled in blocks of 4-6 nights/month
- Night astronomer selects telescopes from quadruplets
- OBs selected from MIDI and AMBER queues
- LST intervals allow user to achieve specific projected baseline
- Science targets interleaved with interferometric calibrators

Next baseline: UT1-UT3

Available LST range:

RunID	OB_ID	OB Name (RA DEC)	LST start-end
088.C-1007(F) Mosoni/ Sipos/ Juh\'asz/	586856 M	SCI_DGTau_F 4.451 +26.10	2.8 - 5.8

LST currently reachable | LST not reachable this month

00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Offered configurations

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Configurations offered using the UTs

AMBER is offered on all four available UT triples:

- UT1-UT2-UT3
- UT1-UT2-UT4
- UT1-UT3-UT4
- UT2-UT3-UT4

MIDI is offered on all six UT baselines:

- UT1-UT2-57m
- UT1-UT3-102m
- UT1-UT4-130m
- UT2-UT3-47m
- UT2-UT4-89m
- UT3-UT4-62m

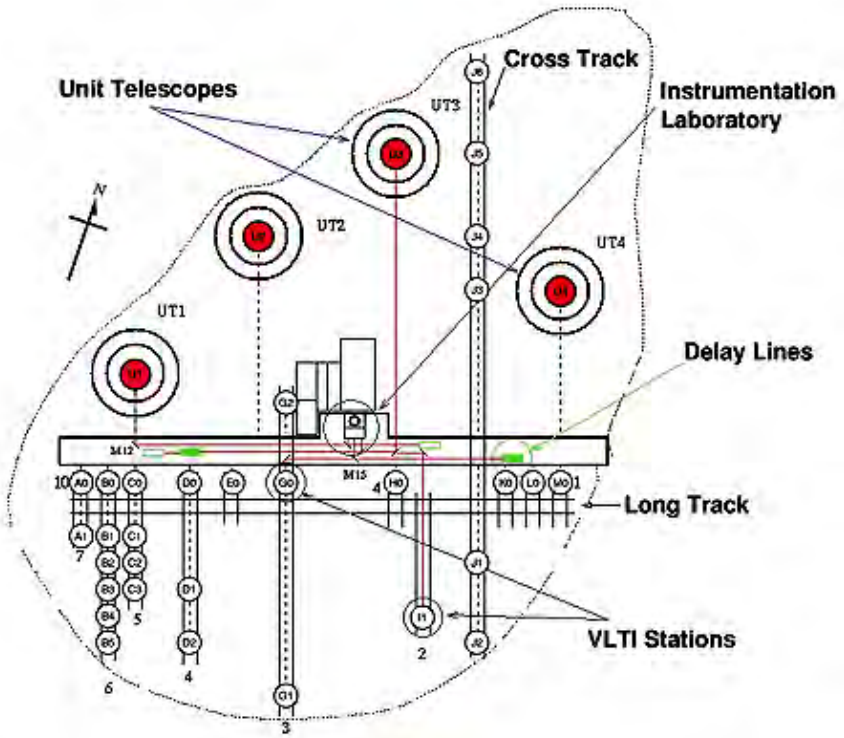
Configurations offered using the Auxillary Telescopes

Starting with P85 the Auxillary Telescopes are offered in 4 telescopes configurations. For each of these quadruplets, all possible 2 telescopes and 3 telescopes configurations can be used.

At the time of Phase I, user are only requested to provide informations on which of the available quadruplets they wish to use for observations. The decision on which specific baselines will be used at the time of the observation will be decided at the time of the Phase II or in preparation of the visitor run.

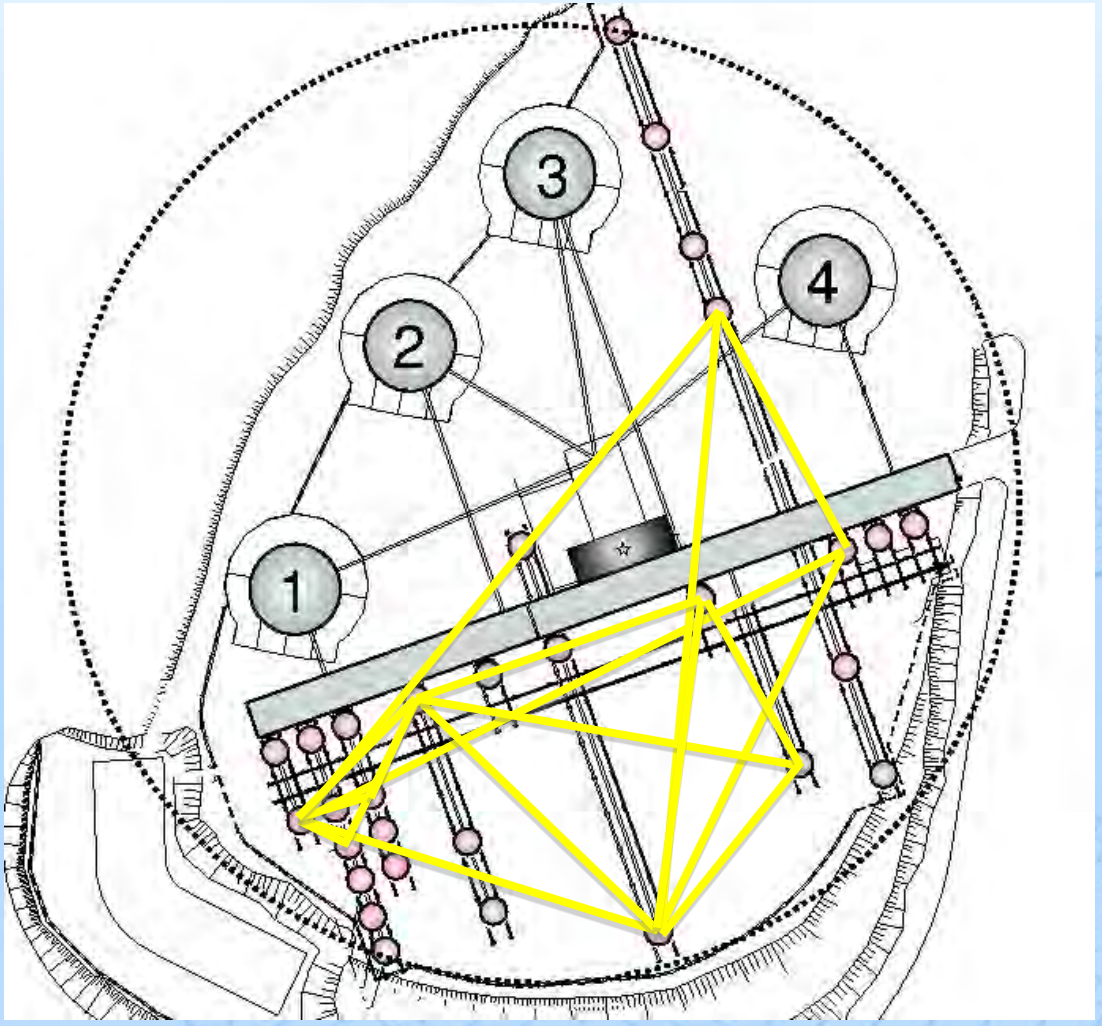
The 3 offered quadruplets are:

- A1-G1-K0-J3 (new)
- D0-H0-G1-I1
- A1-B2-C1-D0

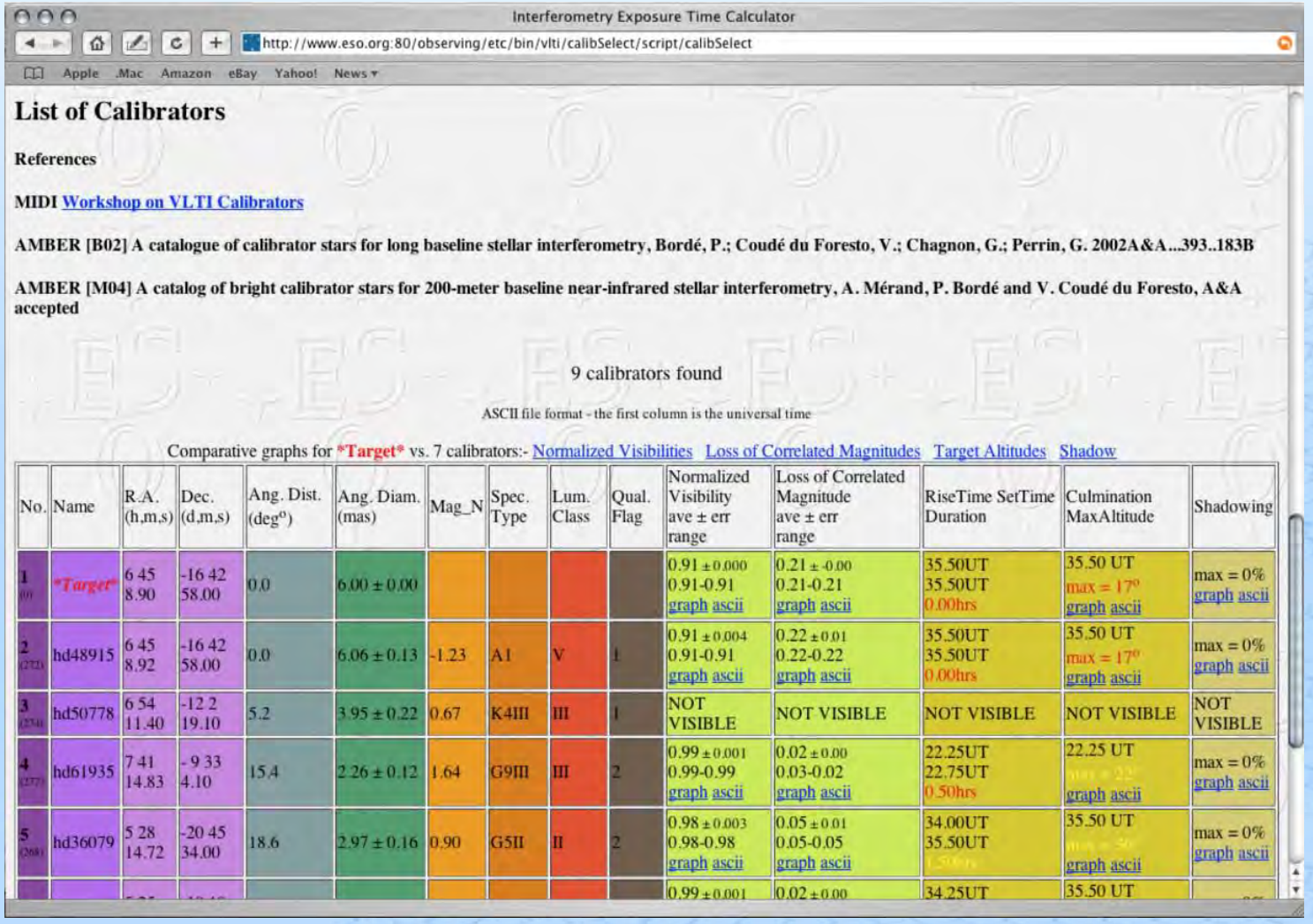


Site Layout

Configurations



Calibrator selection



List of Calibrators

References

MIDI Workshop on VLTI Calibrators

AMBER [B02] A catalogue of calibrator stars for long baseline stellar interferometry, Bordé, P.; Coudé du Foresto, V.; Chagnon, G.; Perrin, G. 2002A&A...393..183B

AMBER [M04] A catalog of bright calibrator stars for 200-meter baseline near-infrared stellar interferometry, A. Mérand, P. Bordé and V. Coudé du Foresto, A&A accepted

9 calibrators found

ASCII file format - the first column is the universal time

Comparative graphs for *Target* vs. 7 calibrators:- Normalized Visibilities Loss of Correlated Magnitudes Target Altitudes Shadow

No.	Name	R.A. (h,m,s)	Dec. (d,m,s)	Ang. Dist. (deg°)	Ang. Diam. (mas)	Mag_N	Spec. Type	Lum. Class	Qual. Flag	Normalized Visibility ave ± err range	Loss of Correlated Magnitude ave ± err range	RiseTime SetTime Duration	Culmination MaxAltitude	Shadowing
1	*Target*	6 45 8.90	-16 42 58.00	0.0	6.00 ± 0.00					0.91 ± 0.000 0.91-0.91 graph ascii	0.21 ± -0.00 0.21-0.21 graph ascii	35.50UT 35.50UT 0.00hrs	35.50 UT max = 17° graph ascii	max = 0% graph ascii
2	hd48915	6 45 8.92	-16 42 58.00	0.0	6.06 ± 0.13	-1.23	A1	V	1	0.91 ± 0.004 0.91-0.91 graph ascii	0.22 ± 0.01 0.22-0.22 graph ascii	35.50UT 35.50UT 0.00hrs	35.50 UT max = 17° graph ascii	max = 0% graph ascii
3	hd50778	6 54 11.40	-12 2 19.10	5.2	3.95 ± 0.22	0.67	K4III	III	1	NOT VISIBLE	NOT VISIBLE	NOT VISIBLE	NOT VISIBLE	NOT VISIBLE
4	hd61935	7 41 14.83	-9 33 4.10	15.4	2.26 ± 0.12	1.64	G9III	III	2	0.99 ± 0.001 0.99-0.99 graph ascii	0.02 ± 0.00 0.03-0.02 graph ascii	22.25UT 22.75UT 0.50hrs	22.25 UT graph ascii	max = 0% graph ascii
5	hd36079	5 28 14.72	-20 45 34.00	18.6	2.97 ± 0.16	0.90	G5II	II	2	0.98 ± 0.003 0.98-0.98 graph ascii	0.05 ± 0.01 0.05-0.05 graph ascii	34.00UT 35.50UT	35.50 UT graph ascii	max = 0% graph ascii
										0.99 ± 0.001	0.02 ± 0.00	34.25UT	35.50 UT	

Jean-Marie Mariotti Center (JMMC) tools