Precision Integrated Optics Near-Infrared Experiment

Le Bouquin, Berger, Lazareff, Zins, Traub, Jocou, Kern, Haguenauer, Absil, Augereau, Benisty, Blind, Bonfils, Delboulbe, Feautrier, Germain, Gitton, Labeye, Lizon, Monin, Magnard, Malbet, Maurel, Menard, Micallef, Michaud, Montagnier, Morel, Moulin, Perraut, Popovic, Rabou, Rochat, Roussel, Roux, Stadler, Tatulli, Ventura...

+ CRISTAL and FOST teams from IPAG

First idea of “PIONIER” …

Karine Perraut <kperraut@obs.ujf-grenoble.fr> 22 Jun 2003 17:58
To: Jean-Baptiste Le Bouquin <Jean-Baptiste.Lebouquin@obs.ujf-grenoble.fr>, Hide Details
malbet@obs.ujf-grenoble.fr, Pierre Kern <kern@obs.ujf-grenoble.fr>, autrePionier
Karine Perraut <kperraut@obs.ujf-grenoble.fr>, Pierre Labeye <Pierre.Labeye@cea.fr>,
Jean-Philippe Berger
Compte-rendu - Reunion VLTI-4T

```
On propose a l'ESO de realiser un VINCI ++ avec les caractéristiques suivantes :
  + recombinaison de 4 telescopes
  + fonctionnement en bande H
  + capacite de faible dispersion spectrale (type prisme)
  + un coaxial 4T par paire sans voies photometriques
```

Then the idea get lost for about 6 years…

… so let’s jump directly to 2009.

Context in 2009

General

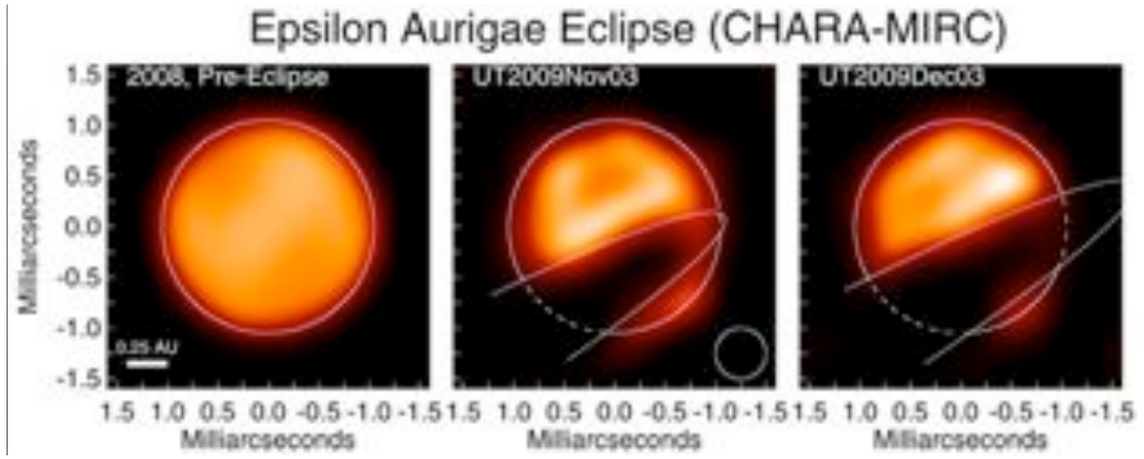
- OLBIN enters the era of imaging instrument
- The game is mainly in the US with CHARA/MIRC.
- Current sensitivity cannot reach YSO

At VLTI

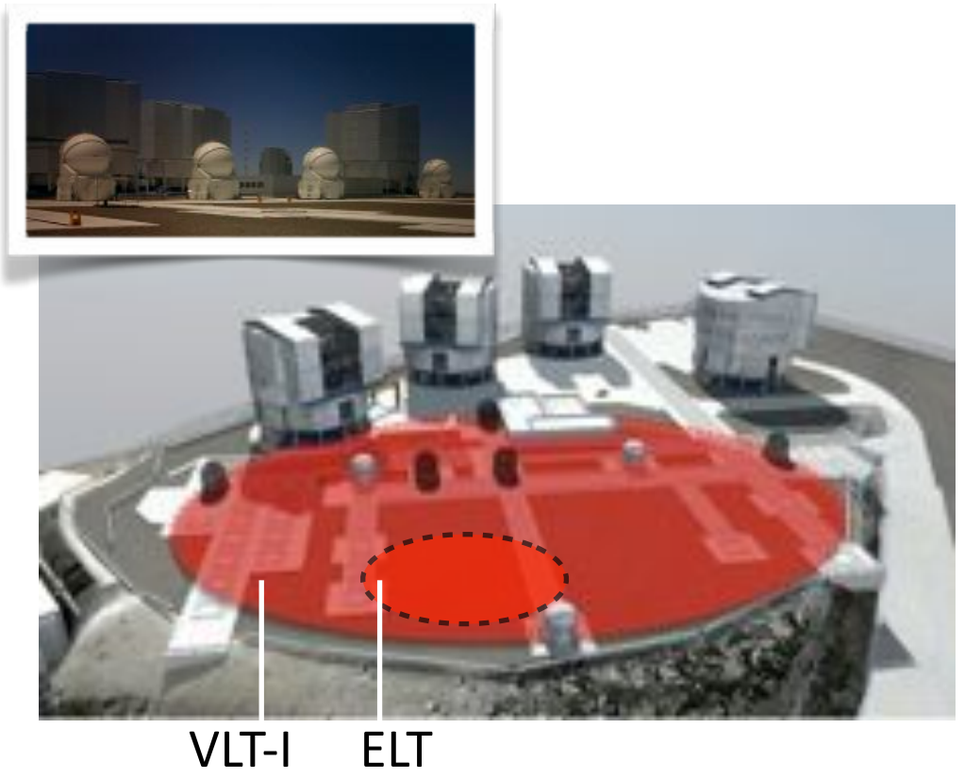
- Working better and better !!
- 4 telescopes already available since 2007
- Next-generation projects planned for 2014 (GRAVITY and MATISS)

At IPAG

- Expertise and interest in imaging interferometry
- Difficulties to run some projects with AMBER/MIDI (T-Tauri, exozodial disks, faint companions)
- 4 telescopes IONIC beam combiner available on-the-shelve: a result from several years of R&D
- Room for a fast project. Starting date : mid 2009 ??



Kloppenborg et al Nature 2010



The proposition to ESO

Proposition made in 2009 by IPAG to ESO

- Build an instrument to combine the light of 4 telescopes of VLTI, using the visitor-instrument framework.
- On sky by end of 2010, with few days of commissioning.
- Exploit this instrument with few weeks per semester over the 2011-2013 period.

Special courtesies to JP Berger, PI of the project at that time

Initial funding and collaboration

- First: Local funding (UJF), and then national (CNRS, INSU, ANR)
- Camera on loan from W. Traub (JPL).
- Integrated optics component is direct heritage from the research in instrumentation (CNRS, INSU, ANR) made at LAOG.

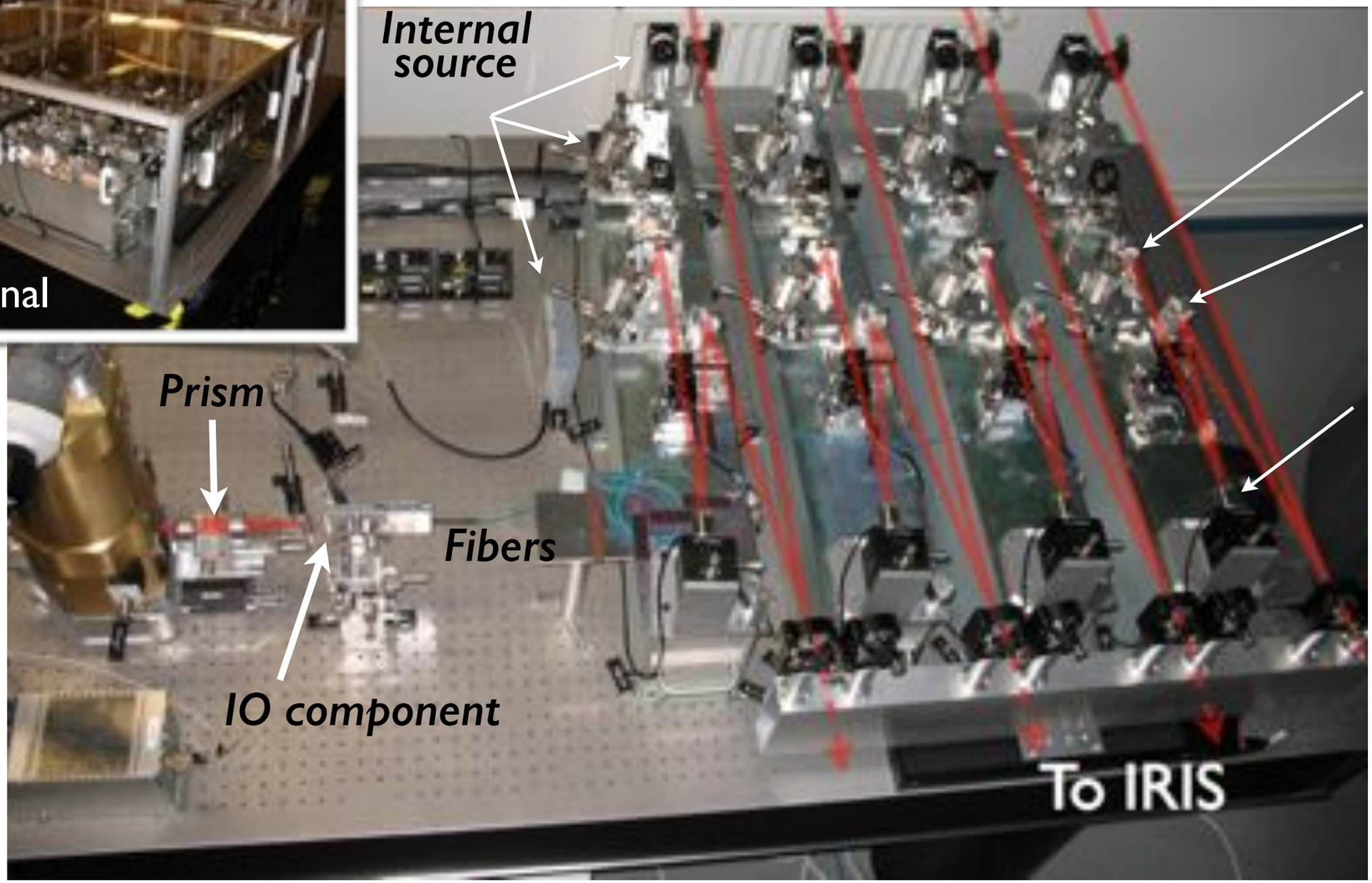
Initial science objectives

- Massive young stellar objects (Herbig Ae Be)
- Low mass young stellar objects (T Tauri)
- Debris disks around Main Sequence stars (EXOZODI)
- Binaries, faint companions and Hot Jupiters

Topic	Sp. Band	Mag.	V^2 error	CP error
Herbig AeBe disks	H,K	> 5	5%	5deg
T Tauri disks	H,K	> 7	5%	2deg
Debris disks	H,K	-	1%	1deg
Faint companions	H,K	-	-	0.5deg
Hot Jupiters	H,K	-	-	0.03deg

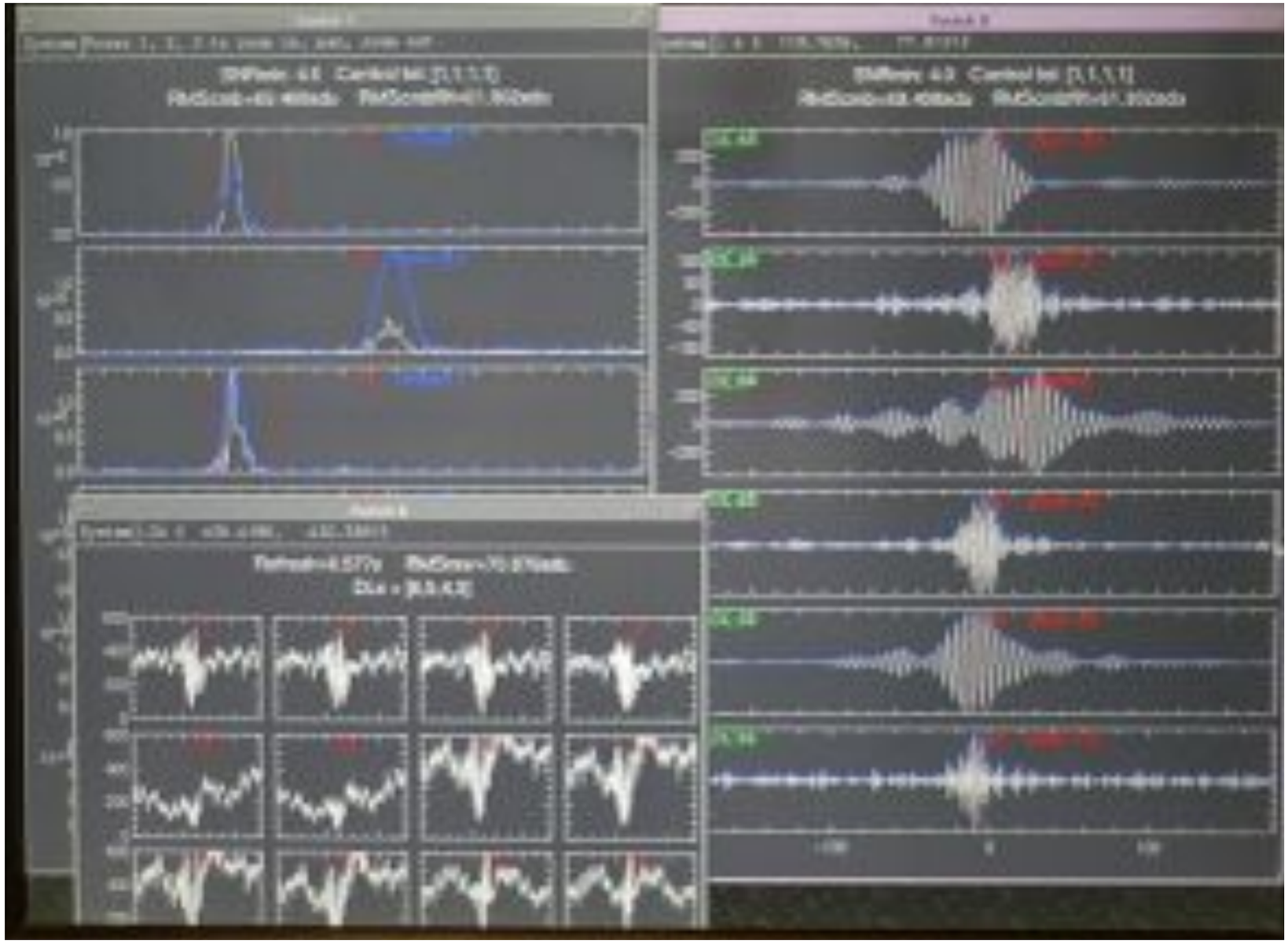
If we were back in 2009, just after the ESO agreement,
what would we do the same way ?
what would we change in the project ?

(1) An instrument entirely based on proved concepts



(1) An instrument entirely based on proved concepts

- 1 fringe scan lasts 500ms
- One observation = 5 files of 100 scans
- Fringe visibility is computed as an energy in the PSD



The PIONIER fringes remind you something ?

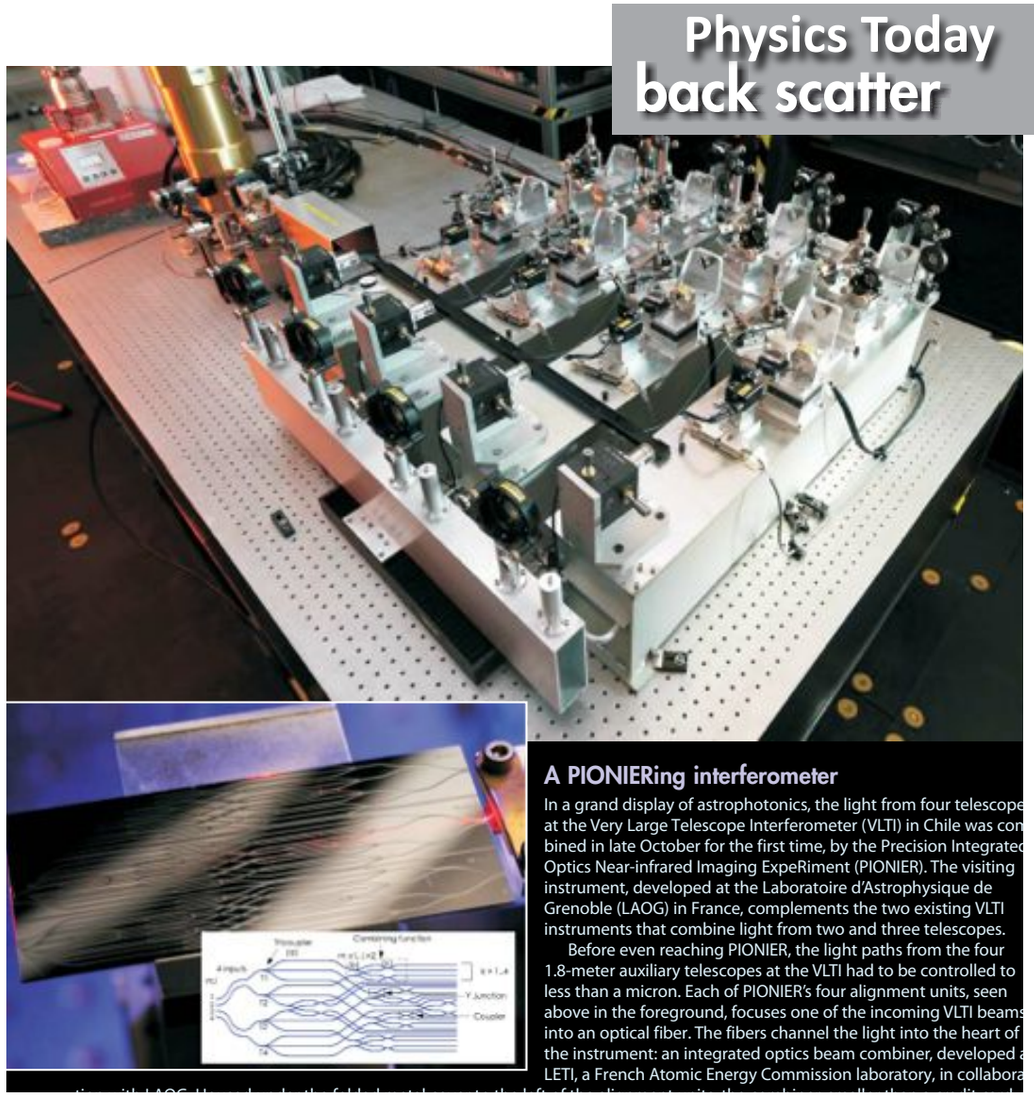
VLTI 2010

IOTA 2002

(2) A short but realistic schedule, A small but efficient team

- "green light" from ESO: End of 2009
- Integration: Jan. 2010 - Sep. 2010
- First proposals accepted: Aug. 2010
- First Light and Science: Oct. 2010
- First 4-UTs fringes obtained for the 10-year anniversary of the VLTI first fringes (March, 17, 2011).

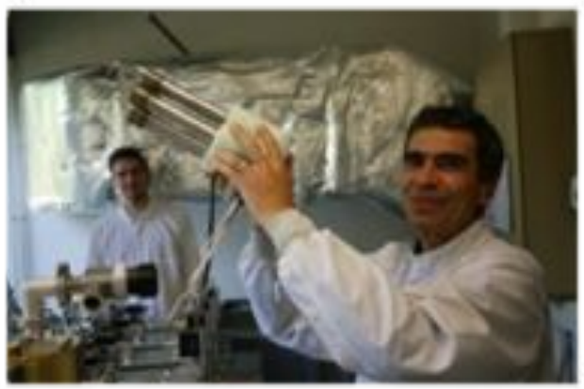
- Total consolidated cost is approximately 1 million euros



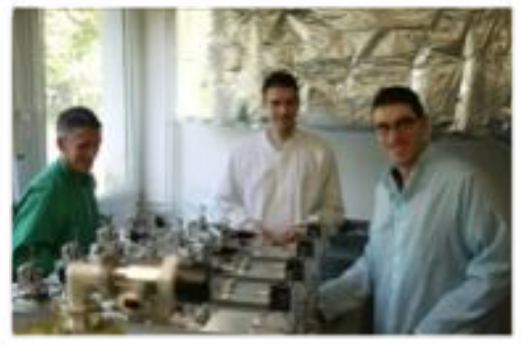
PIONIER installed at the focus of VLTI as of 2010

(2) A short but realistic schedule, A small but efficient team

Cryogeny



Mecha + Optics



Electronic

Software / Control

Two interventions on the camera dewar ... stress !!

Project Management
+ Administration

(3) A close collaboration with ESO Paranal/Garching

ESO

- Support for software development (see below)
- Technical/Financial support for integrations
- Great reactivity to problems, sometimes using pieces of other instruments!
- Paranal is now in charge of daily alignment

PIONIER

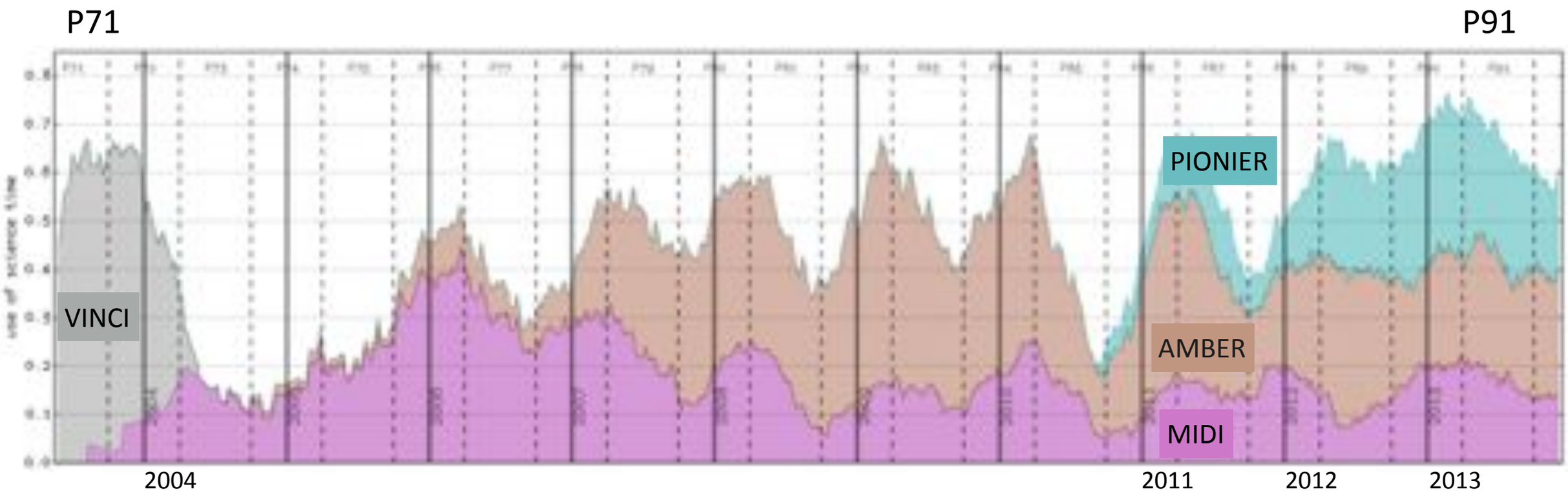
- Minimal interfaces and load on VLTI by design
- Serve as demonstrator for new generation control hardware (envisioned for ELT)
- Debug the VLTI with 4T
- Feedback on polarisation in VLTI and AMBER

(3) A close collaboration with ESO Paranal/Garching

ESO and Paranal teams celebrating the first fringes of PIONIER, and the first 4-telescope fringes of VLTI in october 2010.

If we were back in 2009, just after the ESO agreement,
what would we do the same way ?
what would we change in the project ?

(1) Hire postdocs for immediate productivity



- About 30% of VLTI science time (40 nights / semester)
- Complementary to AMBER (mainly asked for seeing 0.6”)
- Still increasing in P93 because open in delegated visitor-mode
- So far a total of 277n scheduled on PIONIER at VLTI

(1) Hire postdocs for immediate productivity

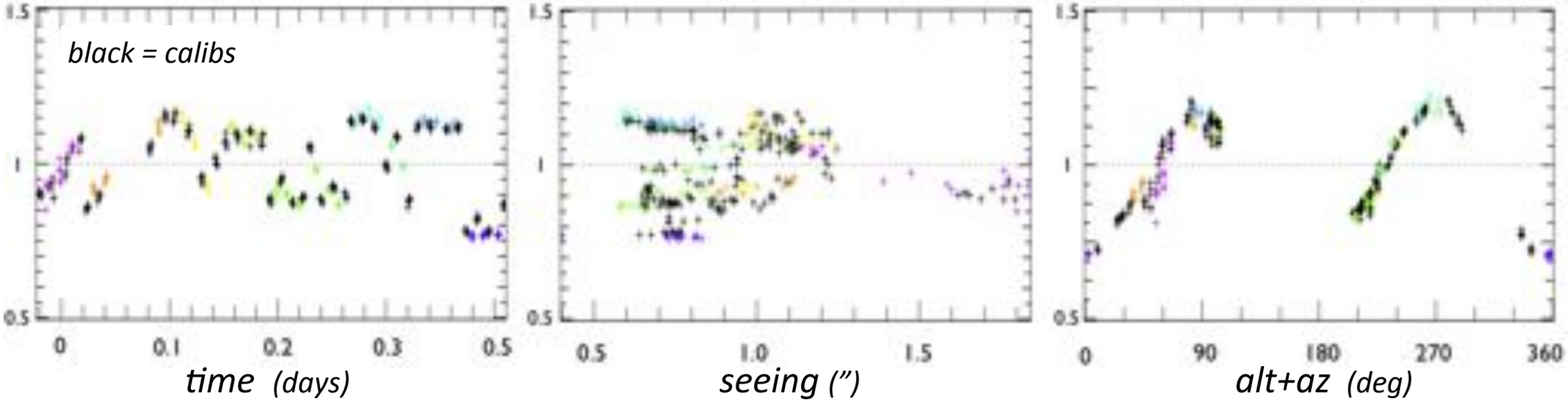
- Only 4 articles in 2011, then 5 in 2012, and 7 in 2013
- 11 articles (over 19) are from peoples outside the initial science team
- The most important articles (3 Large Programs) are still in preparation

- submitted: J. Menu, et al., "TW Hya: multi-wavelength interferometry of a transition disk"
- submitted: J. Kluska, et al., "Semi-Parametric Approach for image Reconstruction of Young Stellar objects"
- submitted: A. Carmona, et al., "Constraining the structure of the transition disk HD 135344B"
- accepted in A&A: J.B Le Bouquin, et al.: "Refined masses and distance of the young binary Haro 1-14 C"
- accepted in A&A: A. Gallenne, et al., "Multiplicity of Galactic Cepheids from long-baseline interferometry. II. The Companion of AX
- accepted in A&A: E. Choquet, et al., "The close environment of high-mass X-ray binaries at high angular resolution"
- 2013MNRAS.435.2501L: R. Lachaume and J.P. Berger, "Bandwidth smearing in infrared long-baseline interferometry. Application t
- 2013A&A...553A.131S: H. Sana, J.-B. Le Bouquin et al.: "Three-dimensional orbits of the triple-O stellar system HD150136"
- 2013A&A...552A..4O: J. Olofsson, M. Benisty et al., "Sculpting the disk around T Chamaeleontis: an interferometric view"
- 2013A&A...551A..121L: J.-B. Le Bouquin, H. Beust, G. Duvert et al, "Masses and age of the Chemically Peculiar double-lined binar
- 2012A&A...546L..9D: D. Defrère, J. Lebreton, J.-B. Le Bouquin, A.-M. Lagrange et al, "Hot circumstellar material resolved around b
- 2012MNRAS.423.2711D: De Becker M., Sana H., Absil O., Le Bouquin J-B. et al, "The particle accelerator HD 167971 revealed by
- 2012A&A...540A..76S: Stefl S., Le Bouquin J-B. et al, "Activity in the circumstellar disk of the Be star 48 Lib"
- 2012A&A...541A..89L: Le Bouquin, J.-B.; Absil, O., "On the sensitivity of closure phases to faint companions in optical long baselin
- 2012A&A...543A..31L: B. Lazareff, et al., "A novel technique to control differential birefringence in optical interferometers. Demonst
- 2011A&A...535A..68A: Absil O., Le Bouquin J-B, et al, "Searching for faint companions with VLTI/PIONIER"
- 2011A&A...536A..55B: Blind N., Boffin H., Berger J-P. et al, "The symbiotic star SS Leporis: Milli-arcsecond imaging with PIONIER/
- 2011A&A...534L..11C: Chesneau O., Meilland A., Banerjee K., Le Bouquin et al, "The 2011 outburst of the recurrent nova T Pyx"
- 2011A&A...535A..67L: Le Bouquin J-B, Berger J-P, et al, "PIONIER: a 4-telescope visitor instrument for VLTI"

(2) Request more technical time

Stability of the transfer function versus various parameters

V2



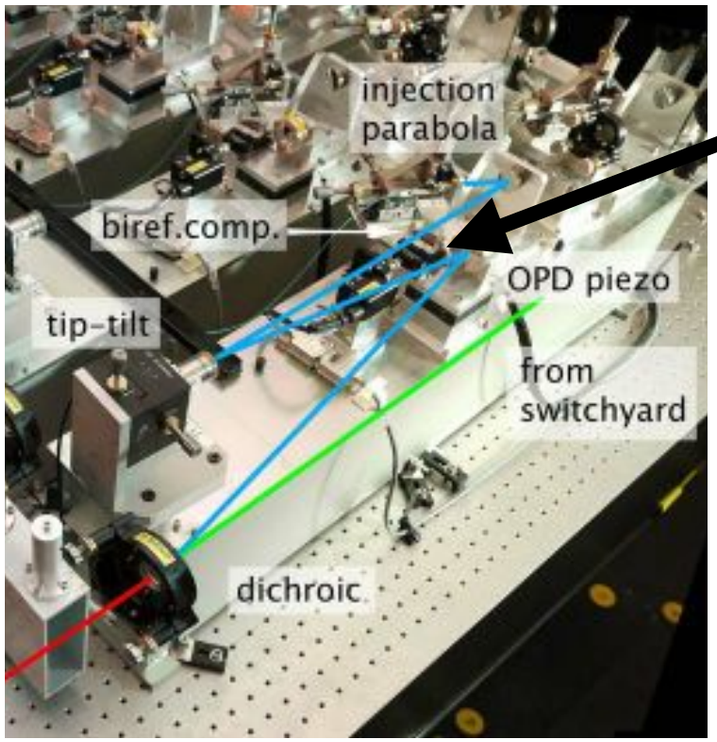
During the first year: to better characterise the system :

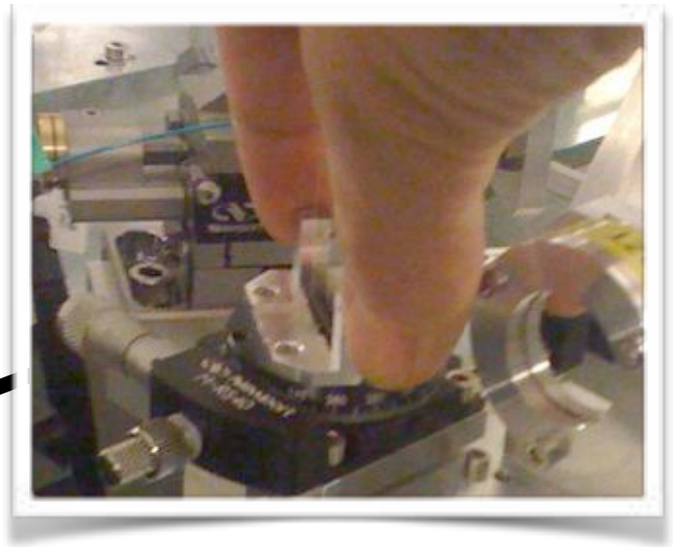
- the main effect to calibrate was discovered in Summer 2012.
- SMALL spectral dispersion only tested first on Mai 2011.

During all the lifetime of the instrument, to better explore the capabilities that were voluntarily discarded during integration:

- ABCD data analysis could have served as prototype for GRAVITY.
- External groupe tracking for AMBER never attempted (could reach H~8.5)

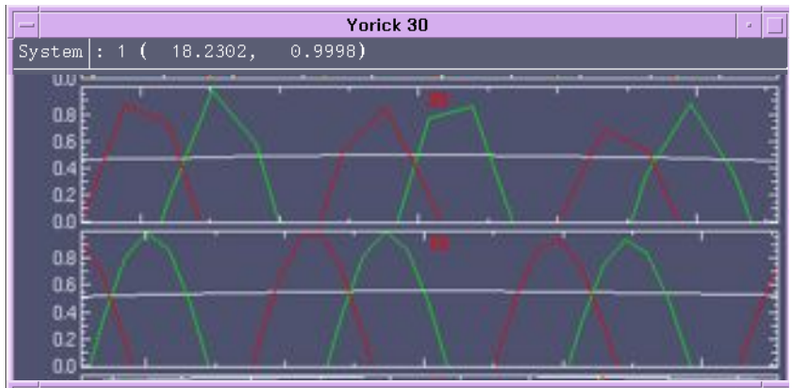
(3) Fully automated maintenance procedure



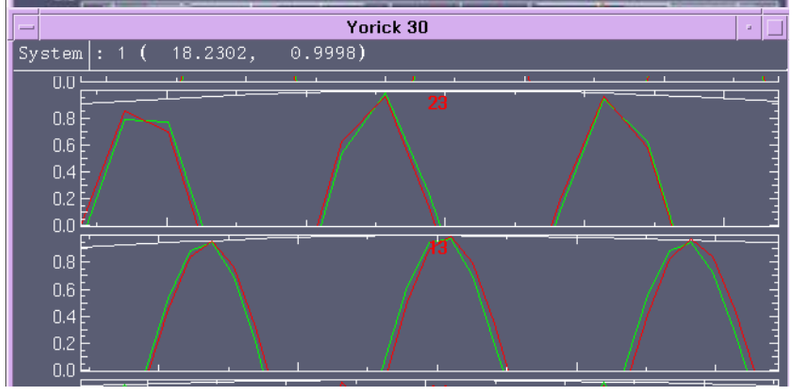


Daily polarisation alignment with the Lithium Niobate plates (x4).

Before



After



- Easier to train new people (about 10 PhD/postdoc have been trained)
- Save travel effort by allowing remote, with basic support from Paranal
- Easier and faster to fully delegate operation to ESO

Altogether, are we happy ?

Karine Perraut <kperraut@obs.ujf-grenoble.fr> 22 Jun 2003 17:58
To: Jean-Baptiste Le Bouquin <Jean-Baptiste.Lebouquin@obs.ujf-grenoble.fr>, malbet@obs.ujf-grenoble.fr, Pierre Kern <kern@obs.ujf-grenoble.fr>, Karine Perraut <kperraut@obs.ujf-grenoble.fr>, Pierre Labeye <Pierre.Labeye@cea.fr>, Jean-Philippe Berger
Hide Details
autrePionier
Compte-rendu - Reunion VLTI-4T

```
On propose a l'ESO de realiser un VINCI ++ avec les caractéristiques suivantes :
  + recombinaison de 4 telescopes
  + fonctionnement en bande H
  + capacite de faible dispersion spectrale (type prisme)
  + un coaxial 4T par paire sans voies photometriques
```

Technically we achieved exactly the proposition made 10 years ago.

We reached most of the top level requirements and performances.

Table 1. Summary of the scientific requirements compared to the already demonstrated performances. Error is defined as the accuracy for one calibrated data point.

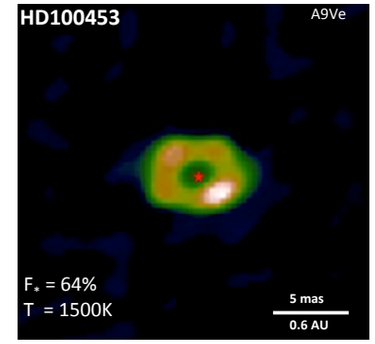
Topic	Sp. Band	Mag.	V^2 error	CP error
Herbig AeBe disks	H,K	> 5	5%	5deg
T Tauri disks	H,K	> 7	5%	2deg
Debris disks	H,K	-	1%	1deg
Faint companions	H,K	-	-	0.5deg
Hot Jupiters	H,K	-	-	0.03deg
Demonstrated	H	7.5 (AT)	10 - 1%	0.5deg

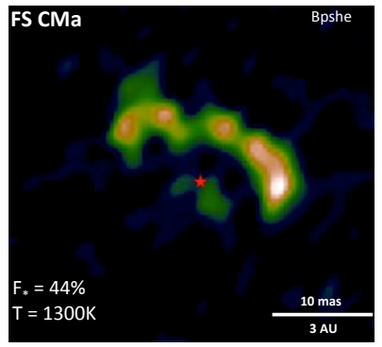
The future of PIONIER

Primary goals of PIONIER are "achieved"

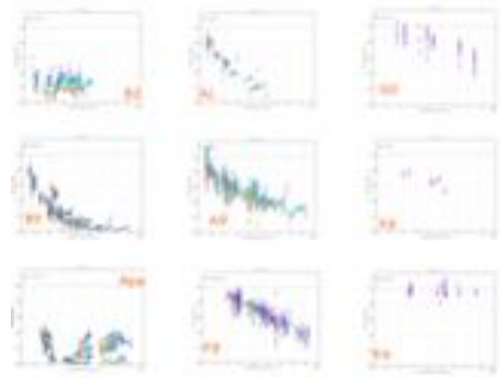
- Debug and validate the VLTI with 4 telescopes
- Provide a sensitive imaging instrument
- Observe a large sample of YSO with the ATs (more than 30 Herbig and 15 T Tauri)

Preliminary Images of YSO (talk Kluska)





Large Surveys of YSO,
(talk Berger)
O-stars,
(talk Sana)
debris disks
(talk Augereau)
…



Current agreement with ESO for operation at Paranal until Sept. 2014 What's next ? Shall we stop ?

- Move to another interferometer ?
- Keep this simple combiner at VLTI ?
- Push for a smart upgrade of PIONIER to make it complementary to GRAVITY/MATISSE ?

RAPID detector
(talk Guieu)

PIONIER science meeting

Monday 13, 9:30-12:30 --- Session YSO

- 09:30 Introduction (JB Le Bouquin)
- 10:00 UJF Director for Research (TBC)
- 10:15 Review Young Stellar Object (JP.Berger)
- 11:00 T-Tauri (F.Anthonioz)

11:15 Coffee Break

- 11:30 Imaging YSO (J.Kluska)
- 11:45 T-Cha (J.Olofsson)
- 12:00 GG-Tau (E.di Folco)
- 12:15 Infrared variability of protoplanetary disks (A.Juhasz)

Monday 13, 13:45-17:00 --- Session High Dynamic and multiplicity

- 13:45 Review Debris disks (JC.Augereau)
- 14h30 Review High contrast companions (O.Absil)
- 15:15 Companions to AF stars (S.Borgniet)

15:30 Coffee Break

- 16:00 Review Massive stars (H.Sana)
- 16:45 Orion multiplicity (R.Grellman)

Tuesday 14, 09:00-12:30 --- Session Stellar Physics

- 09:00 Review Mira stars (C.Paldini)
- 09:45 Review Symbiotic binaries (H.Boffin)
- 10:30 Supergiants (M.Montarges)

10:45 Coffee Break

- 11:15 Eta Car (J.Groh)
- 11:30 Achernar (A.Domiciano)
- 11:45 Altair (Merand)
- 12:00 Review Cepheids (P.Kervella)

Tuesday 14, 13:45-17:00 --- Session "Explorations"

- 13:45 Attempt toward GC (S.Yazici)
- 14:00 Attempt toward GC (T.Paumard)
- 14:15 Review Data reduction (JB.Le Bouquin)
- 14:45 JMMC support to PIONIER (G.Mella)
- 15:00 Reliable model fitting (R.Lachaume)
- 15:15 A nuller upgrade for PIONIER: is it a bad idea? (S.Lacour)

15:30 Coffee Break

- 16:00 The RAPID detector upgrade (S.Guieu)
- 16:15 Discussion on the future of PIONIER

Have a nice meeting !