PIONIER : Science with a Four Telescope VLTI Instrument

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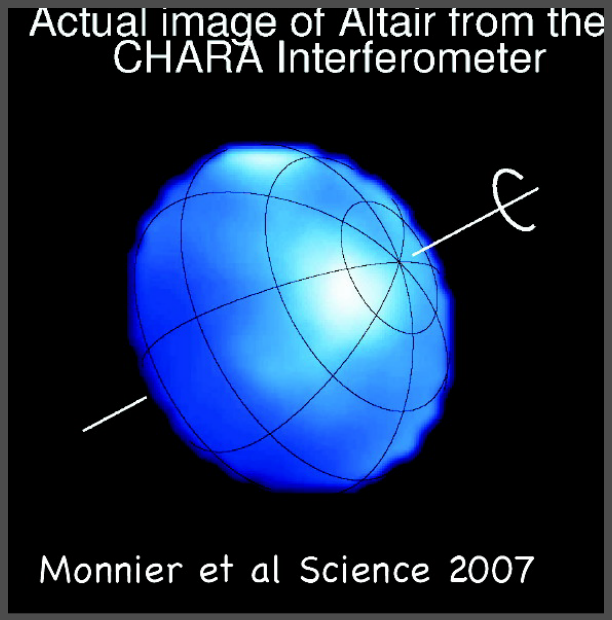
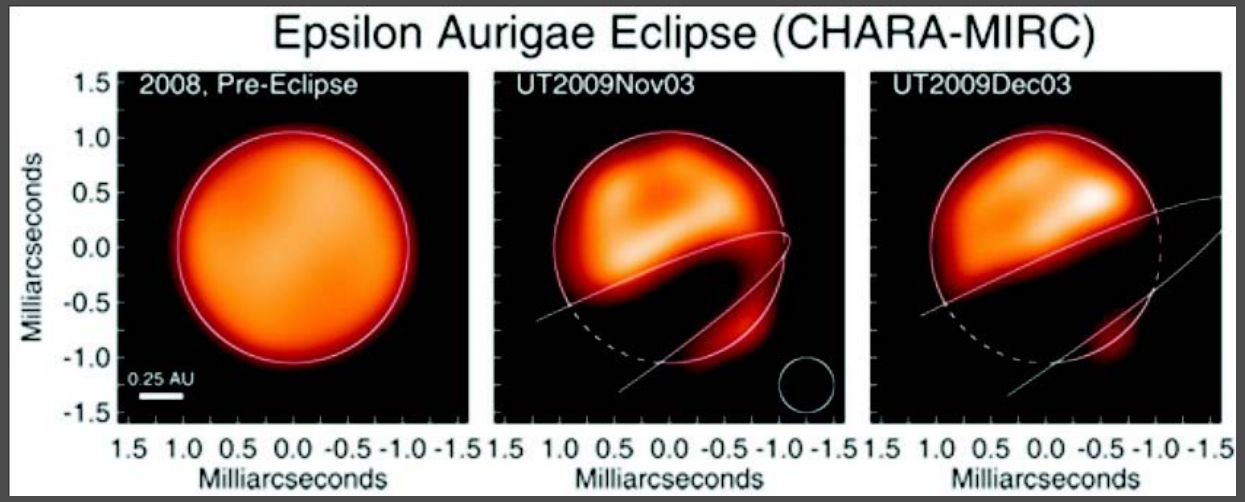
Outline

- **Context**
- **Instrument description**
- **Commissioning**
- **Results from first year of operation**
- **Perspective**

Context > Instrument > Comm > Results > Perspective

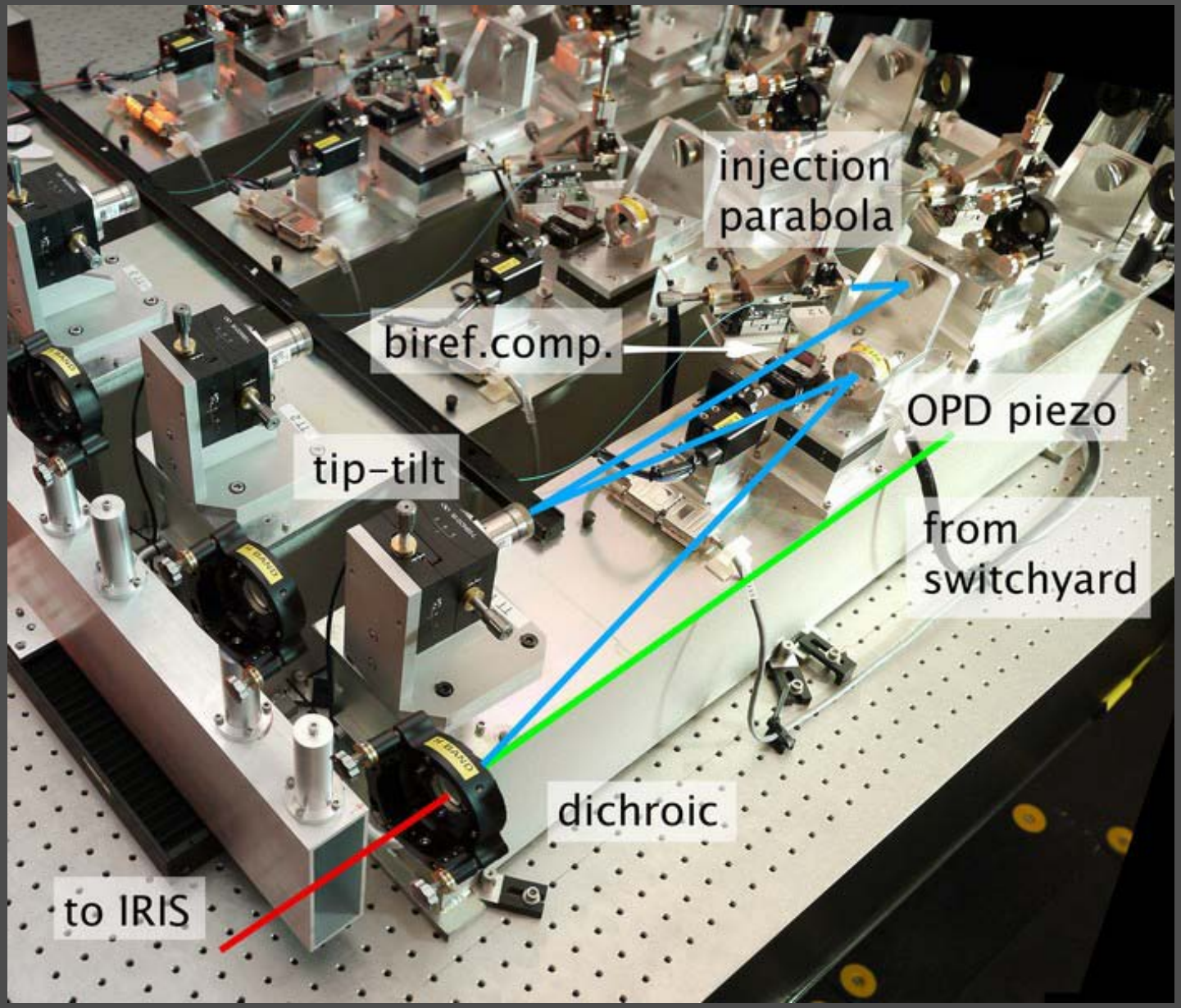
- **Context in 2009**
  - **Optical long baseline interferometry enters era of imaging at mas scale**
  - **Sensitivity limits mostly to stellar physics**
  - **Game dominated mostly by US (CHARA)**
  - **VLTI improving (AMBER), but time-consuming**



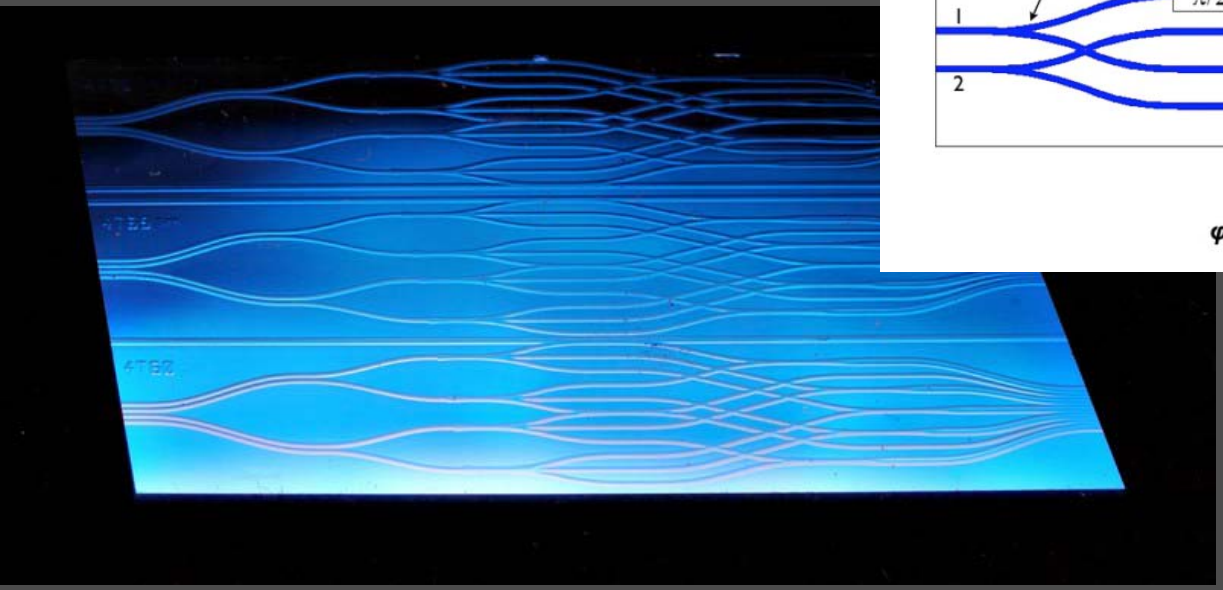


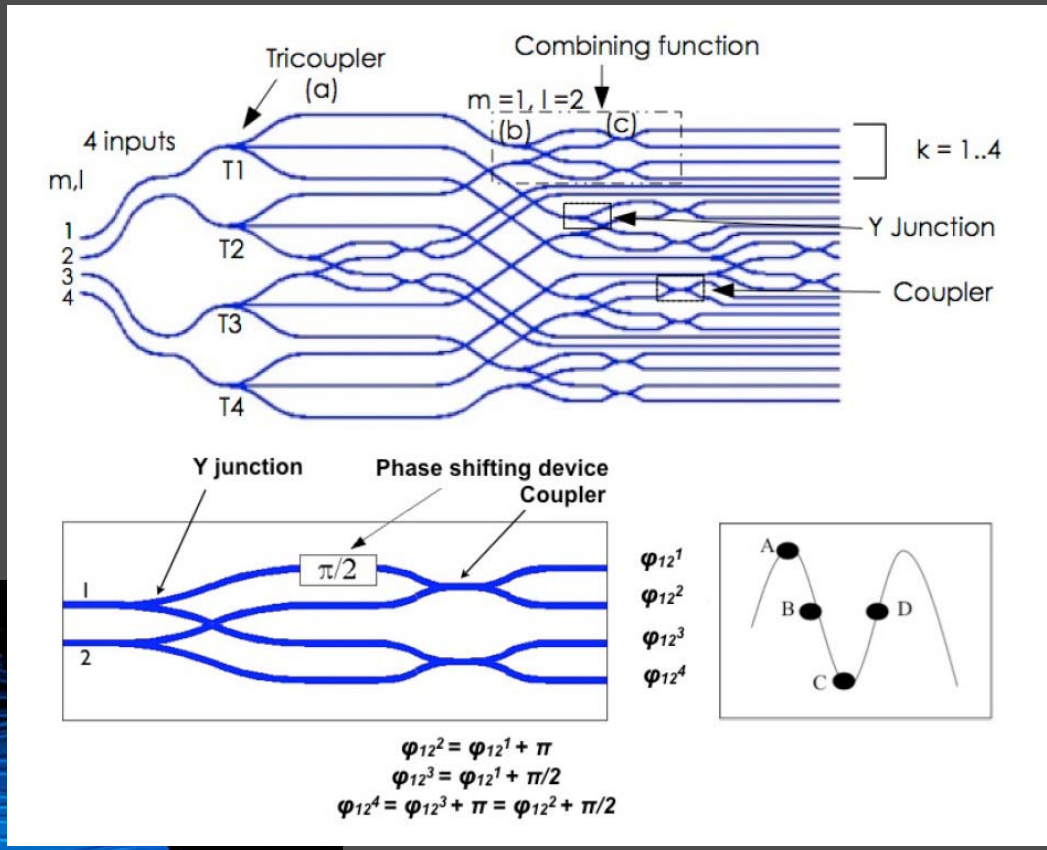
Context > Instrument > Comm > Results > Perspective

- **VLTI context in 2009**
  - **4 ATs avaialble since 2006**
  - **But instruments allow for 2 or 3 telescopes only**
  - **Next-generation projects planned for 2014/15 (GRAVITY and MATISSE)**
- **LAOG (now IPAG) context in 2009**
  - **Expertise and interest in imaging interferometry**
  - **IONIC 4-telescope beam combiner available off-the-shelf (following 10 years of development with LETI)**
- **Opportunity for a fast track project**
  - **LAOG proposal to ESO**
  - **Visitor instrument**
  - **On sky end 2010**
  - **Approved by STC Nov 2009**
- **Support**
  - **Funding: Université Joseph Fourier – IPAG – INSU**
    ANR "Exozodis" – ANR "2G VLTI"
  - **Camera on loan from IOTA/PTI, courtesy W. Traub**

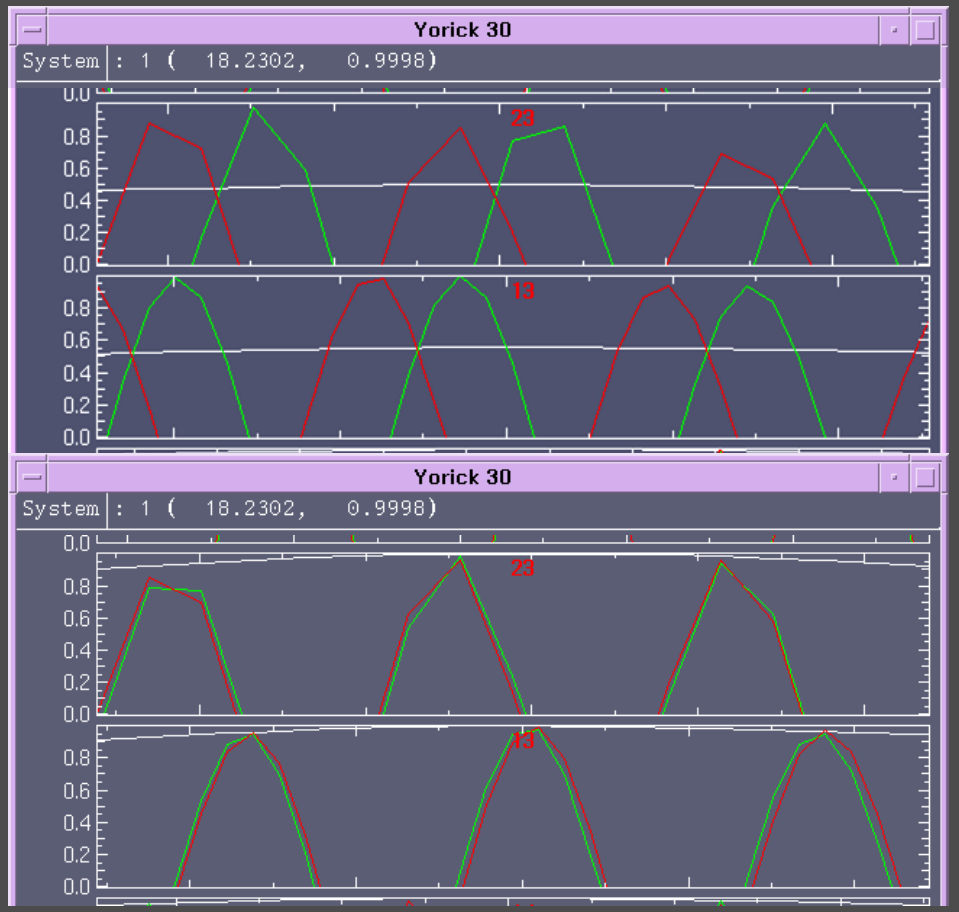

injection
parabola
biref.comp.
OPD piezo
tip-tilt
from
switchyard
dichroic
to IRIS

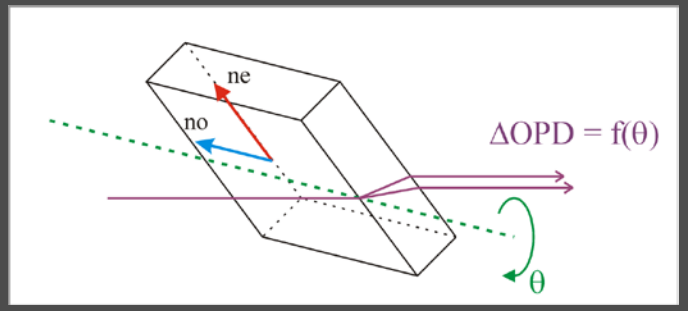
- **IONIC 4-beam combiner**
  - **Compactness**
  - **Stability where it matters most**
  - **Credit: P. Labeye (LETI) and M. Benisty (LAOG)**





- **Birefringence**
  - Pol-maintaining fibers are birefringent
  - OPDs not aligned for two polarizations
  - Requires pol splitting and separate detection
- **Birefringence compensation**
  - Birefringent plates (LiNbO3) on optical path with adjustable inclination
  - Phases (group and fringe) can be aligned → detected together
  - Better S/N and speed

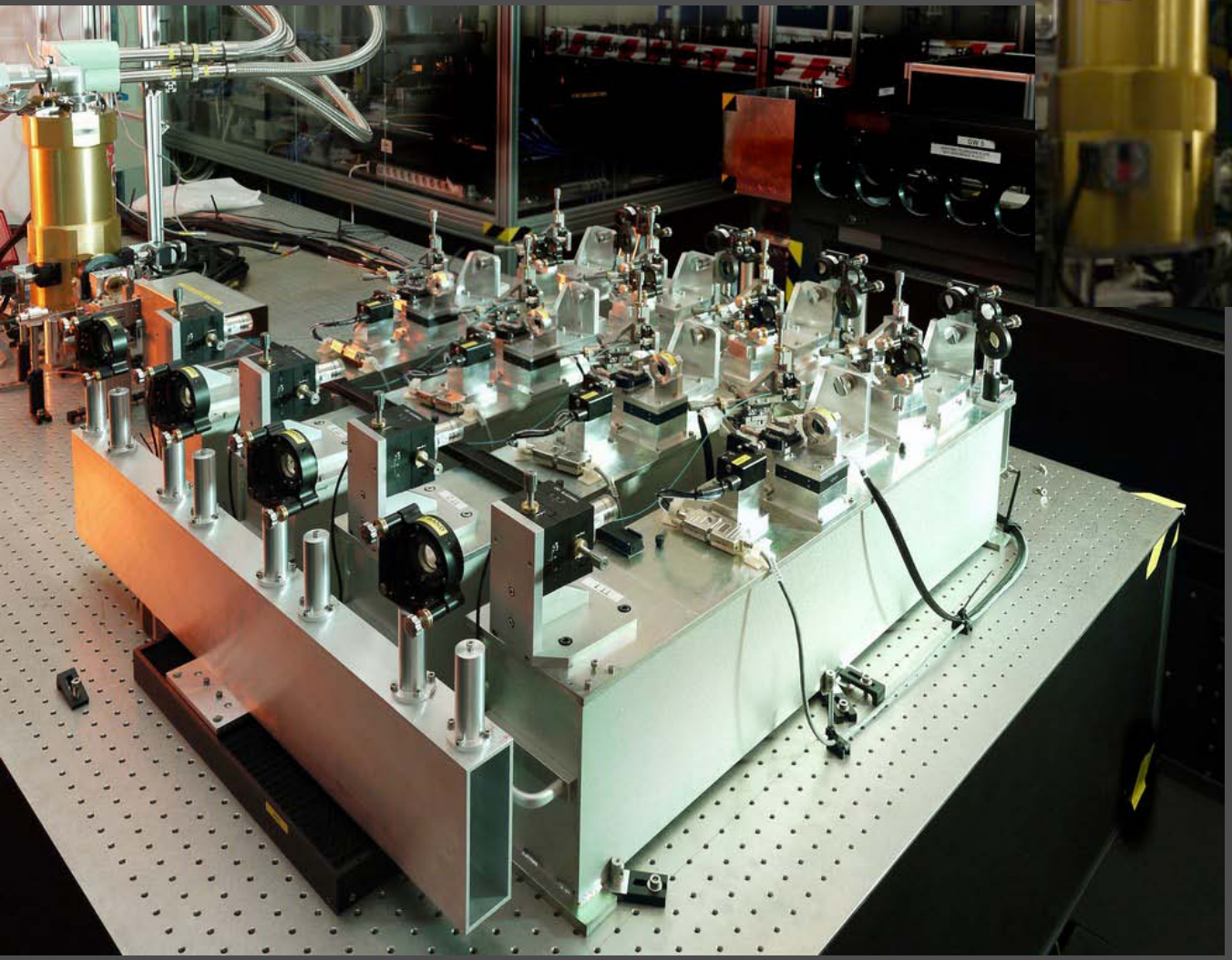




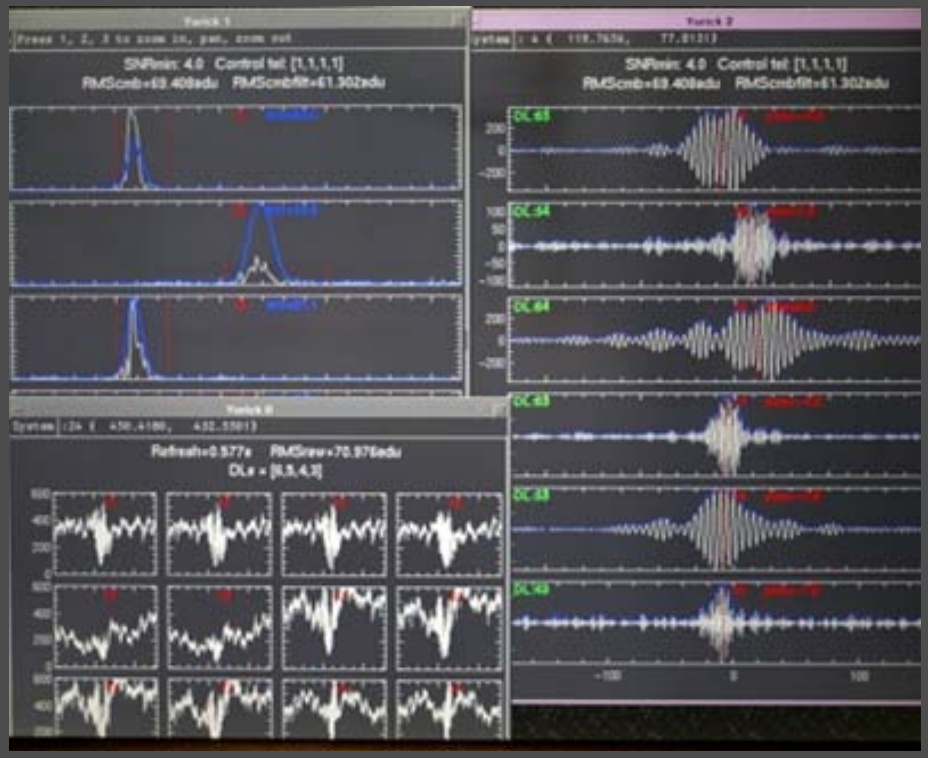
- **Operation**
- **6 baselines; 3 closures**
- **Scan the OPDs across the white fringe (150 – 400 ms typ)**
- **Three dispersion modes:**
  - **Broadband 1.55 – 1.80 µm**
  - **Small dispersion (3 resolution elements, R ≈ 20)**
  - **"Large" dispersion (7 resolution elements, R ≈ 40)**

- **Packing…**

- **Unpack & Install**
  Oct 20-24, 2010

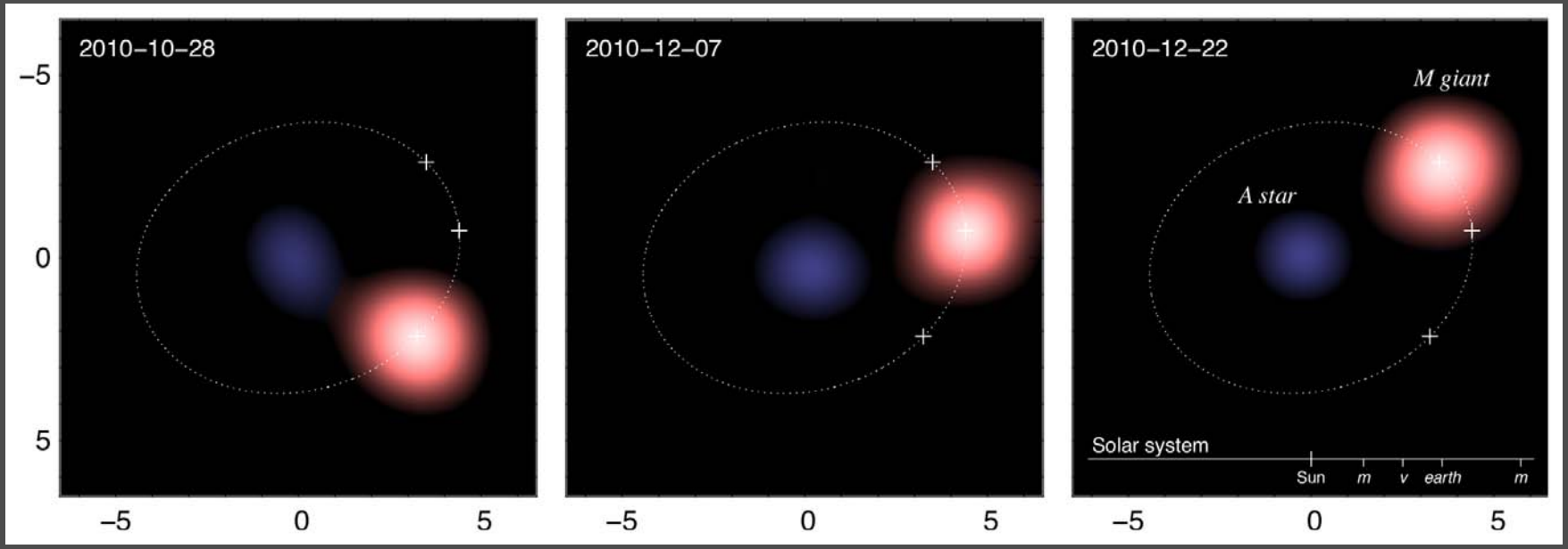


- **First light + fringes**
  Oct 25, 2010
- **T0 : VLTI preset**
- **T0+10 min: fringes on 3 baselines**
- **T0+30min: fringes on 6 baselines**
- **T0+1day: science demonstration**



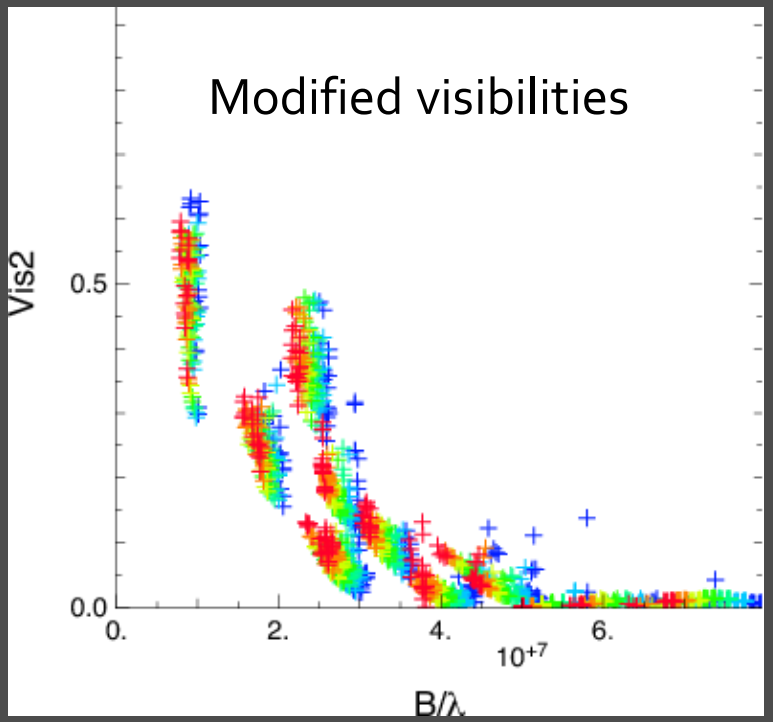
Results : SS Lep

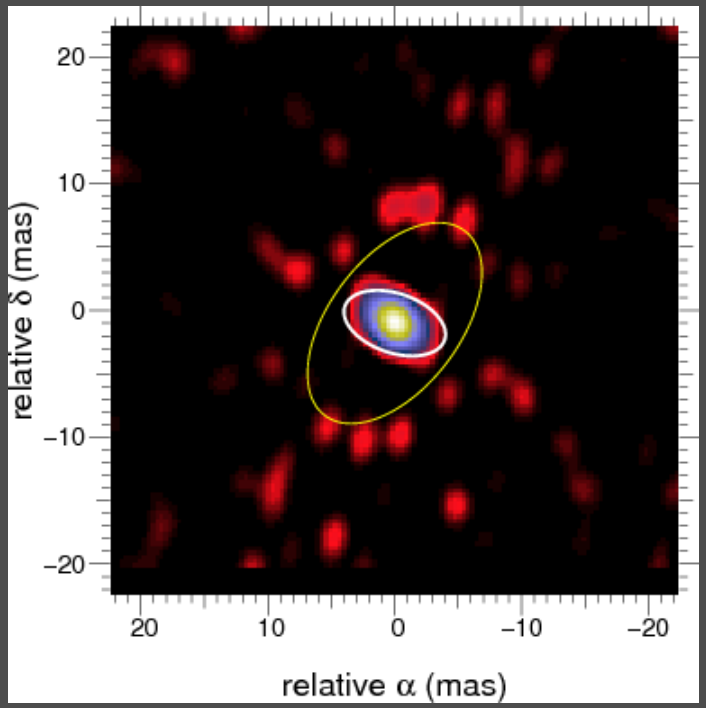
- **An incisive look at the symbiotic star SS Leporis**
  - **N. Blind, H.M.J. Boffin, J.P. Berger, J.B. Le Bouquin, A. Mérand, B. Lazareff, G.Zins. Submitted.**
  - **Orbit, masses, radius (M giant), temperatures, envelope**
  - **Constraints on co-evolution of Algol-like system**



Results : MWC158

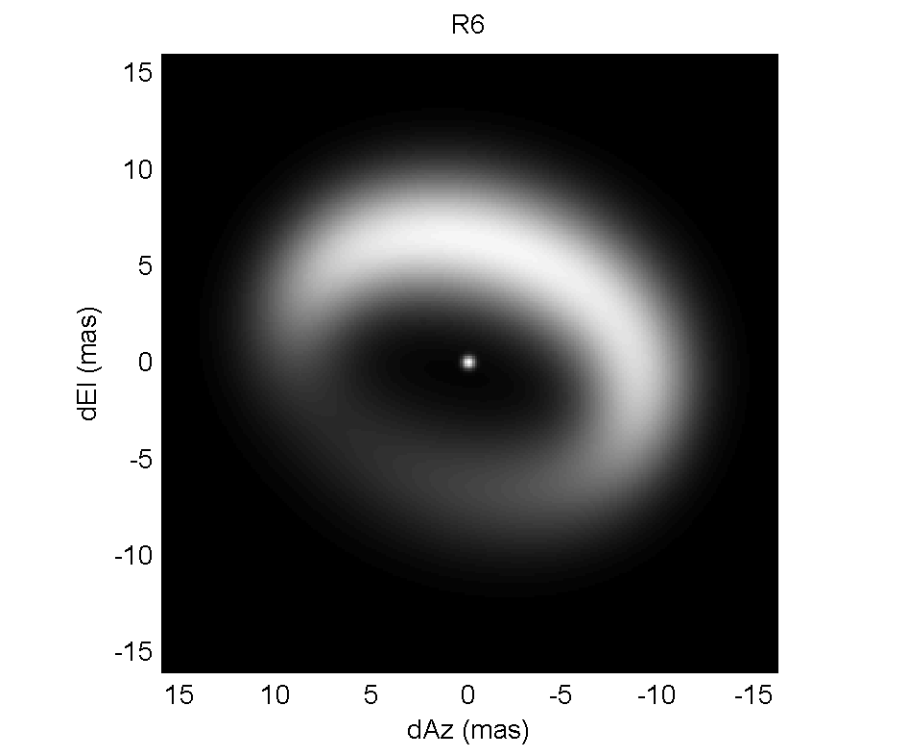
- **Imaging the inner disk region of MWC158**
  - **F. Malbet, J. Kluska, J.-P. Berger, F. Ménard, C. Pinte, J.-B. Le Bouquin, B. Lazareff, R. Millan-Gabet, W. Traub, M. Benisty**
  - **Image reconstruction with MIRA (polychromatic object)**





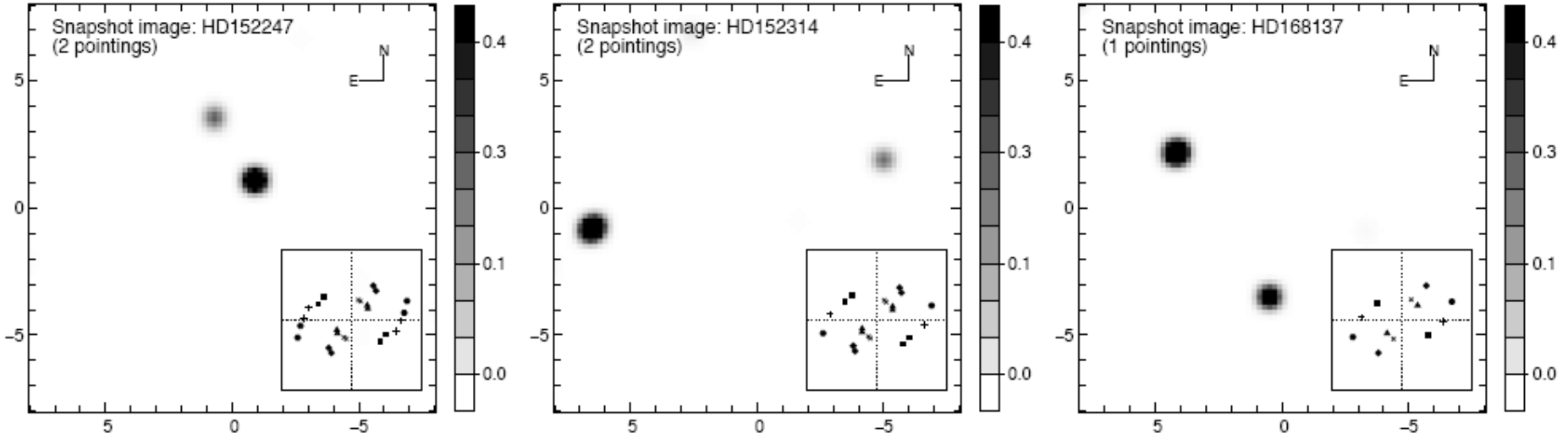
Results : HD45677

- **The sublimation ring of HD45677**
  - **B. Lazareff, J.P. Berger, M. Benisty, W.F. Thi, J.B. Le Bouquin, G. Zins, W. Traub, R. Millan-Gabet**
  - **Parametric image of star and bright inner ring at sublimation radius**
  - **Radius (9.5mas) and temperature (1300K) of emitting ring in agreement with *puffed up ring* model**



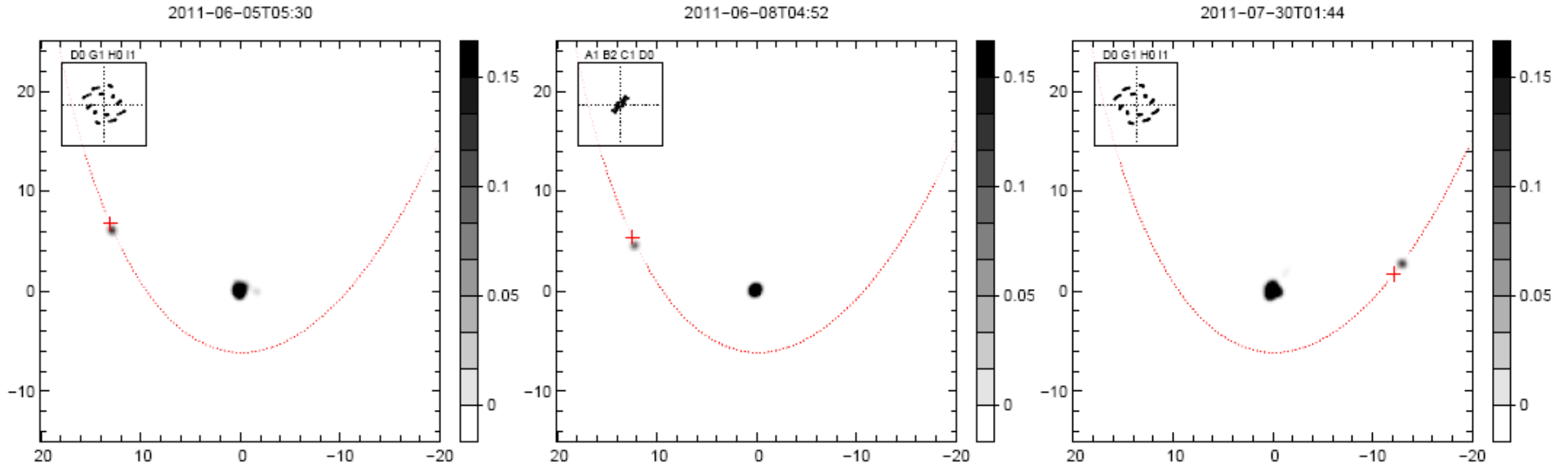
Results : Massive star binaries

- **H. Sana, J.B. Le Bouquin, M. De Becker, O. Absil, J.P. Berger B. Lazareff, R. Millan-Gabet, A. Merand, C. Martayan**
  - **Absolute mass determination of high mass stars**
  - **Three binaries with H=6…7.5 observed in 1.5 hour**
  - **[Pionier + AT] as efficient as [Amber + UT]**



Results : δ Sco

- A VLTI view of δ Sco at periastron
  - J.B. Le Bouquin, S.Stefl, D.Baade, J.P.Berger, A.C.Carciofi, M.Cure, X.Haubois, B.Lazareff, R.Millan-Gabet, A.Okazaki, T.Rivinius, G.Zins
  - Model-independent imaging of central star, secondary, and disk
  - Combined with Amber Brγ data, spectro-image of extended rotating disk
  - Perturbation of disk near peariastron ?

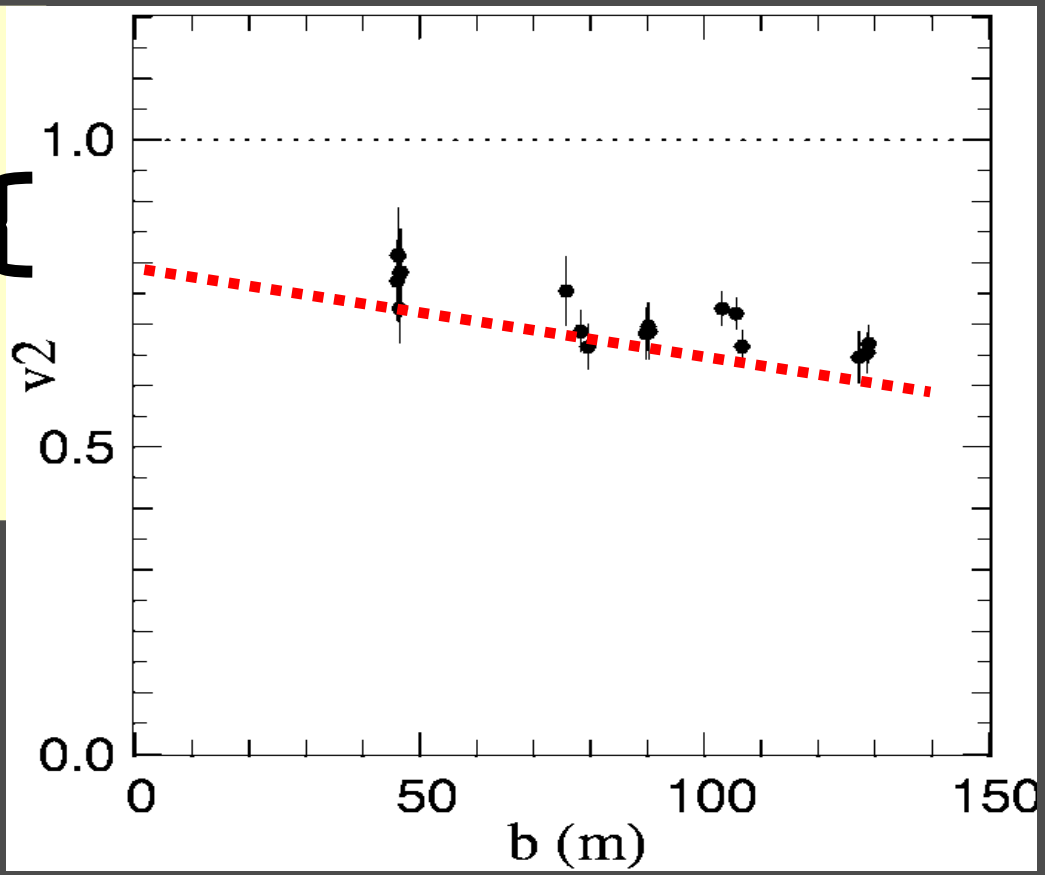


Results : T Tauri Survey

- **Extended component is frequent, different source to source**
- **Closure phases are very small, or null**
- **Example: HT Lupi, the PIONIER measurements K2, ~1Myr, class II**

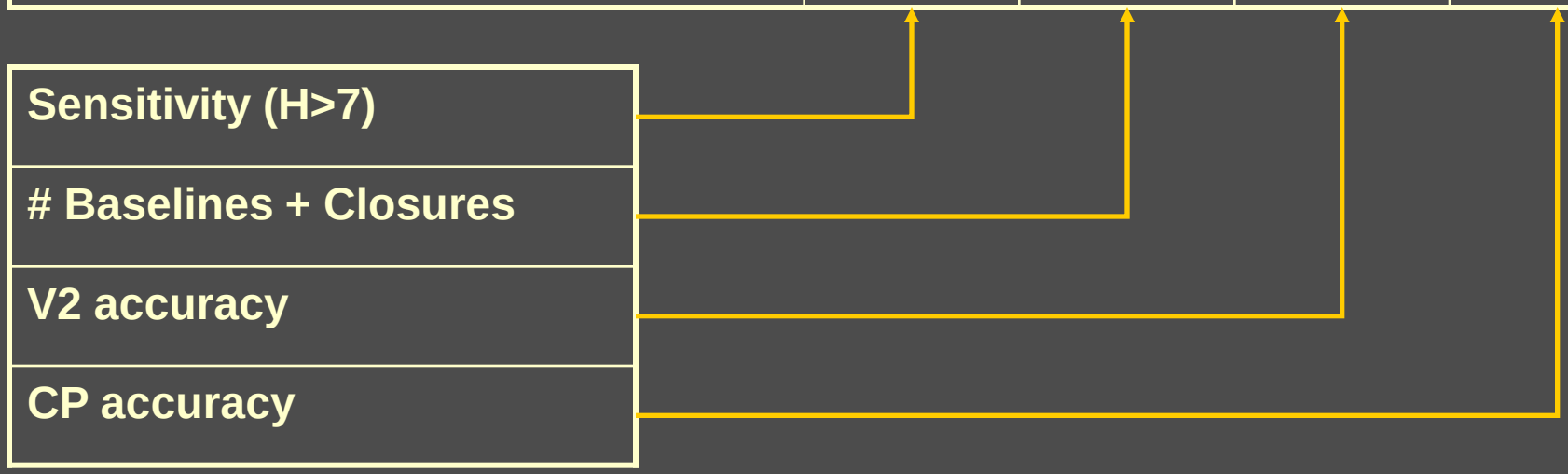
~8-15%
incoherent flux

Rin ~ 0.12AU



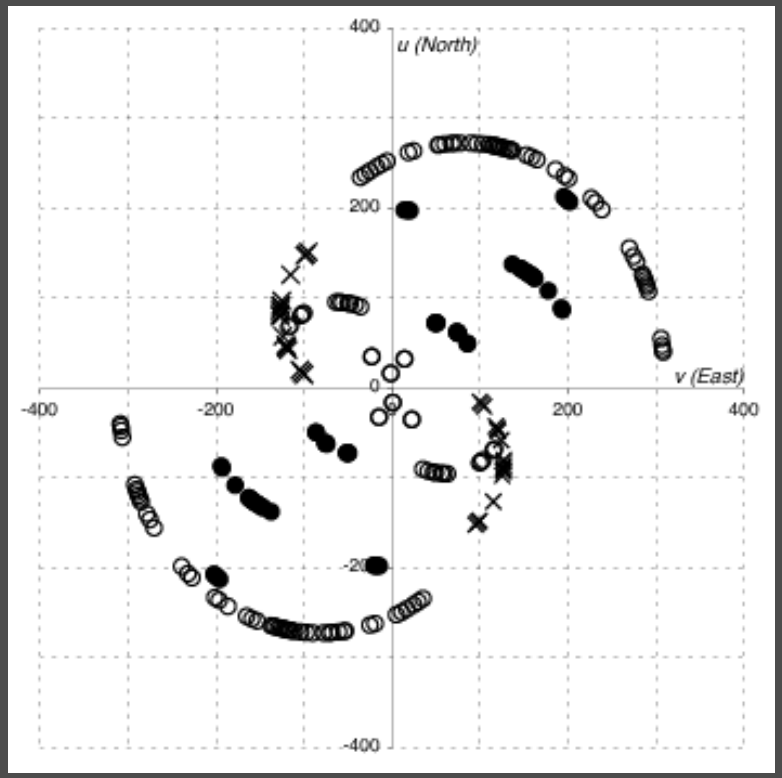
The PIONIER benefits. Real user testimonies.

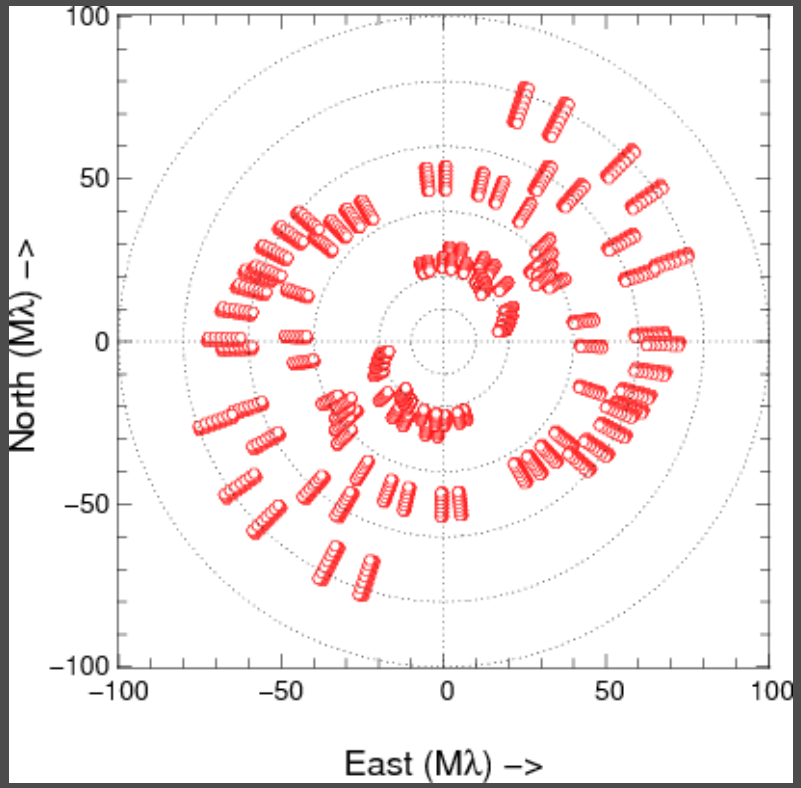
T. Tauri (Menard)	■	■	■	
AeBe Imaging (Berger)	■	■		
Massive binaries (Le Bouquin)	■			
Transitional disks (Benisty)	■	■		
Faint companions (Absil)		■		■
Debris disks (Absil)		■	■	
Hot jupiters (Absil)		■	■	■



The PIONIER benefits. Achernar; uv coverage

- **Vinci : Several years of observing**
- **Pionier: one night**





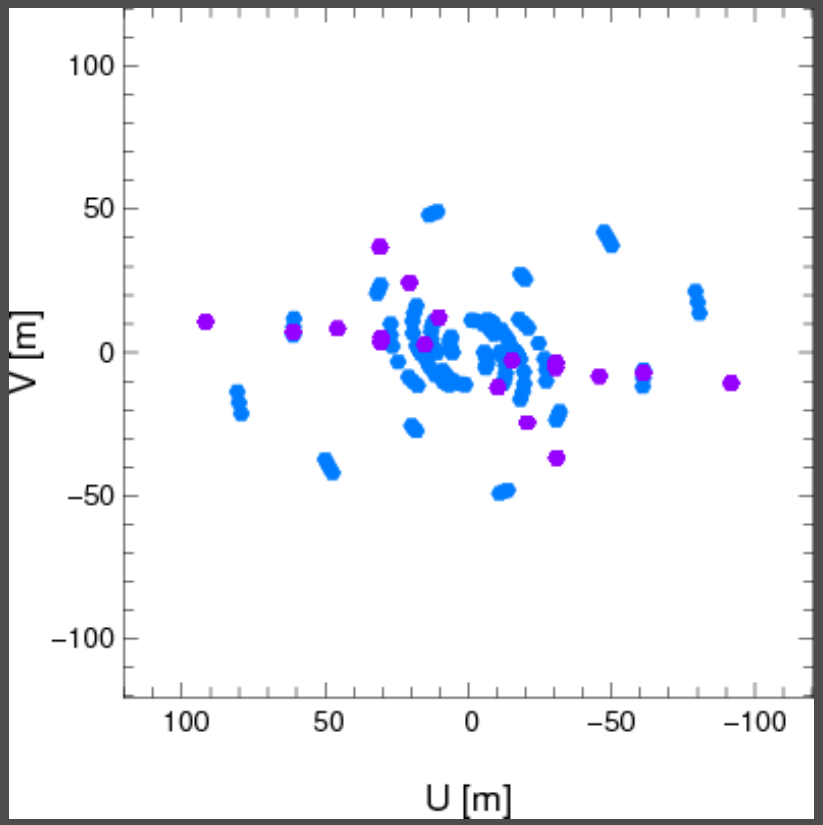
The PIONIER benefits. Massive binaries

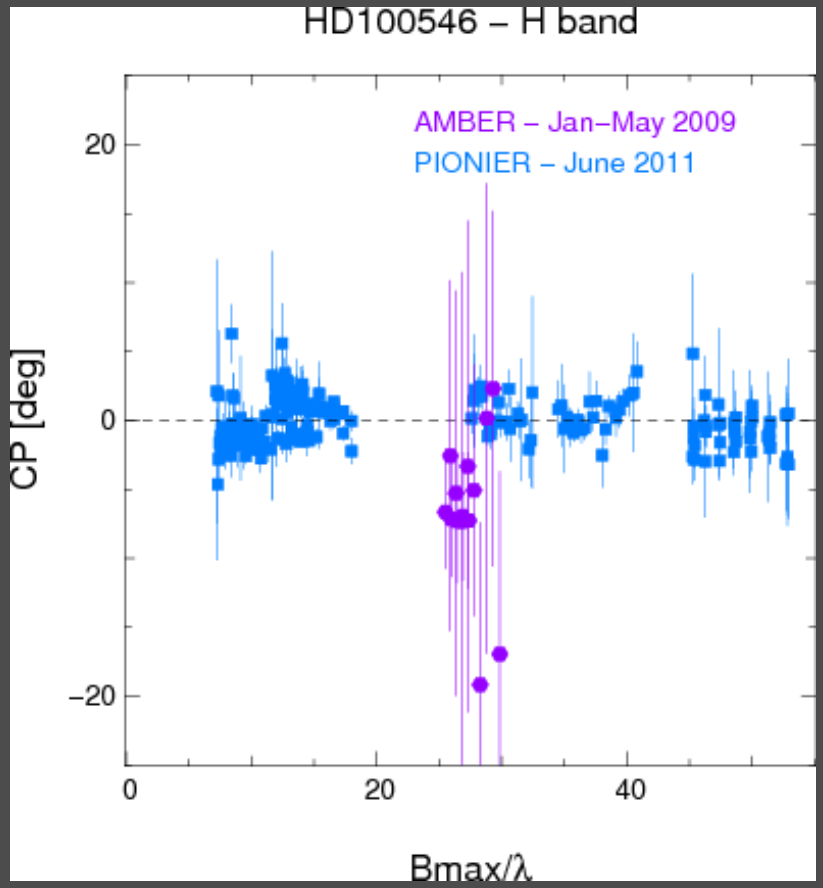
- **Amber + UTs 3 – 4 targets / night**
- **Pionier + ATs 8 targets / night @ H > 7mag**

The PIONIER benefits. Transitional disks

- **Observations of HD100546 with Amber and Pionier**

λ Amber λ Pionier





- **Remote operation of disperser change – Done**
- **Identify and eliminate instrument and reduction software systematics – In progress**
- **Implement K band – Planned summer 2012**
- **Change to Rapid (EMCCD) camera; low readout noise – 2013?**
- **Most significant limitations on performance:**
  - **Phase piston (atmosphere + telescopes)**
  - **Camera electronic transients**

Acknowledgements to:

- Pionier instrument team
- Paranal VLTI team