PIONIER : Science with a Four Telescope VLTI Instrument

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 available 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
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)
Context > Instrument > Comm > Results > Perspective

- Packing...
Context > Instrument > Comm > Results > Perspective

- Unpack & Install
  Oct 20-24, 2010
Context > Instrument > **Comm** > Results > Perspective

- 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

Anguish

Bliss
Results: SS Lep

- An incisive look at the symbiotic star SS Leporis
  - Orbit, masses, radius (M giant), temperatures, envelope
  - Constraints on co-evolution of Algol-like system
Results: MWC158

- Imaging the inner disk region of MWC158
  - Image reconstruction with MIRA (polychromatic object)
Results: HD45677

- The sublimation ring of HD45677
  - 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

  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: $\delta$ Sco

- A VLTI view of $\delta$ Sco at periastron
  - Model-independent imaging of central star, secondary, and disk
  - Combined with Amber Br$\gamma$ data, spectro-image of extended rotating disk
  - Perturbation of disk near periastron?
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

\( R_{in} \sim 0.12 \text{AU} \)

\( \sim 8-15\% \) incoherent flux
The PIONIER benefits. Real user testimonies.

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Sensitivity (H&gt;7)</th>
<th># Baselines + Closures</th>
<th>V2 accuracy</th>
<th>CP accuracy</th>
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Legend: Green = Yes, Yellow = Partially Yes, Red = No

Notes:
- V2 accuracy: High
- CP accuracy: Moderate
- Sensitivity: High (>7)

26-OCT-2011
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