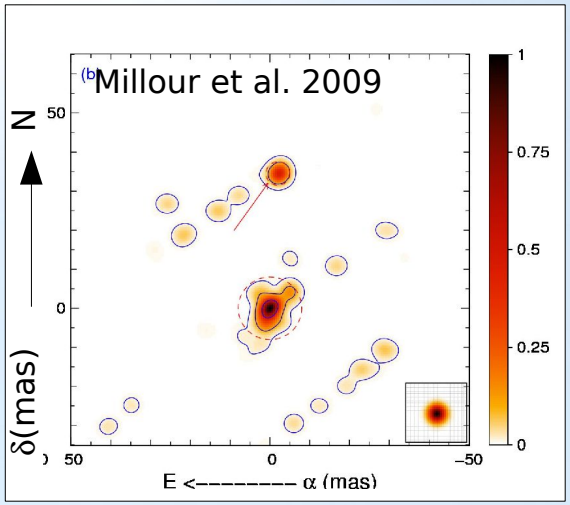
Image reconstruction software: Available tools and new developments

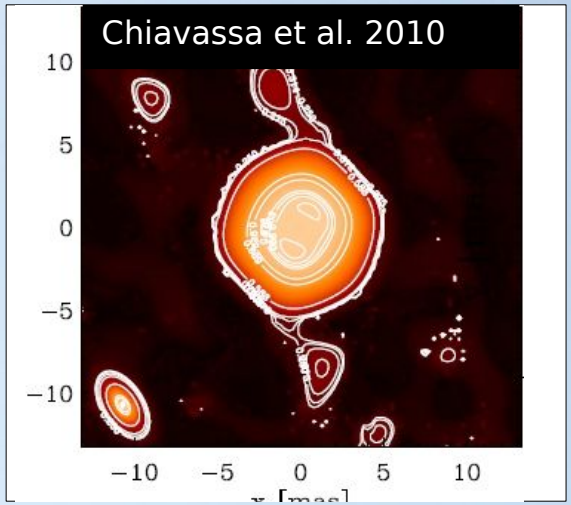
Florentin Millour

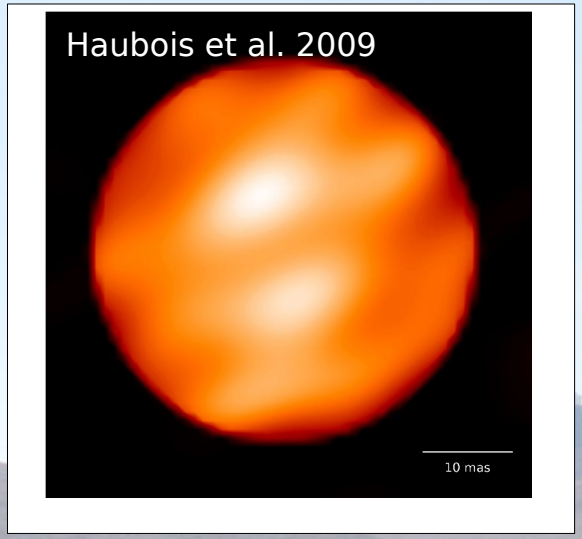
Observatoire de la CÔTE d'AZUR

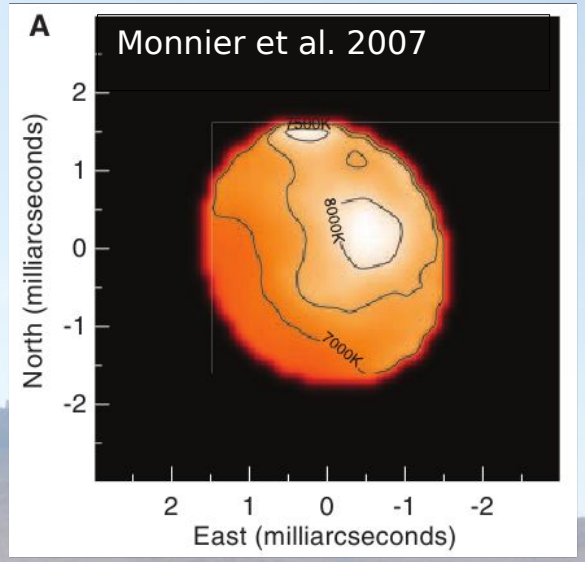
Imaging with interferometry

- **Squared visibility (V^2)**





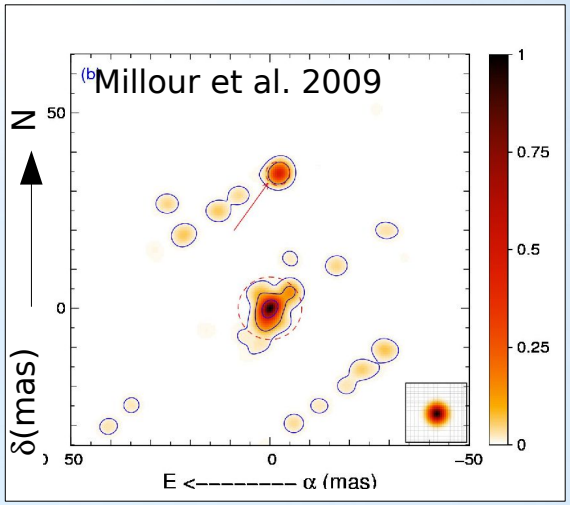


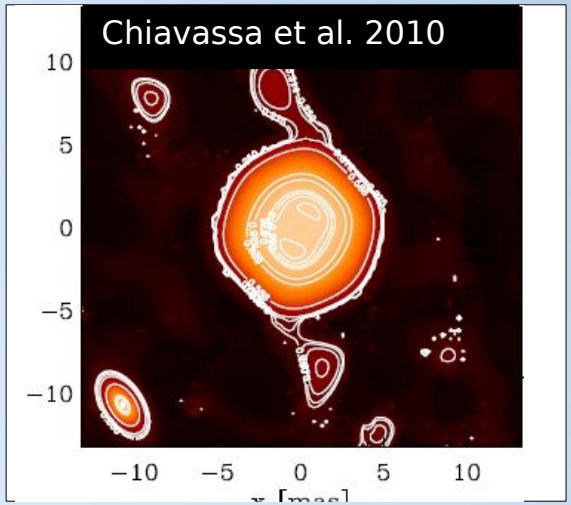


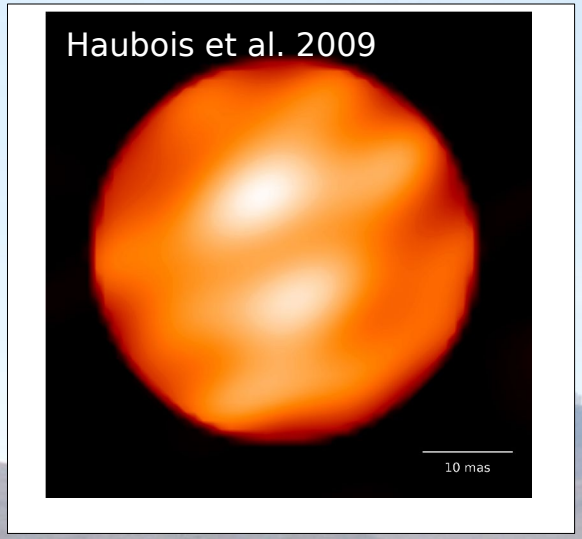
- **If $N_{tel} > 2$**
  Closure phase
- **If spectrograph**
  Spectra,
  Differential phases,
  Differential visibility
- **If well-sampled UV plane**
  Image synthesis

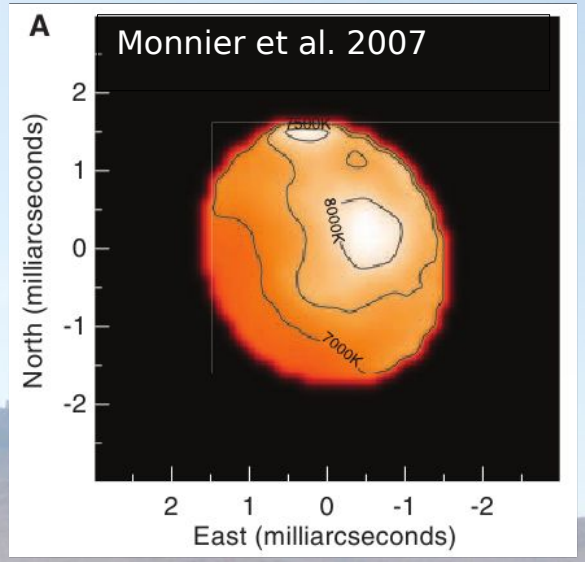
Imaging with interferometry

- **Squared visibility (V^2)**









- If $N_{tel} > 2$
  Closure phase
- If spectrograph
  Spectra,
  Differential phases,
  Differential visibility
- If well-sampled UV plane
  Image synthesis

Image-reconstruction limits

Problems

- $N_{pixels} >> N_{observations}$
- Weak phases (1/3 information 3T)
- Bad UV sampling
- Convergence

Workarounds

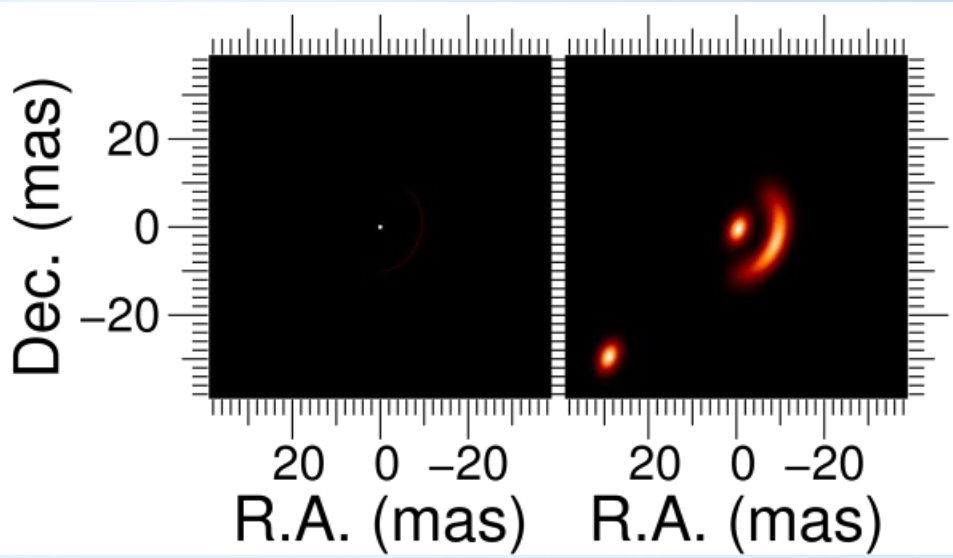
- Regularization
- Prior
- Field-of-view
- Symmetries
- Spectral coverage
- Phase referencing

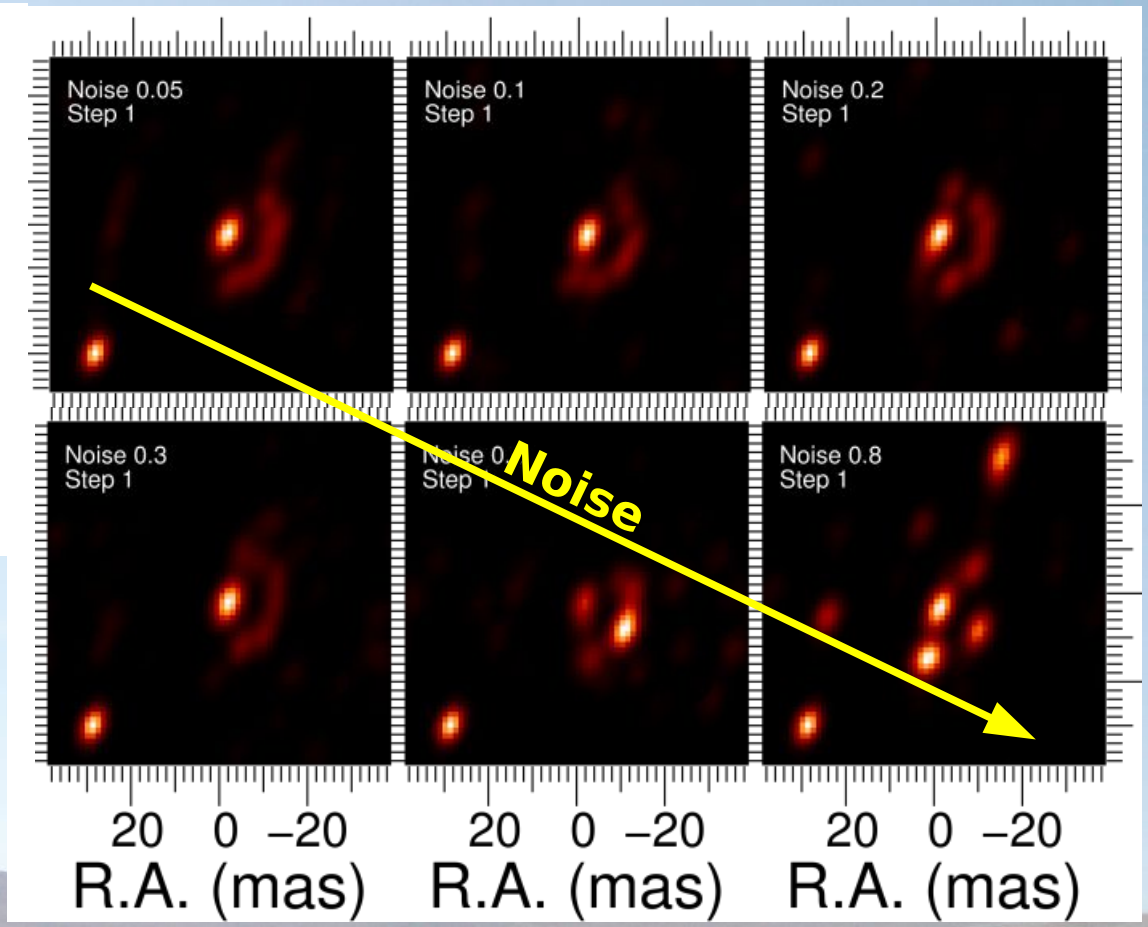
Limits: noise

- Example : disk simulation « observed » with VLTI/AMBER

Model

Simulations AMBER
Reconstruction MIRA

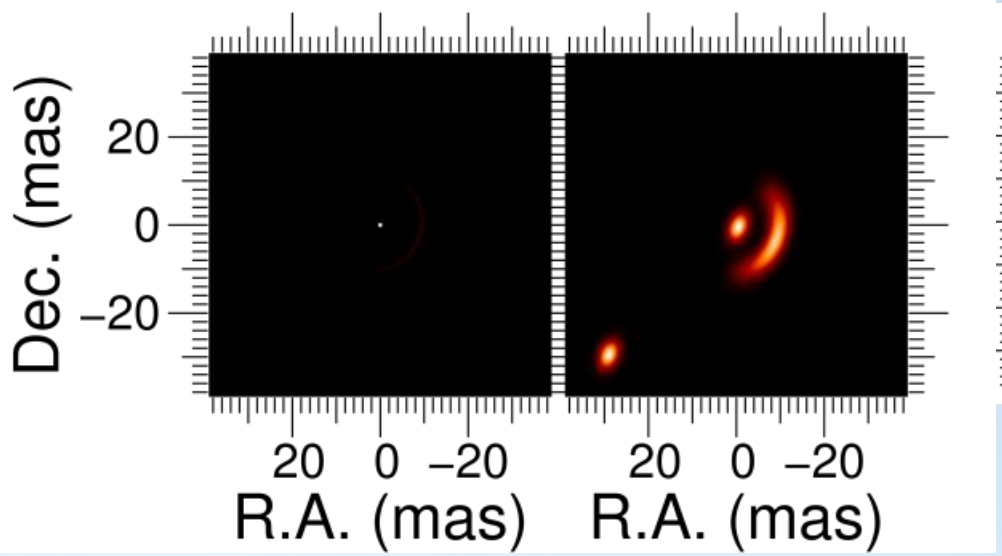




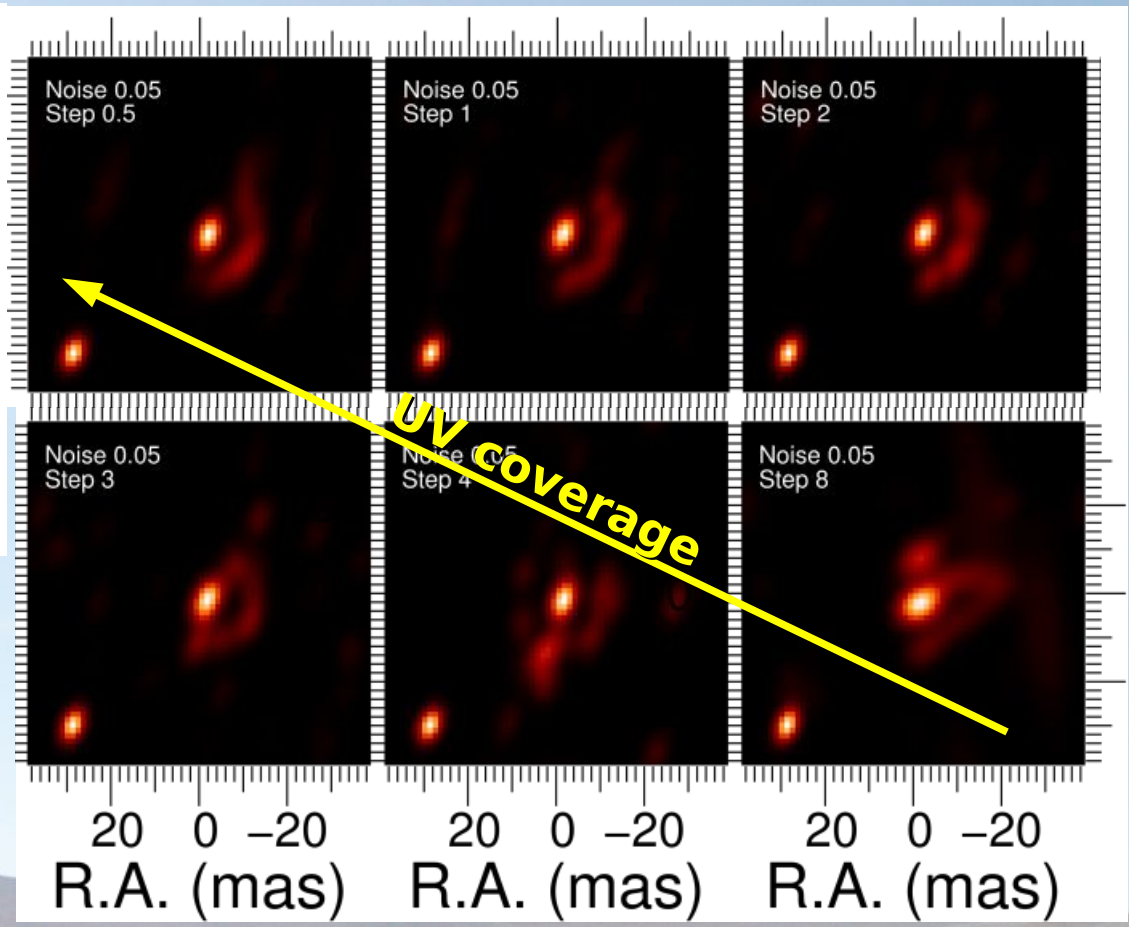
Limits: UV plane

- Example : disk simulation « observed » with VLTI/AMBER

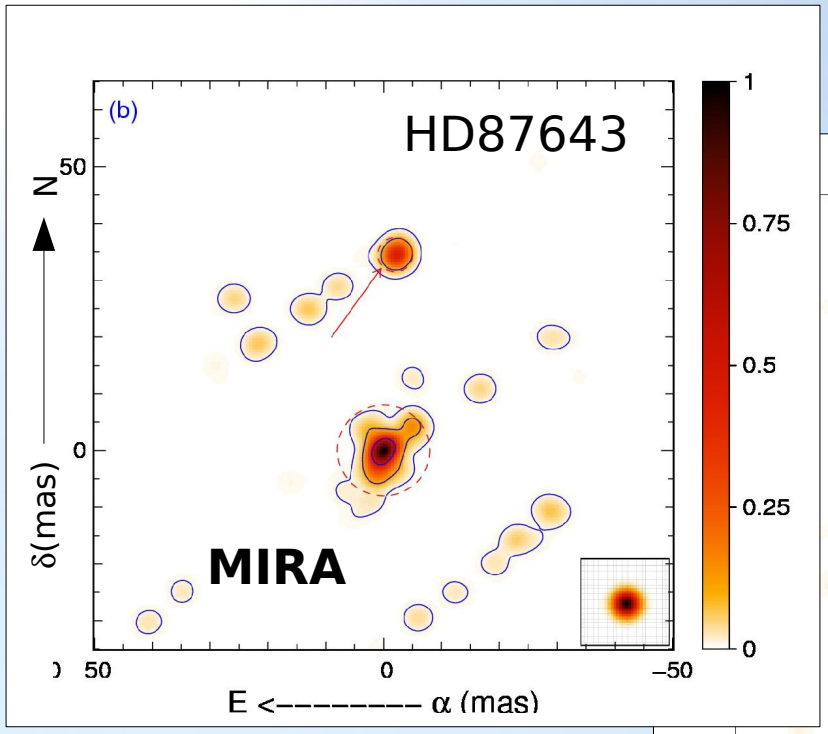
Model

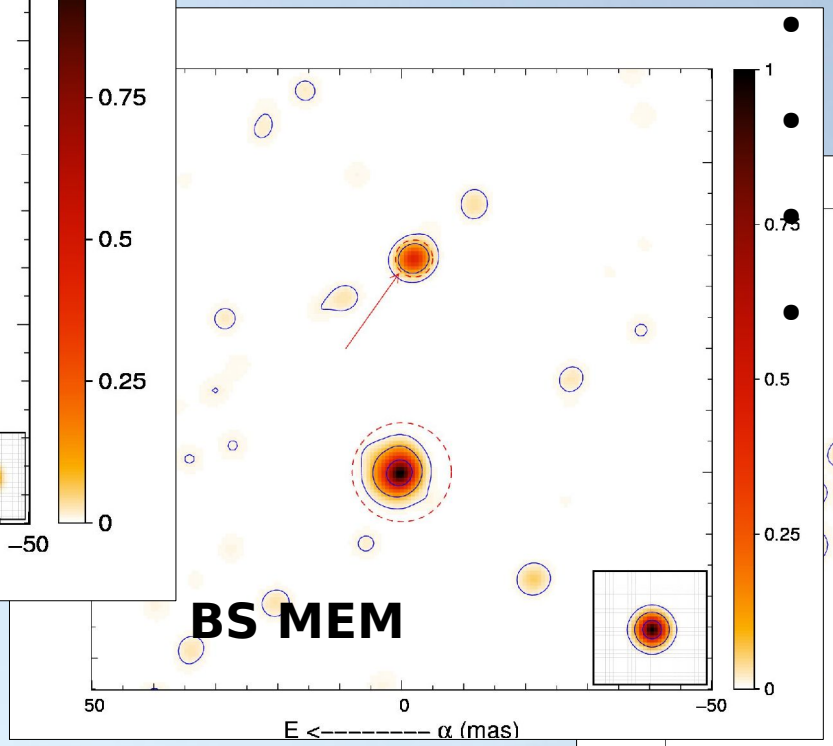


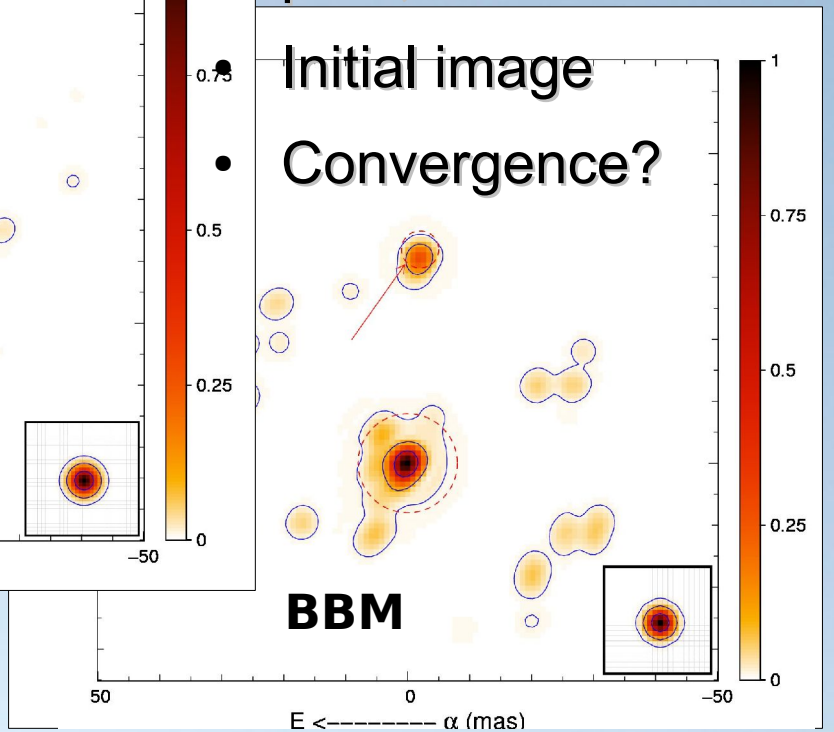
Simulations AMBER
Reconstruction MIRA



Available image-reconstruction software







Millour et al. 2009

- **Many free parameters:**
- Super-parameter,
- prior,
- Initial image
- Convergence?

And also:

- **WISARD**
- **MACIM**
- **VLBMEM**
- **CASA**

$N_{parameters} >> N_{obs}$

=> regularization prior

Available image-reconstruction software

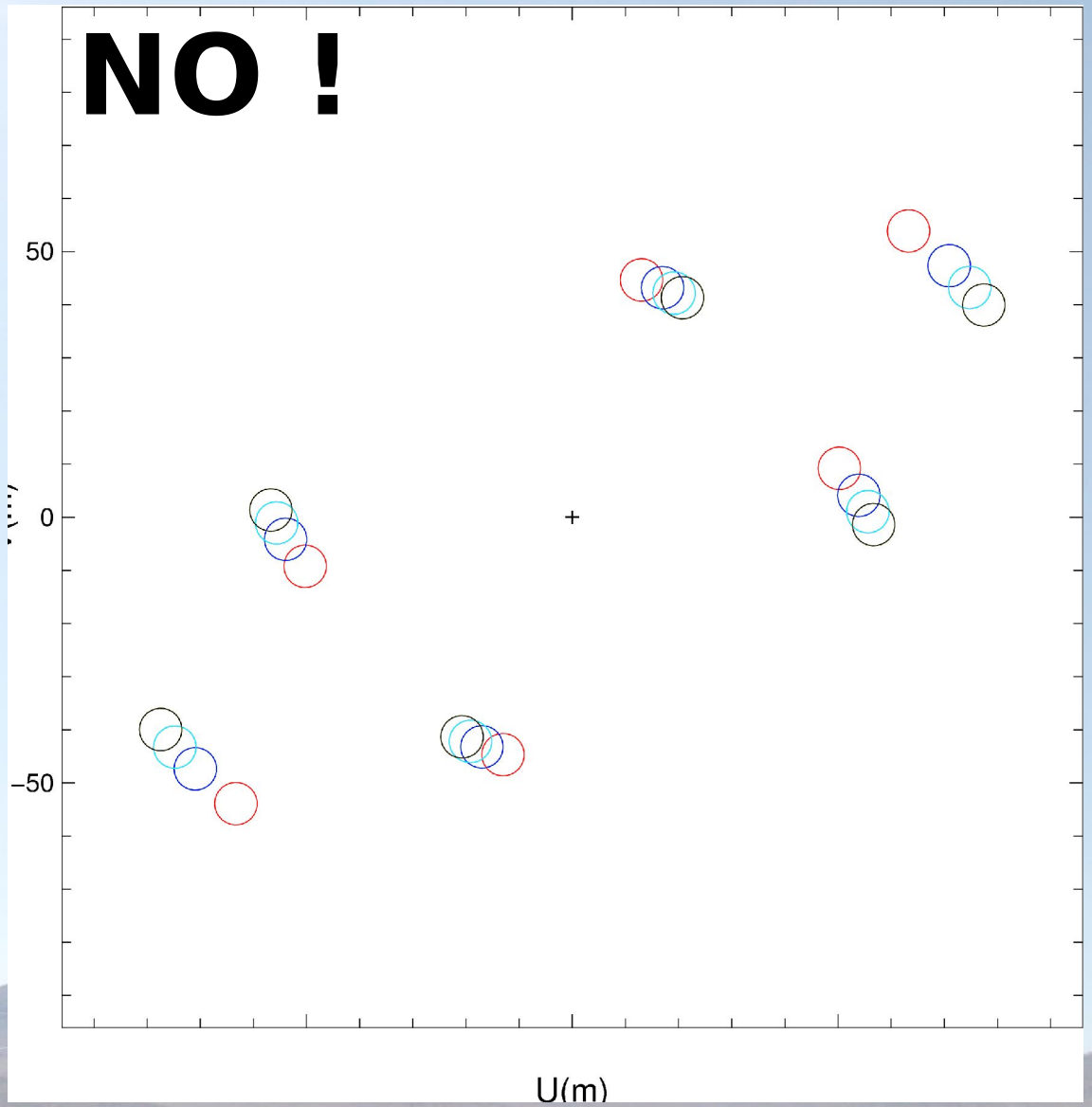
Works straight out of the box

- MIRA : Univ. Lyon (E. Thiébaut)
- BBM : MPIFR (K.-H. Hofmann)
- BSMEM : Univ. Michigan (F. Baron)
- WISARD : JMMC (M. Vannier)
- MACIM : Univ. Sydney (M. Ireland)

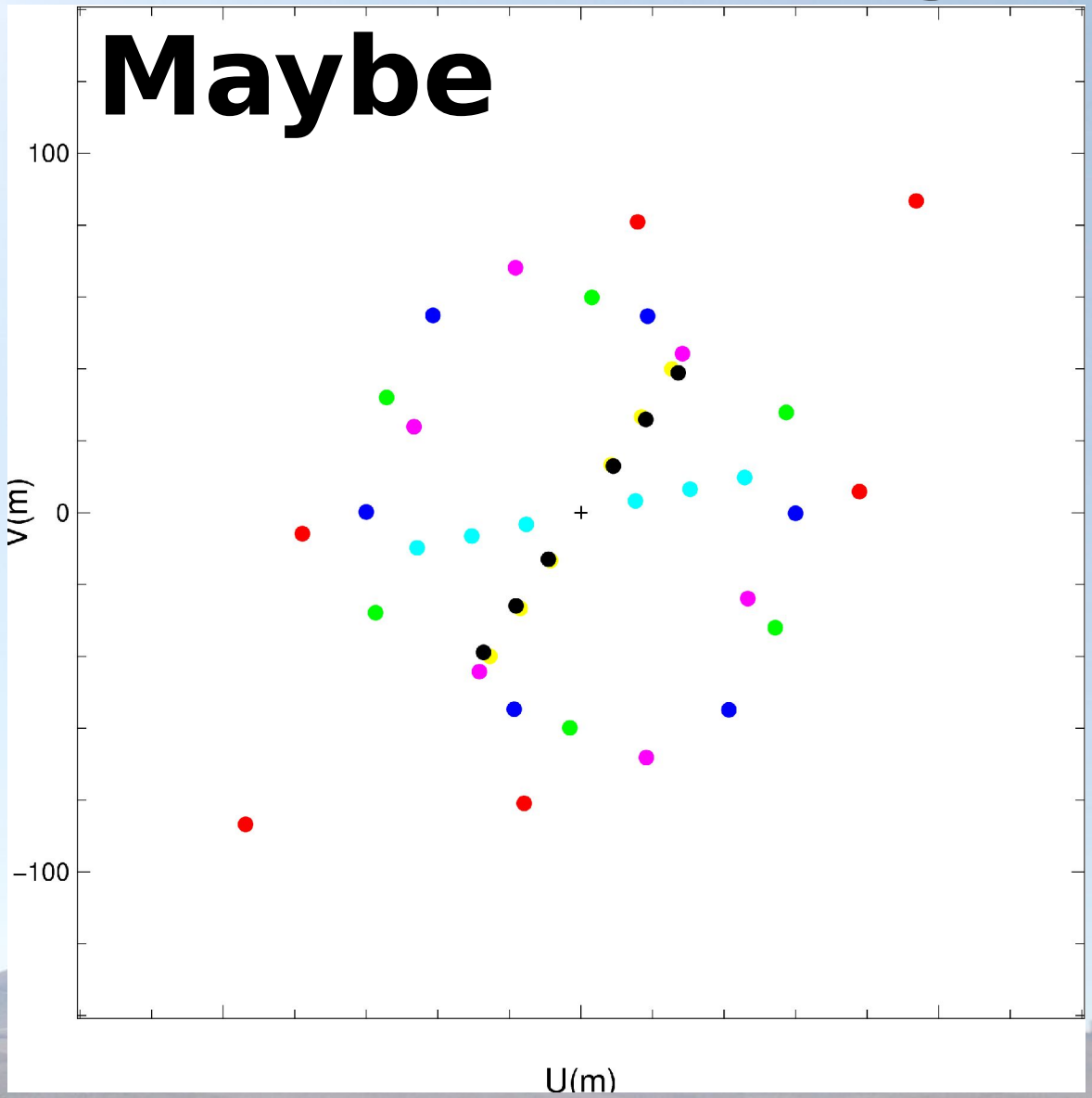
No OIFITS interface

- AIPS : NRAO
- CASA : ESO
- VLBMEM : Caltech

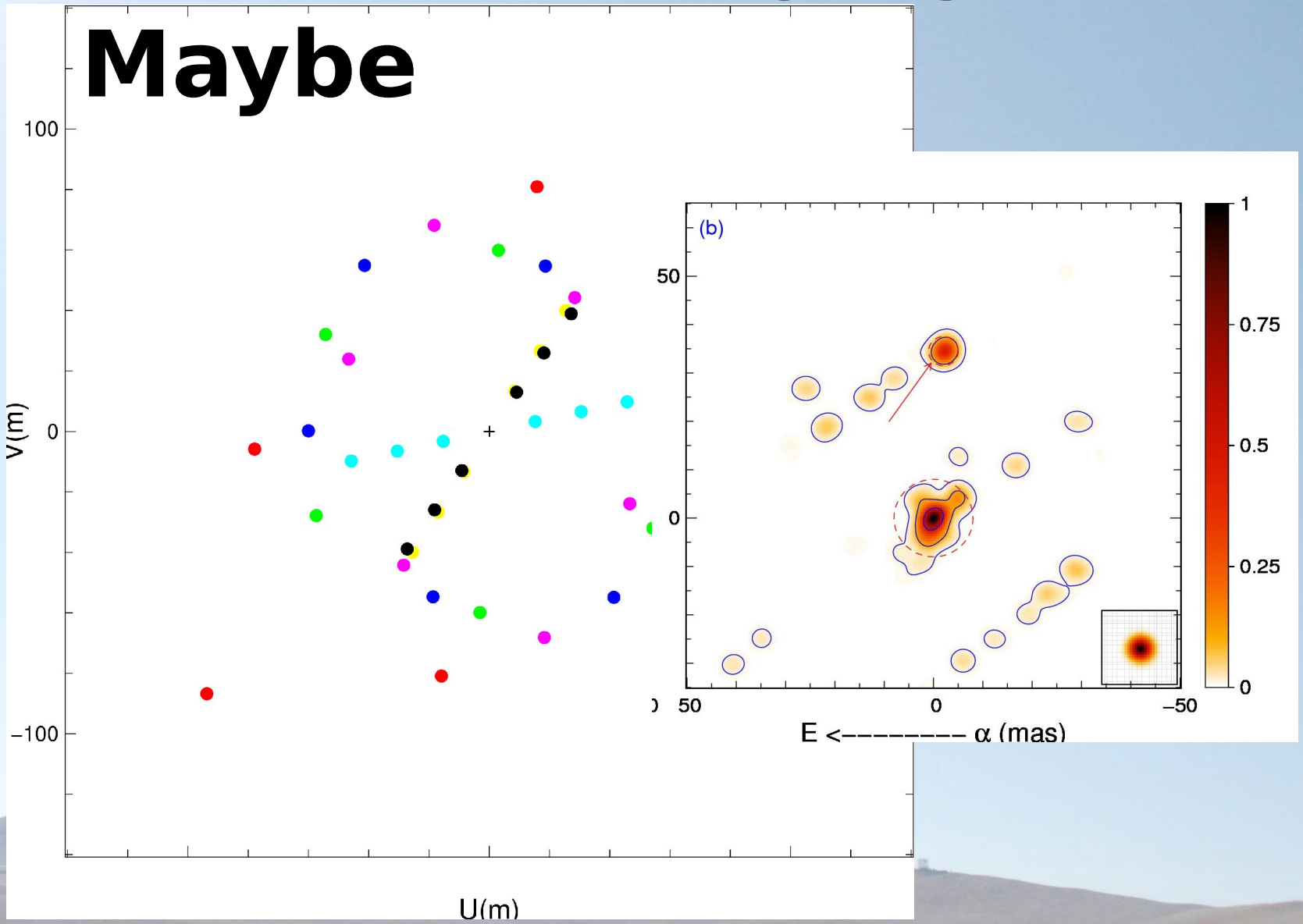
Is your UV plane suitable for imaging ?



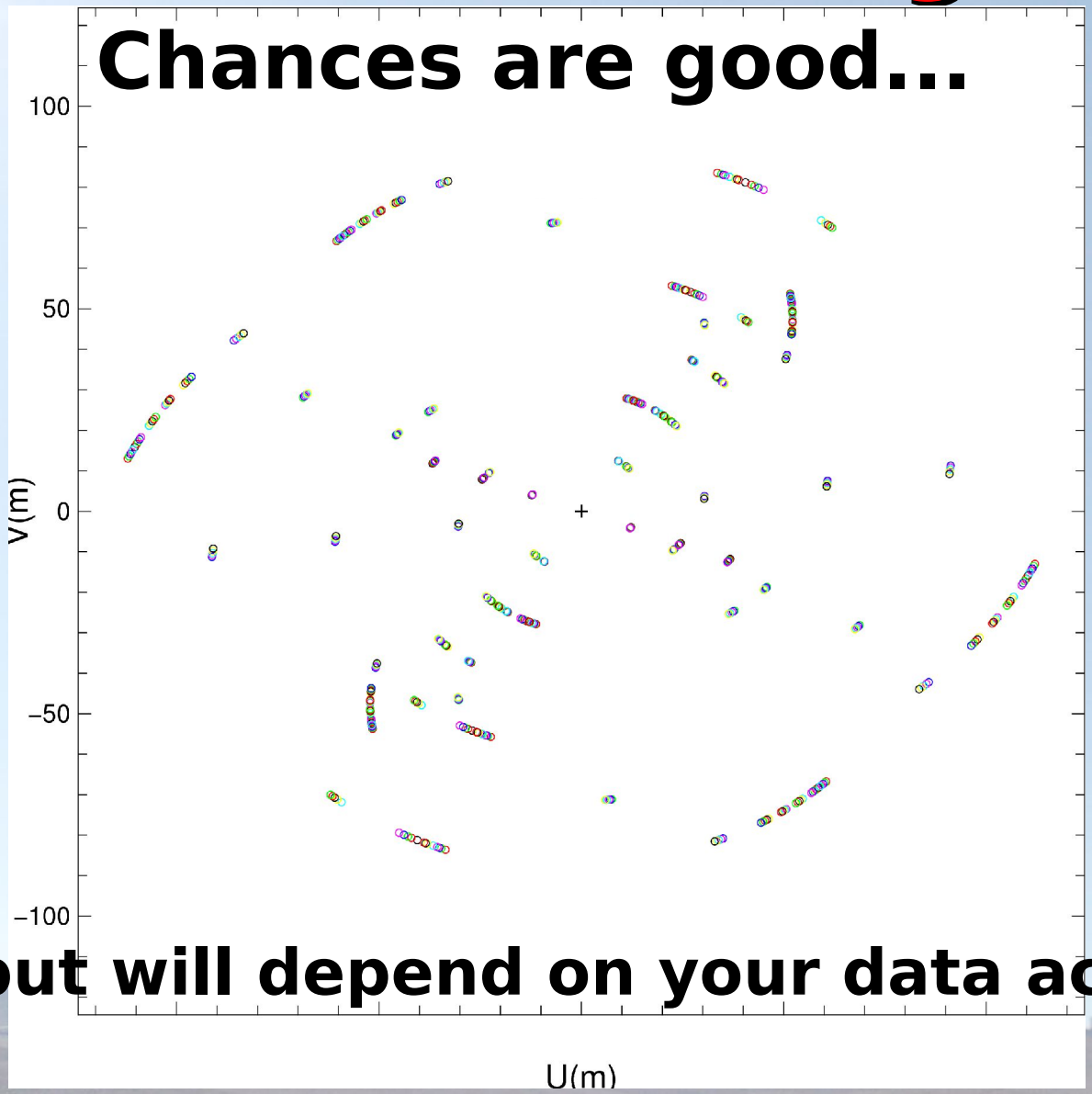
Is your UV plane suitable for imaging ?



Is your UV plane suitable for imaging ?



Is your UV plane suitable for imaging ?



...but will depend on your data accuracy

Developments in OI imaging

- WISARD
  - Imaging software developed at JMMC
- Self-Calibration
  - A way of getting closer to phase-referencing
- ANR « POLCA » (Lyon, Nice, Grenoble, Paris)
  - Sparse sampling development
  - Better description of interferometric data
- Others
  - Baron, Monnier et al. developments

The differential phase

Principle

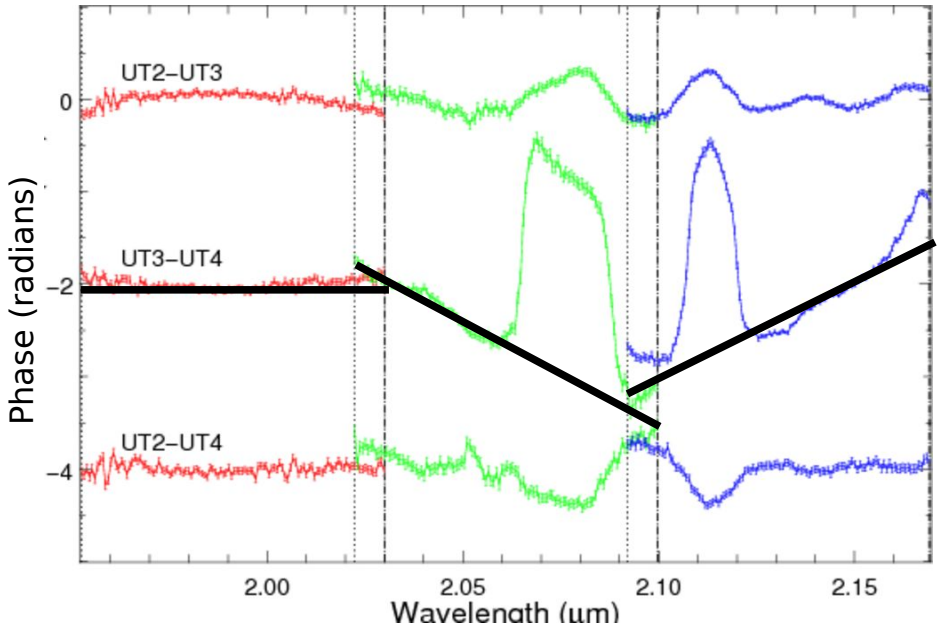
- 2-telescopes phase as a function of λ
- Some hase information lost :
  - Constant
  - Slope

Precision 10^{-2} radians (6μas) but

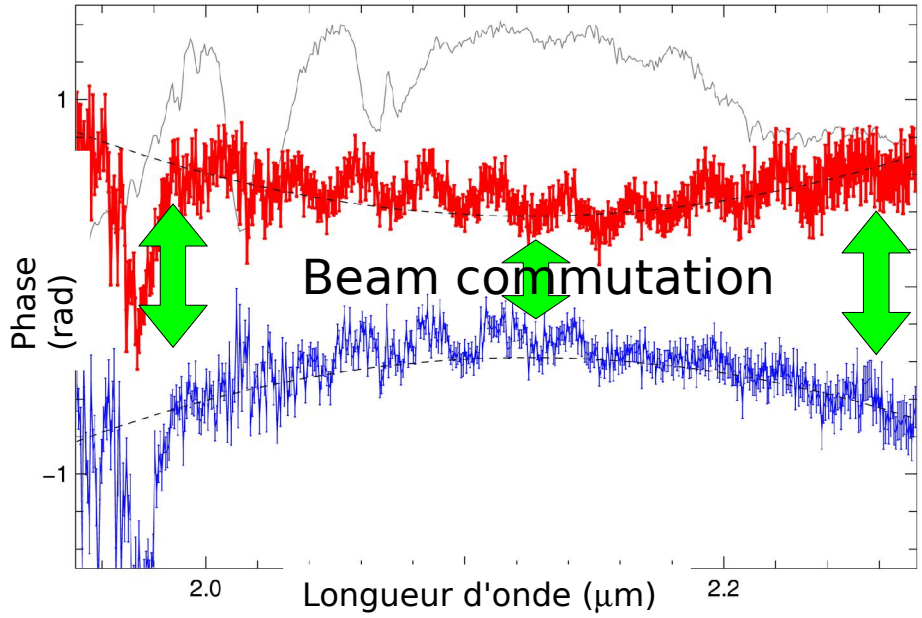
- Air chromatic dispersion
- Instrumental problems

(stability, dichroics, polarizers)

γ^2 Velorum (Millour et al. 2007)



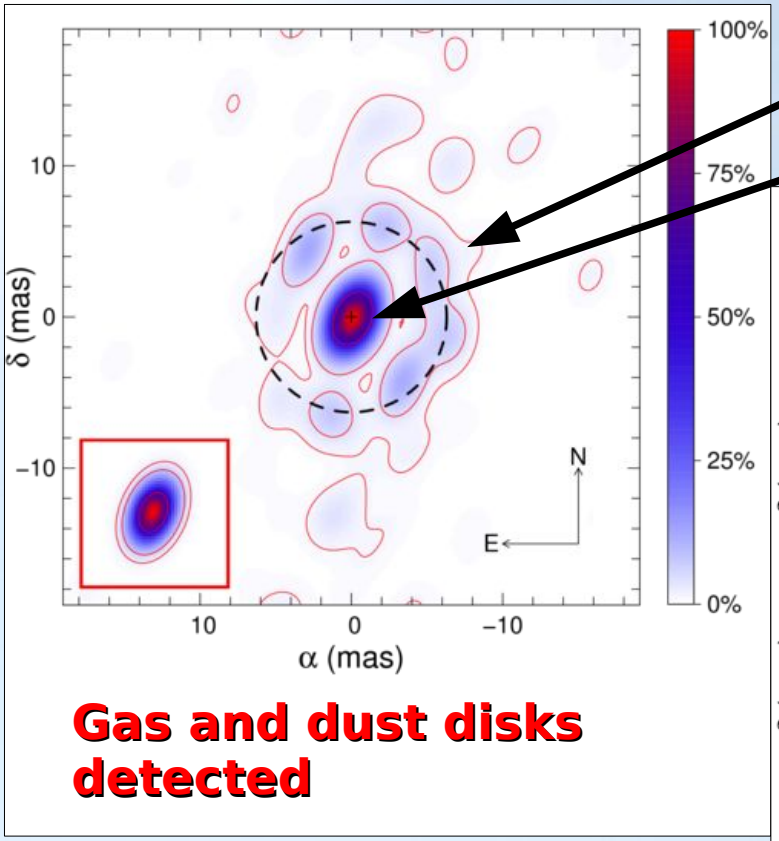
AMBER phases report (2007)



Hyperspectral imaging

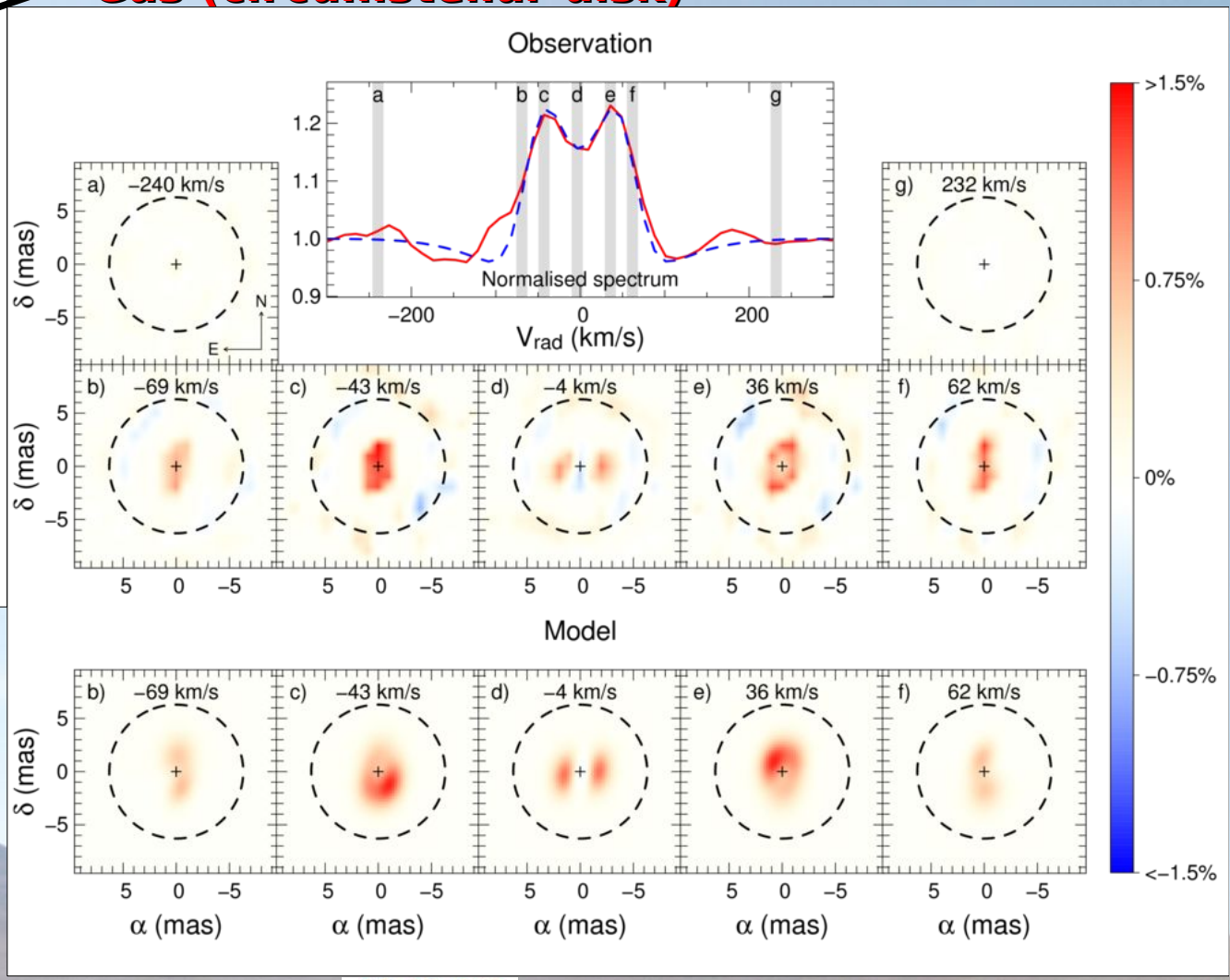
3 Pup : supergiant A[e] star

- **Dust (Inner sublimation rim)**
- **Gas (circumstellar disk)**



Gas and dust disks detected

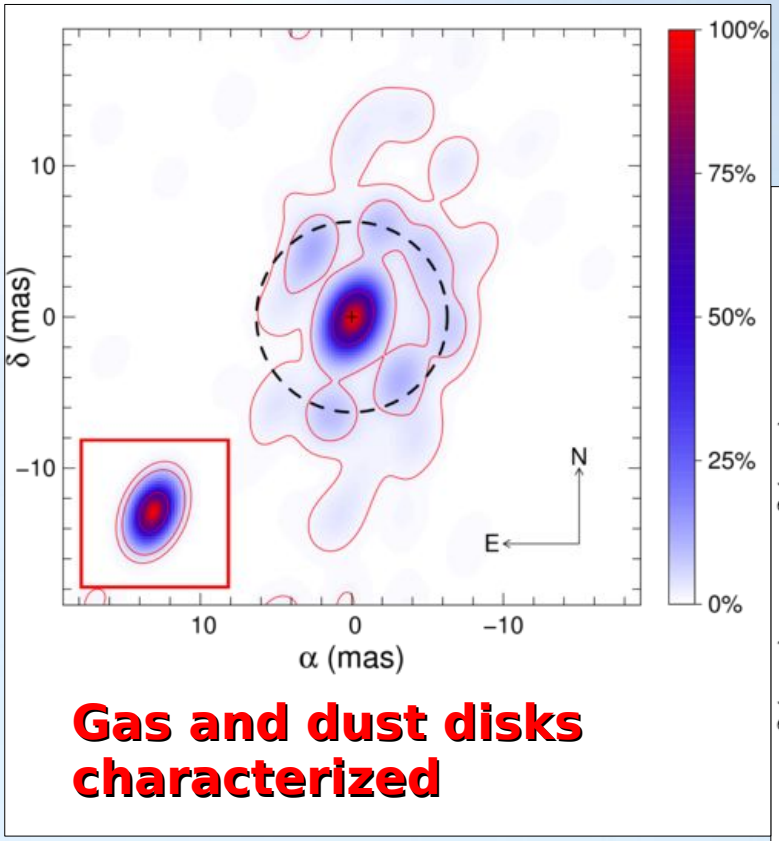
Millour et al. 2011



Hyperspectral imaging

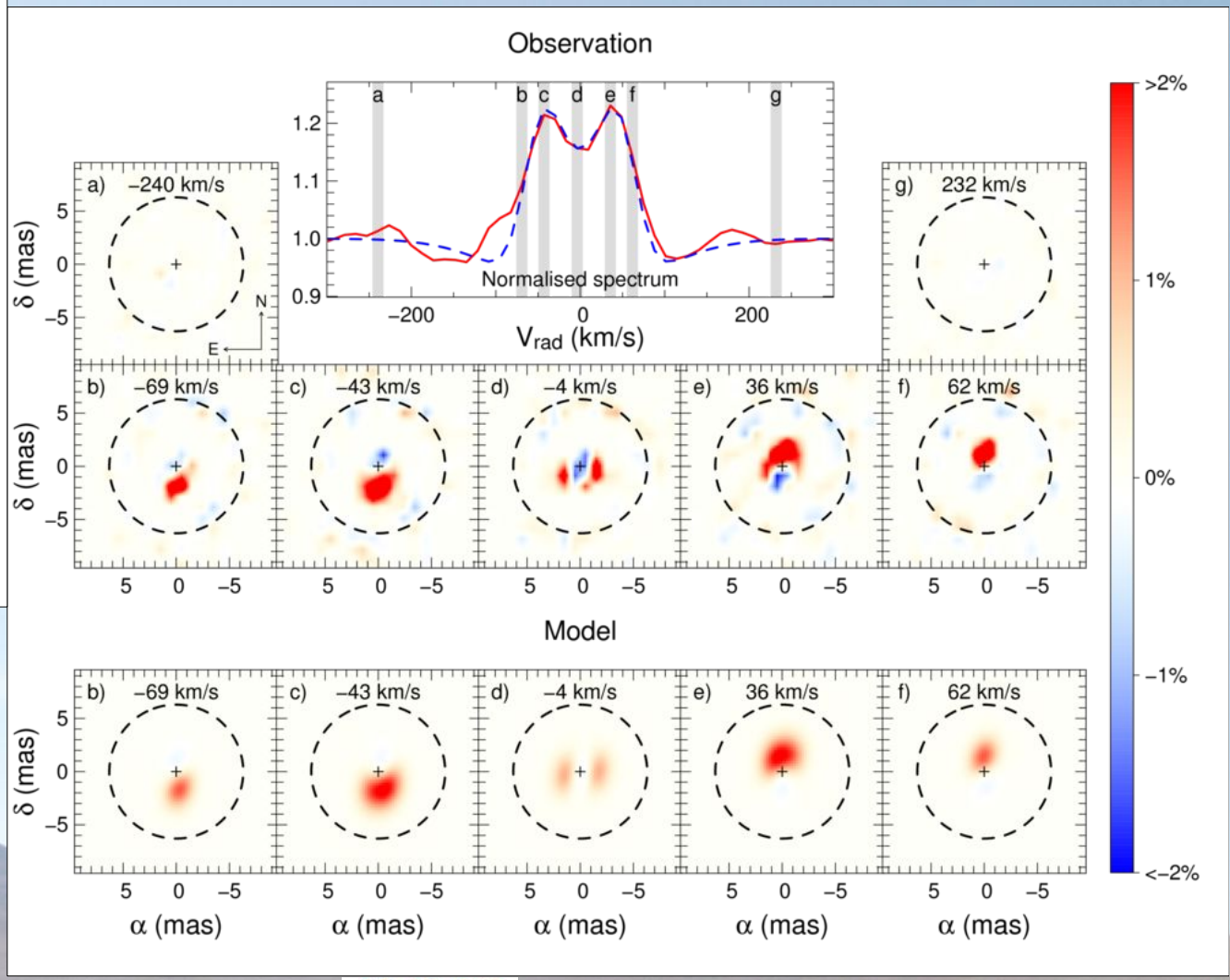
3 Pup : supergiant A[e] star

self-calibration : differential phases in the image-reconstruction process!

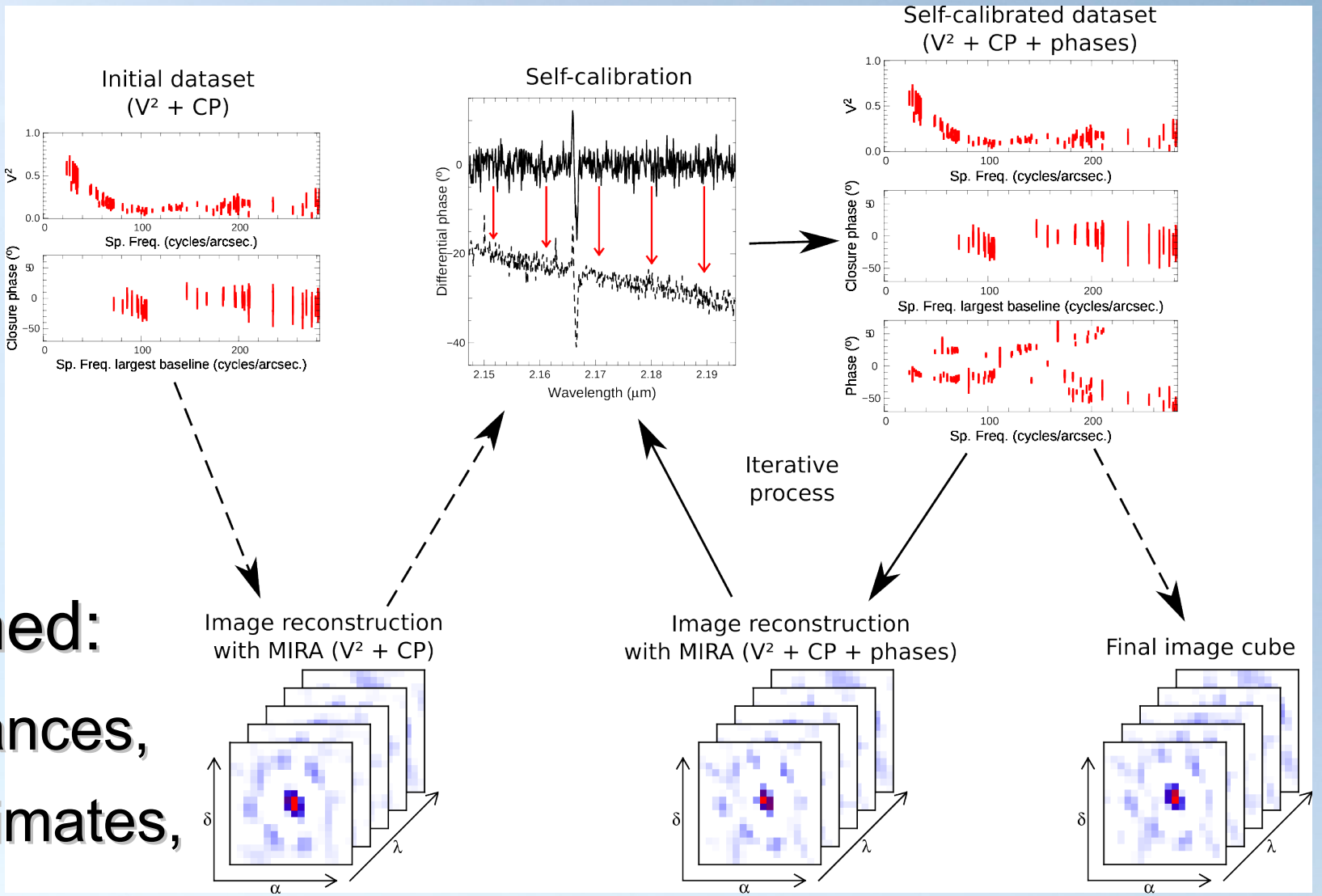


Gas and dust disks characterized

Millour et al. 2011



How does it work?

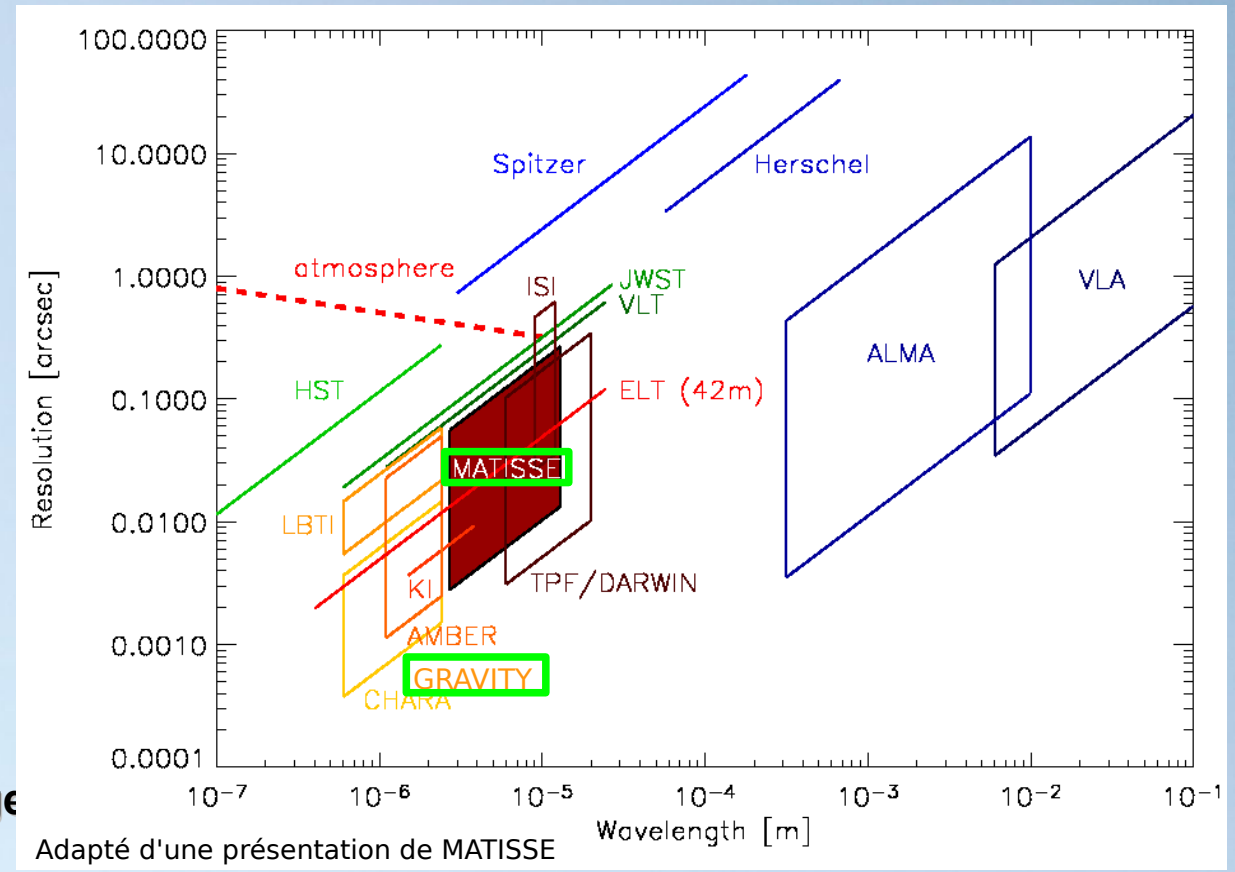


- To be refined:
  - Performances,
  - Error estimates,
  - Initial guess,
  - Convergence,

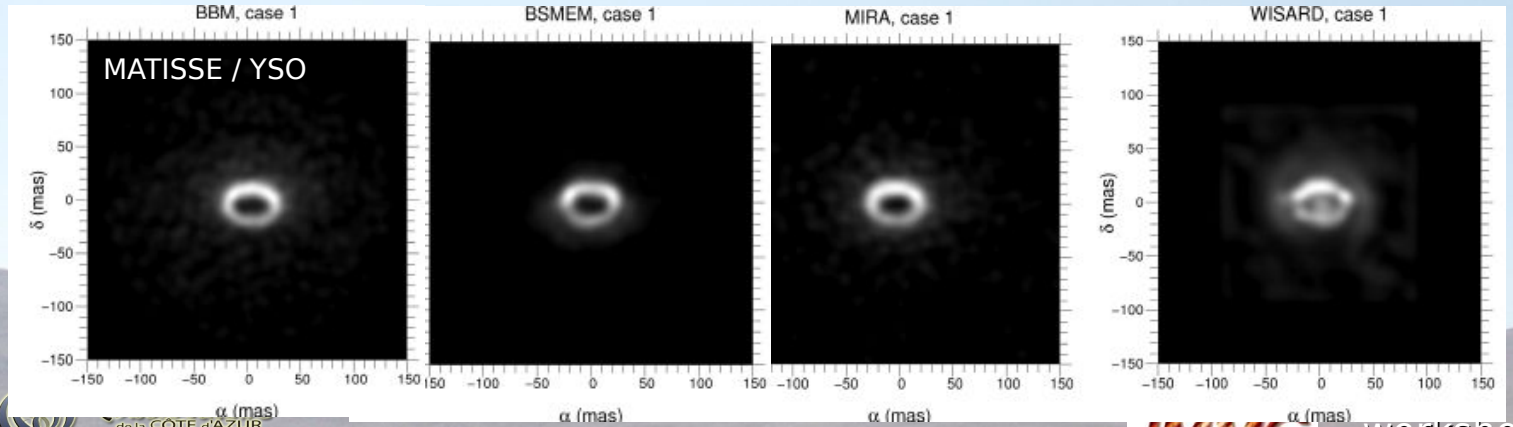
Millour et al. 2011

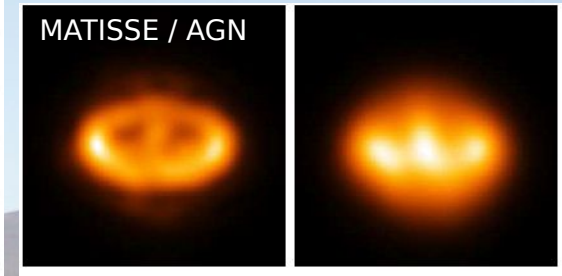
2nd generation VLTI

- **GRAVITY**
  - 4T, bande K
  - R=30, 300, double champ
  - Le centre Galactique
- **MATISSE**
  - 4T, bandes L, M et N
  - R=30, 300, 2500
  - Des images dans l'infrarouge



Adapté d'une présentation de MATISSE






Thanks !