Introduction to phases and closure phases

…in the YSO and exoplanet context
part II

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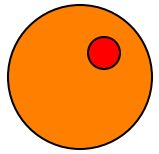
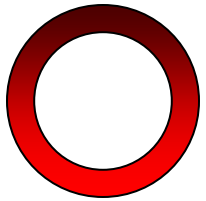
See Goutelas 2006 andMichelson 1999 Monnier's paper

Closure phase in practical

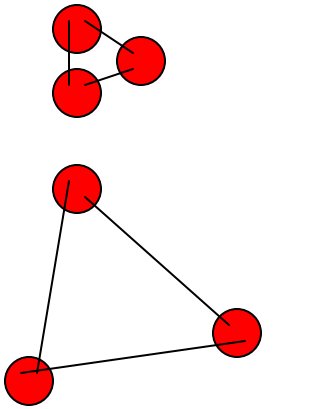
- Building block functions to interpret closure phases
- Choosing a baseline configuration
- Why YSO emission should be skewed ?
- Imaging ?

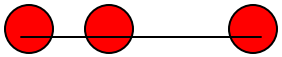
Closure phase modelling building blocks

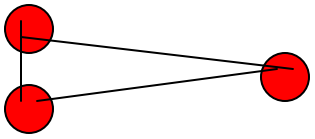
- In the absence of model independent imaging intepreting closure phases requires to start with simple models
- Once the simple models have helped you narrow your actual model parameter space, go for a more complex model
- Remember that closure phase is also sensitive to resolution.

Binary	
Spot on resolved surface	
Skewed ring	

Choosing a baseline configuration







Short baseline equilateral triangle	Investigate structure at the largest scale.
Long baseline equilateral triangle	If big enough removes extended envelop contribution and reveals central object skewness
Co-linear baseline	Probes the brightness distribution in single direction. Reveals asymmetric elongation PA
One short+ 2 long baseline	The closure phase on one triangle is equal to the phase on the shortes baseline

Why should YSO emission should be skewed ?

Answer one: m ▪ ▪ ultiplicity

The GW Orionis case

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

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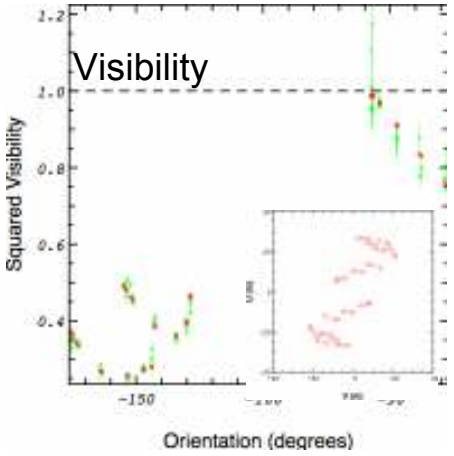
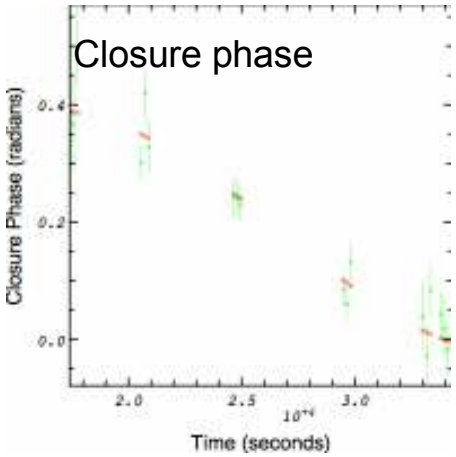
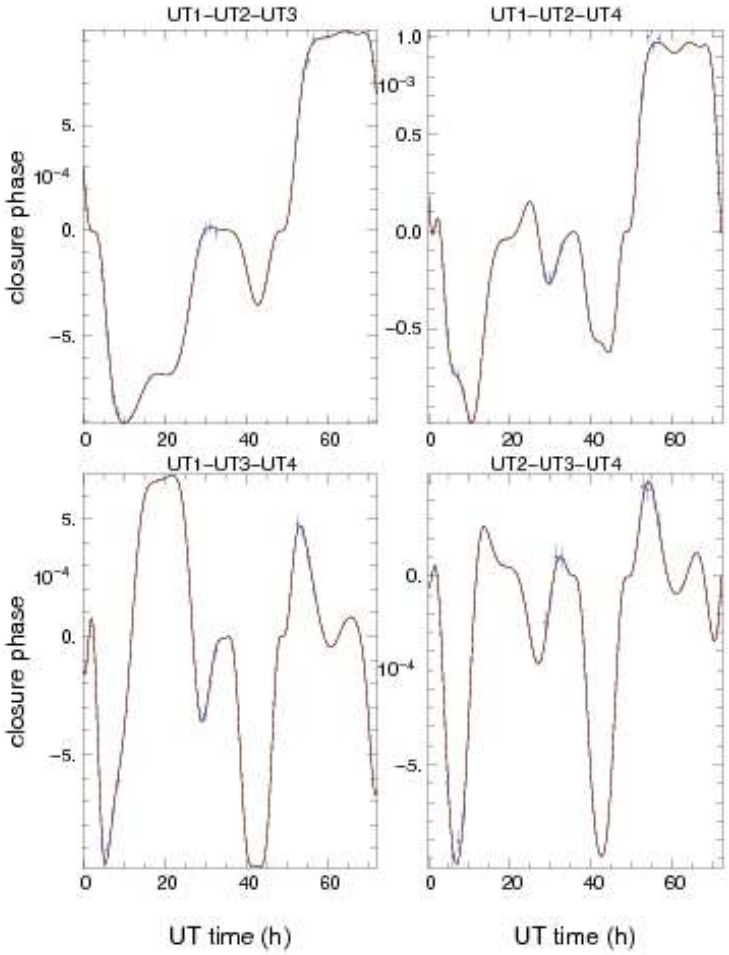


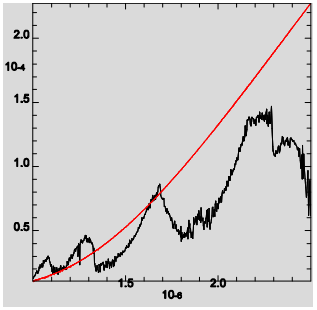


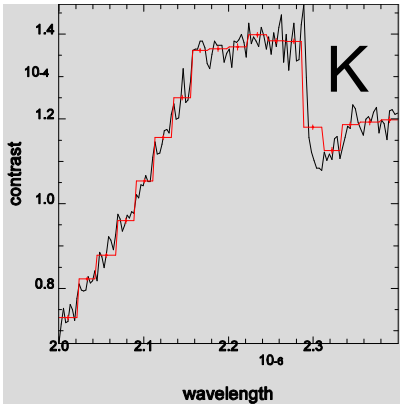
Berger, Monnier, Millan-Gabet, 2007

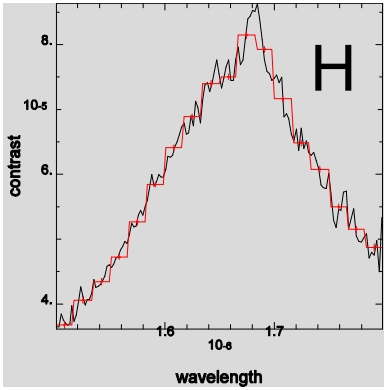
Detection of hot jupiters with closure phases prospective study for VSI/VLTI



VSI:
4 UT telescopes
3 nights,
4 measurements/night
Spectral resolution





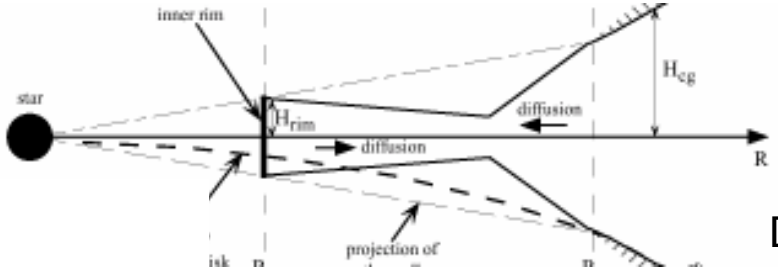


S. Renard (in this room), Absil, Berger, Bonfils, Forveille, 2007

Why should YSO emission should be skewed ?

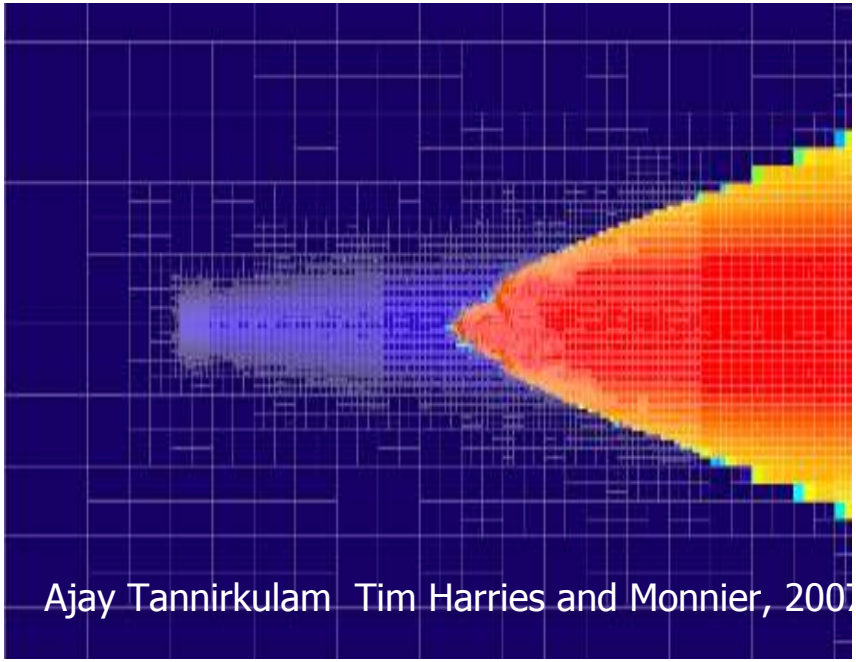
Answer two: inner disk geometry

Gas/dust density structure



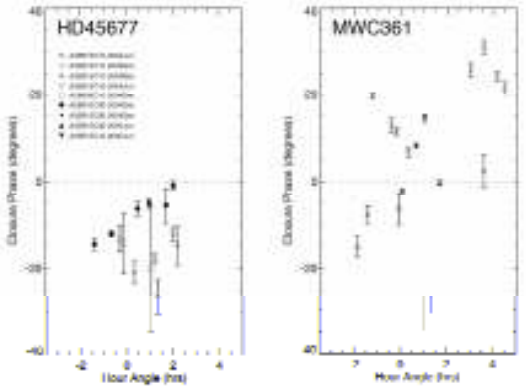
Dust settling

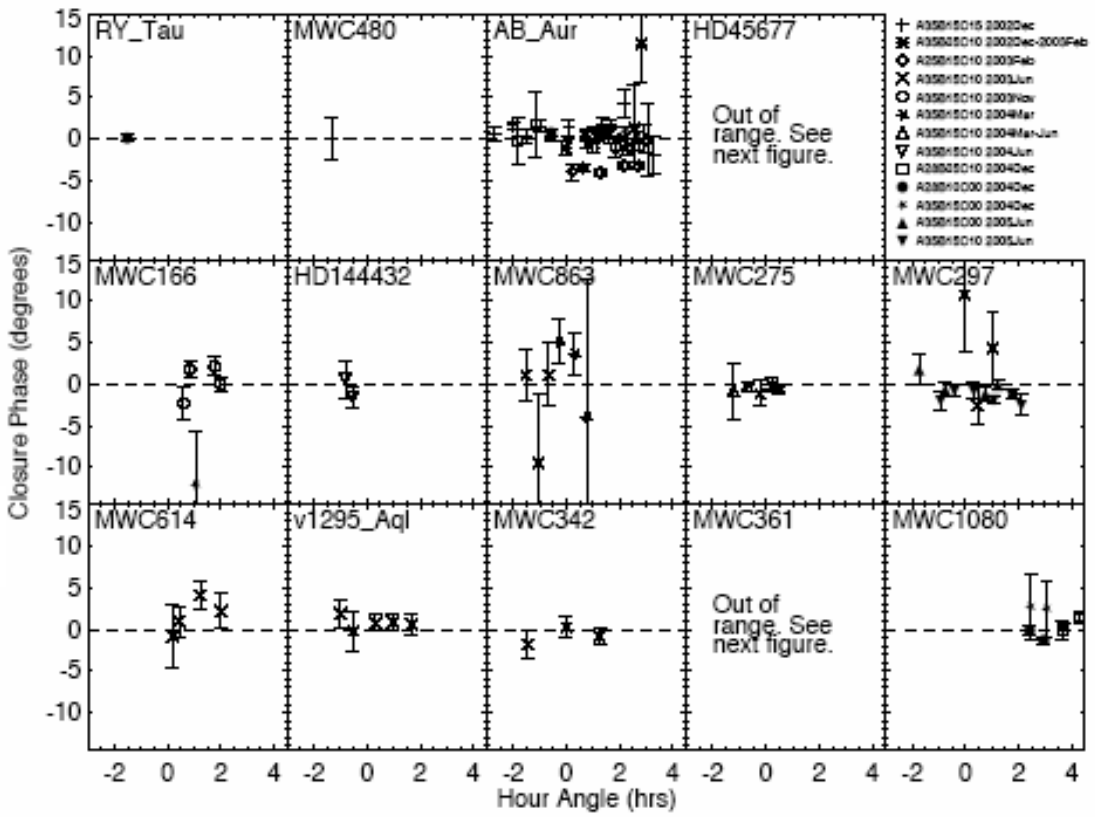
QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.



Isella et al. 2005

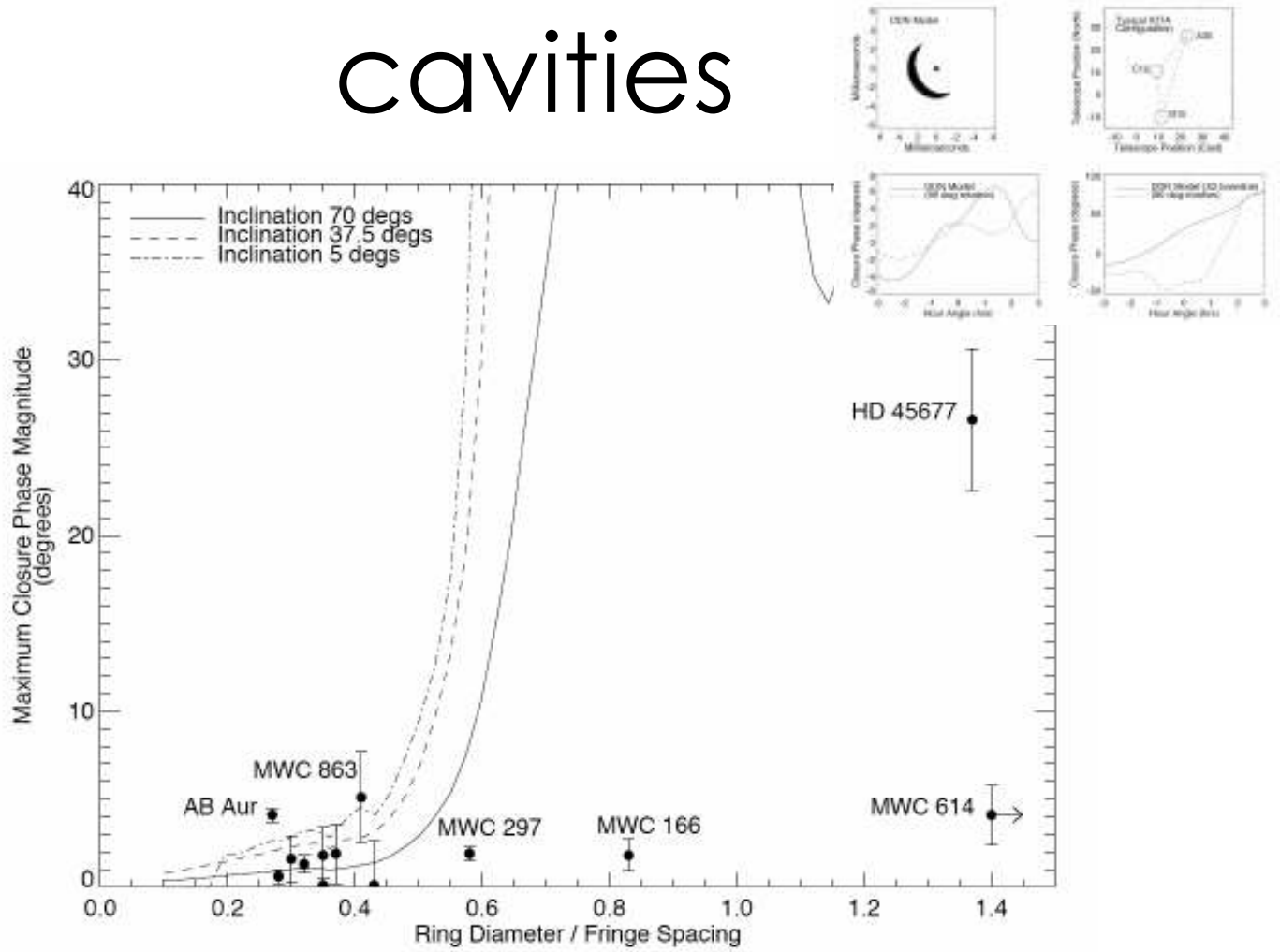
First Yso closure phase survey (IONIC3/IOTA)





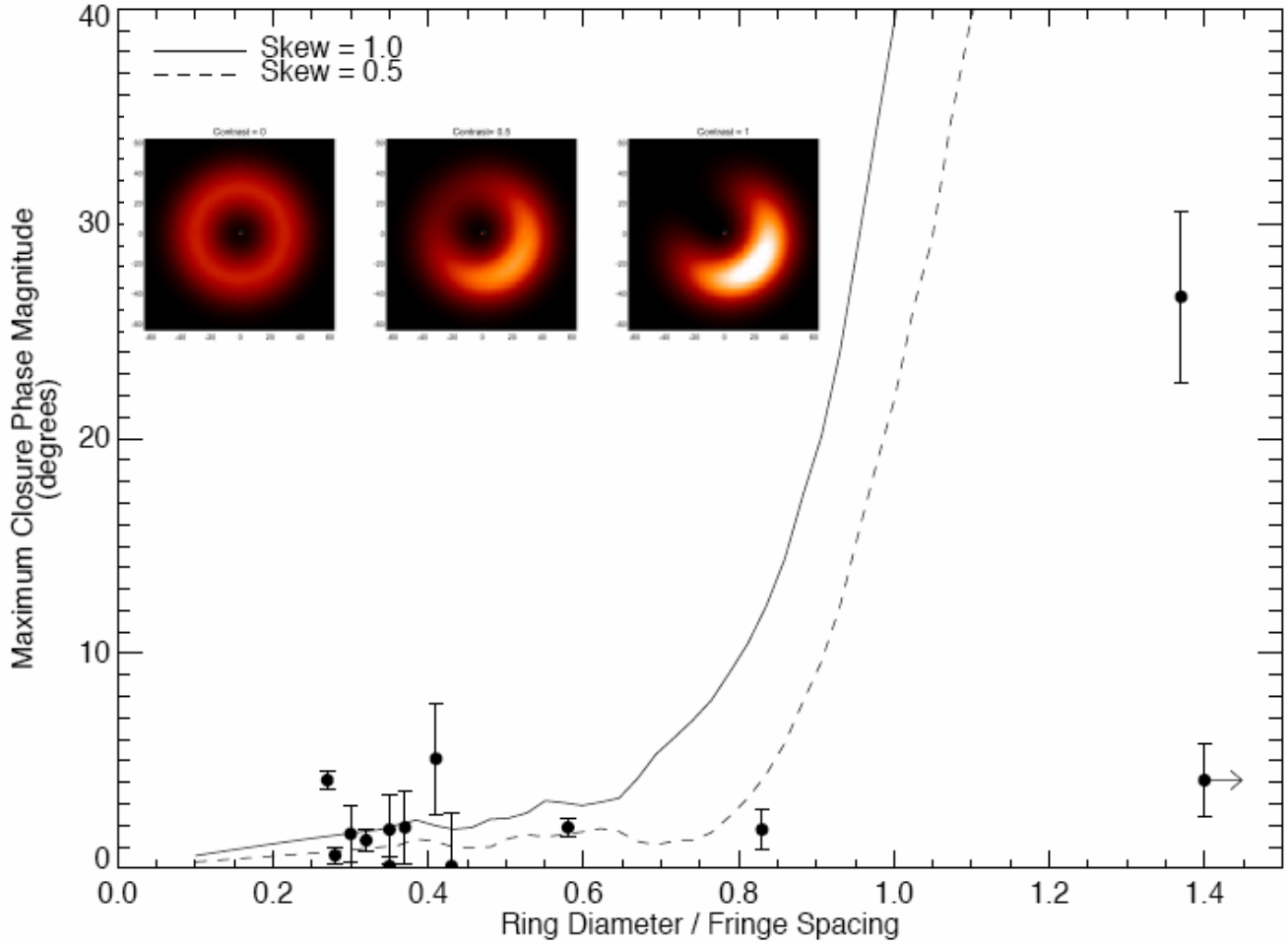
Monnier, Berger, Millan-Gabet et al. 2006

Inner wall with vertical cavities



Inner wall with smooth cavities

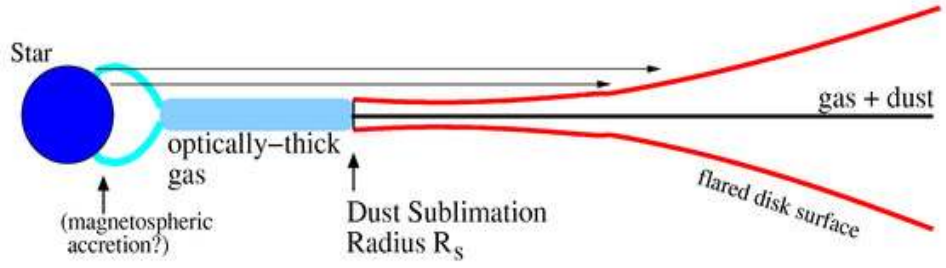
Resolution quite not there but VLTI should do (piece of cake needs just more sentivity)

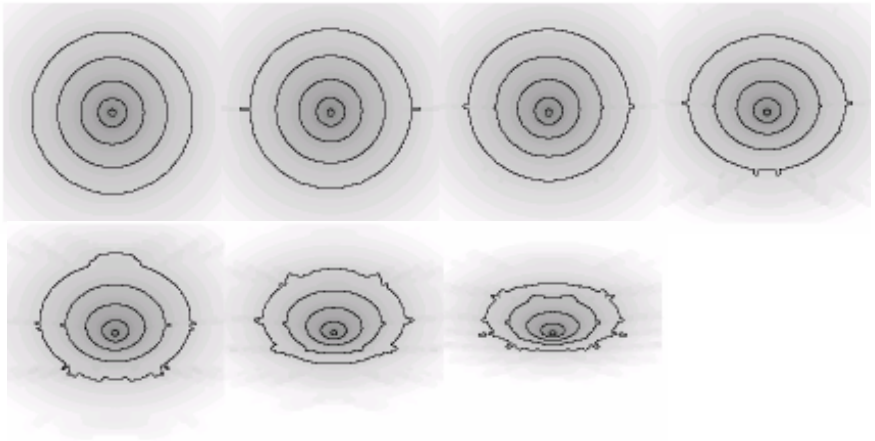


Why should YSO emission should be skewed ?

Answer three: disk structure

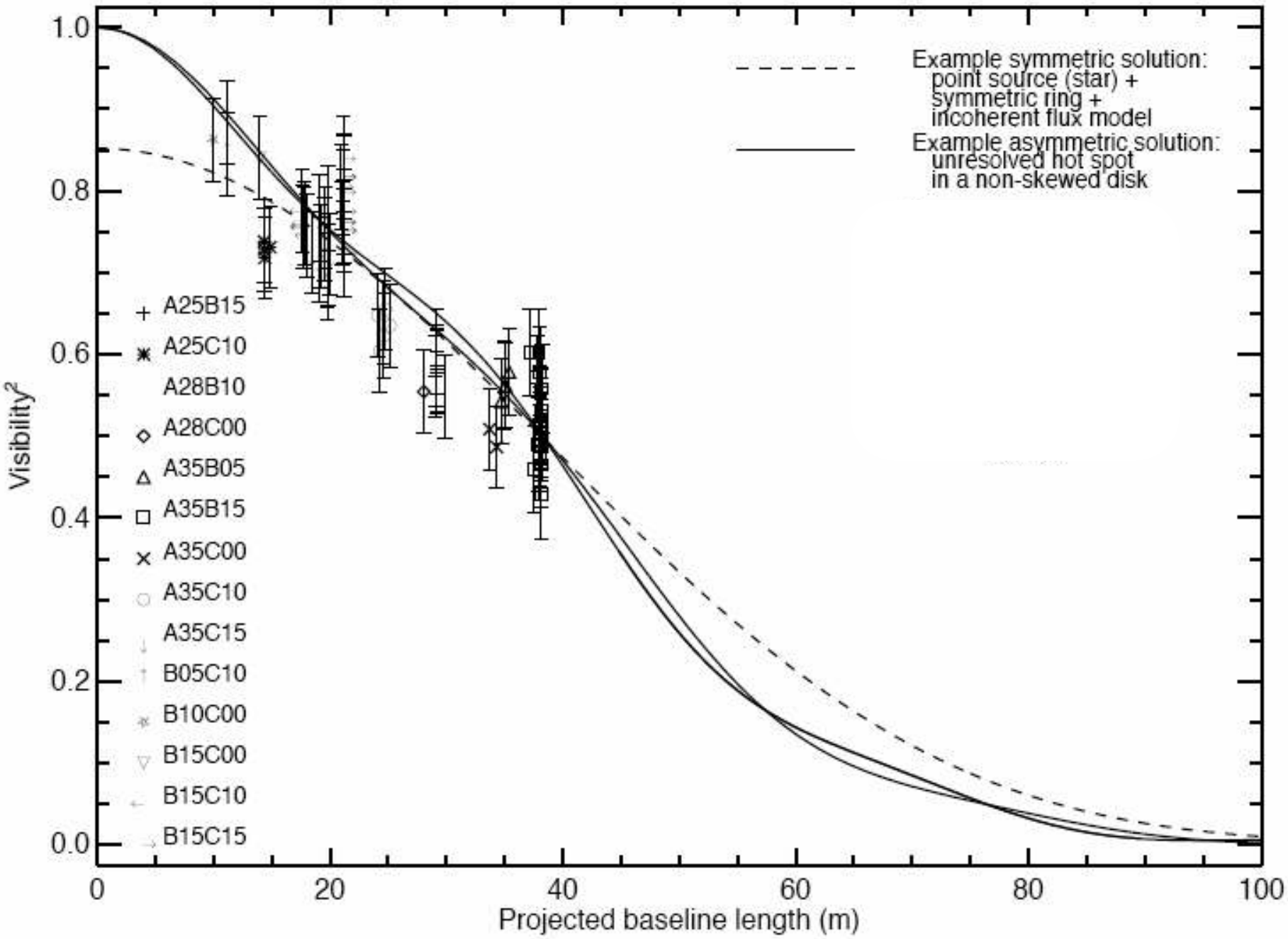
- Disk flaring
- Scattered emission (scattering phase function)
- … and more (jet/wind) emission

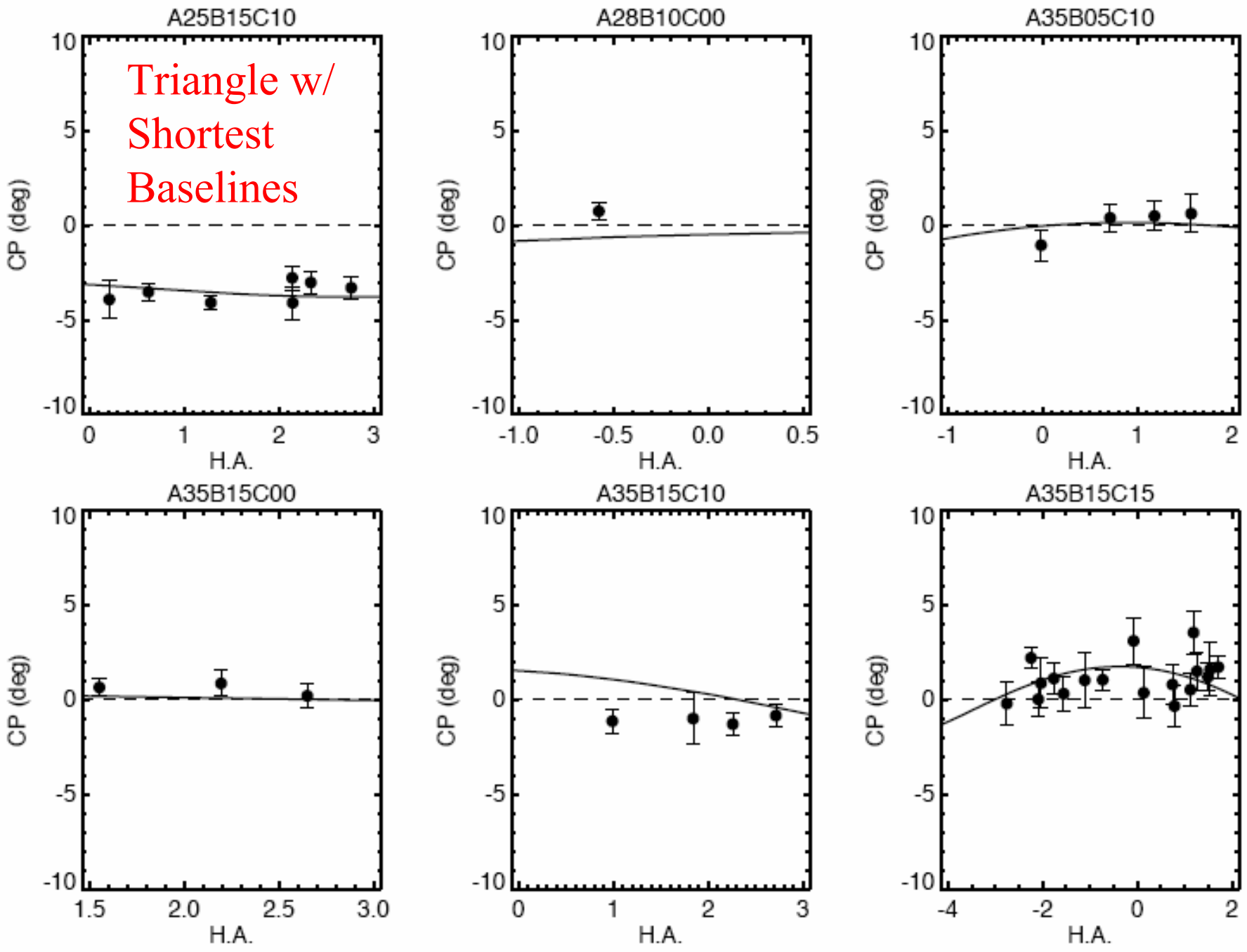




Malbet, 2001

Beware o ▪ f closure phases the peculiar case of AB Aur


Example symmetric solution:
point source (star) +
symmetric ring +
incoherent flux model
Example asymmetric solution:
unresolved hot spot
in a non-skewed disk
A25B15
A25C10
A28B10
A28C00
A35B05
A35B15
A35C00
A35C10
A35C15
B05C10
B10C00
B15C00
B15C10
B15C15
Visibility²
Projected baseline length (m)
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100


A25B15C10
A28B10C00
A35B05C10
A35B15C00
A35B15C10
A35B15C15
CP (deg)
H.A.
Triangle w/
Shortest
Baselines

AB Aur Results

- Long Baselines -> zero closure phase
- Point-Symmetric on scales of 4-10 milliarcseconds

- Short Baselines -> non-zero closure phase
- Asymmetric on scales of 10-50 milliarcseconds
- 4 degrees corresonds to ~7% asymmetry

- What could this be?

What interferometry won't tell us:

What is the physical cause of this localized, bright emission?

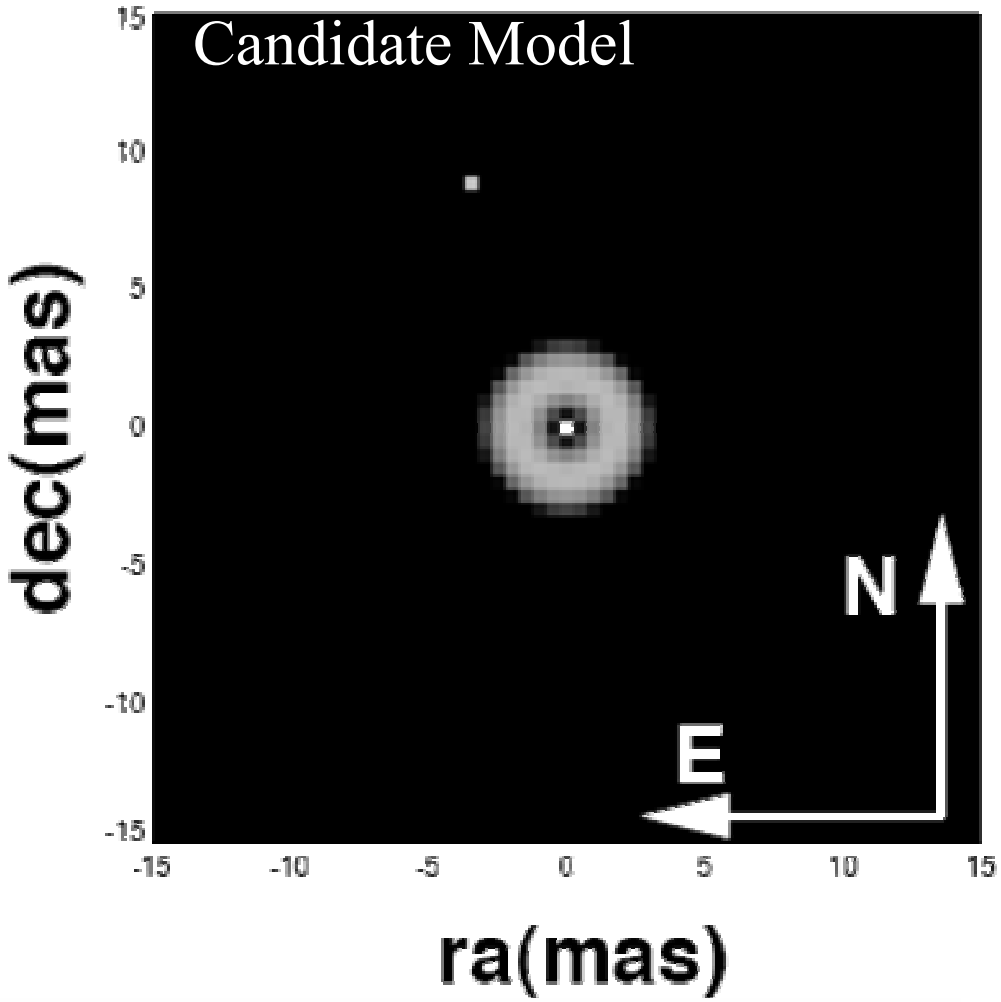
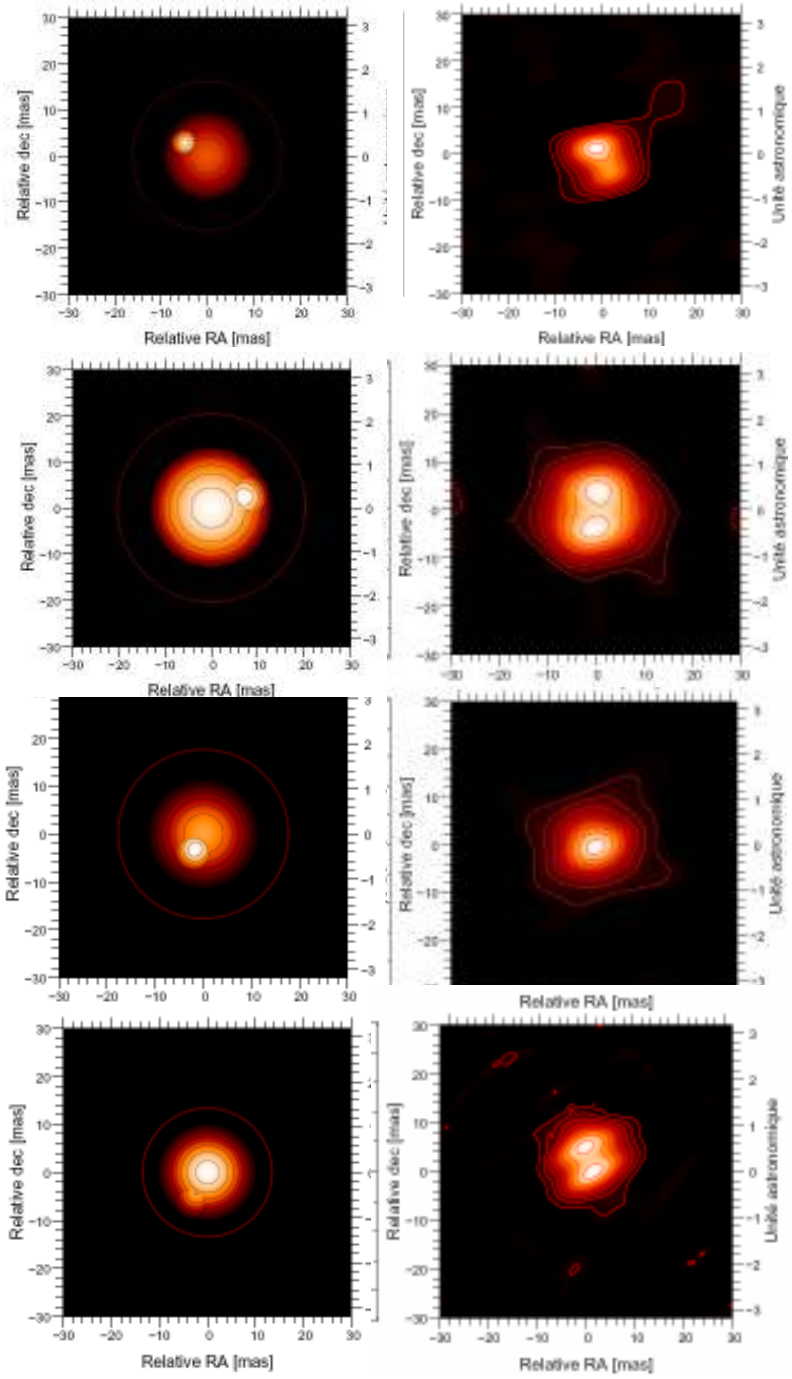


Table 1. Results from Fitting to "Disk Hot Spot" Model[a]

Model Description	Fraction of Light Star	Disk	Spot	Disk Properties	Spot Properties	Reduced χ^2 (V^2,CP)
Unresolved hot spot with non-skewed disk[b]	0.3	0.68	0.02	Ring Diameter 3.6 mas Ring Width/Diameter 0.25	Unresolved Spot r_G =9 mas at PA 22°	1.5
Gaussian hot spot with skewed disk	0.3	0.62	0.08	Ring Diameter 3.1 mas Ring Width/Diameter 0.5 Max Skew=1.0 at PA 172°	Gaussian FWHM 12 mas r_G =29 mas at PA 12°	1.8

Imaging vs. closure phases

- Not opposed: complementary
- Unless you have tens of closure phases and visibilities fitting in the visibility and closure phase space provides the best way to quantify your measurements
- A preliminary inspection in the Fourier space can provide a good hint for image reconstruction prior



S. Lacour et al 2007 (IONIc3/IOTA)

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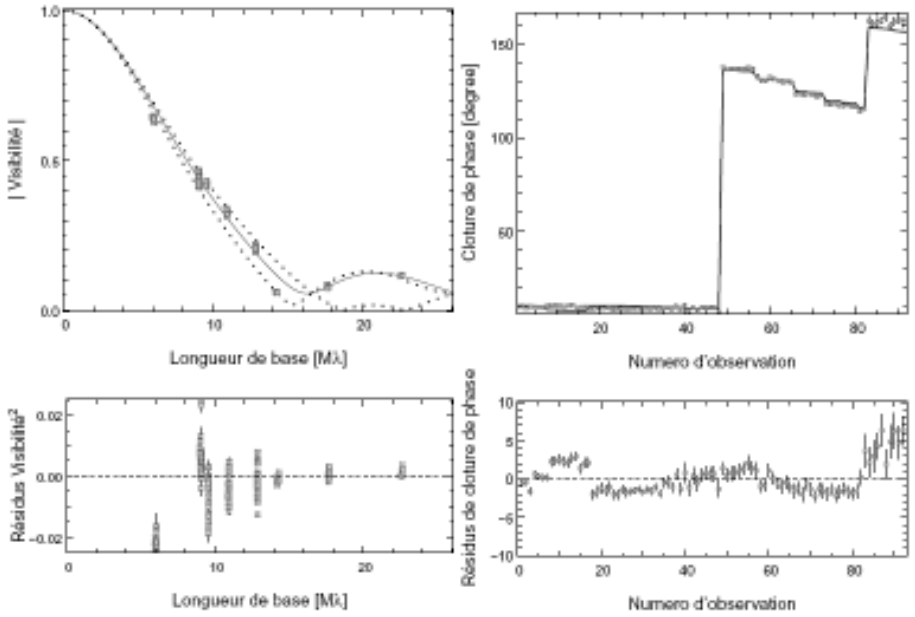

Conclusion

- Phases and closure phases are just beginning to be exploited in Yso science
- Closure phases allows precision interferometry (easier calibration). Allow brightness distribution skewness to be probed.
- Now is time for you to step in…
- Think about VLTI second generation instruments VSI (6T), Matisse (4T), Gravity (4T), how many baselines, how many closure phases?