# An incisive look at the interacting binary SS Leporis

## Milli-arcsecond imaging with PIONIER/VLTI


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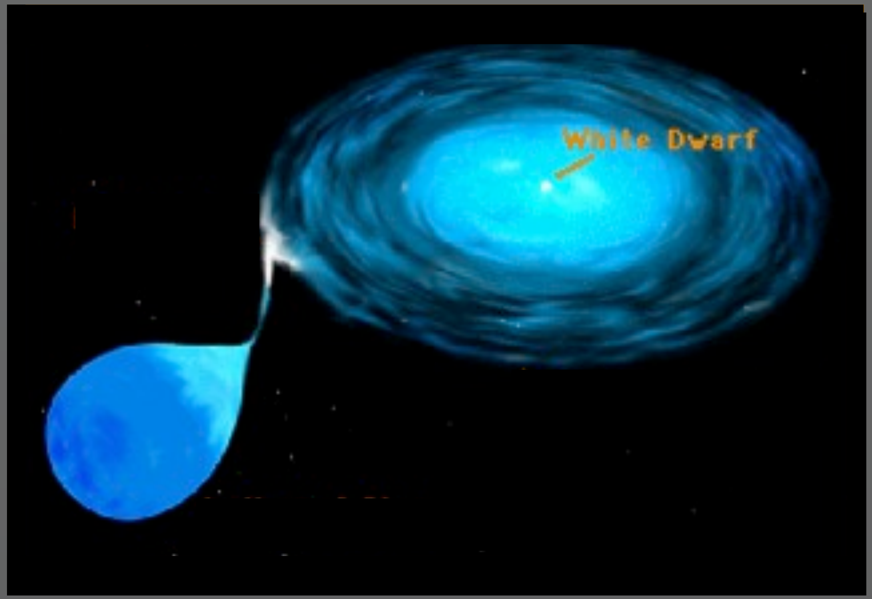
# Interest of interacting binaries

In general: a mass losing giant + a compact star + complex structures

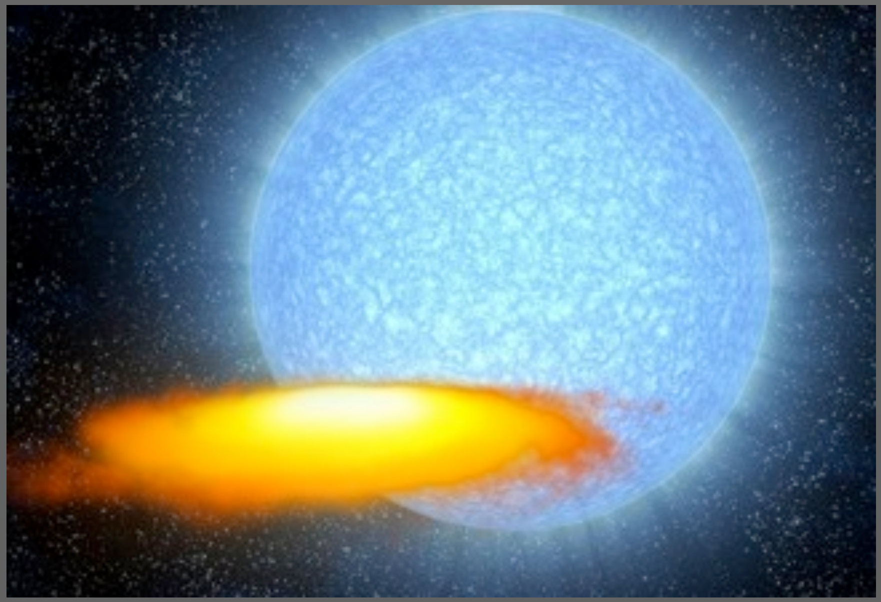
Properties relevant to many astrophysical objects → Excellent laboratories to study numerous physical processes

**Evolution dominated by mass transfer processes**




Roche lobe overflow (RLOF)

Stellar wind accretion



# The breakthrough of interferometry

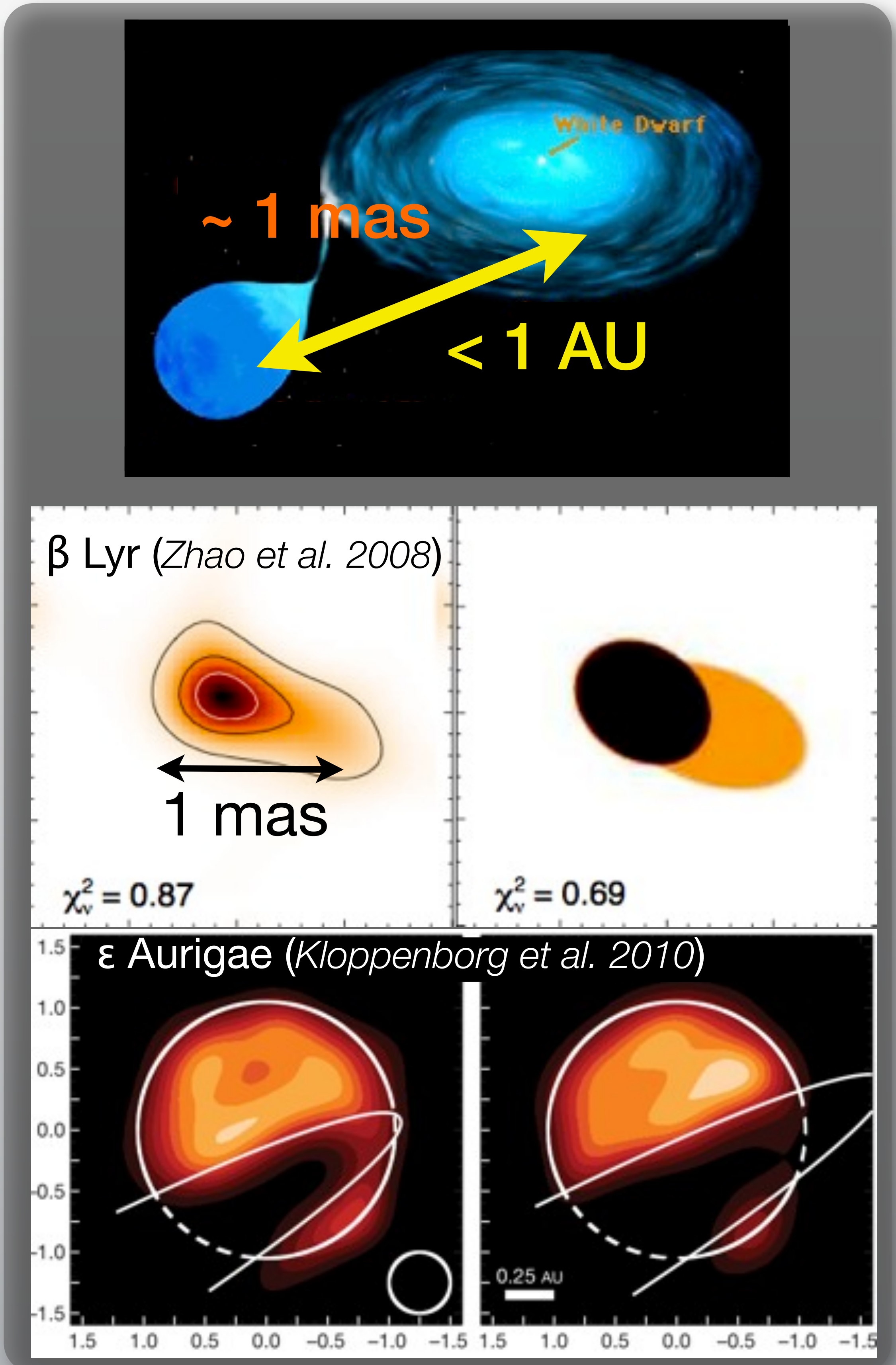
<u>Spectroscopy or Photometry</u>

→ Indirect observables

→ Assumptions required

Numerous unsolved problems, e.g.:

*ellipsoidal variability in detached system?*




**<u>Optical interferometry</u>**

→ Direct observables

Constraints on physical sizes, morphology

New model-independent imaging capability

# The case of SS Leporis

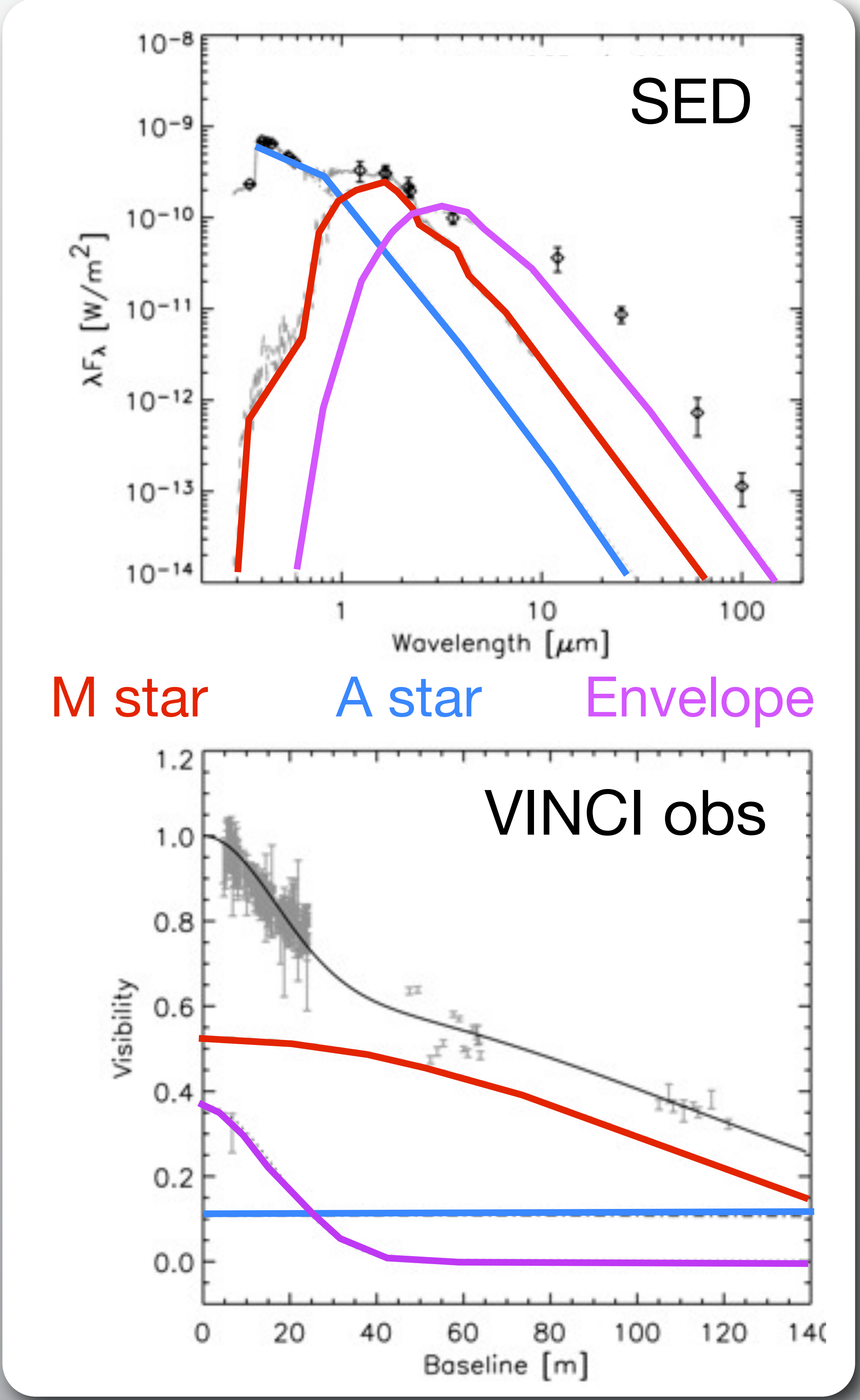
M giant + A star + circumbinary envelope
Precursor of post AGB binaries

Algol-type system
Mass ratio $M_A/M_M \sim$ 2 to 4
→ hints for mass transfer

**Roche lobe overflow**

Distance ~ 270 to 370 pc
Orbit: - P = 260d
- Quasi circular
- Inclination *estimated* to ~ 30°
- Separation ???

*Verhoelst et al. 2007,* Welty et al. 1995, Jura et al. 2001



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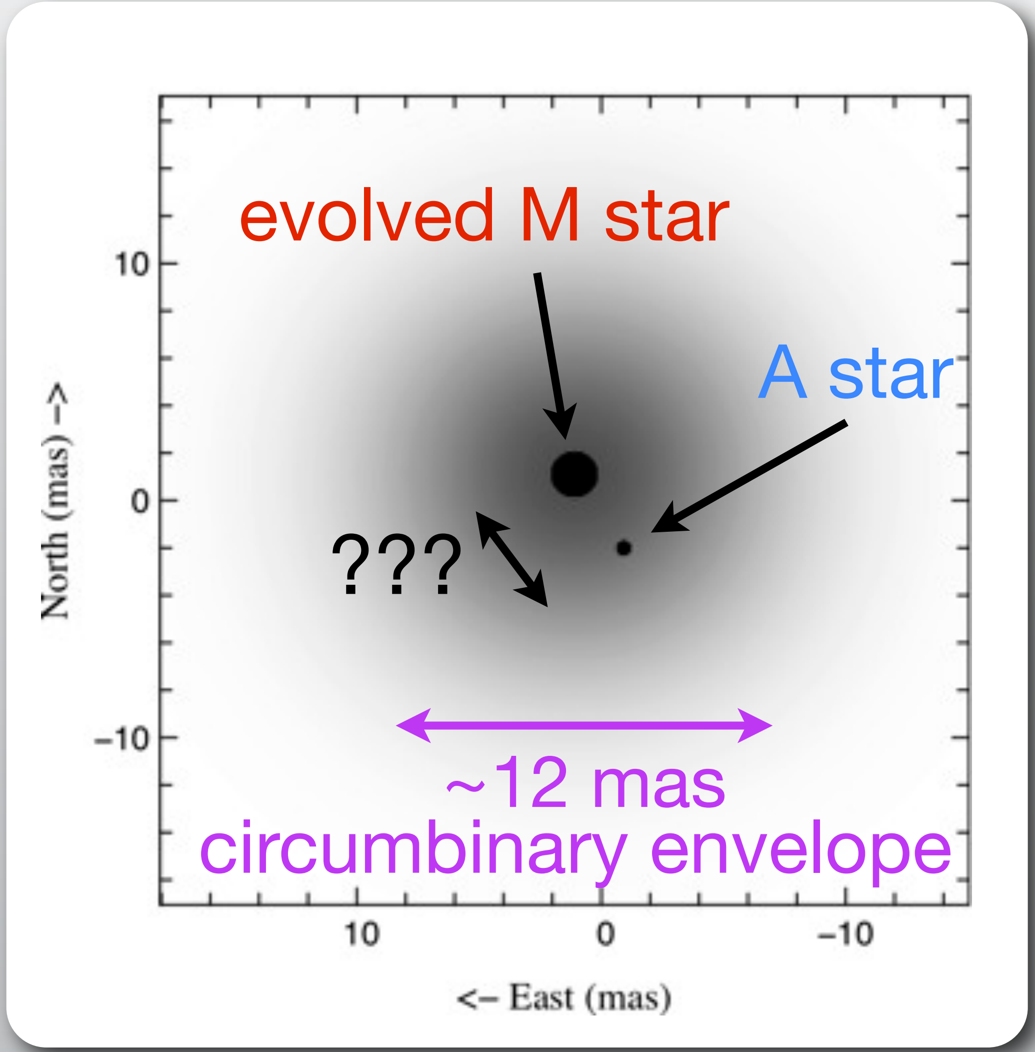


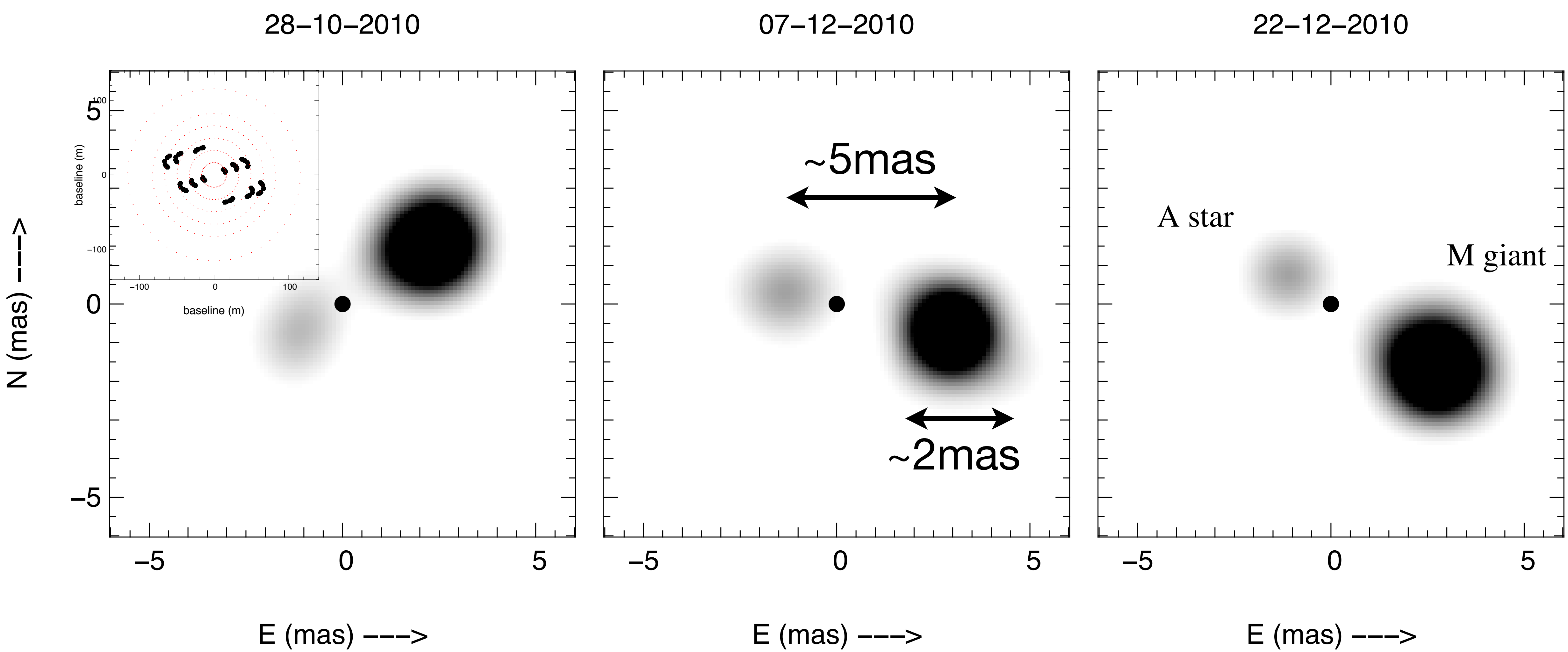

*Verhoelst et al. 2007,* *Welty et al. 1995, Jura et al. 2001*

# VLTI observations

4 AMBER archive + 4 PIONIER comissionning

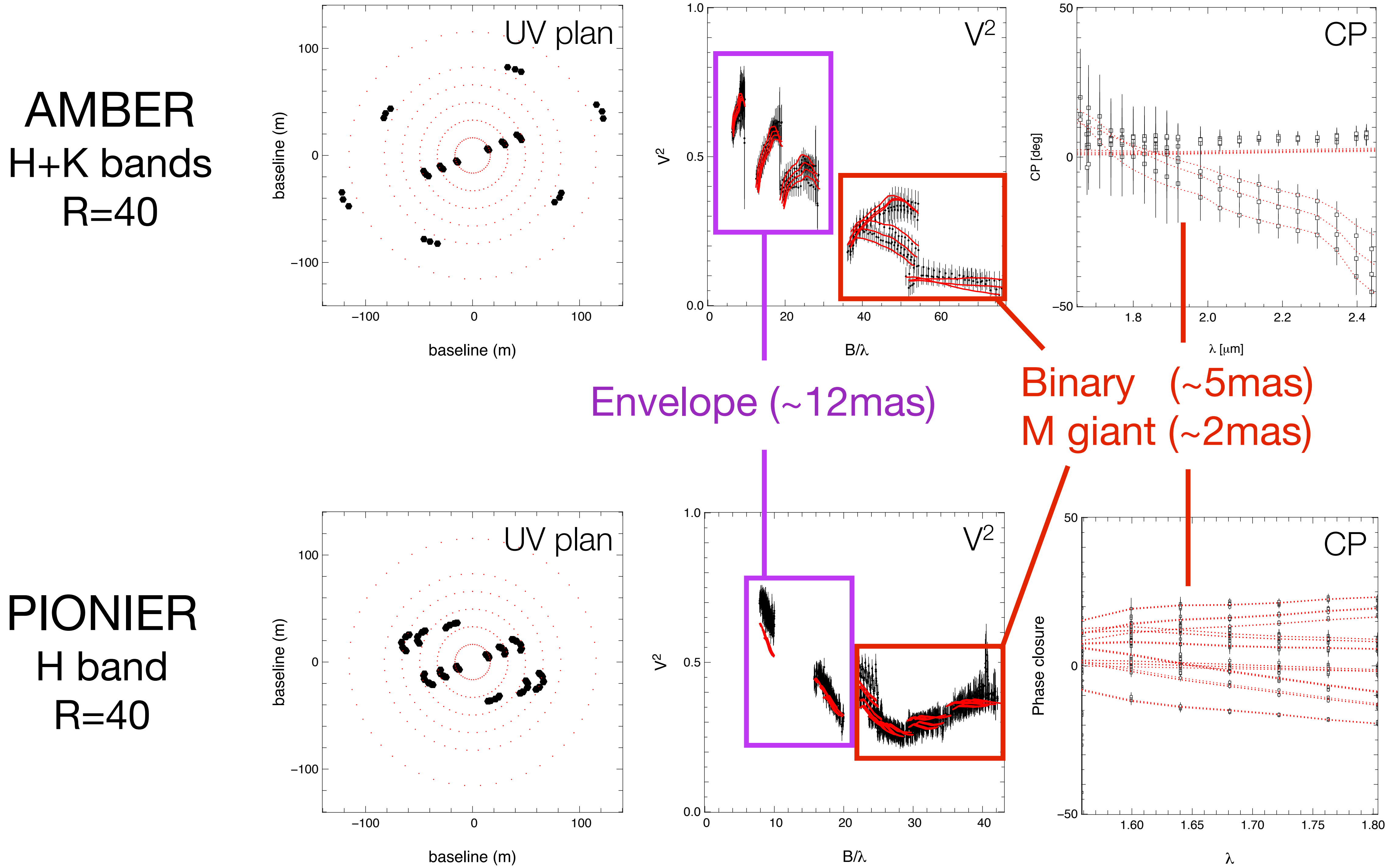
## PIONIER images: **SS Lep as a *visual* binary**

Commissionning data: resolution ~1mas, 2-4h obs each
1st images of an interacting binary @ VLTI



# VLTI observations

## Parametric modeling: a binary plus circumbinary material



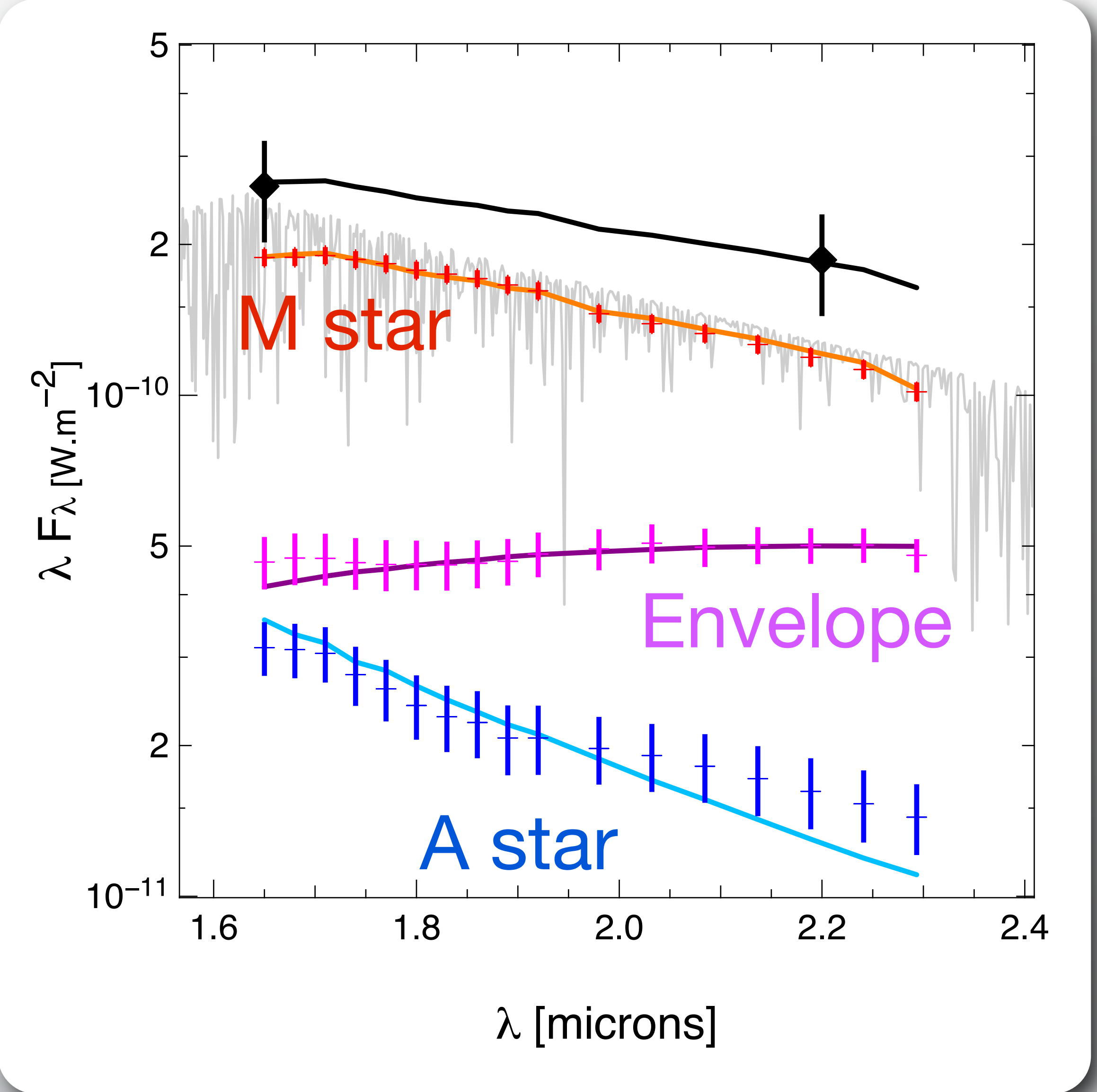
# The energy balance

M star MARCS model
3200±200K
high metallicity?

A star Rayleigh-Jeans, 9000K
10x oversized (∅~0.6mas)
OR
accretion disk ?

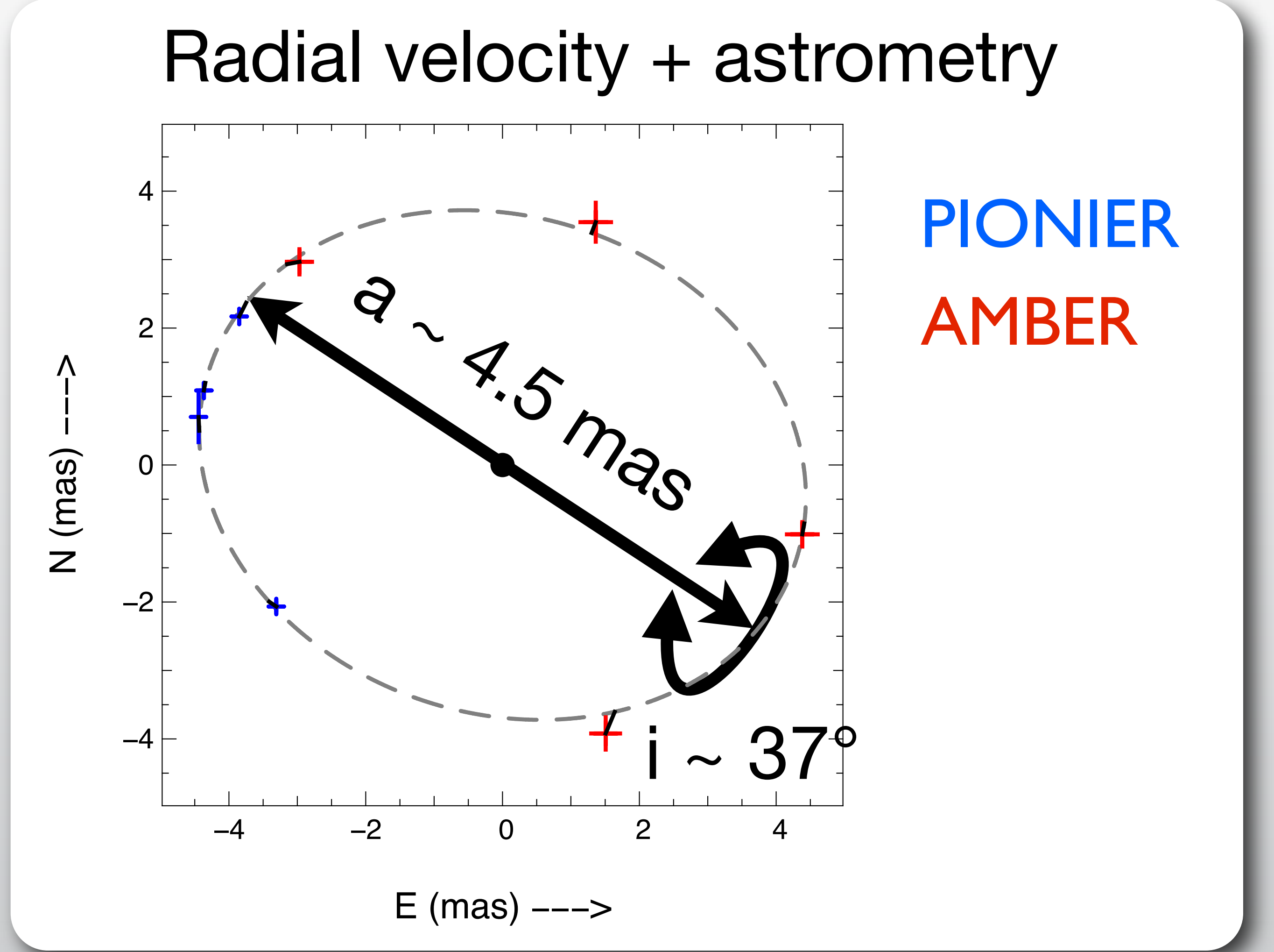
Envelope BB @1700K, gaussian?
FWHM ~8mas

Relative flux + 2MASS points →




!!! low resolution spectrum

# The orbit and masses



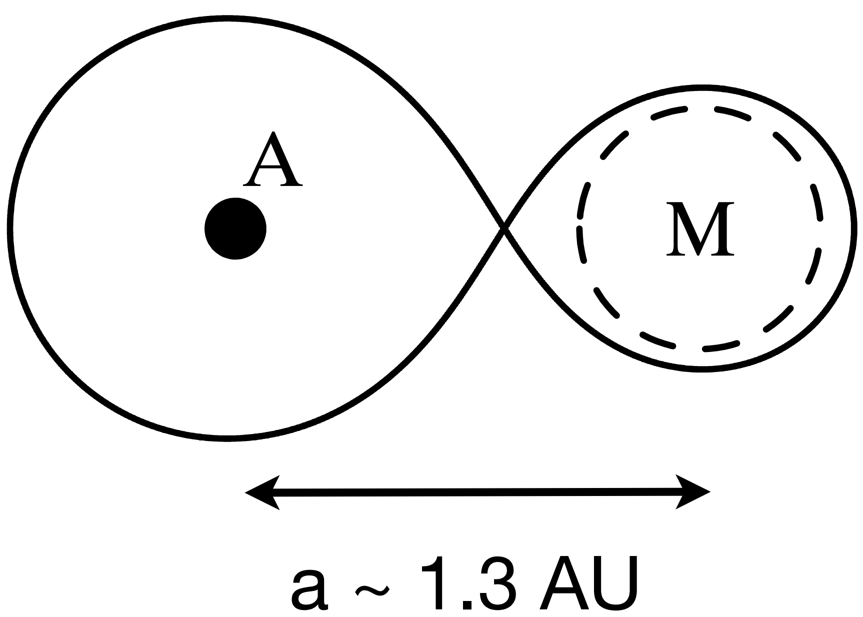

| | Before | Now |
|---|---|---|
| d [pc] | 330±70 | 280±25 (Hipparcos) |
| $M_A$ [$M_\odot$] | 2~3 | 2.7 ± 0.3 |
| $M_M$ [$M_\odot$] | 0.35~1 | 1.3 ± 0.3 |
| $M_A/M_M$ | 4±1 | 2.2 ± 0.3 |

Errors dominated by the distance uncertainty

# Mass transfer: stellar wind accretion!

| | Before | Now |
|---|---|---|
| $\varnothing_M$ [mas] | 3.1 ± 0.3 | 2.2 ± 0.01 |
| d [pc] | 330±70 | 280±25 |
| $\varnothing_M$ [$R_\odot$] | 220±60 | 130±7 |
| Roche lobe filling | 140±20 % | 85±3 % |

Errors dominated by the distance uncertainty

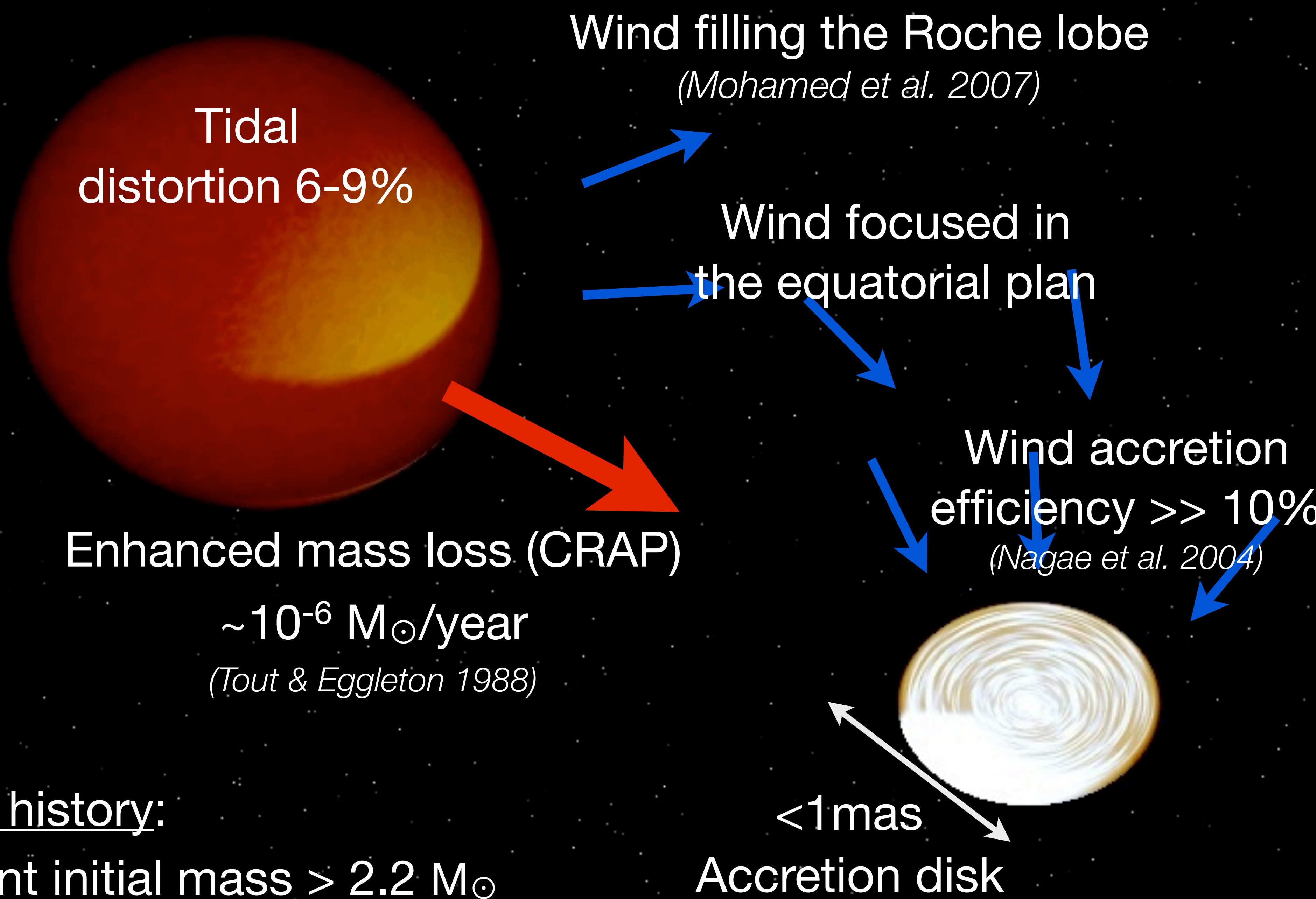



No Roche lobe overflow

↓

Stellar wind accretion

# Current vision of SS Lep




System history:

- Giant initial mass > 2.2 $M_\odot$
- No need for a RLOF

# Summary

**Results**: new vision of the system
Interfero + spectro: - orbit + masses
- important constraints on the mass transfer process

**Future work** on SS Lep:

- Last PIONIER run: hints for an outburst?
- Circumbinary disk morphology → NaCo/SAM + PIONIER
- Tidal distortion of the M giant? → PIONIER
- Wind morphology + real size of the giant → MR AMBER + VEGA
- Accretion disk or oversized star? → VEGA

**+** simultaneous spectro/photometry

**Important potential of interferometry for interacting binaries**
with model-independent imaging, e.g.:

- Ellipsoidal variability in detached systems?
- Impact of radiation pressure on the Roche lobe geometry?
- Wind focused in the orbital plan?
- ...