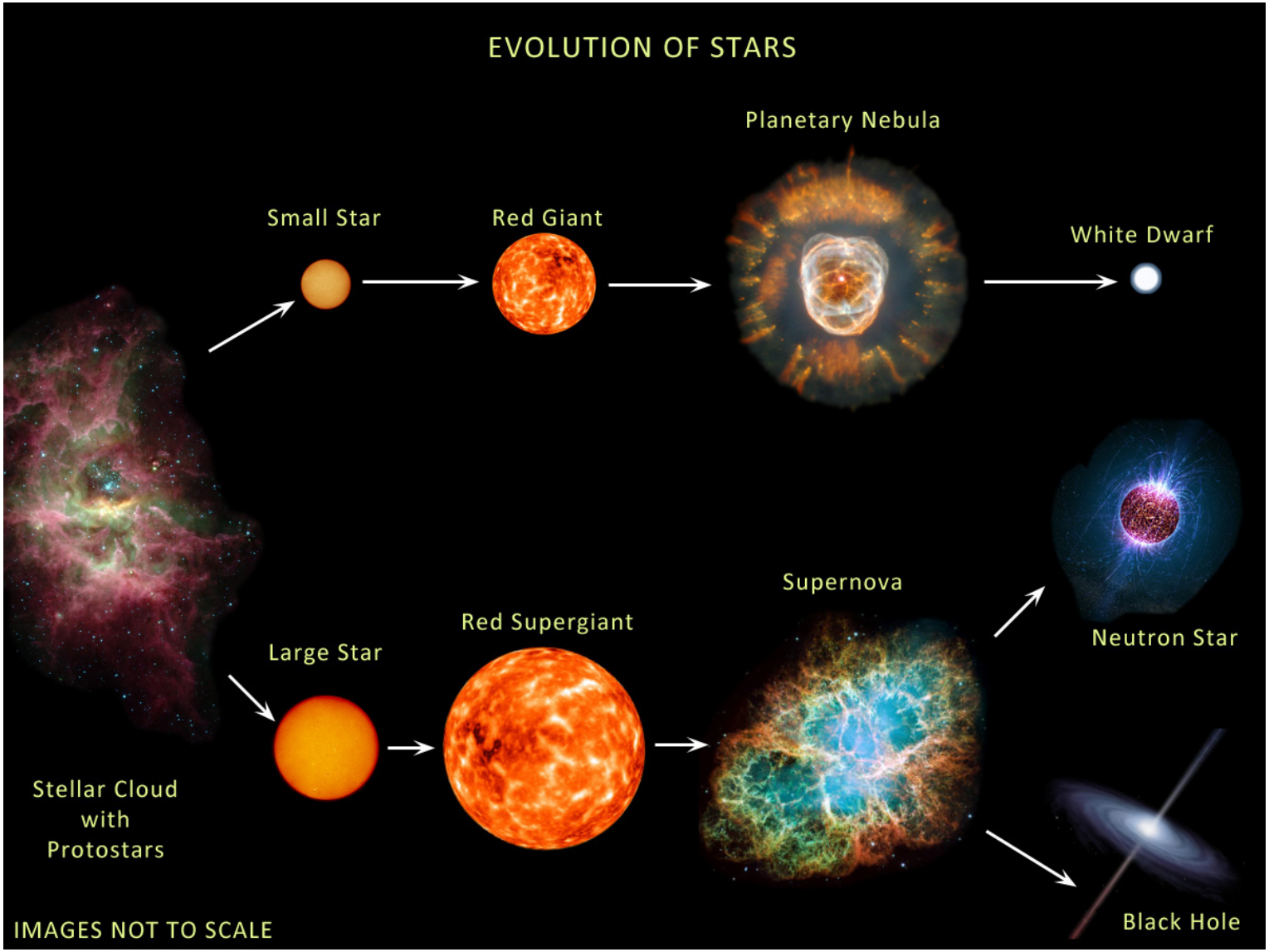
About the angular diameter of red supergiant stars

Miguel Montargès (IRAM)

VLTI Community Days
ESO Garching - March 9th 2017

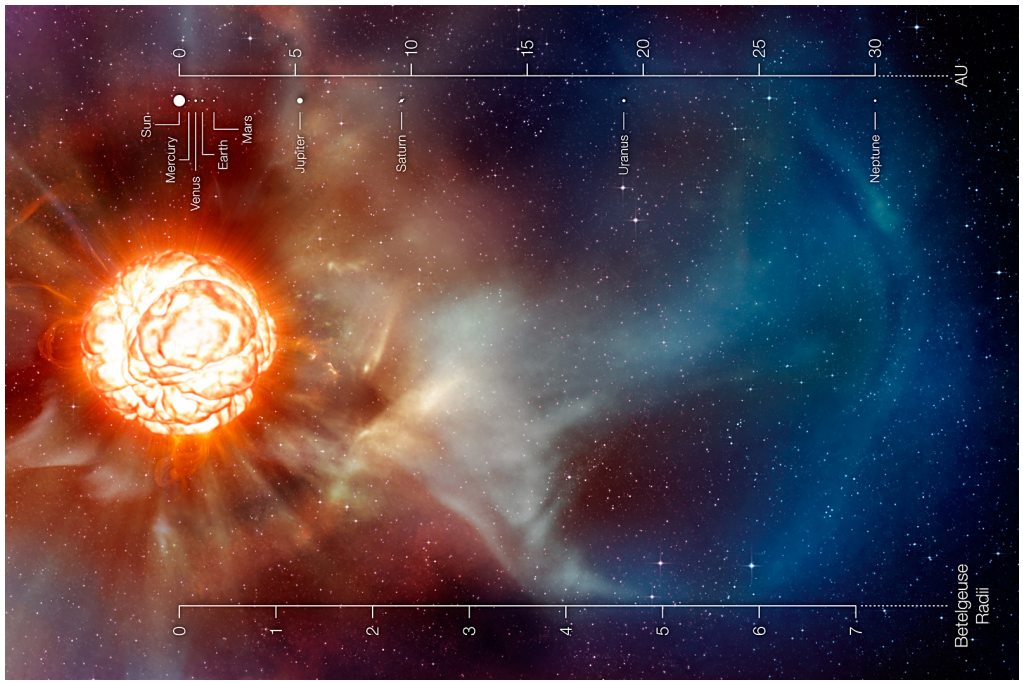
Stellar evolution



Trigerring the RSG mass loss

- Physical process remains unknown (no flares, no large pulsations)
- Josselin & Plez (2007) suggested a convection triggered mass loss
- Auriere et al. (2010) observed magnetic field $\sim$ 1 G

  + Airapetian et al. (2000): model Alfvén-wave triggered outflow



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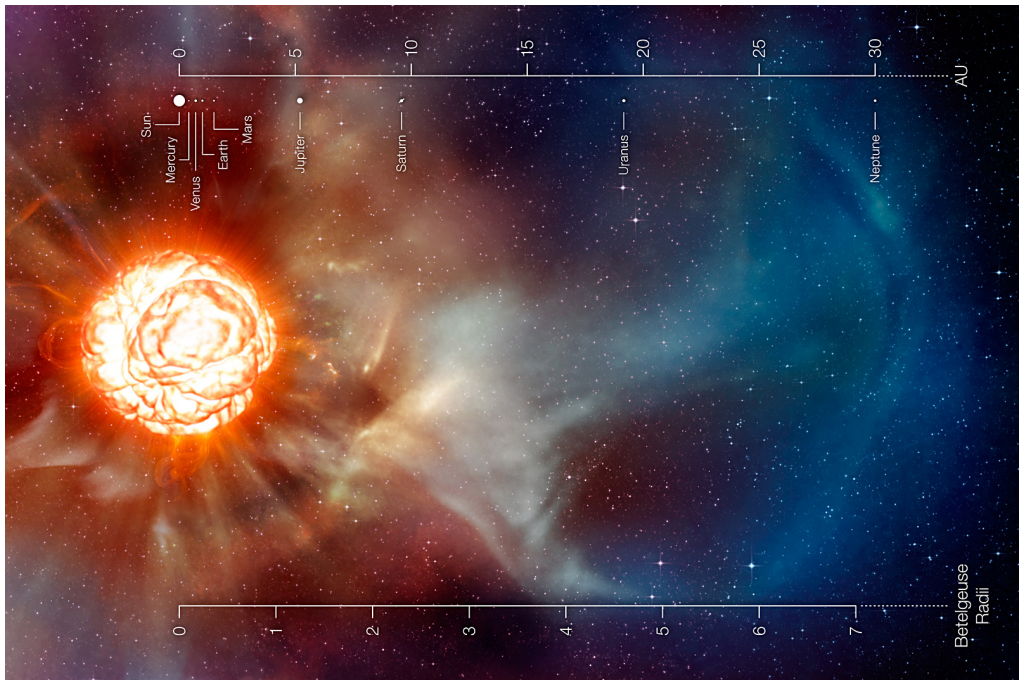
$\rightarrow$ Study of the photosphere $+$ CSE



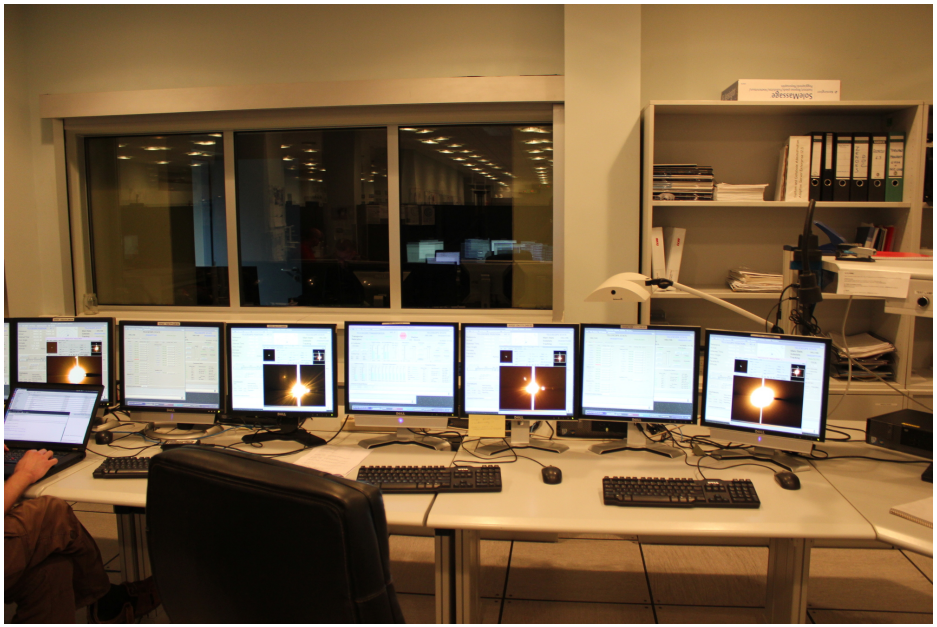
Spatial scales

(P. Kervella)

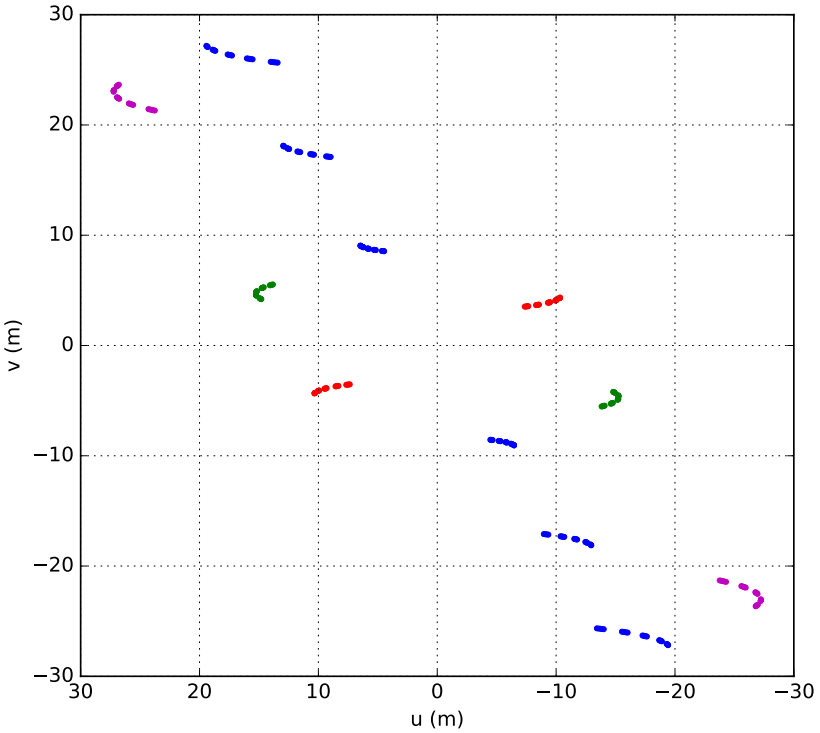
PIONIER monitoring of Betelgeuse (α Ori)

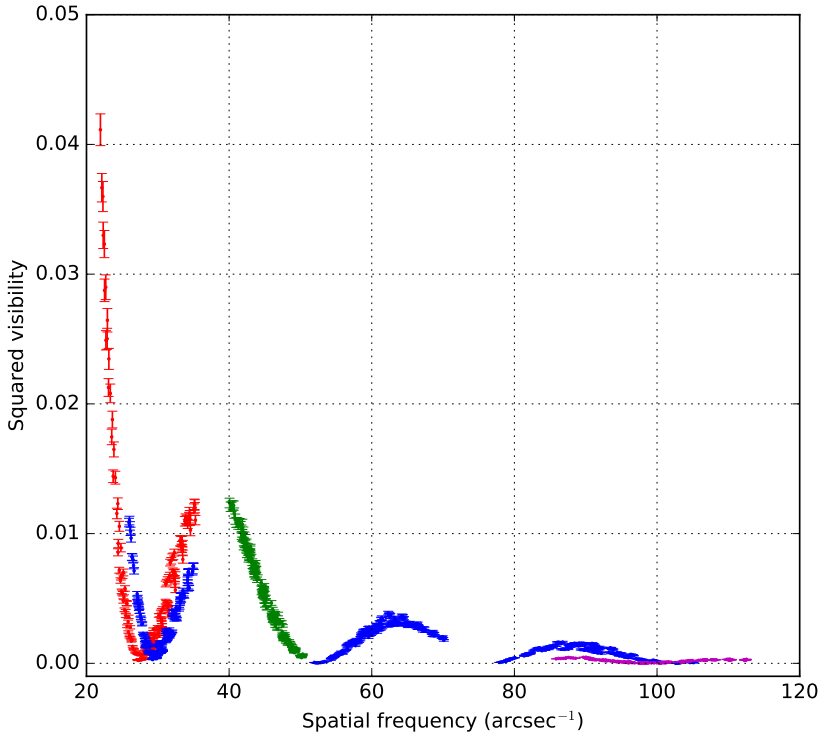
- VLTI/PIONIER observations (4 telescopes, H band, low spectral resolution, R = 40)
- 4 epochs of monitoring: Jan. 2012, Feb. 2013, Jan. 2014 and Nov. 2014
- Only the compact array configuration (baseline length $\in [11; 36\ \mathrm{m}]$)

$\Rightarrow$ Montargès et al. (2016), *A&A*, 588, A130



Betelgeuse@PIONIER: Shape of the visibilities (2013)





- Consistent between the 4 epochs (3 different features to avoid detector saturation)

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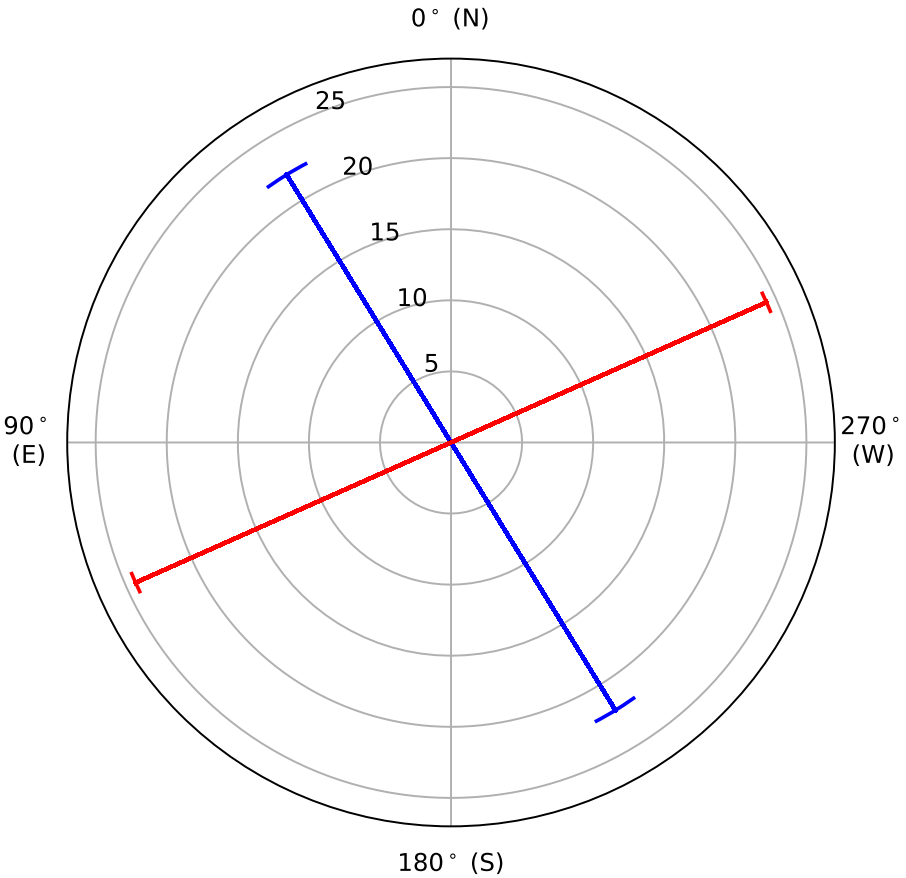

Limb-darkened disk fit:
44.21 vs 48.56 mas
$\Rightarrow$ 10% difference !

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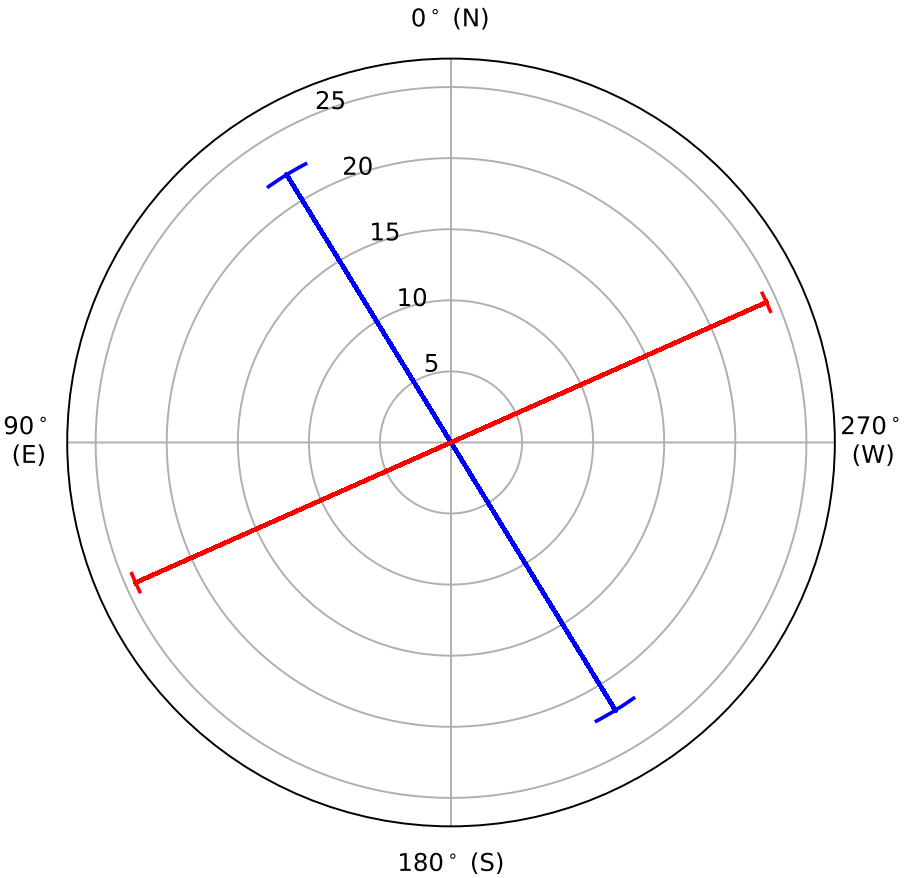

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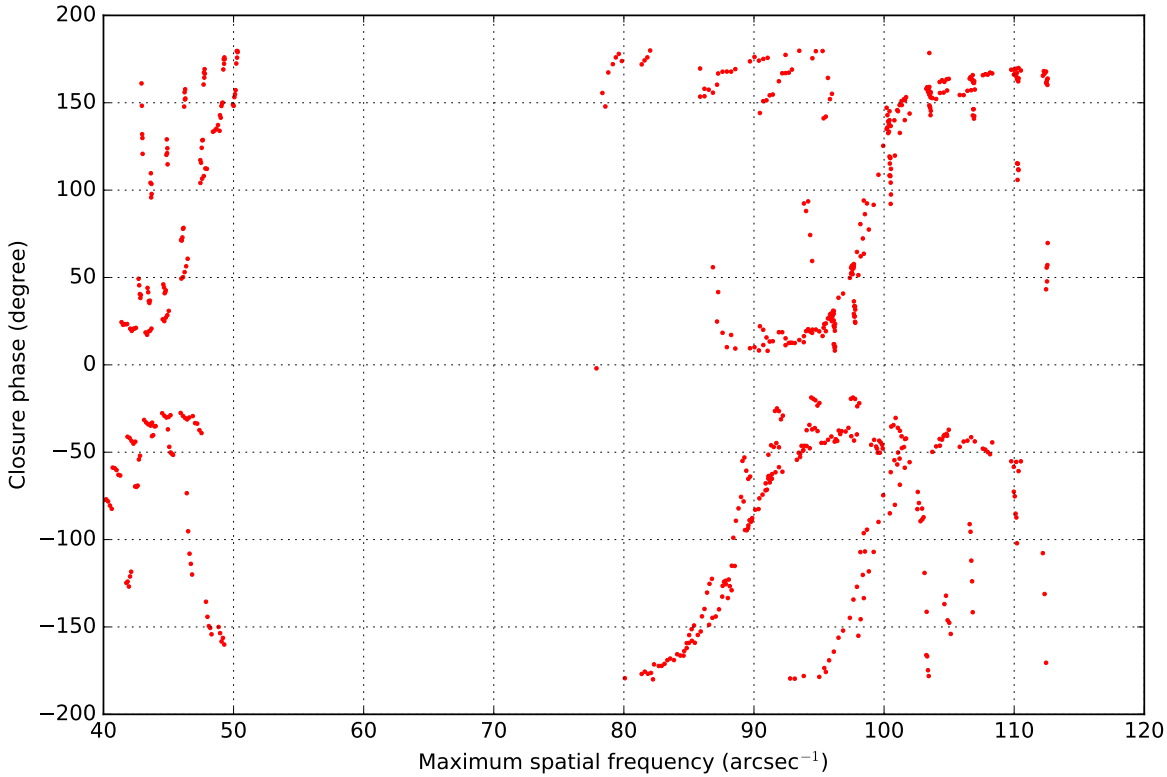
AND litterature value $\sim$ 42 mas

Betelgeuse@PIONIER: Shape of the closure phase (2013)



- Strong signal
- Incompatible with elliptical model

Betelgeuse@PIONIER: LDD model + gaussian hotspot

- Chiavassa et al. (2009, 2010) showed that convection can displace the nulls of the visibility function (as a function of P. A.)

→ Difficulty: angular diameter cannot be inferred from the first null anymore

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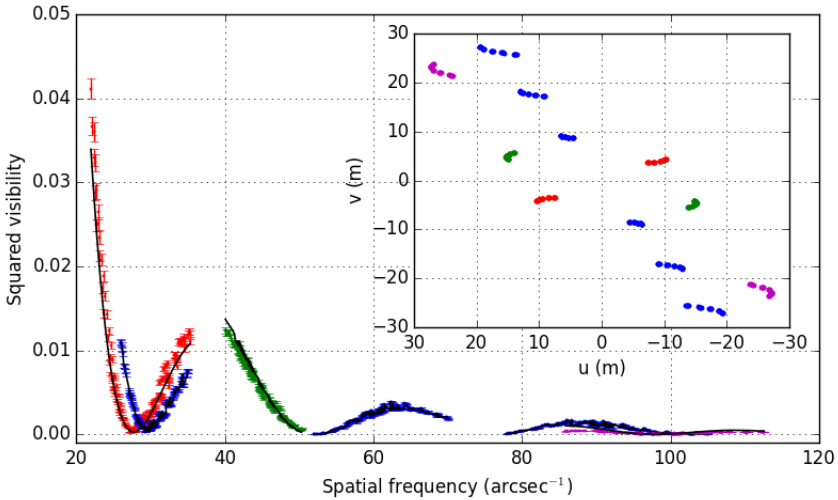
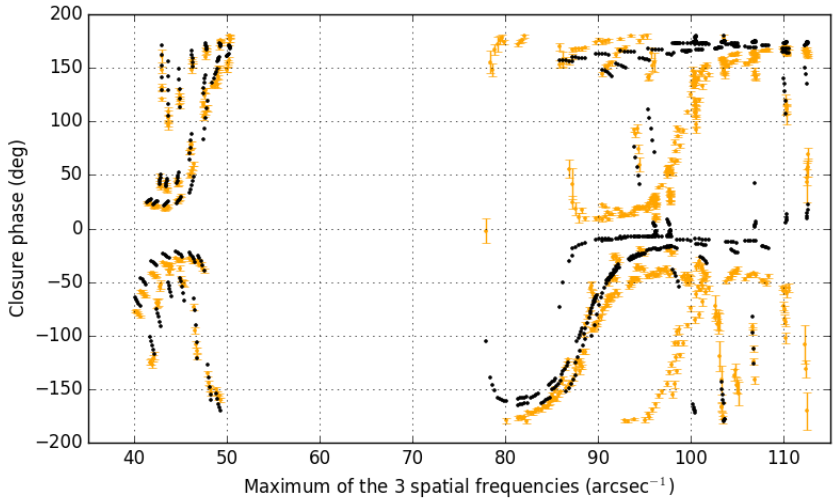
- Good agreement + angular diameter consistent with literature$\sim$ 43 mas)





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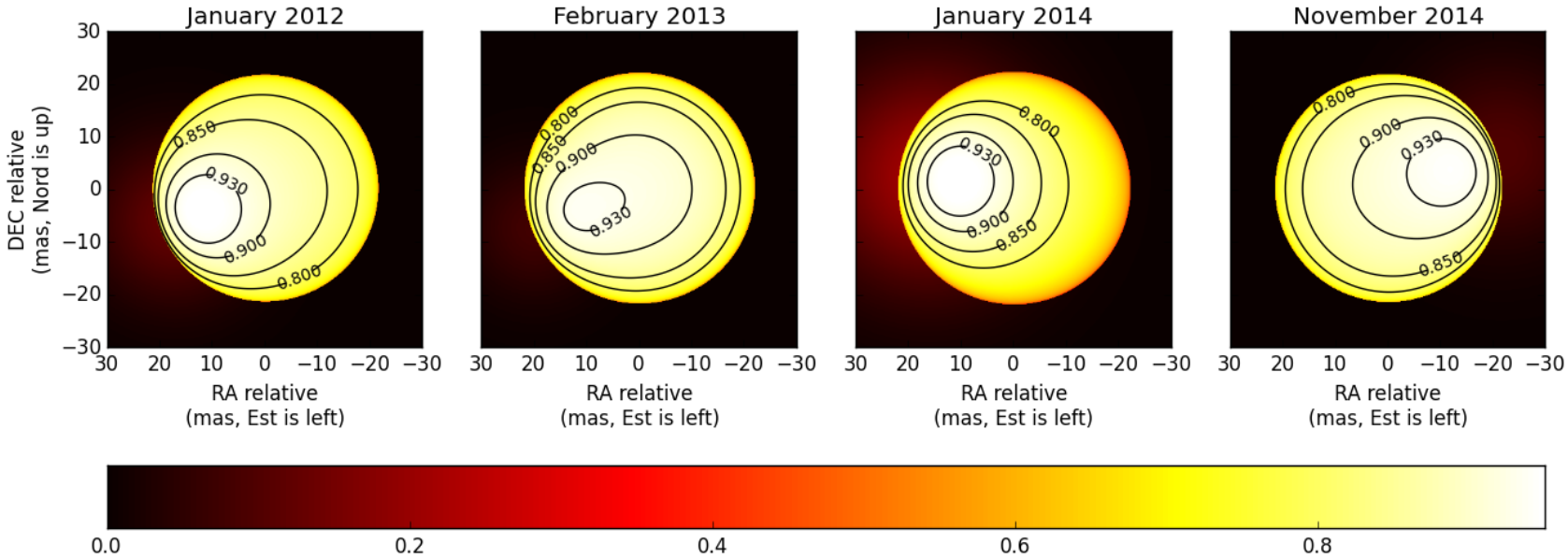
- Consistent on the 4 epochs
- ⚠ Photocenter displacement up to 2 mas ($\pi \sim 6$ mas)
- Spots already observed on Betelgeuse (see Haubois et al. 2009, Ravi et al. 2011, Ohnaka et al. 2011)



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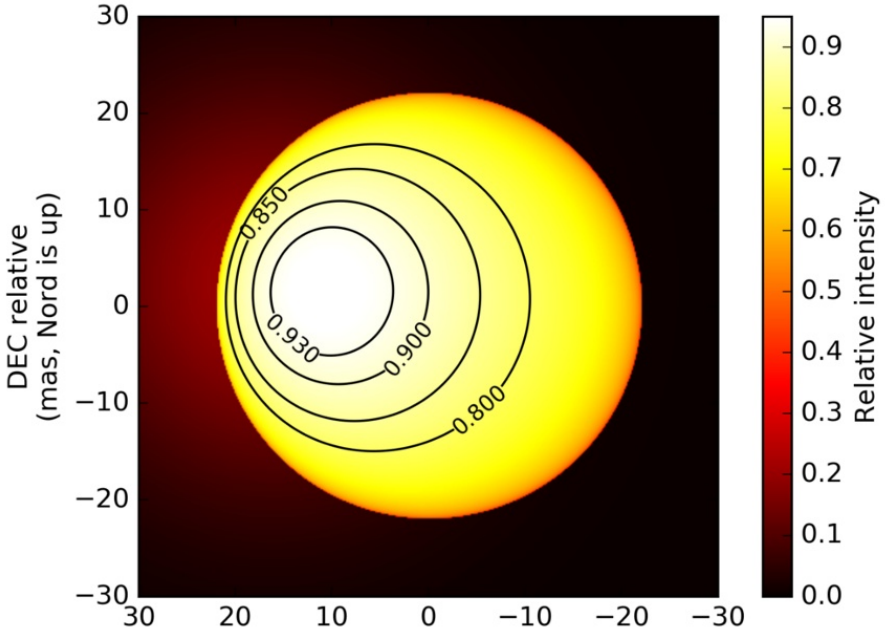
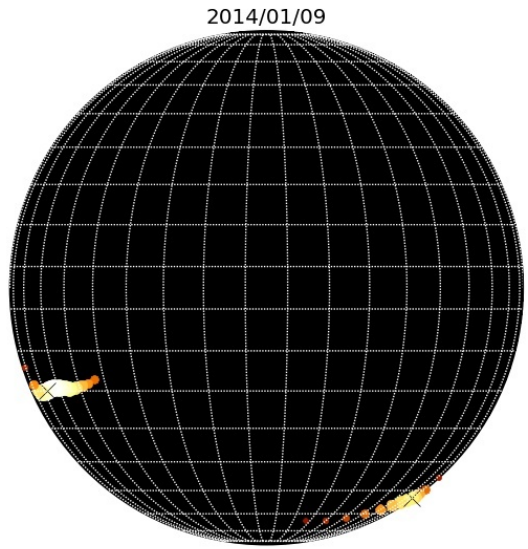
- Consistent with spectro-polarimetric observations at TBL/NARVAL (Aurière et al. 2016)

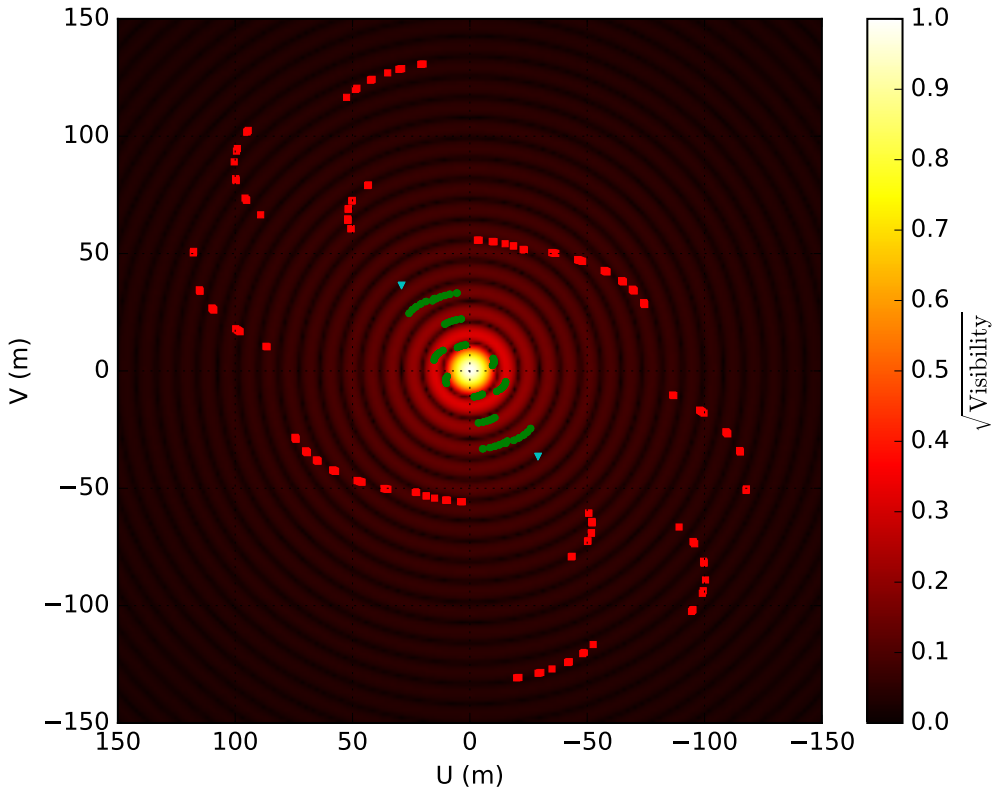




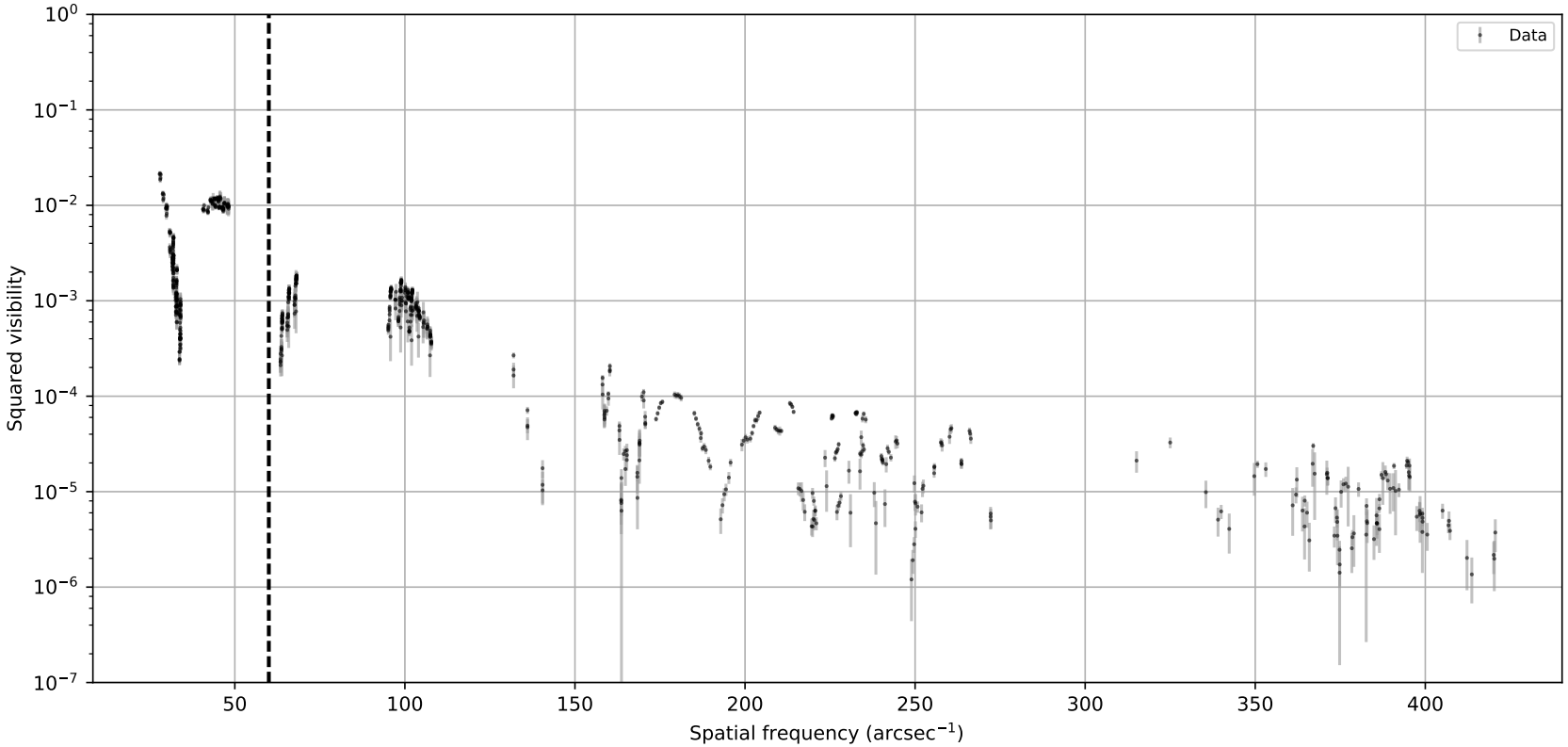
Antares@PIONIER

- VLTI/PIONIER observations (4 telescopes, H band, low spectral resolution, R = 40)
- 3 different configurations (baseline lengths : 11-150 m)

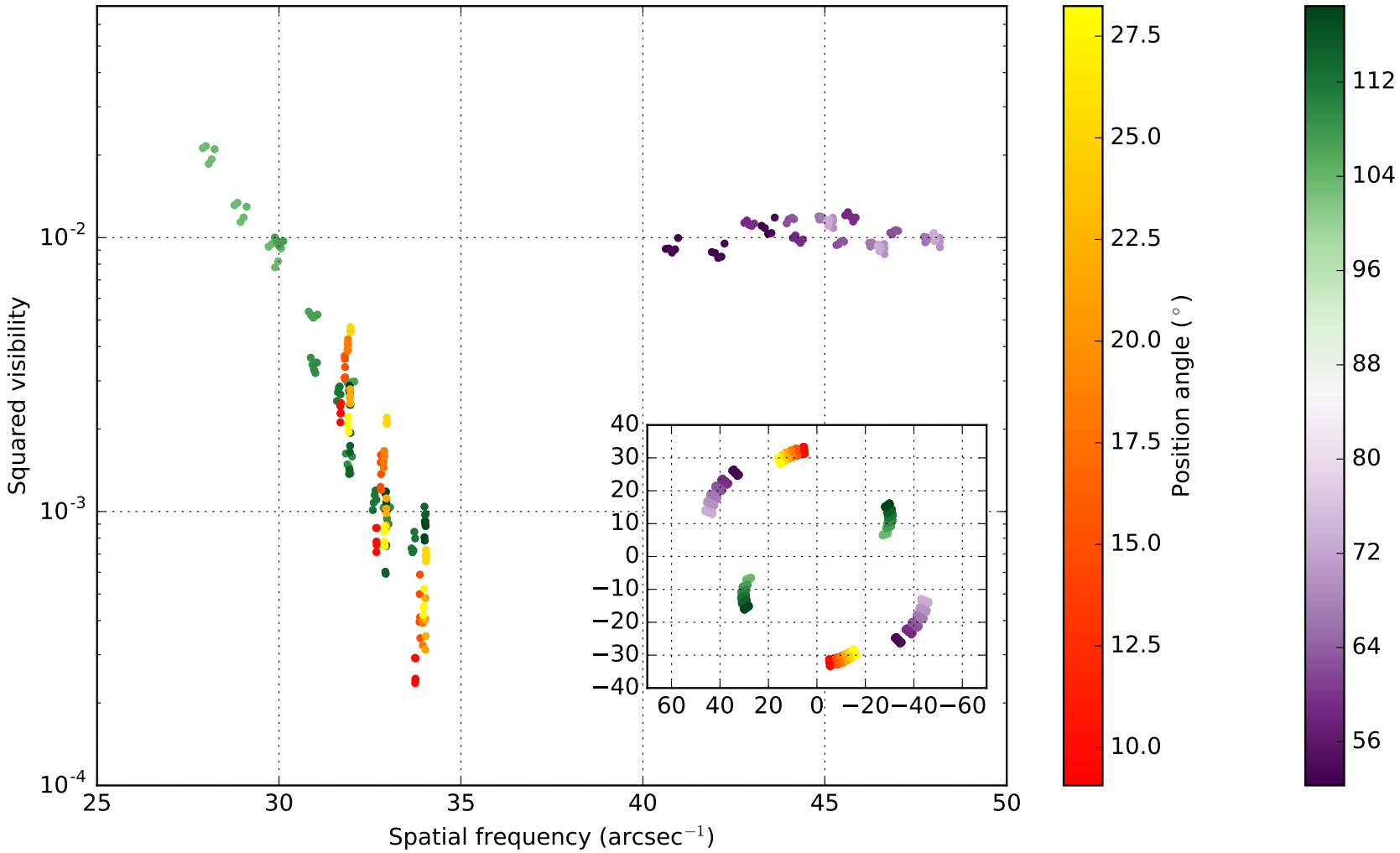
$\Rightarrow$ Montargès et al. subm., *A&A*



Antares@PIONIER: dataset



Antares@PIONIER: 1st and 2nd lobe



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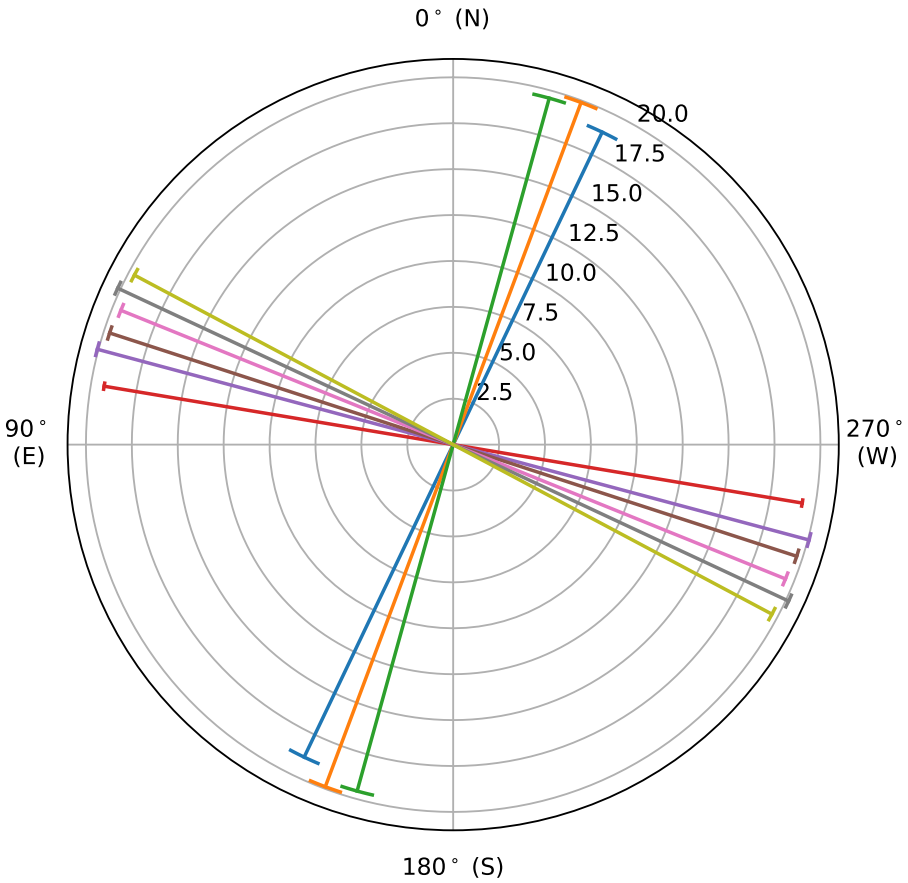

LDD diameters (at 1.61 μm):
37.70-39.03 mas
$\Rightarrow$ 4% difference

AND does not fit the closure phases !

Antares@PIONIER: modeling

⚠ Weak signal compared to Betelgeuse $\rightarrow$ small spots ?

⚠ Angular resolution $\sim$ 1/16th of the stellar diameter !

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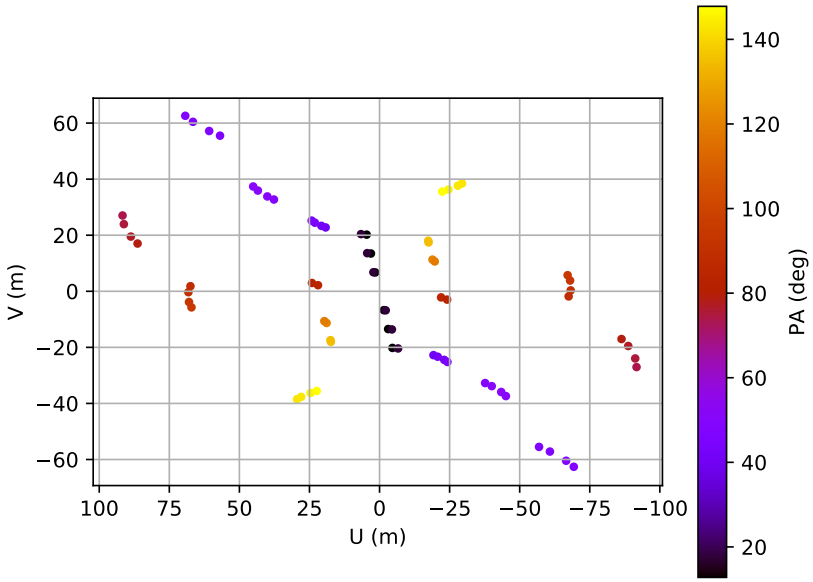
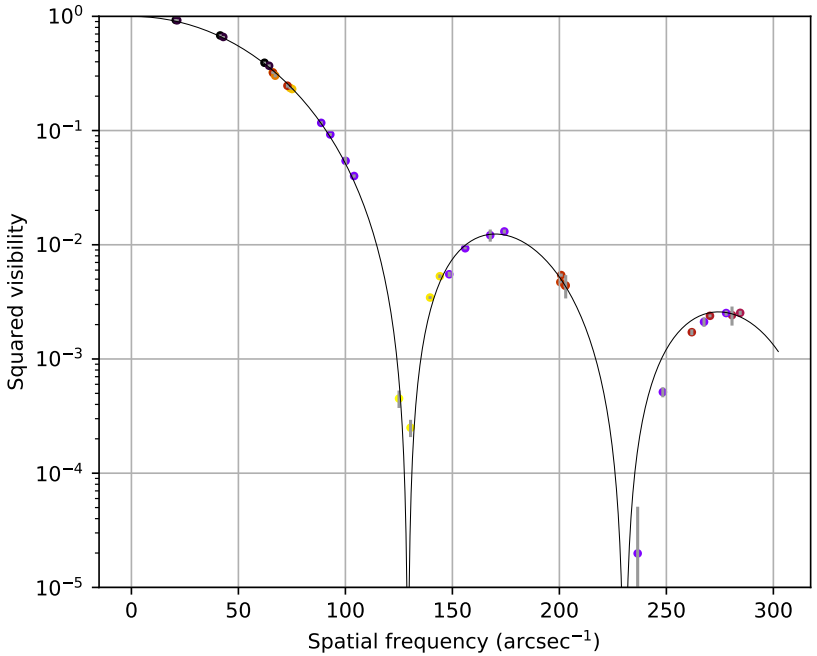
Best match:

- Gaussian spot distributions with a FWHM of 17 and 2 mas (not resolved !)
- LDD diameter: 37.89 ± 0.10 mas at 1.61 μm
- $\chi^2(V^2 + CP)$ as low as 28 (627 for best LDD alone)

On going DDT program on CE Tau with PIONIER

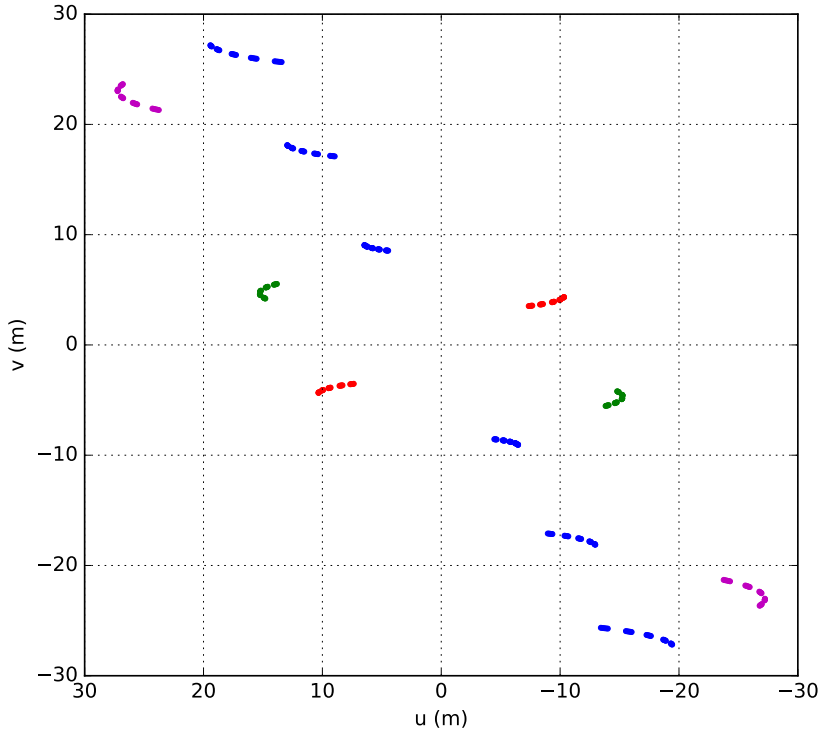


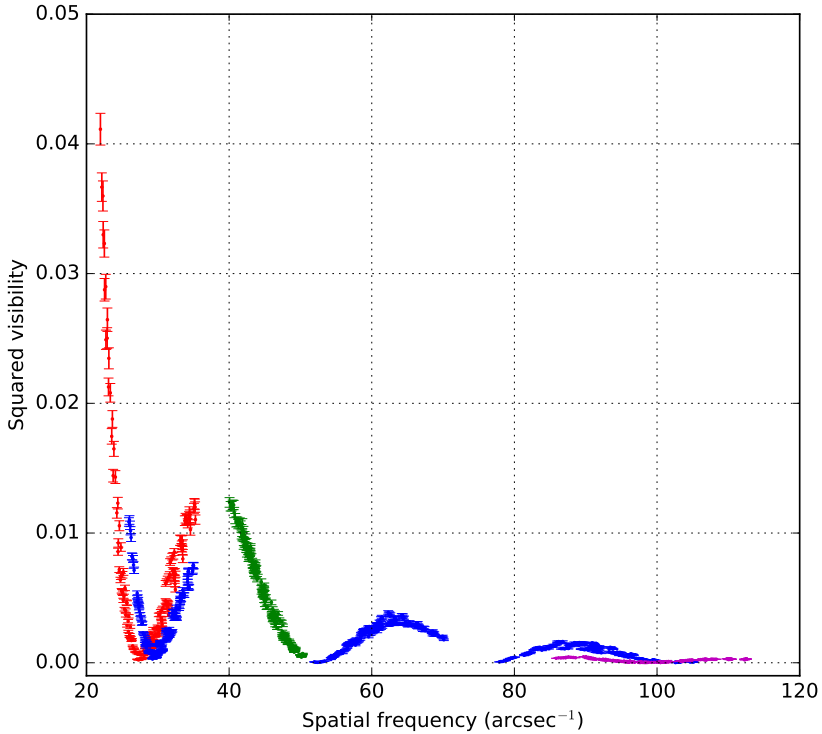


At 1.62 μm:

- $\theta_{\mathrm{LDD}} = 10.07 \pm 0.05$ mas
- $\chi^2 = 10.89$

Conclusions





What would we have concluded with only
the red (48.56 mas) or blue (44.21 mas) baselines ?