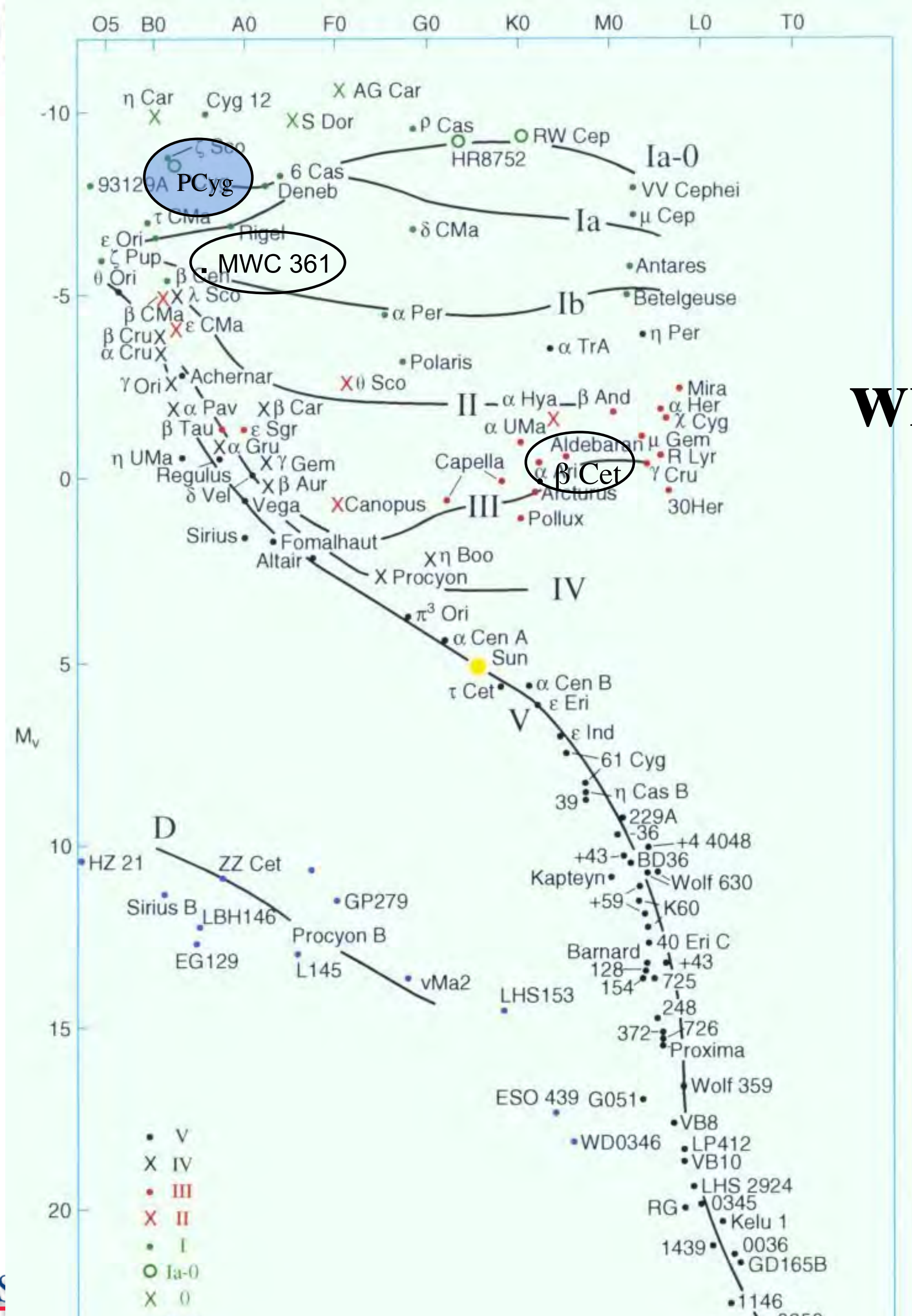


Circumstellar environments with VEGA/CHARA

Isabelle Tallon-Bosc
CRAL Lyon

Thibaut Merle
Observatoire de la CÔTE d'AZUR

Karine Perraut
IPAG Institut de Planétologie et d'Astrophysique de Grenoble

& VEGA team

Interferometry to determine chromosphere extents in K red giants

→ **Berio, Merle et al. (2011)**

How?

Cores of strong lines as the Ca II IR triplet (CaT) are formed in stellar chromospheres in NLTE

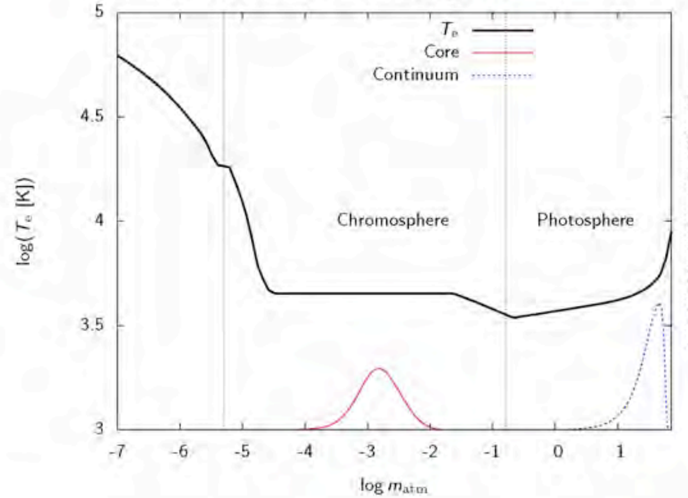
→ probes of chromosphere extents

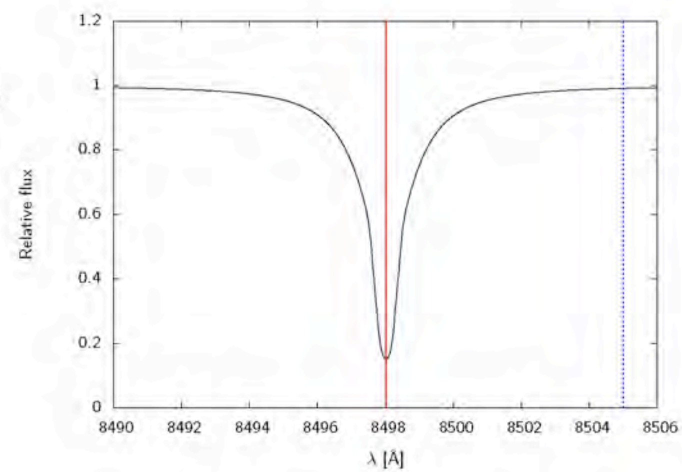
Interferometric observations

2010 campaign on VEGA/CHARA:

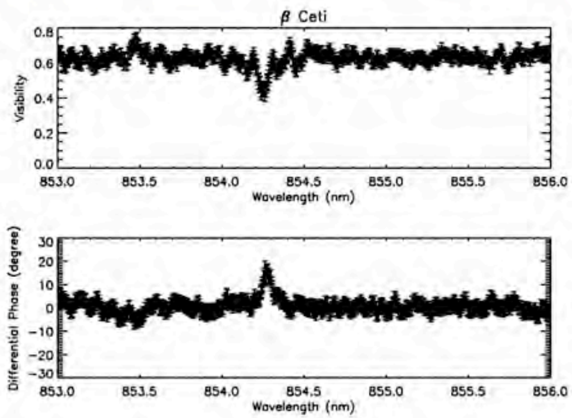
- in the continuum for 7 K giants
- in the CaT for 4 K giants
- focus on β **Cet** for which we have a model atmosphere with chromosphere (Eriksson et al. 1983)

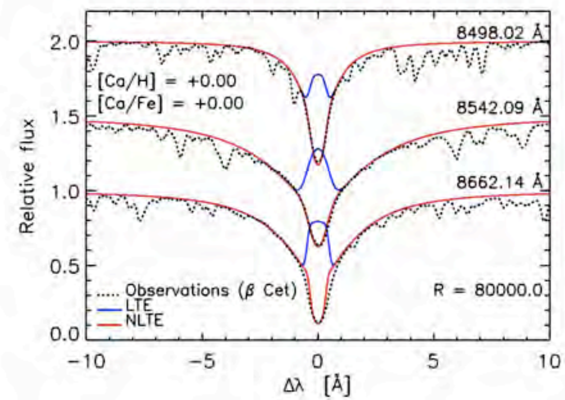
Example for a red giant

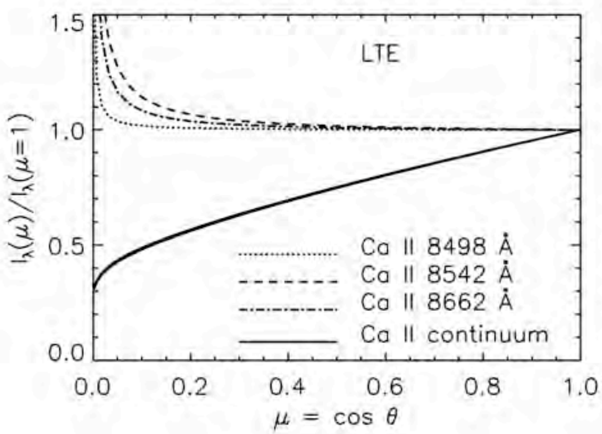


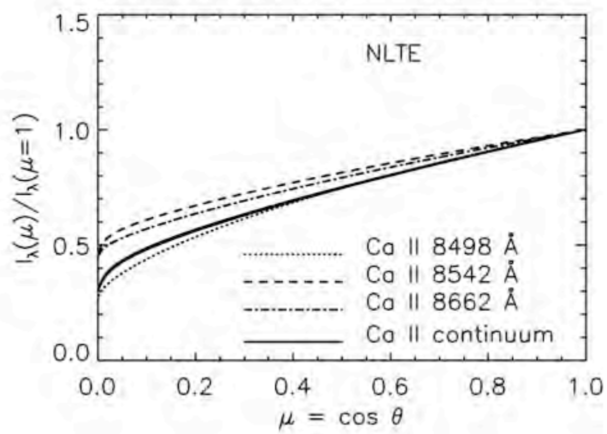


Observations by interferometry in the CaT of β Cet









Chromosphere extents for β Cet

λ [Å]	θ_{UD} [mas]	θ_{LD} [mas]	R_C [$R_\star$]
Cont		5.29 ± 0.08	
8498	5.82 ± 0.20	6.11 ± 0.21	1.16 ± 0.04
8542	6.40 ± 0.23	6.72 ± 0.24	1.27 ± 0.05
8662	6.58 ± 0.24	6.91 ± 0.25	1.31 ± 0.05

Berio, Merle et al. (2011)

Comparison of results

Disagreement with :

- Linsky & Haisch (1979) who predict very thin chromospheres less than 1% of the stellar radius due to the presence of corona

Good agreements with:

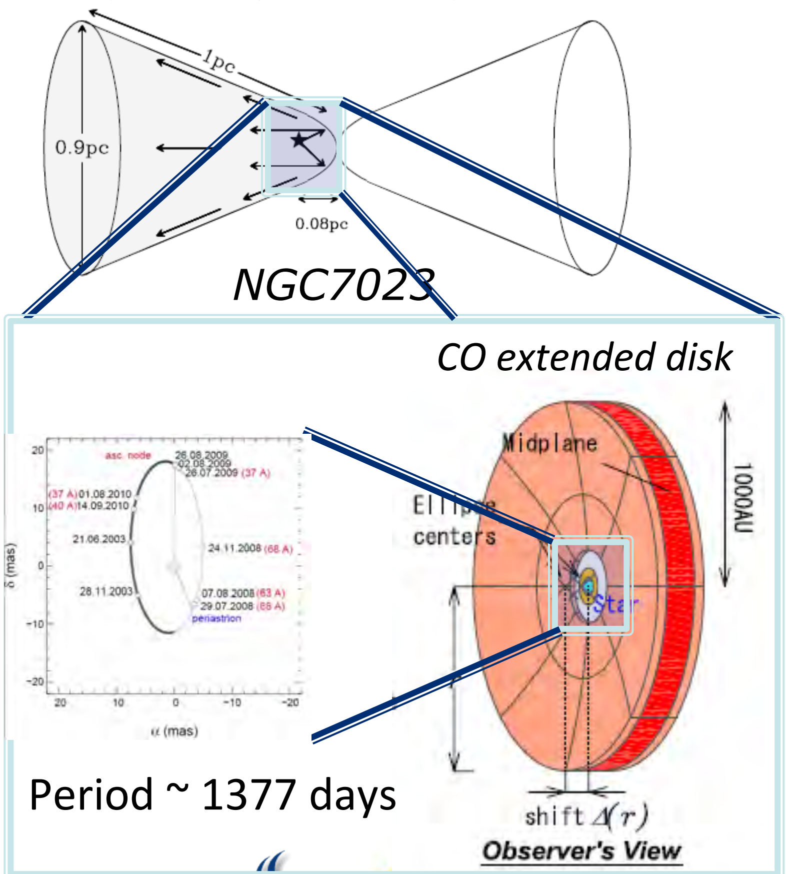
- acoustic wave heating model of chromosphere (Cuntz 1990a, b) which predicts extents $\sim 10 - 20$ % of stellar radius
- MHD wave heating model of chromosphere (Suzuki 2007) which explains the evolution of the chromosphere structure of such stars

Prospects

Other observations of β Cet are under investigation with VEGA/CHARA to study the variability of the chromosphere structure (PI: P. Berio)

Study of the Hα emission in Herbig AeBe stars

CO biconical cavity formed by the outflow activity



MWC361 (Herbig Be)

AB Aur (Herbig Ae)

Karine PERRAUT
(karine.perraut@obs.ujf-grenoble.fr)

Myriam Benisty (IPAG)
Denis Mourard (OCA)
Gustavo Lima (IPAG until june 2012)
Catherine Dougados (IPAG)

VEGA spectrum over the orbit

High state

Low state

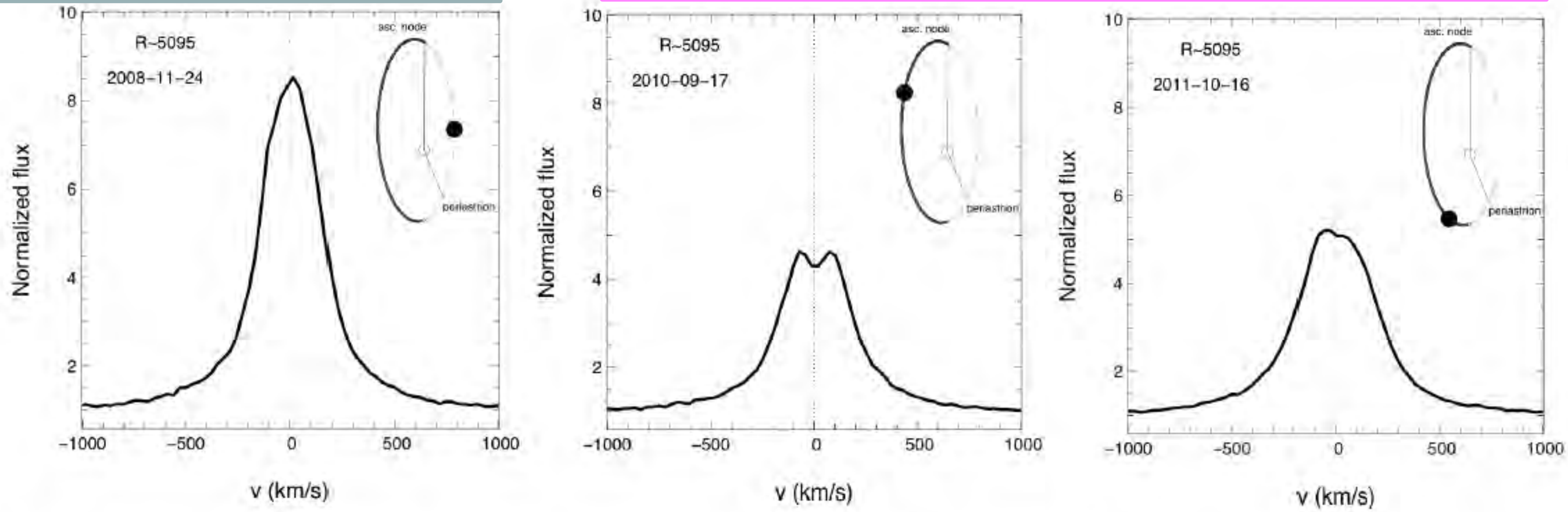
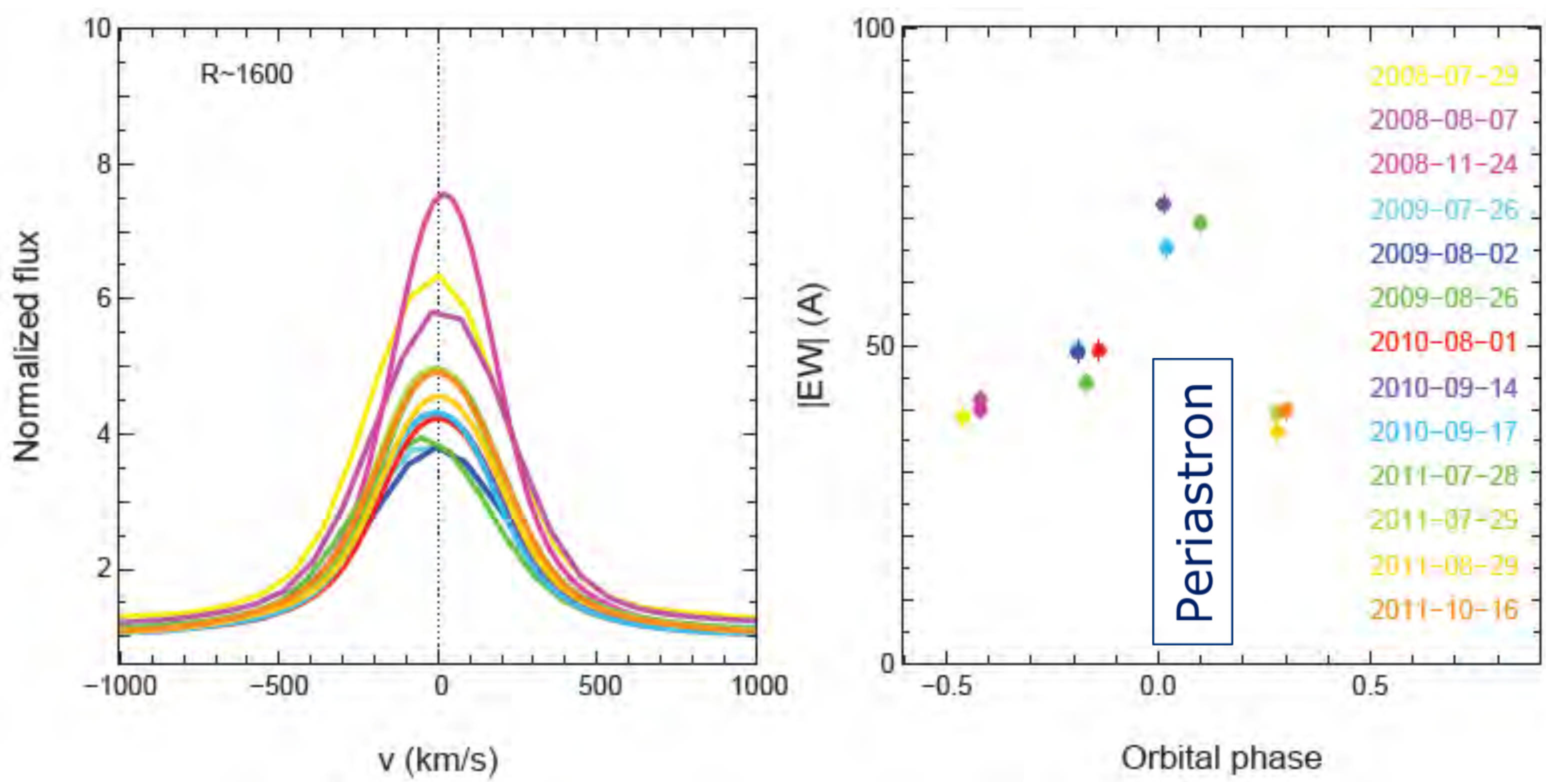


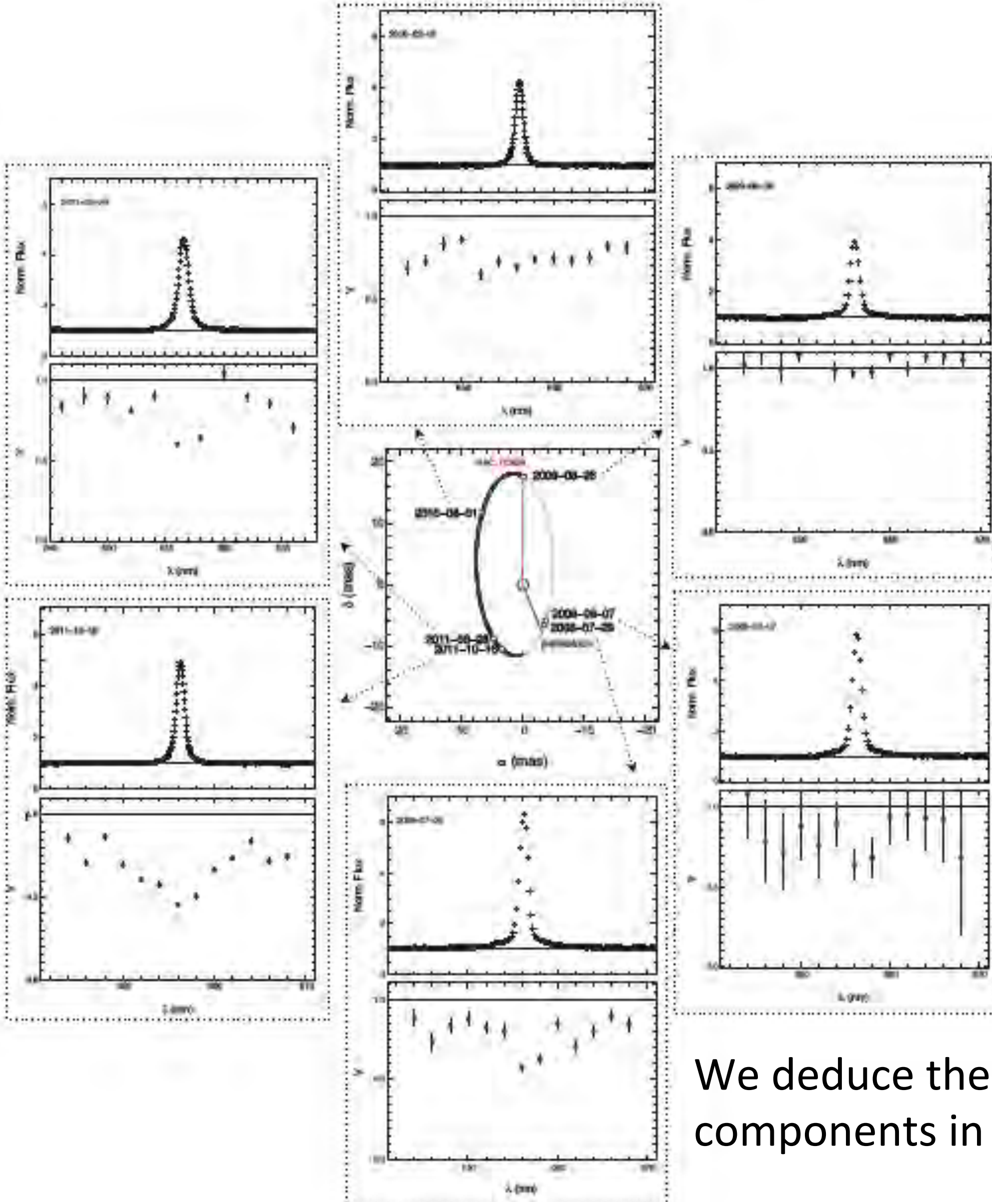
Fig. 2. Variation of the line profile with the orbital phase. All spectra were taken with R~5000. In each panel, the astrometric orbit is plotted, with a full black circle indicating the time of the observation.

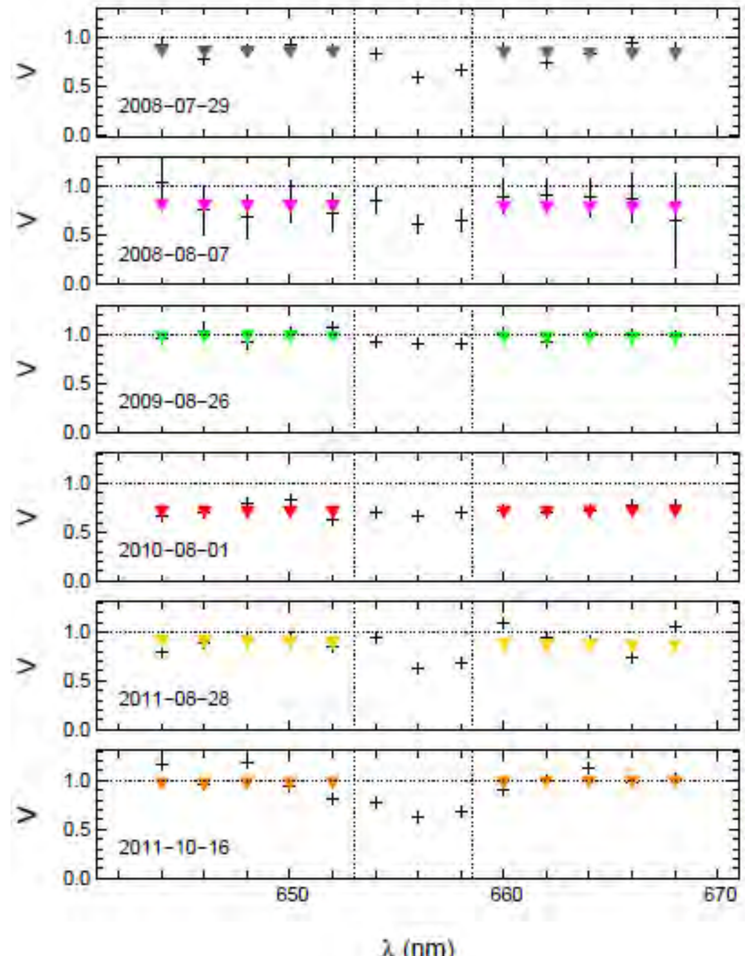
Hα Equivalent Width



EW clearly increases at the periastron.

VEGA visibility data set

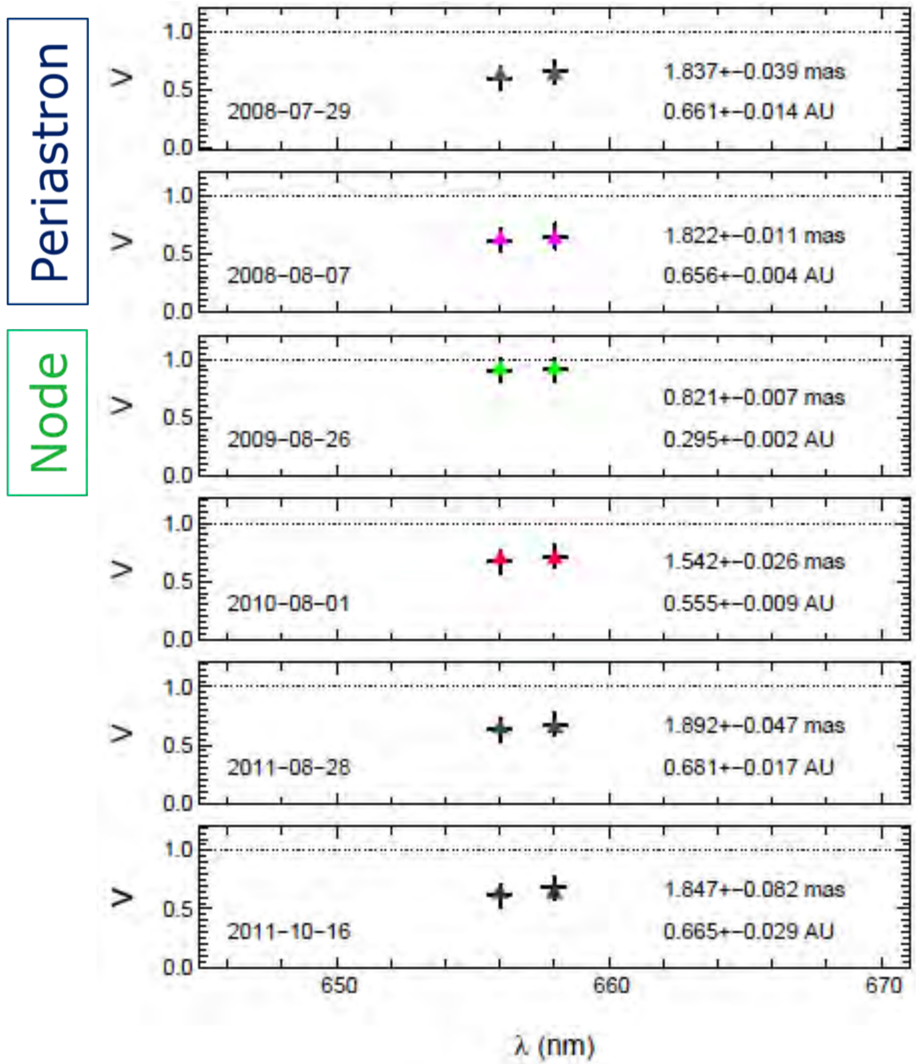




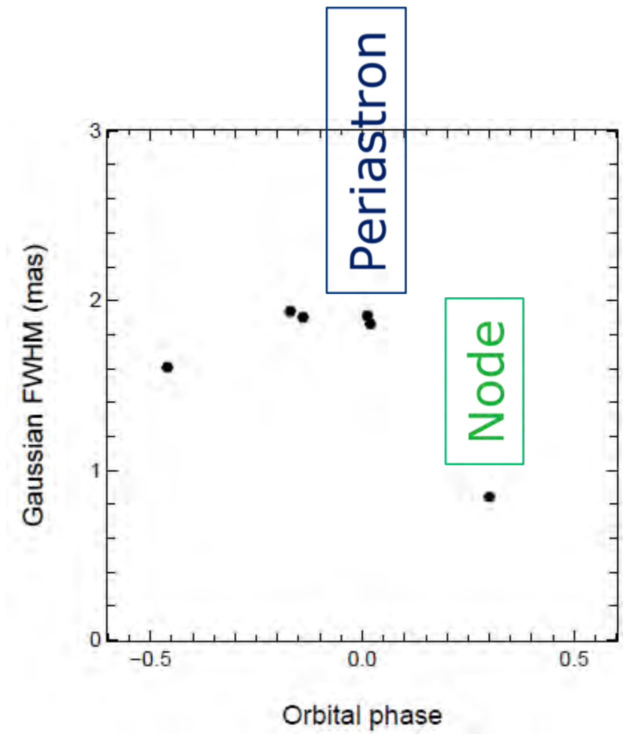
We deduce the flux ratio between components in the visible:

R = 0.160 ± 0.012

Characteristic size of the Hα emitting region



We deduce the visibility in the Hα line and then the characteristic size of the emitting region assuming a gaussian disk model.



MWC361 – Conclusions

Astronomy & Astrophysics manuscript no. Draft-MWC361˙v1.2
February 1, 2012

To be submitted in the coming weeks

Origin of the H_α line in the young massive binary HD 200775

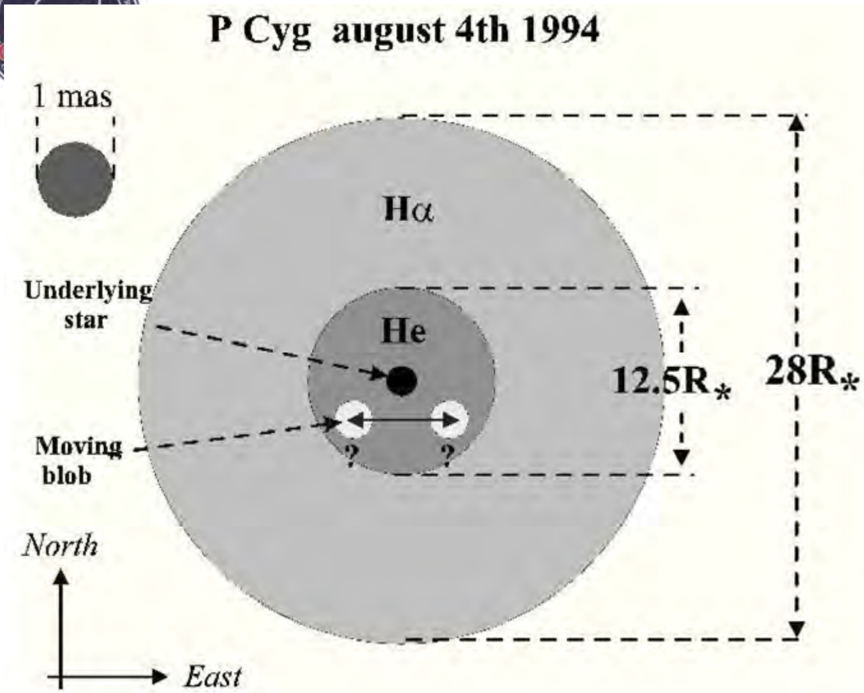
M. Benisty[1], K. Perraut[2], et al.

[1] Max Planck Institut für Astronomie, Konigstühl 17, 69117 Heidelberg, Germany
[2] Laboratoire d'Astrophysique de Grenoble, CNRS-UJF UMR 5571, 414 rue de la Piscine, 38400 St Martin d'Hères, France

Received ...; accepted ...

ABSTRACT

Context. Herbig Be stars are intermediate-mass young stars surrounded by a complex circumstellar environment. Like their lower mass counterparts, the T Tauri stars, a large fraction lies in multiple systems. **Mechanisms formation & timescale involved in formation of SB. Enjeux? Questions?** Studying multiple systems is therefore of strong interest to better understand the formation processes, the mechanisms that affect their circumstellar environment and constrain the stellar evolution.
Aims. HD 200775 (MWC 361) is a young massive spectroscopic binary, with uncertain classification, that shows strong and variable H_α emission. It has been suggested that its spectral behaviour is influenced by the binary nature of the object. In this paper, we aim at studying the mechanisms that shape their close environment at the AU-scale, and their dependence on binarity.



Vakili et al 1997, GI2T

P Cygni

Isabelle Tallon-Bosc

Michel Tallon

CRAL

Olivier Chesneau

OCA

Luc Dessart

OAMP

- **LBV** (luminous blue variable)
  - transition phase of ~40000 years to Wolf-Rayet
- **Nova phenomena** in 1600, 1655, 1665, …
  - stable enough now
- **Teff ~ 20000 K**
- **$M_* \sim 30\ M_\odot$**
  - mass-loss $\sim 10^{-4}\ M_\odot$/an
- **d ~ 1.8 +/- 0.1 kpc** (Lamers et al.1983)
- **$R_* \sim 76\ R_\odot$ (~0.2 mas)** ==> **$Ø_{UD}$= 0.4 mas**

Previous observations at the visible

- GI2T (1994) : $Ø_{UD\,(H\alpha)}$ ~ 5.5 mas $Ø_{UD\,(\mathbf{HeI\,-667.8})}$ ~ 2.5 mas
  (Baseline = 17.7m R=3800)

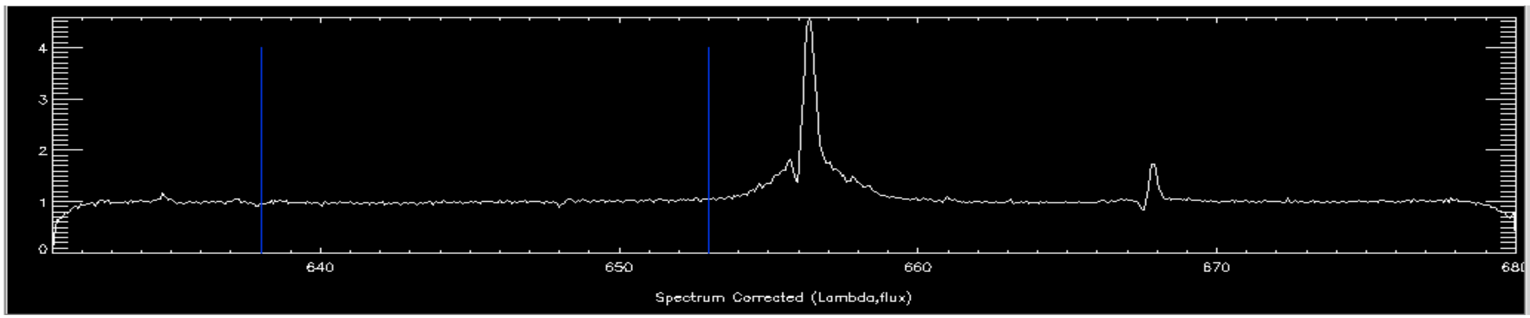
- NPOI Measures *Balan et al. 2010*
  - Baselines of 19 - 80 m, 2005, 2007, 2008.
  - Differential $V^2(H_\alpha)$
    - continuum supposed to be with $Ø_{UD}$~ 0.2 mas (~Dirac)
    - variation of results < 1% for $Ø_{UD}$ continuum varying from 0 to 1 mas
  - 4 differential phase closures => object is symmetric
  - 15 spectral channels from 560 to 870 nm.
    - **spectral channel on H_α : $\Delta\lambda$ = 15 nm**

- Fitted models :
  - $Ø_{UD}$= 0.2 mas (70%) + $Ø_G$= 5.64 mas (17%) + $Ø_G$= 1.8 mas (13%) χ^2=1.5
  - $Ø_{UD}$= 0.2 mas (72%) + $Ø_G$= 5.46 mas (18%) + $Ø_{UD}$= 3.06 mas (10%) χ^2=1.5
  - $Ø_{UD}$= 0.2 mas (79%) + $Ø_{UD}$= 7.2 mas (21%) χ^2=2.8

VEGA Observations

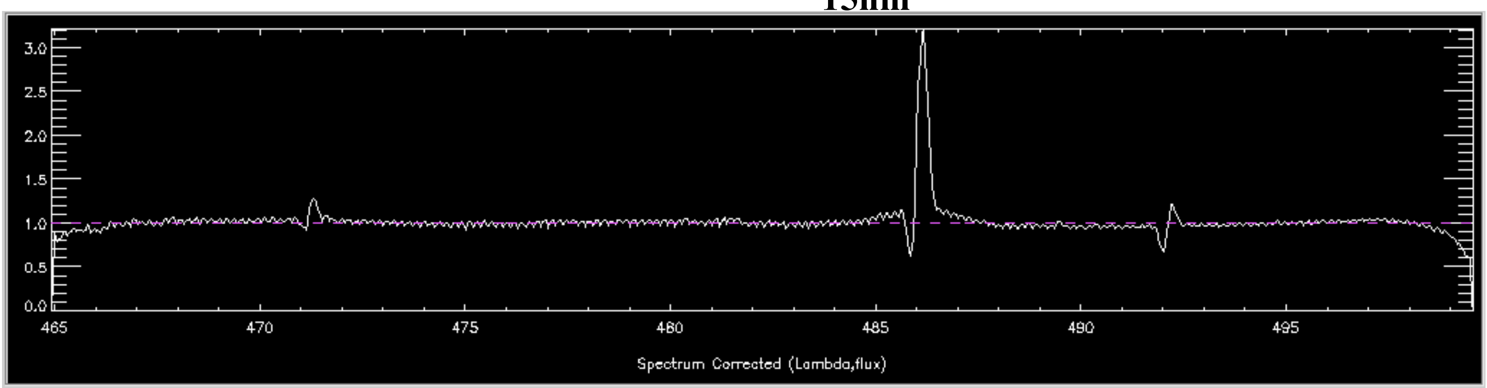
-12 nights in 2008, 2010 S1S2, E1E2, W1W2, and 1 triplet W2W1E2 in 2011, of different quality

- different calibrators (some bad... :-( ) :
  - the last used : HD192640 $\O_{UD}$= 0.445 mas
  - the most used : HD188892 $\O_{UD}$= 0.225 mas (same as Balan et al.)



λc = 645nm $\Delta\lambda$ =15nm **Hα** **HeI 667.8**

15nm

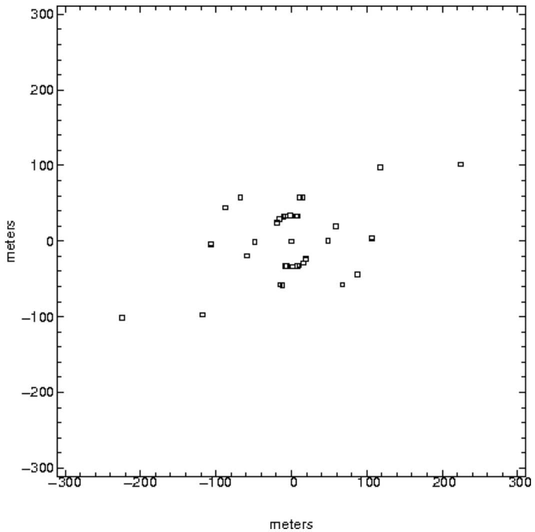


λc = 475nm $\Delta\lambda$ =18nm **Hβ**

25nm

GeorgiaStateUniversity NSF NOAO l'Observatoire de Paris LESIA NExScI NASA Exoplanet Science Institute SUSI Observatoire de la CÔTE d'AZUR

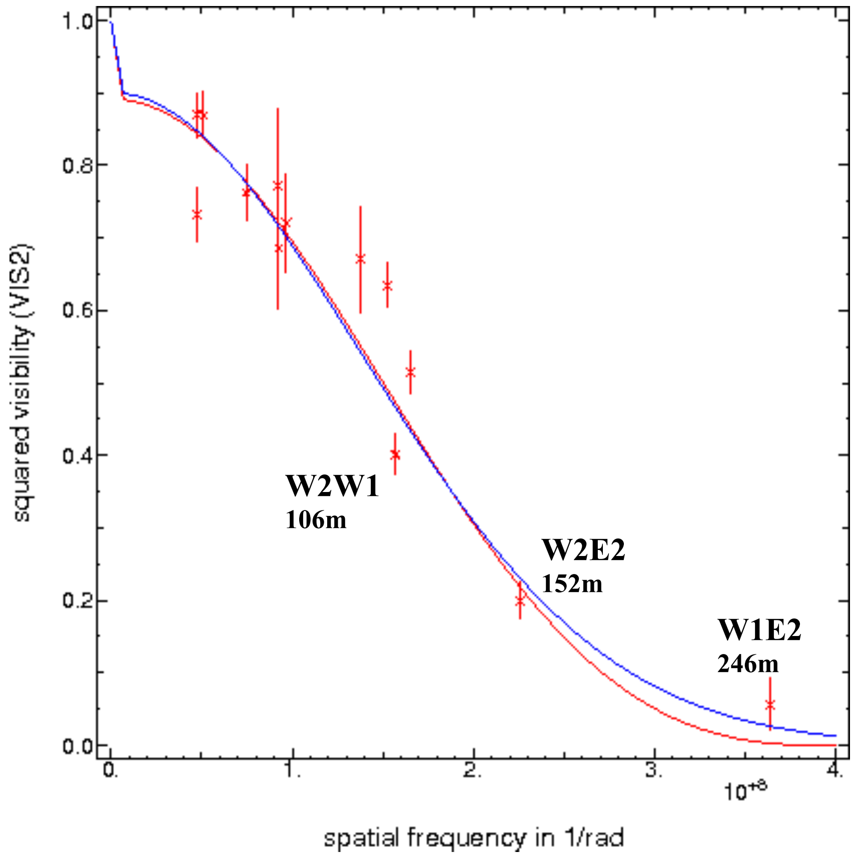
V^2 Measurements



at λc = 645nm ($\Delta\lambda$ 15nm)

Ø^*_{UD}= 0.65 +/- 0.01 mas
i_* = 0.95 +/- 0.24
i_bg = 0.05 +/- 0.01
$\chi^2 = 4.89 \quad \sigma_{\chi 2} = 0.41$

FWHM* = 0.40 +/- 0.01 mas
i_* = 0.95 +/- 0.24
i_bg = 0.05 +/- 0.01
$\chi^2 = 5.05 \quad \sigma_{\chi 2} = 0.41$



Comparison with NPOI results

Fitted models by Balan et al.:

$Ø_{UD}$= 0.2 mas (79%) fixed + $Ø_{UD}$= 7.2 mas (21%) $\chi^2=2.81$

$Ø_{UD}$= 0.2 mas (70%) fixed + $Ø_G$= 5.64 mas (17%) + $Ø_G$= 1.8 mas (13%) $\chi^2=1.5$

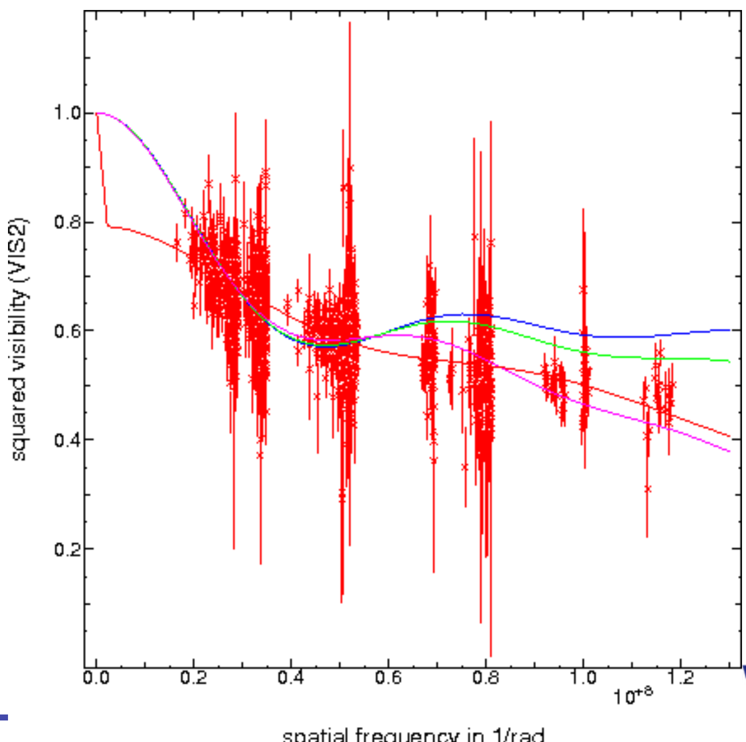
But if **$Ø_{UD}$= 0.4 mas (79%) fixed then $Ø_{UD}$= 7.3 mas (21%)** $\chi^2 \searrow 2.38$

And making $Ø_{UD}$ free :

$Ø_{UD}$= 0.74 mas +/- 0.01(82%) + $Ø_{UD}$= 7.75+/-0.3 mas (18%) $\chi^2 \searrow 1.81$ $\sigma_{\chi 2}=0.036$

And adding a background :

$Ø_{UD}$= **0.65 +/- 0.01 mas** (79%) + $Ø_{UD, H\alpha}$= **5.56+/-0.12 mas** (9%) + bg (11%) $\chi^2 \searrow 1.58$ $\sigma_{\chi 2}=0.036$



- Compatibility of VEGA and GI2T measurements with NPOI measurements

- Several models may be suitable

Comparison with NPOI results

Best fitted model by Balan et al.:

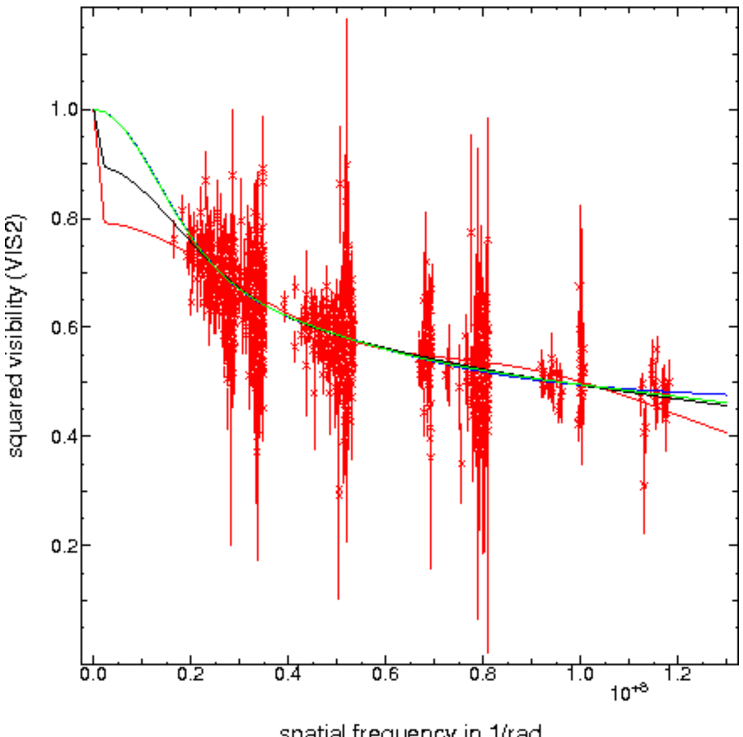
$\O_{UD}$= 0.2 mas (70%) fixed + $\O_G$= 1.8+/-0.13 mas (13%) + $\O_G$= 5.64+/-0.17 mas (17%) *χ^2=1.528*

But if **$\O_{UD}$= 0.4 mas (79%) fixed then**

$\O_G$= 2.18 +/-0.13 mas (10%) + $\O_G$= 5.82 +/-0.22 mas (16.5%) ***χ^2=1.522*** *$\sigma_{\chi 2}$=0.036*

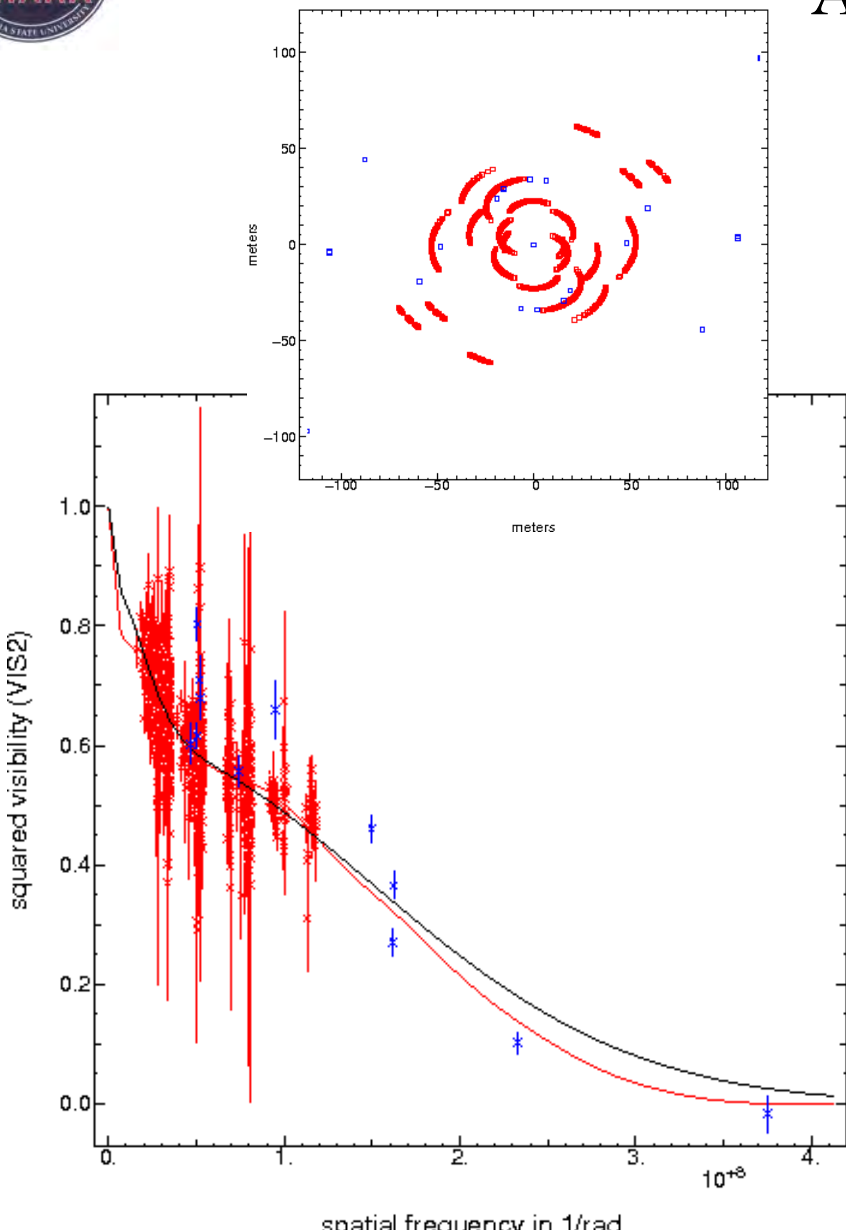
And adding a background : $\O_{UD}$= 0.4 mas **(73%)**

$\O_G$= 1.79 +/-0.3 mas (8%) + **$\O_G$= 4.57 +/-0.4 mas** (13.5%) + **bg** (5.5%) ***χ^2=1.524*** *$\sigma_{\chi 2}$=0.036*



Several ' best fitted' models

Adding VEGA measurements



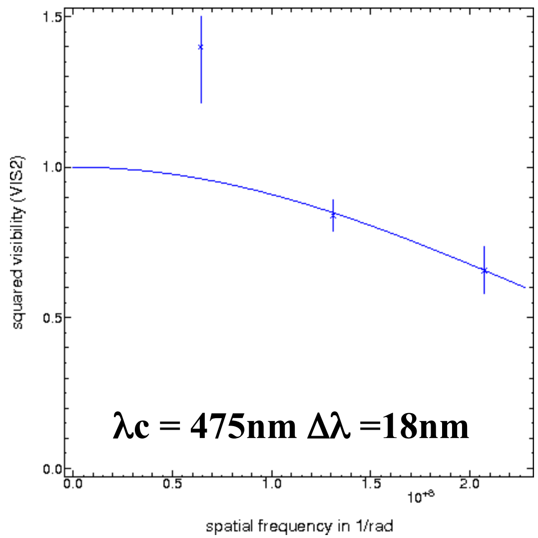
$\varnothing^*_{UD}$= 0.65 +/- 0.01 mas
$\varnothing_{UD,wind}$ = 5.58 +/- 0.12 mas
i_* = 0.795 +/- 0.020
i_w = 0.095 +/- 0.003
i_bg = 0.11 +/- 0.004
χ^2 =*1.655* $\sigma_{\chi 2}$=*0.036*

FWHM* = 0.37 +/- 0.01 mas
$FWHM_{wind}$ = 4.03 +/- 0.12 mas
i_* = 0.78 +/- 0.020
i_w = 0.155 +/- 0.003
i_bg = 0.065 +/- 0.008
χ^2 =*1.618* $\sigma_{\chi 2}$=*0.036*

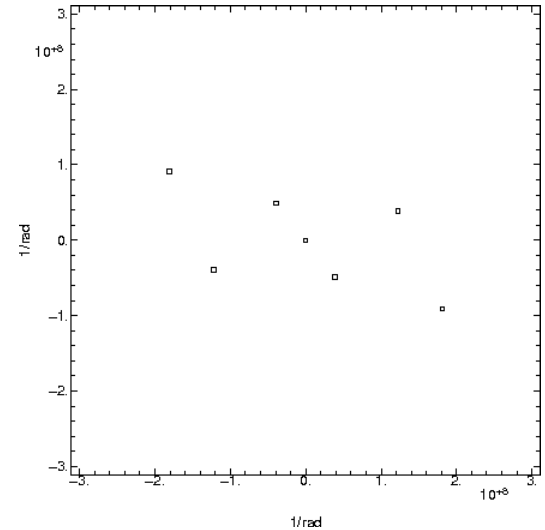
χ^2 ↗ slightly

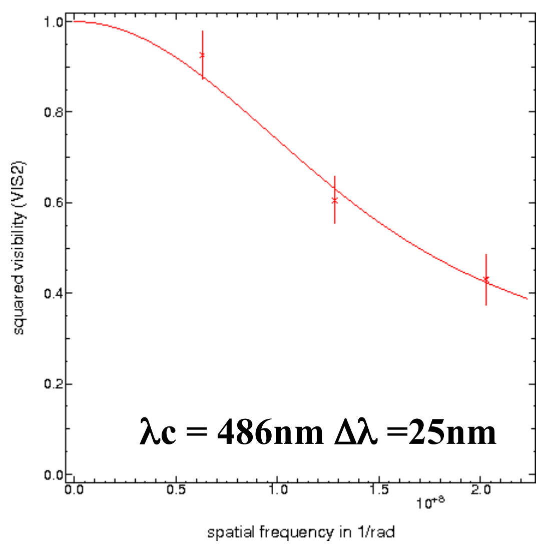
Probably no radial symmetry

First Hβ measurements



$Ø^*_{UD}$= **0.40 +/- 0.04 mas**





$Ø^*_{UD}$= 0.4 mas fixed

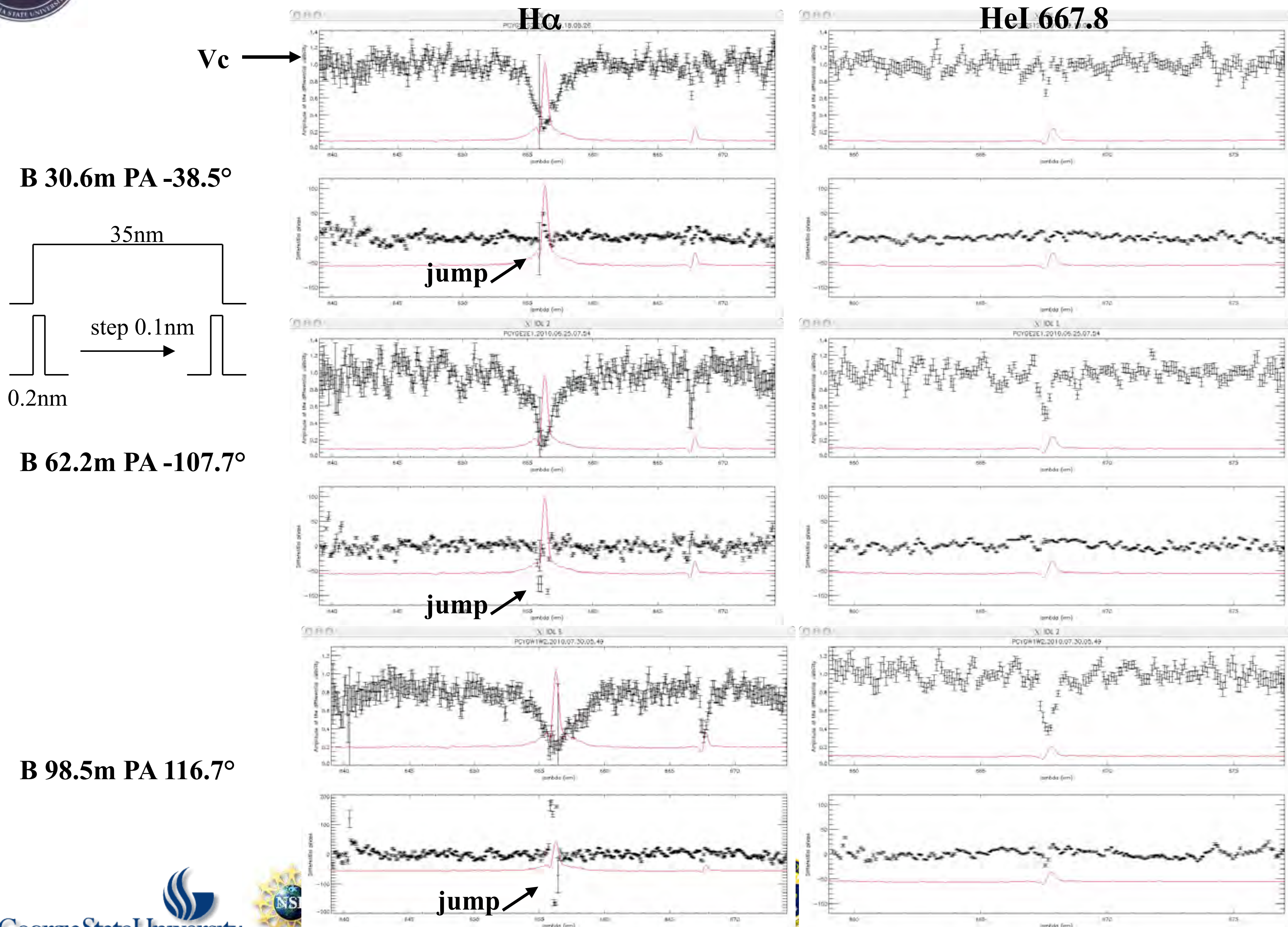
$Ø_{UD,wind}$ **= 1.59 +/- 0.42 mas**

i_w = 0.22+/- 0.07

χ^2 =*1.18*

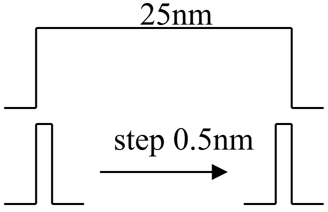
For the same uv-coverage, go to the ...

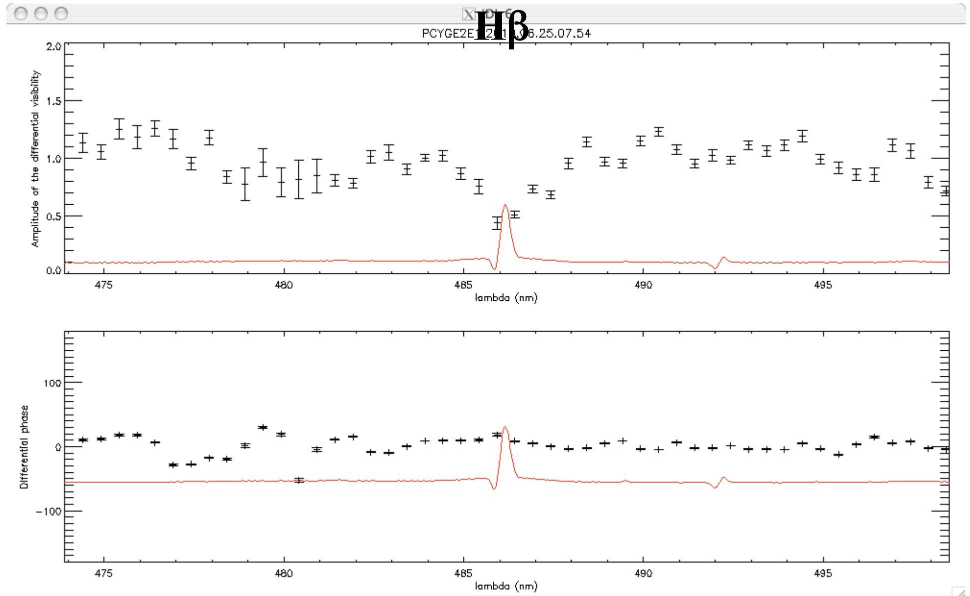
Differential visibilities V(λ)



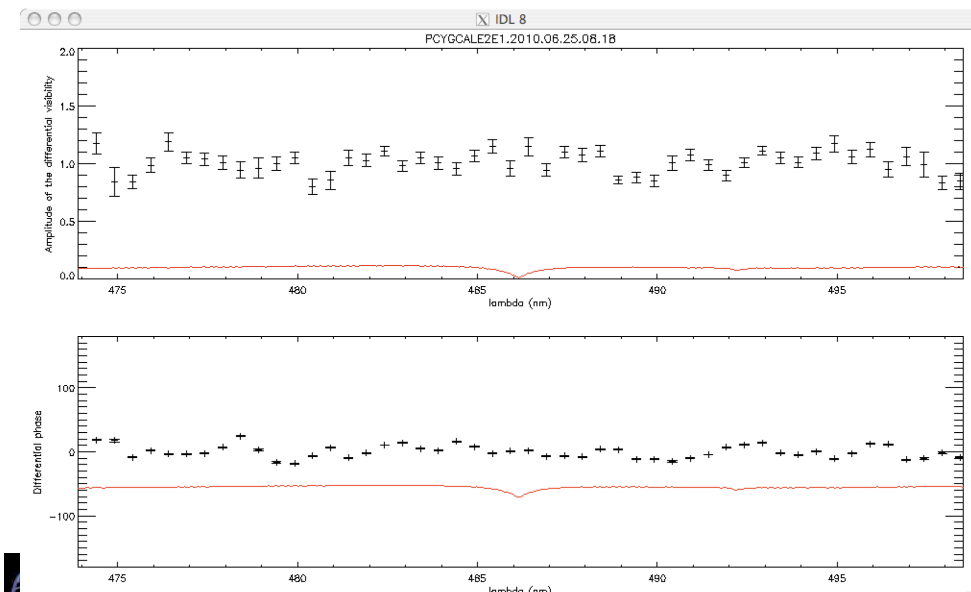
V(λ) around Hβ

B 62.2m PA -107.7°



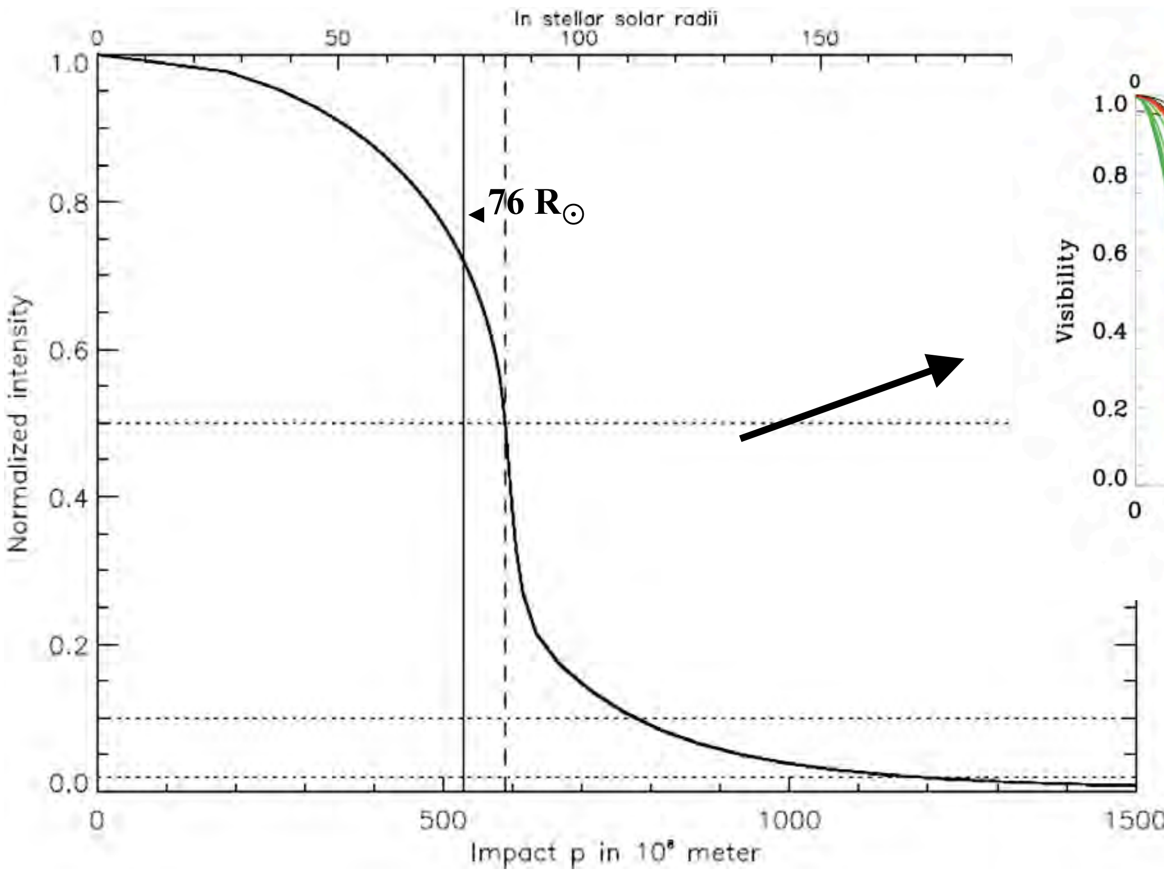


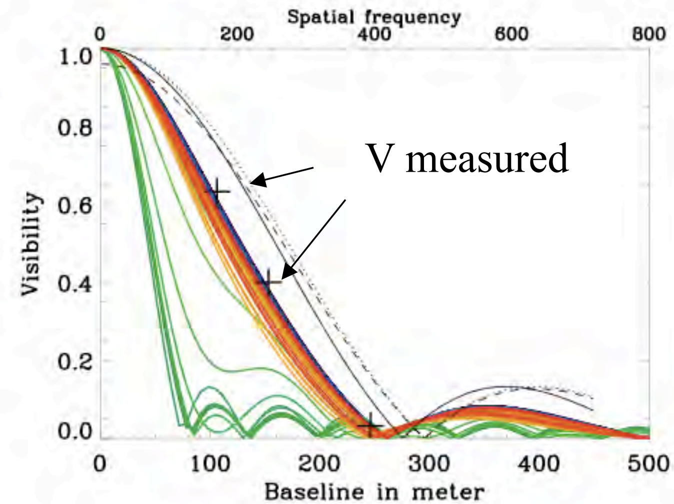
Calibrator



Theoritical model CMFGEN

- line-blanketed non-LTE model-atmosphere CMFGEN *(Dessart & Hillier 2005 after Najarro model)*





Radial profile Ip of the contiuum near the Hα line versus the distance from the center of the star in **R**$_\odot$

Fit of data sets at #λ with LITpro under way

Conclusions

- to present this work in a paper, whatever the result of the fit is.

- to observe again P Cygni in a next future :

➛ model of the object more refined,
taking into account the obvious asymetries

➛contemporaneous data on Hα and Brγ lines
thanks to the dual and successfull VEGA/CLIMB operational mode