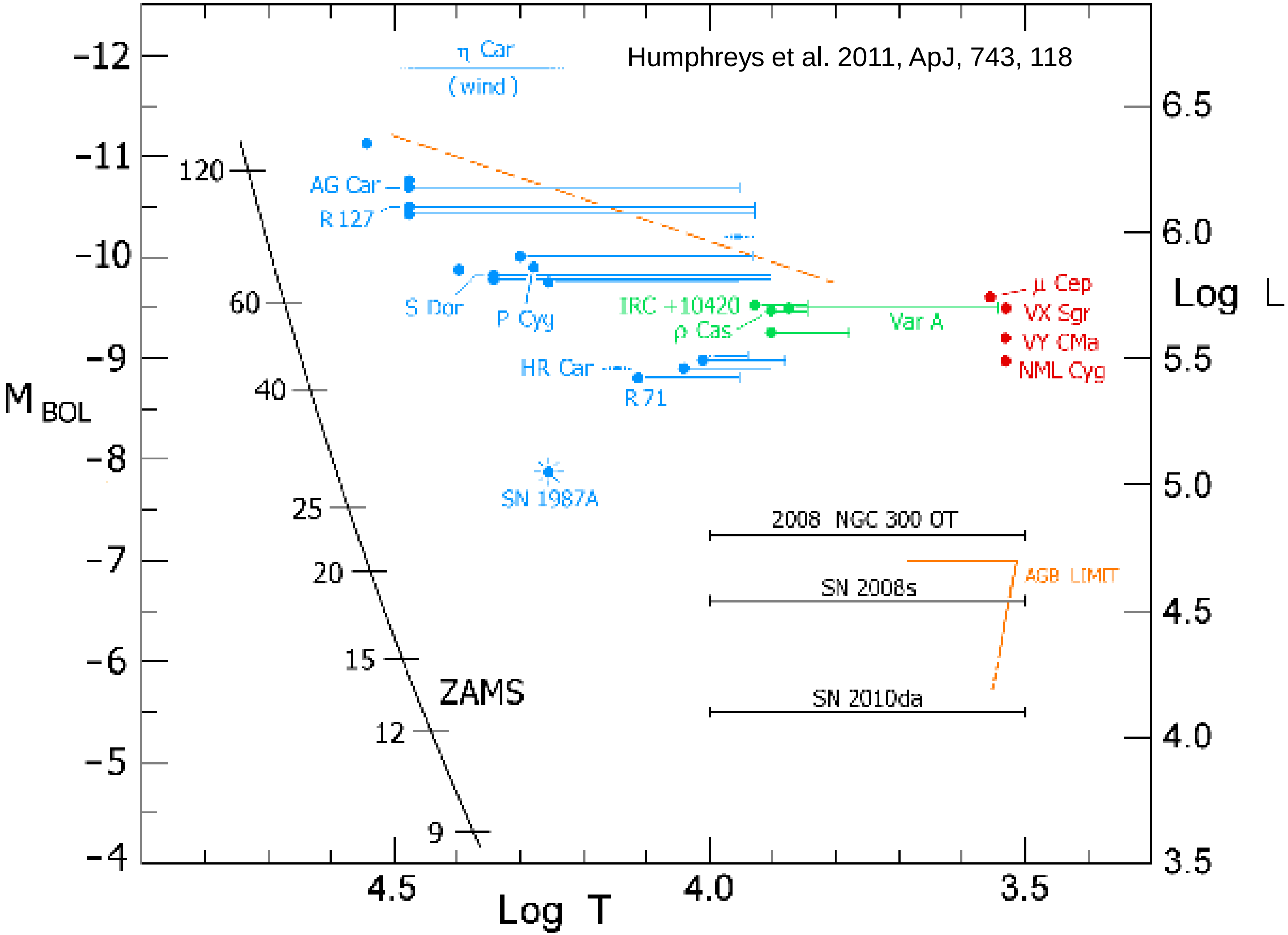
First imaging of the H-band wind of the Luminous Blue Variable P Cygni

Noel Richardson, Gail Schaefer, et al.

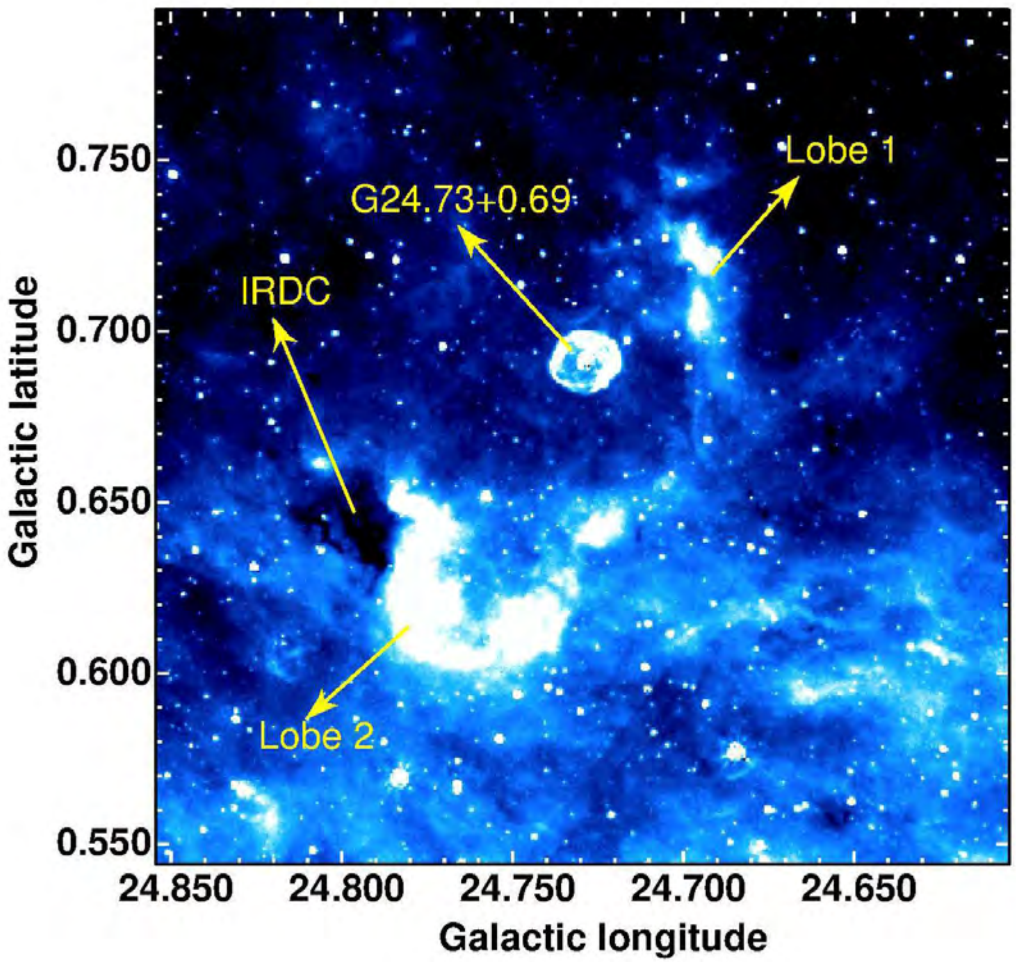
Luminous Blue Variables

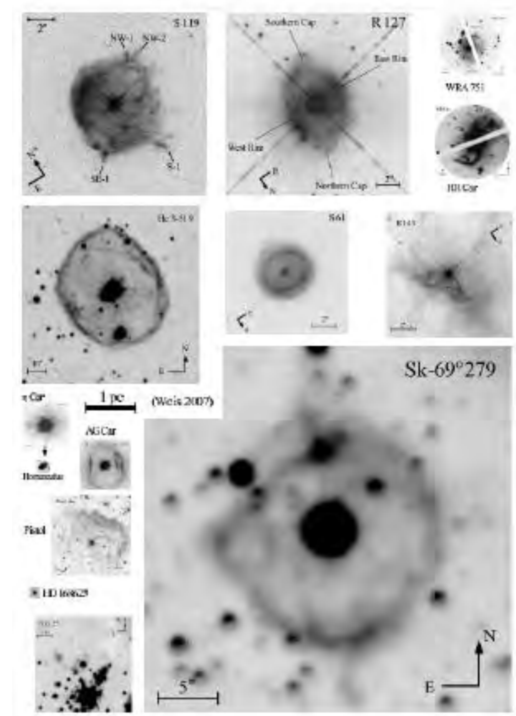
- Massive post main-sequence stars (>~40 solar masses)
- Extremely Strong stellar winds
- Variable on multiple timescales
- Extremely luminous



Humphreys et al. 2011, ApJ, 743, 118
η Car
(wind)
AG Car
R 127
S Dor
P Cyg
IRC +10420
ρ Cas
Var A
μ Cep
VX Sgr
VY CMa
NML Cyg
HR Car
R 71
SN 1987A
2008 NGC 300 OT
AGB LIMIT
SN 2008s
SN 2010da
ZAMS
120
60
40
25
20
15
12
9
M BOL
Log L
Log T
-12
-11
-10
-9
-8
-7
-6
-5
-4
6.5
6.0
5.5
5.0
4.5
4.0
3.5
4.5
4.0
3.5

Why do we care about LBVs?

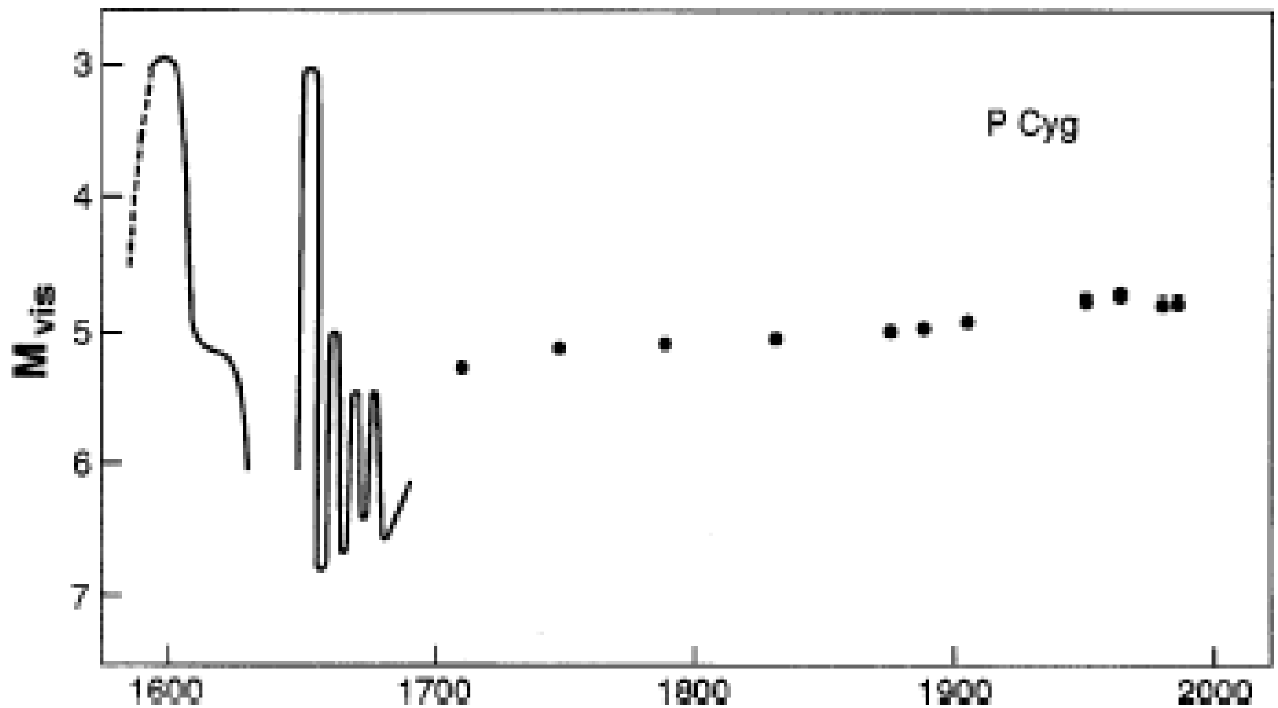




Petriella, Paron, & Giacani. 2012, A&A, 538, 14

P Cyg – the first LBV

- Discovered in August 1600 by Willem Blaeu
  - A giant eruption, lost about 1 solar mass of material



The wind of P Cyg

Assuming $R_*=75\,R_\odot$, the following stellar parameters for P Cygni are derived:

$L_*=5.6\times10^5\,L_\odot$ $(T_{\rm eff}=1.82\,{\rm kK})$

$n_{\rm He}/n_{\rm H}=0.3$ $\dot{M}=3.0\times10^{-5}\,M_\odot\,{\rm yr}^{-1}$

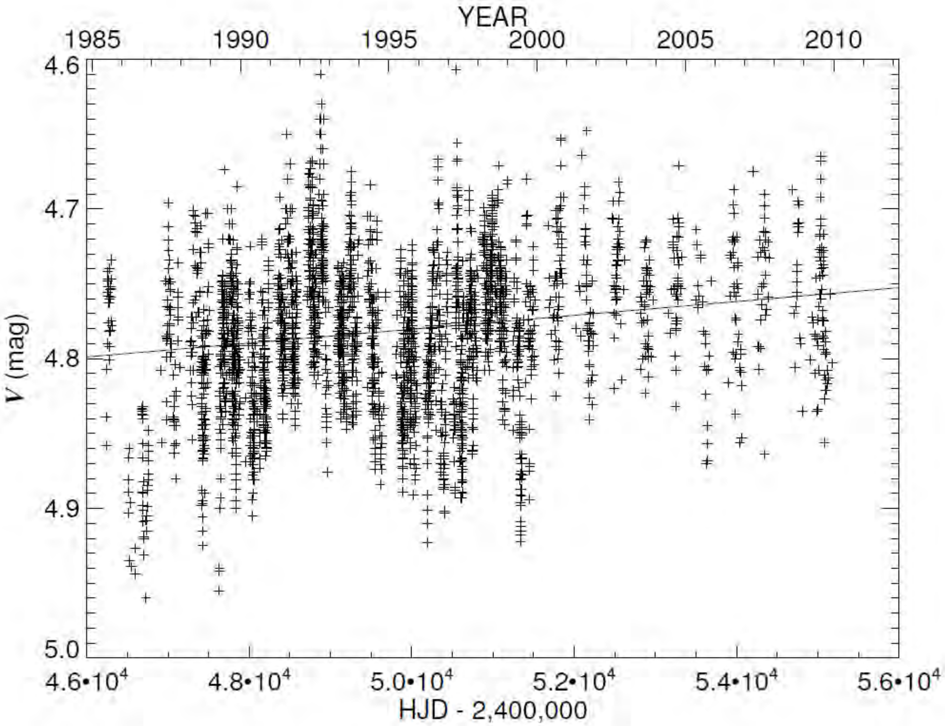
$V_\infty=185\,{\rm km\,s}^{-1}$ $\beta=2.5$

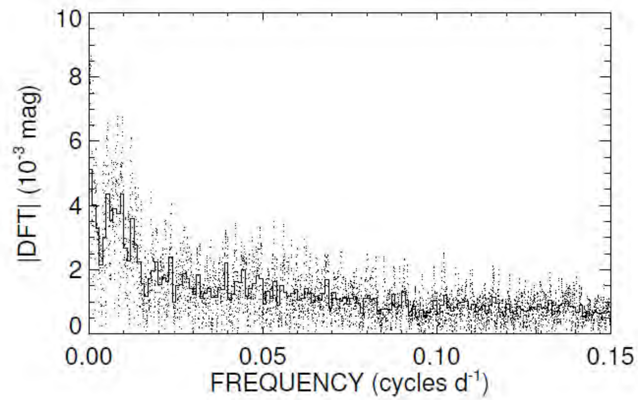
$\log g_{\rm eff}=1.20.$

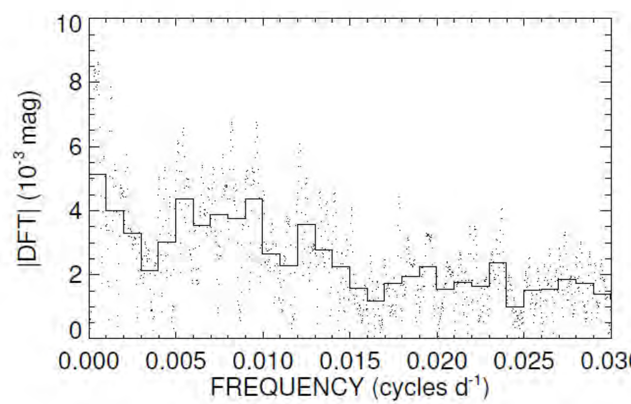
These imply a stellar distance of 1.7 ± 0.1 kpc, which is consistent with determinations in the literature.

• Najarro et al. 1997, A&A, 326, 1117

Our long-term Hα and photometric project

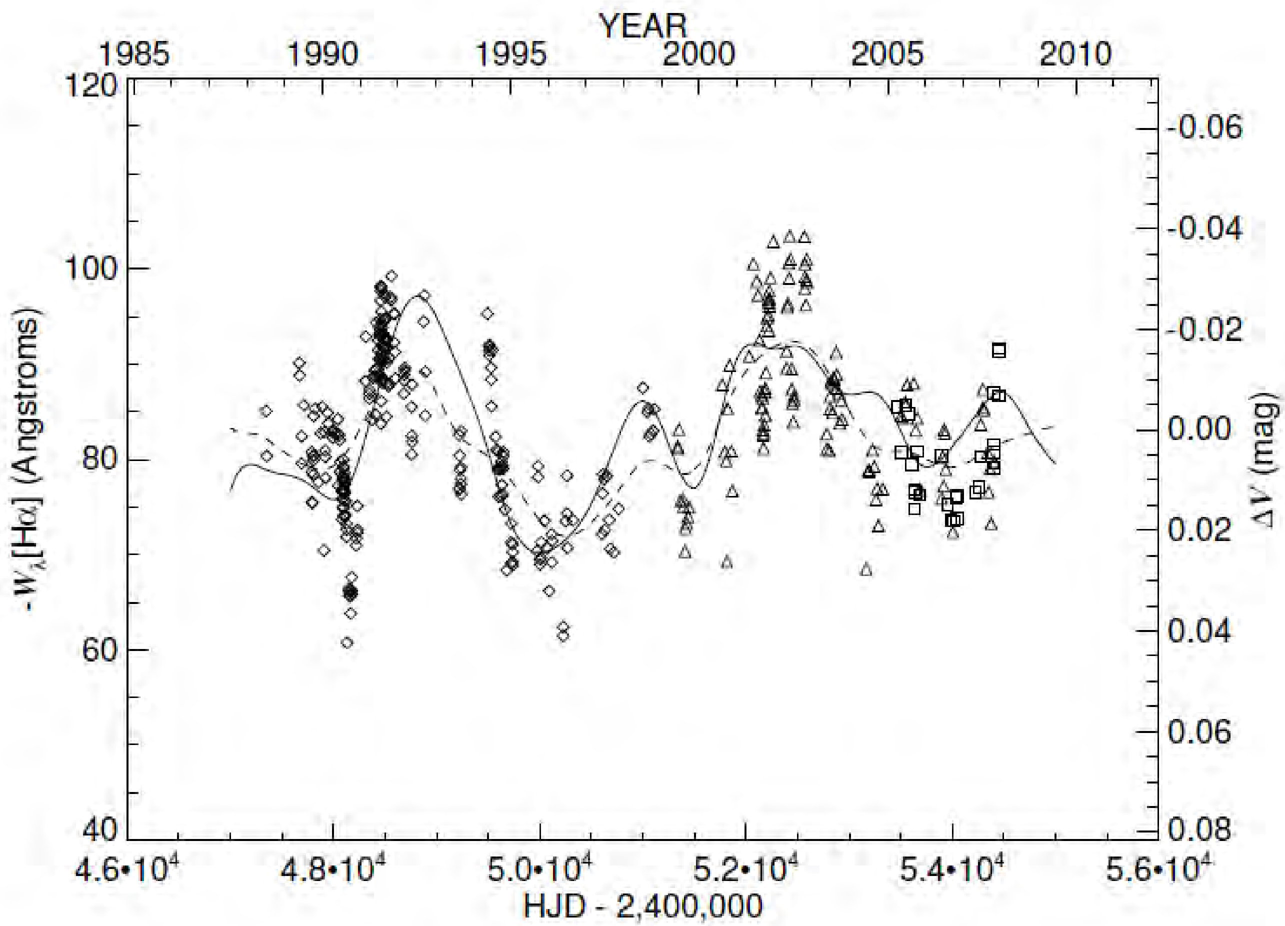




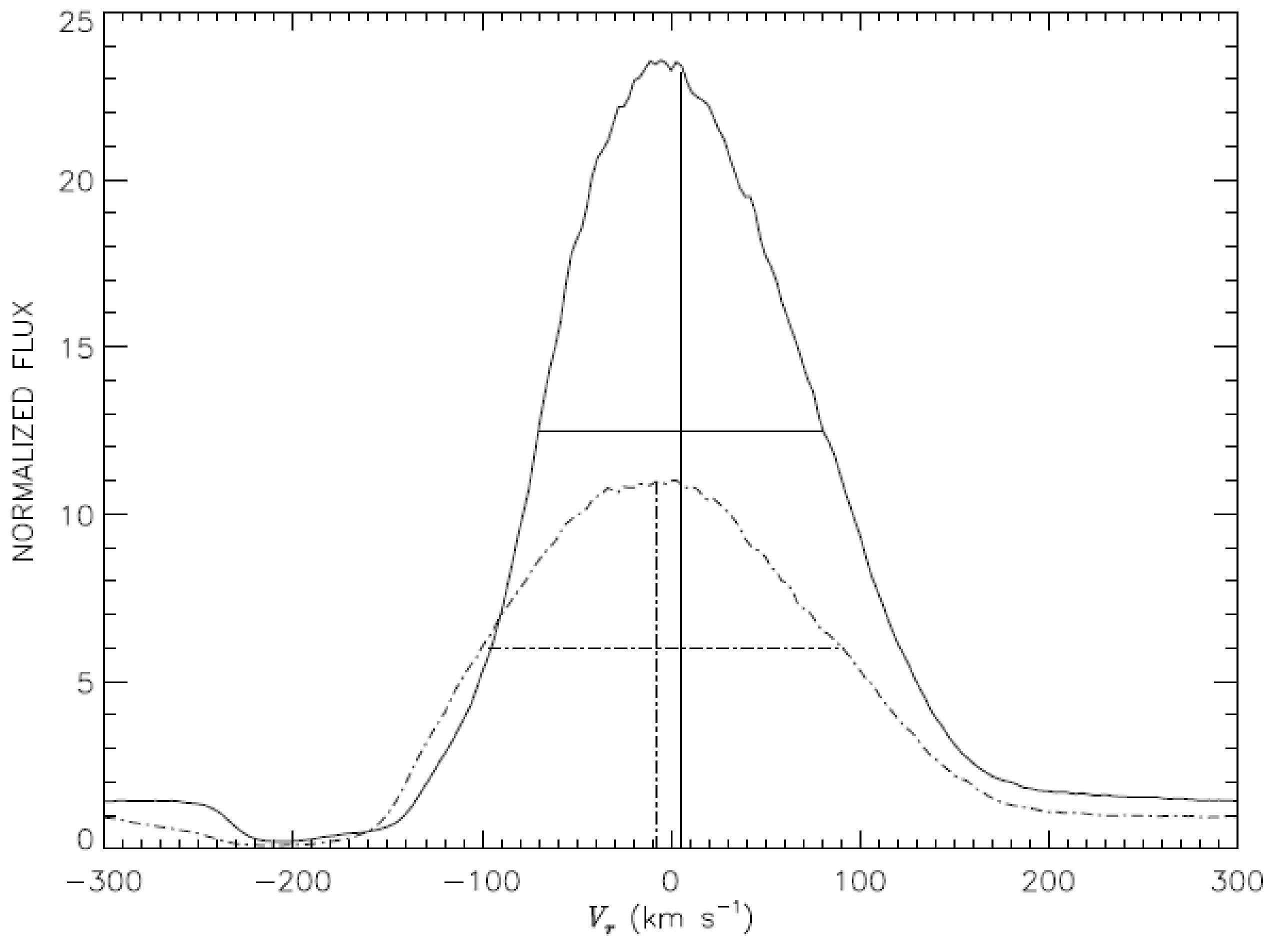


Richardson et al. 2011, AJ, 141, 120

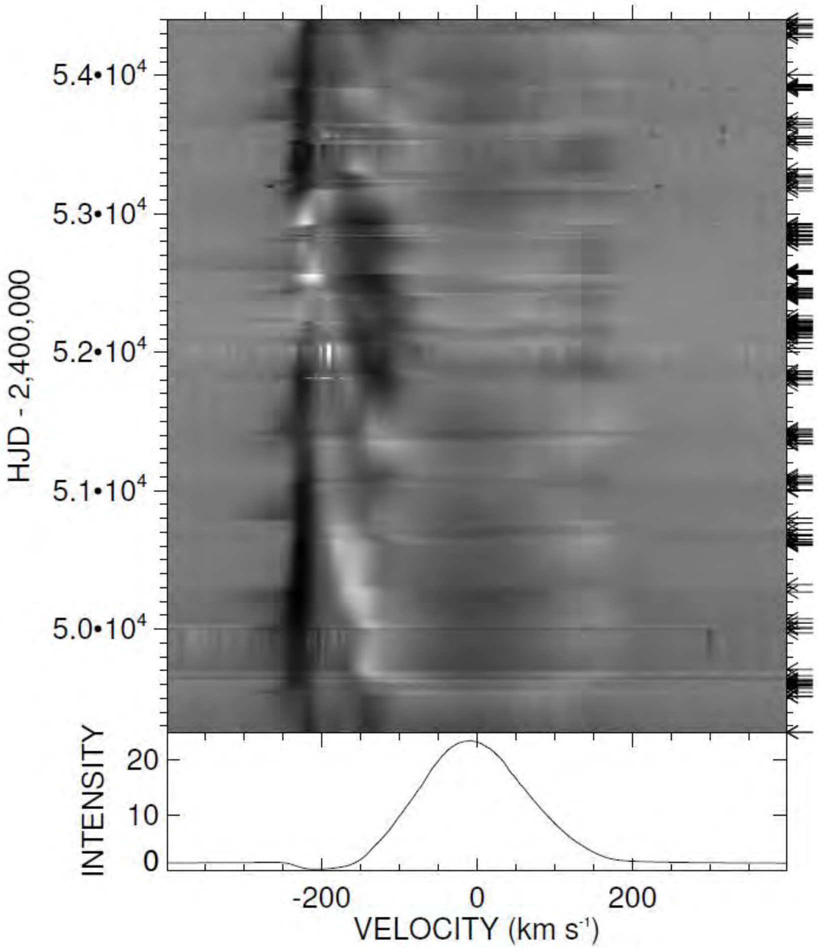
Hα Equivalent Width

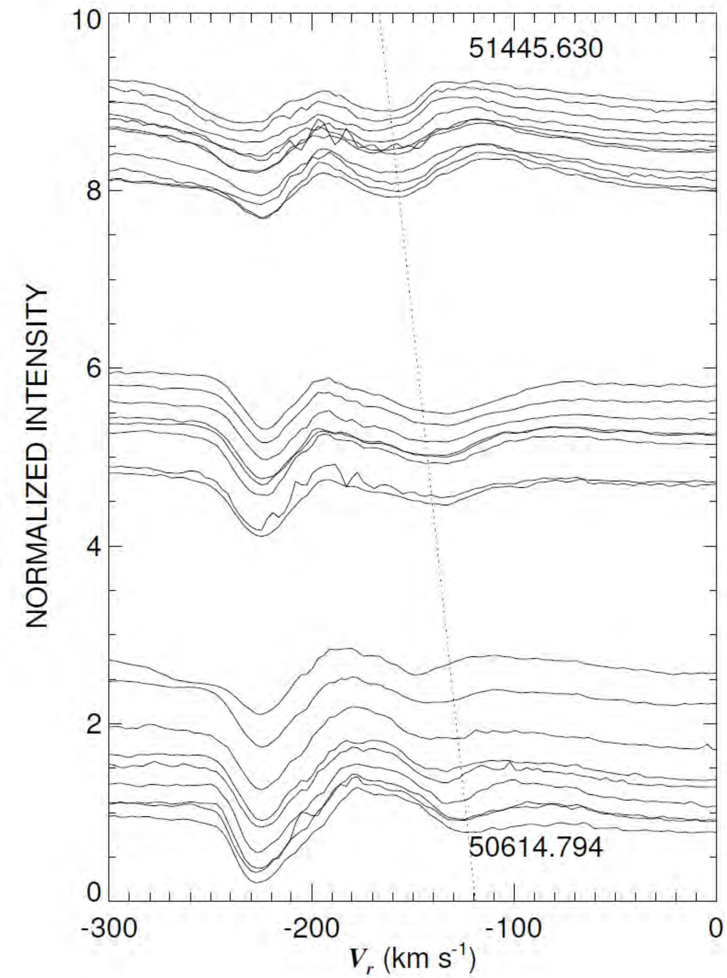


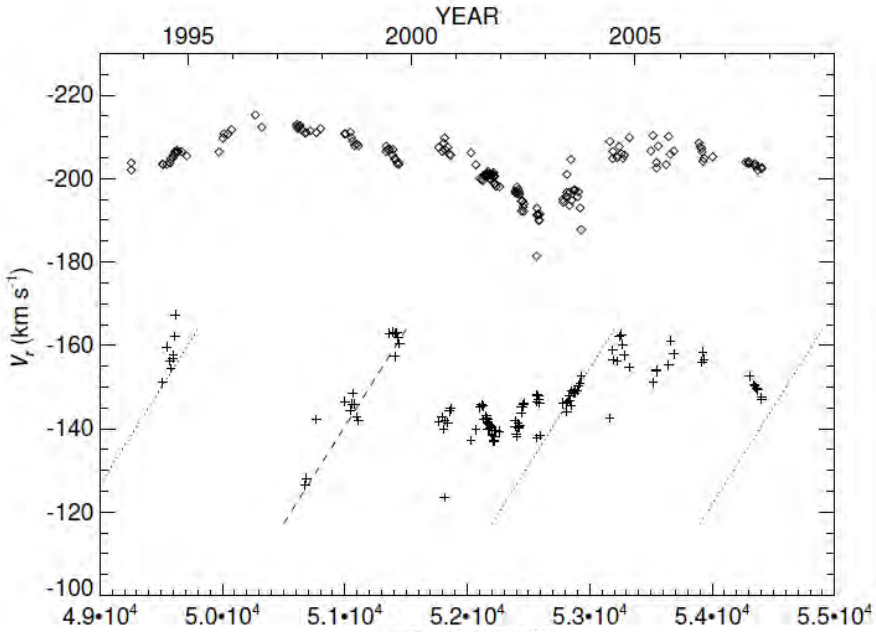
The Hα Profile

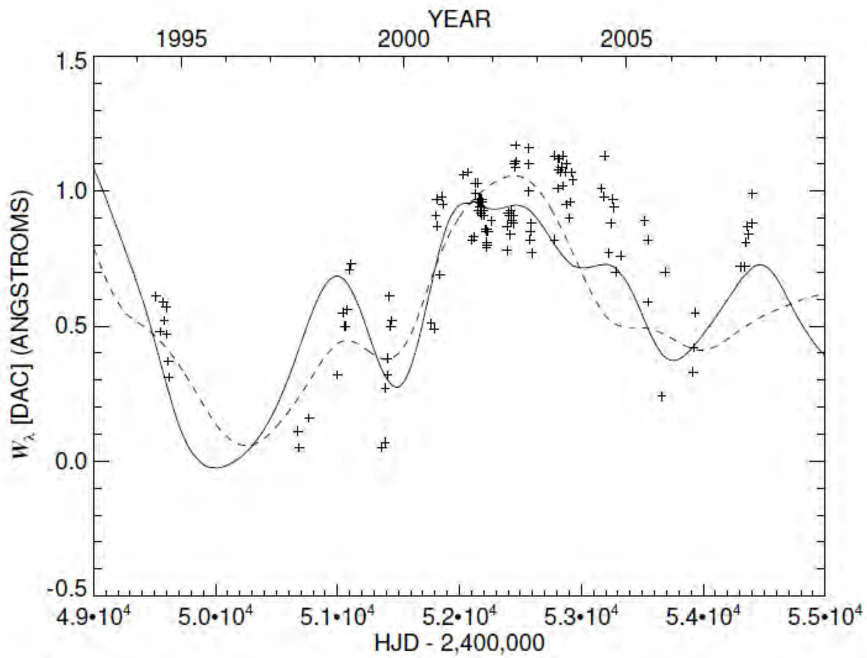


Subtle Profile Variability






YEAR
1995
2000
2005
-220
-200
-180
-160
-140
-120
-100
V_r (km s^-1)
4.9•10^4
5.0•10^4
5.1•10^4
5.2•10^4
5.3•10^4
5.4•10^4
5.5•10^4

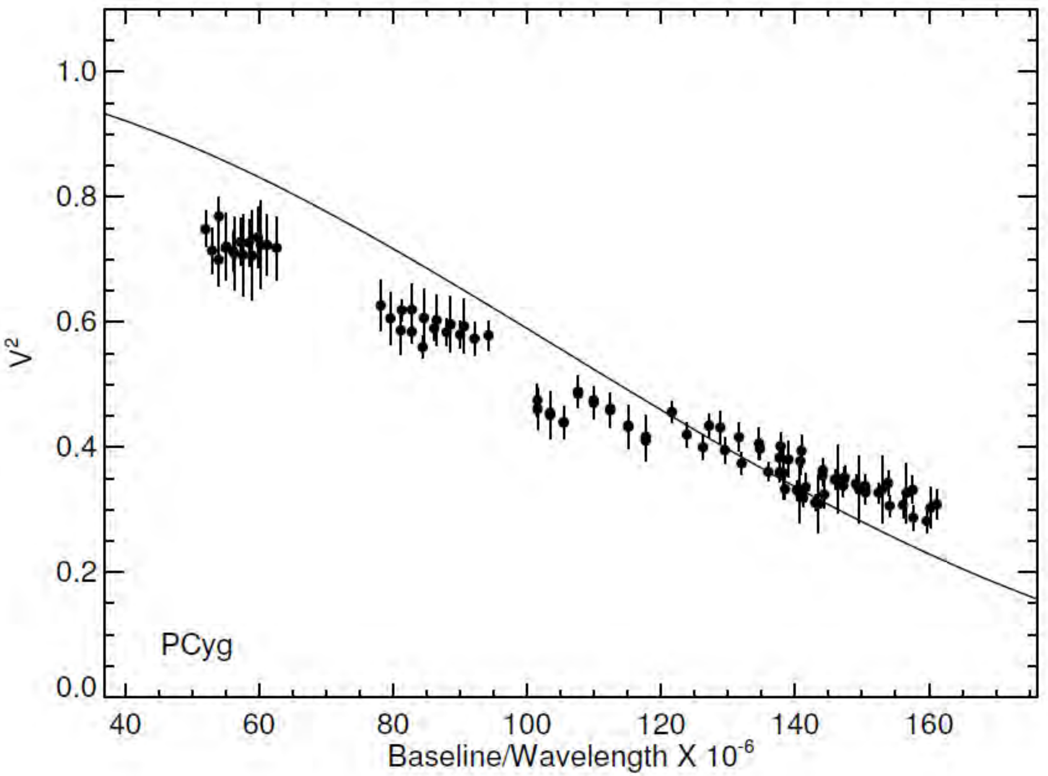

YEAR
1995
2000
2005
1.5
1.0
0.5
0.0
-0.5
W_λ [DAC] (ANGSTROMS)
4.9•10^4
5.0•10^4
5.1•10^4
5.2•10^4
5.3•10^4
5.4•10^4
5.5•10^4
HJD - 2,400,000

Implications

- Long term accelerated component in wind with acceleration of -0.47 ± 0.002 km s^{-1} d^{-1}.
- Strength of this component varies in sync with long-term behavior.
  - Wind is spherical

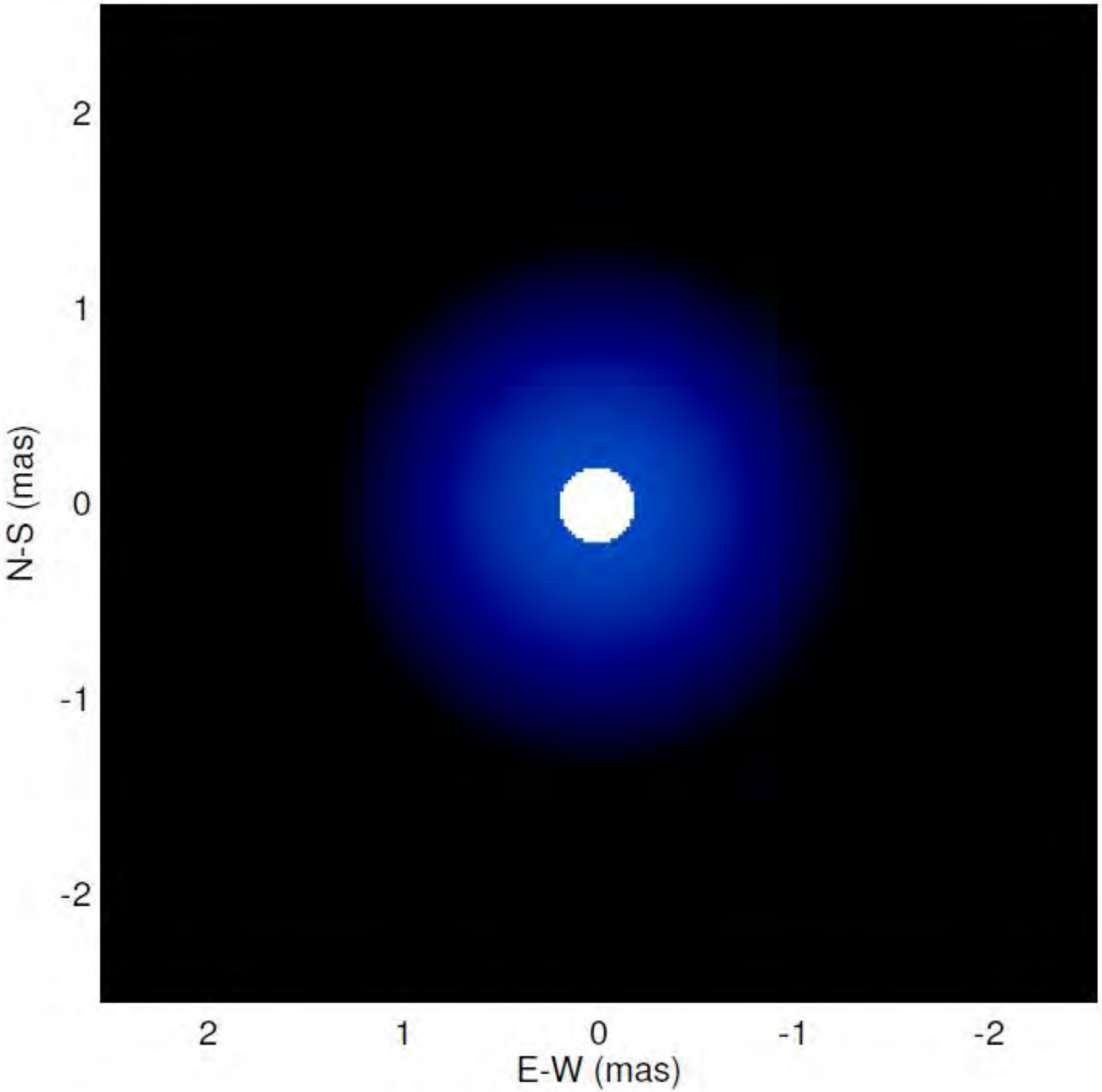
MIRC Observations

- 2 data sets with 4-T (inner array), 2010 Aug 23

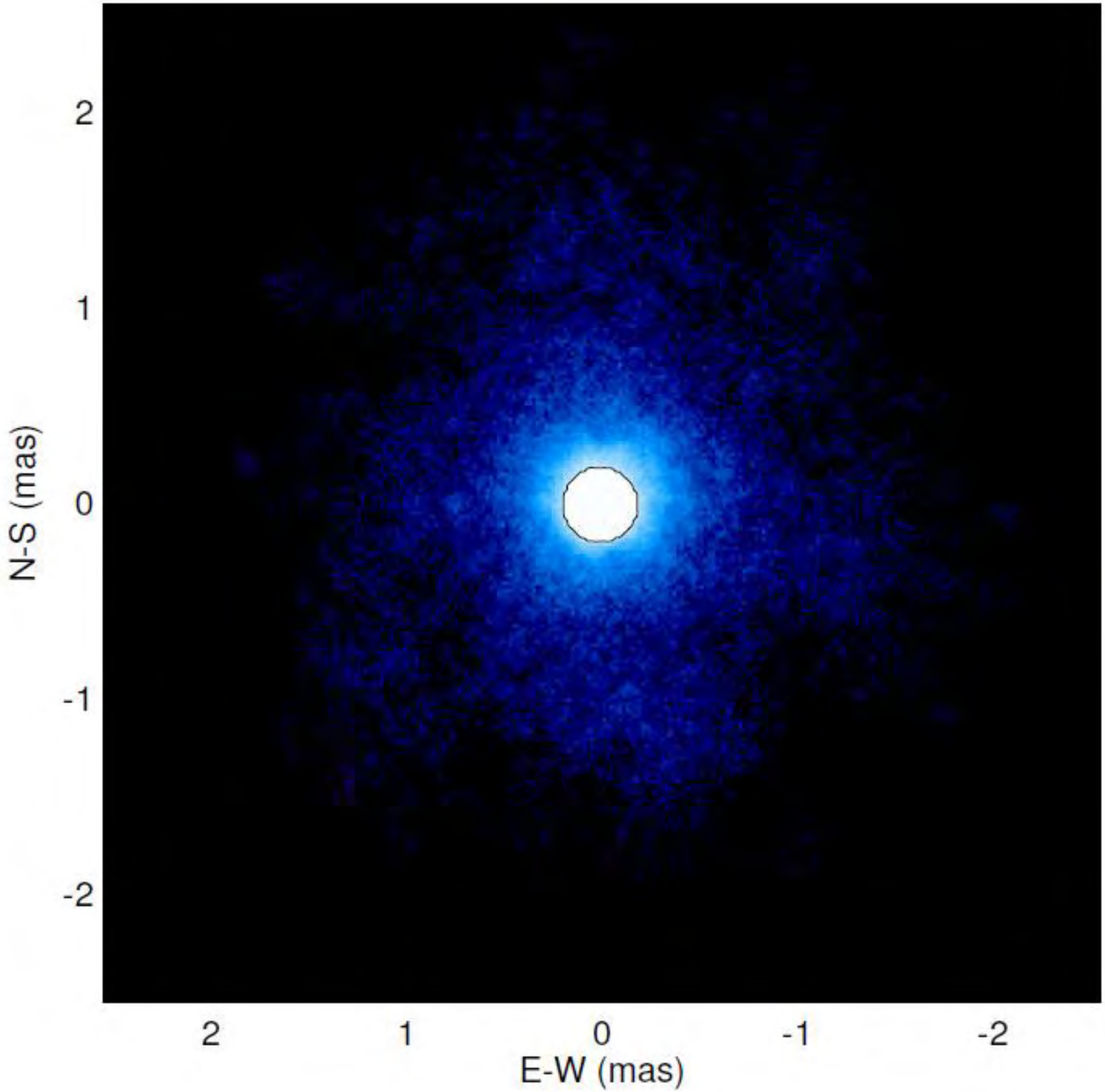


MIRC Observations

- Best (simple) model: star of size 0.39 mas (from wind models of Najarro et al.)
- Gaussian wind of 1.150 ± 0.026 mas in size (40% of the light).

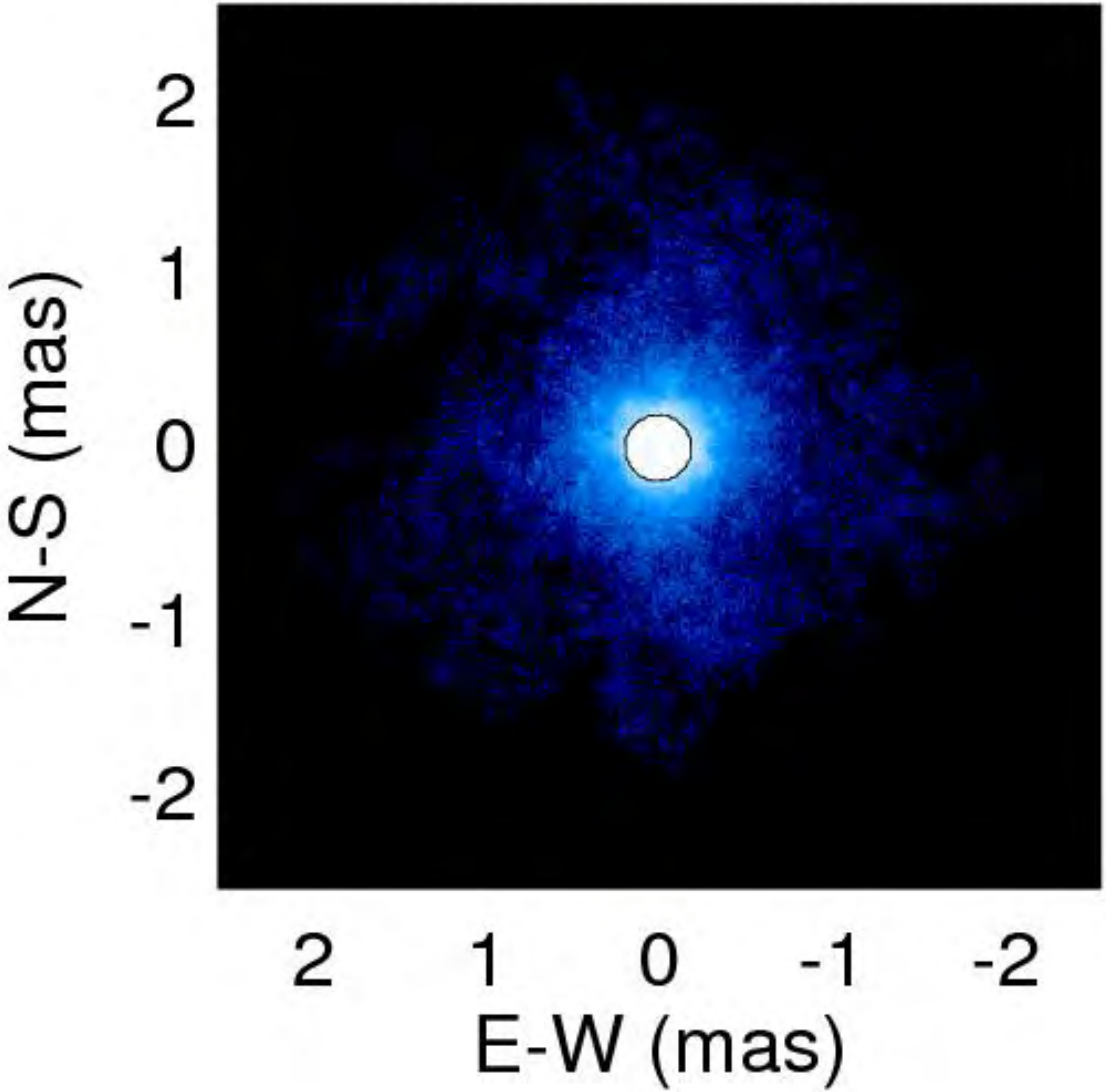


2
1
0
-1
-2
N-S (mas)
2
1
0
-1
-2
E-W (mas)


2
1
0
-1
-2
N-S (mas)
2
1
0
-1
-2
E-W (mas)

6T MIRC – UT 2011 Sep 3

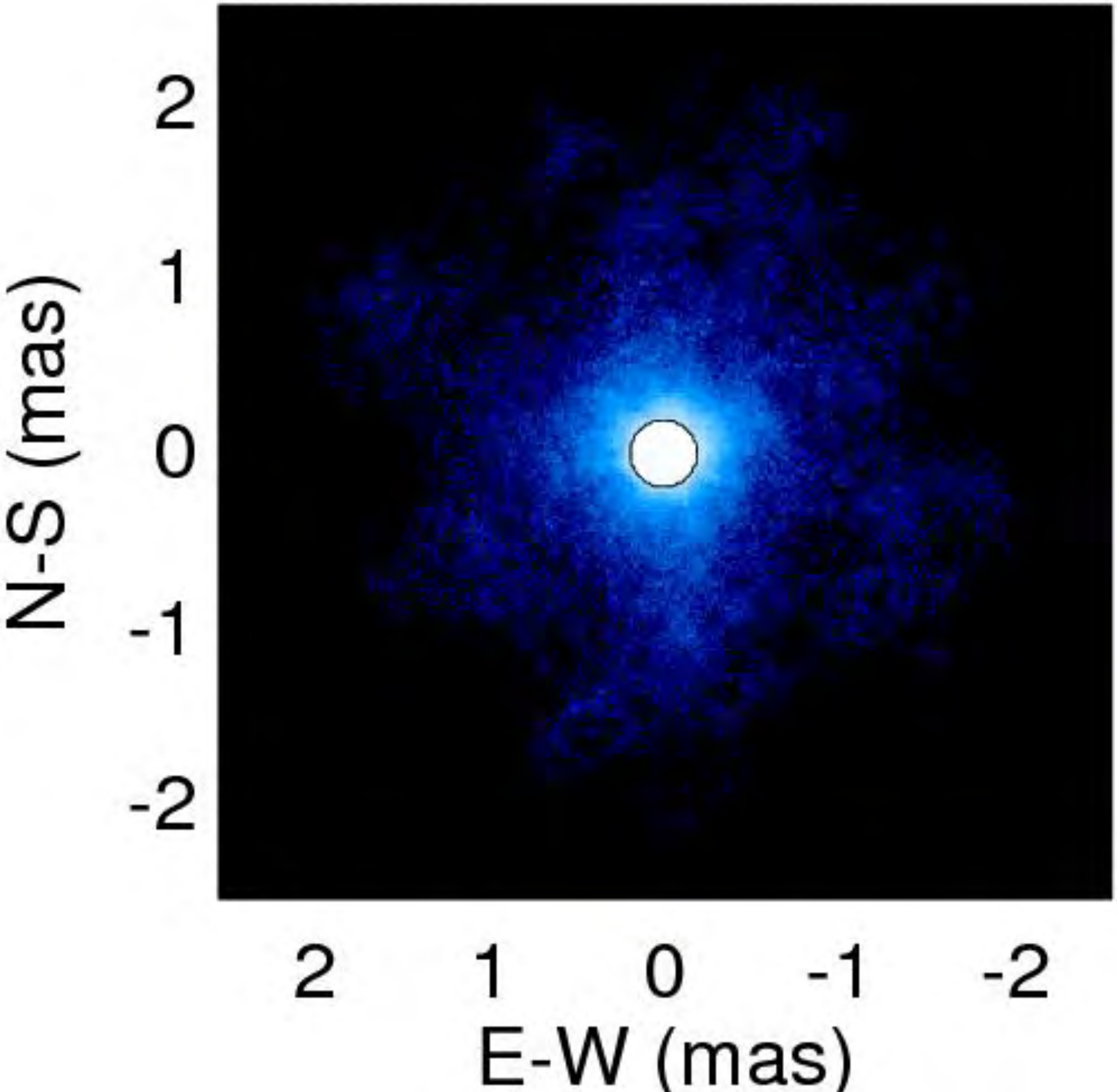
- Best simple model: star of size 0.39 mas
- Gaussian wind size 0.93 mas (47.5% of the flux)



N-S (mas)
2
1
0
-1
-2
2
1
0
-1
-2
E-W (mas)

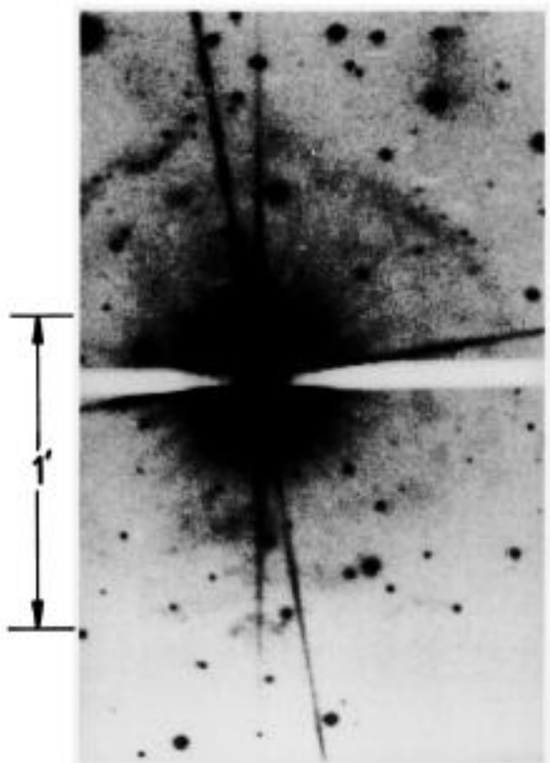
Combined data

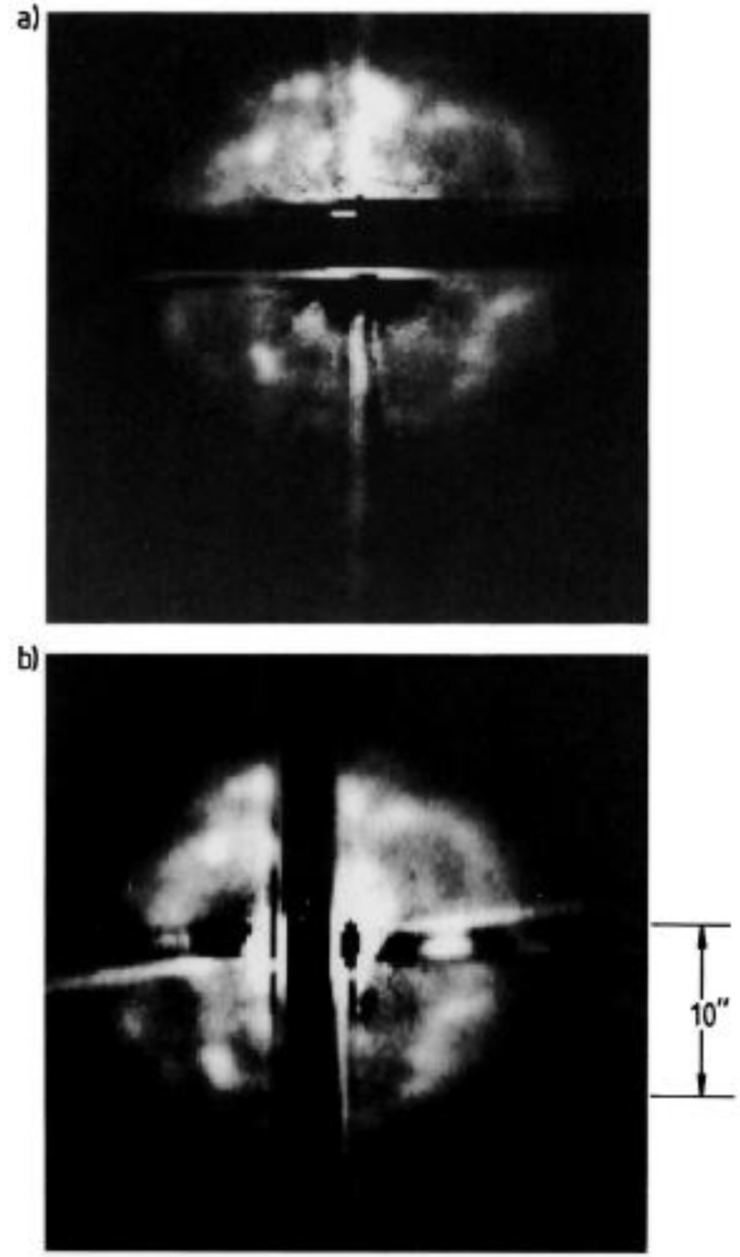
- Wind: 0.83 mas FWHM; 52% of flux


2
1
0
-1
-2
N-S (mas)
2
1
0
-1
-2
E-W (mas)

Future Work

- One more epoch this year to confirm the asymmetry
- How does the asymmetry compare to the large scale structure from the great eruption?





- Barlow et al. 1994