Integral Field Unit Spectroscopy of the Helium Nova V445 Puppis

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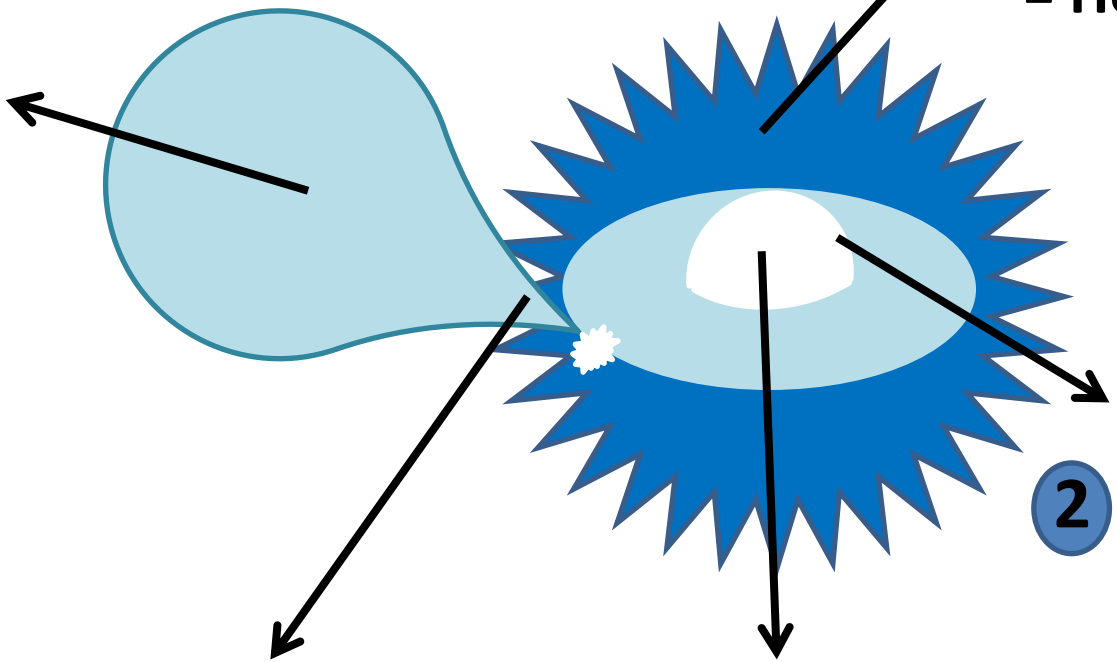
Stella Novae: Past and Future Decades

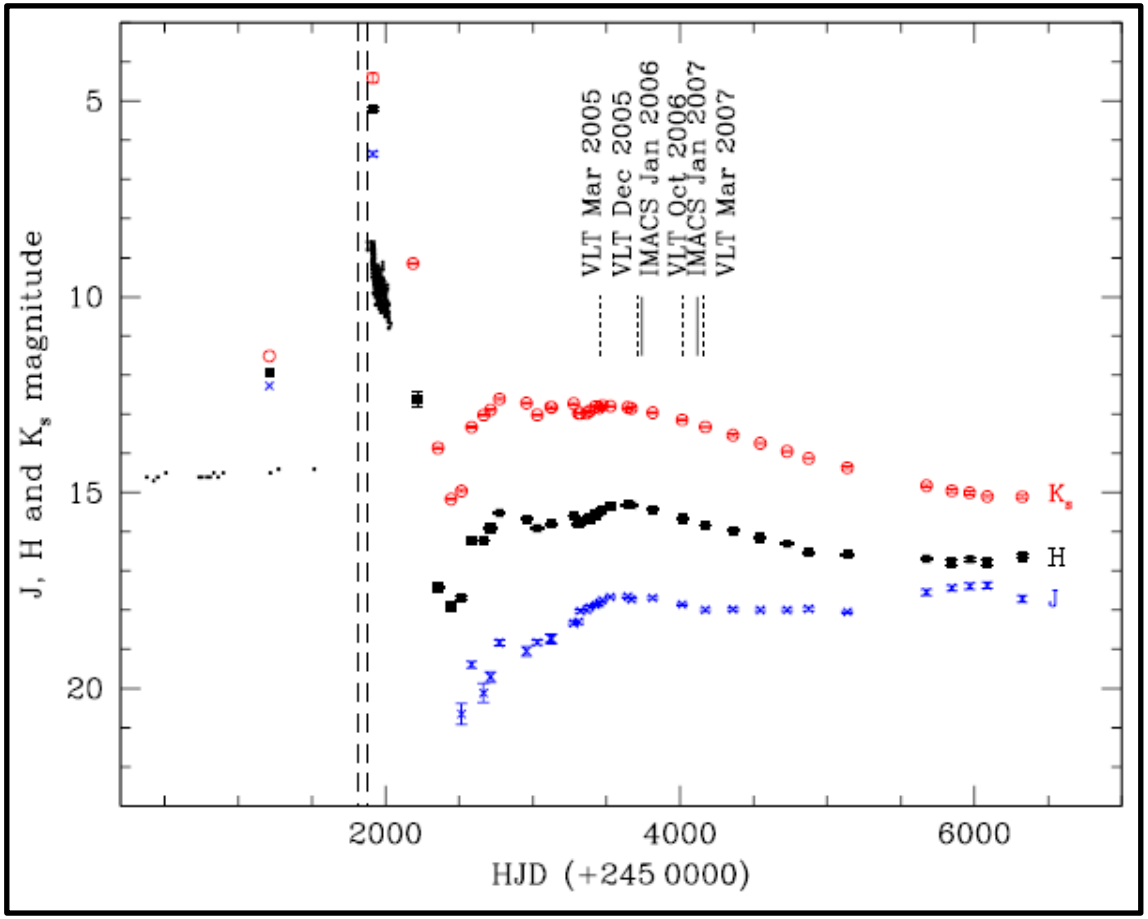
Content

Helium Novae

- first predicted by Kato et al. (1989)
- only one known: V445 Puppis



V445 Puppis as a helium nova

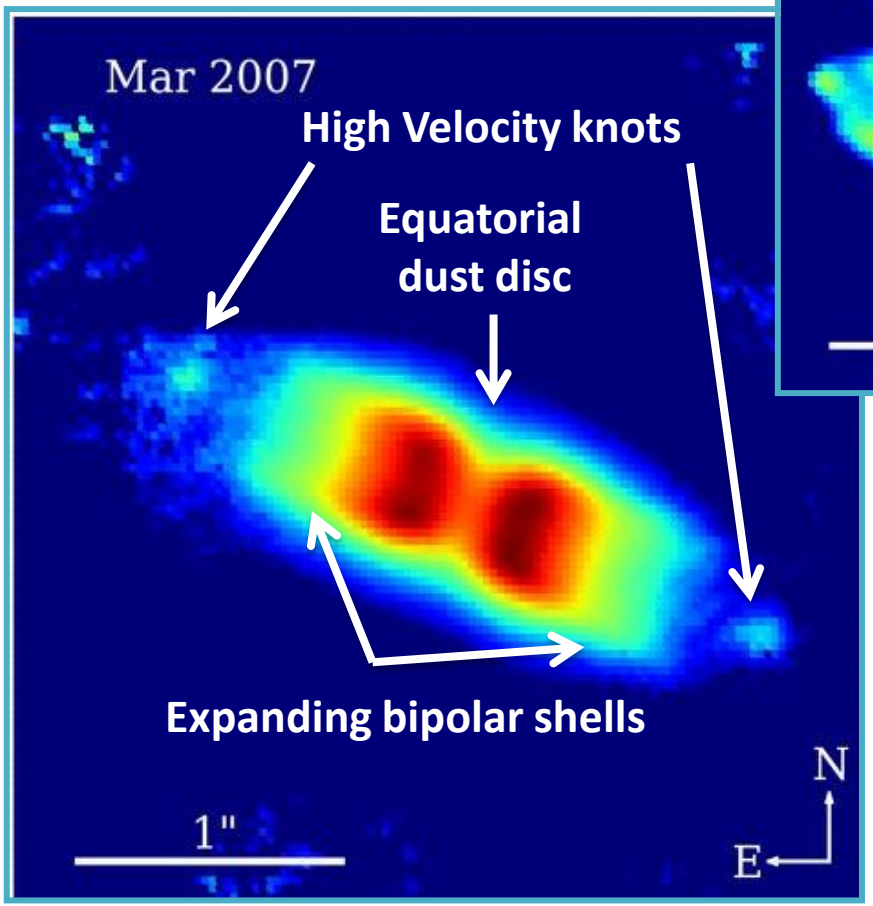


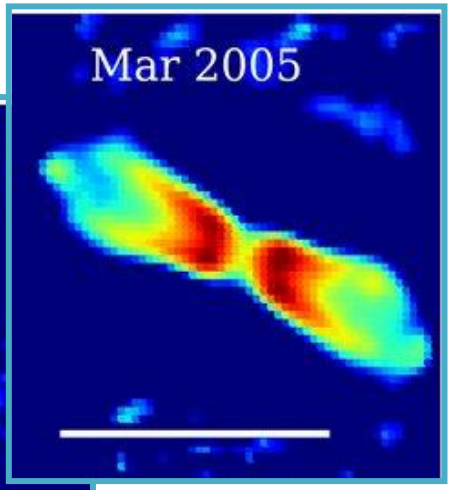
Left: Near-infrared light curves of V445 Puppis before, during and after outburst.

- **28 Nov. 2000: discovered in outburst**
- **Jul 2001: thick carbon dust shell forms**
- **Jan 2013: progenitor still obscured by dust disc**

V445 Puppis

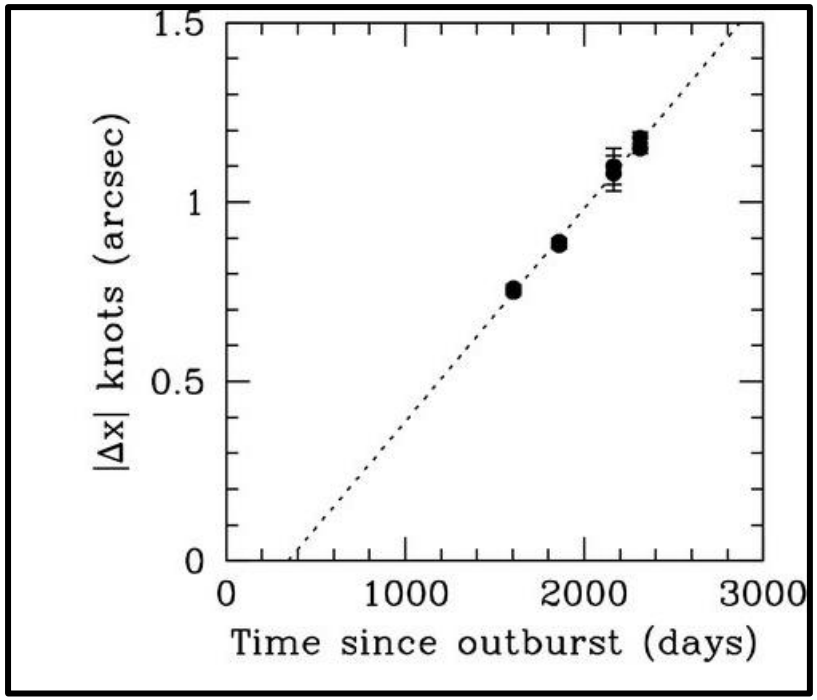
V445 Pup Properties	
Shell Inclination	3.9 ± 0.4 deg
Distance to Nova	8.2 ± 0.3 kpc
Equatorial Velocity	500 km.s^{-1}
Shell polar expansion velocity	6720 ± 250 km.s^{-1}
Knot Velocity	8450 km.s^{-1}





Evolving nova shell of V445 Puppis obtained with NAOS/CONICA on the VLT. (Woudt et al. 2009)

Knots Evolution



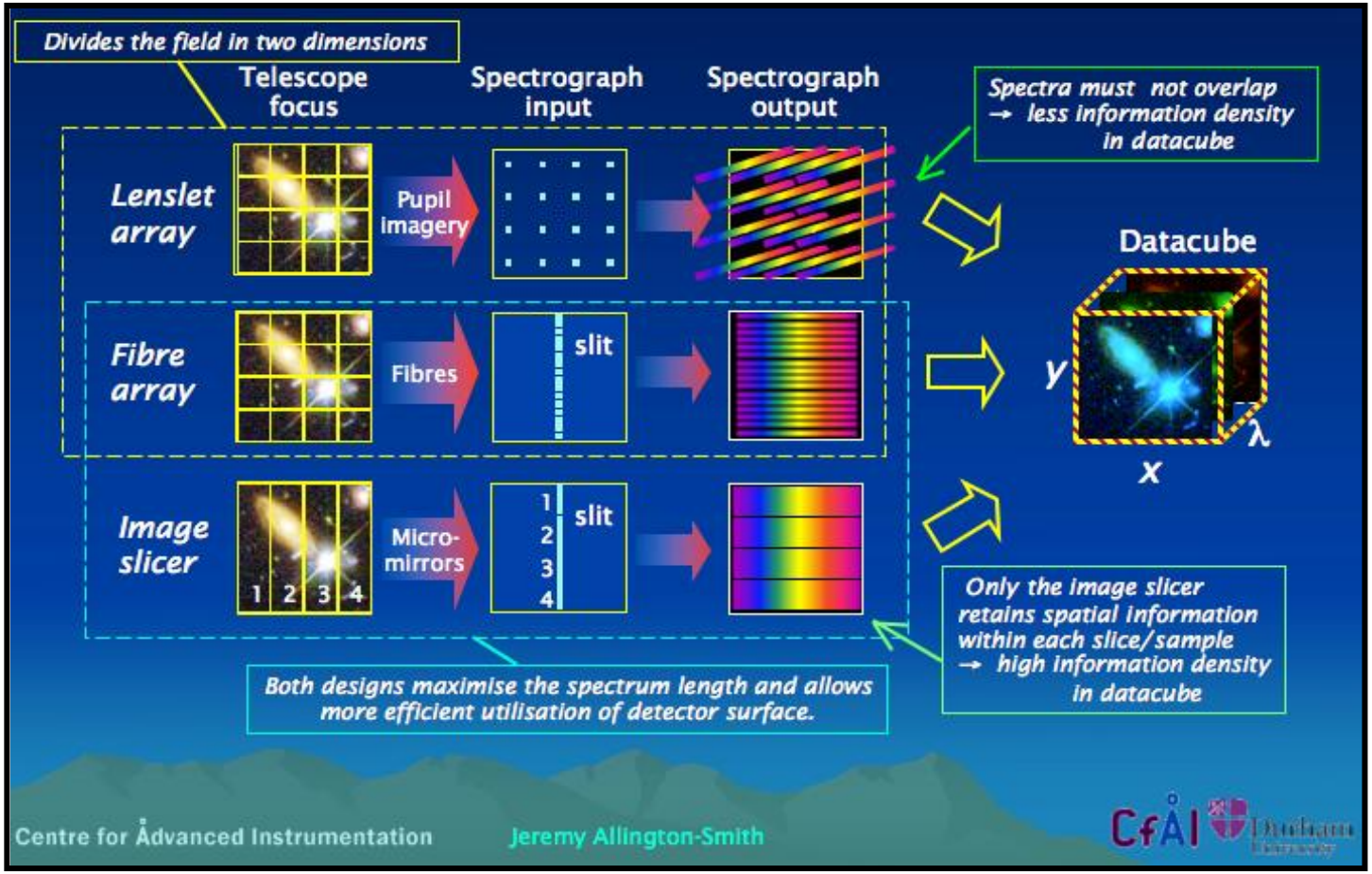
Above: Change in position of knots over time (Woudt et al. 2009)

- **Behave independently from shell**
- **origin coincides with strong radio flare ~345 days post-outburst (Rupen et al. 2001)**

Linear Expansion:
0.217" ± 0.010 yr^{-1}
(Woudt et al. 2009)

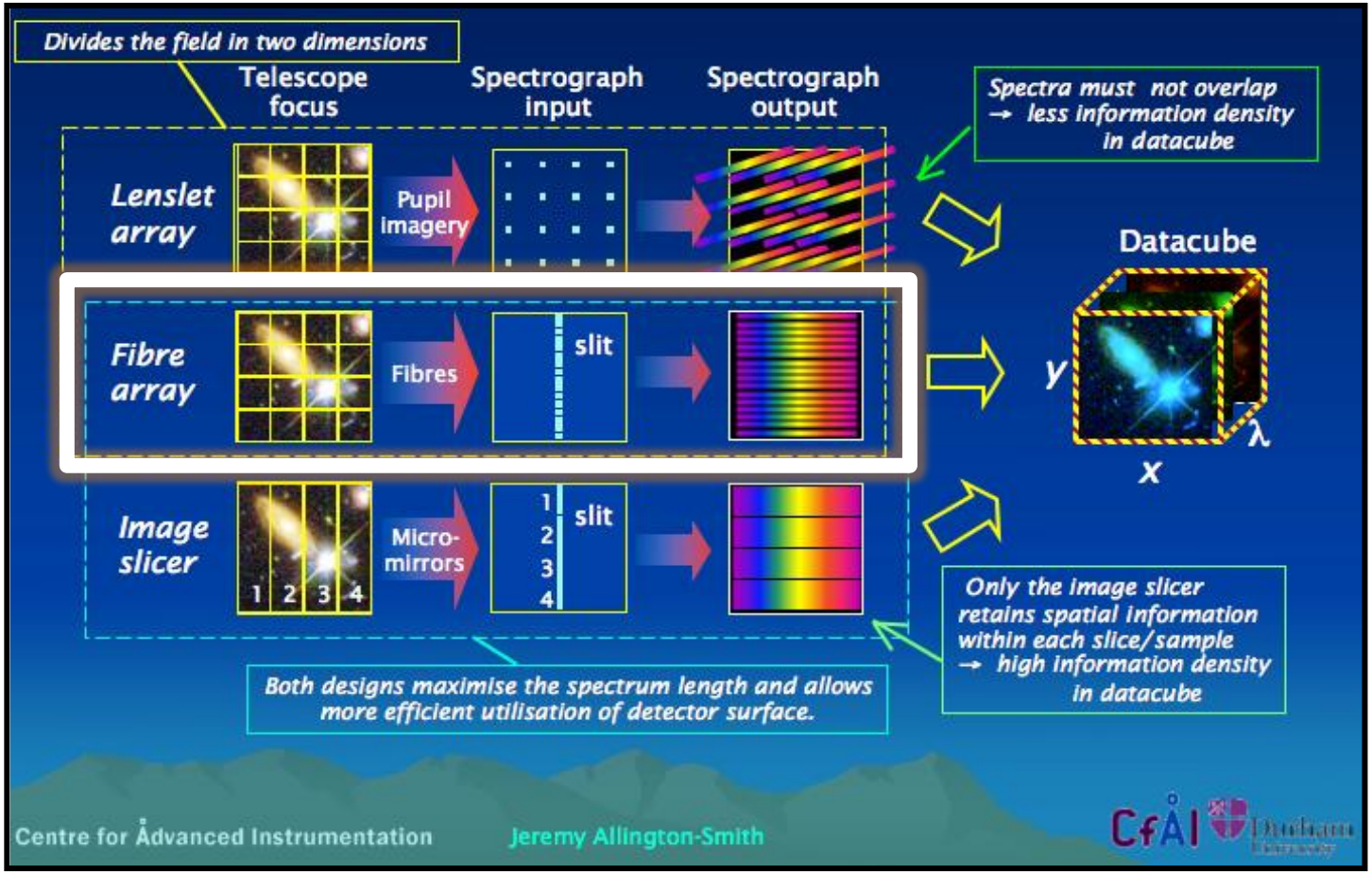
Observations

Integral Field Unit Spectroscopy



Credit: http://ifs.wikidot.com

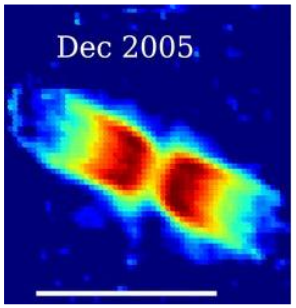
Integral Field Unit Spectroscopy



Credit: http://ifs.wikidot.com

V445 Pup Observations

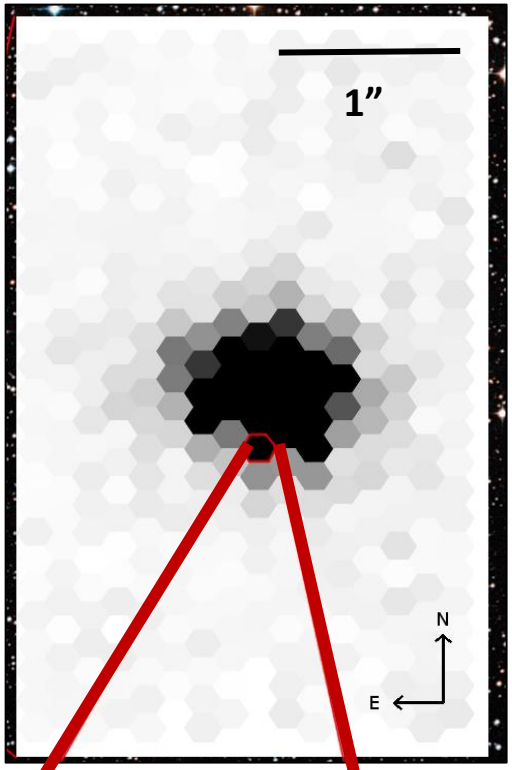
- using IMACS IFU
- 400 fibres (16 x 25)
- Covers wavelength regime: ~400nm to ~900nm.



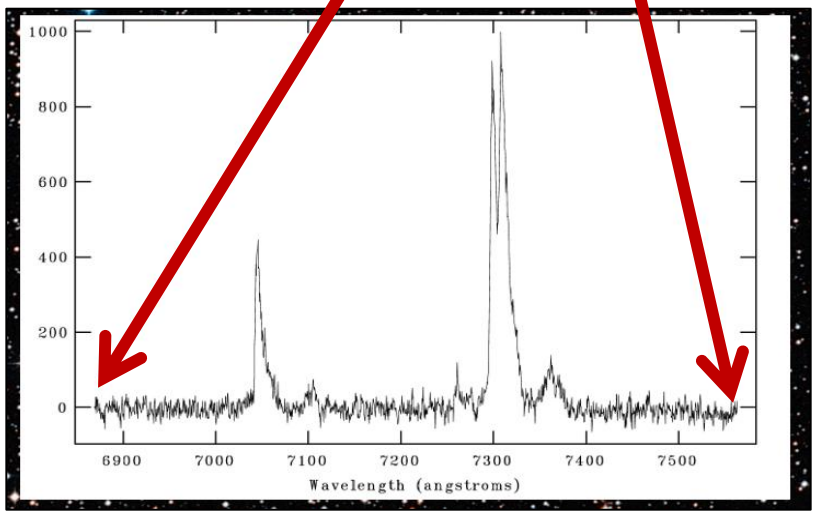
Observations are seeing limited:

- 0.2” per fibre element
BUT
- seeing ~ 0.5” for both nights

Right: V445 Pup, projected onto 400 fibres of IMACS IFU long camera

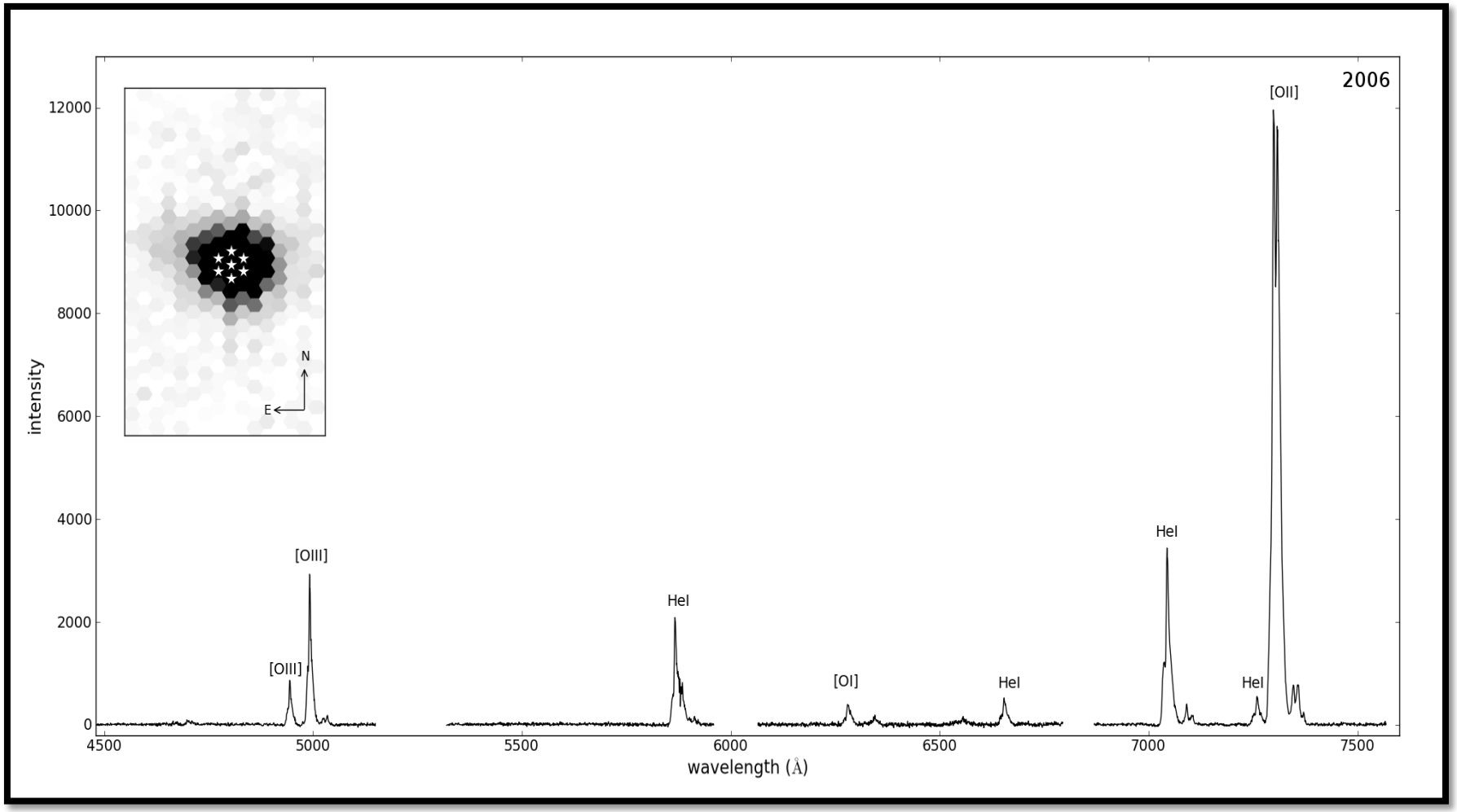


Right: spectra extracted from one fibre of one CCD

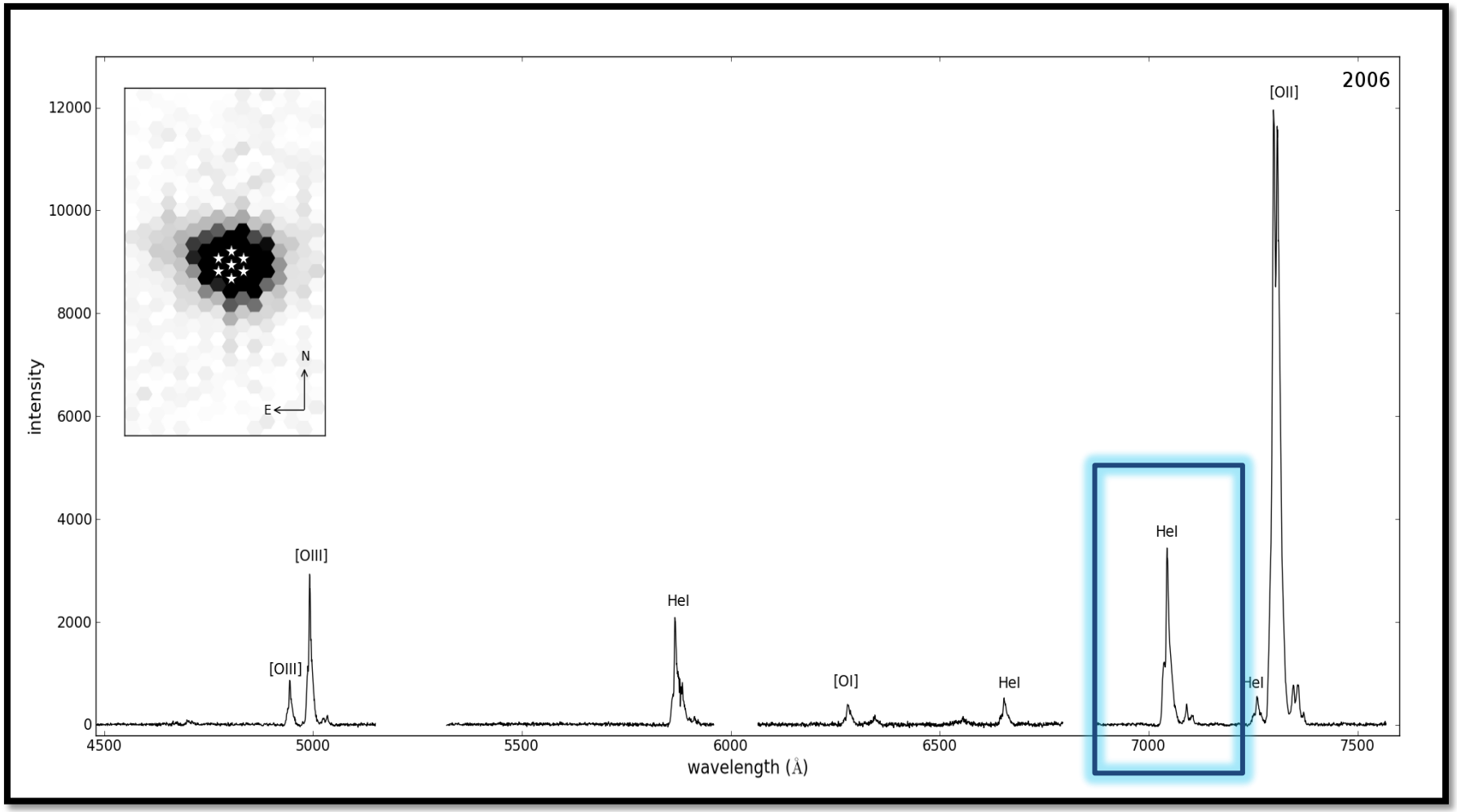


Results

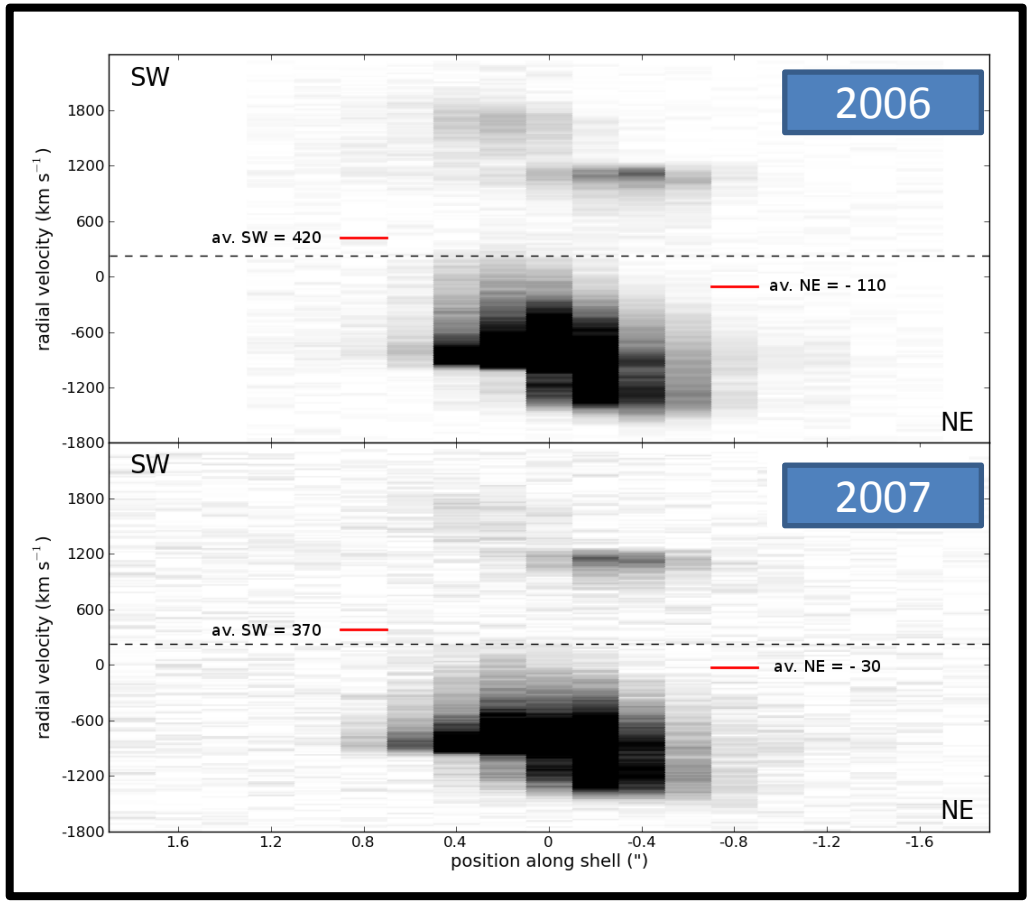
V445 Puppis Spectrum 2006

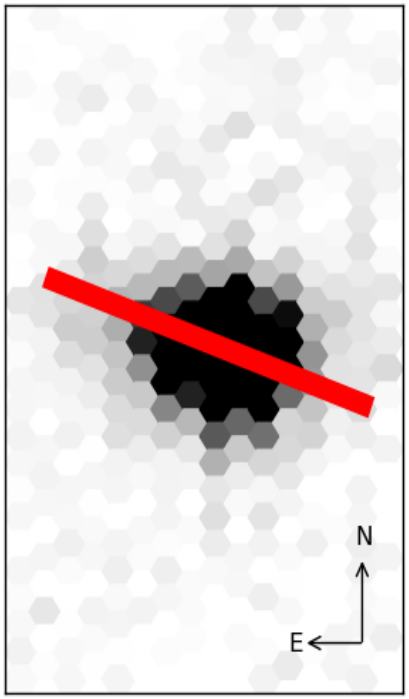


V445 Puppis Spectrum 2006



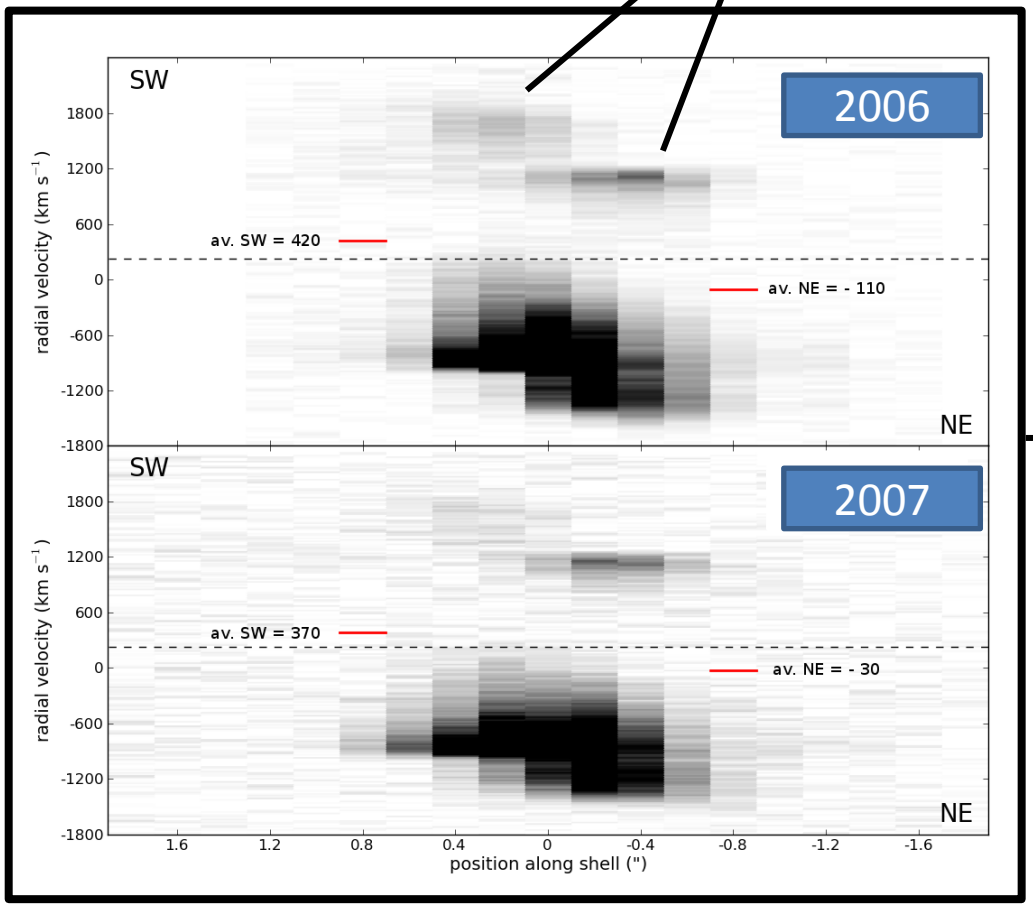
Examining the Nova Shell





Examining the Nova Shell

Step feature due to inclination of nova towards us: NE lobe is closer.

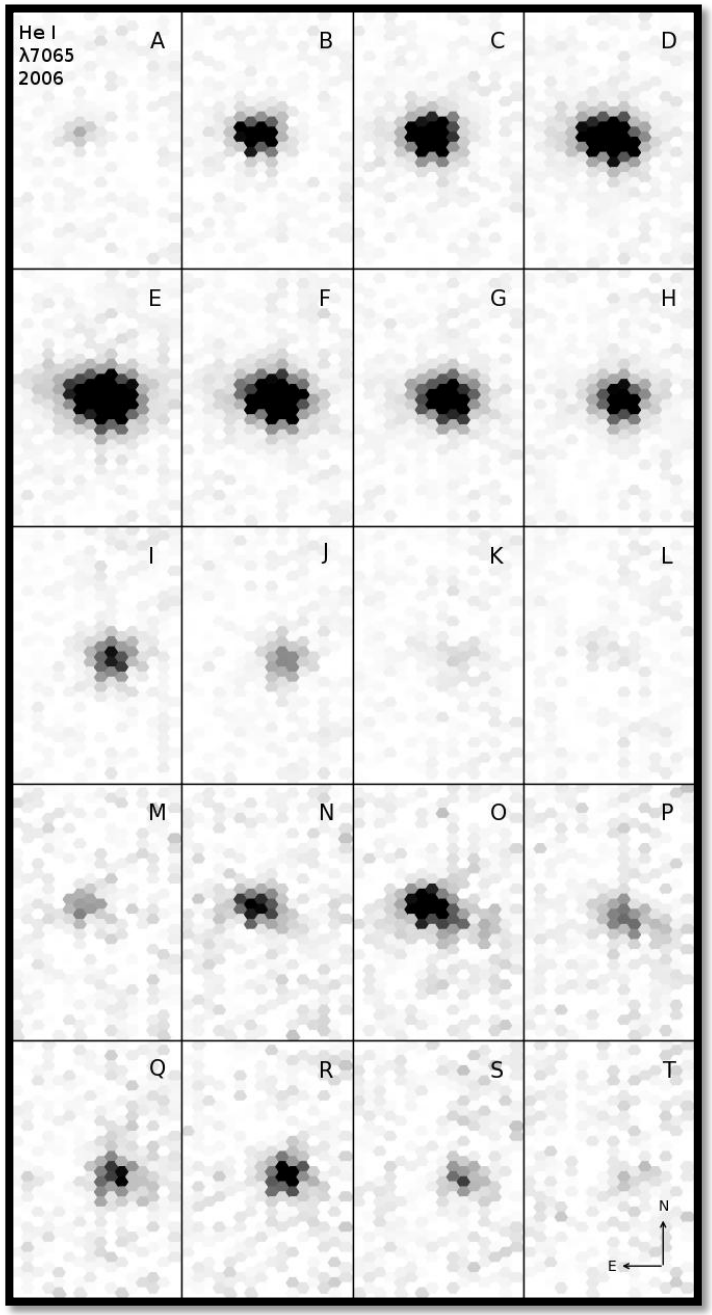


Red-shifted

Blue-shifted

Red-shifted

Blue-shifted


He I
λ7065
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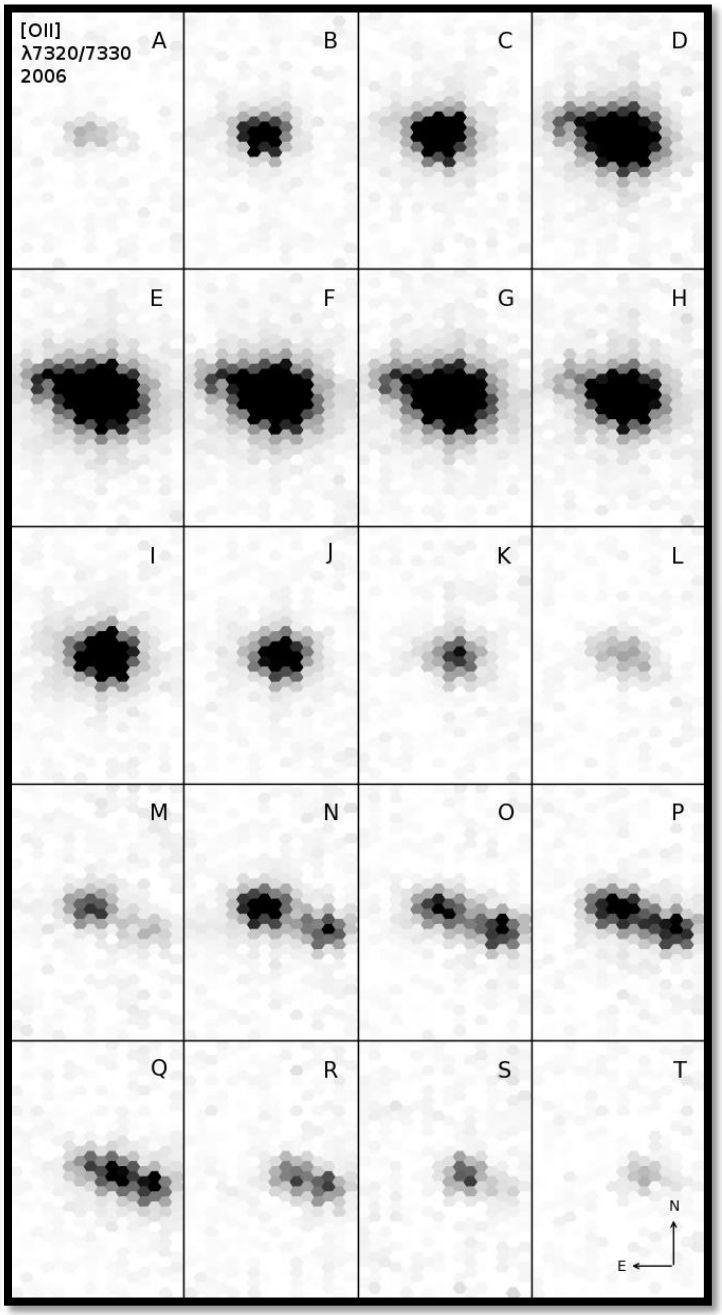
[OII]
λ7320/7330
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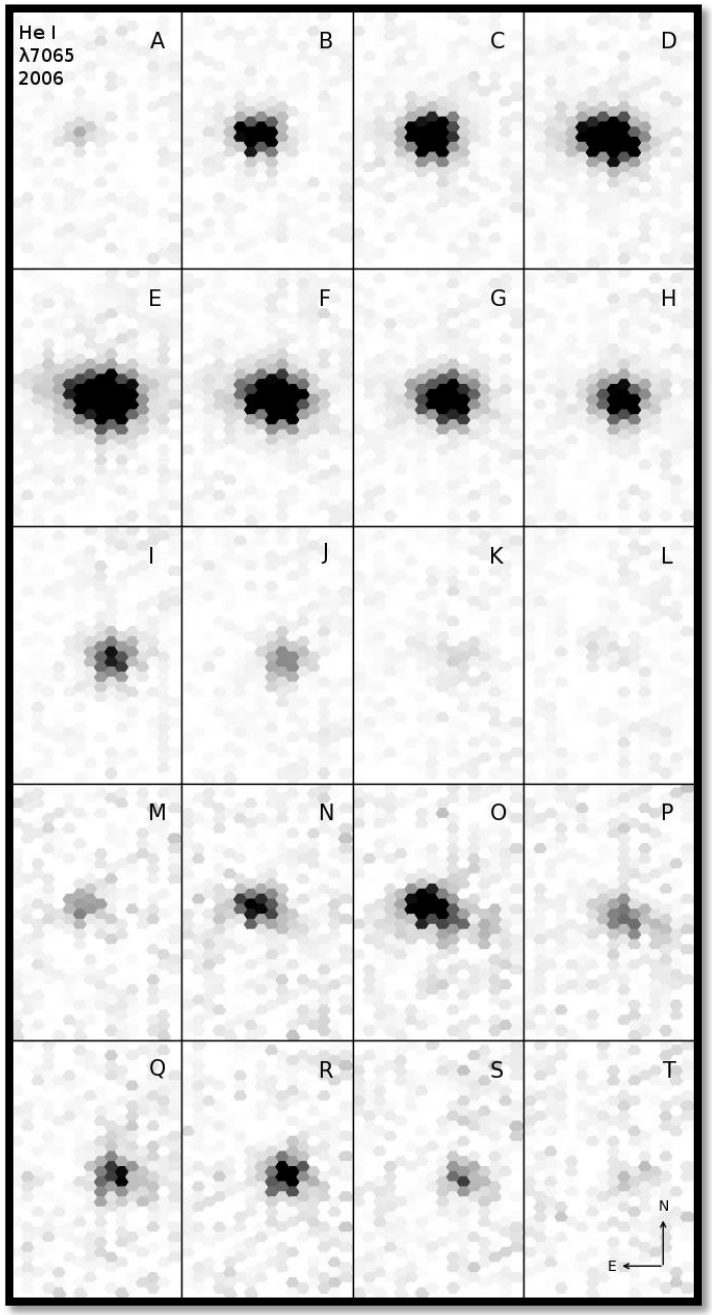
[O II]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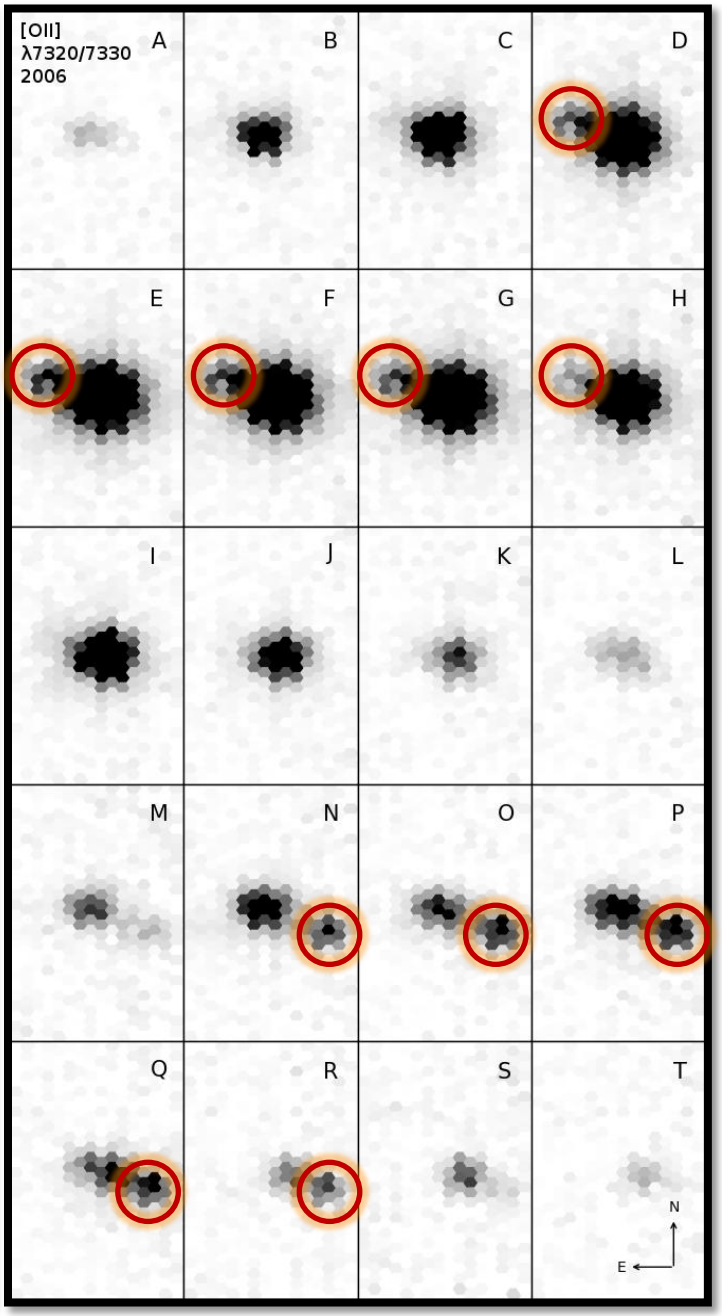
He I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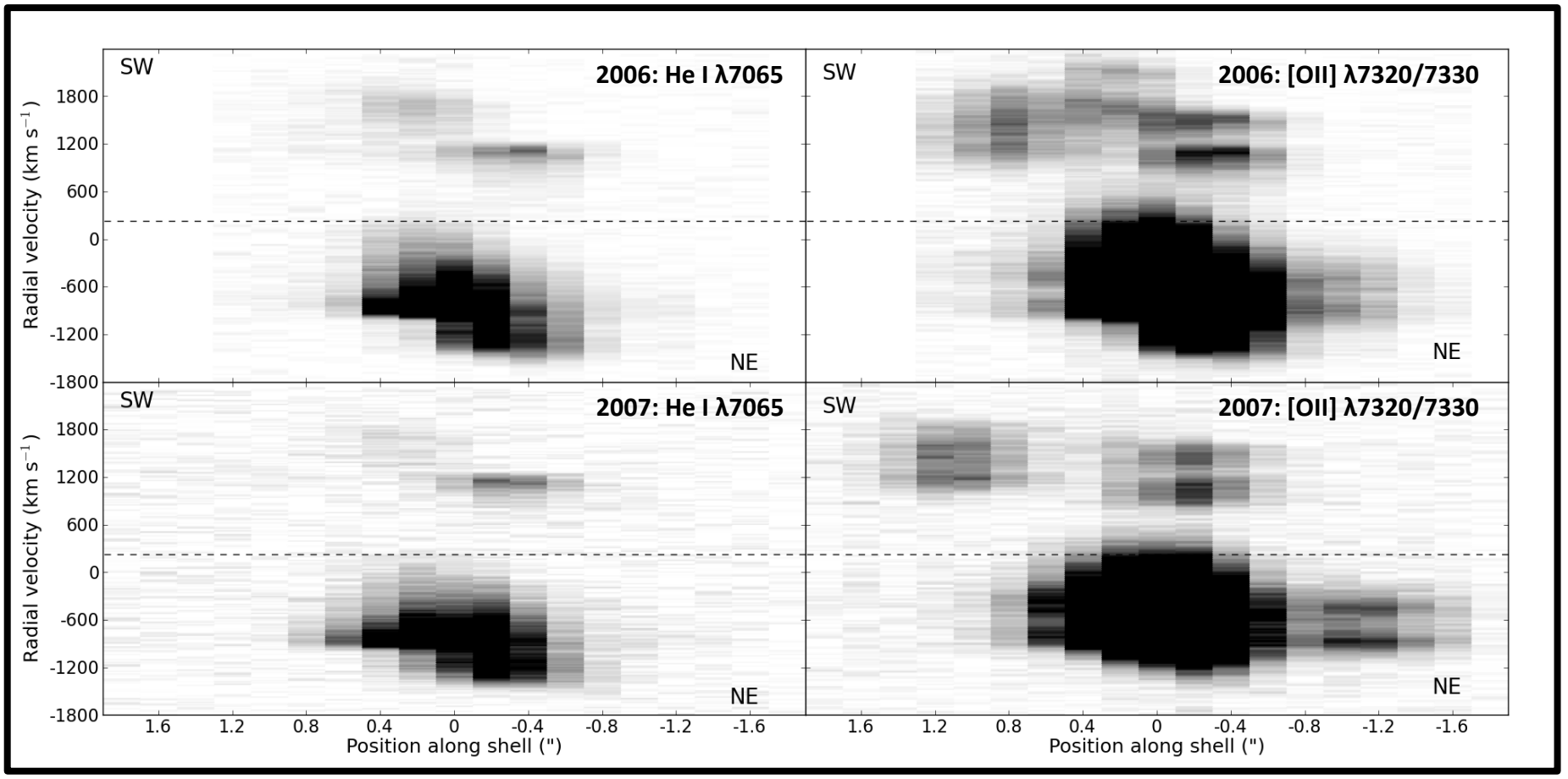
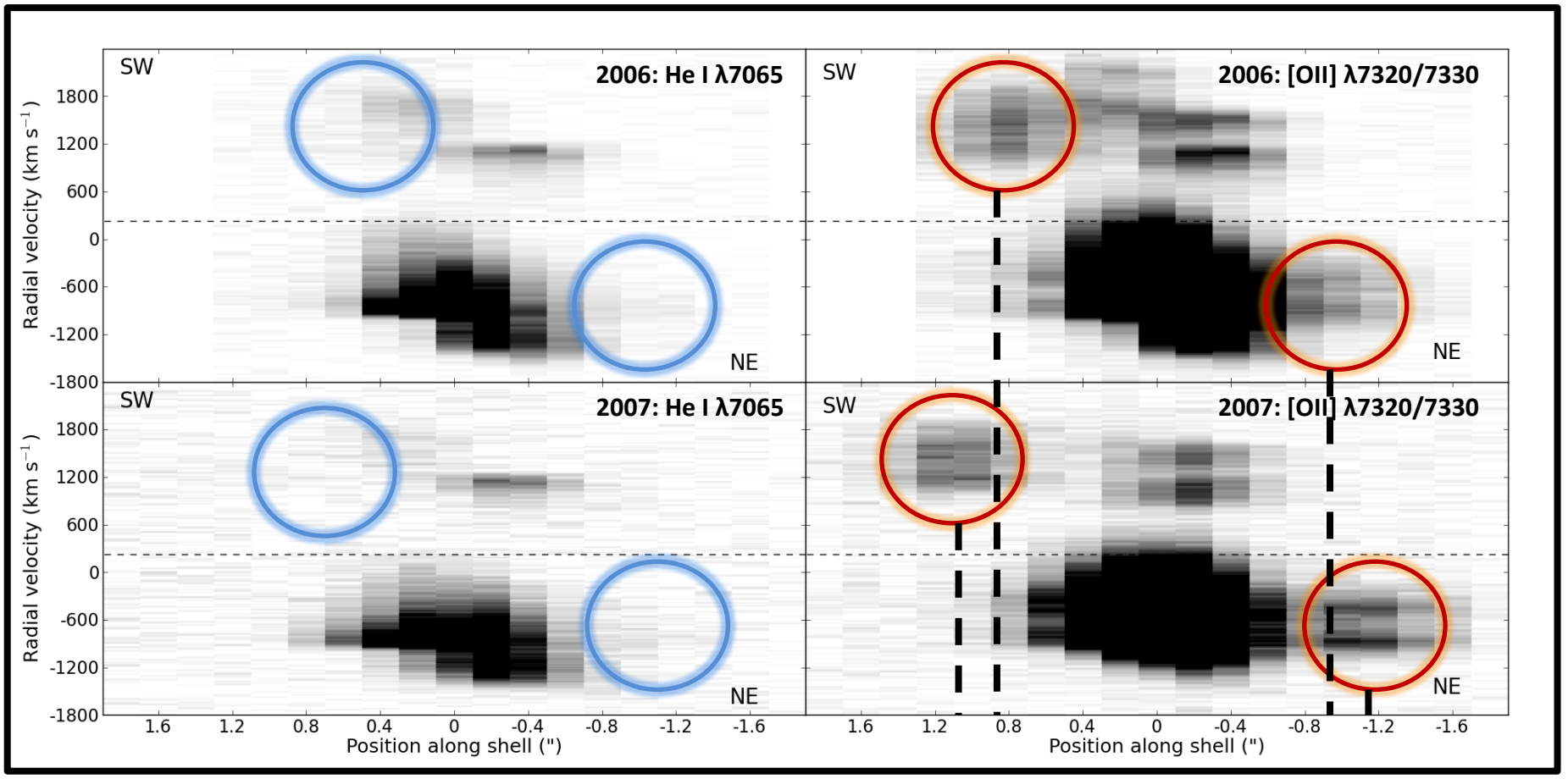
[O II]



He I

[O II]

Spatially-resolved velocity profiles of the emission line He I λ7065 and the [O II] λ7320/7330 doublet (right panels)

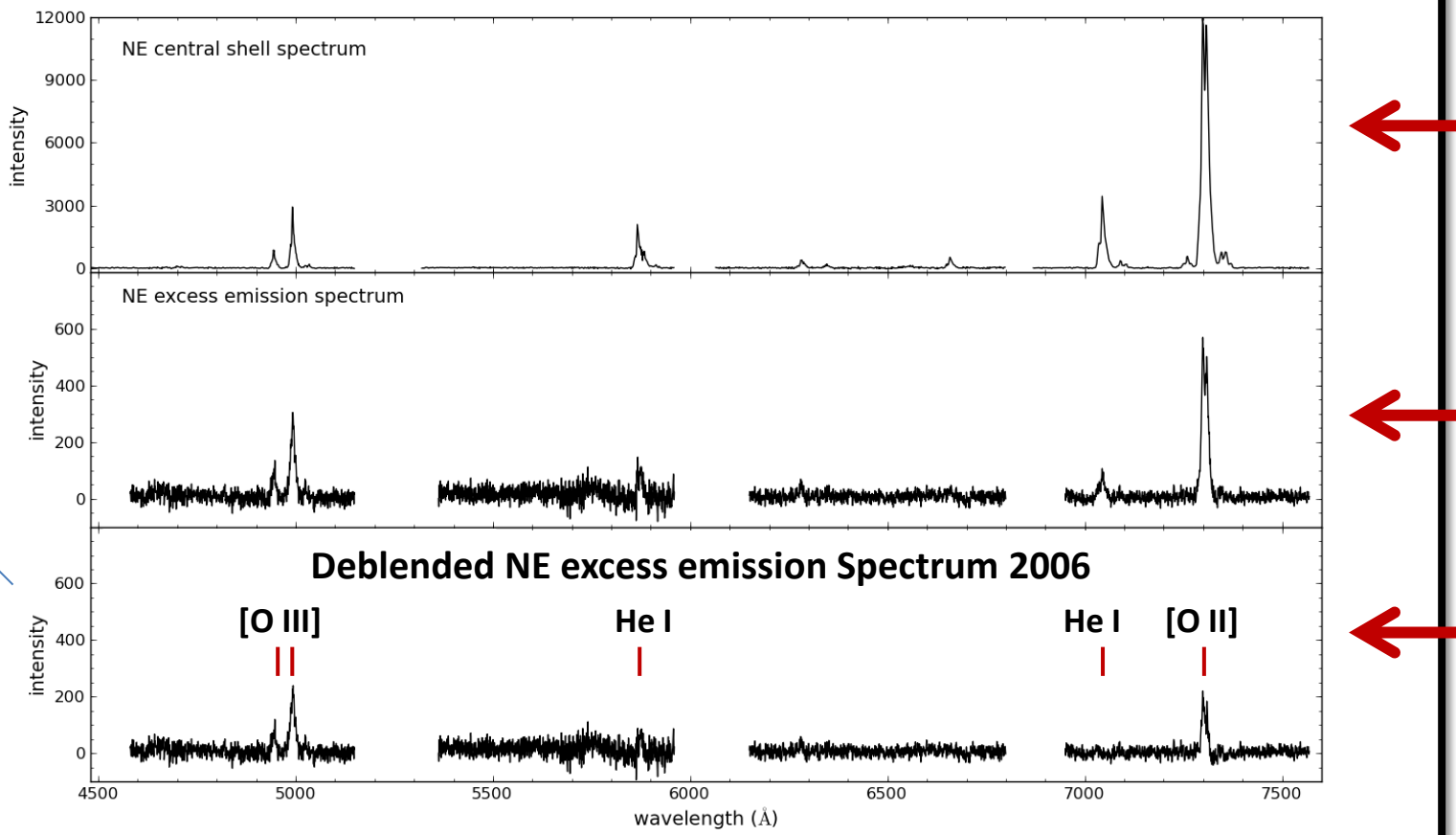


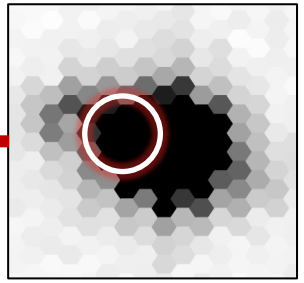
He I

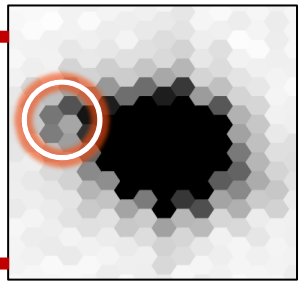
[O II]

Spatially-resolved velocity profiles of the emission line He I λ7065 and the [O II] λ7320/7330 doublet (right panels)

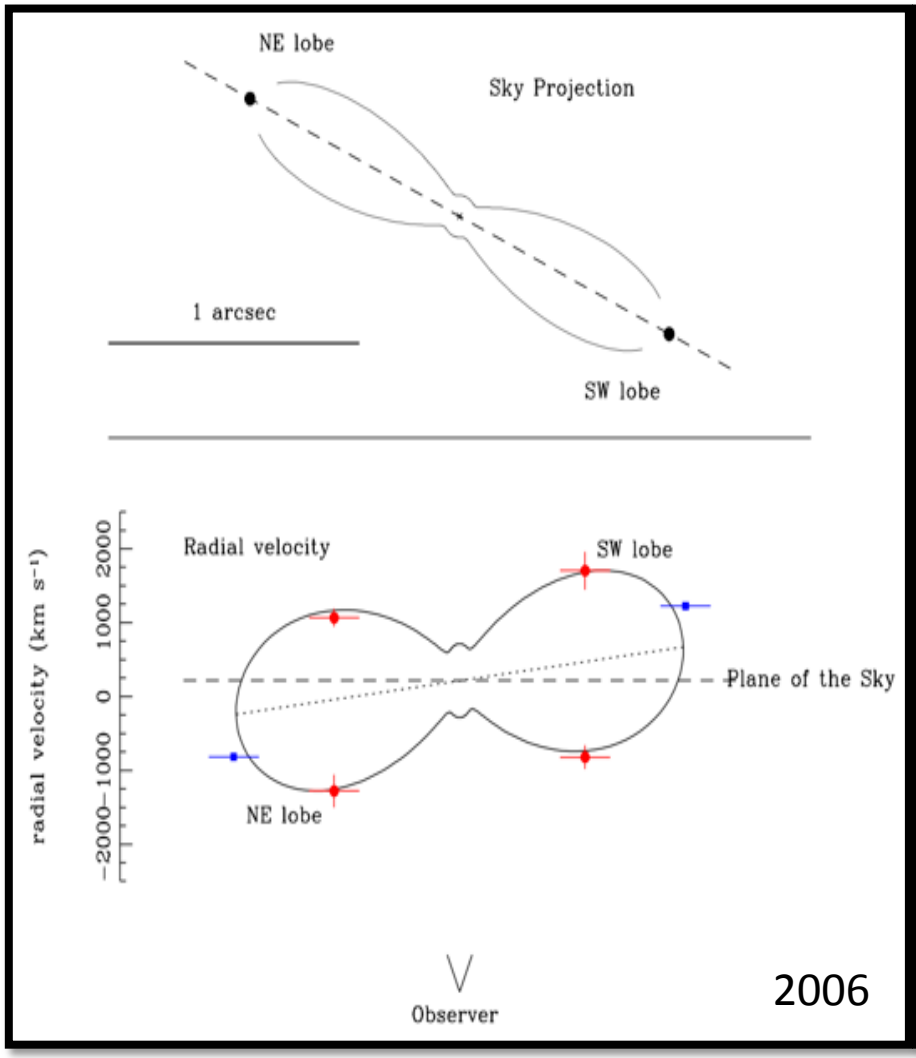
Excess Emission Spectra

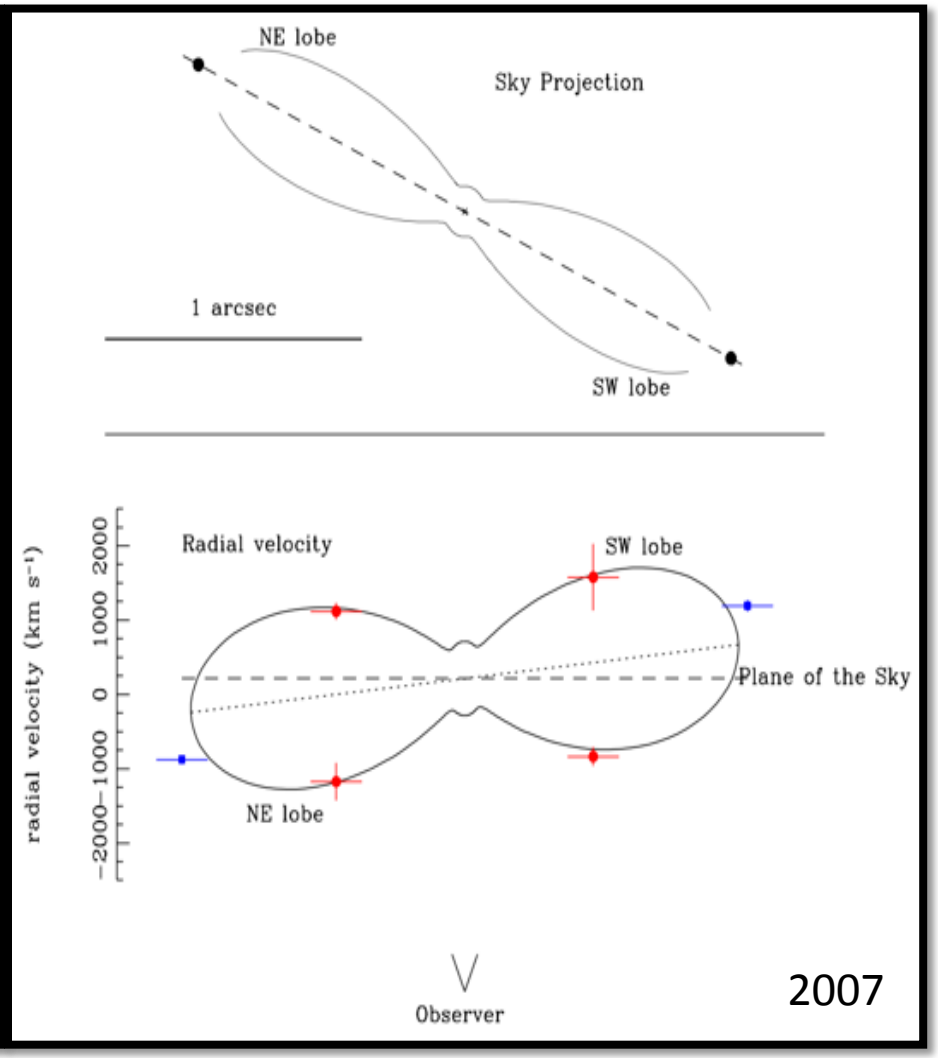






Spatio-kinematic Modelling





Cause of High Velocities in Knots?

Bow Shocks?

- **due to highly collimated outflows in the nova shell.**

  V445 Pup has:

  - an initially very narrow waist.

  - two high speed knots associated with an excess of [O II] and [O III]

- **comparable to 1D hydro-dynamical planetary nebulae models (Schönberner et al. 2005, Raga et al. 2008)**

  - some PNe have jet structures called FLIERS (fast low ionisation emission regions)

Ionization Front?

- **extreme velocities do not represent the bulk motion of the ejecta or of the knots (Schönberner et al. 2005)**

Future Analysis

- **results can be used in hydrodynamic simulations of axis-symmetric V445 Pup like objects.**

- **multi-wavelength observations when the equatorial dust disc is clear and the nova remnant is observable will help determine the source of the excess oxygen.**

… ?

Future Analysis

- **results can be used in hydrodynamic simulations of a V445 Pup like system.**

- **multi-wavelength observations when the equatorial dust disc is clear and the nova remnant is observable will help determine the source of the excess oxygen.**

HST images!
May 2013