Tauri-like Outflow Activity in the Brown Dwarf Mass Regime

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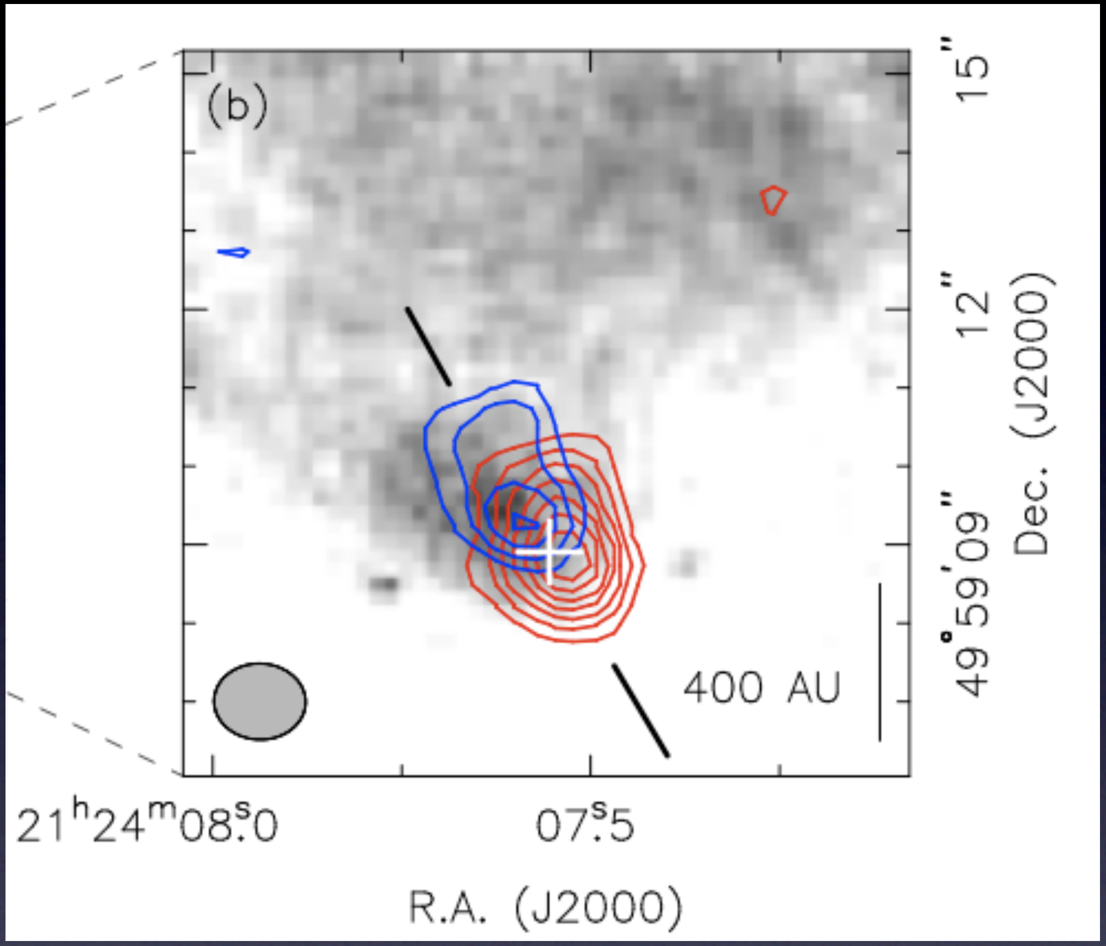
Protostellar Jets in Context, Rhodes, July 2008

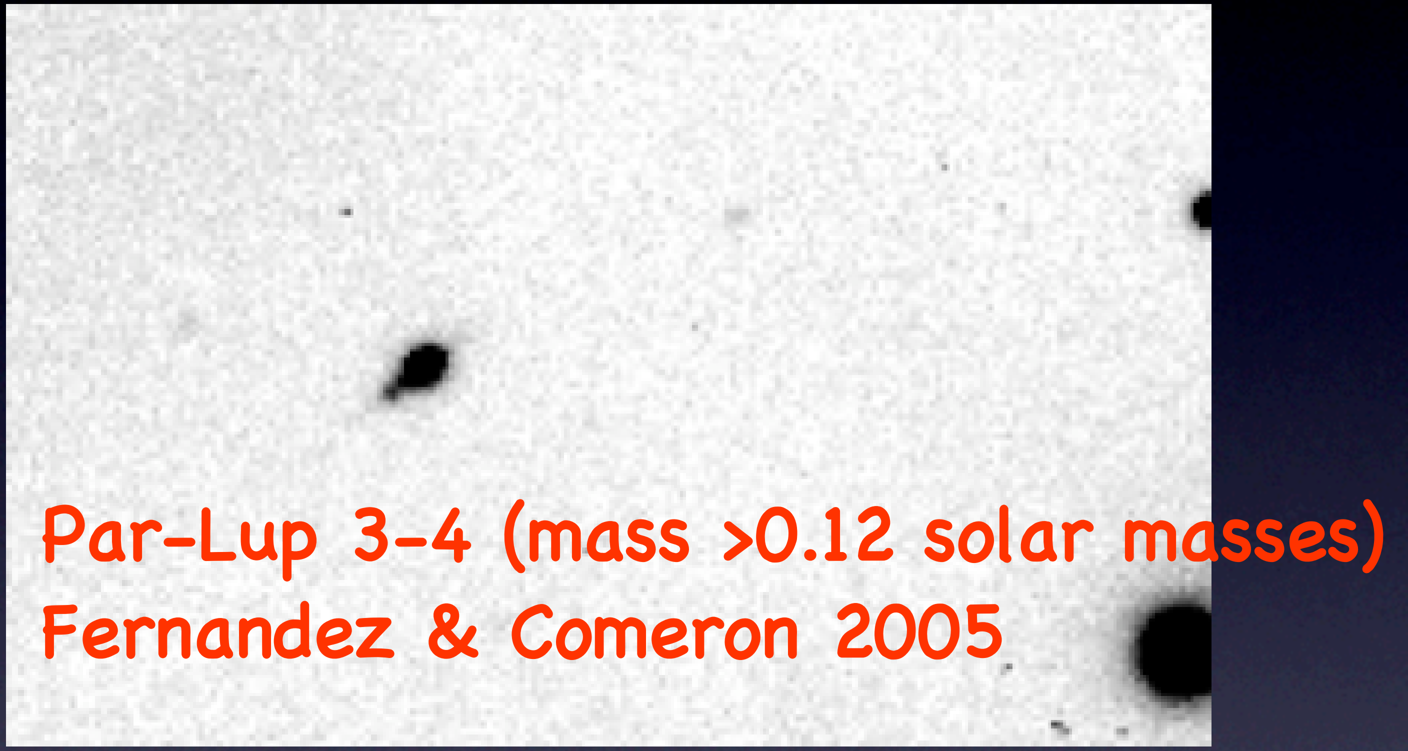
Why Study Brown Dwarf Outflows

The main motivation is very simply to investigate if outflows change when we move to substellar masses and whether or not BD outflows can tell us anything about the mass outflow mechanism in general.

Other Important Studies

L1014-IRS, Bourke et al 2006





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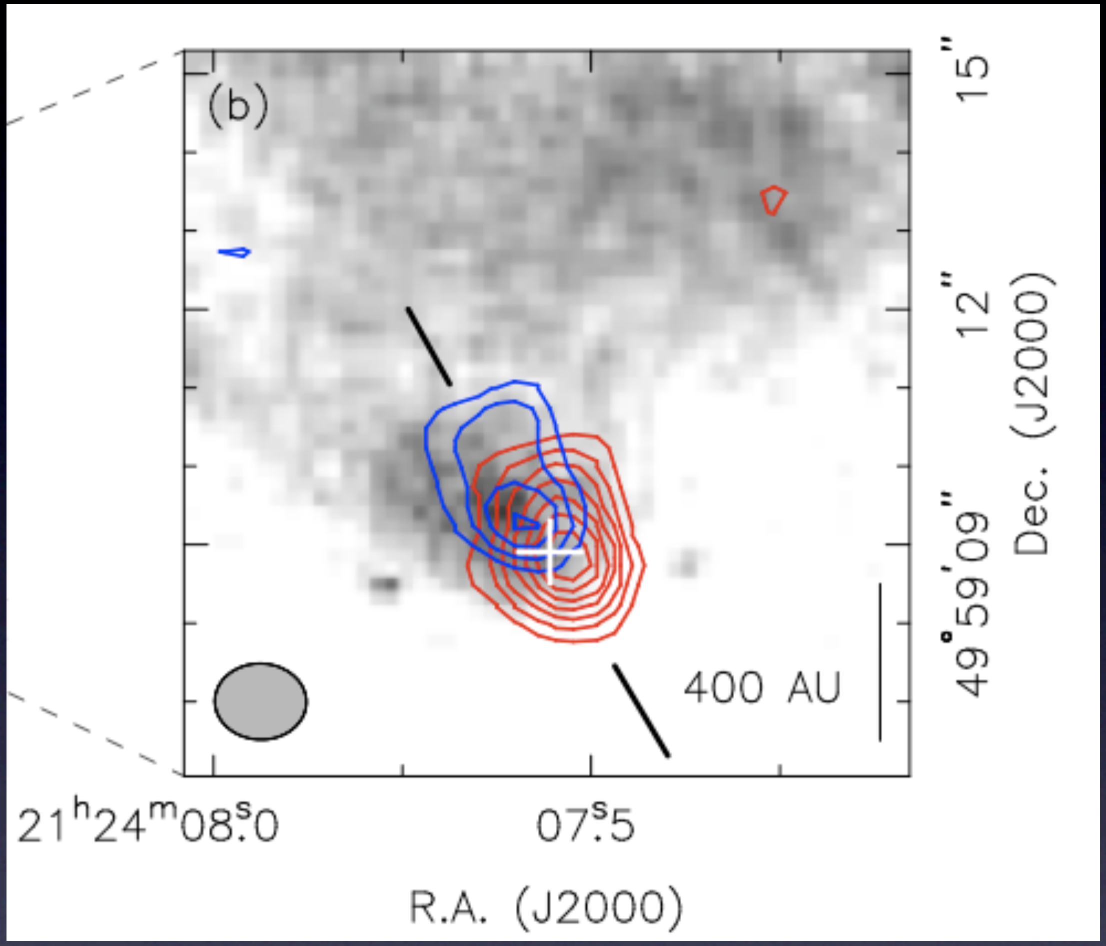
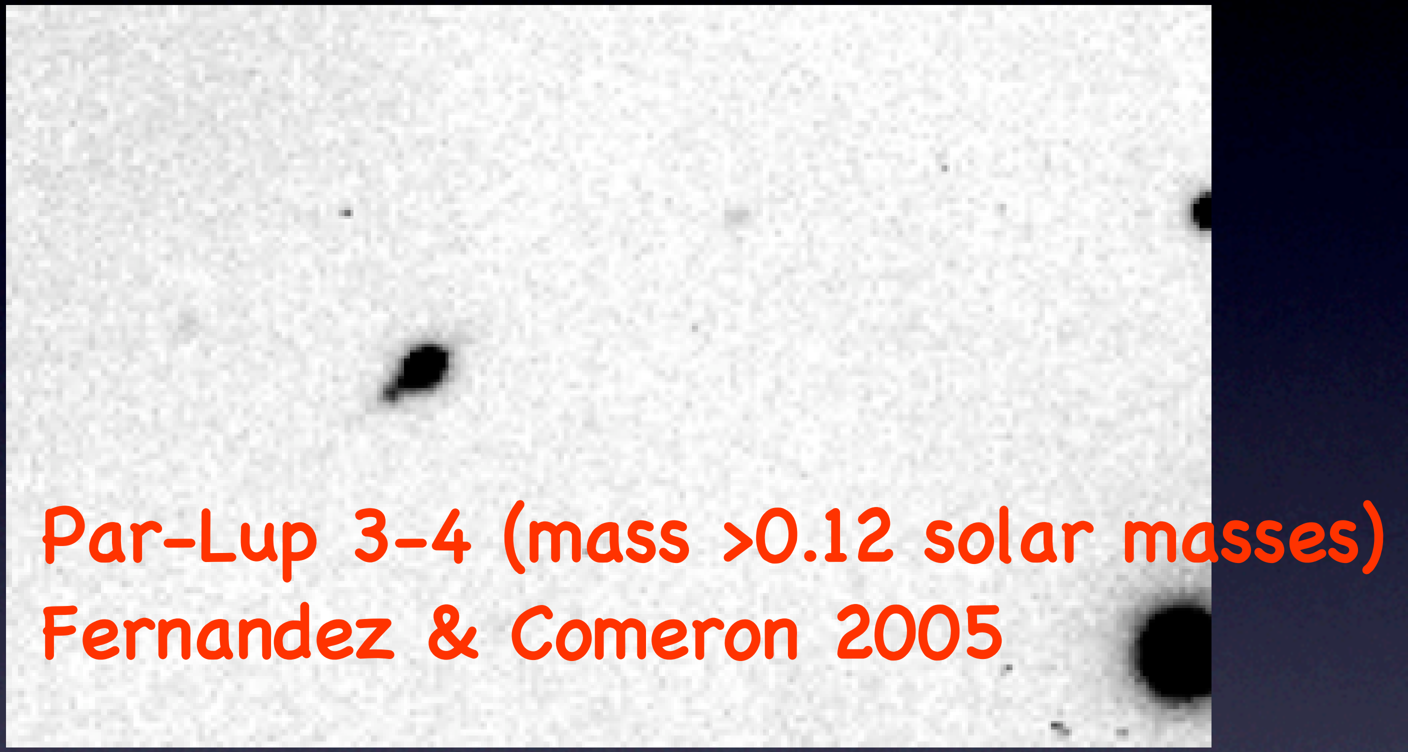
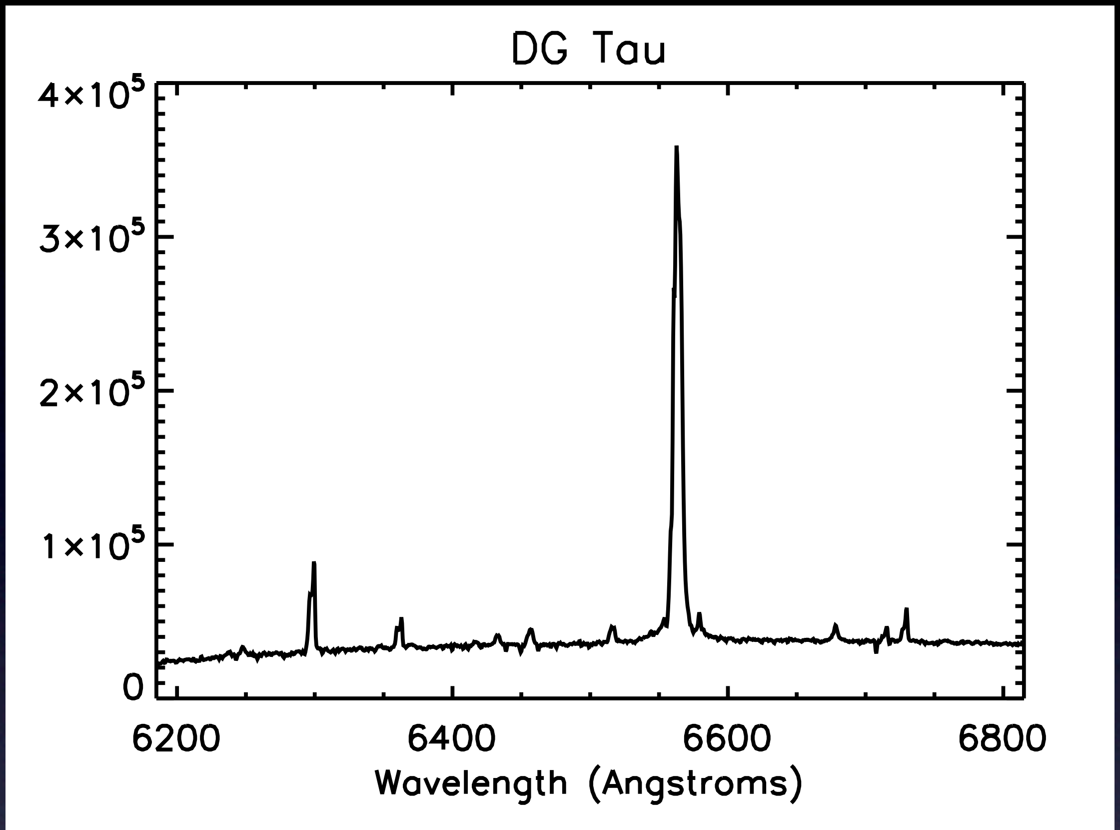


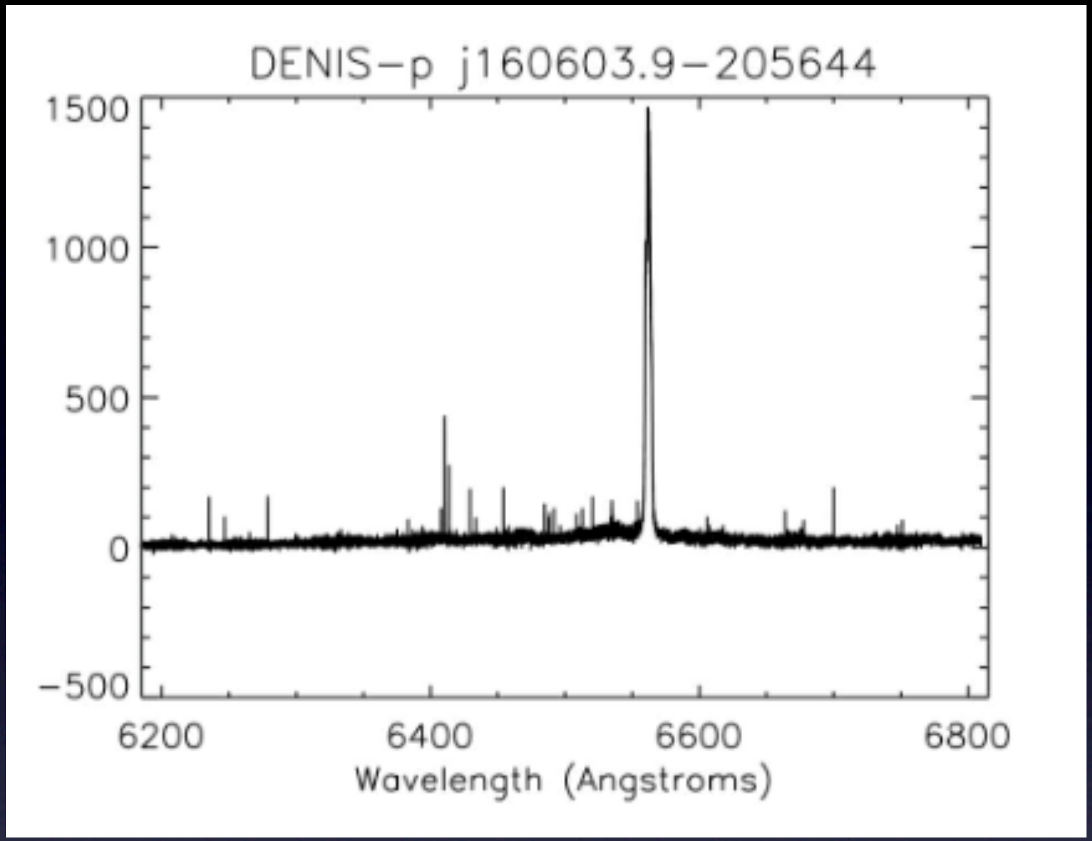


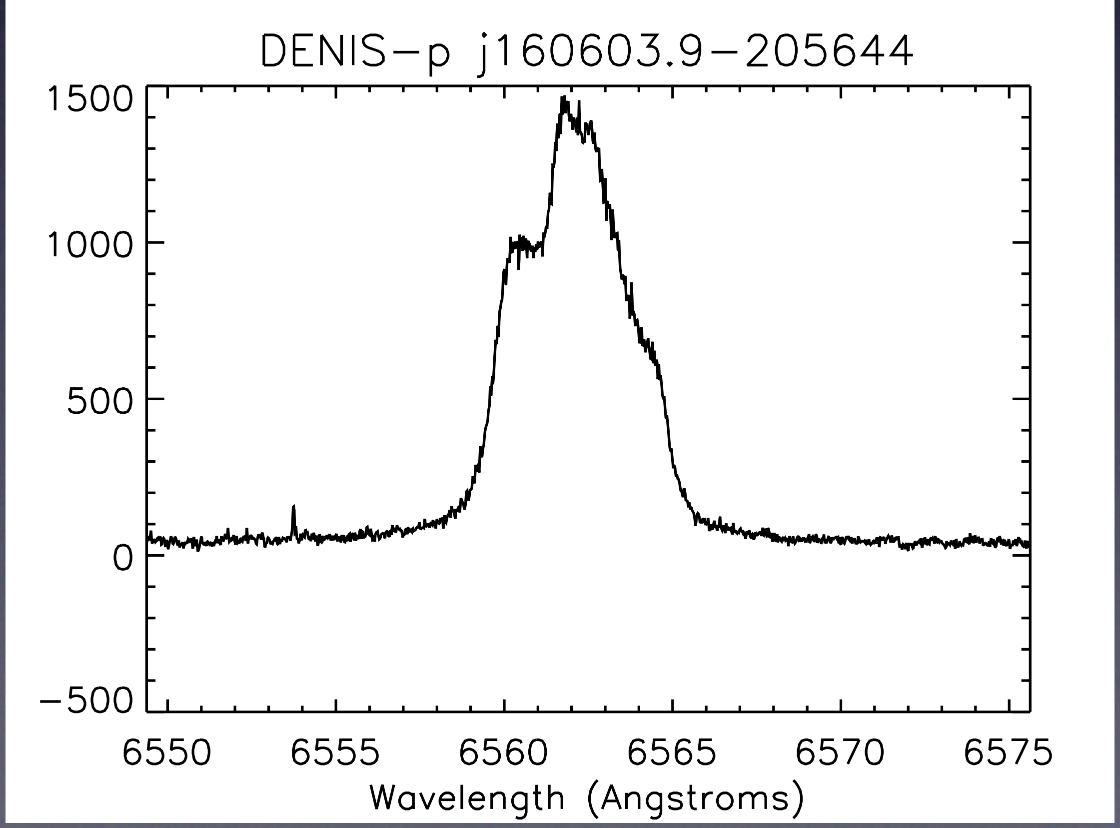
Fernandez & Comeron 2001, 2005
Comeron et al 2003.
BarradoyNavascues et al 2003
Muzerolle et al 2001, 2003
Natta et al 2001, 2002, 2005
Masciadri & Raga 2004

Brown Dwarf Outflows: A New Way to Study the Outflow Phenomenon

Making a Comparison with T Tauri Stars







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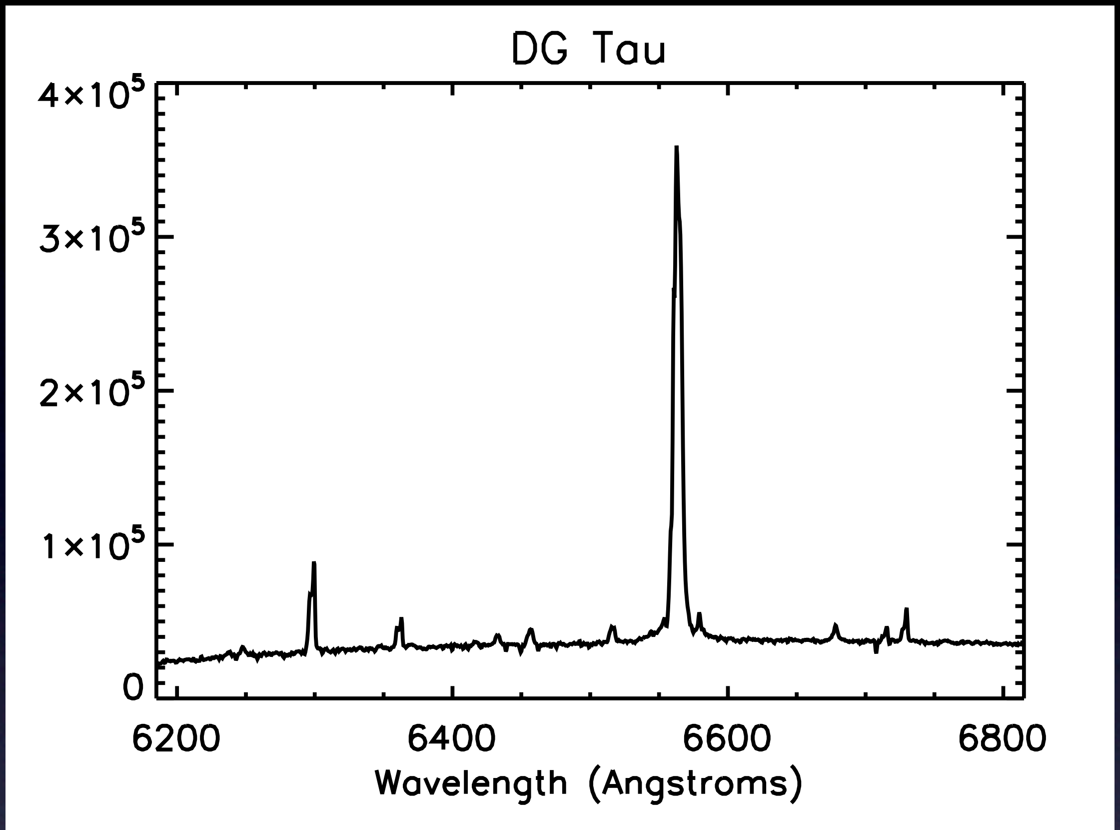

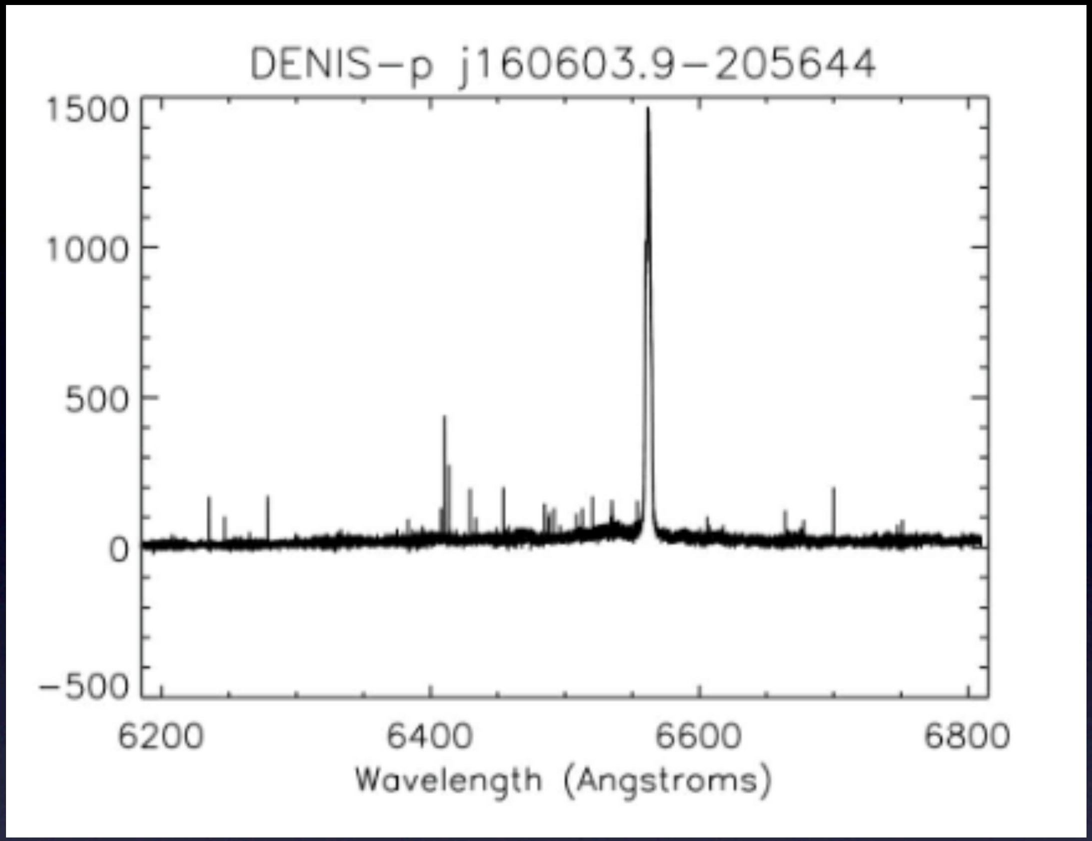

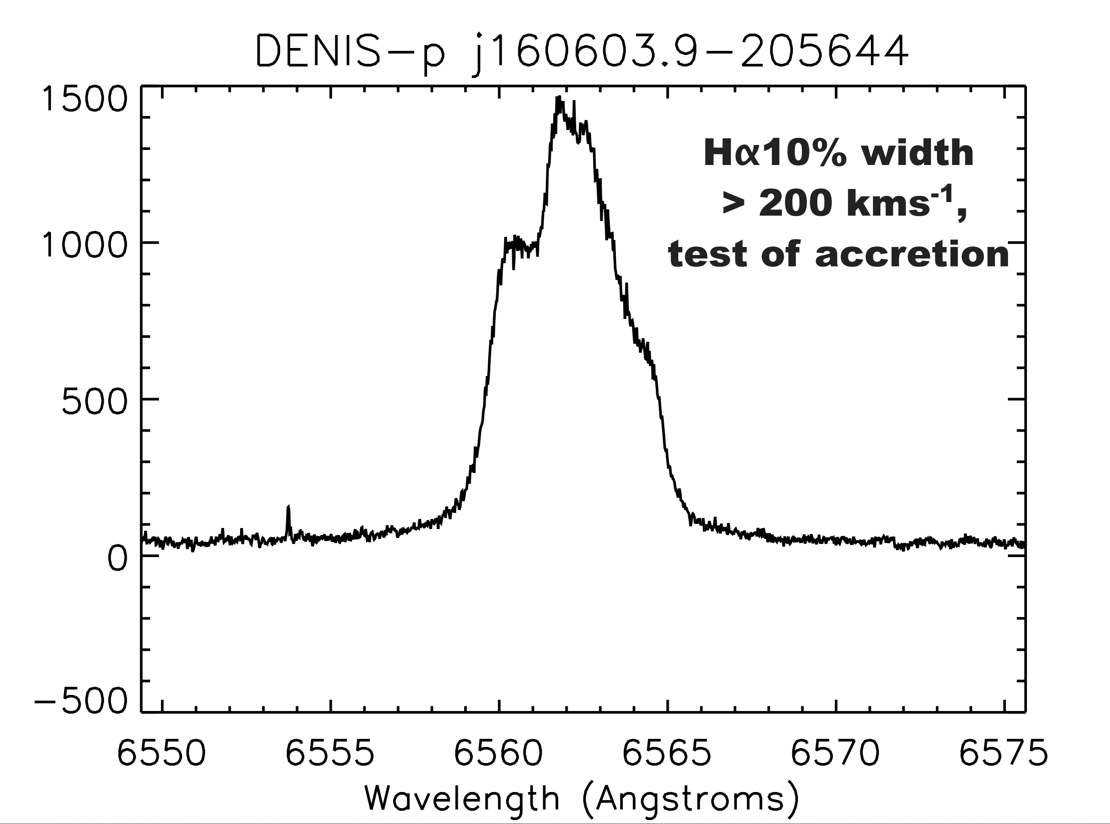

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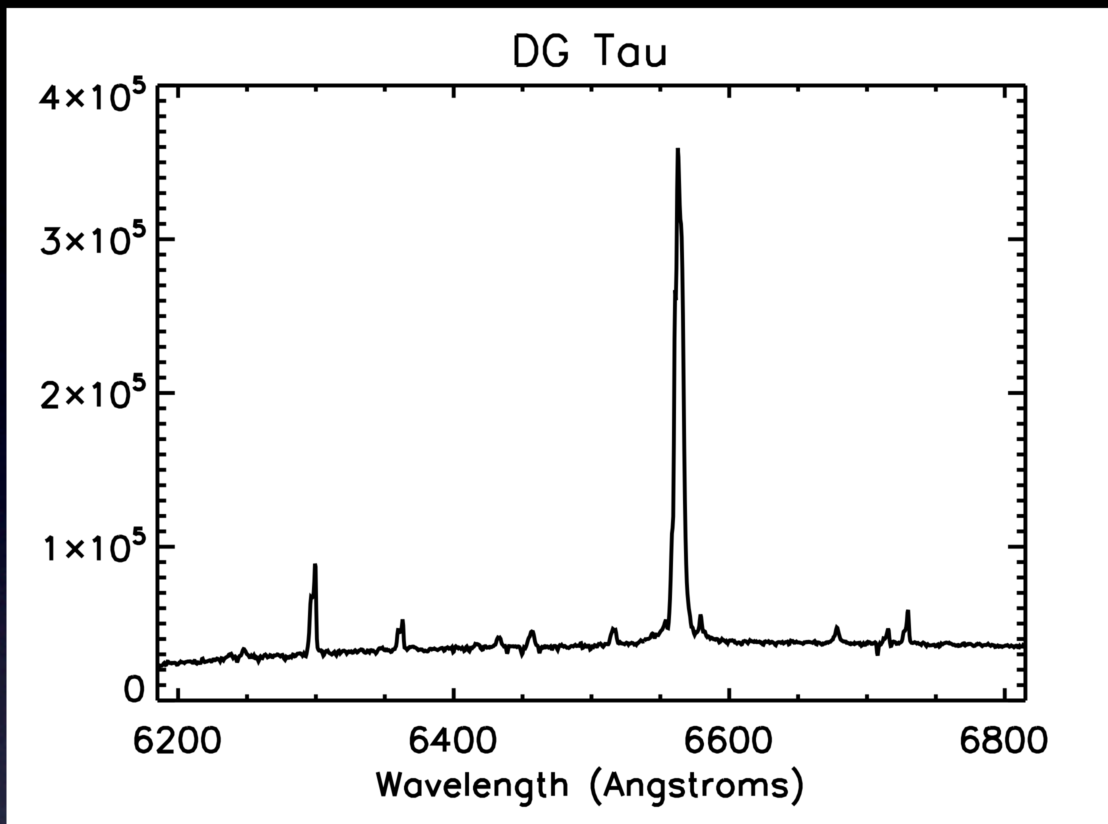

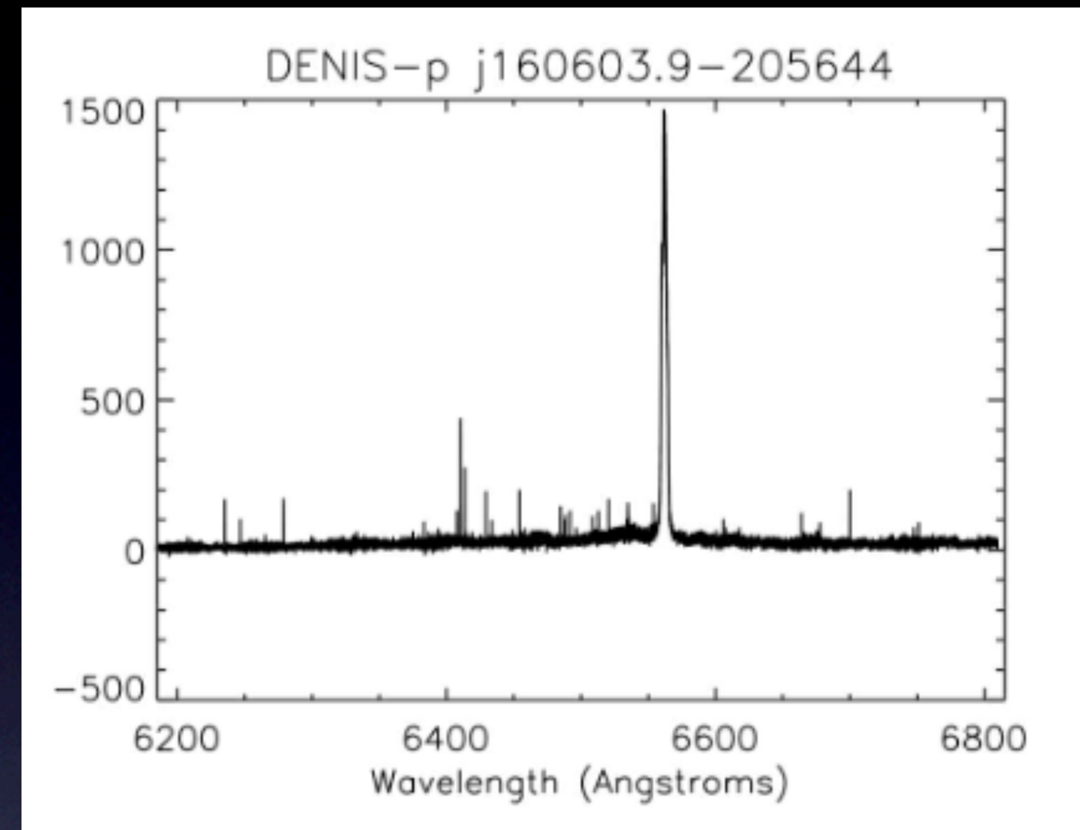

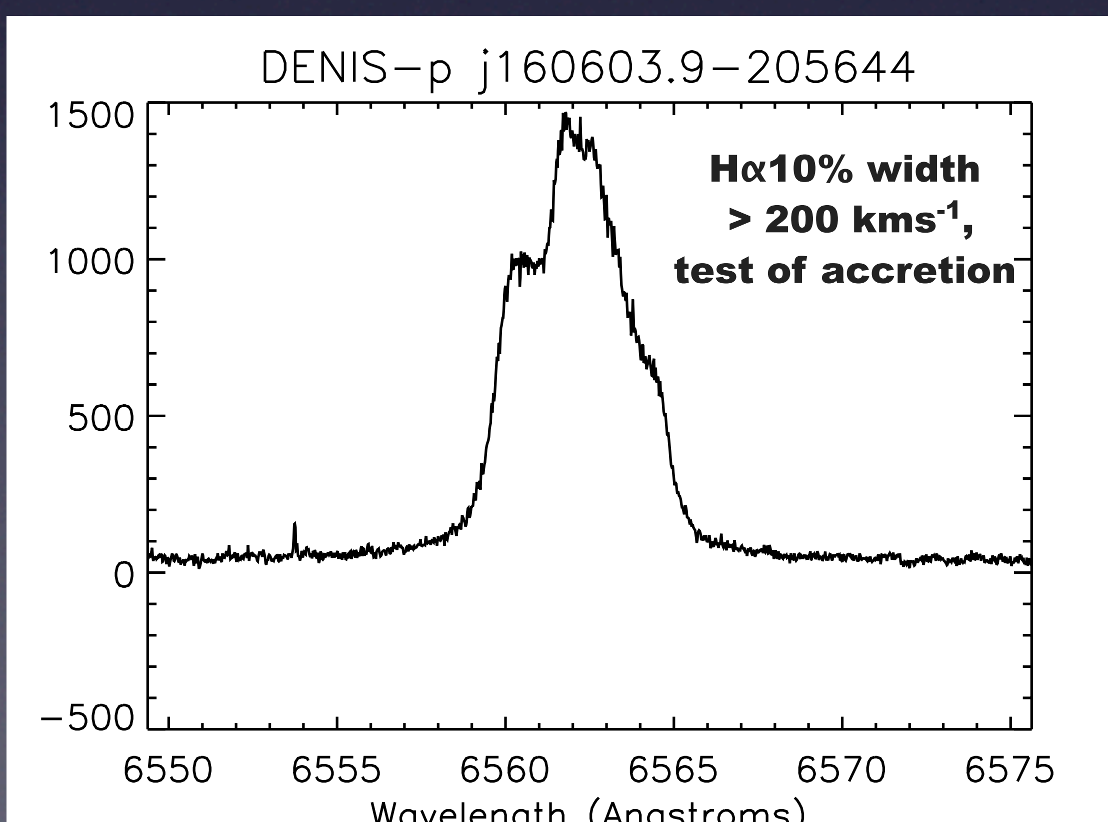

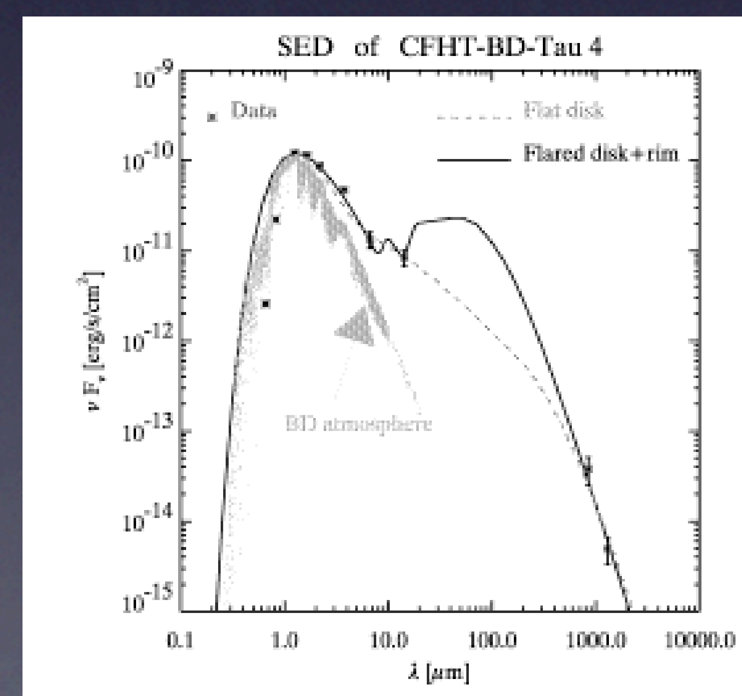

Martin et al 2001

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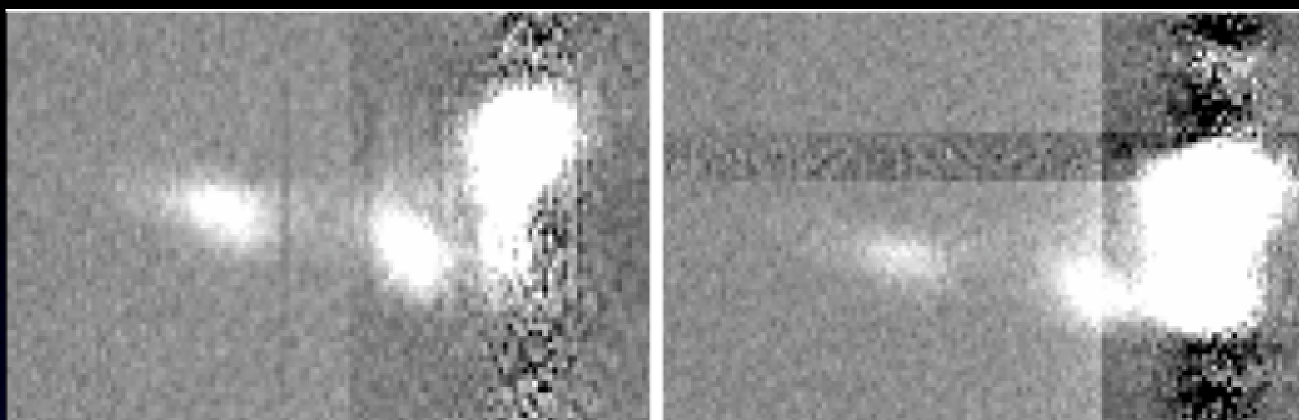
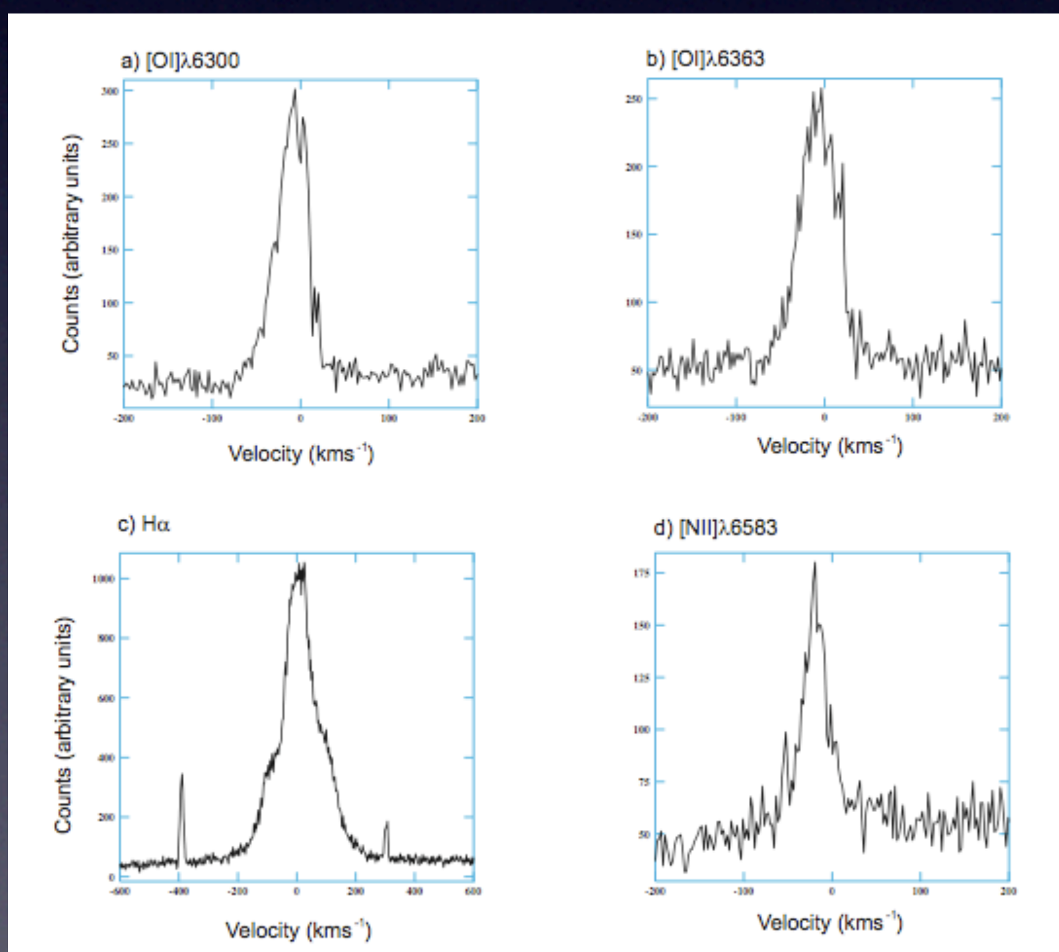
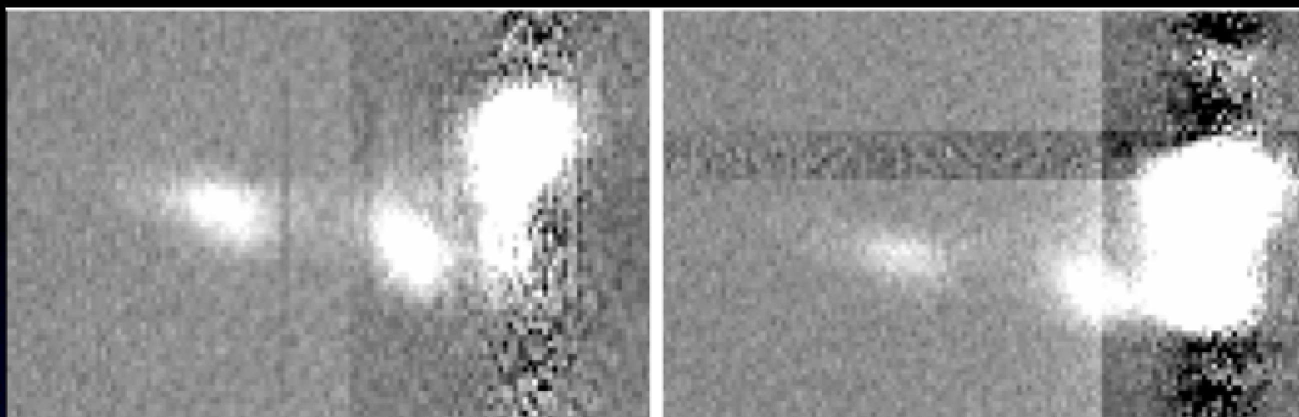


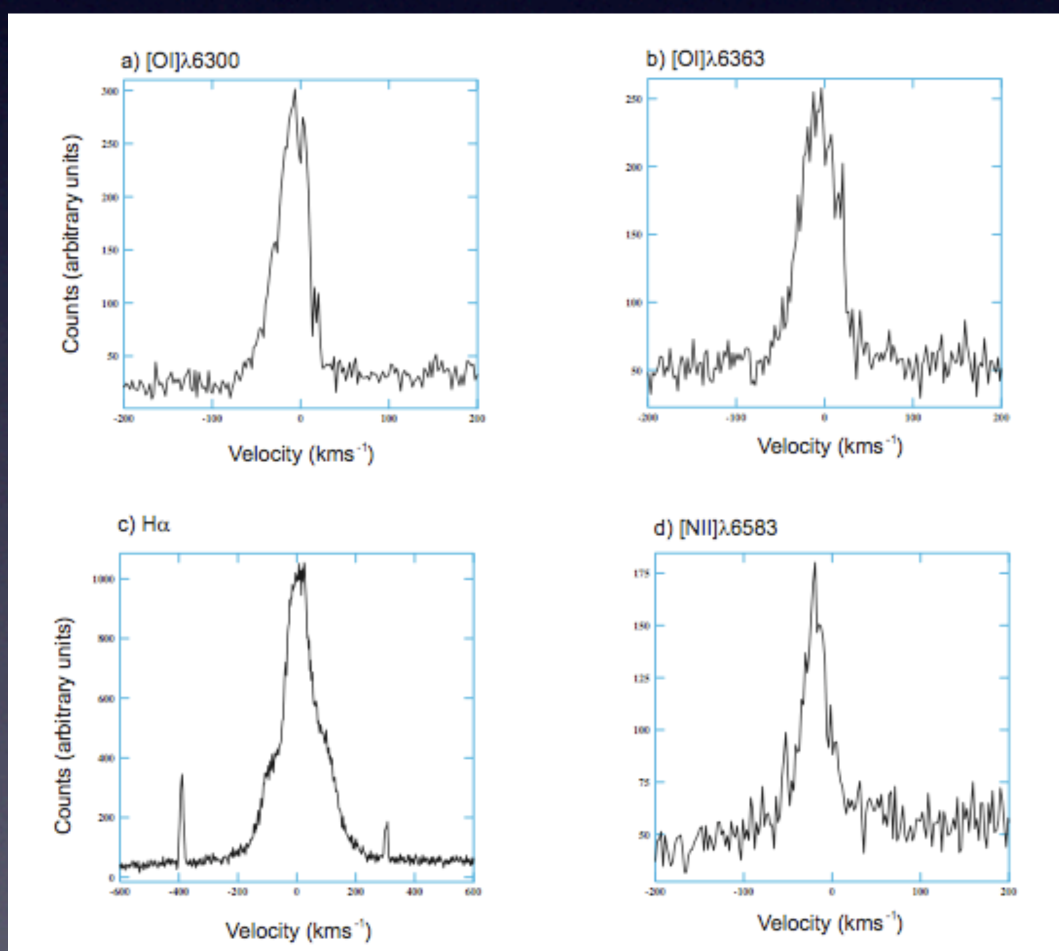


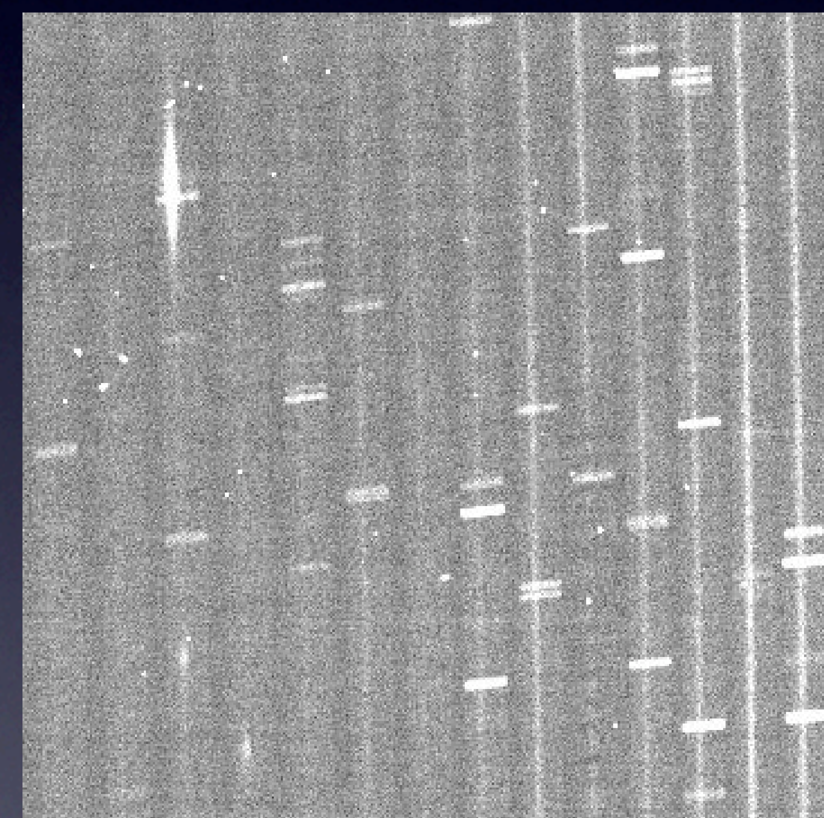
Brown Dwarf Outflows: A New Way to Study the Outflow Phenomenon

Making a Comparison with T Tauri Stars

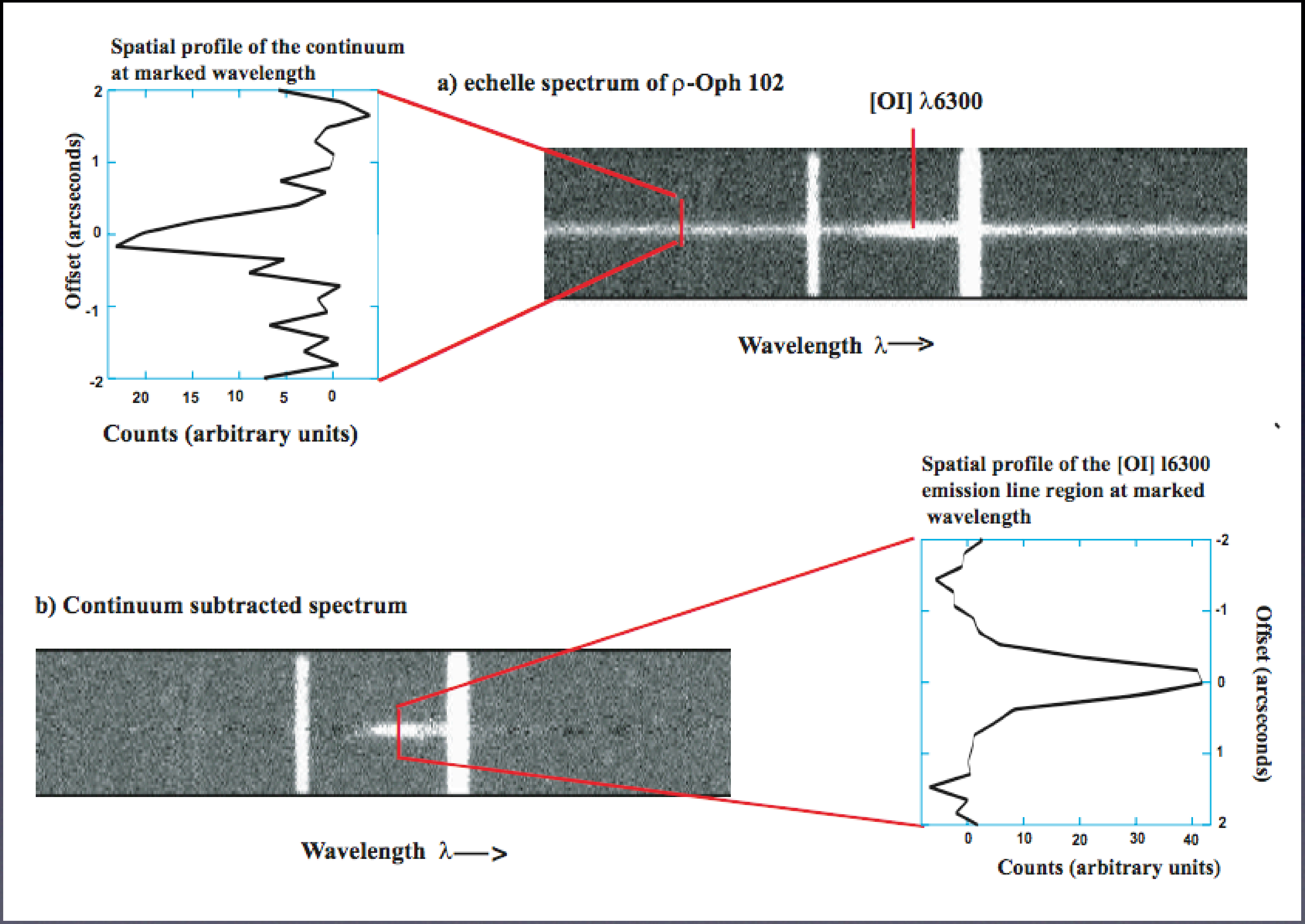


LS-RCrA 1





Brown Dwarf Outflows: A New Way to Study the Outflow Phenomenon
Spectro-astrometry



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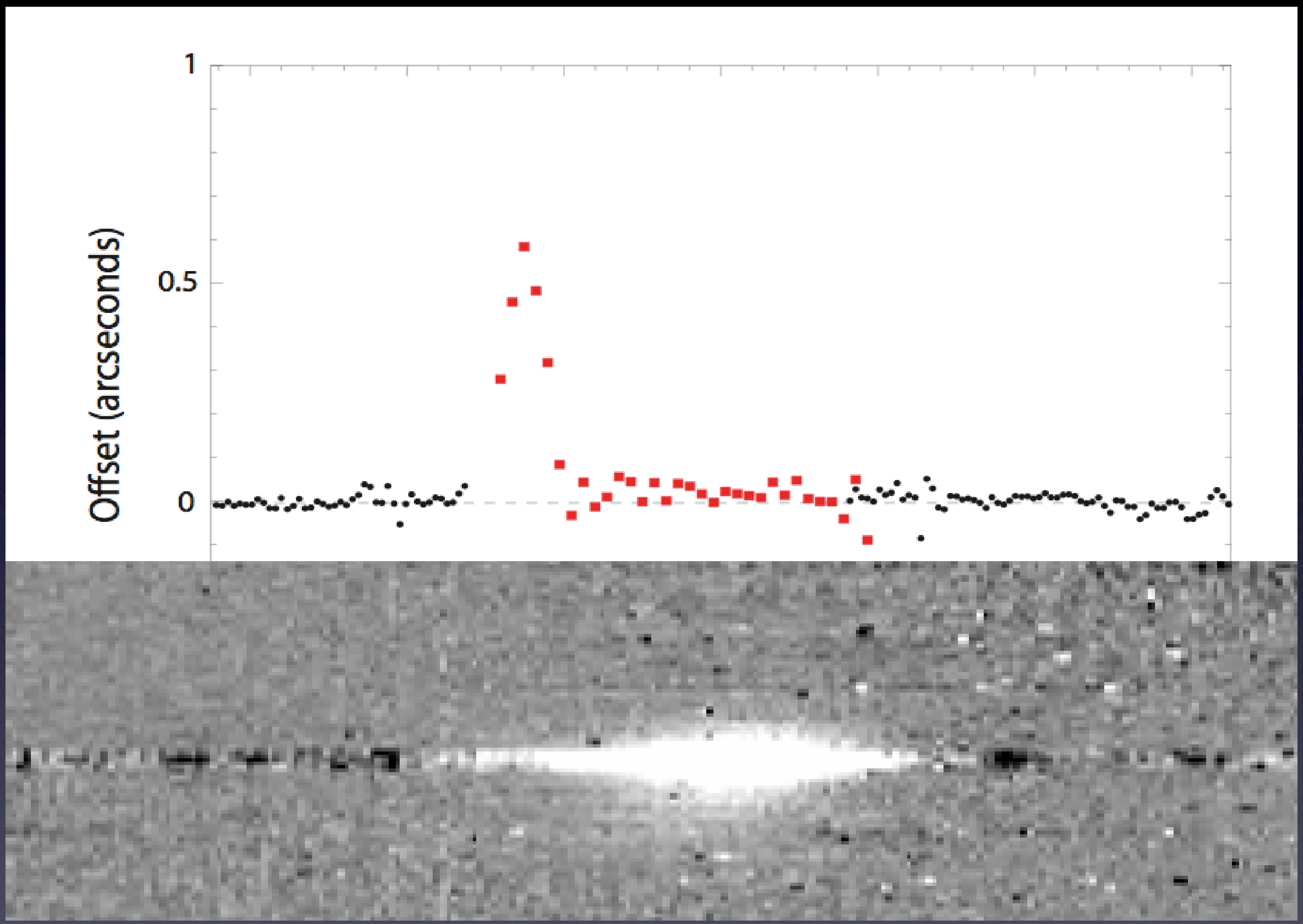

Whelan & Garica 2008
Whelan et al 2004, 2005, 2006, 2007
Podio et al 2008
Takami et al 2001, 2003

$$\sigma_{centroid} = \frac{seeing(mas)}{2.3548\sqrt{N_p}}$$

Seeing = 1 arcsec
Accuracy = 1mas

5 sources with confirmed outflows, 1 possible

target	spectral type	estimated mass M_jup	lines analysed with spectro-astrometry	publication
ISO-Cha I 217	M6.25	70	[SII]λλ6717, 6731	Whelan et al 2008, in prep
ρ -Oph 102	M6.5	60	[OI]λλ6300,6363, [SII]λ6731	Whelan et al 2005
LS-RCr A1	M6.5	40	Hα, [NII]λ6583	Whelan et al 2006,2008,
2MASS1207-3932	M8	24	[OI]λ6300	Whelan et al 2007
ρ -Oph 32	M8	40	[OI]λ6300	Whelan et al 2008, in prep
2MASS1101-7625	M8		Hα	Whelan et al 2008, in prep

5 sources with confirmed outflows, 1 possible

Moving into a phase where we can begin to do some statistics

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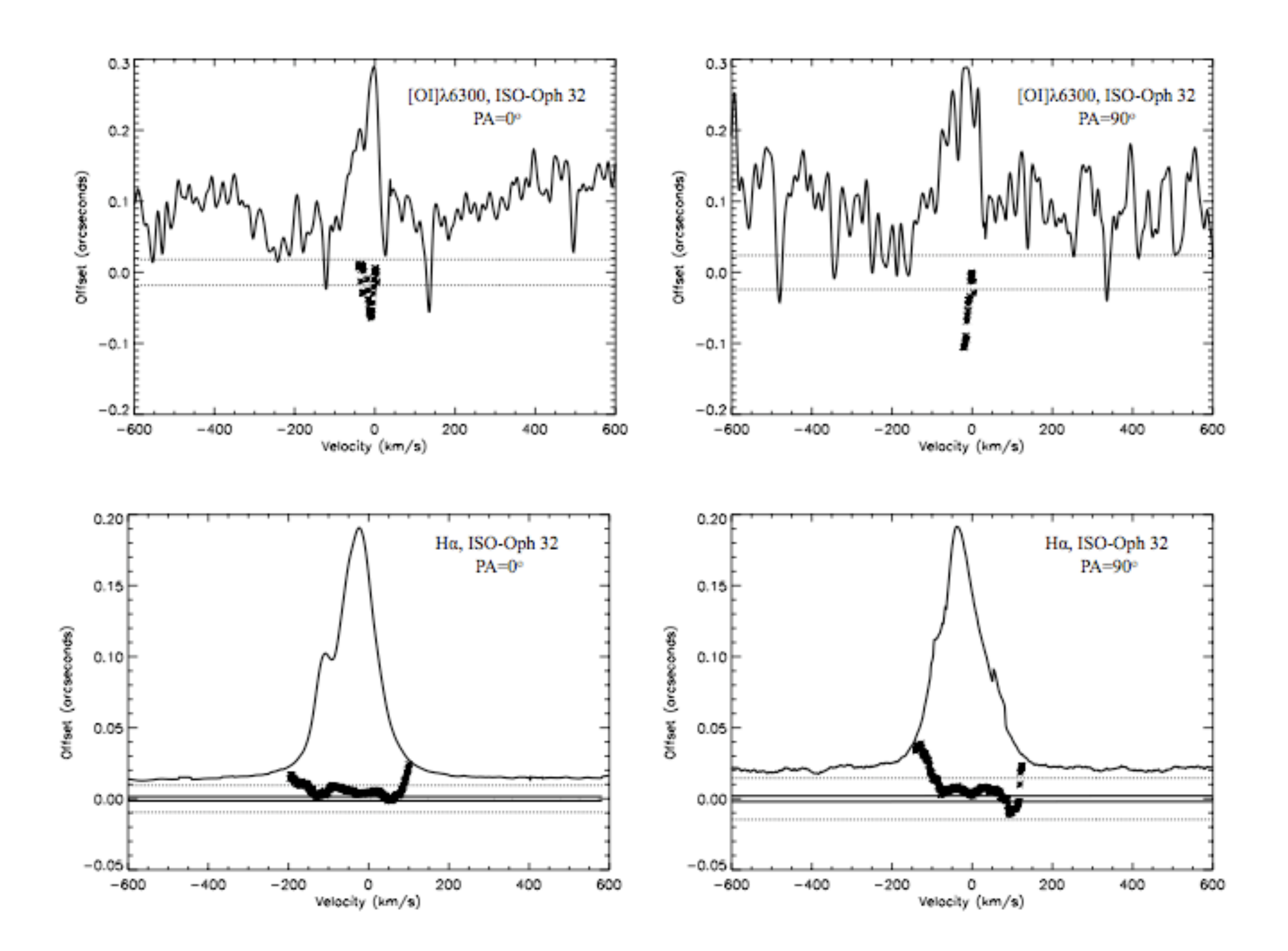
2MASS1101-7625	M8		Hα	Whelan et al 2008, in prep

ISO-Oph-32



Whelan et al 2008, in preparation, data obtained in period 79

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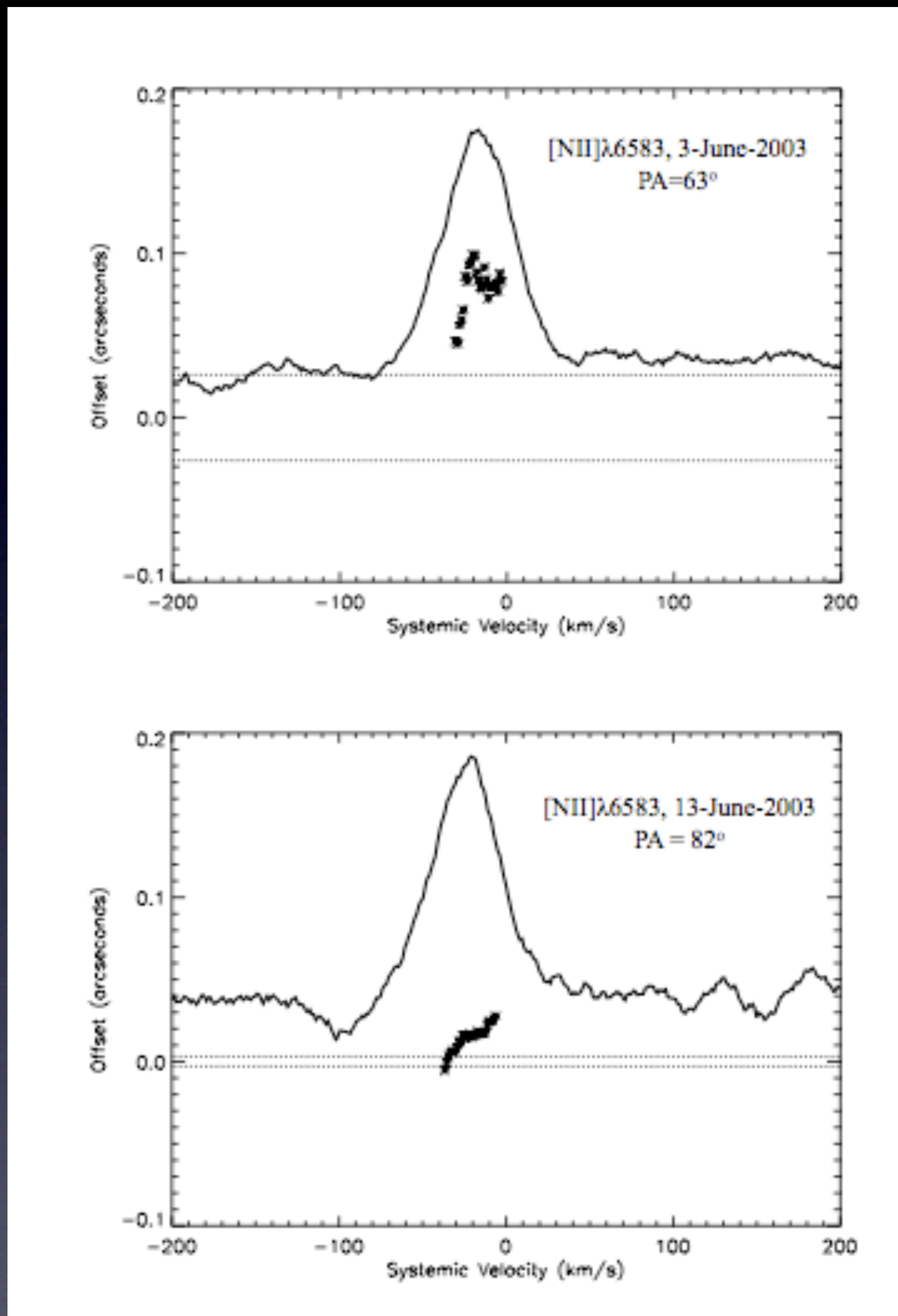
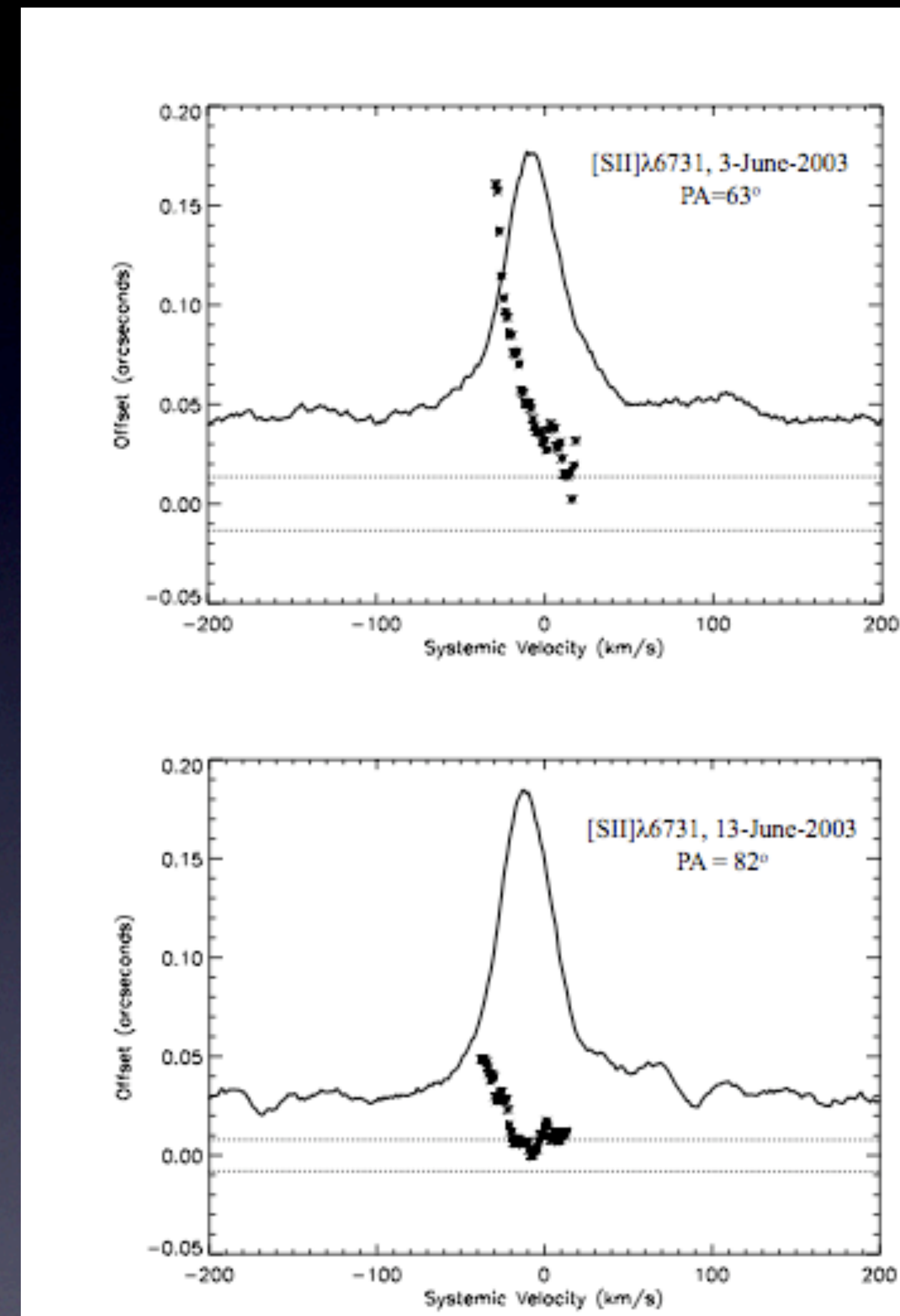
LS-RCrA 1

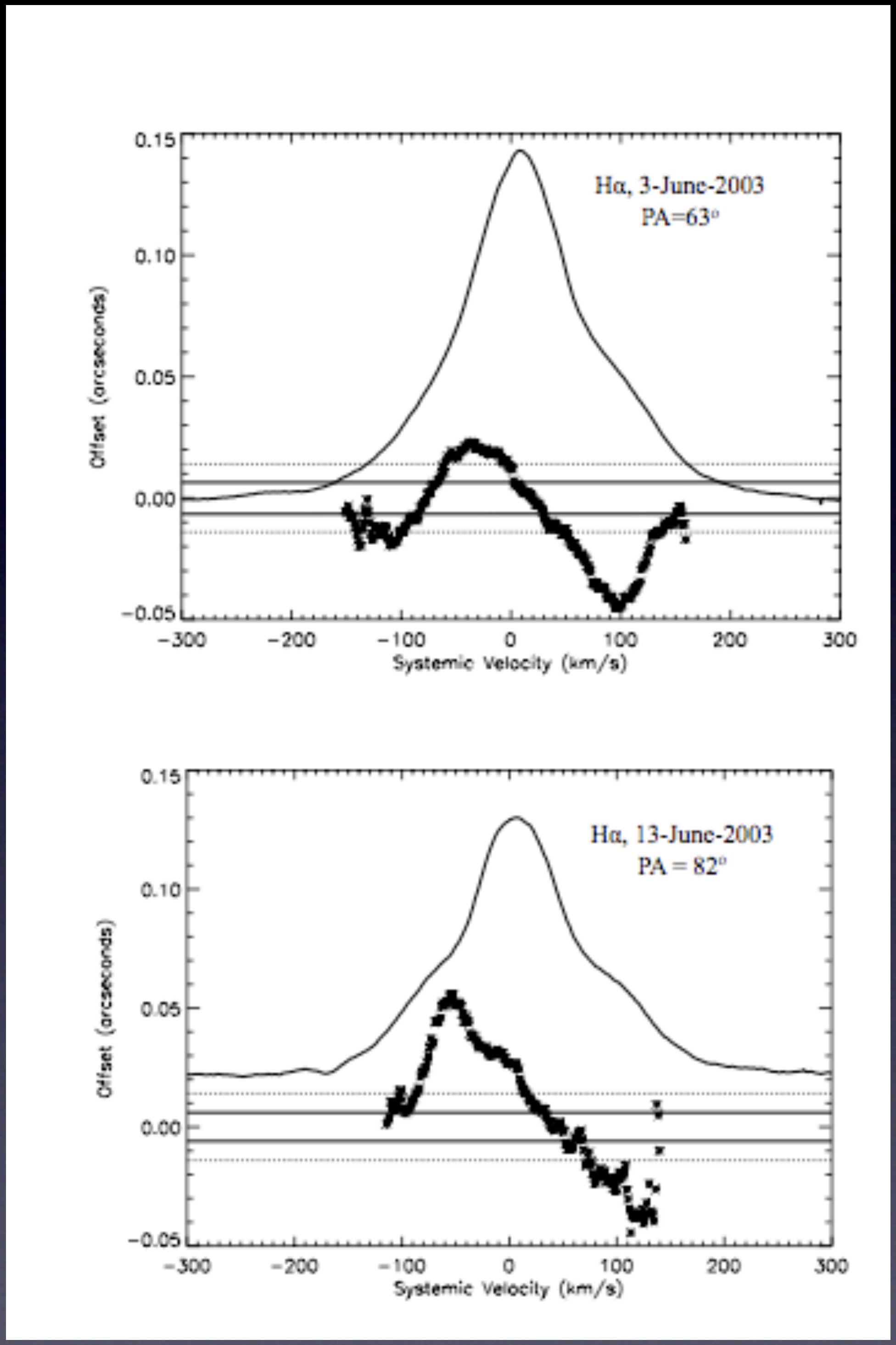




Whelan et al 2008, in preparation, data taken from ESO archive

Protostellar Jets in Context, Rhodes, July 2008

LS-RCrA 1



Whelan et al 2008, in preparation, data taken from ESO archive

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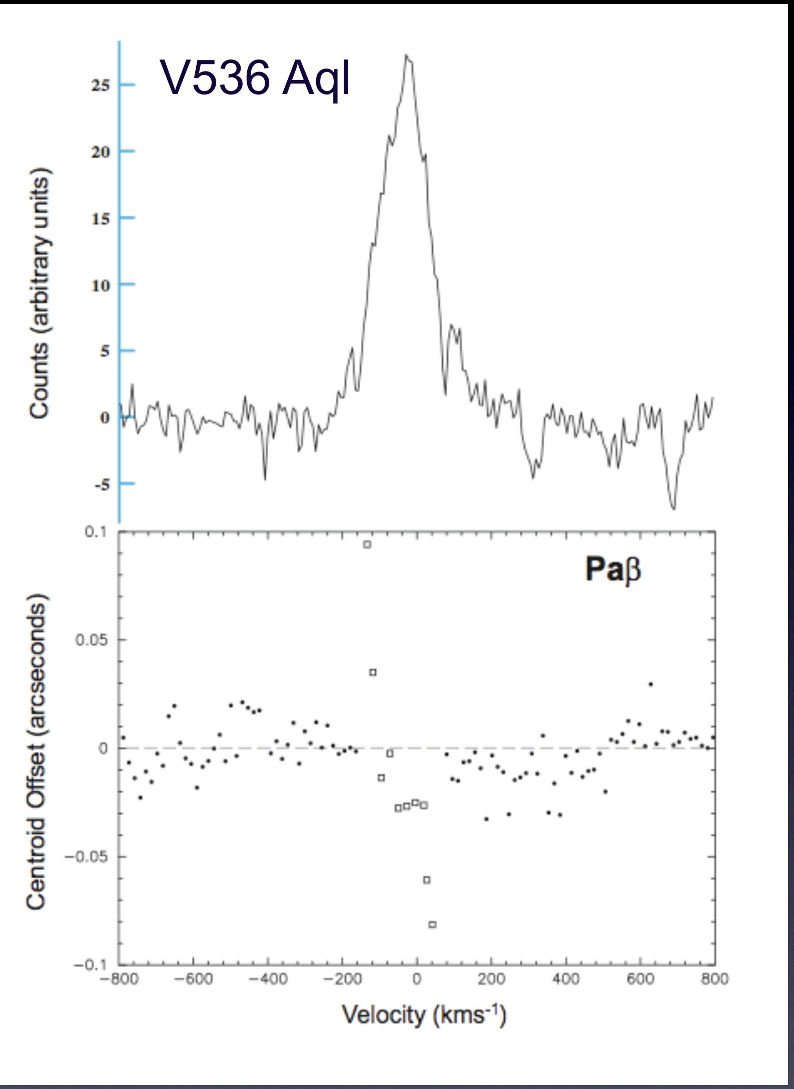
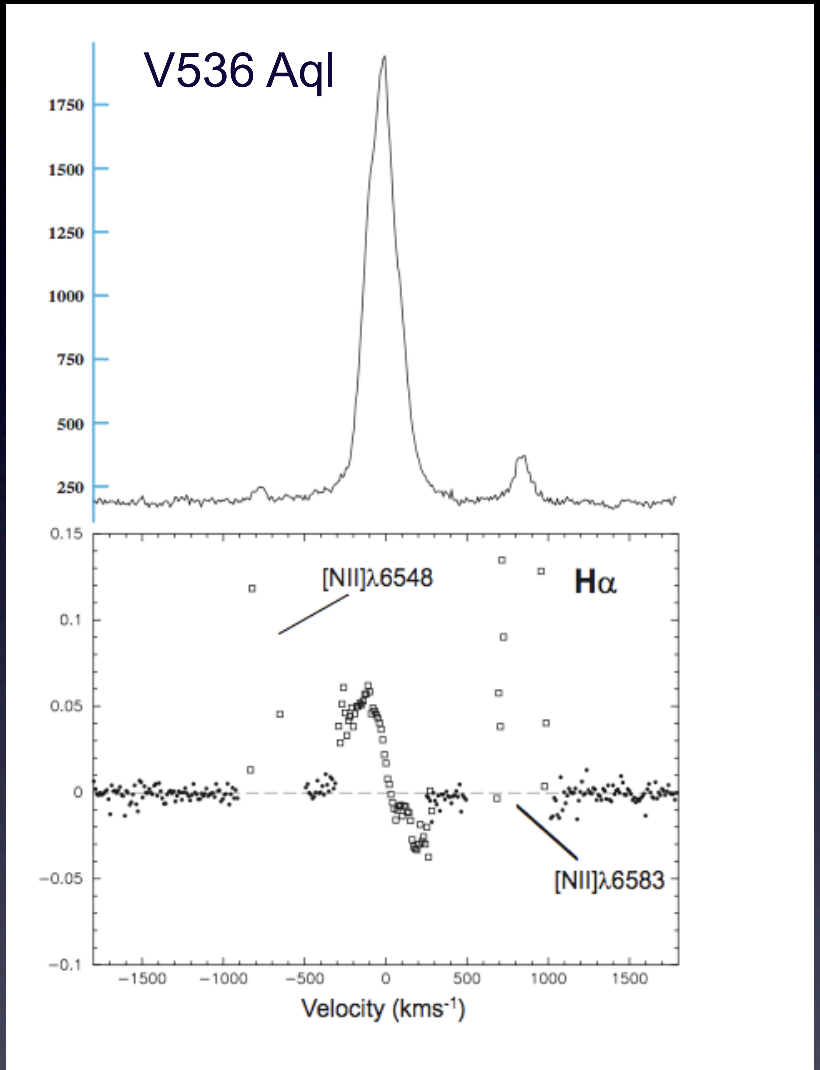
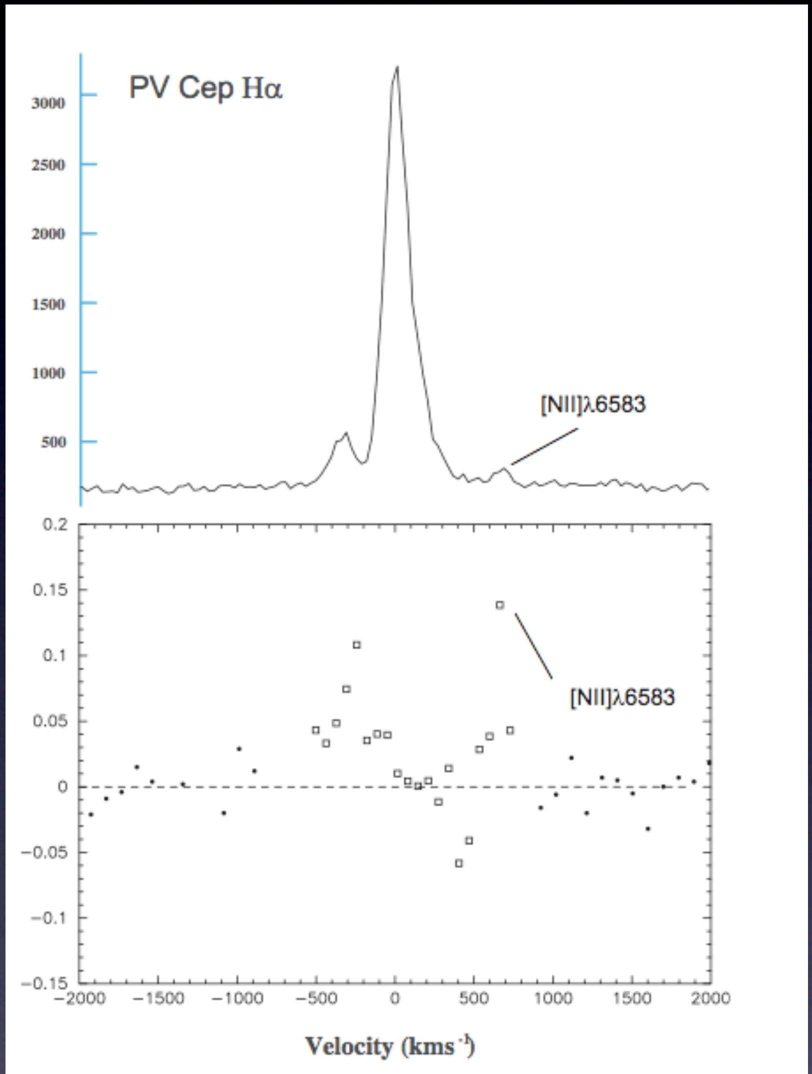
Similar Results for YSOs







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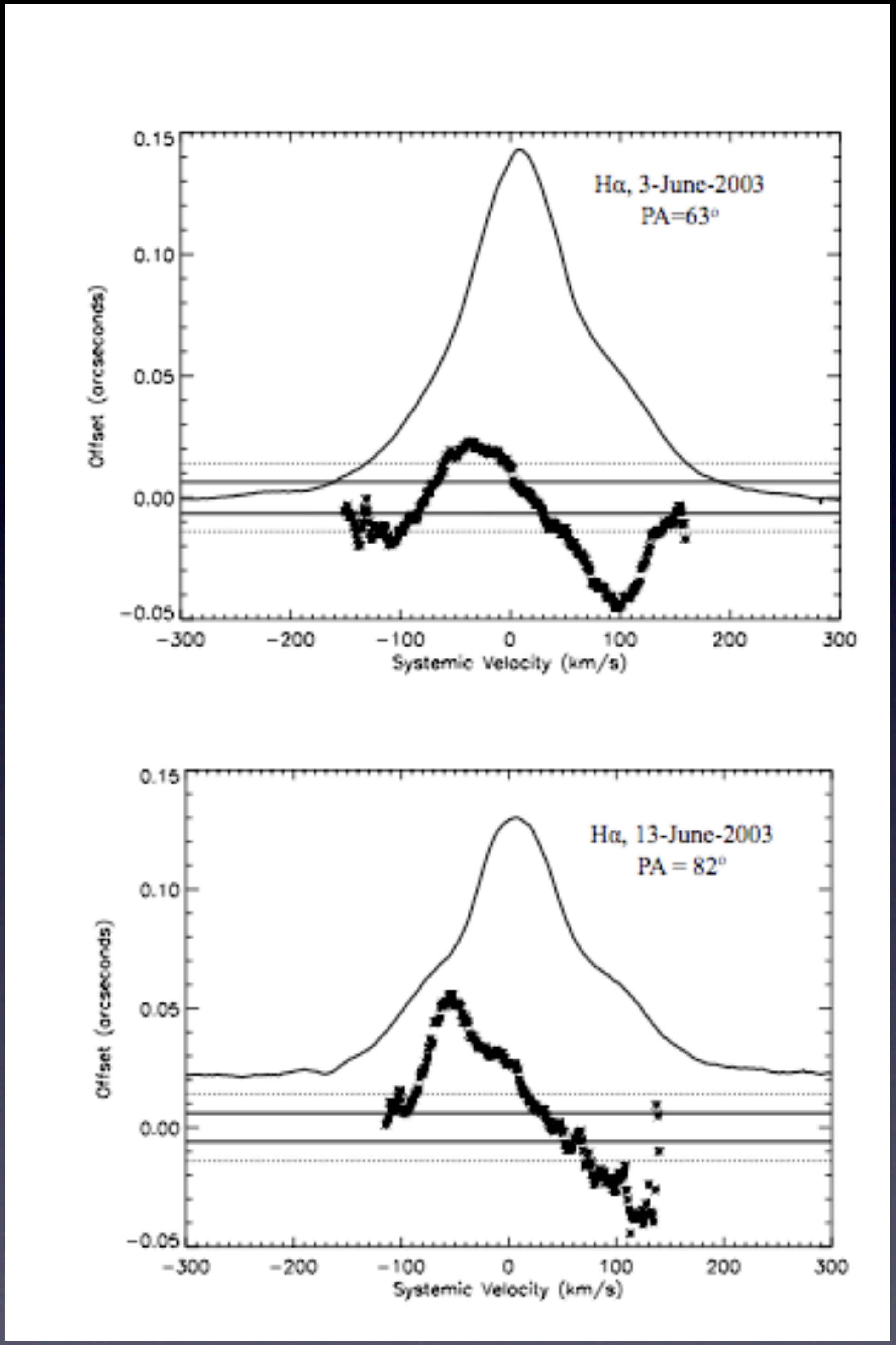

Whelan et al 2008, in preparation, data taken from ESO archive

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LS-RCrA 1

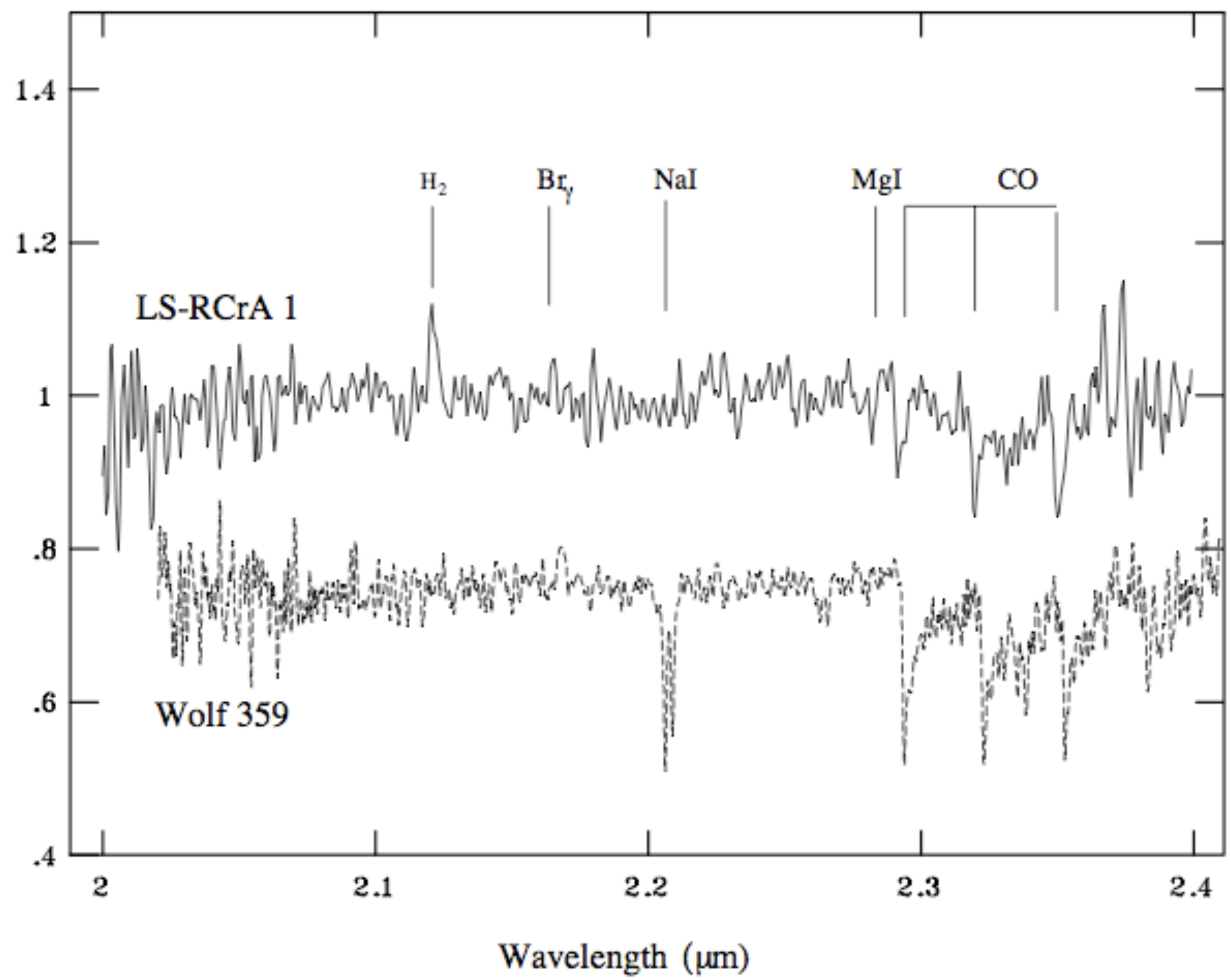
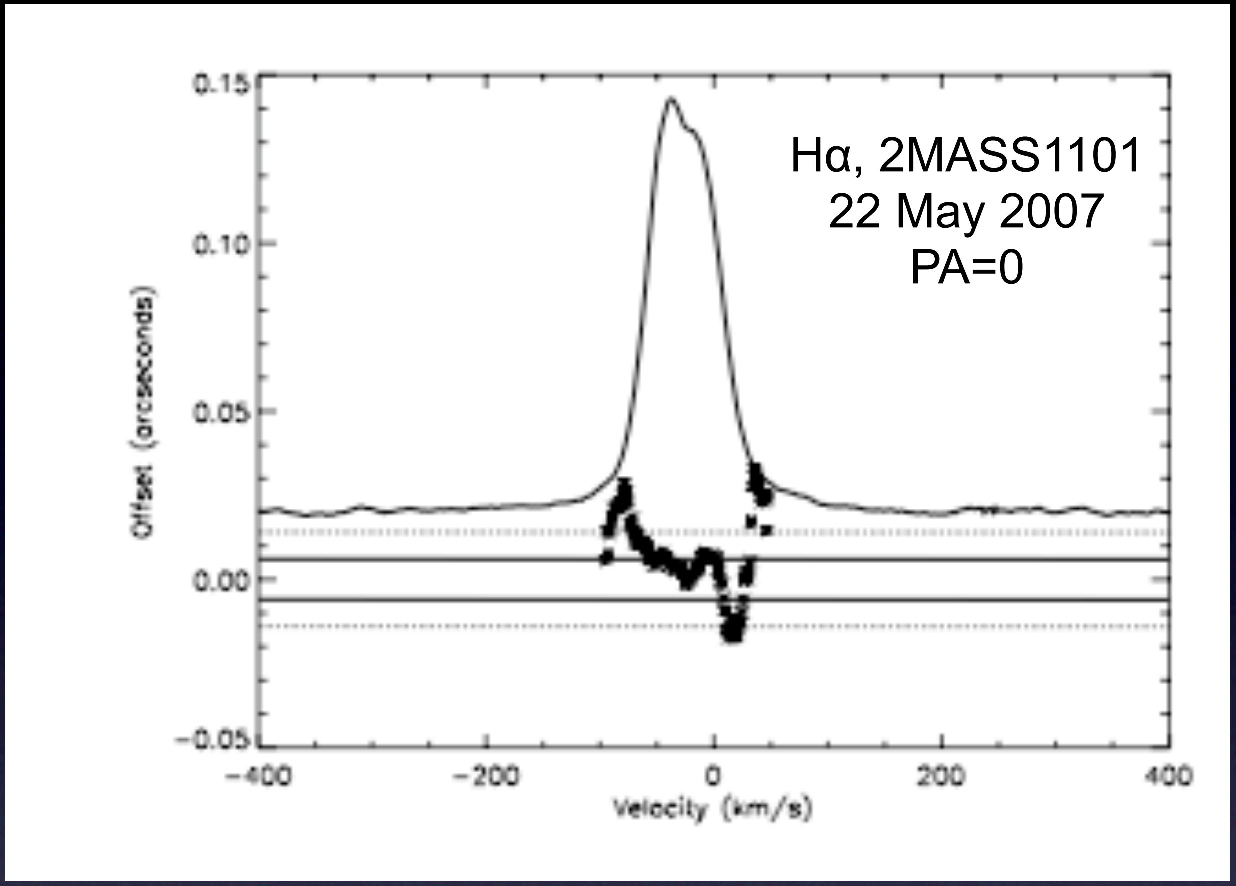
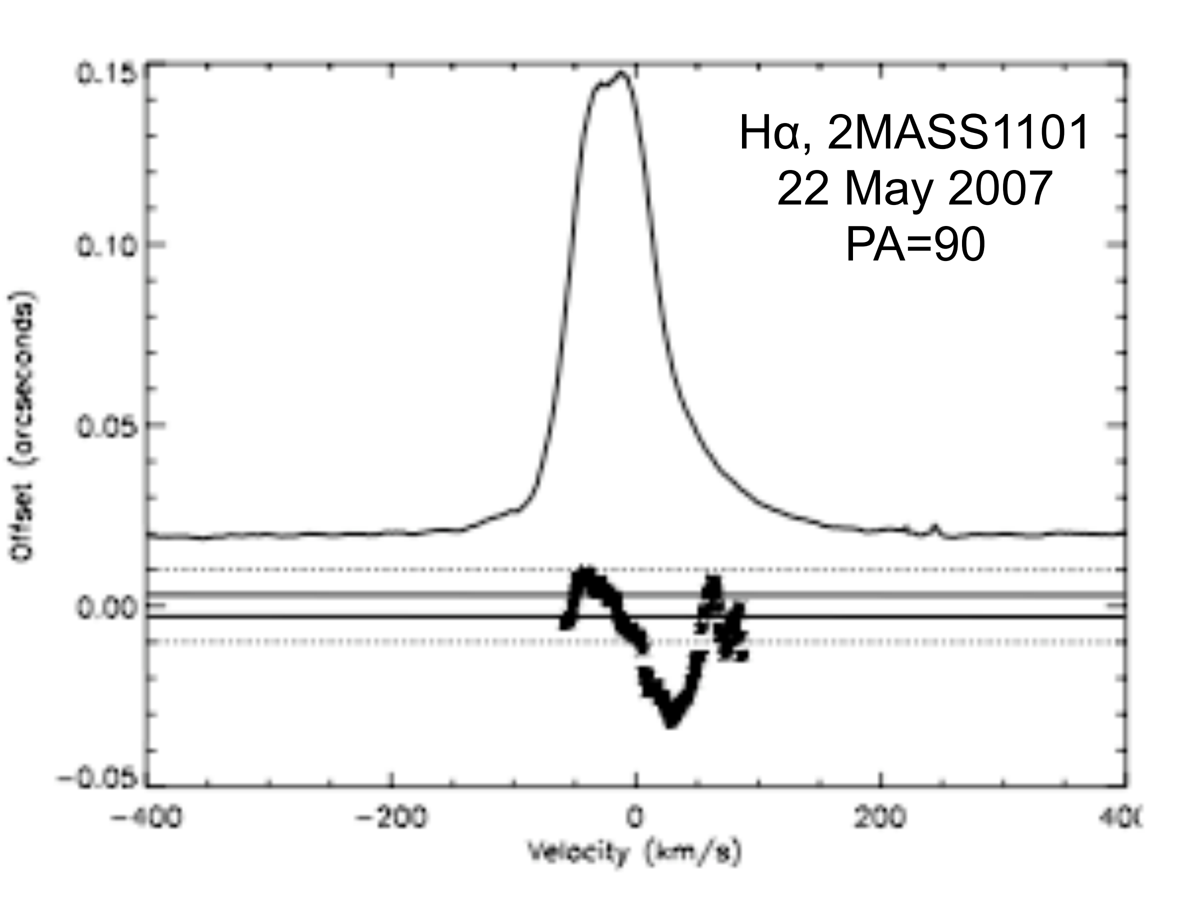


Fig. 6. *K*-band spectrum of LS-RCrA 1 obtained with ISAAC at the VLT. The intensity has arbitrary units and a base line of 0. The most prominent features are marked, as well as the positions of other features commonly appearing in low- to mid-resolution spectra of late-type objects and that are absent from the present one. Below: the spectrum of an M 6 standard star (Wolf 359; Kleinmann & Hall 1986) is plotted with a dashed line; it has been shifted from its position at continuum equal to 1.

2MASS1101-7625





Whelan et al 2008, in preparation, data taken from ESO archive

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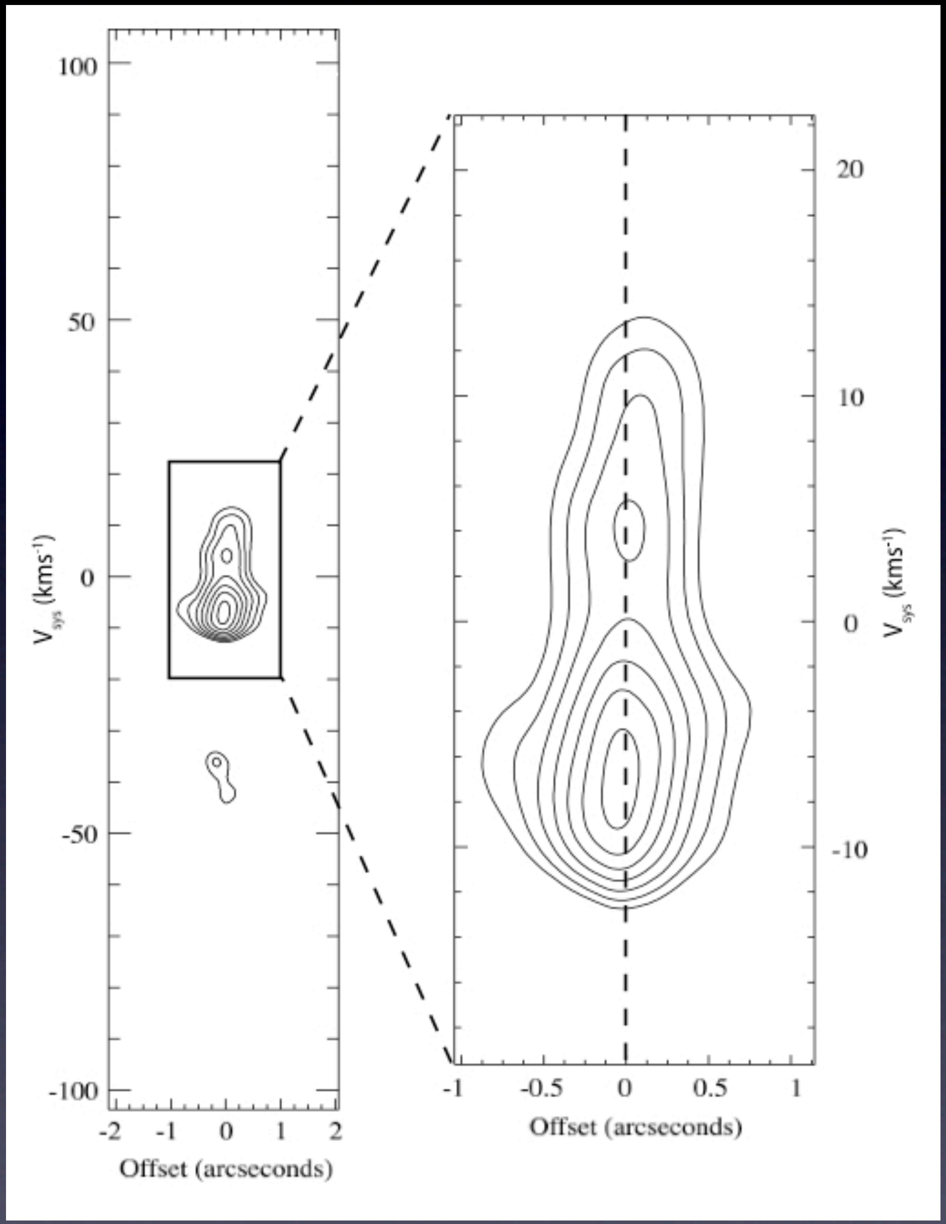
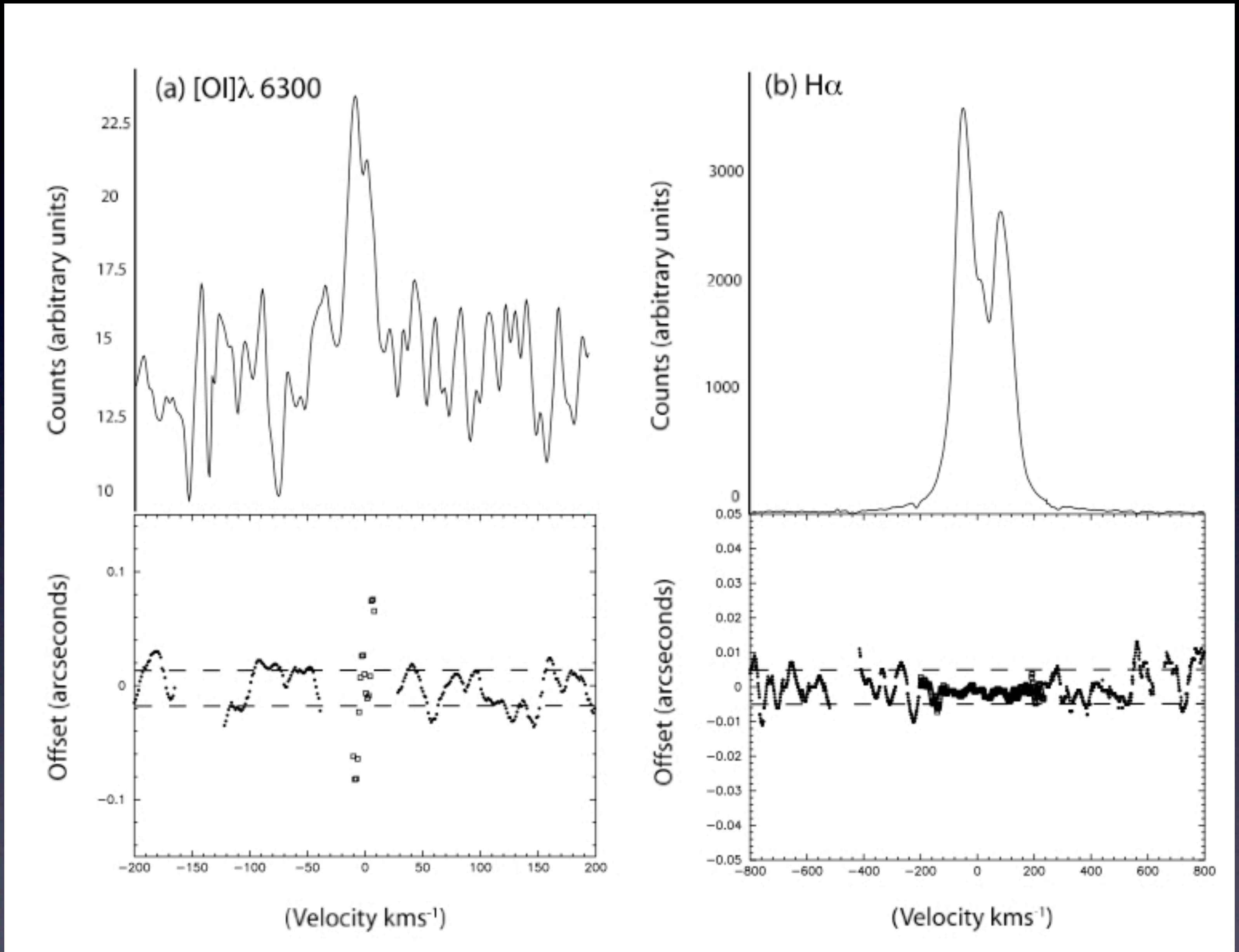
2MASS1207-3932





Whelan et al 2007, data obtained in period 77

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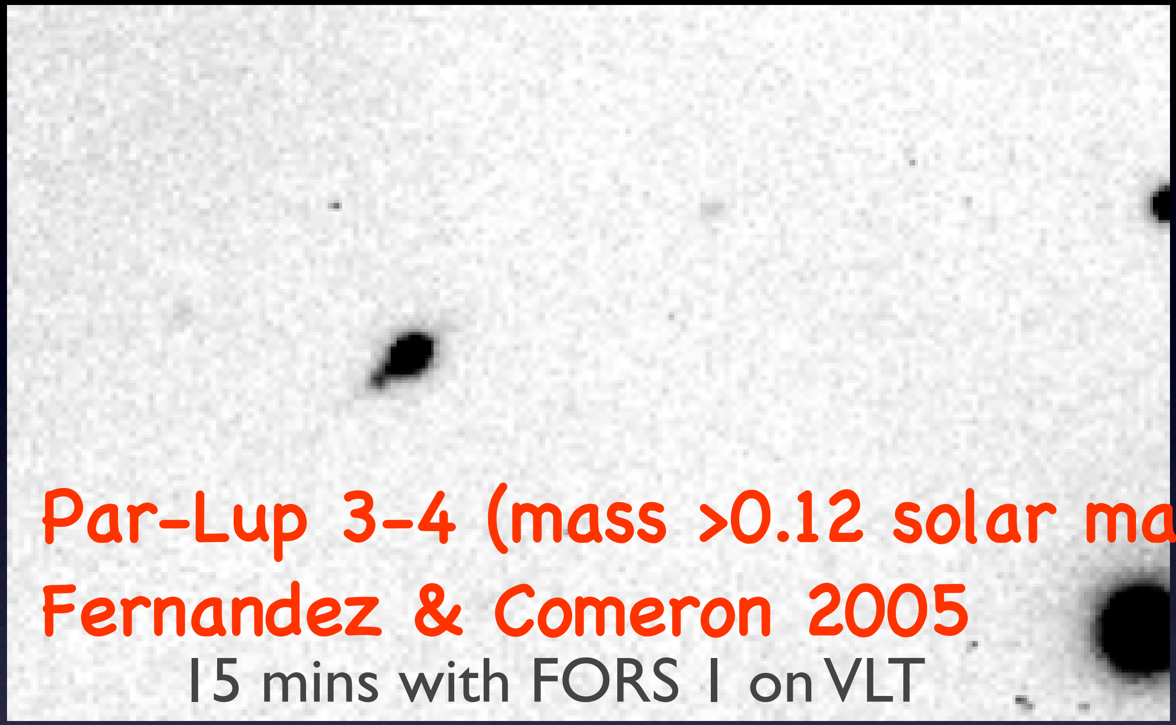
Imaging Outflows from Brown Dwarfs

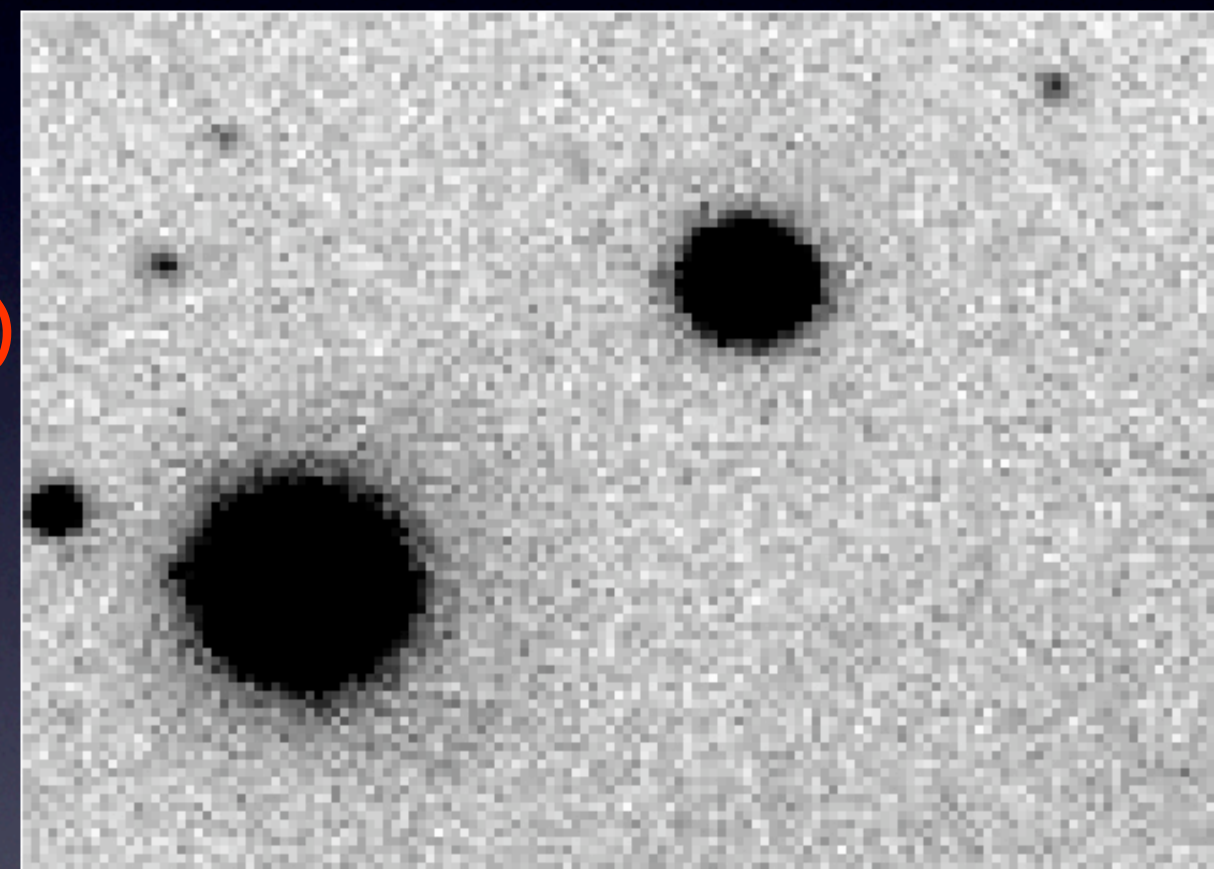
FORS-1 time granted in period 80



Par-Lup 3-4 (mass >0.12 solar masses)
Fernandez & Comeron 2005

Imaging Outflows from Brown Dwarfs

FORS-1 time granted in period 80



Imaging Outflows from Brown Dwarfs

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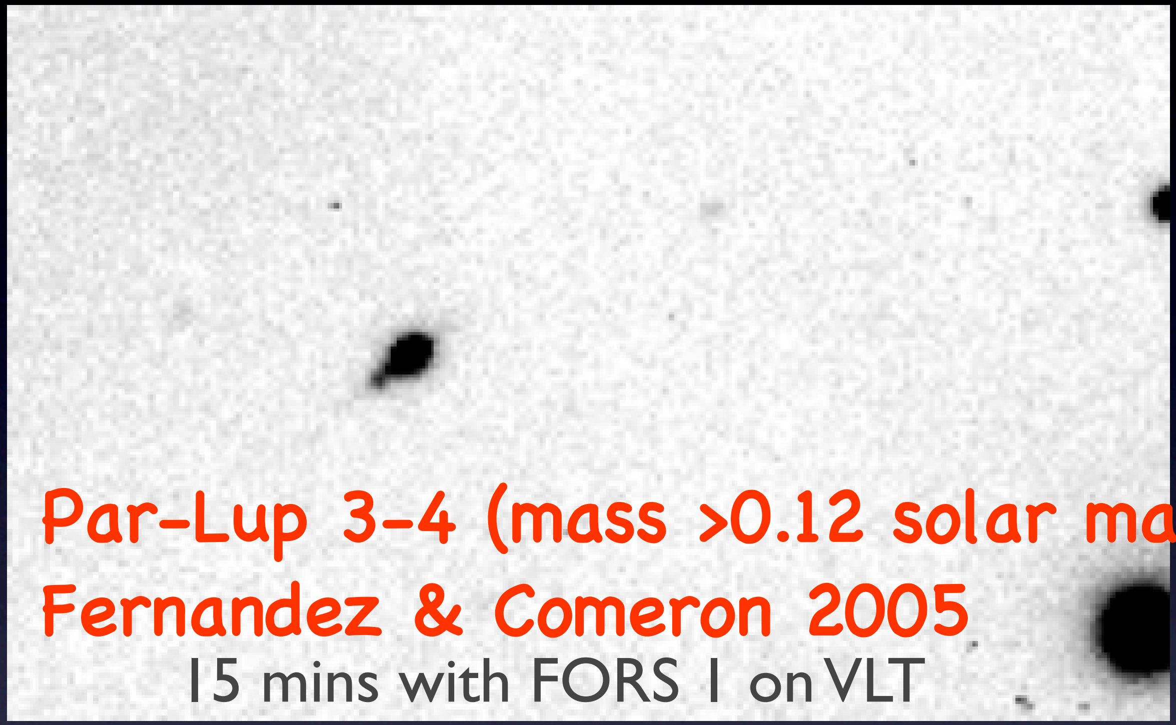

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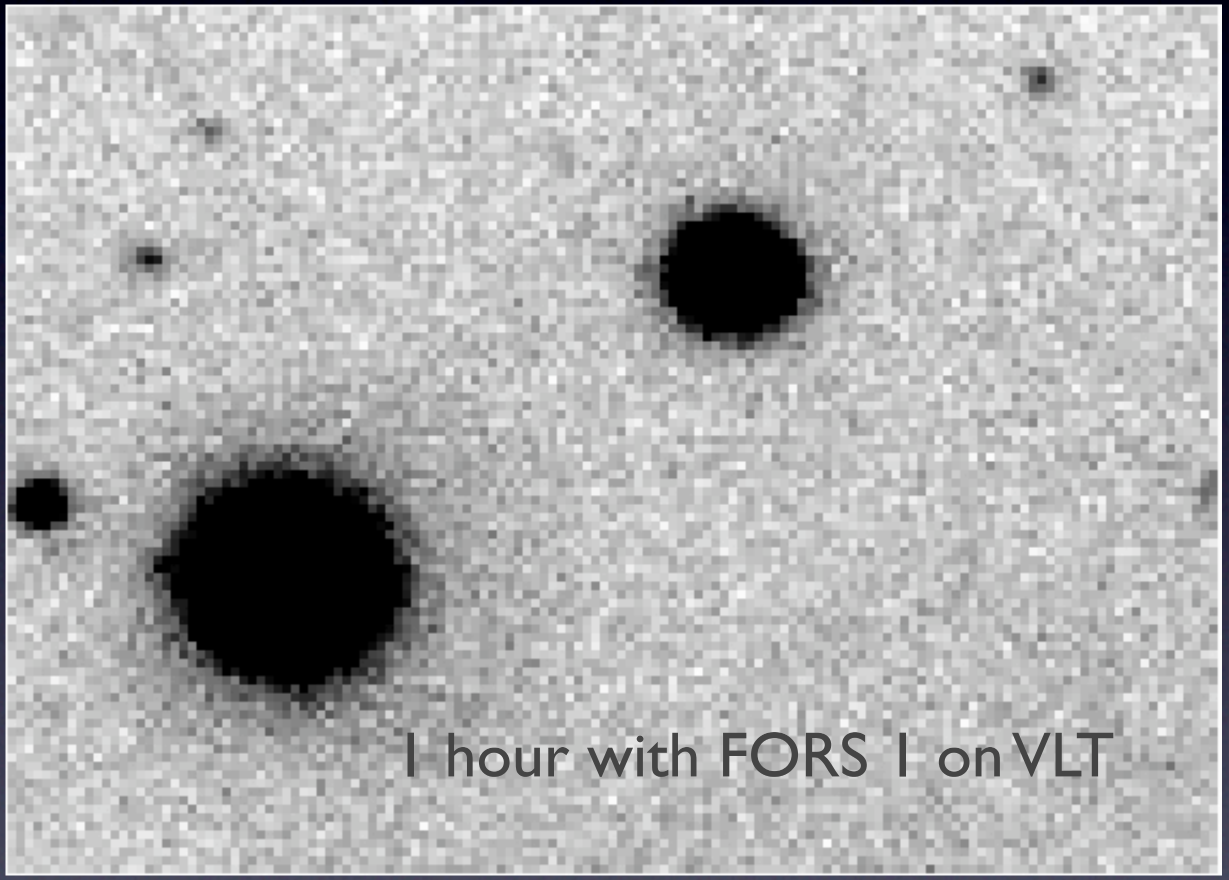
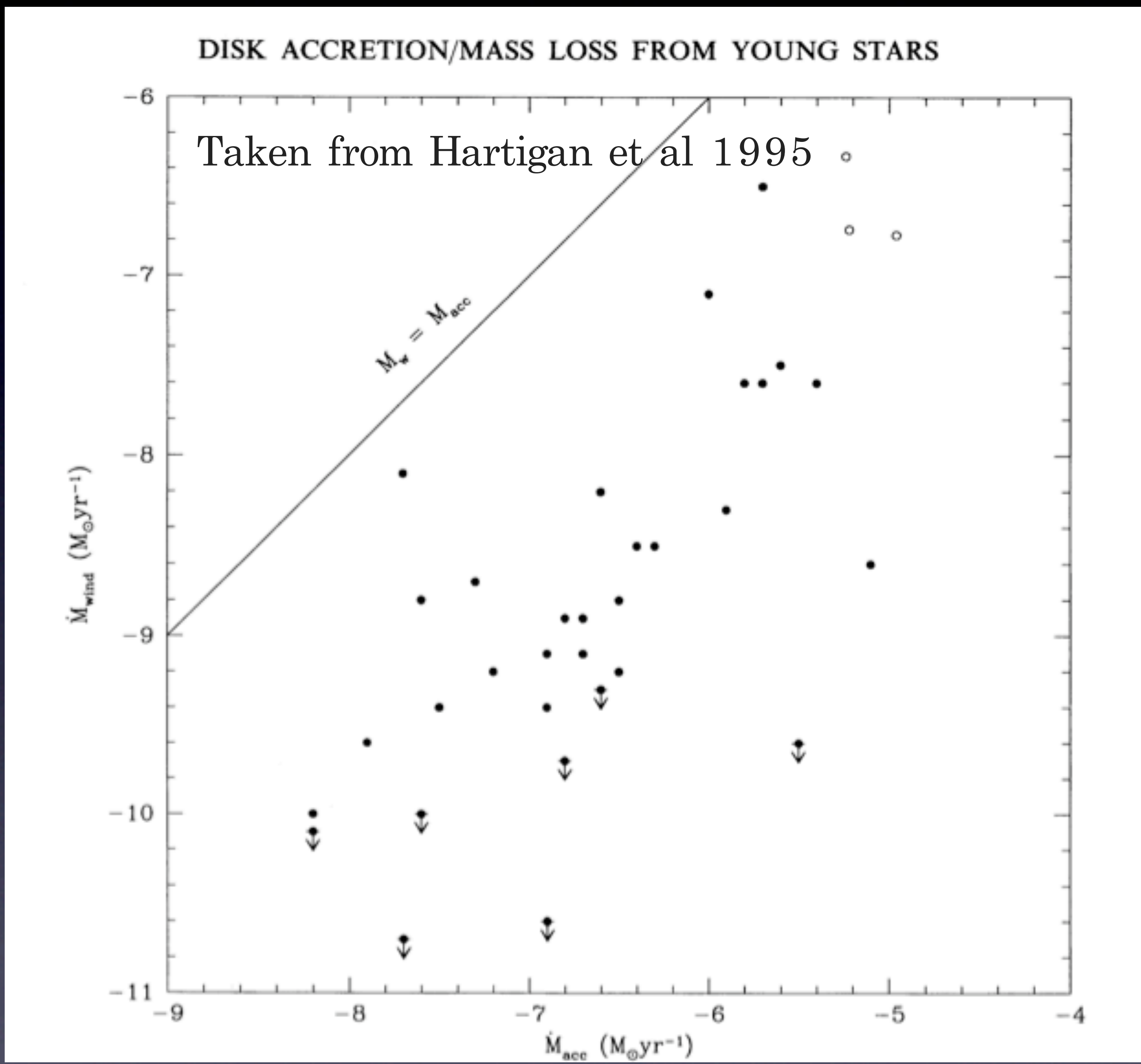


Measuring Ratio of Outflow to Infall



Is $\dot{M}_{out}/\dot{M}_{acc} = 0.1$ in BDs

Source	2MASS1207	ρ-Oph 102	LS-RCrA 1
Mass (M_{jup})	24	60	35
$\dot{M}_{acc}$ ($M_\odot yr^{-1}$)	10^{-11}	1.25×10^{-9}	10^{-9}
[OI]λ6300(kms^{-1}, $''$)	+4/-8,+0.08/-0.08	-40, 0.085	-9, –
[SII]λ6731(kms^{-1}, $''$)	–,–	-45, 0.085	-15,–
[NII]λ6583	–,–	-45,–	-19,–

Table 1: Table comparing the mass (in Jupiter masses), mass accretion rates and typical FEL velocities of 2MASS1207, ρ-Oph 102 and LS RCrA 1. The accretion rate for ρ-Oph 102 was derived using the Hα emission line and is taken from Natta et al. (2004). For 2MASS1207 and LS RCrA 1 Mohanty et al. (2005) used the CaIIλ8662 line fluxes to infer the mass accretion rates. The mass estimate for LS-RCr A1 is taken from Barrado y Navascués et al. (2004).

Conclusions

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- No evidence of multi-component FELs. The fact that [NII]λ6548 is observed suggests that what we are seeing is the counterpart to the HVC observed in CTTSs.

- Increase the sample, extend into the NIR and look for molecular outflows. Most importantly constrain the ratio between outflow and infall