Forbidden Lines and Disk Winds

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Optical forbidden lines of [O I] and [S II] in TTS are predominantly blueshifted, indicating winds and disk occultation, with profiles that can be decomposed into kinematic components attributed to high velocity collimated jets (HVC) and low velocity disk winds (LVC). ***We find that wind launching conditions depend on the accretion luminosity, that both faster inner winds and slower outer winds are linked to each other when both are present, as well as to the jet and the accretion rate, and that mass loss rates from the inner disk exceed those from the outer disk.***

[OI] 6300 LVC Kinematics

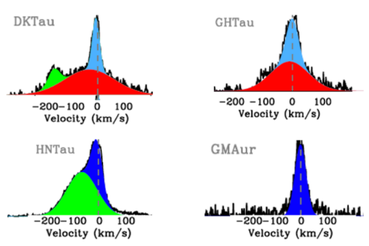
Banzatti et al 2018

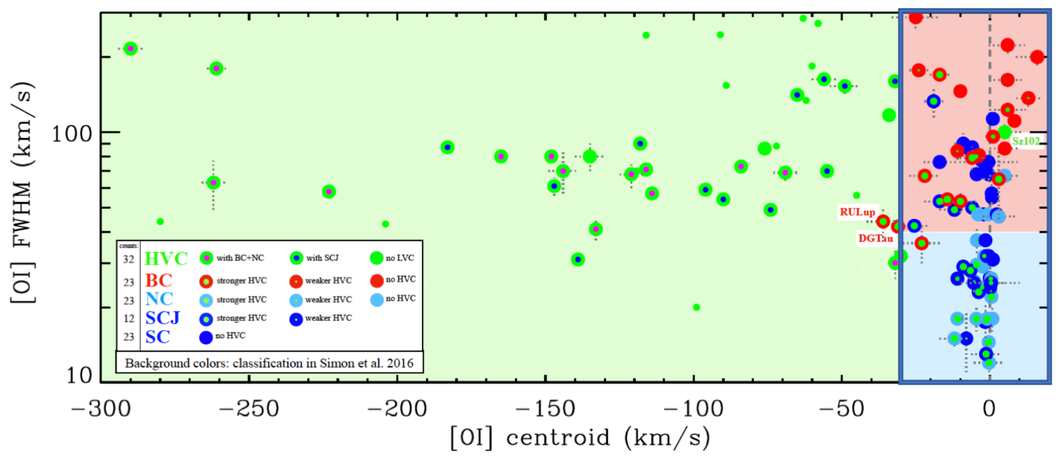
Gaussian Components

- *63 TTS, Keck HIRES, Magellan MIKE*
- *WTTS photospheric templates*
- *Assignment to HVC, 4 LVC types*

BC + NC
n = 23, 75% with HVC

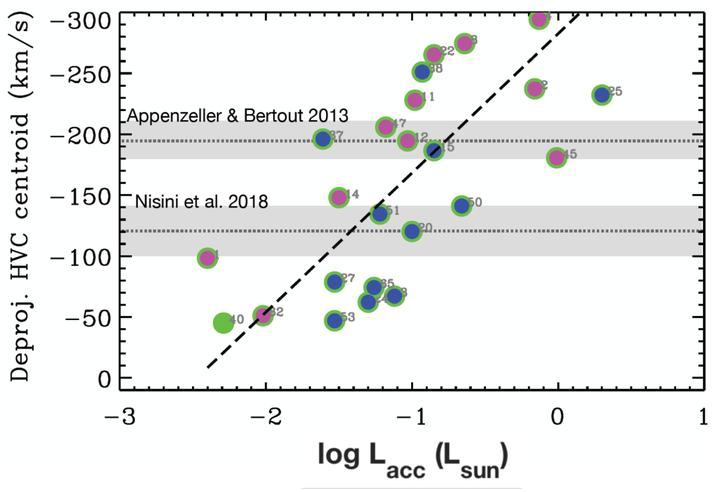
SC
n = 35, 34% with HVC

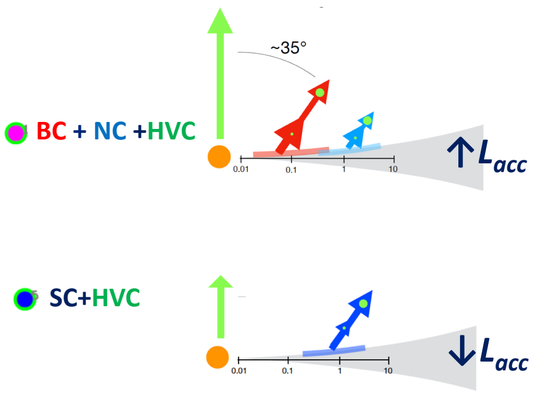




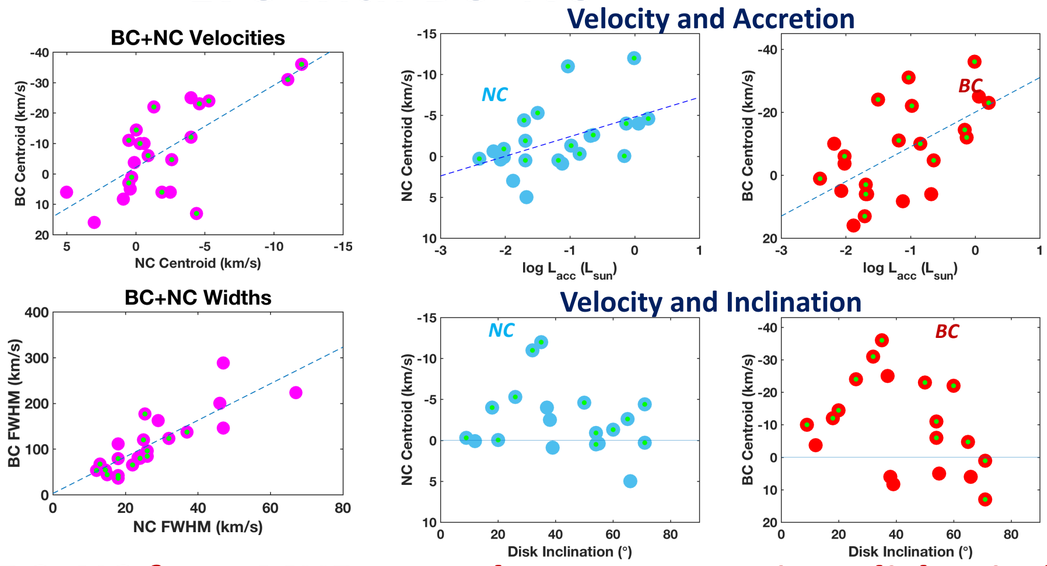
- ***WIND:** LVC Centroid Velocities predominantly blueshifted*
- ***Inferred KEPLERIAN RADII:** BC: 0.05-0.5 AU; NC: 0.5-5 AU*

LVC with HVC





LVC with BC+NC



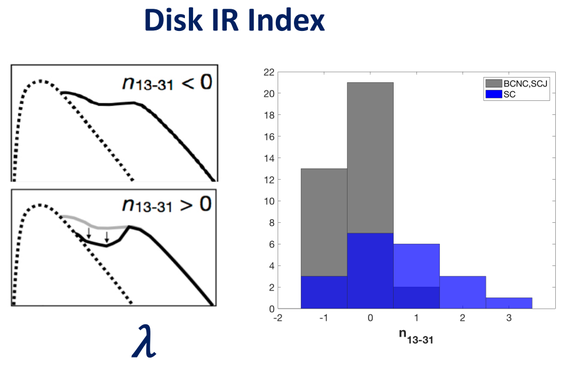
DISK WIND STRUCTURE DEPENDS ON L_{ACC}

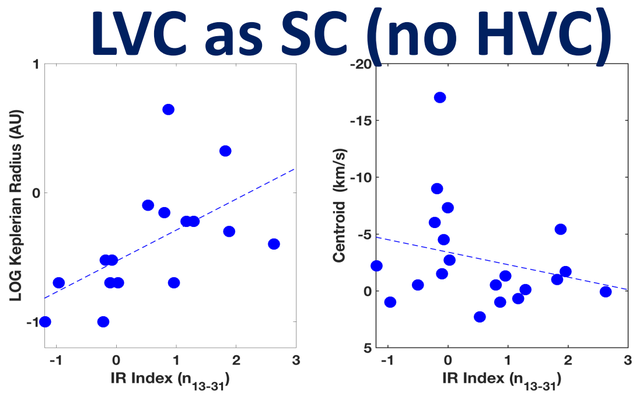
- *L_{acc} , jet terminal velocity decrease in tandem as LVC transitions from BC+NC to SC*

BOTH BC, NC from MHD, not photoevaporative, disk wind

- *Blueshifts of NC, BC correlate with each other and L_{acc}*
- *Blueshift maxima at inclination ~ 35º*

LVC as SC (no HVC)





LVC STRUCTURE FOR EVOLVED DISKS

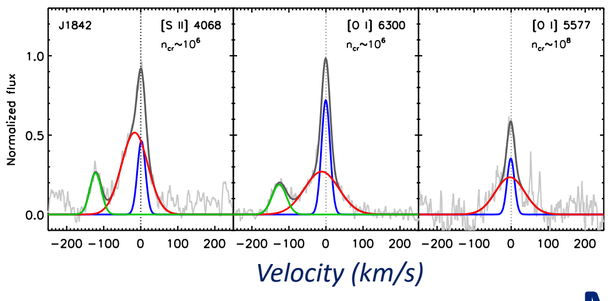
- **Only LVC as SC have IR index > 1 (evolved disk)**
- **As inner disk clears, SC shifts to larger R_{kep}, smaller V_c**

LVC Line Ratios

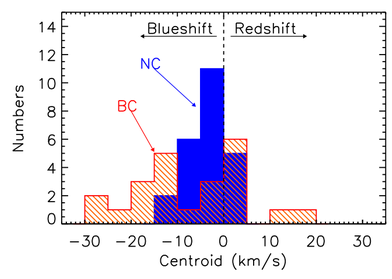
Fang et al 2018

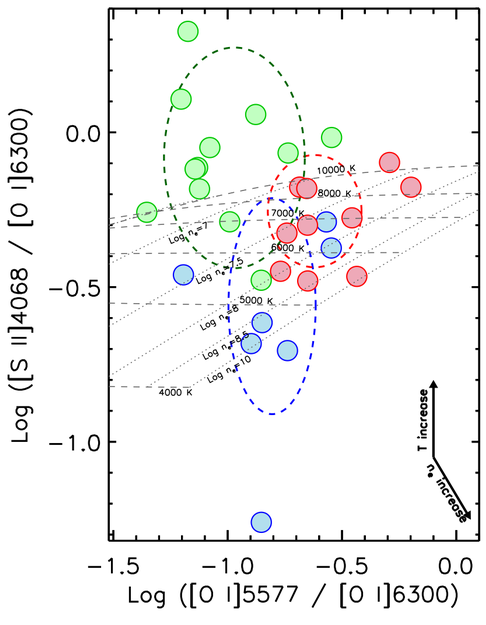
Gaussian Components

- *48 TTS, Keck HIRES, flux calibrated*
- *WTTS photospheric templates*
- *Assignment to HVC, 2 LVC types (BC,NC)*



- *[OI] 6300 in 45 TTS*
- *[OI] 5577 in 26 TTS*
- *[SII] 4068 in 22 TTS*



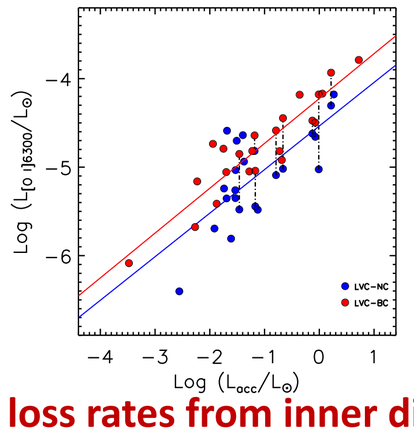


COMPONENT RATIOS

- *All 3 lines detected in 18 sources*
- *Distinct mean ratios for HVC, BC, NC*
- *Ratios for HVC indicate shocks*
- *Ratios for LVC indicate thermal excitation*
  - T 5000 to 10000 K, N_e $10^7 - 10^8$ cm^{-3}
  - Enables estimates for M_{gas}

$$M_{\rm gas} = {\rm C(T)}\ L_{6300}$$
$$\mathrm{C(T)} = \frac{\eta m_{\rm H}}{\alpha({\rm O})} \frac{Z(T)}{g_{\rm u} A h\nu}\ e^{h\nu/kT}$$

Mass Loss Rates: Inner vs Outer Disk Wind



$$\dot{M}_{\rm wind} = M_{\rm gas}\ \frac{V_{\rm wind}}{l_{\rm wind}}$$

	BC / NC	
$L_{[OI]}$, M_{gas}	2.5	
V_{wind}	2.5	
$l_{wind} = f \times R_{kep}$	0.1	if $f_{BC} / f_{NC} = 1$
$\dot{M}_{wind}$	60	if $f_{BC} / f_{NC} = 1$

Mass loss rates from inner disk wind exceed outer disk wind

- $\dot{M}_{wind\text{-}BC} \sim 0.1\ \dot{M}_{acc}$ *and* $\sim \dot{M}_{HVC}$ *if* $f_{BC} = 10$, T=7500 K