Unveiling the circumstellar physics of Young Stellar Objects with GIANO and GRAVITY

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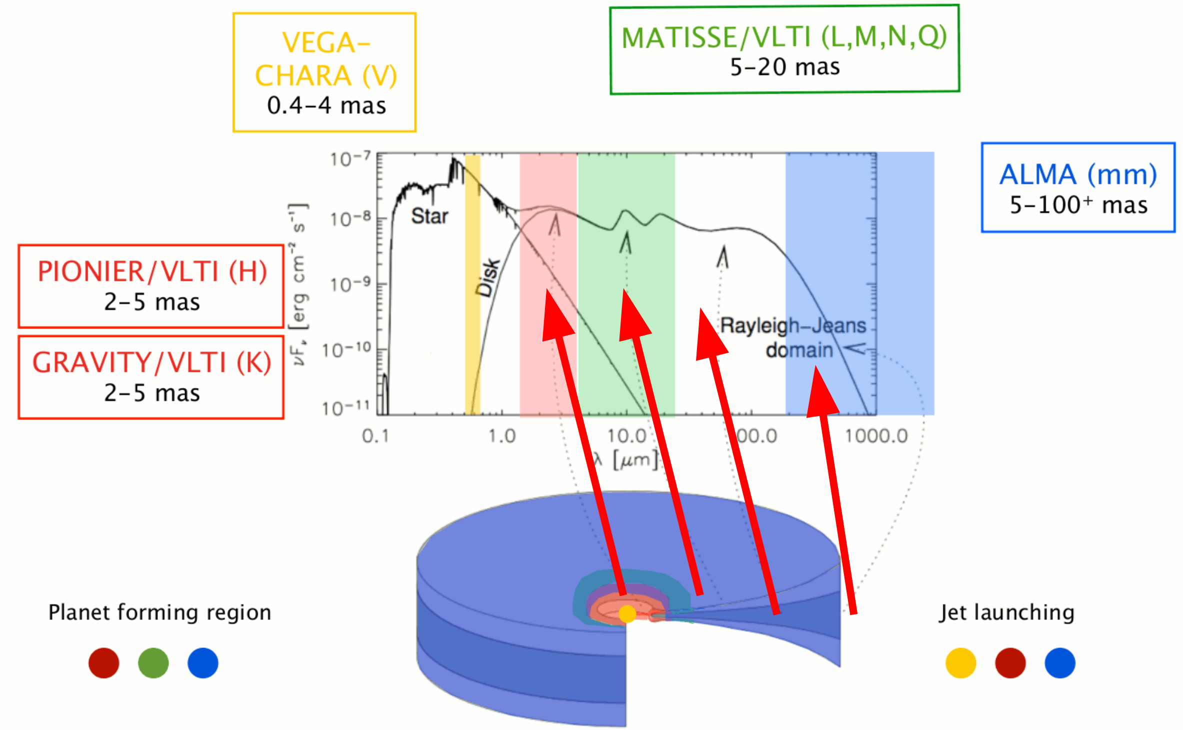
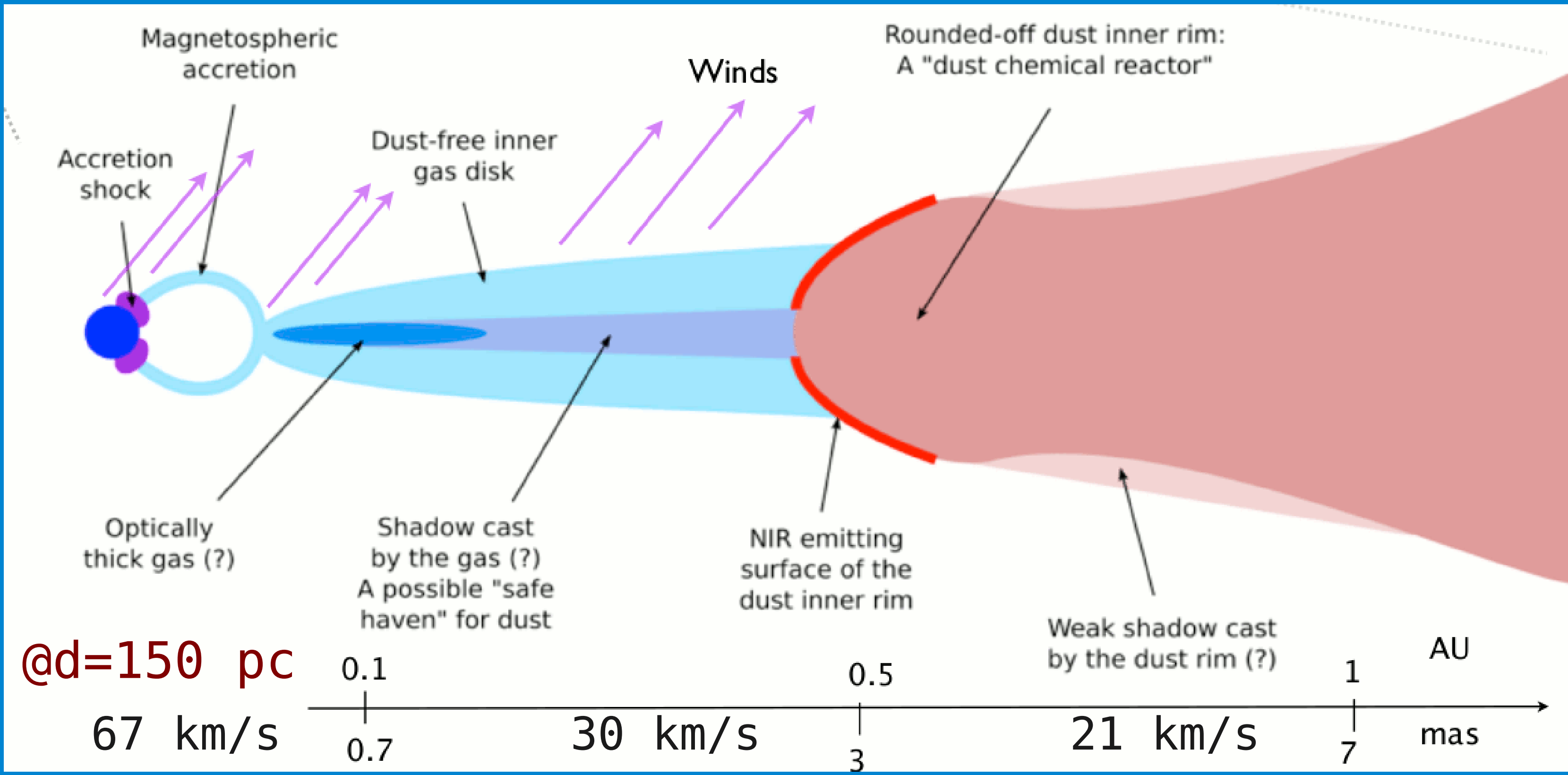
La missione e le prospettive scientifiche di TNG nell'astrofisica del 2020 – Padova, March 1-3 2017

Circumstellar environment of young stars

(courtesy M. Benisty)

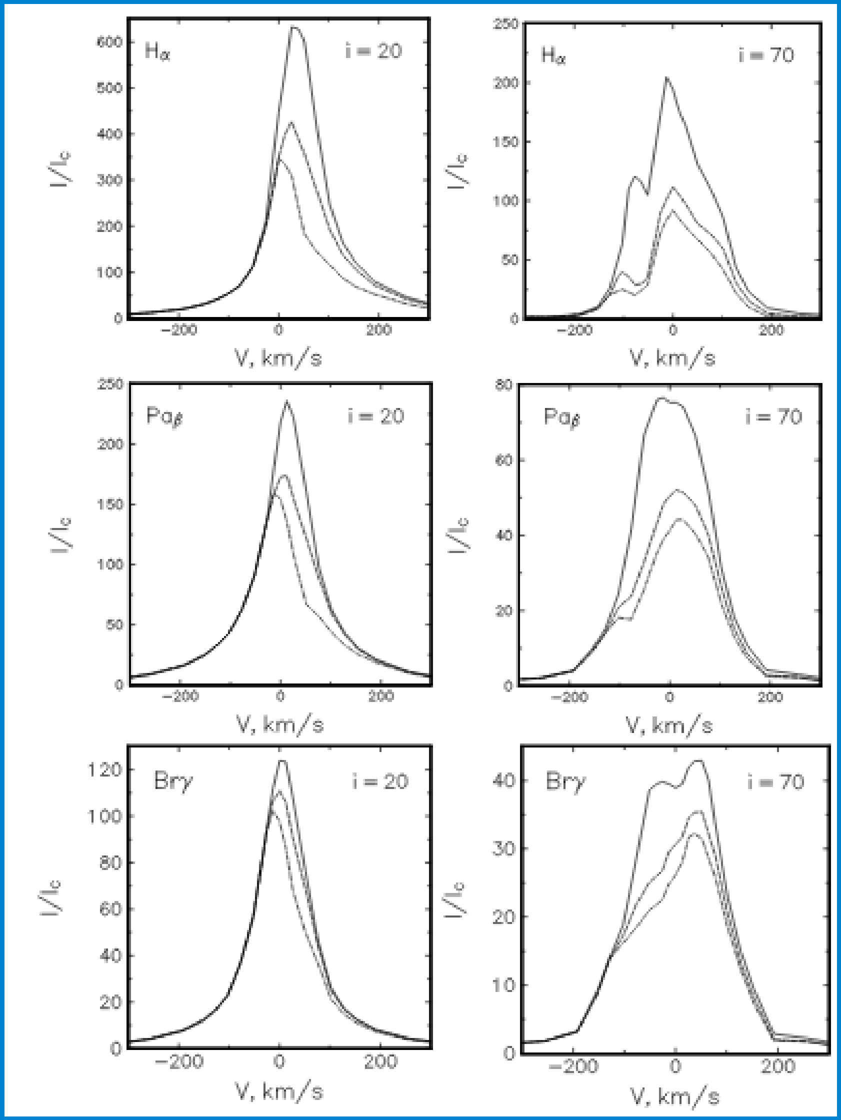


Developed for low-mass stars
Does this scenario apply to younger and /or more massive objects as well?

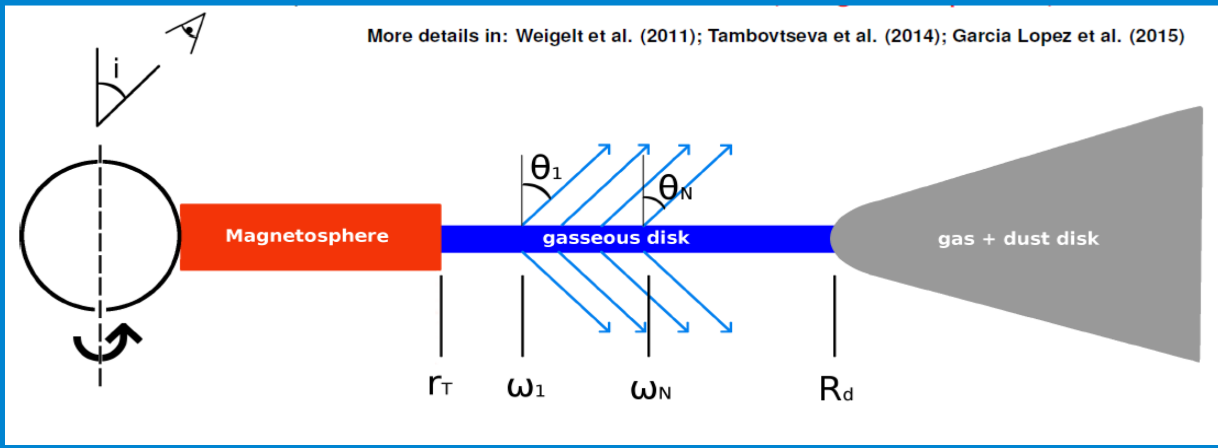


Line modelling

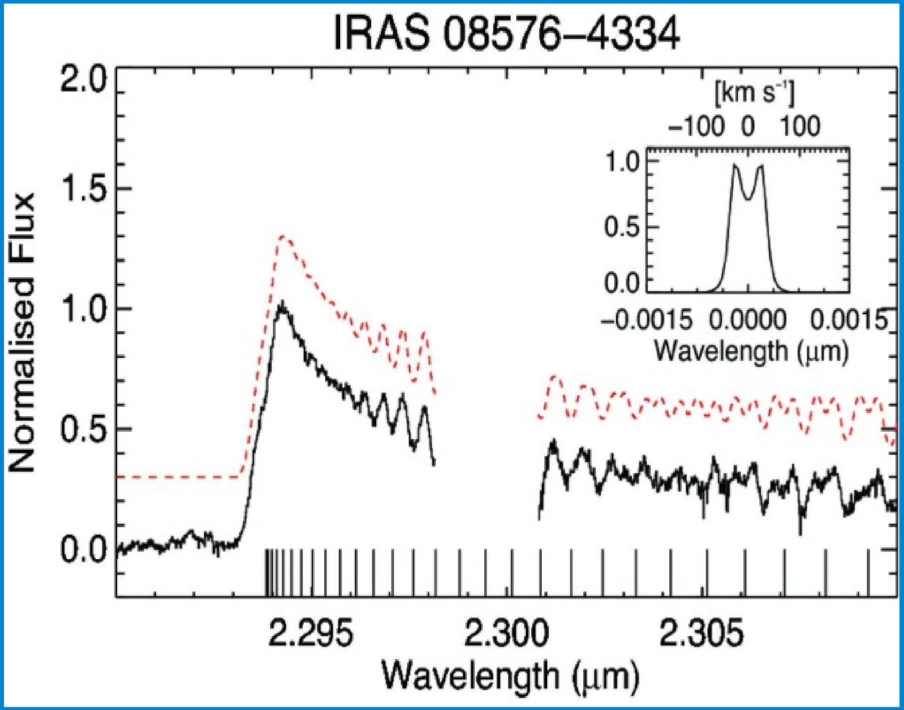
HI lines



Tambovtseva+ 2014



CO band-heads



Ilee+ 2013

Line modelling of high resolution spectra:
Three young stars observed during GIANO/TNG commissioning night of July 30, 2013

Herbig Be star HD200775 (a.k.a. MWC 361)

- **B3 star, 5-15x10^3 $L_\odot$**
- **Double system: primary 10.7 $M_\odot$, secondary 9.3 $M_\odot$**
- **Distance 429 pc, Av 0 1.8 (Rv=3.1) – 3,0 (Rv=5.0)**

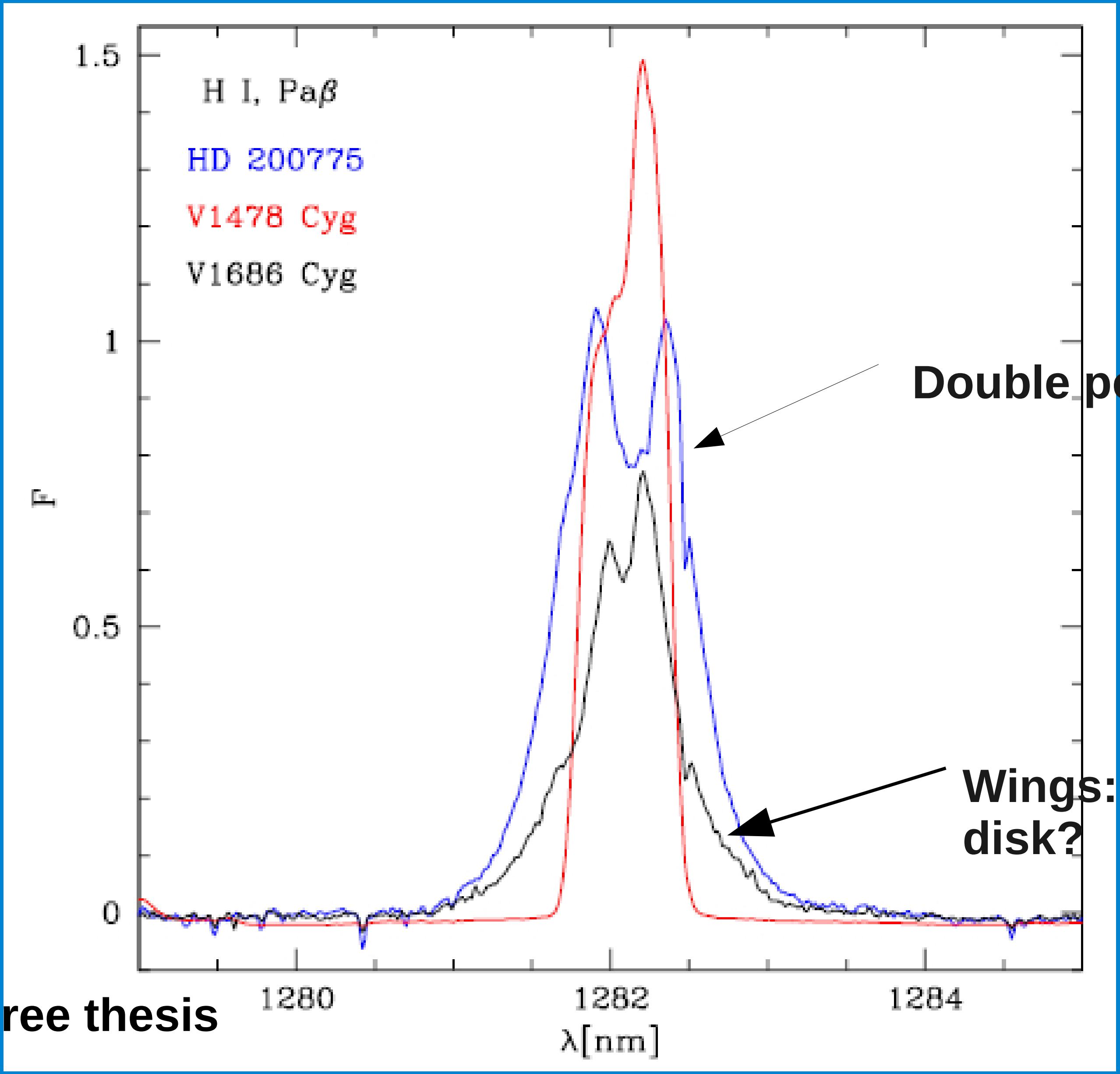
Be star V1478 Cyg (a.k.a. MWC349A)

- **B star, possible LBV, 3x10^4 $L_\odot$**
- **Mass 20 $M_\odot$**
- **Distance 1200 pc, Av = 10-10.7**

Herbig Ae star V1686 Cyg (a.k.a. LkHα 224)

- **B2-F9 star, 257 $L_\odot$**
- **Mass > 3.5 $M_\odot$**
- **Distance 980 pc, Av = 5.22 (Rv = 6,1)**

Line profile comparison: Paβ

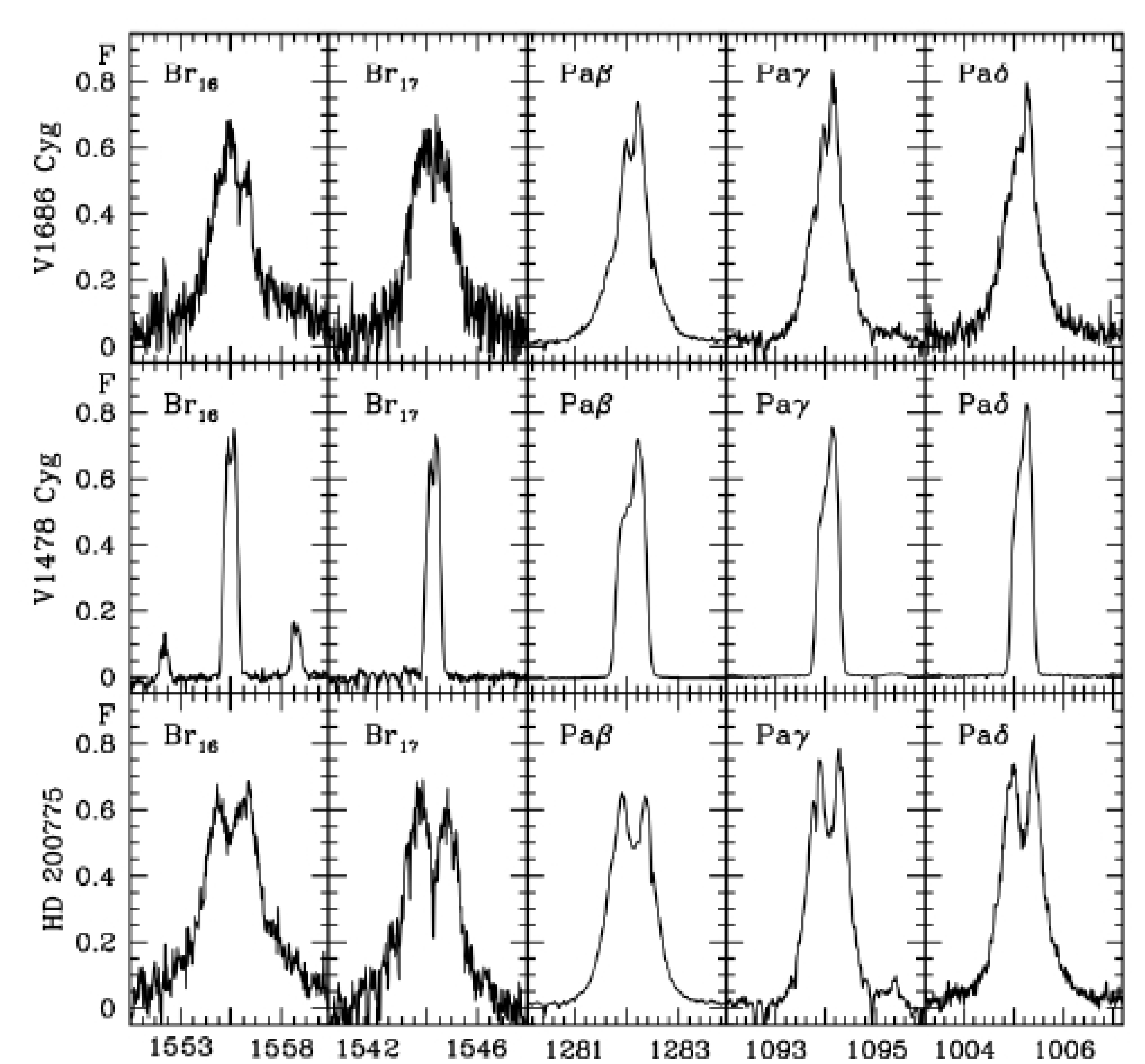


Double peaks: disk?

Wings: innermost gas disk?

T. Pecchioli, degree thesis

Line profile comparison: Brackett and Paschen lines



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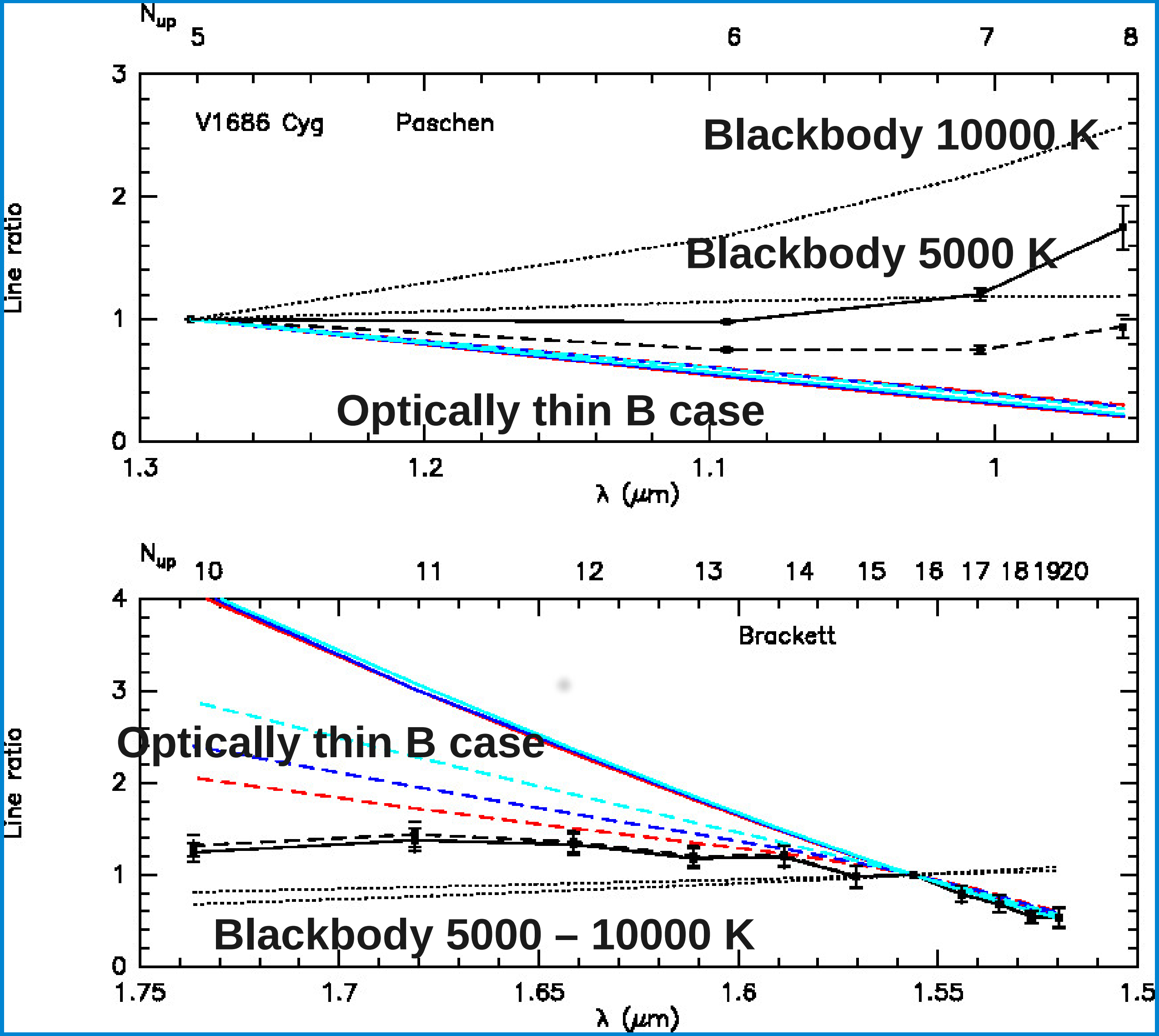
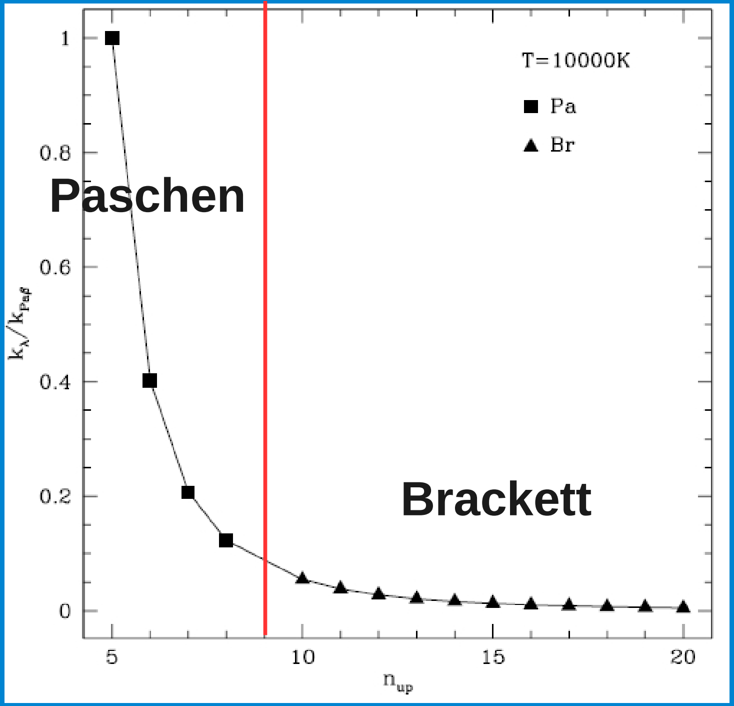
T

V1686 line ratios





Line opacity, LTE,10000 K, normalized to Paβ

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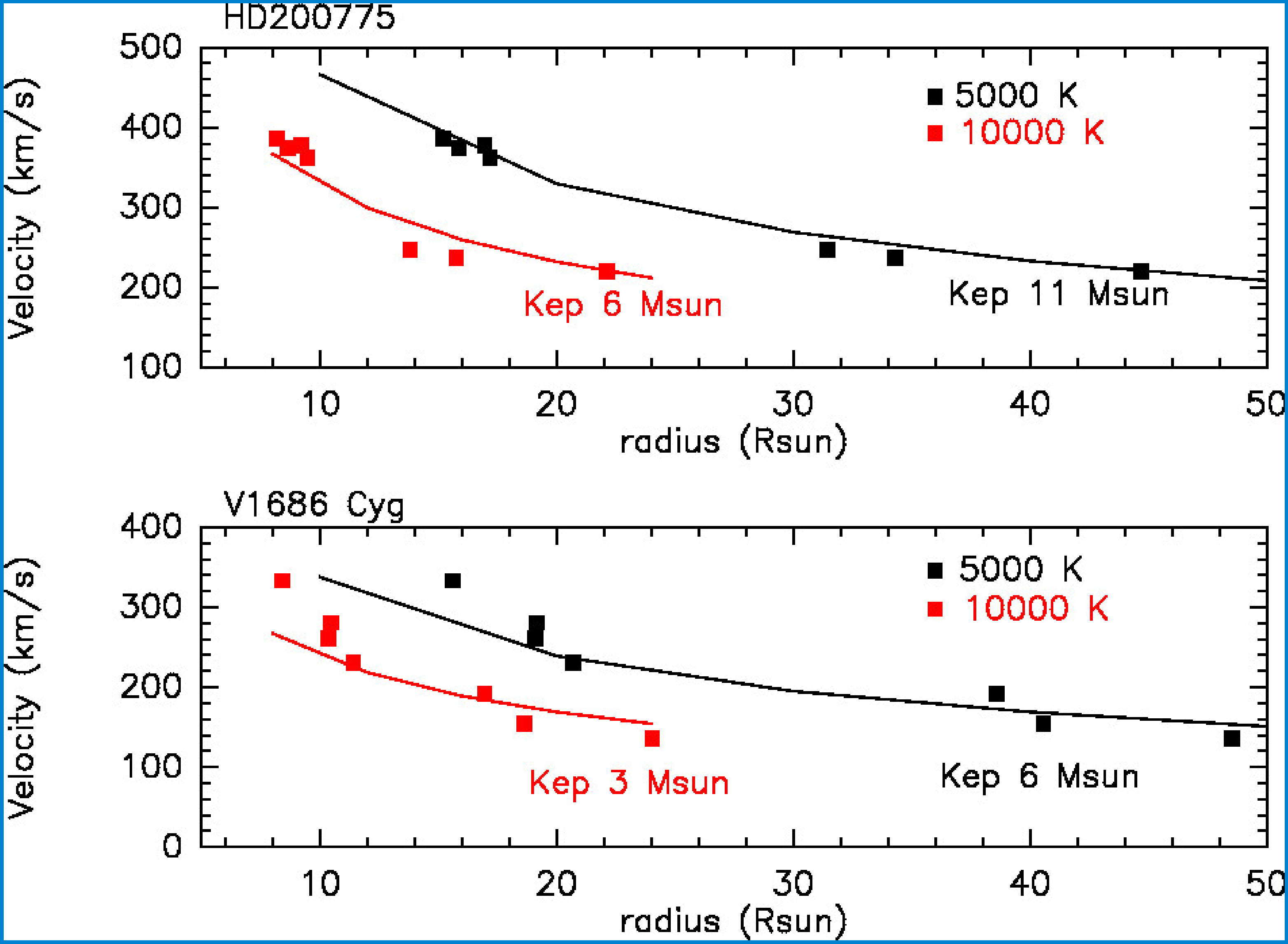
Distance to star vs. line widths

Assuming lines optically thick: $F_\lambda = \pi (R/dist)^2 B(\lambda,T) \Delta\lambda$



$M_\odot \sin^2 i$

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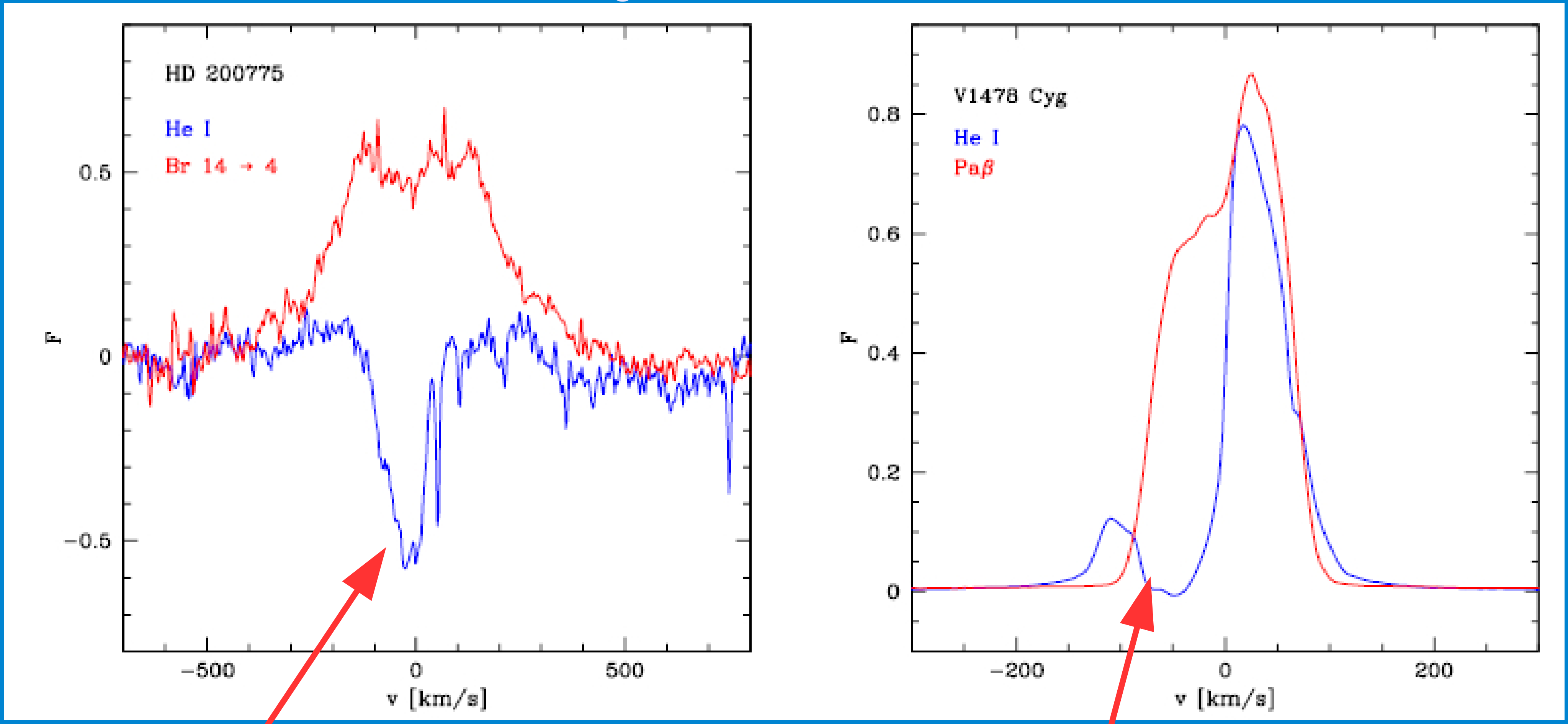
HeI 1.083 µm: wind tracer (Edwards et al. 2006)

Other HeI lines in the K band, e. g. 2.06 micron



in absorption, blueshifted

Self-absorbed line blueshifted dip
Consistent with disk wind 75 km/s

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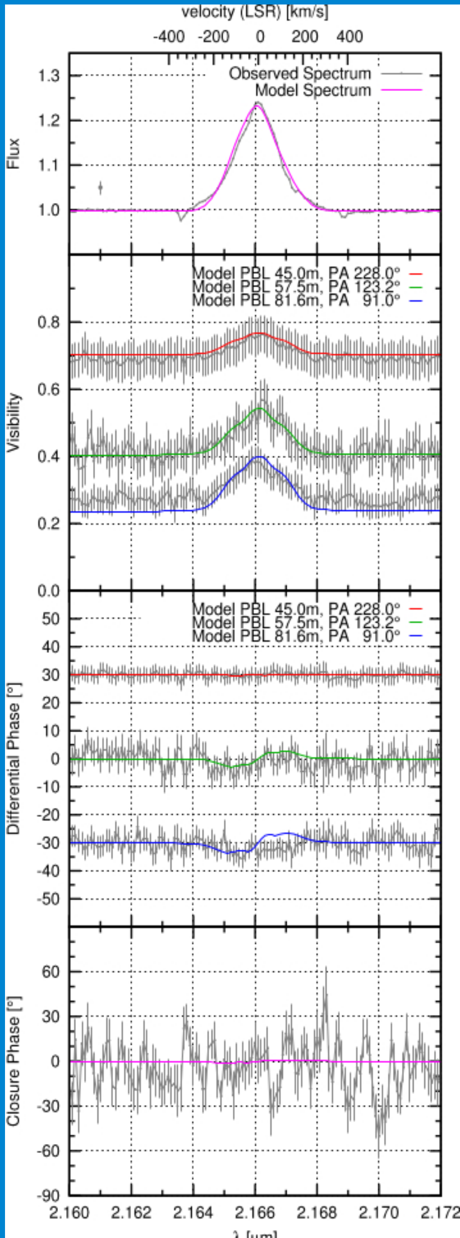
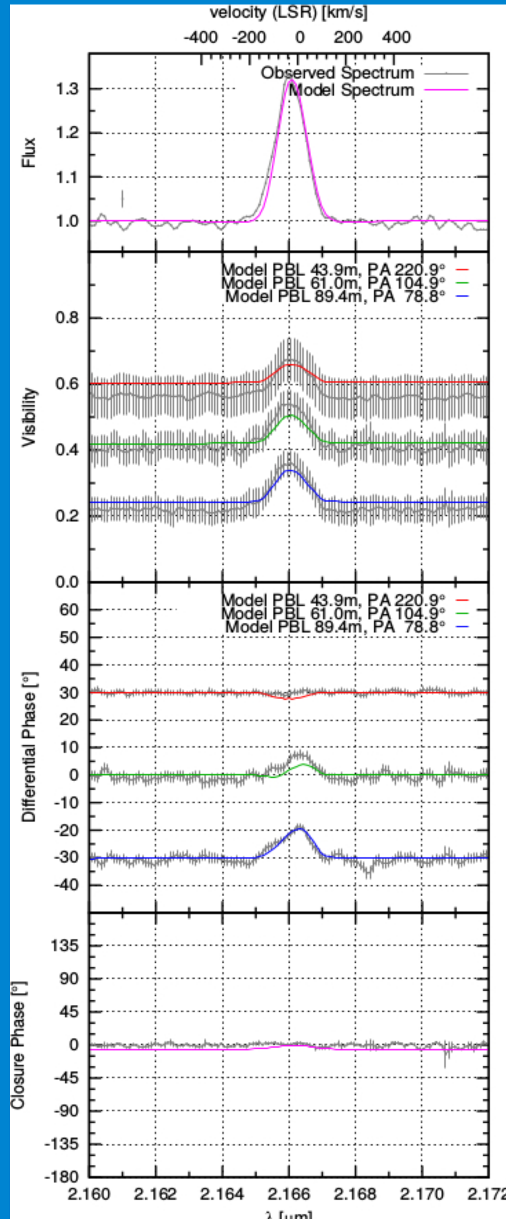
Line modelling+high spatial resolution data:
Jet launching region with AMBER@VLTI

HD 163296

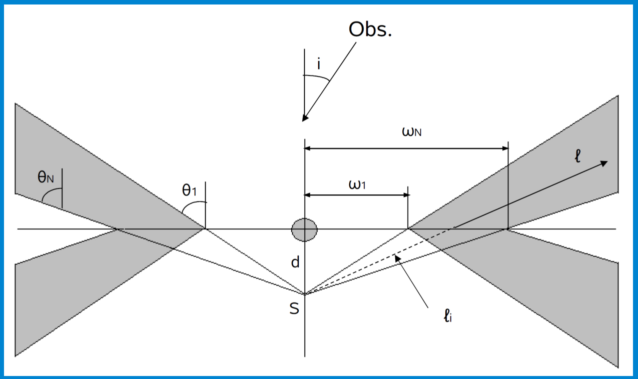


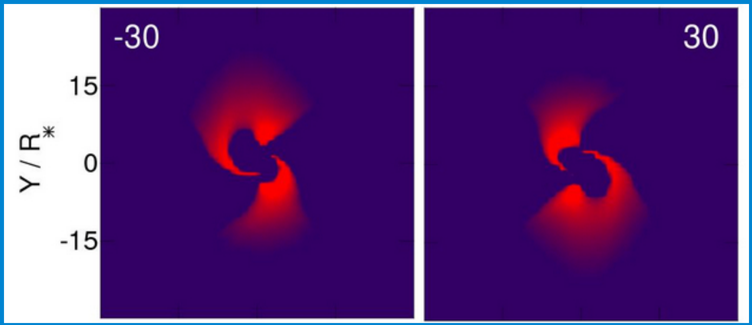
HD 98922



Magneto-centrifugally

driven disk wind



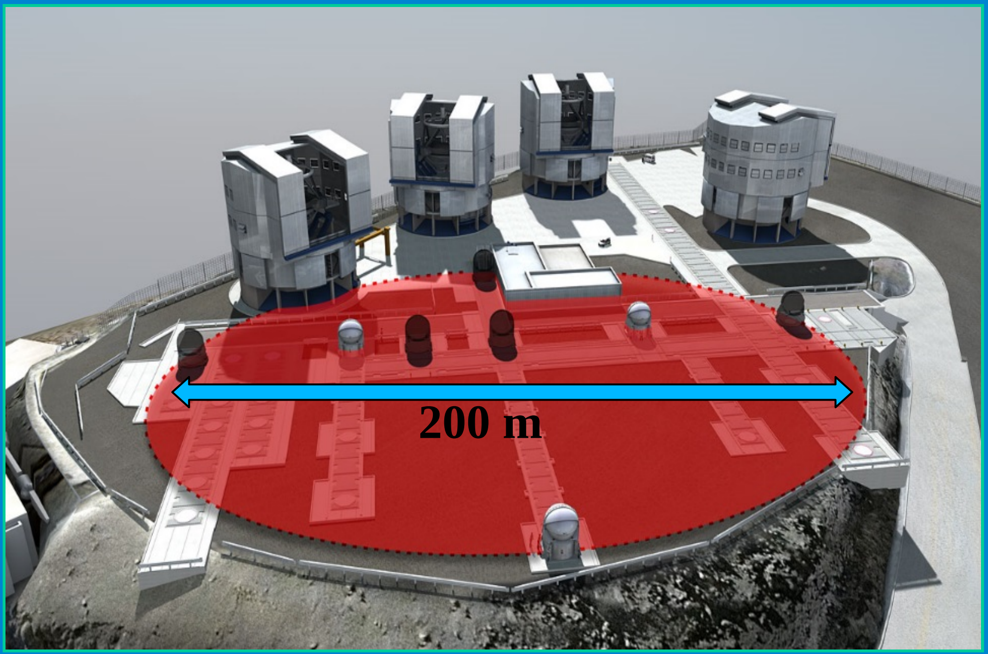


model

GRAVITY: image reconstruction!

Garcia Lopez+ 2015; Caratti o Garatti+ 2015

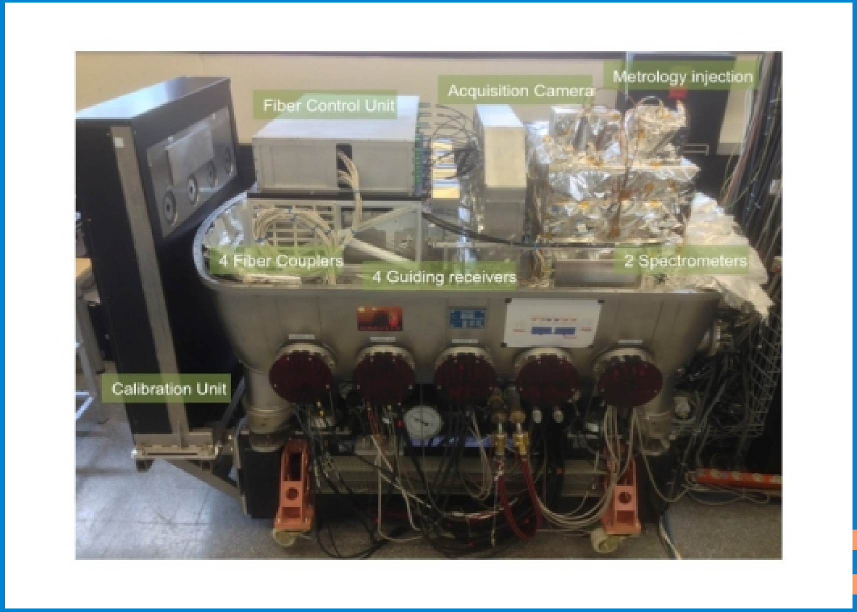
GRAVITY@VLTI



2nd generation beam combiner for the VLTI:

- Combines 4 UTs/ATs (baselines up to 200 m)
- R~22, 500, 4000
- Fully integrated with ATs/UTs
- Phase referencing
- Next year it will also operate with CIAO the new IR WFS --> embedded objects!
- For now offered with MACAO

- GRAVITY GTO for YSOs (MPIA, MPE, IPAG, Uni Cologne, Porto) has 20 UT and 120 AT nights.



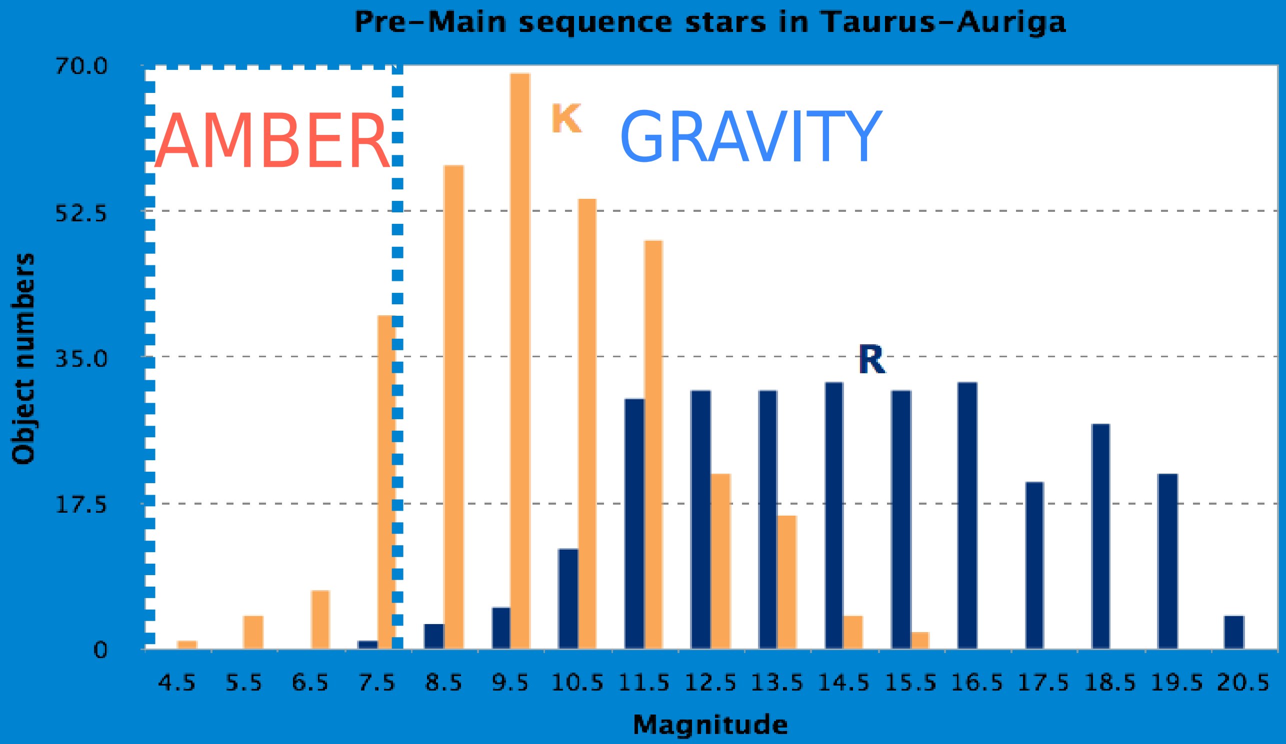
GRAVITY/VLTI GTO programme

- Aim: Statistical study of the gas content in YSO disks to spatially resolve the hot (Br) and warm (CO) gas in disks.

Large sample of YSOs (~100) spanning a wide range of stellar masses (0.1-30 M_{sun}), ages (10^4-10^7 yr) and disk properties (full and Tds).

- Objectives:

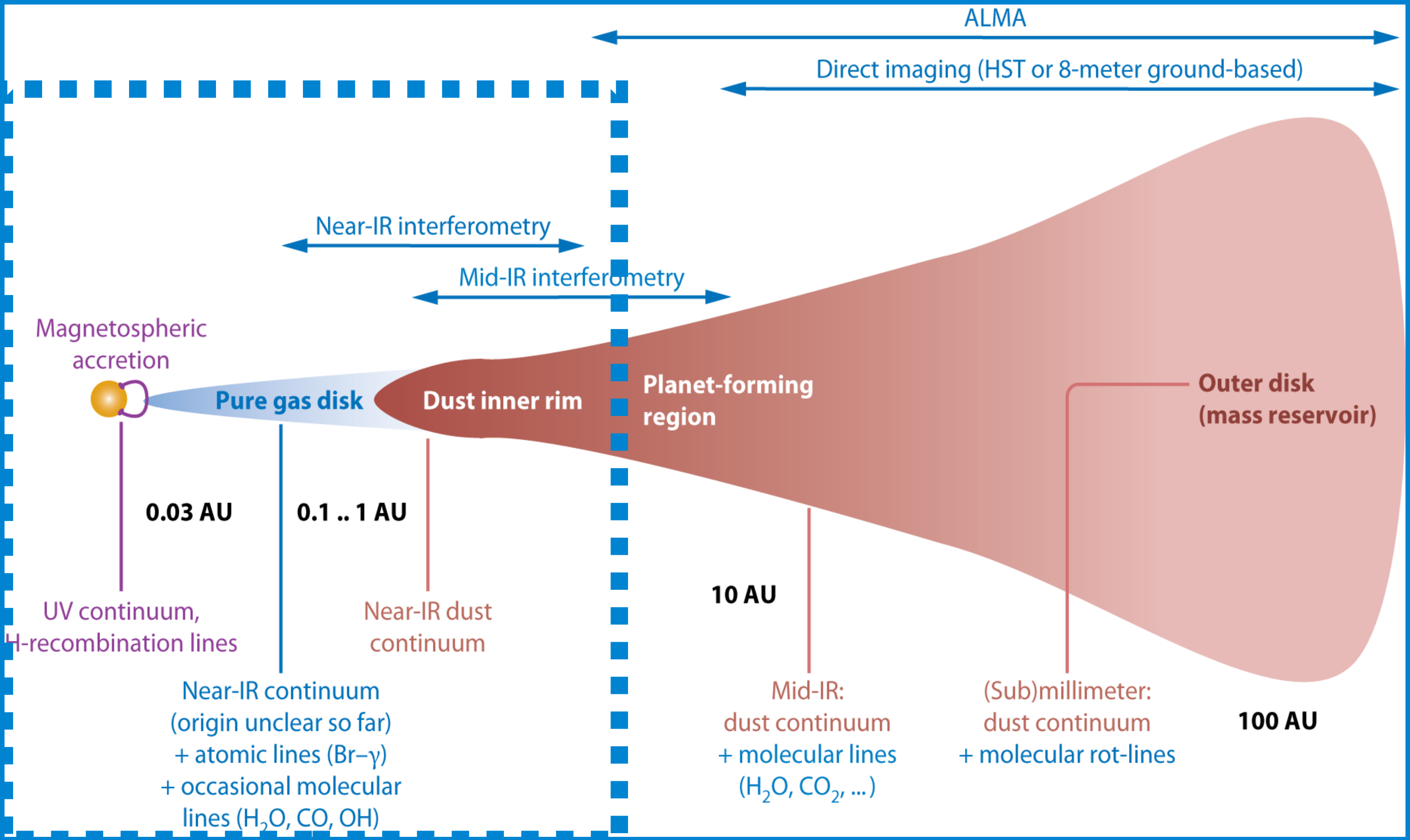
Probe the accretion/ejection region.
Constrain disk dynamics and obtain accurate stellar masses.
Constrain the morphology of the dust sublimation front.
Correlate our results with the stellar-disk properties.



Questions we would like to address

Line studies (e.g. Brγ, CO, H_2): Jet origin, accretion/ejection connection, line variability, disk kinematics

Continuum/dust studies: rim morphology, disk structure (differentiate thermal emission from scattered light -Tds-, disk imaging)



[Dullemond et al. 2010]

A proposal to extend the circumstellar regions and phenomena probed by GRAVITY through high resolution spectroscopy with GIANO

- More than 100 GTO targets can be observed with the TNG. The sample spans a large range of ages (from Class I to T-Tauri and Herbig Ae/Be stars) and masses (low-mass stars to High Mass Young Stellar Objects);
- UV plane sampling sparse, interferometry misses information → high resolution spectroscopy+line modelling to recover information; reverse true for high-resolution emission lines with no other information, model degeneracy.
- The broad-band and high-resolution capability of GIANO would allow using a large number of different lines (HI, HeI, CO,...) to probe circumstellar regions that will not be seen by GRAVITY;
- More distant targets will be less resolved spatially, but still resolved spectroscopically with GIANO;
- The programme would last 2 years (30 to 50 hrs/semester) and would allow studying the spectroscopic variability of YSOs on typical timescales of weeks to years (accretion/ejection variations, warped disk eclipsing, disk instabilities, interactions with close companions …);
- High resolution broad-band spectroscopy and high spatial resolution observations complement each other!

A proposal to extend the circumstellar regions and phenomena probed by GRAVITY through high resolution spectroscopy with GIANO

Other points we intend to address:

- Where is the jet launching region located (disk wind, X wind …)?
- What triggers accretion variations?
- Intermediate mass stars (Herbig Ae/Be) do not have an outer convection layer and are not expected to host surface magnetic fields. How does the circumstellar structure change, if it does?
- Does the accretion scenario applies to high-mass stars as well?

The programme would largely exploit the experience gained through the Arcetri GTO on YSOs with AMBER/VLTI (218 AT hours in 2007/2010, limited to few bright objects) and the development of the spectrometer GIANO