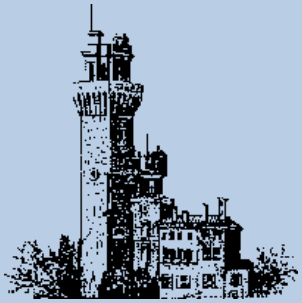

High precision radial velocities: the case for NIR

Ilaria Carleo & Raffaele Gratton

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Up to now

- Up-to-now 592 planets have been discovered using RVs
- All of them have been discovered using instruments working in the visible
- The most successful instruments (HARPS-HARPS-N and HIRES) achieve 0.3 m/s precision
- NIR instruments are well behind: better instruments achieve ~10 m/s accuracy
- Less RV signal, lack of spectral coverage and of accurate wavelength reference

HARPS-N vs GIANO

- Two instruments at the same telescope
- HARPS-N is an instrument fully optimized for RVs ➔ internal errors of ~0.3 m/s in best cases
- GIANO has currently several limitations (low fiber efficiency, unstable slit illumination, lack of an accurate wavelength reference) ➔ internal errors of ~10 m/s in best cases

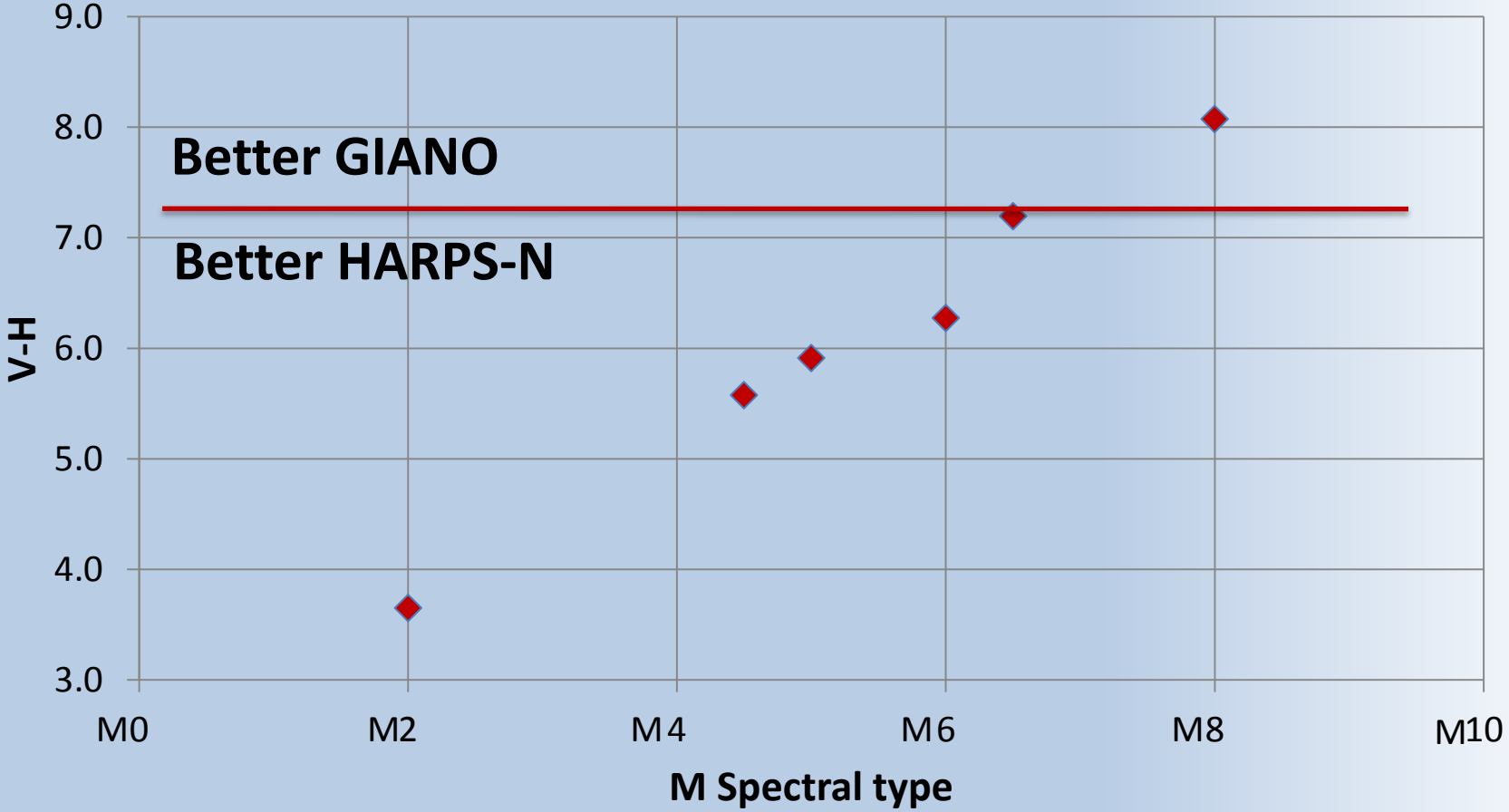
Still there are niches for GIANO

- Approximate error HARPS-N
  - Err(km/s) = $10^{0.2\ V-4.5}$
- Approximate error Giano
  - Err(km/s) = $10^{0.2\ H-3.05}$

➔ GIANO is better then HARPS-N for stars:

- with (V-H)>7.25 (later than M6.5)

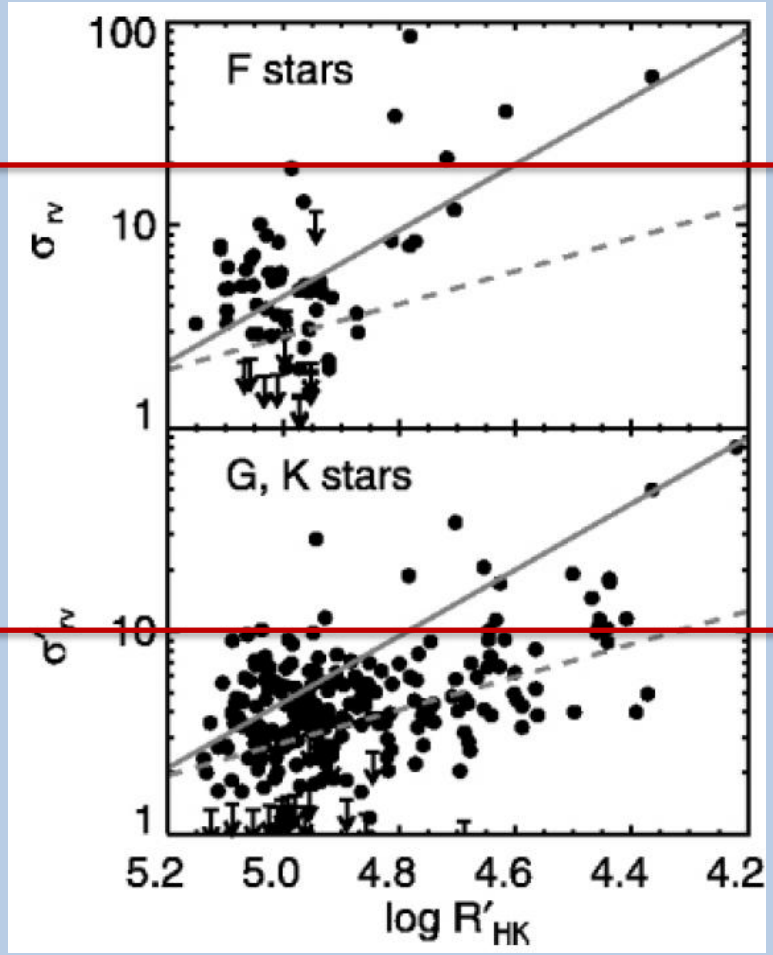
V-H colour vs spectral type



Comparison HARPS-N vs GIANO
Bright active stars

Better GIANO

Better HARPS-N

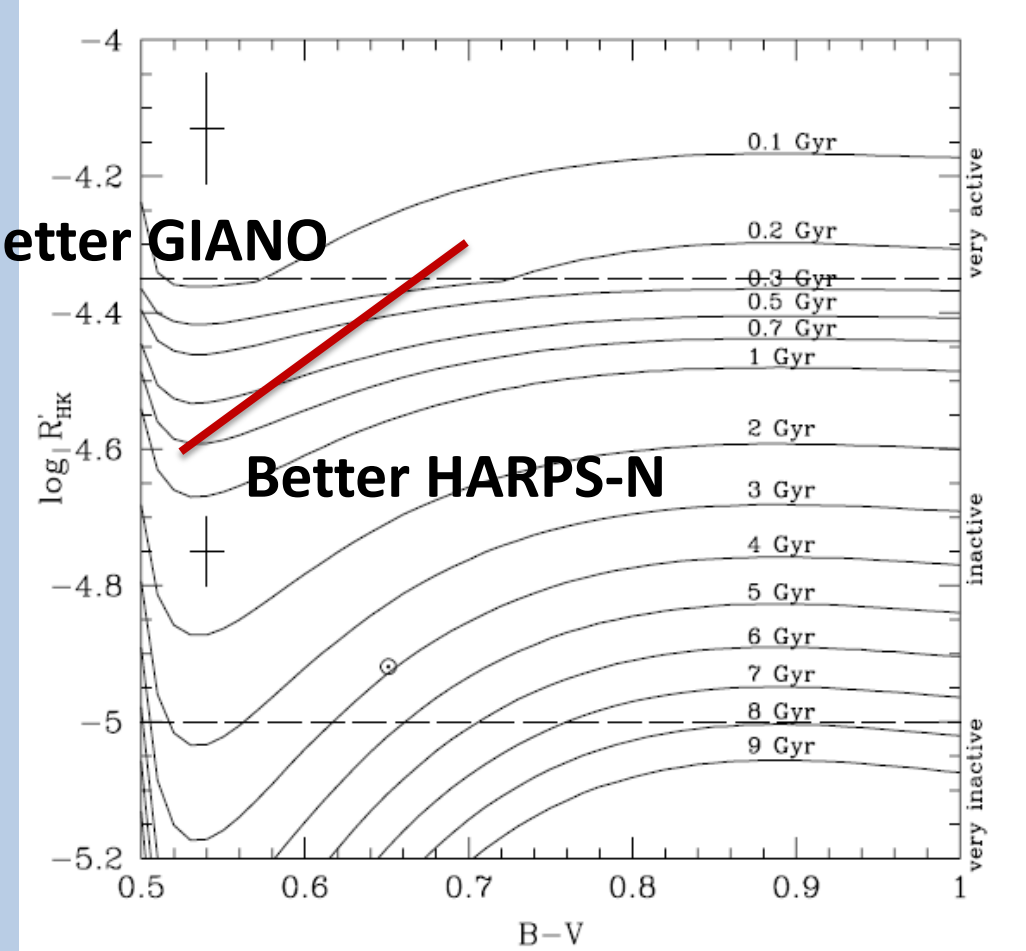


Better GIANO

Better HARPS-N

Data from
Wright 2005

Activity vs Age
➔ bright young F-G stars



Data from Mamajek & Hillebrand 2008

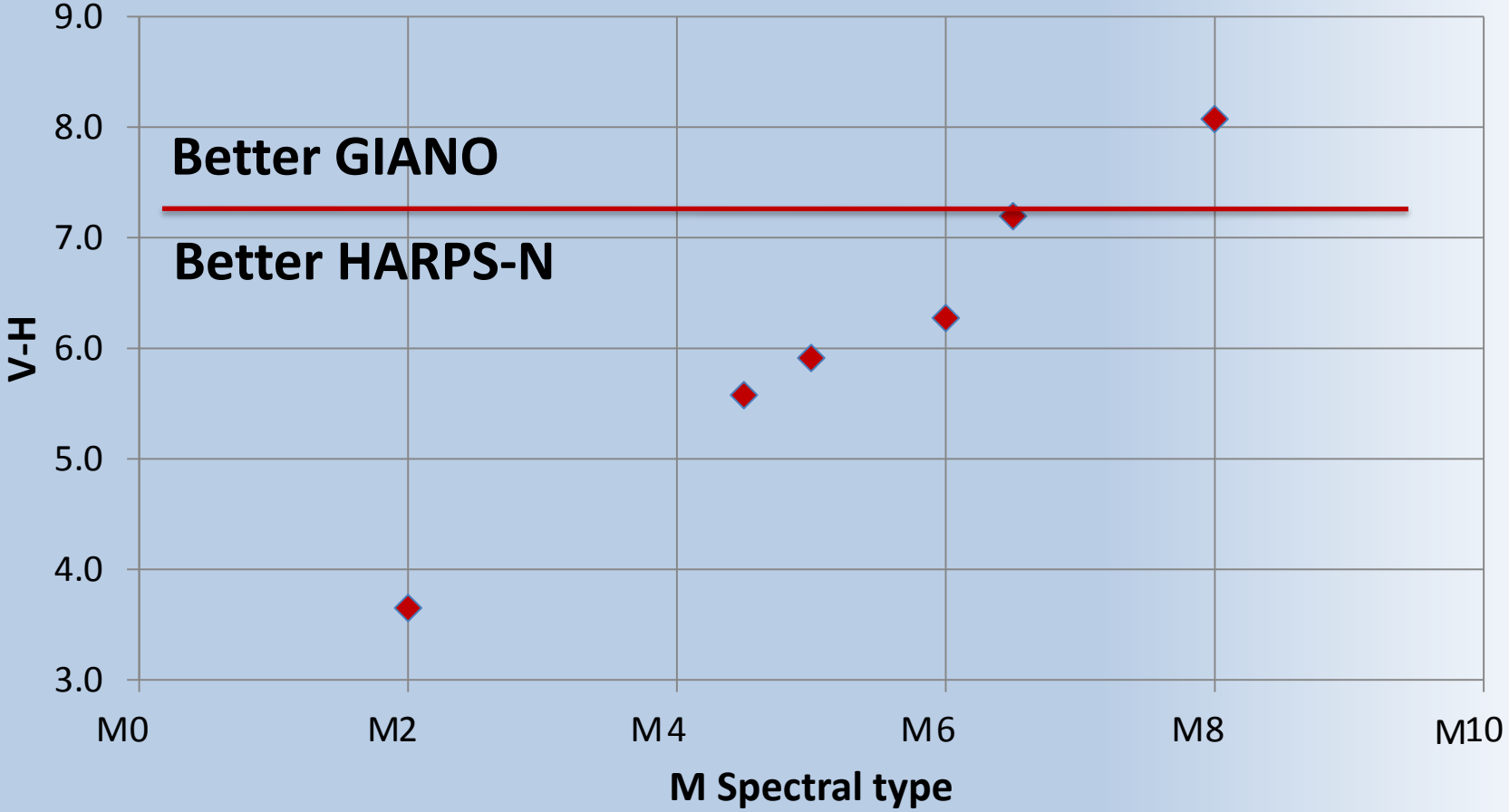
GIARPS

- GIARPS (Claudi et al.) is the new common feeding for HARPS-N and GIANO
- GIANO will be fed by a train of optics rather fibers
  - Higher efficiency
  - Elimination of modal noise
  - Stable slit illumination with a closed loop active tip/tilt mirror
  - Insertion of an ammonia cell for H and K bands
- Funded by WOW; should be ready at mid-2016

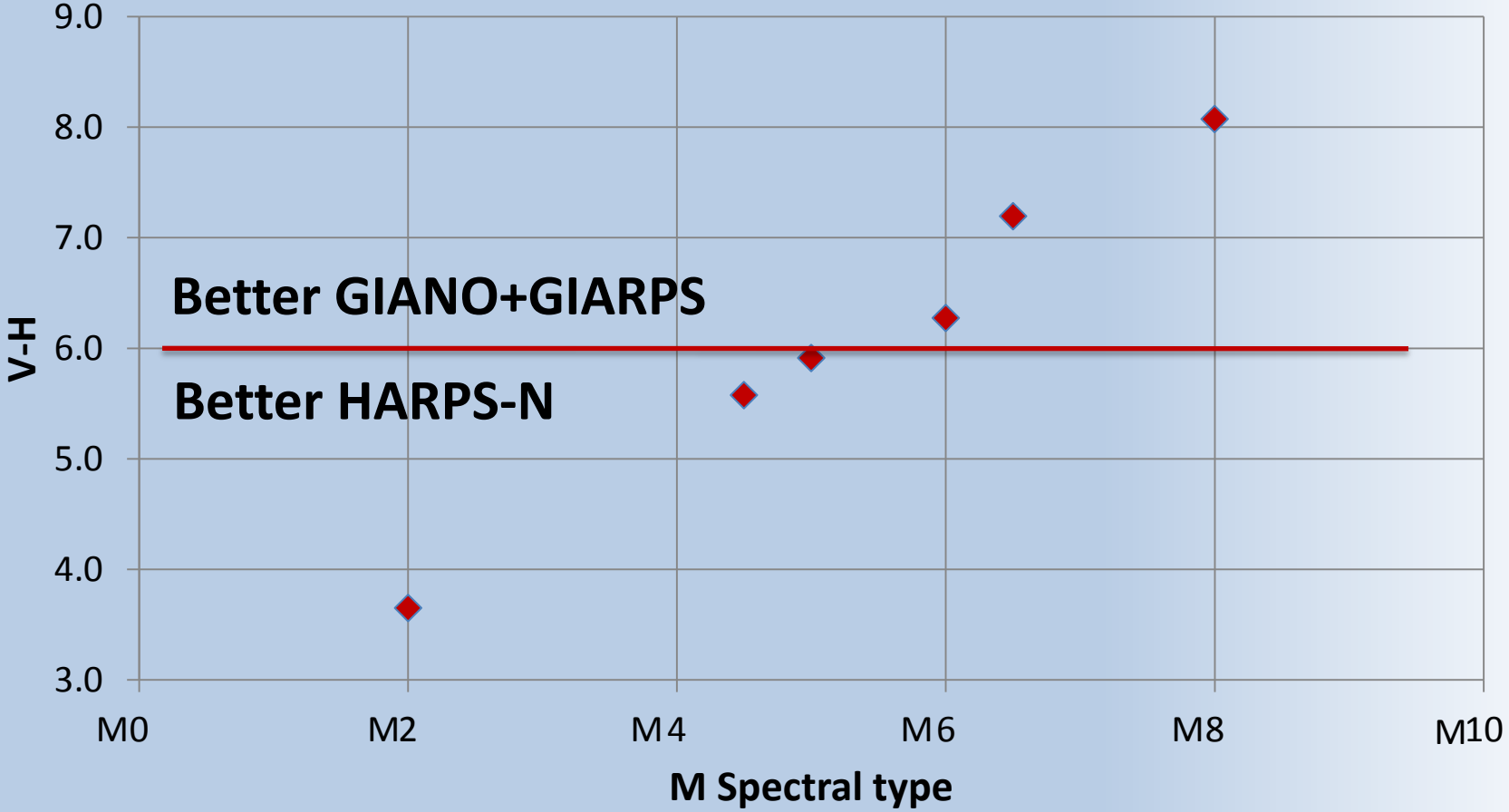
GIARPS makes GIANO a much better RV instrument

- Internal error should be reduced because of the higher efficiency
- Systematic errors reduced by the stable slit illumination
- Expected accuracy with ammonia cell ~3 m/s in best cases
- With simultaneous use of VIS-NIR HR spectrographs, GIARPS will be a forerunner for HIRES

V-H colour vs spectral type



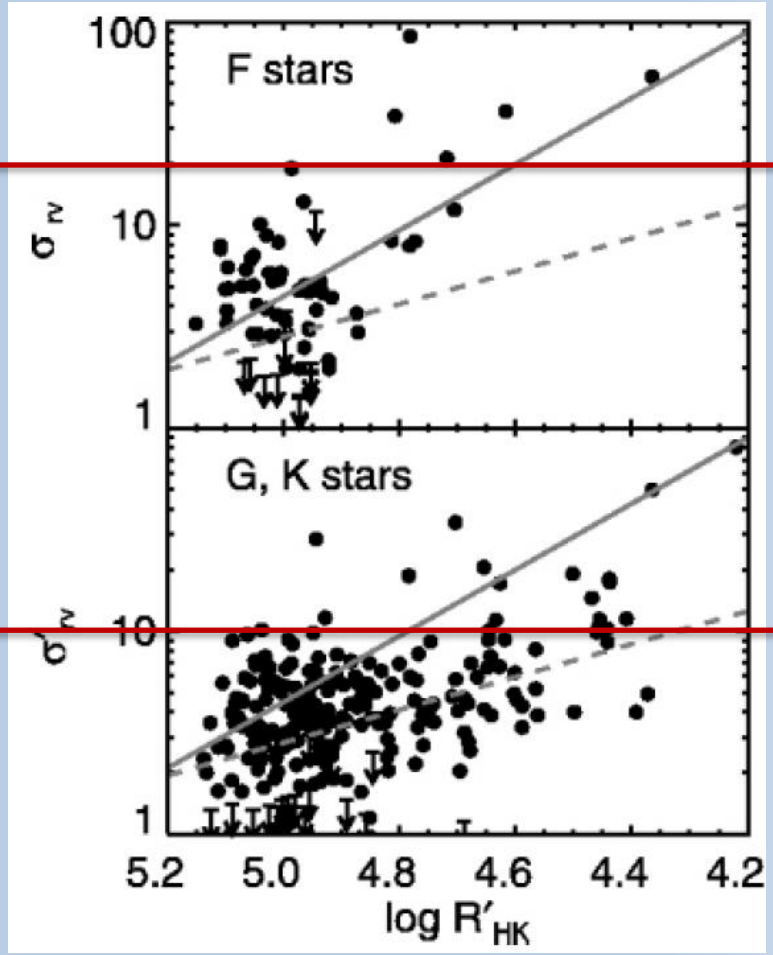
V-H colour vs spectral type



Comparison HARPS-N vs GIANO
Bright active stars

Better GIANO

Better HARPS-N



Better GIANO

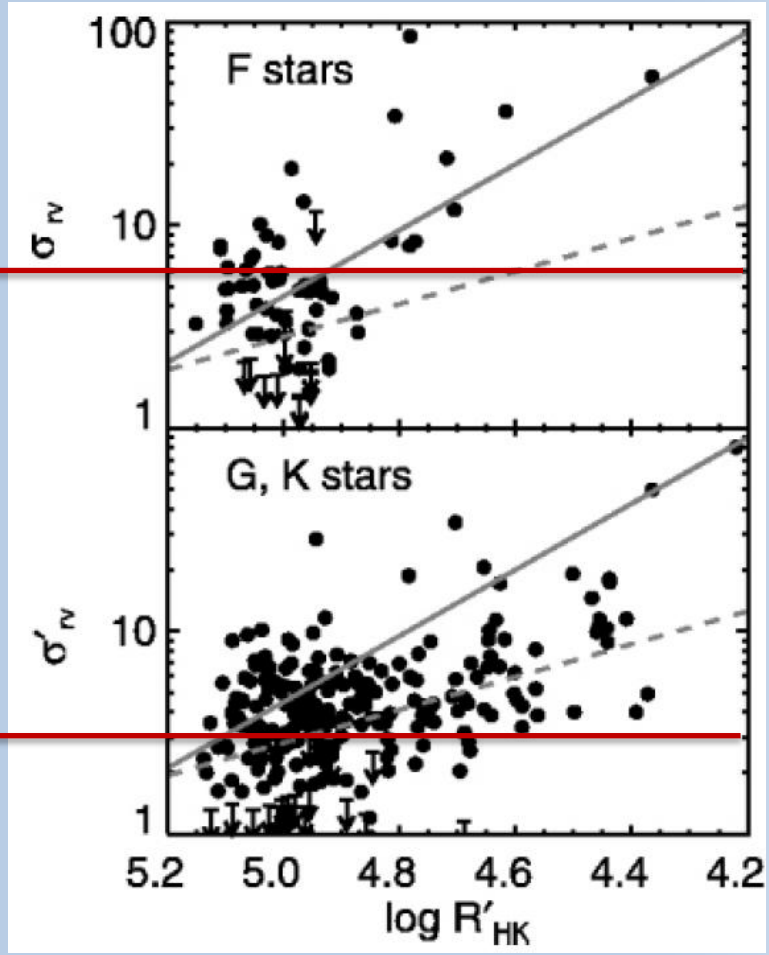
Better HARPS-N

Data from
Wright 2005

Comparison HARPS-N vs GIANO
Bright active stars

Better GIANO+GIARPS

Better HARPS-N

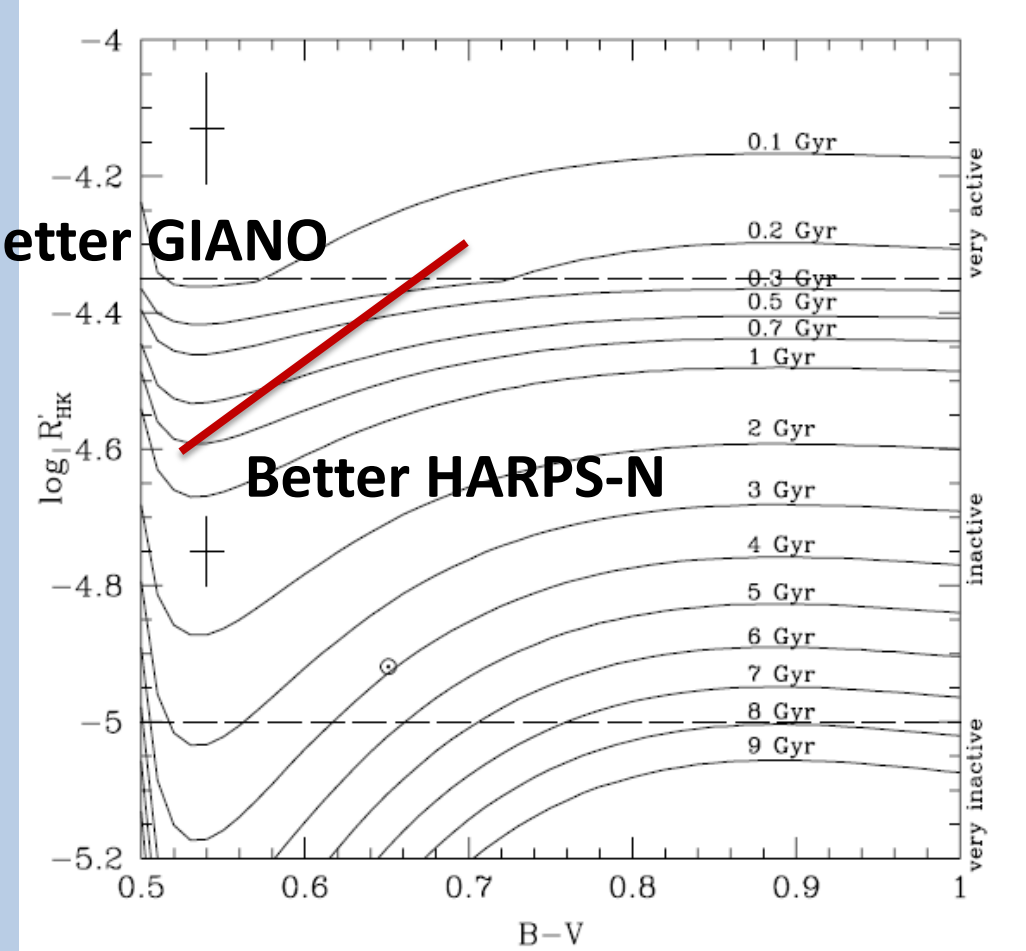


Better GIANO+GIARPS

Better HARPS-N

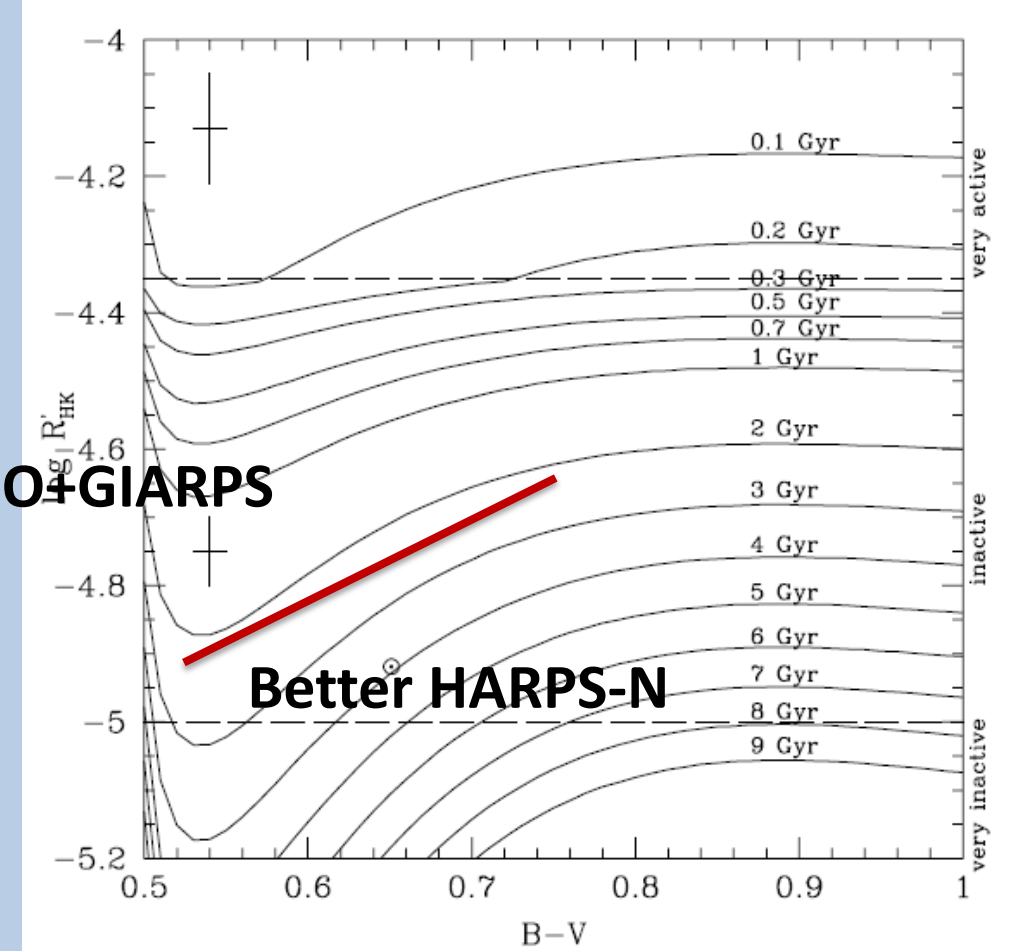
Data from
Wright 2005

Activity vs Age
➔ bright young F-G stars



Data from Mamajek & Hillebrand 2008

Activity vs Age
➔ bright young F-G stars



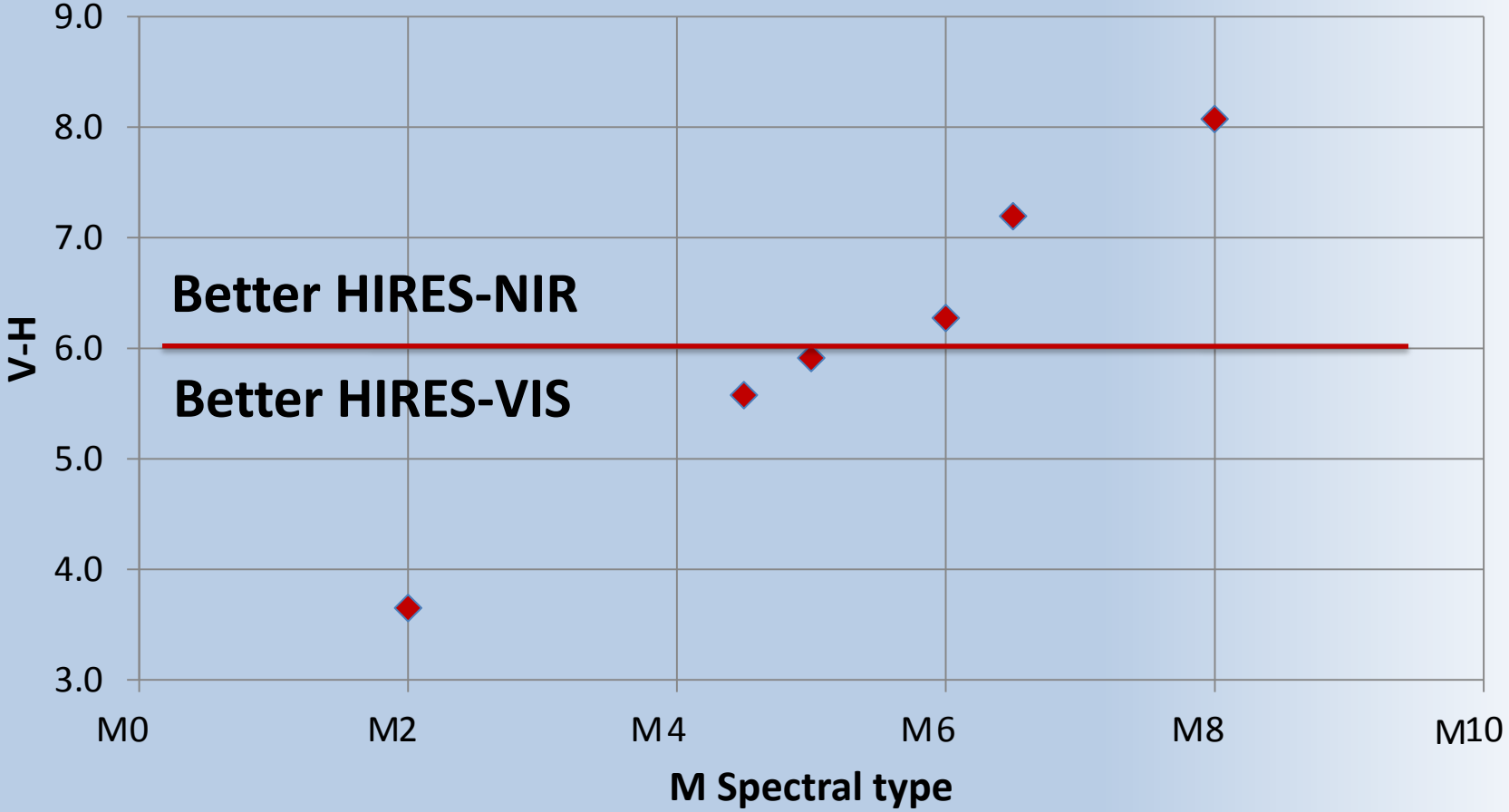
Data from Mamajek & Hillebrand 2008

HIRES-Vis vs HIRES-NIR

- Approximate photon noise error HIRES-Vis
  - Err(km/s) = $10^{0.2\ V-5.55}$
- Approximate photon noise error HIRES-NIR
  - Err(km/s) = $10^{0.2\ H-4.35}$

- ➔ HIRES-NIR is better then HIRES-Vis for stars:
  - with (V-H)>6 (later than M5)

V-H colour vs spectral type



However this only concerns internal errors

- Stellar RV jitter is ~1.5 m/s for good (inactive) targets
- For inactive stars, HARPS-N RV jitter dominates over photon noise for V<8.4
- It is expected to be the major source of noise for all HIRES targets with V<13.6 → e.g. all solar- type stars within 600 pc from the Sun
- Stellar RV jitter is expected to be about 1/3 in the NIR wrt to optical (Dumusque et al.)

Three regimes with HIRES

If a good reference (e.g. laser comb) will be available:

- For bright targets (~V<11), the lower jitter in the NIR implies that we need ~1/10 as many observations with HIRES-NIR than with HIRES-VIS to get similar confidence levels
- For very faint sources (~V>13), HIRES-VIS leads to more accurate results unless the source is very red
- For intermediate magnitudes, to be examined case-by-case (depends on activity/colour)

Conclusion

- For a wide range of cases, HIRES-NIR will be more efficient than HIRES-VIS for detection and characterization of planets using RVs
- This requires accurate wavelength reference for NIR
- GIARPS at TNG, simultaneously feeding HARPS-N and GIANO, is a very interesting forerunner for HIRES