

The B fields in OB stars (BOB) survey

A fresh view on He-strong stars



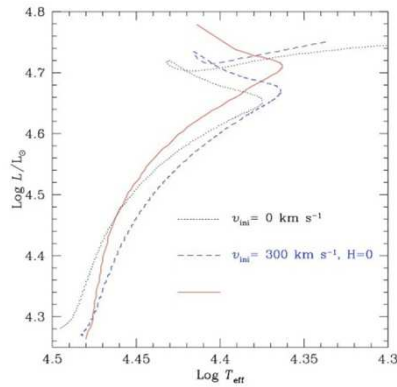
On behalf of the BOB collaboration:

Morel, T. (P.I.), Castro, N., Fossati, L., Hubrig, S., Langer, N., Schöller, M., Przybilla, N., González, J. F., Arlt, R., Barbá, R., Briquet, M., Carroll, T., de Koter, A., Dufton, P. L., Hamann, W.-R., Herrero, A., Ilyin, I., Irrgang, A., Kharchenko, N., Kholtygin, A., Maíz Apellaniz, J., Mathys, G., Nieva, M.-F., Oskinova, L., Piskunov, A., Reisenegger, A., Sana, H., Schneider, F., Scholz, R., Simon Díaz, S., Spruit, H., and Yoon, S.-C.

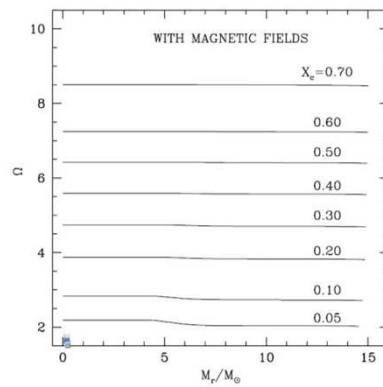
Institute for Astro- and Particle Physics



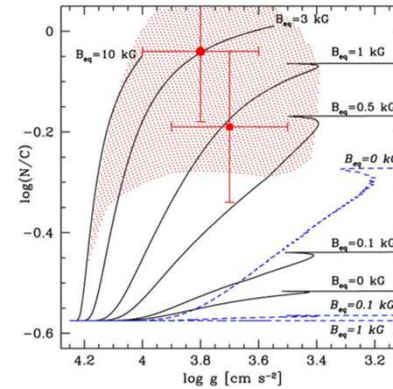
Effects of magnetic fields in massive stars



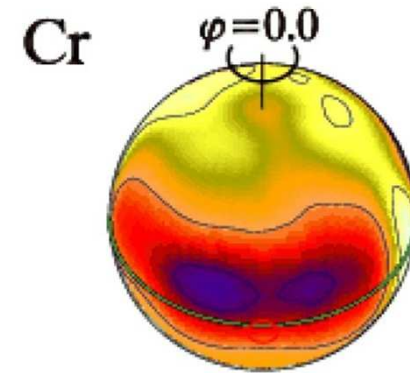
Evolution



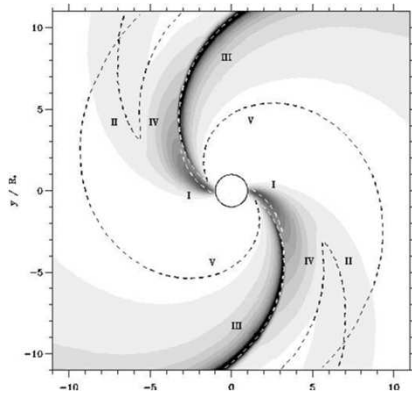
Magnetic braking
Rotational profile



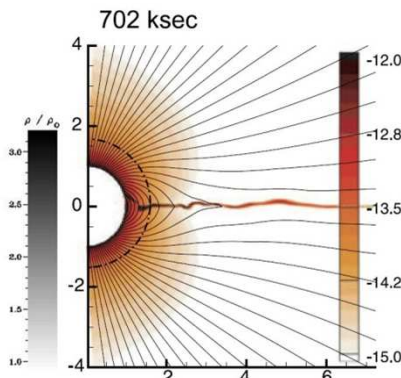
Internal mixing



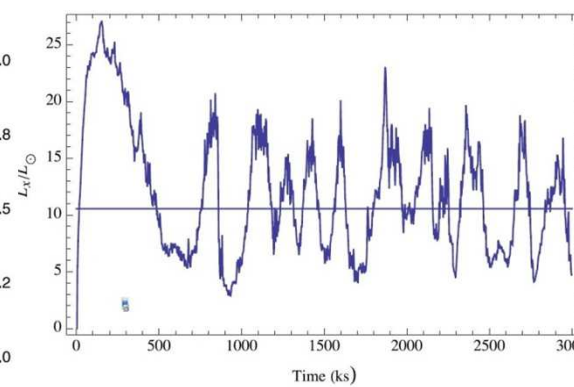
Inhomogeneous
surface abundances



Seed perturbations
for large-scale
wind structures



Channeling of
stellar wind



X-ray properties



End products
magnetars,
 γ ray bursts, ...

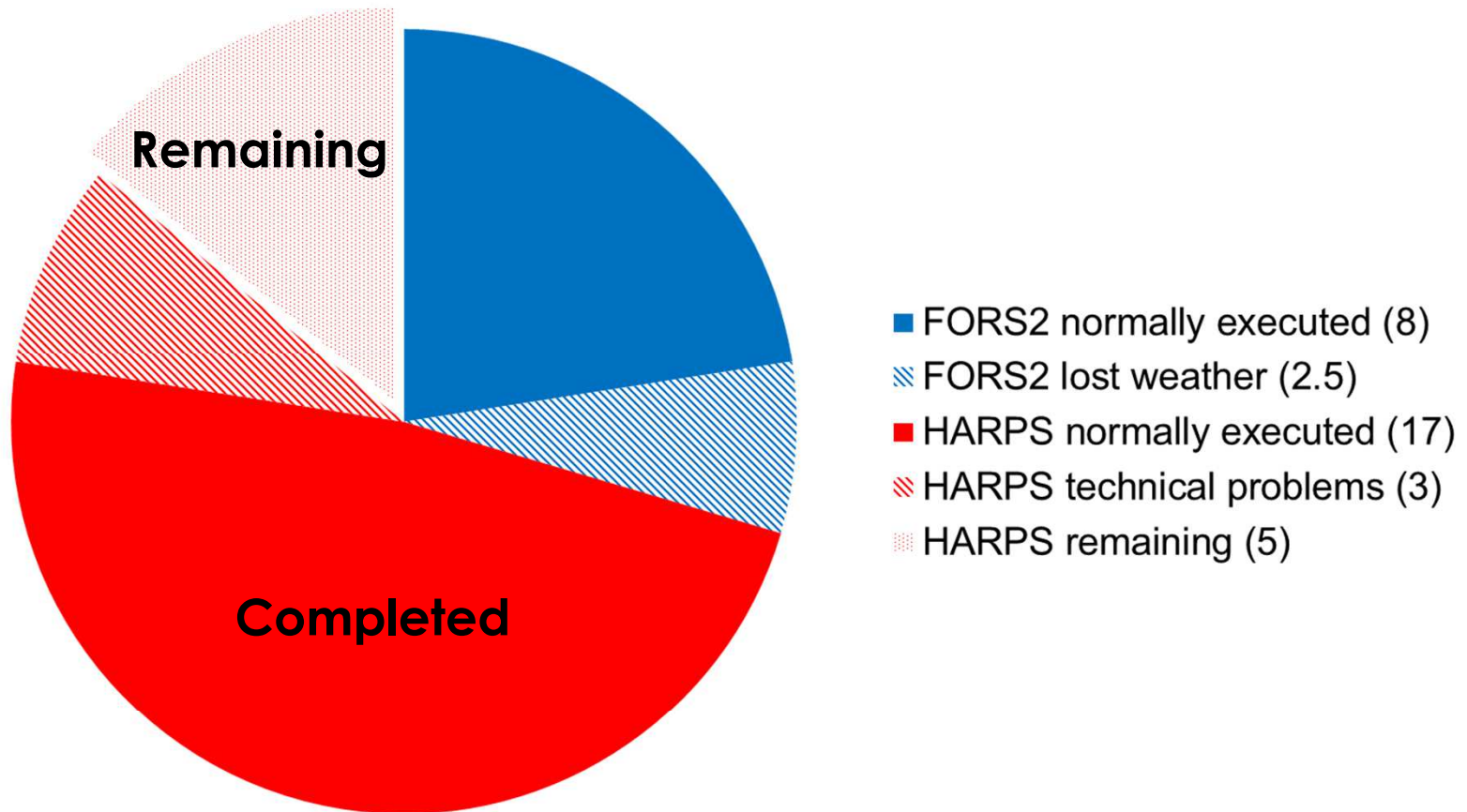
The B fields in OB stars (BOB) project



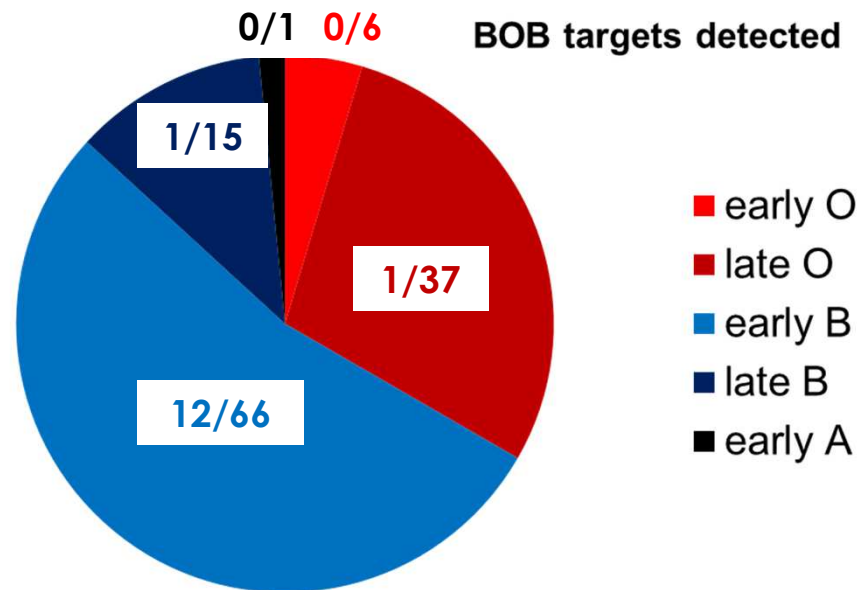
- a total of 35.5 nights allocated over two years (P93-P96) as an ESO Large Programme on FORS2 ($R\sim 2,000$) and HARPSpol ($R\sim 115,000$)
- survey biased towards slow rotators to enhance field detectability
- for both FORS2 and HARPS, data reduction and analysis carried out completely independently by two groups (Bonn and Potsdam)
- field detection considered as real only if highly significant ($>5\sigma$) for both groups

Breakdown of observations

35.5 nights awarded in total



Incidence rate of magnetic fields in OB stars



	MiMeS	BOB
Number stars surveyed	~525	125
Number first detections	~35	14
Detection rate	7±1%	~11%

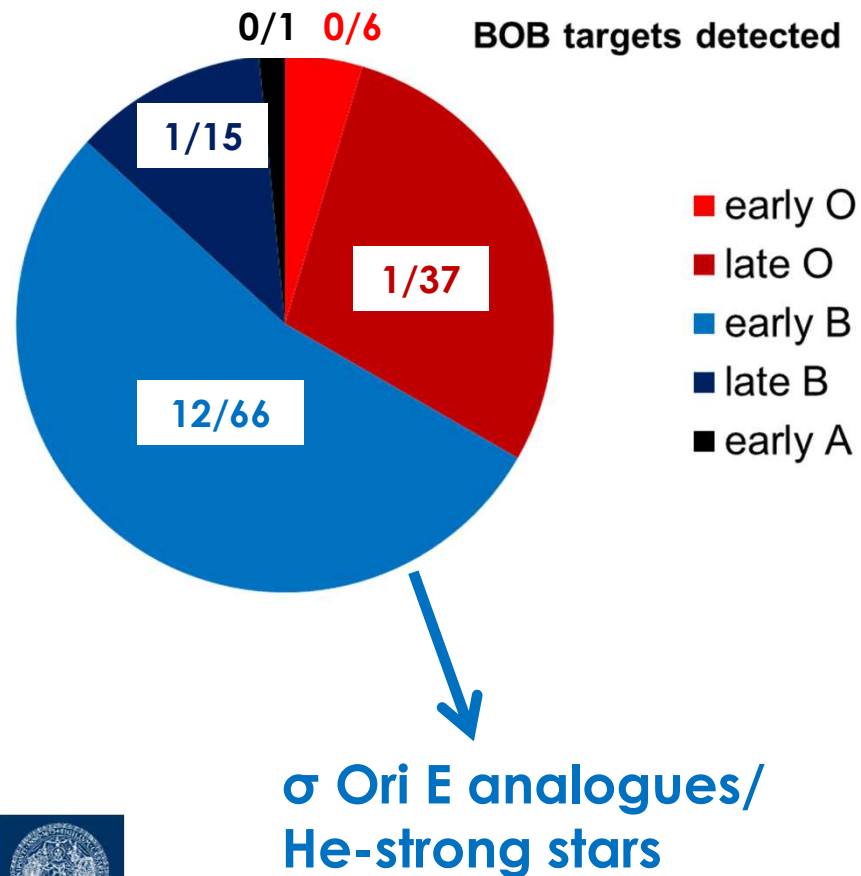


Figures not to be taken at face value:

A few BOB candidates still being followed up and analysis not fully completed

Selection effects of both surveys to be taken into account before comparison

Incidence rate of magnetic fields in OB stars



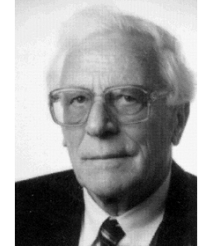
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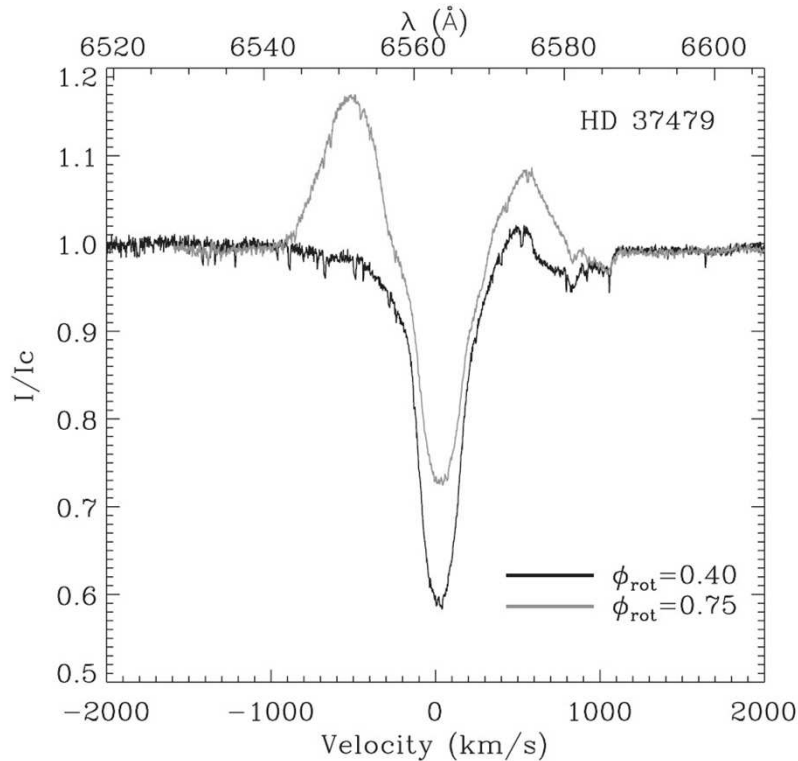
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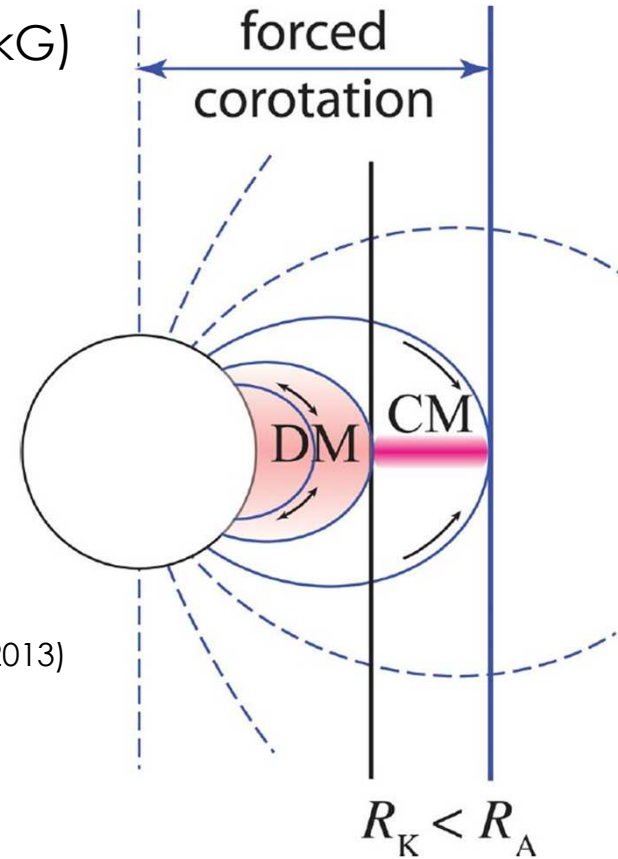


σ Ori E analogues/He-strong stars

- early B-type stars with strong fields ($B_d \sim 10$ kG)
- fast rotation ($P_{rot} \sim 1$ day or less)



Petit et al. (2013)

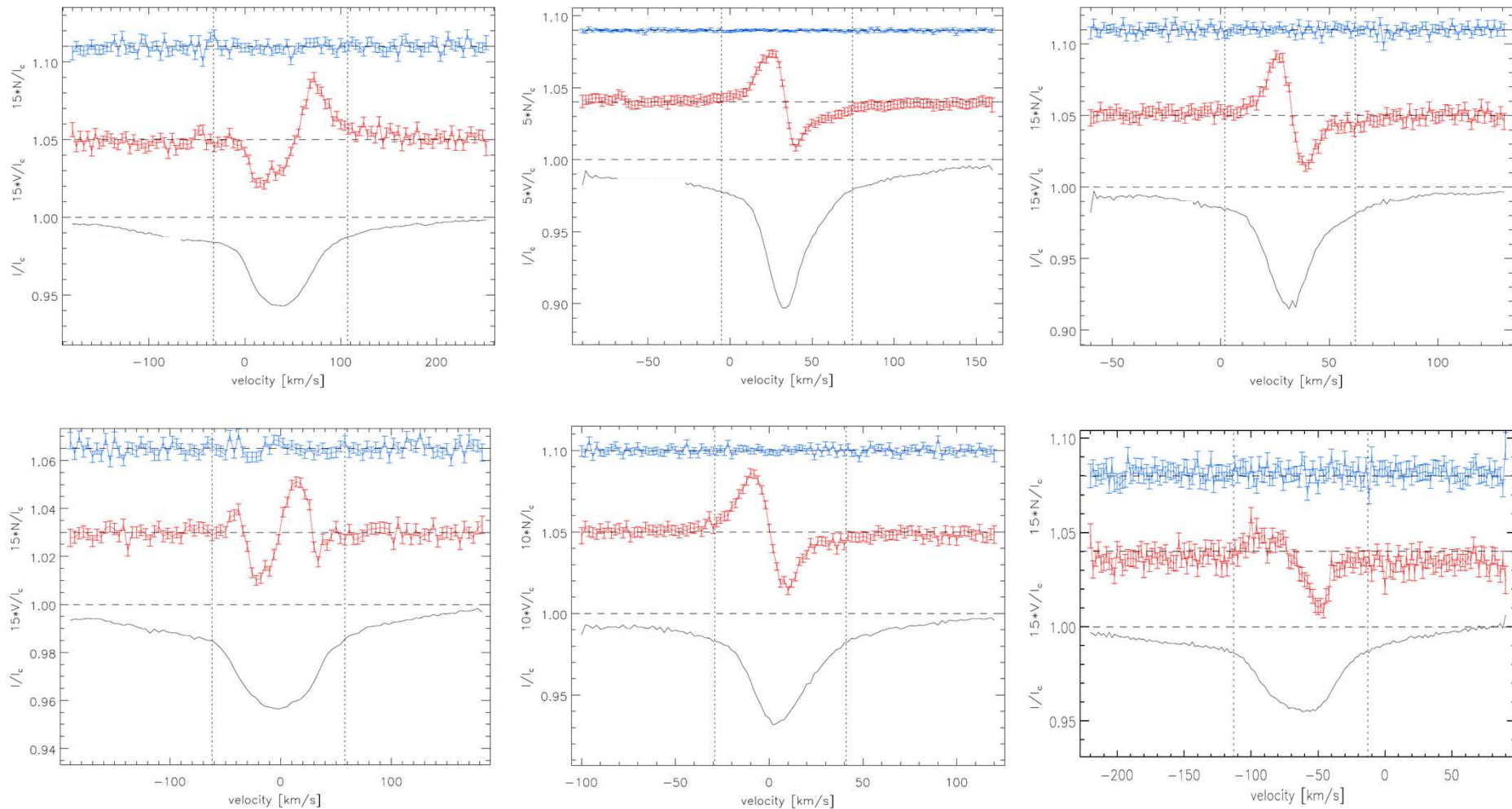


- centrifugal magnetosphere
- in T_{eff} -range $\sim 18,000$ - $25,000$ K: **He-strong stars**

- He enrichment / spots
- rare class of objects ~ 30 known



Magnetic field detections in He-strong stars



- Bonn group: LSD analysis Potsdam group: SVD/LSD analysis
- dipolar field strength: several kG to >16 kG

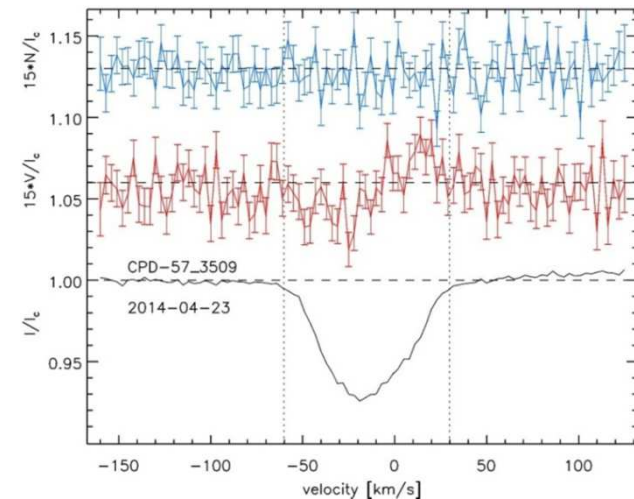
CPD -57° 3509: A He-strong star in NGC 3293

		FORS2 observations				
		Hydrogen lines		All lines		
		V	N	V	N	
No detection	06 02 2014	Bonn	-356±125	-361±126	-143±78	-39±78
		Potsdam	-287±126	-377±139	-23±60	-101±64
Detection	07 02 2014	Bonn	659±109	-120±97	710±58	68±56
		Potsdam	694±108	-116±104	539±51	1±48
No detection	01 06 2014	Bonn	-71±75	-53±75	40±46	-51±47
		Potsdam	-19±71	-28±86	87±54	-45±59
Detection	02 06 2014	Bonn	1050±93	-85±61	943±43	2±39
		Potsdam	979±68	-108±77	920±48	2±50
	17 03 2015	Bonn	607±110	0±110	734±64	9±64
		Potsdam	582±99	-75±101	671±62	-33±61

HARPS observations

ND: FAP > 10⁻³ MD: 10⁻⁵ < FAP < 10⁻³ DD: FAP < 10⁻⁵

		V	N		
23 04 2014	Bonn	-557±73	DD	76±72	ND
	Potsdam	-492±78	DD	-59±59	ND



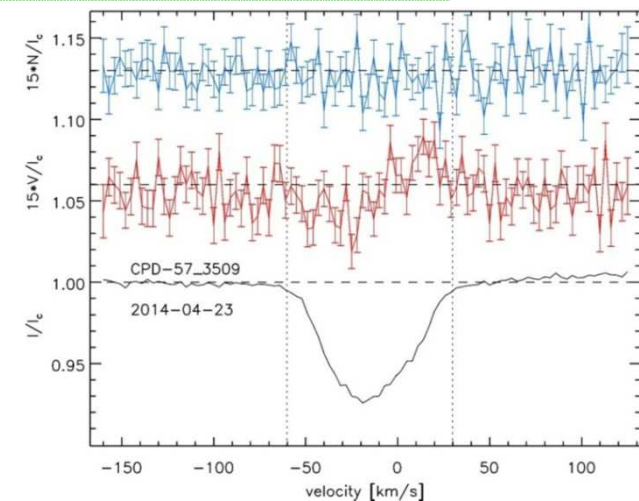
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Strong, daily variations of the field

HARPS observations
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CPD -57° 3509: A He-strong star in NGC 3293

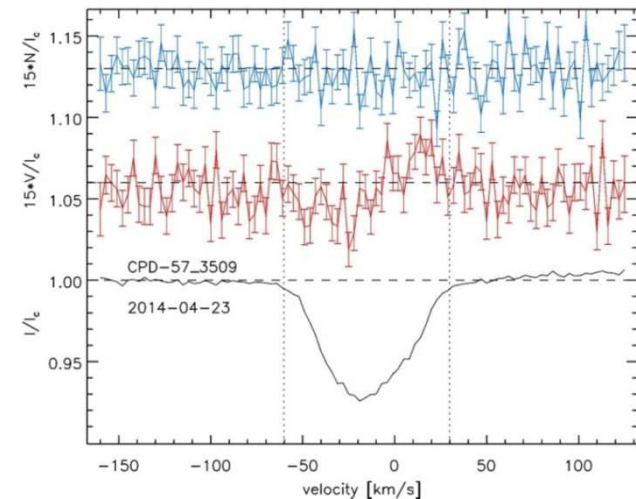
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			V	N	V	N
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No detection	01 06 2014	Bonn	-71±75	-120±97	-	-
		Potsdam	-19±71	-120±97	-	-
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		Potsdam	582±99	-75±101	671±62	-33±61

High consistency of measurements

HARPS observations

ND: FAP > 10⁻³ MD: 10⁻⁵ < FAP < 10⁻³ DD: FAP < 10⁻⁵

		V		N		
23 04 2014	Bonn	-557±73	DD	76±72	ND	
	Potsdam	-492±78	DD	-59±59	ND	



CPD -57° 3509: A He-strong star in NGC 3293

FORS2 observations

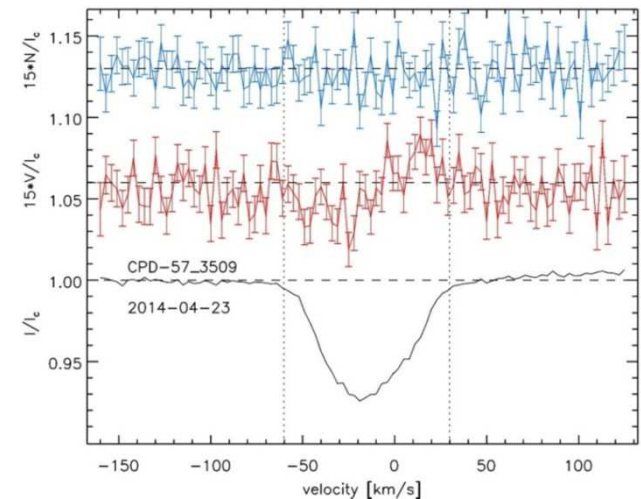
			Hydrogen lines		All lines	
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Dipolar field > 3.1 KG

HARPS observations

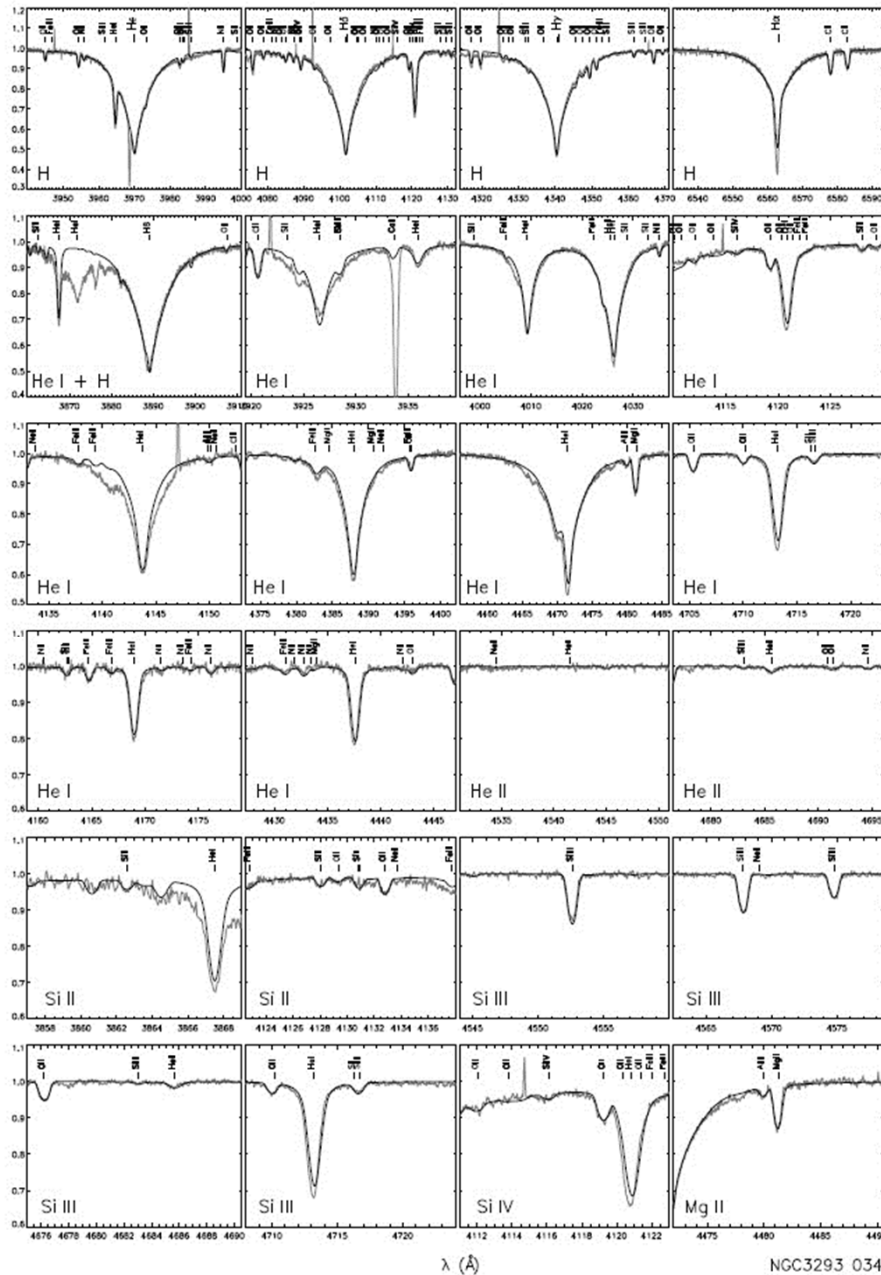
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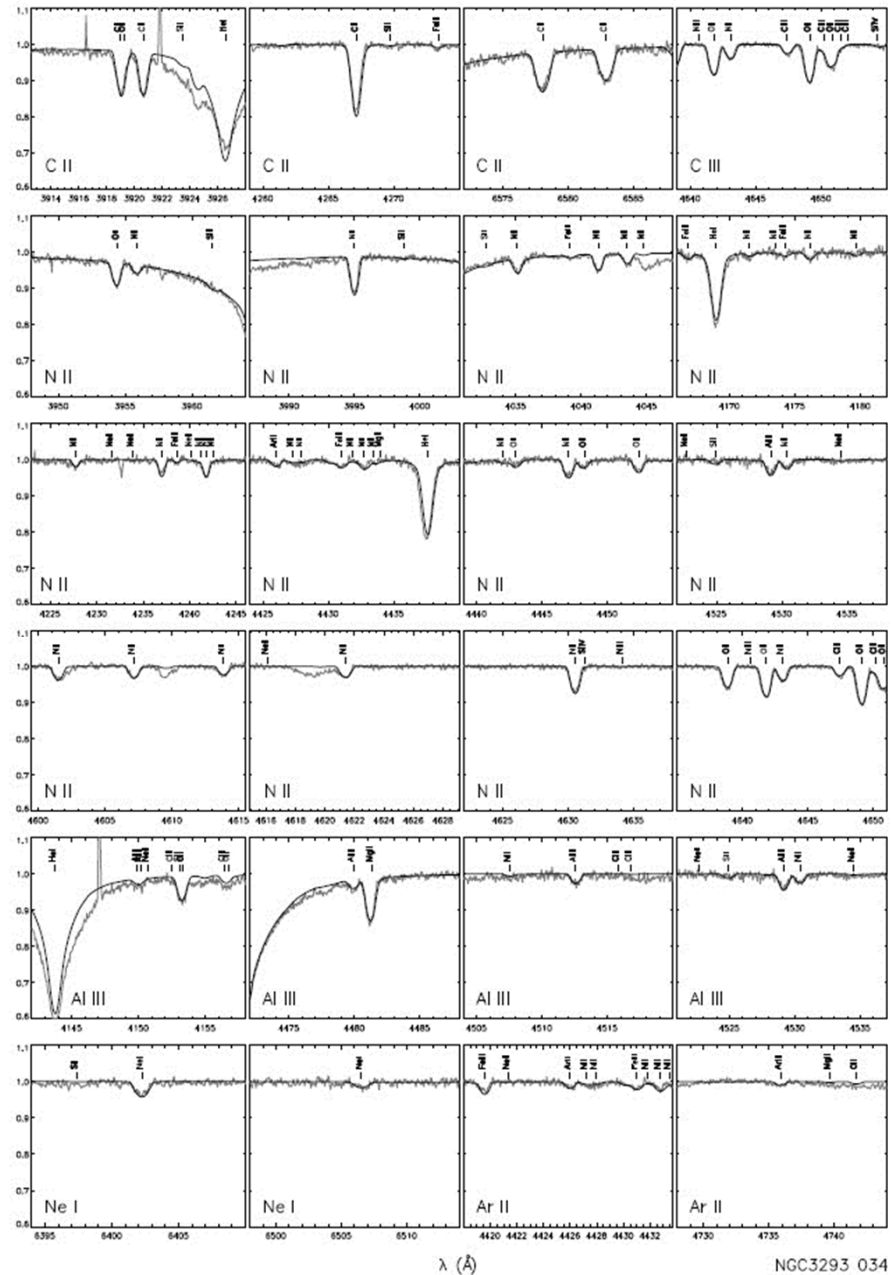
CPD -57° 3509: Quantitative Analysis

hybrid NLTE:
ATLAS/DETAIL/SURFACE



λ (Å)

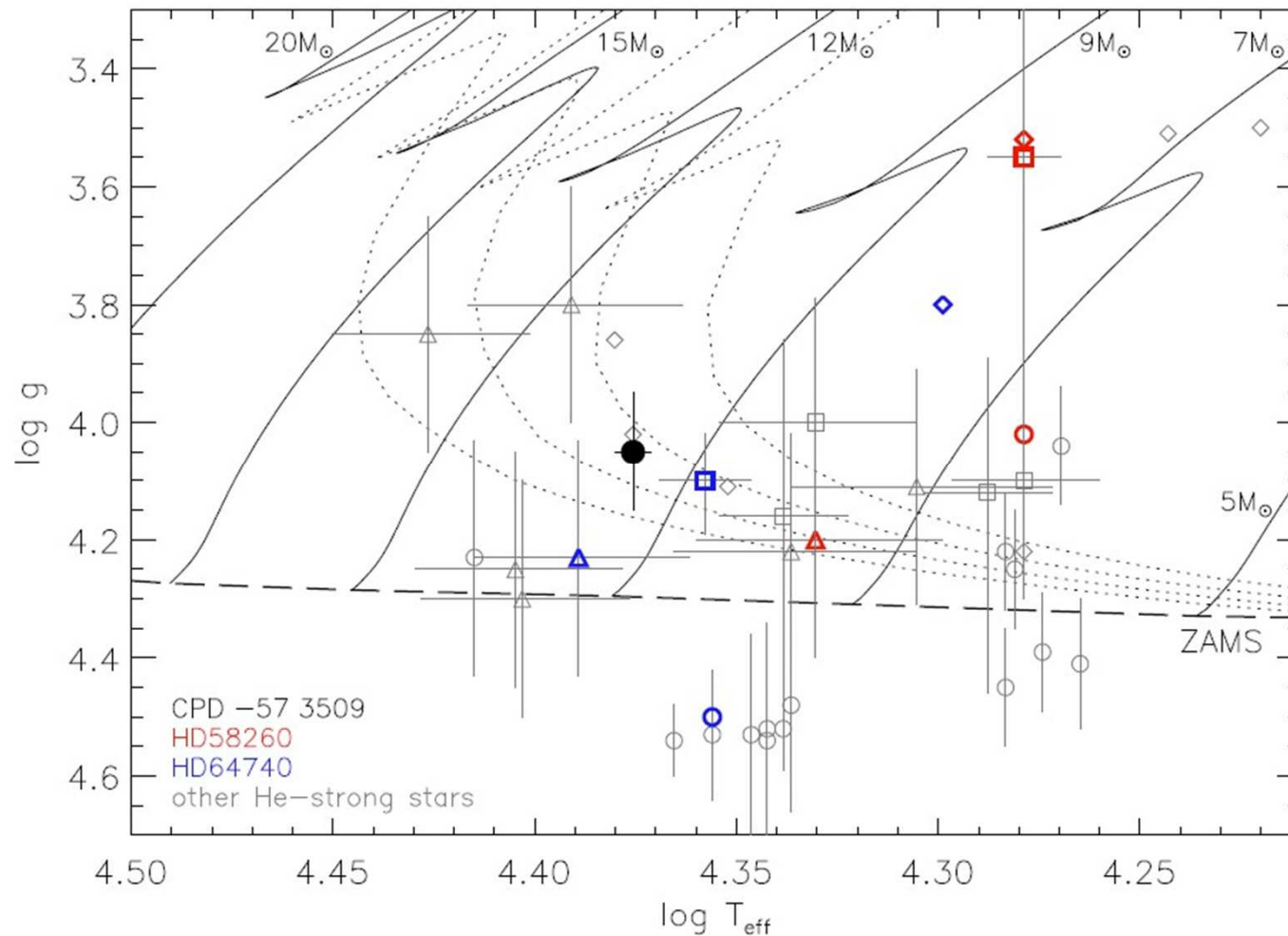
NGC3293_034



λ (Å)

NGC3293_034

CPD -57° 3509: Quantitative Analysis



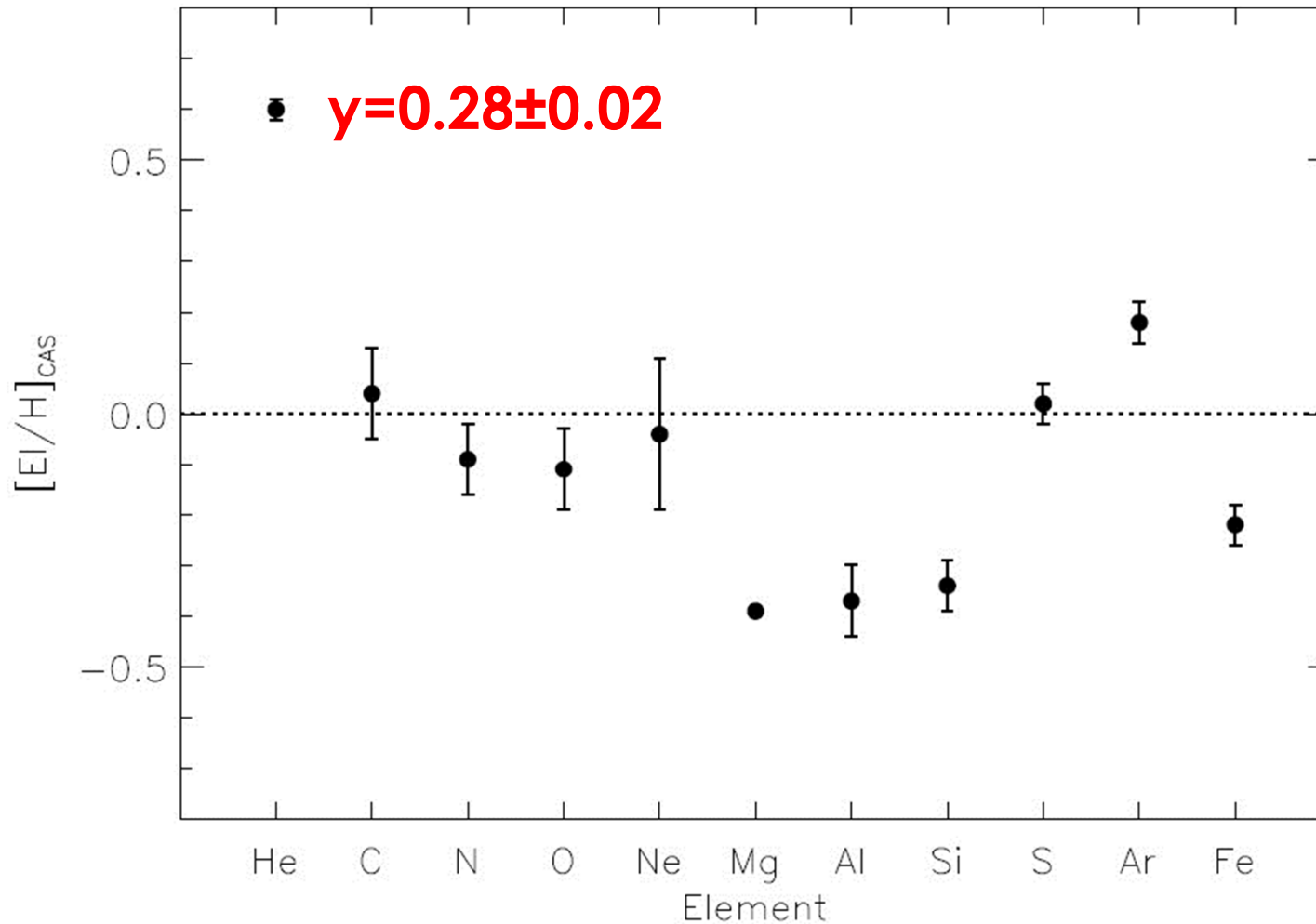
Tracks & Isochrones:
Ekström et al. (2012)

CPD -57° 3509:
half of MS lifetime
already spent

tight age constraint
because of
cluster membership

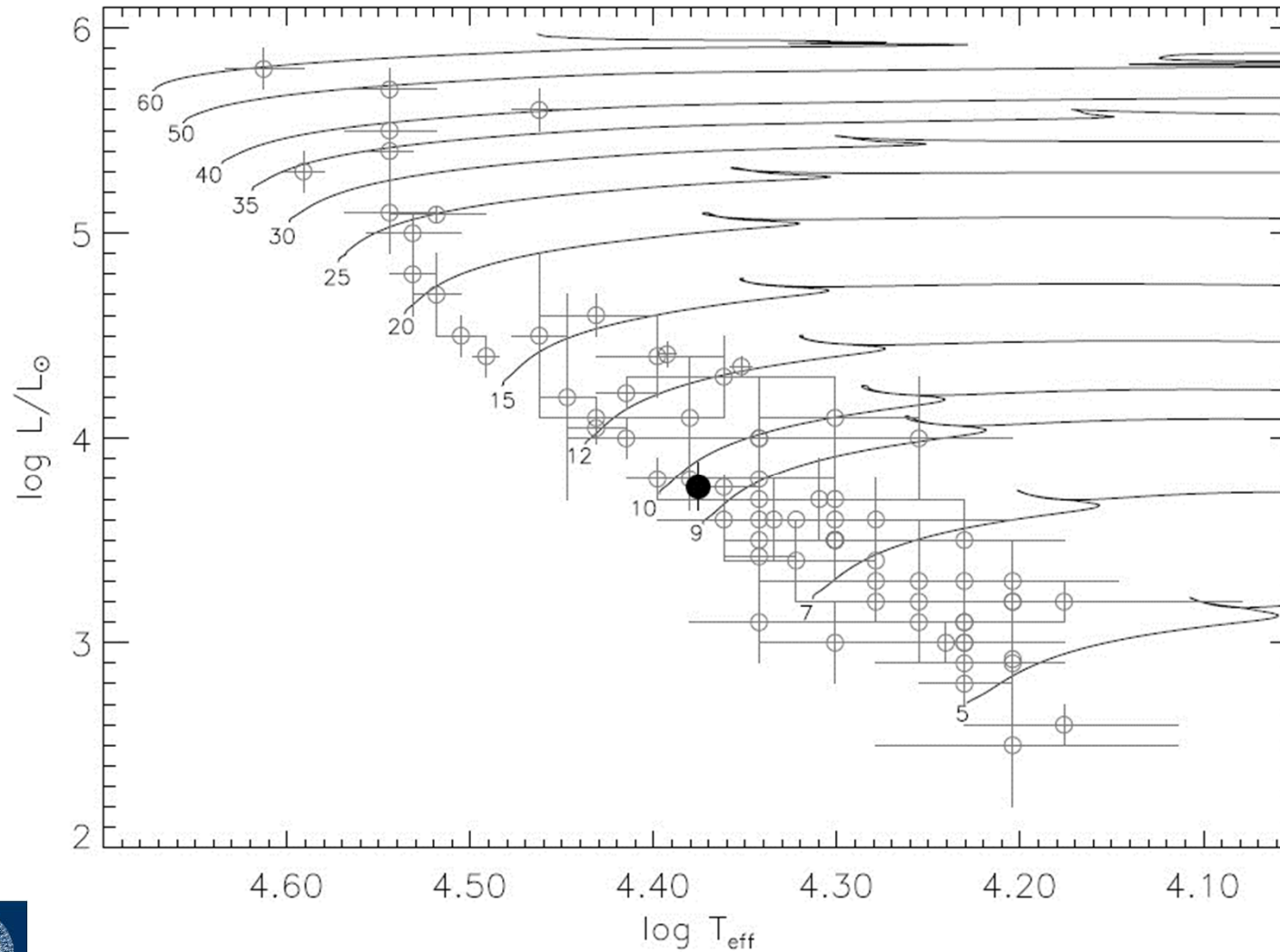
No consensus on atmospheric parameters of He-strongstars in literature:
Zboril et al. (1997); Leone et al. (1997); Hunger & Groote (1999); Cidale et al. (2007)

CPD -57° 3509: Quantitative Analysis



- first comprehensive NLTE abundance analysis
- abundance pattern because of fractionated stellar wind:
fall-back of neutral He

CPD -57° 3509: Quantitative Analysis

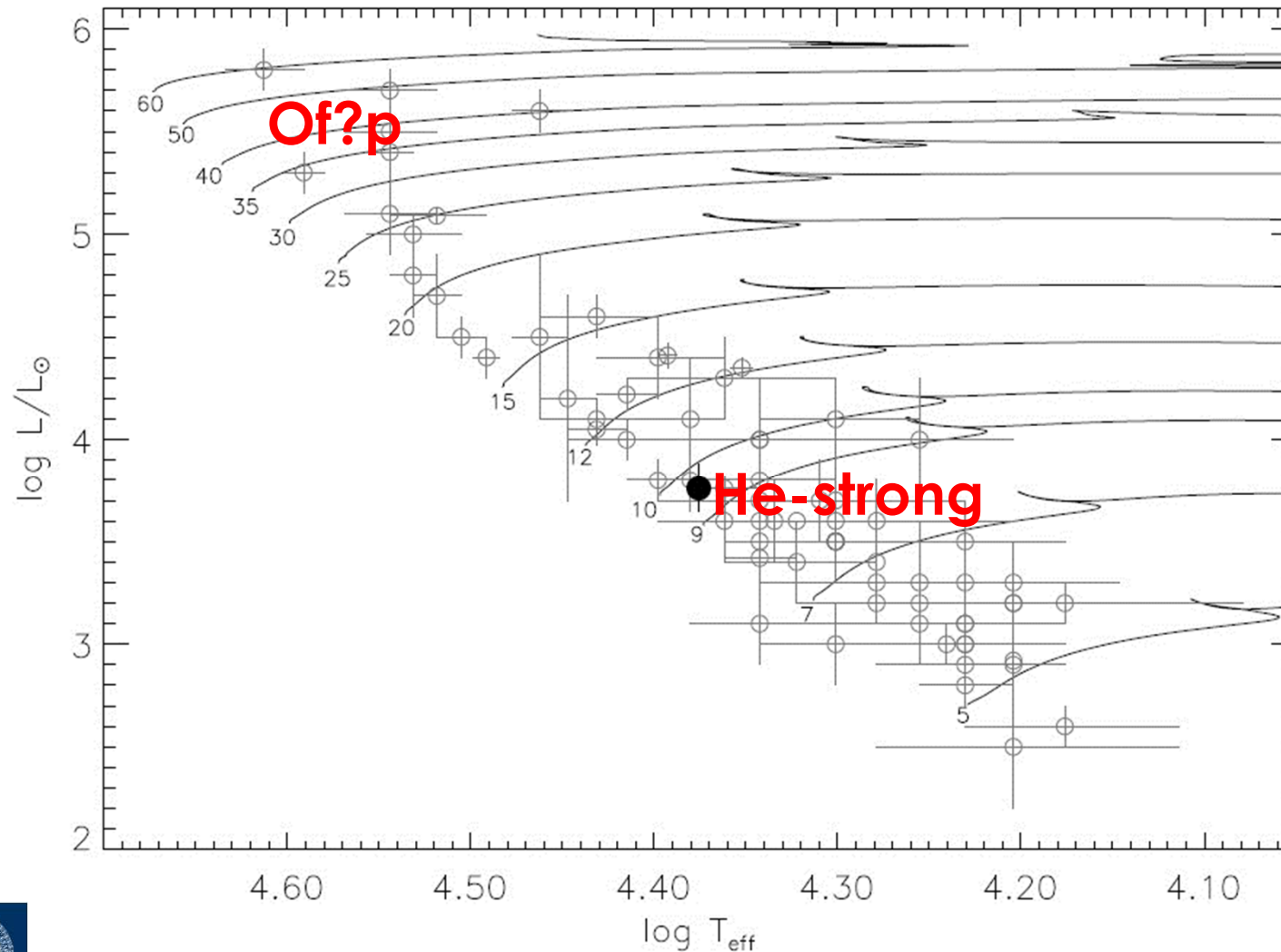


Tracks:
Brott et al. (2011)

**CPD -57° 3509:
luminosity known
from cluster distance**



CPD -57° 3509: Quantitative Analysis



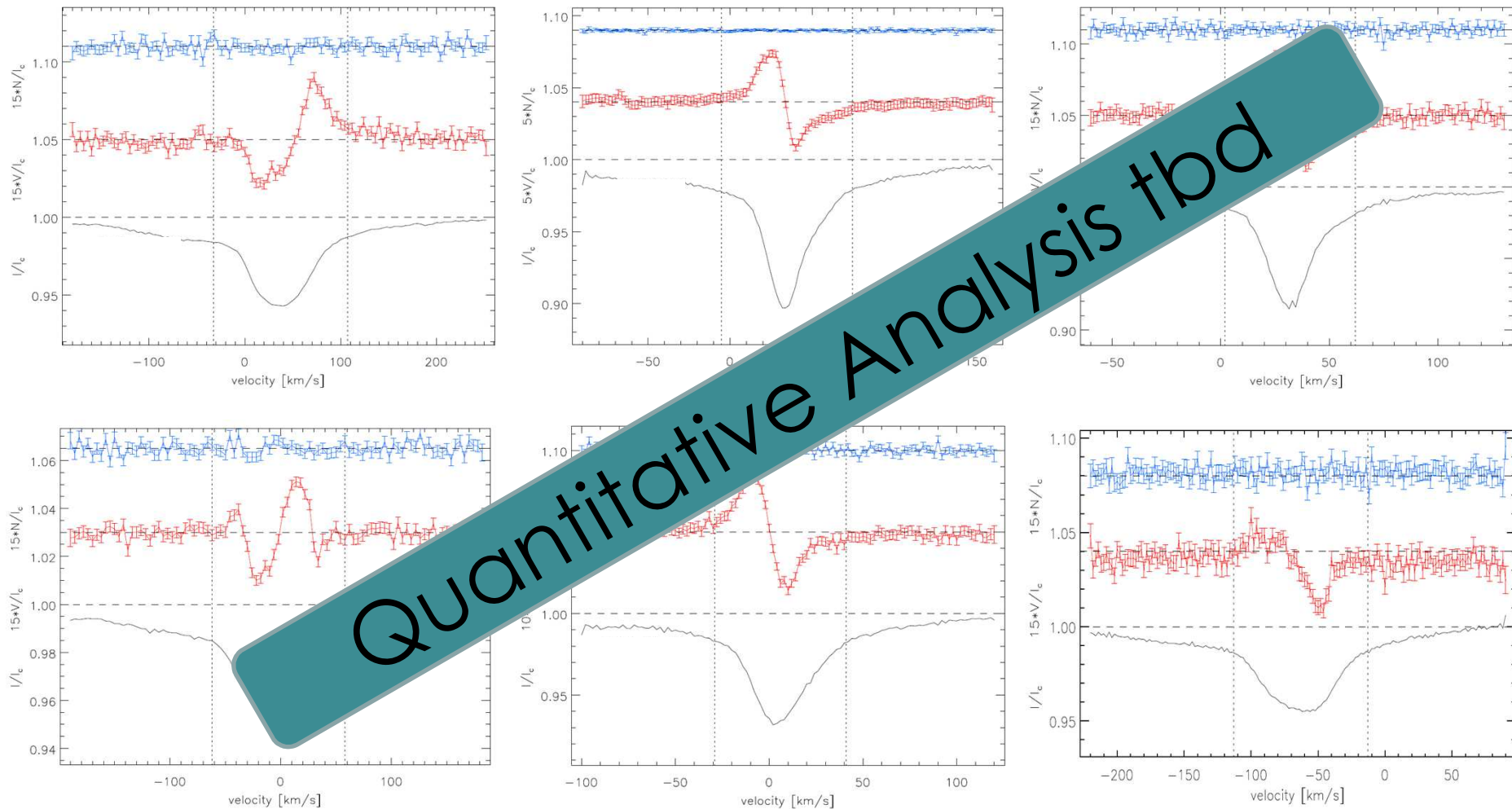
Tracks:
Brott et al. (2011)

CPD -57° 3509:
luminosity known
from cluster distance

- two classes of spectroscopically distinct magnetic stars among massive stars



Magnetic field detections in He-strong stars



- Bonn group: LSD analysis Potsdam group: SVD/LSD analysis
- dipolar field strength: several kG to >16 kG