High Contrast Imaging of Massive Stars

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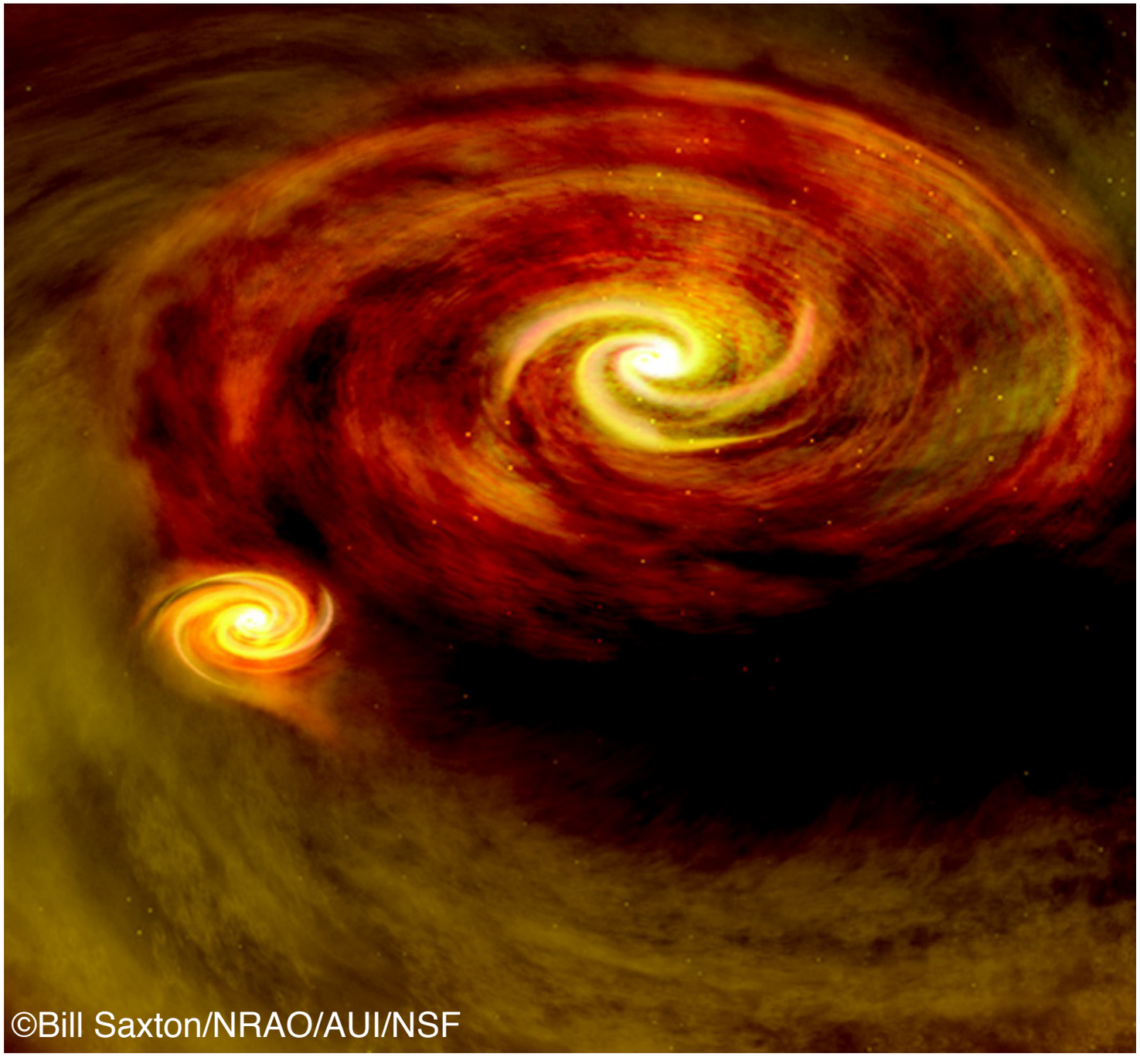
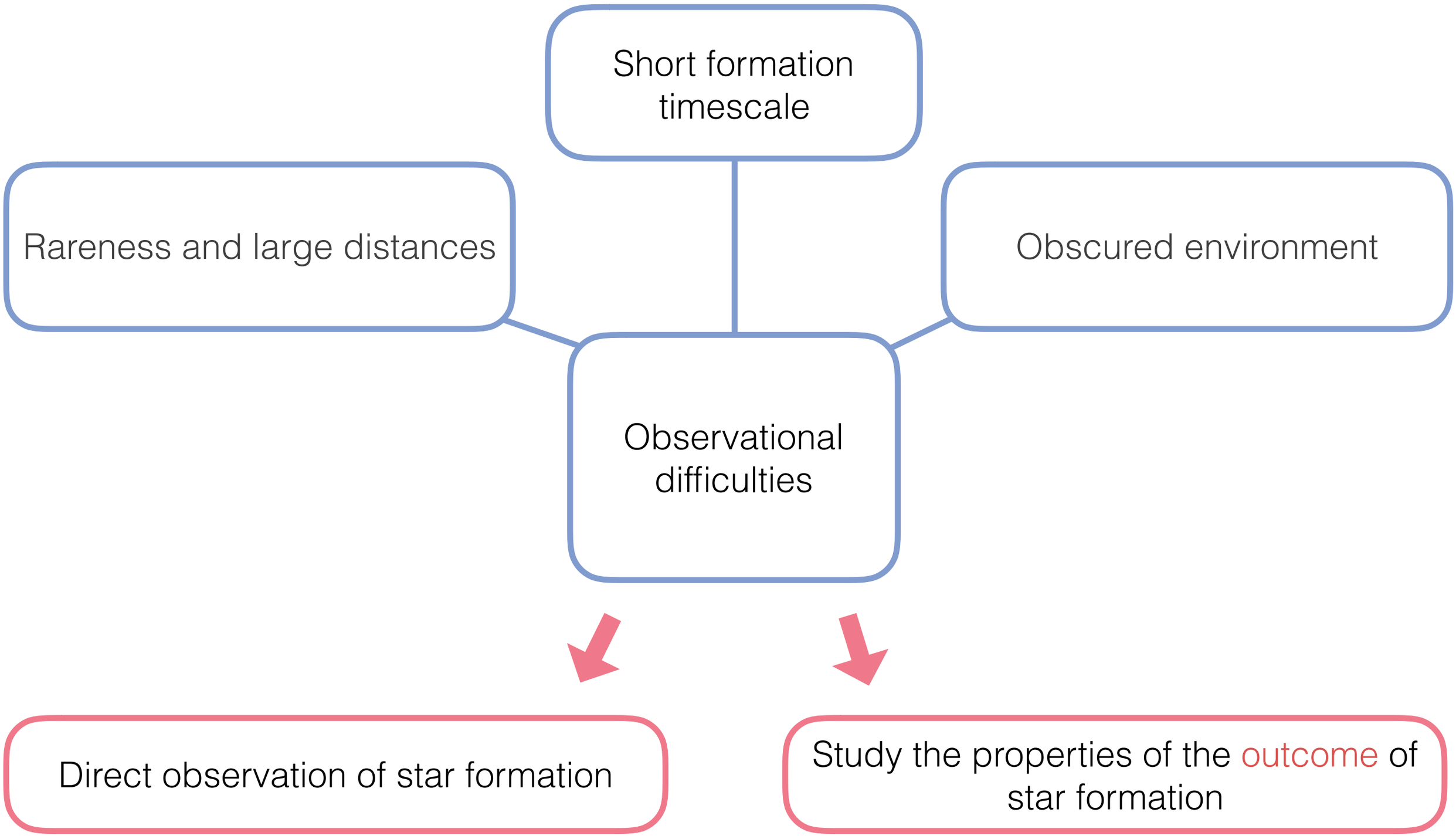
What are massive stars?

Massive Star Formation



Massive Star Formation Problems



C H I P S

Carina

High contrast

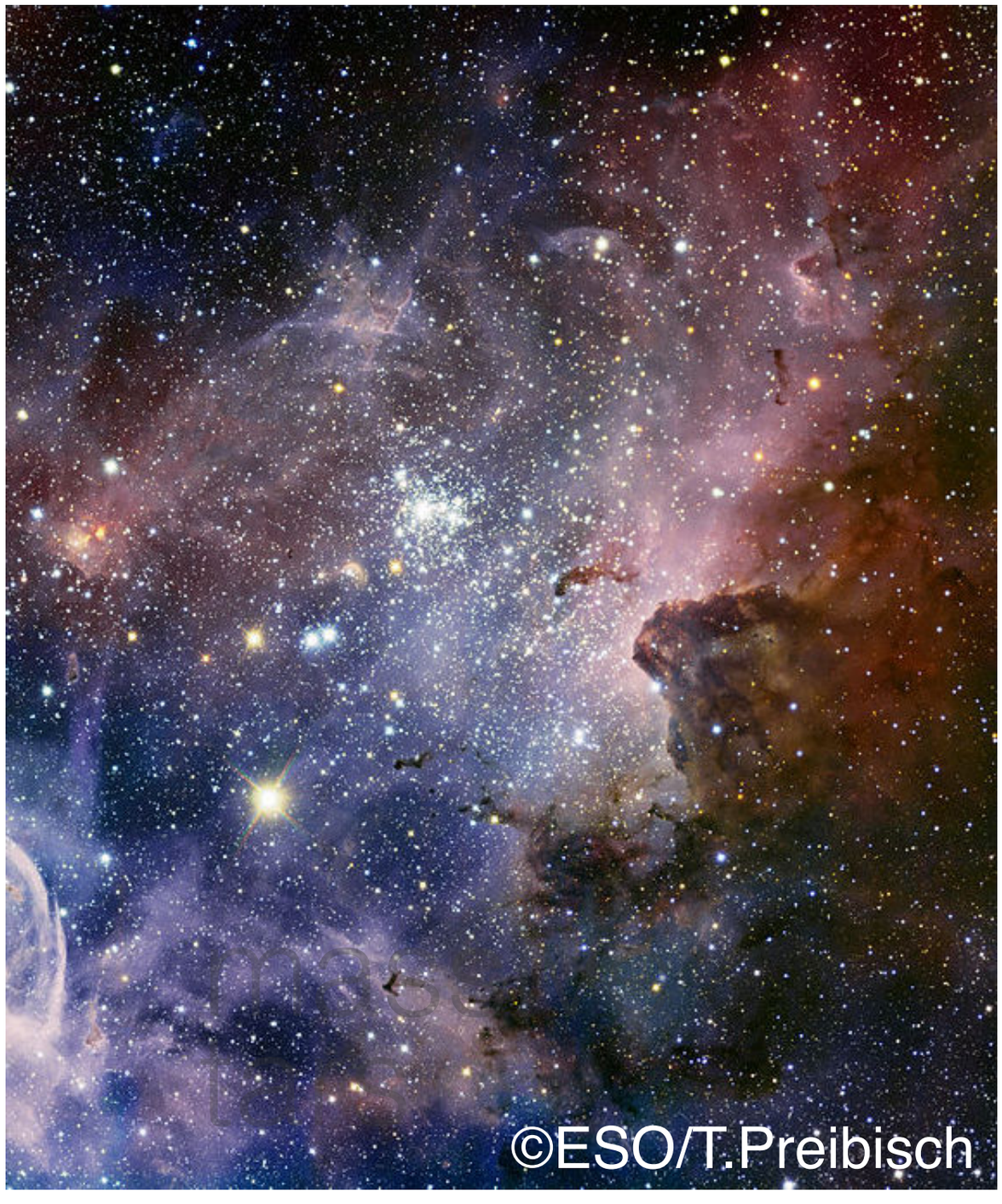
Imaging

Project of

Smassive
tars

Carina

close massive star region



Carina

High contrast

Imaging

Project of

Smassive Stars

close massive star region

VLT/SPHERE in IRDIFS mode

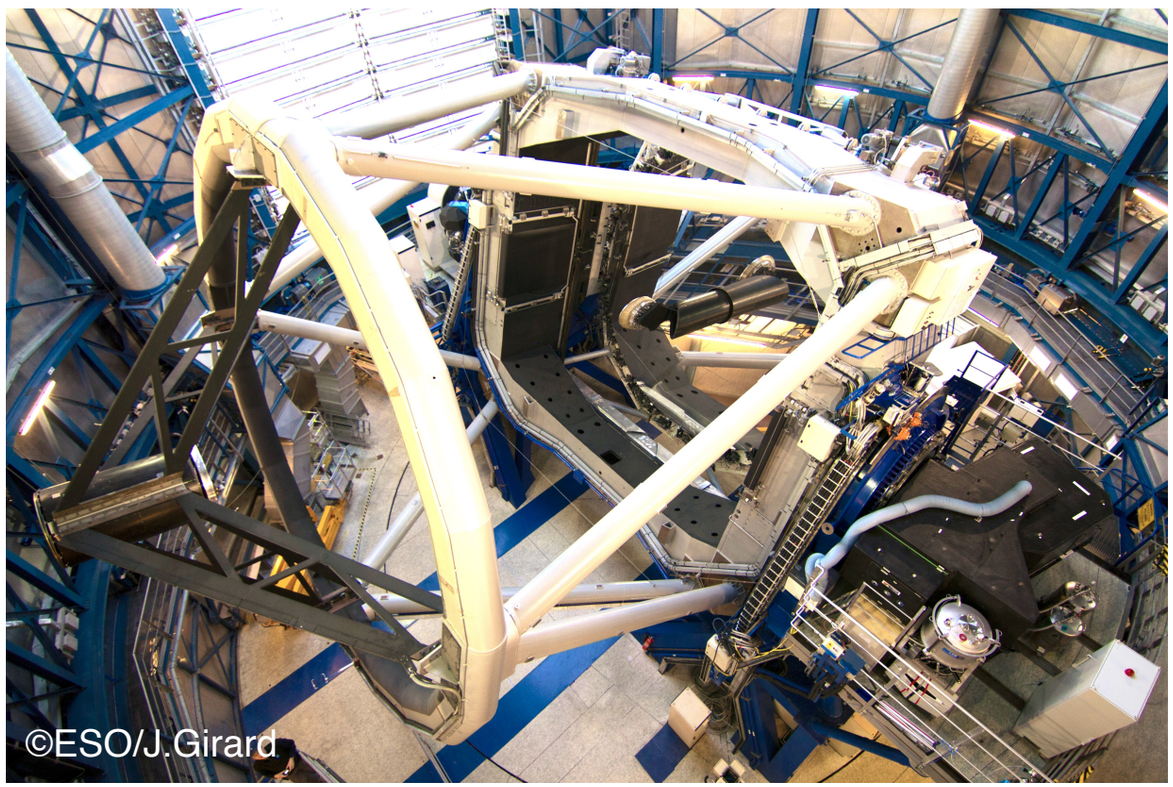
Carina

close massive star region

High contrast

Imaging

VLT/SPHERE in IRDIFS mode



SPHERE	IFS	IRDIS
Spectral Range (μm)	0.95-1.75	0.95-2.32
FOV (arcsec^2)	1.73	11
Pixel Scale (marcsec)	7.4	12.25
Bands	Y-J-H	K (1&2)

Carina

High contrast

Imaging

Project of

Smassive Stars

close massive star region

VLT/SPHERE in IRDIFS mode

faint and low-mass companions

Carina

High-contrast

Imaging

Project of

Smassive Stars

close massive star

63 stars in P102

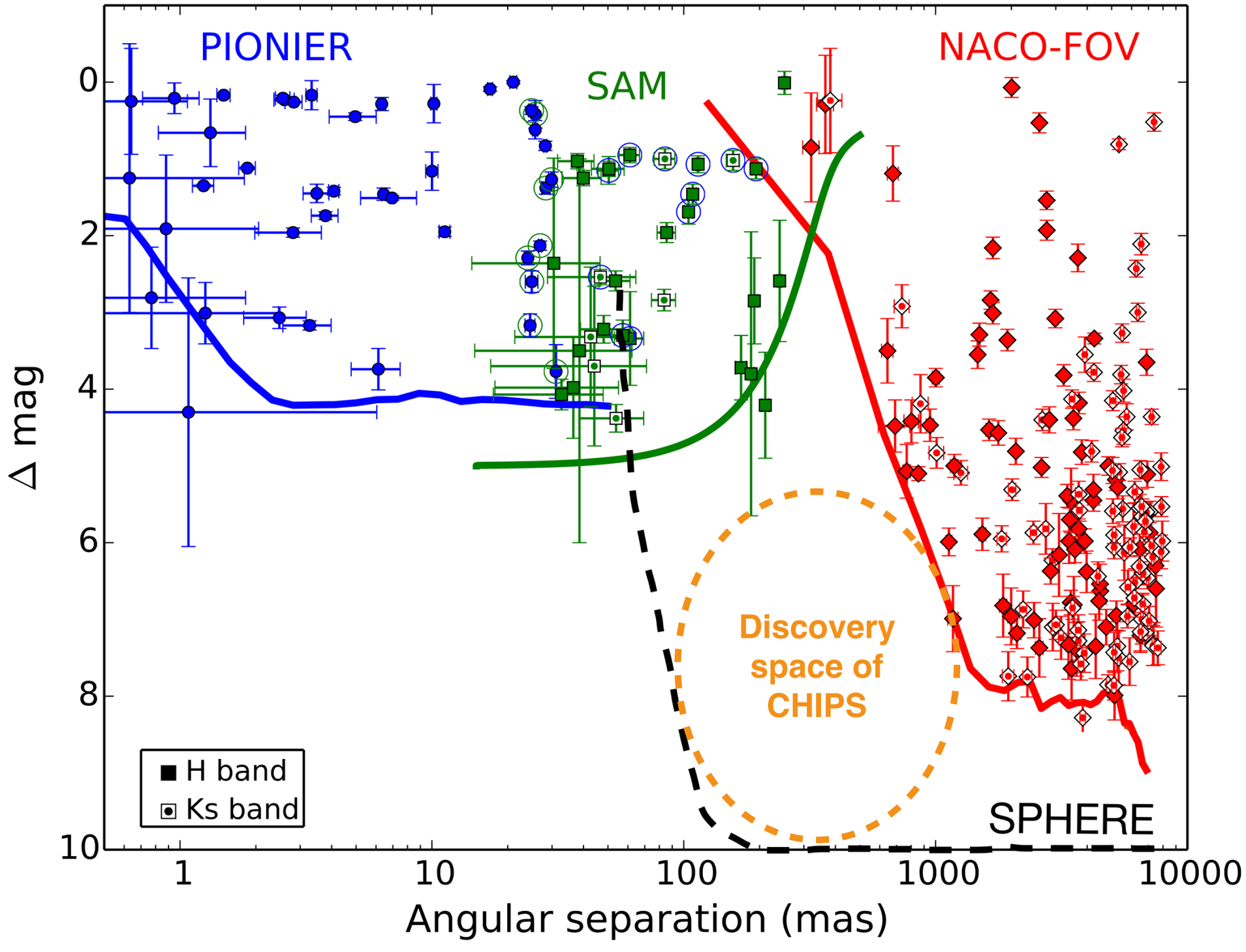
28 stars already reduced

VLT/SPHERE in IRDIFS mode

4D data cubes

Multiplicity properties of 91 massive O and WR

SMaSH+ (Sana et al, 2014)

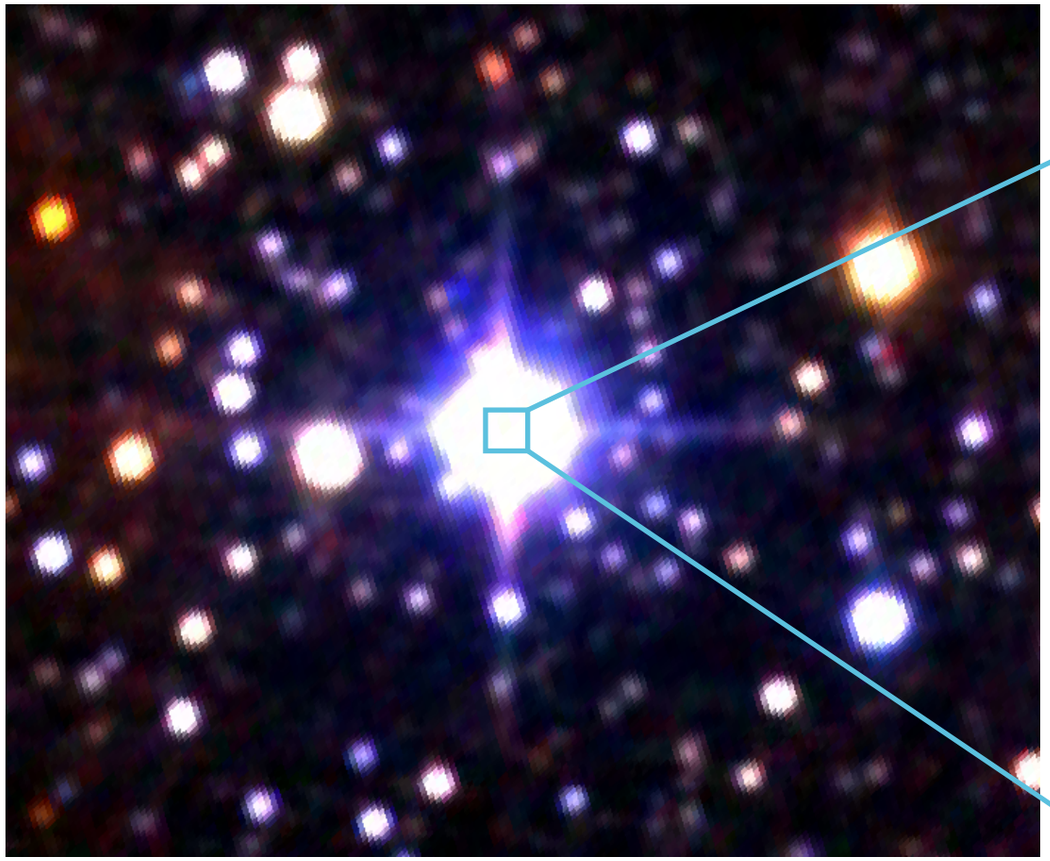


From Sana et al, 2014

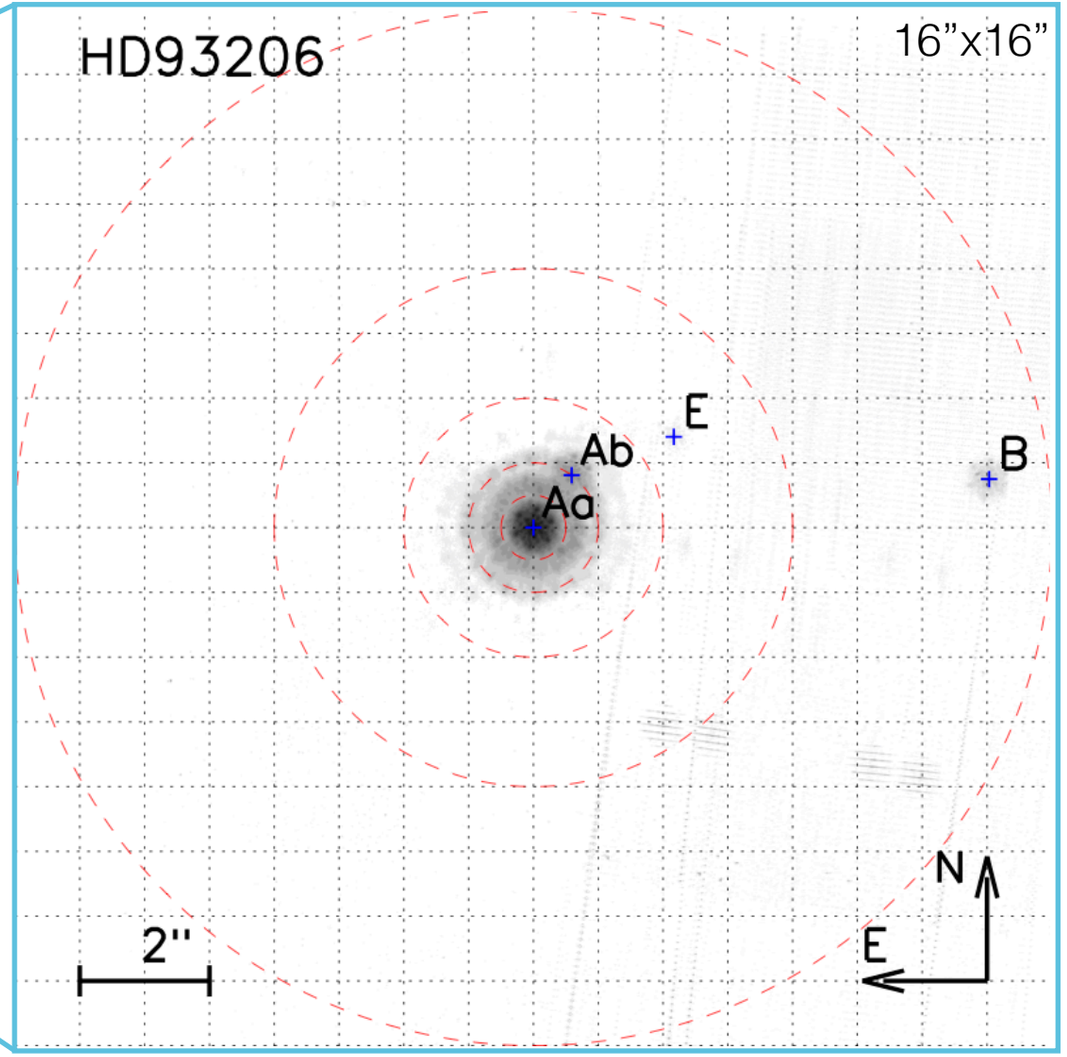
Some example data

QZ Car (HD 93206)

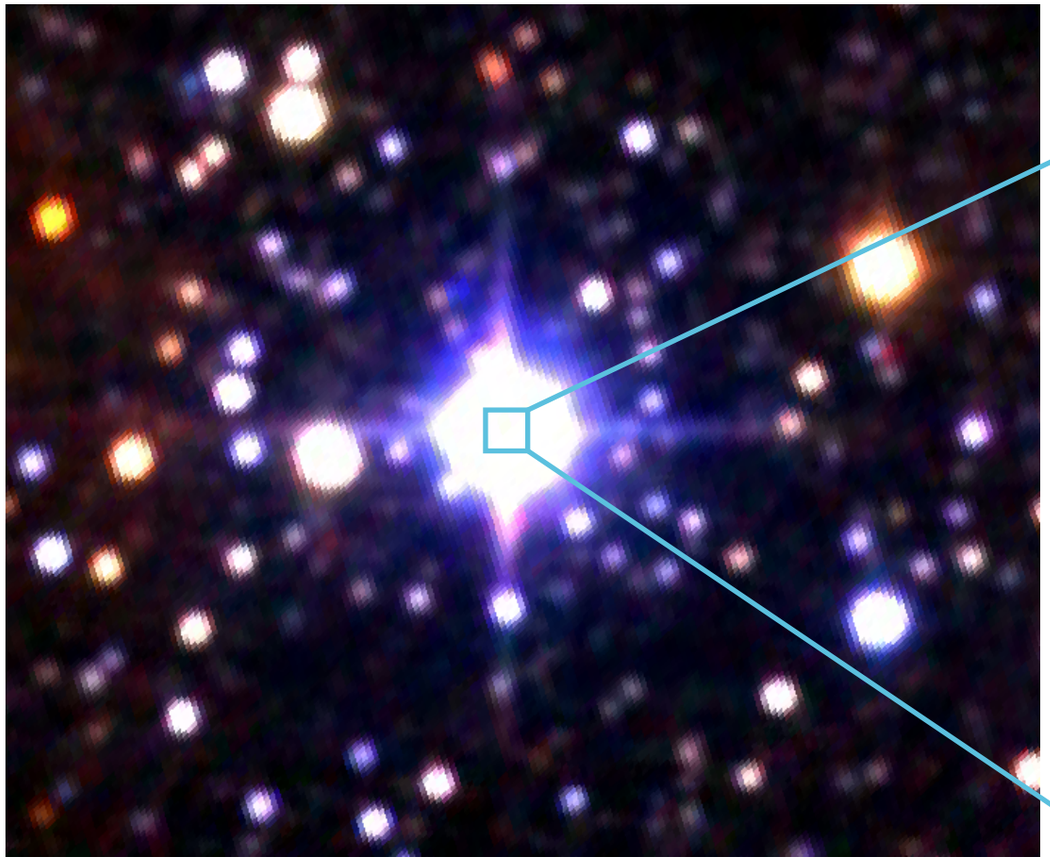
FOV = 5’, 2MASS



FOV = 5’, 2MASS

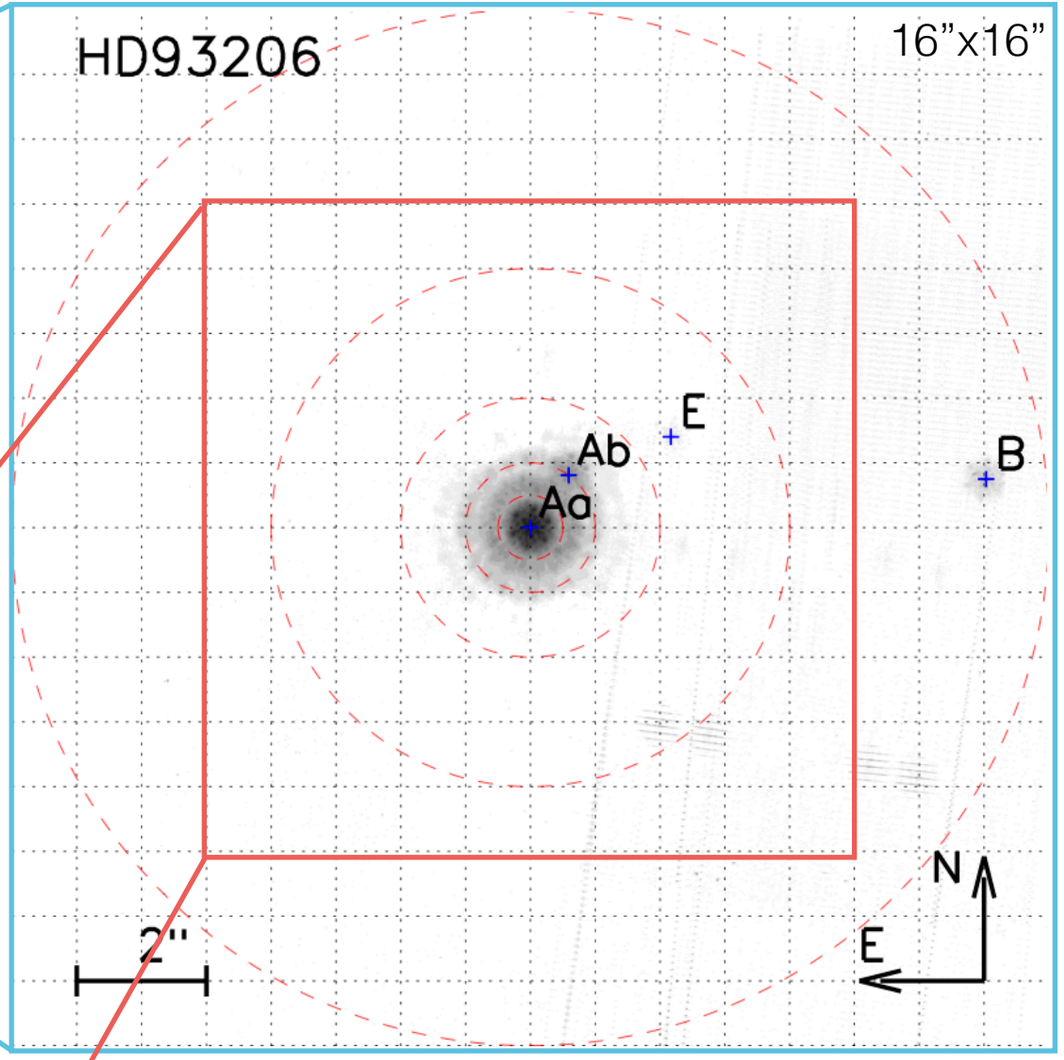


SMaSH+ Image
Sana et al, 2014

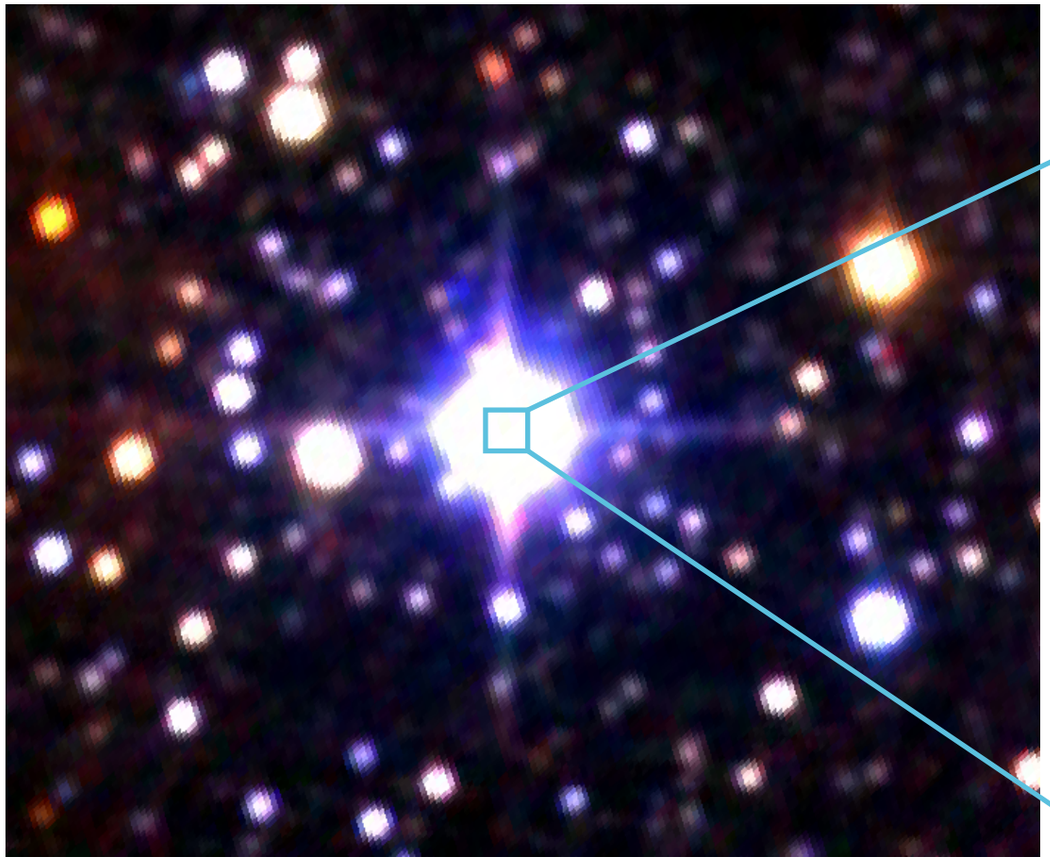


FOV = 5’, 2MASS

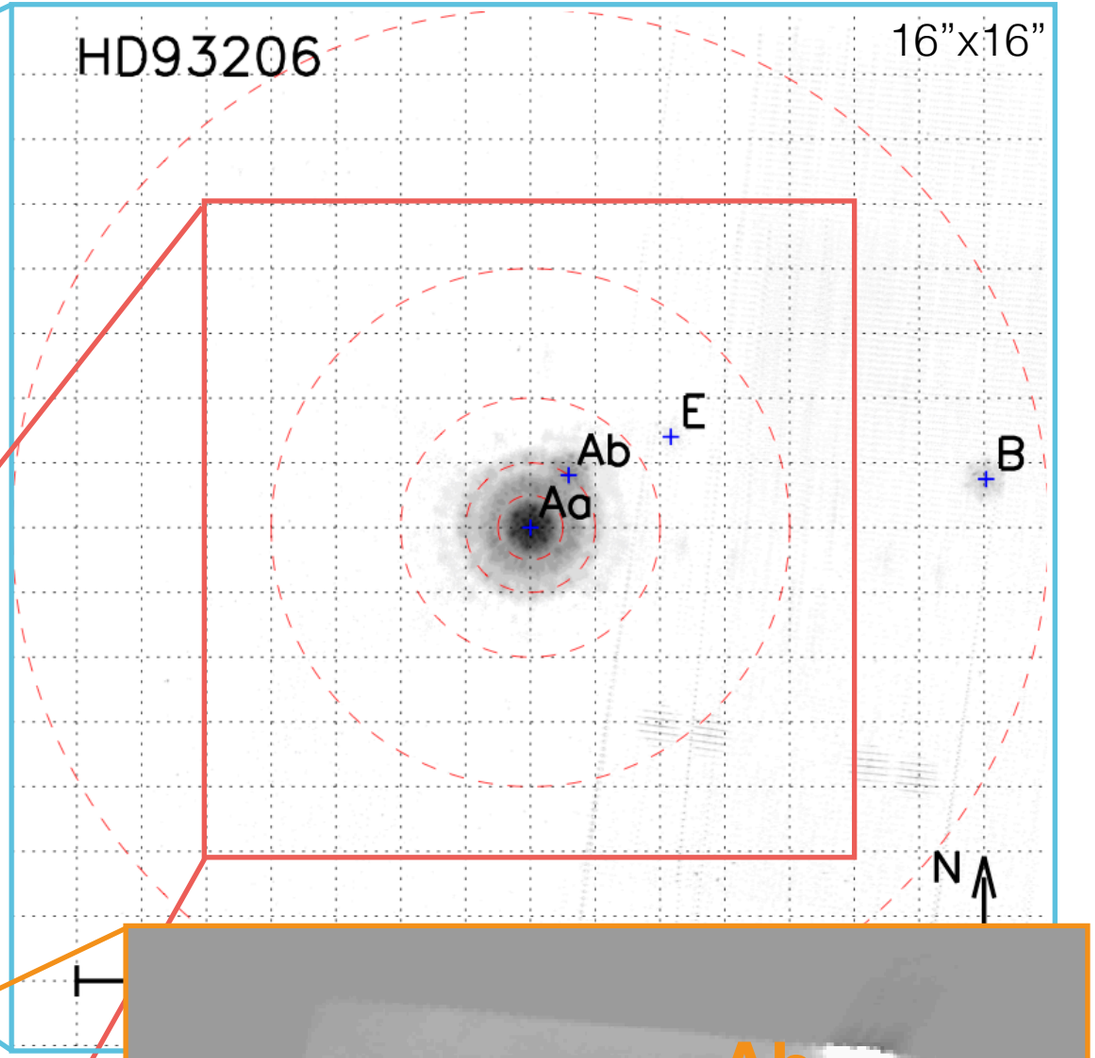
IRDIS

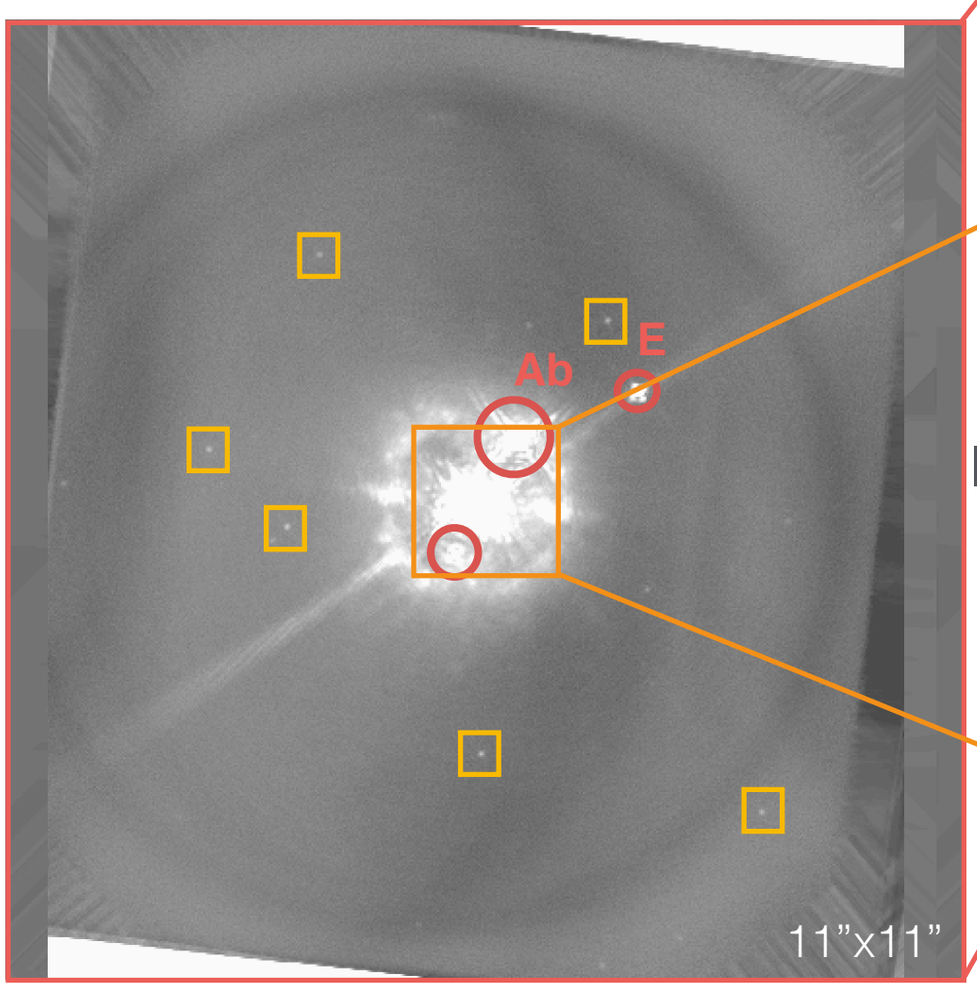


SMaSH+ Image
Sana et al, 2014



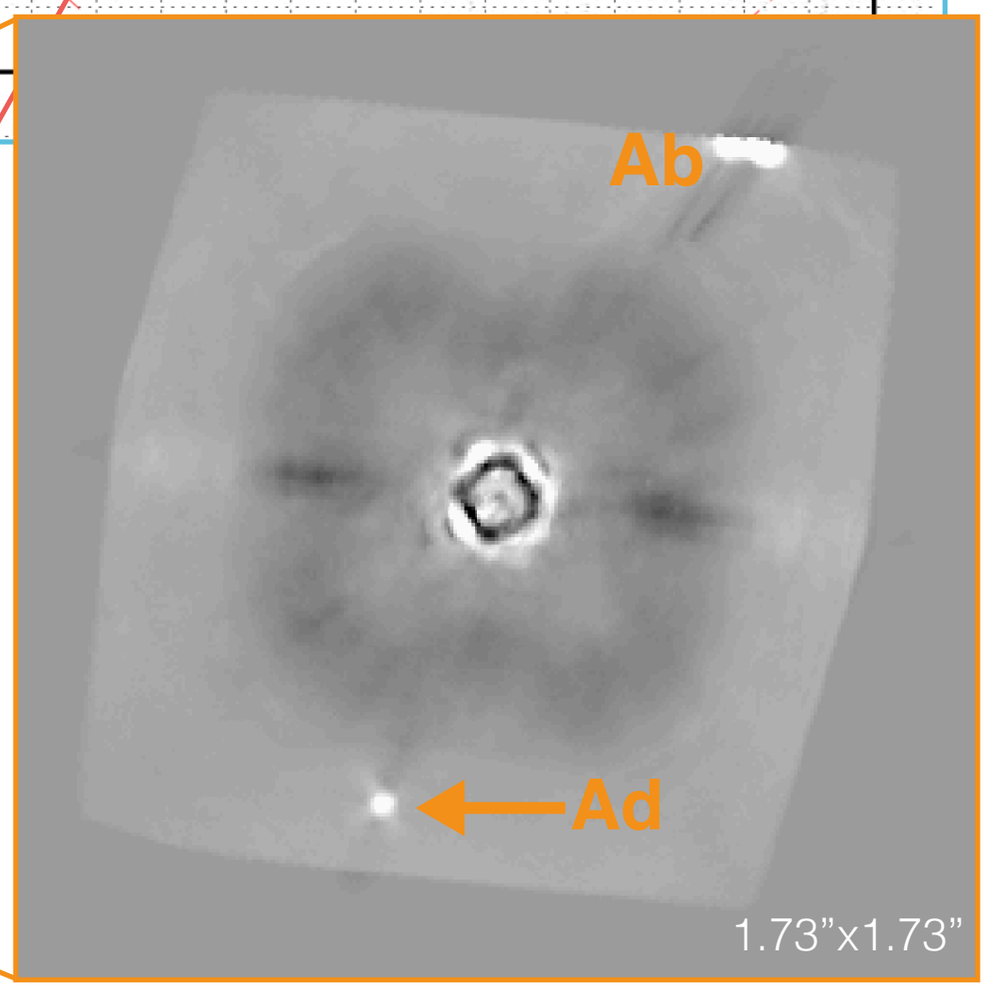
FOV = 5’, 2MASS



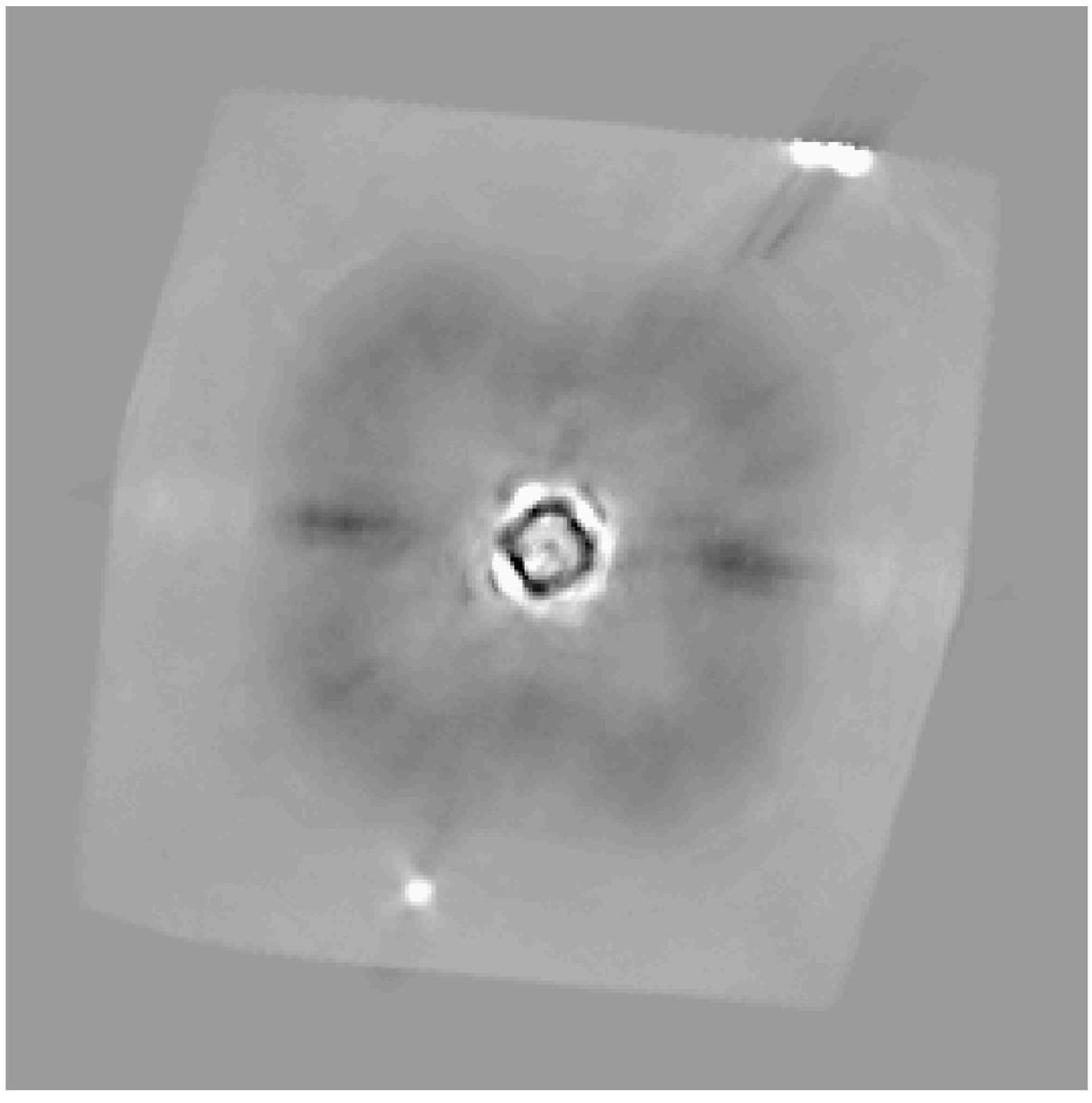


IRDIS

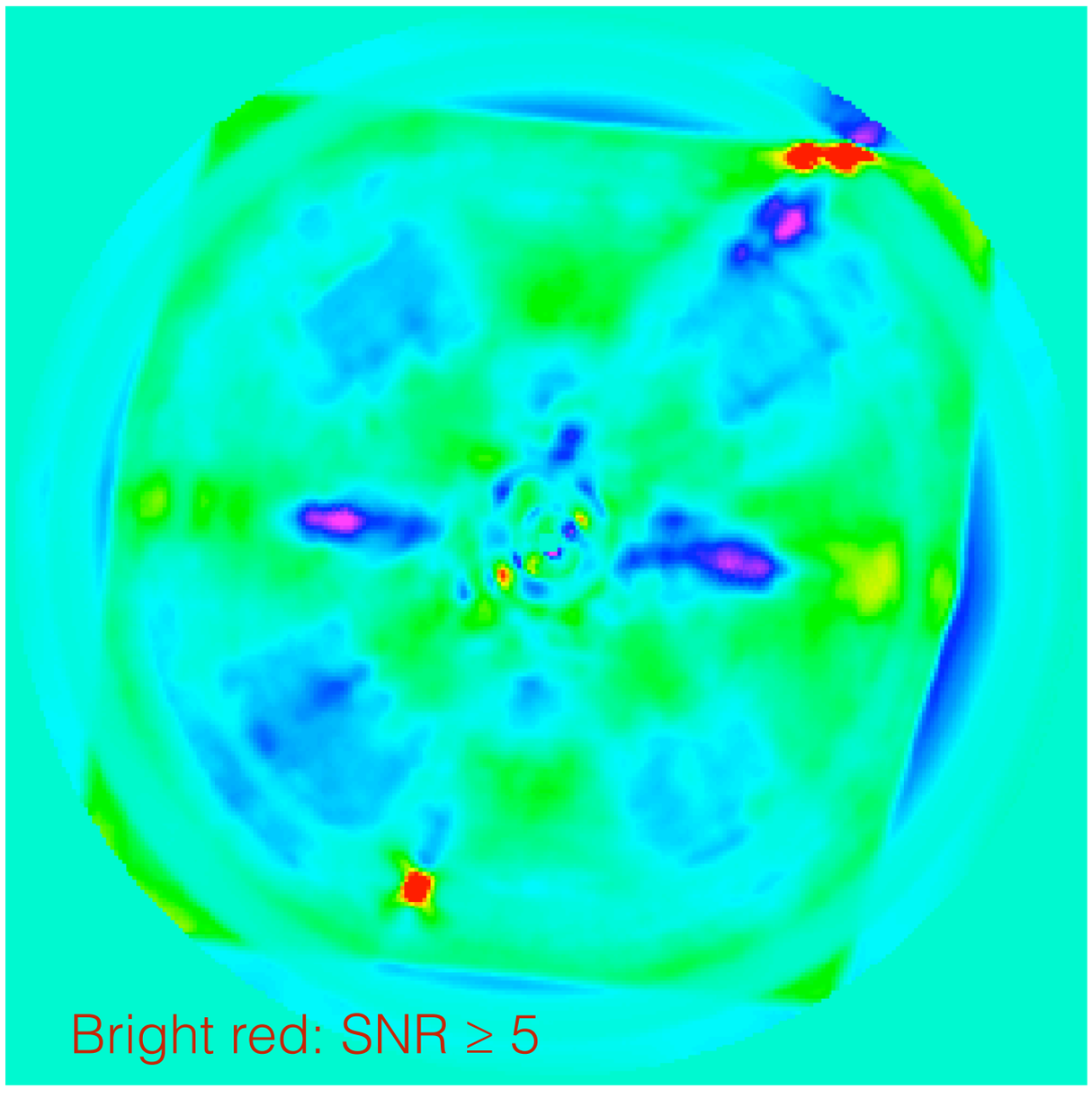
IFS



Detection method

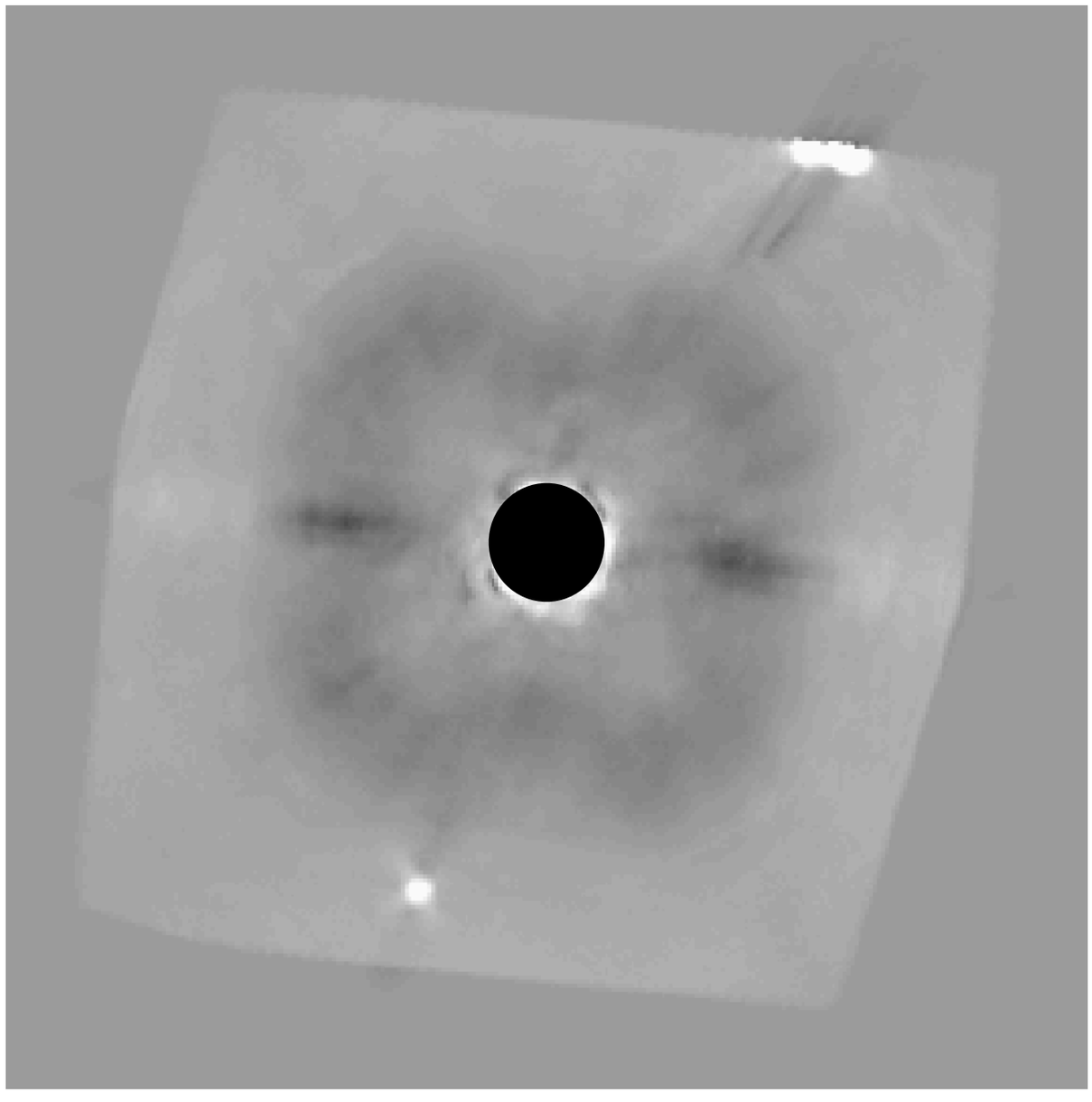


Derotated and wavelength collapsed image

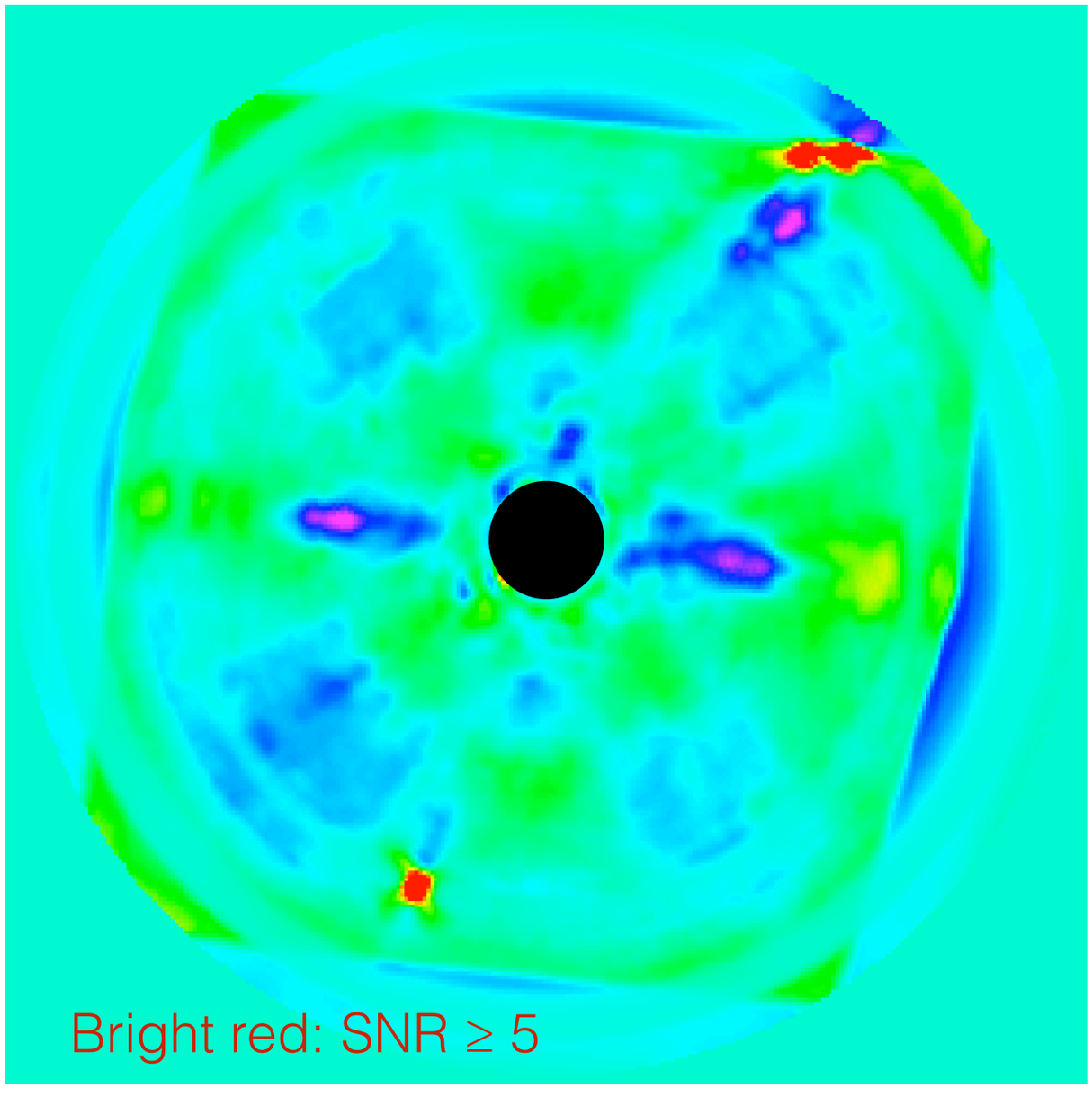


SNR map

Detection method

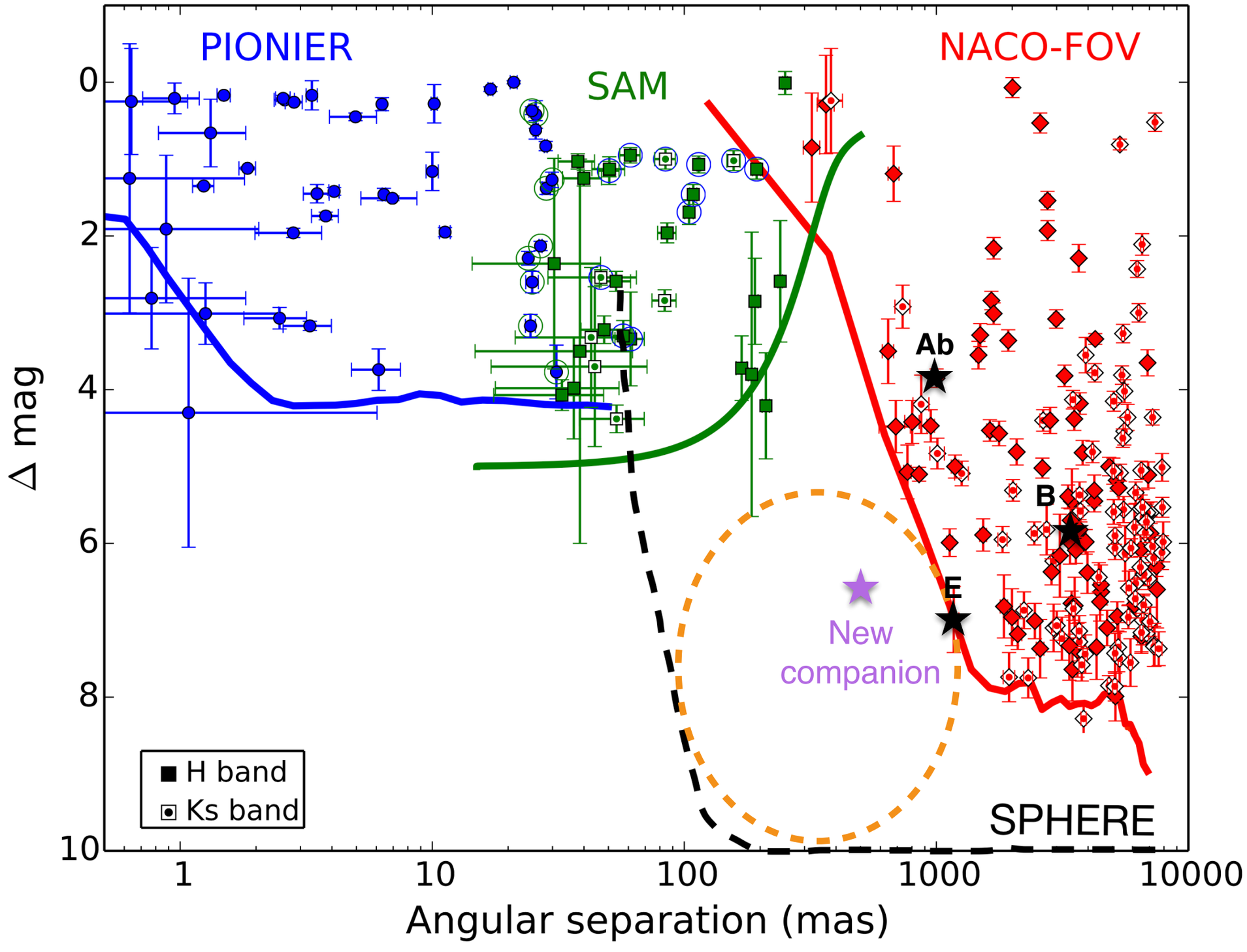


Derotated and wavelength collapsed image



SNR map

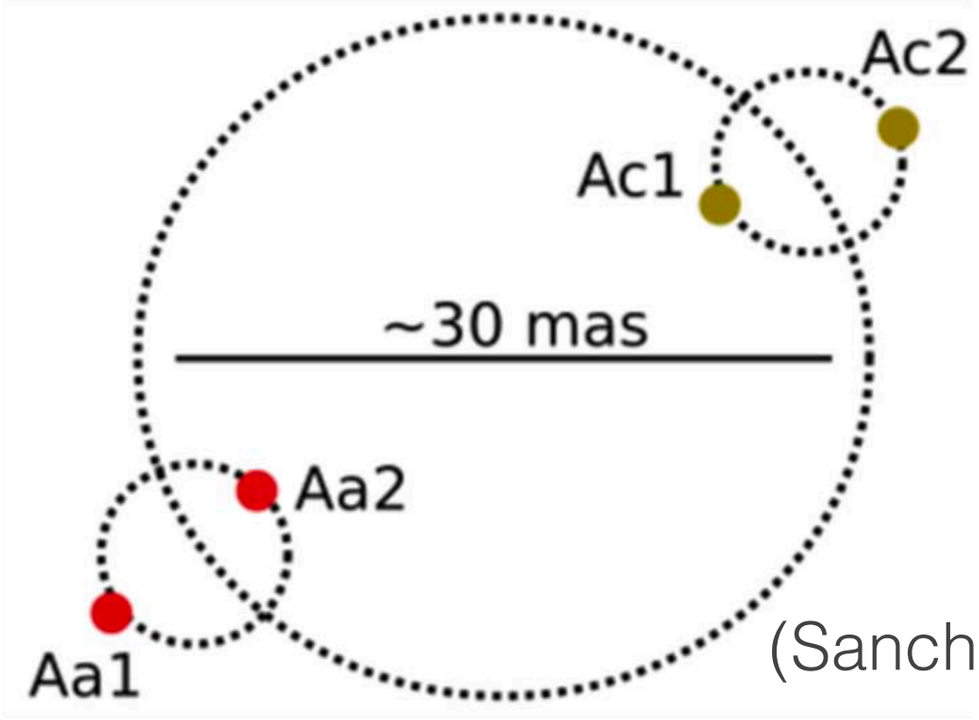
SMaSH+ (Sana et al, 2014)



Adapted from Sana et al, 2014

Spectrum Extraction

QZ Car (HD 93206)

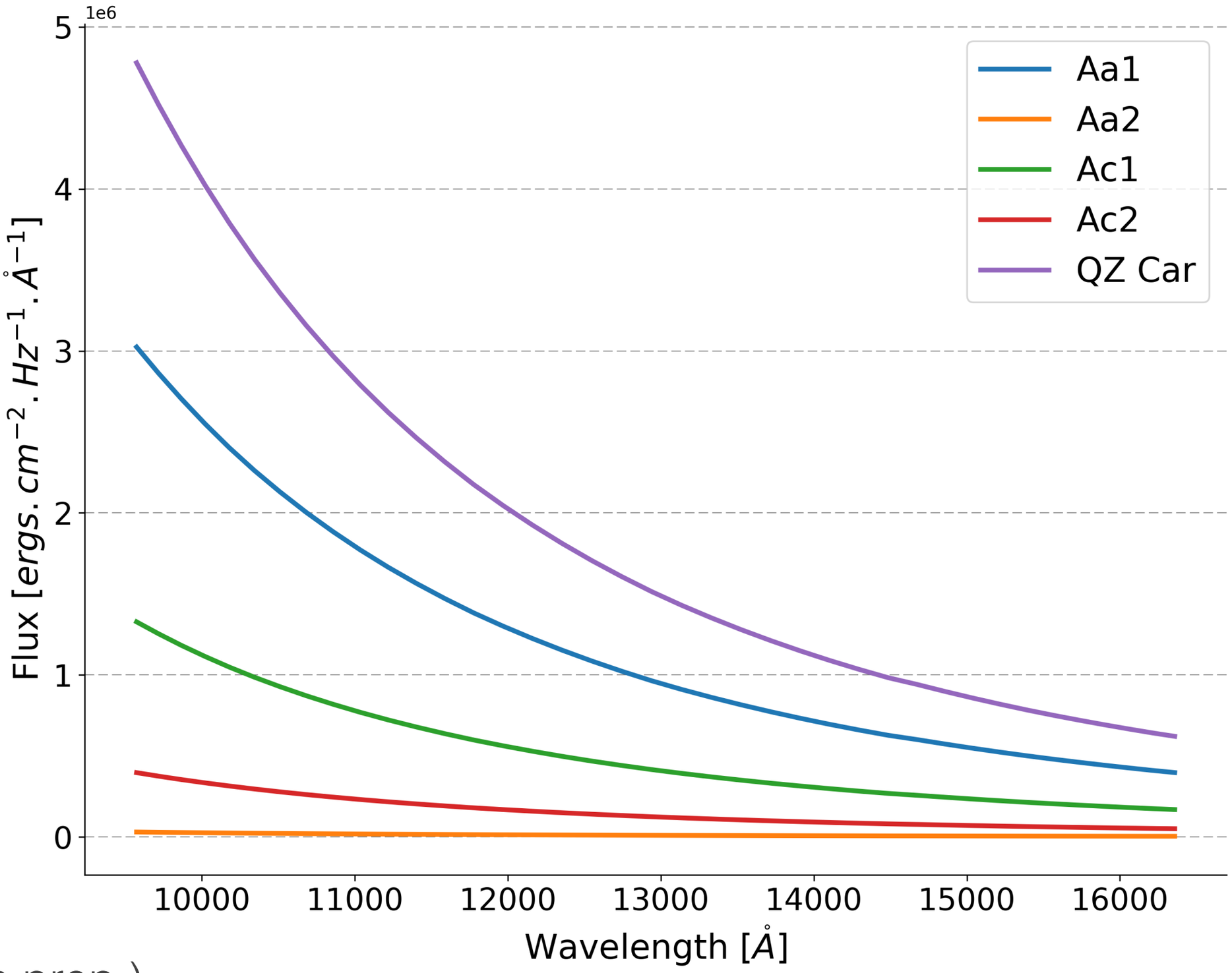


(Sanchez-Bermudez et al. 2017)

Component	Spectral Type	T_{eff} (K)	R_* ($R_\odot$)	M_* ($M_\odot$)	L_* ($\log[L_*/L_\odot]$)	$\dot{M}$ ($M_\odot.yr^{-1}$)	log(g)	v_∞ ($km.s^{-1}$)
Aa1	O9.7 I	32000	22.5	40	5.7	8.21×10^{-6}	3.19	1794.3
Aa2	b2 v	20000	6.0	10	3.7	2.39×10^{-14}	4.3	1186.4
Ac1	O8 III	32573	26.9	14.1	5.3	3.32×10^{-6}	3.57	2191.2
Ac2	o9 v	32463	8.9	28	4.9	3.16×10^{-9}	3.92	2427.1

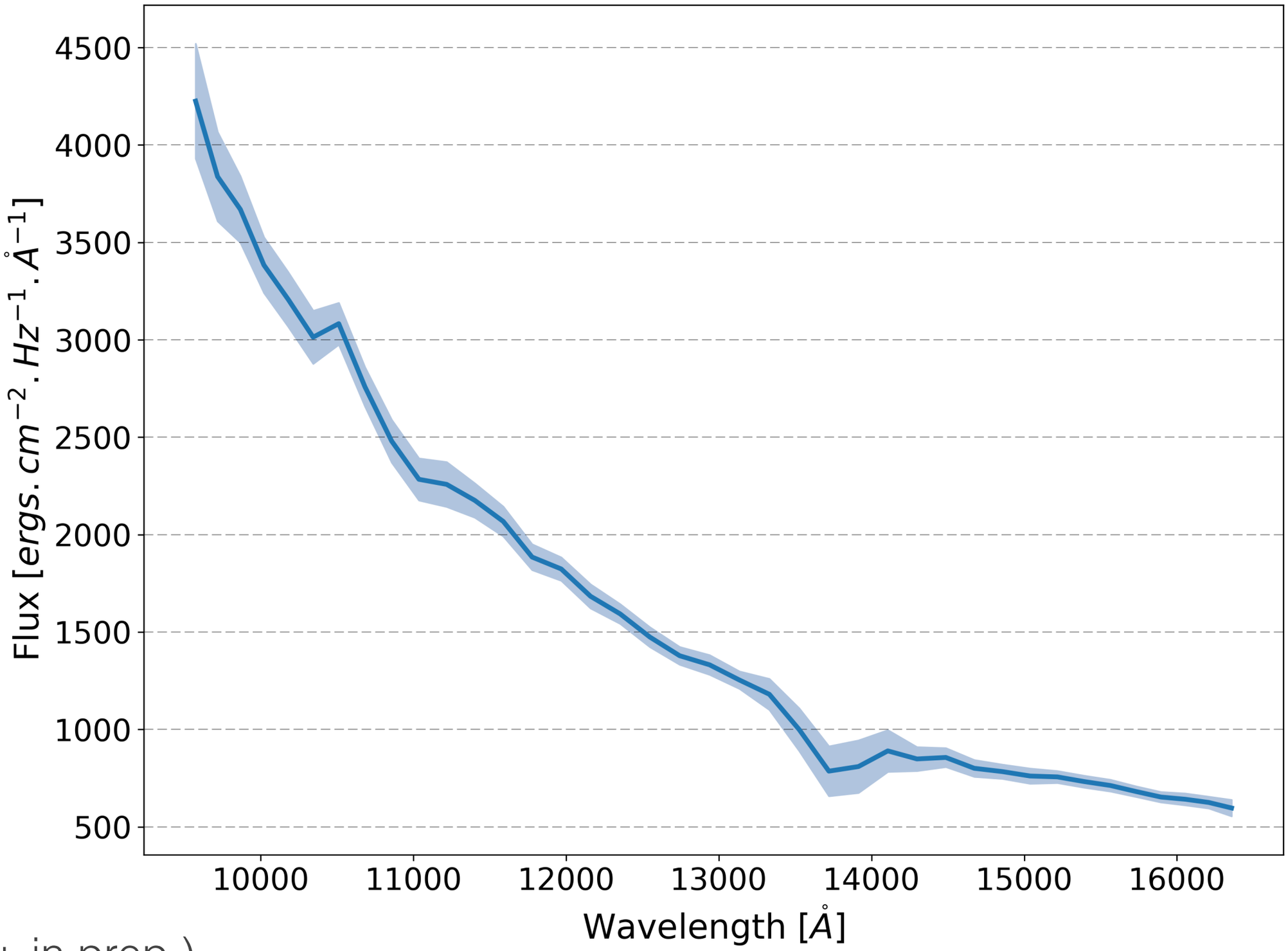
(Rainot+ in prep.)

QZ Car spectrum with FASTWIND



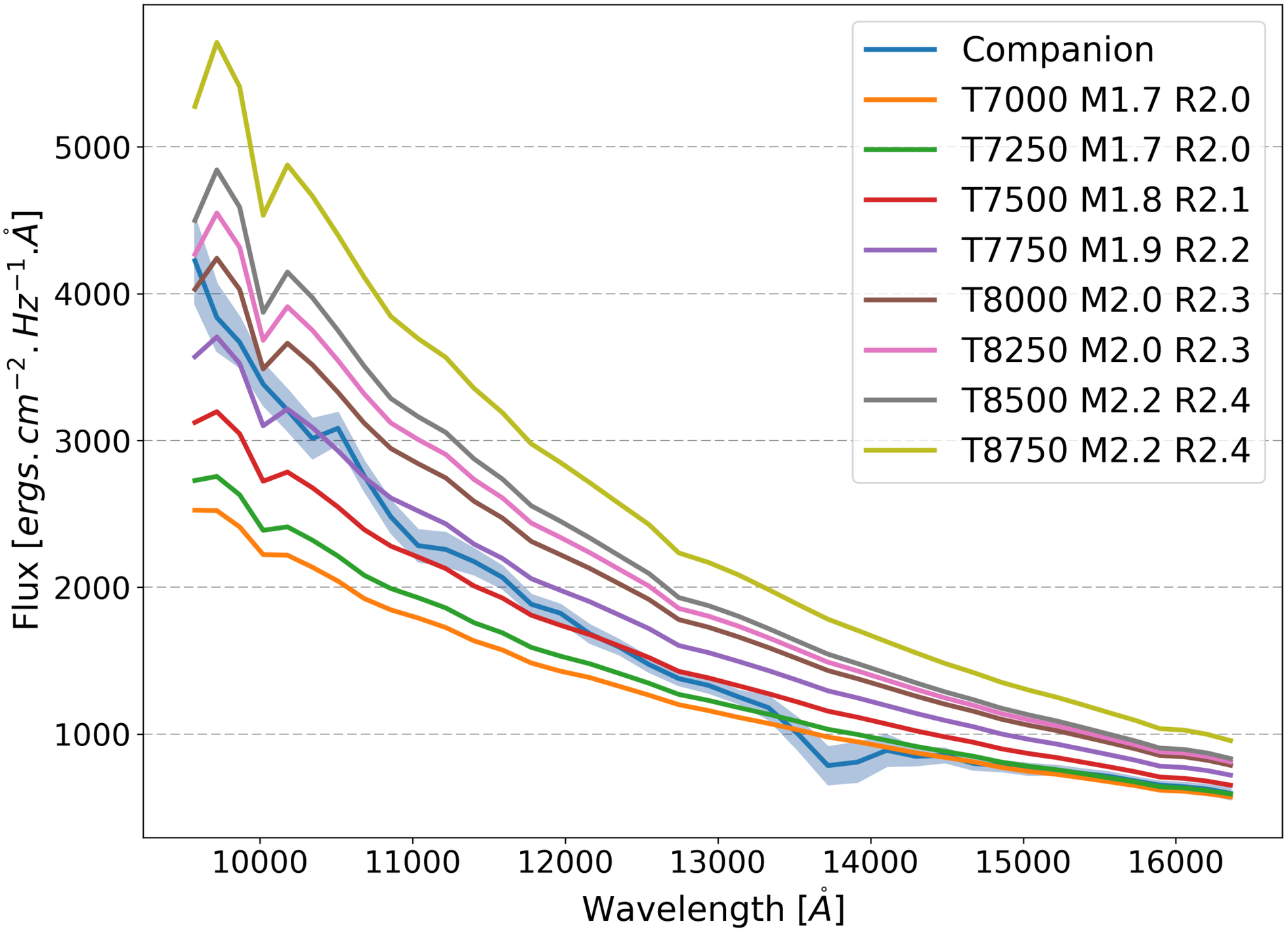
(Rainot+ in prep.)

Calibrated spectrum



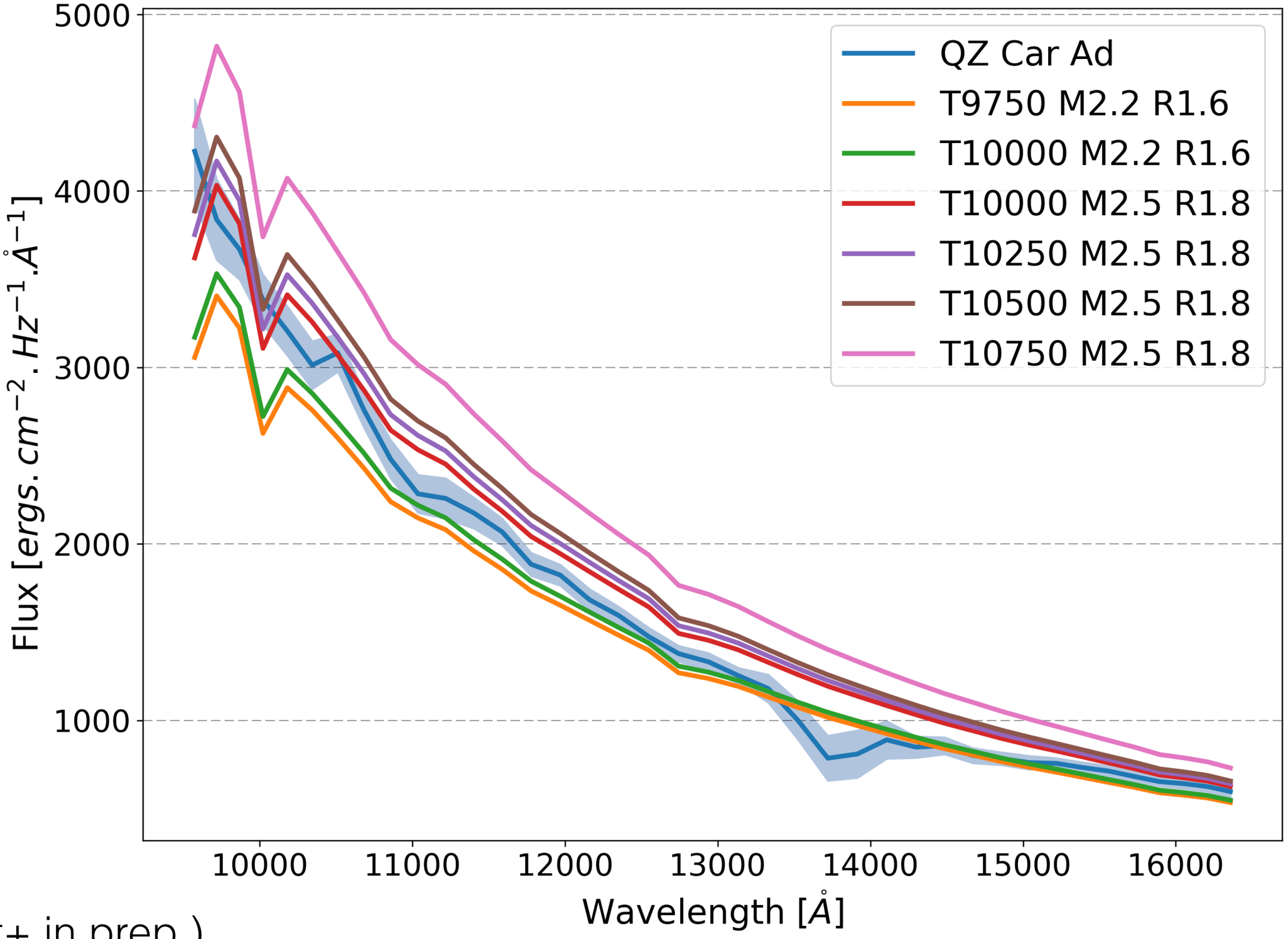
(Rainot+ in prep.)

ZAMS



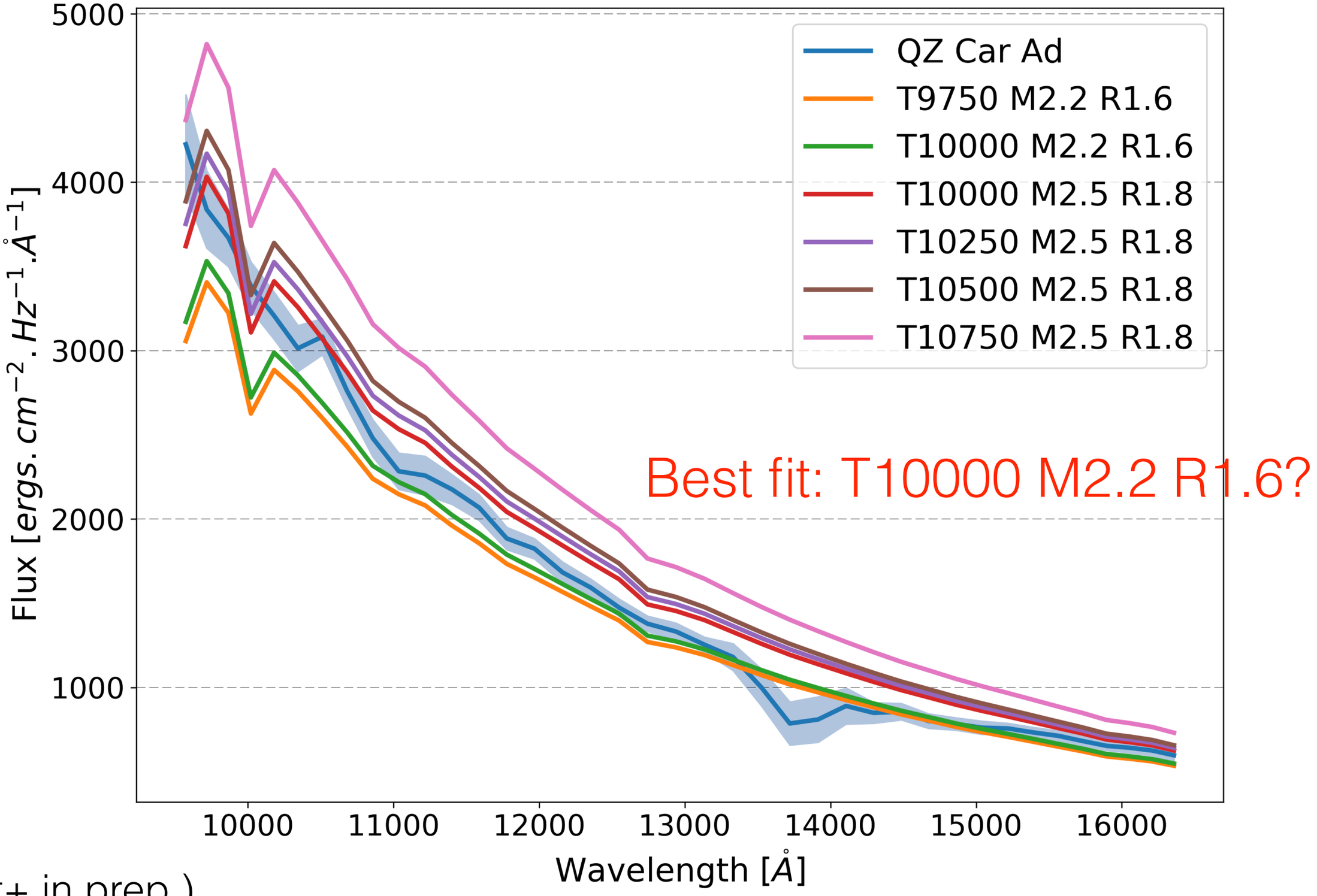
(Rainot+ in prep.)

Early MS



(Rainot+ in prep.)

Early MS



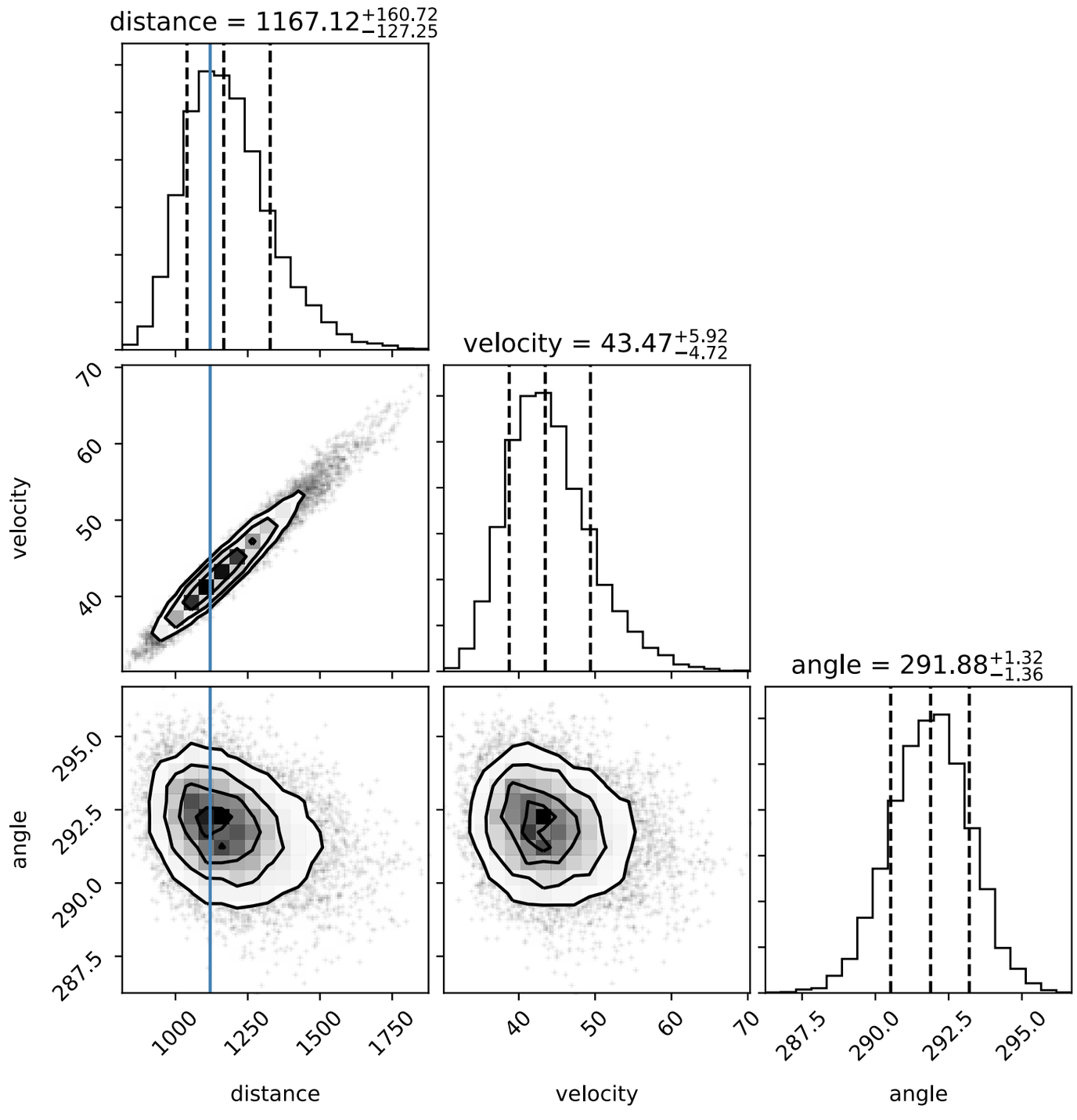
(Rainot+ in prep.)

Multiplicity Results - IFS

Images	Visible companions (SNR > 5σ)	Candidates (5σ > SNR > 3σ)
28	6	12

- Detection ratio ≃ 0.42 companions/star
- Expected ≃ 38 companions / 91 images

GAIA distance



(Rainot+ in prep.)

Conclusion

- Discovery of a new companion: QZ Car Ad at 1.2kpc
- Might be an A0 star with: T= 10000K, M = 2.2M, R = 1.6R
- Masses limits of IRDIS detected sources
- 63 stars remain to be observed with SPHERE (P102)
- First paper to be submitted soon!

https://arainot.github.io alan.rainot@kuleuven.be

Thank you!

https://arainot.github.io

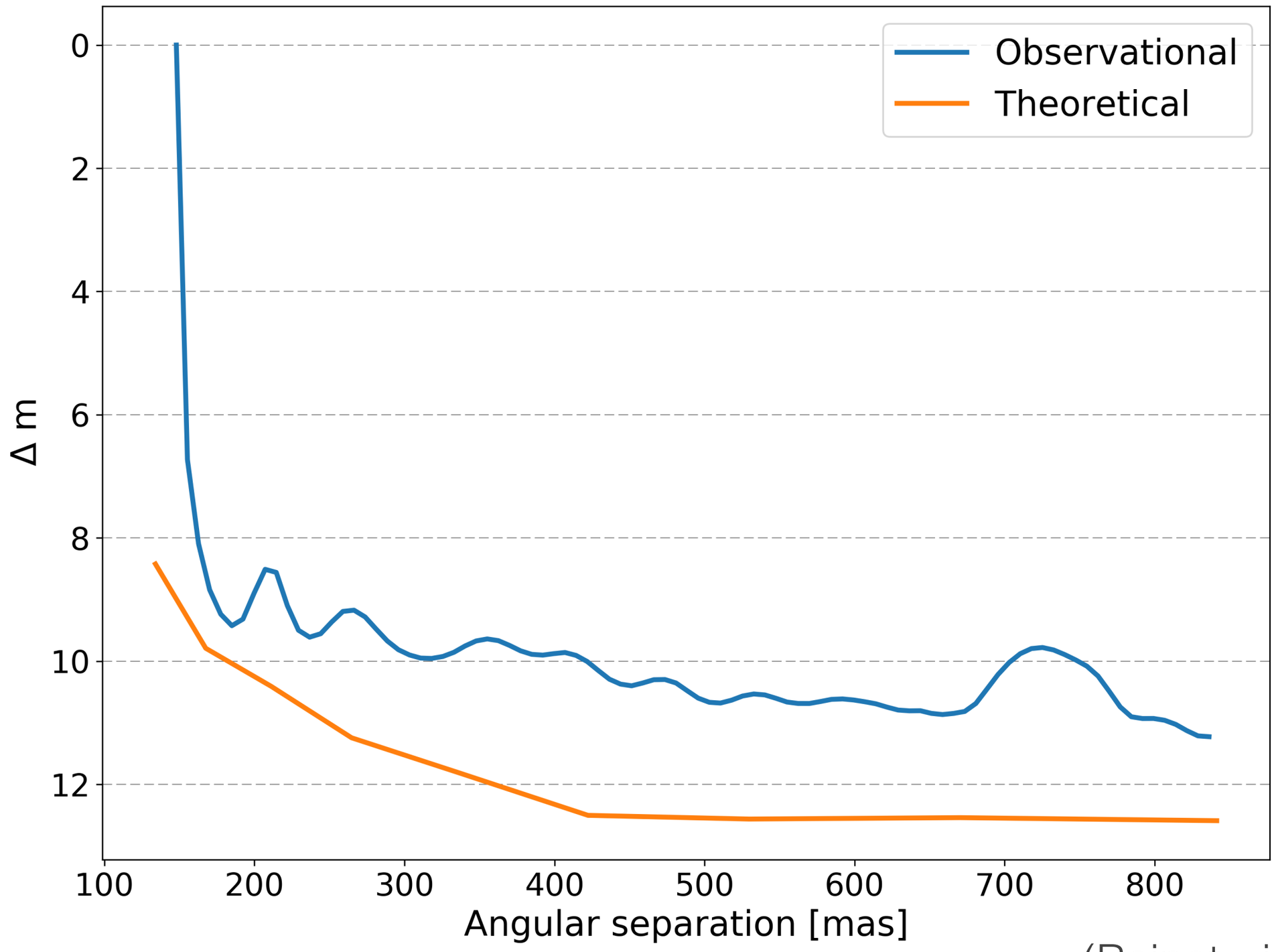
alan.rainot@kuleuven.be

Extra Slides

https://arainot.github.io

alan.rainot@kuleuven.be

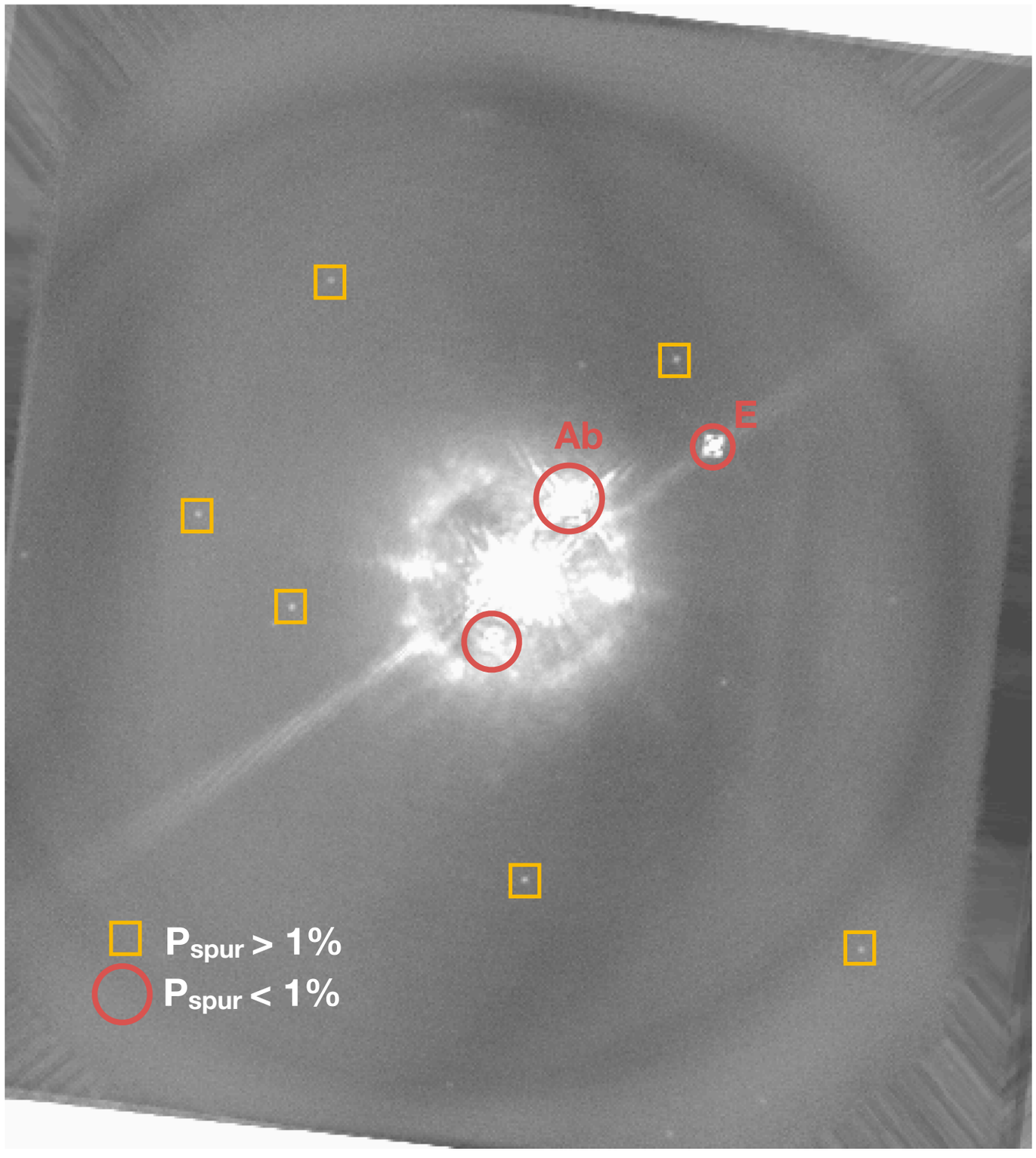
IFS Contrast Curves



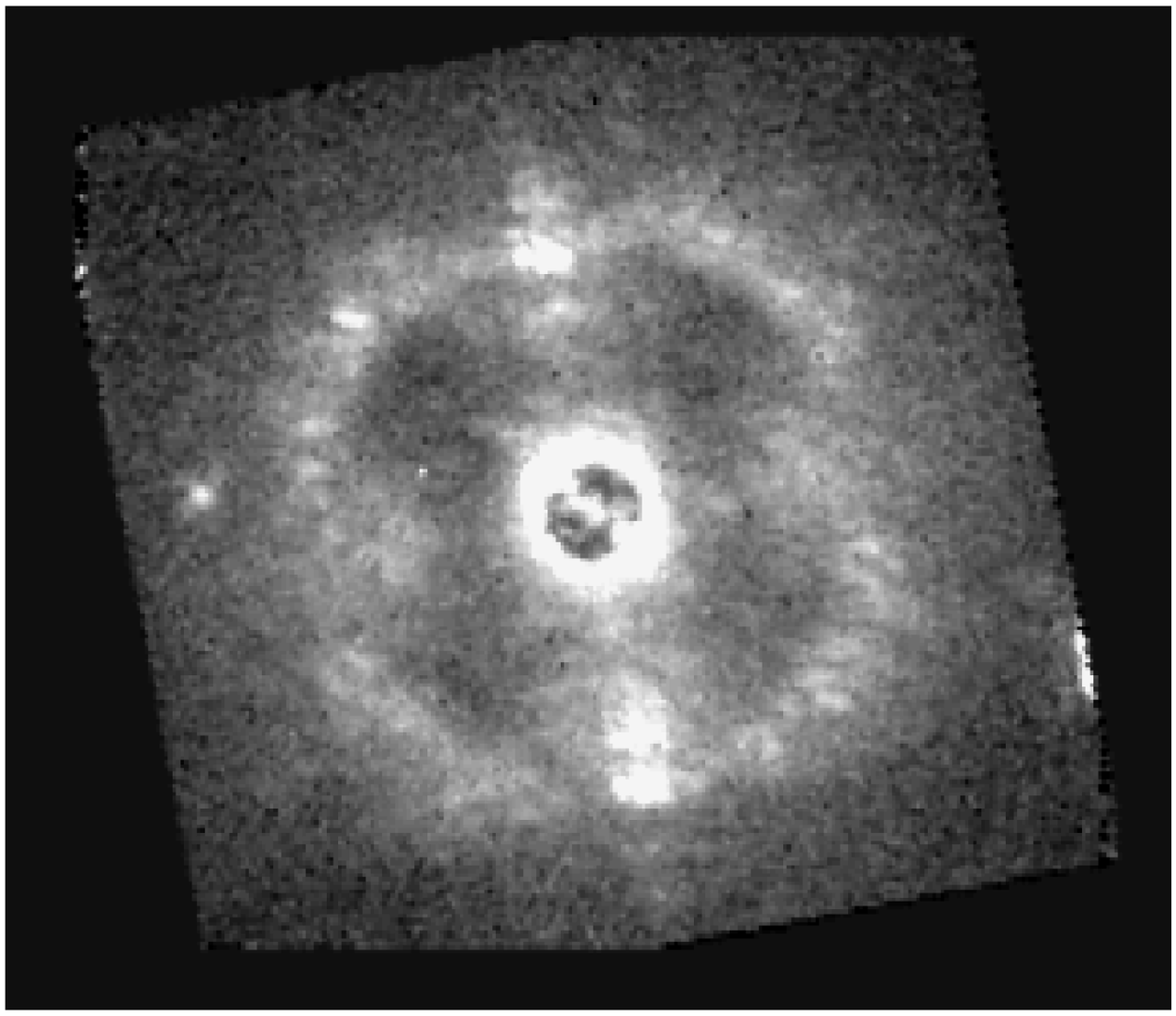
(Rainot+ in prep.)

IRDIS

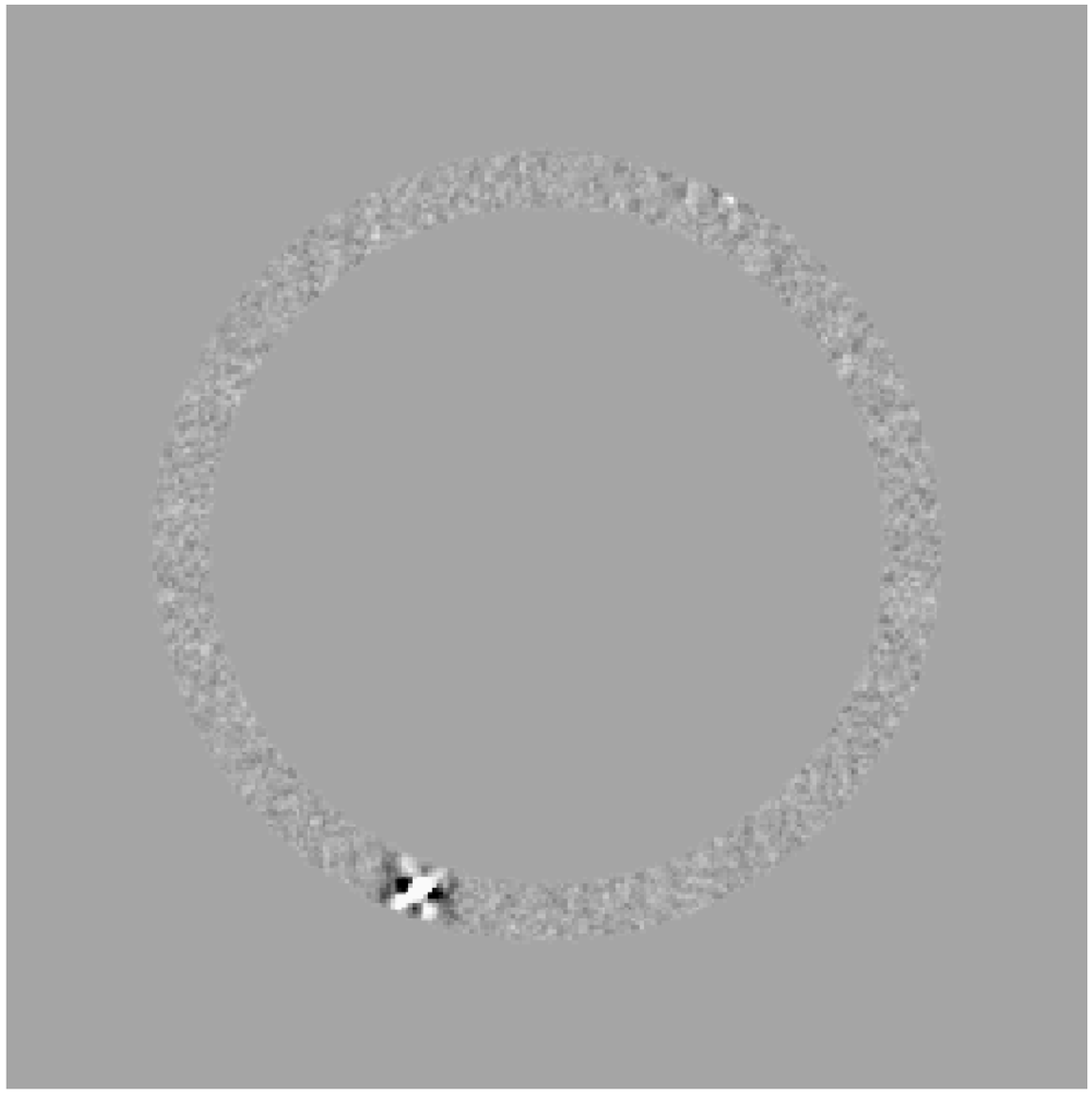
(Rainot+ in prep.)



Analysis Techniques

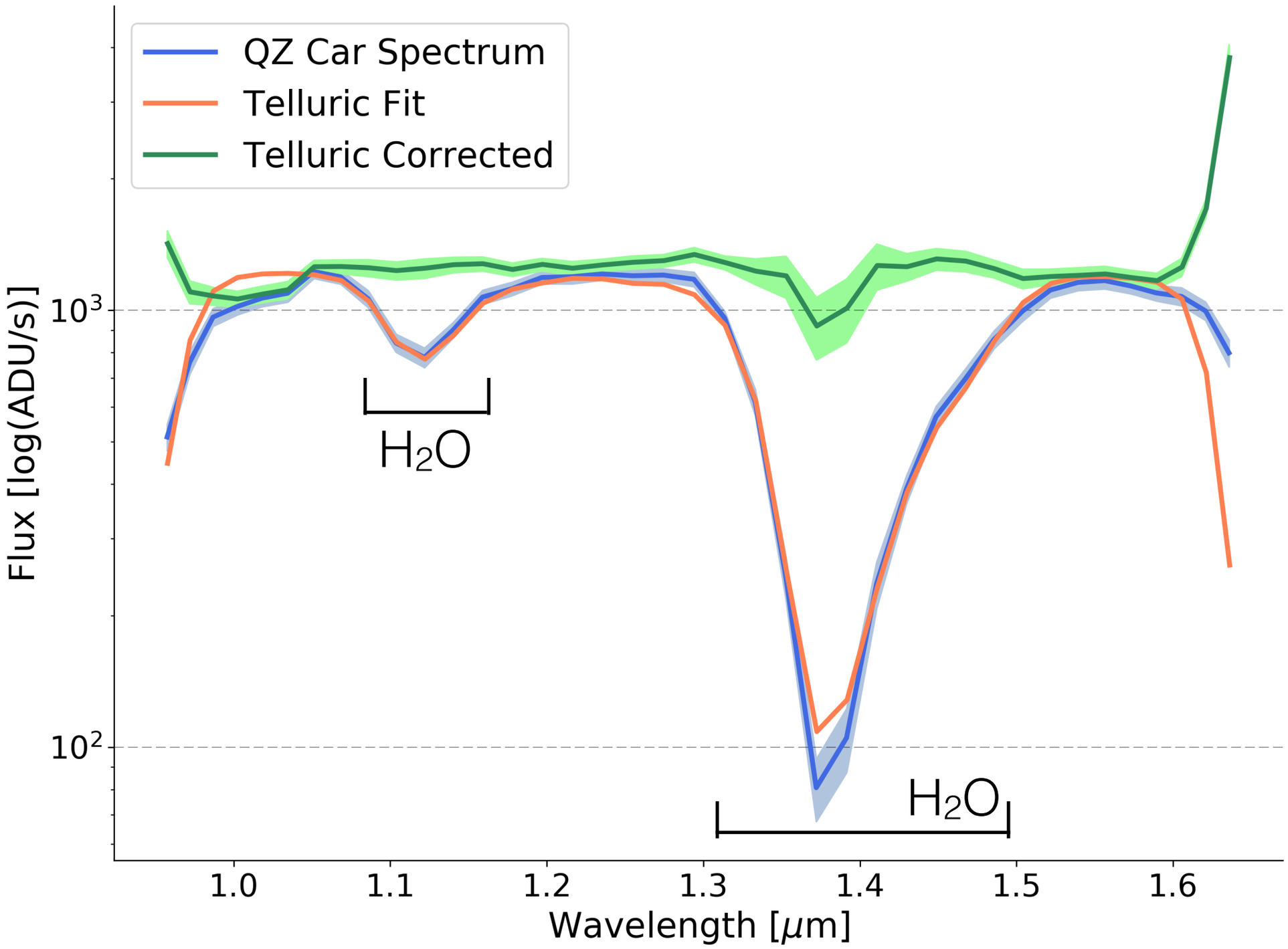


Original image



Post-processed cube

PSF Fitting


QZ Car Spectrum
Telluric Fit
Telluric Corrected
Flux [log(ADU/s)]
10^3
10^2
H_2O
H_2O
1.0
1.1
1.2
1.3
1.4
1.5
1.6
Wavelength [μm]