PLATO Benchmark stars and Interferometry

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CENTRE NATIONAL D'ÉTUDES SPATIALES

Questions

- How can interferometry help to define benchmarks?
- Precision/accuracy on temperatures/radii
- Current status and perspectives
- Limits of this technique

Interferometry

- 2+ telescopes creates a large 'mirror'
- measure interference patterns and their contrast

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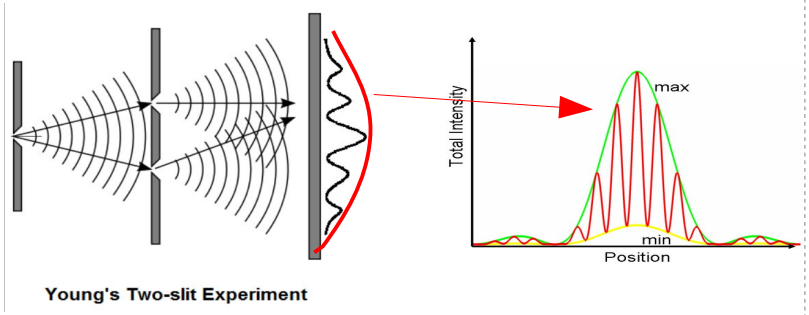
V = Visibility = $\frac{(I_{max} - I_{min})}{(I_{max}+I_{min})}$



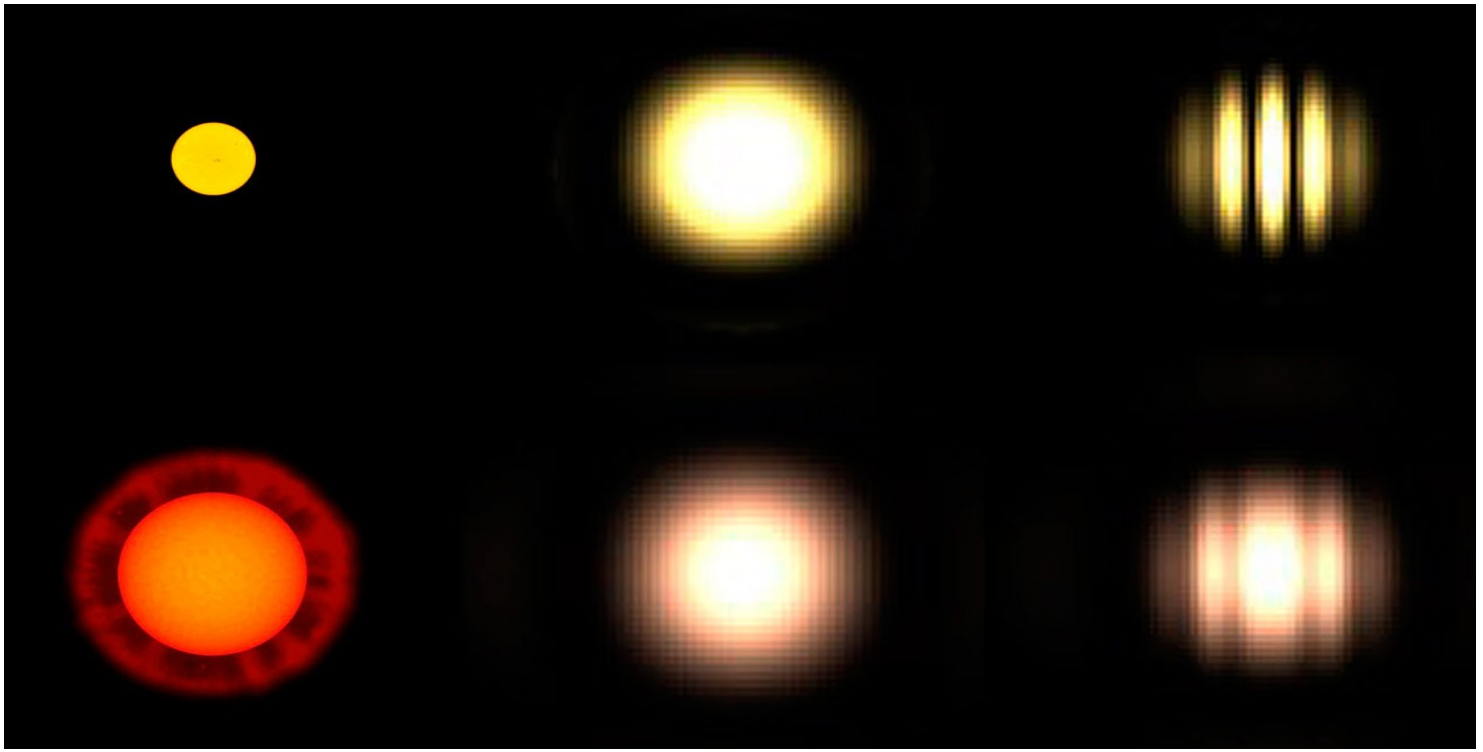
Credits: Stigmatella aurantiaca and wikipedia

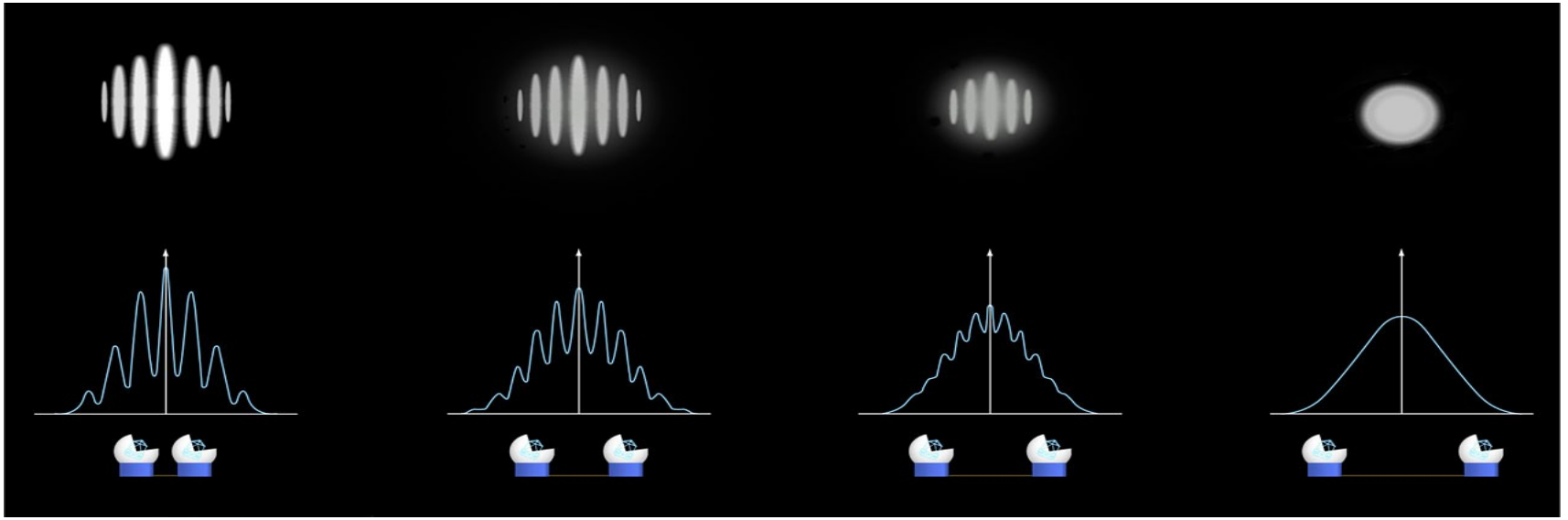
$$V = \frac{2J_1(x)}{x}$$

$$x = \pi B \theta \lambda^{-1}$$

Angular diameter

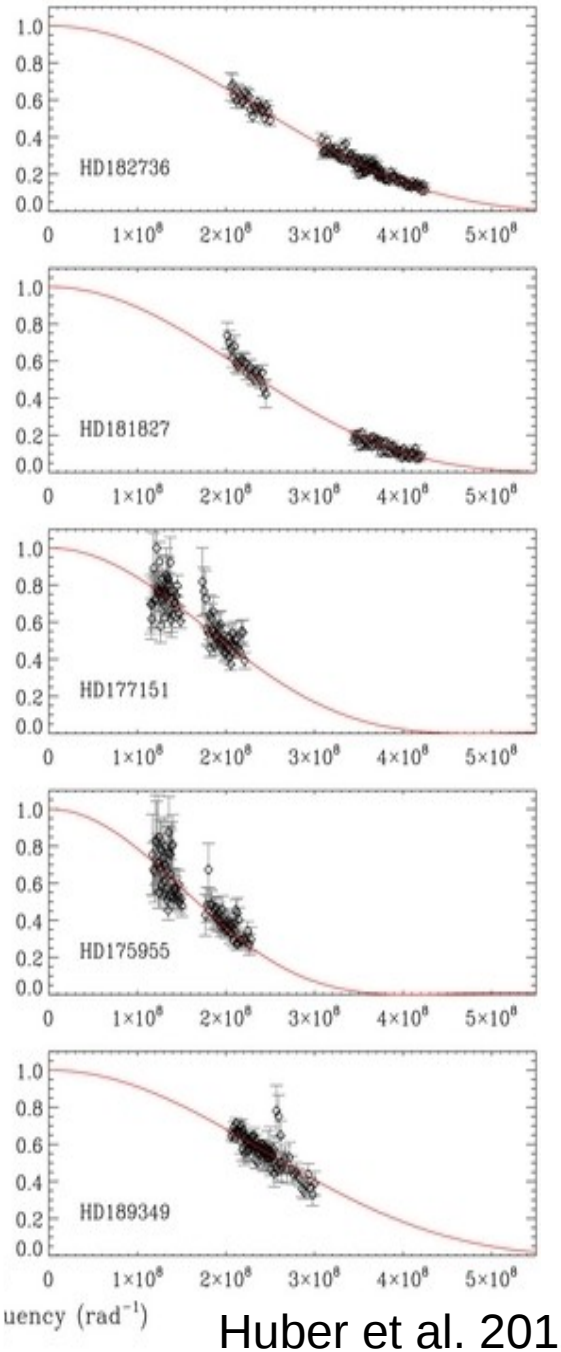
Note: also sensitive to limb-darkening!!



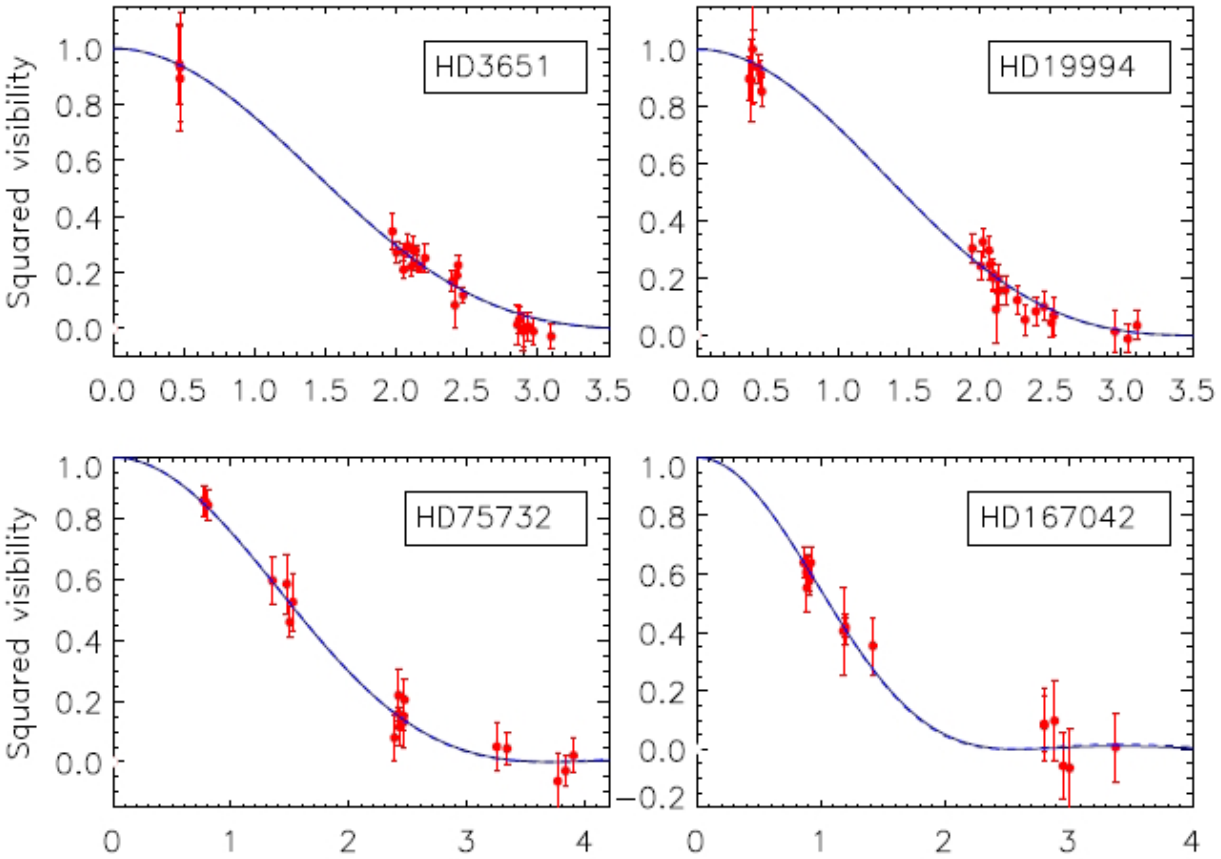


https://cdn.eso.org/images/screen/eso0111e.jpg

V2 curves



Huber et al. 2012



Ligi et al. 2016

Interferometry

- 2+ telescopes creates a large 'mirror'
- measure interference patterns and their contrast
- High angular resolution
- Angular Diameters -> teff, R
- Orbits -> binaries

Angular diameters

$$R = \frac{\theta}{\pi}$$

$$T_{\rm eff} = \left(\frac{4}{\sigma_{\rm SB}} \frac{F_{\rm bol}}{\theta^2} \right)^{0.25}$$

Radius : direct constraint for mass, age, and logg
: direct comparison with seismic R

Teff : direct determination only mildly dependent on models (flux)

Teff & logg : abundance analyses

Teff & R : mixing-length parameter
:"observable" constraints
For age

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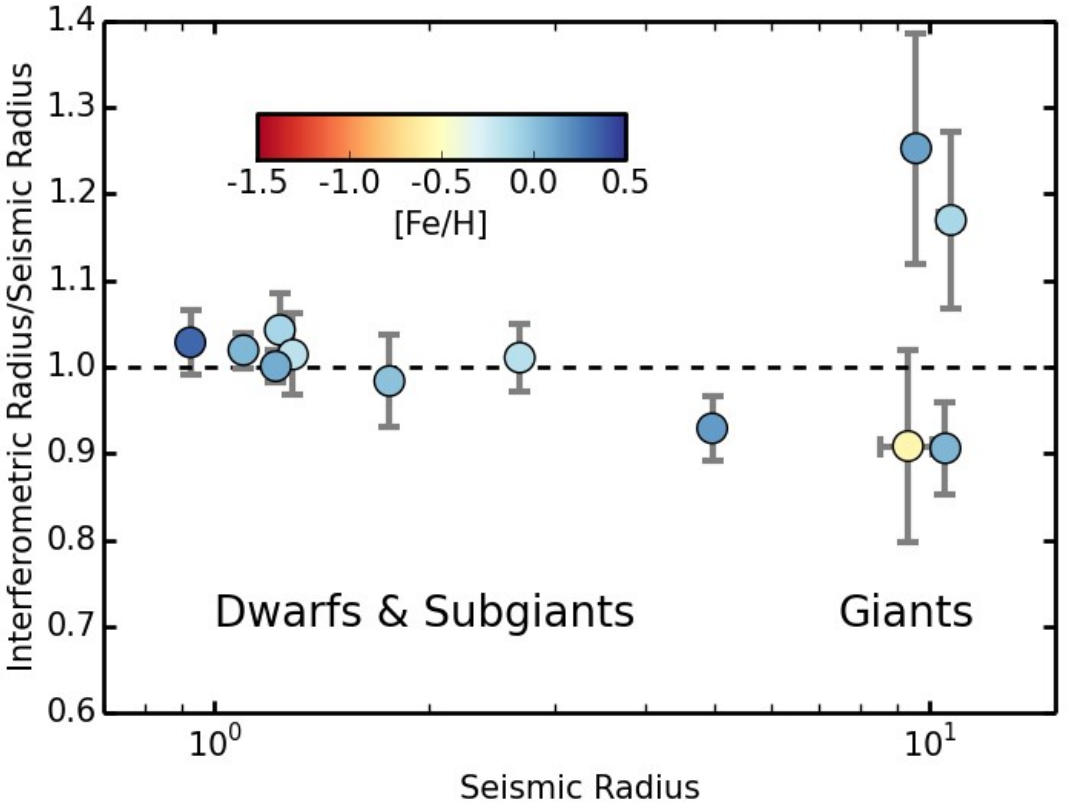
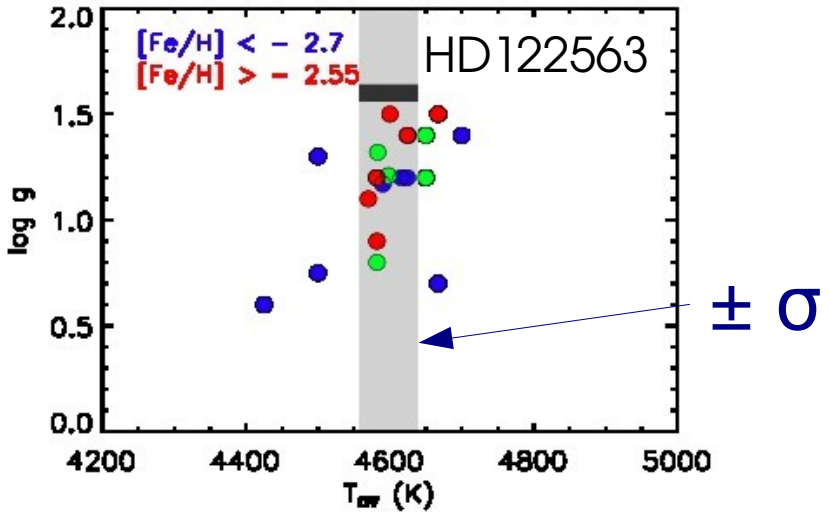
Comparison of seismic/interferometric radii



Huber et al. 2012 (adapted)

Precision/Accuracy



Creevey et al. 2012

Heiter et al. 2015

Name	θ_{LD} [mas]	$u(\theta_{LD})$	$\%u(\theta_{LD})$
F dwarfs			
Procyon	5.390	0.030	0.6
HD 84937	0.153	0.005	3.0
HD 49933	0.445	0.012	2.7
FGK subgiants			
δ Eri	2.394	0.029	1.2
HD 140283	0.353	0.013	3.7
ϵ For	0.788	0.016	2.0
η Boo	2.189	0.014	0.6
β Hyi	2.257	0.019	0.8
G dwarfs			
α Cen A	8.511	0.020	0.2
HD 22879	0.382	0.011	3.0
μ Cas	0.973	0.009	0.9
τ Cet	2.015	0.011	0.5
α Cen B	6.000	0.021	0.4
18 Sco	0.676	0.006	0.9
μ Ara	0.763	0.015	2.0
β Vir	1.450	0.018	1.2
K dwarfs			
ϵ Eri	2.126	0.014	0.7
Gmb 1830	0.679	0.015	2.2
61 Cyg A	1.775	0.013	0.7
61 Cyg B	1.581	0.022	1.4

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Current/Usable Instruments

	baselines	T, bands	nm	Angular resolution	
NPOI	16-97/432	2, 16	550 - 850	1/0.2	V < 6.5
VLTI PIONIER	46–132 11–132	4, 6	H / K band	0.8–20	H < 8
GRAVITY		4, Simul.star/ calib	K band 2-2.4mum R=44,500, 4000	2-30 10-100 muas (astrometry)	K < 9.5*, 6.5
CHARA Classic CLIMB MIRC	34–330	 2-3, 1 6, N	 J,H,K H,K	1-5 0.7-4	H,K<9.5
VEGA PAVO FRIEND		2-4, 1-16	V,R	0.2-3 mas	V<8

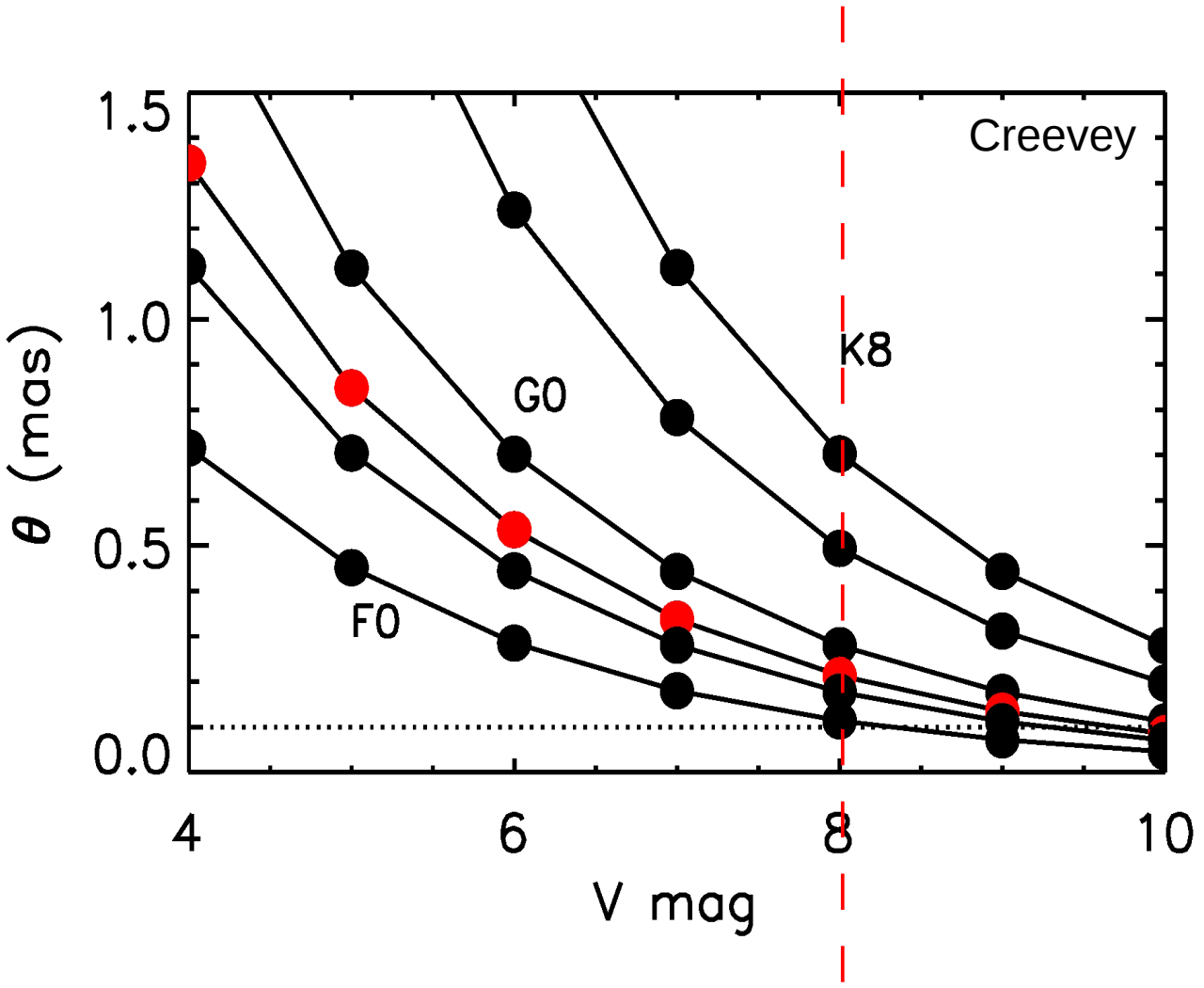
Amber/midi
MATISSE: spectral information: image reconstruction

Small sample of Programs

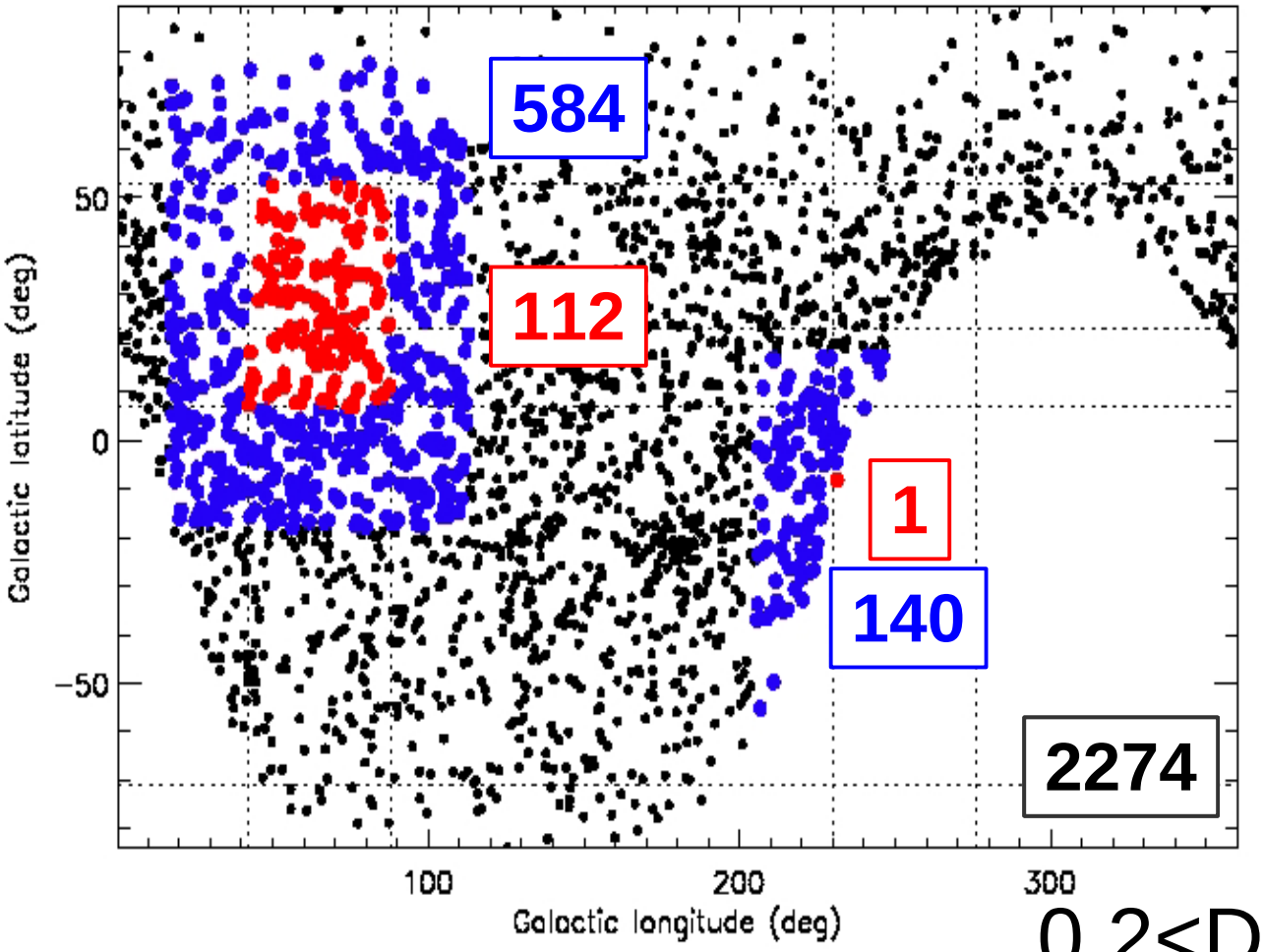
- Lots in the literature: but filtering for PLATO core program stars, less
  - Richichi et al. 2005, Boyajian et al. 2012, 2013,

    Baines et al., White et al. 2013, Huber et al. 2012, Creevey et al.2012, 2015, Ligi et al. 2016, Heiter et al. 2015, ...
- MS stars: mostly CHARA higher angular resolution
  - Exoplanet, seismic, (giants), cool,...
- Surface Brightness relations: predicting theta

Predicted Diameters of PLATO



Estimates of targets (< 2 Rsol)

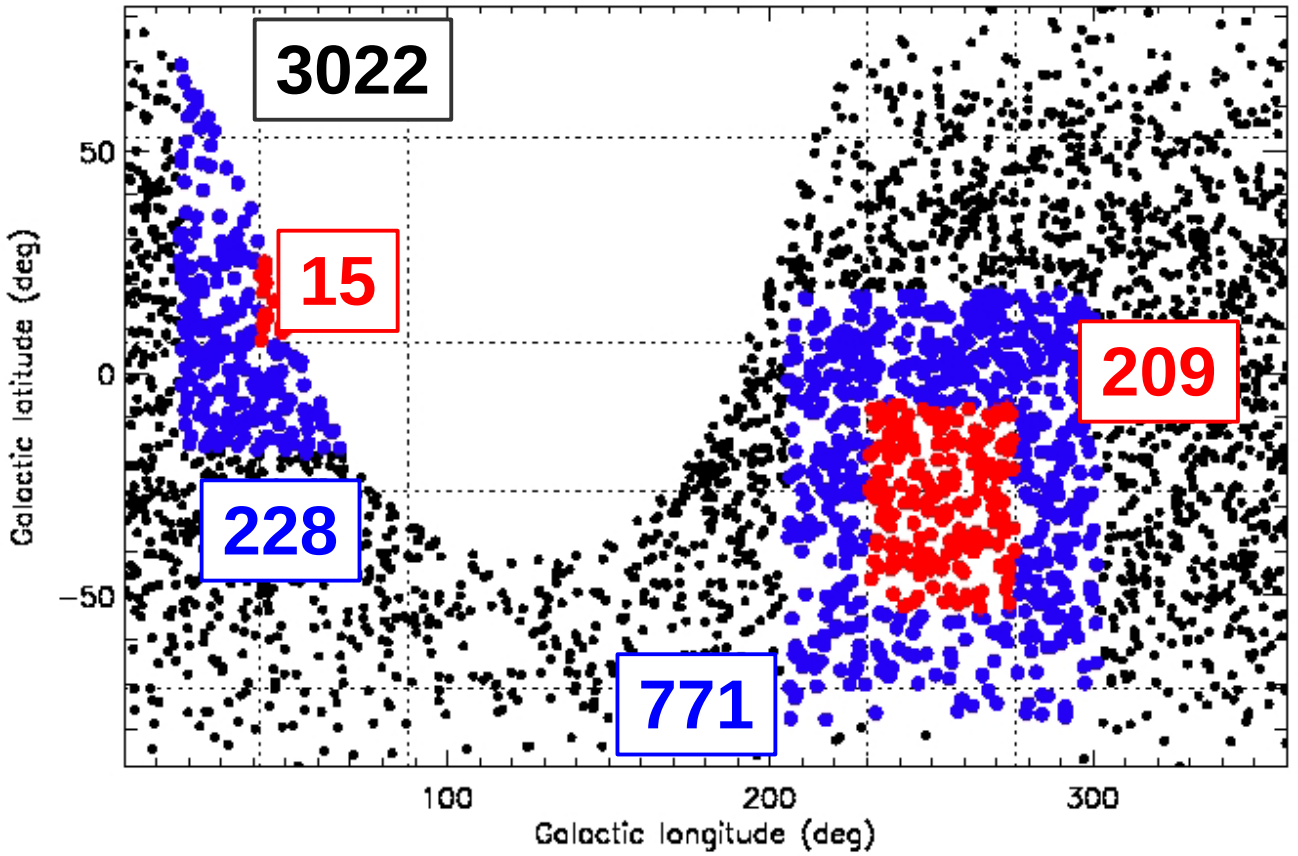


CHARA/PTI

0.2<D<3.0mas

Dec>-20

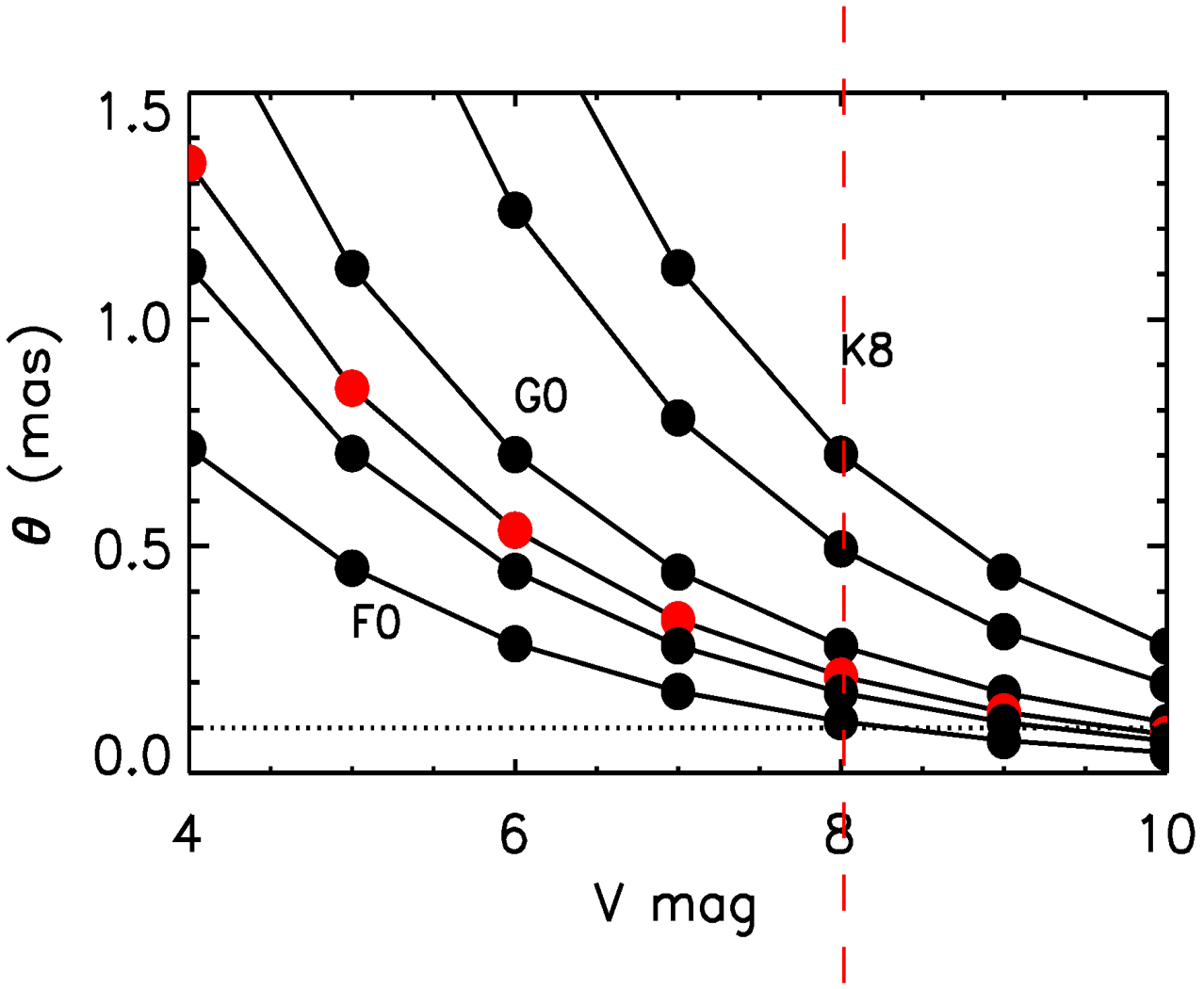
Estimates of targets (< 2 Rsol)



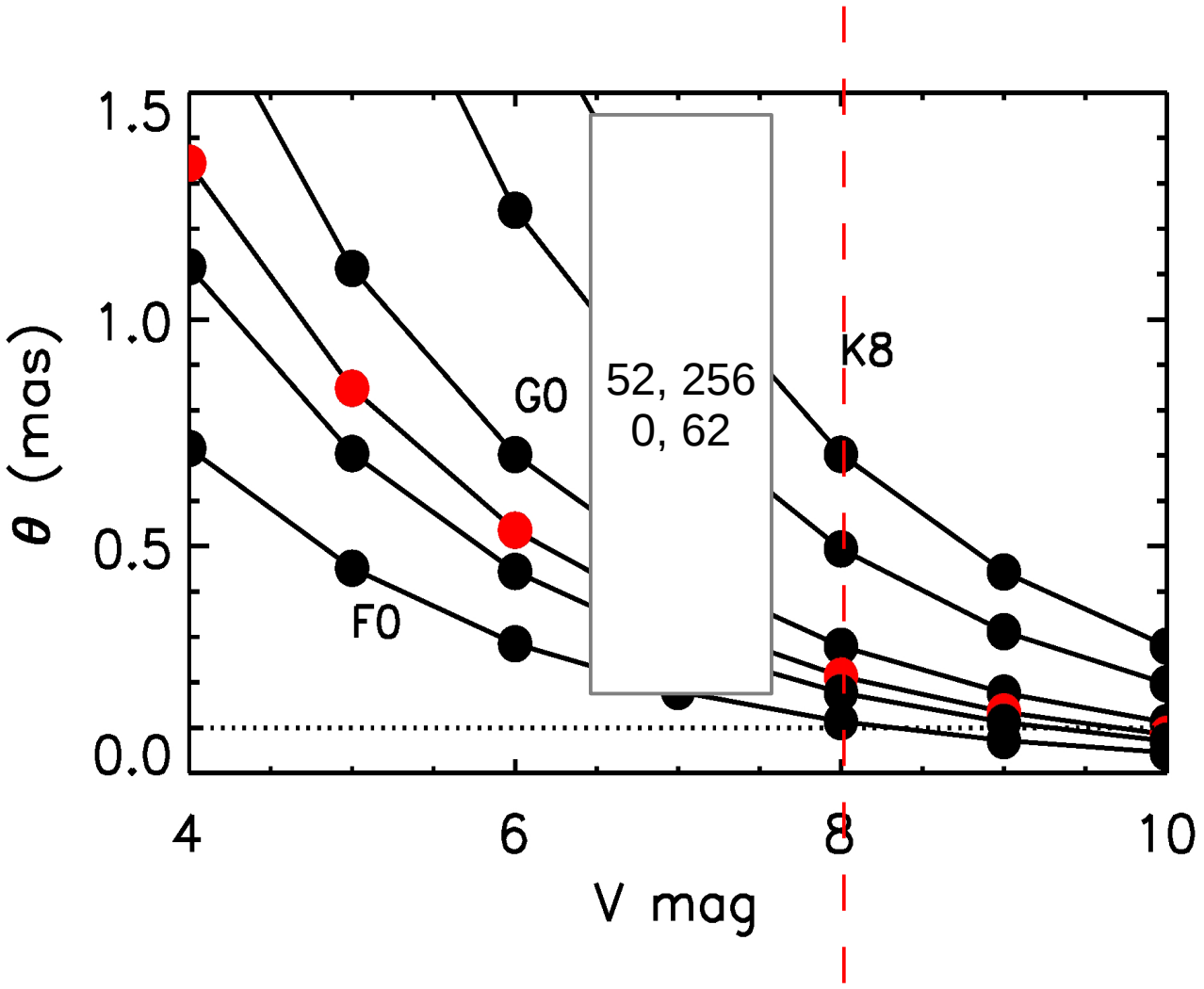
VLTI - south

- 1.0<D<6.0mas

Predicted Diameters of PLATO



Predicted Diameters of PLATO



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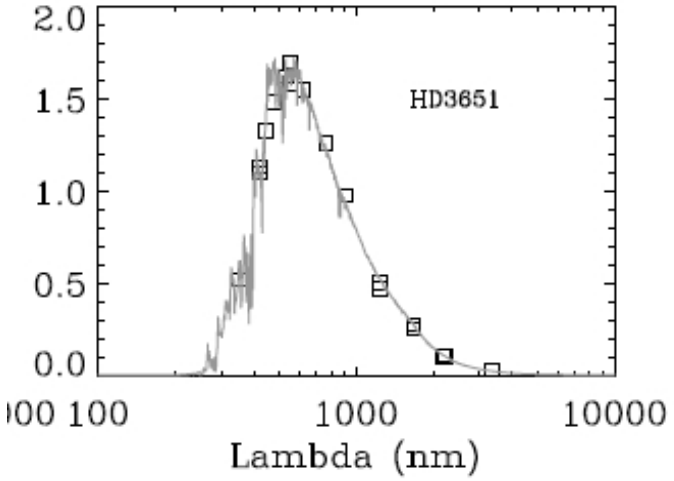
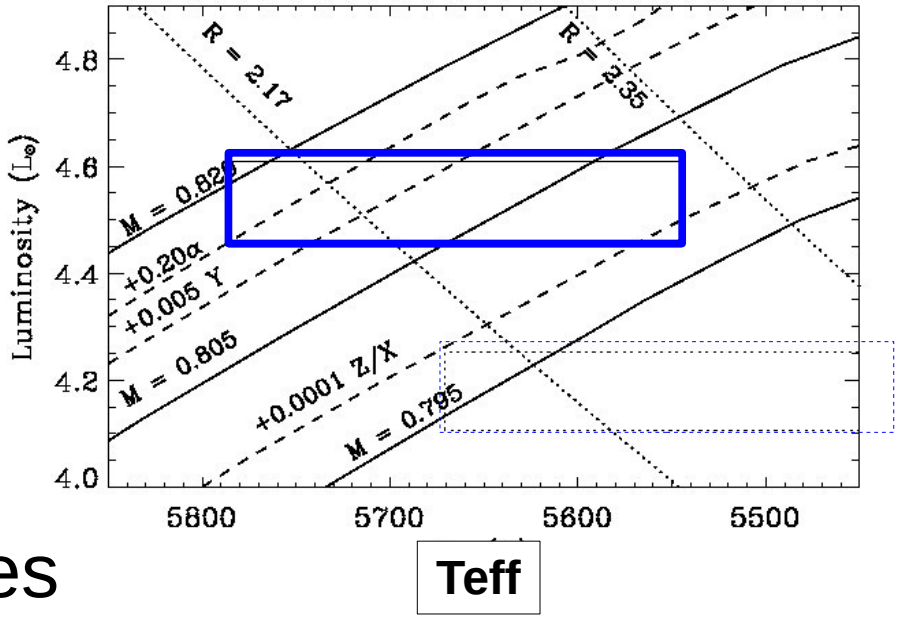
Be careful ...

- Difficulties, such as Fbol, Av, limb-darkening

Ligi et al. 2016

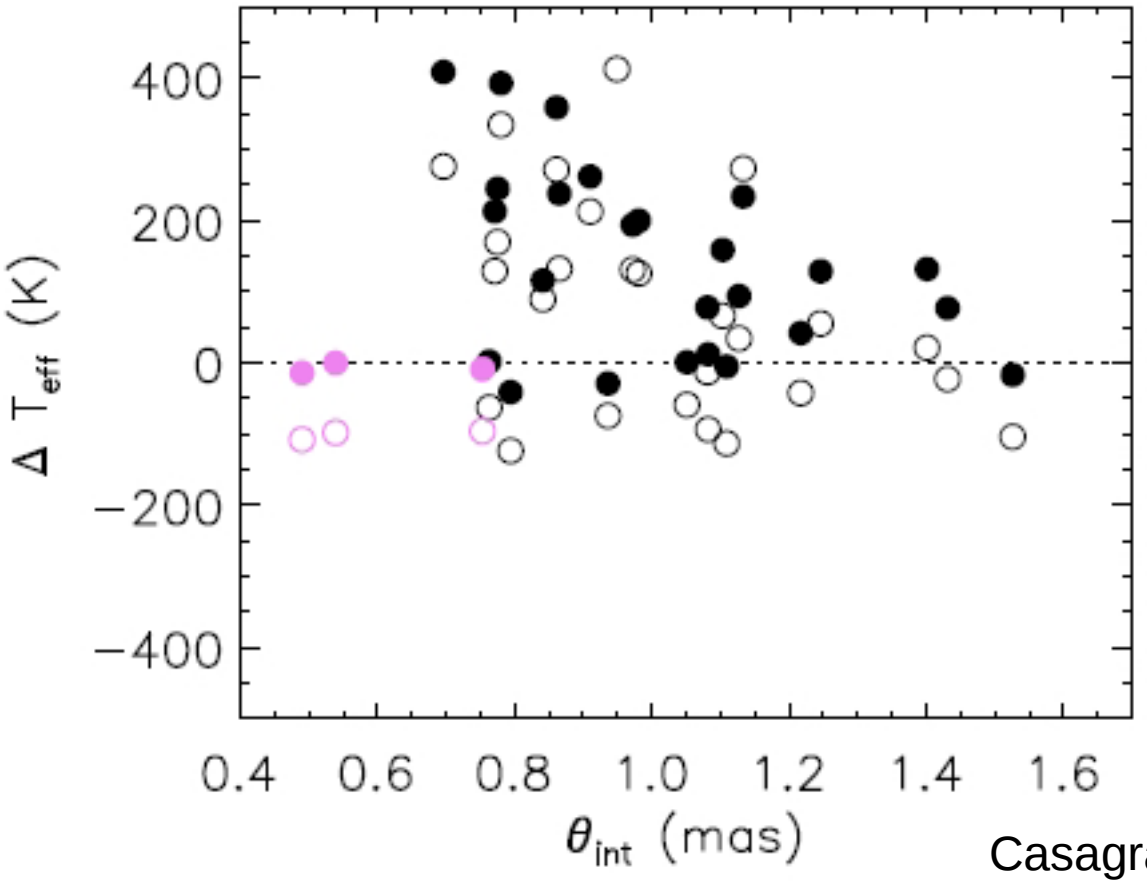


Creevey et al. 2015



- Calibrators lead to biases
- Accuracy/Precision >0.5%

Careful control of systematics



Casagrande et al. 2014

Comparison of theta from interferometry and IRFM:
Current effort at overlapping stars (White, Creevey, Boyajian, ..)

And to keep in mind ...

- Binaries
- Limb-darkening
- Gaia preparation

Thank you!