OBSERVATIONAL CALIBRATION OF THE PROJECTION FACTOR OF VARIABLE STARS IN THE GAIA ERA

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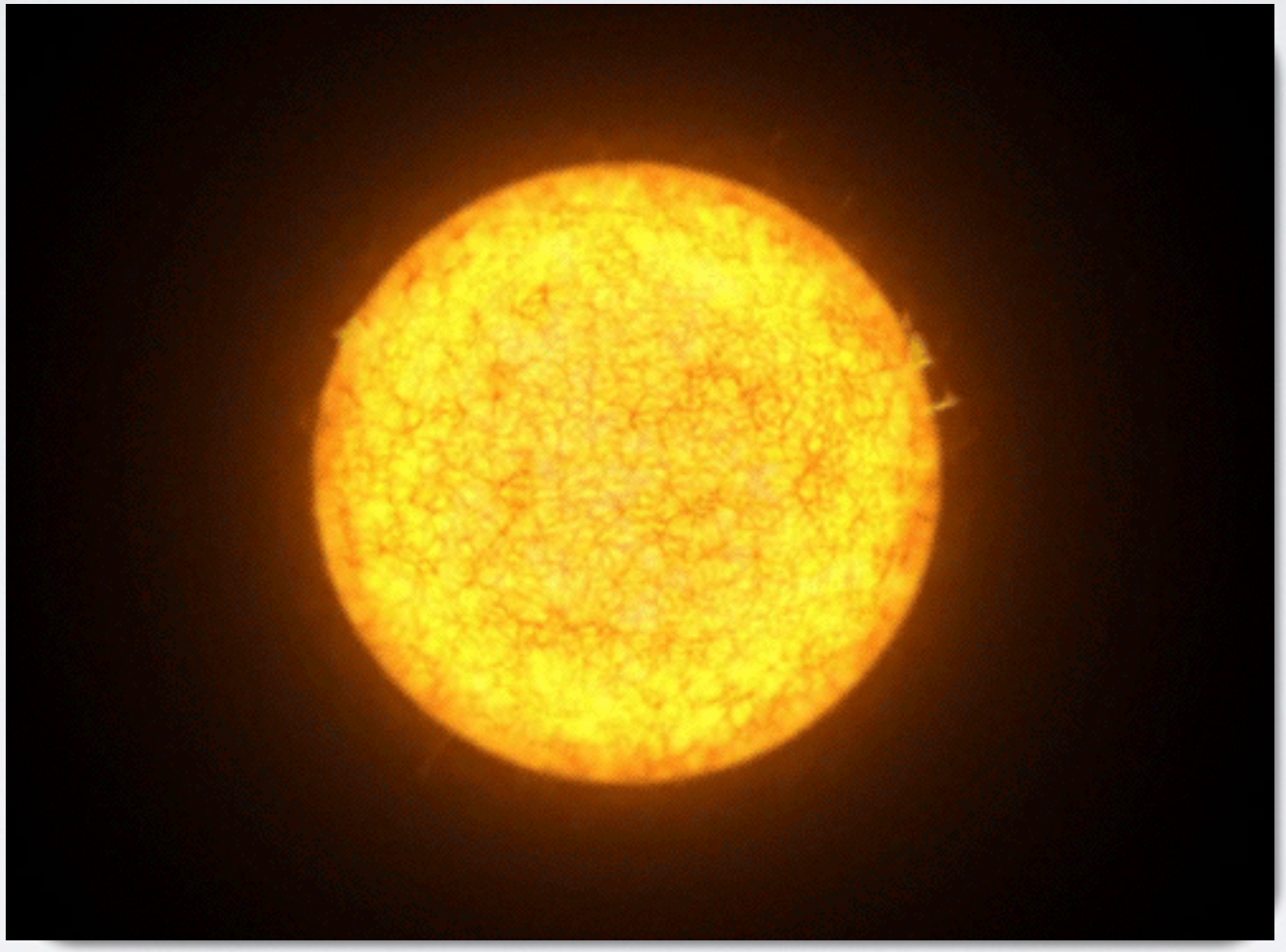
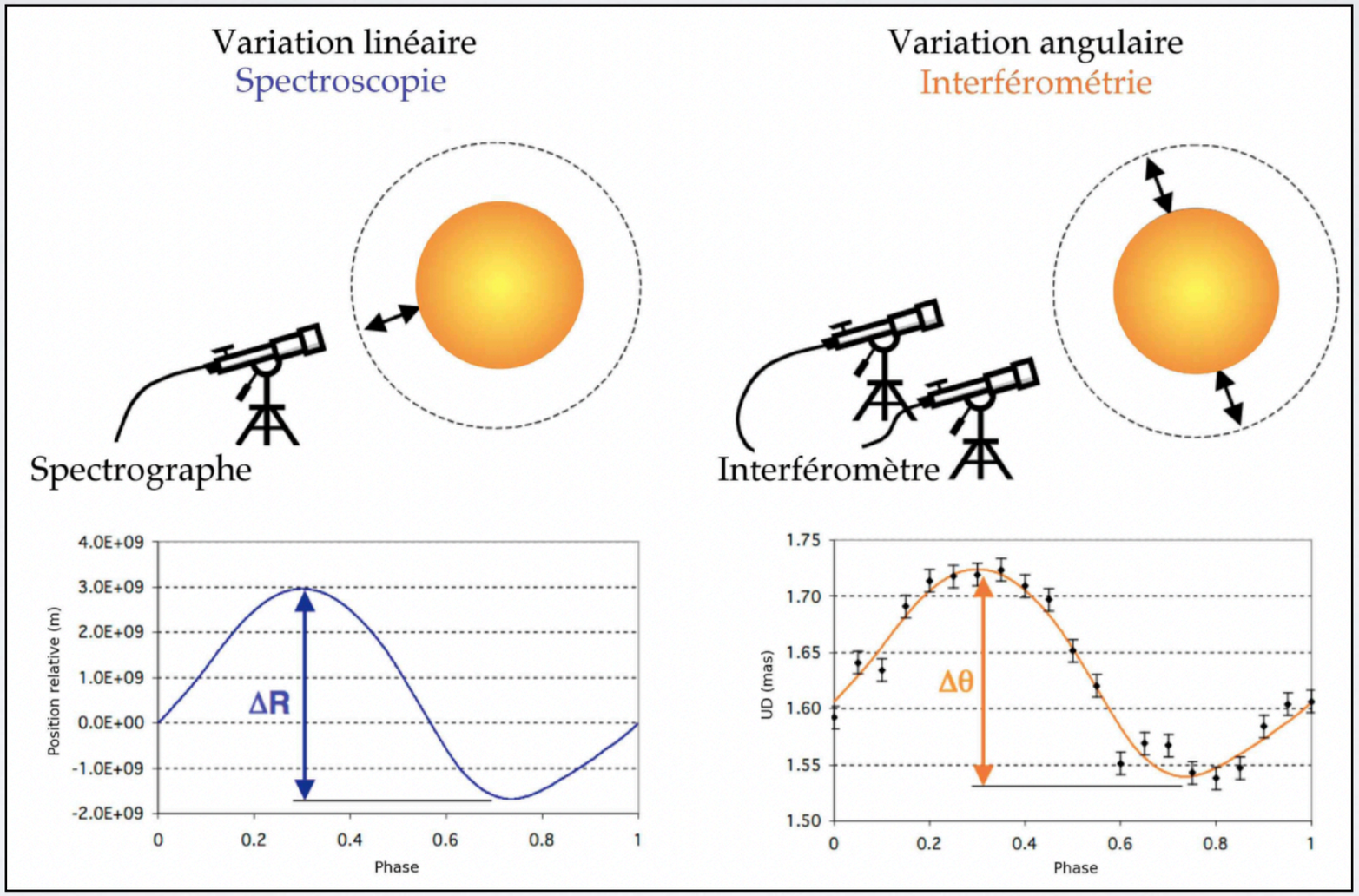


The parallaxe of pulsation

The **Parallax of Pulsation** (PoP) method compares the **integrated pulsation velocity** and **angular diameter variations** of pulsating stars (RR Lyrae, Cepheids, …), in order to derive the **distance**.

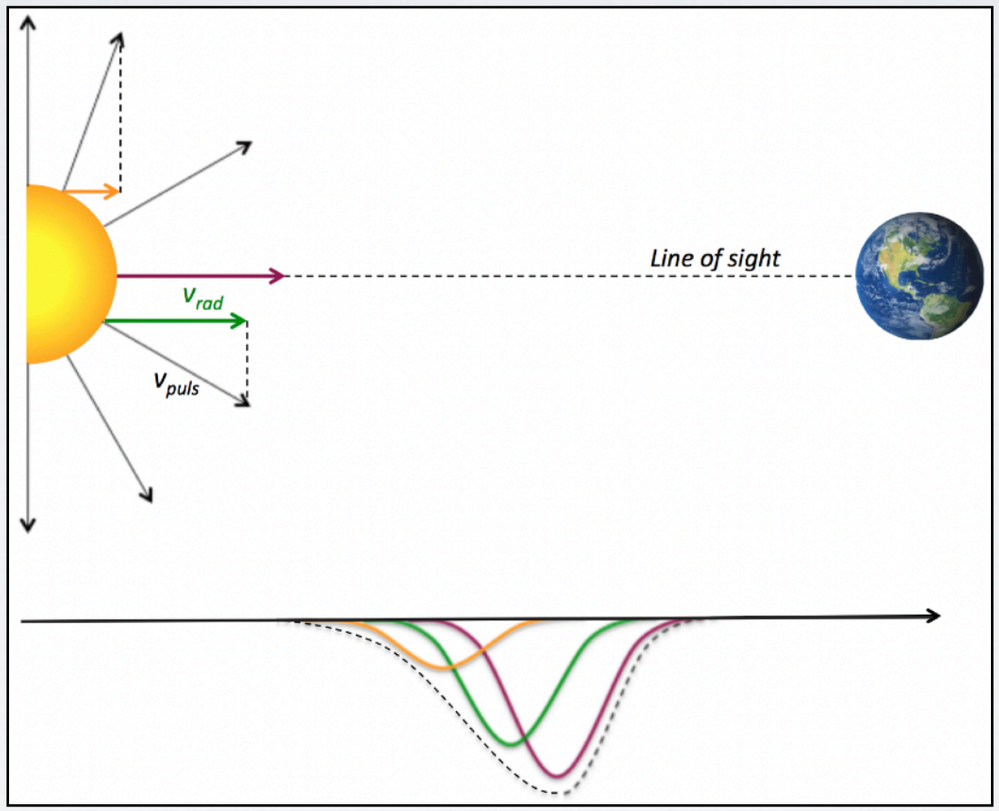


This method is central in **calibrating the Levitt's law** (Period-Luminosity relation).

Limitations on the PoP method

Most important source of errors

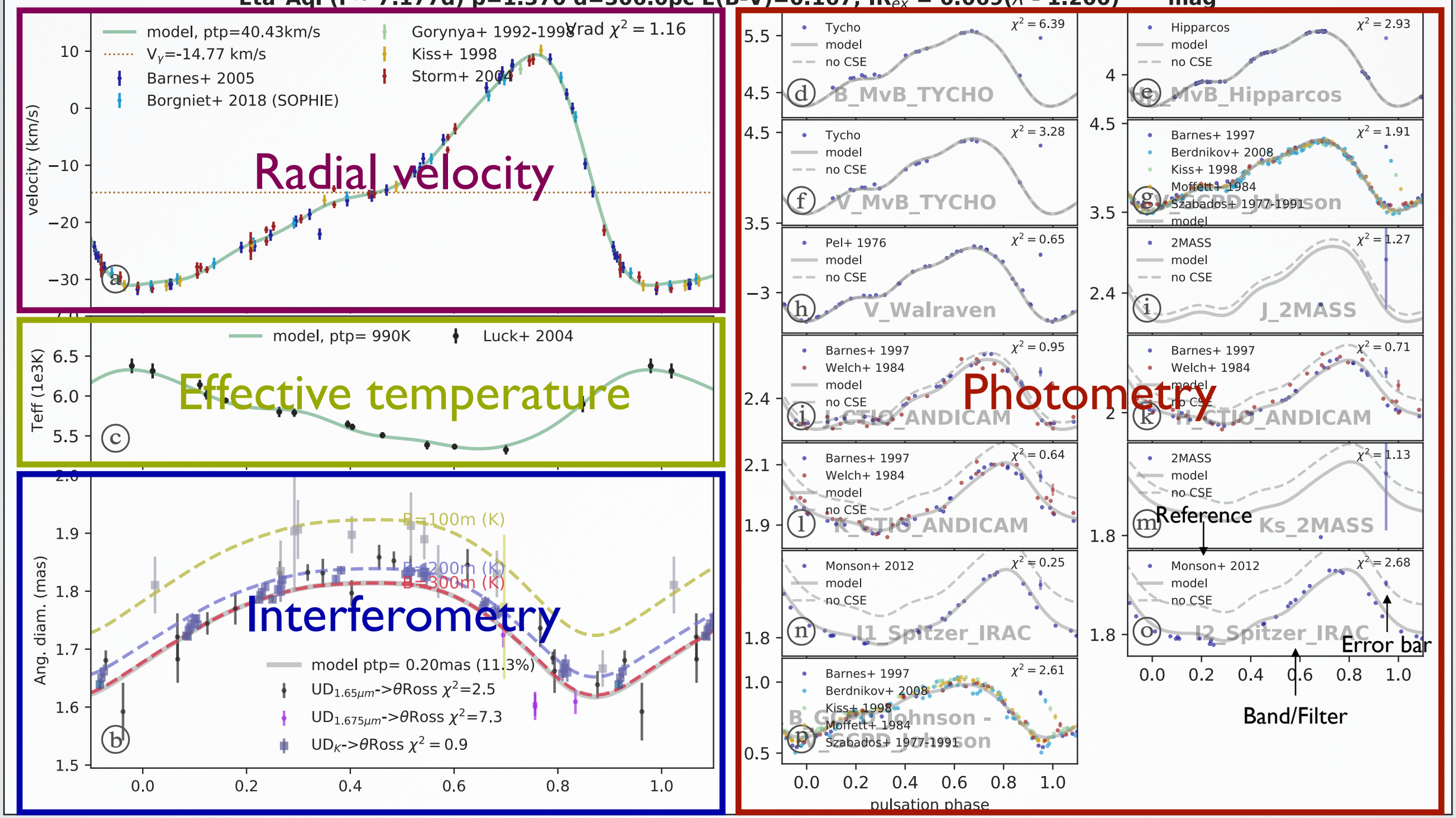
Use of a **projection factor** to estimate the pulsation velocity from the radial velocity. This parameter is still uncertain to 7% (value around 1.3): **bias to distance.**



We can add…

Only 2 photometric bands adjusted, relies reddening/SB laws still uncertain, low order interpolation, poor difficulties to combine data with poor phase coverage, etc… leading to **too simplistic assumptions, poor statistical significances and biases to the distance**

SpectroPhotoInterferometry of Pulsating Stars

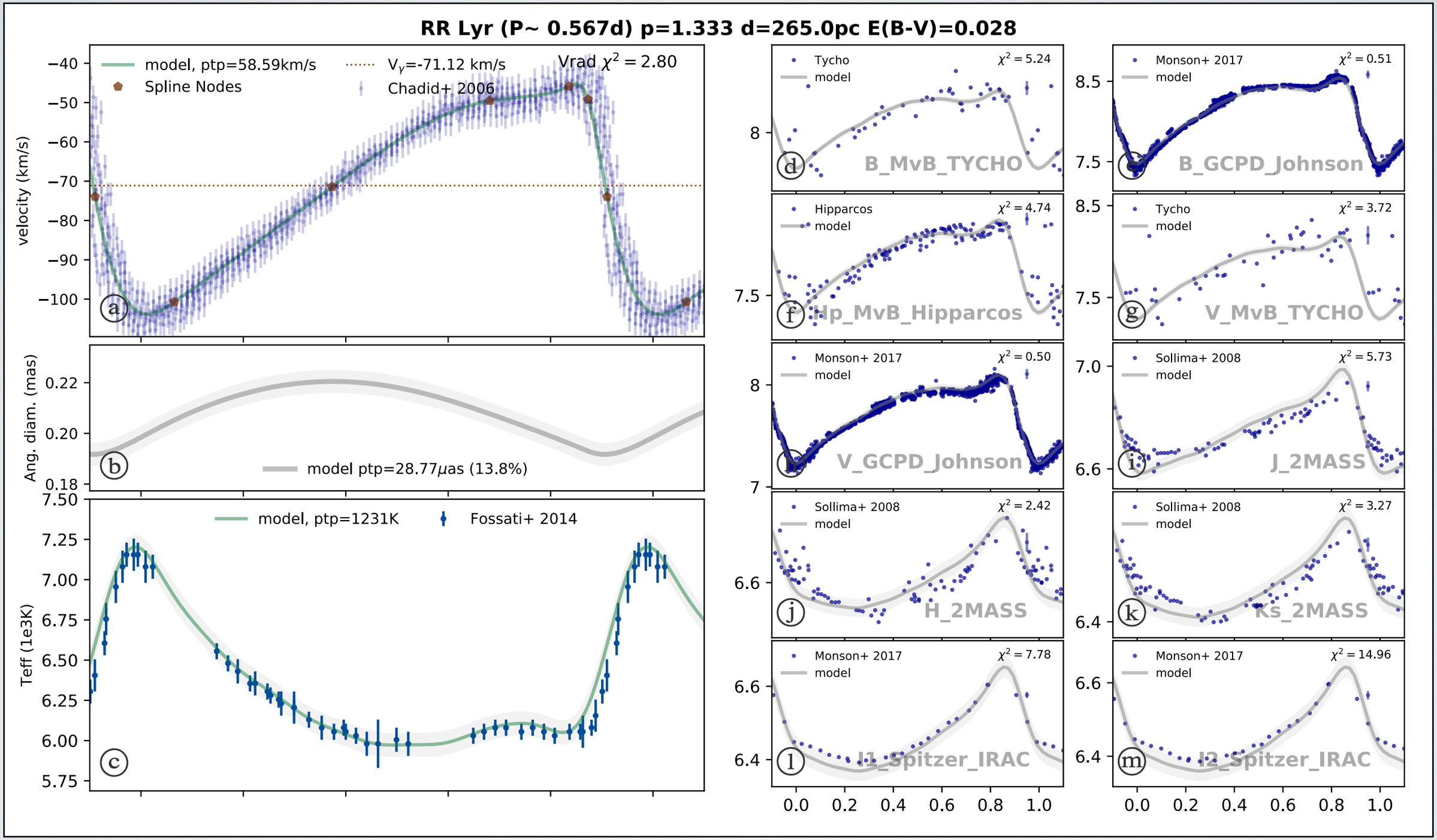


Combinaison of **all data** possible

Simultaneous fit of all parameters (Vpuls(t), Teff(t), E(B-V), pfactor, period, etc…)

Atmospheric models to derive synthetic photometry from Teff

Application to RR Lyrae variables

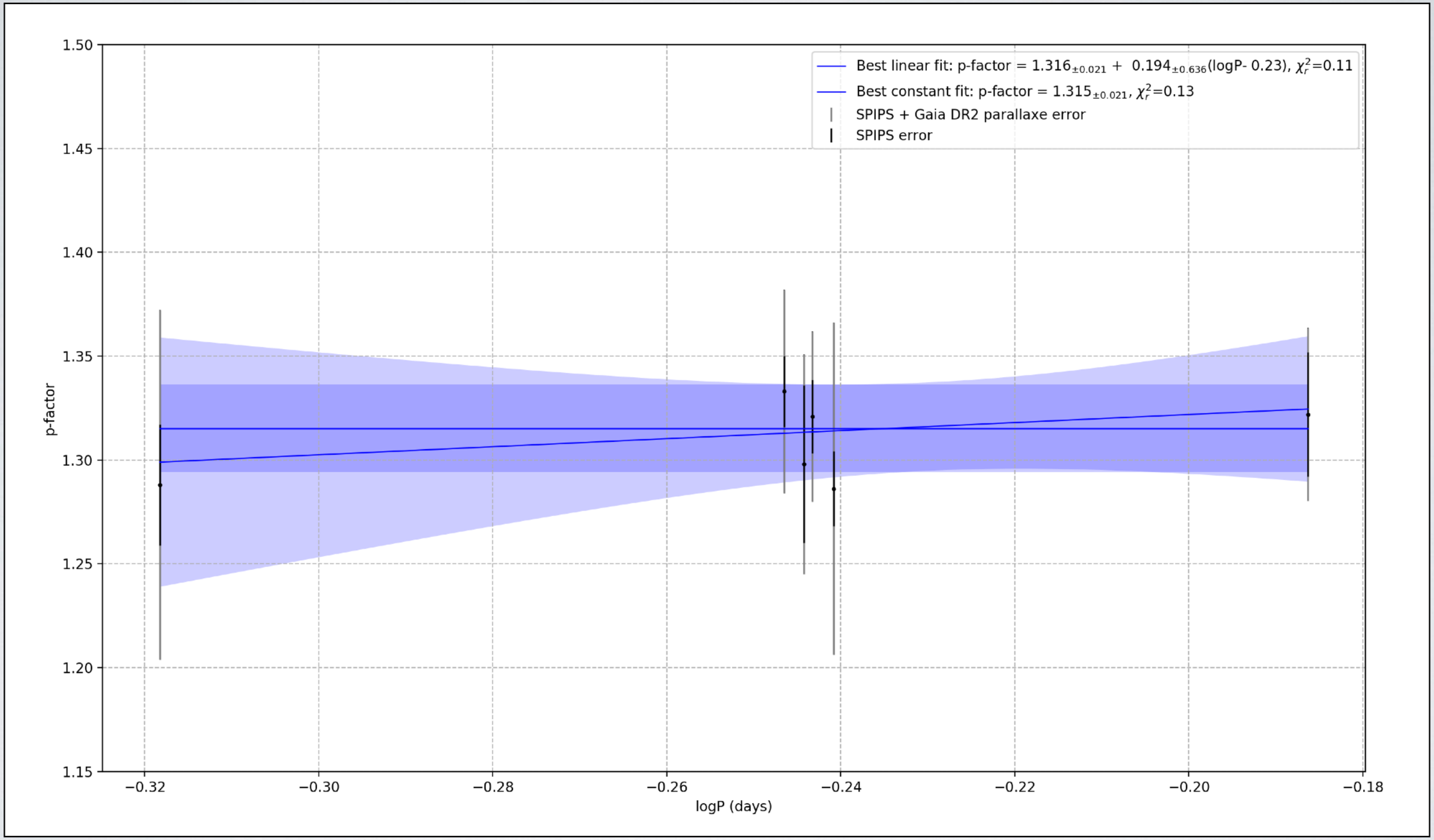


Up to now (Gaia DR2), only **RR Lyr** had a distance with a good accuracy (Benedict 2007)

But still a **lack of good dataset** (mostly IR and vrad) → poor number of useable stars for BW

Period-*p*factor relation

Selection of the sample considering Gaia DR2 quality parameters (SNR, RUWE, …)

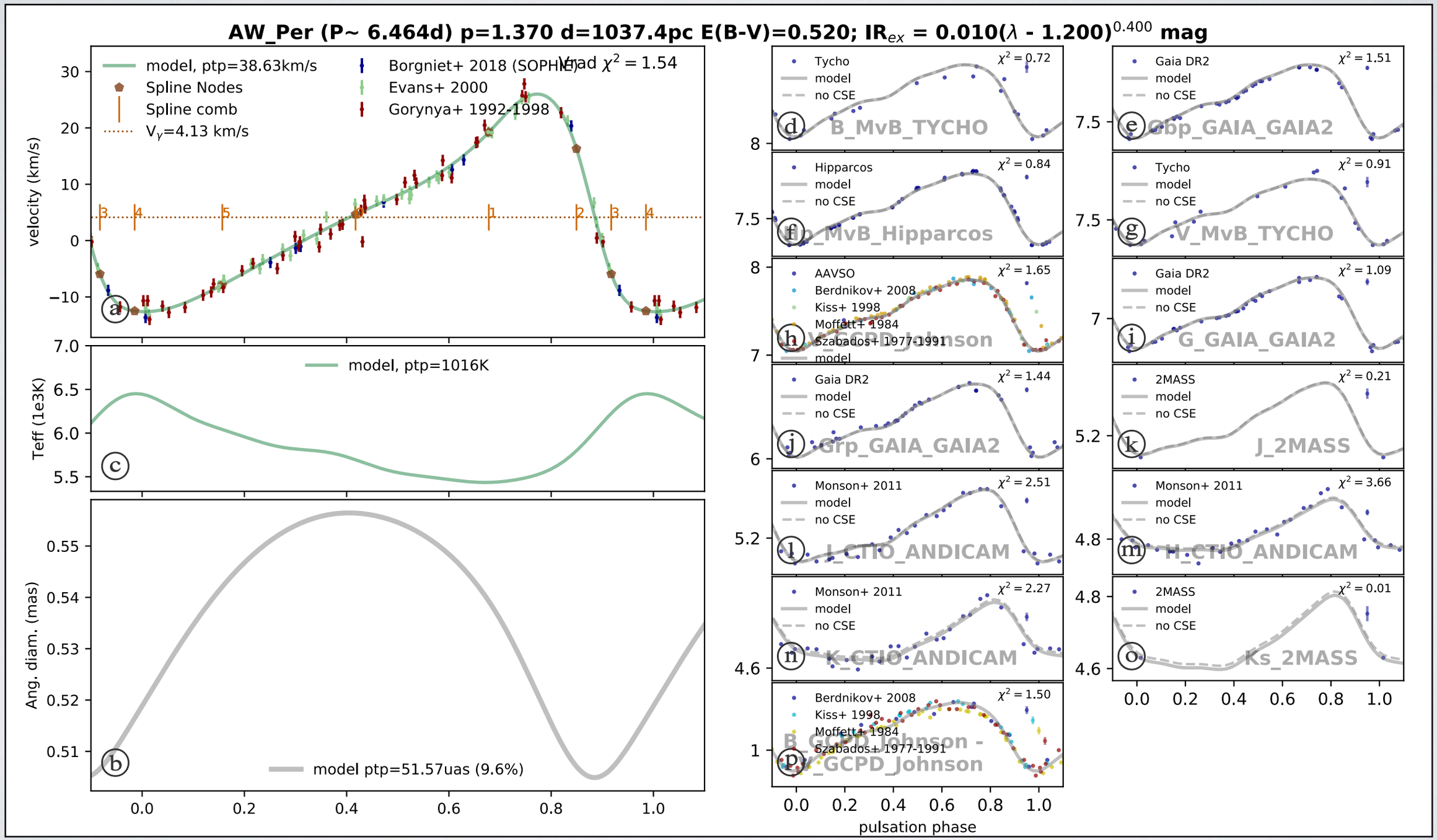


~**1-5%** of precision on the projection factor with **SPIPS+Gaia**

In the future, more precise parallaxes and more data will permit to constrain the *p*-factor of RR Lyrae stars

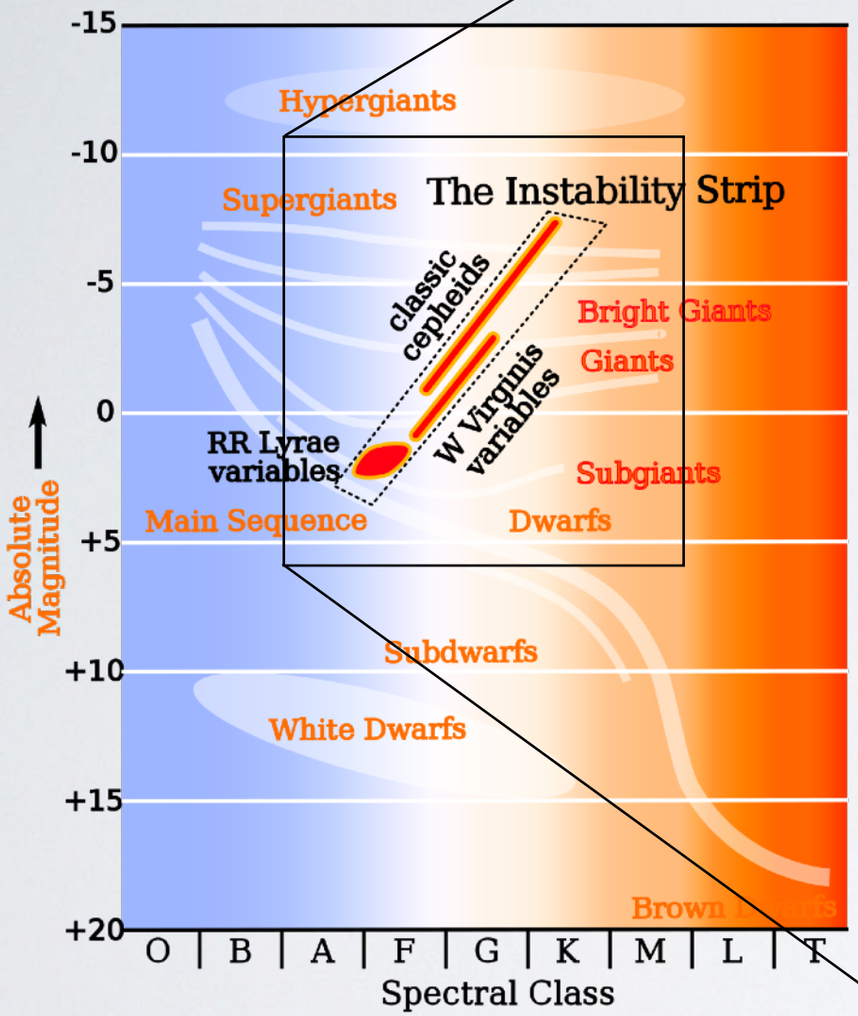
Application to Cepheids variables

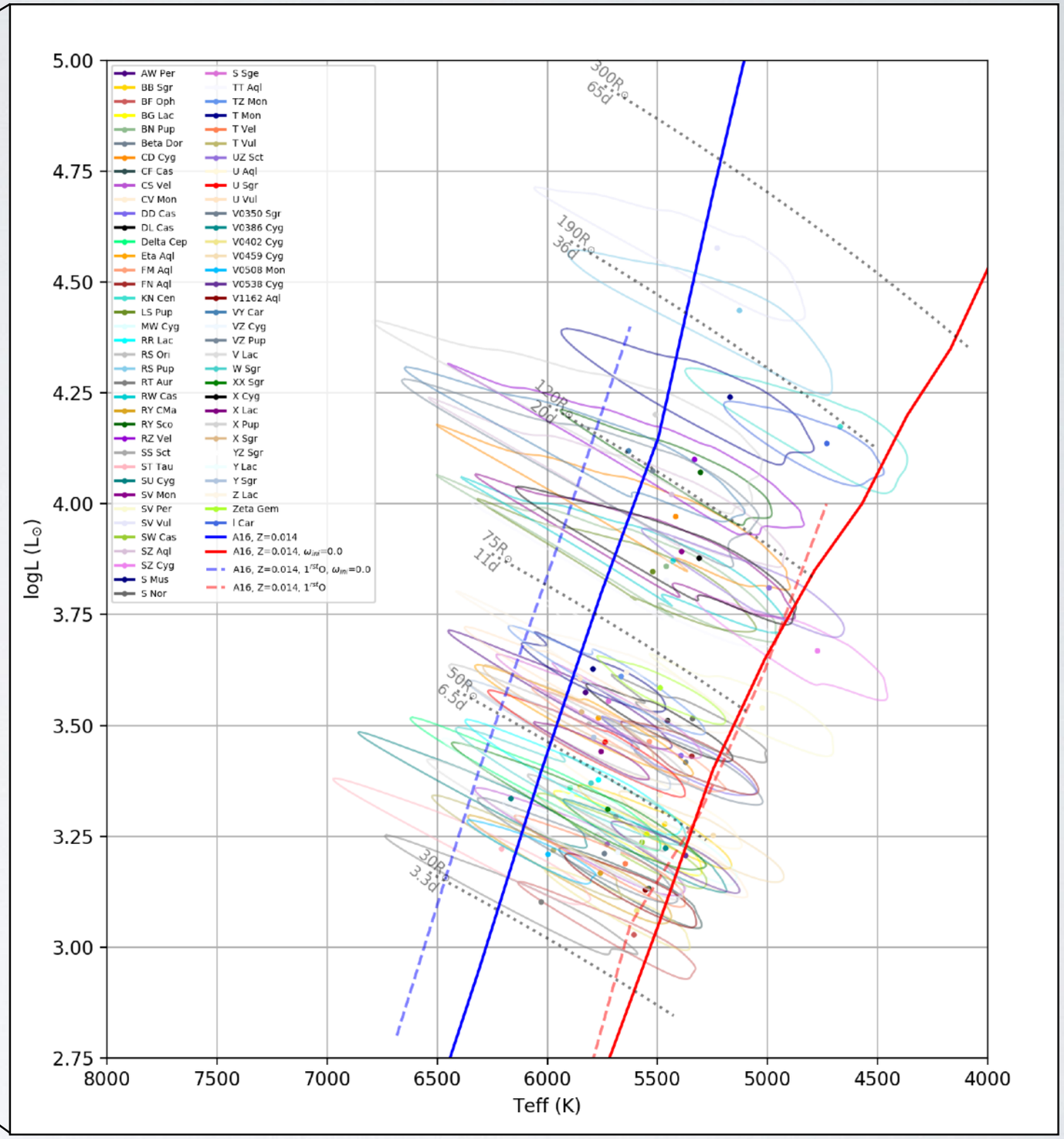
Cepheids variables = larger sample with excellent datasets, possibility to constrain the angular diameter with interferometric observations



77 Cepheids (P=3-50 days) with an excellent dataset studied with the SPIPS method (p=1.37) to derive d/p ratios and physical parameters

Position in the Hertzprung-Russell Diagram



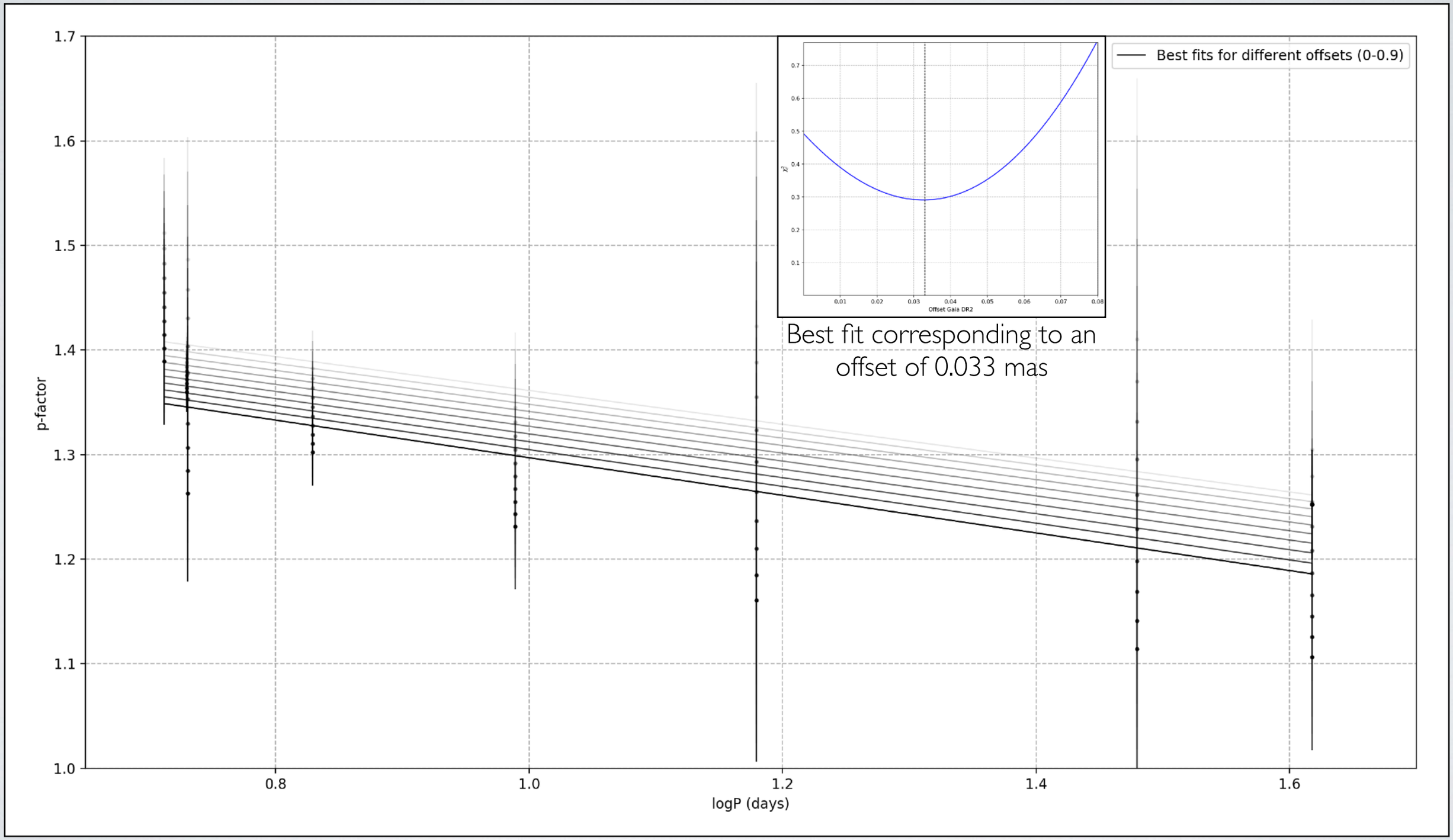


Instability strip of the HR diagram is still a blurred area

Cepheids are very dynamic objects and move significantly outside the strip during a pulsation

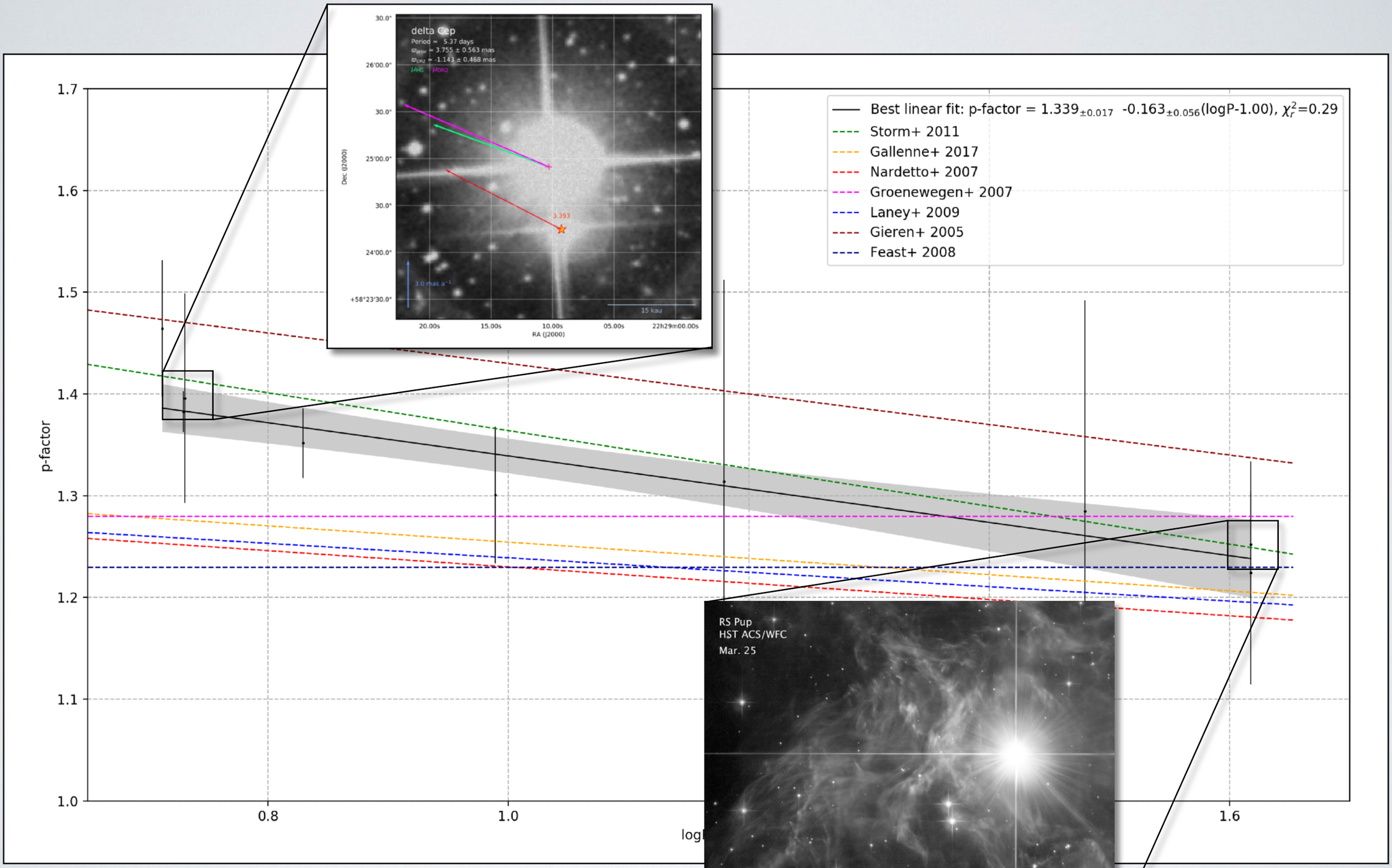
The Gaia context

Companions' parallaxes (Kervella et al. 2019) are a good alternative to Cepheids' as they are not subject to astrometric biases

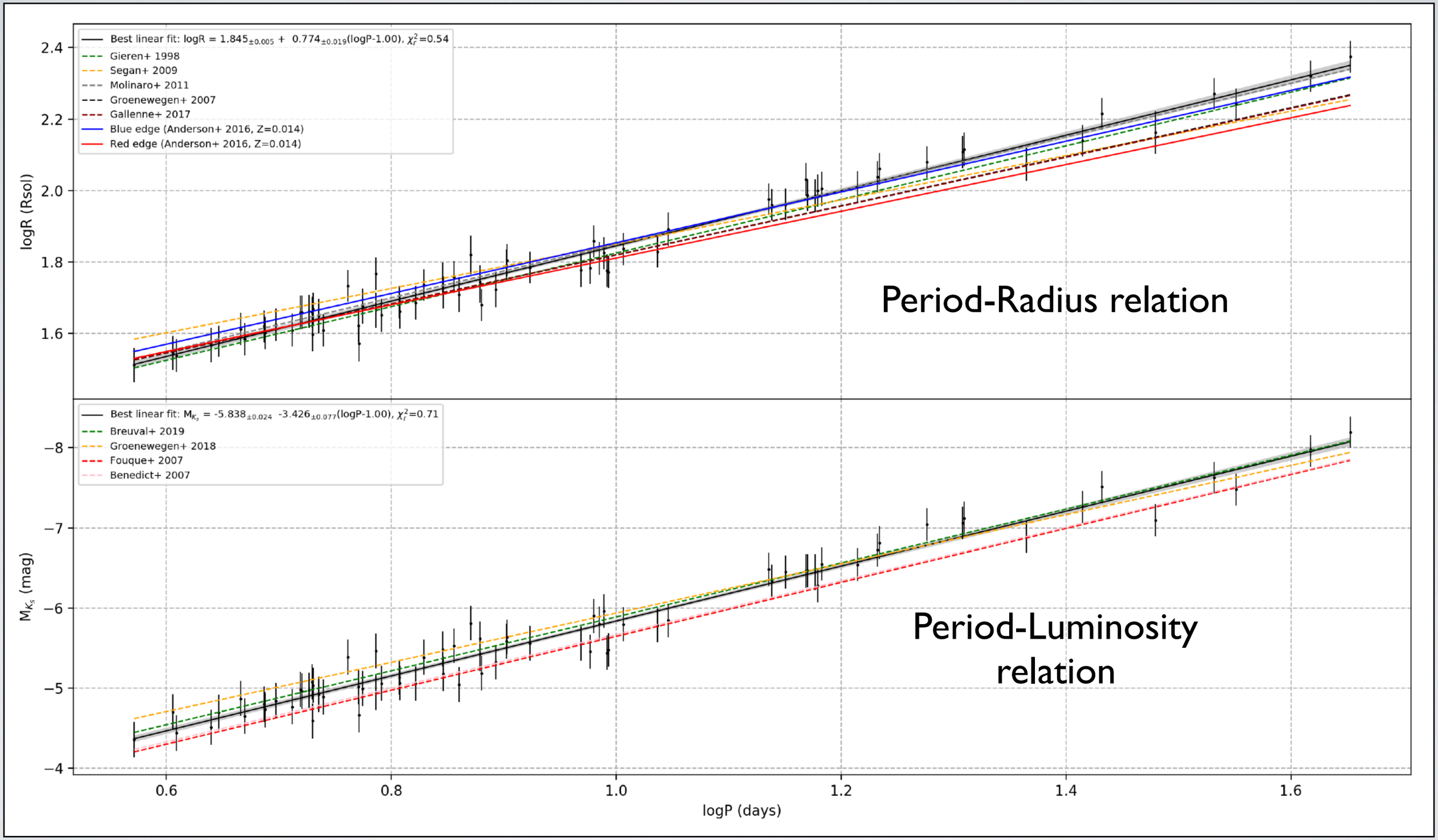


But only few of them can be used in the BW method and their small parallaxes are more uncertain and more subject to the offset

Use of Cepheids' companions to determine the *p*-factor



Determination of the PR and PL relations

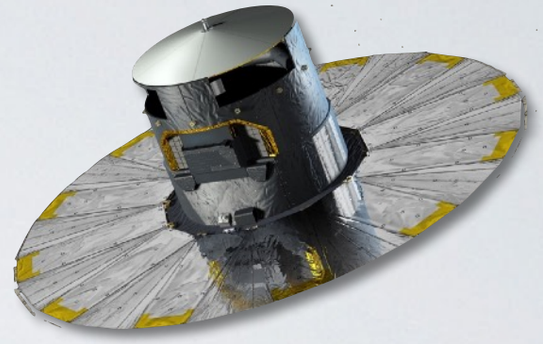


The P*p* relation determined from Companions parallaxes leads to consistent PR and PL relations with a good **precision** on the slopes and the zero-points ~**1-2%**

In the future…

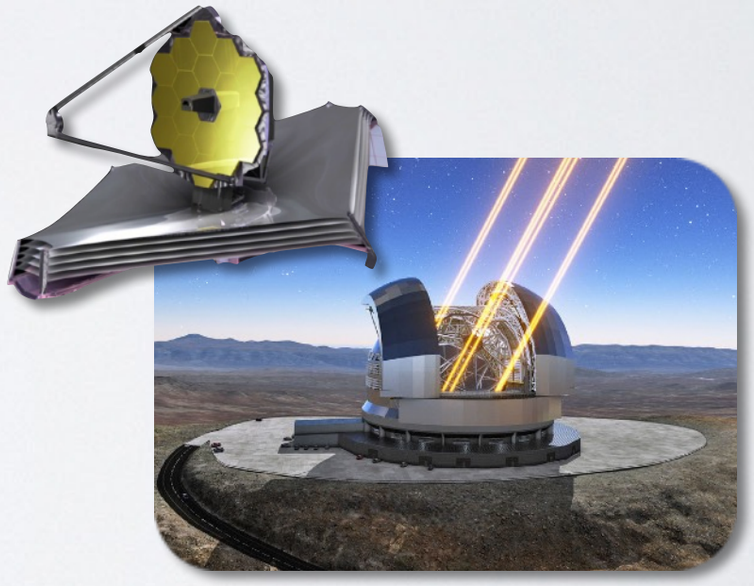
Gaia DR3 (and later)

- ⭐ More accurate **parallaxes** and **photometry**
- ⭐ **Radial velocity points with corresponding epochs**
- ⭐ **Well known offset (🙏)**



VLTI (MATISSE, GRAVITY)

- ⭐ New knowledges on variable stars' **binary systems** and **envelopes properties**



JWST, E-ELT

- ⭐ Observations with **high resolution light curves** in galaxies in the **Local Group and beyond**

All these new instruments will permit all new understanding of the physics behind variable stars and cosmology thanks to an unmatched precision of their distance scale.

Thank you