

# The Catalog of Radial Velocity Standard Stars for Gaia

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Caroline Soubiran, Gérard Jasiewicz, Laurent Chemin, Stéphane Udry,  
Françoise Crifo, Daniel Hestroffer, David Katz, Lionel Veltz



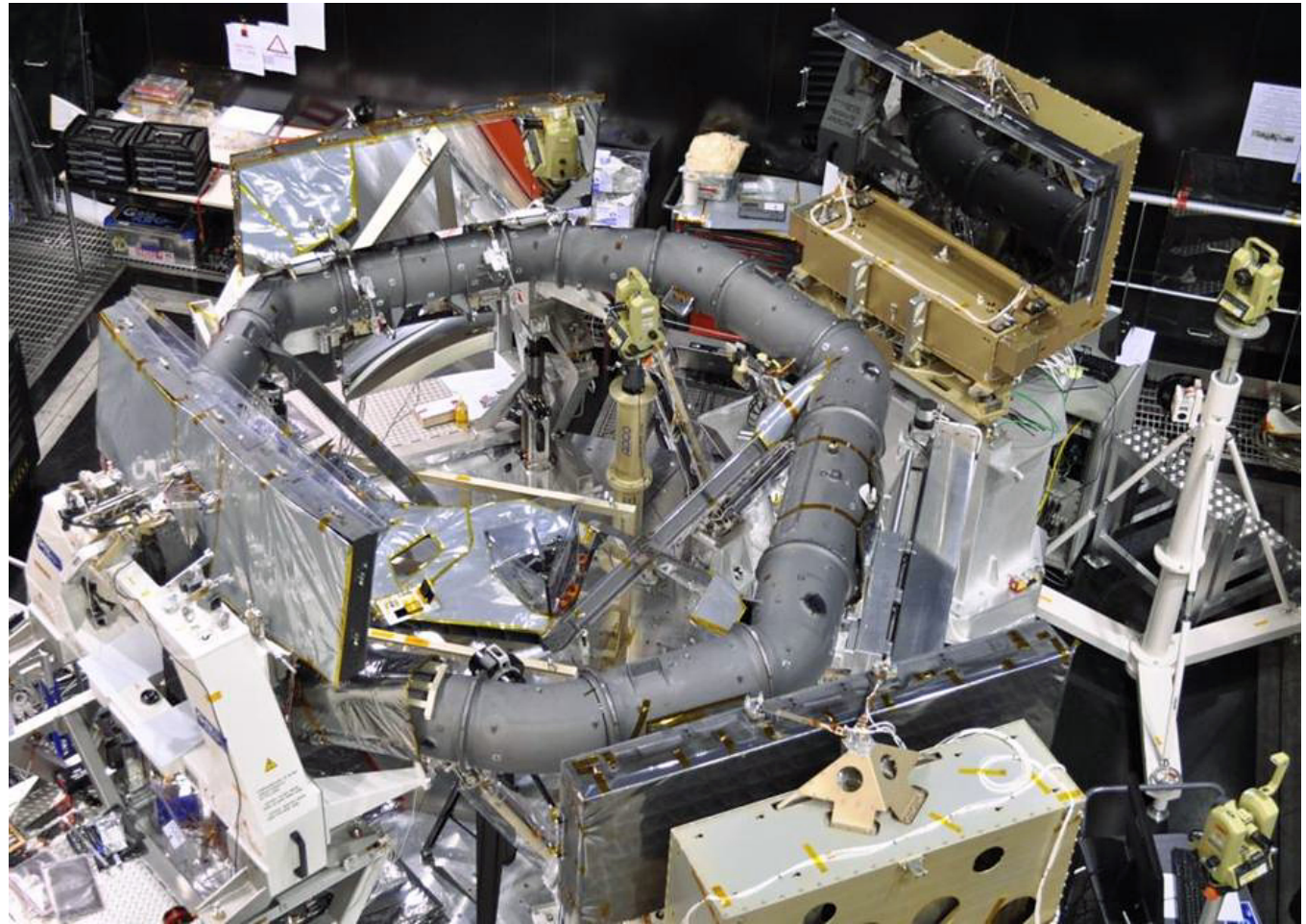
*SF2A 2012, session AS GAIA & AS GRAM, Nice, 5 June 2012*



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## Gaia news



*credit ESA*

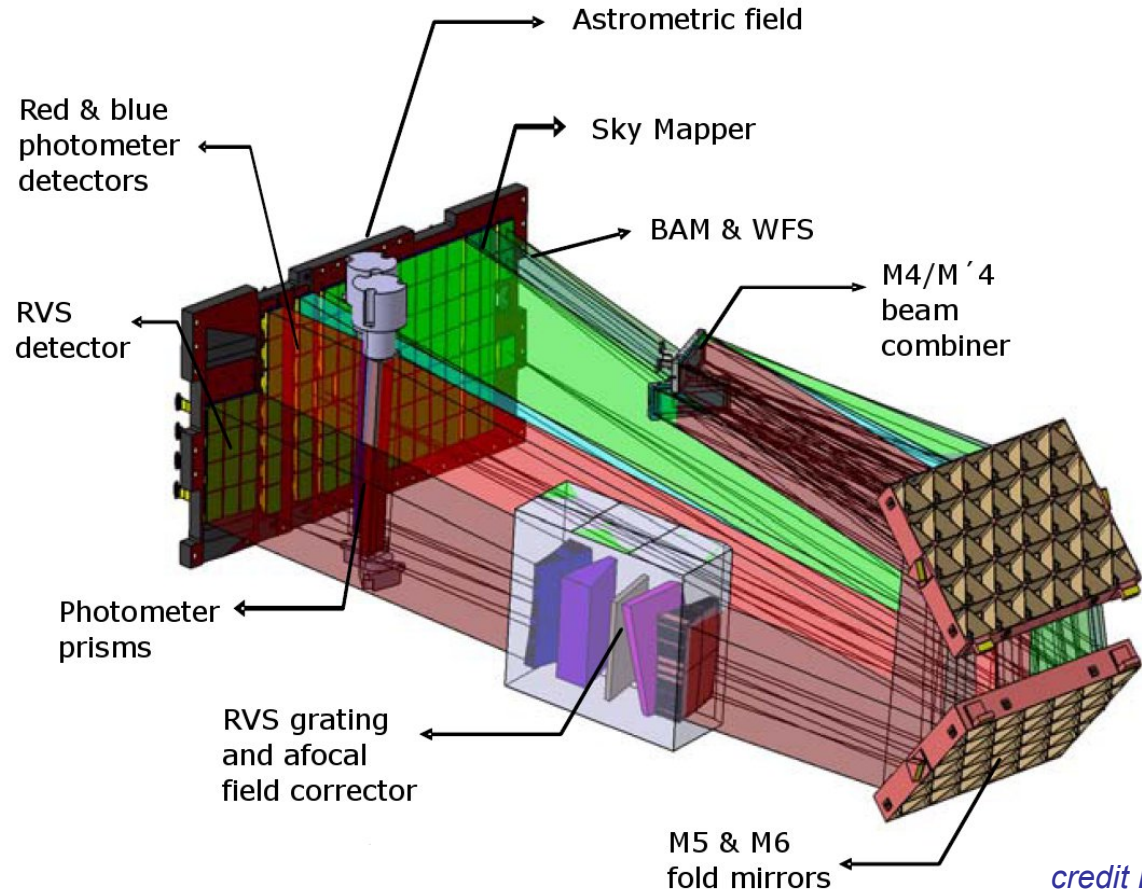
- manufacturing phase complete, all flight hardware delivered
- under assembly and test at Astrium (Toulouse)



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# The Radial Velocity Spectrometer



All 10 mirrors and RVS integrated

$R \sim 10000$   
 $\lambda\lambda 847-874 \text{ nm}$

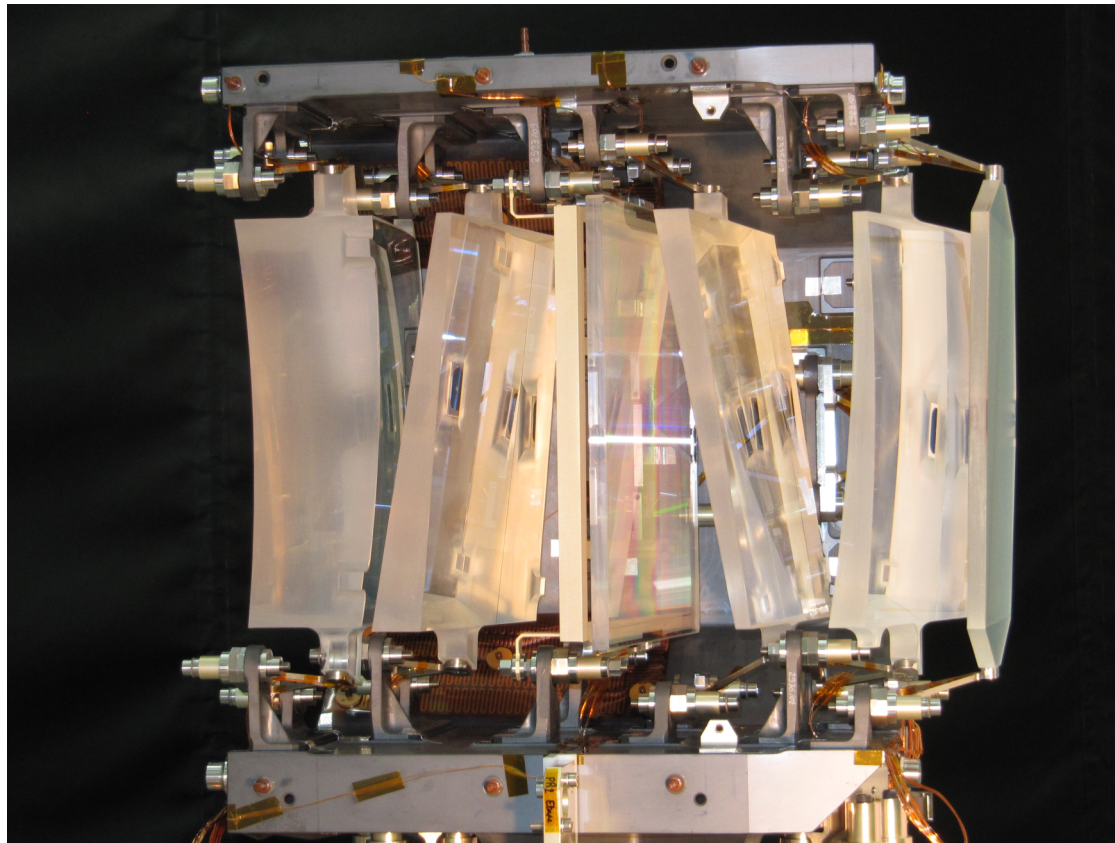
*credit ESA*



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# The Radial Velocity Spectrometer



*credit ESA*

Optical module of the radial-velocity spectrometer (RVS), containing a grating plate (middle), four fused-silica prismatic lenses, as well as a bandpass-filter plate (far right).



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# RVS spectroscopic survey

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- Stellar and interstellar parameters :
  - Radial velocities  $V \leq 17$ ,  $\sim 150 \cdot 10^6$ ,  $\sigma_{RV}$  1 to 15 km/s
  - Rotational velocities  $V \leq 13$ ,  $\sim 5 \cdot 10^6$
  - Atmospheric param.  $V \leq 13$ ,  $\sim 5 \cdot 10^6$
  - Abundances  $V \leq 12 \sim 2 \cdot 10^6$
  - Interstellar reddening  $V \leq 13$  from 862 nm DIB
- Diagnostics :
  - Binarity/multiplicity, variability, ...

==> kinematics and dynamics of MW, chemical tagging, binaries...

*(Wilkinson, Vallenari, Turon, Munari, Katz et al., 2005MNRAS..359.1306W)*



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# RVS calibration

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- ❑ No calibration device (no flat field lamp, no wavelength calibration lamp)  
--> self calibrated instrument
  
- ❑ internal wavelength scale by Spectroscopic Global Iterative Solution on self-selected calibration stars continually updated
  
- ❑ alignment of SGIS solution to absolute frame + RVZP from objects known in advance from ground :
  - asteroids but very few and not well distributed on the sky
  - stars but existing IAU standards (IAU Com 30) too bright and too few



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# Building a new full sky list of RV standard stars

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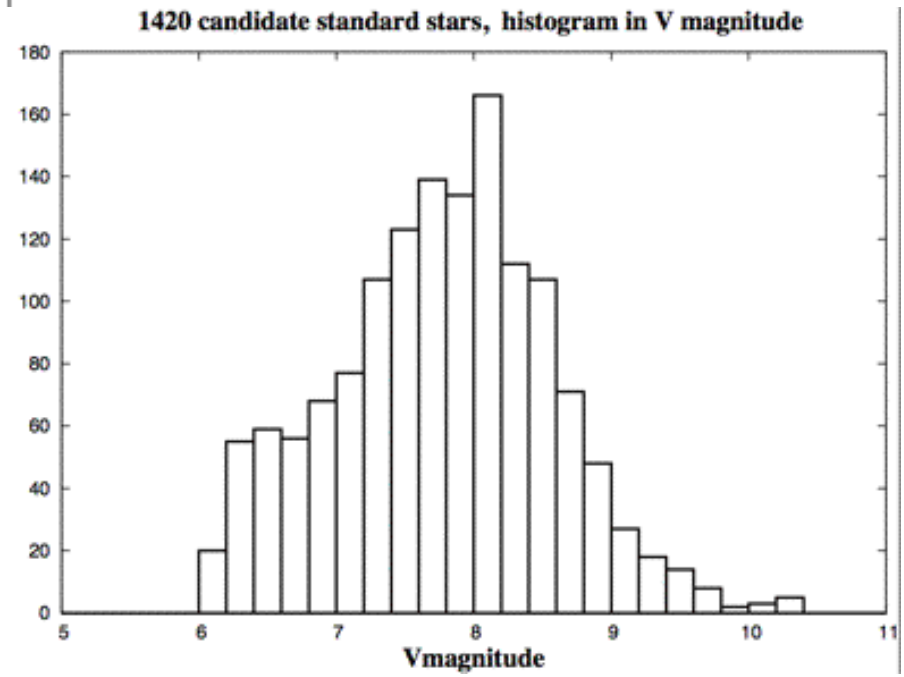
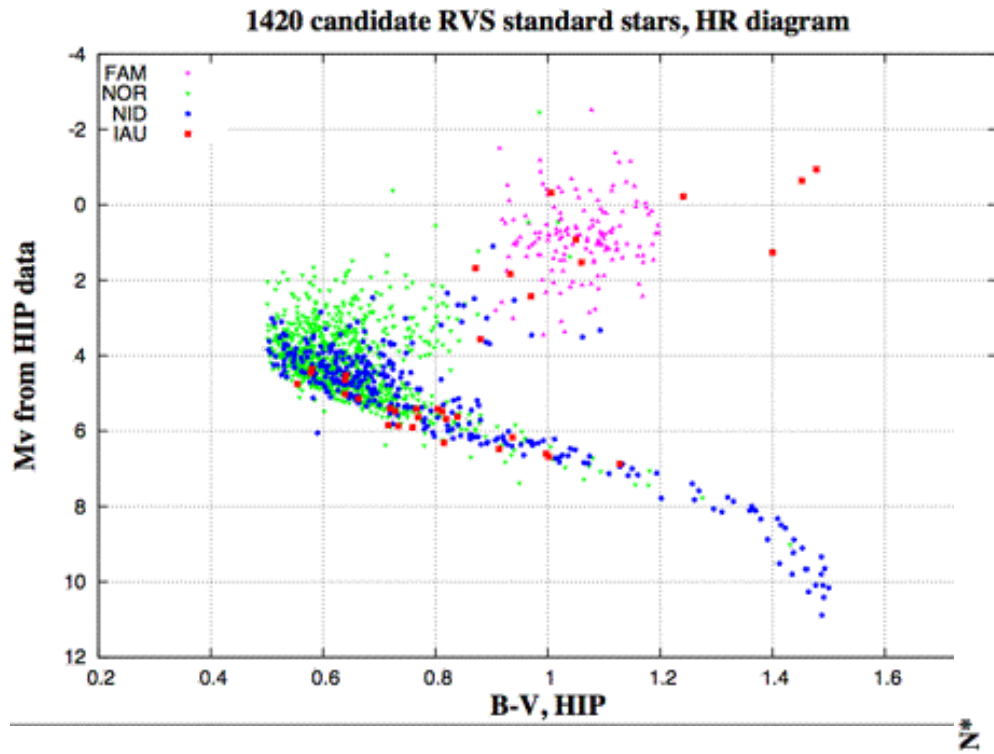
- RVS constraints :
  - homogeneous sky coverage
  - ~1000
  - magnitude range  $6 < V < 10.5$
  - stability 300 m/s
- criteria in favour of stable stars :
  - already studied
  - spectral type
  - photometric variability
  - multiplicity

==> 1420 candidates (Crifo et al. 2010A&A...524A..10C)



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stars selected in Nidever et al. 2002, Nordström et al. 2004, Famaey et al. 2005



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# The observing program

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- check the stability of the 1420 RV standard star candidates at 300 m/s
- at least 2 measurements per star before launch
- 70 observing nights since 2006 thanks to PNCG, PNPS and AS Gaia support
- end of pre-launch programme, 1st release in 2012
- 1 more RV measurement per star during operations



SOPHIE@OHP-T193

+ HARPS and ELODIE archives



NARVAL@TBL-Pic du midi



CORALIE@Euler La Silla



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Gaia  
DPAC  
Data Processing & Analysis Consortium

## Number of RV measurements collected :

CORALIE : 2318

SOPHIE : 2137

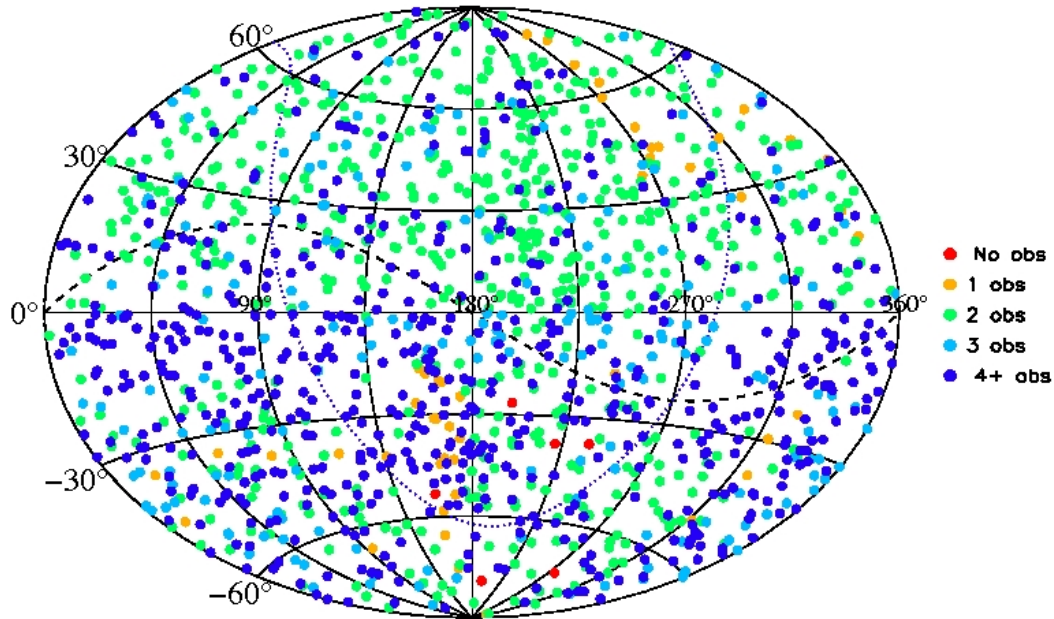
NARVAL : 205 ← *include RVS range*

ELODIE : 1060

HARPS : 655

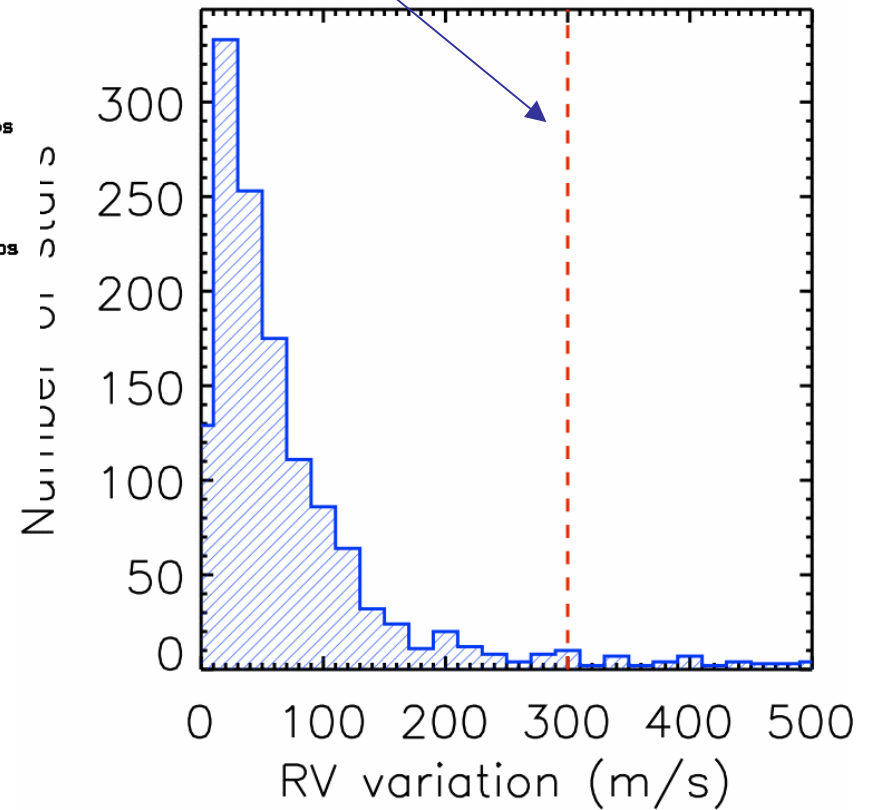


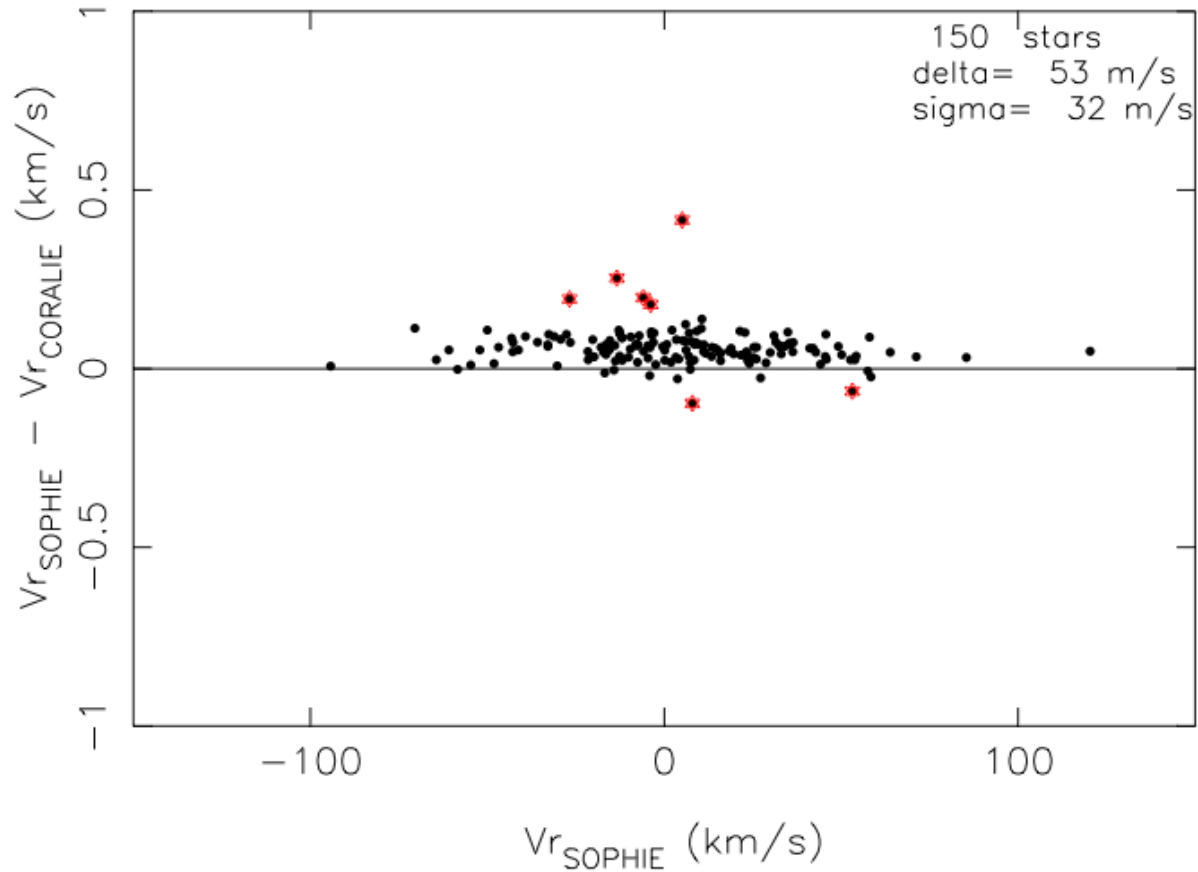
# RVS standard stars



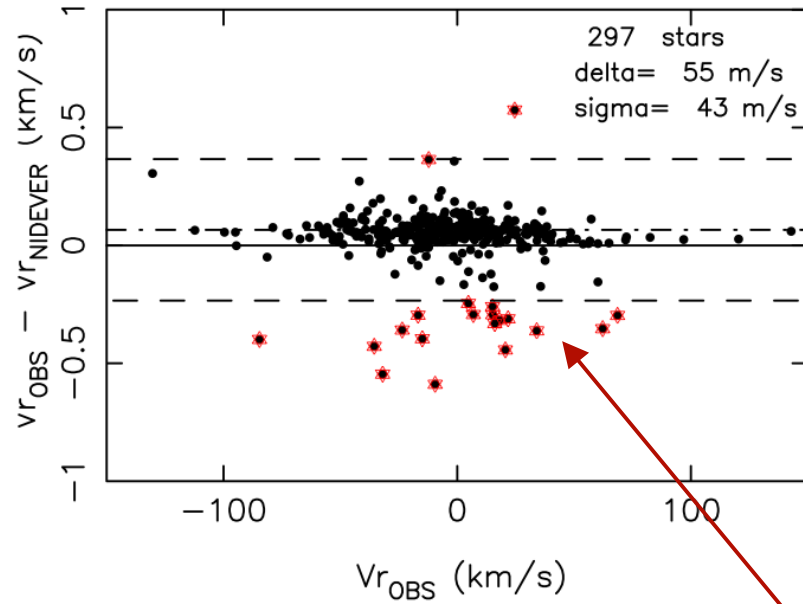
*status of the observations as of June 2012*

*stability threshold for the RVS calibration stars*

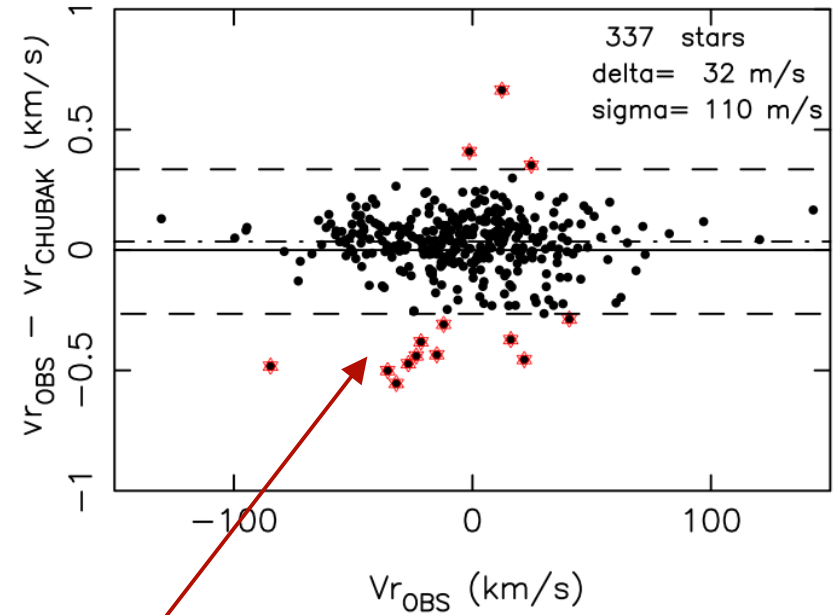




- offset (53 m/s) --> RVZP
- sigma (32 m/s) --> RV error + intrinsic variability



Nidever, Marcy et al. 2002



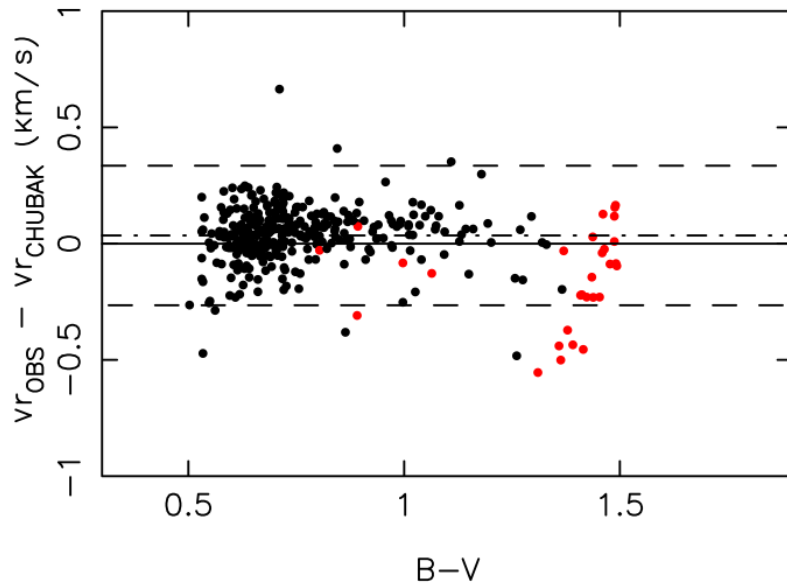
Chubak, Marcy et al., 2012

intrinsic variable stars + systematics due to method

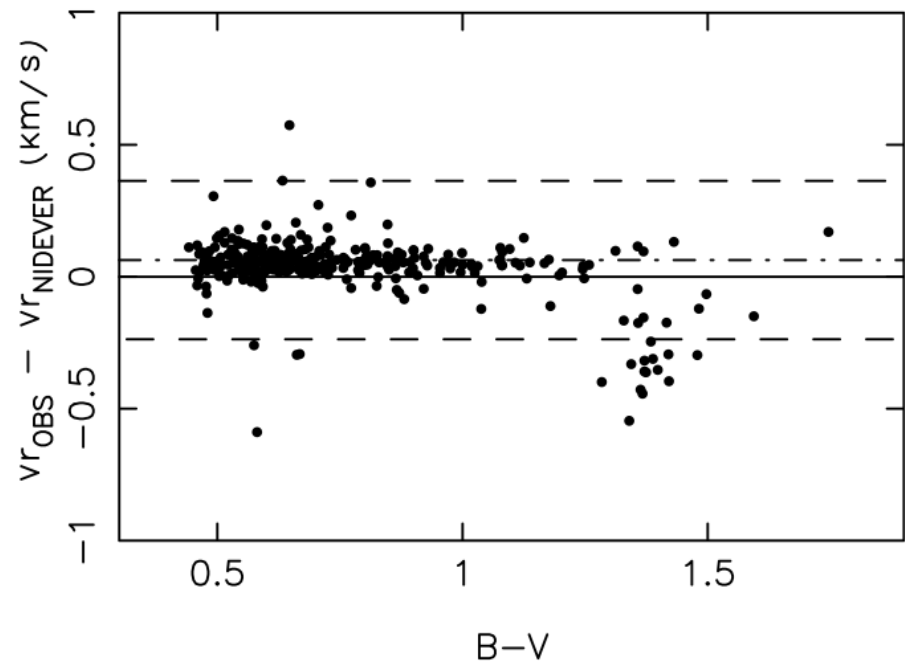


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- Nidever and Chubak use real templates for the CCF
- We use masks computed from synthetic spectra



Limitations of spectroscopic RV measurements :

- Gravitational redshift (Sun:  $0.6 \text{ km s}^{-1}$ )
- Convective shifts (F V:  $1 \text{ km s}^{-1}$  ; K V:  $0.2 \text{ km s}^{-1}$ )
- Other astrophysical effects : stellar rotation, stellar activity (active regions + starspots), granulation ...
- Small-mass companions : exoplanets...

A&A 401, 1185–1201 (2003)  
DOI: 10.1051/0004-6361:20030181  
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**Astronomy  
&  
Astrophysics**

## The fundamental definition of “radial velocity”

Lennart Lindegren and Dainis Dravins

### 3.3.8. Conclusions about spectroscopic “standard” stars

Physical and instrumental effects, such as those listed above (and others, such as errors in laboratory wavelengths), imply that there most probably do not exist any stars whose spectral features could serve as a real standard on precision levels better than perhaps  $300 \text{ m s}^{-1}$ .



SF2A 2012, session AS GAIA & AS GRAM, Nice, 5 June 2012



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## Next steps :

- publication of the pre-launch version of the catalog, on the SOPHIE RV instrumental scale
- define the RVZP of the catalog with asteroids
- gravitational redshift + convective shifts from 3D hydrodynamical model atmospheres
- re-observe the 1420 stars in 2016-2018 to check the long term stability



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