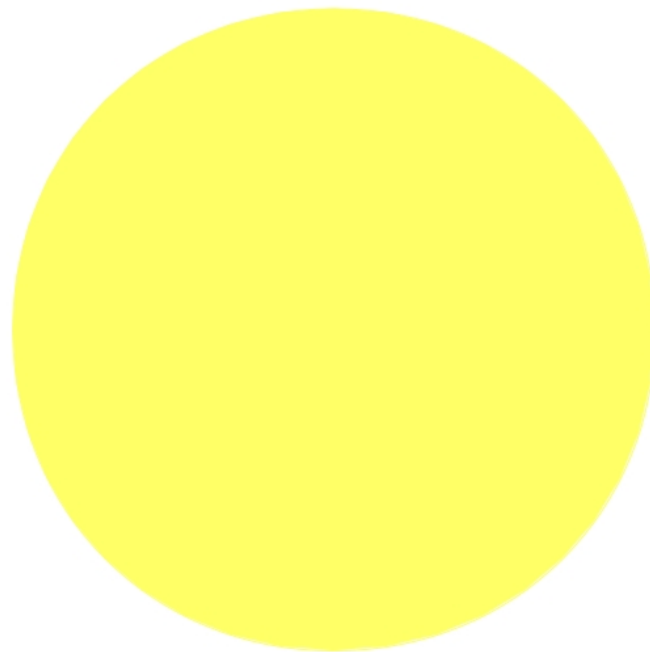


# Searching for fast hot subdwarfs before and after Gaia DR2

**Stephan Geier**

**Stellar Astrophysics, University of Potsdam**

Andreas Irrgang, Uli Heber, Roberto Raddi, Alexander Bastian, Thomas Kupfer,  
Matti Dorsch, et al.



**Sun**

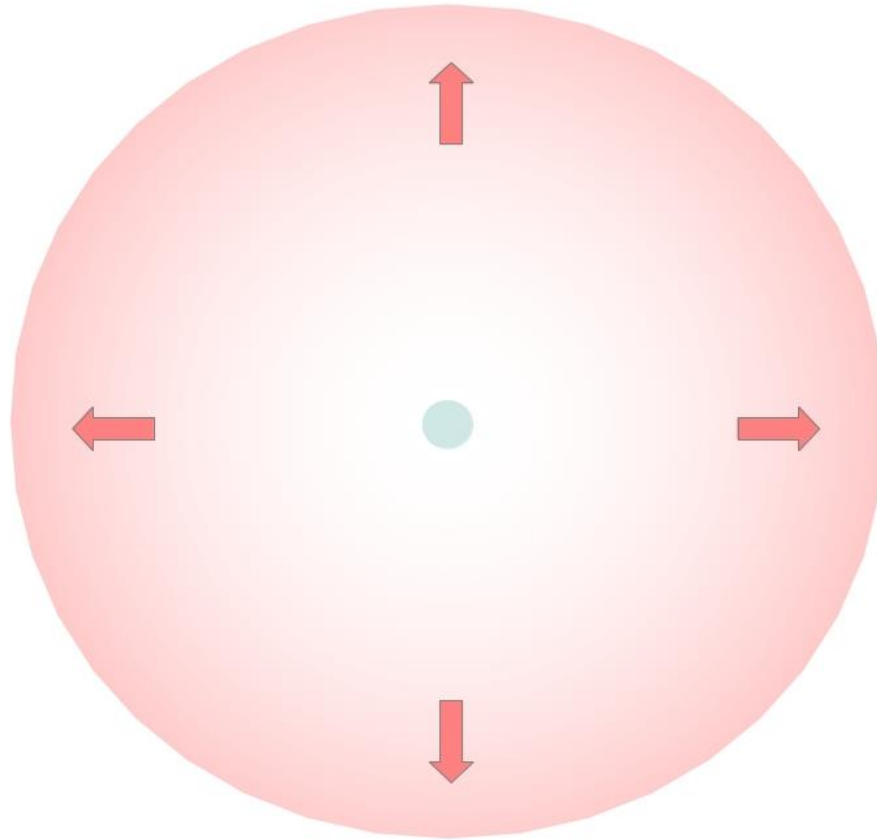


**sdO/B**

$$M = 0.5 M_{\odot}$$

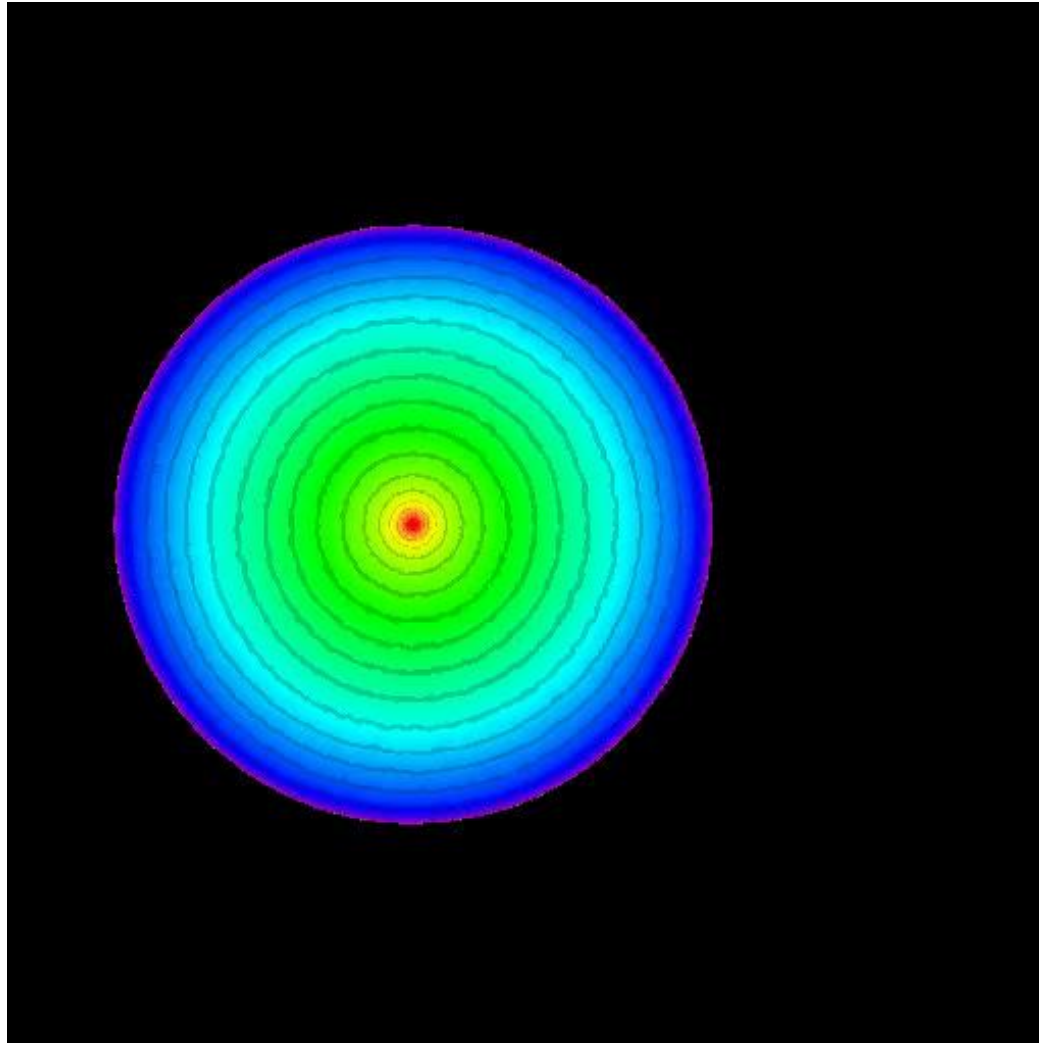
$$R = 0.2 R_{\odot}$$

# Hot subdwarfs

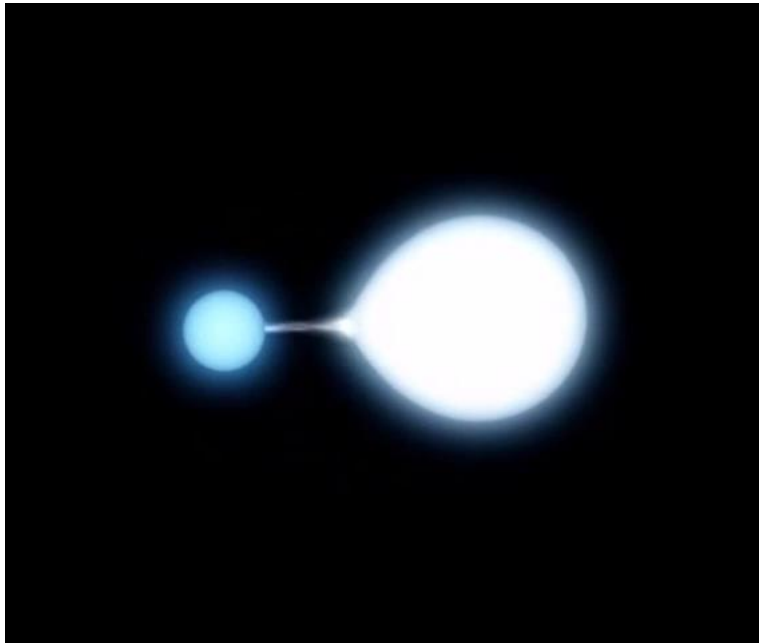


**Mass-loss**

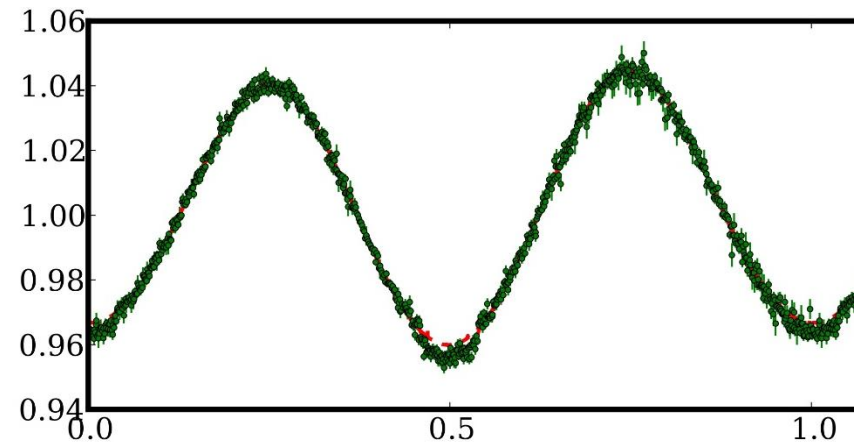
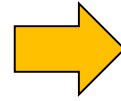
# Hot subdwarfs



# Hot subdwarfs

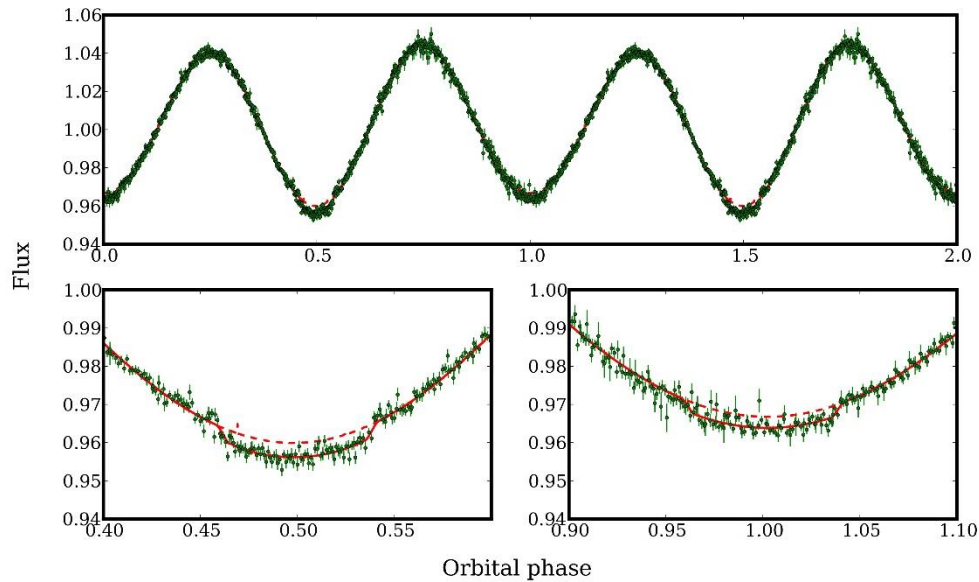


(ESO, modified by Geier)



**Ellipsoidal variation → Massive compact companion**  
**(+ eclipses) (e.g. white dwarf)**

# Hot subdwarfs & Supernovae Ia

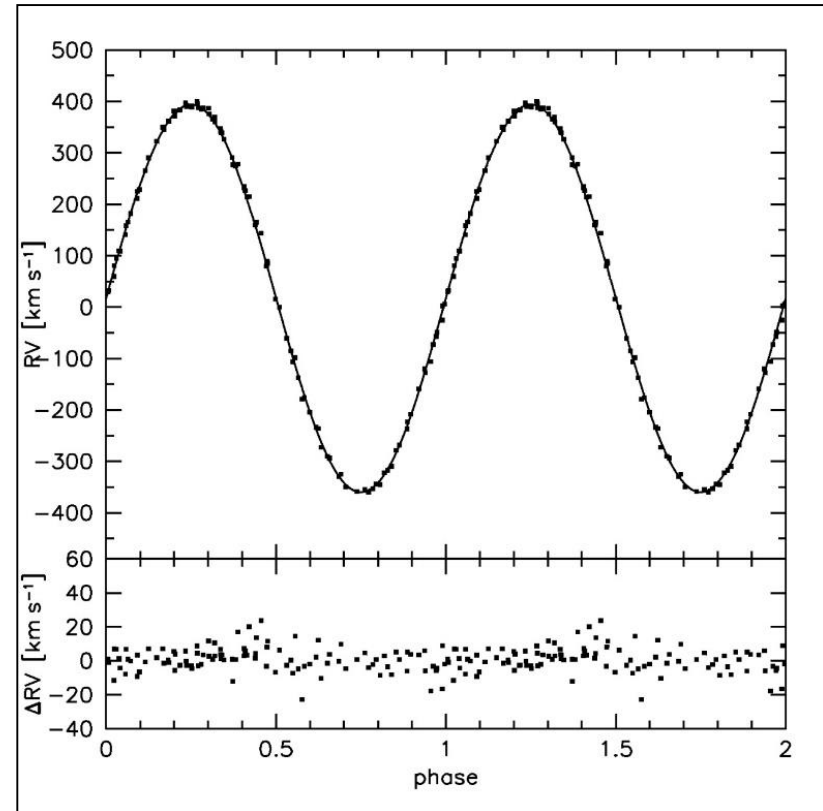


$$K = 377 \text{ km/s}$$

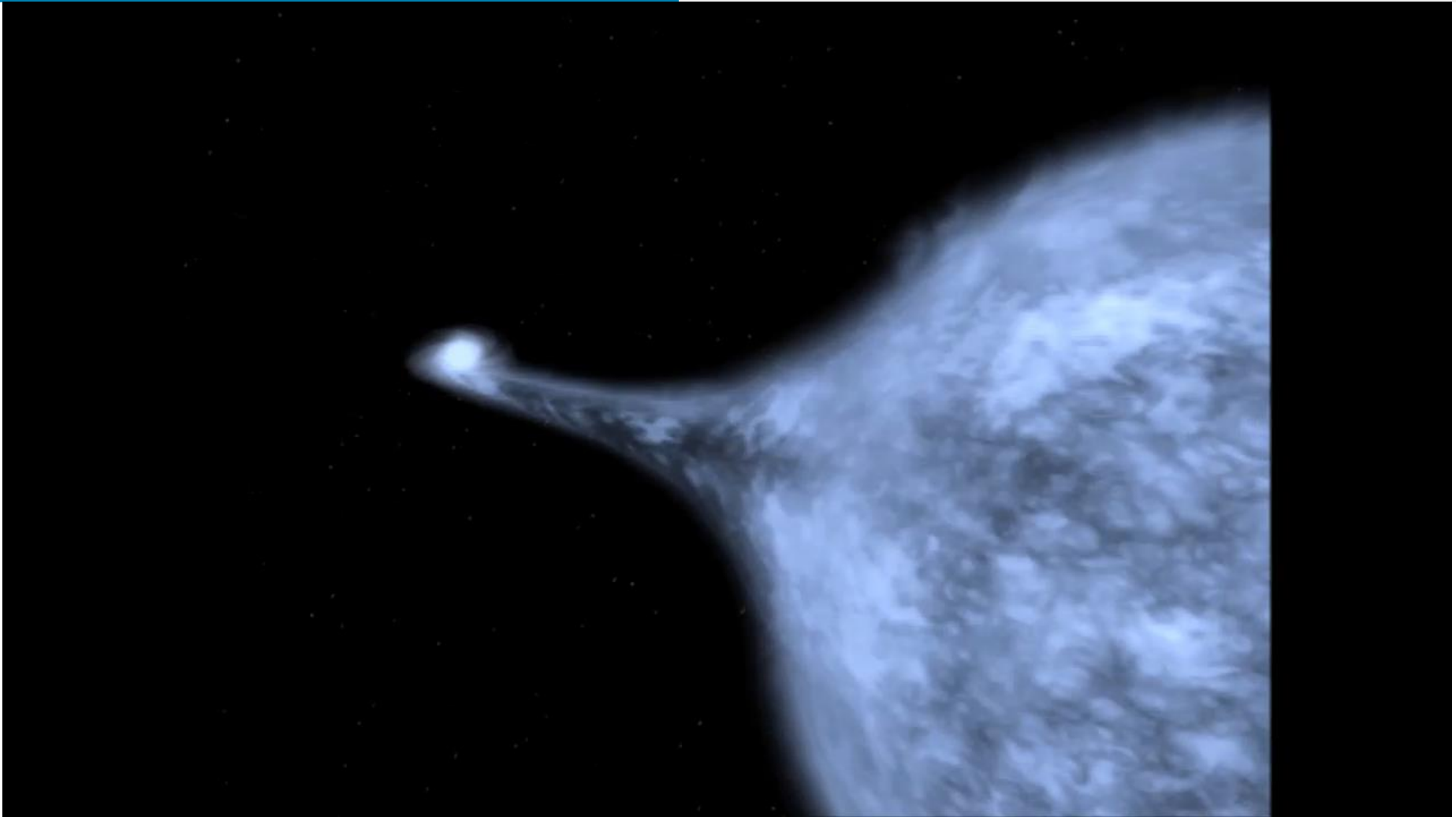
$$P = 0.0498 \text{ d}$$

$$M_{\text{WD}} = 0.51 M_{\odot}$$

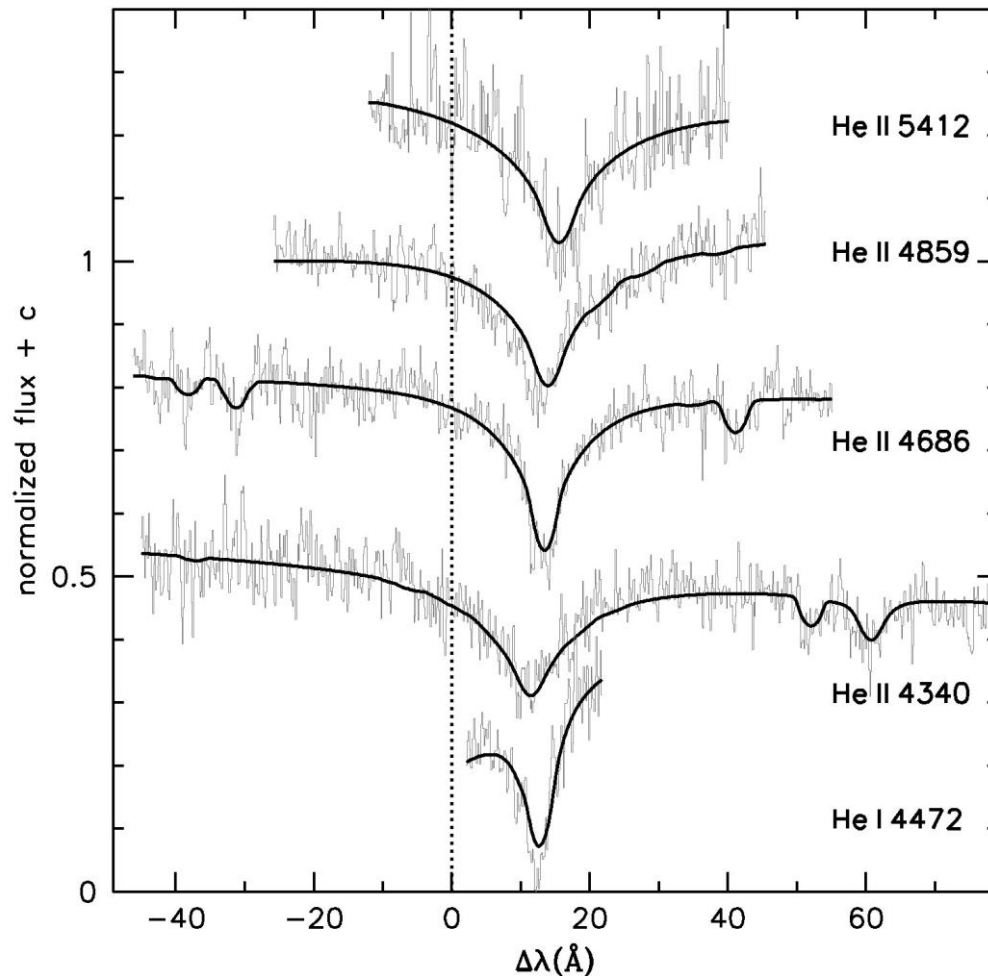
$$M_{\text{WD}} = 0.76 M_{\odot}$$



# Double-detonation thermonuclear supernova scenario



# HVS 2 (US 708)



**US 708**

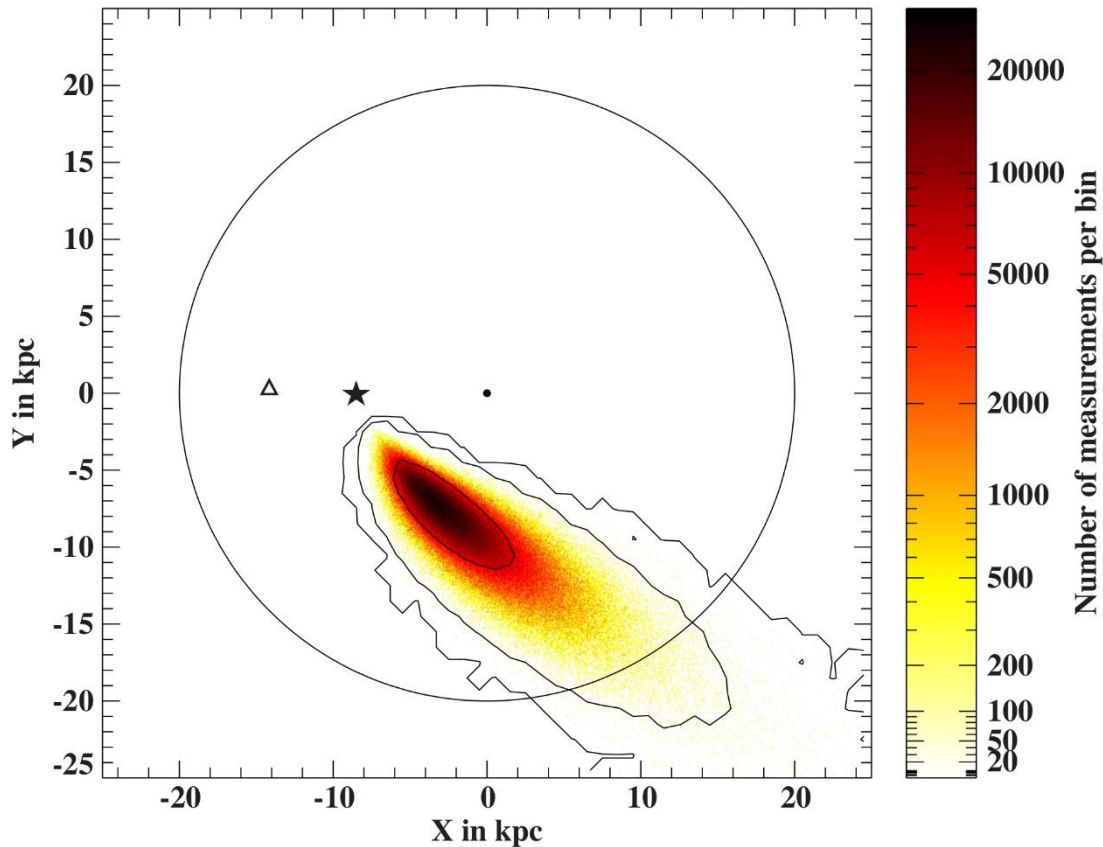
**High Doppler shift  
of spectral lines**

→ **High radial velocity**

**+ ground-based  
proper motion**



# HVS 2 (US 708)



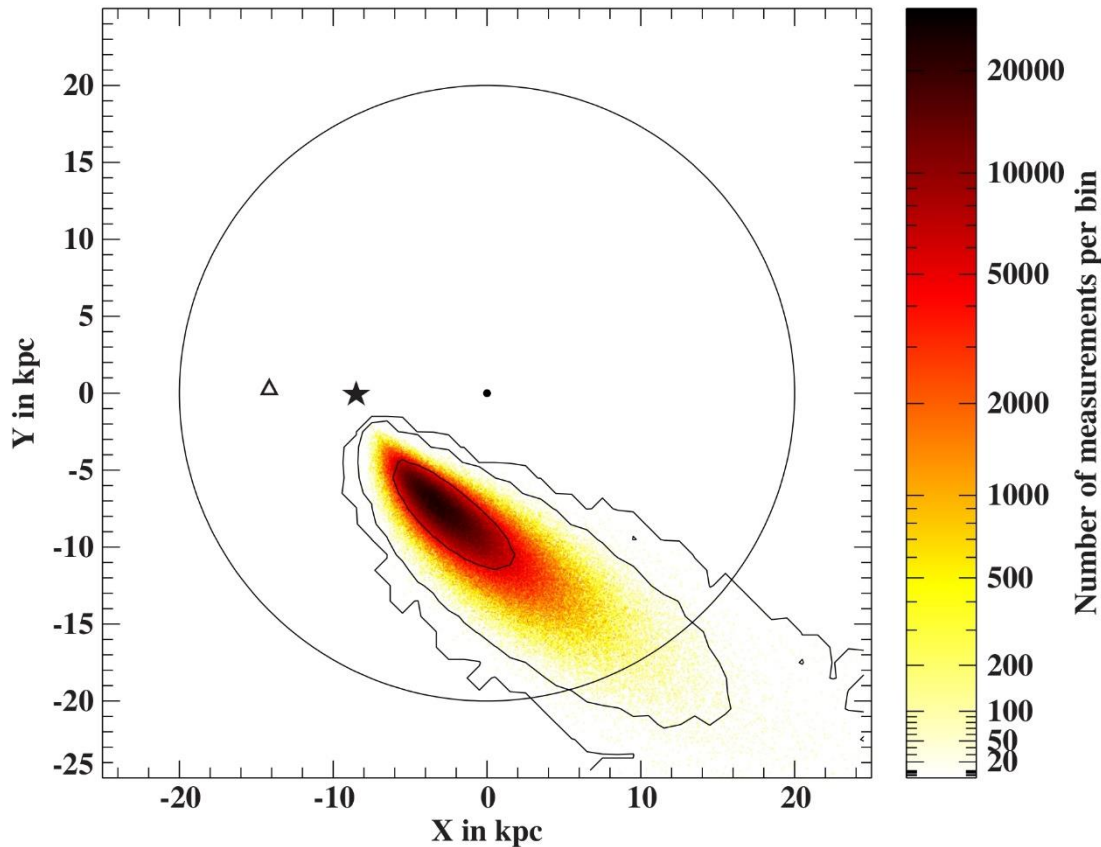
**US 708**

**Galactic restframe  
velocity**

$$v_{\text{grf}} = 1157 \pm 53 \text{ km/s}$$

**Fastest unbound  
star in the Galaxy**

# HVS 2 (US 708)



**Hot subdwarfs are close enough to select HVS candidates from ground based proper motions**

# HVS 2 (US 708)

A&A 527, A137 (2011)  
DOI: [10.1051/0004-6361/201015539](https://doi.org/10.1051/0004-6361/201015539)  
© ESO 2011

**Astronomy  
&  
Astrophysics**

## The Hyper-MUCHFUSS project: probing the Galactic halo with sdB stars<sup>★</sup>

A. Tillich<sup>1</sup>, U. Heber<sup>1</sup>, S. Geier<sup>1</sup>, H. Hirsch<sup>1</sup>, P. F. L. Maxted<sup>2</sup>, B. T. Gänsicke<sup>3</sup>, T. R. Marsh<sup>3</sup>, R. Napiwotzki<sup>4</sup>,  
R. H. Østensen<sup>5</sup>, and R.-D. Scholz<sup>6</sup>

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<sup>2</sup> Astrophysics Group, School of Physics and Geographical Sciences, Lennard-Jones Laboratories, Keele University, ST5 5BG, UK

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<sup>4</sup> Centre of Astrophysics Research, University of Hertfordshire, College Lane, Hatfield AL10 9AB, UK

<sup>5</sup> Instituut voor Sterrenkunde, K.U. Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium

<sup>6</sup> Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany

**Previous survey was based on RV-selection only**



# How do we find more of them?



fotolia / zatvorniknik (Ausschnitt)

# Look for the freaks



# Assemble the haystack

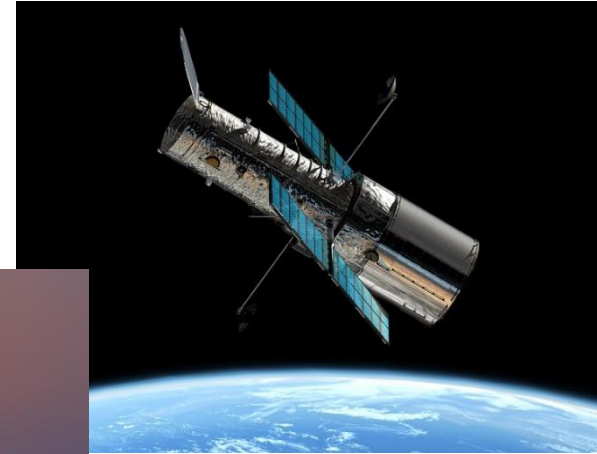
**Hot subdwarf catalog** (Geier et al. 2017, A&A, 600, 50, Vizier)

**5613 unique sources**

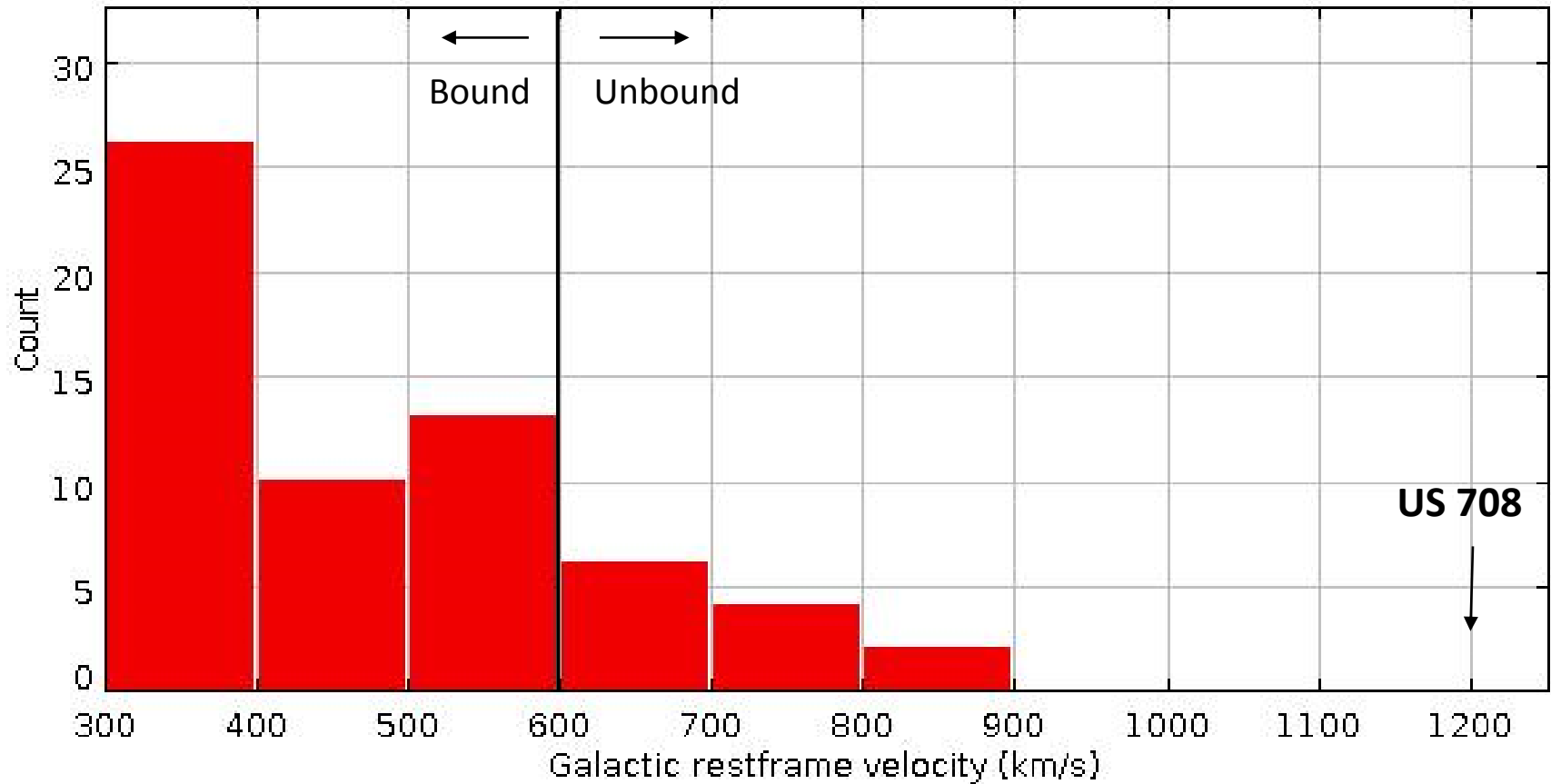
- **Compilation of all known larger samples of sdOBs**  
(sdOB database, EC, HE, HS, SPY, GALEX, LAMOST, FBS, SDSS)
- **Proper motions** (USNO-B1.0, SDSS, PPMXL, UCAC4, SPM4, APOP UCAC5, HSOY, GPS1)
- **1900 sdO/Bs with atmospheric parameters, spectroscopic distances and radial velocities**
- **50-70 candidates with  $v_{\text{grf}} > 300 \text{ km s}^{-1}$  selected for follow-up**
- **Five fast sdO/Bs published → ULI'S TALK**  
Nemeth et al. 2016, ApJ, 821, L13, ; Ziegerer et al. 2017, A&A, 601, 58



# Spectroscopic follow-up



# Before Gaia

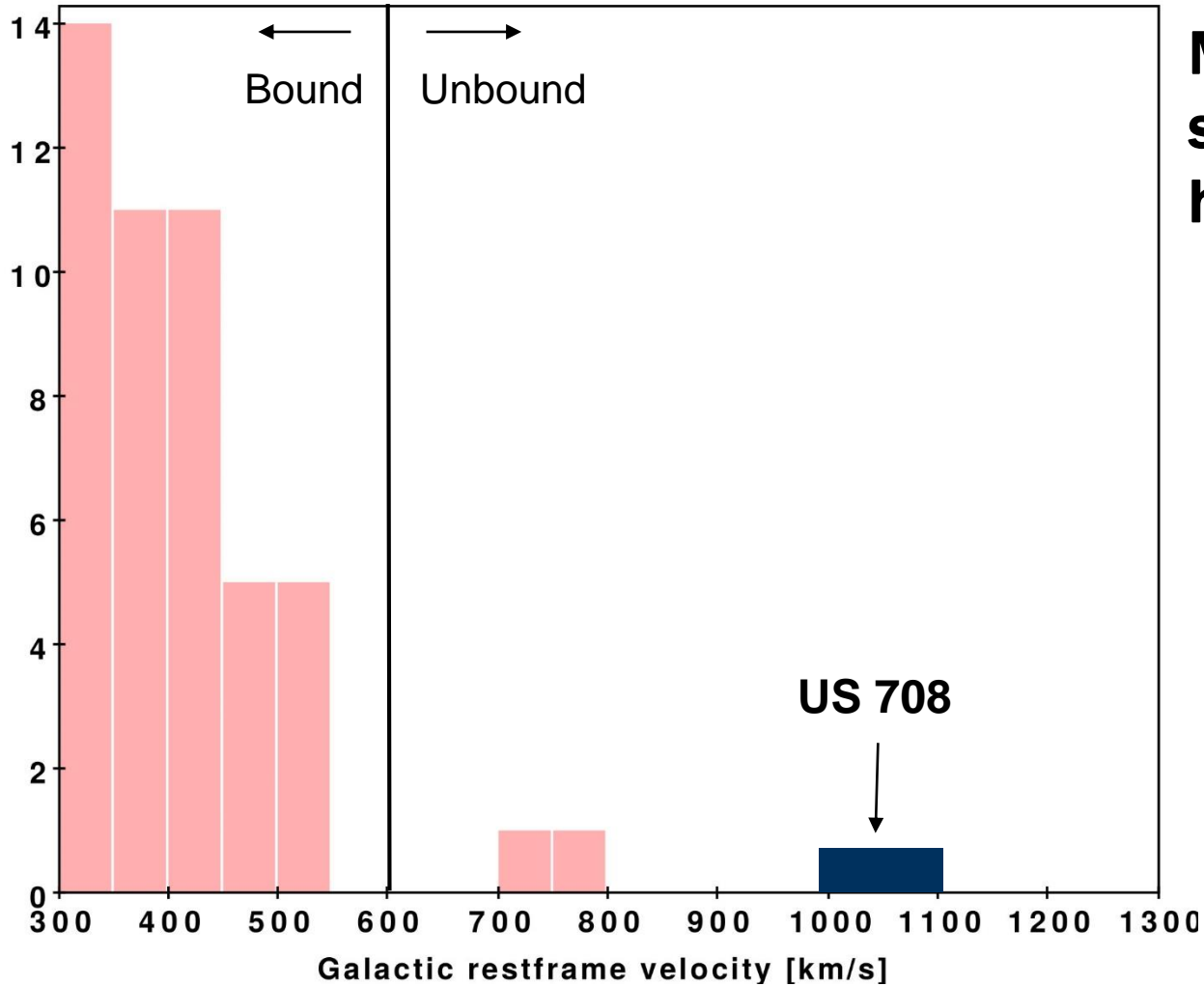






gaia

# After Gaia

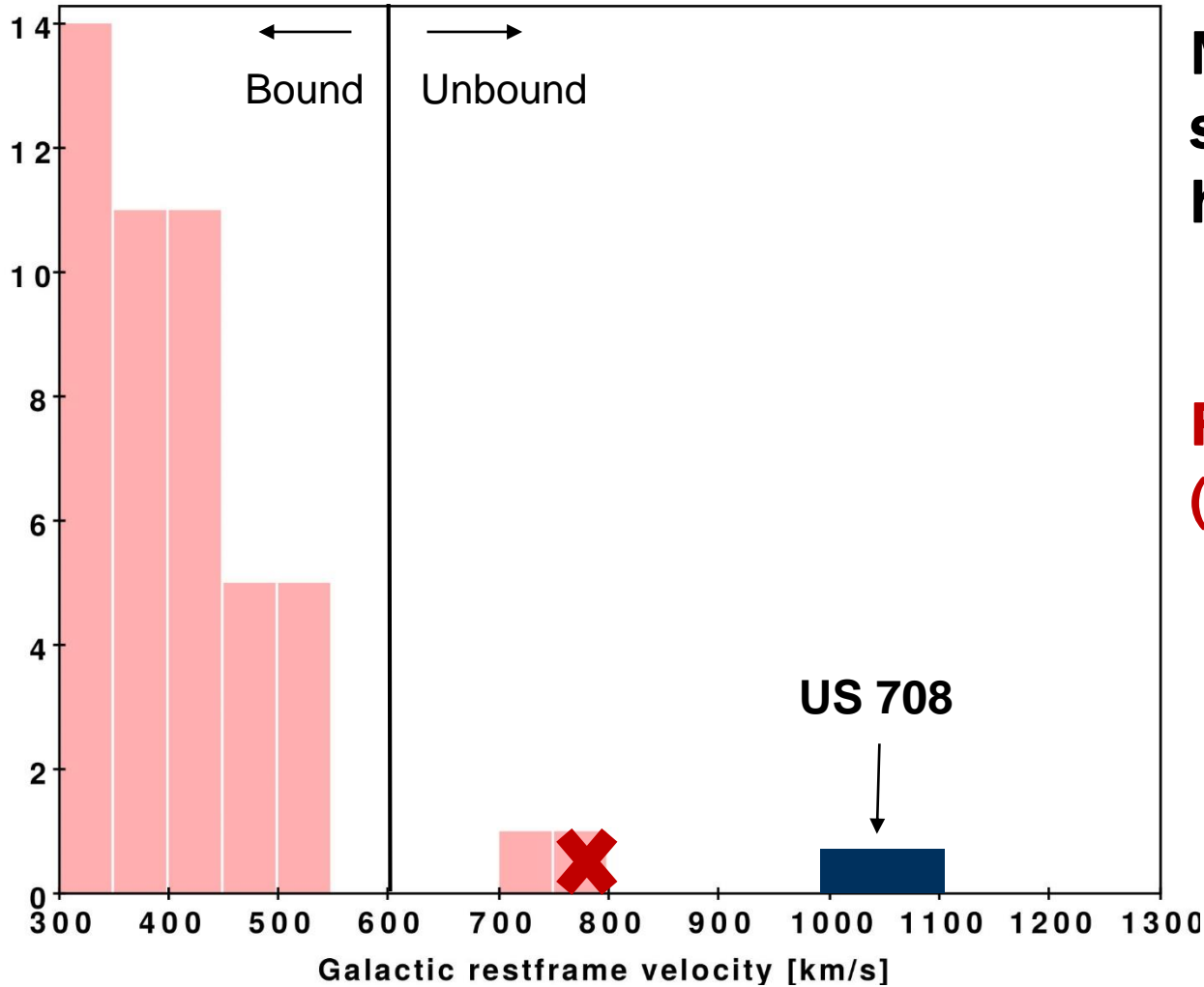


**Most fast hot subdwarfs are bound halo stars**



gaia

# After Gaia



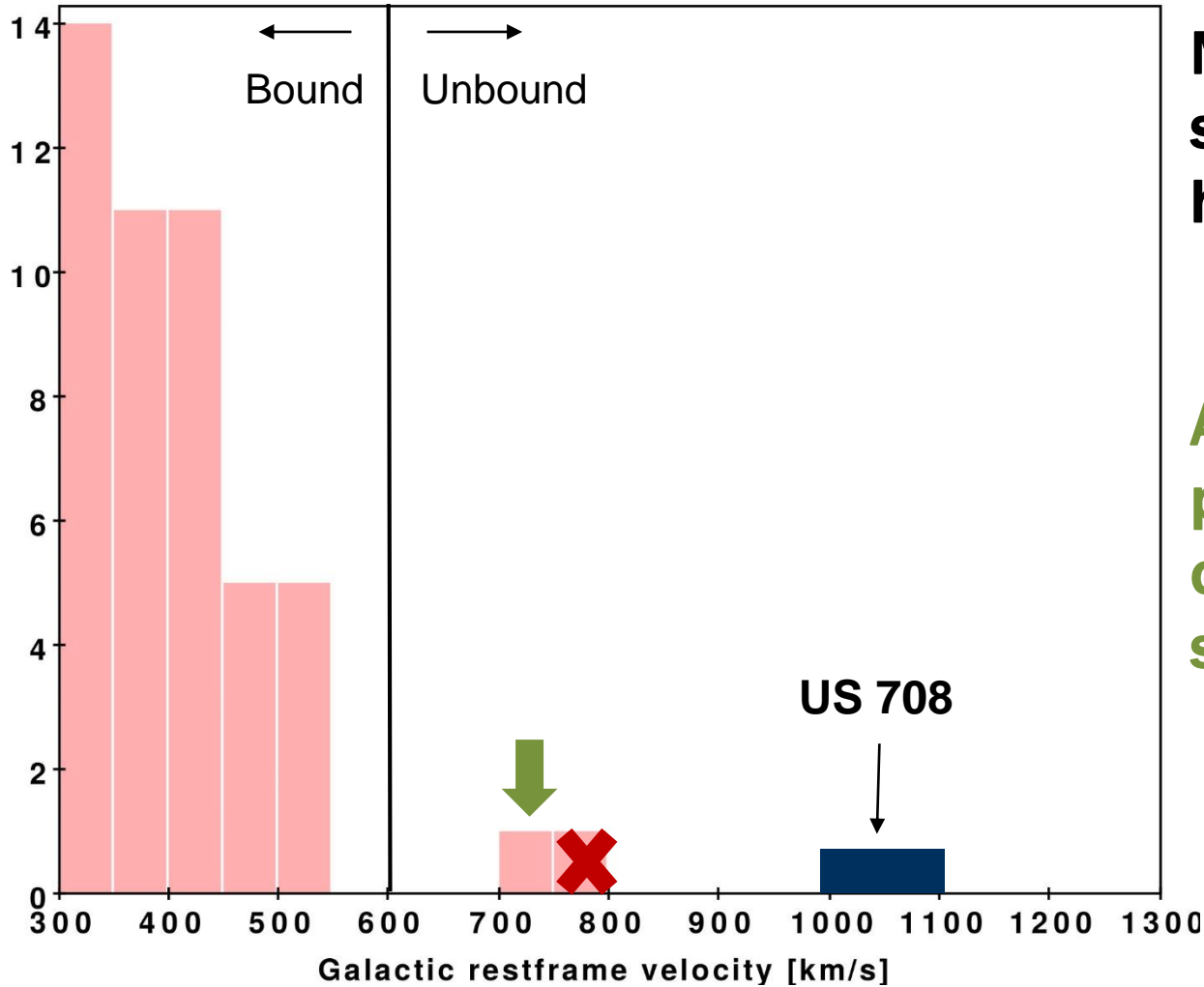
**Most fast hot subdwarfs are bound halo stars**

**Fake composite sdB (resolved blend)**



gaia

# After Gaia



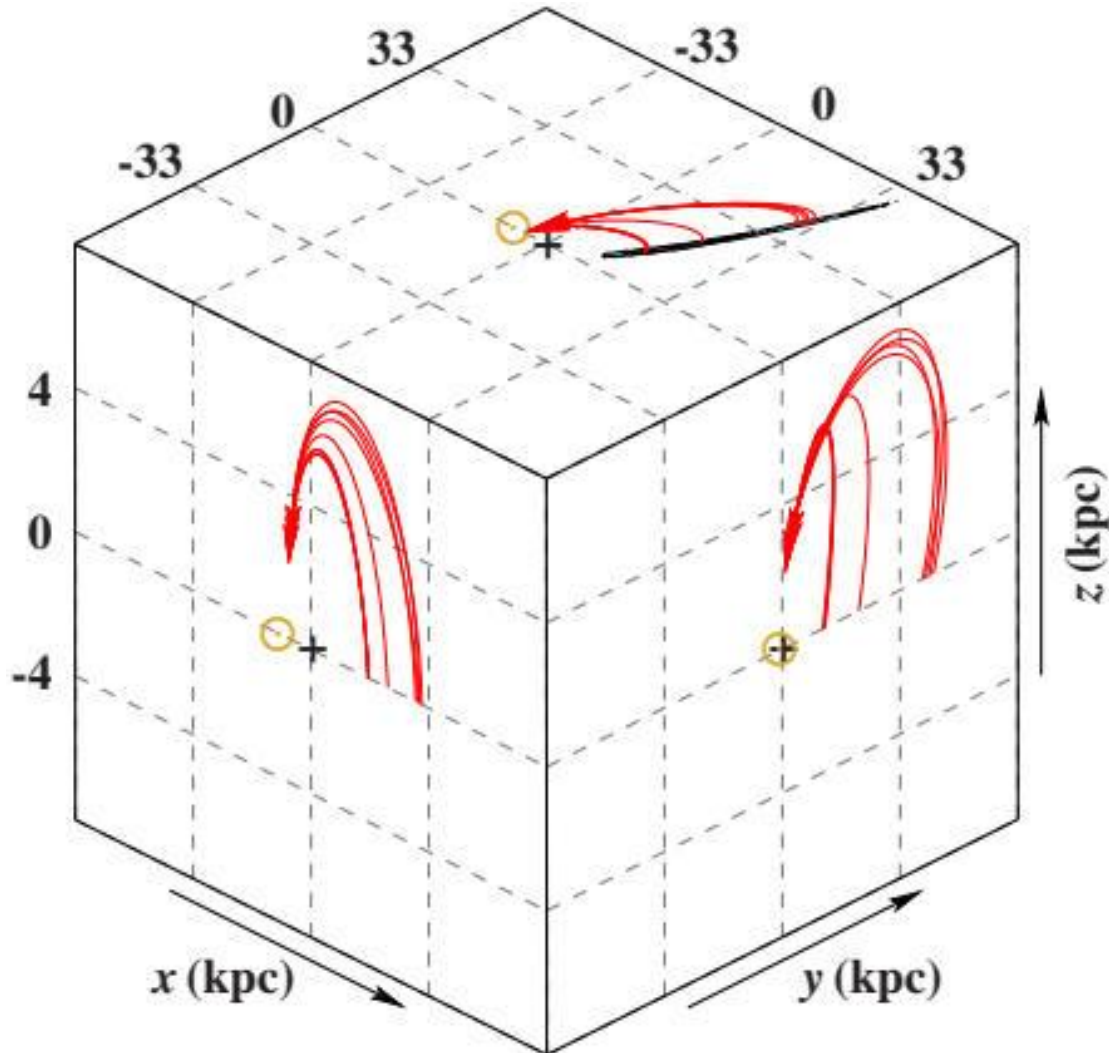
**Most fast hot  
subdwarfs are bound  
halo stars**

**Atmospheric  
parameters  
consistent with BHB  
star**



gaia

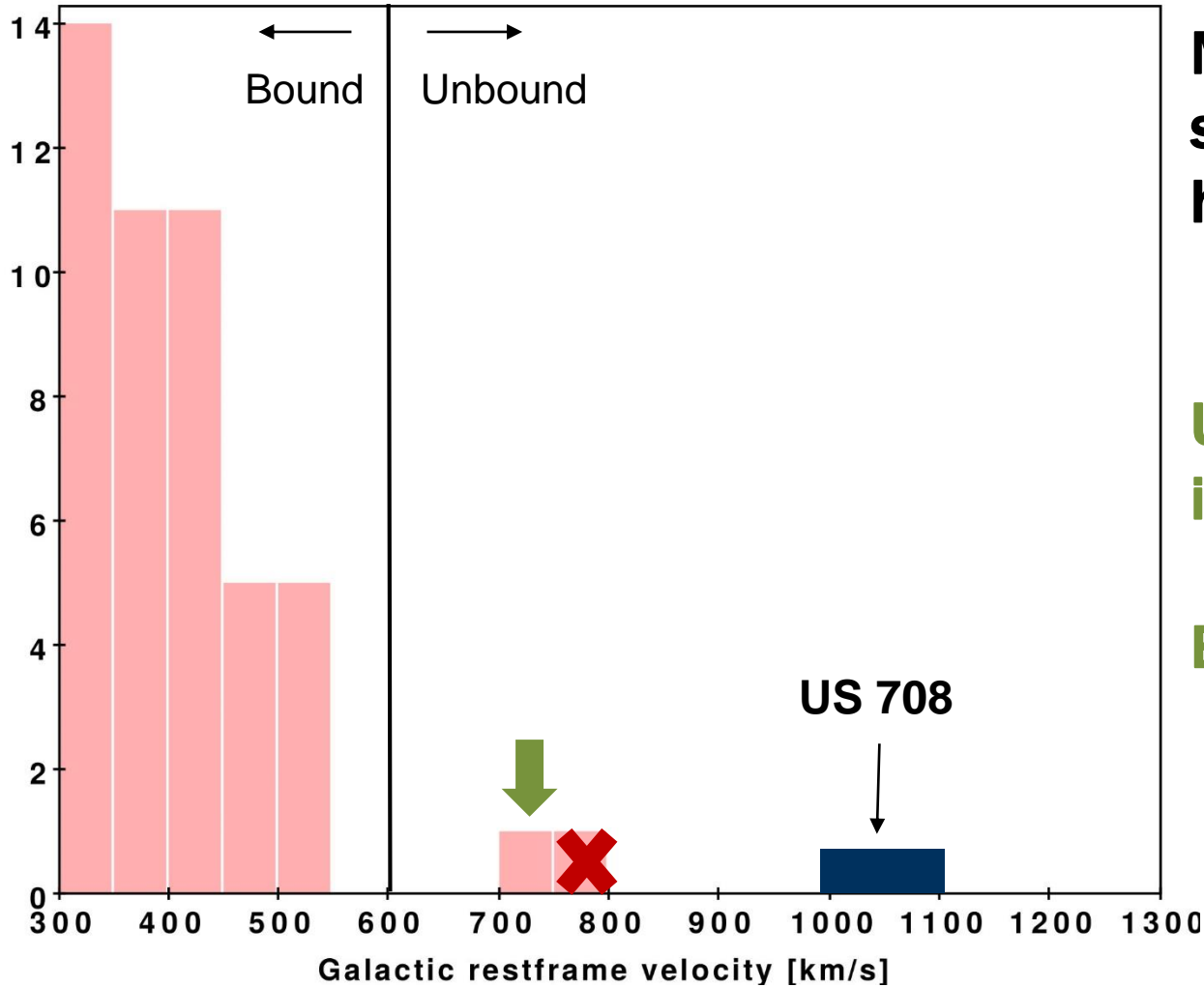
# After Gaia





gaia

# After Gaia



**Most fast hot subdwarfs are bound halo stars**

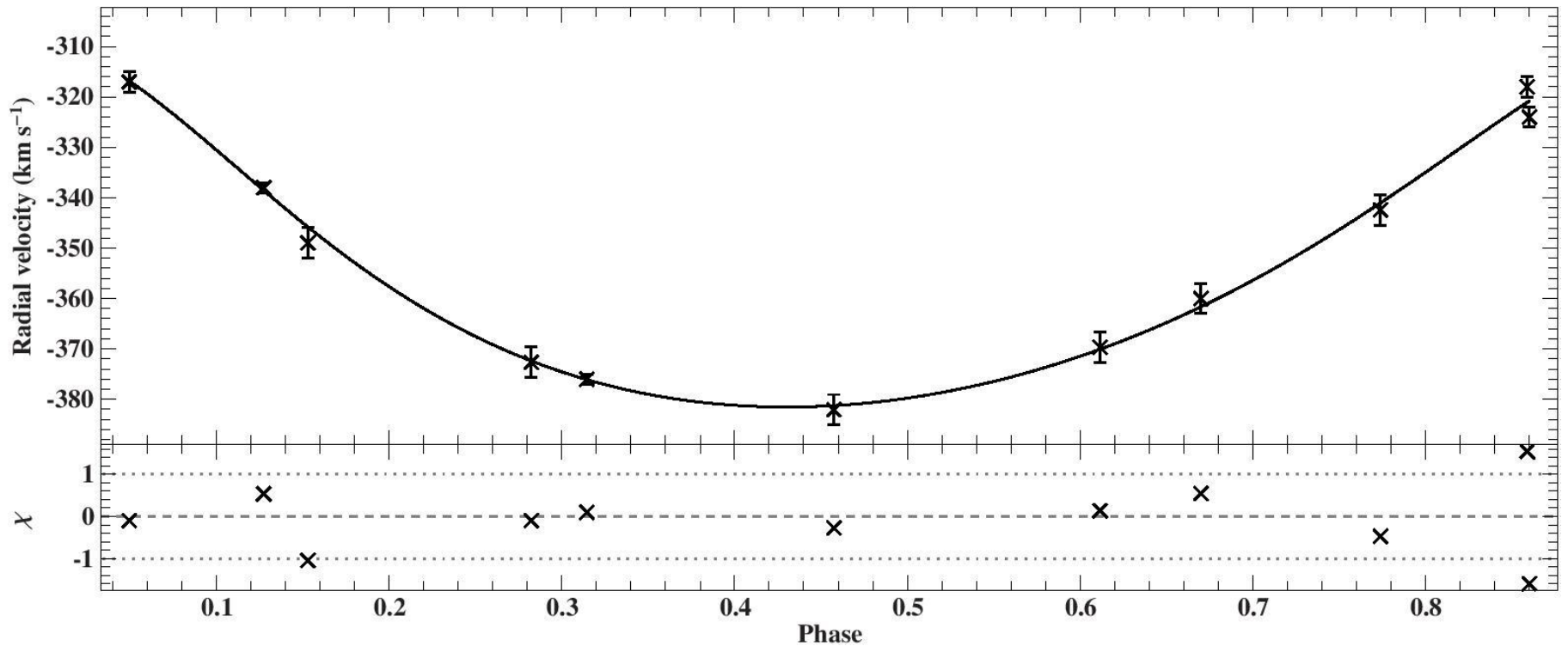
**Unbound and incoming!**

**Extragalactic origin?**



gaia

# After Gaia

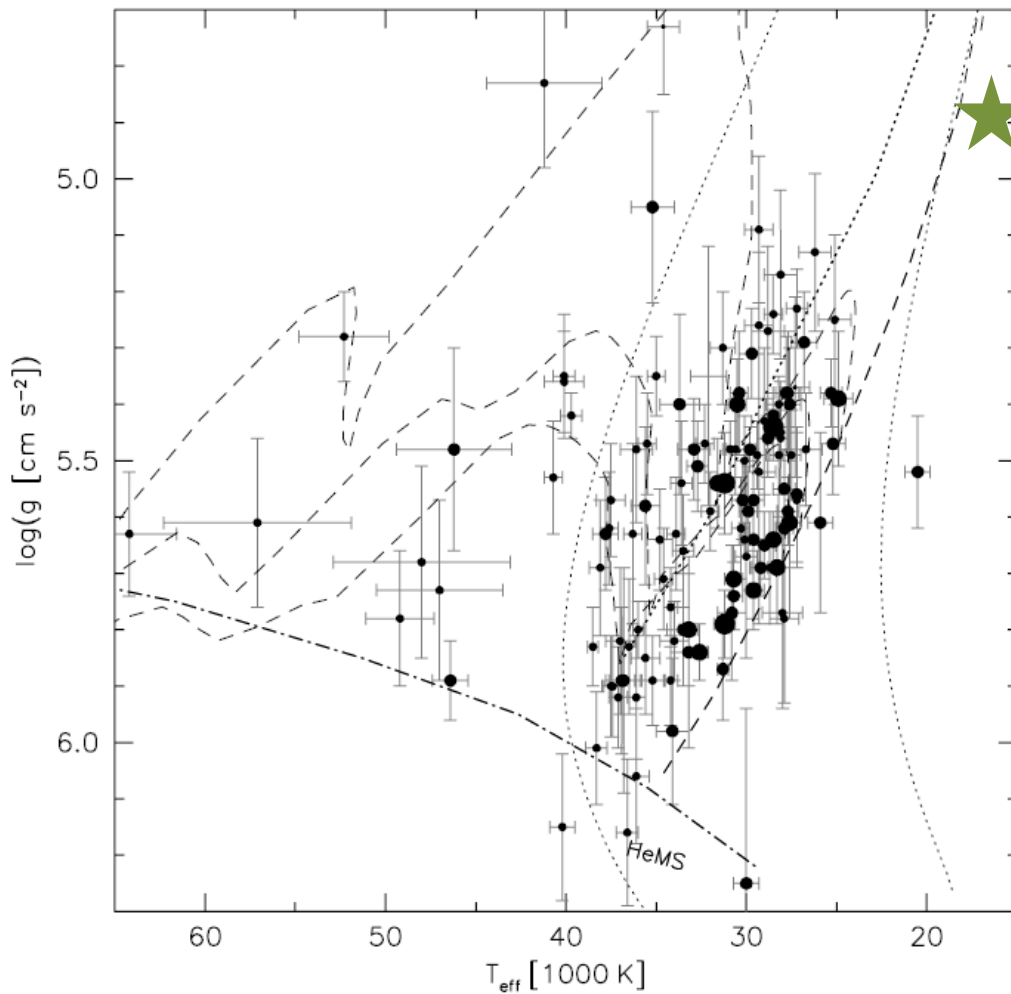


**Star shows small RV variations and is likely a close binary**



gaia

# After Gaia



Atmospheric parameters are also consistent with pre-He-WD

→ All those objects are in close binaries

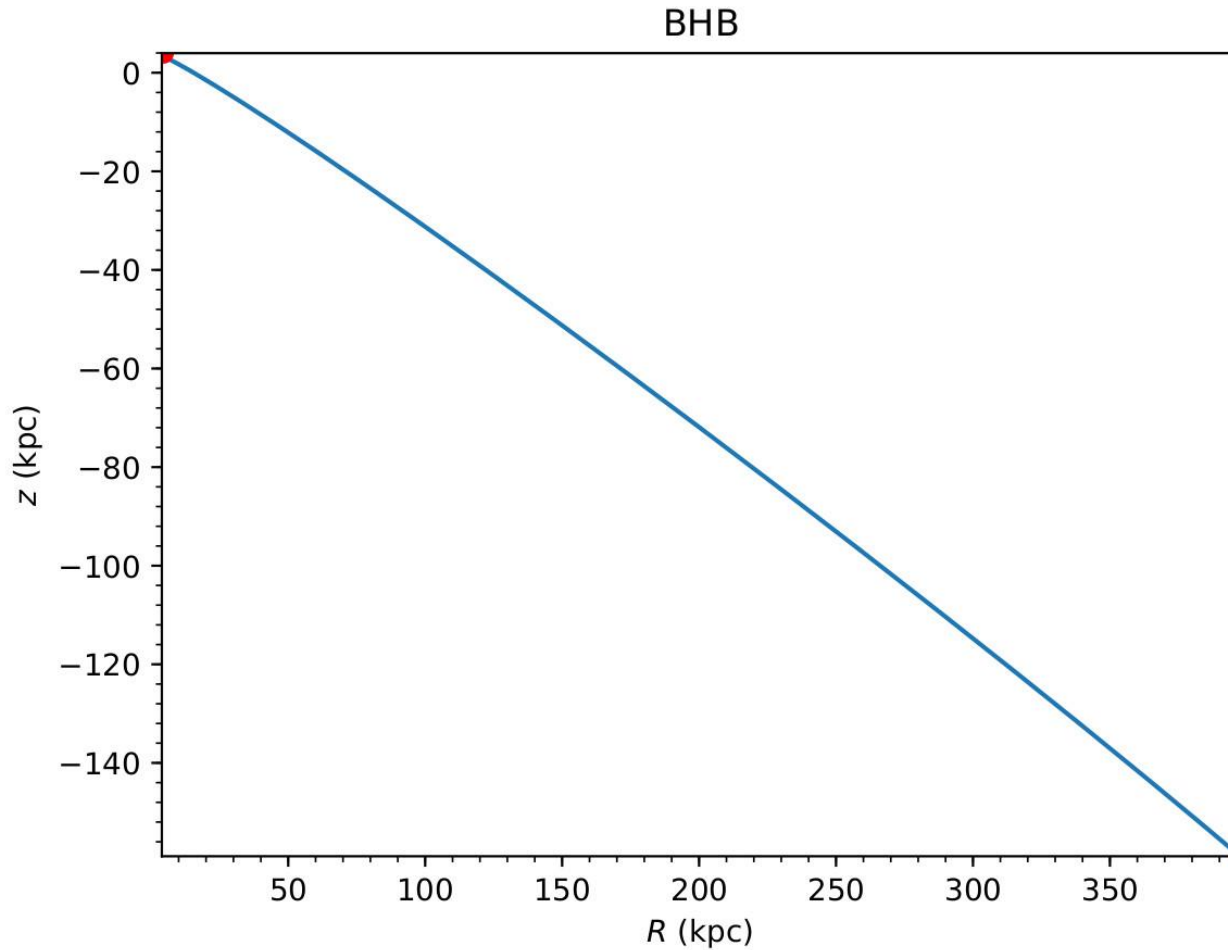
→ The mass of such an object is only about  $0.2M_{\odot}$

→ Spectroscopic distance smaller



gaia

# After Gaia

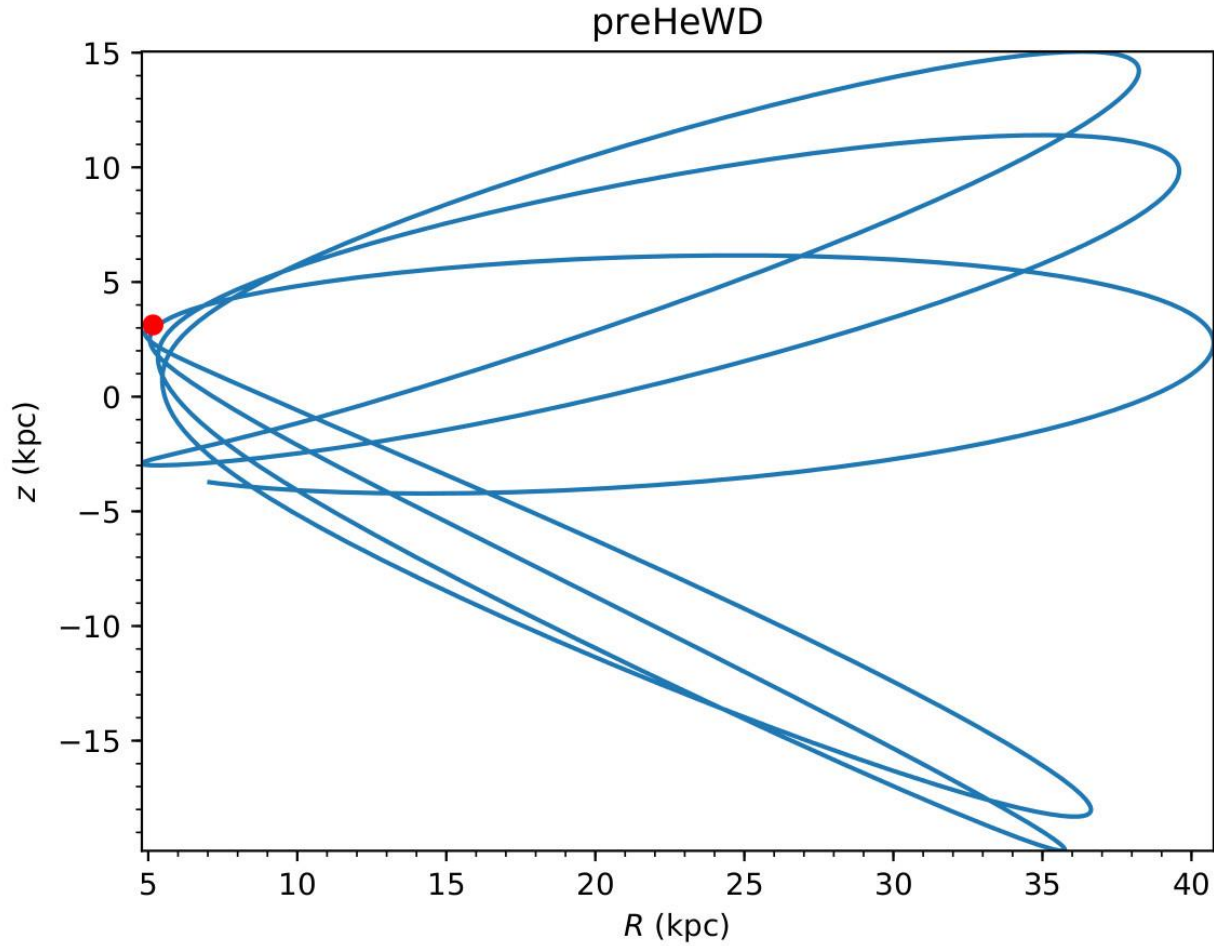






gaia

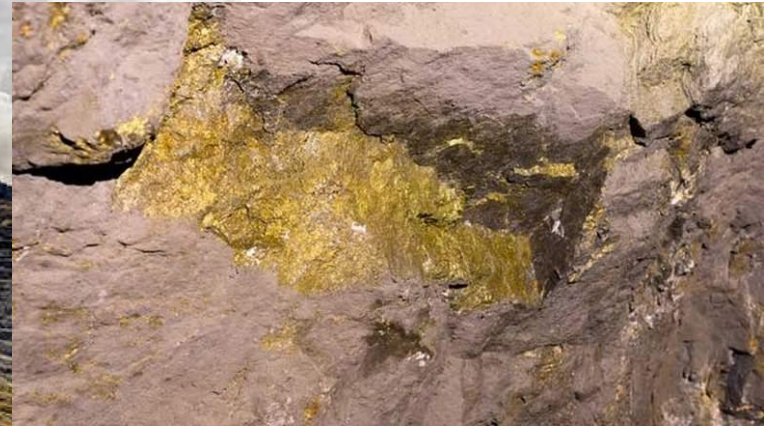
# After Gaia





gaia

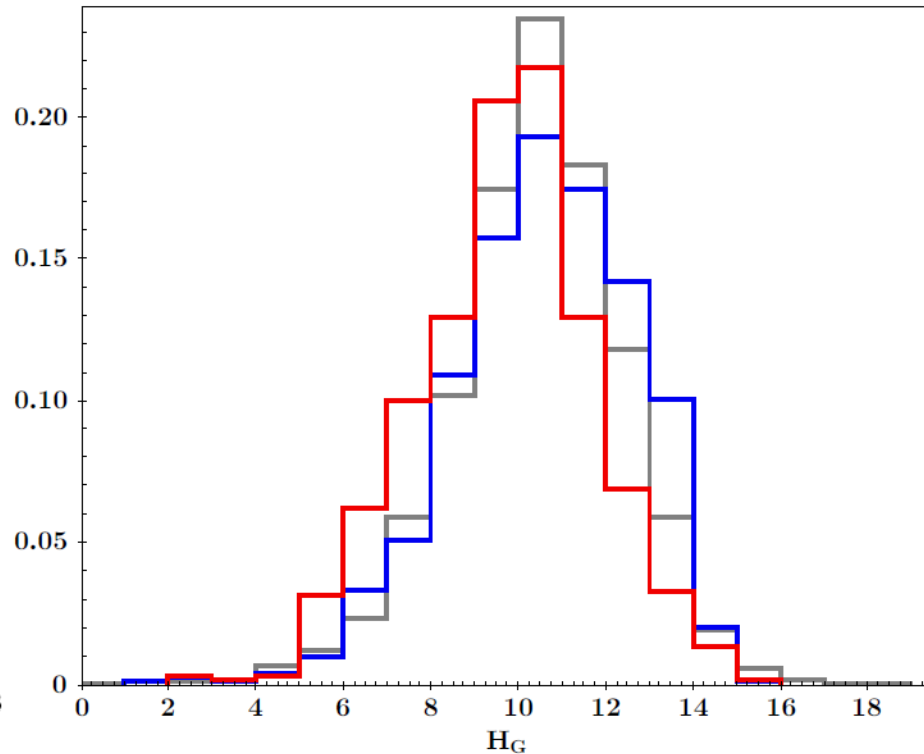
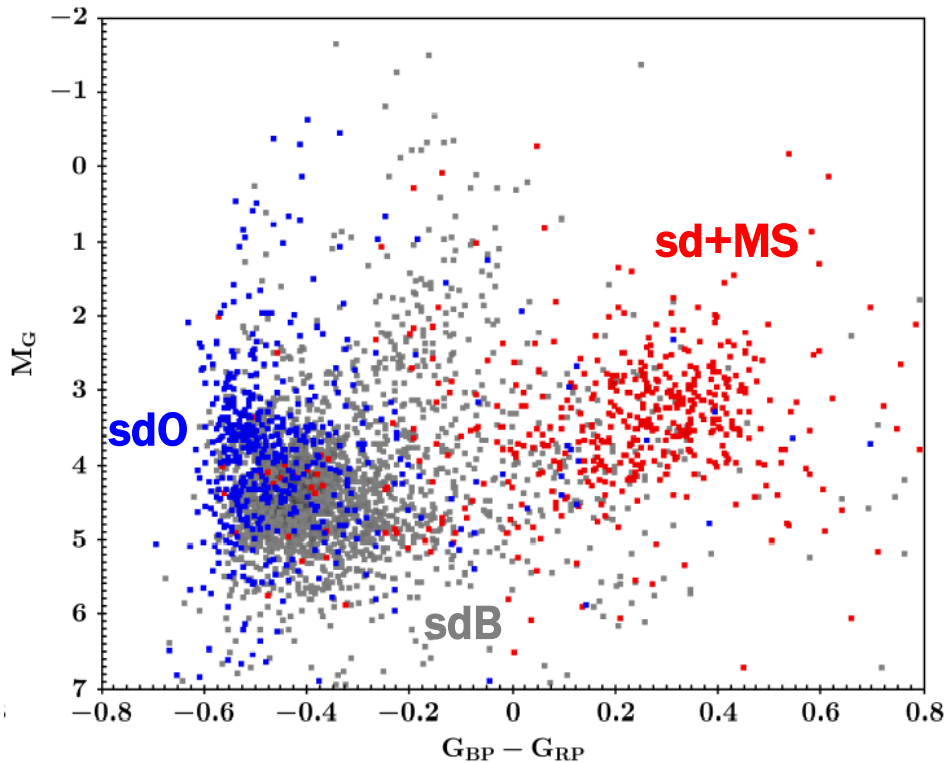
# Data Mining





gaia

# Increasing the sample



**Find location in Gaia parameter space**  
**→ Define search criteria and apply them**

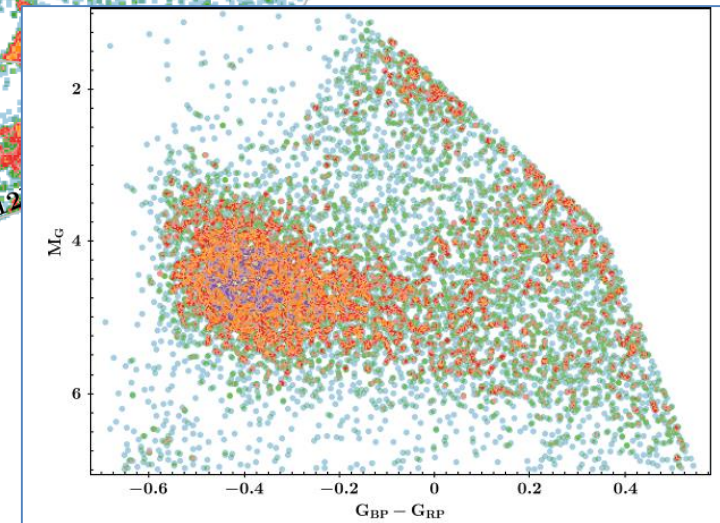
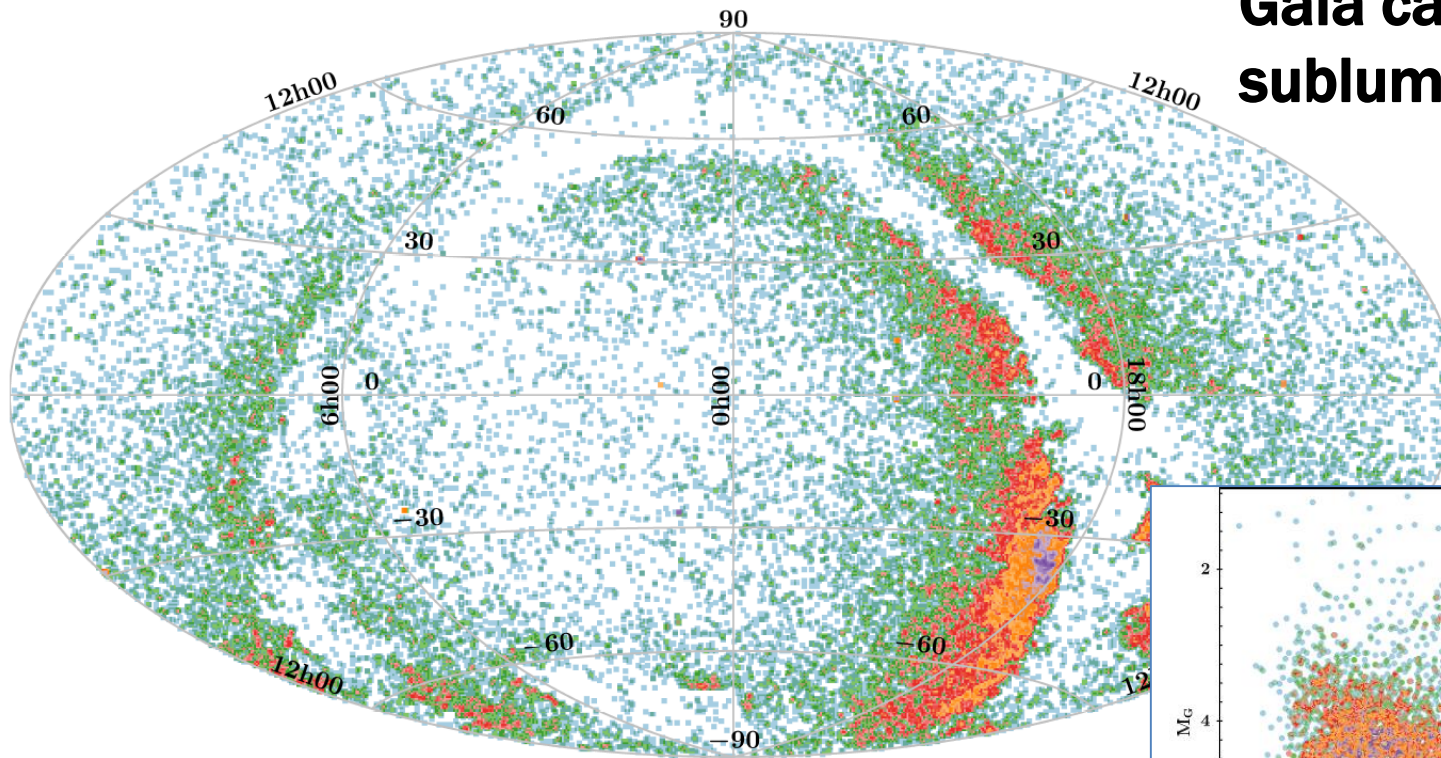




**gaia**

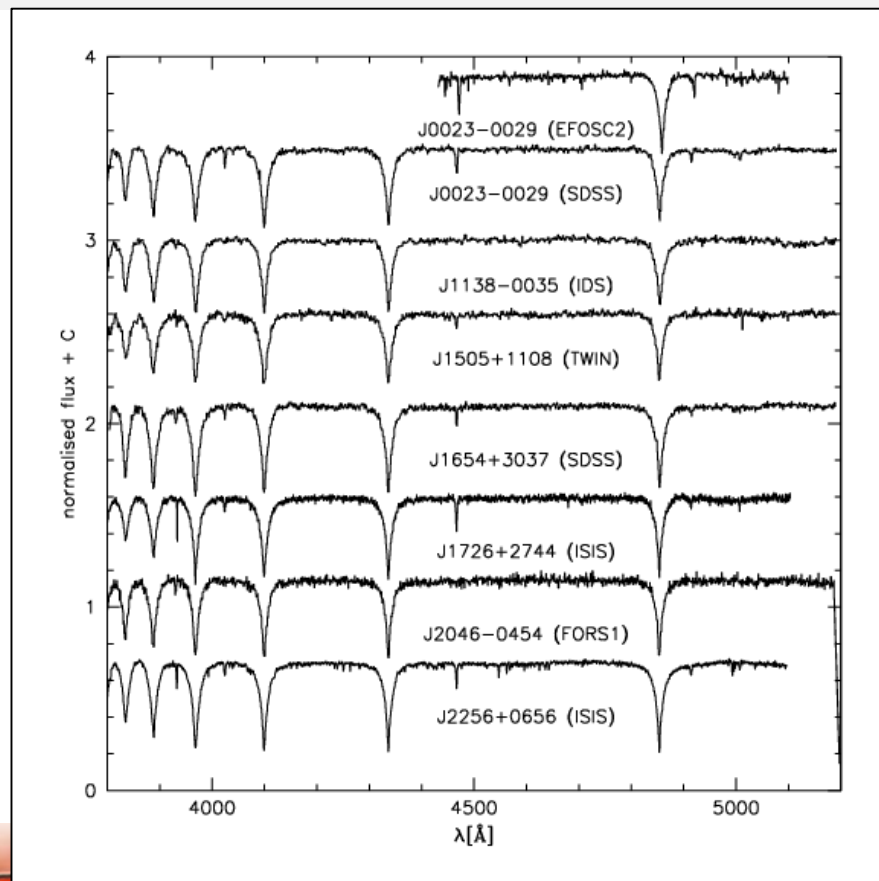
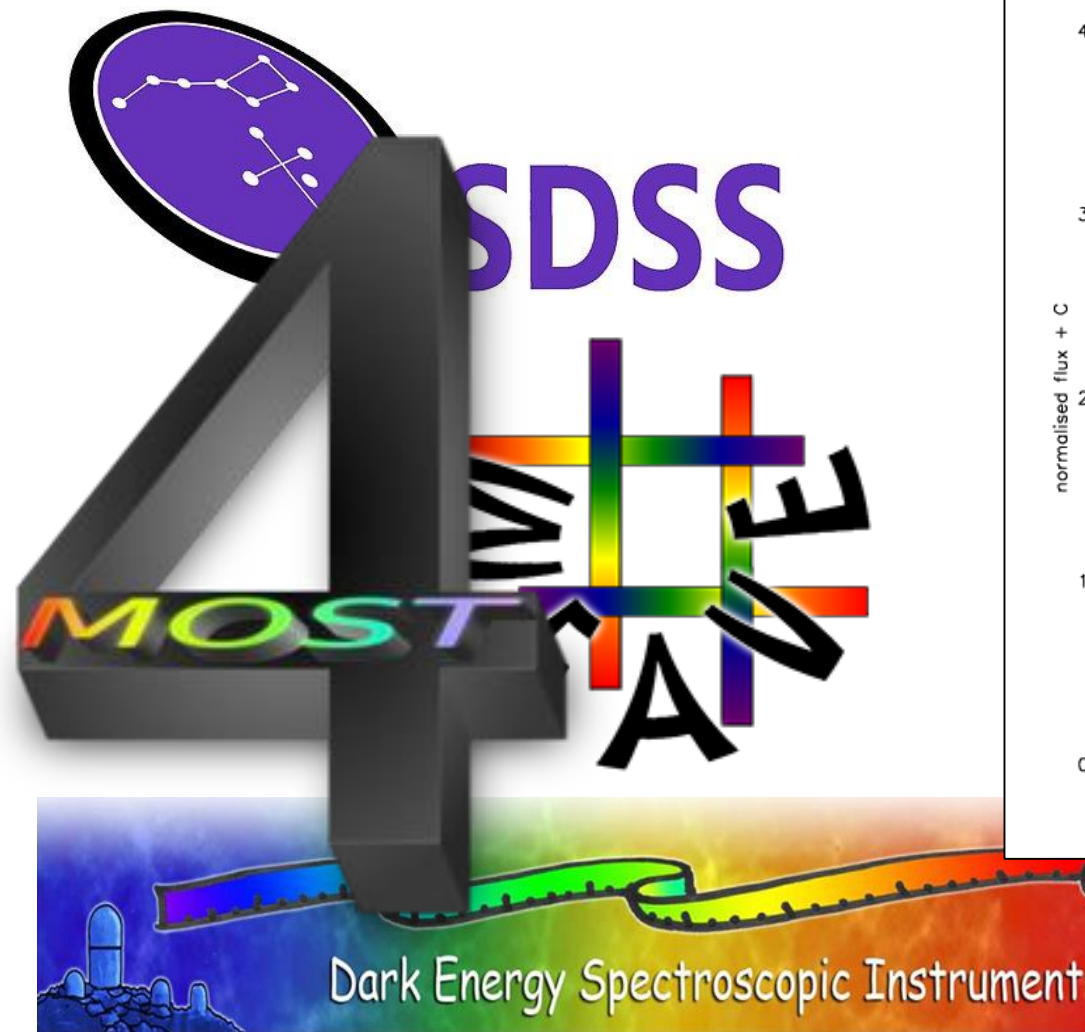
# Increasing the sample

**Gaia catalogue of hot  
subluminous stars**



**Total sample 39800**

# Input for 4MOST et al. (2019-2029)





**gaia**

**And now we start again ...**

„Nach dem Spiel ist vor dem Spiel!“

Sepp Herberger





**gaia**

**And now we start again ...**

