Tracing Radial-Velocity Drift in the ACE Spectrograph:

Instrumental Stability and Environmental Effects at Piszkéstető

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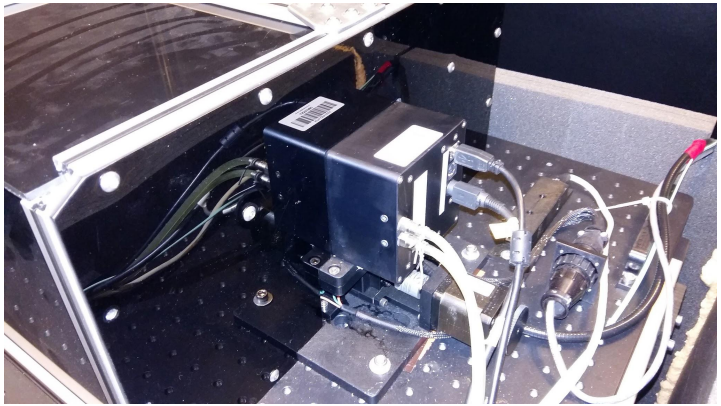
Budapest University of Technology and Economics

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FIKUT NEXTGEN | 5 November 2026



Piszkéstető Observatory



ACE spectrograph

Fibre-fed échelle spectrograph

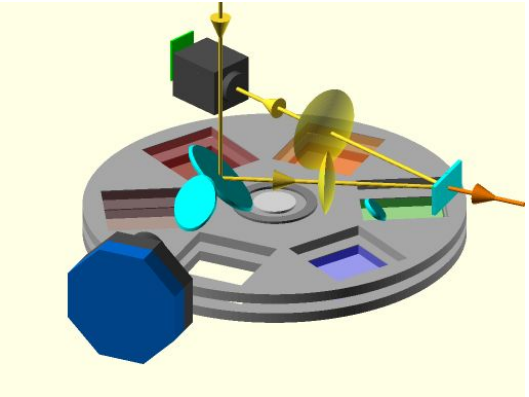
Photos: Konkoly Observatory / CCDSH

What is a spectrograph?

Science mode: the stellar frame

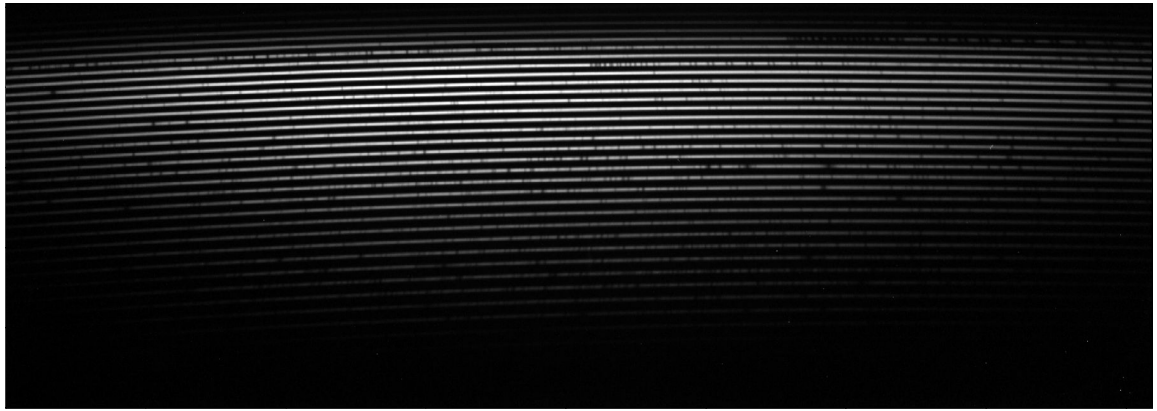
HD 168009, 14 August 2026, 600 s exposure

ACE science path



The telescope supplies the starlight.

What the CCD records

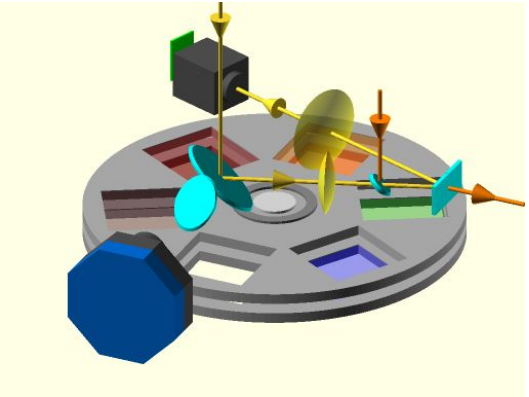


Each stripe is a spectral order.
Absorption lines interrupt the bright stripes.

Calibration mode: the ThAr frame

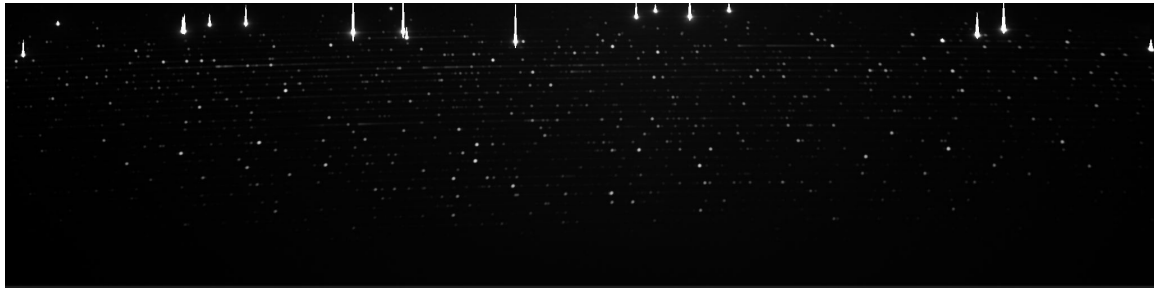
The lamp provides emission lines with known laboratory wavelengths.

ACE calibration path



A mirror injects lamp light into the science fibre.

A real ThAr detector image



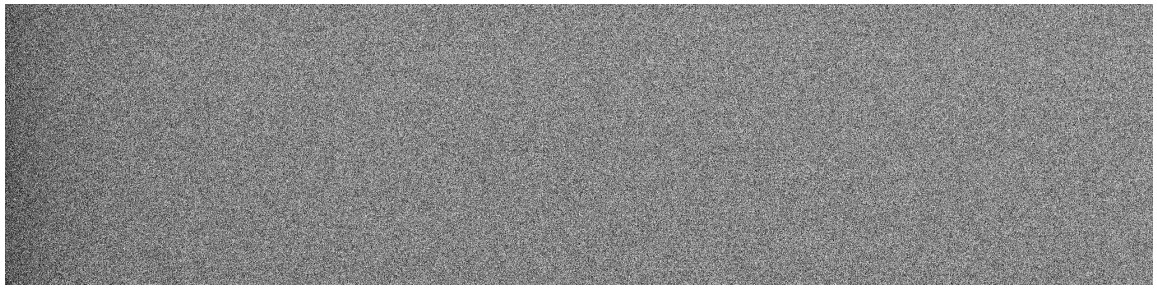
Bright spots mark emission lines.
They give us reference points for calibration.

Bias and flat frames

Calibration images help separate the detector response from the stellar signal.

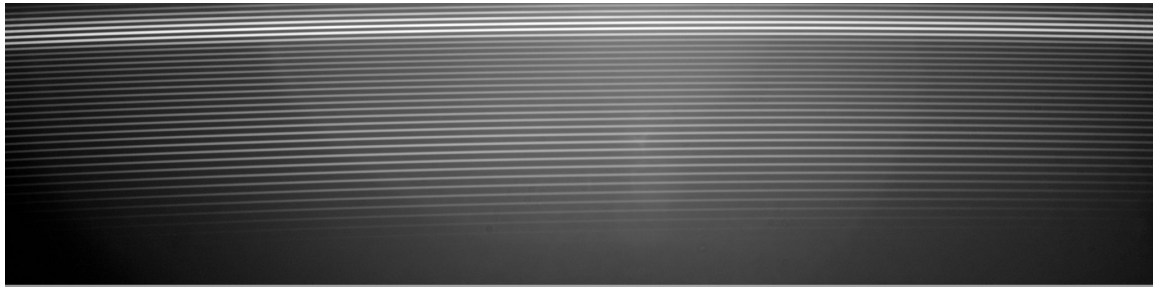
Master bias

Measures the electronic offset of the detector.

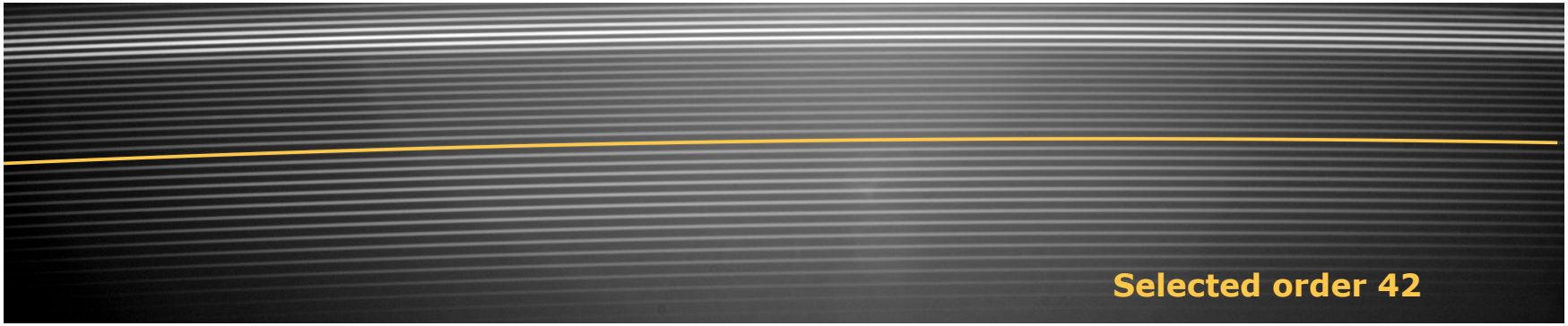


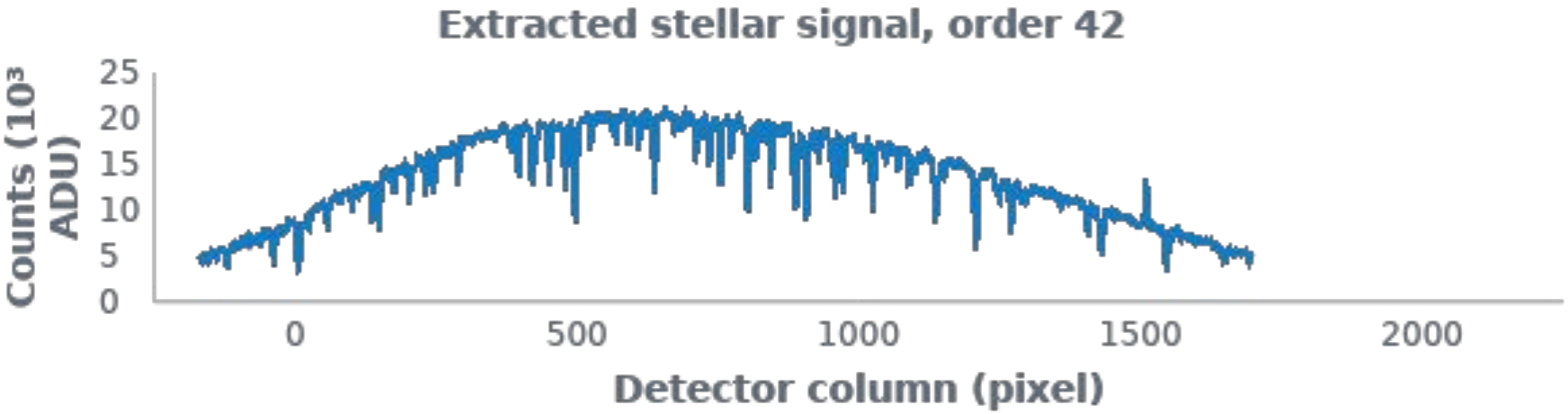
Master flat

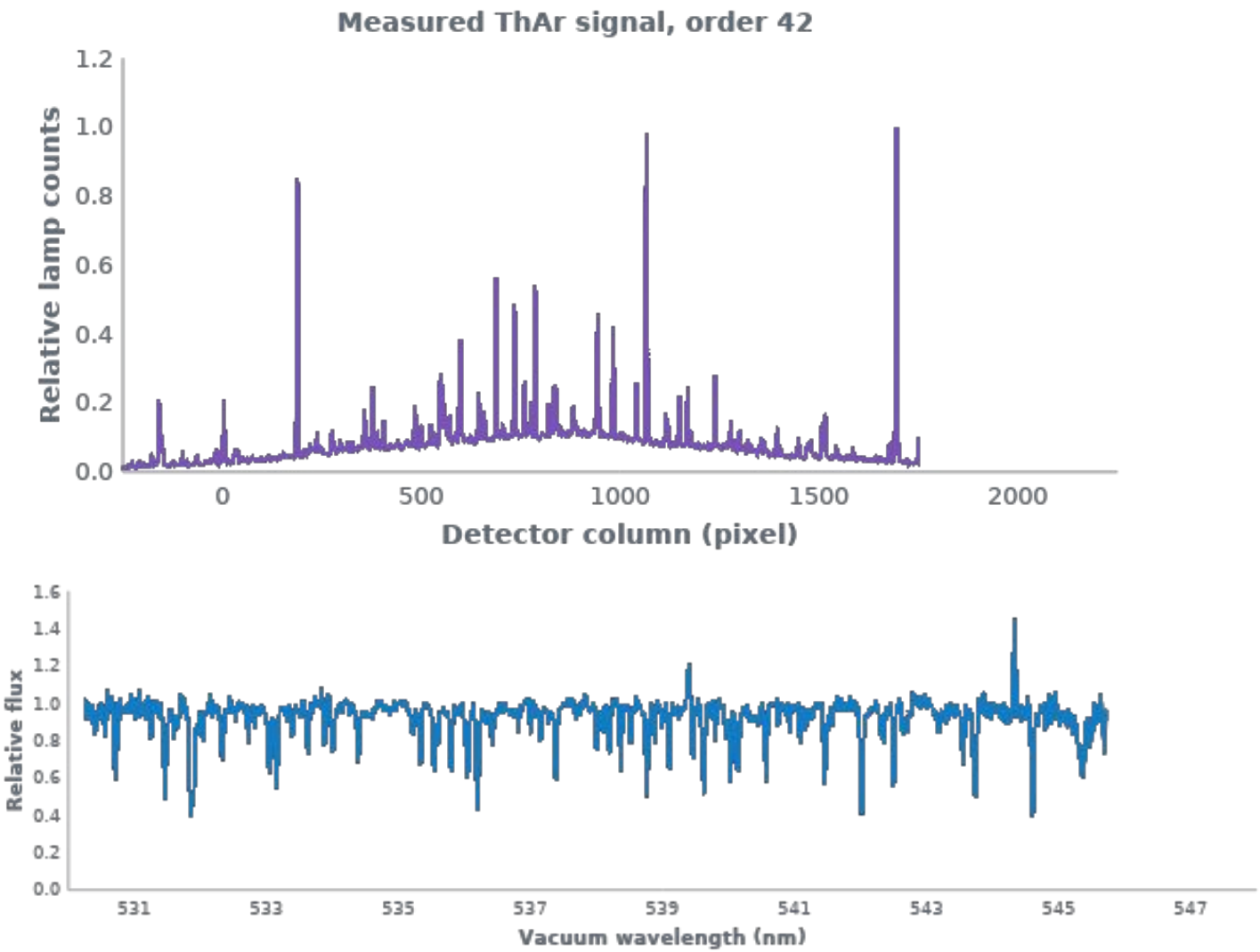
Reveals the orders and the illumination response.



Each image has its own contrast stretch.

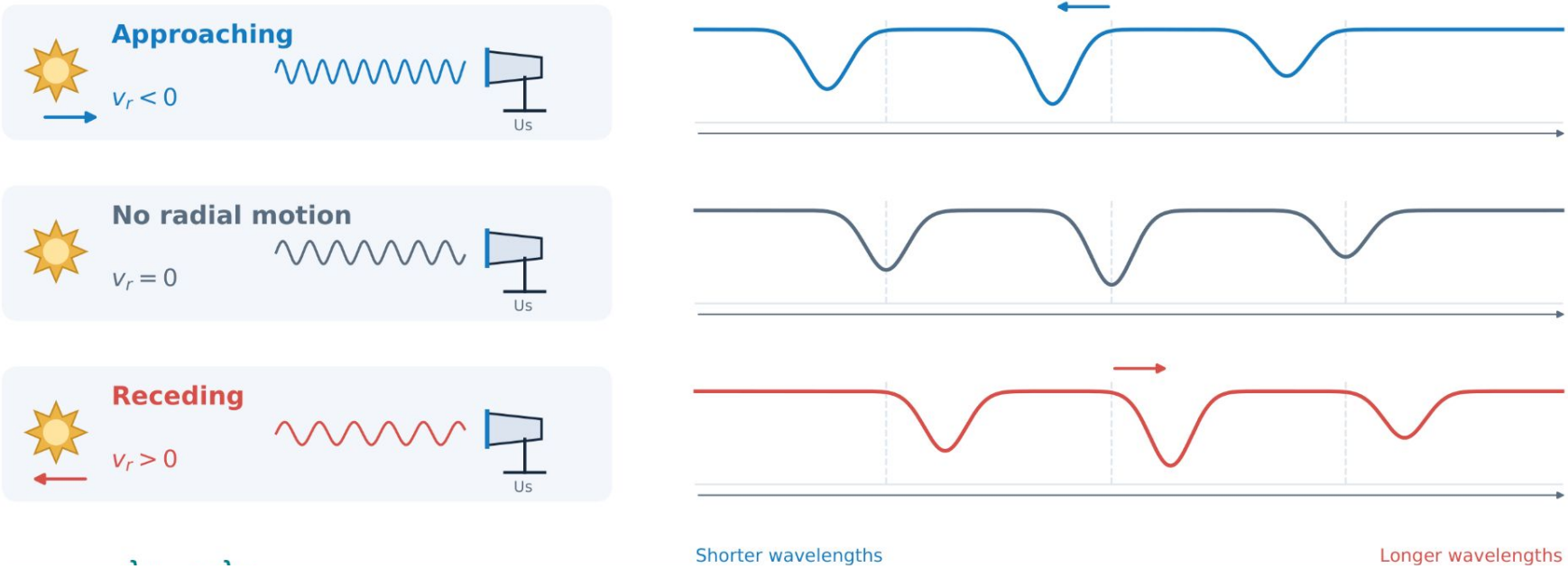

Selected order 42


Extracted stellar signal, order 42
Counts (10³ ADU)
25
20
15
10
5
0
0
500
1000
1500
2000
Detector column (pixel)


Measured ThAr signal, order 42
Relative lamp counts
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
500
1000
1500
2000
Detector column (pixel)
Relative flux
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
531
533
535
537
539
541
543
545
547
Vacuum wavelength (nm)

Why radial velocity?

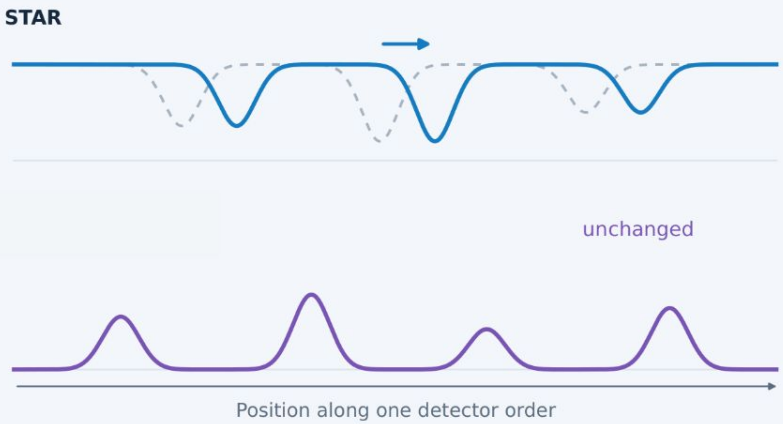
Radial Velocity Direction



Schematic Doppler illustration. The line patterns show the direction of the shift, not measured velocities.

Stellar motion

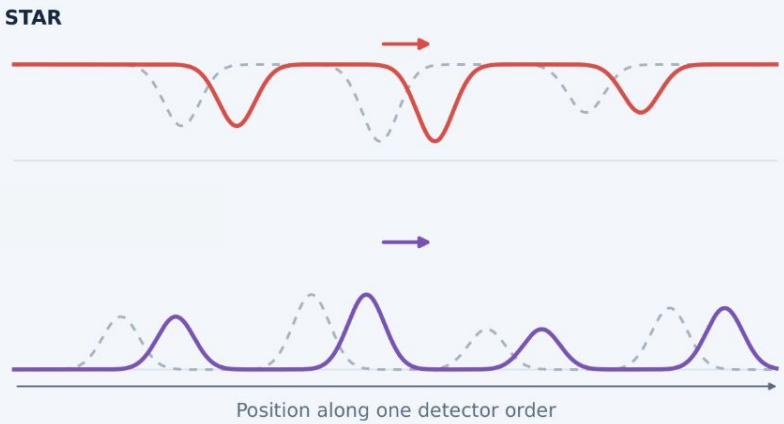
Instrument stays stable



Only the star’s lines move.

Instrument drift

Stellar velocity stays constant

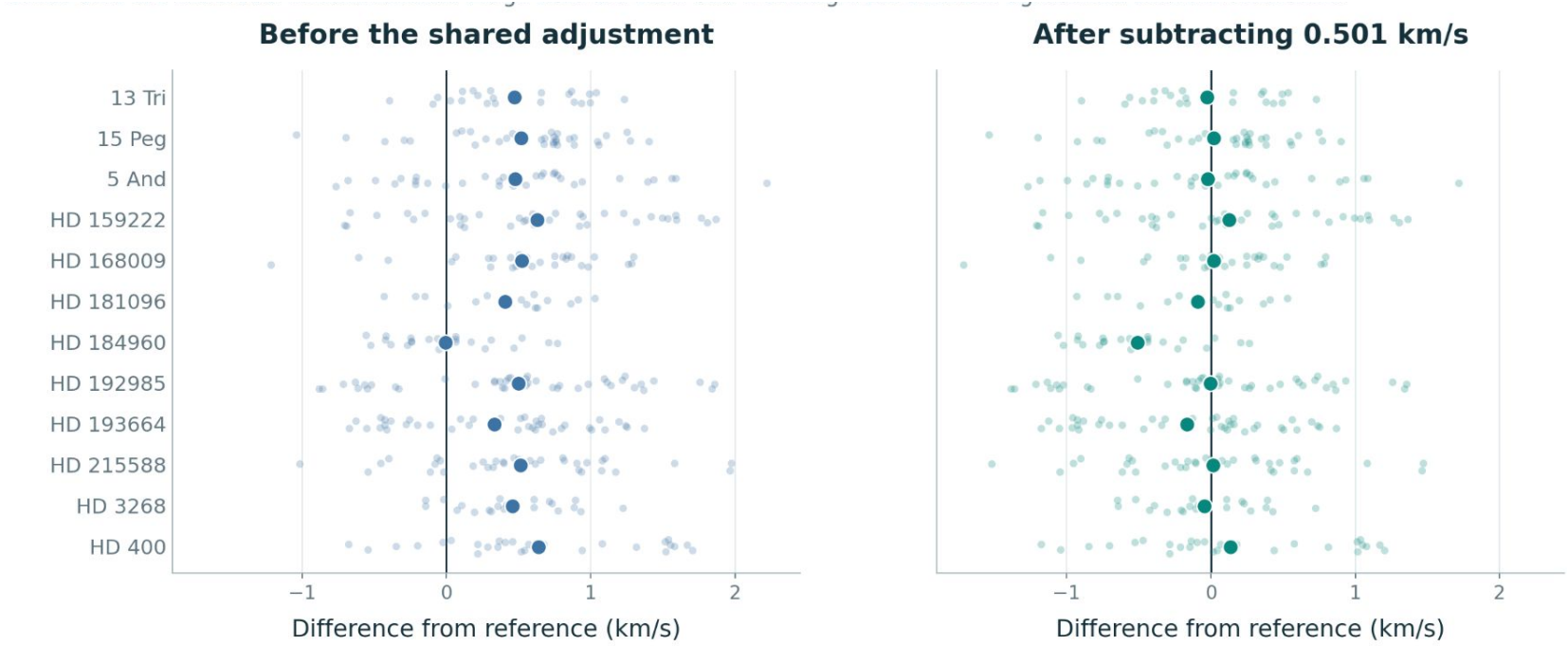


Both patterns move on the detector.

Purple peaks represent ThAr lamp emission. Dashed patterns mark the earlier detector positions.

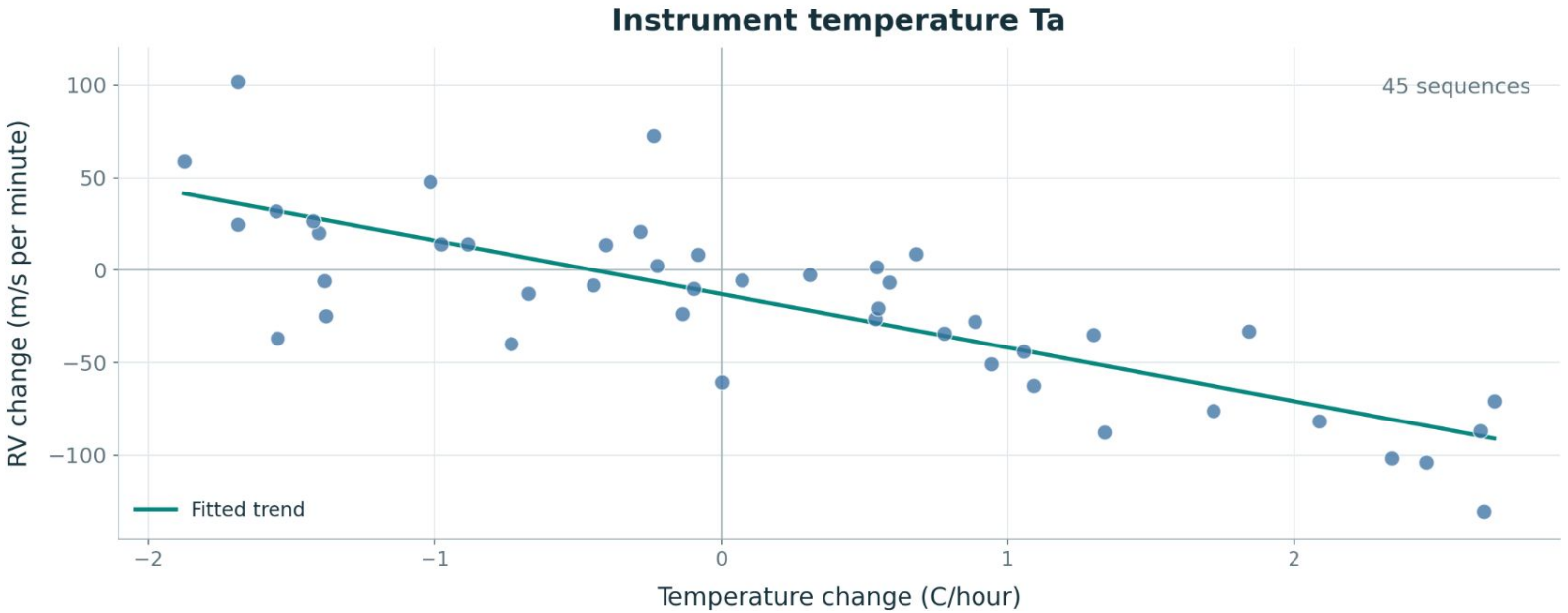
How Reliable is our ACE at finding RVs ?

Zero Point Correction



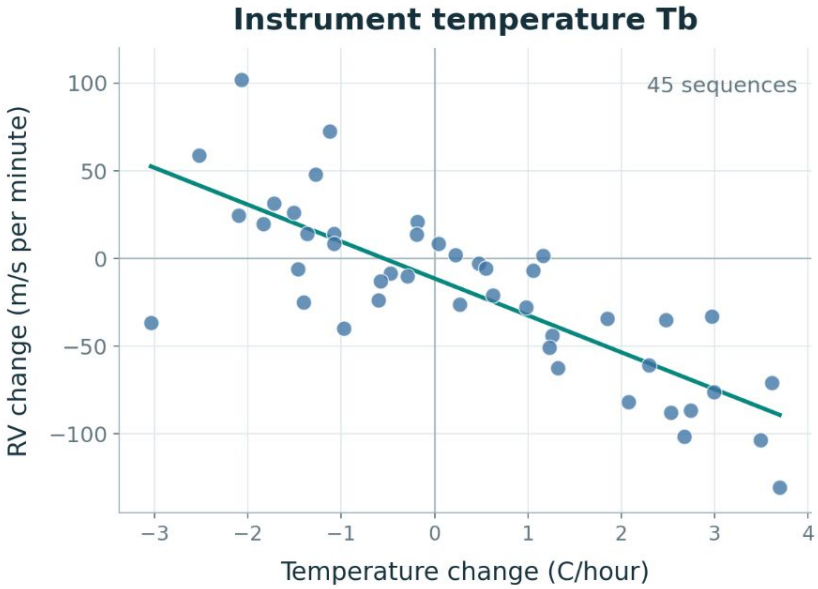
363 selected reference spectra. 14 anomalous exposures excluded.
The same 0.501 km/s offset is subtracted from every RV. This shifts the centre without removing the scatter.

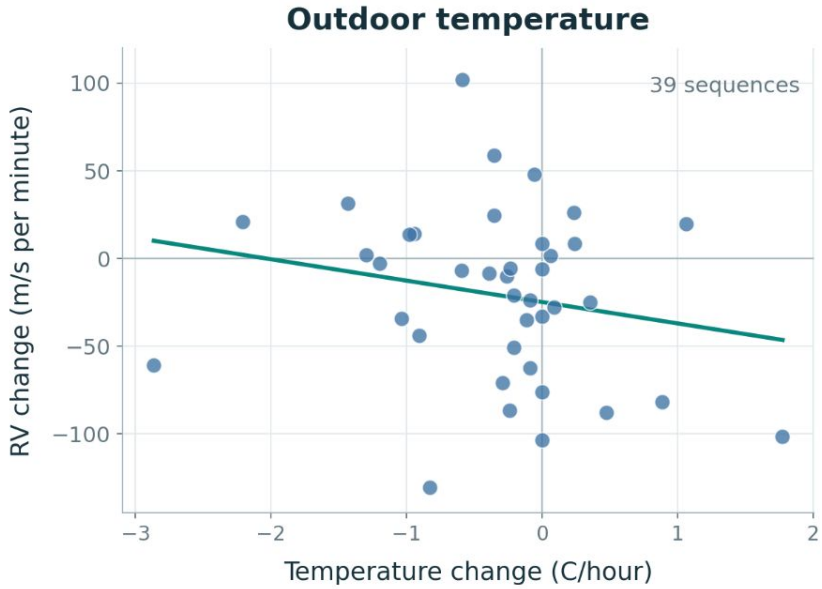
Bench Temperature



Each dot is one observing sequence (45 total), comparing RV and temperature change rates.
The fitted line describes an association. This plot alone does not isolate a temperature effect.

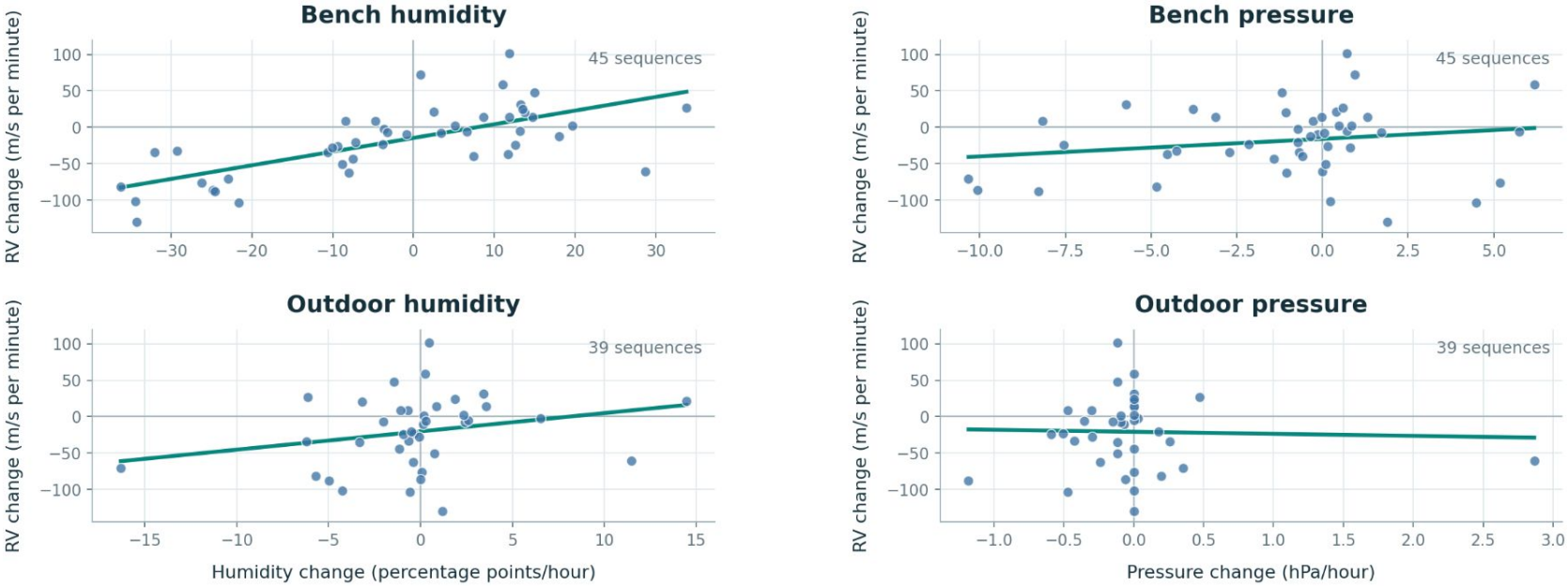
Other Temperature Sensors





45 instrument sequences. 39 have matched outdoor data. Six lack matched outdoor records.
Each dot compares changes within one observing sequence. Missing matches do not establish sensor failure.

Other Environmental Factors



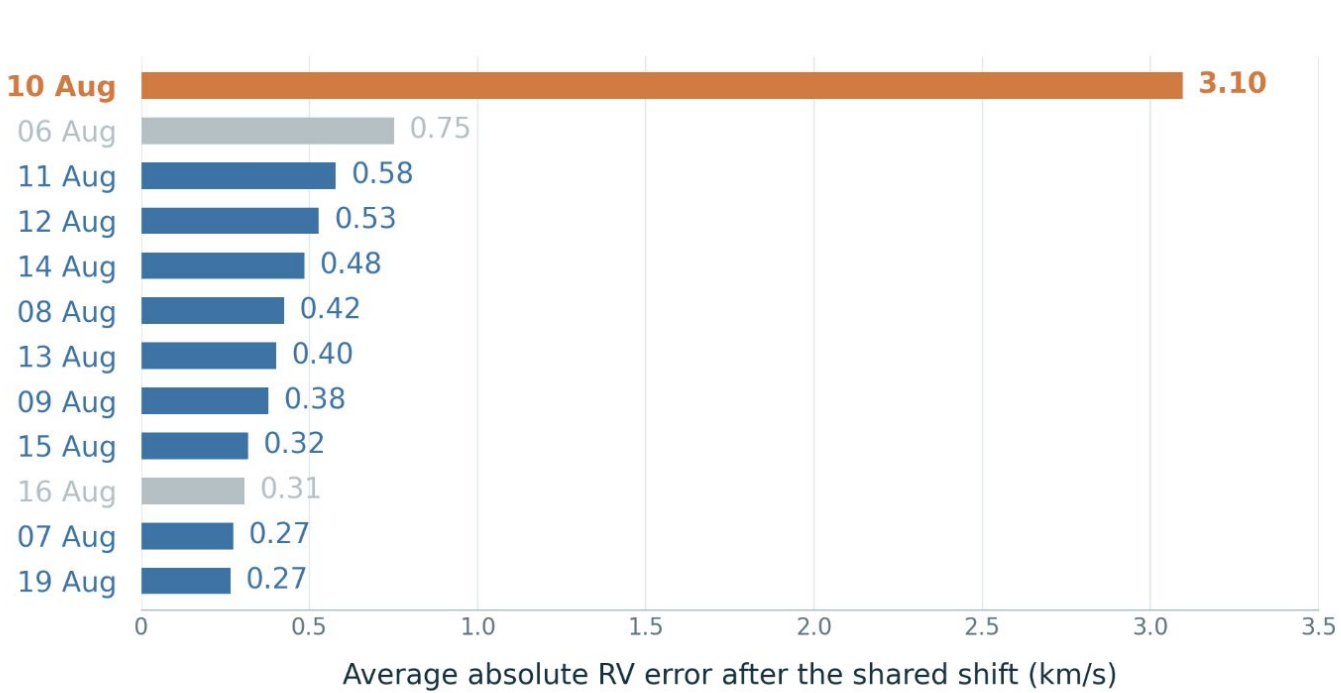
45 indoor sequences and 39 with outdoor data. Lines describe the observed associations.
The environmental measurements change together, so these plots do not isolate independent causes.

Thermal Correction didn’t work



Original RVs. Shared offset removed. Environmental test: 173 spectra over 10 nights (7 improve, 3 worsen).
Aug 10: 25 exposures. Outlier sequences excluded. 733 to 681 m/s = 0.733 to 0.681 km/s.

An Outlier

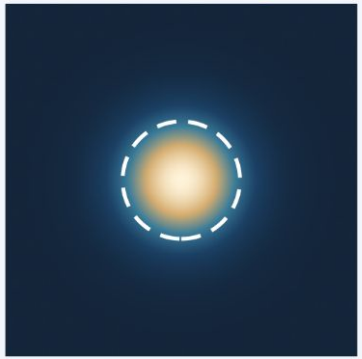


	Spectra	Stars
10 Aug	68	8
06 Aug	2	1
11 Aug	72	12
12 Aug	43	12
14 Aug	32	11
08 Aug	18	5
13 Aug	30	11
09 Aug	24	8
15 Aug	36	12
16 Aug	3	1
07 Aug	13	3
19 Aug	36	12

Original RVs. All 377 reference spectra, anomalies retained. Shared 0.501 km/s offset removed.
August 10: all 68 reference exposures (8 stars), including the 13 large-outlier exposures.

Could it be seeing ?

Good seeing



White circle = fixed fibre opening

Compact stellar image

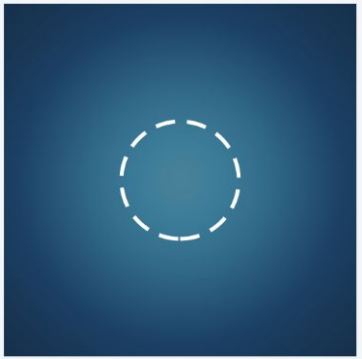
Image FWHM: 1.0 arcsec

Same 2.0 arcsec fibre diameter

94% enters the fibre

More light enters the fibre.

Poor seeing



White circle = fixed fibre opening

Broader stellar image

Image FWHM: 3.0 arcsec

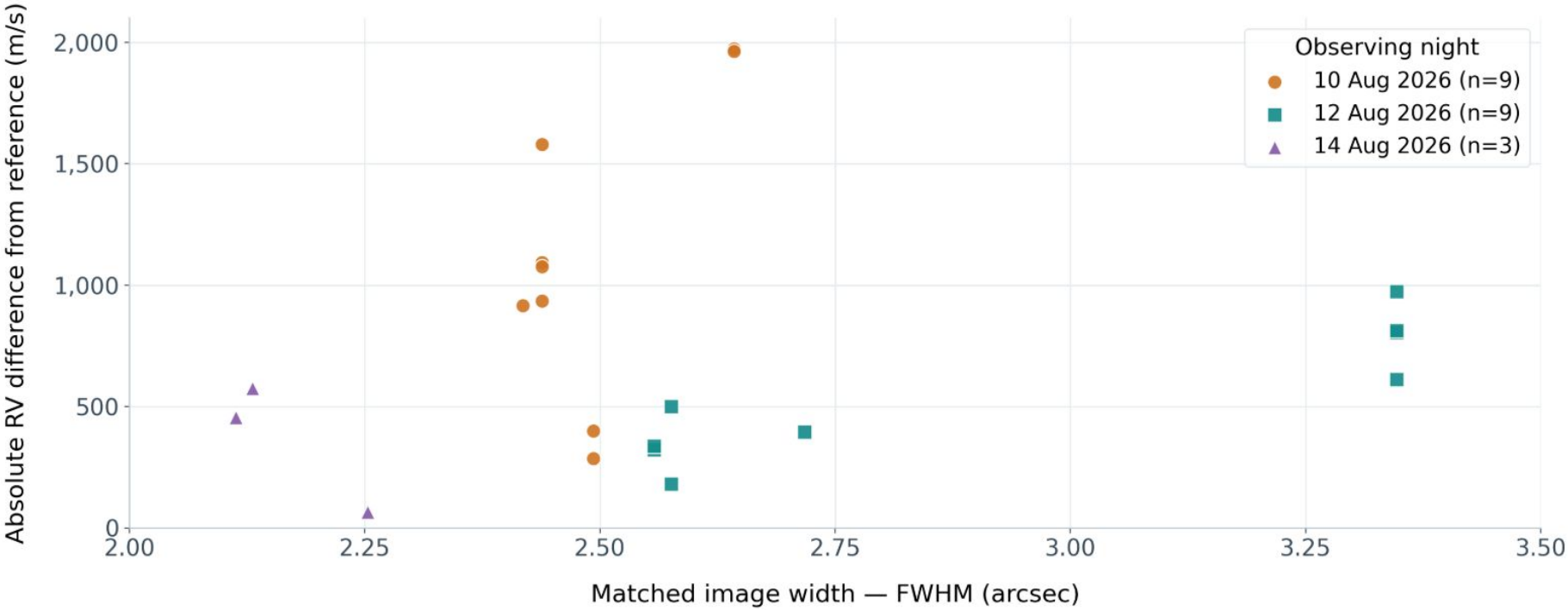
Same 2.0 arcsec fibre diameter

27% enters the fibre

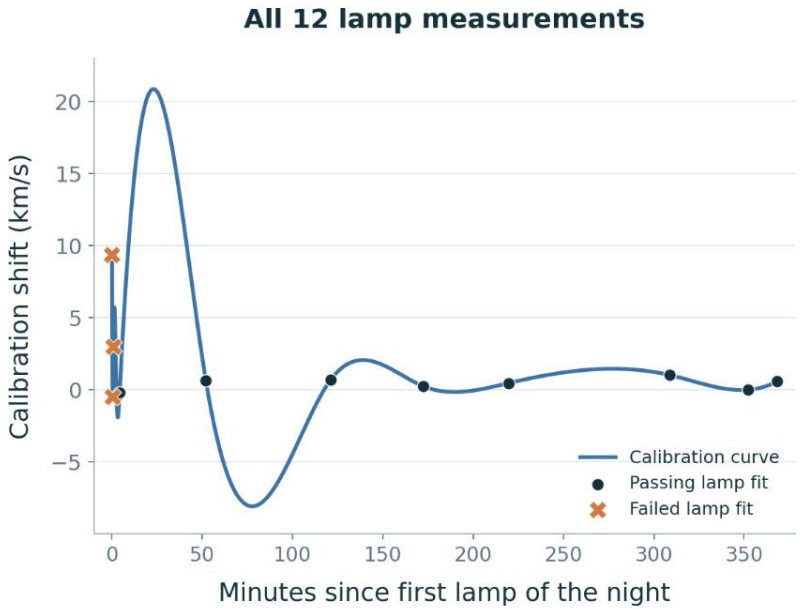
More light falls outside it.

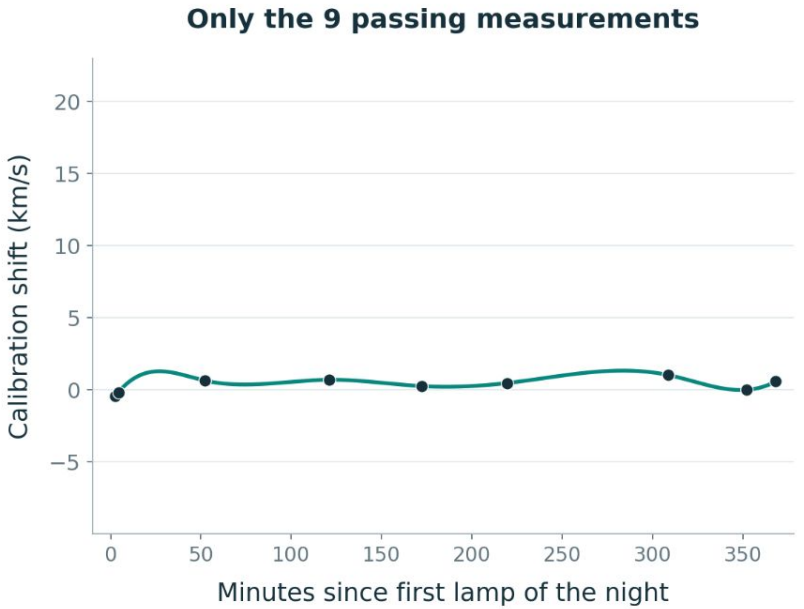
Image quality and RV errors: HD 215588

One reference star · 21 spectra · 3 observing nights · 11 distinct imaging exposures



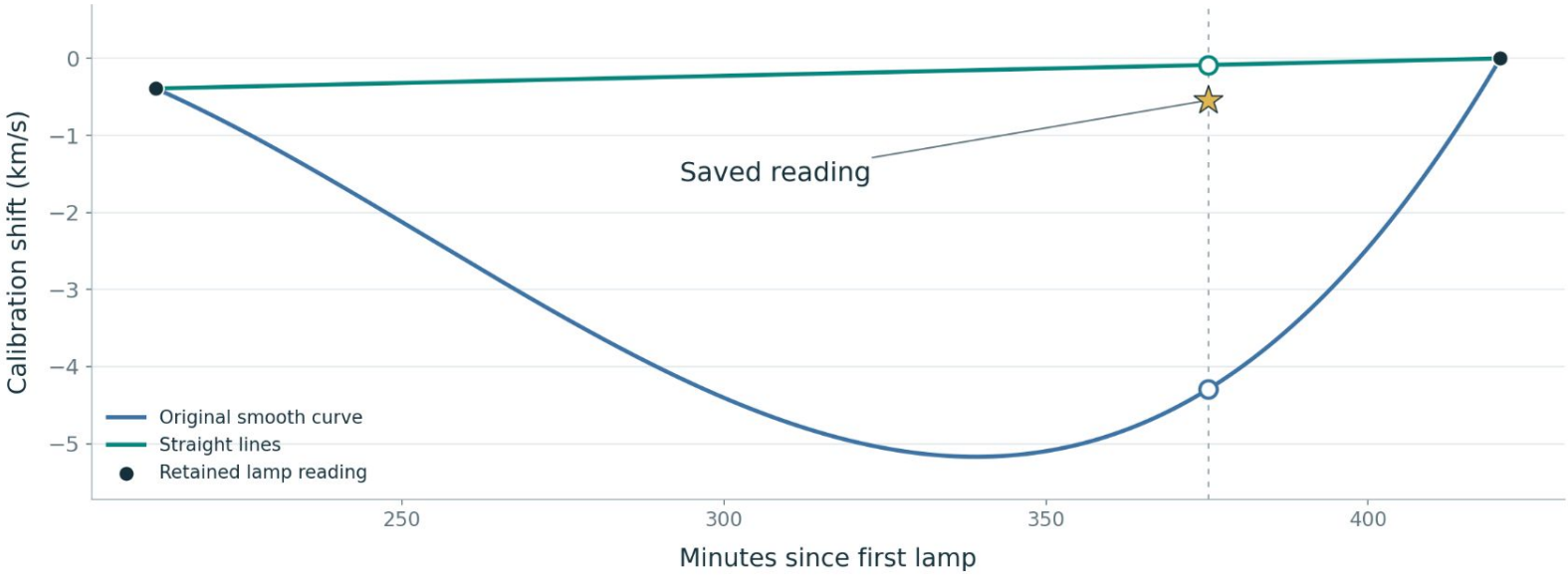
Wavelength Calliberation





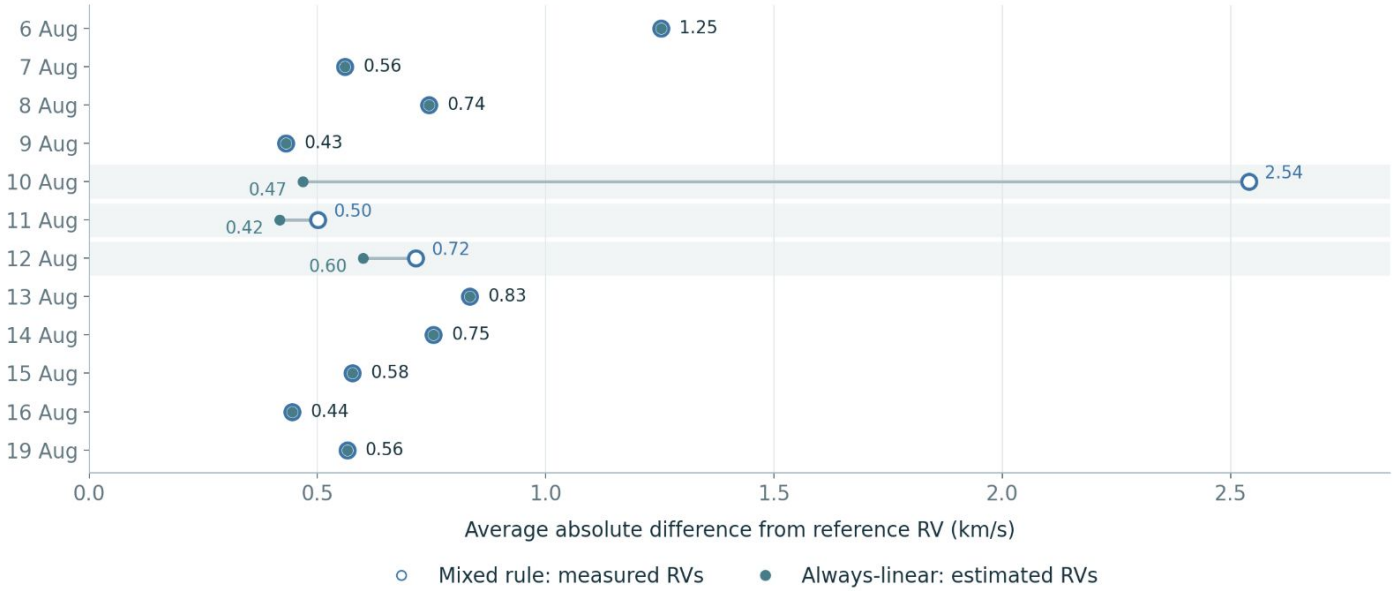
10 August: reconstructed curves using the same cubic method and reference, with 12 lamps versus 9 passing fits. The three failed fits are excluded only on the right. These are calibration shifts, not stellar RV errors.

Interpolation Problems



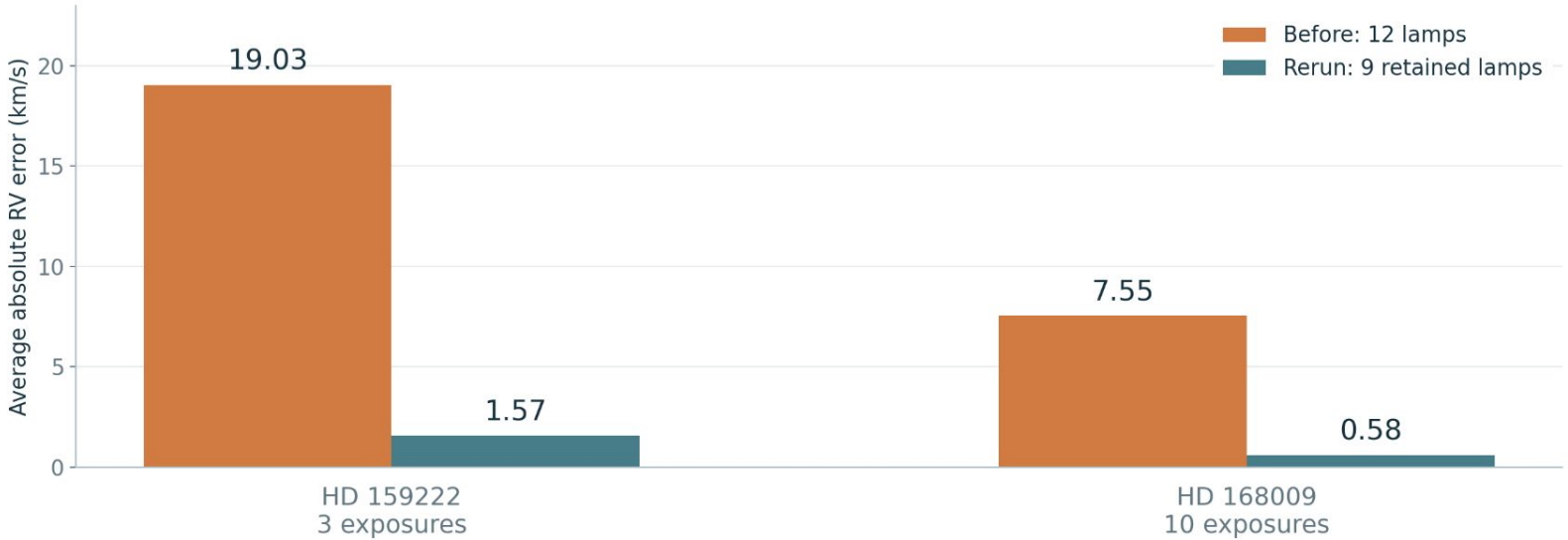
Hidden-lamp prediction test on 11 August, showing the largest cubic miss among 10 scored cases. Linear is closer in 6 of 10 overall. The saved reading is a lamp shift, not a stellar RV.

Drastic Correction



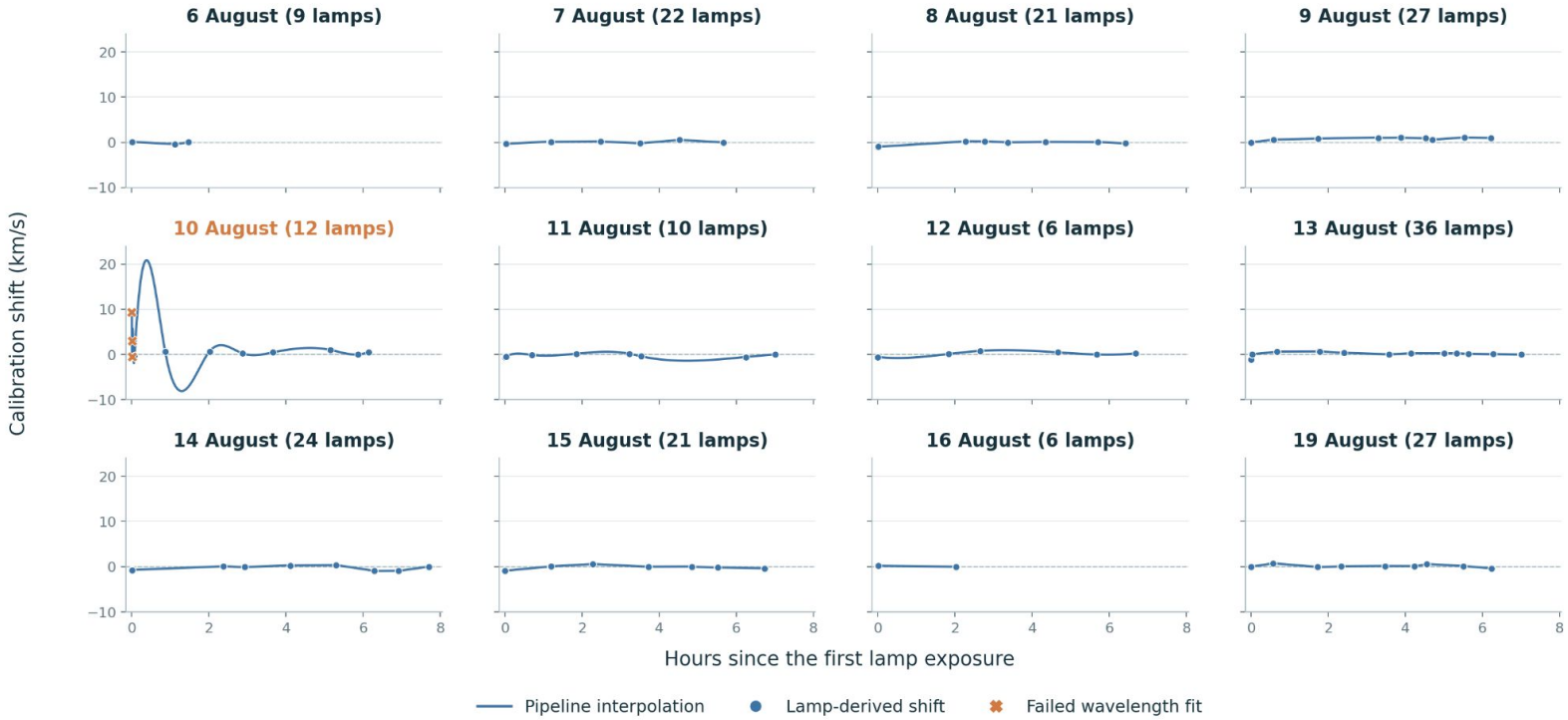
Diagnostic RVs. 377 reference spectra (Aug 10: 68), same 221 lamps. No shared offset removed.
Mixed-rule RVs are measured. **Linear RVs are estimates**. Always-linear stellar reruns are still needed.

For Problematic Stars



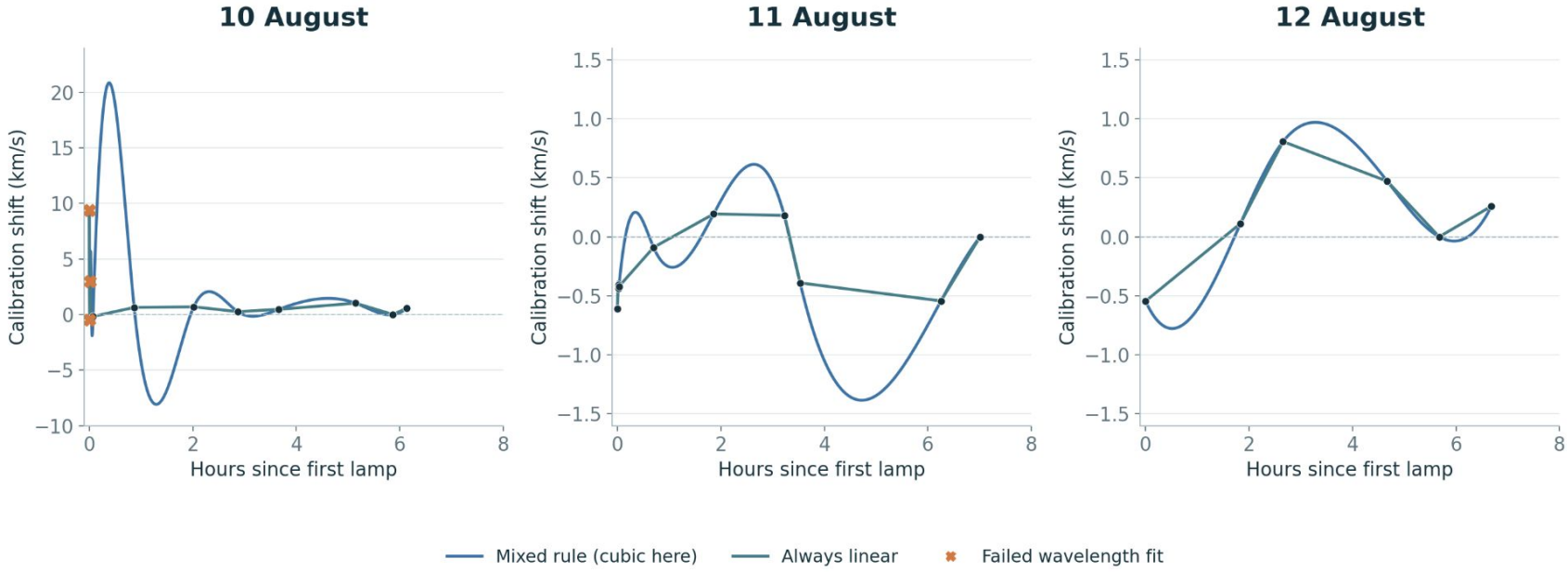
Diagnostic RVs. 13 exposures (3 HD 159222, 10 HD 168009). No shared offset removed.
Measured rerun removes 3 failed fits and keeps cubic. Complete settings equivalence remains unverified.

Full Data Generalization



Original mixed-rule reconstruction: all 221 lamp shifts across 12 nights, using common axes.
Each night has its own reference. The lines are interpolated calibration shifts, not stellar RV errors.

Problematic Nights



Same original lamp inputs. Both lines reconstruct corrections between lamp exposures.
Vertical scales differ across panels. The curves alone do not measure stellar RV accuracy.

Takeaways and Future Work

0.5 km/s persistent offset.
Better Wavelength Calibration.

Investigating other Environmental and Instrumental Effects and their Compounded effects

Thank you