

Enabling 1000x more sensitive spectrographs for exoplanet search

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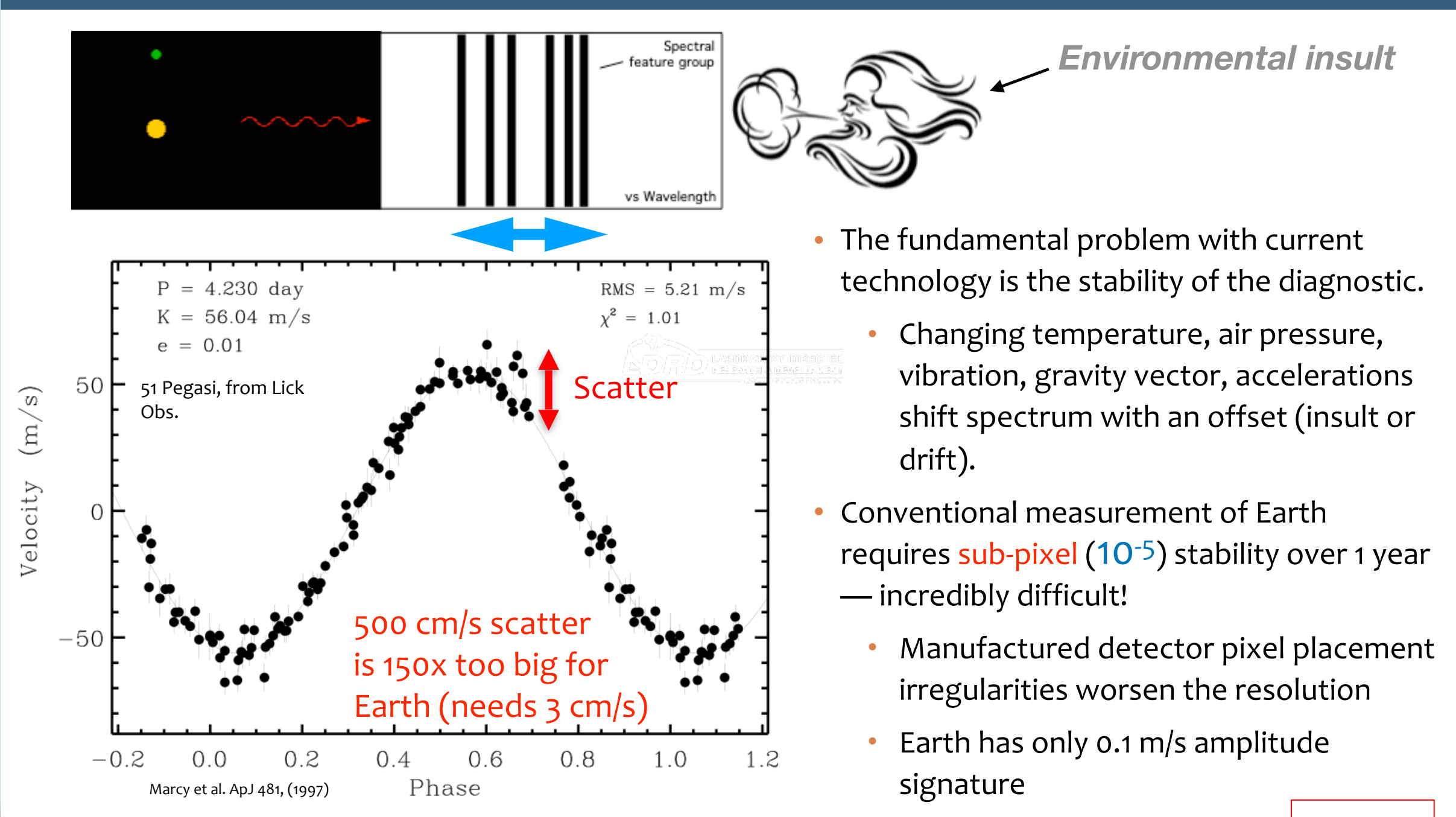
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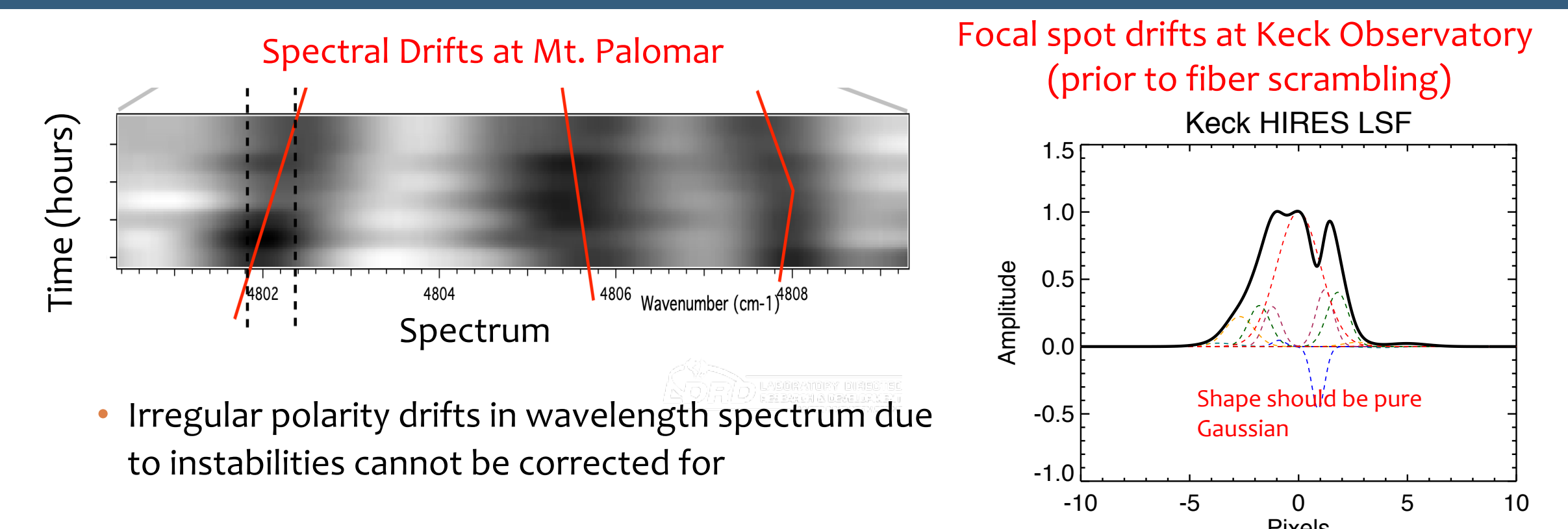
LLNL-PRES-829715

Exo-Planets are discovered by Doppler velocity shifts of starlight



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Spectrograph Drift and focal irregularities define the system resolution



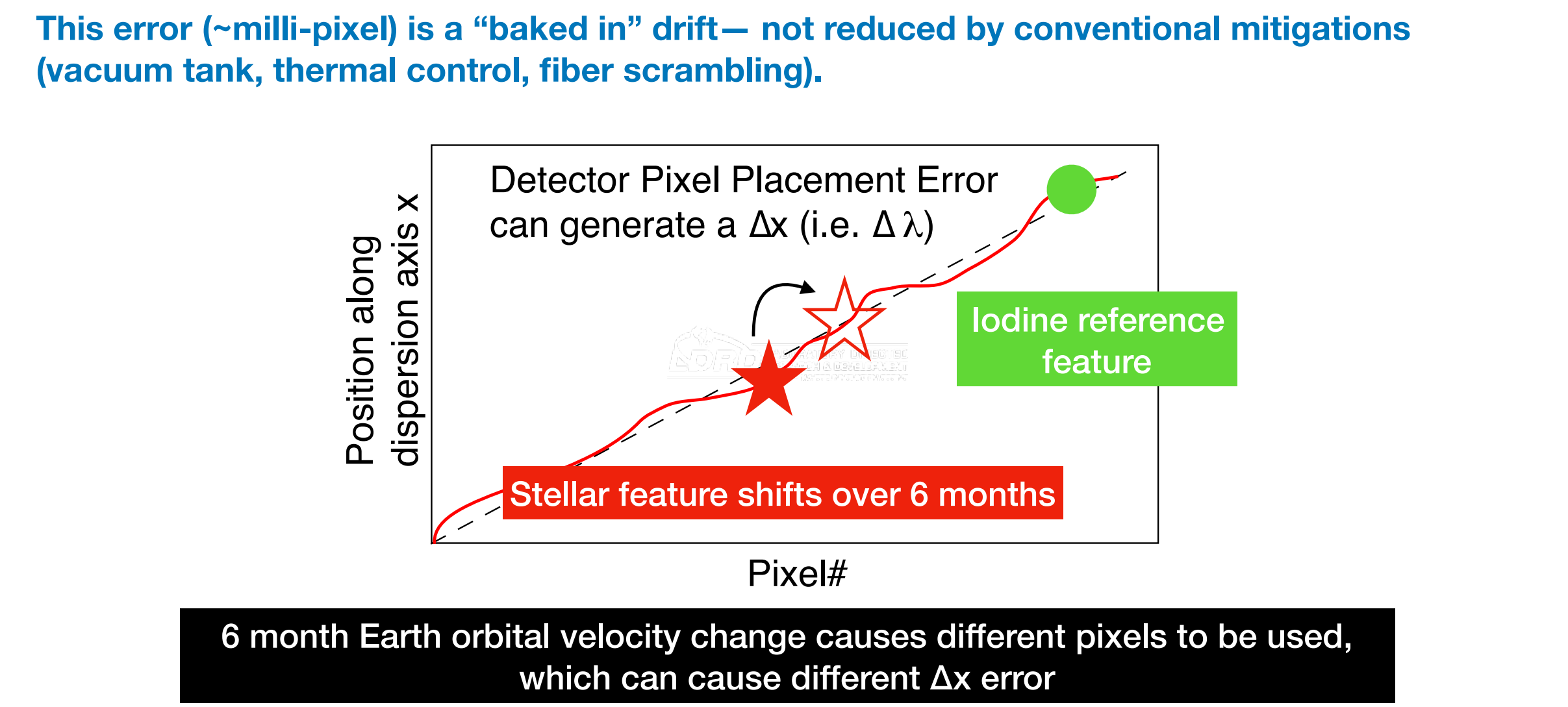
Conventional mitigations: large vacuum tanks, bulky thermal blankets, massive sturdy mounts

Still, the required 10^{-5} pixel stability needed is not achieved

A fundamentally different approach is needed to advance the sensitivity of Doppler spectroscopy

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Another problem: Manufactured Pixel Placement is Irregular on Detector

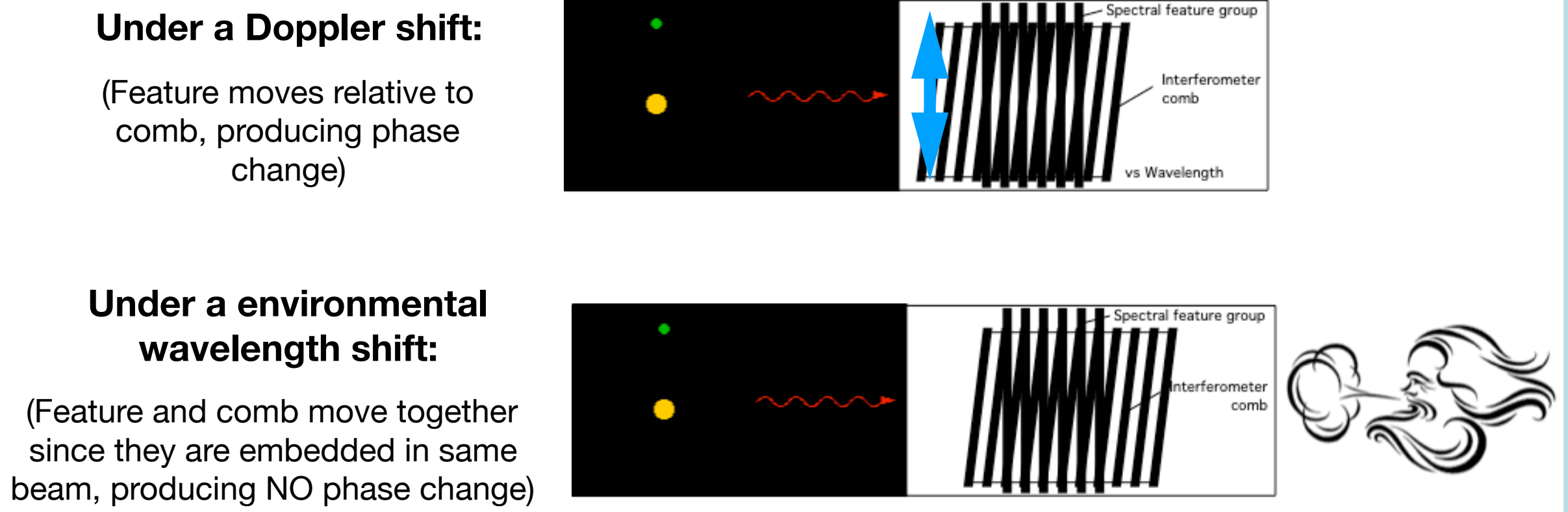


These could be much larger than the 10^{-5} pixel tolerance needed to detect Earth-like planets

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Externally Dispersed Interferometry* (EDI), advantage for Doppler planet search:

Horizontal Moire are perfectly robust to wavelength distortions



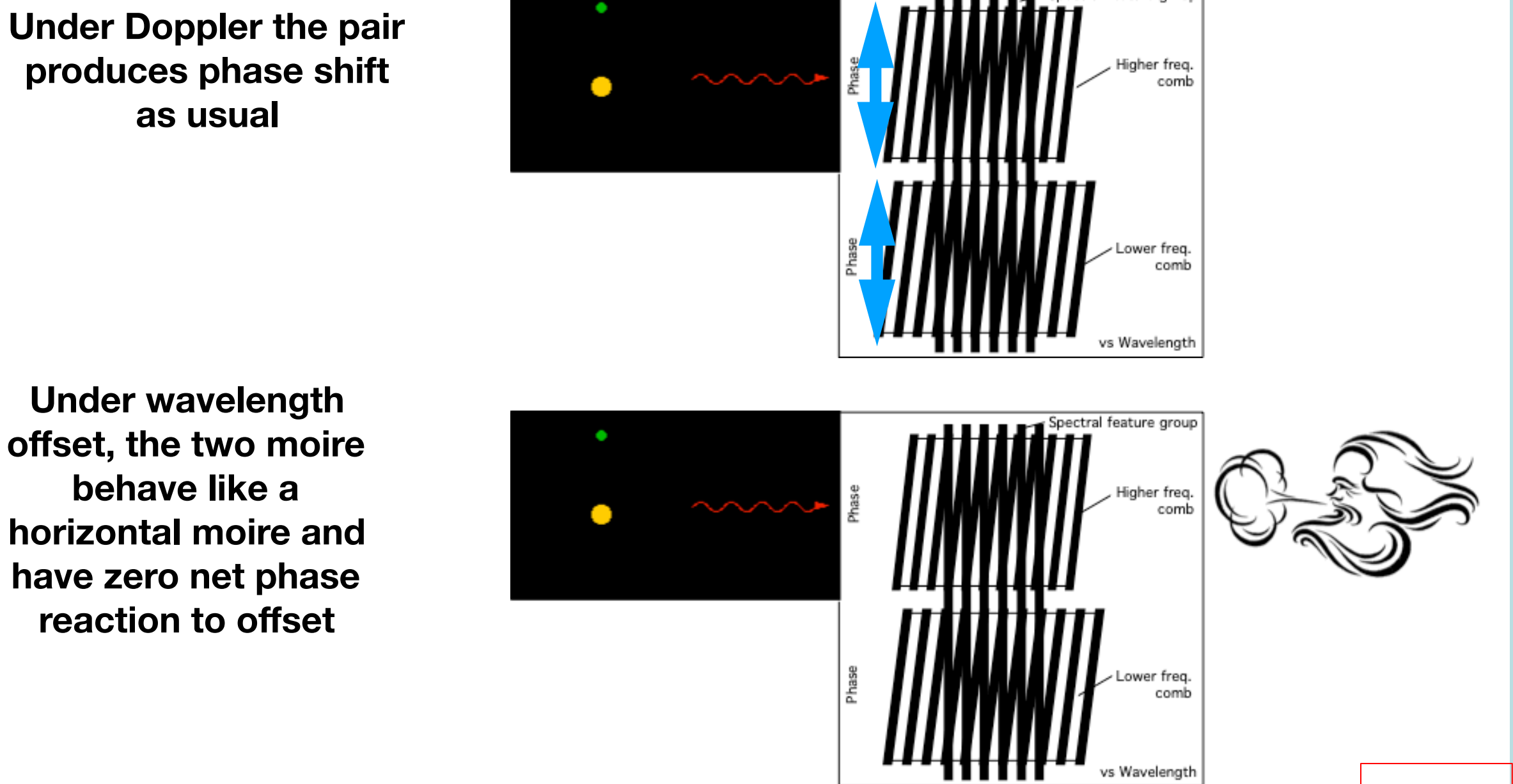
Horizontal Moire occurs when feature frequency matches interferometer comb

Problem: realist spectra have a variety of frequencies—will generate Moire with variety of tilts

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New Idea: use two slightly different interferometers simultaneously

For each frequency, select weights and combine data to effectively cancel slope of moire



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Demo of software using multiple pairs of intrfr. delays

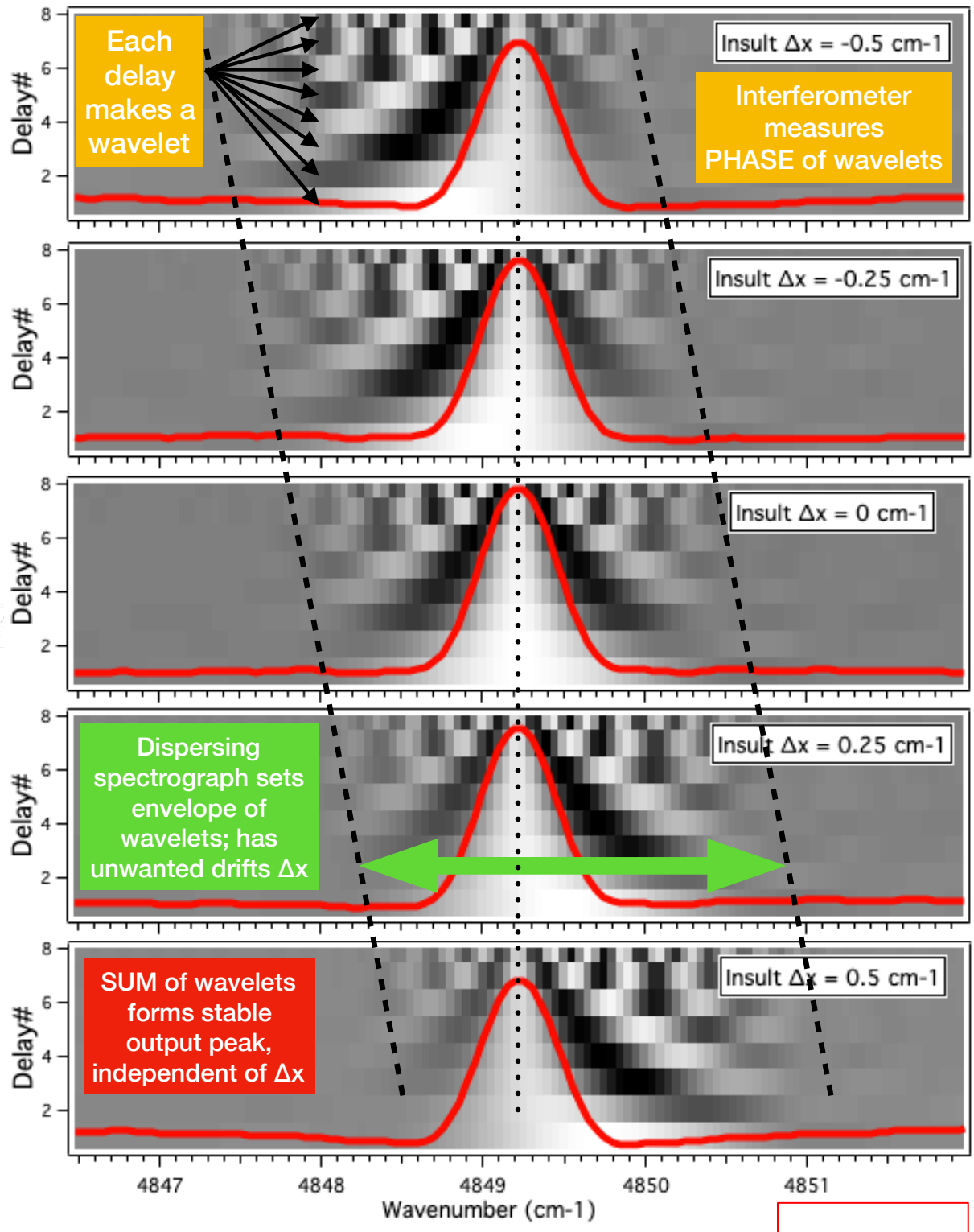
Using EDI measured data of ThAr lamp at Mt. Palomar project

but simulated insult Δx

The wavelet location is deliberately shifted sideways to simulate Δx .

The EDI output is the sum of wavelets which is the red peak, which is nearly stationary.

1000x reduction in drift!



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We recommend using BOTH conventional mitigations and EDI

Conventional mitigations: reduces environmental insult Δx

EDI: reduces TRC to ~0.001 - 0.1

Output spectrum shift

$$\Delta \lambda_{out} = \Delta x * TRC$$

TRC is Translational Reaction Coefficient

(Conventional: TRC = 1)

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*See "Method for boosting dispersive spectrograph stability 1000x using interferometry with crossfaded pairs of delays", David J. Erskine, J. Astr. Tele. Instrum. Sys., 7(2):025006, June 2021
<https://doi.org/10.1117/1.JATIS.7.2.025006>