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Exoplanet Exposure Triangle:

Optimising spectroscopic observations of transiting exoplanets

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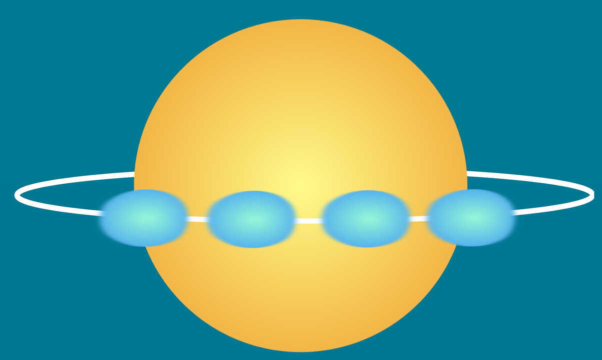
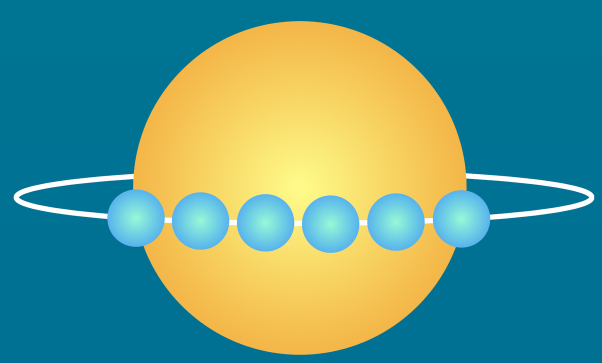
The problem: Observing an exoplanet transit, a choice must be made: does one opt for a **small number of longer exposures**, capturing more photons and increasing the signal-to-noise ratio (S/N)? Or for a **large number of shorter exposures**, reducing the smearing effect that arises from the planet's changing radial velocity? Our goal was to establish the exact boundaries of this effect to understand its impact on observations.



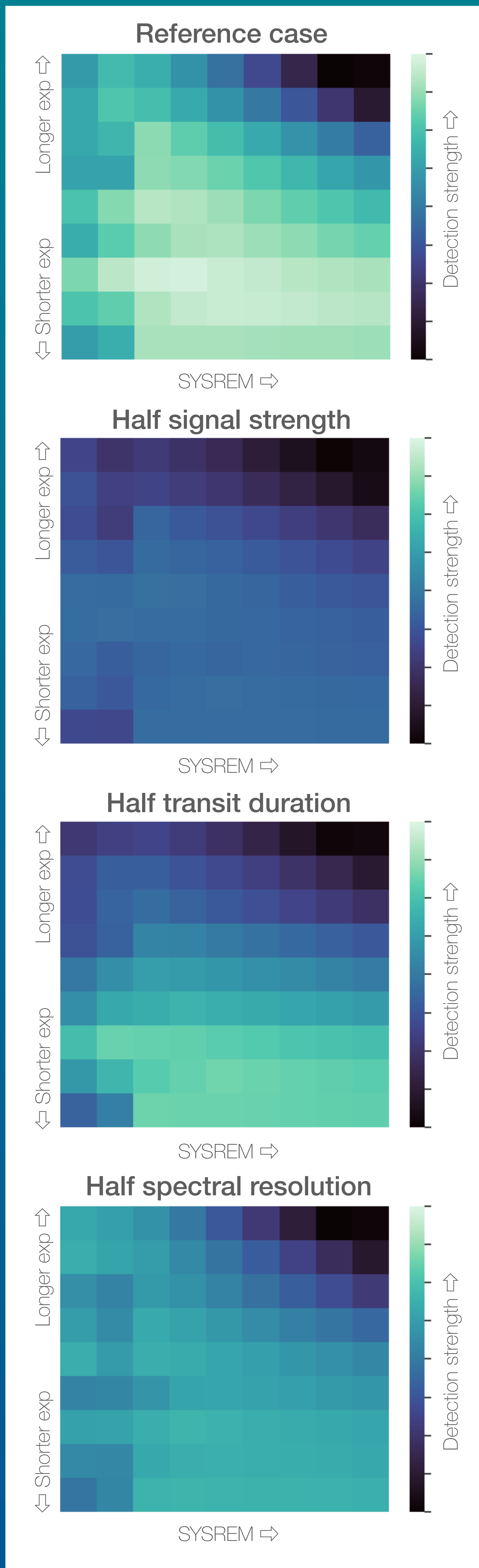
👍 High S/N
👎 High smear



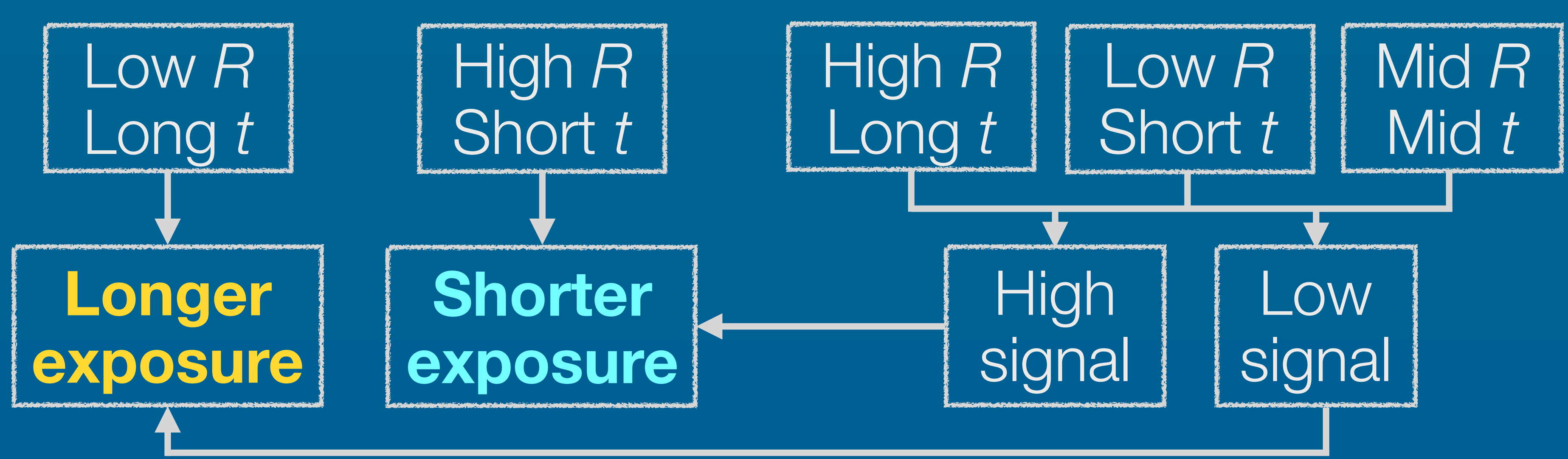
👍 Low smear
👎 Low S/N

Method: We simulate the transmission spectrum (R~100,000) of a reference case, transiting gas giant **WASP-127 b**,[1,2] as it would be observed by **VLT/CRIRES+** at Paranal, Chile.[3] Using a realistic noise model, we simulate 100 realisations of the same transit event over nine different time resolutions, varying parameters to create a total of four hypothetical scenarios. We analyse the simulations by using **SYSREM**[4] (for telluric + stellar removal) and **cross-correlating** (CC) with a model template. The strength of the CC detection of each data set is recorded and the averages are plotted as per the figures on the right.

Result: We demonstrate that there is a **continuous change** in cross-correlation significance **based on time resolution**, with detection strength maxima depending on system parameters, instrumentation, and no. of SYSREM iterations. Observers must therefore take **several factors into account**, using a strategy akin to the "exposure triangle" from traditional photography. As a generalised recommendation, we provide a **strategy flow chart** (below) for spectral resolution *R* and transit duration *t*.

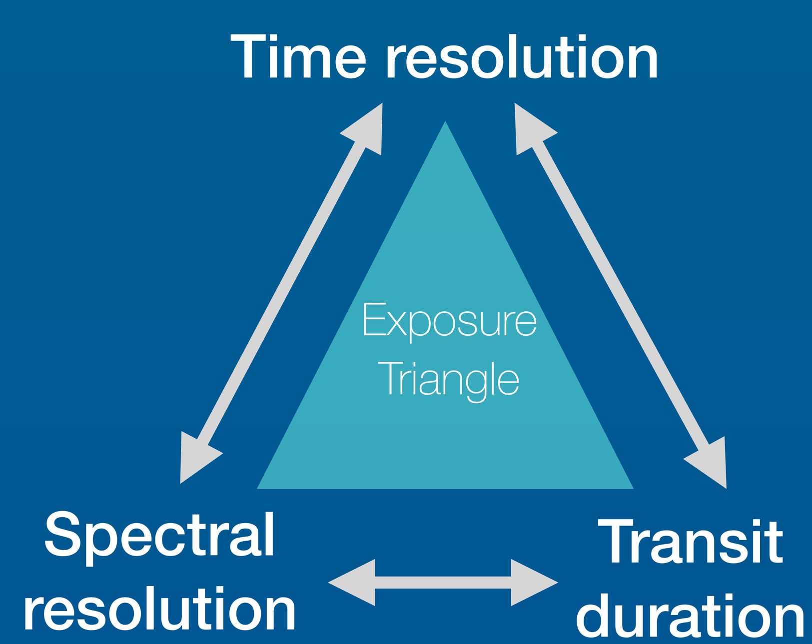


What exposure length should I go for?



ADS link:

Individual nights: We also prove the significant impact of night-to-night variation. This work's idealised cases still saw severe fluctuations between single realisations, implying real-life data would be even more impacted.



[1] Lam K. W., et al., 2017, A&A, 599, 1
[2] Seidel, J. V., et al. 2020, A&A, 643, A45
[3] Dorn, R. J., et al. 2023, A&A, 671, A24
[4] Tamuz, O., et al. 2005, MNRAS, 356, 1466–1470

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