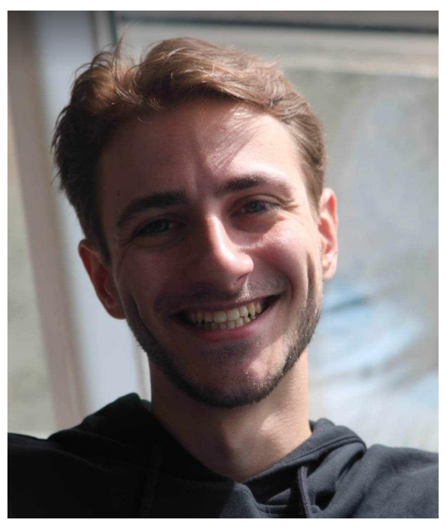

FastYield, an interactive tool to explore exoplanets detectability including spectral correlations

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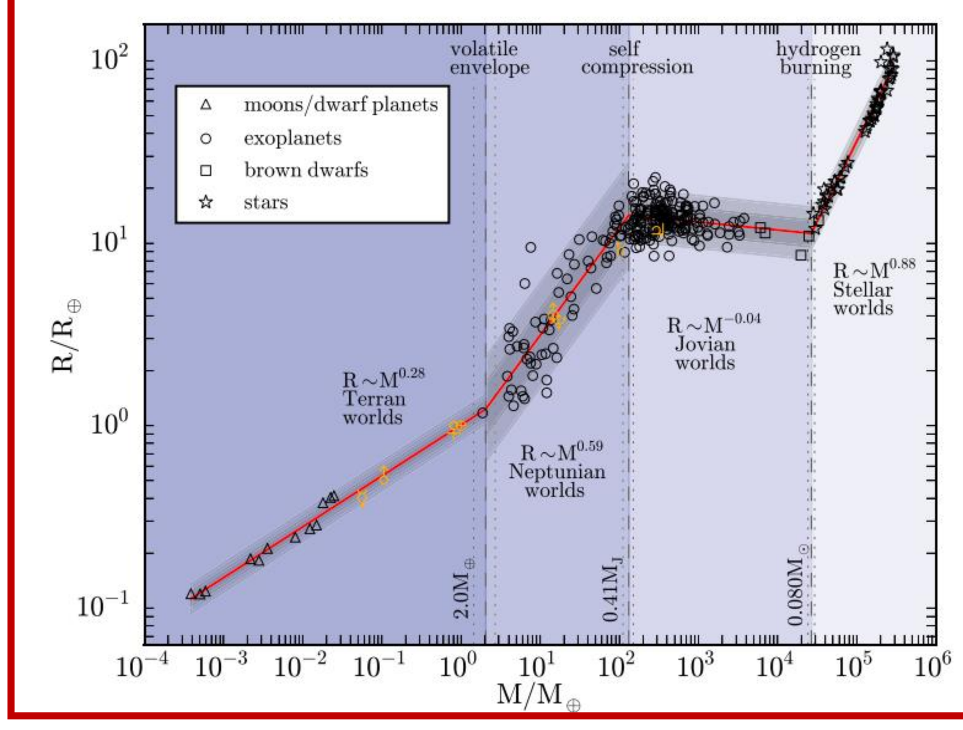
Abstract: Thanks to a recently developed semi-analytical and numerical tool (**FastCurves**), the performance and detection limits **of a direct imaging instrument** can be assessed **assuming that a medium to high spectral resolution data is available, and that molecular mapping is used to process this data. FastCurves** has been tested both with on-sky and simulated data, confirming its reliability (**Martos et al. submitted**). We are now applying its estimation capability to a large sample of known exoplanets (but also to any user-defined catalog), while considering both various observing capabilities (ELT/HARMONI, ELT/ANDES, VLT/ERIS, JWST/MIRI/MRS and JWST/NIRSpec/IFU) and various planetary models (including both thermal and reflected light contributions).

Chen & Kipping 2017 [2]



NASA EXOPLANET ARCHIVE [1]

Input catalog (~5600 planets) → Chen & Kipping (2017) → **Mass or radius estimation with empirical mass-radius law, if necessary**

$T_p = \sqrt{\frac{R_*}{SMA}}\, T_*$

FastYield

Temperature estimation, if necessary (except for direct imaged planets)

Planets w/ no R (except direct imaged planets), SMA, d or w/ T<200K are dropped (~ 5000 planets remain)

Estimating the planetary spectrum :

$$F_p = \underbrace{\left(\frac{R_p}{SMA}\right)^2 \times F_* \times A_g(T_p)}_{\text{REFLECTED}} + \underbrace{\left(\frac{R_p}{d}\right)^2 \times F_{p,0}(T_p)}_{\text{THERMAL}}$$

- F* = stellar spectrum model (BT-NextGen) renormalized to star magnitude
- Ag = albedo simulated by PICASO (gas giant) or tellurics with SkyCalc (earth-like) or flat albedo (icy planet)
- Fp,0 = thermal planet spectrum model with BT-Settl, Exo-REM or PICASO (gas giant)

Transit and radial velocity planets | Direct imaged planets

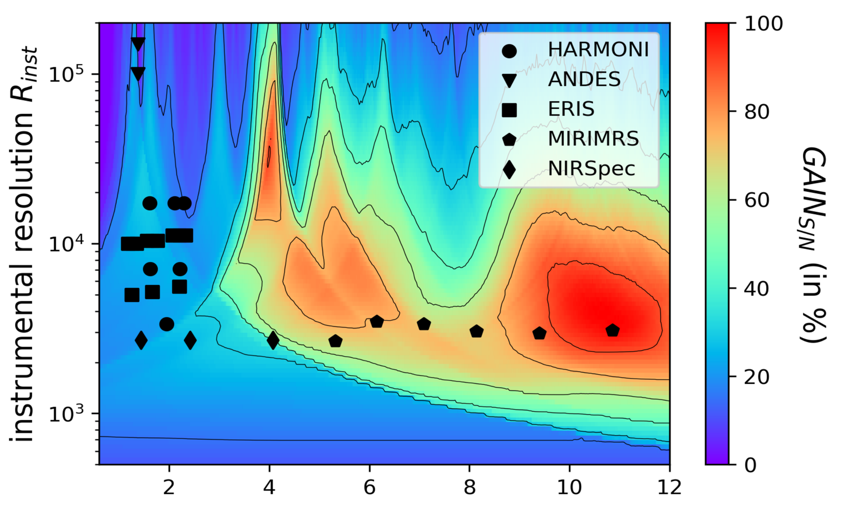
For transit planets, R is well known, but for radial velocity planets it is M that is well known (the R used is estimated using Chen & Kipping's law)

FastCurves-based SNR computation

Planets spectra normalized using K-band photometry

YIELD

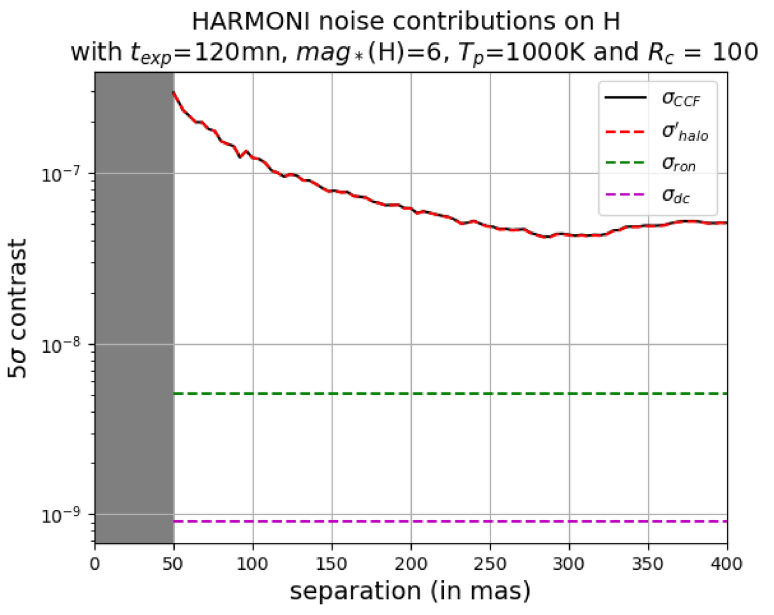
S/N fluctuations (without tellurics absorption) in thermal light with BT-Settl model, T_p=1000K, T_*=5000K, Δv_r=25km/s and N_λ=4096



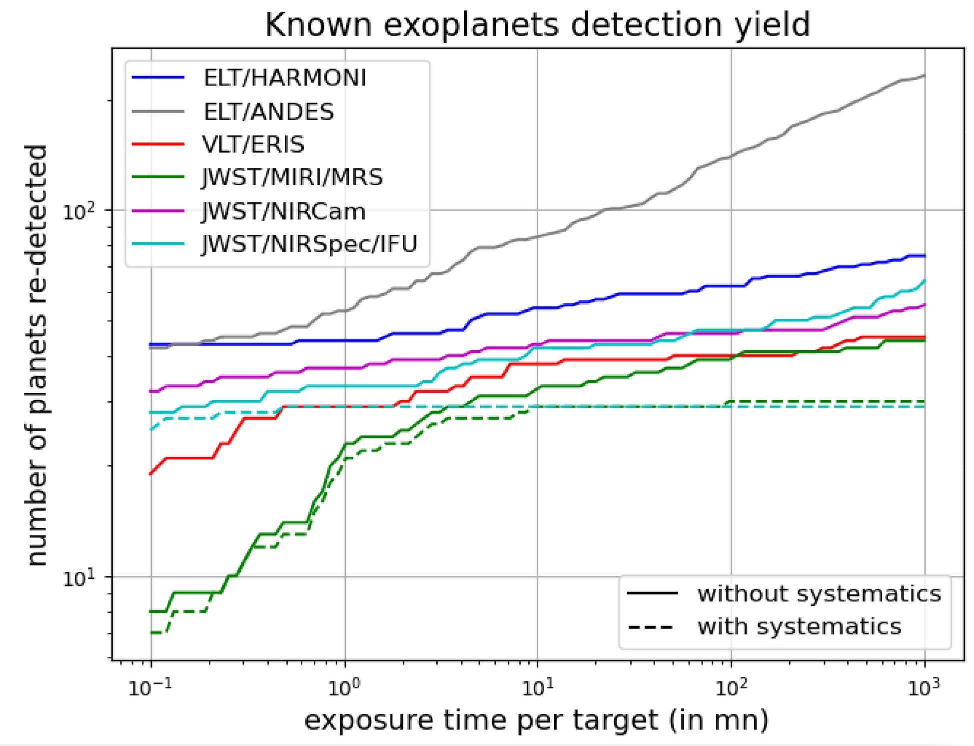
FastCurves [3]

FastCurves can be used to estimate detection limits related to various parameters of the instrument (PSF profiles, transmission, detector characteristics, etc.) and of the planets (magnitude, temperature, gravity, albedo, etc.). **FastCurves** shows promise as an **ETC** for **predicting IFS performance** when employing molecular mapping (high-pass filtering) as a post-processing method for speckle removal.

HARMONI noise contributions on H with t_{exp}=120mn, mag_*(H)=6, T_p=1000K and R_c = 100

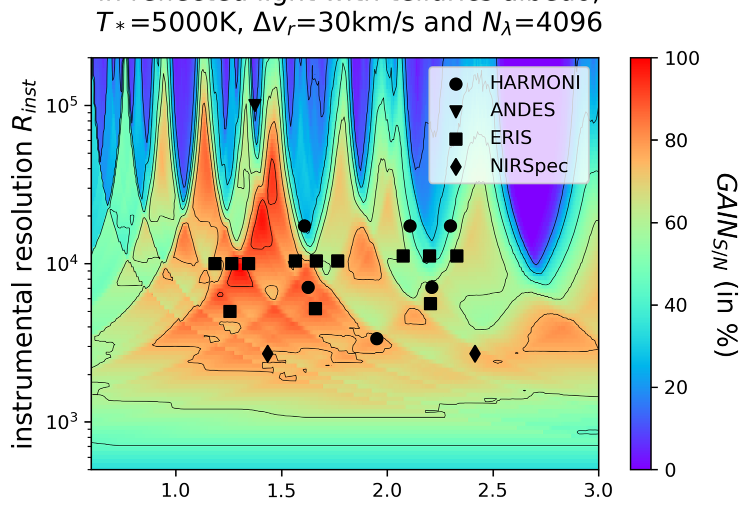


Known exoplanets detection yield

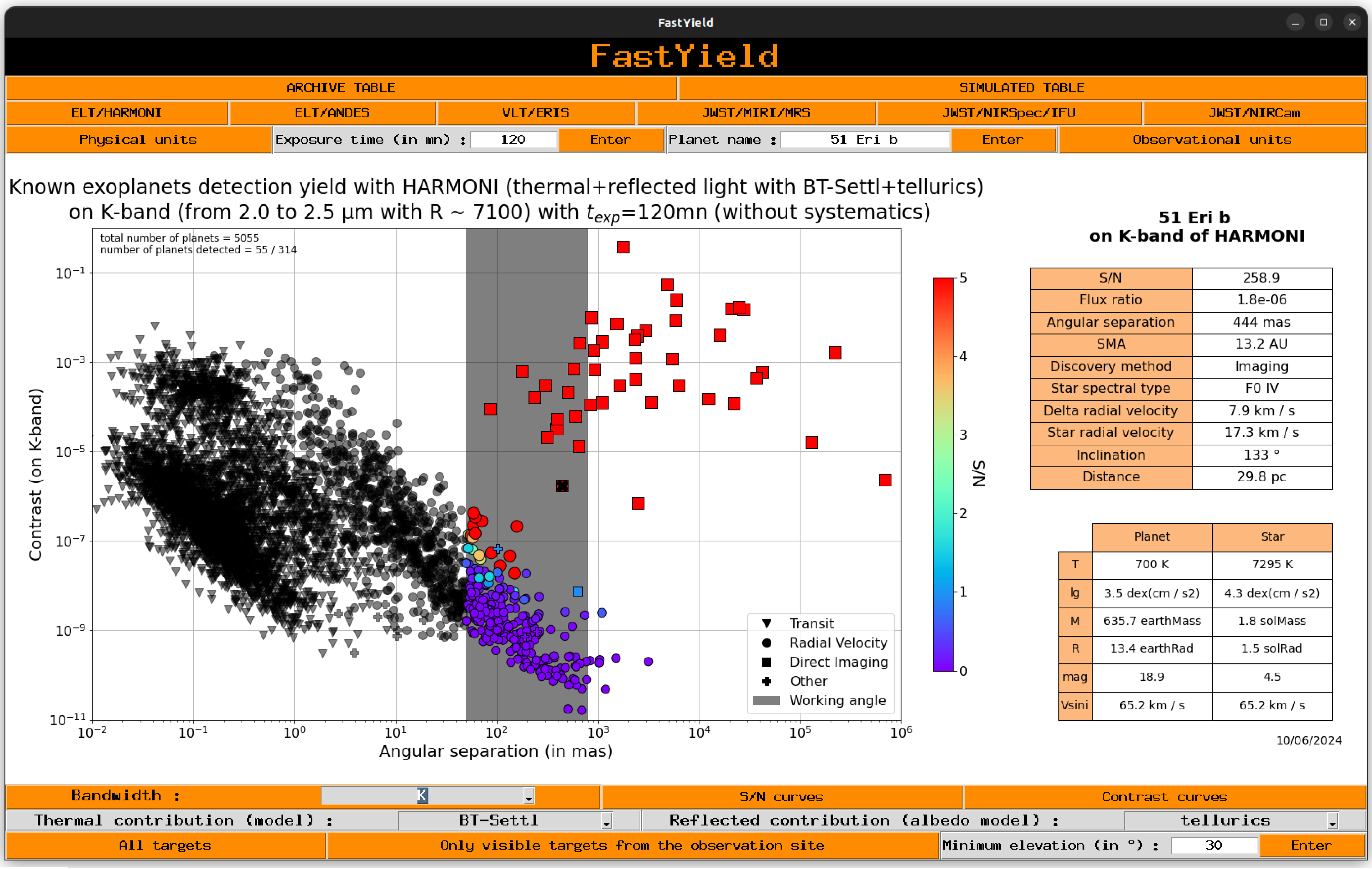


→ See the poster 1609 on JWST/MIRI/MRS application

S/N fluctuations (without tellurics absorption) in reflected light with tellurics albedo, T_*=5000K, Δv_r=30km/s and N_λ=4096



→ See the poster 1611 on reflecting planets direct detection



Take-away message :

- **FastYield** is a tool that **enables quick assessment of detection performance** for different instruments across a variety of exoplanets.
- It helps in **understanding what limits detection** and **how to optimize the useful signal** that can be measured.
- It can also **assist in the design and architecture of future instruments** (depending on the type of planets to be detected).
- It is important to remain **cautious about the estimated performance**, as these metrics heavily depend on the assumptions made and the atmospheric models used.

Github :

FastCurves (initial version): https://github.com/ABidot/FastCurves

FastYield (includind updated FastCurves): https://github.com/StevMartos/FastYield

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[1] Akeson, R. L., Chen, X., Ciardi, D., et al. 2013, Publications of the Astronomical Society of the Pacific, 125, 989–999
[2] Chen, J. & Kipping, D. 2016, The Astrophysical Journal, 834, 17 Fruchter, A. S. & Hook, R. N. 2002, Publications of the Astronomical Society of the Pacific, 114, 144
[3] Bidot, A., Mouillet, D., & Carlotti, A. 2024, Astronomy amp; Astrophysics, 682, A10