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Exoplanets with ELT-METIS I: Estimating the Direct Imaging Exoplanet Yield Around Nearby Stars within 6.5 Parsecs

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Direct imaging is a powerful exoplanet discovery technique that is complimentary to other techniques with great promise in the era of 30-meter class telescopes. Space-based transit surveys have revolutionized our understanding of the frequency of planets at small orbital radii around sun-like stars. The next generation of extremely large ground-based telescopes will have the angular resolution and sensitivity to directly image planets with R < 4 Earth radii around the very nearest stars. Here we predict yields from a direct imaging survey of a volume-limited sample of sun-like stars with the Mid-Infrared ELT Imager and Spectrograph (METIS) instrument, planned for the 39-m European Southern Observatory (ESO) Extremely Large Telescope (ELT) that is expected to be operational towards the end of the decade. Using Kepler occurrence rates, a sample of stars with spectral types A-K within 6.5 pc, and simulated contrast curves based on an advanced model of what is achievable from coronagraphic imaging with adaptive optics, we estimate the expected yield from METIS using Monte Carlo simulations. We find the METIS expected yield of small planets in the N2 band (10.10 - 12.40 μm) is 1.15 planets which is greater than similar observations in the L (3.70 - 3.95 μm) and M (4.70 - 4.90 μm) bands. We also determine a 42% chance of detecting at least one Jovian planet in the background limited regime assuming a 1-hour integration. We calculate the yield per star and estimate optimal observing revisit times to increase the yield. We also analyze this survey if performed in the northern hemisphere and find there are additional targets worth considering. Finally, we present an observing strategy in order to maximize the possible yield for limited telescope time, resulting in 1.52 expected planets in the N2 band.