Multi-site All-Sky CAmeRA

MASCARA

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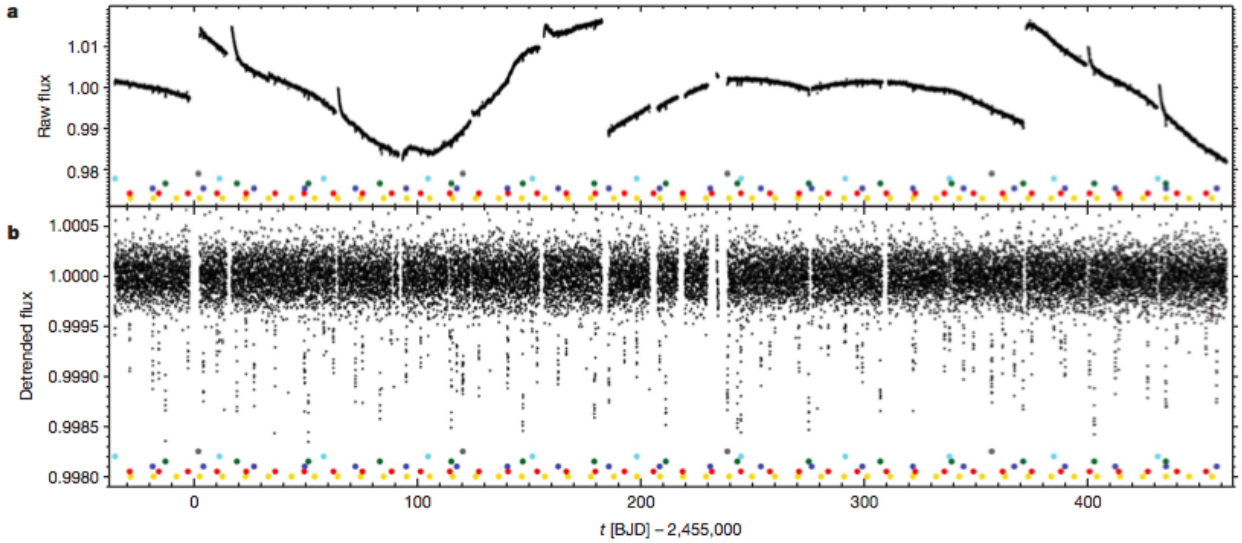
- **Aim**: To find the brightest transiting exoplanets in the sky
  Key-targets for exoplanet atmosphere studies
- **Concept**: Several stations – each, battery of wide-field cameras
  Monitoring near-entire sky at each location
  low-cost, off-the-shelf components

Fully Funded

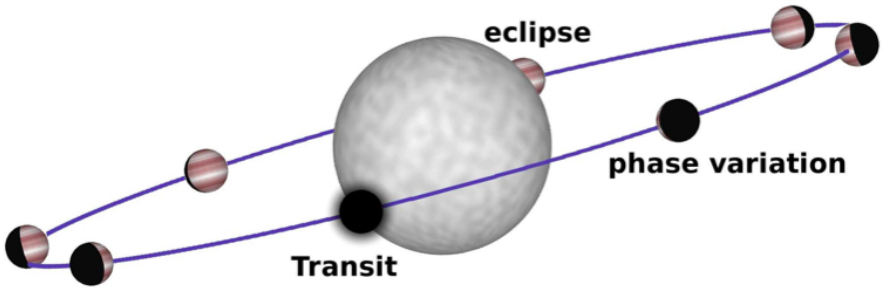
MASCARA: Scientific Rationale

- RV-surveys and Kepler + CoRoT space missions revolutionize exoplanet research: First rocky planets – CoRoT-7b & Kepler-10b
- Exoplanet population in the Milky Way rapidly being unravelled
  > tens of billions of planets in the Milky Way
- Unexpected diversity of systems:

  Kepler -11: Six planets transiting one star of which 5 Neptune-size planets within the orbit of Mercury (Lissauer et al. 2011)



MASCARA: Scientific Rationale



- Planet characterization on transiting systems is a great success
- Eclipse measurements of a ~dozen planets measured with Spitzer
- Majority of atmospheric measurements on two bright transiting planets: **HD209458b (V=7.7)** and **HD189733b (V=7.7)**

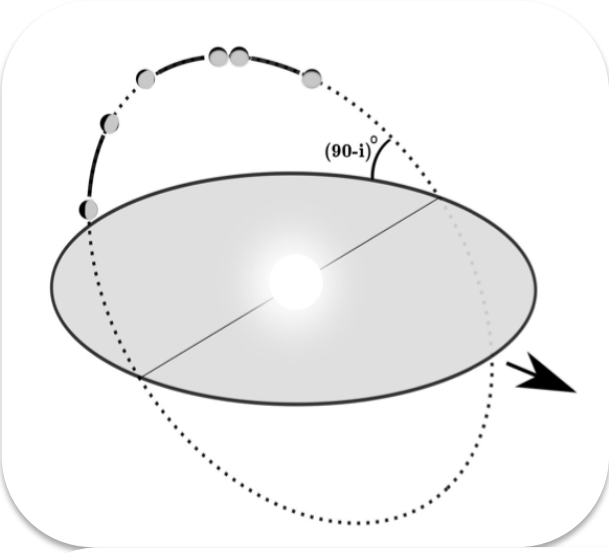
  Molecular and atomic gases (H, C, O, CH4, H2O, CO), evaporating atmospheres, global winds/circulation, thermal maps.

Atmospheric studies require very bright targets!

CRIRES@VLT

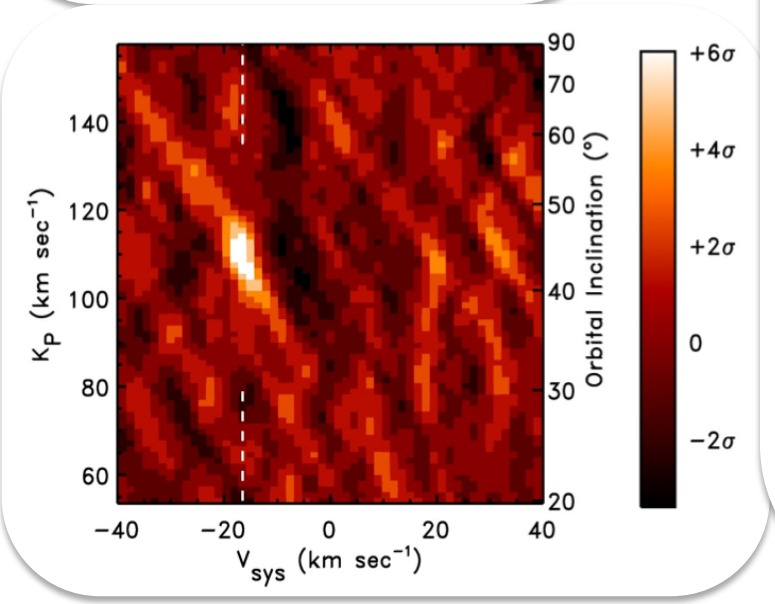
Detection of CO in dayside spectrum of tau Bootis b

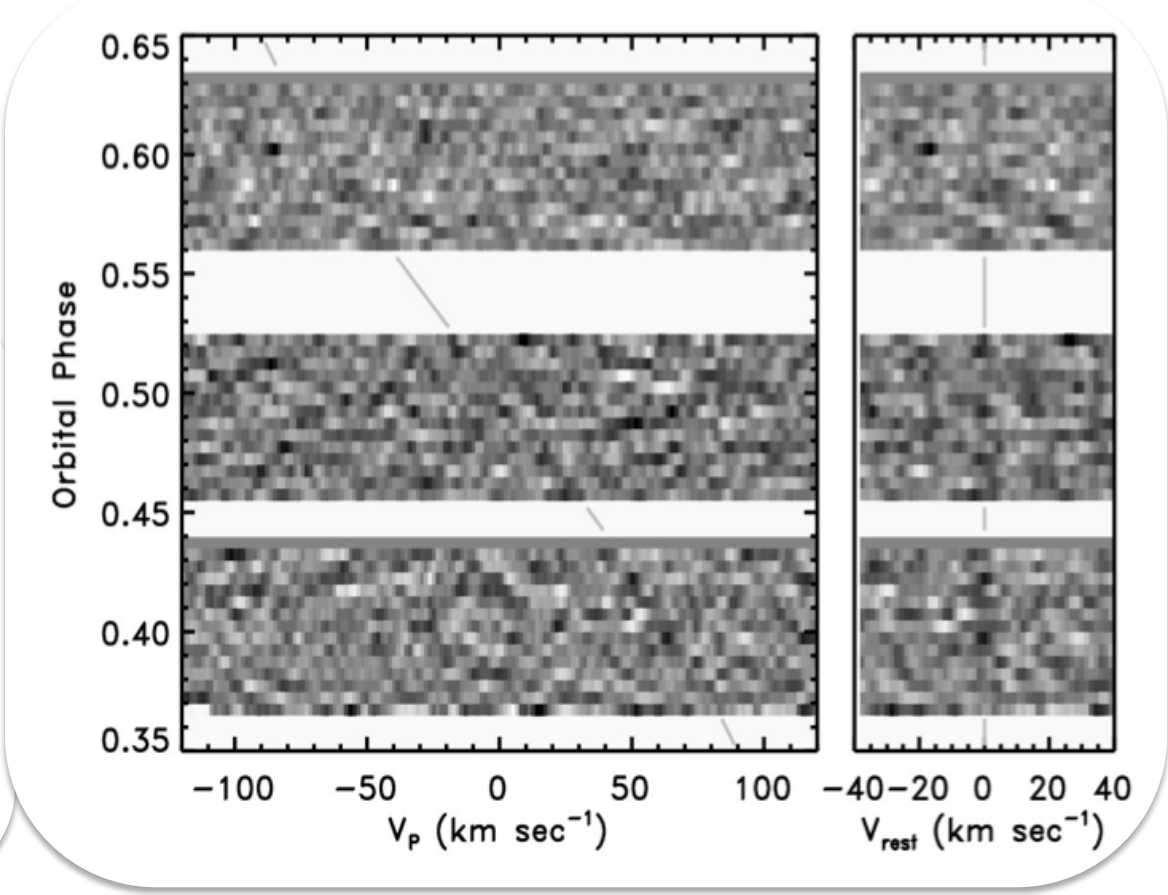
(Brogi et al. Nature 2012 – see also Rodler et al. '12)



First detection of non-transiting planet→ inclination, mass

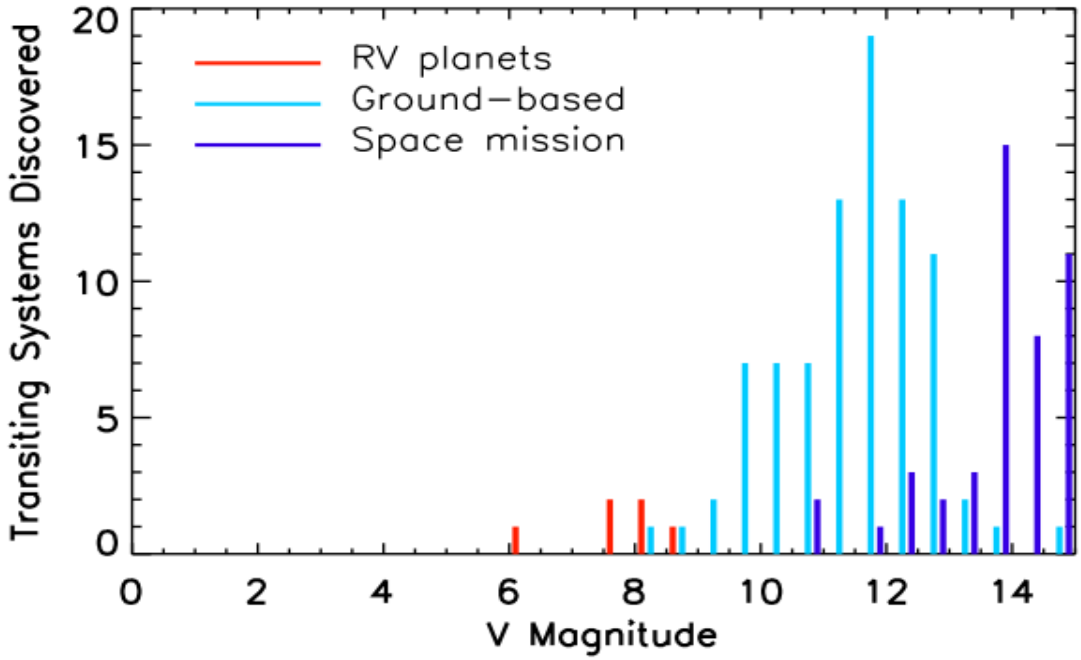
18 hrs VLT on a V=4 star





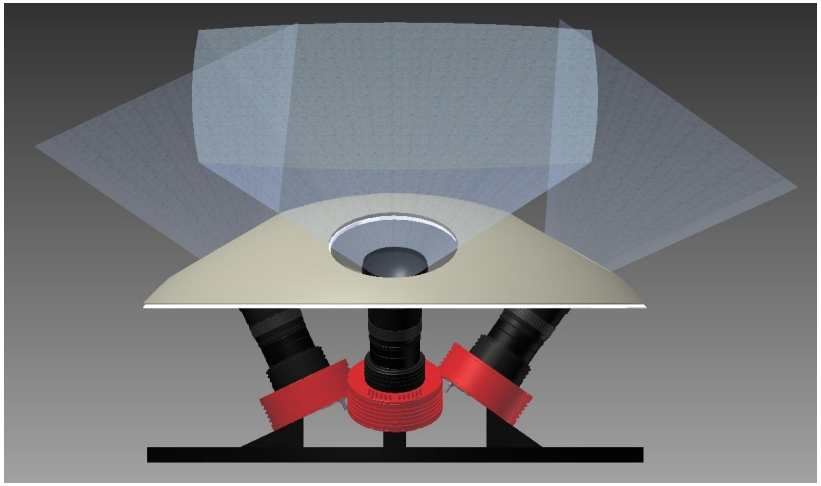
MASCARA: Scientific Rationale

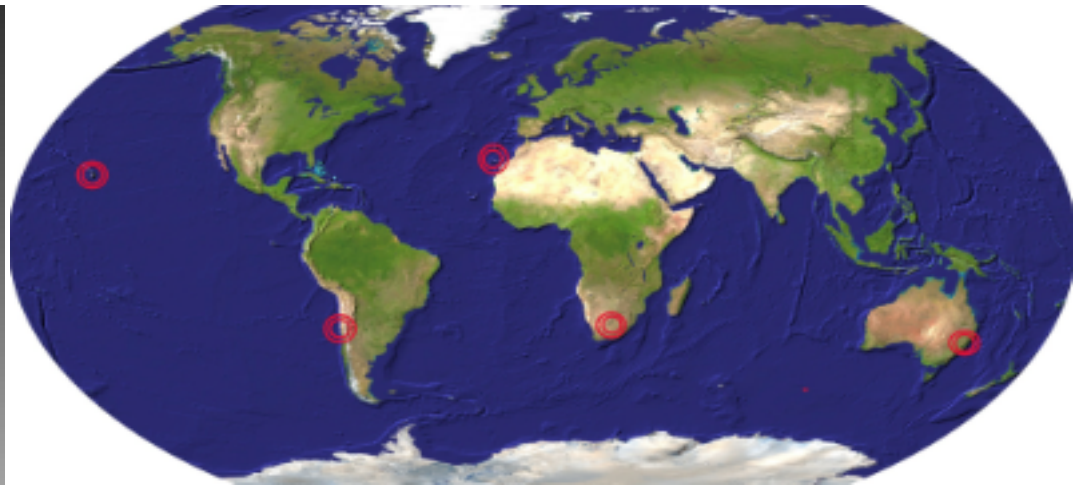
- RV and Transit surveys → population transiting systems at V=4-8.
- Current transit surveys do not cover this magnitude regime
- All known transiting planet at V<8 were found first by RV signature
  only small fraction of stars is RV monitored
- We need a bright-star transit survey → MASCARA



MASCARA: Concept

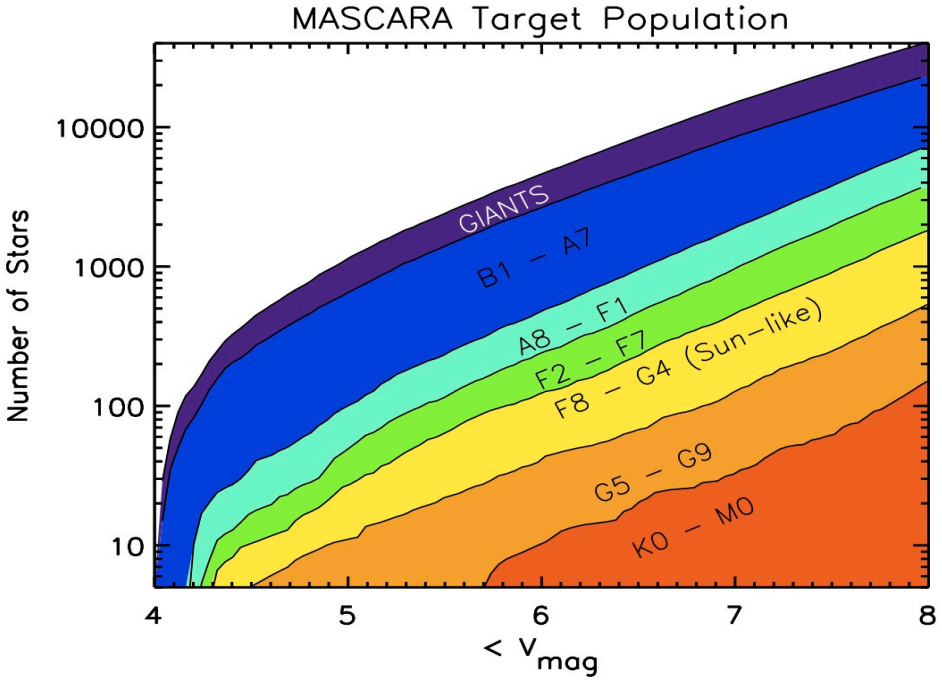
- ~5-6 stations across the globe, monitoring the near entire sky
  airmass <2-3, quasi-continuously monitoring
- Each station: 4-5 wide-field lenses + detectors
  off-the-shelf components
- Fixed camera system → no tracking
  short exposures (~5 sec) to avoid stars producing trails on detector
- Photometric precision 1% per hour for V=8 star

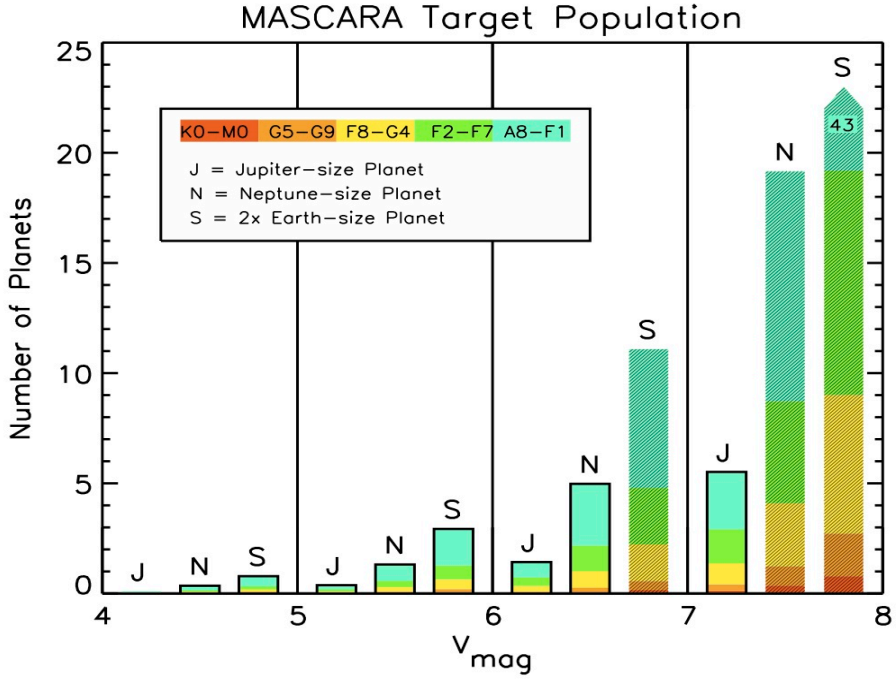




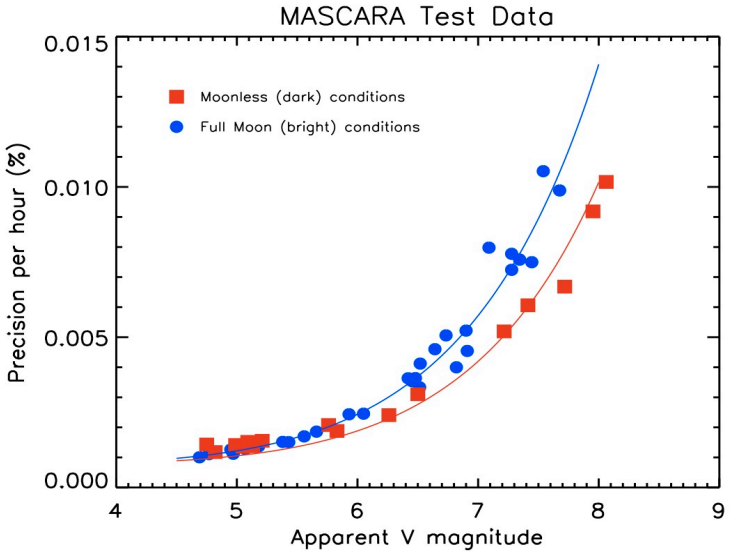
MASCARA: Planet Population

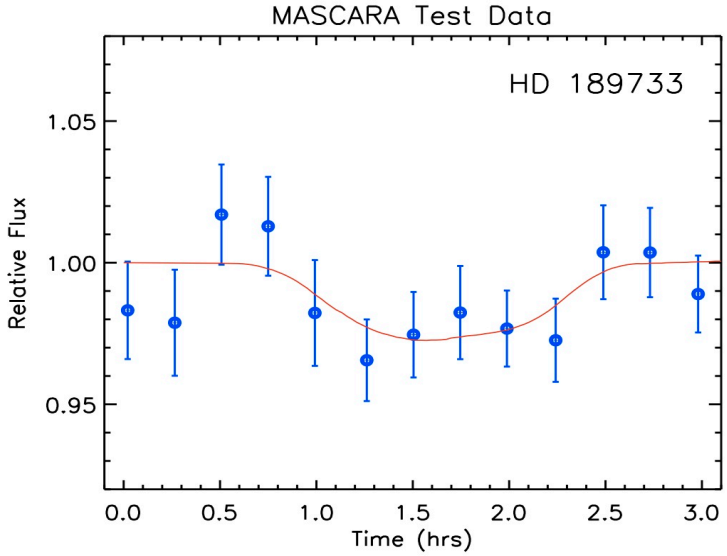
- Transits of Jupiter-size planets can be detected individually
- Neptune/Super-Earth planets are found by co-adding transits
  55 Cnc e (V=6) detected at ~3σ after 1 yr (7σ after 4 yr) of MASCARA operation.
- Target population is mainly hot, short-period planets
  ~5 Hot Jupiters, ~5 Hot Neptunes, ~5 Hot Super-Earths

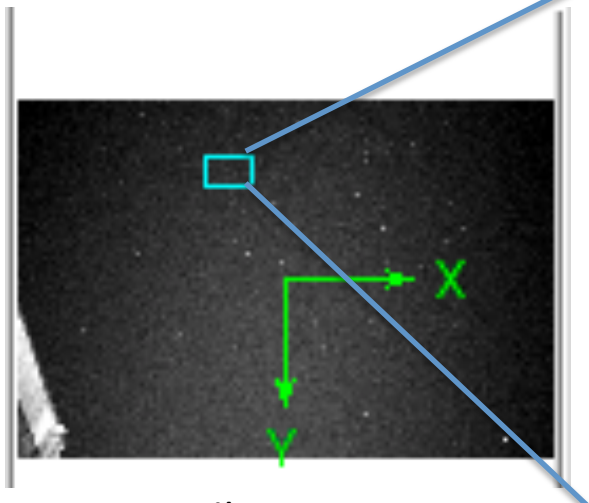




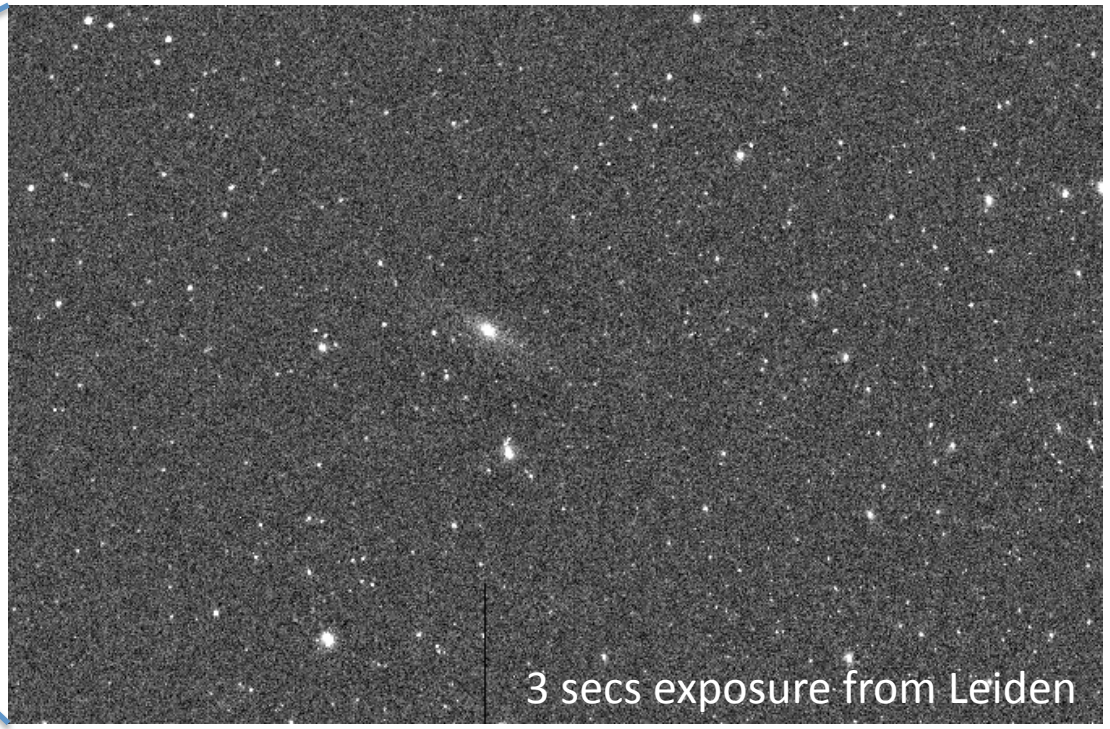
MASCARA: Photometry Tests







Atik 11000-M



MASCARA: Preliminary Design

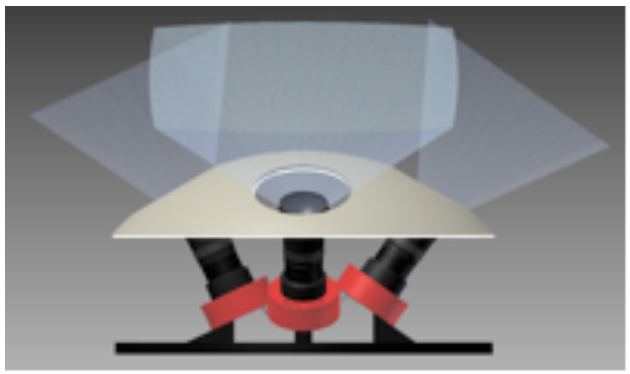
- Critical choice of camera and shutter operations
  limited shutter life time (10^5) rules out consumer cameras
- Cooled amateur astronomy cameras + off-the-shelf lenses (Canon)
- Pros and Cons:
  - min. Exposure time + data rate
  - pixel size and full-well capacity
  - few wide angle versus many narrow-angle systems
- Camera top 3:
  - Atik 11000-M (modified to high read-out speed)
  - FLI Mirconline ML29050M
  - Apogee A16000

MASCARA: Preliminary Design

- Currrently testing Atik 11000-M for its real-world performance
- Expectations: 1% per hour for V=9, avoiding saturation for V=2-3.
- 1 Tbyte of data per night/station
- Local storage of 1 week of data – rudimentary data reduction on site.

MASCARA: Preliminary Design

- MASCARA Housing Protection from wind, cold, precipitation
  Requires on board (or befriended) weather station
- Contains: cameras+lenses, camera control pc's, enclosure control
- Temperature control of cameras, computers and housing
  prevent build-up of moisture, freezing, and/or overheating of systems



MASCARA: Costs + Roll out

~50 kEuro per station [funding for 5 stations + 2 postdocs (3 yr)]

Anna-Lea Lesage (Hamburg), Julien Spronck (MIT)

- 2012 – 2013: Final design, prototype construction, tests in the Netherlands
- End 2013: First station on Canary Islands (plan).
- 2014 – 2015: roll out of remaining stations

MASCARA: competing projects

- Dedicated space missions - PLATO (ESA) and TESS (NASA)
  MASCARA cannot compete (cooler planets) – but PLATO/TESS are much later
- Dedicated transit searches with small space telescopes
  (MOST; ExoplanetSat; Cheops) → targeted observations
- Search for (transiting) planets around M-dwarfs
  (Mearth; NGTS) – different stellar population – highly complementary


MASCARA
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