

A night sky with the Milky Way galaxy and a telescope on a mountain peak. The Milky Way is visible as a bright, star-filled band across the sky. The telescope is a large, white, multi-faceted structure with two prominent vertical columns, situated on a dark, rocky mountain peak. The overall scene is a deep blue and black, with numerous stars of varying brightness scattered throughout.

Photonic Spectrograph for NTT

*Intended Proposal for ESO .. end of March
Pathfinder for high resolution spectrograph for E-ELT*

Spot the high resolution infrared capability offered by ESO?

La Silla

[EFOSC2](#) (ESO Faint Object Spectrograph 2)
[HARPS](#) (High Accuracy Radial velocity Planetary Searcher)
[SofI](#) (Son of ISAAC)

Paranal

[AMBER](#) (Near-infrared interferometric instrument)
[FLAMES](#) (Fibre Large Array Multi Element Spectrograph)
[FORS2](#) (FOcal Reducer/low dispersion Spectrograph 2)
[HAWK-I](#) (High Acuity Wide field K-band Imager)
[KMOS](#) (K-band Multi-Object Spectrograph)
[MIDI](#) (MID-infrared Interferometric instrument)
[MUSE](#) (Multi Unit Spectroscopic Explorer)
[NACO](#) (NAOS-CONICA: High Resolution NIR Camera and Spectrograph)
[OMEGACAM](#) (Wide Field Imager for the VST at Paranal)
[SINFONI](#) (Spectrograph for INtegral Field Obs. in the NIR)
[UVES](#) (UV-Visual Échelle Spectrograph)
[VIMOS](#) (Visual Multi-Object Spectrograph)
[VIRCAM](#) (VISTA InfraRed CAMera)
[XSHOOTER](#) (UV-Visual-NIR medium resolution échelle spectrograph)

Chajnantor

[LABOCA](#) (Large Apex BOLometer CAMera)
[SHFI](#) (Swedish Heterodyne Facility Instrument)
[ARTEMIS](#) (Architectures de bolomètres pour des Télescopes à grand champ de vue dans le domaine sub-Millimétrique au Sol)
[CHAMP+](#) (Carbon Heterodyne Array of the MPIHR)
[FLASH](#) (First Light APEX Submillimeter Heterodyne receiver)
[SUPERCAM](#) (64 pixel 329-360 GHz imaging spectrometer)

There are more details on the offered instruments and the ESO facilities on the Period 94 [Instrumentation and Facilities](#) page. The main characteristics of all instruments offered at La Silla, Paranal and Chajnantor in this call are described in the [Instrument summary table](#). Any updates after the release of this Call will be listed on the [Late Breaking News](#) webpage.

The ESO proposal submission deadline is:

**27 March 2014,
12:00 noon Central European Time.**

Spot the Southern project?



CARMENES

- Public
- Project
- Institutions
- People
- Gallery
- Publications
- Conferences
- Spectrographs
- Private
- Referees

Spectrographs

Comparable spectrographs in the near infrared

Acronym	Name	Telescope	Year
NIRSPEC	Near InfraRed SPECTrograph	Keck II	1999
PHOENIX	A cryogenic, long slit, high resolution infrared spectrograph	Gemini South	2001
CRIRES	Cryogenic high-resolution InfraRed Échelle Spectrograph	Very Large Telescope UT1	2006
TEXES	Texas Echelon Cross Échelle Spectrograph	Gemini North	2006+
T-EDI	TripleSpec - Exoplanet Discovery Instrument	Mt. Palomar 200 inch telescope	2008+
IR ET	Infrared Exoplanet Tracker	ARC 3.5 m Apache Point Observatory	2010
GIANO	A bifront infrared spectrometer highly optimized both for low and high spectral resolution	Telescopio Nazionale Galileo	2012
FIRST	Florida InfraRed Silicon immersion grating spectrometeR	T13 2.0 m Automatic Spectroscopic Telescope	2013
HPF	Habitable zone Planet Finder	Hobby-Eberly Telescope	2015
SPIRou	A nIR high-precision-RV échelle spectropolarimeter for CFHT	Canada-France-Hawaii Telescope	2017
IRD	Infrared Doppler instrument	Subaru	>2014
SIMPLE	A "simple" high resolution near infrared spectrograph	European-Extremely Large Telescope E-ELT	>2020
NAHUAL	Near-infraRed High-resolUtion spectrogrAph for pLanet hunting	Gran Telescopio Canarias	Cancelled†
UPF	UKIRT Planet Finder	United Kingdom Infrared Telescope	Cancelled†

Motivation

Find terrestrial-mass exoplanets in the habitable zones of the nearest stars

Numerous transit survey detections, radial velocities lag behind but vital for searches of closest stars and transit follow-up.

Exoplanet.eu

The Extrasolar Planets Encyclopaedia

Established in February 1995
Developed and maintained by the [exoplanet TEAM](#)
update : April 9, 2014 (1780 planets)
Please report any problems to vo.exoplanet@obspm.fr

News

March 6, 2014 702 new planet candidates from the recent Kepler announcement have been added to the [Catalog](#)

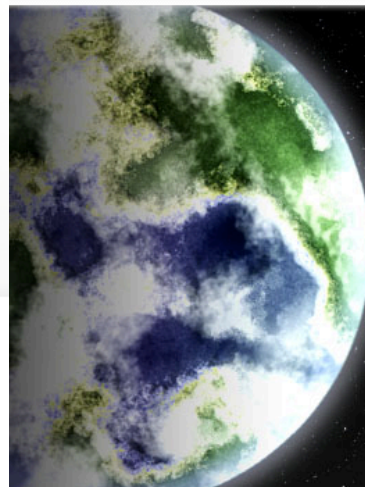
exoplanets.org

Exoplanets
Data Explorer

Methodology
and FAQ

Exoplanets
Links

California
Planet Survey



Table



Plots

1463

EOD Planets
Planets with good orbits listed in the Exoplanet Orbit Database

27

Other Planets
Including microlensing and imaged planets

1490

Total Confirmed Planets

3705

Unconfirmed Kepler Candidates

5195

Total Planets
Confirmed planets + Kepler Candidates

What limits us?

- * HARPS ... its limited by scrambling, not the spectrograph.
- * .. and by the way they calibrate.
- * .. poor at M-dwarf science (stops at 700nm)
- * ~4-5% throughput
- * .. and it cost about >€10m

Solution

- * Step 1 - GIANO to NTT .. working 50k spectrograph currently at TNG but not connected
- * Step 2 - Pathfinder spectrograph for NTT incorporating new technologies

Why bother?

- * Most nearby planets are around M dwarfs
- * Stepping stone for high resolution facility for E-ELT

Exoplanets around the majority of stars .. including M dwarfs

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Featured Research

from universities, journals, and other organizations

Save/Print: Share:

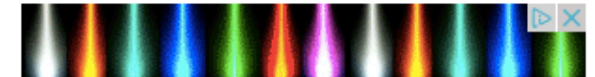
Virtually all red dwarf stars have at least one planet in orbit around them

Date: March 4, 2014

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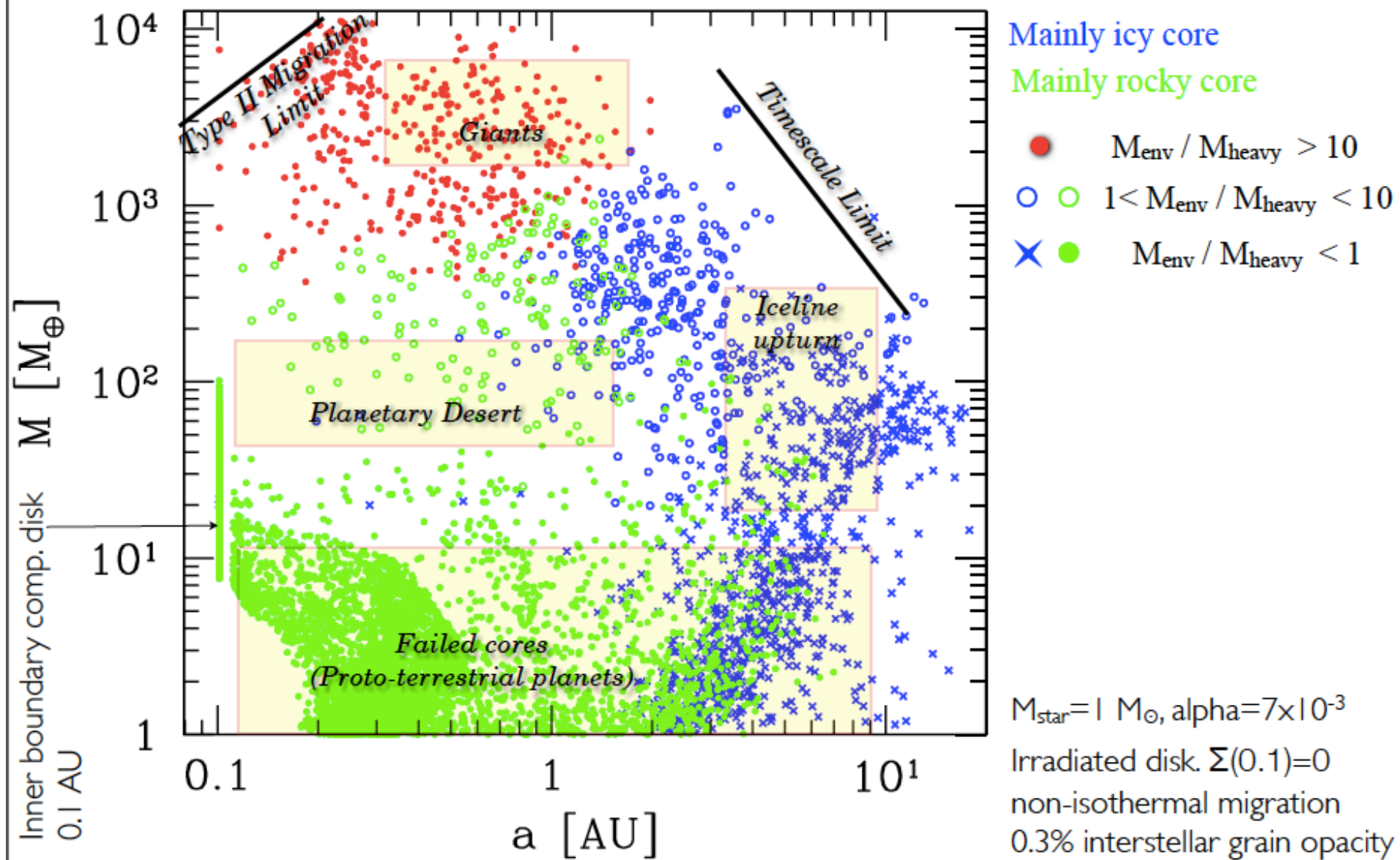
Breaking News:

What Can Be Learned From Gunshot Residue?



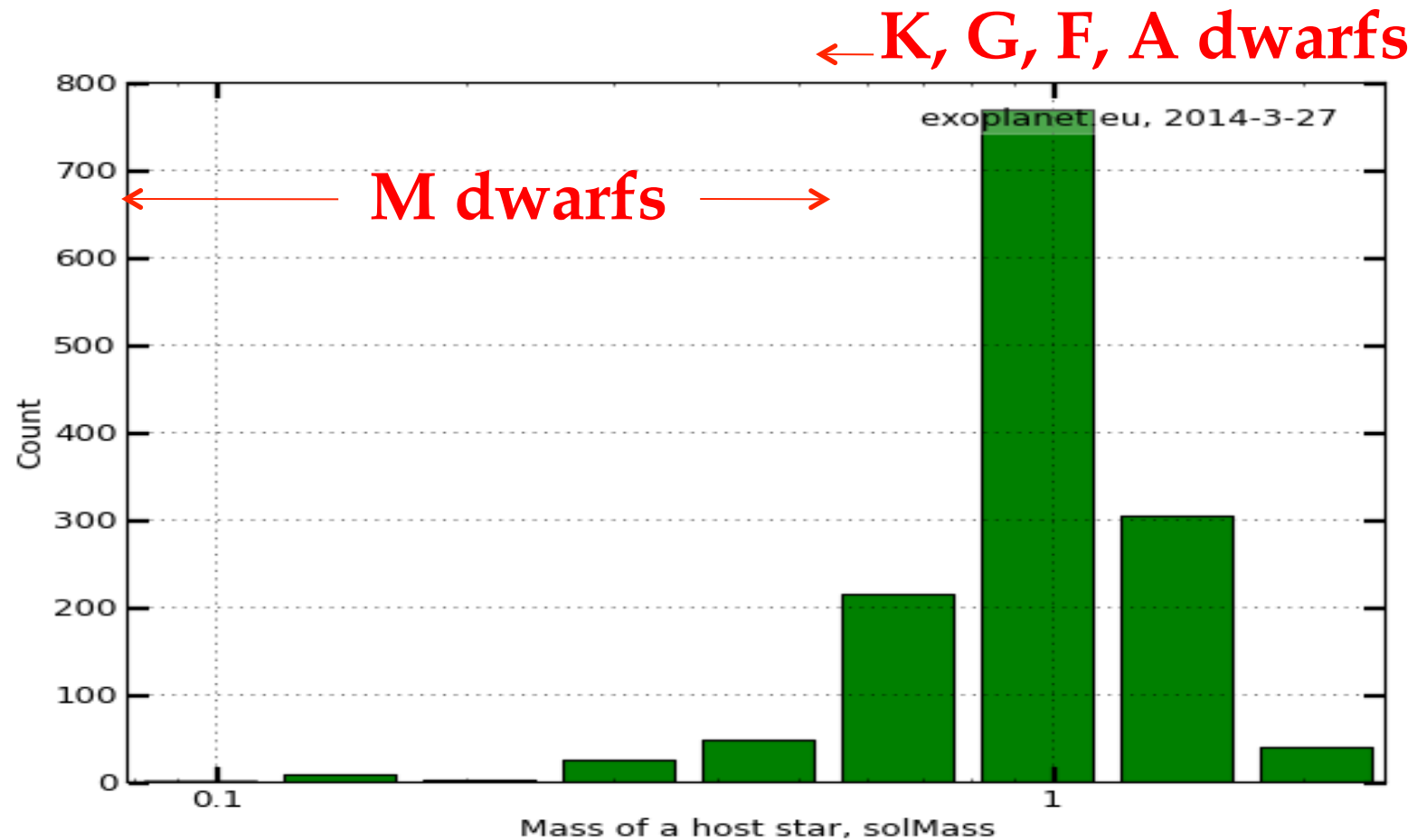
Kepler (e.g., Dressing & Charbonneau 2014),
Ground-based (e.g., Tuomi et al. 2014)

Theoretically .. current exoplanets are the tip of the Iceberg



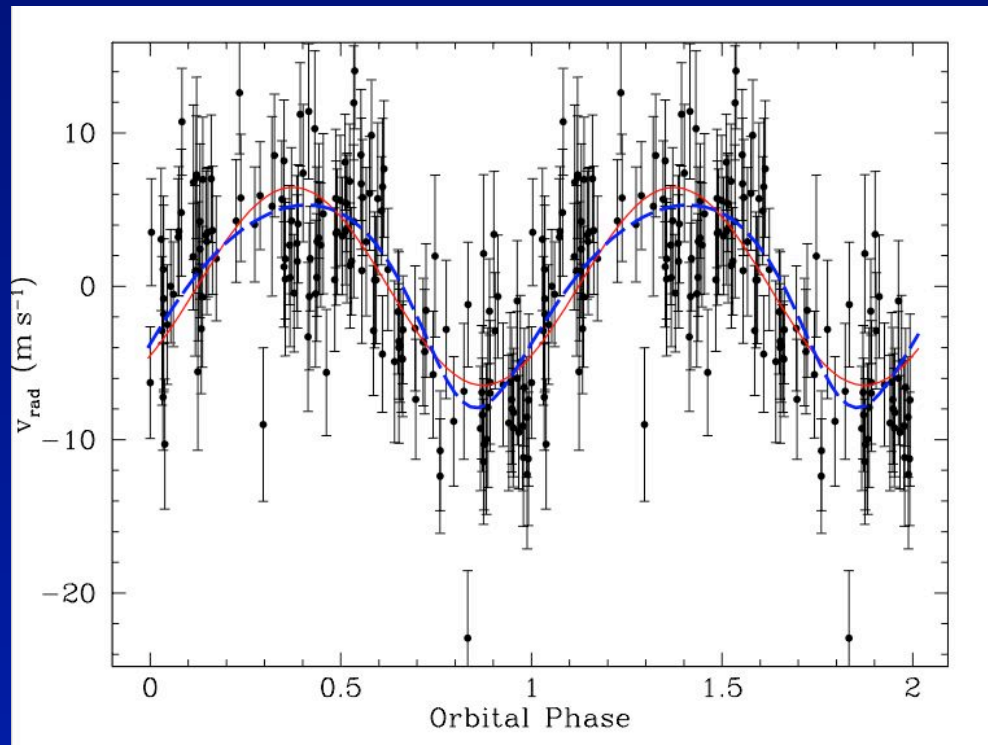
Astrophysically ... a void

Number of planets by star mass



Optical RVs are hardwork for M dwarfs

Low mass planets are being discovered around M dwarfs but tough even with Keck



Gl876 (M4V), 4.7pc

1.9 day period

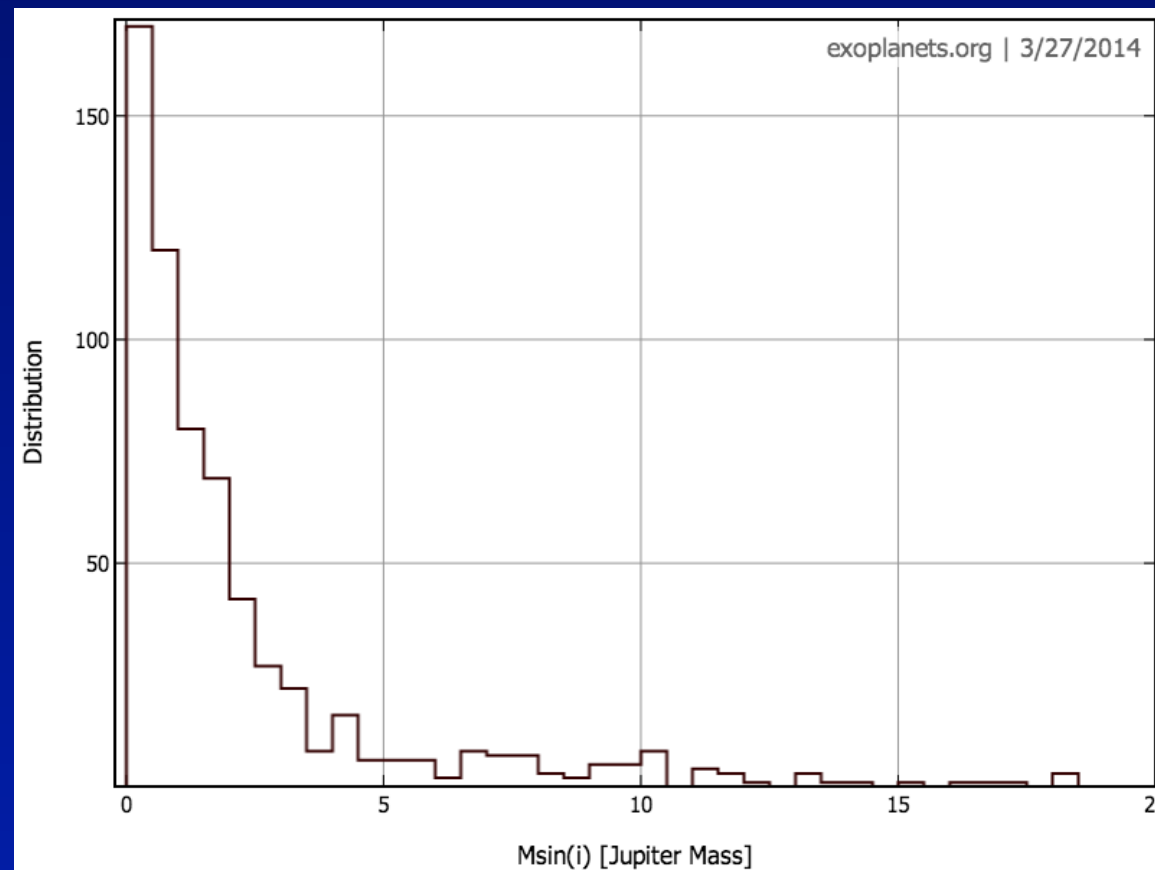
$M_{\text{sin}i} = 7.5 M_{\text{Earth}}$

1997-2005 Keck
monitoring
including data on 6
consecutive nights

Rivera et al. 2005

Plenty of low-mass planets though at few Earth masses we are close to detection threshold

Low-mass planets dominate despite **strong bias** against detection



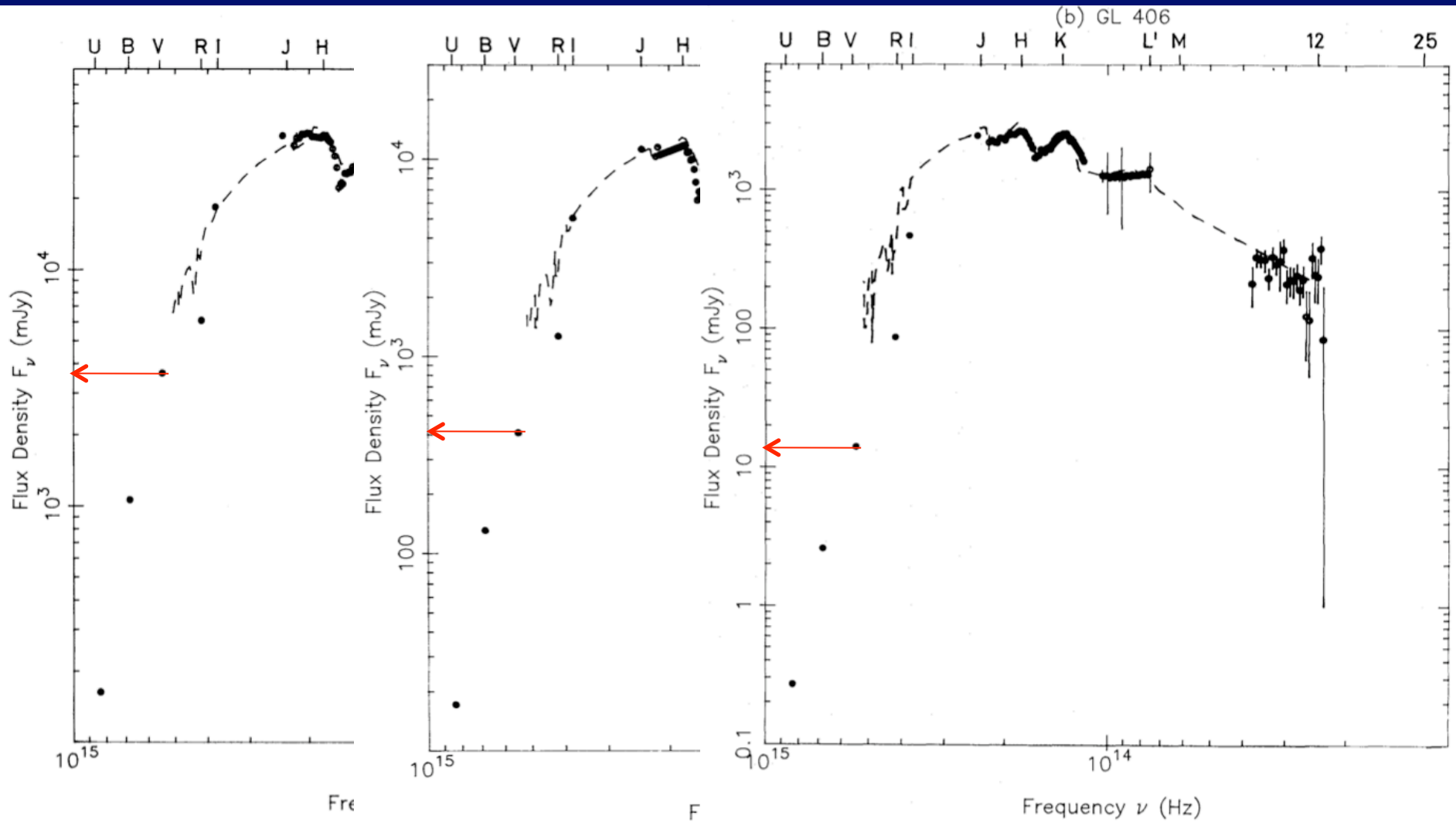
Why the infrared?

Berriman & Reid 1987

M2

M4

M6

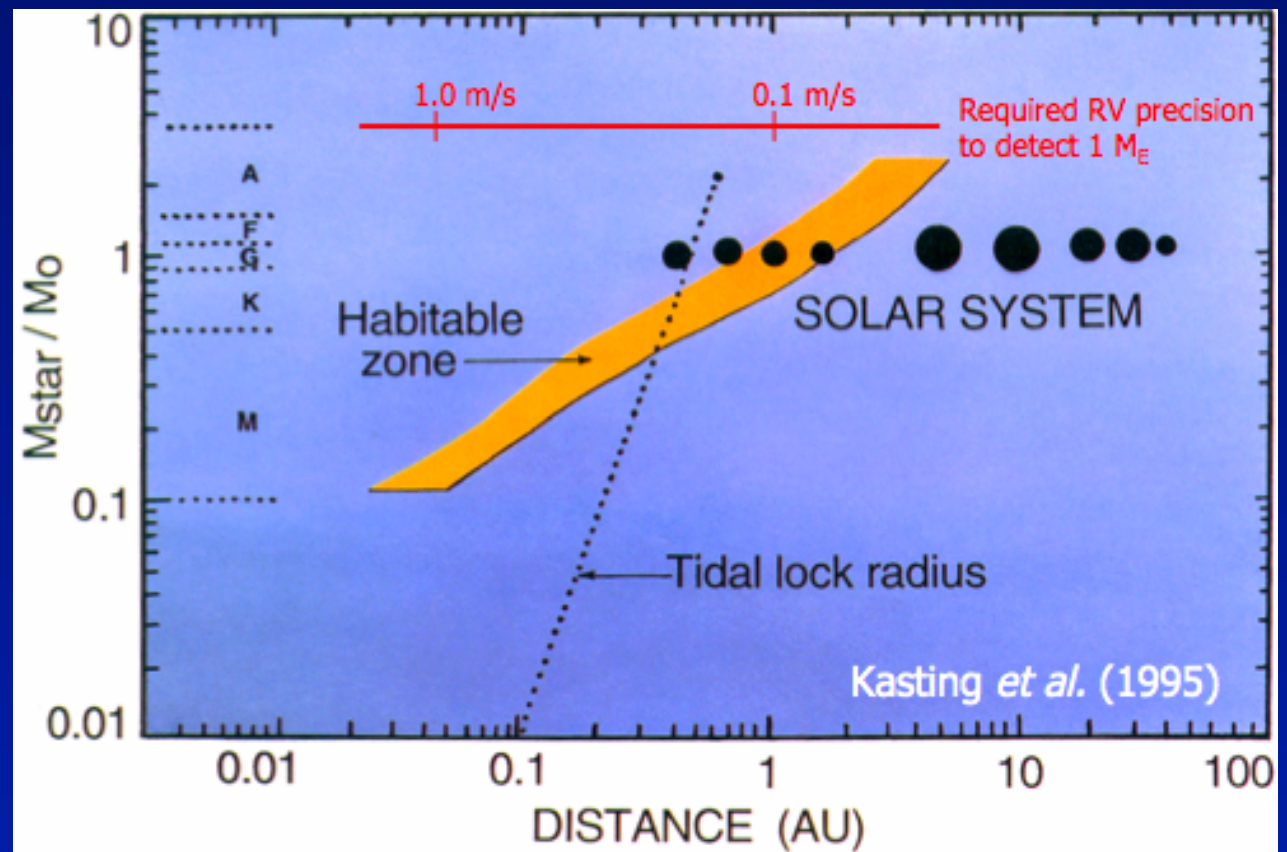


Habitable zones more accessible

- * The habitable zones of low-mass stars have shorter orbital periods

Habitable zone
inside 0.3 AU for M
dwarfs

Tidally locked
planets may or may
not be good places
to look for life



Technical challenges of RV in the NIR

- Simultaneous wavelength fiducial covering NIR is required for high precision RV spectroscopy

- Use of ultrabroad laser comb



Simulation / Prototype

- Significant telluric contamination in the NIR

- Mask out ~ 30 km/s around telluric features deeper than 2%

- At $R=70,000$ (2.5 mm PWV, 1.2 air-mass) this leaves 87% of Y, 34% of J, and 58% of H

- Simulations indicate resulting 'telluric jitter' < 0.5 m/s



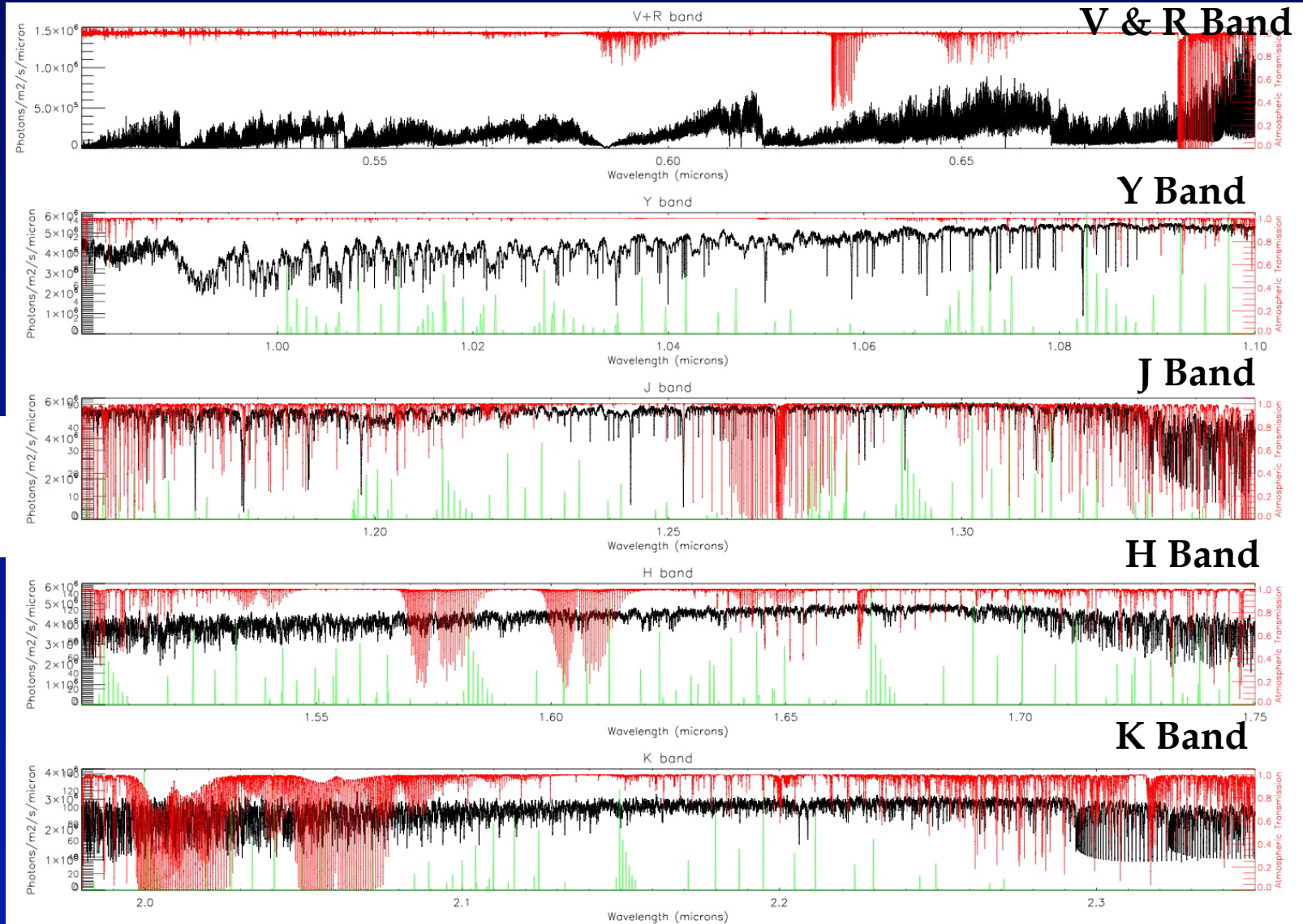
High dry site

Atmospheric limits?

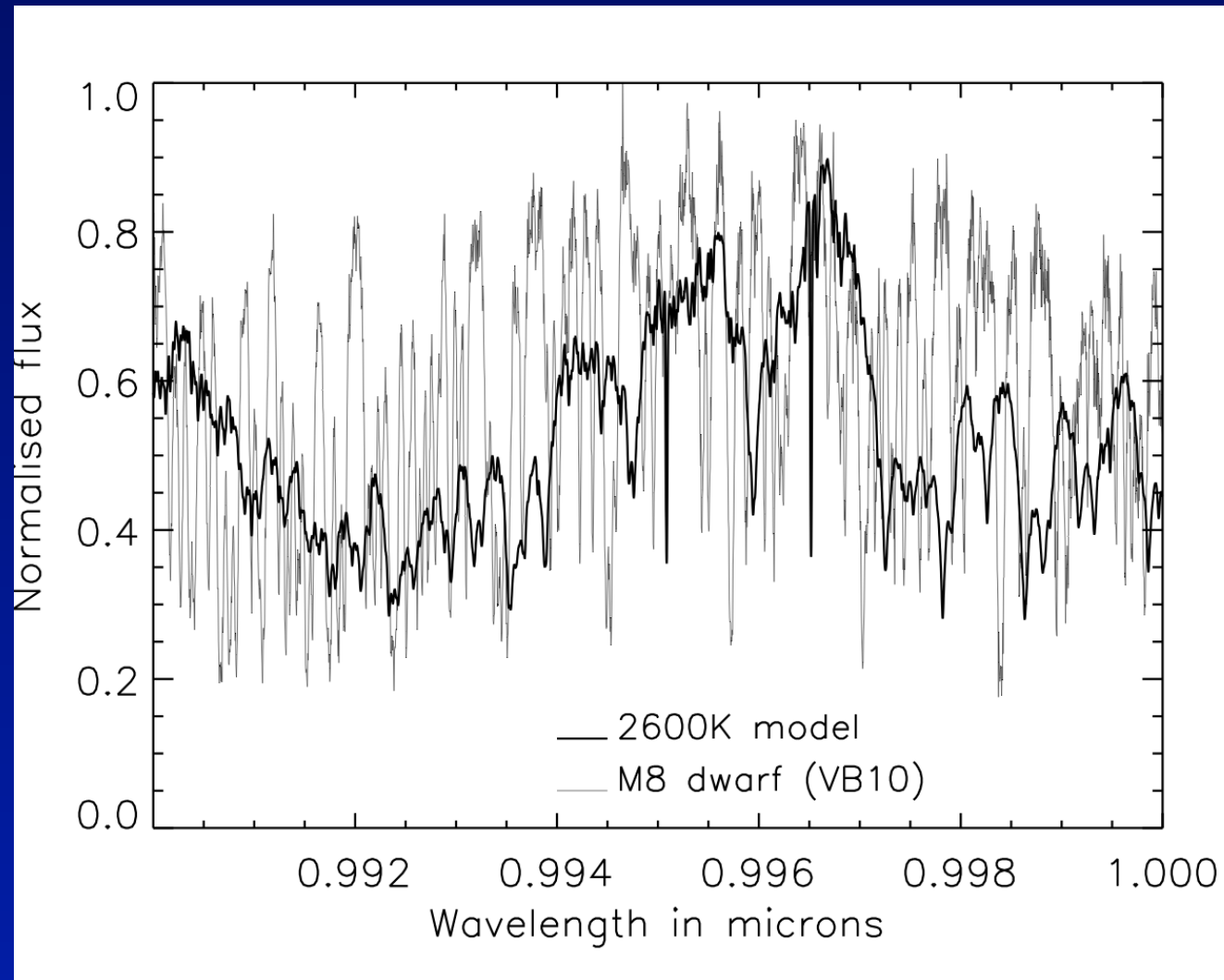
La Silla is excellent site to avoid tellurics

M6V
 $T_{\text{eff}} = 2800 \text{ K}$
 $\text{Log } g = 5$
 $v \sin i = 0 \text{ km/s}$

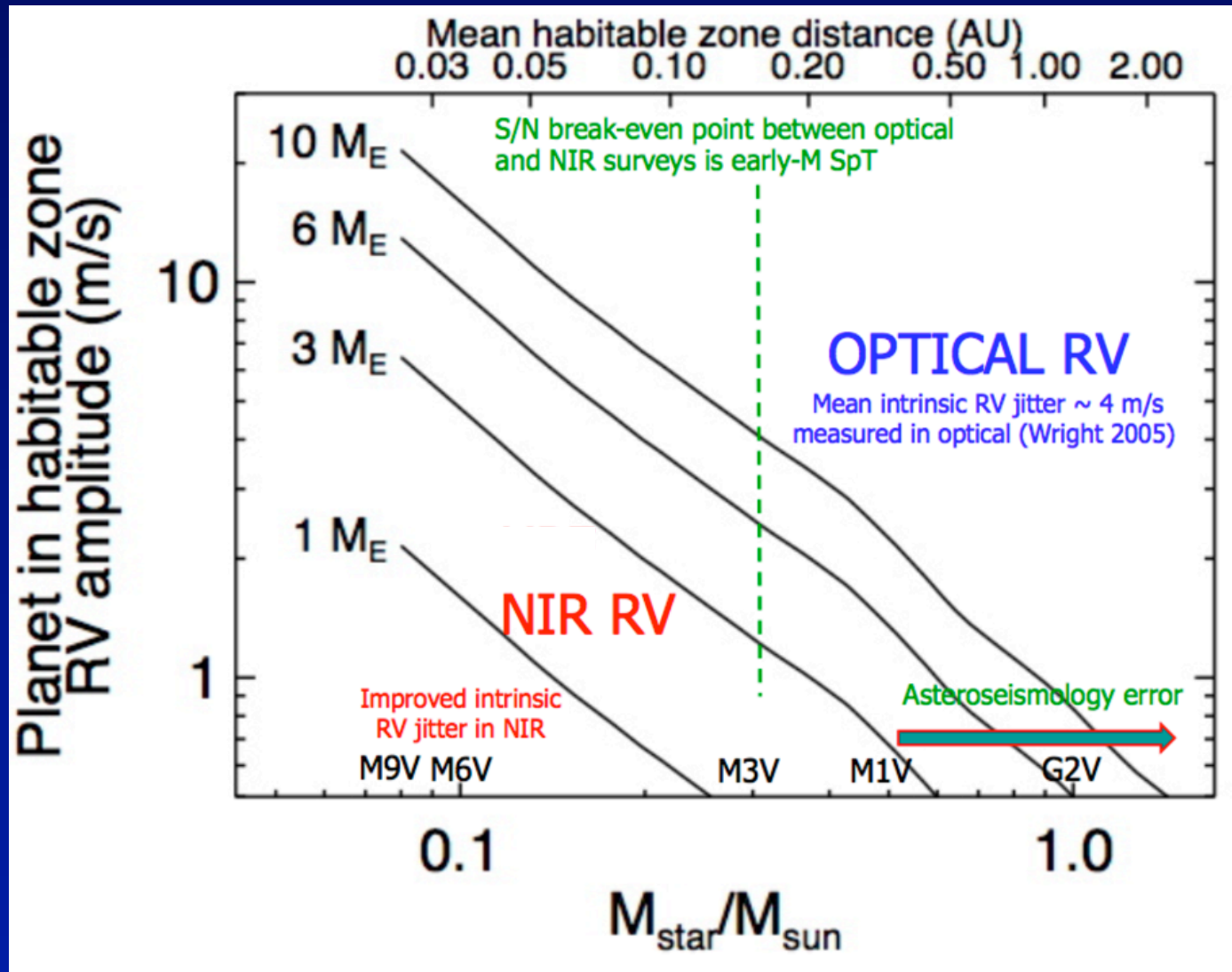
Model
Telluric
OH



Plenty of radial velocity information



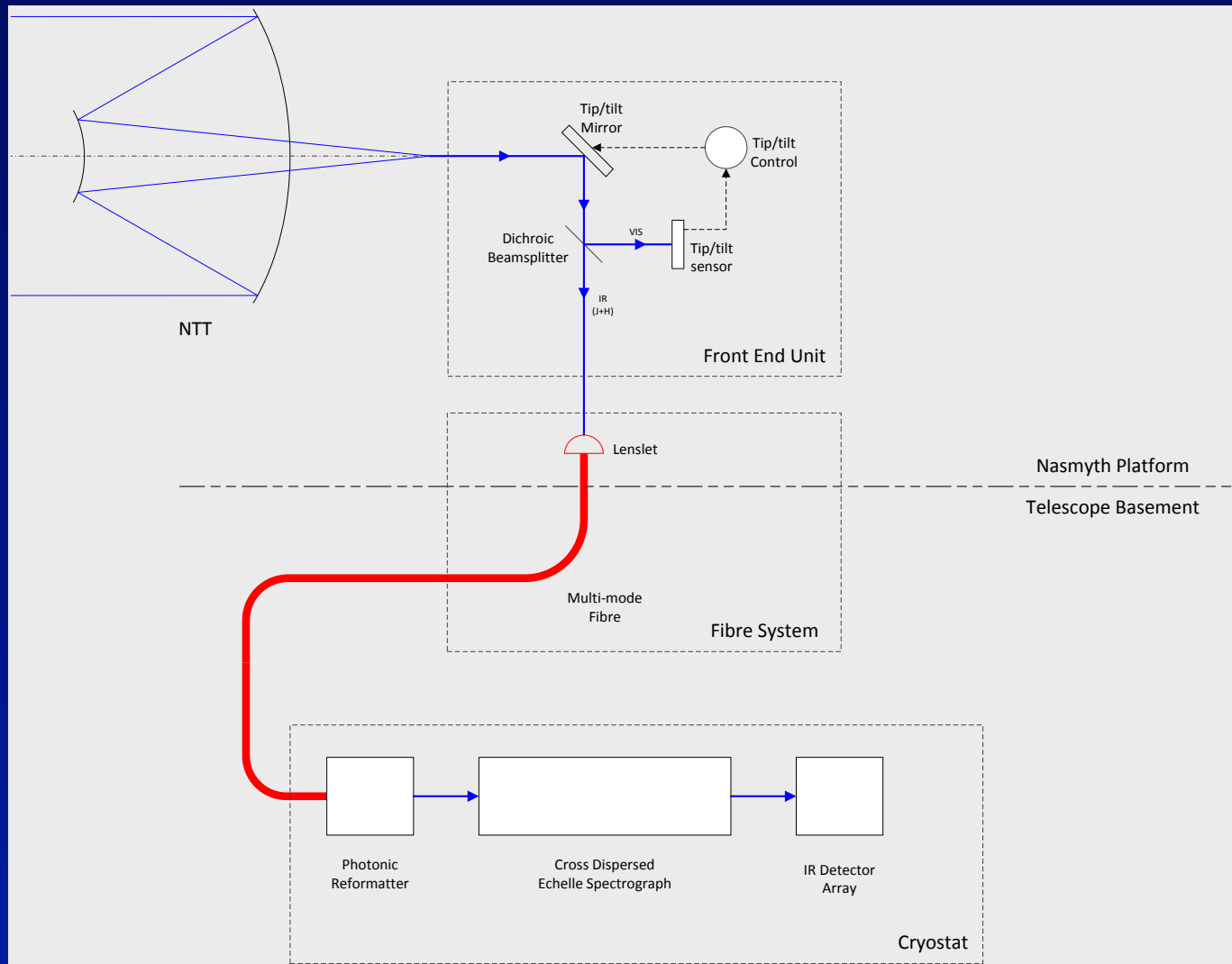
The potential in the infrared



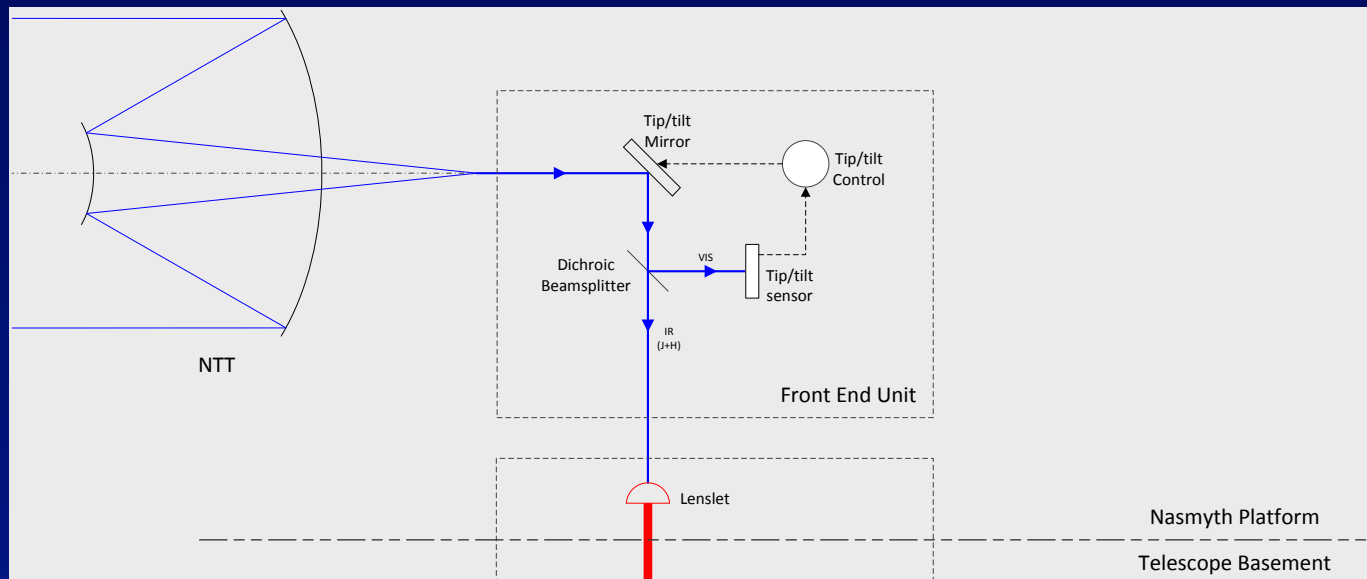
Design Baseline Concept

- * Fed by photonic lantern
- * Cross dispersed at fibre output in echelle spectrograph
- * 4k IR detector
- * Reflective camera
- * Fixed echelle, cross disperser, camera
 - * No mechanisms (in main optical path)

Photonic Spectrograph Layout (1)

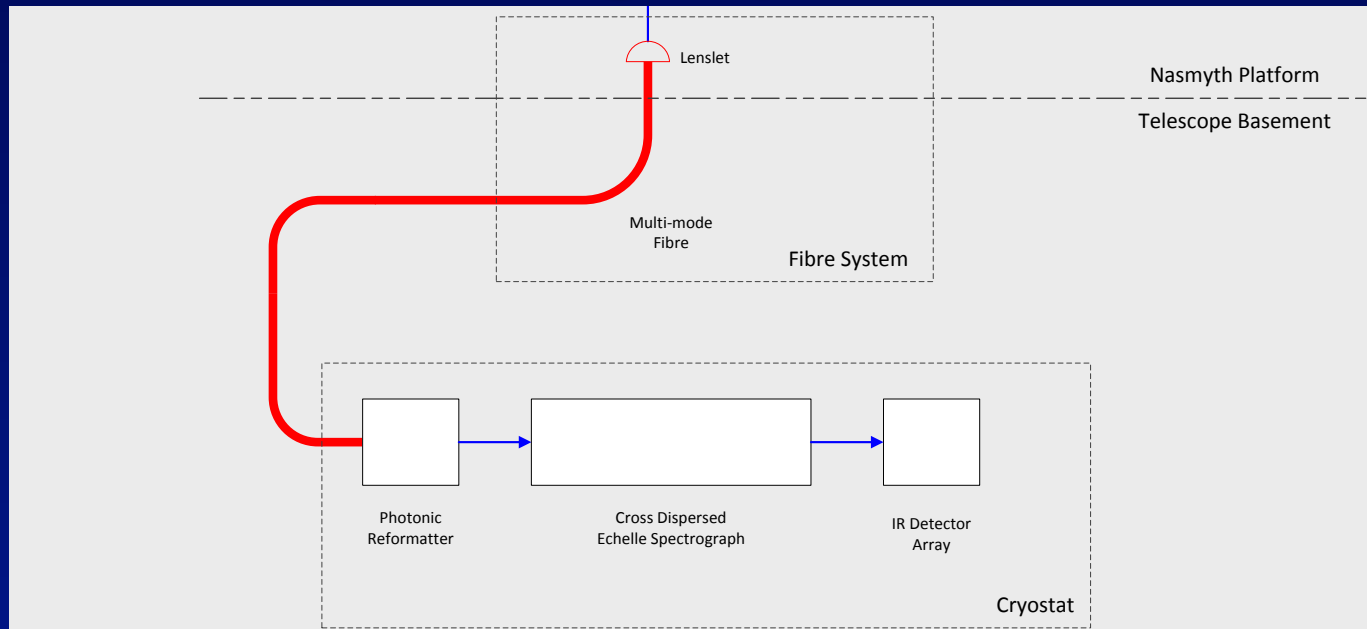


Photonic Spectrograph Layout (2)



- * Light from telescope fed into Front End Unit (FEU) mounted on Nasmyth platform
- * Visible light from target is split off onto a tip/tilt sensor via a dichroic beamsplitter
- * This is used to control a tip/tilt mirror which stabilises the target image on the input to the fibre system
- * IR light (J+H) passes through into the fibre system

Photonic Spectrograph Layout (3)



- * Beam enters multi-mode fibre via a lenslet - matches number of modes in fibre to number of modes in telescope PSF
- * Fibre carries light to spectrograph located in telescope basement
- * Photonic reformatter converts multi-mode fibre into linear array of single mode outputs
- * Reformatted output forms entrance slit for spectrograph
- * Slit is $\sim 10 \mu\text{m}$ wide by $10.N \mu\text{m}$ high (N =number of modes)
- * Narrow slit means smaller spectrograph for same spectral resolution compared to seeing limit or traditional image slicer spectrographs
- * Efficiency $\sim 5\%$ (HARPS) $\rightarrow >20\%$

Mock survey - 100 nights/yr for 5 years assuming std overheads

Y=11.75 J=11.25 H=10.75, S/N=150 in 1hr

<i>~Sp Type:</i>	Mass	No. of stars
M2.5 V	0.3	200
M3.0 V	0.24	200
M4.0 V	0.19	200
M5.0 V	0.15	200
M6.0 V	0.12	114
M6.5 V	0.1	37
M8.0 V	0.09	14
M9.0 V	0.08	5
Total		970

Survey size of 1000 recommended by NASA exoplanet community report

Other Science

- * Ionisation history of the Universe from rapid follow-up of $z > 7$ GRBs
- * Studies of weather, temperature, gravity and abundance for cool stars, particularly, brown dwarfs, protostars and M giants
- * Zeeman Doppler Imaging
- * Characterization of extrasolar planets
- * Abundance analysis of comets
- * Planetary weather and circulation patterns
- * Asteroseismology
- * Nuclear activity in nearby galaxies

Synergy

- * Optical transit surveys – many other ground-based transit search surveys .. coming K2, JWST, CHEOPS, TESS, PLATO
- * Astrometric ... GAIA

Conclusion

- * Modelling indicates <1 m/s is achievable, $>20\%$ efficiency
- * Limits probably driven by stability of stars
- * Method to detect sub Earth-mass planets in habitable zones of *closest* stars
- * Conservative design can achieve science goals