

carmenes

A Radial-Velocity Survey for Terrestrial Planets in the Habitable Zones of M Dwarfs



Andreas Quirrenbach
and the CARMENES Consortium

The 3.5m Telescope on Calar Alto (Southern Spain)

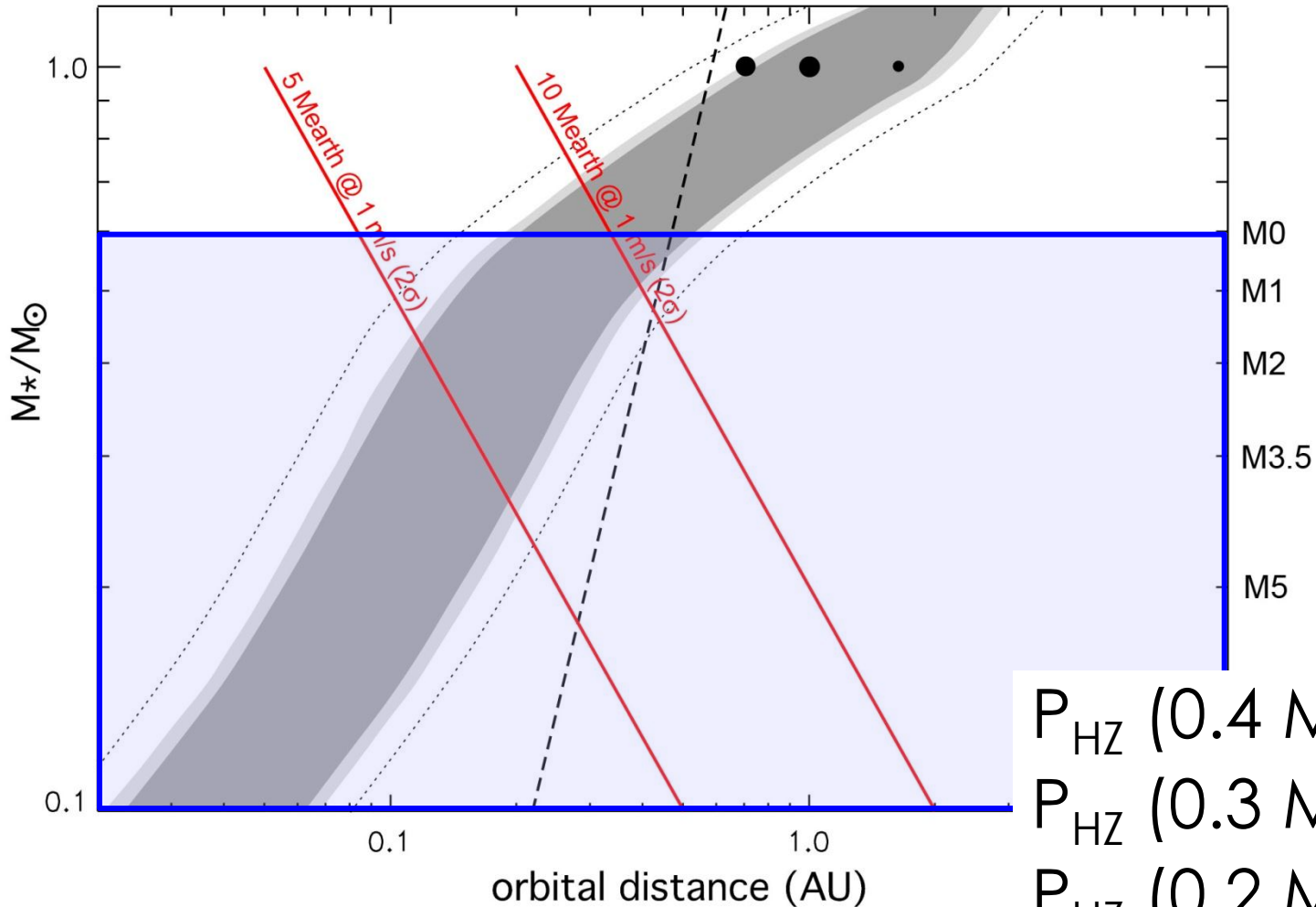


Goals and Plan for CARMENES



- Search for Earth-like “habitable” planets around low-mass stars (M-stars)
 - Number and formation mechanisms
 - Properties and “habitability”
- Survey of 300 M stars
 - Simultaneously in visible light and near-infrared
- 10 data points per star and year
 - 600 to 750 nights needed
 - Guaranteed in contract with CSIC and MPG

A “shortcut”: M-type dwarfs

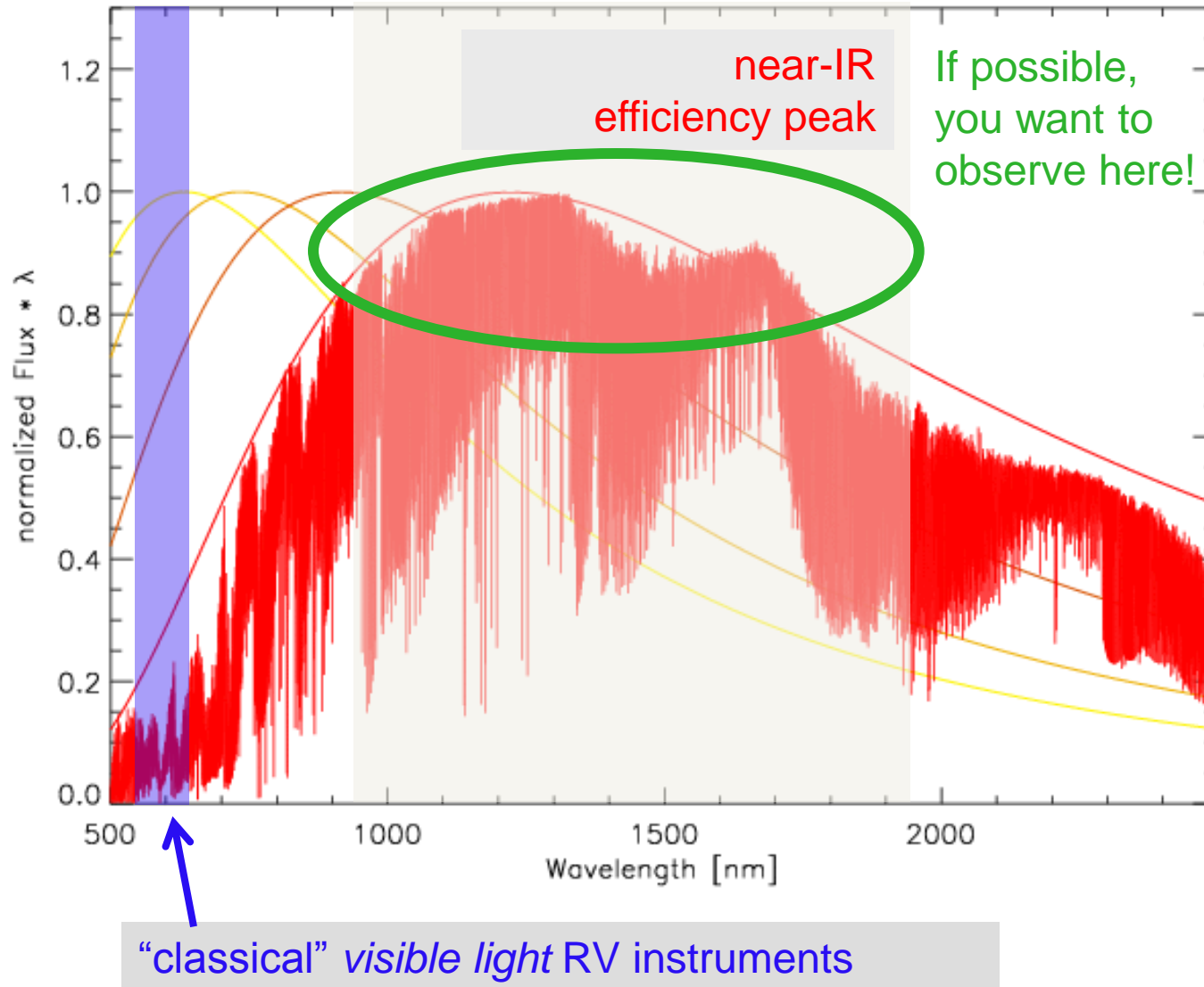


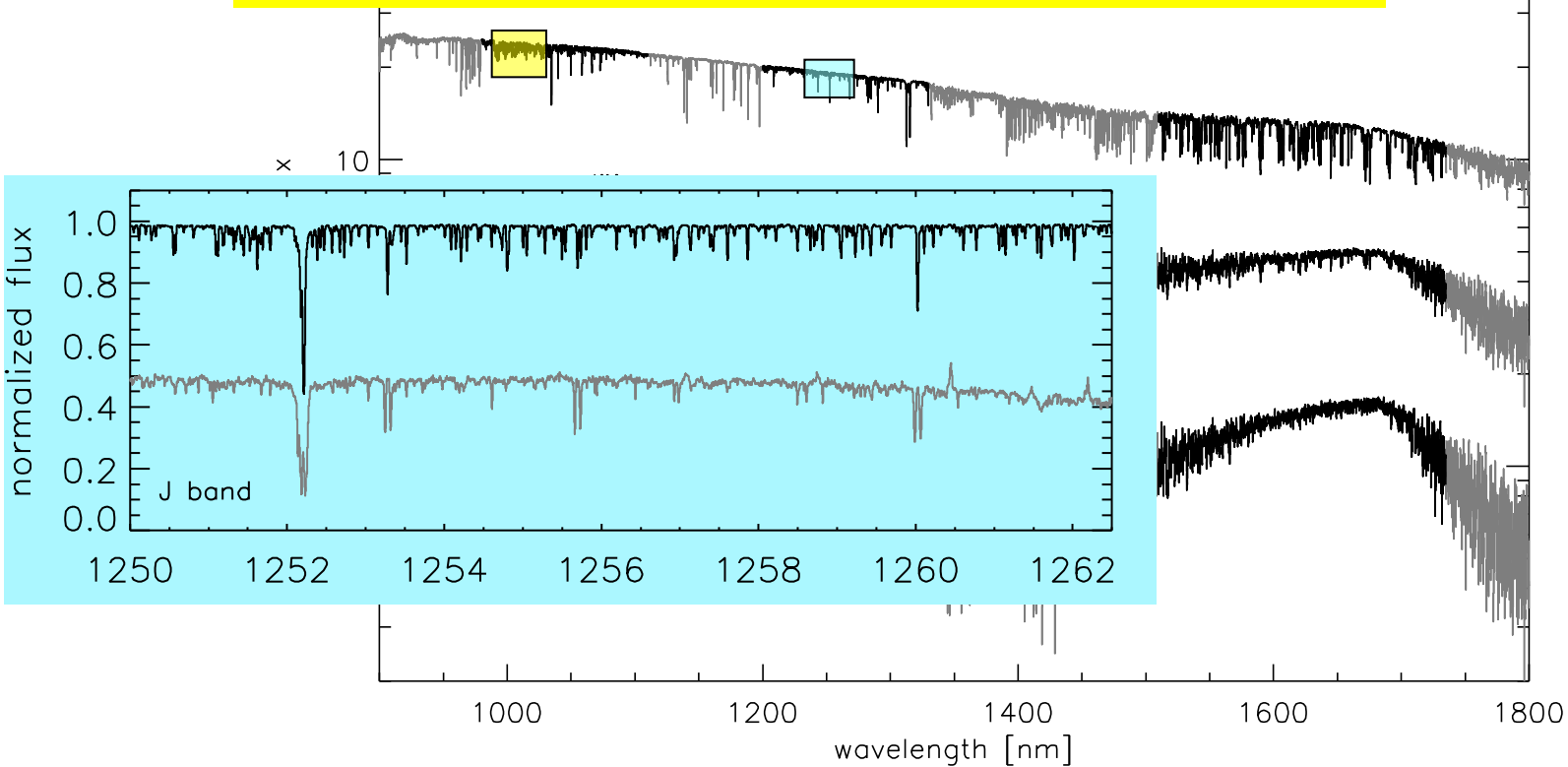
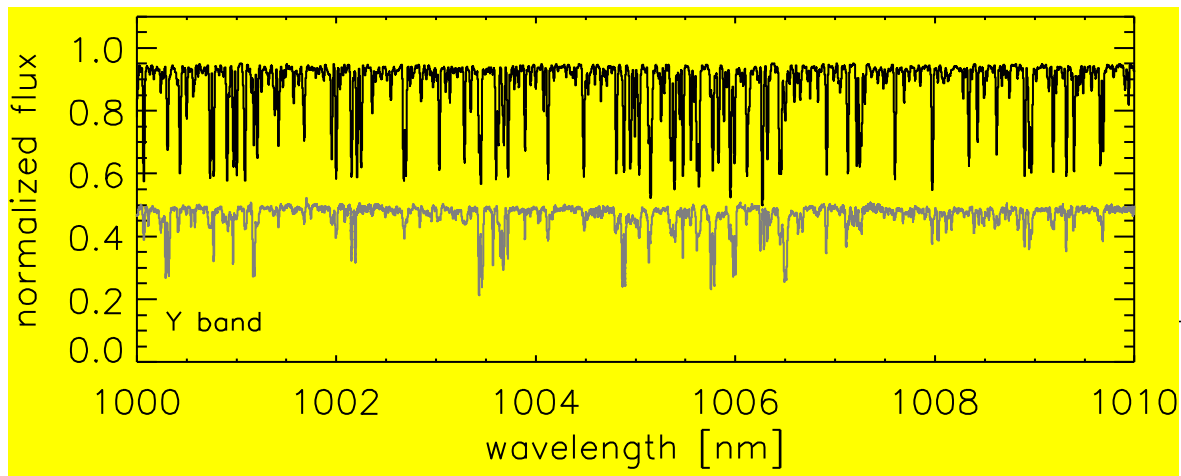
$$P_{\text{HZ}} (0.4 M_\odot) = 25 \text{ d}$$

$$P_{\text{HZ}} (0.3 M_\odot) = 18 \text{ d}$$

$$P_{\text{HZ}} (0.2 M_\odot) = 12 \text{ d}$$

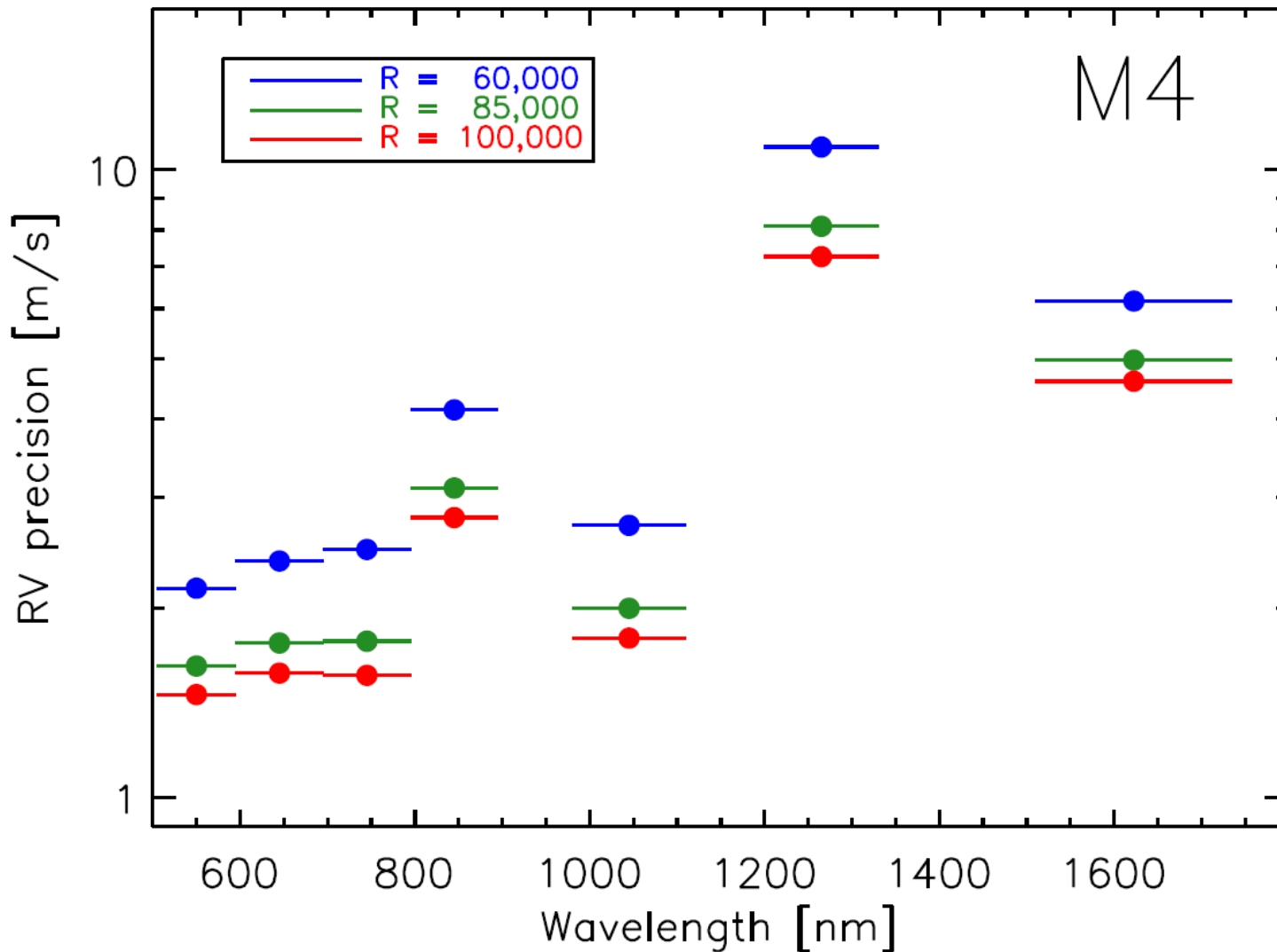
The SED of M-type stars



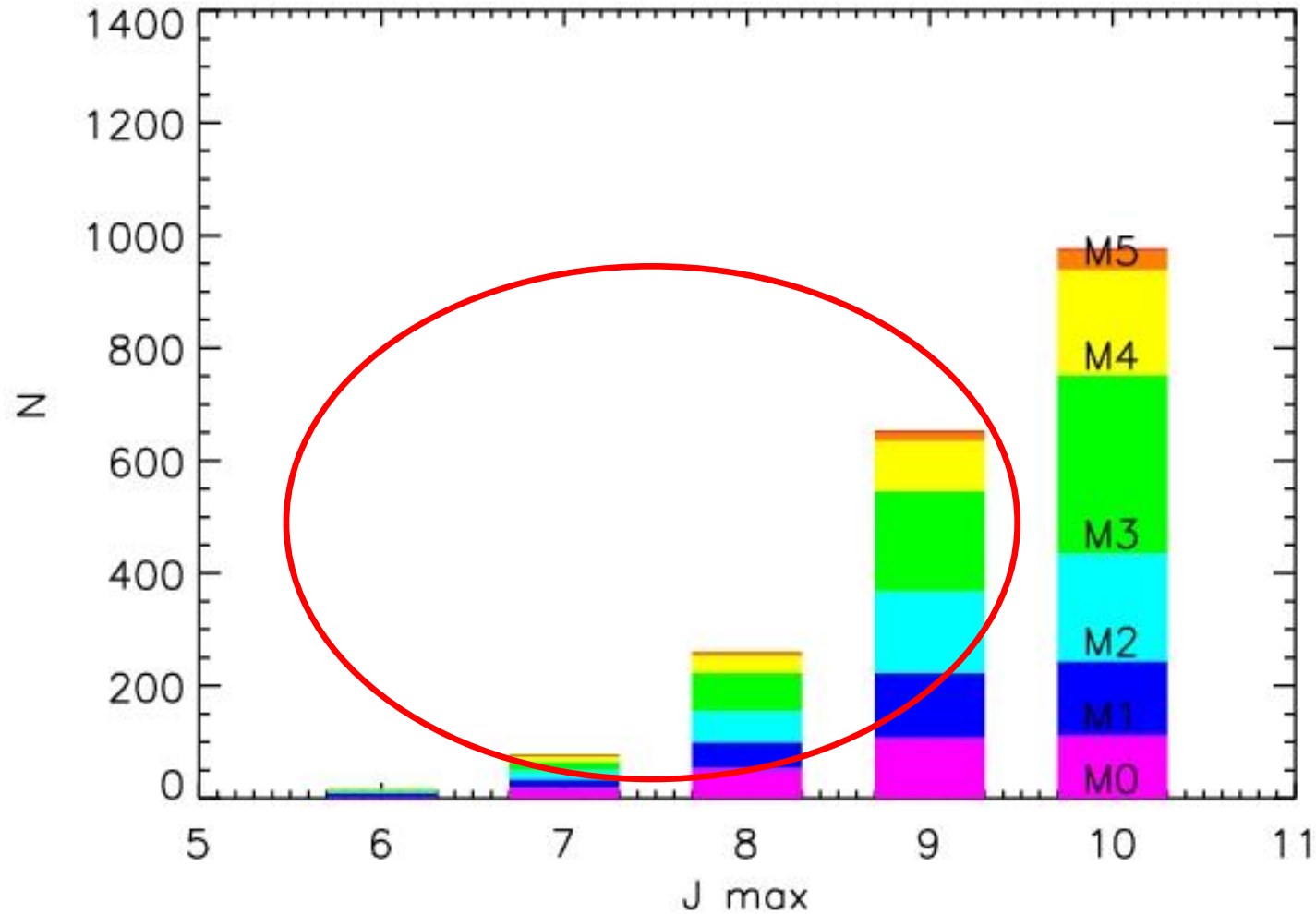


PHOENIX models

Relative Precision Achievable for M4 Star in Visible and near-IR



Stellar sample



Guiding Principles for Instrument

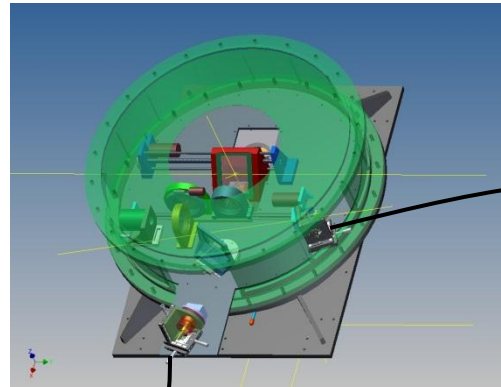


- Single-purpose instrument
 - Design driven by survey requirements
- High stability for terrestrial planet detection
 - Thermal and mechanical stability
 - Stable input
 - No moving parts in spectrographs
- High resolution for slow rotators
- Large wavelength coverage for discrimination against intrinsic variability
- High efficiency for faint stars

Instrument Overview



Front-End



Cooling System
Vac.pumps
Sensors
MCE

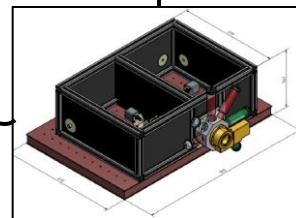
ICS + ICE
GUI
Scheduler
Pipeline

Scrambler

Scrambler

XPM

XPM



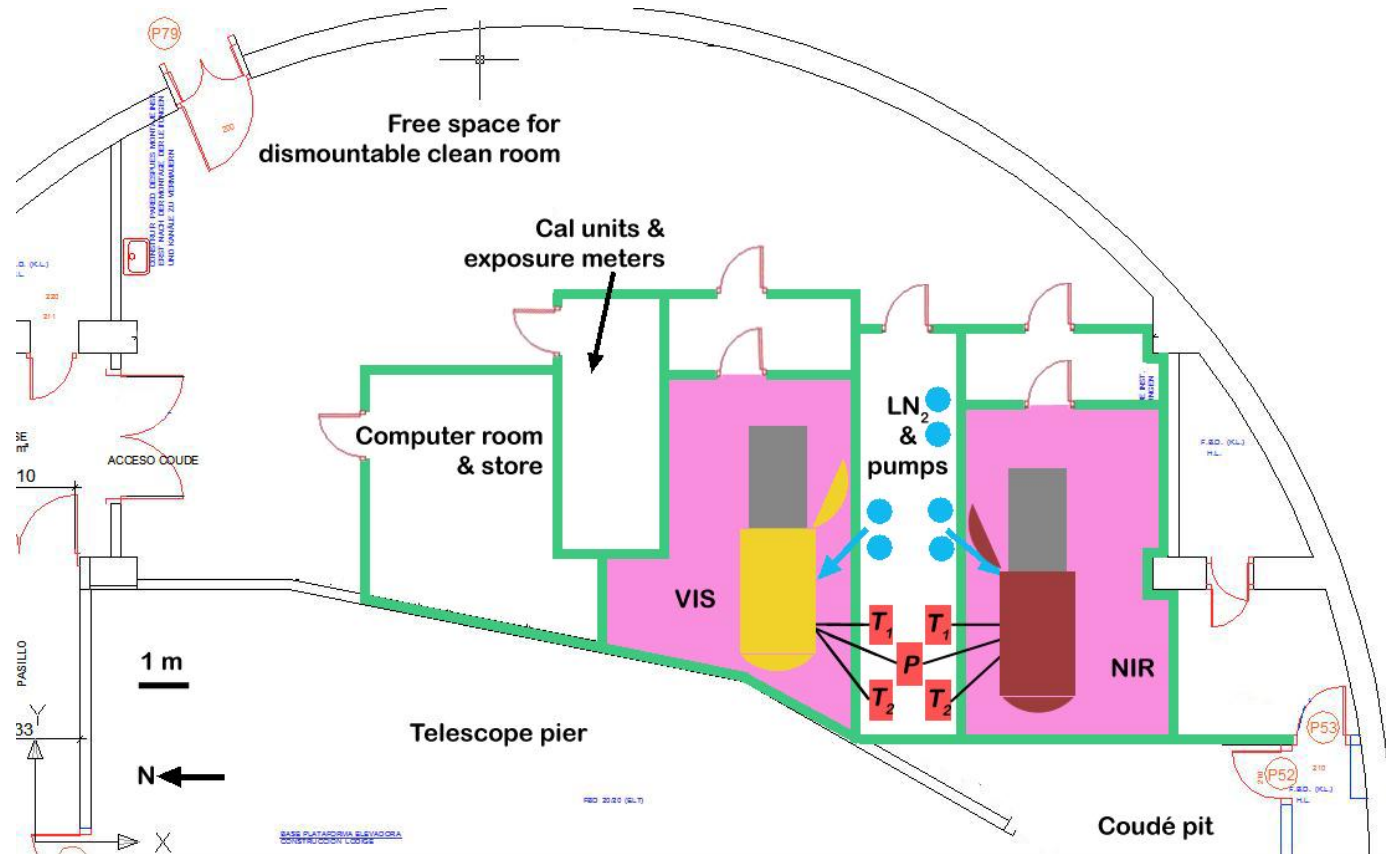
CalUnit

NIR Spectrograph

VIS Spectrograph

Instrument Location

- 1 Climatic room for each channel.
- Environmental conditions: $285\text{-}288 \pm 1 \text{ K}$.



Properties of Spectrographs



- Optical spectrograph
 - 0.53 ... 1.05 μm , $R = 82,000$
 - Precision ~ 1 m/s
 - Vacuum tank, temperature stabilized
 - 4k x 4k deep depletion CCD detector
- Near-Infrared spectrograph
 - 0.95 ... 1.7 μm , $R = 82,000$
 - Vacuum tank, cooled to 140K, stabilized
 - Precision goal 1 m/s
 - Two 2k x 2k Hawaii 2.5 μm detectors

Spectrograph Layout

White pupil fiber-fed echelle spectrograph

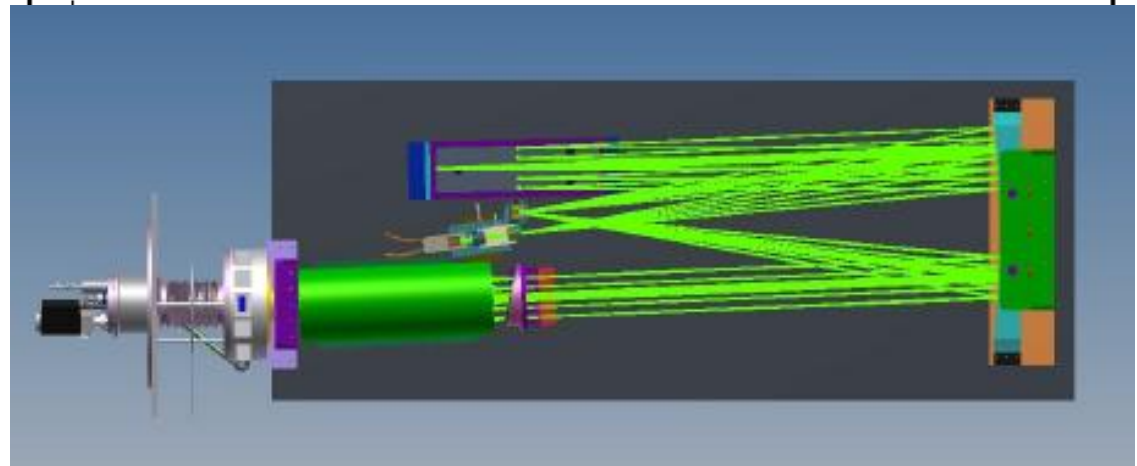
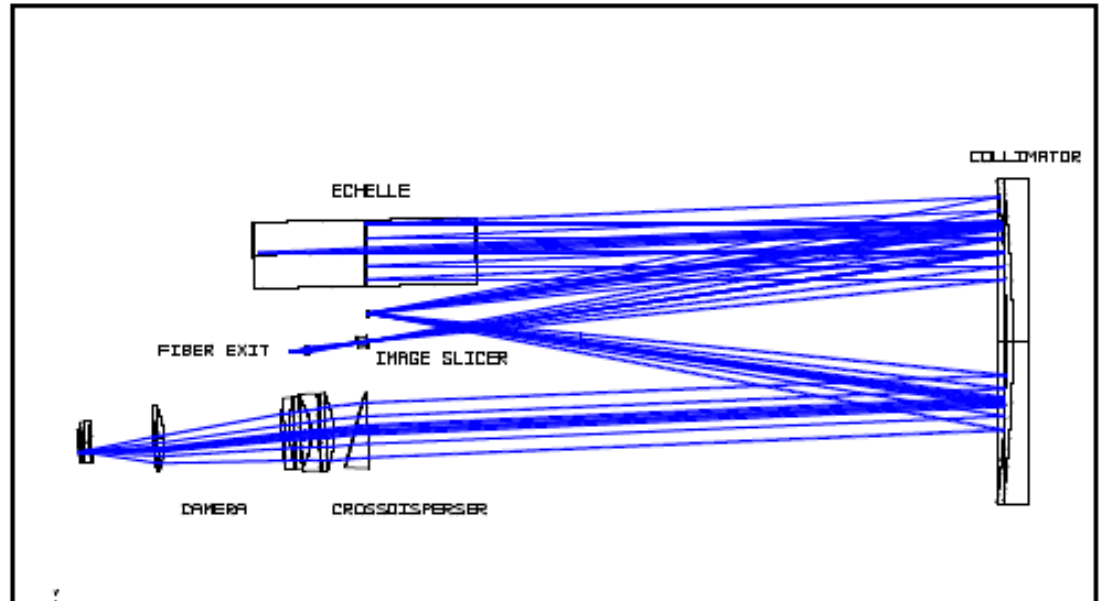
FiberExit-FNoptics-Slicer

Single-piece Collimator (3passes)

R4 Echelle grating

Grism cross-disperser

Dioptric camera



Spectrograph and Vacuum Tank Layout

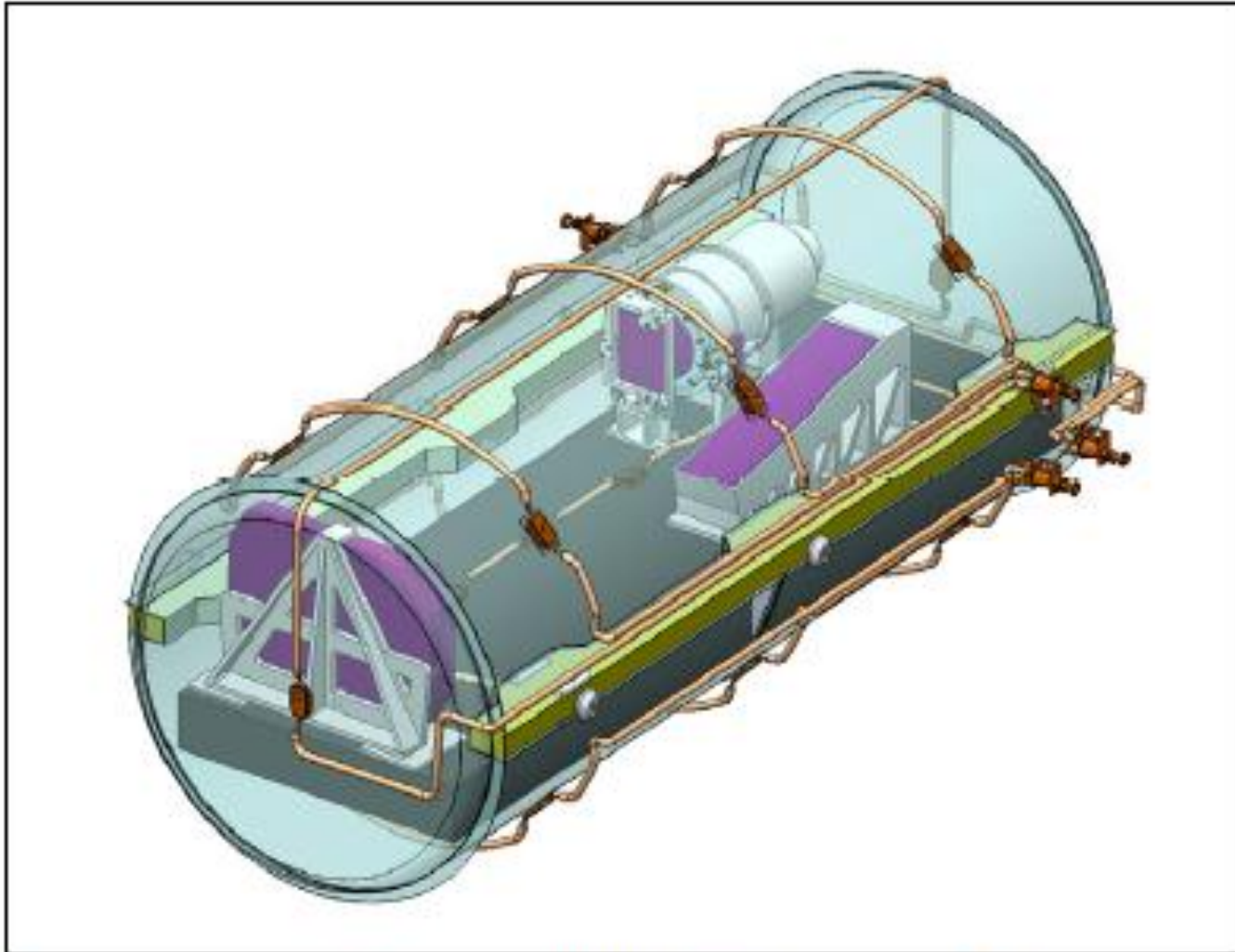
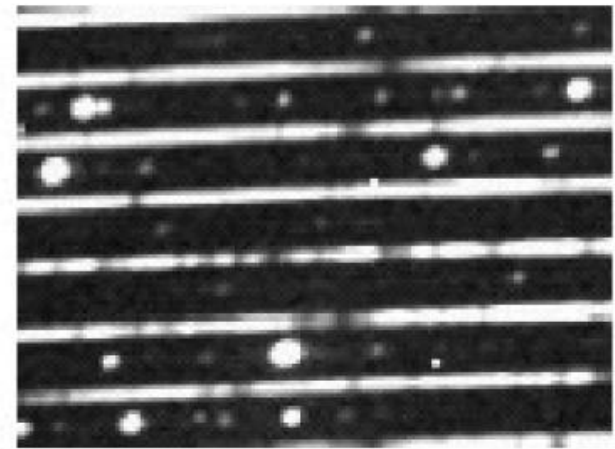
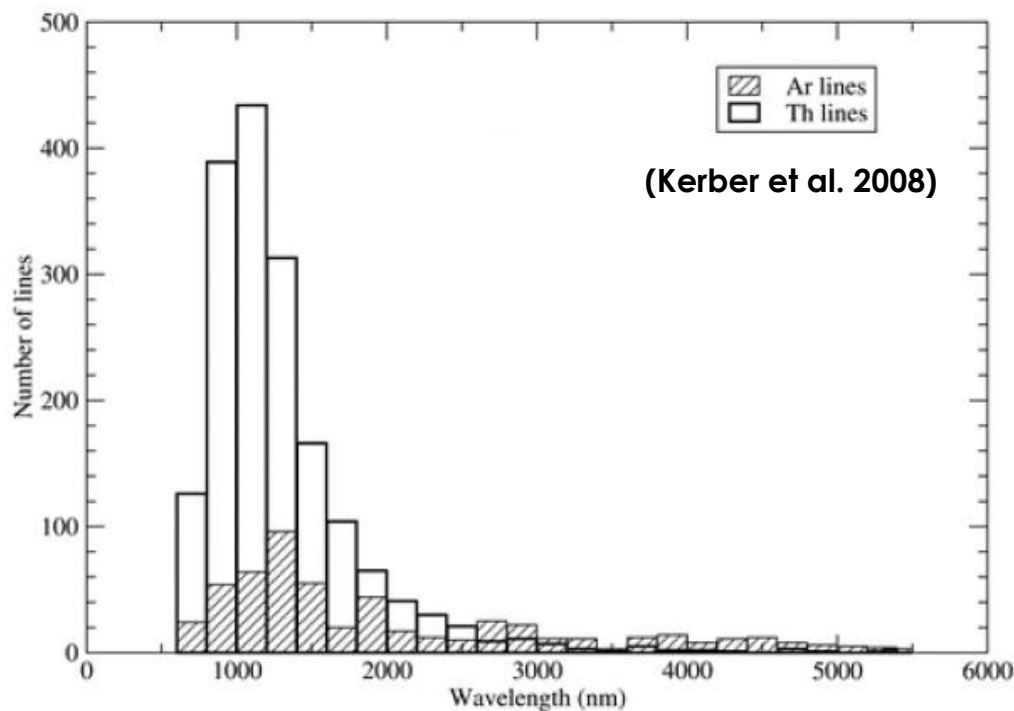


Figure 2. General view of the CARMENES NIR Optical Bench fully assembled.

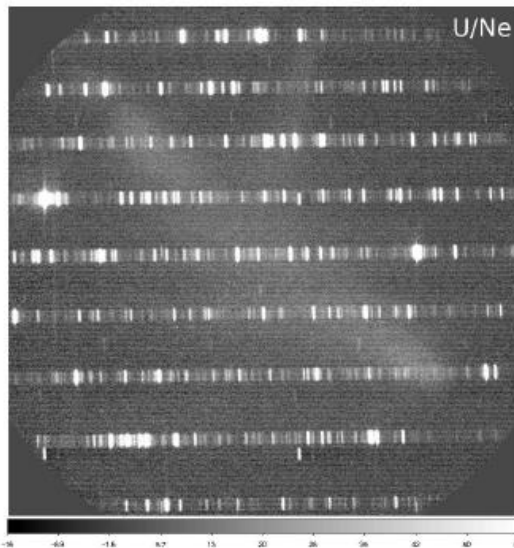
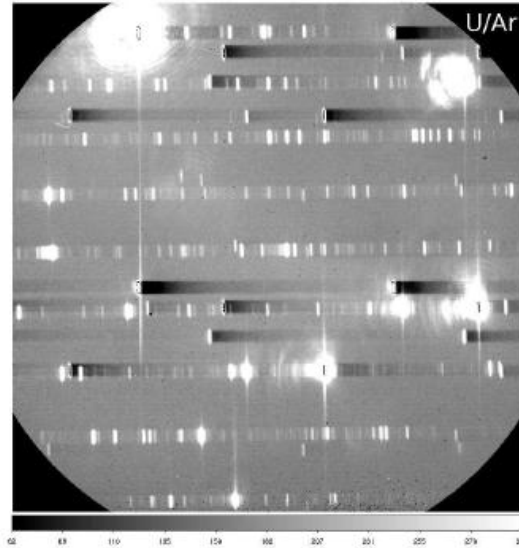
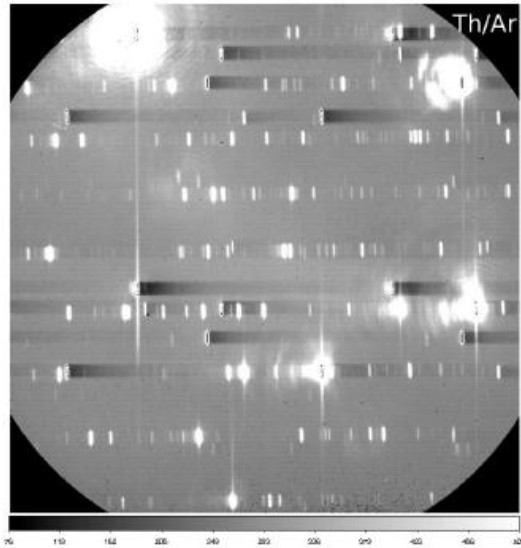
Calibration: Wavelength reference

- Hollow cathode lamps: Thorium-Argon-Neon for daily and master calibrations.



Enough suitable Th-Ar lines in the NIR range

Comparison of Th/Ar, U/Ar and U/Ne Lamps



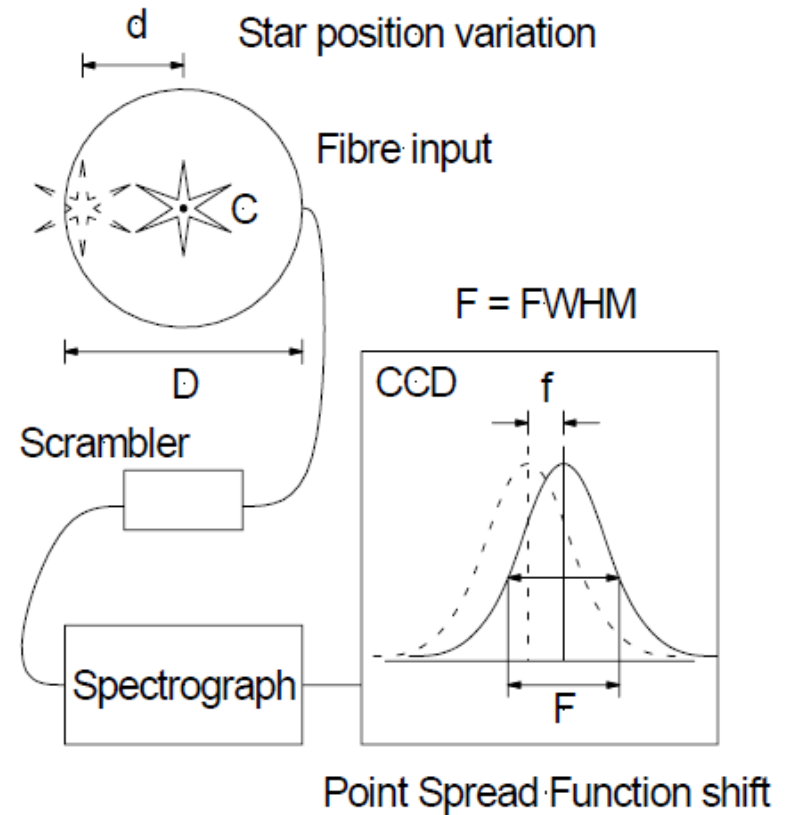
Redman et al. 2011

Requirements for RV precision



Stable slit illumination and instrument are required for high RV precision.

- Highly stable injection of light in the fibre (guiding $\sim 0.1''$)
- Image scrambler or octagonal fiber



The CARMENES Consortium



- Landessternwarte Königstuhl, U Heidelberg, Germany
- Institut für Astrophysik, U Göttingen, Germany
- MPI für Astronomie, Heidelberg, Germany
- Thüringer Landessternwarte, Tautenburg, Germany
- Hamburger Sternwarte, U Hamburg, Germany

- Instituto de Astrofísica de Andalucía, Granada, Spain
- Universidad Complutense de Madrid, Madrid, Spain
- Institut de Ciències de l'Espai, Barcelona, Spain
- Instituto de Astrofísica de Canarias, Tenerife, Spain
- Centro de Astrobiología, Madrid, Spain

- Centro Astronómico Hispano-Alemán

Time Line



Official Start	11/2010
Preliminary Design	to 07/2011
Final Design	07/2011 – 11/2012
Construction	11/2012 – 12/2013
Commissioning	01/2014 – 03/2014
Data Taking	04/2014 – 12/2018