Calibrating our search for exo-worlds with MARVEL

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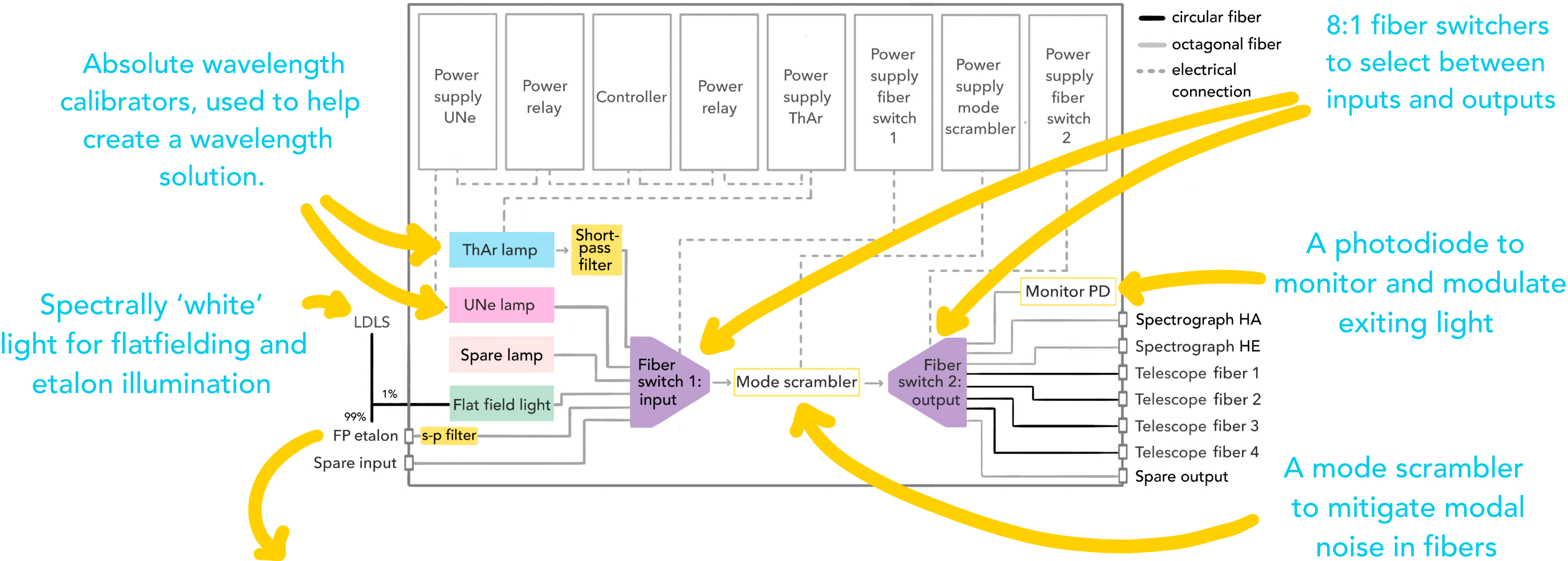
Thousands of exoplanets have been detected to date via transit! But without their true densities, the majority remain uncharacterized, and getting high-precision instrument time is difficult. Enter MARVEL.

MARVEL? Like, the comics?

No, no. MARVEL (Mercator Array for Radial VELocities) is a new facility at the Roque de los Muchachos Observatory with a 1 m/s precision covering the range of 380-950nm that will conduct a large-scale dedicated radial velocity (RV) follow-up survey of transiting exoplanets. One big hurdle in achieving this is in the instrument's calibration.
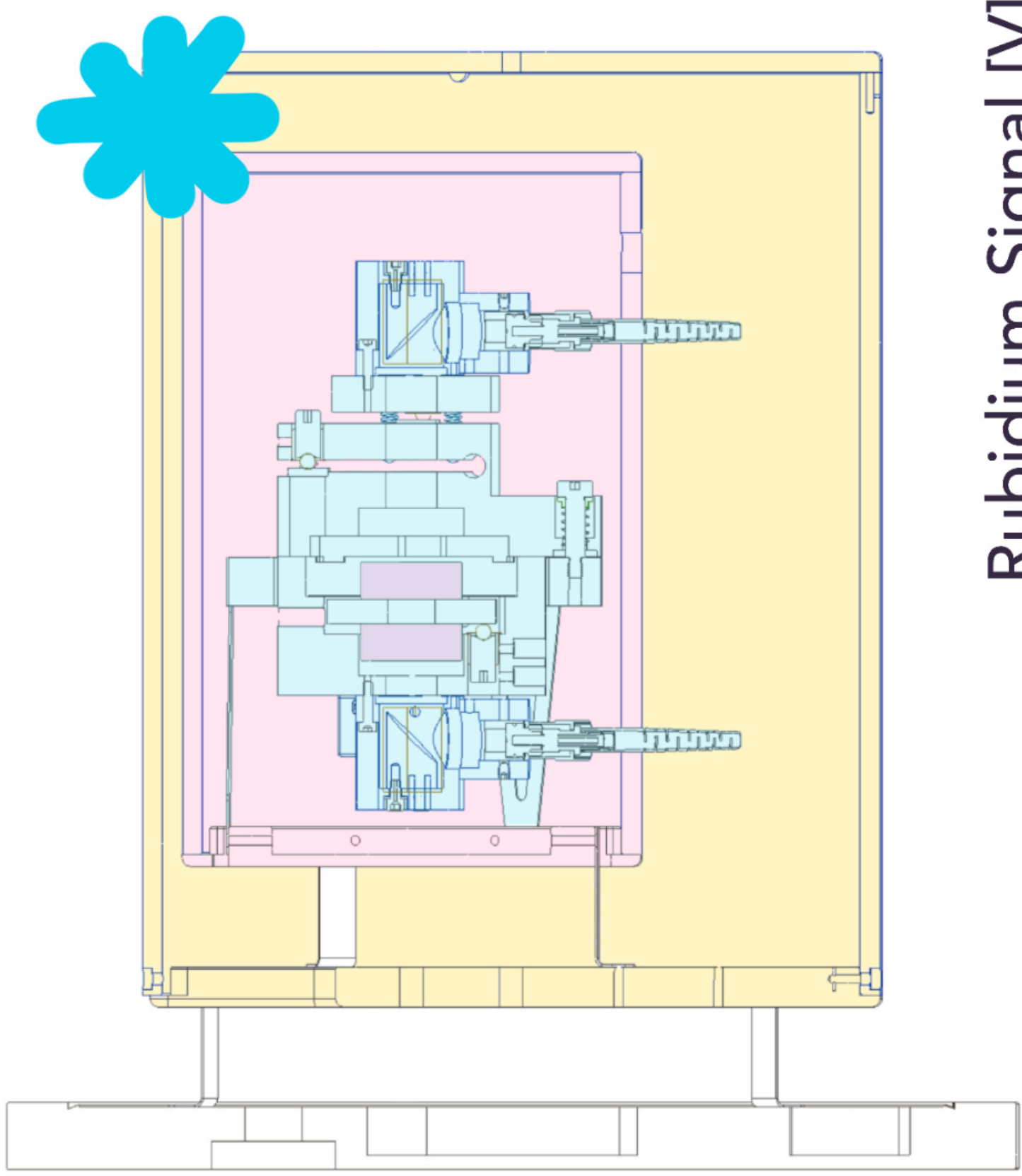
What goes into MARVEL's calibration unit?

Absolute wavelength calibrators, used to help create a wavelength solution.

Spectrally 'white' light for flatfielding and etalon illumination

8:1 fiber switchers to select between inputs and outputs

A photodiode to monitor and modulate exiting light

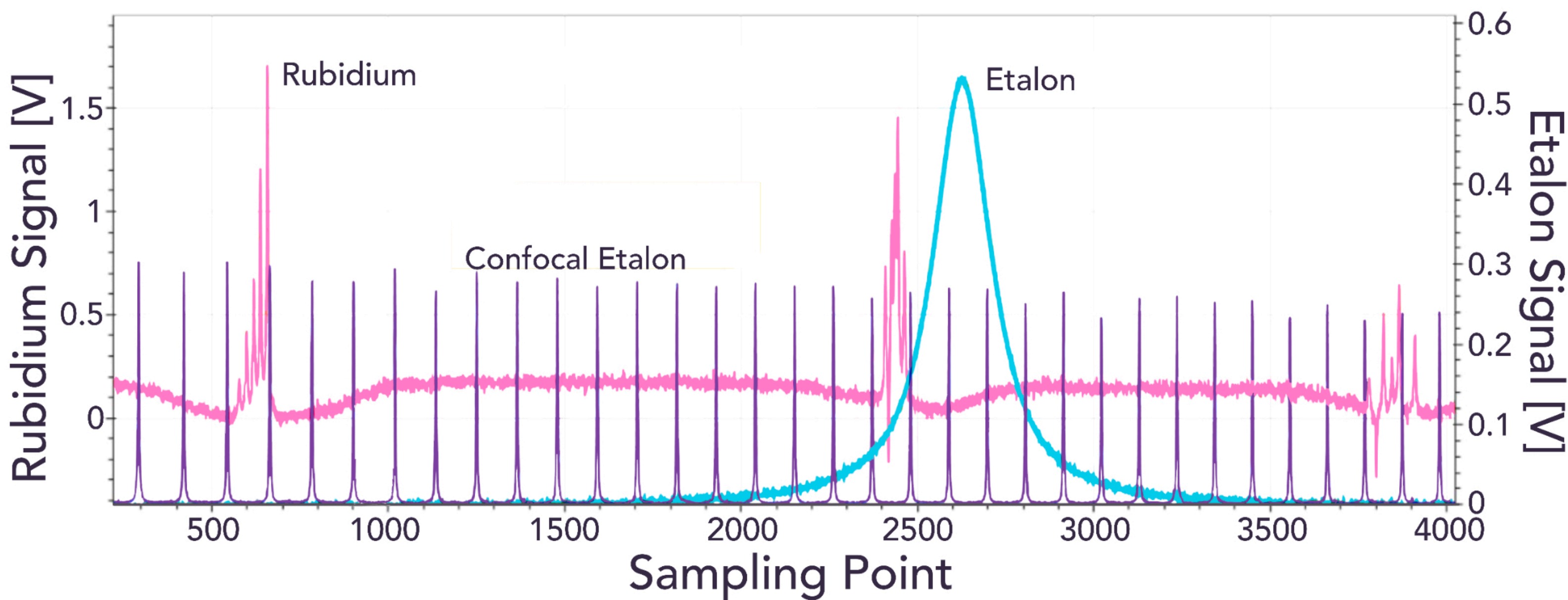A mode scrambler to mitigate modal noise in fibers

How do we reach 1m/s precision?

Credit: Stan Letchev

Credit: Jake Pember

Calibration lamps' spectral lines have some disadvantages such as variable intensity and uneven spacing. So we construct a wavelength solution using them in combination with a thermally-stable Fabry-Perot etalon, that is locked to a hyperfine Rubidium transition. The confocal etalon is used to linearize the scan axis. (Adapted from Stürmer et al. 2017)

Achieving higher RV precision through calibration involves deliberate optimization at every step, big and small, hardware and software. From the etalon, lamps, and fiber shapes, to the MARVEL simulator (Janssens et al. 2022) and data reduction pipeline, design and process matter! Once we push to 1m/s, this will let us characterize exciting system architectures, and provide ground-based observations to support future space missions.