POSTER **EP-10**

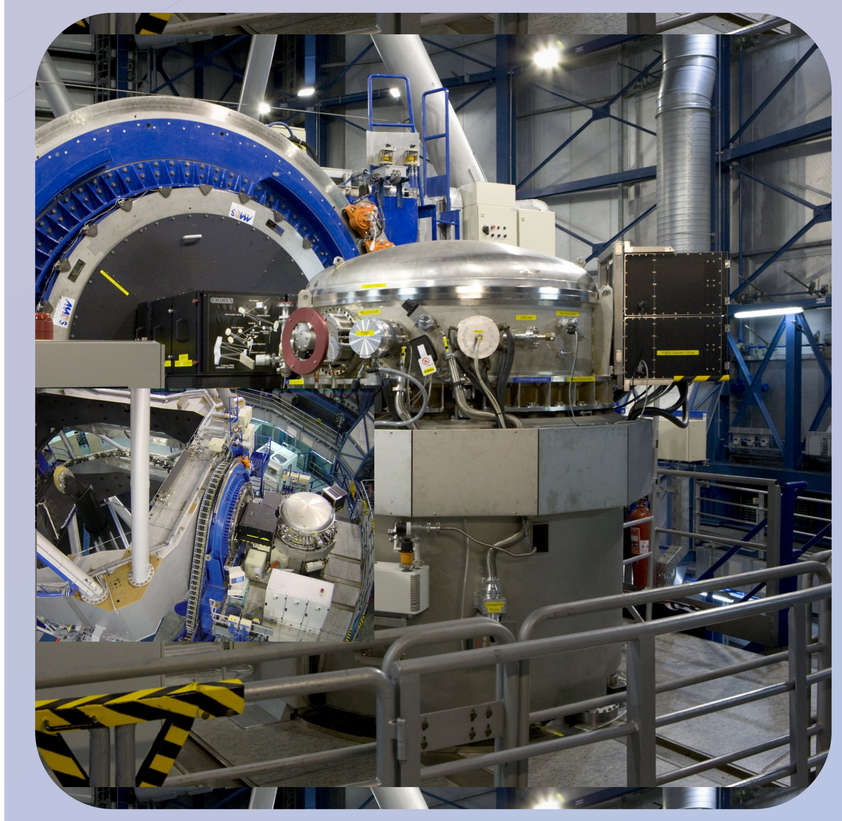
CRIRES+

The 3m/s Planet Finder in the near-infrared

U. Seemann[a],
G. Anglada-Escudé[a], *D. Baade*[b], *P. Bristow*[b], *R. J. Dorn*[b], *R. Follert*[c], *D. Gojak*[b], *J. Grunhut*[b], *A. P. Hatzes*[c], *U. Heiter*[d], *D. I. Ives*[b], *Y. Jung*[b], *H.-U. Käufl*[b], *B. Klein*[b], *J.-L. Lizon*[b], *M. Lockhart*[d], *T. Löwinger*[c], *T. Marquart*[d], *C. Marvin*[a], *E. Oliva*[e], *E. Origlia*[e], *J. Paufiqué*[b], *N. Piskunov*[d], *E. Pozna*[b], *A. Reiners*[a], *A. Smette*[b], *J. Smoker*[b], *.E Stempels*[d], *E. Valenti*[b]

[a] Universität Göttingen, Institut für Astrophysik, Göttingen, Germany [b] European Southern Observatory, Garching, Germany [c] *Thüringer Landessternwarte Tautenburg, Germany* [d] *Uppsala Universitet, Department for Physics and Astronomy, Sweden* [e] *INAF, Arcetri, Italy*
ulf.seemann@phys.uni-goettingen.de

CRIRES at the ESO/VLT is one of the few adaptive optics enabled instruments that offer a resolving power of R=100.000 from 1 – 5µm. An instrument upgrade (“CRIRES+”) has commenced to implement cross-dispersion capabilities, spectro-polarimetry modes, a new detector mosaic, and a new gas absorption cell. These capabilities will make CRIRES+ a powerful radial-velocity machine for exoplanet studies on the 3m/s level.



◄ ***Fig. 1:*** **CRIRES is mounted on VLT/UT1 Antu.**

▼ ***Fig. 2:*** **Optical layout of CRIRES+ (Oliva et al., 2014). The new wavelength calibration sources, a new detector array and the cross-dispersion unit, comprising a wheel of gratings (for each band), order filters, and camera are newly developed key items to transforming CRIRES into the next-generation CRIRES+. Red marks location of calibration gas-cell for exoplanet observations.**

▲ ***Fig. 3:*** **Expected Doppler amplitudes for different planet masses (as diagonal lines) for a 0.1 Msun star. The top horizontal line is the current radial velocity precision of CRIRES; the lower is a conservative predicted value for CRIRES+. These horizontal lines also display the estimate of the detection thresholds after obtaining 25 epochs. Expected planets (red) based on Kepler results (Dressing & Charbonneau, 2013). The green shaded zone is the approximate extent of the habitable zone for low mass stars.**

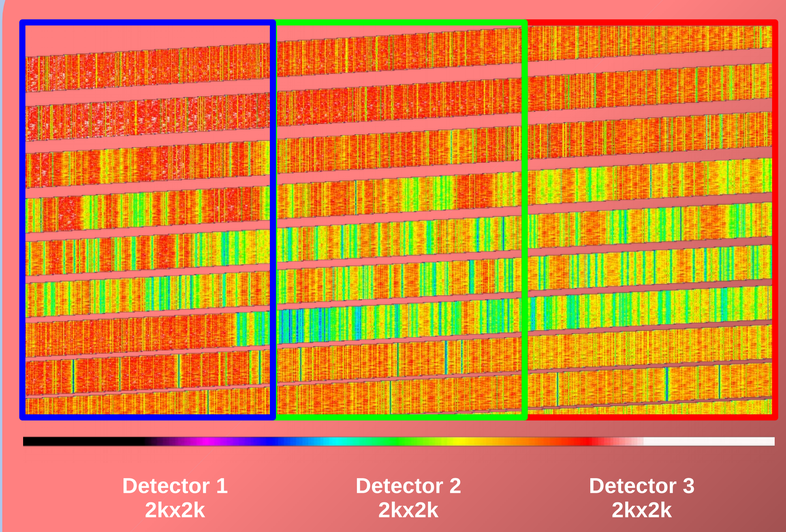
▲ ***Fig. 4:*** **K-band spectrum of an M4 dwarf (black) at R=100k. Wavelength coverage of the current pre-dispersed CRIRES (blue boxes a four detectors) is limited to a single order. CRIRES+ covers the plotted range in a single shot. The reference gas-cell spectrum of CH3D for precision RV wavelength calibration for comparison (light red)**

CRIRES+ will boost the simultaneous wavelength coverage of the current instrument (~λ/70 in a single-order) by a factor of >10 in the cross-dispersed configuration, while still retaining a 10 arcsec slit suitable for long-slit spectroscopy. CRIRES+ dramatically enhances the instrument's observing efficiency, and is tailored for high-precision radial-velocity studies on the 3m/s level to characterize extra-solar planets and their atmospheres (Follert et al., 2014). The RV precision is enabled by specialized, highly accurate wavelength calibration techniques.

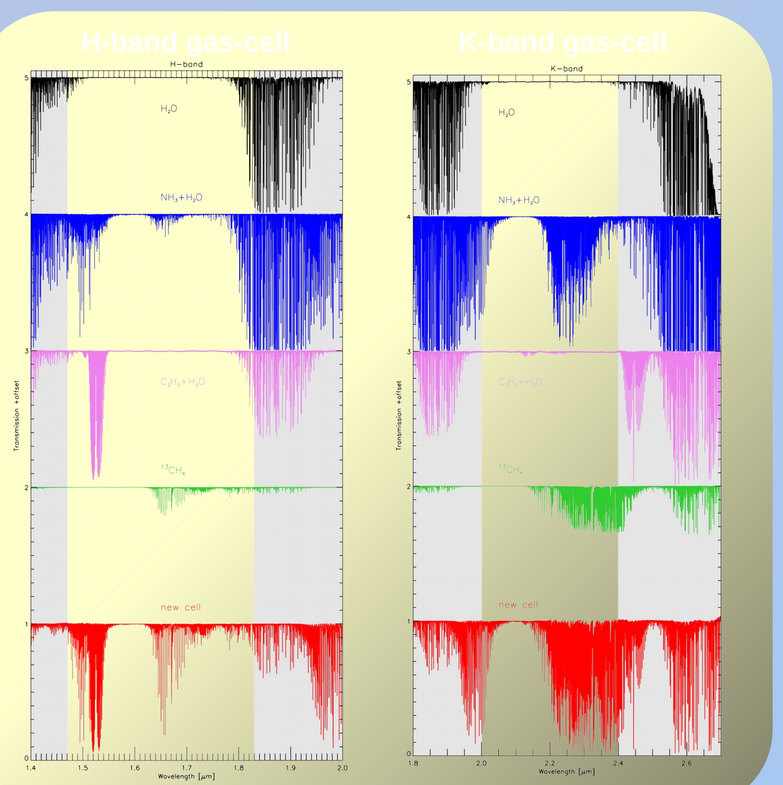
The development of new wavelength calibrators for high-resolution spectroscopy in the NIR is crucial for high-precision RV work for exoplanet search and characterization.

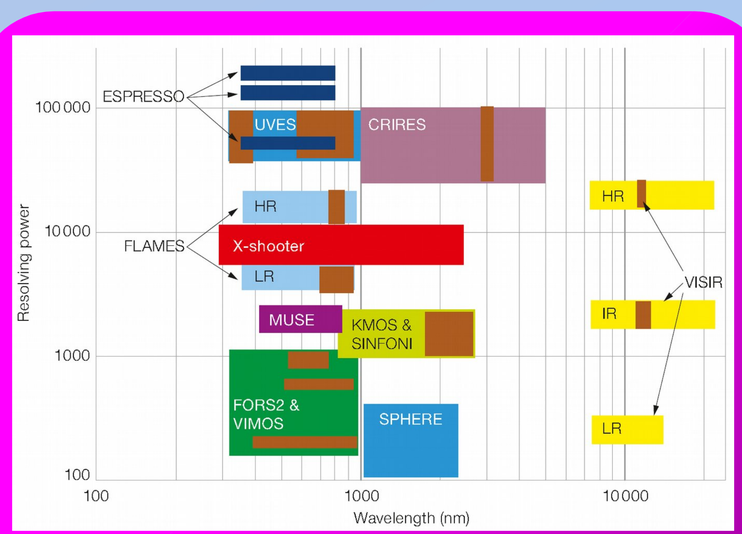
The highest precision is enabled by a new NIR absorption gas-cell for CRIRES+ that allows to beat instrumental effects down to the 3m/s level (Seemann et al., 2014).
This cell delivers a dense forest of molecular absorption lines in the H and K bands, and can be used simultaneously or off-line for wavelength calibration.

Fabry-Perot étalons provide a source of homogeneously spaced, continuous features over broad wavelength regions where emission lamps or gas-cells do not show suitable lines. CRIRES+ exploits étalons to cover the full operational spectral range (1 – 5µm).



▲ ***Fig. 5:*** **Focal plane format of the new CRIRES+ cross-dispersion mode. This forward simulation shows a Y band spectrum of an M dwarf. Three 2kx2k HAWAII2RG detectors image the echelle orders with a minimal gap in between them.**

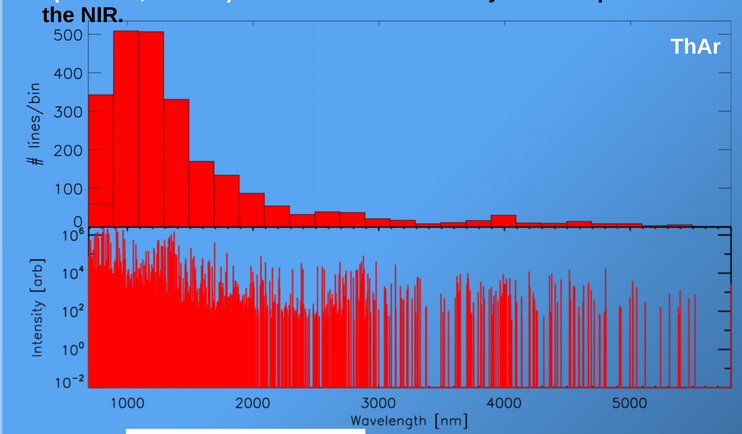


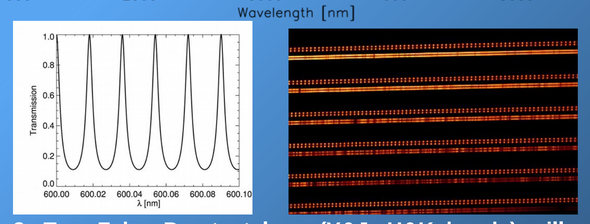


▲ ***Fig. 6:*** **CRIRES+ occupies a unique parameter space and is the only high-resolution NIR spectrograph on an 8m class telescope in the southern hemisphere (Pasquini et al., 2013).**

◄ ***Fig. 5:*** **H and K-band FTS spectra of ambient water vapor (top), individual species (middle panels, may contain water), and new gas-cell (bottom, water-free). The cell shows excellent sharp, deep, and dense lines over most of the wavelength range. These lines are designed to enable 3m/s RV precision with CRIRES+ (Seemann et al., 2014).**

▼ ***Fig. 7:*** **Hollow-cathode lamps are well established emission line sources for wavelength calibration, though the frequency of lines and their density severely drops in the NIR (histogram, top, and emission spectrum, bottom). ThAr is not suitable anymore for precision RVs in the NIR.**





▲ ***Fig. 8:*** **Two Fabry-Perot etalons (Y&J, H&K bands) will provide CRIRES+ with a continuous homogeneous wavelength solution.**

Presented at the 2014 *Planet Formation and Evolution* workshop, Kiel, Germany. We acknowledge generous project sponsoring by the German BMBF.

Get in touch here at the PFE workshop now!