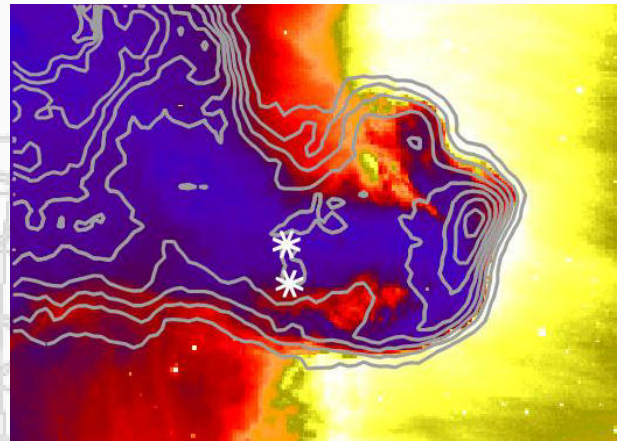




The Carbon Hetrodyne Array of the Max- Planck-Institute

CHAMP⁺ is a new technologies focal-plan array for spectroscopy with APEX in the high submillimeter atmospheric windows (see the transmission plots in the science flyers). Even at exceptionally good sites like Chajnantor the very best atmospheric conditions are rare and simultaneous operation of an ensemble of detectors is one way to enhance the scientific efficiency of a facility. To this end we build-up on the experience gained with the pre-cursor instrument, CHAMP, operating successfully at lower frequencies around 460 GHz on the best site in the northern hemisphere, on Mauna Kea Hawaii, for almost 3 years. As an example, we show a beautiful map of the emission of warm carbon monoxide CO (the 4-3 line) toward the Horsehead Nebulae. In 2004 the instrument was returned to the MPIfR laboratories for refurbishment and upgrades. The instrument is now in final integration and will be commissioned at the APEX in November this year.



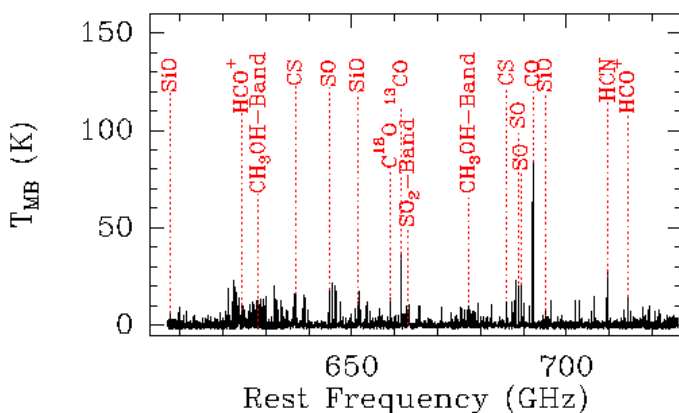
The distribution of warm carbon monoxide as measured towards the Horsehead nebulae with the precursor instrument to CHAMP⁺.

CHAMP⁺ Key Facts

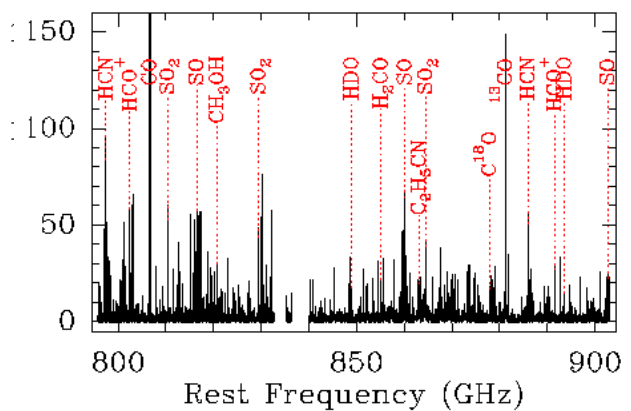
Aiming at the best possible performance of the upgraded receiver, and balancing the technically doable vs. the scientific demands:

- the array composes two sub-arrays with of 7 detector elements each, with closest feasible packing density. The two sub-arrays operate simultaneously in the atmospheric windows at wavelengths of 450 μ m (620-720 GHz) and 350 μ m (780-950 GHz), with wide frequency coverage on sky.

Champ+ Lower frequency band

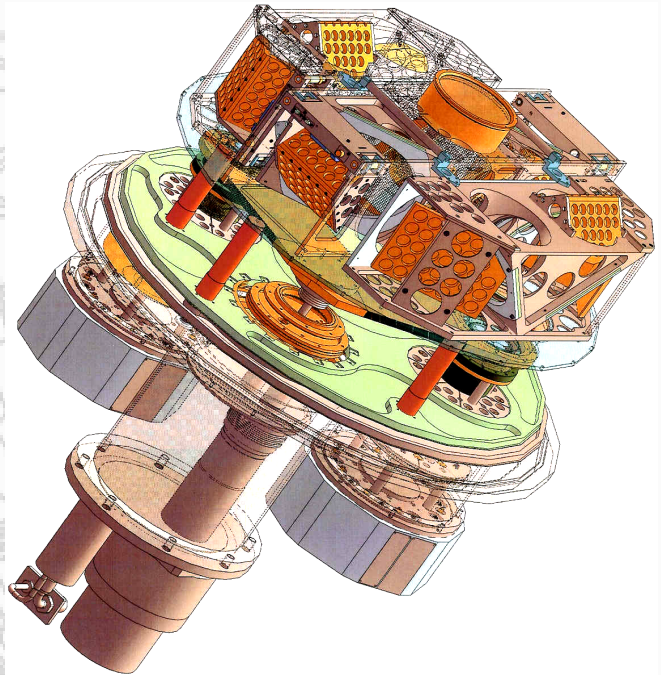


Champ+ higher frequency band



Line Surveys in part of the frequency bands covered by CHAMP⁺, revealing the molecular complexity of star-forming regions that will be possible to study with the array with unprecedented sensitivity. Observations can be performed simultaneously in both atmospheric windows.

- The best available detectors will be integrated through our collaboration with SRON (The Netherlands), as spin-off of their technology developments for ALMA: the mixers in the 450 μm sub array, reveal uniformly low noise temperatures of less than 150 K – a truly great achievement!
- the 3 local oscillator reference sources, needed for heterodyning the signal to lower frequencies, are developments in collaboration with our partners in the Herschel/HIFI space mission (namely, the Polish Space Research Agency and JPL);
- for best system sensitivity the design allows for cold optics (operated at 15 K), and single-sideband operation (thus eliminating atmospheric noise contributions, and improving the system sensitivity by as much as a factor of 2);
- the detection bandwidth will be 4 GHz per detector element, so allowing spectroscopy of broad extragalactic lines;
- the frontend will be linked to a flexible auto-correlator backend (with 32x1 GHz wide channels);
- the data acquisition will allow for advanced observing modes (like “fast scanning while frequency switching”);
- operation of the complete instrument is designed to be remote controllable (which requires, in particular, that mixers and local oscillators are “tunerless”).



The above schematic displays the CAD model of CHAMP⁺, including the 15 Kelvin optics together with the two inserts containing the SIS mixers, and the 3 stages cooling machine.



As an example, for the southern galaxy M83 we display the footprint of the array (red dots, one sub-array with seven mixers). While scanning across the source (in yellow) we will observe the source with best possible (FWHM) spacing between the pixels.

To conclude, CHAMP⁺ is our ultimate answer to the above question „How to make astronomical observations in the atmospheric transmission limited submillimeter windows more effective?“ With CHAMP⁺ in operation the scientific throughput will be enhanced by factors 10–100 (as compared to a classical single-pixel detector). The instrument is currently in final integration, and will be commissioned at the APEX in November this year.

There is great complementarity of APEX to near-future far-infrared missions, namely the **Herschel** Satellite (the 4th cornerstone in ESA’s “Horizons 2000” program) and the “Stratospheric Observatory for Infrared Astronomy (**SOFIA**)”. Both missions extend into the far-infrared regime and cover submillimeter windows that are inaccessible to earth-bound observatories because of atmospheric absorption. CHAMP⁺ will play a key role with supplementary supporting observations.