Abstract

We review the development of our digital broadband Fast Fourier Transform Spectrometers: FFTS. In just a few years, FFTS back-ends – optimized for a wide range of radio astronomical applications – have become a new standard for heterodyne receivers, particularly in the mm and sub-mm wavelength range. They offer high instantaneous bandwidths with many thousands spectral channels on a small electronic board. Our FFT spectrometers make use of the latest version of commercially available analog-to-digital converters (ADC) and the most complex field programmable gate array (FPGA) chips available today. These state-of-the-art chips have made possible to build spectrometers with instantaneous bandwidths up to 2.5 GHz and 65536 (64k) spectral channels.

Our next FFTS development will be the design of a spectrometer with instantaneous bandwidth ≥4 GHz and up to 128k spectral channels, aiming at operational readiness in time for the commissioning of our upGREAT detector array for SOFIA and the LAsMA array receiver at APEX.

Future Developments

In current FFTS applications an IF processor is needed for down-mixing the receiver signals to baseband. However, the analog processors have many disadvantages, e.g. cost-intensive and not calibration- and aging-free. The notification of new ADCs with track-and-hold amplifiers, operating at GHz frequencies, will allow direct sampling of the IF of current and future receivers by bandpass-sampling techniques, with much reduced complexity and reduced costs.

Dual sideband (2SB) receivers are extensively used in mm/submm radio astronomy for line observations of complex astronomical signals to avoid spectral confusion. Today, excellent 2SB receivers obtain sideband rejection ratios of 10 – 15 dB, insufficient for a number of astronomical observations. Currently, we are working on a concept to replace the analog IF-hybrid by a corresponding digital signal processing on the FPGA together with a set of calibration vectors. For an accurate calibrated receiver we expect a sideband separating ratio of ~40 dB over the full bandwidth for 8-bit sampling.

AFFTS: The 32 × 1.5 GHz bandwidth Array-FFTS

XFFTS: The 2.5 GHz eXtended bandwidth / 65536 channel FFTS

In development: UWFFTS – The Ultra-Wide-band FFTS

New concept: DSSFFTS – The Digital Sideband Separating FFTS